



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

**DISTRIBUTION AND DEMOGRAPHICS OF MARINE
MAMMALS IN SOCIAL THROUGH PHOTO-IDENTIFICATION,
GENETICS, AND SATELLITE TELEMETRY: A SUMMARY OF
SURVEYS CONDUCTED 1 JULY 2011 – 15 JUNE 2012**

by

Erin A. Falcone and Gregory S. Schorr

August 2012

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Energy and Environmental Readiness Division,
Washington, D.C.

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14. ABSTRACT Results from the second year of a three-year project investigating the distribution, demographics, and behavior of cetaceans in the US Navy's Southern California operational area are summarized. Eighteen small vessel surveys for cetaceans, which included species verification tests in conjunction with M3R (Marine Mammal Monitoring on Navy Undersea Ranges) acoustic monitoring at the Southern California Anti-submarine Warfare Range (SOAR), as well as photo-identification, satellite tagging, and biopsy sampling of species of interest, were conducted in July 2011 and January and March 2012. 112 groups of 14 cetacean species were encountered. Twenty-one satellite tags, some depth reporting, were deployed on four species, with an emphasis on Cuvier's beaked and fin whales. Among other findings, preliminary results of photo-identification studies combined with 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. Beaked whales particularly show this higher than expected residency to SOAR.					
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**Distribution and Demographics of Marine Mammals in SOCAL through
Photo-Identification, Genetics, and Satellite Telemetry:
A summary of surveys conducted 1 July 2011 – 15 June 2012**

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Annual progress report (year 2 of 3) for Grant N00244-10-1-0050 through the Naval Postgraduate School

Submitted 25 July 2012

Summary

This report summarizes the results of the second year in a three-year project investigating the distribution, demographics, and behavior of cetaceans in the US Navy's SOCAL operational area. From June 2011 through June 2012 we conducted small vessel surveys for cetaceans throughout SOCAL with an emphasis on the Southern California Anti-submarine Warfare Range (SOAR), west of San Clemente Island (SCI). These surveys included species verification tests in conjunction with M3R (Marine Mammal Monitoring on Navy Undersea Ranges, Moretti *et al.* 2006) acoustic monitoring at SOAR, as well as photo-identification, satellite tagging, and biopsy sampling of species of interest. Eighteen surveys were conducted in July 2011, January 2012, and March 2012. We encountered 112 groups of 14 cetacean species. Twenty-one satellite tags were deployed on four species, with an emphasis on Cuvier's beaked whales and fin whales. These tags provided location data for periods up to 174 days (median = 17 days). Three Cuvier's beaked whales were tagged with depth-reporting satellite tags, which collected over 720 hours of dive data in addition to movement data to augment the 3800 hours of dive data from beaked whale tags deployed in year one. A manuscript on general diving parameters has been prepared for submission to a peer-reviewed journal, and a comparison of movement and dive behavior from tagged whales to concurrent MFAS (Mid Frequency Active Sonar) exercises is underway, which will provide insight into how these animals interact with military training on realistic temporal and spatial scales. Thirteen tags were deployed on fin whales, providing detailed information on the movements and habitat use of this species both within the Southern California Bight and between adjacent regions. All fin whale tags were deployed in January and March, providing the first significant sample of winter/spring movement data from this species, though most of these whales remained in an apparently stable aggregation immediately off the port of Long Beach throughout their tag deployment periods. 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 and Methods

Detailed background data and survey methods were provided in the year-one progress report for this grant, available as an electronic document through the Naval Postgraduate School at <http://edocs.nps.edu/npspubs/scholarly/TR/2011/NPS-OC-11-005CR.pdf>. There were no substantive changes to these methods in year two.

In addition to the previously described methods, we began compiling concurrent sonar use data for tags deployed on Cuvier's beaked whales in 2010 and 2011 with our collaborators from the Naval Undersea Warfare Center (NUWC), D. Moretti and E. McCarthy. NUWC staff received summaries of exercises involving MFAS on SOAR from the Range Operations Center of the Southern California Offshore Range (SCORE) for periods when tags were actively transmitting. The start and end times and positions for ships involved in these exercises were compiled and provided to Cascadia Research Collective (CRC). Raw Argos positions from each satellite tag deployment were passed through both an Argos filter (Douglas Filter, version 8.02; see 2011 report) and a Bayesian State-Space Model (SSM) to estimate the position of the tagged animal on a 6-hour interval throughout the deployment period (Jonsen *et al.* 2005); each modeled location included 97.5% confidence interval for both the latitude and longitude, thus generating an ellipse of variable size in which the animal was highly likely to occupy during the period. For each position in the SSM that coincided with an exercise on SOAR, the minimum distance from the position to the start and end locations of each ship were calculated. Instances where the tagged whale was likely to be within 100 km of an exercise were identified, and tag positions were then compared against more detailed records of sonar events during the exercise to determine the likely closest point of approach between the whale and the ship. NUWC reviewed hydrophone archives to determine the sonar transmission status of the ship during the approach period. Modeled tag positions during active passes were provided to NUWC for modeling received levels in the area where the whale was likely to have been.

Results and Discussion

Effort and Sightings

A total of 18 successful surveys were conducted during three field efforts during year two; surveys were canceled on three field days due to poor weather conditions. With the exception of most transit days to and from SCI, all surveys included at least some effort on, or adjacent to, SOAR (Table 1, Figure 1), though range access during March 2012 was often limited by conflicting exercises and/or weather conditions, and thus many surveys were focused on the waters immediately north of SCI and SOAR during that effort (within the San Nicolas Basin). March 2012 surveys represent our first data collection during this month at SCORE since surveys began in 2006.

Table 1. Summary of survey effort by day, June 2011-June 2012. (Note that “Totals” for Species is the number of unique species identified throughout the study year, and thus not a summation across days.)

Date	Effort (Hrs)	Distance (Km)	Survey Area	Sightings	Species
21-Jul-2011	2.8	97.0	Dana Point-Wilson Cove	3	2
22-Jul-2011	13.2	220.4	SCORE	11	4
23-Jul-2011	12.6	214.8	SCORE	4	3
24-Jul-2011	10.2	185.2	SCORE	4	4
25-Jul-2011	3.2	119.8	Wilson Cove-Dana Point	4	2
13-Jan-2012	2.9	102.2	Dana Point-Wilson Cove	3	1
14-Jan-2012	11.0	203.7	SCORE	5	4
15-Jan-2012	10.0	194.5	SCORE	8	5
17-Jan-2012	7.7	168.5	SCORE	10	5
18-Jan-2012	8.0	165.9	SCORE	4	4
19-Jan-2012	7.3	95.4	SCORE	8	4
20-Jan-2012	8.5	168.5	Wilson Cove-Long Beach	9	4
14-Mar-2012	5.7	116.9	Dana Point-Wilson Cove	5	3
15-Mar-2012	7.7	118.5	SCORE	4	2
16-Mar-2012	8.0	75.9	SCORE	8	2
19-Mar-2012	4.6	81.5	SCORE	3	3
20-Mar-2012	11.3	187.1	SCORE	13	4
21-Mar-2012	9.3	235.2	SCORE-Dana Point	6	3
18	144.0	2751	Totals	112	14

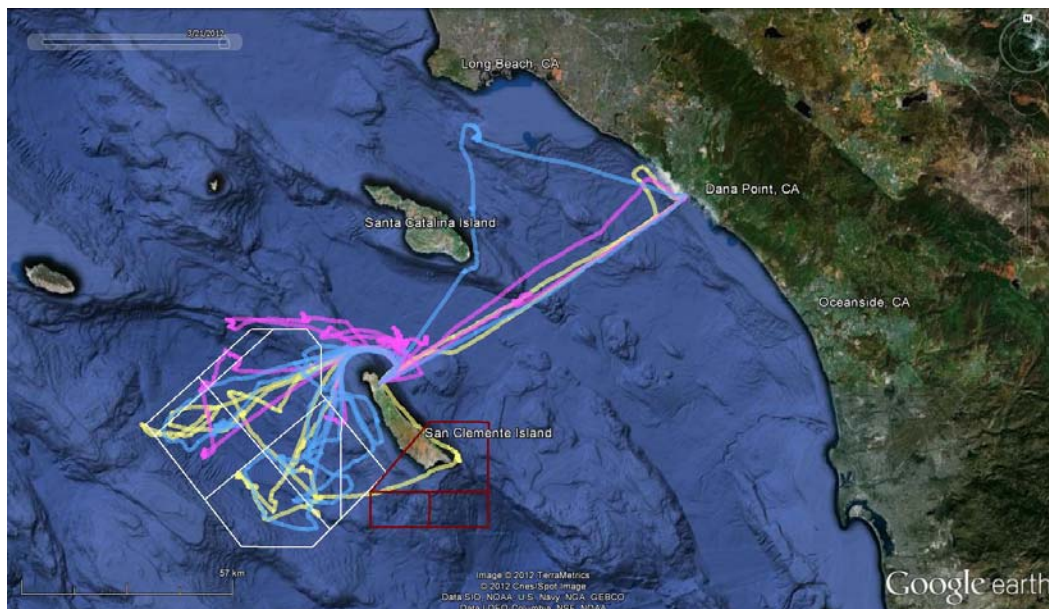


Figure 1. Vessel track lines from surveys conducted in year two. Tracks in yellow are from July 2011, blue from January 2012, and pink from March 2012. SOAR is outlined in white.

Fourteen cetacean species were sighted during these surveys (Table 2, Figures 2A-2B). Species assemblages were similar to those noted in prior surveys, though the species diversity in January 2012 was much higher than was seen in January 2011. The 2012 survey was also longer (7 versus 4 survey days); thus the low density observed in year one may have been an artifact of effort. Gray whales were again among the most frequently detected species in January, though their geographic distribution differed. Gray whales were predominantly sighted traveling south through the central San Nicolas Basin in January 2011; in 2012 they were densely concentrated near shore along both the east and west sides of SCI. Many large whale blows were seen within the three-mile safety zone surrounding the Seabased Weapons Advanced Tactics (SWAT) zones around the north end of the island during daily transits to and from SOAR. These sightings could not be approached for detailed data collection and species confirmation, but, based on sightings in and around Wilson Cove just to the south, they were likely gray whales. Opportunistic observations from shore suggested gray whales were also regularly occurring in the Mine Training Range on the northwest corner of the island, and boat-based sightings further south along the west coast of the island included whales that were milling in a limited area rather than engaged in directed travel through the area, as is more typical of gray whales in Southern California at this time of year.

There were several other notable sightings. A group of 12 transient killer whales were encountered traveling northeast across SOAR on 18 January 2012. Transient killer whales have been sighted on several occasions at other parts of SOCAL in the course of this work, but this was the first time they were detected on the range. A small group of Cuvier's beaked whales was briefly observed on the east side of SCI on 19 January 2012 in rough sea conditions as we approached Wilson Cove (Figure 2A). This is our first observation of this species east of SCI since beginning surveys here in 2006, despite daily transits through this part of the Catalina basin. A solitary adult male sperm whale was observed on the range in July 2011, representing the first sighting of this species in the course of this project, though they have been occasionally detected acoustically.

Cuvier's beaked whales were sighted less frequently during year two than year one, with one sighting per approximately 24 hrs' effort this year as opposed to one sighting per 13 hrs' effort last. The proportion of time in conditions suitable for working with beaked whales was similar from year to year (65% of hours on effort). The proportion of hours spent working on SOAR with acoustic support was also similar between years; so there was no obvious cause for reduced sighting rates related to survey effort data.

Table 2. Summary of cetacean sightings by species, including photo-ID, tissue samples collected, and satellite tags deployed, from June 2011 through June 2012.

Group	Species	Est		Avg Group Size	Estimated Photo IDs	Tissue Samples	Tags Deployed
		Groups Sighted	Individuals Sighted				
Large Whales	Blue Whale (<i>Balaenoptera musculus</i>)	1	1	1	1		
	Fin Whale (<i>Balaenoptera physalus</i>)	25	67	2	62	7	13
	Gray Whale (<i>Eschrichtius robustus</i>)	17	39	2	17		
	Humpback Whale (<i>Megaptera novaeangliae</i>)	1	1	1	0		
	Sperm Whale (<i>Physeter macrocephalus</i>)	1	1	1	1		
Beaked Whales	Cuvier's Beaked Whale (<i>Ziphius cavirostris</i>)	4	19	5	17		3
Delphinids	Common Dolphin, Sub-species unknown (<i>Delphinus</i> spp.)	6	630	112			
	Long-beaked Common Dolphin (<i>Delphinus capensis</i>)	7	938	140			
	Short-beaked Common Dolphin (<i>Delphinus delphis</i>)	12	1312	264			
	Risso's Dolphin (<i>Grampus griseus</i>)	23	351	26	64		3
	Northern Right Whale Dolphin (<i>Lissodelphis borealis</i>)	6	256	43			
	Pacific White-sided Dolphin (<i>Lagenorhynchus obliquidens</i>)	2	43	22		2	
	Killer Whale, Transient Ecotype (<i>Orcinus orca</i>)	1	12	12	12	1	2
	Bottlenose Dolphin (<i>Tursiops truncatus</i>)	5	69	13	16	2	
Porpoises	Dall's Porpoise (<i>Phocoenoides dalli</i>)	1	1	1			
Totals					190	12	21

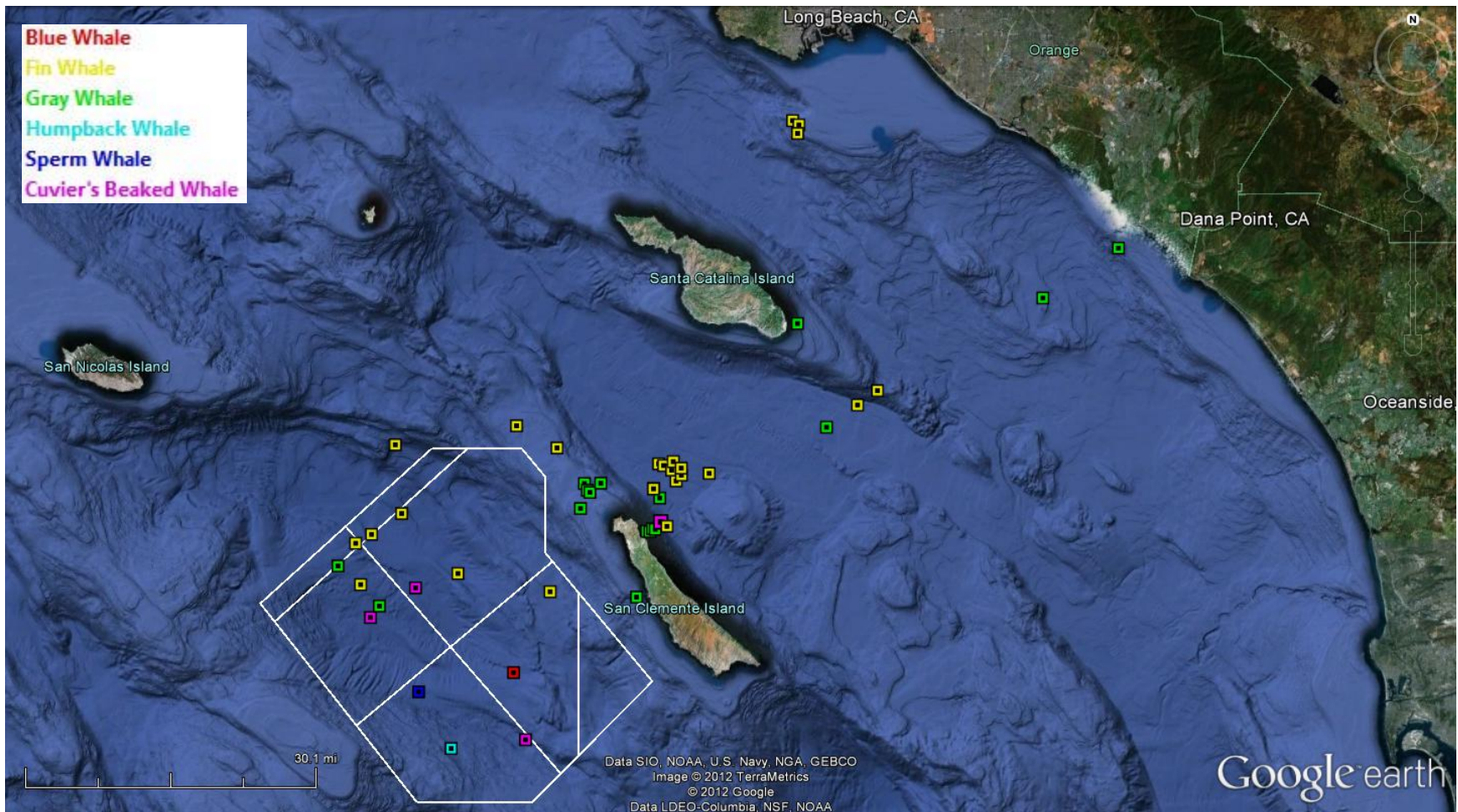


Figure 2A. Sightings of baleen and beaked whales in July 2011, January 2012, and March 2012.

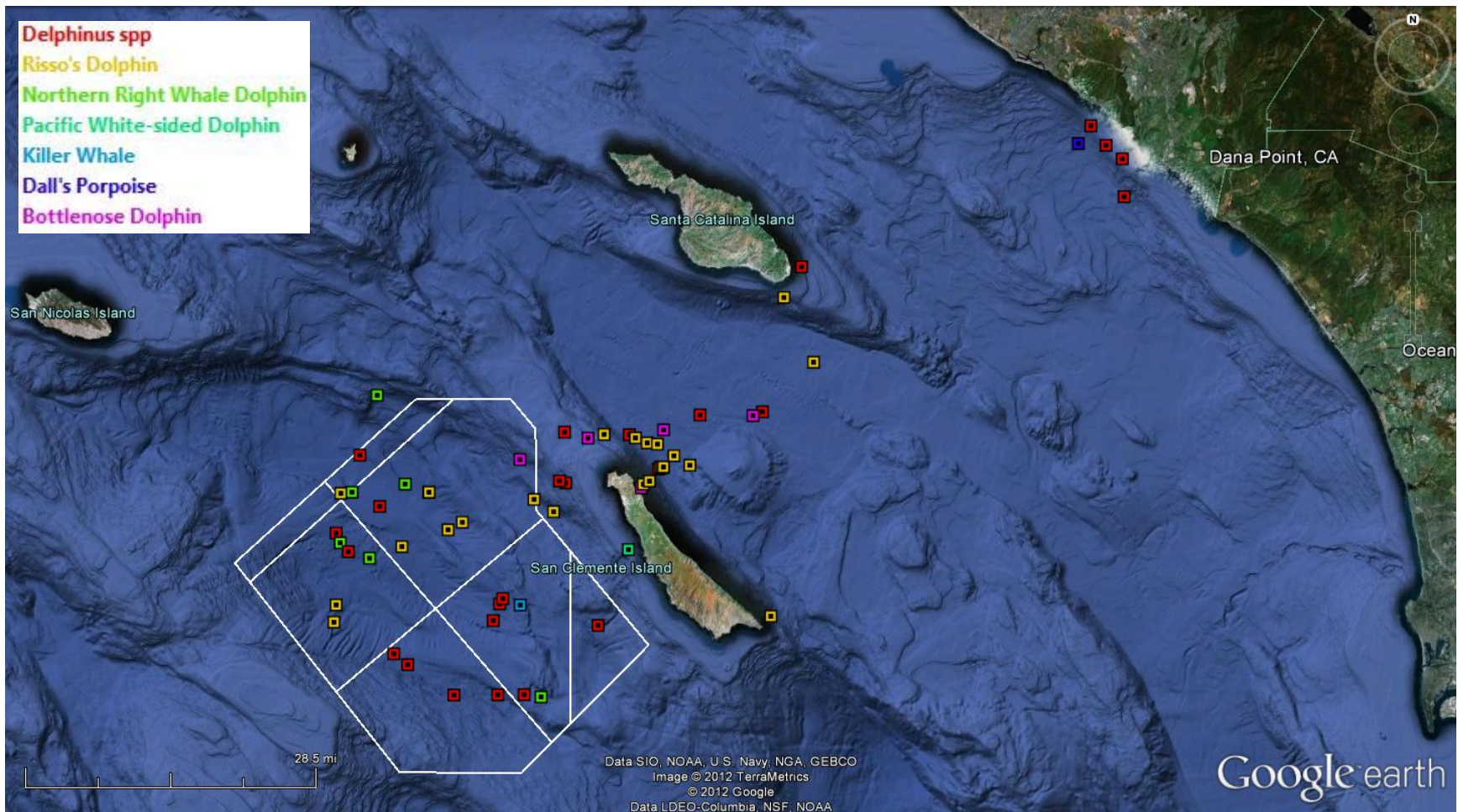


Figure 2B. Sightings of delphinids and porpoises in July 2011, January 2012, and March 2012.

Photo-Identification

Individual identification photographs were collected from eight species during year two. Photographs from six of these species were contributed to other ongoing photographic studies managed by CRC or collaborators; photos of Cuvier's beaked whales and fin whales were processed as part of this project.

There were 19 individual Cuvier's beaked whales sighted during the study period. Three of four individuals photographed in July 2011 had adequate quality images for comparison to the existing catalog. These whales were not found and added to the catalog as new individuals. Photographs of 15 individuals from 2012 have not yet been fully processed, but include at least two previously identified individuals, one of which was CRCID 42, the first Cuvier's beaked whale tagged at SOAR in 2008.

Of 67 fin whales sighted during this study period, 62 were photographed for identification purposes. These identifications, along with an additional 230 from other Cascadia projects and collaborations in 2011 and previous years, are in the final stages of processing. Preliminary results suggest this collection will total approximately 100 unique individuals after reconciliation and quality screening. So far 13 of these whales have been identified in previous years, and 15 were sighted on multiple days in 2011. The span of dates between same-year sightings ranged from 2-171 days, with most spanning more than one month. In some cases sightings spanned several seasons during the year- though it can't be determined from photographs if the whale was present at all times between sightings. Whales from 2012 will not be compared to prior years until 2011 has been completely integrated. However, an aggregation of whales encountered off the coast of Long Beach, CA, in January 2012 contained at least two individuals with sightings during summer and fall of 2009 and 2010, one of which was previously satellite tagged. These results, while preliminary in nature, continue to suggest that there may be a smaller sub-population of fin whales with higher than expected residency to the SOCAL region. Expanded seasonal coverage is beginning to show that some whales may occupy the region year-round, unlike most other large baleen whales (*e.g.*, blue, humpback, and gray whales), which are generally only present in significant numbers at certain times of year.

Satellite Telemetry

Twenty-one satellite tags were deployed on four species (Table 3). Fifteen tags provided location data for periods up to 164 days (the longest is still transmitting), and five tags provided locations with dive behavior records for up to 27 days. One location/dive tag never transmitted.

Table 3. Summary of satellite tag deployments during year two.

Species	TagID	Deploy Date	Trans Duration (Days)	Data Type
Cuvier's Beaked Whale	Zc Tag 017	7/23/2011	10	Location/Dive
	Zc Tag 019	1/15/2012	12	Location/Dive
	Zc Tag 020	1/15/2012	26	Location/Dive
Fin Whale	Bp Tag 031	1/20/2012	178 as of July 16	Location
	Bp Tag 032	1/20/2012	10	Location
	Bp Tag 033	1/20/2012	24	Location
	Bp Tag 034	1/20/2012	18	Location
	Bp Tag 035	1/20/2012	18	Location
	Bp Tag 036	3/14/2012	10	Location
	Bp Tag 037	3/15/2012	7	Location
	Bp Tag 038	3/16/2012	49	Location
	Bp Tag 039	3/16/2012	1	Location
	Bp Tag 040	3/20/2012	38	Location
	Bp Tag 041	3/20/2012	42	Location
	Bp Tag 042	3/20/2012	17	Location
	Bp Tag 043	3/21/2012	23	Location/Dive
Killer Whale	Oo Tag 028	1/18/2012	14	Location
	Oo Tag 029	1/18/2012	16	Location
Risso's Dolphin	Gg Tag 007	7/24/2011	0	None
	Gg Tag 008	7/24/2011	5	Location/Dive
	Gg Tag 010	1/20/2012	11	Location

Cuvier's Beaked Whales

Three depth-reporting LIMPET tags were deployed on Cuvier's beaked whales, two on individuals from the same group. Transmission durations from Cuvier's beaked whales tagged during this contract period were lower than the first year (median = 12, n = 3, versus median = 71, n = 5), likely due to a tag integrity issue which has since been remedied. The grand mean distance to tagging location for all individuals across all transmission days was only 32 km. Two tagged individuals remained within the San Nicolas Basin for the entire transmission duration (Zc Tags 019 and 020), while one moved 236 km southeast of the tagging location before transmissions ceased (Table 4, Figure 3A). When combined with movement data from previous years, 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. Tagged individuals continue to preferentially use the western and northern edges of the San Nicolas Basin, with generally low straight-line movements between filtered Argos locations when in the area (Figure 3B, Table 4). The average rates of movement

between locations for Zc Tag 019 and 020 were 1.3 and 1.5 km/hr, respectively (Table 4). For Zc Tag 017, the rate was 1.14 km/hr while within the San Nicolas Basin (n=18, range 0.24-4.66), but it increased to 2.83 km/hr (n=5, 2.02-4.27) when the animal left the area.

The comparison of tag movements with sonar use at SOAR revealed three periods of interest in 2010 and 2011. The most complete of these comparisons involves an exercise in August 2010, where a single surface ship passed within 10 km of a modeled position for Zc Tag 010 while actively transmitting an MFAS signal. The behavior log from this tag indicated the whale was conducting a deep, likely foraging, dive when the MFAS transmission commenced. A detailed analysis of modeled received levels and diving behavior from the tag is underway.

Table 4. Movement summaries for three satellite tagged Cuvier's beaked whales.

Tag ID	Transm. Duration (days)	Cumulative Straight-line Distance (Km)	Avg Dist To Deploy (Km)	Max Dist to Deploy (Km)	Avg rate of straight-line movement (Km/Hr)
Zc Tag 017	9.7	462	65.4	236	1.9
Zc Tag 019	12	362	12.3	33	1.3
Zc Tag 020	26.4	1025	17.7	50	1.5

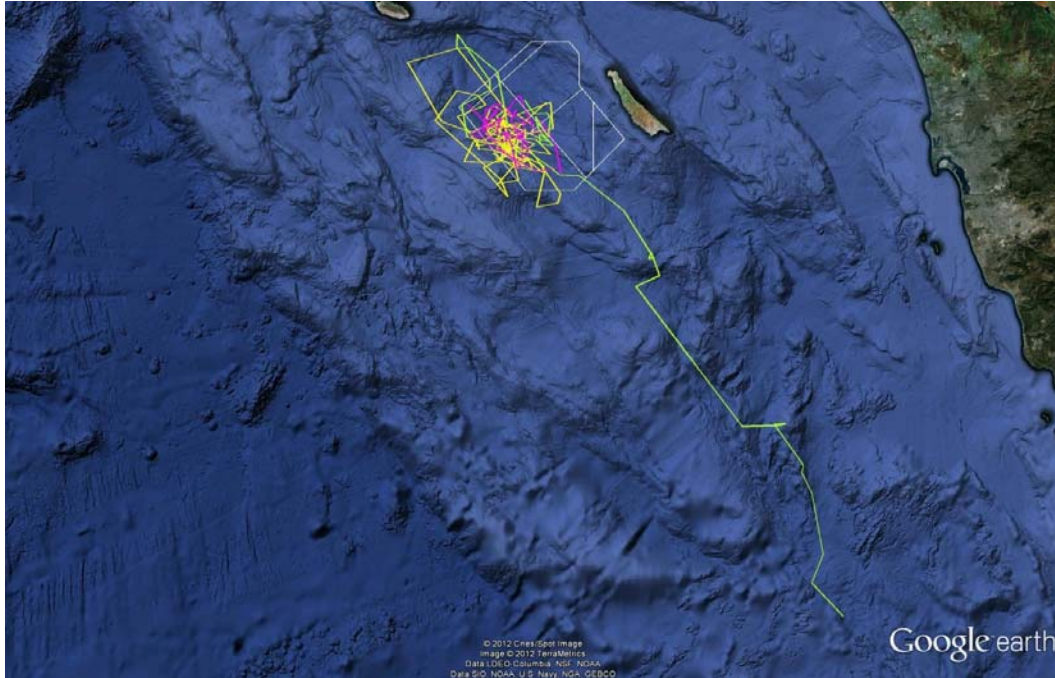


Figure 3A. Movements of three Cuvier's beaked whales satellite tagged in year two. The pink and yellow tracks are from two whales tagged in the same group in January 2012 (Zc Tag 019 and 020), while the green track illustrates movements of Zc Tag 017, tagged in July 2011.

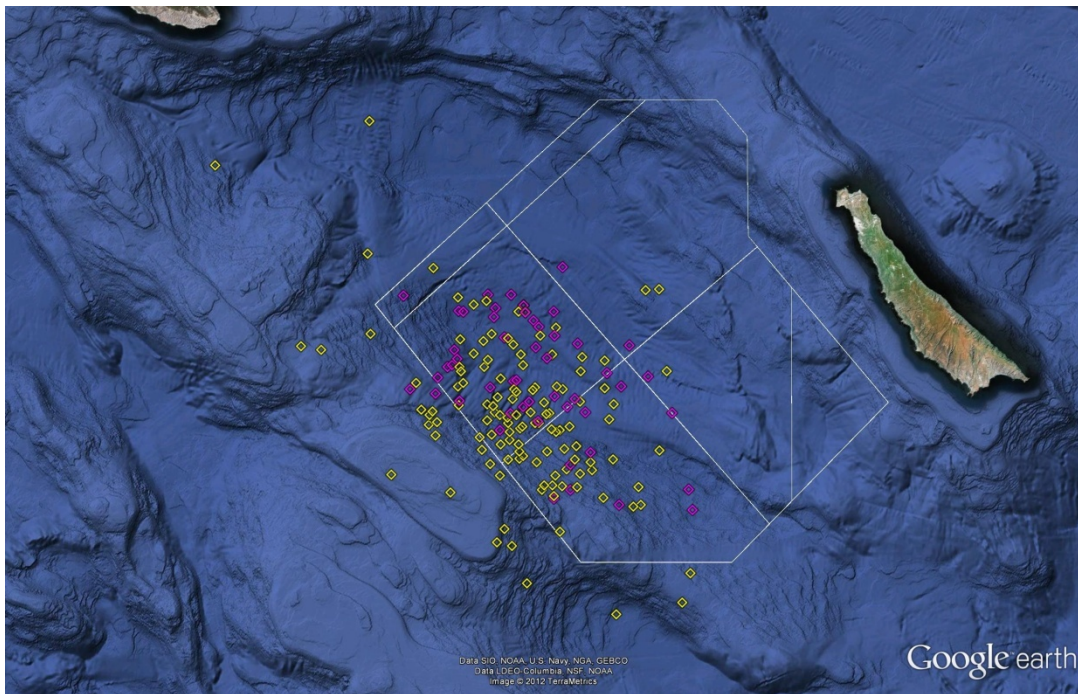


Figure 3B. All filtered Argos locations from Zc Tag 019 and 020, indicating the preference for the western San Nicolas basin, consistent with results from previous tag deployments.

Fin Whales

Thirteen tags were deployed on fin whales in January and March of 2012. Due to poor weather conditions offshore at the end of the January survey, one day of effort was conducted in the nearshore waters off Los Angeles where a concentration of fin whales had been reported for several weeks. Four tags were deployed in this aggregation of approximately 15 whales, which appeared to be feeding on krill at the shelf edge outside the port of Long Beach (Figure 4A). Grand mean distance to deployment was only 17.4 km with a maximum of 55.7 km for these whales, suggesting this aggregation likely remained associated with the shelf edge around the Palos Verdes peninsula, though the longest of these tags transmitted only 24 days.

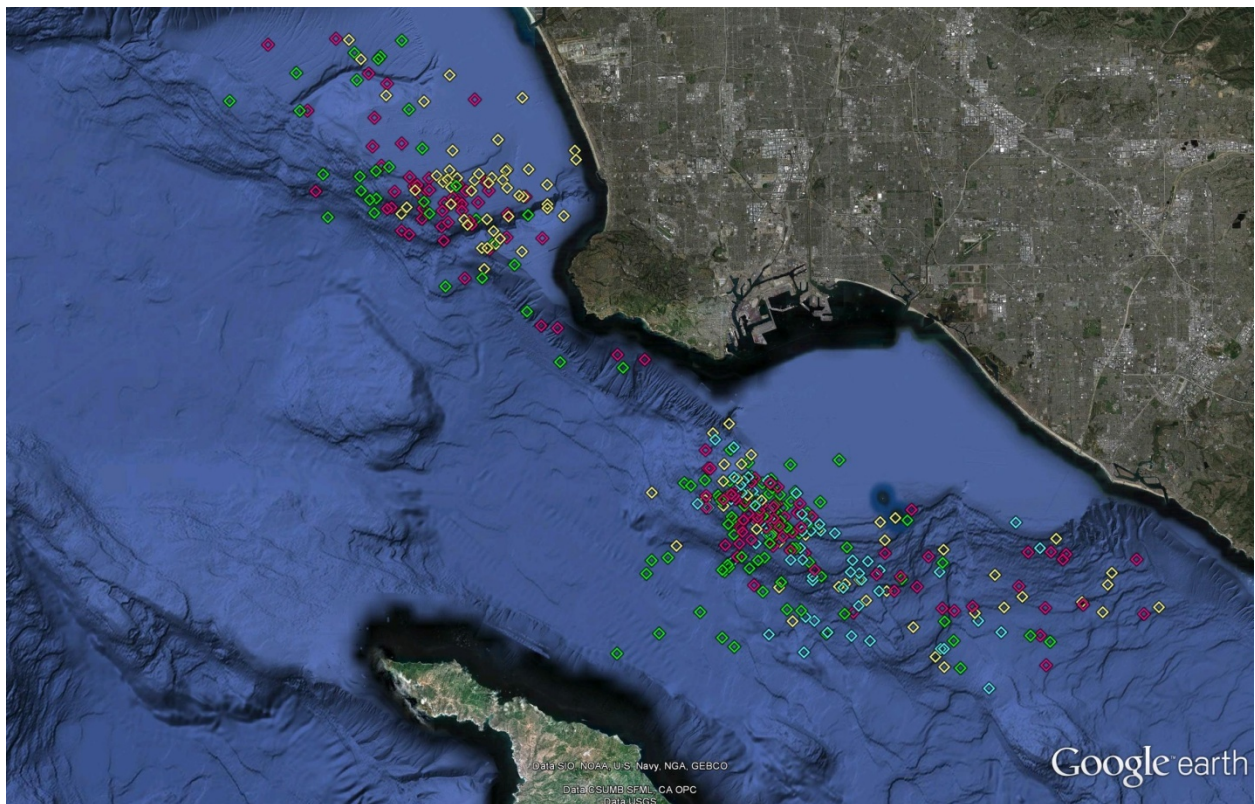


Figure 4A. One daily Argos location for each of the four fin whales tagged off the Port of Long Beach in January 2012.

One additional tag, Bp Tag 031, was deployed on a solitary sub-adult between Catalina Island and San Clemente Island during the transit from SCI to Long Beach. Though tagged only 60 kilometers away, Bp Tag 031 utilized a much broader area during the same time period as the whales tagged near shore off Long Beach, though it did appear to visit the area of the other tagged whales (Figure 4B).

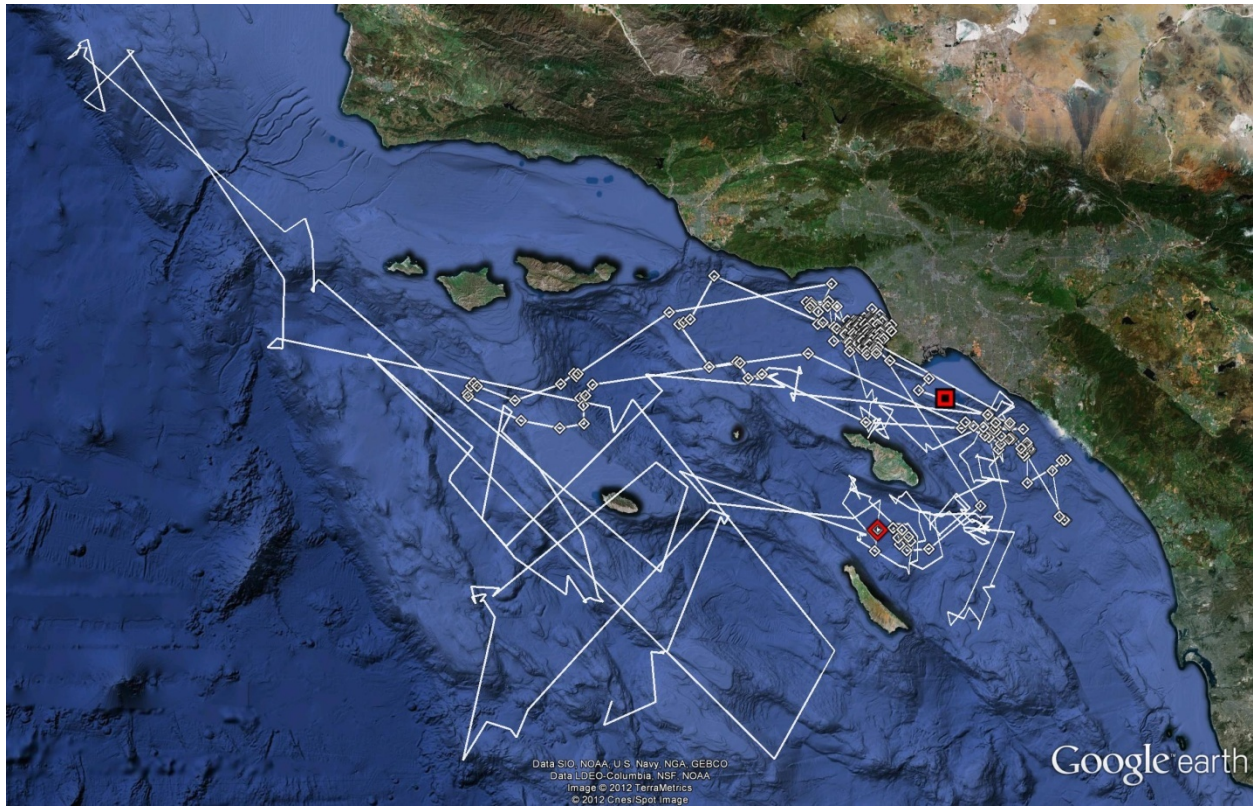


Figure 4B. Map of movements by Bp Tag 031 through day 150. The red diamond indicates this whale's tagging location, and the red square indicates the area where individuals in Figure 4A were tagged on the same day. The gray diamonds are positions from Bp Tag 031 during the period when inshore tags were also active (Figure 4A). While Bp Tag 031 utilized the same area, it did not do so as exclusively as the other whales.

An additional eight tags were deployed on fin whales in a loose aggregation using the waters north and west of SCORE in March of 2012 (Table 3) (Figures 5A and 5B). Unlike the individuals tagged in January which primarily utilized the nearshore shelf edge (Figure 4A), these individuals primarily utilized the deepwater basins.

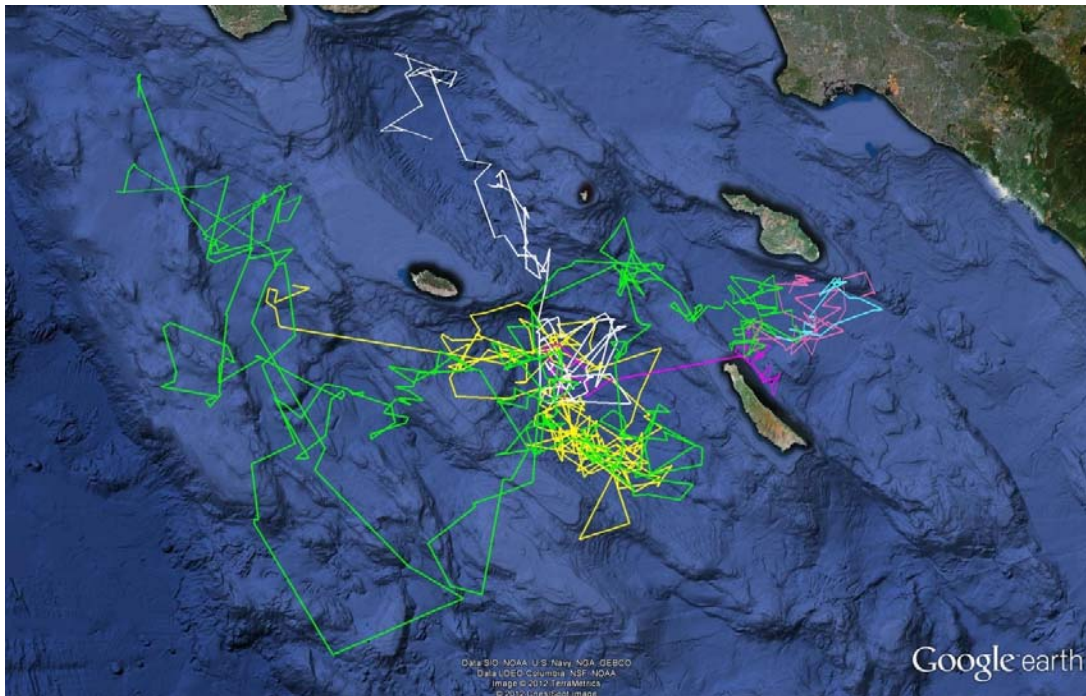


Figure 5A. Map showing movements of six fin whales tagged in March 2012, whose movements were generally restricted to the Southern California Bight. Transmission durations ranged from 2-49 days.

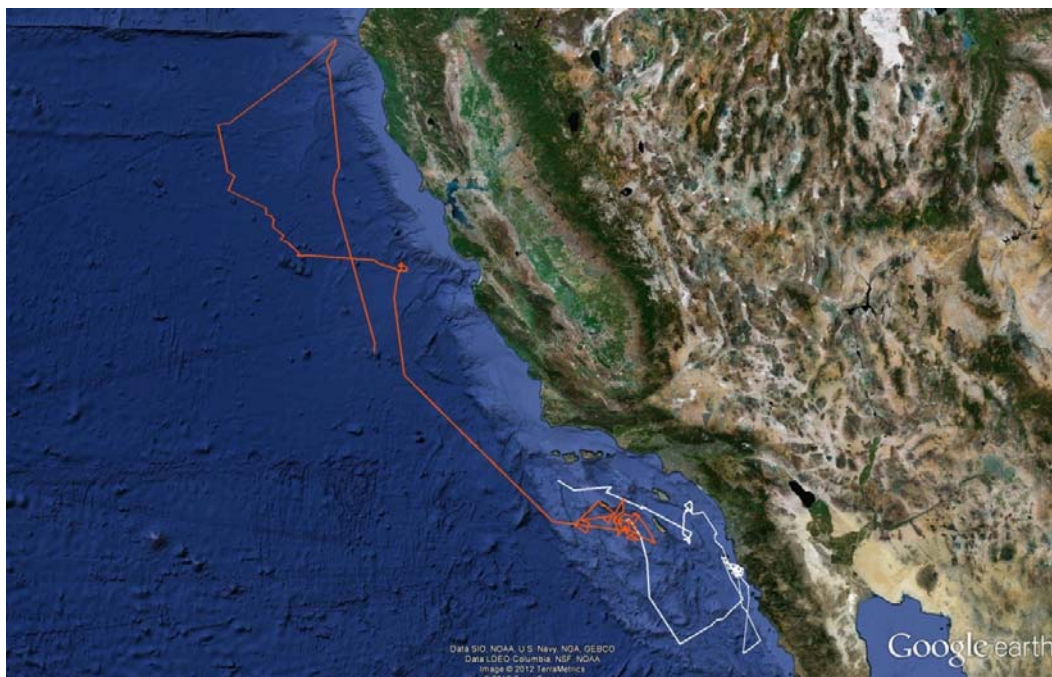


Figure 5B. Extra-regional movements of two fin whales tagged in the San Nicolas Basin in March 2012. Transmission durations were 38 and 42 days.

Bp Tag 043 was tagged with a location/depth reporting tag, which provided movement data for 22.5 days (Table 3) and over 15 days of diving behavior. The tag recorded 991 dives deeper than 25m and longer than 30 seconds, with a median duration of 5.9 min and median depth of 44m. The maximum dive depth recorded was 263.5m, and maximum dive duration was 15.4 minutes. Only 17.5% of all dives were deeper than 100m (accounting for 26% of total dive time). Surface events between qualifying dives (where the whale did not descend below 25m for > 30 sec) had a median duration of just 1.5 min, though were occasionally much longer (range = 0.03 – 790 min). Despite the typically short duration of most surfacing events, and the deep water habitat the whale predominantly utilized (Figure 5A), the behavioral record suggests the whale spent over 70% of its time shallower than 25m depth. Given the extensive use of SOAR and the waters immediately around it by navy vessels and the commercial shipping traffic around Los Angeles, the dive behavior of this whale underscores the elevated risk of ship strike to which fin whales in the region are exposed.

Killer Whales

Two killer whales were tagged on SOAR in January 2012, each from a unique matrilineal group (Alisa Schulman-Janiger, pers. comm.). The whales remained mostly associated for the first 7 days before separating offshore of Point Buchon (Figure 6). Transmission durations were 13.5 and 16.2 days, during which time both whales moved more than 348 km from the tagging location, each covering a cumulative minimum straight-line distance of 1796 km and 1231 km. The average rate of movement was 4.0 km/hr.

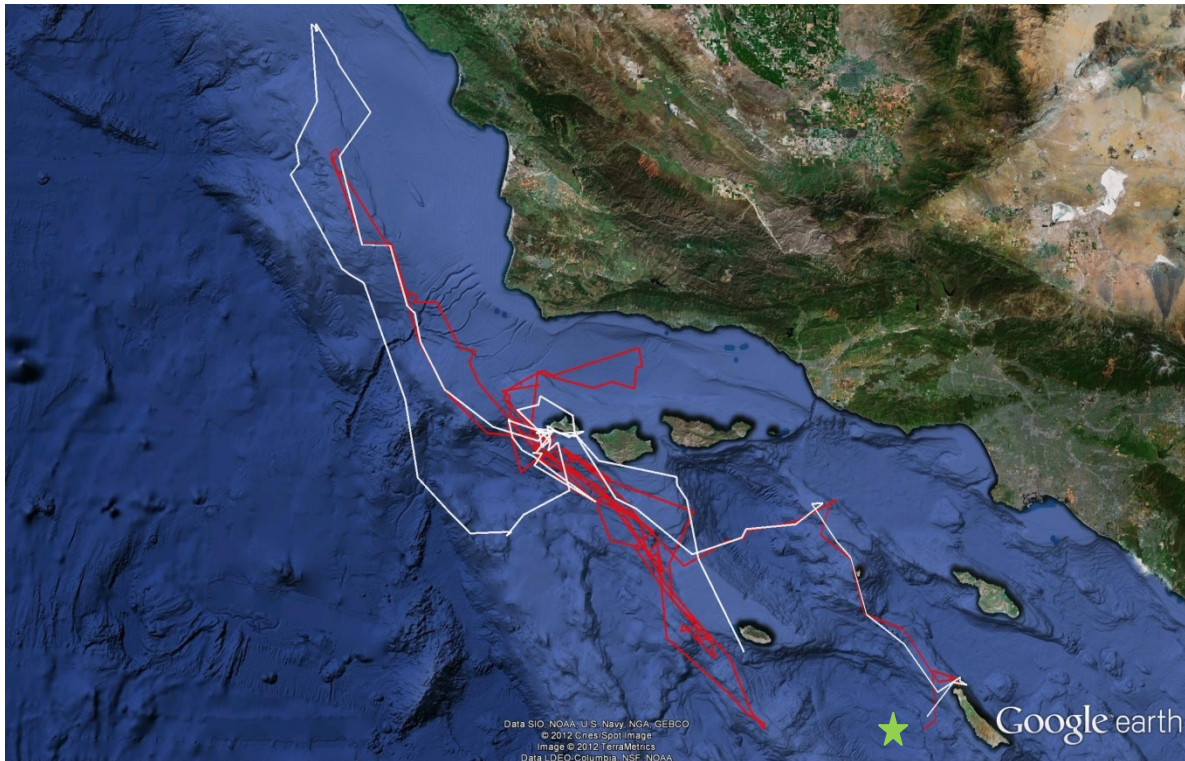


Figure 6. Tracks of two tagged killer whales on SOAR. (Green star indicates tagging location.)

Risso's Dolphin

Three tags were deployed on Risso's dolphins during the reporting period, though one tag never transmitted (Table 3). One tag was deployed inside the boundaries of the *Shore Bombardment Area* (SHOBA) at SCORE, and the animal spent three days within the range on the east side of San Clemente Island (Figure 7). Both individuals largely remained island-associated during the deployment period, with additional use of shelf edges of nearby basins. One of the tags also provided more than 33 hours of dive data during the 5.3-day deployment. The mean depth of dives > 30 m and longer than 1 min was 106 m (SD = 139, n = 116) with a maximum depth of 704 m. Mean dive duration was 3.9 min (SD = 1.9) with a maximum of 9.3 min.

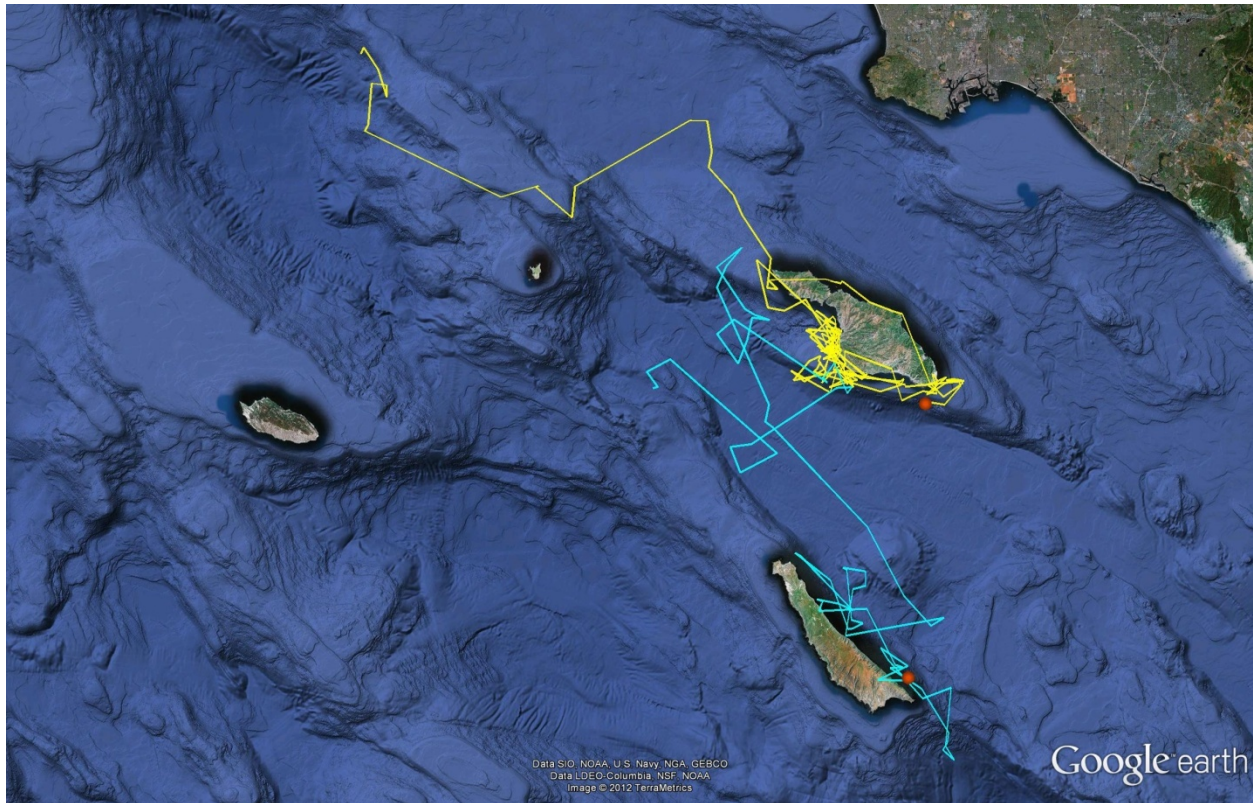


Figure 7. Movements of Risso's dolphins. Gg Tag 008 is represented by the blue track, Gg Tag 010 by yellow. Tagging locations are indicated by red circles.

Concluding Remarks

The data gathered in the second year of this grant continue to provide new insights into the occurrence, distribution, habitat use, and behavior of cetaceans in the Southern California Bight-- as are the stated goals of this grant. The long term movement and dive behavior records from Cuvier's beaked and fin whales on an active navy training range represent a unique dataset for evaluating the interactions of these populations with military exercises. These analyses will become a primary focus of year three.

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