Biological and Behavioral Response Studies of Marine Mammals in Southern California, 2014 ("SOCAL-14")

FINAL PROJECT REPORT

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1. EXECUTIVE SUMMARY

SOCAL-14 extended significant progress made in a multi-institutional scientific research program entitled Southern California Behavioral Response Study (SOCAL-BRS). Based on progress and evolution within this effort, field effort has been conducted and is planned to occur from 2010-2016 in areas of 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 mid-frequency active sonar (MFAS), on marine mammals. In SOCAL-14, additional basic data were acquired on diving, foraging, social, and vocal behavior of focal marine mammal species, including measurements in targeted behavioral contexts and extended applications of improved sampling capabilities. There was coordination between SOCAL-14 and operational Navy vessels engaged in training operations to extend earlier integration of real operational sonars in experimental contexts, but unfortunately none were successfully completed in SOCAL-14. SOCAL-BRS continues to be closely coordinated with related research in the U.S. and Europe, notably through a multi-study collaboration on response metrics and statistical analytical methods[1]. A number of new SOCAL-BRS scientific findings were published since the SOCAL-13 report[2]; these are discussed below and are freely available on the project website <www.socal-brs.org>.

Like previous field campaigns, SOCAL-14 included an interdisciplinary collaboration of experts in various disciplines of field methods, behavioral analysis, and active and passive acoustic methods. Some but not all specified research objectives for SOCAL-14 were met. Animals of most focal species (but not beaked whales) were tagged, a substantial number of experimental exposures and silent control sequences using simulated MFAS were conducted (including the first on a minke whale), but we were not able to conduct experiments using full-scale operational Navy MFAS systems (SQS-53C) as was done in 2013. Two 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 beaked whale and dolphin groups and

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

[2] Friedlaender A.S., Goldbogen, J..A. Hazen E.L., Calambokidis, J.A., Southall, B.L. (**2014**). Feeding performance of sympatric blue and fin whales exploiting a common prey resource. Marine Mammal Science. DOI: 10.1111/mms.12134.

Goldbogen, J. A., A. K. Stimpert, S. L. DeRuiter, J. Calambokdis, A. S. Friedlaender, G. S. Schorr, D. J. Moretti, P. L. Tyack, B. L. Southall. (**2014**). Using accelerometers to determine the calling behavior of tagged baleen whales. The Journal of Experimental Biology, jeb-103259.

Stimpert, A. K., DeRuiter, S. L., Southall, B. L., Moretti, D. J., Falcone, E. A., Goldbogen, J. A., Friedlaender, A., Schorr, G.S., & Calambokidis, J. (**2014**). Acoustic and foraging behavior of a Baird's beaked whale, Berardius bairdii, exposed to simulated sonar. *Scientific Reports*, 4: 7031. DOI: 10.1038/srep07031.

Goldbogen, J. A., Hazen, E. L., Friedlaender, A. S., Calambokidis, J., DeRuiter, S. L., Stimpert, A. K., & Southall, B. L. (**2014**). Prey density and distribution drive the three-dimensional foraging strategies of the largest filter feeder. Functional Ecology. DOI: 10.1111/1365-2435.12395.

directed tag boats to animal locations where they were tracked and/or tagged. Eighteen tags (of three kinds) were secured on 21 individual animals of four different marine mammal species. Almost all deployments were on three focal species (fin whale, Risso's dolphin, and blue whale), with one tag deployed on a minke whale incidentally exposed to sonar during an experiment focused on fin whales. We conducted a total of 10 controlled exposure experiment (CEE) sequences involving 12 tagged individuals of four marine mammal species equipped with high-resolution suction cup acoustic tags and tracked both visually and acoustically. These CEEs all included either simulated MFAS signals or silent (no noise) controls as used in previous projects[3]. 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.

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] 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 active 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-14, 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-14 General Methodology

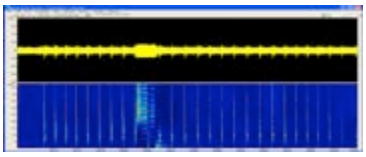
The overall research methods and vessel configuration used in SOCAL-14 field were generally similar to those used in earlier seasons in terms of the broad approach and protocols described in Southall *et al*. (2012), with several exceptions. As in previous field seasons, multi-disciplinary teams used state-of-the-art technologies (and in some cases

developed new analytical tools) to conduct different aspects of locating, tagging, and tracking animals and conducting controlled exposure experiments (CEEs). However, we continued to evolve capabilities to work in smaller teams and configurations and to respond rapidly to opportunities to coordinate with Navy training operations.

The field 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 CEEs to determine sound exposure conditions in which behavioral responses may occur. Specialized interdisciplinary teams for the collaborating institutions consisted of highly experienced scientists, engineers, and field personnel.

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-14, including all photos involving animals included in this report, were taken under the authorization and conditions of NMFS permit #14534.]

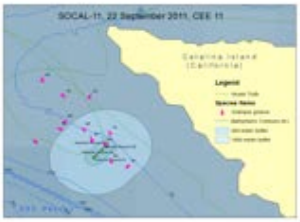


Passive acoustic monitoring utilized different listening platforms and systems to detect and monitor vocalizing animals before and during CEEs. These included a combination of listening sensors on the U.S. Navy SCORE range (the marine mammal monitoring on ranges or "M3R" team), towed passive acoustics from the central research platform and a separate sailboat (*R/V Baylis*), 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 some SOCAL-14 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-14 the 10-element version with smaller top-side control system first tested in 2013 was used.

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. Recent analyses currently being published demonstrate the profound increase in the ability to understand and describe whale behavior and potential responses to CEE stimuli with the addition of these methods.

SOCAL-14 did attempt to coordinate CEEs with Navy vessels operating in the context of regularly planned training operations, but due to various logistical constraints this was unfortunately not achieved.

SOCAL-14 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-14): **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

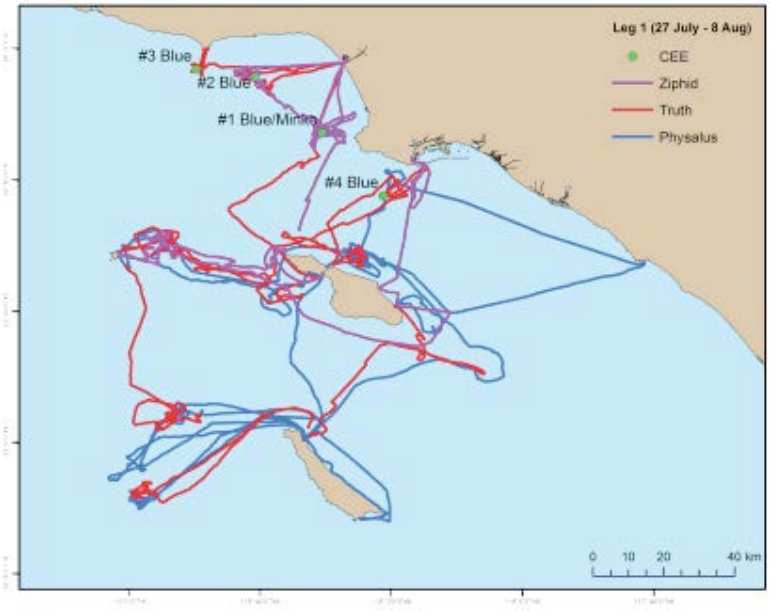
The SOCAL-BRS general operational area includes both southern and northern "inshore" areas around southern California, and an offshore area that includes the U.S. Navy's SCORE range (see figure to right). During SOCAL-BRS, operations have occurred throughout this region, with all sound transmissions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

SOCAL-14 was conducted in two experimental phases, each involving slightly different configurations and operational areas. For both periods ("Phases I and II") the slightly larger SOCAL-BRS configuration of research vessels and personnel, 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. A small field team configuration based exclusively

from RHIB platforms was scheduled for later in the year, but this did not occur as the planned coordination with Navy training during this period was not possible. 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.

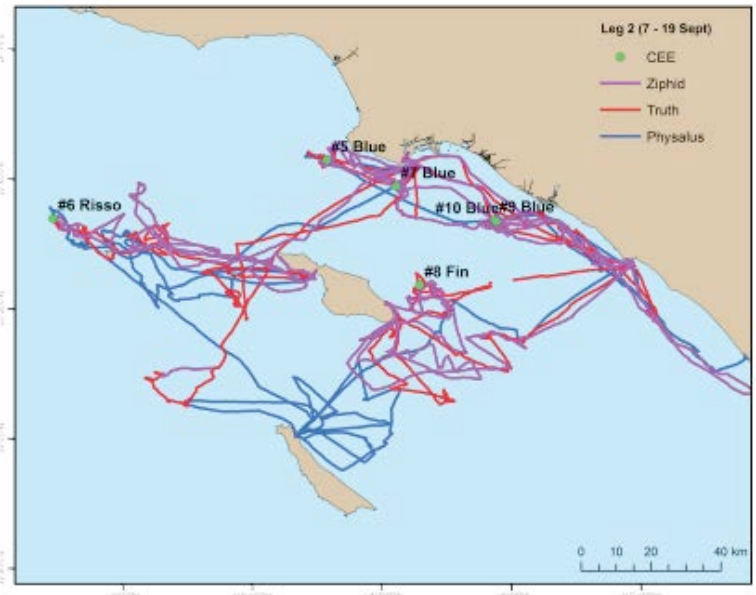
27 July - 7 Aug 2014: PHASE I

Operations during this phase focused on tagging to measure baseline behavior, control (no sonar transmission) experiments, and scaled source CEEs, as there were not options for coordination with real Navy training operations. The field contingent of 18 was 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 (*Ziphid* and *Physalus*) were again used working in generally overlapping areas (purple and blue tracks respectively in the figure below). For much of this period, however, one of the RHIBs (*Physalus*) was based from San Clemente Island, affording options to spread effort more broadly with more effort around the SCORE range even if SOCAL-BRS did not have full access. This was done adaptively with the option of keeping the RHIB based there or from Truth, which gave flexibility based on weather, animals, and available access to the SCORE range. 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 offshore for most of this period and SOCAL-BRS had very limited access to the range. Consequently, much of the effort was concentrated both around Catalina and in areas of Redondo canyon and the Palos Verdes Peninsula. A total of four CEE sequences (involving either control or simulated MFA exposures) were conducted with blue and minke whales (#2014-01 through 2014-04), several of which involved multiple simultaneously tagged animals. The locations of the sound source for each of these are indicated in the figure above and each is discussed in more detail below.



7- 20 September 2014: PHASE II

The full complement of research vessels and field personnel (20 total) used in previous years was available for SOCAL-14 phase II. 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 (*Ziphid* and *Physalus*) were again used working in generally overlapping areas (purple and blue tracks respectively in the figure below).



Additionally, a dedicated PAM vessel (*R/V Derek M. Baylis*) 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 variable with several periods of marginal conditions and a few periods of calm offshore conditions. A specified Navy vessel with MFAS was conducting sonar training on the SCORE range and was coordinating with SOCAL-BRS during Phase II. Several baleen whales were tagged during this period and efforts were made to conduct CEEs with this ship, but unfortunately this coordination was not possible. As planned given such a scenario, the scaled MFAS source was available and used to conduct several CEE sequences, along with a number of full silent control sequences. These included simulated MFAS CEEs with blue whales (#2014-07 and 2014-10) and control (no sonar transmissions) sequences (#2014-05, -06, -08, and -09) with blue and fin whales and Risso's dolphins. Considerable incidental exposure to MFAS during this period occurred from other Navy operations than those coordinated with SOCAL-BRS, including during several experimental sequences, one involving an interesting rapid swimming behavior in an unidentified cetacean observed and documented by SOCAL-14.

5. VISUAL SURVEY RESULTS

Trained and experienced marine mammal visual observers were used on both RHIBs and the *Truth* during all phases of SOCAL-14 and by a dedicated visual team on the *R/V Baylis* (the sailing vessel operating the towed PAM system) on Phase II. 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 (~250 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 *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 ~250m range 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* and thus contributed to mitigation mode during CEEs as well. Visual observers across all platforms (including the *R/V Baylis* for phase II) 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-14 for the *Truth*, RHIB, and *Baylis* visual observers, are given below for all platforms, operational effort phases, and observational modes.

SOCAL-14 Results from Visual Observer Team - all Platforms

Table 1. Survey effort days during SOCAL-14 field operation for *R/V Bayliss* (BAY), tagging RHIB *Physalus* (PHY), tagging RHIB *Ziphid* (ZIP), and *R/V Truth*

Project/Objective	BAY	PHY	Truth	ZIP
SOCAL14-I		10	10	10
SOCAL14-II	12	10	12	12

Table 2. Total marine mammal sighting events for SOCAL-14 field operations for all phases and platforms (abbreviations same as above)

Project/Objective	BAY	PHY	Truth	ZIP
SOCAL14-I		20	125	44
SOCAL14-II	32	13	164	40

Table 3. Marine mammal species sighted (confirmed to species) for SOCAL-14 field operations for all phases and platforms (abbreviations same as above). A total of 14 marine mammal species were confirmed across all platforms (common names below)

Project/Objective	BAY	PHY	Truth	ZIP
SOCAL14-I		7	11	7
SOCAL14-II	9	7	10	8

Blue whale
Fin whale
Minke whale
Humpback whale
Cuvier's beaked whale
Long-beaked common dolphin
Short-beaked common dolphin
Delphinus sp.
Risso's dolphin
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.

Project/Objective	BAY	PHY	Truth	ZIP
SOCAL14-I		391	1902	1323
SOCAL14-II	2302	434	9441	1951

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:

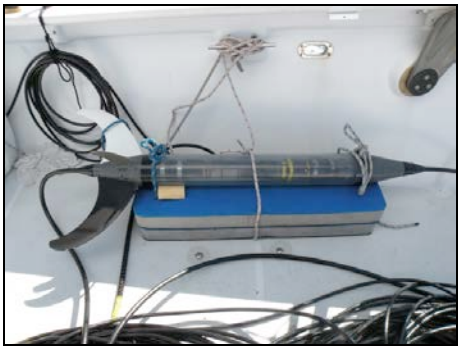
- Range and bearing to group; group swim direction
- Group size (low/best/high)
- Calf presence (binary)
- # of subgroups (categorical)
- Group spacing (categorical)
- Group shape (categorical)
- Distance between sub-groups (categorical)
- Display events (binary)
- Behavioral state

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.

During SOCAL-14 Phase I, the PAM component included the towed hydrophone effort and two acousticians aboard the *Truth*. Phase II expanded to two central research vessels: the source and visual search platform (*Truth*) and a stand-alone PAM sailing research vessel (R/V *Derek M. Baylis*). On Phase II, the PAM vessel supported two acousticians and three visual observers. During both phases of SOCAL-14 the *Truth* also served as a base for two Rigid Hull Inflatable Boats (RHIBs) that were used for tagging and tracking. Animals were tagged using D-tags (which record behavior and acoustic data) and exposed to simulated MFAS signals transmitted from the scaled source deployed from the *Truth*.



Passive acoustic monitoring methods, including towed tetrahedral acoustic array and acoustic monitoring station.

Phase I

The PAM component of SOCAL-14 Phase I was based from the *Truth*. This vessel departed anchorage each morning between 0600 and 0700 to transit to the study area within Southern California waters. A towed hydrophone array was deployed ~160 m behind the survey vessel, and when the vessel reached the study area acoustics personnel initiated survey effort immediately. The primary hydrophone array was a tetrahedral towed array (TT14k). The TT14k (shown above) contained four hydrophones (HTI 96min) with a frequency response range from 1 to 140 kHz. To maintain stability of TT14k the *Truth* traveled at a maximum speed of 8 knots. Acoustic survey effort ended when the survey vessel stopped to conduct a CEE or silent control sequence. The study area varied daily, based on the weather and sea state conditions, as well as the intended survey track of the *Truth* and RHIB tagging team.

Visual observation for cetaceans was conducted by four personnel from the flying bridge of the *Truth* using handheld binoculars and naked eye during daylight hours. Observers scanned 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.

Phase II

During Phase II (7 September – 20 September 2014), the PAM component of the SOCAL-BRS survey was conducted on a 65' Wyliecat motor-sailer, the R/V *Derek M. Baylis* (Fig. 1a). The vessel departed anchorage each morning between 0430 and 0600 to transit to the day's study area within Southern California waters. The same towed tetrahedral hydrophone array, TT14k, from Phase II was deployed upon entering the study area, and acoustics personnel initiated survey effort immediately. Visual observation began once there was sufficient daylight. Survey continued until target animals were detected, or until 1600, when the vessel would transit to anchorage. The study area varied daily, based on the weather and sea state conditions, as well as the intended survey track of the *Truth* and RHIB tagging team.

Visual observation for cetaceans was conducted during daylight hours from the bow of the R/V *Derek M. Baylis* using 7x50 handheld binoculars and naked eye. Observers scanned 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.

The TT14k was towed ~160 m behind the R/V *Derek M. Baylis* to detect, localize, and

classify sounds associated with cetaceans. In addition, TT14k was used to monitor for anthropogenic noise in the study area that could impact experiments in progress. The primary array was improved from previous years, and provided improved localization capabilities. A linear towed array was on board as a backup, but was not used.

Recording System

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[4]. 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[5], beaked whale alarm, the surface bounce module, the spectrogram, the waveform, and Wigner plot.

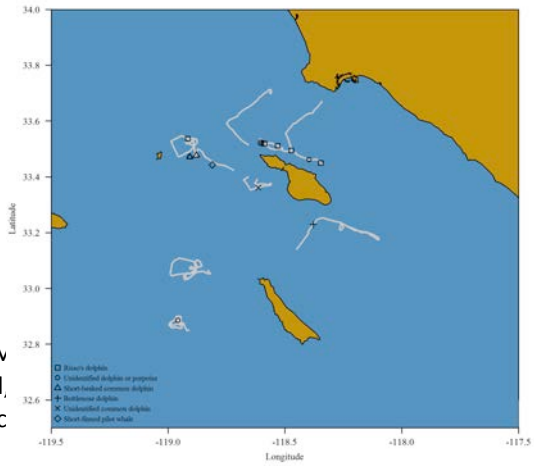
When beaked whales were detected, the acoustics team tracked animals using automated localization methods within PAMGUARD. Basic detection information was provided to the chief scientist aboard the *Truth*, who decided whether to initiate tagging efforts. Although beaked whales and sperm whales were the top priority species for the 2014 SOCAL-BRS, other species were considered for tagging efforts.

Autonomous Recorder Deployments

During both phases of SOCAL-14, autonomous drifting recorders were deployed. A Loggerhead DSG-Ocean acoustic datalogger was deployed to measure vessel noise of the *Truth*, *Baylis*, and RHIBs, ambient noise levels in the vicinity of acoustic playback experiments (CEE or control sequence), and received sound levels at varying distances from Navy MFAS and simulated MFAS sources (during CEE and control sequences).

RESULTS

Over 385 km of acoustic survey effort was conducted during SOCAL-14 Phase I aboard the *Truth*. The PAM component aboard the *Truth* had a total of 15 acoustic detections of cetaceans (Table 5, fig to right). These detections included



[4] Gillespie, D., Gordon, J., McHugh, R., McLaren, D., M and Deng, X.-Y. (2008). PAMGUARD: Semiautomated, detection and localisation of cetaceans, Proc. Inst. Ac

[5] Keating, J. L. and Barlow, J. (**2013**). Summary of PAMGUARD beaked whale click detectors and classifiers used during the 2012 Southern California Behavioral Response Study. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-517, 17 p.

short-beaked common dolphins (*Delphinus delphis*), unidentified common dolphin species (*Delphinus* spp.), bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus*), and short-finned pilot whales (*Globicephala macrorhynchus*). There were no acoustic detections of beaked whales and, as a result, the focus shifted to a secondary species for the project (Risso's dolphins). There were a total of six Risso's dolphin detections. Several detections were approached for tagging efforts, which resulted in successful CEE and control sequences.

Table 5. Acoustic detections of marine mammals from *Truth* during SOCAL-14 Phase I.

Species group		***Detections***	
Subgroup			
Common name	***Scientific name(s)***	***Acoustic (only)***	***Acoustic & Visual***
Delphinids			
Small delphinids			
Short-beaked common dolphin	*Delphinus delphis*	0	2
Unidentified common dolphin	*Delphinus spp.*	0	1
Unidentified delphinid		3	0
Large delphinids			
Bottlenose dolphin	*Tursiops truncatus*	0	2
Risso's dolphin	*Grampus griseus*	1	5
Short-finned pilot whale	*Globicephala macrohynchus*	1	0
Totals		**5**	**10**

On August 2nd, the Southern California Offshore Range (SCORE) had two acoustic detections from bottom-mounted hydrophones (near San Clemente Island) of beaked whales, but we were not able to visually or acoustically detect them from the *Truth*. When the *Truth* reached the reported location from the SCORE range, weather conditions had increased to a Beaufort 5. After surveying the area there were no acoustic

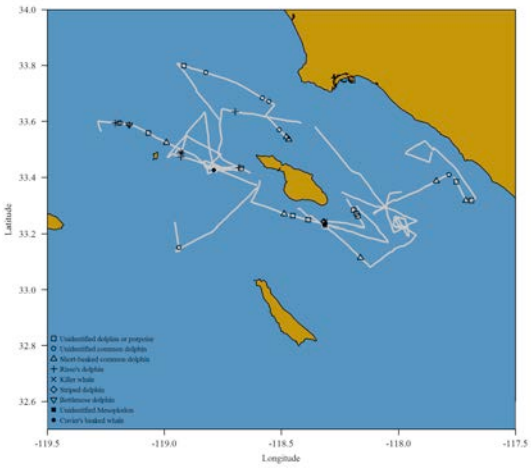
detections from the towed hydrophone array to direct boats in the rough seas, so the search was called off.

Five deployments of a DSG-Ocean acoustic datalogger acoustically recorded blue whales (B and D calls), unidentified dolphins, and CEEs. These recordings were collected to profile the acoustic environment throughout each exposure and control sequence for both phases (Table 6).

Table 6. Summary of detections collected by the DSG-Ocean autonomous drifting recorders during both phases of SOCAL-14.

Date	***Detection Type***	***Comments***
7/30/2014	Unidentified delphinid	3 detections of periods of whistles; Possibly common dolphins
7/30/2014	Mid-Frequency Active Sonar	CEE
7/31/2014	Blue whale	6 D calls
7/31/2014	Unidentified delphinid	Single detection of clicks and whistles
8/01/2014	Unidentified delphinid	Single detection of clicks and whistles; Possibly common dolphins
8/05/2014	Blue whale	40 B calls
8/06/2014	Blue whale	116 B calls
8/06/2014	Mid-Frequency Active Sonar	CEE
9/10/2014	Blue whale	57 B calls
9/10/2014	Risso's dolphin	Detection of clicks and burst pulses (Visual confirmation of species)
9/10/2014	Killer whale	Detection of clicks, whistles, and burst pulses (Visual confirmation of species)
9/11/2014	Blue whale	88 B calls
9/11/2014	Unidentified delphinid	Single detection of clicks, whistles, and burst pulse; Possibly common dolphins
9/17/2014	Blue whale	32 A calls; 99 B calls
9/17/2014	Mid-Frequency Active Sonar	US Navy

9/18/2014	Blue whale	76 A calls; 83 B calls
9/18/2014	Mid-Frequency Active Sonar	US Navy
9/19/2014	Blue whale	16 B calls
9/19/2014	Low-Frequency Active Sonar	US Navy
9/19/2014	Mid-Frequency Active Sonar	CEE



Over 925 km of acoustic survey effort was conducted during SOCAL-14 Phase II aboard the PAM survey vessel. The towed hydrophone array, TT14k, was used again for all recordings. It was affected by rough seas on September 12th, causing a reversal of left and right localization angles; this issue was resolved for monitoring efforts on September 14th.

A total of 53 cetaceans were detected from the R/V *Derek M. Baylis*, of which 38 were detected using acoustic methods (Table 7). Acoustic detections included short-beaked common dolphins, unidentified common dolphin species, striped dolphins (*Stenella coeruleoalba*), bottlenose dolphins, Risso's dolphins, killer whales (*Orcinus orca*), and two species of beaked whales (Cuvier's beaked whale, *Ziphius cavirostris* & unidentified Mesoplodon beaked whale, *Mesoplodon spp.*). There were a total of 2 beaked whale detections and both beaked whales were detected using acoustic methods. The acoustic detection of a Cuvier's beaked whale was west of Catalina Harbor, Catalina Island in the same location of several acoustic detections in previous years. Efforts were made to tag this animal, but due to weather conditions this was not accomplished. Acoustic species classification of the unidentified Mesoplodon as 'BW43' was based on characteristics outlined previously[6]. This acoustic detection was off the southern tip of Catalina Island; there was no associated sighting.

A pod of 7 killer whales (likely offshore ecotype) was acoustically and visually detected northwest of Catalina Island on September 10th within close range to a group of Risso's dolphins. RHIBs approached for tagging efforts, but no tags were successfully deployed.

[6] Baumann-Pickering, S., McDonald, M. A., Simonis, A. E., Berga, A. S., Merkens, K. P. B., Oleson, E. M., Roch, M. A., Wiggins, S. M., Rankin, S., Yack, T. M., and Hildebrand, J. A. (2013). Species-specific beaked whale echolocation signals, J. Acoust. Soc. Am. 134, 2293-2301.

On September 16th a second pod of killer whales was acoustically detected off the southern tip of Catalina Island. During this acoustic detection we only recorded high-frequency modulated vocalizations[7] and were not able to localize the animals for tagging.

On September 17th, 18th, and 19th mid-frequency active sonar was detected by the towed tetrahedral array. None of these acoustic detections were solicited by the project and at one point these transmissions overlapped with the project's CEE.

The R/V *Derek M. Baylis* deployed a DSG-Ocean acoustic datalogger five times that acoustically recorded blue whales (A and B calls), Risso's dolphins, killer whales, unidentified dolphins, US Navy sonar, and the project's CEE (Table 7). These recordings were collected to profile the acoustic environment throughout each exposure and control sequence.

Table 7. Acoustic and visual detections on the *Baylis* during SOCAL-14 Phase II.

Species group				
Subgroup			***Detections***	
Common name	***Scientific name(s)***	***Acoustic (only)***	***Visual (only)***	***Acoustic & Visual***
Small delphinids				
Short-beaked common dolphin	*Delphinus delphis*	0	1	7
Unidentified common dolphin	*Delphinus spp.*	1	2	8
Striped dolphin	*Stenella coeruleoalba*	0	0	1
Unidentified delphinids		8	2	2
Large delphinids				
Killer whale	*Orcinus orca*	1	0	1
Bottlenose dolphin	*Tursiops truncatus*	0	0	1
Risso's dolphin	*Grampus griseus*	2	1	4
Small beaked whales				

[7] As described by: Simonis, A. E., Baumann-Pickering, S., Oleson, E., Melcón, M. L., Gassmann, M., Wiggins, S. M., and Hildebrand, J. A. (2012). High-frequency modulated signals of killer whales (*Orcinus orca*) in the North Pacific, J. Acoust. Soc. Am. 131, EL295-301.

Cuvier's beaked whale	*Ziphius cavirostris*	1	0	0
Unidentified Mesoplodon[8]	*Mesoplodon spp.*	1	0	0
Large whales				
Blue whale	*Balaenoptera musculus*	0	1	0
Fin whale	*Balaenoptera Physalus*	0	1	0
Minke whale	*Balaenoptera acutorostrata*	0	2	0
Unidentified Mysticete		0	2	0
Unidentified small cetacean		0	1	0
Totals		**14**	**15**	**24**

PAM DISCUSSION

Acoustic detections collected by the PAM component of the SOCAL-BRS were very different from previous years. There were no beaked whale detections during Phase I and only 2 acoustic detections of beaked whales on Phase II. Sperm whales were not detected during the SOCAL-14 season for the first time since the project started in 2009, but short-finned pilot whales and killer whales were detected for the first time. Overall acoustic detections recorded in 2014 (53) were substantially less than 2012 (147) and 2013 (180) field seasons, with relatively the same amount of time with the towed-hydrophone array in the water. The lower detection rates could have been caused by poorer acoustic propagation conditions than in previous years, or alternatively this could have been simply due to a lower density of cetaceans in the survey area. There is not enough data to make a conclusive reason for the change in acoustic detections, but shifting field season dates for future should be considered. The following additional changes in methodology should be considered for field efforts in future years:

1. Add the ability to localize on tonal sounds (dolphin whistles and sonar) through software improvements in PAMGUARD.
2. Develop a towed array system that can be used from a large, enclosed rigid-hulled inflatable boat (Navy interceptor).

[8] The acoustic detection of an unidentified Mesoplodon was not confirmed visually and should be considered a “possible” detection.

a. Obtain access to an Interceptor prior to the field season for design setup.
b. Work to decrease the PAM hardware for use on a smaller vessel.
c. Improve automation of acoustic detections to allow use with only one or two acousticians.
d. Identify a location for a stern pulley to be attached to the boat.

7. SUMMARY OF TAG DEPLOYMENTS

A similar suite of acoustic and movement tags were used in SOCAL-14 as in previous projects, each with somewhat different capabilities and thus intended functions. These included:

DTAGs – designed and supplied by WHOI collaborators[9], these tags are attached with suction cups for up to tens of hours, recording digital sound (variable bandwidth from ~100Hz up to 240 kHz) as well as depth and 3-D accelerometer and magnetometer data. Version 3 DTAGs were used in SOCAL-14.

Mk-10s[10] – 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[11] – 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-14.

SIRTRACK[12] - 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, as well as custom video tag deployments on two whales as a secondary objective.

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[9] 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.
[10] http://www.wildlifecomputers.com/Media/MDS/TDR10_FastlocGPSBackmountSuite.pdf
[11] http://www.acousonde.com/
[12] http://sirtrack.com

Twenty-one tags (of three kinds) were secured on 18 individual animals of four different marine mammal species during all phases of SOCAL-14. These included multiple deployments on Risso's dolphins, several instances of multiple tags deployed simultaneously on baleen whales, and the second successful tag deployment and first SOCAL-BRS CEE on a minke whale. Unfortunately, no beaked whales were tagged in SOCAL-14 and success on fin whales was more limited than in previous seasons. A summary of the overall tag deployments by species and tag type is given below, followed by a breakdown of attachment type and duration by individual. A total of over 100 hours of high-resolution acoustic and movement tag data were collected across all deployments.

TOTAL SOCAL-14	18 individuals of 4 species (with 21 tags of 3 types)
Rissos dolphins:	4 individuals (4 DTAG3)
Fin Whales:	1 individual (1 DTAG3)
Blue Whales:	12 individuals (12 DTAG3; 1 MK-10; 2 custom video)
Minke Whales:	1 individuals (1 DTAG3)

Date	Approximate deployment time	Species	Animal ID
Phase I			
28-Jul	0:01	Rissos Dolphin	n/a
30-Jul	6:26	Minke Whale	ba14_211a
30-Jul	1:42	Blue Whale	bw14_211a
30-Jul	3:57	Blue Whale	bw14_211b
31-Jul into 1-Aug	26:20:00	Blue Whale	bw14_212a
1-Aug	3:50	Blue Whale	bw14_213a
5-Aug	6:20	Blue Whale	bw14_217a
6-Aug	6:15	Blue Whale	bw14_218a
6-Aug	1:23	Blue Whale	bw14_218b
Phase II			
8-Sep	6:21	Blue Whale	bw14_251a
10-Sep	1:13	Rissos Dolphin	gg14_253a
11-Sep	0:01	Rissos Dolphin	n/a
11-Sep	3:11	Rissos Dolphin	gg14_254a
13-Sep	10:42	Blue Whale	bw14_256a (DTAG)
13-Sep	8:42	Blue Whale	bw14_256a (MK-10)
16-Sep	6:10	Fin Whale	bp14_259a
18-Sep	4:57	Blue Whale	bw14_261a
19-Sep	4:26	Blue Whale	bw14_262a
19-Sep	3:34	Blue Whale	bw14_262b

8. CONTROLLED EXPOSURE EXPERIMENTS (CEEs)

General Methodology and Sound types

CEEs were conducted using similar methods and sound types to those used in earlier phases of the SOCAL-BRS project[13]. 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.

[13] 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.

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 MFAS and no noise control 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-14 experimental signals used in CEEs were intended to be either simulated or real MFAS signals but unfortunately coordination with real Navy ships in 2014 was not possible. Simulated MFAS signals were projected from the 10-element vertical line array source described above 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.

Full no-noise "control" sequences were conducted as well, which included a baseline period, a "mock" exposure (sound source deployed but not transmitting), and a "post-exposure" sequence. These were conducted within a balanced sequence of simulated MFAS 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

Specific protocols for conducting CEEs in SOCAL-14 were very similar to previous efforts and were specified in the project test plan prior to the field season. These 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:

SIMULATED MFAS SOURCE CEEs

- 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.

REAL NAVY MFAS SOURCE CEEs

- Position Navy vessel at an appropriate range and course trajectory from the focal group or animal to meet the specified received level objectives for each species group (110-130 dB RMS for beaked whales; 120-150 dB RMS for all other species) 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 MFAS 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[14]:
  - o *Directed, high speed or other abnormal swimming behavior (at surface), especially toward shore.*
  - o *Unusual and abnormal surface/subsurface behavior involving apparent disorientation and confusion or dramatic changes in group cohesion.*
- Controlled sound exposures were conducted with focal groups that included dependent calves that were not neonates (no fetal folds for non-ESA listed species). However, if the *mother-calf pair had become clearly separated during transmissions* (as determined by one of the principal investigators based on the input of trained marine mammal observers) CEEs would have been terminated.
- Any Navy vessel MFAS would occur 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.

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

Summary of SOCAL-14 CEEs

During two experimental phases of SOCAL-14, CEEs using either simulated MFAS or no noise control "exposures" were successfully completed with 12 individuals of four marine mammal species (Risso's dolphin (1), fin whale (1), blue whale (9), and minke whale (1)). Ten complete CEE transmission sequences were conducted, each on different days. Two of these included exposures with multiple individuals. Once during SOCAL-14, scaled MFAS transmissions were terminated during the CEE prior to the 30 min. maximum transmission period according to specified safety protocols, as the result of a non-focal California sea lion 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-14 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.

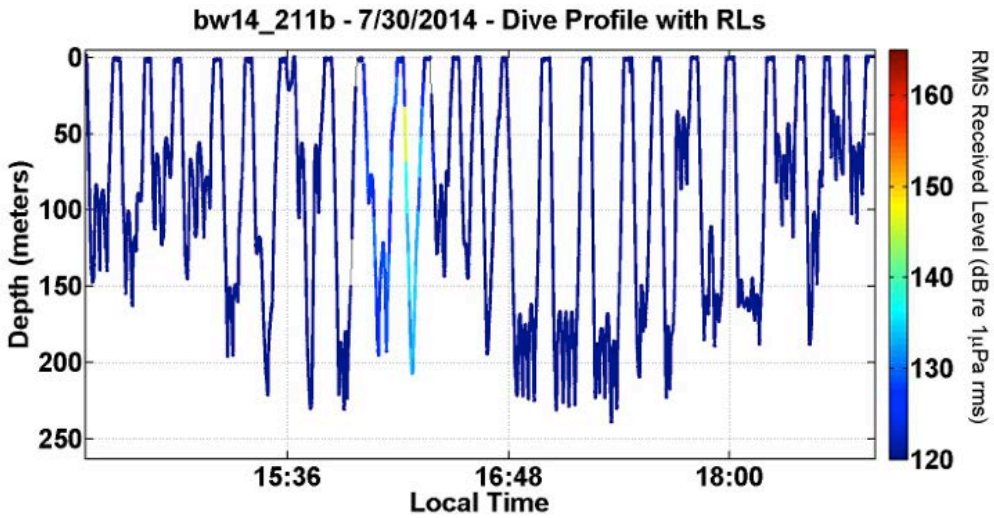
SOCAL-14 - Phase I Sequences

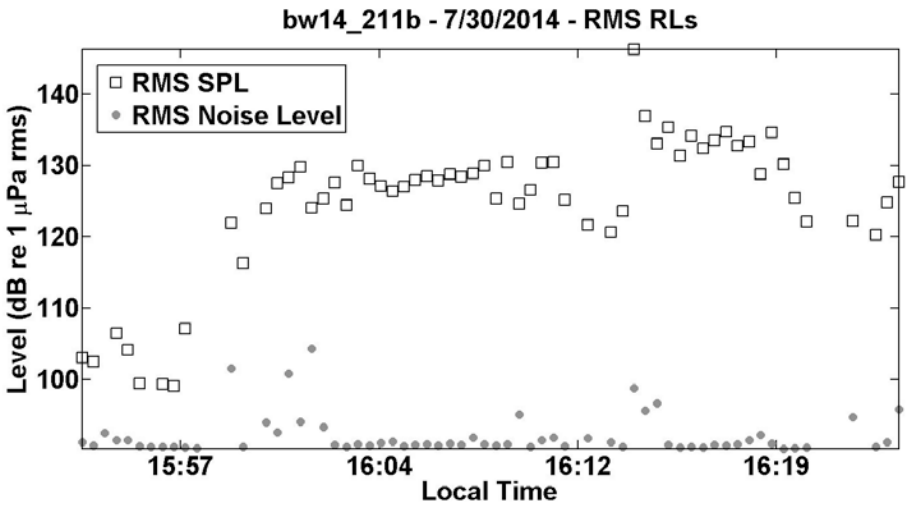
Date	Species	Animal ID	From Boat	CEE #	CEE Type	CEE TIME (local PDT)	CEE Duration (min)
Phase I							
30-Jul	**Minke Whale**	**ba14_211a**	Ziphid	***#2014_01***	SIMULATED MFAS	**1554-1624**	30
30-Jul	**Blue Whale**	**bw14_211b**	Ziphid	***#2014_01***	SIMULATED MFAS	**1554-1624**	30
31-Jul into 1-Aug	**Blue Whale**	**bw14_212a**	Ziphid	***#2014_02***	SILENT CONTROL	**1416-1446**	30
1-Aug	**Blue Whale**	**bw14_213a**	Ziphid	***#2014_03***	SILENT CONTROL	**1536-1606**	30
6-Aug	**Blue Whale**	**bw14_218a**	Ziphid	***#2014_04***	SIMULATED MFAS	**1201-1231**	30

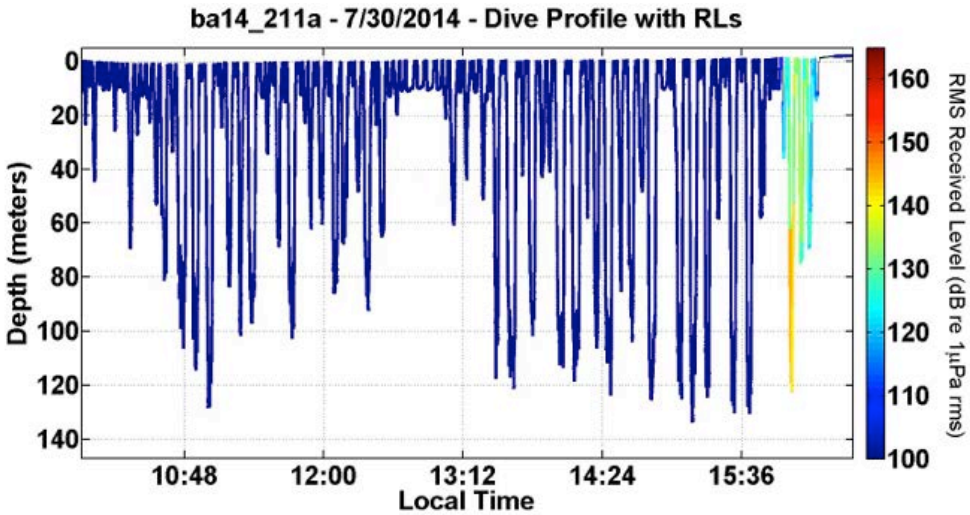
CEE # 2014-01

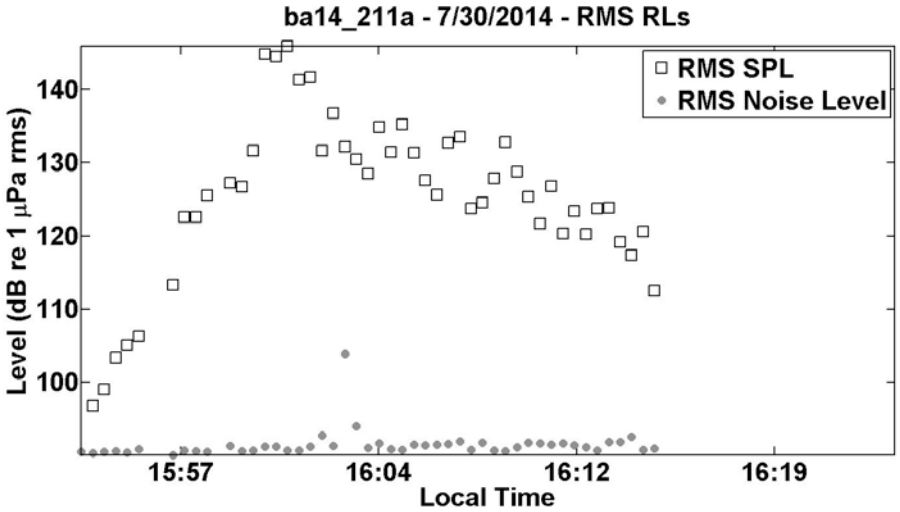
- DATE and TIME: **30 July 2014 (1554-1624)**
- LOCATION (Source at start of CEE): **Redondo Canyon (33.7865; -118.5096)**
- FOCAL SPECIES: **BLUE WHALE (MINKE WHALE INCIDENTAL)**
- INDIVIDUAL ID(s): **bw14_211b (blue whale) and ba14_211a (minke whale)**
- CEE TYPE (DURATION): **SIMULATED MFAS (30:00)**
- SUMMARY: Mixed species feeding aggregation in same general of Redondo canyon with blue, fin, and minke whales. A blue whale was the focus here but a minke whale was also tagged and was incidentally exposed to the CEE at a similar

level as the blue whale. Full prey mapping sequences were conducted both before and after the CEE, focused on the blue whale. The minke whale tag detached from the animal near the end of the CEE sequence.





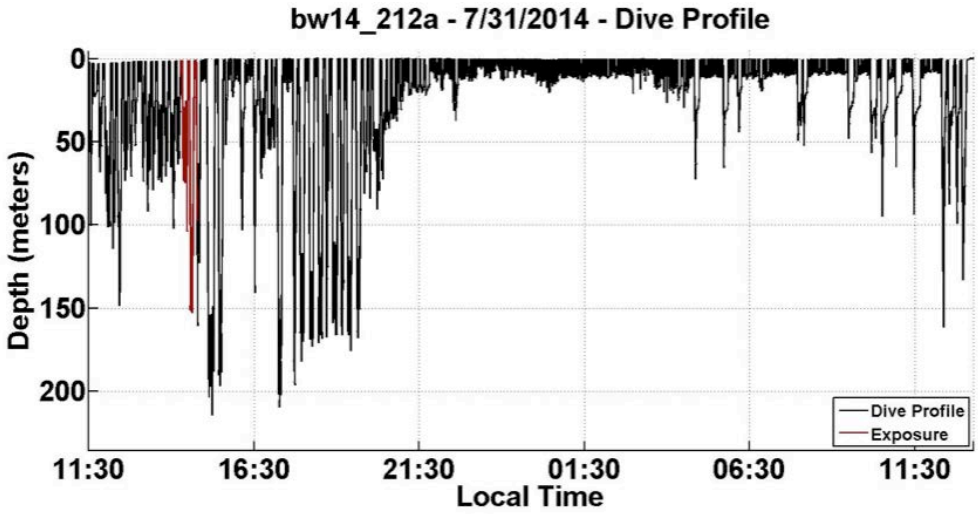




CEE # 2014-02

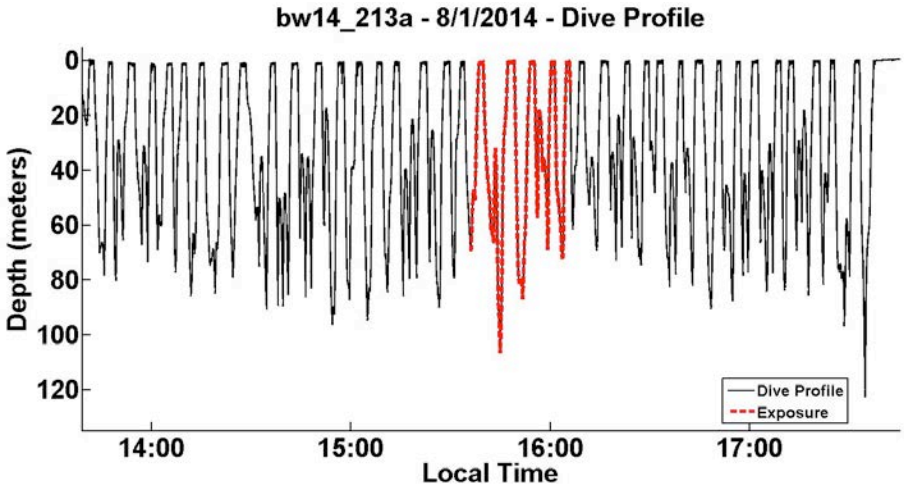
- DATE and TIME: **31 July 2014 (1416-1446)**
- LOCATION (Source at start of CEE): **Santa Monica Canyon (33.9288; -118.6799)**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw14_212a**
- CEE TYPE (DURATION): **SILENT CONTROL (30:00)**
- SUMMARY: Mixed species (blue, fin, humpback, and minke whales) feeding aggregation in which one blue whale was tagged for sufficient time to conduct a CEE. Complete silent control sequence with full focal follow was conducted. Prey mapping was conducted before but conditions were too rough afterwards to complete post-exposure prey mapping. There was a large amount of krill visible at

the surface and we obtained voucher samples.



CEE # 2014-03

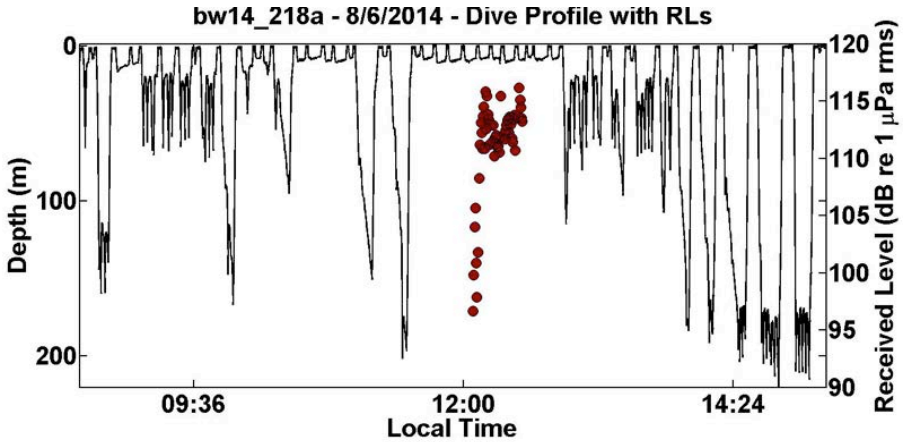
- DATE and TIME: **1 August 2014 (1536-1606)**
- LOCATION (Source at start of CEE): **Santa Monica Canyon (33.9483; -118.8297)**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw14_213a**
- CEE TYPE (DURATION): **SILENT CONTROL (30:00)**
- SUMMARY: Single blue whale tagged in mixed species feeding aggregation in a similar area of Santa Monica Canyon as 31 July CEE. Complete silent control sequence with full focal follow was conducted. Full prey mapping sequences were conducted before and following the silent control.

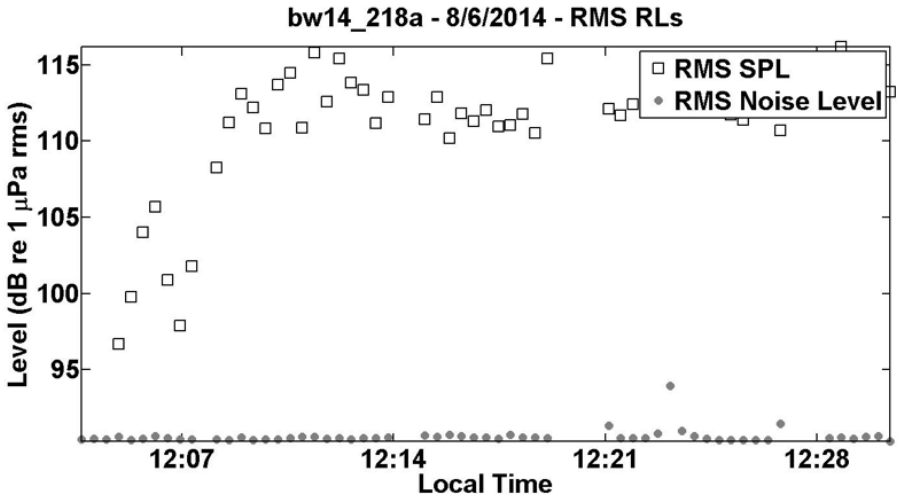


CEE # 2014-04

- DATE and TIME: **6 August 2014 (1201-1231)**
- LOCATION (Source at start of CEE): **San Pedro Channel near shipping lanes (33.6271; -118.3555)**

  FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw14_218a**
- CEE TYPE (DURATION): **SIMULATED MFAS (30:00)**
- SUMMARY: Single blue whale tagged early in the day in the San Pedro Channel; in addition to the primary DTAG a secondary video tag was simultaneously deployed. Complete simulated MFAS sequence with full focal follow was conducted in the shipping lanes with some ships in the vicinity that were documented. Full prey mapping sequences were conducted before and following the simulated MFAS CEE.



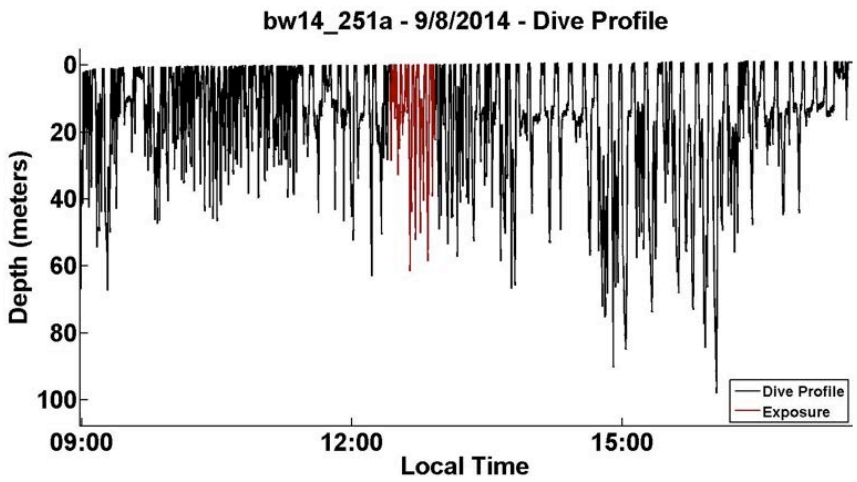


SOCAL-14 - Phase II CEE Sequences

Date	Species	Animal ID	From Boat	CEE #	CEE Type	CEE TIME (local PDT)	CEE Duration (min)
Phase II							
8-Sep	**Blue Whale**	**bw14_251a**	Ziphid	***#2014_05***	SILENT CONTROL	**1225-1255**	30
11-Sep	**Rissos Dolphin**	**gg14_254a**	Ziphid	***#2014_06***	SILENT CONTROL	**1058-1129**	30
13-Sep	**Blue Whale**	**bw14_256a**	Ziphid	***#2014_07***	SIMULATED MFAS	**1045-1115**	30
16-Sep	**Fin Whale**	**bp14_259a**	Ziphid	***#2014_08***	SILENT CONTROL	**1058-1129**	30
18-Sep	**Blue Whale**	**bw14_261a**	Ziphid	***#2014_09***	SILENT CONTROL	**1321-1338**	30
19-Sep	**Blue Whale**	**bw14_262a**	Ziphid	***#2014_10***	SIMULATED MFAS	**1102-1130**	28
19-Sep	**Blue Whale**	**bw14_262b**	Ziphid	***#2014_10***	SIMULATED MFAS	**1102-1130**	28

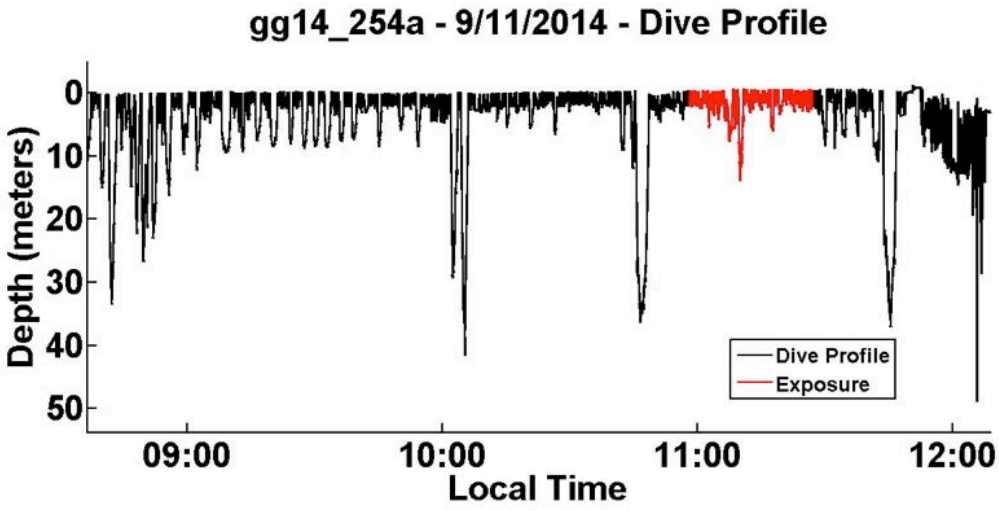
CEE # 2014-05

- DATE and TIME: **8 September 2014 (1225-1255)**
- LOCATION (Source at start of CEE): **SW of Palos Verdes (33.7164; -118.4770)**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw14_251a**
- CEE TYPE (DURATION): **SILENT CONTROL (30:00)**
- SUMMARY: Single blue whale tagged in mixed species feeding aggregation off Palos Verdes. Complete silent control sequence with full focal follow was conducted. Full prey mapping sequences were conducted before and following the silent control, although conditions marginal following the silent control.



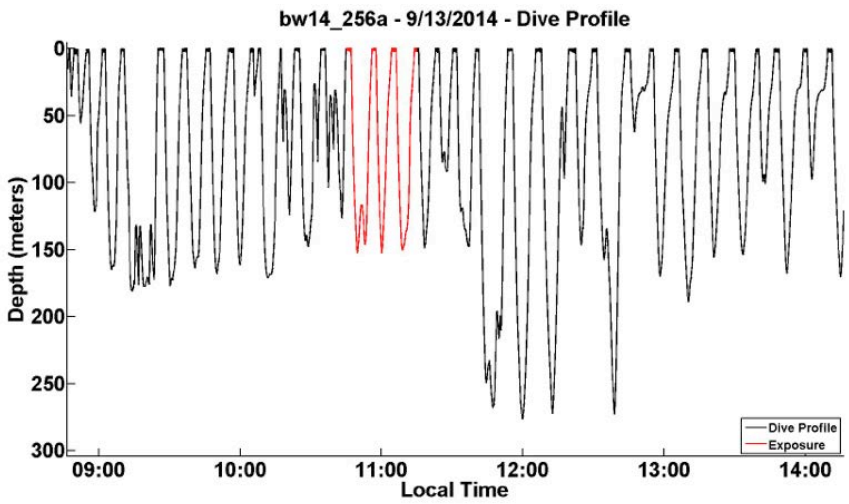
CEE # 2014-06

- DATE and TIME: **11 September 2014 (1058-1128)**
- LOCATION (Source at start of CEE): **NW of Santa Barbara Island (33.5665; -119.1819)**
- FOCAL SPECIES: **RISSO'S DOLPHIN**
- INDIVIDUAL ID(s): **gg14_254a**
- CEE TYPE (DURATION): **SILENT CONTROL (30:00)**
- SUMMARY: Animal tagged in a large dispersed aggregation of over 100 Risso's dolphins. Another animal was tagged earlier in the day but was not attached during this full silent control sequence. Tag deployed on gg14_254a came off about 15 min following the control sequence.



CEE # 2014-07

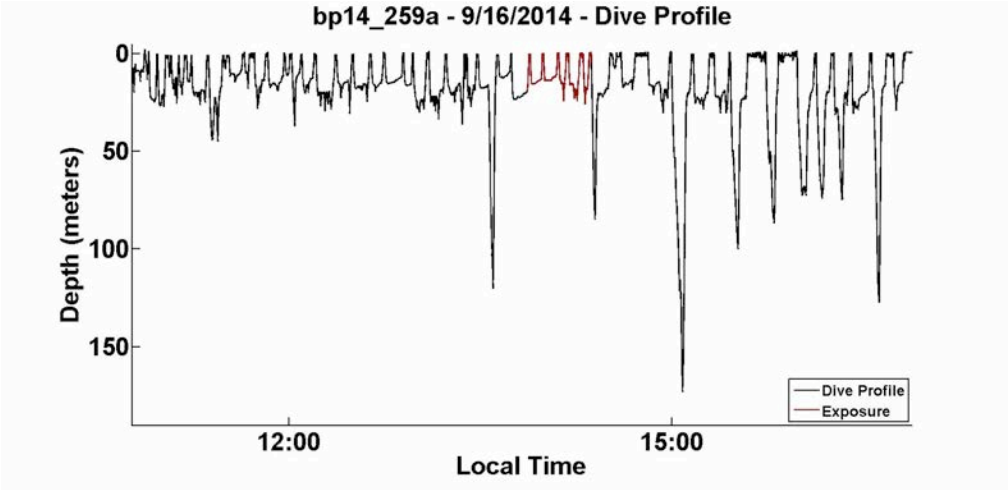
- DATE and TIME: **13 September 2014 (1045-1115)**
- LOCATION (Source at start of CEE): **San Pedro Channel near shipping lanes (33.6493; -118.2982)**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw14_256a**
- CEE TYPE (DURATION): **SIMULATED MFAS (30:00)**
- SUMMARY: Animal tagged in San Pedro Canyon and double tagged with DTAG and a MK-10. We were in the shipping lanes and had to maneuver a little with ships around us and were almost shut down from fin whale less than 300m but it moved outside the potential shut-down zone without seeming to deviate it's course and the full CEE sequence was completed. Full prey mapping sequences were conducted before and after. Following the CEE we lost the focal follow on this whale and did not recover the MK-10 until the following day and the DTAG actually several weeks later after some issues with the VHF signal.



CEE # 2014-08

- DATE and TIME: 1**6 September 2014 (1058-1128)**
- LOCATION (Source at start of CEE): **East of Catalina (33.3950; -118.2375)**
- FOCAL SPECIES: **FIN WHALE**
- INDIVIDUAL ID(s): **bp14_259a**
- CEE TYPE (DURATION): **SILENT CONTROL (30:00)**

- SUMMARY: Fin whale alone that was later joined by a larger animal on the shelf out from Avalon. Plan was to coordinate this CEE with Navy ship, but it was unavailable when this animal was tagged so we proceeded with scaled source control. Full prey mapping sequences were conducted before and after, but later sequences were limited by sea state conditions.



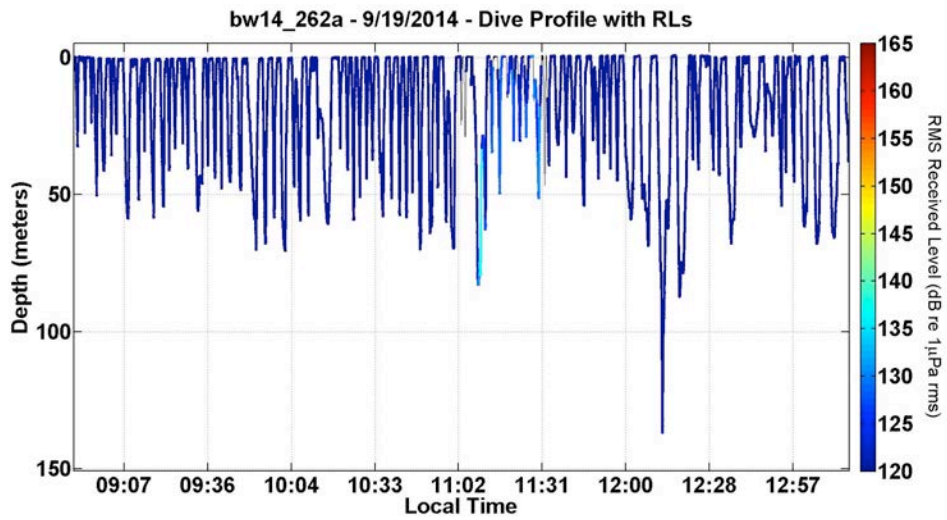
CEE # 2014-09

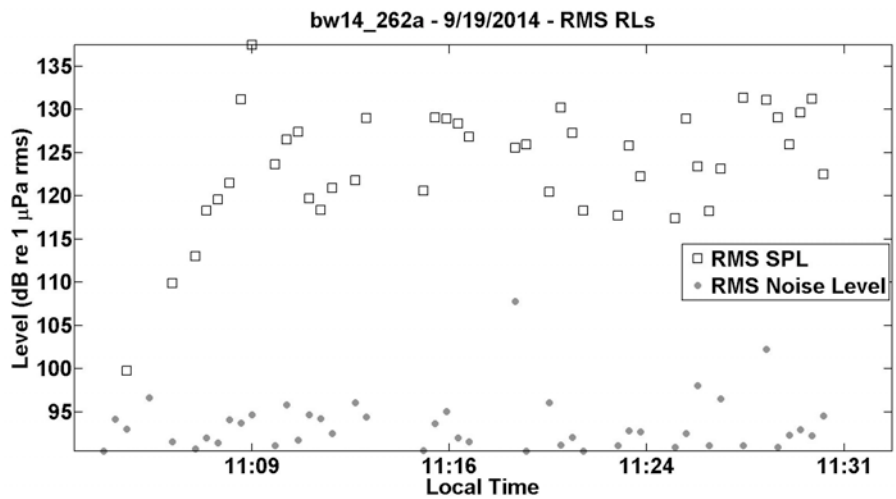
- DATE and TIME: **18 September 2014 (1321-1338)**
- LOCATION (Source at start of CEE): **Off Newport Beach (33.5622; -118.0441)**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw14_261a**
- CEE TYPE (DURATION): **SILENT CONTROL (30:00)**
- SUMMARY: Tagged blue whale doing long, deep dives that was tricky to track, but focal follow was established. Again planned CEE with Navy ship was not possible so a full control sequence was conducted. Full prey mapping sequences were conducted before and after, but marginal conditions following the sequence limited post-CEE prey measurements.

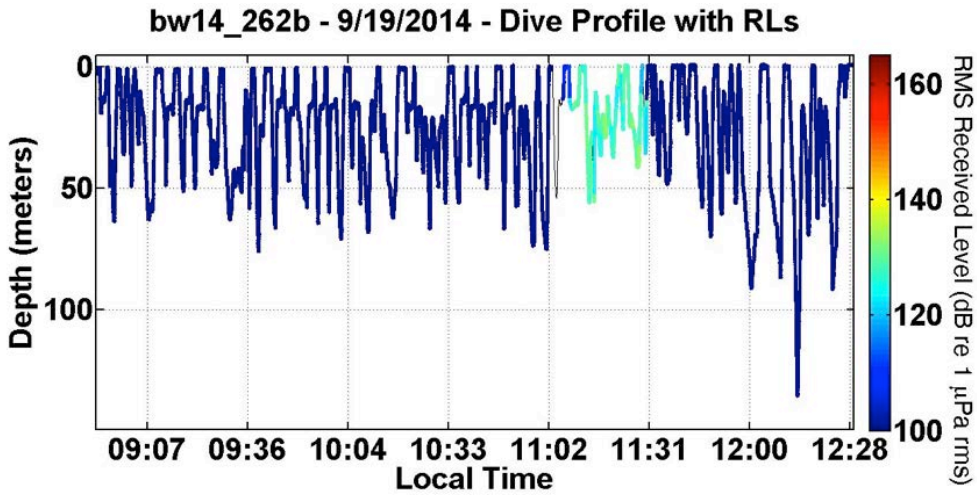
CEE # 2014-10

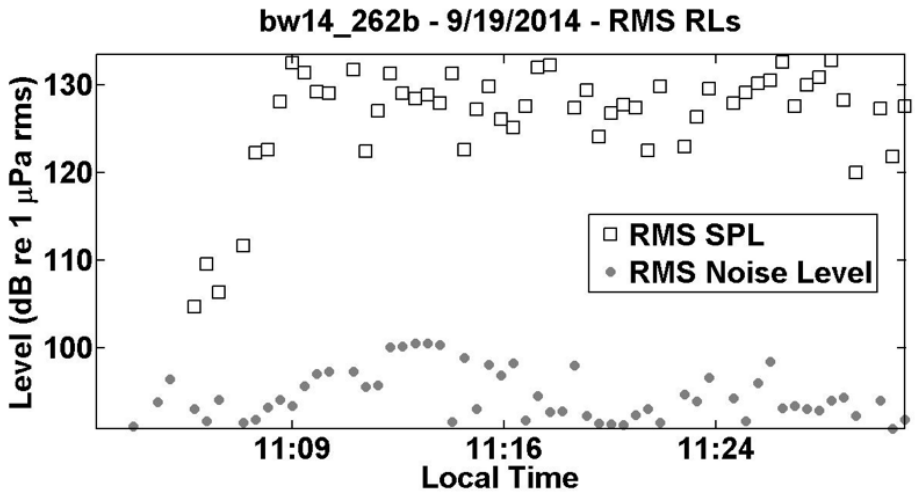
- DATE and TIME: **19 September 2014 (1102-1130)**
- LOCATION (Source at start of CEE): **San Pedro Channel near oil rigs (33.5590; -118.0399)**
- FOCAL SPECIES: **BLUE WHALE**
- INDIVIDUAL ID(s): **bw14_262a; bw14_262b**

- CEE TYPE (DURATION): **SIMULATED MFAS (28:00)**
- SUMMARY: Two blue whales tagged (both animals in a lead-trail pair) in a mixed species feeding aggregation (blue and humpback whales, dolphins, and sea lions. Both animals were surface lunge feeding. Again the Navy ship with which we were coordinating was unavailable so simulated MFAS sequence was conducted; this sequence was cut two minutes short because a sea lion came inside the 200m shut down zone when the source was active. Excellent full prey mapping sequences conducted before and after the CEE. One of the tags came off in surface-active interactions but after these measurements were completed. Analysis of acoustic tag data revealed incidental lower-frequency sonar (~ 1kHz) for periods before and during the MFAS CEE for both whales, which complicates analysis; only the MFAS exposure (3-4 kHz is depicted below).









CEE Summary and Assessment

In some regards, SOCAL-14 was more limited in terms of accomplishments than other field seasons, due to our limited ability to locate and tag focal species (most notably beaked whales), but also because of the inability to successfully complete CEEs with real Navy ships. Focal species were located and some were tagged, but overall success was more limited than in previous seasons and this was the first year in which no beaked whales were tagged and CEEs completed. Additionally, field coordination with real Navy ships did occur, but ships were unavailable during periods when animals were tagged.

Despite these limitations, significant progress was made in some areas during SOCAL-14. These included complete CEE sequences on priority species (fin whales and Risso's dolphins) and a significant increase in the number of control (no noise) sequences with blue whales. Additionally, while completed incidentally to another tagged whale, the first

SOCAL-BRS CEE with a minke whale was conducted in 2014; these results are being analyzed and combined in collaboration with the 3S research project being conducted in Norway given the limited sample sizes for each project. Finally, while both SOCAL-14 field phases included the *Truth* plus RHIB configurations (a RHIB-only period for November was cancelled because there was no Navy ship availability), a slightly different adaptation of this mode was applied in which one RHIB could base from either San Clemente Island or the *Truth* depending on circumstances. This modification enabled a more adaptive spread of field effort, which is expected to be integrated more into subsequent efforts.

As described above and implemented in SOCAL-14 as in previous field seasons, very specific protocols were in place regarding MFAS transmissions. As in previous seasons, no CEE sequences were prematurely terminated as a result of specific observed negative reactions. Rather, in one instance a CEE was terminated when a California sea lion entered the specified 200m exclusion zone, apparently ignoring ongoing full-power transmissions.

While CEE results were limited for fin whales and Risso's dolphins, the sequences conducted for each species (one each) add to the moderate sample size; these data are currently being analyzed using several quantitative and qualitative methods and will be augmented by additional real and simulated MFAS CEEs and control sequences in 2015 and 2016 (discussed below) before being published. SOCAL-14 resulted in nine full CEE sequences for blue whales (five simulated MFAS, four silent controls). These results have been added to the larger sample size for this species and individual response analyses using quantitative and qualitative methods are being completed this year. Based on an initial and more general assessment of the results, blue whale data from SOCAL-14 appeared consistent with earlier experiments suggesting short-term responses in some but not all conditions with a lack of evident changes in behavior during control (no noise) sequences**.** While blue whale CEEs using real Navy ships remain a priority for subsequent field efforts, subsequent simulated MFAS CEEs likely will not.

9. OVERALL ASSESSMENT: ACCOMPLISHMENTS VS. OBJECTIVES

The following is an assessment of the specified objectives for SOCAL-14 relative to actual accomplishments. Some but not all objectives were achieved.

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

Objective partially achieved. Twenty-one tags were deployed on 18 individual animals of four different marine mammal species. This included tags for some primary focal species (fin whales, Risso's dolphins), including several with multiple animals in the same group, and a second tag on a minke whale. However, few beaked whales were seen or heard and no tags

were successfully deployed on beaked whales. Over 50h of baseline data (before MFA transmissions and during control sequences) were collected for fin and blue whales and a small amount on Risso's dolphins.

(2) ***Conduct* controlled exposure experiments (CEEs) with both realistic sources and scaled sources (when realistic ones not available).**

Objective partially achieved. Despite efforts to coordinate SOCAL-14 with real Navy MFAS operations, no CEEs with real sources were conducted in SOCAL-14. Four simulated MFA CEEs were conducted when real MFA sources were unavailable as well as six 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.

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

Objective fully achieved. Two relatively similar configurations of research vessels, field personnel, and coordination with Navy vessels were used during SOCAL-14. These were largely similar to SOCAL-13 configurations but included different approaches to towed PAM capabilities. A new approach to the Truth-based configuration was used in which one RHIB could base from San Clemente Island when offshore conditions and SCORE range access was favorable and could base with the Truth when they were not. This 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.

10. SOCAL-14 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 (presently nine peer-reviewed publications have resulted from this project with an additional ten either in press, in review, or in final preparation) 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. 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 ten public lectures and webinars, as well as eigt scientific presentations during professional meetings in 2014. There were also many 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-14

* Coordination of operational Navy sonar training with field tagging efforts can be accomplished, but operational and weather conditions can limit achievements.
* While results suggest that responses may differ for full scale and simulated MFAS sources, CEEs with simulated sonar retain some utility, particularly for poorly understood species. 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 with possible simulated MFAS CEEs when real Navy sources are unavailable remains important.
* 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. The lone shut-down implemented in SOCAL-14 was the result of a California sea lion 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.

SOCAL-BRS next steps

Based in part on limited success in SOCAL-14, and with an adaptation of effort to emphasize RHIB-only periods with smaller teams able to more rapidly adapt to changing Navy ship schedules, a further two field campaigns (SOCAL-15 and -16) are planned to occur. These will again prioritize real Navy MFAS sources as much as possible. Future SOCAL-BRS efforts will include an adaptive mix of field configurations and research teams with an emphasis on small teams (RHIBs-only) but in a more limited capacity including some of the moderate sized teams and research platforms typically used in earlier field seasons. We intend to adapt both towed PAM and prey mapping applications to the RHIB-only configurations.