A COMPREHENSIVE REPORT OF AERIAL MARINE MAMMAL MONITORING IN THE SOUTHERN CALIFORNIA RANGE COMPLEX: 2008-2012

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Final Report

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IN THE

SOUTHERN CALIFORNIA RANGE COMPLEX: 2008-2012

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EXECUTIVE SUMMARY

NOTABLES

The most comprehensive marine mammal abundance and behavior study to date in the U.S. Navy's Southern California (SOCAL) Range Complex was during 2008-2012. Out of this effort come several notable achievements:

- High quality, up-to-date population density estimates were derived for all target species.
- First-observed behavior across multiple variables was recorded. Similarly, a large number of focal follows were performed, leading to a large database of detailed surface behavior over significant time periods for all target species.
- A systematic protocol for comprehensively documenting the abundance and behavior of marine mammals from the air was designed, refined, field tested and documented.
- Post-survey analysis revealed a large number of highly intriguing, previously undocumented results. These include relationships between deep undersea topographic features and a wide variety of marine mammal surface behaviors. These environmental relationships lead to a number of descriptive hypotheses involving California current upwelling, predator avoidance and sea-floor sound wave propagation, and the influence of these factors on marine mammal distribution and behavior.

OVERVIEW

Between October 2008 and April 2012, 15 aerial surveys were conducted in subregions of the SOCAL Range Complex in the Southern California Bight (SCB) (i.e., the study area) to monitor and obtain baseline data on the occurrence, distribution, density, abundance, and behavior of marine mammals and sea turtles on behalf of the U.S. Navy. The purpose of these surveys was to provide a comparative baseline with which to assess potential effects (or lack thereof) of mid-frequency active sonar (MFAS), underwater detonations, and other U.S. Navy exercise and training activities on these animals. The behavior of cetaceans in offshore SCB waters is poorly described, and previous systematic survey data there are over 12 years old. No sea turtles were seen during this period; therefore, they are not further discussed in this document.

SURVEY METHODOLOGY

Surveys were conducted primarily (*n=14;* 93 percent) from a high-winged, twin-engine Partenavia aircraft; the remaining survey (*n*=1; 7 percent) was conducted from an Aero Commander aircraft. Survey personnel consisted of two observers, one recorder/photographer/videographer, and one or two pilots. Surveys included five primary modes:

1. Systematic line-transect "search" effort along east-to-west oriented lines located east and west of San Clemente Island (SCI) (flown at 244-305 meters [m] altitude and 100 knots [kt])
2. "Verify" involving breaking from line transect effort to circle and photograph sightings to verify species, numbers and behavior with photographs
3. "Focal follow" involving circling (at 365 to 457 m altitude and 0.5 to 1.0 kilometers (km) radial distance) of high priority species to video and collect focal behavior (i.e. "focal follow") data for periods of 5 to 60 minutes (min) (typically 15 to 20 min)
4. Circumnavigation of the shoreline and nearshore waters of SCI to search for possible stranded animals
5. Visual-acoustic behavior follows involving deployment of sonobuoys simultaneous with real-time acoustic and video monitoring of behavior.

TARGET SPECIES

High priority species included federally listed threatened and endangered species (e.g., fin, blue, humpback, and sperm whales), gray whales, Risso's dolphins, bottlenose dolphins, and as possible, beaked whales. Data were collected using custom-developed software on an event recorder or notebook computer equipped with WAAS-enabled global positioning system.

Approximately 190,310 individuals in 2,151 groups representing at least 6 mysticete, 10 odontocete, and 3 pinniped species were seen. The most commonly seen species group was unidentified common dolphins (*n*=461 groups), followed by California sea lions (*n*=422), Risso's dolphins (*n*= 286), fin whales (*n*=122), and bottlenose dolphins (n=103). Calf presence was associated with 5 percent of all the 331 mysticete sightings. Two percent (*n*=36) of all sightings consisted of mixed-species of marine mammals. Beginning in April 2011, systematic counts of ocean sunfish (*Mola mola*) and boats were recorded, resulting in 300 *Mola mola* sightings and 244 boats (15 percent of which were U.S. Navy boats).

TIMEFRAME

At least one survey occurred in every calendar month except December, with effort in 2011 and 2012 limited to winter when few previous surveys have been conducted. A total of 72,467 km of flight effort occurred over the 5-year period. Overall, 99 percent of the total 65,238 km of flight time was associated with a Beaufort (Bf) sea state less than 4.

DATA ANALYSIS

Data analyses focused on four tasks:

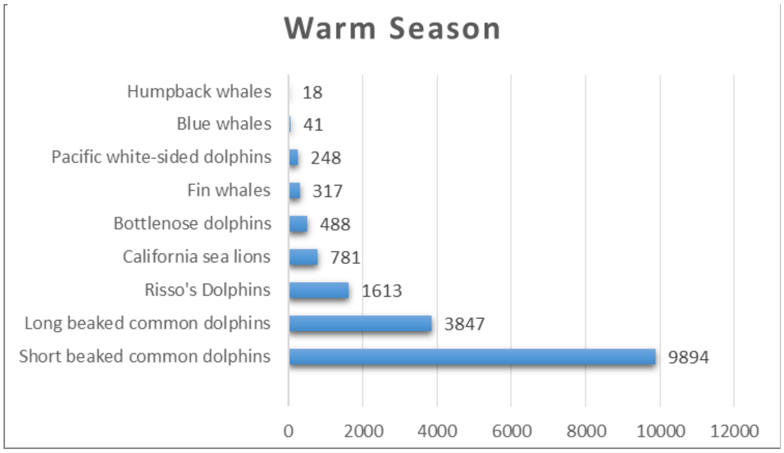
1. Estimating density and abundance by applying standard line-transect analysis approaches

2. Identifying first-observed behavior of sightings including group size, behavior state, heading, and dispersal distance between nearest neighbors within a group
3. Determining relative occurrence, distribution and abundance using resource selection function (RSF) analyses
4. Analyzing focal follow behavioral data collected on Risso's dolphins, including video.

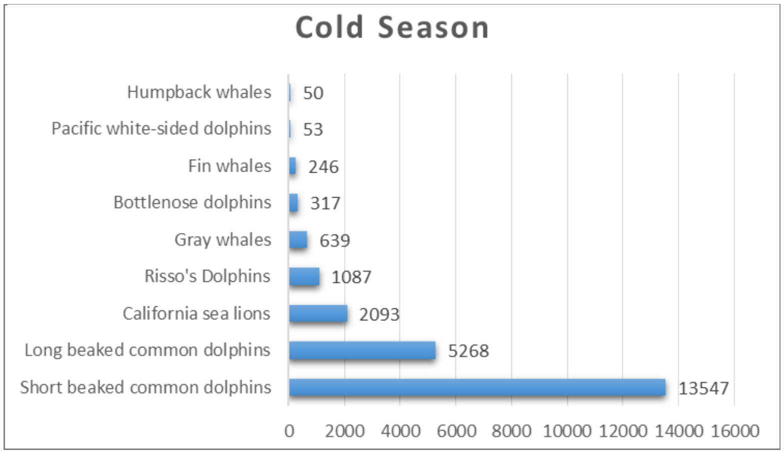
DISTANCE, multiple and linear regression, sequential, and summary statistical analyses were used to describe and quantify the potential influence of selected explanatory variables on the aforementioned response variables. Results of these analyses are summarized separately below.

DENSITY AND ABUNDANCE

Totals of 15,406 km of observation effort and 863 marine mammal sightings during 2008-2012 were suitable for estimating density and abundance because they were seen during acceptable sighting conditions (i.e., on-effort sightings during systematic lines flown in Bf 4 or less). These sightings represented at least 19 species of marine mammals.



Note that gray whales were not seen during the warm-water season (May-October).



Note that blue whales were not seen during the cold season (November-April).

Several other species were observed for which sightings were too few to estimate numbers present and/or were seen only during off-effort periods: minke whale (*n*=6 on-effort groups), northern elephant seal (*n*=5), northern right whale dolphin (*n*=5), Dall's porpoise (*n*=3), Cuvier's beaked whale (*n*=2), killer whale (*n*=2), harbor seal (*n*=1), Bryde's whale (n=1), and sperm whale (n=1).

Density and abundance estimates obtained during the 2008-2012 aerial surveys provide the most up-to-date and one of the largest marine mammal databases collected within the SOCAL Range Complex. Results also provide winter density and abundance estimates, whereas relatively few other surveys have been conducted in this region during the winter period.

FIRST-OBSERVED BEHAVIOR

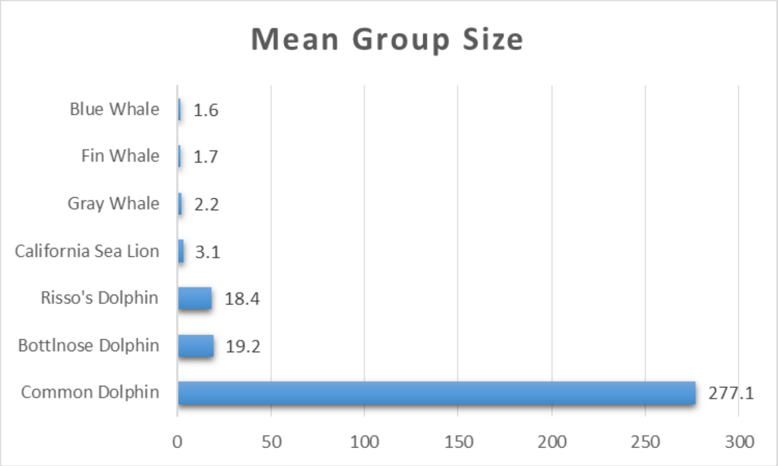
The purpose of first-observed behavior analyses was to describe and quantify typical baseline behavioral parameters of marine mammal species occurring in the study area relative to selected environmental and other explanatory variables, as very little is known about behavioral parameters for most of them. First-observed behavior analyses used the following response variables recorded at the initial sighting of each marine mammal group:

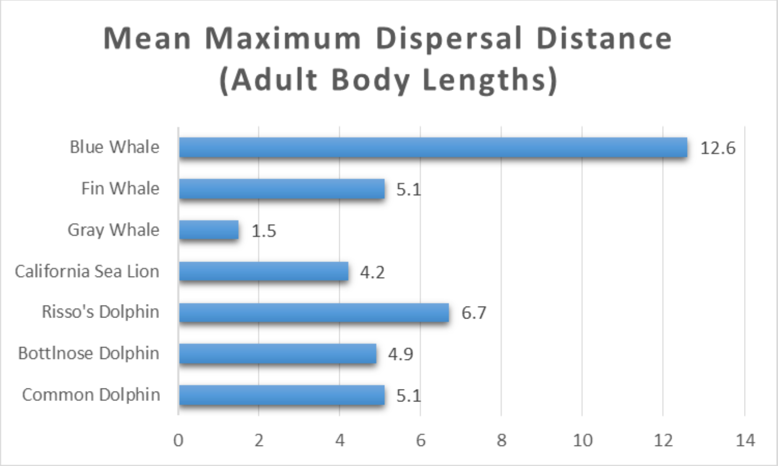
- Group size
- Travel direction (compass heading)
- Maximum dispersal (in body lengths)
- Behavior state.

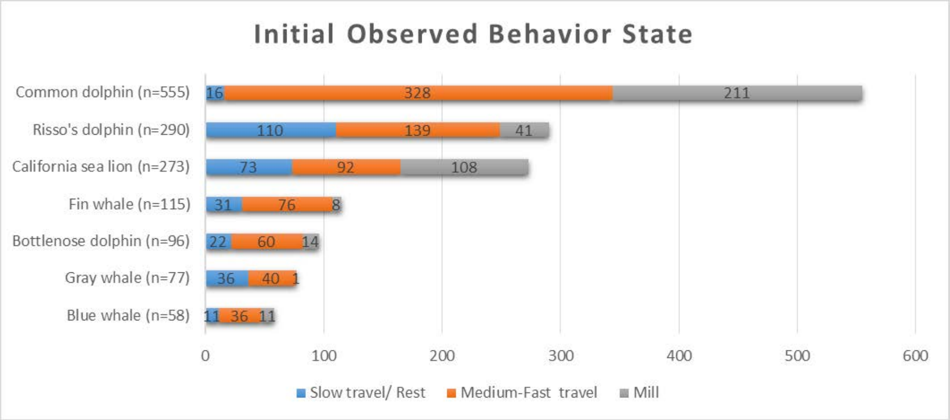
Seven species or species groups were deemed to have adequate sample sizes (n > 20) and were analyzed statistically using this approach: Risso's dolphin, common dolphin (combining short-beaked, long-beaked and unidentified common dolphins), bottlenose dolphin, fin whale, blue whale, gray whale, and California sea lion.

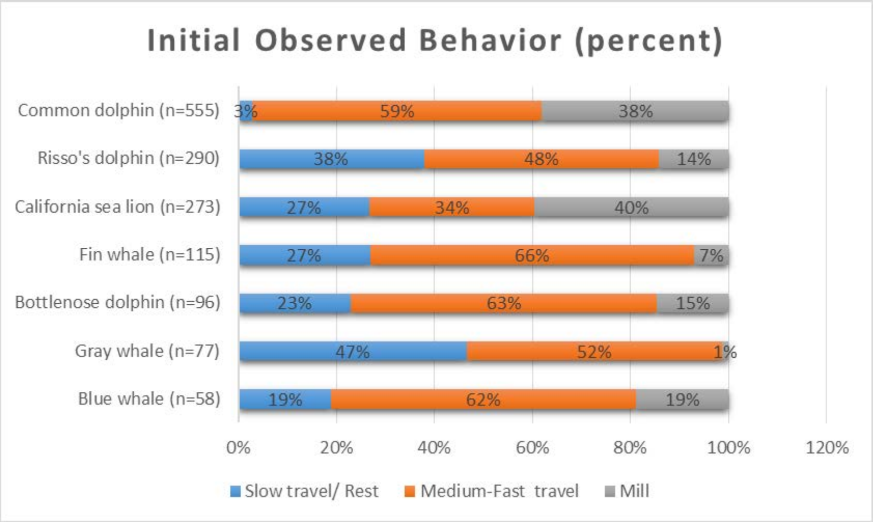
Analyses and Results

Behavior and group characteristics differed significantly across species as illustrated in the following graphs:









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Statistical analyses showed that group size and behavior state, and to a lesser extent maximum dispersal were significantly related to a number of explanatory variables for most of the seven species examined. See **Appendix G** for a complete description of the function, the variables and resources analyzed. The most interesting results follow.

Important Variables

The most significant explanatory variables associated with response variables were

- Subregion (east versus [vs.] west of SCI)
- Time of year

- Time of day
- Slope aspect (compass direction the undersea slope faced)
- Presence of a calf.

Heading was highly variable for most species and significant associations with this variable were rare.

Species Highlights

Statistical relationships for each species:

- *Risso's dolphin*: behavior was significantly influenced by time of year, time of day, calf presence, the presence of other marine mammal species, and water depth.
- *Common dolphin*: behavior was significantly associated with calf presence, subregion, time of year, slope aspect, time of day, and water depth.
- *Bottlenose dolphin:* behavior was significantly associated with calf presence, time of year, time of day, water depth, and slope aspect.
- *Blue whale*: behavioral patterns were seasonal and concentrated primarily close to shore in the study area. Group size more than tripled in fall compared to spring when feeding aggregations of blue whales were relatively common.
- *Fin whale*: apparent courting/reproductive, foraging, and nursing behaviors occur in the study area. Differential use of habitat is most notably related to subregion, time of day, and calf presence. Fin whale behavior was also highly dependent on the type of sea-floor thousands of feet beneath them, including a preference for deeper water and behavior differences over steep slopes.
- *Gray whale*: behavior was significantly influenced by subregion, season, and slope aspect. Notably, group size and maximum dispersal distance were larger west vs. east of SCI. In addition, slope aspect was strongly associated with behavior state: slow travel was 5 times more frequent over south-facing vs. north-facing slopes.
- *California sea lion*: One of the strongest predictive models was the influence of subregion on maximum dispersal distance and also behavior state. Maximum dispersal distance was significantly larger between individuals west (3.3 body lengths [BL]) vs. east of SCI (1.6 BL). In addition, milling was 2.4 times more likely to occur west vs. east of SCI.

HABITAT FUNCTION

The distribution, occurrence, and relative abundance of marine mammals was assessed by applying Resource Selection Function (RSF) analyses to identify areas commonly used by and presumably important to marine mammals. RSF modeled the relative probability of use at locations in the study area as a function of the site characteristics and behavior.

SPECIES PATTERNS

Some significant associations between habitat use and behavior were revealed for all five species examined.

1. *Bottlenose dolphin*. Travel significantly decreased from east to west in the Santa Catalina Basin (i.e., east of SCI) (too few sightings occurred west of SCI for RSF). Highest probability of occurrence was along the mainland coast and near Santa Catalina Island with very low predicted occurrence in the center of the basin. Travel frequency also decreased significantly with deeper water depths and increasing distance from shore.
2. *Risso's dolphin*. Slow travel/rest was strongly associated with deep water over steep slopes, while medium/fast travel was more likely in the middle of basins. Both behaviors were significantly more likely to occur in the eastern portion of the study area and closer to shore.
3. *California sea lion*. Milling was significantly more likely in the far western edge of the study area, with decreasing probability to the east. Medium/fast travel was significantly more likely in the western half of the study area compared to slow travel/rest which was more dispersed and patchy across the study area. Highest habitat use occurred along steep slopes surrounding the center of the San Nicolas Basin (SNB) and nearby islands.
4. *Fin whale*. The fin whale was the only species for which over approximately 50 percent of the SNB (west of SCI) had high probability of use. However, localized high-use areas occurred throughout the study area. Slow travel/rest/mill was highest along steep slopes where medium/fast travel was least likely to occur. In contrast, medium/fast travel was most likely over relatively flat basins and underwater plateaus where slow travel/rest/mill was unlikely to occur. Fin whales also preferred deeper vs. shallower waters.
5. *Gray whale*. While the nearshore coastal waters provide an important migratory path for gray whales, habitat use extended throughout all but the far west margin of the study area. Importantly, gray whale mother/calves used offshore waters. Mill/slow travel/rest were strongly associated with seafloor aspect: gray whales were unlikely to engage in this behavior over north-facing slopes.

Relevance

RSF revealed high-use areas and associated geographical features with behavior and biological function (e.g., foraging, courting, resting, etc.). Knowing baseline habitat-use and selection patterns is critical before attempting to interpret potential effects (or lack thereof) of U.S. Navy activities.

RISSO'S DOLPHIN FOCAL FOLLOWS

Risso's Overview

Opportunistic focal behavioral observations (i.e., focal follows) (Altmann 1974, Mann 1999) were conducted on 17 marine mammal species. Data consisted of periods of at least 5 min when a selected focal group was circled by the aircraft. However, analyses were limited to selected focal behavioral data for Risso's dolphins given this species had the largest sample size, its tendency to remain for long periods near the water surface, and its identification as a priority species within the U.S. Navy's SOCAL Marine Species Monitoring Plan. High-definition (HD) video was taken of focal Risso's dolphin groups and behavioral data were recorded with an event recorder in a customized datasheet using custom software. Post-field analysis involved transcribing behavioral data from video onto a custom Excel spreadsheet.

Risso's Analyses

Analyses focused on a subset of three response variables consisting of:

1. Heading (in degrees magnetic),
2. Maximum dispersal distance and
3. Behavior state.

There were 51 Risso's dolphin groups recorded during focal-follow sessions ranging in duration from 5 to 59 min (mean duration 21.6, standard deviation [SD] = 12.9). The number of 30-second (sec) scan periods with relevant data (e.g., reorientation rate, maximum dispersal distance, or behavior state) for all focal follows combined totaled 1,446 useable data points for reorientation rate, 1,275 data points for maximum dispersal, and 1,359 data points for behavior state.

Risso's Results

- The behavior of Risso's dolphins was significantly related to calf presence and time of day. Notably, Risso's dolphins were 13 times more likely to slow travel/rest than common dolphins and 1.7 times more likely than bottlenose dolphins. This difference is likely related to the presumed predominant nocturnal foraging habits of Risso's dolphins.
- A significant tendency to slow travel-rest indicates that Risso's dolphins are a good candidate focal species to study relative to potential effects of Navy MFAS. If Risso's dolphins were to react to such activity, a change in behavior state to medium-fast travel away from the disturbance would be expected. This behavior state transition has frequently been reported among other delphinids as a significant change in response to anthropogenic disturbance, including vessels and human swimmers (e.g., Orams 1997, Constantine 2001, Forest 2001, Constantine et al. 2003, 2004). A more detailed examination of video and field data, including other response (e.g., dive and surface duration) and

explanatory variables, may reveal other significant baseline patterns that may be sensitive indices of disturbance.

CONCLUSIONS

1. In summary, results indicate that a number of environmental and other variables significantly influence behavior, group size, abundance, and habitat use patterns of marine mammal species in the SOCAL Range Complex. Not only were significant difference found between the subregions west and east of SCI, other highly unexpected results emerged from these surveys that merit additional research.
2. It is important to note that cetaceans are hardly ever “individuals, but are instead socially complex groups of animals. It is critically necessary that an evaluation of disturbance includes evaluation of group behaviors, social interactions, distances apart, potential changes or masking of vocalizations, and—as possible—assessments of changes in affiliations. Changes in overall group behavioral patterns and social disruption are likely to be important as responses to anthropogenic activities.

   These factors must be considered when evaluating potential effects (or lack thereof) of U.S. Navy activities on marine mammal species, particularly differences east and west of SCI given the expected higher level of U.S. Navy MFAS training activities west of SCI.

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AIC	Akaike's Information Criterion
Bf	Beaufort sea state
BL	body length(s)
BRS	Behavioral Response Study
CDS	Conventional Distance Sampling
CO	Calibrated omni-directional
DoN	Department of the Navy
DF	Direction-finding
ESA	Endangered Species Act
ft	foot/feet
hr	hour(s)
ICMP	Integrated Comprehensive Monitoring Program
km	kilometer(s)
kt	knot(s)
m	meter(s)
MFAS	mid-frequency active sonar
MMPA	Marine Mammal Protection Act
min	minute(s)
MTE	military training events
NM	nautical mile(s)
NAVFAC	Naval Facilities Engineering Command
NMFS	National Marine Fisheries Service
NW	northwest
PAM	passive acoustic monitoring
RSF	Resource Selection Function
SAG	Scientific Advisory Group
SCB	Southern California Bight
SCBa	Santa Catalina Basin
SCI	San Clemente Island
SD	standard deviation
SE	southeast
sec	second(s)
SNB	San Nicolas Basin
SOCAL	Southern California
SPUE	Sightings Per Unit Effort
U.S.	United States
WNW	west-northwest

1.0 INTRODUCTION

BACKGROUND AND REPORT OBJECTIVE

This report provides a comprehensive summary and analysis of aerial surveys conducted on the United States (U.S.) Navy's Southern California (SOCAL) Range Complex to monitor marine mammals and sea turtles between October 2008 and April 2012, as required by the National Marine Fisheries Service (NMFS). The U.S. Navy developed range complex-specific monitoring plans to provide marine mammal and sea turtle monitoring as required under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973. The primary purpose of these surveys was to meet goals identified in the U.S. Navy's SOCAL Marine Species Monitoring Plan (Department of the Navy [DoN] 2009b, 2010a, 2011c) and Integrated Comprehensive Management Program (ICMP) (DoN 2010b). This involved collecting baseline data on occurrence, distribution, numbers and behavior of marine mammals and sea turtles. In particular, the integrative and comprehensive analyses reported herein are directly relevant to addressing "Overarching (Specific Study) Questions," components of the Conceptual Framework, and ICMP and Science Advisory Group (SAG) goals associated with the SOCAL Range Complex. Of particular relevance is addressing the U.S. Navy's "Overarching Question No. 6: *Are there existing unanalyzed U.S. Navy-funded or other agency data that can be used to further our understanding of the proposed questions?"* and the related sub-question No. 6a directive: "*Conduct further analysis of monitoring data collected on the SOCAL Range Complex from previous years focusing on 2008-2011 first.*" This report directly addresses these questions as well as others identified in the U.S. Navy's ICMP and the SAG Recommendations (DoN 2011b).

Baseline data on marine mammals are needed to compare and identify potential changes (or lack thereof) in occurrence, numbers, distribution, and behavior in response to naval activities particularly involving mid-frequency active sonar (MFAS) and underwater detonations (explosive events). Very little is known about the behavior of most marine mammal species while they inhabit the SOCAL Range Complex. Note that no sea turtles were seen. Although sea turtles are commonly seen during similar aerial surveys in the U.S. Navy's Hawaii Range Complex (e.g., Smultea and Mobley 2009, DoN 2011a), none have been observed on the SOCAL Range Complex during any of the aerial surveys from 2008 to 2012. Thus, they are not further addressed herein.

Numerous aerial surveys have been conducted to address various questions and were funded by different agencies over the last four decades in the Southern California Bight (SCB) (e.g., Dohl et al. 1986, Forney et al. 1995, Forney and Barlow 1998, Carretta et al. 1998, Carretta et al. 2000, Barlow et al. 2009, DoN 2010c, 2011c, 2012, Eguchi and Seminoff 2012). These surveys have focused on the occurrence, distribution, abundance, and density of marine mammals, primarily from spring through fall, with minimal effort conducted during winter. None of these surveys focused on behavior. Vessel-based and tagging studies in the SOCAL Range Complex have provided detailed information on the behavior of individual cetaceans, particularly in recent years (e.g., Falcone et al. 2009, Schorr et al. 2010, Falcone and Schorr 2011), including behavioral responses to playback of MFAS (e.g., Southall et al. 2012). Passive acoustic monitoring (PAM) studies have provided detailed data based on large sample sizes characterizing acoustic behavior, and have documented changes in calling and other behavior in the presence of MFAS in the SOCAL Range Complex (Hildebrand et al. 2011) and other areas (Norway, Florida, Hawaii) (e.g., Moretti et al. 2006, 2010, Au and Oswald 2011, Au 2012). Studies from different platforms (e.g., vessel, aerial, attached tags) complement one another, as each has its own benefits and limitations (e.g., Dawson et al. 2008). Advantages and unique perspectives from the aerial platform include (1) coverage of a large area in a short period; (2) a "bird's eye" view of behavior and inter-individual spacing and interactions, including up to several large whale lengths below the water surface; (3) when flown outside the hearing range of observed animals, an aircraft can be used as a non-intrusive observation platform (unlike vessels, whose sounds pervade for many miles below the water surface [summarized in Richardson et al. 1995]); and (4) the ability to collect line-transect density and abundance data without concerns about platform attraction or avoidance, as is an issue with vessel-based surveys.

Fifteen aerial surveys were conducted on behalf of the U.S. Navy in selected subregions of the SOCAL Range Complex (i.e., the study area) to monitor and provide baseline data on the occurrence, distribution, numbers, and behavior of marine mammals between October 2008 and April 2012; these are summarized herein and in **Appendices A-H**. Results of each survey were summarized in the U.S. Navy's annual reports submitted to NMFS (DoN 2009a, 2010c, 2011c, 2012) as well as in contractor reports submitted to the U.S. Navy (e.g., Smultea et al. 2009, 2010a, 2011a, 2012). Additional funding has been provided by the U.S. Navy to conduct specific analyses for some of these results and surveys. This additional effort has included density and abundance estimates (Jefferson et al. 2011, 2012), analyses of first-observed behaviors (Smultea et al. 2011b), and an inventory of video taken during focal follows (Smultea and Bacon 2011). In addition, a peer-reviewed journal article was published from these data (Smultea et al. 2012b), with two more articles close to submission (Jefferson et al. in prep., Smultea et al. in prep.). Eighteen conference presentations have been given since 2009 and are summarized in DoN 2011a, 2012. However, the full October 2008 through April 2012 database for the study area aerial surveys had not been previously integrated or summarized until now. Furthermore, analyses of focal follows have not been conducted until this document where focal follows of Risso's dolphins are presented (focal follows of other species remain to be analyzed). Such analyses and integration are important to assess the effectiveness of meeting monitoring goals and to identify future monitoring goals relative to NMFS requirements and U.S. Navy management policies.

REPORT ORGANIZATION

This report is organized into the following stand-alone sections, each with its own introduction, methods, and results specific to the focus of that section:

1. *General Overview and Results Summary* presents the approach, methods, and results in terms of effort and sightings of the 2008-2012 SOCAL Range Complex aerial surveys;

2. *Integration of Winter Density and Abundance Estimates* presents integrated estimates of density and abundance of marine mammals applying line-transect DISTANCE analyses for the 15 aerial survey conducted in the study area from October 2008 through April 2012;
3. *First Observed Behavior Analysis* summarizes first-observed behaviors of marine mammals including behavior state, heading, and inter-individual dispersal distance using multi-variate statistics relative to habitat and social parameters; Focal Behavior / Video Analysis: Risso's Dolphin: describes results of sequential and other analyses of group behavior of Risso's dolphins during focal follows; and
4. *Marine Mammal Distribution, Occurrence, and Relative Abundance Analysis* summarizes numbers and habitat use patterns of marine mammals based on (1) selected habitat parameters using a Resource Selection Function (RSF) analysis (Manly et al. 1993, 2002), and (2) a summary review and comparison of the 2008-2012 study area aerial survey data relative to historical data on the frequency of occurrence of marine mammals in the SCB.

In addition to the above sections, nine appendices are provided at the end of this report as follows:

- *Appendix A: Tables* provides summary tables of results including effort, sightings, types of statistical analyses conducted.
- *Appendix B: Figures* presents figures related to results including sighting and effort maps, and selected summary behavioral graphs.
- *Appendix C: Photos* contains selected photos of high priority and unusual cetacean species or events taken during the survey period.
- *Appendix D: Survey Methodology* provides a detailed summary of the survey protocol, including figures and tables defining and describing behavioral definitions (i.e., an ethogram), survey personnel roles, etc.
- *Appendix E: Report–Density and Abundance of Marine Mammals* provides detailed descriptions, figures and tables of results summarized in Item 2 above.
- *Appendix F*: *First-Observed Behaviors of Marine Mammals* contains detailed statistical methods and results.
- *Appendix G*: *Focal Follows of Risso's Dolphins* provides detailed statistical methods and results.
- *Appendix H*: *A Case Study* contains the behavior of a focal group of Risso's dolphins based on video data.
- *Appendix I: Marine Mammal Resource Selection Function Analyses* provides detailed statistical methods and results.

A map of the SOCAL Range Complex study area is shown below (**Figure 1**). To simplify report narrative, short summaries of some of the appendix reports are provided in the main body of the report, and tables and figures are presented in appendices rather than within the text due to their large quantity. Scientific names are provided in **Appendix A.**

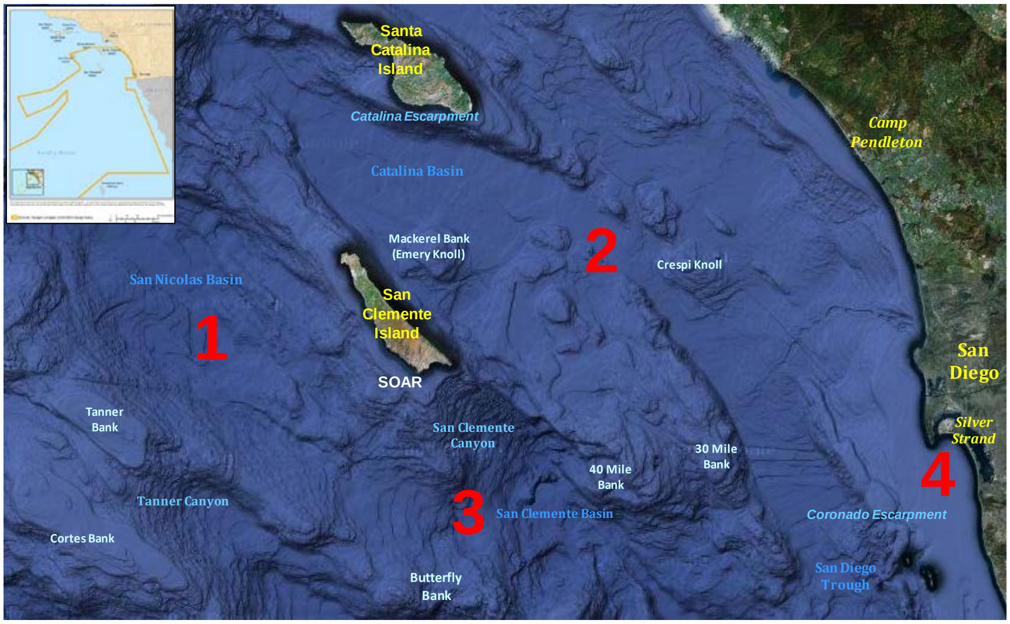

Figure 1. Priority areas selected by the U.S. Navy for marine mammal and sea turtle monitoring within the U.S. Navy's Southern California Range Complex: (1) San Nicolas Basin, (2) Santa Catalina Basin, (3) south of San Clemente Island/San Clemente Basin, and (4) Silver Strand.

2.0 GENERAL OVERVIEW AND RESULTS SUMMARY

APPROACH

The primary focus of the 2008 through 2012 aerial surveys was to collect recent baseline data on marine mammals inhabiting the SOCAL Range Complex study area. This effort represents the most extensive, focused survey effort on the SOCAL Range Complex. It also represents some of the first systematically quantified assessments of the behavior of a number of poorly-described species, including species listed under the ESA (e.g., blue, fin, and sperm whales). Other little-known species addressed herein include the short-beaked common dolphin, long-beaked common dolphin, and Risso's dolphin. An additional focus of these surveys was to identify any observable unusual behaviors potentially indicative of effects of U.S. Navy training activities involving MFAS. Given these overarching goals, in 2008, the U.S. Navy and its contractors identified a suite of measurable parameters that could be assessed from aerial surveys. These parameters consisted of variables that could be used to identify potential effects of U.S. Navy activities based on results of other studies assessing impacts of anthropogenic activities and sounds on marine mammals. For example, field studies have shown that spacing between individuals may decrease or increase in response to various stimuli (e.g., Morretti et al. 2006, Smultea and Würsig 1995, Bacon et al. in press, Bredvik et al. 2011). The parameters are summarized in **Appendix A**. Because few data were available to quantify typical or "normal" behavior for most of the species occurring off southern California, let alone within the SOCAL Range Complex, data from 2008 through 2012 were meant to provide a relative baseline for future determination of potential effects.

METHODS

Methods for aerial surveys have been described in detail in past reports; authors recommend referring to Smultea et al. (2009) for detailed description. A summary of these methods integrated across the 14 aerial surveys are provided in **Appendix D** as a single comprehensive reference source, including any changes made across surveys (e.g., equipment, personnel roles, etc.). Fourteen surveys have been conducted primarily from a Partenavia P68-C or a Partenavia Observer, with one remaining survey from an Aero-Commander (**Appendix A,** Table A-1). In addition, 2 days during one survey were flown from a Bell 206 helicopter to assess the utility of this platform for conducting focal-follow observations (see Smultea et al. 2010 for the results of this assessment). All 15 surveys involved systematic searching along pre-determined east-west transect lines located primarily east (Santa Catalina Basin) or west (San Nicolas Basin) of SCI (**Appendix B,** Figure B-1. One survey (November 2008) occurred in a grid south of SCI, and three surveys in Silver Strand just south of San Diego (winter 2011). Winter density and abundance estimates of marine mammals were applied using line-transect DISTANCE analyses (Buckland et al. 2001, 2004). In 2009 and 2010, the team aerial circumnavigated the shoreline of SCI on one day during three surveys to search for injured or stranded marine mammals or sea turtles, in addition to conducting line-transect and focal follow effort.

All 15 aerial surveys also involved some level of focal follow observation effort, depending on the specific survey goals. The general approach was to depart San Diego as soon as conditions permitted (i.e., 1 hour [hr] after sunrise, fog layer lifted, no rain, Beaufort sea state [Bf] <5), following standard line-transect survey protocol along systematic transect lines until a priority focal individual/group was located (priority included ESA-listed species, beaked whales, and Risso's dolphins - see **Appendix D**). The focal group was then circled at 365 to 457 meters (m) (1,200 to 1,500 feet [ft]) at radial distances of 0.5 to 1.0 kilometers (km) to avoid potential disturbance of the focal group. The latter protocol was developed during studies of bowhead whales in the Arctic relative to offshore oil and gas exploration activities (e.g., Richardson et al. 1985a,b, 1986, 1990, 1995, Würsig et al. 1985, 1989). These studies indicated that at these distances and altitudes, no significant changes in whale behavior were detected relative to the observation aircraft operating well outside the theoretical 26-degree incident angle of sound transmission emitted from an aircraft through the air-to-water interface (i.e., Snell's cone; see diagram in **Appendix D,** Figure 1) (Urick 1972; Richardson et al. 1995). In winter 2012, sonobuoys were deployed from the aircraft to simultaneously monitor vocal and visually observed behavior of cetaceans (see Acoustic-Visual Behavior Study subsection). Descriptions of the four primary survey modes (search, verify, focal follow, shoreline survey) and types of effort are provided in **Appendix D**.

During eight surveys from 2008 to 2010, aircraft personnel consisted of one pilot, a recorder/photographer/videographer in the co-pilot seat, and two observers in the center seats looking out bubble windows (**Appendix D,** Table D-3). Beginning in 2011, the U.S. Navy required two pilots; this requirement necessitated that the recorder/photographer/videographer was seated in the rear left seat.

STATISTICAL ANALYSES

Most statistical analyses were conducted by biostatisticians at WEST, Inc., using the Matlab and R software programs. The exception was density and abundance analyses that were conducted by Clymene Enterprises, who used DISTANCE 6.0 software. Statistical analysis approaches were chosen by the field biologists (who had designed the field protocols and collected and summarized the data) in consultation with the biostatisticians and other biologists experienced in assessing impacts of anthropogenic activities on marine mammals. Table 1 in **Appendix D** lists all the original hypotheses identified when the monitoring studies first began in 2008. These hypotheses were developed by the team of experienced biologists in the context of the U.S. Navy's SOCAL Marine Species Monitoring Plan goals (DoN 2009b), and were reviewed by U.S. Navy personnel from the Naval Facilities Engineering Command (NAVFAC) Southwest and Pacific, and Pacific Fleet.

Table 12 in **Appendix A** lists the statistical analyses applied to each of the core analysis tasks (i.e., density and abundance estimates, focal follows of Risso's dolphins, first-observed behaviors, and RSF analyses). A comprehensive list of all the selected "response" (i.e., dependent) variables and "explanatory" (i.e., independent) variables is provided in Table 1 in **Appendix F**. Specific response and explanatory variables used for each of the core analyses are identified separately in each associated appendix (i.e., **Appendices F-H**). As indicated in the *Approach* section above, response variables were chosen that included quantifiable indices used in other studies to describe baseline distribution and behavior and/or to identify effects of underwater anthropogenic sounds on marine mammals (e.g., reviewed in Richardson et al. 1995, Southall et al. 2007.

For the 2008 through 2012 baseline results discussed herein, the statistical analysis goals were to:

1. Identify if and how the selected marine mammal response variables may be influenced by explanatory variables (e.g., time of day, season, water depth, slope, etc.) under baseline "naturally occurring" conditions.
2. Identify response variables that could be used in the future to assess and differentiate potential changes in response to U.S. Navy training activities.

Species selected for statistical analyses were those determined to have adequate sample sizes by the biostatisticians in consultation with the biologists, depending on the analyses. These included up to 10 species per core analysis task as follows (listed in alphabetical order by common name): blue whale, bottlenose dolphin, California sea lion, fin whale, gray whale, humpback whale, long-beaked common dolphin, Pacific-white sided dolphin, Risso's dolphin, and short-beaked common dolphin. Minimum sample size was considered to be 8 samples per species for density and abundance analyses, 21 samples for first-observed behavior, and 25 samples for RSF statistical analyses. A sample size of 51 Risso's dolphin groups was used for focal group behavioral analyses as this was the largest focal sample size of all the species during the study.

Specific statistical analysis methods are discussed separately for each core analysis task under later corresponding section headings and in the more detailed associated **Appendices F** through **H**.

See **Appendix D** for further details on general methodology, software, and equipment.

RESULTS AND DISCUSSION

The 15 aerial surveys conducted in the study area from October 2008 through April 2012 spanned all months of the year except December. This effort covered all four solar seasons (winter, spring, summer, autumn). Survey dates, total effort and sightings, and other summary details for each of the 15 surveys are presented in **Appendices A** and **B**. In 2008-2010, surveys occurred only in late spring, summer, and fall. To facilitate comparisons with past aerial surveys focused near SCI in 1998-1999 by Carretta et al. (2000), we followed their definition of the cold- (November-April) and warm-water seasons (May-October) characterizing SCB waters. We conducted eight surveys during the cold-water season and seven surveys in the warm-water season.

Effort and Number of Sightings

A total of 72,647 km (39,129 nautical miles [nm]) of survey effort occurred during the 15 surveys on 86 days in 2008-2012 (**Appendix A,** Table A-1 and **Appendix B,** Figure B-3). The majority (34 percent or 21,503 km) of this effort consisted of systematic line-transect effort, followed by transit, circling, and connector effort. Nineteen species of marine mammals were confirmed, including 6 mysticetes, 10 odontocetes, and 3 pinnipeds. A total of 2,151 marine mammal sightings (i.e., groups) were made comprising an estimated 190,310 individuals (**Appendix A,** Table A-3). The most frequently seen species group in terms of number of sightings (*n*= 461, 21 percent) and individuals (n= 108,606, 57 percent) was the common dolphin (*Delphinus* spp.) followed by the California sea lion and Risso's dolphin (**Appendix A,** Table A-3). The most commonly seen mysticete whale was the fin whale followed by the gray whale and blue whale.

Most species (*n*=14, 74 percent) were seen year-round though some species were seasonal. Gray whales, killer whales, and Dall's porpoises were seen only during the cold-water season while harbor seals, Bryde's whales, and sperm whales were seen only during the warm-water season (**Appendix A,** Table A-5). Common dolphins had the largest mean group size of 236 (**Appendix A,** Table A-5). Sightings per unit effort (SPUE) were highest for common dolphins (0.008 sightings/km flown) followed by California sea lions and Risso's dolphins (these are approximate, as they include all effort types [e.g., transit, circling, systematic) and all Bf) (**Appendix A,** Table A-5). The predominant Bf was 3 (39 percent) followed by Bf 2 (35 percent) (**Appendix A,** Tables A-2 and A-13) based on the total 65,238 km of all observation effort during all leg types (**Appendix A**, Table A-13). This was followed by Bf 1 (13 percent), Bf 4 (12 percent) and Bf 5 (1 percent). (More detailed estimates of density and abundance of marine mammals are discussed in the next chapter and in **Appendix E**).

Dead Sightings

Seven (0.003 percent) (**Appendix A,** Table A-1) of the total 2,151 sightings consisted of dead animals. In November 2008, a dead California sea lion was seen on 2 consecutive days near the same location just off central-west SCI. A dead, subadult male blue whale was also seen during November 2008, south of SCI, with rope line loosely draped around its lower body and the line was attached to two fishing buoys. Two blue sharks (*Prionace glauca*) were videotaped circling around the carcass and over 30 gulls (*Laridae* sp.) were recorded on top of the carcass. Two dead, floating unidentified sea lions (probable California sea lions) were seen separately in July 2009. A dead humpback whale was seen on 10 and 11 May 2011; these two sightings were presumed to be the same animal based on examination of photos of the underside of the tail flukes. A blue shark about 3 m (9.8 ft) long was seen circling the dead humpback whale on 11 May. On 10 May, the whale was seen about 7 km (4 nm) west of Soledad, San Diego, and no sharks were seen. A dead California sea lion was seen in February 2012.

Calf Sightings

Overall, 165 (8 percent) of the total 2,151 cetacean sightings contained at least one calf. A calf was considered to be an individual two-thirds or less the length of an adult, that swam beside and slightly behind an adult (Shane 1990, Fertl 1994). Fifteen (5 percent) of the total 331 mysticete sightings had a calf (**Appendix B,** Figure B-24). In comparison, 150 (12 percent) of the total odontocetes sightings had at least one calf. The only confirmed species for which a calf was never observed was the minke whale (total 11 sightings), Bryde's whale (2 sightings), Cuvier's beaked whale (4 sightings) and Dall's porpoise (5 sightings). The most frequently sighted species with a calf was the common dolphin (38 percent of 172 sightings). No pinnipeds pups were confirmed at sea. Apparent nursing was observed among cetaceans on three occasions including among gray, fin, and killer whales (Moore et al. 2012). Nursing behavior as well as "calf riding mother" behavior was documented in video for 2 sightings, both of which were gray whales (Moore et al. 2012). Future examination of the many photographs, particularly of delphinids, would likely reveal other apparent nursing events.

Mixed-Species Sightings

Thirty-six (2 percent) of 2,151 total sightings consisted of mixed-species sightings (i.e., at least two different species swimming together and/or interacting) (**Appendix A,** Table A-4). The species most frequently seen associated with another marine mammal species was the Risso's dolphin (17 or 6 percent of 283 total sightings of this species). Risso's dolphins were seen with one to two other species. The greatest number of species seen together was three on three different occasions. These mixed sightings consisted of: (1) sperm whales, Risso's dolphins, and northern right whale dolphins, (2) Risso's dolphins, California sea lions, and unidentified dolphins, and (3) Pacific white-sided dolphins, common dolphins, and California sea lions. The most unusual mixed species sighting was 24 sperm whales (including four calves) with 11 Risso's dolphins and approximately 50 northern right whale dolphins on 12 May 2011 (Smultea et al. 2011a, Bredvik et al. 2011, Bacon et al. in press). This encounter was videotaped for 67 minutes (min) and included footage of Risso's dolphins repeatedly charging the heads of adult sperm whales, which responded by dropping their lower jaw and exposing their white lower lips/jaws (see photographs in **Appendix C,** Photo 6). This was believed to be a case of kleptoparasitism, whereby the Risso's dolphins may have been charging the sperm whales to induce regurgitation of prey remains that the dolphins could consume. The latter has been suggested for a sighting of pilot whales harassing sperm whales in the Gulf of Mexico when squid remains were found nearby (Weller et al. 1996).

Other Marine Species Sightings

Opportunistic and/or unusual sightings of other marine species were recorded during survey flights as requested by the Navy Technical Representative. These included approximately 30 large gulls perched on a dead blue whale's (see *Dead Sightings* above) ventrum and two blue sharks seen swimming near the whale's head and peduncle (2008); a red crab aggregation (extending 1 kilometer [km] long and about 200 meters [m] across); numerous krill aggregations (fish schools including a school of about 30 tuna near a kelp flotsam), three other shark sightings of six individuals, and ocean sunfish (*Mola mola*). Ocean sunfish sightings were recorded systematically during the April 2011 survey (and continued through the 2012 survey period). Ocean sunfish sightings are summarized in **Appendix A,** Table A-1. During the 2011-2012 surveys, 300 ocean sunfish were observed (**Appendix C,** Figure B-25). The highest number of individuals occurred in January 2012 (n=91) and April 2011 (n=68).

Vessels

Beginning with the April 2011 survey, vessel counts were recorded during systematic transect lines (and continued through the four winter 2012 surveys). A total of 244 vessels were counted and are summarized in **Appendix A**, Table A-13. Vessel types in descending order of frequency included non-Navy boats (84 percent), U.S. Navy boats (12 percent), helicopters (1 percent), U.S. Navy aircraft (1 percent), and submarines (1 percent) (**Appendix B**, Figure B-24). Based on the 11,384 km of associated systematic effort in 2011 and 2012, the overall number of vessel/aircraft SPUE was 0.02 vessels per km flown (**Appendix A**, Table A-14). The SPUE of Navy boats was 0.03 per km flown. No boats or aircraft were seen west of SCI (**Appendix B**, Figure B-24). In particular, high concentrations of vessels occurred off Silver Strand just outside San Diego Harbor and near Avalon, Santa Catalina Island (**Appendix B**, Figure B-24).

Behavioral Observations and Video/Photography Summary

A total of 300 focal group behavior sessions were conducted in 2008 through 2012 (**Appendix A,** Table 1). Fifty-three percent (n = 160) of these were 5 to 9 minutes (min) in length, with the remainder greater than 10 min long. One-hundred forty-six of the 300 focal sessions were videotaped. An estimated total of 2,072 min of useable video (see **Appendix A**, Table A-1 and Smultea and Bacon 2011) was obtained during the 15 surveys. Focal sessions involved the following 17 species: blue, fin, minke, gray, humpback, Bryde's, Cuvier's beaked, sperm, and killer whales; and Risso's, bottlenose, short-beaked common, long-beaked common, and northern right whale dolphins; California sea lion; and Dall's porpoise. Statistical analyses of 51 focal follows of Risso's dolphins are described under *Focal Behavior / Video Analysis* and **Appendix G**.

Selected first-observed behavior and group parameters were obtained for up to 1,649 of the total 2,151 sightings (see Methods and **Appendix D** for the list of parameters). These parameters were collected on 7 of the total 19 species seen. This included up to 78 gray whales, 122 fin whales, 65 blue whales, 295 Risso's dolphins, 103 bottlenose dolphins, 564 common dolphins (including long- and short-beaked), and 422 California sea lions. Results of statistical analyses of first-observed data for the seven most commonly seen species are presented in First Observed and Behavior Analysis sub-section and **Appendix F**.

A total of 18,935 photographs were taken in 2008 through 2012. Photographs were used to confirm species, as needed. Photographs of common dolphins were examined by a species expert (Dr. T.

A. Jefferson) to confirm species identification as short- vs. long-beaked common dolphins when possible.

Acoustic-Visual Behavior Study

The acoustic-visual behavior study conducted in winter 2012 was a pilot study designed to simultaneously collect both visual and acoustic data from focal groups of whales and dolphins being monitored from an aircraft circling overhead. Project goals included: (1) integration of hardware and software to allow simultaneous acoustic and visual data-collection and processing, and (2) real-time mapping of acoustic and visual data for marine mammals. Our ultimate goal was to attempt to provide information about behaviors of whales that can be detected acoustically, and to attempt to correlate these with surface and sub-surface behaviors (as monitored from the airplane in real-time and recorded on video and/or audio files). Sonobuoy deployments were also intended to provide important information on the general acoustic environment in the near vicinity of focal groups (e.g., anthropogenic noise, other marine mammal sounds, and natural noise).

The methods used in this component of the study involved integrating established visually based behavioral monitoring protocols (e.g., see Smultea and Lomac-MacNair 2010 and **Appendix D**) with PAM methods using sonobuoys. The integration was mostly implemented by modifying existing software programs that were already in use for aerial surveys (e.g., Mysticetus) or were developed for passive acoustic data acquisition and processing. See Smultea et al. (2012a) for detailed methods for the Acoustic-Visual Behavior Study.

Seven partial or whole flight days with sonobuoy effort occurred, for a total of 23.7 hours (hr) of flight effort (**Appendix D,** Table D-8). A total of 23 sonobuoys were deployed: 21 in the Direction-finding (DF) mode and 2 in the Calibrated omni-directional (CO) mode (**Appendix D,** Table D-9). The total 23 sonobuoys were deployed as follows: 1 during initial testing in the Santa Barbara Channel, 12 on fin whale focal groups (1 of which failed), 6 on gray whales (1 of which failed), 2 on a solitary humpback whale (but only fin whale sounds were detected), and 2 (both CO mode) on Risso's dolphins. One of the sonobuoy failures occurred because its flotation bag did not deploy (a common source of failure in other studies). Overall, the sonobuoy failure rate was approximately 9 percent (2 of 23 sonobuoys).

Because this was a pilot study, methods and protocols were refined and modified continuously throughout the effort. For example, since the existing software was not designed specifically to be used in this way, we had to modify it significantly for the project's requirements. The limited space and cargo capacity of our Partenavia observation aircraft made this effort even more challenging. For example, acoustic hardware had to be reduced into a much smaller package than typically used on ships. Also, the additional weight of the sonobuoys and acoustic processing hardware limited both the number of observers that could be carried and flight duration. Finally, the space constraints made videography (particularly in the first 3 days of effort) very difficult. Considerable effort was required to set up, integrate, and test hardware and software as well as establish and refine new protocols. In spite of these challenges, the team was able to collect both acoustic and visual data that provided a unique insight into the behaviors of marine mammals that could not be obtained using other methods. In addition, the team demonstrated that sonobuoys could be deployed from small boats, repositioned as needed and retrieved to eliminate any marine debris resulting from this effort. The data collected from this effort are directly relevant to goals of the U.S.. Navy's SOCAL Marine Species Monitoring Plan to describe baseline behavior and occurrence of marine mammals in the SOCAL Range Complex (DoN 2011c).

3.0 ANALYSIS AND INTEGRATION OF WINTER DENSITY AND ABUNDANCE ESTIMATES

This section summarizes the analysis and integration of systematic line-transect data collected from the aircraft during 15 aerial surveys conducted in the marine waters around SCI in 2008 through 2012. Density and abundance estimates are provided for both the warm-water (May-October) and cold-water seasons (November-April). We previously estimated density and abundance for the warm-water seasons of 2008 through 2011 in Jefferson et al. (2011) and for winter 2011 in Jefferson et al. (2012). The latter analyses were based on systematic line-transect effort lines plus the shorter, perpendicular connecting "connector" lines. Herein, we provide updated and refined estimates for the 2008 through 2012 warm-water and 2011 through 2012 cold-water seasons based only on systematic line-transect effort (i.e., we exclude the connector lines, due to concerns about introducing potential bias). Estimates are provided for the survey area subregions located west and east of SCI (i.e., San Nicolas Basin and Santa Catalina Basin, respectively). **Appendix E** provides a more detailed stand-alone report along with figures and tables.

METHODS

Field methods and equipment for collecting data suitable to estimate density and abundance followed standard line-transect protocol (see Methods under Overview above and **Appendix E**). Density and abundance estimates were made using standard line-transect methods (Buckland et al. 2001) and the software DISTANCE 6.0 under a conventional distance sampling (CDS) approach. Due to limited sample sizes for some species, sightings were pooled to provide four estimates of the detection function for baleen whales, large delphinids, small delphinids, and California sea lions. Estimates of density and abundance were made for species observed a minimum of eight times on effort.

RESULTS AND DISCUSSION

Totals of 15,406 km of observation effort and 863 marine mammal sightings during 2008 through 2012 were suitable for estimating density and abundance (on-effort sightings during systematic lines flown in Bf 4 or less). These sightings represented at least 19 species of marine mammals. For the warm-water season in 2008 through 2012, the estimated average number of individuals present (in descending order) were 9,894 short-beaked common dolphins, 3,847 long-beaked common dolphins, 1,613 Risso's dolphins, 781 California sea lions, 488 bottlenose dolphins, 317 fin whales, 248 Pacific white-sided dolphins, 41 blue whales, and 18 humpback whales (see Figures and Tables in **Appendix E**). During the cold-water season, the estimated averages were 13,547 short-beaked common dolphins, 5,268 long-beaked common dolphins, 2,093 California sea lions, 1,087 Risso's dolphins, 639 gray whales, 317 bottlenose dolphins, 246 fin whales, 53 Pacific white-sided dolphins, and 50 humpback whales. Blue whales were not observed during the cold-water season, and gray whales were not seen during the warm-water season. Several other species were observed for which sightings were too few to estimate numbers present and/or were seen only off effort: minke whale (n = 6 on-effort groups), northern elephant seal (n = 5), northern right whale dolphin (n = 5), Dall's porpoise (*n* = 3), Cuvier's beaked whale (*n* = 2), killer whale (*n* = 2), harbor seal (*n* = 1), Bryde's whale (n = 1), and sperm whale (n = 1).

Density and abundance estimates obtained during the 2008 through 2012 aerial surveys provide the most up-to-date and one of the largest marine mammal data bases collected within the concentrated area of the SOCAL Range Complex. Results also provide winter density and abundance estimates, when relatively few other surveys have been conducted in this region. Carretta et al. (2000) conducted line-transect aerial surveys for marine mammals near San Clemente Island on behalf of the U.S. Navy in 1998 and 1999 in an overlapping survey area during all months of the year (Figure 1). Their study and the finds in this report provide some of the only at-sea density and abundance estimates for California sea lions on the SOCAL Range Complex. See **Appendix E** for a detailed discussion and interpretation of abundance and density results.

4.0 FIRST-OBSERVED BEHAVIOR ANALYSIS

First-observed behavior analyses used similar parameters (e.g., group size, heading, maximum dispersal distance, and behavior state) as summarized in past individual reports for SOCAL Range Complex aerial surveys in 2008 through 2011 (e.g., see Smultea et al. 2009). Summary statistics for this analysis were previously reported for the combined 2008 through 2011 data in Smultea et al. (2011a in DoN 2011a). Seven species or species groups were deemed to have adequate sample sizes (n > 20) and were analyzed statistically using this approach: Risso's dolphin, common dolphin (combining short-beaked, long-beaked and unidentified common dolphins), bottlenose dolphin, fin whale, blue whale, gray whale, and California sea lion. Results of this analysis are presented in detail in **Appendix F**.

METHODS

Field data-collection equipment and methods were described briefly above under General Overview/Methods and in detail in **Appendix D**. Analyses focused on a subset of response variables consisting of: (1) group size, (2) maximum dispersal distance between nearest neighbors within a group, (3) heading, and (4) behavior state. Ten explanatory variables were evaluated to assess whether they influenced response variables: (1) subregion (east or west of SCI), (2) calf presence or absence, (3) presence or absence of other species, (4) season (warm or cold water), (5) water depth, (6) time of day (in minutes since sunrise), (7) Julian date, (8) slope (in degrees), (9) aspect (degrees), and (10) closest distance to shore (see Table A-12 in **Appendix A** and **Appendix F**). Water depth, slope, and distance from shore were determined using geo-spatial analysis capabilities of the software Mysticetus.

Statistical analyses were conducted by WEST, Inc., using the software program R (**Appendix F**). Statistics applied to the data included Pearson Correlation, Fisher's exact test, t-test, and regression modeling (**Appendix F**). Separate regression modeling was conducted for each of the response variables, and in each case, a different type of model was used for each response as appropriate.

RESULTS AND DISCUSSION

The following subsections provide a general descriptive summary and interpretation of notable results. See **Appendix F** for further details of results including graphs and tables.

Summary Statistics

In addition to statistical analyses, descriptive summary statistics were calculated for the seven species used in first-observed behavior analyses and are presented in **Appendix A,** Tables A-7, A-10, and A-11. Summary statistics were calculated for the following response variables: group size, maximum dispersal distance, and behavior state. For the first two continuous variables (group size and dispersal distance), summary statistics included sample size, minimum and maximum values, mean, median, standard deviation, standard error, and upper and lower 90 percent confidence intervals. For the categorical variable of behavior state, summary statistics included the frequency and percent of occurrence of each behavior state based on the first-observed such data collected when a sighting was made. Notable comparisons and trends are summarized below:

1. Mean group size was much larger for the common dolphin (277.1 individuals) than any of the other six species. The next largest mean group sizes were for the bottlenose dolphin (19.2) and Risso's dolphin (18.4). Mean group sizes for the remaining California sea lion (3.1) and three baleen whales were much smaller (gray whale, 2.2; fin whale, 1.7; and blue whale, 1.6).
2. Among baleen whales, mean maximum dispersal distance between nearest neighbors was closest for gray whales (1.5 BL), over three times farther for fin whales (5.1 BL), and over eight times farther for blues whales (12.6 BL).
3. Mean maximum dispersal distances for the three delphinids and the California sea lion were similar: Risso's dolphin (6.7 BL), bottlenose dolphin (4.9 BL), common dolphin (5.1 BL), and California sea lion (4.2 BL).
4. Percent frequency of occurrence (i.e., "activity budget") differed notably across species based on the three behavior states analyzed. Risso's dolphins exhibited the highest proportion of slow travel/rest (38 percent of 290 sightings) followed by both the California sea lion and fin whale (27 percent of 273 and 115 sightings, respectively). In contrast, the gray whale (*n*=77 groups) and common dolphin (*n*=555 groups) were very infrequently observed slow traveling/resting (1 percent and 3 percent, respectively).
5. Mill behavior was most common among gray whales (47 percent of 77 groups), common dolphins (38 percent of 555 sightings) and California sea lions (39 percent of 273 sightings). Mill was observed only 7 to 15 percent of the time among fin whales (n=115 groups) and Risso's and bottlenose dolphins (*n*=290 and *n*=96 groups, respectively).
6. Overall, medium-fast travel was the most frequently observed behavior state for all seven species ranging from 66 percent of 115 fin whale groups to as low as 34 percent of 273 Risso's dolphin groups.

Results of more detailed statistical analyses summarized below by species indicated that group size, maximum dispersal distance, and behavior states were significantly associated with a number of explanatory variables.

Risso's Dolphin

1. The best predictors of behavior state for Risso's dolphin were time of year and distance from shore (**Appendix F**, Table F-3). Milling increased across the year (relative to fast-medium travel) while slow travel decreased across the year (again relative to fast-medium travel). Thus, as the seasons progressed across the calendar year, Risso's dolphins were

more likely to mill than to slow travel. In addition, milling and to a lesser extent, slow travel/rest, increased with increasing distance from shore (by a factor of 1.4 for every 10 km from shore for mill vs. a 0.8 factor increase for slow travel/rest) (**Appendix F**, Table F-4).

2. With respect to time of day, medium-fast travel significantly decreased while mill and slow travel increased across the day. For each hour (60 min) after sunrise, Risso's dolphins were 0.93 times more likely to mill and 0.89 times more likely to slow travel/rest (both relative to medium-fast travel). This behavioral pattern may be related to the apparent nocturnal foraging habits of Risso's dolphins (Soldevilla 2011). Results herein, including focal video analyses, indicate that Risso's dolphins predominantly slow travel/ rest and socialize during the daytime. Similar to spinner dolphins (Norris and Dohl 1980), Risso's may rest and socialize during the daytime and become more active while foraging at night, presumably on squid based on limited stomach-content studies (Norris and Dohl 1980, Würsig and Würsig 2010).
3. The best predictors of group size among Risso's dolphins were calf presence, the presence of other accompanying species, and time of year based on results of the AIC values in regression modeling:
    a. Group size of Risso's dolphins was significantly higher when at least one calf was present (25 dolphins) vs. no calf (15 dolphins) (**Appendix F**). For reasons similar to bottlenose dolphins (see above), larger groups likely decrease predation risk to calves.
    b. Similarly, Risso's group size was significantly higher when another species was present (25 Risso's dolphins) vs. absent (15 Risso's dolphins) (**Appendix I**).
    c. Group size increased significantly across the year from 12 dolphins in February to 23 dolphins in November (**Appendix I**). This may be related to reproduction or changes in prey distribution or habits.
4. The best predictors of maximum dispersal distance were time of year, time of day, and to a lesser extent water depth based on results of regression modeling as follows (**Appendix F**, Figure F-2).
    a. Maximum dispersal distance increased significantly (1) with increasing water depth (from 2.3 BL over depth 100 m to 5.7 BL over water depth 2000 m), and (2) across the year (from 2.4 BL in February to 6.0 BL in November).
    b. In contrast, maximum dispersal distance decreased with time of day (from 6.5 BL in early morning to 2.1 BL in late afternoon).

In summary, behavioral and social characteristics of Risso's dolphins appeared to be significantly influenced in the study area by time of year, time of day, calf presence, the presence of other marine mammal species, and water depth. In addition, RSF analyses show preferential use of certain habitats and features on the range, primarily steep underwater drop offs near SCI (see

Appendix I). Similarly, Kruse (1989) found that Risso's dolphins in Monterey Bay were strongly associated with deep, steep bathymetry. Photo-identification studies in the Azores indicated strong site fidelity and differential habitat use by mothers with calves, adult males, and adult females (Hartman et al. 2008). Further detailed analyses of focal-follow video particularly groups with juveniles and calves may reveal similar patterns.

Common Dolphin

1. Behavior state was significantly related to season and subregion (**Appendix F**, Tables F-14 and F-15). Milling was 1.9 times more likely to occur during the warm-water vs. the cold-water season (compared to medium/fast travel [fm travel]) (**Appendix F**, Table F-16). Milling among common dolphins appears to be related to foraging/feeding, and was frequently associated with "zig zag" and tight circling behavior resembling feeding behavior reported for bottlenose dolphins (Leatherwood 1975, Miller 2003, Maresh et al. 2004). Milling also included pairs or trios of common dolphins sprinting in coordinated fashion for tens of meters, then abruptly turning and slowing down, repeating this sequence intermittently (as documented with video). The latter observations occurred simultaneous with unusually high reported densities of sardines in the study area.
2. Slow travel was 4.1 times more likely to occur west vs. east of SCI (**Appendix F**, Table F-16). Similar to RSF analyses (see *Resource Selection Function Analyses* below and **Appendix I**), behavior patterns among a number of marine mammal species appear to differ significantly between the waters west and east of SCI.
3. Group size was significantly related to calf presence, slope aspect, and time of year (**Appendix F**, Table F-18).
    a. Groups with one or more calves had over twice as many individuals (485) as groups without a calf (205) (**Appendix F**, Figure F-3). Given that this same pattern was found for bottlenose and Risso's dolphins and is consistent with behavioral ecology theory on benefits of social group living (e.g., Davies et al. 2012), increased group size likely benefits calf survival. Availability of resources and predation pressure has been linked to group size pattern among both bottlenose dolphins (Wells et al. 1980, Weller 1991) and spinner dolphins (Norris and Dohl 1980).
    b. Group size decreased significantly across the calendar year from 245 individuals to 170 (**Appendix F**, Figure F-3). This could be related to decreased socializing/ orienting towards one another relative to reproduction or changes in prey abundance or characteristics. Group size has been shown in many species to be associated with prey availability, i.e., greater prey abundance supports larger group sizes, though predation often plays a role as well (Davies et al. 2012). Predicted group size was highest for north-facing slopes and lowest for south-facing slopes (**Appendix F**, Figure 3). This could be related to greater upwelling on north-facing slopes associated with the predominant southern currents in the region,

potentially supporting higher prey densities in return supporting larger dolphin groups.

   c. Further analyses and background literature searches are needed to interpret the relationships between group size patterns and the above variables.

4. Maximum dispersal distance between individuals increased significantly with calf presence from 3.4 to 5.1 BL (**Appendix F,** Figure F-4). The meaning of this pattern is unclear. When we observed common dolphins with calves, there were typically multiple calves in what appeared to be segregated mother-calf subgroups. An in-depth literature search on this topic may reveal possible hypotheses for this significant correlation.
5. Maximum dispersal significantly decreased across the day from 4.8 BL in early morning to 2.8 BL near dusk. This could indicate increased socializing near dusk. Huddling behavior and close inter-individual spacing is commonly associated with socializing delphinids (e.g., Norris and Dohl 1980, Würsig and Würsig 2010).
6. As depth increases, heading of common dolphin groups was significantly more likely to be NE than NW, SE, or southwest (SW). For example, for each 100 m increase in depth, the odds of heading NW decrease by a factor of 0.90. Interpretation of this pattern is unclear without further analyses of detailed topography and other factors in the study area.

In summary, common dolphin social and behavioral characteristics were significantly associated with calf presence, subregion, time of year, slope aspect, time of day, and water depth. The effects of these explanatory variables on behavior must be considered when evaluating potential effects (or lack thereof) of U.S. Navy activities on this species, particularly differences east and west of SCI given the expected higher level of Navy MFAS training activities west of SCI.

Bottlenose Dolphin

1. Behavior state was significantly related to water depth, slope aspect, and time of year.
   a. Slow travel increased with deeper water depths (by a factor of 1.3 for every 100 m increase in depth).
   b. Milling behavior increased across the season (by a factor of 3 for every 100 Julian days in the calendar year).
   c. Milling behavior also increased progressively as slope aspect changed from approximately southeast (SE) to west-northwest (WNW). At WNW-facing aspects, common dolphins were 100 times more likely to mill than over SE-facing slopes (**Appendix F**, Figure F-5 and Table F-28). The odds of slow travel increased progressively as aspect changed from approximately south-southeast to NW by a factor of 12 at the maximum. When combined, these results indicate that common dolphins were most likely to mill and slow travel over slope aspects of WNW to NW.

2. Observed increases in milling behavior as the year progresses and towards WNW facing aspects could be associated with increased socializing and/or feeding near the surface as reported for bottlenose dolphins elsewhere (Leatherwood 1975, Miller 2003, Maresh et al. 2004).
3. Group heading was significantly related to distance from shore. In particular, dolphins were most likely to be heading SW nearshore: with each 10 km increase in distance from shore, the odds of heading SW decreased by a factor of 0.3 (**Appendix F**, Table F-37).
4. Group size was significantly associated with the presence or absence of a calf (**Appendix F**, Table F-31). Groups with one or more calves had over twice as many individuals (38.9) as groups without a calf (17.1) (**Appendix F**, Figure F-6). Larger group sizes may provide increased protection for young through increased vigilance and dilution effects among other benefits of group living (Shane et al. 1986, Fertl 1994, Mann et al. 2000, Campbell et al. 2002). Bottlenose dolphins may also form nursery groups involving social-sexual segregation as reported elsewhere for the species (e.g., Connor et al. 2000, Lusseau and Newman 2004, Gowans et al. 2007, Gibson and Mann 2008). Further examination of photographs and video from bottlenose dolphin sightings relative to geographic and other parameters may shed light on this.
5. Maximum dispersal of bottlenose dolphins:
    a. Decreased significantly across the day from 4.9 BL in the morning to 2.9 BL in the late afternoon

    b. Significantly increased across the year from 2.2 BL in February to 5.8 BL in October (**Appendix F**, Figure F-7)

    c. Significantly increased with increasing distance from shore, though this effect was small (3.3 BL near 300 m from shore vs. 3.0 BL near 8 km from shore) (**Appendix F**, Figure F-7).

In summary, bottlenose dolphin social and behavioral characteristics were related to calf presence, time of year, time of day, water depth, and aspect. Results of RSF analyses indicate that this species selectively uses certain areas within the study area (see **Appendix I**). Further integration of behavioral and RSF analyses is expected to lead to refined identification of habitat-use patterns.

Blue Whale

1. Group size was associated with time of year, increasing from 1.0 whale in spring to 3.5 whales in fall (**Appendix F**).
2. During late summer and fall, aggregations of feeding blue whales were frequently observed approximately 10 km west of San Diego near the edge of a drop off associated with the shelf edge (**Appendix B**). The increase in group size in fall is believed to be

related to increased concentrations of prey leading to concentrations of feeding blue whales.

3. Preliminary analyses of video from blue whale focal follows documented intra- and inter-specific (with fin whales) competition for krill patches. Further detailed analyses of video may elucidate the nature of these and other social interactions.
4. Mean dispersal distance for blue whales was much farther than for the other baleen species (see *Summary Statistics* above). This suggests that loose blue whale groups may form as an artifact of prey distribution rather than solely for social purposes.
5. No other strong correlations were found between blue whale behaviors and the explanatory variables examined.

In summary, blue whale behavioral patterns were seasonal and concentrated primarily close to shore in the study area. Results indicate that group size more than tripled in fall compared to spring, likely in association with feeding aggregations of blue whales.

Fin Whale

1. Behavior state was significantly related to time of year and distance from shore (**Appendix F**, Tables F-51 and F-52). Milling was most likely to occur close to shore: for each 10 km increase in distance, the odds of milling decreased by a factor of 0.2. Fin whales were 0.8 times more likely to slow travel early vs. late in the year. Among fin whales, milling and slow travel appeared to be associated with social interactions and feeding based on preliminary focal follow data and video. During both behaviors, but particularly during social interactions, individuals frequently oriented towards and away from one another. Detailed analyses of focal-follow data would allow quantification of social vs. feeding behavior relative to milling and touching, etc.
2. Calf presence and time of day were the best predictors of group size for fin whales (**Appendix F**). Group size was larger when a calf was present (3.2 vs. 1.6 whales) and decreased across the day from 2.4 whales in the morning to 1.4 in the late afternoon (**Appendix F**, Figure F-10).
3. The best predictors of maximum dispersal distance were calf presence and subregion, though calf presence was not significant. Maximum dispersal distance tended to be smaller when a calf was present (1.0 vs. 2.5 BL), and was smaller east of SCI (2.5 BL) vs. west of SCI (4.7 BL) (**Appendix F**). Results indicate that mother-calf pairs tended to be accompanied by at least one other non-calf whale and that fin whales in general tended to be social. Maximum observed group size was seven fin whales and groups of three to five fin whales were not uncommon.
4. A strong trend for decreased group size across the day suggests that socializing with other whales is more likely to occur in the mornings than the afternoons.

5. Preliminary analysis of videos and focal follow data demonstrate that fin whales in the SCB appear to interact socially. This has involved non-calf whales touching, and rolling over, onto and near one another in what appears to be courtship behavior similar to that observed among humpback whales (M. Smultea, pers. obs.). This behavior has also been accompanied by apparent intra-specific aggression, including chasing and displacement among groups of three or more fin whales that may be males competing for a female(s). Nursing by fin whales has also been video-recorded as has inter- and intra-specific competition for prey.
6. A strong trend for fin whales to be spaced farther apart within groups west vs. east of SCI and for groups with a calf to have tighter dispersal may indicate differential use of subregions. Correlation of social interactions based on further detailed video analyses may elucidate the nature of these interactions. Notably, RSF analyses indicate that waters west of SCI are selectively preferred by fin whales for certain behaviors (see **Appendix I**).

In summary, available data suggest that the SOCAL Range Complex provides courting/reproductive, foraging, and nursing habitat for fin whales and that differential use of habitat is related to region, time of day, age, and possibly reproductive class.

Gray Whale

1. Gray whale behavior state was almost exclusively travel (either slow or fm travel): only one of the total 77 behavior states was mill (**Appendix D**, Table D-4). This is not unexpected given that gray whales are migrating to and from southern Mexico breeding/calving grounds and more northern feeding grounds during the winter off southern California, with little or no foraging occurring (Rice et al. 1984, Moore et al. 2003).
2. For gray whales, the best predictor of group size was subregion (nearly significant at the 0.05 percent level based on confidence intervals), and to a lesser extent slope aspect (see **Appendix I**, *Gray* Whale and **Appendix F,** Table F-66). Group size tended to be larger west vs. east of SCI (2.7 vs. 1.7 whales, respectively) (**Appendix F,** Figure F-13). Predicted group size as a function of aspect showed that highest group size was predicted for east-northeast-facing slope aspects (**Appendix F**, Figure F-13). Correspondingly, lowest predicted group size occurred for slopes facing west-southwest. The offshore migration characteristics of gray whales are poorly understood. Larger offshore group sizes may form in response to increased predation pressure, as increased group size has been shown to decrease the risk of predation for many species (e.g., Davies et al. 2012). Predation pressure on migrating gray whales is known to be relatively high, particularly in offshore waters.
3. The best predictor of maximum dispersal distance was also subregion. Maximum dispersal tended to be greater west than east of SCI (1.4 BL vs. 0.7 BL, respectively) (**Appendix F**, Tables 69 and 70 and Figure F-14).
4. Dispersal distance tended to decrease slightly across the winter sighting season from 0.8 BL in February to 0.5 BL in April.

5. Unlike fin whales, gray whales inhabit the study area only during the winter and spring migrations. Larger group sizes and greater dispersal distances west of SCI may be indicative of differential habitat use by gray whales during migration. Predation pressure may be greater west of SCI, favoring larger group sizes for predator avoidance. These differences by region may also be related to age and sex class. Sumich and Show (2011) found that large (>11.5 m) gray whales were more likely to occur in offshore migration corridors near SCI than smaller, presumably younger gray whales.
6. Results indicate that mill behavior is uncommon among migrating gray whales (see *Summary Statistics* above). Preliminary analyses of focal follow data indicate that milling individuals orient towards one another, often swim closely together, and touch, including nursing mothers with calves.
7. The observed decrease in dispersal distance across the winter is likely related to the increasing presence of north-migrating cows with calves following the calving period off Mexico, that tend to swim close together.
8. Aspect was strongly related to behavior state. Slow travel was 5 times more likely to occur over south-facing vs. north-facing slope aspects (compared to fm travel). Thus, inversely, medium-fast travel was most likely to occur over north-facing slopes. Gray whales may use north-facing slopes as migration orientation or pathway cues in the SCB during their northward and southward seasonal migrations. Further interpretation of this relationship requires further analyses and literature review.
9. The odds of gray whales heading SE decreased significantly by a factor of 0.9 for as the winter progresses (**Appendix F**, Table F-73). This is consistent with the ration of south-migrating gray whales to diminish and northbound gray whales to increase across the winter after returning from Mexican breeding/calving grounds.

In summary, data indicate that social and behavioral parameters among gray whales are influenced by region, season, and aspect. Behavioral characteristics are significantly different east and west of SCI. Similarly, results of RSF analyses indicate that offshore areas near SCI provide relatively high-use habitat for gray whales calves (**Appendix I**). Mothers with calves were also observed west of SCI (**Appendix B**).

California Sea Lion

1. One of the strongest predictive models for California sea lions was the influence of subregion on maximum dispersal distance and also behavior state.
    a. Maximum dispersal distance was significantly larger between individuals west (3.3 BL) vs. east of SCI (1.6 BL) (**Appendix F**, Figure F-16). RSF analyses indicate that behavior patterns of this species are influenced by a number of environmental parameters that predict preferred high-probability use areas in the San Nicolas

Basin (SNB) and near SCI (**Appendix I**). Dispersal distance may be related to behavior state.

   b. Milling was 2.4 times more likely to occur west of SCI in the SNB than east of SCI (**Appendix F**, Table F-76). Furthermore, frequency of slow travel decreased across the year at a rate of 0.6 with each 100 Julian days. Milling and slow travel are likely associated with social and foraging behaviors. Since this species has highest densities west of SCI, these results are not unexpected. Fm travel is likely more frequent E of SCI where individuals may be transiting along the coastline or between islands and/or haul-outs and rookeries.

2. Group size of California sea lions was significantly larger (7.2 individuals) when other marine mammal species were associated with them vs. when not (2.8 individuals) (**Appendix F**, Figure F-15). California sea lions likely associate with other species to forage on similar prey. Inter-specific associations likely improve prey detection abilities (Barlow et al. 2009).

In summary, California sea lion group behavioral characteristics were found to be significantly related to a number of explanatory variables. These effects must be considered when evaluating potential effects of U.S. Navy activities.

5.0 FOCAL BEHAVIOR / VIDEO ANALYSIS: RISSO'S DOLPHIN

From 2008 through 2012, focal behavioral observations (Altmann 1974, Mann 1999) were conducted on 17 marine mammal species (see *Behavioral Observations and Video/Photography Summary*). These data consisted of periods of at least 5 min when a selected focal group was circled by the aircraft at altitudes of approximately 365 to 457 m (1,200-1,500 ft) and radial distances of approximately 0.5 to 1.0 km. This section is limited to a summary of results and analyses of selected quantified focal behavioral data for Risso's dolphin groups from 2008 through 2012. **Appendix G** discusses methods and results in more detail. Risso's dolphins were selected as a focal species due to (1) a relatively robust sample size (*n*=51 groups, including accompanying video); (2) their tendency to remain at or near the surface for extended periods compared to other species, thereby allowing longer observation periods; (3) their light body coloration facilitating tracking, including below the water surface to depths of approximately 10 to over 15 m; and (4) their identification as a priority species in the U.S. Navy's SOCAL Monitoring Plan and the Southern California Behavioral Response Study (BRS) (Southall et al. 2012).

Detailed analyses of the behavior from other focal species will be considered for future analyses by the U.S. Navy if additional funding becomes available. In particular, analyses of small groups of baleen whales provides data on respiration rates, and dive and surface durations of individuals that are not possible with large groups of dolphins, including the Risso's dolphin. Note that other behavioral parameters from Risso's dolphin focal groups (and other species) can be analyzed in the future, including group dive and surface durations, frequency of surface-active (e.g., breach) behaviors, associations between individuals, etc. A case study of a videotaped group of focal Risso's dolphins is provided in **Appendix H** and illustrates the detailed behavioral information that can be obtained by other detailed analyses of focal follows. However, limited resources necessitated selecting a limited number of specific parameters to analyze in this report. These parameters are meant to provide a baseline to compare with behavior during periods of exposure to U.S. Navy noise-generating activities in the future.

METHODS

Field methods applicable to focal behavior sampling are briefly described herein, but are provided in further detail in **Appendix D**. High-definition (HD) video was taken (as feasible) of focal Risso's dolphin groups using a Canon EOS 7D (2008 through 2010) or Sony HD HDR-XR550 and HXR-NX5U NXCAM (2010 through 2012) video camera to document animal behavior. Observer commentary was simultaneously recorded on the video camera's audio channel during focal follows. In addition, observer commentary was recorded using a Sony digital voice recorder connected to the aircraft's audio input or with a mini-microphone taped into an observer's headphone or a spare headphone (thus, audio was recorded when the video was both off and on). Behavioral data were recorded with a Palm Pilot TX (dimensions approximately 7 by 12 cm) (2008), Apple iTouch (2009), iPhone (2009 through 2010) or laptop computer (2010 through 2012) in a customized datasheet using BioSpectator (2008 through 2009), Microsoft Excel (2010 through 2011), or Mysticetus (2011 through 2012) software. Software and hardware efficiency has been improved with new evolving technology over the 5-year period.

Post-field analysis involved transcribing behavioral data from video onto a custom Excel spreadsheet. These data were then merged with behavioral data systematically collected in the field. In addition, digital voice recordings were used to fill in data gaps as needed, such as periods when the video was not focused on the group, or the airplane wing or glare obscured the video's view. Thus, it was important to have observations/commentary from a focal observer with a wide perspective combined with video taken by a dedicated videographer.

Data entered onto the focal behavior spreadsheet included the following variables: date, time, group identification number, species, group size, number of calves, behavior state, orientation/heading (in degrees magnetic), minimum and maximum dispersal distance between nearest neighbors (estimated from video and/or in the field based on average adult BL), Bf, declination angle to sighting (to estimate distance to the focal group), the presence of any vessels (**Appendix A**, Table A-14) or other potential disturbance (e.g., helicopters) within approximately 1 km (within view for large U.S. Navy vessels), and comments/notes (see **Appendix D** for definitions and ethogram). Behavior state, heading, and dispersal distance were recorded approximately every minute in the field based on scan sampling methodology (Altmann 1974). During post-field video/audio transcription, the latter parameters were noted for every 30-second (sec) period that Risso's dolphins were in view, based on the most recent data collected within each 30-sec period prior, starting on the minute (e.g., for the period 13:00:00-13:00:30, then 13:00:30-13:01:00, etc.).

STATISTICAL ANALYSES

Data processing and analyses were conducted using the MATLAB software program by WEST, Inc. Analyses focused on a subset of three response variables consisting of: (1) heading (*hdg*) (in degrees magnetic), (2) maximum dispersal distance (*maxdsp*) between nearest neighbors within a group, and (3) behavior state (see ethogram in **Appendix D,** Table F-4 and **Appendix G**). Seven explanatory variables were evaluated to assess whether they influenced the aforementioned response variables. These consisted of (1) presence or absence of at least one calf (*calf*), (2) presence or absence of other marine mammal species within the Risso's dolphin group (*othergrp*), (3) presence or absence of boat(s) within 1 km (*boat*), (4) *season* (warm or cold water), (5) time of day category (morning [8:00-12:00], early afternoon [12:01-16:00], and late afternoon [16:01-dusk]) (*timecat*), (6) calendar month of the year (*month*), and (7) time (minutes) since sunrise (*tfsun*) (**Appendix G**). The first four variables were binary (1 or 0), two (*timecat and month*) were categorical, and the last one (*tfsun*) was continuous, derived from field data (**Appendix A**, Table A-12). For the binary variables *calf, othergrp,* and *boat*, if a calf (or another species, or a nearby boat) was observed at least once during a focal-follow session, then the variable was assigned a value of 1, indicating presence (vs. 0 for absence). Month was intended as a more detailed alternative to season. Most observations occurred in February through April, so each of these months was retained as a category. The remaining cold-water months (November - January) and warm-water months (June - October) were collapsed into separate categories. Time from sunrise, *tfsun*, used local sunrise tables and was calculated as the fraction of a day that elapsed between sunrise and the first observation of a focal-follow session.

Three separate statistical analyses were undertaken using the Risso's focal group data:

1. Reorientation rate (*rrate*) was derived from heading, and defined as change in heading (degrees) per minute, following the approach described in Bowles et al. (1994), Smultea and Würsig (1995), and Gailey et al. (2007). Observations for each focal follow were sorted by observation time. Observation times were converted to "scan times" by rounding to the next 30-sec interval (e.g., observation times of 11:15:11 and 11:15:41 were assigned scan times of 11:15:30 and 11:16:00, respectively). Standard multiple-linear-regression models were used to examine the relationship between heading and candidate explanatory variables. A stepwise procedure based on Akaike Information Criterion (AIC) was used to evaluate candidate models and automatically select the model with the lowest AIC (Burnham and Anderson 2002). To avoid problems from strong associations among explanatory variables, several alternate stepwise runs were conducted with different initial sets of variables.
2. Splitting-joining was a response variable derived from maximum dispersal distance to assess whether the splitting and joining of subgroups was influenced by selected explanatory variables. It was defined based on observed variability in maximum dispersal distances, in particular, the standard deviation in maximum dispersal (after examining the distribution of raw maximum dispersal distance data for patterns). Multiple linear regression was conducted (like for *reorientation rate*), with log-transformed standard deviation of maximum dispersal as the response. In addition, standard deviation of maximum dispersal was transformed into a binomial response variable (low and high standard deviation) and analyzed using logistic regression. Candidate explanatory variables were re-examined for evidence of association since the analysis dataset was not identical to the reorientation rate dataset. Models were selected via a stepwise AIC-based procedure as described above for reorientation rate.
3. Sequential analysis was conducted to assess the likelihood of a behavior state changing (i.e., a transition) during a focal follow. Behavior states were categorized as either 'fm' (medium-fast travel), 'mill' (milling with no consistent group heading), or 'slow' (slow travel/rest) (see ethogram **Appendix D,** Table D-4):
    a. Transitions between behavior states in each successive pair of observations were identified for each focal follow. A given observation at time *t*-1 would have behavior categorized as either 'fm', 'mill', or 'slow'. The subsequent observation at time *t* would have behavior in any one of the same three categories. Thus, there were nine possible behavior transitions: (1) fm – fm, (2) fm – mill, (3) fm – slow, (4) mill – fm, (5) mill – mill, (6) mill – slow, (7) slow – fm, (8) slow – mill, and (9) slow

– slow. If there were *n* observations for a focal follow session, then there were *n* – 1 transitions for that session.

b. Explanatory variables differed somewhat from the variables used in the other two analyses (**Appendix G**). Time category had three possible values: 'am', 'early pm', and 'late pm'. Therefore, two indicator variables (*timecat1* and *timecat2*) were used to represent time, with 'late pm' serving as the reference category.

c. Multinomial logistic regression was used to model the relationship between the response (behavioral transitions) and the covariates. The slow – slow transition served as the reference category; coefficients were estimated for the remaining eight categories. AIC corrected for small sample size was calculated for each model.

Based on results of the regression modeling and AIC values, the "importance value" for each explanatory variable was calculated for the three analyses described above. The importance value was defined as the sum of the Akaike weights for each model in which that variable appeared. Thus, if a variable appeared in all 10 models, its importance value would equal 1; otherwise, the importance value was bounded between 0 and 1.

Further details of the statistical analyses performed for the three analysis parameters are described in **Appendix G**.

RESULTS AND DISCUSSION

There were 51 Risso's dolphin groups recorded during focal-follow sessions ranging in duration from 5 to 59 min (mean duration 21.6, standard deviation [SD] = 12.9). The number of 30-sec scan periods with relevant data (e.g., reorientation rate, maximum dispersal distance, or behavior state) for all focal follows combined totaled 1,446 useable data points for reorientation rate, 1,275 data points for maximum dispersal, and 1,359 data points for behavior state. Statistical results of these three focal-follow parameters are summarized separately below, with detailed results including graphs and tables presented in **Appendix G**.

Reorientation Rate

1. The only explanatory variables that appeared to influence reorientation rate was the presence of other marine mammal species (*othergrp*) with the Risso's dolphins, although this relationship was not statistically significant. The 90 percent confidence interval for the coefficient of *othergrp* was (-0.34, 11.38). As this confidence interval includes zero, there is not adequate evidence in the data to conclude that reorientation rate was related to *othergrp*. However, a positive coefficient indicates that when other species are present, the average reorientation rate is higher than when other species are absent (**Appendix G**).

2. This trend suggests that Risso's dolphins may be changing their headings more often when other species are intermixed with them, possibly to socially interact with (i.e., orient towards) other species and/or conversely, to move away from them.
3. Inter-specific associations are often associated with prey aggregations (e.g., Shane et al. 1986, Acevedo-Gutiérrez 1991 Vaughn et al. 2007), within which species may compete for food or space. Our preliminary interpretation of videos of Risso's dolphins with bottlenose dolphins suggests that the bottlenose dolphins are following the Risso's dolphins and have been seen swimming between subgroups of Risso's dolphins; the bottlenose dolphins appeared to be "separating" the Risso's dolphins.

Splitting/Joining

1. None of the explanatory variables were found to influence splitting-joining of focal Risso's dolphin groups. This was likely related to the high variation in rates of splitting and joining relative to the explanatory variables examined. Thus, none of the explanatory variables were found to improve model fit.

Behavior State

1. Risso's focal groups spent most of their time slow traveling/resting (60 percent of 1,359 records), followed by medium-fast travel (33 percent); milling behavior was rare (7 percent) (**Appendix G**, Table G-3).
    a. The 61 percent is nearly twice as frequent as indicated for first-observed behavior analyses (32 percent of 290 Risso's sightings were slow/travel rest). (Note that only the first behavior state was recorded for each of the latter sightings vs. focal follows where behavior state was noted every 30 sec for the same group). The difference could be related to differences in subregions where focal data were collected: RSF results showed that Risso's dolphins tended to use different areas/habitat types for slow travel/rest vs. medium/fast travel (see **Appendix I**). Analyzing locations and other environmental parameters associated with Risso's focal follows would shed light on this difference. This difference also could be related to a much shorter observation period (~0.5 to 3 min) for first-observed data vs. focal data (5 to 60 min).
    b. Predominant slow travel/rest by focal Risso's dolphins (61 percent) strongly contrasted common dolphins which rarely slow traveled-rested (3 percent of 555 first-observed groups) (**Appendix A**, Table A-16 and *First Observed Behavior Analysis – Common Dolphin*). Also in contrast, common dolphins frequently milled (38 percent) while Risso's dolphins did not (14 percent). We believe this is related primarily to reported differences in predominant prey, and apparent diurnal (commons) vs. nocturnal (Risso's dolphin) foraging habits in the SCB (Pusineri et al. 2007, Soldevilla et al. 2011).

    c. The Risso's dolphin behavior pattern is consistent with other nocturnal-feeding delphinids. They typically rest and socialize during daytime and actively feed at night when prey move closer to the water surface in the deep scattering layer (e.g., squid) (Norris and Dohl 1980, Würsig and Würsig 2010).

2. Risso's dolphins rarely changed behavior state during focal follows. Results clearly showed that any particular behavior observed at time *t*-1 was most likely to be followed by the same behavior at time *t*. Although all possible transitions did occur, transitions from one behavior state to another were infrequent. This again could be related to location, since RSF analyses showed that behavior differed by region and other parameters (see above and **Appendix I**).
3. When calves were present, Risso's dolphins were 4.28 times more likely to continue fm travel than were groups with no calves (based on odds ratio results from estimated regression coefficients [**Appendix G**, Table G-6]). The reason for this pattern is unknown, but may be related to predation pressure, location, or other parameters. More detailed analyses focused on calf groups may reveal reasons for this difference. Identifying specific habitat needs of calf groups is important for conservative management of this species because calf survival is integral to sustained populations.
4. Similarly, calf groups were more likely to transition from fm-mill and mill-fm than non-calf groups (relative to slow-slow transitions). This suggests that socializing and possibly foraging may occur more frequently among calf groups (milling is associated with animals orienting towards one another, touching, and/or sudden apparent foraging sprints based on our unquantified observations). Detailed video analyses focusing on this behavior would help explain this pattern.
5. During mornings, fm-fm transitions were less likely than later in the day (**Appendix G**, Table G-6). Conversely, in the early afternoon, Risso's dolphin groups were 6 times more likely to continue fm travel than compared to early morning and late afternoon. This suggests that later in the day, traveling Risso's dolphins tend to keep traveling. We hypothesize that as dusk approaches they are transiting to nocturnal foraging areas, transitioning from earlier social and rest activity. Similarly, spinner dolphins (Norris and Dohl 1980) and dusky dolphins (Würsig and Würsig 1980, 2010) rest and socialize during the day with activity level increasing near dusk after which they feed in pelagic waters.

In summary, the behavior of Risso's dolphins was significantly related to calf presence and time of day. Their predominant slow travel/rest behavior contrasts that of the other delphinid species observed. This difference is likely related to their presumed nocturnal foraging habits. A significant tendency to slow travel-rest indicates that Risso's dolphins are a good candidate focal species to study relative to potential effects of Navy MFAS. If Risso's dolphins were to react to such activity, a change in behavior state to medium-fast travel away from the disturbance would be expected. This behavior state transition has frequently been reported among other delphinids as a significant change in response to anthropogenic disturbance, including vessels (Constantine et al. 2003, 2004) and human swimmers (Orams 1997, Constantine 2001, Forest 2001). A more detailed examination of video and field data, including other response (e.g., dive and surface duration) and explanatory variables, may reveal other significant baseline patterns that may be sensitive indices of disturbance.

6.0 MARINE MAMMAL DISTRIBUTION, OCCURRENCE, AND RELATIVE ABUNDANCE ANALYSIS: RESOURCE SELECTION FUNCTION

This section addresses the distribution, occurrence, and relative abundance of marine mammals in the study area using the 2008 through 2012 aerial monitoring survey data. These topics were addressed using the following three approaches:

1. Distribution and occurrence data were analyzed by applying RSF analyses (Manly et al. 1993, 2002).
2. Relative abundance was addressed by conducting a comparative analysis of changes in the relative frequency of occurrence of marine mammal species in the SCB. Results of the 2008 through 2012 aerial marine mammal monitoring data were compared with available historical data.
3. Relative abundance was also addressed by conducting density and abundance analyses using line-transect data and DISTANCE analyses (summarized previously in Section Analysis and Integration of Winter Density and Abundance Estimates and **Appendix E**).

RSF analyses are described below. The comparative analysis mentioned in (2) above is presented in **Appendix J**.

INTRODUCTION

The goal of the RSF was to identify areas commonly used by and presumably important to marine mammal species in the SOCAL Range Complex. The basic premise of resource selection modeling (Manly et al. 2002) is that resources (which may be food items, land cover types, or any quantifiable habitat characteristic) that are important to individuals will be "used" disproportionately to the availability of those resources in the environment (i.e., certain resources or habitats/attributes will be selectively "preferred"). Habitat modeling, including predictive modeling, has been conducted based on line-transect density and abundance of marine mammals in the SCB (e.g., Forney 2000, Becker et al. 2010) and elsewhere (i.e., the eastern tropical Pacific [e.g., Ferguson 2005, Ferguson et al. 2006 Barlow et al. 2009]). RSF differs from the latter approach as it accounts for the spatial availability of all habitats within a study area, not just areas where marine mammals occur. RSF thus facilitates estimating the probability of habitat occurrence relative to actual use by species.

RSF was selected by biologists involved with the 2008 through 2012 data collection in consultation with biostatisticians at WEST, Inc., as a means to identify and quantify baseline preferential distribution patterns of marine mammals on the SOCAL Range. Using the 2008 through 2012 RSF data as a baseline will facilitate quantitative statistical comparison and identification of any potential changes in preferred habitat-use patterns (or lack thereof) of marine mammals relative to exposure to U.S. Navy MFAS, underwater explosions or other future activities. WEST, Inc., biostatisticians have been conducting RSF analyses for over 20 years on terrestrial animals and marine mammals; they have co-authored a reference book on the subject (Manly et al. 1993, 2002) and have authored multiple peer-reviewed journal articles (e.g., McDonald and Amstrup 2001, Amstrup et al. 2001, McDonald and McDonald 2002, McDonald et al. 2003), conference presentations, and workshops. The RSF approach has been successfully used to identify and predict habitat-use patterns and to identify changes in these patterns relative to anthropogenic activities (e.g., oil and gas exploration, construction and other anthropogenic activities, including disturbance). It has also recently been applied by the U.S. Fish and Wildlife Service and WEST, Inc., to identify potential effects of global warming on polar bears (Durner et al. 2009). It has proven to be a useful management tool to identify and quantify effects as well as viable mitigation and management opportunities.

For this analysis, RSF were developed for marine mammal sighting locations obtained along systematic and connector survey transects from 2008 through 2012 (see **Appendix D** for definitions of effort types). Standard logistic regression models were developed to estimate a linear function of site characteristics that reliably predicted observed use from 2008 to 2012. The model results estimated the relative probability of use at locations in the study area, as a function of the site characteristics (Manly et al. 2002).

Samples sizes of five marine mammal species were detected in adequate abundance to support the development of an RSF model: bottlenose dolphin, Risso's dolphin, California sea lion, fin whale, and gray whale. The behavior state of individuals was recorded during the surveys and provided information to conduct separate modeling for three states: mill, slow travel (including rest), and medium/fast travel (see ethogram in **Appendix D** for definitions).

METHODS

For the RSF analysis, characteristics at marine mammal locations were contrasted to characteristics at randomly selected "available" locations in the study area. The available set of points for the resource selection was obtained by placing a systematic grid at a random location within the study area (excluding all observations on land [with depth greater than 0] and outside the main survey areas). Most species were modeled within the Santa Catalina Basin (SCBa) and SNB regions using a set of 35,167 available points; however, the bottlenose dolphin was modeled only in the SCBa region with a set of 23,455 available points, as sample size was inadequate for this species in the SNB.

RSFs were estimated using the standard logistic regression model to predict the probability of the species being detected at a sampled site as a function of seven covariate variables describing habitat characteristics in the study area: latitude, longitude, depth (m), "northness" (calculated as the cosine of aspect), "eastness" (calculated as the sine of aspect), slope, and distance from shore (km) (see **Appendix I** for further details). Models were run for the 127 possible combinations of these variables and ranked using the AIC (Burnham and Anderson 2002), a statistic that evaluates model fit based on the log likelihood. The top AIC models for each species and behavior state were identified. The RSF models were used to predict the relative probability of selection for areas within the study area. These values were mapped spatially and color coded to indicate the relative value of the resource selection prediction (see map figures in **Appendix I**).

RESULTS AND DISCUSSION

Notable trends and significant correlations for the RSF modeling for the bottlenose dolphin, Risso's dolphin, California sea lion, fin whale, and gray whale are summarized below. This is followed by a short interpretation of results. Associated tables and figures, including maps of relative probability of behavior state occurrence by area, are illustrated in **Appendix I**. Underwater feature locations referenced below are identified in Figure 1 under *Introduction* above. Statistical results are summarized in further detail in **Appendix I**.

RSF models for the three behavior states (mill, slow travel/rest, and medium/fast travel) and all observations combined were fit for the five species (Table 1, **Appendix I**). Due to the low number of mill behavior states observed for the bottlenose dolphin, fin whale, and gray whale, mill was combined with slow travel/rest for these three species. In the following results discussions, probability (p) values <0.05 are considered statistically significant, while p values of 0.05-0.10 are considered a "strong correlation." Specific patterns of habitat selection are also discussed based on predicted probability values illustrated on RSF analysis maps in **Appendix I**.

Bottlenose Dolphins

A total of 31 bottlenose dolphin groups were used in RSF analyses. Most (*n*=19) were engaged in medium/fast travel or slow-travel/rest (n=11), with one remaining group milling (Table 1, **Appendix I**). The one milling group was thus combined with slow travel/rest for RSF analyses. An RSF was not conducted for the SNB west of SCI because no bottlenose dolphins were sighted there during systematic or connector effort.

Notable Results

1. The only significant correlations for behavior state per the RSF model was for medium/fast travel and all behavior states combined based on the variables longitude, water depth and distance from shore (Table I-2, **Appendix I**).
2. Overall, for both medium/fast travel (p=0.0302) and all travel behavior states (p<0.0579), bottlenose dolphin habitat use decreased significantly from east to west in the study area (based on longitude) (Figures I-2, I-3, and I-7, **Appendix I**).
3. Habitat use for medium/fast travel and all travel also decreased significantly with (a) deeper water depths (both with p=0.0003), and (b) increasing distance from shore (p=0.0419 and 0.0201, respectively).
4. Slow travel/mill behavior was predicted to be highest in the northern part of the study area, but this trend was not significant (p=0.1328) (Figures I-1 and I-7, **Appendix I**).

5. Based on observed bottlenose dolphin locations and RSF habitat value modeling, the highest habitat selection indices within the SCBa occurred along steep slopes paralleling the mainland coastline, the eastern side of SCI, and east and southeast of Santa Catalina Island (Figure I-7, **Appendix I**). In particular, predicted "hot spots" for bottlenose dolphins were associated with underwater seamounts, including Emory Knoll NE of SCI and an un-named knoll approximately 30 km to the southeast, and directly E of SCI (Figure I-7, **Appendix I**).
6. An obvious lack of predicted use was near the middle of SCBa over the relatively flat San Diego Trough (Figure I-7, **Appendix I**).

Interpretation

1. The trend for mill/slow travel to occur in the northern portion of the study area near Santa Catalina Island may be related to the "island" ecotype of bottlenose dolphins occurring there (Shane 1994). Shane (1994) reported that mill and slow travel among these dolphins was typically associated with socializing. Similarly, mill/slow travel during this 2008-2012 study often included socializing (i.e., touching, orienting towards one another). Combined results suggest that this area provides important social and potentially reproductive habitat.
2. The tendency for medium/fast travel to occur along underwater drop-offs/steep slopes may be associated with foraging or fast transit between feeding or other areas.
3. Further examination and analyses of the over 1 hr of focal behavior videos we have taken of bottlenose dolphins in the SCB would further elucidate the functional importance of these behavior states and other behaviors relative to differential habitat use.

Risso's Dolphin

A total of 135 Risso's dolphin groups were used in RSF analyses. Most (*n*=63) were engaged in slow-travel/rest, followed by medium/fast travel (*n*=56), or milling (*n*=14) (Table I-1, **Appendix I**).

Notable Results

1. Risso's dolphins tended to use different areas/habitat types for slow travel/rest vs. medium/fast travel. Slow travel/rest was strongly associated with deep water ($p=0.0803$) while medium/fast travel was generally associated with shallower water ($p=0.1298$).
2. In general, both types of behavior were significantly more likely to occur in the eastern portion of the study area ($p<0.03$) and closer to shore ($p<0.04$).
3. Medium/fast travel was also significantly associated with latitude ($p=0.019$), with highest probability to the south (Table I-6, **Appendix I**).

4. Examination of RSF probability maps revealed higher-resolution patterns within these general trends. Patterns appeared to be associated with underwater topographic features, pointing to differential habitat selection based on behavioral state as follows.
5. <u>East of SCI</u>: Slow travel was strongly associated with steep slopes off the northeast side of SCI and south of Santa Catalina Island, where medium/fast travel was unlikely to occur (Figure I-11 in **Appendix I**). In contrast, medium/fast travel was most likely to occur southeast of SCI where little or no slow travel was likely to occur (Figure I-11, **Appendix I**). The latter gap is associated with Fortymile Bank, a relatively flat area between San Clemente Canyon to the west and Coronado Canyon to the east.
6. <u>SNB (west of SCI):</u> Medium/fast travel was highly unlikely to occur to the west and northwest of SCI, but slow travel was likely to occur there (Figure I-11, **Appendix I**). The latter behavior in this area coincided with a steep underwater drop off running generally ESE from San Nicolas Island to SCI (Figure 1). In comparison, predicted medium/fast travel was concentrated along a relatively narrow margin just W of and paralleling SCI, again along a steep, narrow underwater ledge.
7. <u>Mainland coastline</u>: RSF-predicted habitat selection along the mainland coast was similar for mill, slow travel/rest and medium/fast travel. These behaviors had the highest probability closest to the shore to approximately 25 to 40 km offshore (**Appendix I**). This area roughly coincides with the relatively featureless San Diego Trough.

Interpretation

1. Based on video and field observations, slow travel among Risso's dolphins appears to involve rest and socializing characterized by overall tight, inter-individual spacing. Milling involving some individuals crisscrossing through the group or subgroup has also been observed occasionally during slow travel/rest. Shane (1995) reported that Risso's dolphins off Santa Catalina Island spent most of their time resting/slow traveling.
2. In contrast, medium/fast travel involves what appears to be directed point-to-point movement. As such, these behavior states are likely associated with different functions.
3. Habitat with high medium/fast travel use paralleled underwater features and/or the coastline. Shane (1995) observed that Risso's dolphins off Santa Catalina Island tended to travel up and down the coastline during the day, a similar pattern to the RSF pattern along SCI.
4. During daylight observations, medium/fast-directed travel is the most efficient means to move between habitats. Risso's dolphins may do this to move efficiently between areas used for socializing, resting or possibly foraging. We observed (and recorded on video) apparent foraging a few times: individuals or pairs of Risso's sprinted a short (~25-50 m) distance then dove steeply and rapidly, surfacing 1-2 min later; several northern right whale dolphins were following these Risso's in some instances.

5. Other studies have shown that Risso's dolphins are strongly associated with deep waters over steep slopes (Kruse 1989, Forney and Barlow 1998, Kruse et al. 1999, Carretta et al. 2000, Baird 2008, Jefferson et al. 2008, Carretta et al. 2011). Limited available data suggest that this species feeds predominantly at night on squid (e.g., Shane 1995, Kruse et al. 1999, Baird 2008, Jefferson et al. 2008, Soldevilla et al. 2011). Risso's dolphins may preferentially socialize and slow travel/rest during daytime in preferred habitat that may later be used for foraging at night. Night-time foraging cetaceans typically rest and socialize during daytime periods, including spinner dolphins (e.g., Norris and Dohl 1980, Norris et al. 1994, Benoit-Bird and Au 2003, Thorne et al. 2012) and dusky dolphins (Benoit-Bird et al. 2004, Vaughn et al. 2007, Würsig et al. 2007, 2010, Vaughn-Hirshorn et al. 2012).
6. We found significant and previously undocumented statistical results correlating behavior with a number of environmental variables. While we have identified many correlating factors, the fundamental behavioral triggers remain poorly understood. More detailed analyses of focal follow video from this species (*n*=51 groups) may illuminate and differentiate potential effects of U.S. Navy activities from naturally occurring baseline behavior.

California Sea Lion

A total of 157 California sea lion groups sighted at sea were used in RSF analyses. Most (*n*=41) were milling, followed by medium/fast travel (*n*=34), then slow-travel/rest (*n*=18). An additional 32 sightings were excluded from RSF analyses due to missing behavioral data when sightings were so dense and frequent that it was not possible to collect behavioral data (see **Appendix I**).

Notable Results

Habitat selection differed significantly by behavior state for some co-variates, including longitude, "eastness" (i.e., east aspect), distance from shore, and water depth as described below (Table 3, **Appendix I**).

1. As expected, occurrence of California sea lions was highest near San Clemente and San Nicolas islands where they haul-out throughout the year, and seasonally concentrate to breed, pup and molt (e.g., Carretta et al. 2000). A distinct gap in expected occurrence and distribution occurred in the central to southern portion of the SCB in the San Diego Trough (Figures I-4 and I-8, **Appendix I**).
2. Milling was significantly ($p=0.0090$) more likely to occur in the far western portion of the range, with decreasing probability to the east (Figures I-1 and I-8, **Appendix I**). Milling was often associated with apparent foraging involving quick turning and diving.
3. Similarly, medium/fast travel ($p=0.0023$) and all travel combined ($p<0.001$) were significantly more likely to occur in the western half of the study area (Figures I-3 and I-8, **Appendix I**). RSF probability maps indicated highest use along the steep slopes

surrounding the center of the SNB and near islands. However, this behavior was unlikely to occur in the centers of the SNB and SCB (i.e., the San Diego Trough).

4. Medium/fast travel was also significantly (p=0.0297) associated with deeper water depths, and strongly associated with proximity to shore (p=0.0917).
5. Slow travel/rest habitat-use patterns were less apparent. High-use areas were distributed patchily based on habitat selection probability maps. However, overall, within these patches, there was a strong correlation with east-facing slopes (p=0.0863). RSF probability maps showed highest use at east-facing slopes near the islands and also east of Santa Catalina Island just west of Irvine (Figures I-2 and I-8, **Appendix I**).

Interpretation

At-sea occurrence, relative abundance, and distribution information on California sea lions based on systematic surveys in offshore areas of the SCB are virtually non-existent. Carretta et al. (2000) estimated abundance of this species at sea near San Clemente and other nearby islands. In **Appendix E**, we report at-sea line-transect density and estimates for this species. Bearzi (2006) reported at-sea number estimates for this species in Santa Monica Bay based on small-vessel surveys (Bearzi et al. 2008). However, our RSF analyses provide the first at-sea habitat-use pattern statistics.

1. As expected, the overall highest at-sea use areas were around the islands, particularly SCI. This correlates with seasonally high haul-out numbers documented there (e.g., Carretta et al. 2000).
2. RSF analyses indicated that California sea lions show preferential use of different areas within the study area for different behaviors as discussed below:
    a. The SNB, particularly the far western edge of the range, appears to be an important foraging habitat for California sea lions based on high observed milling frequencies.
    b. Medium/fast travel was associated with steep drop-offs along the edges of basins and islands. This behavior may involve animals traveling quickly to foraging and/or haul-out areas.
    c. It is interesting that the center of the SNB is predicted to provide important milling (foraging) habitat but is highly unlikely to be used for medium/fast travel. This relationship is currently unclear and merits further interpretation and investigation.
    d. The significant correlation of high-use slow travel/rest with east-facing slopes is also unclear. This is undoubtedly related to proximity of island rookeries and haul-outs but may also be related to lees or other oceanographic conditions favoring such behavior. Focal-follow behavioral analyses may help elucidate this

relationship combined with literature searches for related studies. Such areas appear to provide important habitat for the species.

Fin Whale

Sixty fin whale groups were used in RSF analyses. Most (*n*=36) were engaged in medium/fast travel (*n*=36), followed by slow travel/rest (*n*=20), and milling (*n*=2) (Table A-1, **Appendix I**). However, the two milling groups were combined with slow travel/rest for RSF analyses due to small sample size. Similar to Risso's dolphins, fin whales appeared to exhibit differential habitat use/selection, including based on behavioral state, as follows.

Notable Results

1. Overall, based on all combined behavioral data, fin whales were the only species of the five examined for which nearly the entire SNB (west of SCI) had high probability of use (in Figures I-2 and I-8, **Appendix I**).
2. Preferred areas for slow travel/rest/mill differed from those where medium/fast travel was most likely to occur. Slow travel/rest/mill occurred predominantly along steep slopes (Figure I-8, **Appendix I**) where medium/fast travel was least likely to occur.
3. In contrast, medium/fast travel was mostly likely to occur over relatively flat basins and over underwater plateaus where slow travel/rest/mill was unlikely to occur.
4. Overall, fin whales were significantly more likely to be associated with deeper vs. shallower waters (p=0.0017).
5. Fin whales were also significantly more likely to be associated with closer distances to shore across all behavior states (p=0.0359).
6. In general, the probability of encountering fin whales increased significantly from east to west (p=0.0276), and from north to south (p=0.0413) (Figure I-8, **Appendix I**).
7. Slow travel/rest/mill was strongly associated with steep slope drop offs near the southeast coasts of San Nicolas and Santa Catalina islands and off the mainland shelf (areas where medium/fast travel were least or less likely to occur) (Figure I-8, **Appendix I**).
8. In contrast, medium/fast travel was most likely to occur over the relatively flat center of the SNB, the San Diego Trough, and Fortymile Bank (Figure I-8, **Appendix I**). The maps in Figure 9 clearly show a lack of slow travel/rest/mill in these basins.

Interpretation

1. Consistent with past results summarized from our aerial data (e.g., DoN 2011a, Smultea et al. 2009, 2010, 2011a, 2012a); fin whales were the only cetacean species highly likely to occur in the SNB west of SCI.

2. RSF results also revealed other high-probability use areas preferentially selected by fin whales in the study area.
3. Similar to Risso's dolphin patterns, RSF probability maps indicated that fin whales traveled quickly over relatively flats basins and troughs.
4. In contrast, slow travel/rest/mill behavior was strongly associated with steeply sloped bathymetry contours along islands and coastlines.
5. Preliminary observations and video analyses of focal groups of fin whales indicate that medium/fast travel is associated with directed point-to-point movement, with minimal changes in heading/orientation. In contrast, slow travel/rest/mill appears to be more frequently associated with feeding (open-mouthed lunging, defecation, krill patches), socializing (rolling and touching, orienting towards one another) and apparent rest. Thus, these two types of behavior states are believed to serve different biological functions.
6. Based on the above, fin whales are believed to feed predominantly over steep slopes in the study area where upwelling is most likely to occur, providing and concentrating prey.
7. In contrast, over flatter topographic regions where prey is less likely to concentrate, fin whales are most likely to travel at medium/fast speed, possibly in transit to other areas; this may include, perhaps, steeper areas where they tend to be seen socializing and feeding. Directed travel is also likely associated with those individuals that migrate through the area. Little to nothing is known about residency times of fin whales in the SCB where they occur year-round, unlike most other baleen whale species.
8. This study found significant and previously undocumented statistical results correlating behavior with a number of environmental variables. While many correlating factors have been identified, the fundamental behavioral triggers remain poorly understood. More detailed analyses of focal follow video from this species (n=21 groups) may illuminate and differentiate potential effects of U.S. Navy activities from naturally occurring baseline behavior.
9. These focal follows have involved following individuals for extended periods of time (up to 60+ min). They should thus reveal more detailed information on types and levels of social behavior and foraging occurring by area, habitat features, and known individuals. Virtually nothing has been published on social interactions among fin whales. We have videotaped apparent socio-sexual behavior for this species on the study area numerous times. These data indicate that the area appears to be important for courting/reproductive activities. Numerous focal follows of fin whale calves have also been conducted but have not been analyzed in detail.
10. These RSF studies statistically indicate that the SNB west of SCI and the areas surrounding SCI are high-probability use areas for fin whales, and that subareas and features there are used differentially by fin whales. Such baseline information is important to differentiate

potential effects of U.S. Navy activities from naturally occurring behavior among this species.

Gray Whale

Forty gray whale sightings were used in RSF analyses. Most were engaged in slow-travel/rest (n=18) or medium/fast travel (n=21), with only one sighting observed milling (Table A-1, **Appendix I**). Milling was therefore combined with slow-travel behavior.

Notable Results

1. The overall probability of gray whale sightings of all types significantly decreased with increasing distance from the mainland coast (Figures I-2 and I-9, **Appendix I**).
2. Gray whale habitat use extended throughout all but the far west margin of the study area.
3. Certain surface-observed behavior states were strongly associated with seafloor aspect (i.e., the compass direction of the slope of the seafloor face). In particular, gray whales were unlikely to travel slowly over north-facing slopes (p=0.0958).
4. Overall, gray whales were significantly more likely to be observed moving faster (medium/fast travel) when closer to shore, including near San Clemente and Santa Catalina islands (Figures I-1 and I-9, **Appendix I**).
5. RSF habitat-use probability maps suggest that central SCB between SCI and the mainland is used primarily by slow-traveling/resting gray whales, with very low use by medium/fast traveling individuals (Figure I-9, **Appendix I**). This suggests some inverse relationships in habitat selection based on behavior state/travel speed.

Interpretation

1. As expected, gray whales selectively preferred shallower, nearshore waters, particularly close to the mainland coast, regardless of behavior state. Notably, nearly all focused research on gray whales in the SCB has focused on nearshore, coastal mainland waters (e.g., Reilly et al., 1983, Poole 1984, Sumich and Show 2011).
2. Gray whales were regularly seen scattered offshore near islands in the study area, with lowest probability of occurrence on the western edge of the range.
3. In offshore areas, the highest probability of occurrence was concentrated along the shores of SCI and Santa Catalina Island. Similarly, Sumich and Show (2011) reported during winter 1988-1990 that some southbound gray whales regularly used two offshore migratory corridors within 40 to 50 km W of SCI and within 80 to 90 km W of Santa Catalina Island. They found that more grays used these two offshore corridors than the coastal mainland corridor. These three corridors appeared to converge near the California-Mexico border. Based on photogrammetry data, Sumich and Show (2011) suggested that smaller (<11.5 m) and presumably younger, gray whales preferentially use the coastal migratory corridor in the SCB.

4. While the nearshore coastal waters provide an important migratory path for gray whales, the entire study area is used by gray whales during winter and spring migration. This information is important given the prior limited systematic studies of gray whale relative abundance, distribution and occurrence in offshore coastal areas.
5. We observed gray whale calves in offshore waters (see **Appendix B**, Figure B-23). Further data analyses are needed to determine the exact locations and numbers of calves and yearlings in such waters.
6. Gray whales are predicted to use nearshore waters of SCI for fast travel based on RSF results.
7. The reason for the strong tendency for gray whales to travel faster over north-facing slope aspects is unclear. This may be related to currents or other oceanographic features (e.g., upwelling, water temperature changes) that influence behavior and migration movement patterns. It is possible that whales follow these contours or associated oceanographic indices during generally east-west movements between the mainland coast and outer islands. Predator-avoidance may also influence observed regional travel speed differences along north-facing aspects.
8. The team has found significant and previously undocumented statistical results correlating behavior with a number of environmental variables. The teams has identified many correlating factors, the fundamental behavioral triggers remain poorly understood. More detailed analyses of focal follow video from this species (n=5 groups) may illuminate and differentiate potential effects of Navy activities from naturally occurring baseline behavior.
9. Additional analyses could include a quantitative analysis of the level of use of offshore north- and south-bound migration corridors by gray whales (including calves) compared to the results of Sumich and Show (2011) from over 10 years ago in the same region.
10. We have also videotaped apparent nursing and socio-sexual behavior among gray whales on the study area numerous times (e.g., Moore et al. 2012). Thus, the area appears to be important for courting/reproductive/nursing activities. Numerous focal follows of gray whale mother-calves have also been conducted but have not been analyzed in detail.

CONCLUSIONS

1. RSF analyses revealed some significant correlations between habitat use and behavior states for all five species examined. This approach serves to identify high-use areas and contributes to attributing biological meanings and levels of importance to these features and areas (e.g., foraging, courting, resting, etc.).
2. Understanding, systematically quantifying, and describing baseline habitat-use and selection patterns is critical before attempting to interpret potential effects (or lack thereof) of U.S. Navy MFAS, underwater explosions, and other activities.

3. For many of these species, RSF results provide the most extensive, up-to-date concentrated database on the occurrence, distribution, relative abundance, and habitat-use behavioral patterns available in the study area.
4. RSF analyses described herein were designed to provide a means to systematically, quantitatively and statistically assess potential changes in habitat-use and selection patterns relative to U.S. Navy activities. The RSF approach has been successfully applied for this purpose to numerous other species relative to anthropogenic activities. The baseline provided herein is integral to successful implementation of this approach (Manly et al. 2002).

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