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).

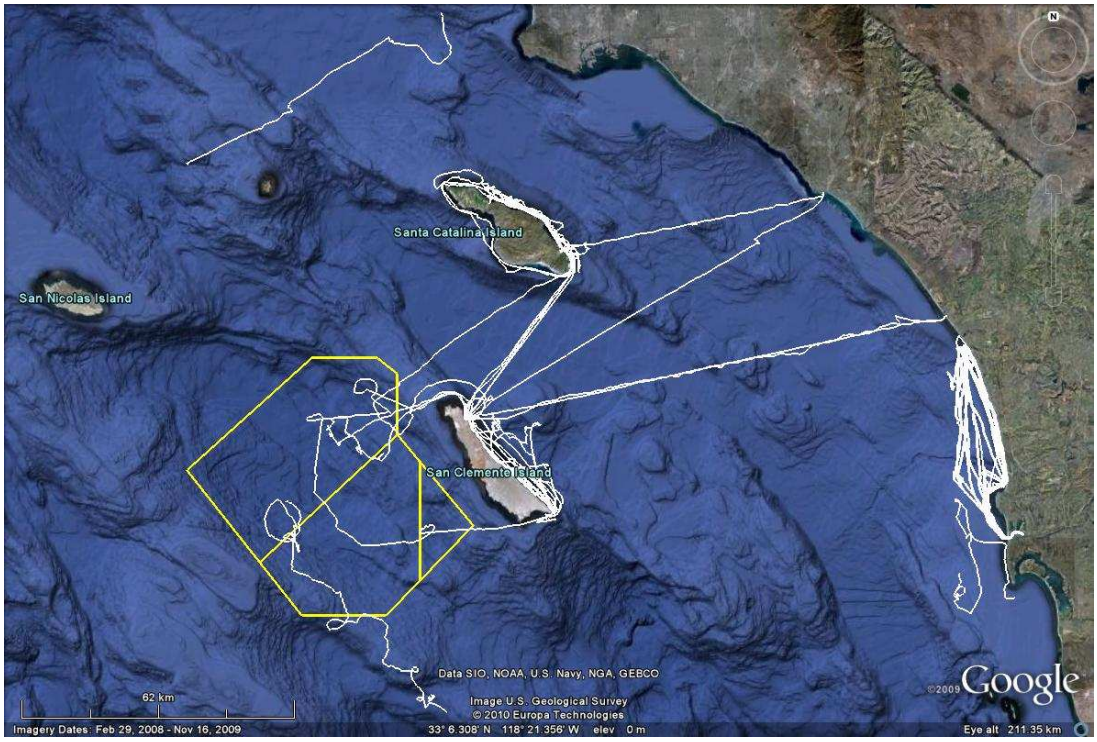

Figure 1. SIO small vessel survey tracks from monitoring at SCORE (boundaries of SOAR range in yellow), Catalina Island and the San Diego coastline from August 2009 – July 2010.

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.

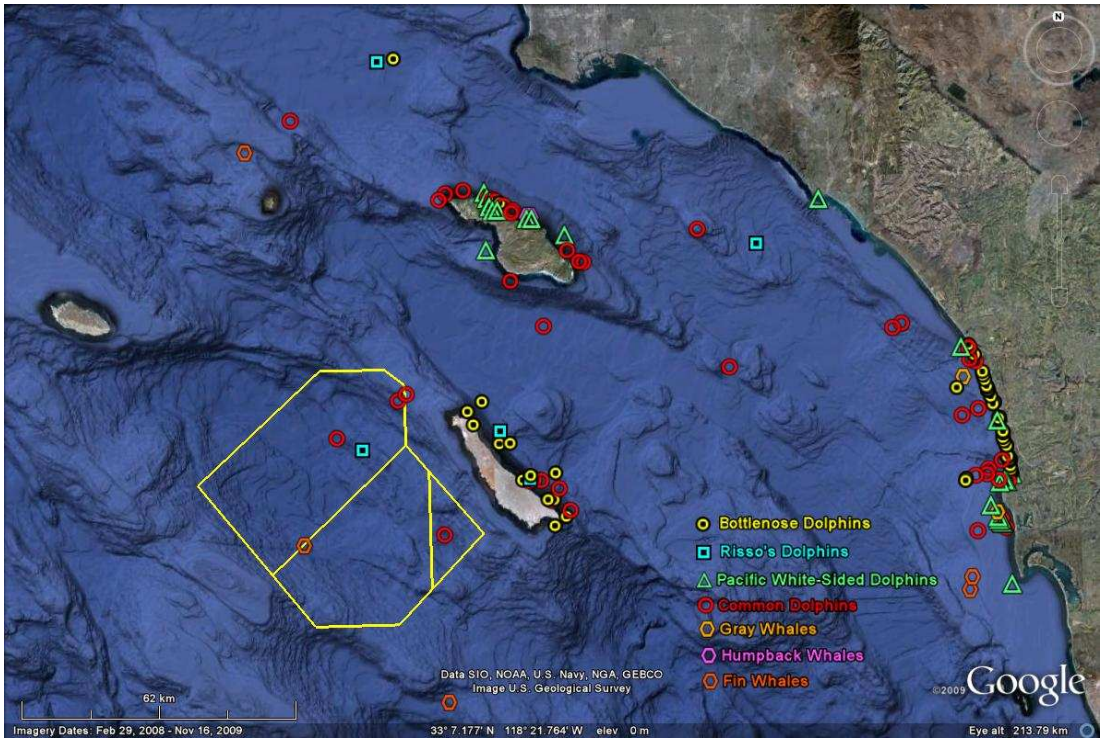

Figure 2. Cetacean sightings documented on all SIO small boat surveys in southern California from August 2009 – July 2010.

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 ($\bar{x}$ = 3.8) was nearly four times higher than the mean number of delphinid groups sighted per survey in November 2009 ($\bar{x}$ = 1.0) (Tables 5 and 6). Species diversity was also low during November 2009 as common dolphins were the only species sighted in the study area. In contrast, the June 2010 field effort documented four of the five delphinid species common to the waters around San Clemente Island, including bottlenose, Risso's, short-beaked and long-beaked common dolphins.

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

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

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

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

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

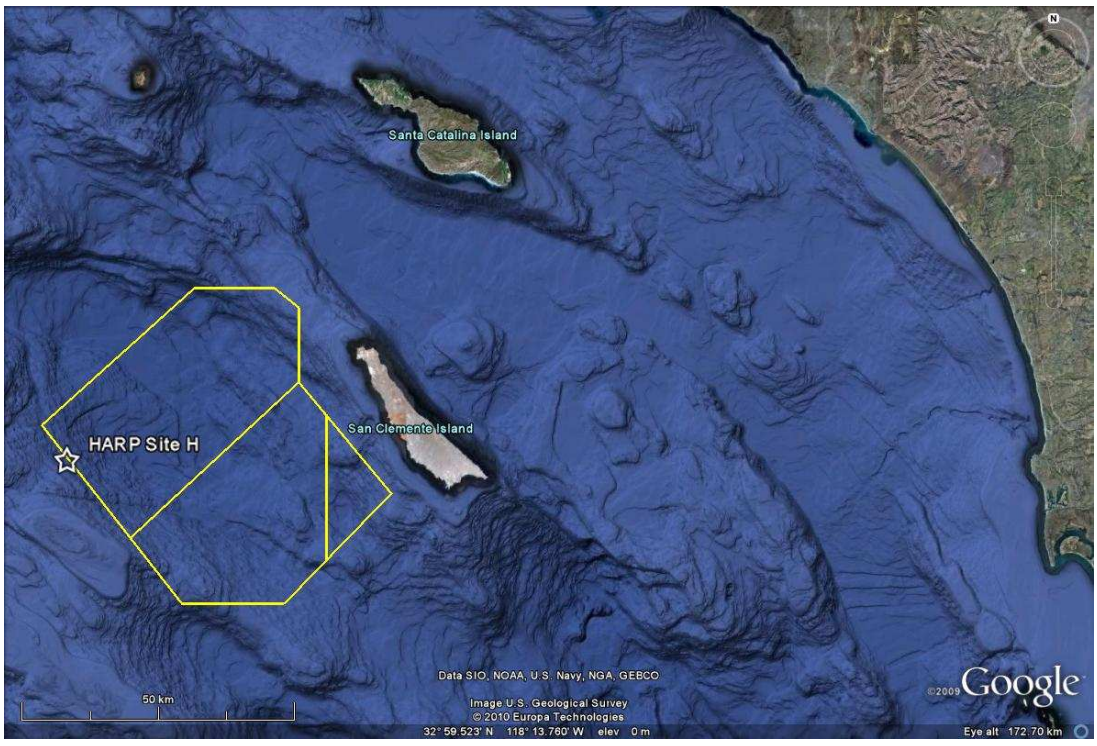

Figure 3. Location of HARP site H, west of the SOAR range off San Clemente Island (boundaries of SOAR range in yellow).

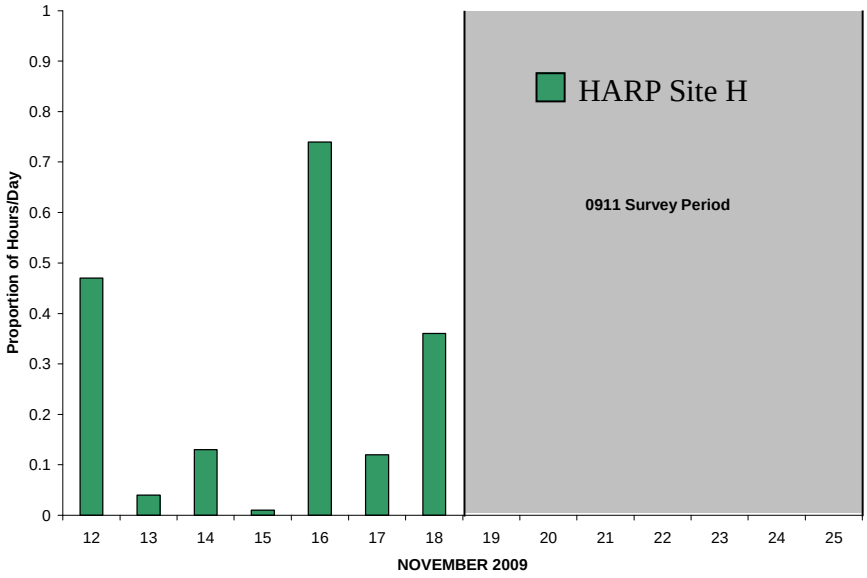

Figure 4. MFAS occurrence in proportion of hours per day from HARP site H from 12 to 25 November, 2009. Grey area represents period of no HARP data collection.

Bottlenose Dolphin Photo-Identification

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

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

Rate of discovery

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

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

Sighting frequency and site fidelity

Sighting frequencies for the 318 dolphins identified at San Clemente Island from 2006-2009 ranged from 1-6 ($\bar{x}$ = 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.

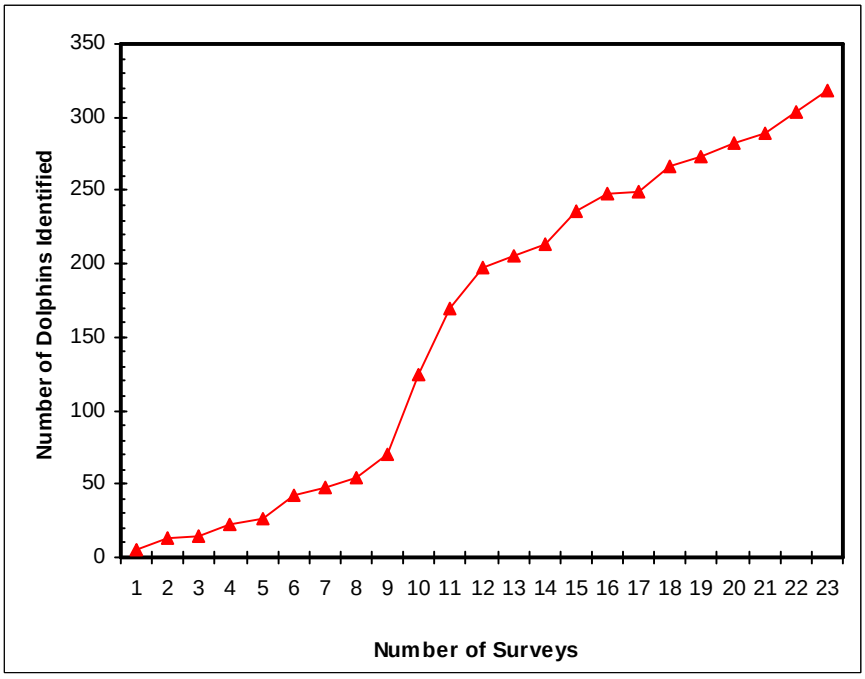

Figure 5. Cumulative number of bottlenose dolphins photo-identified at San Clemente Island over surveys in which at least one dolphin was identified. N = 318 individuals.

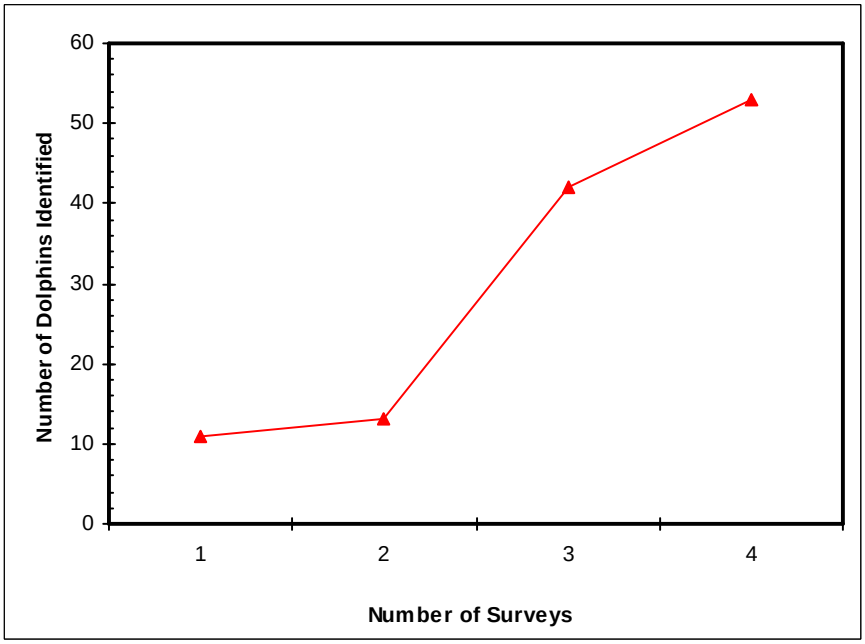

Figure 6. Cumulative number of dolphins photo-identified at Catalina Island over surveys in which at least one dolphin was identified. N = 53 individuals.

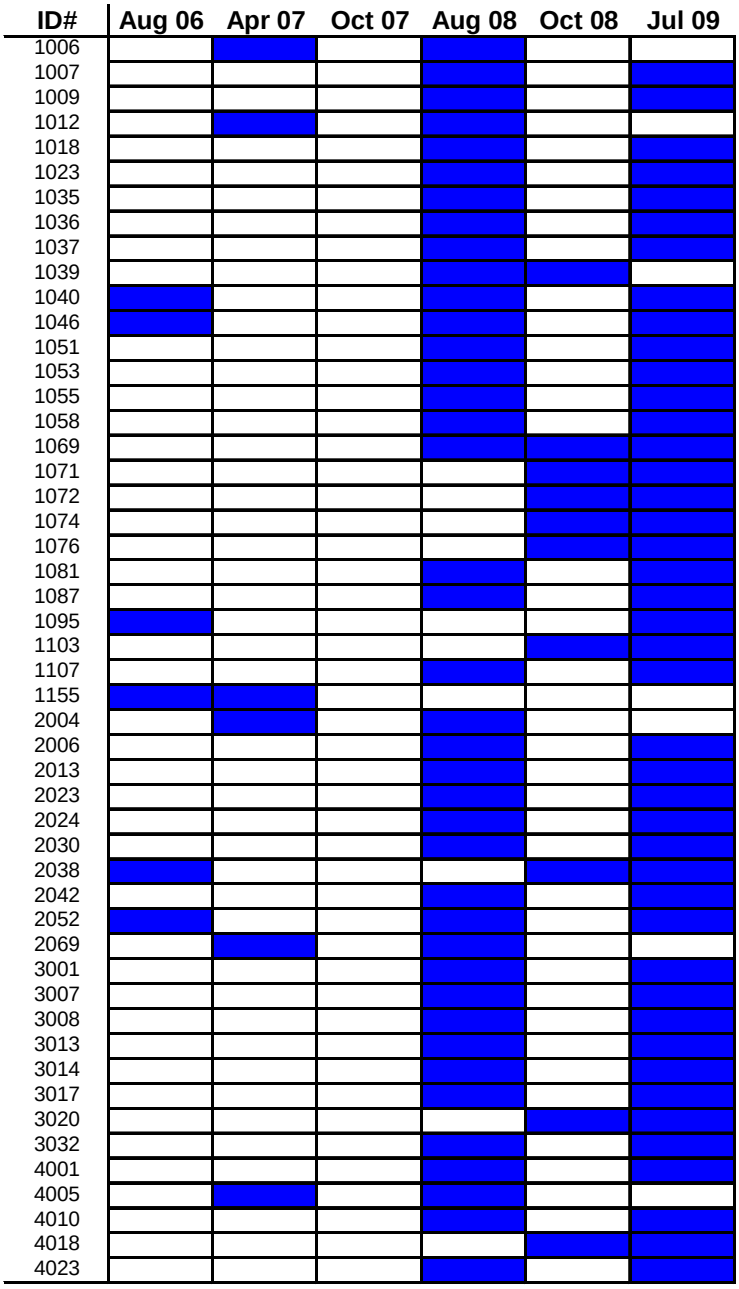

Figure 7. Sighting matrix for the fifty bottlenose dolphins photographically identified during two or more survey periods at San Clemente Island from August 2006 to July 2009.

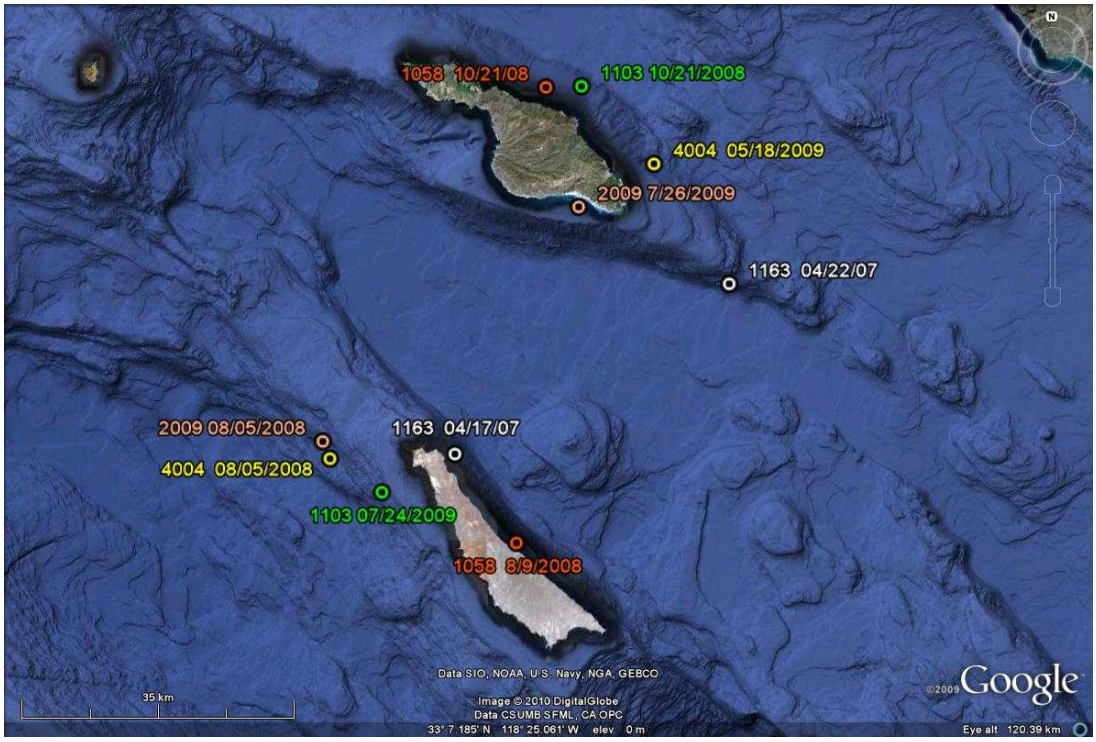

Figure 8. Sighting locations, ID codes and dates for the five photo-identified individual bottlenose dolphins documented off both San Clemente and Catalina Islands.

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 delphnid 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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APPENDIX 1