Marine Mammal Monitoring
For the U.S. Navy's
Hawaii Range Complex
And
Southern California Range Complex

Department Of The Navy

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EXECUTIVE SUMMARY

This report presents the U.S. Navy's Year 2 level of effort, regulatory compliance, scientific accomplishments, and preliminary data obtained from marine mammal monitoring in the Hawaii Range Complex and Southern California Range Complex.

Year 2 encompassed the period from 02 August 2009 to 01 August 2010. As outlined in the Hawaii and Southern California Range Complex sections within this report, significant accomplishments were achieved from visual surveys, deployments of passive acoustic monitoring devices, marine mammal satellite 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 generally, the U.S. Navy met or exceeded its monitoring goals as stated in the range complex specific Monitoring Plans modified through the 01 October 2009 Monitoring Report to the National Marine Fisheries Service.

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AMR	Adaptive Management Review
ASW	anti-submarine warfare
Bf	Beaufort
CalCOFI	California Cooperative Oceanic Fisheries Investigation
CRC	Cascadia Research Collective
CREEM	Centre for Research into Ecological and Environmental Modeling
dB	decibel
DoN	Department of the Navy
EAR	Ecological Acoustic Recorder
ft	feet
GPS	global positioning service
GUNEX	Gunnery Exercise, Surface-to-Surface
HARP	high-frequency acoustic recording package
HRC	Hawaii Range Complex
kHz	kilohertz
M3R	Marine Mammal Monitoring on Navy Ranges
MDSU	Mobile Diving and Salvage Unit
MFAS	mid-frequency active sonar
MISSILEX	Missile Exercise, Surface-to-Surface
MMO	marine mammal observer
MMRC	Marine Mammal Research Consultants
MTE	Major Training Event
nm	nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NUWC	Naval Undersea Warfare Center
PAM	passive acoustic monitoring
PIFSC	Pacific Islands Fisheries Science Center
PMAP	Protective Measures Assessment Protocol
PMRF	Pacific Missile Range Facility
R/V	research vessel
RIMPAC	Rim Of the Pacific Exercise
RHIB	Rigid hull inflatable boat
SCC	Submarine Commanders Course
SES	Smultea Environmental Sciences
SINKEX	Sinking Exercise
SOAR	Southern California Offshore Anti-submarine warfare Range
SSC PAC	Space and Naval Warfare Systems Center Pacific
SWFSC	Southwest Fisheries Science Center
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 of 1972 and the Endangered Species Act of 1973.

This report continues to provide range complex specific monitoring results for Year 2 (02 August 2009 to 01 August 2010) within the Navy's Hawaii Range Complex and Southern California Range Complex.

As a recap, 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 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, major exercise measures agreed to by the Navy through permitting) effective at avoiding temporary threshold shift injury, and mortality of marine mammals and sea turtles?

Monitoring methods proposed 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. These research elements include visual surveys from vessel or airplanes, passive acoustic monitoring, marine mammal observers, 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 (DoN 2009a,b). 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. This also includes incorporation of new techniques (e.g. photo-ID).

In addition to Fleet funded Monitoring Plans described above, the Chief of Naval Operations Energy and Environmental Readiness Division and the Office of Naval Research have developed a coordinated Science & Technology and Research & Development program focused on marine mammals and sound. Total investment in this program for fiscal year 2010 was approximately $26 million. Several significant projects relative to Navy operational impact or lack of impact to marine mammals are currently funded and ongoing within the Hawaii Range Complex and Southern California Range Complex. For example, in the Southern California 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 Southern California Range Complex Monitoring Plan (see Section Appendix A of Southern California Range Complex section).

Report Objective

Design of the Range Complex specific Monitoring Plans represented part of a new Navy-wide assessment, and as with any new program, there are many coordination, 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 NMFS-Navy agreements. Monitoring results are presented each year to 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) Under the Hawaii Range Complex and Southern California Range Complex 2010 Marine Mammal Protection Act Letters of Authorization, present data and results from the Navy-funded Range Complex marine mammal and sea turtle monitoring conducted in the Hawaii Range Complex and Southern California Range Complex during the Study Year 2 from 02 August 2009 to 01 August 2010.

Included in this assessment are reportable metrics of monitoring as requested by the NMFS. This Year 2 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) Set the foundation for adaptive management review with NMFS for incorporation of proposed revisions to the Navy's 2011 Monitoring Plans based on actual lessons learned from 2009 and 2010. This can include data quality in answering the original study questions, assessment of logistic feasibility, availability of monitoring resources, use of new techniques not originally incorporated in this year's Monitoring Plan, and any other pertinent information.

HAWAII RANGE COMPLEX

Monitoring in the Hawaii Range Complex

This section reports accomplishments from the Navy's marine species field monitoring efforts in the Hawaii Range Complex (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 DoD RDT&E range. PMRF includes 1,020 nm^2 of instrumented ocean area at depths between 1,800 feet and 15,000 feet. Various subcomponents of the range complex are more fully described in the Final Hawaii Range Complex Overseas Environmental Impact Statement/Environmental Impact Statement (DoN 2008a). Of note and in regards to in-water unit-level training and major training events (MTE) using sonar and explosives, a much more limited subset of the range complex is used.

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 Office of Naval Research and the Environmental Readiness Division of the Chief of Naval Operations. Reporting will primarily focus on the Pacific Fleet compliance monitoring required under the Fleets MMPA permit 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 Navy and NMFS and used as a goal for implementation.

During study year two (02 August 2009 to 01 August 2010), U.S. Pacific Fleet implemented aerial and vessel surveys, embarked marine mammal observers on Navy platforms, tagged Hawaiian monk seals and deployed passive acoustic monitoring devices. This work builds upon U.S. Pacific Fleet -funded field work that has occurred in the Hawaiian Islands since the Rim of the Pacific (RIMPAC) exercise in 2006.

HRC YEAR 2 (02 AUG 2009 TO 01 AUGUST 2010 MONITORING OBJECTIVES

The goal of the HRC Monitoring Plan as revised (DoN 2009) 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 2010 monitoring objectives as initially agreed upon by the NMFS and Navy.

U.S. Pacific Fleet began conducting aerial and vessel surveys in conjunction with major exercises in 2006. Most aerial and vessel surveys from 2006-2008 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 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 proposed to use visual surveys (aerial and vessel) and marine mammal observers aboard Navy vessels during ASW and explosive events to meet its goals in FY09. Navy also proposed to purchase passive acoustic monitoring devices in 2009 and lay groundwork for purchasing tagging devices in 2010.

Table H-1. FY10 monitoring commitments for the Hawaii Range Complex (DoN 2009)

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) for FY11
Marine Mammal Observers (MMO) STUDIES 1,2,3,4,5	80 hours aboard Navy vessels during MTE, ULT, and/or explosive events	
Tagging STUDIES 1,2,3	Tag a goal of 15 individual marine mammals	
Passive Acoustics Monitoring (PAM) STUDIES 1,2,3	Deploy four autonomous devices; collaborate with data collection and analysis from other N45/ONR R&D-funded autonomous PAM devices (goal of 10 devices total). Analyze PIFSC acoustic data collected in 2009.	
Mitigation Effectiveness STUDY 5	Lookout effectiveness study by MMOs on Navy surface vessels during 3 ASW events and 6 explosive events	

HAWAII YEAR 2 MAJOR TRAINING EXERCISE SUMMARY

Given the focus on monitoring around Navy at-sea training events, a list of MTEs that occurred in the HRC between August 2009 and August 2010 is provided in **Table H-2**. Marine mammal sightings during MTEs are a form of compliance monitoring and represent substantial numbers of sightings. For HRC, MTEs may include Rim of the Pacific exercises (RIMPAC), Undersea Warfare Exercises (USWEX), and Multi Strike Group Exercises.

There were two MTEs in the HRC between 1 August 2009 and 1 August 2010 – one USWEX and RIMPAC. During transits and training events during those MTEs, Navy lookouts reported 47 marine mammal sightings for an estimated 286 marine mammals. There were zero marine mammal sightings reported at a range less than 1000 yards concurrent with MFAS use.

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

Table H-2. Hawaii Range Complex major training events from 02 August 2009 to 01 August 2010.

MTE Type	Dates	# Of Days	# of Ships Involved	# of Sea Turtle Sightings	# of Sea Turtles	# Of Marine Mammal Sightings	# Of Marine Mammals
USWEX	11 - 18 Nov 2009	4	8	None reported	None reported	None reported	None reported
RIMPAC	6 - 31 July 2010	26	26	7	25	47	286
Totals:		30	34	7	25	47	286

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 2009 to 01 August 2010.

Species Type	# of sightings	% of total sightings	# of sea turtles or marine mammals	% of total number of marine mammals
Dolphins	33	61%	256	82%
Whales	14	26%	30	10%
Pinniped	0	0%	00	0%
Sea Turtles	7	13%	25	8%
Totals:	54	100%	311	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 2009 to 01 August 2010 in the SOCAL range Complex.

mitigation range	# of sightings	total # of marine mammals	Breakdown by species type		
			# of dolphins	# of whales	# of sea turtles
< 200 yards	0	0	0	0	0
200-500 yards	0	0	0	0	0
500-1000 yards	0	0	0	0	0
Totals:	0	0	0	0	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.

The three categories of mitigation measures (Personnel Training, Lookout and Watchstander Responsibilities, and Operating Procedures) outlined in the HRC EIS/OEIS and approved by NMFS (DoN 2008, NMFS 2009a, 2009b) were effective in detecting and appropriately mitigating exposures of marine mammals to mid-frequency sonar. Fleet commanders and ship watch teams continue to improve individual awareness and enhance reporting practices. Additionally, a lookout effectiveness study has been initiated by the Navy which will provide data to demonstrate the effectiveness of the Navy's suite of mitigation measures.

HAWAII YEAR 2 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), RIMPAC 2008 (Mobley 2008c, Smultea and Mobley 2008).

Monitoring in 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 is being collected by embarking marine mammal observers on Navy platforms, tagging Hawaiian monk seals, deploying passive acoustic monitoring devices and conducting visual surveys from research vessels.

Table H-5 presents a summary of Navy funded marine mammal monitoring within the Hawaii Range Complex during Year 2.

Major accomplishments from U.S. Pacific Fleet's Year 2 compliance monitoring in HRC:

- Visual (Aerial) Survey
  - Aerial surveys were conducted during two Submarine Commanders Courses (SCC) by a contracted aircraft in close-proximity (e.g. between 200 and 2,500 yards) to Navy surface vessels. Logistical challenges were overcome by close coordination with Pacific Missile Range Facility (PMRF) range and P-3 pilots to allow for survey aircraft to share airspace with P-3 and helicopters involved in several training scenarios. This success demonstrates that that during certain training events, contracted aircraft may be used as a method for conducting behavioral monitoring of submerged and at-surface marine mammals. (**Appendix G and H**)
  - Extended focal follows were obtained for several marine mammal species.
  - Aerial surveys were conducted in front of surface vessel with MMOs on board, providing an opportunity for coordination during sightings.
  - Coastline and pelagic surveys during and after training events in search of otherwise-undetected strandings.
- Visual (Vessel) Survey
  - A small vessel survey was conducted off Kauai and Niihau during the Rim of the Pacific (RIMPAC) Exercise. The survey was scheduled to gather data mid-exercise and in conjunction with scheduled "opposed-transit" events. (**Appendix E**)
  - A small vessel survey was conducted off Kaula Islet pre-RIMPAC. (**Appendix F**)
  - In conjuction with PIFSC, a vessel and acoustic survey was conducted in 2009. Additional survey results are presented here. (**Appendix M)**
- Passive Acoustic Monitoring
  - Four PAM devices were deployed in areas of the HRC where underwater detonations and anti-submarine warfare exercises may occur nearby. (**Appendix E**)
  - Recordings of PMRF underwater range hydrophones continued at twice per month. Efforts focused on manual verification for presence of beaked whales in the acoustic data. Manual verification is done to confirm that selected automated beaked whale click detections are indicative of the presence of beaked whales (a high percentage of automatically detected beaked whale clicks are false positives). The manual verification process matches observed characteristics with known beaked whale echolocation click details, and foraging dive vocal behavior. To date beaked whales have been confirmed via manual analysis. Analysis from data collected during SCC in February 2010 focused towards two marine mammal species for which automated classifiers are available, beaked whales and minke whales. (**Appendix J**)
  - Groundwork for collaboration and acoustic data sharing between Navy and Hawaii Institute of Marine Biology (HIMB) was laid. Contract will be awarded this fall.
  - Analysis of marine mammal acoustic and behavioral data from several data sets and sources (SIO, PIFSC and Cascadia) was conducted. (**Appendix I and M**)
- Marine mammal observers (MMO)
  - The Navy's lookout effectiveness study commenced when four Marine Mammal Observers (MMOs) embarked during the February 2010 Submarine Commanders Course (SCC) in the HRC. This study was collaboratively developed by Navy,

NMFS Science Centers and University of St. Andrews. Study was also implemented in AFAST and SOCAL ranges this year. (**Appendix C**)

- MMOs embarked on a Navy cruiser during the August 2009 SCC, gathering sighting and behavioral information. (**Appendix D**)
- MMOs monitored two Sinking Exercises (SINKEX) and four underwater detonations while embarked on Navy platforms. (**Appendix B**)

- Tagging
  - Eleven Hawaiian monk seals were tagged with "cell phone tags" on Oahu, Molokai and Kauai by National Marine Fisheries Service, Pacific Islands Fisheries Science Center. Funds were provided to tag 15 animals and tagging efforts will continue into the next data year. At this writing, tracks from several animals have been finalized with several more still reporting after a couple of months. (**Appendix A**)

Table H-5. U.S. Navy funded marine mammal monitoring accomplishments within the Hawaii Range Complex from 01 August 2009 to 01 August 2010.

Study Type	U.S. Navy 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) 31.3 hours - 26-30 Aug 2009 (aerial) 2) 33 hours – 15-19 Feb 2010 (aerial) 3) 21.5 hours 26-28 June 2010 (vessel) 4) 78 hours 17-25 July 2010 (vessel)	1) SCC (ASW) 2) SCC (ASW) 3) Pre-RIMPAC (ASW and explosives) 4) RIMPAC (ASW)	n/a	n/a	120-160 hours before, during and after ASW and/or explosive events	163.8 hours of aerial and vessel surveys
Marine Mammal Observers (Studies 1,2,3,4,5)	1) 42.5 hrs (21.25 hrs x 2 MMOs] – 26-30 Aug 2009 2) 197 hrs [49.2 hrs x 4 MMOs] - 15-19 Feb 2010	1) SCC (ASW) 2) SCC (ASW)	n/a	n/a	80 hours aboard Navy vessels during ASW and/or explosive events	239.3 hours
Tagging (Studies 1,2,3)	11 Hawaiian monk seals tagged off Kauai, Oahu and Molokai	Coverage overlaps ULT, SCC, RIMPAC	Navy funding supports Cascadia Research Collective cetacean tagging off Hawaii and Oahu	n/a	Tag 15 marine mammals	11 monk seals tagged
Passive Acoustic Monitoring (Studies 1,2,3)	1) Two Ecological Acoustic Recording (EAR) devices deployed on Pu`uloa 8 July 2010 2) Two EARS deployed off Ni`ihau 17 July 2010	RIMPAC	1) ONR-funded PAM acoustic methods and tracking (UH/SOEST); 2) ONR-funded Acoustic Ecology of Minke Whales (BioWaves) ; 3) ONR-funded hearing and echolocation of odontocetes (HIMB)	n/a	Deploy 4 devices and collaborate with data collection from other Navy-funded devices. Analyze PIFSC data collected in 2009.	4 EARs deployed, two off Oahu and two off Niihau Acoustic data collected and analyzed from PMRF instrumented range. Acoustic data from HRC analyzed by CPF funded post-doc Groundwork laid for early FY11 contract award to collaborate with HIMB data analysis.
Mitigation Effectiveness (Study 5)	1) 42 hours from 26-30 Aug 2009 2) 197 hours from 15-19 Feb 2010 3) 2 explosive events - 10 July and 17 July 4) 4 explosive events, 15 July	1) SCC (ASW) 2) SCC (ASW) 3) RIMPAC Sinking Exercise 4) RIMPAC Underwater Detonations	n/a		Lookout effectiveness study by MMOs during 3 ASW events and 6 explosive events	Lookout effectiveness during 2 ASW events and 6 explosive events

Metrics exceeded:

Visual surveys: visual surveys (four total) were conducted before, during and after all the multi-unit ASW events in the HRC, totaling significantly more than the targeted number of hours.

Marine mammal observers: hours were exceeded four-fold for marine mammal observer hours. This was in part, due to the lookout effectiveness study design which recommends four marine mammal observers participate in each embark.

Passive Acoustic Monitoring: continuation of acoustic recording and analysis from the PMRF instrumented range was not committed to in prior monitoring plans, however, it has been ongoing with ONR and CPF funding for many years. **Appendix J** contains full reports from this effort.

Metric shortfalls:

Tagging: the Navy's goal was to tag 15 marine mammals however, only eleven were successfully tagged by the 1 August 2010 data cutoff. NMFS is still striving to complete the necessary number of deployments and tagging will continue to complete all 15 deployments. Falling short of our goal is primarily a result of the unpredictability of field work. During multiple field trips, NMFS was presented with an unprecedented lack of seals on the beaches, particularly on Kauai. In three, week-long trips to Kauai, only 4 instruments were deployed. Of the seals that were encountered on those trips, most were pregnant females, young of the year, or animals that were not suitable candidates for instrumentation due to some sort of injury or molt status. During the first field trip to Kauai in February 2010 three cell phone tags were deployed. All of these tags fell off within a few weeks of deployment. This malfunction was due to a bad batch of epoxy that was used to secure the tags to a neoprene base. New epoxy was used on all subsequent deployments to prevent similar issues.

Mitigation effectiveness:

The HRC had fewer ASW events in 2010 than is typical. These fewer events translated to fewer opportunities to monitor. So, although the hours for MMOs well-exceeded the goal of hours, MMOs embarked during two ASW events instead of three.

OTHER NAVY FUNDED RESEARCH IN HAWAII

The Office of Naval Research 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.*

There are two project summarized here: 1) Passive Acoustic Methods for Tracking Marine Mammals Using Widely-Spaced Bottom-Mounted Hydrophones and 2) Passive Acoustic Tracking of Minke Whales, in support of ONR funded project, Tom Norris PI: The ecology and acoustic behavior of minke whales in the Hawaiian and Pacific Islands.

The long-term goals of these projects are to improve and apply passive acoustic methods for tracking marine mammals, with primary effort dedicated to methods that use bottom-mounted hydrophones (esp. U.S. Navy ranges of AUTEC and PMRF). When possible, tracking results are used to study marine mammal behavior and bioacoustics. Two specific challenges are tackled: (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.

Project 1 results to date: (1) Implementation of model-based tracking methods that account for multi-path arrivals and depth-dependent sound speed profiles (particularly important as refraction becomes significant at long distances, such as on Navy ranges). (2) Development of an automated detection algorithm for unknown and unexpected transients in large and unexplored datasets (very useful as a "first sweep" for large volumes of data in which unknown or unpredictable sounds are present). (3) Implementation of several methods to separate and associate calls between hydrophones (for the case of multiple calling animals) – associating calls is a critical step for tracking work, and also benefits efforts aimed at counting animals.

Project 2 results: (1) Acoustic data collected with Fleet funds at PMRF by Steve Martin (SPAWAR) were post-processed using a 3D model-based tracking algorithm to verify the 2D minke whale tracks obtained. These acoustically derived positions were compared with concurrent visual sightings by a team led by BioWaves (Tom Norris) aboard the *R/V Dariabar*. (2) A minke whale boing detector was developed and implemented.

1) *The ecology and acoustic behavior of minke whales in the Hawaiian and Mariana Islands: localization, abundance estimation and characterization of minke whale 'boings' (Tom Norris, BioWaves). Funded in part by ONR.*

See **Appendix K** for full report

2) *The Acoustic Ecology and Behavior of Minke Whales (Balaenoptera acutorostrata) near Tropical and Subtropical North Pacific Islands: Localization, Abundance Estimation and Characterization of Minke Whale 'Boings' (Thomas Norris, Tina Yack, Stephen Martin, Julie N. Oswald, Amanda J. Cummins, Len Thomas). Funded in part by ONR.*

Passive acoustic monitoring, acoustic localization and acoustic/visual line-transect surveys of minke whales were conducted near the Hawaiian and Marianas islands between 2006 and 2010. Acoustic data were collected using: 1) towed hydrophone arrays deployed off Kauai and the Marianas Islands 2) seafloor hydrophones from the U.S. Navy's Pacific Missile Range Facility

(PMRF) northwest of Kauai, 3) the Aloha Cabled Observatory (ACO) seafloor hydrophone northwest of Oahu and, 4) HARP autonomous recorders deployed off the Northwest Hawaiian Island Chain. Significant differences were detected in the pulse repetition rates of boings recorded in Hawaiian versus the Marianas Islands. This information is being used to assess the population characteristics of North Pacific minke whales. Analysis of ACO recordings indicates seasonal patterns, but not diurnal patterns in the number of boings detected. We are in the process of estimating the abundance of vocalizing animals in the main Hawaiian and Northern Mariana Islands study sites using towed hydrophone array data. These results will be compared to estimates made with the PMRF hydrophone data using spatially-explicit capture-recapture methods. Results of these studies are providing a better understand the acoustic ecology and behavior of minke whales in low-latitude breeding areas of the North Pacific.

3) *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 discrimination capability and click parameters of the false killer whale as a function of the development of presbycusis and examining the effects of disrupting echolocation with sound. They measured the audiograms of two new species: the long finned pilot whale (*Globicephala melas*) and the pygmy killer whale (*Feresa attenuata*) and continued the measurement of hearing during echolocation on the false killer whale.

The team began comparative measurements of hearing during echolocation on bottlenose dolphins and harbor porpoise and examined whether or not there were additional automatic gain control mechanisms in the hearing of the false killer whale during echolocation. They also tested the comparative hearing pathways of the bottlenose dolphin and the false killer whale.

Related publications: (Nachtigall et al in press, Mooney et al in press, Pacini et al in press, Muller et al in press, Kloepper et al in press, Ibsen et al 2010, Supin et al 2010)

HRC ADAPTIVE MANAGEMENT AND 2011 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.

The Navy and NMFS convened meetings in 2009 (Raleigh Durham, NC) and July 2010 (Washington DC) in the interest of soliciting input on monitoring objectives and methods. Additionally, the Fleets will convene a monitoring plan review meeting in October 2010 prior to the 2011 Adaptive Management meeting. Results of these meetings as well as success and challenges in the field continue to feed Adaptive Management.

Significant progress was made during range complex compliance monitoring within the Hawaii Range Complex this year. This year's focus was expansion beyond monitoring techniques that are proven in the HRC, while targeting required metrics. We continued to successfully schedule monitoring using civilian aircraft and ships operating concurrently with multiple Navy aircraft and ships in the same area, which required extensive pre-survey coordination between multiple Navy commands. The U.S. Pacific Fleet operational community provided critical interface and coordination which was instrumental in using novel field methods to allow for researchers to conduct monitoring in close-proximity to Navy assets. They also provided berthing and vessels for MMOs on two types of surface vessels.

Cancellations or major date shifts in Navy training events based on logistics, fiscal, or operational needs were challenging to overcome. These kind of changes are difficult to predict and more importantly, more difficult to reschedule from a monitoring prospective when contracts have been awarded, survey equipment has been purchased, rented or relocated; personnel availability and transport arranged; and fixed date contracts put into place. Several planned Navy training events scheduled for monitoring had to be re-scheduled to cover the change in monitoring design.

In view of lessons learned during implementation of the 2010 HRC Monitoring Plan and as part of the Navy's adaptive management review for the Hawaii Range Complex, slight modification of the 2010 Plan is recommended and shown in Tables H-6 and H-7. A separate, stand alone HRC Year 3 Monitoring Plan is provided in Appendix A.

The main rational for restructuring the monitoring shown in Table H-6 is to:

- simplify the presentation of goals, and
- align the technique with the best promise of more accurately addressing the Monitoring Plan objectives

Specific revisions for elements of the proposed 2010 monitoring include:

Visual Surveys: Minor change in order to allow maximum flexibility of platform choice.

Marine Mammal Observers (MMOs): There are two changes to this section. Firstly, since the MMOs are the method being used for study 5, it was erroneous in the 2010 plan to separate out Mitigation Effectiveness in the table. Therefore, it has been combined for FY11. Secondly, there is a change from the metric of *hours* to a metric of *events*. This is to account for the variable time duration of ASW and explosive events as experienced in FY10. MMOs will continue to be used for gathering species and behavioral data as well as implementation of the Lookout Effectiveness developed in 2010 by Navy, University of St. Andrews and NMFS Science Centers.

Tagging: No change.

PAM: Other than editorial changes, the addition here is to include the hydrophones of the Pacific Missile Range Facility instrumented range as a tool for acoustic data gathering and analysis. This was not included in prior monitoring plans although the data collection has been funded since 2002. Adding this method of passive acoustic monitoring will expand our capabilities.

Table H-6. Adaptive management review showing updates to FY10 monitoring plan (strike through are deletions and red font are additions).

Monitoring Technique	Implementation	
Visual Surveys (aerial or vessel) **STUDIES 1,2,3,4,5**	120-160 hours before, during and after ASW and/or explosives training events ~~including major training exercises (MTE), SCC, Unit Level Training (ULT) and/or explosive events.. "During" will be targeted by aerial surveys when feasible.~~	Adaptive Management Review (AMR) for FY11
Marine Mammal Observers **STUDIES 1,2,3,4,5**	~~80 hours aboard Navy vessels during MTE, ULT, and/or explosive events~~ 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 **STUDIES 1,2,3**	~~Install~~ four ~~HARPs~~ PAM devices deployed throughout the year. ~~; collaborate with~~ Continue collaboration of data collection and analysis from ~~other~~ additional N45/ONR R&D funded autonomous PAM devices ~~(goal of 10 devices total)~~. ~~Analyze PIFSC acoustic data collected in 2009.~~ - Continue use of the Pacific Missile Range Facility instrumented range hydrophones to gather and analyze marine mammal acoustic data.	
~~**Mitigation Effectiveness**~~ ~~**STUDY 5**~~	~~Lookout effectiveness study by MMOs on Navy surface vessels during 3 ASW events and 6 explosive events~~	

Legend:

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

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

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

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

Study 5 - Is Navy's suite of mitigation measures for sonar and explosives, and major exercise measures agreed to by Navy through permitting effective at avoiding TTS, injury, and mortality of marine mammals and sea turtles

Table H-7. Final 2011 monitoring commitments resulting from changes red-lined in Table H-6.

Monitoring Technique	Implementation	
Visual Surveys (aerial or vessel) STUDIES 1,2,3,4, 5	120-160 hours before, during and after ASW and/or explosives training events	Adaptive Management Review (AMR) for FY11
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 Range Facility instrumented range hydrophones to gather and analyze marine mammal acoustic data.	

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APPENDIX A Hawaii Range Complex Year 3 Monitoring Plan and Adaptive Management Discussion for the period 02 August 2010 to 01 August 2011

Draft 1 Octobert 2010

This Monitoring Plan is submitted to NMFS in support of the:

Taking and Importing Marine Mammals; U.S. Navy Training in the Hawaii Range Complex; Letter of Authorization Renewal

AND

Biological Opinion on the U.S. Navy's Training in the Hawaii Range Complex

Prepared for
National Marine Fisheries Service
Office of Protected Resources

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

Introduction

In the Hawaii Range Complex (HRC) monitoring plan (DoN 2008), as revised in the 2010 HRC Letter of Authorization (LOA) Renewal Application and Annual Monitoring Report (DoN 2009a and b), and authorized by National Marine Fisheries Service (NMFS) (NMFS 2010), the Navy proposed to continue implementing a diversity of field methods to gather field data from marine mammals and sea turtles in conjunction with training events. As in 2009, methods were specifically chosen to answer the following study questions:

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

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

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

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

Study 5 - Is Navy's suite of mitigation measures for sonar and explosives, and major exercise measures agreed to by Navy through permitting effective at avoiding TTS, injury, and mortality of marine mammals and sea turtles

Metrics (e.g. hours or events) were agreed to by Navy and NMFS and used as a goal for implementation.

FY10 Accomplishments

During study year 2 (02 August 2009 to 01 August 2010), U.S. Pacific Fleet implemented aerial and vessel surveys, embarked marine mammal observers on Navy platforms, tagged Hawaiian monk seals and deployed passive acoustic monitoring devices. This work builds upon U.S. Pacific Fleet - funded field work that has occurred in the Hawaiian Islands since the Rim of the Pacific (RIMPAC) exercise in 2006. There were also additional monitoring efforts within HRC that were funded by the Environmental Readiness Division of the Chief of Naval Operations (CNO N45) and the Office of Naval Research (ONR). Detailed information on accomplishment metrics can be found in Table 1 and in the FY10 Annual Hawaii and Southern California Monitoring Report (DoN2010)

Major Accomplishments from the US Pacific Fleet FY10 Compliance Monitoring in the HRC

- **Visual (Aerial) Survey**
  - Aerial surveys were conducted during two Submarine Commanders Courses (SCC) by a contracted aircraft in close-proximity (e.g. between 200 and 2,500 yards) to Navy surface vessels. Logistical challenges were overcome by close coordination with Pacific Missile Range Facility (PMRF) range and P-3 pilots to allow for survey aircraft to share airspace with P-3 and helicopters involved in several training scenarios. This success demonstrates that that during certain training events, contracted aircraft may be used as a method for conducting behavioral monitoring of submerged and at-surface marine mammals.
  - Extended focal follows were obtained for several marine mammal species.
  - Aerial surveys were conducted in front of surface vessel with MMOs on board, providing an opportunity for coordination during sightings.
  - Coastline and pelagic surveys during and after training events in search of otherwise-undetected strandings.
- **Visual (Vessel) Survey**
  - A small vessel survey was conducted off Kauai and Niihau during the Rim of the Pacific (RIMPAC) Exercise. The survey was scheduled to gather data mid-exercise and in conjunction with scheduled "opposed-transit" events.
  - A small vessel survey was conducted off Kaula Islet pre-RIMPAC.
- **Passive Acoustic Monitoring**
  - Four PAM devices were deployed in areas of the HRC where underwater detonations and anti-submarine warfare exercises may occur nearby.
  - Recordings of PMRF underwater range hydrophones continued at twice per month. Efforts focused on manual verification for presence of beaked whales in the acoustic data. Manual verification is done to confirm that selected automated beaked whale click detections are indicative of the presence of beaked whales (a high percentage of automatically detected beaked whale clicks are false positives). The manual verification process matches observed characteristics with known beaked whale echolocation click details, and foraging dive vocal behavior. To date beaked whales have been confirmed via manual analysis. Analysis from data collected during SCC in February 2010 focused towards two marine mammal species for which automated classifiers are available, beaked whales and minke whales.
  - Analysis of marine mammal acoustic and behavioral data from several data sets and sources (SIO, PIFSC and Cascadia) was conducted.
- **Marine mammal observers (MMO)**
  - The Navy's lookout effectiveness study commenced when four Marine Mammal Observers (MMOs) embarked during the February 2010 Submarine Commanders Course (SCC) in the HRC. This study was collaboratively developed by Navy, NMFS Science Centers and University of St. Andrews. This study was also implemented in AFAST and SOCAL ranges this year.
  - MMOs embarked on a Navy cruiser during the August 2009 SCC, gathering sighting and behavioral information.
  - MMOs monitored two Sinking Exercises (SINKEX) and four underwater detonations while embarked on Navy platforms.
- **Tagging**
  - Eleven Hawaiian monk seals were tagged with "cell phone tags" on Oahu, Molokai and Kauai by National Marine Fisheries Service, Pacific Islands Fisheries Science Center. Funds were provided to tag 15 animals and tagging efforts will continue into the next data year. At this writing, tracks from several animals have been finalized with several more still reporting after a couple of months.

Table 1. U.S. Navy funded marine mammal monitoring accomplishments within the Hawaii Range Complex from 01 August 2009 to 01 August 2010.

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) 31.3 hours - 26-30 Aug 2009 (aerial) 2) 33 hours – 15-19 Feb 2010 (aerial) 3) 21.5 hours 26-28 June 2010 (vessel) 4) 78 hours 17-25 July 2010 (vessel)	1) SCC (ASW) 2) SCC (ASW) 3) Pre-RIMPAC (ASW and explosives) 4) RIMPAC (ASW)	n/a	n/a	120-160 hours before, during and after ASW and/or explosive events	163.8 hours of aerial and vessel surveys
Marine Mammal Observers (Studies 1,2,3,4,5)	1) 42.5 hrs (21.25 hrs x 2 MMOs] – 26-30 Aug 2009 2) 197 hrs [49.2 hrs x 4 MMOs] - 15-19 Feb 2010	1) SCC (ASW) 2) SCC (ASW)	n/a	n/a	80 hours aboard Navy vessels during ASW and/or explosive events	239.3 hours
Tagging (Studies 1,2,3)	11 Hawaiian monk seals tagged off Kauai, Oahu and Molokai	Coverage overlaps ULT, SCC, RIMPAC	Navy funding supports Cascadia Research Collective cetacean tagging off Hawaii and Oahu	n/a	Tag 15 marine mammals	11 monk seals tagged
Passive Acoustic Monitoring (Studies 1,2,3)	1) Two Ecological Acoustic Recording (EAR) devices deployed on Pu`uloa 8 July 2010 2) Two EARS deployed off Ni`ihau 17 July 2010	RIMPAC	1) ONR-funded PAM acoustic methods and tracking (UH/SOEST); 2) ONR-funded Acoustic Ecology of Minke Whales (BioWaves) ; 3) ONR-funded hearing and echolocation of odontocetes (HIMB)	n/a	Deploy 4 devices and collaborate with data collection from other Navy-funded devices. Analyze PIFSC data collected in 2009.	4 EARs deployed, two off Oahu and two off Niihau Acoustic data collected and analyzed from PMRF instrumented range. Acoustic data from HRC analyzed by CPF funded post-doc Groundwork laid for early FY11 contract award to collaborate with HIMB data analysis.
Mitigation Effectiveness (Study 5)	1) 42 hours from 26-30 Aug 2009 2) 197 hours from 15-19 Feb 2010 3) 2 explosive events - 10 July and 17 July 4) 4 explosive events, 15 July	1) SCC (ASW) 2) SCC (ASW) 3) RIMPAC Sinking Exercise 4) RIMPAC Underwater Detonations	n/a		Lookout effectiveness study by MMOs during 3 ASW events and 6 explosive events	Lookout effectiveness during 2 ASW events and 6 explosive events

Metrics exceeded:

Visual surveys: visual surveys (four total) were conducted before, during and after all the multi-unit ASW events in the HRC, totaling significantly more than the targeted number of hours.

Marine mammal observers: hours were exceeded four-fold for marine mammal observer hours. This was in part, due to the lookout effectiveness study design which recommends four marine mammal observers participate in each embark.

Passive Acoustic Monitoring: continuation of acoustic recording and analysis from the PMRF instrumented range was not committed to in prior monitoring plans, however, it has been ongoing with ONR and CPF funding for many years.

Metric shortfalls:

Tagging: the Navy's goal was to tag 15 marine mammals however, only eleven were successfully tagged by the 1 August 2010 data cutoff. NMFS is still striving to complete the necessary number of deployments and tagging will continue to complete all 15 deployments. Falling short of our goal is primarily a result of the unpredictability of field work. During multiple field trips, NMFS was presented with an unprecedented lack of seals on the beaches, particularly on Kauai. In three, week-long trips to Kauai, only 4 instruments were deployed. Of the seals that were encountered on those trips, most were pregnant females, young of the year, or animals that were not suitable candidates for instrumentation due to some sort of injury or molt status. During the first field trip to Kauai in February 2010 three cell phone tags were deployed. All of these tags fell off within a few weeks of deployment. This malfunction was due to a bad batch of epoxy that was used to secure the tags to a neoprene base. New epoxy was used on all subsequent deployments to successfully prevent similar issues.

Mitigation effectiveness: The HRC had fewer ASW events in 2010 than is typical. These fewer events translated to fewer opportunities to monitor. So, although the hours for MMOs well-exceeded the goal of hours, MMOs embarked during two ASW events instead of three.

ADAPTIVE MANAGEMENT AND FY11 MONITORING COMMITMENTS

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.

The Navy and NMFS convened meetings in 2009 (Raleigh Durham, NC) and July 2010 (Washington DC) in the interest of soliciting input on monitoring objectives and methods. Additionally, the Fleets will convene a monitoring plan review meeting in October 2010 prior to the 2011 Adaptive Management meeting. Results of these meetings as well as success and challenges in the field continue to feed Adaptive Management.

Significant progress was made during range complex compliance monitoring within the Hawaii Range Complex this year. This year's focus was expansion beyond monitoring techniques that are proven in the HRC, while targeting required metrics. We continued to successfully schedule monitoring using civilian aircraft and ships operating concurrently with multiple Navy aircraft and ships in the same area, which required extensive pre-survey coordination between multiple Navy commands. The U.S. Pacific Fleet operational community provided critical interface and coordination which was instrumental in using novel field methods to allow for researchers to conduct monitoring in close-proximity to Navy assets. They also provided berthing and vessels for MMOs on two types of surface vessels.

Cancellations or major date shifts in Navy training events based on logistics, fiscal, or operational needs were challenging to overcome. These kind of changes are difficult to predict and more importantly, more difficult to reschedule from a monitoring prospective when contracts have been awarded, survey equipment has been purchased, rented or relocated; personnel availability and transport arranged; and fixed date contracts put into place. Several planned Navy training events scheduled for monitoring had to be re-scheduled to cover the change in monitoring design.

In view of lessons learned during implementation of the 2010 HRC Monitoring Plan and as part of the Navy's adaptive management review for the Hawaii Range Complex, slight modification of the 2010 Plan is recommended and shown in Tables 2 and 3.

The rationale for restructuring the monitoring commitments shown in Table 2 is to:

- simplify the presentation of goals, and
- align the technique with the best promise of more accurately addressing the Monitoring Plan objectives

Specific revisions for elements of 2010 monitoring include:

Visual Surveys: Minor change in order to allow maximum flexibility of platform choice.

Marine Mammal Observers (MMOs): There are two changes to this section. Firstly, since the MMOs are the method being used for study 5, it was erroneous in the 2010 plan to separate out Mitigation Effectiveness in the table. Therefore, it has been combined for FY11. Secondly, there is a change from the metric of *hours* to a metric of *events*. This is to account for the variable time duration of ASW and explosive events as experienced in FY10. MMOs will continue to be used for gathering species and behavioral data as well as implementation of the Lookout Effectiveness developed in 2010 by Navy, University of St. Andrews and NMFS Science Centers.

Tagging: No change.

PAM: Other than editorial changes, the addition here is to include the hydrophones of the Pacific Missile Range Facility instrumented range as a tool for acoustic data gathering and analysis. This was not included in prior monitoring plans although the data collection has been funded since 2002. Adding this method of passive acoustic monitoring will expand our capabilities.

Table 2. Adaptive management review showing updates to FY10 monitoring plan (strike through are deletions and red font are additions).

Monitoring Technique	Implementation	
Visual Surveys (aerial or vessel) **STUDIES 1,2,3,4,5**	120-160 hours before, during and after ASW and/or explosives training events ~~including major training exercises (MTE), SCC, Unit Level Training (ULT) and/or explosive events.. "During" will be targeted by aerial surveys when feasible.~~	Adaptive Management Review (AMR) for FY11
Marine Mammal Observers (MMO) **STUDIES 1,2,3,4,5**	~~80 hours aboard Navy vessels during MTE, ULT, and/or explosive events~~ 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**	~~Install~~ four ~~HARPs~~ PAM devices deployed throughout the year. ~~;~~ ~~collaborate with~~ Continue collaboration of data collection and analysis from ~~other~~ additional N45/ONR R&D funded autonomous PAM devices ~~(goal of 10 devices total)~~. ~~Analyze PIFSC acoustic data collected in 2009.~~ - Continue use of the Pacific Missile Range Facility instrumented range hydrophones to gather and analyze marine mammal acoustic data.	
~~**Mitigation Effectiveness**~~ ~~**STUDY 5**~~	~~Lookout effectiveness study by MMOs on Navy surface vessels during 3 ASW events and 6 explosive events~~	

Legend:

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

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

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

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

Study 5 - Is Navy's suite of mitigation measures for sonar and explosives, and major exercise measures agreed to by Navy through permitting effective at avoiding TTS, injury, and mortality of marine mammals and sea turtles

Table 3. Final 2011 monitoring commitments resulting from changes red-lined in Table 2

Monitoring Technique	Implementation	
Visual Surveys (aerial or vessel) **STUDIES 1,2,3,4, 5**	120-160 hours before, during and after ASW and/or explosives training events	Adaptive Management Review (AMR) for FY11
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 Range Facility instrumented range hydrophones to gather and analyze marine mammal acoustic data.	

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APPENDIX B Marine Mammal Observer Explosives Monitoring

Part I:

Cruise Report Marine Mammal Observer UNDET Monitoring

Hawaii Range Complex, 15 July 2010

Prepared for: US Pacific Fleet

Prepared by: Dr. Robert K. Uyeyama and Dr Sean F Hanser, NAVFAC Pacific

1. INTRODUCTION

1.1 MONITORING PLAN

In order to train with mid-frequency active sonar (MFAS) and underwater explosives, the Navy consulted under the Endangered Species Act and has obtained a permit from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act. The Hawaii Range Complex (HRC) Monitoring Plan, finalized in December 2008, and modified in late 2009 was developed with NMFS to comply with the requirements under the permit. The monitoring plan and reporting for the HRC and other Navy ranges provides science-based answers to questions regarding whether or not marine mammals are exposed and reacting to Navy training. The study questions 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, do they redistribute geographically 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 Observer (MMO) effort is intended to primarily address question 5, as well as potentially question 4.

1.2 UNDERWATER DEMOLITION

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

Description—Underwater demolition exercises are mainly training in the detection and explosive attack of inert, underwater mines. 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.

Location—The activities for this exercise took place offshore in the Pu'uloa Underwater Range (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 for thirty minutes after the animals are last observed. 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: a small rigid-hull inflatable boat (RHIB) less than 30 ft long, provided and piloted by Mobile Diving Salvage Unit One (MDSU-1). Two MMOs were 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 this UNDET monitoring effort.

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

3.1 UNDET MONITORING PARTICIPANTS

MMOs

1. Julie Rivers - Commander, Pacific Fleet (CPF)
2. Robert Uyeyama – Naval Facilities Engineering Command Pacific (NAVFAC PAC)

Cooperating Naval Dive Teams

1. US Navy - Mobile Diving Salvage Unit 1 (MDSU-1)
2. Royal Australian Navy - Clearance Diving Team One
3. Royal Australian Navy - Clearance Diving Team Four
4. Canadian Forces Maritime Command - Canadian Fleet Diving Unit

Vessels Involved in UNDET exercise

1. 4X RHIB ~24 ft (one with 4 Navy MDSU personnel and 2 Navy Biologist MMOs)
2. 2X soft-bottom Zodiac, ~12 ft

3.2 DESCRIPTION OF ACTIVITY

MDSU-1, in cooperation with two diving units from the Royal Australian Navy and one from the Canadian Forces Maritime Command, performed one underwater detonation (UNDET) event each, for a total of four events, on 15 July 2010 in the center of the Puʻuloa underwater training area (Fig. 1) at N21º 17' 29", W157º 59' 14", approximately 1.7 nm from Keahi Point. GPS tracks of the MMO's RHIB are shown in Figure 2.

The intent of the exercises was for training in the disabling of limpet mines, which are mines typically attached magnetically to hulls or surfaces of vessels or structures. A simulated mine was attached to a 1.2 m x 1.5 m (4 ft x 5 ft) metal plate that was suspended underwater between an anchor and a set of two buoys (Fig. 3). The bottom depth of the training location was approximately 15 m. The diving teams were training in the application of an explosive device to disable limpet mines, as well as using the opportunity to observe the methods and protocols of the other participating diving units. Although similar in function, different devices were used by the various diving units. The MDSU-1 divers used a device known as the Limpet Mine Disposal Equipment (LMDE), whereas the Canadian and Australian divers used a Shock Wave Generator (SWAG) (Fig. 4). All of the devices used in the four detonations each contained 0.113 kg (0.25 lbs) net explosive weight (NEW). The UNDET exercise was one of a series of training events involving the cooperation of various Navy dive teams from the United States, Australia, and Canada as part of the multinational major training exercise Rim of the Pacific (RIMPAC).

A total of 6 boats participated together, four RHIBs and two soft-bottom Zodiacs, operated by the cooperating dive teams of the U.S., Australian, and Canadian navies (Fig. 5). The two MMOs were passengers on one of the RHIBs which also carried four members of MDSU-1, including the pilot. The MMO's RHIB departed the dock within Pearl Harbor at 10:11, and arrived at the training location at 10:28. The seastate remained at Beaufort 3 throughout the effort, with a swell height of ~1 m (3-4 ft) and winds of 0-2 kts. Cloud cover was 20% and visibility was excellent throughout the exercise.

During transit to the UNDET site, one green sea turtle was observed at approximately 10:20 at a distance of 5m to the port side of the vessel within the Pearl Harbor channel approximately a third of the distance between the two sets of channel buoys, i.e., just after Buoys 3 and 4, but before Buoys 1 and 2. No waypoint was taken, although the approximate location was N21º 18' 23" W157º 57' 35", which lies ~3.3 km from the training location (Fig. 1).

The RHIB with the MMOs on board was the final vessel to arrive at the training location. It arrived at 10:28, after the metal plate and its mooring buoy had already been placed by the teams from the other vessels. The first dive team was already in preparation for the first underwater detonation of the day. No marine mammals or sea turtles had been observed by the combined Navy dive teams near the UNDET site prior to the arrival of the MMO's RHIB. Because the vessel with the MMOs on board was not explicitly operating any of the detonation activities, it served as the primary Navy lookout vessel. The dive team vessels were arranged around the detonation location at ranges of approximately 0 to 150m in order to observe the UNDET procedures as well as to monitor the perimeter for animals and approaching civilian vessels. The largest distance between vessels was approximately 300m, therefore covering a wide area of observation. During the course of the day, three civilian vessels visible near the site were monitored, and one was intercepted in order to be directed away from the area. A secondary mission of the RHIB with the MMOs was also to visually confirm the location of a recently sunk tugboat (YTB) at the border of the Puʻuloa underwater training area at N21º 17' 05.9" W157 º 59' 24.5" (Fig. 1), where the participating dive units were scheduled to conduct further upcoming cooperative training during the course of RIMPAC. This transit also allowed the MMOs to conduct an informal survey of the intervening waters, along a transit route of length ~776m between the UNDET and YTB locations. No marine mammals or sea turtles were observed.

The RHIB returned to the UNDET site at 11:02, just after the execution of the first detonation (or "shot") at 11:00. As the NEW was small, no plume or surface disturbance was visible during the detonation as the RHIB approached, and no dead fish were observed at the surface upon subsequent examination. The subsequent three UNDET shots were performed at 11:29, 12:03, and 12:35, with the MMO's RHIB observing at a distance of ~75 m. As before, no surface disturbance or plume was visible due to the small explosive weight (Fig. 7). After all of the four scheduled UNDET shots were complete, at 12:37 the MMO's RHIB made one final inspection directly above the detonation location at the buoy, and no dead fish were observed. The buoys, metal plate, and anchors were removed by the Navy divers by 12:52 (Figs. 8, 9, 10, 11). The MMO's RHIB departed the site at 12:55. No marine mammals or sea turtles were observed in 360º scans using both naked eye and binoculars throughout the entire effort including the four detonation shots and subsequent collection of the equipment, nor were any reported by the Navy divers. Therefore no post-sighting monitoring periods were implemented, although the MMOs did verbally confirm that the MDSU-1 Navy divers were aware of the exclusion zone and the required 30 minute monitoring period should any marine mammals or sea turtles be sighted within it. During the return transit to Pearl Harbor, a green sea turtle was observed ~10m to port at 12:58. A GPS waypoint was recorded approximately 20 seconds after the sighting at N21º 17' 27.2" W157º 58' 36.9" (Fig. 1); the distance of this waypoint from the test location is 1.07 km. When accounting for the delay in recording the waypoint at an approximate vessel speed of 15 knots (approximately 155m), the distance of the sighting from the test location was ~ 915 m. The vessel returned to the dock at 13:10, and the Navy divers and two MMOs disembarked, for a total boat time of 2 hours 59 minutes.

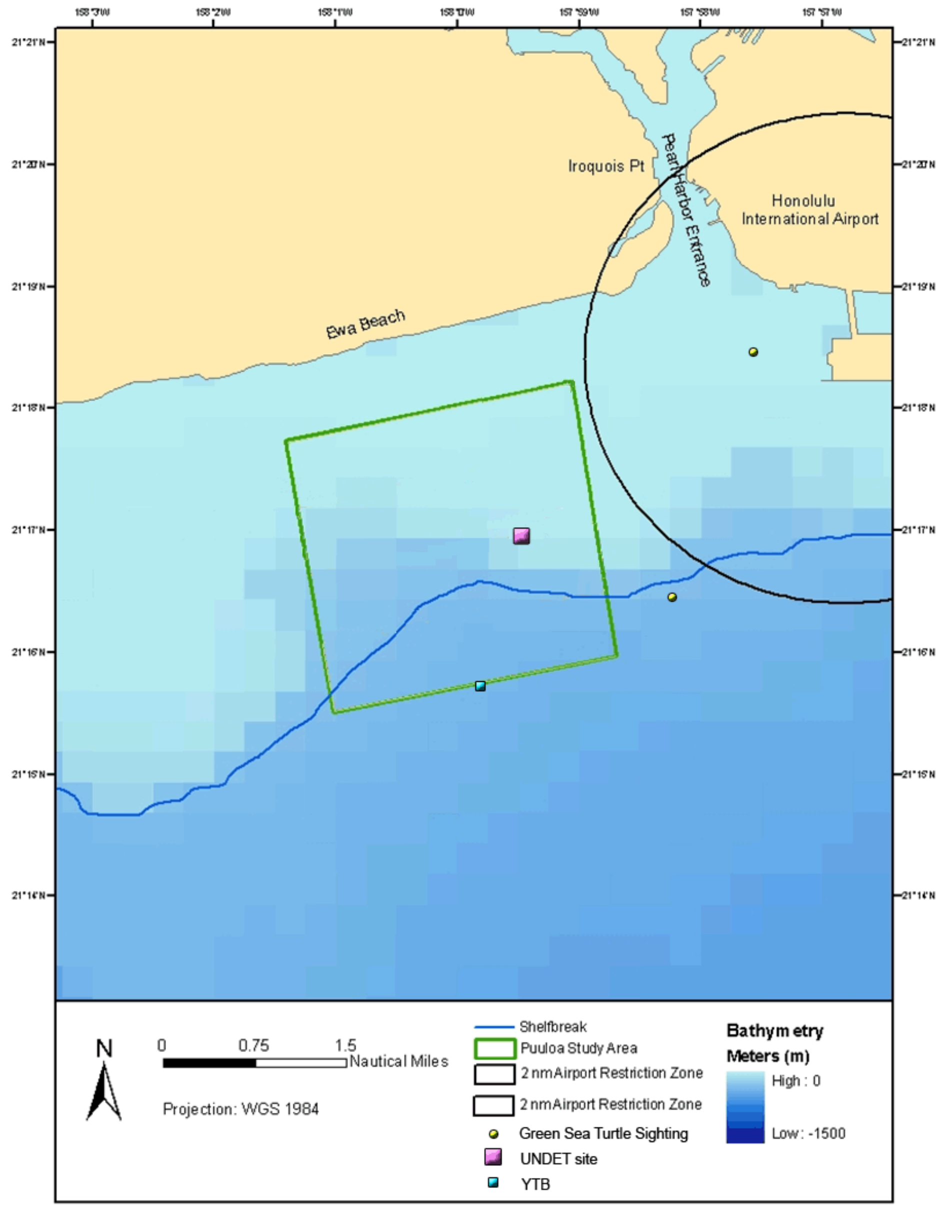

Figure 1. Map of UNDET site and sightings


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Image NASA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image USGS
2839 m

Figure 2. GPS Track of MMO's RHIB between dock and UNDET site – GPS tracks plotted onto Google Earth map

Figure 3. Surface buoys over the UNDET site

Figure 4. One of the two Australian units preparing for a SWAG limpet mine disabling exercise

Figure 5. Four of the vessels involved in the event (three RHIBs, and one Zodiac)

Figure 6. Intercepting approaching civilian vessel traffic after sighting it approaching the exercise area

Figure 7. Undisturbed water surface at the UNDET site at the moment as shot #4 occurs. In the foreground is an unrelated whitecap.

Figure 8. Approaching the site to prepare for collection of all exercise equipment

Figure 9. Retrieval of buoys

Figure 10. Retrieval of 4 ft x 5 ft metal plate

Figure 11. Retrieval of anchor

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 help foster the understanding of why these mitigation measures are in place and how important these measures are to protecting marine life and Navy training. Protocols for the coordination of future UNDET monitoring efforts were also clarified.

4.2 RECOMMENDATIONS

This effort was valuable for the MMOs to observe an UNDET event comprised of multiple cooperating groups, as well as learning about the use of a smaller explosive charge (0.25 lb NEW) and different training context (limpet mine disabling) than previously observed. The UNDET monitoring from the previous year (2009) noted that typical sea turtle observations were made at ranges of ~40 yds, and dolphins at ~200 yds, such that monitoring near the perimeter of the 700 yd exclusion zone might result in missed observations near the UNDET location. During the current effort, the MMOs were able to monitor both the waters immediately adjacent to the

UNDET location and perform an opportunistic transit to the YTB examination to a point just outside the exclusion zone at 776 m before the first shot. During the transit the other vessels remained approximatly 0 – 150 yds away from the UNDET location in various directions. These vessels were able to observe the waters nearer to the UNDET location while the MMO platform was at the perimeter. Therefore, the 2009 recommendation that Navy lookouts focus monitoring near the UNDET site rather than primarily at the exclusion zone perimeter was followed. Although three of the vessels were participants from foreign navies all vessels monitored the water for the presence of civilian vessels and animals, and several civilian vessels were sighted and monitored. If fewer vessels are present, following circular paths at 100-200 yds from the UNDET site might be considered, as it would likely be an improvement over being stationary at that range, or following a perimeter scan a 700 yds. As no animals were sighted except outside the exclusion zone during the transits before and after the effort, the waiting periods were not required. The MMO's vessel was the first to leave the site at 20 minutes past the final detonation, although the other vessels remained longer than 30 minutes.

Two sightings of sea turtles were made during transits to and from the UNDET location, but due to the speed of the vessel, the cameras and GPS were not available for both. In the future, our recommendation is for the MMO to be ready to mark a waypoint immediately with the GPS device available even during transit, since the unit we used (Garmin GPSMap 640) is highly water resistant. If possible, a properly shielded camera could also be available during transits. This way, sightings that occur during the transit to and from the UNDET site, especially those within the exclusion zone, can be recorded. The MMO platform should also request staying at the site the full 30 minutes after the final detonation, even if other Navy vessels remain at the site.

5. ACKNOWLEDGEMENTS

We thank the officers and crew of MDSU-1, including but not limited to CDR Thomas Murphy, LCDR R. Leith Parslow, and CWO3 Chris Lehner, for their outstanding support and hospitality.

APPENDIX B (CONTINUED)

Part 2: Cruise Report Marine Mammal Observer SINKEX Monitoring

Hawaii Range Complex, 10 & 17 July 2010

Prepared for:
Commander, Pacific Fleet

Prepared by:
Sean Hanser and Robert Uyeyama, NAVFAC Pacific

1. INTRODUCTION

In order to train with mid-frequency active sonar (MFAS) and underwater explosives, the Navy consulted under the Endangered Species Act and has obtained a permit from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act. The Hawaii Range Complex (HRC) Monitoring Plan, finalized in December 2008, and modified in late 2009 was developed with NMFS to comply with the requirements under the permit. The monitoring plan and reporting for the HRC and other Navy ranges provides science-based answers to questions regarding whether or not marine mammals are exposed and reacting to Navy training. The study questions 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 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 SINKEX monitoring effort is intended to provide data towards answering questions 4 and 5 above.

2. METHODS

2.1 SINKEX DESCRIPTION

The purpose of the sinking exercise (SINKEX) is to train personnel and test weapons against a full-size ship. Each SINKEX uses an excess vessel hulk as a target that is eventually sunk during the course of the exercise. Any exercise that normally uses a surface target, such as a Gunnery Exercise (GUNNEX) or a missile exercise (MISSILEX)—for example an air to surface missile exercise (ASMEX) or Surface-to-Surface Missile Exercise (SSMEX)-- can be a part of the SINKEX. The hulk ship is towed to a designated location (Fig. 1) where various platforms would use multiple types of weapons to fire shots at the hulk. Platforms can consist of air, surface, and subsurface elements. Weapons can include missiles, precision and non-precision bombs, gunfire and torpedoes. If none of the shots result in the hulk sinking, either a submarine shot or placed explosive charges is used to sink the ship. Charges ranging from 45 to 90 kilograms (100 to 200 pounds), depending on the size of the ship, would be placed on or in the hulk for this purpose.

The vessels used as targets are selected from a list of U.S. Environmental Protection Agency (EPA) approved destroyers, tenders, cutters, frigates, cruisers, tugs, and transports (Department of the Navy and U.S. Environmental Protection Agency, 1996). Vessel hulks that are used must have all hazardous material removed and be approved by EPA in accordance with the memorandum of agreement and the SINKEX permit (40 CFR 220-225, 227-229). In general, examples of missiles that could be fired at the targets include AGM-142 from a B-52 bomber, Walleye AGM-62 from FA-18 aircraft, and a Harpoon from a P-3C aircraft. Surface ships and submarines may use either torpedoes or Harpoons, surface-to-air missiles in the surface-to-surface mode, and guns. Other weapons and ordnance could include, but are not limited to, bombs, Mavericks, Penguins, and Hellfire warheads.

SINKEX is conducted at an approved site (minimum depth 1,800 meters [5,905 feet], at least 93-111 kilometers [50-60 nautical miles] northwest from shore) within PMRF Warning Area W-188 (Fig. 2). The exercise generally lasts 3 to 8 hours.For RIMPAC 2010, three SINKEXs were performed, with marine mammal and sea turtle monitoring studies conducted during the first and the third events. These SINKEX events occurred on 10 July and 17, respectively.

Figure 1. The former USS Anchorage being towed. The hulk utilized for the 17 July SINKEX is seen here on 15 July as it is towed from Pearl Harbor to the SINKEX site.

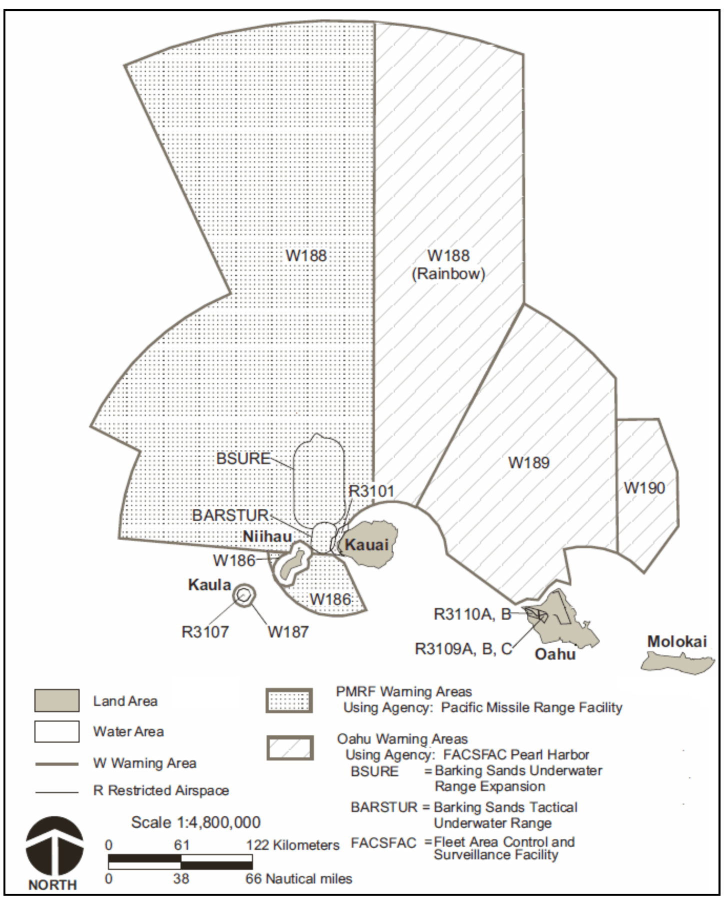

Figure 2. Depiction of PMRF Warning Area W-188 in relation to Hawaiian Islands

2.2 MARINE MAMMAL AND SEA TURTLE OBSERVERS

Monitoring by marine mammal observers (MMO) was conducted from Sikorsky S-61N helicopter platforms (Fig. 3) operated by Croman Corporation, flying from Barking Sands PMRF airfield. The helicopters' primary mission during the SINKEX was to provide an Extended Range Video System (ERVS) live video feed of the exercise to the operations center, as well as video and still photography material for incorporation into Navy media products. For this mission, the helicopters normally carry a total of five personnel: two pilots, one aircrew, and two ERVS operators consisting of the videographer and his assistant, for a total of three riders within the passenger cabin. For the marine mammal and sea turtle monitoring, either one or two Navy civilian biologists also rode on board in the passenger cabin. The biologist observers were equipped with digital still cameras and 7x hand-held binoculars. Additionally, one observer was equipped with a hand-held GPS device to record tracks and waypoints. Due to the mission requirement of providing a near-continuous video feed, a pair of helicopters rotated in the ERVS task. When one helicopter had expended enough fuel to be required to leave the exercise area to transit back to Barking Sand PMRF airfield for refueling, the alternate helicopter had already transited to the exercise location to continue the ERVS mission seamlessly. One MMO was placed in each of these two helicopters to provide maximum monitoring time from this platform. On the second monitored SINKEX on 17 July, both MMOs flew aboard the final flight for a total of five people in the passenger cabin, as it was not overlapping to a previous flight due to operational details, and was also known to be the final flight of the day.

Figure 3. Sikorsky S-61N helicopter used by MMOs. The second open door on the right (with no stairway) was used by the ERVS videographer; the rear door was secured closed during ERVS. The

open window at center between the two doors was open for the duration of the flight, as was a similar window on the opposite side.

2.3 SAFETY AND COMMUNICATION

The helicopter was flown at a prescribed safe altitude and distance from the hulk according to instruction from range control during the period before, during, and after live firing exercises upon the hulk. These standoff distances and altitudes varied according to the ordnance utilized in each portion of the exercise. Range control also deconflicted airspace with P3 aircraft that also participated in the exercise. After scheduled discharge of weapons upon the hulk was complete, the helicopter was cleared by range control to transit to the hulk to perform Battle Damage Assessment (BDA) mode for ERVS. BDA is a detailed visual inspection of damage resulting from the weapons, in the form of videography and photography performed while circling the hulk at close range and an altitude as low as 100m. After BDA, the helicopter ascended to a safe altitude and standoff distance for the subsequent portion of the exercise, and continued as above until relieved by the other ERVS helicopter.

Prior to participating in the monitoring event, the MMOs completed mandatory Helicopter Underwater Egress training instructed by Survival Systems at Marine Corps Base Hawaii (MCBH) consisting of two days of classroom and in-water training on 1-2 June 2010. In-water training included Shallow Water Egress Training (SWET), as well as a Modular Egress Training Simulator (METS) using blacked-out goggles, rifle, flak-jacket, two- or four-point seat belts, and a Helicopter Aircrew Breathing Device (HABD). Additional training acquired by the MMOs in the course included egress from an airborne platform, activating and operating life jackets, assembling and operating life rafts, operating survival equipment, and individual as well as group in-water survival techniques.

For the SINKEX monitoring flights, the MMOs were provided by Croman with life vests equipped with survival equipment including HABDs. Additionally flight suits, helmets, gloves, and communications headsets were provided. The helicopters were also outfitted with mandatory safety equipment. A mandatory safety briefing was attended before each day of flights. The MMOs were seated in the passenger cabin with seat belts, and were also equipped with a helicopter aircrew harness, which attached the MMOs to a webbing strap affixed to the interior attachment points on the ceiling of the cabin. The MMOs were restrained by seat belts for take-off, landing, and transits, but were unbelted and free to move within the cabin during ERVS and monitoring at the site. The aircrew harness was necessary because one of the doors was fully latched open (Fig. 4) during all times that the videographer was active during ERVS, at altitudes up to 10,000 ft. This door was secured when the ERVS task was inactive.

Communication between MMOs with the pilots and the other crew was by aviation headsets. The pilots maintained direct radio communication with the operations center and range controllers.

Figure 4. Extended Range Video System (ERVS). Videographer (right) is operating through an open door during flight. Note webbing restraints from ceiling attached to harnesses of all occupants. The MMO (left) was able to stand and move within the cabin to view the water through several windows on both sides of the craft, as well as through the open door.

3. RESULTS

For the two monitored SINKEXs, the hulks utilized as targets were:

1) 10 July: Former USS New Orleans (LPH-11) helicopter landing platform amphibious assault ship

2) 17 July: Former USS Anchorage (LSD-36) dock landing ship.

3.1 MONITORING FROM THE HELICOPTER

For both events, one MMO rode aboard each of a pair of Sikorsky S-61N helicopters operated by Croman Corporation, flying from Barking Sand PMRF airfield. As described above, a pair of two helicopters rotated flight shifts to provide continuous coverage of the event (Fig. 5). The helicopters transited to the exercise site, then began performing ERVS while flying at a safe standoff distance and altitude. One MMO was equipped with a hand-held GPS device, and tracks from the flights were recorded, but not all portions of all flights were recorded due to limited battery life of the unit (Figs. 6, 7). Because the hulk was unanchored at the beginning of the exercise, it drifted in position during the course of the exercise (e.g., Fig. 6). ERVS was performed by videographer seated in front of a cabin door that was latched open at the right front of the passenger cabin. The videographer's assistant helped with positioning the videographer, as well as occasionally taking digital still photographs. The pilots maneuvered the aircraft to allow the videographer a view of the hulk from his position at the open door. The MMO was able to move within the cabin, and was therefore able to view the hulk and the waters surrounding it from behind or below the videographer, and were also able to utilize several windows on the same side of the aircraft, one of which was open (Fig. 8). Because the aircraft was almost always level, the

MMO was also able to view the water from the open and several closed windows on the opposite (left) side of the aircraft.

Figure 5. Helicopter rotation. ERVS helicopter with MMO aboard (above right) flying near the hulk, as viewed from the second ERVS-MMO helicopter during a rotation between shifts

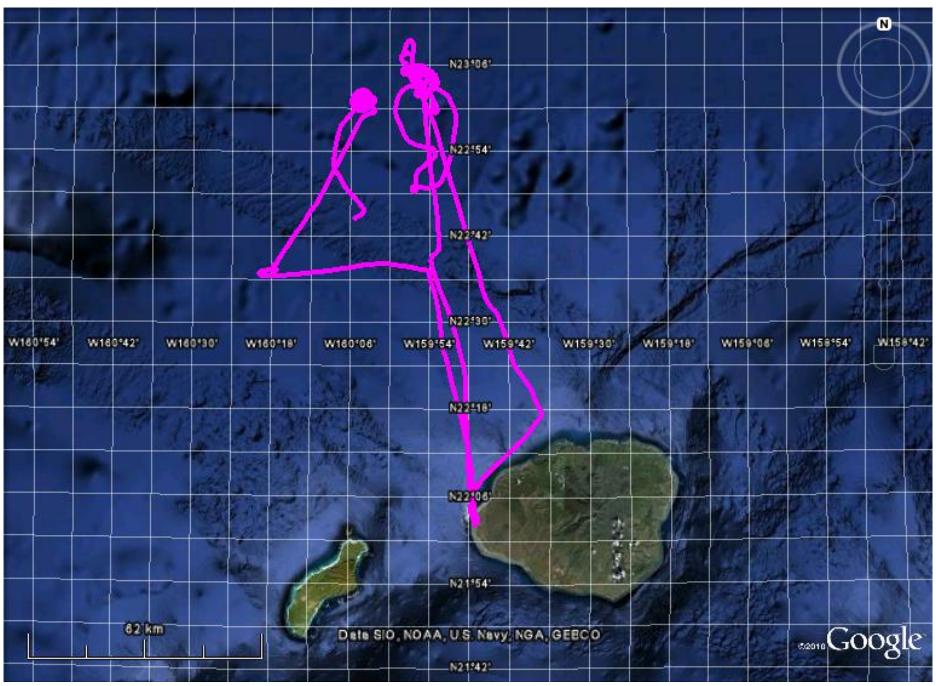

Figure 6. Tracks for two flights on 10 July. Right: 0847-1149 flight, Left: 1430-1730 (track ends at 16:15). Note drift of hulk between flights, which is unanchored during course of the exercise. Second track truncated due to limited battery capacity of GPS device. GPS tracks are plotted onto Google Earth maps.

Figure 7. Track for one flight on 17 July. 0830-1212 flight. GPS tracks are plotted onto Google Earth maps.

Figure 8. Open window. Monitoring could be conducted and photographs could be taken through the open door, two open windows, or other windows, without interfering with the ERVS crew.

3.2 MONITORING TIME

The MMOs performed 27 hrs 27 min of monitoring in total across both SINKEX exercises on 10 July and 17 July (Table 1). On 10 July, sunrise was approximately at 0602 (as computed by the NOAA Earth Systems Research Laboratory Sunrise/Sunset Calculator (http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html), and the first ERVS helicopter departed the airfield at 0847 then arrived at the hulk at 0935, before the first discharge of ordnance at the hulk. On 17 July, sunrise was approximately at 0604, and the first ERVS departed the airfield at 0830, briefly returned to the airfield due to range fouling, departed again at 0925, and arrived at approximately 0955, also before the first discharge of ordnance. Therefore the beginning of firing ordnance at the hulk during both events occurred well past one hour after sunrise, in accordance with mitigations requirements. The sinking of the hulks due to damage sustained from the live fire exercises was observed on the final ERVS flight of both days. On 10 July, the hulk sank during BDA after a gunnery exercise. On 17July, the hulk sank during BDA after a torpedo exercise.

Range clearance and surveillance operations were conducted by P3 aircraft, and not by the ERVS helicopters.

Table 1. MMO monitoring times

10 July				17 July			
MMO 1		MMO 2		MMO 1		MMO 2	
0847-1139	2 hr 52 min	1035-1343	3hr 08 min	0830-1215	3 hr 45 min	1136-1452	5 hr 16 min
1225-1345*	1 hr 20 min	1430-1730	3hr 00 min	1640-1924	2 hr 44 min	1640-1924	2 hr 44 min
1623-1901	2 hr 38min	-		-		-	
Subtotal 6 hr 50 min		Subtotal 6 hr 08 min		Subtotal 6 hr 29 min		Subtotal 8 hr 00 min	
Overall total: 27 hr 27 min							

Times represent in-air time from “wheels-up” to “wheels-down”; MMOs rode in separate aircraft except for the final flight of 17 July.

*Rotation was ended early due to safety requirements of upcoming use of laser-guided munitions during exercise

Figure 9. Sinking of hulks. MMOs observed the SINKEX exercise from the ERVS helicopters until the hulks were sunk: views from BDA. Top:10 July (former USS New Orleans). Bottom: 17 July (former USS Anchorage).

3.3 VISIBILITY AND SIGHTINGS

Beaufort sea state at the site on 10 July was generally between 4 and 6, with the exception of sea state ranging between 3 and 5 on the first flight of the day. Sea state on 17 July ranged from 3 to 5. Proportion of unit time observed for each sea state was not computed, because it was judged that the observers' sea state estimates from the wide variety of altitudes traveled (~300 ft to 10,000 ft; ~91 m to 3,048 m) were likely not to be consistent enough for tabulation. Sightability of marine mammals and turtles within the exercise mitigation zones (i.e., exclusion zone, buffer zone, and safety zone) was judged to decrease in proportion to increasing altitude and distance of the helicopter from the hulk. Cloud cover was generally not an issue because the ERVS mission required the pilots to attempt to maintain a clear line of sight to the hulk, even when flying above the cloud layer. On 10 July the cloud cover ranged from 30% to 100%, although the helicopter was maneuvered such that the hulk was visible >~90% of the time; the exception was first flight of the day which began with 100% cloud cover, but began to show enough breaks through which to view the hulk by the time of the first ordnance shots. On 17 July the cloud cover at the hulk ranged from 20% to 50%. During BDAs, the helicopter flew below the cloud cover near the hulk.

Safe altitudes flown by the ERVS helicopters were: 1) 10,000 ft (3,048 m) for discharge of AGM-65 Maverick missiles; 2) ~6,000-6,500 ft (1,828 – 1,981 m) for other types of missiles such as the AGM-84 Harpoon or AGM-88 HARM; 3) For the firing of the MK-48 torpedo from a submarine, the helicopter flew at an altitude of 2,000 ft (610 m) at a distance of 1 nautical mile on the disengaged side (behind) of the submarine; 4) For the GUNNEX (5-inch guns), the helicopter flew on the disengaged side of the firing surface ships (Fig. 10).

After all shots were completed, and clearance given by range control, the ERVS helicopter descended and approached the hulk for BDA, beginning by slowly circling and overflying the hulk at an altitude of approximately 300 ft, and incrementally circling around the hulk at successively higher altitudes up to 3,000 ft. One live fire portion upon the hulk that was not monitored was the discharge of laser-guided bombs from B-52 aircraft, due to the reason that the personnel and pilots aboard the ERVS helicopter were not equipped with laser-safety gear. The ERVS helicopter returned to the airfield until after this bombing exercise was complete, and then returned to the site of the hulk to conduct BDA.

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

Figure 10. Helicopter position for GUNNEX. ERVS helicopter with MMO aboard departing the

exercise site during preparation for a gunnery exercise (GUNNEX) upon the hulk, as viewed from the second helicopter during rotation between ERVS shifts. Helicopters were position on the disengaged side of the surface ships.

4. CONCLUSIONS

4.1 MARINE MAMMAL AND SEA TURTLE MONITORING

Range operations at Pacific Missile Range Facility, as well as the pilots, aircrew, and staff at Croman Corporation were cooperative and instrumental with the coordination of placing MMOs on board for monitoring the SINKEX events, including the safety requirements for helicopter "dunker" over-water emergency egress training for the MMOs. Dialogue with range operations before the event confirmed that the operators knew the mitigation requirements well and followed them as described in the MMPA permit and Hawaii Range Complex EIS. Protocols for the coordination of future SINKEX monitoring efforts were also clarified. Range clearance and surveillance operations were conducted by P3 aircraft, and not by the ERVS helicopters that the MMOs rode aboard. However if marine mammal and sea turtle sightings were made by the MMOs, these could be communicated via the ERVS pilots to range control.

The Battle Damage Assessment (BDA) portions of the flight were performed at low altitude combined with slow speeds, and therefore were judged by the MMOs to provide excellent observer coverage and sightability of the mitigation radius surrounding the hulk. Live, injured or dead marine mammals or sea turtles would likely be detected due to the low altitude and the helicopter's slow and continuous circular flight pattern around the hulk. Due to the close range of the helicopter to the hulk during BDA, observational effort for marine mammals and sea turtles were possible on both the sides of the aircraft, including the side facing the hulk for ERVS, as well as the opposite side. BDA began at approximately 300 ft (Fig. 11), an altitude lower than the 800-1000 ft typically used for aerial marine mammal and sea turtle surveys, then continued to rise in altitude with each circular path around the hulk to 2,000 ft and above, until reaching the safe altitude required for the next phase of the exercise. The groundspeed of the aircraft during BDA varied, but was always well below the typical 100 kts flown for aerial marine mammal surveys. Although no marine mammals or sea turtles were sighted during BDA, details such as flying sea birds and floating surface debris were easily detectable. (Figs. 12, 13)

At 2,000 ft altitude, isolated sea turtles and small marine mammals would likely not be visible even with hand-held 7x binoculars, and only larger marine mammals or larger groups of smaller marine mammals would be detectable with binoculars or naked eye, with the chances of detection becoming successively smaller at higher altitudes. At the higher altitudes of 6,000-10,000 ft used for safety during missile exercises, although it was judged possible that a large whale or a particularly large aggregation of marine mammals might be detectable with excellent sea state and little cloud cover using binoculars, it was deemed unlikely and not ideal for continuous monitoring for marine mammals and sea turtles (Figs. 14, 15); the same evaluation was given to sightability during gunnery and torpedo exercises due to the standoff distance on the disengaged side of the firing vessels (Figs. 16, 17). Details that were discernable included the impact of ordnance used during the exercise and the resulting smoke cloud, as well as any discoloration of the surrounding water (Fig. 18).

Therefore from the ERVS helicopter platform, the successive BDA segments between each shooting component of the SINKEX provided the MMOs with the best opportunity to monitor the exclusion zone surrounding the hulk in a periodic, serial fashion through the conduction of the exercise.

Video footage taken during the exercise will be provided for review, which may provide additional data.

Figure 11. Sightability during Battle Damage Assessment (BDA). Viewing damage to the former USS New Orleans. The two photographs show the low altitude flown during BDA, providing a close view of the water. The open door at the ERVS videographer is an excellent viewing option for the MMO, in addition to the cabin windows on both sides of the aircraft.

Figure 12. Seabird sighted during BDA. One sea bird sighting was made during BDA across both days. A red-tailed tropicbird (Phaethon rubricauda) was sighted near the hulk during one Battle Damage Assessment on 10 July. It was judged by the MMOs that any marine mammals and sea turtles within the mitigation radius similarly would be visible during the performance of BDA.

Figure 13. Debris sighted during BDA. Small pieces of debris were visible at the surface of the water near the hulk during Battle Damage Assessment. It was judged by the MMOs that any marine mammals and sea turtles within the mitigation radius similarly would be visible during the performance of BDA.

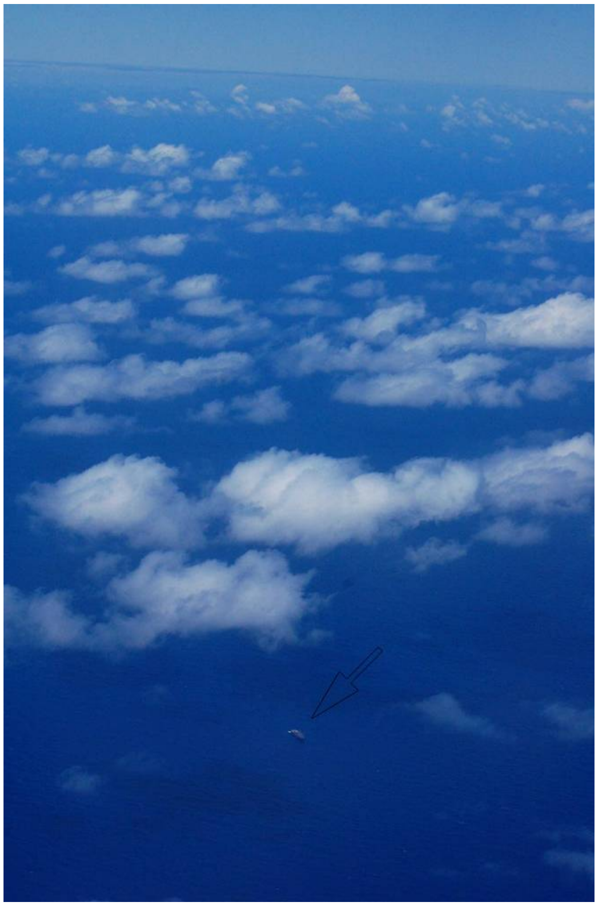

Figure 14. Sightability from 10,000 ft. Top: wide-angle view from 17 July showing hulk (indicated by arrow), cloud layer, and horizon. Bottom: full frame view from a 300mm digital SLR camera during missile impact.

Figure 15. Sightability from 6,000ft. Top: wide-angle view from 10 July showing hulk, cloud layer, and the bottom of the open helicopter door. Bottom: full frame view from a 300mm digital SLR camera.

Figure 16. Sightability during GUNNEX. Safety dictated flight on the disengaged side of the firing surface ships during gunnery exercises (GUNNEX) 10 July. Top: wide view of the surface ships; the hulk (former USS New Orleans) is visible at top right of photo. Bottom: full frame view from a 300mm digital SLR camera.

Figure 17. Sightability during torpedo exercise. Top: wide-angle view from 17 July showing hulk, submarine (center foreground), and P3 aircraft. Bottom: full frame view from a 300mm digital SLR camera during torpedo impact.

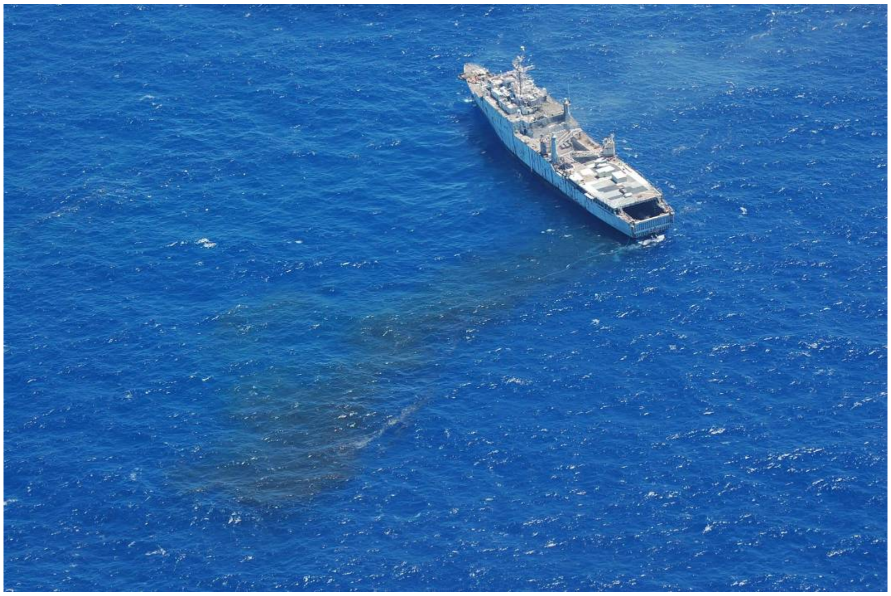

Figure 18. Discoloration of water. Wide angle photograph taken during descent to perform BDA, 17 July. Surface debris is also visible. Discoloration was originally sighted prior to BDA.

4.2 RECOMMENDATIONS

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

Due to safety considerations of altitude and distance, the MMOs were not able to monitor the mitigation area effectively from the ERVS platform during the portions of the flight during, and in preparation for, the firing of ordnance. Also, because the ERVS mission was not intended to provide range clearance, the MMOs were unable to evaluate the primary range clearance and surveillance activities conducted by aircraft such as the P3s. It is possible that MMO presence aboard these craft might provide information regarding the effectiveness of these measures. However, it is unlikely that MMOs aboard the P3s would have as good an observational opportunity between shots as an ERVS helicopter during BDA, due to the helicopters' particularly low altitude and groundspeed during BDA. Therefore MMO presence on both the range clearing/surveillance platform as well as all rotations of the ERVS platform should be considered for the monitoring of future SINKEX events.

5. ACKNOWLEDGEMENTS

We thank the staff at PMRF range operations, Croman Corporation, and Survival Systems for their outstanding support and hospitality in preparation for, and during the exercises.

APPENDIX C Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study: Submarine Commanders Course, February 2010, Hawaii Range Complex

Prepared for: Commander, Pacific Fleet

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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
m	meter(s)
MFAS	mid-frequency active sonar
MMO	marine mammal observer
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
PMAP	Protective Measures Assessment Protocol
PMRF	Pacific Missile Range Facility
SCC	Submarine Commanders Course
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 permit from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act. The Hawaii Range Complex (HRC) Monitoring Plan, finalized in December 2008 for implementation 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:

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?

1. 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?

2. If marine mammals and sea turtles are exposed to MFAS, what are their behavioral responses? Are they different at various levels?

3. What are the behavioral responses of marine mammals and sea turtles that are exposed to various levels and distances from explosives?

4. 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, on the fantail, 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 frigate (FFG). The University of St. Andrews, Scotland, under contract to the U.S. Navy, developed the protocol used for the study. The results gathered were the first attempt to implement this new protocol; therefore, recommendations for ways to improve the protocol are an important part in the outcome of this study. Data collected will 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 (Amy Farak, Sean Hanser, Anurag Kumar, and Julie Rivers) participated in a Submarine Commanders Course (SCC) from 16-20 February, 2010. Additionally, other unit level training was conducted from 21-22 February during which additional data were collected. These MMOs were stationed aboard an FFG, hereafter referred to as FFG A. The goals of the SCC 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.
3. Achieve close coordination between the contracted aerial survey team, Navy aircraft on the range, range control, and the MMO team aboard FFG A to facilitate maximizing survey time and project safety.

SCC Description

SCC events are a requirement to provide the necessary training to prospective submarine commanders in rigorous and realistic scenarios involving anti-submarine warfare.

Participants in this SCC included FFG A, a destroyer, maritime patrol aircraft (fixed-wing patrol squadron), helicopter antisubmarine squadron, submarines, torpedo recovery helicopter and boats, and range control for subsurface, surface, and air.

Methods

Shipboard Monitoring

On the morning of 09 February, the Commander Pacific Fleet Environmental biologist, Naval Facilities Engineering Command Pacific MMO, survey aircraft pilot, and aerial principle investigator participated in a pre-sail brief for all vessel and aircraft participants in the SCC event. During the pre-sail, the details regarding airspace concerns were finalized, as discussed in Section 0. The purpose and function of the MMOs were presented at the pre-sail meeting. Additionally, an in-brief was provided to the commanding officer, executive officer, and operations officer aboard FFG A on 16 February.

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 the FFG A to accomplish its mission objectives. The exceptions would be if a marine mammal was sighted by the MMO within the shut-down zone (200 yards [yds], 183 meters [m]) during MFAS and was not sighted by the lookout, or if the vessel was in danger of striking an animal. In these cases, the MMO would report the sighting to the Navy lookout team for appropriate reporting and action.

The protocol for data collection was provided by the University of St. Andrews and is included as Enclosure 1. This protocol was modified by the MMOs as necessary during the event. The MMO survey was conducted on the bridge wings (elevated 35 feet [ft; 10.7 m] above the waterline) and on the flying bridge of FFG A (elevated 45 ft [13.7 m] above the waterline), with one MMO on each wing (called survey MMOs, or SMMOs) and one MMO on the flying bridge to act as a liaison to the forward lookout (called liaison MMO or LMMO). The fourth MMO was off effort which allowed for a rest period. A rotation schedule was used, such that an MMO would be on effort for an hour on port, an hour as the LMMO on the flying bridge, an hour as an SMMO on starboard, and an off effort hour to rest. 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 sighting, environmental, and sonar parameters. During the first three days (16-19 February), each SMMO collected sighting data through either use of sightings forms or voice data recorders. However, this method was determined to be inefficient, as logging the necessary information was distracting and resulted in losing the location of the animal. As such, the fourth MMO, who had been off effort during the rotation of the previous days, became a data recorder (DMMO) for all MMOs. If applicable, photographs would be taken using a Canon EOS 20D digital camera with a 100 – 400 mm zoom lens, however no opportunities arose.

In addition to collecting data on each sighting, the MMOs would alert the survey aircraft (Section 0), via a hand-held avionics very high frequency (VHF) radio (Section 0), to the location(s) of the animal(s) so that the aircraft could conduct a focal follow of the animal. If the aircraft was currently in a focal follow and another sighting was made, the aircraft would wait until the first focal follow was complete before heading to the second sighting. MMOs were not to inform the survey aircraft of the ships operations, particularly if MFAS was in use, so as to not bias any behavioral observations made by the survey aircraft.

The LMMO stationed on the flying bridge recorded sightings made by the Navy forward lookout. Once the forward lookout sighted an animal or was informed of a sighting by the bridge, the lookout would relay the approximate bearing, distance (estimated by eye), and animal group (whale or dolphin) to the LMMO. The LMMO would relay this information to the SMMOs to determine if the sighting was considered a duplicate. The information relayed by the LMMO would be recorded by each SMMO. However, as indicated above, data collected from 21-23 February were recorded by the DMMO rather than each SMMO.

A GARMIN etrex global positioning system (GPS) was used to take waypoints when sightings occurred or when observation effort changed. The GPS unit allowed the MMOs to obtain positional reports without needing to enter the pilot house. All MMOs maintained communications through hand-held VHF radios.

Aerial Monitoring

Aerial surveys were conducted during the SCC using similar methods as were used during the August 2008/09 and February 2009 surveys. The survey was undertaken by a contracted team aboard a twin-engine, fixed-wing Partenavia. 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.

The SCC involved multiple large naval vessels, submarines, and both fixed-wing (P-3) and rotary-wing (helicopter) aircraft. Thus, coordination of airspace use was paramount to the safety of all aircraft involved. In general, the airspace was divided into altitude strata, such that each aircraft had a specific stratum assigned; helicopters were at the lowest stratum, the survey aircraft was in the middle stratum, and the P-3 was in the highest stratum. However, when the P-3 aircraft was required to fly at lower altitudes to satisfy mission requirements, the P-3, survey aircraft, and range control would coordinate to ensure each aircraft could safely maneuver to the other stratum. Each morning, the survey aircraft would communicate with range control to determine the location of FFG A and to verify the altitude in which they would enter the range. Radio communication between the aircraft and MMOs was also established and verified.

The schedule of events for the survey aircraft was to conduct pre-determined survey pattern on the day before and after the event to obtain animal presence and distribution data. The aerial team also surveyed the coastlines of Kauai, Ni'ihau, Lehua, and Kaula Islet on the day after the SCC. During the SCC (16-20 February), the survey aircraft flew elliptical, "race-track" shaped patterns in front of FFG A. The goal of this flight pattern is to visually cover an area extending from the shutdown zone 200 yds (182 m) in front of the ship out to 2500 yds (2273 m) and approximately 2 nautical miles (nm; 3.7 kilometers [km]) in width. The pilot manually flew this pattern and frequently had to adjust the pattern due to non-systematic and unpredictable changes in speed and headings of FFG A as it conducted training. This mode was to be maintained until a marine mammal/sea turtle sighting was made either by the aircraft or the shipboard MMOs, or until there was a potential conflict with naval airspace. In the event of a marine mammal/sea turtle sighting, the aircraft would cease the flight search pattern and begin circling the animal(s) sighted and initiate focal follow behavior mode.

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

Equipment List & Communications

The equipment used by the MMOs is included in Table 1. Communication between FFG A officers and MMOs was accomplished during meals in the wardroom, evening operational briefs, and on the ship's bridge as required. Additional equipment is recommended, as detailed in Section 0, Lessons Learned. A complete list of all recommended equipment for future MMO opportunities is provided in 0.

Table 1. Equipment Used During SCC

Equipment	Quantity	Location
Hand-held avionics VHF radio	1	**NAVFAC PAC Navy Technical Representative**
Hand-held marine VHF radio	3	• **SMMO on port wing** • **SMMO on starboard wing** • **LMMO on flying bridge**
Hand-held GPS	3	• **GARMIN etrex on flying bridge (16-20 Feb), then on port bridge wing (21-23 Feb)** • **GARMIN GPSmap 276C on starboard bridge wing** • **Trimble located on flying bridge (future use requires training and initial setup)**
Audio data recorders with timestamp	3	• **SMMO on port wing** • **SMMO on starboard wing** • **LMMO on flying bridge**
Binoculars (with reticle)	4	• **SMMO on port wing (Fujinon 7 X 50)** • **SMMO on starboard wing (Fujinon 7 X 50)** • **LMMO on flying bridge (Steiner 7 X 50)** • **DMMO on port wing (Steiner 7 X 50)**
Clipboards	3	• **SMMO on port wing** • **SMMO on starboard wing** • **LMMO on flying bridge**

Results

Shipboard Monitoring

Effort and environmental information was collected when the MMOs began effort, changed rotation, as weather changes occurred, and when the MMOs went off effort. The MMOs spent approximately 49.5 hours searching for marine species during the event (Table 2). Three people were vigilant during virtually all of the on effort hours; therefore this study comprised a total of just over 148 hours of marine species shipboard monitoring. During the days that the vessel was entering or exiting Pearl Harbor, less than two hours could be spent on effort. For all other days, at least 7.75 hours per day were spent on effort. Sea conditions were less conducive for obtaining sightings from 16-18 February, but they improved significantly after 18 February (Table 2).

Standards for reporting sun glare, wind direction, and swell direction had not been clearly determined before the cruise. These environmental variables were not collected in a consistent manner and therefore are not included in this report.

Table 2. Effort Hours and Environmental Conditions During the Study

Date	Hours of Effort	Time	Beaufort Sea State (range)	% Cloud Cover (range, conditions)
16 Feb	1 h 37 min	1653 – 1830	2 – 5	5 – 80, light rain
17 Feb	9 h 58 min	0712 – 1130, 1220 – 1732, 1805 – 1833	5 – 7	20 – 80
18 Feb	10 h 28 min	0705 – 1200, 1232 – 1730, 1815 – 1850	3 – 5	20 – 99, rain
19 Feb	10 h 38 min	0705 – 1201, 1236 – 1732, 1806 – 1852	1 – 3	10 – 60, light rain
20 Feb	7 h 51 min	0711 – 1148, 1500 – 1735, 1817 – 1856	1 – 4	3 – 30
21 Feb	7 h 45 min	0710 – 0754, 0817 – 0920, 1006 – 1107, 1144 – 1326, 1409 – 1450, 1512 – 1702, 1804 – 1848	0 – 3	5 – 40
22 Feb	1 h 5 min	0650 – 0755	2	8
Total	49 h 22 min		0 – 7	

Five marine mammal species were observed during the cruise; no sea turtles were observed (

Table 3Table 3). One dolphin species, *Stenella longirostris* or spinner dolphin, was seen as the vessel was leaving Pearl Harbor. The MMOs were not on effort at the time and were not able to record data on the sighting. Therefore, this sighting was not included in the total sightings count.

The MMOs recorded 18 independent sightings of marine mammals, that is, sightings not seen by the Navy lookout team (Table 3). Additionally, the Navy lookout team recorded 5 independent sightings, and 6 sightings were seen by both the MMOs and the Navy lookout team (Table 3). The aerial survey team alerted the MMOs to one pair of humpback whales before the MMOs could see it, which allowed the MMOs to set up a trial for the Navy lookout team as well as provided confirmed species identification. Three sightings were reported by the MMOs to the Officer of Deck, thus ending those sightings as trials.

Of the five species recorded, two were observed on the Barking Sands Underwater Range Expansion of the Pacific Missile Range Facility (PMRF): humpback whales (*Megaptera novaeangliae*) and striped dolphins (*Stenella coeruleoalba*) (**Figure**). An off effort sperm whale (*Physeter macrocephalus*) sighting occurred in the Kauai channel (between the islands of Kauai and Oahu) while the crew was evaluating the vessel's engines at full speed. A small pod (between four and eight individuals) of rough-toothed dolphin (*Steno bredanensis*) also was observed approximately 30 nm southwest of Oahu on the last full day at sea.

Table 3. Number of Sightings by Species

Species	Independent MMO Sightings	Independent Navy Lookout Team Sightings	Sightings by both Teams	Group Size (range)
Humpback whale (*Megaptera novaeangliae*)	5	2	4	1 – 2
Sperm whale (*Physeter macrocephalus*)	1	0	0	1
Striped dolphin (*Stenella coeruleoalba*)	1	0	1	20 – 25
Rough-toothed dolphin (*Steno bredanensis*)	1	0	0	4 – 8
Unidentified whale	10	3	1	1 – 3
Total	18	5	6	

The highest sightings rates occurred closer to Oahu (Table 4). The three sightings on 16 February occurred just after leaving Pearl Harbor, and the majority of sightings on 21 February were recorded between 1150 and 1430 when FFG A waited within a few nautical miles of Pearl Harbor for a rigid -hull inflatable boat to transport personnel to land.

Reviewing the data qualitatively, poor sighting conditions were correlated with low sightings. The two days with the worst sea states and weather conditions resulted in no sightings (Table 2, Table 4). When sightings were recorded, not all sightings resulted in trails due to the location of the sighting (behind beam). Overall, 41.4% of sightings resulted in trials, with a highest rate of setting up trials at 0.62 trials/hour (Table 4). The results of this study suggest that the rate of setting up trials is less than one trial/hour in February around Oahu and Kauai islands.

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

Date	Hours of Effort	# of Sightings*	Sightings/ Hour	# of Trials	Trials/ Hour
16 Feb	1 h 37 min	3	1.86	1	0.62
17 Feb	9 h 58 min	0	0	0	0
18 Feb	10 h 28 min	0	0	0	0
19 Feb	10 h 38 min	10	0.94	5	0.47
20 Feb	7 h 51 min	8	1.02	2	0.25
21 Feb	7 h 45 min	7	0.90	4	0.52
22 Feb	1 h 5 min	1	0.92	0	0
Total	49 h 22 min	29	0.81 (mean)	12	0.27 (mean)

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

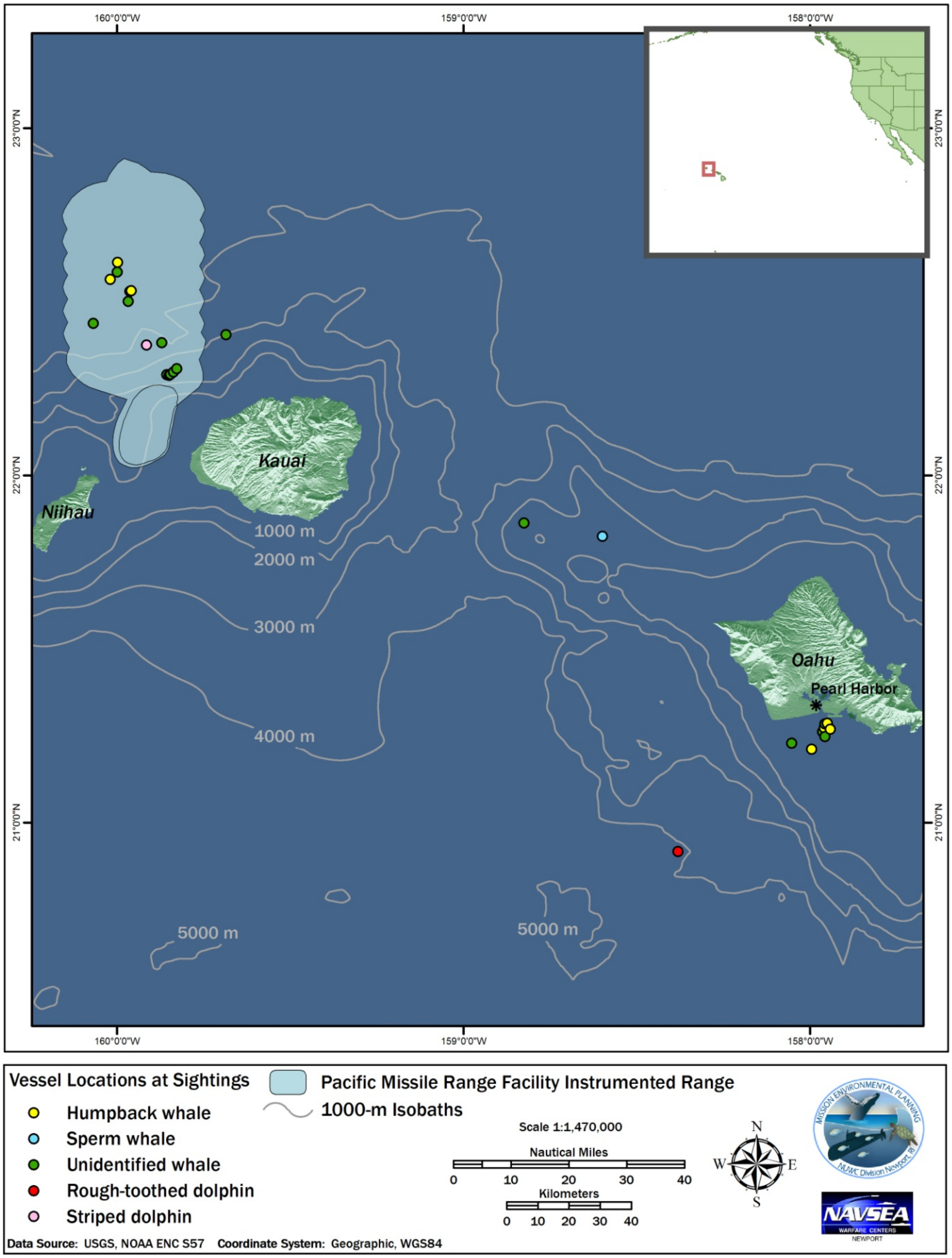

Figure 1. Vessel Locations at Marine Mammal Sightings

Aerial Monitoring

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

Conclusion

Marine Species Monitoring and Lookout Effectiveness

The goals of the SCC 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 survey protocol developed by the University of St. Andrews required changes once implementation was attempted. Data was able to be collected that will feed into a spreadsheet in order to begin determining the effectiveness of the Navy lookouts. The survey was successfully implemented.

   This event is the first in which data was 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 FFG A. This information can be used to determine, if MFAS was in use, to 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 FFG A 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.

Lessons Learned

Many lessons learned were noted for the SCC, and are separated into those for shipboard monitoring, aerial monitoring, and operational information below.

Shipboard Monitoring

- Each SMMO was originally responsible for recording his/her own data; however this resulted in missing and inconsistent reporting of data. Therefore, a DMMO is recommended during these surveys to record all effort and sightings data. This allows for consistency in the data collected, as well as ensures that important information is not accidentally omitted. Additionally, it allowed the SMMOs to focus on the sightings and obtain better resighting information. Furthermore, use of a computer program such as WinCruz would also assist in collection of data. Recommend attempting to test applicability for this protocol. This would allow the data recorder to maintain multiple sightings at one time, and would reduce after-survey effort in logging sightings information. It also would allow MMOs to obtain a new bearing to sightings while the vessel was turning. However, maintaining a backup of the information on sightings forms is also recommended.

- Determining the bearing to the animal proved difficult in many circumstances. In order to obtain the bearing, the MMOs would need to reposition themselves behind either the bigeyes or theodolite. It is recommended that future surveys provide a 360° angleboard located at the MMOs position to more effectively determine bearing and eliminate confusion between port and starboard. Additionally, this would also reduce cueing the Navy lookout team that a sighting by the MMOs has occurred.

- The MMOs used hand-held VHF radios to relay sightings information. However, it also occasionally resulted in the bridge or forward lookout hearing the transmission, therefore cueing them of the sighting. Headsets that can be attached to the radios are recommended for future surveys so as to reduce cueing the Navy lookout team.

- Attending daily ship operations brief while at sea is highly recommended. It facilitates communication between the ship's officers and the MMOs and keeps the MMOs current on the daily operations of the ship.

- On the FFG, the MMOs could not see ship's display monitors that provided the ship location, as available on other vessels. Use of a portable GPS allowed for easier access to ship's locations, without needing to enter the bridge. Using a GPS that allows for marking waypoints is recommended, as a waypoint can be marked as soon as a sighting has occurred. Using the DMMO's GPS also reduces cuing of the Navy lookout team.

- MMOs used small audio recorders to note information on sightings. However, using the recorders relied on the SMMO remembering all data fields required. Use of the recorders as a backup for collecting data is recommended, but not for a primary means of data collection.

- The survey protocol developed by University of St. Andrews recommended the use of two-letter codes for the sighting cue, behavior, and the end of the track. However, the MMOs decided that remembering the cues would be more cumbersome than simply writing what the cue was. Using the codes should not be required during the survey. Codes can be applied afterwards during data consolidation.

- There are potentially two sources of distance and bearing estimates for a sighting: the Navy lookout team's estimate and the MMO's estimate. Sightings reported by the MMO need to clearly state the sources of the estimate. Distances and bearings reported by the Navy lookout team as well as reticle distances and bearings measured by the MMOs should be reported for comparison. The sightings form should accommodate separate estimation of distance and bearing for the same sighting.

- Data was not entered into spreadsheet format nightly, resulting in increased post-event workload. Ideally, entering the data nightly would reduce workload and allow for potential problems to be rectified. However, the MMOs were quite often exhausted when data entry would have been possible (i.e. at night). This could have resulted in mistakes in data entry. If data is entered on the ship, recommend verifying the accuracy of the data post-event.

- MMOs tried a number of permutations using GPS units available. If allowed, two separate GPS units taking data is recommended. One recording the ship track, the other logging specific waypoints when marine species are observed. If the tracking unit is not able to display heading and speed, a third unit would be useful to display that information for the DMMO to note pertinent information on the sightings and effort forms.

- SMMO sightings were not always immediately reported to the DMMO, resulting in the DMMO logging the waypoint inconsistent with the time of sighting. SMMO sightings need to be reported to the DMMO immediately so that the DMMO can log location and time. One central clock should remain with the DMMO as the accepted time marker for data points.

- Communications between the MMOs need to be strictly defined and adhered to. When MMOs reported to the DMMO, the communication was not standard, leading to confusion and inefficiencies. It is recommended that the MMOs adhere to specific words such as "Starboard sighting" to cue the DMMO to note the time of the sighting and location of the ship. This allows the DMMO to easily record these data fields while potentially de-conflicting sighting data reported from multiple MMOs.

- SMMOs did not always clearly indicated when a trial initiated, creating confusion on who should note the trial. The SMMOs should clearly indicate when a trial is started. If the Navy lookout team is inadvertently cued, the SMMO should immediately notify the DMMO, so that the sighting is no longer a trial.

- MMOs attempted to stagger off effort during meal hours. However, the time allotted for meals is limited (one hour), and it was not possible to rotate MMOs. It is recommended that the MMOs go off effort and take meal breaks as a team. Taking a break as a DMMO also was a suitable rest period for MMOs. Ideally, a fifth MMO would allow for an actual break for each MMO during the day.

- Prior to embarkation, it is recommended that the MMOs conduct an equipment check to ensure they are set up properly, run through the protocol, and make sure assignments are understood before getting underway. The MMOs need to be prepared to be on effort immediately once the ship leaves port, as many species occur near the coast.

Aerial Monitoring

- It was extremely helpful to have a contracted aerial survey team present and available for communication during the event. This allowed for the aerial team to notify the MMOs of potential trials, as well as allowing the MMOs to request focal follows when the aerial team was arriving on range.

Operational Information

- On FFG A, the Navy lookouts were stationed in the pilot house and/or on the flying bridge. This allowed the SMMOs to record sighting information without cueing the Navy lookout team. However, other vessels maintain lookouts on the bridge wings, and therefore the protocol will need to be modified to accommodate this difference.

- Although the MMOs provided presentations at the pre-sail, to OPS prior to the event, and to the CO, XO and OPS on the transit day, relevant information about the study goals and affiliations of the MMOs were communicated down through the officer ranks. Many of the officers continued to be leery of MMO presence, as assumptions were made that the MMOs were environmental activists and not trying to help the Navy maintain MMPA compliance. Once the officers realized that the MMOs are working for the Navy, they felt more comfortable with MMO presence on their ship. It is highly recommended that the MMOs brief both senior and junior officers of the purpose of the survey prior to embarkation (e.g. during a meal in port) and that the MMOs are Navy civilians. Future efforts using contractors could be challenging, therefore, it is recommended that contractors are phased in over time, with at least one Navy biologist on board as the primary point of contact.

- The forward Navy lookouts were also frequently unaware of the MMO's purpose. It is recommended that a standardized brief is provided to the lookouts stating the purpose of the MMOs and what information should be provided to the LMMO.

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ENCLOSURE 1 - Lookout Effectiveness Survey ProtocoL

Calibrating US Navy lookout observer effectiveness

Information for Marine Mammal Observers

Version 1.0

ML BURT, L THOMAS and OTHERS

CONTENTS

1 INTRODUCTION

1.1 Aim of the project

The US Navy use lookouts (LO) to detect anything in the water, including marine mammals. Depending on the nature of the activity the vessel is engaged in, action may need to be taken if the animal is within certain ranges of the vessel. Therefore, it is important to be able to detect all animals that come within these ranges and also determine how far away the animals are with accuracy. Lookouts are positioned so that the waters all around the vessel can be searched. As well as dedicated lookouts, officers on the bridge may also be searching and acousticians may also be listening for vocalizations (although we assume that visual confirmation is required before the encounter is classed as a detection). We refer to all of these observers together as the "observation team" (OT). The aim of this project is to calibrate 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 sighted 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 marine mammal observers (MMO) are required to be searching and collecting information on marine mammals that both they and the LO detect.

Data will be collected to help quantify the effectiveness of the OT during Navy exercises in February 2010 using the protocol detailed in this manual. The protocol will then be revised, for use in a second exercise to take place later in 2010. Further iterations are expected thereafter.

1.2 Overview of analysis methods

Three statistical models are required to estimate the probability of an animal getting within a defined stand-off range without being detected by the OT: (1) a model of the probability that an animal, or group of animals, at the surface is detected by the OT as a function of the animal's position relative to the vessel; (2) a model of surfacing behavior of the animal/group; and (3) a model of animal/group movement. The data collected during the survey described here will be used to parameterize the first model. The latter two models will be parameterized from literature sources. To obtain parameters for the first model, the data required will be information on every surfacing of an animal (or group) detected by the MMOs and whether, or not, the OT saw it.

Since the action taken by the vessel once a sighting has been made depends on the distance recorded by the OT, and to some extent the species, we will also make an assessment of the accuracy of distance and species (or species group) determination – although the only data we have to compare this with are the distances and species recorded by MMOs, which may also not be error free. Therefore, while we can estimate the magnitude of the differences between OT and MMO distances and species determinations, we cannot make statements about absolute accuracy of either.

1.3 Overview of survey methods

In order to obtain a realistic probability of detection of every surfacing for the OT, it is important that the OT search as usual. However, some additional information from the OT will be required: namely, information on every surfacing. Since this is not typically recorded, and we do not wish to interfere with the normal operation of the OT, we designate one of the MMOs to ensuring that this information is obtained (as detailed below). This MMO will be called the liaison MMO (LMMO) since they need to liaise with the OT. The other MMOs also search and record every surfacing, in such a way that the OT do not know what they are doing. To distinguish them from the LMMO, we refer to them as surveying MMOs (SMMOs).

With the SMMOs searching and recording every surfacing, a combination of line transect distance sampling (DS) and mark-recapture (MR) methods can be used to estimate the required probability of detection for each surfacing. These methods are frequently used in surveys of marine mammal surveys, but generally without the complication of recording each surfacing. The idea is that when the SMMOs detect an animal surfacing, they are setting up a “trial” for the OT, which can either result in the OT detecting that surfacing or not. The model assumes that probability of detection is a function of distance (both ahead and abeam of the ship), whether that group was sighted by the OT before and potentially other variables. Animals (or groups) that are more-or-less continually at the surface (such as large groups of dolphins) can be analyzed in a similar framework, but here the probability of detection is modelled as a continuous hazard rather than only when discrete surfacing occurs. The data required for continuously available animals is: when and where the SMMOs first detected them, regular updates on position, when and where the OT first detected them (if they did), when and where the OT lost contact with them and when and where the SMMOs lost contact with them.

The primary members of the OT are the dedicated LOs; however there are also observers on the bridge and possibly an acoustic ‘observer’, although the search effort for these observers will be variable depending on their other duties. Nevertheless, sightings information from these observers will also be required. We plan that the LMMO will be stationed next to the LO; hence it is important that other members of the OT communicate their detections to the LO so that the LMMO can record them. If this does not happen, it may be necessary to station an additional LMMO on the bridge, so they can record detections made by the bridge observers.

A key element of this method is that the OT must search as usual and search independently from the SMMOs. If the LO or other observers are aware of sightings made by the SMMOs, the premise of the analysis will break down.

Another key element is that the SMMOs must be able to determine if a detection of a surfacing they have made has been detected by the OT or not (i.e. was the trial a "success" or "failure"). The LMMO is responsible for communicating all OT detections to the SMMOs, who can then judge if this corresponds with to a detection they have made. Also, information about the timing and location of detections will be recorded (by the LMMO for OT detections and by the SMMO for SMMO detections) so that determination of which are duplicates can be refined offline, after the survey.

In addition to the detection probability information, SMMO observers will also provide information on species and group size with which to calibrate the OT.

The most important surfacings are those made before the OT detects the animals, and the first surfacing detected by the OT. Thereafter, repeat detections of the same animal/group by the OT are useful information for refining the detection function shape, and for gleaning information about surfacing rates, but do not bear directly on the main question we wish to answer. Hence, most effort by the SMMOs should go into detecting marine mammals before the OT has seen them, and determining whether each of these surfacings is detected by the OT. Once a group has been detected, the SMMOs should feel free to concentrate on searching for new animals/groups, unless tracking of already detected groups is straightforward. One of the two SMMOs should be searching for new groups, especially if the other SMMO is following a group. The SMMOs are encouraged to search with binoculars or big eye binoculars as much as possible.

1.4 Overview of the manual

This manual describes the survey protocol and sighting procedures of the various observers and details the data to be collected. It should be borne in mind that the protocol may need to be adapted if procedures are found to be infeasible.

2 SURVEY PROCEDURE

2.1 Search platforms

2.1.1 Frigate

The platforms available for observation on a frigate are the bridge, bridge wings (with Big Eyes installed), the upper bridge and the fantail (stern of the ship).

2.2 Observer configuration

2.2.1 OT

Dedicated LOs are positioned on the upper bridge and fantail with additional observers operating opportunistically on the bridge. An acoustic observer may also be available. We assume that the upper bridge LO will be the one primarily making confirmed sightings, and that all sightings by other members of the OT will be reported to them. Officers on the bridge or in combat are responsible for entering marine mammal records into a log (Appendix B); this log will not be used in the current survey as it is not detailed enough for our purposes – instead the LMMO will keep detailed records (see below). All OT personnel should search independently of the SMMOs.

2.2.2 MMO

Three MMO are required; two on the bridge wings who are actively searching (SMMOs) and one with the navy LO on the upper bridge (the LMMO). The primary purpose of the MMO on the upper bridge is to record all detections and surfacings detected by the OT. The MMO should all be in contact with each other and also be aware of any sightings made by the OT.

It is anticipated that the MMOs will rotate positions, for example, port SMMO, starboard SMMO, LMMO, resting. If it is feasible, the fourth MMO could be stationed in the bridge in order to ensure that all bridge sightings are recorded.

It is also conceivable that the LMMO may sometimes be able to operate as an additional search platform, aiding the SMMOs, if they are able to stand behind the LO and hence not cue them with their sightings. This is something that will need to be determined on board the vessel.

Lastly, it may be useful to have a fourth MMO on duty, aiding the SMMOs as a data recorder. It is our hope that the SMMOs will be able to use audio recording devices to record data, rather than having to look down and record data on paper. Looking down greatly increases the chance of losing a tracked animal, missing sightings, etc. However, should it not be possible to obtain an audio recording device, or should its use not be feasible, then having a fourth MMO to transcribe SMMO data would be very valuable.

2.3 OT procedure

It is important that the OT search as usual and independently of the MMO. Having detected a marine mammal, the LO should report each surfacing of the group they detect to the LMMO. The LMMO will be positioned on the upper bridge will record this information. However, the LO should not alter their usual search behaviour in order to better detect repeat surfacings – they should carry on with whatever search behaviour they would use if the MMOs were not present.

If the bridge, or other member of the OT, detect an animal, they should inform the LO. This will both inform the LMMO who can record the information and allow the LO to track each surfacing. It is not necessary for the bridge or other observers to inform the LO of each surfacing they detect after the first one, if it is obvious it is of the same group, unless this is their normal procedure. As stated earlier, we are not focussed on repeat surfacings.

It is our understanding that LOs have access to a compass and this should be used to determine the angle from the trackline to the sighting if this is their usual method. Distances are estimated by eye.

2.4 SMMO procedure

The main functions of the SMMO are to detect and track marine mammals and determine whether sightings made by the OT and reported to them by the LMMO are duplicates with sightings they have made. The SMMOs should search from the vessel to the horizon using binoculars concentrating forward of the vessel to abeam. The search pattern is:

- Port observer: searches on the port side of the vessel from about 5^o starboard to abeam.
- Starboard observer: searches on the starboard side from about 5^o port to abeam.

On detecting an animal, they should attempt to record each surfacing until the animal goes abeam. Tracking an animal has three uses: it helps to identify any animals subsequently seen by the OT; species and group size can be more accurate (because animals and groups are seen more than once) and information on surfacing behaviour is required for the analyses. The MMOs will need to be in contact with each other and thus be aware of any sightings made by the OT which will help with duplicate identification; duplicate sightings are animals seen first by the SMMO and then by the OT (as reported by the LO via the LMMO).

If the OT detect an animal prior to the SMMO, then the SMMO should attempt to locate it to determine species and group size and then continue to track and record each surfacing (but see section 3.4, below). If the OT sighting occurs during SMMO tracking, the SMMO should continue to track the animal until it is lost, or goes abeam, and then attempt to locate the sighting made by the OT.

SMMO should primarily concentrate their search effort forward of abeam but if substantial numbers of animals approach the vessel from behind abeam (i.e. dolphins that can swim faster than the vessel) then it may be necessary to search behind abeam.

Angleboards should ideally be used to measure bearings to sightings relative to the ship and the binoculars should have reticles for use in calculating distances.

Each SMMO should record information into an audio recording device for later transcription on to a SMMO sighting form; alternatively a fourth MMO may be available to do real-time data transcription. Effort information should be recorded on an MMO effort form.

The SMMOs assess the duplicate status of each surfacing.

If there are too many animals in view for an SMMO to keep track of, the SMMO should choose a small number of trials (one or two) that they can track accurately and follow them until it is clear the OT has duplicated that target or the track ends.

2.5 LMMO

The primary function of the LMMO is to record information (section 4) on the first sightings of all the OT. Information on all subsequent sightings should also be recorded if possible. The LMMO will pass the information of sightings to the SMMOs as soon as possible to determine if the OT has duplicated as sighting made by the SMMOs. In some cases this will inform the SMMOs of animals not yet detected. The LMMO can also actively search for animals and inform the SMMOs of any sightings they make (so the SMMOs can use them to set up trials), as long as this does not cue the LO or compromise data recording.

3 SIGHTING PROTOCOL

This section relates to the procedure to be followed on detecting a marine mammal.

3.1 LO

On sighting a marine mammal, the LO should inform the LMMO giving all required information (see section 4) but in particular time of sighting, species, sighting angle, sighting distance and group size. The LO should also give the information for any subsequent sightings of the same group to the LMMO.

3.2 Bridge (or other OT member)

On sighting, or detecting, a marine mammal, the bridge should inform the LMMO – this may be via the LO if LMMO is not in direct contact with the bridge. Subsequent sightings of the same should also be passed to the LO, although it seems likely in practice that the primary responsibility for tracking already sighted groups within the OT will fall upon the LO.

3.3 SMMO

On sighting a marine mammal, the SMMO should

1. Collect and record the following information: time of sighting, species, sighting angle, sighting distance and group size. Other information (such as cue or behaviour) should be collected if there is time.

2. Attempt to track the animal, recording information on all subsequent sightings.

3. Assess duplicate status, maybe in consultation with the LMMO.

4. Inform the bridge of any animal within the operational standoff range of the vessel if active sonar operations are taking place.

3.4 Tracking priority

The first priority for SMMOs is to find and track animals before the OT see them, to set up trials for the OT. When the OT report a sighting (via the LMMO) of a new group they should determine whether it is a duplicate or not (i.e. something they were tracking already). A secondary priority is to track groups already seen by the OT, to determine resighting rates. With this in mind, the procedure for SMMOs on detecting an animal is as follows:

- On locating an animal, or group, attempt to track until the animal is lost or is a long way behind and unlikely to approach the vessel.
- If the OT detect an animal while both SMMOs are searching (i.e. not tracking anything), one SMMO should attempt to locate the OT sighting (to confirm species and group size) and continue to track it and record each surfacing. This will be necessary to determine how many surfacings the OT detect. The other SMMO should continue to search as setting up new trials is more important.
- If the OT detect an animal while one SMMO is engaged in tracking, that SMMO should determine whether the OT sighting is a duplicate or not. If it is, the SMMO should continue tracking the group while the other SMMO searches for new groups. If it is not, the SMMO should continue tracking their group, while the other SMMO attempts to track the group seen by the OT, if possible. If this is not possible, the other SMMO should revert to searching for new groups to track.
- If the OT detect an animal while both SMMOs are engaged in tracking, the SMMOs should continue determine if the OT sighting is a duplicate or not. In either case, they should continue tracking their groups until the track is finished or the group is sighted by the OT.

3.5 Group size definition

In the case of aggregated groups, the angle and distance measurement should be estimated to the geometric centre of the aggregation. A group can be thought of as the smallest unit that can be tracked as a unit. A convenient rule is, for example, to define a group as containing animals not more than 3 animal lengths from each other (this may depend on species). The group may exhibit the same swimming pattern and general behaviour although not necessarily with a synchronised surfacing pattern.

Difficulties may arise when animals are not in tight, easily defined clusters, but in loose aggregations whose boundaries and group size must be determined subjectively. In this case, it is better to identify smaller, homogenous groups within the aggregation, and associate each with an angle, distance and group size.

Problems can also arise when a group is formed of animals swimming in a long line at relatively equal distances from each other (e.g. pilot whales). In this case, group boundaries can be taken at convenient discontinuities in the distribution.

Large groups of dolphins may comprise of several hundreds of animals. Often these groups are compact and form a single unit. Sometimes subgroups may form but may only last for a short time with frequent interchange of animals between groups. In this case, it is better to treat the whole group as a single unit. As these groups will have a continuous cue, it is not necessary to make continuous resightings, but only at appropriate intervals, say 5 minutes or perhaps more frequently close to the vessel.

If relatively stable subgroups can be identified, then the details for the first subgroup sighted should be recorded and then this subgroup should be followed. Include a comment that it is part of a larger aggregation, and if possible, how many other subgroups there are in the aggregation and group sizes. A duplicate sighting would occur if the OT detects the subgroup being tracked.

If a groups splits while being tracked, then one subgroup should be tracked. The groups sizes recorded should reflect that the group has split and is now smaller than the original sighting. The fact that the group has split should be recorded in the data. When tracking of the subgroup has finished, the SMMO should then try to relocate one of the other subgroups and track it.

3.6 Surfacing and availability

A surfacing is defined as any opportunity that an animal is available to be detected visually. This could be when the animals are at the surface or even below the surface if the water is clear enough.

Some animals may be intermittently available, for example if they are at the surface for a short time and then dive and then return to the surface. Others might be continuously available, for example large groups of dolphin schools which surface asynchronously. As ever, it is important to record the first sighting of these and as discussed in section 3.5, record the final sighting and, if feasible, at appropriate intervals such as every 5 minutes.

Some animals may provide both intermittent and continuous cues (i.e. a blow but then stays close to the surface and if the water is clear enough can still be seen). In this case, treat each discrete surfacing (ie. fluke, blow, body) as a resurfacing but include a comment that the animal is continuously available.

4 DATA COLLECTION

It is anticipated that data will be recorded onto audio recorders or paper forms and transcribed at the end of each day. The information collected by the OT is recorded by the LMMO onto a sightings form. Sightings by the SMMOs are recorded or transcribed onto a MMO sighting form. Forms for search effort and weather and other basic information are also provided. Note the form number and total number of forms (at the top of the paper form) is used to prevent forms being lost.

4.1 Sightings form

This form should be used to record all sighting information. All information is required upon initial sighting. Information needed for each resurfacing is indicated in bold.

FIELD	DESCRIPTION
SIGHTING #	**This is the number of each sighting and should be sequential.**
RESIGHTING #	**The number of times the object has been resighted. The initial sighting will have a resighting number of zero and subsequent resightings will be 1, 2, etc. Each resighting starts a new column on the sighting report form.**
RESIGHTING. STATUS	**D definite resightings (at least 90% likely to be the same animal or group) P possible resighting (more than 50% likely) R remote resighting (less than 50% likely)**
TIME	**Time of sighting.**
SPECIES CODE	**The five letter code used to identify the species. Refer to section 4.4. If a species is not listed, then include this information in the 'Comment' for the record.**
DURATION (if cue continuous)	**If the cue is continuous, then indicate the length of time, you were observing this sighting.**
ANIMAL (A) bearing	**Estimated angle of the bow of the ship to the sighting. A sighting dead ahead is 0^o and angles go from $0\text{-}360^o$.**
SIGHTING DISTANCE	**Estimate of sighting distance in metres?**
GROUP SIZE	**Give the best estimate of group size, including calves. In mixed schools enter the number of each species.**
DUPLICATE SIGHT #	**Duplicate sighting number. This allows duplicate sightings to be cross-referenced.**
DUPLICATE TRIAL	**Indicate if this is a valid duplicate: Yes – sighting seen first by MMO No – sighting seen first by OT**
DUPLICATE STATUS	**Duplicate status of a sighting: D – definite duplicate (at least 90% likely to be the same animal) P – possible duplicate (more than 50% likely) R – remote change of being a duplicate (less than 50% likely)**
SHIP LATITUDE	
SHIP LONGITUDE	
SHIP (S) BEARING	

FIELD	DESCRIPTION
RELATIVE MOTION A/S & A'S BEARING	Indicates of the animal is opening away from the ship, closing towards the ship, or moving parallel to the ship's track. The heading of the animal relative to the ship should be recorded relative to the line of sight where 0° indicates the animal is heading directly away, 90° indicates the animal is heading from left to right, 180° - directly towards the ship, 270° - heading right to left.
DETECTION SENSOR	Observer who made the sighting: MMO + observer code LO Bridge Acoustic
NUMBER OF CALVES	Enter the number of calves in a group.
SIGHTING CUE	Indicator of cue which led to the sighting: BL - blow BW – bowride BY - body DV - dive FL – fluke up GL – glint of sunlight off body HS – head slap JU - jump /breach/spin PA – peduncle arch PP – porpoise PS – pectoral fin slap SL- slick, footprint or ring SN – spin SP - splash TS – tail slap WL – seabirds or other associated wildlife OT – other
BEHAVIOUR	BR – Breaching BW – Bow riding FD – Feeding FL - Fluking FS – Flipper slapping ML – Milling LO – Logging RE – Resting TR – Travelling TS – Tail slap VO - Vocalizing
END OF TRACK	Reason for stopping a track. BE - sighting behind the beam LO - sighting lost OB - sighting obscured NC - no change of the sighting with respect to the boat (this may happen if the sighting is far away) MA - sighting passed to other LO to follow OT – other
OPERATIONS INFORMATION	Were any mitigation measures implemented?
COMMENT	Any additional information.

4.1.1 Sighting number/Duplicate sighting number

The duplicate sighting number on the sightings form is the number given to the surfacing by the LMMO, and called down to the SMMOs. If the SMMOs think this is the same as a surfacing they sighted, they give write down the LMMOs sighting number under "DUPLICATE SIGHT #" on the form. Two types of duplicate sighting can be distinguished: those that represent valid trials for estimating the OT detection function and those that do not. Valid trials are where the SMMO saw the surfacing independently (for example because they were tracking the group) and then the LMMO radios down to inform the SMMO that a surfacing has been seen by the OT, and the SMMO determines it's the same as the one they just saw. In this scenario, "Yes" should be entered under "DUPLICATE TRIAL". By contrast, trials do not occur when the LMMO alerts the SMMOs to a surfacing that the OT have seen but the SMMOs had not previously seen, and then the SMMOs see the surfacing and record information on it. In this case, although it's a duplicate (because both OT and SMMO saw the surfacing), it is not a valid trial as the OT saw it first directed the SMMO to see it. Hence "No" should be entered under "DUPLICATE TRIAL".

This duplicate information should be recorded by the SMMO since they are making any duplicate assessment. It is not necessary for the LMMO to fill in this information. The LMMO just need to pass sighting numbers of OT sightings to the SMMO so that the SMMO can fill in the duplicate information on their forms.

4.1.2 Multi species sighting

When recording groups of mixed species, record the information on separate lines but assign the same sighting number.

4.1.3 High density regions

It is anticipated that in the region chosen for the survey, animal density will be low. However, if the density of animals is high, so that the assessment of duplicate status becomes difficult, then indicate this on the effort form (see section 4.2). Cross-referencing of duplicates may need to be reconsidered. If density of animals is high (i.e. detections occur more than once every few minutes), then the timing of sightings becomes critical.

4.2 MMO Effort/weather form

This form should be completed by the LMMO everytime an 'event' occurs, for example at the start/end of search effort, observer rotation, changes in the weather. If the density of animals is too high to make it difficult to assess duplicate status, then indicate this in the 'Event' field. Sometimes the weather will be too bad for searching, in which there will be no search effort.

FIELD	DESCRIPTION
EFFORT	Whether search effort is ON or OFF.
EVENT	Record the event: 1 – begin search effort 2 – stop search effort 3 – observer rotation 4 – weather change 5 – transect waypoint 6 – high animal density 7 – back to normal animal density 8 – end of day
TIME	Time of event
LATITUDE	
LONGITUDE	
Port MMO	MMO who is searching on port side of vessel.
Starboard MMO	MMO who is searching on starboard of vessel.
LMMO	MMO who is acting as liaison MMO.
SEA STATE	Beaufort Sea state on a scale of 0-7.
SONAR	Is sonar On or Off?
EXPLOSIVES	Are explosives in use: Yes or No.
VISIBILITY	General impression for spotting marine animals: B – Bad (<0.5km) P – Poor (0.5 – 1.5km) M – Moderate (1.5 – 10km) G – Good (10 - 15km) E – Excellent (<15km)
WAVE HEIGHT	Light (0 – 3ft) Moderate (4 – 6ft) Heavy (>6ft)
SWELL DIRECTION	
WIND DIRECTION	
WIND SPEED	
% GLARE	
% CLOUD COVER	

4.3 MMO Observer code form

This should be completed at the start of the survey and the observer codes decided. The heights are needed if reticle readings have to be converted to distances.

FIELD	DESCRIPTION
CODE	Two letter code for each observer.
NAME OF OBSERVER	Name of the observer
EYE HEIGHT	Eye height (in feet) of the observer (to be used for converting reticle estimates to distances).
PLATFORM HEIGHT	Height of SMMO platform (in feet) above sea level.

4.4 Table of species codes

CODE	COMMON NAME	SCIENTIFIC NAME
BALMU	Blue whale	*Balaenoptera musculus*
BALPH	Fin whale	*Balaenoptera physalus*
MEGNO	Humpback whale	*Megaptera novaeangliae*
BALAC	Minke whale	*Balaenoptera acutorostrata*
BALED	Bryde's whale	*Balaenoptera edeni*
BALBO	Sei whale	*Balaenoptera borealis*
BALMU	Blue whale	*Balaenoptera musculus*
BAL--	Unidentified rorqual	Balaenopteridae
WHALE	Unidentified whale	
ZIP--	Unidentified beaked whales	Ziphiid
MES--	Unidentified *Mesoplodon*	*Mesoplodon* spp.
MESDE	Blainville's beaked whale	*Mesoplodon densirostris*
ZIPCA	Cuvier's beaked whale	*Ziphius cavirostris*
INDPA	Longman's beaked whale	*Indopacetus pacificus*
PHYMA	Sperm whale	*Physeter macrocephalus*
KOGBR	Pygmy sperm whale	*Kogia breviceps*
KOGSI	Dwarf sperm whale	*Kogia simus*
KOG--	Unidentified pygmy/dwarf sperm whale	*Kogia* spp.
ORCOR	Killer whale	*Orcinus orca*
PSECR	False killer whale	*Pseudorca crassidens*
FERAT	Pygmy killer whale	*Feresa attenuata*
PEPEL	Melon-headed whale	*Peponocephala electra*
GLOMA	Short-finned pilot whale	*Globicephala macrorhynchus*
TURTR	Bottlenose dolphin	*Tursiops truncatus*
STEAT	Pantropical spotted dolphin	*Stenella attenuata*
GRAGR	Risso's dolphin	*Grampus griseus*
STELO	Spinner dolphin	*Stenella longirostris*
STECO	Striped dolphin	*Stenella coeruleoalba*
STEBR	Rough-toothed dolphin	*Steno bredanensis*
LAGHO	Fraser's dolphin	*Lagenodelphis hosei*
DOLPH	Unidentified dolphin	
CET--	Unidentified cetacean	
CHEMY	Green turtle	*Chelonia mydas*
EREIM	Hawksbill turtle	*Eretmochelys imbricata*
DERCO	Leatherback turtle	*Dermochelys coriacea*
CARCA	Loggerhead turtle	*Caretta caretta*
LEPOL	Olive ridley turtle	*Lepidochelys olivacea*
TURTL	Unidentified turtle	
MONSC	Hawaiian monk seal	*Monachus schauinslandi*

5 OTHER ACTIVITIES

5.1 Final cruise report

At the end of the cruise a brief report which contains a general evaluation of the survey (i.e. suitability of vessel, platform locations, search procedure, sighting protocol, equipment, general operation etc.) would be helpful. Perhaps include a summary of the survey data collected (number of miles/km searched, number of sightings of each species) and any problems that have occurred, any adaptations to the protocol that may have been implemented or if any new species codes have been added. This information will be useful to refine survey methods for the next survey and in the analysis of the data.

5.2 And finally!

Have a good time and enjoy the survey! Don't forget you can contact the St Andrews team at any time (time difference allowing).

EQUIPMENT LIST

LO Equipment

Each LO should have the following equipment, which are all provided:

- Compass for measuring sighting angle
- 7x50? binoculars for searching
- Big Eyes for group size
- Headsets or other means of communicating with bridge

MMO Equipment

Each MMO should have the following equipment:

- 7x50? Binoculars with reticles
- Compass (provided on platform)
- GPS or synchronised digital watch
- Radios (handheld or headsets to communicate with other MMO)
- Clipboard
- Pencils
- MMO sighting forms
- MMO effort/weather forms (LMMO only)
- Equipment to communicate with bridge
- Crib sheet for converting reticles to distances?
- Crib sheet of species codes
- Audio recording device, if possible, for recording sightings without needing to look down to paper survey form. Automatic time stamp, if possible.

LO DATA – DAILY MARINE MAMMAL LOG

The following table describes the data recorded in the LO 'Daily marine mammal log'.

FIELD	DESCRIPTION
A. DTG	Date and time of sighting DDHHMM Z MMM YY
B. Species/Type of mammal	Types are Whale/Dolphin/Porpoise/Seal/Sea lion/Turtle/Generic (i.e. unknown)
C. Number of mammals	Number
D. Calves	Yes/No
E. Initial detection source	Visual/Aural
F. Initial bearing/range	Bearing in degrees (true)/ Range in yards
G. Unit position	Latitude DDMMSS N/S and Longitude DDDMMSS E/W
H. Unit course/speed	Course in degrees (true)/ Speed in knots
I. Last known bearing/range	Bearing in degrees (true)/ Range in yards
J. Total time visually observed	Time in minutes
K. Wave height	Wave height in feet
L. Visibility	Visibility in nautical miles
M. MFAS status	No/Yes or On/Off
N. MFAS action taken	Powerdown -6dB/Powerdown -10dB/Shutdown/None
The following fields are completed if MFAS was transmitting when a mammal was sighted and subsequently powered down/shut down, or course changed.	
O. Duration of action	Minutes
P. Maneuver conducted	Turn STBD/Turn PORT
Q. Degrees of course change	Degrees
R. Range action taken	Range in yards
S. Action impact	Tactical degradation assessment – examples: None Slight - degraded ASW screen integrity when ship manoeuvred to open whales Moderate – lost contract when power reduced Significant – engagement interrupted when MFAS as shutdown
T. Narrative of observation	Examples: Dolphins sighted at 1200yds off port bow, closing on ship. Manoeuvred to confirm bow riding and continued MFAS operations.

RECOMMENDED EQUIPMENT LIST FOR MMO SHIPBOARD SURVEYS

Equipment	Quantity	Location
Hand-held marine VHF radio	3	• SMMO on port wing • SMMO on starboard wing • LMMO
Hand-held GPS	3	• SMMO on port wing • SMMO on starboard wing • DMMO • Recommend GPS unit used be consistent; still determining best-suited GPS available
Audio data recorders with timestamp	3	• SMMO on port wing • SMMO on starboard wing • LMMO
Binoculars (with reticle)	4	• SMMO on port wing • SMMO on starboard wing • LMMO • DMMO Recommend all binoculars be Fujinon 7 X 50 for consistency.
Digital watch with seconds showing	4	• SMMO on port wing • SMMO on starboard wing • LMMO • DMMO
Angle board	3	• SMMO on port wing • SMMO on starboard wing • LMMO
Camera	2	• SMMO on port wing • SMMO on starboard wing
Clipboards	4	• SMMO on port wing • SMMO on starboard wing • LMMO • DMMO
Pelican case/drybag	Ship dependent	One container at each MMO location is necessary. Depending on the type of vessel, the number of containers/bags needed may vary. • FFG: 3, one each for starboard bridge wing, port bridge wing, and flying bridge • DDG: 2 • CG: 2
Misc. Supplies: zip ties, duct tape, electrical tape, rubber bands		

APPENDIX D Marine Mammal Monitoring Submarine Commanders Course 09-3 Hawaii Range Complex: Cruise Report

Prepared for the US Pacific Fleet

Prepared by Amy Farak and Tom Vars, Naval Undersea Warfare Center Division, Newport, Rhode Island

SECTION 1: Introduction

In order to train with mid-frequency active sonar (MFAS), the Navy has obtained a permit from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act and Endangered Species Act. The Hawaii Range Complex (HRC) Monitoring Plan, finalized in December 2008 for implementation 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 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?

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

As part of this data collection effort, two U.S. Navy MMOs (Ms. Amy Farak and Mr. Tom Vars) participated in the 2009-3 Submarine Commanders Course (SCC) on August 27-29, 2009. These MMOs were stationed aboard the USS LAKE ERIE (CG 70). The primary goals of the SCC 09-3 monitoring effort were to:

1. Coordinate transit to the Pacific Missile Range Facility (PMRF) to allow LAKE ERIE and the survey aircraft opportunity to test communications and to familiarize the ship to the survey aircraft transect profiles;

2. Collect data on marine mammals observed during operations;
   a. Are marine mammals and sea turtles exposed to MFAS
   b. If so, at what levels
   c. Did exposed marine mammals/sea turtles show a behavioral response; and

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

A secondary goal for the SCC 09-3 was to familiarize the MMOs with at-sea Navy operations and to gather information to facilitate future MMO opportunities. The results of this secondary goal are captured as “lessons learned” in Section 0.

SECTION 2: SCC 09-3 Description

SCC Ops are a requirement to provide the necessary training to prospective submarine commanders in rigorous and realistic scenarios involving undersea warfare.

Participants in SCC 09-3 included USS LAKE ERIE (CG 70), USS REUBEN JAMES (FFG 57), maritime patrol aircraft (fixed-wing patrol squadron), HSL-37 (helicopter antisubmarine squadron), submarines, and range control for subsurface, surface, and air.

SECTION 3: Methods

Shipboard Marine Mammal Monitoring

On the morning of 24 August, the MMOs, Commander Pacific Fleet Environmental representative, survey aircraft pilot, and aerial principle investigator participated in the pre-sail brief for all vessel and aircraft participants in the SCC 09-3 exercise. The original intent was for the MMOs to be stationed on the USS CHUNG-HOON (DDG 93). However, it was announced at the pre-sail that the CHUNG-HOON may not be participating due to an unspecified casualty to the ship, and the MMOs were subsequently transferred to the LAKE ERIE. During the pre-sail, the details regarding airspace concerns were finalized, as discussed in Section 0. Typically, the purpose and function of the MMOs are briefed at the pre-sail and/or to the ship on which the MMOs embark. There was not an opportunity to present this information at the pre-sail nor did the commanding officer of the LAKE ERIE request a briefing.

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 the LAKE ERIE to accomplish its mission objectives. The only exception would be if a marine mammal was sighted by the MMO within the shut-down zone during MFAS (200 yards [yds]) and was not sighted by the lookout. In this case the MMO would report the sighting to the lookout for appropriate reporting and action.

The MMO survey was conducted on the bridge wing of the LAKE ERIE (62 feet [ft] above water's surface), with one MMO on each wing. During on-effort surveys, the MMOs used the naked eye and 7X50 magnification binoculars to scan the area from dead ahead to just abaft of the beam. In searching this area, the MMOs started at the forward part of the sector and searched aft. Binoculars were held so that the horizon was in the top third of the field of view. The field of view was scanned from the horizon towards the ship. Once the field of view was scanned, the binoculars were repositioned and the field of view was scanned again (Figure 1). Once the scan with the binoculars was completed, the eyes were rested for a few seconds and the entire sector was scanned with the naked eye.

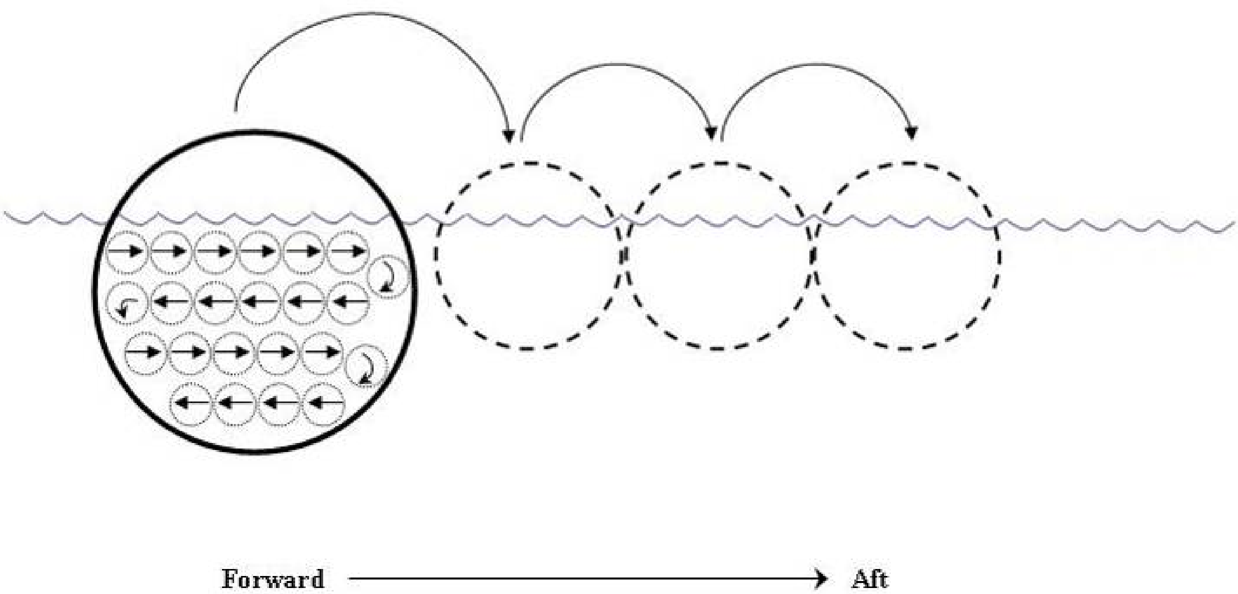

Figure 1. MMO Surface Searching Procedure

If an animal was visually detected, the MMO would collect information on twenty-three sighting, environmental, and sonar parameters (Table 5). Photographs would be taken using a Canon EOS 20D digital camera with a 100 – 400 mm zoom lens.

In addition to collecting data on each sighting, the MMOs would alert the survey aircraft, via a hand-held avionics very high frequency (VHF) radio (Section 0), of the location(s) of the animal(s) so that the aircraft could conduct a focal follow of the animal. If the aircraft was currently in a focal follow and another sighting was made, the aircraft would wait until the first focal follow was complete before heading to the second sighting. MMOs were not to inform the survey aircraft of the ships operations, particularly if MFAS was in use, so as to not bias any behavioral observations made by the survey aircraft.

A GARMIN GPSmap 276C geographic positioning system (GPS) was used to track LAKE ERIE locations during transits. The GPS unit allowed the MMOs to obtain positional reports without needing to enter the wheel house on the bridge. Additionally, ship track lines were able to be plotted for the times when the MMOs were on watch.

Table 5. Shipboard MMO Data Category Descriptions

Data Category	Description
Sightings Information	
Effort (on/off)	**On effort means actively searching for marine mammals; time spent off effort could result from vacating the bridge wing for operational reasons.**
Date	**Format in mm/dd/yy.**
Time	**Time provided in Hawaii Standard Time (HST).**
Location	**This is the location of the LAKE ERIE at the time of the sighting, provided by monitors on the bridge.**
Detection Sensor	**Either visual or aural (if detected passively by the sonar technician) and which MMO observed the animal.**
Species/Group	**Determined by the MMO.**
Group Size	**Estimated by the MMO.**
# Calves	**Estimated by the MMO.**
Bearing (true)	**Estimated by the MMO.**
Distance (yds)	**Estimated by the MMO; reticled binoculars or other measurement devices not available.**
Length of contact	**Estimated by the MMO.**
Environmental Information	
Wave height (ft)	**Estimated by the MMO.**
Visibility	**Estimated by the MMO.**
BSS	**Estimated by the MMO.**
Swell direction (true)	**Estimated by the MMO.**
Wind direction (true)	**Estimated by the MMO.**
Wind speed (kts)	**Provided by monitors on the bridge.**
% glare	**Estimated by the MMO.**
% cloud cover	**Estimated by the MMO.**
Operational Information	
Active sonar in use?	**Specifically refers to MFAS.**
Direction of ship travel	**Provided by monitors on the bridge.**

Animal motion	**Estimated by the MMO.**
Behavior	**<u>Individual behaviors</u>: breach, porpoise, spin, bowride, feeding, head slap, social, tail slap, pectoral fin slap, other** **<u>Whale behaviors</u>: blow, no blow rise, fluke up, peduncle arch, unidentified large splash** **<u>Group behaviors</u>: rest, mill, travel, surface active travel, surface active mill**
Mitigation implemented	**If MFAS in use, the measures implemented, if any, but the LAKE ERIE.**
Comments	**Other comments as necessary.**

Aerial Marine Mammal Monitoring

Aerial surveys were conducted during SCC 09-3. The survey was undertaken from a twin-engine, fixed-wing Beech Aero Commander. The primary goals of the aerial monitoring were to locate and identify marine mammals and sea turtles during the training exercise, and to monitor and report observations of their behavior. This included monitoring for any potentially injured or harmed marine mammals and sea turtles and any unusual behavior or changes in behavior, distribution, numbers, and species associations of animals observed during the training exercise.

The SCC 09-3 exercise involved multiple large naval vessels, submarines, and both fixed-wing (P-3) and rotary-wing (helicopters) aircraft. Thus, coordination of airspace use was paramount to the safety of all aircraft involved. In general, the airspace was divided into altitude strata, such that the helicopters would remain below 500 ft, the survey aircraft would remain between 800 – 1500 ft, and the P-3 aircraft would remain above 3000 ft. However, when the P-3 aircraft was required to fly at lower altitudes to satisfy mission requirements, the P-3, survey aircraft, and range control would coordinate to ensure each aircraft could safely maneuver to the other stratum. Each morning, the survey aircraft would communicate with range control to determine the location of the LAKE ERIE and to verify the altitude in which they would enter the range. Radio communication between the aircraft and MMOs was also established and verified.

The schedule of events for the survey aircraft was to conduct lawn-mower track surveys on the day before and after the exercise to obtain animal presence and distribution data. During the SCC (27-29 August), the survey aircraft flew elliptical, "race-track" shaped patterns in front of the LAKE ERIE. The goal of this flight pattern is to visually cover an area extending from the shutdown zone 1500 yds in front of the ship out to 3000 yds and ~2 nautical miles (nm) wide. The pilot manually flew this pattern and frequently had to adjust the pattern due to non-systematic and unpredictable changes in speed and headings of the LAKE ERIE as it conducted training exercises. This mode was to be maintained until a marine mammal/sea turtle sighting was made either by the aircraft or the shipboard MMOs, or until there was a potential conflict with naval airspace. In the event of a marine mammal/sea turtle sighting, the aircraft would cease the flight search pattern and begin circling the animal(s) sighted and initiate focal follow behavior mode.

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

Communications

Communication between LAKE ERIE officers and MMOs was accomplished during meals in the wardroom, evening operational briefs, and on the ship's bridge as required.

Communication between the MMOs and survey aircraft was conducted using hand-held avionics VHF radios.

Schedule of Events

LAKE ERIE departed Pearl Harbor, Hawaii, on 26 August at 1245 Hawaii Standard Time (HST). SCC 09-3 operations commenced on 27 August at 0800 and were suspended at 0400 on 30 August, with intermittent periods of no MFAS use. MMOs transferred, via rigid hull inflatable boat, to the USS REUBEN JAMES for return to Pearl Harbor on 31 August 2009. A detailed schedule of events is provided below in Table 6.

Table 6. Schedule of Events

27 August	
Time	**Notes**
0800	MMOs on effort
0940	Survey aircraft on effort
1110	MFAS commence
1130	MFAS stop
1137	MMO (Vars) off effort
1155	MMO (Vars) on effort
1158	MMO (Farak) off effort
1218	MMO (Farak) on effort
1230	MMOs and survey aircraft off effort
1400	MMO (Farak) on effort
1404	Survey aircraft on effort
1410	MMO (Vars) on effort
1508	MFAS commence
1520	MFAS stop
1630	MMOs and survey aircraft off effort

28 August	
Time	**Notes**
0800	MMOs on effort
0824	Survey aircraft on effort
0921	MFAS commence
0942	MFAS stop
1110	MFAS commence
1126	MFAS stop
1130	MMOs and survey aircraft off effort

29 August	
Time	**Notes**
0730	MMOs and survey aircraft on effort
1031	Survey aircraft off effort
1058	MFAS commence
1111	MMOs off effort
1113	MFAS stop
1225	MMOs on effort
1251	Survey aircraft on effort
1400	Survey aircraft off effort
1415 1430	MMO (Vars) off effort MMO (Vars) on effort
1538	MFAS commence (do not have stop time)
1630	MMOs off effort

1300	MMOs on effort
1336	Survey aircraft on effort
1447	MFAS commence
1456	Survey aircraft off effort
1527	MFAS stop
1600	MMOs off effort

SECTION 4: Results

4.1 Shipboard Marine Mammal Monitoring

Weather reports, including wind speed, direction, and Beaufort Sea State data, were recorded by the MMOs every half hour when possible (Table 7). The ship track is provided in Figure 2.

No marine mammal and sea turtle were sighted by the MMOs during SCC 09-3. During transit out of Pearl Harbor, two hardshell sea turtles were observed; on the return to port, one dolphin was observed within the harbor. Detailed information on these animals (e.g., location) could not be obtained, as the bridge wings were occupied by the navigational watch, and access to the bridge was not possible and the MMOs could not be on effort at these times.

Table 7. Weather Reports

27 August

Time	Wind Direction/ Speed	Beaufort Sea State
0800	045°T / 17 kts	3
0920	073°T / 13 kts	4
1000	051°T / 23 kts	4
1030	072°T / 25 kts	5
1100	052°T / 23 kts	5
1132	081°T / 24 kts	5
1200	064°T / 21 kts	5
1230	069°T / 19 kts	5
1410	075°T / 16 kts	4
1500	048°T / 16 kts	3
1530	044°T / 23 kts	3
1600	057°T / 21 kts	4
1630	056°T / 25 kts	4

28 August

Time	Wind Direction/ Speed	Beaufort Sea State
0800	083°T /15 kts	2
0830	046°T / 6 kts	2
0900	073°T / 14 kts	2
0930	090°T / 15 kts	2
1000	067°T / 14 kts	2
1030	075°T / 16 kts	3
1100	077°T / 17 kts	3

29 August

Time	Wind Direction/ Speed	Beaufort Sea State
0730	062°T / 17 kts	2
0830	078°T / 20 kts	3
0905	073°T / 20 kts	3
0930	095°T / 22 kts	3
1000	090°T / 23 kts	3
1030	084°T / 19 kts	3
1100	076°T / 21 kts	3
1225	097°T / 20 kts	3
1305	089°T / 20 kts	3
1330	077°T / 24 kts	3
1415	089°T / 18 kts	3
1430	079°T / 20 kts	3
1540	075°T / 21 kts	3
1600	062°T / 18 kts	3
1630	077°T / 17 kts	3

1130	058°T / 17 kts	**3**
1300	071°T / 25 kts	**4**
1330	068°T / 22 kts	**3**
1400	072°T / 19 kts	**3**
1430	069°T / 15 kts	**3**
1500	068°T / 21 kts	**3**
1530	074°T / 16 kts	**3**
1600	**069°T / 20 kts**	**3**

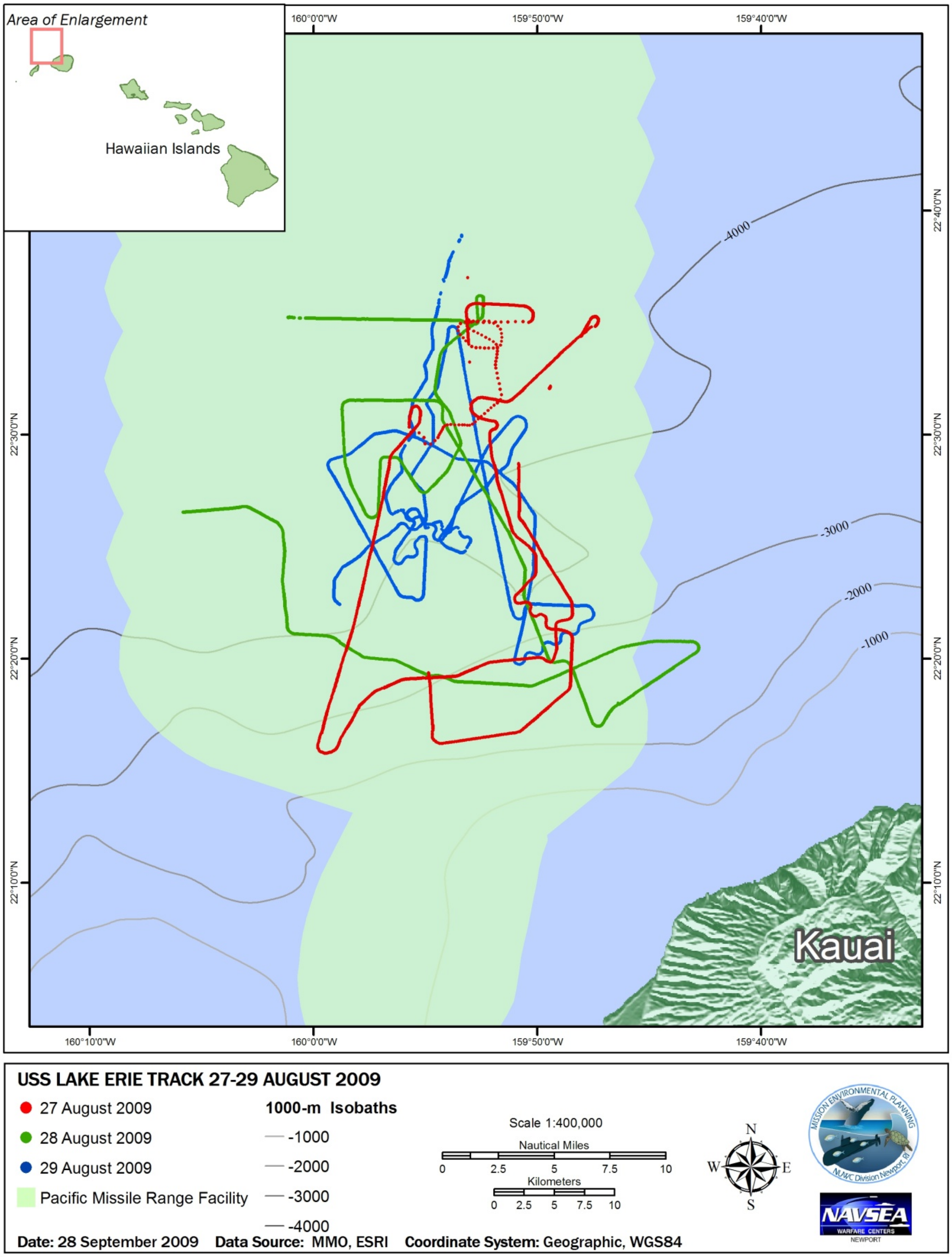

Figure 2. USS LAKE ERIE Ship Track

4.2 Aerial Marine Mammal Monitoring

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

SECTION 5: Conclusion

5.1 Marine Mammal Monitoring

The goals of the SCC 09-3 monitoring effort are provided below, with a conclusion regarding each of the goals:

4. Coordinate transit to the PMRF to allow LAKE ERIE and the survey aircraft opportunity to test communications and to familiarize the ship to the survey aircraft transect profiles

   The survey aircraft was scheduled to conduct pre-exercise surveys on the PMRF on the day prior to exercises commencement. LAKE ERIE was not on range during this period; therefore, no pre-exercise coordination occurred. VHF communication was coordinated during SCC 09-1 in February 2009, and the same procedures were expected. Pre-exercise coordination was unnecessary since VHF communications were established and verified each morning when the survey aircraft came on the range.

5. Collect data on marine mammals observed during operations
   a. Are marine mammals and sea turtles exposed to MFAS?

      No marine mammal or sea turtle sightings were obtained by LAKE ERIE MMOs during MFAS operations. Sea conditions and distance from prime marine mammal habitat severely limited the number of potential ship and aerial sightings during SCC 09-3 operations.

   b. If so, at what levels?

      No marine mammals or sea turtles were observed.

   c. Did exposed marine mammals/sea turtles show a behavioral response?

      No marine mammals or sea turtles were observed.

6. Achieve close coordination between the contracted aerial survey team, Navy aircraft on the range, range control, and the MMO team aboard LAKE ERIE 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.

5.2 Lessons Learned

Many lessons learned were noted for the SCC 09-3 exercise, and are separated into those for shipboard monitoring, aerial monitoring, and operational information below.

5.2.1 Shipboard Marine Mammal Monitoring

- Although MFAS is generally heard by the MMOs on the bridge wings, verification with the ship's and/or sonar logs is recommended to determine start and stop times of MFAS use.
- Observers tend to fatigue and lose focus after a couple hours, increased rotation is recommended. Recommend 3 observers per exercise, rotating at two hours on effort followed by one hour off effort.
- Improve access to VHF radio. A clip on the radio or an earphone would improve communications, as the radio often was difficult to hear given the wind noise on the bridge wing. The radio was either in hand (which has a potential for dropping) or in a pocket, which makes hearing the radio more difficult.
- Attending daily ship operations brief is highly recommended. It facilitates communication between the ship's officers and the MMOs and keeps the MMOs current on the daily operations of the ship.
- Use of a portable GPS allowed for easier access to ship's locations, without needing to enter the bridge. Plotting the ship track would also help verify locations of sightings, if made.

5.2.2 Operational Information

- Future marine mammal monitoring would be better suited to areas nearer prime marine mammal habitat to improve the cost effectiveness of the effort and during time periods of highest abundance.
- If passive detections of marine mammals are made by sonar, it would be beneficial to the MMOs (if time permits and it does not interfere with other duties). Especially in rough sea state, would help the MMOs focus their effort in a particular area. It may be helpful if the MMOs could wear headphones that are connected to the ships internal communication system such that sonar could report passive contacts.
- Identification of an alternate surface ship for MMO support is necessary during pre-exercise planning. Due to unexpected difficulties, the MMOs were notified at the pre-sail brief that the planned surface ship was unavailable to support the exercise. Having an alternate ship identified would reduce confusion immediately prior to embarkation.

APPENDIX E RIMPAC PAM Deployment and Vessel-Based Monitoring Survey

PASSIVE ACOUSTIC MONITOR DEPLOYMENT AND SMALL VESSEL-BASED MONITORING SURVEYS, 17-15 JULY 2010

FINAL REPORT

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

15 SEPTEMBER 2010

ACRONYMS AND ABBREVIATIONS

ASW	anti-submarine warfare
EAR	ecological acoustic recorder
ESA	Endangered Species Act
ft	foot
HDR|e²M	engineering-environmental Management, Inc., an HDR company
HIMB	Hawai'I Institute of Marine Biology
HRC	Hawaii Range Complex
kHz	kilohertz
km	kilometer(s)
m	meter(s)
MMPA	Marine Mammal Protection Act
nm	nautical mile(s)
NOAA	National Oceanic and Atmospheric Administration
PAM	passive acoustic monitor
RIMPAC	Rim of the Pacific
SPUE	sightings per unit effort
W-186	Warning Area 186
XBT	expendable bathythermograph

Section 1 Introduction

During 23 June through 1 August 2010, the 22nd Rim of the Pacific (RIMPAC 2010) exercise was conducted in the Hawaii Range Complex (HRC). RIMPAC is a biennial, multinational exercise designed to strengthen regional partnerships and improve interoperability. It is an exercise designed to bring multinational military assets together to train towards bettering the Navy's capabilities. Anti-submarine warfare (***ASW***) was the exercise's main feature.

As part of compliance requirements with the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973, the Navy developed the HRC Monitoring Plan to provide marine mammal and sea turtle monitoring (DoN 2008). In order to effectively meet the goals outlined in this Plan, it was determined that one example of training events recommended for monitoring should contain one or more surface combatants conducting ASW during a regularly scheduled training event. Research elements of that Plan include visual surveys and passive acoustic monitoring.

The results of marine mammal monitoring reported here for RIMPAC 2010 represent the first monitoring effort under the U.S. Navy's Marine Species Monitoring Program (Contract # N62470-10-D-3011) issued to engineering-environmental Management, Inc., an HDR company (HDR|e^{2}M).

The monitoring effort for RIMPAC 2010 consisted of the following:

- Vessel-based line transect surveys to assess the diversity, distribution, and behavior of target species (e.g., marine mammals and sea turtles)
- Installation of one shallow- and one deep-water passive acoustic monitors (PAMs) in waters off Ni'ihau.

Section 2 Methods

Study Area

The Navy's Hawaiian Islands Operating Area includes the eight main Hawaiian Islands, as well as Kaua'i and Ni'ihau. Protected marine species monitoring for RIMPAC 2010 focused in Warning Area 186 (W-186), which spans waters south of Kaua'i and Ni'ihau (see **Figure 1**). Bottom depth in W-186 ranges from 100 to 4,000 meters (m) (328 to 13,123 feet [ft]). Kaulakahi Channel is a 15-nautical mile (nm) (28-kilometer [km])-wide channel between Kaua'i and Ni'ihau.

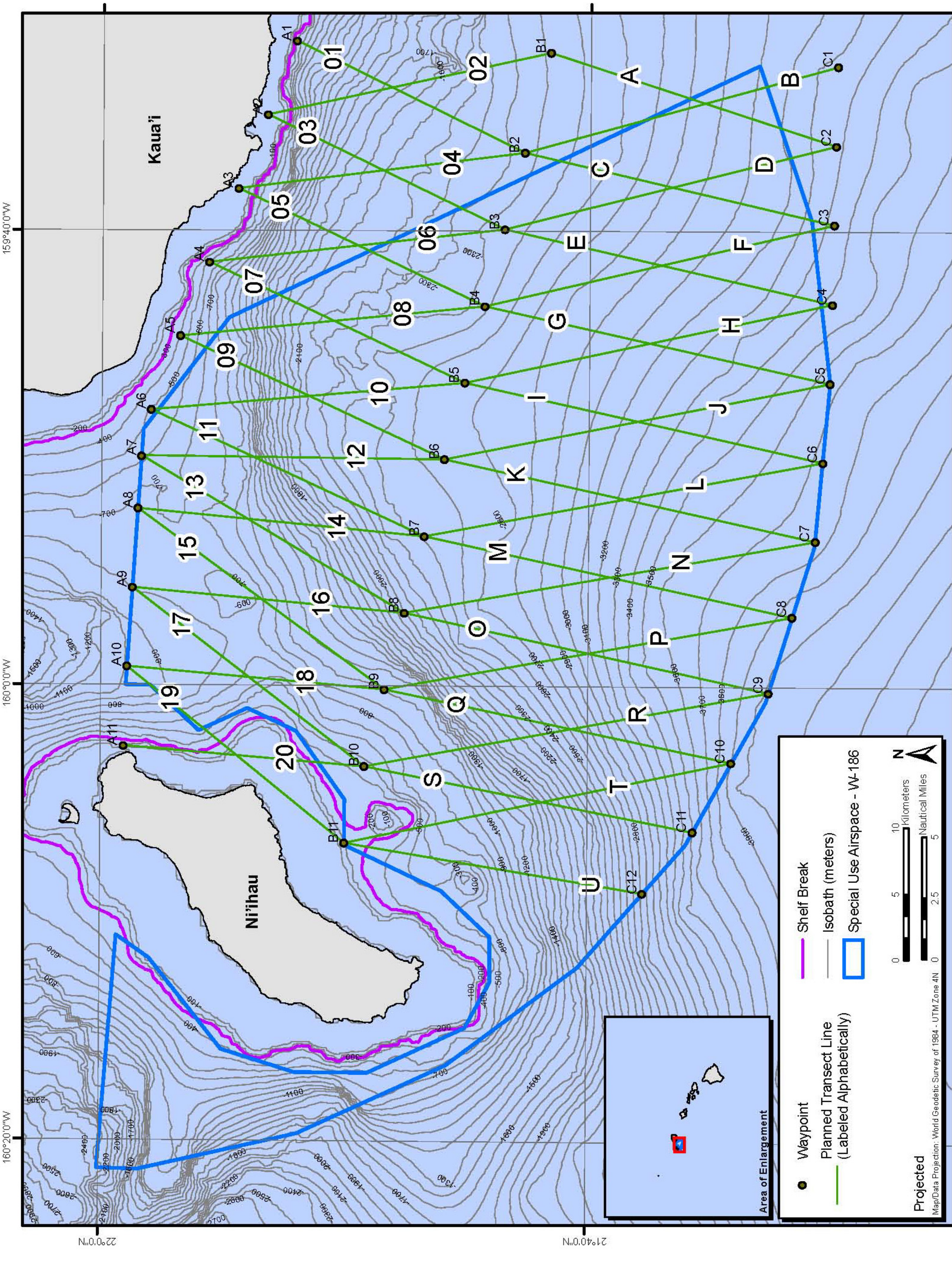

Figure 1. Predetermined Tracklines for the Survey Effort for RIMPAC 2010

Vessel-Based Monitoring

Vessel-based monitoring effort was performed over an 8-day period from 18 through 25 July 2010 (see **Tables 1** and **2**). Survey methods were consistent with current accepted Distance Sampling theory (Buckland et al. 2001) and similar to those used in an earlier RIMPAC (RIMPAC 2008) vessel-based monitoring effort (Smultea 2008).

Table 1. Summary of RIMPAC 2010 Monitoring Effort

Date	Description	Time Out *	Time In *	Total Hours
July 18	Transect survey	0700	1500	8
July 19	Transect survey	0630	1430	8
July 20	Transect survey	0600	1230	6.5
July 21	Transect survey	0600	1600	10
July 22	Transect survey	0630	1300	6.5
July 23	Transect survey	0530	1330	8
July 24	Transect survey	0530	1500	9.5
July 25	Transect survey	0530	1500	9.5
			Total	**66.0**

Table 2. Summary of RIMPAC Monitoring Effort by Trackline Coverage

Date	On-Effort nm (km)	Off-Effort nm (km)	Total Daily Effort nm (km)
18 July	23.19 (42.98)	1.45 (2.68)	24.64 (45.66)
19 July	36.58 (67.79)	9.57 (17.74)	46.15 (85.52)
20 July	23.71 (43.94)	0.64 (1.19)	24.35 (45.13)
21 July	66.26 (122.80)	8.74 (16.19)	75.00 (138.99)
22 July	26.65 (49.39)	6.88 (12.75)	33.53 (62.13)
23 July	45.01 (83.41)	7.35 (13.62)	52.35 (97.03)
24 July	33.12 (61.38)	24.06 (44.58)	57.17 (105.96)
25 July	74.31 (137.72)	4.78 (8.86)	79.09 (146.58)
Totals	**328.82 (609.39)**	**63.46 (117.60)**	**392.28 (726.99)**

The observation platform for the 8-day period was a 38-ft (11.6 m) Bertram charter vessel, the *Kai Bear*, operated out of Port Allen Harbor located on the south-central shore of Kaua'i. The ship went into harbor every night. Survey effort was based on three tiers of equally spaced waypoints approximately 5 km (2.7 nm) apart so that effort was stratified into a nearshore area and an offshore area (see **Figure 1**). Stratification was used to allow for shorter transect lines during higher sea states, thereby allowing greater survey effort. Sawtooth transect lines were used to connect the waypoints, with choice of lines dependent upon prevailing weather conditions. When Beaufort sea state reached 6 or higher, effort was curtailed and the survey vessel returned to harbor.

All six marine mammal observers (see **Table 3**) 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 30-minute intervals: left observer, data recorder, and right observer, followed by a 1.5-hour rest break. Observers scanned from directly in front to 90 degrees on each side using 7x reticled binoculars or naked eye (when ocean swells rendered hand-held binoculars impractical). When a sighting occurred, the observer noted the approximate horizontal angle to the sighting and the number of reticles down from the horizon as well as the sighting cue. The number of corresponding to the reticle was used to calculate the distance to the animal based on the height of the platform (4 m; 13 ft). These were recorded by the data recorder using WinCruz software (available from the National Oceanic and Atmospheric Administration [NOAA]) and on data sheets. Species identity and diagnostic cues were also recorded and digital photographs obtained when possible. 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.

Table 3. Observers and Roles

Observer	Role(s)
Greg Fulling	Chief Scientist / Observer
Joe Mobley	Survey Coordinator / Observer
Michael Richlen	Observer / PAM deployment
Alexis Rudd	Observer / PAM deployment
Jeff Foster	Observer
Aliza Milette	Observer

The expendable bathythermograph (XBT) device did not function properly; therefore, no temperature profile for the water column could be collected.

Passive Acoustic Monitor (PAM) Deployments

Two PAM deployments were made during 12 hours of monitoring effort on July 17 in the vicinity of the island of Ni'ihau (see **Table 4** and **Figure 1**). The two PAMs were ecological acoustic recorders (EARs; Lammers et al. 2008), designed by Whitlow Au of the Hawai'i Institute of Marine Biology (HIMB). Both PAMs were hand-deployed from the *Kai Bear*: one PAM in shallow water (17 m; 56 ft) and one in deep water (732 m; 2,402 ft). The duty cycle on both EARs were set to record every 300 seconds for 30-second sampling durations at a sampling rate of 80 kilohertz (kHz). The original plan is that EARs will be retrieved for downloading of acoustic data during the timeframe of September–October 2010.

Table 4. Summary of PAM (EAR) Deployments

EAR location	Depth (m)	Date Deployed	Sampling Rate	Latitude	Longitude
Shallow-water, South Ni'ihau	17	7/17/2010	80 kHz	21º 47.306'N	160º 11.964'W
Deep-water, North Ni'ihau	732	7/17/2010	80 kHz	21º 59.613'N	160º 12.167'W

Section 3 Results

Survey effort

Observers visually surveyed 392.28 nm (726.99 km) of trackline during 8 days for a total of approximately 66 hours during the RIMPAC 2010 survey. Beaufort sea states ranged from 1 to 6 and followed a trend of building from low sea state to high by mid-day, this forced survey effort to typically end in the early afternoon due to concerns for observer safety. All sightings were made in Beaufort sea states between 2 and 5 (see **Table 5**). Sightings per unit effort (SPUE) were calculated as the total number of marine mammal sightings divided by the total effort (hours/nm/km). For this monitoring exercise, the SPUE was equal to 1 sighting per 7.34 hours, 43.59 nm, and 80.78 km.

Sightings

Nine marine mammal sightings were recorded during approximately 66 hours of effort (see **Table 5** and **Figure 2**). No sea turtles were sighted during the entire survey. Marine mammal sightings consisted of three groups of short-finned pilot whales (*Globicephala macrorhynchus*); two groups of spinner dolphins (*Stenella longirostris*); one mixed-species aggregation of spinner dolphins with pilot whales; one group of rough-toothed dolphins (*Steno bredanensis*); a single Hawaiian monk seal (*Monachus schauinslandi*); and one sighting of unidentified cetaceans (see **Figure 2** and **Table 5**).

Behavior

No evidence of distress or unusual behavior was observed during this RIMPAC monitoring effort. The team was able to conduct two focal follows of pilot whales, both on 21 July (Sightings 5 and 6). The first focal follow was a period of 20 minutes spent with 13 individuals, while the other was 45 minutes with 70 individuals. Detailed behavioral observations made during the focal follows are presented in **Appendix A**. Photographs of suitable quality for photo-identification purposes were collected during focal follows.

PAMs

As noted earlier, PAMs were deployed as close to the original position as possible (see **Figure 1**). Depth and slope of the area necessitated minor position changes (see **Figure 2**). The original plan is that the EARs will be retrieved during the timeframe of September–October 2010 to download collected acoustic data.

Table 5. Summary of Sightings for RIMPAC 2010

Sighting No.	Date	Species	Group Size Best/High/Low			Calves	Time	Beaufort Sea State	Latitude	Longitude	Bottom Depth (m)	Behavioral Summary
1	7/19/10	SL	17	15	20	-	07:08	3	21º 53.66'N	159º 35.41'W	100	Slow travel; no calves
2	7/19/10	Unid	2	2	2	-	10:14	2	21º 52.76'N	159º 39.04'W	1,000	(large splashes seen; no resight)
3	7/19/10	GM/SL	16	20	14	-	11:05	5	21º 51.21'N	159º 39.40'W	1,200	Milling, slow travel; during mid-observation period saw SL likely traveling with GM, but difficult to track animals due to conditions. SL within 10 m of GM
4	7/20/10	GM	1	1	1	-	08:26	2	21º 52.91'N	159º 49.16'W	1,200	Fast travel with quick 180-degree turn; possibly chasing prey
5	7/21/10	GM	14	16	10	2-3	07:31	3	21º 42.78'N	159º 35.41'W	1,700	**Focal follow details in Appendix A.** Somewhat spread out; slow travel and logging; animals spread out then coalesced, though not tightly; 2-3 calves; stayed with group for 20 mins with no change in behavior
6	7/21/10	GM	64	86	49	2-3	13:28	3	21º 49.48'N	159º 45.85'W	2,400	**Focal follow details in Appendix A.** Slow travel; turned into 3 large groups; approached boat; several spyhopped; rolled and fluke slapped; stayed with group for approximately 45 mins
7	7/22/10	SL	8	10	5	-	06:23	3	21º 53.64'N	159º 35.58'W	100	Observed when leaving harbor; traveling in clumps, some surface active others traveling different speeds; approached boat briefly

Sighting No.	Date	Species	Group Size Best/High/Low			Calves	Time	Beaufort Sea State	Latitude	Longitude	Bottom Depth (m)	Behavioral Summary
8	7/23/10	SB	9	16	6	-	08:49	3	21º 54.21'N	159º 51.46'W	900	Very spread apart in deep water; several individuals approached boat; no more than 2 seen in a given subgroup
9	7/24/10	MS	1	1	1	-	12:09	3	21º 54.06'N	159º 54.86'W	800	Individual swimming

Key:
GM = short-finned pilot whale (*Globicephala macrorhynchus*)
GM/SL = mixed-species aggregation of short-finned pilot whale and spinner dolphin
MS = Hawaiian monk seal (*Monachus schauinslandi*)
SB = rough-toothed dolphin (*Steno bredanensis*)
SL = spinner dolphin (*Stenella longirostris*)
Unid = unidentified cetacean

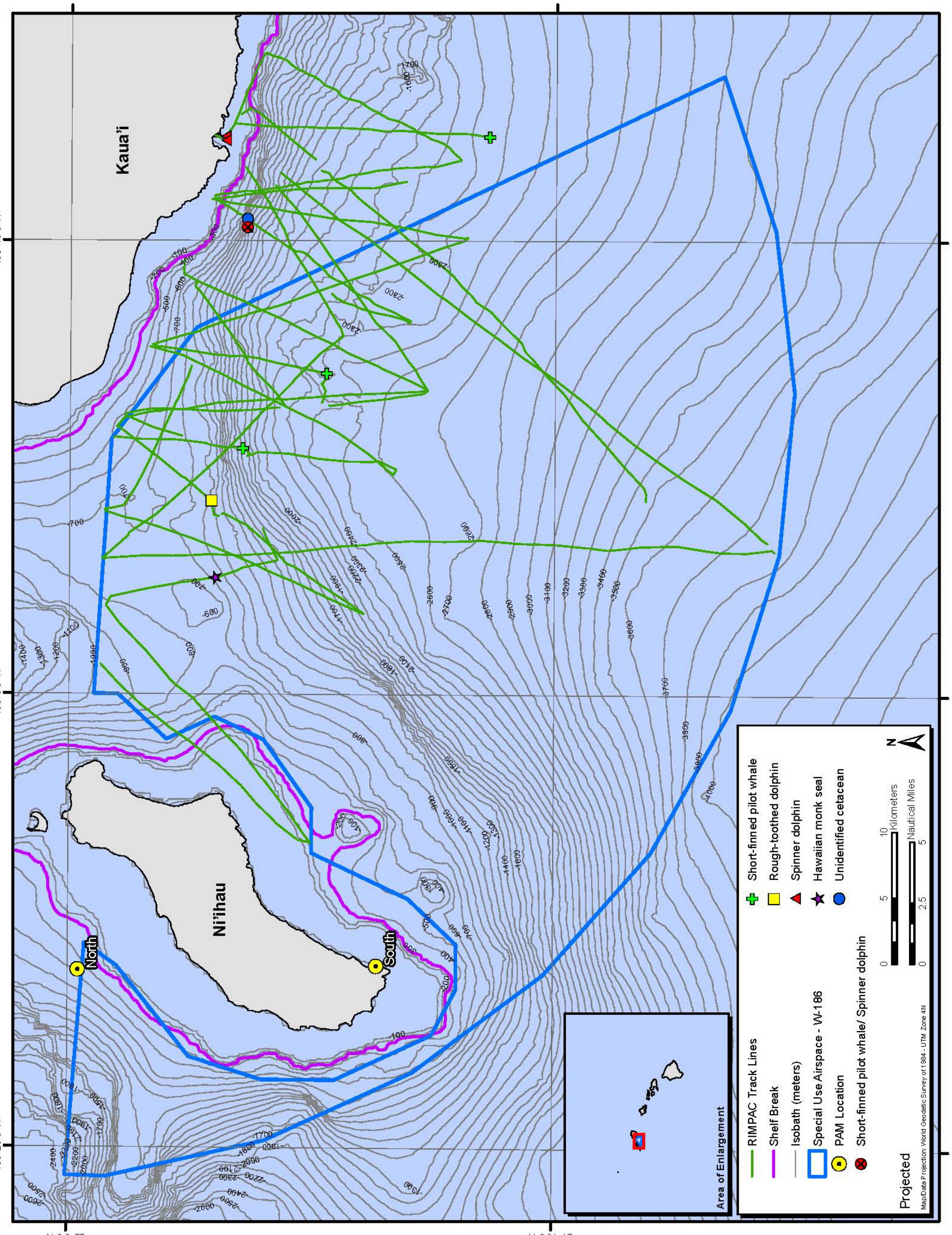

Figure 2. Location of PAMs and Marine Mammal Sightings

Section 4 Recommendations

1. Sea states combined with use of a small vessel precluded surveys of the offshore waters. For future monitoring efforts, we suggest either using a larger vessel with live-aboard capabilities or flying aerial surveys. Aerial surveys would allow greater success for sighting sea turtles. Use of a live-aboard vessel provides two major advantages over a small vessel:
   a. A live-aboard ship is capable of having mounted Big Eye binoculars. Use of Big Eyes would have allowed greater visibility not available on the smaller survey vessel. Hand-held binoculars were not effective in the high sea states due to lack of stability.
   b. The observation team could have surveyed offshore regions during early morning hours, when the sea states were more calm (as noted earlier, sea conditions worsen throughout the day) and worked in the near-shore waters, in the lee of the island (where there is protection from winds and rough sea states) in the afternoon.
2. The Navy has a safety requirement of a 30-day lead time for review of dive plan. Because this project was developed on a short time frame, this requirement obviated the deployment of the shallow-water PAM by divers. Hand deployment of the shallow-water PAM was successful, but in shallower water than anticipated, to allow confirmation of substrate and to allow retrieval by divers in the future.
3. Future surveys may benefit from use of a directional hydrophone on the vessel to potentially increase the number of focal follows. This method would allow greater use of time periods when winds are calm and sighting conditions are more optimal, to possibly visually locate those animals detected acoustically.
4. When this task order was created, the contract between HDR|e²M was recently established; this short time frame allowed little time for pre-planning the field work. Although the work for this Task Order was accomplished, the challenges of executing the survey using limited options highlights the need for as long a timeframe as possible between notification by the Navy and implementation of the monitoring efforts (in this case, the vessel survey and PAM placement).
5. Future monitoring events would be enhanced with the addition of satellite tagging surveys 2-3 months in advance of the vessel survey. This will allow more opportunity to establish movement patterns of the animals in the region before, during, and after the training exercise per the goals of the HRC Monitoring Plan.

Section 5 Acknowledgements

We would like to thank Captain Frank Chaney of the *Kai Bear*, and the ship's deckhand, Chance Dean, for their able assistance during this survey effort. These data were obtained under NOAA permit no. 14451 issued to Joseph R. Mobley, Jr., Ph.D.

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Appendix A
Focal Follow Data

Table A-1 shows the focal follow behavioral data from the RIMPAC 2010 monitoring efforts. The two focal follow events were conducted on 21 July 2010; both were of groups of short-finned pilot whales (*Globicephala macrorhynchus*).

Table A-1. Focal Follow Behavior Data

Record Number	Time	Date	Latitude	Longitude	Recorded Behavior
Sighting Number 5					
Species: *Globicephala macrorhynchus*					
1	73738	72110	N21:42.57	W159:35.61	Animals slow travel and logging at surface - group was initially spread out and seems to be coming closer together
2	73958	72110	N21:42.55	W159:35.72	Animals coming within 20m of vessel with little to no reaction
3	74219	72110	N21:42.53	W159:35.84	At least 2-3 calves - no change in behavior- still slow travel - logging at surface
4	74740	72110	N21:42.47	W159:36.11	Tail slapping from smaller animal
5	75213	72110	N21:42.44	W159:36.30	Stayed with group ~20 mins with no change in behavior - leaving group to go back to transect
Sighting Number 6					
Species: *Globicephala macrorhynchus*					
1	133424	72110	N21:49.49	W159:46.01	Initial behavior is slow travel
2	133442	72110	N21:49.49	W159:46.02	Clumping together and milling
3	133828	72110	N21:49.46	W159:46.10	Direction change
4	134048	72110	N21:49.50	W159:46.12	2-3 individuals broke off main group
5	134254	72110	N21:49.55	W159:46.16	Animals spread out, 1 bigger, loose group and some further out
6	134436	72110	N21:49.60	W159:46.23	Turned 180 degrees
7	134626	72110	N21:49.61	W159:46.27	Groups are spread out again
8	134919	72110	N21:49.64	W159:46.27	3 animals diving
9	135020	72110	N21:49.66	W159:46.30	One animal tail slap and roll by boat
10	135118	72110	N21:49.65	W159:46.32	Overall behavior: started out slow travel, changed to milling
11	140156	72110	N21:49.51	W159:46.65	Most dove at 13:50 and then came back up at 14:01
12	140908	72110	N21:49.57	W159:46.82	Navy ship coming through Ni'ihau- Kaua'i Channel
13	140932	72110	N21:49.58	W159:46.83	Pilot whales dispersing
14	141112	72110	N21:49.59	W159:46.87	Socializing
15	141403	72110	N21:49.58	W159:46.96	End sighting
16	141915	72110	N21:49.65	W159:47.12	Animals last seen doing fast travel

APPENDIX F Kaula Island Ship-Based Marine Mammal Survey - Hawaii Range Complex

August 2010

Prepared for Commander, Pacific Fleet
Prepared by Dr. Robert Uyeyama and Dr. Sean Hanser, NAVFAC Pacific

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 permit from the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act and 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 Kaula Island monitoring effort is intended to provide data towards answering questions 1, 2, and 5 above.

1.2 KAULA ISLAND BACKGROUND

1.2.1 Owner Information

Territorial Executive Order 173 of 13 December 1924 set aside Kaula Island for public purposes under the jurisdiction of the United States Lighthouse Service. In 1939, the U.S. Coast Guard (USCG) assumed control of Kaula (Elmer and Swedberg 1971; Balazs 1979). In 1952, the Department of the Navy obtained permission to use Kaula Island as a munitions target, and the Navy received control of the island from USCG in 1965 (Elmer and Swedberg 1971).

1.2.2 Property Description

Kaula 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), Kauai. Kaula 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).

1.2.3 Prior Use

Kaula Island is associated with Hawaiian culture and is assumed to have been visited in the past

by Hawaiians for fishing and bird collection, but there is no evidence of regular human habitation (Elmer and Swedberg 1971). Three archeological sites were described by Bryan (1939): two sites were originally speculated to be heiaus and one site a shelter cave; however, the heiau sites have been noted to be of questionable origin (Bryan 1939, Elmer and Swedberg 1971, DON 1976a).

The U.S. Lighthouse Service established an automatic gas light near the summit of Kaula 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 Kaula was operated until 1947.

Following World War II, USCG used Kaula Island as a radar navigation target. After receiving permission to use the island for munitions training, in 1952 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 was used during training missions through 1980. From 1981 through 2009, munitions training by the Navy at Kaula Island has been restricted to inert ordnance delivery and aircraft gunnery (Walker 1983, 1984). In 1977, Kaula Island was designated as a Seabird Sanctuary by the State of Hawaii Department of Land and Natural Resources.

1.2.4 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 Kaula 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*) near Kaula (Mobley et al. 2000; Baird et al., 2003).

Due to increasing concerns by the Navy regarding the potential for injury to personnel visiting Kaula by unexploded ordnance, bird aircraft strikes, and steep, unstable terrain, access to the island for land-based surveys has not been granted since 1998. In January 2009, the Navy contracted a private company to obtain aerial imagery of Kaula 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. In order to conduct additional seabird surveys on Kaula Island in the absence of direct access to land, on 21-22 July 2009 avian surveys were conducted via vessel platform, with surveys for marine mammals conducted concurrently (Pepi et al. 2009). Five biologists, including four seabird observers and one marine mammal observer, carried out the surveys. 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 Kaula 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 Kaula 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.

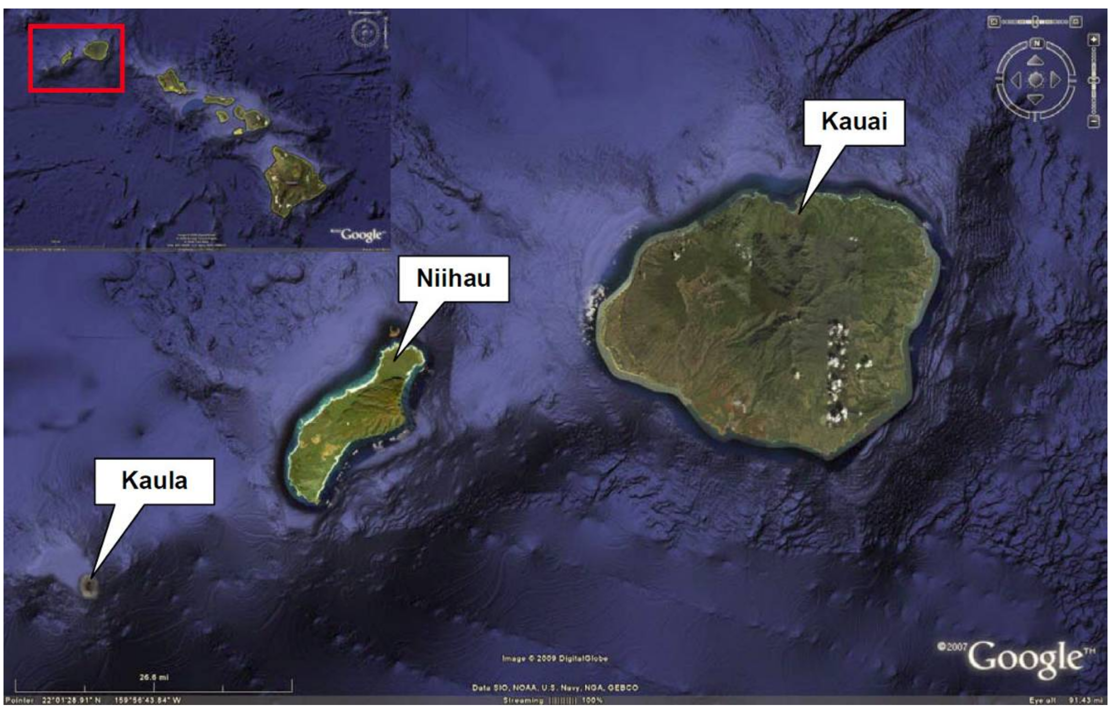

Figure 1. Location of Kaula Island relative to the main Hawaiian Islands (inset) and Kauai and Niihau (imagery from Google Earth).

Figure 2. Aerial imagery of Kaula Island (Walker and Associates).

2. METHODS

2.1 SHIP-BASED SEA BIRD AND MARINE MAMMAL SURVEY

Ship-based surveys were again conducted for seabirds and marine mammals offshore of Kaula Island and in the waters between Niihau and Kauai on 26-28 June 2010. These dates were prior to the RIMPAC major training exercise, and therefore were intended to provide a baseline survey of marine species presence. The waters of the survey area included the PMRF areas W-186, W-187, and W-188 (Fig. 3). Seven biologists, including five from the U.S. Navy, one from the U.S. Fish and Wildlife Service, and one from Hawaii DLNR, 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 8. The M/V Searcher has an observation deck above the bridge, placing observers approximately 20 ft (6 m) above the surface of the water (Fig. 4).

2.2 SURVEY TIMELINE

Three biologists from the U.S. Navy boarded the M/V Searcher at Nawiliwili Harbor, Kauai, on the morning of 26 June, and conducted one day of marine mammal surveys in the waters roughly between Kauai and Niihau, eventually rounding the northern end of Niihau. In the evening the vessel anchored off the west coast of Niihau.

On the morning of 27 June, the vessel resumed a marine mammal survey beginning by rounding the southern end of Niihau, and surveying waters between Niihau and Kauai on the way to eventually reach Port Allen, Kauai in the late afternoon, where the four remaining biologists boarded. The marine mammal survey was continued until daylight allowed along a direct transit to again anchor off the west coast of Niihau.

On the morning of 28 June, a marine mammal survey was conducted on a transit to Kaula Island. Upon reaching Kaula Island, as with the 2009 ship-based survey, a bird survey of the island was conducted as the vessel circumnavigated the island twice at a distance of approximately 750 ft (228 m) from the coastline. Marine mammal sighting were also recorded. After the bird survey, the dedicated marine mammal survey was again resumed as the vessel made its final transit to Port Allen, where all biologists disembarked.

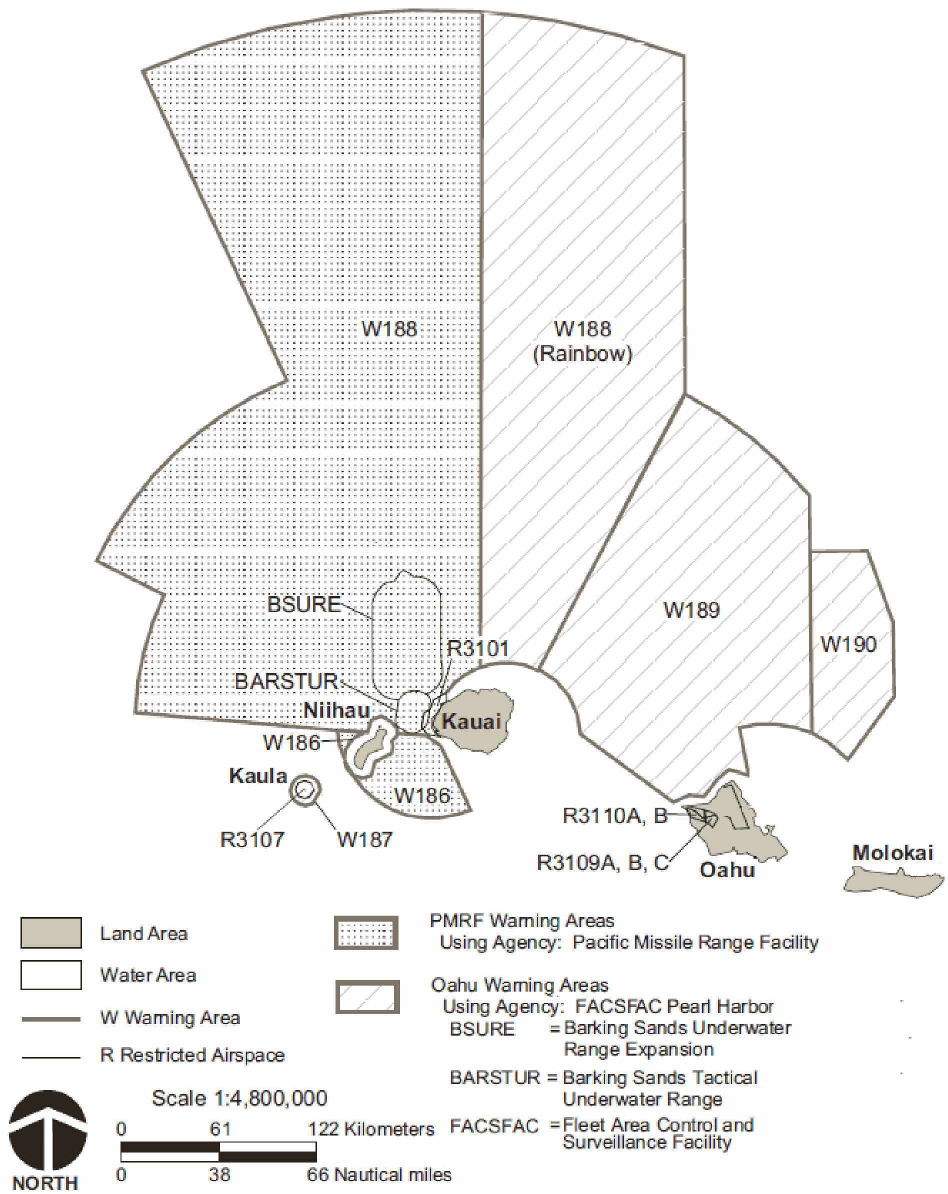

Figure 3. Depiction of PMRF Warning Areas W-186 and W-187 in relation to the Hawaiian Islands

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 primary goals of this project were to locate and identify marine mammals and sea turtles observed before a training exercise. The marine mammal survey portion of the cruise was conducted by three Navy biologists. On biologist was being trained through a Navy internship program, and the other 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, where the approximate observe eye-level height was 7.97 m above sea level (Fig. 5). 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. 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. The observers scanned continuously from abeam to the bow. The left and right observers were each equipped with a pair of "Big Eyes" 25 x 50 binoculars, securely mounted on pedestals located on the port and starboard forward corners of the flying bridge. All three biologists were also equipped with 7x hand-held reticled binoculars. The two observers were also equipped with digital voice recorders and digital cameras, one with a 200 mm zoom lens, and the other with a 400 mm zoom lens. The survey 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 at Kaula Island (Fig. 6), the observations occurred during all daylight hours during "acceptable" survey conditions (i.e., Bf <7) with no rain or other environmental conditions impeding the ability to sight marine mammals near the vessel. Survey lines on the first day of 26 June concentrated the west coast of Kauai in a modified sawtooth pattern, and the survey effort continued afterwards on the transit to the west coast of Niihau to anchor for the night (Fig. 7). Survey lines on 27 June consisted of perpendicular transits across undersea slopes to deeper waters southwest of Niihau and southeast of Kauai, as the vessel made its way to Port Allen for the boarding of the biologists for the bird survey; the vessel again anchored off the west coast of Niihau for the evening (Fig. 8). Survey lines on 28 July were opportunistic, consisting of the transits to Kaula Island, as well as from Kaula Island on the return to Port Allen for disembarkation. (Fig .9).

Figure 5. Flying bridge and port big-eye binocular. The starboard big eye is to beyond the camera view to the right.

Figure 6. Kaula Island bird survey.

Figure 7. Survey track of 26 June. Nawilili Harbor to west coast of Niihau

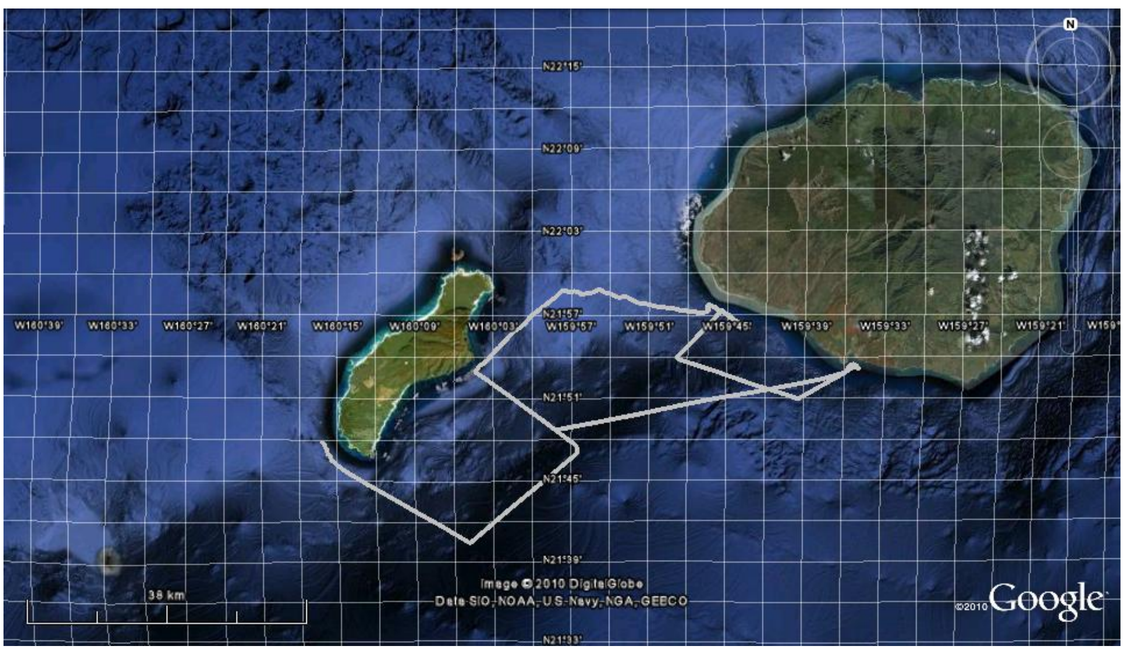

Figure 8. Survey track of 27 June. West coast of Niihau, survey to Port Allen, then transit back to west coast of Niihau.

Figure 9. Survey track of 28 June. West coast of Niihau, two circumnavigations of Kaula Island (lower left), and return rvey to Port Allen.

3. RESULTS

A total of seven marine mammal groups (all cetaceans) were sighted during the three days of observations (Table 1). One of these was a bow-riding group of unidentified dolphins sighted only by the crew of the vessel during an off-effort period due to rain; the remaining six were sighted on-effort by the biologist observers. Five of the cetacean sightings were confirmed to species and consisted of two groups of bottlenosed dolphins (*Tursiops truncatus*), one group of rough-toothed dolphins (*Steno bredanensis*) (Fig. 10), one group of spinner dolphins (*Stenella longirostris*), and one group of false killer whales (*Pseudorca crassidens*) (Fig. 11). The sighting by the crew was an unidentified dolphin species. No sea turtles were sighted. A calf was sighted within the group of false killer whales, and the spinner dolphin group were bow-riding and several animals were sighted with unidentified white material trailing from the flukes, pectoral fins, or visible on the melon.

All sightings and their locations with reference to survey tracks are depicted in Figure 12.

Table 1. Summary of marine mammal sightings

Species	Group size (Min/Max/Best)	Date	Time
Steno bredanensis	3/3/3	26 June	10:09
Unidentified cetacean	1/-/-	26 June	10:29
Unidentified dolphin	(15)	26 June	15:53
Tursiops truncatus	2/2/2	27 June	06:40
Tursiops truncatus	1/2/2	27 June	07:40
Stenella longirostris	7/13/8	28 June	08:33
Pseudorca crassidens	3/3/3	28 June	11:46

Figure 10. Sighting of Pseudorca crassidens 28 June. Calf sighted within group.

Figure 11. Sighting of *Stenella longirostris* at Kaula Island.

Figure 12. Unidentified white material on *Stenella longirostris*

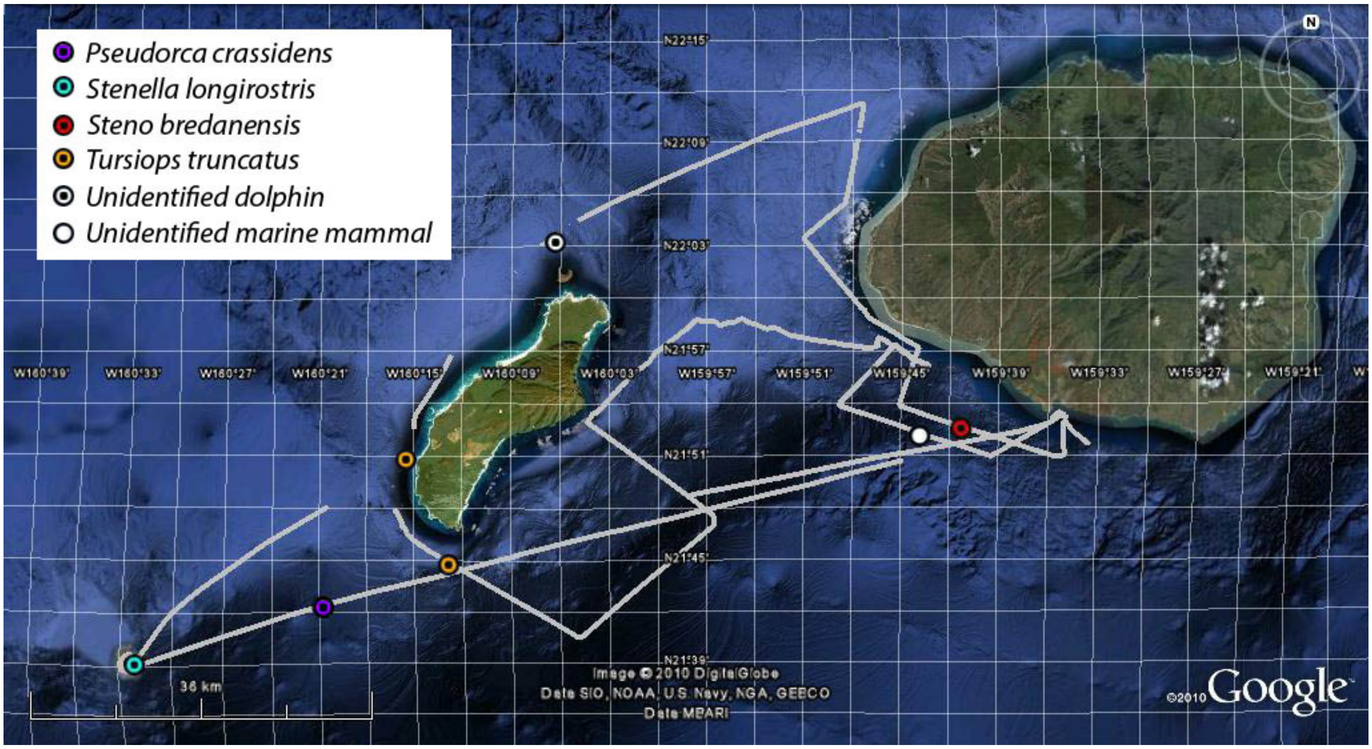

Figure 13. Marine mammal sightings. Sighting locations are superimposed upon survey tracks.

4. CONCLUSIONS

4.1 NIIHAU-KAUAI-KAULA 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 Kaula Island (Mobley et al. 2000, Baird et al. 2003; Pepi et al., 2009). Therefore comparison to past studies with the results of this survey are difficult to interpret. However, this survey is the second of a series of surveys planned to be conducted in conjunction with Kaula Island sea bird surveys, following Pepi et al. (2009). Therefore data resulting from this survey may be considered to be the early portion of an anticipated continuation of a long-term effort in progress to characterize the marine mammal and sea turtle populations in the Kaula Island, as well as Niihau-Kauai area.

4.2 RECOMMENDATIONS

The cooperative combination of marine mammal and sea turtle survey effort with long-term vessel-based sea bird surveys of Kaula Island have proven to be a fruitful, cost-effective, and productive research tool. The continued collection of data in these waters are therefore anticipated to be a relatively long-term effort that can provide baseline information regarding marine mammal and sea turtle populations in the Navy exercise areas.

For future marine mammal cruises to this project area, we also recommend the addition of other efforts that are able to help answer the questions of the MMPA permit monitoring requirements. For example, the ability to perform focal follows (as in Pepi et al., 2009) would provide additional behavioral data, especially for rarer species such as the Hawaiian *Pseudorca crassidens*. For example, it is unknown whether the *Pseudorca* sighted were members of the Insular Hawaiian population, which is currently a candidate for ESA listing. Because the survey was conducted in "passing mode," the individually-identifying dorsal photographs that were obtained were not the best that could be obtained by following the animals, either in the primary vessel, or a deployed smaller vessel. Additionally, other qualified researchers could be placed upon the marine mammal-sea turtle-sea bird cruises to enable the application of tags (e.g., satellite tags) for population and range information, or the collection of biopsies for population structure data.

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APPENDIX G Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with a Navy Training Event, SCC OPS August 16-30, 2009, Final Field Report.

Citation for this report is as follows:

Smultea, M.A., J.R. Mobley, Jr., and K. Lomac-MacNair. 2009. Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with a Navy Training Event, SCC OPS August 16-30, 2009, Final Field Report. Prepared for Commander, Pacific Fleet. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, HI, 96860-3134, under Contract No. N62742-09-P-1966 *issued to Marine Mammal Research Consultants (MMRC), Honolulu, HI, in collaboration with Smultea Environmental Sciences, LLC. (SES), Issaquah, WA, August 2009.*

Section 1 Introduction

Aerial surveys to monitor for marine mammals and sea turtles (MM/ST) were conducted in conjunction with the August 2009 US Navy Submarine Commander's Course (SCC OPS) in the Hawaii Range Complex (HRC) on the Pacific Missile Range Facility (PMRF) instrumented range off Kauai and Niihau, Hawaii (

Figure 3). Surveys occurred on five consecutive days from 26-30 August 2009 before, during and after training activities involving intermittent use of mid-frequency active sonar (MFAS), typically ~100 km (50 nm) west or northwest of Kauai (Figure 2). The first day on August 26 a grid pattern was flown before SCC OPS began (Figure 2). The following three days on August 27-29 the observation aircraft flew elliptical orbits in advance of the *USS Lake Erie* during the SCC OPS (Figure 2). On the final survey day on August 30 after the SCC OPS had ended the grid pattern flown on the first day was replicated (Figure 2). The survey methodology 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 implemented for monitoring of previous SCC OPS off Kauai in August 2008 (Smultea and Mobley 2009) and February 2009 (Smultea et al. 2009a) and a similar unit-level training event off Oahu in June 2009 (Mobley et al. 2009).

Prior to the event the co-Principal Investigator (JM) and pilot, along with Navy biologists, participated in a briefing to the *USS Lake Erie* Commanding Officer as well as the pre-planning conference at Pearl Harbor, Honolulu, Oahu, Hawaii, to coordinate survey efforts with the SCC OPS August 09 training event.

Per the SOW, the goal of the aerial survey was "to monitor and report the presence/absence, distribution/re-distribution, reaction/no reaction, injury, and/or mortality of MM/ST during exposure to SCC OPS Navy training event". This involved monitoring and reporting, in as detailed fashion as possible, 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 *USS Lake Erie*'s activities using a systematic search and focal follow method. This included monitoring for any potentially dead, injured, or distressed animals and "any animals found to be exhibiting behaviors or associations deemed unusual" per the SOW.

As indicated in the SOW, it was recognized *a priori* that post-survey analyses were not expected to be completed under this task as sample size was expected to be limited in offshore survey waters based on previous regional survey data (e.g., Mobley et al. 2000, Barlow 2006, Mobley et al.

2009, Smultea and Mobley 2009, Smultea et al. 2009a,c; also see review in Smultea 2008). Rather, survey data collected during this monitoring effort will be compiled with previous (e.g., Mobley et al. 2009, Smultea and Mobley 2009, Smultea et al. 2009a,b,c,d) and subsequent data, and interpreted over time by the Navy to facilitate increased sample size and thus data validity and relevance.

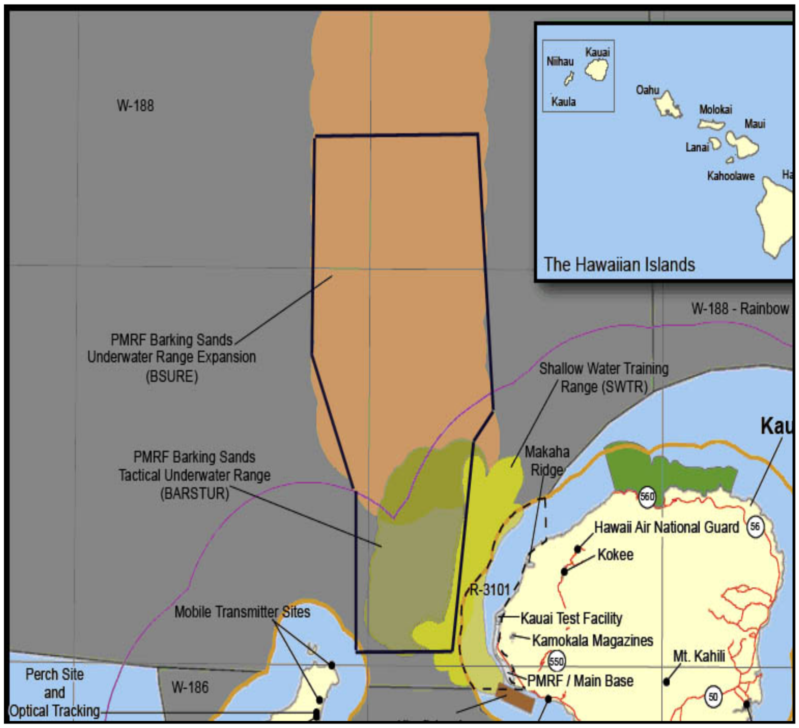


Figure 3. Location of the aerial survey monitoring area in and near the US Navy Pacific Missile Range Facility (PMRF) Range west and northwest of Kauai, Hawaii.

Section 2 Methods

Monitoring effort generally followed protocol first implemented in August 2008 for another SCC OPS off northern Kauai/Niihau (see Smultea and Mobley 2009 for details). This approach involves flying elliptical-shaped patterns in advance of the Navy vessel (i.e., the *USS Lake Erie* in the present case) that extends from the front of the ship (~200 yards [yd]) out to ~2500 yd) over a width of ~4 km (2 nm). However, unlike previous aerial monitoring of SCC OPS, a line-transect grid survey was flown one day before and one day after the SCC OPS in the general operation area. The line-transect grid consisted of 10 north-south oriented lines ~40 km long and spaced equidistantly ~10 km apart (Figure 2). This grid was flown on the first (Aug 26) and last days (Aug 30) of the survey period, before and after the SCC OPS, respectively. During the three intervening days (Aug 27-29), the aircraft flew the elliptical-shaped search patterns in front of the *USS Lake Erie* to search for MM/ST near this vessel during the SCC OPS activities.

Surveys were conducted from a small fixed-wing Twin Aero Commander flying at 100 knots (kt) groundspeed and an altitude of ~1000 ft (305 m), 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 a pilot, a co-pilot, and two professionally trained marine mammal biologists (both with >10 years of related experience). Both biologists sat in the two rear seats of the aircraft and functioned as observers. The observer on the right side of the plane also recorded data. The co-pilot in the front right seat was the photographer and back-up observer when the rear right observer was recording. Observers were not informed of the times and types of underwater transmissions during Navy activities, or the course of the *USS Lake Erie*. Observers maintained contact with Navy biologists who monitored MM/ST from aboard the *USS Lake Erie* using a handheld aviation VHF transceiver.

Following an initial sighting, the aircraft typically broke from the transect search line and orbited the sighting to confirm species identification, obtain behavioral observations, and take photographs (see ,d et al. 2009a,b,c for detailed protocol). Species determination of cetaceans was often made possible via photographs taken with a Canon EOS 5D camera equipped with a 400-mm telephoto lens. Data-collection software (Handbase 4.0) was used on an iPhone to collect basic sighting and environmental data (this same data recorder was used during aerial monitoring surveys for the Navy off southern California in June-July 2009—see Smultea et al. 2009d). SpectatorGo, a behavioral data collection program developed by Biobserve, was used to record interval-sampled behavioral data on the iPhone so that both GPS and altitude data could be incorporated with every data entry. An MMRC/SES team member (M. Deakos) worked closely with the developers to improve the software to match the project's needs. A wide area augmentation system (WAAS) enabled Garmin 296 GPS was used to collect latitude/longitude and altitude data. WAAS technology was developed by the Federal Aviation Administration to augment the Global Positioning System. The WAAS uses a separate satellite system with known positions that correct the GPS signal, resulting in far greater precision than ordinary GPS, particularly in the case of altitude measurements. The sighting and GPS data were merged post-field into an Excel database.

Section 3 Results and Discussion

As stated in the SOW, given the fact that MFAS transmission times were not known plus the small sample sizes of MM/ST observed, it is not possible herein to assess any effects of the August 2009 SCC OPS on MM/ST. Rather, the purpose of this monitoring effort was to gather data than can be compiled with previous and subsequent data to be "fully interpreted over time" by Navy personnel. As such, this section is limited to a summary of the chronology of events, effort, sightings, and behaviors observed as described below.

Two previous aerial monitoring surveys were conducted by Marine Mammal Research Consultants and Smultea Environmental Sciences in conjunction with SCC OPS in the Hawaiian Range Complex in August 2008 and February 2009 (Smultea and Mobley 2009, Smultea et al. 2009a). Over the course of these surveys, protocol has been refined and standardized, including the development and customization of PDAs and associated software to improve the efficiency of data collection and reduce the data post-processing time. These three surveys have shown that search and behavioral observations of MM/ST from a civilian observer aircraft can be conducted safely and effectively (e.g., see Smultea and Mobley 2009 and Smultea et al. 2009a,b,c,d) with minimal interference with at-sea naval training involving multiple large vessels and aircraft.

Similar to the two previous SCC OPS aerial survey monitoring efforts north of Kauai and Niihau, survey conditions were predominantly hampered by high Beaufort (Bf) sea state and thus poor observation conditions due to the exceptionally strong trade winds (> 20 knots) that prevailed during all but the final day of surveys as described below. No MM/ST sightings were seen while accompanying the *USS Lake Erie* during the SCC OPS for three days when wind speeds were highest. However, sightings were made before and after the SCC OPS period as well as during transits to and from the USS *Lake Erie*. Unlike the previous two SCC OPS aerial monitoring efforts, the August 2009 SCC OPS aerial monitoring involved pre- (1 day), during (3 days) and post-ops (1 day) observation periods. In general, as indicated in previous reports and in the Navy's marine species monitoring plan for the HRC (DoN 2008), conducting observations before/during/after exposure to a potential stimulus is considered a logical experimental approach and is a goal of the Navy's aforementioned plan.

Chronology of Events

- On August 26, before SCC OPS began, the observation aircraft departed Oahu and conducted a line-transect survey in a grid pattern north of Niihau and west of Kauai (Table 1, Figure 2). After completing the survey grid, the aircraft circumnavigated Niihau then flew to the Lihue, Kauai, airport.
- The following three days (August 27-29) during SCC OPS, the aircraft departed each day from the Lihue airport and transited to the location of the *USS Lake Erie* located ~15-55 km NW of Kauai (Table 1, Figure 2). The observers then monitored for MM/ST in front of the *USS Lake Erie* for as long as possible given the fuel restrictions of the aircraft (see Methods). Two roundtrips were made on each of the three days to and from the Lihue airport from the *USS Lake Erie* to permit mid-day refueling.
- On the final survey day (August 30) after SCC OPS had ended, the aircraft departed Lihue airport and conducted a line-transect survey following the same grid pattern flown on August 26 (Table 1, Figure 2). This effort included circumnavigating Niihau after completing the systematic survey grid. The aircraft then returned to Oahu.

Effort

A total of 31.4 hr or 7048 km of flight effort (from aircraft wheels up to wheels down) was conducted from 26-30 August 2009 (Table 1). Most (44% or 13.7 hr) of the total 31.4 hr of flight time occurred while accompanying the *USS Lake Erie*, totaling 3019 km (Figure 3). This was followed by transiting to and from the offshore location of the USS *Lake Erie* or the grid lines, and systematic line transects effort (Figure 3). In comparison, during similar MM/ST monitoring during the August 2008 SCC OPS off Kauai, the survey aircraft accompanied the Navy's USS *O'Kane* during 19.0 (67%) of the 28.5 hr of flight time (Smultea and Mobley 2009); during SCC OPS aerial survey monitoring in February 2009 off Kauai, the survey aircraft accompanied the Navy's *USS Russell* during 13.9 hr (51% of the 27.3 hr of flight time (Smultea et al. 2009a).

Effort with Respect to Beaufort Sea State

Similar to previous results (Smultea and Mobley 2009), observation conditions were predominantly poor in offshore Kauai waters where the *Lake Erie* was located and where most of the line-transect grid occurred (Bf 5 or 6 during 75% of 30.1 total hr over water) (Figure 4). In comparison, during SCC OPS Aug 08 aerial monitoring off Kauai, Bf was >4 during 80% of 19.0 hr of with-vessel effort; during SCC OPS Feb 09 aerial monitoring also off Kauai, Bf was >4 during 96% of 13.9 hr of with-vessel effort.

Sightings

A total of 19 sightings consisting of an estimated 238 individuals were recorded during the survey period, including one mixed cetacean species sighting (Tables 1 and 2). Locations of sightings are shown by date in Figures 5 – 9. None of the 19 sightings occurred while the survey aircraft accompanied the *USS Lake Erie*. Most sightings occurred while conducting line-transect surveys within the grid or while circumnavigating Niihau before SCC OPS had begun (n = 8 sightings) or after SCC OPS had ended (n = 6 sightings) (Appendix A). The remaining six sightings occurred primarily in shallow coastal waters near Kauai during transits to and from the airport on August 27-29 (Figures 6-8, Table 2, Appendix A).

Fourteen (74%) of the 19 sightings were identified to species, 5 (26%) of which were confirmed via digital photographs (Appendix B). No video was taken during the surveys. A total of six different marine mammal species were confirmed: the monk seal, pygmy killer whale, false killer whale, and rough-toothed, spinner and spotted dolphins (Table 2, Appendix A and B). One unidentified sea turtle was observed during the survey on the north coast of Kauai on August 27 (Figure 6). Most (57%) of the 14 sightings identified to species were monk seals (n = 8), all of which were seen hauled on western beach of Niihau on August 26 and 30 (this Niihau beach was not overflown during the remaining three survey days—see Figure 2).

In general, the predominant Bf 5-6 in the survey grid and near the *USS Lake Erie* compromised the detection of MM/ST with a few exceptions as summarized below (see Figure 4).

- No sightings were seen in the survey grid on August 26 before SCC OPS began when Bf was primarily 5-6 (Figure 2 and 5).

- While accompanying the *USS Lake Erie* on August 27-29 in offshore north Kauai waters, no sightings were made when Bf was a constant 5 or 6 (Figure 2 and 6-8).
- On the last survey day on August 30 after SCC OPS had ended, four sightings were made in the same survey grid when Bf was largely 2-4 with considerably less Bf 5-6 (Figure 2 and 9).

Behavior

Protocol to collect data on the behavior of MM/ST was the same as previous surveys and followed that outlined in the SOW. This approach consisted of two phases, when possible. The first phase involved recording the initial behavior state, minimum and maximum inter-individual spacing between individuals (estimated in body lengths), direction of travel, species, any conspicuous or unusual behaviors, and any observed changes in behavior. Thus, taking photographs was a high priority to identify and/or confirm species. The second phase was to conduct extended focal follows using the video to supplement detailed behavioral observations when possible. However, as documented during previous aerial monitoring surveys conducted in conjunction with Navy training activities (e.g., Smultea and Mobley 2009, Smultea et al. 2009a,b,c,d), Bf conditions must be sufficiently calm (typically <Bf 4) to allow reliable and accurate collection of behavioral data. For example, in poor Bf conditions (e.g., Bf 5 and 6), it is very difficult to keep track of the sightings and many behaviors are missed, including entire surfacing sequences. Given the predominantly poor Bf conditions during this survey, no focal follows were conducted and no video was taken. However, initially observed behavioral data were recorded as summarized below and in detail in Appendices A and B. All eight monk seal sightings consisted of single animals hauled out and resting on the western coast of Niihau. Among the 11 small odontocete/delphinid sightings, most groups (55% or 6 groups) were first observed traveling, followed by milling (n = 3 groups), surface-active milling (n = 1 group), and surface-active traveling (n = 1). On two occasions, delphinids were observed feeding: (1) a group of 5 rough-toothed dolphins including 1 calf on August 28 that was milling and feeding, and (2) a single false killer whale observed feeding while traveling on August 30. A photograph showing a possible fish in the false killer whale's mouth was taken through the water surface. A change in the initially observed behavior was noted for 2 of the 19 sightings (Appendix B). On August 28, a group of ~50 spinner dolphins initially surface-active milling near the western shore of Kauai changed behavior state to surface-active travel to the southeast (Appendix B). Also on August 28 a mixed species group of 19 rough-toothed dolphins and 5 pygmy killer whales (including 1 calf) traveling to the northwest appeared to change behavior by staying below the water surface for longer periods while the aircraft circled overhead to take photographs (Appendix B). The latter sighting occurred ~10 km off the southwest coast of Kauai (Figure 7). The one sea turtle observed during the survey was seen resting at the water surface on August 27 along the northern shoreline of Kauai (Appendix B, Figure 6).

Table 8. Summary of survey times by date and periods when the observer aircraft was accompanying and not accompanying the *USS Lake Erie*.

Date 2009	Flight Period (Wheels Up)	Flight Period (Wheels Down)	Total Flight Hours	Period not with *USS Lake Erie*	Total Hours not with *USS Lake Erie*	Period with *USS Lake Erie*	Total Hours with *USS Lake Erie*	No. Sightings With *USS Lake Erie* (# indiv)	No. Sightings Away from *USS Lake Erie* (# indiv)
08/26/2009	09:53:39	15:02:21	5:08	9:54 - 15:02	5:08	n/a	0	0	6 (16)
08/27/2009	09:13:53	12:57:00	3:43	9:13 - 9:37 12:32 - 12:57	0:48	09:37 - 12:32	2:55	0	0
08/27/2009	13:47:51	16:50:01	3:02	13:47- 14:07 16:24 - 16:50	0:46	14:07 - 16:24	2:16	0	1 (1)
08/28/2009	07:42:58	12:10:23	4:27	07:42 - 08:23 11:35 - 12:10	1:15	08:23 - 11:35	3:11	0	2 (50)
08/28/2009	13:00:27	15:49:24	2:48	13:00 - 13:35 14:56 - 15:49	1:27	13:35 - 14:56	1:21	0	2 (24)
08/29/2009	06:44:56	11:27:49	4:42	06:44 - 07:30 10:29 - 11:27	1:43	07:30 - 10:29	2:59	0	2 (20)
08/29/2009	12:14:38	14:19:52	2:05	12:14 - 12:47 13:46:14:19	1:06	12:47 - 13:46	0:59	0	0
08/30/2009	06:51:33	12:16:53	5:25	12:16 - 05:25	5:25	n/a	0	0	6 (127)
TOTAL			**31:20**		**17:38**		**13:41**		**19 (238)**

Table 9. Summary of sightings by species and periods with and without the *USS Lake Erie* during the August 2009 SCC OPS aerial survey monitoring.

	With *USS Lake Erie*		Away from *USS Lake Erie*		Total	
Species	**No. Grps**	**No. Indiv.**	**No. Grps**	**No. Indiv.**	**No. Grps**	**No. Indiv.**
Monk Seal (*Monachus schauinslandi*)	0	0	8	9	8	9
False Killer Whale (*Pseudorca crassidens*)	0	0	1	1	1	1
Pygmy Killer Whale (*Feresa attenuata*)	0	0	1	5 (1 calf)	1	5
Rough Toothed Dolphin (*Steno bredanensis*)	0	0	2	24 (1 calf)	2	24
Spinner Dolphin (*Stenella longirostris*)	0	0	1	50	1	50
Spotted Dolphin (*Stenella attenuata*)	0	0	1	110	1	110
Unidentified Dolphin (*Delphinidae*)	0	0	5	38 (1 calf)	5	38
Unidentified Sea Turtle	0	0	1	1	1	1
Total	**0**	**0**	**20** [1/]	**238**	**20**	**238**

[1] This total counts one mixed group of rough-toothed dolphins and pygmy killer whales as two separate sightings.

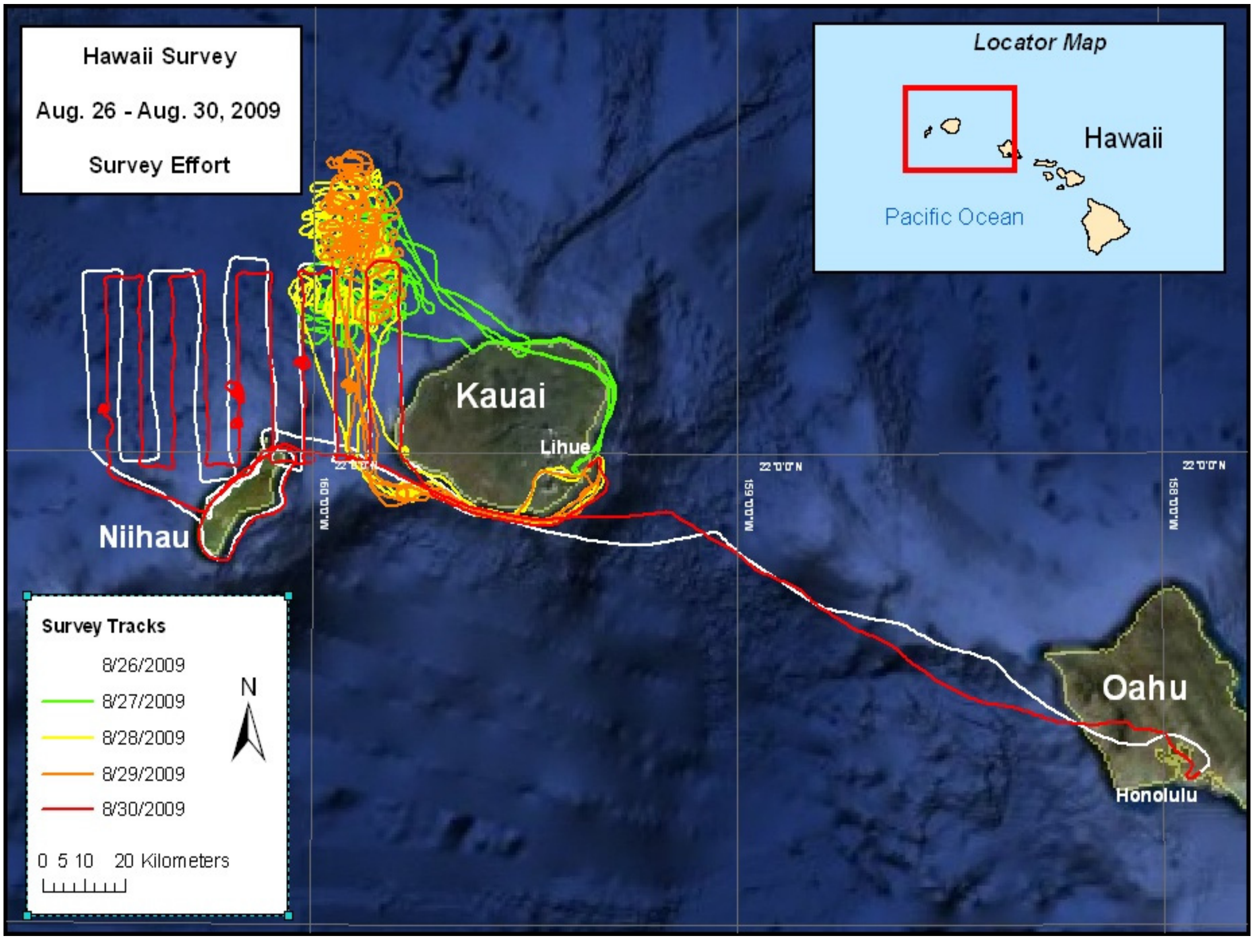
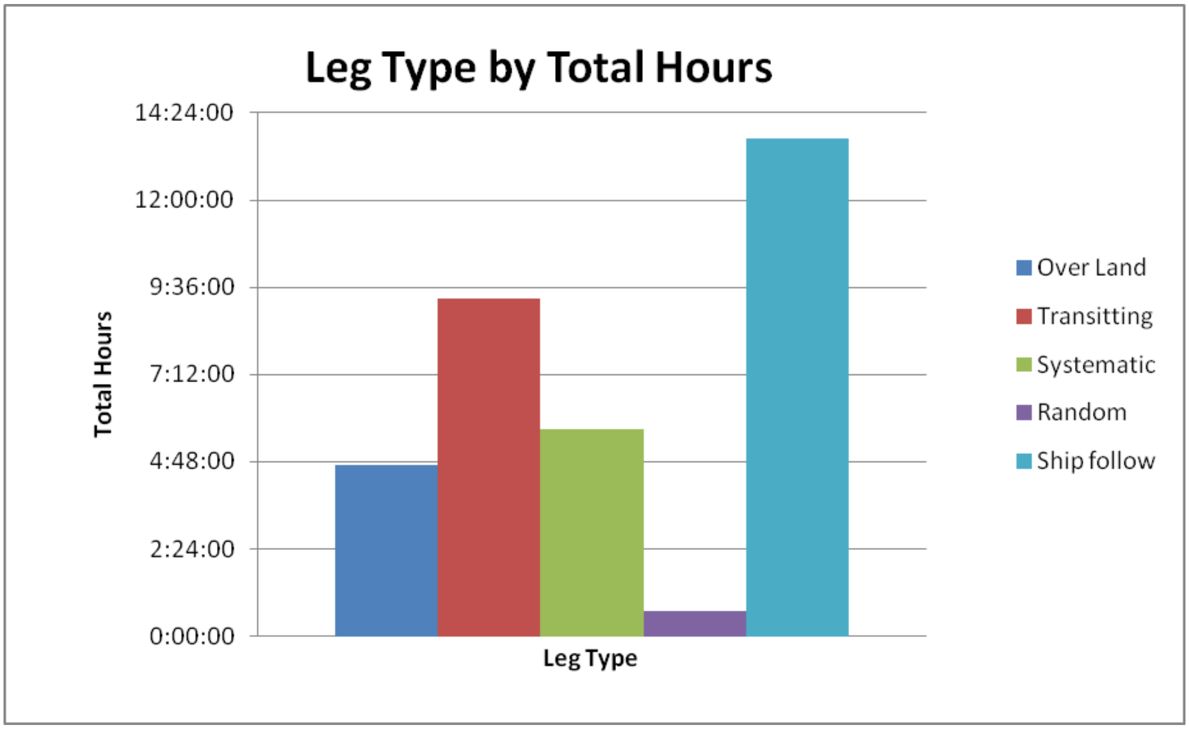


Figure 4. Aerial survey tracks by date during visual observations before (August 26), during (August 27-29), and after (August 30) SCC OPS off Kauai, Hawaii. Parallel lines indicate the line-transect survey grid. Corkscrew-shaped tracks indicate when the aircraft was accompanying the *USS Lake Erie*. Random effort consists of the short lines connecting the longer line-transect grid lines. Remaining lines consist of transit effort while traveling to and from the airport and the *USS Lake Erie* or the survey grid.



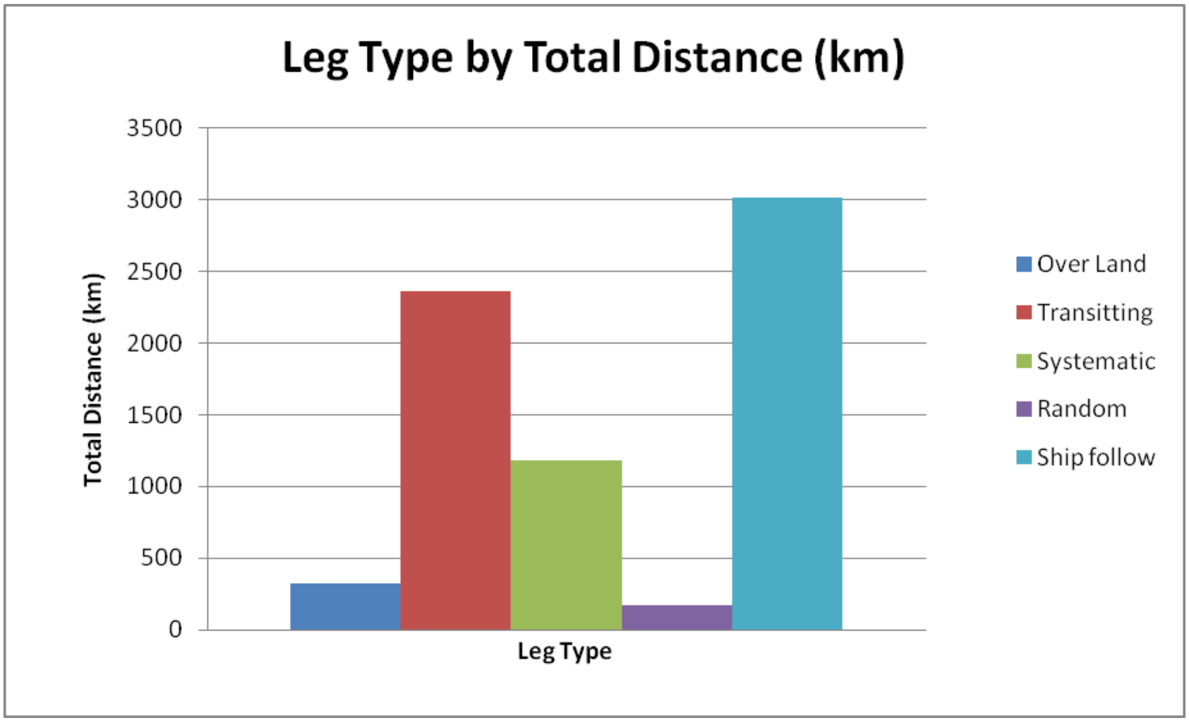


Figure 5. Effort types conducted during the Aug 2009 SCC OPS aerial survey monitoring off Kauai, Hawaii, expressed in hours (upper panel) and km flown (bottom panel).

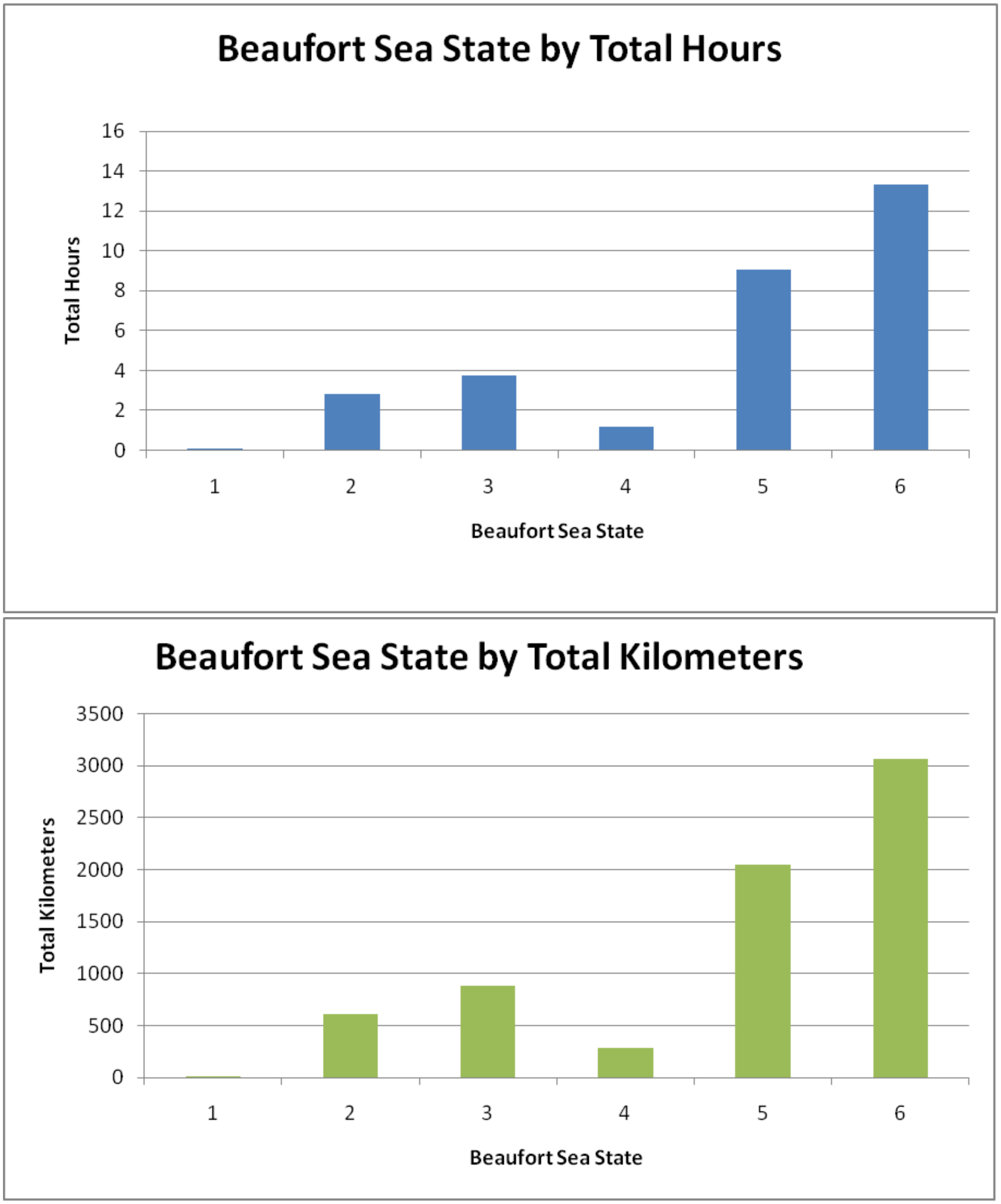


Figure 4. Effort in hours (upper panel) and kilometers (bottom panel) by Beaufort Sea State during the Aug 2009 SCC OPS aerial survey monitoring off Kauai, Hawaii.

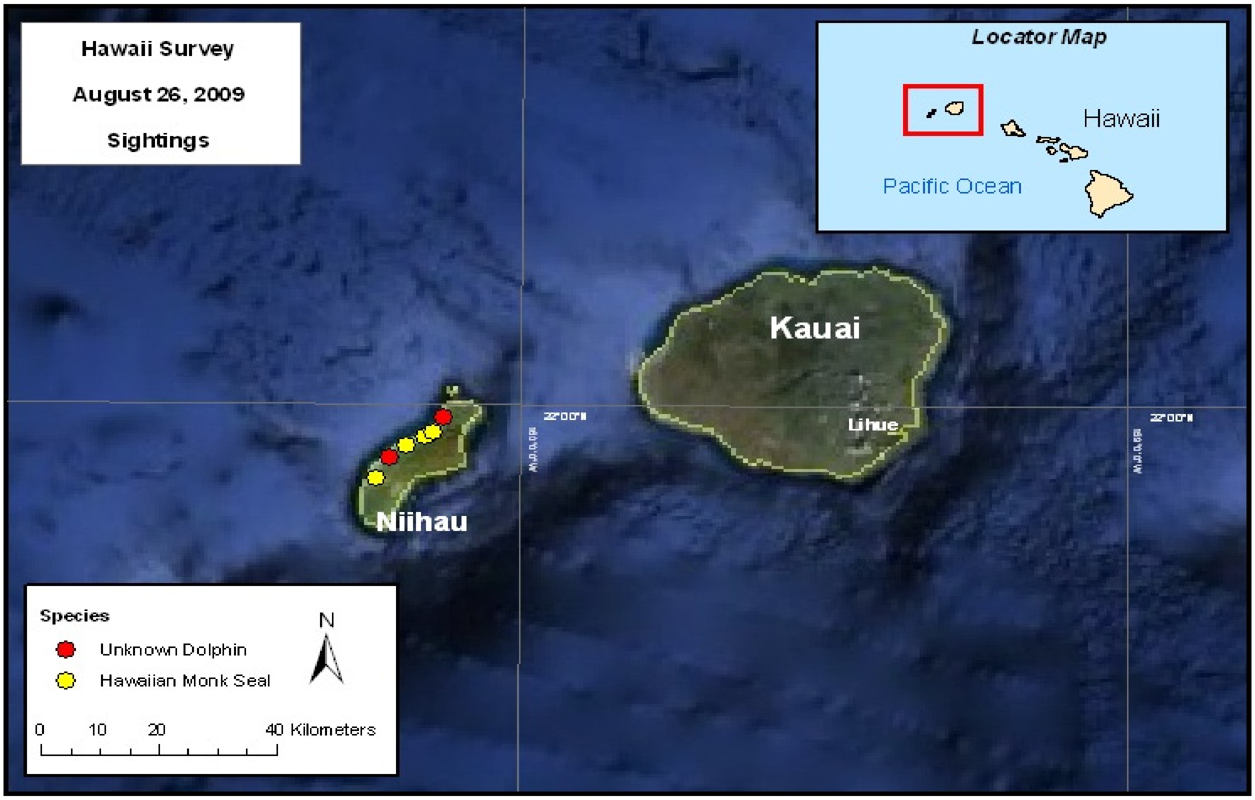


Figure 5. Sightings made on 26 August 2009 off Kauai, Hawaii, before SCC OPS began, while conducting line-transect surveys.

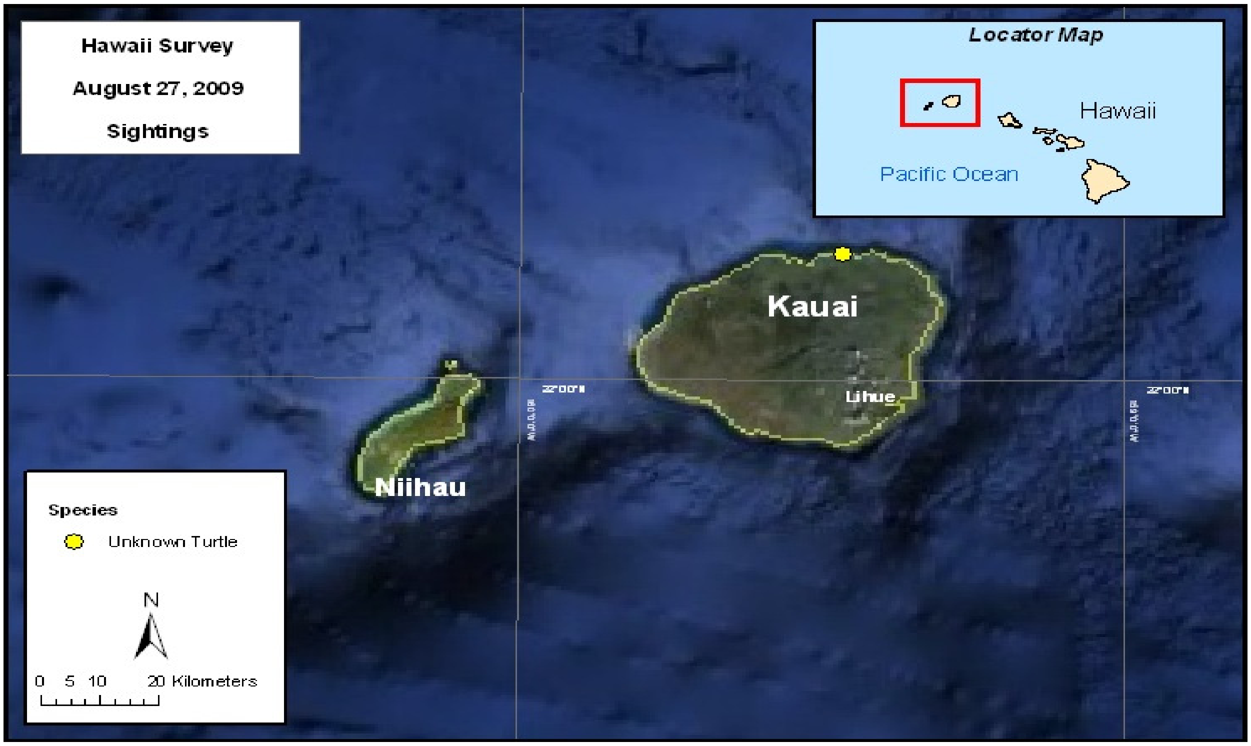


Figure 6. Sightings made on 27 August 2009 during the SCC OPS period off Kauai, Hawaii. Sighting made during transit to/from the *USS Lake Erie*.

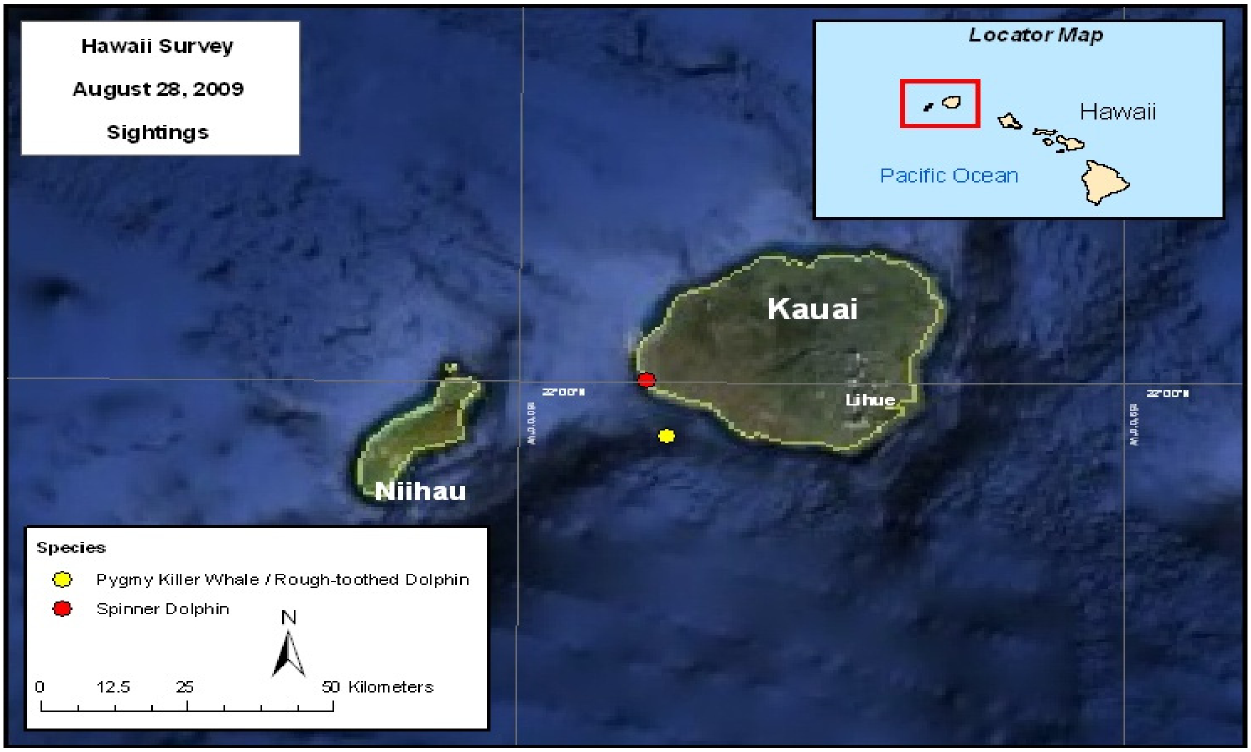


Figure 7. Sightings made on 28 August 2009 during the SCC OPS period off Kauai, Hawaii. All sightings were made during transit to/from the *USS Lake Erie*.

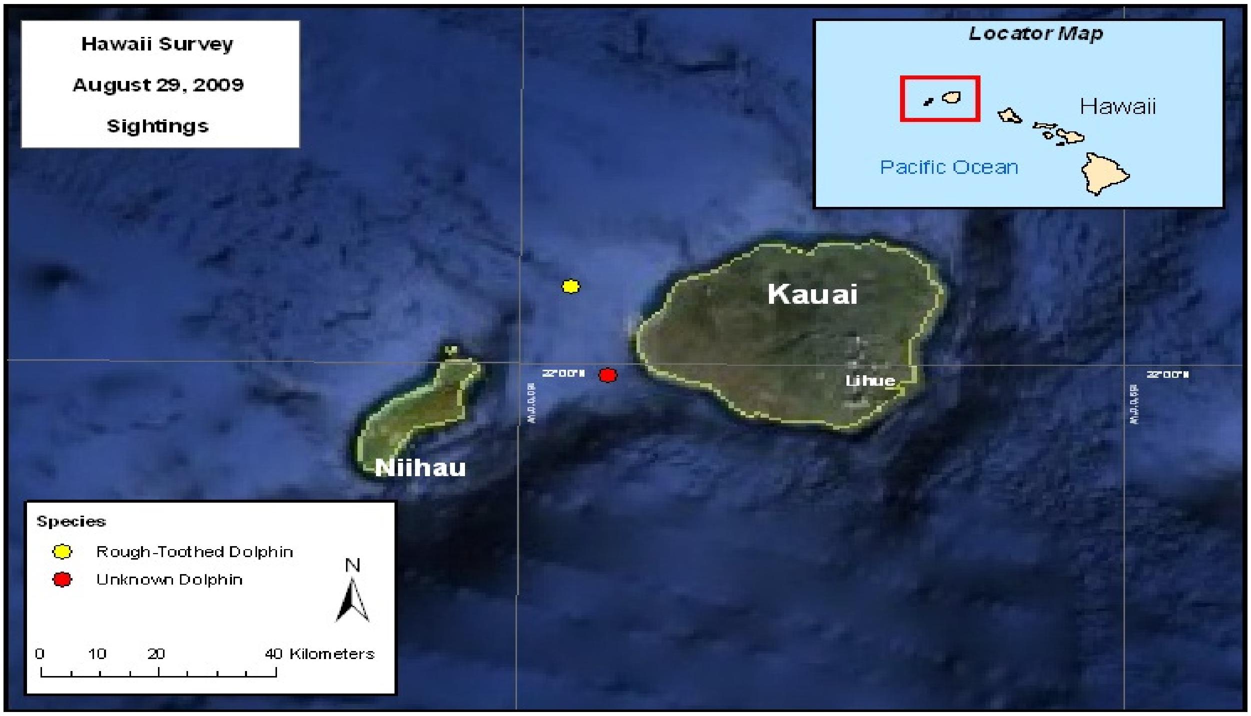


Figure 8. Sightings made on 29 August 2009 during the SCC OPS period off Kauai, Hawaii. All sightings were made during transit to/from the *USS Lake Erie*.

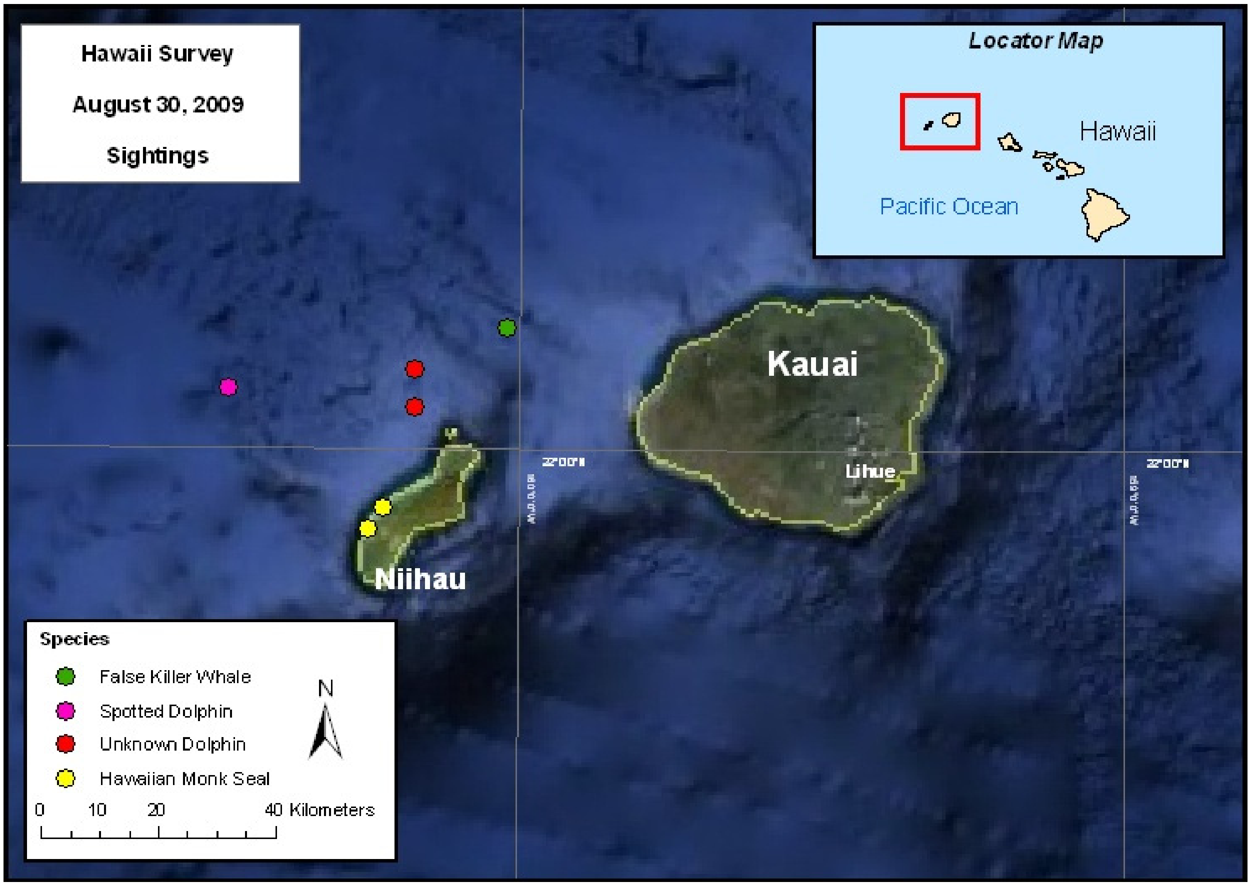


Figure 9. Sightings made on 30 August 2009 off Kauai, Hawaii, after the SCC OPS period, while conducting line-transect surveys.

Section 4 Recommendations

Following are recommendations for future similar MM/ST aerial monitoring efforts during training events. See Smultea and Mobley (2009) for further details and recommendations specifically for SCC OPS monitoring in the HRC. Also see Smultea et al. (2009a,b,c,d) for additional relevant recommendations based on results of aerial monitoring during Major Training Events (MTE) in the SOCAL based on aerial surveys conducted there in fall 2008 and summer 2009.

- In general, the predominant environmental conditions and estimated MM/ST densities in the exposed offshore waters of the area are not conducive to effective monitoring for these species due to high prevailing winds.
- It is highly recommended that this SCC OPS protocol approach be implemented in the Navy SOCAL operating area during a training event. Sighting rates and density of marine mammals are significantly higher throughout the year and the environmental conditions are significantly better for collecting pertinent data in the SOCAL vs. HRC. For example, the sighting rate was ~5-6 sightings per hour of aerial effort in the primary SOCAL range vs. <1 sighting per hour in the offshore waters of the primary HRC SCC OPS area used in

2008-2009. Furthermore, the Bf was >4 for >75% of the SCC OPS aerial monitoring during Aug 2008 and Feb 2009 vs. Bf <4 for >50% of the SOCAL fall 2008 and summer 2009 MTE aerial survey (see Smultea and Mobley 2009; Smultea et al. 2009a,b,c).

- Focal follows should be conducted at altitudes of at least ~1200-1500 ft and radial distances of at least ~1 km (0.5 nm) to avoid and minimize the potential for focal animals to react to the aircraft. This is based on results of the limited available studies of a few cetacean species (mostly whales) as well as preliminary observations during this study and also the recent related results of aerial survey monitoring for the Navy in SOCAL (Smultea et al. 2009b,d). We recommend that the latter protocol be followed unless it can be statistically demonstrated that particular species do not exhibit detectable reactions to the aircraft at closer distances.
- Data collected during this study should be added to previous aerial survey data to permit assessment of any responses on the part of MM/ST to MFAS. These analyses will be important in developing and implementing effective marine mammal monitoring for future planned Navy activities identified for the HRC in the Navy's associated monitoring plans (DoN 2008).

Section 5 Acknowledgements

We are grateful to Navy personnel from US Pacific Fleet Environmental and Naval Facilities Engineering Command Pacific for their support, coordination and facilitation in the implementation of these surveys. Many thanks to the hard working survey and analysis crew consisting of Mark Deakos and Robert Uyeyama. Thank you to Jenelle Black for assistance with document preparation. Also we thank pilots John Sharkey and Reed Fujita of Air Flight Services Honolulu.

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Smultea, M.A., J.R. Mobley, Jr., and K. Lomac-MacNair. 2009d. Aerial survey monitoring for marine mammals off southern California in conjunction with US Navy major training events June 5-11 and July 20-29, 2009 - Final Report. Prepared for Commander, Pacific Fleet. Submitted to Naval Facilities Engineering Command Pacific, EV2 Environmental Planning, Pearl Harbor, HI. Submitted by Marine Mammal Research Consultants, Honolulu, HI, and Smultea Environmental Sciences, LLC., Issaquah, WA, under Contract No. 28H-1087365 issued by California Institute of Technology (CalTech) via Scripps Insitution of Oceanography of the University of California San Diego.

Appendix A. Locations of Marine Mammal and Sea Turtle Sightings Made off Kauai and Niihau during the February 2009 SCC OPS during Aerial Monitoring Surveys.

Date	Time	Count	# Calves	Species Common	Species Latin	Lat ºN	Long ºW
8/26/09	14:14:13	1	0	Monk Seal	*Monachus schauinslandi*	21.94605	160.15157
8/26/09	14:14:31	1	0	Monk Seal	*Monachus schauinslandi*	21.94423	160.15746
8/26/09	14:15:32	1	0	Monk Seal	*Monachus schauinslandi*	21.92728	160.1893
8/26/09	14:18:33	2	0	Monk Seal	*Monachus schauinslandi*	21.87084	160.23619
8/26/09	14:19:56	7	0	Unidentified Dolphin, possible Spinner Dolphin	*Delphinidae,* possible *Stenella longirostris*	21.90682	160.21501
8/26/09	14:27:42	1	0	Monk Seal	*Monachus schauinslandi*	21.94411	160.15627
8/26/09	14:28:17	1	0	Monk Seal	*Monachus schauinslandi*	21.95229	160.14273
8/26/09	14:29:20	2	0	Unidentified Dolphin, possible Bottlenose Dolphin	*Delphinidae,* possible *Tursiops truncatus*	21.97758	160.12608
8/27/09	16:37:07	1	n/a	Unidentified Turtle	Unidentified sea turtle	22.2355	159.46454
8/28/09	08:00:35	50	unk.	Spinner Dolphin	*Stenella longirostris*	22.0031	159.7892
8/28/09	15:14:18	19 mixed	0	Rough-Toothed Dolphin (mixed with Pygmy Killer Whales below)	*Steno bredanensis*	21.90011	159.75417
		5 mixed	1	Pygmy Killer Whale (mixed with Rough-Toothed Dolphins above)	*Feresa attenuata*	21.90011	159.75417
8/29/09	10:40:08	5	1	Rough-Toothed Dolphin	*Steno bredanensis*	22 09.027	159 54.893
8/29/09	11:08:27	15	unk.	Unidentified Dolphin	*Delphinidae*	21 58.639	159 51.127
8/30/09	08:06:54	1	0	False Killer Whale	*Pseudorca crassidens*	22 11.466	160 01.201
8/30/09	08:56:37	2	0	Unidentified Dolphin	*Delphinidae*	22 07.549	160 10.449
8/30/09	09:11:59	12	1	Unidentified Dolphin, possible False Killer Whale	*Delphinidae,* possible *Pseudorca crassidens*	22 03.880	160 10.426
8/30/09	10:27:02	110	unk.	Spotted Dolphin	*Stenella attenuata*	22 05.666	160 28.860
8/30/09	10:48:48	1	0	Monk Seal	*Monachus schauinslandi*	21 54.408	160 13.437
8/30/09	11:11:15	1	0	Monk Seal	*Monachus schauinslandi*	21 52.437	160 14.940

Appendix B. Summary of Behavioral Observations of All Marine Mammal and Sea Turtle Sightings made during the February 2009 SCC OPS aerial monitoring survey off Kauai, Hawaii. (Grp=group, ID=identification, Behav.=behavior, Hdg=heading, mg=magnetic, Min=minimum, Max=maximum, Disp.= dispersal distance between next closest individual in group or subgroup, BL=body lengths, Trav=travel, SAC=surface-active, Unid=unidentified, Bf=Beaufort sea state, Mixed = mixed species group.)

2009 Date	Time	Grp. ID #	Focal Follow?	Grp. Size	# Calf	Species	Reaction/ Change in Behavior?	Initial Behav. State	Other Behav. States	AnimHdg (mg)	Min. Disp. (BL)	Max. Disp. (BL)	Photos?	Video?	Comments
26-Aug	14:14:13	1	N	1	0	Monk Seal	No	Hauled Out	Rest	n/a	n/a	n/a	No	No	
26-Aug	14:14:31	2	N	1	0	Monk Seal	No	Hauled Out	Rest	n/a	n/a	n/a	No	No	
26-Aug	14:15:32	3	N	1	0	Monk Seal	No	Hauled Out	Rest	n/a	n/a	n/a	No	No	
26-Aug	14:18:33	4	N	2	0	Monk Seal	No	Hauled Out	Rest	n/a	1	1	No	No	
26-Aug	14:19:56	5	N	7	0	Unid, Dolphin	No	Mill		n/a	1	15	No	No	Possible spinner dolphin
26-Aug	14:27:42	6	N	1	0	Monk Seal	No	Hauled Out		n/a	n/a	n/a	No	No	
26-Aug	14:28:17	7	N	1	0	Monk Seal	No	Hauled Out		n/a	n/a	n/a	No	No	
26-Aug	14:29:20	8	N	2	0	Unid, Dolphin	No	Travel		200	1	1	No	No	Possible bottlenose dolphin
27-Aug	16:37:07	9	N	1	n/a	Unid, Turtle	No	Resting		n/a	n/a	n/a	No	n/a	
28-Aug	08:00:35	10	N	50	n/a	Spinner Dolphin	Yes/ Change in Behavior State	SAC Mill	SAC Travel	120	1	3	No	No	Changed to SAC travel
28-Aug	15:14:18	11	N	19 Mixed	0	Rough-Toothed Dolphin	Yes/ Change in Behavior State	Travel		300	1	1	Yes	No	Behavioral change was animals staying down more. Mixed group with pygmy killer whales seen at same time.
29-Aug	10:40:08	12	N	5	1	Rough-Toothed Dolphin	No	Mill		n/a	1	20	Yes	No	Feeding observed.
29-Aug	11:08:27	13	N	15	n/a	Unid, Dolphin	No	Mill		n/a	1	6	No	n/a	Unable to circle due to airspace restriction.
30-Aug	08:06:54	14	N	1	0	False Killer Whale	No	Travel		350	n/a	n/a	Yes	No	One photo showing possible fish in mouth underwater.

30-Aug	08:56:37	15	N	2	0	Unid, Dolphin	No	Travel		180	1	1	No	No	
30-Aug	09:11:59	16	N	12	1	Unid, Dolphin	No	Travel		90	1	5	Yes	No	Bird associated, possibly false killer whales, photos seem to show blunt nose, dorsal suggest false killer, pygmy killer, or melon headed but body size and group size would indicate false killer most likely.
30-Aug	10:27:02	17	N	110	n/a	Spotted Dolphin	No	SAC Travel		180	1	4	Yes	No	
30-Aug	10:48:48	18	N	1	0	Monk Seal	No	Hauled Out	Rest	n/a	n/a	n/a	No	n/a	Observed on beach
30-Aug	11:11:15	19	N	1	0	Monk Seal	No	Hauled Out	Rest	n/a	n/a	n/a	No	No	Observed on beach

APPENDIX H Aerial Survey for Marine Mammals and Sea Turtles during SCC February 2010

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

SCC February 16 – 21, 2010

Final Field Report

Submitted to:
NAVFAC Pacific
EV2 Environmental Planning
258 Makalapa Dr., Ste 100
Pearl Harbor, HI 96860-3134

Submitted by:
Marine Mammal Research Consultants (MMRC)
Contract # N62742-10-P-1803

Sept 8, 2010

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Cover Photo: Humpback whales (*Megaptera novaeangliae*) photographed with a telephoto lens from the aircraft during an aerial monitoring survey in Hawaii. Photograph by J. Mobley taken under NOAA Permit No. 642-1536-03 issued to Joseph R. Mobley, Jr. Graphic: K. Lomac-MacNair.

Table of Contents

Section 1 Introduction

Aerial surveys to monitor marine mammals and sea turtles (MM/ST) were conducted in conjunction with the February 2010 US 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 (

Figure 3). Surveys occurred on six consecutive days from 16-21 February 2010 in waters where the guided missile frigate (FFG) *USS Crommelin* and other ships were operating ~100 km (50 nm) west or northwest of Kauai. 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 implemented for monitoring of SCC training events off Kauai in February and August 2009 (Smultea and Mobley 2009a,b).

Prior to the training event the co-Principal Investigator (JM) and pilot (JW) 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 2010 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/or 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 FFG'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 (e.g., Smultea and Mobley 2009a,b) and subsequent data, and analyzed by the Navy.

Survey effort during this training event was of three types (Table 1): a) line transects—following the guidelines of distance sampling theory (Buckland et al., 2001); b) ship follows—flying elliptical orbits in front of the FFG per previous training events (Smultea and Mobley 2009a,b); and c) circumnavigation of islands—flying along the coastlines of Kauai, Niihau and Kaula Island to search for stranded or near stranded MMs. In all cases the mission was to document the presence of MM/STs including species identity, group composition, behavior and any obvious reactions.

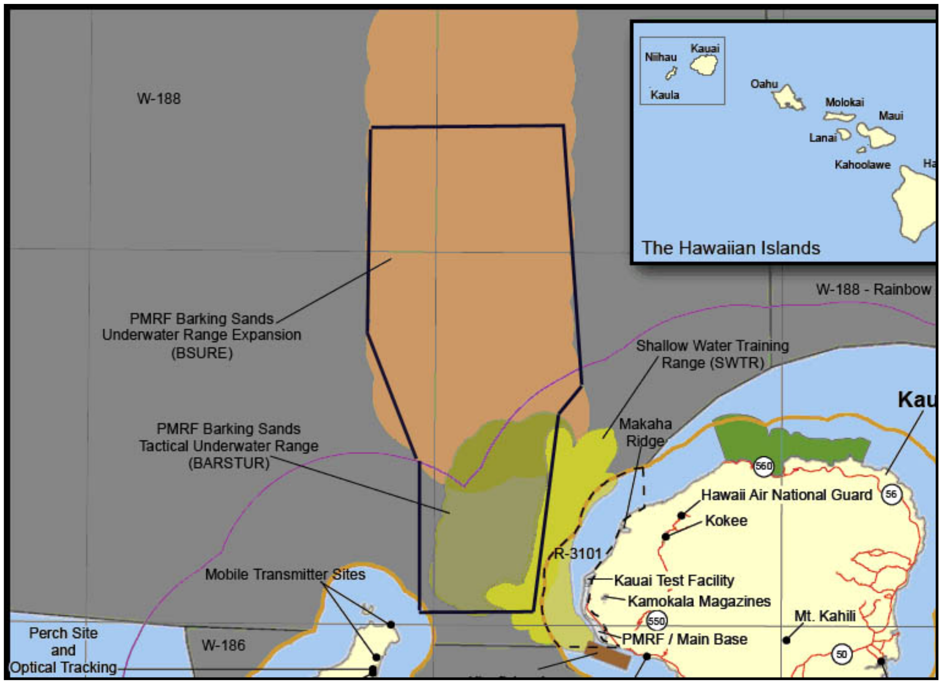

Figure 6. Location of the aerial survey monitoring area in and near the US Navy Pacific Missile Range Facility (PMRF) Range west and northwest of Kauai, Hawaii.

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

Date	**Type of Effort**	**No. Hrs Effort**	**Mean Beaufort Sea State**
2/15/10	Transit from HNL to Kauai	1.00 hr	4.5
2/16/10	Transects	5.36 hrs	4.0
2/17/10	AM: Transects PM: the FFG	3.61 hrs 3.26 hrs	6.0 6.0
2/18/10	the FFG	5.83 hrs	5.0
2/19/10	the FFG	6.26 hrs	4.9
2/20/10	Transects	4.90 hrs	3.5
2/21/10	Circumnavigate Kauai, Niihau & Kaula Island	2.80 hrs	2.1
	TOTAL:	**32.99 hrs**	**Mean: 4.5**

Section 2 Methods

Monitoring effort followed protocol first implemented in previous SCC training events (see Smultea and Mobley 2009a,b for details). The approach involved flying elliptical-shaped patterns in advance of the Navy vessel (FFG) that extended from the front of the ship (~200 m) out to ~2500 m) over a width of ~4 km. When range and/or safety conditions precluded accompanying the FFG, focal follows were conducted opportunistically when target species were sighted off range.

> Surveys were conducted from a small fixed-wing Partenavia P68 Observer flying at 100 knots (kt) groundspeed and an altitude of ~305m (1000 ft), unless the pilot was directed to fly at alternate altitudes by flight controllers for safety reasons. Observations from the monitoring aircraft involved five personnel including the pilot and copilot, plus two biologist observers and one data recorder/videographer. Survey crew and pilot were not informed as to the status of MFAS transmissions which minimized potential for observational bias. When target species 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 taken at the start of each transect leg and when conditions changed. Positional data via GPS were automatically recorded every 10-sec and manually when sightings occurred.

When candidate 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 457m (1500 ft), an altitude shown to minimize reactivity to fixed wing aircraft (Smultea, Kieckhefer & Bowles, 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, as well as digital photos, will be made available to the Navy for subsequent behavioral analysis.

Overall survey effort was divided into three modalities as summarized below:

a) <u>transect surveys</u> (16-20 Feb 2010)—predetermined transects (Figure 3) were followed using accepted distance sampling methods (Buckland et al., 2001) with the goal of determining incidence, distribution and relative abundance of target species in the area;

b) <u>ship follows</u> (17-19 Feb 2010)—involved flying elliptical orbits in front of the FFG (Figure 4) with the goal of finding target species in the vicinity of the FFG and observing and recording their behavior using focal follow methods (Altmann, 1974);

c) circumnavigation surveys (21 Feb 2010)—following the SCC event, the aircraft flew along the coastlines of Kauai, Niihau and Kaula islands (Figure 5) looking for target species along the shoreline as well as any stranded or near stranded marine mammals.

Section 3 Results

Effort

The survey aircraft accompanied the FFG for 7.8 hours (24%) of the total 33 hrs of flight time (Table 2). The remaining 25.2 hrs (76%) while not with the FFG involved performing survey transects, circumnavigating Kauai, Niihau and Kaula Island, as well as transiting between the FFG's location and Lihue, Kauai (see Figures 3-5). The aircraft was considered "with the FFG" upon commencement of elliptical orbits around the ship's location (Figure 4). These ship follows occurred on Feb. 17-19 at distances of approximately 25-70 km offshore of Kauai where the highest Beaufort sea state conditions were encountered (Table 1). As a result, sighting probabilities were low. Thus the fact that only one pod of humpback whales was seen in the vicinity of the ship (Table 2, Figure 4) should not be construed as evidence of absence of MM/ST in the area.

Effects of Sea State on Sighting Probabilities

Effects of seastate. The majority of overall effort (63%) was spent in poor sea state conditions (i.e., Beaufort 5-6) (Figure 2). The majority of sightings (61%), on the other hand, tended to occur in more favorable sea state conditions (i.e., Beaufort 1-4). This pattern is consistent with known effects of sea state on sighting probabilities (Buckland et al., 2001).

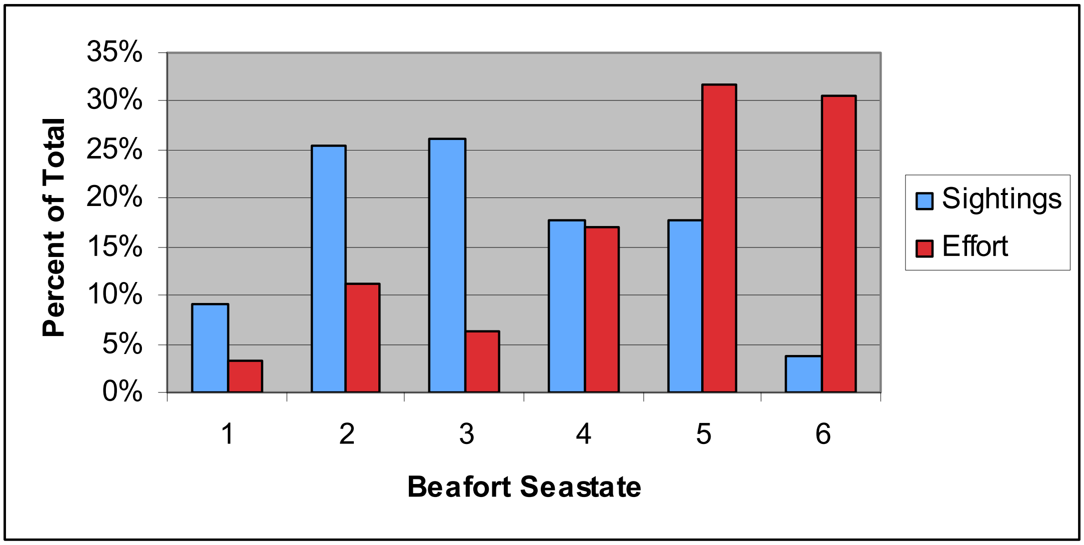

Figure 2. Beaufort sea state conditions for total effort and for sightings.

Table 2. Effort with and not with FFG

Date	Time Wheels Up	Time Wheels Down	Total Flight Hours	Period not with FFG	Total Hours not with FFG	Period with FFG	Total Hours with FFG	No. Sightings With FFG (# groups)	No. Sightings Away from FFG (# groups)
2/15/2010	15:20:30	16:20:30	1:00:00	15:20:30-16:20:30	1:00:00	n/a	n/a	n/a	7
2/16/2010	7:30:30 12:00:00	10:40:00 14:12:00	3:09:30 2:12:00	7:30:30-10:40:00 12:00:00-14:12:00	5:21:30	n/a	n/a	n/a	71
2/17/2010	7:18:30 12:35:00	10:55:00 15:50:30	3:36:30 3:15:30	7:18:30-10:55:00 12:35:00-13:13:30 15:22:30-15:50:30	4:43:00	13:13:30-15:22:30	2:09:00	0	7
2/18/2010	7:30:30 12:35:00	10:55:00 15:00:00	3:24:30 2:25:00	7:30:30-8:17:30 10:19:30-10:55:00 12:35:30-13:13:30 14:39:30-15:00:00	2:21:30	8:17:30-10:19:30	2:02:00	0	16
2/19/2010	7:29:30 12:43:00	11:25:00 15:02:30	3:55:30 2:19:30	7:30:00-7:59:59 10:56:36-11:25:00 12:43:30-13:22:45 14:11:30-15:02:30	2:28:38	7:59:59-10:56:36 13:22:45-14:11:30	3:35:22	1	30
2/20/2010	7:33:00	12:27:00	4:54:00	7:33:00-12:27:00	4:54:00	n/a	n/a	n/a	58
2/21/2010	8:57:34	11:45:20	2:47:46	8:57:34-11:45:20	2:47:46	n/a	n/a	n/a	115
Total			**32:59:46**		**25:13:24**		**7:46:22**	**1**	**304**

Sightings

A total of 304 sightings were made during the six days of surveys (Table 3). The majority (88%) of these sightings were of humpback whales. Most of the latter were observed in shallower areas (<1000 fathoms) shown to be preferred habitat of humpbacks based on past survey results (e.g., Mobley 2004). Of the 265 sightings of humpback whales (Table 3), 115 were seen during transect surveys. When converted to sighting rates, the result is .044 humpback sightings/km effort. This represents more than twice the sighting rate for humpbacks seen north of Kauai during the 2006 NPAL surveys, .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, Bauer & Herman 1999; Mobley 2004; Calambokidis et al. 2008).

The remaining sightings of positively identified species consisted of odontocete species, specifically spinner dolphins, spotted dolphins, bottlenose dolphins, striped dolphins, pilot whales and false killer whales. All of these are typically found in Hawaiian waters (Mobley et al. 2000; Barlow 1996), though false killer whales may be decreasing in numbers (Reeves, Leatherwood & Baird 2009). The total of 17 odontocete sightings recorded during the transect survey portion converts to a sighting rate of .007 odontocete sightings / km effort. This is approximately the same as the .006 sightings/km effort reported for the same region during 2002 surveys on the PMRF instrumented range (Mobley 2004).

A total of 12 sightings of unidentified sea turtles were recorded, all of which were observed in the shallow coastal waters of Kauai, where the animals could be readily observed against the light sandy bottom. Although Hawaiian monk seals were recorded on previous surveys in this region (e.g., Smultea, Mobley & Lomac-MacNair, 2009a), no monk seals were seen during this survey series either swimming or hauled out onshore.

Only one sighting, consisting of a pod of two humpback whales, was sighted in the vicinity of the FFG (Figure 4). This pod became the subject of a focal follow session described in the next section.

Observations across the six 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 near-shore aggregations of marine mammals. The circumnavigation of islands (Feb. 21) similarly revealed no stranded or near stranded animals. Evidence regarding possible effects is further summarized in the next section.

Table 3. Summary of Sightings by Species With and Away From *USS* the FFG

	With *USS* the FFG		**Away from *USS* the FFG**		**Total**	
Species	**No. Grps**	**No. Indiv.**	**No. Grps**	**No Indiv.**	**No. Grps**	**No. Indiv.**
Humpback Whale (*Megaptera novaeangliae*)	1	2	264	465 (9 calves)	265	467 (9 calves)
Bottlenose Dolphin (*Tursiops truncatus*)	0	0	2	10	2	10
False Killer Whale (*Pseudorca crassidens*)	0	0	1	12	1	12
Pilot Whale (*Globicephala macrorynchus)*	0	0	1	2	1	2
Spinner Dolphin (*Stenella longirostris*)	0	0	4	179	4	179
Spotted Dolphin (*Stenella attenuata*)	0	0	1	1	1	1
Striped Dolphin (*Stenella coeruleoalba*)	0	0	1	60	1	60
Unidentified Blackfish	0	0	1	6	1	6
Unidentified Cetacean	0	0	2	5	2	5
Unidentified Dolphin (*Delphinidae*)	0	0	7	163	7	163
Unidentified Whale	0	0	3	3	3	3
Unidentified Sea Turtle	0	0	12	31	12	31
Total	**1**	**2**	**304**		**304**	

*includes transits, circumnavigation, & transect surveys

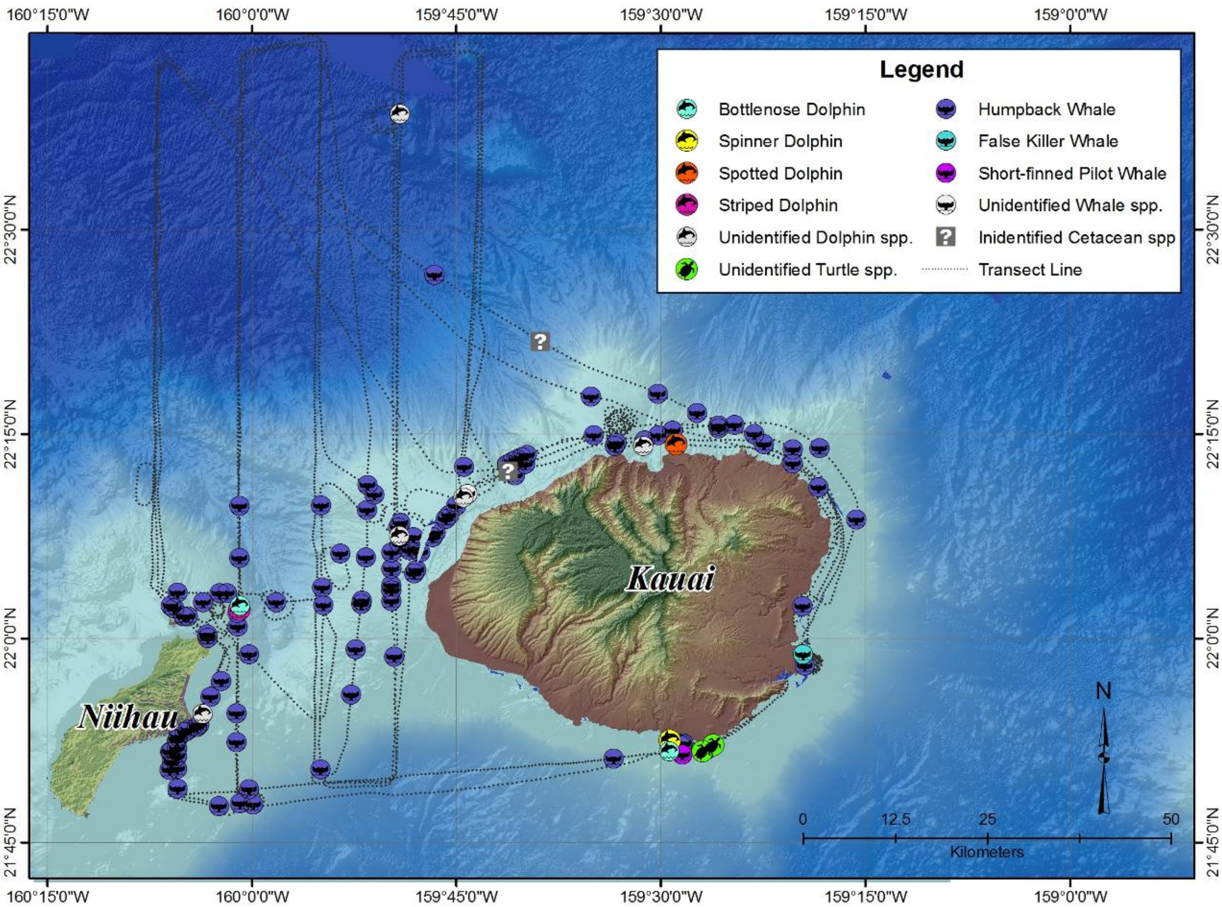

Figure 3. Effort and locations of sightings made during transect portions of MM/ST survey (16-20 Feb 2010) SCC aerial monitoring survey off Kauai, Hawaii. On these days, the survey aircraft followed predetermined transects consisting of north-south systematic lines ~10km apart with random lines connecting the endpoints. Area of coverage is approximately 1,344 sq nm or 4,610 sq km. Lighter shading indicates shallower water (<1000 fathoms).

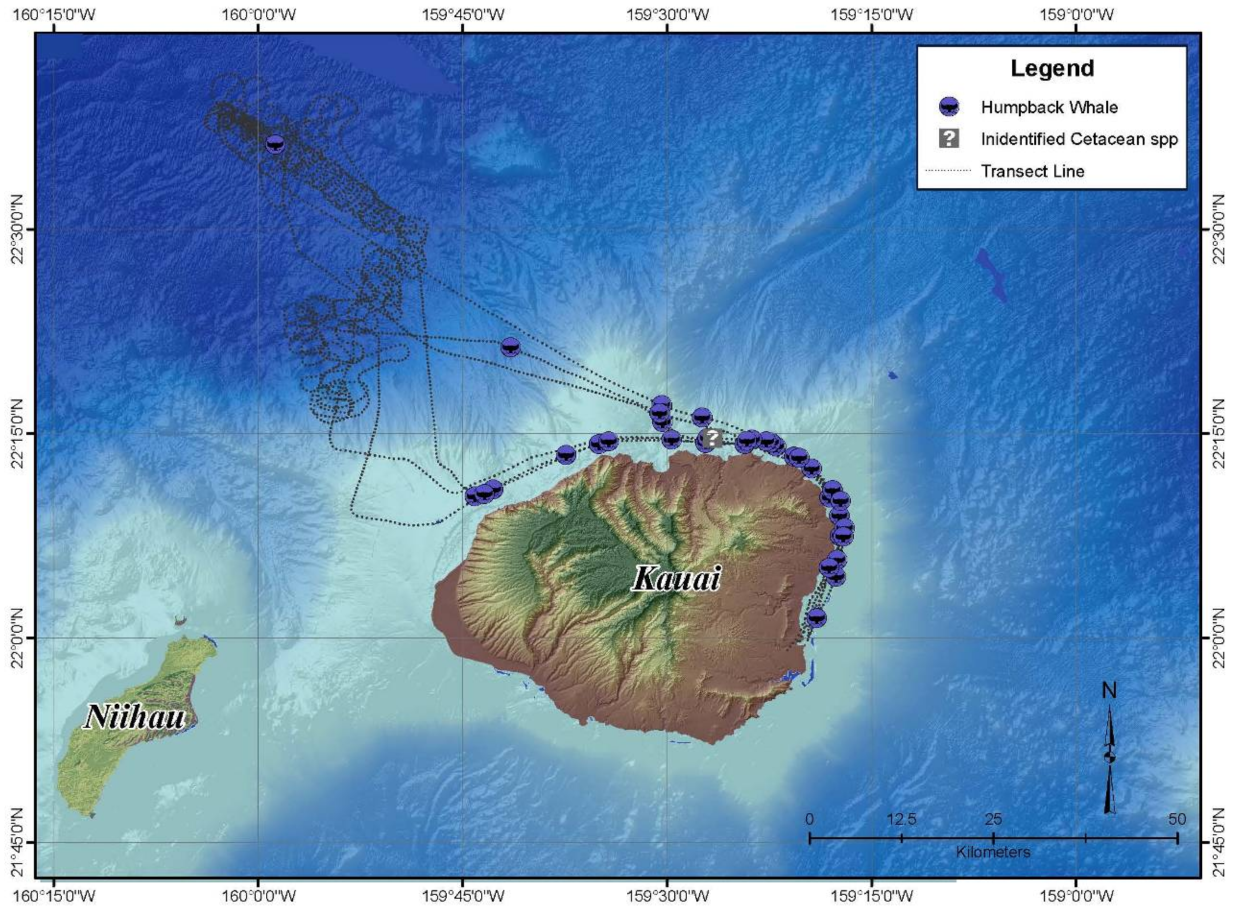

Figure 4. Effort and sighting locations during days involving ship follows with the FFG (17-19 Feb 2010). Nearly all sightings occurred during transits between Lihue and the ship's position. One sighting of a pod of two humpback whales occurred in the vicinity of the FFG (19 Feb 2010; shown in northwest corner) which became the target of a focal follow session with videotape.

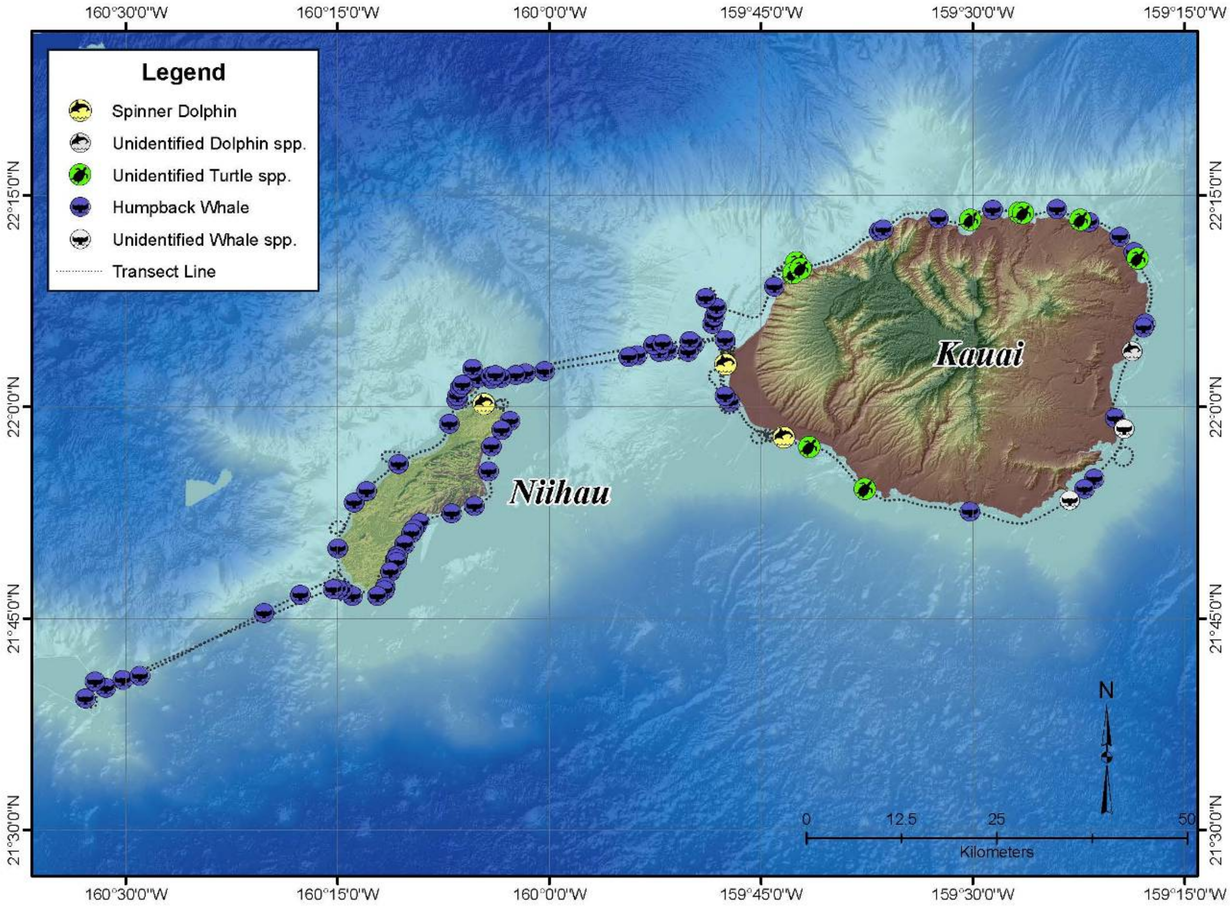

Figure 5. Effort and sighting locations during circumnavigation of the islands of Kauai, Niihau and Kaula Island (west southwest of Niihau) (21 Feb 2010). Species positive identified included spinner dolphins and humpback whales, in addition to unidentified turtle, whale and delphinid species.

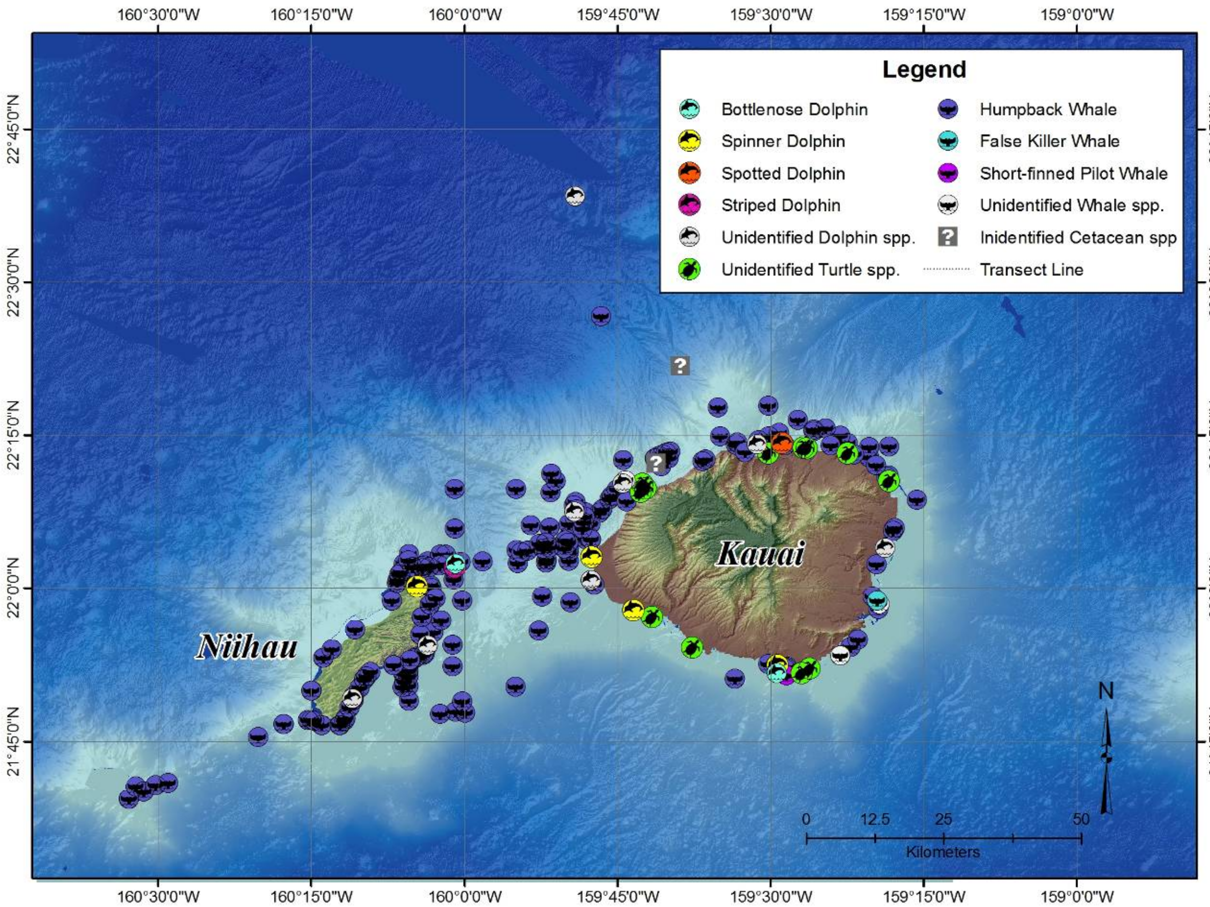

Figure 6. All sightings combined. Locations of sightings from all three survey modalities combined (transect, ship follow and circumnavigation).

Focal Follows

Focal follows were conducted while circling at an altitude of ~1000-1500 ft and a lateral distance of ~1 km (summarized in Table 4). Only one focal behavioral follow was conducted while monitoring near the FFG (Feb 19) involving a pod of two humpback whales. At closest proximity, the pod was located within 1-2 km of the ship, and was observed for a total period of approximately 46 min; however the whales were not in view the entire time due to either high sea state or when 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.

Two additional focal follows were initiated, including a surface active pod of 8-9 humpbacks off the northwest Kauai coast engaged in competitive behavior that were observed for a total of 11 min. A third focal follow involved a pod of approx 12 false killer whales sighted immediately upon take-off from Lihue Airport, Kauai. This session had to be curtailed after two minutes for safety reasons since the survey plane was in the path of approaching aircraft.

In all cases, behavior was called out in real time and recorded onto the audio of the digital videocam. The digital video files (as well as still photos) will be made available to the Navy for subsequent behavioral analysis.

Table 4. Summary of Video Log for Focal Follows (see detailed behavior summary in Appendix C)

Date	Near the FFG?	Time Start	Time End	Total Length (min)	Behavior	Species	Comp (# indiv)	Quality
18-Feb	No	10:31:21	10:42:15	~11:00	Surface active, Affiliation, competitive, travelling	Humpback whales	8-9	Fair
19-Feb	Yes	10:07:00	10:53	~46:00	Surface active, Travel NW	Humpback whales	2	Fair
20-Feb	No	7:40	7:42	~2:00	fast travel	False killer whales	~12	Poor

Communications

Communications were reliably established between the survey aircraft and the FFG using aviation band VHF radios broadcasting on 123.45 MHz. The NTR used a handheld aviation VHF radio while on the bridge wing of the FFG. 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, with the exception of Kaula Island, which was beyond the range of communications (see Recommendations). Daily locations of the FFG were usually communicated via cell phone from Navy POCs to the PI (JM) before the observer aircraft left the Lihue airport and/or once in the air via PMRF Range Control or Outrider Bravo.

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 dealt with using an aggregate index such as "overall sightings per km" reported earlier. The observed sighting rates for humpbacks (.044 sightings/km) suggest that humpbacks were present in the target area at higher densities than previously reported for this area (Mobley, 2006), consistent with reports of an increasing winter population (Calambokidis et al. 2008; Mobley 2004). The sighting rate for odontocetes (.007 sightings/km) was slightly higher than that reported earlier for the same region with no training events ongoing (Mobley 2004) implying that odontocetes were present in the area consistent with previous baseline densities. It is recommended that the presence/absence criterion not be applied on a species-by-species basis due to the normal variability of species seen from survey to survey; i.e., the presence or absence of a given species for all except the most abundant species (i.e., humpbacks) is uninformative.

b) Distribution/redistribution—the same principle described above applies to assessing changes in distribution as well; i.e., changes in distribution can only be reliably detected for the most abundant species, e.g., seasonally present humpbacks in this case. If one examines the locations of humpbacks observed in this survey series (Figure 6), it is clear that they were seen throughout their normal preferred habitat of shallow, coastal regions. 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 as well are 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 ≥ 457 m). In that way one can discern changes in respiration rates, dive times, etc., that may 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, as well as detailed behavioral logs (Appendix C).

d) Injury and/or mortality—Injury and/or mortality is readily discernible for each of the target species due to marked reduction or cessation of locomotion as well as via 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 and/or mortality for any of the target species observed before, during or after the training event.

Given the caveats noted above, overall there were no direct observations of adverse effects of the training event. As concerns the effects of sonar, since the status of MFAS transmissions throughout the survey period were unknown, any specific response of the animals observed to such transmissions would require more detailed behavioral analyses by the Navy. The time-stamped audio/video files from the focal follows will be provided to the Navy in order 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 2009a) and as revised in the Pacific Fleet Annual Monitoring Report (DoN 2009b).

Section 5 Recommendations

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

1) Continue focal follow approach at non-reactive altitudes (e.g., > 457 m)—In contrast to ship-based platforms (other than sailboats) where engine noise can be

detectible over relatively large distances, survey aircraft can be flown at altitudes sufficient to attenuate engine noise to non-reactive levels. Altitudes of 457 m (1500 ft) or higher have been shown to be effective in this regard (e.g., Smultea, Kieckhefer and Bowles, 1995). Thus any observed effects can be attributed to sources other than the observation platform itself.

2) 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 Hawaii Range Complex (HRC) the more abundant species include the seasonally present humpbacks, as well as 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.

3) 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.

4) Consider revising goal of detecting "presence/absence" to focus primarily on aggregate indices such as sighting rates (e.g., sightings/km). For reasons noted above, applying a presence/absence criterion on a species by species basis, except for the most abundant species (e.g., wintering humpbacks), is not a defendable approach.

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

6) For aircraft surveys, remove Kaula Island from the list of regions to be surveyed—Communications were reliably established throughout the survey range, with the exception of Kaula Rock located 25 nmi southwest of Niihau. For safety reasons it is recommended that this location not be included in future aircraft survey SOWs.

Section 6 Acknowledgements

We are grateful to Navy personnel from US 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 the hard working survey crew consisting of Aliza Milette and Kim Valentine, and to our pilot John Weiser and co-pilot Frank Colburn.

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Appendices—Guide to Species:

Species Code	Species (Latin name)
GM	short-finned pilot whale (*Globicephala macrorhynchus*)
MN	humpback whale (*Megaptera novaeangliae*)
PC	false killer whale (*Pseudorca crassidens*)
SA	spotted dolphin (*Stenella attenuata*)
SC	striped dolphin (*Stenella coeruleoalba)*
SL	spinner dolphin (*Stenella longirostris*)
TT	bottlenose dolphin (*Tursiops truncatus)*
UB	unidentified blackfish spp
UC	unidentified cetacean spp.
UD	unidentified dolphin spp.
UW	unidentified whale spp.
UT	unidentified sea turtle spp.

Appendix A: Summary of Sightings with Positions (GPS)

Date	Time	Species	Composition (# Indivs)	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
2/15/2010	15:38:30	MN	2	GPS malfunction			
2/15/2010	15:51:30	MN	1	GPS malfunction			
2/15/2010	15:52:40	MN	1	GPS malfunction			
2/15/2010	16:09:30	MN	1	GPS malfunction			
2/15/2010	16:13:30	MN	1	GPS malfunction			
2/15/2010	16:18:50	MN	2	GPS malfunction			
2/15/2010	16:19:06	MN	2	GPS malfunction			
2/16/2010	7:44:30	MN	2	22	14.244	159	20.983
2/16/2010	7:45:30	MN	2	22	14.983	159	23.149
2/16/2010	7:46:35	MN	2	22	15.410	159	25.781
2/16/2010	7:50:40	MN	1	22	14.922	159	34.931
2/16/2010	7:52:50	MN	3	22	13.435	159	39.817
2/16/2010	7:53:00	MN	1	22	13.273	159	40.188
2/16/2010	7:53:10	MN	1	22	13.107	159	40.558
2/16/2010	7:53:12	MN	1	22	12.937	159	40.926
2/16/2010	7:53:20	MN	1	22	12.937	159	40.926
2/16/2010	7:53:23	MN	1	22	12.758	159	41.290
2/16/2010	7:53:24	MN	1	22	12.758	159	41.290
2/16/2010	7:53:30	MN	2	22	12.758	159	41.290
2/16/2010	7:55:00	UW	1	22	10.600	159	44.195
2/16/2010	7:55:10	UD	1	22	10.312	159	44.481
2/16/2010	7:55:30	MN	1	22	9.698	159	45.012
2/16/2010	7:55:50	MN	1	22	9.053	159	45.528
2/16/2010	7:56:00	MN	1	22	8.736	159	45.785
2/16/2010	7:56:30	MN	2	22	7.735	159	46.505
2/16/2010	7:56:35	MN	3	22	7.402	159	46.748
2/16/2010	7:57:30	MN	1	22	6.468	159	48.448
2/16/2010	7:58:30	MN	1	22	8.137	159	49.266
2/16/2010	7:58:40	MN	1	22	8.448	159	49.088
2/16/2010	8:28:25	UD	20	22	37.356	159	49.385
2/16/2010	8:50:30	MN	4	22	6.277	159	49.755
2/16/2010	8:51:00	MN	2	22	5.088	159	49.771
2/16/2010	8:51:30	MN	2	22	3.890	159	49.770
2/16/2010	8:51:40	MN	1	22	3.495	159	49.767
2/16/2010	8:52:00	MN	1	22	2.702	159	49.759
2/16/2010	8:53:40	MN	2	21	56.152	159	49.490
2/16/2010	9:04:30	MN	1	21	55.842	159	52.719
2/16/2010	9:06:25	MN	4	21	59.187	159	52.368
2/16/2010	9:08:30	MN	4	22	2.497	159	51.984
2/16/2010	9:08:40	MN	2	22	2.775	159	51.939
2/16/2010	9:10:30	MN	3	22	5.937	159	51.650
2/16/2010	9:12:30	MN	1	22	9.403	159	51.551
2/16/2010	9:13:30	MN	1	22	11.231	159	51.510

Appendix A: (cont.)

Date	Time	Species	Composition (# Indivs)	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
2/16/2010	9:52:40	MN	1	22	9.715	160	0.903
2/16/2010	9:56:50	MN	1	22	1.832	160	1.041
2/16/2010	9:57:20	MN	1	22	0.862	160	1.027
2/16/2010	10:01:40	MN	1	21	52.351	160	1.128
2/16/2010	10:19:30	MN	5	21	51.756	159	29.790
2/16/2010	10:25:30	GM	2	21	52.312	159	28.763
2/16/2010	10:27:30	MN	2	21	52.277	159	28.357
2/16/2010	10:30:30	MN	1	21	52.013	159	29.137
2/16/2010	10:30:30	TT	2	21	52.013	159	29.137
2/16/2010	10:34:30	SL	50	21	52.539	159	28.966
2/16/2010	12:07:30	UT	1	21	52.135	159	26.139
2/16/2010	12:07:45	MN	2	21	51.798	159	26.661
2/16/2010	12:08:00	UT	1	21	51.687	159	26.947
2/16/2010	12:11:50	MN	1	21	51.148	159	33.463
2/16/2010	12:28:25	MN	12	21	48.908	160	0.193
2/16/2010	12:29:30	MN	4	21	47.885	160	0.854
2/16/2010	12:30:30	MN	2	21	48.421	159	59.432
2/16/2010	12:37:30	MN	2	21	50.332	160	5.791
2/16/2010	12:37:50	MN	1	21	50.853	160	5.869
2/16/2010	12:38:15	MN	2	21	51.641	160	5.914
2/16/2010	12:40:00	MN	1	21	53.641	160	3.853
2/16/2010	12:44:30	MN	5	21	58.791	160	0.200
2/16/2010	12:53:30	MN	1	22	2.442	159	54.766
2/16/2010	12:55:40	MN	1	22	2.652	159	58.227
2/16/2010	13:04:15	MN	1	22	3.297	160	1.836
2/16/2010	13:04:35	MN	2	22	3.306	160	2.385
2/16/2010	13:06:30	MN	2	22	3.325	160	5.428
2/16/2010	13:55:30	MN	2	22	14.324	159	33.247
2/16/2010	13:56:30	MN	2	22	14.539	159	31.171
2/16/2010	13:57:00	MN	3	22	14.897	159	30.172
2/16/2010	13:57:30	MN	3	22	15.237	159	29.153
2/16/2010	13:59:00	MN	1	22	15.595	159	25.762
2/16/2010	13:59:30	MN	1	22	15.671	159	24.598
2/16/2010	14:02:30	MN	1	22	13.931	159	18.374
2/16/2010	14:05:30	MN	2	22	8.689	159	15.671
2/17/2010	9:43:06	MN	1	21	47.674	160	2.397
2/17/2010	9:46:39	MN	1	21	50.306	160	6.027
2/17/2010	9:47:36	MN	1	21	51.656	160	5.974
2/17/2010	10:41:56	MN	1	22	17.735	159	35.124
2/17/2010	12:46:30	MN	1	22	14.248	159	24.826
2/17/2010	12:52:24	MN	3	22	15.004	159	33.586
2/17/2010	15:44:30	MN	1	22	4.909	159	18.048
2/18/2010	7:36:50	MN	3	22	7.903	159	16.949
2/18/2010	7:40:12	MN	4	22	13.094	159	20.251
2/18/2010	7:42:27	MN	1	22	14.492	159	23.954

Appendix A: (cont.)

Date	Time	Species	Composition (# Indivs)	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
2/18/2010	7:43:48	MN	3	22	14.702	159	26.489
2/18/2010	7:49:05	MN	3	22	13.525	159	36.361
2/18/2010	7:49:18	MN	1	22	13.371	159	36.648
2/18/2010	7:51:02	MN	2	22	11.974	159	40.107
2/18/2010	8:01:00	MN	1	22	15.954	159	50.068
2/18/2010	10:30:19	MN	8	22	13.543	159	38.272
2/18/2010	12:43:05	MN	5	22	8.976	159	17.384
2/18/2010	12:53:44	MN	1	22	14.223	159	35.037
2/18/2010	12:58:15	MN	1	22	10.409	159	44.144
2/18/2010	14:45:30	MN	2	22	19.354	159	40.221
2/18/2010	14:48:56	MN	1	22	15.632	159	30.153
2/18/2010	14:52:53	MN	2	22	10.308	159	18.126
2/18/2010	14:54:30	MN	1	22	7.142	159	17.416
2/19/2010	7:43:29	MN	1	22	14.251	159	26.477
2/19/2010	7:44:39	MN	3	22	14.498	159	28.976
2/19/2010	10:00:10	MN	2	22	36.802	159	57.876
2/19/2010	11:13:30	MN	5	22	17.577	159	31.465
2/19/2010	11:14:52	MN	1	22	16.461	159	28.592
2/19/2010	11:17:23	MN	3	22	14.614	159	23.104
2/19/2010	11:18:04	MN	3	22	13.901	159	21.725
2/19/2010	11:18:49	MN	2	22	12.878	159	20.073
2/19/2010	11:20:52	MN	1	22	9.249	159	17.228
2/19/2010	11:21:52	MN	1	22	6.862	159	17.125
2/19/2010	12:46:03	MN	3	22	0.984	159	19.234
2/19/2010	12:48:07	MN	3	22	3.721	159	17.931
2/19/2010	12:49:54	MN	2	22	6.640	159	17.153
2/19/2010	12:53:42	MN	2	22	12.572	159	19.605
2/19/2010	12:54:55	MN	2	22	13.946	159	21.476
2/19/2010	12:55:06	MN	1	22	14.108	159	21.776
2/19/2010	12:55:07	MN	2	22	14.108	159	21.776
2/19/2010	12:55:32	MN	1	22	14.430	159	22.761
2/19/2010	12:57:00	MN	2	22	14.610	159	25.967
2/19/2010	12:57:01	MN	1	22	14.610	159	25.967
2/19/2010	13:00:30	MN	1	22	14.567	159	33.602
2/19/2010	13:01:58	MN	3	22	13.760	159	36.380
2/19/2010	13:04:38	MN	2	22	11.438	159	41.824
2/19/2010	13:05:00	MN	1	22	10.919	159	42.793
2/19/2010	14:42:31	MN	1	22	21.673	159	42.354
2/19/2010	14:48:32	MN	2	22	16.944	159	31.520
2/19/2010	14:52:05	MN	1	22	14.670	159	24.759
2/19/2010	14:56:00	MN	1	22	11.371	159	18.313
2/19/2010	14:56:28	MN	1	22	10.862	159	17.886
2/19/2010	14:58:40	MN	1	22	5.935	159	17.771
2/20/2010	7:34:34	PC	12	21	58.698	159	20.580
2/20/2010	7:34:34	MN	2	21	58.698	159	20.580

Appendix A: (cont.)

Date	Time	Species	Composition (# Indivs)	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
2/20/2010	8:13:50	SA	1	22	14.257	159	28.866
2/20/2010	8:15:00	UD	6	22	14.133	159	31.318
2/20/2010	8:16:00	MN	1	22	14.099	159	33.359
2/20/2010	8:43:39	MN	2	22	12.764	159	39.968
2/20/2010	8:45:36	MN	1	22	11.943	159	40.678
2/20/2010	8:45:58	UC	3	22	12.236	159	41.198
2/20/2010	8:48:00	MN	2	22	12.564	159	44.432
2/20/2010	9:27:30	UD	4	22	7.501	159	49.181
2/20/2010	9:27:48	MN	1	22	6.901	159	49.145
2/20/2010	9:29:30	MN	2	22	4.769	159	48.114
2/20/2010	9:29:41	MN	2	22	5.236	159	47.773
2/20/2010	9:30:28	MN	1	22	6.315	159	47.658
2/20/2010	9:32:46	MN	1	22	7.439	159	48.150
2/20/2010	9:33:13	MN	1	22	6.552	159	48.027
2/20/2010	9:36:40	MN	1	22	0.540	159	48.657
2/20/2010	9:45:24	MN	2	21	50.356	159	54.974
2/20/2010	9:53:00	MN	1	22	3.732	159	54.846
2/20/2010	9:55:20	MN	1	22	6.210	159	53.489
2/20/2010	10:00:38	MN	1	22	9.767	159	54.920
2/20/2010	10:05:50	MN	1	22	10.521	159	51.015
2/20/2010	10:47:38	MN	1	22	5.861	160	0.919
2/20/2010	10:49:30	TT	8	22	2.393	160	0.877
2/20/2010	10:49:31	SC	60	22	2.075	160	0.912
2/20/2010	10:52:11	MN	2	22	2.640	160	3.574
2/20/2010	10:55:15	MN	1	22	1.580	160	4.677
2/20/2010	10:56:29	MN	2	22	0.023	160	3.226
2/20/2010	11:06:50	MN	2	21	55.699	160	1.117
2/20/2010	11:07:22	MN	1	21	54.486	160	1.137
2/20/2010	11:13:57	MN	1	21	48.946	160	5.453
2/20/2010	11:14:49	MN	2	21	50.413	160	5.491
2/20/2010	11:15:20	MN	1	21	51.323	160	5.496
2/20/2010	11:15:37	MN	1	21	51.920	160	5.497
2/20/2010	11:15:52	MN	1	21	52.523	160	5.484
2/20/2010	11:16:04	MN	1	21	52.790	160	5.384
2/20/2010	11:16:22	MN	2	21	53.124	160	4.899
2/20/2010	11:16:40	MN	1	21	53.280	160	4.661
2/20/2010	11:20:54	MN	1	21	53.487	160	4.051
2/20/2010	11:20:55	MN	1	21	53.487	160	4.051
2/20/2010	11:21:35	UD	50	21	54.431	160	3.606
2/20/2010	11:21:36	MN	1	21	54.431	160	3.606
2/20/2010	11:22:29	MN	3	21	55.698	160	3.029
2/20/2010	11:23:13	MN	1	21	56.860	160	2.256
2/20/2010	11:25:40	MN	2	22	0.281	160	3.301
2/20/2010	11:26:44	MN	1	22	1.609	160	4.992
2/20/2010	11:26:45	MN	1	22	1.609	160	4.992

Appendix A: (cont.)

Date	Time	Species	Composition (# Indivs)	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
2/20/2010	11:27:18	MN	2	22	2.185	160	5.703
2/20/2010	11:27:30	MN	1	22	2.386	160	5.935
2/20/2010	12:05:59	MN	1	22	26.676	159	46.598
2/20/2010	12:10:03	UC	2	22	21.786	159	38.832
2/20/2010	12:14:29	MN	1	22	17.921	159	30.213
2/20/2010	12:15:58	MN	1	22	16.534	159	27.330
2/20/2010	12:18:24	MN	1	22	14.243	159	22.434
2/20/2010	12:19:40	MN	3	22	12.844	159	20.318
2/20/2010	12:20:46	MN	2	22	11.075	159	18.432
2/20/2010	12:24:55	MN	1	22	2.328	159	19.594
2/21/2010	8:58:54	MN	2	21	59.210	159	19.956
2/21/2010	8:59:50	UW	1	21	58.447	159	19.303
2/21/2010	9:04:23	MN	1	21	54.936	159	21.449
2/21/2010	9:04:59	MN	1	21	54.212	159	22.119
2/21/2010	9:05:35	UW	1	21	53.401	159	23.159
2/21/2010	9:09:14	MN	1	21	52.570	159	30.213
2/21/2010	9:13:02	UT	1	21	54.198	159	37.652
2/21/2010	9:15:47	UT	2	21	57.167	159	41.609
2/21/2010	9:16:50	SL	100	21	57.843	159	43.403
2/21/2010	9:29:23	MN	1	22	0.331	159	47.240
2/21/2010	9:29:48	MN	2	22	0.790	159	47.602
2/21/2010	9:29:48	UD	4	22	0.790	159	47.602
2/21/2010	9:33:03	SL	14	22	3.049	159	47.529
2/21/2010	9:44:37	MN	2	22	4.770	159	47.574
2/21/2010	9:44:40	MN	1	22	4.770	159	47.574
2/21/2010	9:45:58	MN	1	22	4.454	159	49.792
2/21/2010	9:47:50	MN	2	22	3.909	159	50.200
2/21/2010	9:48:35	MN	2	22	4.011	159	51.643
2/21/2010	9:49:00	MN	1	22	3.903	159	52.251
2/21/2010	9:49:49	MN	1	22	3.594	159	54.114
2/21/2010	9:50:07	MN	2	22	3.533	159	54.427
2/21/2010	9:53:10	MN	2	22	2.557	160	0.364
2/21/2010	9:53:50	MN	1	22	2.369	160	1.740
2/21/2010	9:54:07	MN	1	22	2.265	160	2.425
2/21/2010	9:54:39	MN	2	22	2.086	160	3.446
2/21/2010	9:54:58	MN	2	22	1.966	160	4.123
2/21/2010	9:55:23	MN	1	22	2.057	160	5.104
2/21/2010	9:56:20	MN	1	22	2.721	160	5.477
2/21/2010	10:00:07	SL	15	22	0.207	160	4.655
2/21/2010	10:03:47	MN	9	21	59.026	160	2.825
2/21/2010	10:04:14	MN	1	21	58.383	160	3.390
2/21/2010	10:04:15	MN	2	21	58.383	160	3.390
2/21/2010	10:04:17	MN	1	21	58.383	160	3.390
2/21/2010	10:05:05	MN	1	21	57.193	160	4.125

Appendix A: (cont.)

Date	Time	Species	Composition (# Indivs)	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
2/21/2010	10:05:07	MN	1	21	57.193	160	4.125
2/21/2010	10:06:08	MN	1	21	55.451	160	4.327
2/21/2010	10:07:43	MN	12	21	52.975	160	5.343
2/21/2010	10:08:38	MN	1	21	52.447	160	6.953
2/21/2010	10:08:39	MN	1	21	52.447	160	6.953
2/21/2010	10:09:49	MN	1	21	51.803	160	9.189
2/21/2010	10:10:09	MN	1	21	51.339	160	9.624
2/21/2010	10:10:15	MN	1	21	51.075	160	9.798
2/21/2010	10:10:16	MN	1	21	51.075	160	9.798
2/21/2010	10:10:41	MN	2	21	50.253	160	10.286
2/21/2010	10:11:15	MN	1	21	49.461	160	10.817
2/21/2010	10:11:30	SL	80	21	49.184	160	10.965
2/21/2010	10:17:52	MN	2	21	49.253	160	10.879
2/21/2010	10:18:06	MN	1	21	49.001	160	10.858
2/21/2010	10:18:08	MN	3	21	49.001	160	10.858
2/21/2010	10:18:36	MN	1	21	48.319	160	11.288
2/21/2010	10:19:20	MN	3	21	47.261	160	11.637
2/21/2010	10:19:21	MN	3	21	46.989	160	11.737
2/21/2010	10:19:41	MN	1	21	46.599	160	12.204
2/21/2010	10:19:42	MN	2	21	46.599	160	12.204
2/21/2010	10:19:43	MN	3	21	46.599	160	12.204
2/21/2010	10:19:44	MN	2	21	46.599	160	12.204
2/21/2010	10:19:45	MN	2	21	46.599	160	12.204
2/21/2010	10:19:47	MN	2	21	46.599	160	12.204
2/21/2010	10:19:48	MN	3	21	46.599	160	12.204
2/21/2010	10:23:30	MN	2	21	46.592	160	13.987
2/21/2010	10:23:56	MN	1	21	47.017	160	14.693
2/21/2010	10:24:10	MN	1	21	47.074	160	15.009
2/21/2010	10:24:11	MN	2	21	47.077	160	15.323
2/21/2010	10:24:12	MN	2	21	47.077	160	15.323
2/21/2010	10:32:25	MN	3	21	46.999	160	15.625
2/21/2010	10:33:01	MN	1	21	40.075	160	31.444
2/21/2010	10:34:36	MN	2	21	39.351	160	32.901
2/21/2010	10:34:37	MN	1	21	39.351	160	32.901
2/21/2010	10:36:10	MN	1	21	40.546	160	32.205
2/21/2010	10:38:29	MN	2	21	40.931	160	29.041
2/21/2010	10:43:49	MN	1	21	45.412	160	20.225
2/21/2010	10:45:20	MN	5	21	46.699	160	17.685
2/21/2010	10:45:21	MN	4	21	46.832	160	17.388
2/21/2010	10:47:58	MN	2	21	49.982	160	14.998
2/21/2010	10:47:59	MN	1	21	49.982	160	14.998
2/21/2010	10:51:30	MN	2	21	53.211	160	13.833
2/21/2010	10:51:31	MN	2	21	53.443	160	13.660
2/21/2010	10:52:02	MN	3	21	54.031	160	12.968
2/21/2010	10:55:48	MN	3	21	55.962	160	10.711

Appendix A: (cont.)

Date	Time	Species	Composition (# Indivs)	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
2/21/2010	10:58:30	MN	3	21	58.809	160	7.113
2/21/2010	10:59:30	MN	1	22	0.504	160	6.576
2/21/2010	10:59:35	MN	2	22	0.798	160	6.533
2/21/2010	10:59:57	MN	1	22	1.365	160	6.361
2/21/2010	11:00:10	MN	2	22	1.589	160	6.182
2/21/2010	11:01:15	MN	1	22	2.206	160	4.162
2/21/2010	11:01:28	MN	3	22	2.253	160	3.854
2/21/2010	11:07:22	MN	2	22	4.376	159	52.625
2/21/2010	11:07:42	MN	1	22	4.470	159	51.996
2/21/2010	11:07:43	MN	2	22	4.470	159	51.996
2/21/2010	11:08:49	MN	1	22	4.694	159	50.083
2/21/2010	11:08:50	MN	1	22	4.694	159	50.083
2/21/2010	11:10:20	MN	2	22	5.872	159	48.450
2/21/2010	11:10:37	MN	4	22	6.456	159	48.302
2/21/2010	11:10:52	MN	3	22	7.045	159	48.187
2/21/2010	11:12:15	MN	2	22	7.743	159	48.967
2/21/2010	11:15:33	MN	1	22	8.533	159	44.105
2/21/2010	11:21:01	UT	12	22	10.013	159	42.495
2/21/2010	11:20:11	UT	1	22	10.247	159	42.534
2/21/2010	11:22:53	MN	3	22	9.675	159	42.683
2/21/2010	11:23:16	UT	1	22	9.818	159	42.186
2/21/2010	11:26:50	MN	1	22	12.457	159	36.667
2/21/2010	11:27:00	MN	2	22	12.605	159	36.395
2/21/2010	11:29:16	MN	2	22	13.360	159	32.474
2/21/2010	11:30:31	UT	1	22	13.257	159	30.181
2/21/2010	11:31:38	MN	2	22	13.993	159	28.611
2/21/2010	11:32:40	UT	2	22	13.775	159	26.747
2/21/2010	11:32:42	UT	3	22	13.740	159	26.448
2/21/2010	11:34:08	MN	1	22	14.043	159	24.078
2/21/2010	11:35:10	UT	1	22	13.243	159	22.399
2/21/2010	11:35:28	MN	2	22	13.103	159	21.789
2/21/2010	11:36:44	MN	1	22	12.079	159	19.647
2/21/2010	11:37:35	MN	1	22	10.988	159	18.627
2/21/2010	11:37:56	UT	5	22	10.530	159	18.360
2/21/2010	11:40:41	MN	4	22	5.925	159	17.838
2/21/2010	11:41:00	MN	2	22	5.640	159	17.960
2/21/2010	11:42:00	UD	4	22	3.940	159	18.745

APPENDIX B: Summary of Sightings and Behavior MN = humpback whale; UW = unidentified whale; UD = unidentified dolphin spp.

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/15/2010	15:38:30	1	No	2	MN	N/A	N/A	GPS malfunction
2/15/2010	15:51:30	2	No	1	MN	N/A	N/A	GPS malfunction
2/15/2010	15:52:40	3	No	1	MN	N/A	N/A	GPS malfunction
2/15/2010	16:09:30	4	No	1	MN	N/A	N/A	GPS malfunction
2/15/2010	16:13:30	5	No	1	MN	N/A	N/A	GPS malfunction
2/15/2010	16:18:50	6	No	2	MN	N/A	N/A	GPS malfunction
2/15/2010	16:19:06	7	No	2	MN	N/A	N/A	GPS malfunction
2/16/2010	7:44:30	8	No	2	MN	N/A	N/A	
2/16/2010	7:45:30	9	No	2	MN	N/A	N/A	
2/16/2010	7:46:35	10	No	2	MN	N/A	N/A	
2/16/2010	7:50:40	11	No	1	MN	N/A	N/A	
2/16/2010	7:52:50	12	No	3	MN	N/A	N/A	
2/16/2010	7:53:00	13	No	1	MN	N/A	N/A	
2/16/2010	7:53:10	14	No	1	MN	N/A	N/A	
2/16/2010	7:53:12	15	No	1	MN	N/A	N/A	
2/16/2010	7:53:20	16	No	1	MN	N/A	N/A	
2/16/2010	7:53:23	17	No	1	MN	N/A	N/A	
2/16/2010	7:53:24	18	No	1	MN	N/A	N/A	
2/16/2010	7:53:30	19	No	2	MN	N/A	N/A	
2/16/2010	7:55:00	20	No	1	UW	N/A	N/A	
2/16/2010	7:55:10	21	No	1	UD	N/A	N/A	
2/16/2010	7:55:30	22	No	1	MN	N/A	N/A	

APPENDIX B (cont.) MN = humpback whale; UD = unidentified dolphin spp.

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/16/2010	7:55:50	23	No	1	MN	N/A	N/A	
2/16/2010	7:56:00	24	No	1	MN	N/A	N/A	
2/16/2010	7:56:30	25	No	2	MN	N/A	N/A	
2/16/2010	7:56:35	26	No	3	MN	N/A	N/A	
2/16/2010	7:57:30	27	No	1	MN	N/A	N/A	
2/16/2010	7:58:30	28	No	1	MN	N/A	N/A	
2/16/2010	7:58:40	29	No	1	MN	N/A	N/A	
2/16/2010	8:28:25	30	No	20	UD	N/A	N/A	
2/16/2010	8:50:30	31	No	4	MN	Fast Travel N	0	
2/16/2010	8:51:00	32	No	2	MN	W	270	
2/16/2010	8:51:30	33	No	2	MN	Slow Travel N	0	
2/16/2010	8:51:40	34	No	1	MN	Slow Travel S	180	
2/16/2010	8:52:00	35	No	1	MN	Dive	N/A	
2/16/2010	8:53:40	36	No	2	MN	Slow SE	135	
2/16/2010	9:04:30	37	No	1	MN	Slow S	180	
2/16/2010	9:06:25	38	No	4	MN	SW	225	
2/16/2010	9:08:30	39	No	4	MN	N/A	N/A	
2/16/2010	9:08:40	40	No	2	MN	N/A	N/A	
2/16/2010	9:10:30	41	No	3	MN	N/A	N/A	
2/16/2010	9:12:30	42	No	1	MN	SE	135	
2/16/2010	9:13:30	43	No	1	MN	Breach W	270	
2/16/2010	9:52:40	44	No	1	MN	Tail Slapping	N/A	
2/16/2010	9:56:50	45	No	1	MN	Slow S	180	
2/16/2010	9:57:20	46	No	1	MN	Breach	N/A	

APPENDIX B (cont.): MN = humpback whale; GM = short-finned pilot whale; TT = bottlenose dolphin; UT = unid sea turtle; SL = spinner dolphin								
Date	**Time**	**Grp #**	**Focal Follow**	**Grp Size (calf)**	**Species**	**Behavior**	**Animal Bearing (degrees)**	**Comments**
2/16/2010	10:01:40	47	No	1	MN	Surface Active NE	45	
2/16/2010	10:19:30	48	No	5 (1)	MN	Slow Travel NE/Milling	45	Initially group of 2 MN (slow Travel NE) that joined with 3 other MN's apprx. 1 min after the 1st sighting of the 2 MN's.
2/16/2010	10:25:30	49	No	2	GM	N/A	N/A	
2/16/2010	10:27:30	50	No	2	MN	Slow UW	N/A	
2/16/2010	10:30:30	51	No	1	MN	N/A	N/A	
2/16/2010	10:30:30	52	No	2	TT	Slow with MN above	N/A	
2/16/2010	10:34:30	53	No	50	SL	N/A	N/A	
2/16/2010	12:07:30	54	No	1	UT	Slow Swim SE	135	
2/16/2010	12:07:45	55	No	2	MN	N/A	N/A	
2/16/2010	12:08:00	56	No	1	UT	Slow Swim	N/A	
2/16/2010	12:11:50	57	No	1	MN	Slow Swim W	270	
2/16/2010	12:28:25	58	No	12	MN	Slow Swim W	270	
2/16/2010	12:29:30	59	No	4	MN	Slow Swim SW	225	
2/16/2010	12:30:30	60	No	2	MN	E	90	
2/16/2010	12:37:30	61	No	2	MN	SE, bubbling	135	
2/16/2010	12:37:50	62	No	1	MN	SW	225	
2/16/2010	12:38:15	63	No	2	MN	Milling	N/A	
2/16/2010	12:40:00	64	No	1	MN	SA	N/A	
2/16/2010	12:44:30	65	No	5	MN	Slow Travel E	90	

APPENDIX B (cont): MN = humpback whale

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/16/2010	12:53:30	66	No	1	MN	N/A	N/A	
2/16/2010	12:55:40	67	No	1	MN	SE	135	
2/16/2010	13:04:15	68	No	1	MN	Slow W	270	
2/16/2010	13:04:35	69	No	2	MN	Slow SW	225	
2/16/2010	13:06:30	70	No	2	MN	SA, N	0	
2/16/2010	13:55:30	71	No	2	MN	N/A	N/A	
2/16/2010	13:56:30	72	No	2	MN	NW	315	
2/16/2010	13:57:00	73	No	3	MN	W	270	
2/16/2010	13:57:30	74	No	3	MN	Head Lunge, W	270	
2/16/2010	13:59:00	75	No	1	MN	SA, NW	315	
2/16/2010	13:59:30	76	No	1	MN	E	90	
2/16/2010	14:02:30	77	No	1	MN	N/A	N/A	
2/16/2010	14:05:30	78	No	2	MN	N/A	N/A	
2/17/2010	9:43:06	79	No	1	MN	N/A	N/A	
2/17/2010	9:46:39	80	No	1	MN	Slow Travel NE	45	
2/17/2010	9:47:36	81	No	1	MN	Slow Travel NE	45	
2/17/2010	10:41:56	82	No	1	MN	Breach	N/A	
2/17/2010	12:46:30	83	No	1	MN	UW Swim E	90	
2/17/2010	12:52:24	84	No	3	MN	Slow Travel N	0	
2/17/2010	15:44:30	85	No	1	MN	Breach	N/A	
2/18/2010	7:35:46	86	No	3 (1)	MN	Slow Travel SE	135	
2/18/2010	7:40:12	87	No	4	MN	Under Water Travel NW	315	
2/18/2010	7:42:27	88	No	1	MN	Slow Travel E	90	

APPENDIX B (cont.): MN = humpback whale

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/18/2010	7:43:48	89	No	3	MN	Travel ENE	68	
2/18/2010	7:49:05	90	No	3	MN	Fast Travel NE	45	
2/18/2010	7:49:18	91	No	1	MN	Fast Travel NE	45	
2/18/2010	7:51:02	92	No	2	MN	Slow Travel NE	45	
2/18/2010	8:01:00	93	Attempted	1	MN	N/A	N/A	Attempted focal follow but could not recapture
2/18/2010	10:30:19	94	Yes	8	MN	competition with affiliation	N/A	
2/18/2010	12:43:05	95	No	5	MN	Slow Swim SE	135	
2/18/2010	12:53:44	96	No	1	MN	Slow Swim E	90	
2/18/2010	12:58:15	97	No	1	MN	Slow Swim W	270	
2/18/2010	14:45:30	98	No	1	MN	Breach	N/A	
2/18/2010	14:48:56	99	No	2	MN	Slow Swim W	270	
2/18/2010	14:52:53	100	No	2	MN	Slow Swim NW	315	
2/18/2010	14:54:30	101	No	1	MN	Blow	N/A	
2/19/2010	7:43:29	102	No	1	MN	Slow E	90	
2/19/2010	7:44:39	103	No	3	MN	E	90	
2/19/2010	10:00:10	104	Yes	2	MN	SA, Travel NW	315	Near the FFG, wpts 17-22 on Colorado
2/19/2010	11:13:30	105	No	5	MN	Slow Swim E	90	
2/19/2010	11:14:52	106	No	1	MN	N/A	N/A	
2/19/2010	11:17:23	107	No	3	MN	SA; N	0	
2/19/2010	11:18:04	108	No	3	MN	Tail Slap; NE	45	
2/19/2010	11:18:49	109	No	2	MN	Slow N	0	

APPENDIX B (cont.):			MN = humpback whale					
Date	**Time**	**Grp #**	**Focal Follow**	**Grp Size (calf)**	**Species**	**Behavior**	**Animal Bearing (degrees)**	**Comments**
2/19/2010	11:20:52	110	No	1	MN	Breach	N/A	
2/19/2010	11:21:52	111	No	1 (1)	MN	N/A	N/A	
2/19/2010	12:46:03	112	No	3	MN	Slow Swim N	0	
2/19/2010	12:48:07	113	No	3	MN	Slow Swim N	0	
2/19/2010	12:49:54	114	No	2	MN	Slow Swim N	0	
2/19/2010	12:53:42	115	No	2	MN	Slow Swim NW	315	
2/19/2010	12:54:55	116	No	2	MN	SE	135	
2/19/2010	12:55:06	117	No	1	MN	N/A	N/A	
2/19/2010	12:55:07	118	No	2	MN	N/A	N/A	
2/19/2010	12:55:32	119	No	1	MN	Milling	N/A	
2/19/2010	12:57:00	120	No	2	MN	N/A	N/A	
2/19/2010	12:57:01	121	No	1	MN	Breach	N/A	
2/19/2010	13:00:30	122	No	1	MN	Breach	N/A	
2/19/2010	13:01:58	123	No	3	MN	Breach; NE	45	
2/19/2010	13:04:38	124	No	2	MN	Milling	N/A	
2/19/2010	13:05:00	125	No	1	MN	N/A	N/A	
2/19/2010	14:42:31	126	No	1	MN	Slow Swim E	90	
2/19/2010	14:48:32	127	No	2	MN	Slow Travel WSW	248	
2/19/2010	14:52:05	128	No	1	MN	Slow Swim	N/A	
2/19/2010	14:56:00	129	No	1	MN	Breach-E	90	
2/19/2010	14:56:28	130	No	1	MN	Slow Swim-S	180	
2/19/2010	14:58:40	131	No	1	MN	Breach; E	90	
2/20/2010	7:34:34	132	Yes	12	PC	Fast Travel N	0	Orbit 25 min; still photos
2/20/2010	7:34:34	133	No	2	MN	N/A	N/A	(near PC) Orbit 25 min; still photos

APPENDIX B (cont.): MN=humpback whale; UC=unid cetacean; UD=unid. dolphin spp. TT=bottlenosed dolphin; SC = striped dolphin

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/20/2010	8:13:50	134	No	1	SA	Fast Swim E	90	
2/20/2010	8:15:00	135	No	6	UD	N	0	Unid Blackfish
2/20/2010	8:16:00	136	No	1	MN	W	270	
2/20/2010	8:43:39	137	No	2	MN	Slow Swim NE	45	
2/20/2010	8:45:36	138	No	1	MN	Slow Swim N	0	
2/20/2010	8:45:58	139	No	3	UC	Under Water	N/A	
2/20/2010	8:48:00	140	No	2	MN	Slow Swim SE	135	
2/20/2010	9:27:30	141	No	4	UD	S	180	
2/20/2010	9:27:48	142	No	1	MN	SW	225	
2/20/2010	9:29:30	143	No	2	MN	Slow N	0	
2/20/2010	9:29:41	144	No	2	MN	Slow N	0	
2/20/2010	9:30:28	145	No	1	MN	N/A	N/A	
2/20/2010	9:32:46	146	No	1	MN	Slow S	180	
2/20/2010	9:33:13	147	No	1	MN	N/A	N/A	
2/20/2010	9:36:40	148	No	1	MN	Slow Travel NW	315	
2/20/2010	9:45:24	149	No	2	MN	Slow Travel E	90	
2/20/2010	9:53:00	150	No	1	MN	Slow Travel N	0	
2/20/2010	9:55:20	151	No	1	MN	Slow Travel N	0	
2/20/2010	10:00:38	152	No	1 (1)	MN	Milling	N/A	
2/20/2010	10:05:50	153	No	1	MN	Milling	N/A	
2/20/2010	10:47:38	154	No	1	MN	Breach	N/A	
2/20/2010	10:49:30	155	No	8	TT	N/A	N/A	
2/20/2010	10:49:31	156	No	60	SC	Very Scattered	N/A	min 50/ best 60/ max 75
2/20/2010	10:52:11	157	No	2	MN	N/A	N/A	

APPENDIX B (cont.): MN = humpback whale; UC = unid cetacean; UD = unid dolphin								
Date	**Time**	**Grp #**	**Focal Follow**	**Grp Size (calf)**	**Species**	**Behavior**	**Animal Bearing (degrees)**	**Comments**
2/20/2010	10:55:15	158	No	1	MN	E	90	
2/20/2010	10:56:29	159	No	2	MN	Dove NW	315	
2/20/2010	11:06:50	160	No	2	MN	Slow NW	315	
2/20/2010	11:07:22	161	No	1	MN	SSE	158	
2/20/2010	11:13:57	162	No	1	MN	S	180	
2/20/2010	11:14:49	163	No	2	MN	N/A	N/A	
2/20/2010	11:15:20	164	No	1	MN	Breach	N/A	
2/20/2010	11:15:37	165	No	1	MN	E	90	
2/20/2010	11:15:52	166	No	1	MN	E	90	
2/20/2010	11:16:04	167	No	1	MN	Dove	N/A	
2/20/2010	11:16:22	168	No	2	MN	N/A	N/A	
2/20/2010	11:16:40	169	No	1	MN	N/A	N/A	
2/20/2010	11:20:54	170	No	1	MN	S, Tail Slap	180	
2/20/2010	11:20:55	171	No	1	MN	SW	225	
2/20/2010	11:21:35	172	No	50	UD	Scattered, with MN & dispersed	N/A	
2/20/2010	11:21:36	173	No	1	MN	Slow S	180	
2/20/2010	11:22:29	174	No	3	MN	Slow Travel W	270	
2/20/2010	11:23:13	175	No	1	MN	Slow Travel S	180	
2/20/2010	11:25:40	176	No	2	MN	Slow Travel NW	315	
2/20/2010	11:26:44	177	No	1	MN	Slow Travel SW	225	
2/20/2010	11:26:45	178	No	1	MN	Slow Travel SW	225	
2/20/2010	11:27:18	179	No	2	MN	N	0	
2/20/2010	11:27:30	180	No	1	MN	N	0	

APPENDIX B (cont.): MN = humpback whale; SL = spinner dolphin; UD = unid dolphin UW = unid whale; UT = unid sea turtle

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/20/2010	12:05:59	181	No	1	MN	N	0	
2/20/2010	12:10:03	182	No	2	UC	E	90	
2/20/2010	12:14:29	183	No	1	MN	N/A	N/A	
2/20/2010	12:15:58	184	No	1	MN	NE	45	
2/20/2010	12:18:24	185	No	1	MN	NW	315	
2/20/2010	12:19:40	186	No	3	MN	NW	315	
2/20/2010	12:20:46	187	No	2	MN	NW	315	
2/20/2010	12:24:55	188	No	1	MN	NE	45	
2/21/2010	8:58:54	189	No	2	MN	Slow Swim NE	45	Circumnav of Kauai
2/21/2010	8:59:50	190	No	1	UW	Slow Swim S	180	
2/21/2010	9:04:23	191	No	1	MN	Slow Swim SW	225	
2/21/2010	9:04:59	192	No	1	MN	SW	225	
2/21/2010	9:05:35	193	No	1	UW	Dove	N/A	
2/21/2010	9:09:14	194	No	1	MN	Milling	N/A	
2/21/2010	9:13:02	195	No	1	UT	N/A	N/A	
2/21/2010	9:15:47	196	No	2	UT	Slow Swim	N/A	
2/21/2010	9:16:50	197	No	100	SL	Milling	N/A	
2/21/2010	9:29:23	198	No	1	MN	Milling	N/A	
2/21/2010	9:29:48	199	No	2 (1)	MN	UW	N/A	
2/21/2010	9:29:48	200	No	4	UD	N/A	N/A	possible Tt
2/21/2010	9:33:03	201	No	14	SL	UW Mill	N/A	
2/21/2010	9:44:37	202	No	2	MN	Slow N	0	
2/21/2010	9:44:40	203	No	1	MN	W, bubble trail	270	
2/21/2010	9:45:58	204	No	1	MN	Dive	N/A	

APPENDIX B (cont.): MN = humpback whale; SL = spinner dolphin

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/21/2010	9:47:50	205	No	2	MN	Travel W	270	
2/21/2010	9:48:35	206	No	2	MN	Slow E	90	
2/21/2010	9:49:00	207	No	1	MN	Head Slap, W	270	
2/21/2010	9:49:49	208	No	1	MN	N/A	N/A	
2/21/2010	9:50:07	209	No	2	MN	NE	45	
2/21/2010	9:53:10	210	No	2	MN	Slow Travel ESE	113	
2/21/2010	9:53:50	211	No	1	MN	Slow Travel E	90	
2/21/2010	9:54:07	212	No	1	MN	Slow Travel SE	135	
2/21/2010	9:54:39	213	No	2	MN	Slow Travel SE	135	
2/21/2010	9:54:58	214	No	2	MN	Slow Travel W	270	
2/21/2010	9:55:23	215	No	1	MN	Dive	N/A	
2/21/2010	9:56:20	216	No	1	MN	UW Slow NE	45	
2/21/2010	10:00:07	217	No	15	SL	Fast Swim, dispersed	N/A	photos, min 11/ best 15/ max/ 20
2/21/2010	10:03:47	218	No	9	MN	Slow Swim N	0	
2/21/2010	10:04:14	219	No	1	MN	Slow Swim N	0	
2/21/2010	10:04:15	220	No	2	MN	Slow Swim SE	135	
2/21/2010	10:04:17	221	No	1	MN	Slow Swim SE	135	
2/21/2010	10:05:05	222	No	1	MN	Slow Swim S	180	
2/21/2010	10:05:07	223	No	1	MN	Slow Swim S	180	
2/21/2010	10:06:08	224	No	1	MN	Slow Swim	N/A	
2/21/2010	10:07:43	225	No	2	MN	NE	45	
2/21/2010	10:08:38	226	No	1	MN	Diving NE	45	
2/21/2010	10:08:39	227	No	1	MN	Slow Swim W	270	
2/21/2010	10:09:49	228	No	1	MN	Tail Slap	N/A	

APPENDIX B (cont.): MN = humpback whale; UD = unid dolphin

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/21/2010	10:10:09	229	No	1	MN	Logging	N/A	
2/21/2010	10:10:15	230	No	1	MN	N/A	N/A	
2/21/2010	10:10:16	231	No	1	MN	Slow Swim	N/A	
2/21/2010	10:10:41	232	No	2	MN	Slow Swim W	270	
2/21/2010	10:11:15	233	No	1	MN	Slow Swim	N/A	
2/21/2010	10:11:30	234	No	80	UD	N/A	N/A	Min 70/ Best 80/ Max 90, probable SL
2/21/2010	10:17:52	235	No	2	MN	Slow Swim NE	45	
2/21/2010	10:18:06	236	No	1	MN	Slow Swim W	270	
2/21/2010	10:18:08	237	No	3	MN	Slow Swim N	0	
2/21/2010	10:18:36	238	No	1	MN	Diving W	270	
2/21/2010	10:19:20	239	No	3 (1)	MN	SE	135	
2/21/2010	10:19:21	240	No	3	MN	NW	315	
2/21/2010	10:19:41	241	No	1	MN	Milling	N/A	
2/21/2010	10:19:42	242	No	2	MN	Milling	N/A	
2/21/2010	10:19:43	243	No	3	MN	Milling	N/A	
2/21/2010	10:19:44	244	No	2	MN	Milling	N/A	
2/21/2010	10:19:45	245	No	2	MN	Milling	N/A	
2/21/2010	10:19:47	246	No	2	MN	Milling	N/A	
2/21/2010	10:19:48	247	No	3	MN	Milling	N/A	
2/21/2010	10:23:30	248	No	2	MN	SE	135	
2/21/2010	10:23:56	249	No	1	MN	SE	135	no observer or position recorded
2/21/2010	10:24:10	250	No	1	MN	Slow Swim S	180	

APPENDIX B (cont.): MN = humpback whale

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/21/2010	10:24:11	251	No	2	MN	Slow Swim NE	45	
2/21/2010	10:24:12	252	No	2	MN	Slow Swim SW	225	
2/21/2010	10:32:25	253	No	3	MN	Slow Swim	N/A	
2/21/2010	10:33:01	254	No	1	MN	Slow Swim S	180	
2/21/2010	10:34:36	255	No	2	MN	Slow Swim SE	135	
2/21/2010	10:34:37	256	No	1	MN	Slow Swim	N/A	
2/21/2010	10:36:10	257	No	1	MN	Slow Swim E	90	
2/21/2010	10:38:29	258	No	2	MN	Slow Swim SW	225	
2/21/2010	10:43:49	259	No	1	MN	Slow Swim SW	225	
2/21/2010	10:45:20	260	No	5	MN	Slow Swim	N/A	
2/21/2010	10:45:21	261	No	4	MN	Slow Swim	N/A	
2/21/2010	10:47:58	262	No	2 (1)	MN	N/A	N/A	
2/21/2010	10:47:59	263	No	1	MN	N/A	N/A	
2/21/2010	10:51:30	264	No	2	MN	NE	45	
2/21/2010	10:51:31	265	No	2	MN	NE	45	
2/21/2010	10:52:02	266	No	3 (1)	MN	Calf Breach	N/A	
2/21/2010	10:55:48	267	No	3 (1)	MN	NE	45	
2/21/2010	10:58:30	268	No	3	MN	NE Surface Active	45	
2/21/2010	10:59:30	269	No	1	MN	N/A	N/A	
2/21/2010	10:59:35	270	No	2	MN	NE	45	
2/21/2010	10:59:57	271	No	1	MN	N/A	N/A	
2/21/2010	11:00:10	272	No	2	MN	NE	45	
2/21/2010	11:01:15	273	No	1	MN	W	270	
2/21/2010	11:01:28	274	No	3	MN	N/A	N/A	

APPENDIX B (cont.) MN = humpback whale; UT = unid. sea turtle

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/21/2010	11:07:22	275	No	2	MN	Slow Swim W	270	
2/21/2010	11:07:42	276	No	1	MN	W	270	
2/21/2010	11:07:43	277	No	2	MN	N/A	N/A	
2/21/2010	11:08:49	278	No	1	MN	N/A	N/A	
2/21/2010	11:08:50	279	No	1	MN	Slow Swim	N/A	
2/21/2010	11:10:20	280	No	2	MN	S	180	
2/21/2010	11:10:37	281	No	4	MN	N/A	N/A	
2/21/2010	11:10:52	282	No	3	MN	S	180	
2/21/2010	11:12:15	283	No	2	MN	N/A	N/A	
2/21/2010	11:15:33	284	No	1	MN	N/A	N/A	
2/21/2010	11:20:11	285	No	1	UT	N/A	N/A	
2/21/2010	11:21:01	286	No	12	UT	N/A	N/A	ca. 12 turtles sighted, no angle, position, or observer recorded
2/21/2010	11:22:53	287	No	3	MN	Pec Slap	N/A	
2/21/2010	11:23:16	288	No	1	UT	Slow Swim	N/A	
2/21/2010	11:26:50	289	No	1	MN	Slow Swim	N/A	
2/21/2010	11:27:00	290	No	2	MN	W	270	
2/21/2010	11:29:16	291	No	2	MN	W	270	
2/21/2010	11:30:31	292	No	1	UT	N/A	N/A	
2/21/2010	11:31:38	293	No	2	MN	N	0	
2/21/2010	11:32:40	294	No	2	UT	N/A	N/A	
2/21/2010	11:32:42	295	No	3	UT	N/A	N/A	
2/21/2010	11:34:08	296	No	1	MN	Slow Travel W	270	

APPENDIX B (cont.): UT = unid. sea turtle; MN = humpback whale; UD = unid. dolphin spp.

Date	Time	Grp #	Focal Follow	Grp Size (calf)	Species	Behavior	Animal Bearing (degrees)	Comments
2/21/2010	11:35:10	297	No	1	UT	N/A	N/A	
2/21/2010	11:35:28	298	No	2	MN	Slow Travel W	270	
2/21/2010	11:36:44	299	No	1	MN	NW	315	
2/21/2010	11:37:35	300	No	1	MN	Slow Travel W	270	
2/21/2010	11:37:56	301	No	5	UT			
2/21/2010	11:40:41	302	No	4	MN	NW Competitive	0	
2/21/2010	11:41:00	303	No	2	MN		315	
2/21/2010	11:42:00	304	No	4	UD			

Appendix C: Focal Follow Behavior Summary

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 18	6	10:31	0:02	3 humpbacks (Mn's) surface (this is 1st visible on the mid-top of frame). There are other Mn's that come into view that are visible under the surface: approximately 5 body lengths from the first Mn's observed at the surface and are just behind and to the left of the initial Mn's sighted. There are 3 Mn's visible below the surface heading at an angle towards 4 Mn's ahead. There is one Mn with white pecs in each of the closely grouped Mn's. The video continues with all Mn's in view below the surface until they are out of view. 8-9 animals were reported by observers verbally on video. (-10 animals in view on video.		y
	6	10:31	0:37	Time verbally stamped on video as 10:31:21	y	n
	6	10:32	0:37	At least 1 Mn visible at the surface in the center of the frame		y
	6	10:32	0:40	Another Mn is visible by a Mn with white pecs (WP), positioned ahead and to the left of it.		y
	6	10:32	0:42	The Mn that on left is at the surface.		y
	6	10:32	0:44	The left Mn went under.		y
	6	10:32	0:51	No animals are visible.		y
	6	10:32	0:59	Mn with WP observed below the surface but not yet visible on video.	y	n
	6	10:32	1:05	1 Mn with WP surfacing - visible on bottom-middle of frame		y
	6	10:32	1:08	That WP Mn is down, puka is visible and another puka is also visible to the right of the WP Mn's puka, approximately 5-6 body lengths away.		y
	6	10:32	1:14	Pukas no longer in frame		
	6	10:32	1:25	Mn with WP observed under the surface but not visible in frame yet.	y	n
	6	10:33	1:33	2 Mn with WP's under the surface, seen by observer but not visible in frame.	y	n
	6	10:33	1:34	Surfacing by one of the WP Mn's (from last entry), seen by observer but not visible in frame.	y	n

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 18 (cont.)	6	10:33	1:42	Another Mn observed that is about to surface with the WP Mn from last entry. Not visible in frame.	y	n
	6	10:33	2:03	puka out of frame		
	6	10:33	2:03	Observer reports that there is another sighting approximately 500 meters to the north of the current focal follow. Not visible in frame.	y	n
	6	10:33	2:13	There is a puka visible on the bottom left of frame.		y
	6	10:33	2:14	Puka no longer visible in frame		
	6	10:33	2:17	Puka visible again.		y
	6	10:34	2:21	Observer reports surface activity and then at least one animal visible below surface with WP- slow swimming under surface (not visible in frame). Altitude is approximately 1500 ft.	y	n
	6	10:34	2:34	1 Mn surfaced less than one body length to left of WP Mn swimming under surface.		y
	6	10:34	2:39	The Mn from the last entry went under, puka is still visible in frame, then 2 Mn's with WP's are visible below the surface less than one body length from the animal that just dove. They are swimming in a vertical line, head to peduncle and both have WP.		y
	6	10:34	2:44	The lead WP Mn surfaced with a bubble trail, the lagging WP Mn is still visible below the surface and the Mn that was on the left is no longer visible.		y
	6	10:34	2:50	The lead WP Mn went under. Both Mn with WP still visible under the surface, they are positioned rostrum to tail fluke.		y
	6	10:34	2:57	Both Mn's with WP still visible underwater. They are no longer swimming vertically with each other. Now the Mn that was lagging is veering a little left of the lead Mn.		y
	6	10:34	3:02	Lead Mn is no longer visible, the Mn that was lagging is still visible below the surface.		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 18 (cont.)	6	10:34	3:07	The Mn that was lagging is still visible and another Mn surfaced just ahead and to the left, 1/2 a body length from WP Mn from last entry.		y
	6	10:34	3:13	The last Mn to surface in previous entry went under as the Mn with WP, that was lagging, surfaced. The Mn's are less than 1 body length from each other.		y
	6	10:34	3:18	Both Mn's now under the surface but only the Mn with WP is visible.		y
	6	10:35	3:25	4 Mn's observed approaching area - not visible in frame.	y	n
	6	10:35	3:45	1 Mn with WP surfaced.		y
	6	10:35	3:55	Another Mn surfaced ahead of and to the left of the WP Mn in previous entry. There are other Mn's visible below the surface and 2 body lengths away, that are swimming in the same direction of the Mn with WP.		y
	6	10:35	3:58	3 Mn's now at the surface, 1-2 body lengths from each other.		y
	6	10:35	4:00	4 Mn's at the surface plus 1-2 visible below the surface, all 1-3 body lengths from each other and swimming in the same direction. The positioning of the Mn's at the surface: One Mn in the center, two are ahead of the center MN- on the left and on the right, there is one that is lagging behind the center Mn and has WP and is on the left.		y
	6	10:35	4:05	There are approximately 9 Mn's visible above and below the surface and are in the same general orientation as described in the previous entry.		y
	6	10:35	4:39	Some of the Mn's are diving.		y
	6	10:35	4:53	All Mn's are underwater and at least 3 of them can still be seen.		y
	6	10:36	4:56	A Mn that is positioned at the rear of the group and has WP surfaced and dove.		y
	6	10:36	5:01	A lead Mn with WP surfaced and went under.		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 18 (cont.)	6	10:36	5:09	There is only one Mn still visible and it is under the surface and has WP and is diving deep.		y
	6	10:36	5:19	No animals are visible.		
	6	10:37	5:21	GPS Location: N' 22.12 W' 159.37	y	n
	6	10:37	5:35	Mn observed below the surface but not visible in frame.	y	n
	6	10:37	5:37	1 puka visible in the top middle of the frame.		y
	6	10:37	5:43	Another puka is visible to the left of the puka (from last entry) in the frame.		y
	6	10:37	5:44	Approximately 2 surfacings observed, but not visible in frame. The pukas from the last entry are no longer visible in frame.	y	n
	6	10:37	5:49	2 Mn observed at the surface by observer but only a puka is visible in frame.	y	y
	6	10:37	5:55	2 Mn visible in frame, one is below the surface and the other is at the surface, they are approximately 1.5 body lengths from each other.		y
	6	10:37	6:01	Only one of the Mn's from the last entry in visible in frame and it went down and is visible below the surface.		y
	6	10:37	6:06	Both Mn's are now visible below the surface in the frame.		y
	6	10:37	6:12	At least 6 Mn's are now visible below the surface and are all less than 1 body length from the other and are all swimming in the same direction.		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 18 (cont)	6	10:37	6:13	One Mn surfaced.		y
	6	10:37	6:17	The Mn from the last entry went under and one Mn ahead of it surfaced.		y
	6	10:37	6:20	The last Mn to surface (from previous entry) went under and one that was just behind it surfaced.		y
	6	10:38	6:25	The last Mn to surface (from previous entry) went under and several others are still visible under the surface.		y
	6	10:38	6:37	Now there are only pukas visible in frame.		y
	6	10:38	6:43	No animals or pukas are visible.		
	6	10:38	6:45	1 Mn surfaced and is visible on the top left of the frame.		y
	6	10:38	6:51	The Mn from the last entry went under, puka is still visible in frame.		y
	6	10:38	7:08	No animals or pukas are visible.		
	6	10:38	7:12	There is a Mn with WP visible under the surface on the top left of frame.		y
	6	10:38	7:12	There are 2 Mn's with WP visible under the surface and a blow from another Mn is visible. All Mn's are within 1-2 body lengths from each other.		y
	6	10:38	7:15	2 Mn's just surfaced and 4-5 others are visible below the surface - the 2 that surfaced are in the middle and all others are ahead and to the left and also behind. At least 2 Mn's with WP are visible.		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 18 (cont.)	6	10:38	7:21	Other Mn's are beginning to surface.		y
	6	10:39	7:24	Other Mn's are reported at a distance from the ones that we are following and are not visible in video.	y	n
	6	10:39	7:32	Several of the Mn's that we are following are diving. The Mn in the middle position performed a high-arch fluke-up dive and it appears to chase a Mn with a possible charge strike.		y
	6	10:39	7:35	All Mn's are under the surface, some still visible.		y
	6	10:39	7:40	One Mn at the surface.		y
	6	10:39	7:46	The Mn from the last entry dove and is still visible under the surface as well as one Mn with WP who is 2-3 body lengths ahead.		
	6	10:39	7:57	A trailing Mn is observed surfacing but not visible in frame. The Mn with WP is still visible in frame.	y	y
	6	10:39	8:06	There are only dissapating pukas visible in frame.		y
	6	10:39	8:09	1 Mn surfaced in the mid-right of frame.		y
	6	10:39	8:17	The left Mn from the last entry went under.		y
	6	10:39	8:17	There is a Mn with WP visible under the surface.		y
	6	10:40	8:26	The WP Mn from last entry surfaced and there are at least 2 Mn visible behind and approximately 1 body length away that are beginning to surface.		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 18 (cont.)	6	10:40	8:43	Several Mn's visible surfacing and going under, 1-2 body lengths from each other.		y
	6	10:40	9:06	Several Mn's still visible surfacing and going under, swimming just below the surface. 7-8 Mn's are visible, some less than one body length from another and at the farthest 2 body lengths from another.		
	6	10:40	9:20	Mn's still surfacing and going under. They are in the same orientation as last entry, however one surfaced approximately 5 body lengths behind the main group.		y
	6	10:41	10:00	All Mn's are now below the surface - one of the lead animals was the last to go under and is now the only Mn still visible, there are also several pukas visible.		y
	6	10:41	10:04	No animals or pukas are visible. One Mn was observed at a distance heading in our pod's direction and performing a breach- not visible in video.	y	n
	6	10:42	10:28	Our pod observed but not visible in frame.	y	n
	6	10:42	11:10	Verbal time stamp: 10:42:15, altitude of 1500ft. End observation.	y	
Feb. 19	7	10:07		We are with FFG and have sighted Mn's twice but have no video of them yet.	y	n
	7	10:08		video off		
	8	10:09	0:08	Mn's resighted at the surface but not visible in frame.	y	n
	8	10:09	0:26	There is a puka visible on the bottom right corner of frame that is visible for approximately 5 seconds. We are at about 1600 ft and the way point is 18.		y
	8	10:13	4:07	video off		

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 19 (cont.)	9	10:13	0:01	Mn's sighted but not yet visible in video. They are approximately .25 miles from the FFG.	y	n
	9	10:15	1:54	The FFG is at an angle of 19 from the right side of the plane; N'22 37.29 W'160 00.28	y	y
	9	10:17		Verbal report: Mn's are heading NNW according to the direction of the way points recorded so far.	y	n
	9	10:17	4:00	Mn's observed surfacing- not visible in frame.	y	n
	9	10:17	4:05	2 Mn's visible at the surface on the bottom right of frame.		y
	9	10:18	4:15	Pukas are visible at the top middle of the frame.		y
	9	10:18	5:01	Mn's sighted at the surface and then are visible on the video only after they already went below the surface.		y
	9	10:19	5:14	Now there is only a puka visible in the frame.		y
	9	10:19	5:18	The puka disappeared.		
	9	10:20	6:29	Mn observed underwater and began to surface but not visible in frame.	y	n
	9	10:20	6:39	Mn observed surfacing, but not in frame.	y	n
	9	10:20	6:43	1 Mn visible blowing at the surface in video (This individual is Mn_A).		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 19 (cont.)	9	10:20	6:47	A second Mn (Mn_B) is visible under the surface, just to the right of Mn_A.		y
	9	10:20	6:47	A third animal is verbally reported but is not visible in video, however, upon analyzing the video, it seems there is a blow visible that looks as though it has drifted from the position of Mn_A.	y	n
	9	10:20	6:49	Mn_B surfaced.		y
	9	10:20	6:50	Mn_B performed a peduncle slap.		y
	9	10:20	6:57	Both Mn's visible under the surface.		y
	9	10:20	7:01	Mn_B traveling at the surface.		y
	9	10:20	7:04	Mn_B went below the surface.		y
	9	10:20	7:06	Mn_A is surfacing on the left of Mn_B.		y
	9	10:21	7:10	Both Mn's are traveling below the surface.		y
	9	10:21	7:18	Mn_A surfaced.		y
	9	10:21	7:25	Mn_A dove. Puka visible after the dive.		y
	9	10:21	7:41	The puka is no longer visible in frame. A waypoint was taken at this time but the number was not reported verbally- possibly waypoint 20.	y	

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 19 (cont.)	9	10:21	7:46	A blow was observed by eye but not seen in video. Immediately after a back is visible at the surface.		y
	9	10:21	7:49	The Mn that surfaced (from last entry) is now visible below the surface.		y
	9	10:21	7:55	Only a puka is visible in frame.		y
	9	10:21	8:04	Now there are two pukas clearly visible from 2 Mn's, one puka is behind and to the left of the puka from the last Mn to surface.		y
	9	10:22	8:09	A breach was performed by the Mn on the right- immediately after the breach neither Mn is visible. Water disturbance is the only thing that is visible.		y
	9	10:23	9:31	No longer any animals or water disturbance visible in frame.		
	9	10:23	9:44	Mn's observed heading up to the surface but not visible in frame.	y	n
	9	10:23	9:45	1 Mn visible at the surface with a blow.		y
	9	10:23	9:50	The Mn from the last entry is now below the surface and only the puka is visible.		y
	9	10:23	10:03	The puka is no longer visible.		
	9	10:24	10:38	1 Mn is diving- this is visible at the bottom middle of frame.		y
	9	10:24	10:42	Only a puka is visible in frame.		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 19 (cont.)	9	10:24	10:55	The puka is no longer visible.		
	9	10:25	11:33	There is a small part of a back that is visible at the surface on the bottom right of the frame and it comes in and out of view on frame due to obstruction by the wing of the plane.		y
	9	10:25	12:00	Observers report that Mn is still in view however the wing prevents the videographer from capturing it on video.	y	n
	9	10:26	12:16	Mn surfaced, blow is visible on the top right of frame.		y
	9	10:26	12:24	There is a puka visible in the middle of the frame.		y
	9	10:26	12:34	Puka is no longer visible. At an altitude of 1600 ft.	y	n
	9	10:26	12:55	There is 1 Mn's back visible at the surface.		y
	9	10:26	13:00	There is no longer any Mn visible in frame.		
	9	10:27	13:42	The pilot reports that the FFG is w/in 250 yds of last Mn sighting.	y	
	9	10:28	14:20	Observer reports a blow but it not visible in frame.	y	n
	9	10:29	15:54	Mobley verbally reports direction of travel as NNW after reviewing waypoints.	y	
	9	10:31	17:09	FFG observed heading in the direction of where we are circling (presumed Mn's current location).	y	

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 19 (cont.)	9	10:31	17:44	Mn's observed but not visible in video, 3 blows were reported and the 3 Mn's were reported.	y	n
	9	10:32	18:33	1 Mn is visible at the surface.		y
	9	10:32	18:37	Only a puka is visible in frame.		y
	9	10:32	18:55	Puka is no longer visible.		y
	9	10:32	19:00	1 Mn is visible at the surface and diving.		y
	9	10:32	19:05	1 Mn is at the surface.		y
	9	10:32	19:05	Mn is no longer visible in frame.		
	9	10:32	19:21	2 surfacings observed but not visible in video.	y	n
	9	10:33	19:24	2 backs observed but not visible in video.	y	n
	9	10:33	19:30	A shallow dive is observed but not visible in video.	y	n
	9	10:36	23:00	FFG in video.		y
	9	10:40	26:27	FFG visible again.		y

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 19 (cont.)	9	10:42	28:32	FFG visible again.		y
	9	10:42	28:46	A blow was observed but not visible in video.	y	n
	9	10:42	28:52	Verbal time stamp: 10:42:09	y	n
	9	10:42	29:04	Another blow observed but not visible in video.	y	n
	9	10:44	30:08	Mn observed at the surface but not visible in frame.	y	n
	9	10:44	30:14	1 Mn visible just below the surface on the mid-left of frame.		y
	9	10:44	30:16	A blow and a Mn body is visible in frame.		y
	9	10:44	30:23	The Mn from the last entry went down and now only puka is visible.		y
	9	10:44	30:39	No longer any Mn or Puka visible.		
	9	10:44	31:04	waypoint 22 recorded, no animals visible.	y	
	9	10:45	31:12	Mobley reports that the Mn's have been traveling at a pretty consistent NNW direction after reviewing waypoints. The FFG is visible in video w/in a couple hundred yards of where our plane was circling above the sighting.	y	y
	9	10:46	32:36	Mn's observed at the surface but not visible in video.	y	n

Appendix C (cont.):

Date	Episode No.	Clock Begin	Elapsed Begin	Description	Verbal Confirm Only (Y/N)	On Video (Y/N)
Feb. 19 (cont.)	9	10:46	32:45	Verbal time stamp: 10:46:03	y	
	9	10:47	33:16	FFG visible in frame.		y
	9	10:48	34:18	FFG changed direction and is now heading away from our general location.	y	
	9	10:50	36:14	FFG is visible in frame.		y
	9	10:53	39:59	End of video.		
Feb. 20	10	7:40	00:01	There is a blow visible on the right middle of the frame.		y
	10	7:40	00:14	There are 2 backs and 2 blows visible on the top right of frame.		y
	10	7:40	00:17	There are at least 2 pukas visble in frame- but no animals at surface.		y
	10	7:40	00:28	There are 2 backs and blows visible at the surface.		y
	10	7:40	00:39	Only pukas are visible in frame.		y
	10	7:40	00:48	No pukas or animals are visible in video.		
	10	7:42		End of video.		

APPENDIX I Analysis of HRC PAM data from 2009-2010

Marine Physical Laboratory
of the Scripps Institution of Oceanography
University of California, San Diego

California Institute of Technology
Contract # 28H-1087365
June 17, 2009 – May 31, 2010
Submitted to:
Naval Postgraduate School

Marine Mammal Monitoring for the Hawaii Range Complex

Principal Investigator: John Hildebrand
Marine Physical Laboratory
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Contract Number: 28H-1087365
Project Title: Marine Mammal Monitoring for the Hawaii Range Complex (HRC)
Project Duration: June 17, 2009 – May 31, 2010

Executive Summary

This report summarizes work conducted in FY2009-FY2010 with Navy support to characterize marine mammal sounds related to passive acoustic monitoring in the Hawaii Range Complex (HRC). Existing acoustic data from the Hawaii Range Complex area were analyzed to provide better descriptions of acoustic signals by species. Recordings were either from a boat-based hydrophone during small boat-based surveys, or from an autonomous bottom-moored High-frequency Acoustic Recording Package (HARP). Recordings were made of pygmy killer whales (*Feresa attenuata*) during four encounters, melon-headed whales (*Peponocephala electra*) during three encounters, Risso's dolphins (*Grampus griseus*) during one encounter, and rough-toothed dolphins (*Steno bredanensis*) during one encounter. Echolocation click parameters were calculated for single species recordings during visual and acoustic surveys by boat-based hydrophones, as well as using sightings from small boat surveys and locations of satellite tagged individuals in the vicinity of the HARP. False killer whales and short-finned pilot whales had the lowest peak frequencies (15-21 kHz) in comparison to the other species. Pygmy killer whale echolocation clicks showed a bimodal distribution of peak frequencies (in the range of 35 to 50 kHz or 75 to 100 kHz). Melon-headed whales had peak frequency in the range of 31 to 35 kHz. Risso's dolphins showed a distinct peak/notch frequency structure in their echolocation clicks (peaks appear at 24.5, 26.7, 34.6 and 40.3 kHz). Automatic classification of echolocation clicks of false killer whales and short-finned pilot whales was performed using a Gaussian mixture model. This method resulted in a mean misclassification of 10.7 ± 0.7%. Two unknown but distinct echolocation click types were observed in the HARP data. One was a high frequency click that had its minimum frequency at around 70 kHz and extended beyond the frequency range of the recorder (100 kHz). The other click type was a low frequency click that had a distinct banding pattern with peak structure at 12.2, 16.4 and 23.8 kHz, close to the peaks seen for short-finned pilot whales.

An acoustic analyst manually screened the HARP data collected off the west coast of the Island of Hawaii during the time period of February 10, 2009 until March 9, 2009. Distinct call types were found for beaked whales with frequency modulated upsweep echolocation pulses (particularly those previously noted at Cross Seamount), sperm whales, high frequency clicks of unknown origin, low frequency banded echolocation clicks, and a large number of unidentified echolocation clicks. Odontocetes were acoustically active every day of the recording period (65% of total hours had echolocation clicks). Beaked whales were detected on 41% of the recording days but only during short periods per day (4% of total hours). Events of anthropogenic noise were logged and categorized as ship noise or echosounder.

Characterization of Marine Mammal Recordings from the Hawaii Range Complex

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I) Descriptions of acoustic signals by species

Acoustic recordings of cetaceans were obtained either with an autonomous bottom-moored High-frequency Acoustic Recording Package (HARP) deployed off the island of Hawaii (Wiggins and Hildebrand 2007), or with a boat-based hydrophone during several small boat-based field projects undertaken off the island of Hawaii (see Baird et al. 2008a). The boat-based hydrophone system (sampling frequency of 192 kHz) was deployed opportunistically when in the presence of a single species of cetacean, typically at distances of less than 100 m from the animals and positioned such that the animals were likely to pass within 50 m of the hydrophone . Species present were confirmed both visually and with photographs. The HARP was deployed in approximately 620 m of water (19°34.8 N 156°00.9 W, figure 1) in an area that has been regularly surveyed during small boat field projects since 2002 and is known to be an area where a wide diversity of odontocetes are found (Baird et al. 2008a, 2008b, 2009, 2010; McSweeney et al. 2007, 2009; Schorr et al. 2009). The HARP was recording either continuously or on an intermittent schedule with five minutes of recordings in 8 or 15 minutes intervals (Table 1). Information on cetacean presence in the vicinity of the HARP, to confirm species recorded acoustically, was obtained in one of two ways. During small boat-based field efforts the area around the HARP was surveyed periodically, typically with the vessel stopping at the location and 360 scans with binoculars, to assess whether any cetaceans were at the survey in the area. In addition, individuals of a number of species were tagged with location-only satellite tags (see Schorr et al. 2009a, 2009b; Baird et al. 2010) and tracked with the ARGOS satellite system. The distance from all filtered locations (see Schorr et al. 2009a) to the HARP location was measured using the Posdist[1] function in Excel, and consecutive satellite locations that spanned the HARP site (indicating an animal passing the HARP location) or within 2 km of the HARP were used to assess acoustic detection from the HARP recordings.

[1]Available from http://www.afsc.noaa.gov/nmml/software/excelgeo.php

Table 1: HARP deployment cycles off the west coast of the Island of Hawaii. Duty cycle: cont. = continuous, recording time/recording interval in minutes;

	Start	End	Duty cycle	# hour bins	# daily bins
Hawaii 01	08/ 11/2007, 0000 hours	10/04/2007, 0616 hours	cont.	1302	55
Hawaii 02	04/19/2008, 0600 hours	07/04/2008, 1419 hours	5/8	1832	77
Hawaii 03	07/ 08/2008, 0000 hours	10/15/2008, 2048 hours	5/15	2396	100
Hawaii 05	02/10/2009, 0000 hours	03/09/2009, 0615 hours	cont.	654	28
Hawaii 06	04/23/2009, 1000 hours	8/18/2009, 1748 hours	5/15	2815	118

Recordings with the boat-based hydrophone were obtained from pygmy killer whales (*Feresa attenuata*) during four encounters, melon-headed whales (*Peponocephala electra*) during four encounters (two from the Hawaii resident population and two from the Main Hawaiian Islands population; see Aschettino 2010), Risso's dolphins (*Grampus griseus*) during one encounter, and rough-toothed dolphins (*Steno bredanensis*) during one encounter (Table 2).

Three visual sightings of short-finned pilot whales (*Globicephala macrorhynchus*) and one sighting of rough-toothed dolphins occurred in close proximity to the recording HARP (figure 2). Three satellite tagged false killer whales (*Pseudorca crassidens*) from the Hawaii insular population were repeatedly in the area around the HARP. Seven satellite positions were close enough to the HARP that acoustic detections during that time period were likely corresponding with vocalizations of these animals (figure 3), which resulted in four time periods with false killer whale echolocation click periods on HARP recordings.

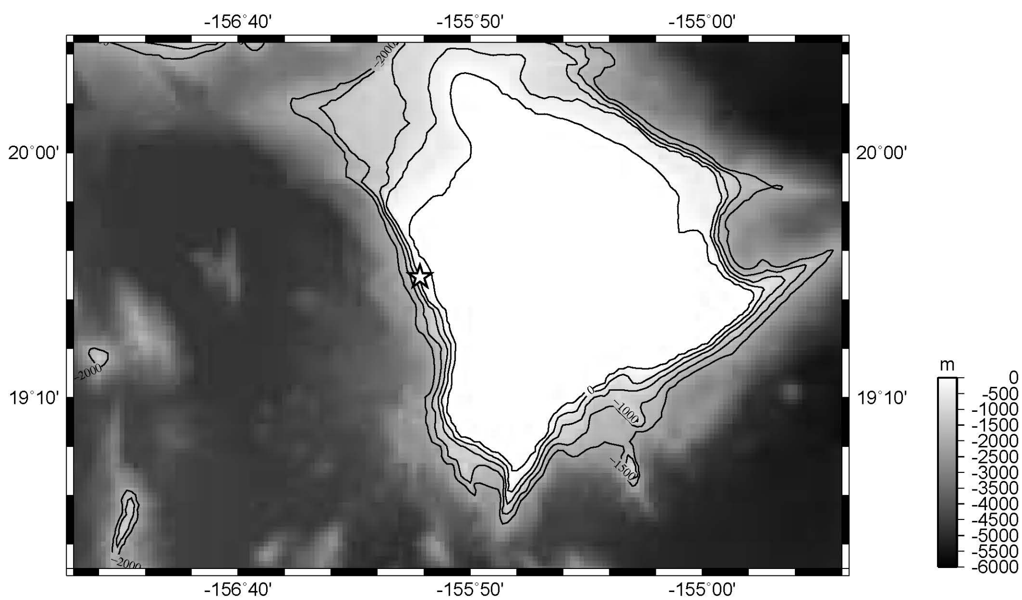


Figure 1: Location of the High-frequency Acoustic Recording Package (HARP) indicated with a star on the west coast of the Island of Hawaii, position 19°34.8 N 156°00.9 W.

1) Echolocation click parameters of confirmed species

Echolocation clicks were analyzed and described in detail for future species classification by their acoustic signals. Echolocation click parameters have been calculated for all single species recorded during boat-based surveys as well as when satellite tagged or visually sighted species were in the vicinity of the HARP and recordings were made (Table 2).

False killer whales and short-finned pilot whales had the lowest peak and center frequencies in comparison to the other species (Table 2, figure 4). Their overall appearances of all clicks (figure 4/I+IIB) as well as their mean spectra of all clicks (figure 4/I+IIC) were very similar. Possible features for discrimination were a slightly broader distribution of peak frequencies for short-finned pilot whales (figure 4/I+IIA) and their potentially species-specific peaks at 12.6, 18.8 and 28.2 kHz (figure 4/IIC). Whether these peaks are consistent for this species will have to be verified with further single species recordings. The only other species we know of so far, which might produce echolocation clicks that are also in this frequency range, would be killer whales and Baird's beaked whales. Killer whales are rare in Hawaiian waters (Baird et al. 2006) and Baird's beaked whales have not been documented in Hawaii. Both should be different in the spectral structure of their echolocation clicks. Therefore sequences on the autonomous HARP data with peak frequencies in the range of 15-21 kHz are most often of origin false killer whale or short-finned pilot whale.

Pygmy killer whale echolocation clicks showed a bimodal distribution of peak frequencies (figure 4/IIIA-C). Clicks had their peak frequency either in the range of 35 to 50 kHz or 75 to 100 kHz. Clicks with low peak frequency had also low amplitude (figure 4/IIIB), which was either due to the distance or, more likely, the angle of the animal to the recording hydrophone. A similar correlation has previously been demonstrated by Madsen et al. (2004).

Melon-headed whales had their peak frequency in the range of 31 to 35 kHz (Table 2, figure 4/IV). This was higher than known from a previous study at Palmyra Atoll (Baumann-Pickering, 2009) where the peak frequency was around 25-29 kHz. Recordings in Hawaii were made from two different populations, one of which is resident to the island of Hawaii and the other that moves throughout the main Hawaiian Islands and into offshore waters (Aschettino 2010), and it is possible there may be population-level differences between them that will be investigated at a future date when more recordings are available. Rough-toothed dolphins and melon-headed whales are probably difficult to discriminate (Table 2, figure 4/V). No further efforts have been made to classify these signals automatically.

Risso's dolphins showed a very distinct peak/notch frequency structure in their echolocation clicks (figure 4/VI). The peaks appear in the mean spectra at 24.5, 26.7, 34.6 and 40.3 kHz (figure 4/VIC). These values differ from values reported for Risso's dolphins in Southern California, where the peaks lie at 22.1, 25.6, 30.3 and 39.0 kHz (Soldevilla et al., 2008).

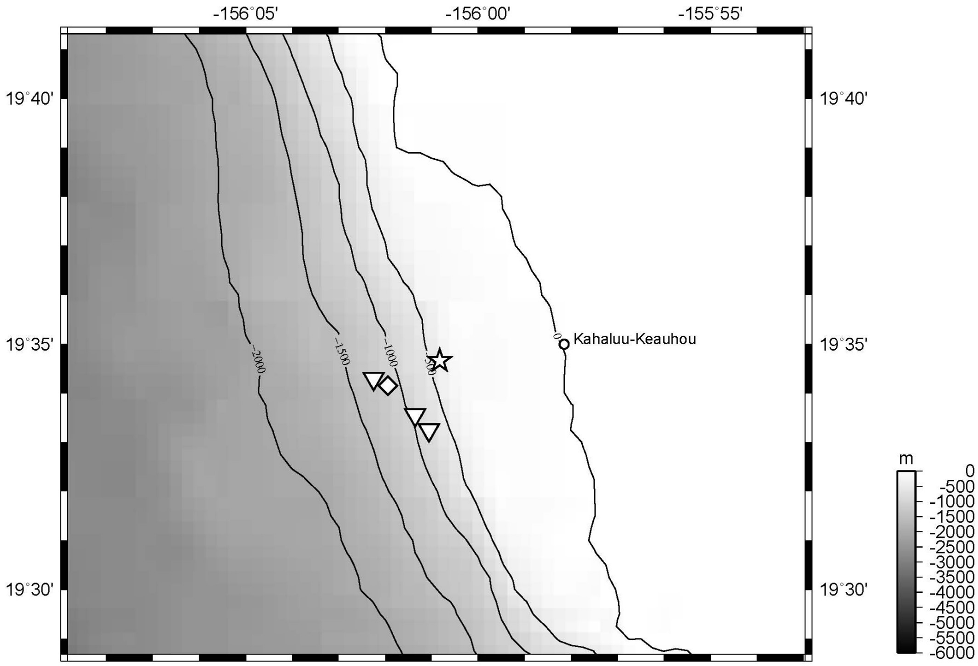


Figure 2: Location of visual sightings of short-finned pilot whales (triangles) and rough-toothed dolphins (diamond) near the HARP (star).

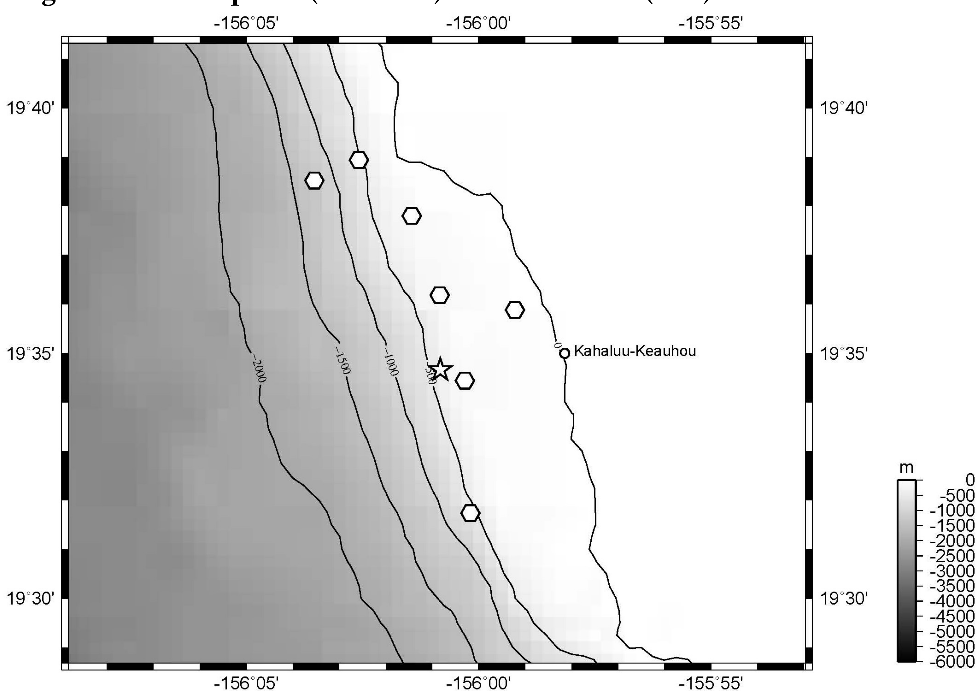


Figure 3: Location of satellite tagged false killer whales (hexagons) near the HARP (star). In most cases tagged false killer whales were transiting alongshore and groups were typically spread inshore and offshore (Baird et al. 2010), thus whales in the group likely passed close to the HARP.

Table 2: Echolocation click parameters. Values are given as medians followed by first and third quartiles in brackets. n= number of clicks.

	Peak Frequency (kHz)	Center Frequency (kHz)	Duration (ms)	Inter-click Interval (ms)	Bandwidth -10dB (kHz)	Bandwidth -3dB (kHz)
I) False killer whale						
HARP Hawaii 7.26.08	15.2	18.5	0.21	198	18.3	8.5
(n=2,738)	[13.2 17.5]	[16.5 22.0]	[0.17 0.28]	[66 484]	[14.0 23.8]	[6.2 10.9]
HARP Hawaii 7.27.08	16.7	20	0.23	82	19.5	8.5
(n= 3,089)	[14.0 17.9]	[17.5 23.0]	[0.18 0.30]	[24 258]	[13.2 27.3]	[5.8 11.3]
HARP Hawaii 8.1.08	16.4	19.5	0.23	352	16.4	7.4
(n=3,010)	[14.0 19.1]	[17.2 23.7]	[0.17 0.32]	[121.3 853.5]	[11.3 22.2]	[5.4 10.5]
HARP Hawaii 8.16.08	17.1	20.2	0.24	150	18.3	8.2
(n=4,536)	[14.0 19.9]	[17.7 24.9]	[0.18 0.32]	[48.4 390.1]	[12.1 26.1]	[5.8 10.5]
II) Short-finned pilot whale						
HARP Hawaii 8.25.07	17.5	21.8	0.37	179	11.7	5
(n=1,374)	[13.2 19.9]	[14.5 28.9]	[0.23 0.56]	[52.3 245]	[7.4 18.7]	[3.9 7.8]
HARP Hawaii 5.01.08	19.1	22.8	0.32	184	11.3	5
(n=3,428)	[15.2 20.3]	[20.0 26.8]	[0.20 0.47]	[99.1 241.9]	[7.8 17.5]	[4.2 7.0]
HARP Hawaii 5.15.08	20.7	24.7	0.32	188.7	16.7	6.25
(n=4,863)	[15.2 27.7]	[21.1 28.5]	[0.22 0.45]	[97.3 244.8]	[10.1 23.8]	[4.6 8.9]
III) Pygmy killer whale						
array Hawaii 4.24.08	84	65	0.3	75.6	52.5	10.5
(n=534)	[73.1 88.1]	[59.0 69.2]	[0.23 0.63]	[37.2 137.9]	[22.5 64.5]	[5.5 16.5]
array Hawaii 12.06.08	82	65	0.2	55	52.5	12.7
(n=1263)	[48.3 87.3]	[58.0 69.3]	[0.17 0.25]	[39.0 102.0]	[34.5 63]	[7.8 17.6]
array Hawaii 12.09.08	36	38	0.2	404	36	14
(n=127)	[25.1 44.6]	[31.4 49.4]	[0.18 0.35]	[10.8.6 2734]	[19.8 45.7]	[6.7 18]
array Hawaii 4.20.09	47.2	56.4	0.2	99	62.6	17.6
(n=648)	[42.3 79.5]	[50.0 63.8]	[0.15 0.29]	[70.4 158.6]	[42.3 71.6]	[14.6 22.5]

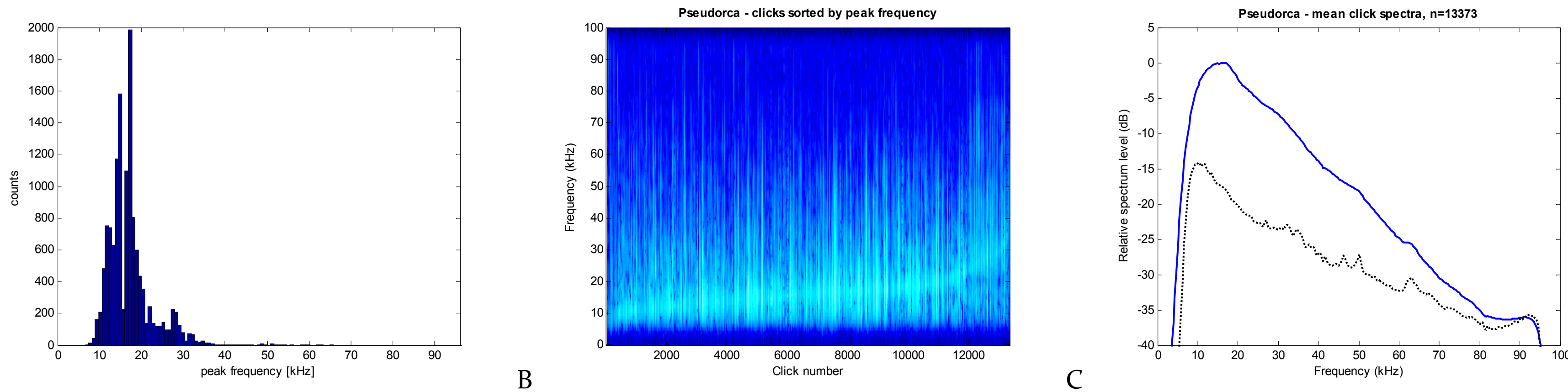
Table 2 continued: Echolocation click parameters. Values are given as medians followed by first and third quartiles in brackets. n= number of clicks.

	Peak Frequency (kHz)	Center Frequency (kHz)	Duration (ms)	Inter-click Interval (ms)	Bandwidth -10dB (kHz)	Bandwidt h -3dB (kHz)
IV) Melon-headed whale						
array Hawaii 4.25.08	34.5	43.9	0.29	173.3	24.7	9
(n=125)	[20.6 50.43]	[36.1 50.0]	[0.20 0.41]	[98.1 326.2]	[12.3 33.3]	[5.1 11.8]
***array Hawaii 12.10.08**	34.1	38.6	0.37	23	24.3	7.8
(n=6,985)	[25.5 43.8]	[33.9 47.9]	[0.26 0.54]	[11.8 53.6]	[13.1 33.3]	[4.8 12.3]
array Hawaii 12.15.08	31.1	36.2	0.32	24	25.1	9.37
(n=2,361)	[25.1 40.1]	[31.9 43.1]	[0.21 0.49]	[12.4 52.5]	[16.1 32.2]	[5.9 13.5]
V) Rough-toothed dolphin						
HARP Hawaii 7.12.08	25	30	0.18	130	37	13.2
(n=4013)	[21.8 33.9]	[26.3 33.5]	[0.14 0.23]	[72.1 241.4]	[26.1 44.1]	[8.2 20.7]
array Hawaii 5.01.09	34	37	0.27	155	28.1	11.2
(n=329)	[26.6 43.9]	[31.6 43.9]	[0.19 0.38]	[95.0 332.0]	[22.1 35.2]	[7.7 14.2]
VI) Risso's dolphin						
array Hawaii 4.27.09	43.8	56	0.32	209	21.7	5.6
(n=221)	[41.9 52.5]	[50.3 60.5]	[0.20 0.64]	[129.5 470.9]	[10.5 39.3]	[3.7 10.5]

* Two encounters from a single day are combined

I) False killer whale (*Pseudorca crassidens*)

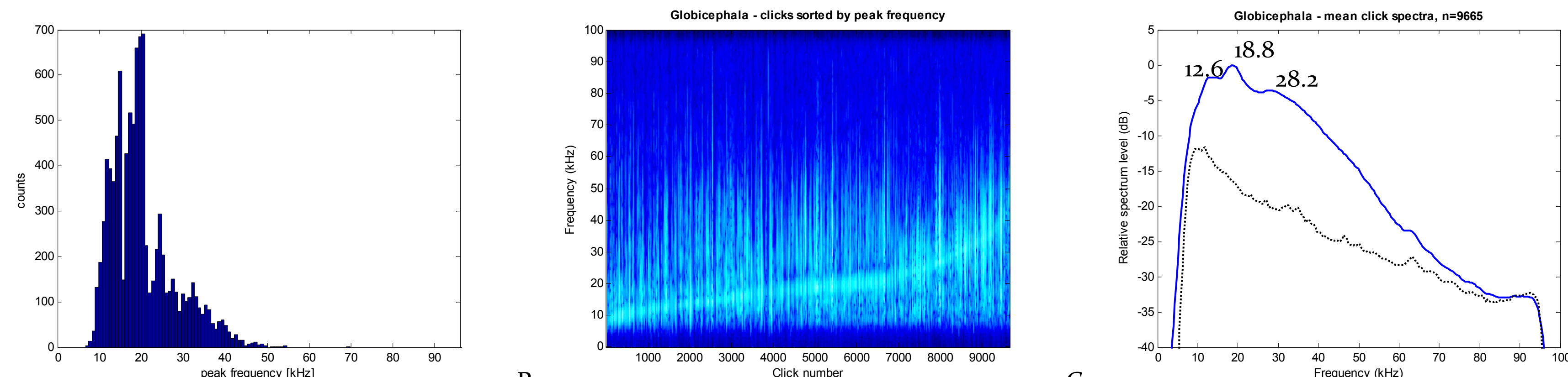
HARP



A B C

II) Short-finned pilot whale (*Globicephala macrorhynchus*)

HARP

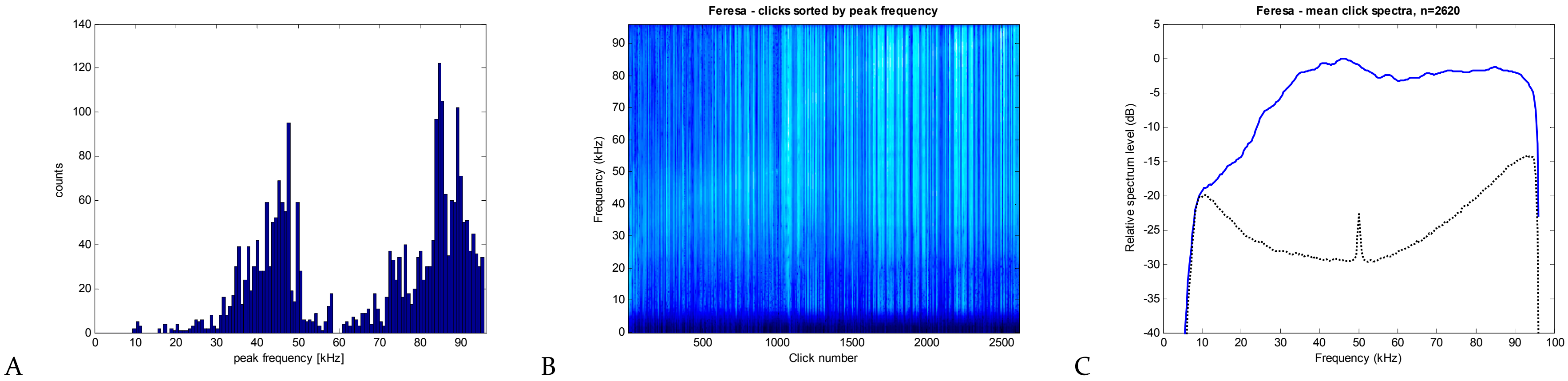


A B C

Figure 4: Echolocation clicks of I) false killer whales, II) short-finned pilot whales, III) pygmy killer whales, IV) melon-headed whales, V) rough-toothed dolphins, and VI) Risso's dolphins. A) Distribution of peak frequency, B) Concatenated spectrogram sorted by peak frequency with frequency over click number and spectrum level coded in color, C) Mean spectra (solid line) and mean noise (dashed line) with relative spectrum level over frequency.

III) Pygmy killer whale (*Feresa attenuata*)

Boat-based hydrophone



IV) Melon-headed whale (*Peponocephala electra*)

Boat-based hydrophone

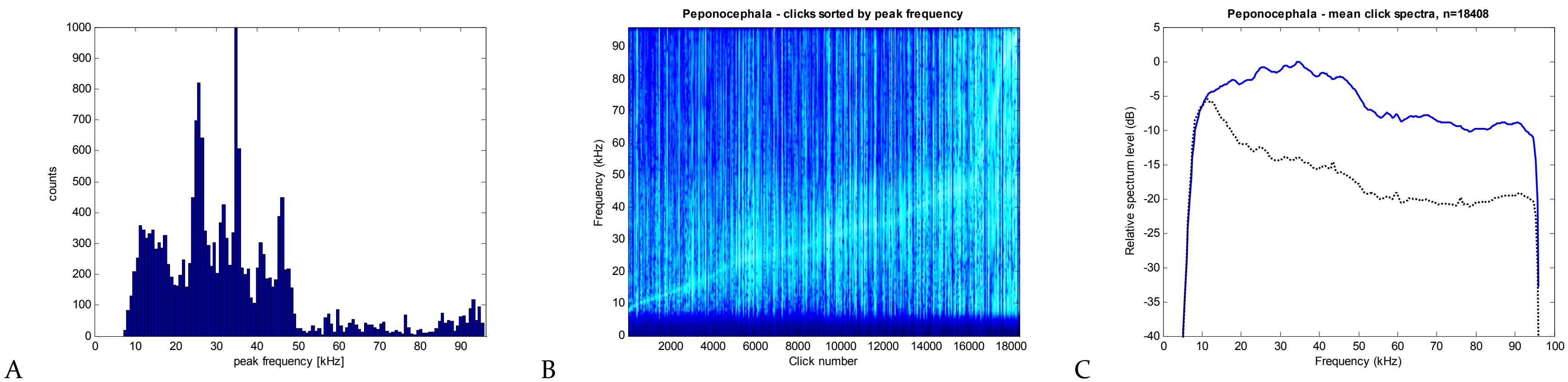
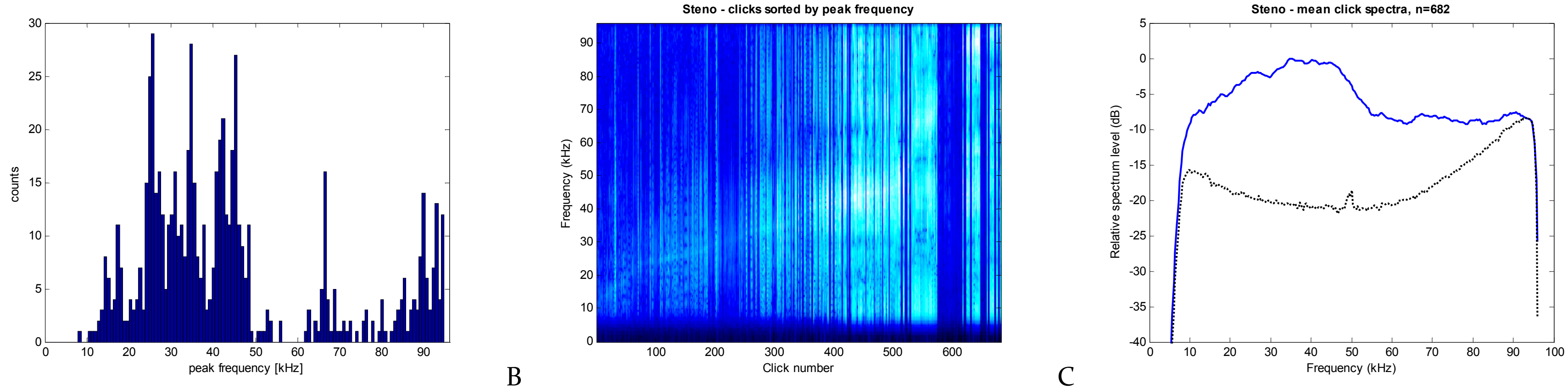


Figure 4 continued: Echolocation clicks of I) false killer whales, II) short-finned pilot whales, III) pygmy killer whales, IV) melon-headed whales, V) rough-toothed dolphins, and VI) Risso's dolphins. A) Distribution of peak frequency, B) Concatenated spectrogram sorted by peak frequency with frequency over click number and spectrum level coded in color, C) Mean spectra (solid line) and mean noise (dashed line) with relative spectrum level over frequency.

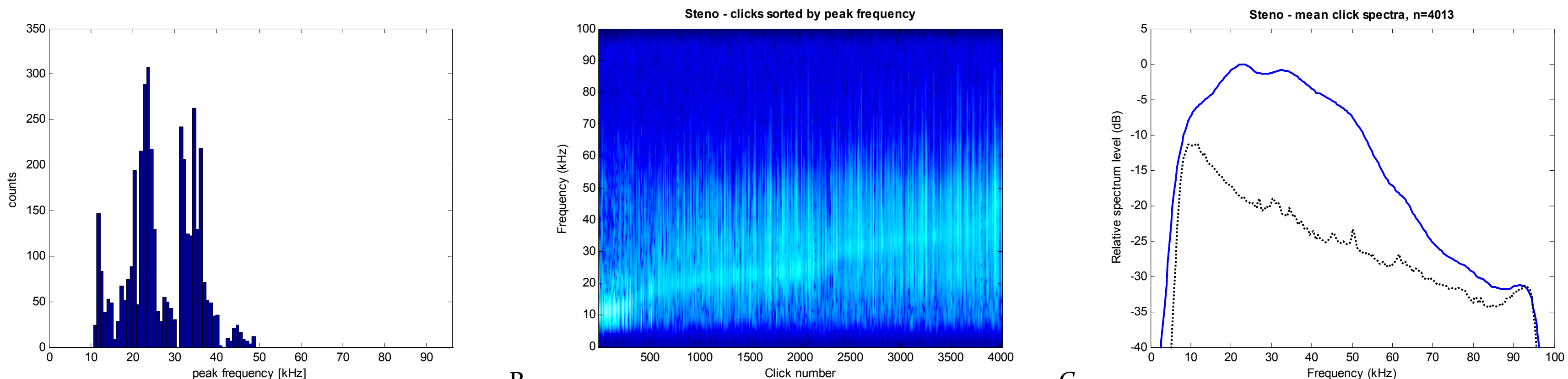
V) Rough-toothed dophin (*Steno bredanensis*)

Boat-based hydrophone



A B C

HARP



A B C

Figure 4 continued: Echolocation clicks of I) false killer whales, II) short-finned pilot whales, III) pygmy killer whales, IV) melon-headed whales, V) rough-toothed dolphins, and VI) Risso's dolphins. A) Distribution of peak frequency, B) Concatenated spectrogram sorted by peak frequency with frequency over click number and spectrum level coded in color, C) Mean spectra (solid line) and mean noise (dashed line) with relative spectrum level over frequency.

VI) Risso's dolphin (*Grampus griseus*)
Boat-based hydrophone

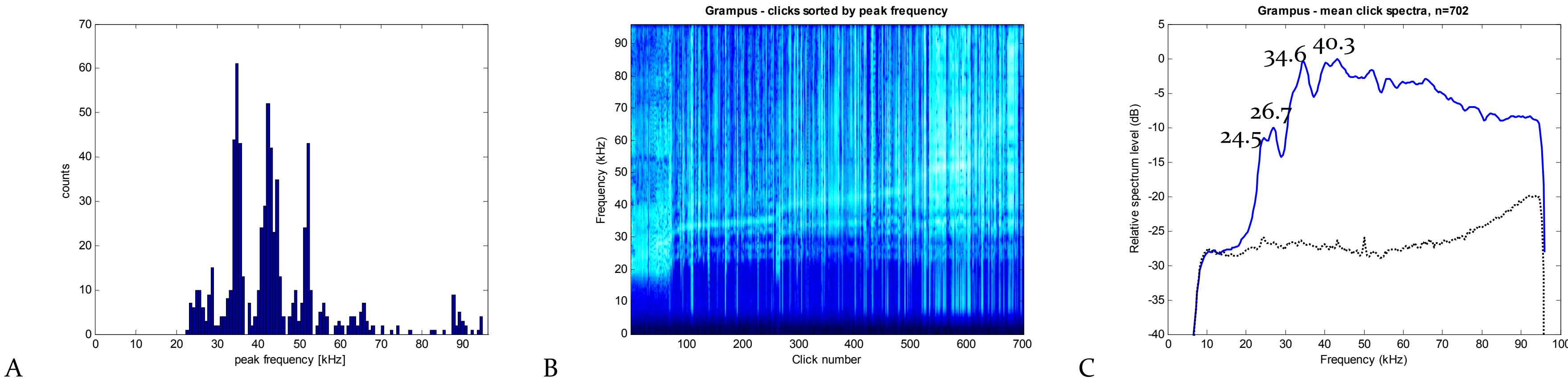


Figure 4 continued: Echolocation clicks of I) false killer whales, II) short-finned pilot whales, III) pygmy killer whales, IV) melon-headed whales, V) rough-toothed dolphins, and VI) Risso's dolphins. A) Distribution of peak frequency, B) Concatenated spectrogram sorted by peak frequency with frequency over click number and spectrum level coded in color, C) Mean spectra (solid line) and mean noise (dashed line) with relative spectrum level over frequency.

2) Automatic classification of echolocation clicks of false killer whales and short-finned pilot whales

Automatic classification of echolocation clicks of false killer whales and short-finned pilot whales was performed using a Gaussian mixture model (Roch et al., 2008) with a 3-fold test, 100 experiments, 16 mixtures and 200 consecutive clicks grouped as coming from the same species. This resulted in a mean error rate of misclassification of 10.7 ± 0.7%, and a median error rate of 9.3%. When looking at the falsely classified data more closely, there appeared to be one particular HARP recording of short-finned pilot whales (figure 5) that had more than 60% misclassifications in all experiments. We will have to increase our sample size to evaluate if this is an irregularity caused by recording a visually undetected species (e.g. false killer whales).

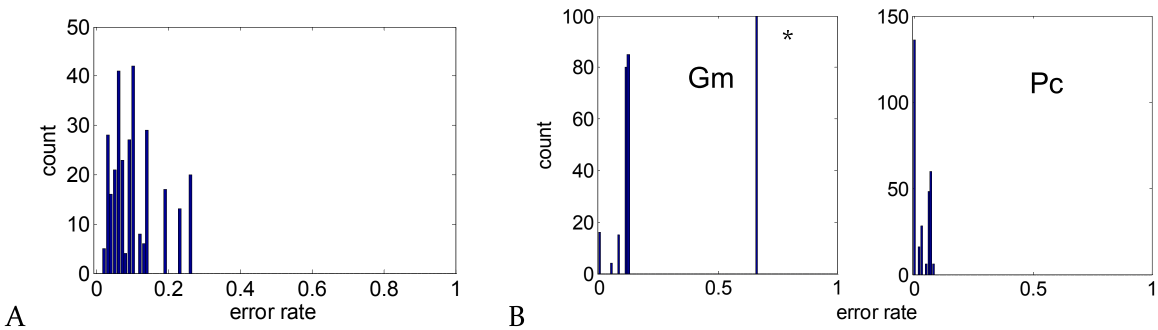


Figure 5: Distribution of error rates for automatic classification of echolocation clicks of false killer whales (Pc) and short-finned pilot whales (Gm). A) Overall error rate, B) error rate detailed for Pc and Gm.
*** indicates dataset with highest incorrect classification in all experiments.**

3) Echolocation clicks of unknown origin

Two distinct echolocation click types were notable in the long-term autonomous HARP data. One click type was a high frequency click that had its lowest frequency at around 70 kHz and was extending beyond the frequency range of the recorder (figure 6). The example click has in its timeseries and spectrogram a hint of a sweep indicating a possible beaked whale species of unknown kind. Data with a higher sampling rate would show this more clearly.

The other click type was a low frequency click that had a distinct banding pattern with peak structure at 12.2, 16.4 and 23.8 kHz (figure 7). This banding appears to be very close to the peaks reported for short-finned pilot whales above (figure 4/IIC) with 12.6, 18.8 and 28.2 kHz. Further data needs to be gathered of single species encounters or tagged animals to strengthen this hypothesis.

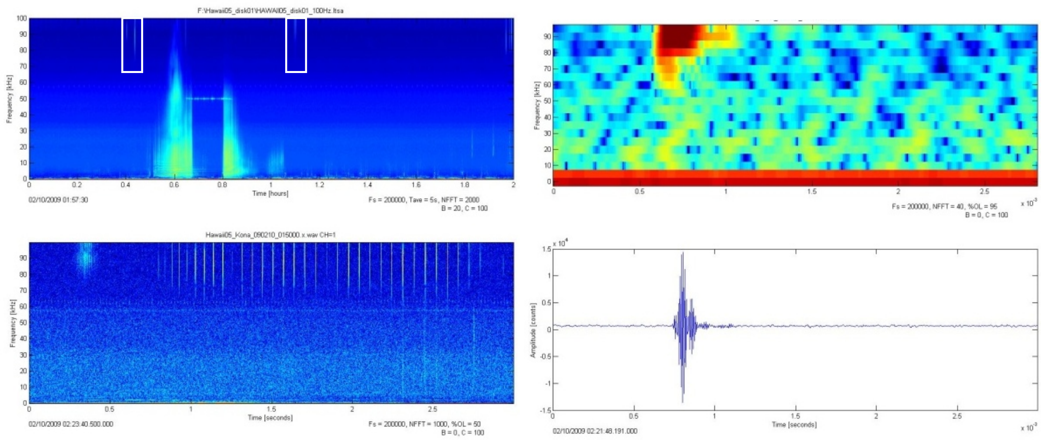


Figure 6: Example of high frequency clicks of unknown origin. Top left: Long-term spectral average of 2 hours of data. White boxes indicate areas of interest. Bottom left: spectrogram of 3 seconds. Right: Example click in detail, with top spectrogram and bottom timeseries.

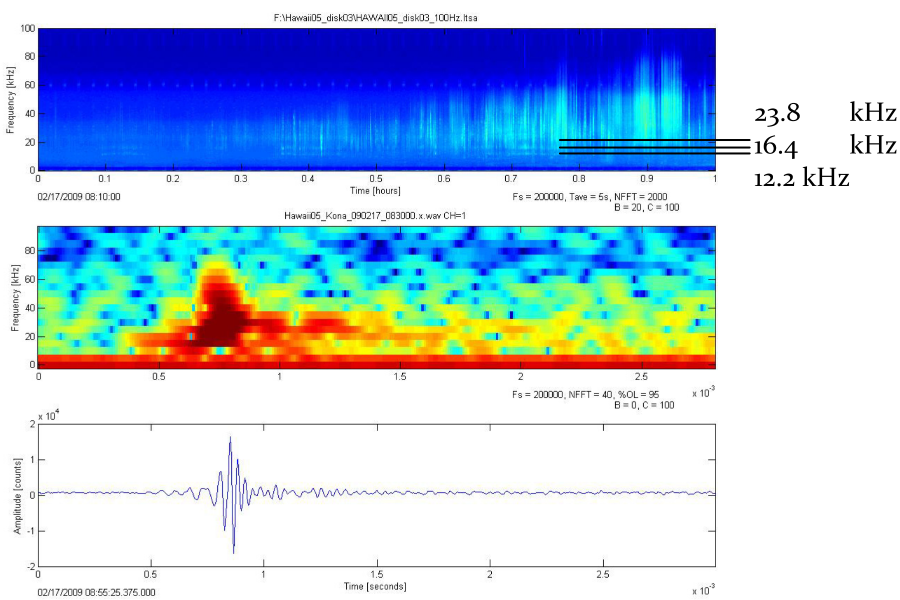


Figure 7: Notable banding pattern in echolocation clicks. Top: Long-term spectral average of 1 hour. Banding pattern in echolocation clicks, frequencies indicated by horizontal lines. Center spectrogram and bottom timeseries of example echolocation click.

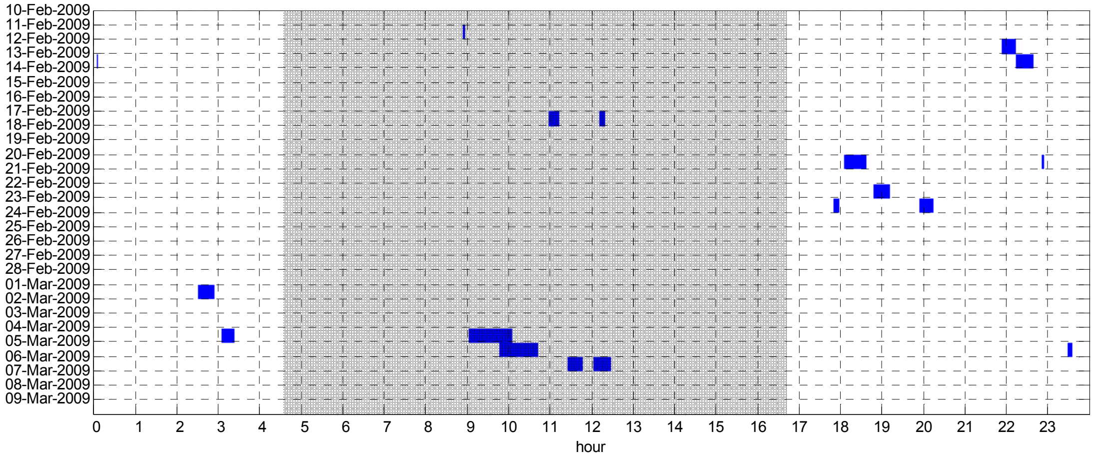
II) Acoustic detections of marine mammals from HARP

1) Manual acoustic detections

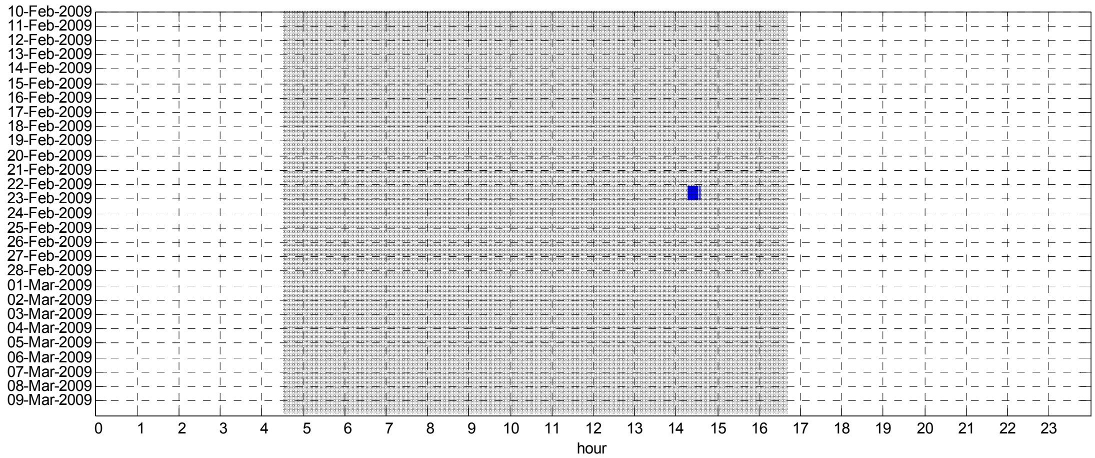
A trained analyst manually screened the HARP data collected off the west coast of the island of Hawaii (figure 1) during the time period of February 10, 2009, 0000 hours GMT until March 9, 2009, 0615 hours GMT (deployment Hawaii 05, Table 1). A MATLAB based software package called *TRITON* was used for data display and event logging. Potential sound events detected in a one-hour or shorter spectrogram were investigated at finer temporal scales to identify the origin of the sound by species or type of anthropogenic sound. Start and end of a distinct vocalization period were marked.

Distinct call types were found for beaked whales with their frequency modulated upsweep echolocation pulses (figure 8A), particularly those first noted at Cross Seamount (McDonald et al., 2009) (figure 8B), sperm whales (figure 8C), high frequency clicks of unknown origin (figure 8D, described in figure 6), and low frequency, banded echolocation clicks (figure 8E, described in figure 7). Additionally, a large number of echolocation clicks originating from unidentified odontocetes were noted that could not be attributed to a certain species or a distinct call type (figure 8F).

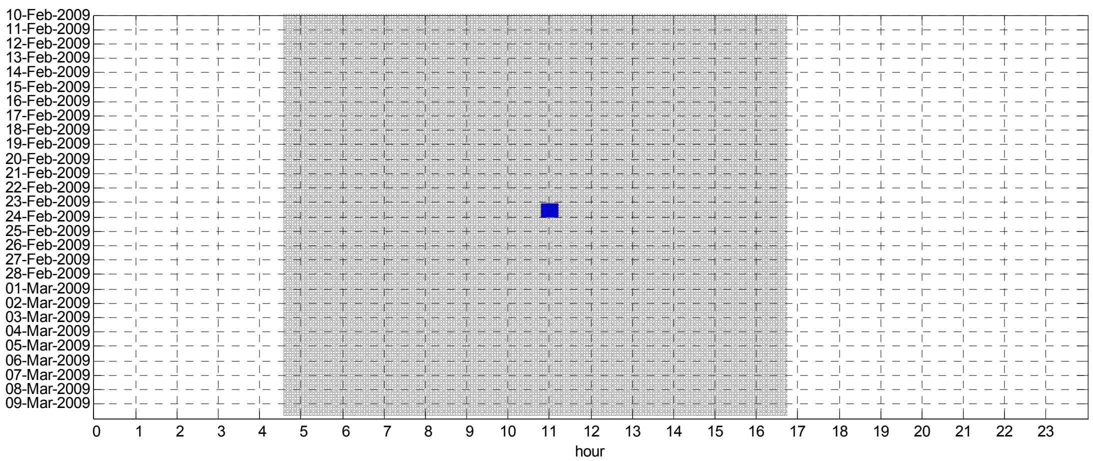
Odontocetes were acoustically active every day of the recording period with approximately 65% of total hours with echolocation click activity (Table 3). Beaked whales were detected on 41% of the recording days yet only during short periods per day, resulting in about 4% of total hours with beaked whale echolocation pulses (Table 3). Low frequency, banded clicks (figure 6) were noted with similar regularity.



A: Beaked Whale spp.

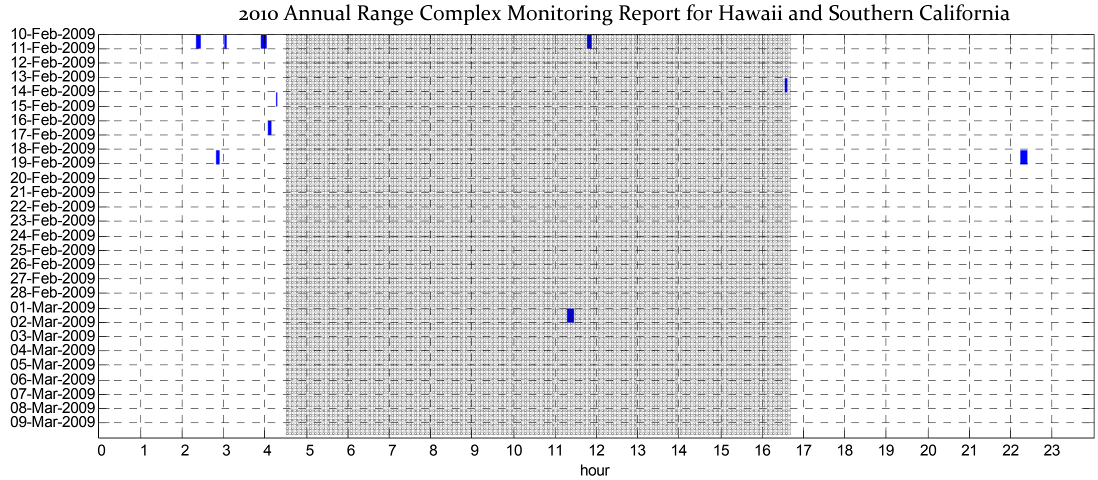


B: Frequency modulated upsweep, first reported from Cross Seamount, Hawaii (McDonald et al., 2009).

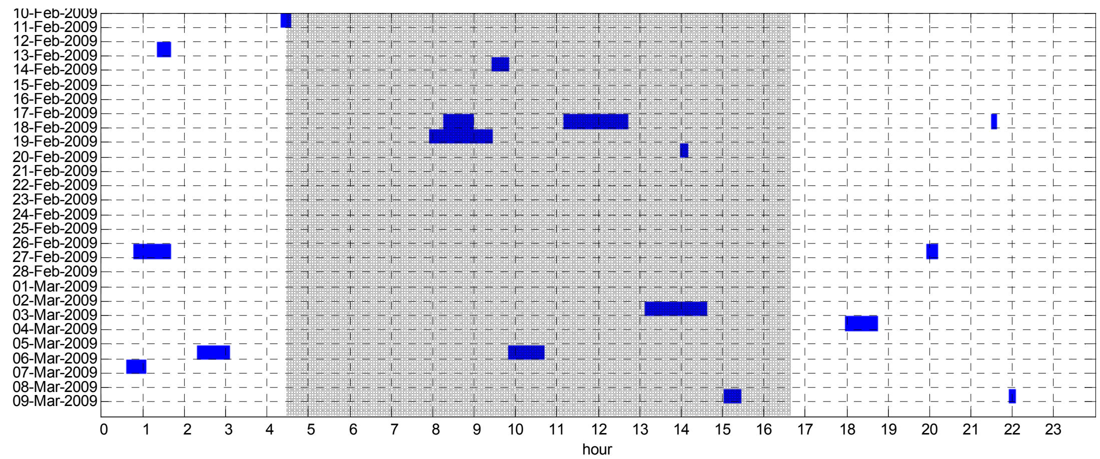


C: Sperm whale

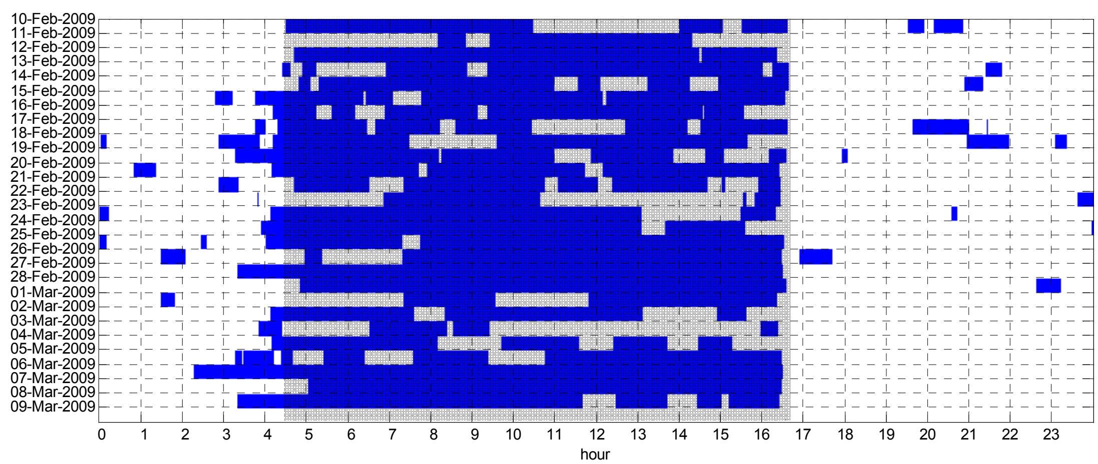
Figure 8: Manual detections of A) all beaked whale echolocation pulses with frequency modulated (FM) upsweep, B) FM pulses, known from Cross Seamount, Hawaii, C) Sperm whale echolocation clicks, D) High frequency clicks of unknown origin (figure 6), E) Low frequency, banded echolocation clicks (figure 7), and F) Unidentified odontocete echolocation clicks. Time is given in GMT, local approximate night time indicated with gray background.



D: High frequency echolocation clicks



E: Low frequency, banded echolocation clicks



F: Unidentified odontocete echolocation clicks

Figure 8 continued: Manual detections of A) all beaked whale echolocation pulses with frequency modulated (FM) upsweep, B) FM pulses, known from Cross Seamount, Hawaii, C) Sperm whale echolocation clicks, D) High frequency clicks of unknown origin (figure 6), E) Low frequency, banded echolocation clicks (figure 7), and F) Unidentified odontocete echolocation clicks. Time is given in GMT, local approximate night time indicated with gray background.

Table 3: Manual detections of marine mammal species and anthropogenic sound sources during February 10, 2009 until March 9, 2009.

	# hour bins	percent	# day bins	percent
Marine mammal sounds				
Beaked whale spp.	23	3.5%	11	40.7%
Cross Seamount beaked whale	1	0.2%	1	3.7%
Sperm whale	1	0.2%	1	3.7%
High frequency clicks (figure 6)	10	1.5%	6	22.2%
Low frequency clicks (figure 7)	26	4.0%	12	44.4%
Clicks of other odontocete spp.	361	55.2%	27	100.0%
Anthropogenic sounds				
25 kHz echosounder	5	0.8%	3	11.1%
28.8 kHz echosounder	39	6.0%	12	44.4%
30 kHz echosounder	83	12.7%	19	70.4%
33 kHz echosounder	4	0.6%	2	7.4%
43 kHz echosounder	1	0.2%	1	3.7%
50 kHz echosounder	362	55.4%	27	100.0%
80 kHz echosounder	5	0.8%	4	14.8%
ship engine noise	464	70.9%	27	100.0%

2) Automatic acoustic detections

An automatic routine in Matlab detected odontocete clicks (method described in Soldevilla et al., 2008) and subsequently classified frequency modulated clicks as of origin beaked whale. The classifier was an expert system, which screened 75 s segments of data as a unit and evaluated the temporal and spectral parameters of detected clicks within each segment. A detailed description of the classification procedure is currently under preparation for publication.

The detector is capable of detecting all FM pulses currently known for beaked whales in the Pacific Islands region, namely Blainville's beaked whale (*Mesoplodon densirostris*), Cuvier's beaked whale (*Ziphius cavirostris*), signals known from an unknown species at Palmyra Atoll (possibly *Mesoplodon hotaula*, Baumann-Pickering et al., 2010), and an unknown species at Cross Seamount (McDonald et al., 2009). The detector was verified for missed and false detections for the manually screened time period described above (section II/1). It detected 51 segments with beaked whale vocalizations out of which 6 segments were misclassified, resulting in a 12% false detection rate. There were a total of 28 beaked whale sequences detected. A sequence was defined as a series of echolocation activity of undefined length with gaps not longer than 10 minutes. The detector missed 6 of these sequences, resulting in a 21% missed detection rate, the analyst missed 9 of these, resulting in a 32% missed detection rate. From data collected in Southern California on which the classifier was tested in more detail, it is known that the number of false detections is fairly stable over time. This means that the percentage of false detections will decrease with an increase of beaked whale detections. The number of missed detections is dependent on overall activity. The missed detection rates are higher during periods of high acoustic activity, mostly due to mixed species recordings.

The data automatically analyzed were five deployments of the HARP off the island of Hawaii. The analysis is preliminary and further evaluation of the outcome will be necessary.

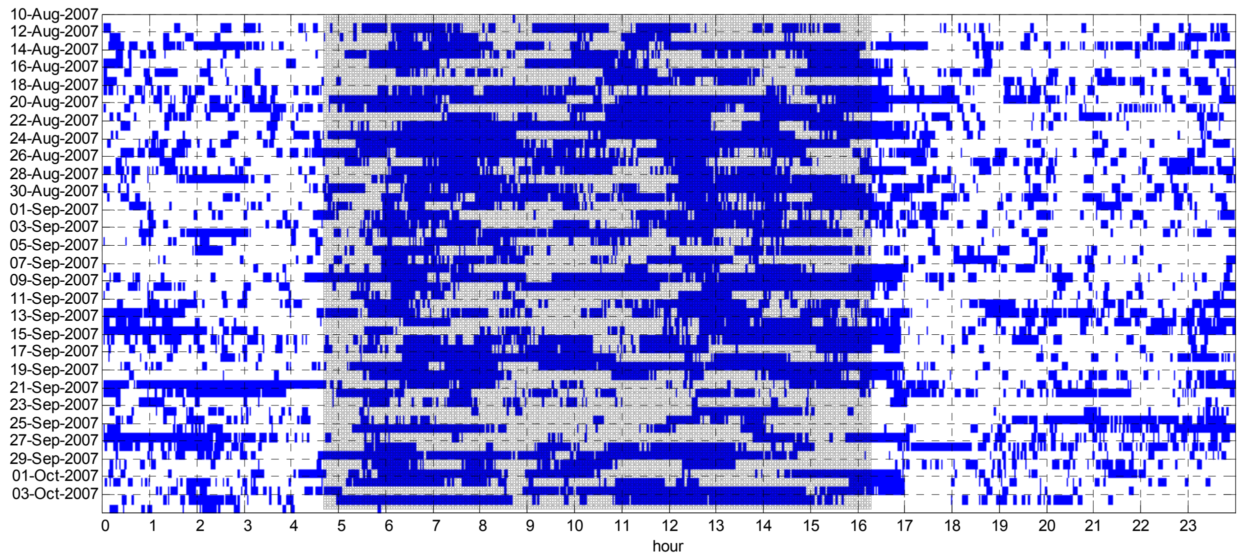
Automatic detections of echolocation clicks of all odontocete species show a higher echolocation activity during night time (figure 9). This could be related to a higher foraging activity at night for the two most frequently encountered species of odontocetes in the area, pantropical spotted dolphins and short-finned pilot whales (e.g. Baird et al. 2001, 2003). There seems to be an irregularity in the output of the detector with unexpectedly high numbers of detections starting in Hawaii 02, early June and all through deployment Hawaii 03 (figure 9B, 9C). This irregularity will have to be investigated further. Overall, odontocete echolocation clicks were detected every day of the recording period and during 79 to 96% of hourly bins (Table 4). On average, deployments Hawaii 01, 05 and 06 taken into account, there were 87% of all hours with detections of echolocation activity.

Beaked whale echolocation pulses were automatically detected throughout the entire recording period (figure 10). Detection rates ranged between 42 and 86% of days with detections and 3 to 9% of hours with detections (Table 4). On average, they were acoustically detectable during 55% of days and 5 % of hourly bins. In most cases beaked whales were detected on one day and not on the next (figure 11). On fewer occasions, between 2 and 19 days of consecutive detections were noted. There did not seem to be a dominant preferred time of the day for vocalizations (figure 12), not surprisingly given the lack of diel pattern in deep foraging dives documented for both Cuvier's and Blainville's beaked whales in the area (Baird et al. 2008c), and the similar uses of water depths during the day and night by Blainville's beaked whales (Schorr et al. 2009a). Only during the very active beaked whale deployment Hawaii 01 was a preference for night time activity notable. Echolocation activity appears to be particularly low at the hours of dusk and dawn. In future analysis the beaked whale detections should be investigated more closely to species level. Possibly one species was dominating the detections in Hawaii 01 and showed a preference for vocal activity during a certain time of the day.

Table 4: Automatic detections of echolocation clicks of all odontocetes and beaked whale pulses during five HARP deployments.

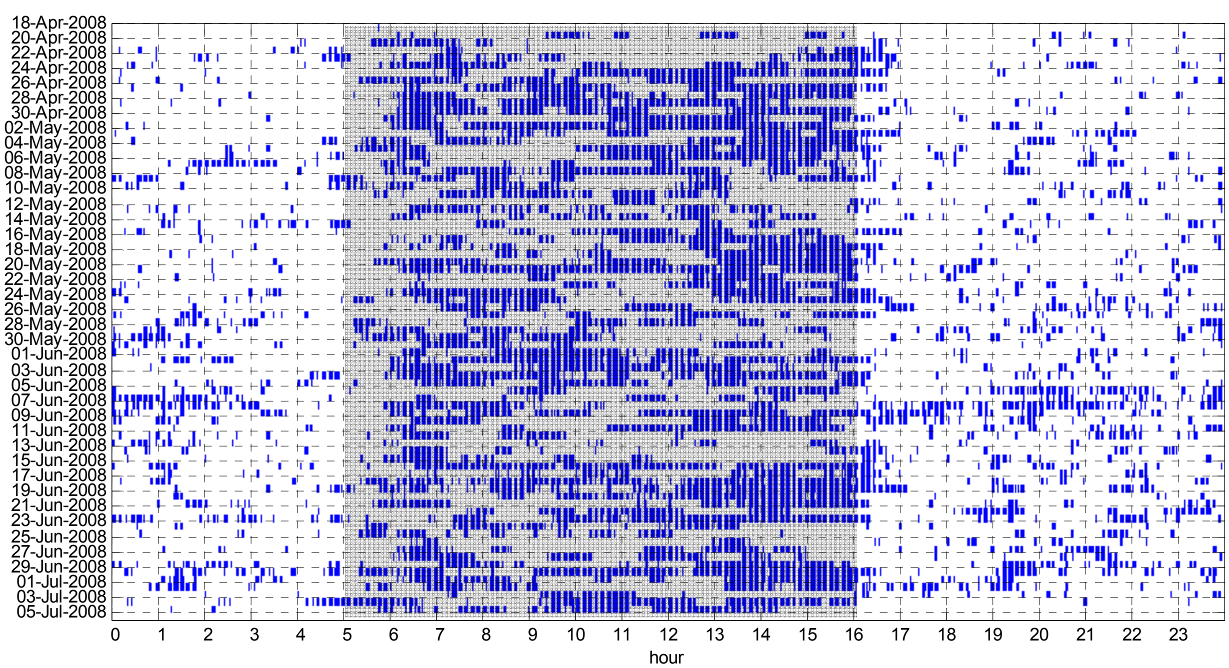
	# hour bins	percent	# day bins	percent
Odontocete detections				
Hawaii 01	1139	87.5%	55	100.0%
Hawaii 02	1455	79.4%	77	100.0%
Hawaii 03	2396	100.0%	100	100.0%
Hawaii 05	628	96.0%	28	100.0%
Hawaii 06	2349	83.4%	118	100.0%
Total (HI01+05+06)	4116	86.7%	378	100.0%
Beaked whale detections				
Hawaii 01	114	8.8%	47	85.5%
Hawaii 02	95	5.2%	48	62.3%
Hawaii 03	81	3.4%	42	42.0%
Hawaii 05	29	4.4%	15	53.6%

Hawaii 06	107	3.8%	54	45.8%
Total	426	4.7%	206	54.5%

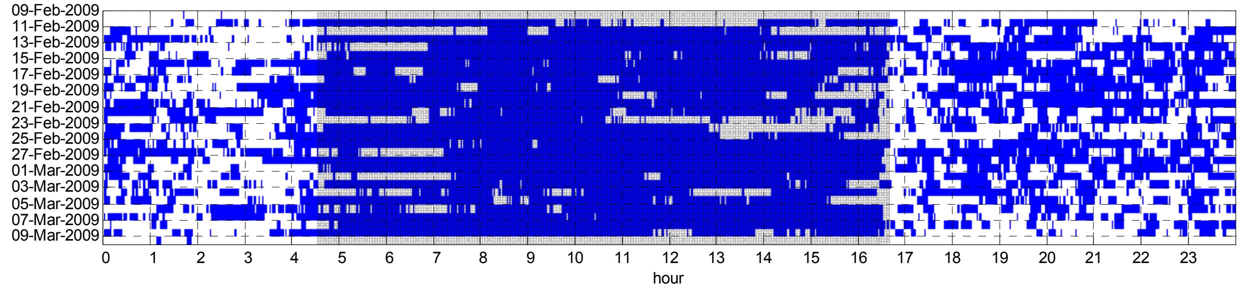


A: Odontocete spp. Hawaii 01, duty cycle continuous

Figure 9: Automatic detections of echolocation clicks of all odontocete species during deployment A) Hawaii 01, B) Hawaii 02, C) Hawaii 05, and D) Hawaii 06. Time is given in GMT, local approximate night time indicated with gray background. Duty cycle is shown as recording time/recording interval in minutes.

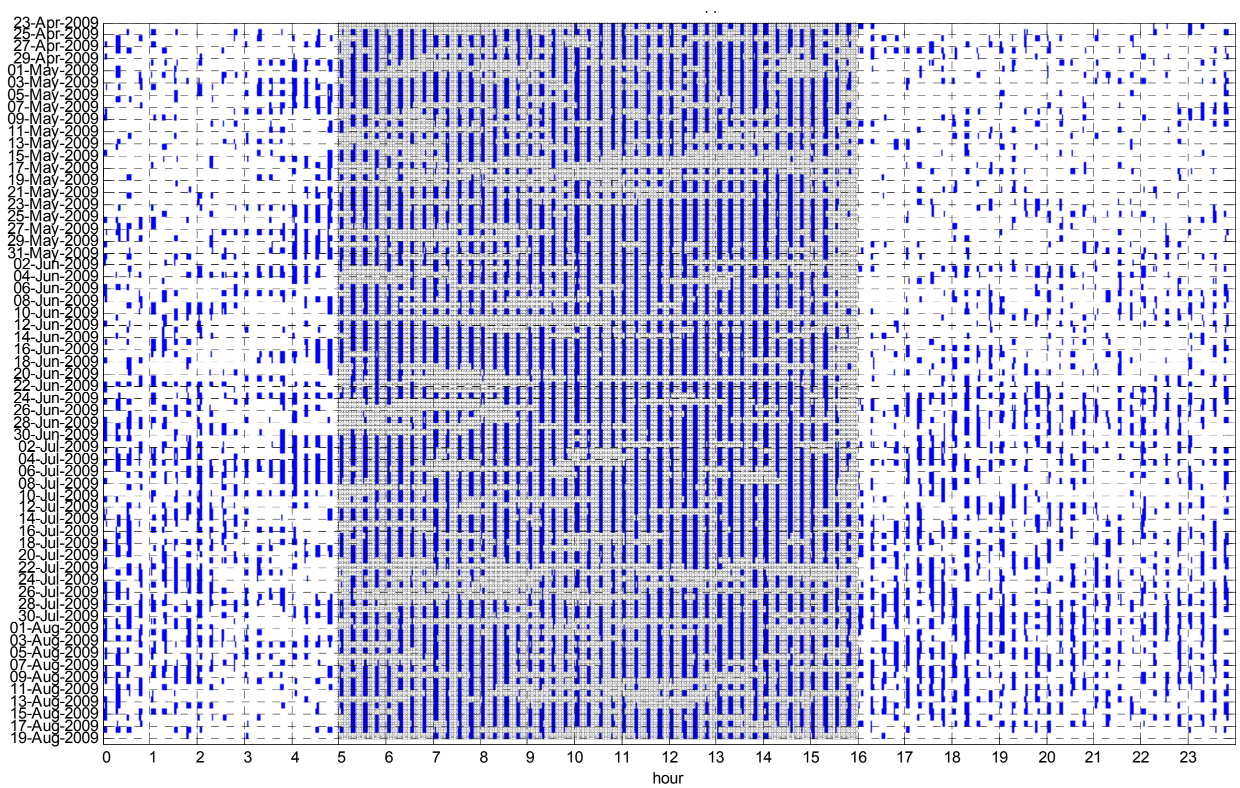


B: Odontocete spp. Hawaii 02, duty cycle 5/8



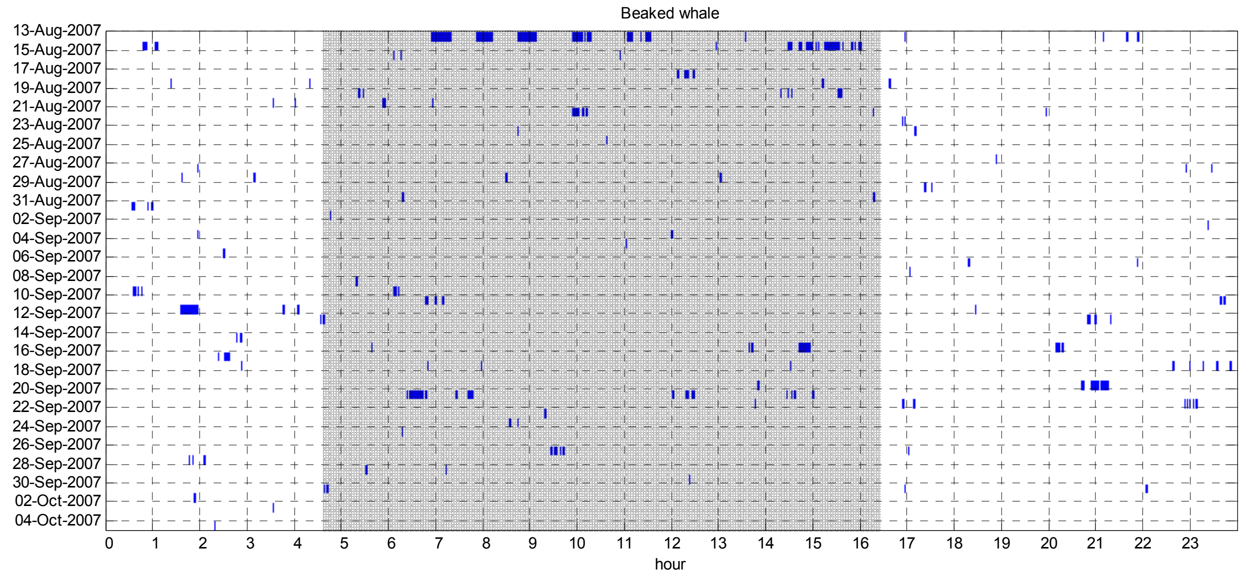
C: Odontocete spp. Hawaii 05, duty cycle continuous

Figure 9 continued: Automatic detections of echolocation clicks of all odontocete species during deployment A) Hawaii 01, B) Hawaii 02, C) Hawaii 05, and D) Hawaii 06. Time is given in GMT, local approximate night time indicated with gray background. Duty cycle is shown as recording time/recording interval in minutes.

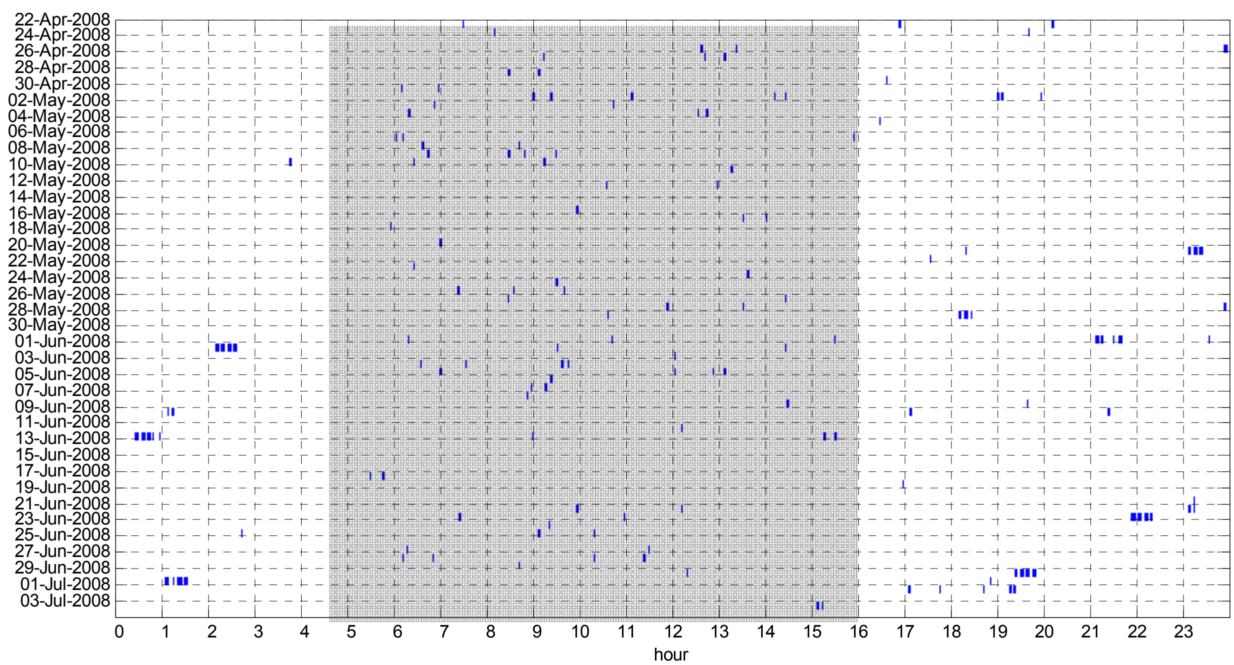


D: Odontocete spp. Hawaii 06, duty cycle 5/15

Figure 9 continued: Automatic detections of echolocation clicks of all odontocete species during deployment A) Hawaii 01, B) Hawaii 02, C) Hawaii 05, and D) Hawaii 06. Time is given in GMT, local approximate night time indicated with gray background. Duty cycle is shown as recording time/recording interval in minutes.

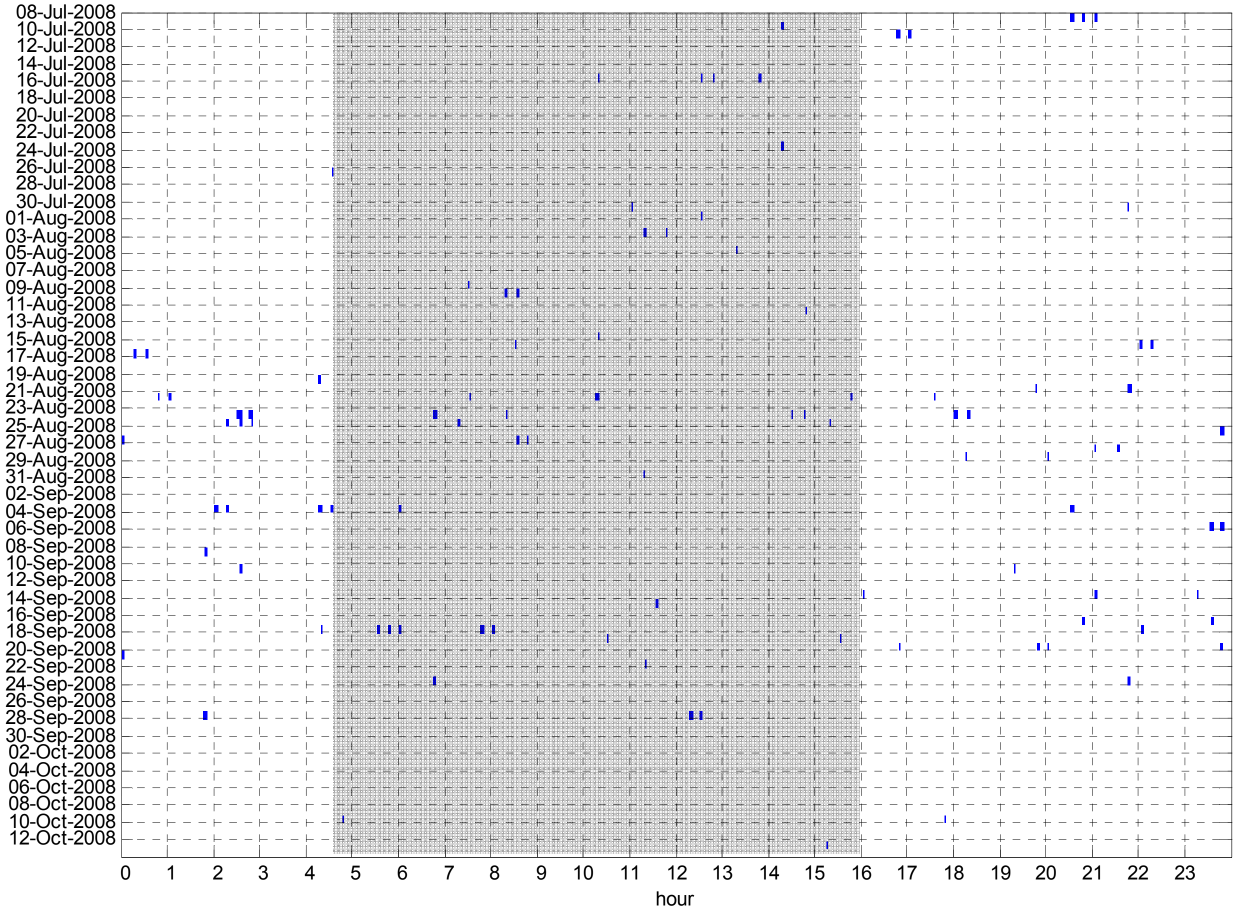


A: Beaked whale Hawaii 01, duty cycle continuous

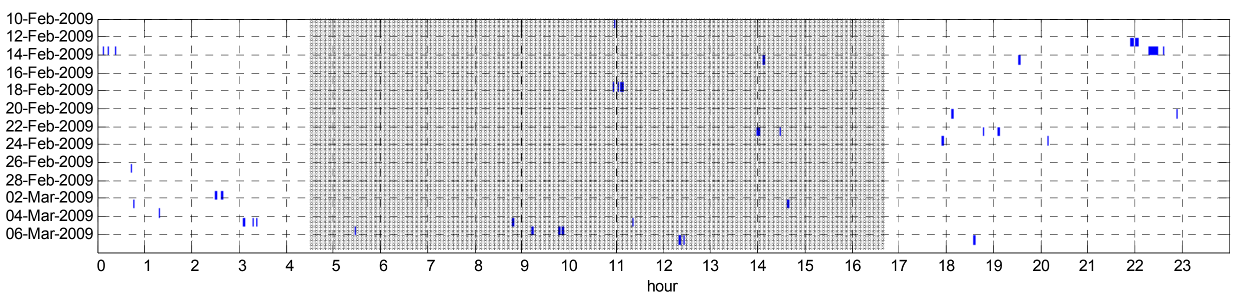


B: Beaked whale Hawaii 02, duty cycle 5/8

Figure 10: Automatic detections of beaked whale echolocation pulses during deployment A) Hawaii 01, B) Hawaii 02, C) Hawaii 03, D) Hawaii 05, and E) Hawaii 06. Time is given in GMT, local approximate night time indicated with gray background. Duty cycle is shown as recording time/recording interval in minutes.

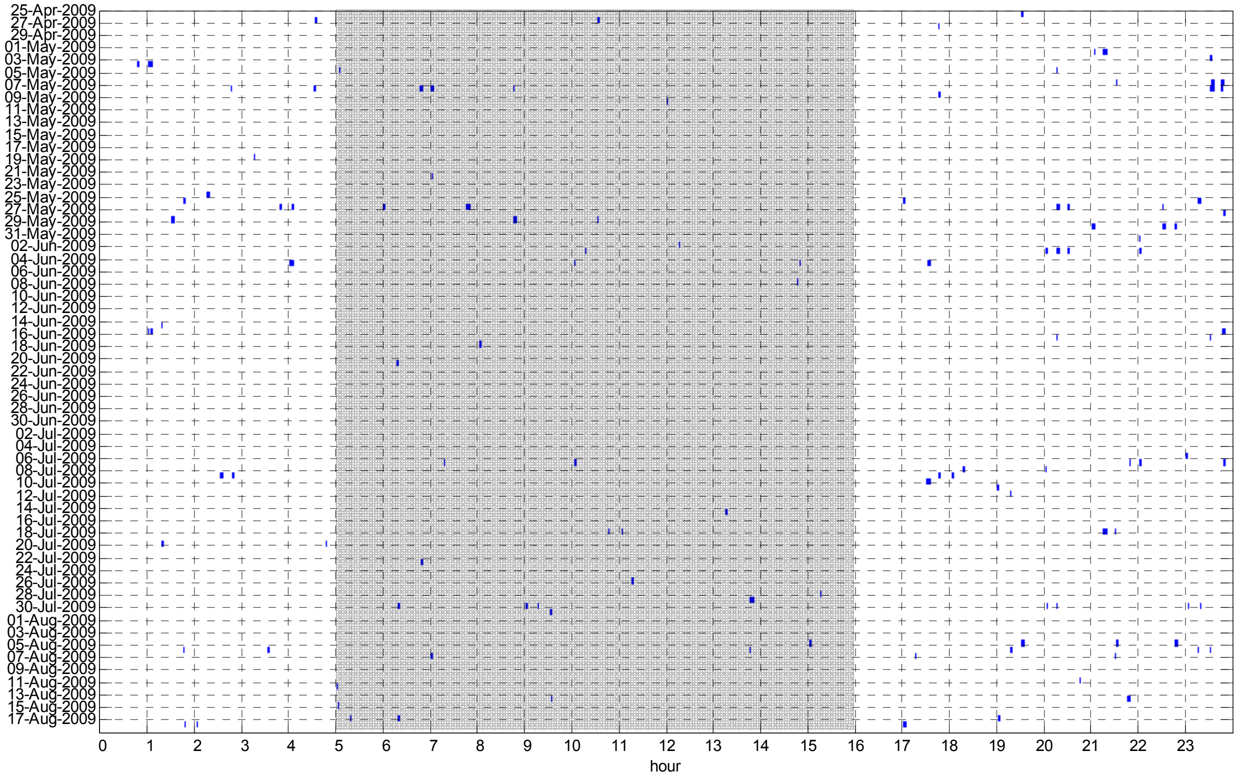


C: Beaked whale Hawaii 03, duty cycle 5/15



D: Beaked whale Hawaii 05, duty cycle continuous

Figure 10 continued: Automatic detections of beaked whale echolocation pulses during deployment A) Hawaii 01, B) Hawaii 02, C) Hawaii 03, D) Hawaii 05, and E) Hawaii 06. Time is given in GMT, local approximate night time indicated with gray background. Duty cycle is shown as recording time/recording interval in minutes.



E: Beaked whale Hawaii 06, duty cycle 5/15

Figure 10 continued: Automatic detections of beaked whale echolocation pulses during deployment A) Hawaii 01, B) Hawaii 02, C) Hawaii 03, D) Hawaii 05, and E) Hawaii 06. Time is given in GMT, local approximate night time indicated with gray background. Duty cycle is shown as recording time/recording interval in minutes.

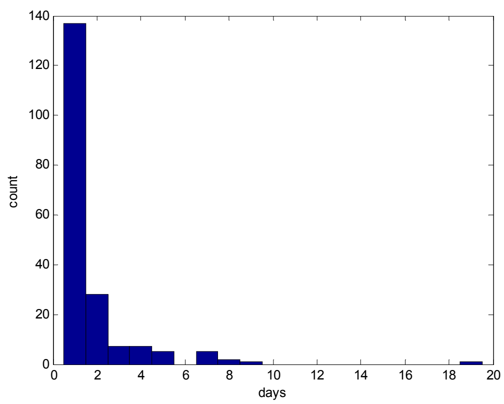


Figure 11: Distribution of number of consecutive days with beaked whale detections

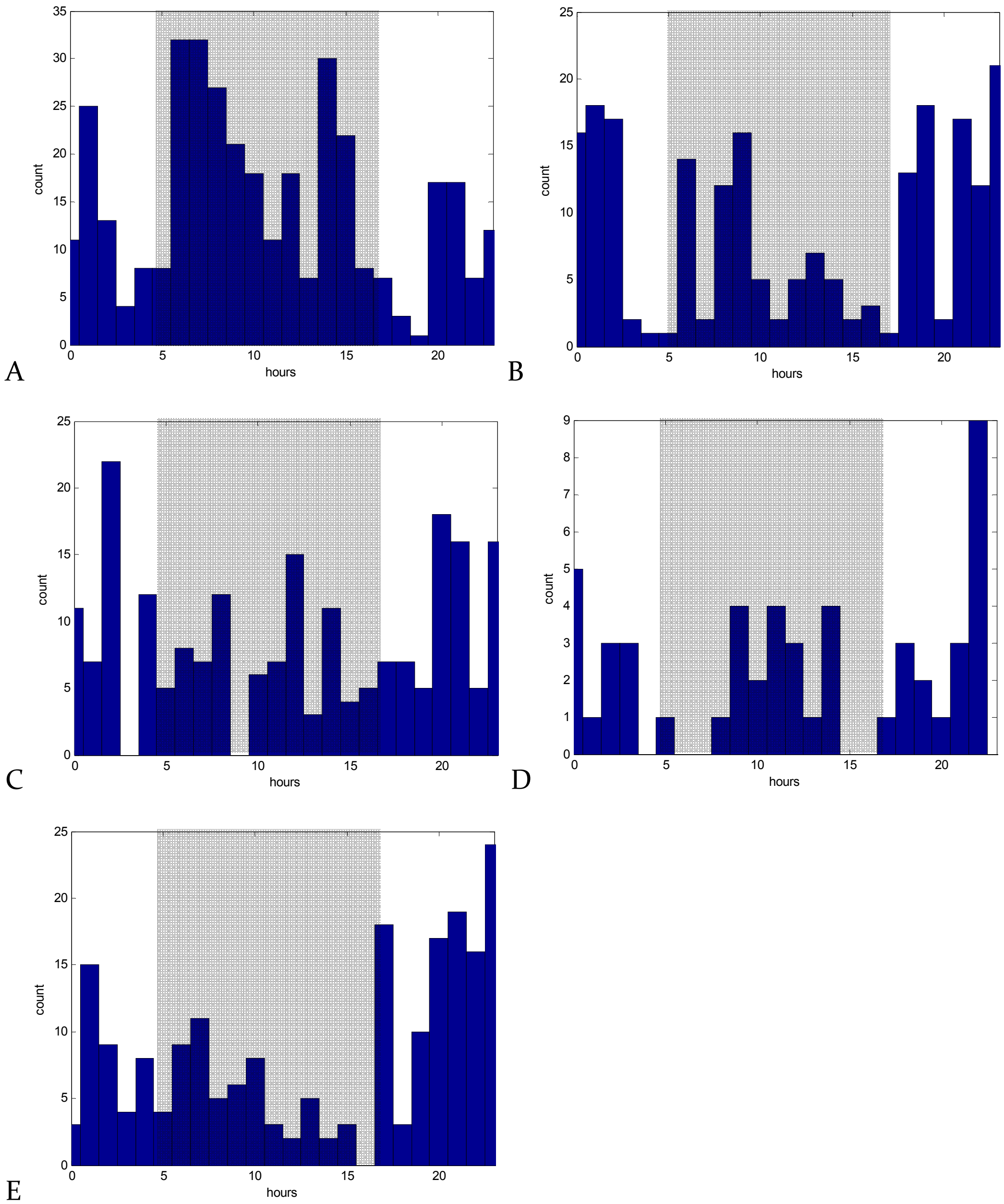


Figure 12: Distribution of automatic detections of beaked whale echolocation pulses versus time of day during deployment A) Hawaii 01, B) Hawaii 02, C) Hawaii 03, D) Hawaii 05, and E) Hawaii 06. Counts are 75 s segments with beaked whale pulses. Time is given in GMT, local approximate night time indicated with gray background.

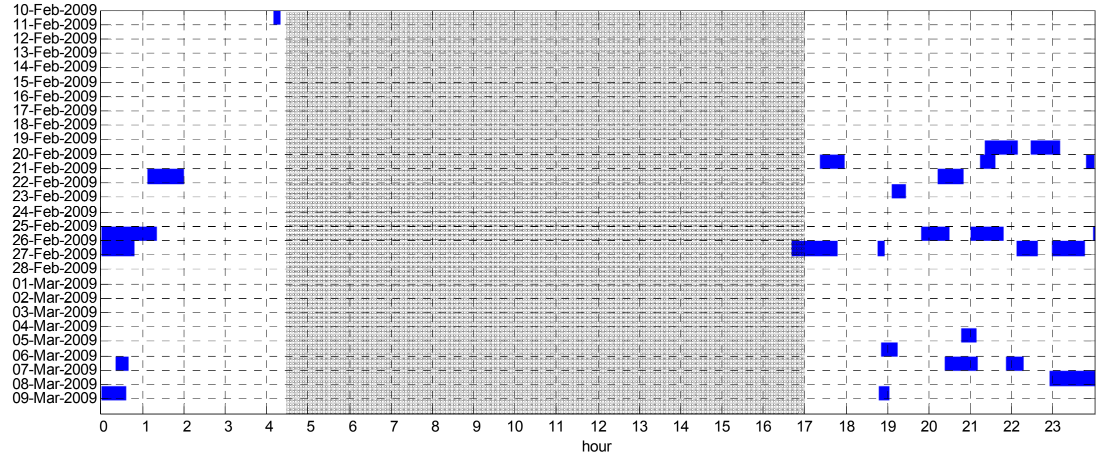
III) Classification and characterization of anthropogenic noise

A trained analyst manually screened the HARP data for deployment Hawaii 05, during the time period of February 10, 2009, 0000 hours GMT until March 9, 2009, 0615 hours GMT. Start and end of an event of human-made noise were logged and assigned to the category of ship (detection of noise caused by the engine) or echosounder.

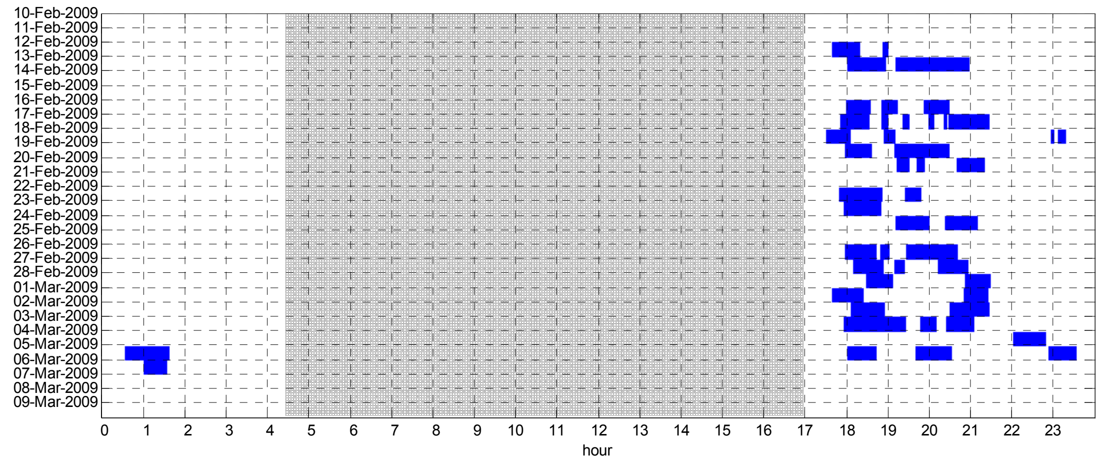
Given the proximity of the HARP to Honokohau and Kailua Harbors, as well as to a Fish Aggregating Device (the "VV" FAD), it is not surprising that ship noise was detected every day of the time period considered (Table 3, figure 13D). The detections encompassed 71% of the total hourly bins analyzed and were mostly present during the day.

The echosounders were manually classified according to their main frequency into seven classes: 25, 28.8, 30, 33, 43, 50 and 80 kHz. The most frequent echosounders were the 50 kHz (covering over 50% of the total time analyzed and present every day, Table 3, figure 13C), the 30 kHz (being present about 15% of the total time, and registered for 70% of the days, Table 3, figure 13B) and the 28.8 kHz (present 6% of the hourly bins and in about 44% of days, Table 3, figure 13A). The 28.8 and 30 kHz echosounders were detected during daytime (figure 13A and 13B), whereas the 50 kHz echosounder was detected throughout the whole day (figure 13C).

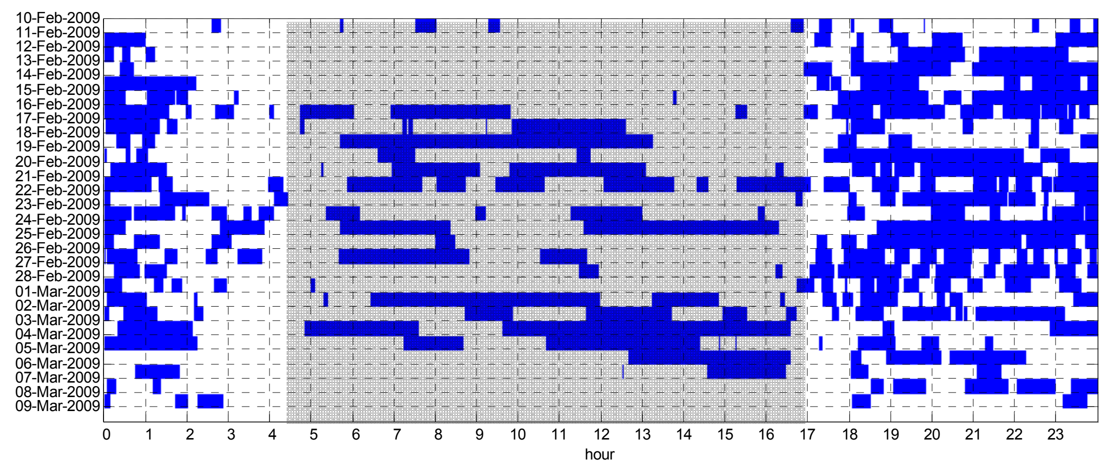
Additionally, power spectral density plots over the frequency range show the contribution in amplitude of every echosounder type to the overall ocean noise (figure 14). In all cases there is a prominent peak at 50 kHz and in most cases another at 30 kHz, which speaks for the considerable contribution of those echosounder types to the overall noise, sometimes more than 10 dB in 80-hour averages.



A: Echosounder 28.8 kHz

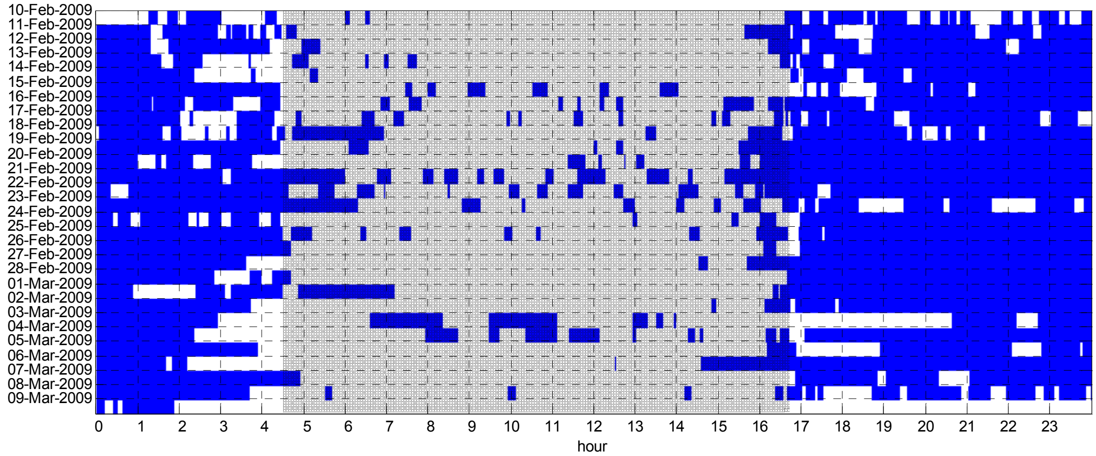


B: Echosounder 30 kHz



C: Echosounder 50 kHz

Figure 13: Manual detections of anthropogenic noise in Hawaii 05. A) Echosounders with main frequency at 28.8 kHz, B) Echosounders 30 kHz, C) Echosounders 50 kHz and D) Ship engine noise.



D: Ship engine noise

Figure 13 continued: Manual detections of anthropogenic noise in Hawaii 05. A) Echosounders with main frequency at 28.8 kHz, B) Echosounders 30 kHz, C) Echosounders 50 kHz and D) Ship engine noise.

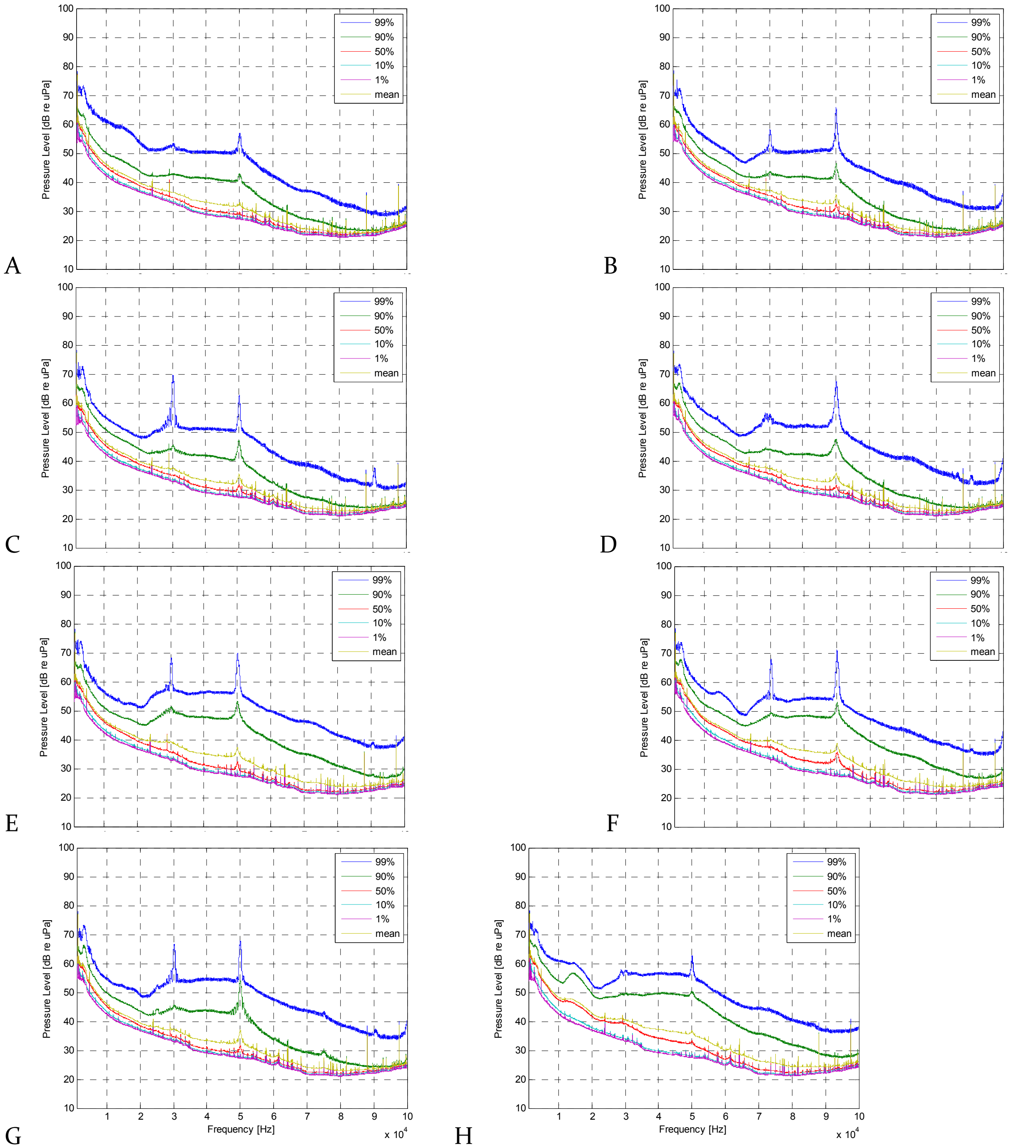


Figure 14: Power spectral densities of 80 hours of recordings per plot. Different percentiles are depicted in color. Prominent peaks at 30 and 50 kHz of mainly the 99th and 90th percentile, corresponding to the contribution of echosounders to the overall ocean noise. In the plots C, D, E, F, and G, there are smaller peaks at 90 kHz, being side band energy of the 30 kHz echosounder. Data from Hawaii 05 time period A) 2/16/2009, 1845 h – 2/13/2009, 0920 h, B) 2/13/2009, 0921 h – 2/16/2009,1844 h, C) 2/16/2009, 1845 h – 2/20/2009, 0730 h, D) 2/20/2009, 0731 h – 2/23/2009, 1331 h, E) 2/23/2009, 1332 – 2/26/2009, 2255 h, F) 2/26/2009, 2256 h – 3/2/2009, 0819 h, G) 3/2/2009, 0820 h – 3/5/2009, 1742 h, and H) 3/5/2009, 1743 h – 3/9/2009, 0306 h.

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APPENDIX J Report on passive acoustic analysis for marine mammals before and after the Submarine Commanders Course training exercise at PMRF Feb 16-19, 2010

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27 Sept 2010

Executive Summary:

This report provides passive acoustic evidence of the presence of beaked and minke whales on the Pacific Missile Range Facility (PMRF) instrumented acoustic range (BSURE and BARSTUR) before and after the Feb 2010 Submarine Commanders Course training event (SCC). The effort focuses on these species utilizing automated species passive acoustic detection and classification algorithms. Manual verification of selected automatic detections was performed to confirm presence of the species under investigation. Results indicate presence of beaked whales (BW), suspected to be Blainville's and Cuvier's (*Mesoplodon densirostris and Ziphius cavirostris* respectively) and minke whales (*Balaenoptera acutorostrata*) before and after the SCC on the PMRF range. While data does show a lower number for the POST versus the PRE periods, it is not clear if the differences are due to the exercise or normal variations.

Introduction:

Passive acoustic monitoring (PAM) for marine mammal species is a technology undergoing rapid change, with significant progress in areas of detection, classification and density estimation for various species. Density estimation is a pivotal area as it is defined as the number of animals per unit area. Understanding the normal variation of the densities for marine mammal species that frequent US Navy ranges is important to understanding potential impacts due to US Navy exercises. Without this baseline information, both short and longer term impacts from sonar operations can be difficult to determine and acoustic density estimation techniques are a promising tool to aid in this understanding.

Recent progress in acoustic density estimation of vocalizing marine mammal species includes demonstrated methods for estimating Blainville's beaked whale species density (Marques et al. 2009) at the Atlantic Undersea Test and Evaluation Center (AUTEC), located in the Bahamas. This method utilized cue counting (beaked whale echolocation clicks were the cues) and relied on data from acoustic tags attached to whales for obtaining other required parameters such as the probability of detection as a function of distance, and the foraging echolocation click cue rate. Both cue counting and dive counting methods for Blainville's beaked whale density estimation has also recently been reported for data collected before, during, and after a mid-frequency sonar exercise at AUTEC (Moretti et al., 2010).

Passive acoustic data from the Pacific Missile Range Facility (PMRF) has been utilized in demonstrating techniques to study the density of minke whales by virtue of their boing vocalization. These studies use data collected in the winter and early spring in 2006 and 2007 (Marques et al., 2010 and Martin et al., in preparation). The methods also utilized cue (minke boing vocalization) counting methods, but did not require tagging of animals to arrive at the probability of detection as a function of distance. Spatially explicit capture-recapture methods were applied to the acoustic cues to derive the probability of detection function.

Application of these density estimation methods referenced above currently require significant manual verification effort, which is beyond the scope of this study. However, advances are being made to reduce the amount of manual effort involved, and it is feasible that in the not too distant future, density estimate capability for some species will be possible with relatively low effort in terms of cost and time.

This report provides results of an analysis of acoustic data before and after the SCC operation at PMRF conducted 16-19 Feb 2010. The analysis is focused on beaked whales and minke whales using automation tools recently developed for these species. These species are also ideally suited for acoustic study due to the difficulty in visually sighting them in Hawaii in the winter and early spring due both to availability bias (animals spending limited time at the surface), and difficulty detecting the species (small blows, limited body out of water when at surface, rough sea state). There are other species detectable in the passive acoustic data, such as humpback whales via their song, and sperm whales via their echolocation clicks. Vocalizations from other species of marine mammals are also present in the acoustic data (e.g. whistles and echolocation clicks from undetermined species). Significant efforts have not been directed at these other species in the area to date for a variety of reasons (e.g. humpbacks are too distant from the sensors for distance sampling density estimations, and reliably detecting the smaller Odontoceti species acoustically is not as advanced as it is for the species involved in this study).

Methods:

Acoustic data collection

A personal computer based data acquisition system was installed at PMRF in 2002 for the express purpose of collecting raw passive acoustic data from the 24 broadband hydrophones at PMRF (many other hydrophones are available but most are high pass filtered and not suitable for studies at frequencies below ~10 KHz). The data collection system records the hydrophones continuously, saving data as files representing 10 min of data with no gaps between the end of one file, and the start of the following file. The system was modified in 2006 to increase the sample rate to 96 kHz and again in 2007 to record 7 additional high pass filtered hydrophones, both modifications done explicitly in order to improve the probability of detecting beaked whale echolocation clicks. Figure 1 shows a Google earth map of the approximate location of the hydrophones utilized in this analysis. The fifteen farthest offshore hydrophones (i.e. those labeled with numbers from 44 to 60) were utilized for minke whale analysis, while the remainder of the hydrophones shown were utilized for beaked whale analysis. The current data collection system was limited to 31 hydrophones of data: the additional seven were selected for depths where beaked whales are often found, and compliment the broadband hydrophones spatial coverage, albeit in two areas only. The depths of the hydrophones utilized for the minke analysis range between 3.5 km to 4.8 km, while the depth of the hydrophones used for the beaked whale analysis ranged from 600m to over 1.8km. Calibration data is currently not available for the hydrophones utilized in the analysis, so amplitudes are relative vice absolute.

The data set for this analysis consisted of a total of 126.1 hr for the 28 hydrophones shown in figure 1 for the following periods: PRE SCC 80.8 hr starting at 14:59 HST on 12 Feb 2010 and concluding at 23:40 15 Feb 2010; and POST SCC 45.3 hr of data collected after the SCC training event and between 03:04 HST 20 Feb 2010 and 00:20 on 22 Feb 2010.

The hydrophone spacing is such that one can NOT guarantee detecting beaked whale dives on the range given expected maximum detection ranges of 4km to 6km (Zimmer et al., 2005; Marques et al., 2009, respectively). On the other hand, if minke whale boing vocalizations are of sufficient level (e.g. on the order of 150dB re: μPa) for animals in the BSURE instrumented range area, it is assumed that the sound will be detected by bottom mounted hydrophones.

Acoustic data automated processing Beaked Whale

Both Blainville's and Cuvier's beaked whales have been sighted at the PMRF underwater range area by Dr. J. Mobley during various aerial surveys conducted from 2002 through the present. These species echolocation clicks have been identified in publications (e.g. Zimmer et al., 2005; Johnson et al., 2006). A hallmark of these clicks are that they exhibit a frequency upsweep characteristic in their approximately 0.3 millisecond duration, which makes them distinct from many other species clicks that do not show appreciable frequency sweep. The dive behavior for these two species near the big Island of Hawaii has also been documented (Baird et al., 2006). It is estimated that the acoustic detection of dive vocal time (time an animal emits foraging clicks during a dive) can range from as low as 10 min to as high as 40 min when utilizing 10 min binned data, as in this study. Also, the time between dive vocal periods (from one dive to another) can range from 2 hr to over 3.5 hr. Data from Cross Seamount, located in near Hawaiian waters, (McDonald et al., 2009) shows some clicks on the order of 1 ms in duration that also exhibit frequency upsweep covering a very broad band (potentially band limited by the recordings limitation of 192 kHz sample rate). The inter-click-intervals from Cross Seamount data also show much shorter periods than those reported for both Cuvier's and Blainville's.

An automated beaked whale echolocation click detector (Martin, 2008) implemented in Matlab (Mathworks Inc., Natick, MA USA) processes recorded data for clicks that exhibit frequency modulation characteristics within 0.5 ms decision intervals. The detector purposely does not make a distinction between clicks from Cuvier's or Blainville's beaked whales; in fact, it was designed to be generic in detecting clicks with frequency upsweep as so little is known of beaked whale echolocation clicks for the majority of the species. In a check of the generality of the beaked whale click detector, the Cross Seamount click data was obtained and re-sampled to simulate originating from a PMRF sensor (first order approximation by bandwidth limitation and re-sampling at 96 kHz). Processing 5 min of the modified Cross Seamount data (file Apr09_06_12_39_28.wav) resulted in 636 click detections of which 81 were classified as being from BW which is qualitatively consistent with McDonald et al. 2009.

The automated beaked whale detector reports the time of detection, hydrophone designation per detection, along with several of the features utilized in the decision. Plots are automatically generated for each hydrophone's detections over the analysis time using 10 min non-overlapping windows. These plots are reviewed to find areas where there are reported beaked whale echolocation clicks that correlate with reported dive vocal periods. The dive vocal period is represented by calls grouped between 1, and up to 4, contiguous data points (representing 10 to 40 min time periods) with no beaked whale click calls reported before, or after, these detections. This is done to isolate potential areas of actual beaked whale clicks based upon reported dive vocal intervals for further investigation. Each of the potential beaked whale call periods (potential dive vocal periods, or dives) identified in this manner are then manually investigated using adobe audition plots of the time series and spectrogram. Numbers of manually validated beaked whale echolocation clicks and validated dive vocal periods are tallied. One validated dive vocal period can have very few validated clicks (when the animal is at long distances from the hydrophones with low probability of detection) to hundreds of clicks if the animal is in close proximity to a hydrophone. Summary plots for each hydrophone's manually validated beaked whale detections (in 10 min periods) are generated. A count is tallied of each valid dive vocal period, with at least 10 clicks present in the 10 min period over the 13 hydrophones utilized in the analysis, and normalized by the number of hr analyzed, to arrive at an average beaked whale dive vocal period per hr. This period, and the average number of validated beaked whale clicks detected per hr, then serve as single numbers to compare the before and after exercise activity in terms of beaked whale activity. The final 45.3 hr of the PRE exercise data is also reported separately in order to equalize the POST analysis efforts.

When dive vocal intervals also exhibit longer duration patterns of repeating from 2 hr to 3.5 hr the longer duration patterns then match known characteristics of Blainville's and Cuvier's inter-dive vocal periods, which reinforces the hypothesis that the clicks detected are from beaked whales. However, due to the sparse spacing of the hydrophones in this study relative to the expected detection distance for the beaked whale clicks, not all dives are expected to be detected. Inter-detection-interval histograms are also plotted for data with manually validated beaked whale dive vocal periods to compare with beaked whale inter-foraging click-interval values expected from the literature.

Acoustic data automated processing Minke whale

A Matlab based implementation (Morrissey et al. 2009) minke boing detector based upon a generic Ishmael tonal detector (Mellinger et al 2010) was modified and employed for detecting minke boing vocalizations for the fifteen hydrophones in the analysis. This detector is based upon frequency peak detection and tracking over time in the 1350Hz to 1440Hz spectral band. The raw data corresponding to 0.68 sec before the detection (pre-trigger from detection reported time), for 2.73 sec is processed to generate a spectrum with 0.73 Hz bin resolution which captures the majority of energy in a boing. The frequency of the bin with the maximum amplitude is reported as the boings dominant signal component (DSC) in this band. The maximum relative amplitude, in dB, is reported for each boing, as well as the peak signal to average level over the detection band (a value obtained automatically from detection data serving as a proxy for a signal to noise level but not requiring manual validation of noise segments).

The modified Matlab boing detector operates at a different operating point from the previous Matlab and Ishamel versions which have been characterized. Effort is underway to characterize this detectors probability of detection (P_d)vs. distance at this operating point, along with its probability of false positive (P_{fa}). The unmodified Matlab detector was previously characterized as having a 0.79 P_d with a 0.2 P_{fa}. The detector employed for this automated analysis is very similar but has slightly different parameter set.

The dominant (or peak) frequency of the signal in the detection band is an important feature which not only helps associate the same boing as received on the spatially separated sensors, but also may help identify individual whales. This frequency feature has been previously found to be stable for what is believed to be one individual over a several hour period (N=55, mean freq=1384.4 Hz, se=1.55Hz).

Automated detection of boings is the first stage of automatic processing and results in all automated detections being logged. The next step of automated processing automatically removes redundant reports of the same boing on individual hydrophones due to effects such as multipath arrivals and detector segmentation of single boings into multiple boing reports. This step is necessary in utilizing spatially explicit capture recapture processing for boing density estimation. The effect is a reduction in the overall boing detection counts. An automatic association of boing reports across all hydrophones to correspond with a single boing emitted in the water is then performed. An optional manual process utilizing experienced human operators verifies all detections and associations – the result of which is termed "validated associations". A localization process is currently under investigation using associated boings (manually validated or not). The localization process limits the signal to higher levels (eg. above a threshold of 65dB relative), thereby reducing detections from weak or distant sources. A requirement of having four detections representing both north-south lines of hydrophones is currently utilized. The localization process also integrates localization results over time such that locations with actual vocalizing whales will reinforce, while erroneous localizations (from various error sources) will not reinforce over time. This last process takes advantage of the fact that a minke whale producing boing bouts tends to emit calls repeatedly over several hours.

Automated boing detections are binned into one hr, non-overlapping, periods for each hydrophone. The boing count per hour data are then averaged over the 15 hydrophones and plotted vs. time as mean boings per hour over the PRE and POST SCC periods. The mean and standard deviation of the boing rate per hour was also calculated for each hydrophone

RESULTS

All 126.1 hr of data available for the PRE and POST SCC periods has been automatically processed for the 13 hydrophones used in the beaked whale analysis and 15 hydrophones utilized in the minke analysis.

Beaked whale

Figure 2 provides an example of an automatically detected and manually verified single beaked whale echolocation click, the frequency sweep is evident in both the time series and the spectrogram. Although no attempt was made to differentiate Blainville's clicks from Cuvier's clicks in the manual validation process it was noted that some click envelopes have more of a Gaussian shape and are suspected of being from Blainville's whale, while other clicks had distinctive envelopes that were more rectangular during the onset, these clicks are suspected of being from Cuvier's whales. Similar characteristics have been observed in published figures (Zimmer 2005, Moretti 2010).

Figure 3 provides sample plots of numbers of beaked whale automatically detected clicks in 10 min temporal segments vs time for three separate hydrophones for part of the PRE SCC period. The two upper traces show characteristics which fit with beaked whale vocal behavior and inter-dive intervals. The lower trace provides an example of automatic detections, between approximately 1000 and 1500 on Feb 14 which were not manually validated due to not meeting the criteria for being called dive vocal periods. While there are four areas which do have counts of 10 or more detections in the lower trace, the detections do not go to zero between them. It is possible that beaked whale clicks are present among other odontoceti species and incorrectly rejected using this logic, which would result in an under-estimate of the number of beaked whale echolocation clicks and dive vocal periods.

Figure 4 provides a sample time series plot of 4.5 sec of data from a period validated as beaked whale dive vocal activity. This figure shows inter-click-intervals (ICI's) consistent with published data for beaked whales (Tyack 2006), as well as, potential head scanning evidenced by the varying peak levels of individual clicks in the click train. Figure 5 shows a sample histogram of inter-detection-intervals for ten min of data with validated beaked whale clicks. The histogram shows a peak at 0.29 sec with a range of about 0.22 to 0.32 sec for occurrences greater than 15. Figures 4 and 5 illustrate examples of temporal inter detection, or click, intervals which are consistent with values reported in the literature reinforcing the hypothesis that the validated dive vocal periods do represent foraging dives from beaked whales.

Figure 6 shows a plot of the number of manually validated BW dive vocal periods, or dives, for the PRE SCC 80.8 hr period from 12 Feb 15:00 to 15 Feb 23:50 for the 13 hydrophones used in the beaked whale study. A threshold of 10 clicks is applied and all remaining continuous 10 to 40 minute periods (1 to 4 data points) are summed to represent dive vocal periods, which is 21 in the PRE SCC period of 80.8 hr. Hydrophone # 37 is seen to account for 10, of the 21 total dive vocal periods (or BW dives) detected, however only 3 of these occurred in the last 45.3 hr of the PRE SCC timeframe. Note that for the last 45.3 hr of the PRE period, the number of dive vocal periods detected is 14. In some instances, such as at 15 Feb 15:40 for sensors # 1 and # 133 in figure 6, two dive vocal periods are counted. This could actually be from the dive of a single group of beaked whales, as the two phones are slightly less than 3 km from one another and could potentially detect individuals from the same group during a group dive. Figure 7 shows a similar plot for the post SCC 45.3 hour period which is slightly greater than half of the PRE SCC total period with a total of 14 dive vocal periods.

	PRE SCC total	PRE SCC first 45.3 hrs	PRE SCC last 45.33 hrs	POST SCC 45.3 hrs
Total time analyzed (hrs)	80.83	45.3	45.3	45.3
Validated BW dive vocal periods	21	8	14	14
Validated BW dive vocal periods/hr	0.260	0.177	0.31	0.31
BW clicks detected in val. dives	10,098	3,839	6,643	2,356
BW clicks detected clicks per hr	125.7	84.7	146.6	52.0
BW clicks detected per dive	459	474.5	479.9	168.3

Table 1 – Summary of manually validated automatic beaked whale echolocation click detections and dive vocal periods as defined in text for 13 hydrophones over periods analyzed.

Table 1 summarizes the PRE and POST SCC manually validated dive vocal periods, dive vocal periods per hour, and numbers of clicks detected in valid dive vocal periods (total, per hr and per dive). The table shows the PRE SCC period in three ways, the total 80.8 hrs, and the first, and last, 45.3 hr periods in order to equal the POST SCC effort time. By dividing the PRE SCC period in this manner, there is an overlap of some 10 hr of data. Two dives in the first 45.3 hrs of the PRE SCC period had over 1,000 detected clicks in each dive, two dives in the second 45.3 hrs of the PRE SCC period account for over 2,500 detected clicks, while the largest number of clicks detected in any POST SCC dive was 699, with the second highest count being 168. This shows the variability possible when the hydrophones do not provide full spatial coverage: the number of dives detected, dive vocal periods, and clicks per dive, and are highly dependant upon the distance from the sensors to the vocalizing whales. The data do show reduced BW click counts, counts per hour, and clicks per dive vocal period for the POST as compared to the PRE periods.

The main purpose of this analysis is to show, with a high degree of certainty, that beaked whales are indeed present at PMRF before, and after this exercise in Feb 2010.

Minke whale

Figure 8 shows a typical minke whale boing time series and spectrogram as received on PMRF bottom hydrophones. Higher frequency components are present, but not shown. The detector detects only in the frequency band of 1350 Hz to 1440 Hz. Figure 9 shows an example of 16.7 hr of data from the POST SCC period, of a histogram of the detections dominant frequencies (one value per detection). The histogram shows an overall bimodal distribution, and fine details suggest multiple individual animals within each major frequency region.

PRE SCC Mean Boing Rate per Hr

Phone	Mean	Std Dev
44	39.91	26.73
45	55.14	38.33
46	59.88	42.21
47	75.80	44.40
48	86.1	46.42
49	86.85	50.19
50	91.92	43.79
51	88.16	42.04
53	24.99	24.02
54	56.57	35.80
55	61.12	40.65
56	68.30	36.44
57	67.24	40.64
58	88.71	51.77
60	91.85	43.32

Average of means: 69.50

POST SCC Mean Boing Rate per Hr

Phone	Mean	Std Dev
44	46.62	22.74
45	57.53	24.57
46	72.31	31.27
47	99.89	41.19
48	92.53	39.76
49	93.73	39.61
50	97.56	38.24
51	100.78	43.38
53	28.42	14.88
54	66.24	32.77
55	72.53	36.31
56	85.47	42.23
57	83.73	42.30
58	108.96	50.46
60	96.38	42.71

Average of means: 80.18

Table 2 – Summary of automatic minke boing detection count, mean and standard deviation, for 15 hydrophones over the PRE (left column) and POST SCC periods (right column).

Automatic boing detections from the 15 hydrophones totaled 83,614 boings in the PRE period and 54,316 boings in the POST period. Figure 10 shows the PRE SCC minke whale automatic boing detections per hour averaged over all 15 sensors for the 80.8 hr. This is for the raw boing detections without additional processing (i.e. multipath, and segmentation, removal; associations; manual verification; and localization). The data shows a great deal of variability over time, with a strong peak of 200 mean boings per hour at 10:00 on 13 Feb and lowest values around 03:00 on 15 Feb (around 20 mean boings per hour). Figure 11 shows a similar plot for the POST SCC, which starts at lower values (~20) and whose peak is around 143 mean boings per hr. Table 2 provides the means, and standard deviations, of the boing detections per hr across hydrophones for each of the PRE and POST periods, along with the average of the means across hydrophones.

Figure 12 shows a plot of the mean boing rate per hr for each of the 15 hydrophones utilized over the PRE and POST full hour periods, which corresponds to the means shown in table 2.

Early results for automatically localizing minke whales boing source locations suggests the number of individual vocalizing minke whales in the area at any time, and potential tracking of individual animals over time. Samples of these early localization results are shown in figure 13 showing automatic localization results for two time periods during the PRE SCC separated by 4 hrs 49 min in time. Evidence of three individual whales are seen in the left panel and four in the right panel from the later time period.

Discussion and Conclusions:

This analysis illustrates the type information possible using automated passive acoustic detection and classification processing for marine mammals from the US Navy instrumented range hydrophones. The analysis focused on minke whales and beaked whales using existing automation tools. These species are good candidates for passive acoustic monitoring due to the difficulty of visual sighting them, as witnessed in the low number of these species sighted in the area given appreciable effort from both US Navy personnel (lookouts) and trained observers both on surface and aerial platforms.

This analysis shows, with good confidence, that there were beaked whales, and minke whales, present in the area before, and after, the SCC training exercise. No data was recorded during the actual operation, so nothing can be said for that period. Furthermore, as the normal variations in the number presented here are unknown, it is not possible to say with any confidence if the numbers convey any statistical significance related to effects of the SCC exercise. If one were to have recorded data during the SCC training event, one may have seen statistically significant changes. The limited number of hydrophones utilized in the beaked whale study under-samples the area spatially and can not guarantee detecting a group of diving beaked whales, this hinders detailed analysis for this species. However, it is possible to process large numbers (dozens to hundreds) of range hydrophones in order to ensure detecting groups of diving beaked whales over large areas of the instrumented range.

The number of beaked whale clicks (table 1: det in val. dives, det per hr, and det per dive) indicate lower numbers for the POST SCC period over all three PRE SCC periods shown. The number of beaked whale clicks detected is highly dependant upon how close to the hydrophones the beaked whale group is when diving. The number of detected dives a better metric, and shows how normal variation can impact the results. While the number of beaked whale dives (dive vocal periods validated) in the POST period is the same as that for the last 45.3 hrs of the PRE SCC, it is lower than the first 45.3 hrs of the PRE SCC. This highlights the need to better understand normal variations of beaked whale dives before arriving at conclusions based solely on PRE and POST analysis relative to the exercise between the time periods.

In FY11, the Naval Undersea Warfare Center (D. Moretti and R. Morrissey) will be installing a Marine Mammal Monitoring on Navy Ranges (M3R) system at PMRF. This will allow a more thorough investigation for beaked whales using dozens more hydrophones and potentially guaranteeing detection of beaked whale group dives in large areas of the instrumented range, such as has been done both at AUTEC and SCORE. Dive counting has been shown (Moretti et al. 2010) to have lower variance in density estimation for Blainville's beaked whales at AUTEC. There are additional benefits to using dive counting, such as it alleviates the need to manually validate all click detections, one only has to validate some detections in a dive. However to obtain density, the group sizes need to be known. Baird (Baird et al. 2006) has published group sizes for Blainville's and Cuvier's species off the Kona coast, employing Kona coast data would make more sense at PMRF than the group size estimates for other areas such as the Bahamas, southern California and the Canary Islands.

It appears that once it is known what to look for acoustically for specific marine mammal species, we discover they are present in larger numbers, even on US Navy ranges, than previously known. The data from AUTEC suggests that Blainville's beaked whales regularly use the area to forage, and either go quiet, or leave the area, when mid frequency sonar exercises occur, and that they either return, or resume vocalizing, after the operation has completed. It is uncertain which species of beaked whales are represented in this analysis (suspect both Blainville's and Cuvier's species due to some frequency content and signal envelope differences). Without having data for the SCC exercise, one can only speculate as to the impact of the exercise on beaked whale dive vocal behavior at PMRF. For beaked whale analysis, having more sensor data is clearly desirable for a more complete analysis. Efforts at the southern California offshore range (SCORE) may have parallels with PMRF relative to Cuvier's species. We have very little knowledge of the many other species of beaked whale and their associated acoustics, some of which may be present at PMRF.

This study shows the presence of boing vocalizing minke whales for both the PRE and POST SCC periods in terms of the automatic minke boing detections per hour using 15 hydrophones. While there is some evidence of potentially suppressed boing rates (i.e. the first 10 hr of the POST SCC period where rates steadily rise from a low initial value), a similar situation existed in the final portion of the PRE SCC period (~04:00 to 14:00 15 Feb). The large variations in boing rates observed in both the PRE and POST SCC periods needs to be better understood before arriving at conclusions relative to effects of the exercise. The use of the localization tool suggests the peak in boing rate at 11:00 13 Feb (PRE SCC) could be the result of boing rates much more rapid than normally observed when two minke are in close proximity to one another. The boing rate by hydrophone (figure 12) also shows large variations with indication of a depth relationship given that hydrophones 44 and 53 are the shallowest in the boing analysis. The use of fine resolution frequency content of the boing detection shows promise in helping isolate individuals. Density estimation of the minke boing density is possible; however the cue rate for converting to vocalizing minke whales is currently unknown. The FY9-10 ONR effort (Norris et al.) may provide insight into the boing rate for PMRF utilizing an acoustic surface line transect study in conjunction with analysis of the PMRF hydrophones for the same time period. The amount of manual effort involved in estimating minke boing density using existing techniques is currently beyond the scope of this effort, however less manually intensive methods to perform acoustic density estimation for minke whales (potentially applicable to other species) are under investigation which could developing a baseline for minke whale (boing) density over several years using currently available PMRF data.

The effort to automate localizations of the automatic boing associated detections is showing promise. This effort is capitalizing off the fact that boing vocalizing minke whales typically are producing fairly regular boing rate bouts for multiple hours by integrating boing localizations over time. When estimated animal locations cluster in space and time, it is reasonable to believe an animal is in that area producing the boings that are being detected, associated and localized. Incorrect localizations occur for a variety of reasons: false positive detections, erroneous associations, and boing detection time errors relative to actual boing start times. However, incorrect localizations typically do not reoccur in space and time, and are observed as outliers when observed over multiple hours. This automatic localization effort is exciting as it can reduce Terabytes of multiple days of raw acoustic data, to a few hours of processed products, all done automatically with minimal labor effort involved. An analyst then only needs to manually review for localizing minke whales present on the range by viewing the processed products, and can potentially simply count vocalizing minke whales.

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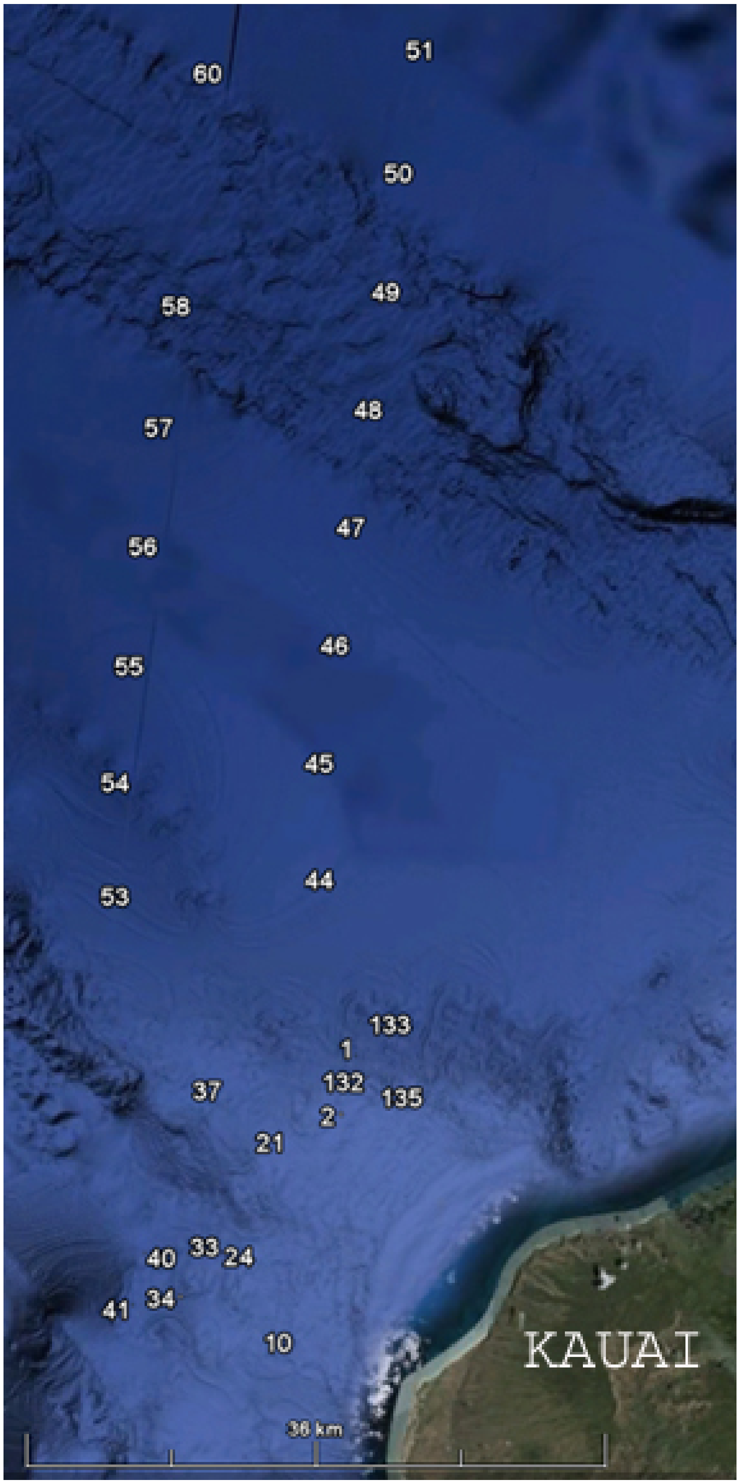

Figure 1 – Approximate location of hydrophones utilized in Pre, and Post, SCC acoustic analysis (true north up). Fifteen hydrophones (44-51 and 53-60) utilized for minke whale boing analysis. The thirteen other phones shown are utilized for beaked whale echolocation analysis.

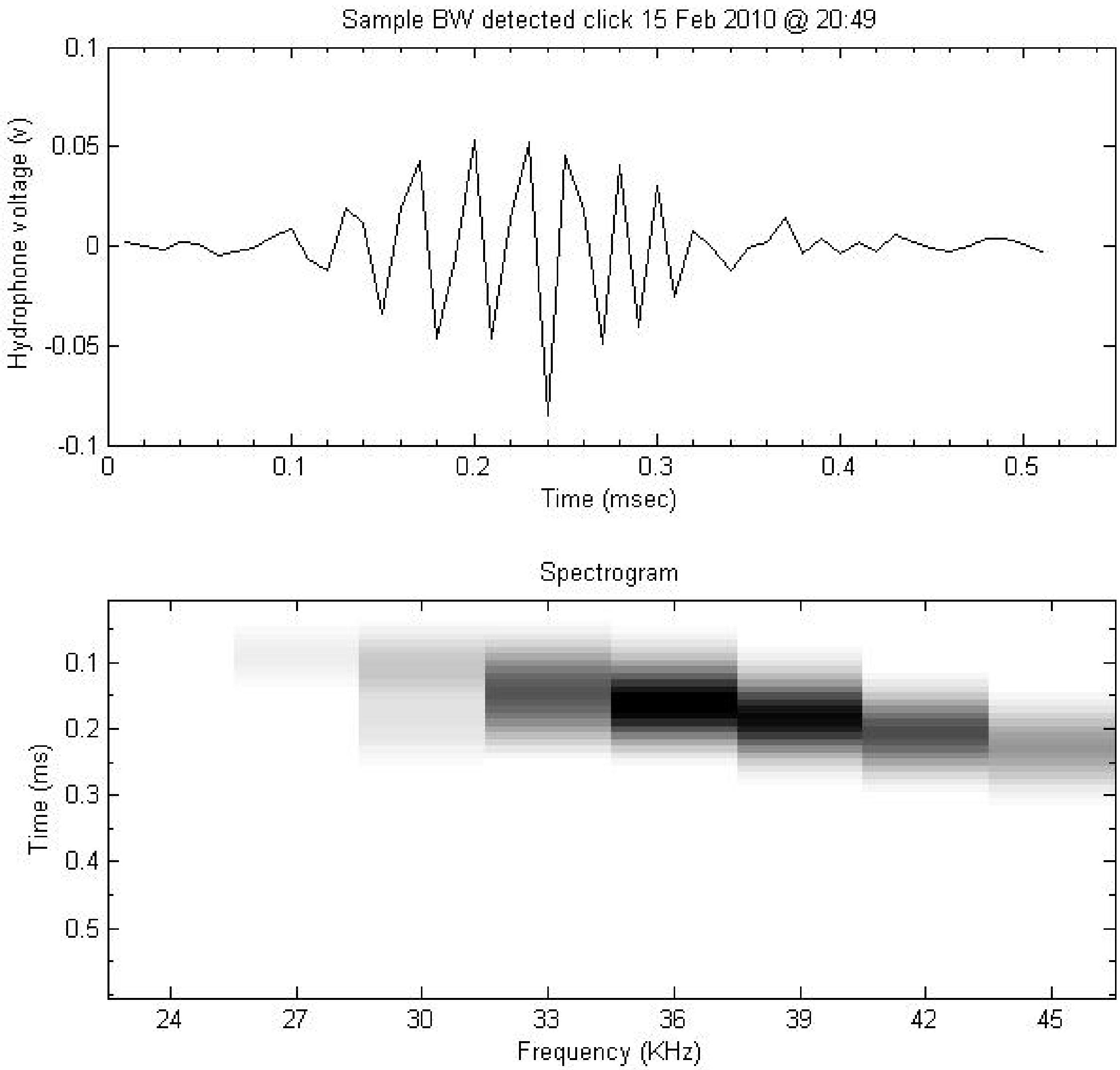

Figure 2 – Sample automatically detected beaked whale foraging click from hydrophone #1 on 15 Feb 2010 @ 20:49. Spectrogram parameters 96 kHz sample rate, 32 point FFT, slip one sample (overlap 31 samples of 32). No appreciable energy below 24 kHz. This sample reflects characteristics similar to those for Blainville's, and Cuvier's, beaked whale foraging clicks. The frequency up sweep is evident in both the time series, and more easily in the spectrogram.

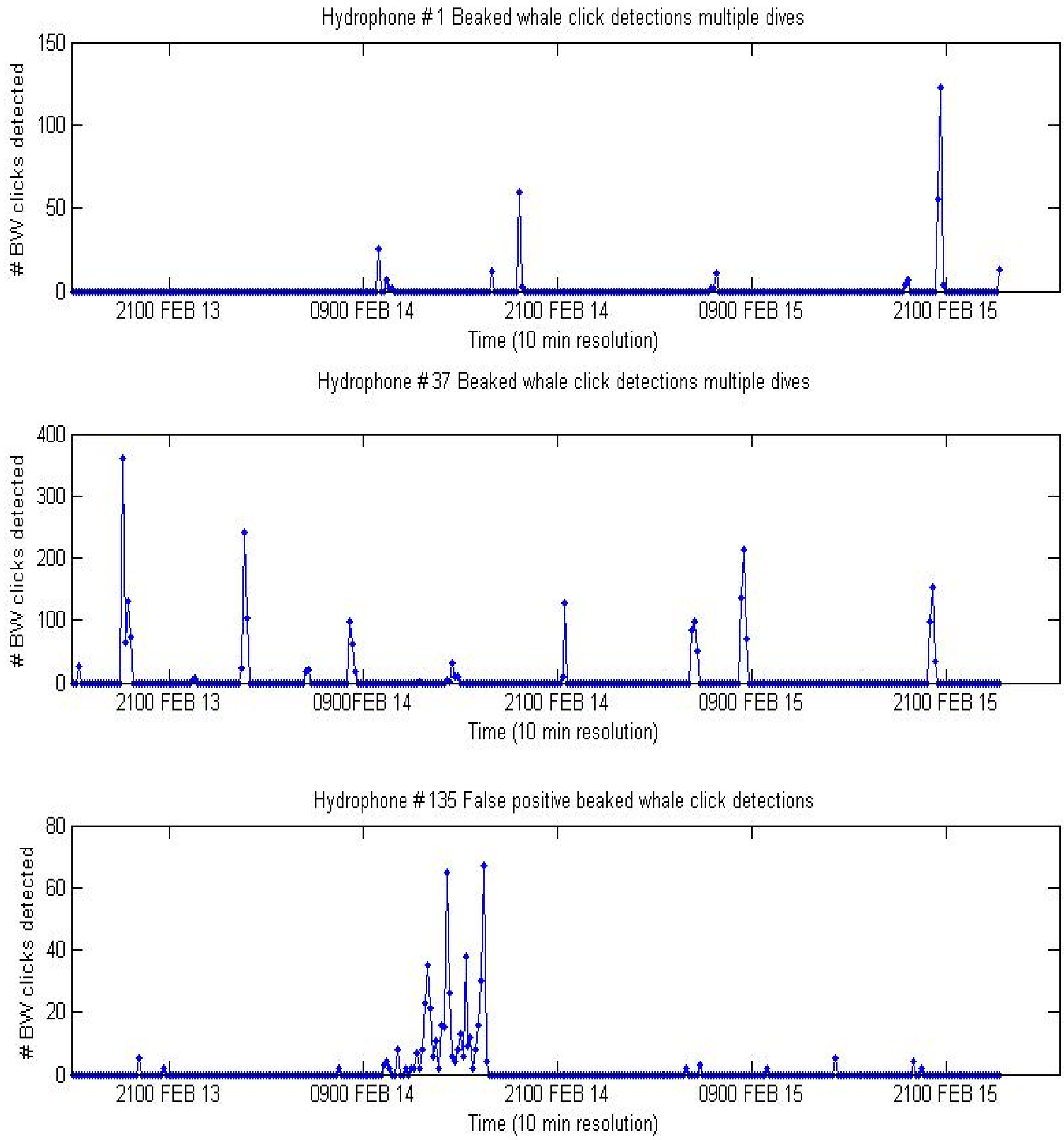

Figure 3 - Outputs of automatic beaked whale echolocation click detector during a portion of the PRE SCC period for three hydrophones. Top: phone # 1 showing two strong indicators for beaked whale dives (counts > 50 just before 2100 Feb 14 and at 2100 Feb 15), with multiple other suspect dives with lower total click counts. Middle: phone # 37 showing strong indication of multiple beaked whale foraging dive echolocation behavior with 20 to 30 min of foraging echolocation behavior throughout the period. Lower: false positive detections of beaked whale clicks – the temporal patterns are distinctly different from beaked whale foraging.

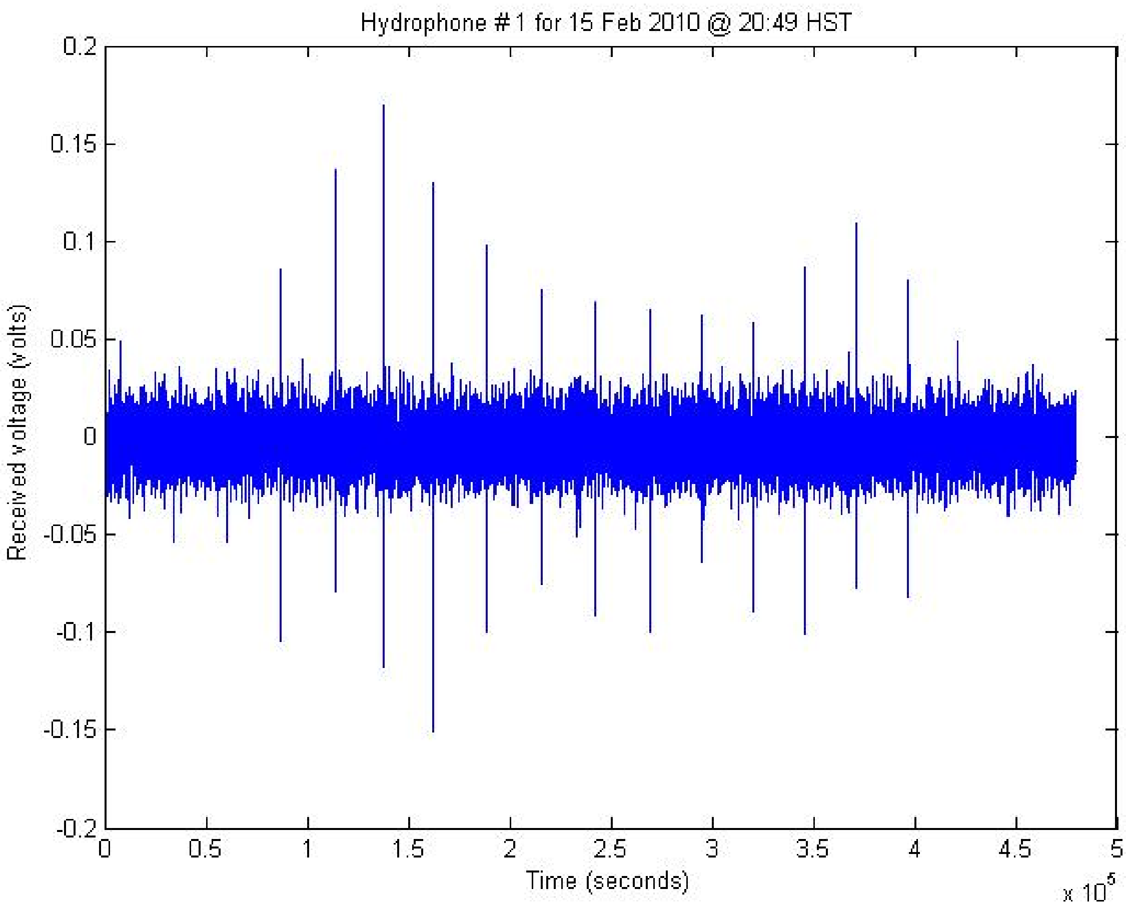

Figure 4 – Beaked whale clicks received on hydrophone # 1 on 15 Feb 2010 at 20:49 HST. Head scan motion apparent in click amplitudes. Inter-detection-intervals for this 10 min period have the peak intervals slightly under 0.3 sec.

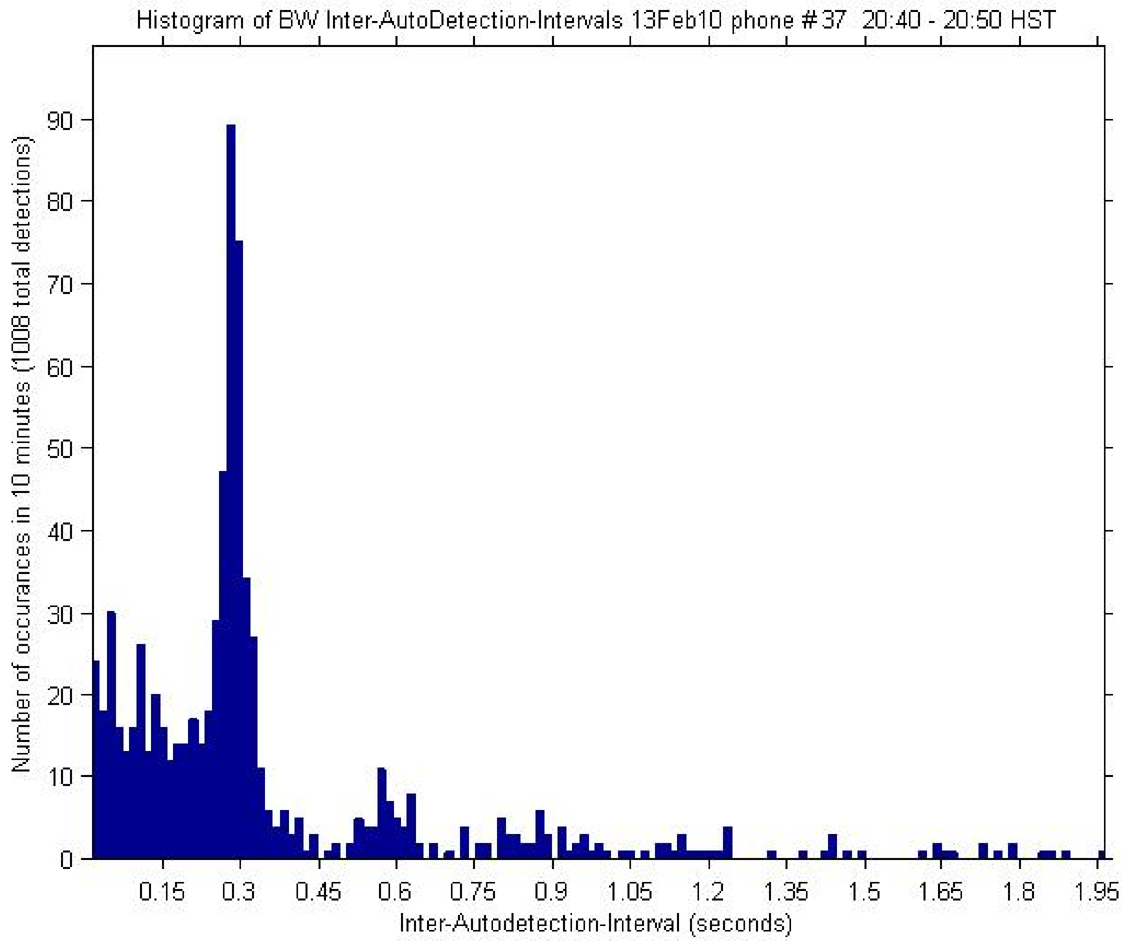

Figure 5 - Histogram of hydrophone # 37 inter-detection-intervals for 13 Feb 2010 between 20:40 and 20:50 HST, which corresponds to the data shown figure 3: middle trace for the first strong peak with > 300 BW clicks detected. The peak is at approximately 0.3 sec inter-detection-interval which is in the range of published information for beaked whales.

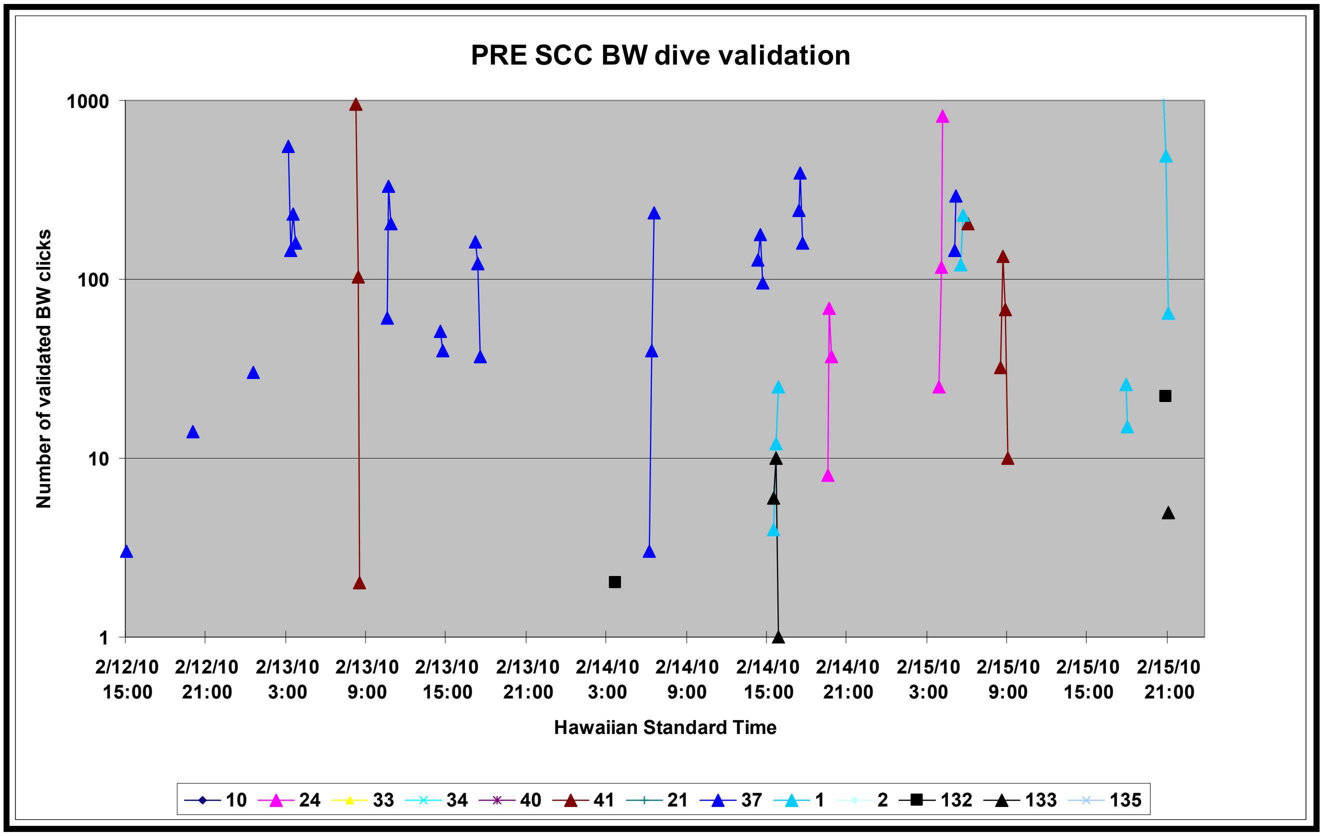

Figure 6 – Pre SCC operation beaked whale manually validated automated click detections per 10 minute period throughout the 80.8 hr period. Twenty one 'dives' with > 9 clicks in 10 min periods are observed.

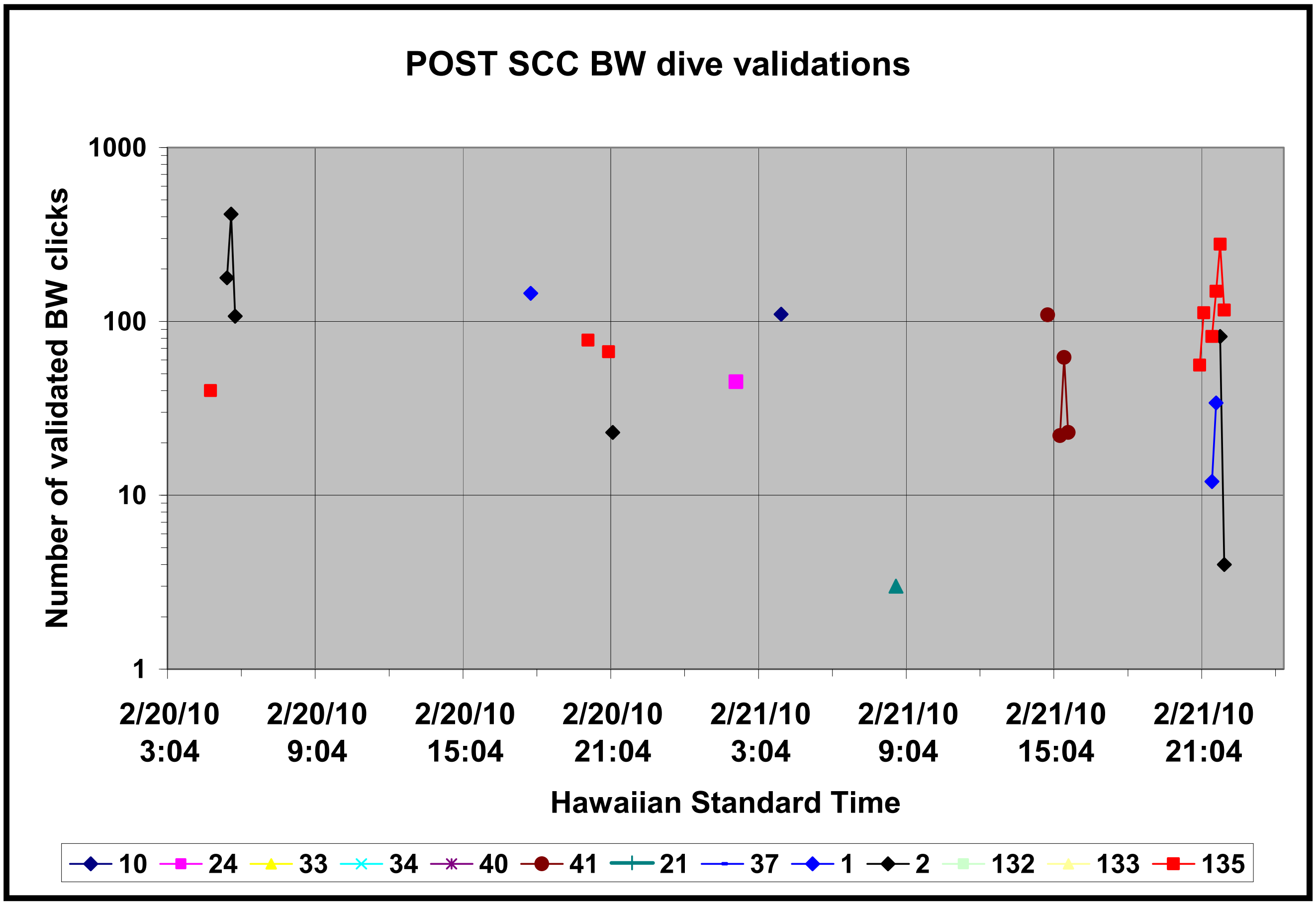

Figure 7 - Post SCC beaked whale dive manual validations. The number of 'dives', as defined in the text, is eleven in this case. Hydrophones 1, 2 and 135 are fairly close together and what is counted as four dives after 21:00 on 21 Feb could actually be fewer dives.

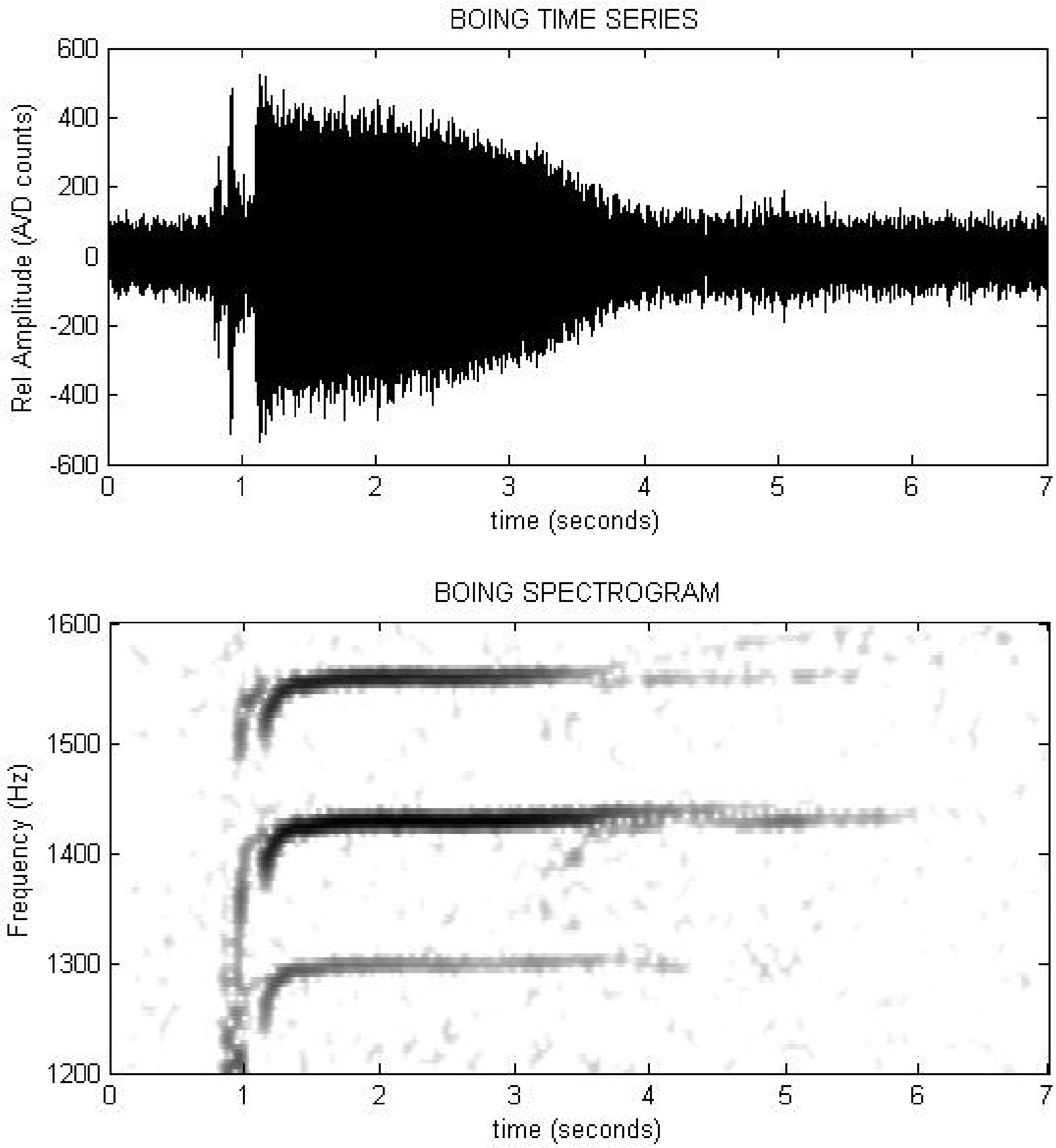

Figure 8 - Minke whale boing vocalization time series and spectrogram between 1200 Hz and 1600Hz.

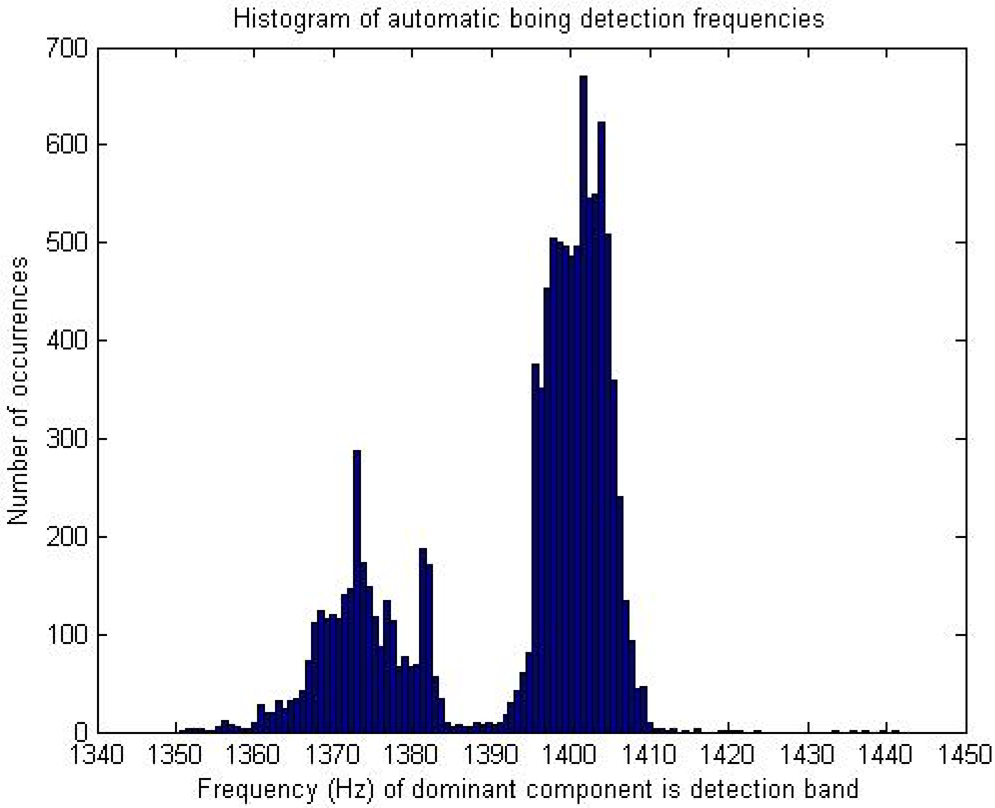

Figure 9 – Histogram of the dominant frequencies of each automatically detected boing over the detection band of 1350 Hz to 1440 Hz. POST SCC 16.7 hour period from 20 Feb 19:44 to 21 Feb 03:22. Data suggests multiple animals present.

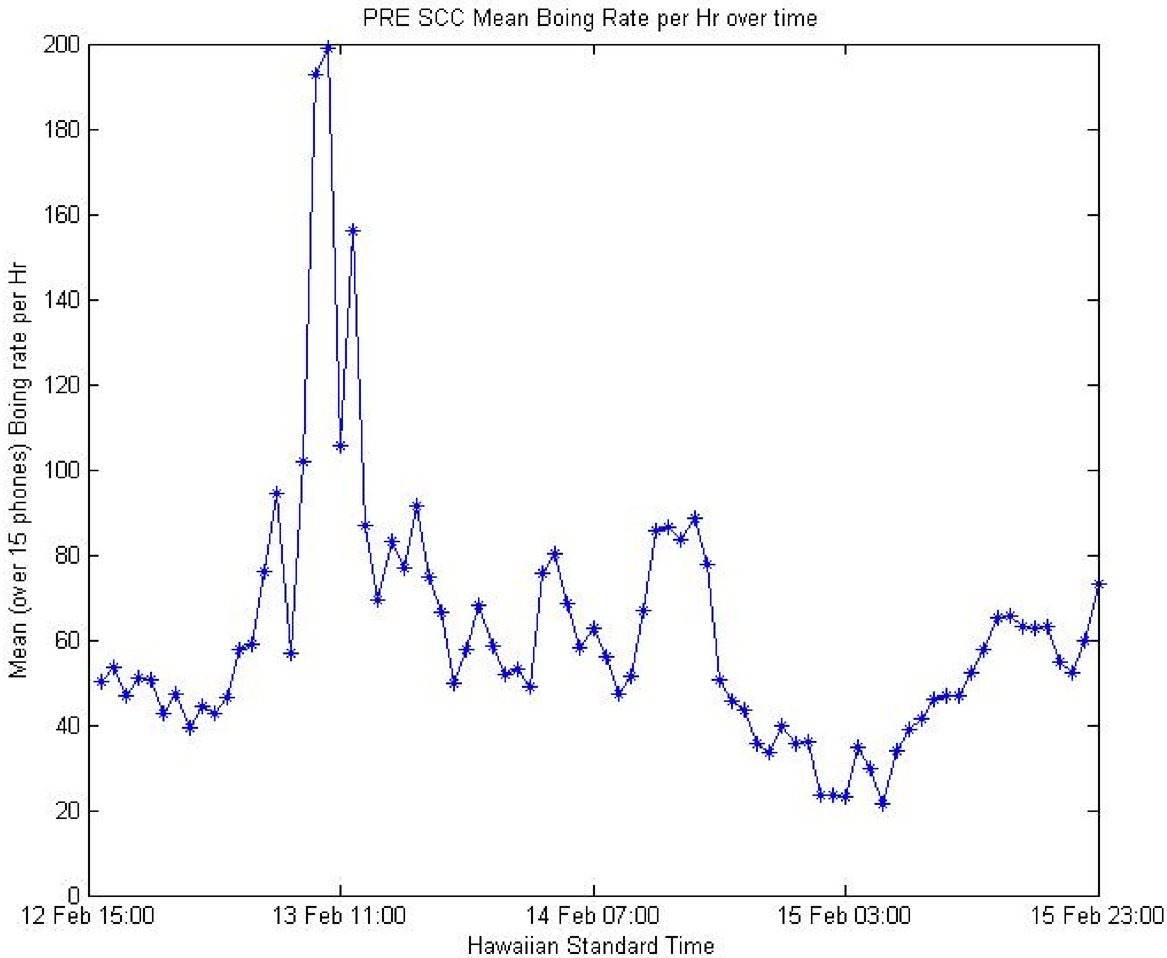

Figure 10 - Pre SCC mean automatic minke boing detections per hr for all 15 hydrophones. Note the high degree of variability. The peak just before 11:00 13 Feb is believed due to having multiple minke whales on the range and emitting boings approx every 5 to 6 min.

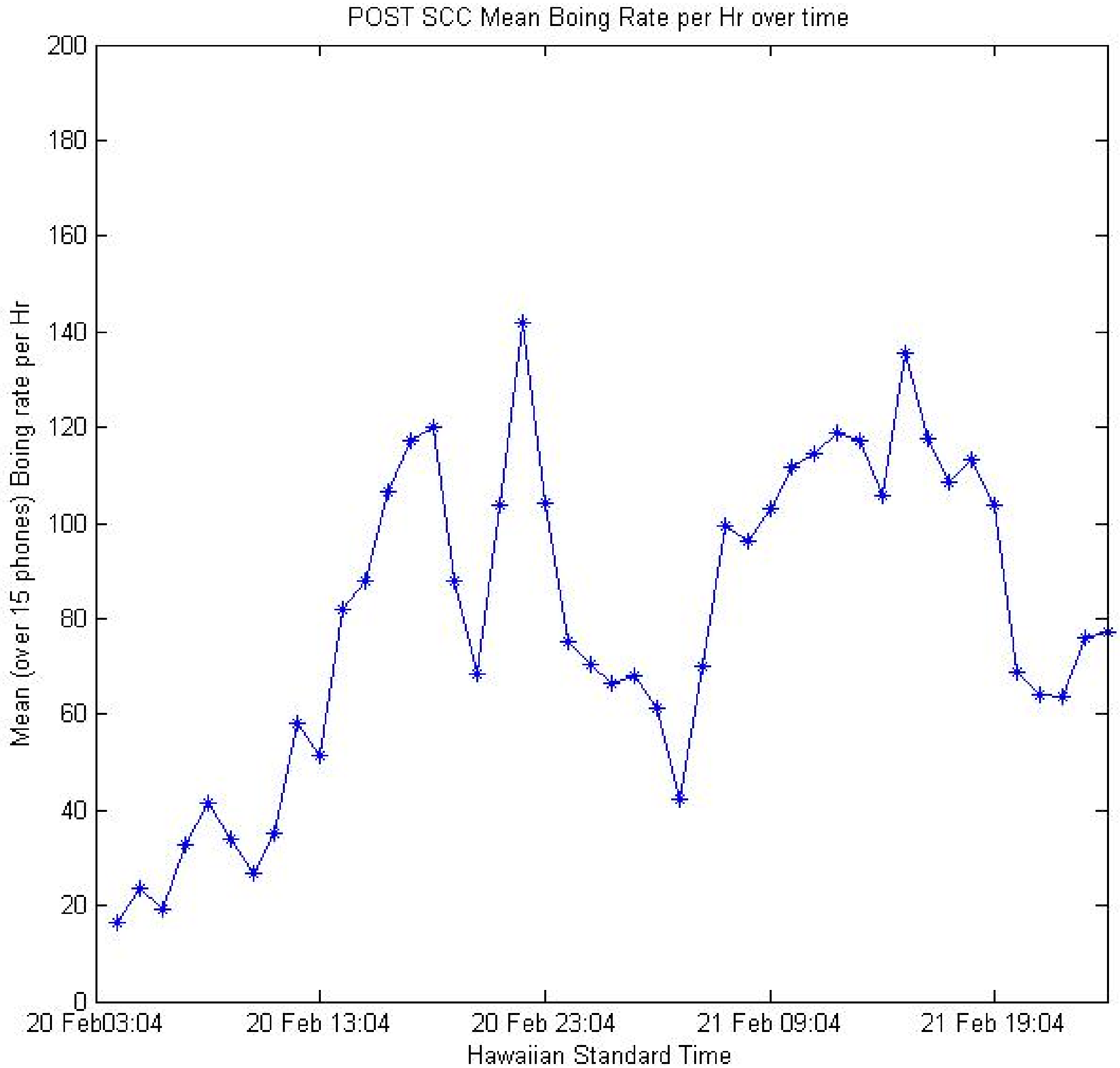

Figure 11 - Post SCC mean automatic minke boing detections per hour for all 15 hydrophones. The peak just at approx. 22:00 on 20 Feb is potentially due to TWO minke whales being in close proximity (within a couple of km of one another) and emitting boings at rates more rapid than typically observed (one every 30 sec vice one every 5 to 6 min).

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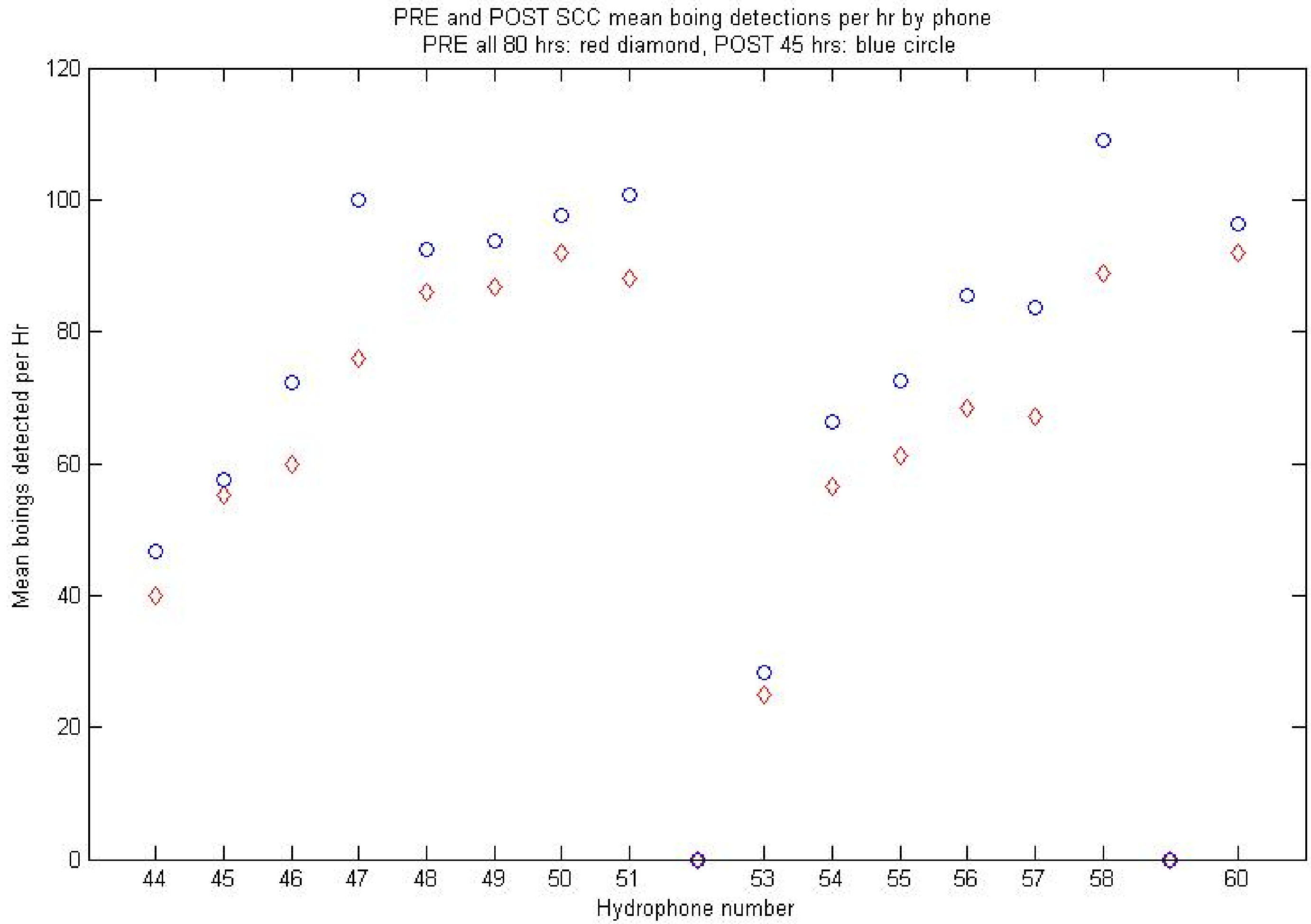

Figure 12 - PRE, and POST SCC automatic minke mean boing detections per hour by phone. All 80 hrs of PRE (red diamonds) shown along with the POST 45 hr (blue circles). The data corresponds to the means shown in table 2, note the standard deviations are on the order of one half of the means.

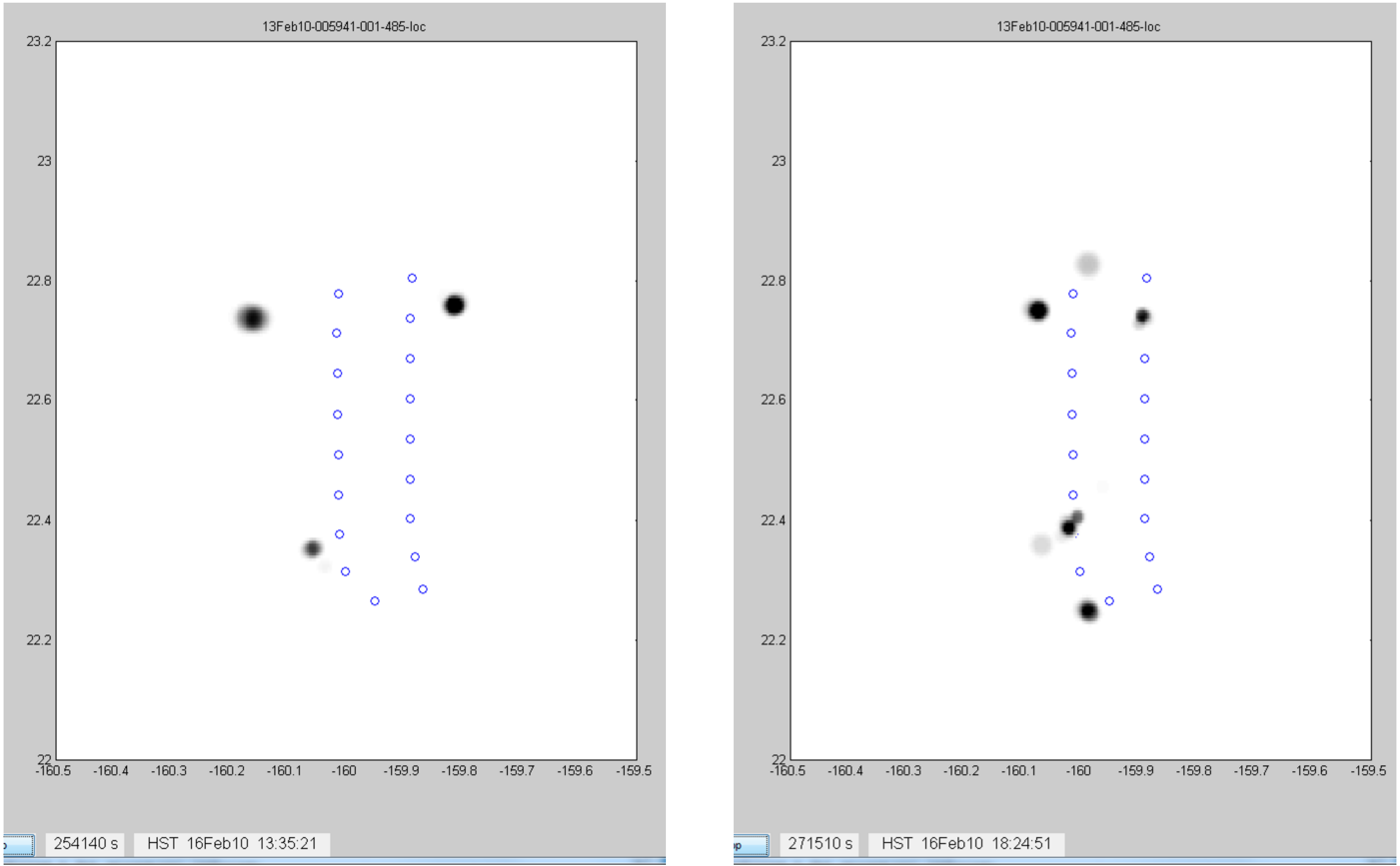

Figure 13 – Two segments of PRE SCC data automatically localized (no manual validations) showing suspected minke whale individuals. Left side: three minke whales at 13:35 HST 15 Feb 2010 (matlab error shows julian date on plots). Right side shows auto localizations 4 hrs and 50 min later. Right panel shows apparent movement of the three minke whales (seen on left panel) towards the hydrophones (blue circles) and a forth individual showing up on south portion of range. Weaker grey circle areas suspect to be erroneous localizations.

APPENDIX K Acoustic Ecology and Behavior of Minke Whales in the Hawaiian and Marianas Islands: Localization, abundance estimation and characterization of minke whale 'boings'

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1. Introduction

Balaenoptera acutorostrata (minke whale) is a small and elusive baleen whale that is rarely sighted in tropical waters of the North Pacific Ocean. During winter and spring, complex sounds called 'boings' are frequently detected around the Hawaiian Islands and other Pacific Islands regions (Thompson and Friedl 1982; Norris et al. 2009). Although boings were described over 45 years ago (Wenz 1964) they were not attributed to minke whales until very recently (Rankin and Barlow 2005). Sightings of *Balaenoptera acutorostrata* are uncommon in tropical and subtropical waters; however, boings are frequently detected around the Hawaiian Islands using seafloor hydrophones and from hydrophone arrays towed from research vessels. Even today, very little is known about acoustic behaviors and ecology of *Balaenoptera acutorostrata.* The long-term objective of this research effort is to improve our understanding of the acoustic ecology and behavior of *Balaenoptera acutorostrata* in their breeding habitat.

A primary goal of this study is to compare characteristics of boings recorded in the Hawaiian Islands (central North Pacific) to other regions in the central and western and North Pacific (e.g. the Northern Mariana Islands). These results will be used to elucidate stock identities and population characteristics for *Balaenoptera acutorostrata* in the Pacific Islands. Another goal is to estimate the local abundance of calling *Balaenoptera acutorostrata* for our main study sites off the Hawaiian Island of Kauai and around the Marianas Islands. Finally, we are collecting information which is being used to assess the calling rates of *Balaenoptera acutorostrata*. This information is necessary to validate cue-counting methods that are being developed to estimate densities of *Balaenoptera acutorostrata* exclusively from their calls (Thomas et al. 2008; Marques et al. 2009; Martin et al. 2009).

2. Methods

To accomplish these objectives, we are using several types of passive acoustic methods to record and analyze data from vocalizing *Balaenoptera acutorostrata*. We used an acoustically quiet, 25m motor-sailing vessel equipped with 2-6 element towed hydrophone arrays (effective bandwidth ~100Hz - 48kHz) to conduct localization experiments in 2009 and an acoustic-visual line-transect survey in 2010. Bioacousticians monitored and processed acoustic data in real-time throughout on-effort periods using various software including Ishmael, PAMGUARD and WhaletrackII. In 2010, AN/SSQ-53F DIFAR sonobuoys were also used. Localizations of individual *Balaenoptera acutorostrata* were estimated using target-motion analysis techniques when possible.

Acoustic data were simultaneously recorded from the Barking Sands Underwater Range Expansion (BSURE) test site seafloor hydrophone array that is part of the Navy's Pacific Missile Range Facility (PMRF) off the West Coast of Kauai. This Navy test range encompasses a large (>2000km^2), deep-water area northwest of the island of Kauai and includes seventeen bottom-mounted hydrophones (effective bandwidth ~100Hz to 18kHz) that were used for this project. PMRF seafloor array data were post-processed using two localization methods:

1) Time-of-arrival (TOA) hyperbolic localization methods (manual and automated), and:
2) A propagation model-based time-of-arrival (PMTOA) localization method (automated).

For the first method, manual techniques were initially used to identify and associate boings from the same calling animal on multiple PMRF seafloor hydrophones. Once associations and accurate TOA's were obtained, 2-D localizations were performed using standard hyperbolic techniques. Sound speed profiles (SSP) were obtained from expendable bathythermographs (XBTs) deployed each day off of the research vessel. For the second method (PMTOA), the upper 760m of SSP was averaged from several XBT deployments, whereas for depths below 760m, SSP's were estimated from historical data.

In 2009, efforts were focused on obtaining localizations from the towed hydrophone array to compare with and validate those obtained from the BSURE seafloor array. In 2010, efforts were focused on conducting an acoustic-visual line-transect survey of the BSURE range for estimating abundance and comparison to the seafloor hydrophone array data-set.

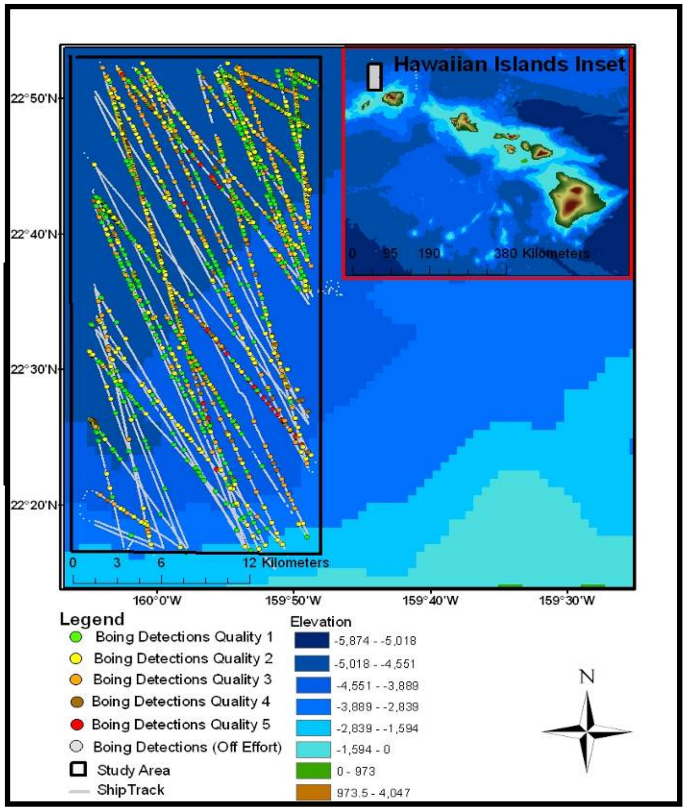
Finally, two additional sources of data were included in this study: 1) data collected using a bottom-mounted hydrophone located at the Station ALOHA Cabled Observatory (ACO) was analyzed to examine seasonal and diurnal variability, and 2) data from an acoustic-visual line-transect survey conducted in winter/spring 2006 for a large region surrounding the Mariana Islands that will be analyzed to derive abundance estimates and assess population structure from boing signal characteristics.

3. Results

We have completed two winter/spring field seasons (2009 and 2010) and are in the process of analyzing the acoustic data and developing automated analysis methods. In 2009, vessel based localization effort was conducted inside the BSURE area for 21 days between 15 March and 28 April and resulted in approximately 850km of survey effort. In 2010, line-transect surveys were conducted for 2.5 months from 12 March to 11 April, resulting in 13 days and over 1520km of line-transect effort. Over 260 hours of recordings were made for both field seasons.

In 2009, we obtained bearings for at least 777 boings that were manually detected using the towed array. Preliminary results from the just-completed 2010 field season indicate that at least 1598 boings were detected manually, of which 1198 bearings were obtained (Fig. 1). Over 50 localizations were made during the line-transect survey effort.

Automated detection and localization methods in PAMGUARD and Ishmael were attempted in real-time during 2010 surveys but were deemed too demanding on the available computer resources
so were discontinued after leg I. Therefore, the acoustic data is being post-processed using automated and semi-automated techniques. These methods are expected to yield more detections and possibly localizations. The results of the automated detections and localizations will be reviewed and validated manually to ensure their reliability. Localizations obtained from the towed hydrophone array data will be compared to localizations collected from the BSURE seafloor hydrophone array. These automated methods will be used to assess localization estimates of animals, track movements, and eventually to estimate the density and abundance of calling animals in the two main study areas using modified distance sampling analysis methods.



Assessment of localization accuracy is important to verify the assumptions of statistical methods being developed in a related effort called the Density Estimation of Cetaceans from passive Acoustic Fixed sensors (DECAF) to estimate densities of calling animals from fixed hydrophones (Thomas et al. 2008). A case study was conducted from the BSURE seafloor hydrophone dataset containing over 6,000 boings automatically detected over a 6 hour period in late April 2009. Comparisons of localizations from the two seafloor array methods described above indicated good agreement (mean diff. = 142.7m; range: 67-280m). Researchers on the survey vessel were able to acoustically detect, track and sight the same individual that was being tracked from the seafloor array. The position of the sighted animal indicated relatively good accuracy (within a few hundred meters) of the positions obtained using the two seafloor localization techniques described earlier. Interestingly, the localizations determined from the towed array, although relatively precise, indicated biases based on the different algorithms used to plot the bearings from the towed hydrophone array to the calling animal. These errors were investigated further by manually plotting data. Results indicated that uncertainties in the true heading of the towed array can significantly affect localization error.

Based on the results of this case study, more fully automated techniques are being developed to facilitate the localization analysis. In addition, improvements were made to existing Matlab-based detectors used to detect boings for the automated localization algorithm. These automated methods were used to reduce processing time during the 2010 field effort.

One year of data collected at the ACO were analyzed (February 2007 – February 2008). These data showed that boings occurred seasonally from October to May with little diurnal variation.

4. Discussion

Analyses of minke whale boings are underway to identify signal characteristics that might be useful for individual identification and as indicators of population structure. We have already found statistically significant differences in the pulse repetition rates of boings from Hawaiian waters compared with those recorded in the Mariana Islands in the Western North Pacific. Interestingly, preliminary results from analysis of boings recorded on the seafloor hydrophone array (work conducted by S. Martin) indicate that there may be reliable signal characteristics that can be used for individual recognition. If so, these signal characteristics can be used to identify and track individuals using passive acoustic methods. We are continuing to analyze data from both Hawaii field seasons and the Marianas effort. Our immediate efforts are focused on obtaining density estimates for our two main study areas. We are also examining the effects of noise produced by our own vessel on the calling rates and acoustic behavior patterns of minke whales. Any effects of vessel noise on calling rates is important to assess in order to evaluate biases in these data caused by our survey vessel, and future vessel based surveys. The results of these investigations will provide important information about a species that is common in the subtropical waters of the North Pacific Ocean, but about which there is little information regarding their ecology and behavior. [Work funded by ONR Marine Mammal Program / ACO access provided by Dr. **D***uennebier]*

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APPENDIX L Preliminary Report for monk seal habitat and monitoring

Preliminary Report Period: February – August 2010

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

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

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

Title: Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex

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}, while fewer seals occupy the main Hawaiian Islands (MHI). It is generally believed that the population in the MHI has greater survival rates and the total number of seals is increasing. Estimated survival from weaning to age 1 yr is 77% in the MHI, much higher than recent NWHI estimates ranging from 42% to 57%. Moreover, MHI females begin reproducing at a younger age and attain higher birth rates than those observed in the NWHI. The estimated MHI intrinsic rate of population growth is 1.13 compared to a range from 0.89 to 0.98 in the NWHI. Assuming an initial abundance of 150 animals in the MHI, projections indicate that if current demographic trends continue, abundance in the NWHI and MHI will equalize in approximately 9 years.

While this increasing population in the MHI provides some hope for the species' continued existence, it opens up 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). Very little is known about the 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.

Tag Capability

The Hawaiian Monk Seal Research Program has begun utilizing 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 novel 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 telemetry 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. The advantages of using a GSM data relay over standard transmissions are low running costs and vastly increased energy efficiency and data bandwidth. 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.

Historical Findings

Very few studies have been conducted on MHI movements and habitat use. The ones that have been done did not determine precise diving locations and were unable to examine the entire dive record. 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 a few days 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 unreliable satellite locations 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 behavior were highly variable between age and sex classes and between the different colonies.

Activities and Findings

Objectives

1) Deploy 15 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

Eleven cell phone tags (Fig. 1) were deployed on adult and sub-adult monk seals between February and August 2010. 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). Seals were captured, sampled, and handled following the methods of Baker and Johanos (2002). After capture, seals were sedated, biomedical samples were taken, and cell phone tags were attached to each animal. Tags were attached along the dorsal midline of the seal using 10 min epoxy. They were set to record data continuously and to transmit data via the GSM cell phone network whenever the seal was within range of a GSM base station. Seals from Molokai have not made regular trips within range of a GSM base station so limited data has been collected for those animals; however, where possible, tags from these individuals will be recovered and the full data record downloaded.

Biomedical sampling included taking eye, oral, nasal, fecal, and genital swabs for parasitology testing, taking blubber biopsies for fatty acid and toxicology analysis, taking fecal samples which are cultured for microbiology, and drawing whole blood. CBCs and serum chemistries are run and whole blood is tested for biotoxins and heartworm. Blood serum is run through a suite of tests including: Morbilliviruses, Brucella, herpesvirus, Toxoplasmosis, Leptospirosis, Chlamydia, Adenovirus, Calicivirus, Parvovirus, and toxicology. Any remaining samples are archived. To date, no abnormalities have been found in the seals included in this study.

Objective 2

Data is downloaded periodically using Google Earth to view the current location and recent movements of the instrumented animals. As of 8/1/2010 seven tags were still recording data (Figs. 2-6). Most of the seals made regular trips to sea to forage and returned to land within 1-2 weeks. However, one adult male (R012) that was tagged on Oahu made an oceanic voyage, which lasted about 1 month (Fig. 5). This type of trip is very uncharacteristic for monk seals because they are benthic foragers and typically travel to and from foraging areas or breeding beaches. This animal traveled over 2000 miles, round trip, in waters over 5000 m deep. Throughout the trip he spent the majority of time diving near the surface, which is not characteristic of monk seal foraging. Further analysis of his diving behavior may elucidate whether he was using different foraging tactics during this trip or performing other activities while out at sea.

Location and movement data will be analyzed after all tags have stopped transmitting. Fixed kernel density home range estimates will be used to determine home range sizes and foraging locations for seals that retained their tags for more than 2 months. Foraging hot spots will be identified if multiple seals are observed foraging repeatedly in the same location.

Objective 3

Analyses correlate monk seal behavior and Navy training activities in the MHI will begin in early 2011, once the tags have ceased transmission, or have been recovered.

Discussion

It should be noted that at the time of writing this report NMFS has been unable to deploy all 15 cell phone tags. While this was in small part due to an initial delay in receiving funds it is primarily a result of the unpredictability of field work. During multiple field trips, NMFS was presented with an unprecedented lack of seals on the beaches, particularly on Kauai. In three, week-long trips to Kauai, only 4 instruments were deployed. Of the seals that were encountered on those trips, most were pregnant females, young of the year, or animals that were not suitable candidates for instrumentation due to some sort of injury or molt status. NMFS is still striving to complete the necessary number of deployments and tagging will continue throughout August to complete all 15 deployments.

During the first field trip to Kauai in February 2010 three cell phone tags were deployed. All of these tags fell off within a few weeks of deployment. This malfunction was due to a bad batch of epoxy that was used to secure the tags to a neoprene base. New epoxy was used on all subsequent deployments to prevent similar issues. Due to their feeding behavior, following the sea floor and flipping over large rocks in search of prey, monk seals are notoriously hard on instruments. Most tags are not recovered because the seals scrape them across rocks while foraging. This type of abuse causes the epoxy to stress and break apart and the tag eventually falls off its base. Some animals do retain their tags until they molt the following year, but a large portion are lost at sea, which is what occurred with an adult male that was tagged for this study on Molokai (RI13).

Tables and Figures

Table 1. Hawaiian monk seals captured and instrumented in the Main Hawaiian Islands

Seal ID	Tag #	Age	Sex	Deploy Site	Deploy Date	Most Recent Location Date	Comments
R012	11393	Adult	M	Oahu	3.1.2010	7.31.2010	
R018	11478	Adult	M	Kauai	6.9.2010	7.17.2010	
R4DI	11337	SubAdult	M	Kauai	2.9.2010	2.25.2010	tag fell off
RE70	11420	Adult	M	Molokai	3.27.2010	5.19.2010	
RI11	11419	Adult	M	Molokai	3.26.2010	7.30.2010	
RI13	11392	Adult	M	Molokai	3.26.2010	Unk	tag fell off
RK05	11475	Adult	M	Kauai	2.10.2010	2.13.2010	tag fell off
RO28	11423	SubAdult	F	Kauai	2.11.2010	2.14.2010	tag fell off
RR70	11396	Adult	M	Oahu	6.29.2010	7.30.2010	
unk	11170	Adult	M	Molokai	3.28.2010	5.20.2010	No permanent ID
R4DF	11476	SubAdult	F	Oahu		7.30.2010	

Figure 1. Photo of R4DF with a cell phone tag attached. The instrument is attached to a neoprene base, which is glued to the pelage of the seal.

Figure 2a. Surface movements for RI11 from 26 March through 30 July 2010.

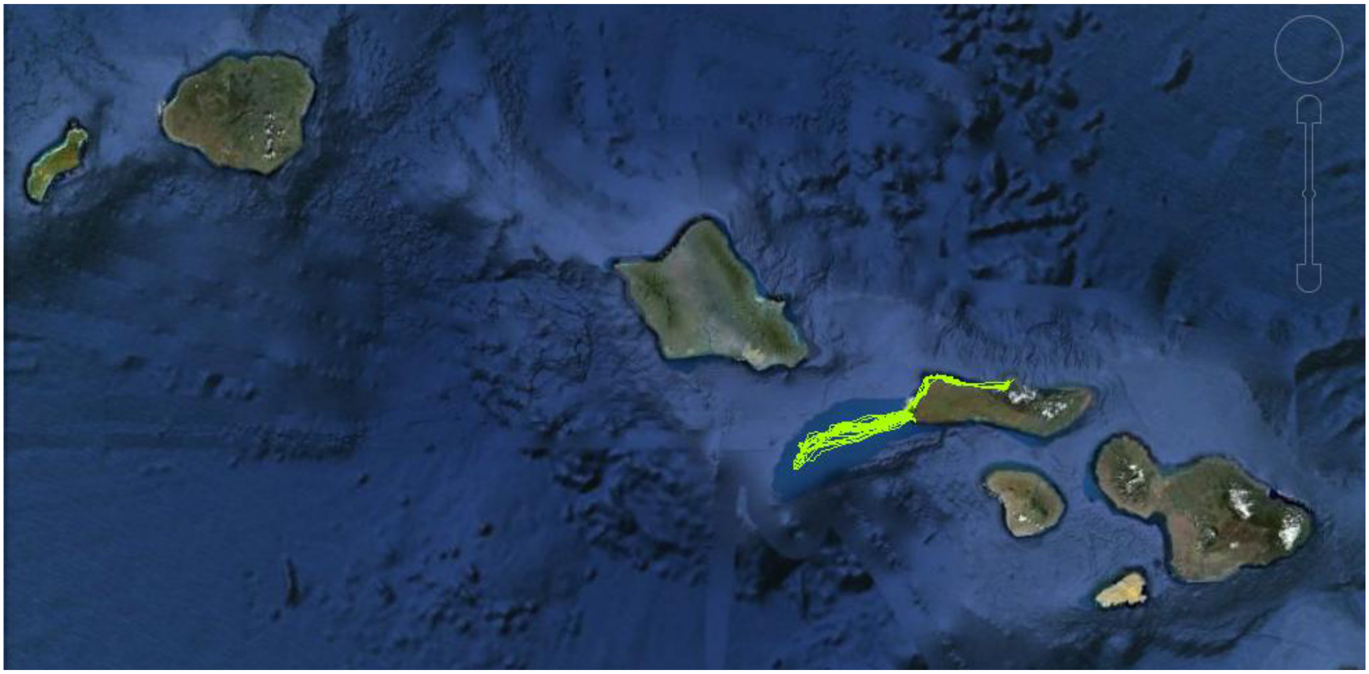


Figure 2b. A subset of dives for RI11 looking towards Molokai from Penguin Bank.

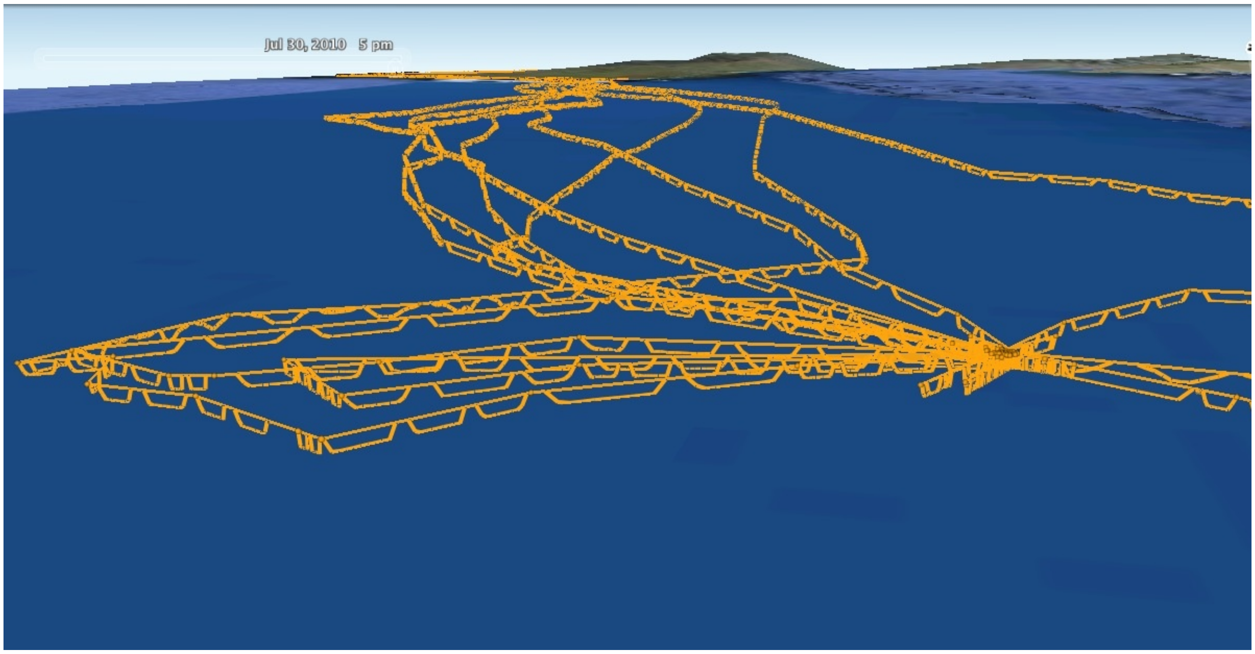


Figure 3a. Surface movements for R018 from 9 June through 17 July 2010.

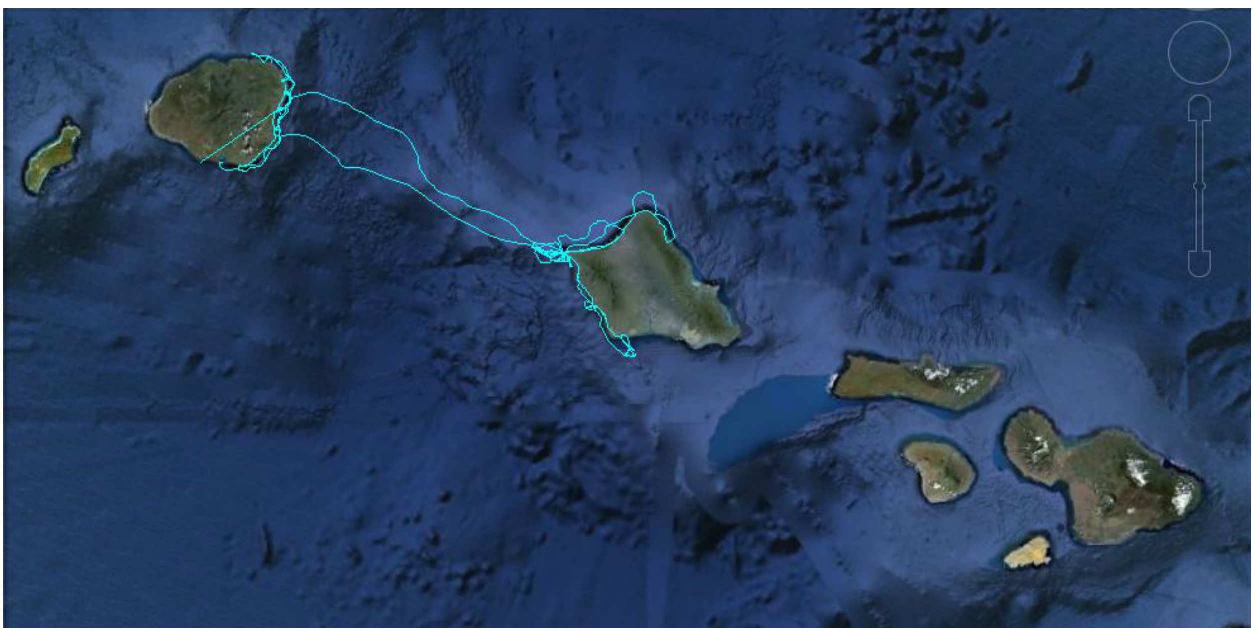


Figure 3b. A subset of dives for R018 looking east towards Kaena Pt on Oahu.

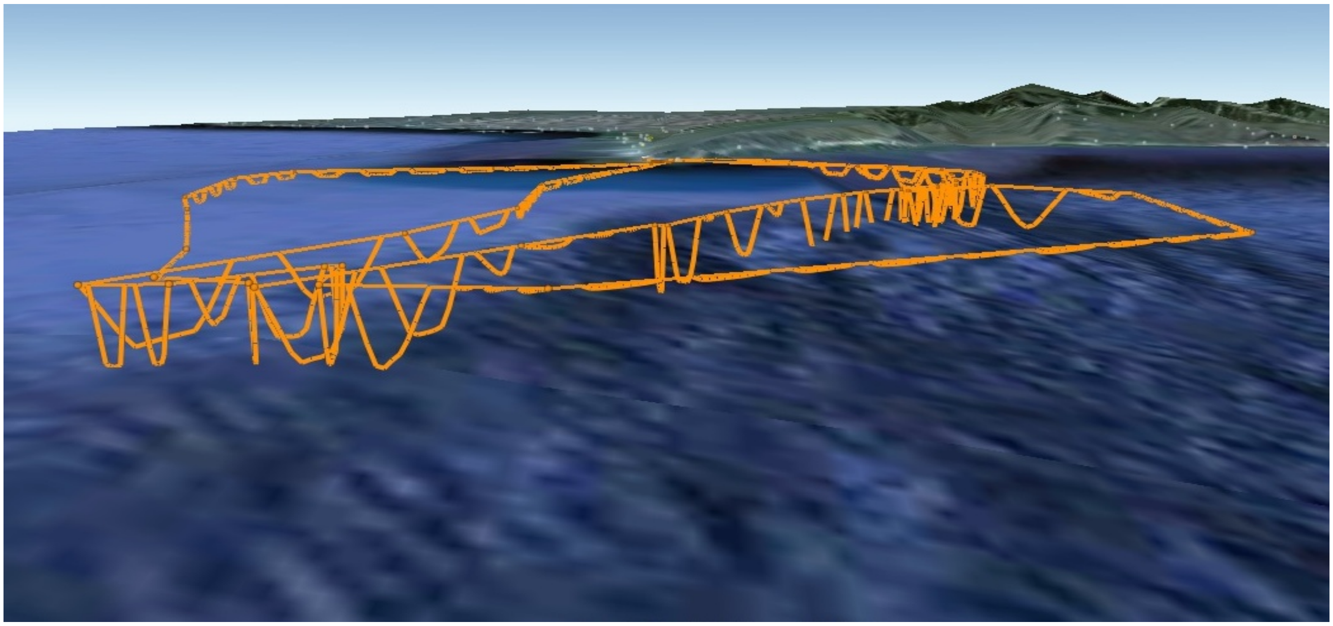


Figure 4a. Surface movements for RR70 from 29 June through 30 July 2010

Figure 4b. A subset of dives for RR70 while foraging near Pearl Harbor.

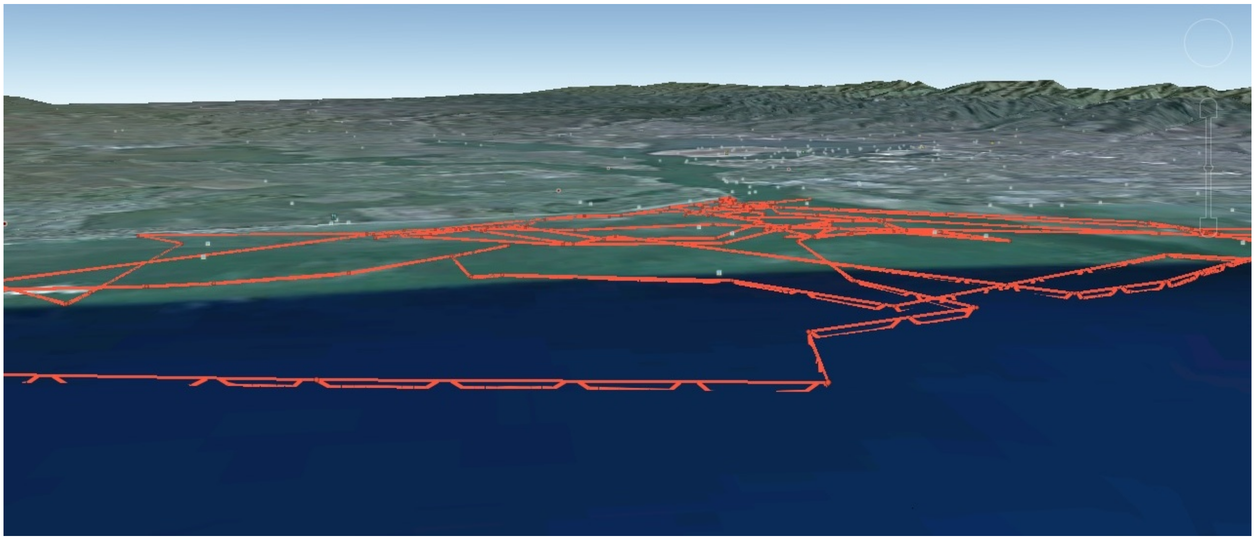


Figure 5a. Surface movements for R012 from 1 March to 31 July 2010.

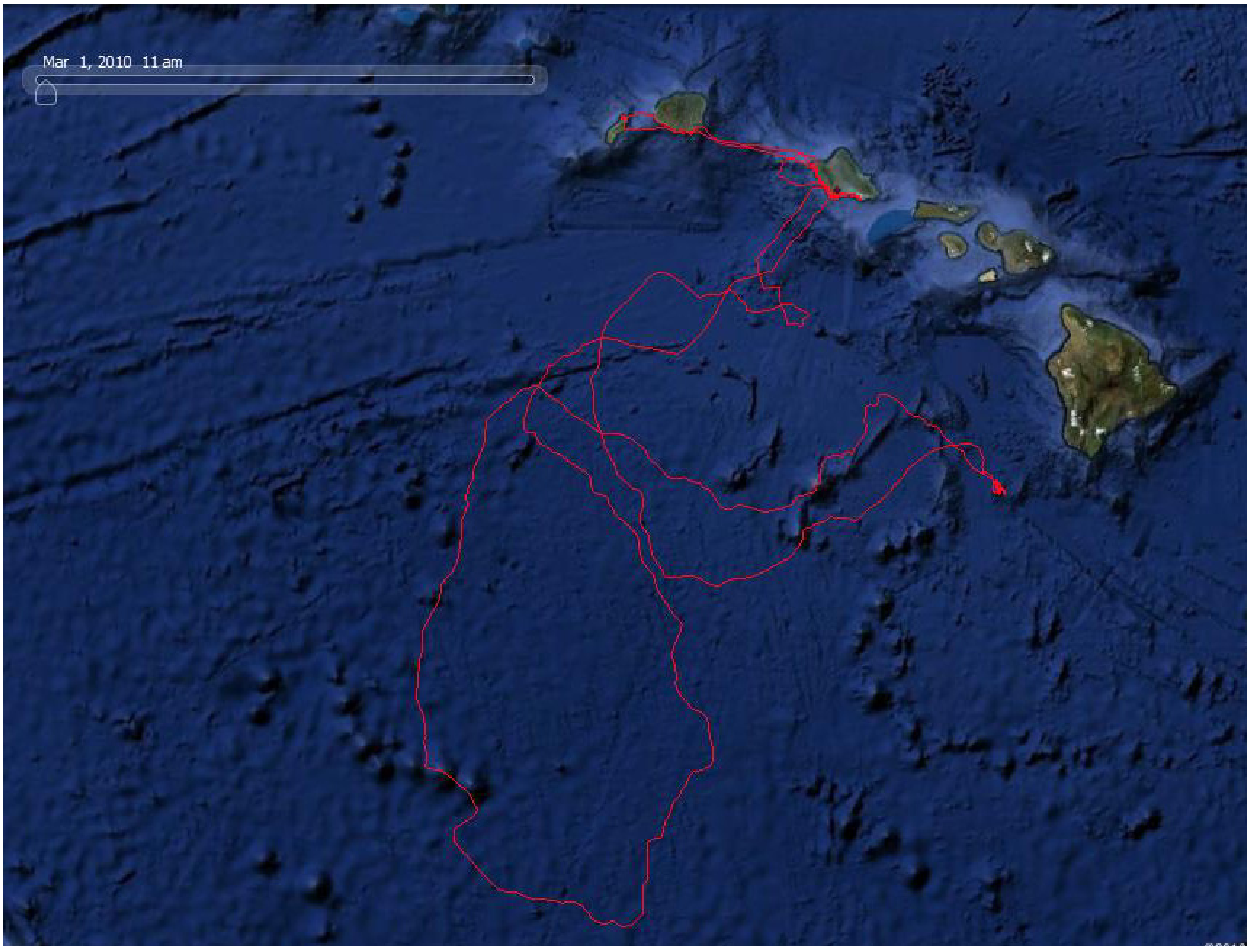


Figure 5a. A subset of dives for R012 while foraging off of White Plains Beach on Oahu.

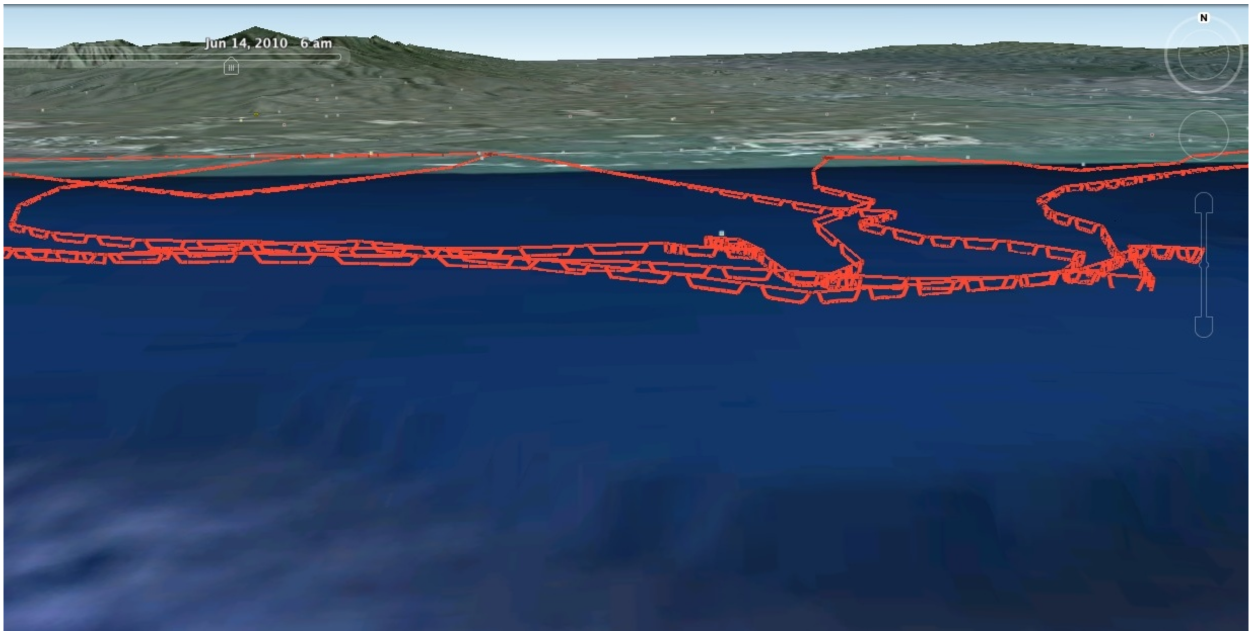


Figure 6a. Surface movements for R4DF from 9 June through 20 July 2010.

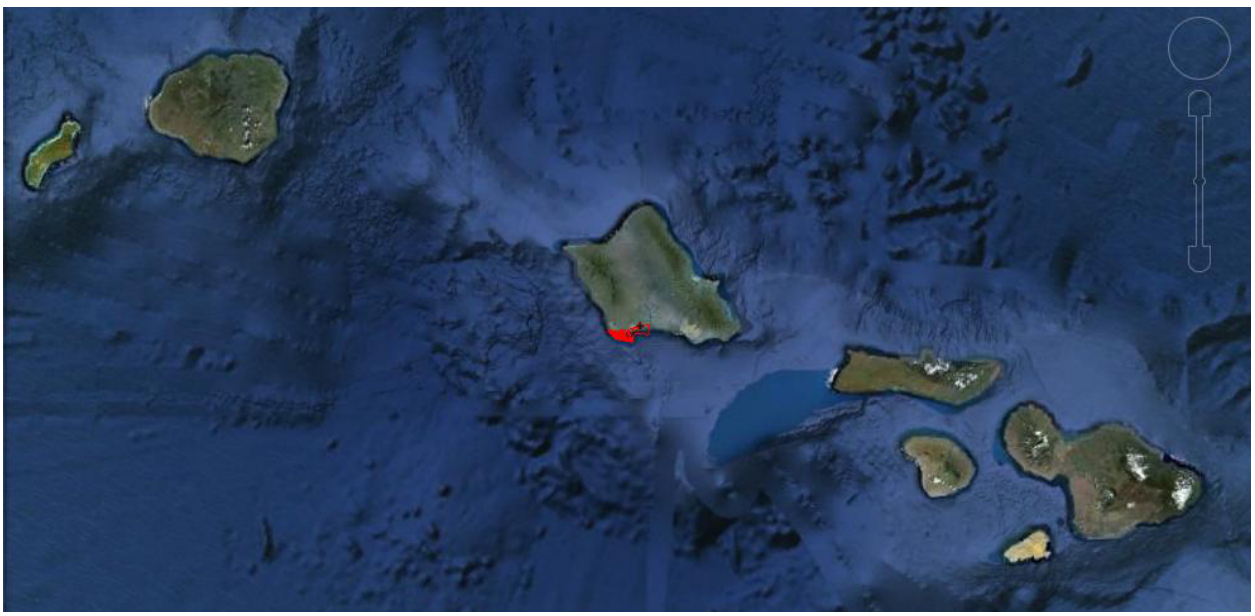
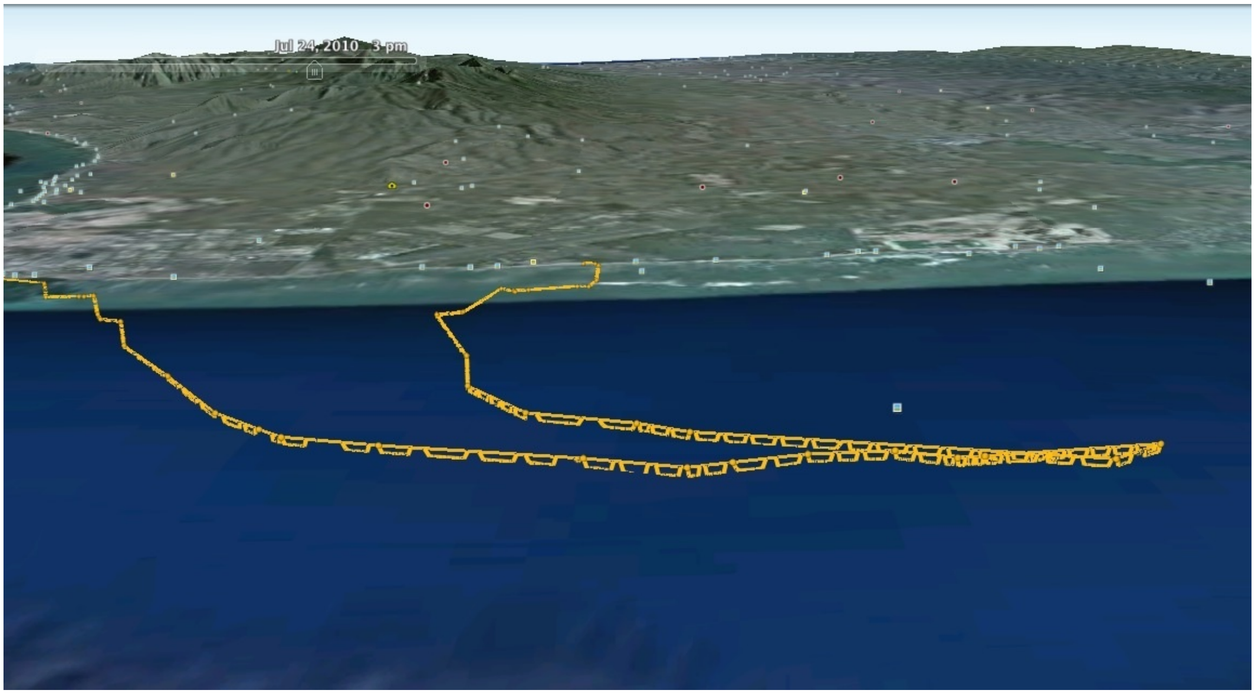


Figure 6b. One foraging trip for R4DF looking towards Barbers Pt on Oahu.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APPENDIX M - 2010 Report to PACFLT: Additional Results from the 2009 Main Hawaiian Islands Cetacean Assessment Survey

2010 Report to PACFLT: Additional Results from the 2009 Main Hawaiian Islands Cetacean Assessment Survey

Erin Oleson & Marie Hill
NOAA-NMFS-Pacific Islands Fisheries Science Center

A cetacean assessment survey of the main Hawaiian Islands was conducted by NMFS in February 2009. The survey was designed to conform to the 2002 NMFS HICEAS survey (Hawaiian Islands Cetacean Ecosystem Assessment Survey). Following a request from the Navy, additional survey lines were added to assess the region east and north of Kauai, and these lines were surveyed to the extent possible. Data collection methods and preliminary results were presented in a 2009 report. Here we report additional results of that survey at the request of the U.S. Navy Pacific Fleet.

Main Hawaiian Islands Cetacean Assessment Survey- February, 2009

The Pacific Islands Fisheries Science Center Cetacean Research Program conducted a visual and acoustic line-transect assessment survey of cetacean populations within the inner waters of the main Hawaiian Islands (MHI) EEZ. The survey was carried out using the NOAA Ship *Oscar Elton Sette* (Cruise OES-09-01). During this survey, sighted groups of cetaceans were photographically identified ands some individuals were also biopsied to collect tissue samples for genetic analyses of stock structure. The cruise was conducted from February 5 to February 27, 2009. Visual and acoustic survey methods have been described in a previous report and will not be included again here. Some results presented previously are repeated here to provide appropriate context.

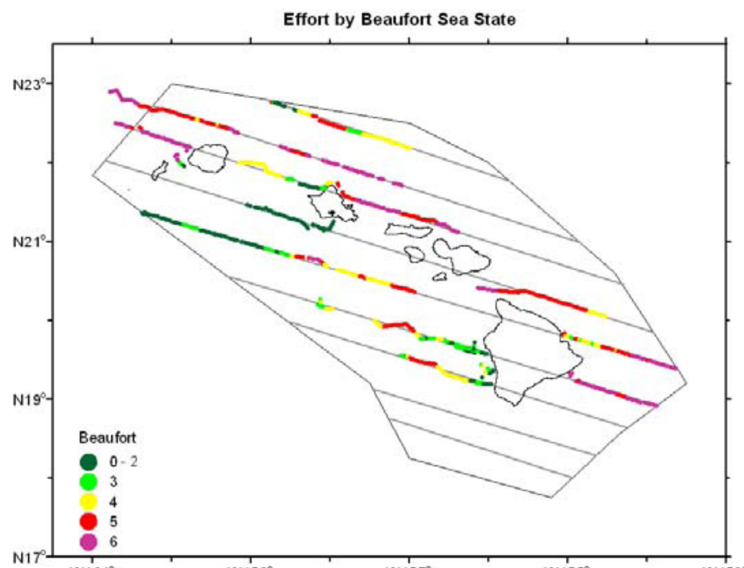


Figure 1.Main Hawaiian Islands inner exclusive economic zone survey region. Gray lines are the predetermined transect lines used to systematically survey the region. The colored lines indicate the region we've surveyed so far, by Beaufort sea state.

At times during the cruise, visual survey operations were not possible because of high winds or seas. Usually, survey operations were suspended at Beaufort Sea State 7 or higher, or if rain made visibility 1 nautical mile or less. During these times, a single observer maintained a weather watch in order to notify the rest of the observer team when conditions improved.

Table 1.Visual and acoustic survey effort.

Date	Start time	Start latitude	Start longitude	End time	End latitude	End longitude	Distance surveyed (nmi)	Average Beaufort
2/5/2009	1751	N21:13.00	W158:14.01	1832	N21:15.26	W158:21.05	6.9	4
2/6/2009	733	N21:59.89	W159:08.92	1819	N21:33.29	W157:45.14	74.4	3.9
2/7/2009	723	N20:38.58	W157:54.09	1414	N20:21.82	W156:56.14	54.9	4.5
2/8/2009	914	N19:34.40	W156:01.36	1811	N19:45.47	W156:37.15	34.9	3
2/9/2009	818	N19:34.48	W156:01.66	1820	N20:00.00	W157:26.76	84.0	3.6
2/10/2009	834	N21:15.60	W157:57.40	1818	N21:28.25	W159:03.06	56.0	1.8
2/11/2009	711	N21:21.13	W160:20.19	1833	N21:00.60	W159:10.84	63.7	2.1
2/12/2009	708	N21:00.07	W159:07.70	1828	N20:08.35	W157:57.84	92.0	3.5
2/13/2009	702	N19:33.39	W157:05.82	1701	N19:12.28	W156:03.97	62.1	4
2/14/2009	655	N19:13.45	W156:09.44	1752	N19:43.62	W156:10.75	55.7	2.3
2/15/2009	1225	N19:42.22	W156:05.12	1805	N19:25.53	W156:04.18	32.7	3.6
2/16/2009	713	N19:51.96	W155:02.03	1812	N19:23.11	W153:37.71	85.3	4.8
2/17/2009	659	N18:55.00	W153:51.95	1802	N19:14.25	W154:51.94	64.4	5.8
2/18/2009	648	N20:03.02	W154:30.71	1816	N20:24.51	W156:07.73	89.3	5.1
2/19/2009	No effort						0	7+
2/20/2009	745	N21:07.10	W156:22.65	1800	N21:33.22	W157:44.68	93.4	5.7
2/21/2009	710	N22:22.48	W159:09.80	1814	N22:53.77	W160:46.95	89.8	5.2
2/22/2009	728	N22:30.17	W160:42.44	1803	N21:57.69	W159:50.76	61.6	5.7
2/23/2009	721	N22:46.54	W158:44.60	1827	N22:11.03	W156:59.34	94.2	3.8
2/24/2009	716	N22:12.17	W158:37.66	1720	N21:42.67	W157:06.51	61.9	5.9
2/25/2009	No effort						0	7+
2/26/2009	No effort						0	7+
						Total	1257.2	

- **Passive Acoustics**

Two hydrophone arrays were available for use during this survey, a 6-element array towed 300 m behind the vessel and a 4-element array towed 350 m behind the vessel. The 6-element array contained two elements with a high-frequency response up to 250kHz. On 20 February, the 6-element array suffered a break in the tubing that houses the hydrophone elements. The 4-element array was used for the remainder of the cruise.

Results

Eighteen days of on-effort survey were completed during the cruise (Table 1), resulting in 117 sightings of 12 cetacean species, in addition to a number of unidentified cetaceans (Appendix Table 1). Over 2320 km of trackline were visually and acoustically surveyed, resulting in a survey area of 182,736 km^2. The geographic distribution of search effort is shown in Figures 1 and 2, respectively. Abundance estimates cannot be calculated from the limited sightings data from this single cruise. The sightings data collected during this survey will be combined, as appropriate, with data collected on future line-transect survey efforts to produce new estimates of abundance. Limited survey effort was completed with the Navy's PMRF range and north of Kauai. An active training event in that region prevented dedicated effort there, though at least 20 on- and off-sightings were logged in the area north of Kauai alone.

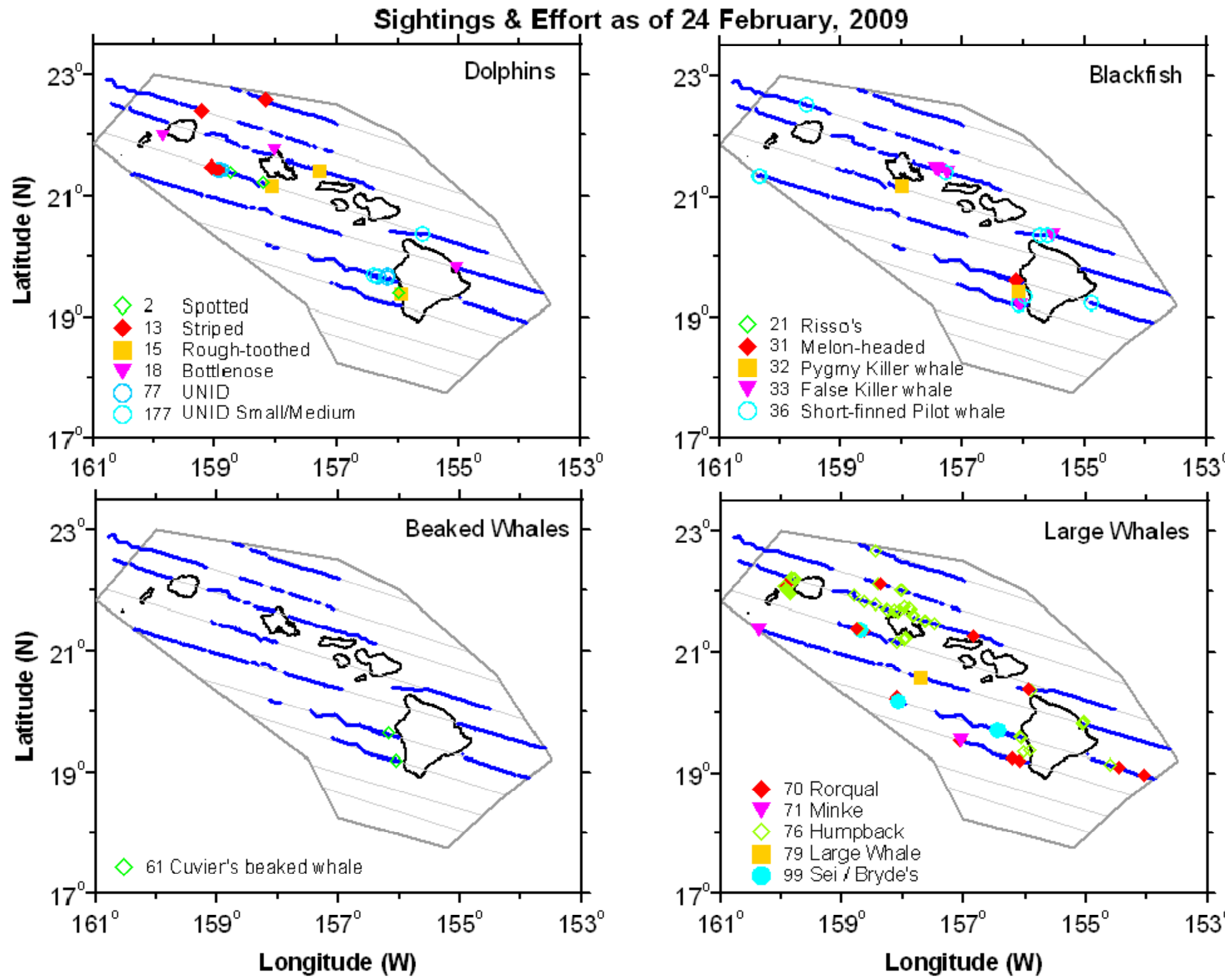


Figure 2. Visual and acoustic survey effort (blue lines) and cetacean visual sightings during the cruise.

- **Passive Acoustics**

Localization of cetacean vocalizations was hampered during the first part of the cruise as the spacing of the individual hydrophone elements within the 6-element array was too close together for robust determination of bearing angle to the sound source. Bearing angles were successfully computed during use of the 4-element array, as the elements are spaced more appropriately for lower frequency dolphin whistles.

A total of 42 sighted cetacean groups were acoustically detected with the hydrophone array (Figure 3, Appendix Table 2). In addition, another 20 cetacean groups were detected only with the acoustic array; however, in most cases we were unable to locate these groups visually, so all are considered unidentified dolphins. There was also nearly continuous acoustic detection of humpback and minke whales during the later part of the cruise while using the 4-element array (Figure 4). No anthropogenic sounds, including military soar, were detected on the acoustic array during the course of this survey.

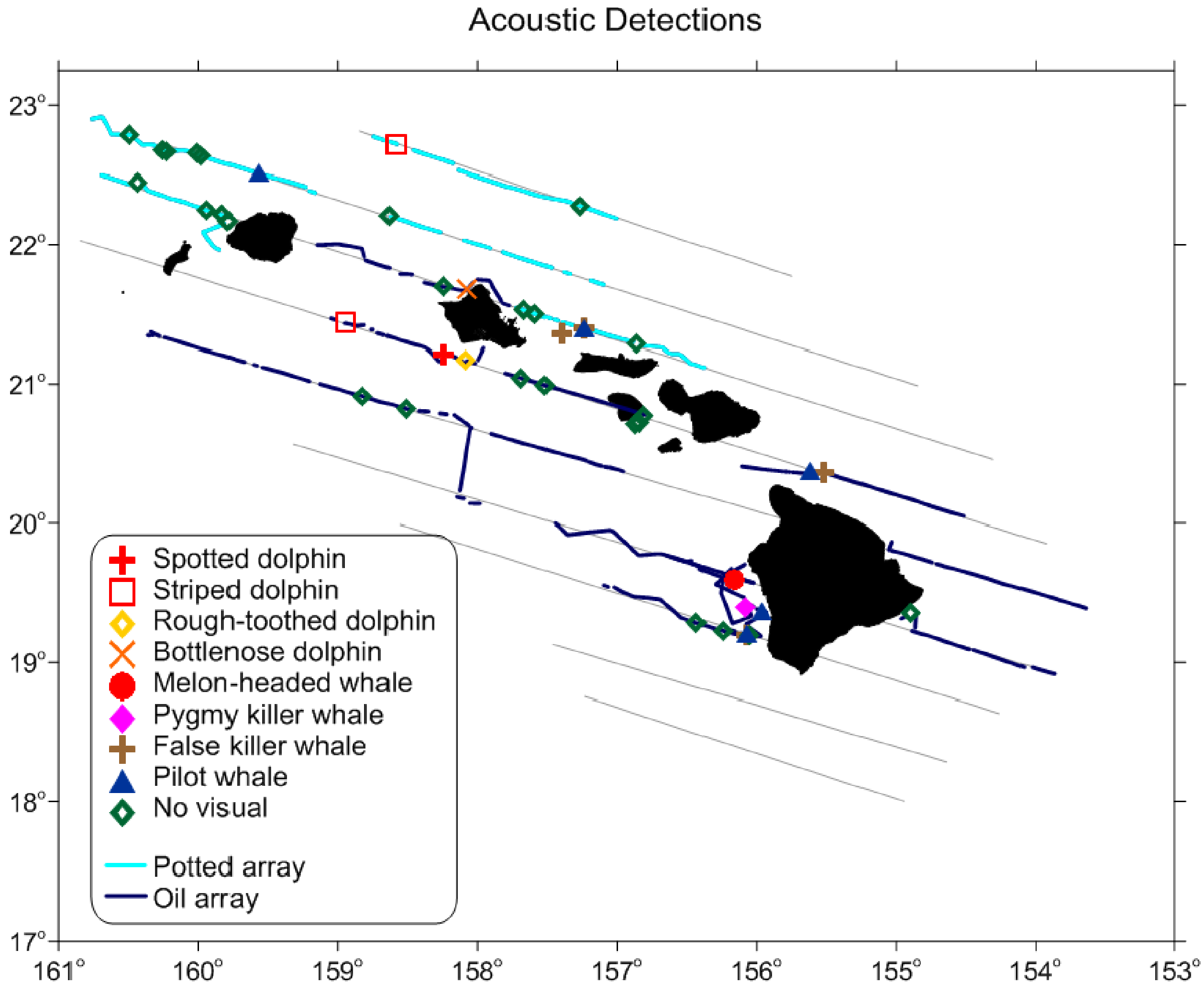


Figure 3. Acoustic detections during visual sightings and acoustic survey effort (by array) during the cruise. N Acoustic detections that were not accompanied by visual verification of species ID are considered unidentified dolphins.

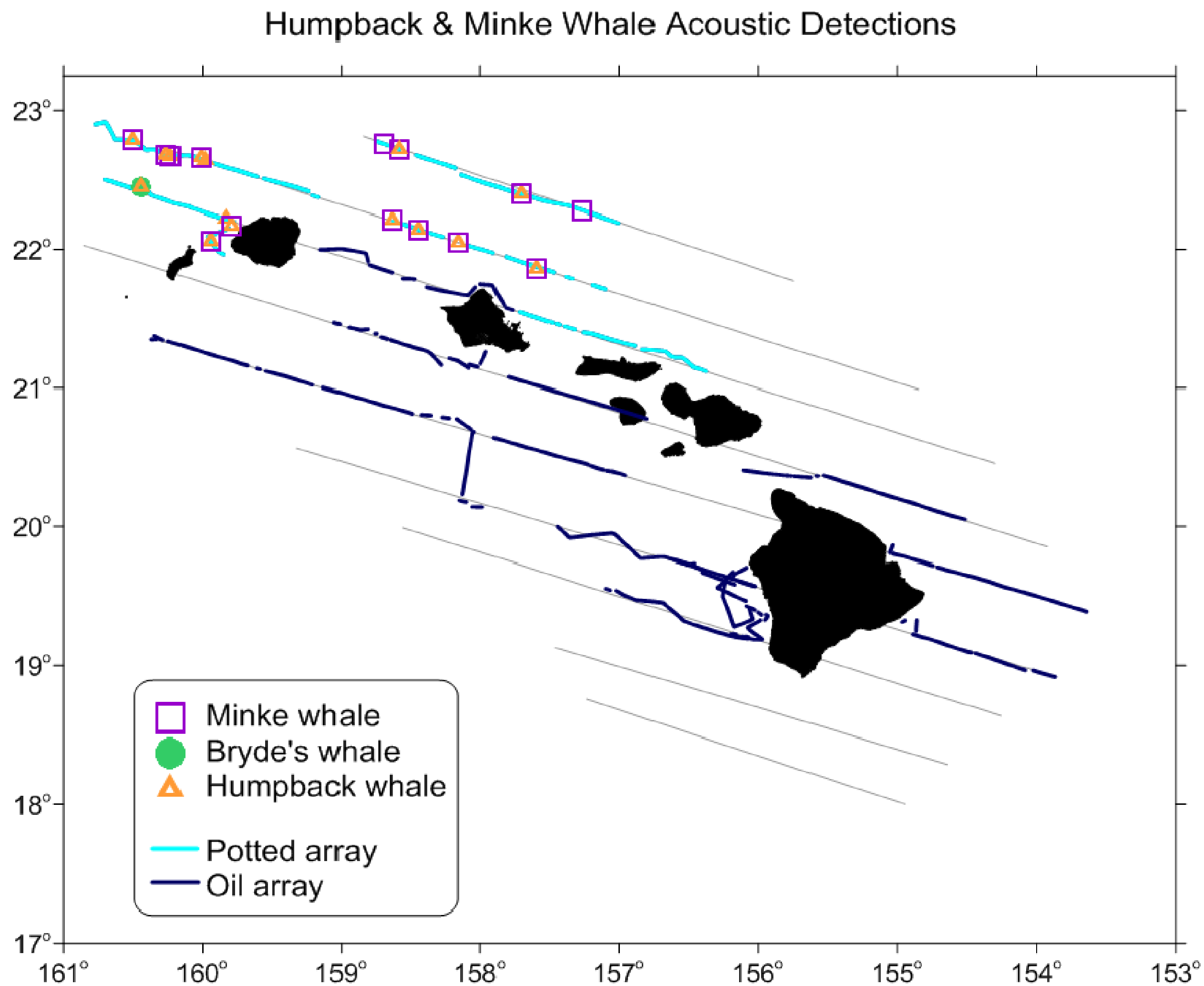


Figure 3. Start location of acoustic detections of humpback and minke whales on the towed hydrophone array. All detections occurred using the potted array because of the low frequency response of that array.

Appendix I. -- Table I. Acoustic detections during the survey. An increase in detections after Feb. 20 can be attributed, in part, to the use of a different array with more gain at low frequencies. 'Unid' = no visual verification of the acoustically detected species. Call types: C = echolocation clicks, W = whistles, and BP = pulsed sounds.

Date (Local)	Time (Local)	Latitude	Longitude	Sighting #	Species	Call Types (C, W, BP)
2/6/2009	14:07	21 41.82	158 14.79		Unid	C, W
2/6/2009	15:11	21 40.88	158 04.41	11	Tt	C, W
2/8/2009	10:08	19 35.45	156 09.93	20	Pe	C, W
2/10/2009	10:11	21 09.93	158 05.20	29	Sb	C, W, BP
2/10/2009	11:57	21 12.46	158 14.66	31	Sa	C, W, BP
2/10/2009	17:31	21 26.26	158 56.71	38	Sc	C, W, BP
2/10/2009	17:46	21 26.48	158 59.07	39	Unid	C, W, BP
2/12/2009	8:52	20 54.64	158 49.18		Unid	W
2/12/2009	10:39	20 49.23	158 30.78		Unid	W
2/13/2009	11:36	19 16.98	156 25.73		unid	W
2/13/2009	13:43	19 11.52	150 04.61	49	Pc	W
2/13/2009	15:06	19 11.98	156 03.25		unid	C, W
2/13/2009	17:00	19 12.33	156 04.15	52	Gm	C, W
2/14/2009	11:20	19 22.07	155 58.00	57	Gm	C, W, BP
2/14/2009	13:01	19 23,70	156 5.19	58	Fa	C
2/19/2009	12:08	21 02.62	157 41.40		unid	C, W
2/19/2009	13:15	20 59.63	157 31.33		unid	C,W
2/19/2009	17:51	20 42.87	156 52.39		unid	W
2/19/2009	18:05	20 43.43	156 50.40		unid	W
2/19/2009	18:26	20 46.08	156 48.38		unid	C, W
2/20/2009	11:11	21 17.47	156 51.73		unid	W
2/20/2009	13:30	21 23.81	157 14.31	79, 80	Pc, Gm	C, W, BP
2/20/2009	15:23	21 21.61	157 23.75	81	Pc	C,W
2/20/2009	17:00	21 30.14	157 35.19		unid	W
2/20/2009	17:28	21 31.53	157 39.72		unid	W
2/21/2009	9:50	22 30.74	159 34.22	87	Gm	
2/21/2009	12:42	22 38.08	159 58.71		Mn, unid	C
2/21/2009	13:08	22 39.61	160 00.48		Mn,Ba, unid	C
2/21/2009	14:11	22 40.22	160 13.69		Mn,Ba, unid	C
2/21/2009	14:26	22 40.41	160 15.53		Mn,Ba, unid	C
2/21/2009	16:03	22 47.21	160 29.60		Mn,Ba, unid	C, W
2/22/2009	9:42	22 26.57	160 26.42	88	Be, Mn,Ba, unid	W
2/22/2009	13:49	22 14.85	159 56.32		Unid	C, W
2/22/2009	14:32	22 12.83	159 49.50	89, 90, 91, 92	Mn, unid	C, W
2/22/2009	14:50	22 12.15	159 46.83	89, 90, 91, 92	Mn, Ba	
2/22/2009	15:58	22 09.83	159 47.62	93, 94, 95, 96	Mn, Ba, unid	C, W
2/22/2009	17:13	22 03.62	159 56.57	97-107	Tt, Mn, Ba	C,W
2/23/2009	7:39	22 45.56	158 41.70		Ba	
2/23/2009	8:19	22 43.23	158 34.92	108, 109	Ba, Mn, Sc	C, W
2/23/2009	13:54	22 24.03	157 42.50		Mn, Ba	
2/23/2009	16:42	22 16.86	157 16.05		Ba, unid	W
2/24/2009	7:13	22 12.24	158 37.92		Mn, Ba, unid	C
2/24/2009	8:27	22 08.48	158 26.40	110-113	Mn, Ba	
2/24/2009	10:16	22 02.97	158 09.42	114, 115	Mn, Ba	
2/24/2009	14:07	21 51.64	157 36.10		Mn, Ba	

Table II. Summary information for all visually sighted groups. Behavior is assessed when the animals are first seen and then when noticeable changes in behavior occur.

Date (Local)	Sight #	Species	Effort	Time (Local)	Lat	Long	Ave Best Est	Ave High Est	Ave Low Est	Behavior Notes	Biopsy?	Photos?
2/6/2009	1	Megaptera novaeangliae	ON	9:50	21.936	-158.815	1	1	1	Breaching	No	No
2/6/2009	2	Megaptera novaeangliae	ON	11:11	21.839	-158.655	2	3	2	n/a	No	No
2/6/2009	3	Megaptera novaeangliae	ON	12:47	21.783	-158.472	1	2	1	n/a	No	No
2/6/2009	4	Megaptera novaeangliae	ON	13:57	21.704	-158.284	2	2	2	Traveling	No	No
2/6/2009	5	Megaptera novaeangliae	ON	14:09	21.697	-158.249	1	2	1	slow travel	No	No
2/6/2009	6	Megaptera novaeangliae	ON	14:38	21.681	-158.163	1	1	1	n/a	No	No
2/6/2009	7	Megaptera novaeangliae	ON	14:41	21.679	-158.153	2	3	2	slow travel	No	No
2/6/2009	8	Megaptera novaeangliae	ON	15:07	21.673	-158.082	2	2	2	fast travel	No	No
2/6/2009	9	Megaptera novaeangliae	ON	15:11	21.683	-158.073	3.5	4.5	3.5	breaching	No	No
2/6/2009	10	Megaptera novaeangliae	ON	15:18	21.695	-158.062	6.5	8.5	6	tail/pec fin slapping	No	No
2/6/2009	11	Tursiops truncatus	OFF	15:50	21.746	-158.020	3	4	n/a	slow travel	No	No
2/6/2009	12	Megaptera novaeangliae	ON	16:10	21.747	-157.987	8	10	7	n/a	No	No
2/6/2009	13	Megaptera novaeangliae	ON	16:41	21.738	-157.909	3	5	3	lobtailing; stationary	No	No
2/6/2009	14	Megaptera novaeangliae	ON	16:57	21.702	-157.891	1	2	1	n/a	No	No
2/6/2009	15	Megaptera novaeangliae	ON	17:33	21.621	-157.845	2	2	2	n/a	No	No

Date (Local)	Sight #	Species	Effort	Time (Local)	Lat	Long	Ave Best Est	Ave High Est	Ave Low Est	Behavior Notes	Biopsy?	Photos?
2/6/2009	16	Megaptera novaeangliae	ON	17:43	21.597	-157.832	1	1	1	fluked	No	No
2/7/2009	17	Unid. large whale	ON	8:33	20.589	-157.725	1	2	1	n/a	No	No
2/8/2009	18	Megaptera novaeangliae	ON	9:30	19.585	-156.067	3	4	3	fluked	No	No
2/8/2009	19	Megaptera novaeangliae	ON	9:43	19.596	-156.103	7	9	6	moderate travel; fluked	No	No
2/8/2009	20	Peponocephala electra	ON	9:55	19.608	-156.137	253	313	217	slow travel; inverted tail slaps; breaching	Yes	Yes
2/8/2009	21	B. borealis/ edeni	OFF	14:07	19.710	-156.457	2	2	2	fast travel; erratic surfacing	No	Yes
2/9/2009	22	Unid. Dolphin	ON	10:15	19.666	-156.320	1	1	1	fast travel; bow ride	No	No
2/9/2009	23	Unid. small delphinid	ON	10:42	19.685	-156.381	30	80	15	jumping	No	No
2/10/2009	24	Megaptera novaeangliae	ON	8:36	21.255	-157.959	2	4	2	travel	No	No
2/10/2009	25	Megaptera novaeangliae	ON	8:46	21.231	-157.968	2	2	1	slow travel; fluke up dive	No	No
2/10/2009	26	Megaptera novaeangliae	ON	8:51	21.217	-157.974	1	2	1	Slow travel	No	No
2/10/2009	27	Megaptera novaeangliae	ON	9:00	21.196	-157.985	1	2	1	Slow travel	No	No
2/10/2009	28	Feresa attenuata	ON	9:10	21.172	-157.997	14	16	12	slow travel; logging	No	Yes
2/10/2009	29	Steno bredanensis	ON	10:06	21.166	-158.077	28	32	26	slow travel; resting	No	Yes
2/10/2009	30	Megaptera novaeangliae	ON	11:07	21.165	-158.115	2	3	2	slow travel	No	No
2/10/2009	31	Stenella attenuata	ON	11:48	21.212	-158.221	42	55	33	travel; logging; milling; bow ride	Yes	No
2/10/2009	32	Unid. Rorqual	ON	14:50	21.347	-158.647	3	5	3	n/a	No	No
2/10/2009	33	B. borealis/edeni	ON	15:16	21.366	-158.714	1	1	1	travel; dive	No	Yes

Date (Local)	Sight #	Species	Effort	Time (Local)	Lat	Long	Ave Best Est	Ave High Est	Ave Low Est	Behavior Notes	Biopsy?	Photos?
2/10/2009	34	Stenella attenuata	ON	16:20	21.390	-158.758	19	28	15	Porpoising, jumping, milling	No	No
2/10/2009	35	Megaptera novaeangliae	ON	16:20	21.390	-158.759	4	5	3	travel	No	No
2/10/2009	36	Unid. Rorqual	OFF	16:30	21.400	-158.785	2	2	2	n/a	No	No
2/10/2009	37	Unid. Dolphin	OFF	17:18	21.427	-158.908	2	3	1	leap	No	No
2/10/2009	38	Stenella coeruleoalba	ON	17:27	21.434	-158.949	62	77	45	side slapping; breaching	No	No
2/10/2009	39	Unid. Dolphin	OFF	17:31	21.438	-158.946	6	12	5	slow travel	No	No
2/10/2009	40	Stenella coeruleoalba	ON	18:17	21.470	-159.048	12	21	9	n/a	No	No
2/11/2009	41	Globicephala macrorhynchus	ON	7:14	21.350	-160.329	41	55	32	travel; milling	No	Yes
2/11/2009	42	Balaenoptera acutorostrata	OFF	9:12	21.365	-160.380	1	1	1	slow travel	No	Yes
2/11/2009	43	Globicephala macrorhynchus	ON	10:12	21.348	-160.352	40	55	33	slow travel	No	No
2/12/2009	44	Unid. Rorqual	ON	16:19	20.268	-158.120	1	1	1	n/a	No	No
2/12/2009	45	Unid. Rorqual	ON	16:30	20.233	-158.126	1	1	1	n/a	No	No
2/12/2009	46	B. borealis/ edeni	ON	17:16	20.177	-158.098	1	1	1	n/a	No	No
2/13/2009	47	Unid. Rorqual	ON	7:15	19.545	-157.063	1	1	1	n/a	No	No
2/13/2009	48	Balaenoptera acutorostrata	OFF	7:23	19.545	-157.042	1	1	1	n/a	No	No
2/13/2009	49	Pseudorca crassidens	ON	13:44	19.192	-156.075	2	3	2	travel	No	Yes
2/13/2009	50	Ziphius cavirostris	OFF	14:53	19.190	-156.070	2	2	1	n/a	No	No
2/13/2009	51	Unid. Rorqual	OFF	16:48	19.209	-156.102	2	3	2	n/a	No	No
2/13/2009	52	Globicephala macrorhynchus	ON	16:54	19.210	-156.084	23	35	16	n/a	Yes	Yes
2/14/2009	53	Unid. Rorqual	OFF	7:19	19.233	-156.222	1	2	1	n/a	No	No
2/14/2009	54	Globicephala macrorhynchus	ON	10:24	19.328	-155.984	9	10	8	n/a	No	Yes
2/14/2009	55	Megaptera novaeangliae	ON	11:06	19.359	-155.932	1	1	1	roll & dive	No	No

Date (Local)	Sight #	Species	Effort	Time (Local)	Lat	Long	Ave Best Est	Ave High Est	Ave Low Est	Behavior Notes	Biopsy?	Photos?
2/14/2009	56	Steno bredanensis	ON	11:11	19.366	-155.944	9	13	7	milling	No	Yes
2/14/2009	57	Stenella attenuata	ON	11:57	19.383	-156.001	81	103	65	jumping; bow ride	No	Yes
2/14/2009	58	Feresa attenuata	ON	12:57	19.429	-156.087	5	5	5	rafting	Yes	Yes
2/14/2009	59	Unid. Dolphin	ON	17:27	19.671	-156.187	1	1	1	n/a	No	No
2/15/2009	60	Ziphius cavirostris	ON	13:09	19.639	-156.184	1	2	1	n/a	No	No
2/15/2009	61	Unid. Dolphin	OFF	13:13	19.631	-156.189	3	15	3	fast travel	No	No
2/15/2009	62	Megaptera novaeangliae	ON	16:58	19.339	-156.040	1	2	1	fast travel	No	No
2/16/2009	63	Megaptera novaeangliae	ON	7:24	19.841	-155.043	1	2	1	n/a	No	No
2/16/2009	64	Megaptera novaeangliae	ON	7:26	19.835	-155.045	1	1	1	n/a	No	No
2/16/2009	65	Megaptera novaeangliae	ON	7:35	19.811	-155.053	2	2	2	fluked	No	No
2/16/2009	66	Tursiops truncatus	ON	7:45	19.802	-155.032	6	7	5	bow ride	Yes	Yes
2/17/2009	67	Unid. Rorqual	ON	7:58	18.962	-154.026	1	1	1	n/a	No	No
2/17/2009	68	Unid. Rorqual	ON	10:37	19.087	-154.444	1	1	1	n/a	No	No
2/17/2009	69	Megaptera novaeangliae	ON	11:43	19.134	-154.600	2	2	1	slow travel; dive	No	No
2/17/2009	70	Globicephala macrorhynchus	ON	13:29	19.227	-154.888	17	21	14	moderate travel;	No	Yes
2/18/2009	71	Pseudorca crassidens	ON	12:42	20.370	-155.536	8	15	6	slow, moderate travel; bow ride	No	Yes
2/18/2009	72	Unid. medium delphinid	ON	15:04	20.367	-155.590	2	5	2	bow ride	No	No
2/18/2009	73	Globicephala macrorhynchus	OFF	15:11	20.369	-155.612	3	5	3	n/a	No	No
2/18/2009	74	Globicephala macrorhynchus	ON	16:03	20.365	-155.742	13	25	9	moderately fast travel	No	No

Date (Local)	Sight #	Species	Effort	Time (Local)	Lat	Long	Ave Best Est	Ave High Est	Ave Low Est	Behavior Notes	Biopsy?	Photos?
2/18/2009	75	Megaptera novaeangliae	ON	16:58	20.380	-155.898	1	1	1	breach	No	No
2/18/2009	76	Megaptera novaeangliae	ON	17:02	20.381	-155.909	2	2	1	n/a	No	No
2/18/2009	77	Unid. Rorqual	ON	17:18	20.386	-155.956	1	2	1	n/a	No	No
2/20/2009	78	Unid. Rorqual	ON	10:57	21.276	-156.834	1	2	1	n/a	No	No
2/20/2009	79	Pseudorca crassidens	ON	13:37	21.399	-157.258	2	5	2	slow travel	No	No
2/20/2009	80b	Globicephala macrorhynchus	OFF	14:03	21.403	-157.282	12	17	9	slow rolls; logging	No	Yes
2/20/2009	80a	Steno bredanensis	OFF	14:03	21.403	-157.282	19	27	15	steady travel	No	Yes
2/20/2009	81	Pseudorca crassidens	OFF	15:43	21.445	-157.396	2	3	2	bow ride; medium travel	No	Yes
2/20/2009	82	Pseudorca crassidens	ON	16:07	21.462	-157.451	2	3	2	fast dive; porpoising	No	Yes
2/20/2009	83	Megaptera novaeangliae	ON	16:24	21.476	-157.495	1	1	1	n/a	No	No
2/20/2009	84	Megaptera novaeangliae	ON	17:17	21.516	-157.632	1	1	1	slow travel	No	No
2/20/2009	85	Megaptera novaeangliae	ON	17:25	21.523	-157.654	2	3	2	slow travel	No	No
2/21/2009	86	Stenella coeruleoalba	ON	7:25	22.389	-159.205	16	26	12	moderate travel; fled from ship	No	No
2/21/2009	87	Globicephala macrorhynchus	ON	9:45	22.508	-159.556	2	4	2	slow travel	No	No
2/22/2009	88	Balaenoptera edeni	ON	8:51	22.438	-160.501	1	1	1	fish chase; 2-5 min dive times	No	Yes
2/22/2009	89	Megaptera novaeangliae	ON	14:25	22.220	-159.845	2	3	2	n/a	No	No
2/22/2009	90	Megaptera novaeangliae	ON	14:36	22.212	-159.815	1	2	1	n/a	No	No
2/22/2009	91	Megaptera novaeangliae	ON	14:37	22.211	-159.813	1	2	1	n/a	No	No
2/22/2009	92	Megaptera novaeangliae	ON	14:39	22.209	-159.807	2	3	2	n/a	No	No

Date (Local)	Sight #	Species	Effort	Time (Local)	Lat	Long	Ave Best Est	Ave High Est	Ave Low Est	Behavior Notes	Biopsy?	Photos?
2/22/2009	93	Megaptera novaeangliae	ON	14:53	22.199	-159.771	1	1	1	n/a	No	No
2/22/2009	94	Megaptera novaeangliae	ON	16:08	22.152	-159.814	1	1	1	n/a	No	No
2/22/2009	95	Megaptera novaeangliae	ON	16:09	22.151	-159.816	1	2	1	slow travel	No	No
2/22/2009	96	Unid. Rorqual	ON	16:47	22.106	-159.924	3	5	2	n/a	No	No
2/22/2009	97	Unid. Rorqual	ON	16:51	22.101	-159.937	1	1	1	n/a	No	No
2/22/2009	98	Megaptera novaeangliae	ON	17:03	22.083	-159.958	1	2	1	n/a	No	No
2/22/2009	99	Megaptera novaeangliae	ON	17:21	22.043	-159.931	2	3	2	n/a	No	No
2/22/2009	100	Megaptera novaeangliae	ON	17:22	22.039	-159.929	1	1	1	slow travel	No	No
2/22/2009	101	Megaptera novaeangliae	ON	17:23	22.038	-159.928	1	1	1	slow travel	No	No
2/22/2009	102	Megaptera novaeangliae	ON	17:26	22.031	-159.923	2	2	2	fluke-up dives	No	No
2/22/2009	103	Megaptera novaeangliae	ON	17:37	22.007	-159.904	1	1	1	n/a	No	No
2/22/2009	104	Megaptera novaeangliae	ON	17:42	21.995	-159.896	1	1	1	n/a	No	No
2/22/2009	105	Megaptera novaeangliae	ON	17:48	21.983	-159.884	1	1	1	n/a	No	No
2/22/2009	106	Megaptera novaeangliae	ON	17:59	21.967	-159.856	1	1	1	breach	No	No
2/22/2009	107	Megaptera novaeangliae	ON	18:02	21.964	-159.850	3	5	3	n/a	No	No
2/22/2009	107	Tursiops truncatus	ON	18:02	21.964	-159.850	5	8	5	bow ride	No	Yes
2/23/2009	108	Megaptera novaeangliae	OFF	9:04	22.676	-158.461	1	1	1	tail slap; breach	No	No
2/23/2009	109	Stenella coeruleoalba	ON	10:50	22.582	-158.177	71	91	64	fast travel	No	No

Date (Local)	Sight #	Species	Effort	Time (Local)	Lat	Long	Ave Best Est	Ave High Est	Ave Low Est	Behavior Notes	Biopsy?	Photos?
2/24/2009	113	Unid. Rorqual	ON	8:51	22.122	-158.379	1	1	1	blow	No	No
2/24/2009	114	Megaptera novaeangliae	ON	10:54	22.021	-158.058	1	1	1	breach; head slap	No	No
2/24/2009	115	Megaptera novaeangliae	ON	11:04	22.013	-158.032	2	3	2	breach	No	No
2/24/2009	110	Megaptera novaeangliae	ON	8:35	22.136	-158.421	2	2	2	fluke-up dive	No	No
2/24/2009	112	Megaptera novaeangliae	ON	8:49	22.124	-158.383	2	2	2	n/a	No	No
2/25/2009	116	Unid. Large delphinid	OFF	12:32	20.891	-155.511	1	1	1	n/a	No	No
2/26/2009	117	Pseudorca crassidens	OFF	17:35	21.018	-156.201	2	3	2	bow ride	No	Yes

END OF HRC SECTION

SOUTHERN CALIFORNIA RANGE COMPLEX

Monitoring in the Southern California Range Complex

This section reports results from the Navy's field monitoring efforts in the Southern California Range Complex from 02 August 2009 to 01 August 2010.

The Navy fully implemented the monitoring plan outlined in the Navy's 2009 Year 1 Monitoring Report to NMFS (DoN 2009) and specified in the Navy's subsequent 2010 Letter of Authorization renewal application for study year two (Year 2) from 02 August 2009 to 01 August 2010 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 field work 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 2 within the offshore waters of Southern California included aerial and vessel visual marine mammals and sea turtles surveys, the first ever embarkation of marine mammal observers on a Navy surface ship in this region, 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 2 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)

Year 2 Monitoring Locations

While all near shore 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 2008 and 2009.

Figure S-1 shows the general Southern California focal areas surveyed the most during Year 2 (from 02 August 2009 to 01 August 2010). The Navy will soon add a fourth proposed focal area for Year 3 monitoring within the Southern California Range Complex as discussed in more detail in the 2011 Monitoring Plan (**Appendix A**).

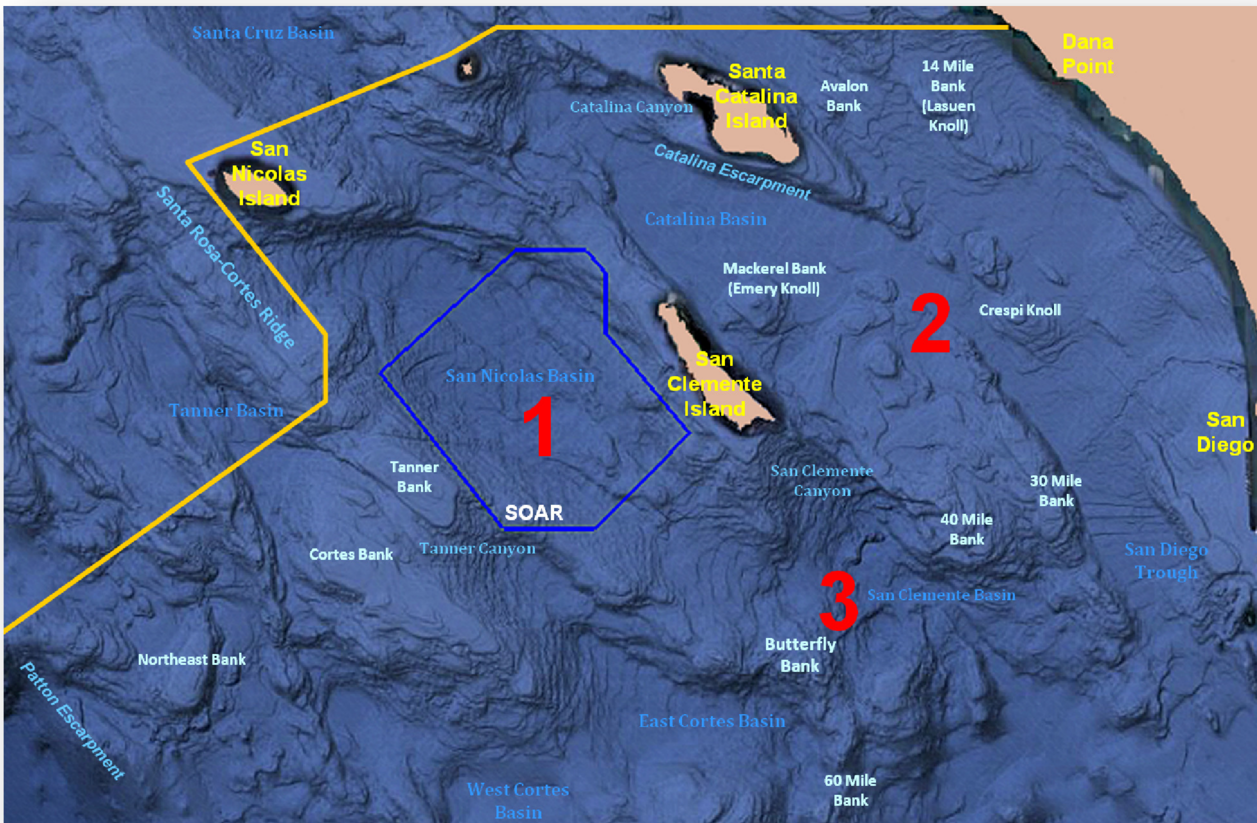


Figure S-1. Study focal areas for Year 2 monitoring within the Southern California Range Complex.

Oceanographic Conditions

The Navy's 2009 Pacific Monitoring Report (DoN 2009) discussed the importance of regional oceanographic conditions on potential marine mammal occurrence within Southern California.

These include the El Niño (warm water regimes) and La Niño (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 2010, with the Navy's Year 2 range complex monitoring period indicated in Figure 2 by the dashed lines around the appropriate months.

During Year 2 monitoring, there were elevated sea surface temperatures from August 2009 through May 2010 indicative of a warm water regime El Nino condition. Current indications going into 2011 are that a switch to a cool water La Niño condition is occurring per the September 2009 update provide on the National Oceanic and Atmospheric Administration's El Niño Southern Oscillation (ENSO) Diagnostic Discussion Archive, which contains monthly descriptive narratives off El Niño and La Niño conditions within the Pacific.

http://www.cpc.noaa.gov/products/expert assessment/ENSO DD archive.shtml

Figure S-2. Warm and cold ocean temperature episodes base on Oceanic Niño index as a predictor of El Niño and La Niño oceanographic conditions within SOCAL from 2008 to 2010.

Eastern Pacific Warm and Cold Water Periods 2008-2010
(Dashline line for monitoring from August 2009 until August 2010)

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	-1.1	-1.1	

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)
(red)	? +1.1°C (? +2.0°F)	(dark blue)	? -1.1°C (? -2.0°F)

(see DoN 2009 for similar plot of years 1950 to 2009)

SOUTHERN CALIFORNIA RANGE COMPLEX YEAR 2 MONITORING ACCOMPLISHMENTS

To assess the Year 2 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 2 Monitoring Objectives include reporting annual results from:

- Visual Surveys
- Marine Mammal Observers
- Passive Acoustic Monitoring
- Southern California Range Complex Navy Exercise and Lookout Summary
- Other Navy Funded Research Results- visual surveys, marine mammal tagging, passive acoustic monitoring, photographic identification (PhotoID), and population assessments

Year 2 Overview

Tables S-1 and S-2 compares the Navy's Year 2 monitoring accomplishments in terms of regulatory commitments to the National Marine Fisheries Service contained in the Navy's 2010 Letter of Authorization renewal application and Year 1 (2008-2009) Monitoring Report.

As indicated in **Table S-1**, all Year 2 monitoring objectives were met, and in some cases significantly exceeded.

Table S-1. Overview of Navy compliance with monitoring requirements in the Southern California Range Complex.

Type of Monitoring	2010 Planned Monitoring as Committed To By The Navy	2010 Completed Year 2 Monitoring Accomplishment
Compliance Funded Monitoring Visual survey	120 hours effort	671 hours of effort completed
Marine Mammal Observers	120 hours of effort	144 hours of effort completed
Passive Acoustic Monitoring	Deploy 2 passive acoustic devices	2 devices deployed; preliminary analysis provided in this report
Navy Exercise Summary	Present results from Navy major training events	Provided in this report
Other Navy Funded Monitoring Marine Mammal Tagging	Present tagging results obtained from Navy Research monitoring	19 satellite tags deployed during Year 2; provided in this report
Photographic Identification (PhotoID)	Present PhotoID results from Navy Research monitoring	Summarized in this report
Other studies	No commitment	Provided in this report, as available

Table S-2. Summary of Navy funded monitoring accomplishments within the Southern California Range Complex from 02 August 2009 to 01 August 2010.

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 2 (2009-2010) accomplished
Visual Surveys (VS) (studies 1,2,3,4,5) 120 hours	27 hrs (A) 18-23 Nov 09	After MTE	94 hrs (R) 02 Nov 09-30 Jul 10	Multiple	**1,061 hours visual survey**
	29 hrs (A) 13-18 May 10	During MTE	77 hrs (R) 11-24 Nov 09	During MTE	
	5 hrs (H) 27-28 Jul 10	During MTE	43 hrs (R) 19-25 Nov 09	During MTE	
	16 hrs (A) 29 Jul-03 Aug 10	During MTE	22 hrs (R) 9-11 Apr 10	No MTE	
	24 hrs (S) 20-23 Jul 10	During MTE	68 hrs (R) 15-30 Jun 10 119 hrs (R) 15-30 Jun 10 390 hrs (S) 14 Jul 09-24 Apr 10	No MTE No MTE Multiple	
Marine Mammal Observers (MMO) (studies 2, 5) up to 120 hrs	144 hrs 22-29 July 10	During ULT	Not applicable	Not applicable	**144 hours of MMO**
Marine Mammal Tagging (MMT) (studies 1, 2, 3)	Not applicable	Not applicable	12 LIMPET satellite tags 11-24 Nov 2009 8 fin whales, 3 blue whales, 1 Risso's dolphin	During MTE	**12 tags Nov 09**
			7 LIMPET satellite tags 2 fin whales, 2 Cuvier's beaked whales, 2 Risso's dolphins, 1 killer whale 15-30 Jun 2010	No MTE	**7 tags Jun 10**
Passive Acoustics Monitoring (PAM) (study 2)	2 Pacific Fleet Funded PAM devices (SIO's HARP) 11 Mar 09 to 26 Mar 10, and continued deployment 15,335 hrs recorded	Before\ During\ After MTEs and ULTs	M3R on Navy instrumented range west of San Clemente Island continued field validation 2009, 2010	Before\ During\ After MTEs and ULTs	**2 PAM devices deployed for total of 15,335 hours of HARP recording; 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

Year 2 Objective Summary

The Navy met and vastly exceeded all of its Year 2 monitoring objectives within the Southern California Range Complex (**Table S-2**).

Year 2 Scientific Summary

The total field effort of Year 2 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 National Marine Fisheries Service authorization under which this monitoring occurs.

Highlights for Year 2 monitoring include:

- **1,061 hours of survey effort**
- **15,870 nm of ocean surveyed**
- **1,181 sightings representing over 76,740 marine mammals**
- **Over 19,753 hours of passive acoustic recordings made**
- **15,858 digital photographs of marine mammals taken**
- **13 hours of digital video of marine mammals taken**
- **85 tissue biopsies taken**
- **19 medium term satellite tracking tags put on marine mammals**

Table S-3. Cumulative total effort and accomplishments from Year 2 Navy funded monitoring in within Southern California from 02 Aug 2009 to 01 Aug 2010.

Navy funding	Performing Organization	Survey Dates or Window	Participating Vessel \ Platform	# Days (days)	Total Survey Time (hrs)	Total Survey Distance (nm)	# Groups Sighted	# Individuals Sighted	# Species visually sighted	Digital Photo/ IDs taken (#)	Digital video taken (hrs)	# of Aerial Survey Behavioral Focal Follows	Total Behavioral Focal Follow Time (hrs)	Biopsies (#)	Satellite Tags (# tags)	# Passive recordings (#)	Total passive recording (hrs)	# Acoustic detection (#)	# Species acoustically detected (#)	# Passive sonobuoys (# buoys)
P	Si	11 Mar 09- 25 Mar 2010 +	HARP "M"	320	na	na	na	na	na	na	na	na	na	na	na	na	7,591	*	14	na
P	Si	14 Mar 09- 26 Mar 2010 +	HARP "N"	325	na	na	na	na	na	na	na	na	na	na	na	na	7,744	*	16	na
N	Si	14Jul 2009-24 Apr 2010 4 CalCOFI cruises	Vessel	92	390	4,030	339	17,632	na	258	na	na	na	na	na	253	747	308	8	166
N	Si	02 Nov 09-30 Jul 2010 SIO\SWFSC bimonthly small boat cruises	RHIB -SI	14	94.5	834	138	9,890	6	6,404	na	na	na	36	na	43	2.8	20	5	na
N	Nw	11 Nov 2009- 30 Jul 2010 M3R	SOAR	152	na	na	na	na	na	na	na	na	na	na	na	na	3,648	*	10	na
N	Si	19-25 Nov 2009	RHIB -SI	7	43.5	515	28	6,202	5	255	0	na	na	1	na	15	1.2	na	na	na
N	C	11-24 Nov 2009	RHIB- C	14	77.5	720	94	7,322	10	na	na	na	na	15	12	na	na	na	na	na
P	Sm	18-23 Nov 2009	Airplane	6	28	2,604	93	12,826	10	2,203	1.5	24	6.5	na	na	na	na	na	na	na
N	Si	9-11 April 2010	RHIB -Si	3	22.4	221	10	1,113	6	106	na	na	na	1	na	0	0	na	na	na
P	Sm	13-18 May 2010	Airplane	6	29	2,641	152	5,453	9	1,350	5.6	30	10.5	na	na	na	na	na	na	na
N	Si	15-30 Jun 2010	RHIB -Si	11	68.4	686	31	868	5	1,410	0	na	na	23	na	4	0.5	na	na	na
N	C	15-30 Jun 2010	RHIB- C	15	118.7	1,310	66	2,340	12	na	na	na	na	9	7	na	na	na	na	na
P	P	22-28 Jul 2010	MMOs	7	144.4	400	105	680	7	899	na	na	na	na	na	na	na	na	na	na
P	Sm	27-28 Jul 2010	Helicopter	2	5.3	242	16	1,971	4	500	1.8	5	3.3	na	na	na	na	na	na	na
P	Sm	29 Jul-03 Aug 2010	Airplane	5	15.7	1,446	70	9,119	5	2,400	4.5	14	6.0	na	na	na	na	na	na	na
N	Si	20-23 Jul 2010	Vessel	3	23.8	221	39	1,324	6	73	na	na	na	na	na	4	18.3	20	4	3
HARP only summary				**645**	-	-	-	-	-	-	-	-	-	-	-	-	**15,335**	-	-	-
aerial visual only summary				**19**	**78**	**6,933**	**331**	**29,369**	**28**	**6,453**	**13.3**	**73**	**26.3**	-	-	-	-	-	-	-
ship\boat visual only summary				**159**	**839**	**8,537**	**745**	**46,691**	**50**	**8,506**	-	-	-	**85**	**19**	**319**	**770**	**348**	**17**	**169**
ALL visual summary (EXCLUDING HARPs, MMO)				**330**	**917**	**15,470**	**1,076**	**76,060**	**78**	**14,959**	**13.3**	**73**	**26**	**85**	**19**	**319**	**770**	**348**	**27**	**169**
Totals all efforts:				**982**	**1,061**	**15,870**	**1,181**	**76,740**	**85**	**15,858**	**13.3**	**73**	**26**	**85**	**19**	**319**	**19,753**	**348**	**57**	**169**

notes:
HARP= high-frequency acoustic recording package (i.e., bottom mounted passive acoustic monitoring device;
M3R= Marine Mammal Monitoring on Navy Ranges; Detection system being tested on Navy's underwater instrumented range west of San Clemente Island, the Southern California Offshore Anti-submarine warfare Range (SOAR); 11-24 Nov 2009 and 14-30 Jun 2010 validation testing, and continuous 24-hr recording from May 2010 through 30 July 2010
RHIB= rigid-hull inflatable boat; Airplane= Partenavia P-68-C (Nov, May), P-68-OBS (Jul); helicopter= Bell 206-L- III; vessel = R/V Sproul
MMO= 4 marine mammal observers (biologists) embarked on US Navy destroyer
P= U.S. Pacific Fleet; Si= Scripps Institute of Oceanography; Nu= Navy Undersea Warfare Center; N= OPNAV N45, C= Cascadia Research Collective, Sm= Smultea Environmental Services; Nw= Naval Undersea Warfare Center Newport
CalCOFI= California Cooperative Oceanic Fisheries Investigation, a joint agency 61-year old California survey series. Navy has been funding since 2004, marine mammal survey as part of 4 regularly scheduled cruises per year (14 Jul - 5 Aug 2009, 6 -22 Nov 2009, 12 Jan - 3 Feb 2010, 4 - 24 Apr 2010)
+ = Mar 2009 to Mar 2010 dates dictated by field deployment cycle
na= not applicable or summarized for this event type
*= In many cases, number of actual detections are large. For instance echolocating dolphins can be hundreds per minute. To make data more comparable, HARP summaries use fixed time window (one hour or one minute) and then detected presence or absence of animals in these windows

SOUTHERN CALIFORNIA YEAR 2 VISUAL SURVEYS (AERIAL SUMMARY)

Under terms and conditions of the Navy's Year 2 01 August 2009 to 02 August 2010 Monitoring Plan, the Navy completed 1,061 hours of visual surveys out of a planned total of 120 hours. Of the 1,061 hours of visual survey effort, aerial visual surveys accounted for 77 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 or helicopter. Typical on-station survey times for a single flight was around five hours for a civilian airplane (Partenavia P-68-C or P-68-OBS) or 2-3 hours for a civilian helicopter (Bell 206-L- III).

Year 2 was the first time a helicopter was successfully used specifically for marine mammal focal follows, where the helicopter follows a group of marine to allow prolonged, detailed behavioral observations. While focal follows are also conducted during the airplane surveys, the helicopter proved to be a stable, excellent platform from which to both observe as well as shoot high resolution digital photographs and video.

While all visual survey effort is presented in **Table S-2** and **S-3**, specific aerial visual survey accomplishments in Year 2 include:

Completion of four aerial survey periods, a 27 hour airplane survey from 18-23 November 2009; a 29 hour airplane survey 13-18 May 2010; and a back to back helicopter and airplane survey from 27-28 July 2010 (helicopter- 5 hours) and 29 Jul-03 Aug 2010 (airplane- 16 hours)

- Over 6,933 nm surveyed
- 331 sighting of approximately 29,369 marine mammals
- 6,453 hi-resolution digital photos taken
- 13.3 hours of digital video taken
- Completion of 73 focal follows greater than 5 min each of various marine mammals for total of 26.3 hours of detailed behavioral focal follows

Bell 206-L-III helicopter used during aerial surveys 27-28 July 2010.
Photos by M. Smultea courtesy of Smultea Environmental Sciences.

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,

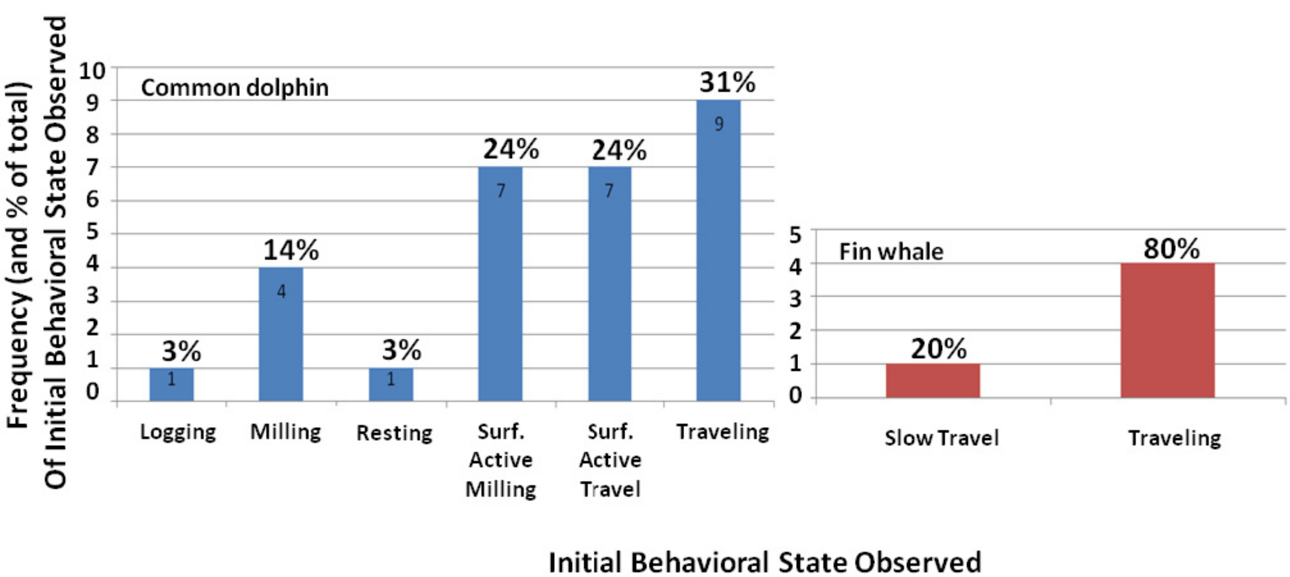
3. Conduct focal follows of priority cetacean species including video-documentation of underwater behavior,

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 survey in next year's monitoring for both spatial coverage, but more importantly to continue gather baseline behavioral data on marine mammals at-sea. For instance, although compiled from just one survey (18-23 November 2009), **Figure S-3** shows some of the basic observations, in this case for common dolphins and fin whale, being obtained from aerial surveys in Southern California.

Figure S-3. Frequency of initially observed behavioral states for common dolphins and fin whales during November 2009 Southern California aerial survey.



The following photographs over the next few pages highlight some of the unique sightings within the Southern California Range Complex during Year 2.

Minke whale (Balaenoptera acutorostrata) breach sequence as observed from the aircraft on November 21, 2009 using a telephoto lens during the November 2009 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 Mark Deakos courtesy of Smultea Environmental Sciences.

[The Navy verified that there was no active sonar used within the Southern California Range Complex on the day of this sighting, 21 Nov 2009, nor were any Navy vessels in the vicinity of the sighting location. The nearest sonar use was over three days previous on 18 November.]

Below are photos from a rare (for Southern California) sighting of killer whales (Orcinus orca) observed on November 21, 2009 from the aircraft during the November 2009 aerial marine mammal monitoring survey off San Diego, California. Photographs were taken (with a telephoto lens) of a calf apparently nursing from an adjacent adult lying on its side underwater while another juvenile approached the pair (right photo below). Photos by Mark Deakos courtesy of Smultea Environmental Sciences.

On May 16 from 13:54 to 14:17 at the northern portion of the Navy's underwater instrumented range west of San Clemente Island [northeast portion of San Nicolas Basic], an unusually behaving group of 14 Risso's dolphins was tracked from the airplane for a focal follow lasting approximately 23 minutes. The group consistently traveled fast and was surface-active with frequent porpoising and whitewater observed as the dolphins headed consistently to approximately 060 degrees magnetic. The observation was considered unusual because Risso's dolphins during our past surveys have most frequently been observed traveling slowly or milling with little to no surface-active behaviors. Approximately 18 minutes of video was taken while following this group.

The Navy had a major training event ongoing in the Southern California Range Complex on this day. However, in an analysis of ship positions and sonar use, the ships in the strike group involved with the training were 30-50 nautical miles to the southeast of the Risso's dolphin sighting location. San Clemente Island would have been between the two locations (the Risso's dolphin site and Navy ship concentration). The nearest 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 Risso's behavioral observations 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.

Photo on 16 May 2010 of a pod of 14 Risso's dolphins travelling rapidly (Photo by L. Mazzuca).

SOUTHERN CALIFORNIA YEAR 2 MARINE MAMMAL OBSERVERS

Under terms and conditions of the Navy's Year 2 01 August 2009 to 02 August 2010 Monitoring Plan, the Navy completed 144 hours of Marine Mammal Observers (MMO) out of a planned 80-120 hours of MMOs.

There was one MMO event in the Southern California Range Complex within Year 2. Four experienced Navy civilian marine science biologists embarked on a Navy destroyer from 22 to 28 July 2010. 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.

Up until late in 2010, there had been significant logistical challenges in finding short-term training schedules, which change frequently, as well as getting formal approval for MMOs to board Navy ships within Southern California. This year, although not strictly a field monitoring achievement, one of the Year 2 accomplishments was finally establishing business rule for both requesting MMO access to Navy ships, and building the working relationship with the appropriate Navy command which could liaison directly with the ship for scheduling. This should lead to improved subsequent MMO opportunities within next year's range complex monitoring.

The following pages provide details for the July Southern California MMO event. Given the end of the monitoring year nature of this particular MMO event (22-28 July) as compared to the 02 August to 01 August monitoring period, only a preliminary MMO summary report has been prepared at the time of this report submission.

During the six day MMO underway period, the MMOs made 105 sightings of approximately 680 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 time frame.

August 2010

Marine Mammal Observer Report

- Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study During Unit Level Training 22-28 July 2010 within the SOCAL Range Complex-

Prepared for:

Commander, U.S. Pacific Fleet


U.S. Navy photos by Robert Uyeyama of 22-28 July Southern California Range Complex MMO event

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INTRODUCTION

In a concerted effort to address monitoring questions posed in the Navy's range complex monitoring plans, marine mammal observers (MMO) are used in a two-part effort to observe marine mammal behaviors in the vicinity of Navy ships, and to compare Navy shipboard lookout effectiveness. These include comparing embarked MMO sightings at-sea to standard Navy lookout reports. Navy lookouts can be on the ship's bridge, on the bridge wings, and/or on the flying bridge. For the lookout effectiveness portions, civilian biologists were utilized to collect data that would characterize the likelihood of detecting marine species in the field of view aboard a U.S. Navy destroyer (DDG). The University Of St. Andrews, Scotland, under contract to the U.S. Navy, developed an initial protocol for use during this study. This protocol was reviewed by National Marine Fisheries Service personal from two regional science centers. Necessary changes to the protocol were identified and made during three prior field implementations and MMO events in 2009 and 2010. 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 such, this report describes basic observations with the remaining lookout effectiveness data to be pooled at a later date.

As part of this data collection effort, four U.S. Navy civilian MMOs (Dr. Sean Hanser, Ms. Mandy Shoemaker, Dr. Robert Uyeyama, and Dr. Stephanie Watwood) participated in a Unit Level Training (ULT) event on the Southern California Range Complex from 22-29 July 2010. These MMOs were stationed aboard an Arleigh Burke class Navy destroyer, referred to as "DDG C".

The goals of the MMO event during unit level training monitoring and this study were:

- Collect data to assess the effectiveness of the Navy lookout team.
- Obtain data to characterize possible exposure of marine species to ship mid-frequency active sonar and behavioral reactions or lack of reactions to this exposure

METHODS

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 C to accomplish its mission objectives. The exceptions would be if a marine mammal was sighted by the MMO within the shut-down zone during mid-frequency active sonar training (within 200 yards) and the animal was not sighted 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 initial protocol for data collection was provided by the University of St. Andrews; this protocol was modified by the MMOs on three prior surveys. Additional changes were made as necessary during this event. The MMO survey on DDG C was conducted on the bridge wings (elevated 60 feet above the waterline), with one MMO on each wing (called survey MMOs, or SMMOs. One MMO acted as a liaison to the starboard and port lookouts (called liaison MMO or LMMO). 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 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 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 DDG-C was not altered as result of the MMO 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 or SMMOs reported sightings made by the Navy starboard lookout. The LMMO was also responsible for noting sightings made by the bridge team or watchstanders. 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's recorded effort-related events (e.g., begin effort, end effort, observer rotation, weather change) the DMMOs recorded time, location, and weather information 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 each observation day, all photographs were reviewed to assist with species identification.

RESULTS

The MMO team was vigilant during virtually all of the on effort hours; therefore this study comprised a total of approximately 150.5 hours of on effort hours of marine mammal shipboard monitoring. 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 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 generally vigilant through a majority of the rotation. Time considered off-effort included some training activities such as chaff exercises and refueling at-sea; however observations were still possible and sightings were made during other exercises such as man overboard, evasive maneuvering, helicopter operations, and torpedo launcher air shots. Activities that required the team to vacate the bridge level entirely were not counted towards effort totals, and included radar exercises, and meals. The refueling operation on 22 July, which did not require the MMO team to vacate the bridge entirely, was not included although observational efforts were still made from the starboard bridge wing.

The first two days presented almost ideal environmental sighting conditions (Table 1). In total, 105 sightings comprising 680 individual marine mammals were recorded during the seven days of observation. Trials were successfully conducted on all seven days of the event, with 92 of 105 sightings (88%) available for trials, or an average rate of 1.84 trials per hour of effort across all seven days. This average trial rate was equivalent to that of the single best day of the six-day DDG B Lookout Effectiveness cruise in the Jacksonville Range Complex, where the other five days each resulted in no trials being performed. For the July Southern California Range Complex MMO event, of the 105 sightings, seven different species were positively identified, and three of the sightings were mixed-species groups (Table 2). The species identified were California sea lion (*Zalophus californianus*), bottlenose dolphin (*Tursiops truncatus*), long-beaked common dolphin (*Delphinus capensis*), short-beaked common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), blue whale (*Balaenoptera musculus*), and minke whale (*Balaenoptera* *acutorostrata*) (Figure 1). Among other unidentified sightings, one was judged to likely be either a fin whale (*Balaenoptera physalus*) or sei whale (*Balaenoptera borealis*). The three mixed-species groups were: 1) California sea lions with small rorquals, likely\possibly minke whales; 2) California sea lions with dolphins, probably bottlenose dolphins; and 3) Risso's dolphins with bottlenose dolphins. The first two days of the effort had the greatest frequency of unique sightings with 5.82 sighting/hour on 22 July and 5.16 sightings/hour on 23 July. This sighting frequency is representative both of higher animal density in Southern California as well as exceptional seastate conditions (Beaufort 1-2) that were encountered on those days. Approximately 899 digital photographs of marine mammals were taken.

Potentially unusual behavior was observed for one pinniped sighting while MFAS was active. A California sea lion sighted at a range of 364 – 400 m at a bearing of 30º to starboard was observed to be continuously leaping through more than a dozen leaps, in different directions with each leap, including often changing leap direction 180º between consecutive leaps. The cause of this behavior cannot be conclusively determined. There are significant data unknowns about at-sea behavior for many marine mammals, pinnipeds included. For instance, although this could have been a reaction to the sonar use, or ship presence, it just as well could have been a reaction to other natural events. For instance, it is unknown if the leaping sea lion observed during this trip was reacting to unseen prey or subsurface predator. Southern California has a significant migratory population of white sharks and may represent a potential nursery for white shark juveniles[2]. White sharks are known to prey on marine mammal including sea lions.

CONCLUSIONS

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 execution of this study in waters known to contain a high density of marine mammals produced a commensurately greater amount of useful data (i.e., trials) than in past cruises. However the high sighting rates experienced on some days resulted in some difficulties for the DMMO to efficiently record data, which included sightings and resightings for both sides of the vessel from both MMOs and Navy Lookouts where multiple groups of animals were simultaneously available. Therefore some changes will be recommended in the final report regarding both the construction of the data recording forms as well as contingencies in scanning protocol regarding effort expended toward searching for resights or following continuously-available animals, especially after seen by the Navy L or if the animals have passed abeam. This event is the third 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 and behavioral reactions or lack of reactions.

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[2] Jorgensen, S.J., Reeb, C.A., Chapple, T.K., Anderson, S., Perle, C., Van Sommeran, S.R., Fritz-Cope, C., Brown, A.C., Klimley, A.P., and Block, B.A. 2009. Philopatry and migration of Pacific white sharks. Proc. R. Soc. B. doi:10.1098/rspb.2009.1155

http://www.topp.org/sites/topp.org/files/topp/publications/Jorgensen_et_al_rspb200911551.pdf

Weng, K.C., O'Sullivan, J.B., Lowe, C.G., Winkler, C.E., Dewar, H., Block, B.A.2007. Movements, behavior and habitat preferences of juvenile white sharks *Carcharodon carcharias* in the eastern Pacific. Marine Ecology Progress Series 338: 211-224

Sightings information included the bearing and distance of the animal to DDG C. This information can be used to determine, if MFAS was in use and to 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. There were no behavioral reactions noted during this period that indicated adverse response, although quantification of biological reaction is difficult and the data from this MMO event is still under review.

Minor changes to the data forms, protocols, and recommended equipment were made by the MMO team, and will be considered for implementation in future lookout effectiveness studies. In particular, it was possible for the MMOs to conduct sightings and report them even when they were stationed in front of the Navy lookouts. The higher density of animals found in the waters of the Southern California Range Complex (as compared to the Jacksonville range complex or Hawaii range complex) allowed for a significantly greater number of trials. Future lookout effectiveness studies in the Southern California Range Complex are recommended when possible. However, the higher frequency of sightings may necessitate slight adjustments to the data-entry forms, as well as the sighting protocol to facilitate accurate and efficient data collection as well as maximizing sighting effort.

Table 1. MMO survey times and environmental conditions from 22-28 July 2010 MMO event.

Date	Observation Time	Beaufort Sea State	% Cloud Cover	Visibility
22 Jul	1300-1341, 1607-1658, 1821-1934	1	0 – 100	Good-Excellent
23 Jul	0728-1201, 1258-1631	1 – 2	70 – 100	Good – Excellent
24 Jul	0741-0917, 1000-1202; 1316-1631	3 – 5	99 – 100	Moderate
25 Jul	0736-1141, 1242-1650	4 – 5	92 – 100	Good
26 Jul	1039-1146, 1254-1702, 1757-1947	2 – 3	20 – 100	Moderate – Excellent
27Jul	0731-1151, 1234-1701, 1749-1857	2 – 4	0 – 100	Good – Excellent
28 Jul	0721-1158, 1342-1517, 1541-1701	2 – 5	5 – 100	Good

Table 2. Summary of MMO marine mammal observations from 22-28 July 2010 MMO event.

Species	Unique animal group sightings [1]	Total number of animals (based on best group size estimate)
California sea lion	9 (11)	16
Bottlenose dolphin	6 (7)	88
Long-beaked common dolphin	2	105
Short-beaked common dolphin	3	135
Risso's dolphin	2 (3)	14
Blue whale	3	6
Minke whale	3	3
Mixed species group	3	-
Unidentified common dolphin	2	105
Unidentified balaenopterid	12	13
Unidentified small balaenopterid [2]	0 (1)	2
Unidentified otariid	6	6
Unidentified pinnipeds	18	24
Unidentified dolphin	18 (19)	142
Unidentified whale	13	16
Unidentified marine mammal	5	5
Totals:	**105**	**680**

[1] Numbers in parentheses includes composition of the three mixed species groups
[2] One among these sightings was judged to be either a fin whale, Bryde's whale, or sei whale
Additionally, three sightings of three sea-lion carcasses in a state of decomposition were sighted on 22 July at 15:25, 23 July at 14:06, and 25 July at 13:53. GPS coordinates of the vessel at the time of sighting, as well as opportunistic photographs were taken of all three sightings. These sightings are not tabulated in the sighting tables. Carcass sightings were relayed to NMFS Southwest Region Stranding Coordinator.

Figure 1. Selected photographs of marine mammal sightings – a. long beaked common dolphins; b. Risso's dolphins; c. California sea lions; d. blue whale; e. bottlenose dolphins; f. unidentified large balaenopterid (likely fin whale, Bryde's, or sei whale).

SOUTHERN CALIFORNIA YEAR2 PASSIVE ACOUSTIC MONITORING

Under terms and conditions of the Navy's Year 2 01 August 2009 to 02 August 2010 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) were designed, manufactured, deployed, 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 sound including Navy sonar and broadband commercial and some military ship sounds. One HARP at a depth of 4,265 feet 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**).

Preliminary analysis of these two HARPs for the time period 11 March 2009 to 26 March 2010 is contained in **Appendix C**. The reporting period of March-to-March 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. The Navy and Scripps' initial goal was to have a full years worth of data for presentation within the Navy's 2010 monitoring report.

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 was 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 PAM highlights accomplished in Year 2 include:

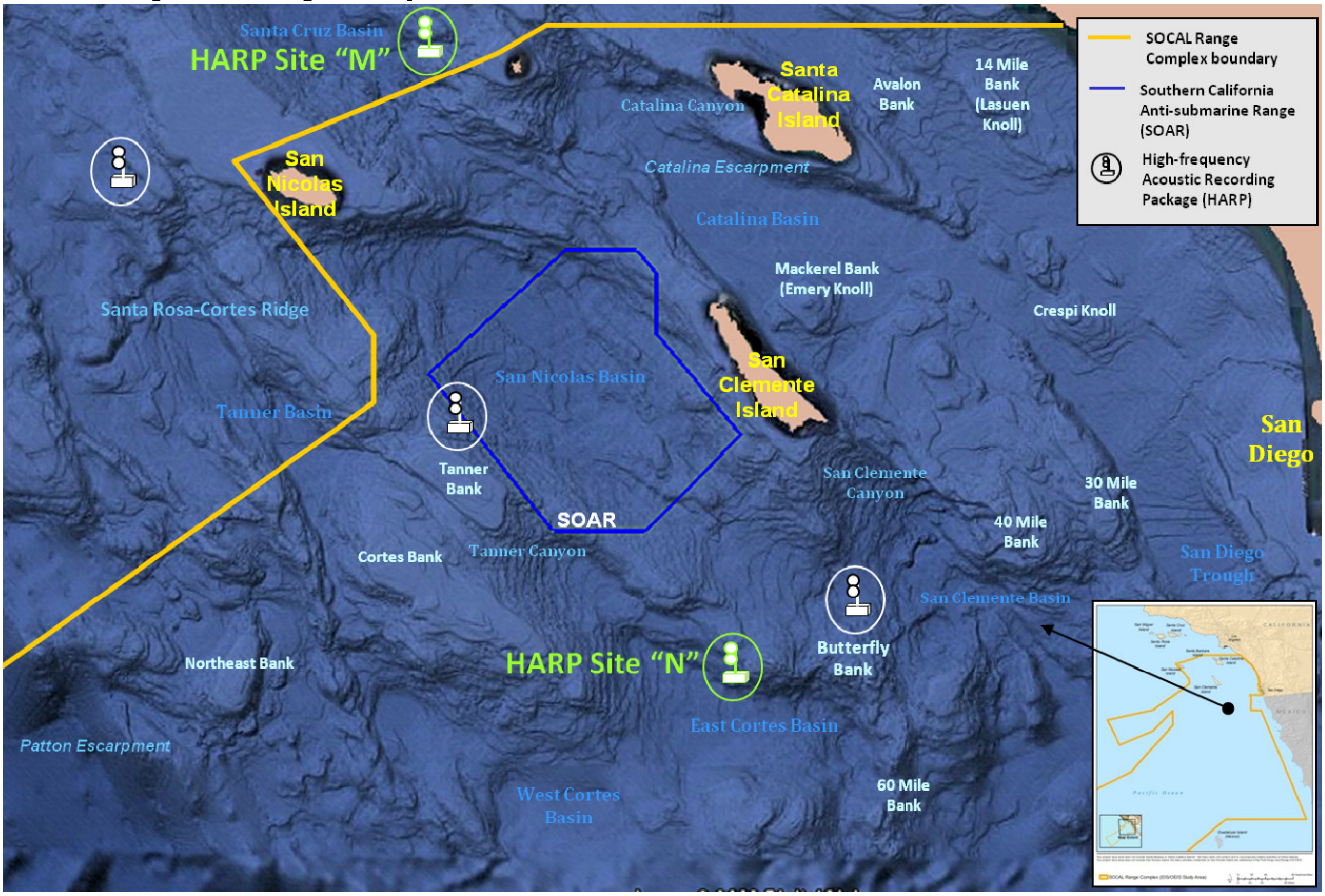
HARP M- 7,591 hours of passive acoustic recordings

- Detected marine mammals include: blue whale, fin whale, unidentified whale, Bryde's whale, minke whale, humpback whale, sperm whale, killer whale, unidentified beaked whale, Baird's beaked whale, Risso's dolphin, Pacific white-sided dolphin, unidentified odontocete, and pinniped. Anthropogenic sounds include mid-frequency active sonar, echosounders, ship noise, and explosions.

HARP N- 7,744 hours of passive acoustic recordings

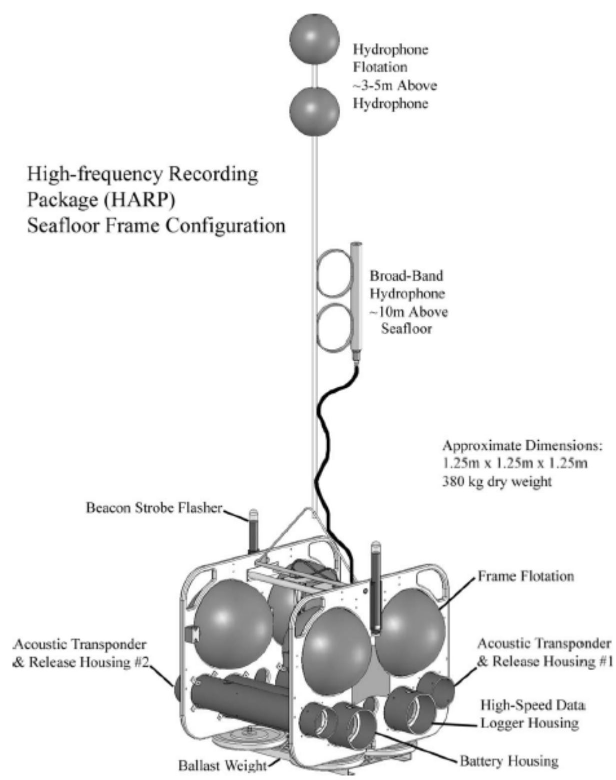
- Detected marine mammals include: blue whale, fin whale, unidentified whale, Bryde's whale, minke whale, humpback whale, sperm whale, killer whale, unidentified beaked whale, "43 kHz" beaked whale, "50 kHz" beaked whale, Baird's beaked whale, Risso's dolphin, Pacific white-sided dolphin, unidentified odontocete, and pinniped. Anthropogenic sounds include mid-frequency active sonar, echosounders, ship noise, and explosions.

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.

(HARP schematic is shown right. Buoys "M" and "N" are two HARPs funded by US Pacific Fleet compliance monitoring; remaining HARPs are funded by the Navy's research program; buoy locations as of July 2010)



Vessel noise- Discussions of anthropogenic ship sounds in terms of passive acoustic monitoring within the Southern California Range Complex must take into account both commercial as well as military ship traffic. While Navy major training events often have multiple ships at sea for period of up to two or three weeks, cumulatively over a year's time, from August 2009 to August 2010, this only resulted in 40 non-consecutive days of Navy multi-ship at-sea time (See following *Southern California Range Complex Exercise Summary Results* Section). In addition, most of the Navy combatant ships (cruisers, destroyers, and frigates) are engineered to be as quite as possible to enhance their warfighting capabilities, and are often difficult to detect at long ranges via passive acoustics.

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 just a three month period from September to November 2009.

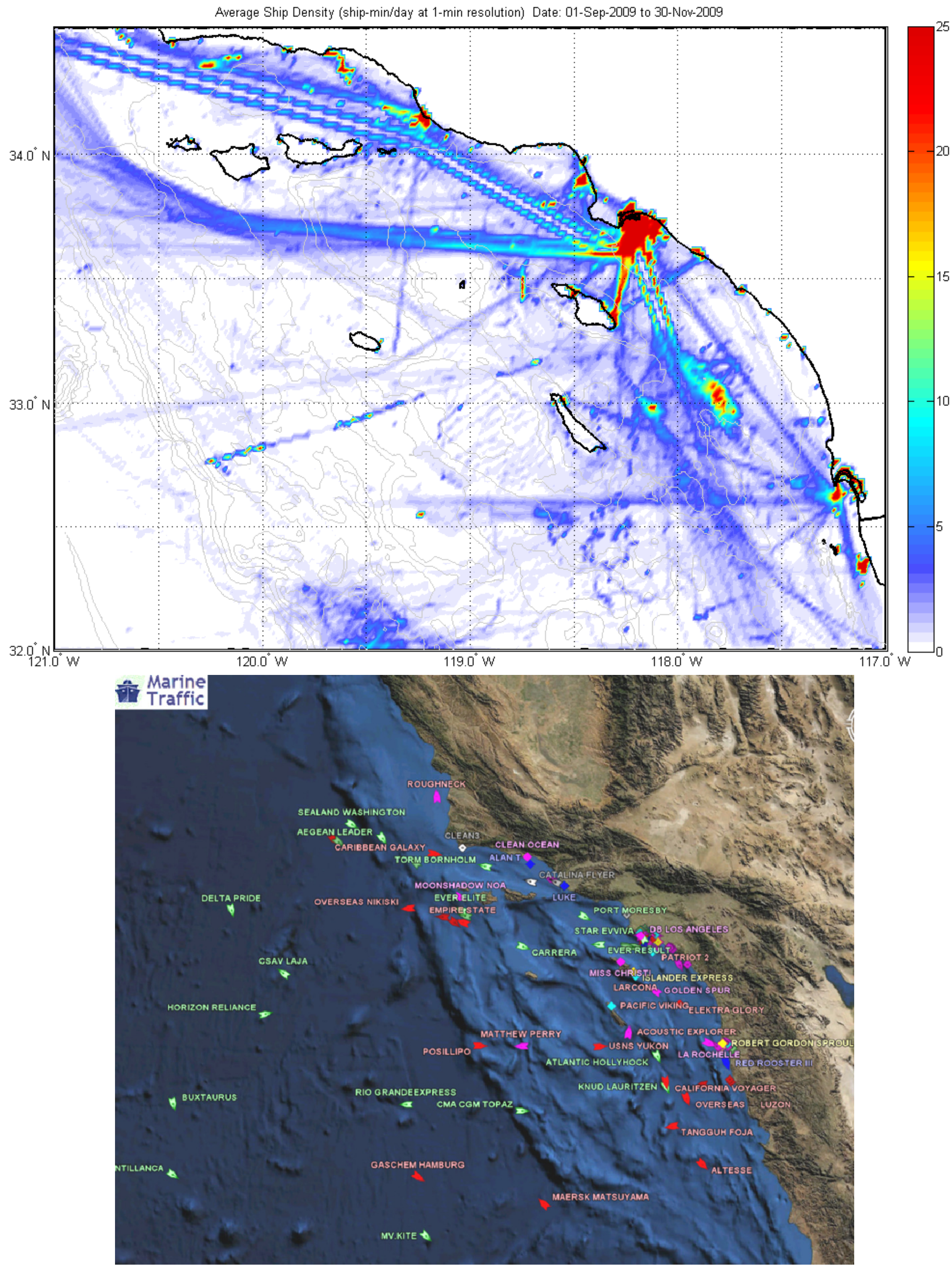


Figure S-5. Average commercial ship density in Southern California based on analysis on cumulative Automatic Identification System (AIS) data from September to November 2009.

(top graphic courtesy of J. Joseph, Naval Postgraduate School, Ocean Acoustics Lab; bottom panel shows representative individual ship traffic from AIS data at 2:00 PM on 15 September 2010)

SOUTHERN CALIFORNIA YEAR 2 MAJOR TRAINING EXERCISE SUMMARY

SUMMARY: 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 and 2010 were effective in appropriately mitigating exposure of marine mammals to mid-frequency sonar. For the most part, during this year's major exercise events, 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 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 lesson learned in marine mammal sighting and reporting.

For the five major training events conducted in the Southern California Range Complex this reporting period (02 Aug 2009 to 01 Aug 2010), the Navy conducted over 4,127 hours of Marine Species Awareness Training for 2,795 Navy personnel prior to getting underway. In addition, over the 40 non-consecutive major training event days in this same period (**Table S-4**), the Navy performed over 25,835 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 events from 02 August 2009 to 01 August 2010.

MTE Type	Dates	# Of Days	# of Ships Involved	# Of Marine Mammal Sightings	# Of Marine Mammals
SUSTEX	11-18 November 2009	8	8	13	136
IACII	08-10 March 2010	3	5	34	249
COMPTUEX	17 March to 02 April 2010	17	7	25	190
IACII	14-16 May 2010	3	8	56	319
COMPTUEX	23 Jul-14 Aug 2010 *	9 *	11	82	313
	Totals:	40 days	39 ships	210 sightings	1,207 marine mammals

Note: * A COMPTUEX occurred from 23 July 2010 until 14 August 2010. Given this exercise occurred between monitoring report periods which run from Aug to Aug, details from this event are summarized for the period 23-31 July. Data from 01-14 August will be included in the 2011 Monitoring Report (Aug 2010 to Aug 2011).

SUSTEX= Sustainment Exercise

COMPTUEX= Composite Training Unit Exercise

IACII = Integrated Anti-submarine Warfare Course Phase II

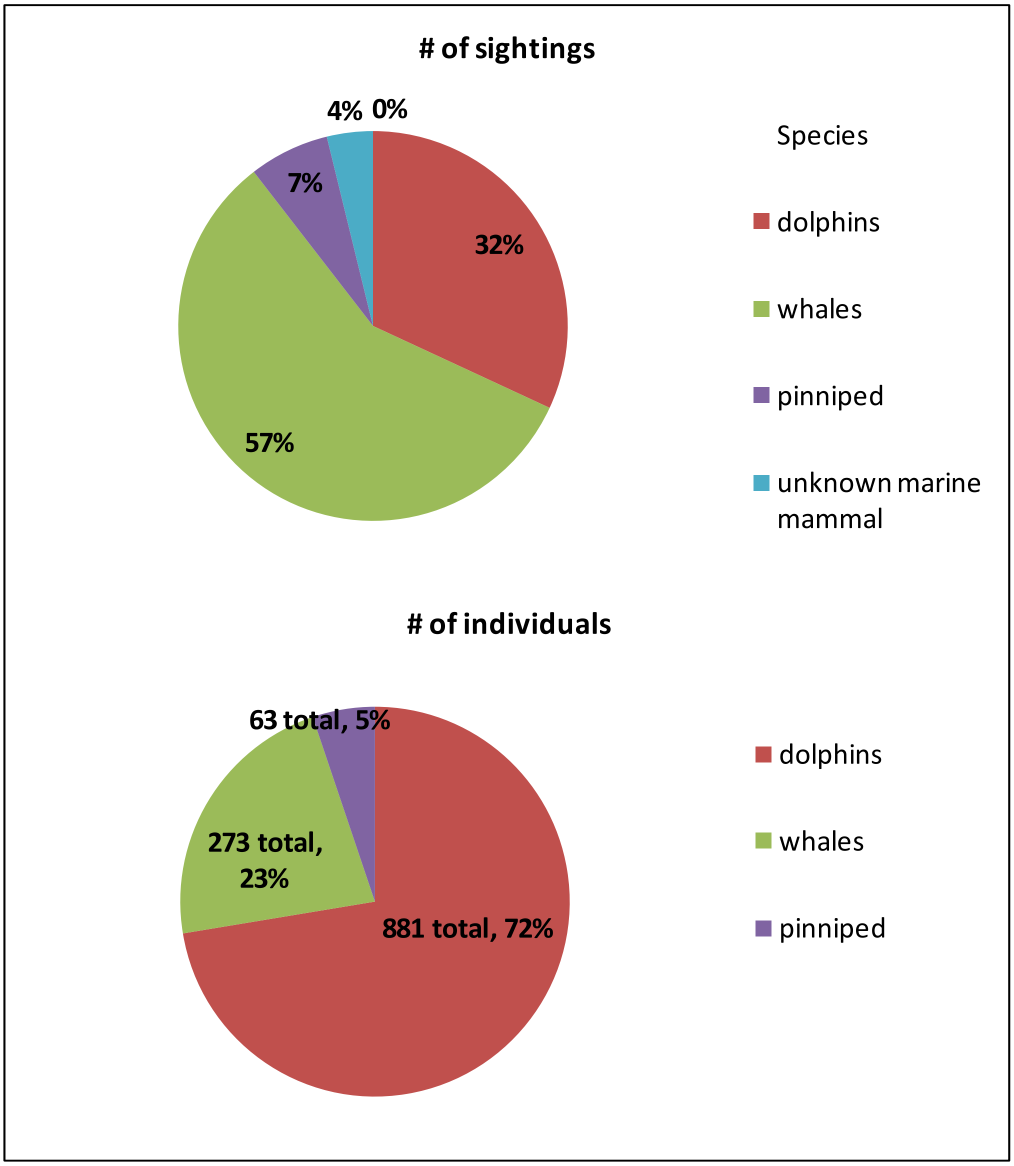


Figure S-6. Chart of marine mammal sightings (top panel) and sightings by species type (bottom panel) during SOCAL Range Complex major training events from 02 August 2010 to 01 August 2010.

SOCAL Major Training Event Marine Mammal Observations

There were approximately 210 sightings of an estimated 1,217 marine mammals over the course of five major training events in the Southern California Range Complex (**Table S-5, Figure S-6**). Breakdown of sightings by species type were:

-Dolphins: 67 sightings of 881 animals (32% of total sightings, 72% of total animals)
-Whales: 121 sightings of 273 animals (58% of total sightings, 22% of total animals)
-Pinniped: 14 sightings of 63 animals (7% of total sightings, 5% of total animals)

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 events from 02 August 2009 to 01 August 2010.

Species Type	# of sightings	% of total sightings	# of marine mammals	% of total number of marine mammals
Dolphins	67	32%	881	72%
Whales	121	57%	273	23%
Pinniped	14	7%	63	5%
Unidentified marine mammals	8	4%	not reported	not applicable
Totals:	210	1,207		

Note: Totals represent sum of observations during both MFAS\explosive events, and during non-MFAS\ non-explosives training periods.

Navy lookouts and bridge watchstanders on surface ships within the Southern California Range Complex during 2009-2010 (U.S. Navy photographs).

SOCAL Major Training Event Mitigations

Of the 210 Navy marine mammal sightings during major training events, there were 62 sightings within 1,000 yards that qualified as mitigation events (**Table S-5** and **Table S-6, Figure S-7**). In other, words mid-frequency active sonar surface ships had their sonar on, and followed the appropriate mitigation (secure or power down) depending on the range to the marine mammal.

These 62 mitigation events represented 29.5% of all marine mammal sightings for an estimated total of 306 marine mammals during this annual reporting period. As stated previously, with dolphins occurring either more frequently or in larger numbers within Southern California, of the 306 marine mammals observed during mitigation events, 218 were dolphins, 50 whales, and 38 pinnipeds (**Table S-5**).

Of the 62 mitigation events, there were 29 periods when sonar was turned off (i.e., secured) at ranges <200 yards from the ship, 27 periods when sonar power was turned down (i.e., powered down), and six periods when mitigation did not occur but with the explanations detailed below. There were also three reports of a Navy ship changing course in addition to applying sonar mitigation in order to open the range between the marine mammal and ship. The Navy lost a minimum of 20 hours of training time due to subsequent shut downs and power downs as a result of applying marine mammal mitigation during these sighting events at ranges less than 1,000 yards. There were no reports of any marine mammal behaving in any unusual manner during mitigation events.

Table S-6. 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 2009 to 01 August 2010 in the Southern California range Complex.

mitigation range	# of sightings	total # of marine mammals	Breakdown by species type		
			# of dolphins	# of whales	# of pinnipeds
< 200 yards	15	75	33	21	21
200-500 yards	27	120	92	12	16
500-1000 yards	20	111	93	17	1
Totals:	62 *	306 *	218	50	38

* 62 sightings of 306 marine mammals is 29% of the total sightings and 25% of the total individuals observed during all major training events periods (MFAS\explosive and non-MFAS\non-explosive periods) (*see Table S-5*).

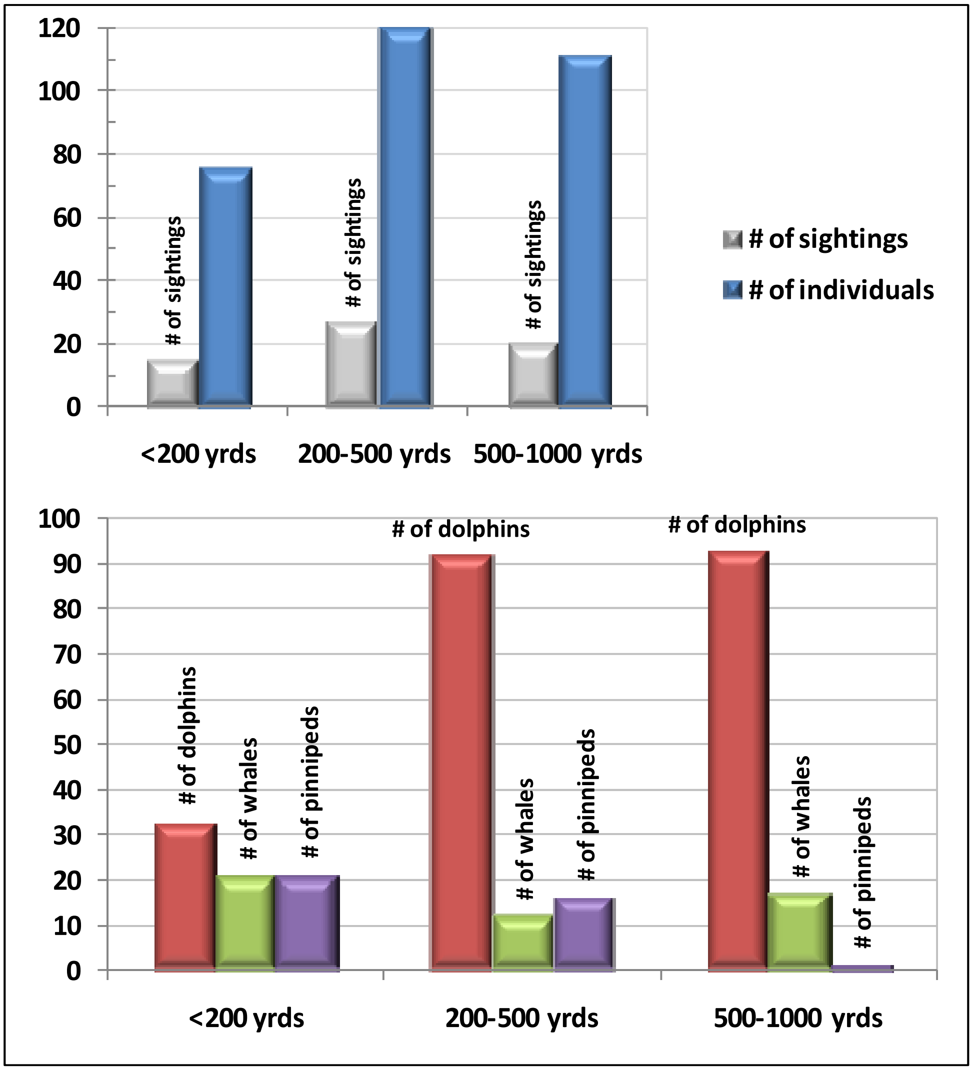


Figure S-7. Bar chart showing marine mammal sightings concurrent with MFAS mitigation (top panel) and breakdown of sightings by species type (bottom panel) from 02 August 2009 to 01 August 2010 in the SOCAL Range Complex.

Navy Safety Zone Adherence

For the most part, during this year's major exercise events, the proscribed NMFS safety zones were adhered to with the exceptions noted below. These six cases ranked by range between the marine mammal(s) and ship represent times when mitigation was not performed, although under the agreed to mitigation procedures with NMFS no mitigation is required in the case of bowriding dolphins, or if a marine mammal is leaving a mitigation zone.

Range	Ship Action	Analysis	Relative ship (circle-blue arrow) and marine mammal position (square-green arrow)
< 200 yards			
1 pinniped	Ship did not shut down sonar	Ship was doing 144T @ 8 knots, and spotted seal at 050T, or slightly abaft the beam. By the time the seal sighting was received and understood by the bridge, it was already passed and opening (i.e., behind the ship), due in part to the confusion with 2 dolphins spotted at the same time at the same bearing, but beyond the mitigation zones (>1,000 yards). The ship's Officer of the Deck (OOD) realized the dolphins were not an issue, and disregarded other reports coming from the same bearing. By the time it was made clear to the OOD, the seal was outside of the safety zones. By happenstance, a Navy exercise representative was aboard this ship during the event. He conducted training with the ship's bridge team after the incident to explain what happened and provide guidance. **Assessment: erroneous initial reporting, then ship soon passed beyond mitigation range. Maximum exposure estimated to be << 189 dB given the orientation of the ship**	
9 pinnipeds	Ship did not shut down sonar	Ship was doing 211T when sea lions were spotted at 200T, or slighting abaft the starboard beam. **Assessment: Ship soon passed beyond mitigation range to the pinnipeds. Maximum exposure estimated to be <<189 dB given the orientation of the ship**	
2 whales	Ship powered down vice shut down sonar	Ship was doing 032T when whales were spotted 010T, or slightly to the left of the ship's bow. The ship powered down sonar for over an hour until the whales were well clear (>>1,000 yards) behind. **Assessment: Maximum exposure estimated to be <179 dB.**	
200-500 yards			
1 dolphin	Ship did not power down sonar	Ship was doing 175T when dolphin spotted at 070T approaching the ship from the left rear. Dolphin continued to close and eventually ride the bow wave (bowride). **Assessment: dolphins were bowriding, no mitigation required**	
5 dolphins	Ship did not power down sonar	Ship was doing 175T when dolphins spotted at 070T approaching the ship from the rear. Dolphins continued to close and eventually ride the bow wave (bowride). **Assessment: dolphins were bowriding, no mitigation required**	
2 pinnipeds	Ship did not power down sonar	Ship was doing 210T when pinnipeds spotted at 220T, or slightly off the right bow. **Assessment: none. Maximum exposure estimated to be <189 dB**	
500-1000 yards			
50 dolphins		Ship was doing 160T when dolphins spotted at 290T, or behind and to the right of the ship closer to the 1000 yard edge of the mitigation zone. Ship relative motion quickly put dolphins outside of mitigation range >1000 yards. **Assessment: minimum exposure, prior to no mitigation required**	

SOUTHERN CALIFORNIA YEAR 2 NAVY RESEARCH FUNDED MONITORING

Visual surveys, Marine Mammal Tagging, M3R, PhotoID Results

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 2009 - July 2010

- 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[3] and surrounding areas of Southern California in 11-24 November* 2009 and 15-30 June 2010 **

  * Cacadia report combines July 2009 and November 2009 field efforts (**Appendix D**). Only November 2009 effort summarized in this report. The Navy's 2009 Monitoring Report (DoN 2009) contains the July 2009 field discussions.
  ** Data tabulation still ongoing for June event.

[3] SCORE is an older acronym for Southern California Offshore Range, and is the equivalent of the newer designation for the Southern California Range Complex

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 19-25 November 2009 and 14–24 June 2010. In addition, fourteen surveys were conducted along the San Diego coastline and three surveys were conducted in 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**.

Scripps small boat surveys accomplishments in parallel with Year 2 monitoring in the Southern California Range Complex include:

94 hours of visual survey effort over 834 nm
138 sightings of 9,890 marine mammals, and 6,404 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 2009 to August 2010.

Species	# of Groups	# of Individuals	# of ID Images	# of Re-cordings	# of Biopsies
Coastal Bottlenose Dolphin	40	273	3,948	17	4
Offshore Bottlenose Dolphin	17	395	1,658	4	25
Risso's Dolphin	7	144	297	1	1
Pacific White-Sided Dolphin	26	260	4	11	2
Short-Beaked Common Dolphin	26	4,889	74	3	3
Long-Beaked Common Dolphin	10	3,484	280	4	0
Common Dolphin, species unknown	4	433	0	3	0
Fin Whale	5	9	53	0	1
Humpback Whale	1	1	17	0	0
Gray Whale	2	2	73	0	0
Totals:	**138**	**9,890**	**6,404**	**43**	**36**

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.

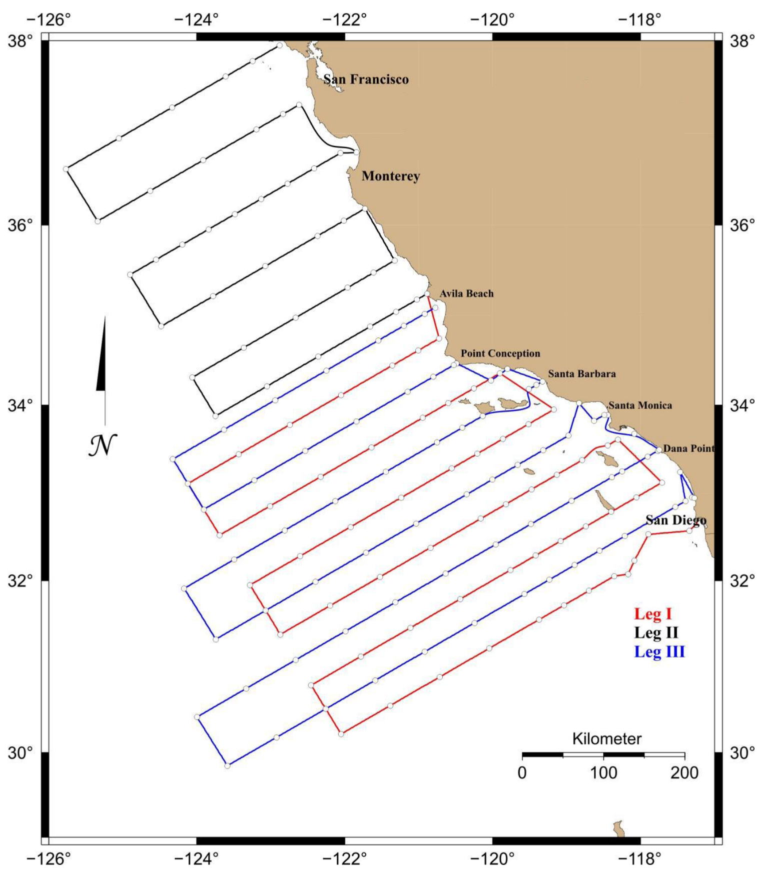
More information on the 61-year history of the CalCOFI program is available online at:

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 2009 to 01 August 2010 include:

- 390 hours of survey effort covering 4,030 nm
- 339 sightings of 17,632 marine mammals
- 258 digital photographs of marine mammals taken
- 747 hours of passive acoustic recording of marine mammal vocalizations
- **Appendix D** has a more complete discussion of CalCOFI results



CalCOFI station positions for standard transect (blue), trawling transect (red), and northern transect (black). Image courtesy of CalCOFI program.

Cascadia Research Collective small vessel surveys and satellite tagging of marine mammal at SCORE and surrounding areas of Southern California in 11-24 November 2009, and 15-30 June 2010

Cascadia Research participated in the fourth and fifth 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)[4]. 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. Cumulatively, including 2009 and 2010 field work, this effort has contributed to photoID of 68 fin whales and 58 Cuvier's beaked whales.

Cascadia survey, photoID, and tagging accomplishments in parallel with Year 2 monitoring in the Southern California Range Complex include:

196 hours of visual survey effort over >1,310 nm
160 sightings of 9,662 marine mammals
24 biopsies taken
19 medium duration Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) satellite tracking tags deployed

- 8 fin whales, 3 blue whales, 1 Risso's dolphin- November 2009
- 2 fin whales, 2 Cuvier's beaked whales, 2 Risso's dolphins, 1 killer whale- June 2010

Tagging Highlights

Figure S-8 shows the long term movement of a tagged male Cuvier's beaked whale from the November 2009 survey. The beaked whale stayed a portion of its time along the western side of San Nicolas basin, before heading south past Baja when the tag was lost. 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, just male beaked whales, or just this particular individual. **Figure S-9** shows 127 day track movement data for a fin whale tagged in the November 2009 survey. This whale was tagged on the middle of the Navy's instrumented range west of San Clemente Island, but spent time (presumably foraging) west and south of San Nicolas Island, before heading south down along the coast of Baja Mexico.
Figure S-10 shows a Cuvier's beaked whale with an attached satellite tag affixed during the June 2010 survey, while **Figure S-11** shows the track movement data for the two Cuvier's beaked whales tagged during that survey.

[4] 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.

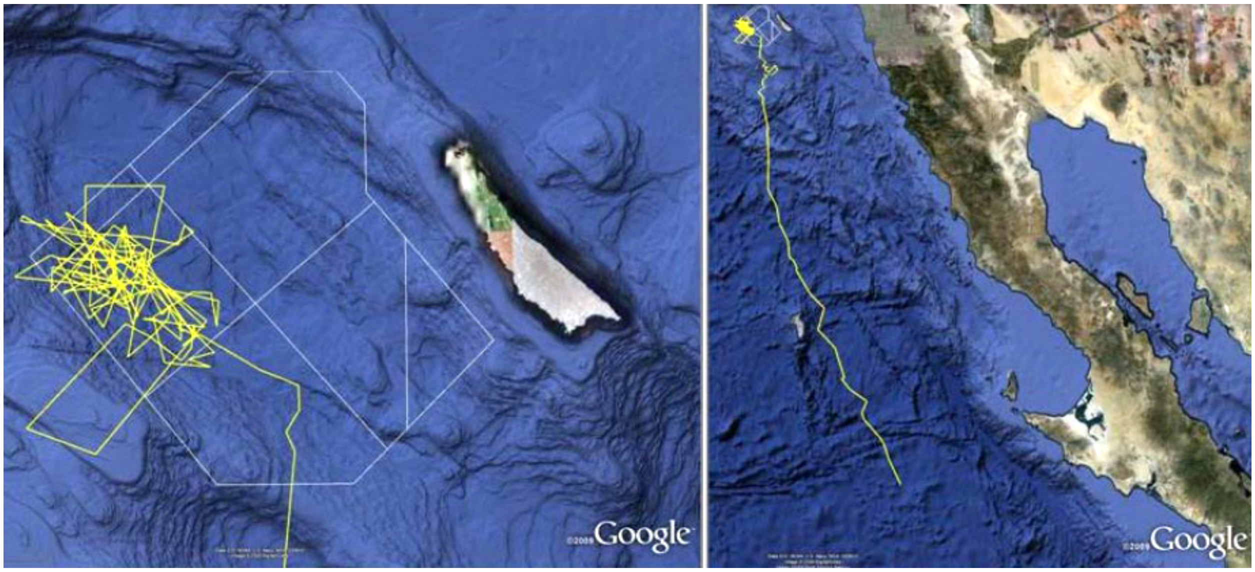


Figure S-8. Movements of a tagged adult male Cuvier's beaked whale showing the first month of movements after tagging in late July 2009 (3A) and the movement to the south (3B).

(Graphic courtesy of Cascadia Research Collective)

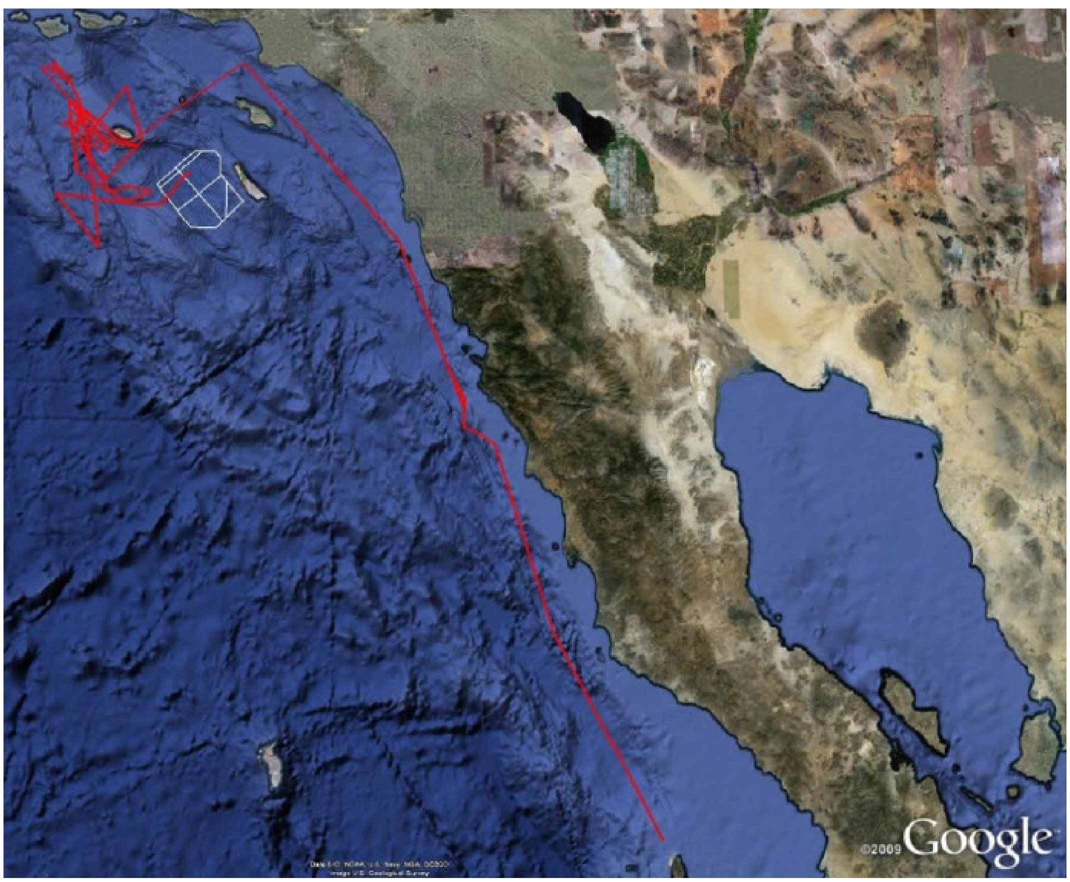


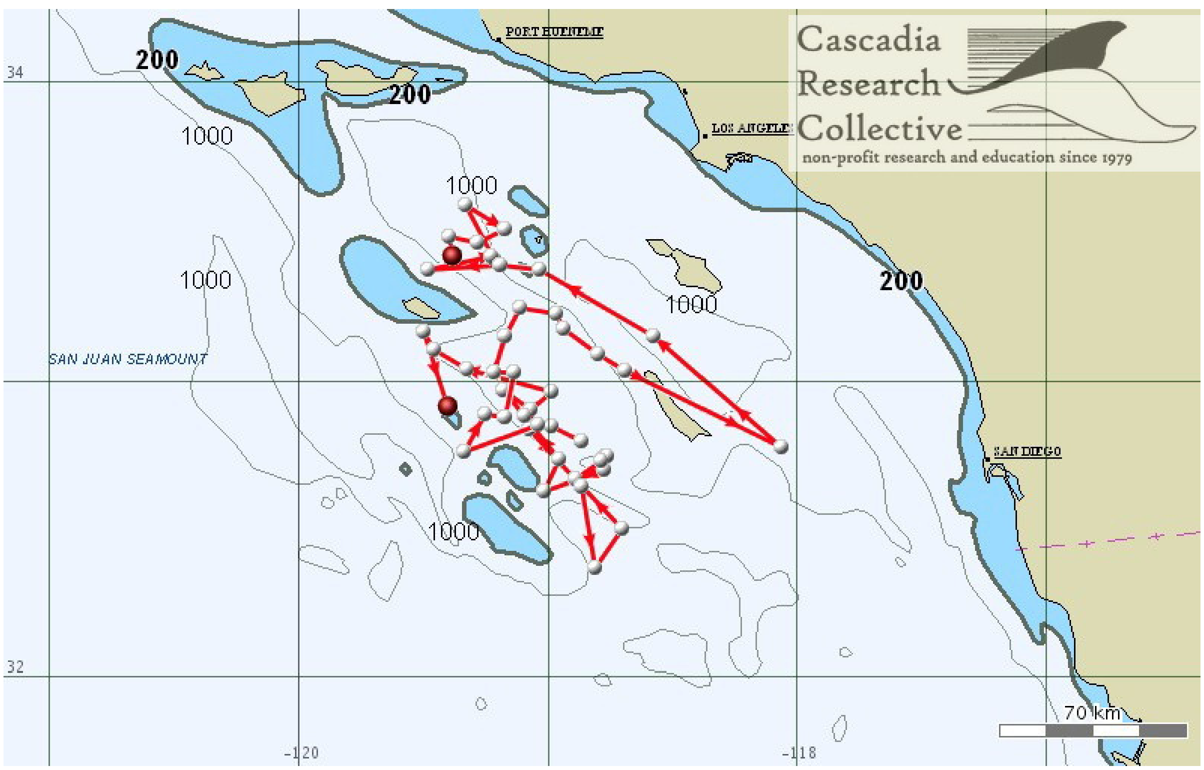
Figure S-9.Trackline representing the movements of a tagged fin whale over 127 days (total transmission duration for this whale was 160 days).

(Graphic courtesy of Cascadia Research Collective)

Figure S-10. Picture of Cuvier's beaked whale with satellite tag attached during 15-30 June 2010 visual survey and tagging field work in the Southern California Range Complex.

(Photograph courtesy of Erin Falcone, Cascadia Research Collective)

Figure S-11. Track movements of two satellite tagged Cuvier's beaked whales in the Southern California Range Complex.



(Unfiltered Argos satellite track log; Graphic courtesy of Erin Falcone, Cascadia Research Collective)

OTHER NAVY FUNDED RESEARCH IN CALIFORNIA

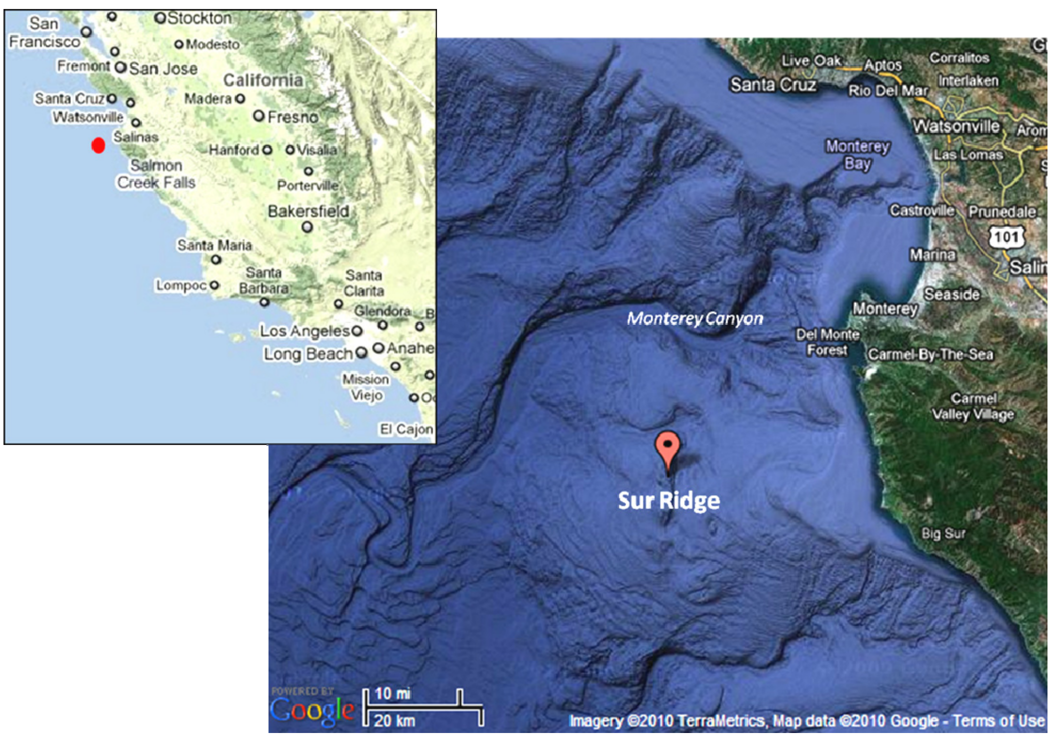
Naval Postgraduate School

The Naval Post-graduate school at Monterey, CA deployed a bottom-mounted HARP along the central California coast near the Sur Ridge to detect marine mammal vocalizations and seasonality in that region. The HARP has been in place since 23 September 2009.

Deployment details for this HARP are provided below. Approximate location for the HARP is along the Sur Ridge, south of Monterey Canyon.

Source	Start Date and Stop Date
Sur Ridge HARP (PS08)	23 September 2009 to 6 January 2010 @50% duty cycle (5 min/10 min)
Sur Ridge HARP (PS09)	22 February 2010 to ~ November 2010 @20% duty cycle (5 min/25 min)

The Naval Postgraduate School HARP data analysis is still ongoing for the September 2009 to January 2010 deployment. A technical report summarizing these results is in preparation and should be available at the end of 2010. Naval Postgraduate school also prepared the merchant ship automated information system plot for Southern California shown in **Figure S-5**.



Sur Ridge off central California

SOCAL-10

SOCAL-10 is the first phase of a multi-year effort (~2010-2015), notionally referred to as SOCAL-BRS (Behavioral Response Study). This research collaboration is designed to increase understanding of marine mammal behavior and reactions to sound. Direct, scientific information about these responses to different human sounds is very limited, but critically needed by both regulatory agencies to support informed conservation management decisions and requirements and militaries for effective operational planning to minimize environmental risk. This *project* extends previous BRS efforts conducted in the Bahamas and Mediterranean Sea in 2007-2009 and is being coordinated with related and successful field efforts (e.g., population surveys of Navy range areas, satellite tagging before active sonar operations) underway in southern California. SOCAL- 10 will use controlled exposure experiments to carefully measure behavioral responses of individual animals to sound exposure. It is part of an integrated, international effort using similar experimental approaches and observational tracking of animals during real activities. This project will take place during August and September 2010 in coastal areas from San Diego to Santa Barbara and the Channel Islands, as well as an offshore area on and around the U.S. Navy's training range near San Clemente Island. SOCAL-10 includes collaborations among scientists, acousticians, and engineers from National Oceanic and Atmospheric Administration, academic and private research laboratories, and U.S. Navy supported organizations.

Field work for BRS-10 to include marine mammal tagging began in August and September 2010. The Navy's next Monitoring Report in 2011 will contain more information on SOCAL-10 accomplishments.

Southern California marine mammal tagging efforts near Long Beach California under the SOCAL-10 project in September 2010.

Photo (left) M. Weiss, Office of Naval Research, (right) J. Calambokidis, Cascadia Research Collective.

CONCLUSIONS FOR SOUTHERN CALIFORNIA RANGE COMPLEX YEAR 2 MONITORING

The Navy achieved all of its planned annual monitoring objectives in Year 2 from 02 August 2009 to 01 August 2010. 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 2 to learn more about baseline marine mammal occurrence, movement, and behavior within the Southern California Range Complex. To this end, over 11,900 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 1 (2008-2009) and Year 2 (2009-2010) efforts will be made available online for download by the spring or early summer of 2011.

Finally, **Appendix A** contains the Navy's proposed Year 3 Southern California Range Complex Monitoring Plan for the period 02 August 2010 to 01 August 2011.

Most of the same techniques used as measures of accomplishments for Year 2 will also apply in Year 3.

APPENDICES A-D

APPENDIX A Southern California Range Complex Year 3 Monitoring Plan and Adaptive Management Discussion for the period 02 August 2010 to 01 August 2011

APPENDIX B Southern California Aerial Survey Reports

APPENDIX C Passive Acoustic Monitoring Reports For Scripps Institute of Oceanography High-frequency Acoustic Recording Packages within the Southern California Range Complex

APPENDIX D Navy Research Funded Year 2 Project Reports

APPENDIX A Southern California Range Complex Year 3 Monitoring Plan and Adaptive Management Discussion for the period 02 August 2010 to 01 August 2011

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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 3 Monitoring Plan

02 August 2010 to 01 August 2011

01 October 2010

This Monitoring Plan is submitted to NMFS in support of the:

Taking and Importing Marine Mammals; U.S. Navy Training in the Southern California Range Complex; Letter of Authorization Renewal

AND

Biological Opinion on the U.S. Navy's Training in the Southern California Range Complex

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Introduction

This is the Navy's revised Year 3 Monitoring Plan (2010-2011) for the Southern California Range Complex. This Monitoring Plan replaces previous plans and is applicable for the time period from 02 August 2010 to 01 August 2011.

Justification for the Year 3 Monitoring Plan is contained in the adaptive management and meeting summaries described below.

Monitoring objectives and metrics, however, are for the most part similar in Year 3 as to what was planned and accomplished in Year 2.

Adaptive Management For Monitoring In The SOCAL Range Complex

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, especially in terms of marine ecosystems and spatial management, focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable ecosystems (Gregory 2006, Leslie and McLeod 2007, Williams el at. 2007, deYoung et al. 2008, Ruckelshaus et al. 2008, Levin et al. 2009, Curtin and Prellezo 2010, Foley et al 2010, Gibbs et al. 2010, Johnson 2010). Adaptive management helps science managers maintain FLEXIBILTY 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 (Williams et al. 2007). Further discussion of adaptive management in the natural resource community is available from the U.S. Department of Interior's Adaptive Management Guidelines:

http://www.doi.gov/initiatives/AdaptiveManagement/index.html

The NMFS has acknowledged that the SOCAL monitoring will enhance the understanding of how sonar or underwater detonations (as well as other environmental conditions) may, or may not, be associated with marine mammal injury or behavioral disturbance. Additionally, NMFS also pointed out that information gained from the investigations associated with the Navy's monitoring may be used in the adaptive management of mitigation or monitoring measures in subsequent NMFS authorizations, if appropriate. Therefore, the Navy's adaptive management of SOCAL monitoring under its Marine Mammal Protection Act responsibilities involves close coordination with NMFS to align marine mammal monitoring with the overall objectives stated within the Introduction to this report. To date, 2010 monitoring within the SOCAL Range Complex only represents Year 2 of a planned five year effort. As such, it would be premature to draw detailed conclusions or initiate comprehensive monitoring changes without further consultation and public review. This formal review is currently slated to occur in the spring of 2011. Using an adaptive management framework, and in consideration of the two meetings described below, the Navy is hereby revising its Year 3 Monitoring Plan.

Southern California Marine Mammal Workshop January 2010

A Southern California marine mammal workshop was conducted in January of 2010 with recognized marine mammal scientists, regional NMFS representatives, and interested organizations. The workshop proceedings and recommendations are summarized in Kerosky et al. 2010. There were several prevalent themes throughout the workshop. One of the more important consensus workshop agreements was the need for expanded information on baseline marine mammal distribution, biology, and behavior. Another agreement was the need to expand the collaboration and sharing of information between various marine mammal science disciplines.

U.S. Ocean Policy

On 19 July 2010, the President signed a new Executive Order on Stewardship of the Ocean, Our Coasts, and the Great Lakes which adopted the final recommendation of the Interagency Ocean Policy Task Force. Key recommendations include "Use the best available science and knowledge to inform decisions affecting the ocean…" and "Increase scientific understanding of ocean…" (EO 2010, CEQ 2010). Another integral part of these policy directions was to instill a collaborative spirit within the Federal Government in the planning, management, and program execution of ocean science projects. Both of these tenants, improved and using best available science along with increased collaboration, are similar to preceding recommendations of the Joint Subcommittee on Ocean Science and Technology (JSOST) on "Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies "(Southall et al. 2009).

Year 3 Monitoring

For Year 3 monitoring from 02 August 2010 to 01 August 2011, the Navy proposes to keep the same level of monitoring effort in the Southern California Range Complex as was committed and accomplished in 2010. **Table 1** highlights these Year 3 goals.

In addition, an alternative location for some monitoring to occur is also proposed in addition to those areas monitored previously in Year 1 (2008-2009) and Year 2 (2009-2010). This new focus area would include the ocean areas from shoreline to approximately 10 nm immediately offshore of San Diego in the vicinity of Coronado, Silver Strand, and Imperial Beach (**Figure 1**).

In support of the JSOST recommendations, Southern California workshop recommendations, and Ocean Policy direction, the Navy is committed to structuring the Southern California Range Complex 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.

As can be seen by the Year 1 and Year 2 monitoring results (DoN 2009, 2010), the Southern California Range Complex aerial visual surveys are adding a significant amount of new information on at-sea marine mammal behavior in Southern California. This effort is unprecedented in the scope to document in text, photos, and digital video marine mammal behavioral activities and distributional patterns at relatively small spatial scales. Navy funded passive acoustic monitoring and satellite tagging in Southern California is contributing to new information on presence, or absence, and movement patterns of particular species over both short and long time scales. In terms of collaboration, in addition to annual monitoring reports to NMFS which are publically available from the NMFS website, the Navy this year has funded efforts to make public the marine mammal field data collected under the SOCAL Range Complex monitoring. The initial effort funded by U.S. Pacific Fleet this year will upload aerial sighting data from Southern California to a publically accessible server for scientific collaboration. Study data from 2008 through 2010 should be available by late spring of 2011, with periodic updates as the Southern California Range Complex monitoring continues.

Keeping the same level of effort from 2010 through 2011 is supported by the continued accomplishments of the Southern California Range Complex monitoring, and directly compliments many of the impact and baseline data needs discussed at the July 2010 Marine Mammal and Sound workshop. In addition, two follow-on monitoring reassessments are planned. The Navy in consultation with leading marine mammal biologists will convene a working level review of the Navy's Integrated Comprehensive Management Plan and associated range complex monitoring plans in October 2010. The NMFS and Navy will also jointly convene another public workshop on range complex monitoring in the spring of 2011 to continue the review and dialog on effective marine mammal monitoring.

Table 1. Navy's Year 3 (02 August 2010 to 01 August 2011) monitoring plan goals for the Southern California Range Complex.

Monitoring Technique	Implementation	
Visual Surveys (aerial or vessel) STUDIES 1,2,3,4, 5	Portions of major training events, or unit level training events using sonar; or offshore or inshore detonation events (100-150 combined hours)	Adaptive Management Review (AMR) for 2012
Marine Mammal Observers (MMO) STUDIES 1, 3, 4, 5	Opportunistic; major training events, unit level training events, or offshore or inshore detonation events as available (50-100 total hours)	
Passive Acoustics Monitoring (PAM) STUDIES 1,2, 3	Continue data collection and analysis from a minimum of two U.S. Pacific Fleet funded passive acoustic recording devices; Present results from ongoing, other Navy funded (CNO N45) marine mammal research in Southern California	
Exercise Summary From Navy Lookout Reports STUDY 5	Continue to collect/analyze marine mammal sightings from Navy lookouts during major training events and present results	
Other Navy funded research Summary STUDIES 1,2, 3	Present results from ongoing, other Navy funded (CNO N45) marine mammal research in Southern California	

NO metric changes are envisioned in 2011 from the level of effort and funding performed in 2010

TOTAL Navy 2011 Goal:

• 100 to 150 hours visual survey funded by US Pacific Fleet as well as presentation of N45 R&D visual survey efforts

• 50-100 hours Marine Mammal Observers

• Deploy (2) Passive acoustic monitoring devices: continue data collection/analysis from a minimum of two (2) US Pacific Fleet-funded passive acoustic recording devices

• present results as available from other Navy funded research projects such as visual surveys, passive acoustic monitoring, tagging, and photoID

NMFS-NAVY 2008 AGREED UPON RESEARCH QUESTIONS

Study 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?

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

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

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

Study 5= Is Navy's suite of mitigation measures for sonar and explosives, and major exercise measures agreed to by Navy through permitting effective at avoiding temporary threshold shift, injury, and mortality of marine mammals and sea turtles?

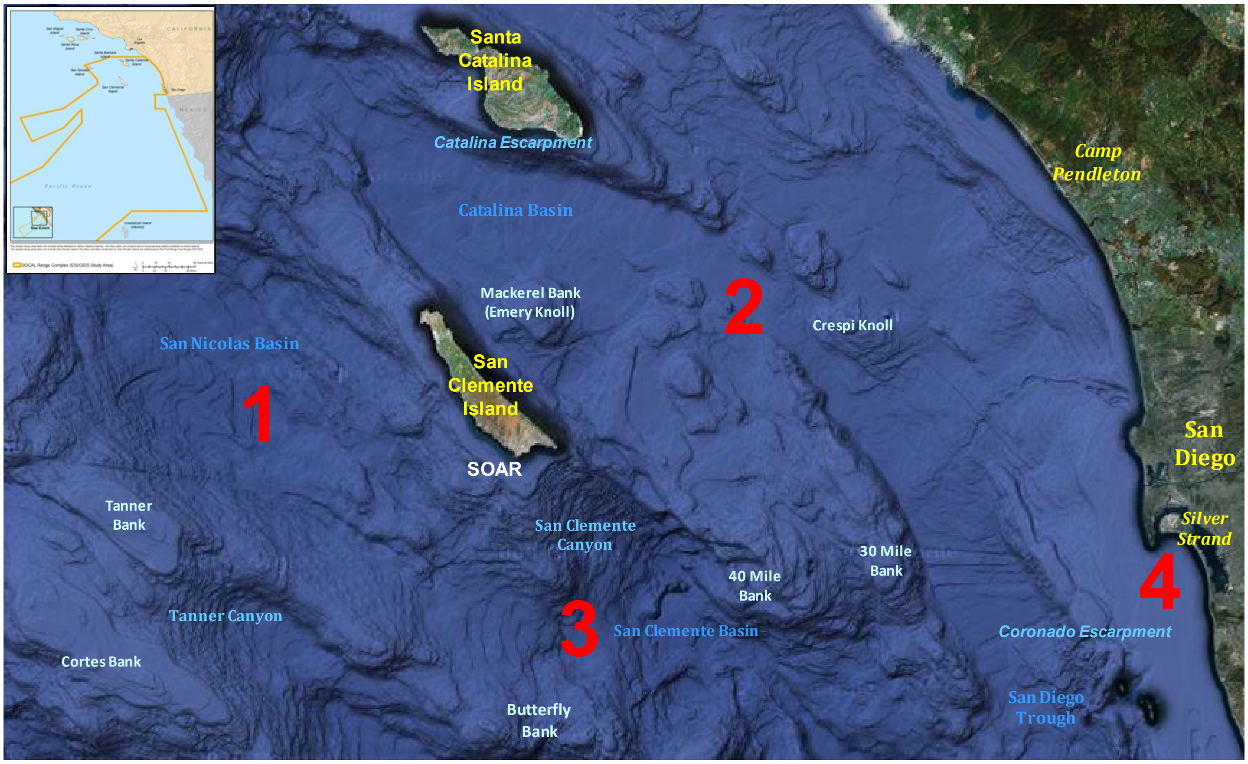

Figure 1. Navy's 2010-2011 monitoring focus areas within Southern California.
(map from Google Maps)

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APPENDIX B Southern California Aerial Survey Reports

Sub-Sections

18-23 Nov 2009 (airplane- 27 hours)

13-18 May 2010 (airplane- 29 hours)

27-28 Jul 2010 (helicopter- 5 hours) and 29 Jul-03 Aug 2010 (airplane- 16 hours)

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Aerial Survey Marine Mammal Monitoring off Southern California in Conjunction with US Navy Major Training Events (MTE)

SOCAL Nov 18-23, 2009
Final Field Report

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Cover Photos: Killer whale (*Orcinus orca*), California sea lion *(Zalophus californianus),* Cuvier's beaked whale *(Ziphius cavirostris),* and short-beaked common dolphin *(Delphinus delphis)* photographed with a telephoto lens from the aircraft during the SOCAL November 09 aerial monitoring survey. Photos by Mark Deakos courtesy of Smultea Environmental Sciences.

Section 1 Introduction

In support of the U.S. Navy's (Navy) Marine Mammal Monitoring Plan (M3P) in the Southern California Range Complex (SOCAL) (DoN 2009), aerial surveys were conducted by Smultea Environmental Sciences (SES) to monitor marine mammals and sea turtles (MM/ST) during November 2009 in the SOCAL area. This was the fifth such aerial survey in SOCAL conducted by SES or SES/Marine Mammal Research Consultants (MMRC). Monitoring occurred in conjunction with several Navy Major Training Events (MTEs) involving mid-frequency-active sonar (MFAS). Portions of these MTEs occurred in offshore waters near San Clemente Island (SCI) off San Diego, California. Naval training has been conducted within SOCAL for over 40 years, and marine mammals are also known to be abundant there (e.g., summarized in Carretta et al. 2000, 2008; DoN 2008, 2009). As part of SOCAL, the Navy operates the Southern California Anti-submarine Warfare Range (SOAR) west of San Clemente Island (Figure 1).

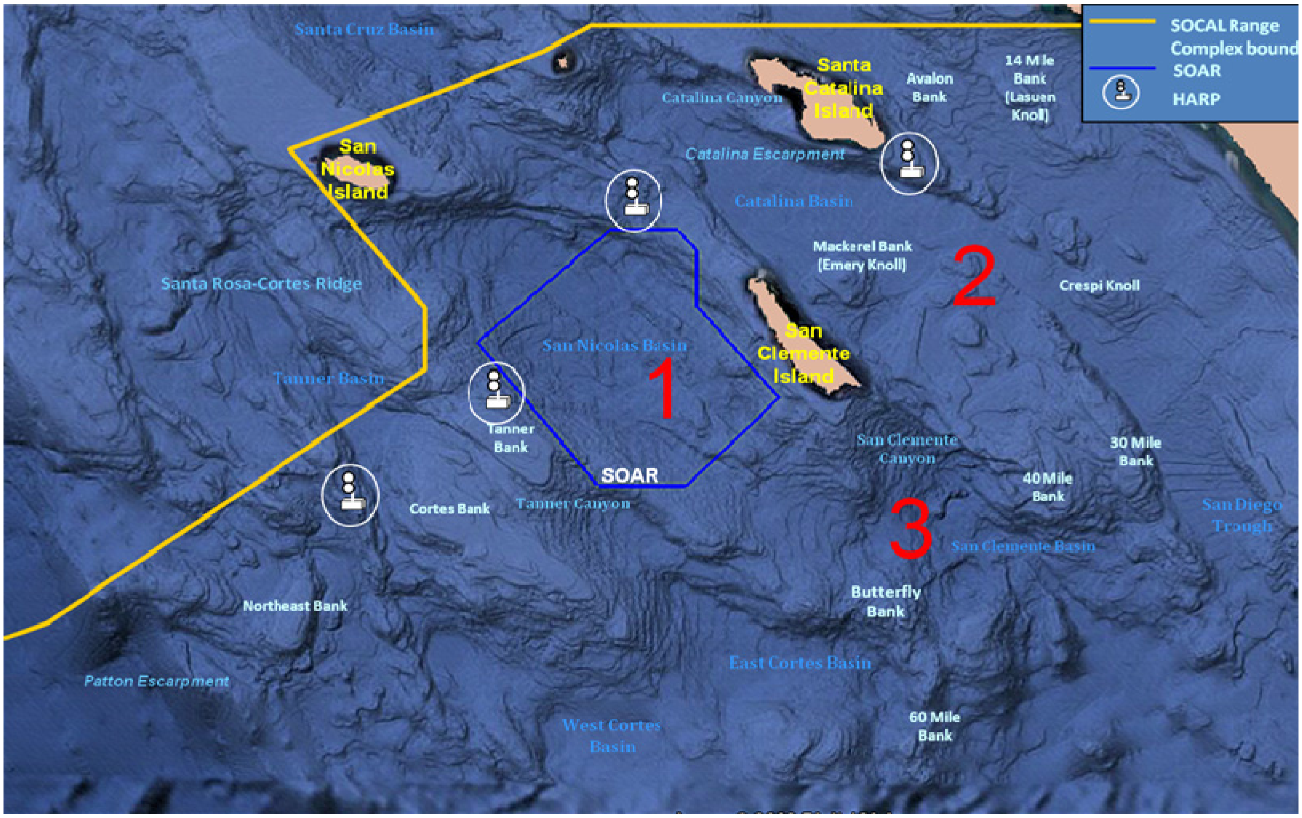


Figure 7. Location of the aerial survey monitoring area and underwater topographic features within the Navy's Southern California Range Complex (SOCAL). Numbers indicate survey areas of interest to the Navy in order of priority; orange line designates the SOCAL boundary; blue lines designate the Southern California Offshore Anti-submarine Warfare Range (SOAR); icons are approximate locations of Navy-funded bottom-mounted passive- acoustic high-frequency acoustic recording packages (HARPs).

The contracted work involved considerable pre-survey planning via email and telephone with the Navy Technical Representative (NTR) given the logistical complexity of the MTEs, as well as a pre-planning meeting in San Diego just prior to the survey (see below). In particular, coordinating multiple Navy activities on the SOCAL range was logistically challenging and time-consuming for Navy personnel given the high degree of safety planning. Protocol was similar to that implemented for aerial surveys in SOCAL in summer 2009 (see Smultea et al. 2009a,b).

Project Planning

Meetings and communications with Navy personnel identified the actual survey areas, periods, and communications protocols to be used. This was required to coordinate logistics and ensure safety and open communication between the Navy and the aerial monitoring team during the surveys, given the complexity of multiple naval aircraft and vessel operations involved with the MTEs and other missions. Clearance from various Navy commands was obtained by Navy environmental planners on behalf of SES prior to the research aircraft flying in the SOCAL.

In addition, pre-planning meetings were conducted. These communications were needed to coordinate survey efforts with others conducting marine mammal research in the same region and period including the Naval Undersea Warfare Center (NUWC), Scripps Institute of Oceanography (SIO), and Cascadia Research Collective (CRC). Other ongoing studies involved passive acoustics, tagging, photo-identification, and behavioral studies from small vessels (including a small CRC and two small SIO vessels), some of which were funded by the Office of Naval Research (ONR) and N45 funds (e.g., Falcone et al. 2009a,b). Communications identified ways the various research groups and platforms could collaborate and assist one another in obtaining complimentary data, thus maximizing the utility of simultaneously operating studies. Of particular focus was conducting simultaneous aerial and small vessel (CRC, SIO) tagging and photo-identification studies primarily west of SCI. The goal was to alert one another about the locations of unusual sightings such as beaked whales and killer whales.

Project Questions and Hypotheses

Project questions and hypotheses were developed by SES based on the five questions identified in the Navy's SOCAL M3P designed to assess potential effects of MFAS and underwater detonations on MM/ST during Navy MTEs (DoN 2009; see Smultea et al. 2009a,b). See the 2008 SOCAL aerial survey report (Smultea et al. 2009a,b) for more detailed related information.

An important factor limiting the ability to assess potential effects of MFAS in this report is that the Navy did not disclose MFAS transmission times and locations for national security reasons. Thus, it is not possible for us herein to compare data from specific operational MFAS "on" and "off" periods during MTEs, nor data on distance and relative location of MFAS sources vs. sightings.

Approach

The approach implemented to address SOCAL M3P requirements was to conduct surveys to monitor the occurrence and behavior of MM/ST from a small fixed-wing aircraft in the SOCAL relative to MFAS transmission periods. The primary survey areas were SOAR west of SCI and the Northern Air Operating Area (NAOPA) range between SCI and the mainland coast (Figure 1). The study approach involved implementing search, verify, and focal follow modes as described in Smultea et al. (2009a,b). Notably, sea turtles were considered unlikely to be seen in the MTE based on available data (reviewed in DoN 2008). See Smultea et al. (2009a) for a detailed list of primary monitoring goals of the aerial surveys.

As described in Smultea et al. (2009a), priority species were (1) MM/ST exhibiting unusual or distressed behavior, (2) near-stranded, stranded, or dead MM/ST, (3) MM/ST species listed as endangered or threatened under the ESA, (4) beaked whales, and (5) Risso's dolphins, dwarf/pygmy sperm whales (Kogia sp.), and other deep-diving odontocetes considered potential "surrogate" representatives for deep-diving beaked whales (see DoN 2009).

Section 2 Methods

Methods followed those outlined in the SOCAL aerial survey monitoring reports for the October/November 2008 surveys (Smultea et al. 2009a) and the June/July 2009 surveys (Smultea et al. 2009b). Thus, they are not repeated herein. See Smultea et al. (2009a) for the most detail on protocol and methodology. For the November 2009 SOCAL aerial survey, a Partenavia P68 was used as the observation aircraft for the entire survey (Figure 2a), as the glass-nosed Partenavia P68 Observer (Figure 2b) was not available for use (it was being used to conduct multiple weeks of pinniped surveys by the NMFS Southwest Fisheries Science Center). As in past surveys, we used an Apple iTouch for data collection.

As done during past surveys, a marine mammal species expert (Dr. Tom Jefferson, Clymene Enterprises, San Diego, CA) reviewed our photographs to verify or identify species. Additional experts were consulted as deemed appropriate, especially for large whale sightings, to differentiate as possible between sei, fin, and Bryde's whales.

Figure 2a. The Partenavia P68 Observer fixed-wing, twin-engine aircraft used during the November 2009 aerial survey monitoring.

Figure 2b. The Partenavia P68 Observer fixed-wing, twin-engine aircraft used during the October-November 2008 aerial survey monitorin (note the glass nose). This plane was not available during the November 2009 surveys but is preferred to conduct surveys when it is available given the glass nose and improved sighting effectiveness from the pilot and co-pilot seats.

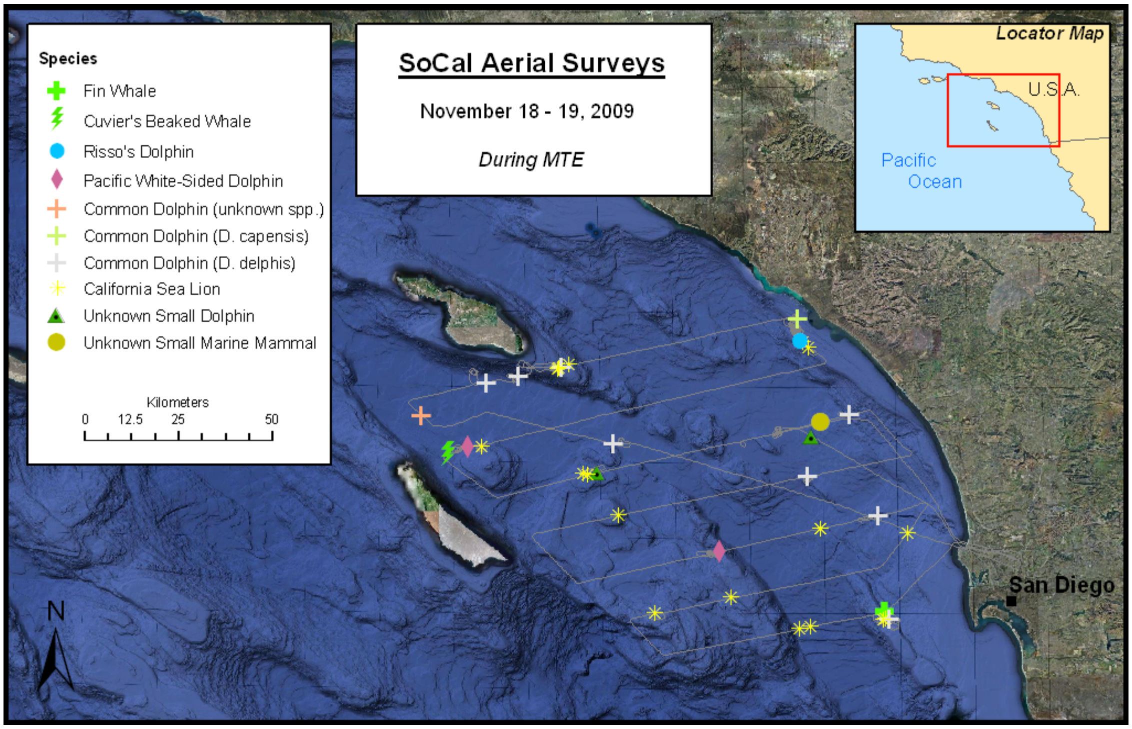


Figure 3. Aerial survey track lines and marine mammal sightings in the SOCAL during a Major Training Event (MTE) (November 18-19, 2009).

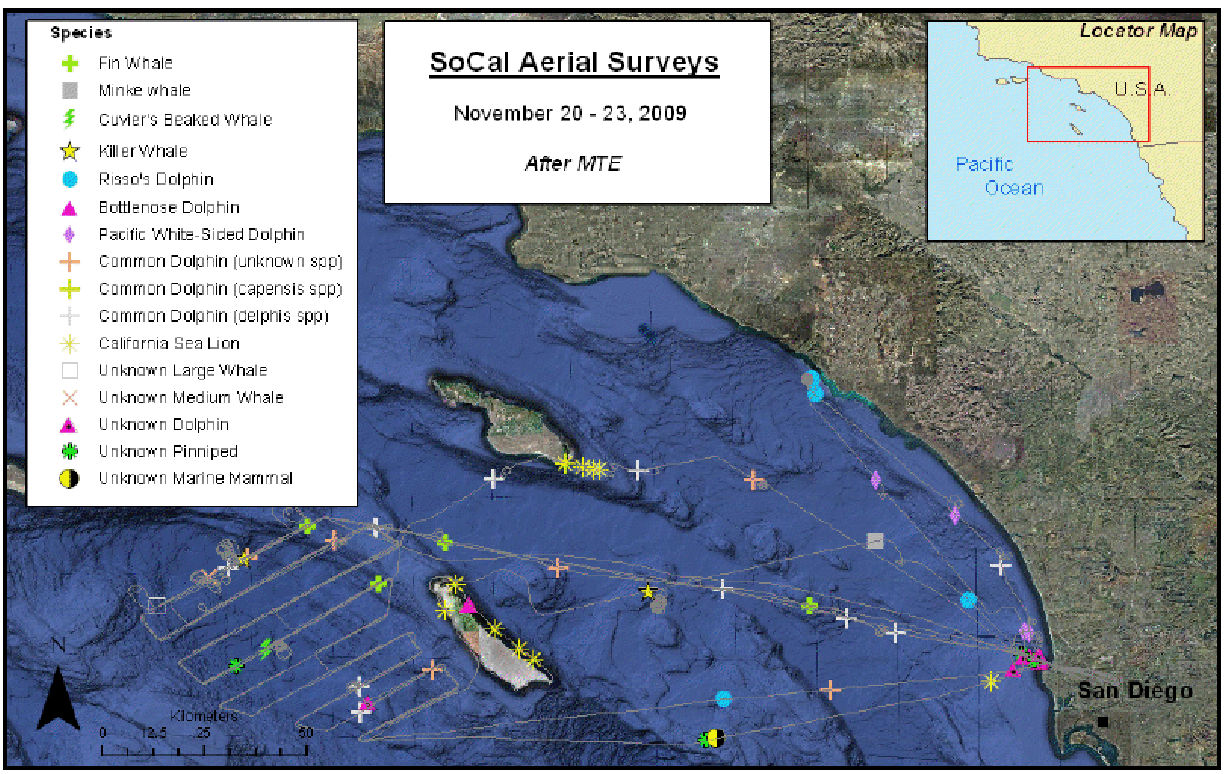


Figure 4. Aerial survey track lines and marine mammal sightings in the SOCAL after a Major Training Event (MTE) (November 20 - 23, 2009).

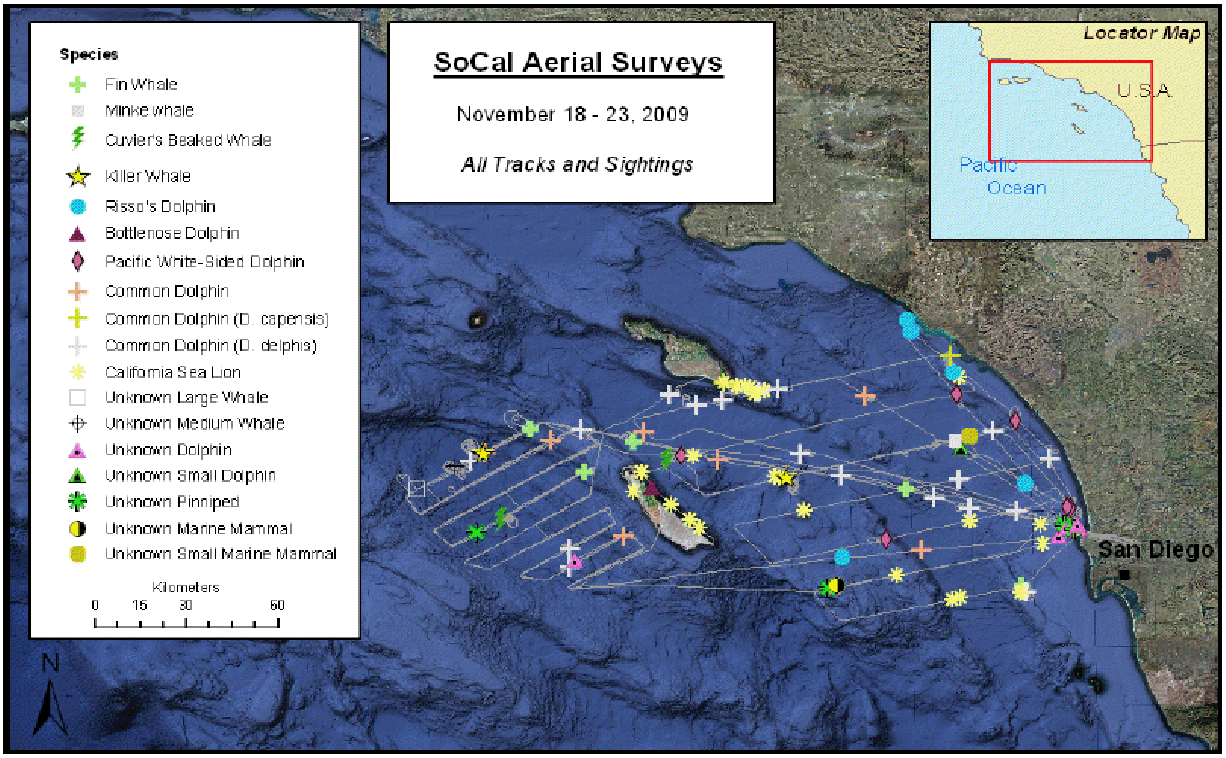


Figure 5. All track lines and sightings made during aerial monitoring surveys in SOCAL November 18 - 23, 2009.

Section 3 Results

This section closely follows the format of the summer 2009 SOCAL aerial survey monitoring report (Smultea et al. 2009b). Results are summarized in Tables 1-5, Figures 2-13, and Appendix A.

Effort

A total of 27.46 hr of flight and ~5233 km (2827 nm) of flight effort were conducted during the November 2009 SOCAL aerial survey between aircraft "wheels up" off the ground to "wheels down" when the plane landed (Tables 1 and Table 2). Surveys were flown on every day during November 18 – 23 for a total of 6 flight days. Overall, most (34%) of the total 5,233 km of observation effort in November consisted of systematic line-transect. This was followed by circling sightings for focal follows and/or species identification (26%), transit (19%), and random effort (13%) (Table 2). Random effort consisted primarily of transits to and from systematic survey lines but also included one circumnavigation of SCI totaling 120 km searching for potential stranded animals (Table 2). Overall, Bf (Beaufort sea state rating) ranged from 1-6 during November. Bf 3 predominated (43%) followed by Bf 2 (33%) (Figure 7).

Table 1. Aerial survey flight times, total hours, and nautical miles flown by date and survey period November SOCAL 2009 aerial survey.

Date	Time Engines On	Time Engines Off	Total Engine Time	Time Wheels Up	Time Wheels Down	Total Flight Time	Start Obs.	End Obs.	Total Obs. Time	Flight Area	General Weather	Comments
18 Nov	13:31	17:07	3:36	13:40	17:05	3:25	13:43	16:49	3:05	NAOPA South ½	Morning fog, clear by midday, light haze, Bf 2-3	Started late--morning fog. Too dark to observe on return transit, sunset @ 16:48. Large common dolphin grp (2000+) spread over 15 km. Not permitted on SOAR
19 Nov	10:03	14:33	4:30	10:13	14:31	4:18	10:17	14:25	4:08	NAOPA North ½	Morning fog, fog near San Clemente Isld (SCI) Winds 8-12 kt offshore. Bf 2-3, Bf 3-4 on return from SCI	Fuel truck 1hr late. Cuvier's beaked whale @11:14 on transit line. Large common dolphin grp (1200+) spread over 8 km. Not permitted on SOAR
20 Nov	10:28	15:08	4:40	10:47	15:03	4:16	10:50	14:57	4:06	SOAR (1 NAOPA line on return)	Fog in NAOPA during transect to SOAR. Bf 2-5	1 Unid. Med. whale NW SOAR. Saw Cascadia RHIB ~5 km away. RHIB 30 min later tracking beaked whale vocals. Spoke to them on VHF Ch 16 then 10
21 Nov	9:35	14:38	5:03	9:50	14:35	4:44	9:53	14:27	4:34	Circumnavigate SCI, ½ East SOAR	Light fog and haze in a.m., unable to fly some W ends of SOAR lines with high Bf >5 offshore. Bf 2-5 elsewhere	Killer whales with calves. Multiple-breaching minke whale.
22 Nov	8:45	13:40	4:55	9:02	13:36	4:33	9:06	13:25	4:19	SOAR then 1 NAOPA line on return	Light haze, predicted NW wind 20-25 kt. Bf 3-4 in SOAR, Bf 2-4 in NAOPA	Sunset 16:45pm, not enough light for second flight. Common dolphins seen in SOAR, 2 fin whale sightings.
23 Nov	7:38	12:18	4:40	7:54	12:13	4:19	7:57	12:06	4:08	½ North SOAR (1 NAOPA line on return)	Bf 2-3, clear, no fog or haze	Killer whales, 4 Cuvier's beaked whales. Not permitted on SOAR after 11:00
	13:55	16:22	2:27	14:06	16:15	2:08	14:09	16:08	1:58	Followed shelf N off coast	Bf 2-4, clear with no fog or haze	Sunset 16:43, ended flight due to limited light. Focal observ. of Risso's dolphins near Laguna coastline
		Total Engine Time	**29:51**		**Total Hours Flown**	**27:46**		**Total Obs Time**	**26:22**			

Table 2. Summary of aerial survey effort (km and nm) by leg type during the November SOCAL 2009 MTE aerial surveys.

Leg Type	Leg Type Definition	Total km Flown	*Total nm Flown*
Systematic	Pre-determined line transect legs located in SOAR and NAOPA	1790	*967*
Random	Short lines connecting longer systematic lines	669	*361*
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	1335	*721*
Circumnavigating Coast	Flying parallel to SCI coastline approximately 0.5 km offshore to search for potential strandings	120	*65*
Transiting	Flying between the airport and the survey grid locations	983	*531*
Fog Effort	Opportunistic observation effort conducted when fog or low clouds partially obscured view	83	*45*
Transiting Low Light	Transiting (see above) at dawn or dusk when low-light conditions compromised visibility	42	*23*
Navy-Directed Transiting	Flying off intended course as directed by Navy to avoid Navy activities	137	*74*
Sighting	Flying from the survey line to a sighting location before circling began	74	*40*
TOTAL		**5233**	***2827***

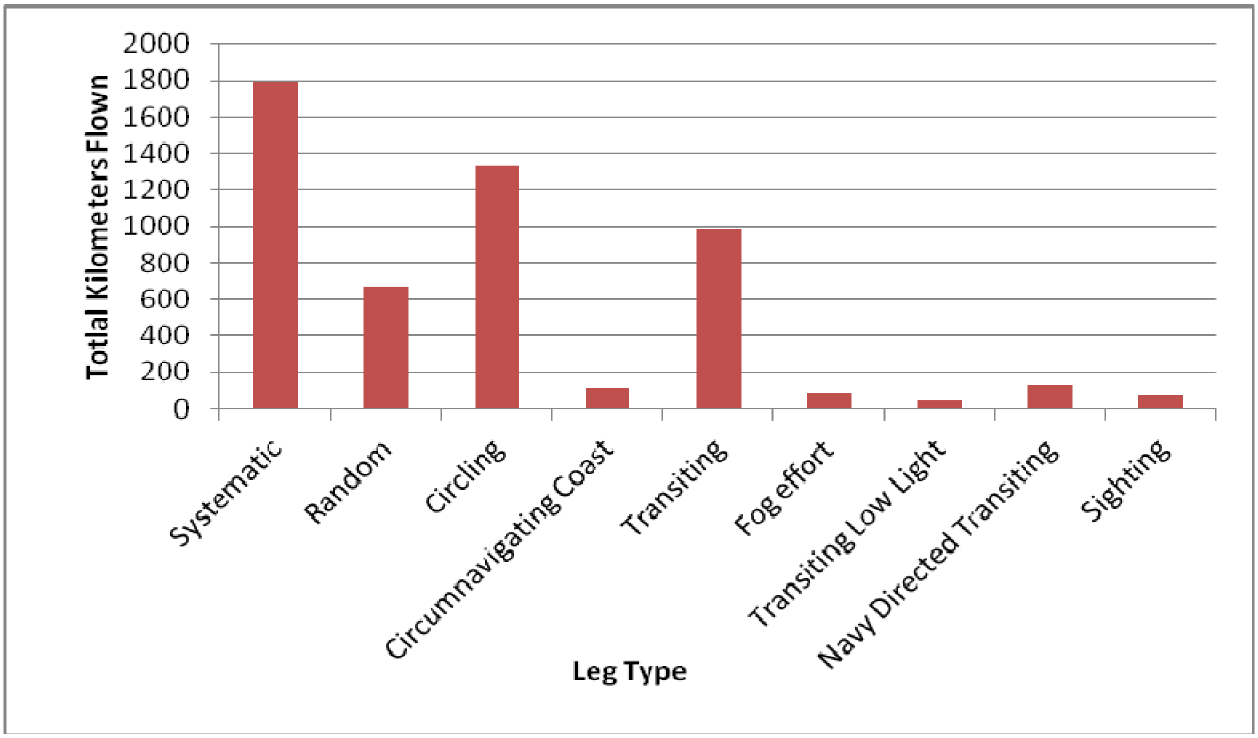


Figure 6. Summary of aerial survey effort (km) by leg type during the November SOCAL 2009 MTE aerial surveys.

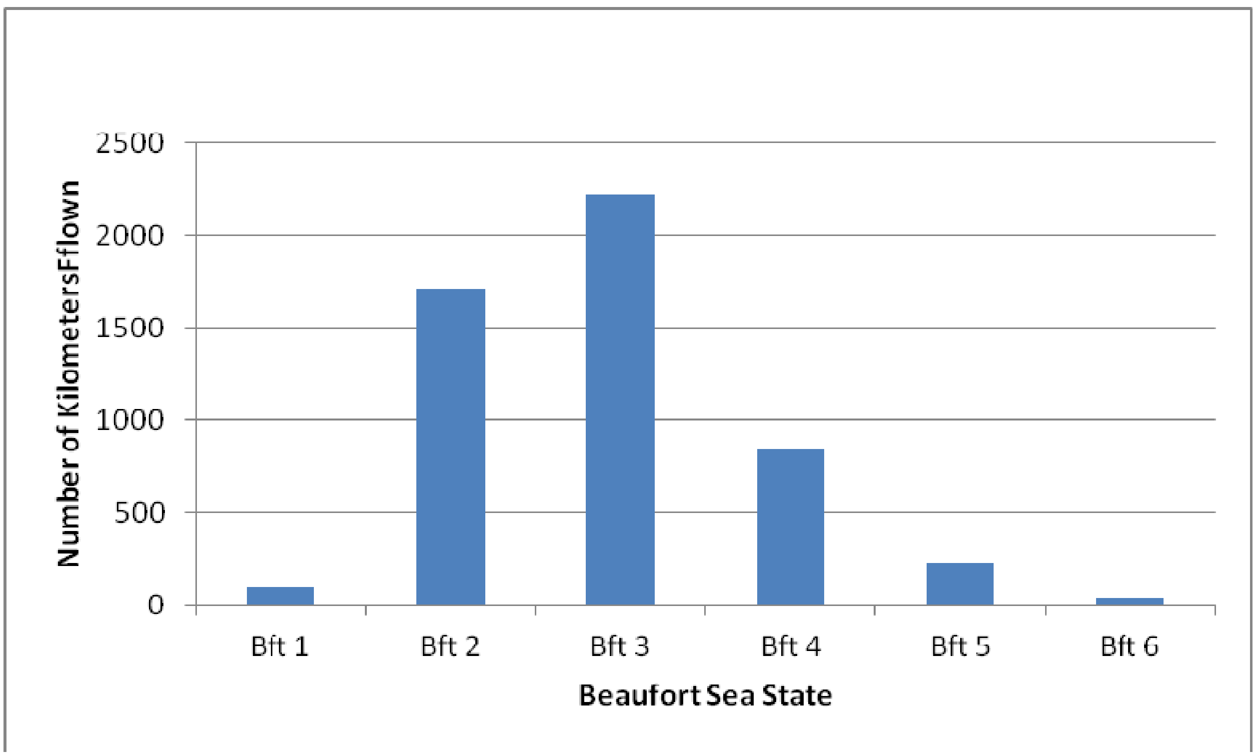


Figure 7. Summary of aerial survey effort (km) by Beaufort sea state during the November SOCAL 2009 MTE aerial surveys.

Sightings

A total of 94 sightings of ~12,829 individual marine mammals was observed (Table 3). Of the total 94 sightings, 79.8% were identified to species (*n* = 42) or genus (*n* = 75) (Table 3 and Appendix A). Not all sightings were identified to species because there was not always time to fly off course to identify and circle sightings. Rather, the priority was 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 the SOAR survey area.

At least 10 different marine mammal species were identified (Table 3); no sea turtles were seen similar to the previous five SOCAL aerial surveys (Smultea et al. 2009a,b). Sightings included two baleen whale species (fin and minke whales), Cuvier's beaked whale, killer whale, five dolphin species (bottlenose, short- and long-beaked common, Pacific white-sided, Risso's), and one pinniped species (California sea lion)(Table 3). Unidentified sightings usually occurred when there was no time to circle (see above). Overall, the California sea lion was the most frequently identified species group (30% or 28 of 94 total groups) followed by common dolphins of the genus Delphinus (19% or 18 groups) (Table 3). In terms of number of individuals seen, the common dolphin was the most abundant (*n* = ~11,944 or 93% of the total 12,829 individuals seen). California sea lions (*n* = 28 groups of 127 individuals) were the most commonly identified pinniped species.

Estimated mean group sizes were highest for short-beaked common dolphins (537) (Table 3). Mean group sizes for other delphinid species (*n* = 14 groups) were considerably smaller. For example, overall mean group size for five Risso's dolphin sightings was 33 individuals/group (Table 3). Baleen whales had the smallest observed group sizes (mean group size for fin = 2 whales/group, *n* = 5 groups and mean group size for minke = 1 whale/group, *n* = 1).

Table 3. Summary of marine mammal sightings by species during the November SOCAL 2009 MTE aerial surveys. Highlighted gray species have photos within the report as follows. Minke whale photos located in Appendix C. Cuvier's beaked whale photo located on the cover page. Killer whale photos located on the cover page and in Appendix D. Short-beaked common and California sea lion photos located on the cover page.

Species (Common Name)	**Scientific Name**	**Total No. of Sightings**	**Total Estimated No. Individuals**	**Mean Group Size**
Fin Whale	*Balaenoptera physalus*	5	9	2
Common Minke Whale	*Balaenoptera acutorostrata*	1	1	1
Cuvier's Beaked Whale	*Ziphius cavirostris*	2	6	3
Killer Whale	*Orcinus orca*	2	67	34
Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	6	274	46
Risso's Dolphin	*Grampus griseus*	5	167	33
Common Bottlenose Dolphin	*Tursiops truncatus*	1	4	4
Short-beaked Common Dolphin	*Delphinus delphis*	18	9666	537
Long-beaked Common Dolphin	*Delphinus capensis*	2	53	27
Common Dolphin sp.	*Delphinus* sp.	7	2225	318
California Sea Lion	*Zalophus californianus*	28	127	5
Unidentified Dolphin	Delphinidae sp.	7	177	25
Unidentified Small Dolphin	Delphinidae sp.	2	45	22.5
Unidentified Large Whale	Cetacea	1	1	1
Unidentified Medium Whale	Cetacea	1	1	1
Unidentified Pinniped	Pinnipedia	4	4	1
Unidentified Marine Mammal	Cetacea or Pinnipedia	1	1	1
Unidentified Small Marine Mammal	Cetacea or Pinnipedia	1	1	1
Totals:		**94**	**12,829**	

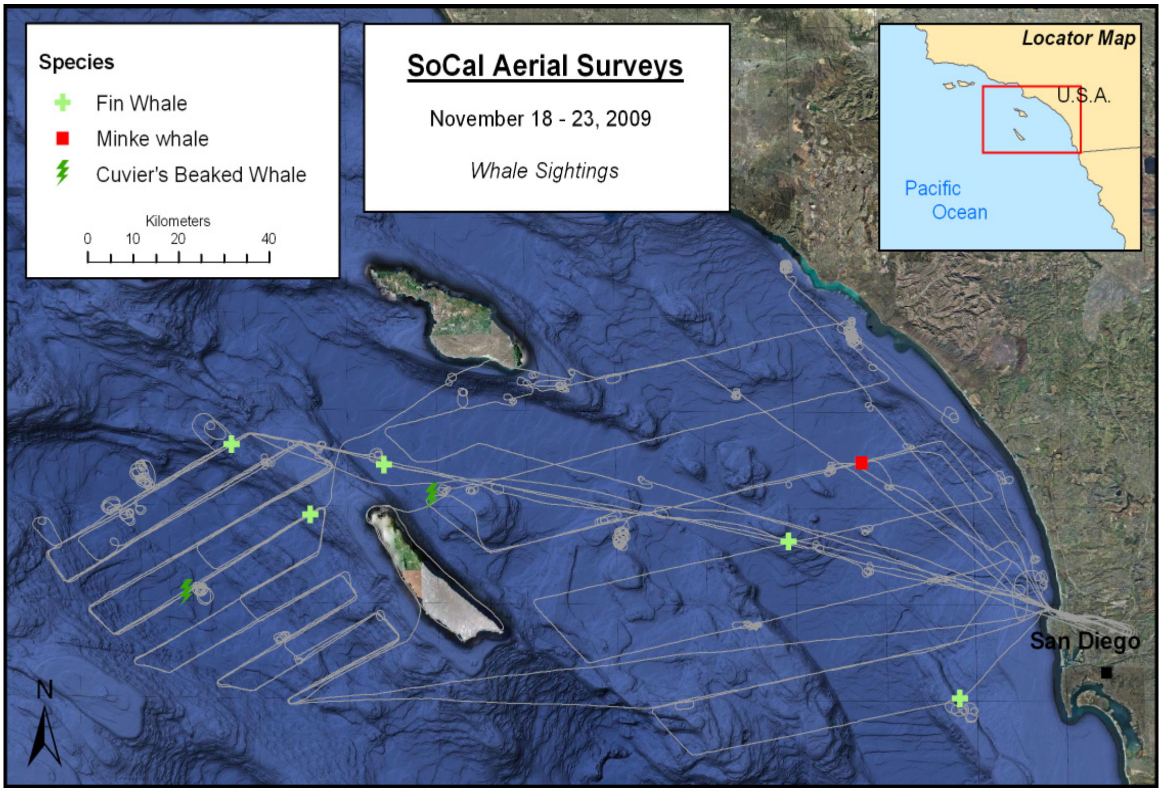


Figure 8. Whale sightings made during aerial survey monitoring in the SOCAL November 18 - 23, 2009.

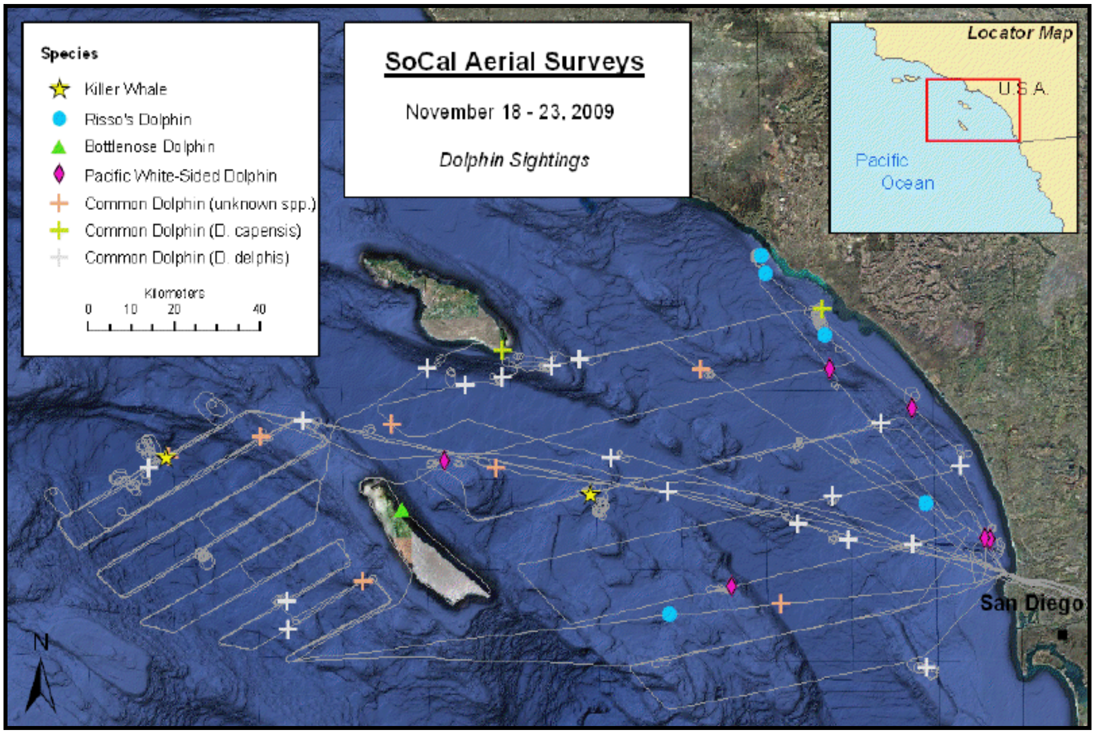


Figure 9. Dolphin sightings made during aerial survey monitoring in the SOCAL November 18 - 23, 2009.

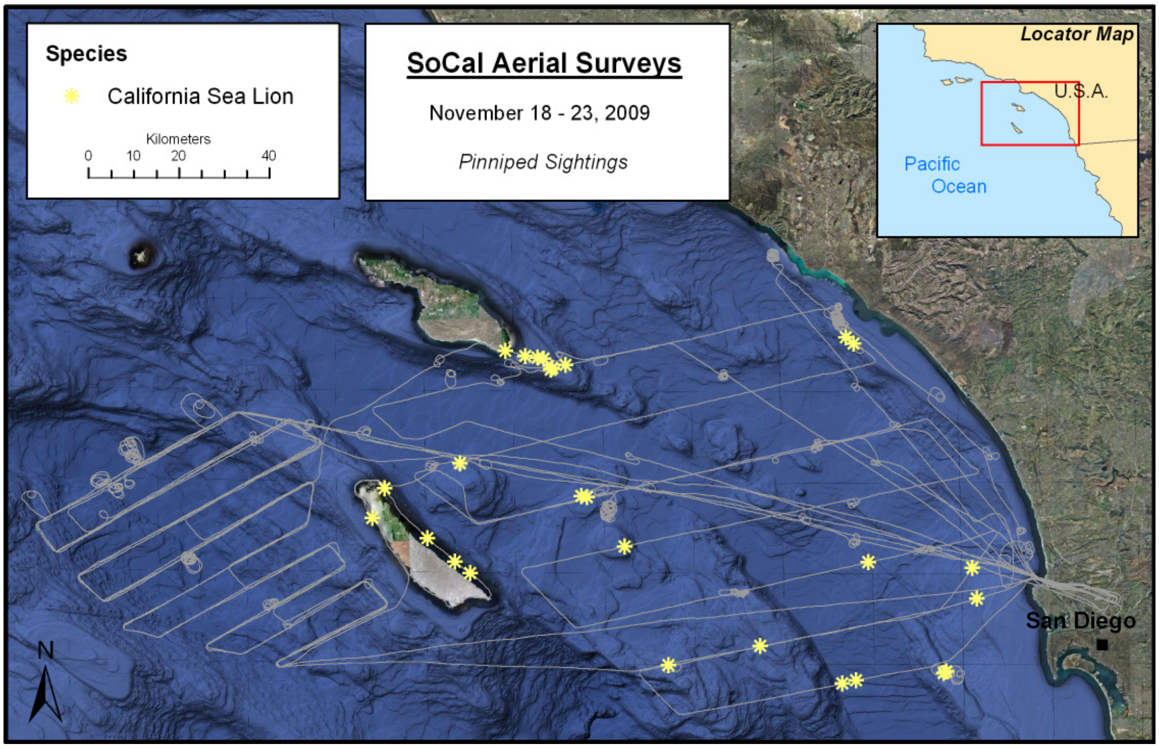


Figure 10. Pinniped sightings made during aerial survey monitoring in the SOCAL November 18 - 23, 2009.

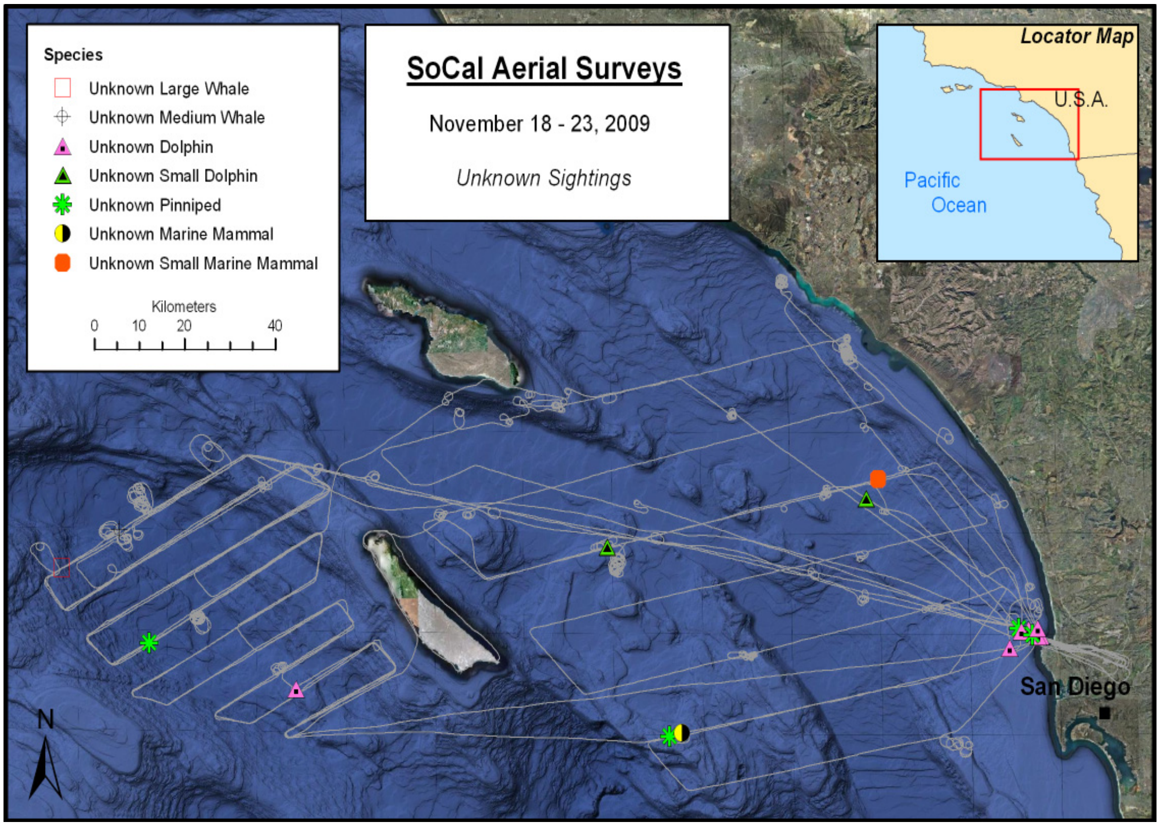


Figure 118. Unknown species sightings made during aerial survey monitoring in the SOCAL November 18 - 23, 2009.

Distribution

In November 2009, line-transect surveys were conducted only E and W of SCI (see Figures 3 and 4). Transect lines E of SCI in NAOPA were the same as those followed in October/November 2008 and June/July 2009 (see Smultea et al. 2009a,b). Survey lines W of SCI in SOAR in November 2009 were similar to those followed in June-July 2009 and October-November 2008, but extended further north and slightly farther apart in November 2009 vs. the earlier surveys to maximize coverage of the Navy-identified SOAR survey area within the ~4.5-5-hr limit of the aircraft's fuel tank.

Two Cuvier's beaked whale sightings were observed: one just E of the northern end of SCI at the edge of a steep topographic drop-off, the second one near the middle of SOAR in the San Nicholas Basin (Figure 8). All five fin whale sightings occurred along the edge of steep topographic drop-offs, including three sightings in or near SOAR, one off San Diego, and one in the middle of the NAOPA survey grid (Figure 8). Risso's dolphins, Pacific white-sided dolphins, and long-beaked common dolphins tended to be coastally distributed (Figure 9). In contrast, short-beaked common dolphins were distributed generally through much of the study area but particularly along steep underwater reliefs such as the south side of Santa Catalina Island. Two rare sightings of killer whales were made during the survey: one on the north end of SOAR and the second one in the NAOPA survey grid (Figure 9). Killer whales had never been seen during any of the five previous aerial surveys conducted in the same areas (Smultea et al. 2009a,b). The only pinnipeds identified to species were California sea lions. The highest concentration of this species occurred along the narrow bank extending off the southeast tip of Santa Catalina Island (Figure 10). Concentrations were also seen along the E side of San Clemente Island during the circumnavigation survey of the island. No pinnipeds were seen in SOAR. In addition, California sea lions were seen scattered throughout offshore waters between San Diego and SCI.

Behavior

Four species or genus had sample sizes considered large enough (n = 5) to warrant summarizing initially observed behavior state, heading, and estimated mean dispersal distance between individuals: fin whales (n = 5), common dolphins (n = 29), Risso's dolphins (n = 5), and Pacific white-sided dolphins (n = 6)(Figures 12-15). Common dolphins were frequently observed engaged in surface-active behavior states and travel (Figure 12). In contrast, Risso's dolphins were rarely seen engaged in surface-active behaviors (Figure 13); rather, they predominantly traveled and also exhibited rest and milling more frequently than common dolphins (Figures 12 and 13). The most frequently observed heading among common dolphins was to the WSW (Figure 12). Inter-individual spacing (i.e., dispersal) for both common and Risso's dolphins was usually 1-3 body lengths, though spacing was sometimes as much as 12-15 body lengths (Figures 12 and 13). Fin whales were always initially observed traveling either to the east-northeast or the northwest-north, spaced 1-3 body lengths apart (Figure 14). Although the sample size for Pacific white-sided dolphins was small, observations indicate that behavior state and heading varied (Figure 15). This species most frequently exhibited further maximum inter-individual spacing than the other species (Figures 12-15).

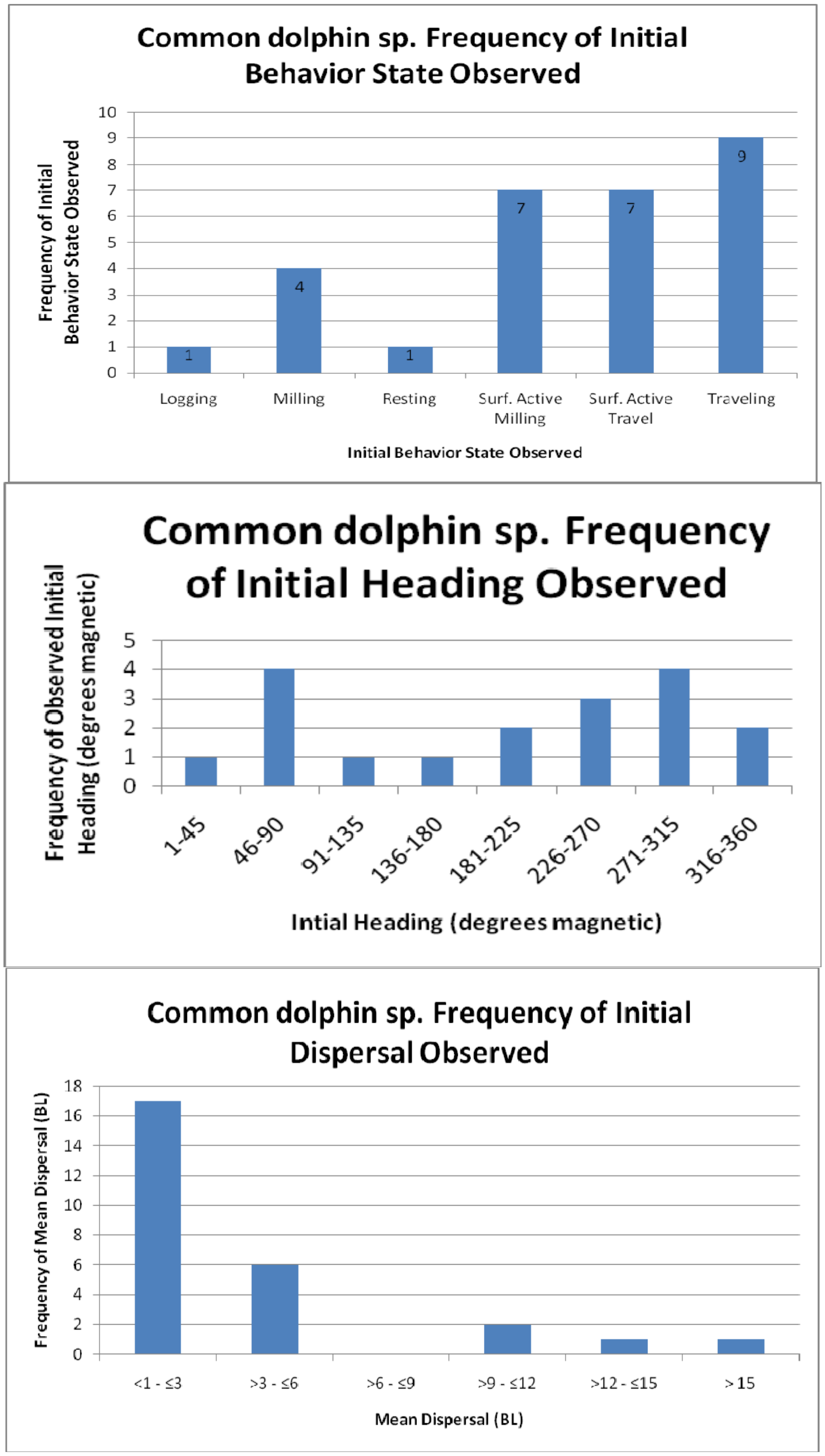
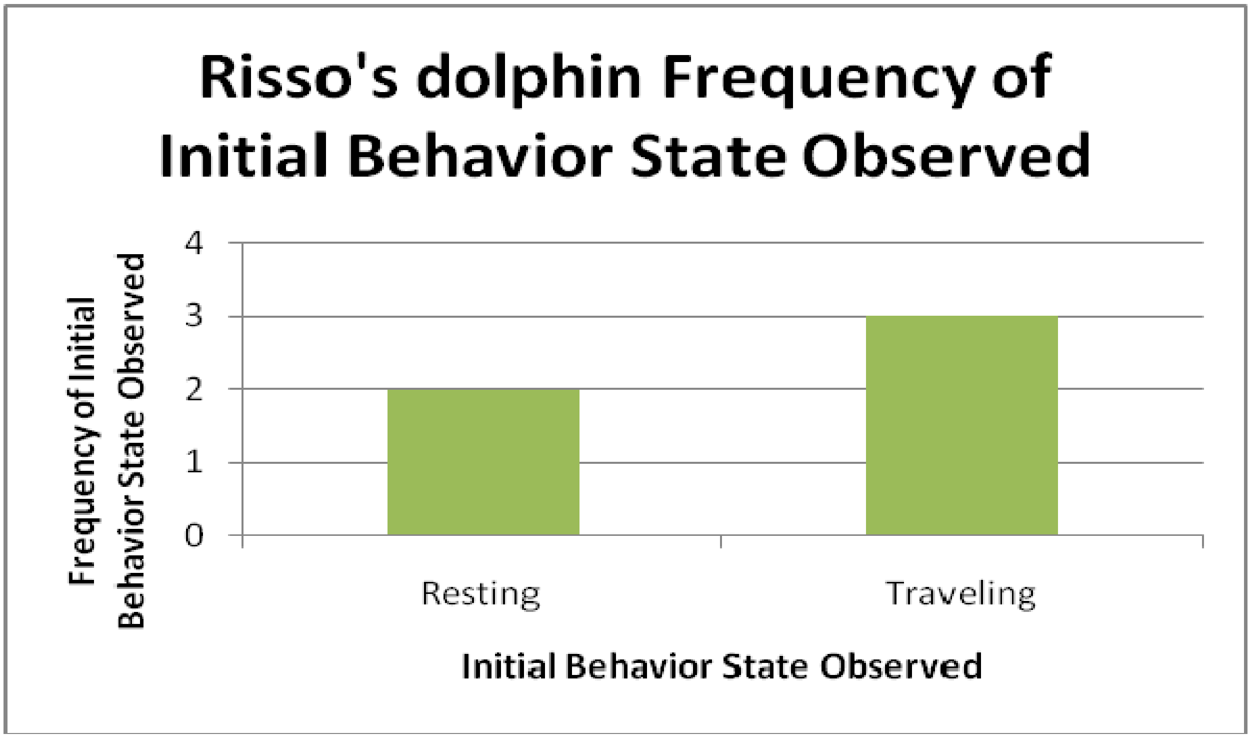


Figure 12. Common dolphins during the November SOCAL 2009 survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths).



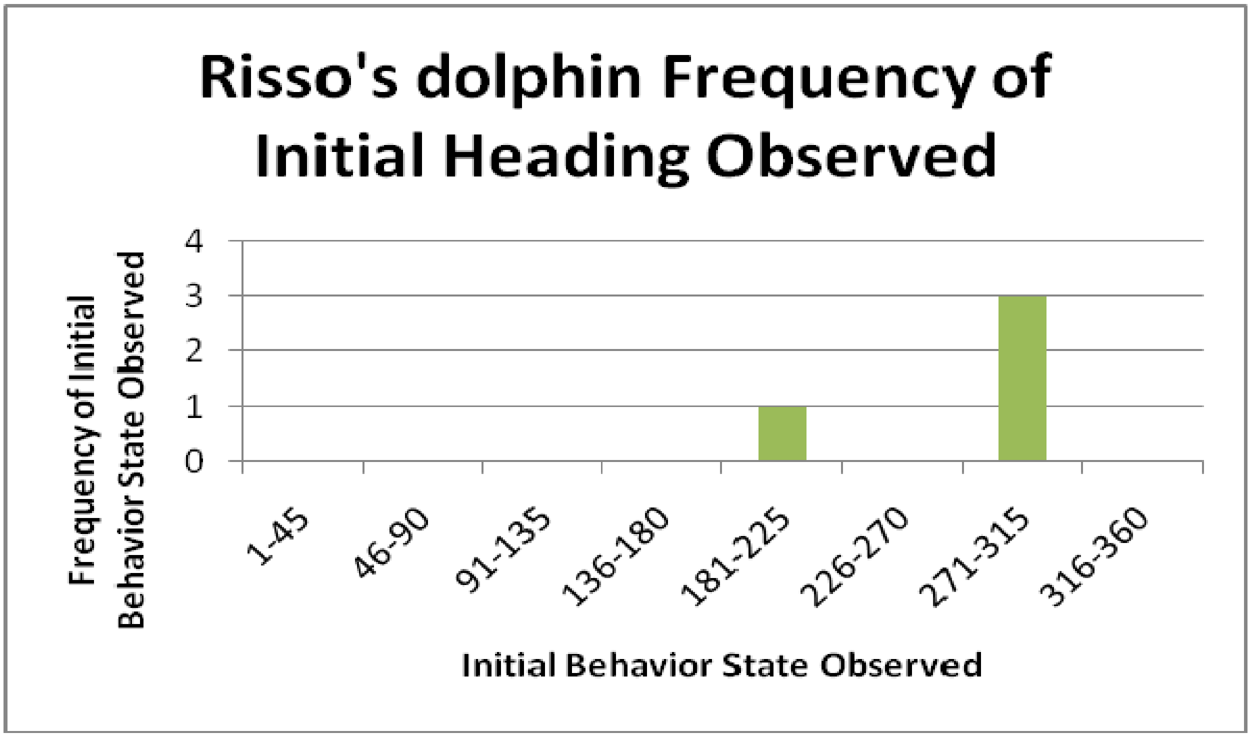


Figure 13. Risso's dolphins during the November SOCAL 2009 survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths).

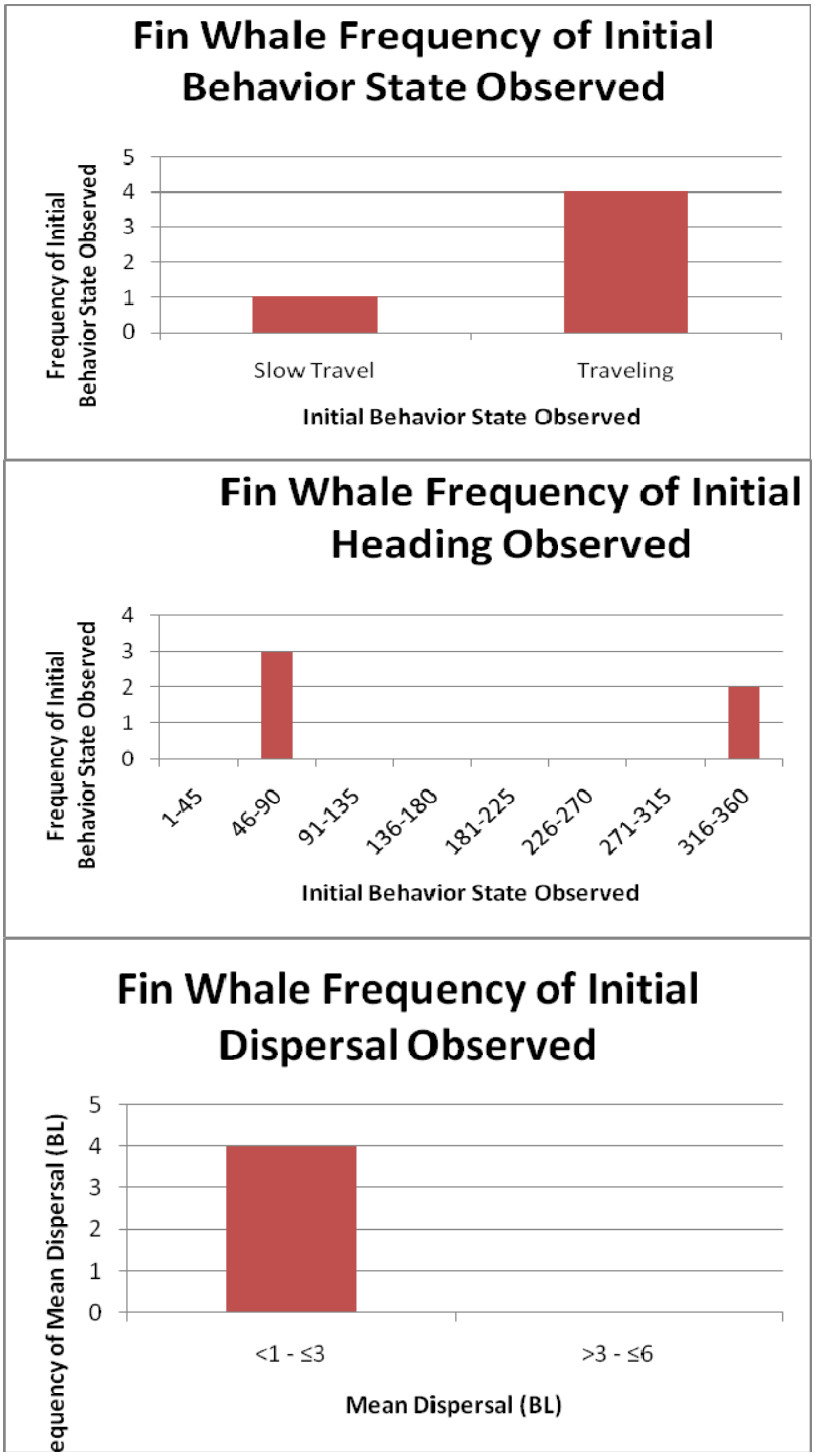


Figure 14. Fin whales during the November SOCAL 2009 survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths).

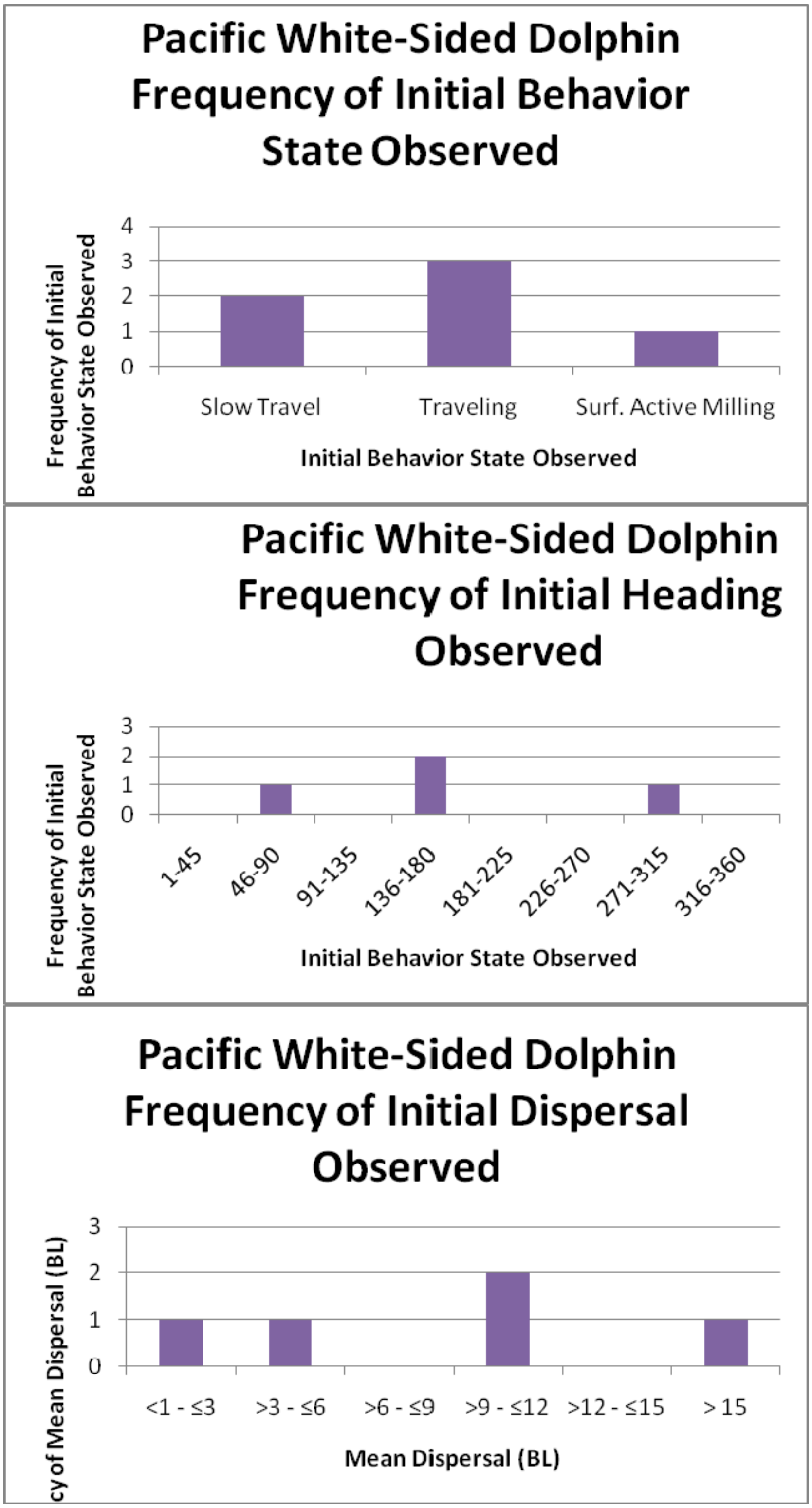


Figure 15. Pacific white-sided dolphins during the November SOCAL 2009 survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths).

Focal Follows

Approximately 26 (28%) of the 94 sightings were circled for at least 5 min by the aircraft to photo-verify species and make group-size estimates as needed/feasible. Ten of these sightings were circled for 10 to 43 min to conduct "extended focal follows" (>10 min) (defined in Smultea et al. 2009a)(Appendix B). For extended follows altitude was increased to 1200-1500 ft and radial distance maintained as possible at 0.5-1.0 km. The total 10 extended focal follows most frequently involved short-beaked common dolphins (*n* = 11) or Pacific white-sided dolphins (*n* = 4). Detailed analyses of focal follow behavioral data (e.g., re-orientation and respiration rates, dive times, etc.) were not conducted given the inability to know MFAS transmission times, the small sample sizes, budget limitations, and goals of the SOW. Detailed analyses of this kind may be undertaken in the future and combined with results herein to provide a larger sample size.

Unusual Observations

Our observations based on aerial survey effort are necessarily limited only to those animals we saw and most of those observations were brief in duration, restricting the ability to make a more informed assessment. However, a few notable behavioral events were recorded.

A distinctly unusual behavior we observed was a minke whale seen on November 21 at 14:10 (Table 3). This single whale was first seen breaching (Appendix C) and continued breaching nearly entirely out of the water repeatedly at a fast travel pace throughout most of the observations as we circled it at an altitude of over 1000 ft and a radial distance of over approximately 0.5 km (well beyond the theoretical Snell's Cone distance and thus outside the estimated underwater hearing distance of the nearby circling plane). None of the experienced (over 50 years of combined observation experience) had seen this type of behavior exhibited by a minke before. Upon later talking with other colleagues, they agreed that this repetitive breaching behavior by a minke was indeed unusual for the SOCAL region. Notably, the minke was seen about 50 min after an unusually rare group of about 55 killer whales (Appendix D) was first seen at 13:58 on the same day, on the same NAOPA survey line; the minke whale was about 50 km east of the killer whale sighting (Figures 8 and 9). It is possible that the minke may have been responding to the killer whales (assuming the killer whales were vocalizing and could be heard at that distance by the minke), as killer whales are known to prey upon large whales.

Other rare/unusual observations occurred on November 21 among the large group of socializing killer whales described above (see Appendix B). Numerous photographs were taken of this group as we followed the whales from the aircraft above 1000 ft altitude from 13:18 until 13:58. Photographs were taken of a juvenile killer whale apparently nursing as the adjacent adult rolled on its side and back. In the same photograph, another juvenile is approaching the apparent nursing pair within less than one body length (see Appendix D). Also, at a different time within this group, an apparent subadult male killer whale swam on its side with an erect penis observable through the water (see Appendix D).

Photography/Videography

Over 2219 digital photos were taken during ~42 (45%) of the total 94 sightings (Table 4). No photos were taken during the remaining 52 sightings because the animals were too far away and/or the sighting was too brief because we did not have time to circle and photograph them due to the priority to complete the survey grid in SOAR relative to fuel limitations.

A total of ~1.3 hr of video was taken during focal follows that was considered useable for behavioral analyses (Table 5). Video included footage of systematic observations of the behavior of Cuvier's beaked whales, Risso's dolphins, and killer whales, including systematically assessing the behavior of Risso's dolphins relative to the observation aircraft circling overhead for 5 min each at 2000, 1500 and 1000 feet altitude and approximately 1.0 km radial distance.

Aerial Survey Collaboration with Other Researchers

The pre-planning meeting held in San Diego by the Navy was critical in providing the opportunity for the various local researchers to communicate and assist one another. From the meeting, we were able to identify Navy activities and safety protocol, restricted areas during MTEs and other activities, communication protocols and types of communication available, and anticipated weather conditions. Other ongoing research coinciding with the aerial survey period described herein included small-vessel marine mammal research by Cascadia Research Collective and UC San Diego/SIO as well as passive acoustic studies conducted by Navy marine mammal researchers. The meeting provided a venue to meet face-to-face, exchange contact information for field and post-field purposes, and identify ways we could potentially communicate and assist one another in the field. In particular, radio and cell phone communications between the small-vessel researchers deploying from SCI and our aircraft crew allowed us to get on-site local weather conditions that were otherwise unattainable. This was critical in helping us effectively maximize and plan our limited aerial time. For example, when the vessel-based researchers alerted us that SOAR was fogged in, we would wait out the fog rather than waste time flying the approximately 45 min to SOAR to find out it could not be surveyed. We also assisted one another by sharing species sighting locations. For example, we alerted the small-vessel teams when we had priority species sightings including Cuvier's beaked whales and killer whales.

Table 4. Photo log of photographs taken during aerial survey monitoring in the SOCAL November 18 - 23, 2009.

Date	Time	Sighting ID	Species	Focal (Y/N)	Photo Frames
18-Nov	13:51	SOCAL SES_Nov09 001	Fin Whale	N	10-19
18-Nov	13:53	SOCAL SES_Nov09 003	Short-beaked Common Dolphin	N	20-70
18-Nov	14:57	SOCAL SES_Nov09 010	Short-beaked Common Dolphin	N	71-115
18-Nov	15:16	SOCAL SES_Nov09 013	Pacific White-Sided Dolphin	N	116-197
18-Nov	16:09	SOCAL SES_Nov09 015	Short-beaked Common Dolphin	N	198-253
18-Nov	16:27	SOCAL SES_Nov09 016	Short-beaked Common Dolphin	N	254-269
19-Nov	10:59	SOCAL SES_Nov09 021	California Sea Lion	N	271-289
19-Nov	11:12	SOCAL SES_Nov09 022	Cuvier's Beaked Whale	N	290-304
19-Nov	11:21	SOCAL SES_Nov09 023	Pacific White-Sided Dolphin	Y	306-350
19-Nov	12:46	SOCAL SES_Nov09 028	Long-beaked Common Dolphin	N	352-412
19-Nov	13:07	SOCAL SES_Nov09 030	Short-beaked Common Dolphin	Y	413-497, 531-544
19-Nov	13:13	SOCAL SES_Nov09 032	California Sea Lion	N	499-530
19-Nov	13:27	SOCAL SES_Nov09 033	Short-beaked Common Dolphin	Y	545-566
19-Nov	13:35	SOCAL SES_Nov09 034	Short-beaked Common Dolphin	Y	567-612
19-Nov	14:01	SOCAL SES_Nov09 036	Short-beaked Common Dolphin	N	613-656
20-Nov	12:32	SOCAL SES_Nov09 040	Short-beaked Common Dolphin	N	657-699
20-Nov	13:58	SOCAL SES_Nov09 041	Short-beaked Common Dolphin	N	700-744
21-Nov	10:02	SOCAL SES_Nov09 046	Short-beaked Common Dolphin	Y	745-789
21-Nov	10:11	SOCAL SES_Nov09 047	Short-beaked Common Dolphin	N	790-798
21-Nov	13:18	SOCAL SES_Nov09 054	Killer Whale	Y	799-1048
21-Nov	14:10	SOCAL SES_Nov09 055	Minke whale	Y	1049-1100
22-Nov	9:26	SOCAL SES_Nov09 059	Short-beaked Common Dolphin	Y	1102-1133
22-Nov	9:45	SOCAL SES_Nov09 060	Fin Whale	Y	1134-1175
22-Nov	9:59	SOCAL SES_Nov09 061	Fin Whale	Y	1176-1229
22-Nov	10:18	SOCAL SES_Nov09 063	Short-beaked Common Dolphin	Y	1230-1312
22-Nov	12:12	SOCAL SES_Nov09 065	Short-beaked Common Dolphin	Y	1314-1389
22-Nov	12:37	SOCAL SES_Nov09 066	Common Dolphin sp.	N	1391-1431
23-Nov	8:25	SOCAL SES_Nov09 072	Common Dolphin sp.	N	1432-1473
23-Nov	8:46	SOCAL SES_Nov09 073	Killer Whale	Y	1474-1641
23-Nov	10:15	SOCAL SES_Nov09 075	Cuvier's Beaked Whale	Y	1642-1751
23-Nov	11:08	SOCAL SES_Nov09 077	Short-beaked Common Dolphin	N	1752-1810
23-Nov	11:18	SOCAL SES_Nov09 080	California Sea Lion	N	1811-1868
23-Nov	11:21	SOCAL SES_Nov09 082	California Sea Lion	N	1869-1902
23-Nov	11:26	SOCAL SES_Nov09 083	Short-beaked Common Dolphin	N	1903-1938
23-Nov	11:37	SOCAL SES_Nov09 084	Common Dolphin sp.	Y	1939-1960
23-Nov	14:13	SOCAL SES_Nov09 087	Pacific White-Sided Dolphin	N	1961-1975
23-Nov	14:23	SOCAL SES_Nov09 088	Short-beaked Common Dolphin	Y	1976-1990
23-Nov	14:33	SOCAL SES_Nov09 089	Pacific White-Sided Dolphin	Y	1991-2048
23-Nov	14:52	SOCAL SES_Nov09 090	Risso's Dolphin	Y	2049-2140
23-Nov	14:53	SOCAL SES_Nov09 091	Risso's Dolphin	N	2141-2153
23-Nov	15:31	SOCAL SES_Nov09 092	Pacific White-Sided Dolphin	N	2154-2197
23-Nov	15:59	SOCAL SES_Nov09 093	Pacific White-Sided Dolphin	Y	2198-2219

Table 6. Video log of usable video taken during aerial survey monitoring in the SOCAL November 18 - 23, 2009.

Date	Start Time	End Time	Total Video (hr::min:sec)	Sighting ID	Species	Video Notes
19-Nov	11:14:15	11:15:40	0:01:25	SOCAL SES_Nov09 022	Cuvier's beaked whale	Limited usable video, animals not at surface during recording
19-Nov	11:59:33	12:21:44	0:22:11	SOCAL SES_Nov09 027	Risso's dolphin	Usable video, able to decipher body dispersal and basic behavior
19-Nov	12:22:21	12:43:20	0:20:59	SOCAL SES_Nov09 027	Risso's dolphin	Useable video, able to decipher body dispersal, sub groups and basic behavior
21-Nov	13:24:56	13:25:51	0:00:55	SOCAL SES_Nov09 054	Killer whale	Useable video, relative glare blocks view for a portion of the video, able to decipher body dispersal, sub groups and basic behavior
21-Nov	13:25:54	13:48:31	0:22:37	SOCAL SES_Nov09 054	Killer whale	Useable video, no glare, able to decipher body dispersal, sub groups and basic behavior, zoomed in and clear for much of the video.
21-Nov	13:25:54	13:35:04	0:09:10	SOCAL SES_Nov09 054	Killer whale	Useable video, limited glare, able to decipher body dispersal, sub groups and basic behavior and surface-active behavior, possible reaction.
			Total = 1.3 Hours			

Section 4 Discussion

Key Role of Aerial Surveys

Survey results provide further support of the key and unique roles that aerial surveys play in addressing Navy monitoring plan goals (see review in Smultea et al. 2009a,b). These include:

- providing the advantage of surveying key Navy areas of interest (e.g., areas W and E of SCI) within one day, providing a “snapshot” of marine mammal numbers, presence, distribution and behavior before, during and after MTEs,
- collecting quantifiable behavioral data known to be indices of stress/disturbance,
- conducting focal follows of priority cetacean species including video-documentation of underwater behavior,
- providing a platform from which the behavior and potential reactions of cetaceans to MTEs may be studied without confounding results (vs. from vessels), and
- locating and identifying dead floating and stranded animals.

Section 5 Recommendations

A comprehensive list of recommendations to improve data collection techniques, analyses, interpretations, and applications was provided in the SOCAL 2008 and 2009 aerial survey reports (Smultea et al. 2009a,b). Below are a few recommendations in addition to those.

1. Sighting data from 2008 and 2009 SOCAL aerial surveys should be preliminarily analyzed using free DISTANCE software (Buckland et al. 2001) to ascertain whether existing samples sizes are sufficiently large to calculate reasonable abundance and density estimates for some marine mammal species. This requires additional data analysis and preparation beyond the scope of this study. This is important to assess whether changes in abundance can be statistically linked to before, during and after MFAS activity periods. Additional DISTANCE analyses can be conducted if preliminary results are promising.

2. Preliminary and follow-up statistical analyses of behavioral indices successfully collected and summarized herein should be analyzed using a behavioral analysis program. These data could be analyzed in excel using summary and other statistics. This analysis was beyond the scope of our study. Such information is important to statistically identify minimum sample sizes required to identify statistically significant changes in attributes that could be related to MFAS activities, in consultation with a professional statistician.

3. Video of behavioral data collected during this study should be analyzed using Noldus video analysis software (www.noldus.com) or other video analysis software. Analysis of video data is typically a tedious and time-consuming process. However, Noldus has developed video data analysis software that increases analysis efficiency and helps to standardize the process. Such results provide the most detailed and accurate method for objectively quantifying measurable behavioral data (e.g., inter-animal dispersal distances, respiration rates, relative changes in orientation, frequency of behaviors, etc.) because videotape can be re-reviewed, etc. The most effective approach is to combine the video data with a recorded vocal narration of behavior, notes taken using a behavioral software program, e.g., BioSpectator Go, and/or handwritten notes on forms, all of which we did during the study. This approach has been successfully used to quantify and identify subtle and other significant changes in measurable behavioral variables of bowhead, gray and humpback whales, that in turn were statistically shown to be influenced by anthropogenic underwater sound and other stimuli (reviewed in Richardson et al. 1995). However, the above analyses were beyond the scope of the current study.

4. Formal Pre-Planning Meetings should continue to be conducted and attended by all key research and Navy representatives involved with the aerial surveys as well as other entities conducting research in the same areas. This allows coordinating and maximizing the ability of various simultaneously operating platforms to collect data useful to assess potential effects of Navy training activities on marine mammals. This helps to reduce data-collection costs through multi-use of platforms. It also increases efficiency and safety of field operations and provides the opportunity for team building, data sharing, and collaboration.

5. A formal post-field Information Transfer Meeting should be held ~2-3 months after the fiscal monitoring year has been completed. This allows the various researchers and Navy representatives to share data and techniques, to identify additional future collaborative efforts, and to build relationships between researchers and Navy representatives involved in the activities. This could include Navy personnel explaining the challenges faced when trying to coordinate and obtain approval for the monitoring research, and identifying ways in which researchers can assist in this process. It also gives both research and Navy representatives the opportunity to question one another about results and goals, and to identify ways to improve and smooth related endeavors, and to assist one another in data collection and meeting study goals.
6. Sighting rates for each species and leg type and overall sighting rates for marine mammals in general for aerial survey effort will be discussed in the May 2010 aerial survey report.

Section 6 Acknowledgements

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Appendix A List of All November 2009 Sightings

Appendix A. 18-23 November 2009: Summary of all individual marine mammal sightings, including location latitudes and longitudes, made during the SOCAL 2009 aerial monitoring surveys off San Diego, California.

Date 2009	Estim. Group Size	Species Common Name	Species Scientific Name	Initial time	Latitude °N	Longitude °W
18-Nov	2	Fin Whale	*Balaenoptera physalus*	13:51:04	32.68913	117.44074
18-Nov	1	California Sea Lion	*Zalophus californianus*	13:53:32	32.67002	117.44039
18-Nov	700	Short-beaked Common Dolphin	*Delphinus delphis*	13:53:50	32.66984	117.42958
18-Nov	2	California Sea Lion	*Zalophus californianus*	13:57:21	32.66727	117.44552
18-Nov	1	California Sea Lion	*Zalophus californianus*	14:10:54	32.65277	117.62013
18-Nov	1	California Sea Lion	*Zalophus californianus*	14:11:48	32.64681	117.64692
18-Nov	3	California Sea Lion	*Zalophus californianus*	14:27:28	32.68284	117.99215
18-Nov	1	California Sea Lion	*Zalophus californianus*	14:36:10	32.71965	117.80952
18-Nov	1	California Sea Lion	*Zalophus californianus*	14:50:27	32.87171	117.38854
18-Nov	2200	Short-beaked Common Dolphin	*Delphinus delphis*	14:57:13	32.91285	117.45735
18-Nov	1	California Sea Lion	*Zalophus californianus*	15:09:36	32.88289	117.59560
18-Nov	1	California Sea Lion	*Zalophus californianus*	15:09:36	32.88289	117.59560
18-Nov	4	Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	15:16:58	32.82819	117.83760
18-Nov	1	California Sea Lion	*Zalophus californianus*	15:55:36	32.91363	118.07924
18-Nov	100	Short-beaked Common Dolphin	*Delphinus delphis*	16:09:28	33.00604	117.62626
18-Nov	15	Short-beaked Common Dolphin	*Delphinus delphis*	16:27:28	33.15057	117.52497
18-Nov	1	Unknown Small Marine Mammal	Cetacea or Pinnipedia	16:33:54	33.13287	117.59280
18-Nov	44	Unknown Small Dolphin	Delphinidae sp.	16:49:20	33.09864	117.61693
19-Nov	1	Unknown Small Dolphin	Delphinidae sp.	10:49:22	33.01333	118.13102
19-Nov	3	California Sea Lion	*Zalophus californianus*	10:50:37	33.01181	118.16543
19-Nov	3	California Sea Lion	*Zalophus californianus*	10:59:28	33.00926	118.15465
19-Nov	1	Cuvier's Beaked Whale	*Ziphius cavirostris*	11:12:05	33.05897	118.48570
19-Nov	9	Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	11:21:12	33.07514	118.43829
19-Nov	1	California Sea Lion	*Zalophus californianus*	11:27:44	33.07574	118.40604
19-Nov	1	California Sea Lion	*Zalophus californianus*	11:56:06	33.30809	117.62477
19-Nov	1	California Sea Lion	*Zalophus californianus*	11:56:43	33.32059	117.63944
19-Nov	38	Risso's Dolphin	*Grampus griseus*	11:56:57	33.32366	117.64320
19-Nov	50	Long-beaked Common Dolphin	*Delphinus capensis*	12:46:19	33.37649	117.64842
19-Nov	3	California Sea Lion	*Zalophus californianus*	13:07:11	33.26698	118.19724
19-Nov	1250	Short-beaked Common Dolphin	*Delphinus delphis*	13:07:42	33.26326	118.21339
19-Nov	5	California Sea Lion	*Zalophus californianus*	13:09:49	33.25728	118.22596
19-Nov	48	California Sea Lion	*Zalophus californianus*	13:13:33	33.26036	118.22353
19-Nov	150	Short-beaked Common Dolphin	*Delphinus delphis*	13:27:51	33.24113	118.31784

Date 2009	Estim. Group Size	Species Common Name	Species Scientific Name	Initial time	Latitude °N	Longitude °W
19-Nov	225	Short-beaked Common Dolphin	*Delphinus delphis*	13:35:49	33.22538	118.39483
19-Nov	209	Common Dolphin sp.	*Delphinus* sp.	13:48:31	33.14809	118.54843
19-Nov	500	Short-beaked Common Dolphin	*Delphinus delphis*	14:01:42	33.08187	118.08963
20-Nov	2	Unknown Dolphin	Delphinidae sp.	10:51:47	32.85782	117.27065
20-Nov	1	Unknown Medium Whale	Cetacea	11:40:45	33.04281	119.10160
20-Nov	150	Common Dolphin sp.	*Delphinus* sp.	12:23:11	33.12370	118.82376
20-Nov	150	Short-beaked Common Dolphin	*Delphinus delphis*	12:32:17	33.15428	118.73392
20-Nov	75	Short-beaked Common Dolphin	*Delphinus delphis*	13:58:45	32.74472	118.76582
20-Nov	150	Unknown Dolphin	Delphinidae sp.	13:59:55	32.76465	118.74965
20-Nov	1	Unknown Pinniped	Pinnipedia	14:36:56	32.68159	118.00736
20-Nov	1	Unknown Marine Mammal	Cetacea or Pinnipedia	14:37:44	32.68712	117.98355
20-Nov	6	California Sea Lion	*Zalophus californianus*	14:55:12	32.81191	117.37985
21-Nov	800	Short-beaked Common Dolphin	*Delphinus delphis*	10:02:45	32.92006	117.59237
21-Nov	16	Short-beaked Common Dolphin	*Delphinus delphis*	10:11:46	32.95104	117.69774
21-Nov	1	California Sea Lion	*Zalophus californianus*	12:33:42	32.96914	118.58096
21-Nov	1	California Sea Lion	*Zalophus californianus*	12:38:30	33.02688	118.55594
21-Nov	4	Bottlenose Dolphin	*Tursiops truncatus*	12:40:23	32.98140	118.52742
21-Nov	4	California Sea Lion	*Zalophus californianus*	12:42:49	32.92923	118.47136
21-Nov	1	California Sea Lion	*Zalophus californianus*	12:44:50	32.88396	118.41644
21-Nov	1	California Sea Lion	*Zalophus californianus*	12:46:04	32.86141	118.38637
21-Nov	55	Killer Whale	*Orcinus orca*	13:18:29	33.01147	118.13367
21-Nov	1	Minke whale	*Balaenoptera acutorostrata*	14:10:48	33.12108	117.63501
21-Nov	45	Risso's Dolphin	*Grampus griseus*	14:21:55	32.99077	117.43195
21-Nov	15	Unknown Dolphin	Delphinidae sp.	14:28:14	32.85645	117.27518
22-Nov	2	Unknown Dolphin	Delphinidae sp.	9:07:57	32.86910	117.29496
22-Nov	1150	Short-beaked Common Dolphin	*Delphinus delphis*	9:26:13	33.01536	117.96945
22-Nov	2	Fin Whale	*Balaenoptera physalus*	9:45:14	33.11754	118.58091
22-Nov	2	Fin Whale	*Balaenoptera physalus*	9:59:51	33.15439	118.88303
22-Nov	900	Common Dolphin sp.	*Delphinus* sp.	10:17:20	33.08472	119.01415
22-Nov	1300	Short-beaked Common Dolphin	*Delphinus delphis*	10:18:53	33.06281	119.05640
22-Nov	1	Unknown Large Whale	Cetacea	10:29:09	32.97671	119.21522
22-Nov	175	Short-beaked Common Dolphin	*Delphinus delphis*	12:12:28	32.80048	118.76859
22-Nov	80	Common Dolphin sp.	*Delphinus* sp.	12:37:36	32.83863	118.60928
22-Nov	9	Risso's Dolphin	*Grampus griseus*	13:09:11	32.77275	117.96823
22-Nov	850	Common Dolphin sp.	*Delphinus* sp.	13:14:40	32.79440	117.73471
22-Nov	1	Unknown Dolphin	Delphinidae sp.	13:24:15	32.83645	117.33218
23-Nov	1	Unknown Pinniped	Pinnipedia	7:59:56	32.87120	117.31362

Date 2009	Estim. Group Size	Species Common Name	Species Scientific Name	Initial time	Latitude °N	Longitude °W
23-Nov	2	Fin Whale	*Balaenoptera physalus*	8:12:06	32.97615	117.78029
23-Nov	25	Common Dolphin sp.	*Delphinus* sp.	8:25:38	33.06319	118.33086
23-Nov	12	Killer Whale	*Orcinus orca*	8:46:32	33.08380	119.02205
23-Nov	1	Unknown Pinniped	Pinnipedia	10:13:14	32.84582	119.04101
23-Nov	5	Cuvier's Beaked Whale	*Ziphius cavirostris*	10:15:44	32.88215	118.97244
23-Nov	1	Fin Whale	*Balaenoptera physalus*	10:56:51	33.02622	118.72665
23-Nov	50	Short-beaked Common Dolphin	*Delphinus delphis*	11:08:21	33.25804	118.47327
23-Nov	3	Long-beaked Common Dolphin	*Delphinus capensis*	11:16:14	33.29372	118.31627
23-Nov	3	California Sea Lion	*Zalophus californianus*	11:16:14	33.29372	118.31627
23-Nov	5	California Sea Lion	*Zalophus californianus*	11:18:47	33.28388	118.27686
23-Nov	1	California Sea Lion	*Zalophus californianus*	11:20:38	33.28070	118.25271
23-Nov	26	California Sea Lion	*Zalophus californianus*	11:21:01	33.27875	118.24051
23-Nov	800	Short-beaked Common Dolphin	*Delphinus delphis*	11:26:51	33.27671	118.15614
23-Nov	11	Common Dolphin sp.	*Delphinus* sp.	11:37:01	33.25588	117.90258
23-Nov	6	Unknown Dolphin	Delphinidae sp.	12:05:18	32.86544	117.30841
23-Nov	1	Unknown Pinniped	Pinnipedia	12:05:59	32.85934	117.28662
23-Nov	20	Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	14:13:03	32.92111	117.29726
23-Nov	10	Short-beaked Common Dolphin	*Delphinus delphis*	14:23:08	33.06743	117.35761
23-Nov	35	Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	14:33:50	33.18030	117.45937
23-Nov	65	Risso's Dolphin	*Grampus griseus*	14:52:00	33.44473	117.76702
23-Nov	10	Risso's Dolphin	*Grampus griseus*	14:53:55	33.47875	117.77623
23-Nov	200	Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	15:31:33	33.25700	117.63232
23-Nov	6	Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	15:59:52	32.92333	117.30729
23-Nov	1	Unknown Dolphin	Delphinidae sp.	16:08:16	32.87046	117.27654

Appendix B List of All November 2009 Focal Observations

Appendix B. 18-23 November 2009: Summary of all focal observations (total observation time at least 5 min long), including location (latitude/ and longitude) made during the SOCAL 2009 aerial monitoring surveys off San Diego, California.

Date	Initial Time	Total Observation Time (hh:mm:ss)	Latitude°	Longitude°	Species	Estimated Group Size	Initial Behavior State	Sighting Notes
18-Nov	13:53:50	0:10:10	32.66984	117.4296	Short-beaked common dolphin	700	Surface-Active Milling	
18-Nov	15:16:58	0:18:40	32.82819	117.8376	Pacific white-sided dolphin	4	Travel	
18-Nov	16:09:28	0:05:25	33.00604	117.6263	Short-beaked common dolphin	100	Travel	
18-Nov	16:27:28	0:05:09	33.15057	117.525	Short-beaked common dolphin	15	Milling	possible feeding, bird associated
19-Nov	11:21:12	0:06:17	33.07514	118.4383	Pacific white-Sided dolphin	9	Travel	possible feeding
19-Nov	11:56:57	0:43:00	7:46:04	117.6432	Risso's dolphin	38	Resting	Conducted focal observation at1500 ft , boat approached, possible reaction, subgroups joined then separated after boat left
19-Nov	13:07:42	0:18:48	33.26326	118.2134	Short-beaked common dolphin	1250	Surface- Active Travel	
19-Nov	13:27:51	0:06:38	33.24113	118.3178	Short-beaked common dolphin	150	Milling	
19-Nov	13:35:49	0:05:16	33.22538	118.3948	Short-beaked common dolphin	225	Surface- Active Travel	
20-Nov	11:40:45	0:25:27	33.04281	119.1016	Unidentified medium whale	1	Resting	Logging at surface
21-Nov	10:02:45	0:07:46	32.92006	117.5924	Short-beaked common dolphin	800	Travel	
21-Nov	13:18:29	0:39:47	33.01147	118.1337	Killer whale	55	Travel	Closed saddles, likely transients, nursing, male with erect penis photographed (apparent subadult); no large adult males observed
21-Nov	14:10:48	0:05:38	33.12108	117.635	Minke whale	1	Surface-Active Travel	Breaching when first observed, continued repetitive breaching
22-Nov	9:26:13	0:07:25	33.01536	117.9695	Short-beaked common dolphin	1150	Surface- Active Milling	Bird association, group spread over 8 km, dolphins tight

Date	Initial Time	Total Observation Time (hh:mm:ss)	Latitude°	Longitude°	Species	Estimated Group Size	Initial Behavior State	Sighting Notes
								circling
22-Nov	9:45:14	0:08:02	33.11754	118.5809	Fin whale	2	Slow Travel	
22-Nov	9:59:51	0:11:46	33.15439	118.883	Fin whale	2	Travel	
22-Nov	10:18:53	0:05:34	33.06281	119.0564	Short-beaked common dolphin	1300	Travel	
22-Nov	10:29:09	0:07:00	32.97671	119.2152	Unidentified large whale	1	Other	Unable to observe in close range due to restricted airspace area
23-Nov	8:46:32	0:34:36	33.0838	119.0221	Killer whale	12	Traveling	
23-Nov	10:15:44	0:33:03	32.88215	118.9724	Cuvier's beaked whale	5	Logging	Long skinny, white bodies observed. Brought aircraft up to 1500 ft altitude for focal observation, body length approx. 15 to 20 ft
23-Nov	11:37:01	0:07:26	33.25588	117.9026	Common dolphin sp.	11	Milling	With birds and seaweed
23-Nov	14:23:08	0:05:49	33.06743	117.3576	Short-beaked common dolphin	10	Travel	Bird association, group stayed below surface
23-Nov	14:33:50	0:05:01	33.1803	117.4594	Pacific white-Sided dolphin	35	Surface-active Travel	Bird association, possible feeding
23-Nov	14:52:00	0:29:03	33.44473	117.767	Risso's dolphin	65	Travel	Two subgroups.
23-Nov	15:59:52	0:07:25	32.92333	117.3073	Pacific white-Sided dolphin	6	Travel	

Appendix C Minke Whale Photos

Minke whale (Balaenoptera acutorostrata) breach sequence as observed from the aircraft on November 21 using a telephoto lens during the November 2009 SOCAL marine mammal monitoring survey off San Diego, California, demonstrating the ability to observe cetaceans and behavior sub-surface during an aerial survey. Photos by Mark Deakos courtesy of Smultea Environmental Sciences.

Appendix D Killer Whale Photos

Below are photos from a rare (for southern California) sighting of killer whales (Orcinus orca) observed on November 21 from the aircraft during the November 2009 SOCAL marine mammal monitoring survey off San Diego, California (see Appendix B). Photographs were taken (with a telephoto lens) of a calf apparently nursing from an adjacent adult lying on its side underwater while another juvenile approached the pair (right photo below). A subadult male with an erect penis was also photographed as it approached another individual from the rear to within 0.25 body length (third photo below). Photos by Mark Deakos courtesy of Smultea Environmental Sciences.

Aerial Survey Marine Mammal Monitoring off Southern California in Conjunction with US Navy Major Training Events (MTE)

SOCAL May 13-18, 2010

Draft Report

Authors:

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Cover Photos: Blue whale (Balaenoptera musculus), common dolphins (Delphinus sp.) and Pacific white-sided dolphins (Lagenorhynchus obliquidens) photographed with a telephoto lens from the Partenavia fixed-wing aircraft during the May 2010 SOCAL aerial monitoring survey. Photos by Mari A. Smultea/SES. Cover page design and layout by Kate Lomac-MacNair and Roxann Merizan.

Section 1 Introduction

In support of the U.S. Navy's (Navy) Marine Mammal Monitoring Plan (M3P) in the Southern California Range Complex (SOCAL) (DoN 2009), aerial surveys were conducted by Smultea Environmental Sciences (SES) to monitor marine mammals and sea turtles (MM/ST) during May 2010 in the SOCAL area off San Diego, California. This was the sixth such aerial survey 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). Portions of these MTEs occurred in and near offshore waters of the Southern California Anti-submarine Warfare Range (SOAR) west of San Clemente Island (Figure 1). Naval training has been conducted within SOCAL for over 40 years, and marine mammals are also known to be abundant there (e.g., summarized in Carretta et al. 2000, 2008; DoN 2008, 2009).

The contracted work involved considerable planning and communications with and by the Navy Technical Representative (NTR) given the logistical complexity of the MTEs, the need to coordinate multiple Navy aircraft and vessel activities, and the high degree of safety planning. Clearance from various Navy commands was obtained by Navy environmental planners on behalf of SES prior to the research aircraft flying in the SOCAL. Aerial surveys were also coordinated with other marine mammal researchers conducting passive acoustics, tagging, photo-identification, and behavioral studies from small vessels in the SOCAL, some of which were funded by the Office of Naval Research (ONR) and N45 funds (e.g., the Naval Undersea Warfare Center [NUWC], Scripps Institute of Oceanography [SIO], and Cascadia Research Collective [CRC]) (e.g., see Falcone et al. 2009a,b). This served to identify ways researchers could collaborate and assist one another in obtaining complimentary data.

Project questions and hypotheses were developed by SES based on the five questions identified in the Navy's SOCAL M3P designed to assess potential effects of MFAS and underwater detonations on MM/ST during Navy MTEs (DoN 2009; see Smultea et al. 2009a,b). An important factor limiting the ability to assess potential effects of MFAS in this report is that the Navy did not disclose MFAS transmission times and locations for national security reasons. Thus, it is not possible for us herein to compare data from specific operational MFAS "on" and "off" periods during MTEs, nor data on distance and relative location of MFAS sources vs. sightings.

Protocol was similar to that implemented for aerial surveys in SOCAL in summer and fall 2009 designed 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, to address growing interest by NMFS and the NTR the May 2010 survey effort focused more on collecting behavioral data using focal follow techniques by circling sightings for extended periods and obtaining video (see Methods below).

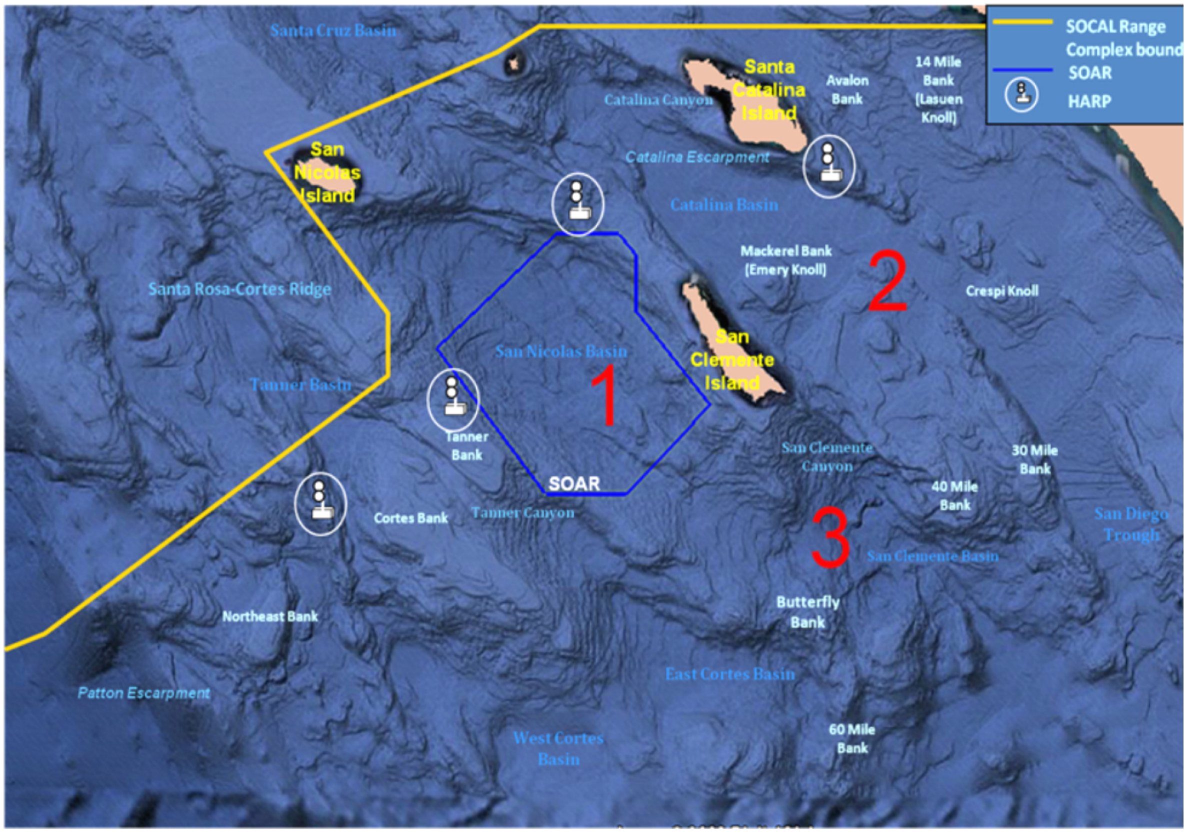

Figure 1. Location of the aerial survey monitoring area and underwater topographic features within the Navy's Southern California Range Complex (SOCAL). Numbers indicate survey areas of interest to the Navy in order of priority; orange line designates the SOCAL boundary; blue lines designate the Southern California Offshore Anti-submarine Warfare Range (SOAR); icons are approximate locations of Navy-funded bottom-mounted passive- acoustic high-frequency acoustic recording packages (HARPs).

Section 2 Methods

The approach implemented to address SOCAL M3P requirements was to conduct surveys to monitor the occurrence and behavior of MM/ST from a small fixed-wing aircraft in the SOCAL relative to MFAS transmission periods. The primary survey areas were SOAR west of San Clemente Island (SCI) and the Northern Air Operating Area (NAOPA) range between SCI and the mainland coast (Figure 1). This involved implementing "search", "verify", and "focal follow" modes as described in Smultea et al. (2009a,b). Notably, sea turtles were considered unlikely to be seen in the MTE based on available data and none have been seen during this or our past aerial surveys (reviewed in DoN 2008).

As described in Smultea et al. (2009a), priority species were (1) MM/ST exhibiting unusual or distressed behavior, (2) near-stranded, stranded, or dead MM/ST, (3) MM/ST species listed as endangered or threatened under the ESA, (4) beaked whales, and (5) Risso's dolphins, dwarf/pygmy sperm whales, and other deep-diving odontocetes considered potential "surrogate" representatives for deep-diving beaked whales (see DoN 2009).

A Partenavia P68, twin-engine, fixed-wing aircraft was used for the May 2010 survey. Line-transect "search" effort occurred at altitude 1000 ft and speed 100 kt; occasionally, we flew as low as 700 ft altitude (as permitted by a Letter of Confirmation and General Authorization for Scientific Research issued by NMFS to SES) over non-ESA-listed species to photo-verify species (i.e., "verify" mode), or when low clouds necessitated lower flight altitude. Altitudes of 1200-1500 ft were flown while circling sightings to obtain behavioral data in "focal follow" mode (see Smultea et al. 2009a,b). As in past surveys, we used two Apple iTouches for field data collection (one for line-transect and one for focal behavior data). The recently released Apple iPad was tried the first survey day; however, technical limitations related to software interfacing of this new system quickly became apparent. Expected software revisions are anticipated to allow future use of the iPad.

Section 3 Results

This section closely follows the format of the summer and fall 2009 SOCAL aerial survey monitoring reports (Smultea et al. 2009a,b). Results are summarized in Tables 1 through 5 and Figures 2 through 9. More detailed results are provided in Appendices A through D.

Effort

A total of 28.40 hr of flight time and 4,891 km (2641 nm) of flight effort were conducted during the May 2010 SOCAL aerial survey between aircraft "wheels up" off the ground to "wheels down" when the plane landed (Table 10 and Table 11). Surveys were flown every day from May 13 through May 18 for a total of five flight days. Most (43%) of the total 4,891 km of observation effort involved circling sightings for focal follows and/or species identification. This was followed by systematic line-transect (26%), transit (21%), random effort (8%), and island circumnavigation (2%) (Table 11). Beaufort sea state rating (Bf) ranged from 1-4 during the May survey. Bf 3 predominated (52%) followed by Bf 2 (36%) (Figure 11). Effort occurred in FLETA HOT only on May 15, as requested by the NTR; surveys in FLETA HOT had not been conducted since the November 2008 aerial survey monitoring (Smultea et al. 2009a). Effort occurred in SOAR west of SCI only on May 16 and was limited to the northern one-half of SOAR due to low clouds and to avoid airspace conflicts with Navy activities as directed by Navy personnel (Table 10, Figure 9). SCI was circumnavigated to search for potential strandings on May 17.

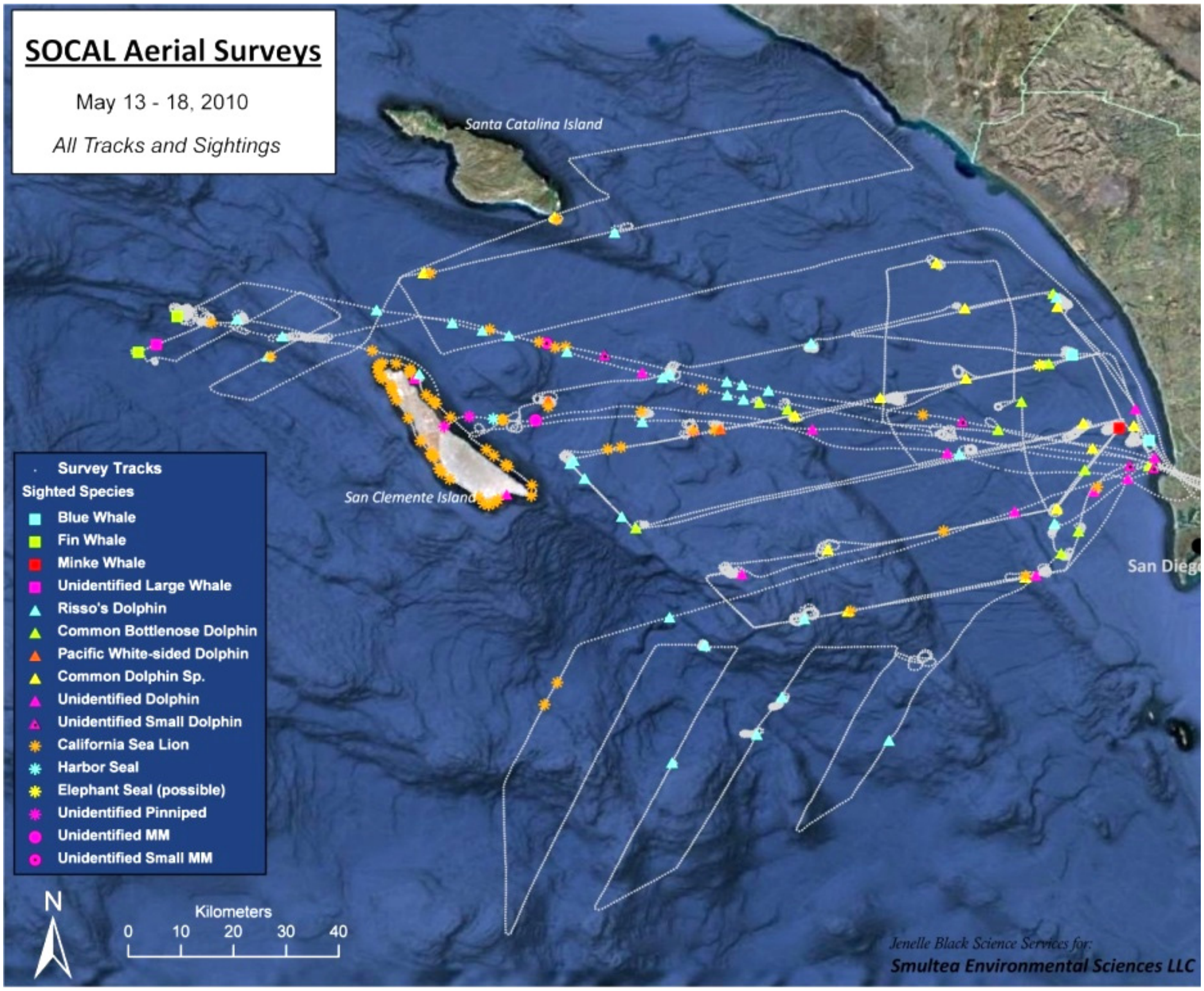

Figure 9. All track lines and sightings made during aerial monitoring surveys in SOCAL May 13 – 18, 2010.

Table 10. Aerial survey flight times, total hours (hh:mm) by date, and survey area during the May SOCAL 2010 aerial survey.

Date	Time Engines On	Time Engines Off	Total Engine Time	Time Wheels Up	Time Wheels Down	Total Flight Time	Flight Area	Comments
13-May	8:51	14:03	5:12	8:58	14:01	5:03:14	NAOPA	Bernd Wuersig flying, priority is focals. Mostly Beaufort 2 some 3.
14-May	14:05	10:31	3:34	10:37	14:04	3:26:12	N SOAR	Bernd Wuersig flying, priority is focals. Low marine cloud layer in morning delays start and limits our ability to fly high.
15-May	16:02	11:08	4:53	11:19	16:00	4:41:11	FLETA HOT	Completed survey grid at FLETA HOT.
16-May	13:01	17:41	4:40	13:07	17:39	4:31:54	SOAR	Overcast, heavy low marine layer in morning prevented us from flying until afternoon. Low clouds at SOAR closed in on us and had to leave SOAR.
17-May	9:37	13:35	3:58	9:42	13:35	3:52:39	NAOPA, San Clemente Island	Circumnavigated San Clemente Island, no strandings seen. Completed this first flight then refueled and made second flight this day.
17-May	14:57	17:56	2:59	15:03	17:54	2:50:37	Central NAOPA	Second flight, looking for Risso's and large whales for focal sessions.
18-May	9:07	13:33	4:26	9:15	13:32	4:16	SE corner of NAOPA	Low- lying clouds pushing from west and south.
		Total Engine Time	29:44		**Total Hours Flown**	28:42		

Table 11. Definitions and summary of aerial survey effort (km and nm) by leg type during the May SOCAL 2010 MTE aerial surveys.

Leg Type	Leg Type Definition	Total km Flown	Total nm Flown
Systematic	Pre-determined line-transect legs located in SOAR, NAOPA and FLETA HOT	1268	685
Random	Short lines connecting longer systematic lines	370	200
Transiting	Flying between the airport and the survey grid locations	956	516
Navy-Directed Transiting	Flying off intended course as directed by Navy during a survey to avoid Navy activities	91	49
Circling	Flying circles around sightings to verify species and group size via photography and/or to conduct focal behavioral sessions with videography as possible	2125	1147
Circumnavigating Coast	Flying parallel to San Clemente Island coastline approximately 0.5 km from shore to search for potential strandings	83	45
TOTAL		**4893**	**2641**

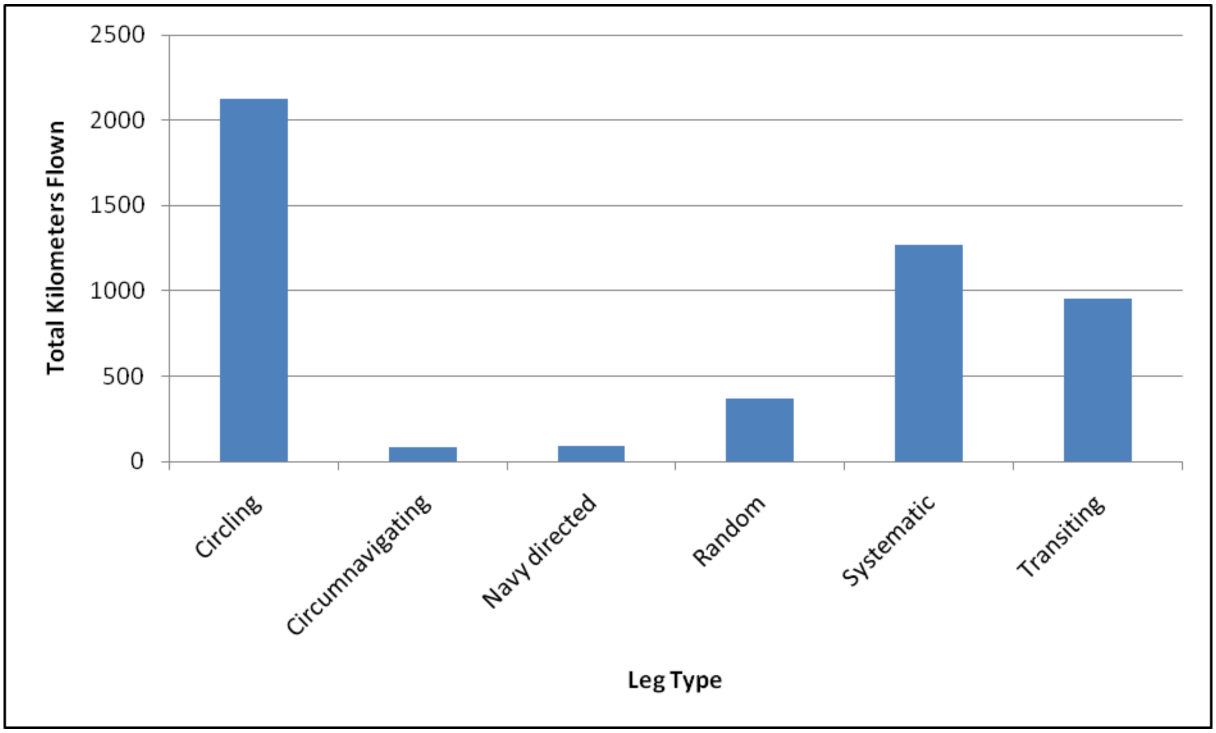

Figure 10. Summary of aerial survey effort (km) by leg type during the May SOCAL 2010 MTE aerial surveys.

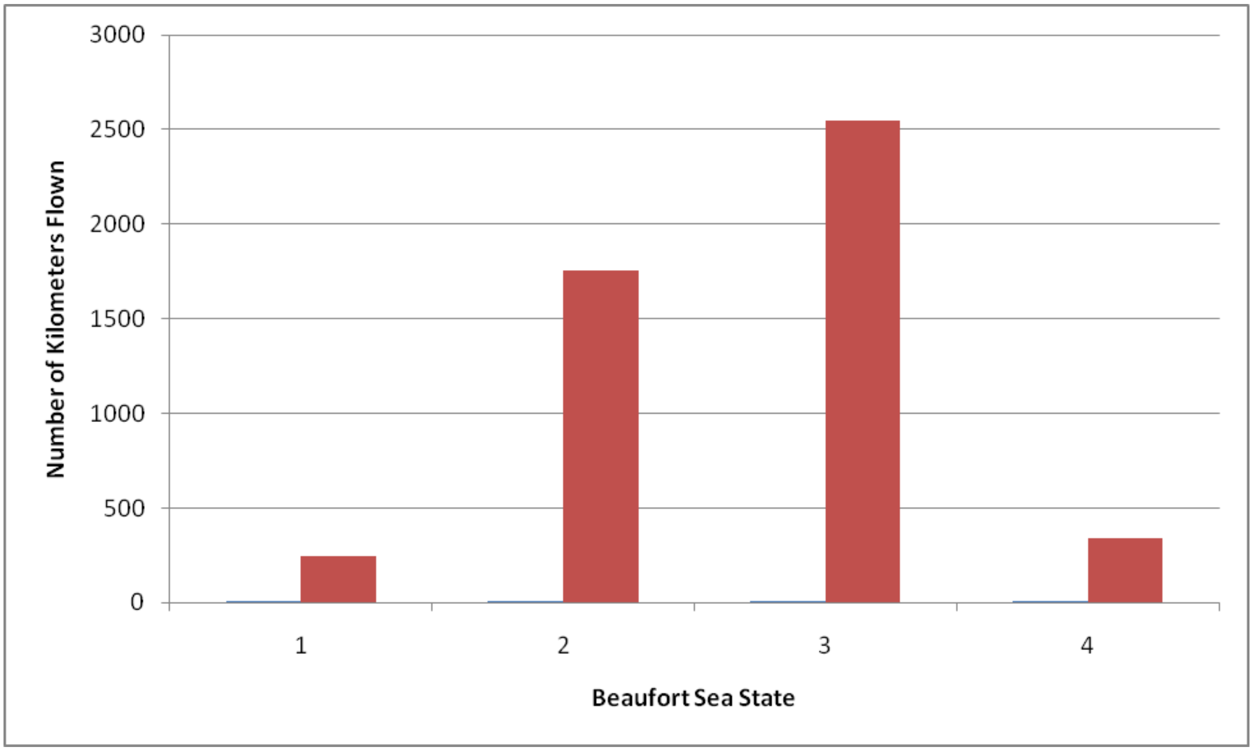

Figure 11. Summary of aerial survey effort (km) by Beaufort sea state during the May SOCAL 2010 MTE aerial survey.

Sightings

A total of 152 sightings of ~5,453 individual marine mammals was observed (Table 12 and Appendix A). Of the total 152 sightings 85% were identified to species (*n* = 129). 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).

Ten different marine mammal species were identified. Sightings included three baleen whale species (blue, fin and minke whale), five dolphin species (bottlenose, short- and long-beaked common, Pacific white-sided, and Risso's dolphin), and two pinniped species (California sea lion and harbor seal). Overall, the California sea lion was the most frequently identified species (41% or 62 of 152 total groups) followed by the Risso's dolphin (22% or 33 groups). In terms of number of individuals seen, the common dolphin was the most abundant (*n* = ~3,000 or 55% of the total 5,453 individuals seen). Photographs are currently being reviewed by Dr. T.A. Jefferson to differentiate and verify short- and long-beaked common dolphins, as has been done for past surveys, and will be updated as relevant in the final report.

Table 12. Summary of marine mammal sightings by species during the May SOCAL 2010 MTE aerial surveys. Sightings organized in order of frequency observed starting with those seen most commonly.

Species (Common Name)	Scientific Name	Total No. of Sightings	Total Estimated No. Individuals
California Sea Lion	*Zalophus californianus*	62	159
Risso's Dolphin	*Grampus griseus*	33	432
Common Dolphin sp.	*Delphinus* sp.	14	3300
Unidentified Dolphin	Delphinidae sp.	13	736
Common Bottlenose Dolphin	*Tursiops truncatus*	12	292
Unidentified Small Dolphin	Delphinidae sp.	4	429
Blue Whale	*Balaenoptera musculus*	2	2
Fin Whale	*Balaenoptera physalus*	2	4
Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*	2	81
Unidentified Marine Mammal	Cetacea or Pinnipedia	2	11
Unidentified Pinniped	Pinnipedia	2	2
Harbor Seal	*Phoca vitulina*	1	2
Minke whale`	*Balaenoptera acutorostrata*	1	1
Unidentified Large Whale	Cetacea	1	1
Unidentified Small Marine Mammal	Cetacea or Pinnipedia	1	1
Totals:		**152**	**5,453**

Sighting Rates

Table 4 compares sighting rates based on combined systematic, random and transit effort (i.e., point-to-point linear effort) for various species and species groups during November 2010 and May 2010 SOCAL aerial surveys. (See Smultea and Lomac-MacNair 2010 for other results of the November 2009 SOCAL aerial survey.) Overall, data show that sighting rates for all combined marine mammals based on number of *individuals* observed per km, per nm and per hour were higher in November than May. However, the number of *groups* sighted per unit of effort (i.e., number of sightings) was slightly higher in May vs. November. Among species, sighting rates of Risso's dolphins were approximately three times higher in May vs. November. In contrast, sighting rates of common dolphins and Pacific white-sided dolphins were approximately three times higher in November vs. May. Sighting rates of California sea lions were similar during November and May. Killer whales (n = 2 sightings) and Cuvier's beaked whales (n = 2 sightings) were seen only in November, while common bottlenose dolphins (n = 9) and harbor seals (n = 1) were observed only in May. Table 5 provides sighting rates by survey effort type based on number of groups observed (i.e., sightings made) per unit of effort (i.e., per km, nm, and hour). (See Table 2 for definitions and total km and nm of effort types.) The highest sighting rates for both November and May occurred while circumnavigating San Clemente Island due to high numbers of California sea lions in coastal waters. This was expected since effort was biased by paralleling the coastline where California sea lions concentrate to haul out. The sighting rate was twice as high in May vs. November during the circumnavigation effort, coinciding with known peaks of

Table 13. Sighting rates by species during the November 2009 and May 2010 SOCAL aerial surveys during systematic, random and transit effort.

Species (Common Name)	Nov-10				May-10			
	Total No. of Sightings (Total # Individuals)	Sightings/km (Indiv./km)	Sightings/nm (Indiv./nm)	Sightings/hr (Indiv./hr)	Total No. of Sightings (Total # Individuals)	Sightings/km (Indiv./km)	Sightings/nm (Indiv./nm)	Sightings/hr (Indiv./hr)
Whales								
Blue Whale	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	0.0007 (0.0007)	0.001 (0.001)	0.15 (0.15)
Fin Whale	5 (9)	0.001 (0.003)	0.003 (0.005)	0.36 (0.64)	2 (4)	0.0007 (0.002)	0.001 (0.003)	0.15 (0.30)
Minke whale`	1 (1)	0.0003 (0.0003)	0.0005 (0.0005)	0.07 (0.07)	1 (1)	0.0004 (0.0004)	0.0007 (0.0007)	0.08 (0.08)
Unidentified Large Whale	1 (1)	0.0003 (0.0003)	0.0005 (0.0005)	0.07 (0.07)	1 (1)	0.0004 (0.0004)	0.0007 (0.0007)	0.08 (0.08)
Unidentified Medium Whale	1 (1)	0.0003 (0.0003)	0.0005 (0.0005)	0.07 (0.07)	0 (0)	0 (0)	0 (0)	0 (0)
Dolphins								
Killer Whale	2 (67)	0.0006 (0.02)	0.001 (0.04)	0.14 (4.79)	0 (0)	0 (0)	0 (0)	0 (0)
Cuvier's Beaked Whale	2 (6)	0.0006 (0.002)	0.001 (0.003)	0.14 (0.43)	0 (0)	0 (0)	0 (0)	0 (0)
Risso's Dolphin	5 (167)	0.001 (0.05)	0.003 (0.09)	0.36 (11.93)	28 (373)	0.01 (0.14)	0.02 (0.27)	2.15 (28.69)
Common Dolphin sp.	25 (11891)	0.007 (3.45)	0.013 (6.4)	1.79 (849.36)	15 (3300)	0.006 (1.27)	0.01 (2.36)	1.15 (253.85)
Common Bottlenose Dolphin	0 (0)	0 (0)	0 (0)	0 (0)	9 (255)	0.003 (0.1)	0.006 (0.18)	0.69 (19.61)
Pacific White-sided Dolphin	6 (274)	0.002 (0.08)	0.003 (0.15)	0.43 (19.57)	2 (81)	0.0007 (0.03)	0.001 (0.06)	0.15 (6.23)
Unidentified Dolphin	6 (27)	0.002 (0.008)	0.003 (0.01)	0.43 (1.93)	10 (689)	0.004 (0.27)	0.007 (0.49)	0.77 (53)
Unidentified Small Dolphin	2 (45)	0.0006 (0.01)	0.001 (0.02)	0.14 (3.21)	4 (429)	0.002 (0.17)	0.003 (0.31)	0.31 (33)
Pinnipeds								
California Sea Lion	19 (83)	0.006 (0.02)	0.01 (0.04)	1.36 (5.93)	22 (58)	0.008 (0.02)	0.016 (0.04)	1.70 (4.46)
Harbor Seal	0 (0)	0 (0)	0 (0)	0 (0)	1 (2)	0.0004 (0.0008)	0.0007 (0.001)	0.08 (0.15)
Unidentified Pinniped	4 (4)	0.001 (0.001)	0.002 (0.002)	0.29 (0.29)	2 (2)	0.0008 (0.0008)	0.001 (0.001)	0.15 (0.15)
Unidentified Marine Mammal	1 (1)	0.0003 (0.0003)	0.0005 (0.0005)	0.07 (0.07)	1 (10)	0.0004 (0.004)	0.0007 (0.007)	0.08 (0.77)
Unidentified Small Marine Mammal	1 (1)	0.0003 (0.0003)	0.0005 (0.0005)	0.07 (0.07)	2 (2)	0.0007 (0.0007)	0.001 (0.001)	0.15 (0.15)
Overall Marine Mammal	81 (12578)	0.02 (3.65)	0.04 (6.77)	5.79 (898.43)	102 (5209)	0.04 (2.01)	0.073 (3.72)	7.85 (400.69)

Table 14. Sighting (Stg) rates of marine mammal (MM) groups by effort type during the November 2009 and May 2010 SOCAL aerial surveys.

Effort Type	Species Group	Nov 18-23, 2009							May 13-18, 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
Systematic	Whales	6	1790	967	8	0.003	0.006	0.75	4	1268	685	7	0.003	0.006	0.57
	Dolphins	21				0.012	0.022	2.63	29				0.023	0.042	4.14
	Pinnipeds	17				0.009	0.018	2.13	13				0.010	0.019	1.86
	All MM	46				0.026	0.048	5.75	46				0.036	0.067	6.57
Random	Whales	0	669	361	2	0	0	0	1	370	200	2	0.003	0.005	0.5
	Dolphins	4				0.006	0.011	2	10				0.027	0.05	5
	Pinnipeds	3				0.004	0.008	1.5	1				0.003	0.005	0.5
	All MM	7				0.010	0.019	3.5	12				0.032	0.06	6
Transit	Whales	2	983	531	4	0.002	0.004	0.5	1	956	516	4	0.001	0.002	0.25
	Dolphins	23				0.023	0.043	5.75	29				0.030	0.056	7.25
	Pinnipeds	3				0.003	0.006	0.75	12				0.013	0.023	3
	All MM	28				0.028	0.053	7	42				0.044	0.081	10.5
Circling	Whales	0	1335	721	7	0	0	0	0	2125	1147	12.9	0.000	0.000	0
	Dolphins	1				0.001	0.001	0.143	0				0.000	0.000	0
	Pinnipeds	0				0.000	0	0	0				0.000	0.000	0
	All MM	1				0.001	0.001	0.143	0				0.000	0.000	0
Circumnavigating San Clemente Island	Whales	0	120	65	0.2	0	0	0	0	83	45	0.5	0.000	0.000	0
	Dolphins	2				0.017	0.031	10.000	3				0.036	0.067	6
	Pinnipeds	5				0.000	0	0	37				0.446	0.826	74
	All MM	7				0.058	0.108	35.000	40				0.482	0.893	80
Navy-directed Transiting	Whales	0	137	74	0.6	0	0	0	0	91	49	0.4	0.000	0.000	0
	Dolphins	1				0.007	0.014	1.667	7				0.077	0.142	17.5
	Pinnipeds	4				0.000	0	0	3				0.033	0.061	7.5
	All MM	5				0.036	0.068	8.333	10				0.110	0.204	25

California sea lion concentrations (Carretta et al. 2000). The second highest sighting rates for both November and May occurred during Navy-directed transiting effort (i.e., irregular re-routing to avoid conflict with Navy activities). This result was biased because the Navy-directed legs were short and occurred primarily near SCI where animals tend to concentrate near underwater ridges and drop offs (see Distribution section below). Sighting rates were generally similar for systematic, random, and transit effort in both November and May, ranging from 3.5 to 10.5 sightings per hour. However, sighting rates were slightly higher during transit and systematic effort than during random effort. Sighting rates were less than 0.2 sightings per hour during circling effort that occurred after the aircraft began circling a primary sighting made during other effort types. Thus, additional sightings were rarely made while circling a primary sighting. This was as expected because we were concentrating on the primary sighting rather than searching for additional animals, and because we repeatedly circled in the same small area around the primary sighting.

Distribution

Effort Distribution

In May 2010, line-transect surveys were conducted throughout NAOPA, northern SOAR, and in FLETA HOT to the south (see Figure 9 and Table 10). Transect lines east of SCI in NAOPA were the same as those followed in our previous five surveys (October and November 2008, June and July 2009, and November 2010 --- see Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010). Survey lines west of SCI in SOAR in May 2010 replicated those followed in June, July and November 2009. However, the SOAR transect lines extended further north and slightly farther apart than lines followed in June and July 2009 and October and November 2008. This line configuration maximized coverage of the Navy-identified SOAR survey area within the ~4.5-5-hr limit of the aircraft's fuel tank. Permission to survey SOAR was only granted by the Navy on May 14 and 16 from 10:00 to 15:00 to avoid potential airspace conflicts. However, low marine cloud layers on these days limited the time and vantage available to survey SOAR given associated cloud clearance requirements and permit restrictions. The FLETA HOT survey grid was flown on one day; this same area was surveyed previously by us in November 2008 on two days (Smultea et al. 2009a).

Sighting Distribution

Relatively few whales were seen during May 2010 (n = 6 sightings). The two fin whales and one unidentified large whale were seen in the far northwestern corner of SOAR (Figure 12); in comparison, during October and November 2008, fin whales were seen relatively frequently in this small area (see Smultea et al. 2009a). In contrast, the two blue whale groups in May 2010 were seen within 10 km of the mainland coast near San Diego, as was the one minke whale sighting. Concentrations of blue whales were also observed in this area during our June and July 2008 aerial surveys in SOCAL (see Smultea et al. 2009b).

Dolphin distribution generally appeared to be segregated between Risso's (n = 33) and common dolphins (n = 14), the two most commonly identified species (Figure 13). (At the time of this draft report, photographs had not yet been examined to differentiate short- and long-beaked common dolphins.) Risso's dolphins were seen primarily in the western one-half of NAOPA and west to SOAR, concentrated along underwater ridges and drop offs. However, 21 percent (n = 7) of Risso's groups occurred further south in FLETA HOT. Risso's dolphin was the only marine mammal species seen in FLETA HOT and the only dolphin species seen in SOAR (n = 5). In contrast, common dolphins occurred predominantly in the eastern one-half of NAOPA. They were fairly evenly distributed throughout this area and did not appear to be strongly associated with any bathymetric features except the continental shelf. Of the 12 common bottlenose dolphin sightings, 92% occurred approximately 15-80 km offshore of the coast primarily within the San Diego Trough (refer to Figure 1). Many of the unidentified dolphins were spotted just outside San Diego in restricted busy airspace where it was unsafe and/or not allowed by air traffic control to circle dolphins to verify species. Based on relatively large group sizes, frequent surface-active behavior, and distribution, many of the unidentified dolphins are believed to have been common dolphins. No dolphins were seen along the two northernmost survey lines in NAOPA; dolphin sightings have tended to be relatively low in this area during our previous SOCAL aerial surveys as well (see Smultea et al. 2009a,b and Smultea and Lomac-MacNair 2010).

As expected, pinniped sightings (95% identified as California sea lions) were concentrated along the coast of SCI (Figure). This pattern was evident while circumnavigating SCI to search for potential strandings. (Notably, no stranded or dead marine mammals were observed). However, many pinnipeds (again, nearly exclusively California sea lions) were also recorded at sea primarily within approximately 30 km east of SCI. Small numbers were also scattered from SCI to the mainland coast. Very few pinnipeds were seen in SOAR or FLETA HOT, and only in the northwestern corner of FLETA HOT. Pinnipeds were also scarce in the northeast section of NAOPA where cetaceans were also scarce (see above). Overall, the at-sea distribution of California sea lions was associated with SCI and underwater ridges (similar to dolphins), with few, if any, occurring over flat underwater basins or shelves. The latter pattern is believed to reflect the generally higher concentrations of mesopelagic prey associated with underwater ridges and upwelling.

Behavior

Common and Risso's dolphins had sample sizes considered large enough (n = 14 and 33, respectively) to warrant summarizing initially observed behavior state, heading, and estimated mean dispersal distance between individuals (Figure and Figure 14). Both species were most frequently observed traveling slowly and milling. Similar behavior was observed for Risso's dolphins during our past five SOCAL aerial surveys. However, during past surveys, common dolphins were more surface-active than observed during the May survey (e.g., Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010). In contrast, Risso's dolphins have rarely been seen engaged in surface-active behaviors. For the May survey we added a modifier to the travel behavior state to indicate estimated slow (1-3 km/hr), medium (4-7 km/hr) and fast (>7 km/h) travel speed because we noted in earlier surveys that Risso's dolphins tended to swim slowly. Results supported this observation as 22 of 24 traveling Risso's groups traveled slowly as did 8 of 9 common dolphin groups.

The most frequently observed heading among common dolphins was from SE to SW; previous surveys recorded common dolphins headed mostly SW to W or to the NE. Similarly, Risso's dolphins were predominantly headed generally S to W or to the NE, again consistent with our earlier surveys. Mean inter-individual spacing (i.e., dispersal) among common dolphins was consistently tight (i.e., 1-3 body lengths between nearest neighbors). Most Risso's dolphins were also spaced 1-3 body lengths apart, although this spacing was less consistent than among common dolphins. The latter patterns of dispersal were also similar to results of our previous five SOCAL aerial surveys.

Unusual Observations

On May 16 from 13:54 to 14:17 at SOAR, an unusually behaving group of 14 Risso's dolphins was tracked from the airplane for a focal follow lasting approximately 23 minutes. The group consistently traveled fast and was surface-active with frequent porpoising and whitewater observed as the dolphins headed consistently to approximately 060 degrees magnetic. The observation was considered unusual because Risso's dolphins during our past surveys have most frequently been observed traveling slowly or milling with little to no surface-active behaviors (e.g., see Figure 14). Approximately 18 minutes of video was taken while following this group (see Appendix E).

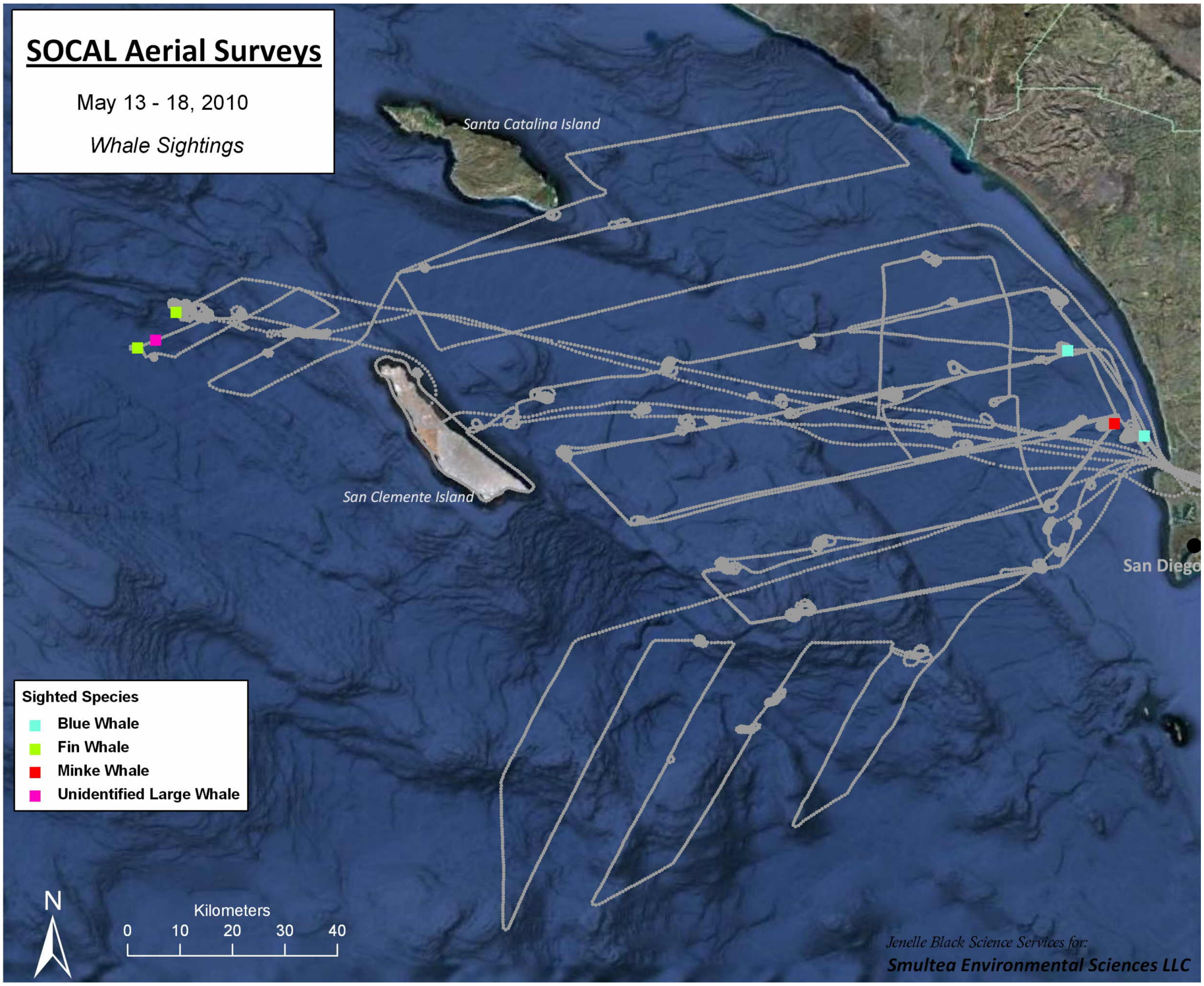

Figure 12. Whale sightings made during aerial survey monitoring in the SOCAL May 13-18, 2010.

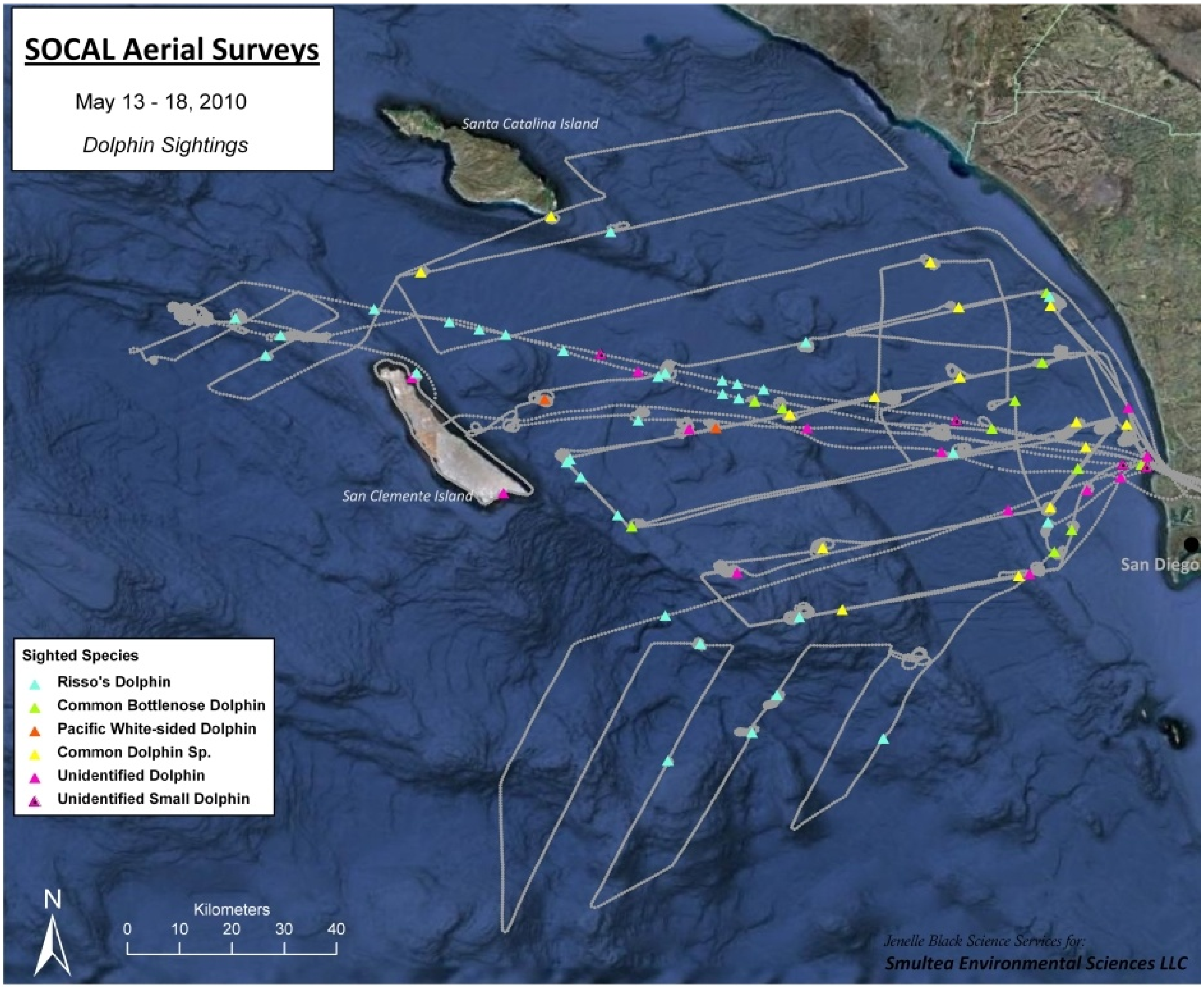

Figure 13. Dolphin sightings made during aerial survey monitoring in the SOCAL May 13-18, 2010.

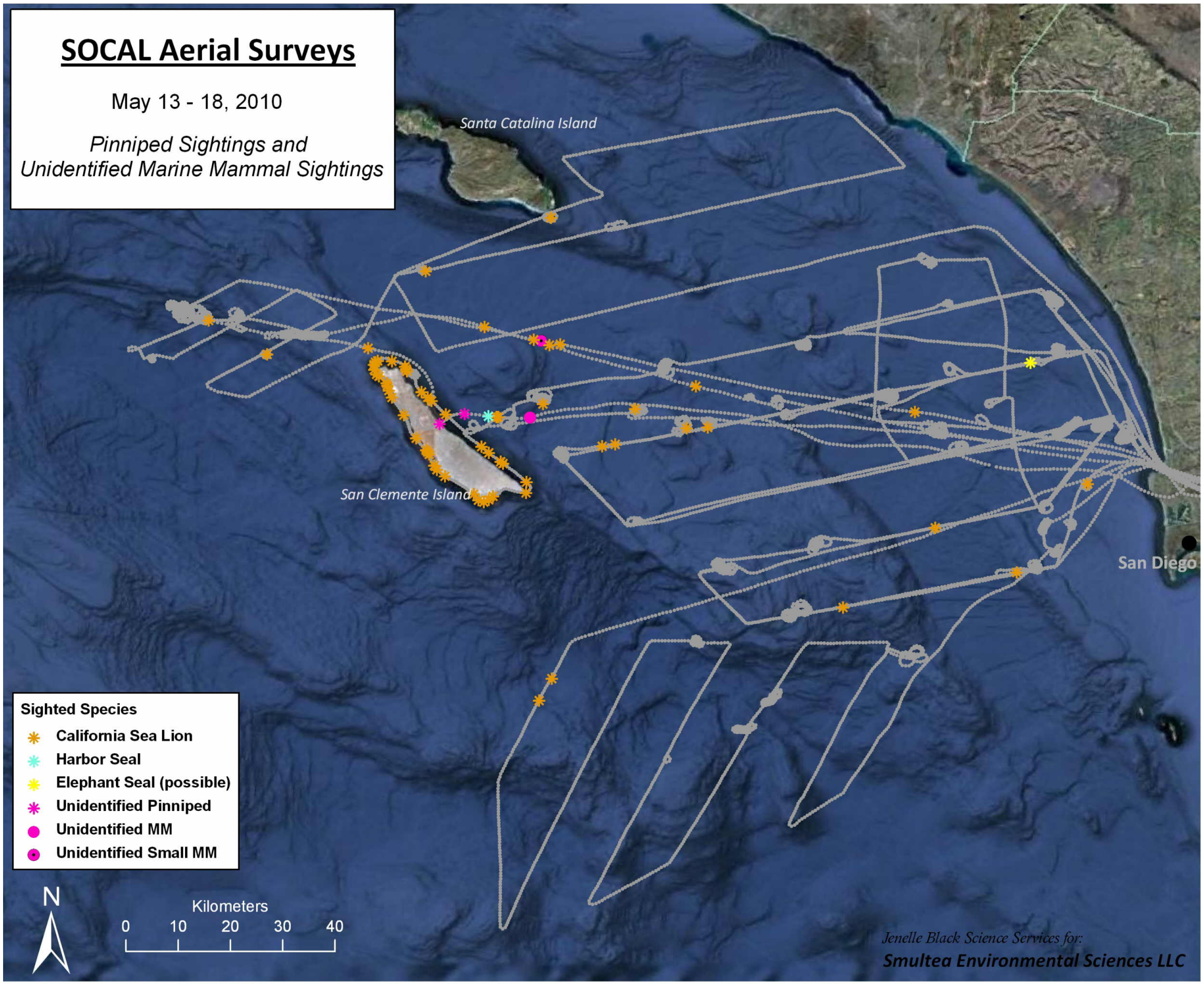

Figure 7. Pinniped sightings made during aerial survey monitoring in the SOCAL May 13-18, 2010.

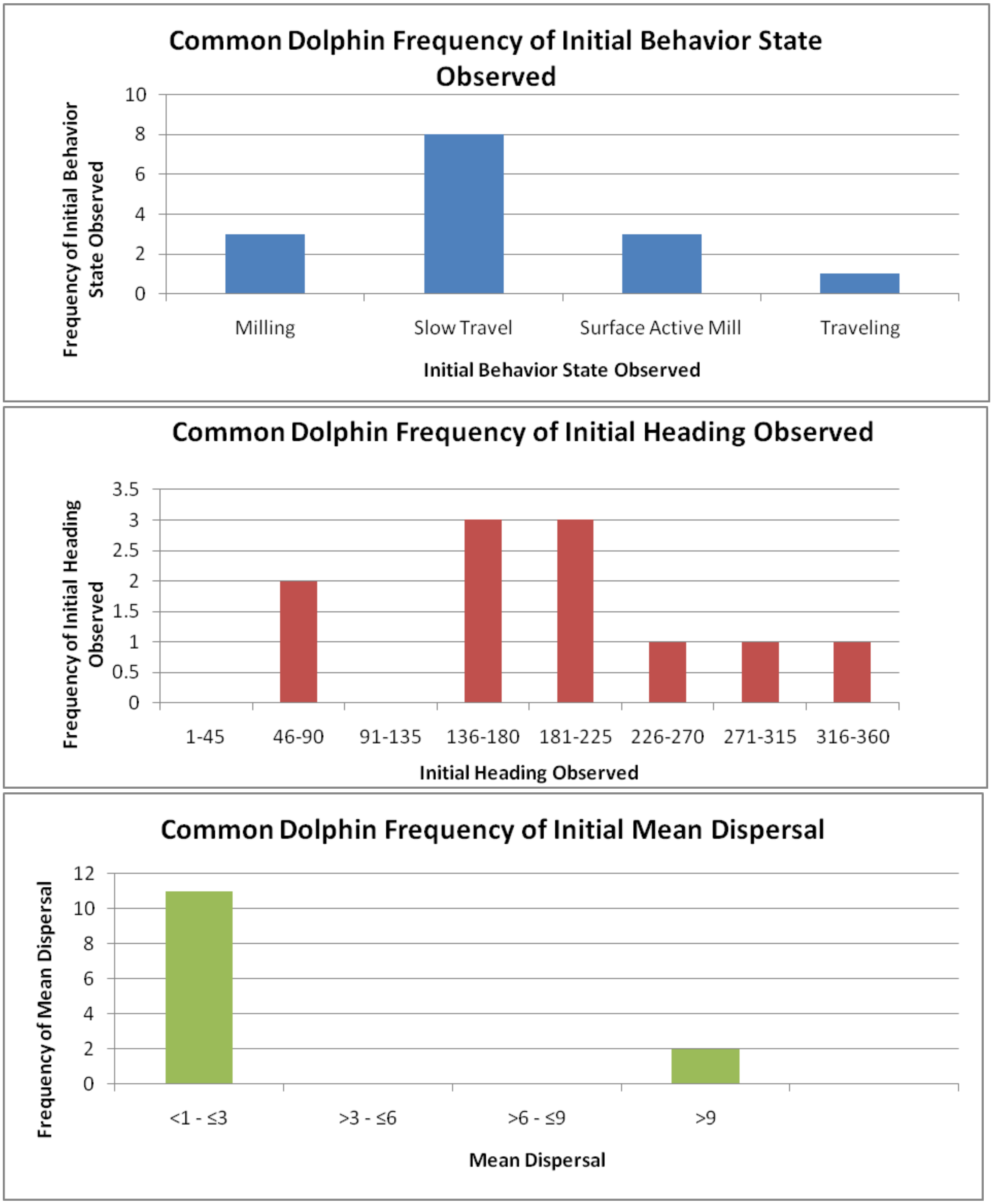

Figure 8. Common dolphins during the May SOCAL 2010 survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths).

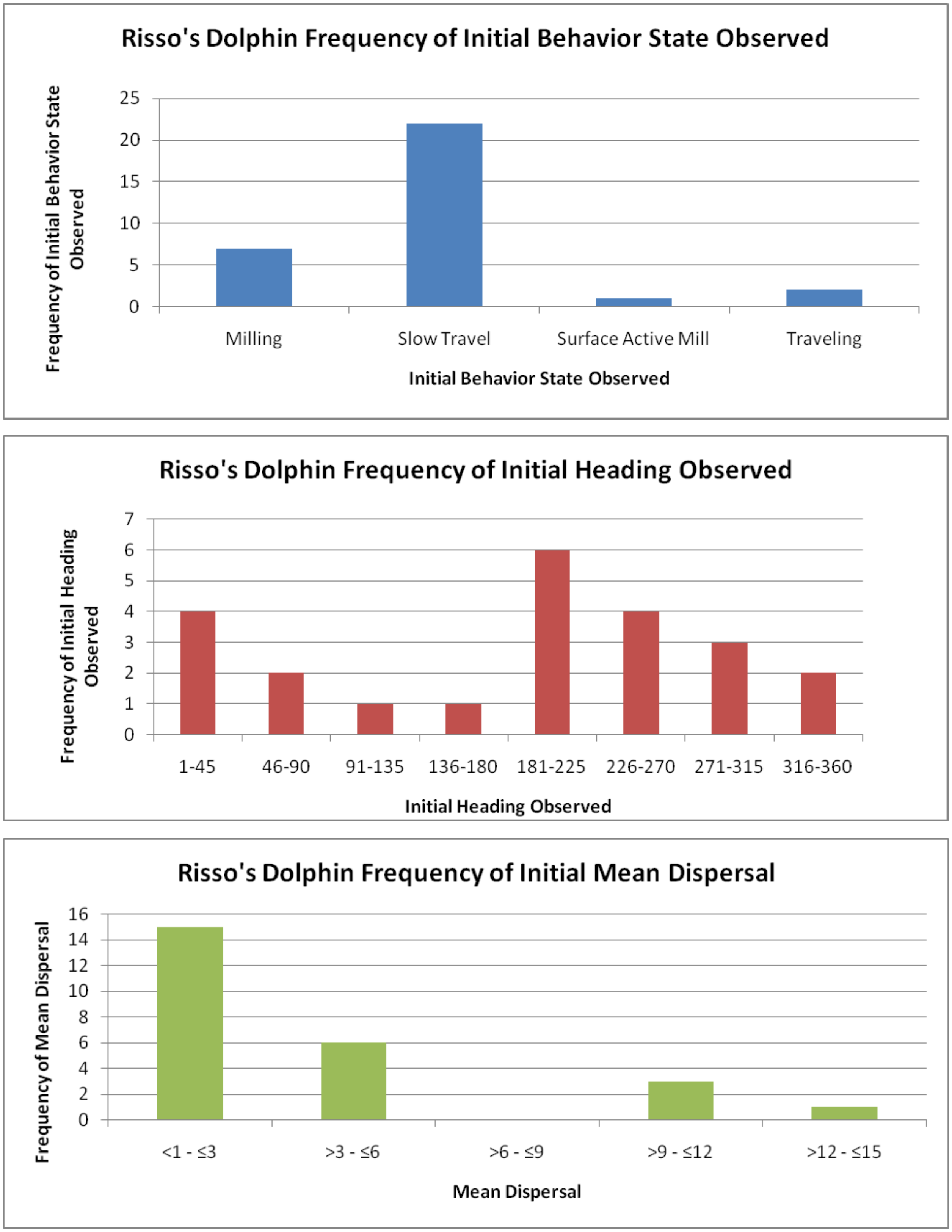

Figure 14. Risso's dolphins during the May SOCAL 2010 survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths).

Photographs and Video

A total of ~1350 digital photographs and 5.5 hours of high-definition (HD) video were taken during May 2010. A preliminary list of photographs and video are presented in Appendix B and Appendix C. 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 operating 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 for identifying species, calves, etc. The latter tasks are time-consuming and were outside the scope of this contract. As done for our previous surveys, Dr. T.A. Jefferson will review our photographs to confirm or speciate short-beaked vs. long-beaked common dolphins and other species as relevant.

Section 4 Discussion

Key Role of Aerial Surveys

The key and unique roles that aerial surveys play in addressing Navy monitoring plan goals have been discussed thoroughly in our previous reports (see review in Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010). Thus, they are not discussed again herein.

Survey Highlights

During the May 2010 aerial surveys, Dr. Bernd Wuersig of the Marine Mammal Research Program at Texas A&M University joined our field team to provide expert review and critique of our behavioral study approach and protocol, and to assist us in the field. Dr. Wuersig is one of the pioneer marine mammal behavioral experts who successfully developed and applied the use of small fixed-wing aircraft to study the behavior of focal groups of bowhead whales by circling animals for extended periods (e.g., Wuersig et al. 1989, Richardson et al. 1986, 1995). This research illustrated that at sufficient altitudes and radial distances, the animals exhibited no statistically detectable response to the observation platform. A similar protocol was applied to a study of the behavioral response of bottlenose dolphins to the *Mega Borg II* oil spill in the Gulf of Mexico in 1990 (Smultea and Wuersig 1995) and to humpback whales near Kauai in 1993 and 1994 (Bowles et al. 1995). Our SOCAL aerial surveys have taken these basic protocols and further developed, adapted, and applied them to multiple other species inhabiting the SOCAL as described in this and previous reports. From these observations, we have learned that Risso's dolphins and blue and fin whales are the most practical species upon which to focus our efforts. This is because they are relatively common, observable below the water surface, form groups of a size that are relatively easy to track, remain near the surface for extended periods, are of light color and/or large size facilitating tracking, and/or are of particular management interest (e.g., ESA status and/or a surrogate deep-diving species to the beaked whale [i.e., the Risso's dolphin]). Dr. Wuersig provided a positive review of our protocol and helped us further refine our techniques.

As summarized in Table 6 the May 2010 aerial survey contributed the highest number (n = 20) of focal behavioral observations at least 10 min long relative to our previous five SOCAL aerial surveys, largely because we had shifted our focus to focal follows. In addition, we also conducted the longest focal session during May 2010 (144 min with fin whales); our previous longest focal follow duration was 60 min with a fin whale in November 2009. The largest mean group size for all marine mammal combined was also recorded during May 2010 (137.9 individual marine mammals/group); the next highest mean group size of 109.4 individuals/group was recorded during October 2008.

Overall marine mammal sighting rates based on number of individuals sighted per hour and per km or nm were over twice as high in November 2009 vs. May 2010. However, there was some variation between species. These trends generally agree with results of other surveys in SOCAL. Based on effort type, combined marine mammal sighting rates were highest while circumnavigating SCI to search for potential strandings just offshore of the coastline. Nearly all such sightings were identified as California sea lions, and the effort was biased because it occurred where this species is known to concentrate. November sightings rates while circumnavigating were twice as high in May vs. November, consistent with other studies and known seasonal concentrations of California sea lions. Sighting rates were slightly higher during transit effort followed by systematic and random effort during both November and May.

Funding has not been available to analyze the detailed behavior of cetacean groups we have observed in the SOCAL. However, the Navy plans to further analyze these data through the IDIQ Marine Mammal Monitoring contract recently awarded to e2M/HDR. 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).

May survey results are unique in that they are the first data collected during May among our five previous aerial surveys. This contributes to building 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 five previous aerial surveys for Risso's and common dolphins, by far the two most frequently observed cetacean species by us in the SOCAL. Results consistently show that Risso's dolphins spend the majority of their time slowly traveling at the surface in relatively tight cohesive groups of typically less than 50 individuals, and rarely engage in surface-active behaviors. They also remain within view of the aircraft observers at or below the surface for the longest periods compared to other SOCAL marine mammal species observed. In particular, the light, white body coloration and scarring of Risso's dolphins 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 (see Appendix D).

Aerial Survey Collaboration with Other Researchers

No other marine mammal researchers were conducting field surveys in the SOCAL range simultaneously to our May survey to our knowledge. However, our data will be shared with researchers from the University of California San Diego/Scripps Institute of Oceanography, Cascadia Research Collective, the Navy's Marine Mammal Research Program (e.g., Dr. Dave Moretti), and other Office of Naval Research and N45-funded studies, including the 2010 Behavioral Response Study (BRS) led by Dr. Brandon Southall. Shared data of interest that we collected include locations of beaked, blue and fin whales, and bottlenose and Risso's dolphins. In particular, baseline behavioral and distribution data we have collected on these species is of relevance to the BRS program. Beginning in the SOCAL in late summer 2010, the BRS program plans to conduct playback sound with some of these species to assess potential behavioral responses. Thus, our baseline behavioral data provide a substantial database for comparison of typical behavior of these species. Very little 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).

Section 5 Recommendations

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

We are grateful to Navy personnel from US Pacific Fleet Environmental and Naval Facilities Engineering Command Pacific for their support, coordination and facilitation in the implementation of these surveys. We thank our excellent survey observer biologists Mark Deakos, Lori Mazzuca and Bernd Wuersig, our database and GIS manager and report editor Jenelle Black of Jenelle Black Sciences, and hard-working dedicated technical assistants Cathy Bacon and Roxann Merizan. We are grateful for our competent and safety-conscious pilot Barry Hanson of Aspen Helicopters, Oxnard, California.

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Appendix A List of All May 2010 Sightings

Appendix C. May 2010: Summary of all individual marine mammal sightings made during the May SOCAL 2010 aerial monitoring surveys off San Diego, California.

Date	Initial time	Common Name	Species	Best Count	Latitude	Longitude
May 13	09:02:30	Common Bottlenose Dolphin	*Tursiops truncatus*	5	32.862850	-117.297050
May 13	09:03:42	Unidentified Dolphin	Delphinidae sp.	150	32.840867	-117.333133
May 13	09:11:06	Unidentified Dolphin	Delphinidae sp.	83	32.675650	-117.489533
May 13	09:11:39	Common Dolphin Sp.	undifferentiated *Delphinus*	15	32.671933	-117.507967
May 13	09:27:20	California Sea Lion	*Zalophus californianus*	1	32.673983	-117.507317
May 13	09:39:33	Risso's Dolphin	*Grampus griseus*	25	32.601167	-117.885567
May 13	10:13:00	Unidentified Dolphin	Delphinidae sp.	12	32.677633	-117.992183
May 13	10:40:18	Common Dolphin Sp.	undifferentiated *Delphinus*	150	32.719833	-117.845050
May 13	11:02:49	Common Dolphin Sp.	undifferentiated *Delphinus*	300	32.789750	-117.453933
May 13	11:16:56	Common Dolphin Sp.	undifferentiated *Delphinus*	300	32.936033	-117.409150
May 13	12:10:27	Risso's Dolphin	*Grampus griseus*	7	32.776283	-118.197683
May 13	12:13:19	Risso's Dolphin	*Grampus griseus*	3	32.841450	-118.260983
May 13	12:14:31	Risso's Dolphin	*Grampus griseus*	4	32.866683	-118.285500
May 13	12:21:59	Unidentified Dolphin	Delphinidae sp.	3	32.924117	-118.075050
May 13	12:31:28	California Sea Lion	*Zalophus californianus*	3	32.922383	-118.075467
May 13	12:44:00	Common Dolphin Sp.	undifferentiated *Delphinus*	350	32.979633	-117.756067
May 13	13:41:58	Common Bottlenose Dolphin	*Tursiops truncatus*	30	33.037617	-117.467883
May 14	10:50:56	Unidentified Small Dolphin	Delphinidae sp.	1	32.939267	-117.616217
May 14	10:52:35	California Sea Lion	*Zalophus californianus*	2	32.949650	-117.683067
May 14	10:59:11	Risso's Dolphin	*Grampus griseus*	16	32.991833	-117.947083
May 14	11:00:28	Risso's Dolphin	*Grampus griseus*	1	33.001500	-117.992117
May 14	11:01:04	Risso's Dolphin	*Grampus griseus*	2	33.006983	-118.018183
May 14	11:06:21	Unidentified Small Dolphin	Delphinidae sp.	23	33.052317	-118.227783
May 14	11:08:01	California Sea Lion	*Zalophus californianus*	1	33.066200	-118.293350
May 14	11:08:56	Unidentified Small Marine Mammal		1	33.071950	-118.325867
May 14	11:09:17	California Sea Lion	*Zalophus californianus*	3	33.074350	-118.338917
May 14	11:10:32	Risso's Dolphin	*Grampus griseus*	1	33.085683	-118.390300
May 14	11:11:45	Risso's Dolphin	*Grampus griseus*	10	33.094667	-118.435817
May 14	11:12:59	Risso's Dolphin	*Grampus griseus*	5	33.107350	-118.487333
May 14	11:16:19	Risso's Dolphin	*Grampus griseus*	1	33.129533	-118.616617
May 14	11:26:09	Fin Whale	*Balaenoptera physalus*	3	33.117933	-118.957217
May 14	13:22:45	California Sea Lion	*Zalophus californianus*	1	33.096083	-118.423217
May 14	13:25:29	California Sea Lion	*Zalophus californianus*	3	33.065117	-118.311900
May 14	13:26:02	Risso's Dolphin	*Grampus griseus*	3	33.058350	-118.291367
May 14	13:29:15	Unidentified Dolphin	Delphinidae sp.	1	33.022567	-118.162733
May 14	13:30:08	Risso's Dolphin	*Grampus griseus*	15	33.014017	-118.128200
May 14	13:31:46	California Sea Lion	*Zalophus californianus*	1	32.994150	-118.059433

Date	Initial time	Common Name	Species	Best Count	Latitude	Longitude
May 14	13:32:47	Risso's Dolphin	*Grampus griseus*	25	32.984050	-118.017317
May 14	13:33:24	Risso's Dolphin	*Grampus griseus*	9	32.976433	-117.989800
May 14	13:34:03	Common Bottlenose Dolphin	*Tursiops truncatus*	19	32.971267	-117.962317
May 14	13:38:22	Common Bottlenose Dolphin	*Tursiops truncatus*	18	32.959300	-117.914500
May 14	13:56:15	Unidentified Small Dolphin	Delphinidae sp.	350	32.863367	-117.330133
May 14	13:57:16	Unidentified Small Dolphin	Delphinidae sp.	55	32.859000	-117.289367
May 15	11:29:45	Unidentified Dolphin	Delphinidae sp.	30	32.785033	-117.526250
May 15	11:46:06	Risso's Dolphin	*Grampus griseus*	4	32.603917	-118.115883
May 15	11:52:56	California Sea Lion	*Zalophus californianus*	1	32.491717	-118.307833
May 15	11:54:29	California Sea Lion	*Zalophus californianus*	1	32.454000	-118.329517
May 15	12:30:17	Risso's Dolphin	*Grampus griseus*	17	32.555733	-118.055783
May 15	13:02:02	Risso's Dolphin	*Grampus griseus*	2	32.355300	-118.111833
May 15	13:27:23	Risso's Dolphin	*Grampus griseus*	33	32.402950	-117.966950
May 15	13:53:20	Risso's Dolphin	*Grampus griseus*	23	32.467483	-117.924117
May 15	14:58:34	Risso's Dolphin	*Grampus griseus*	12	32.393333	-117.740950
May 15	15:13:02	Common Bottlenose Dolphin	*Tursiops truncatus*	45	32.713133	-117.446917
May 15	15:26:52	Risso's Dolphin	*Grampus griseus*	15	32.764400	-117.458283
May 16	13:21:14	Unidentified Dolphin	Delphinidae sp.	100	32.884983	-117.641467
May 16	13:39:25	Unidentified Marine Mammal		10	32.940600	-118.344817
May 16	13:40:47	California Sea Lion	*Zalophus californianus*	1	32.941050	-118.402950
May 16	13:41:05	Harbor Seal	*Phoca vitulina*	2	32.942700	-118.417183
May 16	13:42:04	Unidentified Pinniped	Pinnipedia sp.	1	32.946617	-118.458217
May 16	13:43:31	Unidentified Pinniped	Pinnipedia sp.	1	32.929600	-118.500917
May 16	13:50:01	California Sea Lion	*Zalophus californianus*	1	33.059633	-118.623817
May 16	13:54:18	Risso's Dolphin	*Grampus griseus*	14	33.084583	-118.777583
May 16	14:21:59	Risso's Dolphin	*Grampus griseus*	30	33.114050	-118.855550
May 16	14:43:44	California Sea Lion	*Zalophus californianus*	1	33.107467	-118.898567
May 16	14:47:00	Unidentified Large Whale	Cetacea sp.	1	33.070033	-118.992567
May 16	14:48:00	Fin Whale	*Balaenoptera physalus*	1	33.057017	-119.023733
May 16	15:08:55	Risso's Dolphin	*Grampus griseus*	6	33.050217	-118.803250
May 16	15:10:53	California Sea Lion	*Zalophus californianus*	1	33.048833	-118.798017
May 16	15:39:30	Common Dolphin Sp.	undifferentiated *Delphinus*	300	33.288717	-118.312300
May 16	15:43:16	California Sea Lion	*Zalophus californianus*	25	33.284183	-118.309150
May 16	16:26:20	Risso's Dolphin	*Grampus griseus*	6	33.262017	-118.209917
May 16	16:40:50	Common Dolphin Sp.	undifferentiated *Delphinus*	30	33.192917	-118.536750
May 16	16:43:52	California Sea Lion	*Zalophus californianus*	1	33.191733	-118.524617
May 17	10:17:04	Unidentified Dolphin	Delphinidae sp.	90	32.925450	-117.871900
May 17	10:24:43	Risso's Dolphin	*Grampus griseus*	28	32.938500	-118.162717
May 17	10:28:26	California Sea Lion	*Zalophus californianus*	1	32.955467	-118.164283

Date	Initial time	Common Name	Species	Best Count	Latitude	Longitude
May 17	10:47:10	California Sea Lion	*Zalophus californianus*	2	32.890300	-118.428833
May 17	10:47:38	California Sea Lion	*Zalophus californianus*	2	32.880017	-118.416217
May 17	10:48:24	California Sea Lion	*Zalophus californianus*	1	32.864267	-118.395833
May 17	10:48:40	California Sea Lion	*Zalophus californianus*	1	32.861383	-118.392000
May 17	10:50:23	California Sea Lion	*Zalophus californianus*	5	32.829417	-118.351533
May 17	10:51:24	California Sea Lion	*Zalophus californianus*	1	32.811250	-118.352217
May 17	10:52:56	Unidentified Dolphin	Delphinidae sp.	1	32.814133	-118.394383
May 17	10:53:33	California Sea Lion	*Zalophus californianus*	1	32.804817	-118.409250
May 17	10:53:53	California Sea Lion	*Zalophus californianus*	4	32.799333	-118.416317
May 17	10:54:12	California Sea Lion	*Zalophus californianus*	1	32.795317	-118.424767
May 17	10:54:40	California Sea Lion	*Zalophus californianus*	2	32.798183	-118.433800
May 17	10:55:06	California Sea Lion	*Zalophus californianus*	4	32.809167	-118.442267
May 17	10:57:11	California Sea Lion	*Zalophus californianus*	3	32.839767	-118.491650
May 17	10:57:59	California Sea Lion	*Zalophus californianus*	2	32.850883	-118.505233
May 17	10:58:18	California Sea Lion	*Zalophus californianus*	3	32.857700	-118.510117
May 17	10:59:01	California Sea Lion	*Zalophus californianus*	3	32.876983	-118.518833
May 17	10:59:12	California Sea Lion	*Zalophus californianus*	2	32.880800	-118.521250
May 17	10:59:25	California Sea Lion	*Zalophus californianus*	2	32.884267	-118.524183
May 17	11:00:25	California Sea Lion	*Zalophus californianus*	2	32.905033	-118.541500
May 17	11:02:01	California Sea Lion	*Zalophus californianus*	1	32.944550	-118.562367
May 17	11:03:28	California Sea Lion	*Zalophus californianus*	1	32.974867	-118.582683
May 17	11:03:51	California Sea Lion	*Zalophus californianus*	3	32.987083	-118.588217
May 17	11:04:13	California Sea Lion	*Zalophus californianus*	1	32.995717	-118.590733
May 17	11:04:30	California Sea Lion	*Zalophus californianus*	4	32.999833	-118.592383
May 17	11:05:04	California Sea Lion	*Zalophus californianus*	2	33.011733	-118.605717
May 17	11:05:16	California Sea Lion	*Zalophus californianus*	2	33.014583	-118.609300
May 17	11:05:32	California Sea Lion	*Zalophus californianus*	3	33.022667	-118.613183
May 17	11:05:52	California Sea Lion	*Zalophus californianus*	4	33.031400	-118.614333
May 17	11:06:05	California Sea Lion	*Zalophus californianus*	2	33.035200	-118.611300
May 17	11:06:17	California Sea Lion	*Zalophus californianus*	1	33.038050	-118.607083
May 17	11:07:06	California Sea Lion	*Zalophus californianus*	1	33.037283	-118.583083
May 17	11:08:00	California Sea Lion	*Zalophus californianus*	6	33.028000	-118.560250
May 17	11:08:10	California Sea Lion	*Zalophus californianus*	4	33.024017	-118.558483
May 17	11:08:20	California Sea Lion	*Zalophus californianus*	3	33.019900	-118.557033
May 17	11:08:45	Unidentified Dolphin	Delphinidae sp.	45	33.012133	-118.551983
May 17	11:10:08	Risso's Dolphin	*Grampus griseus*	7	33.020083	-118.543783
May 17	11:13:09	California Sea Lion	*Zalophus californianus*	7	32.983983	-118.531867
May 17	11:13:33	California Sea Lion	*Zalophus californianus*	1	32.975133	-118.521633
May 17	11:13:55	California Sea Lion	*Zalophus californianus*	6	32.968917	-118.514700

Date	Initial time	Common Name	Species	Best Count	Latitude	Longitude
May 17	11:15:07	California Sea Lion	*Zalophus californianus*	3	32.945733	-118.490467
May 17	11:20:30	California Sea Lion	*Zalophus californianus*	3	32.941450	-118.399800
May 17	11:29:06	Pacific White-sided Dolphin	*Lagenorhyncus obliquidens*	45	32.975050	-118.323333
May 17	11:31:38	California Sea Lion	*Zalophus californianus*	1	32.963833	-118.323267
May 17	11:50:51	Risso's Dolphin	*Grampus griseus*	11	33.019750	-118.115933
May 17	12:16:03	Risso's Dolphin	*Grampus griseus*	12	33.072933	-117.874150
May 17	12:49:00	Common Bottlenose Dolphin	*Tursiops truncatus*	12	33.157517	-117.460367
May 17	12:49:19	Risso's Dolphin	*Grampus griseus*	35	33.151100	-117.455133
May 17	15:08:01	Unidentified Dolphin	Delphinidae sp.	40	32.876950	-117.287317
May 17	15:09:05	Blue Whale	*Balaenoptera musculus*	1	32.906017	-117.295767
May 17	15:37:43	Common Dolphin Sp.	undifferentiated *Delphinus*	120	32.931883	-117.322500
May 17	15:51:42	Risso's Dolphin	*Grampus griseus*	6	32.883367	-117.620767
May 17	16:27:34	Common Bottlenose Dolphin	*Tursiops truncatus*	22	32.756717	-118.173633
May 17	16:40:26	Risso's Dolphin	*Grampus griseus*	44	32.872117	-118.279533
May 17	17:00:20	California Sea Lion	*Zalophus californianus*	1	32.891150	-118.221350
May 17	17:01:00	California Sea Lion	*Zalophus californianus*	2	32.894617	-118.198833
May 17	17:06:00	California Sea Lion	*Zalophus californianus*	4	32.923517	-118.039067
May 17	17:06:14	Pacific White-sided Dolphin	*Lagenorhyncus obliquidens*	36	32.925900	-118.029100
May 17	17:18:36	Common Dolphin Sp.	undifferentiated *Delphinus*	500	32.949200	-117.901683
May 17	17:37:24	Unidentified Small Marine Mammal possible elephant seal	Pinnipedia sp.(?)	1	33.034400	-117.483783
May 17	17:44:42	Unidentified Dolphin	Delphinidae sp.	180	32.960183	-117.319983
May 18	09:23:12	Unidentified Dolphin	Delphinidae sp.	1	32.819017	-117.390683
May 18	09:23:53	California Sea Lion	*Zalophus californianus*	1	32.826283	-117.384833
May 18	09:28:22	Common Bottlenose Dolphin	*Tursiops truncatus*	50	32.751117	-117.417150
May 18	09:46:39	California Sea Lion	*Zalophus californianus*	1	32.613917	-117.806667
May 18	10:08:03	California Sea Lion	*Zalophus californianus*	2	32.751150	-117.647850
May 18	10:20:29	Minke Whale	*Balaenoptera acutorostrata*	1	32.927417	-117.347533
May 18	11:12:36	Blue Whale	*Balaenoptera musculus*	1	33.052383	-117.427600
May 18	11:36:21	Common Dolphin Sp.	undifferentiated *Delphinus*	120	33.135383	-117.453700
May 18	11:47:08	Common Dolphin Sp.	undifferentiated *Delphinus*	45	33.132650	-117.611417
May 18	12:18:10	Common Bottlenose Dolphin	*Tursiops truncatus*	40	32.856050	-117.406717
May 18	12:28:53	Common Bottlenose Dolphin	*Tursiops truncatus*	28	32.972500	-117.514850
May 18	12:47:44	Common Dolphin Sp.	undifferentiated *Delphinus*	1000	33.209883	-117.660100
May 18	13:15:20	Common Bottlenose Dolphin	*Tursiops truncatus*	23	32.924650	-117.554567
May 18	13:22:15	Common Dolphin Sp.	undifferentiated *Delphinus*	70	32.893300	-117.393183

Appendix B May 2010 Focal Follows

Appendix D. List of all focal behavioral follows longer than 5 min conducted during the May SOCAL 2010 aerial monitoring surveys off San Diego, California. Video was taken on some of these groups as indicated in Appendix C. This summary is based on a preliminary "quick look" and should not be considered a detailed analysis or summary of useable video.

Date	Focal Start Time	Focal End Time	Duration of Focal (hr:min:sec)	Video Segment Lengths (hr:min:sec)	Total Minutes of Video (hr:min:sec)	Latitude (Degrees N)	Longitude (Degrees W)	Species	Grou p Size	Preliminary Focal Notes
13-May	9:39:33	10:05:32	0:25:59	0:11:35 + 0:10:22	0:21:57	32.3607	117.53134	Risso's Dolphin	4	
13-May	10:13:00	10:38:03	0:25:03	0:11:37 + 0:06:24	0:18:01	32.40658	117.59531	Unid. Dolphin	12	
13-May	10:40:18	10:54:10	0:13:52			32.4319	117.50703	Common Dolphin sp.	150	
13-May	11:02:49	11:08:43	0:05:54			32.47385	117.27236	Common Dolphin sp.	300	
13-May	12:44:00	13:38:07	0:54:07	0:01:26	0:01:26	32.58778	117.45364	Common Dolphin sp.	350	
14-May	11:26:09	13:09:49	1:43:40	0:11:33 + 0:02:45 + 0:11:38 + 0:11:32 + 0:11:35 + 0:05:45	0:54:48	33.07076	118.57433	Fin Whale	3	Long focal, 3 fins, possible calf
15-May	12:30:17	12:54:00	0:23:43	0:11:44 + 0:08:12	0:19:56	32.33344	118.03347	Risso's Dolphin	17	
15-May	13:27:23	13:51:40	0:24:17	0:11:43 + 0:08:19	0:20:02	32.24435	117.57964	Risso's Dolphin	33	
15-May	13:53:20	14:18:53	0:25:33	0:11:43	0:11:43	32.28049	117.55447	Risso's Dolphin	23	
15-May	15:26:52	15:49:51	0:22:59	0:11:44	0:11:44	32.45864	117.27497	Risso's Dolphin	15	
16-May	13:54:18	14:17:40	0:23:22	0:11:47 + 0:06:29	0:18:16	33.0512	118.47029	Risso's Dolphin	14	
16-May	14:21:59	14:43:04	0:21:05	0:10:01	0:10:01	33.06788	118.50972	Risso's Dolphin	30	
16-May	14:47:00	14:53:32	0:06:32			33.04202	118.59554	Unid. Large Whale	1	
16-May	15:08:55	15:14:48	0:05:53	0:01:53	0:01:53	33.03013	118.48195	Risso's Dolphin	6	
16-May	15:39:30	15:44:51	0:05:21			33.1743	118.18404	Common Dolphin sp.	300	
17-May	12:16:03	12:36:03	0:20:00			33.04376	117.52449	Risso's Dolphin	12	
17-May	12:49:00	13:18:42	0:29:42			33.09451	117.27622	Common Bottlenose Dolphin	12	
17-May	12:49:19	13:18:36	0:29:17			33.09066	117.27308	Risso's Dolphin	35	Mixed with Tursiops

Date	Focal Start Time	Focal End Time	Duration of Focal (hr:min:sec)	Video Segment Lengths (hr:min:sec)	Total Minutes of Video (hr:min:sec)	Latitude (Degrees N)	Longitude (Degrees W)	Species	Group Size	Preliminary Focal Notes
17-May	15:09:05	15:38:30	0:29:25			32.54361	117.17746	Blue Whale	1	Did focals for over 20 min w video small vessel was passing blue approx 0.5 nm at fast pace when we first saw blue then another small vessel passed later at approx 1 mile
17-May	15:51:42	16:10:09	0:18:27	0:04:48	0:04:48	32.52897	117.3698	Risso's Dolphin	6	Video was on Risso's almost entire 15 min focal while above and below surface
17-May	16:27:34	16:34:35	0:07:01			32.45403	118.10418	Common Bottlenose Dolphin	22	
17-May	16:40:26	16:58:30	0:18:04	0:00:29 + 0:02:09 + 0:11:28 + 0:01:43	0:15:49	32 52.327	118 16.772	Risso's Dolphin	44	
17-May	17:06:00	17:15:00	0:09:00			32.5548	118.02044	California Sea Lion	4	
17-May	17:06:14	17:14:44	0:08:30			32.55554	118.01746	Pacific White-sided Dolphin	36	
17-May	17:18:36	17:25:42	0:07:06			32.56952	117.54101	Common Dolphin sp.	500	
18-May	10:20:29	10:47:42	0:27:13	0:11:38 + 0:03:20	0:14:58	32.55645	117.20852	Minke Whale	1	
18-May	11:12:36	11:31:23	0:18:47	0:01:28 + 0:01:30 + 0:01:30	0:04:28	33.03143	117.25656	Blue Whale	1	
18-May	11:36:21	11:41:28	0:05:07			33.08123	117.27222	Common Dolphin sp.	120	
18-May	12:28:53	12:34:57	0:06:04			32.5835	117.30891	Common Bottlenose Dolphin	28	
18-May	12:47:44	12:58:41	0:10:57			33.12593	117.39606	Common Dolphin sp.	1000	

TOTALS: >5 min focals for May= 10

>10 min focals for May= 20

Appendix C List of May 2010 Video

Appendix E. Video recorded during May SOCAL 2010 aerial monitoring surveys off San Diego, California based on preliminary "quick look" review.

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Preliminary Species Identification	Preliminary Video Notes
SOCAL May 2010_Video_13 May_094125_IDXX_Rissos	May-10	9:41:25	9:53:00	0:11:35	Risso's Dolphin	spread out, all different orientations,0.5 to 30 body lengths apart, milling, multiple breaches, split into subgroups
SOCAL May 2010_Video_13 May_095238_IDXX_Rissos	May-10	9:52:38	10:03:00	0:10:22	Risso's Dolphin	3-8 body lengths apart, 2 subgroups, slow travel, oriented at 240, one animal approx. 40 body lengths away from other groups, milling, low level social, shift in position to slow travel
SOCAL May 2010_Video_13 May_101623_IDXX_UnIdDolphin	May-10	10:16:23	10:28:00	0:11:37	Unidentified Dolphin, probable Common Dolphin sp.	spread out, slow travel, milling, oriented at 290, potential reaction to aircraft, 1000 ft., 1-6 body lengths apart, 4 animals, 2 subgroups
SOCAL May 2010_Video_13 May_102736_IDXX_UnIdDolphin	May-10	10:27:36	10:34:00	0:06:24	Unidentified Dolphin	orientation at 270, spyhop ?, 3 animals,0 .5- 4 body lengths apart, 2 subgroups, subsurface, slow travel
SOCAL May 2010_Video_13 May_112121_IDXX_commonsp.	May-10	11:21:21	11:33:00	0:11:39	Common Dolphin sp.	300-500 indiv., surface active travel, milling, oriented at 220, dispersal is less than 1 throughout, no change in behavior, heading S, no calves seen, many seagulls traveling with the dolphin, slight zigzagging, the stragglers are approx. 40 body lengths away from main group
SOCAL May 2010_Video_13 May_113227_IDXX_commomsp.	May-10	11:32:27	11:44:00	0:11:33	Common Dolphin sp.	15 body lengths apart, oriented at 220, group size remains the same
SOCAL May 2010_Video_13 May_114434_IDXX_commonsp.	May-10	11:44:34	11:46:00	0:01:26	Common Dolphin sp.	oriented at 230, birds above dolphins at surface
SOCAL May 2010_Video_13 May_121923_IDXX_UnIdDolphin	May-10	12:19:23	12:31:00	0:11:37	Unidentified Dolphin	mill/travel, oriented 240, dispersal 1-4 and 1-1, milling all directions, angle 22, oblong egg group shape, wider than long, 3 gulls above them, surface-active, angle 21, 1500 ft. after 10 minutes went to 1000 ft.
SOCAL May 2010_Video_13 May_122534_IDXX_UnIdDolphin	May-10	12:25:34	12:29:00	0:03:26	Unidentified Dolphin	
SOCAL May 2010_Video_13 May_122818_IDXX_Casealion	May-10	12:28:18	12:29:00	0:00:42	California Sea lion	3 individuals seen
SOCAL May 2010_Video_13 May_124728_IDXX_Commonsp.	May-10	12:47:28	12:59:00	0:11:32	Common Dolphin sp.	slow travel, leaping, very rapid movement of one animal in middle of others, long line, oriented at 200 and 210, poss. reaction to aircraft, shift between a blob and one that was milling in a long line, medium travel with some white water, disperal of 1-10, medium travel, now wider than long

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Preliminary Species Identification	Preliminary Video Notes
SOCAL May 2010_Video_13 May_125928_IDXX_Commonsp.	May-10	12:59:28	13:11:00	0:11:32	Common Dolphin sp.	slow travel, 1 and 1-3 body lengths, oriented at 220, wing formation, split into subgroups, overall movement from group to group, leap, breach, egg shape, wider than long, very surface active
SOCAL May 2010_Video_13 May_131740_IDXX_Commonsp.	May-10	13:17:40	13:22:00	0:04:20	Common Dolphin sp.	ragged line, wider than long, oriented towards the north, medium travel, now longer than wide, dispersal 1-4, close to them presumably within cone, oriented at 020, milling, moving towards 300, no obvious reaction to airplane, evenly spaced 1-2, oriented now at 330
SOCAL May 2010_Video_14 May_112927_IDXX_Fin	May-10	11:29:27	11:41:00	0:11:33	Fin whale	huge mola mola seen, been down for 4 minutes, blow, whale scat seen, just below surface, 1 adult, oriented 090, poss calf
SOCAL May 2010_Video_14 May_114115_IDXX_Fin	May-10	11:41:15	11:44:00	0:02:45	Fin whale	Logging at surface, full size adult, subsurface,
SOCAL May 2010_Video_14 May_114422_IDXX_Fin	May-10	11:44:22	11:56:00	0:11:38	Fin whale	blow, oriented 090, slow travel, subsurface, 1 animal, angle 8 degrees, visibility decreasing, whale just below surface
SOCAL May 2010_Video_14 May_115528_IDXX_Fin	May-10	11:55:28	12:07:00	0:11:32	Fin whale	fin whale, slow travel, resting at times, subsurface, occasionally blowing
SOCAL May 2010_Video_14 May_120725_IDXX_Fin	May-10	12:07:25	12:19:00	0:11:35	Fin whale	blow, oriented 210, not quite sure if it is same animal as before, laying just below surface motionless, occasionally blowing,0 .5- 6 body lengths apart, slow travel, now oriented at 250, poss. 2 pairs, 3 animals, one rolled up under the kelp, defecation seen on video, 2 mola molas
SOCAL May 2010_Video_14 May_121815_IDXX_Fin	May-10	12:18:15	12:24:00	0:05:45	Fin whale	occasional blows, oriented at 200, 3 animals, defecation, dispersal is over 10 body lengths, one whale moving away from other 2, oriented at 360
SOCAL May 2010_Video_15 May_123217_IDXX_Rissos	May-10	12:32:16	12:44:00	0:11:44	Risso's Dolphin	dispersal 1-8, 16 animals, slow travel to 060, angle 14 degrees, milling, different heading, 800 ft. cloud cover not allowing to go higher, line abreast formation, no calves seen, 2 subgroups, dorsals breaking the surface
SOCAL May 2010_Video_15 May_124348_IDXX_Rissos	May-10	12:43:48	12:52:00	0:08:12	Risso's Dolphin	dispersal less than 1 to 6 body lengths, in oval formation, below surface, animals spread out to 1 to 8 body lengths, mostly below surface, oriented 300, spread out longer then wider, couple still clumped, staggered line abreast, now in u shape with small clumps, 2 in lead, rest behind line abreast, whales move close together, angle 19, less than 900 ft.

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Preliminary Species Identification	Preliminary Video Notes
SOCAL May 2010_Video_15 May_133017_IDXX_Rissos	May-10	13:30:17	13:42:00	0:11:43	Risso's Dolphin	just below surface, oriented 310, line abreast, slow travel, dispersal 1-3 and 1-4, 3 groups, one with 10 animals, other with 8 animals, always visible at or below the surface, groups are less than 100 meters apart, 2 groups coming together, third group still behind, 2 groups have formed as one with 23 indiv., bird flock formation, second group behind with 9 animals.
SOCAL May 2010_Video_15 May_134141_IDXX_Rissos	May-10	13:41:41	13:50:00	0:08:19	Risso's Dolphin	dispersal 1-3 and 1-4, subgroup is line abreast, and 70 body lengths from large group, oreinted at 240, inverted triangle formation, 25 in main group, 2 tail slaps, dispersal now 1-6, subgroup now 30 body lengths behind main group and to the left, other group now 15 body lengths away, subgroup is milling, main group line abreast in a letter C formation, angle is 18 degrees, unident. splash,
SOCAL May 2010_Video_15 May_140217_IDXX_Rissos	May-10	14:02:17	14:14:00	0:11:43	Risso's Dolphin	brief social, disperal is 1-7, oriented at 240, one mother-calf group, line abreast, angle is 21 degrees, dispersal now 1-5, now oriented 210, staggered line abreast over a large area, dispersal now 1-10,
SOCAL May 2010_Video_15 May_141356_IDXX_Rissos	May-10	14:13:56	14:18:00	0:04:04	Risso's Dolphin	maternal group staying to the side of main group, dispersal is less than 1 to 6, animals seem to stay headed the same direction all day, dispersal now less than 1 to 5, milling, spread out, longer than wider, oriented at 240 and 210, angle is 16 degrees
SOCAL May 2010_Video_15 May_153016_IDXX_Rissos	May-10	15:30:16	15:42:00	0:11:44	Risso's Dolphin	disperal 1-4, oriented to 8 o'clock, clumped line abreast, longer line than wide, oriented 180, subsurface
SOCAL May 2010_Video_16 May_155829_IDXX_Risso's	May-10	15:58:29	16:10:16	0:11:47	Risso's Dolphin	Surface- active travel with rooster tails, group in an inverted triangle, 14 individ., oriented at 030 and 060, dispersal 1-15, single animal in back 100 body lengths, 600 ft, spread out in an elongated line, line abreast towards end of video
SOCAL May 2010_Video_16 May_161015_IDXX_Risso's	May-10	16:10:15	16:16:44	0:06:29	Risso's Dolphin	Surface-active travel, group still oblong than wide, oriented at 060, dispersal 1-15, rooster tailing, no calves seen, white water seen when dolphin come to surface, angle is 11 degrees, 700 ft
SOCAL May 2010_Video_16 May_163157_IDXX_Risso's	May-10	16:31:57	16:41:58	0:10:01	Risso's Dolphin	Surface-active, dispersal 1-20 and 1-10, 30 indiv., slow travel, oriented to 120, group in broad oval
SOCAL May 2010_Video_16 May_171207_IDXX_Risso's	May-10	17:12:07	17:14:00	0:01:53	Risso's Dolphin	dispersal is 1-20, shallow dive

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Preliminary Species Identification	Preliminary Video Notes
SOCAL May 2010_Video_17 May_102724_Casealion	May-10	10:27:24	10:38:50	0:11:26	California Sea Lion	16 CA sea lion
SOCAL May 2010_Video_17 May_104902_IDXX_UnidPinnCAsea lion	May-10	10:49:02	11:00:28	0:11:26	Unidentified Pinniped_CA sea lion	1 unidentified pinniped, 24 CA sea lion, voice only no video
SOCAL May 2010_Video_17 May_110029_IDXX_Casealion_Unid Dolp_Risso's	May-10	11:00:29	11:11:54	0:11:25	California Sea Lion_Unid Dolphin_Risso's	37 Cal. Sea lion, voices only, no video, unidentified dolphin, vocals hard to understand, poss 30-45 dolphin, 5 Rissos's
SOCAL May 2010_Video_17 May_160452_IDXX_Risso's	May-10	16:04:52	16:09:40	0:04:48	Risso's Dolphin	6 animals, slow travel, dispersal 1-2, in tight ball, shallow dive, oriented at 270, subsurface, angle 16
SOCAL May 2010_Video_17 May_160452_IDXX_Risso's	May-10	16:42:31	16:43:00	0:00:29	Risso's Dolphin	Dispersal is 1-2, a big group, on line 4 of NAOPA, at 3 o'clock
SOCAL May 2010_Video_17 May_164231_IDXX_Risso's	May-10	16:43:01	16:45:10	0:02:09	Risso's Dolphin_CA sea lion	oval longer than wider group shape, oriented at 270, dispersal 1-2, approx. 34 indiv., 1700 ft., 1 CA Sea Lion
SOCAL May 2010_Video_17 May_164301_IDXX_Risso's_Casealion	May-10	16:45:12	16:56:40	0:11:28	Risso's Dolphin	24 angle for CA Sea Lion, 54 angle for Risso's, slow travel, 1-2 and 1-3 and 1-4 dispersal, oval longer then wider group size, oriented at 270 and 300, no calves seen, 44 animals, line abreast, 1500 ft.
SOCAL May 2010_Video_17 May_164512_IDXX_Risso's	May-10	16:56:39	16:58:22	0:01:43	Risso's Dolphin	wider than longer group size, slow travel, oriented at 300, dispersal 1-4, two lines, no vessels in view, angle is 44, 1500 ft.
SOCAL May 2010_Video_18 May_103224_IDXX_Minke	May-10	10:32:24	10:44:02	0:11:38	Minke Whale	multiple blows, oriented at 1 o'clock, subsurface, variable dive times
SOCAL May 2010_Video_18 May_104422_IDXX_Minke	May-10	10:44:22	10:47:42	0:03:20	Minke Whale	blow, surfaced very briefly
SOCAL May 2010_Video_18 May_111452_IDXX_Blue	May-10	11:14:52	11:16:20	0:01:28	Blue Whale	Blue whale, boat went next to whale and whale defecated, multiple blows, oriented at 220, slow travel,
SOCAL May 2010_Video_18 May_112720_IDXX_Blue	May-10	11:27:20	11:28:50	0:01:30	Blue Whale	blow, flukes
SOCAL May 2010_Video_18 May_112852_IDXX_Blue	May-10	11:28:52	11:30:22	0:01:30	Blue Whale	whale not visible

Appendix D Selected Photographs of Sightings

All photos by Mari A. Smultea courtesy of Smultea Environmental Sciences.

Blue whale (Balaenoptera musculus) traveling at the surface (below left) and diving (below right) on May 17th in NAOPA. The relatively light body coloration of blue whales allows observers to track them underwater for longer periods of time and at deeper water depths than darker whale species.

Common dolphins (Delphinus sp.) (below left) surface-active fast traveling (porpoising) and common dolphins (Delphinus sp.) (below right) with sea gulls, surface-active fast traveling/possible feeding, on 17 May 2010 in NAOPA. Photos by Mari Smultea courtesy of Smultea Environmental Sciences.

Common dolphin (Delphinus sp.) (below left) mother and calf surface-active traveling in a group of commons on 17 May 2010 in NAOPA. Common dolphins (Delphinus sp.) (below right) (including a calf on bottom right) surface-active fast traveling on 17 May 2010 in NAOPA. Photos by Mari Smultea courtesy of Smultea Environmental Sciences.

Pacific white-sided dolphins (Lagenorhynchus obliquidens) (below bottom) surface-active fast traveling on 17 May 2010 in NAOPA. Common bottlenose dolphins (Tursiops truncates) (below top) traveling on 17 May 2010 in NAOPA. Photos by Mari Smultea courtesy of Smultea Environmental Sciences.

Risso's dolphin (Grampus griseus) (below) slow traveling on 17 May 2010 in NAOPA. Note how the dolphins are readily visible below the water surface due to their light body coloration. This enables observers to track them for longer periods of time underwater than darker cetacean species. Photos by of Mari Smultea courtesy of Smultea Environmental Sciences.

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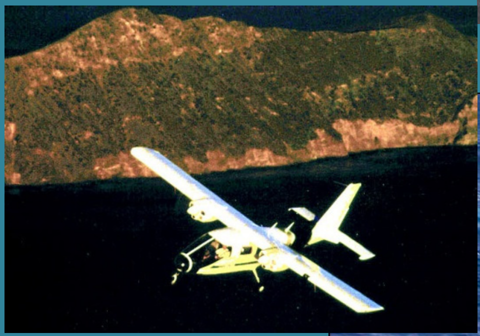
Aerial Survey Marine Mammal Monitoring off Southern California in Conjunction with US Navy Major Training Events (MTE)

SOCAL July, 2010

Surveys July 27 – August 3

Draft Report



SES SMULTEA ENVIRONMENTAL SCIENCES, LLC

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Cover Photos: Blue whale (Balaenoptera musculus), photographed with a telephoto lens from the Partenavia in the SOCAL 2010, and the Bell 206 helicopter and Partenavia Observer fixed-wing airplane used during the July 2010 SOCAL aerial survey monitoring . Photos of blue whale and helicopter by Mari A. Smultea/SES; photographer of Partenavia unknown. Cover page design and layout by Kate Lomac-MacNair and Roxann Merizan.

Section 1 Introduction

In support of the U.S. Navy's (Navy) Marine Mammal Monitoring Plan (M3P) in the Southern California Range Complex (SOCAL) (DoN 2009), aerial surveys were conducted by Smultea Environmental Sciences (SES) to monitor marine mammals and sea turtles (MM/ST) during July 2010 in the SOCAL area off San Diego, California. This was the seventh such aerial survey 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). Portions of these MTEs occurred in and near offshore waters of the Southern California Anti-submarine Warfare Range (SOAR) west of San Clemente Island (Figure 1). Naval training has been conducted within SOCAL for over 40 years, and marine mammals are also known to be abundant there (e.g., summarized in Carretta et al. 2000, 2008; DoN 2008, 2009).

The contracted work involved considerable planning, communications and clearances with and by the Navy Technical Representative (NTR) given the logistical complexity and high degree of safety planning associated with the MTEs.

Project questions and hypotheses were developed by SES based on the five questions identified in the Navy's SOCAL M3P designed to assess potential effects of MFAS and underwater detonations on MM/ST during Navy MTEs (DoN 2009; see Smultea et al. 2009a,b). An important factor limiting the ability to assess potential effects of MFAS in this report is that the Navy did not disclose MFAS transmission times and locations for national security reasons. Thus, it is not possible for us herein to compare data from specific operational MFAS "on" and "off" periods during MTEs, nor data on distance and relative location of MFAS sources vs. sightings.

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 total seven surveys, a helicopter (Bell XXX) 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).

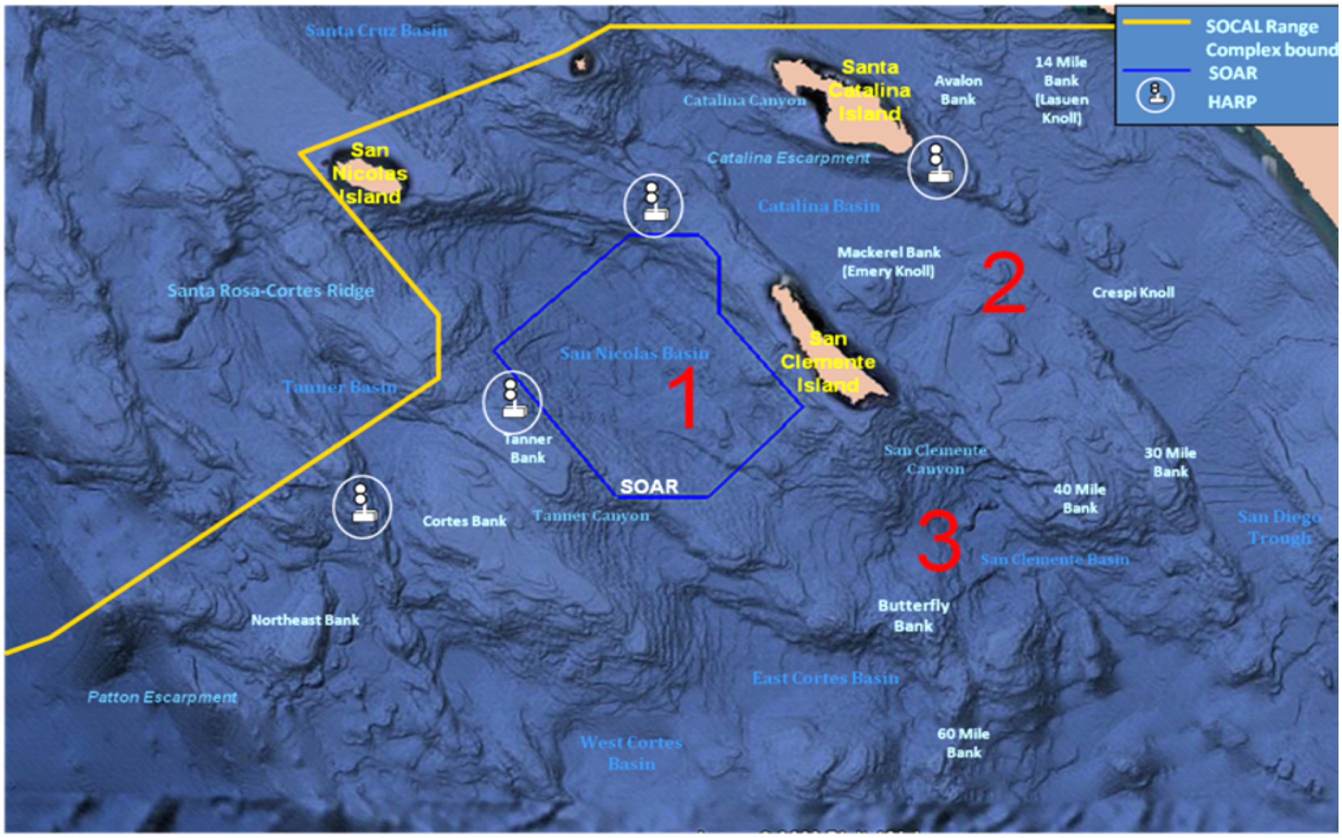

Figure 15. Location of the aerial survey monitoring area and underwater topographic features within the Navy's Southern California Range Complex (SOCAL). Numbers indicate survey areas of interest to the Navy in order of priority; orange line designates the SOCAL boundary; blue lines designate the Southern California Offshore Anti-submarine Warfare Range (SOAR); icons are approximate locations of Navy-funded bottom-mounted passive- acoustic high-frequency acoustic recording packages (HARPs).

Section 2 Methods

Two aircraft were used for the survey: (1) a fixed-wing, twin-engine Partenavia Observer with a glass nose (the same one used on our previous SOCAL surveys), and (2) a Bell 206 helicopter (front cover). Both aircrafts were owned and operated by Aspen Helicopters, Oxnard, California. This was the first time a helicopter had been used for a survey; the goal was to evaluate the feasibility of this platform 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. 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 (Figure 3). 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 (Figure 4). In the helicopter, the pilot sat in the right front seat while the survey recorder/photographer sat in the left

The primary survey areas were the SOAR west of San Clemente Island (SCI) (as permitted given Navy exercise activities) and the Northern Air Operating Area (NAOPA) range between SCI and the mainland coast (Figure 1). “Search”, “verify”, and “focal follow” modes were implemented as described in Smultea et al. (2009a,b, 2010a,b). Notably, sea turtles were considered unlikely to be seen in the MTE based on available data and none have been seen during this or our past aerial surveys (reviewed in DoN 2008).

As described in Smultea et al. (2009a), priority species were (1) MM/ST exhibiting unusual or distressed behavior, (2) near-stranded, stranded, or dead MM/ST, (3) MM/ST species listed as endangered or threatened under the ESA, (4) beaked whales, and (5) Risso’s dolphins considered potential “surrogate” representatives for deep-diving beaked whales (see DoN 2009). Past surveys have shown that Risso’s dolphins are the easiest small cetacean to track during focal follows given their light body coloration that increases ability to track them underwater, their tendency to travel slowly at and near the water surface often for extended periods, and their apparent tolerance of close vessels and small aircraft (Smultea et al. 2010b, SES unpublished data).

Line-transect “search” effort was flown at altitude 1000 ft and speed 100 kts; occasionally, we flew as low as 700 ft altitude (as permitted by a Letter of Confirmation [LoC] for a General Authorization [GA] issued by NMFS to SES) over non-ESA-listed species to photo-verify species (i.e., “verify” mode), or when low clouds necessitated lower flight altitude. If an ESA-listed species was seen, the aircraft immediately moved above 1000 ft altitude and 1 km radial distance, as applicable, as specified in the GA. During focal follows, aircraft were flown in at altitudes of 1200-1500 ft and radial distances of approximately 1 km to remain outside the expected 13-degree-radial “Snell’s sound cone” produced by the aircraft (i.e., beyond where the animals could hear the aircraft below the water). Clockwise circles were flown in the Partenavia since the only opening window for observers was in the front right seat; video and photographs were taken through this window. Counter-clockwise circles were flown by the helicopter since two observers were on the left hand side. As in past surveys, we used two Apple iTouches for field data collection (one for line-transect and one for focal behavior data).

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).

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). Results are summarized in Tables 1 - 3, Figures 2 - 7, and Appendices A - G. However, unlike previous reports, **Error! Reference source not found.** indicates aerial survey days when MTES-associated MFAS was operating in SOCAL. This activity occurred on five of the seven July 2010 survey days, including the first survey date of July 27.

Effort

A total of 18.1 hr of flight time and 3125 km (1688 nm) of effort were conducted during the May 2010 SOCAL aerial survey between aircraft "wheels up" off the ground to "wheels down" when the plane landed (Table 1 and Table 2). Surveys were flown on seven days from July 27 to August 3 (0); no survey occurred on August 31 due to aircraft mechanical repair needs. Most (74% of 14.3 hrs) 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 11). Beaufort sea state rating (Bf) ranged from 1-5 during the July survey. Bf 3 predominated (16%) followed by Bf 2 (12%) (Figure 11). 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 (Table 1, Table 2, 0). 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 time higher than the cost of the Partenavia fixed-wing plane.

Sightings

A total of 86 sightings of ~11,090 individual marine mammals was observed (Table 12 and 0). 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). Photographs are currently being reviewed by Dr. T.A. Jefferson to differentiate and verify short- and long-beaked common dolphins, as has been done for past surveys.

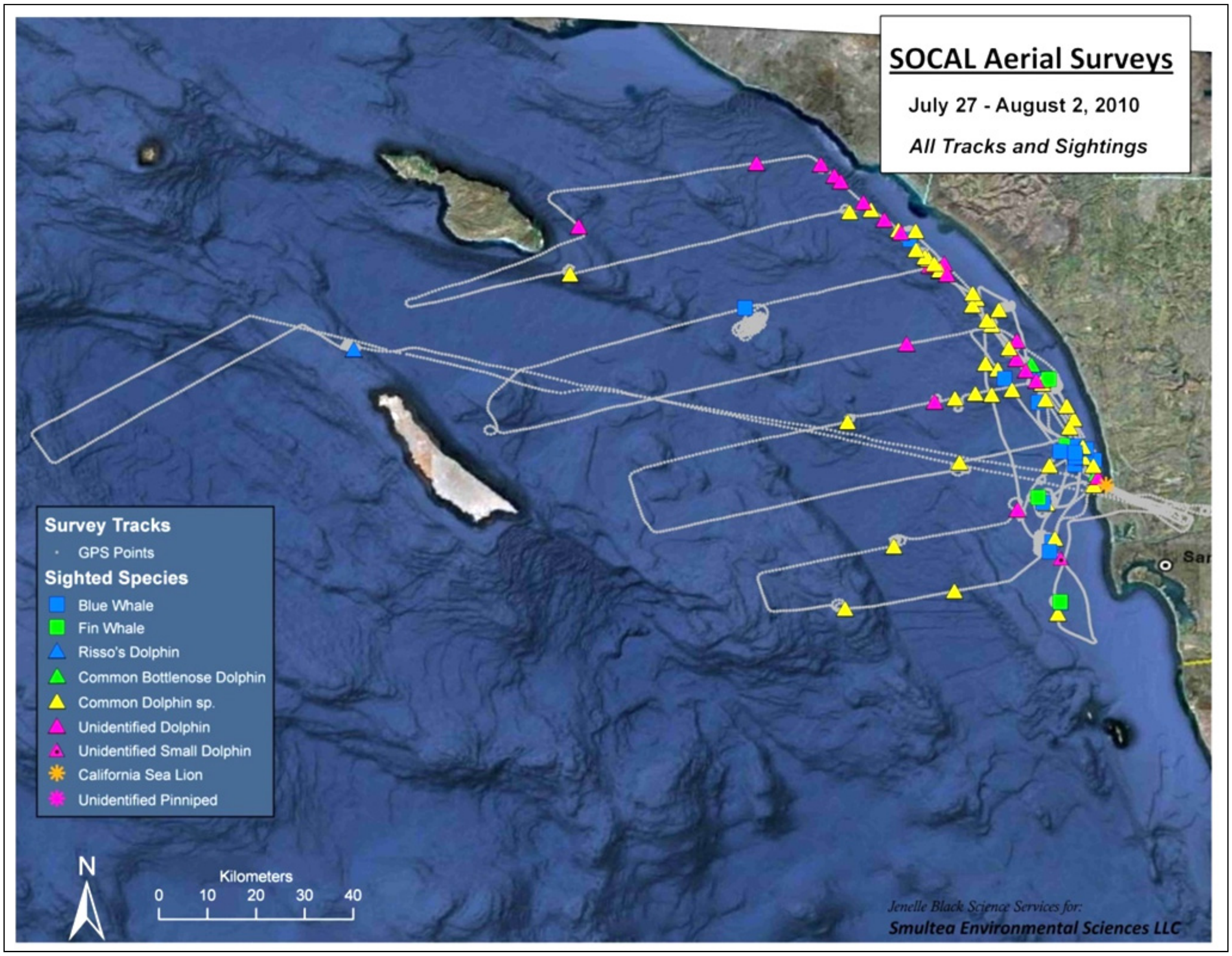

Figure 16. All track lines and sightings made during aerial monitoring surveys in SOCAL July 27 – August 3, 2010

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Table 15. Aerial survey flight times, total hours (hh:mm) by date, and survey area during the July 2010 SOCAL aerial survey

Date 2010	Platform	Location	Time Lift Off	Time Landed	Total Flight Time	Total Engine Time	Start Observ	End Observ	Total "On Effort" Observ	MTE-assoc. MFAS?	Survey Notes
July 27	Helicopter Bell 206	Coastal NAOPA	14:01	16:35	02:34	02:41	14:06	16:29	01:20	Yes	Assessing effectiveness of helicopter as platform for focal behavioral observations with Bernd Wuersig. Flew <5 km from coast. Heavy morning fog/low clouds. Ceilings 1400-1600 ft, fog/heavy overcast. Conducted focals near San Diego on feeding blue and fin whales, observed frequent defecation.
July 28	Helicopter Bell 206	Coastal NAOPA	13:37	16:08	02:31	02:40	13:42	16:03	01:36	No	Assessing effectiveness of helicopter as platform for focal behavioral observations with Bernd Wuersig. 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.
July 29	Partenavia OBS	NAOPA (SOAR fogged in)	14:29	16:39	02:11	02:34	14:33	16:19	00:30	Yes	Flying Partenavia Observer. Heavy fog/low clouds delayed departure until afternoon. Conducted focals on feeding blue and fin whales again in same area as yesterday.
July 27	Helicopter Bell 206	Coastal NAOPA	14:01	16:35	02:34	02:41	14:06	16:29	01:20	Yes	Assessing effectiveness of helicopter as platform for focal behavioral observations with Bernd Wuersig. Flew <5 km from coast. Heavy morning fog/low clouds. Ceilings 1400-1600 ft, fog/heavy overcast. Conducted focals near San Diego on feeding blue and fin whales, observed frequent defecation.
July 28	Helicopter Bell 206	Coastal NAOPA	13:37	16:08	02:31	02:40	13:42	16:03	01:36	No	Assessing effectiveness of helicopter as platform for focal behavioral observations with Bernd Wuersig. 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.
July 30	Partenavia OBS	N SOAR	13:45	16:05	02:20	02:38	14:18	15:29	01:11	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.
July 31	Partenavia OBS	S NAOPA (SOAR fogged in)	14:27	18:27	04:00	04:18	14:31	18:21	03:22	Yes	Heavy fog/low clouds delayed departure until afternoon. Focals on blue whales in NAOPA; SOAR fogged in/ inaccessible.
August 1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No flight. Aircraft grounded due to mechanical issues
August 2	Partenavia OBS	Central NAOPA	14:45	17:52	03:07	03:24	14:49	17:46	02:37	Yes	Mechanic fixed plane by 1 pm. Flew N NAOPA lines. Focal on blue whales.
August 3	Partenavia OBS	N NAOPA	15:27	18:07	02:40	02:52	15:31	18:00	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 effective focals.
			Total Flight Time		19:23	21:07	**Total Observ.Time**		12:17		

Table 16. Definitions and summary of aerial survey effort (km and nm) by leg type during the July 2010 SOCAL MTE aerial surveys.

Leg Type	Leg Type Definition	Total km Flown	Total nm Flown	Total hrs Flown
Systematic	Pre-determined line-transect legs located in SOAR, NAOPA and FLETA HOT	592	320	3.0
Random	Short lines connecting longer systematic lines	111	60	0.5
Transiting	Flying between the airport and the survey grid locations	654	353	3.8
Navy-Directed Transiting	Flying off intended course as directed by Navy during a survey to avoid Navy activities	0	0	0
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	1549	836	10.0
Circumnavigating Coast	Flying parallel to SCI coastline approximately 0.5 km offshore to search for potential strandings	0	0	0
Fog Effort	Transiting above fog layer with limited or no visibility to water	220	119	0.9
TOTAL		3125	1688	18.1

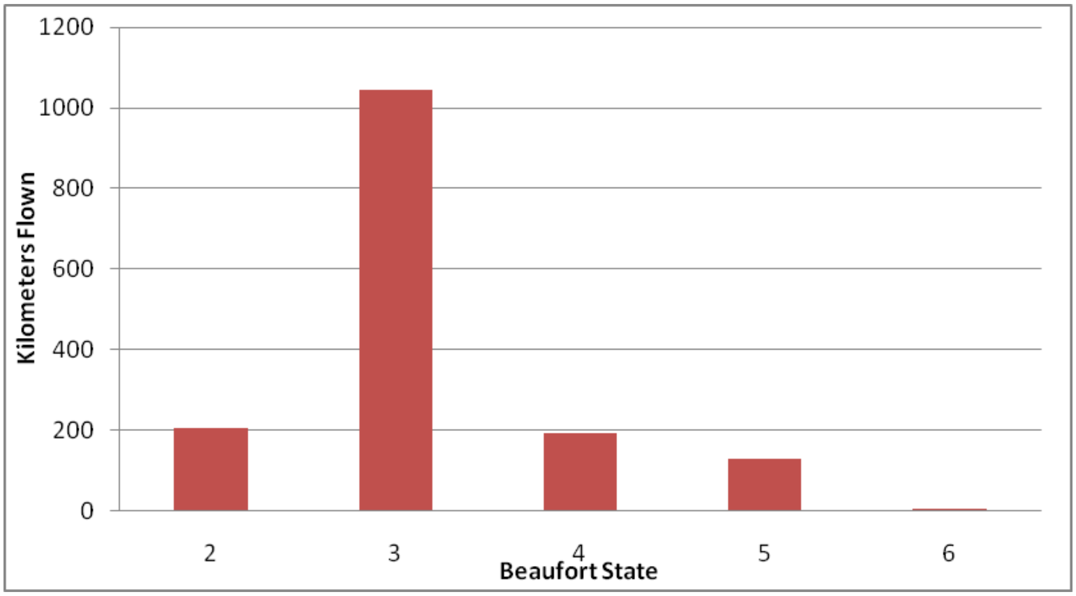

Figure 17. Summary of aerial survey effort (km) by Beaufort sea state during the July 2010 SOCAL MTE aerial survey. Includes only Random, Systematic, and Transiting survey effort.

Table 17. Summary of marine mammal sightings by species during the July SOCAL 2010 MTE aerial surveys. Sightings organized in order of frequency observed starting with those seen most commonly.

Species (Common Name)	Scientific Name	Total No. of Sightings	Total Estimated No. Individuals
Common Dolphin sp.	*Delphinus* spp.	40	9,354
Blue Whale	*Balaenoptera musculus*	18	44
Unidentified Dolphin	Delphinidae spp.	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

Sighting Rates

Sighting Rates are tabulated in several 0 tables, due to their large sizes. Tables C-1 and C-2 compare sighting rates based on combined systematic, random and transit effort (i.e., point-to-point linear effort) for various species and species groups 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 C-1; the number of *individuals* sighted per unit effort is displayed in Table C-2. During July 2010 only, sighting rates were highest for common dolphins and blue whales based on both numbers groups and individuals per km and hr. Other species were seen at considerably lower sighting rates due to fewer sightings per unit effort. Differences were evident in the seasonal sighting rates of a number of marine mammal species. Sighting rates of Risso's dolphins were remarkably higher in May than in November and July. In contrast, sighting rates for individual common dolphins were roughly three times higher in July and November vs. May. Blue whale sighting rates were also highest in July, and were considerably lower for May and November. Pacific white-sided dolphins and California sea lions were absent or virtually absent in July; reduced densities of these two species are expected during summer based on past surveys in SOCAL (Carretta et al. 2000?). Bottlenose dolphins were not seen in November. However, fin whale sighting rates were similar across all three survey months. The overall number of marine mammal sightings per unit effort were also similar across November, May and July. However, the sighting rate based on number of individual marine mammals seen per hour was about three times higher in November than May and twice as high in July as May. Sighting rates by survey effort type based on number of groups and number of individuals per unit of effort (i.e., per km, nm, and hour) are provided in Tables C-3 and C-4, respectively. (See Table 2 for definitions and total km and nm of effort types.) In July, overall marine mammal 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. Sighting rates were similar across systematic effort for the three survey months, but differed for transit and random effort. During random effort, individual sighting rates were five to seven times higher during May vs. November and July, most evidently for dolphins. For transit effort, individual sighting rates were at least five times higher during July 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 July 2010.

Distribution

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 **Error! Reference source not found.**, Table 10, and 0). 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).

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 west of La Jolla near a large buoy (Figure 2 and Figure 3, 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 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 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 dolphin, 86% of 19 unidentified dolphin, and 100% of 3 common bottlenose dolphin groups were within 20 km 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).

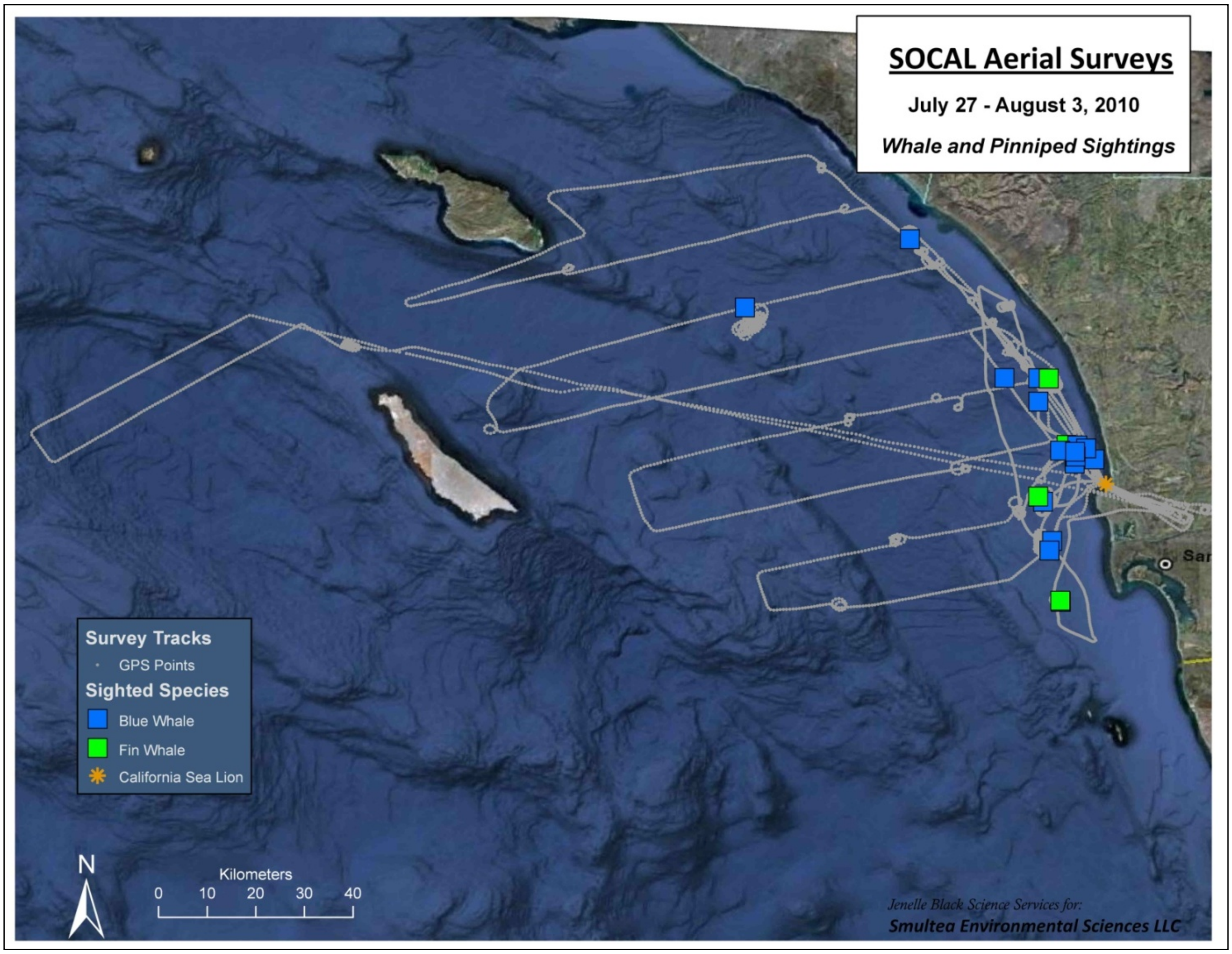

Figure 18. Whale sightings made during aerial survey monitoring in the SOCAL survey area July 27 – August 3, 2010.

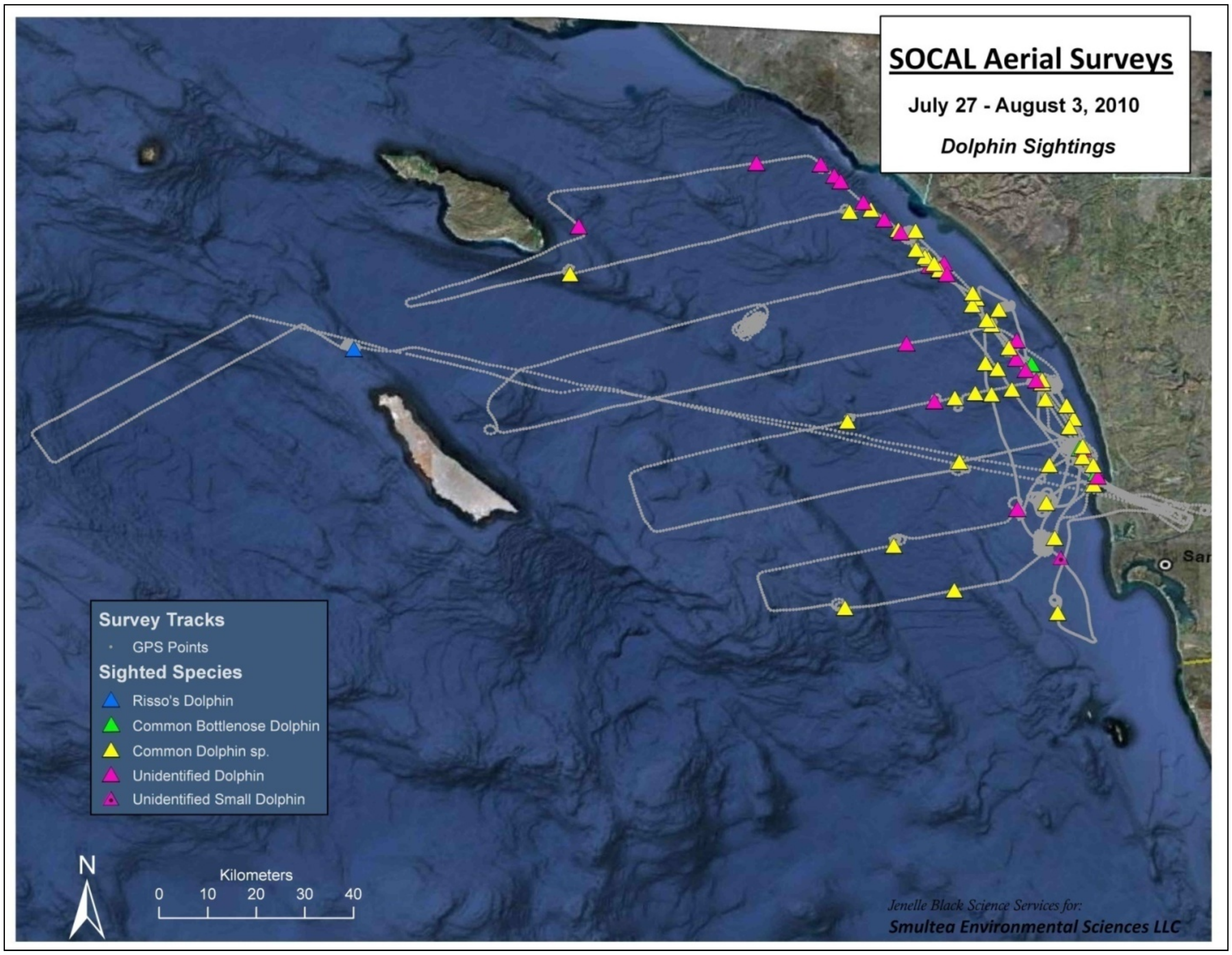

Figure 19. Dolphin sightings made during aerial survey monitoring in the SOCAL survey area July 27 – August 3, 2010.

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 (Figure 6, middle panel);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 (Figure 6, bottom panel).

Blue whales predominantly traveled at a slow to medium speed, consistent with previous surveys (Figure 7, top panel). Feeding behavior was frequently observed during focal follows of both blue and fin whales as evidenced by inflated lunges, lunging on prey balls, and frequent reddish defecations (0 and 0). Blue whale headings were more variable than those of common dolphins, with some tendency to head southerly and northerly (Figure 7, center panel). Mean dispersal between closest neighbors among blue whales was variable and ranged from 1 to 24 body lengths dispersal (Figure 14, bottom panel).

Focal Follows

Focal follow effort was emphasized more during this July and the May 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 were conducted for 5-9 min. A preliminary total of 19 focal follows at least 5 min long totaling 553 minutes (9 hr 13 min) was conducted during the July 2010 survey (0). Five (26%) of the 19 focals were conducted 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. About one-half (47% or 9) of the 19 focals occurred with blue whales or blue whales with fin whales (*n* = 1). All nine of the blue whale focals were over 10 min long and four were over 1 hour long (0). Video was taken on eight of the nine blue whale focal groups. In addition to blue whales, focal follows occurred with the one Risso's dolphin sighting for a total of ~20 min with 12 min of video. Only three of eight common dolphin focals lasted over 10 min, two of which included video; the remaining five common dolphin focals involved only circling of the group to verify species by taking photos. Based on our first SOCAL surveys in October and November 2008, we decided it was not effective to conduct extended focal follows on common dolphins as they tended to occur in large (typically over 100 dolphins) spread-out groups that were too difficult to consistently track with the video and for behavioral monitoring. In addition, common dolphins were not considered priority species per the M3P as they are not ESA-listed and are not considered a logical deep-diving surrogate for beaked whales. Further preliminary detail on observed behaviors is provided in the Appendices and in the description below.

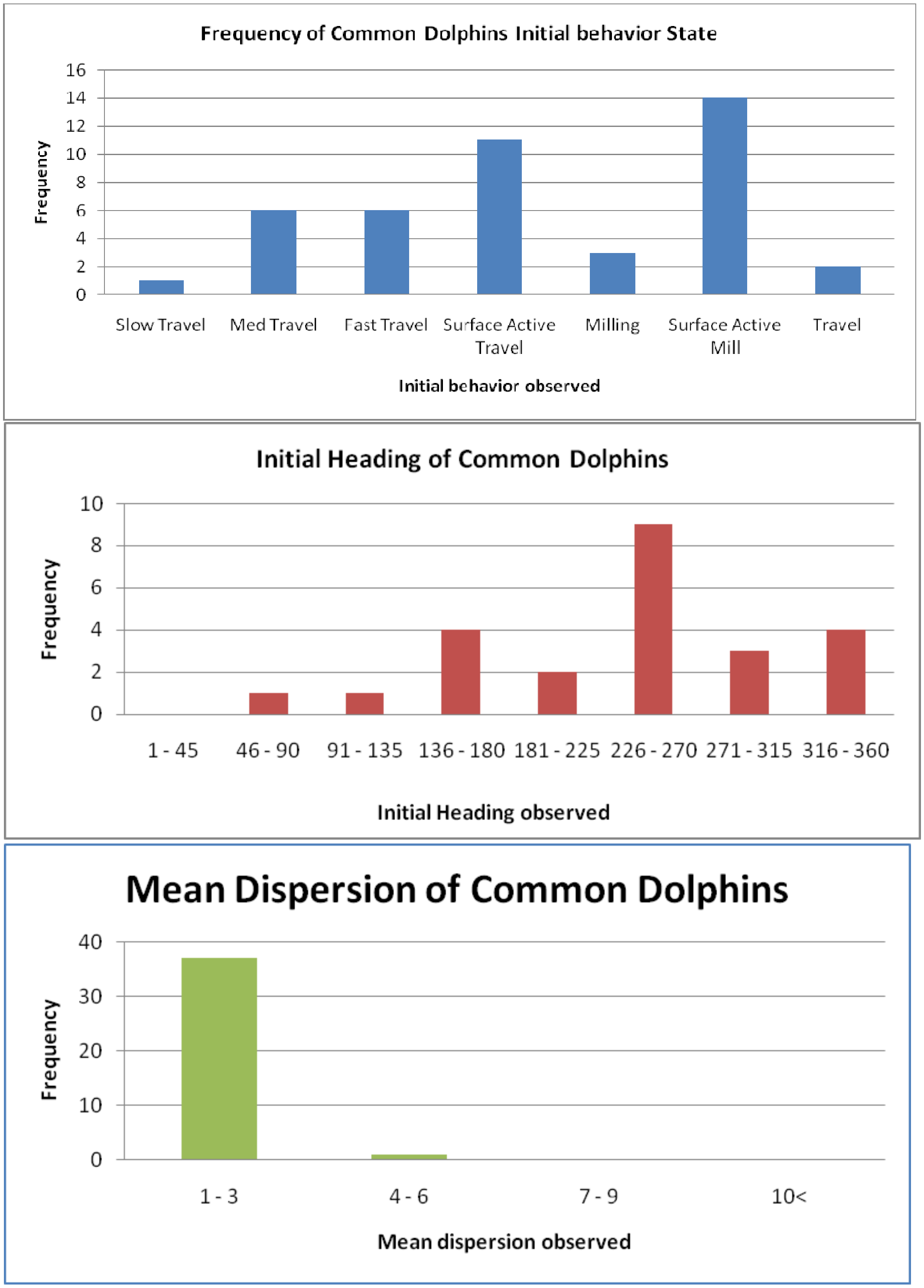

Figure 20. Common dolphins during the July 2010 SOCAL survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths)

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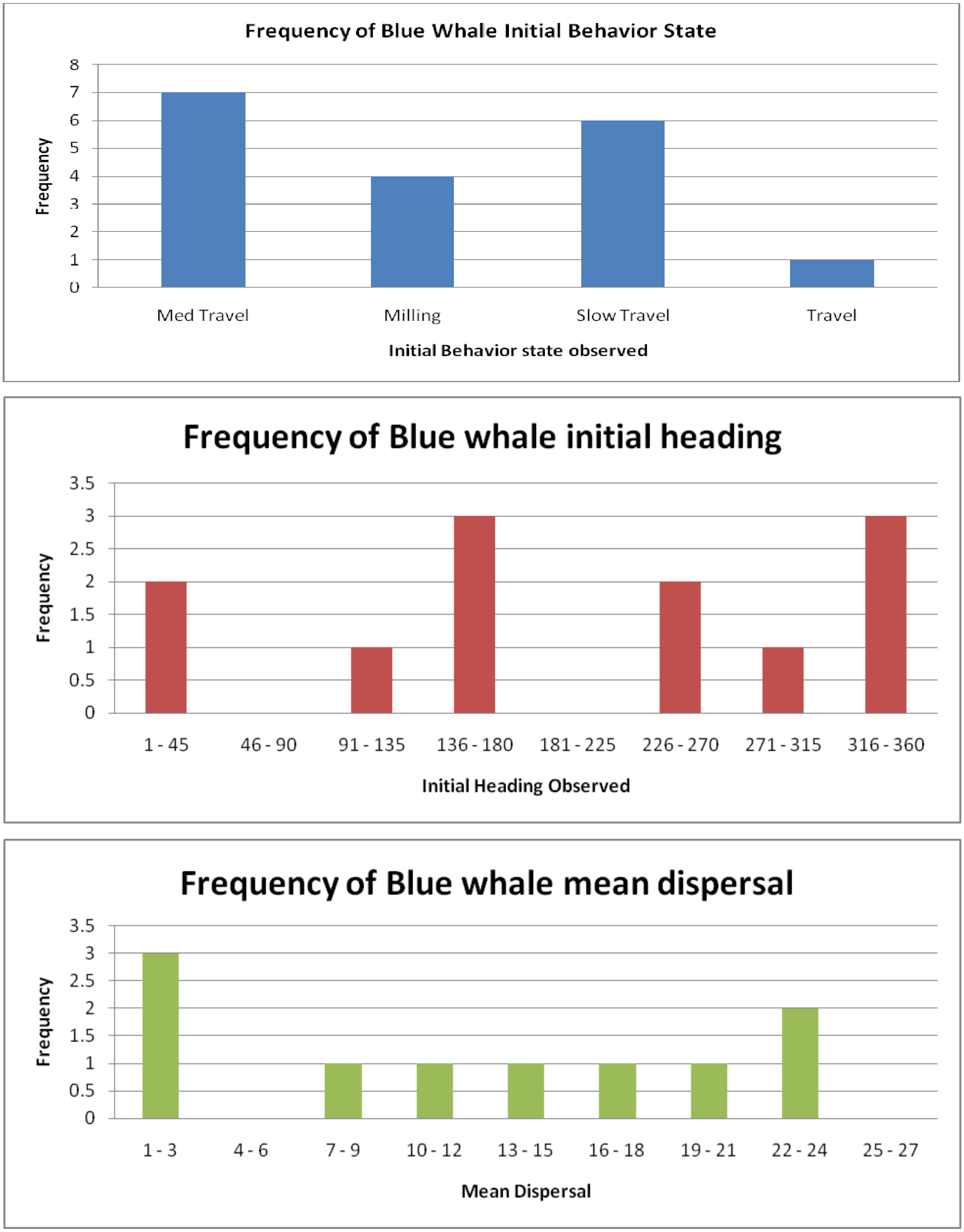

Figure 21. Blue whale behavior during the July 2010 SOCAL survey periods: Upper panel: frequency of initially observed behavioral states. Middle panel: frequency of initially observed headings (degrees magnetic). Bottom panel: frequency of mean dispersal distance between individuals (in estimated body lengths).

Unusual Observations

Summarized preliminarily below are three unusual encounters and associated observations with blue and fin whales in the SOCAL. Two encounters were observed from the helicopter and one from the airplane. These encounters are included because they have not been previously seen during our past SOCAL surveys. In addition, there are few if any available data or literature on such observations.

The overhead and prolonged 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.

Blue Whale Mother and Calf #1

On 27 July 2010, a focal follow was conducted on a mother and calf (young-of-the-year) blue whale pair from 15:24-16:24 and included video (Appendix E). We have rarely seen blue whale calves during our seven SOCAL aerial surveys. Video was taken on this pair from 15:51-16:24. The interesting aspect of this encounter was that the calf may have been nursing from the mother based on review of the video. After a series of surfacings and blows, the calf dove below the mother who was at the time visible below the water surface. The pair appeared 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 on her side in what we believe was likely nursing behavior. See Appendix E for further detail on this group based on a preliminary "first look" at the video.

Blue Whale Mother and Calf #2

On 2 August 2010, 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 pair 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.

Blue-Fin Whale Interaction

On 28 July 2010, we did behavioral circles around a loose grouping of blue and fin whales, and took particularly valuable 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 the videographer's 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. We are presently acquiring frame-by-frame analysis capability, and will report on details of interactions at some other time.

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 sec. In 0, we link 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 chronologically in 0 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.

Photographs and Video

A preliminary total of ~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. Preliminary lists of photographs and video are presented in 0 and 0. 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. As done for our previous surveys, Dr. T.A. Jefferson will review our photographs to confirm or speciate short-beaked vs. long-beaked common dolphins and other species as relevant.

Section 4 Discussion

Key Role of Aerial Surveys

The key and unique roles that aerial surveys play in addressing Navy monitoring plan goals have been discussed thoroughly in our previous reports (see review in Smultea et al. 2009a,b, Smultea and Lomac-MacNair 2010). Thus, they are not discussed again herein.

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 18 summarizes our comparison.

Aerial Survey Collaboration with Other Researchers

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 as part of the Behavioral Response Study (BRS) led by Dr. Brandon Southall and funded by N45 and Office of Naval Research Funds. In addition, our (other) data will be 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. Beginning in the SOCAL in fall 2010, the BRS program will be conducting playback sound studies to some of these 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).

Table 18. 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;
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 2008, July 2010	July 2010

Table 19. Summary of SOCAL Marine Mammal Aerial Surveys

	Survey							
	October	**November**	**June**	**July**	**November**	**May**	**July**	**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	7 surveys: May, June, July, Oct, Nov
No. Days Flown	5	4	6	9	6	6	7	36
Major Training Exercise (MTE) Before, During or After Survey?	Before/During	After	After	After	During/After	During	During/After	During, before or after
Total Flight Hr (Wheels up/down)	28	21	30	34	28	29	19	189
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)	33,880 km 18,294 nm
No. Navy-directed Survey Changes (appox)	9	7	12	10	3	1	0	42
No. Coastline Surveys for Strandings (San Clemente Isld)	0	2	1	0	1	1	0	5
No. Groups Seen	115	185	161	240	93	152	86	1,032
Estim. No. Individuals	12,587	5732	9489	22,719	12,826	5,453	11,090	79,896
Mean Group Size	109.4	31	58.9	94.7	137.9	35.9	131.3	85.6
No. Dead Sightings	0	3 *(2 CA sea lions, 1 blue whale)*	0	2 *(2 prob. CA sea lions)*	0	0	0	5
No. Species	9	9	11	10	10	9	5	16
No. Focal Groups Circled 5-9 min	22	20	24	37	14	10	6	139
No. Extended Focal Groups Circled >10 min	5	7	7	8	10	20	13	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)	144 min.
No. Photos Taken	1050	1280	1099	2301	2203	1350	2900	12,183
Estimated Usable Video (min)	53	41	83	50	90	334	373	1024

Section 5 Conclusions and Recommendations

Survey Highlights

Dr. Bernd Wuersig of the Marine Mammal Research Program at Texas A&M University joined our field team for the second time (also in May 2010) to provide expert review and critique of our behavioral study approach and protocol, and to assist us in the field. Dr. Wuersig again 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 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 18 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 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 Table 19 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.

As the seventh aerial survey we have conducted for Navy monitoring in the SOCAL, the combined data 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 and previous six aerial surveys contributes to building 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 their light, white body coloration and scarring of Risso's dolphins making 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 (see 0).

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

We are grateful to Navy personnel from US Pacific Fleet Environmental and Naval Facilities Engineering Command Pacific and UCSD/SIO personnel Dr. John Hildebrand, Paula Hodgkiss and Linda Sawyer for their support, coordination and facilitation in the implementation of these surveys. We thank our excellent survey observer biologists Mark Deakos, Kate Lomac-MacNair, and Lori Mazzuca. We are grateful for our competent and safety-conscious pilots Kathleen Veatch and Michael Estomo of Aspen Helicopters, Oxnard, California.

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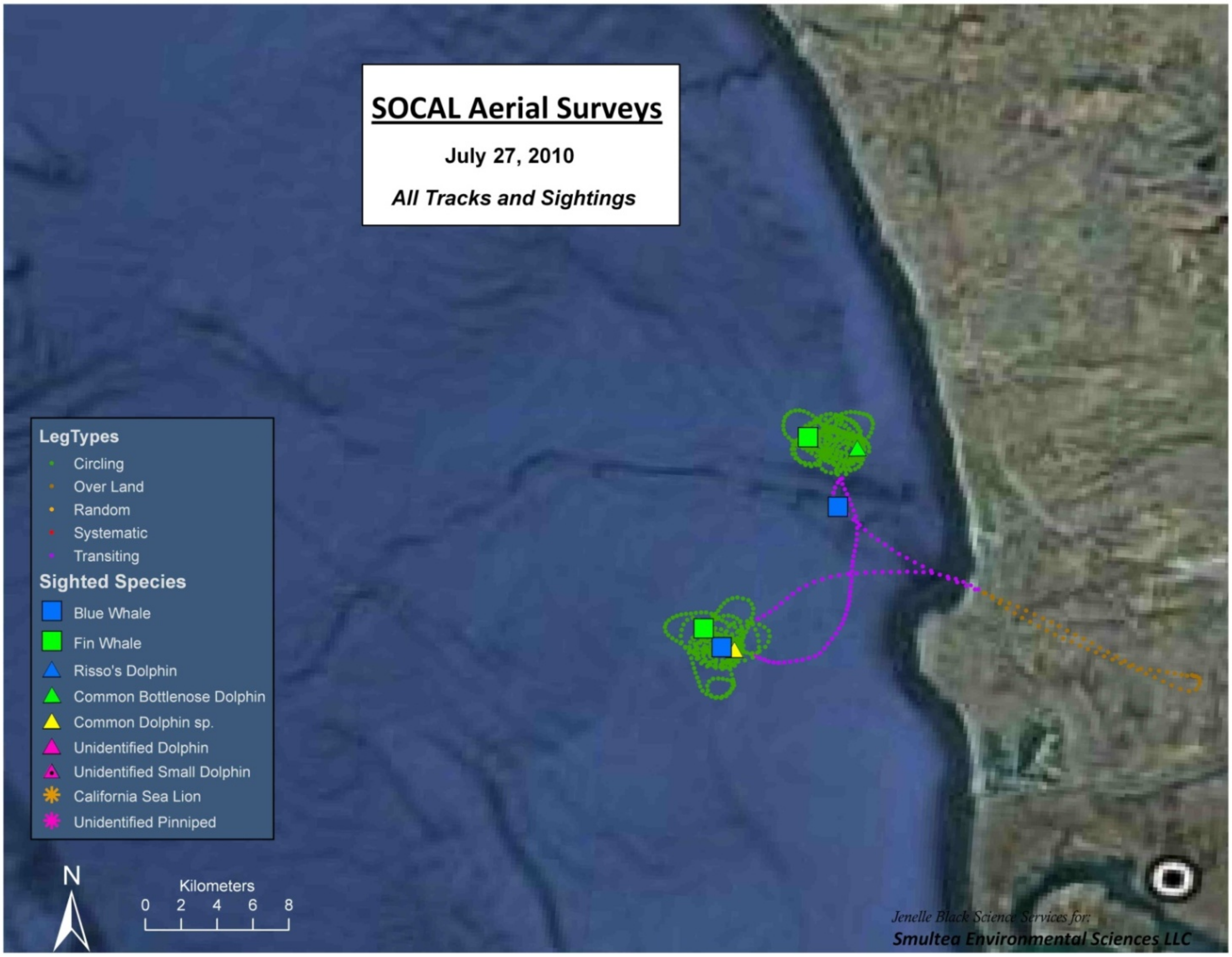
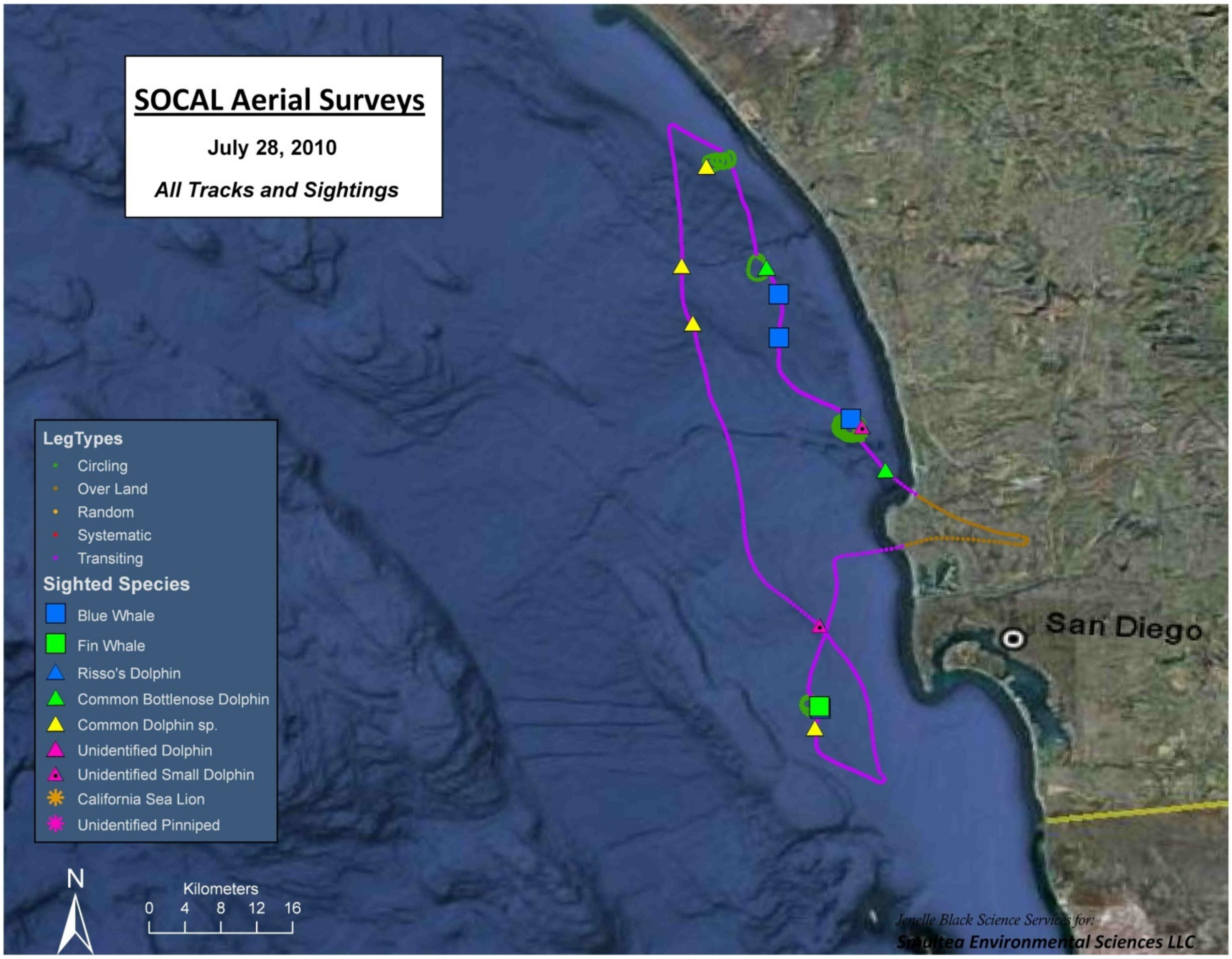
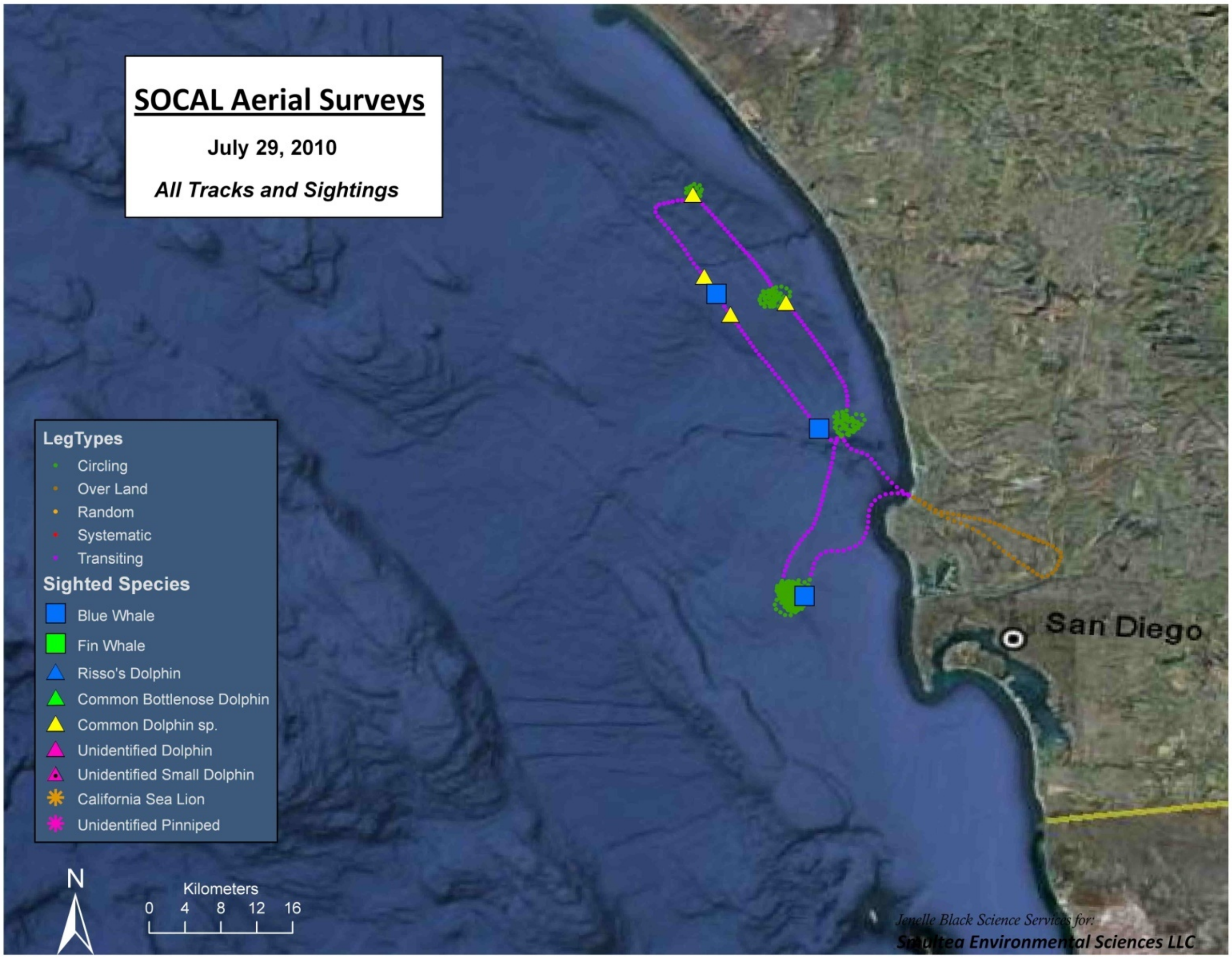
Smultea, M.A. and K. Lomac-MacNair, C.E. Bacon, R.K. Merizan, and J.S.D. Black. 2010. Aerial Survey Monitoring for Marine Mammals off Southern California in Conjunction with US Navy Major Training Events, May 13-18, 2010 – Draft Report, August 2010. Prepared for Commander, Pacific Fleet. Pearl Harbor, HI, Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, HI, 96860-3134, under Contract No. N62742-10-P-1816 issued to Smultea Environmental Sciences, LLC. (SES), Issaquah, WA, 98027. Submitted August 2010.

Appendix A Maps of Daily Surveys and Sightings




SOCAL Aerial Surveys
July 28, 2010
All Tracks and Sightings
LegTypes
Circling
Over Land
Random
Systematic
Transiting
Sighted Species
Blue Whale
Fin Whale
Risso's Dolphin
Common Bottlenose Dolphin
Common Dolphin sp.
Unidentified Dolphin
Unidentified Small Dolphin
California Sea Lion
Unidentified Pinniped
N
Kilometers
0 4 8 12 16
San Diego
Jenelle Black Science Services for:
Smultea Environmental Sciences LLC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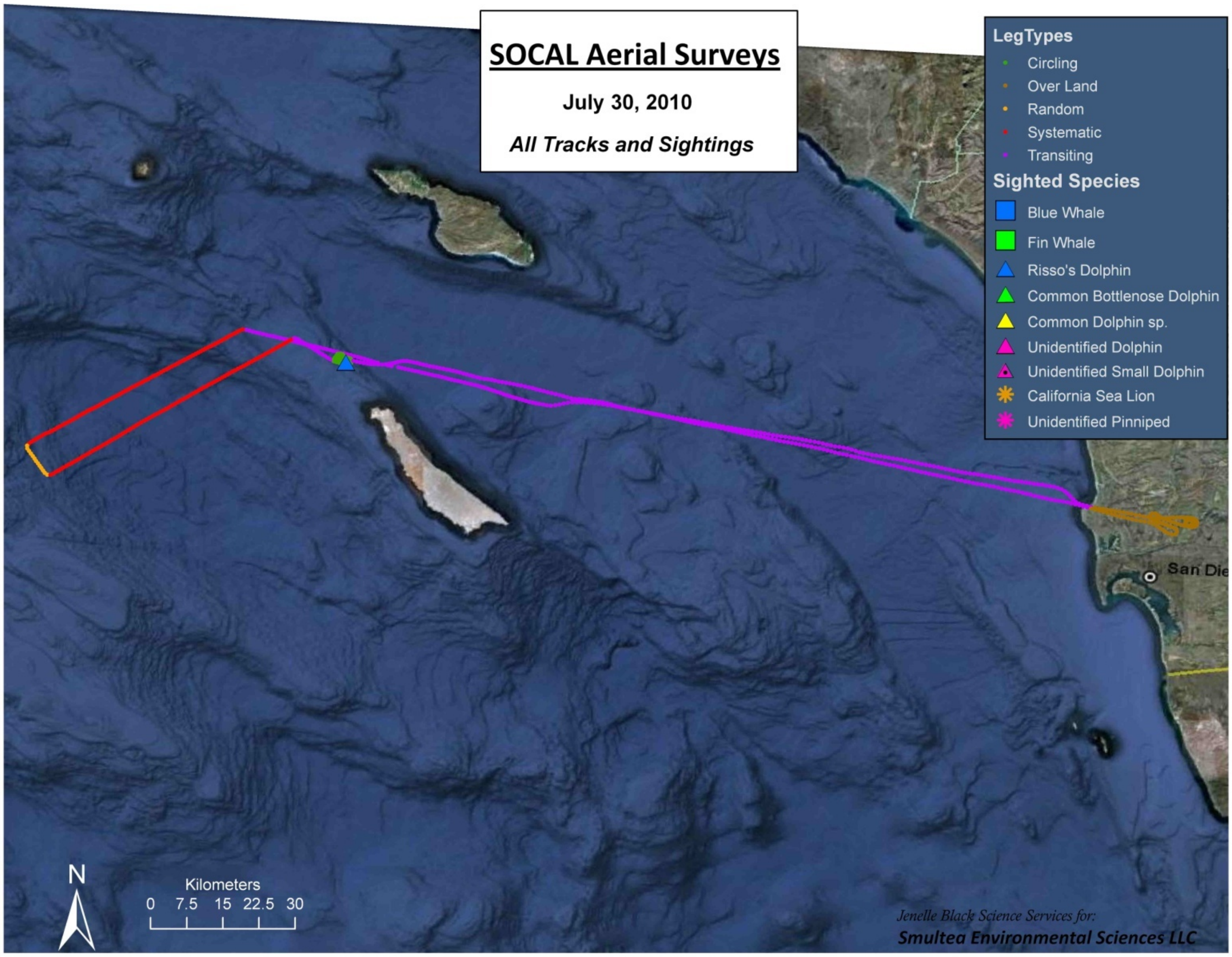
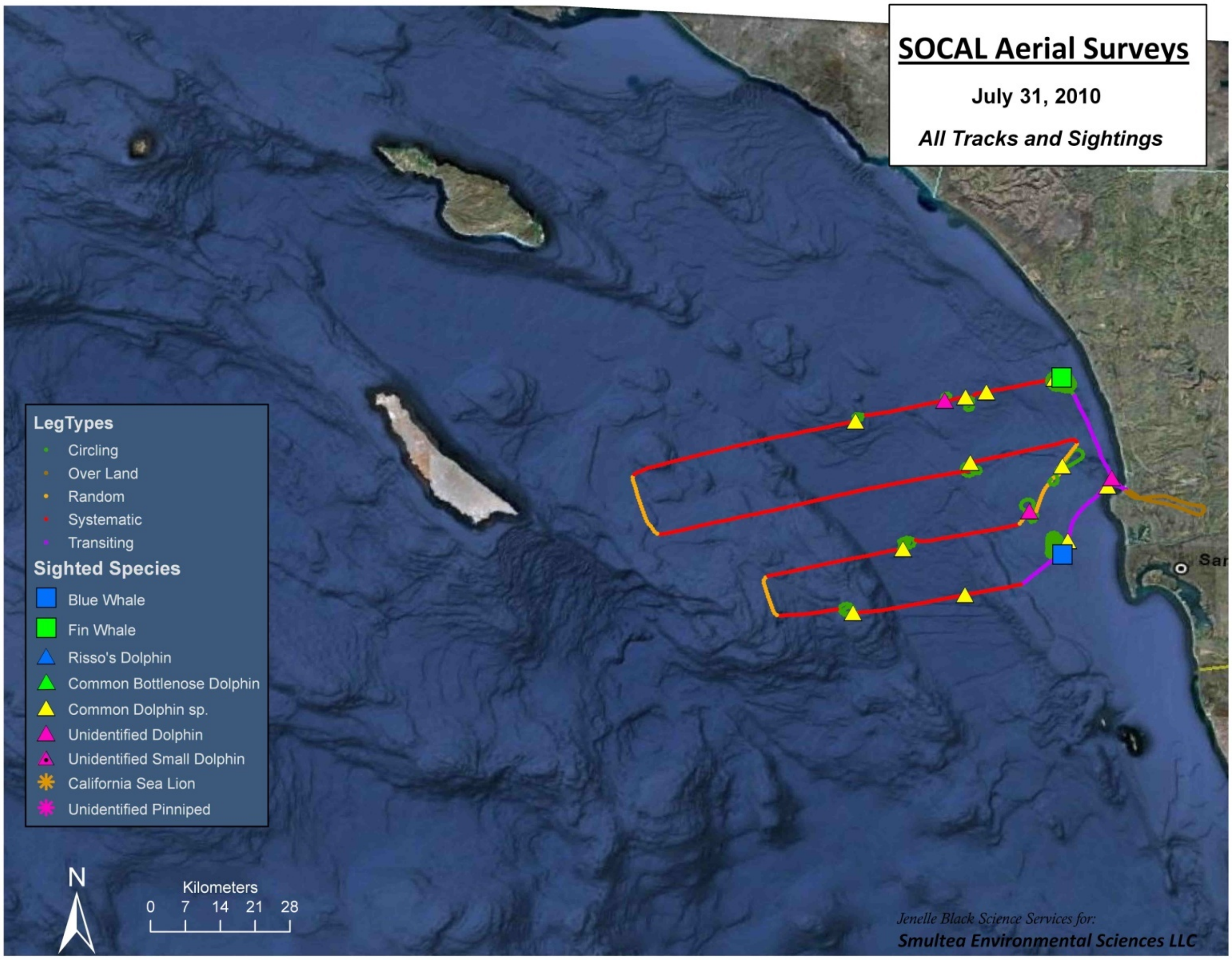
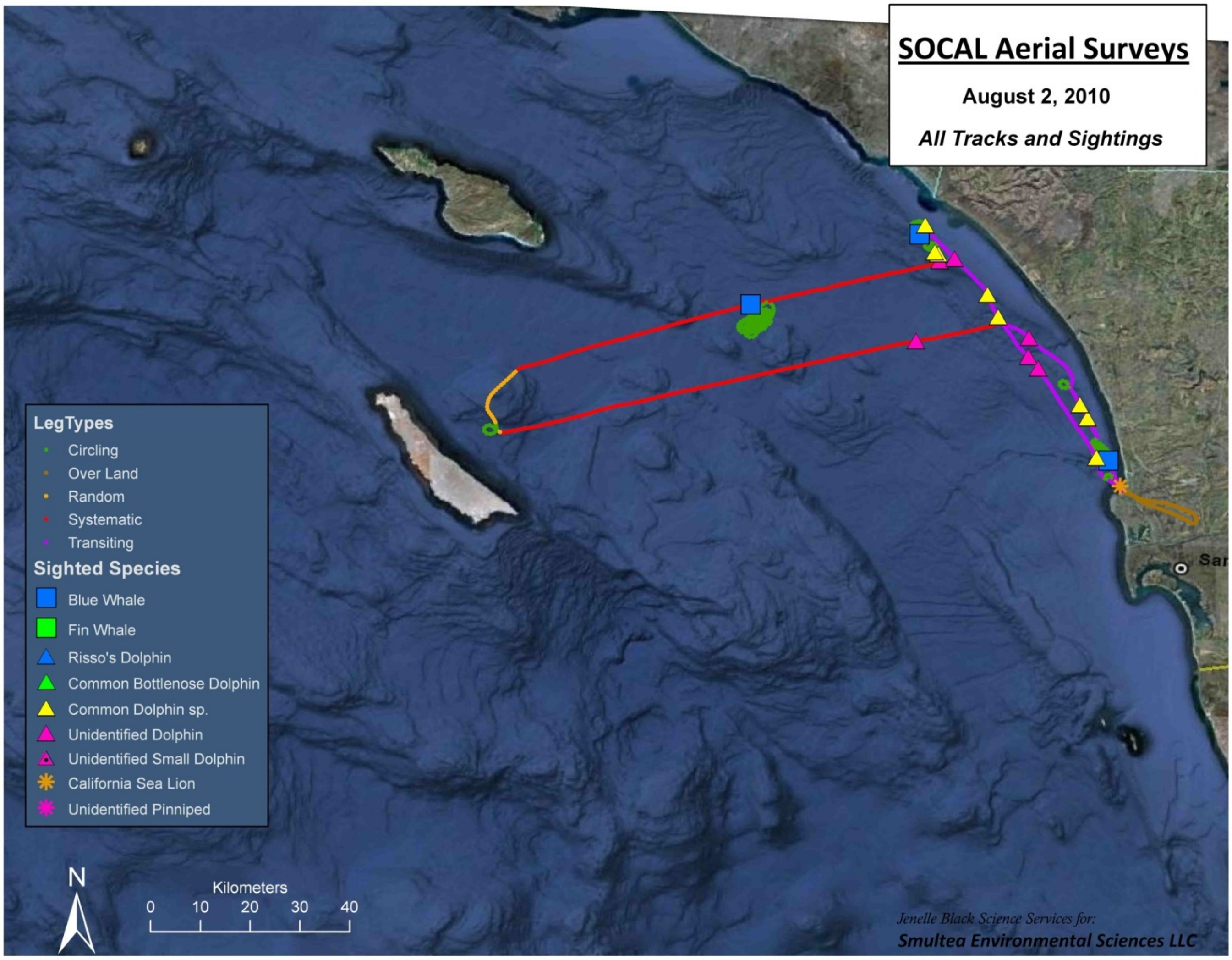
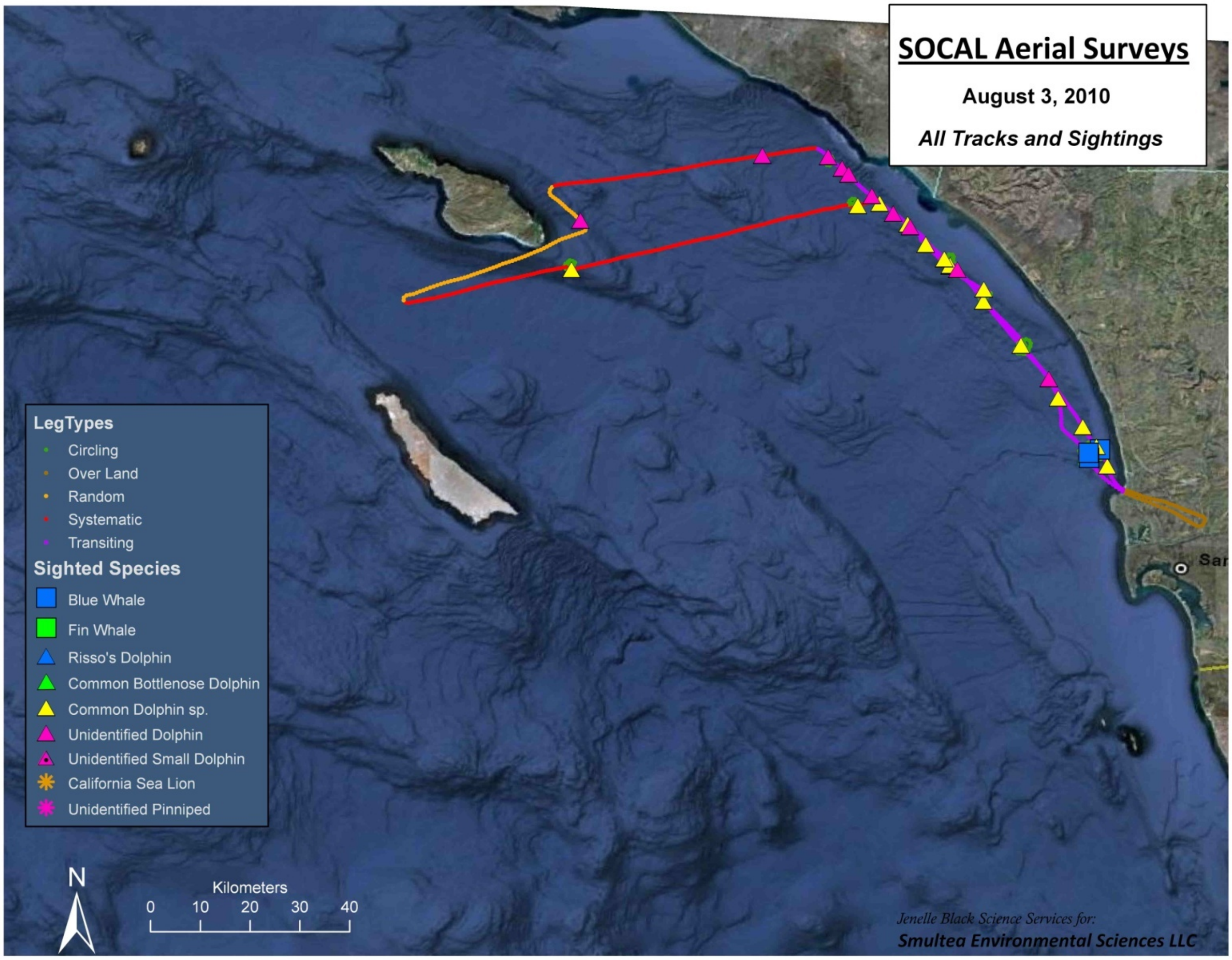
July 29, 2010
All Tracks and Sightings
LegTypes
Circling
Over Land
Random
Systematic
Transiting
Sighted Species
Blue Whale
Fin Whale
Risso's Dolphin
Common Bottlenose Dolphin
Common Dolphin sp.
Unidentified Dolphin
Unidentified Small Dolphin
California Sea Lion
Unidentified Pinniped
San Diego
N
Kilometers
0 4 8 12 16


SOCAL Aerial Surveys
July 30, 2010
All Tracks and Sightings
LegTypes
Circling
Over Land
Random
Systematic
Transiting
Sighted Species
Blue Whale
Fin Whale
Risso's Dolphin
Common Bottlenose Dolphin
Common Dolphin sp.
Unidentified Dolphin
Unidentified Small Dolphin
California Sea Lion
Unidentified Pinniped
N
Kilometers
0 7.5 15 22.5 30
Jenelle Black Science Services for:
Smultea Environmental Sciences LLC


SOCAL Aerial Surveys
July 31, 2010
All Tracks and Sightings
LegTypes
Circling
Over Land
Random
Systematic
Transiting
Sighted Species
Blue Whale
Fin Whale
Risso's Dolphin
Common Bottlenose Dolphin
Common Dolphin sp.
Unidentified Dolphin
Unidentified Small Dolphin
California Sea Lion
Unidentified Pinniped
N
Kilometers
0 7 14 21 28
Jenelle Black Science Services for:
Smultea Environmental Sciences LLC


SOCAL Aerial Surveys
August 2, 2010
All Tracks and Sightings
LegTypes
Circling
Over Land
Random
Systematic
Transiting
Sighted Species
Blue Whale
Fin Whale
Risso's Dolphin
Common Bottlenose Dolphin
Common Dolphin sp.
Unidentified Dolphin
Unidentified Small Dolphin
California Sea Lion
Unidentified Pinniped
N
Kilometers
0 10 20 30 40
Jenelle Black Science Services for:
Smultea Environmental Sciences LLC


SOCAL Aerial Surveys
August 3, 2010
All Tracks and Sightings
LegTypes
Circling
Over Land
Random
Systematic
Transiting
Sighted Species
Blue Whale
Fin Whale
Risso's Dolphin
Common Bottlenose Dolphin
Common Dolphin sp.
Unidentified Dolphin
Unidentified Small Dolphin
California Sea Lion
Unidentified Pinniped
N
Kilometers
0 10 20 30 40
Jenelle Black Science Services for:
Smultea Environmental Sciences LLC

Appendix B List of All July 2010 Survey Sightings

Sighting Date	Sighting Time	Common Name	Species	Best Count	Longitude	Latitude
07/27/2010	14:09:01	Blue Whale	*Balaenoptera musculus*	4	-117.32050	32.89900
07/27/2010	14:16:15	Common Bottlenose Dolphin	*Tursiops truncatus*	50	-117.31067	32.92833
07/27/2010	14:47:30	Fin Whale	*Balaenoptera physalus*	1	-117.33550	32.93383
07/27/2010	15:23:46	Common Dolphin sp.	undifferentiated *Delphinus*	400	-117.37233	32.82733
07/27/2010	15:24:19	Blue Whale	*Balaenoptera musculus*	6	-117.37883	32.82867
07/27/2010	16:21:15	Fin Whale	*Balaenoptera physalus*	2	-117.38783	32.83817
07/28/2010	13:43:11	Common Bottlenose Dolphin	*Tursiops truncatus*	6	-117.28067	32.88150
07/28/2010	13:46:21	Blue Whale	*Balaenoptera musculus*	3	-117.31550	32.93283
07/28/2010	14:06:22	Unidentified Small Dolphin	unidentified Delphinidae	20	-117.30483	32.92500
07/28/2010	14:40:04	Blue Whale	*Balaenoptera musculus*	1	-117.38767	33.01400
07/28/2010	14:42:26	Blue Whale	*Balaenoptera musculus*	1	-117.38783	33.05750
07/28/2010	14:44:00	Common Bottlenose Dolphin	*Tursiops truncatus*	6	-117.40000	33.08383
07/28/2010	14:56:06	Common Dolphin sp.	undifferentiated *Delphinus*	400	-117.46033	33.18500
07/28/2010	15:13:48	Common Dolphin sp.	undifferentiated *Delphinus*	60	-117.48517	33.08583
07/28/2010	15:16:50	Common Dolphin sp.	undifferentiated *Delphinus*	600	-117.47383	33.02833
07/28/2010	15:31:50	Unidentified Small Dolphin	unidentified Delphinidae	200	-117.34750	32.72617
07/28/2010	15:44:38	Common Dolphin sp.	undifferentiated *Delphinus*	200	-117.35150	32.62367
07/28/2010	15:45:58	Blue Whale	*Balaenoptera musculus*	5	-117.34600	32.64333
07/28/2010	15:45:58	Fin Whale	*Balaenoptera physalus*	3	-117.34717	32.64533
07/29/2010	14:37:26	Blue Whale	*Balaenoptera musculus*	2	-117.36200	32.75583
07/29/2010	15:50:41	Common Dolphin sp.	undifferentiated *Delphinus*	380	-117.38033	33.04883
07/29/2010	16:05:57	Common Dolphin sp.	undifferentiated *Delphinus*	110	-117.47383	33.15700
07/29/2010	16:13:49	Common Dolphin sp.	undifferentiated *Delphinus*	40	-117.46250	33.07517
07/29/2010	16:14:22	Blue Whale	*Balaenoptera musculus*	1	-117.45033	33.05783
07/29/2010	16:15:16	Common Dolphin sp.	undifferentiated *Delphinus*	60	-117.43617	33.03717
07/29/2010	16:19:58	Blue Whale	*Balaenoptera musculus*	3	-117.34733	32.92300
07/30/2010	15:08:36	Risso's Dolphin	*Grampus griseus*	9	-118.65333	33.11183
07/31/2010	14:31:55	Common Dolphin sp.	undifferentiated *Delphinus*	600	-117.28500	32.86100
07/31/2010	14:35:46	Common Dolphin sp.	undifferentiated *Delphinus*	100	-117.35683	32.76233
07/31/2010	14:36:31	Blue Whale	*Balaenoptera musculus*	6	-117.36700	32.73800
07/31/2010	15:44:29	Common Dolphin sp.	undifferentiated *Delphinus*	100	-117.54267	32.66533
07/31/2010	15:50:33	Common Dolphin sp.	undifferentiated *Delphinus*	200	-117.74500	32.63283
07/31/2010	16:07:24	Common Dolphin sp.	undifferentiated *Delphinus*	60	-117.65483	32.74817
07/31/2010	16:21:53	Unidentified Dolphin	unidentified Delphinidae	25	-117.42633	32.81583
07/31/2010	16:32:32	Common Dolphin sp.	undifferentiated *Delphinus*	12	-117.36683	32.89733
07/31/2010	16:46:05	Common Dolphin sp.	undifferentiated *Delphinus*	110	-117.53317	32.90317
07/31/2010	17:22:26	Common Dolphin sp.	undifferentiated *Delphinus*	15	-117.74033	32.97783
07/31/2010	17:30:45	Unidentified Dolphin	unidentified Delphinidae	1	-117.57950	33.01517
07/31/2010	17:33:13	Common Dolphin sp.	undifferentiated *Delphinus*	125	-117.54183	33.02150
07/31/2010	17:37:33	Common Dolphin sp.	undifferentiated *Delphinus*	40	-117.50417	33.03033
07/31/2010	17:41:12	Common Dolphin sp.	undifferentiated *Delphinus*	450	-117.38017	33.05467
07/31/2010	17:41:32	Blue Whale	*Balaenoptera musculus*	1	-117.36817	33.05667
07/31/2010	17:41:32	Fin Whale	*Balaenoptera physalus*	1	-117.36817	33.05667

Sighting Date	Sighting Time	Common Name	Species	Best Count	Longitude	Latitude
07/31/2010	18:20:41	Unidentified Dolphin	unidentified Delphinidae	90	-117.27733	32.87600
08/02/2010	14:49:42	California Sea Lion	*Zalophus californianus*	2	-117.26233	32.86100
08/02/2010	14:51:25	Blue Whale	*Balaenoptera musculus*	2	-117.28417	32.90717
08/02/2010	14:53:04	Blue Whale	*Balaenoptera musculus*	1	-117.30517	32.91217
08/02/2010	14:53:04	Common Dolphin sp.	undifferentiated *Delphinus*	300	-117.30517	32.91217
08/02/2010	15:02:45	Common Dolphin sp.	undifferentiated *Delphinus*	40	-117.32167	32.98350
08/02/2010	15:03:33	Common Dolphin sp.	undifferentiated *Delphinus*	35	-117.33500	33.00733
08/02/2010	15:09:36	Unidentified Dolphin	unidentified Delphinidae	75	-117.42733	33.12800
08/02/2010	15:15:32	Unidentified Dolphin	unidentified Delphinidae	120	-117.63100	33.12217
08/02/2010	15:55:32	Blue Whale	*Balaenoptera musculus*	2	-117.92983	33.18833
08/02/2010	16:47:54	Unidentified Dolphin	unidentified Delphinidae	200	-117.58817	33.26650
08/02/2010	16:48:19	Common Dolphin sp.	undifferentiated *Delphinus*	55	-117.59067	33.27883
08/02/2010	16:53:12	Common Dolphin sp.	undifferentiated *Delphinus*	175	-117.59717	33.28233
08/02/2010	16:56:05	Blue Whale	*Balaenoptera musculus*	2	-117.62500	33.31483
08/02/2010	17:19:09	Common Dolphin sp.	undifferentiated *Delphinus*	75	-117.61433	33.33083
08/02/2010	17:29:49	Unidentified Dolphin	unidentified Delphinidae	50	-117.56150	33.27050
08/02/2010	17:32:21	Common Dolphin sp.	undifferentiated *Delphinus*	250	-117.50200	33.20567
08/02/2010	17:33:57	Common Dolphin sp.	undifferentiated *Delphinus*	70	-117.48283	33.16583
08/02/2010	17:36:39	Unidentified Dolphin	unidentified Delphinidae	125	-117.42833	33.09400
08/02/2010	17:37:31	Unidentified Dolphin	unidentified Delphinidae	50	-117.41050	33.07317
08/03/2010	15:32:41	Common Dolphin sp.	undifferentiated *Delphinus*	*	-117.28583	32.89717
08/03/2010	15:33:39	Blue Whale	*Balaenoptera musculus*	1	-117.29900	32.92717
08/03/2010	15:35:22	Common Dolphin sp.	undifferentiated *Delphinus*	25	-117.30533	32.93200
08/03/2010	15:36:42	Common Dolphin sp.	undifferentiated *Delphinus*	40	-117.33000	32.96767
08/03/2010	15:42:06	Common Dolphin sp.	undifferentiated *Delphinus*	1000	-117.44150	33.11417
08/03/2010	15:52:18	Common Dolphin sp.	undifferentiated *Delphinus*	*	-117.50950	33.19333
08/03/2010	15:55:05	Common Dolphin sp.	undifferentiated *Delphinus*	600	-117.50883	33.21533
08/03/2010	15:57:43	Common Dolphin sp.	undifferentiated *Delphinus*	100	-117.57017	33.25683
08/03/2010	15:59:00	Common Dolphin sp.	undifferentiated *Delphinus*	*	-117.56967	33.25833
08/03/2010	16:02:29	Common Dolphin sp.	undifferentiated *Delphinus*	1100	-117.61367	33.29600
08/03/2010	16:04:07	Common Dolphin sp.	undifferentiated *Delphinus*	350	-117.64617	33.33267
08/03/2010	16:06:11	Common Dolphin sp.	undifferentiated *Delphinus*	400	-117.69683	33.37000
08/03/2010	16:07:32	Common Dolphin sp.	undifferentiated *Delphinus*	250	-117.73617	33.36600
08/03/2010	16:23:44	Common Dolphin sp.	undifferentiated *Delphinus*	300	-118.25333	33.25083
08/03/2010	16:47:03	Unidentified Dolphin	unidentified Delphinidae	125	-118.23733	33.33900
08/03/2010	16:59:54	Unidentified Dolphin	unidentified Delphinidae	70	-117.90867	33.45633
08/03/2010	17:03:26	Unidentified Dolphin	unidentified Delphinidae	140	-117.78983	33.45400
08/03/2010	17:07:10	Unidentified Dolphin	unidentified Delphinidae	50	-117.76483	33.43317
08/03/2010	17:07:38	Unidentified Dolphin	unidentified Delphinidae	200	-117.75267	33.42233
08/03/2010	17:09:21	Unidentified Dolphin	unidentified Delphinidae	*	-117.71100	33.38367
08/03/2010	17:10:52	Unidentified Dolphin	unidentified Delphinidae	25	-117.67233	33.35183
08/03/2010	17:12:01	Unidentified Dolphin	unidentified Delphinidae	35	-117.64167	33.32767
08/03/2010	17:14:31	Common Dolphin sp.	undifferentiated *Delphinus*	7	-117.58017	33.26983
08/03/2010	17:18:17	Unidentified Dolphin	unidentified Delphinidae	11	-117.55650	33.25067
08/03/2010	17:26:16	Unidentified Dolphin	unidentified Delphinidae	*	-117.39117	33.05417
08/03/2010	17:27:28	Common Dolphin sp.	undifferentiated *Delphinus*	120	-117.37450	33.01917
08/03/2010	17:31:06	Blue Whale	*Balaenoptera musculus*	1	-117.31867	32.91200
08/03/2010	17:34:51	Blue Whale	*Balaenoptera musculus*	2	-117.31967	32.92117

* Individual animal counts for these sightings are pending further survey data analysis.

Appendix C Sighting Rate Tables

Appendix Table C- 1. Sighting rates of marine mammal groups by species during the November 2009, May, and July 2010 SOCAL aerial surveys during systematic, random and transit effort.

Species (Common Name)	Nov 2009				May 2010				July 2010			
	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
Fin Whale	5	0.001	0.003	0.19	2	0.0007	0.001	0.072	4	0.0013	0.0024	0.22
Minke Whale`	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0
Unidentified Large Whale	1	0.0003	0.0005	0.037	1	0.0004	0.0007	0.036	0	0	0	0
Unidentified Medium Whale	1	0.0003	0.0005	0.037	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
Cuvier's Beaked Whale	2	0.0006	0.001	0.075	0	0	0	0	0	0	0	0
Risso's Dolphin	5	0.001	0.003	0.19	28	0.14	0.02	1.011	1	0.00032	0.00059	0.06
Common Dolphin sp.	25	0.007	0.013	0.94	15	1.27	0.01	0.54	40	0.013	0.024	2.21
Common Bottlenose Dolphin	0	0	0	0	9	0.98	0.006	0.32	3	0.00096	0.0018	0.17
Pacific White-sided Dolphin	6	0.002	0.003	0.22	2	0.03	0.001	0.072	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
Unidentified Small Dolphin	2	0.0006	0.001	0.075	4	0.17	0.003	0.14	2	0.00064	0.0012	0.11
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
Harbor Seal	0	0	0	0	1	0.0007	0.0007	0.036	0	0	0	0
Unidentified Pinniped	4	0.001	0.002	0.15	2	0.0007	0.001	0.072	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
Unidentified Small Marine Mammal	1	0.0003	0.0005	0.037	2	0.0007	0.001	0.072	0	0	0	0
Overall Marine Mammal	81	0.02	0.04	3.034	102	0.04	0.073	3.68	86	0.028	0.051	4.75

Appendix Table C- 2. Sighting rates of individual marine mammals by species during the November 2009, May, and July 2010 SOCAL aerial surveys during systematic, random and transit effort.

Species (Common Name)	Nov 2009				May 2010				July 2010			
	Total # Individuals	Individuals/km	Individuals/nm	Individuals/hr	Total # Individuals	indiv./km	indiv./nm	indiv./hr	Total # Individuals	indiv./km	indiv./nm	indiv./hr
Whales												
Blue Whale	0	0	0	0	2	0.0007	0.001	0.14	44	0.014	0.026	2.43
Fin Whale	9	0.003	0.005	0.64	4	0.002	0.003	0.29	7	0.0022	0.0041	0.39
Minke whale`	1	0.003	0.0005	0.07	1	0.0004	0.0007	0.71	0	0	0	0.00
Unidentified Large Whale	1	0.003	0.0005	0.07	1	0.0004	0.0007	0.71	0	0	0	0.00
Unidentified Medium Whale	1	0.003	0.0005	0.07	0	0	0	0	0	0	0	0.00
Dolphins												
Killer Whale	67	0	0.04	4.79	0	0	0	0	0	0	0	0.00
Cuvier's Beaked Whale	6	0.002	0.003	0.43	0	0	0	0	0	0	0	0.00
Risso's Dolphin	167	0.05	0.09	11.93	373	0.14	0.27	26.64	9	0.0029	0.0053	0.50
Common Dolphin sp.	11891	3.45	6.4	849.36	3300	1.27	2.36	235.71	9154	2.99	5.54	505.75
Common Bottlenose Dolphin	0	0	0	0	255	0.98	0.18	18.21	62	0.02	0.037	3.43
Pacific White-sided Dolphin	274	0.08	0.15	19.57	81	0.03	0.06	5.79	0	0	0	0.00
Unidentified Dolphin	27	0.08	0.01	1.93	689	0.27	0.49	49.21	1392	0.45	0.82	76.91
Unidentified Small Dolphin	45	0.01	0.02	3.21	429	0.17	0.31	30.64	220	0.07	0.13	12.15
Pinnipeds												
California Sea Lion	83	0.02	0.04	5.93	58	0.02	0.04	4.14	2	0.00064	0.0012	0.11
Harbor Seal	0	0	0	0	2	0.0007	0.001	0.14	0	0	0	0.00
Unidentified Pinniped	4	0.001	0.002	0.29	2	0.0007	0.001	0.14	0	0	0	0.00
Unidentified Marine Mammal	1	0.0003	0.0005	0.07	10	0.004	0.007	0.71	0	0	0	0.00
Unidentified Small Marine Mammal	1	0.0003	0.0005	0.07	2	0.0007	0.001	0.14	0	0	0	0.00
Overall Marine Mammal	12578	3.65	6.77	898.43	5209	2.01	3.72	372.07	11090	3.55	6.57	612.71

Appendix Table C- 3. Sighting rates of marine mammal (MM) groups by effort type during the November 2009, May 2010, and July 2010 SOCAL aerial surveys.

Effort Type	Species Group	Nov 18-23, 2009							May 13-18, 2010							July 27- August 3, 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
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	0.0017	0.0031	0.3333
	Dolphins	21				0.012	0.022	2.55	29				0.023	0.042	3.9939	10				0.0169	0.0313	3.333
	Pinnipeds	17				0.009	0.018	2.06	13				0.01	0.019	1.7904	0				0	0	0
	All MM	46				0.026	0.048	5.58	46				0.036	0.067	6.3351	11				0.0186	0.0344	3.6667
Random	Whales	0	669	361	1.72	0	0	0.00	1	370	200	2.10	0.003	0.005	0.4768	0	111	59.94	0.5	0	0	0
	Dolphins	4				0.006	0.011	2.33	10				0.027	0.05	4.76821	3				0.0270	0.0501	6
	Pinnipeds	3				0.004	0.008	1.75	1				0.003	0.005	0.4768	0				0	0	0
	All MM	7				0.01	0.019	4.08	12				0.032	0.06	5.7219	3				0.027	0.0501	6
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	0.0183	0.0339	4.2105
	Dolphins	23				0.023	0.043	6.17	29				0.03	0.056	6.3971	1				0.0011442	0.0021188	0.2632
	Pinnipeds	3				0.003	0.006	0.81	12				0.013	0.023	2.6471	42				0.0480549	0.0889906	11.052632
	All MM	28				0.028	0.053	7.51	42				0.044	0.081	9.2647	59				0.0675057	0.1250106	15.526316
Circling	Whales	0	1335	721	7.20	0	0	0.00	0	2125	1147	12.91	0	0	0	5	1549	836.46	10	0.0032279	0.0059776	0.5
	Dolphins	1				0.001	0.001	0.14	0				0	0	0	5				0.0032279	0.0059776	0.5
	Pinnipeds	0				0	0	0.00	0				0	0	0	0				0	0	0
	All MM	1				0.001	0.001	0.14	0				0	0	0	10				0.0064558	0.0119551	1
Circumnavigating San Clemente Island	Whales	0	120	65	0.21	0	0	0.00	0	83	45	0.48	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
	Pinnipeds	5				0	0	23.32	37				0.446	0.826	77.4419	0				0	0	0
	All MM	7				0.058	0.108	32.64	40				0.482	0.893	83.7209	0				0	0	0
Navy-directed Transiting	Whales	0	137	74	0.63	0	0	0.00	0	91	49	0.39	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
	Pinnipeds	4				0	0	6.34	3				0.033	0.061	7.6056	0				0	0	0
	All MM	5				0.036	0.068	7.92	10				0.11	0.204	25.3521	0				0	0	0

Appendix Table C- 4. Sighting rates of individual marine mammals (MM) by effort type during the November 2009, May 2010, and July 2010 SOCAL aerial surveys.

Effort Type	Species Group	Nov 18-23, 2009							May 13-18, 2010							July 27- August 3, 2010						
		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	Total Animals	Total km	Total nm	Total hr	Individual/km	Individual/nm	Individual/hr
Systematic	Whales	4				0.0022	0.0041	0.48	6				0.0047	0.0088	0.83	1				0.0017	0.0031	0.33
	Dolphins	3823				2.14	3.95	463.5	3080				2.43	4.5	424.18	10				0.017	0.031	3.33
	Pinnipeds	8				0.0045	0.0083	0.97	20				0.016	0.029	2.75	0				0	0	0
	All MM	3835	1790	967	8.25	2.14	3.97	464.96	3106	1268	685	7.26	2.45	4.53	427.76	11	592	319.68	3	0.019	0.034	3.67
Random	Whales	8				0.012	0.022	4.66	1				0.0027	0.005	0.477	0				0	0	0
	Dolphins	8207				12.27	22.73	4785.42	582				1.57	2.91	277.51	3				0.027	0.05	6
	Pinnipeds	77				0.12	0.21	44.9	25				0.068	0.125	11.92	0				0	0	0
	All MM	8292	669	361	1.72	12.39	22.97	4834.99	608	370	200	2.1	1.64	3.04	289.91	3	111	59.94	0.5	0.027	0.05	6
Transit	Whales	2				0.002	0.0038	0.54	1				0.001	0.0019	0.22	16				0.018	0.034	4.21
	Dolphins	3835				3.9	7.22	1029.22	1465				1.53	2.84	323.16	1				0.0011	0.0021	0.26
	Pinnipeds	3				0.0031	0.0056	0.81	18				0.019	0.035	3.97	42				0.048	0.089	11.053
	All MM	28	983	531	3.73	0.028	0.0527	7.51	1495	956	516	4.53	1.56	2.9	329.78	59	874	471.96	3.8	0.068	0.13	15.53
Circling	Whales	0				0	0	0	0				0	0	0	5				0.0032	0.006	0.5
	Dolphins	150				0.11	0.2	20.84	0				0	0	0	5				0.0032	0.006	0.5
	Pinnipeds	0				0	0	0	0				0	0	0	0				0	0	0
	All MM	150	1335	721	7.2	0.11	0.2	20.84	0	2125	1147	12.91	0	0	0	10	1549	836.46	10	0.0065	0.012	1
Circumnavigating San Clemente Island	Whales	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
	Pinnipeds	35				0.29	0.54	163.21	96				1.16	2.13	200.93	0				0	0	0
	All MM	85	120	65	0.21	0.71	1.31	396.37	149	83	45	0.48	1.8	3.31	311.86	0	0	0	0	0	0	0
Navy-directed Transiting	Whales	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
	Pinnipeds	2				0.015	0.027	3.17	5				0.055	0.1	12.68	0				0	0	0
	All MM	449	137	74	0.63	3.28	6.068	711.13	95	91	49	0.39	1.044	1.94	240.85	0	0	0	0	0	0	0

May 2010 Focal Follows

Preliminary list of focal behavioral follows longer than 5 min conducted during the July SOCAL 2010 aerial monitoring surveys off San Diego, California. Video was taken on some of these groups as indicated in Appendix D.

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	6/2	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	
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	

Date	Start Time	End Time	Duration of Focal (hr:min:sec)	Latitude	Longitude	Species	Group Size	Notes
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

5 min focals for July= 6
10min focals for July= 13

List of July 2010 Video

Video recorded during July SOCAL 2010 aerial monitoring surveys off San Diego, California based on preliminary review of video. This summary is based on a preliminary "quick look" and should not be considered a detailed analysis or summary of useable video.

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Sighting ID	Preliminary Species Identification	Video Notes
SOCAL July 2010_Video_27 July_141025_IDXX_Blue	7/27/2010	14:10:25	14:14:38	0:04:13	XX	Blue Whale	multiple blows, no vocals due to noise of helicopter, subsurface, 1 indiv.,
SOCAL July 2010_Video_27 July_141538_IDXX_Boat	7/27/2010	14:15:38	14:15:41	0:00:03	XX	Boat	Private Sail Boat near blue whale
	7/27/2010	14:16:10	14:17:58	0:01:48	XX		Fast travel, oriented at 350,
	7/27/2010	14:18:28	14:19:38	0:01:10	XX		
SOCAL July 2010_Video_27 July_142206_IDXX_Blue	7/27/2010	14:22:06	14:26:58	0:04:52	XX	Blue Whale	1 indiv., below surface, multiple blows, slow travel, blew and dove,
SOCAL July 2010_Video_27 July_143839_IDXX_Blue	7/27/2010	14:38:39	14:41:09	0:02:30	XX	Blue Whale	below surface, 1 indiv., slow travel, blew and shallow dive
SOCAL July 2010_Video_27 July_144431_IDXX_Blue	7/27/2010	14:44:31	14:45:20	0:00:49	XX	Blue Whale	1 indiv., below surface, blew and dove
SOCAL July 2010_Video_27 July_144703_IDXX_Fin	7/27/2010	14:47:03	14:48:15	0:01:12	XX	Fin Whale	1 indiv, below surface, surfaces blows, and dives again and seen below surface
SOCAL July 2010_Video_27 July_145232_IDXX_Blue	7/27/2010	14:52:32	14:52:53	0:00:21	XX	Blue Whale	Flukes up and dove
SOCAL July 2010_Video_27 July_145601_IDXX_Blue	7/27/2010	14:56:01	14:58:25	0:02:24	XX	Blue Whale	1 indiv., below surface, multiple blows, slow travel,
SOCAL July 2010_Video_27 July_150525_IDXX_Blue	7/27/2010	15:05:25	15:06:54	0:01:29	XX	Blue Whale	1 indiv., resting below surface, multiple blows
SOCAL July 2010_Video_27 July_150939_IDXX_Blue	7/27/2010	15:09:39	15:12:42	0:03:03	XX	Blue Whale	multiple blows, 1 indiv., shallow dive, slow travel,
SOCAL July 2010_Video_27 July_152454_IDXX_Blue	7/27/2010	15:24:54	15:25:16	0:00:22	XX	Blue Whale	1 indiv, subsurface blows, arched back then flukes up and dives
SOCAL July 2010_Video_27 July_152550_IDXX_Blue	7/27/2010	15:25:50	15:28:32	0:02:42	XX	Blue Whale	whale scat, 1 indiv., slow travel

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Sighting ID	Preliminary Species Identification	Video Notes
SOCAL July 2010_Video_27 July_153626_IDXX_Blue	7/27/2010	15:36:26	15:44:27	0:08:01	XX	Blue Whale	2 indiv., swimming towards helicopter, whale #2 reorientes 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
SOCAL July 2010_Viedo_27 July_155012_IDXX_Blue	7/27/2010	15:50:12	15:50:27	0:00:15	XX	Blue Whale	Flukes and dove
SOCAL July 2010_Video_27 July_155104_IDXX_Blue	7/27/2010	15:51:04	16:01:13	0:10:09	XX	Blue Whale	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,
SOCAL July 2010_Video_27 July_160446_IDXX_Blue	7/27/2010	16:04:46	16:08:32	0:03:46	XX	Blue Whale	1 indiv. , 3 spots of scat, multiple blows, slow travel, arched back, flukes up and dove
SOCAL July 2010_Video_27 July_161013_IDXX_Blue	7/27/2010	16:10:13	16:12:17	0:02:04	XX	Blue Whale	2 indiv., multiple blows, slow travel, front animal 4 body lengths apart, not 2 body lengths apart, the 2nd is behind to the left,
SOCAL July 2010_Video_27 July_161740_IDXX_Blue	7/27/2010	16:17:40	16:21:07	0:03:27	XX	Blue Whale	1 indiv. subsurface, looks as if it is floating just below surface, milling, whale turns slightly on its side, arched back and dove
SOCAL July 2010_Video_27 July_162117_IDXX_Unid	7/27/2010	16:21:17	16:21:27	0:00:10	XX	Unidentified Whale Scat	Whale scat
SOCAL July 2010_Video_27 July_162141_IDXX_Unid	7/27/2010	16:21:41	16:21:47	0:00:06	XX	Unidentified Whale Scat	Big blob of whale scat

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Sighting ID	Preliminary Species Identification	Video Notes
SOCAL July 2010_Video_28 July_134711_IDXX_Blue	7/28/2010	13:47:11	13:50:24	0:03:13	XX	Blue Whale	cannot hear vocals, multiple blows, arched back and dove,
SOCAL July 2010_Video_28 July_135623_IDXX_Blue	7/28/2010	13:56:23	14:30:50	0:34:27	XX	Blue Whale	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
SOCAL July 2010_Video_28 July_145741_IDXX_Common sp.	7/28/2010	14:57:41	15:03:56	0:06:15	XX	Common Dolphin sp.	Surface active milling, dispersal 1-8, 1400 ft, angle 26, well over 100 animals, 2 groups, 1st group scattered
SOCAL July 2010_Video_28 July_152622_IDXX_Boat	7/28/2010	15:26:22	15:26:28	0:00:06	XX	Boat	Private Boat Only
SOCAL July 2010_Video_28 July_154558_IDXX_Blue_Fin	7/28/2010	15:45:58	15:54:22	0:08:24	XX	Blue Whale_Fin Whale	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
SOCAL July 2010_Video_29 July_143809_IDXX_Blue	7/29/2010	14:38:09	15:19:36	0:41:27	XX	Blue Whale	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
SOCAL July 2010_Video_29 July_155244_IDXX_Commo nsp.	7/29/2010	15:52:44	15:55:45	0:03:01	XX	Common Dolphin sp.	800 ft., looking at subgroup, orientation 270, unidentified splash, 2 gulls over dolphin
SOCAL July 2010_Video_29 July_155549_IDXX_Commo nsp.	7/29/2010	15:55:49	15:57:44	0:01:55	XX	Common Dolphin sp.	
SOCAL July 2010_Video_29 July_160820_IDXX_Commo nsp.	7/29/2010	16:08:20	16:09:05	0:00:45	XX	Common Dolphin sp.	
SOCAL July 2010_Video_30 July_131258_IDXX_Risso's	7/30/2010	15:12:58	15:13:32	0:00:34	XX	Risso's Dolphin	Oriented at 2 o'clock
SOCAL July 2010_Video_30 July_151558_IDXX_Risso's	7/30/2010	15:15:58	15:27:32	0:11:34	XX	Risso's Dolphin	line abreast, dispersal 1-2, oriented at 330, dispersal now 1-5

Video Name (Draft)	Date 2010	Video Start Time	Video End Time	Total Video (min)	Sighting ID	Preliminary Species Identification	Video Notes
SOCAL July 2010_Video_31 July_143756_IDXX_Blue	7/31/2010	14:37:56	14:59:20	0:21:24	XX	Blue whale	.5 body lengths apart, 2 indiv
SOCAL July 2010_Video_31 July_145923_IDXX_Blue	7/31/2010	14:59:23	15:29:16	0:29:53	XX	Blue Whale	2 indiv.
SOCAL July 2010_Video_31 July_153608_IDXX_Blue	7/31/2010	15:36:08	15:37:32	0:01:24	XX	Blue Whale	oriented at 300, 2 ind.,one whale fluked and the second one sounded, angle is 26
SOCAL July 2010_Video_31 July_174437_IDXX_Blue	7/31/2010	17:44:37	17:55:48	0:11:11	XX	Blue Whale	
SOCAL July 2010_Video_31 July_175549_IDXX_Blue	7/31/2010	17:55:49	18:19:39	0:23:50	XX	Blue Whale	oriented at 150
SOCAL July 2010_Video_2 August_155827_IDXX_Blue	8/2/2010	15:58:27	16:36:41	0:38:14	XX	Blue Whale	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
SOCAL July 2010_Video_2 August_165955_IDXX_Blue	8/2/2010	16:59:55	17:59:30	0:59:35	XX	Blue Whale	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,

Photo Log

Preliminary 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
3-Aug	1	Common dolphin sp.		1657	1734		3:46:18	3:47:58
3-Aug	2	Common dolphin sp.		1736	1798		3:52:54	3:53:38
3-Aug	3	Common dolphin sp.		1800	1833		3:58:16	3:58:46
3-Aug	4	Common dolphin sp.		1835	1900		3:59:02	4:08:14
3-Aug	5	Common dolphin sp.		1902	1976		4:24:52	4:26:26
3-Aug	6	Common dolphin sp.		2003	2042		5:04:20	5:05:42
3-Aug	7	Common dolphin sp.		2044	2069		5:14:52	5:16:30
3-Aug	8	Blue whale	1	2076	2078		5:33:52	5:34:06
3-Aug	9	Blue whale	2	2080	2107		5:34:16	5:34:46
3-Aug	10	Common dolphin sp.		2109	2132		5:39:42	5:41:08
3-Aug	11	Blue whale	1	2125	2170		5:42:08	5:43:20
3-Aug	12	Common dolphin sp.		2171	2189		5:44:08	5:47:42
3-Aug	13	Blue whale	1	2190	2228		5:48:06	5:51:58
3-Aug	14	Blue whale	1	2230	2249		5:54:18	5:54:56
3-Aug	15	Blue whale	2	2251	2262		5:55:46	5:56:00

Photos of Fin and Blue Whales Feeding

Below is a chronological description of eight consecutive photographs gleaned from HD video taken from the helicopter on 28 July 2010 of a loose aggregation of three blue (*Balaenoptera musculus*) and three fin whales (*B. physalus*) in SOCAL off San Diego. Photographs are taken from a video scene duration of 24 seconds at the end of a focal follow in the afternoon from 15:45:54 – 15:54:18. The caption numbers for each photo refer to arbitrary seconds into the 6th minute of the scene as described below. The photos are listed in order as AA29, then A39 through G53. The numbers refer to arbitrary seconds into the 6th minute of the scene as described below.

<u>AA29 (photo on above left):</u> shows three fin whales traveling side by side, whale 1 (#1) about one body length (BL) from whale 2 (#2), and whale 2 about one-half BL from whale 3 (#3). #3 is about 2 BL from an orange "bait ball' (on bottom left of photo, probably euphausiid crustaceans). There is a blue whale in the video frame as well, but this has been cropped out to concentrate on the fin whale action.

<u>A39 (photo on above right):</u> ten seconds later, shows #1 turning to its right by about 30 degrees. This was at first interpreted as a turn towards the bait ball, but a slight shimmer underwater (and clearer in subsequent frames) shows that a blue whale (labeled here as (bw)) is about to surface. It is likely that #1 is reacting to the blue whale in front of it, to avoid it.

B41 (photo on left above): two seconds later, has #1 diving and #2 also turning to its right. Subsequent action indicates that #2 is indeed cueing onto the baitball, at a distance of approximately 2 BL. The surfacing blue whale is becoming more visible.

C44 (photo on right above): three seconds later, has #3 also reacting to the baitball, by turning to the right, and twisting its body with whitewater at the surface. Whales #2 and #3 are about one-third BL apart.

D48 (above left photo): 4 seconds later (and also just before then), #3 markedly speeds up and it seems that it is using its closer track to the baitball to "outrace" #2. The blue whale has surfaced, blown, and is rotating through its surfacing sequence.

E51 (above right photo): 3 seconds later, #3 is lunging while turning to the right and on its axis. The baitball is in the open mouth of #3. Whale #2 is submerged but visible, and glides past at about one-third BL from #3. Another blue whale surfaces at bottom right, one-half BL from the first blue whale.

F52: 1 second later, the lunge continues, and it is likely that fin whale #1 is seen just below the surface, one-half BL from #2

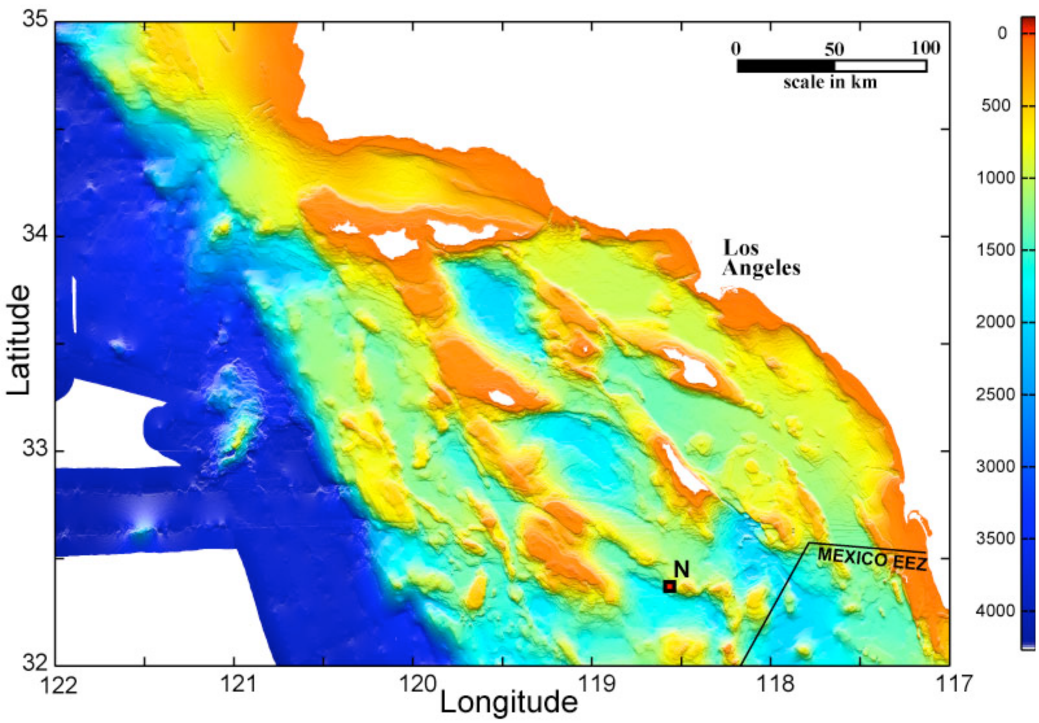
G53: 1 second later, the fin whale's lunge continues, #3 has rotated through almost 180 degrees and is closing its mouth.

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

High Frequency Acoustic Recording Package Annual Data Summary Report March 14, 2009 – March 26, 2010 SOCAL Site N



John Hildebrand, Hannah Bassett, Simone Baumann, Greg Campbell, Amanda Cummins, Sara Kerosky, Mariana Melcon, Karlina Merkens, Lisa Munger, Marie Roch, Lauren Roche, Anne Simonis and Sean Wiggins

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University of California San Diego, LA Jolla, CA 92037-0205

Contract Numbers: FISC N00244-08-1-0028 and FISC N00244-10-C-0021

Project Title: Southern California Marine Mammal Studies

Location: Site N, Latitude 33°22 N, Longitude 118°34 W, approx. Depth 1300 m

Deployment Cruises: SOCAL 32-37, R/V Sproul

Recording Period: March 14, 2009 – March 26, 2010

Sample Rate: 200kHz Recording Interval: Continuous

Summary

This report summarizes the underwater sounds detected during a series of deployments of a High Frequency Acoustic Recording Package (HARP) in the southern California (SOCAL) offshore region. The HARP records broadband (10 Hz – 100 kHz) acoustic data, including both marine animal and anthropogenic sound. This report summarizes initial analysis to detect the presence of marine mammals by species as well as the occurrence of naval sonar and other anthropogenic sound events.

The HARP deployments were conducted at site N, located south of San Clemente Island (Latitude 33°22 N, Longitude 118°34 W, approx. Depth 1300 m), an area of naval training activity. The HARP at site N was deployed and recovered by the R/V Sproul during cruises SOCAL 32 (March 14, 2009) through SOCAL 38 (April 11, 2010). It recorded acoustic data continuously at a 200 kHz sample rate with data gaps in-between deployments, resulting in a total of 325 days (7744 hours) of recording over a period of 377 days. Table 1 provides a summary of HARP deployment dates, locations, and recording times.

We investigated the temporal occurrence of marine mammal and anthropogenic sound using manual analysis of three frequency bands: 10-1000 Hz (Low); 1000-5000 Hz (Mid); and 5-100 kHz (High). For each of these bands one or more analysts scanned the data using a long-term spectrogram display with approximately one hour of data per display. A MATLAB based software package called *TRITON* was used for data display and event logging. Potential sound events detected in a one-hour or shorter spectrogram were investigated at finer temporal scales to identify the origin of the sound by species or type of anthropogenic sound. Table 2 gives a summary, by species-call type or anthropogenic sound source, of the number of hours and days which sounds were detected, as well as the percentage of hours or days they were detected.

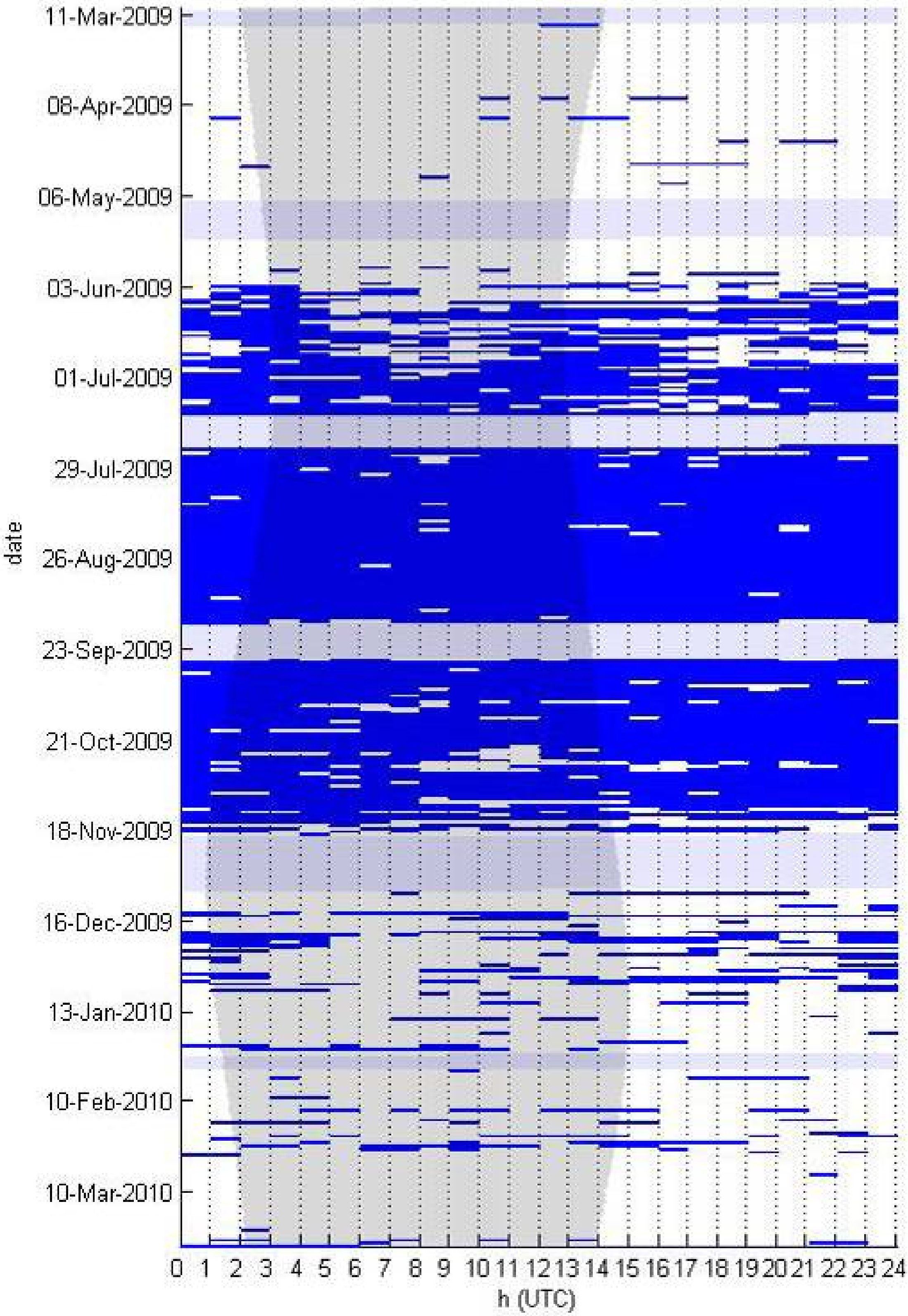
The detections for each call type or anthropogenic sound are also presented as a series of plots below. Sound detections are represented as a solid bar in hourly or minute bins, with each day of data along a horizontal line. Nighttime is indicated in a darker transparent color, and periods of off-effort (no acoustic data) are shown in light blue. Detected marine mammals include: blue whale, fin whale, unidentified whale, Bryde's whale, minke whale, humpback whale, sperm whale, killer whale, unidentified beaked whale, "43 kHz" beaked whale, "50 kHz" beaked whale, Baird's beaked whale, Risso's dolphin, Pacific white-sided dolphin, unidentified odontocete, and pinniped. Anthropogenic sounds include mid-frequency active sonar, echosounder, ship noise and explosion.

Table 1. HARP Deployment Dates, Locations and Recording Times.

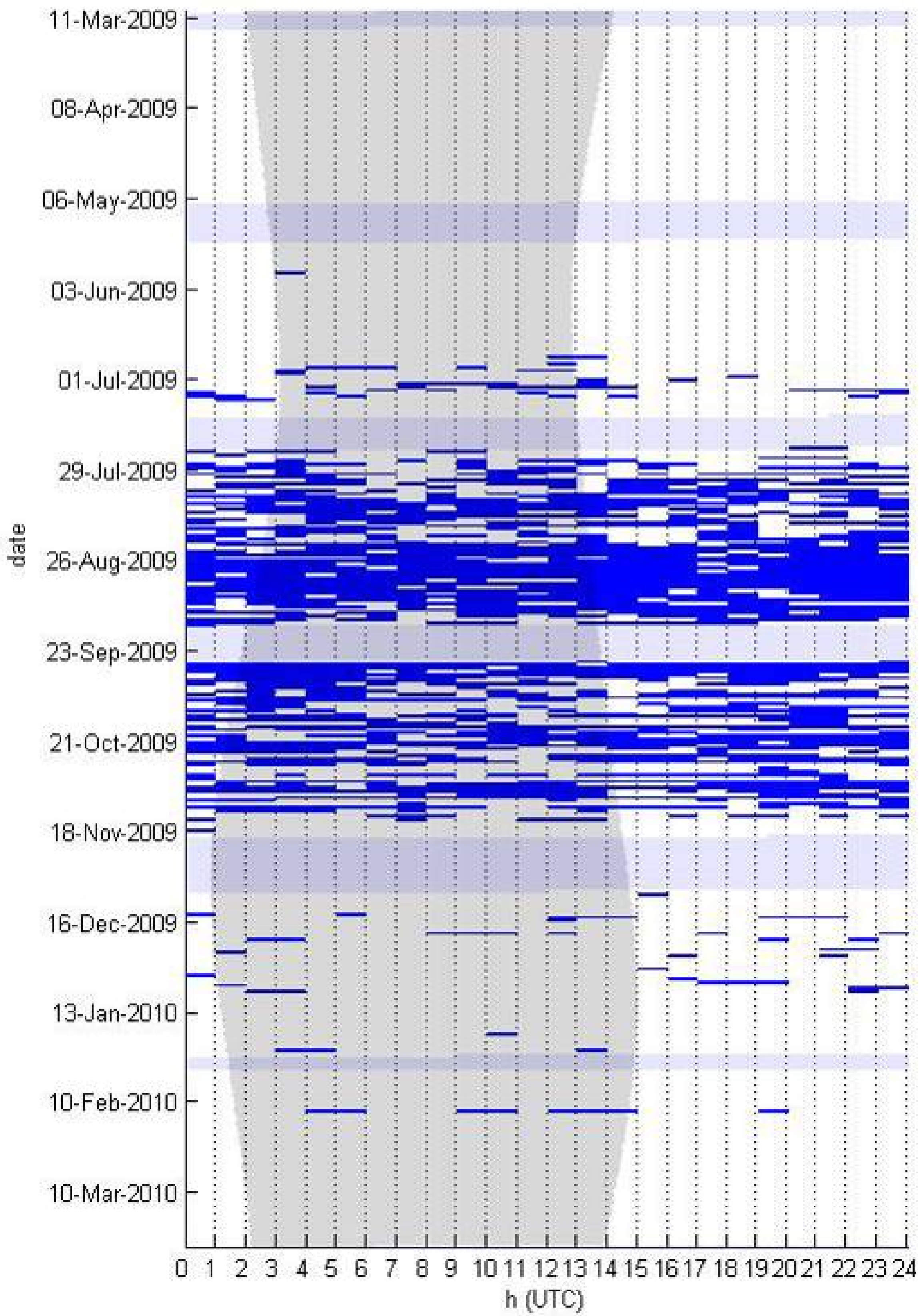
Site/ Cruise	Deployment Date	Recovery Date	Deployment Latitude N	Deployment Longitude W	Depth (m)	Recording Start	Recording End	Days	Hours
SOCAL32N	3/14/2009	5/19/2009	32-22.205	118-33.905	1295	3/14/2009	5/7/2009	54	1302
SOCAL33N	5/19/2009	7/22/2009	32-22.197	118-33.893	1295	5/19/2009	7/12/2009	54	1302
SOCAL34N	7/22/2009	9/25/2009	32-22.186	118-33.885	1287	7/22/2009	9/15/2009	55	1303
SOCAL35N	9/25/2009	12/6/2009	32-22.191	118-33.887	1295	9/26/2009	11/19/2009	55	1313
SOCAL36N	12/5/2009	1/30/2010	32-22.186	118-33.769	1282	12/6/2009	1/26/2010	52	1221
SOCAL37N	1/30/2010	4/11/2010	32-22.184	118-33.768	1280	1/31/2010	3/26/2010	55	1303

Table 2. Detections of Marine Mammal Species and Anthropogenic Sound Sources.

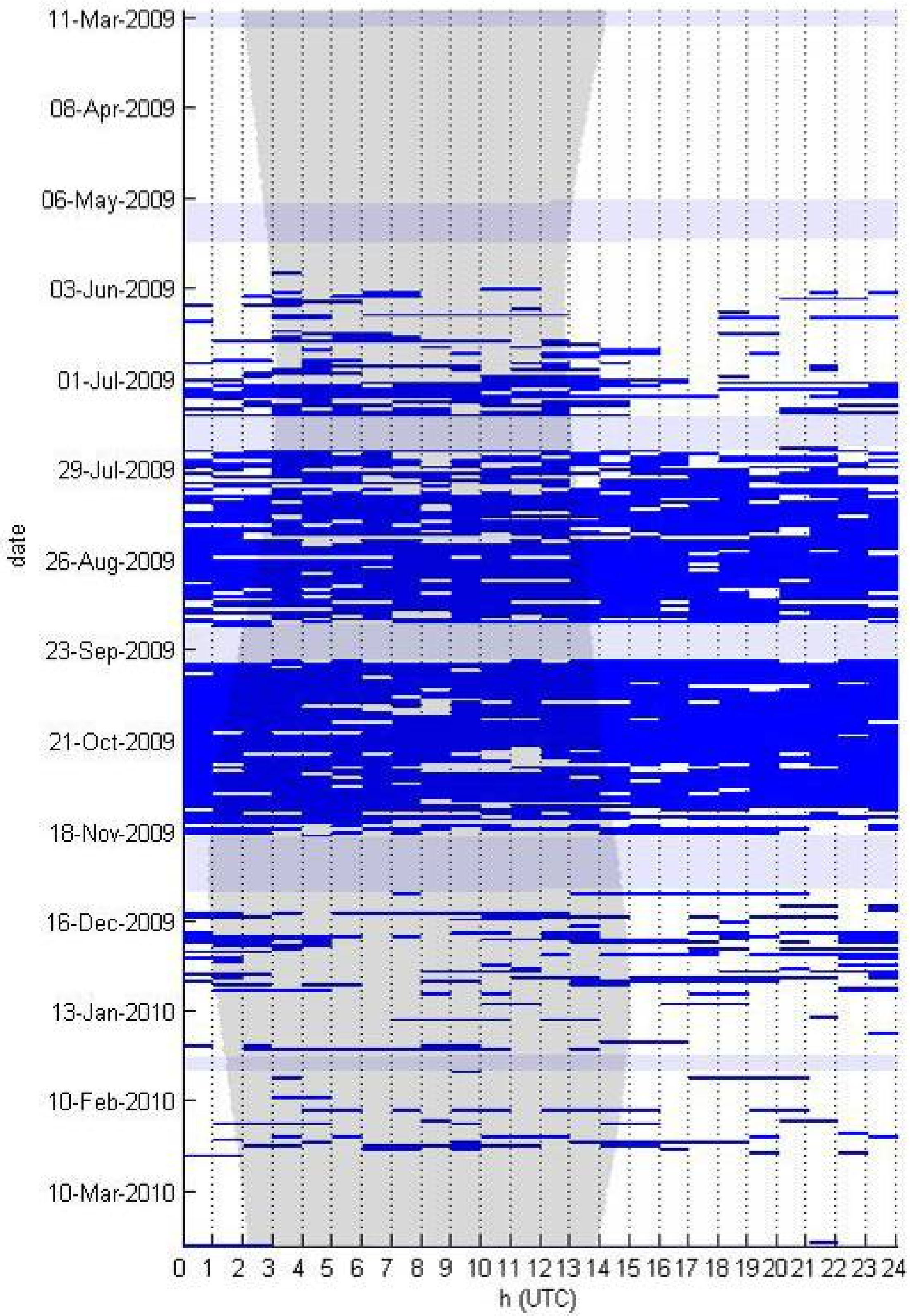
Species/Source	Call Type	Hour Bins	Percent Hours	Daily Bins	Percent Days
Blue Whale	All	3362	43	217	67
Blue Whale	A	1574	20	139	43
Blue Whale	B	2674	35	201	62
Blue Whale	D	1677	22	146	45
Blue Whale	Song	530	7	93	29
Fin Whale	All	5848	76	322	99
Unidentified Whale	50 Hz	872	11	224	69
Bryde's Whale	All	245	3	50	15
Minke Whale	All	2	0.03	2	1
Humpback Whale	All	1548	20	209	64
Humpback Whale	Song	472	6	105	32
Odontocete	Clicks	4548	59	325	100
Sperm Whale	Clicks	65	1	18	6
Killer Whale	Whistles/ Clicks	19	0.2	10	3
Unidentified Odontocete	Low-Freq. Whistles/ Clicks	41	1	18	6
Beaked Whale	Clicks	882	11	259	80
43 kHz Beaked Whale	Clicks	2	0.0	2	1
50 kHz Beaked Whale	Clicks	5	0.1	5	2
Baird's Beaked Whale	Clicks	18	0.2	12	4
Risso's Dolphin	Whistles/ Clicks	91	1	37	11
Pacific White-sided Dolphin	Whistles/ Clicks	49	1	26	8
Pinniped	All	25	0.3	18	6
Anthropogenic	All	4462	58	325	100
Anthropogenic	Mid-Frequency Active Sonar	816	11	131	40
Anthropogenic	Echosounder Ping	258	3	81	25
Anthropogenic	Ship Engine Noise	3914	51	320	98
Anthropogenic	Explosion	252	3	94	29



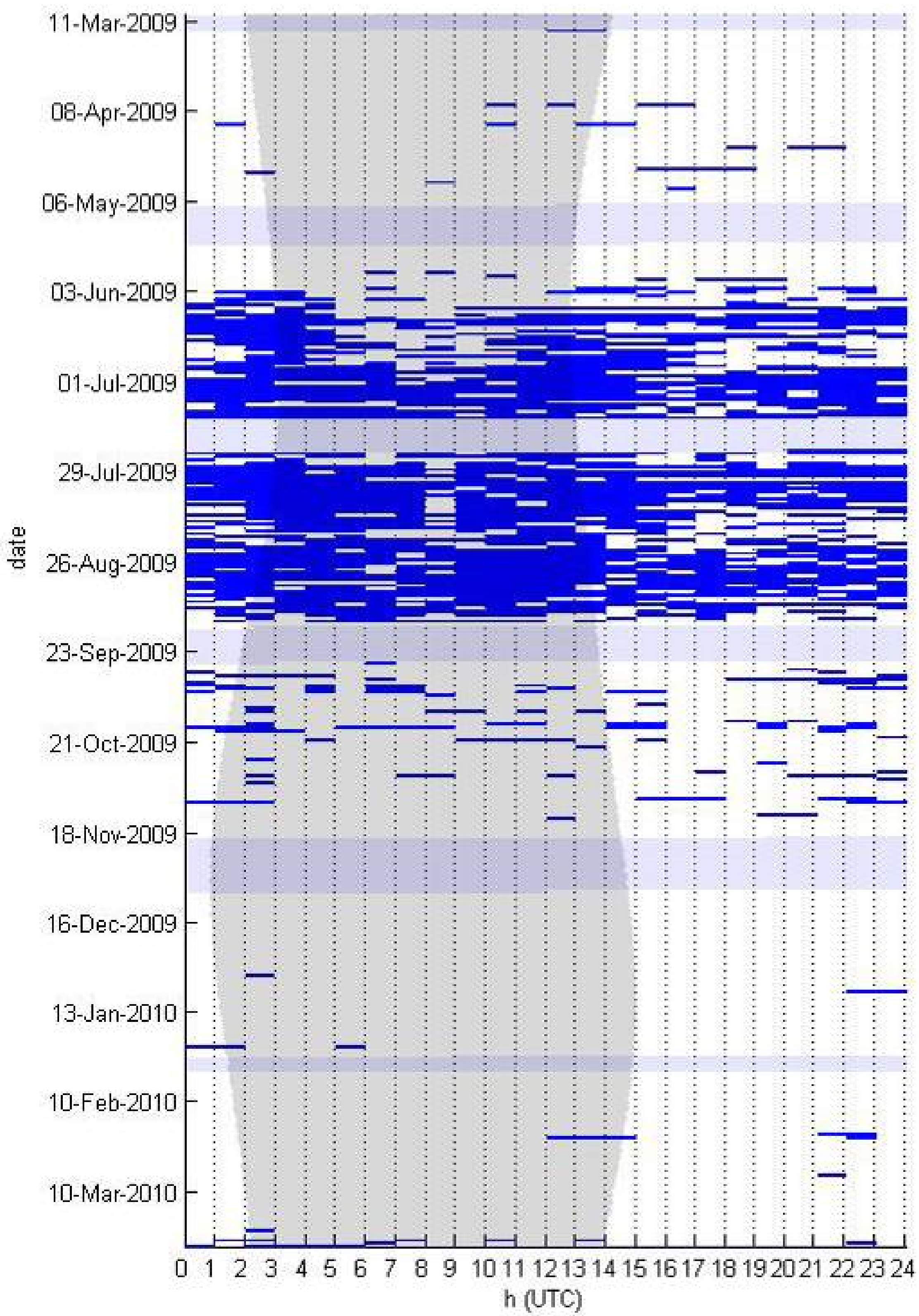
Blue Whale – All Call Types in Hourly Bins



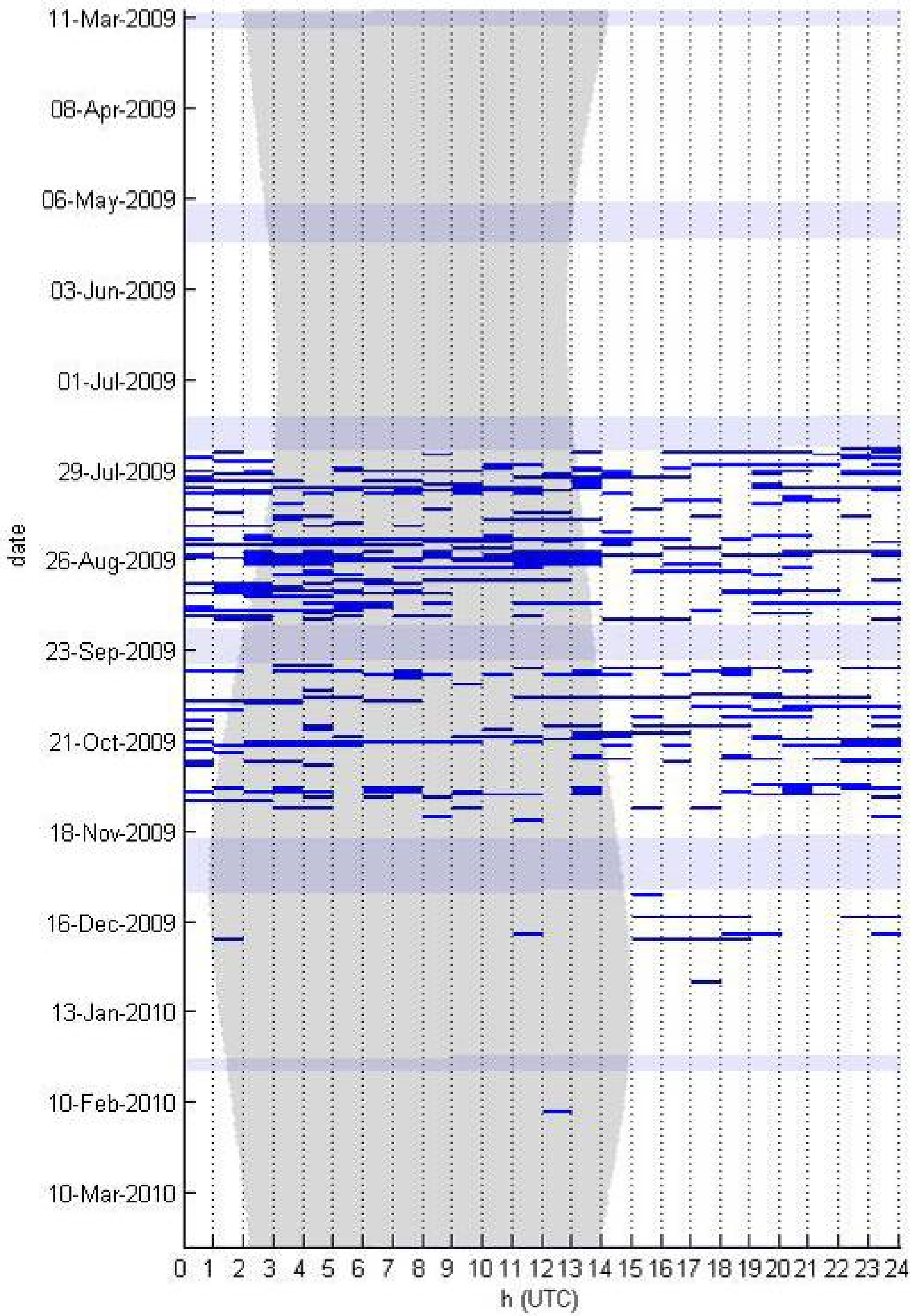
Blue Whale - "A" Call in Hourly Bins



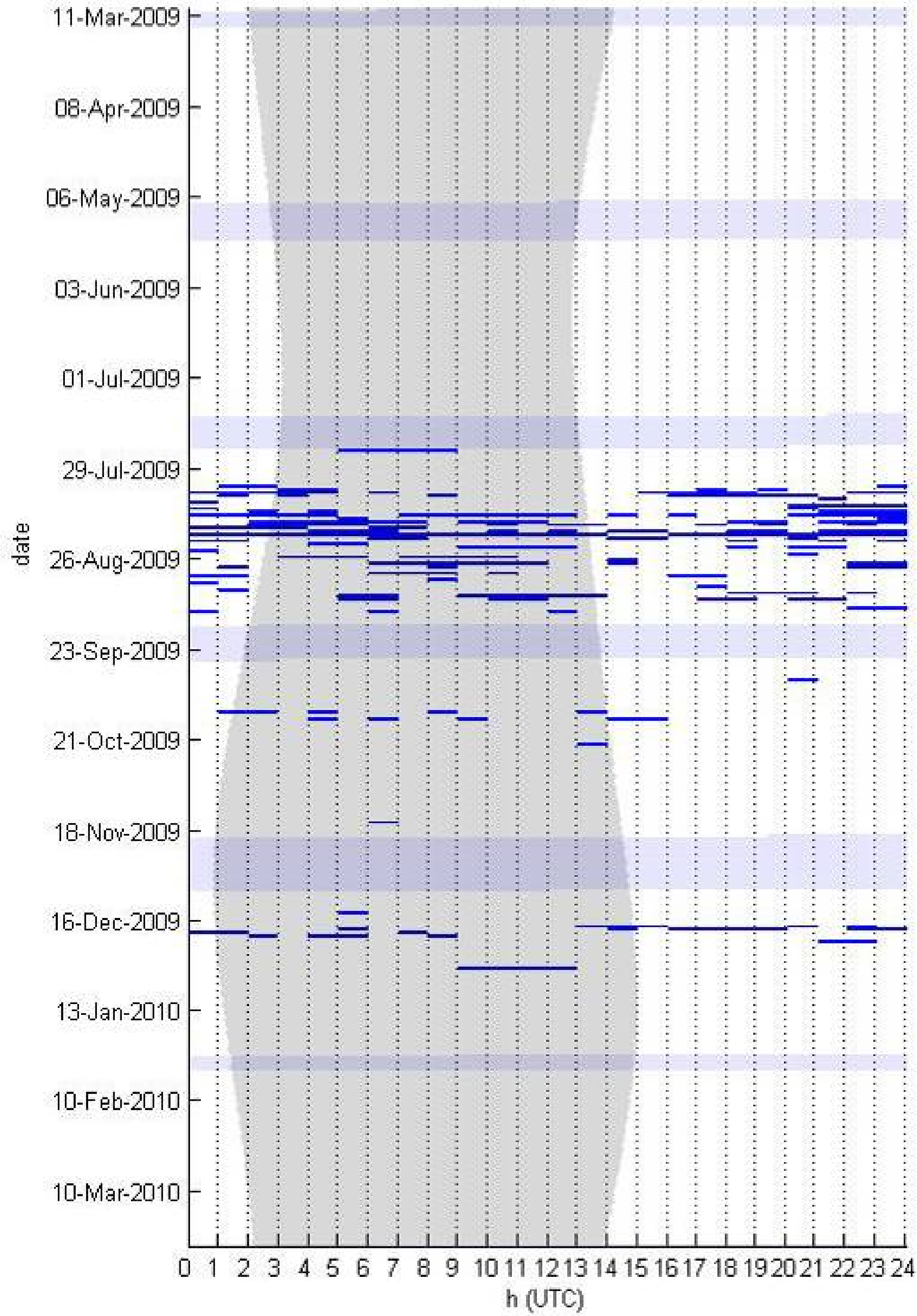
Blue Whale - "B" Call in Hourly Bins



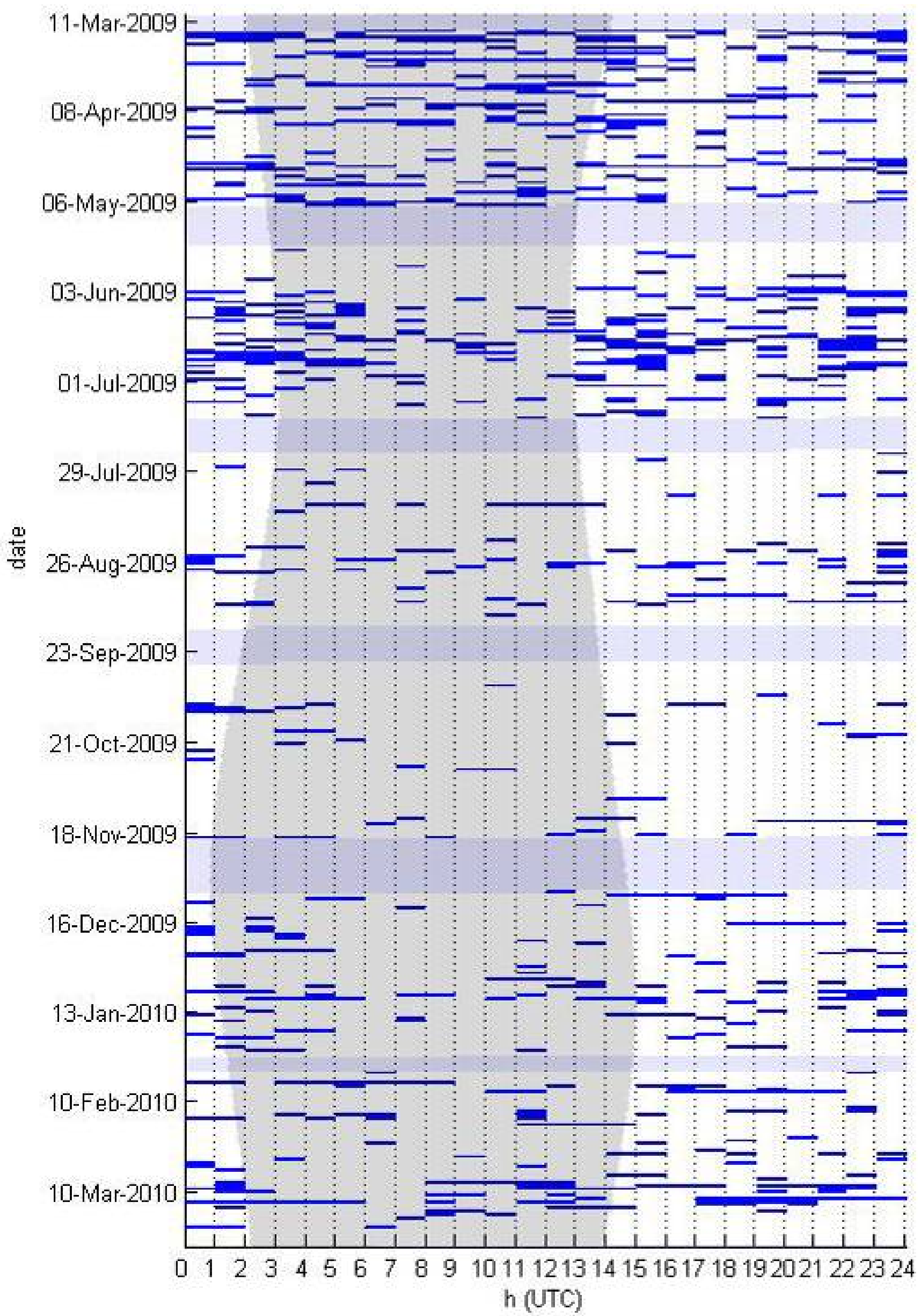
Blue Whale - "D" Call in Hourly Bins



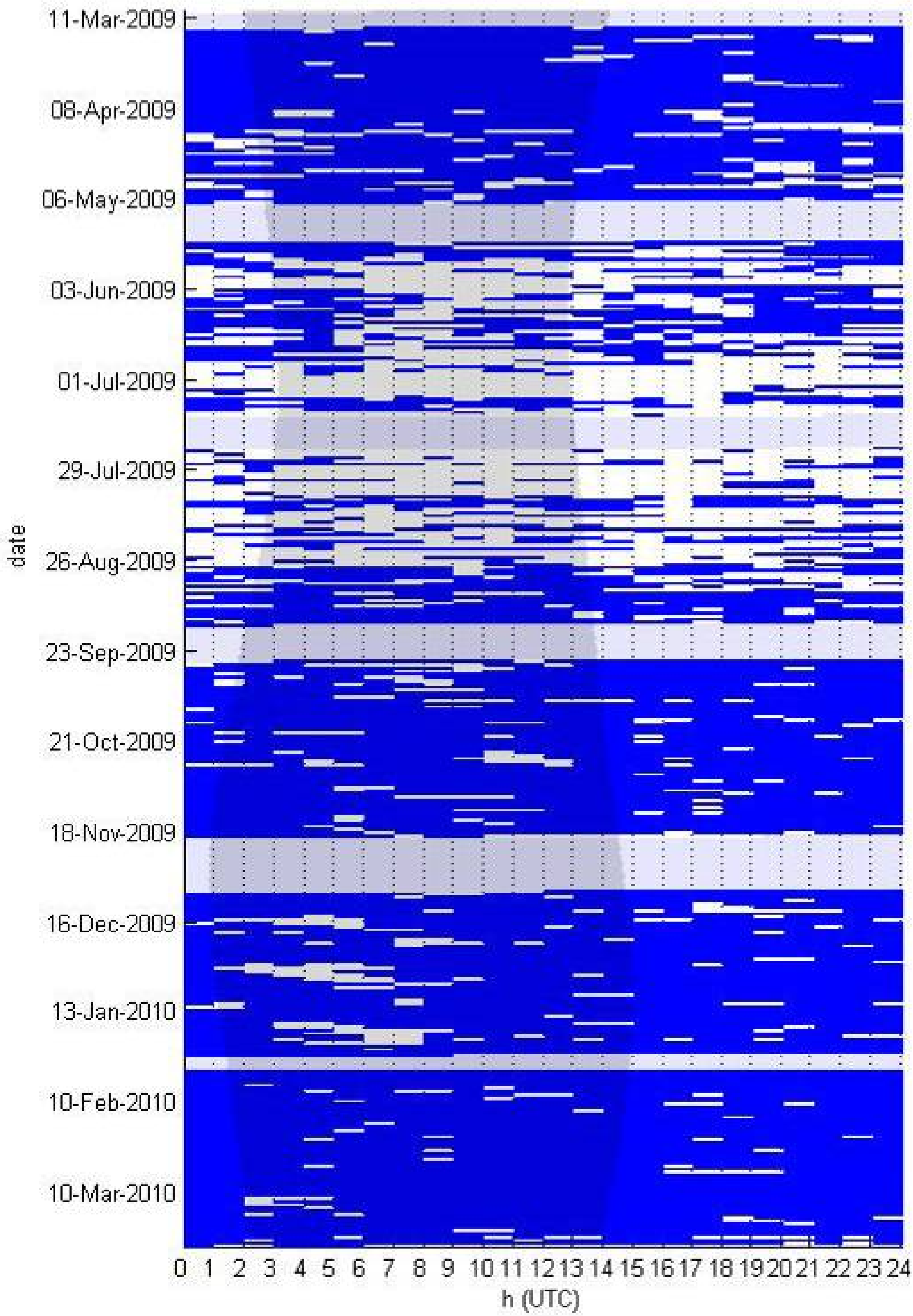
Blue Whale - Song in Hourly Bins



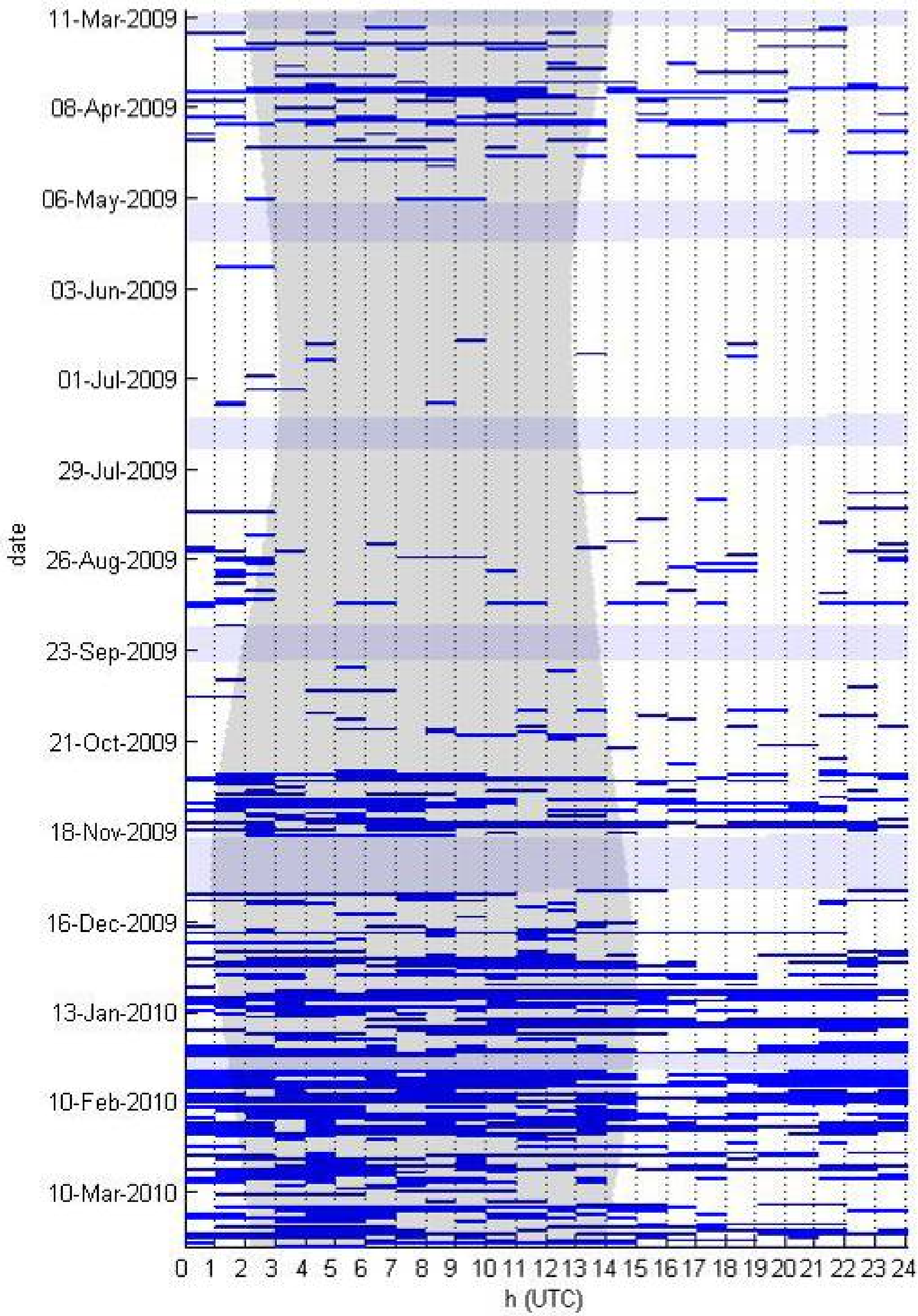
Bryde's Whale – All Call Types in Hourly Bins



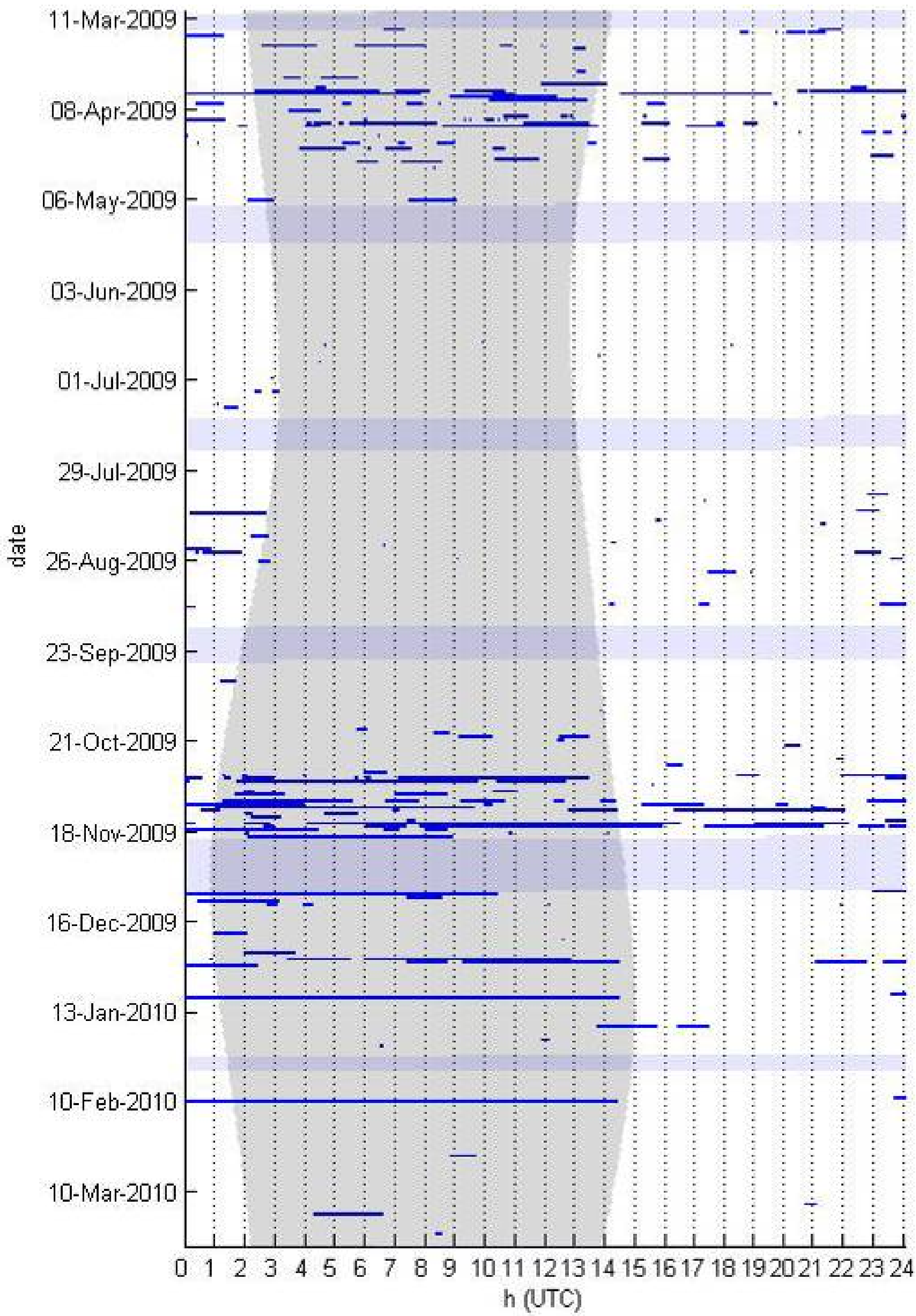
Unidentified Whale - 50 Hz Call in Hourly Bins



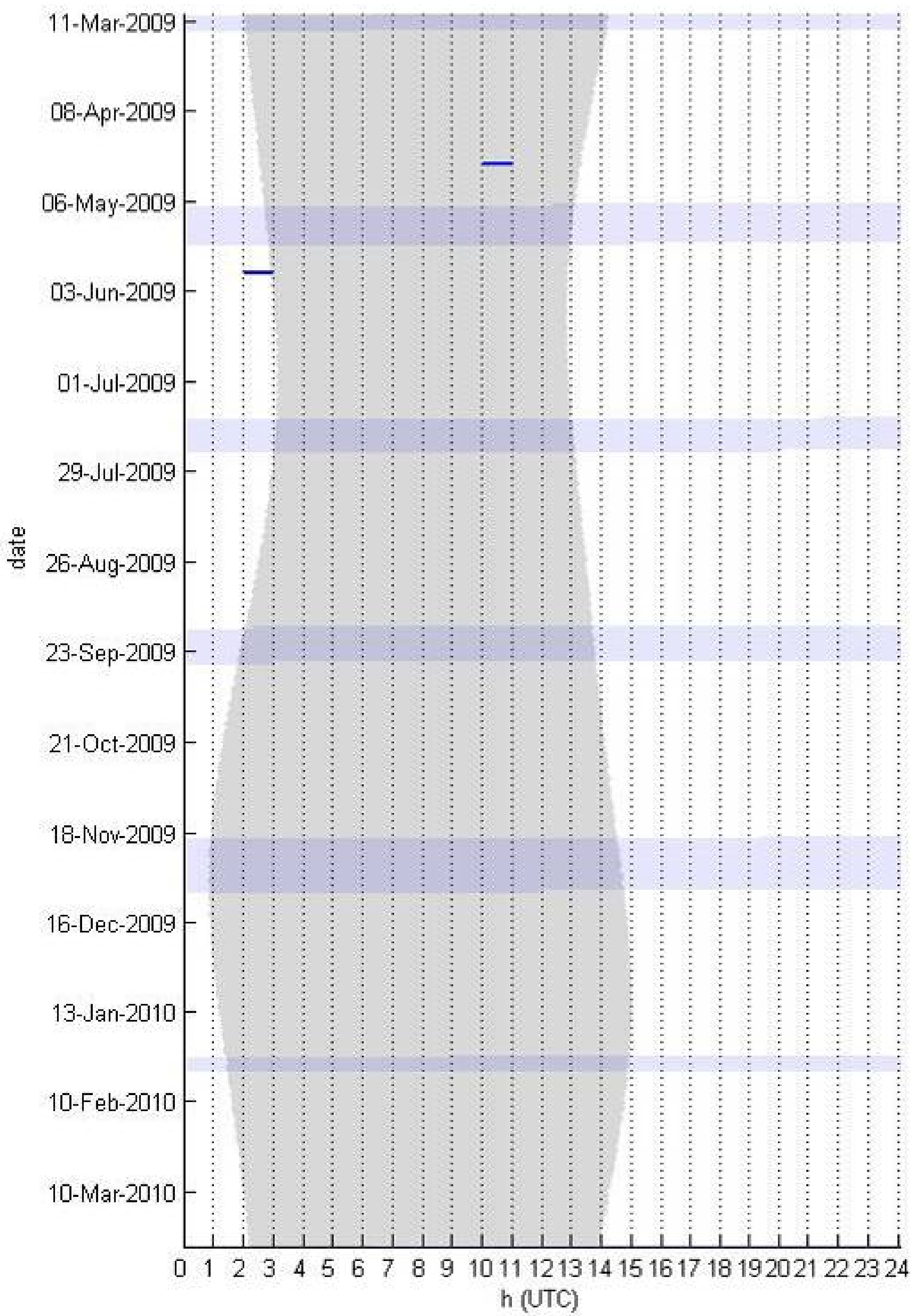
Fin Whale - All Call Types in Hourly Bins



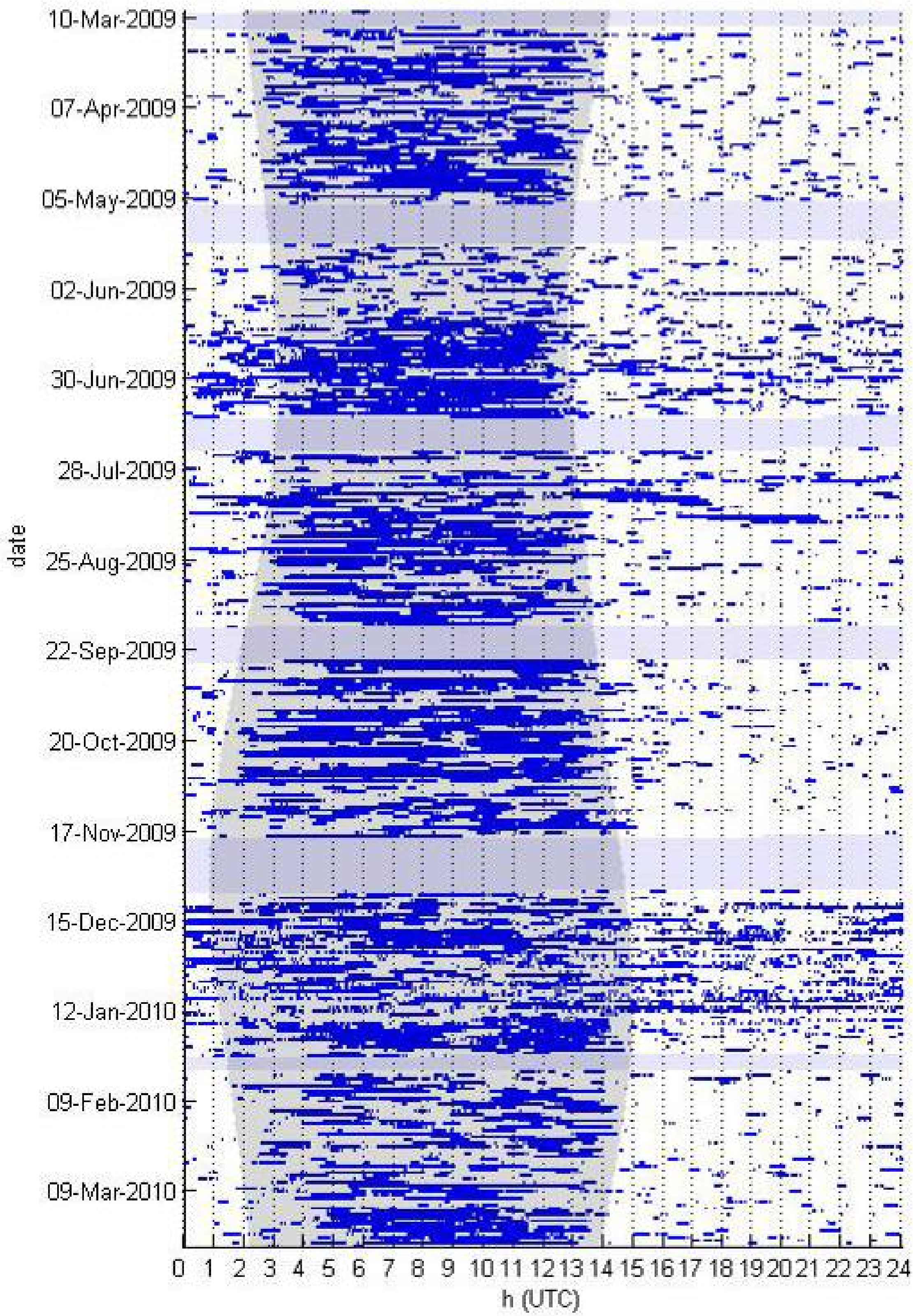
Humpback Whale - All Call Types in Hourly Bins



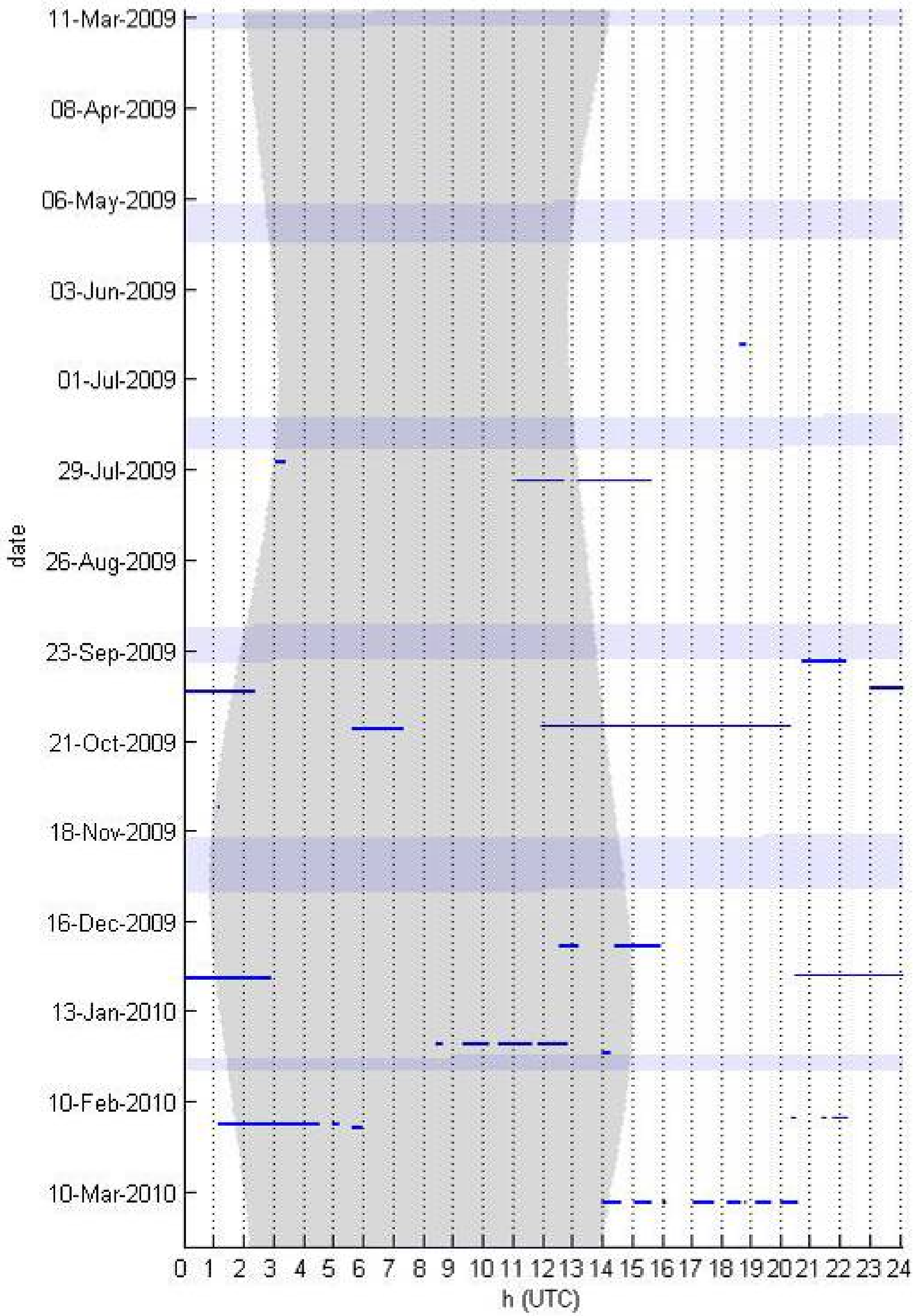
Humpback Whale - Song in One-Minute Bins



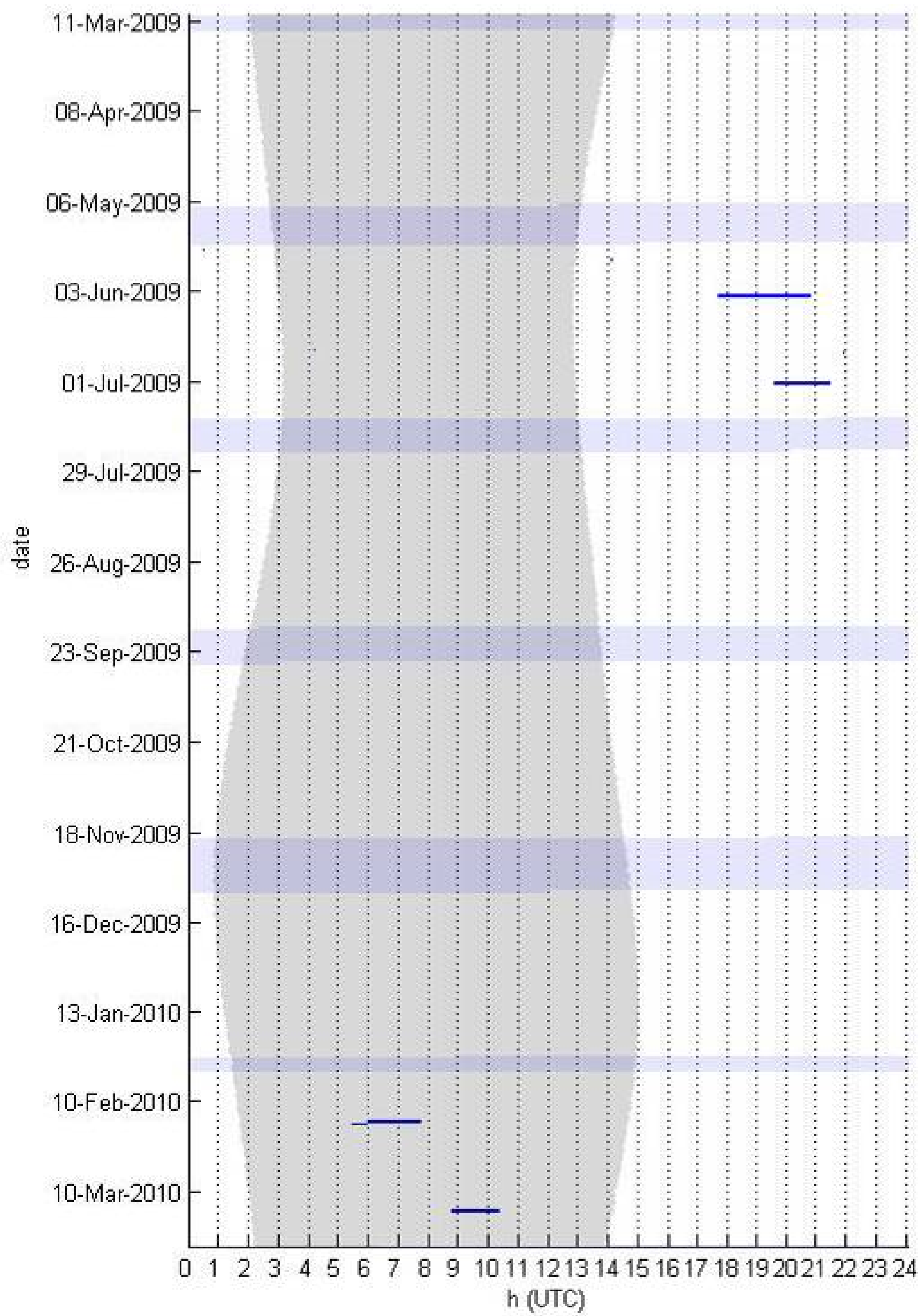
Minke Whale – All Call Types in Hourly Bins



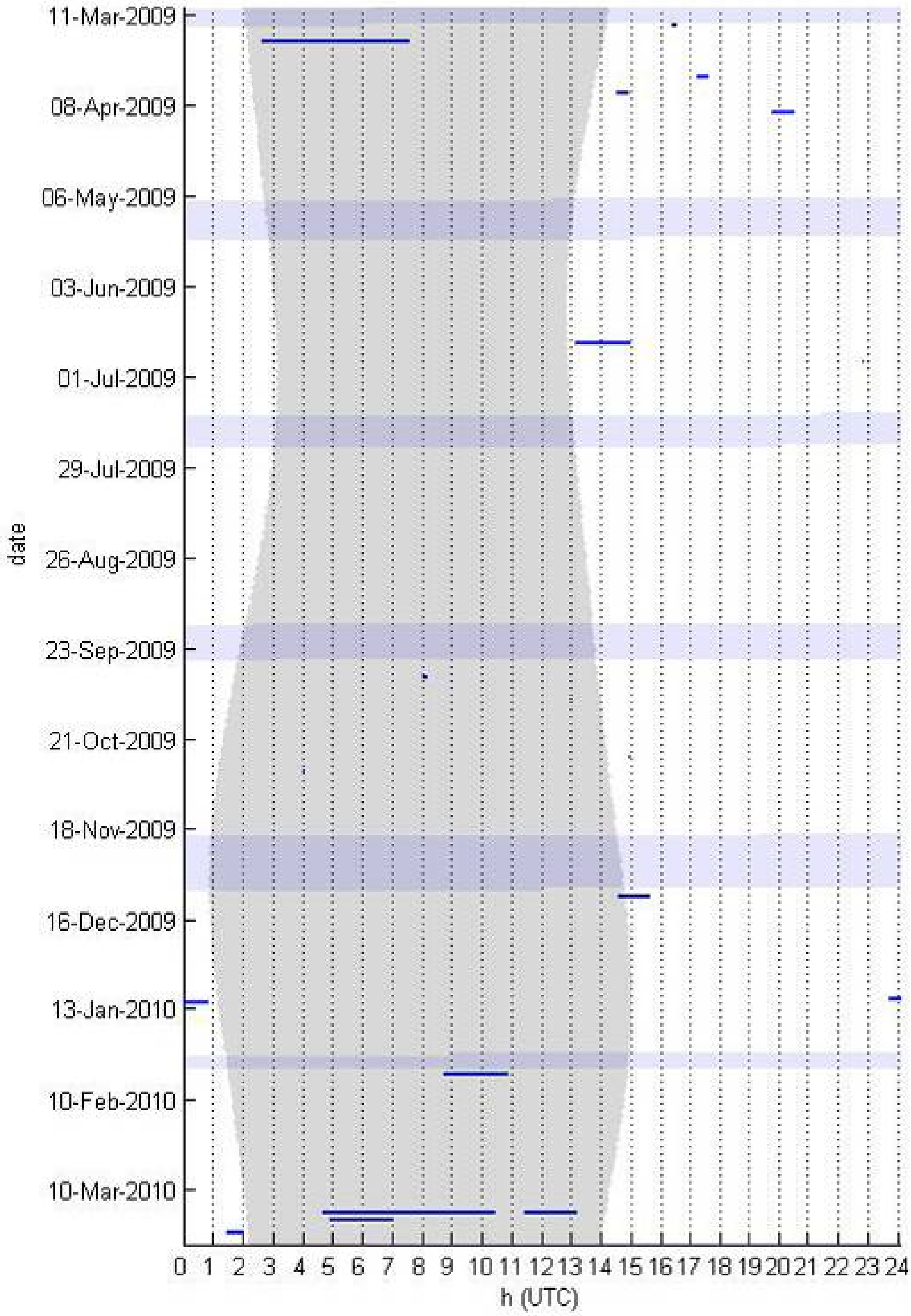
Odontocete - Echolocation Clicks in One-Minute Bins



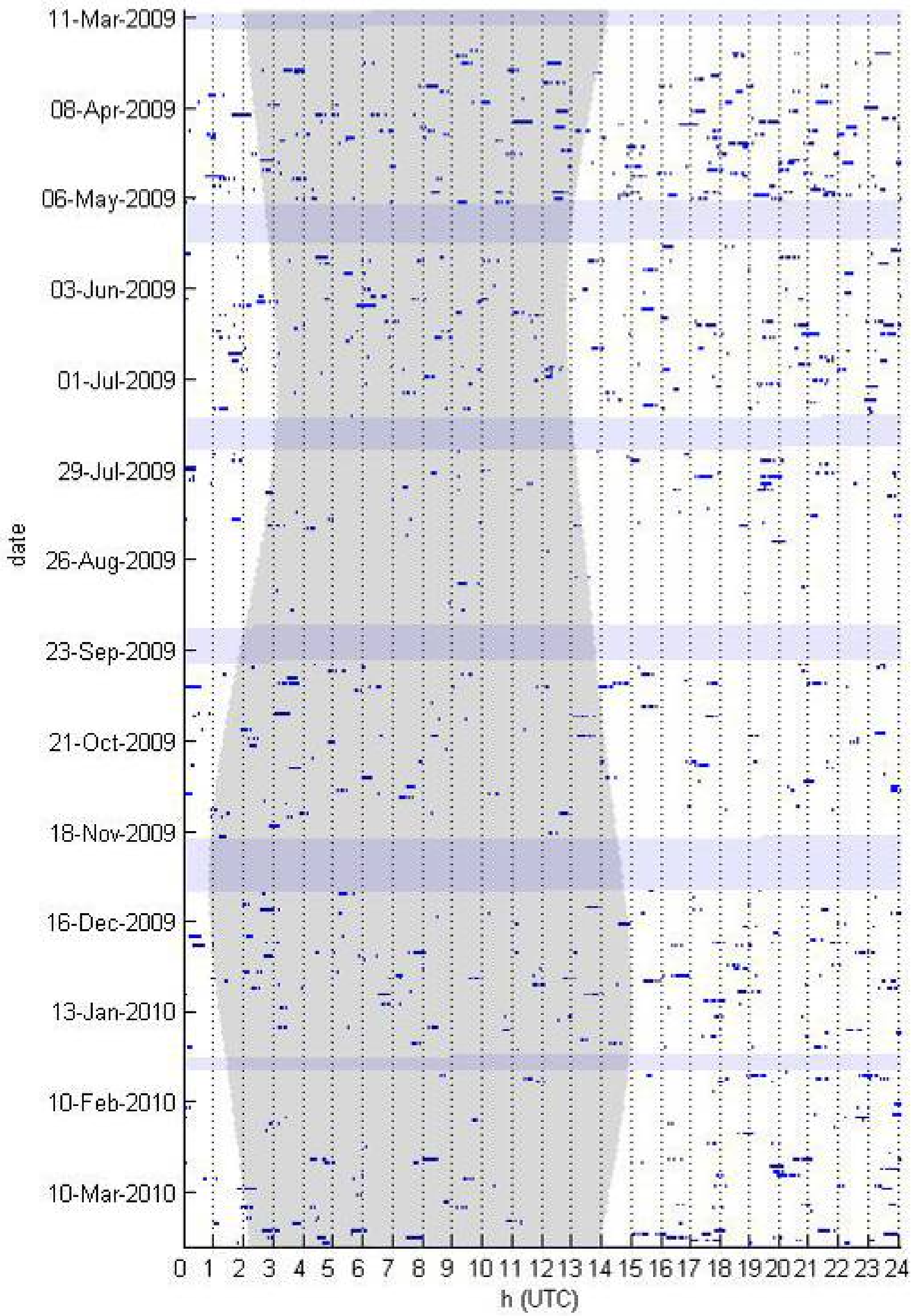
Sperm Whale - Echolocation Clicks in One-Minute Bins



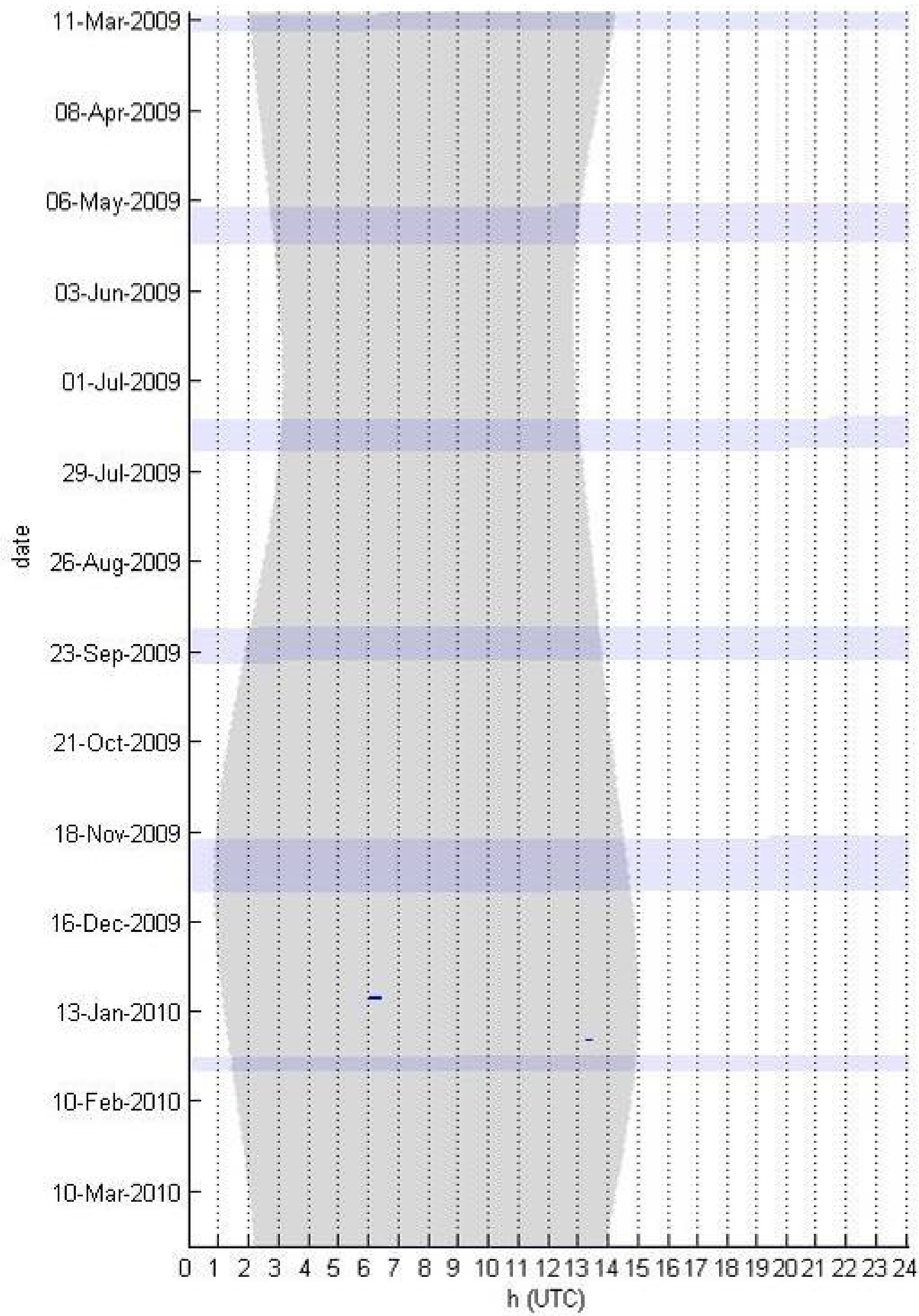
Killer Whale – Whistles and Echolocation Clicks in One-Minute Bins



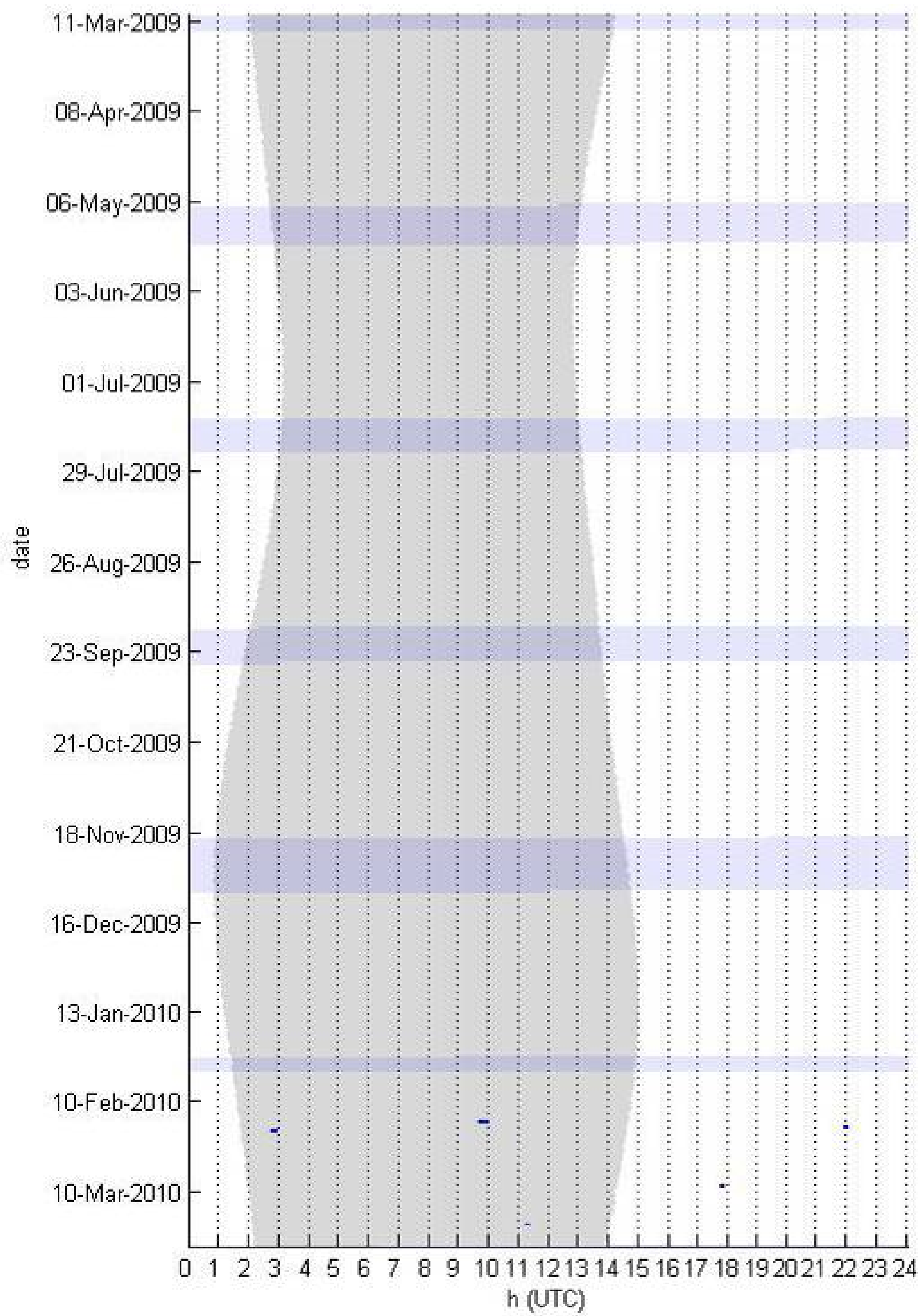
Unidentified Odontocete – Low-Frequency Whistles and Echolocation Clicks in One-Minute Bins



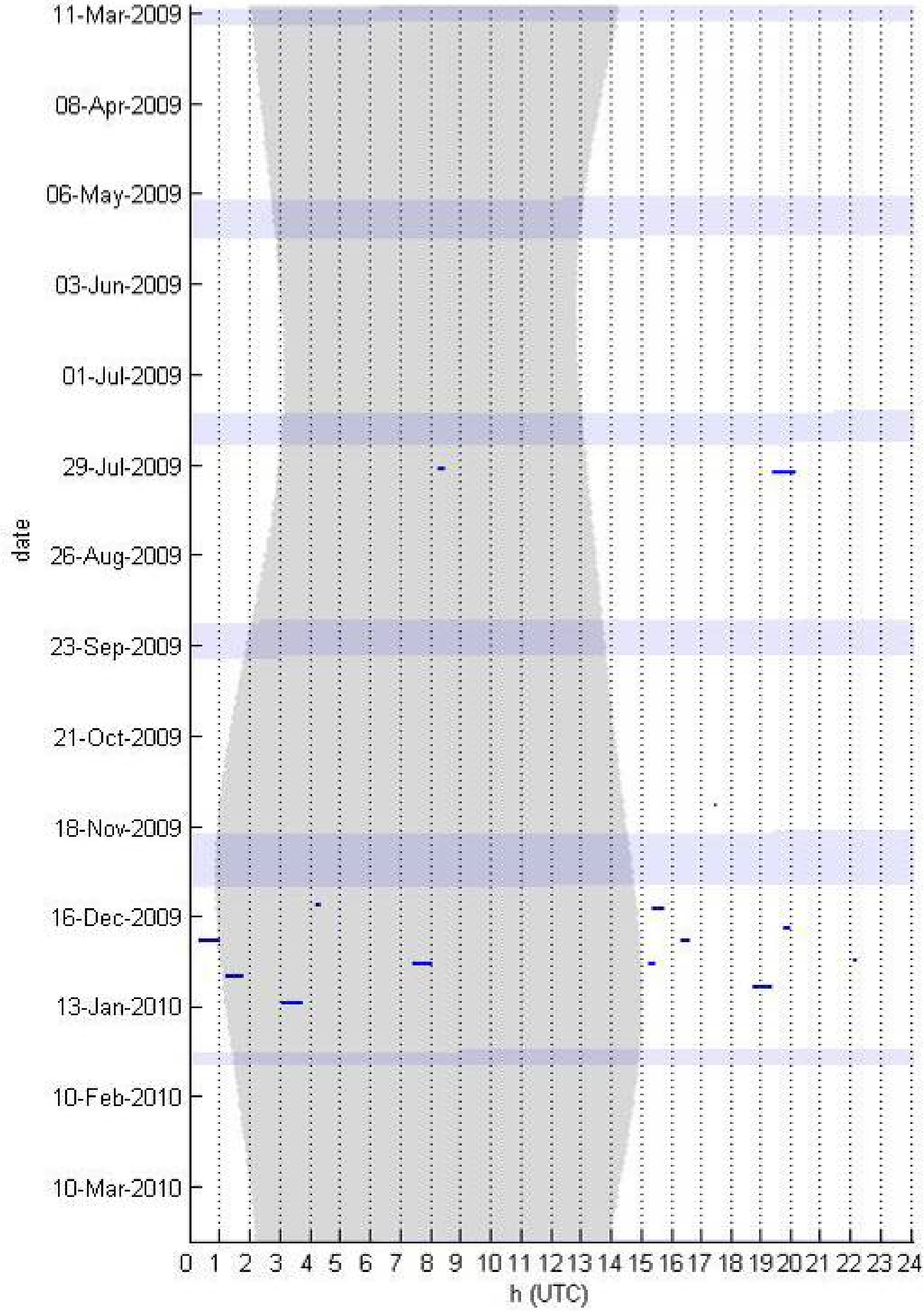
Beaked Whale - Frequency-Modulated Clicks (20 kHz < Peak Frequency < 55 kHz) in One-Minute Bins



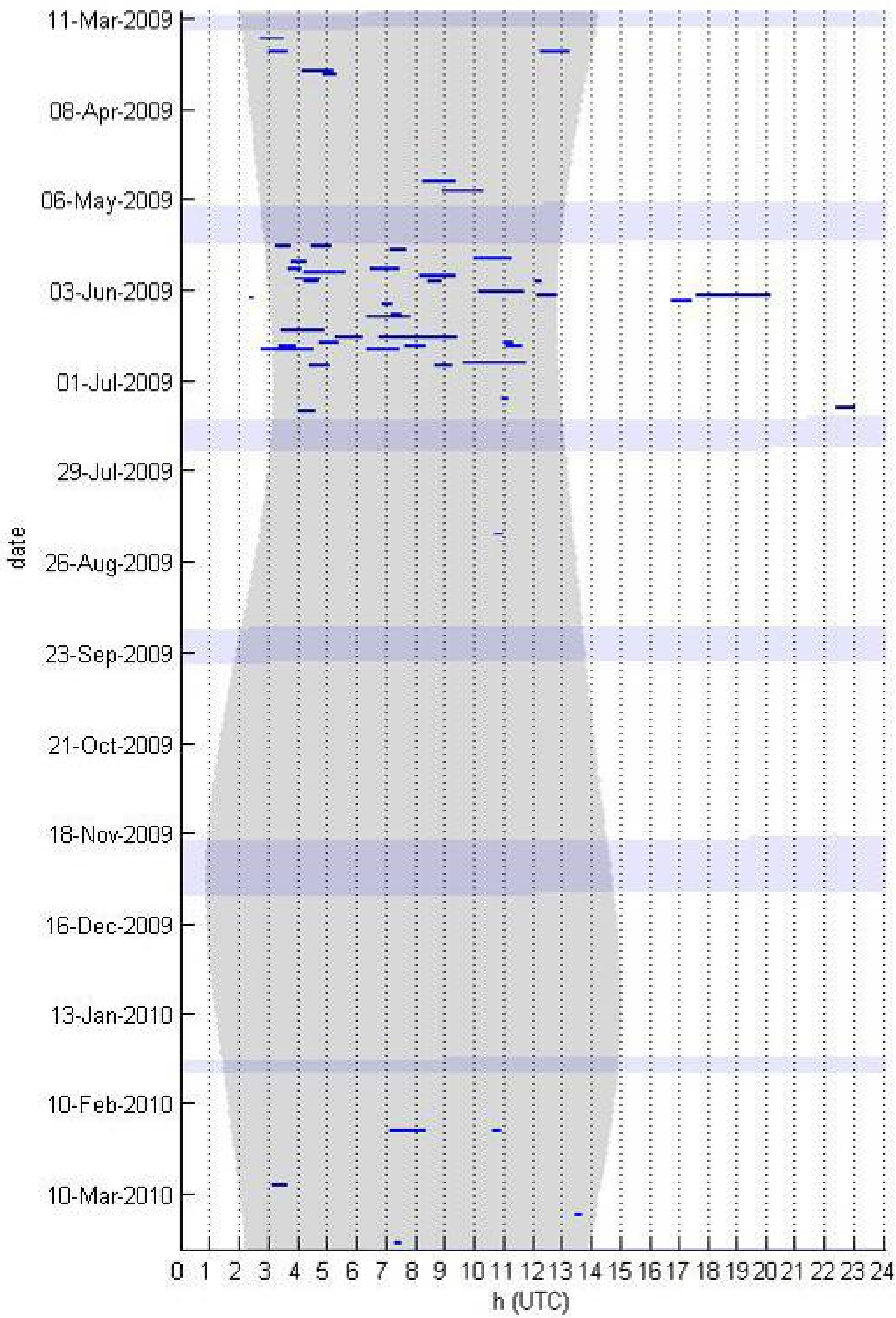
43 kHz Beaked Whale - Echolocation Clicks in One-Minute Bins



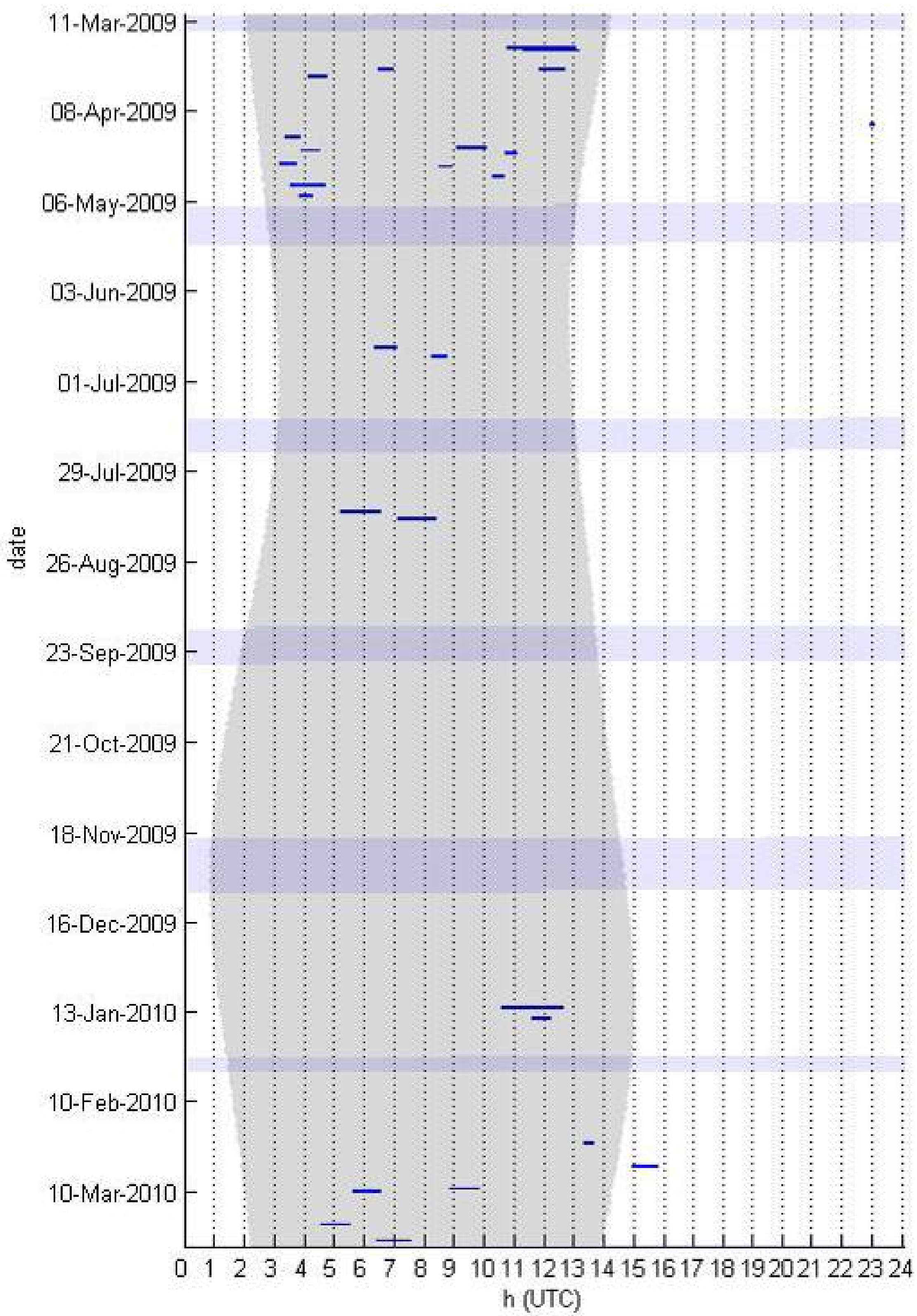
50 kHz Beaked Whale - Echolocation Clicks in One-Minute Bins



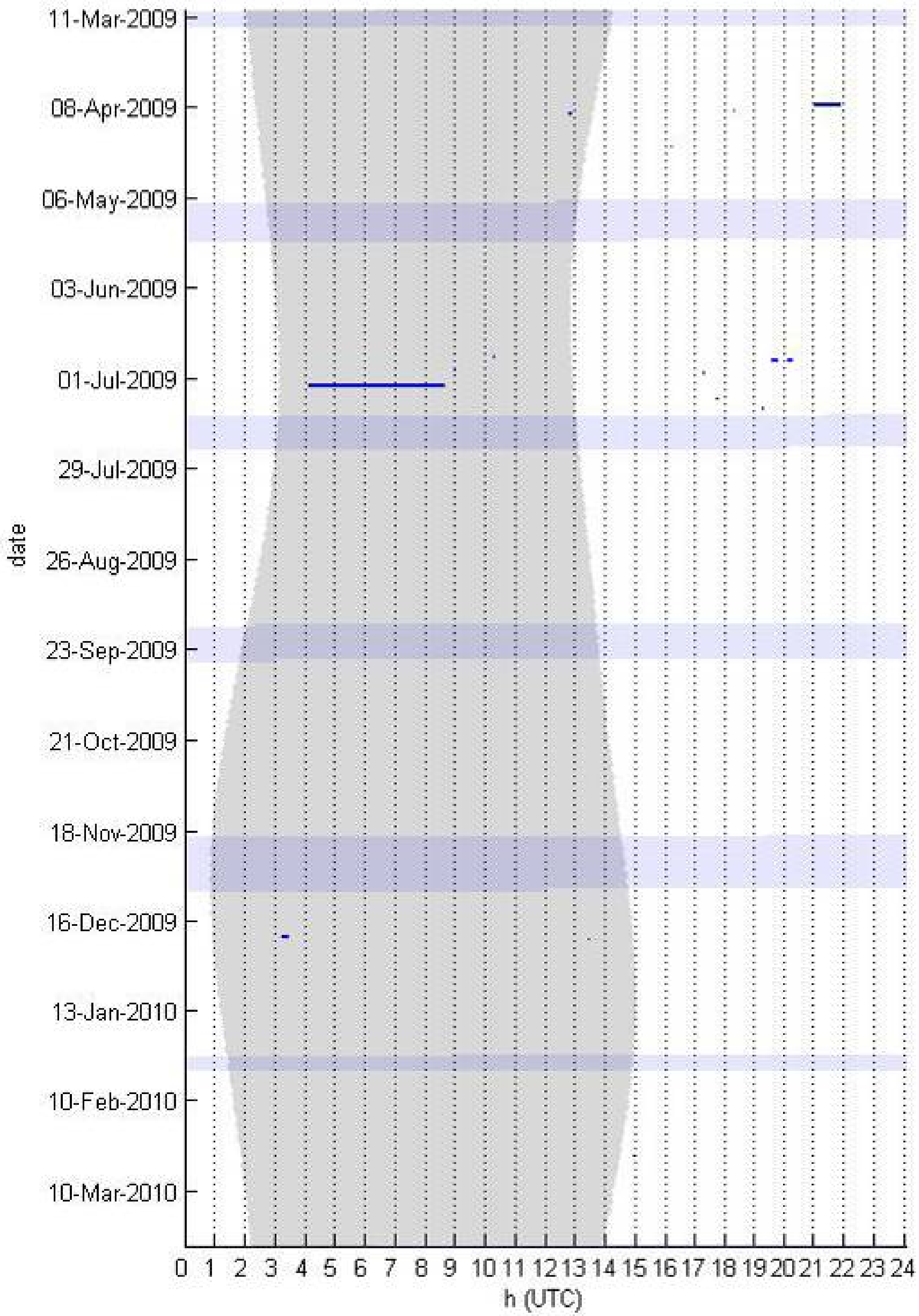
Baird's Beaked Whale - Echolocation Clicks in One-Minute Bins



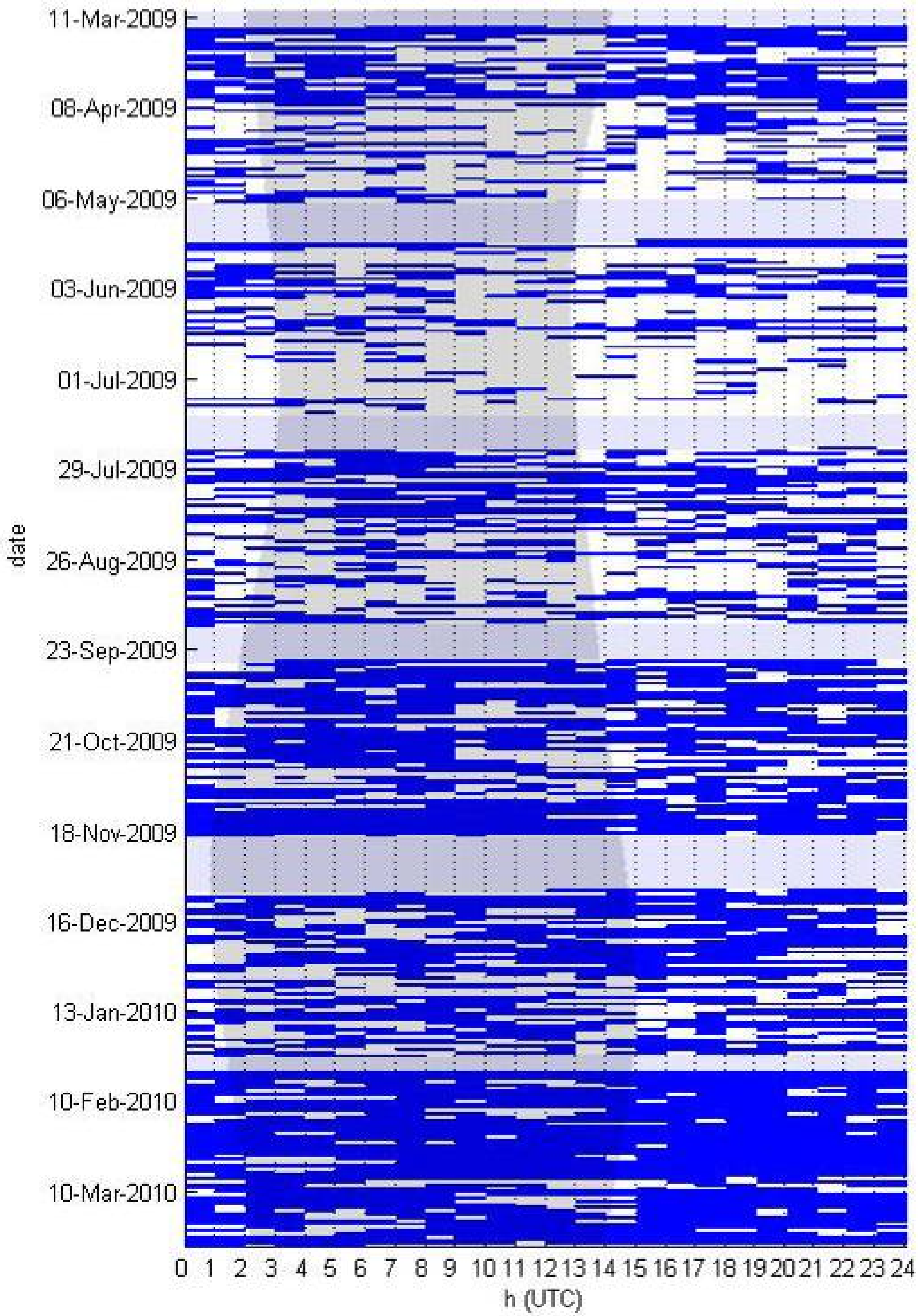
Risso's Dolphin - Echolocation clicks in One-Minute Bins



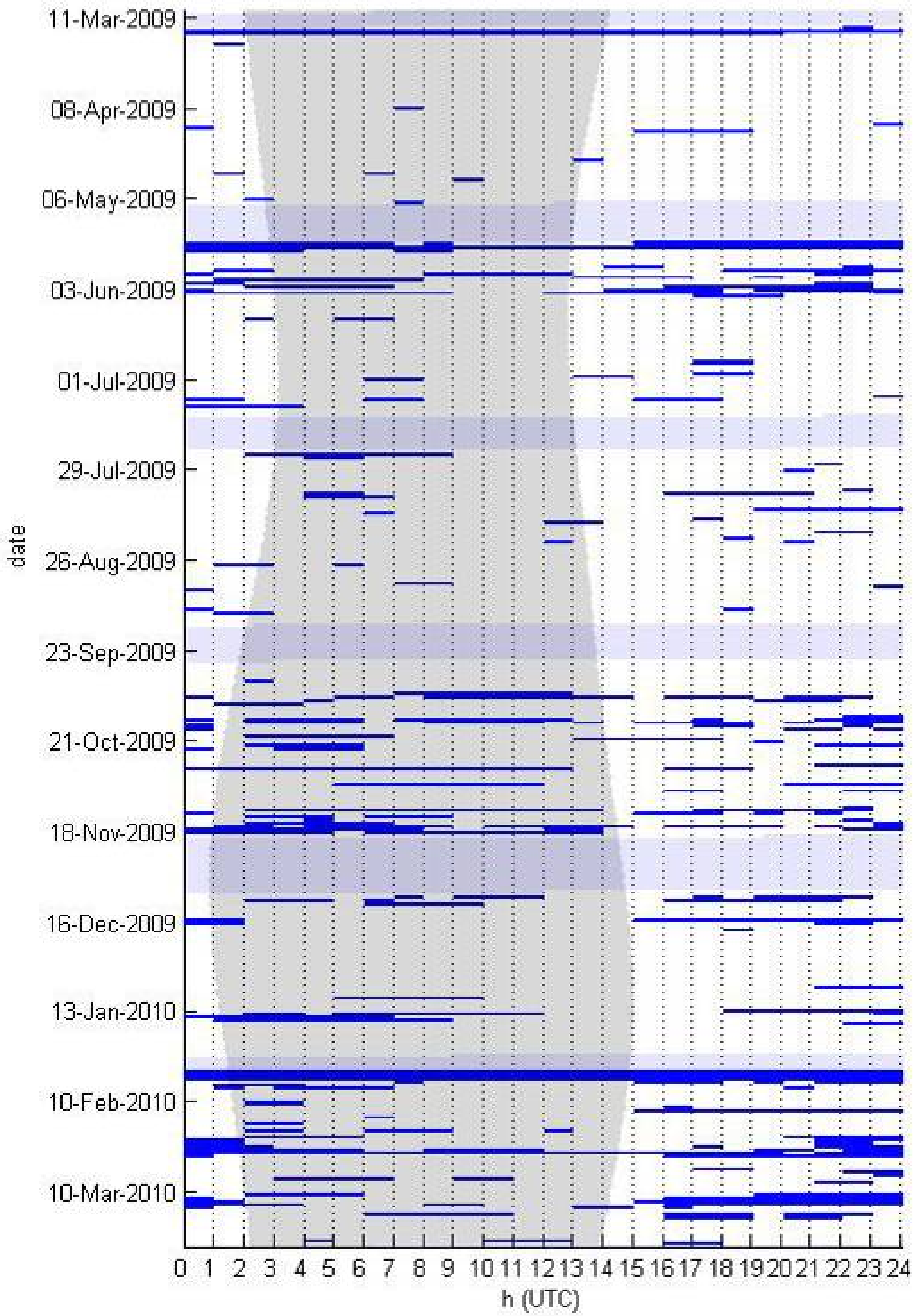
Pacific White-sided Dolphin – All Echolocation Clicks in One-Minute Bins



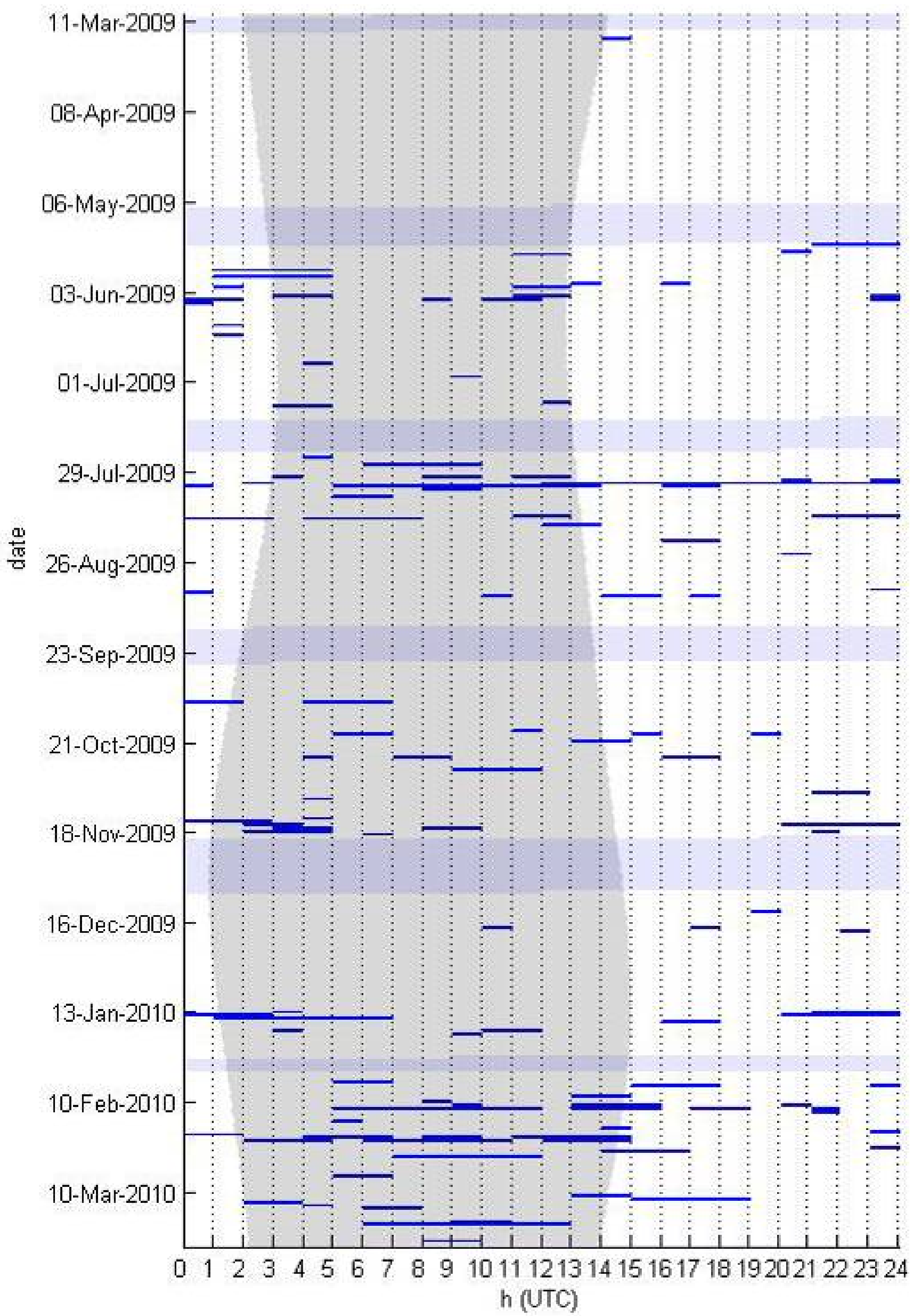
Pinniped - All Call Types in One-Minute Bins



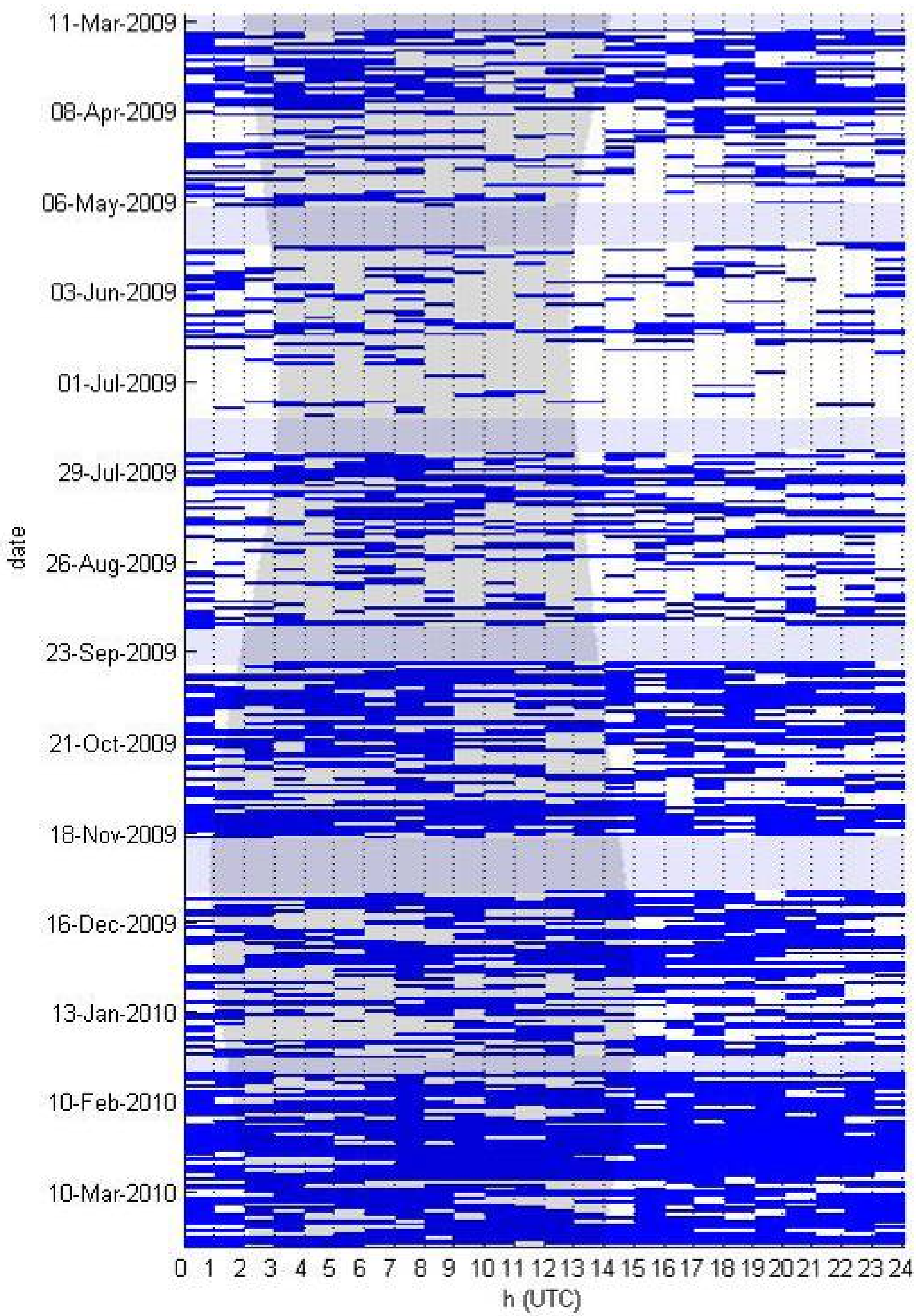
Anthropogenic - All Sound Sources in Hourly Bins



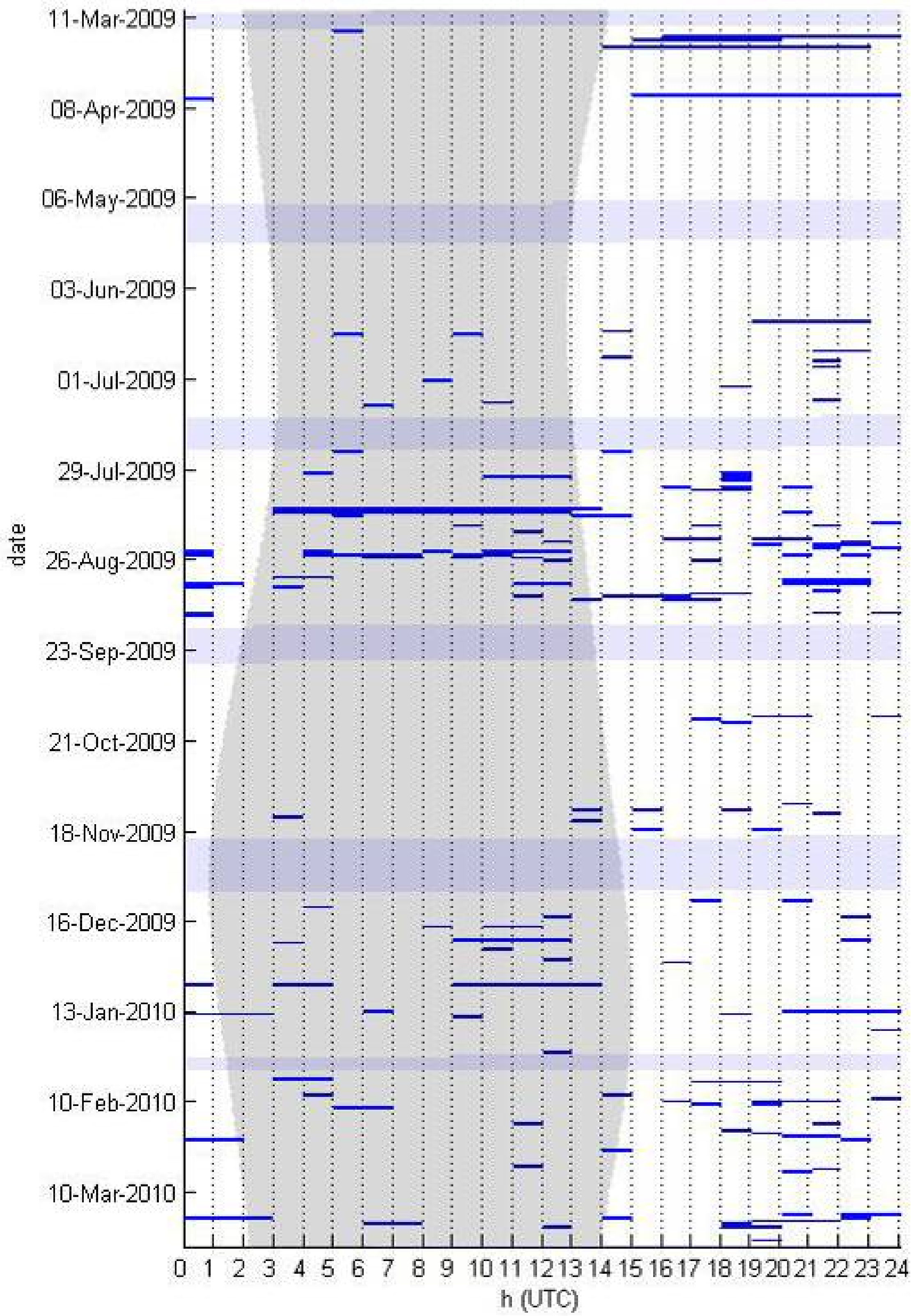
Anthropogenic –Mid-Frequency Active Sonar in Hourly Bins



Anthropogenic - Echosounder, Various Frequencies, in Hourly Bins



Anthropogenic - Ship Engine in Hourly Bins



Anthropogenic - Explosion in Hourly Bin

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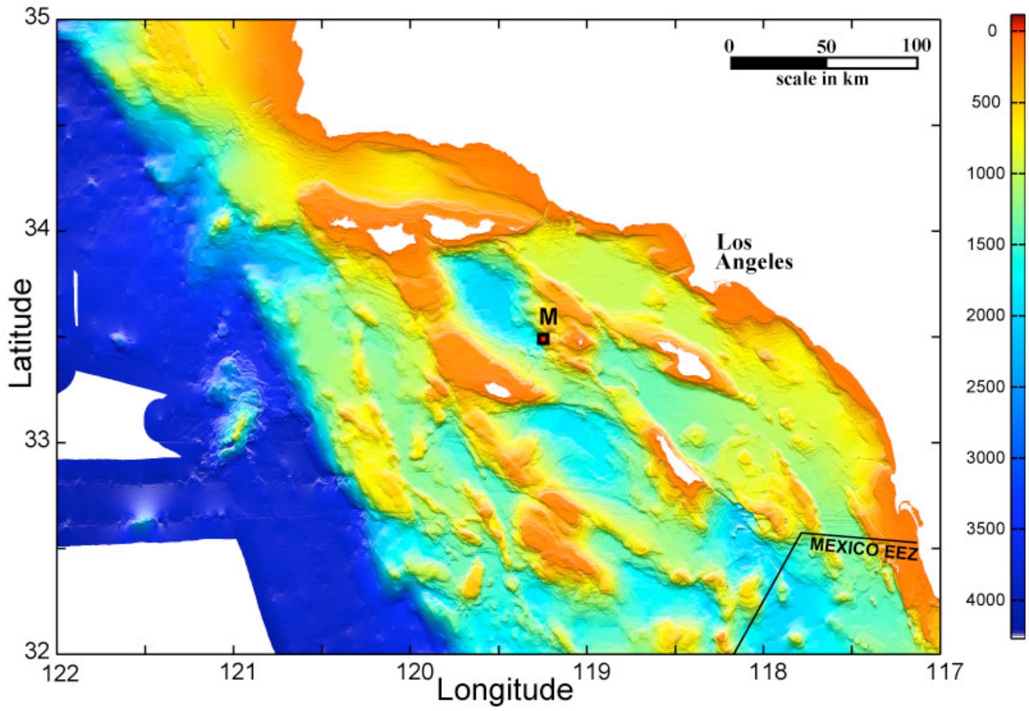
SCRIPPS Whale Acoustics

High Frequency Acoustic Recording Package Annual Data Summary Report March 11, 2009 – March 25, 2010

SOCAL Site M



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Contract Number: FISC N00244-08-1-0028 and FISC N00244-10-C-0021
Project Title: Southern California Marine Mammal Studies
Location: Site M, Latitude 33°31N, Longitude 119°15 W, approx. Depth 1000 m
Deployment Cruises: SOCAL 32 - 37, R/V Sproul
Recording Period: March 11, 2009 – March 25, 2010
Sample Rate: 200kHz Recording Interval: Continuous

Summary

This report summarizes the underwater sounds detected during a series of deployments of a High Frequency Acoustic Recording Package (HARP) in the southern California (SOCAL) offshore region. The HARP records broadband (10 Hz – 100 kHz) acoustic data, including both marine animal and anthropogenic sound. This report summarizes initial analysis to detect the presence of marine mammals by species as well as the occurrence of naval sonar and other anthropogenic sound events.

The HARP deployments were conducted at site M, which is located to the west of Santa Barbara Island and north of the primary area of naval training activity near San Clemente Island. The HARP at site M was deployed and recovered by the R/V Sproul during cruises SOCAL 32 (March 11, 2009) through SOCAL 38 (April 9, 2010). It recorded acoustic data continuously at a 200 kHz sample rate with data gaps in-between deployments, resulting in a total of 320 days (7591 hours) of recording over a period of 379 days. Table 1 provides a summary of HARP deployment dates, locations, and recording times.

We investigated the temporal occurrence of marine mammal and anthropogenic sound using manual analysis of three frequency bands: 10-1000 Hz (Low); 1000-5000 Hz (Mid); and 5-100 kHz (High). For each of these bands one or more analysts scanned the data using a long-term spectrogram display with approximately one hour of data per display. A MATLAB based software package called *TRITON* was used for data display and event logging. Potential sound events detected in a one-hour or shorter spectrogram were investigated at finer temporal scales to identify the origin of the sound by species or type of anthropogenic sound. Table 2 gives a summary, by species-call type or anthropogenic sound source, of the number of hours and days which sounds were detected, as well as the percentage of hours or days they were detected.

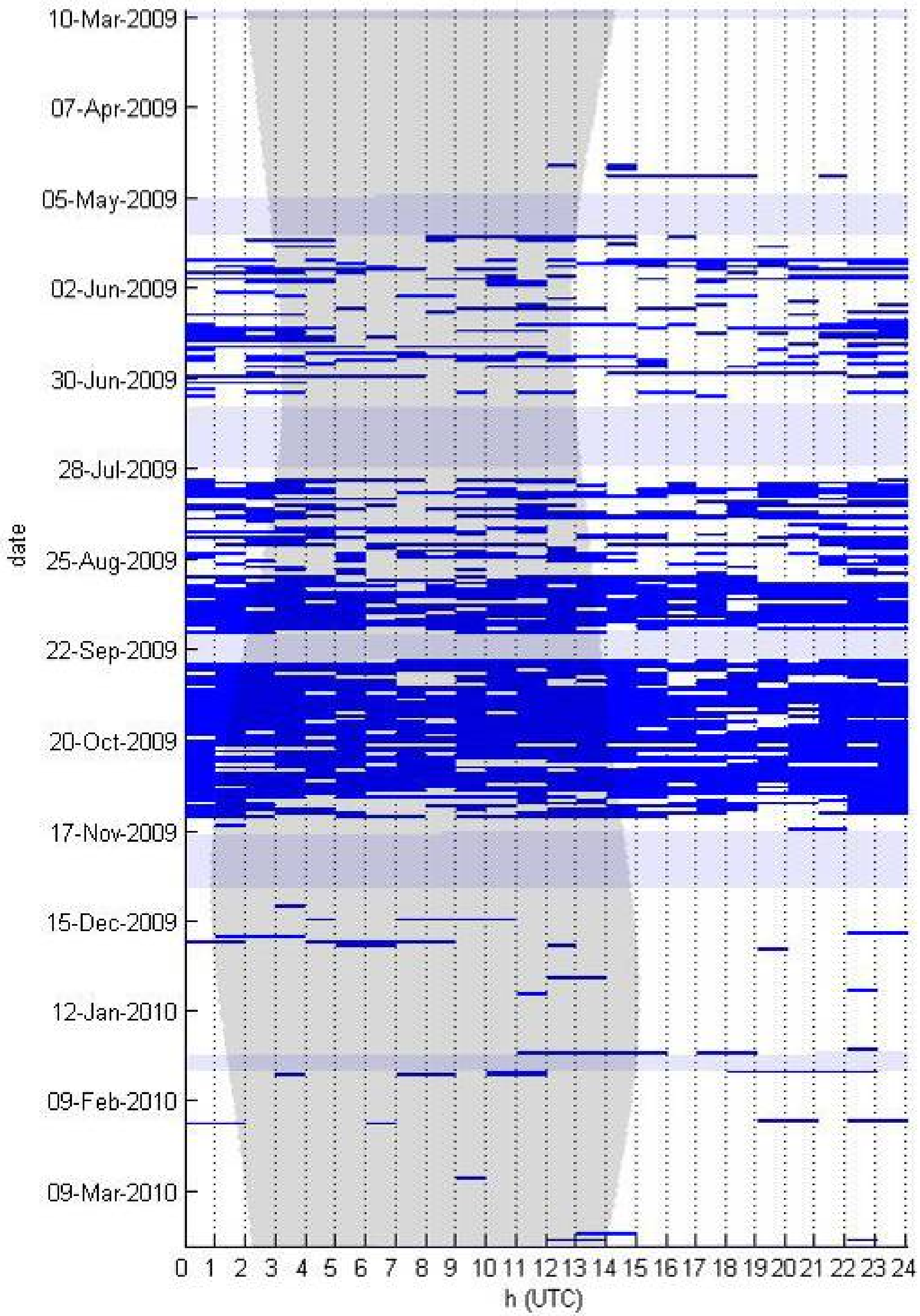
The detections for each call type or anthropogenic sound are also presented as a series of plots below. Sound detections are represented as a solid bar in hourly or minute bins, with each day of data along a horizontal line. Nighttime is indicated in a darker transparent color, and periods of off-effort (no acoustic data) are shown in light blue. Detected marine mammals include: blue whale, fin whale, unidentified whale, Bryde's whale, minke whale, humpback whale, sperm whale, killer whale, unidentified beaked whale, Baird's beaked whale, Risso's dolphin, Pacific white-sided dolphin, unidentified odontocete, and pinniped. Anthropogenic sounds include mid-frequency active sonar, echosounder, ship noise and explosion.

Table 1. HARP Deployment Dates, Locations and Recording Times.

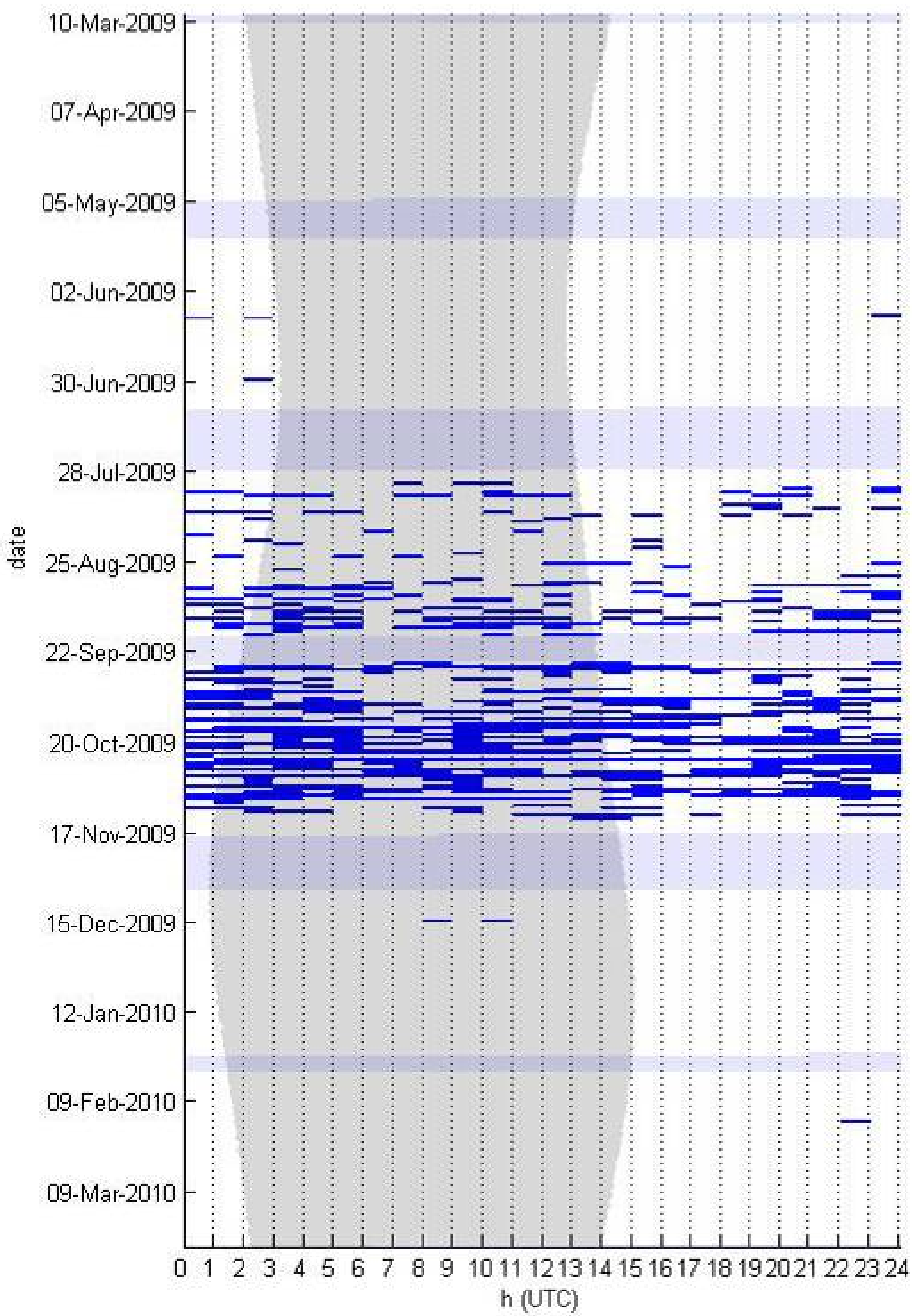
Site/Cruise	Deployment Date	Recovery Date	Deployment Latitude N	Deployment Longitude W	Depth (m)	Recording Start	Recording End	Days	Hours
SOCAL32M	3/10/2009	5/16/2009	33-30.579	119-15.280	1123	3/11/2009	5/4/2009	55	1303
SOCAL33M	5/16/2009	7/26/2009	33-30.580	119-15.253	1120	5/17/2009	7/8/2009	53	1263
SOCAL34M	7/27/2009	9/25/2009	33-30.927	119-14.794	902	7/27/2009	9/16/2009	52	1226
SOCAL35M	9/25/2009	12/4/2009	33-30.923	119-14.779	912	9/25/2009	11/17/2009	54	1275
SOCAL36M	12/4/2009	1/29/2010	33-30.937	119-14.798	912	12/5/2009	1/24/2010	51	1221
SOCAL37M	1/29/2010	4/9/2010	33-30.915	119-14.960	891	1/30/2010	3/25/2010	55	1303

Table 2. Detections of Marine Mammal Species and Anthropogenic Sound Sources.

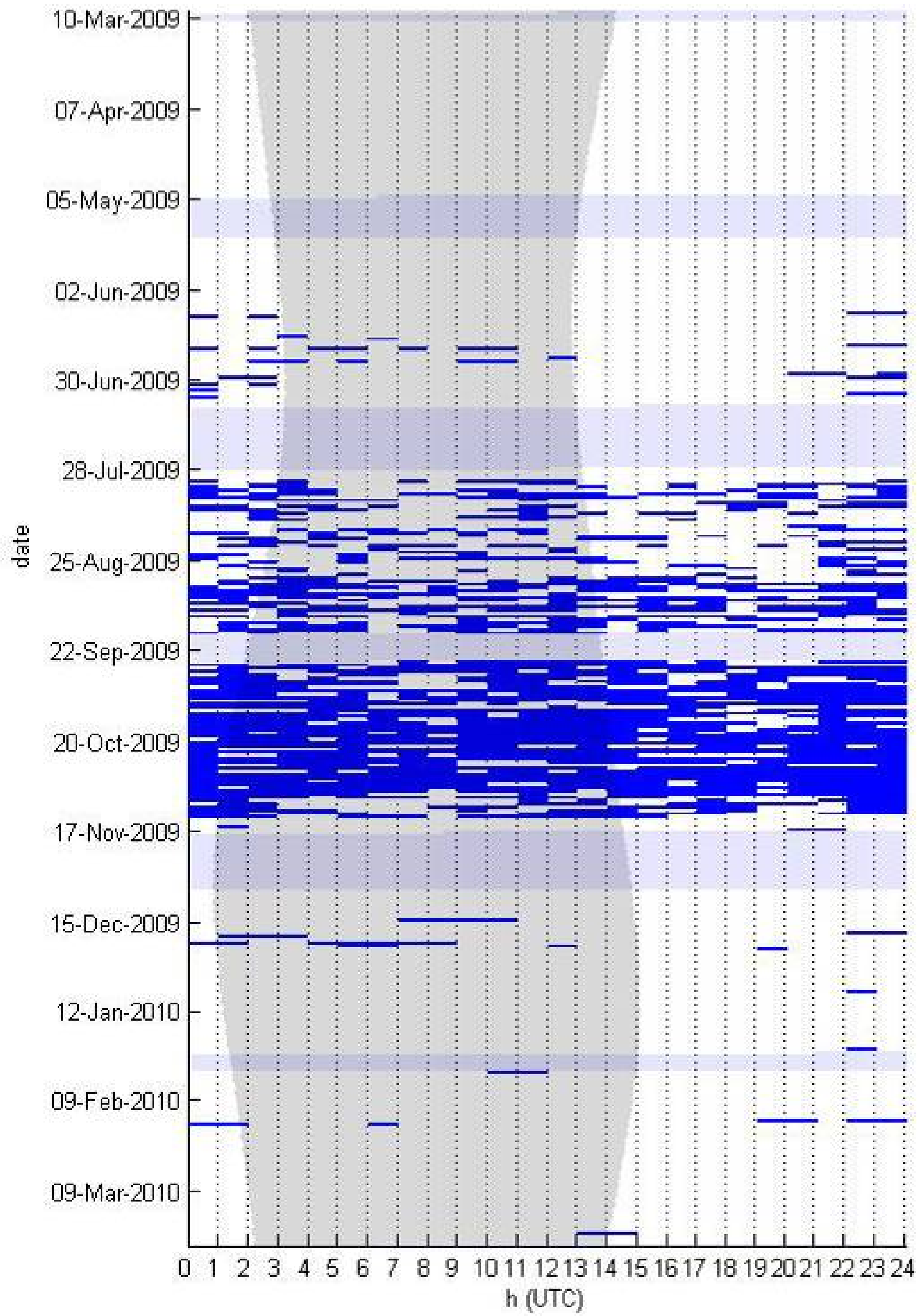
Species/Source	Call Type	Hour Bins	Percent Hours	Daily Bins	Percent Days
Blue Whale	All	967	13	112	35
Blue Whale	A	182	2	44	14
Blue Whale	B	507	7	73	23
Blue Whale	D	368	5	76	24
Blue Whale	Song	171	2	34	11
Fin Whale	All	4263	56	266	83
Unidentified Whale	50 Hz	1175	15	197	62
Bryde's Whale	All	182	2	29	9
Minke Whale	All	22	0.3	7	2
Humpback Whale	All	1192	16	184	58
Humpback Whale	Song	804	11	90	28
Odontocete	Clicks	4859	64	320	100
Sperm Whale	Clicks	76	1	25	8
Killer Whale	Whistles/ Clicks	29	0.4	12	4
Unidentified Odontocete	Low-Freq. Whistles/ Clicks	15	0.2	9	3
Beaked Whale	Clicks	231	3	146	46
Baird's Beaked Whale	Clicks	6	0.1	4	1
Risso's Dolphin	Whistles/ Clicks	460	6	139	43
Pacific White-sided Dolphin	Whistles/ Clicks	208	3	42	13
Pinniped	All	555	7	58	18
Anthropogenic	All	3190	42	290	91
Anthropogenic	Mid-Frequency Active Sonar	258	3	50	16
Anthropogenic	Echosounder Ping	36	0.5	24	8
Anthropogenic	Ship Engine Noise	2543	34	269	84
Anthropogenic	Explosion	504	7	99	31



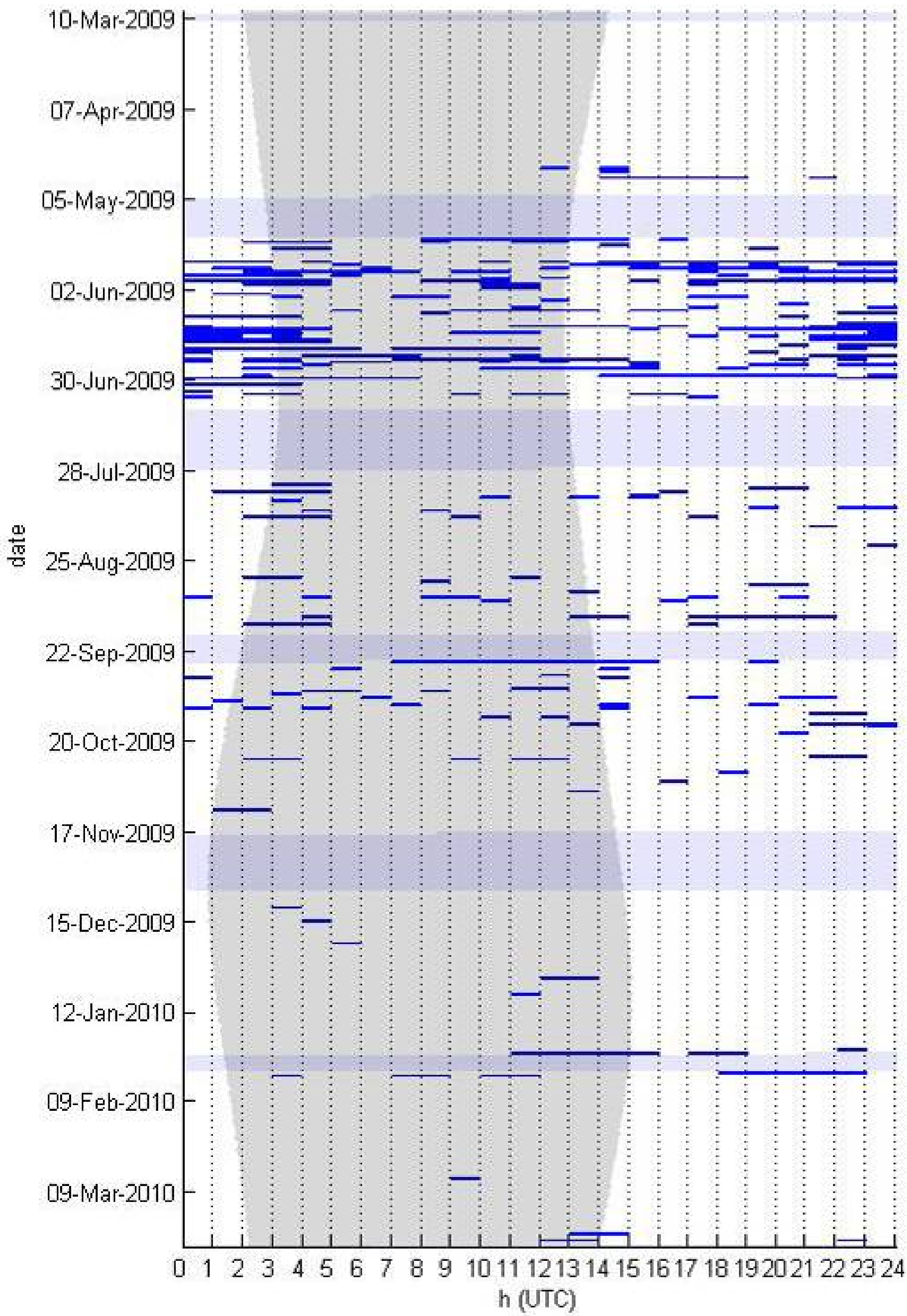
Blue Whale – All Call Types in Hourly Bins



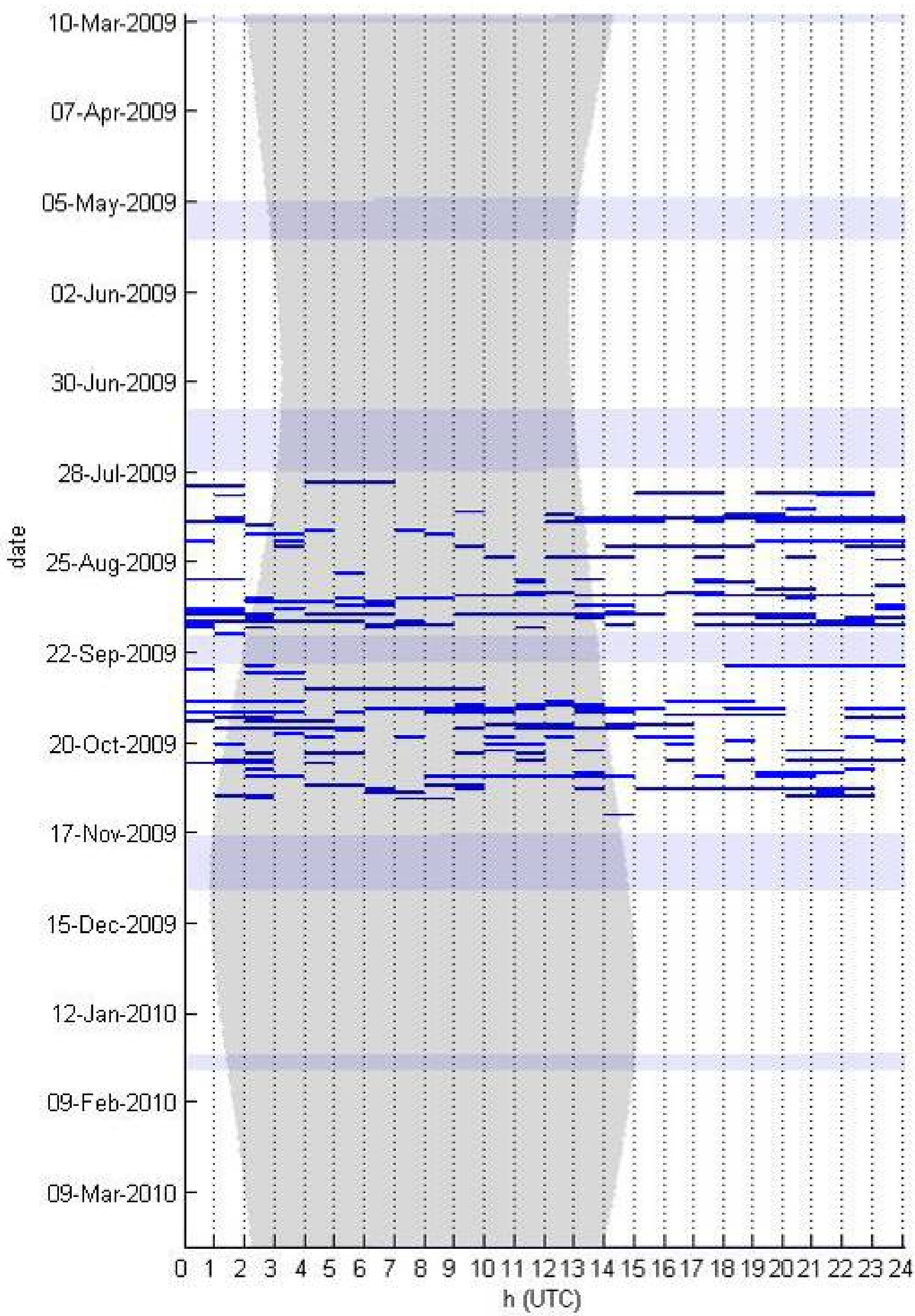
Blue Whale - "A" Call in Hourly Bins



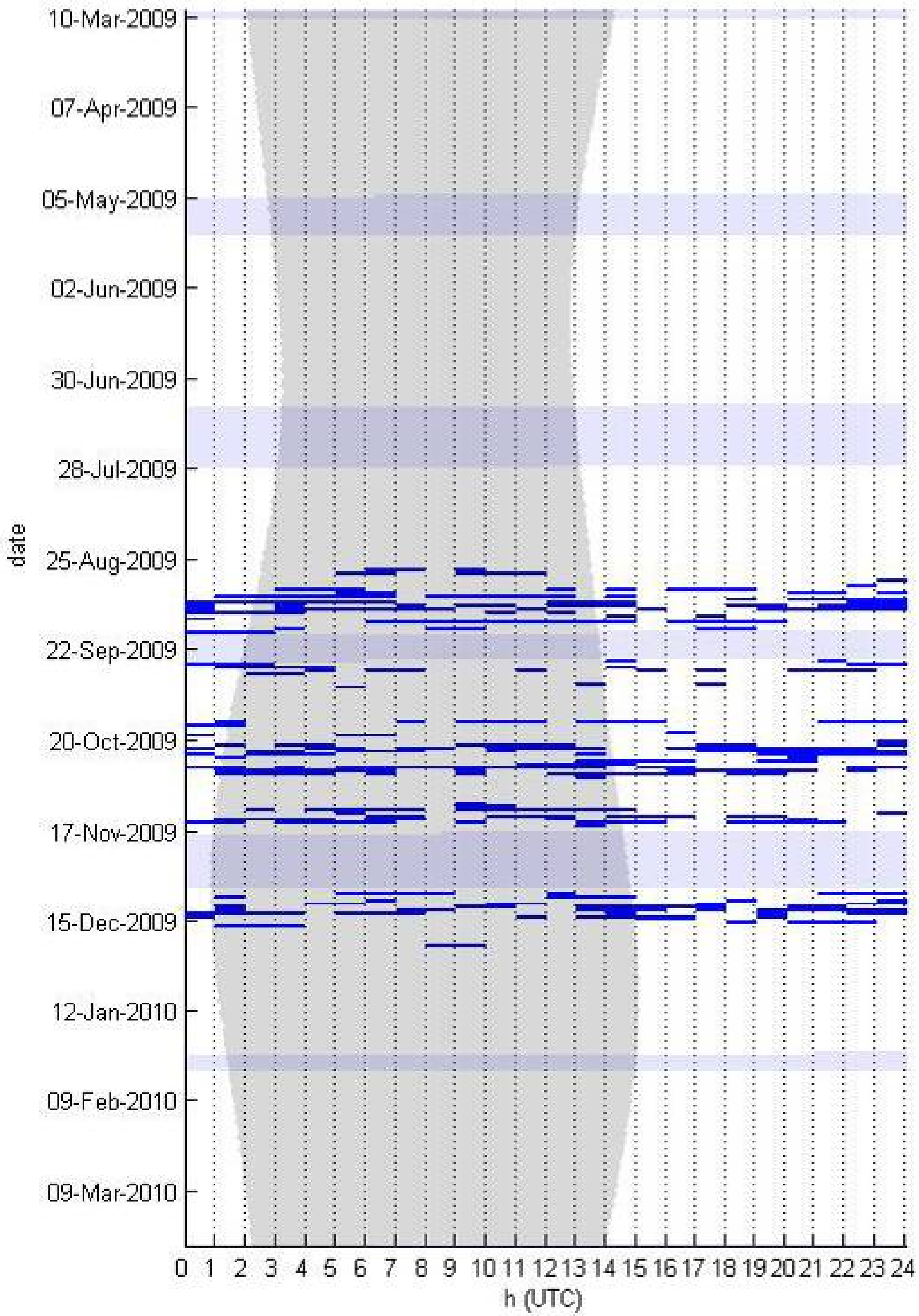
Blue Whale - "B" Call in Hourly Bins



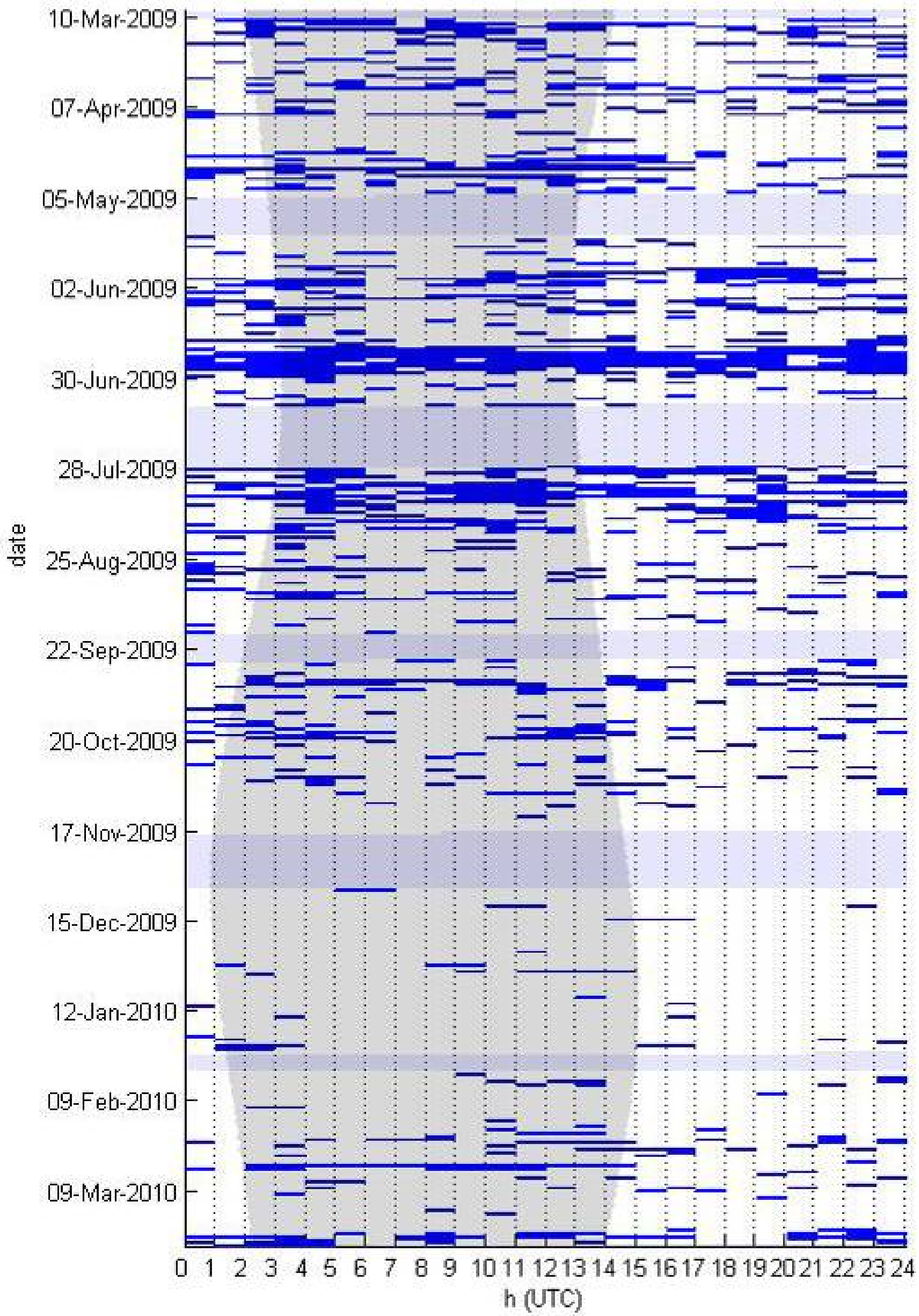
Blue Whale - "D" Call in Hourly Bins



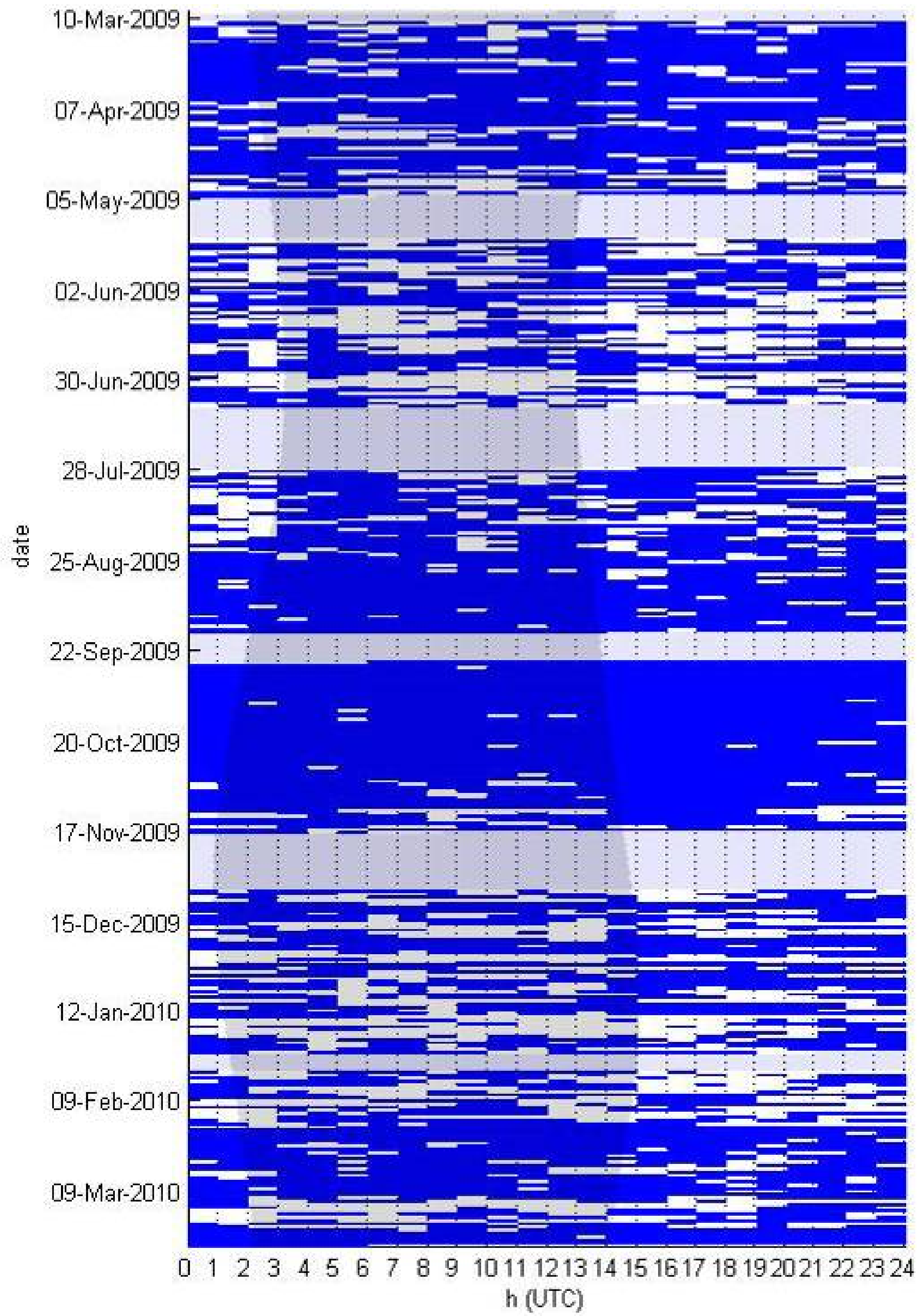
Blue Whale - Song in Hourly Bins



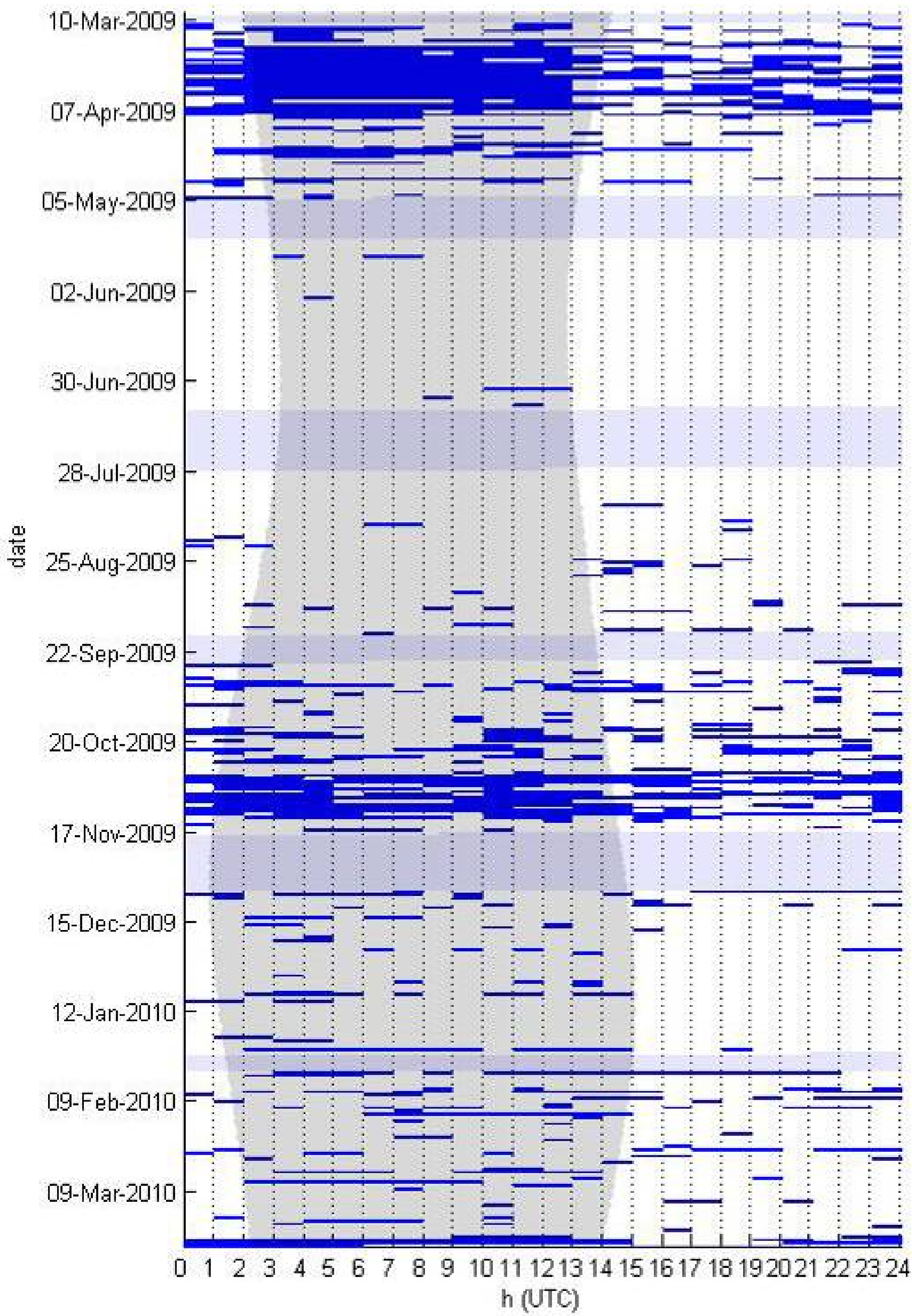
Bryde's Whale – All Call Types in Hourly Bins



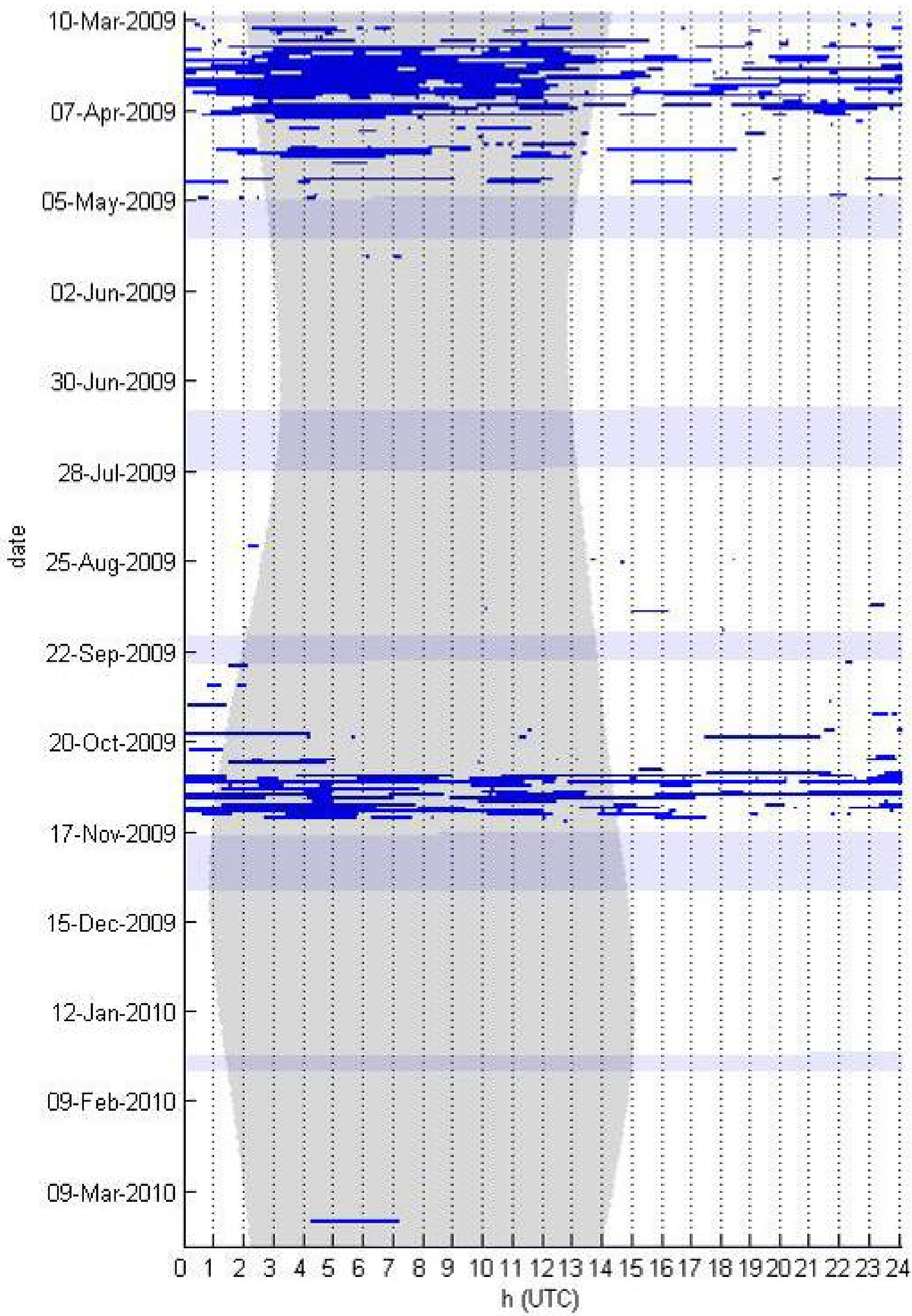
Unidentified Whale - 50 Hz Call in Hourly Bins



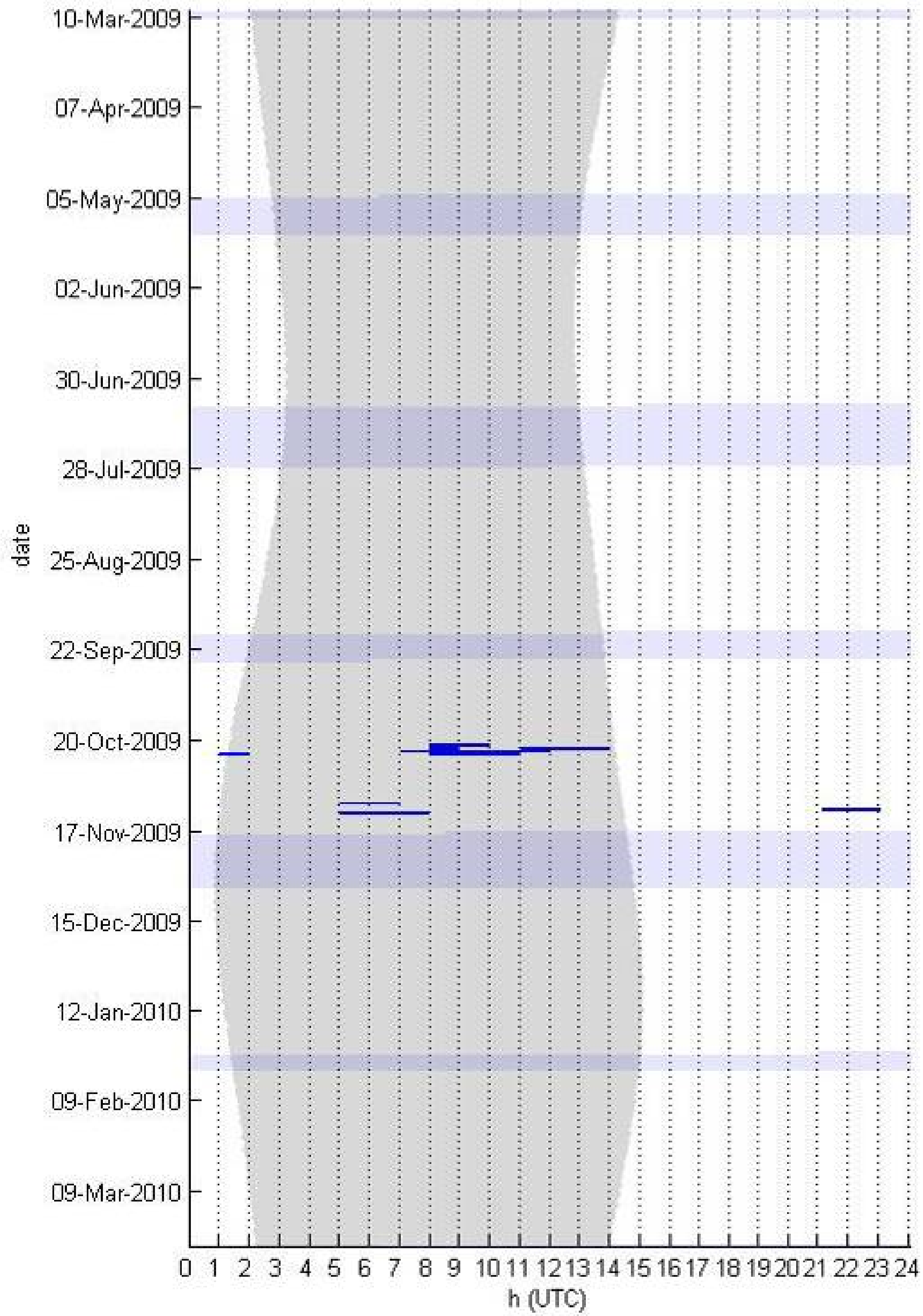
Fin Whale - All Call Types in Hourly Bins



Humpback Whale - All Call Types in Hourly Bins



Humpback Whale - Song in One-Minute Bins



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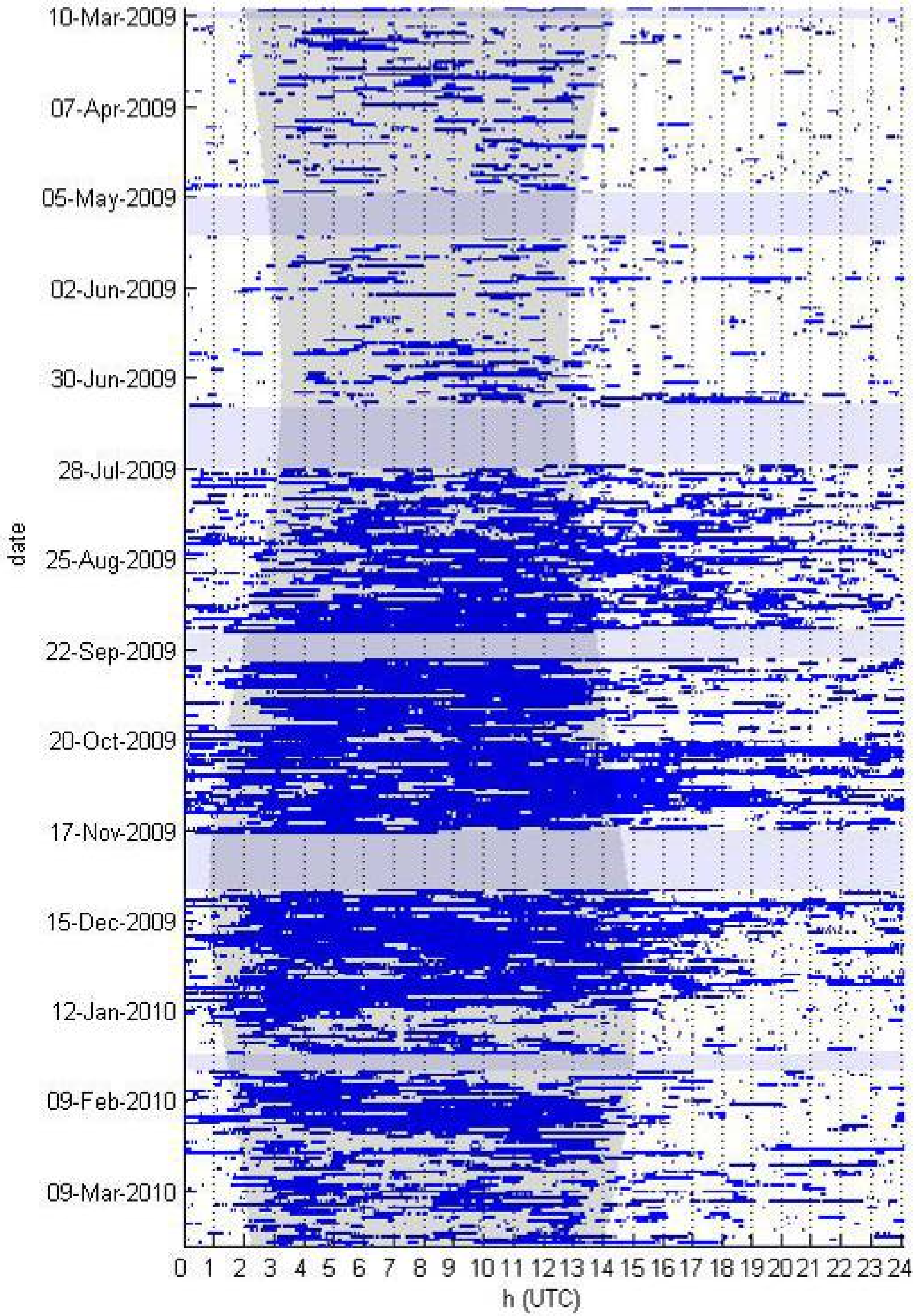
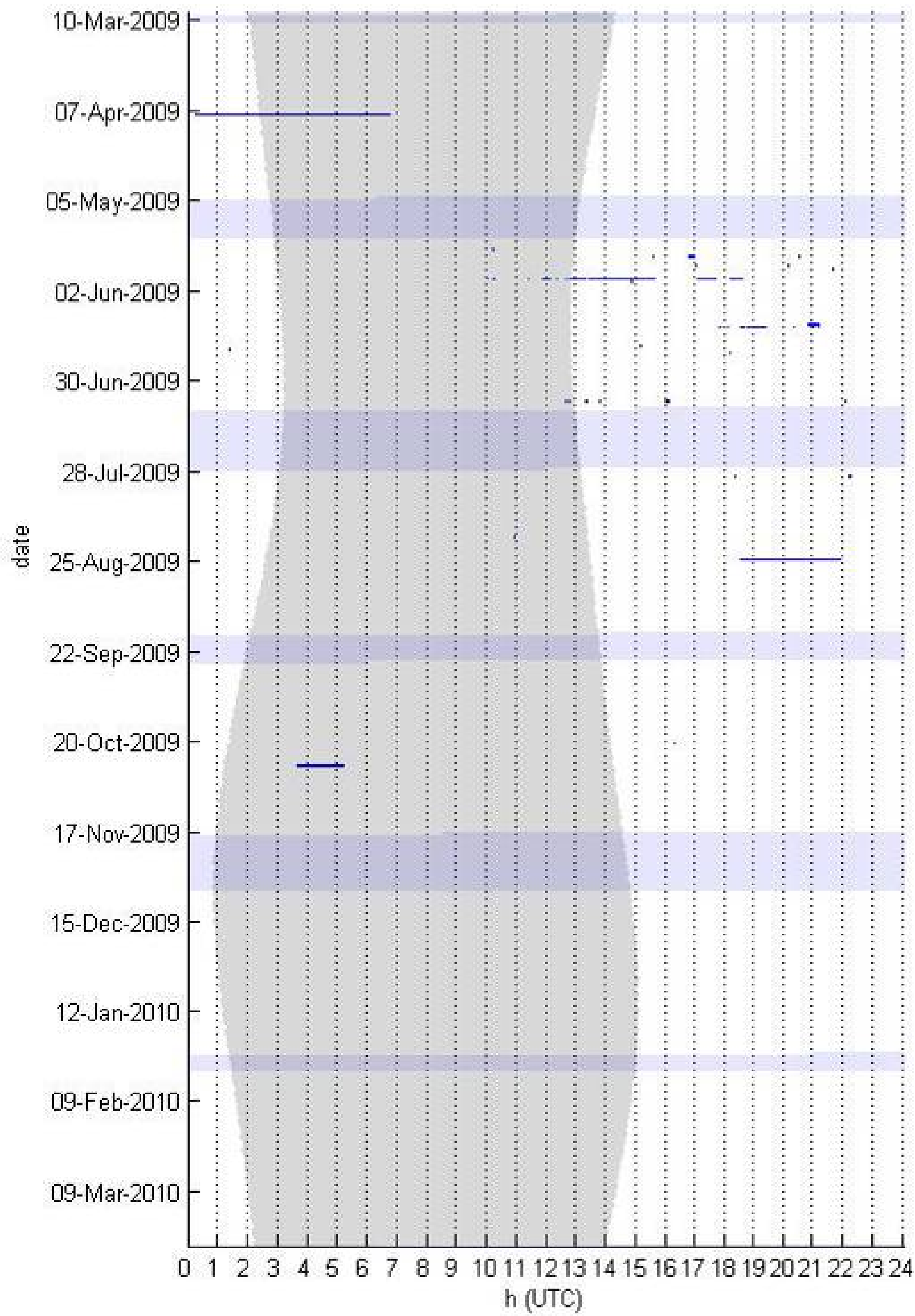
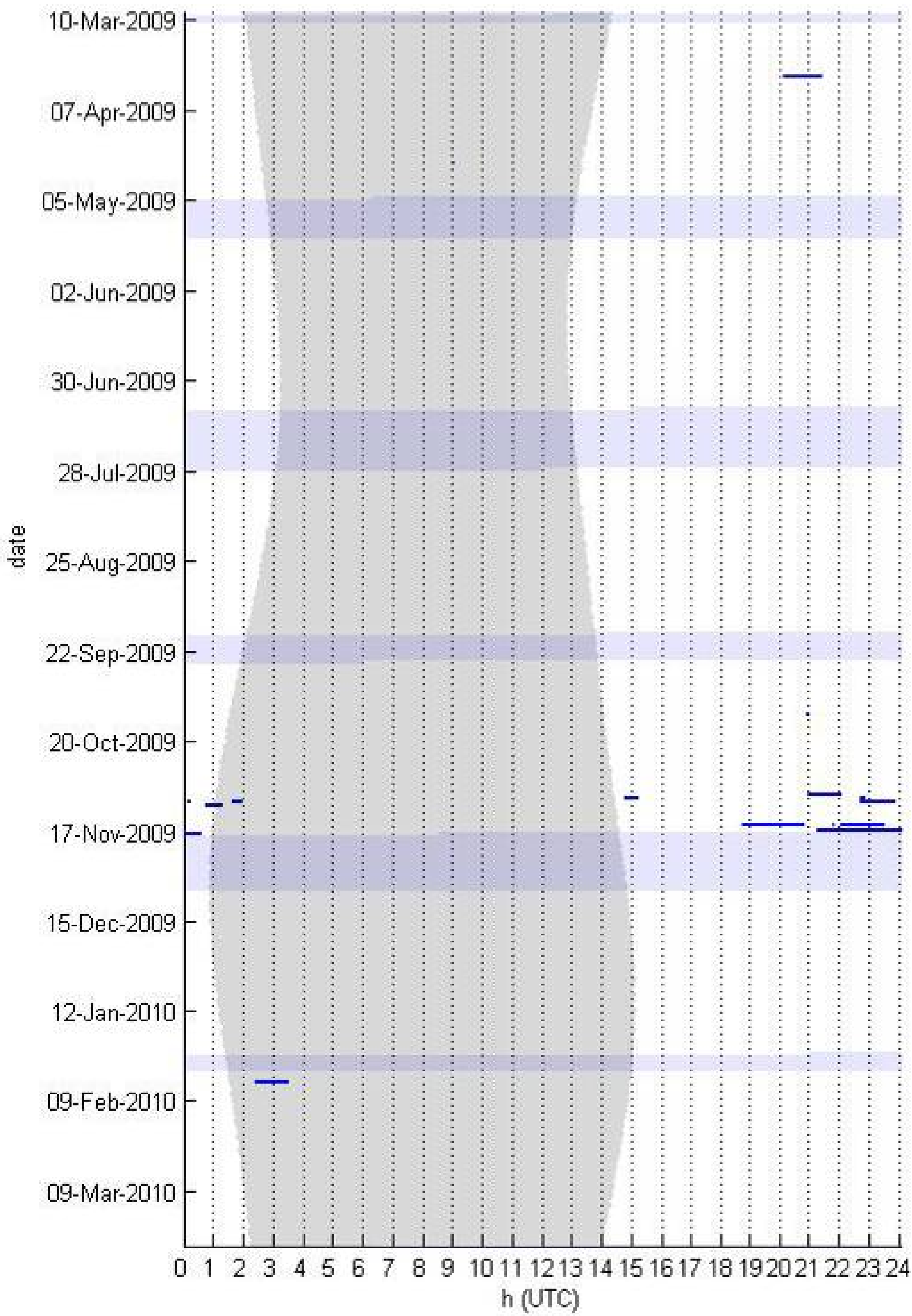


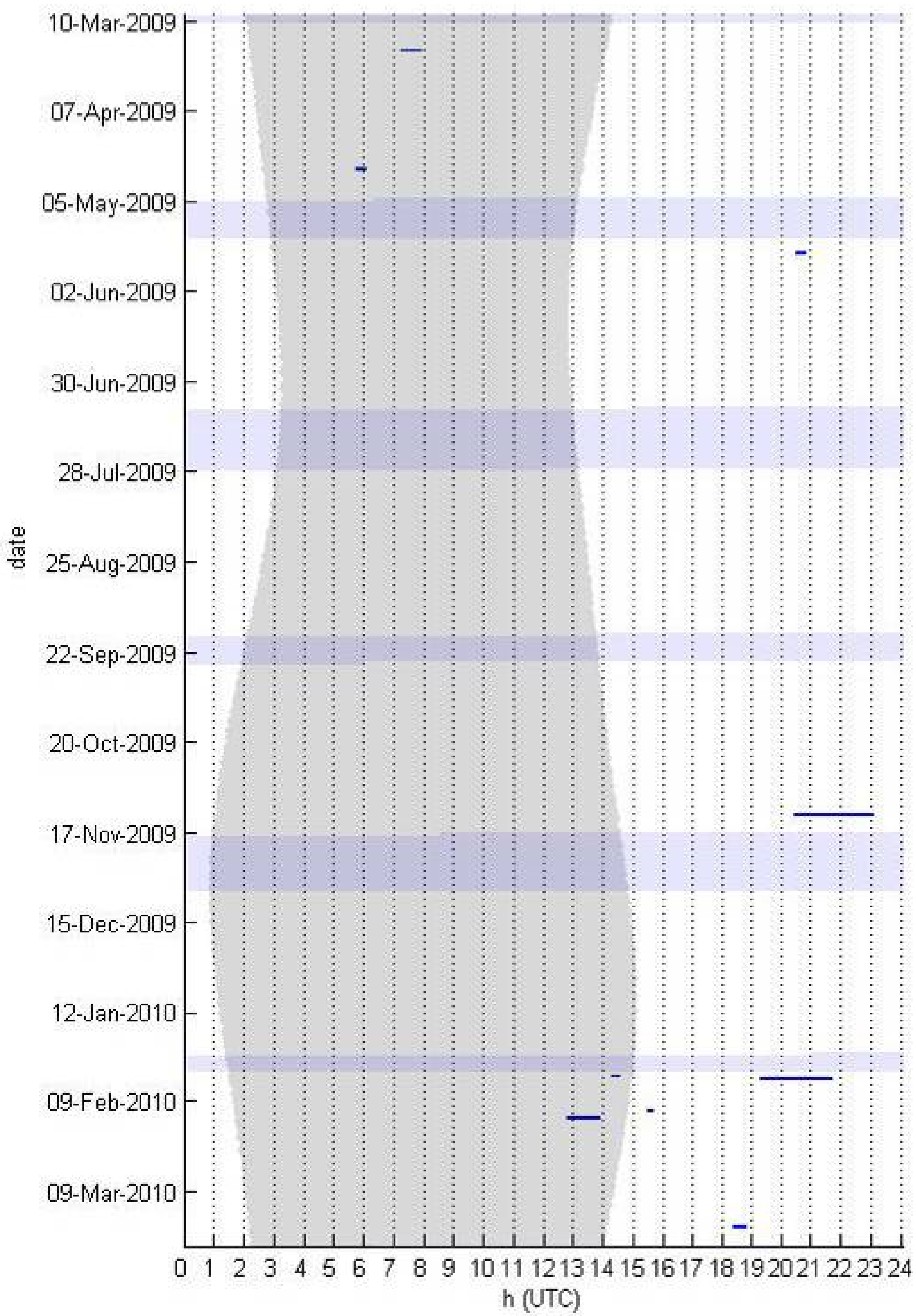
Odontocete - Echolocation Clicks in One-Minute Bins



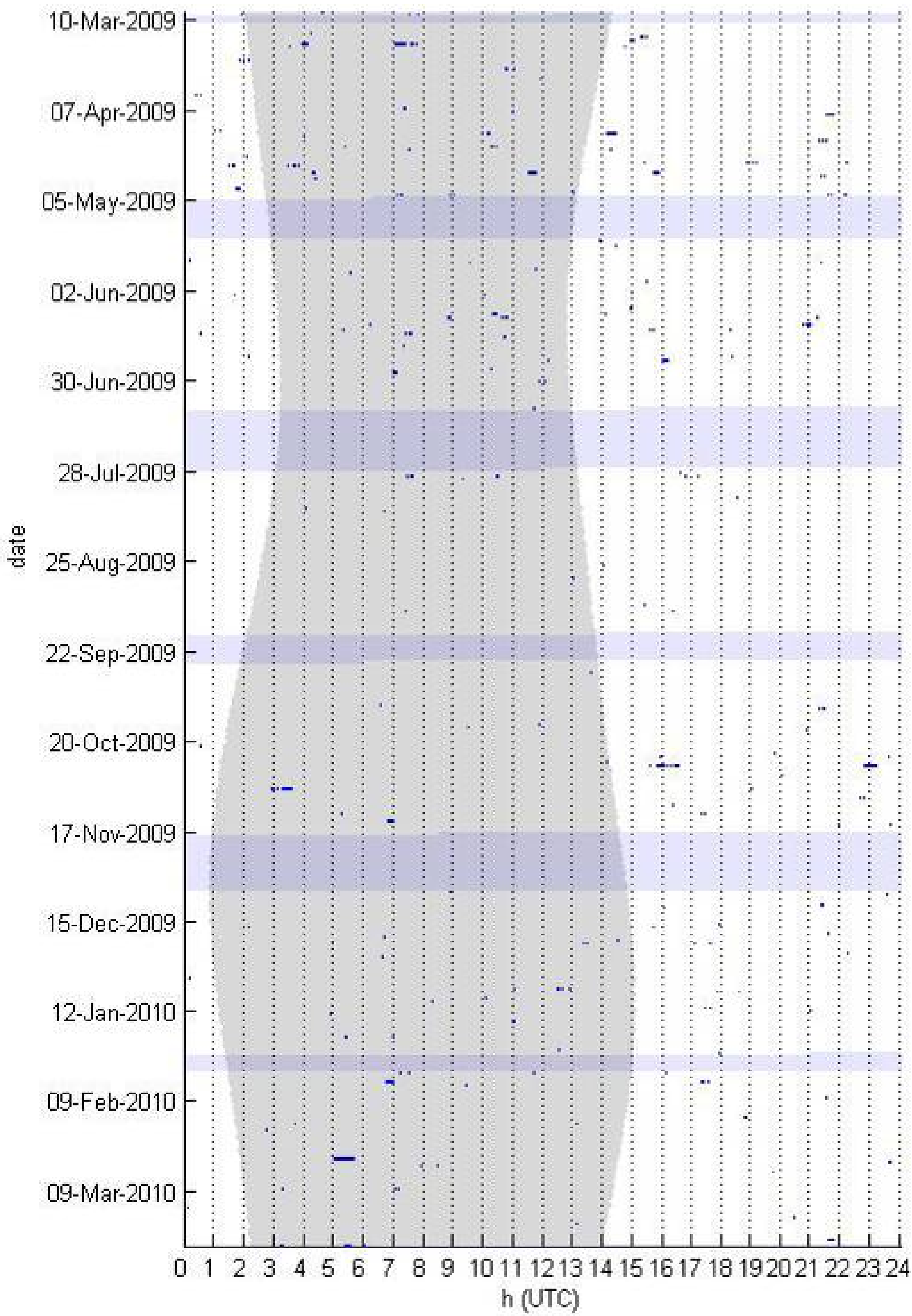
Sperm Whale - Echolocation Clicks in One-Minute Bins



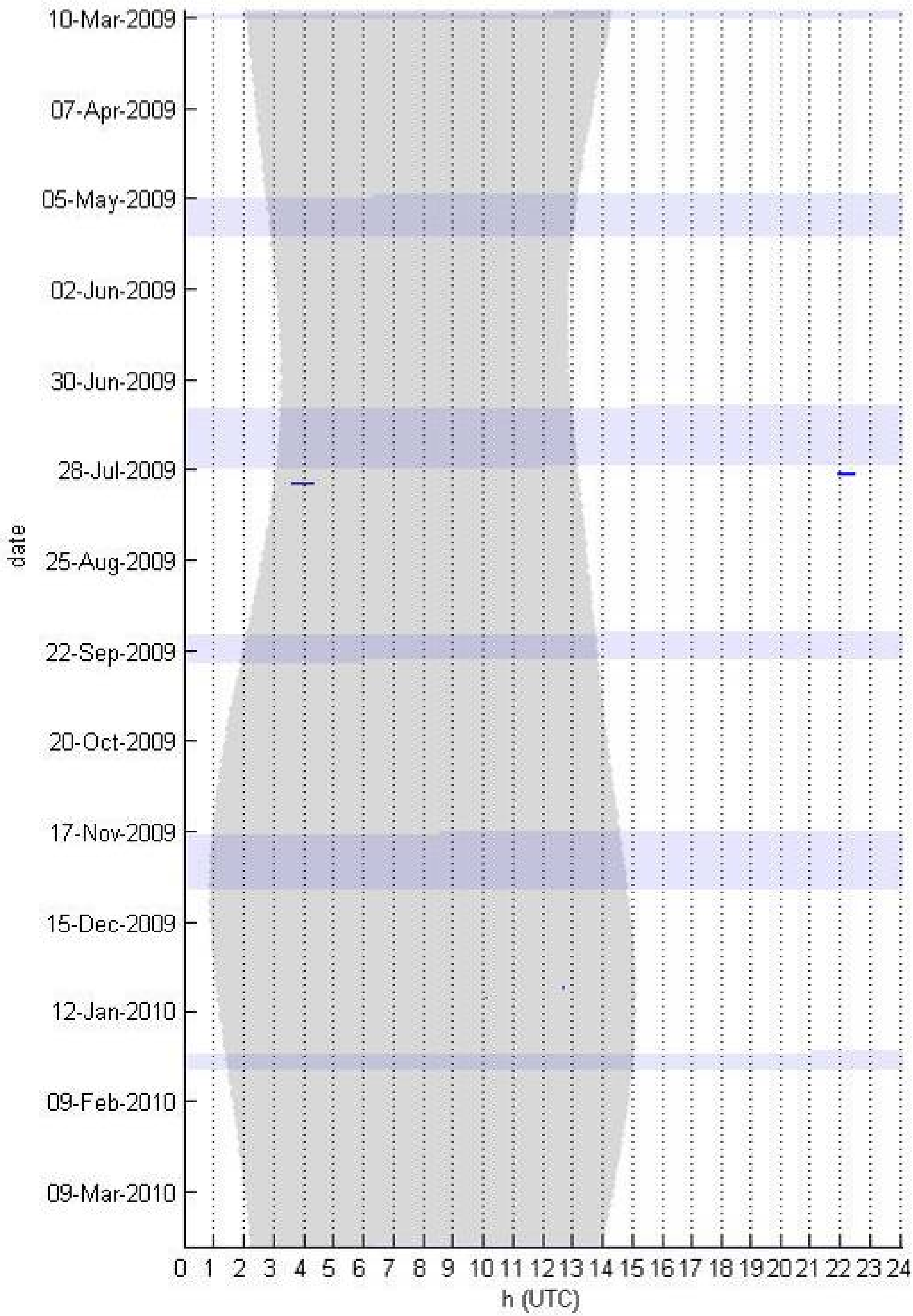
Killer Whale – Whistles and Echolocation Clicks in One-Minute Bins



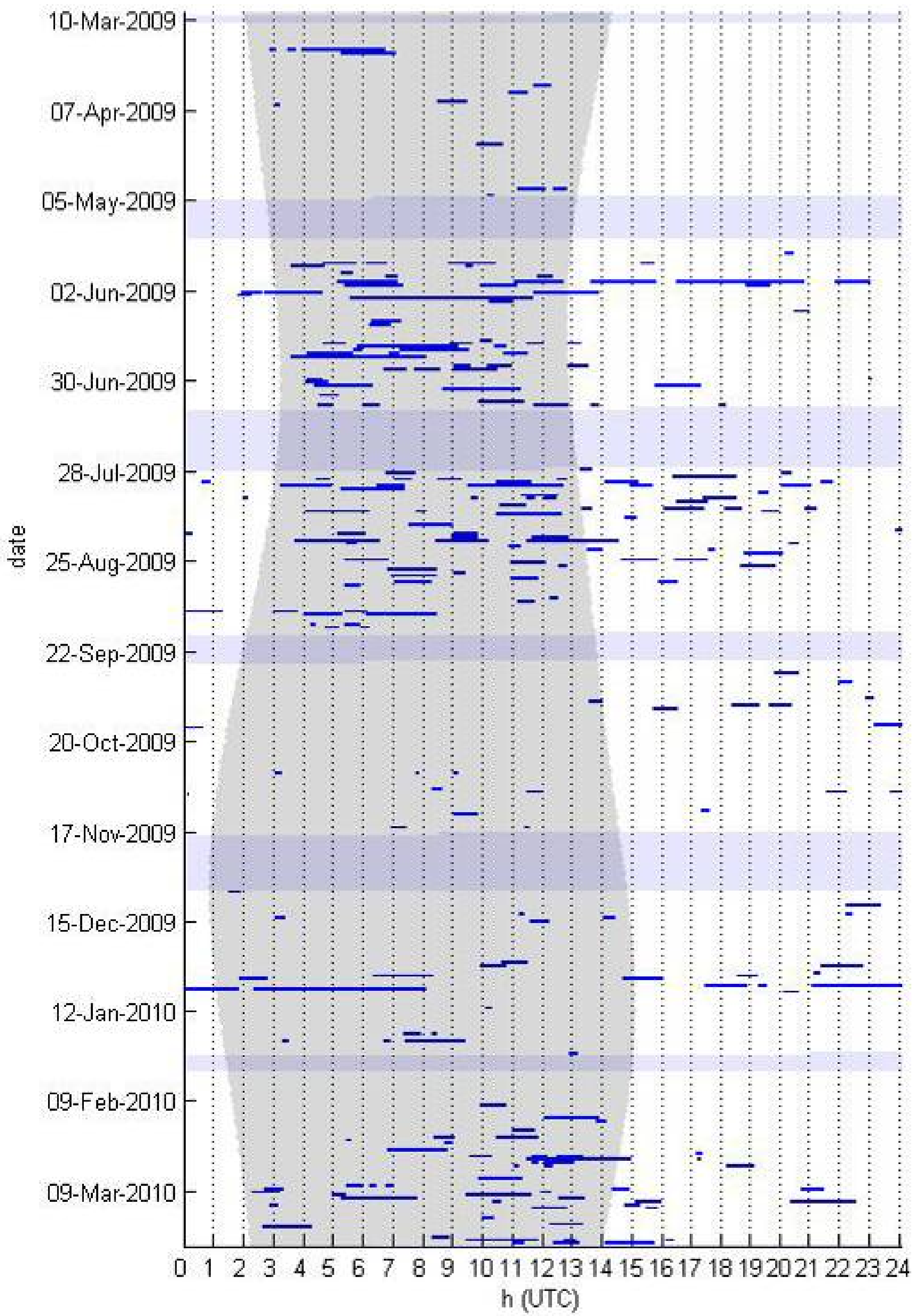
Unidentified Odontocete – Low-Frequency Whistles and Echolocation Clicks in One-Minute Bins



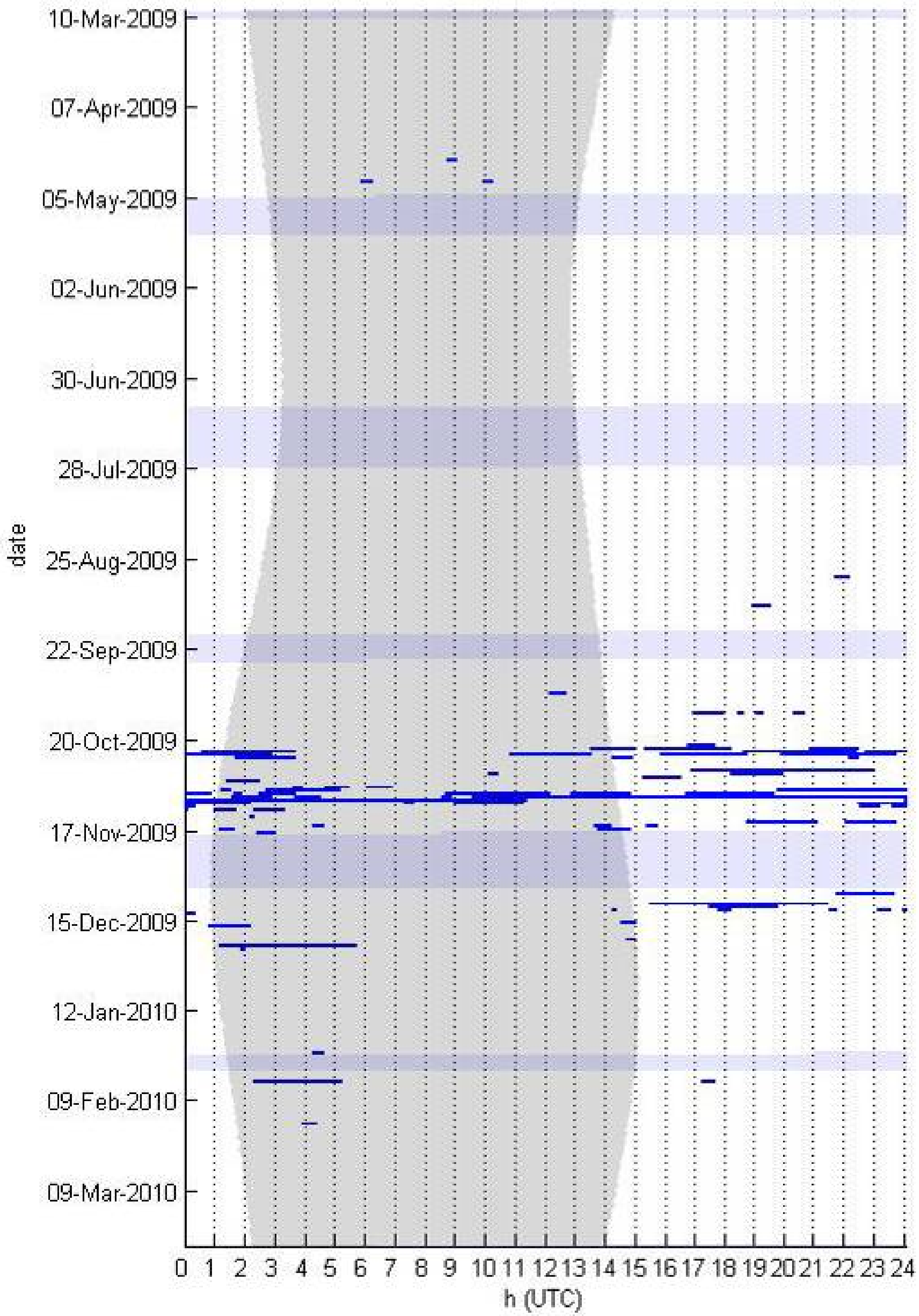
Beaked Whale - Frequency-Modulated Clicks (20 kHz < Peak Frequency < 55 kHz) in One-Minute Bins



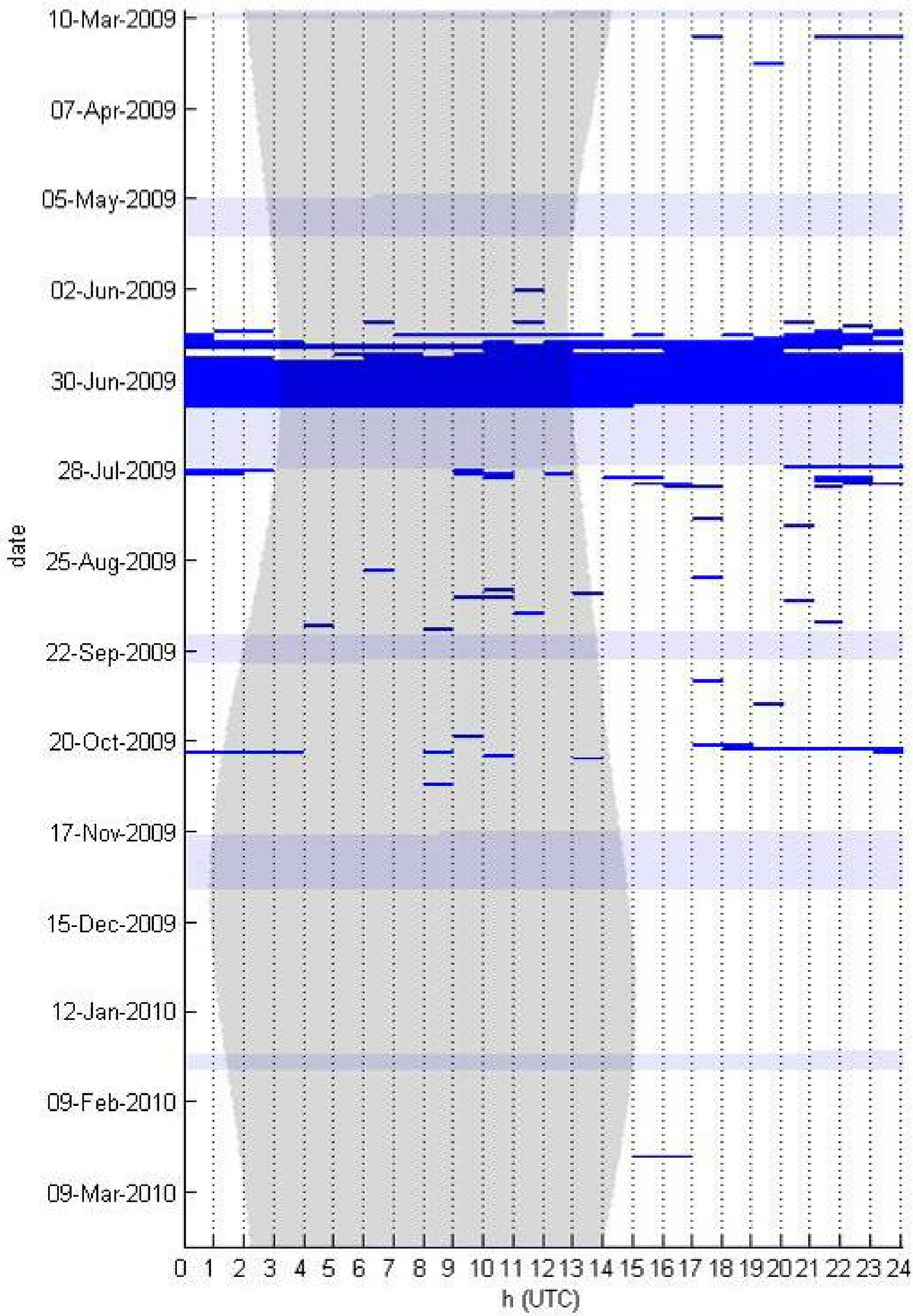
Baird's Beaked Whale – All Call Types in One-Minute Bins



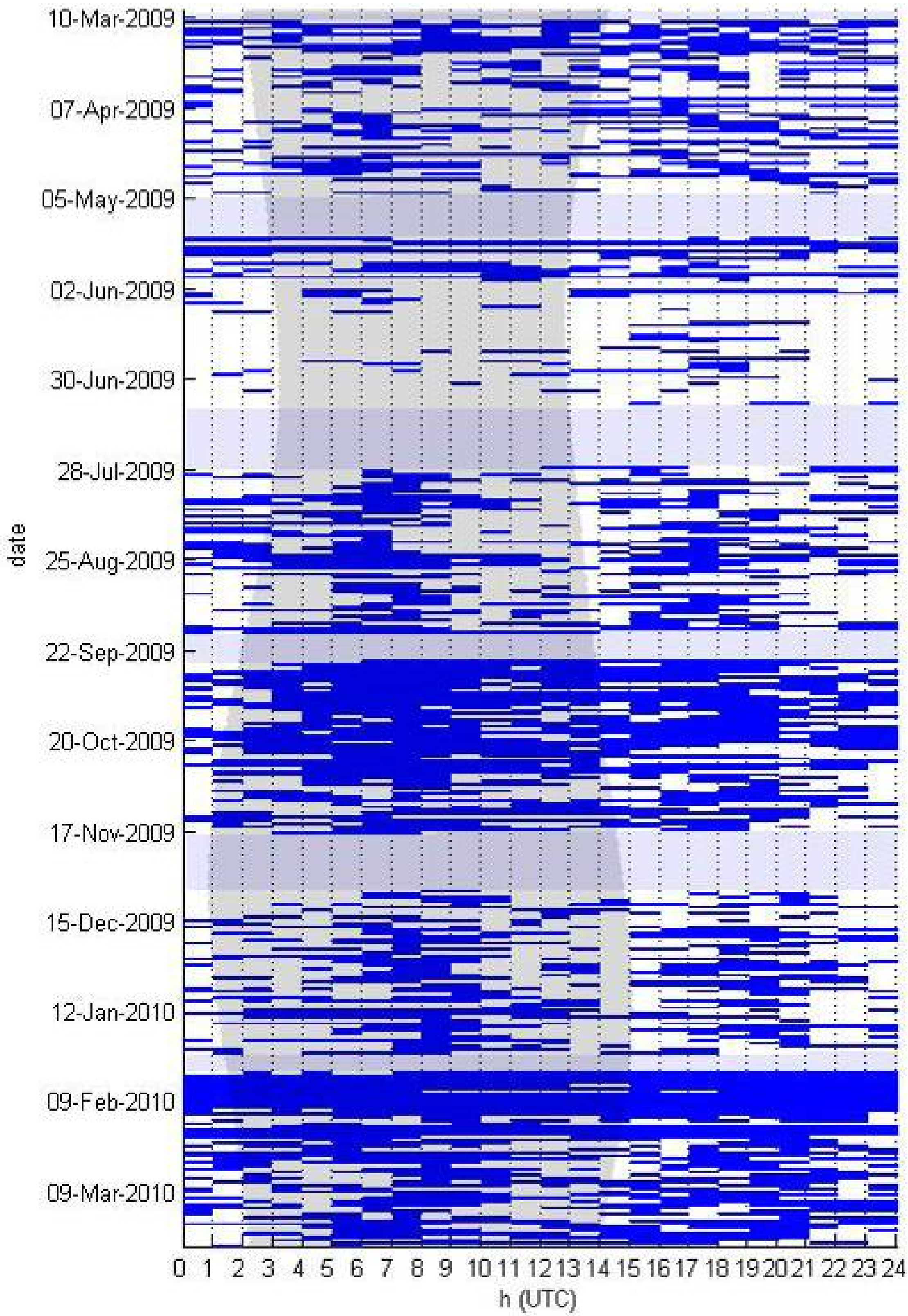
Risso's Dolphin - Echolocation clicks in One-Minute Bins



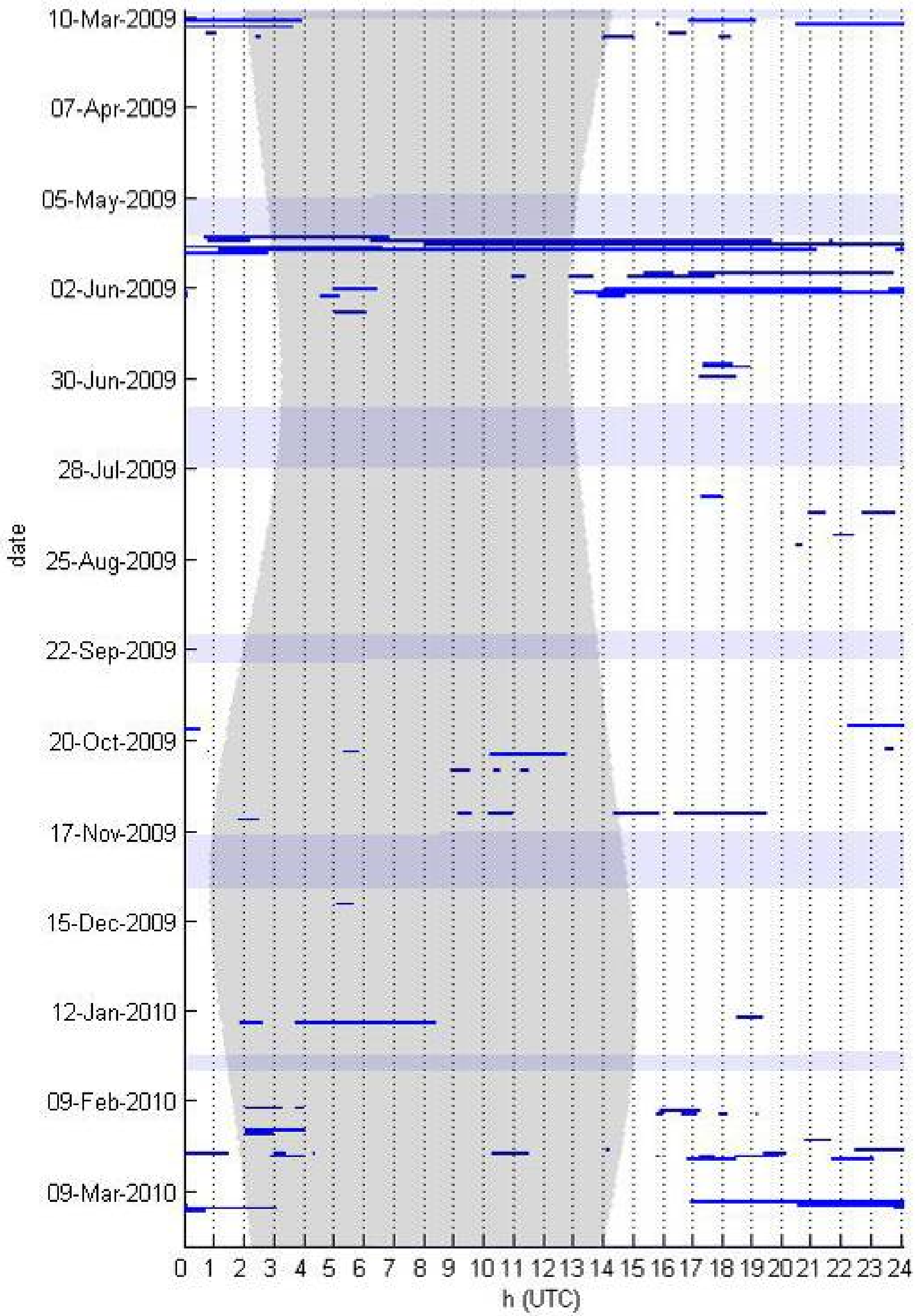
Pacific White-sided Dolphin – All Echolocation Clicks in One-Minute Bins



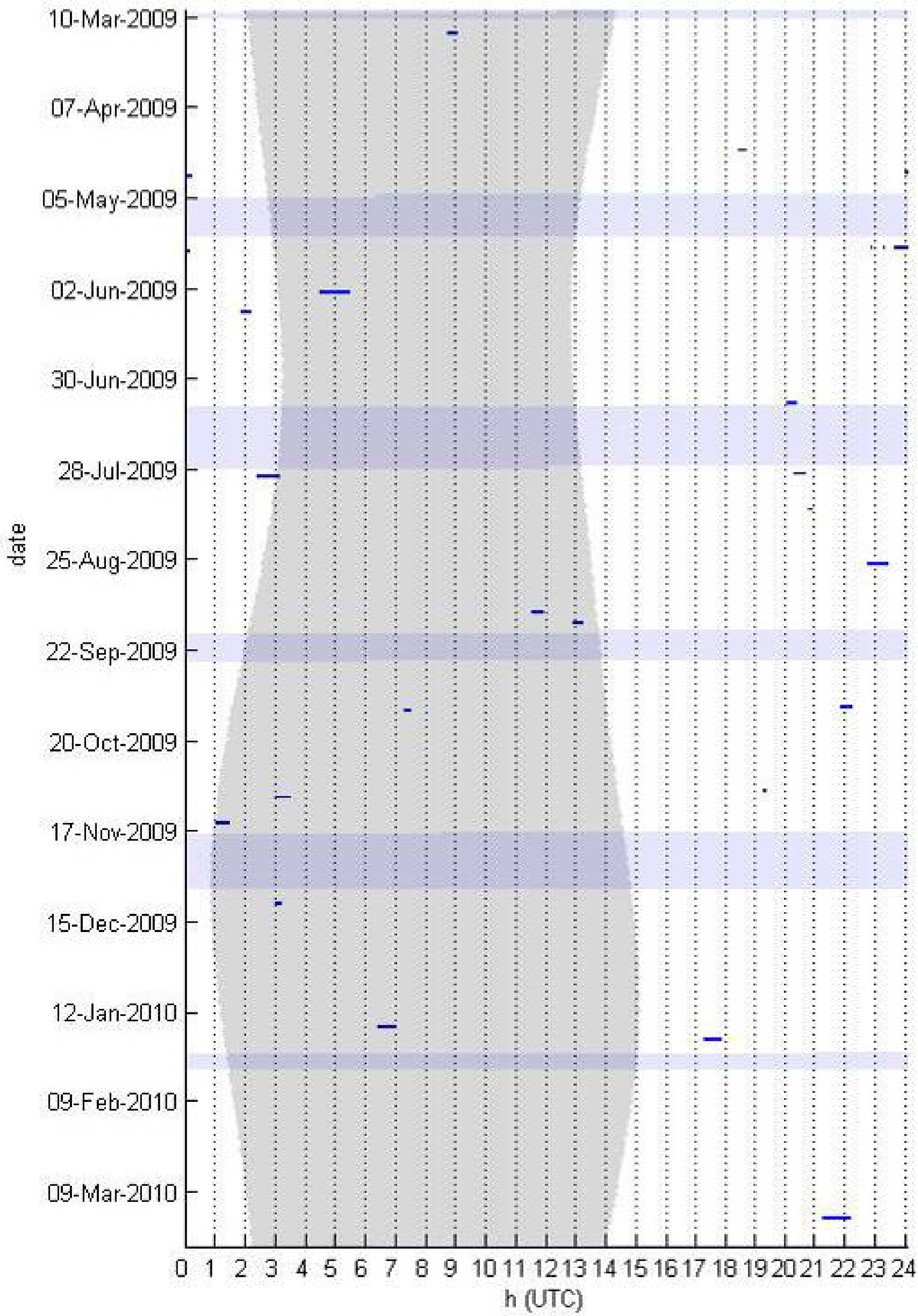
Pinniped - All Call Types in Hourly Bins



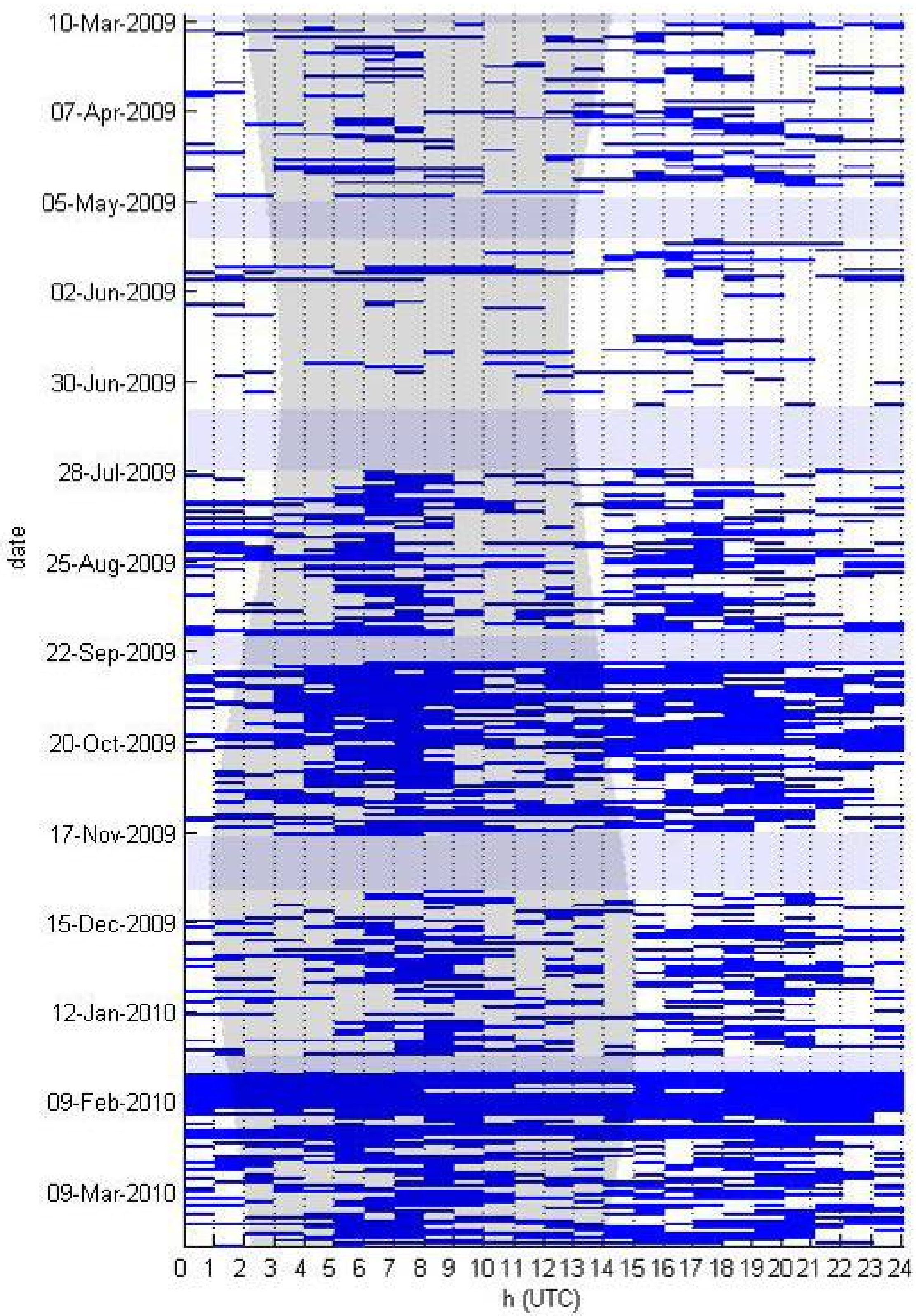
Anthropogenic - All Sound Sources in Hourly Bins



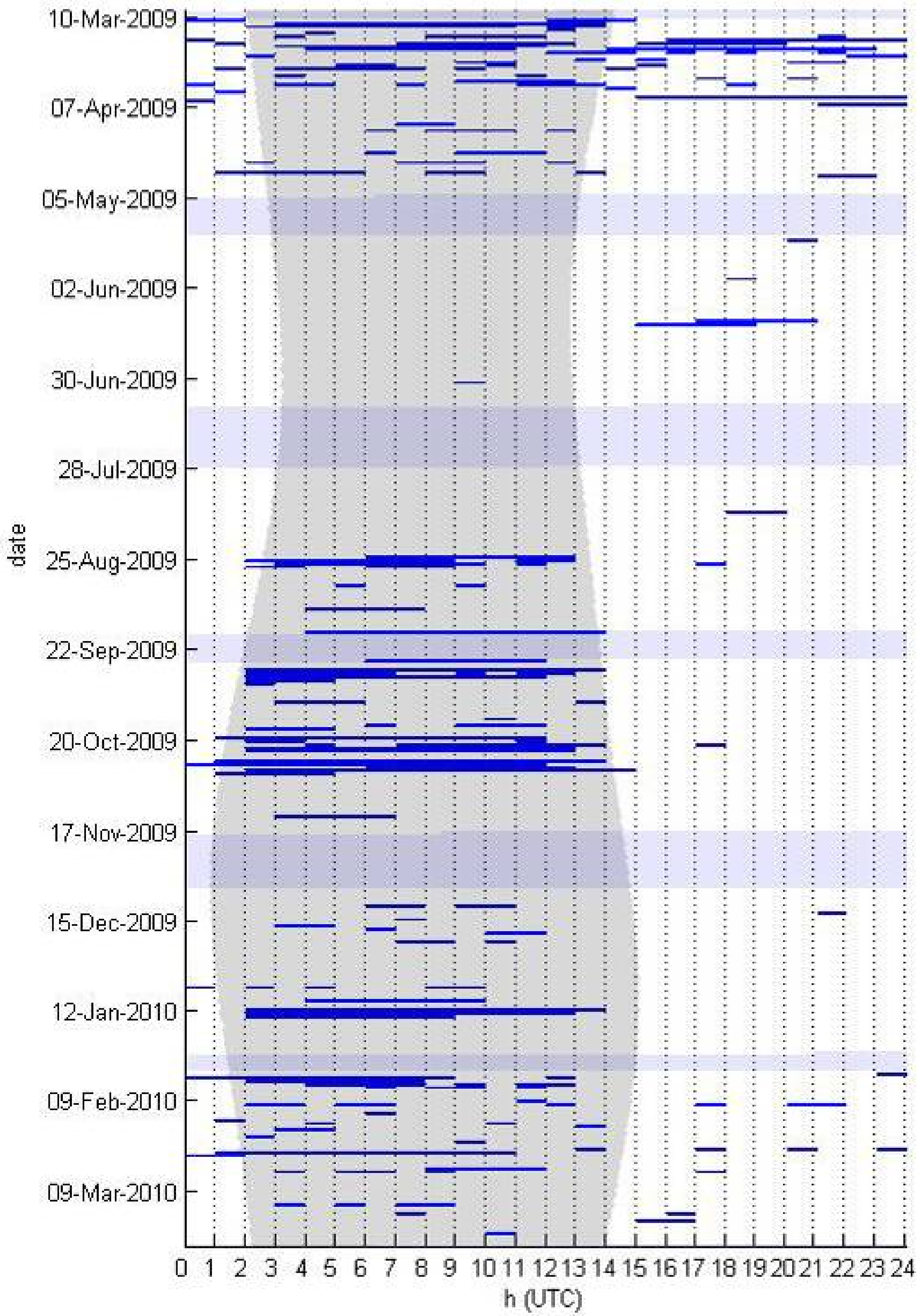
Anthropogenic –Mid-Frequency Active Sonar in One-Minute Bins



Anthropogenic - Echosounder, Various Frequencies, in One-Minute Bins



Anthropogenic - Ship Engine in Hourly Bins



Anthropogenic - Explosion in Hourly Bins

APPENDIX D Navy Research Funded Year 2 Project Reports

- **Scripps Institute of Oceanography small boat based marine mammal surveys in Southern California: Report of Results for August 2009 - July 2010**

- **Scripps Institute of Oceanography marine mammal surveys during California Cooperative Oceanic Fisheries Investigation (CalCOFI) field cruises in Southern California**

- **Cascadia Research Collective small vessel surveys and satellite tagging of marine mammal at SCORE and surrounding areas of Southern California in 2009**

SIO small boat based marine mammal surveys in Southern California: Report of Results for August 2009 - July 2010

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31 August 2010

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 2009 – July 2010. 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 peripheral locations including Catalina Island and the San Diego coastline. This geographically broad approach was designed to increase the effectiveness of our SOCAL 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 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 2009/2010.

METHODS

Survey Effort

SIO small vessel surveys were conducted at San Clemente and Catalina Island from 19-25 November 2009 and 14–24 June 2010. In addition, fourteen surveys were conducted along the San Diego coastline and three surveys were conducted in offshore waters during this same time period. Surveys were conducted from a 6.8 m rigid-hulled inflatable boat (RHIB) equipped with twin outboard engines (R/V Paula Christine). 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 SOAR array (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).

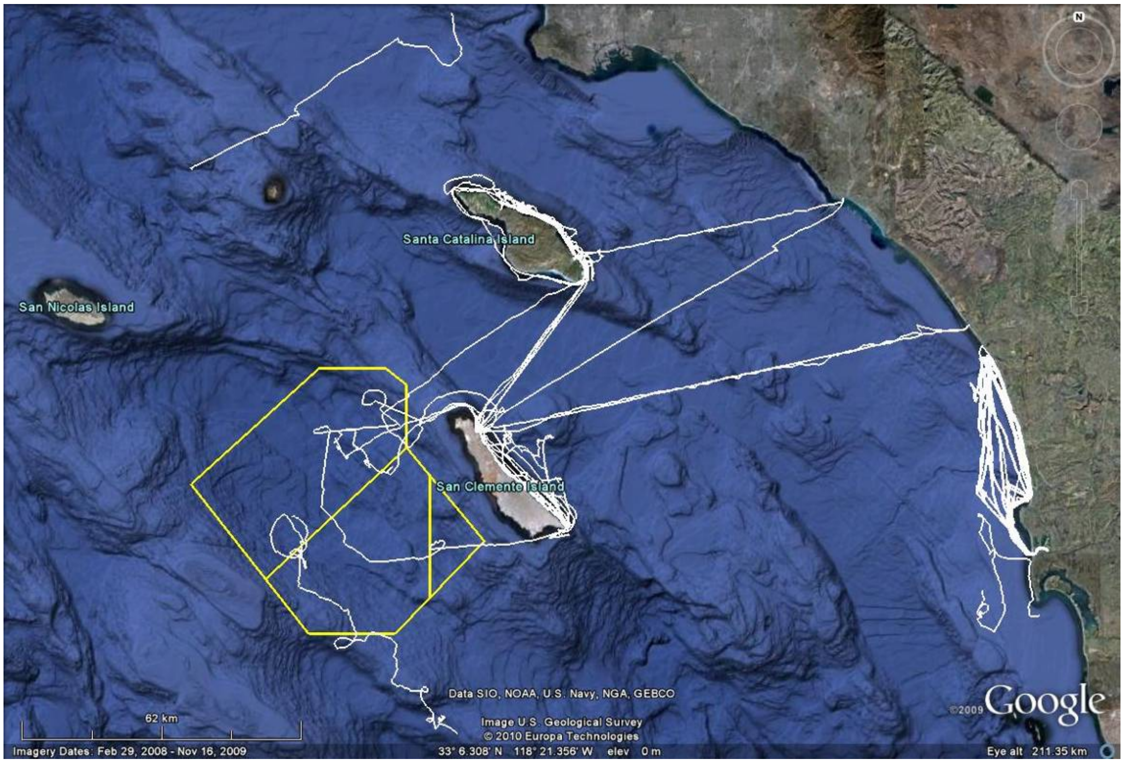

Figure 1. SIO small vessel survey tracks from monitoring at SCORE (boundaries of SOAR range in yellow), Catalina Island and the San Diego coastline from August 2009 – July 2010.

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 D40 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 six 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 briefly 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 2009/2010 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 was assessed from continuous recordings collected at HARP site H simultaneous with small boat surveys at San Clemente Island. MFAS events were 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 were 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 five odontocete and three mysticete species. Bottlenose dolphins were the most commonly sighted species at San Clemente Island and off the San Diego coastline while common dolphins were the most frequently encountered cetacean at Catalina Island. Humpback whales were the least frequently encountered species with only one sighting during the period. Plots of all cetacean sightings documented during the 2009/2010 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 1-4.

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 2.6 km and 9.2 km respectively. One-hundred percent of bottlenose and 66% of Risso's dolphin sightings occurred off the SOAR range with the remaining one sighting of this species occurring on the eastern portion of the range. Sightings of fin whales were made exclusively on the SOAR range. Common dolphins varied in distribution ranging from near-shore waters to offshore waters with a mean sighting distance of 7.6 km from shore.

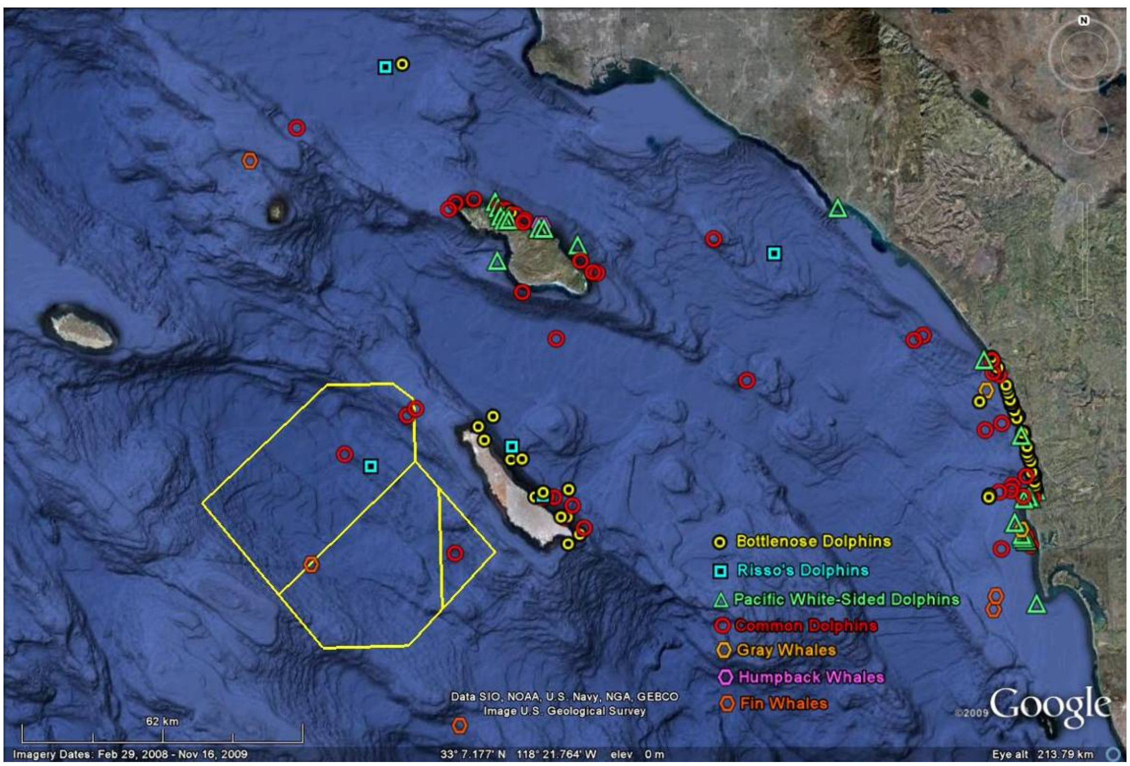

Figure 2. Cetacean sightings documented on all SIO small boat surveys in southern California from August 2009 – July 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected November 19-25, 2009 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	-	-	-	-	-
Risso's Dolphin	1	18	-	-	-
Pacific White-Sided Dolphin	11	91	-	5	1
Short-Beaked Common Dolphin	6	3003	22	3	-
Long-Beaked Common Dolphin	5	2656	94	4	-
Common Dolphin, species unknown	4	433	-	3	-
Fin Whale	-	-	-	-	-
Humpback Whale	1	1	17		
Gray Whale	-	-	-	-	-

Table 2. Summary information on sighting, photo-identification, acoustical and biopsy data collected June 14-24, 2010 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	257	1175	3	22
Risso's Dolphin	4	36	189	1	1
Pacific White-Sided Dolphin	-	-	-	-	-
Short-Beaked Common Dolphin	12	508	28	-	3
Long-Beaked Common Dolphin	1	66	18	-	-
Common Dolphin, Species unknown	-	-	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	-	-	-	-	-

Table 3. Summary information on sighting, photo-identification, acoustical and biopsy data collected August 2009 – July 2010 on fourteen 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	40	273	3948	17	4
Offshore Bottlenose Dolphin	3	128	463	1	3
Risso's Dolphin	1	60	95	-	-
Pacific White-Sided Dolphin	14	151	4	6	1
Short-Beaked Common Dolphin	7	855	17	-	-
Long-Beaked Common Dolphin	3	240	155	-	-
Common Dolphin, Species unknown	-	-	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	2	2	73	-	-

Table 4. Summary information on sighting, photo-identification, acoustical and biopsy data collected 9-11 April 2010 on three surveys in offshore waters of the Southern California Bight.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	1	10	20	-	-
Risso's Dolphin	1	30	13	-	-
Pacific White-Sided Dolphin	1	18	-	-	-
Short-Beaked Common Dolphin	1	523	7	-	-
Long-Beaked Common Dolphin	1	522	13	-	-
Common Dolphin, Species unknown	-	-	-	-	-
Fin Whale	5	9	53	-	1
Humpback Whale	-	-	-	-	-
Gray Whale	-	-	-	-	-

San Diego Coastal Surveys

Between 1 November 2009 and 30 July 2010, a total of fourteen surveys were conducted along the San Diego coastline. Appendix 1 provides survey-specific summaries for each day of effort. 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.

Encounter Rate - San Clemente Island

Comparative analysis of encounter rates between the two survey periods at San Clemente Island is restricted by limited survey effort in November 2009 due to marginal weather conditions. In spite of the limited sample from the November surveys, differences in cetacean occurrence and diversity between the two periods were apparent. The mean number of delphinid groups encountered per survey off San Clemente Island in June 2010 ($\bar{x}$ = 3.8) was nearly four times higher than the mean number of delphinid groups sighted per survey in November 2009 ($\bar{x}$ = 1.0) (Tables 5 and 6). Species diversity was also low during November 2009 as common dolphins were the only species sighted in the study area. In contrast, the June 2010 field effort documented four of the five delphinid species common to the waters around San Clemente Island, including bottlenose, Risso's, short-beaked and long-beaked common dolphins.

Table 5. Survey effort and encounter rate for 5 commonly encountered delphinid species off San Clemente Island, California 20 November, 2009.

Species	Study Period	Number of Survey Days	Number of Survey Hours	Number of Groups	Mean Groups per Survey	Groups per Hour
Delphinids (overall)	**Nov-09**	**1**	**9.3**	1	**1.0**	**0.11**
Bottlenose Dolphin				0	0.0	0.00
Risso's Dolphin				0	0.0	0.00
Pacific White-Sided Dolphin				0	0.0	0.00
Short-Beaked Common Dolphin				1	1.0	0.11
Long-Beaked Common Dolphin				0	0.0	0.00
Common Dolphin Species				0	0.0	0.00

Table 6. Survey effort and encounter rate for 5 commonly encountered delphinid species off San Clemente Island, California 16 – 24 June, 2010.

Species	Study Period	Number of Survey Days	Number of Survey Hours	Number of Groups	Mean Groups per Survey	Groups per Hour
Delphinids (overall)	**Jun-10**	**8**	**60.3**	30	**3.8**	**0.50**
Bottlenose Dolphin				13	1.6	0.22
Risso's Dolphin				4	0.5	0.07
Pacific White-Sided Dolphin				0	0.0	0.00
Short-Beaked Common Dolphin				12	1.5	0.20
Long-Beaked Common Dolphin				1	0.1	0.02
Common Dolphin Species				0	0.0	0.00

To further assess the differences in encounter rates observed between the November 2009 and June 2010 survey periods, we examined the occurrence of MFAS in the basins around San Clemente Island. HARP acoustical recordings, collected at site H on the western edge of the SOAR range (Figure 3) during 2009 and 2010, were manually reviewed and all MFAS events were documented. MFAS occurred for 1 – 17 hours on each of seven days immediately prior to the November 2009 survey period (Figure 4). An assessment of MFAS activity during the June 2010 period is pending as these data are currently being processed in preparation for analysis.

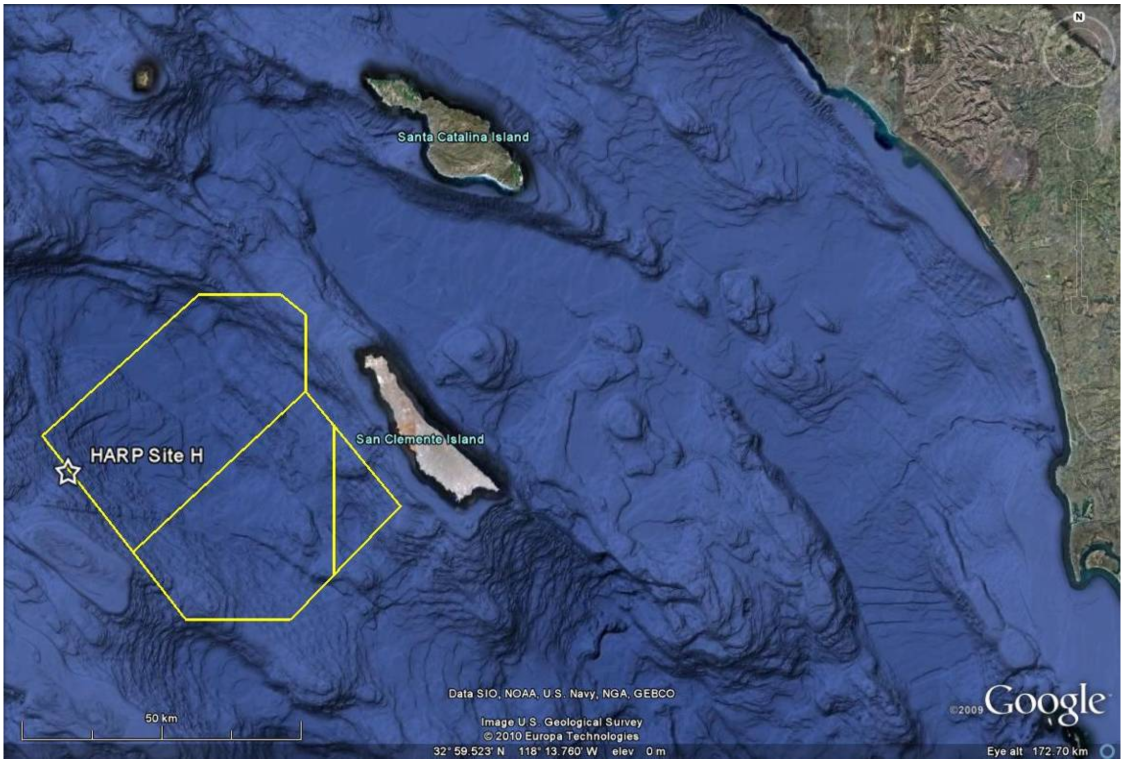

Figure 3. Location of HARP site H, west of the SOAR range off San Clemente Island (boundaries of SOAR range in yellow).

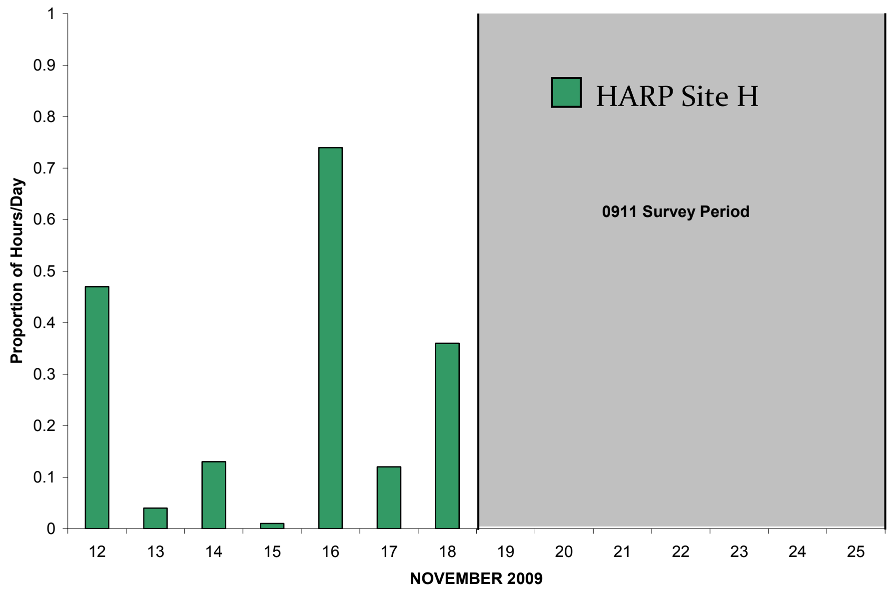

Figure 4. MFAS occurrence in proportion of hours per day from HARP site H from 12 to 25 November, 2009. Grey area represents period of no HARP data collection.

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 clearly 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 provide needed data gaps in our understanding of bottlenose dolphin population structure off southern California.

Analysis of the combined SIO/SWFSC and Cascadia Research Collective bottlenose dolphin photographic database from 2006-2009 was recently completed, resulting in a catalog of 318 distinctive individuals from San Clemente Island and 53 individuals from Catalina Island. Photo-identification analysis indicated variable levels of intra- and inter-annual site fidelity to the San Clemente Island study area as well as movement between the two island sites. Mark-recapture abundance estimation models will be applied to the database in an exploratory manner with application planned after completion of the 2010 field season. Details on the results of our analyses through May 2010 are provided below.

Rate of discovery

The rate at which individual dolphins were identified off San Clemente Island from 2006-2009 was examined across surveys in which at least one dolphin was photographically identified (n=23 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 across the four-year study period. While the consistent positive slope in the curve indicates that the population is larger than the current sample, photo-identification data collected from 2006-2009 indicates that 13% (n = 41) of the 318 individuals identified have been sighted in two or more of the four study years. Based on this trend, we expect the overall proportion of previously identified individuals to increase with additional surveys at San Clemente Island.

The rate at which individual dolphins were identified off Catalina Island from 2006-2009 was examined across surveys in which at least one dolphin was photographically identified (n = 4 surveys, Figure 6). The rate of discovery curve indicates that new individuals were exclusively documented across the three-year period. The consistent positive slope combined with no re-sightings of the 53 identified individuals indicates that the population is larger than the current sample and dedicated surveys at Catalina Island are needed to provide more comprehensive coverage of bottlenose dolphins occurring at this site.

Sighting frequency and site fidelity

Sighting frequencies for the 318 dolphins identified at San Clemente Island from 2006-2009 ranged from 1-6 ($\overline{x}$ = 1.4, SD = 0.8). Seventy-two percent (n = 228) of the dolphins were photographed once, 19% (n = 60) two times, 7% (n = 21) three times and 3% (n = 9) four or more times.

Re-sightings of the same individuals within one survey period (8-14 days) were frequent, indicating short-term site fidelity to the area. The number of study years in which identified dolphins were photographed (annual sighting frequency) averaged 1.2 yr (SD = 0.4, range = 1–3). Eighty-seven percent (n = 277) of the identified population was photographed during only one year, 12% (n = 37) was observed during two years, and 1% (n = 4) was sighted during three years (Figure 7). None of the identified individuals were sighted during all four study years; 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 four years.

Inter-Island Movement patterns

Photographic comparisons of 53 dolphins identified from 2006-2009 at Catalina Island with the 318 animals documented at SCI from 2006-2009 resulted in five individuals being identified in both study areas (Figure 8). Sighting intervals for the five inter-island identifications averaged 199 days (SD = 151, range = 5–355), demonstrating movement between the islands over relatively short time periods. These data represent the first photographically documented movement of bottlenose dolphins between Catalina Island and San Clemente Island.

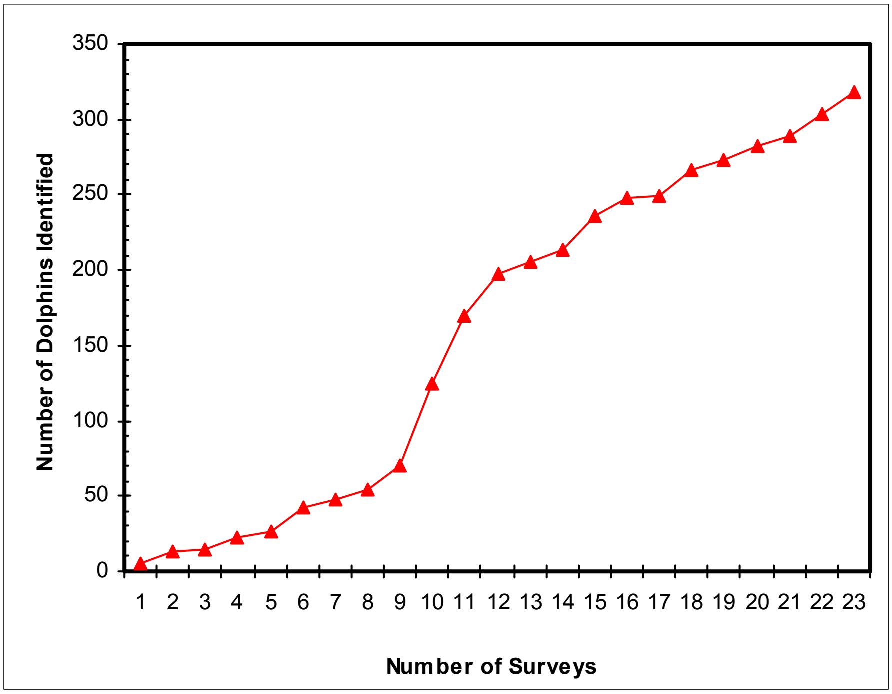

Figure 5. Cumulative number of bottlenose dolphins photo-identified at San Clemente Island over surveys in which at least one dolphin was identified. N = 318 individuals.

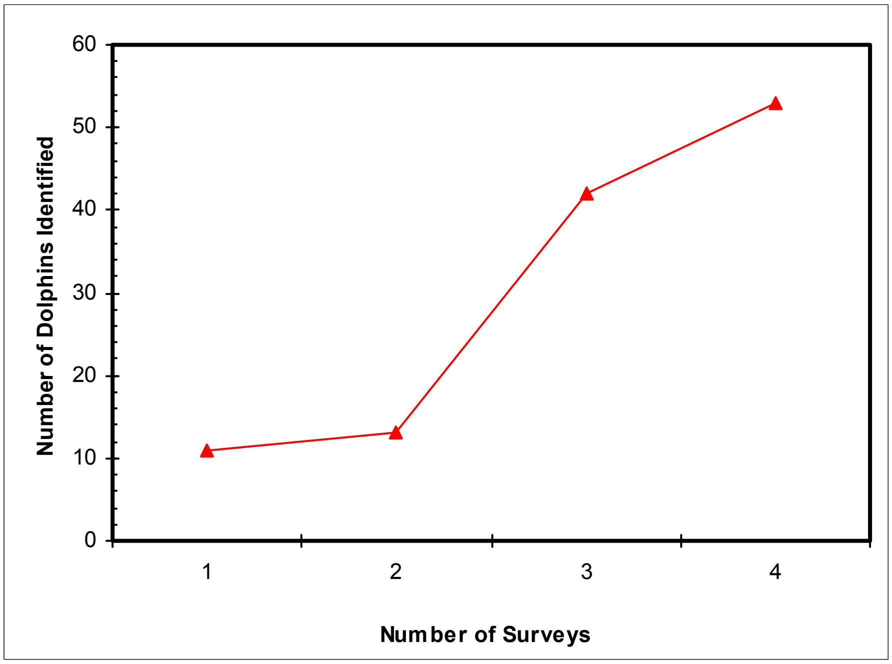

Figure 6. Cumulative number of dolphins photo-identified at Catalina Island over surveys in which at least one dolphin was identified. N = 53 individuals.

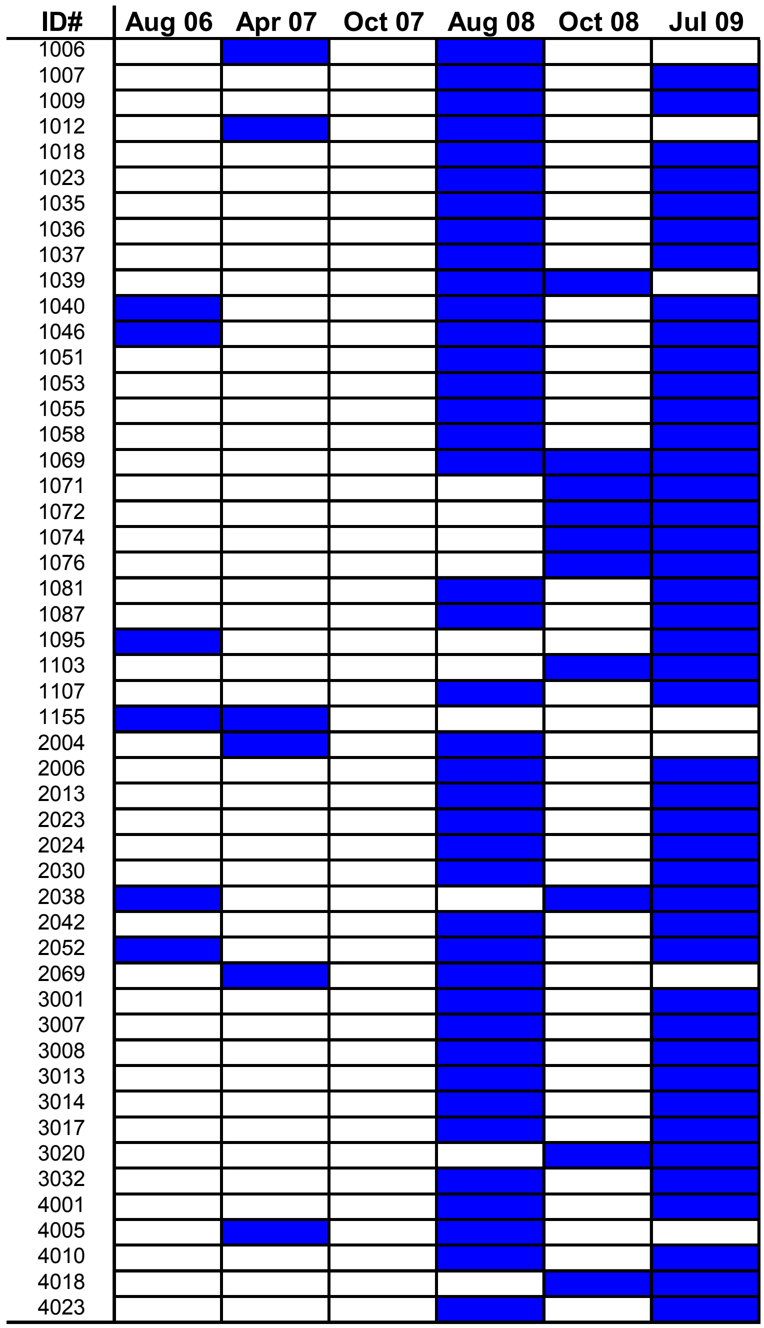

Figure 7. Sighting matrix for the fifty bottlenose dolphins photographically identified during two or more survey periods at San Clemente Island from August 2006 to July 2009.

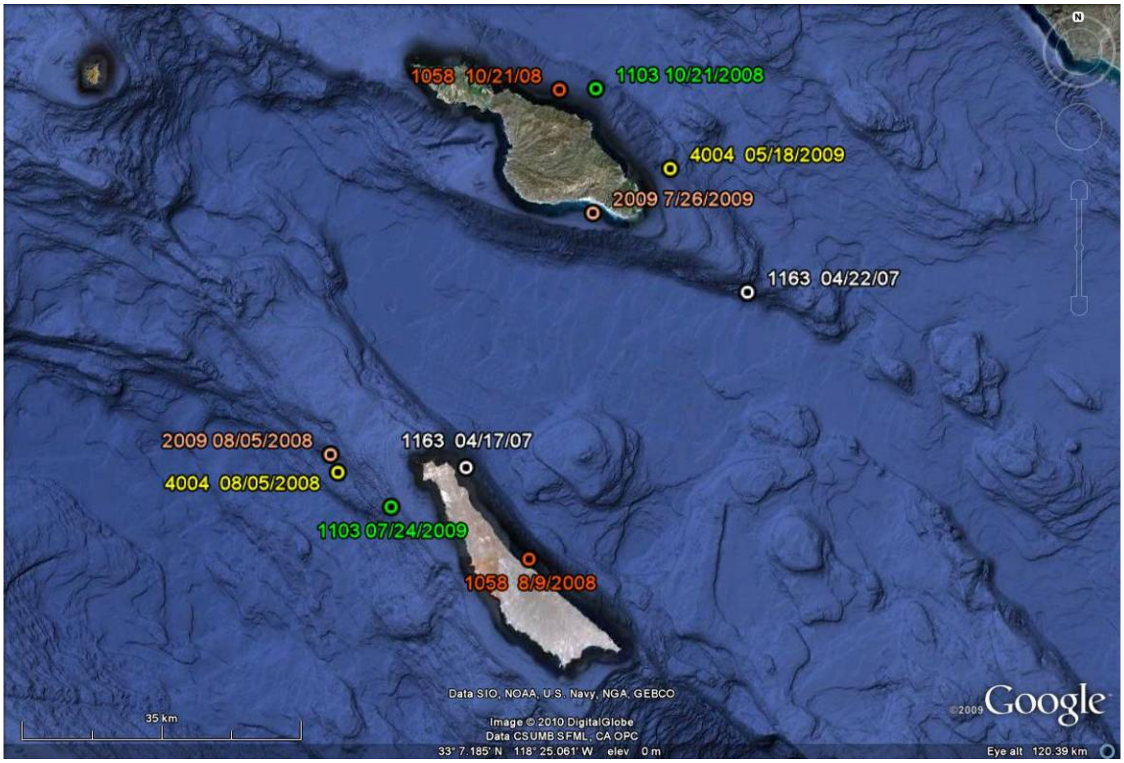

Figure 8. Sighting locations, ID codes and dates for the five photo-identified individual bottlenose dolphins documented off both San Clemente and Catalina Islands.

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 2010 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 planned surveys in 2011 at San Clemente and Catalina Island as well as off the San Diego coastline will be analyzed by Nick Kellar and colleagues at SWFSC for glucocorticoids (GC) concentrations.

As part of the cortisol analysis, we have been validating our protocol to measure the hormone from cetacean blubber. Using bowhead whales (killed by native hunters in Alaska) as voucher specimens, in which we know many aspects of life-history and physiological condition of each individual including the serum concentrations of cortisol, we have measured blubber cortisol levels in 104 animals. The mean (SE) measured blubber cortisol value was 536 (± 86.8) pg/g and we find a significant relationship between blubber and serum cortisol levels with $R2 = 0.2245$ (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 of if insular (i.e. island associated) population segments exist and if so, can they be genetically differentiated from pelagic and coastal forms of the species.

Pacific White-Sided Dolphin Biopsy and Acoustical Sampling

Genetic and morphometric 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 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 were collected during the 2009/2010 field season. 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.

Acoustical Recordings

Acoustical recordings collected from October 2008 to July 2010 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 2009/2010 field season encompassed five odontocete and three mysticete species. Bottlenose dolphins were the most commonly sighted species at San Clemente Island and off the San Diego coastline while common dolphins were the most frequently encountered cetacean at Catalina 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 66% of Risso's dolphin sightings occurred off the SOAR range with the remaining one sighting of this species occurring on the eastern portion of the range. Sightings of fin whales around San Clemente Island were made exclusively on the SOAR range.

Encounter Rate

Encounter rates for all delphinid species were higher during the June 2010 versus November 2009 survey periods with an approximately four-fold increase in schools encountered per survey and per hour of effort. While field effort in November was limited to one survey, the variable encounter rates and species diversity relative to MFAS trials observed during the current period are consistent with similar observations from the 2008/2009 field season at San Clemente Island. Encounter rates for all delphinid species were significantly higher during the August 2008 versus October 2008 survey periods with an approximately four-fold increase in schools encountered per survey and per hour of effort. In addition, species diversity was low during the October 2008 survey period with sightings limited to several schools of common dolphins, one school of bottlenose dolphins and no sightings of Risso's or Pacific white-sided dolphins. During the August survey period, no MFAS signals were detected in the region, whereas during the October survey period, MFAS signals were present for a total of 44 hours across six days (Campbell *et al.* 2010).

Information on seasonal distribution and abundance of the five delphinid species encountered in the San Clemente Island study area was examined to determine if seasonal movement patterns may be a potential explanation for the observed variation in delphinid encounter rates and diversity between survey periods.

Aerial surveys of marine mammals conducted around San Clemente Island and surrounding waters during 1998-1999 provide one index of seasonal occurrence patterns for delphinids common to the region (Caretta *et al.* 2000). Short-beaked common dolphins occurred year-round and were the most abundant marine mammal in the study area. Common dolphin abundance was 2.5 times greater during the warm-water months of May through October than during the cold-water months of November through April; however, this was attributed to smaller group sizes versus fewer groups overall. Pacific white-sided dolphins were present only during the cold-water months of November-April. Risso's dolphins were present year round but their abundance was three times higher during cold-water months than during warm-water months. Bottlenose dolphins, the least abundant delphinid species in the study area, were present in approximately equal numbers year-round off San Clemente Island.

Larger scale aerial and shipboard assessments of delphinid seasonal distribution and occurrence patterns in the Southern California Bight have been conducted off the U.S. west coast by NOAA/SWFSC (Barlow 1995; Forney *et al*. 1995, Forney and Barlow 1998). Seasonal shifts in distribution and abundance of short beaked common dolphins have been identified based on winter/spring 1991-1992 and summer/fall 1991 surveys; however, seasonal distribution patterns are highly variable, purportedly in response to oceanographic changes on both seasonal and inter-annual time scales (Forney 1997, Forney and Barlow 1998). Pacific white-sided dolphin sighting data suggest seasonal north-south movements, with animals found primarily off California during the colder water months and shifting northward into Oregon and Washington as water temperatures increase in late spring and summer (Green *et al*. 1992; Forney 1994). Risso's dolphin distribution data suggest seasonal patterns similar to, yet less pronounced than that observed for Pacific white-sided dolphins with increased abundance in northern waters during summer months. Bottlenose dolphin sighting data from aerial surveys conducted in winter/spring 1991-1992 (Forney *et al*. 1995) and shipboard surveys conducted in summer/fall 1991 (Barlow 1995) indicated no apparent seasonality in distribution.

While these results suggest a correlation between MFAS activity and low delphinid occurrence and diversity in the area, additional data needs to be collected. Small boat surveys with simultaneous HARP deployments planned for 2010 and 2011 will allow for a more comprehensive assessment of a potential link between MFAS and delphinid presence/absence in the San Clemente Island region.

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 318 distinctive individual bottlenose dolphins from San Clemente and 53 from Catalina, including five individuals resighted off both islands, will provide the basis for deriving abundance estimates and residency patterns. Similarly, the 150+ Risso's dolphins identified during the study period represent a first-ever 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 vital new information valuable to understanding their relationship (both spatial and temporal) to Navy activities off southern California.

Additionally, photo-identification of fin and humpback whales also proved valuable and significantly 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 HARP data analysis will examine the occurrence of MFAS 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. During the 2010 and 2011 field seasons, we plan to collect additional biopsies to allow for a thorough assessment of GC concentration measurements 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 presumably 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 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 bottlenose dolphins in offshore waters; data which are crucial to comprehensive monitoring efforts in SOCAL. Expanded and dedicated biopsy sampling of offshore and coastal bottlenose dolphins planned for the 2010 and 2011 field seasons should provide the sample sizes needed to conduct a thorough assessment of these hormonal and genetic parameters.

CONCLUSIONS

The primary objectives of the 2009/2010 SIO small boat based research program are 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 any possible effects from MFAS trials. Expanded and directed data collection in the SOCAL region planned for the 2010 and 2011 field seasons should provide for a more comprehensive assessment and interpretation of the variables described in this report.

ACKNOWLEDGEMENTS

The authors first thank Dave Morretti, Nancy DiMarzio, Ron Morissey, Susan Jarvis, Jessica Ward and Tarry Rago for acoustic range monitoring and logistical support. We gratefully acknowledge Amanda Cummins, Chris Garsha, Elizabeth Henderson, John Hurwitz, Nick Kellar, Sara Kerosky, Lauren Roche, Sean Wiggins and numerous interns, research assistants and graduate students for their assistance with fieldwork and data collection. We thank Erin Falcone, Greg Schorr and Annie Douglas for providing photographic data to supplement our analysis. Alice Hwang deserves recognition for her excellence in photo-identification sorting and matching. We thank Dean Yamashita, D. J. Pascua, Heidi Nevitt, Robert Tahimic and numerous other personnel on San Clemente Island and at North Island, San Diego for essential logistical and technical support. We are grateful to Frank Stone for supporting our work through CNO-N45. Data were collected under NMFS permit number 774-1714.

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APPENDIX 1 To Small Boat Surveys

California Coastal Bottlenose Dolphin Abundance Survey – 11/02/09
Prepared By: Greg Campbell

The first in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 02, 2009. The primary objectives were to collect photo-identification, biopsy and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other cetacean species common to the region, and surveying HARP site P.

Six hours of field effort covering 62 miles yielded two groups of coastal bottlenose and one group of Pacific white-sided dolphins (Figure 1). Photo-identification efforts produced high quality images from the majority of bottlenose dolphins encountered. One biopsy sample from coastal bottlenose dolphins was collected for an assessment of microbiological contaminants. Heavy fog precluded the completion of the complete survey route, collection of acoustical recordings, and surveying HARP site P. Details on sighting, photo-ID, acoustical and biopsy data are provided in Table 1.

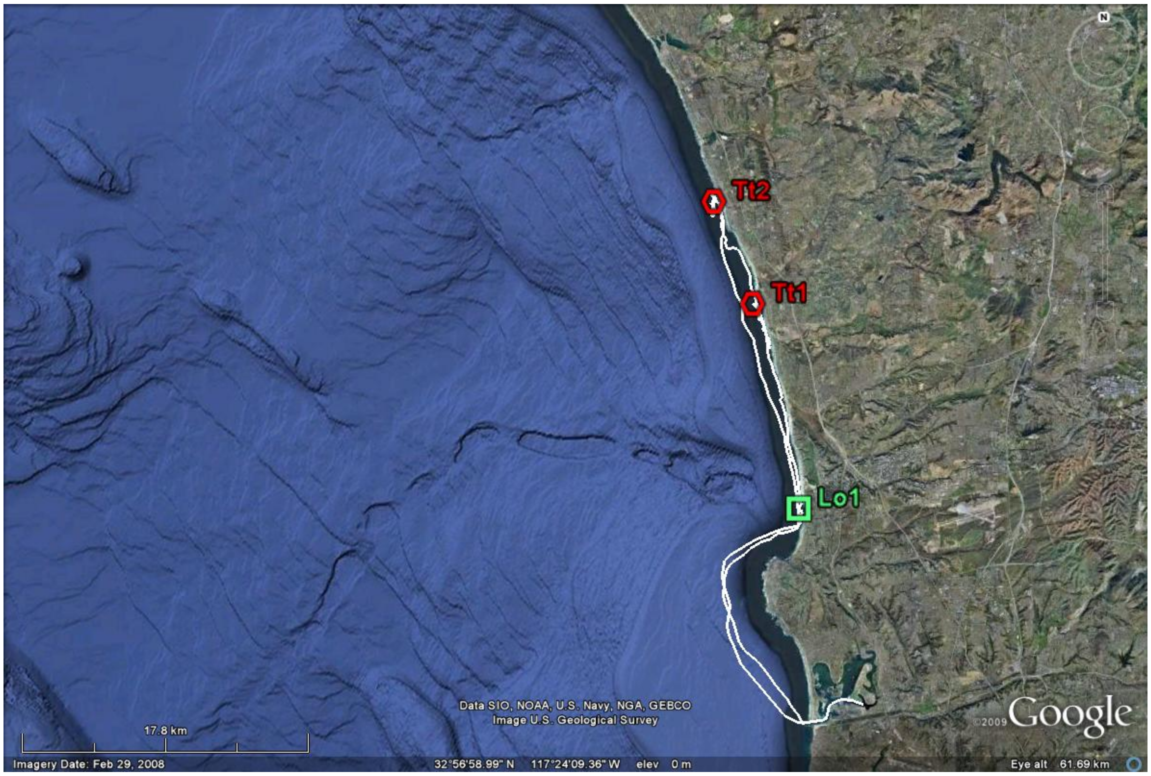

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *L. obliquidens*, off the San Diego coastline, November 02, 2009.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 02, 2009.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
L. obliquidens	Lo1	15	-	-	-
T. truncatus	Tt1	5	67	-	-
T. truncatus	Tt2	6	68	-	1

California Coastal Bottlenose Dolphin Abundance Survey – 11/30/09
Prepared By: Greg Campbell

The second in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 30, 2009. The primary objectives were to collect photo-identification, biopsy and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other cetacean species common to the region, and surveying HARP site P.

Seven hours of field effort covering 66 miles yielded four groups of coastal bottlenose and two groups of Pacific white-sided dolphins (Figure 1). Photo-identification efforts produced high quality images from the majority of bottlenose dolphins encountered. One biopsy sample from coastal bottlenose dolphins was collected for an assessment of microbiological contaminants. Time and weather constraints precluded the collection of acoustical recordings and surveying HARP site P. Details on sighting, photo-ID, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *L. obliquidens*, off the San Diego coastline, November 30, 2009.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 30, 2009.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
L. obliquidens	Lo1	10	-	-	-
L. obliquidens	Lo2	25	-	-	-
T. truncatus	Tt1	6	40	-	1
T. truncatus	Tt2	7	40	-	-
T. truncatus	Tt3	6	32	-	-
T. truncatus	Tt4	9	62	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 07/30/10
Crew: Greg Campbell, Dave Weller, John Hurwitz, Tara Whitty

The fourteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on July 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.

Four hours of field effort covering 50 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. Acoustical recordings of clicks and whistles as well as two biopsy samples were collected from bottlenose dolphins (*Tt*3) encountered four miles off the coastline. HARP site P was not surveyed due to the fact that no instrument was present at the site. 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* and *D. capensis* off the San Diego coastline, July 30, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, July 30, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	3	29	-	-
T. truncatus	Tt2	2	12	-	-
T. truncatus	Tt3	46	200	1	2
D. capensis	Dc1	45	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 01/07/10
Prepared By: Greg Campbell

The third in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 07, 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 cetacean species common to the region, and surveying the area around HARP site P.

Seven hours of field effort covering 68 miles yielded three groups of Pacific white-sided, one group of common, one group of coastal bottlenose, and one mixed group of offshore bottlenose and Risso's dolphins 1.5 mi. SE of HARP site P (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose and Risso's dolphins encountered. Acoustical recordings yielded clicks and buzzes from Pacific white-sided dolphins. Coastal bottlenose dolphin biopsy sampling was not in the protocol for this survey. Details on sighting, photo-ID, acoustical and biopsy data are provided in Table 1.

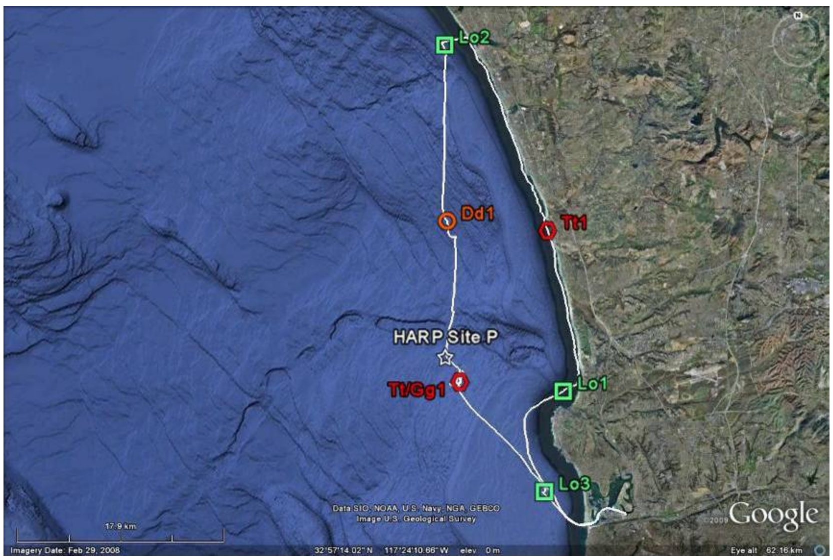

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *L. obliquidens*, *D. delphis*, and *G. griseus* off the San Diego coastline, January 07, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 07, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	6	36	3	-
T. truncatus/G. griseus	Tt/Gg1	22/60	68/95	-	-
D. Delphis	Dd1	29	-	-	-
L. obliquidens	Lo1	10	-	-	-
L. obliquidens	Lo2	24	-	1	-
L. obliquidens	Lo3	4	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 01/25/10
Prepared By: Greg Campbell

The fourth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 25, 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 cetacean species common to the region.

Seven hours of field effort covering 70 miles yielded sightings of three groups of bottlenose dolphins and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of individuals encountered. Time and weather constraints precluded the collection of acoustical recordings, and bottlenose dolphin biopsy sampling was not in the protocol for this survey. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

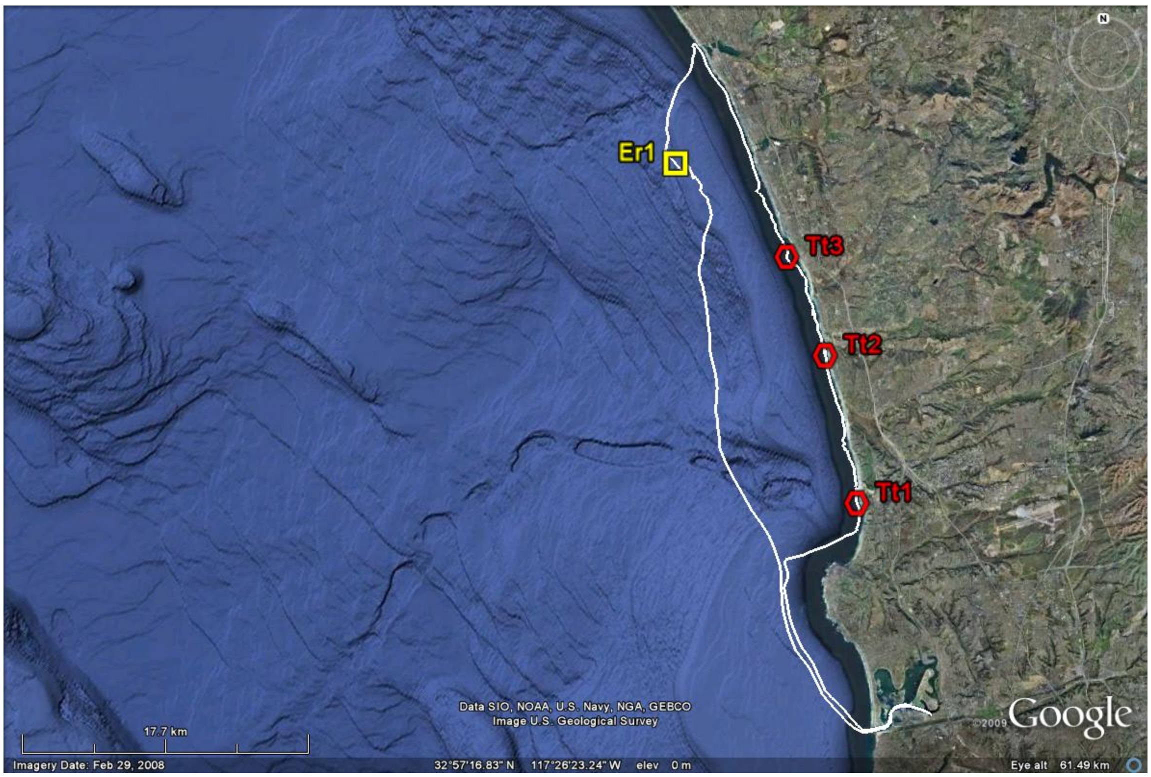

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *E. robustus* off the San Diego coastline, January 25, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 25, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	18	401	-	-
T. truncatus	Tt2	5	130	-	-
T. truncatus	Tt3	10	207	-	-
E. robustus	Er1	1	53	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 02/19/10
Prepared By: Greg Campbell

The fifth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 19, 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 73 miles yielded sightings of two 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 and acoustical recordings yielded both whistles and echolocation clicks. Deteriorating weather conditions precluded the collection of biopsy/acoustical data from PWS dolphins. 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* and *L. obliquidens* off the San Diego coastline, February 19, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 19, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	6	91	-	-
T. truncatus	Tt2	12	286	3	-
L. obliquidens	Lo1	11	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 02/24/10
Prepared By: Greg Campbell

The sixth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 24, 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.

Eight hours of field effort covering 75 miles yielded sightings of two groups of bottlenose dolphins, four groups of Pacific white-sided dolphins, two groups of long-beaked common dolphins and one juvenile gray whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. One biopsy sample with three associated recordings of clicks was collected from PWS dolphins. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

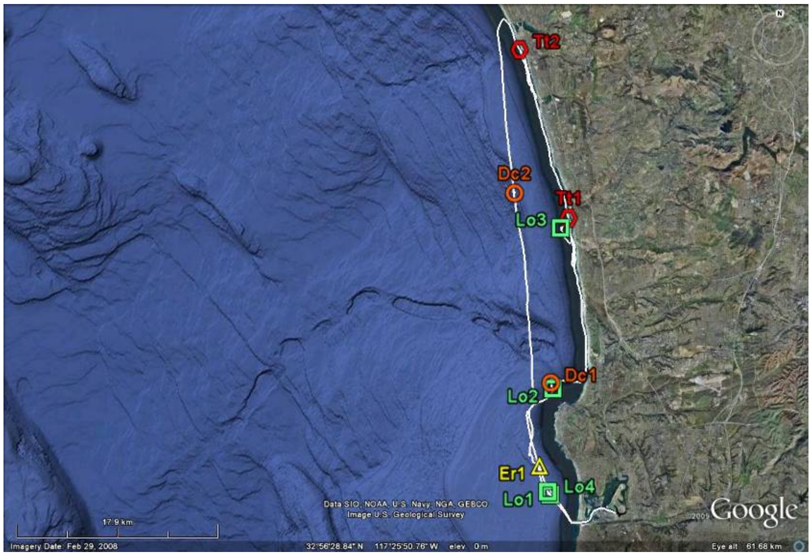

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *L. obliquidens*, *D. capensis* and *E. robustus* off the San Diego coastline, February 24, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 24, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	9	130	-	-
T. truncatus	Tt2	9	161	-	-
L. obliquidens	Lo1	7	4	3	1
L. obliquidens	Lo2	10	-	-	-
L. obliquidens	Lo3	5	-	-	-
L. obliquidens	Lo4	9	-	-	-
D. Capensis	Dc1	105	-	-	-
D. Capensis	Dc2	27	-	-	-
E. robustus	Er1	1	20	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 03/12/10
Prepared By: Greg Campbell

The seventh in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 12, 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.

Ten hours of field effort covering 85 miles yielded sightings of seven 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. Acoustical recordings of coastal bottlenose dolphins (*Tt1*) yielded whistles, clicks and mid-frequency active sonar signals. Bottlenose dolphins were also encountered at HARP site P where one biopsy sample was collected for stock structure analysis and one individual with unique pigmentation patterns was observed. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

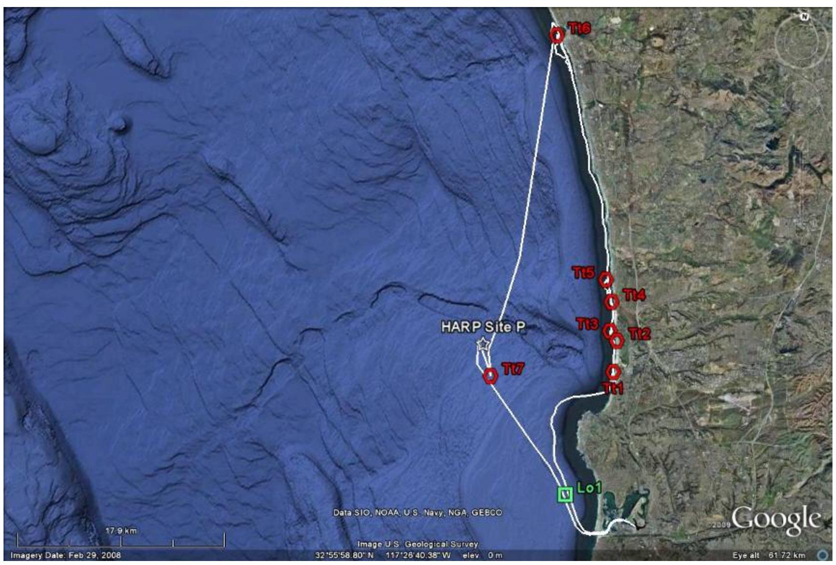

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *L. obliquidens* off the San Diego coastline, March 12, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 12, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	8	115	4	-
T. truncatus	Tt2	9	93	-	-
T. truncatus	Tt3	3	52	-	-
T. truncatus	Tt4	8	96	-	-
T. truncatus	Tt5	7	89	-	-
T. truncatus	Tt6	4	115	-	-
T. truncatus	Tt7	60	195	-	1
L. obliquidens	Lo1	5	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 03/29/10
Prepared By: Greg Campbell

The eighth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 29, 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 73 miles yielded sightings of three groups of bottlenose dolphins, two groups of Pacific white-sided dolphins and one group of common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings yielded whistles and clicks from coastal bottlenose dolphins and clicks from Pacific white-sided dolphins. Behavioral and time constraints precluded collection of biopsy samples from PWS dolphins. No cetaceans were encountered during a survey of the waters around HARP site P. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

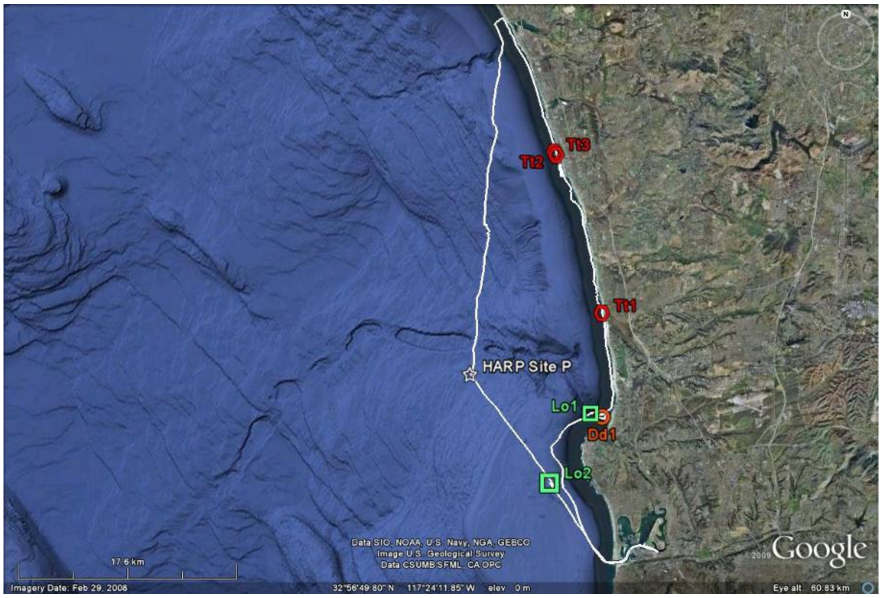

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *L. obliquidens* and *D. delphis* off the San Diego coastline, March 29, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 29, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	7	170	4	-
T. truncatus	Tt2	2	29	-	-
T. truncatus	Tt3	5	56	-	-
L. obliquidens	Lo1	11	-	2	-
L. obliquidens	Lo2	5	-	-	-
D. delphis	Dd1	73	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 04/23/10
Prepared By: Greg Campbell

The ninth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on April 23, 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 71 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. Large swell and increasing winds precluded the collection of acoustical recordings and surveying site P. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

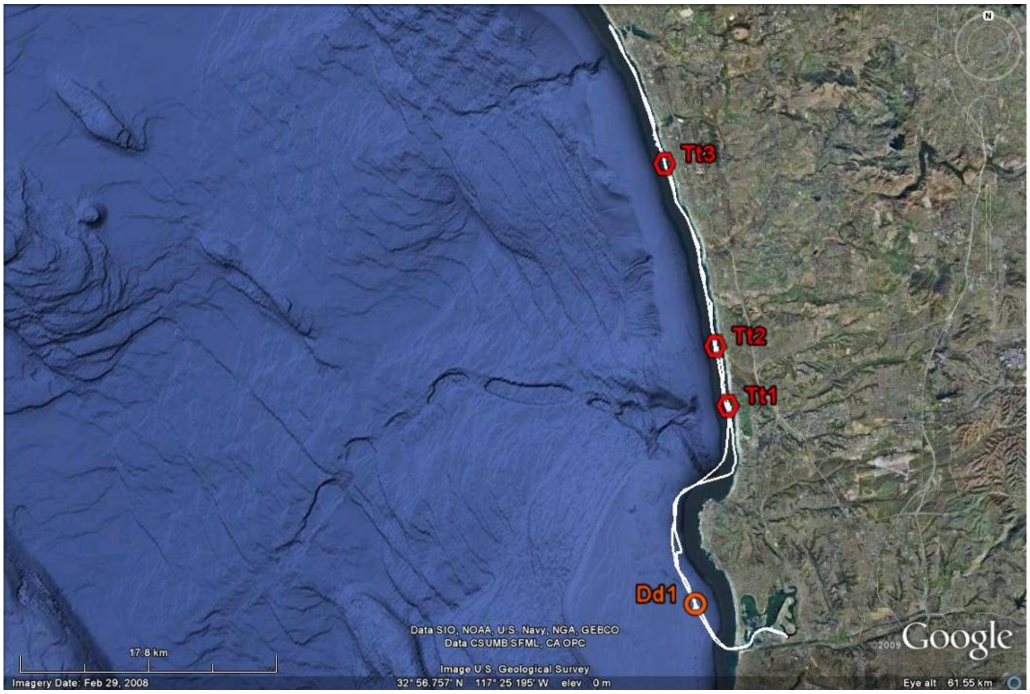

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *D. delphis* off the San Diego coastline, April 23, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, April 23, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	21	322	-	-
T. truncatus	Tt2	4	37	-	-
T. truncatus	Tt3	3	45	-	-
D. delphis	Dd1	275	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 05/07/10
Prepared By: Greg Campbell

The tenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on May 07, 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 71 miles yielded sightings of six groups of bottlenose dolphins, one group of long-beaked common dolphins and two groups of 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 (*Tt7*) yielded whistles and clicks; however, snapping shrimp created a marginal signal/noise ratio. 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* and *D. capensis* off the San Diego coastline, May 07, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, May 07, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	2	17	-	-
T. truncatus	Tt2	3	24	-	-
T. truncatus	Tt3	3	33	-	-
T. truncatus	Tt4	3	22	-	-
T. truncatus	Tt5	9	147	-	-
T. truncatus	Tt6	9	81	3	-
D. capensis	Dc1	65	55	-	-
D. delphis	Dd1	7	-	-	-
D. delphis	Dd2	85	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 05/14/10
Crew: Greg Campbell, Dave Weller. Amanda Cummins, Mary Grady

The eleventh in a series of small boat cetacean surveys off the San Diego county coastline was conducted on May 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.

Seven hours of field effort covering 68 miles yielded sightings of four 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. HARP site P was not surveyed due to the fact that no instrument was present at the site. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

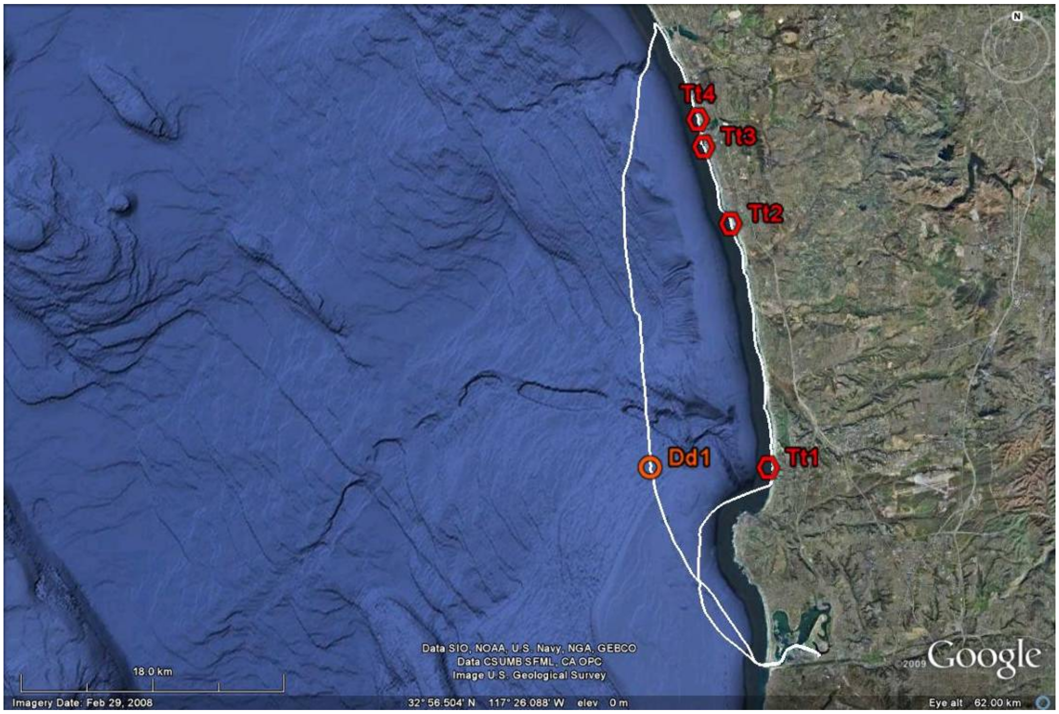

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *D. delphis* off the San Diego coastline, May 14, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, May 14, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	9	222	-	-
T. truncatus	Tt2	5	77	-	-
T. truncatus	Tt3	4	18	-	-
T. truncatus	Tt4	14	191	-	-
D. delphis	Dd1	165	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 06/04/10
Crew: Greg Campbell, Amanda Cummins, John Hurwitz

The twelfth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on June 4, 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 85 miles yielded sightings of one group of bottlenose dolphins, one group of short-beaked common dolphins and one mixed group of long-beaked and short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. HARP site P was not surveyed due to the fact that no instrument was present at the site. 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* and *D. capensis* off the San Diego coastline, June 4, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, June 4, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	7	147	-	-
D. delphis	Dd1	212	17	-	-
D. delphis / *D. capensis*	Dd/Dc1	147	11	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 07/23/10
Crew: Greg Campbell, Dave Weller, John Hurwitz

The thirteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on July 23, 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.

Four hours of field effort covering 43 miles yielded sightings of one group 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. Two biopsy samples were collected from coastal bottlenose dolphins for an assessment of stress hormones and microbiological contaminants. HARP site P was not surveyed due to the fact that no instrument was present at the site. 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* and *D. delphis* off the San Diego coastline, July 23, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, July 23, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	5	60	-	2
D. delphis	Dd1	38	-	-	-

CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATION (CALCOFI) CRUISES: 2009-2010

Greg Campbell, Karlina Merkens and John Hildebrand
Marine Physical Laboratory, Scripps Institution of Oceanography
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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 on 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 two 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 planned for the future. Recent analysis of baleen whale density relative to habitat type and productivity levels has proven insightful for expanding the scope and complexity of our habitat modeling efforts.

Visual monitoring for cetaceans on four quarterly CalCOFI cruises during 2009-2010 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.

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 high intensity, low frequency flow noise and protection from signal aliasing at high frequencies. The multi-channel array data are 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. Acoustic monitoring on CalCOFI stations is conducted with both broadband passive 57B omni-directional and 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 are recorded with this system.

Cetacean surveys conducted in August 2009, November 2009 and January 2010 utilized the standard CalCOFI station pattern; efforts in April 2010 surveyed the trawling and northern transects (see Figure 1). Summary data on effort and sightings from the four CalCOFI surveys conducted from August 2009 – April 2010 are provided in Tables 1 and 2. Plots of all visual detections as a function of season are provided in Figures 2 and 3.

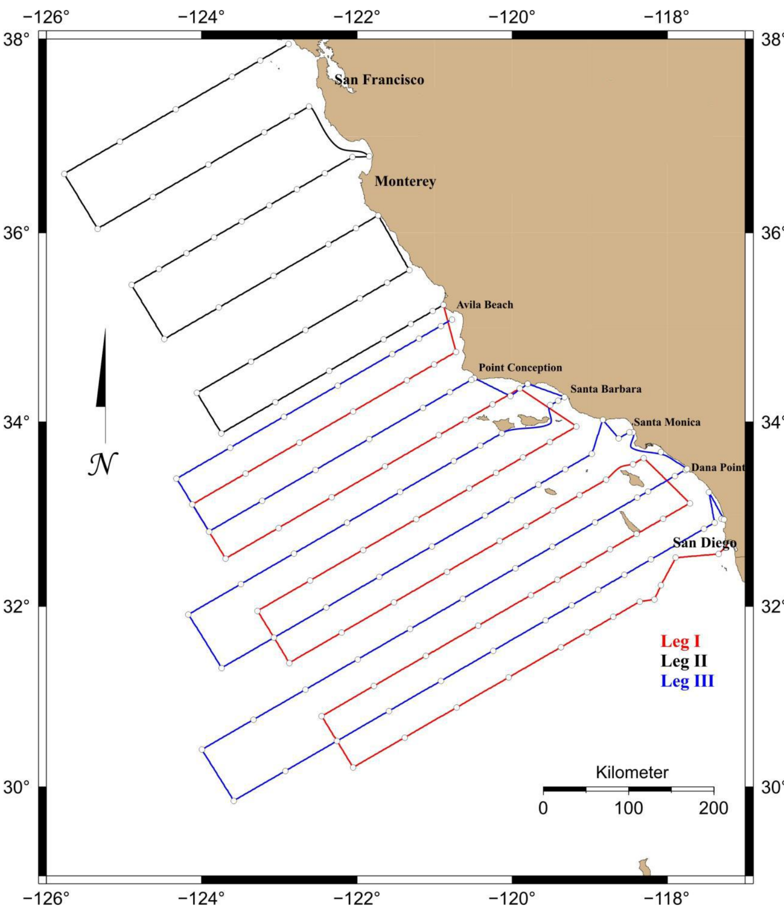

Figure 1. CalCOFI station positions for standard transect (blue), trawling transect (red), and northern transect (black). Image courtesy of CalCOFI program.

Table 1. Summary data from four CalCOFI cruises between August 2009 and April 2010.

CalCOFI Cruise Dates	Survey Effort (hrs)	Distance Surveyed (nm)	Number of Cetacean Sightings	Number of Individuals	Number of Digital Photos	Number of Acoustic Recordings	Total Hours of PAM	Number of Acoustic Detections/ Species	Number of Sonobuoys Deployed
14 Jul - 5 Aug 2009	102	965	110	2,050	7	62	123	129/8	36
6 -22 Nov 2009	96	842	49	3,364	29	55	212	53/7	29
12 Jan - 3 Feb 2010	97	898	105	8,998	5	71	196	126/8	36
4 - 24 Apr 2010	95	1325	75	3,220	217	65	216	*	65
Totals	390	4,030	339	17,632	258	253	747	308	166

Table 2. CalCOFI cetacean sightings by cruise from August 2009 – April 2010.
Ns = number of sightings; Ni = number of individuals

	CC0907 (14 Jul - 5 Aug 2009)		CC0911 (6 -22 Nov 2009)		CC1001 (12 Jan - 3 Feb 2010)		CC1003 (4 Apr - 24 Apr)	
Species	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**
Bm	17	21	1	1	0	0	0	0
Bp	12	14	3	10	3	6	1	14
Dc	5	351	2	953	5	237	0	0
Dd	27	1167	9	1532	8	3146	3	830
Dsp	14	284	8	712	12	3228	4	68
Er	0	0	0	0	22	47	1	1
Gg	4	45	2	18	8	84	5	337
Lb	0	0	1	5	2	720	1	650
Lo	0	0	2	22	2	84	6	871
Mn	0	0	7	11	4	6	22	106
Oo	0	0	0	0	0	0	1	6
Pd	0	0	2	11	7	63	17	87
Pm	6	9	0	0	3	25	1	5
Sc	1	58	0	0	0	0	0	0
Tt	7	82	1	3	1	7	0	0
UD	1	1	3	76	10	1307	2	232
ULW	16	18	7	9	18	38	11	13
Zcav	0	0	1	1	0	0	0	0
TOTALS	110	2050	49	3364	105	8998	75	3220

SPECIES CODE

Bm = *Balaenoptera musculus* (blue whale)	Gg = *Grampus griseus* (Risso's dolphin)	Pm = *Physter macrocephalus* (sperm whale)
Bm = *Balaenoptera physalus* (fin whale)	Lb = *Lissodelphis borrealis* (N. right-whale dolphin)	Sc = *Stenella coeruleoalba* (striped dolphin)
Dc = *Delphinus capensis* (long-beaked common dolphin)	Lo = *Lagenorhynchus obliquidens* (Pacific whiste-sided dolphin)	Tt = *Tursiops truncatus* (bottlenose dolphin)
Dd = *Delphinus delphis* (short-beaked common dolphin)	Mn = *Megaptera noveangliae* (humpback whale)	Zcav = *Ziphius cavirostris* (Cuvier's beaked whale)
Dsp = *Delphinus spp.* (unid. Common dolphin)	Oo = *Orcinus orca* (killer whale)	UD = unidentified dolphin
Er = *Eschrichtius robustus* (grey whale)	Pd = *Phocoenoides dalli* (Dall's porpoise)	ULW = unidentified large whale

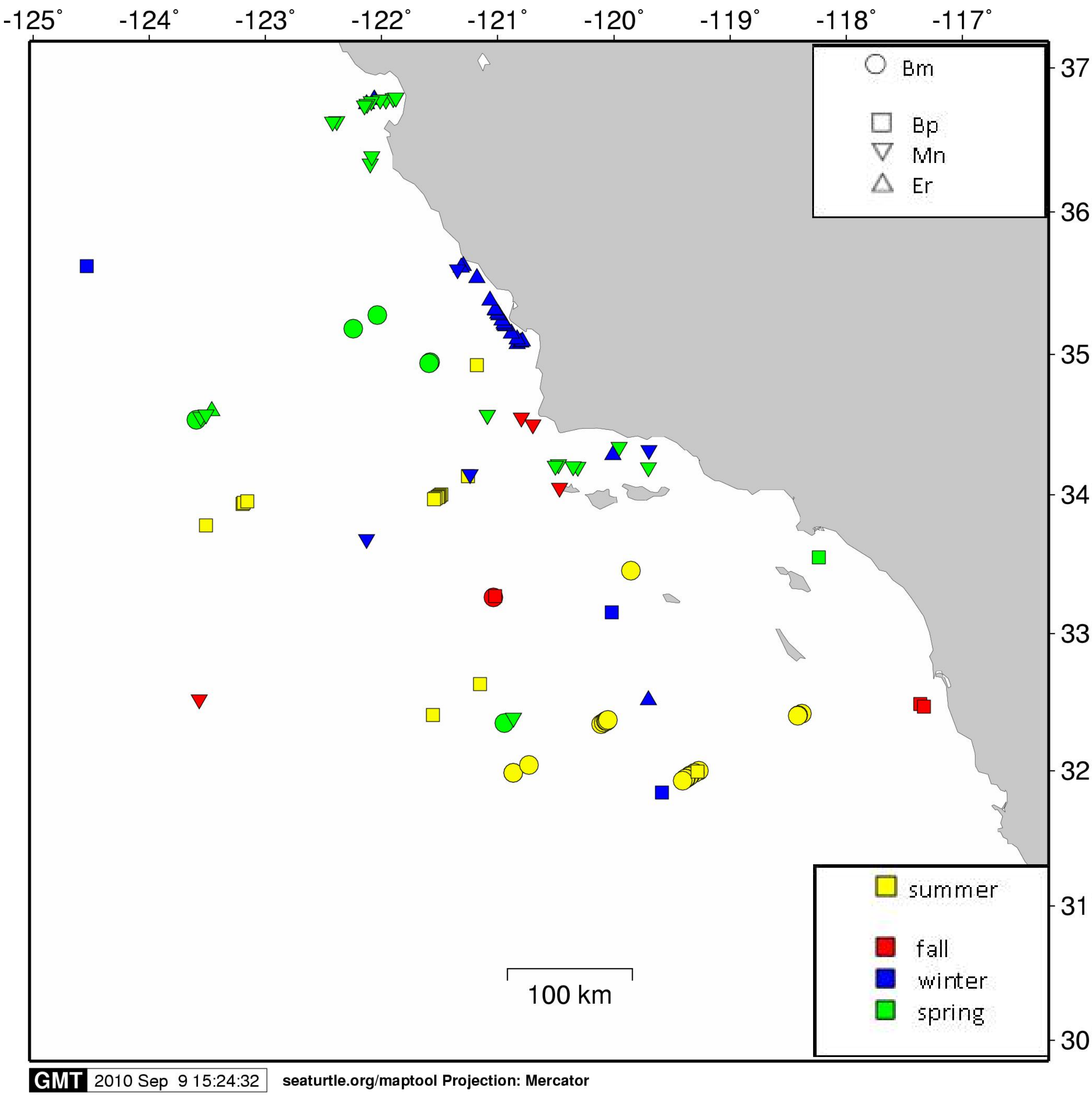

Figure 2. Baleen whale sightings during CalCOFI cruises between August 2009 and April 2010.

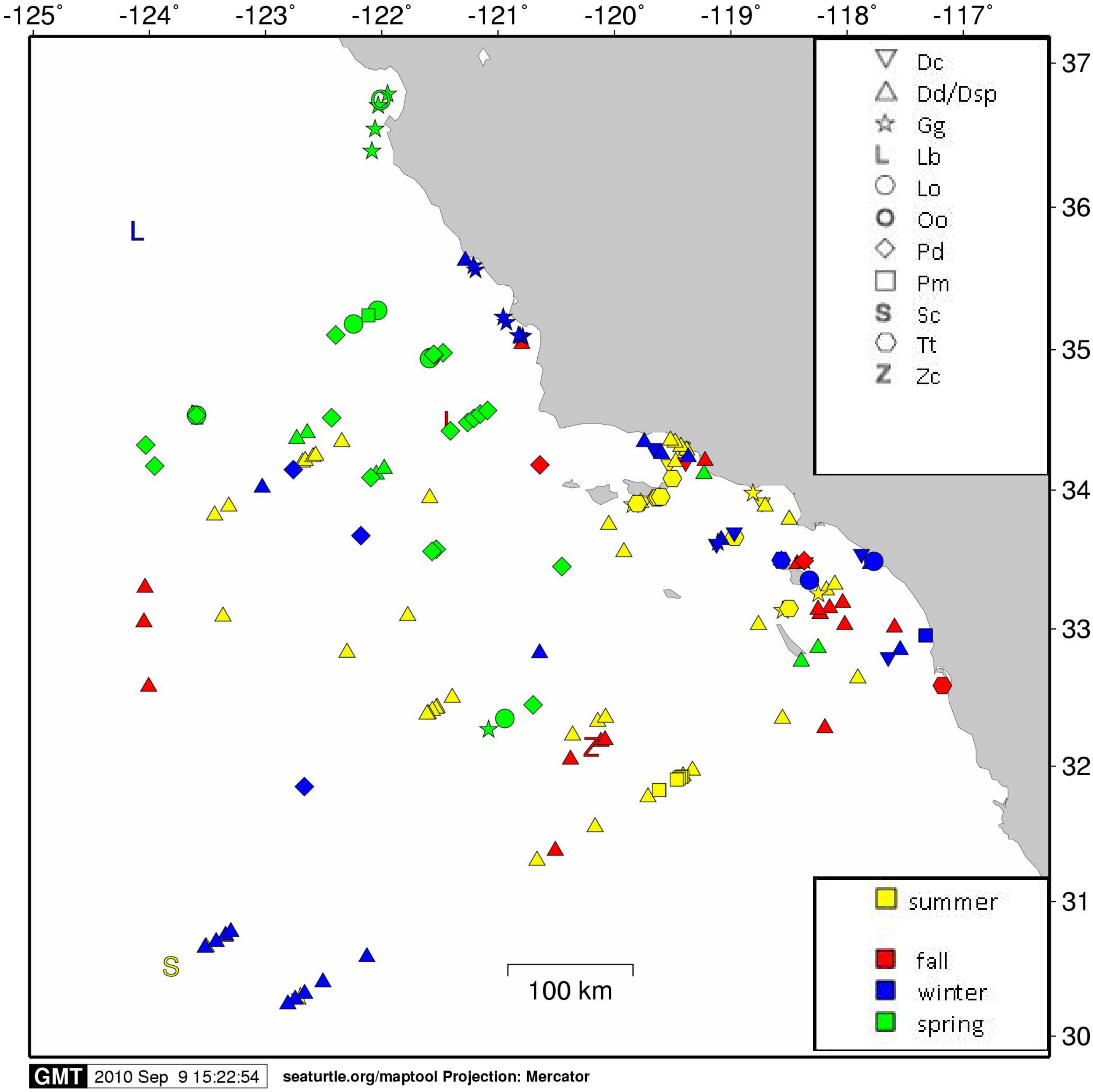

Figure 3. Toothed whale sightings during CalCOFI cruises between August 2009 and April 2010.

Cascadia Research Collective
non-profit research and education since 1979

Small vessel surveys and satellite tagging of marine mammals at SCORE and surrounding areas of SOCAL in 2009:

A summary of effort, sightings, and satellite tag deployments with an assessment of the "fast and light" approach to small vessel surveys in the region

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Introduction

In 2009, Cascadia Research participated in the fourth year of collaborative marine mammal surveys centered on the Southern California Offshore Range (SCORE). The primary mission of these surveys since their inception has been to provide visual verification of passive acoustic detections on the SOAR array using the M3R system (Moretti et al. 2006). 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 (e.g. Andrews et al. 2008, Schorr et al. 2009). While previous surveys have been successful (See http://www.cascadiaresearch.org/SCORE/SCOREMain.htm for annual summaries) and provided sufficient sighting and photo-identification data on Cuvier's beaked whales at SCORE for a journal article (Falcone et al. 2009), effort during scheduled surveys, at the SOAR array in particular, has often been limited by rough sea conditions and conflicting naval operations in the study area. To maximize efficiency during other projects along the US West Coast, Cascadia has historically operated many of its small vessel surveys on a temporally and geographically flexible schedule whenever possible. This has allowed us to target periods of calm weather and unpredictable aggregations of study species as they occur, resulting in more efficient and effective data collection. We felt moving away from a fixed schedule and expanding our geographic coverage into adjacent areas of SOCAL might also increase the effectiveness of this study by allowing us to target good weather windows when the range was unrestricted for data collection, and also providing opportunities to collect data from animals in adjacent areas which will be necessary to define the status of range populations within the broader regional context of SOCAL. We viewed 2009 as an opportunity to test the approach in this setting, given the additional logistical challenges of working at SCORE (e.g. housing, coordination with passive acoustic monitoring assets, range access).

While the first survey in July ended up on a fixed schedule in association with other monitoring activities at the range, and thus was not temporally flexible, and the range was closed throughout September and October for hydrophone replacement (thus limiting our opportunities for surveys during what is typically the best weather during the year), we were able to attempt a series of more flexible surveys in November. During both periods we expanded data collection into adjacent areas of SOCAL when access to SOAR was limited. This summary provides an overview of effort, sightings, and tag deployments in 2009, with an assessment of the "fast and light" approach to small vessel surveys in the region and recommendations for future surveys.

Survey Effort

Cascadia conducted visual surveys from a single RHIB during two periods in 2009: 18-26 July, and 11-24 November. Survey hours, including time spent on and off the instrumented range, are summarized along with sightings in Table 1. All RHIB tracks are presented in Figure 1. RHIB surveys in July were in conjunction with aerial surveys and a large vessel line-transect survey aboard the R/V Sproul from 21-27 July 2009. Cascadia provided visual observations from the Sproul during this survey. As continuous PAM was also underway during this period using both the SOAR array and a towed array from the ship, one goal of this period is to compare the efficacy of each methodology using these concurrent samples. All sightings data from the Sproul was provided to Scripps Institution of Oceanography for that analysis.

More than half of survey hours in July were spent on SOAR, although conditions were marginal throughout much of the time (Table 1). On days when range access was restricted by weather or conflicting operations effort was shifted into adjacent areas of SOCAL. Access to the range was restricted throughout most of the available survey period in November, which paired with weather, resulted in only one day on SOAR that trip. Subsequently remaining survey days were used to scout alternative locations for collecting data on beaked whales, and also to collect identification photos, tissue samples, and deploy satellite tags on range species outside the core study area. An emphasis was placed on fin whales given that those tagged previously at SCORE have frequently moved between the range and inshore SOCAL.

Table 1. Summary of RHIB survey effort by Cascadia Research at SCORE and surrounding areas in 2009.

Survey	Total Survey Hours	Hours in Excellent or Good conditions	Hours on Range	Number of sightings	Number of species sighted	Number of tags deployed
18-26 July 2009	81.3	44.9 (55%)	45.0 (55%)	77	9	8
11-24 November 2009	77.5	50.5 (65%)	10.6 (14%)	94	10	12

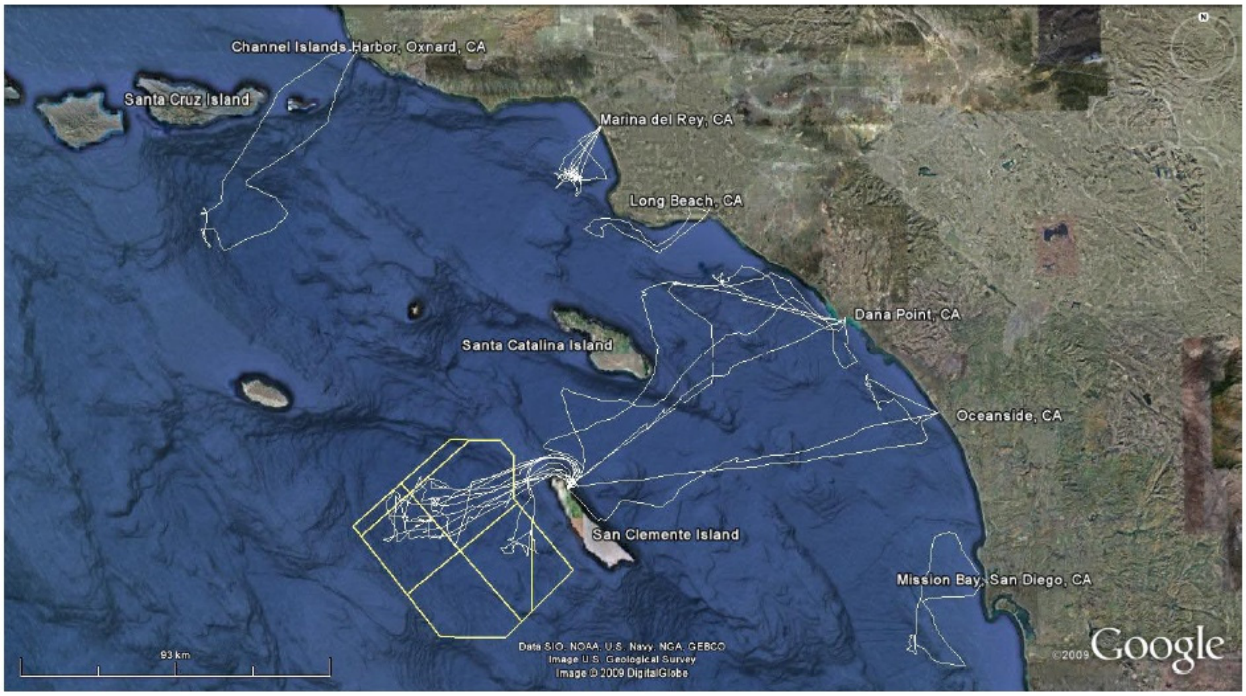


Figure 1. CRC RHIB survey tracks (in white) from both dedicated monitoring at SCORE (boundaries of SOAR range in yellow) and supplemental effort at other parts of SOCAL in 2009.

Sightings

Sightings are summarized in Tables 2a and 2b for the July and November survey periods. It is difficult to make simple comparisons between sighting rates in 2009 with those from previous survey years given the much greater proportion of effort spent working outside the core study area, however in general the distribution and proportion of sightings by species at SOAR was similar to trends observed previously. Common dolphins remained the most frequently sighted species both on and off the range, with a slightly higher proportion of sightings of short-beaked than long-beaked sightings. Five groups of Cuvier's beaked whales were sighted in the western part of SOAR during surveys in July, two if which were encountered without acoustic direction from M3R. During this same time period the *Sproul* line-transect survey sighted no beaked whales and aerial surveys reported only a single group. Figure 2 shows all cetacean sightings other than common dolphins.

Fin whales continue to be the most frequently encountered baleen whale during these surveys, particularly in offshore areas, although both blue and minke whales were sighted much more frequently in 2009 during coastal surveys. As has often been the case with fin whales they tended to occur both on and off the range in localized concentrations when encountered. A group of 8-12 fin whales was encountered on the range in July, and while there was insufficient effort on the range in November to confidently say that fin whales were not present, no fin whales were seen during the one day spent on the range that month. In contrast, a sizeable aggregation was observed over a period of days in the vicinity of the Palos Verdes Peninsula, feeding on surface swarms of krill and small bait fish along the canyons and shelf edge between Long Beach and Marina del Rey. This concentration, which we estimated at 20-30 fin whales with lesser numbers of blue whales and minke whales, had been reported both prior to our surveys in November and was still present as of late-December based on satellite telemetry from tagged individuals and reports from whale watch operators and even the local media. Based on both existing large whale datasets from the region and the local reports such an aggregation has not been reported off coastal southern California for any of these species this late in the year. While photo-ID and satellite tag data suggest that blue whales migrate to lower latitude breeding areas in the winter, although with less geographic predictability than humpback or gray whales, the migratory habits of fin whales in the North Pacific are virtually unknown. Observations from historical whaling data and more recent sighting data suggest that they may not follow a migratory pattern similar to other baleen whales (Mizroch et al. 2009), and our observations of fin whales aggregated off California well into December support this supposition. Although no calves were observed in the aggregation of fin whales in November, in addition to feeding, animals were frequently engaged in “racing” and other agonistic behavior often associated with courtship in better known blue whales, supporting that these whales have a seasonal reproductive cycle, but that they may not migrate to tropical and sub-tropical waters breed. Understanding the seasonal movements and reproductive habits of fin whales is of particular relevance if aggregations in SOCAL training areas during winter months are engaged are breeding as well as feeding behavior, and subsequently may be more sensitive to certain types of disturbance at these times.

Another sighting of note during surveys in November was a group of four Cuvier’s beaked whales in the northwestern Santa Cruz Basin. Historically, Cuvier’s beaked whales on the range have been found almost exclusively in the northwestern segment of the array, which corresponds to the western portion of the San Nicolas Basin (Falcone et al 2009). This prompted us to question whether this species might also occur in higher concentrations in the western part of other deep basins in the Southern California Bight, and in particular the Santa Cruz Basin, which can be reached relatively easily from Channel Islands Harbor on the mainland coast (as opposed the San Nicolas Basin which can only be accessed by RHIB from San Clemente Island during periods of favorable weather). The Santa Cruz basin also has the added advantage of being within the lee of Point Conception during moderate northwesterly wind and swell conditions that prevail throughout summer months off southern California, with additional protection from Santa Cruz Island itself in its northernmost reaches. A group of beaked whales was also sighted south of this area during another Cascadia survey using a small towed array in September. While a combination of scheduling and conditions only allowed for a single survey of the Santa Cruz Basin in November, finding beaked whales with no acoustic support that day is very encouraging that the Santa Cruz Basin can be an alternate site for focal studies of beaked whales in SOCAL. Future effort here will be invaluable to ongoing photo-ID studies to help define the southern California population of this species. Additional tag deployments will contribute to baseline data from the species in southern California, and may provide an opportunity to investigate differences in habitat use and movement patterns in whales from regions with varying degrees of naval activity.

Processing and analysis of photo-identification data for all species is underway. An estimated total of 74 fin whales and eight Cuvier’s beaked whale identifications were collected in 2009. These will be compared against existing catalogs of these species from SCORE developed and maintained by Cascadia, currently totaling 68 fin whales and 58 Cuvier’s beaked whales. Identifications of blue and humpback whales will be processed as part of long-term photo-ID studies of these species by Cascadia. Identifications of bottlenose (N=115) and Risso’s (N=168) dolphins have been provided to SIO and SWFSC for processing.

Table 2a. Summary of sightings by species, CRC RHIB July 2009.

Species	Groups Sighted	Groups On SOAR	Groups Off SOAR	Est Total Individuals	Avg Group Size	Est ID	Samples	Tags Deployed
Minke Whale	2	1	1	2	1.0	2		
Blue Whale	8	0	8	11	1.4	11		
Fin Whale	7	4	3	19	2.7	15	1	5
Long-beaked Common Dolphin	12	0	12	429	35.8		2	
Short-beaked Common Dolphin	16	1	15	2333	145.8			
Common Dolphin, Sub-species unknown	5	2	3	53	10.6		1	
Risso's Dolphin	12	3	9	267	22.3	136	4	1
Pacific White-sided Dolphin	1	1	0	10	10.0			
Elephant Seal	1	0	1	1	1.0			
Bottlenose Dolphin	7	2	5	144	20.6	60	2	1
Cuvier's Beaked Whale	5	5	0	10	2.0	4		1

Table 2b. Summary of sightings by species, CRC RHIB, November 2009.

Species	Groups Sighted	Groups On SOAR	Groups Off SOAR	Est Total Individuals	Avg Group Size	Est ID	Samples	Tags Deployed
Minke Whale	12	0	12	20	1.7	10		
Blue Whale	17	0	17	44	2.6	37	4	3
Fin Whale	27	0	27	74	2.7	59	9	8
Long-beaked Common Dolphin	6	0	6	663	110.5			
Short-beaked Common Dolphin	17	2	15	6141	361.2			
Risso's Dolphin	3	0	3	63	21.0	32	2	1
Pacific White-sided Dolphin	4	0	4	224	56.0			
Elephant Seal	1	0	1	1	1.0			
Humpback Whale	1	0	1	2	2.0	0		
Bottlenose Dolphin	5	0	5	86	17.2	55		
Cuvier's Beaked Whale	1	0	1	4	4.0	4		

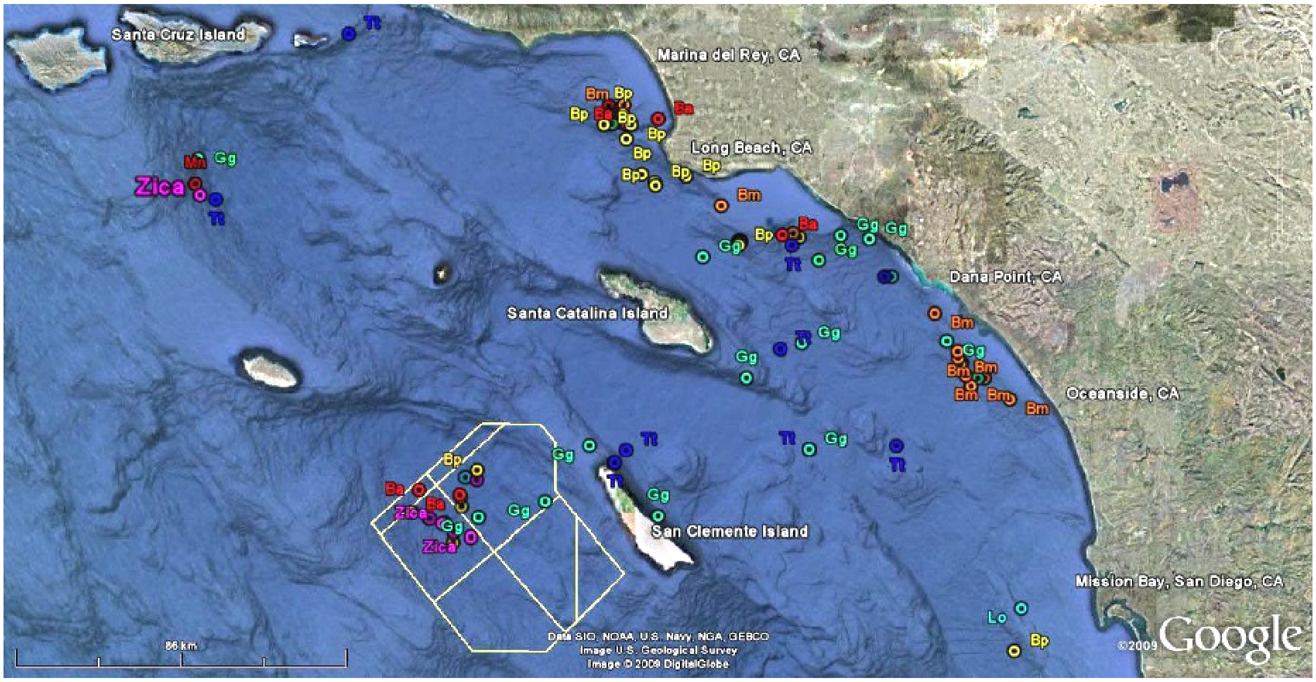
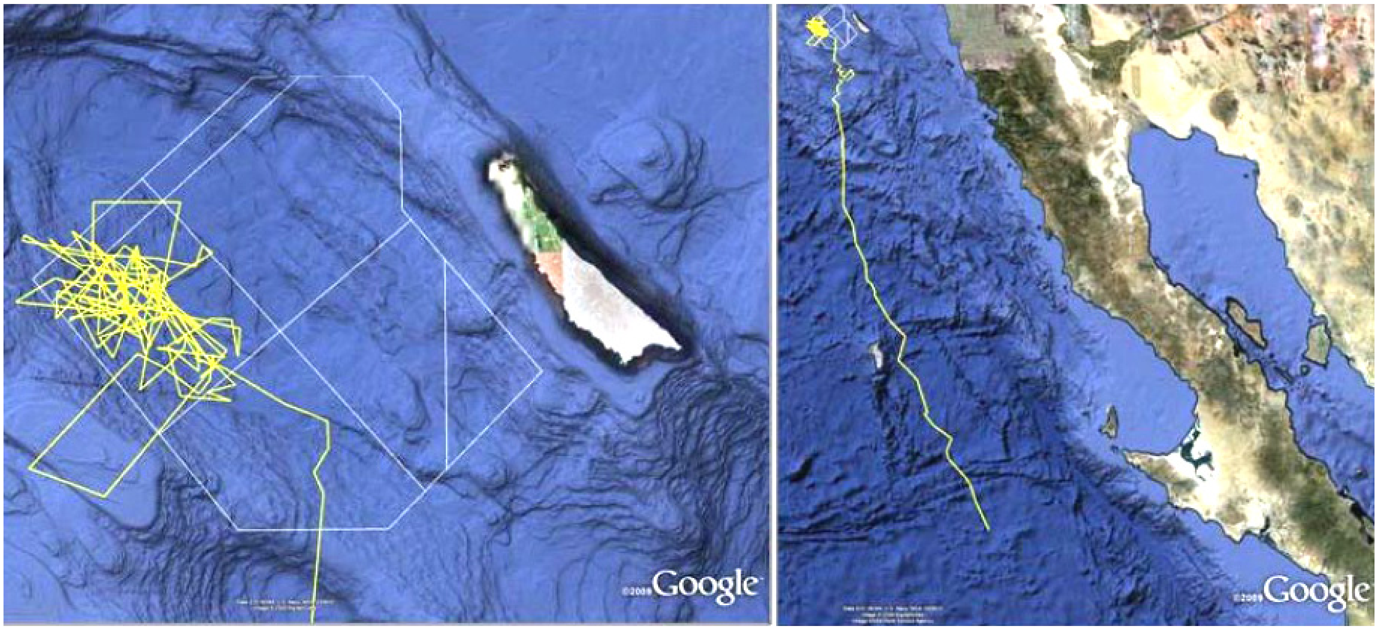


Figure 2. Cetacean sightings from CRC RHIB surveys in 2009 (common dolphins excluded, though they were present during all surveys). Baleen whales are in red (minke, "Ba" and humpback, "Mn"), orange (blue, "Bm"), and yellow (fin whales, Bp). Dolphins are in blue (bottlenose, "Tt") and turquoise (Risso's, "Gg" and Pacific whitesided, "Lo"). Cuvier's beaked whales, "Zica", are in magenta.

Satellite tag deployments

Twenty Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) satellite tags (two of which were financed by other projects) were deployed on six different species, both on and off the range, in 2009. These tags augment the four tags deployed on the range in 2008 (one on a Cuvier's beaked whale and three on fin whales). Additional tags were deployed on both these species this year (one Cuvier's and 13 fins), as well as two Risso's dolphins, one bottlenose dolphin, and three blue whales- representing the first time this type of tag has been applied to latter three species. An attempt was made to tag a minke whale, but the tag body grazed the leading edge of the fin resulting in a lost tag. The LIMPET tags are designed to provide movement data from tagged individuals, typically with multiple positions per day for periods ranging from several weeks to several months, depending on the species, programming, and type of attachment while being as minimally invasive as possible.

While sample sizes on all species, with the possible exception of fin whales, remain too small to characterize movement patterns from the species in general, there are a few observations of note. Both sighting data and movement data from the one previously tagged adult female Cuvier's beaked whale suggested that these whales may have ranges largely coincident with the San Nicolas Basin and those basins nearby, however the adult male Cuvier's beaked whale tagged in July 2009 ultimately traveled nearly 700 km almost due south into Mexican waters before contact with the tag was lost (Figure 3a and b).



3A 3B

Figure 3. Movements of a tagged adult male Cuvier's beaked whale showing the first month of movements (3A) and the movement to the south (3B).

Both the Risso's and bottlenose dolphins that were tagged at San Clemente Island moved between islands, demonstrating that these populations are not island-specific, although neither moved east into coastal waters during tag contact (average transmission duration = 16.5 days), so it is possible both Risso's and bottlenose dolphins found offshore may be distinct from their coastal counterparts. It is known that there are different populations of bottlenose dolphins near shore and offshore in southern California (e.g. Defran and Weller, 1999, Defran et al., 1999), but the role the islands play in the structure of the offshore population has not been well studied and satellite tagging, in addition to ongoing photo-ID studies using photos from this project, has much to offer in this regard for both these relatively common species around San Clemente Island.

Thirteen fin whales were tagged in 2009 to augment data from three individuals tagged in 2008. Five tags were deployed in July with transmission durations ranging from 12 to 160 days (Figure 4). Eight tags were deployed in November 2009, however median transmission duration for those tags was only 6 days (range = 0 to 12). While it is possible that behavioral states (racing, conspecific interactions, etc) may have resulted in damage or dislodgment of the tag and may account for some of the short transmission durations, it is also likely there were hardware issues with the tags themselves based on several tags which failed to transmit despite apparently normal deployment and attachment. We are continuing to work with the manufacturer to address possible sources of failure and verify any changes in new tag deployments. Analysis of percentage of time spent in training ranges and shipping lanes is currently underway and will ultimately be added to a habitat use and movement pattern analysis for southern California fin whales.

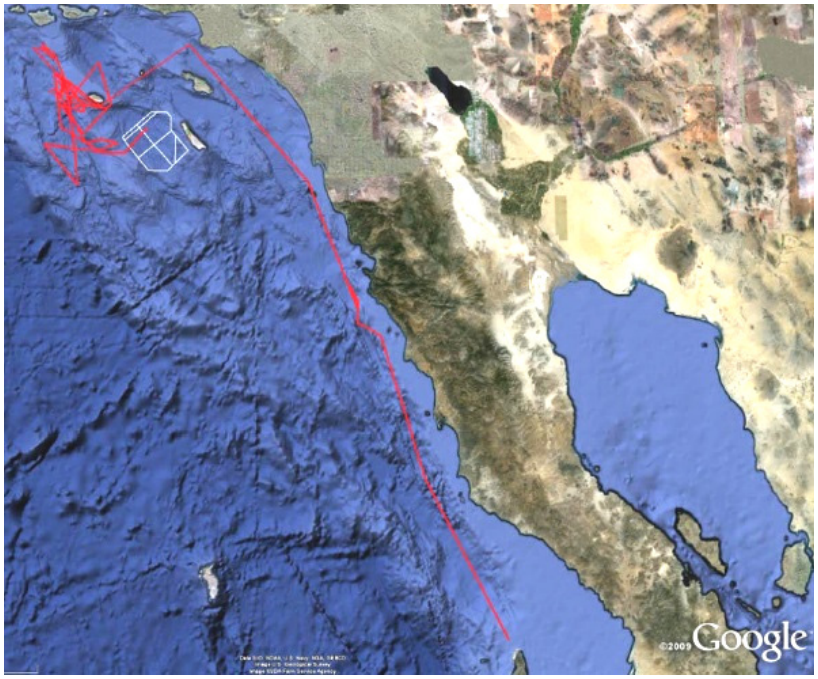


Figure 4. Trackline representing the movements of a tagged fin whale over 127 days (total transmission duration for this whale was 160 days). While the whale was tagged on the SOAR range, much of its time was spent in the waters surrounding San Nicolas Island.

Three blue whales were tagged during November, representing the first time this type of tag has been deployed on this species. Two of the tags are still transmitting at the time of this report, now on day 49. Both of these whales moved well south into Mexican waters within several weeks of tag deployment and currently remain outside US waters.

Analysis of the movements of tagged individuals in relation to Navy generated anthropogenic noise sources (e.g. MFAS) are currently underway in collaboration with NUWC. The results of this analysis may allow for an assessment of individual and, once sample sizes are large enough, population level impacts due to naval exercises and will allow for an analysis of the habitat use and movement patterns of species which inhabit the SOCAL region.

Assessment of "fast and light" operations at SCORE and adjacent areas

While not totally unexpected, this project did not lend itself well to operating on a temporally flexible schedule, at least for conducting monitoring surveys in conjunction with M3R at SCORE. This was due primarily to the logistical challenges of obtaining housing on island on short notice and frequent restrictions on range access for both vessel surveys and M3R. We still believe that building a degree of flexibility into future survey protocols is valuable, but to guarantee a minimum number of days on range each year will require at least some effort scheduled in advance. Given the high likelihood that a significant portion of days during any given survey will be compromised by weather and range scheduling conflicts, scheduled trips should be of longer duration than in previous years, which ranged from 5-10 days in length. With the overhaul of the hydrophone array in September and October of this year and funds for fieldwork not available until July, it was not the ideal year to test the "fast and light" system, as it left only parts of August and November to attempt surveys. But during these times we discovered that even when the range was available and weather favorable, securing lodging on island on short notice was difficult or impossible at times. Also the need to install Intuicom tracking packages and range radios ahead of each survey costs up to a half day of time. One solution to these challenges would be to identify a permanent ongoing housing arrangement and purchase hardware that could be permanently installed on RHIBs so that staff could come and go from the island more flexibly.

Though temporal flexibility may always be limited by logistics as SCORE, geographic flexibility is much more feasible and provides a way to better use field days that can't be expended on the range, as seen this year. When the range was closed for a day and a half in July 2009, we were able to work back inshore, reposition further up the coast and cover waters from Dana Point to Long Beach, the inside shelf edge of Santa Catalina Island, and a wide swath of waters in the Santa Catalina Basin before returning to the range. This provided a substantial amount of sighting and photo-ID data from adjacent regions, which is very relevant baseline data for characterizing the SCORE populations within a broader regional context. We also feel that the many days spent tagging off-range in November were much better spent moving throughout the Southern California Bight as opposed to being restricted to SCORE when conditions and range restrictions prevented work there, and hope to continue to operate in this fashion in 2010.

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