Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2012 ("SOCAL-12")

FINAL PROJECT REPORT

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SOCAL-12 Project Report – *Table of contents*

1. EXECUTIVE SUMMARY

SOCAL-12 was the third year of a scientific research project (planned for 2010-2015) entitled Southern California Behavioral Response Study (SOCAL-BRS) occurring in the Southern California Bight. The overall objective is to provide a better understanding of marine mammal behavior and a direct scientific basis to estimate the risk and minimize adverse effects of human sounds, particularly military sonar, on marine mammals. SOCAL-BRS continues to produce significant new basic diving, foraging, and social data on a wide variety of marine mammals, extending previous behavioral response studies (BRS), and is closely coordinated with ongoing studies in the U.S. and Europe, particularly through a joint collaboration on response metrics and statistical analytical methods. Several scientific publications from the earlier phases of the project have recently been published and multiple others are in review and/or final preparation (discussed below).

Like the previous two field campaigns, SOCAL-12 included an interdisciplinary collaboration of experts in various disciplines of field methods, behavioral analysis, and active and passive acoustic methods. SOCAL-12 partially or fully achieved all specified research objectives. During two operational phases, researchers observed, photographed, and/or tracked several thousands of individuals of 16 marine mammal species. Passive acoustic teams detected numerous beaked whale and sperm whale groups and directed tag boats to animal locations where they were subsequently sighted. Twenty-six tags (of five kinds) were secured on 20 individual animals of nine different marine mammal species. This included multiple tags for primary focal species, including the first-ever acoustic/movement tag on a Baird's beaked whale and tags on traveling/calling baleen whales. Additionally, several new species for the SOCAL-BRS project were tagged, including humpback whales (two animals in a group) and common dolphins (briefly). SOCAL-12 had less success in tagging Risso's dolphins than in SOCAL-11, although weather conditions and species selection contributed to this. The lower overall numbers in total tags and CEEs from the two previous field campaigns was not unexpected in that it reflected the more ambitious objectives to focus more effort on offshore species and more challenging species.

Researchers conducted eight CEEs on eight tagged individuals of five marine mammal species equipped with suction cup acoustic tags and tracked both visually and acoustically. Additionally, for two species (killer whales and common dolphins) that were incidentally exposed during CEEs directed at other species, dedicated focal follows were completed in a "tagless" CEE scenario. Simulated military sonar signals (several orders of magnitude less intense than real sonar) and noise in a comparable frequency band (identical to SOCAL-10 and -11) were presented as experimental stimuli under very specific protocols. Changes in behavior from baseline movement and/or acoustic behavior were measured as a function of sound exposure. Preliminary results based primarily on behavior clearly observable in the field are similar to earlier findings, indicating variable responses (ranging from no observable response to apparent temporary avoidance behavior) that depend on species and behavioral contexts during

the experiments. The addition of a second beaked whale species (Baird's) was notable and the preliminary review of tag data appears to indicate a somewhat similar overall response to that of Cuvier's beaked whales, although the ability to understand this in detail is limited given the previous absence of data for this species. The CEE with a tagged pair of humpback whales and focal observations on common dolphins presented a new opportunity for observing behavioral responses to sound in a mixed-species foraging context. Additional analysis and interpretation is underway of the ~100 hours of tag data, as well as thousands of marine mammal observations, photographs, tissue samples, and acoustic measurements.

SOCAL-BRS continues to be supported by several organizations within the U.S. Navy (below) seeking better data to inform decision-making, and was closely coordinated with the U.S. National Oceanic and Atmospheric Administration (NOAA).

2. PROJECT OBJECTIVES

The overall SOCAL-BRS effort (of which SOCAL-12 was the third year) has the following overarching objective:

"SOCAL-BRS is an interdisciplinary, multi-team collaboration designed to *increase understanding* of marine mammal reactions to sound and provide a more robust *scientific basis for estimating impact* of Navy mid-frequency sonar"

For each field season of SOCAL BRS, the research team develops a number of specific research objectives to meet this overarching goal. A number of these remain constant across seasons, particularly considering the limited basic information on behavioral parameters of almost all free-ranging cetacean species. However, others may change based on progress in previous seasons, results from ongoing analyses, targeted research priorities to address regulatory needs, advances in technology, available resources, and other developments. For SOCAL-12, the following specific objectives were explicitly identified before field operations, so that the team and research sponsors can objectively and critically assess the success of field operations. These included:

(1) Obtain baseline behavioral data *(esp. fin & beaked whales and Risso's dolphin in feeding modes);*

(2) Conduct controlled exposure experiments (CEEs)

- *Species focus to remain flexible based on conditions, but with emphasis on* ***Risso's dolphins, beaked and fin whales*** *(blue whales in specific conditions);*
- *Feasibility assessment of "tagless" playback protocols is a secondary objective for SOCAL-12, but only in specific conditions that maximize the probability of success and do not preclude CEEs with tagged animals (target species: bottlenose dolphins, common dolphins);*

(3) Test optimal configuration and areas for subsequent studies involving realistic/actual military sources*; and*

(4) Obtain data to support the Navy's SOCAL range monitoring efforts

3. METHODOLOGY AND FOCAL SPECIES

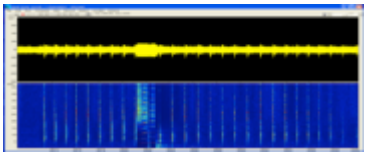
SOCAL-12 General Methodology

The overall research methods used in the SOCAL-12 field campaign were generally very similar to those used in the first two seasons and followed the approach and protocols described in Southall *et al*. (2012)[1], with a few modifications in passive acoustic methods and additional tag sensors. The approach included standard visual sampling methodologies for detecting and tracking marine mammals, typical small boat operations for photo-identification and tagging of research subjects, acoustic monitoring using various sensors (*e.g.*, bottom-mounted hydrophones, towed passive acoustics), and the use of controlled sound exposures in order to study the onset of behavioral responses. Specialized interdisciplinary teams for the collaborating institutions consisted of highly experienced scientists, engineers, and field personnel. We used state-of-the-art tools and technologies to tag and track marine mammals and safely conduct controlled exposure experiments, including on several species that were tested for the first time.

[1] Southall, B. L., D. Moretti, B. Abraham, J. Calambokidis, P.L. Tyack. (2012). Marine Mammal Behavioral Response Studies in Southern California: Advances in Technology and Experimental Methods. Marine Technology Society Journal 46, 46-59.

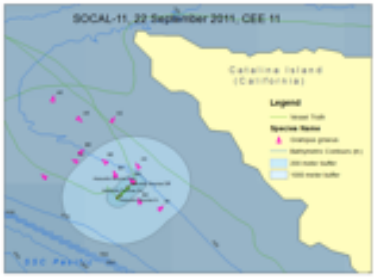
Visual observers, experienced in sighting marine mammals several miles away with specialized binoculars, searched for animals and monitored subjects before, during, and after CEEs. Observers on the central research platform were primarily responsible for locating animals and monitoring during CEEs to fulfill permit requirements for source operations. Visual observers on small boats were primarily responsible for conducting dedicated focal follows of specific animals.

Photo identification was used to identify individuals sighted and involved in CEEs, based on distinct features, scars, and markings. These data are also being used within existing database catalogues for various marine mammal species along the U.S. west coast. [Note: all photos taken during SOCAL-12, including the Cuvier's beaked whale shown here and all others included in this report, were taken under the authorization and conditions of NMFS permit #14534.]



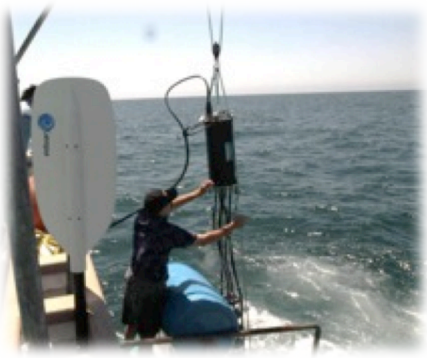
Passive acoustic monitoring utilized different listening platforms and systems to detect vocalizing whales and monitor exposures and responses during CEEs. Their nature depended on the operational location and focal species, but overall they included: listening sensors on the U.S. Navy SCORE range; towed passive acoustic sensors from both a separate sailboat, the *R/V Baylis* (phase I) and the central research platform (phase II); and dipping hydrophones and sonobuoys deployed from the *R/V Truth*.

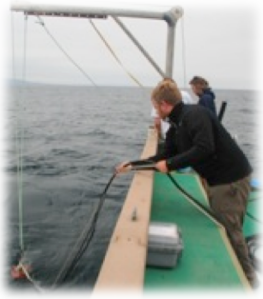
Tagging teams carefully approached and deployed acoustic monitoring tags with non-invasive suction cups from small rigid-hull inflatable boats (RHIBs). The RHIB teams also provided visual monitoring of focal groups during baseline dives and CEEs and recorded behavioral observations in standard focal follow protocols.



Geographical Information Systems (GIS) tools utilized a variety of data streams (including vessel position, visual sightings, and geographic/oceanographic data) for real-time presentation on maps. These data were integrated in a software environment called the Whale Identification, Logging Display System (WILD) which was used for operational awareness and as a time-synchronized archive of all SOCAL-12 vessel movements and other data. This software was completely operationalized and operated exclusively by SOCAL-BRS personnel in phase II.

Sound source engineers operated a specialized underwater speaker that was used to play experimental sounds during CEEs. This relatively compact sound projector was a 15-element vertical line array developed specifically for SOCAL-BRS to enable the production of various test stimuli at sufficiently loud amplitude. Minor modifications were made for SOCAL-12 and the source was tested relative to the detailed calibration conducted previously (see: SOCAL-11 project report - Appendix I).





Fisheries acoustics biologists obtained measurements of prey distribution in relation to high-resolution whale behavior measured using movement tags, and as a covariate for response analysis. These sampling procedures were only used during work with mysticete cetaceans and involved high frequency sounds above their likely hearing ranges.

SOCAL-12 Focal Species

This project was conducted under the terms of U.S. National Marine Fisheries Service (NMFS) research permit #14534-2 (principle investigator B. Southall), Channel Islands National Marine Sanctuary (CINMS) permit #2010-004 for operations within the boundaries of the CINMS, and under the terms of a consistency determination of the California Coastal Commission. As authorized within permit #14534 (and modifications #14534-1 and #14534-2), a number of "focal" marine mammal species were directly

studied in the SOCAL-BRS project. For each species, a fixed number of "takes" of different types were permitted for different activities, including behavioral observation, close approach for photo ID, attachment of both archival acoustic and satellite-linked position monitoring tags[2], and sound exposure from vessels, prey-imaging active sonars, and experimental sounds used in CEEs.

For the five-year period of SOCAL BRS the following species were authorized as "focal" species for tagging and CEEs under NMFS permit #14534-2 (those in **bold** were identified as high priority species in SOCAL-12): blue whale (*Balaenoptera musculus*), **fin whale (*Balaenoptera physalus*)**, humpback whale (*Megaptera novaeangliae*), minke whale (*Balaenoptera acutorostrata*), sperm whale (*Physeter macrocephalus*), **Cuvier's beaked whale (*Ziphius cavirostris*)**, **Baird's beaked whale (*Berardius bairdii*)**, **Blainville's beaked whale (*Mesoplodon densirostris*)**, short-finned pilot whale (*Globicephala macrorhynchus*), **Risso's dolphin (*Grampus griseus*)**, killer whale (*Orcinus orca*), bottlenose dolphin (*Tursiops truncatus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), short or long-beaked common dolphin (*Delphinus* sp.), northern right whale dolphin (*Lissodelphis borealis*), California sea lion (*Zalophus californianus*), northern elephant seal (*Mirounga angustirostris*), and harbor seal (*Phoca vitulina*). As described in greater detail below, during SOCAL-12 almost all of high-priority focal species, as well as some secondary priority species, were encountered, and most were included in the overall research effort.

We were not authorized to focus tagging or CEEs on other marine mammal species occurring in southern California waters. However, the permit and accompanying environmental assessment did consider potential impacts of incidental exposure to sounds during CEEs, although this could not occur within a specified range (1000m).

4. OPERATIONAL AREAS & TIMING

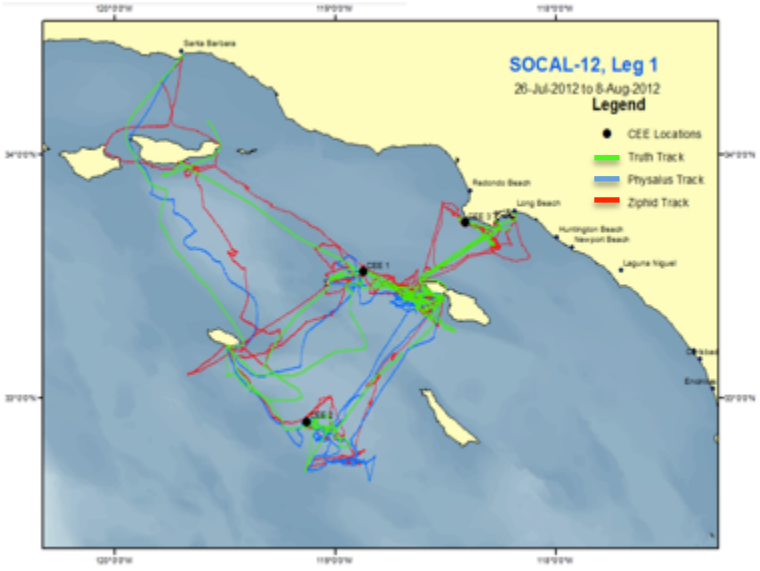
The SOCAL-BRS general operational area includes both southern and northern "inshore" areas around southern California, and an offshore area that includes the U.S. Navy's SCORE range (see figure to right). During SOCAL-BRS, operations have occurred throughout this region, with all sound transmissions occurring at least 1 nm from shore in any area and at least 3 nm from any land mass within the CINMS.

[2] Authorized under a separate NMFS permit (#540-1811).

SOCAL-12 was conducted in two experimental phases, each involving slightly different configurations, operational areas, and slightly different objectives.

For each of these segments, the *R/V Truth* (right: a ~70-foot dive charter vessel converted for use in this research project with a specialized observation platform and other modifications) was used as a base of operations in conjunction with the two ~6m inflatable tagging boats with twin outboard engines (left).

SOCAL-12 phase I was conducted from **26 July – 8 August 12 (14 days)**. As seen in map to the right (tracks of both the central research platform Truth and two tagging RHIBs (Ziphid and Physalus) are shown – see legend), operation generally occurred in the offshore areas around Catalina, Santa Cruz, and San Nicholas Islands and the SCORE range to the west of San Clements Island. Favorable offshore conditions on some days resulted in operations focused on more pelagic species including beaked whales and Risso's dolphins (CEE #1), and much greater success was demonstrated in locating and tagging Cuvier's beaked whales in the Catalina Basin between Catalina Island and Santa Barbara Island. The beaked whale encounter occurred during phase I when a group of six individuals was sighted on the SCORE range and subsequently tracked, tagged, and subjected to a CEE (#2); these events occurred during a period of several days when favorable weather and access to the range enabled the BRS team to work in this area. During a period of poor offshore conditions in phase I, operations occurred around the Palos Verdes peninsula with nearer–to-shore baleen whales (both blue and fin whales in CEE #3).



SOCAL-12 phase II was conducted from **11-23 October (13 days)**. In contrast to both SOCAL-10 and -11, this second field phase was characterized by generally poorer offshore weather conditions. In fact, the final few days of this phase were the first completely unworkable conditions experienced in the three years of the overall project. As seen in the GPS tracks of the vessels in the figure to the left, we focused primarily in deep offshore areas of the Santa Cruz Basin and around Catalina Island. Due to a scheduling conflict with a review meeting at the beginning of phase II (held in Oxnard near the operating area), there was more effort in the Santa Barbara Channel (where CEE #4 was conducted with humpback whales) and in areas around that location. Unfortunately, the most favorable weather during this October period occurred during the review and the following day, when a major military operation on San Nicholas Island further curtailed offshore efforts. Efforts during the second half of this phase were largely based out of Catalina; while there were multiple efforts to move down to the SCORE range (note tracks heading to the southwest), poor weather conditions precluded viable or productive work there (note tracks retreating toward Catalina). However, two CEEs (#5 on blue, #6 on fin) were conducted during this period, and were notable as some of the first ones completed on individuals in a traveling and calling behavioral mode - a condition that had been specifically prioritized prior to SOCAL-12 operations.

5. VISUAL SURVEY RESULTS

Trained and experienced marine mammal visual observers were used on the central research vessel (*R/V Truth*) and on the RHIBs during all phases of SOCAL-12, and during phase I by a dedicated visual team on the *R/V Baylis* (the sailing vessel operating the towed PAM system). Visual observers were on duty from all platforms during essentially all daylight hours when weather and sea conditions permitted (essentially, all SOCAL-12 days other than the last two of phase II). They operated in three different operational modes, including:

Survey Mode – a general search mode to locate possible focal individual(s)

Focal Follow Mode – dedicated tracking of specific individual(s)

Mitigation Mode – visual survey of an area before, during, and just after CEEs to meet specified safety protocols and determine incidental "takes" of non-focal marine mammals for compliance with research permits

On the *Truth*, a rotating team of 2-3 trained and experienced visual observers were based on an elevated (~6m) observation platform with a 360° field of view. These observers used handheld reticle binoculars (7X50 Fujinon and 15X80 Fujinon) and an angle board to determine range and bearing of sightings for entry into the specialized geospatial software system (WILD - described above). The *Truth* and *Baylis* visual observers were most commonly in survey mode, searching for candidate species for potential tagging, communicating information about sighting between platforms, and in some cases obtaining photo ID samples. Prior to selection of focal animals or groups as subjects for tagging or focal follow, RHIB observers searched widely in survey mode as well. Once a focal follow was initiated, typically after a subject was tagged, observers from the RHIBs used primarily naked eye observations given their range to focal animals (~200-300 m).

In almost all cases, visual observers from the RHIBs conducted conventional focal follows reporting the position and behavior of tagged individuals before, during, and after CEEs. The only exception to this was situations where a particular target of interest was spotted first by the *Truth,* who then vectored the RHIBs in; or situations where a high-priority and difficult to track target (beaked whales) was being followed and the *Truth* was a superior visual platform. Individuals and/or groups that were re-sighted were coded accordingly within WILD, keyed to the RHIB sighting numbers where appropriate. In all focal follows, the following behavioral observations were collected:

- Initial surface and terminal dive times of specific focal follow animal or focal group
- Swim direction relative to vessel and sound source
- General behavior - slow/fast travel, milling, feeding, dis/affiliation, tail slap, breach etc.
- Group envelope (spatial extent of group)
- Age class(es)

This variant of conventional focal follow protocols enabled the *Truth* observers to accurately track individual animals or groups of interest (particularly high priority focal individuals like beaked whales, often in support of RHIBs that were less successful in seeing them) and to provide a reliable estimate of potential incidental exposures for permit requirements during CEEs. Additionally, some efforts were made to test protocols for focal follows of groups of smaller odontocete cetaceans from the *Truth* in preparation for potential sound playbacks in which animals were not tagged, although few dedicated trials of these procedures were preformed. However, in two cases, focal follows from the RHIBs were conducted on focal groups that did not include tagged individuals.

The Truth maintained position approximately 1000m from tagged focal animals before, during, and after CEEs, while RHIB observers maintained 200-300 distance and were responsible for maintaining focal follows to provide information about range, bearing and behavior of specific individuals/groups. Additionally, RHIBs were in constant communication with the *Truth* regarding any conditions that would require shutdown of CEEs; RHIB observers thus contributed to mitigation mode during CEEs as well. Visual observers across all platforms (including the *R/V Baylis* for phase I) ensured all specified shutdown conditions were met by monitoring the specified safety radius and providing 360° visual coverage for any abnormal behavioral responses by focal or non-focal animals.

Below are the several tables presenting visual survey results for SOCAL-12 from the *Truth*, RHIB, and *Baylis* visual observers, summarized by operational phases and observational modes.

SOCAL-12 Results from Visual Observer Team - all Platforms

Preliminary SOCAL-12 Results from Truth Visual Observer Team

	Phase I	Phase II
Number of survey days	14	11
Survey sightings *	193	129
Focal follows (< 1 resight)	19	12
Number of mar. mam. species	14	13
Best est. of number of individuals *	3,992	6,420
Number of groups photographed	20	9
Est. blue whale photo-ID	2	1

Number of encounters and best estimate of total individuals encountered on phases 1 and 2 by *Truth* visual observers during SOCAL-12 BRS.

	Leg I		Leg II	
Species	**No. Enc.**	**Est. No. Ind.**	**No. Enc.**	**Est. No. Ind.**
Blue whale	14	20	3	3
Fin whale	3	3	2	3
Minke whale	1	1	5	5
Humpback whale	1	2	5	7
Sperm whale	3	3	1	1
Baird's beaked whale	1	8		
Cuvier's beaked whale	7	19	1	1
Long-beaked common dolphin	26	1754	26	3675
Short-beaked common dolphin	2	68	3	670
Delphinus sp.	58	1429	27	1158
Risso's dolphin	29	219	17	164
Transient killer whale	2	11		
Bottlenose dolphin	10	68	14	169
Elephant seal	10	10	2	2
Northern fur seal	6	6	2	2
CA sea lion			3	34
Unidentified dophin	19	365	16	524
Unidentifed large cetacean			2	2
Grand Total	**192**	**3986**	**129**	**6420**

Preliminary SOCAL-12 Results from RHIB Visual Observations

Vessel	Survey Days	Survey Hours	Survey Distance (nm)	Total Mammal Sightings
Physalus	26	242	2045	73
Ziphid	25	258	2096	118
TOTAL RHIBs	**51**	**500**	**4141**	**191**

Number of marine mammal encounters and estimated number of individuals from phase 1 operations by RHIBs *Physalus* and *Ziphid* and PAM sailboat *Baylis*. Note that many of the sightings were made by multiple vessels and are included in both tables.

	PHY		ZIP		BAY	
Species	**No. Enc.**	**Est. No. Ind.**	**No. Enc.**	**Est. No. Ind.**	**No. Enc.**	**Est. No. Ind.**
Blue whale	6	12	26	35	1	2
Fin whale			1	1		
Minke whale	1	1	1	1		
Sperm whale	1	1	2	2	2	3
Baird's beaked whale	1	7	1	7		
Cuvier's beaked whale	3	8	2	7	2	8
Long-beaked common dolphin	1	260	2	208	5	158
Short-beaked common dolphin	2	256			10	509
Delphinus sp.	5	105	16	1141	42	1188
Risso's dolphin	12	200	14	124	17	219
Pacific white-sided dolphin					1	2
Transient killer whale	1	5	1	6	4	43
Bottlenose dolphin	3	76	10	208		
Elephant seal			1	1		
Unidentified dolphin					12	160
Unidentified large cetacean					3	3
Grand Total	**36**	**931**	**77**	**1741**	**99**	**2295**

Number of marine mammal encounters and individuals from phase 2 RHIB operations

	PHY		ZIP	
Species	**No. Enc.**	**Est. No. Ind.**	**No. Enc.**	**Est. No. Ind.**
Blue whale	1	1	2	2
Fin whale	2	3	2	2
Minke whale	3	3	2	2
Humpback whale	2	4	2	5
Sperm whale			1	1
Long-beaked common dolphin	3	145	3	550
Short-beaked common dolphin	1	200	1	200
Delphinus sp.	9	1935	12	2074
Risso's dolphin	5	117	7	110
Pacific white-sided dolphin	1	12		
Bottlenose dolphin	10	355	7	156
Grand Total	**37**	**2775**	**39**	**3102**

In certain cases (including Risso's dolphin CEEs and a case where common dolphins were followed during a CEE on humpback whales, each described below), additional visual group sampling methodologies were applied. The objectives of these efforts were to compare and complement the standard focal follow measures typically used (focused more on group movement and general behavior) with a focal-individual group sampling method with more detailed observations relating to social behavior. In these cases, the following data were obtained (each minute for tracking data, every two minutes for behavioral data) for groups of animals:

- Range and bearing to group; group swim direction
- Group size (low/best/high)
- Calf presence (binary)
- # of subgroups (categorical)
- Group spacing (categorical)
- Group shape (categorical)
- Distance between sub-groups (categorical)
- Display events (binary)
- Behavioral state

6. SUMMARY OF TAG DEPLOYMENTS

A similar suite of acoustic and movement tags were used in SOCAL-12 as in previous projects, each with somewhat different capabilities and thus intended functions. These included:

DTAGs – designed and supplied by WHOI collaborators[3], these tags are attached with suction cups for up to tens of hours, recording digital sound (variable bandwidth from ~100Hz up to 120 kHz) as well as depth and 3-D accelerometer and magnetometer data. Both version 2 and 3 DTAGs were used in SOCAL-12.

Mk-10s[4] – designed by Wildlife computers, these tags are also attached with suction cups for temporary attachments of up to tens of hours; they measure depth as well as GPS positions when the animal is at the surface.

ACOUSONDEs[5] – these suction cup-attached tags from Greeneridge Sciences, Inc. provide digital sound (variable bandwidth from ~20Hz to 116 kHz), depth, temperature, pitch and roll angles. These were available but not deployed in SOCAL-12.

SIRTRACK[6] - FastLoc GPS position-tracking tags were attached to DTAG2s to obtain GPS position (future versions of the DTAG may have GPS, but current ones do not).

Various time-depth and satellite-linked tracking tags used in a companion project that was coordinated with SOCAL-12.

Depending on the focal species, environmental conditions, timing, and other practical considerations, different combinations of these tags were used in different circumstances. As possible for large whale species, we used dual deployments to obtain a more robust set of measurements of diving, acoustics, and geographic position. While not as prolific in terms of the total number of species and individuals tagged compared to previous field seasons, SOCAL-12 managed to tag a wide variety of species (including several previously untested) and a relatively large number of individuals.

[3] Johnson, M. P., and P. L. Tyack. 2003. A Digital Acoustic Recording Tag for Measuring the Response of Wild Marine Mammals to Sound. IEEE Journal of Oceanic Engineering 28:3-12.
[4] http://www.wildlifecomputers.com/Products.aspx?ID=34
[5] http://www.acousonde.com/
[6] http://sirtrack.com

Tag deployments and attachment durations in SOCAL-12

Date	Total Attachment Time	Species	Tag ID	Animal ID
27-Jul-12	n/a	Sperm Whale	SAT TAG	sw12_209a
27-Jul-12	3:49:55	Rissos Dolphin	DTAG3-102	gg12_209a
28-Jul-12	0:01:00	Bottlenose Dolphin	DTAG3-106	tt12_210a
1-Aug-12	15:49:55	Baird's Beaked Whale	DTAG3-106	bb12_214a
3-Aug-12	0:01:00	Bottlenose Dolphin	DTAG3-103	tt12_216a
3-Aug-12	0:01:00	Bottlenose Dolphin	DTAG3-102	tt12_216b
3-Aug-12	0:01:00	Bottlenose Dolphin	DTAG3-102	tt12_216c
3-Aug-12	0:01:00	Bottlenose Dolphin	DTAG3-102	tt12_216d
4-Aug-12	2:20:37	Blue Whale	MK-10	bw_217
4-Aug-12	19:18:59	Fin Whale	DTAG-2 246 with SIRTRACK	bp12_217a
4-Aug-12	21:16:37	Blue Whale	DTAG-2 216 with SIRTRACK	bw12_217a
4-Aug-12	2:17:24	Blue Whale	DTAG3-102	bw12_217b
4-Aug-12	2:41:59	Blue Whale	MK-10	bw12_217b
5-Aug-12	0:01:00	Cuvier's Beaked Whale	DTAG3-106	zc12_218a
5-Aug-12	0:01:00	Cuvier's Beaked Whale	DTAG3-102	zc12_218b
15-Oct-12	2:54:00	Humpback Whale	DTAG-2 246 with SIRTRACK	mn12_289a
15-Oct-12	(24:48)	Humpback Whale	DTAG-2 241 with SIRTRACK	mn12_289b
18-Oct-12	4:46:00	Blue Whale	DTAG-2 241 with SIRTRACK	bw12_292a
19-Oct-12	0:01:00	Common Dolphin	DTAG3-102	dd12_293a
19-Oct-12	0:01:00	Common Dolphin	DTAG3-102	dd12_293b
20-Oct-12	6:10:00	Fin Whale	DTAG3-105	bp12_294a
	108.3 hours			

All species identified as high priority for SOCAL-12 were tagged, including beaked whales (specifically the first acoustic/movement sensor ever attached to a Baird's beaked whale), fin whales, and Risso's dolphins. Additionally, specific priority was given to locating traveling or likely calling blue and fin whales in order to obtain measures of responses in these different behavioral states - this goal was accomplished for both species during phase II. Less success was realized in tagging Risso's dolphins than in SOCAL-11, although weather conditions and species selection played a role in this reduction; much effort was made in marginal weather conditions, while potentially good days for Risso's were often spent in efforts to tag beaked whales. Humpback whales were added as a focal species for SOCAL-12, and in one interesting case a group of two individuals were both tagged with DTAG and SIRTRACK tags. The same individual sperm whale encountered repeatedly in SOCAL-10 and -11 was again located during SOCAL-12; as specified in the SOCAL-12 test plan, a satellite tracking tag to investigate inter-annual movement patterns was attached, but no CEE was attempted. Finally, multiple efforts

were made to attach suction cup DTAGs to smaller delphinids (bottlenose and common dolphins). While good deployments were made, despite considerable improvements to the attachment structure on the DTAG3, the tags did not remain attached to individuals of either species; subsequent deployment attempts were curtailed and continued attempts with current tag versions are unlikely. The summary tables given here show the breakdown of tags deployed by species within each of the SOCAL-12 experimental phases. Greater success was realized in phase I, which had superior weather across the operational area, notably offshore, relative to phase II. Logistics in phase II were also somewhat compromised during the first week of operations by a conflicting program review meeting.

Phase I Tag Summary:	14 individuals of 7 species (with 17 tags of 5 types)	
14 days	Sperm Whales:	1 individual (1 SAT TAG)
	Rissos dolphins:	1 individual (1 DTAG3)
	Bottlenose Dolphins:	5 individuals (5 DTAG3s)
	Baird's Beaked Whale:	1 individual (1 DTAG3)
	Fin Whales:	1 individual (1 DTAG2; 1 SIRTRACK)
	Blue Whales:	3 individuals (1 DTAG2; 1 DTAG3; 2 MK-10; 2 SIRTRACK)
	Cuvier's Beaked Whale:	2 individual (2 DTAG3s)

PHASE II Tag Summary:	6 individuals of 4 species (with 9 tags of 3 types)	
14 days	Humpback Whales:	2 individuals (2 DTAG2; 2 SIRTRACK)
	Blue Whales:	1 individuals (1 DTAG2; 1 SIRTRACK)
	Common Dolphins:	2 individual (2 DTAG3s)
	Fin Whales:	1 individuals (1 DTAG3)

Twenty-six tags (of five kinds) were secured on 20 individual animals of nine different marine mammal species during SOCAL-12. This included multiple tags for primary focal species, including the first-ever acoustic/movement tag on a Baird's beaked whale and tags on traveling/calling baleen whales. Several new species for the SOCAL-BRS project were tagged, including humpback whales (two animals in a group) and common dolphins (briefly). For the suction cup acoustic/position tags used in SOCAL-12 (not including the satellite tags), this resulted in over 108 hours of tag data across these individuals, the majority resulting from DTAG deployments.

7. CONTROLLED EXPOSURE EXPERIMENTS (CEEs)

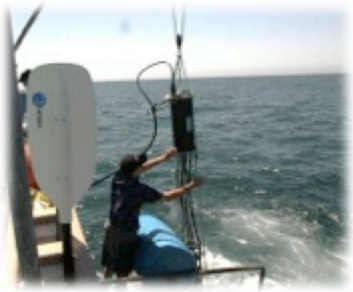
General Methodology and Sound types

CEEs were conducted using similar methods and sound types to previous, related studies in the Bahamas in 2007-08[7] and to those used in SOCAL-10 and -11[8]. The experimental

[7] Tyack, P.L., W.M.X. Zimmer, D. Moretti, B. L. Southall, D.E. Claridge, J.W. Durban, C.W. Clark, A. D'Amico, N. DiMarzio, S. Jarvis, E. McCarthy, R. Morrissey, J. Ward, I.L. Boyd. (2011). Beaked whales respond to simulated and actual navy sonar. PLoS ONE 6(3): e17009. doi:10.1371/journal.pone.0017009.

protocols are based on well-established methods of measuring behavioral responses to various stimuli using a before, during, after (A-B-A) paradigm. Additionally, numerous safety protocols were developed and implemented regarding conditions required to initiate and continue sound exposures, in order to ensure the experiments could be completed safely without causing harm to the animals being investigated or others in the area. Each of these experimental and safety protocols are discussed in slightly greater detail here.

First, all possible means of monitoring animals (visual, acoustic tags, other passive acoustic sensors) were used to observe movement and acoustic behavior in a baseline ("pre-exposure") period. Given that specific criteria were met regarding the operational area (described below), specific and controlled sound "exposure" sequences (using the simulated mid-frequency military sonar and noise control signals described below) were initiated using explicit transmission and monitoring/safety shut-down protocols (also see below). Following the cessation of sound transmissions, monitoring was sustained during a "post-exposure" period. The pre-exposure period served as the control comparison for responses in the exposure phase. If conditions arose when animals were tagged but we were unable to proceed with a CEE because protocol conditions were not met (*e.g.*, presence of neonate animals that would be exposed), a full control sequence would have been conducted with a baseline period, a "mock" exposure (source deployed but not transmitting), and a "post-exposure" sequence. This occurred twice in SOCAL-10, but did not occur in SOCAL-12, where all six CEE sequences included sound transmissions in the exposure phase and all CEEs took place on different days.



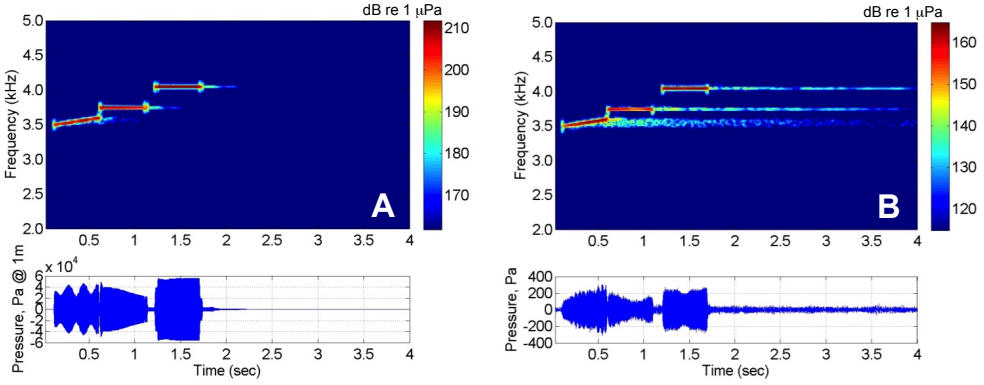
The SOCAL-BRS sound source was custom-built for this project, with the primary goal of reducing the size of both the transducer and the dry-side electronics from previous project. The source could transmit mid-frequency signals at relatively high output levels while running off the ship's AC power supply. It consisted of a 15-element vertical line-array of individual ceramic disk-shaped transducers powered individually and controlled to form a single output beam. This source was tested before and used successfully during SOCAL-10 and -11 and again performed mostly without issue in SOCAL-12, meeting all specifications for output levels in the ramp-up and full power phases, timing of output signals, and rapid shut-down of transmissions when safety protocols required this. All of the battery elements had to be replaced at the beginning of phase II after the source was kept in storage for several months following phase I. This was apparently the result of a slow discharge while

[8] Southall, B. L., D. Moretti, B. Abraham, J. Calambokidis, P.L. Tyack. (2012). Marine Mammal Behavioral Response Studies in Southern California: Advances in Technology and Experimental Methods. Marine Technology Society Journal 46, 46-59.

powered down but still assembled, the lesson learned being that individual elements should be completely disconnected when the unit is in storage.

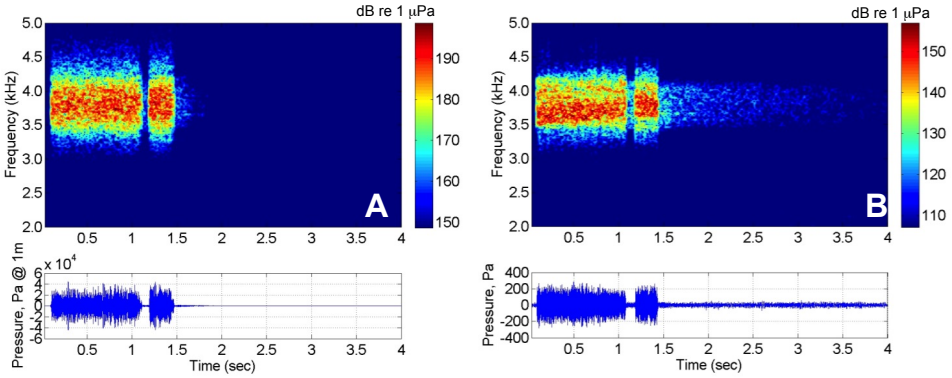
Two sound types were again transmitted during CEEs in SOCAL-12. These included: (1) a simulated mid-frequency active (MFA) sonar signal designed to be similar to the general category of transmit waveforms used in SQS-53C tactical sonars by the U.S. Navy and other nations; and (2) a pseudo-random noise (PRN) control stimulus with similar overall output frequency range, output level, and total power but lacking the tonal structure of the MFA.

The MFA signal had a 0.5s linear frequency modulated upsweep from 3.5 to 3.6 kHz, a 0.5s constant frequency tone at 3.75 kHz, a 0.1s silent interval, and a 0.5s constant frequency tone at 4.05 kHz. Thus, the total duration of the MFA signal was 1.6s. Sounds were nominally transmitted once every 25s (to mimic the output characteristics typical of many 53C systems), beginning at a broadband source level of 160 dB re: 1µPa (RMS) and ramping up 3 dB per transmission to a maximum transmitted source level of 210 dB re: 1µPa. This resulted in a maximum of 72 total signals, or just less than two total minutes of total output energy per CEE sequence. While features of the waveform were specifically designed to mimic the signals used in these systems, there were some important differences, including that the maximum output levels were much lower (~25 dB) than real sonars. Additionally, the single sound source was stationary whereas Navy sonar operations involve mobile sources, sometimes operating in groups and at relatively high speeds and the intermittent transmissions lasted a maximum of 30 min total whereas Navy sources may operate for considerably longer and cover much larger areas. An example of the MFA waveform as transmitted and recorded on the back of a tagged whale is shown below.



Spectrogram displays of a single MFA signal transmission. (A) Recorded with a calibrated reference hydrophone at 22.3m range (levels referenced to 1-m range) using 210 dB RMS source level output setting. (B) Recorded from a calibrated DTAG attached to a blue whale (max RMS level in any 200 ms analysis window was 156 dB). [Note: both figures have a 50 dB color scale range, but ranges differ between plots.]

The PRN stimulus consisted of a 1 sec signal of noise in the 3.5 to 3.9 kHz frequency band, followed by a 0.1 sec silent interval, followed by a 0.3 sec signal of noise in the 3.5 to 4 kHz frequency band. Like the MFA stimulus, the PRN signal lasted for a total duration of 1.4 sec and was repeated every 25 sec, ramping up 3 dB per transmission from 160 dB re: 1µPa to the maximum output source level (which was 206 dB re: 1µPa for this sound type). The total maximum transmission time was 30 min (*i.e.*, 72 total signals maximum or about a minute and a half of total output energy per CEE sequence).



Spectrogram displays of a single PRN signal transmission. (A) Recorded with a calibrated reference hydrophone at 22.3m range (levels referenced to 1-m range) using 206 dB RMS source level output setting. (B) Recorded from a calibrated DTAG attached to a blue whale (max RMS level in any 200 ms analysis window was 152 dB). [Note: both figures have a 50 dB color scale range, but ranges differ between plots.]

Specific CEE Protocols and Shut-Down Criteria

The specific protocols for conducting CEEs in SOCAL-12 are described below, including conditions required to begin, continue/terminate, and monitor the experimental area following CEEs. The following conditions were required to be met prior to CEEs:

- Tags must be attached for a sufficient duration to reduce attachment disturbance effects and to obtain a reasonable amount of baseline behavioral data (using tags and visual observations). For mysticetes and most odontocetes this period was a minimum of 45 minutes, ideally two hours; this was at least one deep foraging dive and complete surface sequence for beaked whales.
- Confirm that *no calves in group are neonates*, as defined within the NMFS scientific research permit (presence of fetal folds for non-ESA listed species and <6 months for ESA-listed species).
- Determine that operational conditions (*e.g.*, weather, location of non-SOCAL-BRS vessels) are likely to allow for successful completion of CEE and interpretation of results, as well as post-exposure monitoring.

- Determine that the sound source is not within 1nm of any landmass or within 3nm from land within the Channel Islands National Marine Sanctuary.

Provided that these conditions were met, as agreed upon by the chief scientist and co-investigators in the field, researchers would then proceed with CEEs according to the following procedures:

- Position source vessel ~1000m from the focal group or animal, taking into account group movement/distribution, to the extent possible.
- Reduce engine propulsion noise and speed, as much as possible.
- Deploy source to specified 20m depth.
- Determine that no marine mammals are present within 200m of source vessel.
- Initiate sound transmissions at a source level of 160 dB re: 1µPa, one transmission every 25s ramped up by 3 dB per transmission to maximum output level.
- Maintain transmissions once each 25s at the maximum source level, unless any contra-indicators require shut-down (see below), for a total maximum transmission time (including ramp-up) of 30 min.

One exposure type was used per focal individual/group, with sufficient pre-exposure baseline and as much post-exposure "recovery" as possible. A pseudorandom sequence within operational areas was used when CEEs occurred in the same area on sequential days to reduce the potential that prior incidental exposures might affect responses in focal animals.

During CEEs, safety shut-down protocols were used, such that any of the following events resulted in the immediate termination of active sound exposures:

- *Any marine mammal inside 200m shut-down zone* around source vessel during transmissions.
- Visual detection from source boat or RHIBs of either the focal animal(s) or incidentally-exposed marine mammals exhibiting the following behaviors[9]:
  - o *Directed, high speed or other abnormal swimming behavior (at surface), especially toward shore.*
  - o *Unusual and abnormal surface/subsurface behavior involving apparent disorientation and confusion or dramatic changes in group cohesion.*
- Controlled sound exposures were conducted with focal groups that included dependent calves that were not neonates (no fetal folds for non-ESA listed species). However, if the *mother-calf pair had become clearly separated during*

[9] None of these behaviors have been observed in any CEE sequence during the three field seasons of SOCAL-BRS.

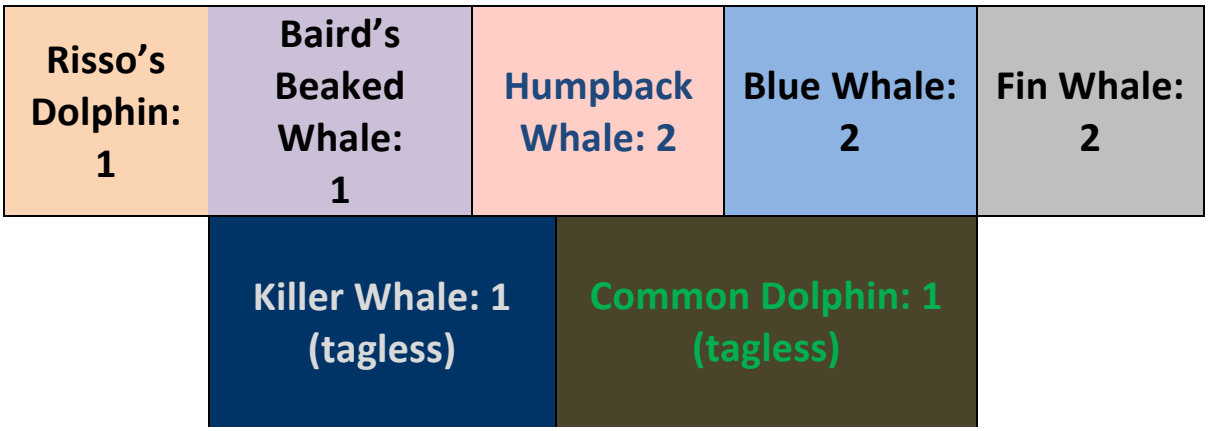
transmissions (as determined by one of the principal investigators based on the input of trained marine mammal observers) CEEs would have been terminated.

After CEEs, the following post-exposure monitoring was conducted:

- Either the source boat and/or RHIB visual teams maintained visual monitoring (and passive acoustic monitoring (PAM), if applicable/possible) of focal groups for at least one hour post-CEE, and VHF radio monitoring for as long as possible;
- Post-CEE visual monitoring of the sound playback area was conducted by both the visual observers on the source vessel and the RHIBs, who maintained focal follow of the tagged animal(s) during the post-exposure period. These observations were maintained within the playback area for a minimum of 45 minutes and typically longer.

Summary of SOCAL-12 CEEs Conducted

During the two experimental phases of SOCAL-12, CEEs were successfully completed with eight individuals (equipped with either version 2 or 3 DTAGs, in some cases with additional ancillary tags) of five marine mammal species (Risso's dolphin, Baird's beaked whale, blue whale, fin whale, humpback whale). Additionally, "tagless" playbacks where RHIB focal follows were completed before, during, and after CEEs were conducted on two occasions - once with a group of killer whales during the Baird's beaked whale CEE and once with a group of common dolphins during the humpback whale CEE.



Six complete CEE transmission sequences were conducted, each on different days, to complete CEEs on these eight tagged individual animals and two groups. The total number of tagged focal animals exceeds the total number of CEE sequences because three of the six CEE sequences involved multiple individuals and/or groups. On one occasion (***CEE# 2012_04***) during SOCAL-12, sound transmissions were terminated during the CEE prior to the 30 min. maximum transmission period according to specified safety protocols. This termination was due to a California sea lion (*Zalophus californianus*),

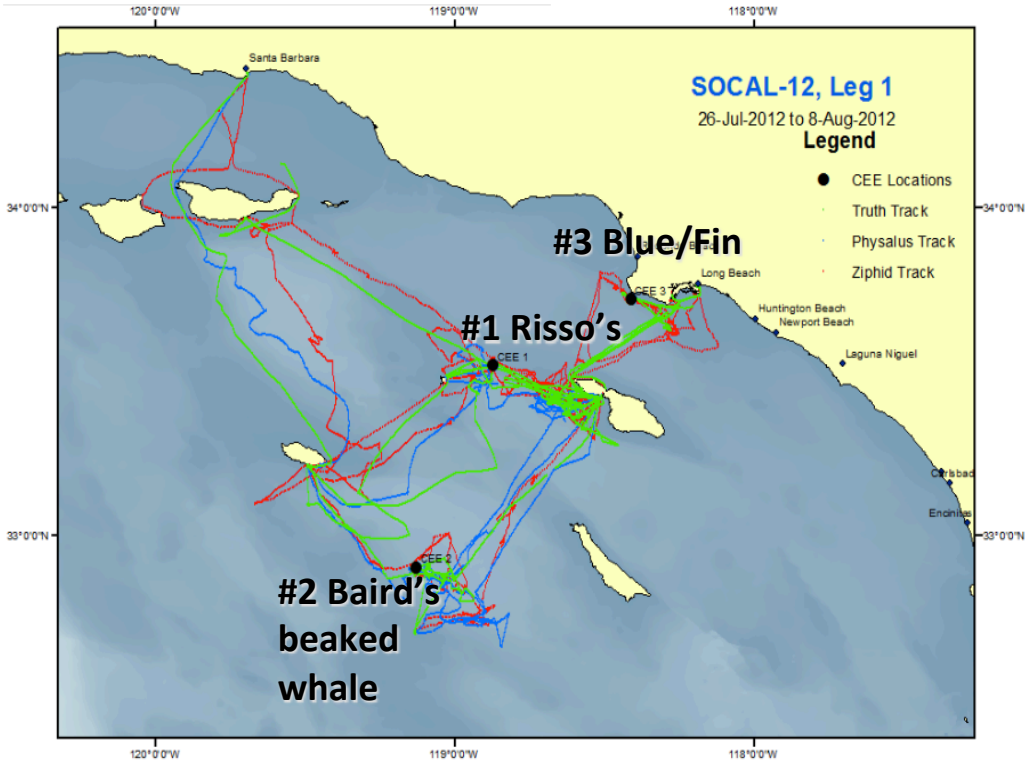
apparently ignoring the sound source transmitting at full power, entering the 200m "shut-down" zone around the sound source.

A chronological list of the CEE sequences by SOCAL-12 experimental phase is given below, showing date, CEE number, sound exposure type and duration, and a brief description of the behavioral state of focal animals during CEEs. Additionally, a map showing the location of each CEE by number is also shown for each experimental phase.

SOCAL-12 - Phase I CEE Sequences

DATE	TIME	SPECIES (ID #)	CEE TYPE (ID #)	CEE DURATION	COMMENTS
27 July 12	1734-1804	**Risso's dolphin (gg12_209a)**	**PRN (#2012_01)**	**30:00**	DTAG3 on a Risso's dolphin and playback later in the day. Slightly extended baseline with source vessel stationary meant start position was slightly >1km. Full sequence but tag came off literally at the last ping.
1 Aug 12	1625-1655	**Baird's Beaked Whale (bb12_214a)**	**MFA (#2012_02)**	**30:00**	First ever suction cup/high resolution acoustic/diving tag and CEE on a Baird's beaked whale. Group of 7 animals was traveling NW through range and had a 4h baseline before CEE. Orcas that were considered tagless CEE were relatively nearby during the CEE. Lost group following CEE then later reacquired on same general track toward San Nicholas.
1 Aug 12	1625-1655	**Killer Whale (tagless)**	**MFA (#2012_02)**	**30:00**	Animals were not tagged so CEE data is restricted to focal follow data from RHIB. Did have this group earlier in the day for tagging attempts with focal individual sampling but no tag attached. Ziphid was tracking in focal follow mode during *Berardius* CEE.
4 Aug 12	1452-1522	**Fin Whale (bp12_217a)**	**PRN (#2012_03)**	**30:00**	Fin whale tagged late am and was in a group several miles from focal blue but they came together closer to the playback and this animal was ~2500m at start and was included in prey mapping
4 Aug 12	1452-1522	**Blue Whale (bw12_217b)**	**PRN (#2012_03)**	**30:00**	Focal blue whale was older calf in a mom-calf pair that was circling around during CEE. Great prey mapping and positioning relative to fin whale but animal was somewhat attracted to focal follow RHIB a few times before/during CEE.

SOCAL-12 - Phase I CEE Locations

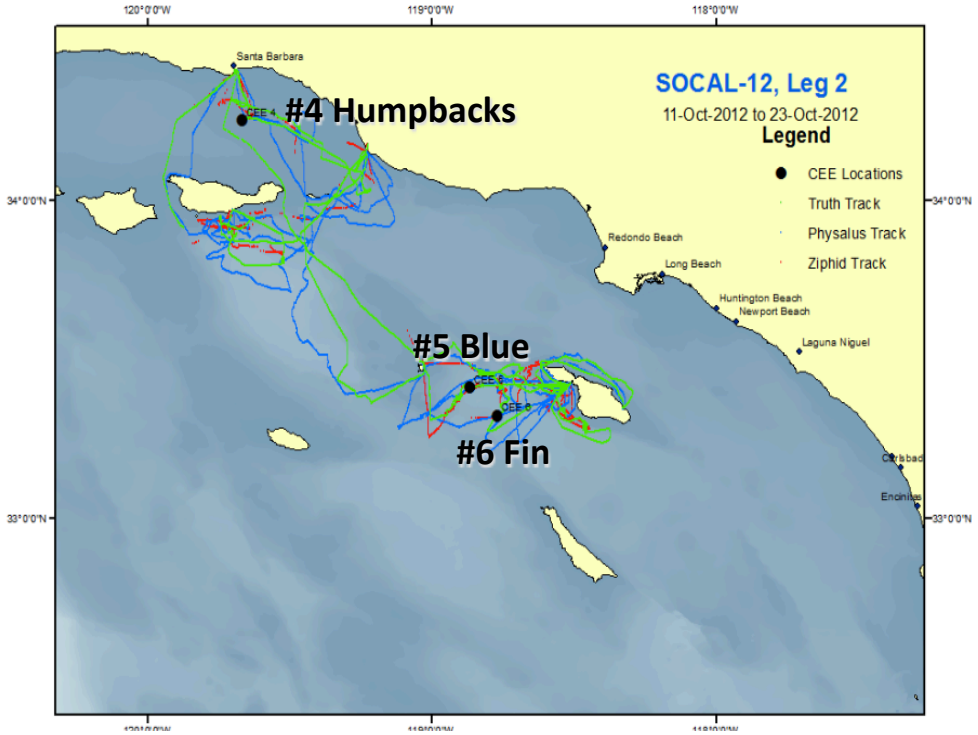


SOCAL-12 - Phase II CEE Sequences

DATE	TIME	SPECIES (ID #)	CEE TYPE (ID #)	CEE DURATION	COMMENTS
15 Oct 12	1326-1356	**Humpback Whales (2) (mn12_289a) (mn12_289b)**	**MFA (#2012_04)**	**26:30**	Two tagged humpbacks in SB channel. Animals in a dense feeding aggregation with dolphins and sea lions. BF4 conditions but positioning factoring in drift worked OK. Sea lion popped up inside mitigation zone right at end.
15 Oct 12	1326-1356	**Common Dolphin (tagless)**	**MFA (#2012_04)**	**26:30**	Same PB as on tagged humpbacks but with group follow dedicated from Physalus on *Delphinus* that were in same feeding aggregation as the humpbacks.

18 Oct 12	1334-1404	**Blue Whale (bw12_292a)**	**PRN (#2012_05)**	**30:00**	Single traveling blue whale doing ~18min dives and moving in a quite consistent direction of travel across the western end of Catalina Basin. Solid CEE with positioning a little tricky with high current but good range at start.
20 Oct 12	1446-1516	**Fin Whale (bp12_294a)**	**PRN (#2012_06)**	**30:00**	Fin whale tagged out in Catalina Canyon. There were two animals in the group and tried to tag the other but no dice. It was a bit of a challenge setting it up with fog and changes in animal heading, but got it done.

SOCAL-12 - Phase II CEE Locations



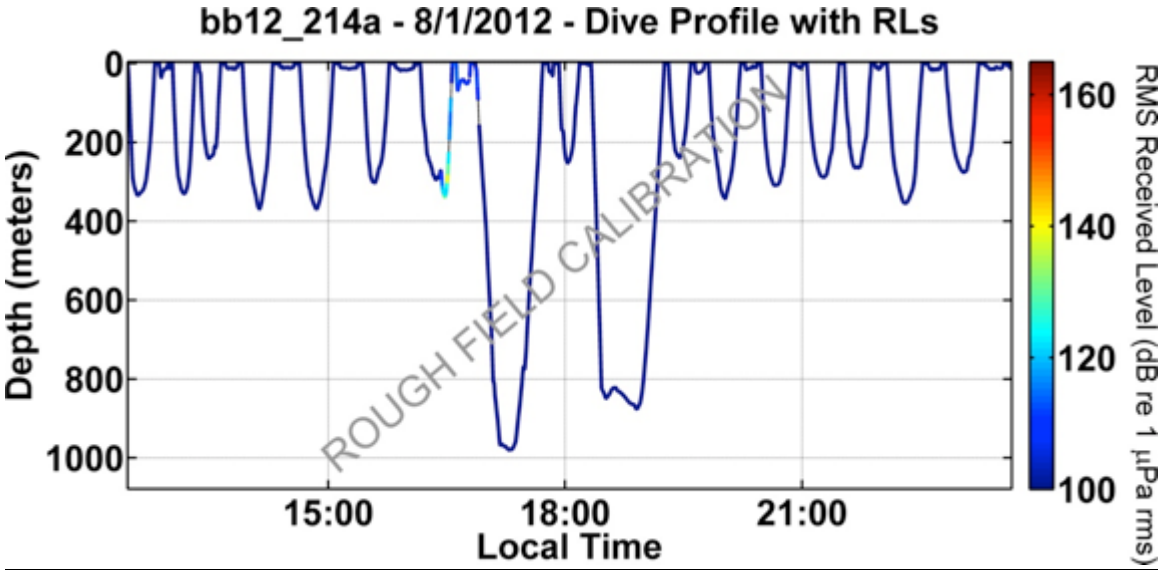
CEE Summary by species

A summary of the CEEs conducted by species as well as a general consideration of the preliminary observations of behavioral responses is given below, beginning with the highest priority focal species identified for SOCAL-12. Detailed analysis of movement, diving, vocal, and other behaviors in the "baseline", "exposure", and "post-exposure" phases of CEEs are currently being conducted to assess the specific responses to sounds of each type in relation to baseline behavioral conditions. The following observations should be considered preliminary based on clear differences in behavior from visual monitoring and/or initial analysis of the tag data; additional or different subtle responses may be revealed by the ongoing detailed behavioral assessments.

Beaked whales

On 1 Aug 2012, the visual observer team about the *R/V Truth* detected a group of six Baird's beaked whales (*Berardius bairdii*). This group was moving through the northwest sector of the SCORE range but was not acoustically detected initially or definitely at any point during a several hour encounter as the animals moved across and ultimately off of the range. The *Truth* vectored in both RHIBs, one of which quickly detected and engaged in tagging efforts with this group of animals. Within a fairly short period, the first-ever deployment of high-resolution acoustic/diving tag (DTAG3) was made on a Baird's beaked whale (ID code: bb12_214a). Earlier in the day, a group of transient killer whales had been followed into an area northwest of where the Baird's beaked whales were located, and as the beaked whales continued to track in that direction, they ultimately came within a few miles of the killer whales, close enough that one RHIB peeled away from the beaked whales and went back into visual focal follow observations of the killer whales. The beaked whales did not appear to divert their course or change their behavior in response to the nearby killer whales.

Following a four-hour baseline period, which included some moderately deep (~300m) dives with intermittent echolocation clicks, an MFA CEE (#2012_02) was conducted. Because they were in the immediate vicinity (within several miles) during the CEE, the orcas were considered a "tagless" CEE (discussed below). As evident in the figure showing the period of time before, during, and after the CEE, the exposures began during the bottom of a moderate dive and continued through the next surface series, following which the tagged animal executed a deep dive to nearly 1000m. The RHIB following the group had maintained successful focal follow with repeated sightings of the group until the CEE began. However, following the CEE the RHIB lost track of the group; they were later reacquired by the Truth on the same general track heading toward San Nicholas Island.



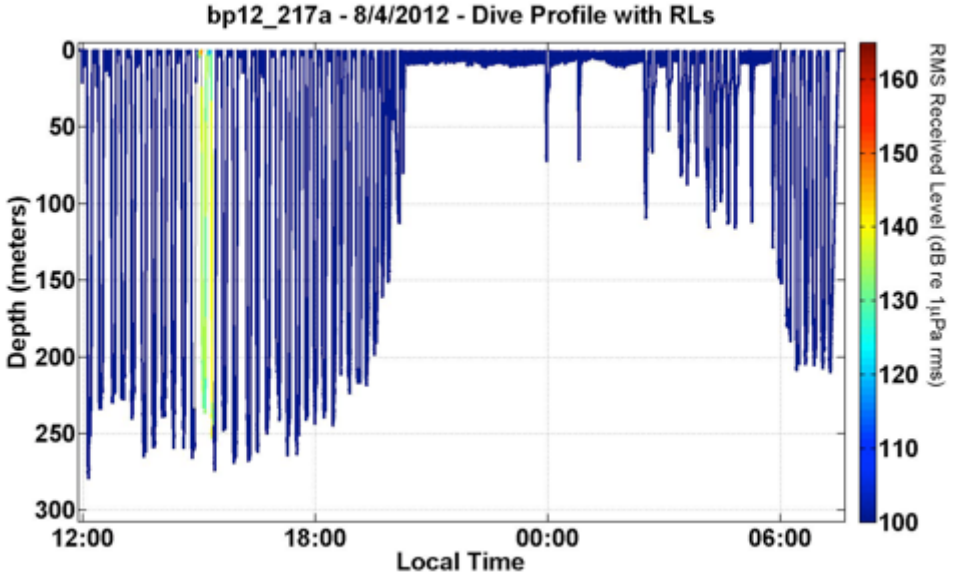
Poor weather precluded extended tracking of the whales into the night, but after an extensive search the following day (ultimately requiring VHF tracking of the detached tag from San Nicholas Island thanks to the combined and much-appreciated efforts of a number of Navy-related contacts) the tag was recovered. The resulting data were significant in that they included the first high-resolution kinematic and acoustic data for any individual of this species, as well as the first CEE response measurements. The absence of previous baseline information against which to compare the response results limits the analysis to something more descriptive in nature. However, based on even a descriptive assessment, there appears to be some change from the baseline behavior that was recorded. It is noteworthy that the animals, which had been repeatedly and regularly detected before exposure, were not again seen for more than an hour after the CEE.

During SOCAL-12, there were multiple acoustic detections and visual sightings of Cuvier's beaked whales. Many of these, along with two very brief tag attachments during phase I, occurred in a deepwater area to the west of Catalina Island. This and the area around Santa Barbara Island appear from the acoustic and visual detections to be favorable areas for beaked whale tagging and CEE efforts. The tag deployments on Cuvier's beaked whales in SOCAL-12 were far too brief to conduct CEEs, however, and the *Berardius* CEE was the only beaked whale CEE completed during SOCAL-12.

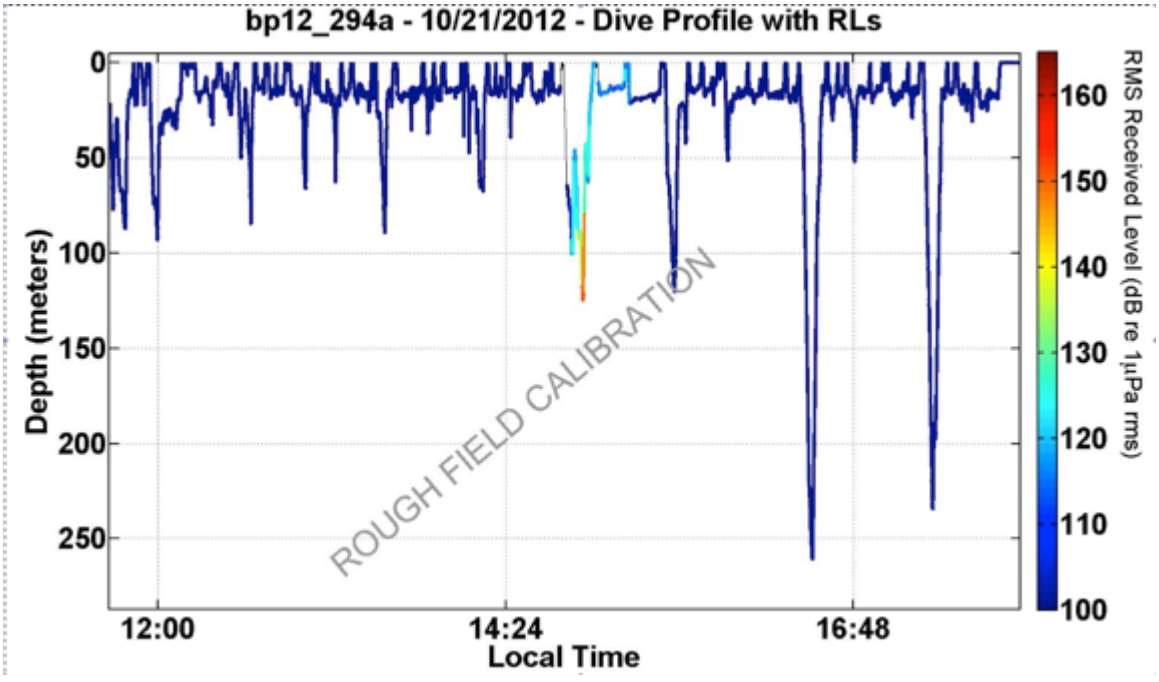
Fin whales

Fin whales were specified as a high priority species for SOCAL-12, and they were successfully tagged and CEEs conducted on two occasions, one in each experimental phase.

The first individual (ID code: bp12_217a) was tagged on 4 August in an area to the southwest of Long Beach along the Palos Verdes Peninsula. This animal was part of a mixed species feeding aggregation, which included a tagged blue whale, during the PRN CEE that was conducted at 1452 PDT (CEE #2012_03). This individual fin whale continued foraging dives to about 250m during and following the CEE and was detected visually before, during, and after as well. The figure below shows the full dive record of the whale during this period, including through the night and as deeper dives resume the following morning.



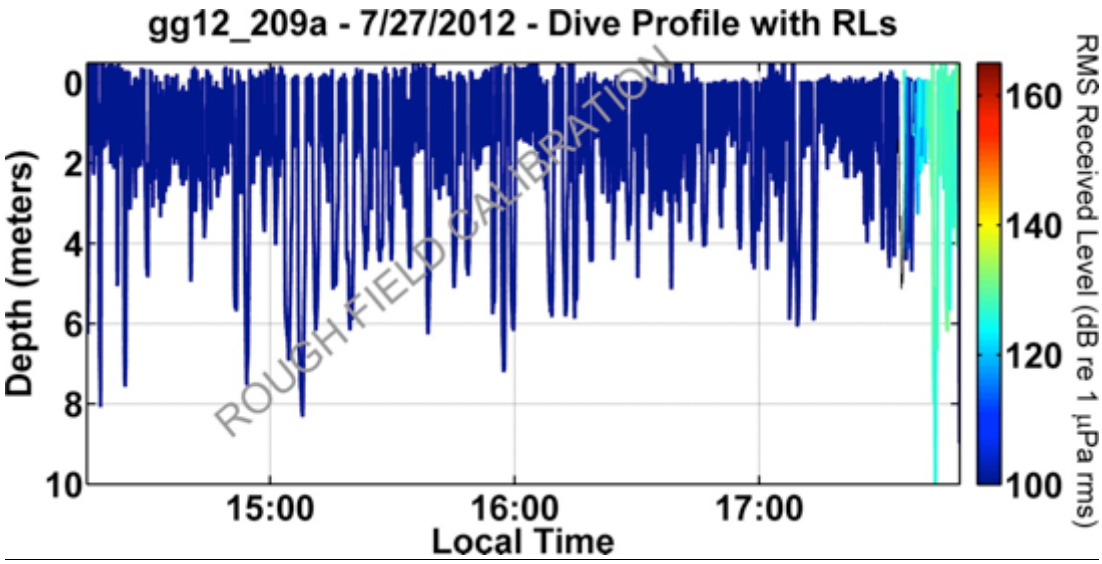
The second individual fin whale that was tagged in SOCAL-12 (ID code: bp12_294a) was tagged on 21 August in an area to the west of Catalina Island. This animal was traveling, apparently alone, and evidence from the dive and acoustic records suggests the animal was calling while traveling. For baleen whales, this calling behavioral mode was considered a high priority because of the relative difficulty of locating and tagging individuals in this behavioral context. A PRN CEE was conducted beginning at 1446 PDT (CEE #2012_06). As shown in the figure below, the whale was intermittently diving to 60-80m; it then completed a slightly deeper dive with some alternating ascent and descent intervals during the CEE, and several much deeper dives during the post-exposure period. The RHIBs maintained a successful visual focal follow, before, during and following the CEE.



Risso's dolphins

Risso's dolphins were also identified as a high priority research species for SOCAL-12 and, based on the relatively high level of success in tagging this species in SOCAL-11, this was envisioned as a primary area of emphasis. However, many of the tagging efforts on Risso's dolphins in SOCAL-12 were conducted in marginal sea conditions and were not successful. Additionally, the relatively high level of success in acoustic and visual detections of Cuvier's beaked whales in areas around Catalina (described above) meant that some of the more promising weather days in these areas were spent in pursuit of those higher priority subjects, which occupied some days that might have otherwise been spent in search for Risso's dolphins. Just one tag deployment and CEE was conducted on this species in SOCAL-12, which was below expectations prior to the field season. For this individual (ID code: gg12_209a), a PRN CEE (#2012_01) was conducted beginning at 1734 PDT. A specified objective prior to SOCAL-12 was to tag animals as possible, then wait until they entered a behavioral state other than the shallow, slow travel or resting behaviors that prevailed during all previous Risso's CEEs. However, it became clear that the group of animals that included gg12_209a was not going to switch to an alternate behavioral state while there was sufficient light with which to conduct the experiment, and the decision was made to proceed with the CEE while the animals were in shallow slow travel mode. There was a nearly 3.5 h baseline

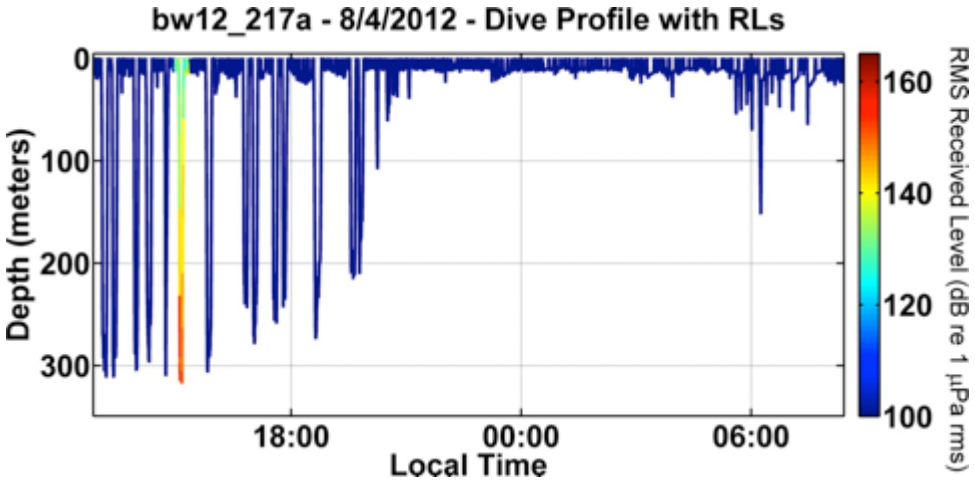
period with tag and visual focal follow data and the full CEE period as well, but the tag detached from the animal just at the end of the CEE interval. Visual focal follow was maintained for the subsequent period post-exposure, during which the group continued on a consistent course.



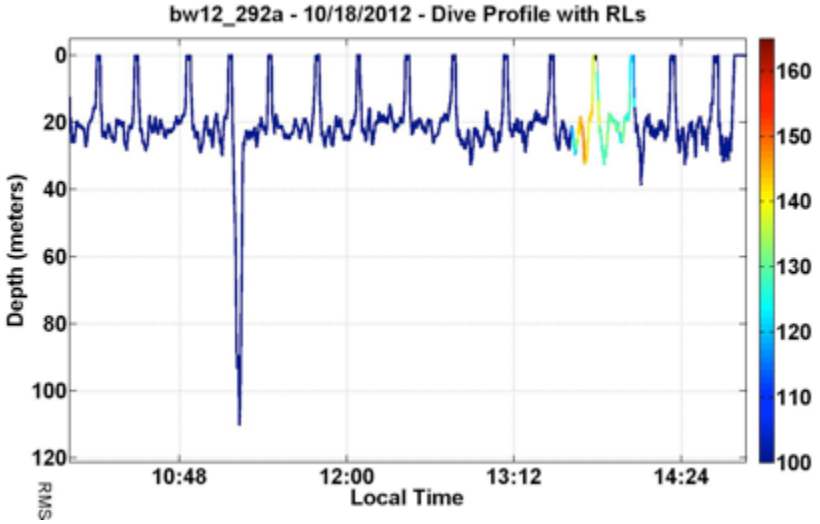
Blue whales

Blue whales were not specified as a high priority species for SOCAL-12, although they were maintained as a potential focal species if weather or other conditions did not favor testing other higher priority species. Additionally, as discussed above, there was recognition that particular behavioral modes including traveling and calling individuals were of particular interest and efforts should be made to focus on them as possible. Two individual blue whales were successfully tagged and CEEs conducted, one in each experimental phase.

The first individual (ID code: bw12_217a) was tagged on 4 August in an area to the southwest of Long Beach along the Palos Verdes Peninsula. This animal was part of a mixed species feeding aggregation, which included a tagged fin whale, during the PRN CEE that was conducted at 1452 PDT (CEE #2012_03). This individual blue whale continued foraging dives exceeding 300m during and following the CEE and was detected visually before, during, and after as well. The figure below shows the full dive record of the whale during this period, including through the night and as slightly deeper dives resumed the following morning.



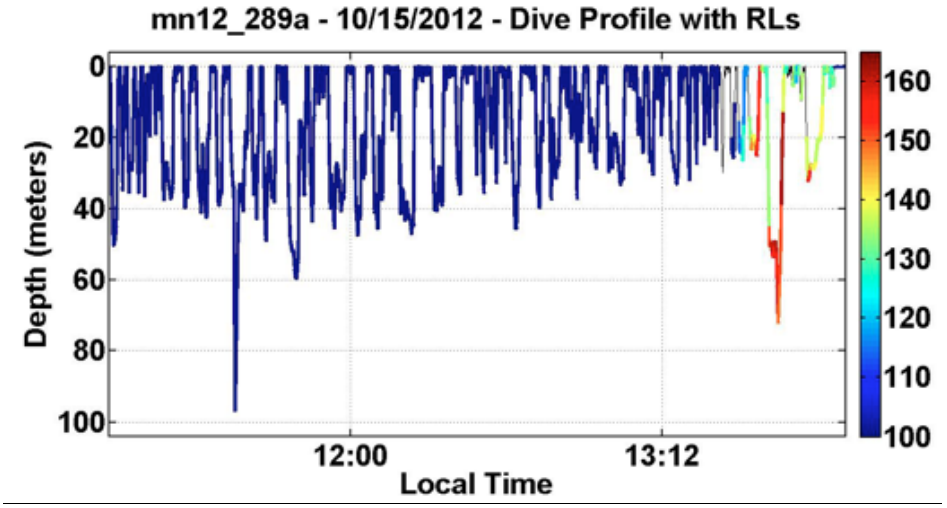
The second blue whale (ID code: bw12_292a) was tagged on 18 Oct 2012 as a lone traveling and presumably calling whale in an area south of Santa Barbara Island. A PRN CEE (#2012_06) was completed as this animal continued to dive to 20-30m while traveling in a consistent manner. Successful visual focal follows were maintained before, during, and following the CEE and easily audible vocalizations of (presumably) the tagged whale were recorded on the tag.

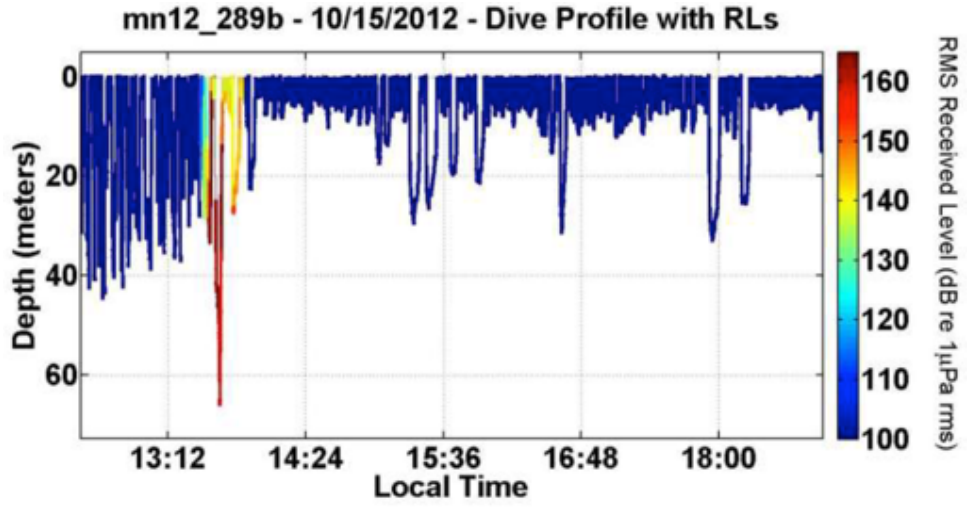


Humpback Whales

For the first time in the SOCAL-BRS project, baleen whales other than blue and fin whales were included in experimental efforts. Two individual humpback whales (ID codes: mn12_289a and mn12_289b) in a mixed species feeding aggregation (including common dolphins, minke whales, California

sea lions, and several kinds of fish-eating birds) were tagged on 15 October in the Santa Barbara Channel. These two humpback whales were observed together in this feeding aggregation for several hours before tagging and were followed in visual focal follow mode before, during, and after an MFA CEE (#2012_04). During this CEE, the second RHIB conducted a visual focal follow on the group of common dolphins (described below). The tag deployed on mn12_289a detached shortly after the CEE, whereas that on mn12_289b remained attached overnight and into the following day. By the end of the CEE period, there was a visible change in the feeding aggregation, in which the animals of all species became less tightly aggregated, although it is unclear if this was necessarily a direct function of the sound exposure. These data are significant because they represent the first CEE data on humpbacks with MFA sounds in the Pacific, but a Norwegian/Dutch/U.K. research project (3S2) has conducted some similar CEEs with humpbacks in Norway, against which the current results may be compared.





"TAGLESS" CEEs -- Observations and Methods Assessment

For several species (killer whales and common dolphins) that were incidentally exposed to CEEs conducted that were focused on tagged individuals of other species, visual focal follow observations were obtained. While no tagged individuals were included in these groups and thus the nature of the resulting data is obviously more limited, this was done in order to both obtain some information for these previously untested (in SOCAL-BRS) species and also as a means of assessing the feasibility and experimental design for dedicated "tagless" CEEs. For each of these cases, a simple summary, behavioral observations, and implications for experimental design of future efforts is described.

Killer whales

On 1 August, a group of six transient killer whales was encountered and focal follow sampling was conducted from both the *Truth* and the RHIBs. After multiple attempts (including near successes), tagging efforts for this group of animals were aborted. Subsequently, the group of Baird's beaked whales described above was located and efforts concentrated on tagging and following that group of animals for much of the day. However, the beaked whales ultimately traveled back into the area where the killer whales were traveling and had been feeding. Prior to the CEE, one of the RHIBs re-engaged with the killer whales and initiated a behavioral focal follow, keying on a large, recognizable male as the focal individual within the group.

PHASE	DATA STREAMS	BEHAVIOUR
TAGGING + EXPOSURE	- TRACK - SOCIAL BEH	- Travel, long distance between surfacings - Tight group, alternatively together or in 2-3 small clusters; coherent; moderate synchrony; not surface active

Behavioral Observations:

- Whales travelling consistently away from sound source both prior to and during CEE, which was conducted targeting *Berardius*; this configuration limits the assessment of potential response to a few observed parameters (e.g., speed, group cohesion).

- These data may be compared to observations of Norwegian killer whale behaviour during tagging and sonar response in the 3S project

Methods Assessment for tagless CEE feasibility:

- Good sea state, data collection partly limited by distance to animals (due to movement pattern)
- Potential combined effects of earlier tagging attempts and sonar exposure
- KW suitable for tagless PB: well-recognisable focal whale and limited group size facilitates high quality data collection
- Would have been difficult to conduct tagless CEE from stationary platform due to fast directed movements of whales.

Common Dolphins

A group of 60 long-beaked common dolphins was observed foraging together with three humpback whales (two individuals with DTAGs described above), two minke whales, and a large number of sea lions and fish-eating birds. This was a combined CEE with the tagged humpback whales and tagless CEE approach with the common dolphins. The data collection method included visual focal follows with group sampling from a RHIB dedicated to following the common dolphins. Additionally, vocalizations of the common dolphins from the tags deployed on the humpback whales and a recording sonobuoy deployed in the area provided qualitative measures of vocal activity of the dolphins before and during the CEE. The sea state was less than ideal (Beaufort (Bft) 5 conditions) by the time of the CEE and this contributed to the difficulties experienced in maintaining focal follows; this ultimately resulted in losing the group.

PHASE	DATA STREAMS	BEHAVIOUR
PRE EXPOSURE	- TRACK - SOCIAL BEH - ACOUSTICS (Dtag + buoy)	- Erratic track (stay at location) - 60 ind., cohesive, synchronous - Very vocal: clicks + whistles
EXPOSURE	- TRACK - SOCIAL BEH - ACOUSTICS (Dtag + buoy)	- Erratic: changes to moving away from location - Group size decreases, animals 'peel off' - Strong reduction vocal activity (clicks)
POST EXPOSURE	- ACOUSTICS (remote)	(group lost due to sea state: Bft 5)

Behavioral Observations:

- Simultaneous shift observed in different data streams (Tag data on humpbacks, tagless focal follow on *Delphinus*, and visual observations from RHIB and observers on *Truth*)
- Consistent with end of foraging (track erratic to move away; group scatters; stop clicking)
- End of foraging could be natural end of feeding event, or response occurring near time of exposure.

Methods Assessment for tagless CEE feasibility:

- Data collection was limited by sea state (resulting in animals being lost shortly after the CEE began during an apparent change in behavior for several species in the feeding aggregation);
- Added value of simultaneous collection of visual focal follow track as well as acoustic and social behavioral sampling;
- Need for more detail and finer time scale, especially for inter-species associations where behaviour may be inter-related among species;
- Future efforts should clearly focus on social behavioral observations and explicitly include acoustic data collection in experimental protocols;
- Stationary platform and sea states >BF3 strongly limiting for small, fast-moving species

8. OVERALL ASSESSMENT: ACCOMPLISHMENTS VS. OBJECTIVES

The following is a simple assessment of the specified objectives for SOCAL-12 relative to the accomplishments realized in the field. All objectives were at least partially achieved, with expectations exceeded in some regards.

(1) *Obtain baseline behavioral data*.

Objective fully achieved. Twenty-six tags (of five kinds) were secured on 20 individual animals of nine different marine mammal species. This included multiple tags for primary focal species, including the first-ever acoustic/movement tag on a Baird's beaked whale and tags on traveling/calling baleen whales. Additionally, several new species for the SOCAL-BRS project were tagged, including humpback whales (two animals in a group) and common dolphins (briefly). SOCAL-12 found less success in tagging Risso's dolphins than in

previous seasons, although weather conditions and species selection played a role in this. The lower overall numbers in total tags from the two previous field campaigns was not unexpected in that it was reflective of the more ambitious objectives to focus more effort in offshore areas on more challenging species.

(2) *Conduct controlled exposure experiments (CEEs)* on baleen whales, beaked whales, and Risso's dolphins.

2a) Species focus to remain flexible based on conditions encountered, but emphasis on baleen whales, beaked whales, and Risso's dolphins, as well as traveling/calling blue whales

- **Objective fully achieved**. Six CEE sequences were conducted on eight tagged individuals of five marine mammal species tagged with suction cup acoustic tags and tracked both visually and acoustically. This included the first-ever such experiment on a new species of beaked whale (Baird's) and a novel (for SOCAL-BRS) species of baleen whale (humpback). Less success was realized with Risso's dolphin than expected, including no CEEs in foraging behavioral states, which represented perhaps the most disappointing aspect of SOCAL-12. However, multiple CEEs were conducted on traveling/calling baleen whales (both fin and blue whales), as well as a simultaneous CEE on a mixed feeding aggregation of sympatric blue and fin whales.

2b) Feasibility assessment of "tagless" playbacks was identified as a secondary objective for SOCAL-12 in conditions that did not conflict with the primary objectives.

- **Objective partially achieved**. No dedicated tagless CEEs were explicitly conducted in SOCAL-12 to test the protocols developed and refined from the SOCAL-11 experiences. However, for two species (killer whales and common dolphins) that were incidentally exposed during CEEs directed at other species, dedicated focal follows were completed in a "tagless" CEE scenario. These observations yielded some resulting behavioral data that are being analyzed to interpret potential behavioral responses. Perhaps more importantly, they yielded some important lessons regarding both the experimental design and species selection for future dedicated efforts with "tagless" CEEs.

(3) *Test optimal configuration for subsequent studies*, which may include realistic/actual military sources

Objective partially achieved. The continued success of smaller field teams with dispersed RHIB operations supports the continued evolution of the BRS effort to a more streamlined and efficient team that could respond in an agile manner to work with realistic operations. This is expected to evolve into smaller shore-based teams operating from even smaller overall platforms and agile tagging and focal follow teams to operate in conjunction with Navy sources serving as experimental sound sources in future studies. However, a third field phase of SOCAL-12 envisioned to directly test these configurations, based off San Clemente Island and using a SCORE range chase vessel as a source platform, was postponed from December to spring 2013 due to funding delays in developing the new sound source. SOCAL-13 promises to offer the essential test of the ability to adapt the SOCAL-BRS configuration to operate in the context of real operations.

9. SOCAL-12 TRANSPARENCY AND PUBLIC IMPACT

The scientific data generated by SOCAL-BRS will contribute to a greater understanding of biologically important areas in southern California, as well as how marine mammals dive, communicate, and respond behaviorally to different sounds. Preliminary data from the first three seasons continues to be presented and discussed with various scientific, educational, government, and conservation organizations to increase public awareness and appreciation of these valuable areas and species. The SOCAL-BRS project is and will remain committed to openness and transparency of the project and to the timely and effective transmission of results. Efforts before, during, and following SOCAL-12 have continued to clearly demonstrate this commitment.

There were numerous open discussions in at least 15 public lectures, webinars, and meetings; exchanges of questions and responses through the project website www.socal-brs.org and from-the-field blog; and other interactions both public and personal with conservation groups and other scientists. This is a process that will continue throughout the SOCAL-BRS project. The first scientific publications from the SOCAL-BRS project have begun to be published (see above) and at least three papers are in review, with another four in final stages of preparation at the time of this report. Finally, researchers from the SOCAL-BRS team have continued to collaborate with scientists and statisticians working on other BRS projects around the world in terms of data analysis, integration, and communication of results to the scientific, public, and regulatory communities. As additional analyses are conducted, the results will continue to be integrated with ongoing, international efforts to better understand behavioral responses of marine mammals to sound. The SOCAL-BRS data will continue to be made available through scientific presentations and publications in a timely manner, as well as through various other public outlets to maximize their utility and impact.

10. CONCLUSIONS AND NEXT STEPS

Overarching conclusions from SOCAL-12

1. ***The overall configuration and operational and experimental protocols for SOCAL-12 were largely effective***

   - SOCAL-12 was again quite productive with a smaller primary research vessel (as opposed to a large oceanographic research vessel); the overall configuration was effective in delivering success in total number of tags, species, and CEEs completed (including several new and important species).

   - A significant amount of data on prey distribution and density estimates were obtained in SOCAL-12, some outside the CEE context and some in areas where tagged blue and fin whales were feeding before, during, and after CEEs, including in one example where individuals of the same species were feeding sympatrically.

   - Dedicated group follow protocols for sampling behavioral responses of non-tagged animals were not explicitly attempted. However, the group sampling protocols derived previously were applied opportunistically for non-tagged species incidentally exposed to CEEs directed to other tagged animals.

   - Additional refinements are being made, moving toward the objective of including real Navy sonar operations in a CEE configuration in SOCAL-13.

2. ***Certain aspects of SOCAL-12 were somewhat less successful than expected***

   - Less than anticipated success in tagging and CEEs with Risso's dolphins.

   - Poorer weather conditions, species focus on beaked whales during favorable weather that did occur, and scheduling conflicts during the second phase limited overall accomplishments in tags and CEEs. Future planning should consider whether effort should occur prior to late October.

3. ***CEE protocols and safety measures apparently worked well***

   - Useful behavioral response data were obtained and included clear responses in some conditions, but in no cases were animals harmed or made to respond in extreme ways outside those anticipated and planned for within the protocols

   - In cases where marine mammals, of either the focal species group or other incidentally present in the area during CEEs, came within the specified safety radii, sound source shut-downs were executed immediately. All shut-down procedures in SOCAL-12 were the result of animals (typically California sea lions) coming within the specified 200m safety radius during CEEs, presumably

to investigate the sounds being transmitted rather than as a function of adverse behavioral responses.

- Through coordination with the Southwest Marine Mammal Stranding Network, SOCAL-12 maintained current information on any marine mammal strandings that might have occurred. There were no live or fresh-dead cetacean strandings in southern California reported during the experimental phases of SOCAL-12 or within several weeks following.

SOCAL-BRS next steps

The overall SOCAL-BRS effort is planned to occur from 2010-2015. SOCAL-13 is expected to be a critical transition year, with a generally similar configuration to previous seasons in some ways and quite different approaches in others. The following are the current understanding of planned next steps for SOCAL-13 and beyond:

- The pilot trial of a new and smaller sound source for scaled CEEs will be tested in spring 2013 with a RHIB and Navy range vessel based from San Clemente Island. This will serve as a field calibration and trial of the more agile field approach using a field crew of just 5-6 individuals.
- The R/V *Truth* will again be used as the primary research platform and sound source vessel for two full experimental phases in the July-September 2013 time window, and operations are expected to occur in similar general areas as in the first two field seasons; precisely where and on which species will depend on environmental conditions and on the distribution of animals.
- During hopefully multiple occasions in SOCAL-13, operational Navy sonar sources will be used in an experimental context to test potential reactions of tagged animals to real training operations. This will occur in close coordination and communication with SOCAL-BRS but will not result in additional training activities for the Navy.
- SOCAL-13 will again include a dedicated research platform for passive acoustic monitoring (PAM) for the detection of odontocete cetaceans (primarily beaked whales) in areas outside of the SCORE range for at least one of these experimental legs.
- SOCAL-13 will again include integrated prey measurements for at least one experimental leg, combining data from scientific echosounders with tagged whale foraging behavior at fine scales.