APPENDIX D. Navy Research Funded Year Three Project Reports

- Distribution and Demographics of Marine Mammals in SOCAL through Photo-Identification, Genetics, and Satellite Telemetry (Cascadia Research Collective)Small boat based marine mammal surveys in Southern California: Report of Results for August 2009 - July 2010 (Scripps Institute of Oceanography and Southwest Fisheries Science Center)
- California Cooperative Oceanic Fisheries Investigation (CalCOFI) field cruises in Southern California (Scripps Institute of Oceanography)

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DISTRIBUTION AND DEMOGRAPHICS OF MARINE MAMMALS IN SOCAL THROUGH PHOTO-IDENTIFICATION, GENETICS, AND SATELLITE TELEMETRY:

A summary of surveys conducted 15 June 2010 – 24 June 2011

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INTRODUCTION

The U.S. Navy manages the Southern California Range Complex (SOCAL), a collection of nearshore and offshore training area which includes much of the waters from Santa Barbara, CA south to Northern Baja California, MEX and extending several hundred miles west. It is among the most heavily used tactical training areas in the world, and is used for a variety of aerial, surface, and subsurface exercises. The Southern California Offshore Range (SCORE) is a subset of complexes within SOCAL centered on San Clemente Island. It in turn includes the Southern California Anti-submarine Warfare Range (SOAR), a focal area for exercises involving MFAS in the San Nicolas Basin, extending approximately 60km west of the island[12]. SOCAL includes a wide variety of marine habitats, and subsequently is home to a high diversity of cetacean species year-round, though with some seasonal fluctuations. While the more coastally-distributed species and populations within the region have generally been well-studied; the distribution, demographics, and behavioral patterns of cetaceans in the outer waters of the Bight are much less well-known. Operations in this region have been subject to rising environmental scrutiny in recent years, as an increasing number of unusual cetacean stranding events have occurred in association with the use of MFAS and other anthropogenic sound sources in other parts of the world. Subsequently, detailed knowledge of how cetaceans use the outer waters of the Southern California, and specifically the waters around SOAR, is critically needed.

Cascadia Research Collective (CRC) began conducting visual surveys at SCORE in August 2006 in collaborations with staff from the Naval Undersea Warfare Center (NUWC), Scripps Institution of Oceanography (SIO), and the Naval Postgraduate School (NPS). The primary objective of these surveys was to provide visual verification of acoustic marine mammal detections on the SOAR

12 http://www.globalsecurity.org/military/facility/socal.htm; accessed 28 June 2011

hydrophone array. NUWC developed a suite of passive acoustic tools to monitor vocal cetacean species using the AUTEC array in the Bahamas, known as Marine Mammal Monitoring on Navy Ranges (M3R) (Moretti et al. 2006). These tests provided data for adapting M3R for use at SOAR, where a much higher density and diversity of vocal species occur. These surveys also provided an opportunity for data collection from a region that had not previously been available to researchers, both due to its remoteness and predominantly rough sea conditions, and also to regular restrictions associated with military operations.

While additional data from all species utilizing the range was of value given the increasing concerns surrounding marine mammals and military activities, the focal species during these surveys were beaked whales. Several species of beaked whales are known to occur along the US West Coast. Of these, Cuvier's beaked whale (*Ziphius cavirostris*) is the most frequently sighted; however sighting rates are too low even for this species to derive reliable population estimates. The animals present along the coasts of California, Oregon, and Washington are currently managed by NMFS as a single stock, estimated at approximately 2,000 individuals as of the most recent stock assessment report (Caretta et al. 2011). While the deep basin of the SOAR range is consistent with habitat used by beaked whales in other parts of the world, the degree to which they occurred on the range was unknown. Cuvier's beaked whales have been involved in the majority of sonar-associated stranding events to date, thus there was reason to expect that they would not be prevalent on SCORE, where MFAS is routinely used year-round. The hope was that M3R would allow researchers to acoustically detect beaked whales on the range, if present, and that visual surveys would provide verification of species and numbers.

Contrary to expectations, a pair of Cuvier's beaked whales was encountered on SOAR with the assistance of acoustic localization in first verification test conducted there in August 2006. A pair of Baird's beaked whales was encountered in the next test, April 2007. The third test occurred in October 2007 during a period of unusually calm weather; 14 groups of Cuvier's beaked whales were encountered, suggesting that not only that they were present on the range, but that they were potentially present in much higher densities than had been reported for anywhere along the US West Coast previously (Falcone et al. 2009). Thus, the study of Cuvier's beaked whales at SOAR and adjacent basins has expanded in recent years, with 2-3 survey periods per year and enhanced data collection, including detailed surfacing behavior observations, photo-identification, genetic sampling, and deployment of satellite tags to collect data on both movement patterns and in some cases dive behavior.

Another key species found in and around SOAR is the fin whale (Balaeanoptera physalus). The fin whale population along the US West Coast was severely depleted by whaling through the late-1970s, and remains on the endangered species list today. Similar to Cuvier's beaked whales, fin whales are presently managed by the NMFS as a single stock from California to Washington State which was estimated at approximately 3,000 individuals in the most recent stock assessment report (Caretta et al. 2011), but there is insufficient data to describe both substructure and migratory patterns within the region. Line-transect surveys conducted from 1996 through 2008 were unable to detect a population trend throughout this time despite the ongoing protected status of the population (Barlow and Forney 2007; Forney 2007; Barlow 2010). Fin whales are the large whale species most frequently involved in vessel collisions throughout its range (Jensen and Silber, 2003), and this has included collisions with naval vessels at and near SOAR. While this species will sometimes utilize coastal habitat, the majority of fin whale sightings along the US West Coast occur in deep water far from shore. Both historical line-transect surveys and previous

research by CRC have detected dense aggregations of fin whales in the outer waters of the Southern California Bight and on SOAR. This tendency to form dense, unpredictable aggregations in a high use training area, and the lack of data on population identity or seasonal use patterns underscores the importance of detecting any trends in formation of these aggregations, if they exist. As with beaked whales, this study has provided a dramatic increase in opportunities to collect detailed data from this offshore species not previously available, including photo-identification, genetics, and satellite telemetry.

While 2010 was the fifth survey season for visual verification tests at SOAR, and thus the majority of regularly encountered species can be reliably identified acoustically using M3R, the array underwent a substantial upgrade prior to the initial surveys of this study year. An additional 89 phones were placed within the existing range boundaries, with expanded bandwidth to ~50Hz to ~45kHz which would in theory allow for the detection of some large baleen whales with the M3R system for the first time.

METHODS

Surveys were conducted using a 6m rigid-hulled inflatable boat (RHIB), powered by two 75hp outboard motors and equipped with a raised bow pulpit to facilitate tag deployments. The vessel was launched from a shore base each morning and surveyed throughout daylight hours as conditions permitted. Effort was apportioned in two ways: dedicated surveys in conjunction with visual verification tests at SOAR, and opportunistic surveys of adjacent areas of SOCAL during periods of favorable weather, with an emphasis on the Santa Cruz Basin immediately to the north of the range. Beaked whales have been encountered in the Santa Cruz Basin without the assistance of acoustic detections in the past, and previously satellite tagged beaked whales from SOAR have also spent time there making it another point of interest within SOCAL. Surveys were generally attempted during months which had not been adequately surveyed in previous years with the goal of expanding seasonal coverage during the study. The vessel was staffed with two observers, both experienced in all aspects of data collection for this project including vessel operation in close proximity to species of interest, photography, remote biopsy sampling, and satellite tag deployment.

Surveys at SOAR were based at Wilson Cove on the northeast side of San Clemente Island. The RHIB was deployed at either Dana Point or Oceanside Harbor at the start of a survey period and remained moored in Wilson Cove for a period of 7-14 days, or until poor weather or conflicting range operations prevented further surveys at SOAR. Each morning the RHIB would transit around the north end of the island to the eastern boundary of the range. Staff from NUWC would monitor the hydrophones from the Range Operations Center on North Island in San Diego, and direct the RHIB via radio into areas where marine mammal vocalizations were detected. While the RHIB could be directed toward any vocalizations for visual verification, they were preferentially directed to those likely to be beaked whales when conditions were suitable for working with this species (typically winds at Beaufort 3 or less). Once the new hydrophones were integrated into M3R, the RHIB was preferentially directed to vocalizations likely to be large baleen whales in the absence of beaked whale vocalizations or when weather was likely to prevent visual detection of beaked whales.

Shorter opportunistic surveys were conducted at points throughout the year when weather forecasts were favorable and when the range was not available. In some cases opportunistic

surveys were conducted during or immediately following dedicated surveys if range access prevented work at SOAR. During these surveys the RHIB was launched at harbors from San Diego to Santa Barbara, though most were conducted from Channel Islands Harbor in Oxnard, CA which provides the closest access to the Santa Cruz Basin. In calm conditions the RHIB would search broadly throughout the deep waters and shelf edges of the basin, stopping periodically to do 20-30 minute auditory scans when winds were below Beaufort 2 (beaked whales can often be detected by the sound of their respirations at ranges greater than they can be detected visually in very calm conditions). Surveys were also occasionally conducted in nearshore waters in response to reports of concentrations of fin whales. Finally, several satellite tags purchased under this grant were deployed opportunistically during a concurrent marine mammal study in the region in which staff from this project participated (see Southall et al. 2011).

Each time a group of cetaceans was encountered, the species, time, latitude, longitude, group size and composition, and overall behavioral state was recorded. For encounters with beaked whales, detailed records of surfacing patterns were also collected for as long as contact with the group was maintained. Photographs were taken for species verification where questionable, and for individual identification for species where this methodology is being employed during this study or by collaborators (beaked, fin, blue, humpback, and killer whales; bottlenose and Risso's dolphins). Remote tissue biopsies were collected from species of interest both in this study (beaked and fin whales), and also for collaborators at the Southwest Fisheries Science Center for ongoing assessments of offshore populations in the Bight (including Pacific white-sided, northern right whale, Risso's, and bottlenose dolphins). Finally, satellite tags were deployed predominantly on beaked whales, fin whales, and Risso's dolphins.

Tags deployed were of the Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET) design (Andrews et al. 2009, Schorr et al. 2009, Baird et al. 2010). Two types were used: a location-only SPOT5 or a location and depth-reporting Mk10-A SPLASH tag (Wildlife Computers, Inc., Redmond, WA). Two attachment darts on the bottom of the tag penetrated 4.5cm (small species, e.g. Risso's dolphins) or 6.5cm (large species, e.g. beaked whales, fin whales) into the dorsal fin. Tags were programmed to transmit for variable periods during the day, corresponding to periods with best satellite overpasses. Dive reporting tags were programmed to best capture the behavior of the intended target species. Decisions on which tag type to use were based on average tag longevity by species, surfacing characteristics, and data gaps.

Data obtained from the Argos system was processed with the Douglas Argos-Filter v.7.08 (available at Alaska.usgs.gov/science/biology/spatial/douglas.html) using two independent methods: distance between consecutive locations, and rate and bearings among consecutive movement vectors. Depth and distance from shore for all locations which passed the Douglas Argos-filter were determined in ArcGIS v. 9.2 (ESRI, Redlands, California). Dive data was decoded using Wildlife Computers-Data Analysis Program (WC-DAP), version 3.0 (Build 30).

At the completion of each survey, sighting data were compiled in a MS Access data structure designed for maintaining data associated with this project. Photographs were reviewed, with those from fin whales and beaked whales processed to identify the best available identification photos of each individual within each sighting. These photographic records were then sent to species-specific MS Access digital cataloging systems also designed and maintained by CRC, where they were reconciled across sightings during the study and compared to photographs of individuals from previous years. Cuvier's beaked whales identified during 2010-2011 were

compared against a historical catalog of approximately 90 individuals, the majority of which were photographed at SOAR from 2006-2009 with a small number of extra-regional contributions from northern Mexico and central California. Fin whales identified in 2010-2011 were combined with fin whales identified in 2009 and compared against a fin whale historical catalog that was just completed under a separate contract in January 2011. This catalog contained approximately 250 individual whales identified at points from Northern Mexico through the Gulf of Alaska from 1988-2008, though the majority of individuals in the catalog were photographed in the Southern California Bight from 2003-2008.

RESULTS AND DISCUSSION

Effort and Sightings

A total of 33 surveys were conducted during the study period, with just over half of these days spent in dedicated surveys based at SCORE and emphasizing SOAR (**Table 1, Figure 1**). Surveys were conducted at SOAR during January and May 2011, representing the first time sighting data was collected during these months since small-boat surveys at SCORE began in 2006.

Twelve cetacean species were sighted during surveys (**Table 2, Figures 2A-2C**). Surveys in January detected several new trends that had not been observed in other seasons. In general, both the diversity and density of species in the study was much lower than has been observed in summer and fall. Only three different species were sighted during surveys at SOAR from 5-7 January 2011: gray whales, Dall's porpoise, and Cuvier's beaked whales. All gray whales observed during this period were traveling south along a fairly narrow path near the center of SOAR (**Figure 2B**). Dall's porpoise are infrequently sighted in all other months of the year, but 9 groups containing up to 25 individuals were observed during surveys in January. While both these patterns have been previously described for the species in question (e.g. Forney and Barlow, 1998 for Dall's porpoise; Sumich and Show, 2011 for gray whales) this confirms their increased seasonal abundance on the range and the continued use of the San Clemente Island migratory corridor by southbound gray whales- though most gray whales observed during this study appeared further west of the island than was observed by Sumich and Show (2011) in the early 1990s. January surveys also provide evidence that Cuvier's beaked whales are present on the range year-round.

Table 1. Summary of survey effort by day June 2010-June 2011 during N45-supported studies in the Southern California Bight. (Note that "Total" for Species is the number of unique species identified throughout the study year, and thus not a summation across days).

Date	Effort (Hours)	Distance (km)	Survey Area	Sightings	Species
15-Jun-10	4.6	102.8	Oceanside-San Clemente Island	4	1
16-Jun-10	5.8	112.3	SCORE	2	1
17-Jun-10	10.1	156.9	SCORE	3	3
18-Jun-10	6.3	162.9	San Clemente Island-Oceanside	0	0
20-Jun-10	5.9	110.4	San Diego	8	5
21-Jun-10	8.8	188.3	SCORE	8	5
22-Jun-10	10.9	186.7	SCORE	2	2
23-Jun-10	7.5	98.1	SCORE	3	3
24-Jun-10	8.7	122.1	SCORE	6	5
25-Jun-10	3.4	49.8	SCORE	2	1
27-Jun-10	12.0	181.9	SCORE	8	5
28-Jun-10	12.9	147.6	SCORE	8	3
29-Jun-10	12.9	186.7	SCORE	8	4
30-Jun-10	2.3	82.3	San Clemente Island-Dana Point	0	0
06-Jul-10	6.6	183.5	Santa Cruz Basin	3	2
04-Jan-11	5.6	114.9	Dana Point-San Clemente Island	5	4
05-Jan-11	10.0	135.4	SCORE	2	2
06-Jan-11	10.4	157.6	SCORE	7	2
07-Jan-11	10.1	154.7	SCORE	7	3
08-Jan-11	3.6	86.1	San Clemente Island-Dana Point	2	2
11-Jan-11	8.7	183.5	Santa Cruz Basin	6	3
30-Apr-11	3.1	81.6	Dana Point-San Clemente Island	0	0
01-May-11	11.5	150.1	SCORE	6	5
02-May-11	13.4	181.9	SCORE	5	4
04-May-11	9.5	134.5	SCORE	3	1
05-May-11	11.9	200.9	SCORE	8	6
06-May-11	10.2	162.9	SCORE	3	2
07-May-11	2.6	82.3	San Clemente Island-Dana Point	1	1
18-Jun-11	7.5	111.2	San Diego South	7	3
20-Jun-11	10.3	205.7	Santa Cruz Basin	4	2
21-Jun-11	10.7	218.3	Santa Cruz Basin	6	3
22-Jun-11	13.2	231.0	Santa Barbara Channel	23	6
23-Jun-11	4.5	121.0	Dana Point-Long Beach	3	3
33	**276**	**4786**	**TOTAL**	**163**	**12**

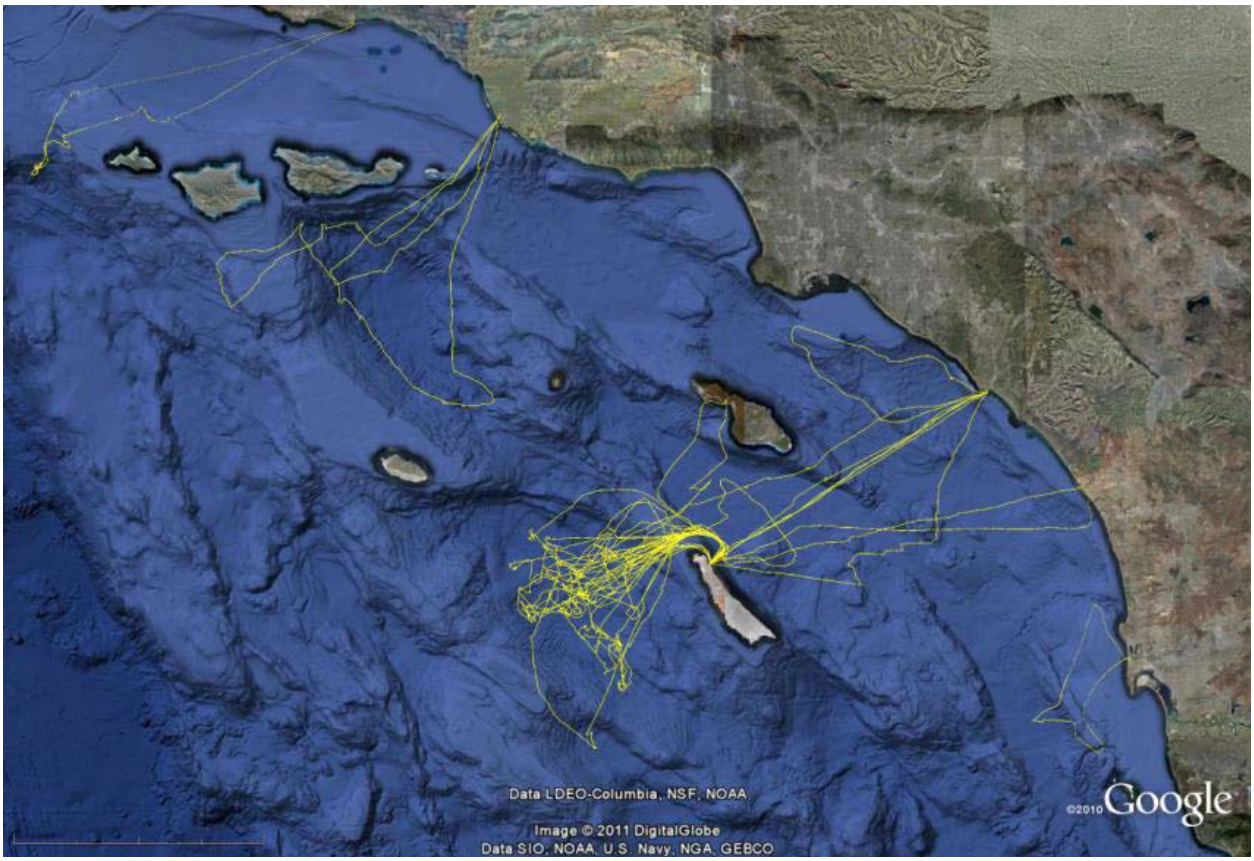

Figure 1. Vessel track lines from surveys conducted June 2010- June 2011.

Table 2. Summary of cetacean sightings by species, including photo-ID, tissue samples collected, and satellite tags deployed from June 2010 through June 2011.

Group	Species	Groups Sighted	Est Individuals Sighted	Avg Group Size	Est Photo IDs	Tissue Samples	Satellite Tags
Baleen Whales	Blue Whale (*Balaenoptera musculus*)	11	39	4	27		
	Fin Whale (*Balaenoptera physalus*)	23	45	2	33	5	7
	Gray Whale (*Eschrichtius robustus*)	9	22	2	4		
	Humpback Whale (*Megaptera novaeangliae*)	5	54	11	29		
	Minke Whale (*Balaenoptera acutorostrata*)	3	3	1	0		
Beaked Whales	Cuvier's Beaked Whale (*Ziphius cavirostris*)	14	34	2	32	1	5
Delphinids	Bottlenose Dolphin (*Tursiops truncatus*)	15	272	18	12		
	Common Dolphin Species (*Delphinus spp*)	9	252	28			
	Long-beaked Common Dolphin (*D. capensis*)	8	1294	162			
	Short-beaked Common Dolphin (*D. delphis*)	14	1332	95			
	Northern Right Whale Dolphin (*Lissodelphis borealis*)	6	677	113		6	
	Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)	6	111	19			
	Risso's Dolphin (*Grampus griseus*)	27	394	15	144	1	4
Porpoises	Dall's Porpoise (*Phocoenoides dalli*)	14	96	7			

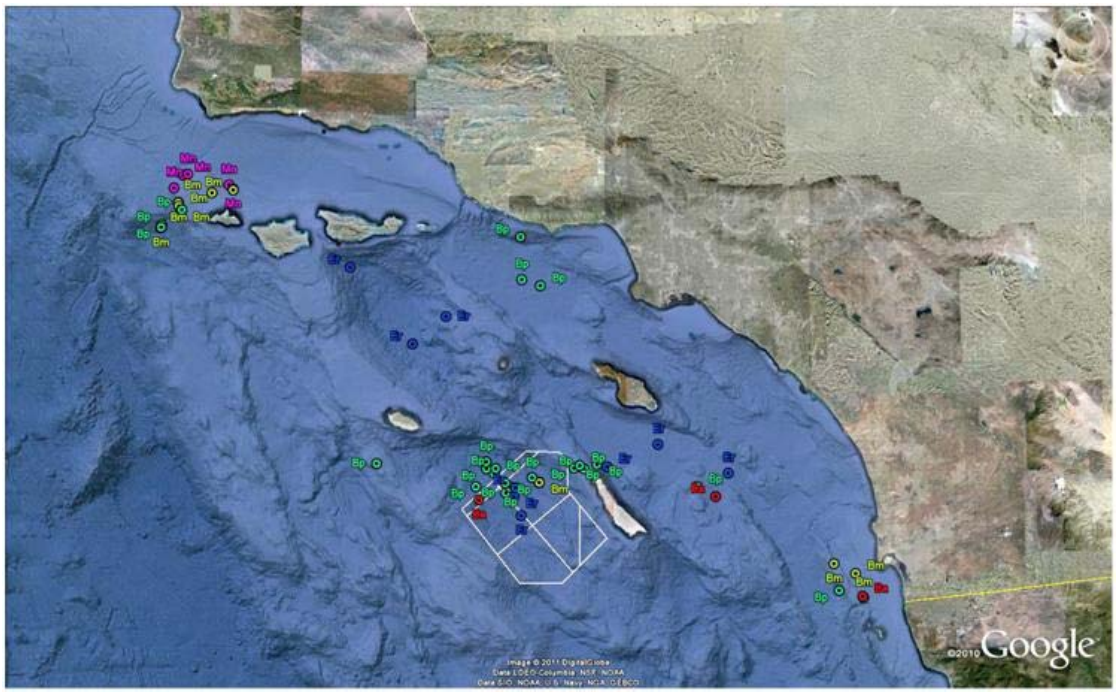

Figure 2A. Sightings of baleen whales June 2010-June 2011. Of note were frequent sightings of southbound gray whales transiting through the center of SOAR in January.

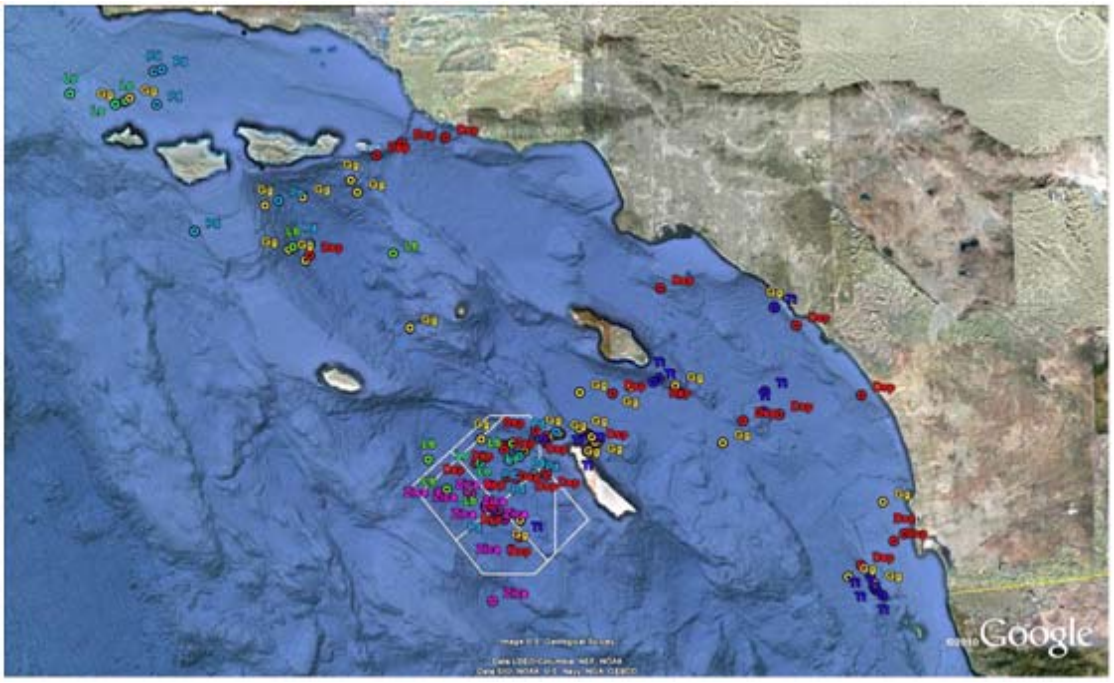

Figure 2B. Sightings of odontocetes June 2010-June 2011. In general the distribution was similar to previous years, though both Dall's porpoise and northern right whale dolphins were encountered more frequently in surveys in winter and spring than in other times of year.

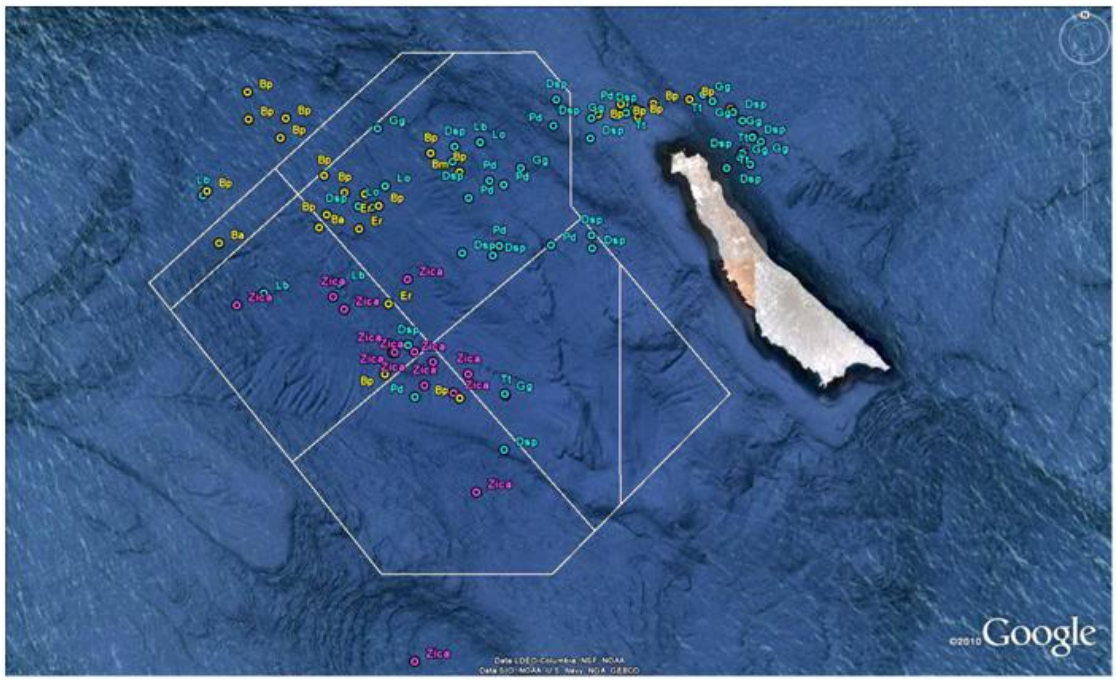

Figure 2C. A detail of cetacean sightings in and around SOAR June 2010- June 2011, with baleen whale species in yellow, small odontocetes in blue, and Cuvier's beaked whales in pink.

Photo-Identification

Individual identification photographs were collected from seven species during surveys. Photographs from five of these species were contributed to other ongoing photographic studies managed by CRC or SIO/SWFSC; photos of Cuvier's beaked whales and fin whales were processed as part of this project.

Of the 34 individual Cuvier's beaked whales sighted during the study, 32 were photographed for identification purposes. These photos were reconciled internally resulting in 29 suitable quality identifications of 25 unique individuals. Two of these individuals were sighted on more than one day in the study period, and 8 (32%) had been photographed at SOAR in previous years. These identifications bring the total number of known individuals in the CRC catalog to 100, of which 79 were photographed on SOAR. To date 11 of these 79 whales have been sighted in more than one year for an overall inter-annual resighting rate of 14%. No identified whales have been observed in areas outside the San Nicolas Basin, though the sample of whales from other areas is quite small. Preliminary comparisons of photographs from the initial years of this study hinted that the San Nicolas Basin, and hence the SOAR range, might be home to a localized population of Cuvier's beaked whales (Falcone *et al*. 2009). This recent increase in matches to previous years along with the results of satellite telemetry (detailed in the next section of this report) both underscore the likelihood that a resident population exists with small core use area. With an additional season of photo-ID data collection the sample should be suitable for estimating population size with mark-recapture statistics.

Of 45 fin whales sighted during this study period, 33 were photographed for identification purposes. Because the fin whale historical catalog through 2008 was only finalized in January 2011,

the internal reconciliation and historical comparison of fin whales from 2009-2010 is still underway at the time of this report, with an anticipated completion in August 2011. All fin whale identifications from this and other fieldwork by CRC in 2011 will be processed beginning in fall of 2011 with results available in late spring 2012. Preliminary results suggest 16 unique individuals were photographed during this study in 2010.

None of these whales were sighted on more than one day, and none appear to have been sighted in previous years. A technical report summarizing fin whale photo-identification along the US West Coast through 2008, which contains a large proportion of data from previous study years in the SCORE region, is available at

http://www.cascadiaresearch.org/Falconeetal2011BPIDcontractreport-Final.pdf.

Satellite Telemetry

Twenty satellite tags were deployed in on seven species including one probable Sei-fin hybrid (**Table 3**). Eleven tags provided location data only for periods up to 124 days. Nine tags provided dive behavior records in addition to locations; these provided up to 90 days of data.

Cuvier's beaked whales

Five depth-reporting LIMPET tags were deployed, one each on unique individuals from different groups of Cuvier's beaked whales. Grand mean distance to tagging location for all individuals across all days transmitting was only 80 Km, with a maximum distance from tagging location of 452 Km (**Table4**). While 3 of the 5 individuals showed movements away from the San Nicolas Basin, two of the three returned (**Figure 3**). When combined with movement data collected from two previously tagged individuals, tagged animals have been documented on SOAR in all months except May to date. These movement patterns suggest a high degree of residency to the Southern California Bight, and to the SOAR range in particular, consistent with photo-ID results. While in the San Nicolas Basin, which includes the SOAR range, individuals preferentially used the western and northern edges of the basin. The average water depth utilized was 1,330m and average minimum-straight line movements between locations suggested movement rates of 1.8 km/hr (**Table 4**). Over 3,800 hours of dive behavior was collected, representing the longest and most complete dataset on Cuvier's movement and dive behavior to date. Analysis is still underway, but preliminary results indicate all individuals dove to greater than 1,500m and two of the individuals had dives to depths greater than 2,000m. Four individuals had dive durations greater than 90 minutes, with one dive exceeding two hours (Schorr et al. 2011). All Cuvier's tags were deployed prior to scheduled MFAS training exercises at SOAR, and analysis of overlapping periods of sonar use concurrent with animal location and dive behavior is currently being undertaken in collaboration with NUWC (D. Moretti), along with a more general in-depth analysis of diving behavior patterns from this unique and comprehensive dataset (**Figure 4**).

*Table 3. Summary of tag deployments made in year 1. L = location only, L/D = location and depth-reporting LIMPET tag. * denotes tags from this contract which were deployed during field efforts funded by other sources.*

Species	TagID	Deploy Date	Transmission Duration (days)	Tag Type
Baird's beaked*	Bba Tag 001	07-Aug-10	32	L
Sei/fin (prob hybrid)*	Bbo/Bp Tag 001	26-Aug-10	21	L
Fin whale	Bp Tag 021	28-Jun-10	124	L
Fin whale	Bp Tag 022	28-Jun-10	27	L
Fin whale	Bp Tag 026	04-May-11	4	L/D
Fin whale	Bp Tag 027	04-May-11	1	L/D
Fin whale	Bp Tag 028	06-May-11	25	L/D
Fin whale	Bp Tag 029	22-Jun-11	Still Trans	L
Fin whale	Bp Tag 030	22-Jun-11	Still Trans	L
Risso's dolphin	Gg Tag 003	24-Jun-10	20	L
Risso's dolphin	Gg Tag 004	24-Jun-10	12	L
Risso's dolphin	Gg Tag 005	08-Jan-11	7	L
Risso's Dolphin	Gg Tag 006	18-Jun-11	Still Trans	L/D
Killer Whale*	Oo Tag 019	07-Sep-10	9	L
Sperm whale*	Pm Tag 014	16-Aug-10	92	L
Cuvier's beaked	Zc Tag 010	29-Jun-10	54	L/D
Cuvier's beaked	Zc Tag 011	29-Jun-10	90	L/D
Cuvier's beaked	Zc Tag 014	06-Jan-11	23	L/D
Cuvier's beaked	Zc Tag 015	06-Jan-11	71	L/D
Cuvier's beaked	Zc Tag 016	06-Jan-11	89	L/D

Table 4. Details of five depth-reporting LIMPET tags deployed on Cuvier's beaked whales.

TAGID	Transm. Duration (days)	Cumulative Straight-line Distance Traveled (Km)	Avg Dist To Deploy (Km)	Max Dist to Deploy (Km)	Avg min rate of straightline movement (Km/Hr)	Avg Dist to Shore (Km)	Avg Water Depth (m)
Zc010	54	1940.2	65.7	265.5	1.7	29.8	-1226.6
Zc011	90	2334.1	153.9	289.5	1.8	48.3	-1256.6
Zc014	23	785.5	33.8	94.4	1.8	30.5	-1181.8
Zc015	71	2731.1	122.9	452.3	2	64.3	-1723.6
Zc016	89	1826	26.1	103.2	1.6	40.8	-1263.1

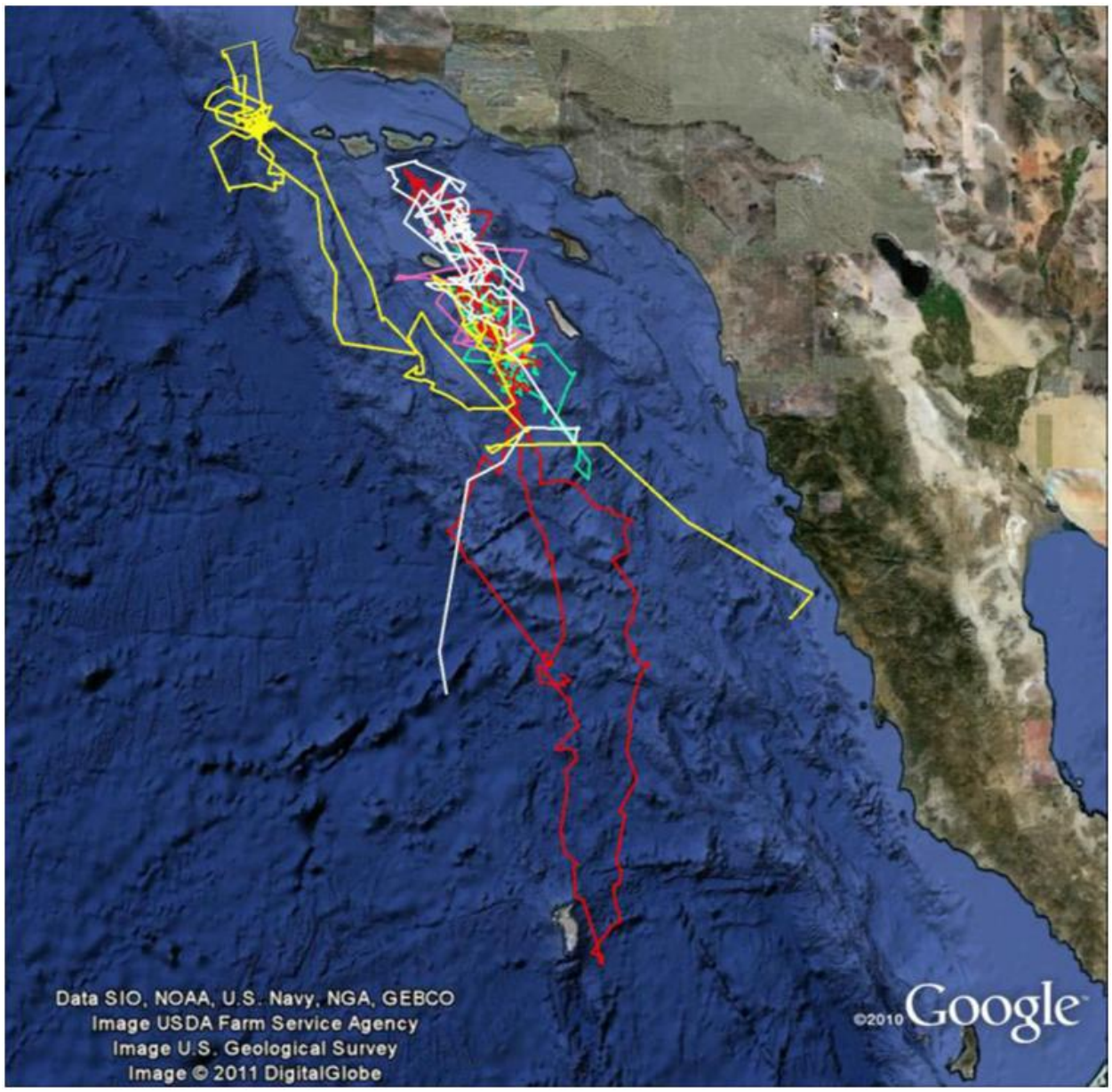

Figure 3. Movements of five Cuvier's beaked whales.

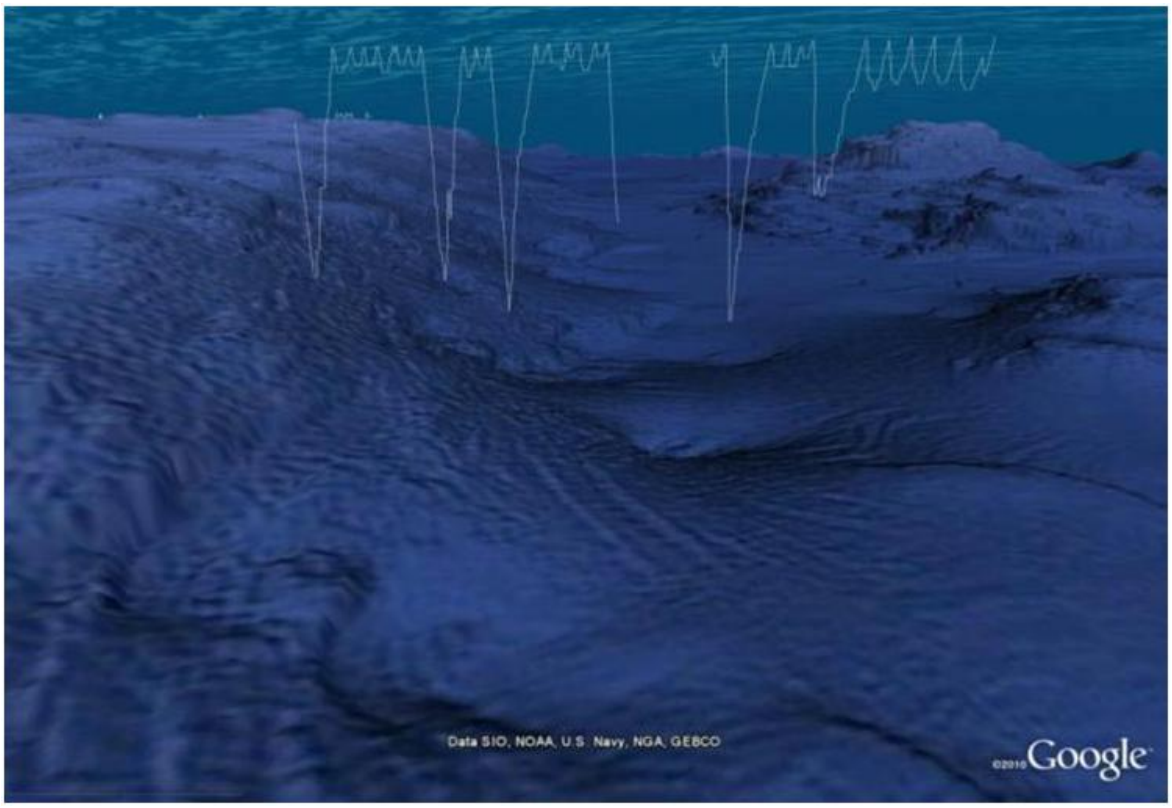

Figure 4. A combination of interpolated tracks from Argos location data and concurrent dive behavior, allows for a rough assessment of dive behavior in relation to bathymetric features. Here, a portion of Zc Tag 011 dive log is displayed with a 3D view of local bathymetry.

Fin Whales

Seven satellite tags were deployed on fin whales on four different days. One pair of individuals was tagged 180km northwest of SOAR, west of San Miguel Island (both individuals still transmitting at the time of this report, and therefore not included in analysis), while the remaining tags were all deployed in or near the San Nicolas Basin. The average distance to deployment for tags which transmitted for more than seven days was 178 km and maximum distance to deployment for all tags was 320 km (Bp Tag 021, with transmission duration of 124 days). Two of the whales made forays out of the Southern California Bight, and north of Point Conception, with Bp Tag 021 spending two months off of Monterey Bay before returning south. While there was some limited use of nearshore waters among the Channel Islands, including within the 3-mile vessel exclusion area around SWAT 1 and 2 on the north end of San Clemente Island, individuals largely spent time in deep water, and further offshore (**Figure 5**). Three of the seven tags were dive-depth reporting LIMPET tags, but only one of these transmitted for longer than 4 days (Bp Tag 028, 25 days). Grand mean average rate of straight line movement between subsequent locations was 2.2 Km/hr, only slightly higher than the 1.8 Km/hr for the Cuvier's beaked whales. Data from these tags will be compiled with other satellite tag data from fin whales along the US West Coast (e.g. Schorr et al. 2010), and will be combined with photo-ID and genetics to better understand the fin whale population that utilizes habitat within the Bight for future management.

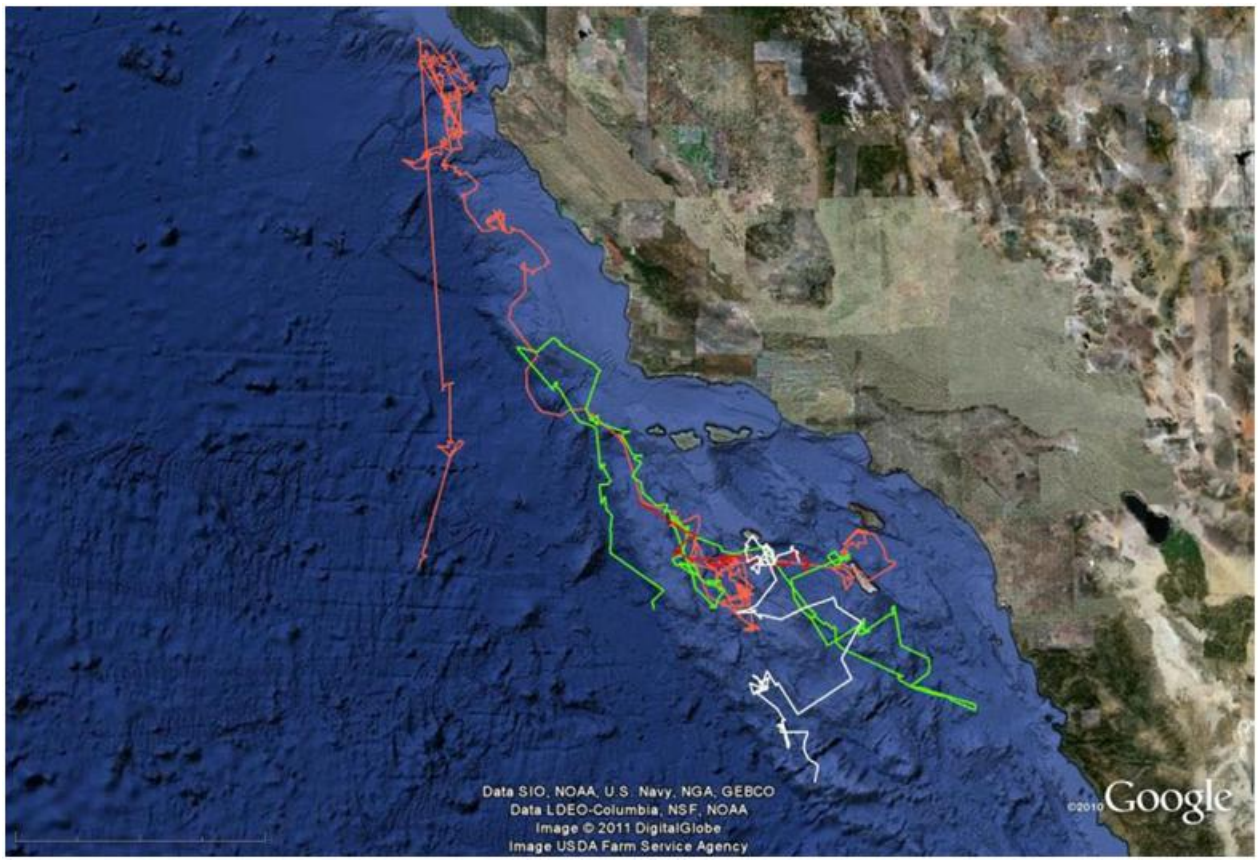

Figure 5. Movement of fin whales tagged during the contract period in the San Nicholas Basin.

Risso's dolphins

Four LIMPET tags were deployed on Risso's dolphins, three location-only and one dive-depth reporting (still transmitting at the time of this report). The median transmission duration was 12 days (range = 7 – 20). The grand mean distance to tagging location was 64 km, with a maximum distance from tagging location of 155 km (**Table 5**). While one individual spent time in the nearshore waters of SHOBA on the south end of San Clemente Island (similar to one individual tagged in July of 2009), the majority of time was spent in the deep water basins, away from the islands and the mainland coast. Grand mean bottom depth at locations was 947.4m and distance to shore was 25.6 km (**Figure 6**). Excluding the one tag still transmitting, all tagged Risso's from this and previous study years have moved between basins, suggesting individuals are not resident to specific islands or basins, though they may be resident within the Bight overall (**Figure 6**). Longer tag deployments will be required to better resolve population structure of this species.

Table 5. Information on four Risso's dolphins tagged between June 2010 and January 2011.

Tag ID	Transm. Duration (days)	Cumulative straight-line Distance Traveled (Km)	Avg Dist to Deploy (Km)	Max Dist to Deploy (Km)	Avg min rate of straightline movement (Km/Hr)	Avg Dist to Shore (Km)	Avg Water Depth (m)
Gg Tag 003	20	1427.1	68.6	154.7	2.6	27.3	-967.7
Gg Tag 004	12	841.3	87.4	148.7	3.4	26.5	-974.4
Gg Tag 005	7	504.2	36.1	66.3	3.1	23	-900.1
Gg Tag 006	*still Transmitting*						

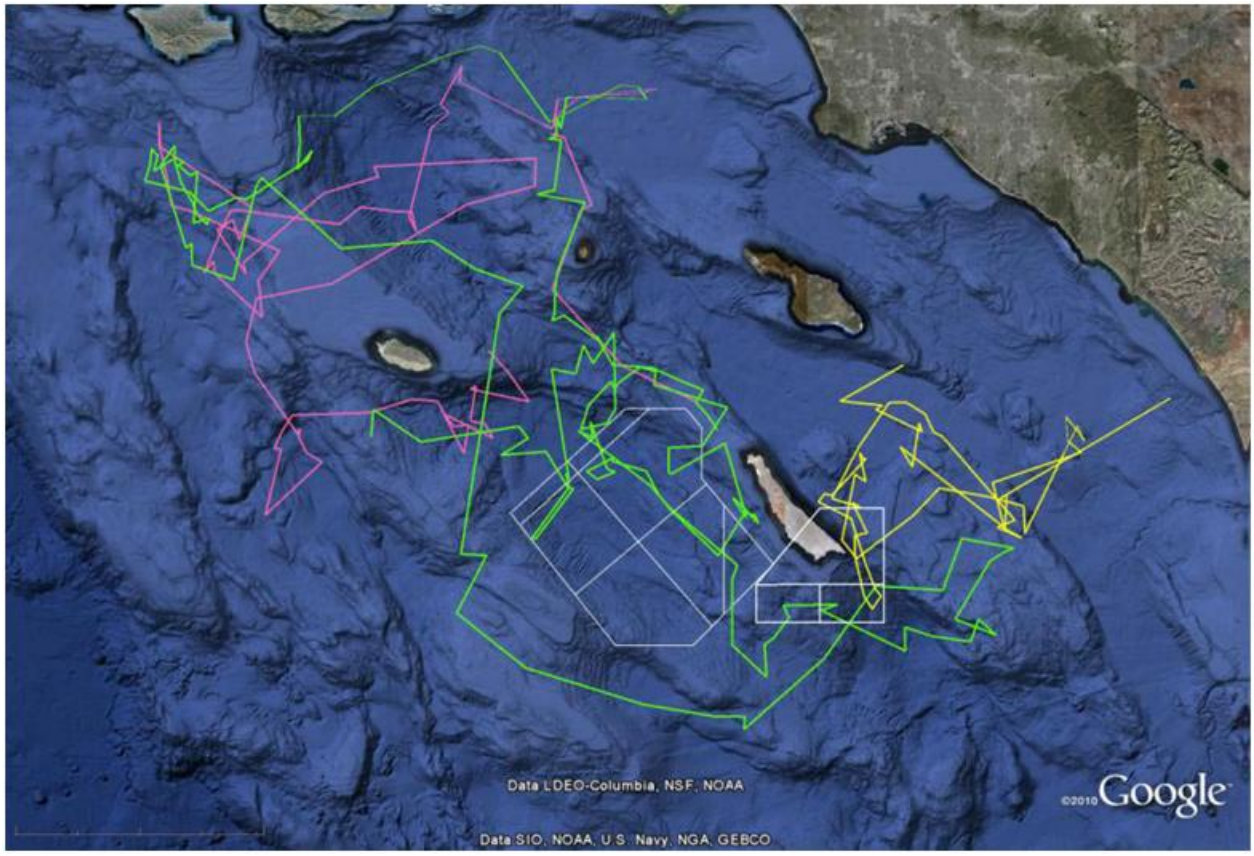

Figure 6. Map showing movements of three tagged Risso's Dolphins, June 2010 thru May 2011. Note the SOAR and SHOBA ranges outlined in white.

CONCLUDING REMARKS

The preliminary results gathered in the first year of effort under this grant continue to provide new insights into the occurrence, distribution and habitat use of cetaceans in the Southern California Bight. The long term movement and dive behavior records from Cuvier's beaked whales, and on an active navy training range, is an especially valuable dataset that may provide new insights into interactions between this population and Navy exercises. We hope that the continued collection of photographic, genetic, and satellite data from fin whales and beaked whales in subsequent years of this will substantially improve the management of these two species. We also hope that these results will provide the necessary behavioral framework in which to evaluate the results of experimental sonar exposure studies, underway concurrently in the region.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Andrews, R.D., R.L. Pitman, and L.T. Balance. 2008. Satellite tracking reveals distinct movement patterns for Type B and Type C killer whales in the southern Ross Sea, Antarctica. Polar Biology DOI 10.1007/s00300-008-0487-z.

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements of satellite-tagged false killer whales around the main Hawaiian Islands. Endangered Species Research doi.10.3354/esr00258.

Barlow, J. 2010. Cetacean abundance in the California Current from a 2008 ship-based line-transect survey. NOAA Technical Memorandum, NMFS, NOAA-TM-NMFS-SWFSC-456. 19 p

Barlow J. and K. Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fishery Bulletin 105:509-526.

Carretta, J.V., K.A. Forney, Erin Oleson, Karen Martien, Marcia M. Muto, Mark S. Lowry, Jay Barlow, Jason Baker, Brad Hanson, Deanna Lynch, Lilian Carswell, Robert L. Brownell Jr., Jooke Robbins, David K. Mattila, Katherine Ralls, and Marie C. Hil. 2010. U.S. Pacific Marine Mammal Stock Assessments: 2010. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-476. 352p.

Falcone , E.A, G.S. Schorr, A.B. Douglas, J. Calambokidis, E. Henderson, M.F. McKenna, J. Hildebrand, and D. Moretti. 2009. Sighting characteristics and photo-identification of Cuvier's beaked whales (*Ziphius Cavirostris*) near San Clement Island, California: a key area for beaked whales and the military? Marine Biology 156:2631-2640.

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. 27p.

Forney, K. A. and J. Barlow. 1998. Seasonal patterns in the abundance and distribution of California cetaceans, 1991-92. Mar. Mamm. Sci. 14:460-489.

Jensen, A.S. and G.K. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-OPR- , 37 pp.

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.

Schorr, G.S., R.W. Baird, M.B. Hanson, D.L. Webster, D.J. McSweeney and R.D. Andrews. 2009. Movements of satellite-tagged Blainville's beaked whales off the island of Hawai'i. Endangered Species Research doi:10.3354/esr00229.

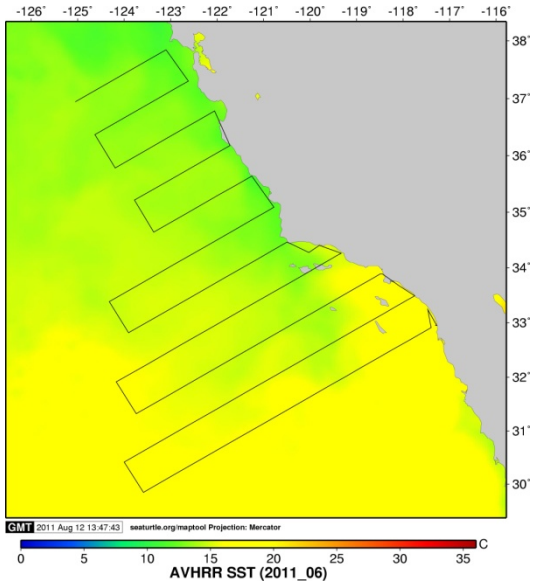
Schorr, G.S. Falcone, E.A., Moretti D.J., Baird, R.W., Webster, D.L., Hanson, M.B., Andrews, R.A. 2011. Satellite telemetry reaches new depths: a case study of the application of a new depth-linked satellite tag to Cuvier's beaked whales. In: Fourth International Science Symposium on Bio-logging. Hobart, Tasmania, Australia. 14-18 March.

Schorr, G.S., E.A. Falcone, J. Calambokidis, and R.D. Andrews. 2010. Satellite tagging of fin whales off California and Washington in 2010 to identify movement patterns, habitat use, and possible stock boundaries. Report prepared under Order No. JG133F09SE4477 to the SWFSC. Available at: http://www.cascadiaresearch.org/finwhales.htm.

Southall, B., J. Calambokidis, P. Tyack, D. Moretti, J. Hildebrand, C. Kyburg, R. Carlson, A. Friedlaender, E. Falcone, G. Schorr, A. Douglas, S. DeRuiter, J. Goldbogen, J. Barlow. 2011. Biological and behavioral response studies of marine mammals in Southern California, 2010 ("SOCAL-10"). Available at: http://sea.typepad.com/sea-blog/2011/03/socal-10-report-now-available.html.

Sumich, J.L., and Show, I.T. 2011. Offshore migratory corridors and aerial photogrammetric body length comparisons of southbound gray whales, *Eschrichtius robustus*, in the southern California Bight, 1988-1990. *Marine Fisheries Review* **73**: 28-34.

CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATION (CALCOFI) CRUISES: 2010-2011



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ABSTRACT

Spatial and temporal distribution patterns, density and abundance of cetaceans in the southern California Bight were assessed through visual and acoustic surveys during four California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from August 2010 – April 2011. Visual monitoring incorporated standard line-transect protocol during all daylight transits while acoustic monitoring employed a towed hydrophone array during transits and sonobuoys at oceanographic sampling stations. Visual effort included 455 observation hours covering 3,800 kilometers yielding 268 sightings of 15 cetacean species. Fin whales were the most frequently sighted baleen whale species, followed by blue, gray, and humpback whales. Common dolphins were the most frequently sighted odontocete species, followed by bottlenose dolphin, Dall's porpoise, Pacific white-sided dolphin, Risso's dolphin, and sperm whale. Seasonal variations in encounter rates and distributions were evident for some species. Grey whales and Dall's porpoise were sighted primarily in fall and winter, whereas blue and fin whales were visually detected in spring and summer. Pacific white-sided dolphins were observed in all seasons except summer. Sperm whales were only sighted during fall and winter cruises. There was no apparent seasonal pattern to sightings of bottlenose, common and Risso's dolphins, though Risso's dolphins were not detected during the fall survey. Spatial variations in visual detections as a function of species were also evident. Bottlenose, Risso's and long-beaked common dolphin as well as humpback and gray whale detections were concentrated in coastal and shelf waters, whereas sperm whale detections occurred exclusively in pelagic waters. Short-beaked common dolphin, Pacific white-sided dolphin, Dall's porpoise, fin, and blue whales had a broader distribution with encounters occurring in coastal, shelf and pelagic waters. Each species showed distinct spatial and temporal distribution patterns across the study area; indicative of species-specific habitat preferences within the California Current ecosystem. Current research is investigating the association between cetacean distribution with biological and physical oceanographic variables measured during CalCOFI surveys. Density and abundance estimates of cetaceans encountered in the study area are currently the focus of an extensive line-transect analysis and modeling effort. Modeling of cetacean habitat preferences in conjunction with density and abundance estimates, will provide data needed to evaluate potential impacts from anthropogenic activities and ultimately for the development of comprehensive management protocols.

INTRODUCTION

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 one 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 three 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 currently underway. Recent analysis of baleen whale density relative to habitat type and productivity levels has proven insightful for expanding the scope and complexity of habitat modeling efforts.

METHODS

Visual Monitoring

Visual monitoring for cetaceans on four quarterly CalCOFI cruises during 2010-2011 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. See Appendix I for a comprehensive list of species included in this report along with their abbreviation codes.

Acoustic Monitoring

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 flow noise at low frequencies and to protect from signal aliasing at high frequencies. The multi-channel array data were 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. In addition, acoustic monitoring while on CalCOFI stations was conducted with both broadband passive SSQ-57B omni-directional and SSQ-53F DIFAR sonobuoys. Sonobuoys were deployed 1 nm before each daylight station to a depth of 30 m and recorded for 2-3 hours while oceanographic sampling was underway. An acoustic technician monitored the sonobuoy signals for cetacean calls using a scrolling spectrogram display. Mysticete calls, sperm whale clicks as well as low frequency dolphin calls, including whistles, buzzes and the lower frequency components of clicks were recorded with this system.

Density and Abundance Analysis

Density and abundance analysis for nine cetacean species common to the study area of approximately 180,930 km^2 are being conducted with Distance 6.0 software. Visual data collected during twenty-eight cruises from July 2004 through April 2011 is being analyzed for both seasonal and annual patterns in density and abundance. Analytic, model-based and probability density designs have been incorporated into the current analysis to assess what approaches are best suited for the CalCOFI dataset. Preliminary analysis support the application of a model-based

design which will allow us to estimate how abundance varies throughout a study area by modeling encounter rates along the line as a function of spatial covariates. Potential covariates include oceanographic variables, geographic coordinates, distance from land, and depth. Model-based approaches have become increasingly popular for analyzing distance sampling data, as they help us to understand what factors influence animal distributions, and they can be used even when transect lines are not randomly placed.

Acoustic Data Analysis

Acoustic data collected from the towed acoustic array was analyzed in real-time for the presence of calls from all odontocete cetaceans. Sonobuoys deployed on CalCOFI stations were analyzed in real-time for presence of blue, fin and humpback whale vocalizations as well as odontocete calls. Field-based event detections from the towed array and sonobuoys are further examined post-cruise to confirm initial signal classification and to better characterize call characteristics. The structural elements of cetacean calls collected on CalCOFI cruises are currently being measured and applied to the development of a suite of detection and classification algorithms. Baleen whale calls are measured along several parameters including duration, frequency structure, and inter-call interval. Odontocete 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. Delphinid 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 analysis to examine the within species/population and between species/population variability inherent in the data.

RESULTS AND DISCUSSION

Line-transect visual surveys

Four surveys covering 3,813 nautical miles of track-line with 455 hours of effort were conducted from 1 August 2010 to 31 July 2011. Cetacean surveys conducted in August 2010, November 2010 and April 2011 utilized the standard CalCOFI station pattern; efforts in January 2011 also surveyed the northern transects. Survey tracks representing visual and acoustic array effort for each of the four cruises are presented in Figure 1. Summary data on effort and sightings from the four CalCOFI surveys conducted from August 2010 – April 2011 are provided in Tables 1 and 2. Plots of all visual detections across the four cruises classified to species are provided in Figure 2.

Cetacean sightings across the four CalCOFI cruises included 10 odontocete and five mysticete species encompassing a total of 268 encounters (Table 2). Encounter rates of cetaceans in the study area varied by species. Fin whales were the most frequently sighted baleen whale species, followed by blue, gray, and humpback whales. Common dolphin were the most frequently encountered odontocete, followed by bottlenose dolphin, Dall's porpoise, Pacific white-sided dolphin, Risso's dolphin, and sperm whale. Killer whales and northern right-whale dolphins and were the least frequently encountered cetaceans with only one sighting per species during the four cruises (Table 2).

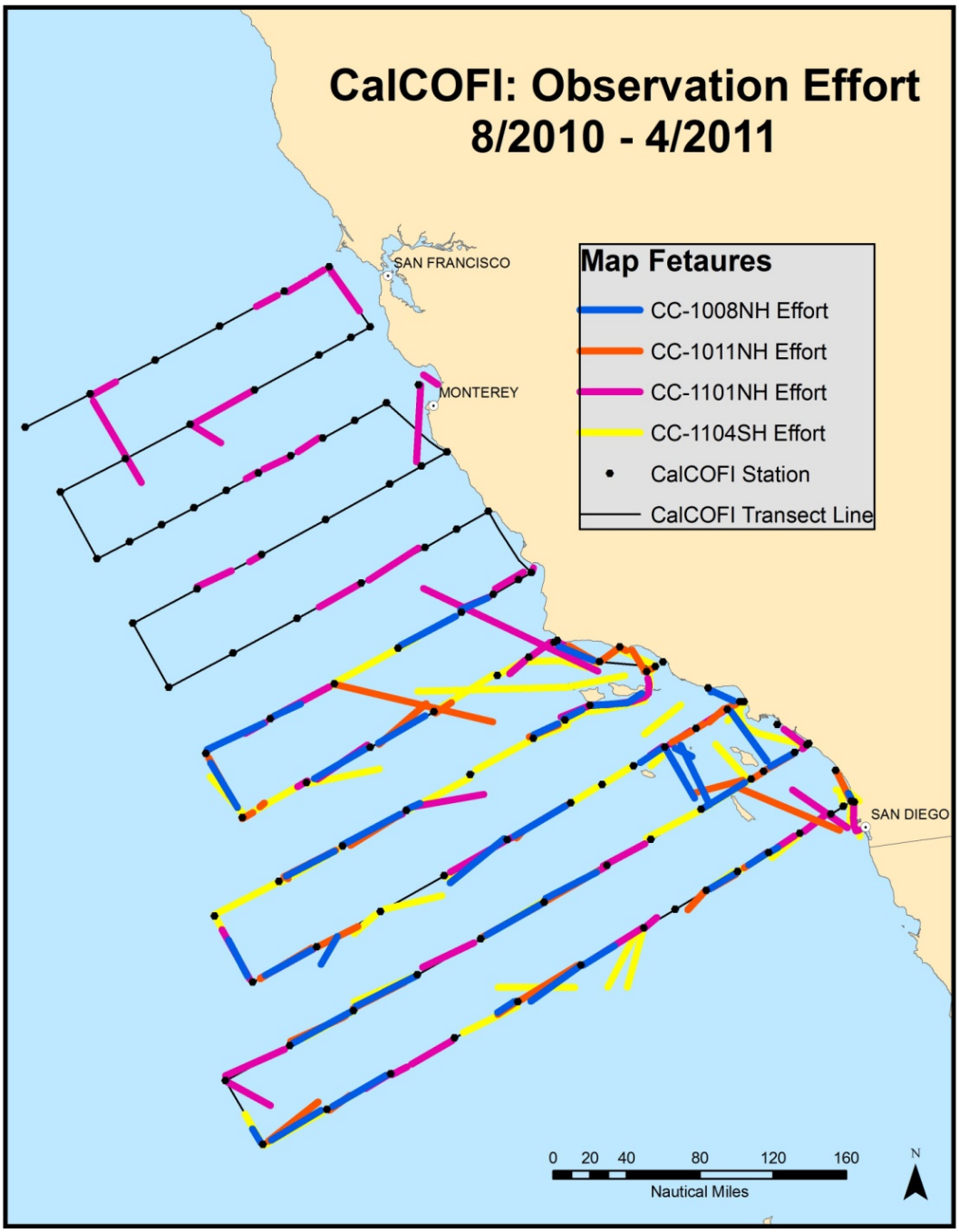

Figure 1. Marine mammal visual/acoustic survey effort by season from four CalCOFI cruises between August 2010 and April 2011.

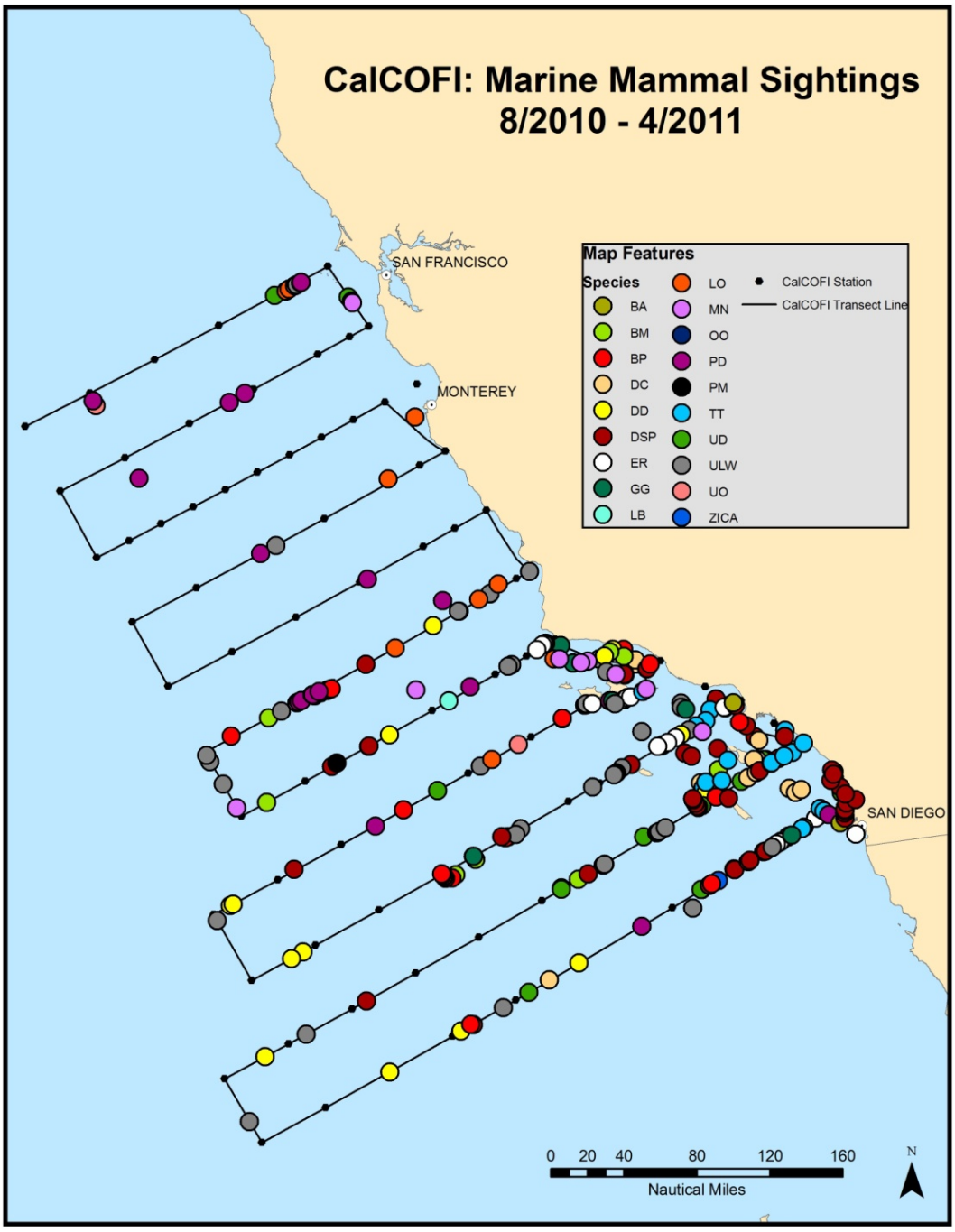

Figure 2. Cetacean sightings by species from four CalCOFI cruises between August 2010 and April 2011.

Table 1. Summary data from four CalCOFI cruises between July 2010 and April 2011.

CalCOFI Cruise Dates	Survey Effort (hrs)	Distance Surveyed (nm)	Number of Cetacean Sightings	Number of Individuals	Number of Digital Photos	Number of Acoustic Array Recordings	Total Hours of Array Recordings	Number of Acoustic Detections /Species	Number of Sonobuoys Deployed	Number of Sonobuoy Detections/ Species	Total Hours of Sonobuoy Recordings
30 Jul - 18 Aug 2010	105	997	90	4,203	665	32	92	95/6	59	54/6	202
28 Oct - 15 Nov 2010	82	582	29	2,827	622	19	64	50/4	38	12/3	112
12 Jan - 6 Feb 2011	126	802	74	1,659	200	33	94	33/5	67	26/3	141
8 Apr - 26 Apr 2011	142	1,432	75	4,710	1,113	29	70	21/5	57	37/5	97
Totals	455	3,813	268	13,399	2,600	113	320	199/8	221	129/6	552

Table 2. CalCOFI cetacean on-effort sightings by cruise from August 2010 – April 2011. See Appendix 1 for species abbreviation codes. Ns = number sightings; Ni = number individuals

	CC1008 (30 Jul - 18 Aug 2010)		CC1011 (28 Oct -15 Nov 2010)		CC1101 (12 Jan - 6 Feb 2011)		CC1104 (8 Apr - 26 Apr 2011)	
Species	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**	**Ns**	**Ni**
Ba	0	0	1	1	2	2	1	1
Bm	10	17	0	0	1	2	3	5
Bp	19	28	1	1	0	0	6	40
Dc	7	409	5	1096	2	137	1	61
Dd	8	997	0	0	3	474	3	502
Dsp	22	2202	6	470	1	140	23	3852
Er	0	0	0	0	19	42	0	0
Gg	2	17	0	0	3	49	1	8
Lb	0	0	0	0	0	0	1	32
Lo	0	0	1	55	6	46	3	104
Mn	0	0	0	0	3	6	5	5
Oo	0	0	0	0	1	1	0	0
Pd	0	0	0	0	15	129	2	23
Pm	0	0	0	0	2	36	2	17
Sc	0	0	0	0	0	0	0	0
Tt	3	36	7	211	6	54	2	22
UD	4	470	4	165	6	535	2	9
ULW	14	18	3	3	4	6	20	29
Zcav	1	9	1	5	0	0	0	0
TOTALS	90	4203	29	2007	74	1659	75	4710

Seasonal variations in visual detection rates as a function of species were apparent. Ninety-three percent of blue whale sightings and 96% of fin whale sightings occurred in spring and summer. Gray whales were only sighted during the winter cruise and humpback whales were only seen during winter and spring surveys. Pacific white-sided dolphins were observed in all seasons except summer with 90% of all sightings in winter and spring. Sperm whales and Dall's porpoise were only sighted during fall and winter cruises. There was no apparent seasonal pattern to sightings of bottlenose, common and Risso's dolphins, though Risso's dolphins were not detected during the fall survey.

The geographic distribution of cetacean species encountered in the CalCOFI study area was not uniform. Spatial patterns of mysticete and odontocete sightings reveal noteworthy variations in the distribution of several common species (Figures 3 and 4). Blue and fin whales had a wide distribution with sightings throughout the study area ranging from coastal to pelagic waters. Humpback whales were seen primarily on the shelf, with the highest concentration in shallow

regions around the Channel Islands. Gray whales were sighted exclusively in shelf waters, generally shoreward of the Channel Islands. Short-beaked common dolphins were seen throughout the study area, while long-beaked common dolphins were seen primarily in coastal regions and around the Channel Islands. Bottlenose and Risso's dolphins were generally sighted on the shelf, near islands and close to shore and only occasionally in more offshore waters. Pacific white-sided dolphins were observed in shelf waters ranging from nearshore to the shelf-break with no defined north-south gradient. Dall's porpoise were seen throughout the northern portion of the study area, and sperm whales were found only in deep offshore waters.

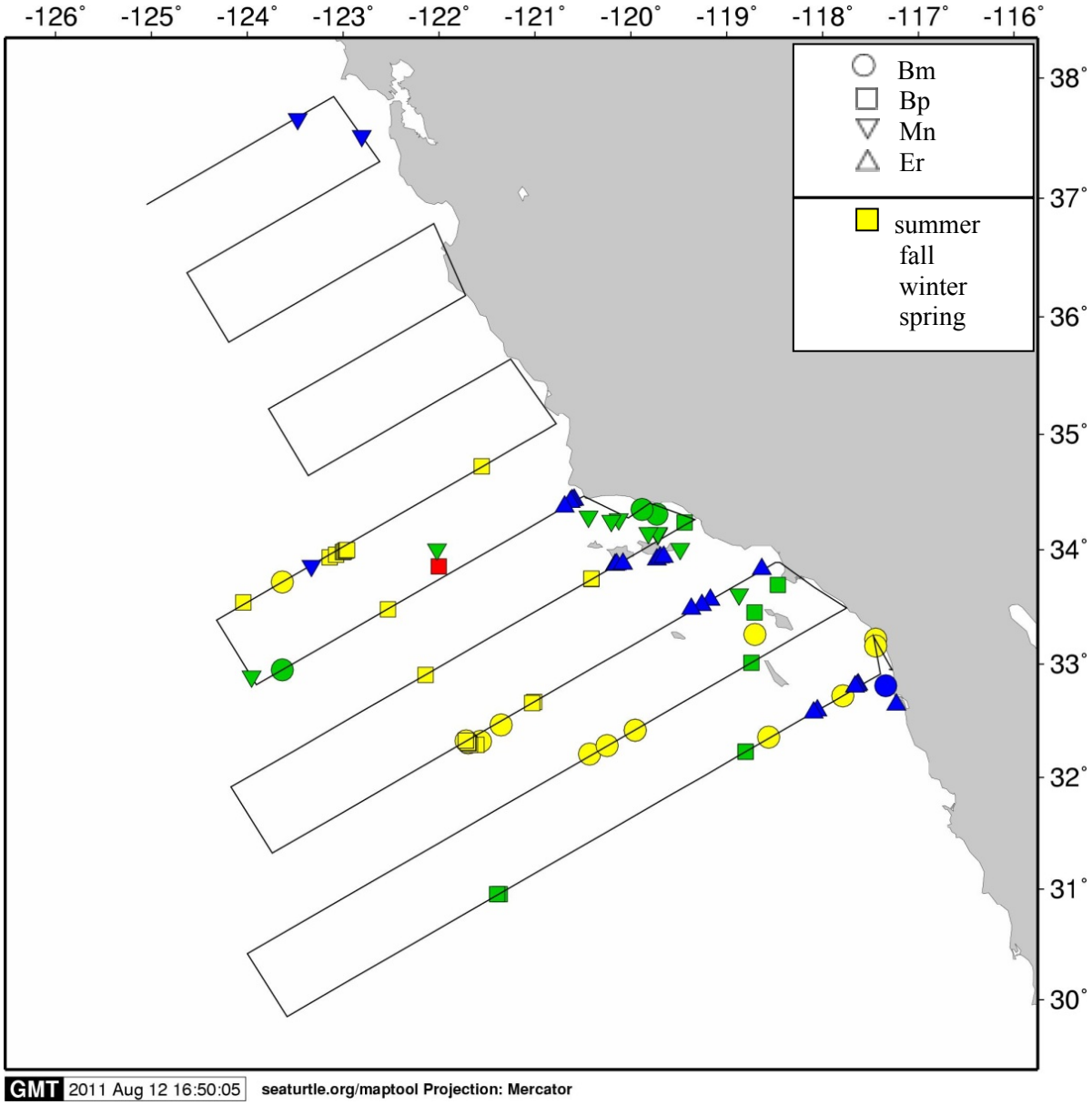

Figure 3. Visual sightings of blue, fin, humpback and grey whales by season from four CalCOFI cruises between August 2010 and April 2011.

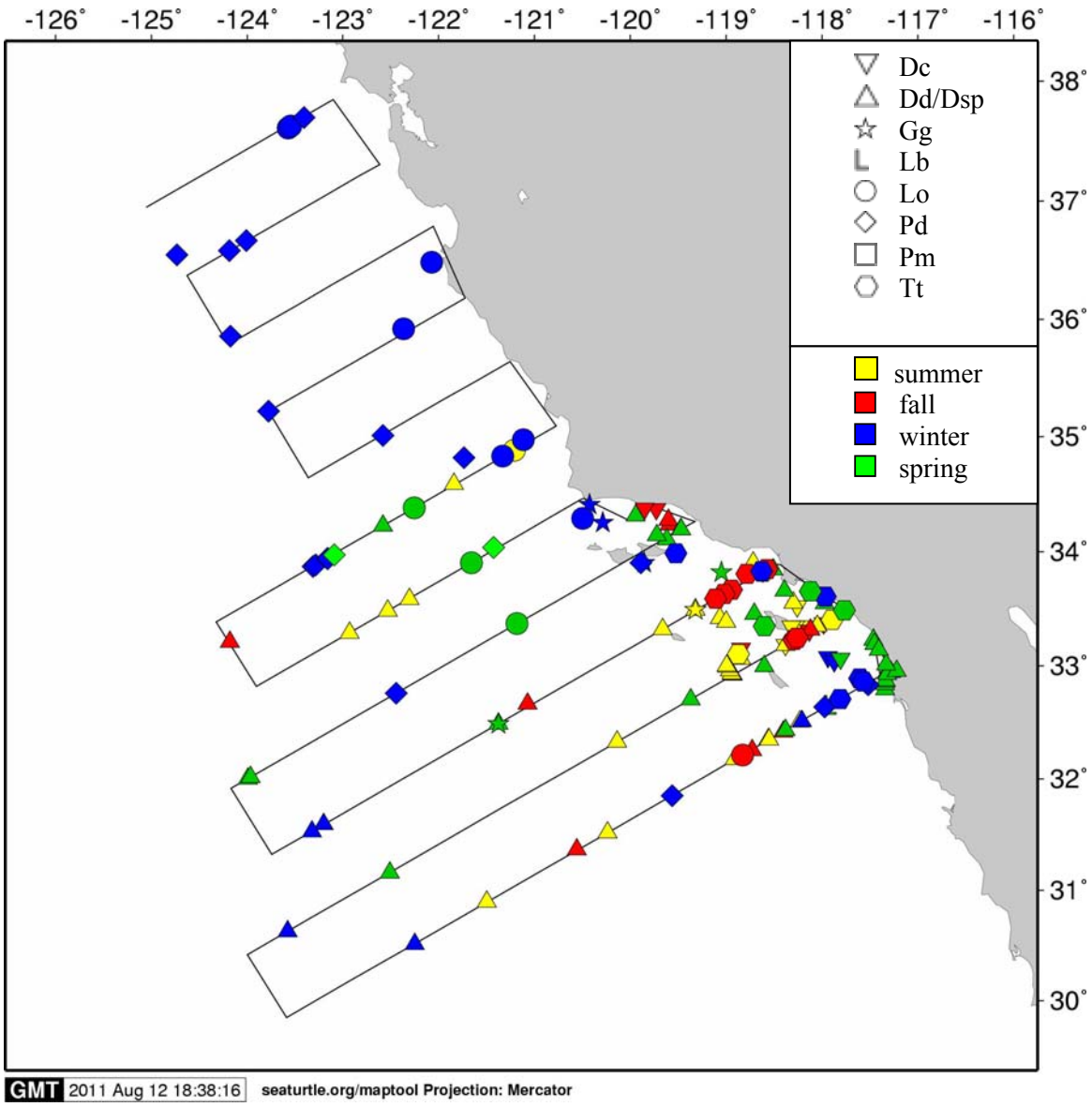

Figure 4. Visual sightings of eight odontocete species by season from four CalCOFI cruises between August 2010 and April 2011.

The relative abundance of baleen whales showed a different trend with noteworthy increases from previous years for three of four common baleen whale species. Fin, humpback, and gray whales had seasonal sighting rates that were the nearly double the average, representing the second highest levels observed for the three species across the seven-year study period (Figure 7). The seasonal increases in relative abundance observed for fin, gray and humpback whales may be an indicator of greater productivity in the southern California Bight in 2010-2011 as compared with previous years. Further examinations of direct metrics of primary productivity such as SST and chlorophyll levels and secondary productivity such as plankton and small fish abundance are needed to better assess potential relationships between baleen whale abundance and pertinent habitat variables.

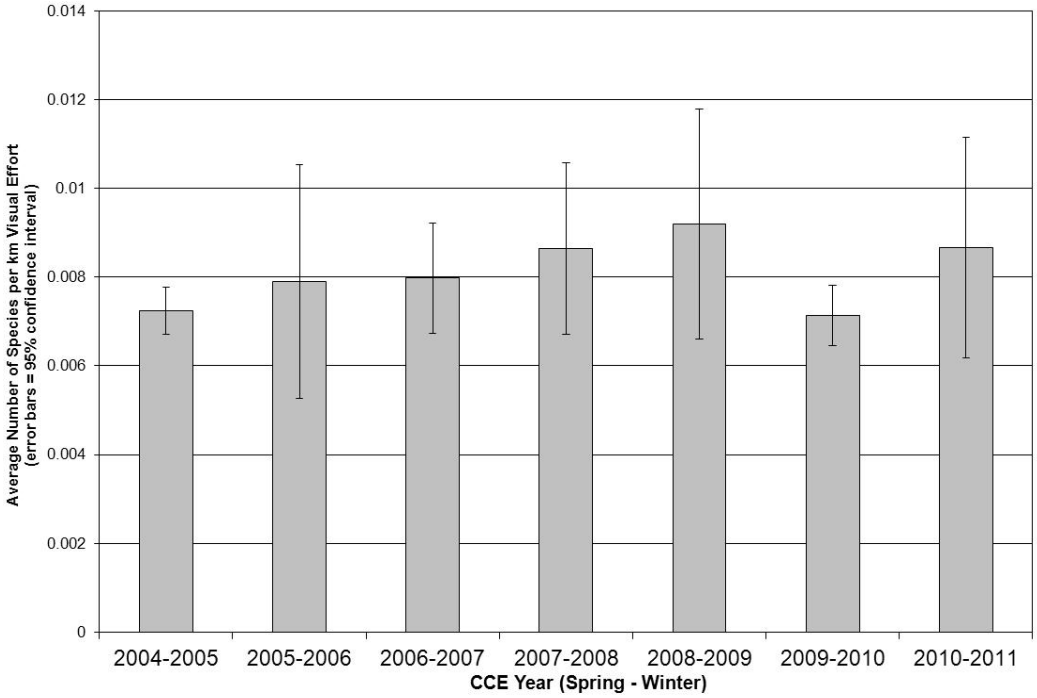

Figure 5. Average species richness (number of cetacean species per km of survey effort) per year (spring – winter). Error bars indicate the 95% CI.

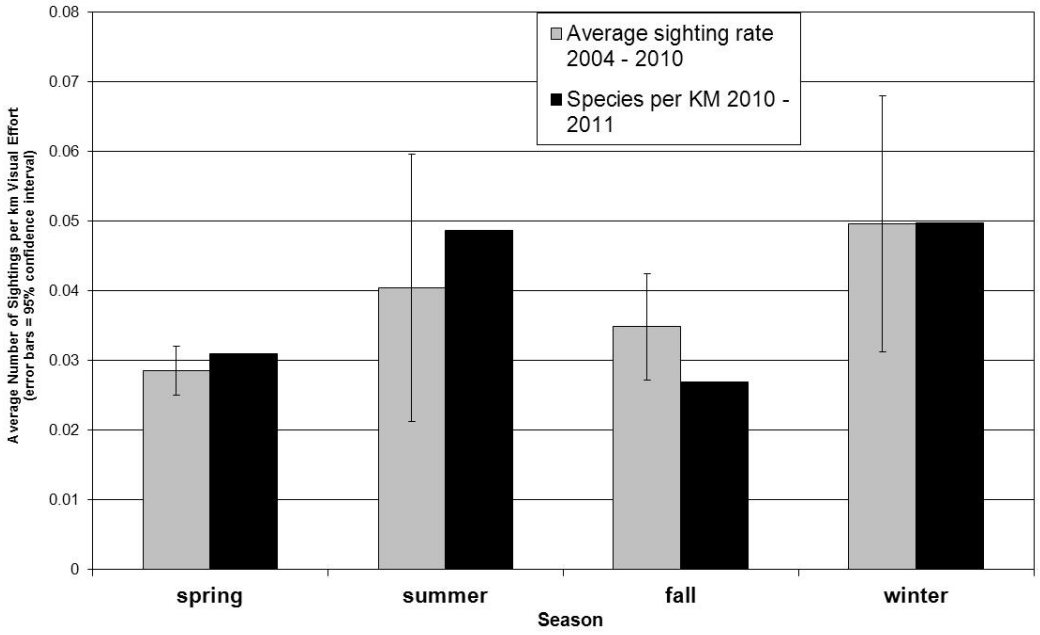

Figure 6. Comparison of the average sighting rates (number of sightings per km visual effort) for July 2004-January 2010 (grey) and the average sighting rates for spring 2010 - winter 2011 (black). Error bars show 95% CI.

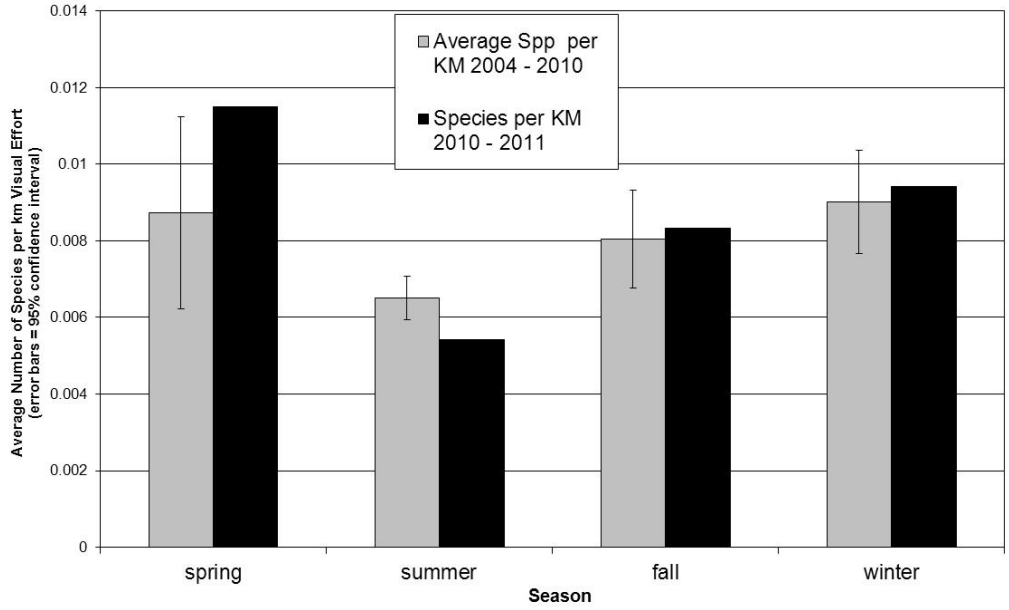

Figure 7. Comparison of the average species richness (number of cetacean species per km of survey effort) for July 2004-January 2010 (grey) and the average sighting rates for spring 2010 - winter 2011 (black). Error bars show 95% CI.

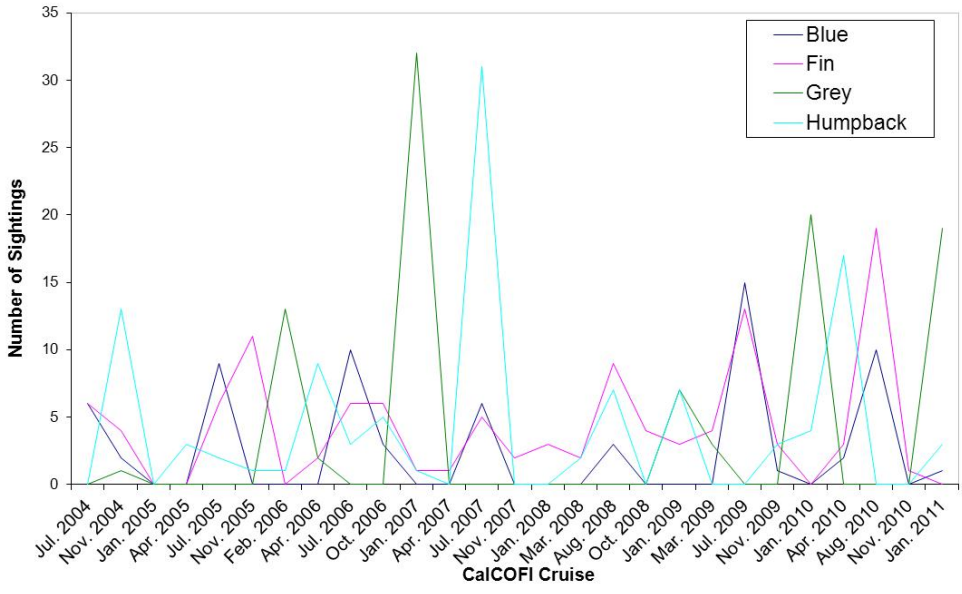

Figure 8. Relative abundance (in number of sightings per cruise) of blue, fin, grey and humpback whales species from July 2004 – January 2011.

Acoustic Monitoring – Towed Array

Acoustic detections from the towed array included 8 odontocete species encompassing a total of 199 detections (Figure 9). Acoustic detection rates varied by species. Of the 199 cetacean acoustic detections, unidentified whistling delphinids comprised 50% (n=99), sperm whales accounted for 19% (n=38), common dolphins 10% (n=20), unidentified clicking delphinids 6% (n=12), Pacific white-sided dolphins 3% (n=6), bottlenose dolphins 2% (n=3), Risso's dolphins 1% (n=1), Cuvier's beaked whales 1% (n=1) and northern right-whale dolphins 1% (n=1). Sperm whale acoustic detections outnumbered visual detections by a factor of nine (38 to 4), reinforcing the utility of using acoustics to document the presence of deep-diving odontocetes.

Spatial patterns in sperm whale and delphinid acoustic array detections were apparent for some species (Figure 9). Sperm whale detections were concentrated in deep pelagic waters as well as slope and shelf waters westward of islands and coastal regions. This spatial pattern of array-based detections of sperm whales is similar to the distribution of visual and sonobuoy detections for this species. Bottlenose and Risso's dolphin detections occurred inshore of the Channel Islands mirroring the visual pattern of detections for these two species. Unidentified whistling and clicking delphind detections were dispersed throughout the study area with the exception of the immediate coastline. The wide distribution and frequent occurrence of unidentified whistling delphinds in the study area, in accordance with the infrequent visual sightings of other whistling species, suggests that the majority of these detections are common dolphins. Further development of our whistle classification algorithms should assist in assigning species identification to these unidentified whistles.

Acoustic Monitoring – Sonobuoys

Real-time acoustic detections from the sonobuoys included four mysticete and two odontocete species encompassing a total of 129 detections (Figures 10 and 11). Acoustic detection rates in the study area varied by species. Of the 129 cetacean acoustic detections, sperm whales comprised 23% (n=30), humpback whales accounted for 19% (n=25), fin whales 18% (n=23), blue whales 10% (n=13), unidentified baleen whales 16% (n=21), and unidentified dolphins 12% (n=16).

Seasonal variations in call detection rates as a function of species were apparent. Humpback whales were frequently detected visually but rarely acoustically inshore in spring and fall, whereas humpbacks were detected acoustically but not visually offshore during winter cruises. Blue and fin whale calls were regularly documented during summer and fall while acoustic detections of these species were rare during winter and fall cruises. Visual detections of blue and fin whales exhibited similar seasonal occurrence patterns, suggesting that acoustic monitoring of these two baleen whale species provides a useful metric for assessing presence/absence in the study area. Sperm whale clicks were detected in all seasons except fall with the majority of detections occurring during the spring cruise. Visual detections of sperm whales were limited to two each during the winter and spring cruises, limiting comparative analysis between visual and acoustic methods for this species. Delphinid calls were heard on all cruises without a clear seasonal pattern.

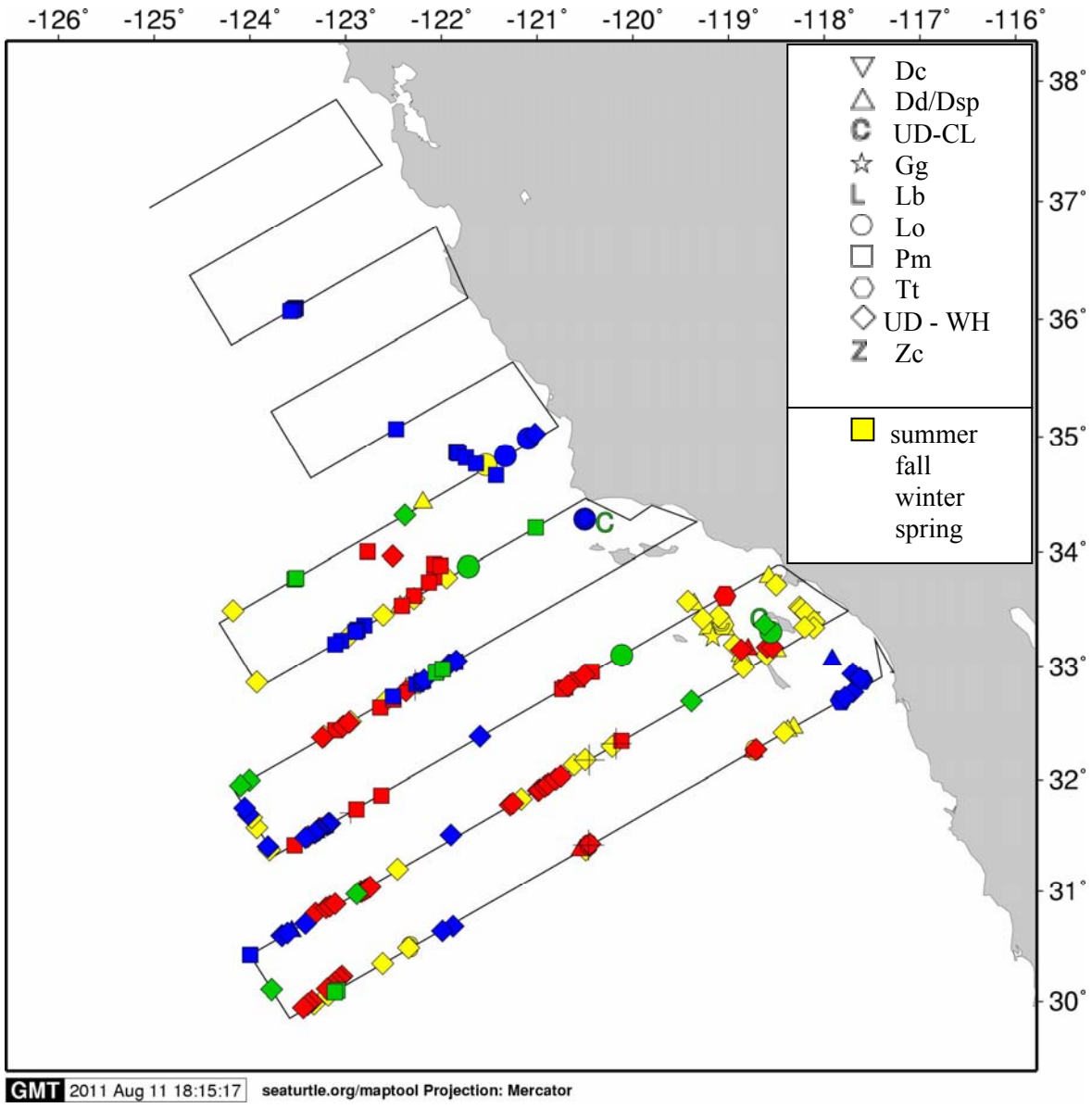

Figure 9. Towed acoustic array detections of odontocete cetaceans by species and season from CalCOFI cruises between August 2010 and April 2011.

Spatial patterns in blue whale, fin whale, humpback whale, sperm whale and delphinid acoustic detections for sonobuoys were also present (Figures 10, 11, and 12). Blue whale, fin whale, humpback whale and delphind detections were dispersed throughout the study area with no apparent spatial pattern. Sperm whale calls were concentrated on deep pelagic stations as well as slope and shelf waters westward of islands and coastal regions.

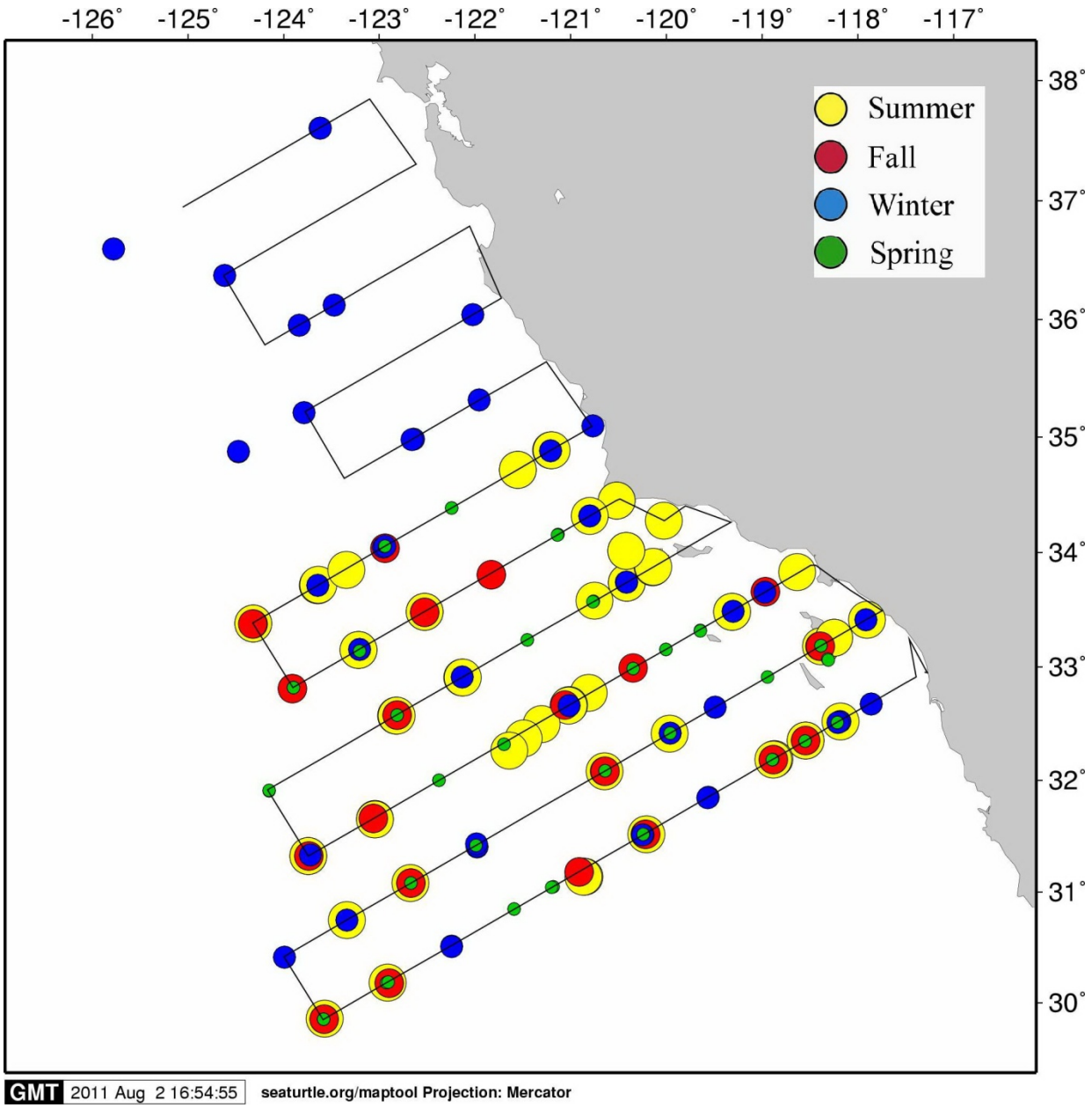

Figure 10. Sonobuoy deployment locations by season from CalCOFI cruises between August 2010 and April 2011. Circle diameter adjusted for visibility on plot and does not reflect amount of effort.

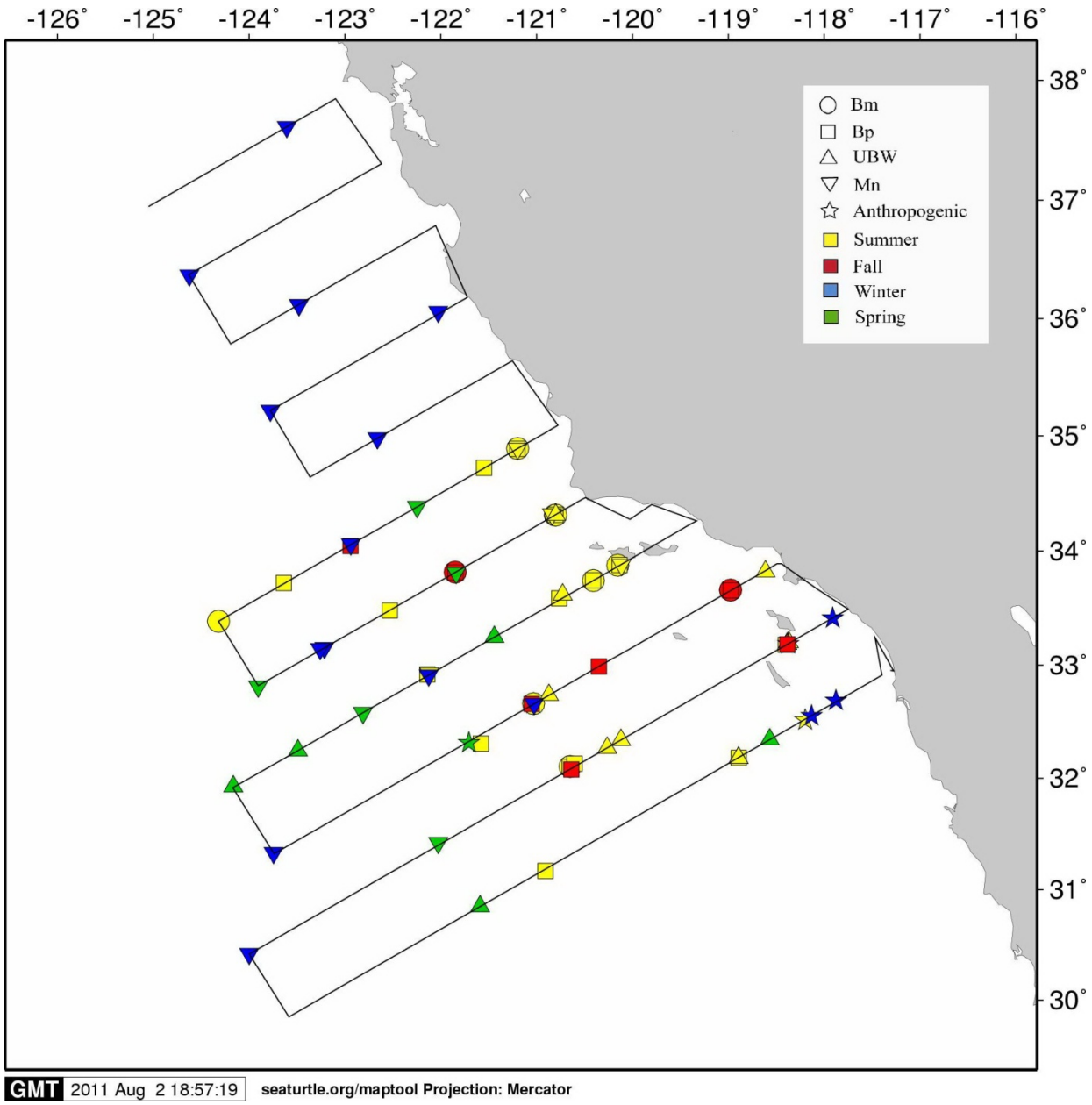

Figure 11. Sonobuoy acoustic detections of mysticete cetacean calls and anthropogenic noise by species and season from CalCOFI cruises between August 2010 and April 2011.

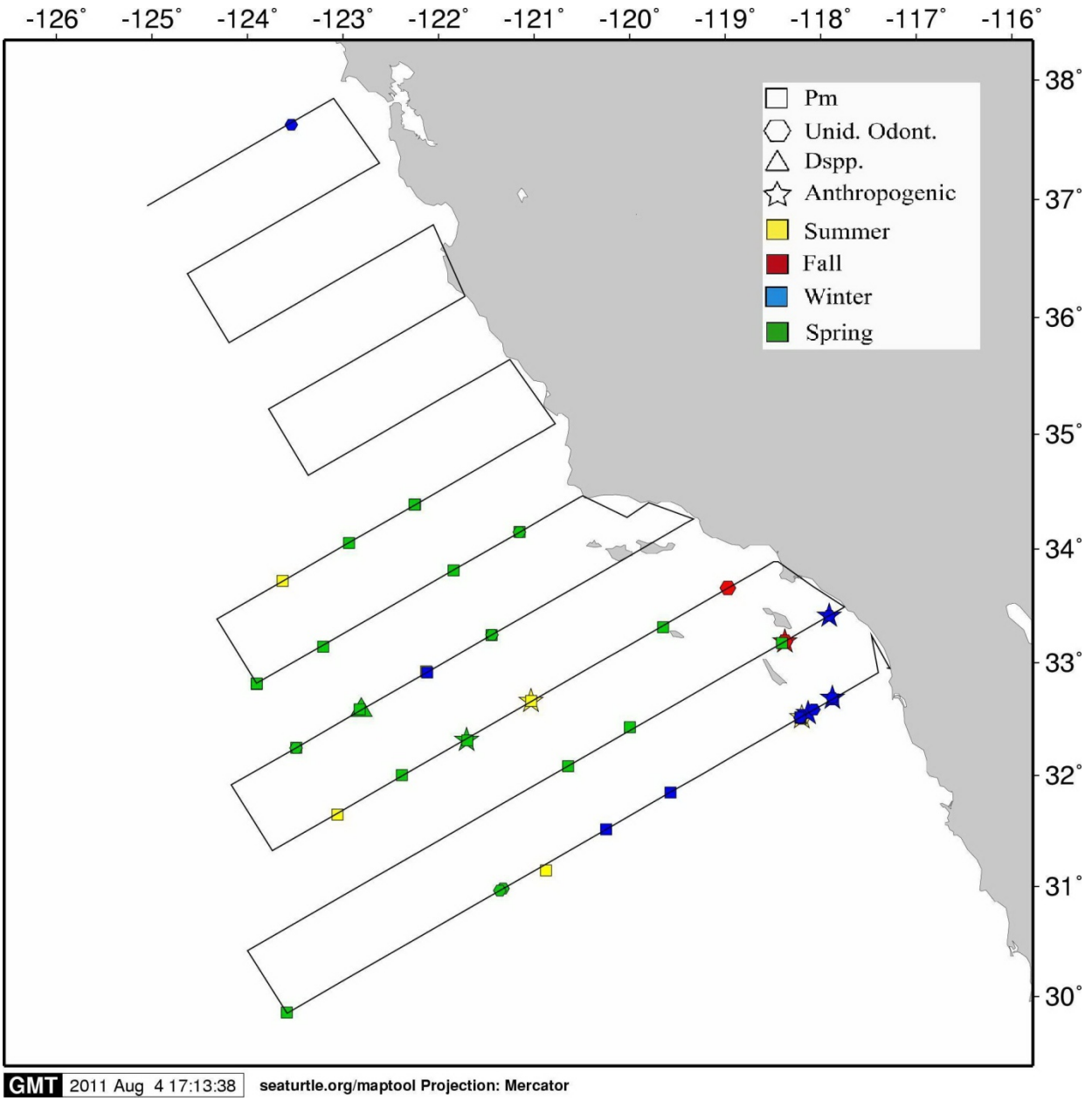

Figure 12. Sonobuoy acoustic detections of odontocete cetacean calls and anthropogenic noise by species and season from CalCOFI cruises between August 2010 and April 2011.

CONCLUSIONS

Marine mammal monitoring on CalCOFI cruises has been conducted over the last seven years to investigate cetacean distribution patterns relative to habitat, to make seasonal estimates of cetacean density and abundance, and to quantify differences in vocalizations between cetacean species. Over the last year, efforts to accomplish these objectives have expanded through incorporating novel analysis approaches, integrating new hardware/software tools, and developing collaborations with other experts in the field. Habitat modeling efforts have been improved through integration of a larger suite of environmental variables collected from CalCOFI

cruises, satellite imagery, and autonomous gliders as well as the utilization of innovative GIS-based software tools. The development of density and abundance estimates for nine cetacean species in the CalCOFI study area are currently the focus of an extensive line-transect analysis and spatio-temporal modeling effort, in collaboration with St. Andrews University. Acoustical census techniques for cetaceans have been improved through recently published advancements in acoustic species-identification, localization software, and group size estimation. Cetacean surveys on CalCOFI cruises provide an avenue to examine seasonal and inter-annual patterns in distribution as well as density and abundance on a longer continuous time scale with a higher rate of sampling than previous cetacean surveys off the California coast. The insight gained from these analyses will provide data for environmental assessments and ultimately management protocols.

ACKNOWLEDGEMENTS

Many individuals have made this research possible. We thank CalCOFI and SWFSC scientists Dave Wolgast, Jim Wilkinson, Amy Hays, Dave Griffith, Grant Susner; ship crew, research technicians, and MARFAC Staff. We appreciate the assistance with data analysis and processing provided by Alex Kesaris. We are grateful to Frank Stone and Curt Collins for supporting our work through CNO-N45 and the Naval Postgraduate School.

Appendix A. Species codes for all cetaceans included in report.

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

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

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INTRODUCTION

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

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

METHODS

Survey Effort

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

STUDY AREAS

San Clemente Island

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

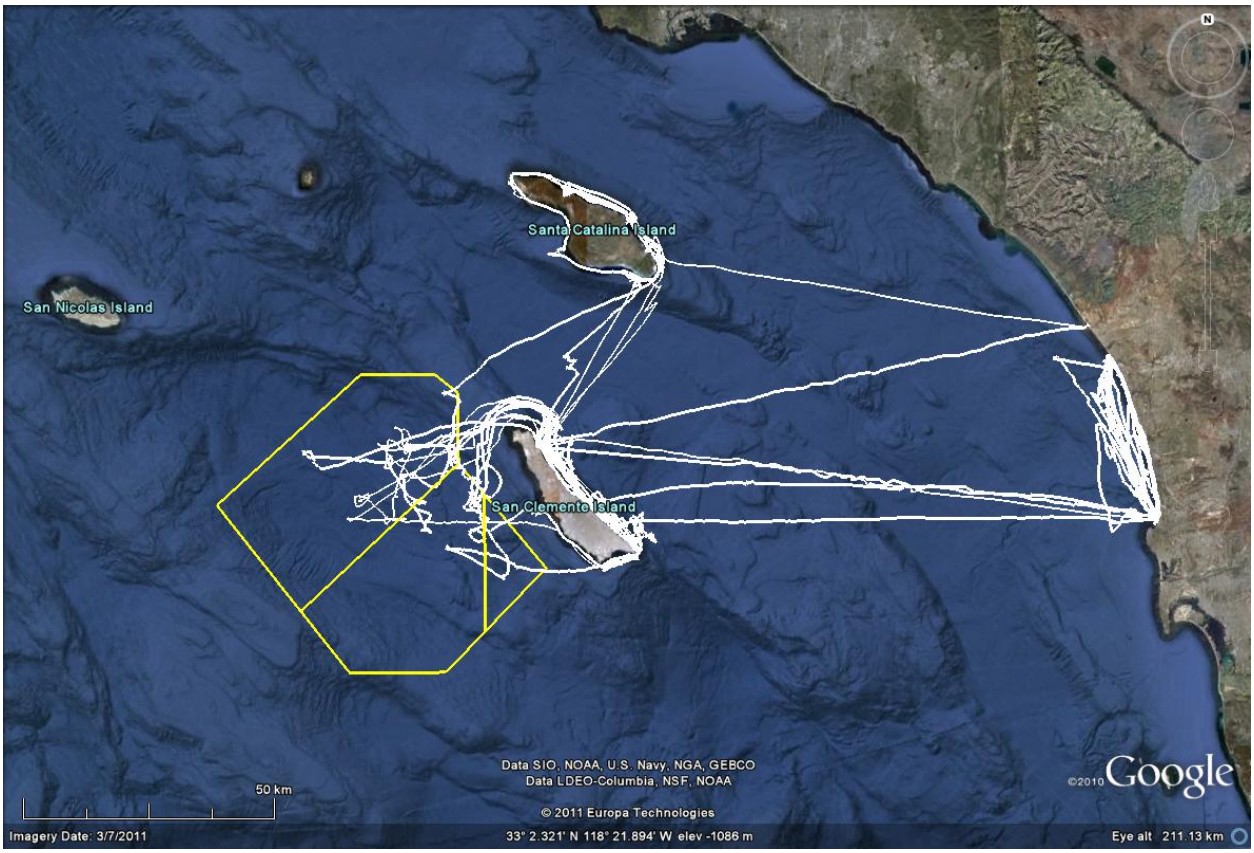

Figure 1. SIO small vessel survey tracks from monitoring at SCORE (boundaries of SOAR range in yellow), Catalina Island and the San Diego coastline from August 2010 – July 2011.

Catalina Island

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

San Diego Coastline

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

PROCEDURE

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

Photo-Identification

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

Biopsy Sampling

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

Drop-Hydrophone Recording System

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

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

HARP Recording System

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

DATA ANALYSIS

Photo-identification

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

Biopsy Sampling

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

Acoustical Recordings

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

HARP Recordings

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

RESULTS

Sightings

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

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

San Diego Coastal Surveys

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

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

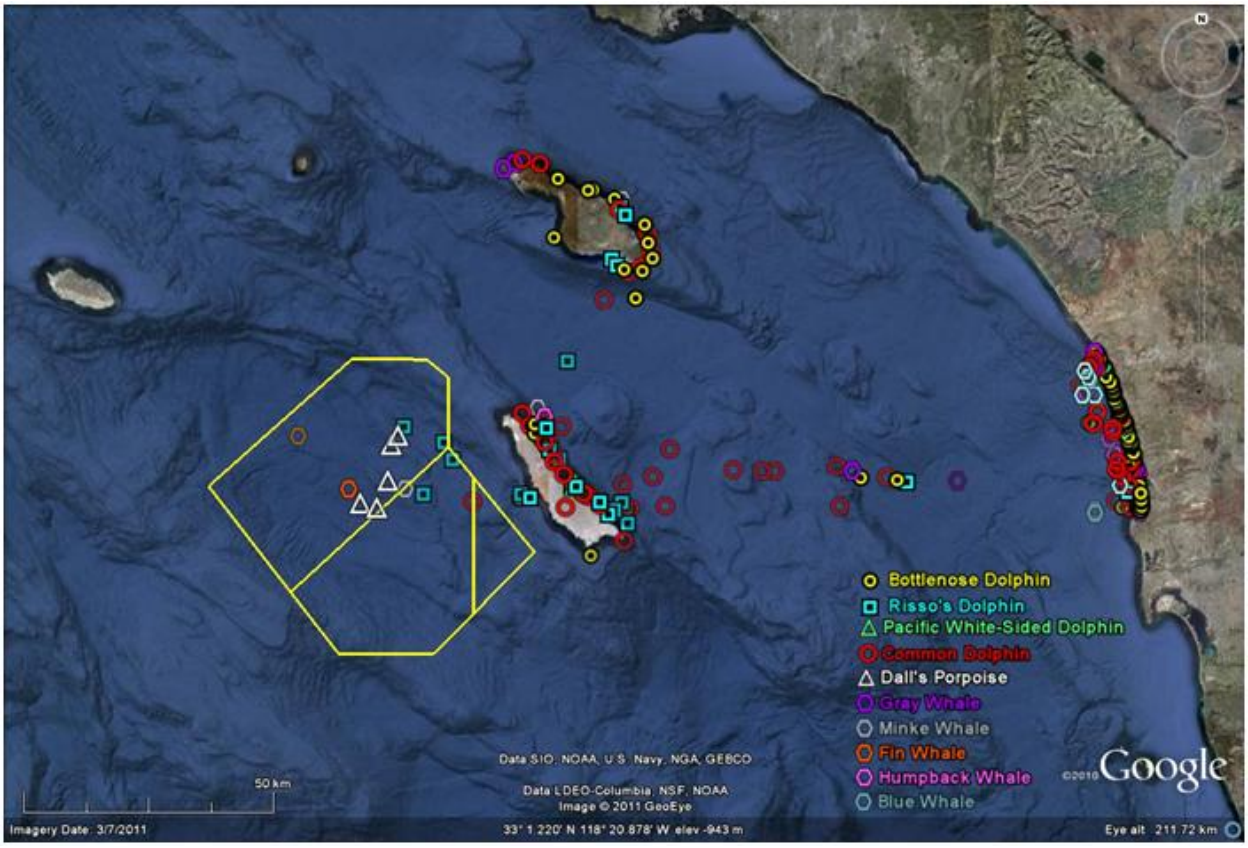

Figure 2. Cetacean sightings documented on all SIO small boat surveys in southern California from August 2010 – July 2011.

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

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

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

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

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

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

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

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

Bottlenose Dolphin Photo-Identification

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

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

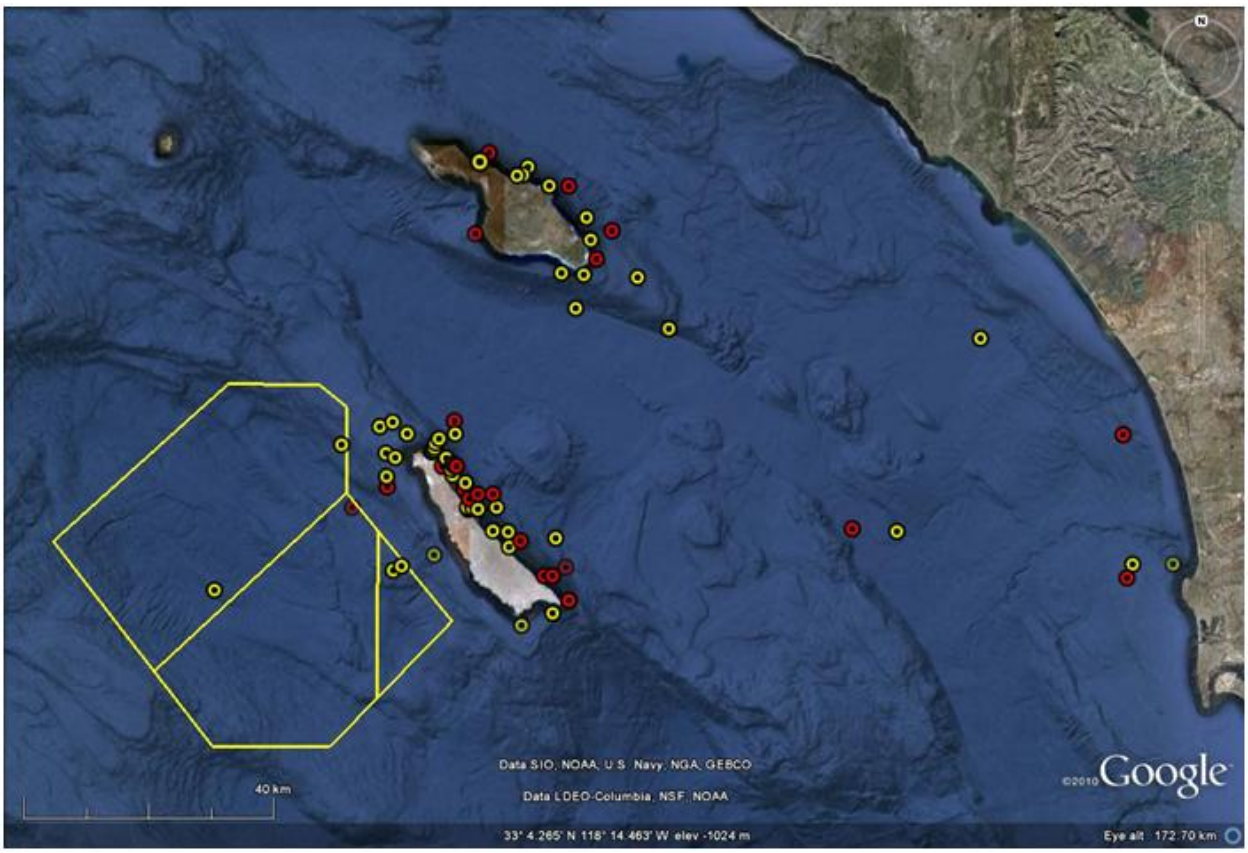

Figure 3. Distribution of offshore bottlenose dolphin sightings from August 2006 – July 2011 where at least one individual was photographically identified; Yellow = Photo-ID, Red = Biopsy and Photo-ID.

Rate of discovery

The rate at which individual dolphins were identified off San Clemente Island from 2006-2011 was examined across surveys in which at least one dolphin was photographically identified (n=29 surveys, Figure 5). Rate of discovery, plotted as the cumulative number of newly identified individuals across each survey, indicates that new (i.e. previously unidentified) individuals were encountered throughout the six-year study period. While the consistent positive slope in the curve indicates that the population is larger than the current sample, 21% (n = 86) of the 419 individuals identified have been sighted in two or more of the eleven survey periods. In addition, the proportion of newly identified individuals decreased from 100% at the beginning of the study to 64% on the most recent survey analyzed (Figure 4). Based on this trend, we expect the overall proportion of newly identified individuals to decrease with additional surveys at San Clemente Island.

The rate at which individual dolphins were identified off Catalina Island from 2006-2011 was examined across surveys in which at least one dolphin was photographically identified (n = 12 surveys, Figure 5). Similar to San Clemente Island, the rate of discovery curve indicates that new (i.e. previously unidentified) individuals were encountered throughout the six-year study period. While the consistent positive slope in the curve indicates that the population is larger than the current sample, 9% (n = 28) of the 312 individuals first identified at Catalina have been sighted in

two or more of the eleven survey periods. In addition, the proportion of newly identified individuals decreased from 100% at the beginning of the study to 62% on the most recent survey analyzed. Based on this trend, we expect the overall proportion of newly identified individuals to decrease with additional surveys at Catalina Island.

Sighting frequency and site fidelity

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

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

Inter-Island Movement patterns

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

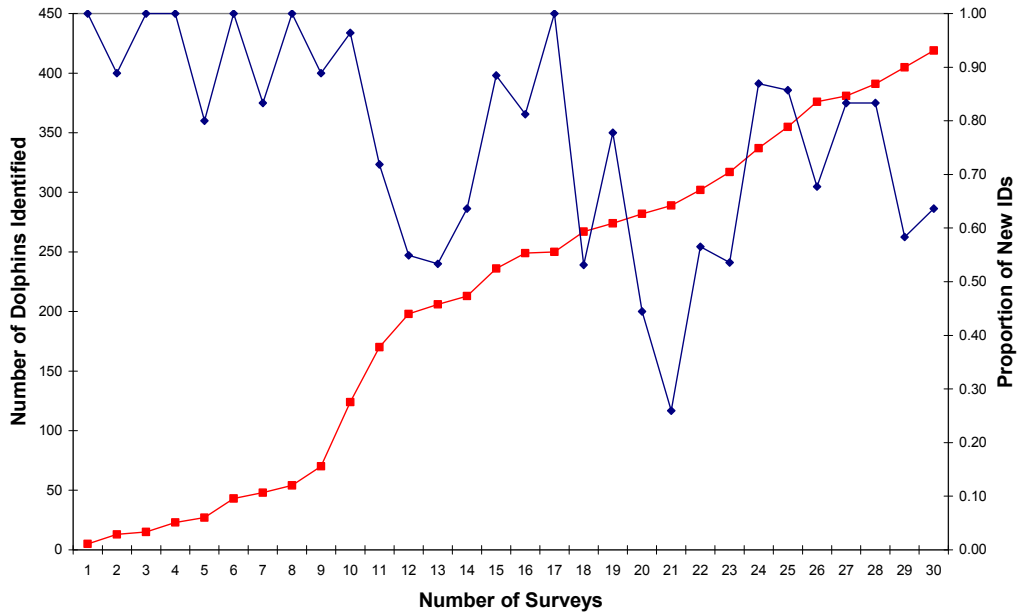

Figure 4. Cumulative number of bottlenose dolphins (red) and the proportion of new individuals photo-identified (blue) at San Clemente Island over 29 surveys in which at least one dolphin was identified. N = 419 individuals.

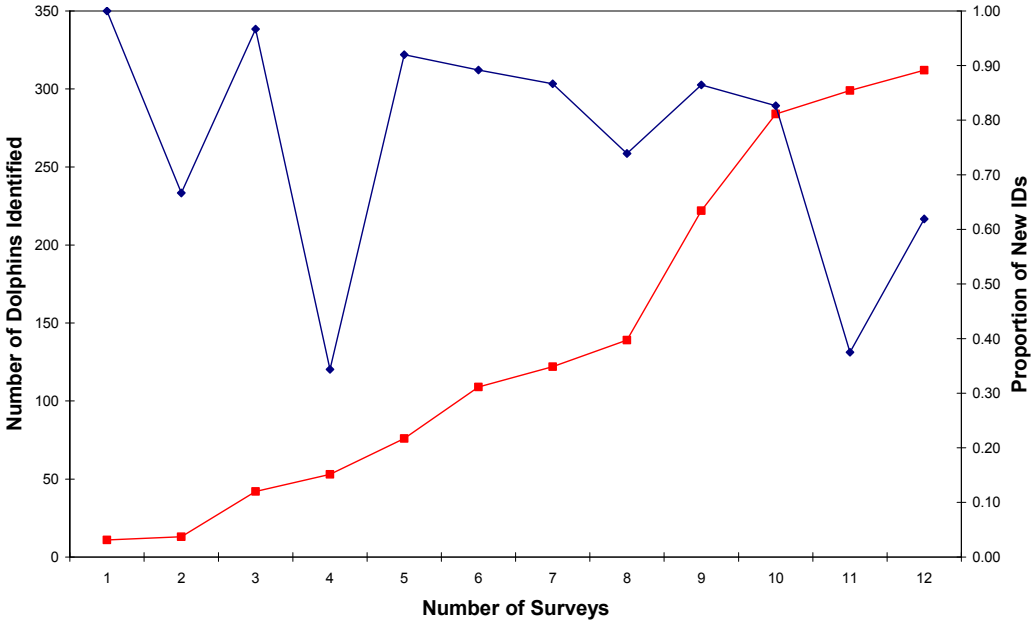

Figure 5. Cumulative number of bottlenose dolphins (red) and the proportion of new individuals photo-identified (blue) at Catalina Island over 12 surveys in which at least one dolphin was identified. N = 312 individuals.

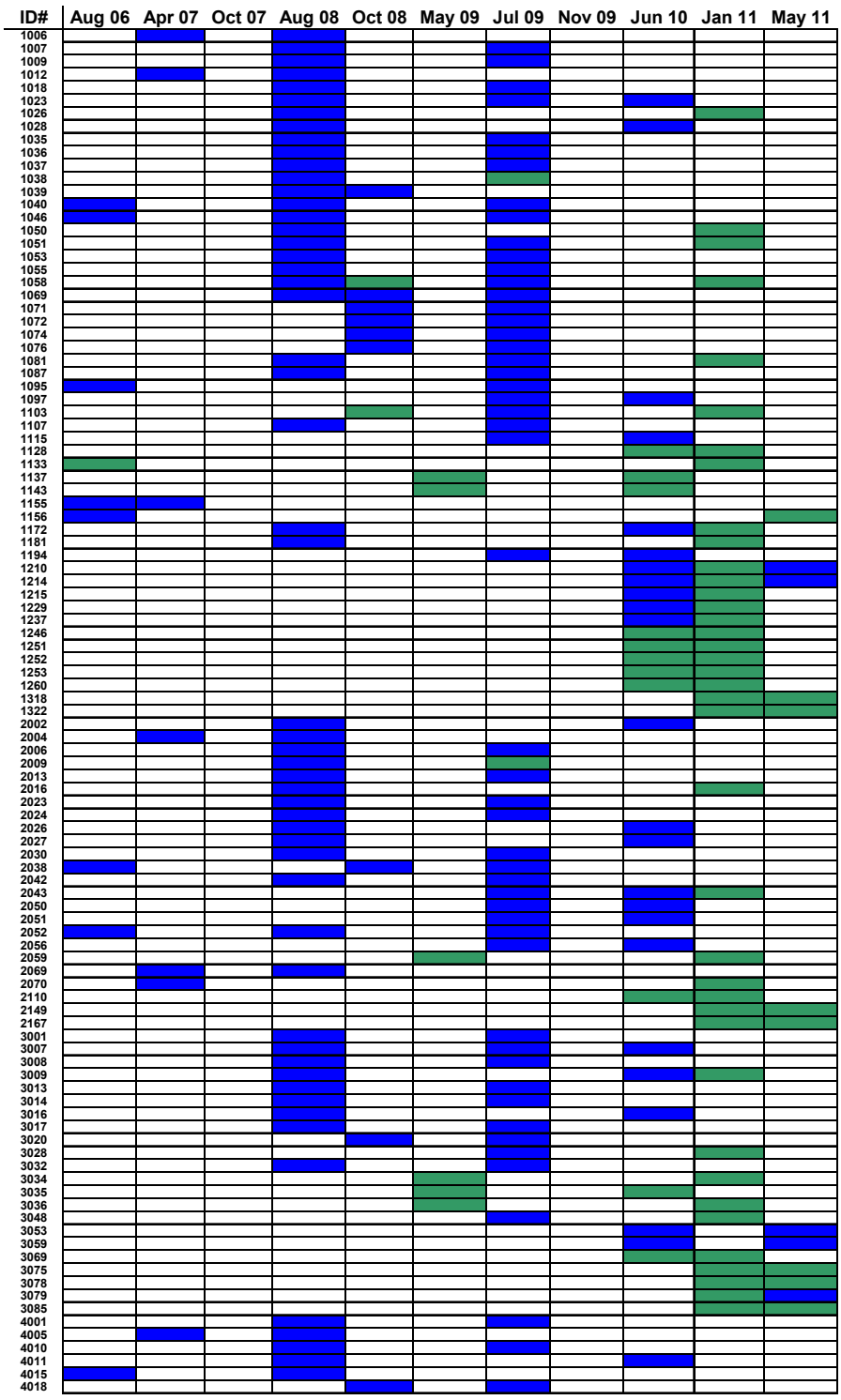

Figure 6. Sighting matrix for the 114 bottlenose dolphins photographically identified during two or more of the 11 survey periods at San Clemente and Catalina Island from August 2006 – May 2011. Blue = SCI; Green = CI.

Bottlenose Dolphin Biopsy Sampling

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

Hormone Study

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

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

DNA Study

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

Based on the geographical distribution of offshore bottlenose dolphin biopsy locations, Lowther (2006) further divided tissue samples into a northern and a southern group. Comparison of DNA structure between the northern and southern samples and with those collected at other locations in the North Pacific suggested structure among the offshore dolphins within the southern California Bight. Additional sampling across a wider geographic and temporal scale, as reported here, is needed to accurately assess the structure of this potentially highly divergent population

(Lowther 2006). Of particular interest in the present study is the assessment whther insular (i.e. island associated) population segments exist and if so, can they be genetically differentiated from pelagic and coastal forms of the species.

Risso's Dolphin Photo-Identification

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

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

Rate of Discovery

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

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

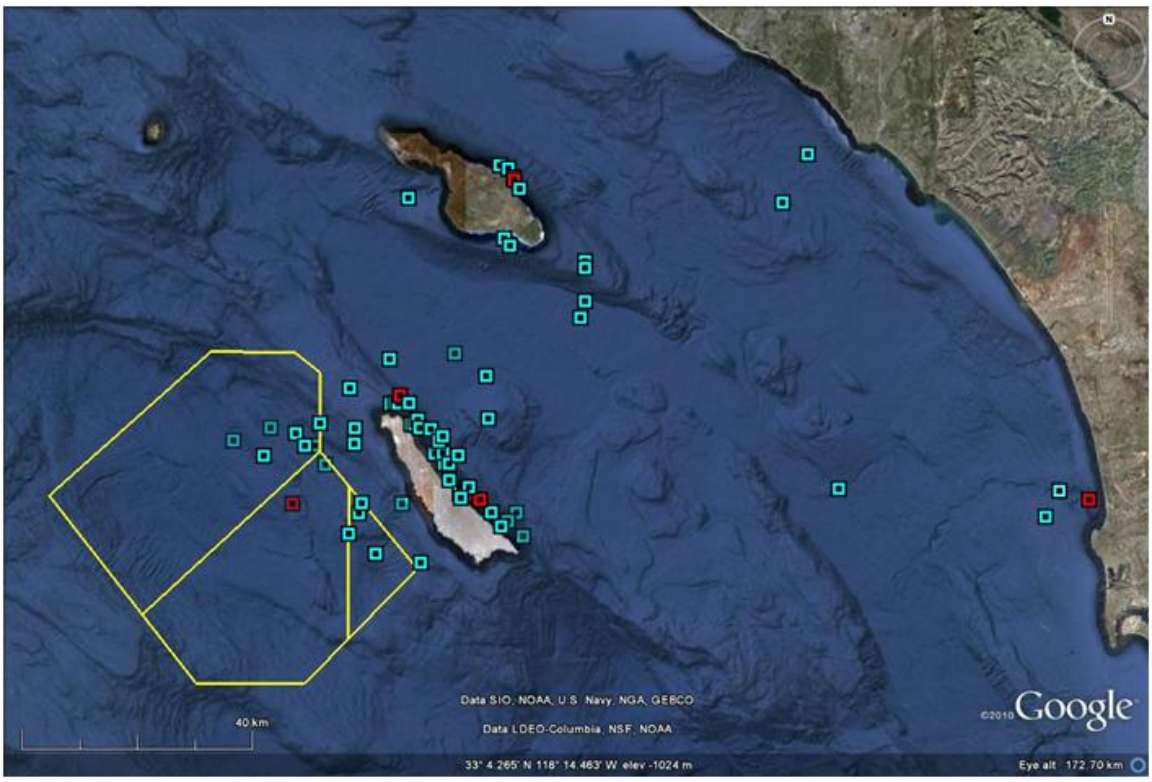

Figure 7. Distribution of Risso's dolphin sightings where at least one individual was photographically identified; Blue = Photo-ID only, Red = Biopsy and Photo-ID.

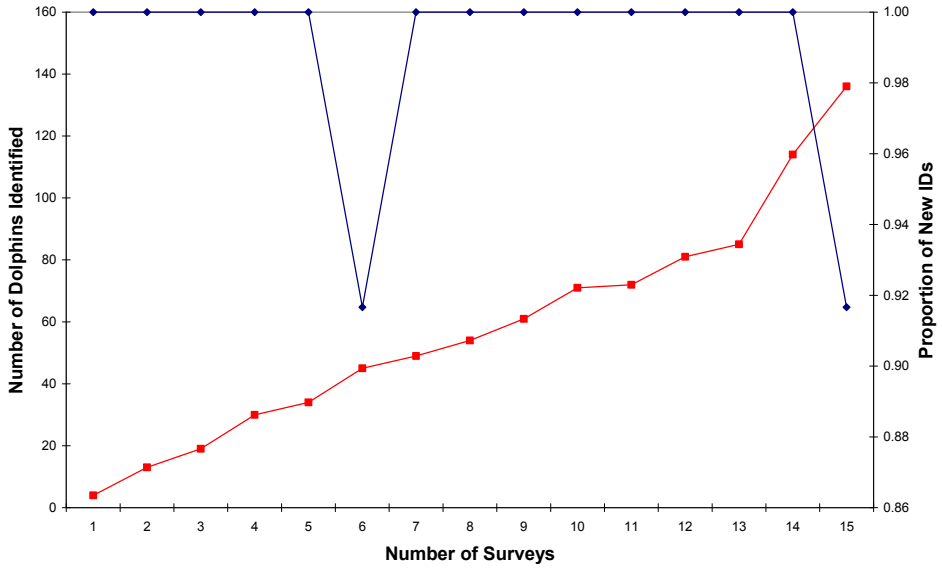

Figure 8. Cumulative number of Risso's dolphins (red) and proportion of new individuals photo-identified (blue) at San Clemente and Catalina Islands over 15 surveys in which at least one dolphin was identified. N = 136 individuals.

Pacific White-Sided Dolphin Biopsy and Acoustical Sampling

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

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

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

Acoustical Recordings

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

DISCUSSION

Sightings

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

Photo-Identification

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

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

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

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

Biopsy Sampling

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

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

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

CONCLUSIONS

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

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LITERATURE CITED

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. 2009. U.S. Pacific Marine Mammal Stock Assessments: 2009. NOAA Technical Memorandum: NMFS-SWFSC-453.

Caretta, J. V., K. A. Forney, E. Oleson, K. Martien, M. Muto, M. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell Jr., J. Robbins, D.K. Mattila, K. Ralls AND M. Hill. 2010. U.S. Pacific Marine Mammal Stock Assessments: 2010. NOAA Technical Memorandum: NMFS-SWFSC-476.

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. 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.

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.

Soldevilla, M. S., E. E. Henderson, G. S. Campbell, S.W. Wiggins, J. A. Hildebrand, AND M. A. Roch 2008. Classification of Risso's and Pacific white-sided dolphins using spectral properties of echolocation clicks. J. Acoust. Soc. Am. 124:609-624.

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: SMALL BOAT SURVEY

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 08/13/10

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Marie Roch

The fifteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on August 13, 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 58 miles yielded sightings of two groups of bottlenose dolphins, one mixed group of short-beaked and long-beaked common dolphins, one group of long-beaked common dolphins and four groups of blue whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins and blue whales encountered. Acoustical recordings of whistles, clicks and buzzes were collected from bottlenose (*Tt1*) and common dolphins (*Dd/Dc1*). Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

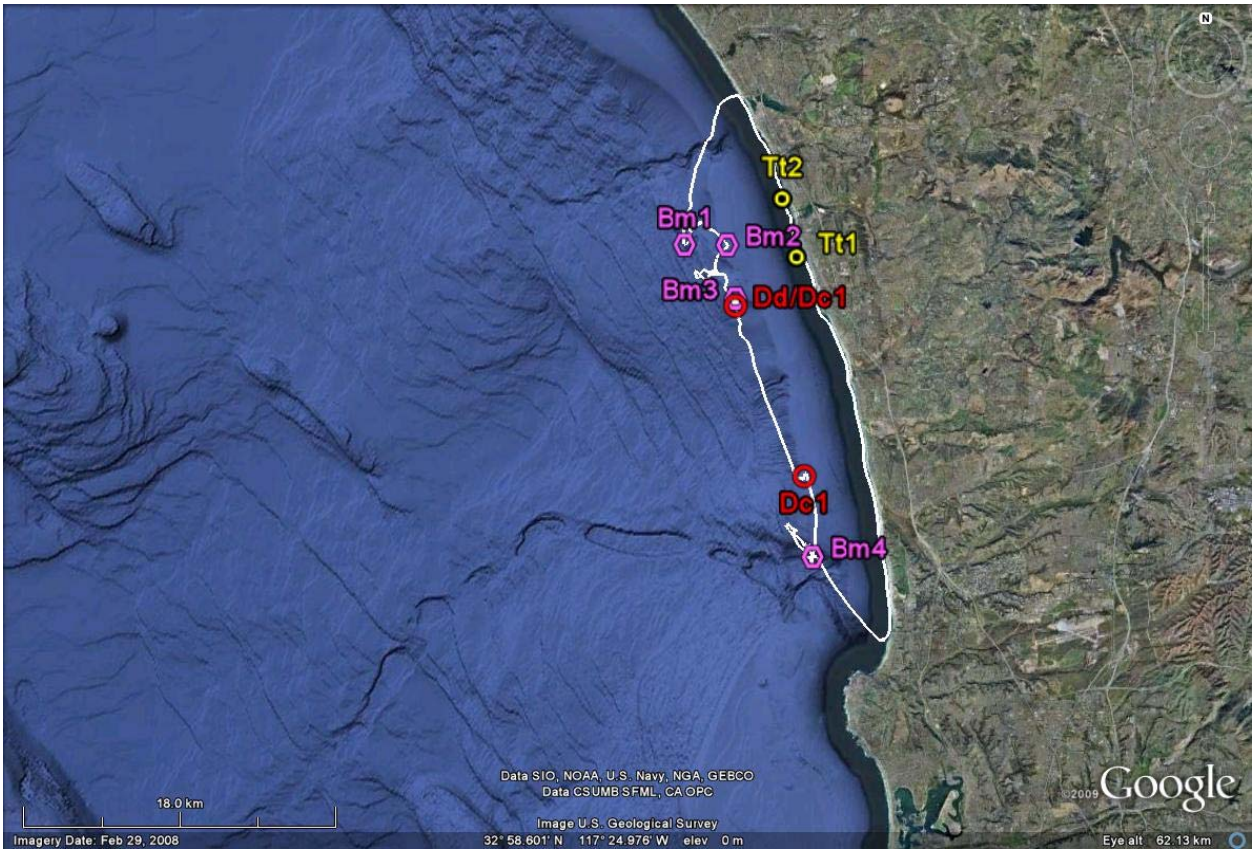

Figure 1. RHIB survey tracks and sighting locations for T. truncatus, D. delphis, D. capensis and B. musculus off the San Diego coastline, August 13, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, August 13, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	3	14	2	-
T. truncatus	Tt2	6	56	-	-
D. delphis / D. capensis	Dd/Dc1	85	4	2	-
D. capensis	Dc1	19	-	-	-
B. musculus	Bm1	3	47	-	-
B. musculus	Bm2	5	91	-	-
B. musculus	Bm3	5	149	-	-
B. musculus	Bm4	4	137	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 08/20/10

Crew: Greg Campbell, Sara Kerosky, Sara Pfeil, Lauren Williams

The sixteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on August 20, 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 52 miles yielded sightings of two groups of long-beaked common dolphins, two mixed groups of short-beaked and long-beaked common dolphins, three blue whales and one unidentified baleen whale (Figure 1). This survey represents the first occasion during the current study where no coastal bottlenose dolphins were sighted. Photo-identification efforts produced high quality images from a large proportion of blue whales encountered and acoustical recordings of common dolphins (*Dd*/*Dc2*) yielded whistles, clicks and buzzes. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

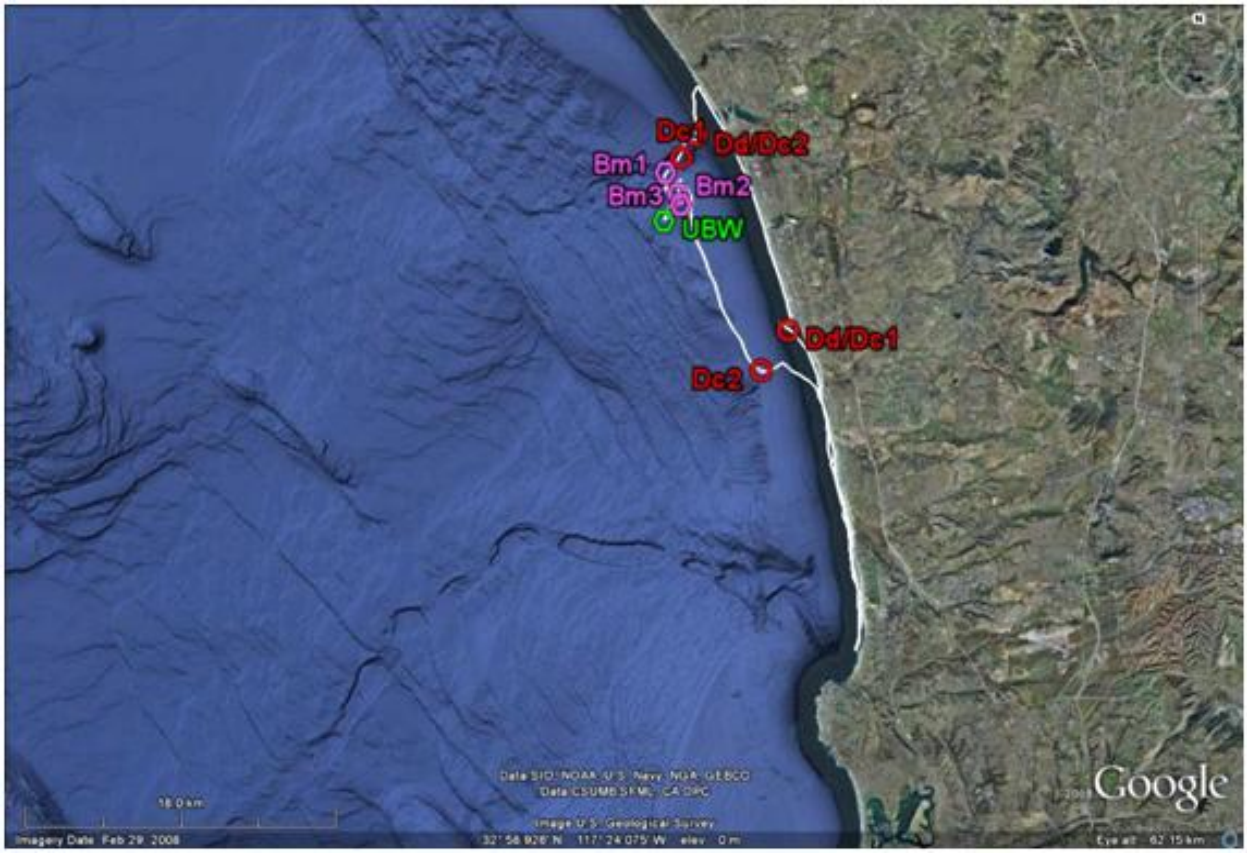

Figure 1. Survey tracks and sighting locations for D. delphis, D. capensis, B. musculus and an unidentified baleen whale off the San Diego coastline, August 20, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, August 20, 2010

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
D. delphis / D. capensis	Dd/Dc1	56	-	-	-
D. delphis / D. capensis	Dd/Dc2	140	5	1	-
D. capensis	Dc1	35	-	-	-
B. musculus	Bm1	1	26	-	-
B. musculus	Bm2	1	19	-	-
B. musculus	Bm3	1	75	-	-
Unid bakeen whale	UBW	1	16	-	-
D. capensis	Dc2	52	18	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 09/14/10

Crew: Greg Campbell, Dave Weller, Tyler Helble, Mary Grady

The seventeenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on September 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.

Six hours of field effort covering 45 miles yielded sightings of five groups of bottlenose dolphins, one group of long-beaked common dolphins and one group 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 (*Tt5*) yielded no vocalizations; however, snapping shrimp created a marginal signal/noise ratio. One biopsy sample was collected from coastal bottlenose dolphins for an assessment of stress hormones and microbiological contaminants. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus, D. capensis and D. delphis off the San Diego coastline, September 14, 2010.

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

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	2	21	-	-
T. truncatus	Tt2	3	88	-	1
T. truncatus	Tt3	5	170	-	-
T. truncatus	Tt4	7	174	-	-
T. truncatus	Tt5	3	25	2	-
D. capensis	Dc1	1206	8	-	-
D. delphis	Dd1	424	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 09/30/10

Crew: Greg Campbell, Dave Weller, Martin Gassman, Alex Kesaris

The eighteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on September 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.

The survey was truncated due to steering problems with our RHIB; however, one hour of field effort covering 4 miles yielded a sighting of one group of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from the two bottlenose dolphins encountered. Upon completion of photographic data collection, we returned to Scripps Pier for boat repairs. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

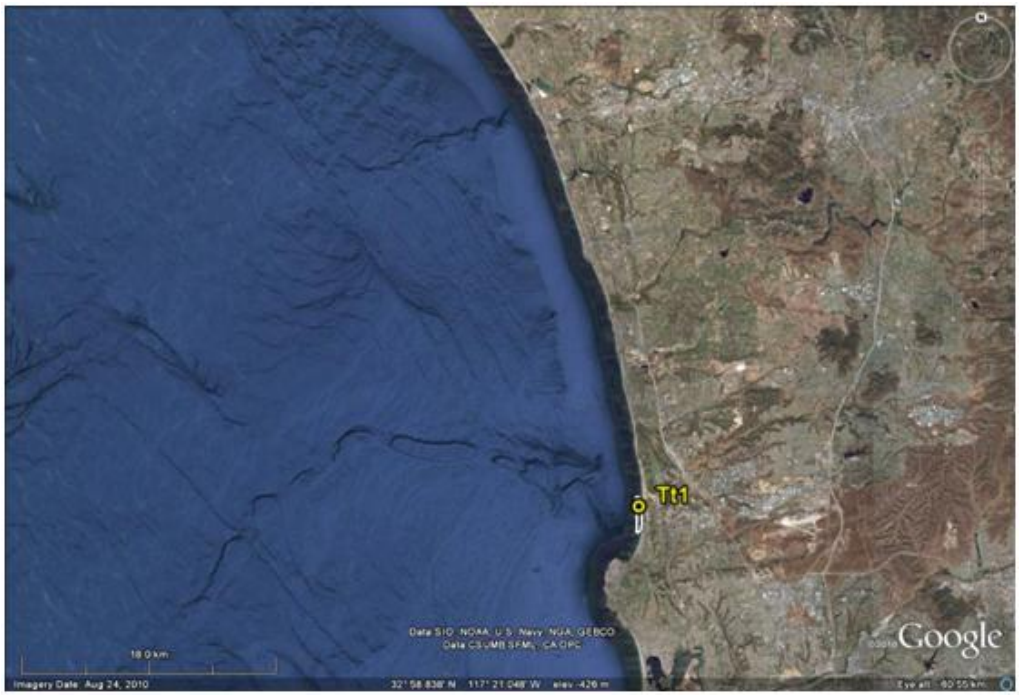

Figure 1. Survey tracks and sighting location for T. truncatus off the San Diego coastline, September 30, 2010.

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

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	2	6	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 10/14/10

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Martin Gassman, Alex Kesaris

The nineteenth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on October 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 Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 53 miles yielded sightings of three groups of bottlenose dolphins, two groups of long-beaked common dolphins, one mixed group of long-beaked and short-beaked common dolphins and one mixed group of Risso's and bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose and Risso's dolphins encountered. Acoustical recordings of common dolphins (*Dd*/*Dc1*) yielded clicks, buzzes and whistles. Three biopsy samples were collected from Risso's dolphins for an assessment of regional stock structure. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

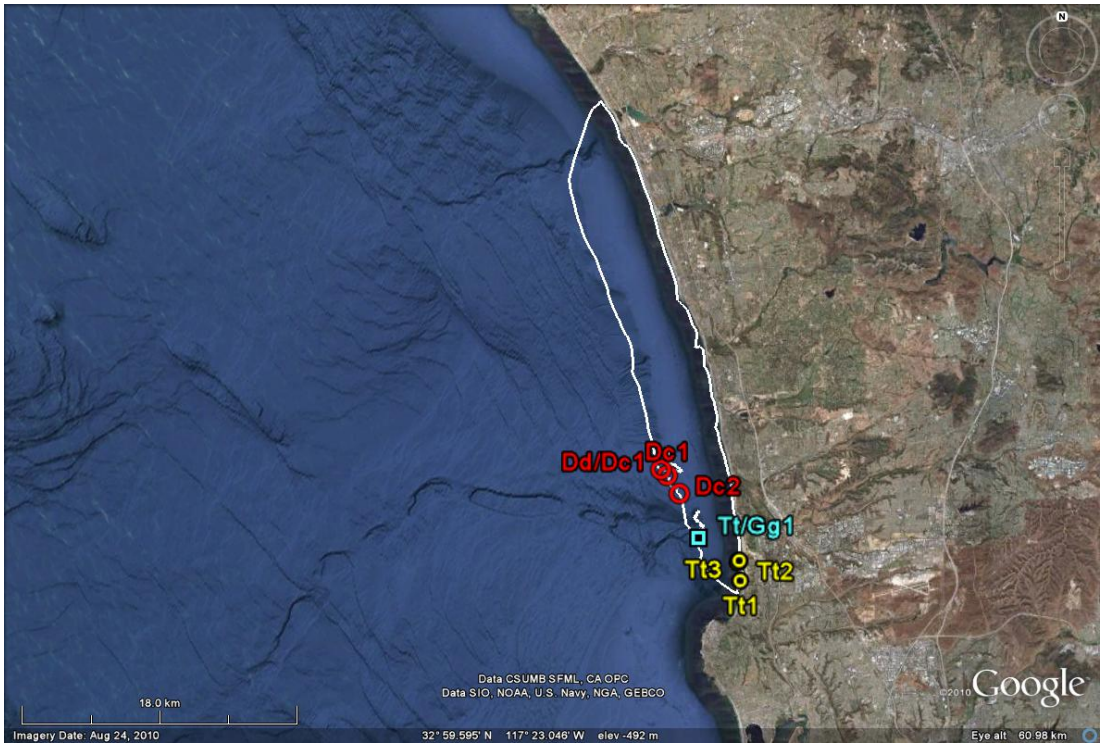

Figure 1. Survey tracks and sighting locations for T. truncatus, G. griseus, D. capensis and D. delphis off the San Diego coastline, October 14, 2010.

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

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	4	21	-	-
T. truncatus	Tt2	3	19	-	-
T. truncatus	Tt3	10	208	-	-
T. truncatus/G. griseus	Tt/Gg1	12/14	307	-	3 (Gg)
D. delphis/D. capensis	Dd/Dc1	375	-	4	-
D. capensis	Dc1	14	-	-	-
D. capensis	Dc2	237	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 10/21/10

Crew: Greg Campbell, Dave Weller, John Hurwitz, Matt Leslie

The twentieth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on October 21, 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 53 miles yielded sightings of five groups of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable and unpredictable dolphin movement patterns precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus off the San Diego coastline, October 21, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, October 21, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	3	27	-	-
T. truncatus	Tt2	1	5	-	-
T. truncatus	Tt3	3	39	-	-
T. truncatus	Tt4	5	75	-	-
T. truncatus	Tt5	10	154	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 11/11/10

Crew: Greg Campbell, Dave Weller, Sara Kerosky

The twenty-first in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 11, 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 Risso's and Pacific white-sided dolphins.

Four hours of field effort covering 19 miles yielded sightings of four groups of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable and unpredictable dolphin movement patterns precluded the collection of acoustical data and biopsy samples. Increasing swell and wind led to the termination of our efforts before the survey was completed. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus off the San Diego coastline, November 11, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 11, 2010

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	23	84	-	-
T. truncatus	Tt2	20	128	-	-
T. truncatus	Tt3	9	107	-	-
T. truncatus	Tt4	12	60	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 11/16/10

Crew: Greg Campbell, Dave Weller, Alex Kesaris

The twenty-second in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 16, 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 47 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. Variable and unpredictable dolphin movement patterns precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus and D. delphis off the San Diego coastline, November 16, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, November 16, 2010

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	10	259	-	-
T. truncatus	Tt2	27	518	-	-
T. truncatus	Tt3	9	144	-	-
D. delphis	Dd1	2122	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 11/30/10

Crew: Greg Campbell, Sara Kerosky, Lauren Roche

The twenty-third in a series of small boat cetacean surveys off the San Diego county coastline was conducted on November 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 Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 57 miles yielded sightings of four groups of bottlenose dolphins and one mixed group of short-beaked and long-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of bottlenose dolphins yielded echolocation clicks and whistles. Variable dolphin movement patterns precluded the collection of biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

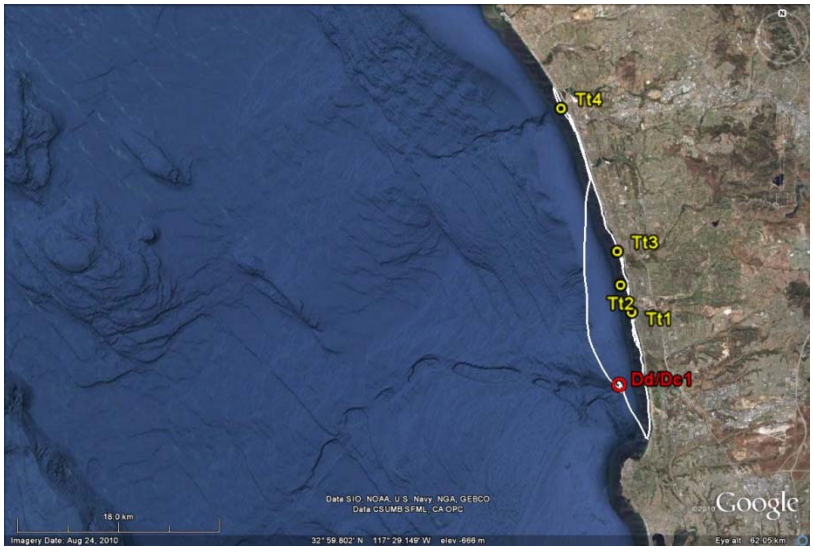

Figure 1. Survey tracks and sighting locations for T. truncatus and D. delphis/D. capensis off the San Diego coastline, November 30, 2010.

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

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	12	395	4	-
T. truncatus	Tt2	23	361	-	-
T. truncatus	Tt3	12	92	1	-
T. truncatus	Tt4	8	72	-	-
D. delphis/D. capensis	Dd/Dc1	820	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 12/17/10

Crew: Greg Campbell, Dave Weller, Lauren Roche

The twenty-fourth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on December 17, 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 Risso's and Pacific white-sided dolphins.

Four hours of field effort covering 42 miles yielded sightings of two groups of bottlenose dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable dolphin movement patterns and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus off the San Diego coastline, December 17, 2010.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, December 17, 2010.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	36	393	-	-
T. truncatus	Tt2	4	51	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 01/20/11

Crew: Greg Campbell, Dave Weller, Alex Kesaris

The twenty-fifth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 20, 2011. 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 Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 54 miles yielded sightings of 10 groups of bottlenose dolphins, one group of Pacific white-sided dolphins and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. The sheer volume of animals that required photo-identification and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

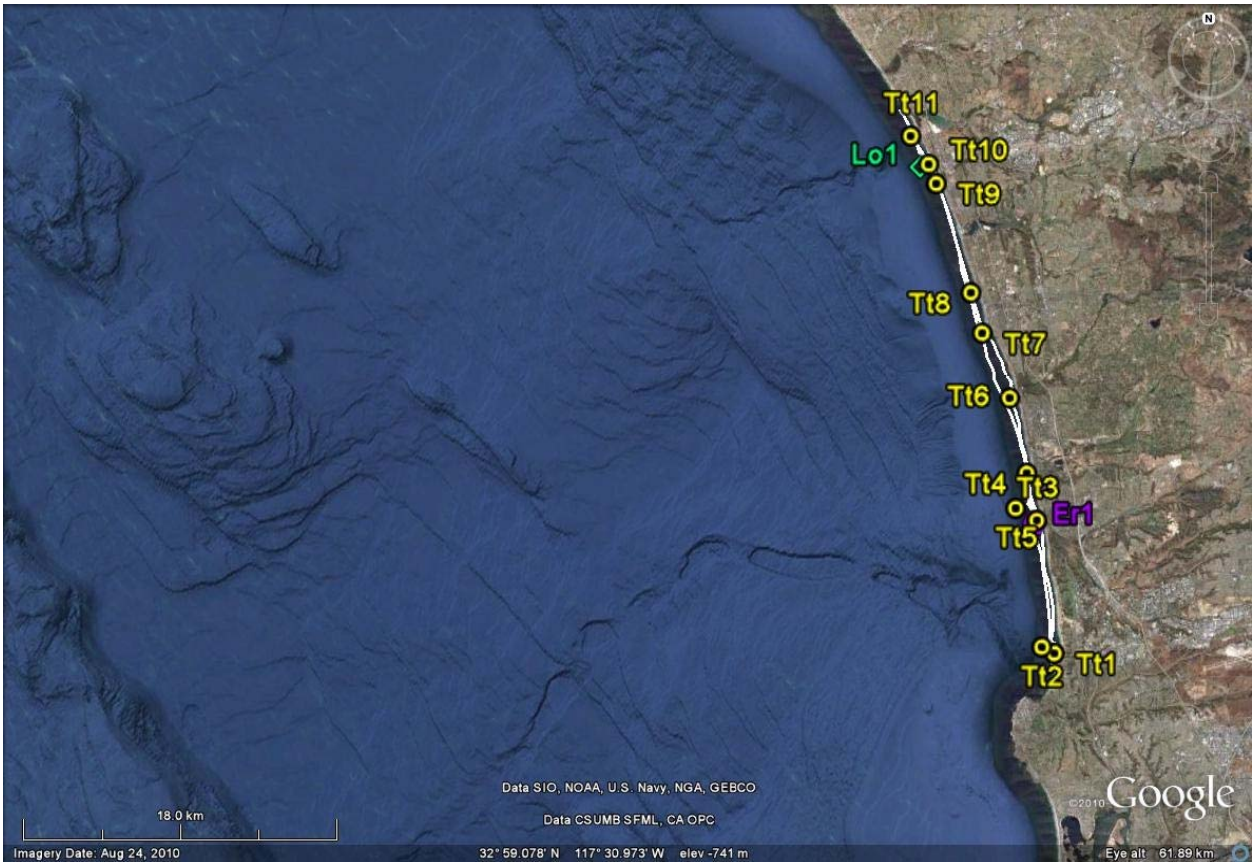

Figure 1. Survey tracks and sighting locations for T. truncatus, L. obliquedens and E. robustus off the San Diego coastline, January 20, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 20, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	13	44	-	-
T. truncatus	Tt2	17	58	-	-
T. truncatus	Tt3	12	74	-	-
T. truncatus	Tt4	2	14	-	-
T. truncatus	Tt5	3	18	-	-
T. truncatus	Tt6	5	35	-	-
T. truncatus	Tt7	7	65	-	-
T. truncatus	Tt8	9	32	-	-
T. truncatus	Tt9	5	48	-	-
T. truncatus	Tt10	4	29	-	-
T. truncatus	Tt11	5	21	-	-
L. obliquedens	Lo1	7	-	-	-
E. robustus	Er1	1	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 01/27/11

Crew: Greg Campbell, Amanda Cummins, Alex Kesaris

The twenty-sixth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on January 27, 2011. 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 54 miles yielded sightings of four groups of bottlenose dolphins, one group of Pacific white-sided dolphins, two groups of common dolphins and two grey whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Variable dolphin movement patterns and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

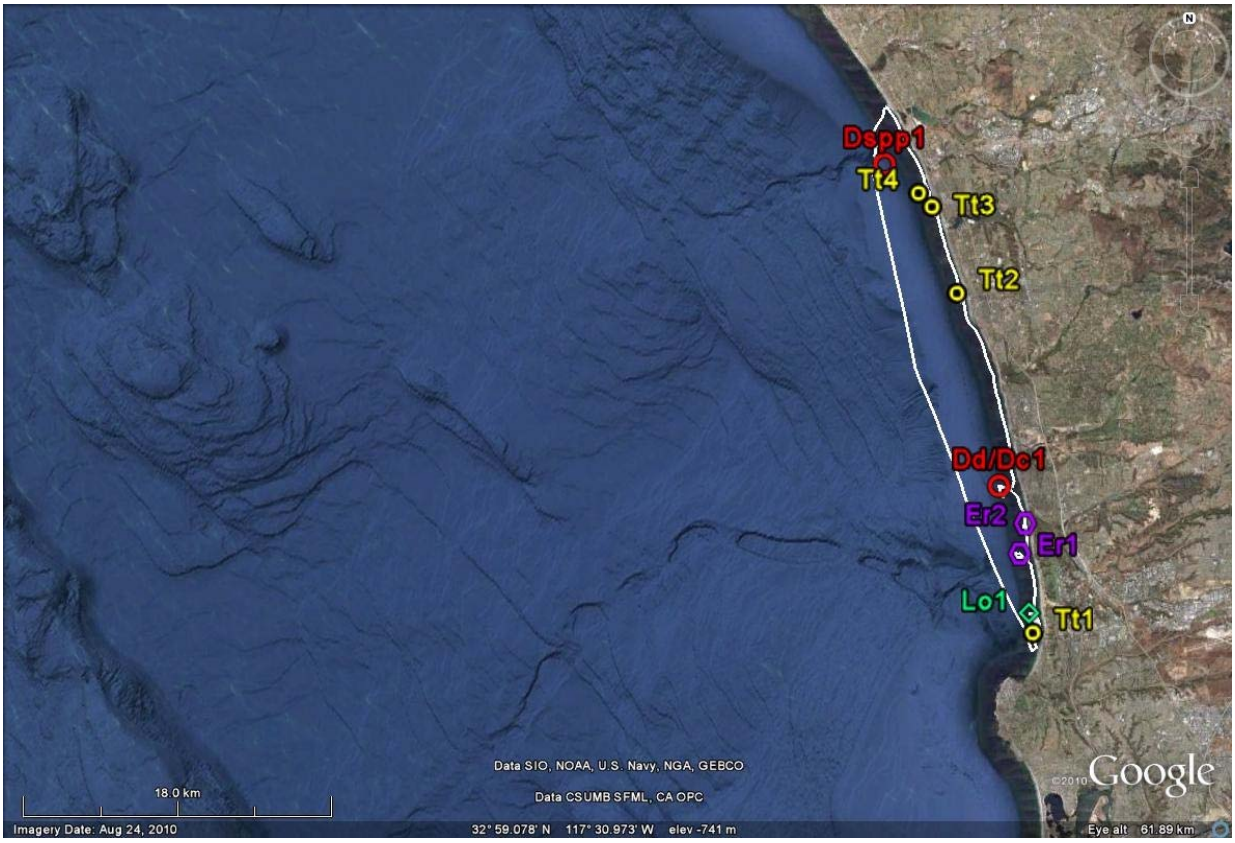

Figure 1. Survey tracks and sighting locations for T. truncatus, L. obliquedens, D. delphis, D capensis and E. robustus off the San Diego coastline, January 27, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, January 27, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	30	215	-	-
T. truncatus	Tt2	7	23	-	-
T. truncatus	Tt3	2	11	-	-
T. truncatus	Tt4	9	23	-	-
L. obliquedens	Lo1	8	4	-	-
D. delphis/D. capensis	Dd/Dc1	50	5	-	-
D. Spp	Dspp1	41	-	-	-
E. robustus	Er1	1	1	-	-
E. robustus	Er2	1	2	-	-

CALIFORNIA COASTAL SAN DIEGO SURVEY – 02/14/11

Crew: Greg Campbell, Amanda Cummins, Sara Kerosky

A small boat cetacean survey concurrent with an aerial survey off the San Diego county coastline was conducted on February 14, 2011. The primary objectives were to use both observation platforms to increase the probability of detection for cetacean species in the region and to confirm species ID and group size estimates.

Seven hours of field effort covering 43 miles yielded sightings of one group of bottlenose dolphins, one group of common dolphins and one unidentified baleen whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

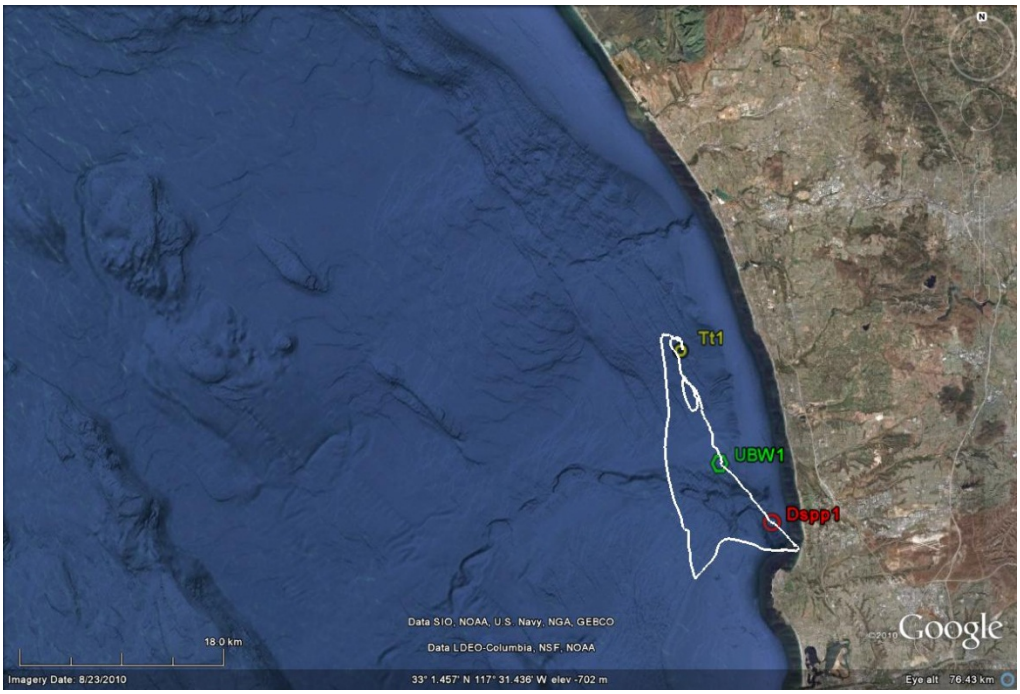

Figure 1. Survey tracks and sighting locations for T. truncatus, D. spp and an unidentified baleen whale off the San Diego coastline, February 14, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 14, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	6	29	-	-
D. spp	Dspp1	12	-	-	-
Unid Baleen Whale	UBW1	9	14	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 02/15/11

Crew: Greg Campbell, Amanda Cummins, Liz Henderson, Alex Kesaris

The twenty-seventh in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 15, 2011. 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 Risso's and Pacific white-sided dolphins.

Seven hours of field effort covering 66 miles yielded sightings of 9 groups of bottlenose dolphins, two groups of short-beaked common dolphins and two grey whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. The sheer volume of animals that required photo-identification and the presence of calves precluded the collection of acoustical data and biopsy samples. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

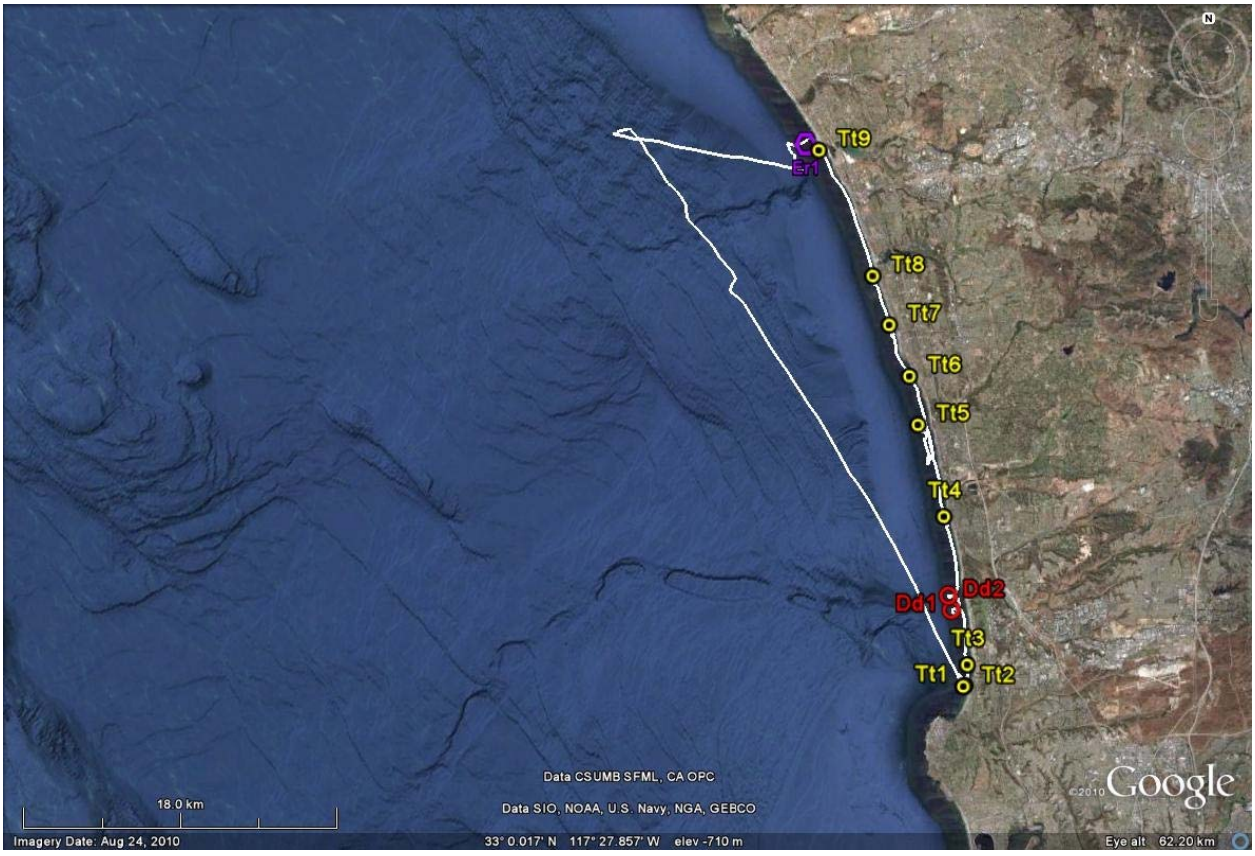

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis and E. robustus off the San Diego coastline, February 15, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 15, 2011

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	15	-	-	-
T. truncatus	Tt2	20	98	-	-
T. truncatus	Tt3	9	67	-	-
T. truncatus	Tt4	8	25	-	-
T. truncatus	Tt5	10	124	-	-
T. truncatus	Tt6	3	54	-	-
T. truncatus	Tt7	18	276	-	-
T. truncatus	Tt8	6	86	-	-
T. truncatus	Tt9	10	68	-	-
D. delphis	Dd1	38	-	-	-
D. delphis	Dd2	300	-	-	-
E. robustus	Er1	2	19	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 02/22/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins

The twenty-eighth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on February 22, 2011. 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 50 miles yielded sightings of two groups of bottlenose dolphins, one group of Pacific white-sided dolphins, and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. One biopsy sample was collected from Pacific white-sided dolphins but the school was lost prior to acoustical data collection. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

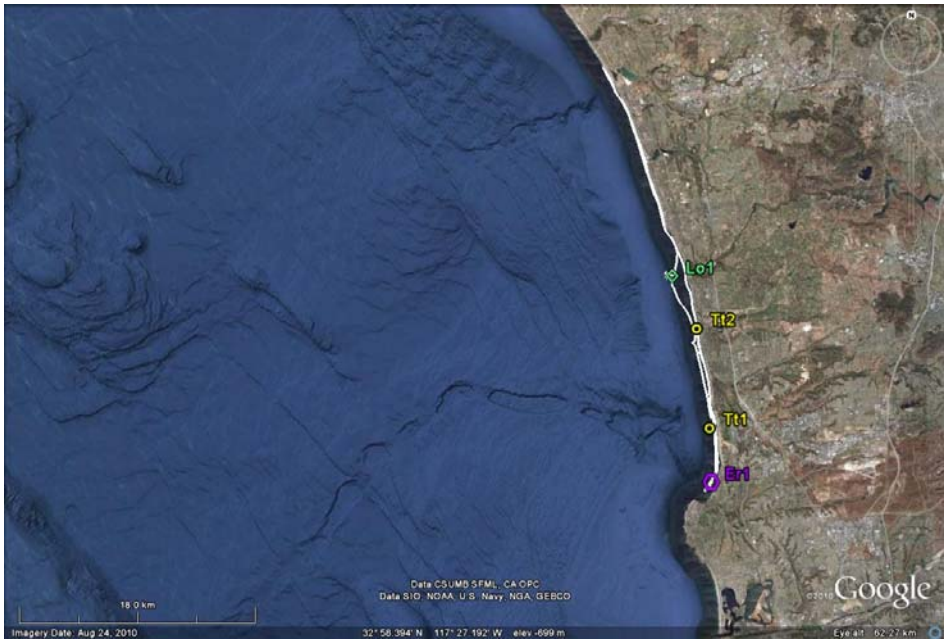

Figure 1. Survey tracks and sighting locations for T. truncatus, L. obliquedens and E. robustus off the San Diego coastline, February 22, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, February 22, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	17	305	-	-
T. truncatus	Tt2	20	286	-	-
L. obliquedens	Lo1	11	75	-	1
E. robustus	Er1	1	11	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 03/16/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins

The twenty-eighth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 16, 2011. 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 49 miles yielded sightings of five 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. Large swell and variable dolphin movement patterns precluded the collection of biopsy and acoustical data. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

Figure 1. Survey tracks and sighting locations for T. truncatus and L. obliquedens and off the San Diego coastline, March 16, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 16, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	15	263	-	-
T. truncatus	Tt2	8	94	-	-
T. truncatus	Tt3	2	7	-	-
T. truncatus	Tt4	3	19	-	-
T. truncatus	Tt5	4	9	-	-
L. obliquedens	Lo1	3	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 03/23/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Kait Frasier

The twenty-ninth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on March 23, 2011. 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 49 miles yielded sightings of four groups of bottlenose dolphins and one group of long-beaked common dolphins (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. Acoustical recordings of bottlenose dolphins (Tt1) yielded high-quality whistles, clicks and buzzes. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

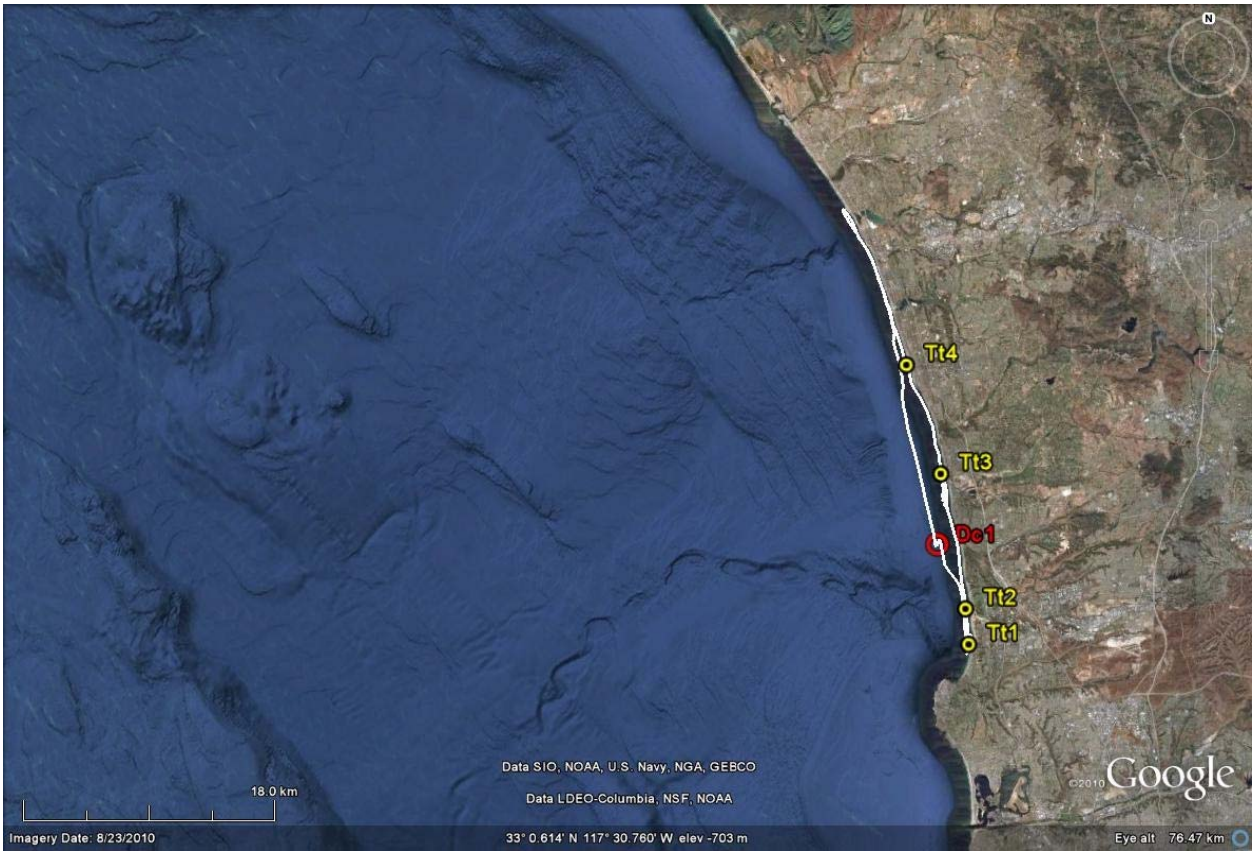

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis/D. capensis and E. robustus off the San Diego coastline, March 23, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, March 23, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	26	198	3	-
T. truncatus	Tt2	5	32	-	-
T. truncatus	Tt3	10	110	-	-
T. truncatus	Tt4	9	42	-	-
D. capensis	Dc1	52	17	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 04/19/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Alex Kesaris

The thirtieth in a series of small boat cetacean surveys off the San Diego county coastline was conducted on April 19, 2011. 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 59 miles yielded sightings of 10 groups of bottlenose dolphins, one mixed group of short and long-beaked common dolphins and one grey whale (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins encountered. The survey included a noteworthy observation (Tt6) of a mom carrying her dead calf across the front edge of her dorsal fin. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

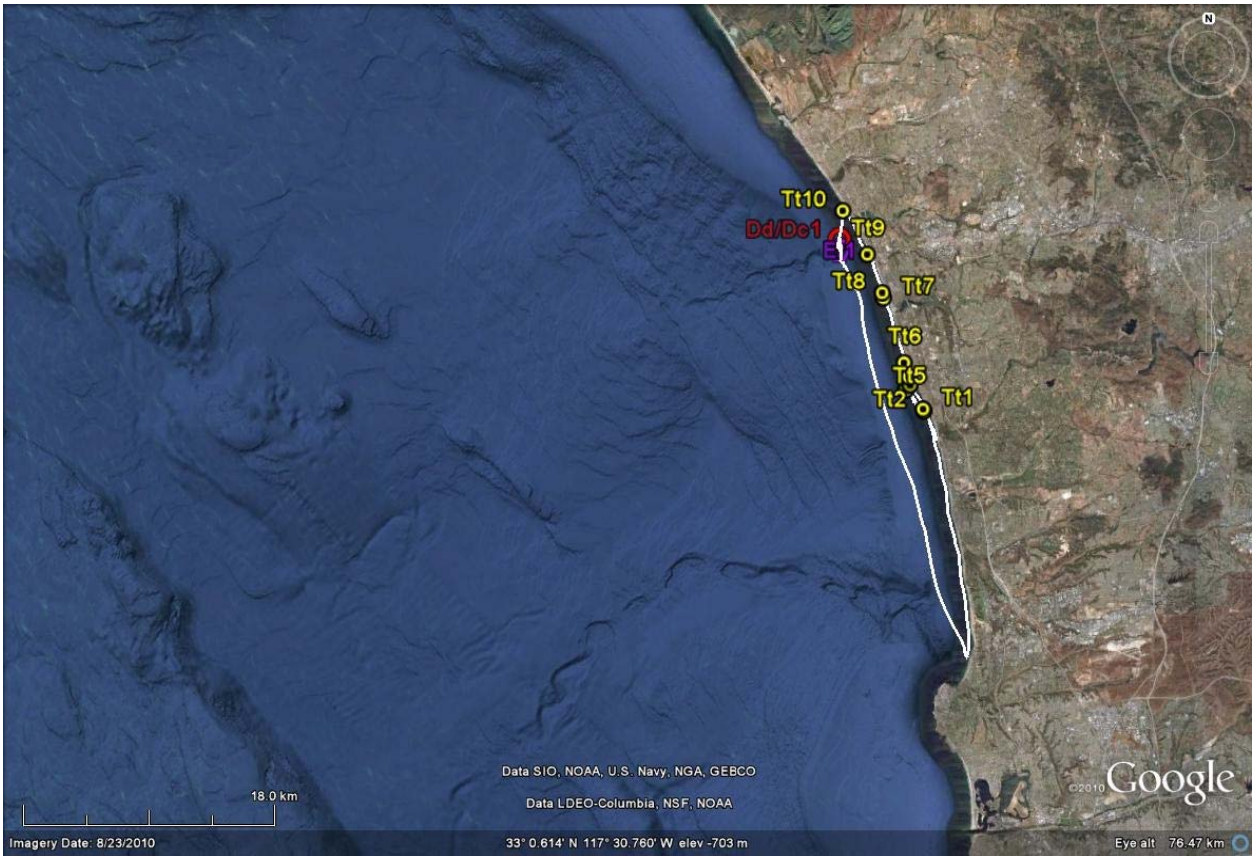

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis/D. capensis and E. robustus off the San Diego coastline, April 19, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, April 19, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	12	199	-	-
T. truncatus	Tt2	6	42	-	-
T. truncatus	Tt3	2	22	-	-
T. truncatus	Tt4	5	21	-	-
T. truncatus	Tt5	4	20	-	-
T. truncatus	Tt6	5	61	2	-
T. truncatus	Tt7	2	11	-	-
T. truncatus	Tt8	3	12	-	-
T. truncatus	Tt9	8	46	-	-
T. truncatus	Tt10	2	7	-	-
E. robustus	Er1	1	1	-	-
D. delphis/ D. capensis	Dd/Dc1	640	-	-	-

CALIFORNIA COASTAL BOTTLENOSE DOLPHIN ABUNDANCE SURVEY – 07/07/11

Crew: Greg Campbell, Dave Weller, Amanda Cummins, Alex Kesaris

The thirty-third in a series of small boat cetacean surveys off the San Diego county coastline was conducted on July 7, 2011. 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 Risso's and Pacific white-sided dolphins.

Six hours of field effort covering 52 miles yielded sightings of four groups of bottlenose dolphins, one group of short-beaked common dolphins, two groups of unidentified common dolphins and three groups of blue whales (Figure 1). Photo-identification efforts produced high quality images from a large proportion of bottlenose dolphins and blue whales encountered. The survey included a noteworthy observation (Bm3) of a blue whale with distinct propeller scars, which has been submitted to the NMFS regional office. Additional details on sighting, photo-identification, acoustical and biopsy data are provided in Table 1.

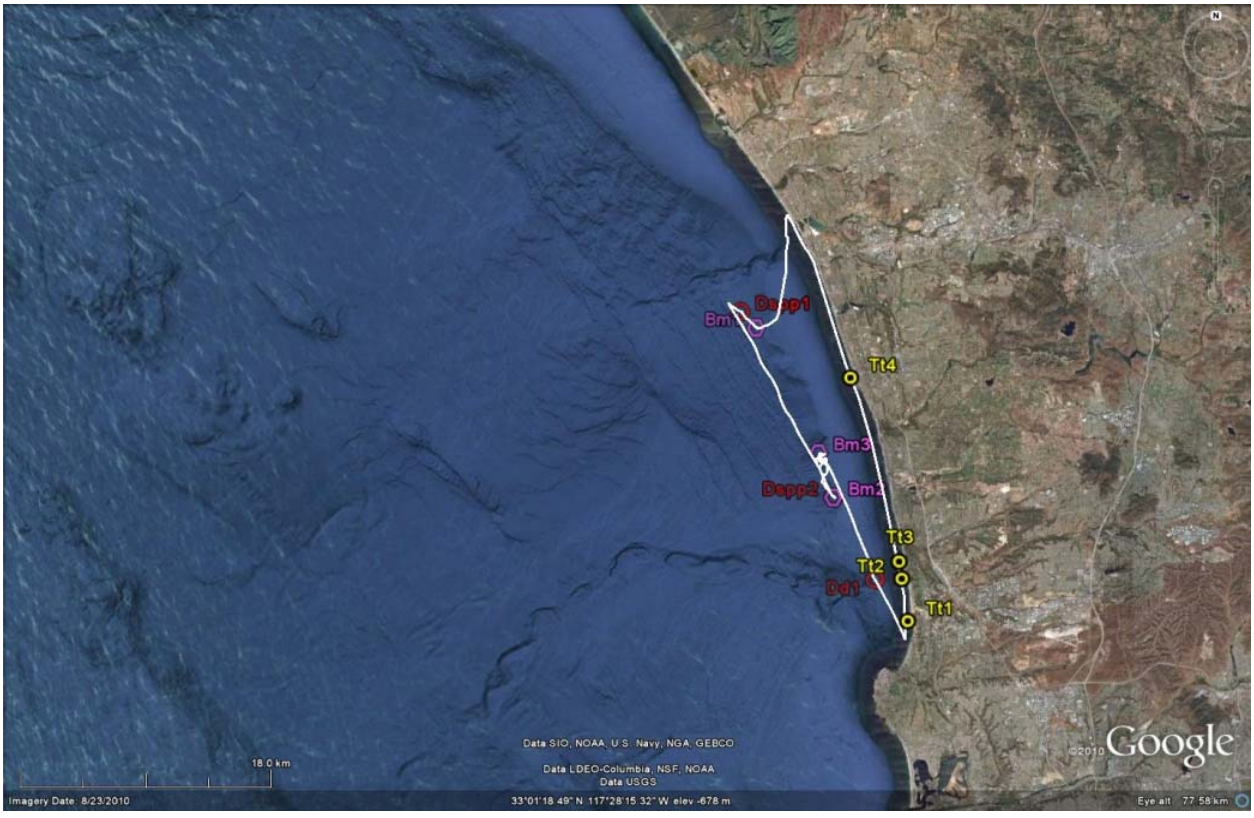

Figure 1. Survey tracks and sighting locations for T. truncatus, D. delphis/D. capensis and E. robustus off the San Diego coastline, July 7, 2011.

Table 1. Summary information on sighting, photo-identification, acoustical and biopsy data collected off the San Diego coastline, July 7, 2011.

Species	Group ID	Number of Individuals	Number of ID Images	Number of Recordings	Number of Biopsies
T. truncatus	Tt1	27	113	-	-
T. truncatus	Tt2	8	45	1	-
T. truncatus	Tt3	7	35	-	-
T. truncatus	Tt4	1	4	-	-
B. musculus	Bm1	1	28	-	-
B. musculus	Bm2	1	21	-	-
B. musculus	Bm3	1	32	-	-
Delphinus spp	Dspp1	10	-	-	-
Delphinus spp	Dspp2	6	-	-	-
D. delphis	Dd1	750	-	-	-