SIO small boat based marine mammal surveys in Southern California: Report of Results for August 2009 - July 2010

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

While the current SIO/SWFSC small boat effort in southern California incorporates data collection from all cetacean species encountered, bottlenose and Risso's dolphins were selected as initial focal species due to their accessibility, existing baseline data and varying life history patterns. The information provided herein provides an outline of our research goals and preliminary results from efforts during 2009/2010.

METHODS

Survey Effort

SIO small vessel surveys were conducted at San Clemente and Catalina Island from 19-25 November 2009 and 14–24 June 2010. In addition, fourteen surveys were conducted along the San Diego coastline and three surveys were conducted in offshore waters during this same time period. Surveys were conducted from a 6.8 m rigid-hulled inflatable boat (RHIB) equipped with twin outboard engines (R/V Paula Christine). Survey tracks from the field effort at the three study sites are presented in Figure 1.

Study Areas

San Clemente Island

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

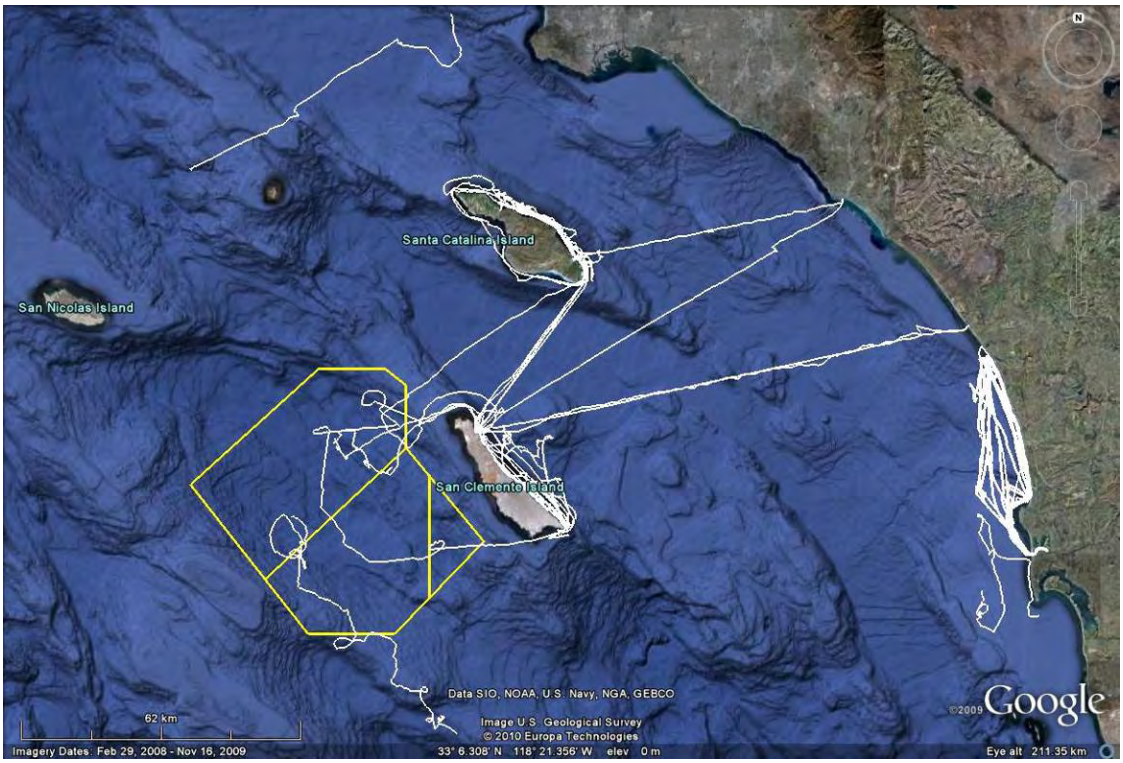

Figure 1. SIO small vessel survey tracks from monitoring at SCORE (boundaries of SOAR range in yellow), Catalina Island and the San Diego coastline from August 2009 – July 2010.

Catalina Island

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

San Diego Coastline

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

Procedure

When cetaceans were sighted, the group was approached and information on species, group size and composition, direction of movement, environmental conditions, latitude/longitude and time was recorded. For bottlenose and Risso's dolphins as well as beaked whales and baleen whales, effort was made to acquire numerous quality photographs of each individual present for individual identification. Biopsy samples were collected from particular species for current/planned projects being conducted by SIO and/or our collaborators at SWFSC. Acoustical recordings of select species calls as well as anthropogenic sounds were conducted

opportunistically. Details on the instrumentation utilized and specific protocols for each method of data collection are outlined below.

Photo-Identification

Photo-identification data were collected using a Canon EOS D40 digital SLR camera equipped with a 100-400 mm Canon EF image-stabilizing lens. Effort was made to acquire numerous quality photographs of dorsal fins, tail flukes and/or lateral flanks (depending on the species) of each individual encountered, without regard to apparent distinctiveness. After completion of photographic effort, the vessel was positioned for acoustical recordings and/or biopsy sampling (see below). Identical procedures were repeated when additional cetacean groups were encountered.

Biopsy Sampling

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

Drop-Hydrophone Recording System

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

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

HARP Recording System

Independent of the small boat operations, we deployed several High-Frequency Acoustic Recording Packages (HARPs) in the basins around San Clemente Island to provide a long-term continuous record of acoustic signals occurring in the region. HARPs are autonomous, bottom mounted instruments containing a single hydrophone tethered 10 m above the seafloor (Wiggins and Hildebrand 2007). The system records signals in the band from 10 Hz to 100 kHz, making it capable of recording a wide variety of sounds ranging from baleen whale calls to MFAS to odontocete echolocation clicks. HARPs are capable of acoustic sample rates of up to 200 kHz and can store 1920 GBytes of acoustic data, allowing continuous recording for 55 days. The HARP can also be duty-cycled (e.g., 20 min on, 10 min off) to extend recording duration. Data collected by HARPs are analyzed for signal content following instrument retrieval using both manual and automated signal recognition methods.

Data Analysis

Photo-identification

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

Biopsy Sampling

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

Acoustical Recordings

The structural characteristics of clicks and/or whistles collected in 2009/2010 from five delphinid species are currently being measured and applied to the development of a suite of detection and classification engines. Echolocation clicks are assessed through the calculation of several variables including duration, inter-click interval, peak frequency points, -3dB bandwidth, -10 dB bandwidth and center frequency. Whistle structure analysis entails the extraction of eight specific variables from each whistle contour: begin frequency, end frequency, minimum frequency, maximum frequency, frequency range, mean frequency, duration, and number of inflection points. Call variables are subsequently applied to multivariate statistical engines to examine the within species/population and between species/population variability inherent in the data.

HARP Recordings

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

RESULTS

Sightings

Cetacean sightings across the three study areas included five odontocete and three mysticete species. Bottlenose dolphins were the most commonly sighted species at San Clemente Island and off the San Diego coastline while common dolphins were the most frequently encountered cetacean at Catalina Island. Humpback whales were the least frequently encountered species with only one sighting during the period. Plots of all cetacean sightings documented during the 2009/2010 study period are presented in Figure 2. Additional details on sighting, photo-identification, acoustical and biopsy data collected from the three study areas are provided in Tables 1-4.

The distribution of cetacean species sighted off San Clemente Island was not uniform (Figure 2). Bottlenose and Risso's dolphin sightings were concentrated in near-shore waters with a mean distance from the island of 2.6 km and 9.2 km respectively. One-hundred percent of bottlenose and 66% of Risso's dolphin sightings occurred off the SOAR range with the remaining one sighting of this species occurring on the eastern portion of the range. Sightings of fin whales were made exclusively on the SOAR range. Common dolphins varied in distribution ranging from near-shore waters to offshore waters with a mean sighting distance of 7.6 km from shore.

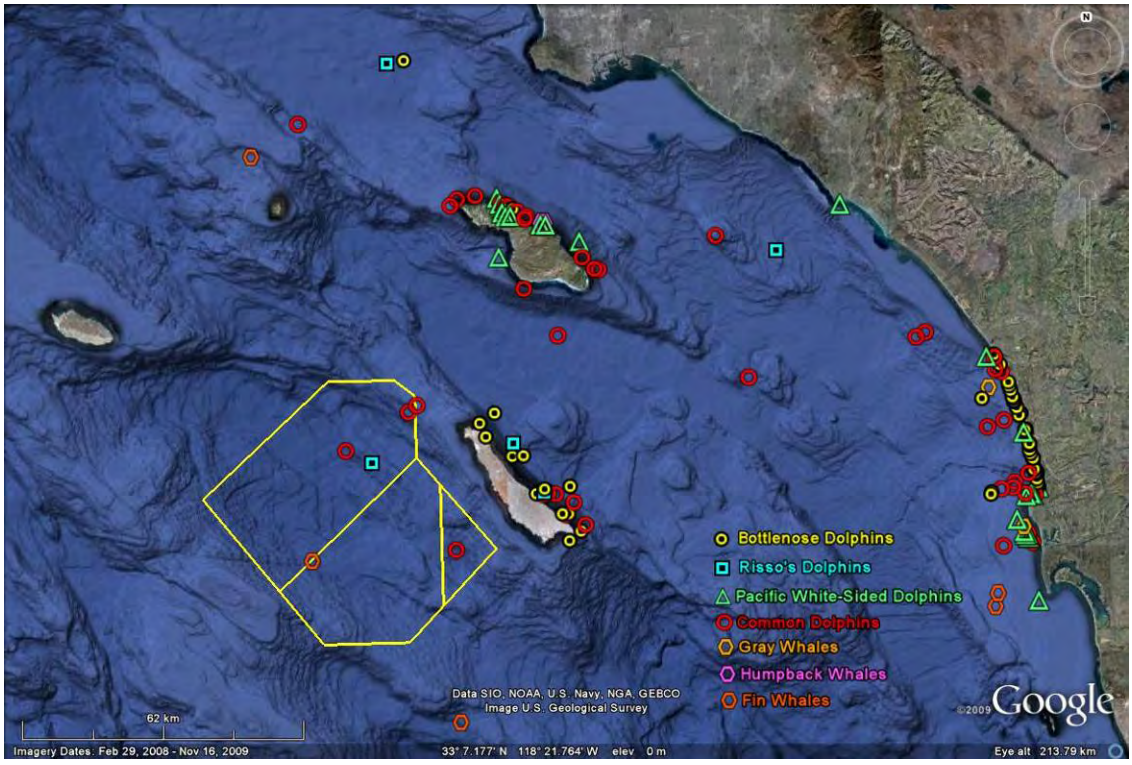

Figure 2. Cetacean sightings documented on all SIO small boat surveys in southern California from August 2009 – July 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected November 19-25, 2009 at San Clemente and Catalina Islands.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	-	-	-	-	-
Risso's Dolphin	1	18	-	-	-
Pacific White-Sided Dolphin	11	91	-	5	1
Short-Beaked Common Dolphin	6	3003	22	3	-
Long-Beaked Common Dolphin	5	2656	94	4	-
Common Dolphin, species unknown	4	433	-	3	-
Fin Whale	-	-	-	-	-
Humpback Whale	1	1	17		
Gray Whale	-	-	-	-	-

Table 2. Summary information on sighting, photo-identification, acoustical and biopsy data collected June 14-24, 2010 at San Clemente and Catalina Islands.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	13	257	1175	3	22
Risso's Dolphin	4	36	189	1	1
Pacific White-Sided Dolphin	-	-	-	-	-
Short-Beaked Common Dolphin	12	508	28	-	3
Long-Beaked Common Dolphin	1	66	18	-	-
Common Dolphin, Species unknown	-	-	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	-	-	-	-	-

Table 3. Summary information on sighting, photo-identification, acoustical and biopsy data collected August 2009 – July 2010 on fourteen surveys off the San Diego coastline.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Coastal Bottlenose Dolphin	40	273	3948	17	4
Offshore Bottlenose Dolphin	3	128	463	1	3
Risso's Dolphin	1	60	95	-	-
Pacific White-Sided Dolphin	14	151	4	6	1
Short-Beaked Common Dolphin	7	855	17	-	-
Long-Beaked Common Dolphin	3	240	155	-	-
Common Dolphin, Species unknown	-	-	-	-	-
Fin Whale	-	-	-	-	-
Humpback Whale	-	-	-	-	-
Gray Whale	2	2	73	-	-

Table 4. Summary information on sighting, photo-identification, acoustical and biopsy data collected 9-11 April 2010 on three surveys in offshore waters of the Southern California Bight.

Species	Number of Groups	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
Offshore Bottlenose Dolphin	1	10	20	-	-
Risso's Dolphin	1	30	13	-	-
Pacific White-Sided Dolphin	1	18	-	-	-
Short-Beaked Common Dolphin	1	523	7	-	-
Long-Beaked Common Dolphin	1	522	13	-	-
Common Dolphin, Species unknown	-	-	-	-	-
Fin Whale	5	9	53	-	1
Humpback Whale	-	-	-	-	-
Gray Whale	-	-	-	-	-

San Diego Coastal Surveys

Between 1 November 2009 and 30 July 2010, a total of fourteen surveys were conducted along the San Diego coastline. Appendix 1 provides survey-specific summaries for each day of effort. These summaries include information on survey effort, plots of sighting locations and survey tracks, and tabular summaries of the species encountered, number of individuals in each group, number of photo- and the number of acoustic recordings and biopsy samples obtained.

Encounter Rate - San Clemente Island

Comparative analysis of encounter rates between the two survey periods at San Clemente Island is restricted by limited survey effort in November 2009 due to marginal weather conditions. In spite of the limited sample from the November surveys, differences in cetacean occurrence and diversity between the two periods were apparent. The mean number of delphinid groups encountered per survey off San Clemente Island in June 2010 ($\overline{x}$ = 3.8) was nearly four times higher than the mean number of delphinid groups sighted per survey in November 2009 ($\overline{x}$ = 1.0) (Tables 5 and 6). Species diversity was also low during November 2009 as common dolphins were the only species sighted in the study area. In contrast, the June 2010 field effort documented four of the five delphinid species common to the waters around San Clemente Island, including bottlenose, Risso's, short-beaked and long-beaked common dolphins.

Table 5. Survey effort and encounter rate for 5 commonly encountered delphinid species off San Clemente Island, California 20 November, 2009.

Species	Study Period	Number of Survey Days	Number of Survey Hours	Number of Groups	Mean Groups per Survey	Groups per Hour
Delphinids (overall)	**Nov-09**	**1**	**9.3**	1	**1.0**	**0.11**
Bottlenose Dolphin				0	0.0	0.00
Risso's Dolphin				0	0.0	0.00
Pacific White-Sided Dolphin				0	0.0	0.00
Short-Beaked Common Dolphin				1	1.0	0.11
Long-Beaked Common Dolphin				0	0.0	0.00
Common Dolphin Species				0	0.0	0.00

Table 6. Survey effort and encounter rate for 5 commonly encountered delphinid species off San Clemente Island, California 16 – 24 June, 2010.

Species	Study Period	Number of Survey Days	Number of Survey Hours	Number of Groups	Mean Groups per Survey	Groups per Hour
Delphinids (overall)	**Jun-10**	**8**	**60.3**	30	**3.8**	**0.50**
Bottlenose Dolphin				13	1.6	0.22
Risso's Dolphin				4	0.5	0.07
Pacific White-Sided Dolphin				0	0.0	0.00
Short-Beaked Common Dolphin				12	1.5	0.20
Long-Beaked Common Dolphin				1	0.1	0.02
Common Dolphin Species				0	0.0	0.00

To further assess the differences in encounter rates observed between the November 2009 and June 2010 survey periods, we examined the occurrence of MFAS in the basins around San Clemente Island. HARP acoustical recordings, collected at site H on the western edge of the SOAR range (Figure 3) during 2009 and 2010, were manually reviewed and all MFAS events were documented. MFAS occurred for 1 – 17 hours on each of seven days immediately prior to the November 2009 survey period (Figure 4). An assessment of MFAS activity during the June 2010 period is pending as these data are currently being processed in preparation for analysis.

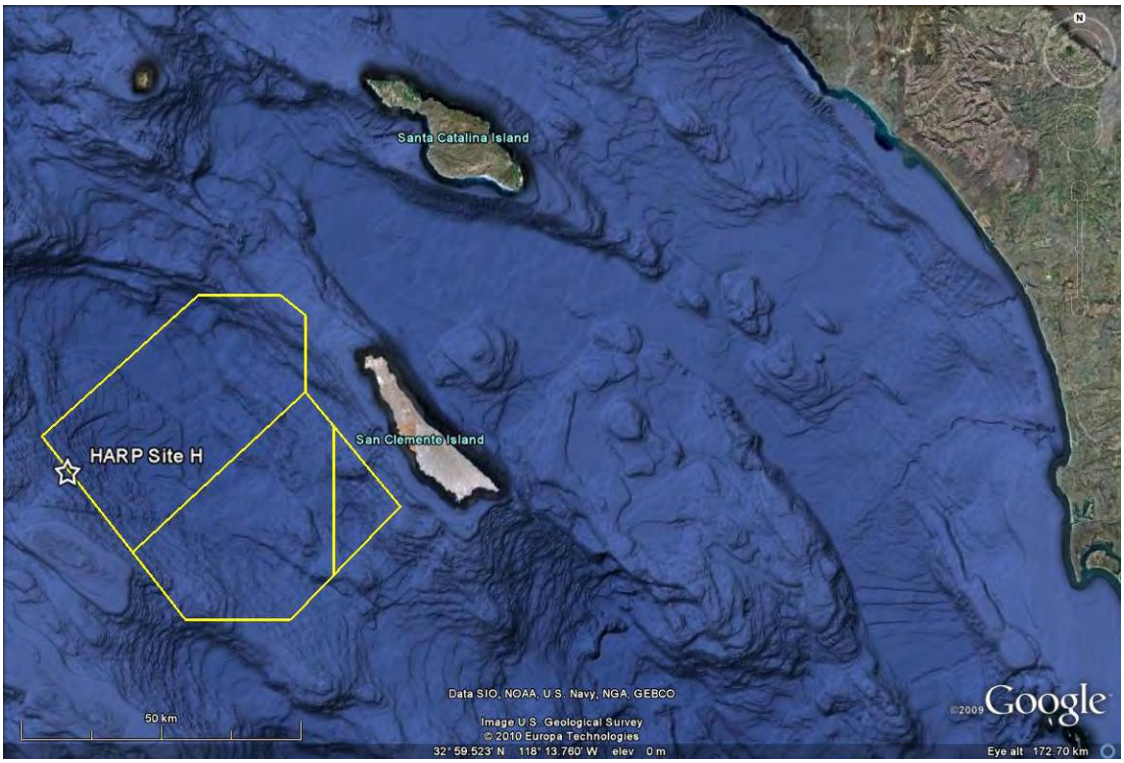

Figure 3. Location of HARP site H, west of the SOAR range off San Clemente Island (boundaries of SOAR range in yellow).

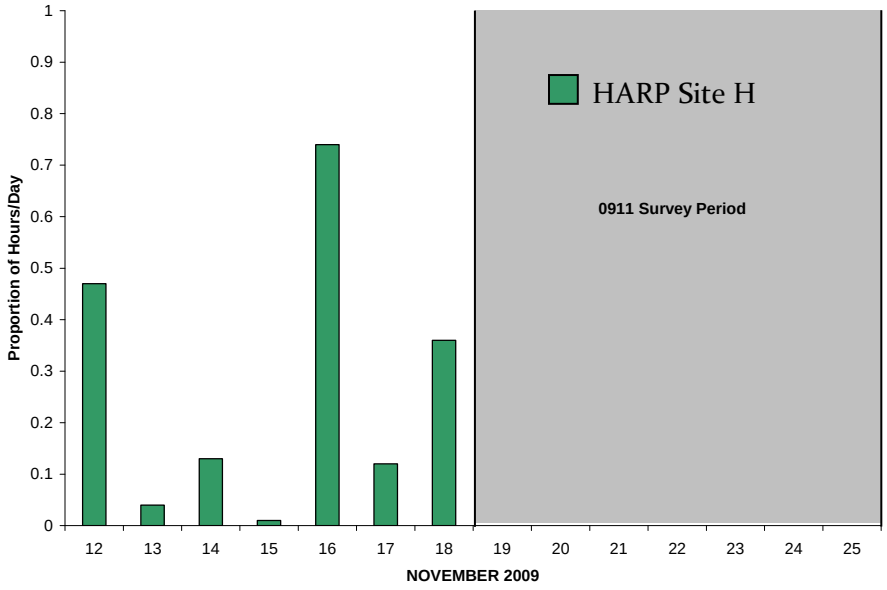

Figure 4. MFAS occurrence in proportion of hours per day from HARP site H from 12 to 25 November, 2009. Grey area represents period of no HARP data collection.

Bottlenose Dolphin Photo-Identification

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

Analysis of the combined SIO/SWFSC and Cascadia Research Collective bottlenose dolphin photographic database from 2006-2009 was recently completed, resulting in a catalog of 318 distinctive individuals from San Clemente Island and 53 individuals from Catalina Island. Photo-identification analysis indicated variable levels of intra- and inter-annual site fidelity to the San Clemente Island study area as well as movement between the two island sites. Mark-recapture abundance estimation models will be applied to the database in an exploratory manner with application planned after completion of the 2010 field season. Details on the results of our analyses through May 2010 are provided below.

Rate of discovery

The rate at which individual dolphins were identified off San Clemente Island from 2006-2009 was examined across surveys in which at least one dolphin was photographically identified (n=23 surveys, Figure 5). Rate of discovery, plotted as the cumulative number of newly identified individuals across each survey, indicates that new (i.e. previously unidentified) individuals were encountered across the four-year study period. While the consistent positive slope in the curve indicates that the population is larger than the current sample, photo-identification data collected from 2006-2009 indicates that 13% (n = 41) of the 318 individuals identified have been sighted in two or more of the four study years. Based on this trend, we expect the overall proportion of previously identified individuals to increase with additional surveys at San Clemente Island.

The rate at which individual dolphins were identified off Catalina Island from 2006-2009 was examined across surveys in which at least one dolphin was photographically identified (n = 4 surveys, Figure 6). The rate of discovery curve indicates that new individuals were exclusively documented across the three-year period. The consistent positive slope combined with no re-sightings of the 53 identified individuals indicates that the population is larger than the current sample and dedicated surveys at Catalina Island are needed to provide more comprehensive coverage of bottlenose dolphins occurring at this site.

Sighting frequency and site fidelity

Sighting frequencies for the 318 dolphins identified at San Clemente Island from 2006-2009 ranged from 1-6 ($\overline{x}$ = 1.4, SD = 0.8). Seventy-two percent (n = 228) of the dolphins were photographed once, 19% (n = 60) two times, 7% (n = 21) three times and 3% (n = 9) four or more times.

Re-sightings of the same individuals within one survey period (8-14 days) were frequent, indicating short-term site fidelity to the area. The number of study years in which identified dolphins were photographed (annual sighting frequency) averaged 1.2 yr (SD = 0.4, range = 1–3). Eighty-seven percent (n = 277) of the identified population was photographed during only one year, 12% (n = 37) was observed during two years, and 1% (n = 4) was sighted during three years (Figure 7). None of the identified individuals were sighted during all four study years; however, photo-identifications of only 27 individuals were collected in 2006 and 27 individuals were identified in 2007, restricting the number of animals that could have been sighted during all four years.

Inter-Island Movement patterns

Photographic comparisons of 53 dolphins identified from 2006-2009 at Catalina Island with the 318 animals documented at SCI from 2006-2009 resulted in five individuals being identified in both study areas (Figure 8). Sighting intervals for the five inter-island identifications averaged 199 days (SD = 151, range = 5–355), demonstrating movement between the islands over relatively short time periods. These data represent the first photographically documented movement of bottlenose dolphins between Catalina Island and San Clemente Island.

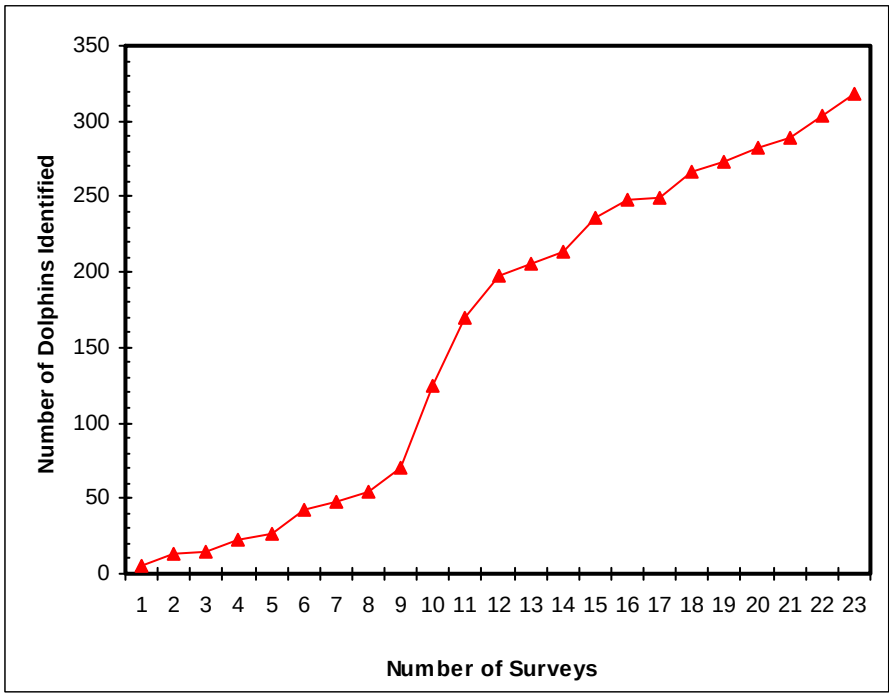

Figure 5. Cumulative number of bottlenose dolphins photo-identified at San Clemente Island over surveys in which at least one dolphin was identified. N = 318 individuals.

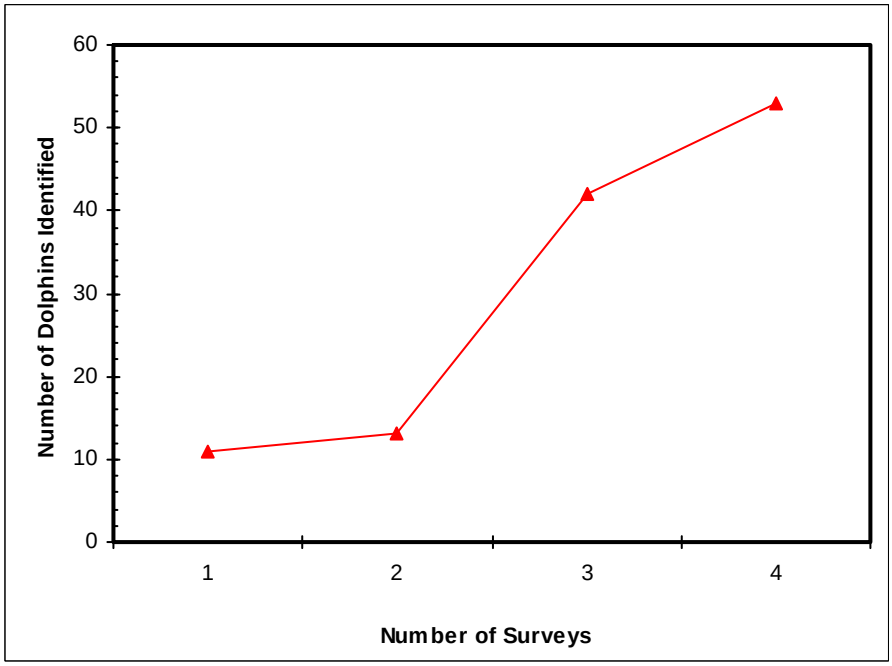

Figure 6. Cumulative number of dolphins photo-identified at Catalina Island over surveys in which at least one dolphin was identified. N = 53 individuals.

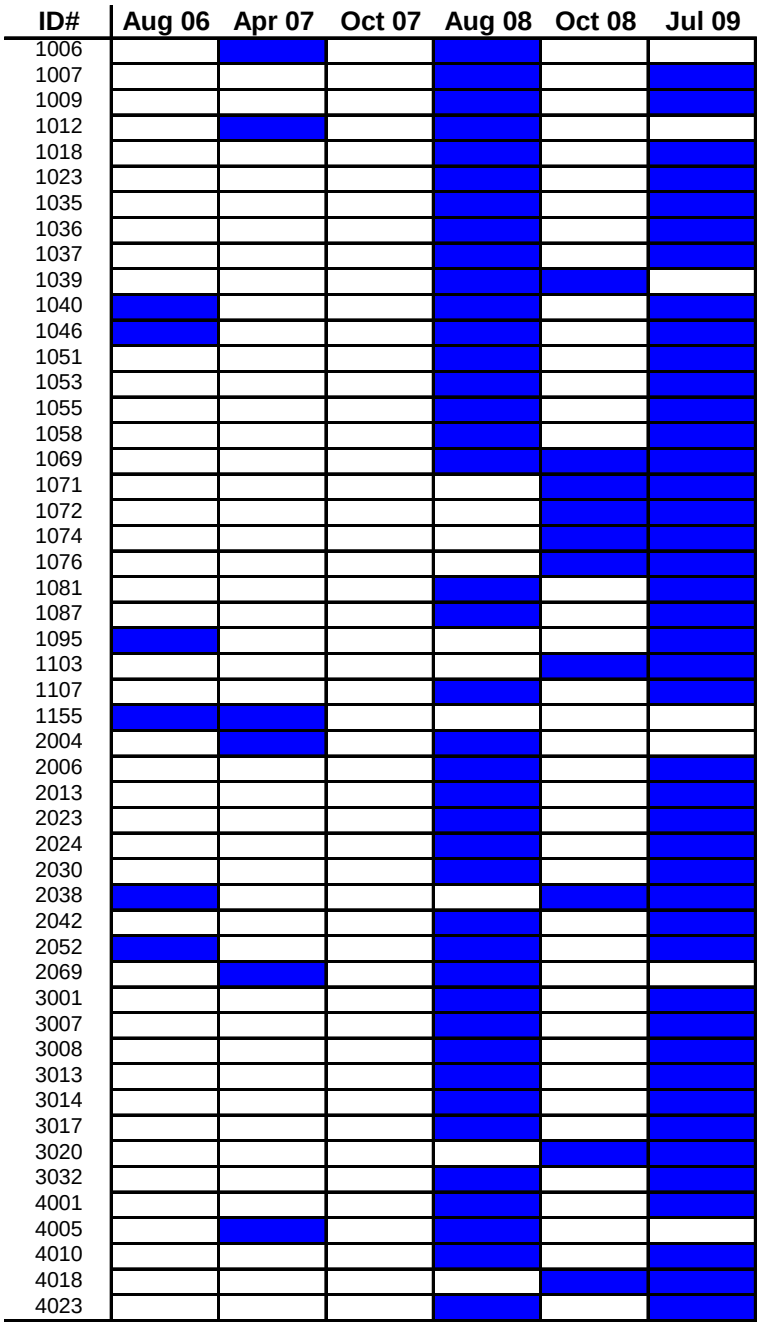

Figure 7. Sighting matrix for the fifty bottlenose dolphins photographically identified during two or more survey periods at San Clemente Island from August 2006 to July 2009.

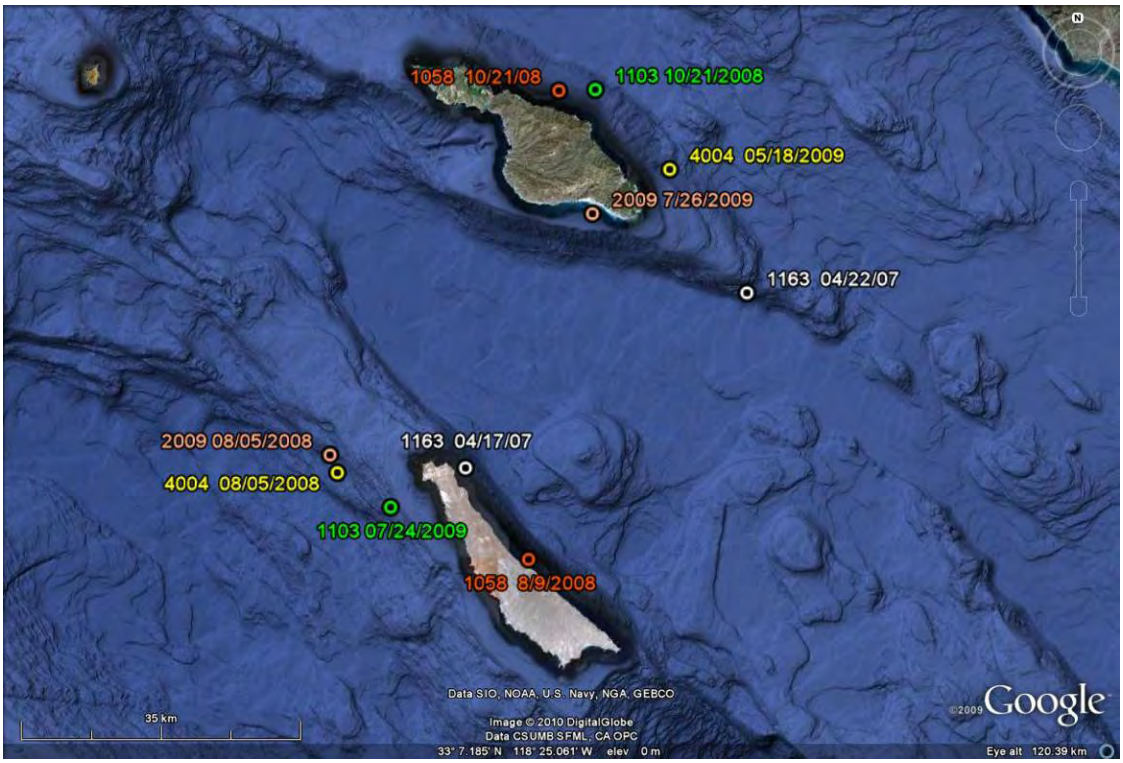

Figure 8. Sighting locations, ID codes and dates for the five photo-identified individual bottlenose dolphins documented off both San Clemente and Catalina Islands.

Bottlenose Dolphin Biopsy Sampling

Biopsy samples taken from bottlenose dolphins at San Clemente and Catalina Islands as well as the San Diego coastline from October 2008 through July 2010 are currently being analyzed by scientists at the NOAA Southwest Fisheries Science Center along three metrics: (1) stress (cortisol) and reproductive (progesterone) hormone levels relative to Mid Frequency Active Sonar exposure, (2) DNA analyses for an assessment of the population structure and relative relatedness of coastal, pelagic and island associated bottlenose dolphins in SOCAL and (3) contaminant loads (persistent organic pollutants and mercury) in coastal versus offshore animals.

Hormone Study

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

As part of the cortisol analysis, we have been validating our protocol to measure the hormone from cetacean blubber. Using bowhead whales (killed by native hunters in Alaska) as voucher specimens, in which we know many aspects of life-history and physiological condition of each individual including the serum concentrations of cortisol, we have measured blubber cortisol levels in 104 animals. The mean (SE) measured blubber cortisol value was 536 (± 86.8) pg/g and we find a significant relationship between blubber and serum cortisol levels with $R2 = 0.2245$ ($p =$

0.035). Though significant, the relationship is fairly loose; a result that was expected given what is known about the dynamics of blubber cortisol production. The serum levels are quite variable as they are integrated over a short period of time and the events just prior to sampling dominate the levels we measure. Blubber cortisol values are integrated over a longer period of time and therefore the act of sampling itself is much less likely to affect the measured value. Given that these bowhead whales were hunted and killed before being sampled, it is not surprising that the levels were higher in the blood and that the relationship between the two matrices is loosely correlated.

DNA Study

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

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

Pacific White-Sided Dolphin Biopsy and Acoustical Sampling

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

Acoustical Recordings

Acoustical recordings collected from October 2008 to July 2010 from the five delphinid species common to the SOCAL region have been incorporated into a larger database of cetacean acoustic data maintained at SIO. Several current projects are assessing clicks and/or whistles for species and population specific call structures that are essential for the interpretation of HARP long-term autonomous recordings conducted by SIO.

DISCUSSION

Sightings

Cetacean sightings across the three study areas during the 2009/2010 field season encompassed five odontocete and three mysticete species. Bottlenose dolphins were the most commonly sighted species at San Clemente Island and off the San Diego coastline while common dolphins were the most frequently encountered cetacean at Catalina Island. The distribution of cetacean species sighted off San Clemente Island was not uniform, with bottlenose and Risso's dolphin sightings mostly concentrated in near-shore waters. One-hundred percent of bottlenose and 66% of Risso's dolphin sightings occurred off the SOAR range with the remaining one sighting of this species occurring on the eastern portion of the range. Sightings of fin whales around San Clemente Island were made exclusively on the SOAR range.

Encounter Rate

Encounter rates for all delphinid species were higher during the June 2010 versus November 2009 survey periods with an approximately four-fold increase in schools encountered per survey and per hour of effort. While field effort in November was limited to one survey, the variable encounter rates and species diversity relative to MFAS trials observed during the current period are consistent with similar observations from the 2008/2009 field season at San Clemente Island. Encounter rates for all delphinid species were significantly higher during the August 2008 versus October 2008 survey periods with an approximately four-fold increase in schools encountered per survey and per hour of effort. In addition, species diversity was low during the October 2008 survey period with sightings limited to several schools of common dolphins, one school of bottlenose dolphins and no sightings of Risso's or Pacific white-sided dolphins. During the August survey period, no MFAS signals were detected in the region, whereas during the October survey period, MFAS signals were present for a total of 44 hours across six days (Campbell *et al.* 2010).

Information on seasonal distribution and abundance of the five delphinid species encountered in the San Clemente Island study area was examined to determine if seasonal movement patterns may be a potential explanation for the observed variation in delphinid encounter rates and diversity between survey periods.

Aerial surveys of marine mammals conducted around San Clemente Island and surrounding waters during 1998-1999 provide one index of seasonal occurrence patterns for delphinids common to the region (Caretta *et al.* 2000). Short-beaked common dolphins occurred year-round and were the most abundant marine mammal in the study area. Common dolphin abundance was 2.5 times greater during the warm-water months of May through October than during the cold-water months of November through April; however, this was attributed to smaller group sizes versus fewer groups overall. Pacific white-sided dolphins were present only during the cold-water months of November-April. Risso's dolphins were present year round but their abundance was three times higher during cold-water months than during warm-water months. Bottlenose dolphins, the least abundant delphinid species in the study area, were present in approximately equal numbers year-round off San Clemente Island.

Larger scale aerial and shipboard assessments of delphinid seasonal distribution and occurrence patterns in the Southern California Bight have been conducted off the U.S. west coast by NOAA/SWFSC (Barlow 1995; Forney *et al.* 1995, Forney and Barlow 1998). Seasonal shifts in distribution and abundance of short beaked common dolphins have been identified based on winter/spring 1991-1992 and summer/fall 1991 surveys; however, seasonal distribution patterns are

highly variable, purportedly in response to oceanographic changes on both seasonal and inter-annual time scales (Forney 1997, Forney and Barlow 1998). Pacific white-sided dolphin sighting data suggest seasonal north-south movements, with animals found primarily off California during the colder water months and shifting northward into Oregon and Washington as water temperatures increase in late spring and summer (Green *et al*. 1992; Forney 1994). Risso's dolphin distribution data suggest seasonal patterns similar to, yet less pronounced than that observed for Pacific white-sided dolphins with increased abundance in northern waters during summer months. Bottlenose dolphin sighting data from aerial surveys conducted in winter/spring 1991-1992 (Forney *et al*. 1995) and shipboard surveys conducted in summer/fall 1991 (Barlow 1995) indicated no apparent seasonality in distribution.

While these results suggest a correlation between MFAS activity and low delphinid occurrence and diversity in the area, additional data needs to be collected. Small boat surveys with simultaneous HARP deployments planned for 2010 and 2011 will allow for a more comprehensive assessment of a potential link between MFAS and delphinid presence/absence in the San Clemente Island region.

Photo-Identification

Photo-identification research to describe the occurrence, site fidelity, movement patterns and abundance of bottlenose and Risso's dolphins off San Clemente and Catalina Islands was highly successful, providing the first data of this type from the area. The catalogue of 318 distinctive individual bottlenose dolphins from San Clemente and 53 from Catalina, including five individuals resighted off both islands, will provide the basis for deriving abundance estimates and residency patterns. Similarly, the 150+ Risso's dolphins identified during the study period represent a first-ever attempt to study this species in the waters off southern California. The current and future results regarding both of these species, by way of the research program described here, provide vital new information valuable to understanding their relationship (both spatial and temporal) to Navy activities off southern California.

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

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

Biopsy Sampling

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

Samples collected around San Clemente and Catalina Island are currently being examined by Nick Kellar (SWFSC) for reproductive (progesterone) and stress (cortisol) hormone levels relative to MFAS exposure. Results of these analyses will be used to assess the relationship of these hormones to reproductive success. During the 2010 and 2011 field seasons, we plan to collect additional biopsies to allow for a thorough assessment of GC concentration measurements in the context of MFAS exposure. Our goal is to collect biopsies at San Clemente Island from 10-20 dolphins at three different times (i.e. conditions) relative to the Naval exercises: 1) approximately

three to four weeks before exercises commence (pre-condition); 2) during the exercises, preferably 7-10 days post-commencement (during-condition); 3) approximately three to four weeks post-termination of the exercises (post-condition). Tissue samples collected during planned surveys at Catalina Island and the San Diego county coastline will also be assessed for GC concentrations with the coastal data providing a baseline index from a population presumably having little to no exposure to MFAS. Biopsy samples will be paired with photo-identification images whenever possible to allow individual animals to be followed over both short (days, weeks, months) and long (years) time scales. HARP recordings acquired from the San Clemente Island region during biopsy sampling periods will be subsequently assessed for MFAS exposure metrics including duration, sound exposure levels and signal structure.

Planned DNA analyses will allow for an evaluation of population structure for bottlenose dolphins in the SOCAL region, which will better define inshore versus offshore versus island-associated populations that are subject to different environmental and human related pressures. Higher resolution stock structure data will be pertinent in calculating mark-recapture population estimates for bottlenose dolphins in offshore waters; data which are crucial to comprehensive monitoring efforts in SOCAL. Expanded and dedicated biopsy sampling of offshore and coastal bottlenose dolphins planned for the 2010 and 2011 field seasons should provide the sample sizes needed to conduct a thorough assessment of these hormonal and genetic parameters.

CONCLUSIONS

The primary objectives of the 2009/2010 SIO small boat based research program are to use sighting, photo-identification, biopsy and acoustical sampling techniques to assess the occurrence, distribution and population structure of small cetaceans in a region that is subject to frequent naval exercises. The results summarized in this report provide the framework for our multi-faceted approach to evaluating any possible effects from MFAS trials. Expanded and directed data collection in the SOCAL region planned for the 2010 and 2011 field seasons should provide for a more comprehensive assessment and interpretation of the variables described in this report.

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LITERATURE CITED

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fishery Bulletin 93:1-14.

Campbell, G. S., D. W. Weller AND J. A. Hildebrand. 2010. SIO small vessel marine mammal surveys in Southern California: Report of results for June 2008 – May 2009. Scripps Institution of Oceanography - Marine Physical Laboratory Report.

Caretta, J. V., Lowry, M. S., Stinchcomb, C. E., Lynn, M. S. AND R. E. Cosgrove. 2000. Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: results from aerial and ground surveys in 1998 and 1999. NOAA Administrative Report LJ-00-02.

Caretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson, R. L. Brownell Jr., J. Robbins, D.K. Mattila, K. Ralls, M. M. Muto, D. Lynch AND L. Carswell. 1999. U.S. Pacific Marine Mammal Stock Assessments: 2009. NOAA Technical Memorandum: NMFS-SWFSC-453.

Curry, B. E. AND J. Smith. 1998. Phylogeographic structure of the bottlenose dolphin (*Tursiops truncatus*): stock identification and implications for management. Pages 227-247 in A. E. Dizon, S. J. Chivers and W. F. Perrin, eds. Molecular genetics of marine mammals. Special Publication Number 3. The Society for Marine Mammalogy, Lawrence, Kansas.

DeDecker, T. D., R. H. Defran AND D. W. Weller. 1999. Occurrence patterns of offshore bottlenose dolphins, *Tursiops truncatus*, in the Southern California Bight. In abstracts of the 13th Biennial Conference on the Biology of Marine Mammals, Maui, HI, p. 45.

Defran, R. H., G. M. Shultz AND D. W. Weller. 1990. A technique for the photographic identification and cataloging of dorsal fins of the bottlenose dolphin, *Tursiops truncatus*. Report of the International Whaling Commission (Special Issue 12):53-55.

Defran, R. H. AND D. W. Weller. 1999. Occurrence, distribution, site fidelity, and school size of bottlenose dolphins, *Tursiops truncatus*, off San Diego, California. Marine Mammal Science 15:366-380.

Defran, R. H., D. W. Weller, D. Kelly AND M. A. Espinoza. 1999. Range characteristics of Pacific Coast bottlenose dolphins, *tursiops truncatus*, in the Southern California Bight. Marine Mammal Science 15:381-393.

Dudzik, K.J., K.M. Baker, AND D.W. Weller. 2006. Mark-recapture abundance estimate of California coastal stock bottlenose dolphins: February 2004 to April 2005. SWFSC Administrative Report LJ-06-02C.

Duffield, D. A., S. H. Ridgway AND L. H. Cornell. 1983. Hematology distinguishes coastal and offshore forms of dolphins *Tursiops*. Canadian Journal of Zoology 61: 930-933.

Falcone, E. A., G. S. Schorr, A. B. Douglas, J. Calambokidas, E. E. Henderson, M. F. McKenna, J. A. Hildebrand AND D. Moretti. 2009. Sighting characteristics and photo-identification of Cuvier's beaked whales, *Ziphius cavirostris*, near San Clemente Isalnd, California: a key area for beaked whales and the military? Marine Biology doi: 10.1007/s00227-009-1289-8.

Forney, K. A. 1994. Recent information on the status of odontocetes in California waters. NOAA Technical Memorandum: NMFS-SWFSC-202.

Forney, K. A., J. Barlow AND J. V. Caretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fishery Bulletin 93:15-26.

Forney, K. A. AND J. Barlow. 1998. Seasonal patterns in the abundance and distribution of California cetaceans, 1991-92. Marine Mammal Science 14:460-489.

Forney, K. A. 2007. Preliminary estimates of cetacean abundance along the U.S. west coast and within four National Marine Sanctuaries during 2005. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-406. 27 p.

Green, G., J. J., R. A. Brueggeman, C. E. Grotefendt, M. L. Bowlby, M. L. Bonnell AND K. C. Balcomb, III. 1992. Cetacean distribution and abundance off Oregon and Washington. Ch. 1. In: Oregon and Washington Marine Mammal and Seabird Surveys. OCS Study 91-0093. Final Report prepared for Pacific OCS Region, Minerals Management Service, U.S. Department of the Interior, Los Angeles, California.

Hanson, M. T. AND R. H. Defran. 1993. The behavior and feeding ecology of the Pacific coast bottlenose dolphin, *Tursiops truncatus*. Aquatic Mammals 19:127-142.

Kellar, N. M., M. L. Trego, C. I. Marks AND A. E. Dizon. 2006. Determining pregnancy from blubber in three species of delphinids. Marine Mammal Science 22, 1-16.

Kellar, N. M., M. L. Trego, C. I. Marks, S. J. Chivers, K. Danil AND F. I. Archer. 2009. Blubber testosterone: A potential marker of male reproductive status in short-beaked common dolphins. Marine Mammal Science. 25, 507-522.

Lowther, J. 2006. Genetic variations of offshore and coastal bottlenose dolphins, *Tursiops truncatus*, in the eastern North Pacific Ocean. M. S. Thesis, University of San Diego, San Diego, California, USA. 126 p.

Lux, C. A., A. S. Costa AND A. E. Dizon. 1997. Mitochondrial DNA population structure of the Pacific white-sided dolphin. Report of the International Whaling Commission 47:645-652.

Moretti, D., R. Morissey, N. DiMarzio AND J. Ward. 2006. Verified passive acoustic detection of beaked whales, *Mesoplodon densirostris*, using bottom-mounted hydrophones in the tongue of the ocean, Bahamas. Applied Acoustics 67: 1091-1105.

Ross, G. J. B. AND V. G. Cockroft. 1990. Comments on Australian bottlenose dolphins and taxonomic status of *Tursiops aduncas* (Ehrenberg, 1832). Pages 101-128 *in* S. Leatherwood & R.R. Reeves, eds. The bottlenose dolphin. Academic Press, San Diego, California.

Walker, W. A. 1981. Geographical variation in morphology and biology of Bottlenose dolphin, *Tursiops*, in the Eastern North Pacific. National Marine Fisheries Service, Southwest Fisheries Center Administrative Report No. LJ-81-03C. 52 pp.

Walker, W. A., S. Leatherwood, K. R. Goodrick, W. F. Perrin AND R. K. Stroud. 1986. Geographic variation and biology of the Pacific white-sided dolphin, *Lagenorhynchus obliquidens*, in the north-eastern Pacific. Pages 441-465 *in* Bryen, M. M. and R. Harrison, eds. Research on dolphins. Clarendon Press, Oxford.

Wiggins, S. M. AND J. A. Hildebrand. 2007. High-frequency Acoustic Recording Package (HARP) for broad-band, long-term marine mammal monitoring. International Symposium on Underwater Technology 2007 and International Workshop on Scientific Use of Submarine Cables & Related Technologies 2007, UT07, 551 – 557.

APPENDIX 1 To Small Boat Surveys

California Coastal Bottlenose Dolphin Abundance Survey – 11/02/09
Prepared By: Greg Campbell

The first in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 02, 2009. The primary objectives were to collect photo-identification, biopsy and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other cetacean species common to the region, and surveying HARP site P.

Six hours of field effort covering 62 miles yielded two groups of coastal bottlenose and one group of Pacific white-sided dolphins (Figure 1). Photo-identification efforts produced high quality images from the majority of bottlenose dolphins encountered. One biopsy sample from coastal bottlenose dolphins was collected for an assessment of microbiological contaminants. Heavy fog precluded the completion of the complete survey route, collection of acoustical recordings, and surveying HARP site P. Details on sighting, photo-ID, acoustical and biopsy data are provided in Table 1.

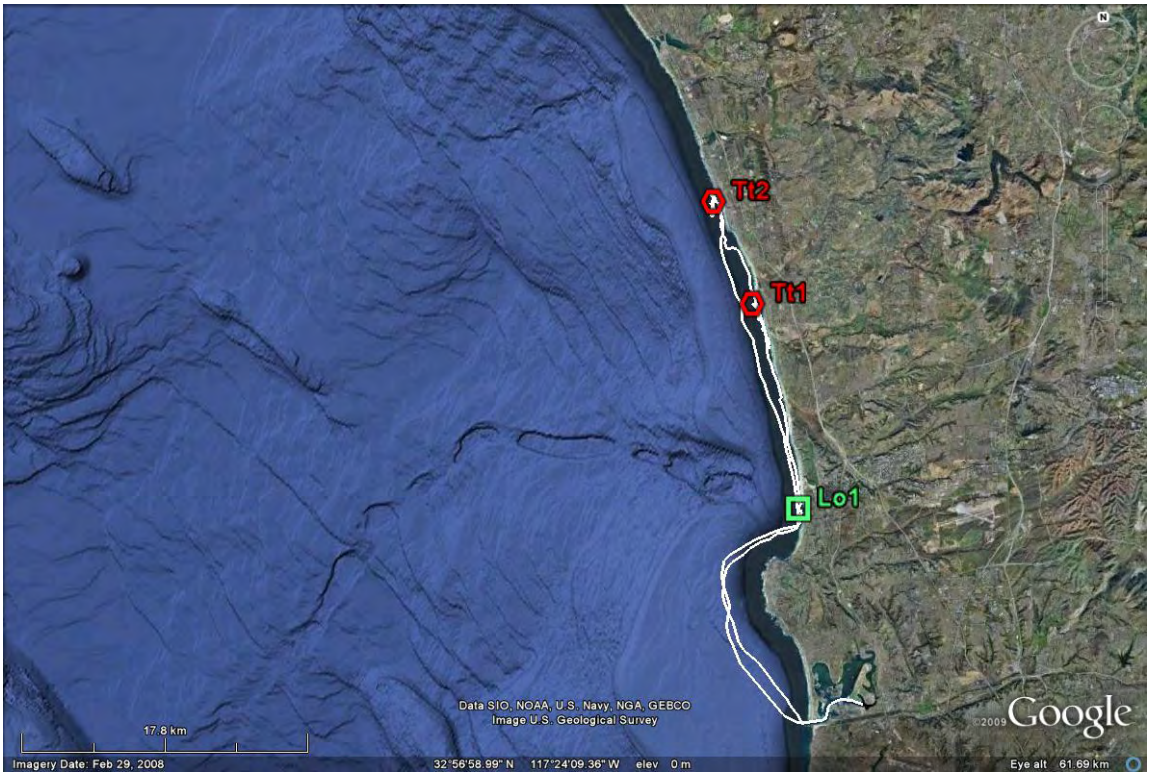

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *L. obliquidens*, off the San Diego coastline, November 02, 2009.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 02, 2009.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
L. obliquidens	Lo1	15	-	-	-
T. truncatus	Tt1	5	67	-	-
T. truncatus	Tt2	6	68	-	1

California Coastal Bottlenose Dolphin Abundance Survey – 11/30/09
Prepared By: Greg Campbell

The second in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 30, 2009. The primary objectives were to collect photo-identification, biopsy and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other cetacean species common to the region, and surveying HARP site P.

Seven hours of field effort covering 66 miles yielded four groups of coastal bottlenose and two groups of Pacific white-sided dolphins (Figure 1). Photo-identification efforts produced high quality images from the majority of bottlenose dolphins encountered. One biopsy sample from coastal bottlenose dolphins was collected for an assessment of microbiological contaminants. Time and weather constraints precluded the collection of acoustical recordings and surveying HARP site P. Details on sighting, photo-ID, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *L. obliquidens*, off the San Diego coastline, November 30, 2009.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 30, 2009.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
L. obliquidens	Lo1	10	-	-	-
L. obliquidens	Lo2	25	-	-	-
T. truncatus	Tt1	6	40	-	1
T. truncatus	Tt2	7	40	-	-
T. truncatus	Tt3	6	32	-	-
T. truncatus	Tt4	9	62	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 07/30/10
Crew: Greg Campbell, Dave Weller, John Hurwitz, Tara Whitty

The fourteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on July 30, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Four hours of field effort covering 50 miles yielded sightings of three groups of bottlenose dolphins and one group of short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of clicks and whistles as well as two biopsy samples were collected from bottlenose dolphins (*Tt3*) encountered four miles off the coastline. HARP site P was not surveyed due to the fact that no instrument was present at the site. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *D. capensis* off the San Diego coastline, July 30, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, July 30, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	3	29	-	-
T. truncatus	Tt2	2	12	-	-
T. truncatus	Tt3	46	200	1	2
D. capensis	Dc1	45	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 01/07/10
Prepared By: Greg Campbell

The third in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 07, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other cetacean species common to the region, and surveying the area around HARP site P.

Seven hours of field effort covering 68 miles yielded three groups of Pacific white-sided, one group of common, one group of coastal bottlenose, and one mixed group of offshore bottlenose and Risso's dolphins 1.5 mi. SE of HARP site P (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose and Risso's dolphins encountered. Acoustical recordings yielded clicks and buzzes from Pacific white-sided dolphins. Coastal bottlenose dolphin biopsy sampling was not in the protocol for this survey. Details on sighting, photo-ID, acoustical and biopsy data are provided in Table 1.

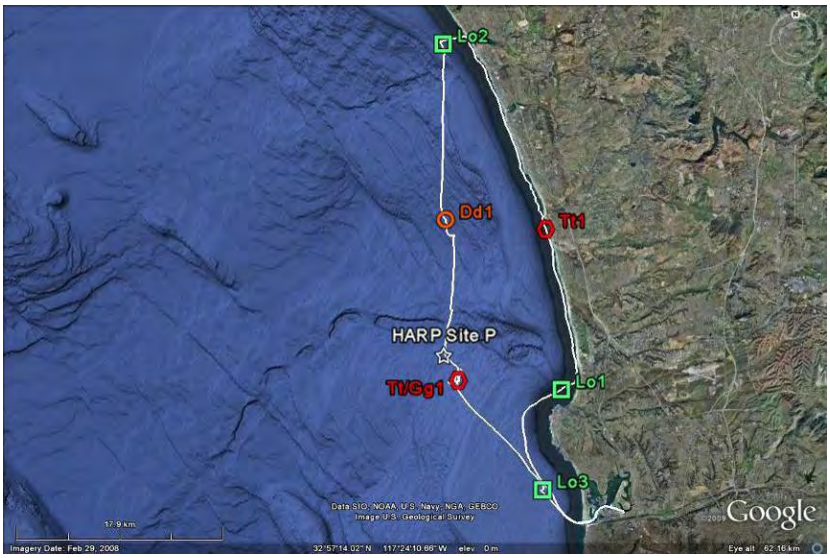

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *L. obliquidens*, *D. delphis*, and *G. griseus* off the San Diego coastline, January 07, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 07, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	6	36	3	-
T. truncatus/*G. griseus*	Tt/Gg1	22/60	68/95	-	-
D. Delphis	Dd1	29	-	-	-
L. obliquidens	Lo1	10	-	-	-
L. obliquidens	Lo2	24	-	1	-
L. obliquidens	Lo3	4	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 01/25/10
Prepared By: Greg Campbell

The fourth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 25, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other cetacean species common to the region.

Seven hours of field effort covering 70 miles yielded sightings of three groups of bottlenose dolphins and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of individuals encountered. Time and weather constraints precluded the collection of acoustical recordings, and bottlenose dolphin biopsy sampling was not in the protocol for this survey. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

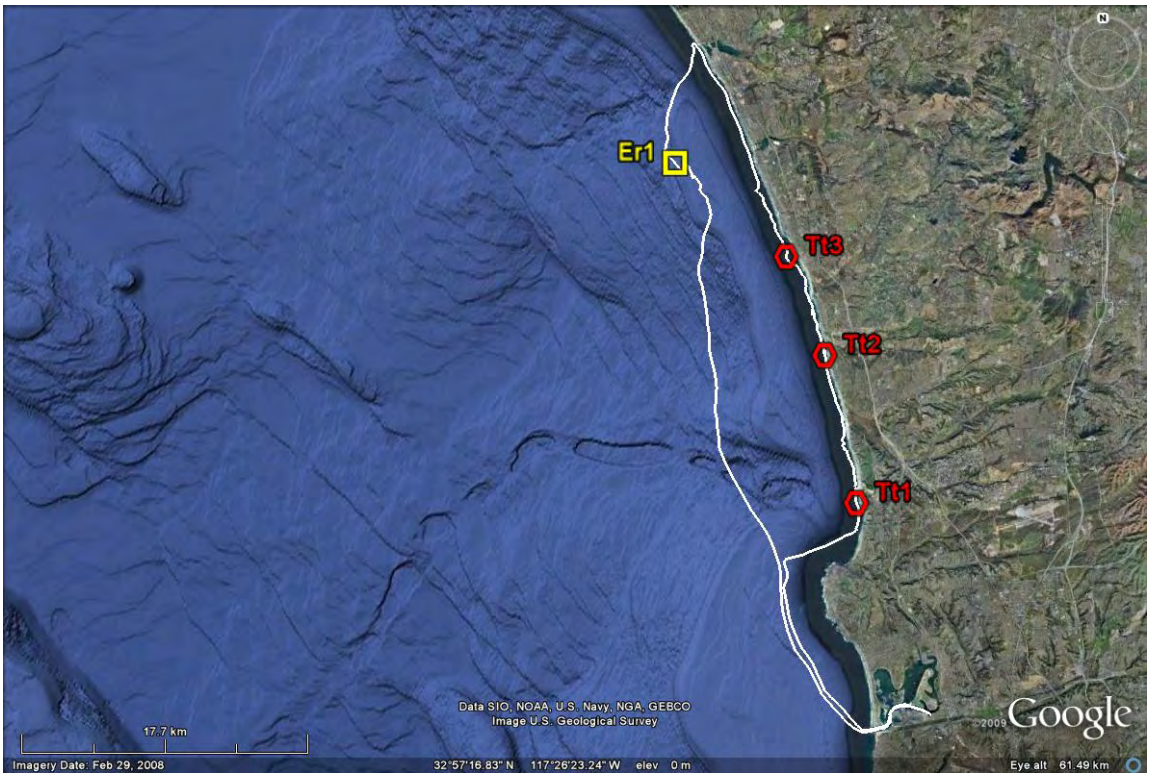

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *E. robustus* off the San Diego coastline, January 25, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 25, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	18	401	-	-
T. truncatus	Tt2	5	130	-	-
T. truncatus	Tt3	10	207	-	-
E. robustus	Er1	1	53	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 02/19/10
Prepared By: Greg Campbell

The fifth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 19, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Six hours of field effort covering 73 miles yielded sightings of two groups of bottlenose dolphins and one group of Pacific white-sided dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered and acoustical recordings yielded both whistles and echolocation clicks. Deteriorating weather conditions precluded the collection of biopsy/acoustical data from PWS dolphins. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *L. obliquidens* off the San Diego coastline, February 19, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 19, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	6	91	-	-
T. truncatus	Tt2	12	286	3	-
L. obliquidens	Lo1	11	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 02/24/10
Prepared By: Greg Campbell

The sixth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 24, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Eight hours of field effort covering 75 miles yielded sightings of two groups of bottlenose dolphins, four groups of Pacific white-sided dolphins, two groups of long-beaked common dolphins and one juvenile gray whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. One biopsy sample with three associated recordings of clicks was collected from PWS dolphins. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

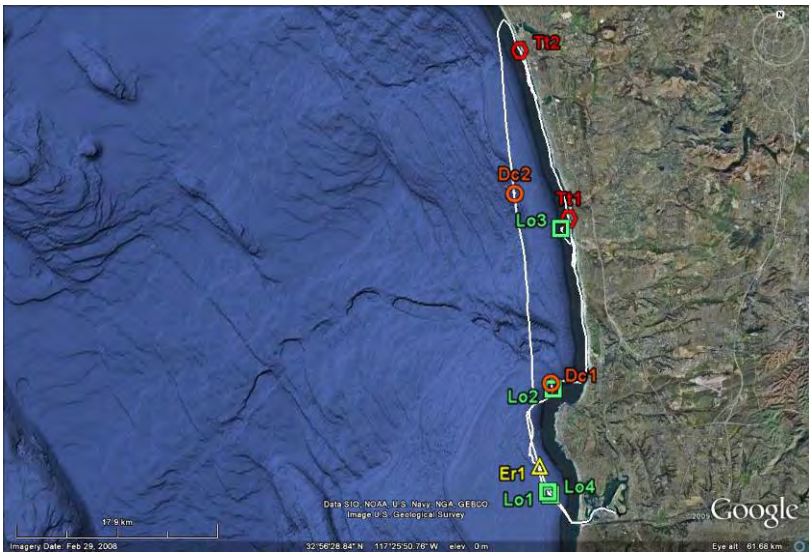

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *L. obliquidens*, *D. capensis* and *E. robustus* off the San Diego coastline, February 24, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 24, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	9	130	-	-
T. truncatus	Tt2	9	161	-	-
L. obliquidens	Lo1	7	4	3	1
L. obliquidens	Lo2	10	-	-	-
L. obliquidens	Lo3	5	-	-	-
L. obliquidens	Lo4	9	-	-	-
D. Capensis	Dc1	105	-	-	-
D. Capensis	Dc2	27	-	-	-
E. robustus	Er1	1	20	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 03/12/10
Prepared By: Greg Campbell

The seventh in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 12, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Ten hours of field effort covering 85 miles yielded sightings of seven groups of bottlenose dolphins and one group of Pacific white-sided dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of coastal bottlenose dolphins (*Tt*1) yielded whistles, clicks and mid-frequency active sonar signals. Bottlenose dolphins were also encountered at HARP site P where one biopsy sample was collected for stock structure analysis and one individual with unique pigmentation patterns was observed. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

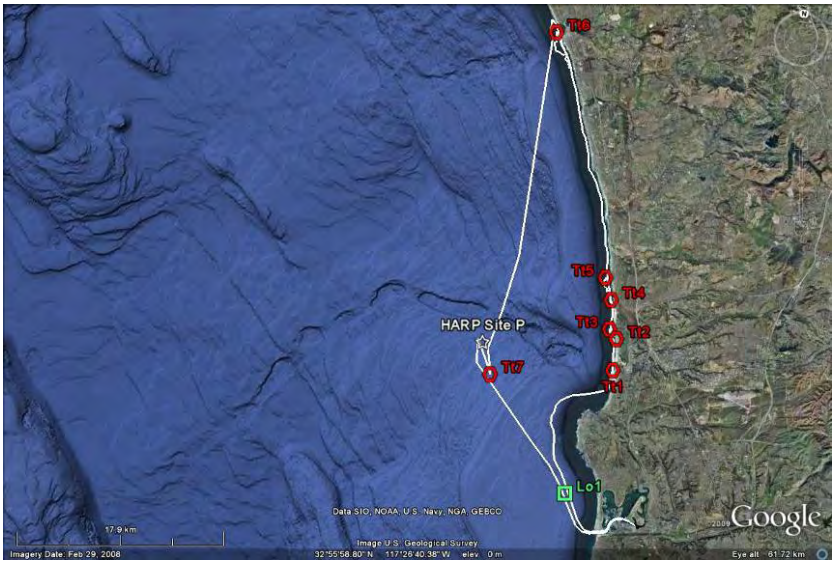

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *L. obliquidens* off the San Diego coastline, March 12, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 12, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	8	115	4	-
T. truncatus	Tt2	9	93	-	-
T. truncatus	Tt3	3	52	-	-
T. truncatus	Tt4	8	96	-	-
T. truncatus	Tt5	7	89	-	-
T. truncatus	Tt6	4	115	-	-
T. truncatus	Tt7	60	195	-	1
L. obliquidens	Lo1	5	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 03/29/10
Prepared By: Greg Campbell

The eighth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 29, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Seven hours of field effort covering 73 miles yielded sightings of three groups of bottlenose dolphins, two groups of Pacific white-sided dolphins and one group of common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings yielded whistles and clicks from coastal bottlenose dolphins and clicks from Pacific white-sided dolphins. Behavioral and time constraints precluded collection of biopsy samples from PWS dolphins. No cetaceans were encountered during a survey of the waters around HARP site P. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *L. obliquidens* and *D. delphis* off the San Diego coastline, March 29, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 29, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	7	170	4	-
T. truncatus	Tt2	2	29	-	-
T. truncatus	Tt3	5	56	-	-
L. obliquidens	Lo1	11	-	2	-
L. obliquidens	Lo2	5	-	-	-
D. delphis	Dd1	73	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 04/23/10
Prepared By: Greg Campbell

The ninth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on April 23, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Six hours of field effort covering 71 miles yielded sightings of three groups of bottlenose dolphins and one group of short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Large swell and increasing winds precluded the collection of acoustical recordings and surveying site P. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *D. delphis* off the San Diego coastline, April 23, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, April 23, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	21	322	-	-
T. truncatus	Tt2	4	37	-	-
T. truncatus	Tt3	3	45	-	-
D. delphis	Dd1	275	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 05/07/10
Prepared By: Greg Campbell

The tenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on May 07, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Seven hours of field effort covering 71 miles yielded sightings of six groups of bottlenose dolphins, one group of long-beaked common dolphins and two groups of short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of coastal bottlenose dolphins (*Tt7*) yielded whistles and clicks; however, snapping shrimp created a marginal signal/noise ratio. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *D. delphis* and *D. capensis* off the San Diego coastline, May 07, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, May 07, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	2	17	-	-
T. truncatus	Tt2	3	24	-	-
T. truncatus	Tt3	3	33	-	-
T. truncatus	Tt4	3	22	-	-
T. truncatus	Tt5	9	147	-	-
T. truncatus	Tt6	9	81	3	-
D. capensis	Dc1	65	55	-	-
D. delphis	Dd1	7	-	-	-
D. delphis	Dd2	85	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 05/14/10
Crew: Greg Campbell, Dave Weller. Amanda Cummins, Mary Grady

The eleventh in a series of small boat cetacean surveys off the San Diego county coastline was conducted on May 14, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Seven hours of field effort covering 68 miles yielded sightings of four groups of bottlenose dolphins and one group of short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. HARP site P was not surveyed due to the fact that no instrument was present at the site. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

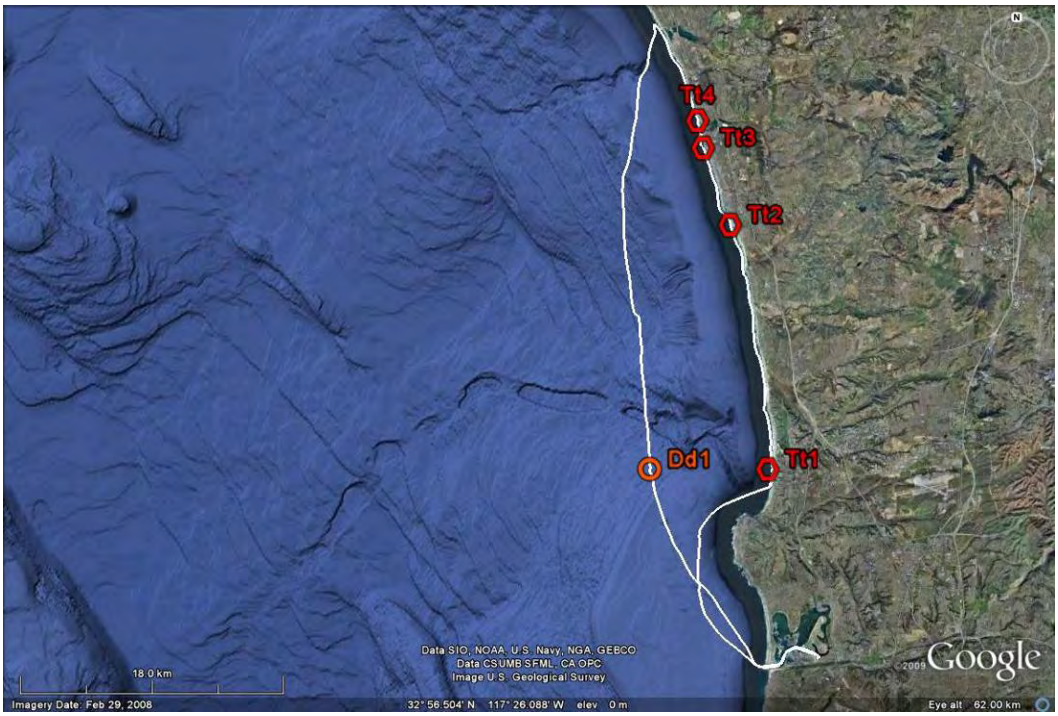

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *D. delphis* off the San Diego coastline, May 14, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, May 14, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	9	222	-	-
T. truncatus	Tt2	5	77	-	-
T. truncatus	Tt3	4	18	-	-
T. truncatus	Tt4	14	191	-	-
D. delphis	Dd1	165	-	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 06/04/10
Crew: Greg Campbell, Amanda Cummins, John Hurwitz

The twelfth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on June 4, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Seven hours of field effort covering 85 miles yielded sightings of one group of bottlenose dolphins, one group of short-beaked common dolphins and one mixed group of long-beaked and short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. HARP site P was not surveyed due to the fact that no instrument was present at the site. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus*, *D. delphis* and *D. capensis* off the San Diego coastline, June 4, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, June 4, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	7	147	-	-
D. delphis	Dd1	212	17	-	-
D. delphis / *D. capensis*	Dd/Dc1	147	11	-	-

California Coastal Bottlenose Dolphin Abundance Survey – 07/23/10
Crew: Greg Campbell, Dave Weller, John Hurwitz

The thirteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on July 23, 2010. The primary objectives were to collect photo-identification and acoustical data from California coastal bottlenose dolphins. Secondary objectives included gathering sighting, photographic, acoustical and biopsy data from other delphinid species common to the region, particularly Pacific white-sided dolphins.

Four hours of field effort covering 43 miles yielded sightings of one group of bottlenose dolphins and one group of short-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Two biopsy samples were collected from coastal bottlenose dolphins for an assessment of stress hormones and microbiological contaminants. HARP site P was not surveyed due to the fact that no instrument was present at the site. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. RHIB survey tracks and sighting locations for *T. truncatus* and *D. delphis* off the San Diego coastline, July 23, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, July 23, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	5	60	-	2
D. delphis	Dd1	38	-	-	-

CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATION (CALCOFI) CRUISES: 2009-2010

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Cetacean surveys have been integrated into California Cooperative Oceanic Fisheries Investigation (CalCOFI) quarterly cruises off southern California since 2004. CalCOFI cruises have been conducted consistently on the same transect lines over the past 60 years and provide on of the longest and most extensive time series of physical and biological oceanographic data in existence. Cetacean monitoring by Scripps Institution of Oceanography incorporates both visual and acoustic methods to assess cetacean populations occurring in the California current ecosystem. The objectives of the cetacean monitoring program are to determine the temporal and spatial patterns of cetacean distribution, to compare visual and acoustic survey methods and results, to quantify differences in vocalizations between cetacean species, and to make seasonal estimates of cetacean density and abundance within the study area. The greatest strength of CalCOFI cetacean surveys is the broad seasonal and geographic coverage within SOCAL. Sample sizes are comparable or greater than the total number of SWFSC sightings from the region. The weakness of CalCOFI cetacean surveys are that, due to time constraints, the vessel cannot alter course during the survey to better estimate group sizes and/or species identification. A comparison of visual and acoustic methods has demonstrated that most species are detected by both methods. CalCOFI cetacean surveys are planned to continue for at least the next two years. To date, estimates of cetacean density and abundance have been limited to blue, fin and humpback whales; however, extensive line-transect analysis encompassing all commonly sighted species is planned for the future. Recent analysis of baleen whale density relative to habitat type and productivity levels has proven insightful for expanding the scope and complexity of our habitat modeling efforts.

Visual monitoring for cetaceans on four quarterly CalCOFI cruises during 2009-2010 utilized standard line-transect marine mammal survey protocol. Visual observers searched during daylight hours under acceptable weather conditions during all transits between CalCOFI stations (Beaufort sea state 0-5 and visibility greater than 1 nm). Data on time, position, ship's heading/speed, and environmental conditions were recorded at regular intervals or when conditions changed. Information on all cetacean sightings was logged systematically, including distance and bearing from the ship, species identification, group composition, estimated group size and behavior. During all surveys, 18x power binoculars were used to improve species identification after an initial sighting using 7x binoculars.

Acoustic monitoring for cetaceans during line-transect surveys was conducted using a 6-element 300 m towed hydrophone array. Each pre-amplified element was band-pass filtered from 3 kHz to 200 kHz to decrease high intensity, low frequency flow noise and protection from signal aliasing at high frequencies. The multi-channel array data are sampled using both a MOTU 896 at 192 kHz and a National Instruments USB 6152 at 500 kHz to allow for a broad range of frequencies to be recorded. An acoustic technician monitored the incoming signals from the towed array using both a real-time scrolling spectrogram and headphones. Acoustic monitoring on CalCOFI stations is conducted with both broadband passive 57B omni-directional and 53F DIFAR sonobuoys. Sonobuoys were deployed 1 nm before each daylight station to a depth of 300 m and recorded for 2-3 hours while oceanographic sampling was underway. An acoustic technician monitored the

sonobuoy signals for cetacean calls using a scrolling spectrogram display. Mysticete calls, sperm whale clicks as well as low frequency dolphin calls, including whistles, buzzes and the lower frequency components of clicks are recorded with this system.

Cetacean surveys conducted in August 2009, November 2009 and January 2010 utilized the standard CalCOFI station pattern; efforts in April 2010 surveyed the trawling and northern transects (see Figure 1). Summary data on effort and sightings from the four CalCOFI surveys conducted from August 2009 – April 2010 are provided in Tables 1 and 2. Plots of all visual detections as a function of season are provided in Figures 2 and 3.

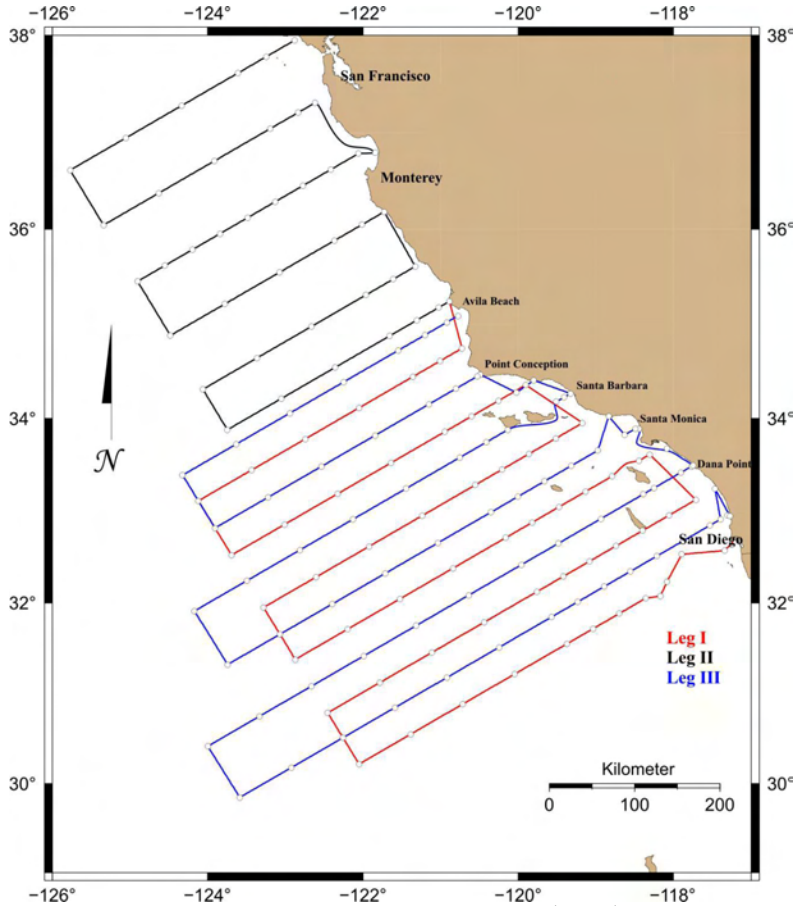

Figure 1. CalCOFI station positions for standard transect (blue), trawling transect (red), and northern transect (black). Image courtesy of CalCOFI program.

Table 1. Summary data from four CalCOFI cruises between August 2009 and April 2010.

CalCOFI Cruise Dates	Survey Effort (hrs)	Distance Surveyed (nm)	Number of Cetacean Sightings	Number of Individuals	Number of Digital Photos	Number of Acoustic Recordings	Total Hours of PAM	Number of Acoustic Detections/ Species	Number of Sonobuoys Deployed
14 Jul - 5 Aug 2009	102	965	110	2,050	7	62	123	129/8	36
6 -22 Nov 2009	96	842	49	3,364	29	55	212	53/7	29
12 Jan - 3 Feb 2010	97	898	105	8,998	5	71	196	126/8	36
4 - 24 Apr 2010	95	1325	75	3,220	217	65	216	*	65
Totals	390	4,030	339	17,632	258	253	747	308	166

Table 2. CalCOFI cetacean sightings by cruise from August 2009 – April 2010.
Ns = number of sightings; Ni = number of individuals

	CC0907 (14 Jul - 5 Aug 2009)		CC0911 (6 -22 Nov 2009)		CC1001 (12 Jan - 3 Feb 2010)		CC1003 (4 Apr - 24 Apr)	
Species	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**
Bm	17	21	1	1	0	0	0	0
Bp	12	14	3	10	3	6	1	14
Dc	5	351	2	953	5	237	0	0
Dd	27	1167	9	1532	8	3146	3	830
Dsp	14	284	8	712	12	3228	4	68
Er	0	0	0	0	22	47	1	1
Gg	4	45	2	18	8	84	5	337
Lb	0	0	1	5	2	720	1	650
Lo	0	0	2	22	2	84	6	871
Mn	0	0	7	11	4	6	22	106
Oo	0	0	0	0	0	0	1	6
Pd	0	0	2	11	7	63	17	87
Pm	6	9	0	0	3	25	1	5
Sc	1	58	0	0	0	0	0	0
Tt	7	82	1	3	1	7	0	0
UD	1	1	3	76	10	1307	2	232
ULW	16	18	7	9	18	38	11	13
Zcav	0	0	1	1	0	0	0	0
TOTALS	110	2050	49	3364	105	8998	75	3220

SPECIES CODE

Bm = *Balaenoptera musculus* (blue whale)
Bm = *Balaenoptera physalus* (fin whale)
Dc = *Delphinus capensis* (long-beaked common dolphin)
Dd = *Delphinus delphis* (short-beaked common dolphin)
Dsp = *Delphinus spp.* (unid. Common dolphin)
Er = *Eschrichtius robustus* (grey whale)
Gg = *Grampus griseus* (Risso's dolphin)
Lb = *Lissodelphis borrealis* (N. right-whale dolphin)
Lo = *Lagenorhynchus obliquidens* (Pacific whiste-sided dolphin)
Mn = *Megaptera noveangliae* (humpback whale)
Oo = *Orcinus orca* (killer whale)
Pd = *Phocoenoides dalli* (Dall's porpoise)
Pm = *Physter macrocephalus* (sperm whale)
Sc = *Stenella coeruleoalba* (striped dolphin)
Tt = *Tursiops truncatus* (bottlenose dolphin)
Zcav = *Ziphius cavirostris* (Cuvier's beaked whale)
UD = unidentified dolphin
ULW = unidentified large whale

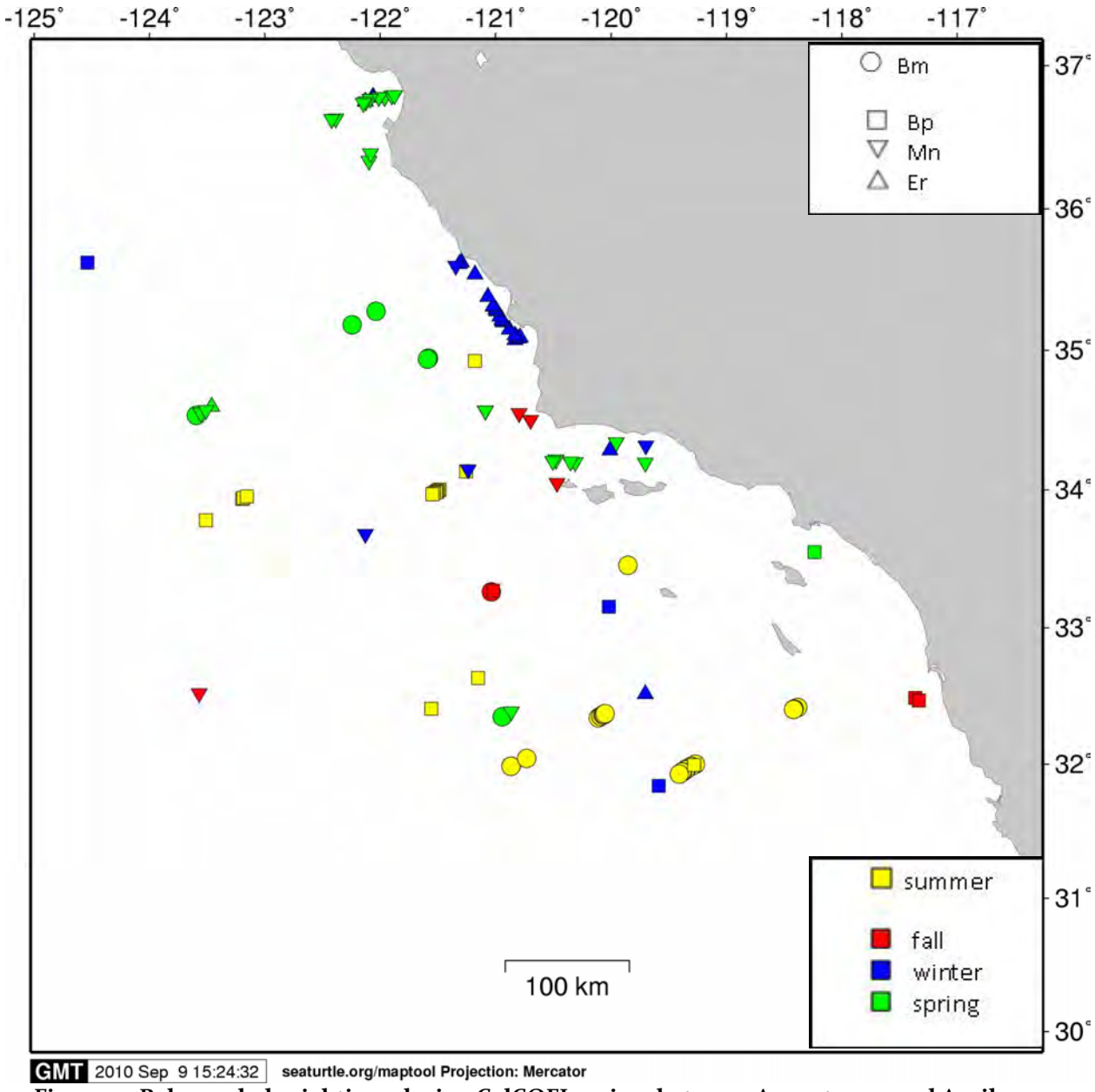

Figure 2. Baleen whale sightings during CalCOFI cruises between August 2009 and April 2010.

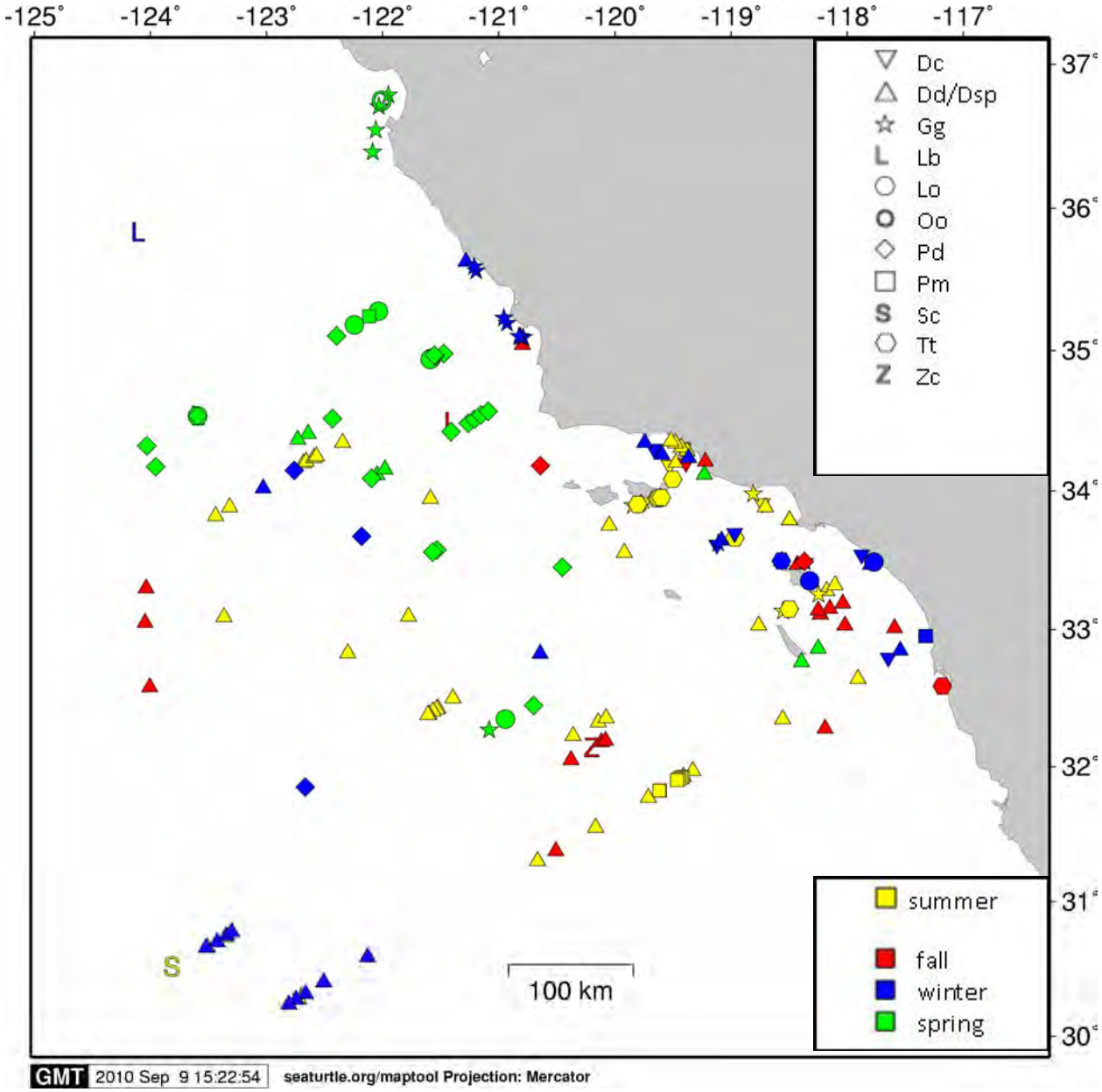

Figure 3. Toothed whale sightings during CalCOFI cruises between August 2009 and April 2010.

Cascadia Research Collective
non-profit research and education since 1979

Small vessel surveys and satellite tagging of marine mammals at SCORE and surrounding areas of SOCAL in 2009:

A summary of effort, sightings, and satellite tag deployments with an assessment of the "fast and light" approach to small vessel surveys in the region

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Introduction

In 2009, Cascadia Research participated in the fourth year of collaborative marine mammal surveys centered on the Southern California Offshore Range (SCORE). The primary mission of these surveys since their inception has been to provide visual verification of passive acoustic detections on the SOAR array using the M3R system (Moretti et al. 2006). Over time, these surveys have evolved to include focal studies of several species of interest to the Navy, including beaked whales and ESA listed baleen whales, via photo-identification, tissue sampling, and the deployment of medium duration satellite tags (e.g. Andrews et al. 2008, Schorr et al. 2009). While previous surveys have been successful (See http://www.cascadiaresearch.org/SCORE/SCOREMain.htm for annual summaries) and provided sufficient sighting and photo-identification data on Cuvier's beaked whales at SCORE for a journal article (Falcone et al. 2009), effort during scheduled surveys, at the SOAR array in particular, has often been limited by rough sea conditions and conflicting naval operations in the study area. To maximize efficiency during other projects along the US West Coast, Cascadia has historically operated many of its small vessel surveys on a temporally and geographically flexible schedule whenever possible. This has allowed us to target periods of calm weather and unpredictable aggregations of study species as they occur, resulting in more efficient and effective data collection. We felt moving away from a fixed schedule and expanding our geographic coverage into adjacent areas of SOCAL might also increase the effectiveness of this study by allowing us to target good weather windows when the range was unrestricted for data collection, and also providing opportunities to collect data from animals in adjacent areas which will be necessary to define the status of range populations within the broader regional context of SOCAL. We viewed 2009 as an opportunity to test the approach in this setting, given the additional logistical challenges of working at SCORE (e.g. housing, coordination with passive acoustic monitoring assets, range access).

While the first survey in July ended up on a fixed schedule in association with other monitoring activities at the range, and thus was not temporally flexible, and the range was closed throughout September and October for hydrophone replacement (thus limiting our opportunities for surveys during what is typically the best weather during the year), we were able to attempt a series of more flexible surveys in November. During both periods we expanded data collection into adjacent areas of SOCAL when access to SOAR

was limited. This summary provides an overview of effort, sightings, and tag deployments in 2009, with an assessment of the "fast and light" approach to small vessel surveys in the region and recommendations for future surveys.

Survey Effort

Cascadia conducted visual surveys from a single RHIB during two periods in 2009: 18-26 July, and 11-24 November. Survey hours, including time spent on and off the instrumented range, are summarized along with sightings in Table 1. All RHIB tracks are presented in Figure 1. RHIB surveys in July were in conjunction with aerial surveys and a large vessel line-transect survey aboard the R/V Sproul from 21-27 July 2009. Cascadia provided visual observations from the Sproul during this survey. As continuous PAM was also underway during this period using both the SOAR array and a towed array from the ship, one goal of this period is to compare the efficacy of each methodology using these concurrent samples. All sightings data from the Sproul was provided to Scripps Institution of Oceanography for that analysis.

More than half of survey hours in July were spent on SOAR, although conditions were marginal throughout much of the time (Table 1). On days when range access was restricted by weather or conflicting operations effort was shifted into adjacent areas of SOCAL. Access to the range was restricted throughout most of the available survey period in November, which paired with weather, resulted in only one day on SOAR that trip. Subsequently remaining survey days were used to scout alternative locations for collecting data on beaked whales, and also to collect identification photos, tissue samples, and deploy satellite tags on range species outside the core study area. An emphasis was placed on fin whales given that those tagged previously at SCORE have frequently moved between the range and inshore SOCAL.

Table 1. Summary of RHIB survey effort by Cascadia Research at SCORE and surrounding areas in 2009.

Survey	Total Survey Hours	Hours in Excellent or Good conditions	Hours on Range	Number of sightings	Number of species sighted	Number of tags deployed
18-26 July 2009	81.3	44.9 (55%)	45.0 (55%)	77	9	8
11-24 November 2009	77.5	50.5 (65%)	10.6 (14%)	94	10	12

Figure 1. CRC RHIB survey tracks (in white) from both dedicated monitoring at SCORE (boundaries of SOAR range in yellow) and supplemental effort at other parts of SOCAL in 2009.

Sightings

Sightings are summarized in Tables 2a and 2b for the July and November survey periods. It is difficult to make simple comparisons between sighting rates in 2009 with those from previous survey years given the much greater proportion of effort spent working outside the core study area, however in general the distribution and proportion of sightings by species at SOAR was similar to trends observed previously. Common dolphins remained the most frequently sighted species both on and off the range, with a slightly higher proportion of sightings of short-beaked than long-beaked sightings. Five groups of Cuvier's beaked whales were sighted in the western part of SOAR during surveys in July, two if which were encountered without acoustic direction from M3R. During this same time period the *Sproul* line-transect survey sighted no beaked whales and aerial surveys reported only a single group. Figure 2 shows all cetacean sightings other than common dolphins.

Fin whales continue to be the most frequently encountered baleen whale during these surveys, particularly in offshore areas, although both blue and minke whales were sighted much more frequently in 2009 during coastal surveys. As has often been the case with fin whales they tended to occur both on and off the range in localized concentrations when encountered. A group of 8-12 fin whales was encountered on the range in July, and while there was insufficient effort on the range in November to confidently say that fin whales were not present, no fin whales were seen during the one day spent on the range that month. In contrast, a sizeable aggregation was observed over a period of days in the vicinity of the Palos Verdes Peninsula, feeding on surface swarms of krill and small bait fish along the canyons and shelf edge between Long Beach and Marina del Rey. This concentration, which we estimated at 20-30 fin whales with lesser numbers of blue whales and minke whales, had been reported both prior to our surveys in November and was still present as of late-December based on satellite telemetry from tagged individuals

and reports from whale watch operators and even the local media. Based on both existing large whale datasets from the region and the local reports such an aggregation has not been reported off coastal southern California for any of these species this late in the year. While photo-ID and satellite tag data suggest that blue whales migrate to lower latitude breeding areas in the winter, although with less geographic predictability than humpback or gray whales, the migratory habits of fin whales in the North Pacific are virtually unknown. Observations from historical whaling data and more recent sighting data suggest that they may not follow a migratory pattern similar to other baleen whales (Mizroch et al. 2009), and our observations of fin whales aggregated off California well into December support this supposition. Although no calves were observed in the aggregation of fin whales in November, in addition to feeding, animals were frequently engaged in "racing" and other agonistic behavior often associated with courtship in better known blue whales, supporting that these whales have a seasonal reproductive cycle, but that they may not migrate to tropical and sub-tropical waters breed. Understanding the seasonal movements and reproductive habits of fin whales is of particular relevance if aggregations in SOCAL training areas during winter months are engaged are breeding as well as feeding behavior, and subsequently may be more sensitive to certain types of disturbance at these times.

Another sighting of note during surveys in November was a group of four Cuvier's beaked whales in the northwestern Santa Cruz Basin. Historically, Cuvier's beaked whales on the range have been found almost exclusively in the northwestern segment of the array, which corresponds to the western portion of the San Nicolas Basin (Falcone et al 2009). This prompted us to question whether this species might also occur in higher concentrations in the western part of other deep basins in the Southern California Bight, and in particular the Santa Cruz Basin, which can be reached relatively easily from Channel Islands Harbor on the mainland coast (as opposed the San Nicolas Basin which can only be accessed by RHIB from San Clemente Island during periods of favorable weather). The Santa Cruz basin also has the added advantage of being within the lee of Point Conception during moderate northwesterly wind and swell conditions that prevail throughout summer months off southern California, with additional protection from Santa Cruz Island itself in its northernmost reaches. A group of beaked whales was also sighted south of this area during another Cascadia survey using a small towed array in September. While a combination of scheduling and conditions only allowed for a single survey of the Santa Cruz Basin in November, finding beaked whales with no acoustic support that day is very encouraging that the Santa Cruz Basin can be an alternate site for focal studies of beaked whales in SOCAL. Future effort here will be invaluable to ongoing photo-ID studies to help define the southern California population of this species. Additional tag deployments will contribute to baseline data from the species in southern California, and may provide an opportunity to investigate differences in habitat use and movement patterns in whales from regions with varying degrees of naval activity.

Processing and analysis of photo-identification data for all species is underway. An estimated total of 74 fin whales and eight Cuvier's beaked whale identifications were collected in 2009. These will be compared against existing catalogs of these species from SCORE developed and maintained by Cascadia, currently totaling 68 fin whales and 58 Cuvier's beaked whales. Identifications of blue and humpback whales will be processed as part of long-term photo-ID studies of these species by Cascadia. Identifications of bottlenose (N=115) and Risso's (N=168) dolphins have been provided to SIO and SWFSC for processing.

Table 2a. Summary of sightings by species, CRC RHIB July 2009.

Species	Groups Sighted	Groups On SOAR	Groups Off SOAR	Est Total Individuals	Avg Group Size	Est ID	Samples	Tags Deployed
Minke Whale	2	1	1	2	1.0	2		
Blue Whale	8	0	8	11	1.4	11		
Fin Whale	7	4	3	19	2.7	15	1	5
Long-beaked Common Dolphin	12	0	12	429	35.8		2	
Short-beaked Common Dolphin	16	1	15	2333	145.8			
Common Dolphin, Sub-species unknown	5	2	3	53	10.6		1	
Risso's Dolphin	12	3	9	267	22.3	136	4	1
Pacific White-sided Dolphin	1	1	0	10	10.0			
Elephant Seal	1	0	1	1	1.0			
Bottlenose Dolphin	7	2	5	144	20.6	60	2	1
Cuvier's Beaked Whale	5	5	0	10	2.0	4		1

Table 2b. Summary of sightings by species, CRC RHIB, November 2009.

Species	Groups Sighted	Groups On SOAR	Groups Off SOAR	Est Total Individuals	Avg Group Size	Est ID	Samples	Tags Deployed
Minke Whale	12	0	12	20	1.7	10		
Blue Whale	17	0	17	44	2.6	37	4	3
Fin Whale	27	0	27	74	2.7	59	9	8
Long-beaked Common Dolphin	6	0	6	663	110.5			
Short-beaked Common Dolphin	17	2	15	6141	361.2			
Risso's Dolphin	3	0	3	63	21.0	32	2	1
Pacific White-sided Dolphin	4	0	4	224	56.0			
Elephant Seal	1	0	1	1	1.0			
Humpback Whale	1	0	1	2	2.0	0		
Bottlenose Dolphin	5	0	5	86	17.2	55		
Cuvier's Beaked Whale	1	0	1	4	4.0	4		

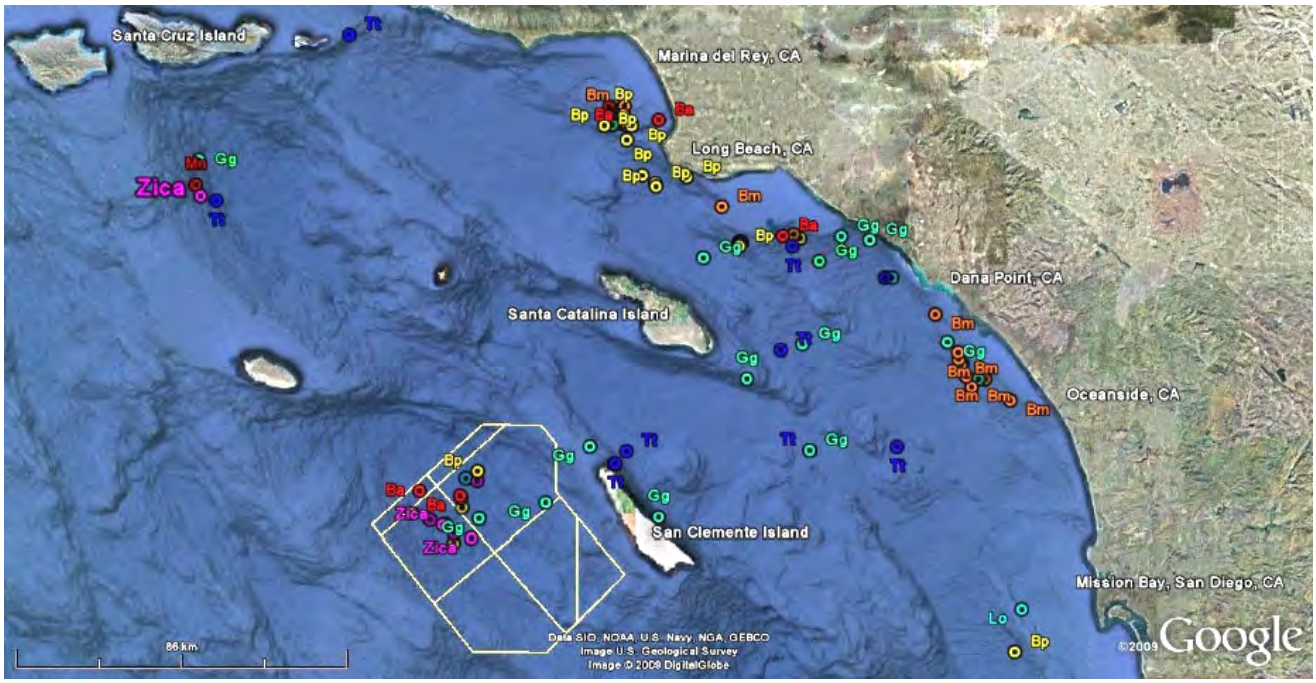
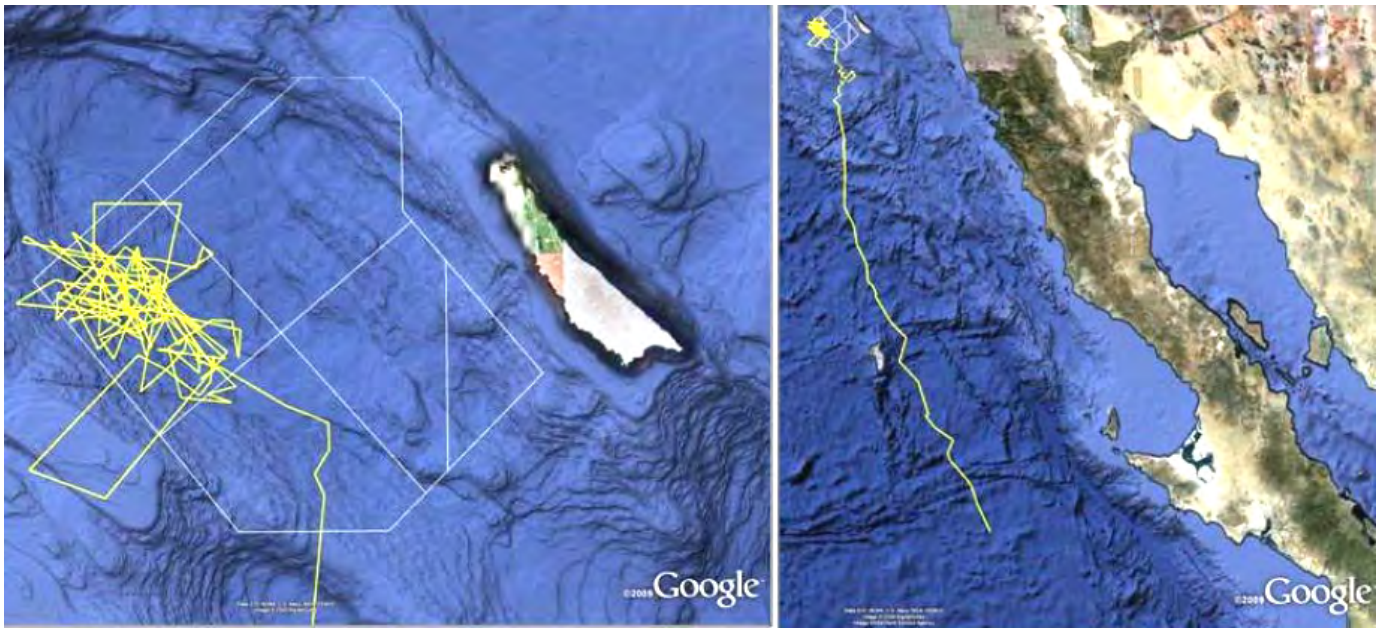


Figure 2. Cetacean sightings from CRC RHIB surveys in 2009 (common dolphins excluded, though they were present during all surveys). Baleen whales are in red (minke, "Ba" and humpback, "Mn"), orange (blue, "Bm"), and yellow (fin whales, Bp). Dolphins are in blue (bottlenose, "Tt") and turquoise (Risso's, "Gg" and Pacific whitesided, "Lo"). Cuvier's beaked whales, "Zica", are in magenta.

Satellite tag deployments

Twenty Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) satellite tags (two of which were financed by other projects) were deployed on six different species, both on and off the range, in 2009. These tags augment the four tags deployed on the range in 2008 (one on a Cuvier's beaked whale and three on fin whales). Additional tags were deployed on both these species this year (one Cuvier's and 13 fins), as well as two Risso's dolphins, one bottlenose dolphin, and three blue whales- representing the first time this type of tag has been applied to latter three species. An attempt was made to tag a minke whale, but the tag body grazed the leading edge of the fin resulting in a lost tag. The LIMPET tags are designed to provide movement data from tagged individuals, typically with multiple positions per day for periods ranging from several weeks to several months, depending on the species, programming, and type of attachment while being as minimally invasive as possible.

While sample sizes on all species, with the possible exception of fin whales, remain too small to characterize movement patterns from the species in general, there are a few observations of note. Both sighting data and movement data from the one previously tagged adult female Cuvier's beaked whale suggested that these whales may have ranges largely coincident with the San Nicolas Basin and those basins nearby, however the adult male Cuvier's beaked whale tagged in July 2009 ultimately traveled nearly 700 km almost due south into Mexican waters before contact with the tag was lost (Figure 3a and b).



3A 3B

Figure 3. Movements of a tagged adult male Cuvier's beaked whale showing the first month of movements (3A) and the movement to the south (3B).

Both the Risso's and bottlenose dolphins that were tagged at San Clemente Island moved between islands, demonstrating that these populations are not island-specific, although neither moved east into coastal waters during tag contact (average transmission duration = 16.5 days), so it is possible both Risso's and bottlenose dolphins found offshore may be distinct from their coastal counterparts. It is known that there are different populations of bottlenose dolphins near shore and offshore in southern California (e.g. Defran and Weller, 1999, Defran et al., 1999), but the role the islands play in the structure of the offshore population has not been well studied and satellite tagging, in addition to ongoing photo-ID studies using photos from this project, has much to offer in this regard for both these relatively common species around San Clemente Island.

Thirteen fin whales were tagged in 2009 to augment data from three individuals tagged in 2008. Five tags were deployed in July with transmission durations ranging from 12 to 160 days (Figure 4). Eight tags were deployed in November 2009, however median transmission duration for those tags was only 6 days (range = 0 to 12). While it is possible that behavioral states (racing, conspecific interactions, etc) may have resulted in damage or dislodgment of the tag and may account for some of the short transmission durations, it is also likely there were hardware issues with the tags themselves based on several tags which failed to transmit despite apparently normal deployment and attachment. We are continuing to work with the manufacturer to address possible sources of failure and verify any changes in new tag deployments. Analysis of percentage of time spent in training ranges and shipping lanes is currently underway and will ultimately be added to a habitat use and movement pattern analysis for southern California fin whales.

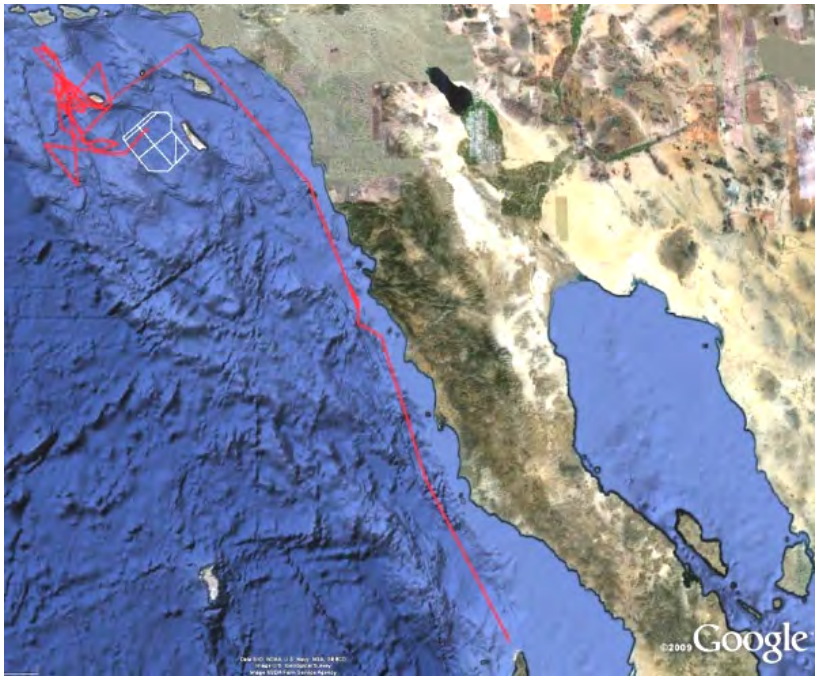


Figure 4. Trackline representing the movements of a tagged fin whale over 127 days (total transmission duration for this whale was 160 days). While the whale was tagged on the SOAR range, much of its time was spent in the waters surrounding San Nicolas Island.

Three blue whales were tagged during November, representing the first time this type of tag has been deployed on this species. Two of the tags are still transmitting at the time of this report, now on day 49. Both of these whales moved well south into Mexican waters within several weeks of tag deployment and currently remain outside US waters.

Analysis of the movements of tagged individuals in relation to Navy generated anthropogenic noise sources (e.g. MFAS) are currently underway in collaboration with NUWC. The results of this analysis may allow for an assessment of individual and, once sample sizes are large enough, population level impacts due to naval exercises and will allow for an analysis of the habitat use and movement patterns of species which inhabit the SOCAL region.

Assessment of "fast and light" operations at SCORE and adjacent areas

While not totally unexpected, this project did not lend itself well to operating on a temporally flexible schedule, at least for conducting monitoring surveys in conjunction with M3R at SCORE. This was due primarily to the logistical challenges of obtaining housing on island on short notice and frequent restrictions on range access for both vessel surveys and M3R. We still believe that building a degree of flexibility into future survey protocols is valuable, but to guarantee a minimum number of days on range each year will require at least some effort scheduled in advance. Given the high likelihood that a significant portion of days during any given survey will be compromised by weather and range scheduling conflicts, scheduled trips should be of longer duration than in previous years, which ranged from 5-10 days in length. With the overhaul of the hydrophone array in September and October of this year and funds for fieldwork not available until July, it was not the ideal year to test the "fast and light" system, as it left only parts of August and November to attempt surveys. But during these times we