Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2013 ("SOCAL-13")

FINAL PROJECT REPORT

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1. EXECUTIVE SUMMARY

SOCAL-13 was a continuation and significant evolution 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. Significant new basic data were acquired on diving, foraging, social, and vocal behavior of focal marine mammal species, including measurements in targeted behavioral contexts and new applications of improved sampling capabilities. Additionally, a major step forward in extending previous behavioral response studies (BRS) was the coordination of tagging and response measurements with operational Navy vessels engaged in training operations but coordinated for controlled sound exposures. SOCAL-BRS continues to be closely coordinated with ongoing studies in the U.S. and Europe, notably through a multi-study collaboration on response metrics and statistical analytical methods[1]. Multiple new SOCAL-BRS scientific findings were published since the SOCAL-12 report[2]; these are discussed below and are freely available on the project website <www.socal-brs.org>.

Like previous two field campaigns, SOCAL-13 included an interdisciplinary collaboration of experts in various disciplines of field methods, behavioral analysis, and active and passive acoustic methods. All specified research objectives for SOCAL-13 were met, most notably the development of a smaller scaled sound source operated off a small (~10m) rigid-hull inflatable boat and the first-ever use of full-scale operational Navy mid-frequency active (MFA) sonar systems (SQS-53C) in the context of a controlled experimental context. Four distinct operational phases were conducted, during which researchers observed, photographed, and tracked thousands of individuals of 14 marine mammal species. Passive acoustic teams detected and tracked multiple beaked whale and sperm whale groups and directed tag boats to animal locations where they were tracked and/or tagged. Forty-five tags (of three kinds) were secured on 41 individual animals of five different marine mammal species. Almost all deployments were on four primary focal species, including two tags deployed on Cuvier's beaked whales. One of those included the first-ever sound exposure using a full-scale, operational military sonar system in controlled conditions for this species, which has been most prominently involved in previous stranding events. Additionally, the first successful acoustic and

[1] Please see: http://www.creem.st-and.ac.uk/mocha/ for additional information

[2] DeRuiter S.L., Southall B.L., Calambokidis J., Zimmer W.M.X., Sadykova D., Falcone E.A., Friedlaender A.S., Joseph J.E., Moretti, D., Schorr G.S., Thomas L., Tyack P.L. (2013). First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. Biol Lett 9: 20130223. . http://dx.doi.org/10.1098/rsbl.2013.0223

Goldbogen J.A., Southall B.L., DeRuiter S.L., Calambokidis J., Friedlaender A.S., Hazen E.L., Falcone E.A., Schorr G.S., Douglass A., Moretti D.J., Kyburg C., McKenna M.F., Tyack P.L. (2013). Blue whales respond to simulated mid-frequency military sonar. Proc R Society B 20130657. http://dx.doi.org/10.1098/rspb.2013.0657

Yack, T.M., J. Barlow, J. Calambokidis, B. Southall, S. Coates. (2013). Identification of previously unknown beaked whale habitat in the Southern California Bight using a towed hydrophone array. J. Acoust. Soc. Amer. 134, 2589-2597

recording tag deployment on a North Pacific minke whale was accomplished in SOCAL-13. Excellent success was experienced in tagging multiple individuals simultaneously, particularly for priority fin whales and Risso's dolphins, including some of the deeper diving and apparent foraging contexts for Risso's dolphins.

Researchers conducted a total of 20 controlled exposure experiment (CEE) sequences involving 32 tagged individuals of five marine mammal species equipped with high-resolution suction cup acoustic tags and tracked both visually and acoustically. These CEEs included simulated MFA sonar signals for 13 individuals as used in previous projects[3], and full scale MFA sonar (from two different U.S. Navy vessels) was used in CEEs for six additional individuals. Navy vessels were positioned using site-specific sound propagation modeling to match received levels specified for focal animals to match those tested with (typically much closer) scaled sound sources. Silent control sequences (no noise exposure) were conducted for an additional 13 individuals using protocols and vessel configurations similar to scaled sound sources. 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 were similar to earlier findings, indicating variable responses (ranging from no observable response to evident temporary avoidance behavior) that depend on species, behavioral contexts during the experiments, and potentially the physical range from animals to sources. While more detailed analyses and additional samples are needed, responses to distant MFA from actual sources appeared less evident than closer scaled sources in some conditions (particularly for beaked whales).

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).

[3] A smaller scaled sound source was used, but operational parameters and source characteristics were the same as those reported in earlier methods (see: 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).

2. PROJECT OBJECTIVES

The overall SOCAL-BRS effort 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 the SOCAL-BRS research team develops specific research objectives to meet this overarching goal. Some remain constant across seasons, particularly considering the limited baseline behavioral data on behavioral parameters at the high degree of resolution possible using acoustic and movement sensors. Others may change based on results from previous seasons, ongoing analyses, and targeted research priorities. For SOCAL-13, the following specific objectives were explicitly identified before field operations, so that the team and research sponsors can objectively and critically assess success. These included:

(1) Obtain baseline behavioral data *to support CEE interpretation and conducting CEEs (both realistic sources and scaled sources)*

(2) Conduct controlled exposure experiments (CEEs) with both real Navy MFA sources and scaled sources - when full-scale sources unavailable *(Species focus to remain flexible based on conditions, but with emphasis on Risso's dolphins, beaked, and fin whales (blue whales in specific conditions);*

(3) Test optimal configuration and areas for subsequent studies involving real Navy MFA sources in contrasting modes

3. METHODOLOGY AND FOCAL SPECIES

SOCAL-13 General Methodology

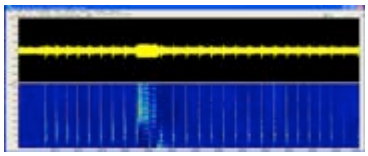
The overall research methods and vessel configuration used in SOCAL-13 field were generally similar to those used in earlier seasons in terms of the broad approach and protocols described in Southall *et al*. (2012), with a few notable exceptions (described below the brief description of general methods). This approach involved 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.

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-13, including all photos included in this report, were taken under the authorization and conditions of NMFS permit #14534.]

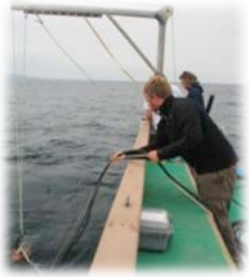
Passive acoustic monitoring utilized different listening platforms and systems to detect and monitor vocalizing animals before and during CEEs. These included a combination of listening sensors on the U.S. Navy SCORE range (the marine mammal monitoring on ranges or "M3R" team), towed passive acoustics from a separate sailboat (*R/V Baylis*) and the central research platform (phase II), and dipping hydrophones and sonobuoys deployed from the *R/V Truth*.



Tagging teams carefully approached and deployed high-resolution acoustic and movement tags with suction cups from small rigid-hull inflatable boats (RHIBs). RHIB teams provided visual monitoring of focal groups before, during, and after CEEs and recorded behavioral observations in focal follow protocols.

Geographical Information Systems (GIS) tools utilized a variety of data streams (including vessel position, some visual sightings, and geographic/oceanographic data) for real-time depiction on maps. These data were integrated in a software environment called the Whale Identification, Logging Display System (WILD) which provided operational awareness and a time-synchronized archive of certain SOCAL-13 data.

Sound source engineers operated compact sound projectors capable of producing relatively high amplitude simulated MFA sonar signals when Navy vessels were unavailable. For SOCAL-13 both the initial 15-element vertical line array used previously and a new 10-element version with a much smaller top-side control system were available. The smaller array (right) was deployed successfully in initial SOCAL-13 field trials off a separate RHIB.



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. Ongoing analyses indicate that the integration of these data provides a profound increase in the ability to understand and describe whale behavior and potential responses to CEE stimuli

Exceptions to the well established and successful overall methods employed in earlier phases of SOCAL-BRS were in several areas. These included the elimination of a pseudo-random noise (PRN) signal as a control stimulus in favor of additional silent (no-noise) sequences and the development, calibration, and implementation of the smaller vertical line array sound source described above. In SOCAL-13 we demonstrated the ability to deploy this source from a slightly larger (11m) RHIB than those used for tagging (left). While this approach has some limitations relative to the centralized research vessel configuration with the ability to move a larger, co-located team and include additional analytical personnel, for certain applications in subsequent BRS efforts this approach has potential to allow an additional, smaller configuration option based largely from San Clemente at a lower cost.

A second major modification in approach included coordination with Navy operational vessels engaged in realistic training operations in order to utilize full-scale Navy MFA

sonar within the context of CEEs. Many aspects of these experiments, including locating, tagging, and tracking focal animals, were identical to earlier research efforts. However, for these CEEs MFA transmissions were generated from operational Navy vessels positioned much further away from focal animals, their location determined from site-specific acoustic propagation modeling conducted using unclassified information about MFA sources to estimate received levels to match those during (much closer) scaled source CEEs. The propagation modeling decision tool uses a MATLAB-based interface, a set of unclassified Navy and NOAA models and databases, and the Navy standard parabolic equation propagation model for long-range propagation to generate maps of received based on the known position of a tagged animal. Received levels from sources moving through the area are plotted along a potential ship trackline. Vessels transmitted for a maximum of 60 minutes in the CEE context at a fixed speed and direct course. Navy vessels were operating in the context of regularly planned training operations and in full compliance with all requirements, mitigation measures, and authorized sonar transmission hours. All SOCAL-13 operations were similarly conducted in complete compliance with requirements and mitigation measures authorized under NMFS permit #14534-2 (described in greater detail below).

SOCAL-13 Focal Species and Permit Requirements

This project was conducted under the terms of U.S. National Marine Fisheries Service (NMFS) research permit #14534-2 (principal 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. For each species, a number of "takes" of different types were permitted for different activities, including behavioral observation, close approach for photo ID, attachment high-resolution archival acoustic and movement tags, and sound exposure from vessels, prey-imaging active sonars, and experimental sounds used in CEEs.

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-13): **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*). Almost all high-priority focal species, as well as some secondary priority species, were encountered and included in the overall research effort.

4. OPERATIONAL AREAS & TIMING

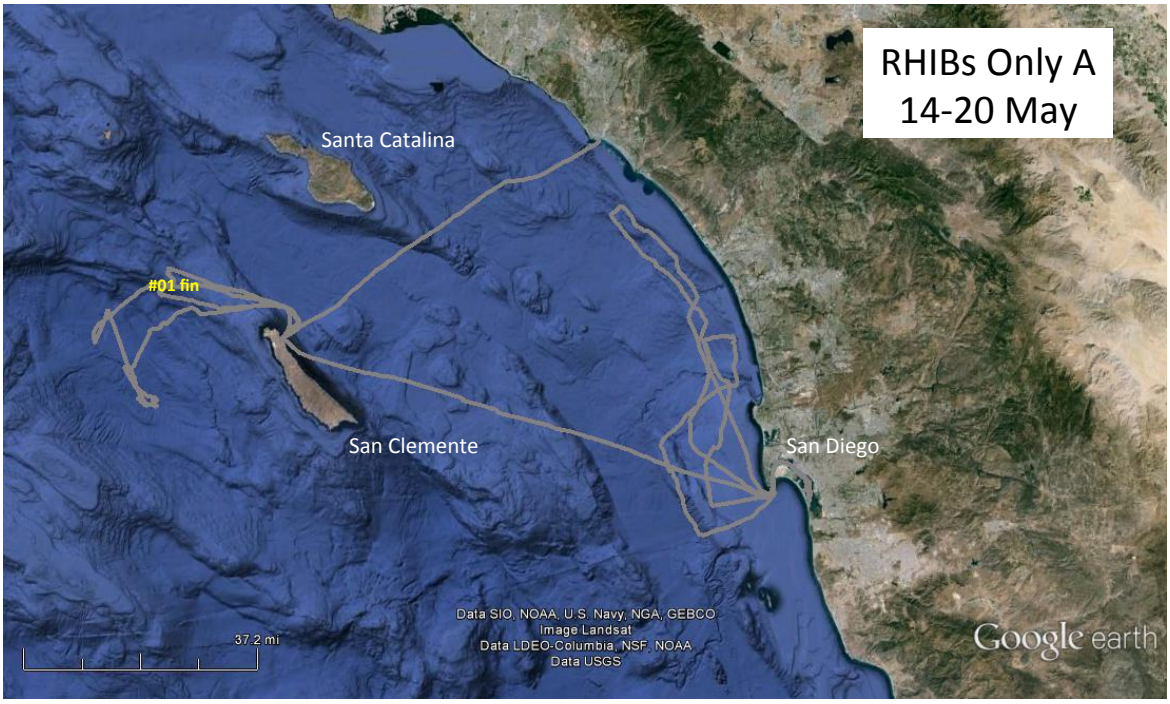
The SOCAL-BRS general operational area includes both southern and northern "inshore" areas around southern California, and an offshore area that includes the U.S. Navy's SCORE range (see figure to right). During SOCAL-BRS, operations have occurred throughout this region, with all sound transmissions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

SOCAL-13 was conducted in four distinct experimental phases, each involving slightly different configurations, operational areas, and slightly different objectives. For the first two of these periods, small field teams were used based exclusively from RHIB platforms. These periods were dubbed "RHIBs-only (A and B)" and involved a combination of shore-based teams from San Clemente Island and at other ports including San Diego and Avalon harbor depending on weather, animals, and position of Navy training operations with which efforts were coordinated. The RHIBs utilized included one or two ~6m tagging boats with twin outboard engines (left) and the 11m SCORE range RHIB described above. For the other two periods ("Phases I and II") the slightly larger configuration of research vessels and personnel typically used in the each of these segments, the *R/V Truth* (right: a ~23m 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 tagging RHIBs. Periods of operations, vessel configurations, and maps showing overall survey effort for each of these four periods are given below. Details regarding tagging and CEE results are provided later in this report.

14-20 May 2013: RHIBs-only A

This period was a pilot effort with a small field team (5) to determine the viability of deploying, testing, and using the smaller sound source and, if successful, to tag focal marine mammals and conduct CEEs according to specified protocols in this configuration. A single tagging RHIB (*Physalus*) was used during this period and it's effort track for the full period is shown in gray in the map below. The SCORE range RHIB (*Interceptor*) carried the sound source and two dedicated marine mammal observers to provide a second platform for locating possible candidates for the tag RHIB and to ensure full compliance with all permit requirements during CEEs. Overall this effort was extremely successful as

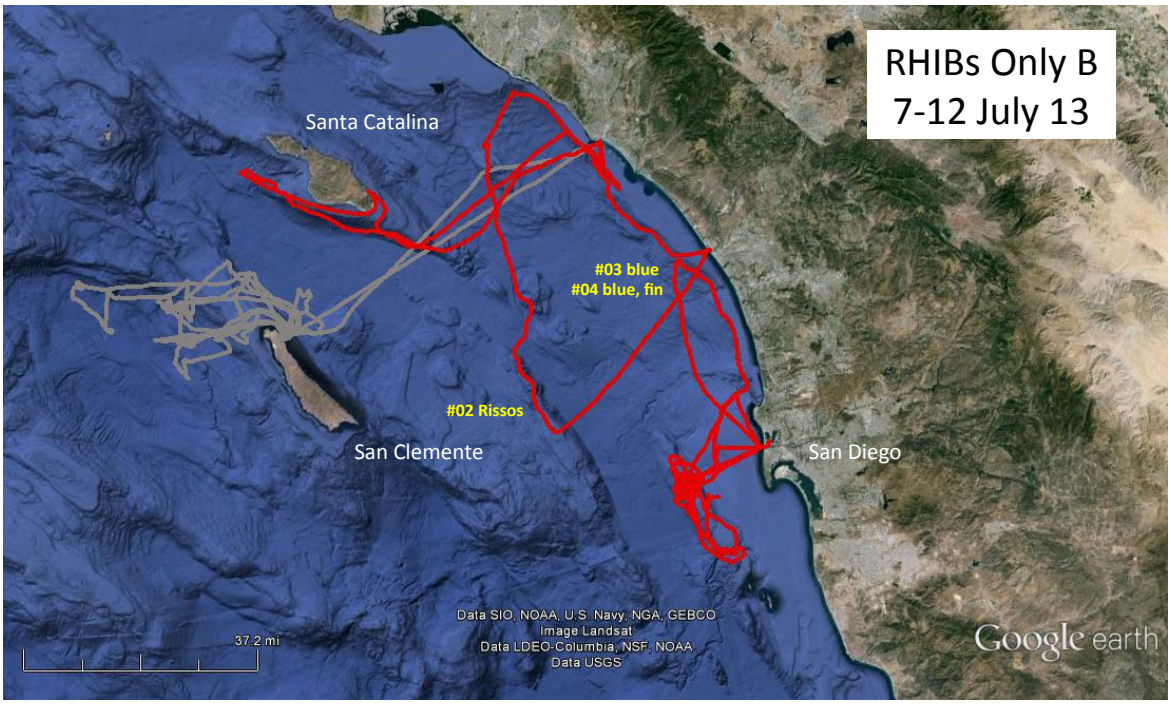
the sound source was successfully deployed, tested, calibrated, and ultimately used in a complete CEE sequence. Relatively poor weather at the start of this period resulted in the field team falling back to work from San Diego for three days. During the second part of this effort relatively good conditions were experienced west of San Clemente Island from which the team was based. Multiple groups of beaked whales were visually detected following acoustic detections from the shore-based M3R team although none were successfully tagged. A fin whale was tagged on the SCORE range and a CEE (#2013-01) was conducted at the position shown in gold below.



7-12 July 2013: RHIBs-only B

This period also included a small field team (5) but only included two tagging RHIBs; effort tracks are shown in the map below (gray: *Physalus*; red: *Ziphid*). No scaled sound source was deployed in this period. Rather the RHIBs worked in slightly different areas (*Physalus* was based from San Clemente Island while *Ziphid* moved from coastal areas around San Diego to sites off Catalina) in order to tag focal marine mammals in general areas where regular, ongoing Navy training operations were ongoing or planned. Coordination of field teams and communication with a Navy vessel (with which significant advance planning was conducted) was managed from the SCORE range operations center in San Diego where the M3R team was based. This effort was extremely successful and represented the first-ever direct coordination between field research teams tagging marine mammals and Navy vessels operating standard MFA in a controlled experimental context. Relatively good weather was experienced throughout this period and on three different occasions the SOCAL-13 field team managed to tag

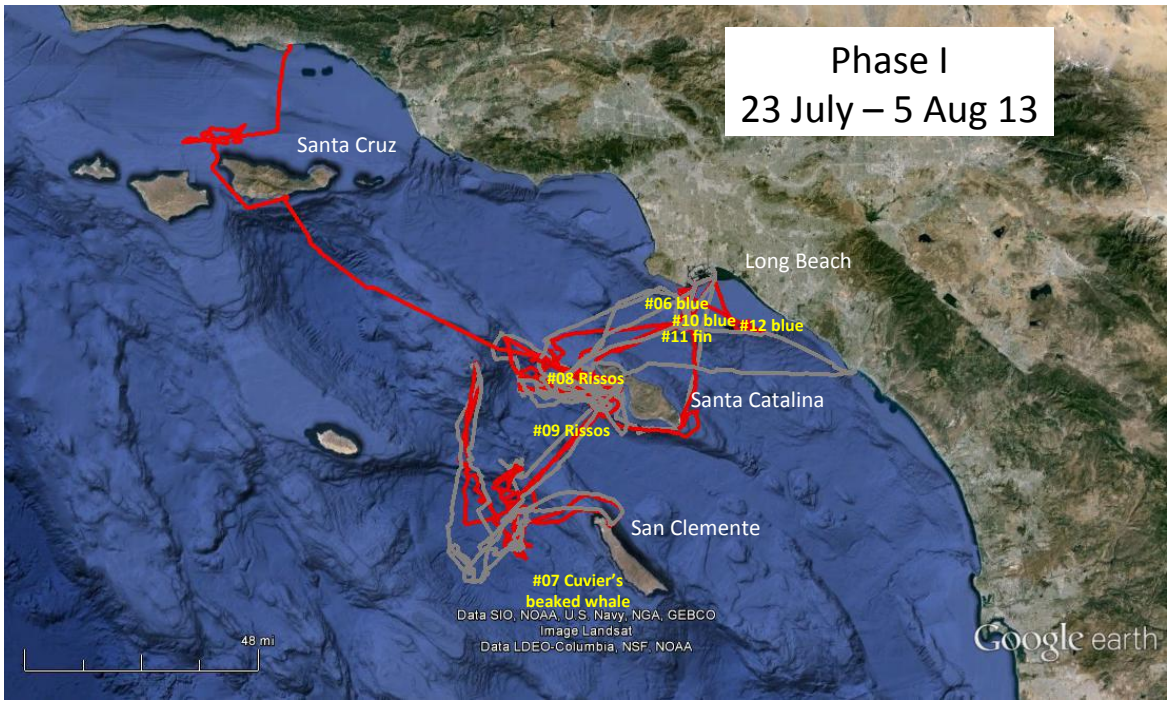
marine mammals from focal species in locations sufficiently close to ongoing training operations that Navy MFA sonar transmissions were used in controlled exposure experiments. In each case, vessel positions were controlled based on *in situ* sound propagation modeling to estimate received sound exposure levels at the position of tagged whales that were within operational protocols and were similar to levels for CEEs with (much closer) scaled sound sources. The locations of the Navy MFA vessel in each case at the time of the CEE are shown in gold in the figure below with a tagged Risso's dolphin (#2013-02), a blue whale (#2013-03), and simultaneously tagged blue and fin whales (#2013-04).



7-12 July 2013: PHASE I

The full complement of research vessels and field personnel (22 total) used in previous years was available for SOCAL-13 phase I. This included the *R/V Truth* that served as central coordination and housing for most of the field team, as well as visual, sound source, prey mapping, and data archive teams. Both tagging RHIBs (*Physalus* and *Ziphid*) were used as well and worked in generally overlapping areas (gray and red tracks respectively in figure below). Additionally, a dedicated PAM vessel (*R/V Bayliss*) supported both towed passive acoustic capabilities and a dedicated visual observation team. Finally, the M3R base of operations at the SCORE command center was manned to provide real-time acoustic detection and tracking capabilities for the SCORE range and to provide communication support with operational Navy vessels. Priority was given to offshore areas, particularly the SCORE range, as weather conditions and ongoing Navy operations permitted. Weather was mixed with several periods of marginal conditions

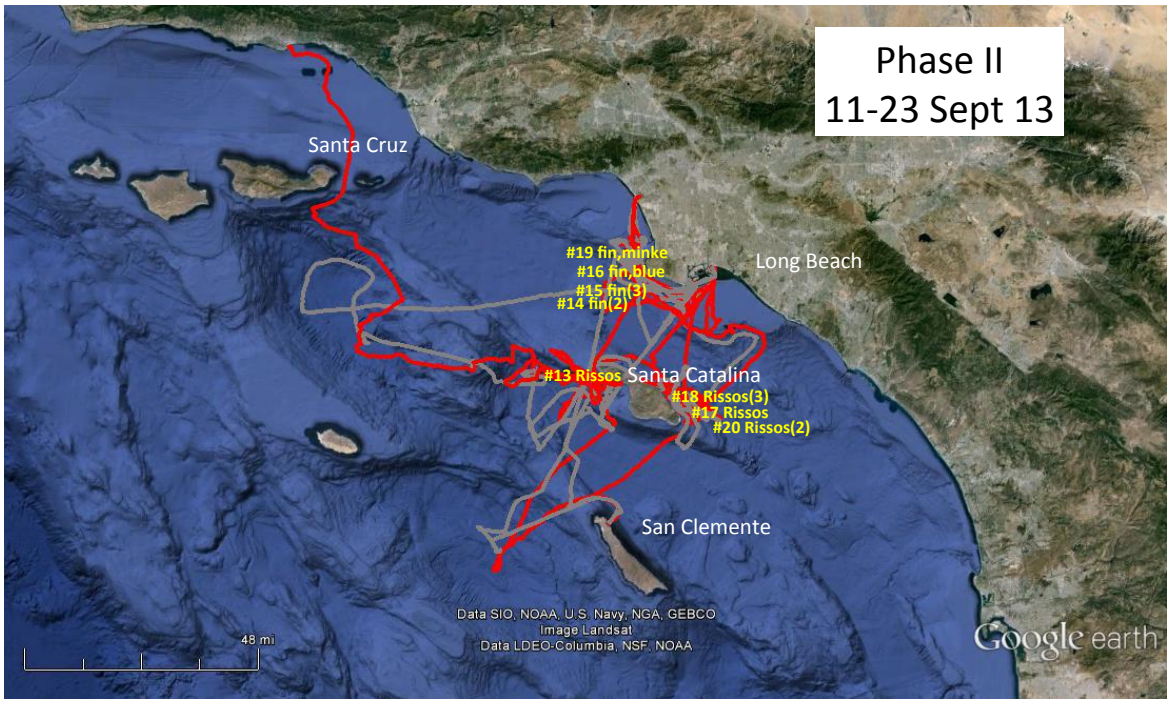
and a four-day stretch in the middle of operations with exceptionally calm weather than allowed the detection and tagging of multiple groups of the highest priority species, Cuvier's beaked whales. A second specified Navy vessel with MFA sonar was available for the first week of Phase I, during which SOCAL-13 managed to tag two Cuvier's beaked whales in areas just north of the SCORE range as well as two Risso's dolphins around Catalina. On two separate occasions, Navy MFA sources were available in the course of their planned training in appropriate proximity and within specified protocols to enable CEEs using realistic MFA exposures. These included the first-ever CEE with real MFA sonar and a tagged Cuvier's beaked whale (#2013-07) as well as a Risso's dolphin (#2013-09). Other CEEs conducted during Phase I (#2013-06, -08, -10, -11, and -12) with Risso's dolphins, fin, and blue whales all either involved scaled source CEEs or control sequences (no sonar transmissions) and were conducted during periods when real MFA sonar sources were unavailable.



11-24 September 2013: PHASE II

During this period, there were no available periods for coordination of tagging and CEE effort with real MFA sound sources. Operations thus focused on tagging to measure baseline behavior, control (no sonar transmission) experiments, and scaled source CEEs. A slightly smaller field contingent (17) was used based from the *R/V Truth* which served as central coordination and housing for most of the field team, as well as visual, sound source, prey mapping, passive acoustic, and data archive teams. Both tagging RHIBs (*Physalus* and *Ziphid*) were again used working in generally overlapping areas (gray and red tracks respectively in the figure below). The M3R base of operations at the SCORE

command center was manned to provide real-time acoustic detection and tracking capabilities for the SCORE range for periods when weather permitted offshore. Conditions were marginal to unworkable offshore for most of this period, and much of the effort was concentrated both around Catalina, particularly on the east side where we experienced quite high concentrations of Risso's dolphins, and in areas of Redondo canyon and the Palos Verdes Peninsula. A total of seven CEE sequences (involving either control or simulated MFA exposures) were conducted with Risso's dolphins, fin, blue, and minke whales (#2013-13 through 2013-20), most of which involved multiple simultaneously tagged animals. The general locations of the sound source for each of these are shown in gold in the figure below and each is discussed in detail below.



5. VISUAL SURVEY RESULTS

Trained and experienced marine mammal visual observers were used on RHIBs during all phases of SOCAL-13, during Phase I by a dedicated visual team on the *R/V Baylis* (the sailing vessel operating the towed PAM system), and on both Phase I and Phase II on the *R/V Truth*. Visual observers were on duty from all platforms during essentially all daylight hours when weather and sea conditions permitted operating 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 variation 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 performed. However, in several cases,

focal follows from the RHIBs were conducted on focal groups that did not include tagged individuals.

The *Truth* maintained position ~1000m from tagged focal animals before, during, and after CEEs as specified in operational protocols, 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* or with the Chief Scientist coordination operations from the SCORE range operations center during RHIBs-only periods 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. Visual survey results for SOCAL-13 for the *Truth*, RHIB, and *Baylis* visual observers, are given below for all platforms, operational effort phases, and observational modes.

SOCAL-13 Results from Visual Observer Team - all Platforms

Table 1. Survey effort days during SOCAL-13 field operation for *R/V Bayliss* (BAY), SCORE range RHIB *Interceptor* (INT), tagging RHIB *Physalus* (PHY), tagging RHIB *Ziphid* (ZIP), and *R/V Truth*

SOCAL-13 Phase	BAY	INT	PHY	Truth	ZIP
SOCAL13-I	14		11	14	14
SOCAL13-II			13	13	13
SOCAL13-RHIB-A		5	8		
SOCAL13-RHIB-B			7		7

Table 2. Total marine mammal sighting events for SOCAL-13 field operations for all phases and platforms (abbreviations same as above)

SOCAL-13 Phase	BAY	INT	PHY	Truth	ZIP
SOCAL13-I	84		31	276	83
SOCAL13-II			44	294	87
SOCAL13-RHIB-A		14	19		
SOCAL13-RHIB-B			27		59

Table 3. Marine mammal species sighted (confirmed to species) for SOCAL-13 field operations for all phases and platforms (abbreviations same as above). A total of 15 marine mammal species were confirmed across all platforms (common names listed below)

SOCAL-13 Phase	BAY	INT	PHY	Truth	ZIP
SOCAL13-I	7		8	13	9
SOCAL13-II			9	11	7
SOCAL13-RHIB-A		5	7		
SOCAL13-RHIB-B			6		7

Blue whale
Fin whale
Minke whale
Sperm whale
Cuvier's beaked whale
Long-beaked common dolphin
Short-beaked common dolphin
Delphinus sp.
Risso's dolphin
Pacific white-sided dolphin
Transient killer whale
Bottlenose dolphin
Elephant seal
Pacific harbor seal
California sea lion

Table 4. Best estimate of total individual marine mammals sighted across all platforms and operational periods

SOCAL-13 Phase	BAY	INT	PHY	Truth	ZIP
SOCAL13-I	3072		1123	12708	3217
SOCAL13-II			1122	10841	2366
SOCAL13-RHIB-A		346	377		
SOCAL13-RHIB-B			541		4018

In certain cases (including Risso's dolphin CEEs), 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. TOWED PASSIVE ACOUSTIC MONITORING

Overview and Methods

The purpose of the Passive Acoustic Monitoring (PAM) component of the SOCAL-BRS is to find beaked whales and sperm whales as test subjects. Secondary objectives include: detecting other marine mammals in the study area; and recording and measuring test vessel noise, ambient noise, and the simulated Navy sonar signal at varying distances from the source vessel.

For SOCAL-13 Phase I, the PAM component was conducted on a 65' Wyliecat motor-sailer, the *R/V Derek M. Baylis*. The vessel departed anchorage each morning between 0400 and 0600 to transit to the day's study area within Southern California waters. A towed hydrophone array was deployed upon entering the study area, and acoustics personnel initiated survey effort immediately. Visual observers initiated effort once there was sufficient daylight. The vessel surveyed until target animals were detected, or until 1600, when it would transit to an anchorage. The geographic area varied daily, based on the weather and sea state conditions, as well as the intended survey track of the R/V Truth and RHIB tagging teams. Visual observation for cetaceans was conducted by personnel from the bow of the *Baylis* using 7x handheld binoculars and naked eye during daylight hours. Observers would scan the area 180° forward of the vessel in search of cetaceans. When cetaceans were detected, basic information regarding the location and species identity were logged in a computer. A hydrophone array was towed ~100 m behind the stern of the towing vessel to detect, localize, and classify sounds associated with cetaceans. The primary array was a tetrahedral array, which provided improved

localization capabilities. A linear towed array (Oil 8) was used as needed or when vessel speeds were greater than 6 knots (Table 5).

Array	*Hydrophone Type (# in array)*	*Useable Frequency Range*	*Dates used*
Tetrahedral	APC 10mm (6)	2-60 kHz	7/24 – 7/31
Oil 8	EDC 1" (2); Reson 4013 (2); APC 10mm (1)	2-40 kHz	7/23-7/24; 7/26-7/28; 7/30-8/4
Oil 10 + In-Line 10	APC 19mm (7); Reson 4013 (2)	2-60 kHz	9/11-9/12
Oil 10	APC 19mm (3); Reson 4013 (2)	2-60 kHz	9/13; 9/17-9/21; 9/23-9/24

Table 5. Useable frequency range and dates used for each hydrophone array during SOCAL-13. On several occasions both arrays were used on the same day.

For Phase II, the PAM component of the SOCAL-BRS survey was conducted from the R/V *Truth*. This vessel departed anchorage each morning between 0600 and 0700 to transit to the study area. A linear hydrophone array was deployed 200m behind the survey vessel when the vessel reached the study area acoustics personnel initiated survey effort immediately. The primary array was a linear towed array (Oil 10), which allowed the Truth to travel between 8 and 10 knots (Table 5). Acoustic survey effort ended when the survey vessel stopped to conduct CEEs. The study area varied daily, based on the weather and seas, as well as the intended survey track of the M/V *Truth* and RHIB tagging team.

Signals from the hydrophone array were digitized using a Fireface UC audio interface, and recordings of all channels were made at a 192 kHz sampling rate using Pamguard software. Two acousticians monitored for cetacean sounds using headphones (aural) and Pamguard software (visual). The detection and identification of beaked whales relied on several features within Pamguard, including the automated click detector, click classifiers, beaked whale alarm, the surface bounce module, the spectrogram, the waveform, and Wigner plot. When beaked whales were detected, the acoustics team tracked animals using localization methods within Pamguard. Basic detection information was provided to the chief scientist aboard the Truth, who would then make a decision regarding tagging efforts based on circumstances.

Results

For SOCAL-13 Phase I, over 1,250 km of acoustic survey effort was conducted. Survey effort alternated use of the linear oil array and the tetrahedral array (Table 5). The tetrahedral array suffered a failure on 31 July caused by sea water intrusion on the connectors. A linear array was used for the remainder of the survey. A total of 116 cetaceans were detected from the *Baylis*, of which 89 were detected using acoustic methods (Fig. 1).

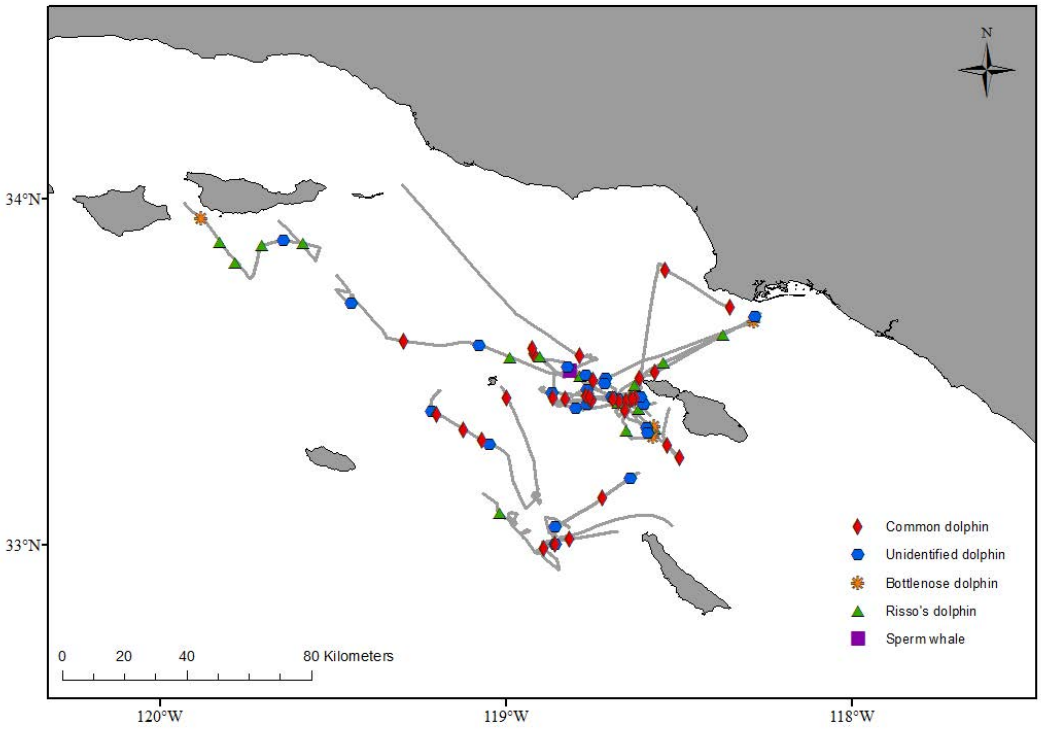


Figure 1. Acoustic detection of non-beaked whale odontocetes from the *R/V Derek M. Baylis* during SOCAL-13 Phase I. Survey tracklines are shown as gray lines.

Detections included long-beaked common dolphins (*Delphinus capensis*), unidentified common dolphin species (*Delphinus* spp.), bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus*), blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), sperm whales (*Physeter macrocephalus*), and two species of beaked whales (*Ziphius cavirostris* & *Berardius bairdii*). There were a total of 12 beaked whale detections on 7 of the 13 survey days; all beaked whales except one were detected using acoustic methods (Fig. 2).

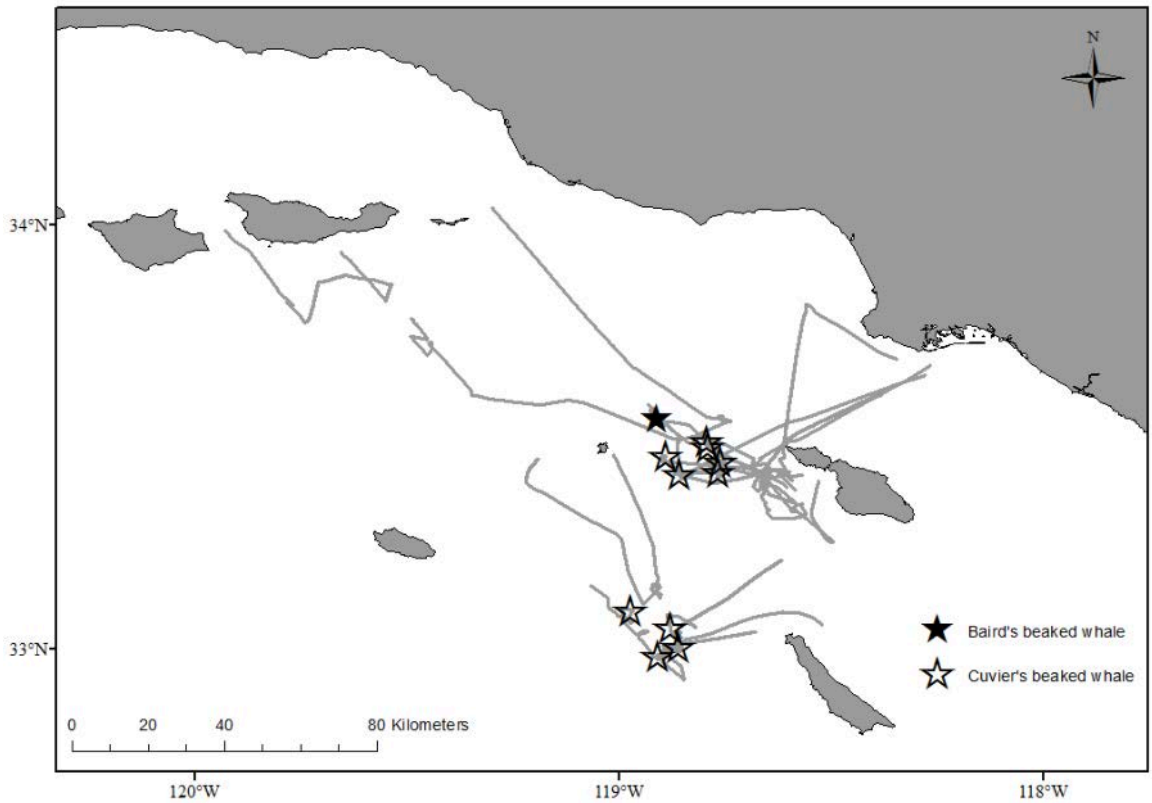


Figure 2. Acoustic detection of beaked whales (stars) from the *R/V Derek M. Baylis* during SOCAL-13 phase I. Survey tracklines are shown as gray lines.

Two acoustic detections of Cuvier's beaked whales were not sighted by our visual team; however species identifications were confirmed by the *Truth* and the SCORE range M3R team. Acoustic species classification of Baird's beaked whale (*Berardius bairdii*) was determined by acoustic characteristics but this not confirmed by visual observation. Several beaked whale detections were approached for tagging efforts, including an example on 28 July in which two groups of Cuvier's beaked whales were acoustically detected by the PAM team on the *Baylis* and visually confirmed by observers on the *Truth*. Efforts were made to tag these animals, but no tags were attached. We returned to the same location on the morning of 28 July and a group of Cuvier's beaked whales were visually detected from the *Baylis* at 0927, tagged at 1048 with a suction cup DTAG, and acoustically detected from the *Baylis* at 1122. These whales were then monitored visually and acoustically for the next 8 hours during which a second group of beaked whales were acoustically detected by the team on the *Baylis* and confirmed by the SCORE range M3R team.

Over 925 km of acoustic survey effort was conducted during SOCAL-13 Phase II aboard the *R/V Truth*. The PAM component had a total of 91 acoustic detections of cetaceans including long-beaked common dolphins, short-beaked common dolphins, unidentified common dolphin species, bottlenose dolphins, Risso's dolphins, and sperm whales. There

were no acoustic detections of beaked whales and with relatively poor offshore weather conditions, focus shifted to a secondary species for the PAM effort (Risso's dolphins). There were a total of 29 Risso's dolphin detections on 8 of the 10 survey days.

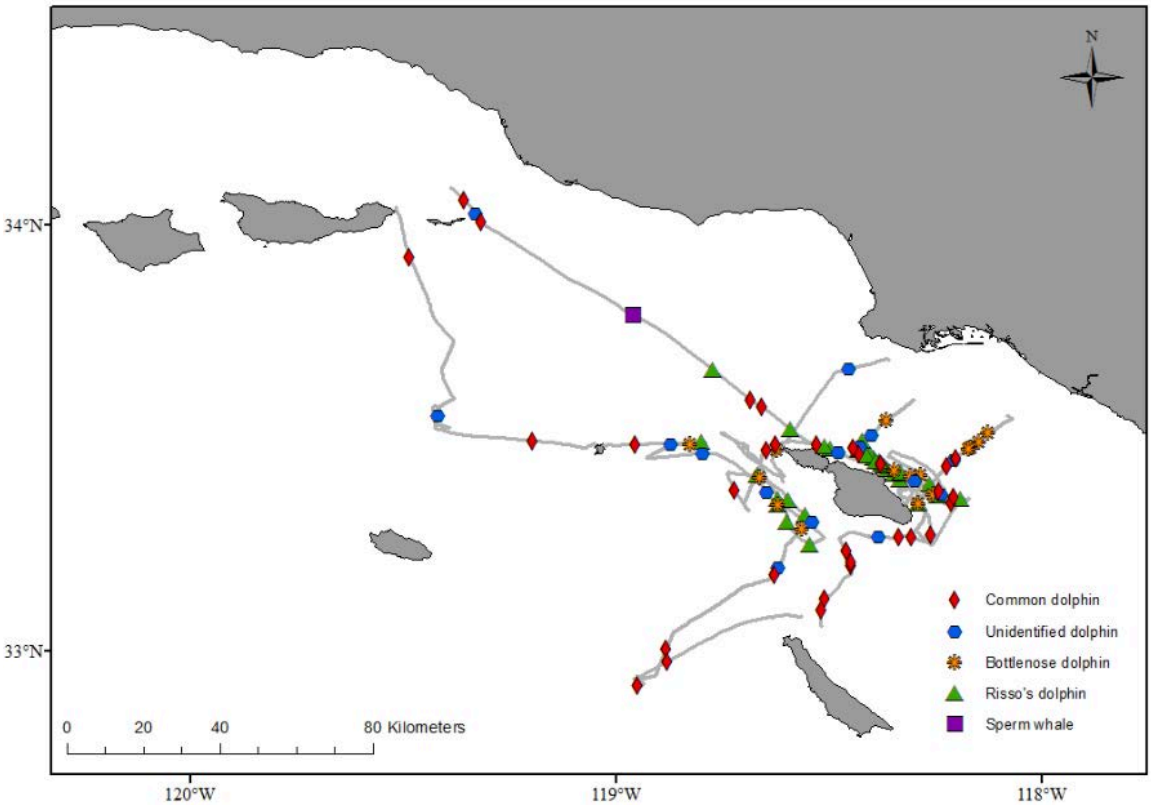


Figure 3. Acoustic detection of odontocetes from the *R/V Truth* during SOCAL-13 Phase II. Survey tracklines are shown as gray lines.

7. SUMMARY OF TAG DEPLOYMENTS

A similar suite of acoustic and movement tags were used in SOCAL-13 as in previous projects, each with somewhat different capabilities and thus intended functions. These included:

DTAGs – designed and supplied by WHOI collaborators[4], 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

[4] 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.

DTAGs were used in SOCAL-13.

Mk-10s[5] – 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[6] – 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-13.

SIRTRACK[7] - 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).

Depending on the focal species, environmental conditions, timing, and other practical considerations, different combinations of these tags were used in different circumstances.

Forty-five tags (of three kinds) were secured on 45 individual animals of five different marine mammal species during all phases of SOCAL-13. This included multiple tags for high-priority primary Cuvier's beaked whales, long duration deployments on Risso's dolphins including in targeted foraging behavioral contexts, and tags on multiple simultaneous baleen whales. A single minke whale was tagged, which was both a new species for the SOCAL-BRS project and the first successful acoustic and movement tag deployment on this species in the North Pacific A breakdown of the overall tag deployments by species and tag type are given below, followed by a breakdown of attachment type and duration by individual for each phase of SOCAL-13. A total of nearly 175 hours of high-resolution acoustic and movement tag data were collected across all deployments.

TOTAL SOCAL-13	41 individuals of 5 species (with 45 tags of 3 types)
Rissos dolphins:	18 individuals (18 DTAG3)
Cuvier's Beaked Whale:	2 individuals (2 DTAG3)
Fin Whales:	10 individuals (10 DTAG3; 3MK-10)
Blue Whales:	10 individuals (8 DTAG3, 8 DTAG2)
Minke Whale:	1 individuals (1 DTAG3)

[5] http://www.wildlifecomputers.com/Media/MDS/TDR10_FastlocGPSBackmountSuite.pdf
[6] http://www.acousonde.com/
[7] http://sirtrack.com

Date	SOCAL-13 Phase	Total deployment time	Species	Animal ID
19-May	RHIBs only-A	5:04	Fin Whale	bp13_139a
9-Jul	RHIBs only-B	5:09	Rissos Dolphin	gg13_190a
10-Jul	RHIBs only-B	4:59	Blue Whale	bw13_191a
11-Jul	RHIBs only-B	0:39	Blue Whale	bw13_192a
12-Jul	RHIBs only-B	3:51	Fin Whale	bp13_193a
12-Jul	RHIBs only-B	5:14	Blue Whale	bw13_193b
23-Jul	PHASE I	0:48	Rissos Dolphin	gg13_204a
23-Jul	PHASE I	3:19	Rissos Dolphin	gg13_204b
26-Jul	PHASE I	3:26	Blue Whale	bw13_207a
27-Jul	PHASE I	0:03	Blue Whale	n/a
27-Jul	PHASE I	0:03	Blue Whale	bw13_208a
29-Jul	PHASE I	8:42	Cuviers Beaked Whale	zc13_210a
30-Jul	PHASE I	7:30	Blue Whale	bw13_211a
30-Jul	PHASE I	3:28	Cuviers Beaked Whale	zc13_211a
31-Jul	PHASE I	1:05	Rissos Dolphin	gg13_212a
31-Jul	PHASE I	0:01	Rissos Dolphin	gg13_212b
1-Aug	PHASE I	4:19	Rissos Dolphin	gg13_213a
2-Aug	PHASE I	4:05	Blue Whale	bw13_214b
2-Aug	PHASE I	0:59	Blue Whale	bw13_214a
2-Aug	PHASE I	2:03	Blue Whale	bw13_214c
3-Aug	PHASE I	1:22	Rissos Dolphin	gg13_215a
3-Aug	PHASE I	0:02	Rissos Dolphin	gg13_215b
3-Aug	PHASE I	0:01	Rissos Dolphin	gg13_215c
4-Aug	PHASE I	4:52	Fin Whale	bp13_216a
5-Aug	PHASE I	4:22	Blue Whale	bw13_217a
12-Sep	PHASE II	6:29	Rissos Dolphin	gg13_255a
12-Sep	PHASE II	4:27	Rissos Dolphin	gg13_255b
14-Sep	PHASE II	0:03	Fin Whale	n/a
14-Sep	PHASE II	0:03	Fin Whale	n/a
14-Sep	PHASE II	5:26	Fin Whale	bw13_mk10_257
14-Sep	PHASE II	5:10	Fin Whale	bw13_257a
14-Sep	PHASE II	0:15	Fin Whale	bw13_257a
14-Sep	PHASE II	2:20	Fin Whale	bp13_257b
15-Sep	PHASE II	6:32	Fin Whale	bp13_258a
15-Sep	PHASE II	5:30	Fin Whale	bp13_258b
15-Sep	PHASE II	6:08	Fin Whale	bp13_258c
16-Sep	PHASE II	4:26	Fin Whale	bp13_259a
16-Sep	PHASE II	5:20	Blue Whale	bw13_259a
18-Sep	PHASE II	4:52	Rissos Dolphin	gg13_261a
19-Sep	PHASE II	6:22	Rissos Dolphin	gg13_262a
19-Sep	PHASE II	13:33	Rissos Dolphin	gg13_262b
19-Sep	PHASE II	9:56	Rissos Dolphin	gg13_262c
21-Sep	PHASE II	1:06	Rissos Dolphin	gg13_264a
22-Sep	PHASE II	3:46	Fin Whale	bp13_265a
22-Sep	PHASE II	2:03	Minke Whale	ba13_265a
23-Sep	PHASE II	3:09	Rissos Dolphin	gg13_266a
23-Sep	PHASE II	2:16	Rissos Dolphin	gg13_266b

8. 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[8] and to those used in earlier phases of the SOCAL-BRS project[9]. Experimental protocols are based on well-established methods of measuring behavioral responses to various stimuli using a before, during, after (A-B-A) paradigm. These are described briefly here with emphasis on methodological differences from previous field seasons.

Numerous safety protocols were again 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. 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 and actual MFA sonar and no noise sequences 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.

As described above, for SOCAL-13 experimental signals used in CEEs were either simulated or real MFA sonar signals. Simulated MFA sonar signals were projected from the slightly smaller 10-element vertical line array source described about and 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. 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. Realistic MFA sonar signals were used from several different Navy vessels with standard 53C sonar systems using signals typical of sonar training operations. These signals varied slightly between the two vessels but were similar and overlapped the fundamental frequency of the simulated MFA sounds in frequency and typically included a two-tone sequence (each 0.5s with a 0.1s delay) and a 30-40s repetition rate. These MFA transmissions from Navy vessels were transmitted for a maximum of 60 min at a constant source level, nominally 235 dB re: 1µPa; vessel starting position and straight-line tracks were selected to meet experimental protocols specifying a 20-30 dB ramp-up in received sounds for different species groups (100-120 dB re: 1µPa received level for

[8] 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.

[9] 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.

beaked whales and 120-150 dB re: 1µPa for all other species). For SOCAL-13 we opted to remove pseudorandom noise (PRN) signal used in earlier field seasons to focus on the contrast between simulated and actual MFA sonar. However, we added additional full "control" sequences with a baseline period, a "mock" exposure (source deployed but not transmitting), and a "post-exposure" sequence. These were conducted within a balanced sequence of simulated MFA sonar CEEs determined *a priori* and nominally blind to visual observers (simulated MFA transmissions were audible on the Truth) and RHIB personnel (who are ultimately responsible for conducting focal follows and to whom transmissions were typically not audible).

CEE Protocols and Shut-Down Criteria

The specific protocols for conducting CEEs in SOCAL-13 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 all 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 scaled sound source is not within 1nm of any landmass or within 3nm from land within the Channel Islands National Marine Sanctuary. Determine that real MFA sources are no closer than 3 nm to shore (typically much further given where most training operations occur), are not vectored either directly perpendicular to or parallel to shore, and do not transmit in canyons.

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:

SCALED SOURCES

- 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.

NAVY SOURCE VESSELS

- Position Navy vessel at an appropriate range and course trajectory from the focal group or animal to meet the specified received level objectives (see above) based on *in situ* sound propagation modeling, taking into account group movement/distribution, to the extent possible.
- RHIB tracking teams maintain focal follows and observe any other animals in the area.
- Navy vessels operate under all monitoring and mitigation requirements for normal authorized training operations.
- Initiate MFA sonar transmissions following final coordination with field teams and transmit at 8 kt speed holding a steady course directed generally (but not directly) toward focal (tagged) animals.
- Maintain transmissions, unless any contra-indicators require shut-down (see below), for a total maximum transmission time of 60 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 between exposure and control (no noise) CEEs within operational areas was balanced as possible when CEEs occurred in the same area on sequential days to meet the experimental design and 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 scaled sound exposures:

- *Any marine mammal inside 200m shut-down zone* around scaled 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[10]:
    - o *Directed, high speed or other abnormal swimming behavior (at surface), especially toward shore.*
    - o *Unusual and abnormal surface/subsurface behavior involving apparent*

[10] None of these behaviors have been observed in any CEE sequence during SOCAL-BRS.

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 transmissions* (as determined by one of the principal investigators based on the input of trained marine mammal observers) CEEs would have been terminated.
- Navy vessel MFA transmissions occurred in full compliance with standard monitoring and mitigation requirements.

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

- Either the scaled 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-13 CEEs

During the four experimental phases of SOCAL-13, CEEs using either simulated or real MFA sonar or no noise control “exposures” were successfully completed with 32 individuals of five marine mammal species (Risso’s dolphin, Cuvier’s beaked whale, blue whale, fin whale, and minke whale).

Rissos:	Cuvier's Beaked Whale:	Blue Whale:	Fin Whale:	Minke Whale:
4 sim MFA 2 real MFA 6 Silent	0 sim MFA 1 real MFA 0 Silent	2 sim MFA 2 real MFA 2 Silent	5 sim MFA 1 real MFA 4 Silent	0 sim MFA 0 real MFA 1 Silent
ALL SPECIES **Simulated MFA: 13** **Real MFA: 6** **Silent Control: 13** **TOTAL: 32**				

Twenty complete CEE transmission sequences were conducted, each on different days, during the four phases of SOCAL-13. Twelve of these included exposures with multiple individuals. Twice during SOCAL-13, scaled MFA transmissions were terminated during the CEE prior to the 30 min. maximum transmission period according to specified safety protocols, once due to a non-focal California sea lion and once due to a focal Risso's dolphin group, apparently ignoring the sound source transmitting at full power, entering the 200m "shut-down" zone around the scaled sound source.

A chronological list of the CEE sequences by SOCAL-13 experimental phase is given below, showing date, CEE number, sound exposure type and duration, and a brief description with a tagged animal dive profile and sound exposure received level (where applicable). Maps showing the location of each CEE are given (in section 4) above.

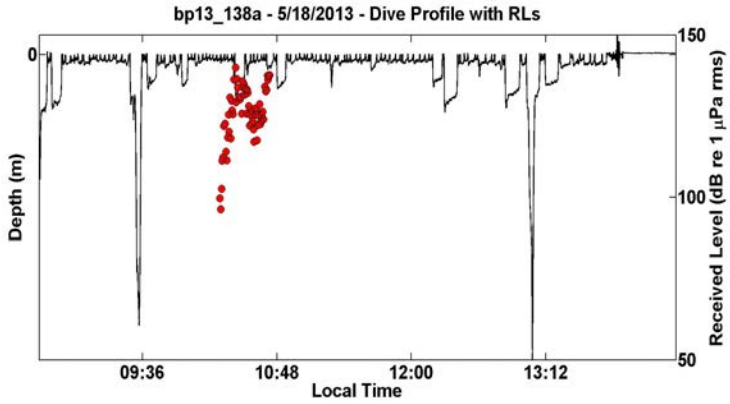
SOCAL-13 - RHIBs-only A CEE Sequences

Date	SOCAL-13 Phase	Total deployment time	Species	Animal ID	From Boat	Playback Number	Playback Type	CEE TIME	Duration (min)
19-May	RHIBs only-A	5:04	Fin Whale	bp13_139a	Physalus	*#2013_01*	SIMULATED MFA	1014-1044	30

CEE # 2013-01

- DATE and TIME: **19 May 13 (1014-1044)**
- LOCATION (Source at start of CEE): **Just north of SOAR range to WNW of SCI**
- FOCAL SPECIES: **FIN WHALE**

- INDIVIDUAL ID(s): **bp13_139a**
- CEE TYPE (DURATION): **SIMULATED MFA (30:00)**
- SUMMARY: First CEE based from SCORE range vessel *Interceptor*. Also first CEE attempted and completed using new, smaller scaled source. CEE occurred just north of range with positions vectored from M3R. Tagged animal was in group of three in primarily surface mode. No overt responses observed during CEE



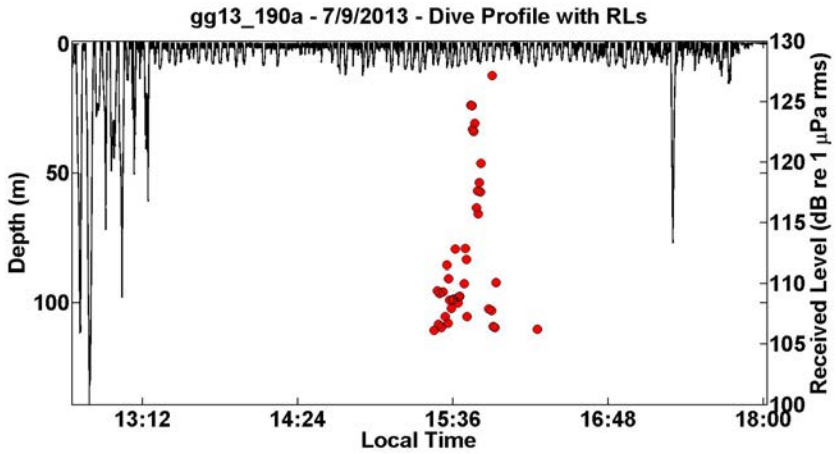
SOCAL-13 - RHIBs-only B CEE Sequences

Date	SOCAL-13 Phase	Total deployment time	Species	Animal ID	From Boat	Playback Number	Playback Type	CEE TIME	Duration (min)
9-Jul	RHIBs only-B	5:09	Rissos Dolphin	gg13_190a	Ziphid	*#2013_02*	REAL MFA	1515-1615	60
10-Jul	RHIBs only-B	4:59	Blue Whale	bw13_191a	Ziphid	*#2013_03*	REAL MFA	1319-1417	58
11-Jul	RHIBs only-B	0:39	Blue Whale	bw13_192a	Physalus	n/a	n/a	n/a	n/a
12-Jul	RHIBs only-B	3:51	Fin Whale	bp13_193a	Physalus	*#2013_04*	REAL MFA	0938-1031	53
12-Jul	RHIBs only-B	5:14	Blue Whale	bw13_193b	Ziphid	*#2013_04*	REAL MFA	0938-1031	53

CEE # 2013-02

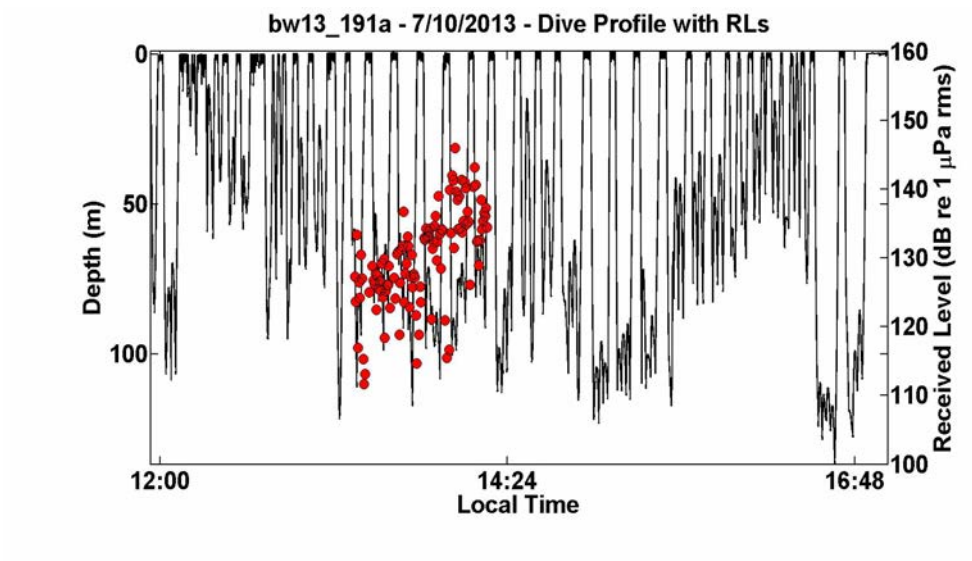
- DATE and TIME: **9 July 13 (1515-1615)**
- LOCATION (Source at start of CEE): **East of SCI (32.841; -118.027); animals north off Catalina**
- FOCAL SPECIES: **RISSO'S DOLPHIN**
- INDIVIDUAL ID(s): **gg13_190a**
- CEE TYPE (DURATION): **REAL NAVY MFA (60:00)**
- SUMMARY: First CEE using real Navy MFA source. Navy ship had been working on SOAR range and Risso's in a group of ~15 was tagged off Catalina. Ship moved to start position according to all specified protocols and requirements. Focal follow maintained throughout full sequence as planned. Risso's remained in slow travel/surface mode throughout CEE with no clearly evident changes in behavior. Modeled RLs were 108-130 dB at 10 m depth and 112-138 dB at 50 m depth.

Actual RLs measured on the animal were ~105-127 dB. Modeled RLs were 108-130 dB at 10 m depth and 112-138 dB at 50 m depth. Actual RLs measured on the animal were ~105-127 dB.



CEE # 2013-03

- DATE and TIME: **10 July 13 (1319-1417)**
- LOCATION (Source at start of CEE): **Offshore ~12 nm SW of Dana Pt.; animal just offshore from Dana Pt.**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw13_191a**
- CEE TYPE (DURATION): **REAL NAVY MFA (58:00)**
- SUMMARY: Blue whale feeding on shelf off Dana Point. Navy ship was conducting training operations in general area to the west. Ship was vectored to position well offshore and within specified protocols to conduct CEE with target levels. Ship transmissions were terminated two min. earlier than full duration but not because of a required shut-down. Possible horizontal movement of focal animal but possible response abated shortly following exposure. Modeled RLs were 123-140 dB at 50 m depth. Actual RLs measured on the animal were ~110-145 dB.



CEE # 2013-04

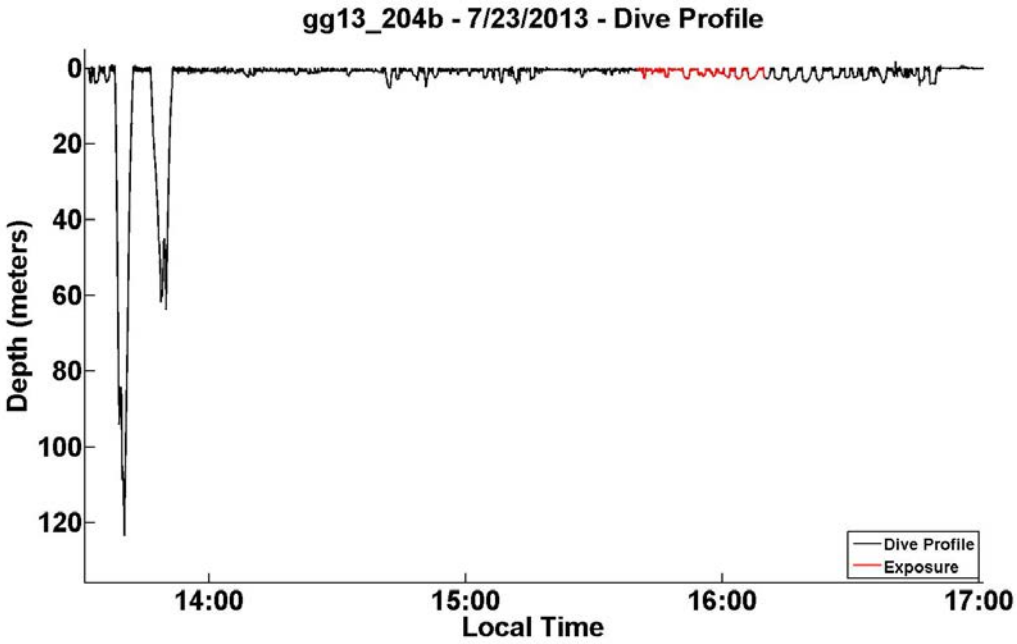
- DATE and TIME: **12 July 13 (1238-1331)**
- LOCATION (Source at start of CEE): **Offshore SW of Dana Point; focal blue whale near Dana Point and incidental fin whale near San Clemente Island**
- FOCAL SPECIES: **BLUE WHALE (1) & FIN WHALE (1)**
- INDIVIDUAL ID(s): **bw13_193a & bp13_193a**
- CEE TYPE (DURATION): **REAL NAVY MFA (55:00)**
- SUMMARY: Blue whale tagged off Dana Point early in the day with Navy ship available in general area to west. CEE conducted according to protocols with ship offshore focused on this blue whale. Fin whale was incidentally part of CEE more distantly to the west (near SCI). Position of vessel was selected to meet blue whale protocols but to optimize incidental exposures on fin whale. Navy source used multiple transmission modes which complicates acoustic analysis (and why no figures given below). Additionally, vessel had to alter course and terminate exposures early because of other vessels in area. This CEE will be excluded from final analysis given these complications.

SOCAL-13 - Phase I CEE Sequences

Date	SOCAL-13 Phase	Total deployment time	Species	Animal ID	From Boat	Playback Number	Playback Type	CEE TIME	Duration (min)
23-Jul	PHASE I	0:48	Rissos Dolphin	gg13_204a	Ziphid	*n/a*	n/a	n/a	n/a
23-Jul	PHASE I	3:19	Rissos Dolphin	gg13_204b	Ziphid	*#2013_05*	SILENT CONTROL	1540-1610	30
26-Jul	PHASE I	3:26	Blue Whale	bw13_207a	Ziphid	*#2013_06*	SILENT CONTROL	1744-1814	30
27-Jul	PHASE I	0:03	Blue Whale	n/a	Ziphid	*n/a*	n/a	n/a	n/a
27-Jul	PHASE I	0:03	Blue Whale	bw13_208a	Ziphid	*n/a*	n/a	n/a	n/a
29-Jul	PHASE I	8:42	Cuviers Beaked Whale	zc13_210a	Ziphid	*#2013_07*	REAL MFA	1801-1901	60
30-Jul	PHASE I	7:30	Blue Whale	bw13_211a	Ziphid	*n/a*	n/a	n/a	n/a
30-Jul	PHASE I	3:28	Cuviers Beaked Whale	zc13_211a	Physalus	*n/a*	n/a	n/a	n/a
31-Jul	PHASE I	1:05	Rissos Dolphin	gg13_212a	Physalus	*#2013_08*	SILENT CONTROL	1656-1705	9
31-Jul	PHASE I	0:01	Rissos Dolphin	gg13_212b	Physalus	*n/a*	n/a	n/a	n/a
1-Aug	PHASE I	4:19	Rissos Dolphin	gg13_213a	Physalus	*#2013_09*	REAL MFA	1812-1824	12
2-Aug	PHASE I	4:05	Blue Whale	bw13_214b	Ziphid	*#2013_10*	SILENT CONTROL	1353-1420	27
2-Aug	PHASE I	0:59	Blue Whale	bw13_214a	Ziphid	*n/a*	n/a	n/a	n/a
2-Aug	PHASE I	2:03	Blue Whale	bw13_214c	Ziphid	*#2013_10*	SILENT CONTROL	1353-1420	27
3-Aug	PHASE I	1:22	Rissos Dolphin	gg13_215a	Ziphid	*n/a*	n/a	n/a	n/a
3-Aug	PHASE I	0:02	Rissos Dolphin	gg13_215b	Physalus	*n/a*	n/a	n/a	n/a
3-Aug	PHASE I	0:01	Rissos Dolphin	gg13_215c	Physalus	*n/a*	n/a	n/a	n/a
4-Aug	PHASE I	4:52	Fin Whale	bp13_216a	Ziphid	*#2013_11*	SIMULATED MFA	1609-1628	19
5-Aug	PHASE I	4:22	Blue Whale	bw13_217a	Ziphid	*#2013_12*	SIMULATED MFA	1104-1112	8

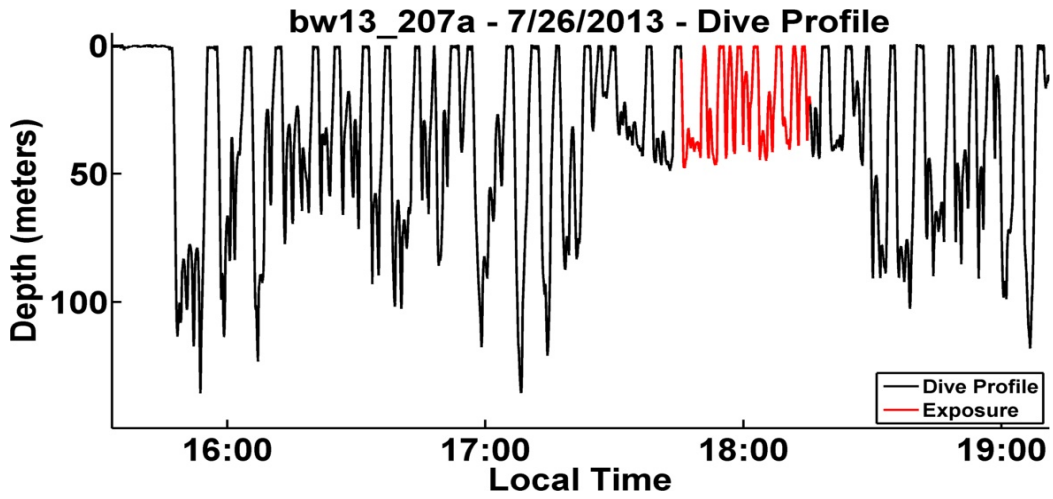
CEE # 2013-05

- DATE and TIME: **23 July 13 (1540-1610)**
- LOCATION (Source at start of CEE): **Just north of Santa Cruz Island in Santa Barbara Channel**
- FOCAL SPECIES: **RISSO'S DOLPHIN**
- INDIVIDUAL ID(s): **gg13_204b**
- CEE TYPE (DURATION): **CONTROL - no sound (30:00)**
- SUMMARY: Full control sequence with Risso's dolphin tagged off Santa Cruz Island. Animal was within 3 nm of SCI so no transmissions possible. Animal tagged and remained in slow/surface travel mode from tagging through mock exposure (no clear change in behavior), then tag came off as animals shifted to more active mode (after sequence)



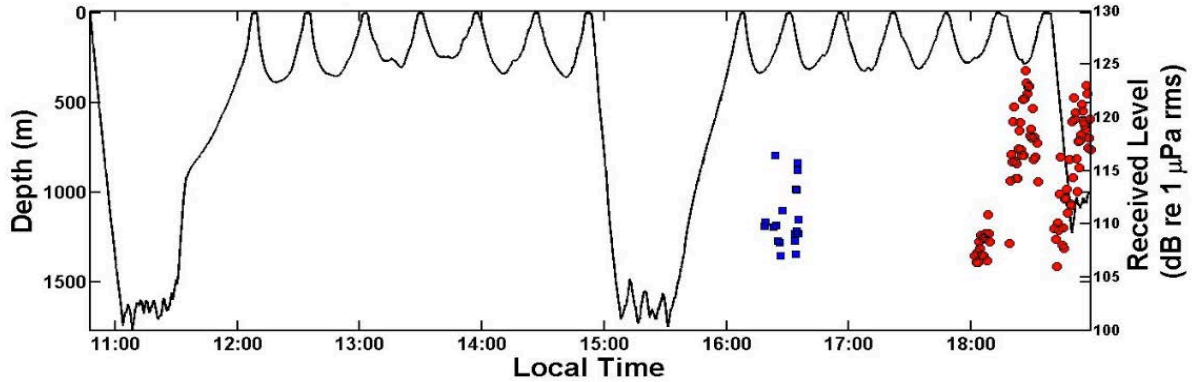
CEE # 2013-06

- DATE and TIME: **26 July 13 (1744-1814)**
- LOCATION (Source at start of CEE): **San Pedro Channel near shipping lanes**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw13_207a**
- CEE TYPE (DURATION): **CONTROL - no sound (30:00)**
- SUMMARY: Full silent control sequence with prey mapping before and after. Blue whale was in a loose group of two others feeding in a basin south of Long Beach near the shipping lane. No clear change in behavior during mock exposure. Tag came off after 10 min of prey mapping post-control, but continued mapping in general area of whales



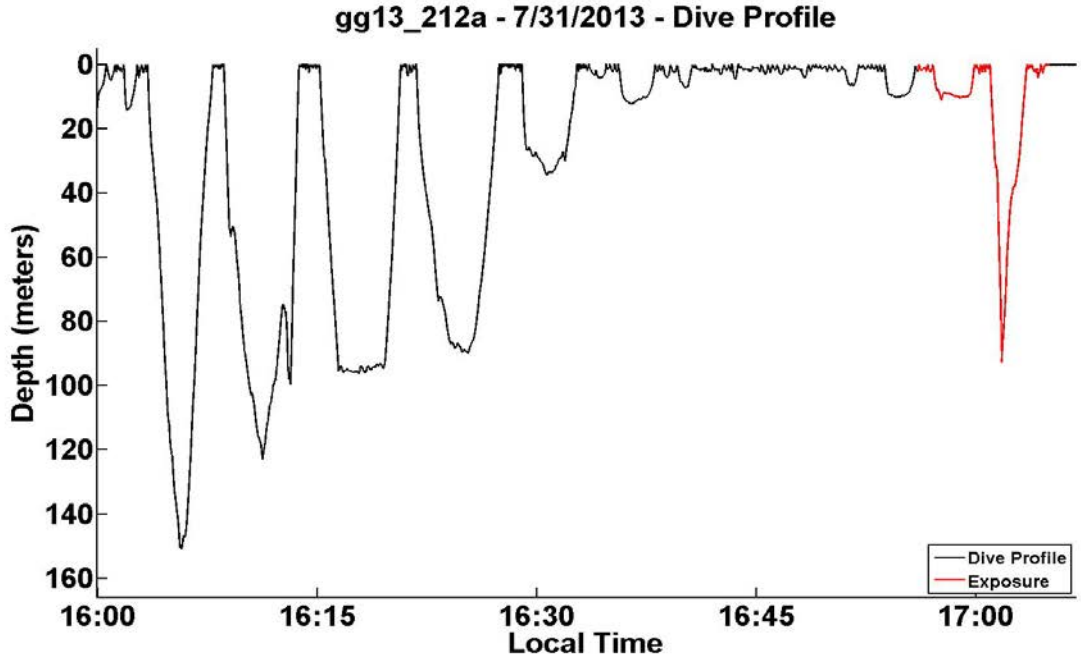
CEE # 2013-07

- DATE and TIME: **29 July 13 (1801-1901)**
- LOCATION (Source at start of CEE): **On SOAR range W of SCI (32.583; -118.450); animal north of range**
- FOCAL SPECIES: **CUVIER'S BEAKED WHALE**
- INDIVIDUAL ID(s): **zc13_210a**
- CEE TYPE (DURATION): **REAL NAVY MFA (60:00)**
- SUMMARY: First-ever full scale CEE with a beaked whale. Animal was tagged in a group of four late morning and we stayed with them all day as they tracked NW off the range. Coordinated with Navy ship conducting other (non-MFA) training in the general area and had ability to use MFA in CEE by late afternoon. Vessel was positioned on the range according to specified protocols and *in situ* sound propagation modeling and ran a successful full 60 min sequence, although the tag came off the whale right at the end of the exposure sequence - thus no post-exposure. After tag was recovered additional uncontrolled Navy sonar earlier in the tag record was discovered from another ship in the area that was not part of the experiment (blue squares in the figure below). Modeled received levels from Navy MFA transmissions were 90-120 dB at 300m depth. Actual levels on the animal from these controlled transmissions (red circles below) were ~90-125 dB re: 1uPa. There were no obvious changes in at least basic dive behaviors for this animal to either the low-level uncontrolled MFA transmissions or the MFA signals presented in a controlled way in the CEE.



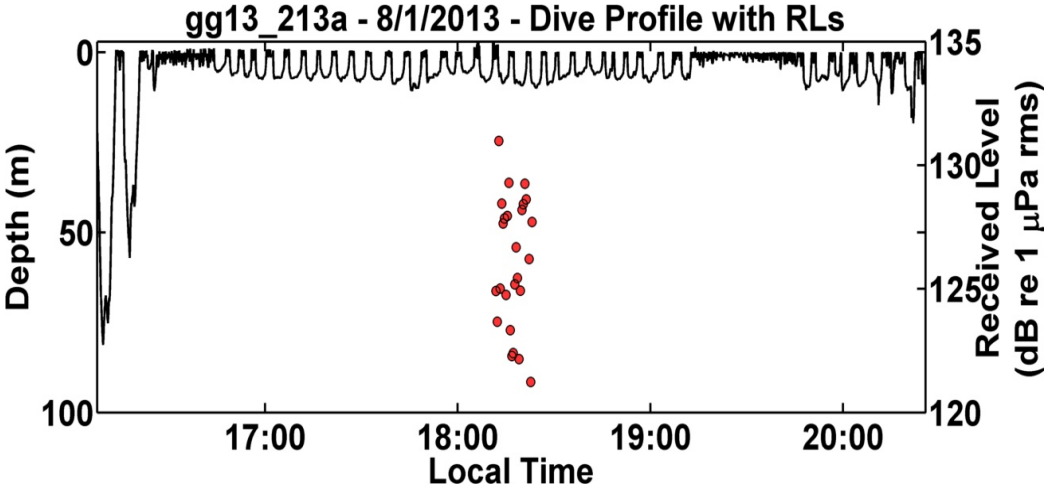
CEE # 2013-08

- DATE and TIME: **31 July 13 (1656-1705)**
- LOCATION (Source at start of CEE): **Just offshore west side of Catalina**
- FOCAL SPECIES: **RISSO'S DOLPHIN**
- INDIVIDUAL ID(s): **gg13_212a**
- CEE TYPE (DURATION): **CONTROL - no sound (09:00)**
- SUMMARY: Risso's tagged off west side of Catalina in a sub-group of 12-15 animals within a larger group that became quite surface active. Tag detached just 9 min into control (mock exposure) sequence so incomplete mock exposure and no post-exposure as quickly lost track of focal group once tag detached. Data will not be included in final analysis.



CEE # 2013-09

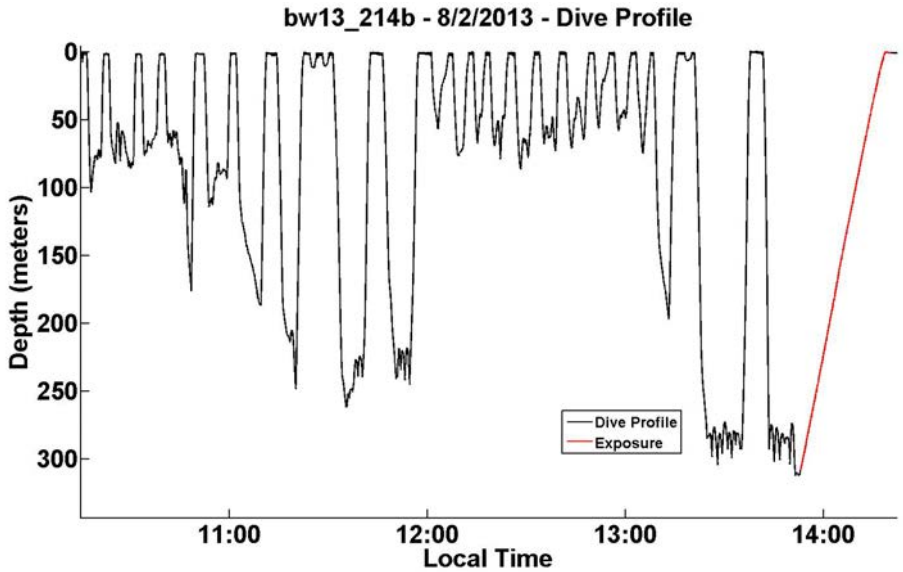
- DATE and TIME: **1 Aug 13 (1812-1824)**
- LOCATION (Source at start of CEE): **Between SCI and Catalina; animal south of Catalina**
- FOCAL SPECIES: **RISSO'S DOLPHIN**
- INDIVIDUAL ID(s): **gg13_213a**
- CEE TYPE (DURATION): **REAL NAVY MFA (12:00)**
- SUMMARY: Risso's tagged in a group of three off south side of Catalina. Positioned Navy ship about 20nm to the NW heading between Catalina and San Clemente Island. Tag rode great and animals did some initial deeper dives then in shallower water on the shelf. Ship went active where positioned according to protocols. but had some mechanical issues and could only transmit for 12 min so likely will not be used in comparative analysis. Ended there and maintained focal follow for full post-exposure sequence. No obvious change in shallow diving behavior for short period with ship at distant range and relatively lower received levels.



CEE # 2013-10

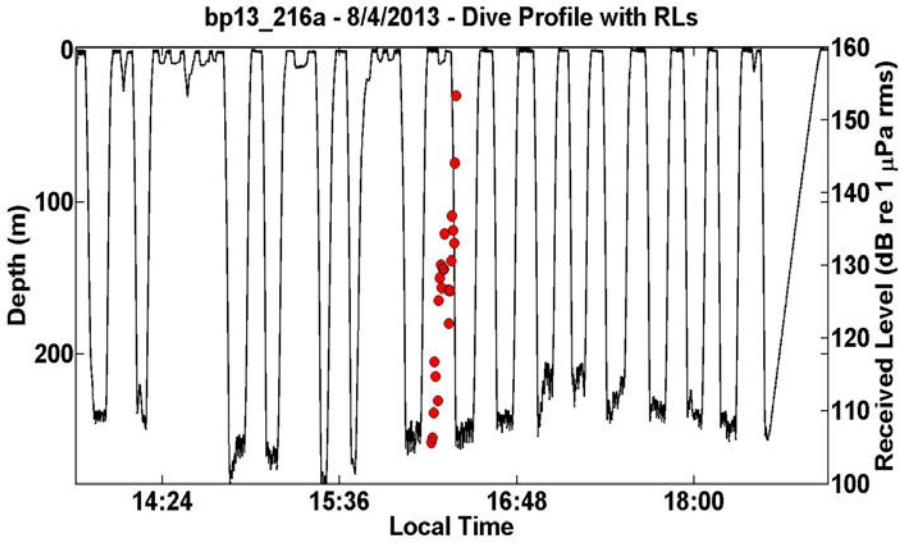
- **2 Aug 13 (1353-1420)**
- LOCATION (Source at start of CEE): **San Pedro Channel - Long Beach shipping lane**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw13_214b**
- CEE TYPE (DURATION): **CONTROL - no sound (27:00)**
- SUMMARY: Blue whale in loose feeding aggregation of 3-4 other animal. Good focal follow with prey mapping before control sequence, but tag fell off just a few minutes into the control "mock exposure" sequence. RHIB maintained the focal follow with all surface positions and readied another tag quickly which was

deployed on same whale for end of post-exposure and post-CEE prey mapping. Data are useful for before/after CEE prey mapping but not within comparisons of mock exposure sequences.



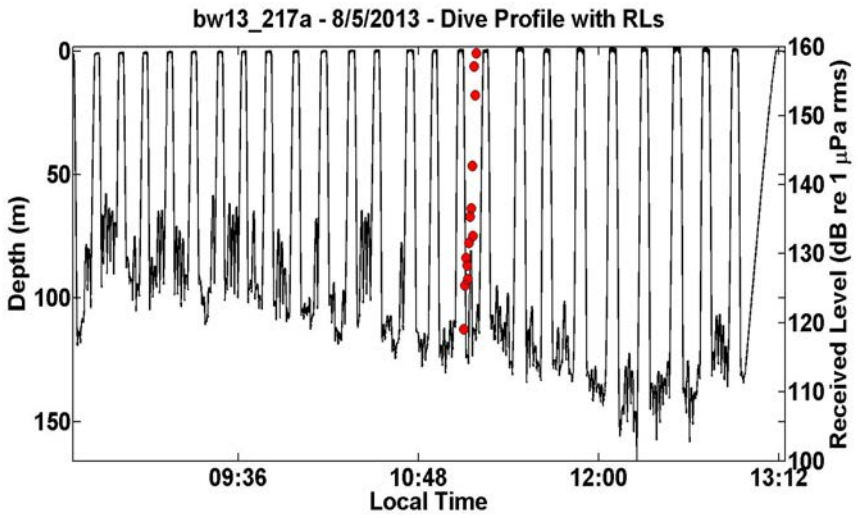
CEE # 2013-11

- DATE and TIME: **4 Aug 13 (1609-1628)**
- LOCATION (Source at start of CEE): **San Pedro Channel - Long Beach shipping lane**
- FOCAL SPECIES: **FIN WHALE**
- INDIVIDUAL ID(s): **bp13_216a**
- CEE TYPE (DURATION): **SIMULATED MFA (19:00)**
- SUMMARY: Fin whale tagged south of Long Beach in shipping lane. Single animal deep feeding that we stayed with despite fairly rough conditions. Had issues with source software and source ran for less than full planned sequence (18 min total). Focal follow maintained throughout and for typical post-exposure. Possible minor horizontal avoidance response during CEE that quickly abated during post-exposure following abbreviated exposure sequence.



CEE # 2013-12

- DATE and TIME: **5 Aug 13 (1104-1112)**
- LOCATION (Source at start of CEE): **Offshore from Huntington Beach**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw13_217a**
- CEE TYPE (DURATION): **SIMULATED MFA (8:00)**
- SUMMARY: Blue whale tagged south of Huntington beach near oil rigs. Conducted pre and post exposure prey mapping although for post we had a hard time keeping up with the whale that began traveling in a directed manner following sound exposure. Playback stopped after just 8 min because of a sea lion within 200m of Truth with source at full power (required shut-down). Will not be included in analysis because of premature termination of exposure.



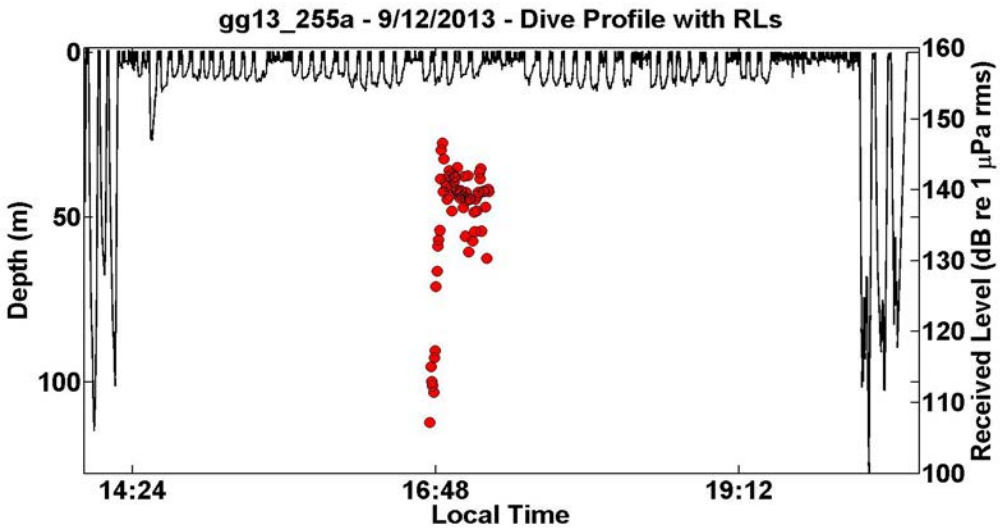
SOCAL-13 - Phase II CEE Sequences

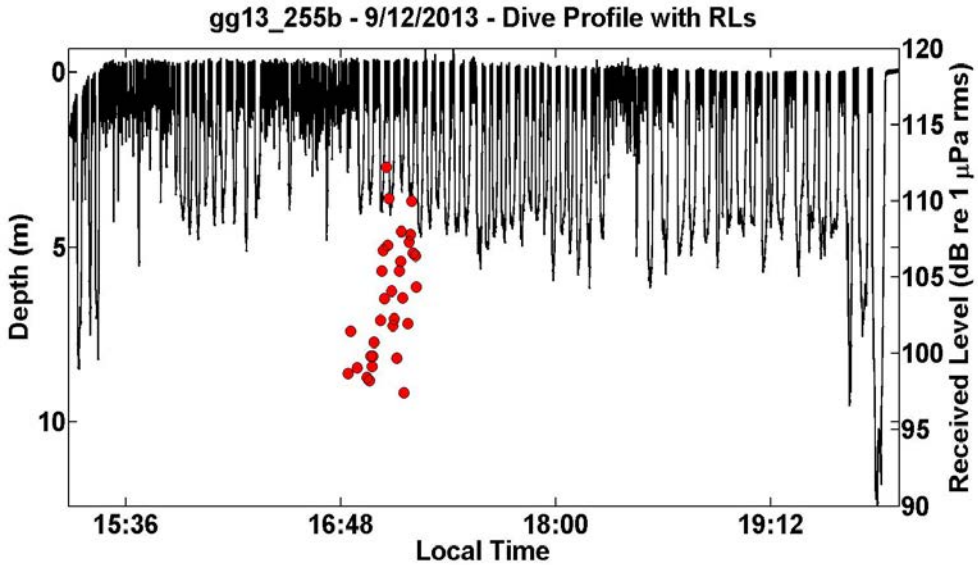
Date	SOCAL-13 Phase	Total deployment time	Species	Animal ID	From Boat	Playback Number	Playback Type	CEE TIME	Duration (min)
12-Sep	PHASE II	6:29	Rissos Dolphin	gg13_255a	Ziphid	#2013_13	SIMULATED MFA	1643-1713	30
12-Sep	PHASE II	4:27	Rissos Dolphin	gg13_255b	Physalus	#2013_13	SIMULATED MFA	1643-1713	30
14-Sep	PHASE II	0:03	Fin Whale	n/a	Ziphid	n/a	n/a	n/a	n/a
14-Sep	PHASE II	0:03	Fin Whale	n/a	Ziphid	n/a	n/a	n/a	n/a
14-Sep	PHASE II	5:26	Fin Whale	bw13_mk10_257	Ziphid	#2013_14	SIMULATED MFA	1600-1630	30
14-Sep	PHASE II	5:10	Fin Whale	bw13_257a	Physalus	#2013_14	SIMULATED MFA	1600-1630	30
14-Sep	PHASE II	0:15	Fin Whale	bw13_257a	Physalus	#2013_14	SIMULATED MFA	1600-1630	30
14-Sep	PHASE II	2:20	Fin Whale	bp13_257b	Ziphid	n/a	n/a	n/a	n/a
15-Sep	PHASE II	6:32	Fin Whale	bp13_258a	Ziphid	#2013_15	SILENT CONTROL	1322-1352	30
15-Sep	PHASE II	5:30	Fin Whale	bp13_258b	Ziphid	#2013_15	SILENT CONTROL	1322-1352	30
15-Sep	PHASE II	6:08	Fin Whale	bp13_258c	Physalus	#2013_15	SILENT CONTROL	1322-1352	30
16-Sep	PHASE II	4:26	Fin Whale	bp13_259a	Physalus	#2013_16	SIMULATED MFA	1116-1146	30
16-Sep	PHASE II	5:20	Blue Whale	bw13_259a	Ziphid	#2013_16	SIMULATED MFA	1116-1146	30
18-Sep	PHASE II	4:52	Rissos Dolphin	gg13_261a	Physalus	#2013_17	SILENT CONTROL	0957-1027	30
19-Sep	PHASE II	6:22	Rissos Dolphin	gg13_262a	Ziphid	#2013_18	SILENT CONTROL	1244-1314	30
19-Sep	PHASE II	13:33	Rissos Dolphin	gg13_262b	Physalus	#2013_18	SILENT CONTROL	1244-1314	30
19-Sep	PHASE II	9:56	Rissos Dolphin	gg13_262c	Physalus	#2013_18	SILENT CONTROL	1244-1314	30
21-Sep	PHASE II	1:06	Rissos Dolphin	gg13_264a	Ziphid	n/a	n/a	n/a	n/a
22-Sep	PHASE II	3:46	Fin Whale	bp13_265a	Physalus	#2013_19	SILENT CONTROL	1242-1312	30
22-Sep	PHASE II	2:03	Minke Whale	ba13_265a	Ziphid	#2013_19	SILENT CONTROL	1242-1312	30
23-Sep	PHASE II	3:09	Rissos Dolphin	gg13_266a	Ziphid	#2013_20	SIMULATED MFA	1324-1336	12
23-Sep	PHASE II	2:16	Rissos Dolphin	gg13_266b	Physalus	#2013_20	SIMULATED MFA	1324-1336	12

CEE # 2013-13

- DATE and TIME: **12 Sept 13 (1643-1713)**
- LOCATION (Source at start of CEE): **Off west side of Catalina near Cat Harbor**
- FOCAL SPECIES: **RISSO'S DOLPHINS (2)**

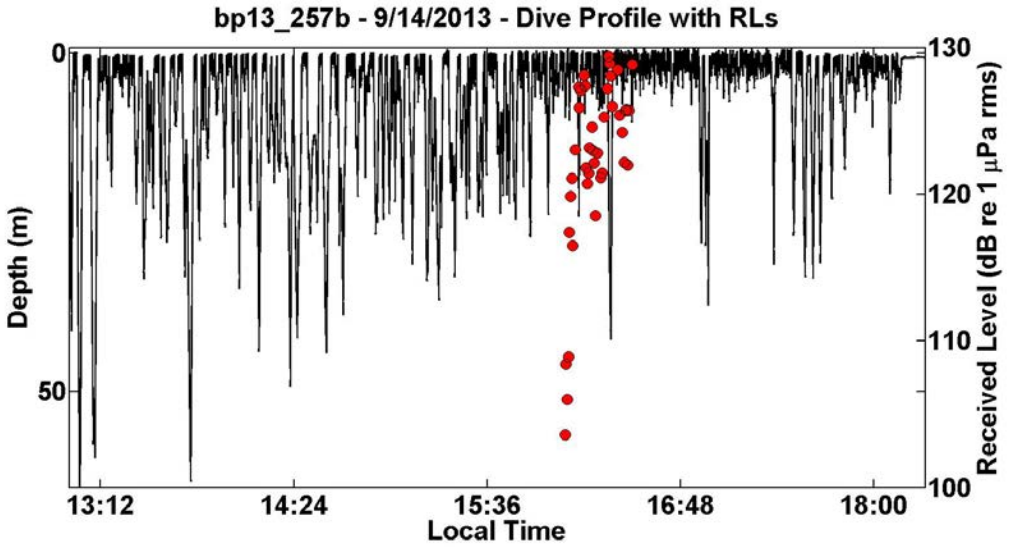
- INDIVIDUAL ID(s): **gg13_255a; gg13_255b**
- CEE TYPE (DURATION): **SIMULATED MFA (30:00)**
- SUMMARY: Two Risso's tagged about 10 nm apart; focal animal ~1 nm from source during CEE. Both were in surface slow travel mode initially and during CEE but one did some deep dives after CEE. Full sequence with both receiving MFA signals and complete focal follows pre- and post-exposure from separate RHIBs. No clear responses in either the closer (~1-2 km) animal (gg13_255a) or the one further (~6-8 km) animal (gg13_255b) from the sound source.
-





CEE # 2013-14

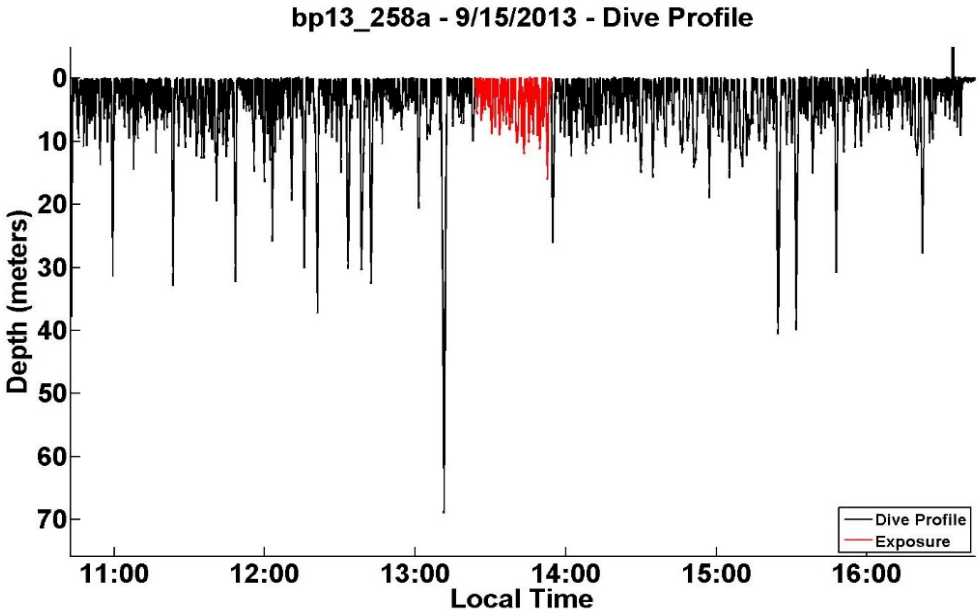
- DATE and TIME: **14 Sept 13 (1600-1630)**
- LOCATION (Source at start of CEE): **Southwest of Palos Verdes Peninsula ~10nm offshore**
- FOCAL SPECIES: **FIN WHALES (2)**
- INDIVIDUAL ID(s): **bp13_257a; bp13_257b was focal (both with MK-10s – see below)**
- CEE TYPE (DURATION): **SIMULATED MFA (30:00)**
- SUMMARY: Fin whales tagged off Palos Verdes. Focal individual had a DTAG and MK-10 and was subject of prey mapping before and after; MK-10 detached quickly. Different fin whale had a DTAG and a MK-10 deployed and was also exposed at slightly greater geographic range from the sound source, but the DTAG was off just prior to exposure. Both whales had complete pre- and post-exposure focal follows from separate RHIBs. Possible behavioral state change around start of CEE in bp13_257b. Other tag was not attached sufficiently long for inclusion in analysis.

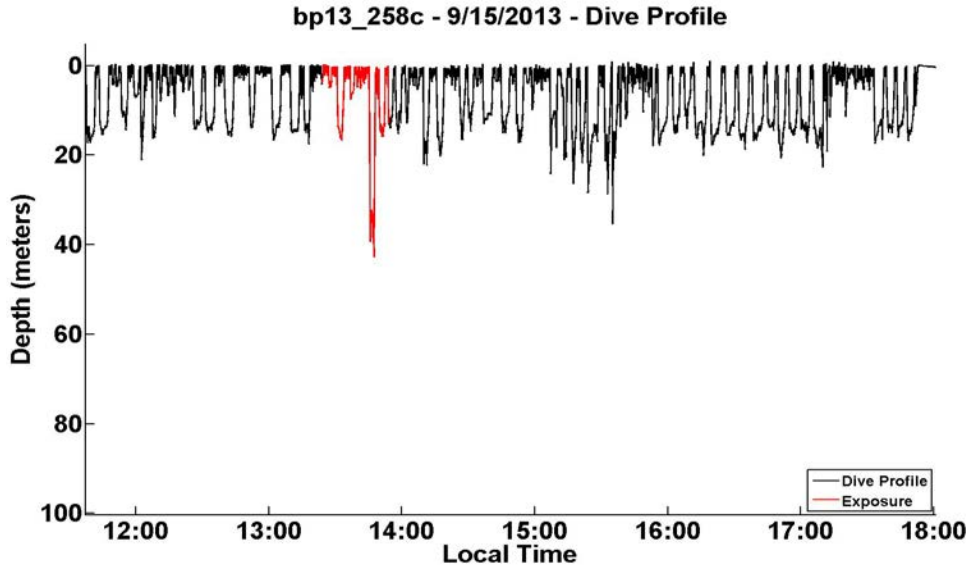


CEE # 2013-15

- DATE and TIME: **15 September 13 (1322-1352)**
- LOCATION (Source at start of CEE): **Off Palos Verdes near Redondo Canyon (33.81339; -118.45149)**
- FOCAL SPECIES: **FIN WHALES (3)**
- INDIVIDUAL ID(s): **bp13_258a; bp13_258b; bp13_258c**

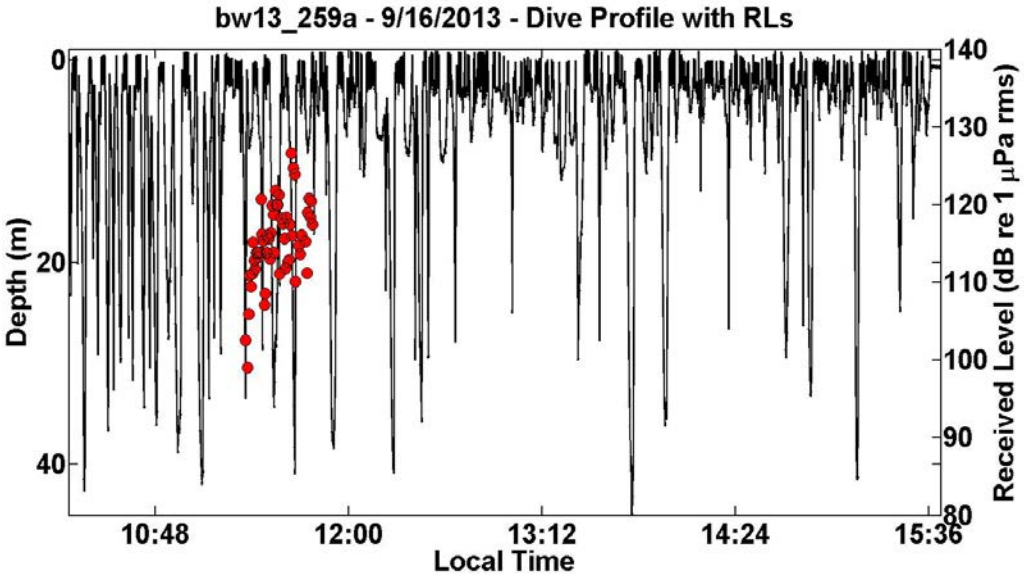
- CEE TYPE (DURATION): **CONTROL - no sound (30:00)**
- SUMMARY: Excellent triple deployment all DTAGS and all complete focal follow sequences; two animals were in the same tight group most of time and RHIB maintained focal follow on all). Complete control sequence with full prey series before and after on one focal individual. Krill samples obtained at the surface from very dense and obvious patches. No clear changes in behavior in any of the animals who were extremely concentrated on foraging. Mechanical issues with tag bp13_258b are still being resolved although data were obtained; no dive profile is thus given here.





CEE # 2013-16

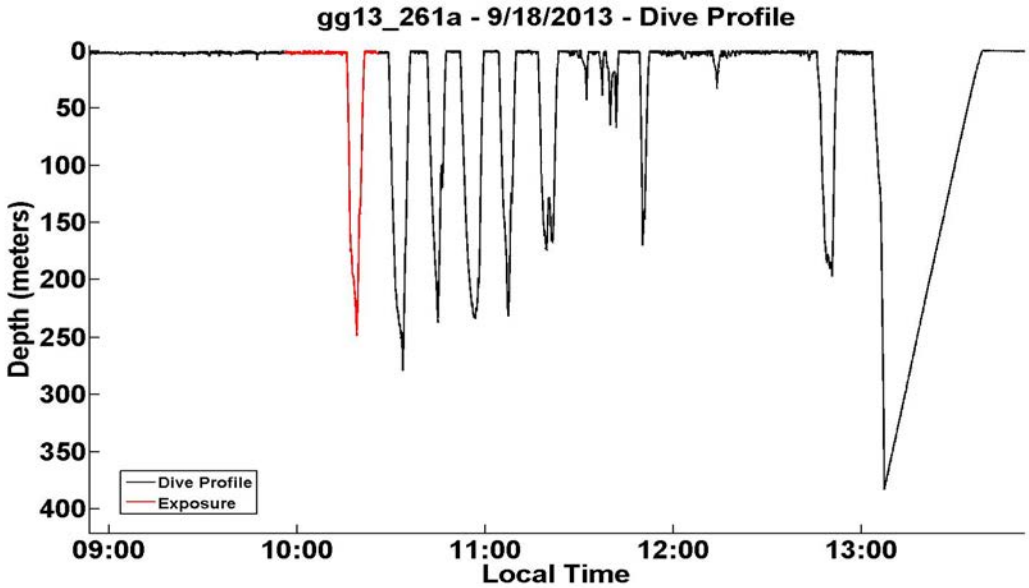
- DATE and TIME: **16 Sept 13 (1116-1146)**
- LOCATION (Source at start of CEE): **Off Palos Verdes near Redondo Canyon**
- FOCAL SPECIES: **FIN WHALE (1) and BLUE WHALE (1)**
- INDIVIDUAL ID(s): **bp13_259a; bw13_259a**
- CEE TYPE (DURATION): **SIMULATED MFA (30:00)**
- SUMMARY: Fin-blue combo CEE with fin being the focal whale at about 1400m to start. This animal was in surface feeding mode moving through some scattered patches. Full CEE with full prey mapping sequence before/after. Blue whale was at range of ~4500m for CEE; no prey mapping around this individual but good focal follow through the whole sequence from separate RHIB. Mechanical issues were also experienced with the tag on bp13_259a but analysis is ongoing. Tag bw13_259a is shown below.



CEE # 2013-17

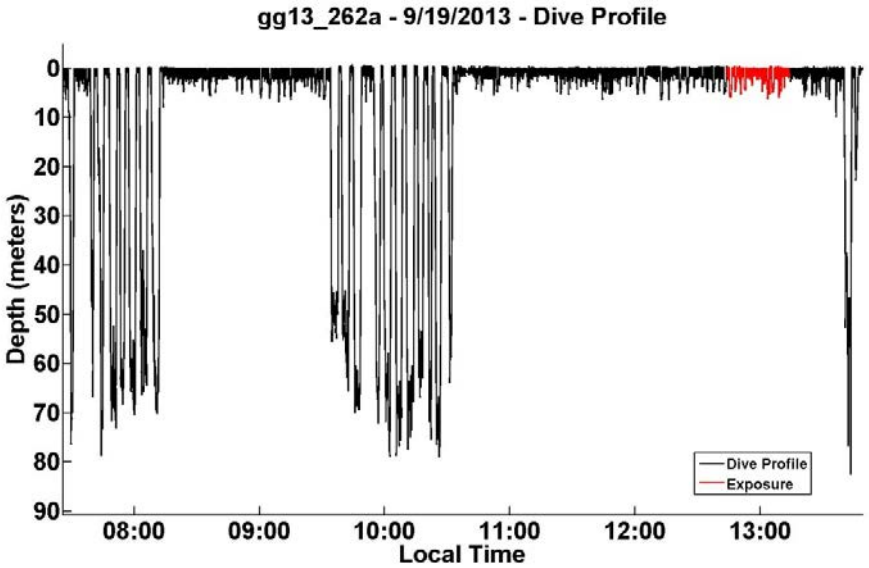
- DATE and TIME: **18 Sept 13 (0957-1027)**
- LOCATION (Source at start of CEE): **Just offshore east side of Catalina**
- FOCAL SPECIES: **RISSO'S DOLPHIN**
- INDIVIDUAL ID(s): **gg13_261a**
- CEE TYPE (DURATION): **CONTROL - no sound (30:00)**
- SUMMARY: Single Risso's tagged near Catalina on the shelf in a group of 4. Animals came offshore and joined with another much larger group. Full control

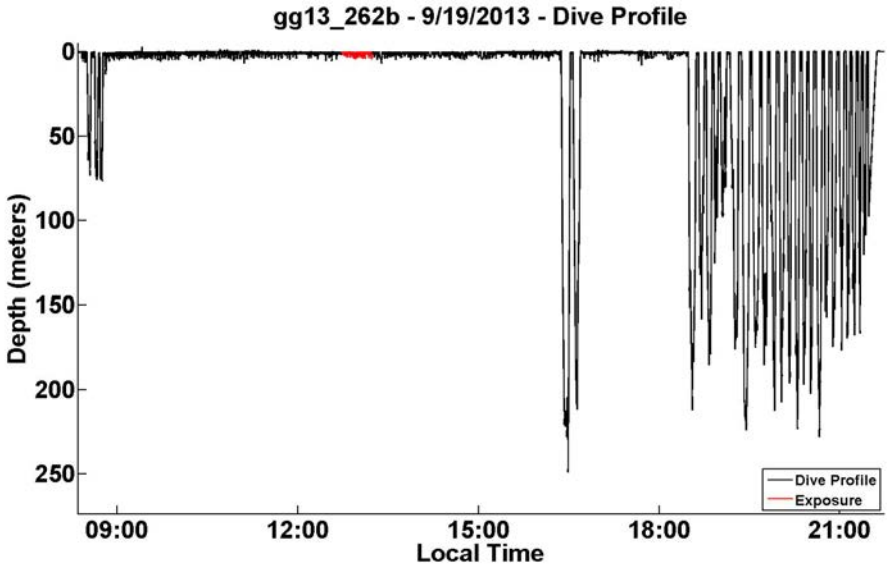
CEE sequence with good spacing and focal follow throughout. Would have had a required shutdown if real CEE as a separate group of Risso's dolphins inside 50m from vessel, but the sequence was not terminated since there was no MFA exposure. Was an apparent behavioral state change in the focal animals during this mock exposure sequence as the animal began deep diving after being in a shallow diving mode.

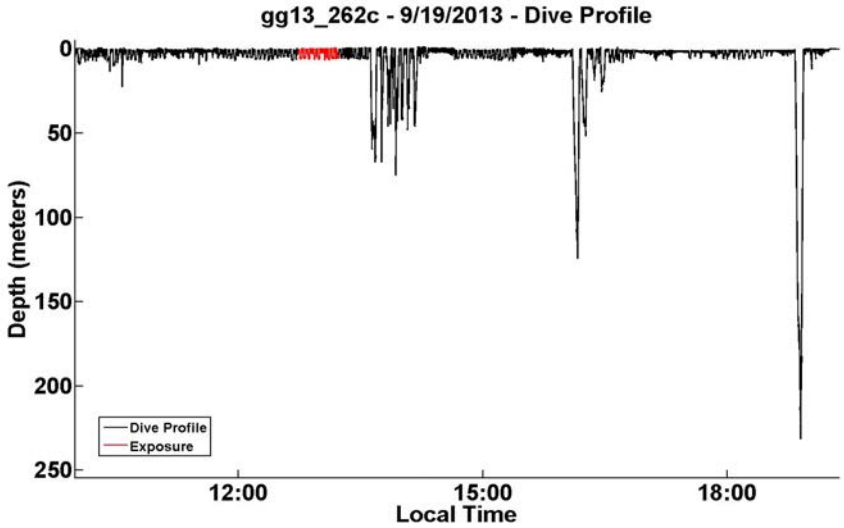


CEE # 2013-18

- DATE and TIME: **19 Sept 13 (1244-1314)**
- LOCATION (Source at start of CEE): **Just offshore east side of Catalina (33.1128; -118.8713)**
- FOCAL SPECIES: **RISSO'S DOLPHIN (3)**
- INDIVIDUAL ID(s): **gg13_262a; gg13_262b; gg13_262c**
- CEE TYPE (DURATION): **CONTROL - no sound (30:00)**
- SUMMARY: Three simultaneous Risso's dolphins were tagged during this mock exposure sequence. Two had DTAGs and long duration focal follows and the other had a DTAG on throughout (but no focal follow). All animals were within a large group foraging quite close to shore near Avalon. This was slated to be an MFA exposure but based on visibility conditions and proximity to shore we went ahead with the sequence but ran a full control with no noise exposure. None of the animals exhibited any clear changes in behavior during the control sequence.


gg13_262a - 9/19/2013 - Dive Profile
Depth (meters)
0
10
20
30
40
50
60
70
80
90
08:00
09:00
10:00
11:00
12:00
13:00
Local Time
Dive Profile
Exposure


gg13_262b - 9/19/2013 - Dive Profile
Depth (meters)
0
50
100
150
200
250
09:00
12:00
15:00
18:00
21:00
Local Time
Dive Profile
Exposure


gg13_262c - 9/19/2013 - Dive Profile
Depth (meters)
0
50
100
150
200
250
12:00
15:00
18:00
Local Time
Dive Profile
Exposure

CEE # 2013-19

- DATE and TIME: **22 Sept 13 (1244-1314)**
- LOCATION (Source at start of CEE): **Off Palos Verdes near Redondo Canyon**
- FOCAL SPECIES: **FIN WHALE (1) & MINKE WHALE (1)**
- INDIVIDUAL ID(s): **bp13_265a; ba13_265a**
- CEE TYPE (DURATION): **CONTROL - no sound (30:00)**
- SUMMARY: Fin whale tagged in Redondo Canyon in a group of two animals surface lunge feeding. Conditions were too rough for prey mapping but ran full control CEE sequence. First ever SOCAL-BRS minke whale was tagged while going for a second fin whale. It was tagged for the duration of the control sequence but was difficult to keep track of and so no focal follow during the mock exposure.
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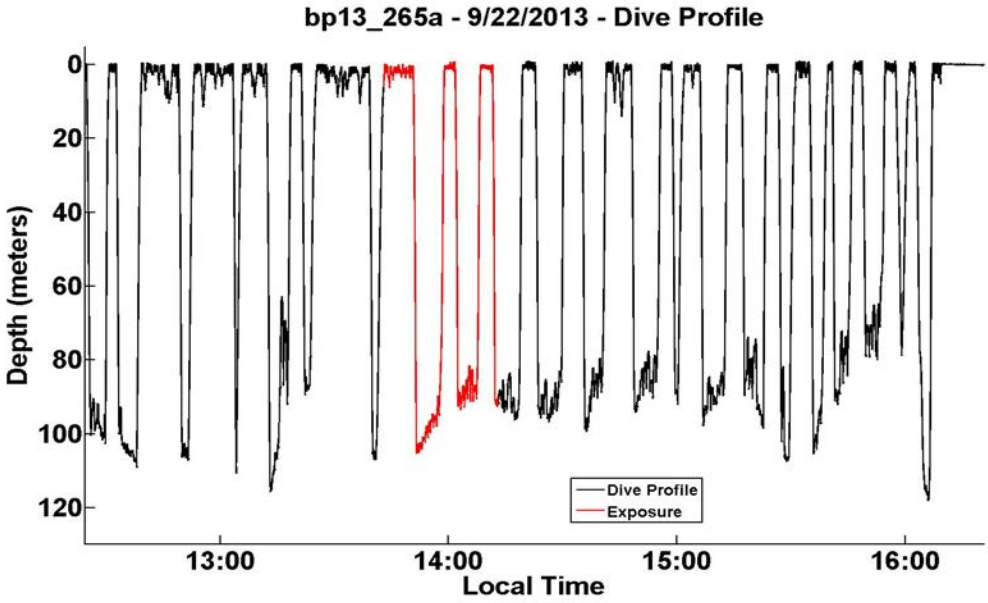

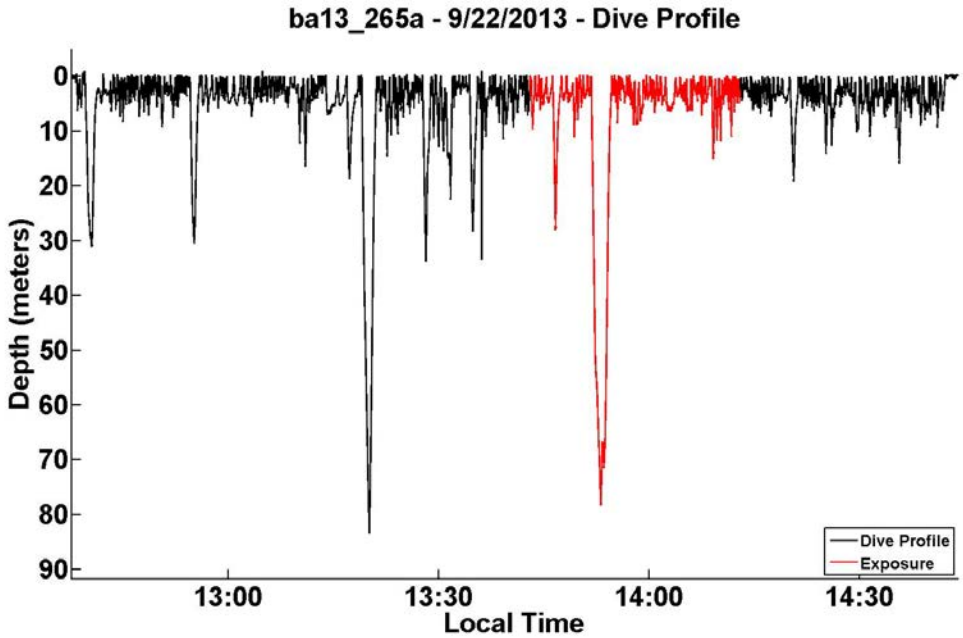

CEE # 2013-20

- DATE and TIME: **23 Sept 13 (1324-1336)**
- LOCATION (Source at start of CEE): **East of Catalina off Avalon ~ 7nm**
- FOCAL SPECIES: **RISSO'S DOLPHINS (2)**
- INDIVIDUAL ID(s): **gg13_266a; gg13_266b**
- CEE TYPE (DURATION): **SIMULATED MFA (12:00)**
- SUMMARY: Focal animal was tagged about 7 nm out of Avalon in a traveling, feeding group. There was a good focal follow before and during CEE, but tag came off a few min into the post-exposure after CEE was shutdown from a Risso's dolphin in the focal group swimming within the 200m zone. A second animal was tagged about 10 nm away and was in a near-shore social group; separate RHIB maintained focal follow pre-, during, and post-exposure. Mechanical issues with both DTAGs but data extracted. Analysis ongoing for the focal Risso's, although data will not be included in final analysis given short duration of CEE. No clear changes in behavior in either focal animal; this was the second CEE shutdown during SOCAL-BRS from Risso's dolphins in the 200m exclusion zone.

CEE Summary and Assessment by species

As discussed in more detail below, SOCAL-13 met and exceeded objectives in terms of tagging and CEE accomplishments by virtue of the number of CEEs on priority species including a number of sequences with multiple individuals, modifications to allow very

small field teams to accomplish CEE objectives, the inclusion of actual operational Navy MFA sound sources within experiments, and the inclusion of additional control "no noise" CEE sequences. There is a substantial amount of ongoing data analysis of diving, movement, and vocal behavior and potential responses to CEEs that is being integrated with CEE results from previous seasons (discussed in more detail below). This analysis, which is more detailed than the simple dive profile and RL plots shown above, is clearly required for a full and statistical analysis of potential responses. Thus, the conclusions for each species given above and in summary by species of the SOCAL-13 results should be considered preliminary and qualitative based on an initial analysis and available field observations.

As described above and implemented in SOCAL-13 as in previous field seasons, very specific protocols were in place regarding MFA sonar transmissions (including real Navy sonars this season). We again did not require any specified shut down of CEE sequences as a result of specific observed negative reactions. Rather, we had two additional scaled source CEEs that were terminated earlier than planned as a result of marine mammals (a California sea lion and a group of Risso's dolphins) entering the specified 200m exclusion zone, apparently ignoring ongoing full-power transmissions.

We also had, and in 2013 actually implemented, a stranding response plan that was based on a specified means of communication and coordination with NOAA's Southwest Regional Stranding Network. On 15 September 2013, a single live-stranded Risso's dolphin was found near Manhattan Beach, CA. As explicitly specified in our stranding response plan, this information was communicated directly to the SOCAL-BRS chief scientist in the field who immediately halted any further CEEs in order to obtain additional information and consult directly with both the stranding network and NOAA's Office of Protected Resources. We did conduct a scaled source MFA CEE approximately 24h earlier (#2013-14) approximately 10 nm from the stranding location and a control sequence (#2013-15) on 15 September several nm closer, both focused on baleen whales (no Risso's were seen during this period by SOCAL-13 observers). SOCAL-13 operations were restricted until consultation with the stranding network and authorizing officials indicated that the animal that stranded was emaciated and in poor health and was most likely a much older animal; subsequent analysis revealed other physiological reasons that were most likely causative reasons for the stranding. The overall conclusion was that this was likely a natural stranding event of a naturally compromised animal and that there was very likely no contribution of SOCAL-13 activities to it's mortality, although we acknowledge that this cannot be absolutely excluded as a possibility given the time and distance. We were authorized to resume field operations and did so following extensive discussions within our field team and a full review of all monitoring measures and requirements. A more detailed description of this event is openly available upon request from the project chief scientist <Brandon.Southall@sea-inc.net>.

Beaked whales

Excellent offshore conditions and multiple groups of beaked whales were encountered during Phase I of SOCAL-13. Two individuals were tagged, but only one CEE was conducted as the DTAG attached to one individual detached prior to the availability of a Navy MFA sonar source. However, baseline (no exposure) behavioral data was obtained from this tag. The CEE that was conducted with a Cuvier's beaked whale (*Ziphius cavirostris*) in SOCAL-13 (#2013_07) was notable in the fact that it represents the first controlled sound exposure experiment using operational MFA sonar and high-resolution acoustic and movement sensors to measure behavior in an individual of the species most commonly represented in sonar-associated marine mammal stranding events.

While the results that can be drawn from this one event remain limited and additional analyses are ongoing, there are some interesting observations from this CEE. The tagged individual appears not to have demonstrated the kinds of clear and rapid reactions to the real MFA sonar as was observed at similar received sound levels in two *Ziphius* involved in scaled source CEEs in SOCAL-10 and -11 (see DeRuiter *et al*., 2012 referenced above). The notable differences between these events is the use of real MFA sonar in the 2013 experiment and the fact that the source was at a distance of approximately 40nm as opposed to 1-2nm in the scaled source CEEs. Additionally, the 2013 *Ziphius* appears not to have responded, at least overtly, to incidental MFA from an uncontrolled sonar transmission earlier in the dive record; this appears similar to the 2011 *Ziphius*. While it is possible that earlier MFA transmissions prior to the tag attachment on the 2013 *Ziphius* may have affected it's potential response to subsequent sonar exposures, or it was already reacting (the group was moving away from the SCORE range where transmissions likely originated from the incidental sonar), these differences across the experiments seem to suggest that source range may be an important factor in determining probability of response for beaked whales. Further CEEs are clearly required to explore this question, including the use of real MFA sonars at closer range and scaled source MFA transmissions at greater range than has been used.

Fin whales

Following two field seasons in 2011 and 2012 where very few fin whales were involved in SOCAL-BRS, 2013 saw conditions much more like 2010. Ten fin whales were tagged, all of which were involved in CEEs with either scaled or real MFA or control "no noise" sequences. Several longer deployments were accomplished, and in several cases multiple animals were tagged simultaneously in the same area including CEEs for animals at different source ranges. Few if any clear behavioral changes as a function of CEEs were observed from the initial assessment of diving and horizontal movement behavior, but again more detailed analyses may reveal subtle changes, particularly with regard to calling behavior in some individuals (analysis is ongoing).

Risso's dolphins

As with fin whales, 2013 was a very successful season for SOCAL-BRS in terms of tagging and CEEs with high priority Risso's dolphins. We encountered large aggregations of Risso's very close to shore and in deeper water, primarily off the east side of Catalina. Our experience with this as being somewhat atypical in their concentration and apparent foraging in shallow water was similar to that reported anecdotally to us by other researchers, naturalists, and the presence of commercial squid boats fishing for likely common prey very close to shore (e.g., in Avalon harbor). A total of 18 individuals were tagged, 12 of which were involved in CEEs. While several individuals exhibited some apparent foraging behavior and the deeper dives specified as a priority behavioral state for CEEs, the majority of CEEs conducted were again in the nearer surface resting or social modes tested previously.

The first-ever real MFA (53C) transmission used in a CEE for any marine mammal was conducted with a Risso's dolphin (#2013-02). The exposure RL was slightly lower than the overall target and the range was on the order of 30 nm. No clear, overt behavioral responses occurred during this sequence. This was generally true of the four scaled source MFAs in SOCAL-13 as well, particularly for #2013-20 where the source was shut down as a result of a group of Risso's dolphins swimming within 200m of the scaled MFA sonar transmitting at full power. The added control sequences were a significant advancement and provide comparison data for exposure CEEs conducted.

Blue whales

Reflecting the SOCAL-13 species priorities indicating blue whales would be de-prioritized relative to the above species, the number of tagged blue whales and CEEs (10 and 6 respectively) were reduced relative to earlier field seasons. The exception to this came during periods where coordination with real Navy sources was possible, and in two instances blue whales were involved in MFA CEEs with real Navy sources. One of these instances was complicated by variability in the type of transmissions and in the vessel track. In the other instance, possible short-term horizontal avoidance occurred based on the focal follow track. This was also the case for one of the two scaled source CEEs, but in the other instance and for both control sequences no clear changes in behavior occurred. Thus, based on the limited information and with the caveats that these observations are based on an initial assessment of the results and not the ongoing and detailed statistical analysis, the blue whale results from 2013 appeared consistent with earlier experiments suggesting short-term responses in some but not all conditions.

9. OVERALL ASSESSMENT: ACCOMPLISHMENTS VS. OBJECTIVES

The following is an assessment of the specified objectives for SOCAL-13 relative to actual accomplishments. All objectives were achieved, with expectations exceeded in some regards.

(1) ***Obtain baseline behavioral data*** to support CEE interpretation and conducting CEEs (both realistic sources and scaled sources)

Objective fully achieved. Forty-five tags (of five kinds) were secured on 41 individual animals of five different marine mammal species. This included multiple tags for primary focal species, including several with multiple animals in the same group. SOCAL-13 also deployed the first-ever acoustic/movement tag on a minke whale in the North Pacific, tags on targeted foraging/deep-diving Risso's dolphins, and multiple tags on calling baleen whales. Over 50h of baseline data (before MFA transmissions and during control sequences) were collected for both fin and Risso's dolphins. Additionally, baseline data were collected from two *Ziphius*, including the individual tagged but not exposed (3.5h) and several hours from the individual involved in the real Navy MFA for several hours prior to the incidental sonar exposure.

(2) ***Conduct* controlled exposure experiments (CEEs) with both realistic sources and scaled sources (when realistic ones not available).** Species focus should remain flexible based on conditions, but with emphasis on Risso's dolphins, beaked, and fin whales (blue whales in specific conditions).

Objective fully achieved. The first-ever operational MFA sonar (53C systems) CEEs were conducted on five occasions with six individuals of four species, including the high-priority Cuvier's beaked whale. In addition, 13 simulated MFA CEEs using a scaled sound source were conducted when real MFA sources were unavailable as well as 13 complete control sequences. Furthermore, active acoustic mapping of prey fields as a key contextual variable was conducted for all but one of the baleen whale CEEs during the two Truth configurations where it was possible; a more detailed summary of these results and analyses is also available as a final report of that project on request

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

Objective fully achieved. Four different configurations of research vessels,

field personnel, and coordination with Navy vessels were tested during SOCAL-13. Each proved successful in deploying tags and conducting CEEs and each had strengths and limitations. The first configuration involved a single tag RHIB and a slightly larger RHIB to house and deploy the smaller scaled sound source. This configuration demonstrated the feasibility of conducting this kind of experimental work with an extremely small field team. The second configuration involved two tagging RHIBs with no scaled sound source focused on coordination with ongoing Navy training operations using a remote command center. This demonstrated the capability to conduct CEEs in the context of operational military training and the potential to coordinate with a small but mobile field team. The third configuration demonstrated the ability of a centralized field team with mobile tagging RHIBs and the command center deployed in the field coordinated with ongoing Navy training operations. The fourth configuration was identical to that used in previous field seasons and involved a similar approach but with an emphasis on scaled source CEEs from the central research vessel which also served to support towed PAM systems and prey mapping capabilities.

10. SOCAL-13 TRANSPARENCY AND PUBLIC IMPACT

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. The increasing body of scientific data generated by SOCAL-BRS is contributing to a greater understanding of biologically important areas in southern California, as well as how marine mammals dive, communicate, and may respond behaviorally to different sounds. Results to date are increasingly being published in the scientific literature with seven peer-reviewed papers to date, two others currently in peer-review, and a large multi-method response analysis paper that will be submitted in the coming months. 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.

Additionally, SOCAL-BRS work has been presented and discussed with various scientific, educational, government, and conservation organizations around the world. There were numerous open discussions in at least a dozen 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, media, and other scientific projects and disciplines. These interactions increase public awareness of advances in the science of noise and marine mammals and also increase appreciation of important biological areas in the southern California Bight. This is a process that will continue throughout the SOCAL-BRS project.

11. CONCLUSIONS AND NEXT STEPS

Overarching conclusions from SOCAL-13

1. ***Coordination of operational Navy sonar training with field tagging efforts can result in much-needed direct, controlled, and high-resolution measurements of behavioral response to real sonar operations***

   - While just a first step with a limited number of CEEs and some lessons-learned for field effort and coordination, the novel use of operational MFA (53C) sonars in an experimental context with dedicated focal follows to ensure data collection and focal animal safety was a major step forward

   - While also limited, the available information from real MFA sonars in both experimental and incidental exposures suggest limited or no clear responses at relatively greater source-animal range than for closer scaled source CEEs, even in conditions were received sound levels are comparable

   - Scaled source CEEs are still useful and needed in the context of real MFA sonar transmissions. Realizing the logistical complexity of coordinating field tagging effort with available Navy vessels engaged in ongoing training with different goals and complexities, maintaining an adaptive approach to allow scaled source CEEs when real Navy sources are unavailable seems clearly important.

2. ***CEE protocols and safety measures again worked well***

   - Useful behavioral response data were obtained and included some apparent responses in certain 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-13 were the result of animals (California sea lions and Risso's dolphins) 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-13 rapidly and successfully implemented a stranding response plan upon receiving information on a live-stranded cetacean in the general area. As described above, all indications are that this individual died from natural causes. However, the existence and rapid implementation of a response plan developed specifically to deal with such an incident was important.

3. Successful tagging and CEE efforts are possible with small field teams

- The use of "RHIBs-only" phases early in SOCAL-13 demonstrated the feasibility of using a very small configuration of vessels and field personnel to successfully conduct both scaled source and real Navy ship MFA CEEs
- There are limitations to this approach in terms of overall flexibility to move to and base from different areas based on conditions, as well as reduced analytical and centralized data archive capabilities. There are also whole teams (towed passive acoustics, active acoustics for prey imaging in baleen whale CEEs) that are not possible in very small teams.
- These limitations notwithstanding, SOCAL-13 experiences with these smaller configurations provides another approach to conducting field BRS efforts in the future that would be more cost-effective and may be more flexible in terms of scheduling.

SOCAL-BRS next steps

The overall SOCAL-BRS effort is planned to occur from 2010-2015. The final two field campaigns (SOCAL-14 and -15) are expected to prioritize real Navy MFA sound sources as much as possible, with an adaptive plan for the use of scaled sources (perhaps at increasing geographic range) and full control sequences. These seasons are expected to continue to prioritize offshore species and the use of the powerful listening capabilities of the SCORE range as much as possible based on weather and other Navy operations. SOCAL-14 and -15 will also continue to include both towed passive acoustic and other listening capabilities as well as integrated prey measurements, combining data from scientific echosounders with tagged whale foraging behavior at fine scales.

Future SOCAL-BRS efforts are expected to have the adaptive mix of field configurations and research teams that has proven so successful in terms of overall accomplishments in deploying tags and conducting CEEs. This will likely include both small teams (RHIBs-only) and the moderate sized teams and research platforms typically used in earlier field seasons. Subsequent efforts to measure behavioral responses of smaller delphinids (e.g., common dolphins, bottlenose dolphins) are clearly important but based on earlier efforts and observations also clearly require different experimental design and configurations than will be used in SOCAL-14 and -15.