SIO small boat based marine mammal surveys in Southern California: Report of Results for August 2010 - July 2011

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INTRODUCTION

This report summarizes small boat based research conducted on cetaceans off southern California by the Scripps Institution of Oceanography (SIO) in collaboration with Southwest Fisheries Science Center (SWFSC) from August 2010 – July 2011. The primary objectives of this research were to use sighting, photo-identification, biopsy and acoustical sampling techniques to assess the occurrence, distribution and population structure of small cetaceans in a region that is subject to frequent naval exercises; this information is needed to evaluate possible effects from Mid Frequency Active Sonar (MFAS) trials and ultimately for the development of appropriate management protocols. Survey effort was focused on the Southern California Offshore Range (SCORE) near San Clemente Island as part of an ongoing collaborative study to assess cetacean populations occurring in this active Navy training area (Moretti *et al*. 2006; Falcone *et al*. 2009). Additional surveys were conducted at Catalina Island and the San Diego coastline. This geographically broad approach was designed to increase the effectiveness of our monitoring efforts by collecting similar data at multiple sites, providing a regional assessment of small cetacean populations inhabiting the area.

While the current SIO/SWFSC small boat effort in southern California incorporates data collection from all cetacean species encountered, bottlenose and Risso's dolphins were selected as initial focal species due to their accessibility, existing baseline data and varying life history patterns. The information provided herein provides an outline of our research goals and preliminary results from efforts during 2010/2011.

METHODS

Survey Effort

SIO small vessel surveys were conducted at San Clemente and Catalina Island from 4-11 January 2011, 1-7 May 2011, and 21–25 July 2011. In addition, nineteen surveys were conducted along the San Diego coastline during this same time period. Surveys were conducted from a 6.8 m rigid-hulled inflatable boat (RHIB) equipped with twin outboard engines. Survey tracks from the field effort at the three study sites are presented in Figure 1.

Study Areas

San Clemente Island

San Clemente Island surveys were based from Wilson Cove on the north-eastern corner of the island; approximately 22 km from the Navy's SOAR array located to the west of the island (see Figure 1). Survey routes were neither systematic nor random as weather, range restrictions, directed acoustic detections, and *a priori* knowledge of focal species distribution were all factors in determining the route for a given day. Survey efforts on the SOAR range in conjunction with M3R-based acoustic detections (Moretti *et al*. 2006) were conducted in sea state Beaufort 3 or less. When prevailing north-westerly winds created unfavorable sighting conditions or naval operations precluded access to the SOAR range, survey efforts were focused on the lee (eastern) side of the island where frequent sightings of bottlenose, Risso's and common dolphins have been documented (Caretta *et al*. 2000).

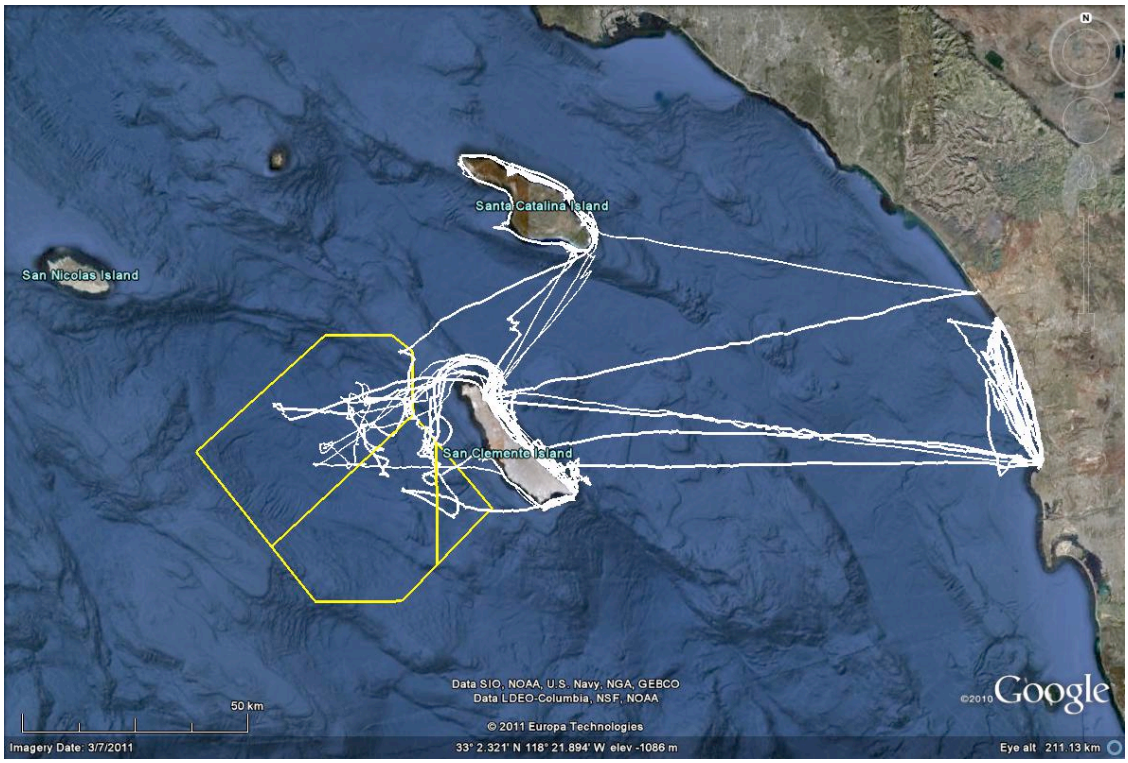

Figure 1. SIO small vessel survey tracks from monitoring at SCORE (boundaries of SOAR range in yellow), Catalina Island and the San Diego coastline from August 2010 – July 2011.

Catalina Island

Catalina Island surveys were based from Avalon on the south-eastern corner of the island (Figure 1). Survey routes were designed to provide systematic coverage of the study area via circumnavigation of the island at a distance of approximately 2 km from shore. When weather conditions precluded our ability to complete a circumnavigation of the island, we employed opportunistic effort to cover areas that had suitable weather and sighting conditions.

San Diego Coastline

The San Diego coastal study area encompassed a 32 km strip of coastline between Scripps Pier and Carlsbad. Surveys of immediate coastal waters were conducted in a systematic manner using methods developed and applied by researchers from San Diego State University since 1984 (see Defran and Weller 1999). When sampling in coastal waters was completed, surveys progressed 12-16 km offshore where there was a greater probability of encountering species common to the two offshore island study areas (e.g. offshore bottlenose dolphins, Risso's dolphins, Pacific white-sided dolphins).

Procedure

When cetaceans were sighted, the group was approached and information on species, group size and composition, direction of movement, environmental conditions, latitude/longitude and time was recorded. For bottlenose and Risso's dolphins as well as beaked whales and baleen whales, effort was made to acquire numerous quality photographs of each individual present for

individual identification. Biopsy samples were collected from particular species for current/planned projects being conducted by SIO and/or our collaborators at SWFSC. Acoustical recordings of select species calls as well as anthropogenic sounds were conducted opportunistically. Details on the instrumentation utilized and specific protocols for each method of data collection are outlined below.

Photo-Identification

Photo-identification data were collected using a Canon EOS 50D digital SLR camera equipped with a 100-400 mm Canon EF image-stabilizing lens. Effort was made to acquire numerous quality photographs of dorsal fins, tail flukes and/or lateral flanks (depending on the species) of each individual encountered, without regard to apparent distinctiveness. After completion of photographic effort, the vessel was positioned for acoustical recordings and/or biopsy sampling (see below). Identical procedures were repeated when additional cetacean groups were encountered.

Biopsy Sampling

Biopsy sampling was conducted with a Barnett Panzer crossbow delivering a carbon biopsy dart with modified tip. The custom built tip was 25 mm in length with a 7 mm diameter circular end and contained three to four internal barbs designed to retain the tissue sample. Samples were labeled in the field according to species, date, and location and placed on ice while on the research vessel. Upon completion of a given survey, samples were temporarily stored at -20°C until transfer to the Southwest Fisheries Science Center for archiving and permanent storage at -80°C.

Drop-Hydrophone Recording System

Acoustical recordings were collected from the RHIB using a mobile, compact hydrophone and recording system. The acoustic sensor consists of two transducers connected to a signal conditioning circuit board encased in a 5 cm oil-filled tube. To allow for broadband data collection and to reduce electronic noise, the circuit board was divided into two stages covering different frequency bands. The stage one frequency band is 10 – 3000 Hz and utilizes six Benthos AQ-1 cylindrical hydrophones in series. The stage two frequency band ranges from 2000 – 100,000 Hz and uses a single omni-directional, spherical SRD HS-150 hydrophone with a flat frequency response (±3 dB) from 1 to 100 kHz.

The analog signals from the circuit boards were digitized and recorded with the Fostex FR-2 field memory recorder. The recording system is capable of sampling two channels at 192 kHz with 24-bit samples, yielding a Nyquist frequency of 96 kHz, with a flat frequency response (±3 dB) from 20 – 80 kHz. Signals were recorded directly to an 8 Gbyte compact flash memory card and subsequently downloaded directly to computer hard-drives.

HARP Recording System

Independent of the small boat operations, we deployed several High-Frequency Acoustic Recording Packages (HARPs) in the basins around San Clemente Island to provide a long-term continuous record of acoustic signals occurring in the region. HARPs are autonomous, bottom mounted instruments containing a single hydrophone tethered 10 m above the seafloor (Wiggins and Hildebrand 2007). The system records signals in the band from 10 Hz to 100 kHz, making it capable of recording a wide variety of sounds ranging from baleen whale calls to MFAS to odontocete echolocation clicks. HARPs are capable of acoustic sample rates of up to 200 kHz

and can store 1920 GBytes of acoustic data, allowing continuous recording for 55 days. The HARP can also be duty-cycled (e.g., 20 min on, 10 min off) to extend recording duration. Data collected by HARPs are analyzed for signal content following instrument retrieval using both manual and automated signal recognition methods.

Data Analysis

Photo-identification

Photo-identification analysis closely followed techniques described by Defran *et al*. (1990) and are summarized as follows: Clear photographs of distinctively marked dorsal fins were sorted by recognizable notch patterns, and the best photograph of each dolphin was selected as the "type photo" to which all other photographs were compared. Subsequently, only unambiguous matches with the "type photo" were accepted as re-identifications of a known individual.

Biopsy Sampling

Tissue samples, collected via biopsy dart, will be analyzed with three primary objectives in mind. To examine population structure, DNA will be extracted using standard molecular protocols with Qiagen DNeasy and genetic sex-determination will be conducted by Real-Time PCR (Stratagene) assay. To assess stress hormone levels, methods to measure blubber cortisol are currently under development (Nick Kellar, SWFSC) and will follow published techniques (Kellar *et al.* 2006; 2009) used to examine reproductive hormones (progesterone and testosterone). Finally, to determine contaminant (DDT, PCBs and PBDEs) levels, standard protocols developed by the Northwest Fisheries Science Center (a collaborator on this aspect of the project) will be followed.

Acoustical Recordings

The structural characteristics of clicks and/or whistles collected in 2010/2011 from five delphinid species are currently being measured and applied to the development of a suite of detection and classification engines. Echolocation clicks are assessed through the calculation of several variables including duration, inter-click interval, peak frequency points, -3dB bandwidth, -10 dB bandwidth and center frequency. Whistle structure analysis entails the extraction of eight specific variables from each whistle contour: begin frequency, end frequency, minimum frequency, maximum frequency, frequency range, mean frequency, duration, and number of inflection points. Call variables are subsequently applied to multivariate statistical engines to examine the within species/population and between species/population variability inherent in the data.

HARP Recordings

The temporal occurrence of MFAS will be assessed from continuous recordings collected at HARP site H simultaneous with small boat surveys at San Clemente Island. MFAS events will be logged based on manual review of long-term spectrograms (LTSAs) containing one hour of acoustical data with a Nyquist frequency of 5 kHz. Event detections documented in the LTSA window will be examined on a finer temporal scale to calculate start and end times, confirm initial signal classification and document the structural characteristics of MFAS signals.

RESULTS

Sightings

Cetacean sightings across the three study areas included six odontocete and five mysticete species. Excluding common dolphins, bottlenose dolphins were the most commonly sighted species at Catalina Island and off the San Diego coastline while Risso's dolphins were the most frequently encountered cetacean at San Clemente Island. Humpback whales were the least frequently encountered species with only one sighting during the period. Plots of all cetacean sightings documented during the 2010/2011 study period are presented in Figure 2. Additional details on sighting, photo-identification, acoustical and biopsy data collected from the three study areas are provided in Tables 1-4.

The distribution of cetacean species sighted off San Clemente Island was not uniform (Figure 2). Bottlenose and Risso's dolphin sightings were concentrated in near-shore waters with a mean distance from the island of 3.8 km and 6.4 km respectively. One-hundred percent of bottlenose and 75% of Risso's dolphin sightings occurred off the SOAR range with the remaining four sightings of this species occurring on the eastern portion of the range. Sightings of fin whales and Dall's porpoise were made exclusively on the SOAR range.

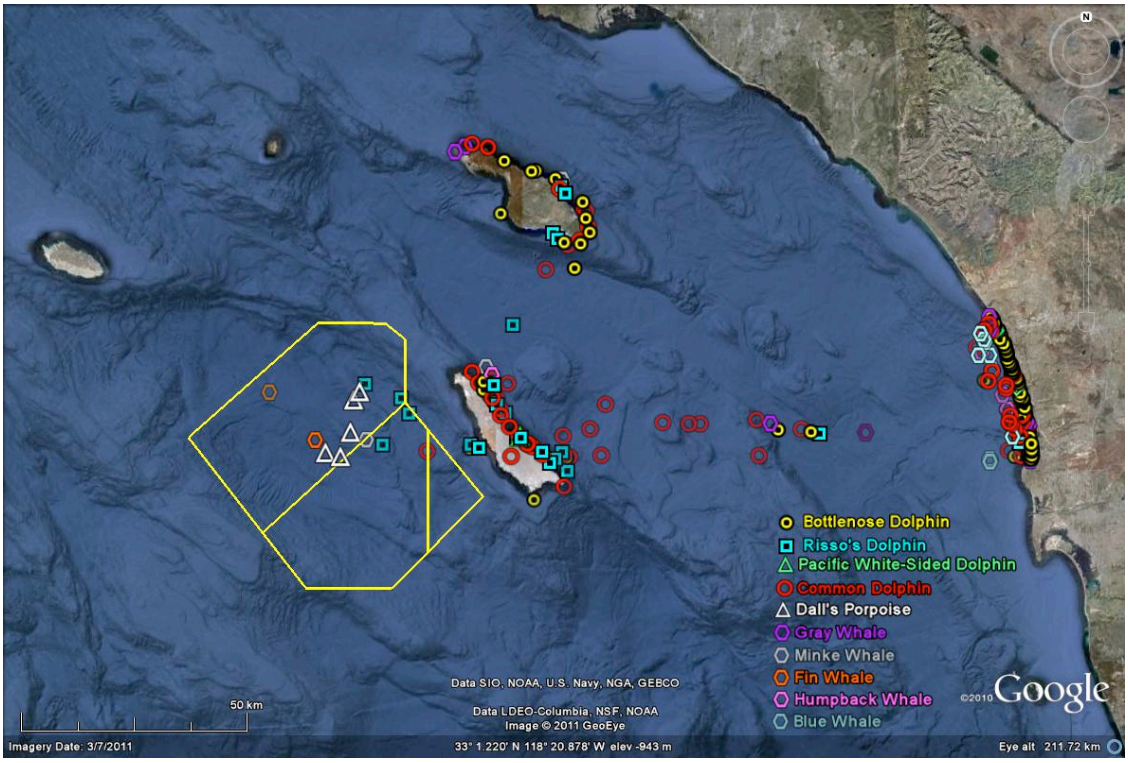

Figure 2. Cetacean sightings documented on all SIO small boat surveys in southern California from August 2010 – July 2011.

Table 1. Summary sighting, photo-identification, acoustical and biopsy data collected January 4-11, 2011 at San Clemente and Catalina Islands.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	13	314	1939	7	4
Risso's Dolphin	6	127	612	1	2
Pacific White-Sided Dolphin	-	-	-	-	-
Short-Beaked Common Dolphin	3	1638	5	-	-
Long-Beaked Common Dolphin	2	256	12	-	-
Dall's Porpoise	5	29	141	-	-
Fin Whale	1	1	10	-	-
Humpback Whale	1	2	-	-	-
Gray Whale	3	4	81	-	-
Blue Whale	-	-	-	-	-
Minke Whale	-	-	-	-	-

Table 2. Summary sighting, photo-identification, acoustical and biopsy data collected May 1-6, 2011 at San Clemente and Catalina Islands.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	3	54	384	3	8
Risso's Dolphin	8	331	1873	9	3
Pacific White-Sided Dolphin	1	10	17	-	-
Short-Beaked Common Dolphin	20	3613	90	-	-
Long-Beaked Common Dolphin	8	434	97	-	-
Common Dolphin, species unknown	2	31	0	-	-
Fin Whale	1	7	211	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	1	2	33	-	
Blue Whale	-	-	-	-	-
Minke Whale	2	2	126	-	-

Table 3. Summary sighting, photo-identification, acoustical and biopsy data collected July 21-25, 2011 at San Clemente Island.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	8	100	753	2	3
Risso's Dolphin	9	185	823	3	2
Pacific White-Sided Dolphin	-	-	-	-	-
Short-Beaked Common Dolphin	14	2114	1	2	-
Long-Beaked Common Dolphin	3	46	-	1	-
Common Dolphin, species unknown	1	450	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	-	-	-	-	-
Blue Whale	3	5	35	-	-
Minke Whale	-	-	-	-	-

Table 4. Summary sighting, photo-identification, acoustical and biopsy data collected August 2010 – July 2011 on nineteen surveys off the San Diego coastline.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Coastal Bottlenose Dolphin	79	729	7592	15	2
Offshore Bottlenose Dolphin	2	18	59	-	-
Risso's Dolphin	1	26	307	-	3
Pacific White-Sided Dolphin	4	29	79	-	1
Short-Beaked Common Dolphin	5	3634	14	-	-
Long-Beaked Common Dolphin	7	1615	43	-	-
Common Dolphin, Species unknown	4	69	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	6	7	34	-	
Blue Whale	10	23	625	-	-

San Diego Coastal Surveys

Between 1 August 2010 and 30 July 2010, a total of nineteen surveys were conducted along the San Diego coastline. These surveys represent one component of a larger field effort on California coastal bottlenose dolphins extending from 2 November 2009 to 19 April 2011, encompassing a total of 31 surveys. Overall, 115 groups, composed of approximately 958 individuals, were approached for photo-identification purposes. Analysis of photo-identification data has been completed for the first 19 surveys of the study, resulting in a catalog of 210 unique individuals. The remaining photo analysis is underway and expected to be completed in September. Upon completion of this component of the project, mark-recapture abundance analysis will be initiated.

Appendix 1 provides survey-specific summaries for each day of effort on our coastal surveys. These summaries include information on survey effort, plots of sighting locations and survey tracks, and tabular summaries of the species encountered, number of individuals in each group, number of photo- and the number of acoustic recordings and biopsy samples obtained.

Bottlenose Dolphin Photo-Identification

Based on morphology (Walker 1981), photo-identification (DeDecker *et al*. 1999) and genetics (Lowther 2006), NMFS management protocol delineates bottlenose dolphins off Southern California into two distinct stocks: a coastal stock of approximately 450 animals (Dudzik *et al.* 2006) and an offshore stock of 3,000 animals (Caretta *et al*. 2009). While each of these metrics supports the theory of separate coastal and offshore populations, none provide the resolution necessary to determine if animals occurring on the shelf and/or near islands in the Southern California Bight may be distinct from animals occurring in pelagic waters. Without a clear understanding of offshore bottlenose dolphin population structure in the SOCAL region, it is difficult to define stocks, thus limiting the power of abundance and survivorship estimates (Duffield *et al*. 1983, Ross and Cockroft 1990, Curry and Smith 1998). To reliably assess the effects of sources of anthropogenic disturbance, such as MFAS, additional information on the population structure of offshore bottlenose dolphins is needed. The current photo-identification

project as well as expanded DNA analysis will fill important data gaps in our understanding of bottlenose dolphin population structure off southern California.

From August 2006 – July 2011, 74 groups of bottlenose dolphins were photographed for individual identification at San Clemente Island, Catalina Island, and in the Gulf of Santa Catalina (Figure 3). Biopsy samples were also collected from 22 of the 74 groups encountered for a total of 65 tissue samples with corresponding individual photo-identifications. Analysis of the combined SIO/SWFSC and Cascadia Research Collective bottlenose dolphin photographic database from August 2006 - May 2011 resulted in a catalog of 419 distinctive individuals from San Clemente Island and 312 individuals from Catalina Island. Photo-identification analysis indicated variable levels of intra- and inter-annual site fidelity to the San Clemente and Catalina Island study areas as well as movement between the two island sites. Mark-recapture abundance estimation models are currently being applied to the database with final results expected in February 2012. Details on the results of our analyses through May 2011 are provided below.

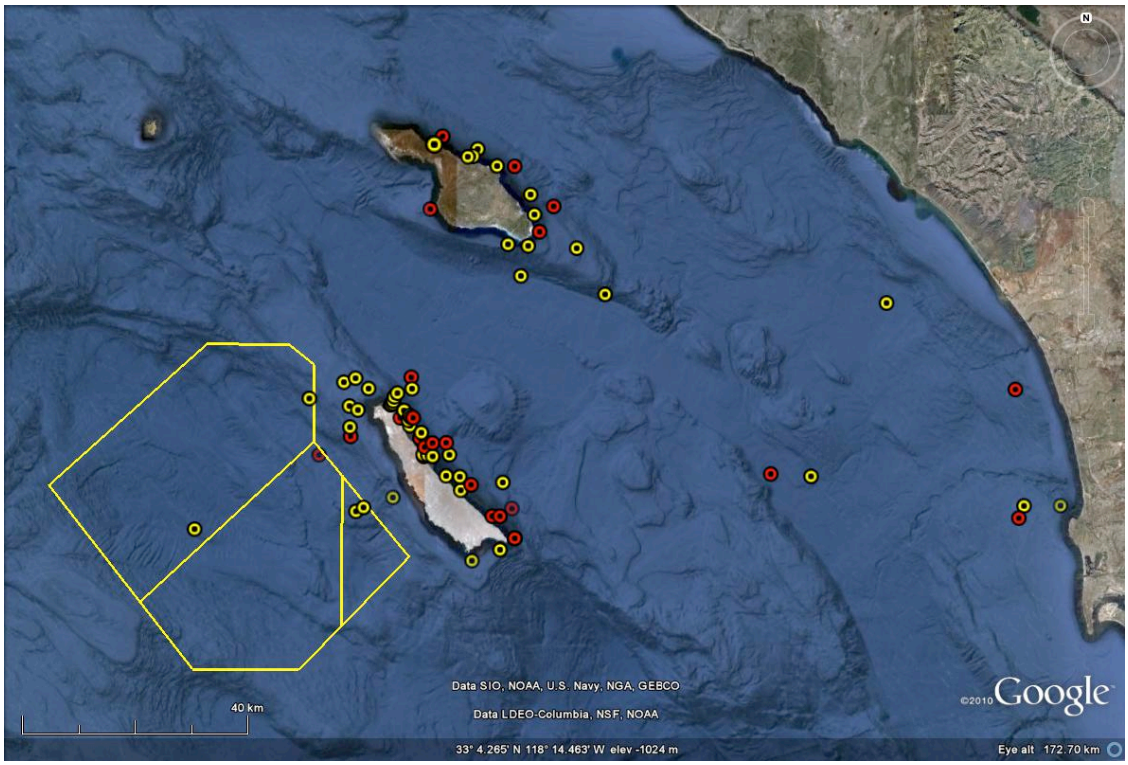

Figure 3. Distribution of offshore bottlenose dolphin sightings from August 2006 – July 2011 where at least one individual was photographically identified; Yellow = Photo-ID, Red = Biopsy and Photo-ID.

Rate of discovery

The rate at which individual dolphins were identified off San Clemente Island from 2006-2011 was examined across surveys in which at least one dolphin was photographically identified (n=29 surveys, Figure 5). Rate of discovery, plotted as the cumulative number of newly identified individuals across each survey, indicates that new (i.e. previously unidentified) individuals were encountered throughout the six-year study period. While the consistent positive

slope in the curve indicates that the population is larger than the current sample, 21% (n = 86) of the 419 individuals identified have been sighted in two or more of the eleven survey periods. In addition, the proportion of newly identified individuals decreased from 100% at the beginning of the study to 64% on the most recent survey analyzed (Figure 4). Based on this trend, we expect the overall proportion of newly identified individuals to decrease with additional surveys at San Clemente Island.

The rate at which individual dolphins were identified off Catalina Island from 2006-2011 was examined across surveys in which at least one dolphin was photographically identified (n = 12 surveys, Figure 5). Similar to San Clemente Island, the rate of discovery curve indicates that new (i.e. previously unidentified) individuals were encountered throughout the six-year study period. While the consistent positive slope in the curve indicates that the population is larger than the current sample, 9% (n = 28) of the 312 individuals first identified at Catalina have been sighted in two or more of the eleven survey periods. In addition, the proportion of newly identified individuals decreased from 100% at the beginning of the study to 62% on the most recent survey analyzed. Based on this trend, we expect the overall proportion of newly identified individuals to decrease with additional surveys at Catalina Island.

Sighting frequency and site fidelity

Sighting frequencies for the 419 dolphins first identified at San Clemente Island from 2006-2011 ranged from 1-6 ($\bar{x}$ = 1.5, SD = 0.8). Sixty-nine percent (n = 291) of the dolphins were photographed once, 20% (n = 85) two times, 7% (n = 28) three times and 4% (n = 15) four or more times. Sighting frequencies for the 312 dolphins first identified at Catalina Island from 2006-2011 ranged from 1-6 ($\bar{x}$ = 1.3, SD = 0.6). Seventy-nine percent (n = 249) of the dolphins were photographed once, 18% (n = 55) two times, 2% (n = 5) three times and 1% (n = 3) four or more times.

Re-sightings of the same individuals within one survey period (5-14 days) were frequent, indicating short-term site fidelity to the island study sites. From the total sample of 731 individual bottlenose dolphins, the number of survey periods in which identified individuals were photographed averaged 1.1 survey periods (SD = 0.4, range = 1–4). Eighty-four percent (n = 617) of the identified population was photographed during only one survey period, 13% (n = 98) was observed during two survey periods, 2% (n = 15) was sighted during three survey periods and <1% (n=1) was sighted during four periods (Figure 6). None of the identified individuals were sighted during all eleven survey periods; however, photo-identifications of only 27 individuals were collected in 2006 and 27 individuals were identified in 2007, restricting the number of animals that could have been sighted during all eleven survey periods. In addition, individuals that were identified during the latter part of the study were not present in the photographic catalog for long enough duration to be re-sighted during multiple survey periods.

Inter-Island Movement patterns

Photographic comparisons of 419 dolphins first identified from 2006-2011 at San Clemente Island with the 312 animals first documented at Catalina during the same period resulted in 22 individuals identified in both study areas (Figure 6). Variable patterns of inter-island movements were apparent from the sighting matrix, with sighting intervals between Catalina and San Clemente ranging from 5 days to 5 years. These data represent the first photographically documented movement of bottlenose dolphins between Catalina Island and San Clemente Island.

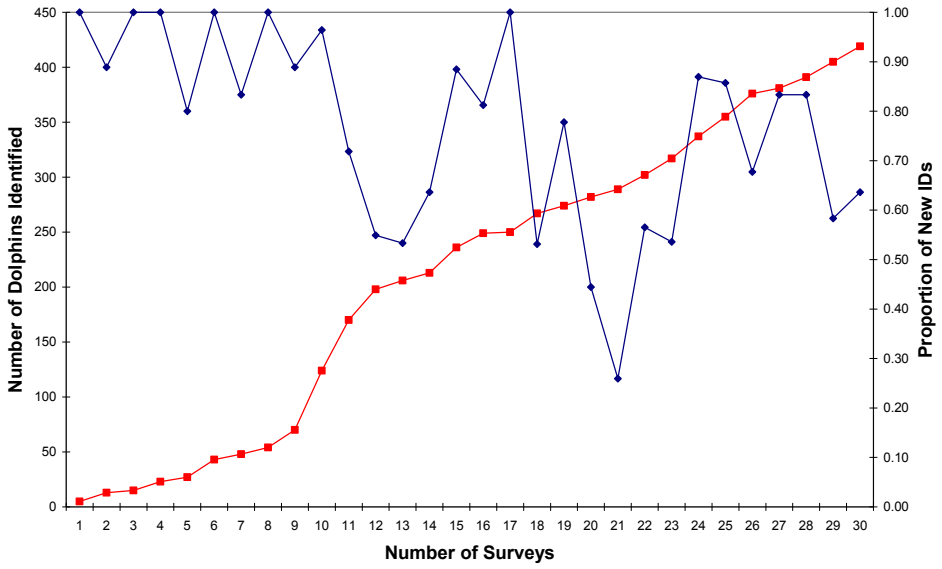

Figure 4. Cumulative number of bottlenose dolphins (red) and the proportion of new individuals photo-identified (blue) at San Clemente Island over 29 surveys in which at least one dolphin was identified. N = 419 individuals.

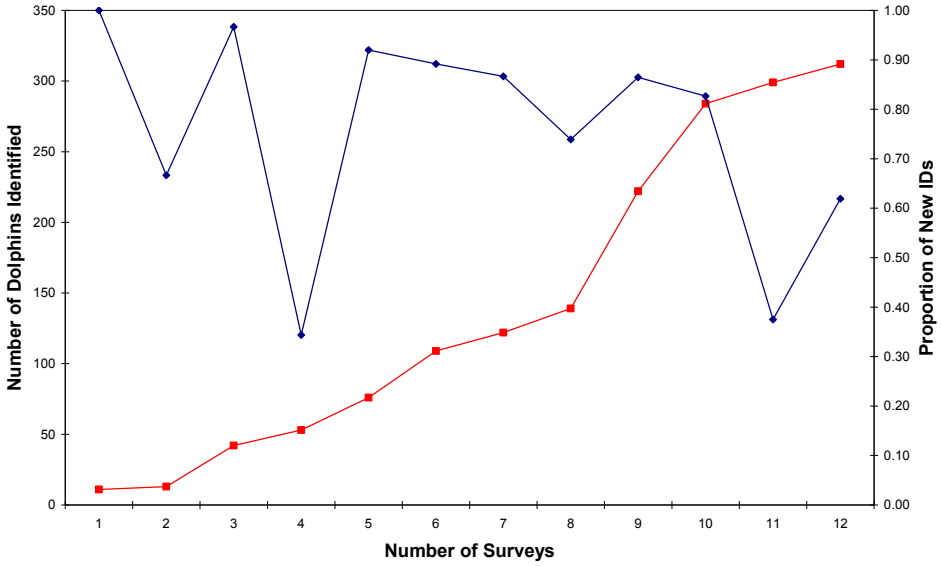

Figure 5. Cumulative number of bottlenose dolphins and the proportion of new individuals photo-identified at Catalina Island over 12 surveys in which at least one dolphin was identified. N = 312 individuals.

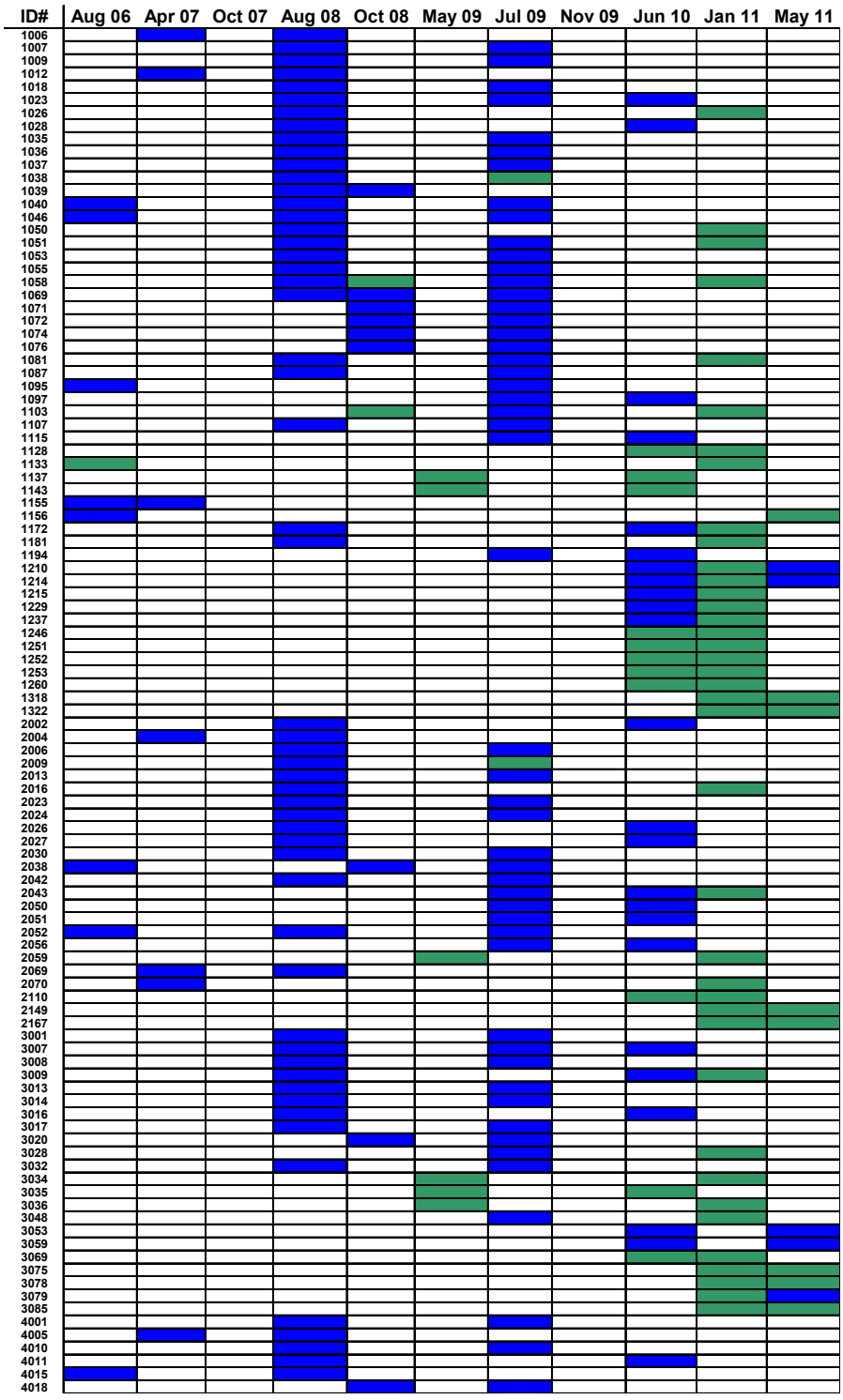

Figure 6. Sighting matrix for the 114 bottlenose dolphins photographically identified during two or more of the 11 survey periods at San Clemente and Catalina Island from August 2006 – May 2011. Blue = SCI; Green = CI.

Bottlenose Dolphin Biopsy Sampling

Biopsy samples taken from bottlenose dolphins at San Clemente and Catalina Islands as well as the San Diego coastline from October 2008 through July 2011 are currently being analyzed by scientists at the NOAA Southwest Fisheries Science Center along three metrics: (1) stress (cortisol) and reproductive (progesterone) hormone levels relative to Mid Frequency Active Sonar exposure, (2) DNA analyses for an assessment of the population structure and relative relatedness of coastal, pelagic and island associated bottlenose dolphins in SOCAL and (3) contaminant loads (persistent organic pollutants and mercury) in coastal versus offshore animals.

Hormone Study

The collaboration between SIO and SWFSC on the San Clemente Island monitoring project led to the incorporation of a recent and developing technique for assessing stress in free-ranging cetaceans. Bottlenose dolphin biopsy samples collected from October 2008 through July 2011 at San Clemente and Catalina Island, as well as off the San Diego coastline, are currently being analyzed by Nick Kellar and colleagues at SWFSC for glucocorticoids (GC) concentrations.

As part of the GC analysis, validation of the protocols used to measure cortisol in cetacean blubber is being conducted, by using bowhead whales (killed by native hunters in Alaska) as voucher specimens. Serum concentrations of cortisol are known for each of these whales and blubber cortisol levels have now been measured in 104 animals. The mean (SE) measured blubber cortisol value was 536 (± 86.8) pg/g and a significant relationship between blubber and serum cortisol levels ($R2 = 0.2245$ ($p = 0.035$). Though significant, the relationship is fairly loose; a result that was expected given what is known about the dynamics of blubber cortisol production. The serum levels are quite variable as they are integrated over a short period of time and the events just prior to sampling dominate the levels we measure. Blubber cortisol values are integrated over a longer period of time and therefore the act of sampling itself is much less likely to affect the measured value. Given that these bowhead whales were hunted and killed before being sampled, it is not surprising that the levels were higher in the blood and that the relationship between the two matrices is loosely correlated.

DNA Study

Genetic comparisons between coastal and offshore bottlenose dolphins in the southern California Bight support the existence of coastal and offshore stocks. Based on nuclear and mtDNA analysis, Lowther (2006) identified 5 haplotypes from 29 coastal animals and 25 haplotypes from 40 offshore animals in the southern California Bight. There were no shared haplotypes between coastal and offshore dolphins and significant genetic differentiation between the two ecotypes was evident.

Based on the geographical distribution of offshore bottlenose dolphin biopsy locations, Lowther (2006) further divided tissue samples into a northern and a southern group. Comparison of DNA structure between the northern and southern samples and with those collected at other locations in the North Pacific suggested structure among the offshore dolphins within the southern California Bight. Additional sampling across a wider geographic and temporal scale, as reported here, is needed to accurately assess the structure of this potentially highly divergent population (Lowther 2006). Of particular interest in the present study is the assessment whether insular (i.e. island associated) population segments exist and if so, can they be genetically differentiated from pelagic and coastal forms of the species.

Risso's Dolphin Photo-Identification

The status of Risso's dolphins off California is not known and there are insufficient data to evaluate trends in abundance (Carretta et al. 2009). Abundance estimates ranging from 4,000 to 11,000 animals have been reported from five ship surveys conducted between 1991 and 2008 (Carretta et al. 2010). Inter-annual variation in the distribution of Risso's dolphin relative to ship survey area is likely responsible for differences in estimated abundance between surveys (Caretta et al. 2010). Without a clear understanding of Risso's dolphin population structure in the SOCAL region, it is difficult to develop and/or monitor abundance and survivorship estimates (Cardetta et al. 2009). To reliably assess the effects of sources of anthropogenic disturbance, such as MFAS, additional information on the population structure of Risso's dolphins is needed. The current photo-identification project as well as well as a first time DNA analysis will provide data to fill gaps in our understanding of Risso's dolphin population structure off southern California.

From August 2006 – July 2011, 69 groups of Risso's dolphins were photographed for individual identification at San Clemente Island, Catalina Island, and in the Gulf of Santa Catalina (Figure 7). Biopsy samples were also collected from six of the 69 groups encountered for a total of 12 tissue samples with corresponding individual photo-identifications. Analysis of the combined SIO/SWFSC and Cascadia Research Collective Risso's dolphin photographic database from August 2006 - July 2008 resulted in a catalog of 165 distinctive individuals from both San Clemente Island and Catalina Island.

Rate of Discovery

The rate at which individual Risso's dolphins were identified off San Clemente and Catalina Island from 2006-2008 was examined across surveys in which at least one dolphin was photographically identified (n=15 surveys, Figure 8). Rate of discovery, plotted as the cumulative number of newly identified individuals across each survey, indicates that new (i.e. previously unidentified) individuals were encountered throughout the three years analyzed to date. The consistent positive slope in the curve indicates that the population is larger than the current sample, with only 1 individual re-sighted during the three year period. In addition, the proportion of newly identified individuals ranged from 92% to 100% throughout the study indicating that on every survey where photo-identifications were acquired, all or most individuals had not been previously documented. This trend suggests that the overall population size for Risso's far exceeds the 165 individuals documented to date with a distribution that likely encompasses an area extending well beyond the San Clemente Island/Catalina Island complex. Analysis of data collected from 2008-2011 is currently underway which will allow for a more comprehensive analysis.

An investigation of Risso's dolphin stock structure, using DNA analysis, off Southern California is planned as is a broader comparison to samples collected at other locations in the North Pacific. Of particular interest in the present study is the assessment of whether insular (i.e. island associated) population segments exist off Southern California and if so, can they be genetically differentiated from pelagic and nearshore forms of the species.

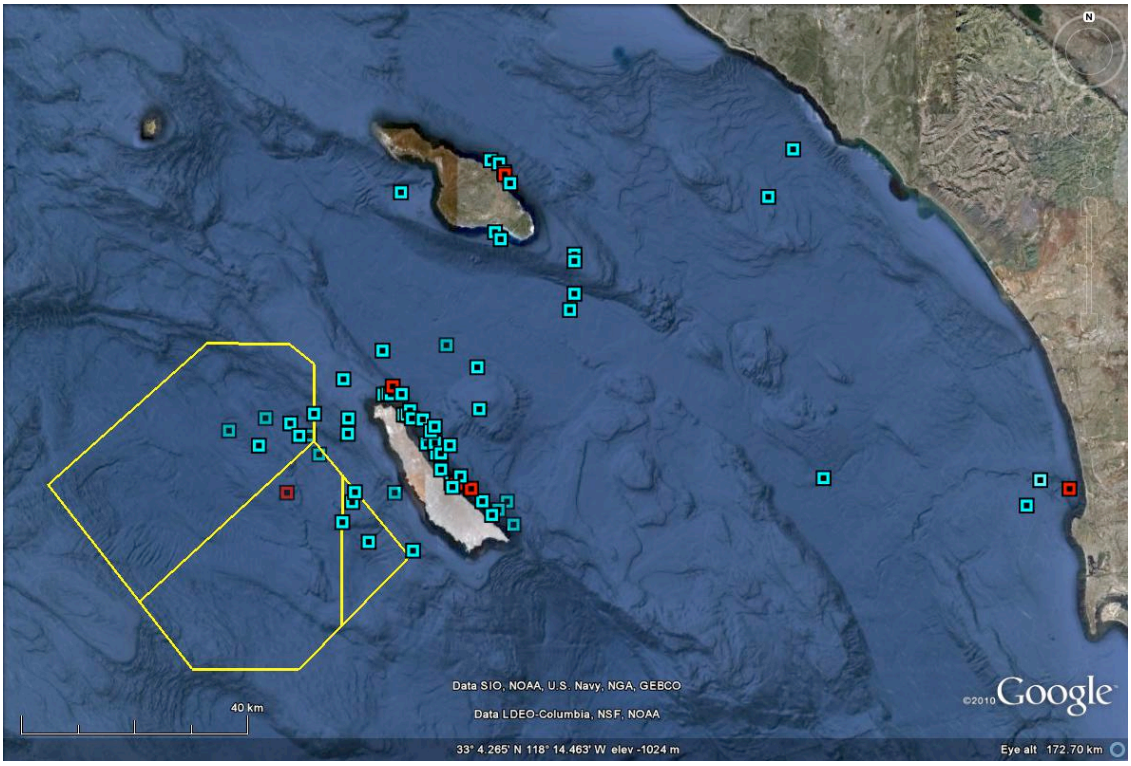

Figure 7. Distribution of Risso's dolphin sightings where at least one individual was photographically identified; Blue = Photo-ID only, Red = Biopsy and Photo-ID.

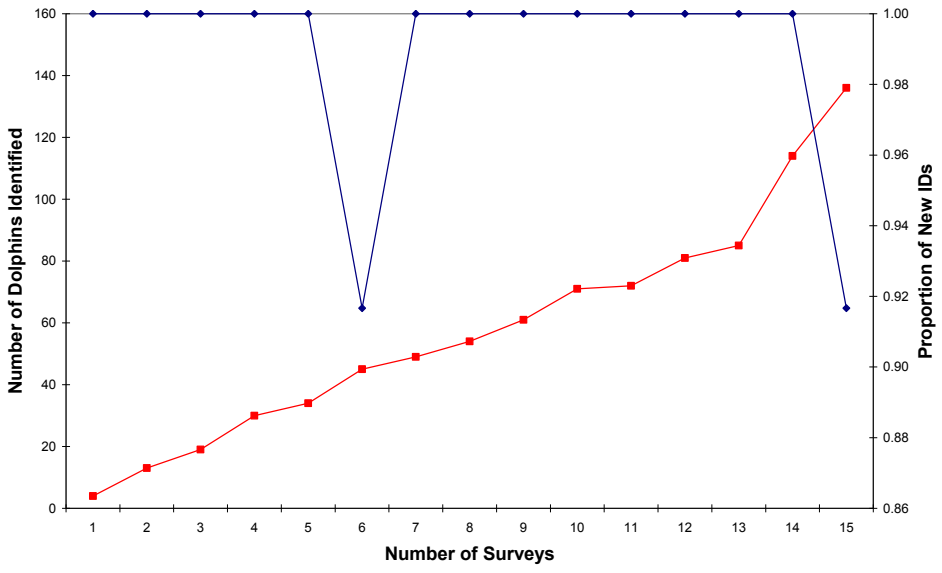

Figure 8. Cumulative number of Risso's dolphins and proportion of new individuals photo-identified at San Clemente and Catalina Islands over 15 surveys in which at least one dolphin was identified. N = 136 individuals.

Pacific White-Sided Dolphin Biopsy and Acoustical Sampling

Genetic, morphometric and acoustical comparisons between Pacific white-sided dolphins in the southern California Bight indicate that two distinct stocks occupy the region. The northern California/Oregon/Washington stock occurs north of 33° N and the southern Baja California stock occurs south of 36° N, with overlap in the two stocks' ranges occurring between 33° and 36° N (Walker 1986, Lux *et al*. 1997, Caretta *et al*. 2009). Based on acoustical recordings of Pacific white-sided dolphin echolocation clicks in the southern California Bight, Soldevilla *et al*. (2010) identified two distinct spectral click structures (Type A and Type B) that were hypothesized to be stock-specific. In order to address the question of micro-geographic variation in click structure between the two northern and southern stocks, biopsy samples in conjunction with acoustical recordings of echolocation clicks have been collected on small vessel surveys from October 2008 to July 2011. Planned analyses will examine the genetic profile of the tissue sample relative to spectral click characteristics to assess potential correlates between call structure and stock structure.

From October 2008 to July 2011, seven groups of Pacific white-sided dolphins were acoustically recorded for click structure identification at Catalina Island, and off the San Diego coastline (Figure 9). Biopsy samples were also collected from six of the 69 groups encountered for a total of 12 tissue samples with corresponding individual photo-identifications.

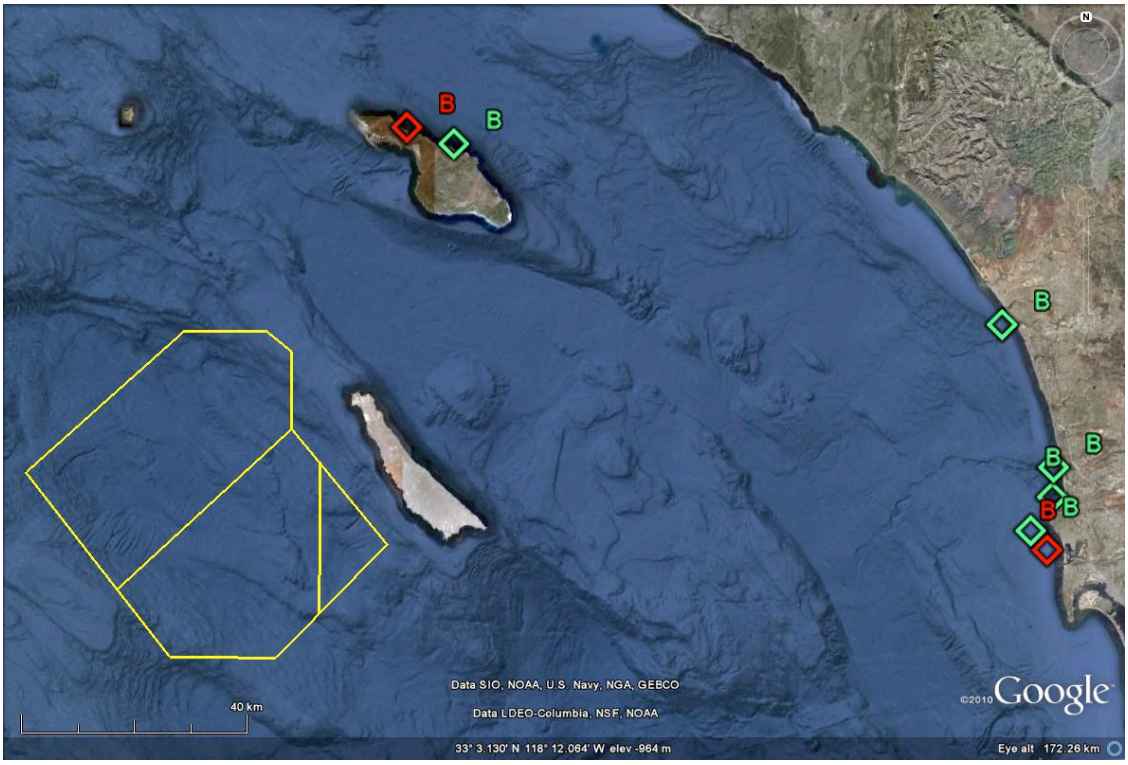

Figure 9. Distribution of Pacific White-Sided dolphin acoustical recordings from 2008-2011. Click type is denoted as Type A or Type B; Green = Acoustical Recording, Red = Biopsy and Acoustical Recording.

Acoustical Recordings

Acoustical recordings collected from October 2008 to July 2011 from the five delphinid species common to the SOCAL region have been incorporated into a larger database of cetacean acoustic data maintained at SIO. Several current projects are assessing clicks and/or whistles for species and population specific call structures that are essential for the interpretation of HARP long-term autonomous recordings conducted by SIO.

DISCUSSION

Sightings

Cetacean sightings across the three study areas during the 2010/2011 field season encompassed six odontocete and five mysticete species. Excluding common dolphins, bottlenose dolphins were the most commonly sighted species at Catalina Island and off the San Diego coastline while Risso's dolphins were the most frequently encountered cetacean at San Clemente Island. The distribution of cetacean species sighted off San Clemente Island was not uniform, with bottlenose and Risso's dolphin sightings mostly concentrated in near-shore waters. One-hundred percent of bottlenose and 75% of Risso's dolphin sightings occurred off the SOAR range with the remaining four sightings of this species occurring on the eastern portion of the range. Sightings of fin whales and Dall's porpoise around San Clemente Island were made exclusively on the SOAR range.

Photo-Identification

Photo-identification research to describe the occurrence, site fidelity, movement patterns and abundance of bottlenose and Risso's dolphins off San Clemente and Catalina Islands was highly successful, providing the first data of this type from the area. The catalogue of 419 distinctive individual bottlenose dolphins from San Clemente and 312 from Catalina, including 23 individuals identified off both islands, will provide the basis for deriving abundance estimates and residency patterns. Similarly, the 136 Risso's dolphins identified from 2006-2008 represent a first attempt to study this species in the waters off southern California. The current and future results regarding both of these species, by way of the research program described here, provide new information valuable to understanding their relationship (both spatial and temporal) to Navy activities off southern California.

Results of the bottlenose dolphin photo-identification studies from San Clemente and Catalina Island demonstrate a generally shallow water distribution and numerous within-year and between-year re-sightings in the two island complex. These trends suggest that at least some individuals in the population are island-associated in their distribution rather than part of an offshore population moving through the region. Additional sampling in the northern channel island complex will be valuable in determining whether the range of this population extends throughout the Channel Islands or is limited to the southern portion of the chain.

Additionally, photo-identification of fin, blue and humpback whales contributed to photographic catalogs maintained by Cascadia Research Collective.

To further assess temporal patterns of distribution for known bottlenose dolphins photographed at the two island sites, planned analysis will examine the occurrence of MFAS via HARP autonomous recordings simultaneous with documented sightings at the two island sites. These analyses will allow for a more detailed examination of potential geographic re-distribution relative to MFAS trials in the SCI region.

Biopsy Sampling

Bottlenose dolphin biopsies collected during offshore and coastal surveys provided samples for analyses along multiple metrics including stress and reproductive hormone levels, as well as genetic structure.

Samples collected around San Clemente and Catalina Island are currently being examined by Nick Kellar (SWFSC) for reproductive (progesterone) and stress (cortisol) hormone levels relative to MFAS exposure. Results of these analyses will be used to assess the relationship of these hormones to reproductive success. We plan to collect additional biopsies to allow for an assessment of GC concentrations in the context of MFAS exposure. Our goal is to collect biopsies at San Clemente Island from 10-20 dolphins at three different times (i.e. conditions) relative to the Naval exercises: 1) approximately three to four weeks before exercises commence (pre-condition); 2) during the exercises, preferably 7-10 days post-commencement (during-condition); 3) approximately three to four weeks post-termination of the exercises (post-condition). Tissue samples collected during planned surveys at Catalina Island and the San Diego county coastline will also be assessed for GC concentrations with the coastal data providing a baseline index from a population having little to no exposure to MFAS. Biopsy samples will be paired with photo-identification images whenever possible to allow individual animals to be followed over both short (days, weeks, months) and long (years) time scales. HARP recordings acquired from the San Clemente Island region during biopsy sampling periods will be subsequently assessed for MFAS exposure metrics including duration, sound exposure levels and signal structure.

Planned DNA analyses will allow for an evaluation of population structure for bottlenose and Risso's dolphins in the SOCAL region, which will better define inshore versus offshore versus island-associated populations that are subject to different environmental and human related pressures. Higher resolution stock structure data will be pertinent in calculating mark-recapture population estimates for both species in offshore waters.

CONCLUSIONS

The primary objectives of the 2010/2011 SIO small boat based research program were to use sighting, photo-identification, biopsy and acoustical sampling techniques to assess the occurrence, distribution and population structure of small cetaceans in a region that is subject to frequent naval exercises. The results summarized in this report provide the framework for our multi-faceted approach to evaluating possible effects from MFAS trials.

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APPENDIX 1

COASTAL SURVEY SUMMARIES FROM Aug 10 – July 11 TO BE ATTACHED HERE