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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

by

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14. ABSTRACT

In the first year of a three-year project, from June 2010 to June 2011 small boat-based surveys for cetaceans were conducted in the U. S. Navy's SOCAL training range, particularly in the Southern California Anti-Submarine Warfare Range (SOAR) and the Southern California Offshore Range (SCORE) centered on San Clemente Island in the Southern California Bight. Surveys included species verification tests, photo-identification, satellite tagging, and biopsy sampling. Because of their apparent sensitivity to Mid-Frequency Active Sonar (MFAS) throughout the world, beaked whales—Cuvier's, in particular—and fin whales were the primary target species.

During 33 surveys conducted during the study period (including in January and May, times not previously surveyed by small boat in this area), 164 groups of cetaceans were encountered at or near SOAR. To address distribution and habitat use, 20 satellite tags (some with depth-reporting capability) were deployed on 6 species. Depth-reporting tags on Cuvier's whales recorded multiple dives > 2000 m and > 2 hours, both deeper and longer than previously reported for this species. Preliminary results of photo-identification data (supplemented by satellite tag data) suggest that Cuvier's and fin whales both may have population sub-units with higher than expected residency in the Southern California Bight. Comparison of movement and dive behavior of tagged whales with concurrent MFAS exercises at SCORE is underway.

15. SUBJECT TERMS

Cuvier's beaked whale, fin whale, Risso's dolphin, beaked whales, satellite tagging, LIMPET tags, photo-identification, M3R, Southern California Bight, SOAR, SCORE, mid-frequency active sonar (MFAS).

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Summary

The SOCAL range complex is one of the US Navy's most active naval training areas, particularly concerning the use of Mid-Frequency Active Sonar (MFAS). Much of SOCAL lies within the Southern California Bight, a productive oceanographic region that hosts a wide variety of marine species. While there is some information on basic assemblages of cetacean species within the bight, detailed knowledge of many species' distribution, habitat use, and population dynamics, particularly with respect to designated training areas, is not clearly understood. From June 2010 through June 2011 we conducted small-boat based surveys for cetaceans throughout SOCAL with an emphasis on the Southern California Anti-submarine Warfare Range (SOAR), west of San Clemente Island. These surveys included species verification tests and photo-identification, satellite tagging, and biopsy sampling of species of interest, and represent the first year of a three-year project. Thirty-three surveys were conducted throughout the year covering more than 4700 km of track line, which included effort in January and May, months not covered during our previous studies in the region. We encountered 164 groups of cetaceans, including 14 groups of Cuvier's beaked whales, our highest priority species given its apparent sensitivity to MFAS in other parts of the world, at or near SOAR. To address distribution and habitat use, and in some cases begin to assess behavioral response to anthropogenic impacts, twenty satellite tags were deployed on six species and one possible hybrid, with an emphasis on Cuvier's beaked whales and fin whales. These tags provided location data for tagged individuals over periods up to 124 days (median = 25 days). Five Cuvier's beaked whales were tagged with prototype depth-reporting satellite tags, which collected over 3800 hours of dive data in addition to movements. These tags recorded multiple dives to over 2000m depth and over 2 hours in duration, both deeper and longer than has been previously reported from this species through other means. A comparison of movement and dive behavior from tagged whales to concurrent MFAS exercises is currently underway, which will provide insight into how these animals interact with training on realistic temporal and spatial scales. Seven tags were deployed on fin whales, providing detailed information to the movements and habitat use of this species both within the Southern California Bight and between adjacent regions. This information will be vitally important to the management of this Endangered Species Act (ESA) listed species, whose population structure and migratory patterns are poorly described. Preliminary results of photo-identification studies, in addition to results from satellite tag data, suggest that both Cuvier's beaked whales and fin whales may have population sub-units with higher than expected residency to the Southern California Bight, and to SOAR in particular in the case of beaked whales. These results can have broad implications to the future management of these two species locally.

Introduction

The US Navy manages the Southern California Offshore Complex (SOCAL), a collection of near shore and offshore training areas which includes many of the waters from Santa Barbara, CA, south to Northern Baja California, Mexico, 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 60 km west of the island[1]. 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 Bight, 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 hydrophone array. NUWC developed a suite of passive acoustic tools to monitor vocal cetacean species using the Atlantic Undersea Test and Evaluation Center (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, due both 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 were 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,

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

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 the National Marine Fisheries Service (NMFS) as a single stock, estimated at approximately 2000 individuals as of the most recent stock assessment report (Carretta *et al*. 2010). 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 beaked whales 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 during the first verification test conducted 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 not only that they were present on the range, but also 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 which was estimated at approximately 3000 individuals in the most recent stock assessment report (Carretta *et al*. 2010), from California to Washington State. There are 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), including collisions with naval vessels at and near SOAR. While this species will sometimes utilize coastal habitat, the majority of fin whales are sighted along the US West Coast 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, underscore 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 not previously available, including photo-identification, genetics, and satellite telemetry, to collect detailed data from this offshore species.

By 2010, the fifth survey season for visual verification tests at SOAR, the majority of regularly encountered species could be reliably identified acoustically using M3R. However, prior to initial surveys in 2010 the array was substantially upgraded. An additional 89 phones were placed within the existing range boundaries, with expanded bandwidth to ~50 Hz to ~45 kHz, which for the first time would in theory allow for the detection of some large baleen whales with the M3R system.

Methods

Surveys were conducted using a 6m rigid-hulled inflatable boat (RHIB), powered by two 75 hp 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 these 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 were 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 (beaked, fin, blue, humpback, and killer whales; bottlenose and Risso's dolphins) where this methodology is being employed during this study or by collaborators. 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 (SWFSC) 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*. 2008, 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 4.5 cm (small species, e.g. Risso's dolphins) or 6.5 cm (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 were processed with the Douglas Argos-Filter version 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 version 9.2 (ESRI, Redlands, California). Dive data were 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 were collected during these months since small-boat surveys at SCORE began in 2006.

Table 1. Summary of survey effort by day, June 2010-June 2011. (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**

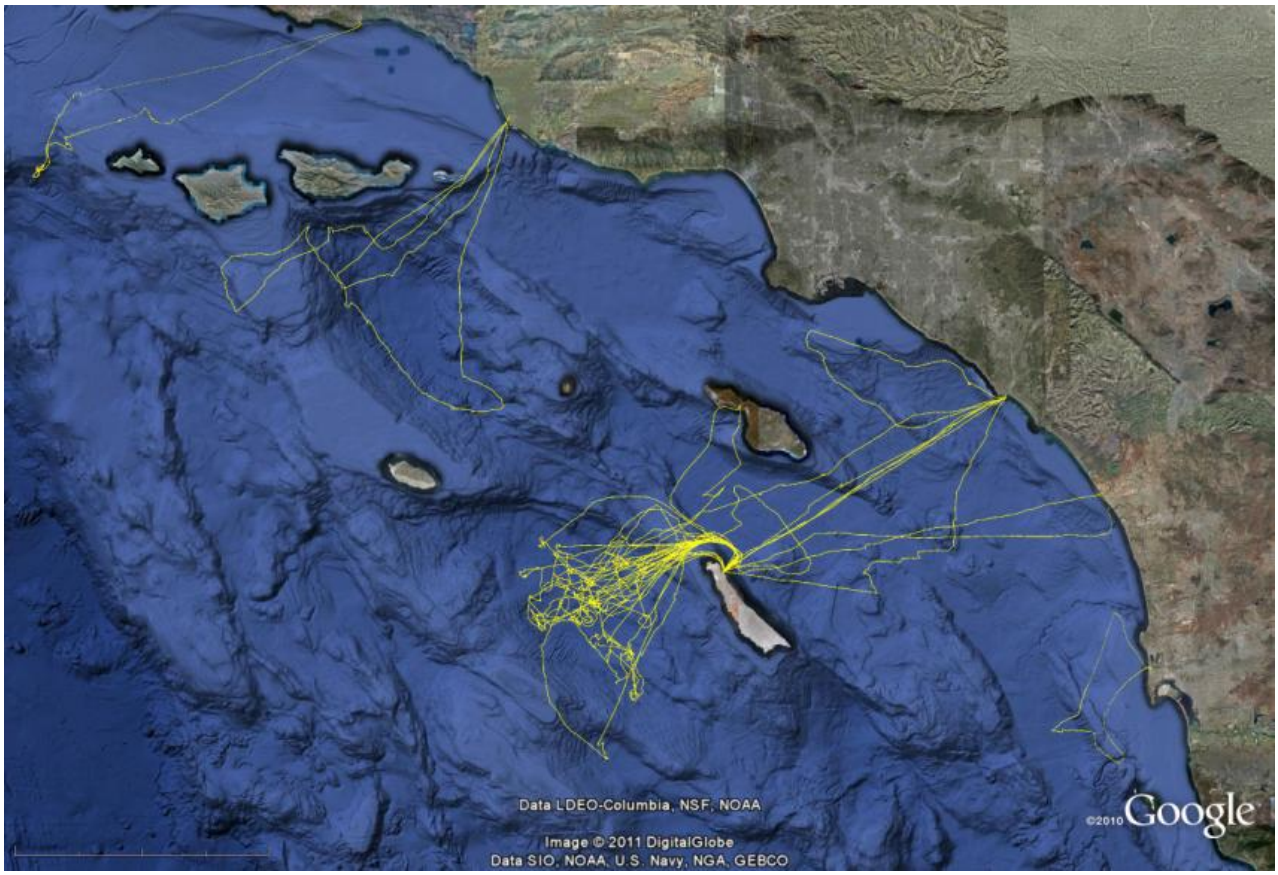

Figure 1. Vessel track lines from surveys conducted June 2010-June 2011.

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 were much lower than have 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 2A). 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 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			

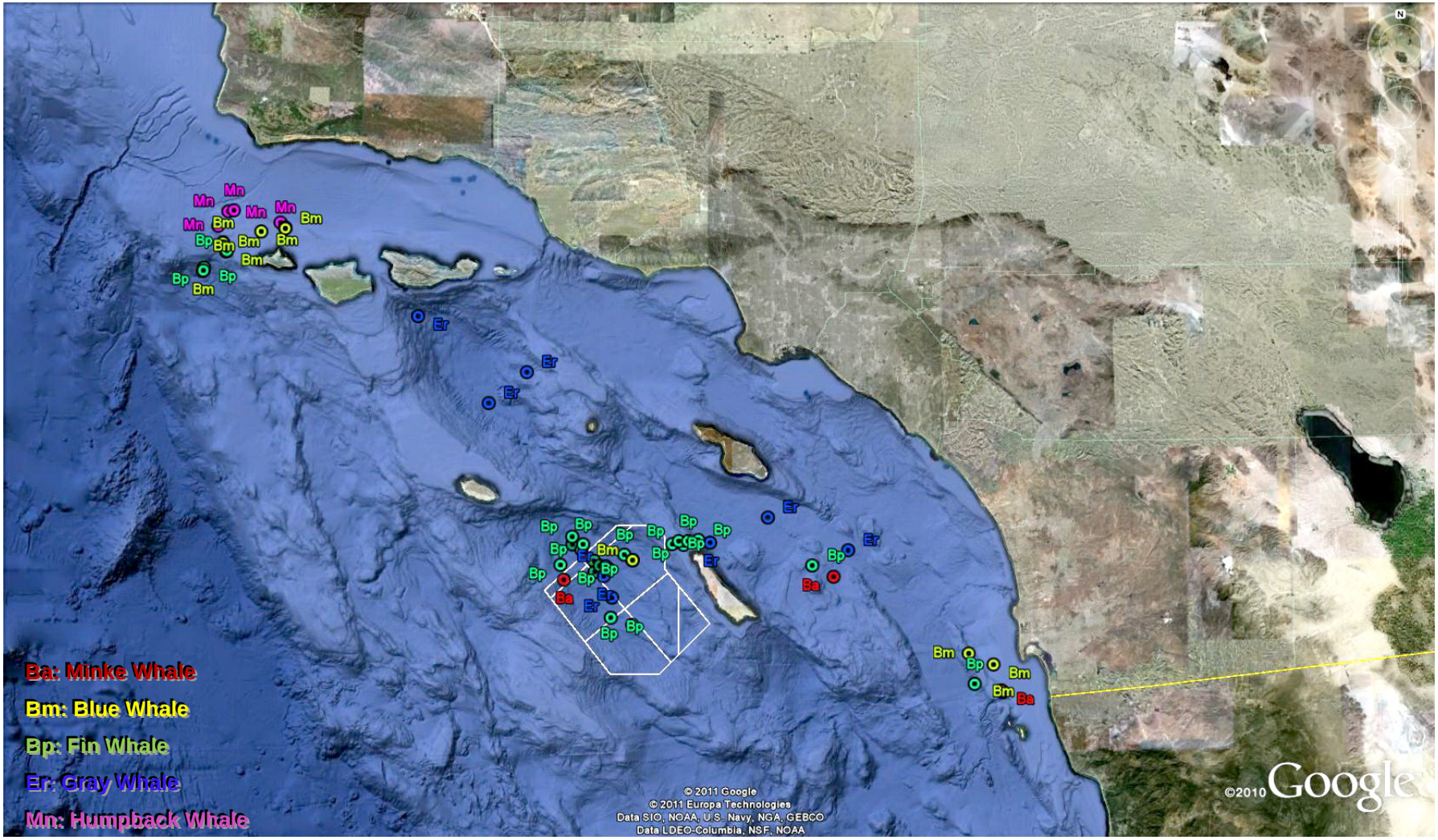

Figure 2A. Sightings of baleen whales, June 2010-June 2011. Of note were frequent sightings of southbound gray whales transiting through the center of SOAR in January.

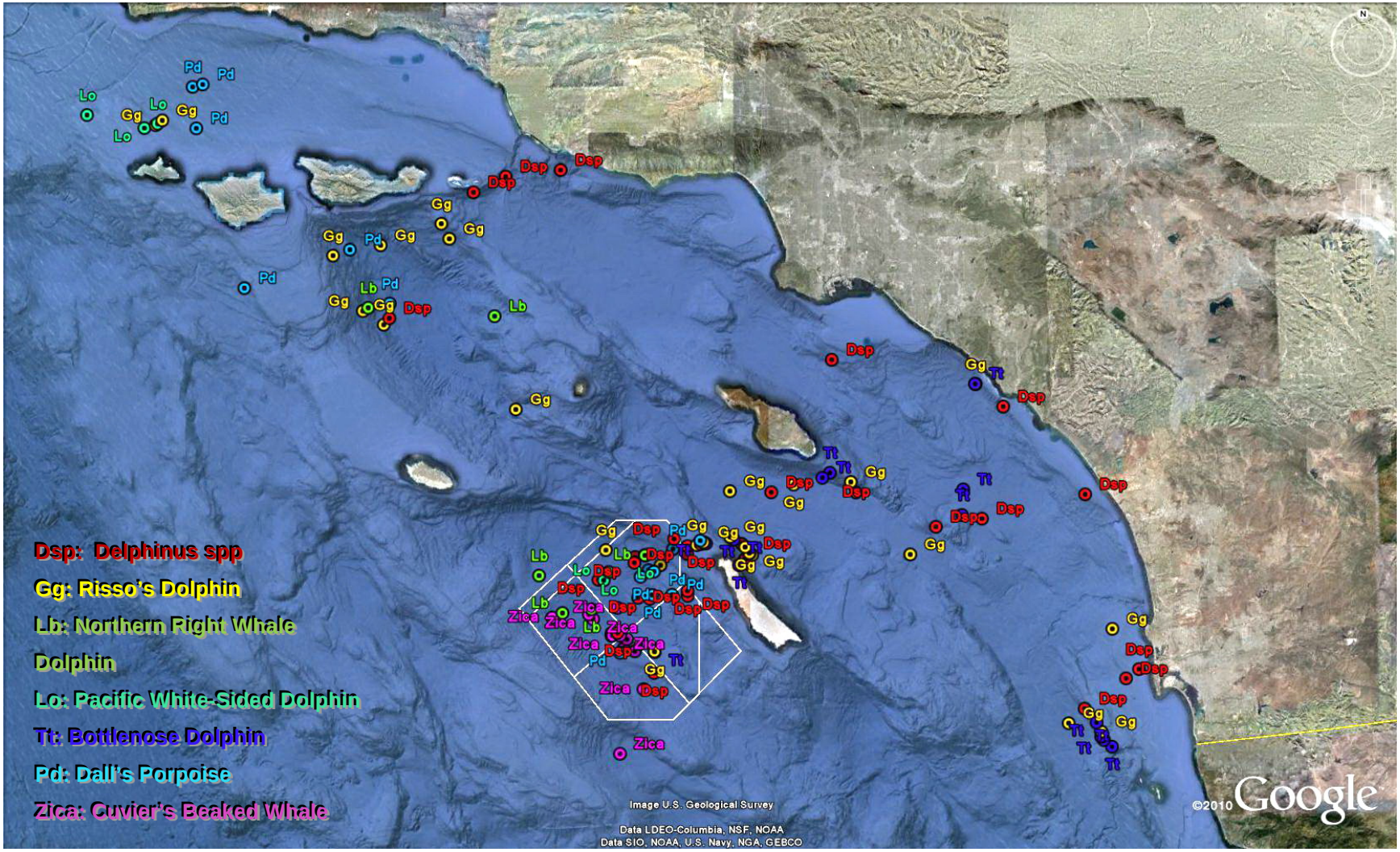

Figure 2B. Sightings of odontocetes, June 2010-June 2011. In general the distribution was similar to previous years, though both Dall's porpoise and northern right whale dolphins were encountered more frequently in surveys in winter and spring than in other times of year.

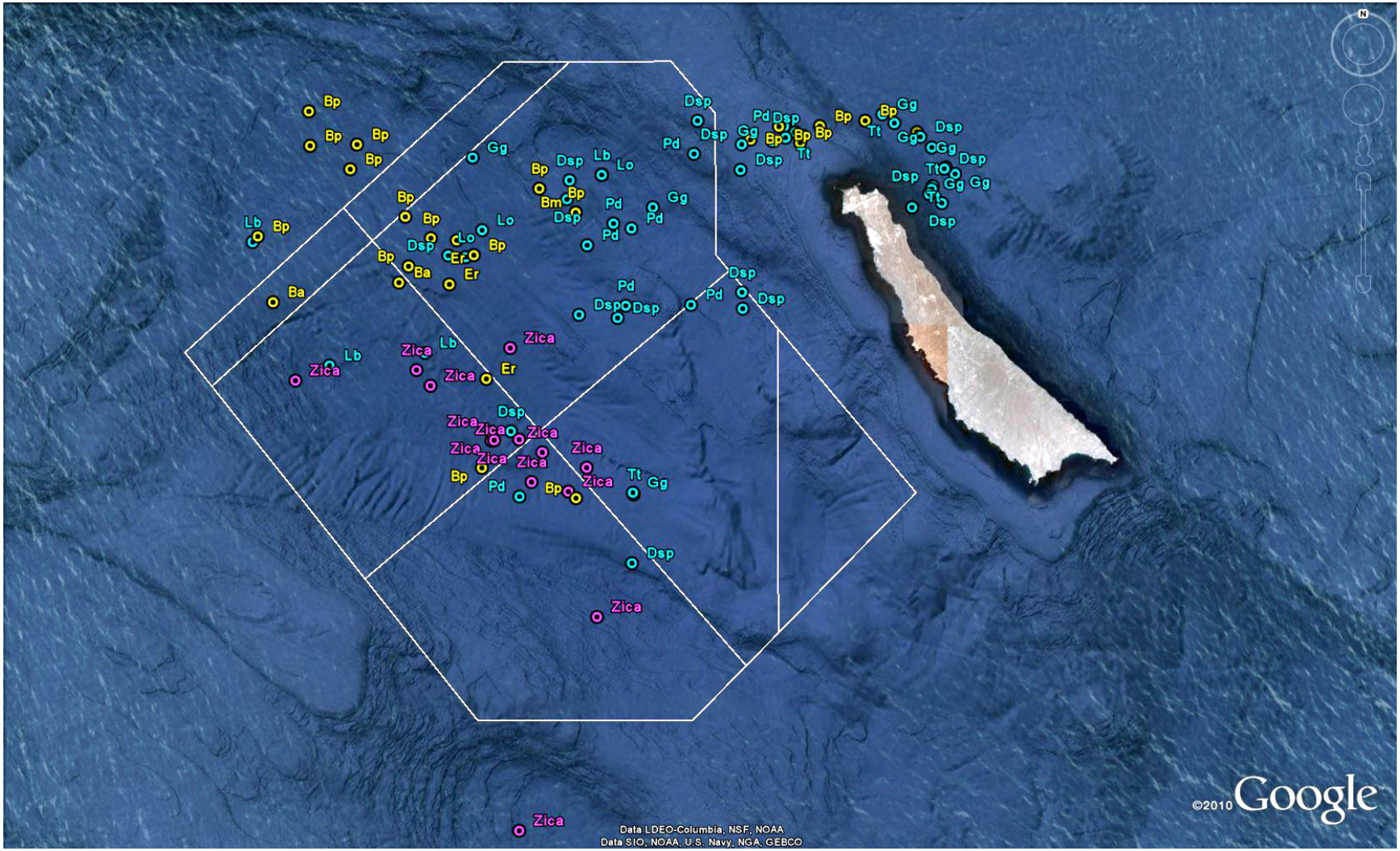

Figure 2C. A detail of cetacean sightings in and around SOAR, June 2010-June 2011, with baleen whale species in yellow, small odontocetes in blue, and Cuvier's beaked whales in pink.

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 field work 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 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.

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

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 (Table 4). 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. 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 1330 m and average minimum-straight line movements between locations suggested movement rates of 1.8 km/hr (Table 4). Over 3800 hours of dive behavior were 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 1500 m and two of the individuals had dives to depths greater than 2000 m. 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 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	2.0	64.3	-1723.6
Zc016	89	1826.0	26.1	103.2	1.6	40.8	-1263.1

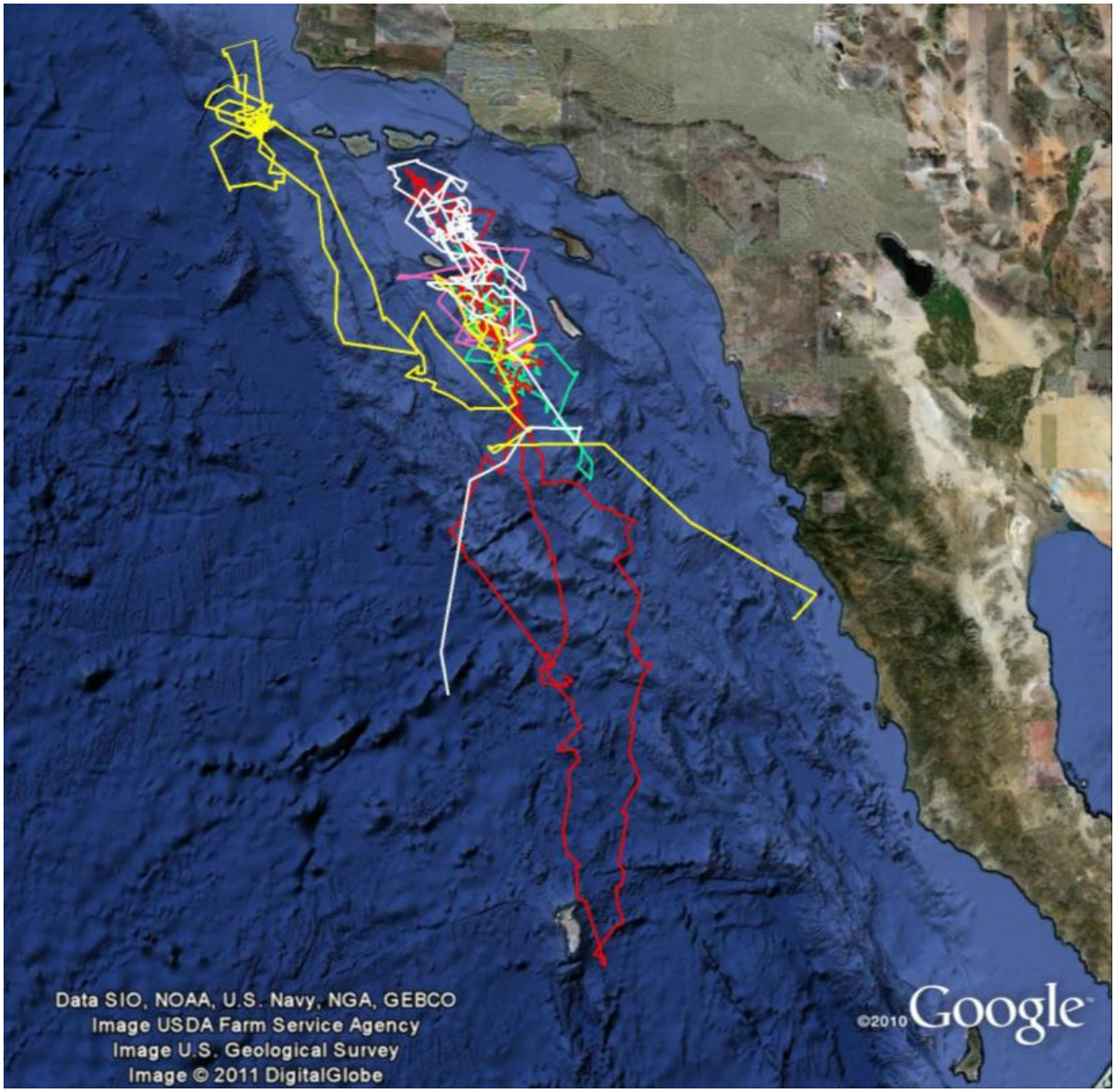

Figure 3. Movements of five Cuvier's beaked whales.

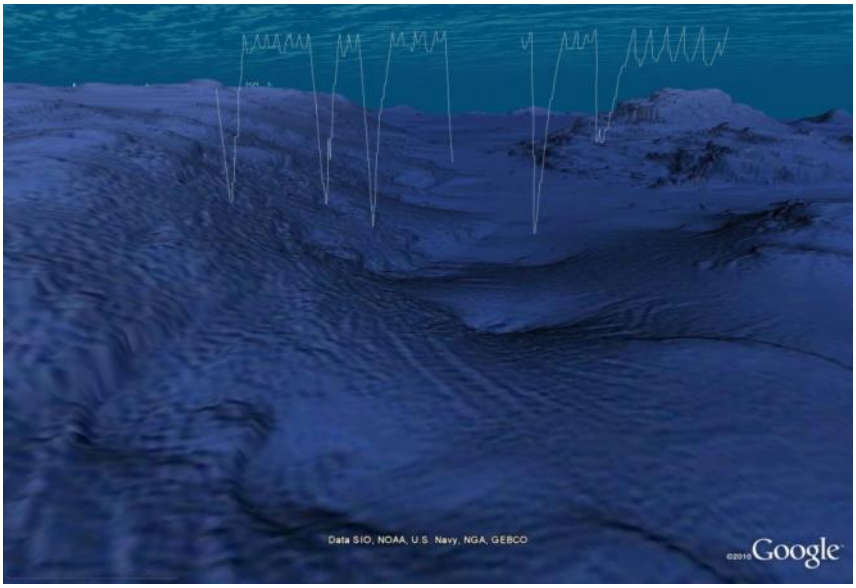

Figure 4. A combination of interpolated tracks from Argos location data and concurrent dive behavior allows for a rough assessment of dive behavior in relation to bathymetric features. Here, a portion of Zc Tag 011 dive log is displayed with a 3D view of local bathymetry.

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 were still transmitting at the time of this report, and therefore are 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, with maximum distance to deployment among all tags being 320 km (Bp Tag 021, with transmission duration of 124 days). Two of the whales made forays out of the Southern California Bight north of Point Conception, with one whale (Bp Tag 021) spending two months off 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 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 for future management the fin whale population that utilizes habitat within the Bight.

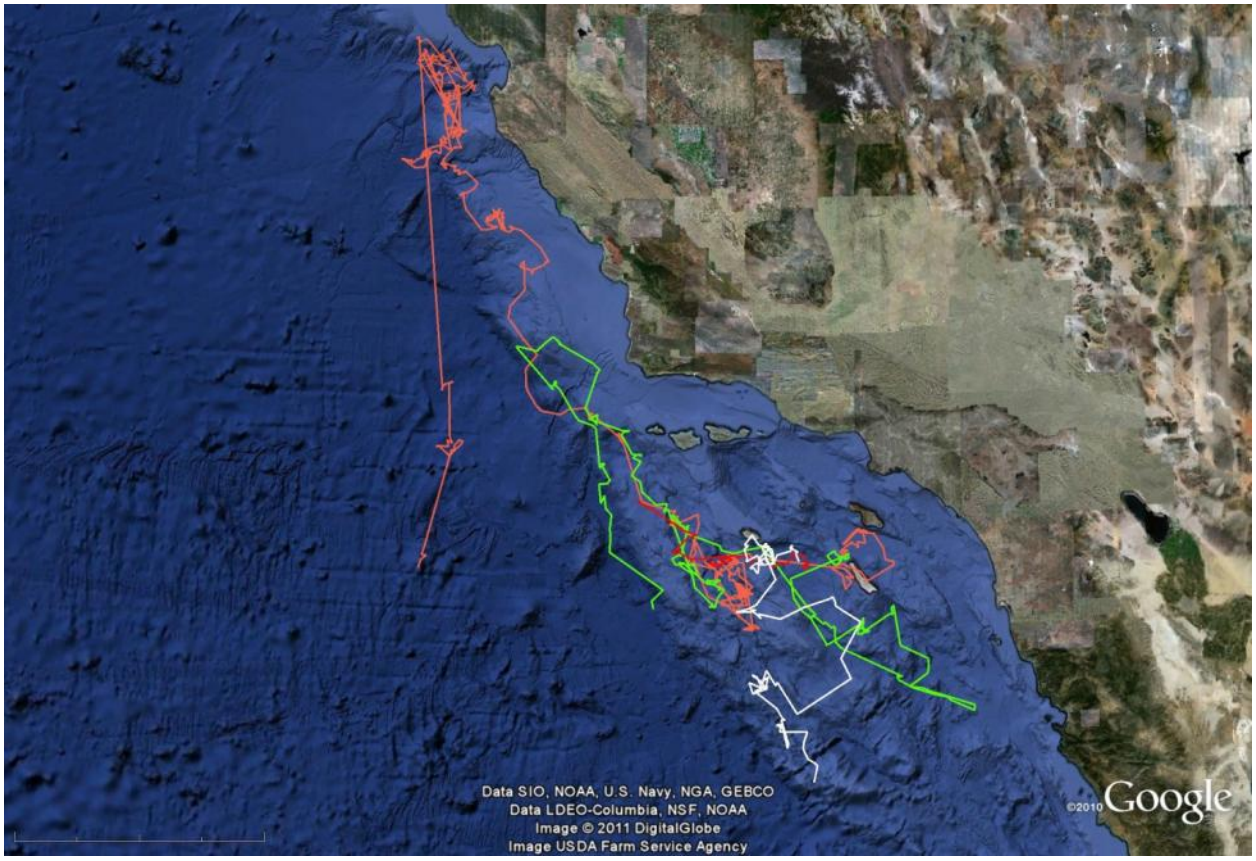

Figure 5. Movement of fin whales tagged in the San Nicolas Basin during the contract period.

Risso's dolphins

Four LIMPET tags were deployed on Risso's dolphins, three location-only and one dive-depth reporting (and still transmitting at the time of this report). The median transmission duration was 12 days (range = 7 – 20 days). 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), Risso's dolphins spent the majority of time in deep water basins, away from the islands and the mainland coast. Grand mean bottom depth was 947.4 m and distance to shore was 25.6 km (Figure 6). Excluding one animal whose tag is 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, but 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	20.0	1427.1	68.6	154.7	2.6	27.3	-967.7
Gg Tag 004	12.0	841.3	87.4	148.7	3.4	26.5	-974.4
Gg Tag 005	7.0	504.2	36.1	66.3	3.1	23.0	-900.1
Gg Tag 006	*still Transmitting*						

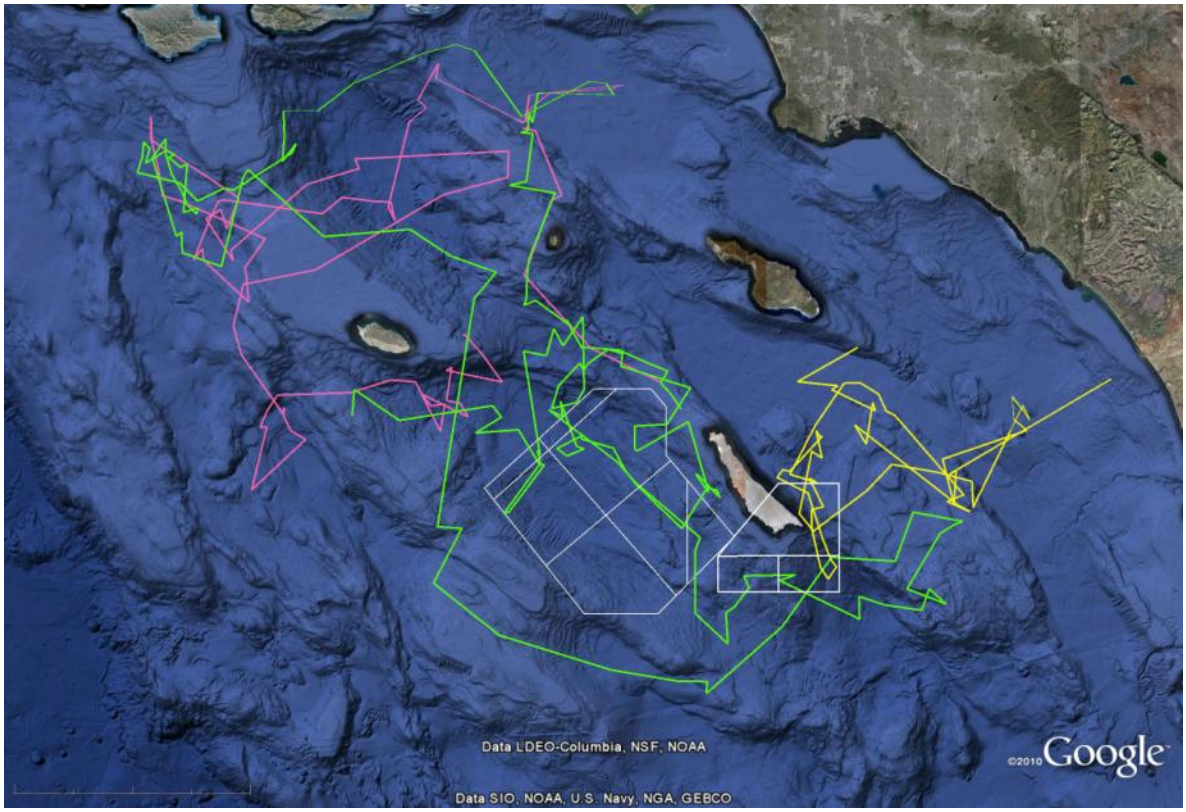

Figure 6. Map showing movements of three tagged Risso's Dolphins, June 2010 through May 2011. Note the SOAR and SHOBA ranges outlined in white.

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, make 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 project will substantially improve the management of these two species. We also hope that these results will contribute to a behavioral framework in which to evaluate the results of experimental sonar exposure studies, underway concurrently in the region.

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Literature Cited

Andrews, R. D., R. L. Pitman, and L. T. Ballance. **2008**. Satellite tracking reveals distinct movement patterns for Type B and Type C killer whales in the southern Ross Sea, Antarctica. *Polar Biology* **31**: 1461-1468. **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* **10**: 107-121. **doi.10.3354/esr00258**.

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

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, E. Oleson, K. Martien, M. M. Muto, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R. L. Brownell Jr., J. Robbins, D. K. Mattila, K. Ralls, and M. C. Hill. **2010**. U.S. Pacific Marine Mammal Stock Assessments: 2010. U.S. Department of Commerce, *NOAA Technical Memorandum* **NOAA-TM-NMFS-SWFSC-476**. 352pp.

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* **NOAA-TM-NMFS-SWFSC-406**. 27pp.

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-25**, 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* **10**: 203-213. **doi:10.3354/esr00229**.

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.

Schorr, G. S., E. A. Falcone, D. J. Moretti, R. W. Baird, D. L. Webster, M. B. Hanson, and R. A. Andrews. **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.

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 I. T. Show. **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.

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