CUVIER'S BEAKED WHALE AND FIN WHALE SURVEYS AT THE SOUTHERN CALIFORNIA OFFSHORE ANTI-SUBMARINE WARFARE RANGE (SOAR)

Annual Report
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Table of Contents

List of Tables

List of Figures

Abstract

The Southern California (SOCAL) portion of the Hawaii-Southern California Training and Testing (HSTT) area (SOCAL TR) is one of the United States Navy's most active training areas, particularly for mid-frequency active sonar (MFAS). Much of SOCAL lies within the Southern California Bight, a productive oceanographic region that hosts a wide variety of marine species. As part of an ongoing study of the distribution and demographics of several marine mammal species within SOCAL, we conducted 32 days of survey effort from 6 January 2022 to 26 November 2022, specifically focusing on the Southern California Anti-submarine Warfare Range (SOAR). The primary goal of these surveys was sighting, photographing, and collecting biopsy samples from Cuvier's beaked whales (*Ziphius cavirostris*) and fin whales (*Balaenoptera physalus*). With combined effort from an ancillary project funded by the United States (U.S.) Navy's Living Marine Resources program, we had 215 sightings of cetaceans, including 34 sightings totaling 110 Cuvier's beaked whales and 38 sightings totaling 60 fin whales. Preliminary reconciliation of identification photographs of Cuvier's beaked whales from directed effort and two opportunistic sightings in 2022 included 56 unique individuals, bringing our catalog to 298 individuals in the SOCAL area. Twenty-eight of these whales (50%) had previous sighting histories at SOAR, with five whales first Identified in 2007 seen in 2022. Sightings including two females identified with their first calves in the study, one with her second calf, and one with her third calf. Identification photos of fin whales from directed and opportunistic data collection in 2021 (n = 295, including a small number of IDs from previous years) were processed. This collection brings our US West Coast fin whale catalog to 1,281 individuals, of which 798 have sighting histories in Southern California. Nine genetic samples were collected in 2022, one each from a Cuvier's and Baird's beaked whale and seven from fin whales. Eight satellite tags were deployed including six Cuvier's beaked whales (one from an ancillary project), and one each on a fin whale and short-finned pilot whale.

Introduction

The Southern California (SOCAL) portion of the Hawaii-Southern California Training and Testing area is a collection of nearshore and offshore training areas that include much of the navigable water from Santa Barbara Island, California, to northern Baja California, Mexico, extending several hundred miles to the west. It is among one of the most heavily used tactical training areas in the world, and is used for a variety of aerial, surface, and subsurface exercises. The Southern California Offshore Range (SCORE) is a subset of complexes within SOCAL centered on San Clemente Island and managed via the Range Operation Center (ROC) on North Island, Coronado. It includes the Southern California Anti-submarine Warfare Range (SOAR), a focal area for exercises involving mid-frequency active sonar (MFAS) systems within the San Nicolas Basin.

Through its N45 Living Marine Resources (LMR) research programs, and more recently in support of Pacific Fleet Monitoring efforts, the US Navy has funded directed studies of cetacean occurrence on SOAR since 2006. Initially, the primary objective of these surveys was visual verification of acoustic marine mammal detections on the SOAR hydrophone array in conjunction with the Marine Mammal Monitoring on Navy Ranges (M3R) program. These early studies documented generally high cetacean diversity on SOAR year-round, with some seasonal fluctuations (Falcone and Schorr, 2014). As a result, Photo-ID studies of both Cuvier's beaked whales (*Ziphius cavirostris*) and fin whales (*Balaenoptera physalus*) were initiated to better understand the structure of these poorly known populations that were present year-round.

The Office of Naval Research (ONR)-supported a power analysis of Cuvier's beaked whale data which determined that long-term photo-ID provided the best power to detect an actual decline in the Cuvier's beaked whale population at SOAR if one were occurring (Moore et al., 2017). This work was expanded upon by Curtis et al. (2020) which used simulations to demonstrate that the probability of detecting abundance changes with the existing photo-ID data is currently low, but will greatly improve through continued effort. Booth et al. (2017) suggested that photo-ID and biopsy are critical tools for accurately monitoring population health, since these provide the collateral data needed to detect changes in reproductive rates before they result in actual declines.

As the surveys progressed, research expanded to incorporate the deployment of dive-reporting satellite tags to study the movements and diving behavior of both these species, and to assess any changes associated with MFAS use. Both satellite tag and photo-ID data from these studies have indicated individual site fidelity to the Southern California Bight (SCB) for several species, including Cuvier's beaked whales on SOAR (Curtis et al., 2021; Falcone et al., 2009; Schorr et al., 2014) and fin whales in the greater SCB (Falcone et al., 2022; Scales et al., 2017). Both findings were somewhat unexpected. Virtually no information was available on stock structure of Cuvier's beaked whales, and individual Cuvier's beaked whale were not expected to preferentially use SOAR, as this is the species most frequently recorded in mass strandings associated with MFAS elsewhere (Bernaldo de Quirós et al., 2019; Cox et al., 2006; D'Amico et al., 2009). Fin whales were believed to range broadly along the US West Coast with no population substructure.

Despite a preference for the region by at least some individuals in the population, sensitivity to MFAS has been documented (DeRuiter et al., 2013; Falcone et al., 2017). Therefore, understanding the ecology, behavior, and population dynamics of these two populations in a region of such frequent Navy training remains critical to effective management, including realistic estimation of takes. Furthermore, there are specific inputs to Population Consequences of Disturbance models currently being developed for beaked whales at SOAR and other Navy ranges, which can only be derived from the individual life history data this research program supports.

Presently, the overall scientific questions addressed by the Navy's Integrated Comprehensive Monitoring Program (henceforth "Pacific Fleet Monitoring") at SOAR, in cooperation with M3R, are the following:

What is the seasonal occurrence, abundance, and density of beaked whales and Endangered Species Act (ESA) listed baleen whales within the Navy's SOCAL, and how are these metrics changing?

Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species, or stocks of blue whale (Balaenoptera musculus), fin whale, humpback whale (Megaptera novaeangliae), Cuvier's beaked whale, and other regional beaked whale species?

What are the baseline population demographics, vital rates, and movement patterns for Cuvier's beaked whales and fin whales?

In addition to detailed data collected for beaked whales and fin whales, the species, group size, and basic behavior is recorded for all cetaceans encountered. For some species, particularly those that are data deficient, we may also collect images, biopsy samples, and deploy Low Impact Minimally Percutaneous External-electronics Transmitting (LIMPET) tags (Schorr et al., 2019).

In this report, we present four components of Pacific Fleet Monitoring work:

1) *Effort and sightings from both Pacific Fleet Monitoring surveys and LMR-funded surveys in 2022.* Survey effort from these projects is summarized independently but resulting sighting and photo-ID data are presented combined to provide the most comprehensive datasets from Navy-funded work in the region.

2) Interim results on photo-ID for Cuvier's beaked and fin whales, plus initial results of satellite tags deployed during the year.

3) An assessment of the performance of SPLASH10-F Fastloc GPS LIMPET tags on Cuvier's beaked whales, including the effect of increased fast repetition rate (the minimum duration between subsequent satellite transmission) on data throughput and battery life for LIMPET tags deployed on Cuvier's beaked whales. Collecting and transmitting dive data via satellite tag on Cuvier's beaked whales also presents numerous challenges (Quick et al., 2019; Schorr

et al., 2014), due to the limited time these whales typically spend at the surface. Cuvier's pose a particular challenge for data transmission, as their inter-breath interval is about 5 seconds, with the average surfacing lasting just 1.9 minutes (Schorr et al., 2017, 2014). Therefore, the tag is only able to transmit approximately 5 times at a 15s repetition (rep) rate during a single surface series (and thus a single satellite overpass). By adding Fastloc GPS collection, transmissions are reduced even further, as the tag cannot transmit during the approximately twenty seconds it takes for the tag to assess a GPS snapshot (Schorr et al., 2017). Therefore, maximizing transmissions is just as important as maximizing reception. This requires hard decisions be made regarding tag programming, generally balancing the resolution of dive data against the completeness of the dive record, decisions which in turn impact the scope of analyses the resulting data can support (Quick et al., 2019). Within the SOCAL training range, we have installed land-based Argos receiving stations to increase message reception opportunities; however, even these do not guarantee complete dive data reception (Jeanniard-du-Dot et al., 2017). In the earlier version of the LIMPET tags, two M3 batteries were used. This battery configuration, while providing excellent energy density for their size, were degraded in lifespan (number of total transmissions) during rapid cycle applications. A 15 second rep rate was deemed to be the fastest feasible, while still allowing for the battery to last for approximately 28 days of total transmissions with our current programming regime. The new tag configuration uses two 1/2 AA batteries and a Hybrid Layer Capacitor (HLC). The HLC is designed to specifically help in situations of rapid cycle applications, and after consultation with the manufactures and Argos, we were given permission to reduce our fast rep rate to as low as 7s. Here, we assess the ability of the current version of the SPLASH10-F tag in the LIMPET tag to transmit at a 10 second fast repetition (rep) rate, versus 15 seconds using on-whale data.

4) Finally, we provide copies of five 2022 publications based on data collected under this long-term monitoring work. The first of these is a multi-regional comparison of scarring density and pigmentation patterns of known-sex, adult Cuvier's beaked whales, the results of which can be used to sex most adult whales in a typical photo-ID catalog for this species, an essential basis to estimating vital rates in this data deficient species (Attachment 1). The second is an assessment of long-term (i.e., multi-season, multi-year) movements by individual fin whales using photo-ID data from the late 1980's through 2019, and the implications these movements have for existing stock definitions (Attachment 2). The third focuses on the movement of Cuvier's beaked whales with respect to Navy sonar using discrete-space continuous-time models (Attachment 3). The fourth is the analysis of movements and diving behavior of satellite tagged Risso's dolphins (Attachment 4). The fifth is an analysis of movements and diving behavior of satellite tagged offshore killer whales (Attachment 5).

Methods

Field Data Collection

Surveys were conducted using a 6.5 to 7.5-meter (m) rigid-hulled inflatable boat (RHIB), powered by two outboard motors and equipped with a raised bow pulpit. The RHIB was launched from a shore base each morning and surveyed throughout daylight hours as conditions permitted. Surveys focused on SOAR were based at Wilson Cove on the northeast side of San Clemente Island. The RHIB was initially launched at Dana Point or Oceanside at the start of the survey period and remained moored in Wilson Cove for a period of 7 to 14 days, or until poor weather or conflicting range operations prevented further surveys at SOAR. When SOAR was available for our use, staff from the Naval Undersea Warfare Center's (NUWC) M3R program would monitor hydrophones from the ROC on North Island in San Diego and direct the RHIB via radio or satellite phone into areas where marine mammal vocalizations were detected. While the RHIB could be directed towards any vocalizations for visual verification, they were preferentially directed to those likely to be beaked whales when conditions were suitable for working with these species (typically winds at Beaufort 3 or less). In general, detections classified as other small odontocetes were bypassed in favor of those from beaked whales or baleen whales.

Effort and sighting data were collected using a custom-built Microsoft Access (Microsoft, Redmond, WA) database on a ruggedized tablet with an integrated Global Positioning System (GPS). Each time a group of cetaceans was encountered, the species, time, latitude, longitude, group size and composition, and overall behavioral state were recorded.

For encounters with beaked whales, detailed records of surfacing patterns were also collected for as long as contact with the group was maintained. Photographs were taken for species verification when questionable, and for individual identification where this methodology is being employed by ourselves or collaborators; these include beaked, fin, blue, humpback, minke (*Balaenoptera acutorostrata*), and killer whales (*Orcinus orca*); common bottlenose (*Tursiops truncatus*) and Risso's (*Grampus griseus*) dolphins. Remote tissue biopsies were collected from species of interest to this study (beaked and fin whales) and from other species as requested by collaborators at the Southwest Fisheries Science Center (SWFSC) for use in ongoing assessments of population structure and stress hormone analyses. Samples were collected using either a crossbow or a pneumatic projector to fire arrows equipped with sampling tips at distances of 5-30 m. Tip lengths were 25 millimeters for small cetaceans and 40 millimeters for large cetaceans. All biopsy darts were retrieved from the water and if a sample was successfully retained, it was processed and stored on ice for transportation to SWFSC. Additionally, a limited number of LIMPET satellite tags were deployed on species which regularly inhabit the training range, and which may be impacted by training activities to provide additional information on distribution, behavior, and overlap with Navy activities.

Photo-Identification

All photos collected during surveys were reviewed, and image metadata were updated with sighting and individual information using ACDSee Pro image management software. Best-of-sighting identification photographs of fin whales and beaked whales from each annual sampling period were combined with opportunistic contributions from citizen science and collaborating researchers, internally reconciled, and then compared to our existing photo-ID catalogs, using methods described in (Curtis et al., 2021) and (Falcone et al., 2022) to build photographic sighting histories. Identification photos of other species were provided to curators of those catalogs at the end of each annual data collection period.

Analyses of Previously Collected Tag Data

Assessment of the SPLASH10-F LIMPET tag on Cuvier's beaked whales

Since 2017, we've deployed a total of eight SPLASH10-F LIMPET tags (Fastloc GPS capable dive-reporting tags) on Cuvier's on SOAR (Table *1*). Three were deployed in 2016 and 2017 as part of a project to develop the tag (Schorr et al., 2017) and five during 2022. An additional six have been deployed at an alternate study site, at Guadalupe Island.

To assess how our current programming is working with this new tag type, we selected two SPLASH10-F LIMPET tags deployed on the SOAR training range for a comparison of the effects of increased fast repetition (rep) rate. The first tag was one of three Fastloc GPS tags deployed on a Cuvier's beaked whale in 2017 with a fast rep rate of 15 sec; we selected the tag with the longer transmission duration and attachment on the dorsal fin. All five tags deployed in 2022 were programmed with a fast rep rate of 10 sec; we selected the tag with the most similar placement to the 2017 tag on the fin and that remained within the San Nicolas Basin. We removed all data collected by the Motes (shore-based Argos receiving stations) for this analysis to compare transmission throughput to satellites only.

Data was processed using Wildlife Computers Data Analysis Program, version 3.0.610. Several key differences between the tags existed that complicated this comparison, most notably: 1) satellite overpass availability varied among years, 2) the tags had slightly different programming parameters, as they were deployed under different projects with different objectives (Table *1*). To account for the difference in deployment durations (10.9 versus 45.8 days) when comparing among metrics based on total data throughput for the deployment, we applied a correction factor of 4.45 to the second tag (Tag 1 Tx duration/Tag 2 Tx duration).

We then added a second tag from 2022 with a 10 sec rep rate to assess the impacts of the faster rate on the number of daily transmissions and the final battery life of the tag. Finally, we reviewed data completeness for tags under the new tag programming regime with the faster rep rate, how future programming might be improved, and what additional tests would be beneficial.

Table 1. FastLoc LIMPET tag deployment and programming parameters. Tx=Transmission, Attach. = Attachment.

TagID	Deploy Date	Tx Duration (Days)	# of Tx hrs	Rep Rate (s)	# GPS attempts /hr	Tag Location	Prob. Reason for end Tx
ZcTag052	11/11/2016	2.4	21	15	3	Dorsal fin	Attach. failure
ZcTag053	1/8/2018	11.7	21	15	3	Below fin	Attach. failure
ZcTag059	7/25/2017	10.29	21	15	3	Dorsal fin	Attach. failure
Zica-164618	1/14/2022	63.6	14	10	1	Dorsal fin	Attach. failure
Zica-202440	1/16/2022	45.8	14	10	1	Dorsal fin	Low voltage
Zica-202436	1/18/2022	12.2	14	10	1	Below fin	Attach. failure
Zica-202439	11/21/2022	14.2	14	10	1	Below fin	Attach. failure
Zica-220816	11/21/2022	15.8	14	10	1	Below fin	Attach. failure

Results and Discussion

Survey Effort and Sightings

A total of 32 days of on-water surveys, some days with two boats, were conducted for this project from January to November 2022, with most survey effort occurring within SOAR (Figure 1,Table *2*). A total of seven survey days were lost due to inclement weather. Four additional survey days in January were conducted for an ancillary project (Figure 2, Table *3*). The percentage of time by project within Navy range boundaries are presented in Table *4*. During all survey effort in the region in 2022, 215 sightings of 15 cetacean species were recorded (Figure 3). Species sighted were: Cuvier's beaked whales, fin whales, humpback whales, minke whales, Baird's beaked whales (*Beraridius bairdii*), blue whales, gray whales (*Escrichtius robustus*), Risso's dolphins, bottlenose dolphins, Dall's porpoise (*Phocoenoides dalli*), common dolphins (*Delphinus* sp.), killer whales, Northern right whale dolphins (*Lissodelphis borealis*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), and short-finned pilot whales (*Globicephala macrorhynchus*).

Cuvier's beaked whales were sighted in the deep waters of the San Nicolas Basin to the west of San Clemente Island except for one sighting of a group of 5 individuals that were sighted in the

Catalina Basin. Cuvier's were encountered during all surveys in 2022 (Figure 4, Figure 5, Figure 6,Table *5*). All fin whale sightings occurred within the San Nicolas Basin with the exception of one encounter during a coastal survey out of Long Beach, and fin whale were also sighted during all surveys in 2022 (Figure 4, Figure 5, Figure 6, Table 6).

Two infrequently sighted species, killer whales and short-finned pilot whales were documented in north SOAR this year. A group of three killer whales, photographically determined to be the Eastern Tropical Pacific ecotype, was encountered in June and a group of 10 pilot whales was documented in November (Appendix 1). All individuals were photographed in both encounters, and a LIMPET tag was deployed on an adult male pilot whale (Figure *14*).

Short-finned pilot whales were last documented during this study on SOAR in October 2007. The encounter in 2022 adds to the incredibly sparse sighting data for this species in the Southern California Bight since the early 1980's when the once relatively common species virtually disappeared from the region (Kendall-Bar et al., 2016). Sightings remain sparse, and generally limited to warmer water years, along the entire US West Coast to date (Carretta et al., 2017).

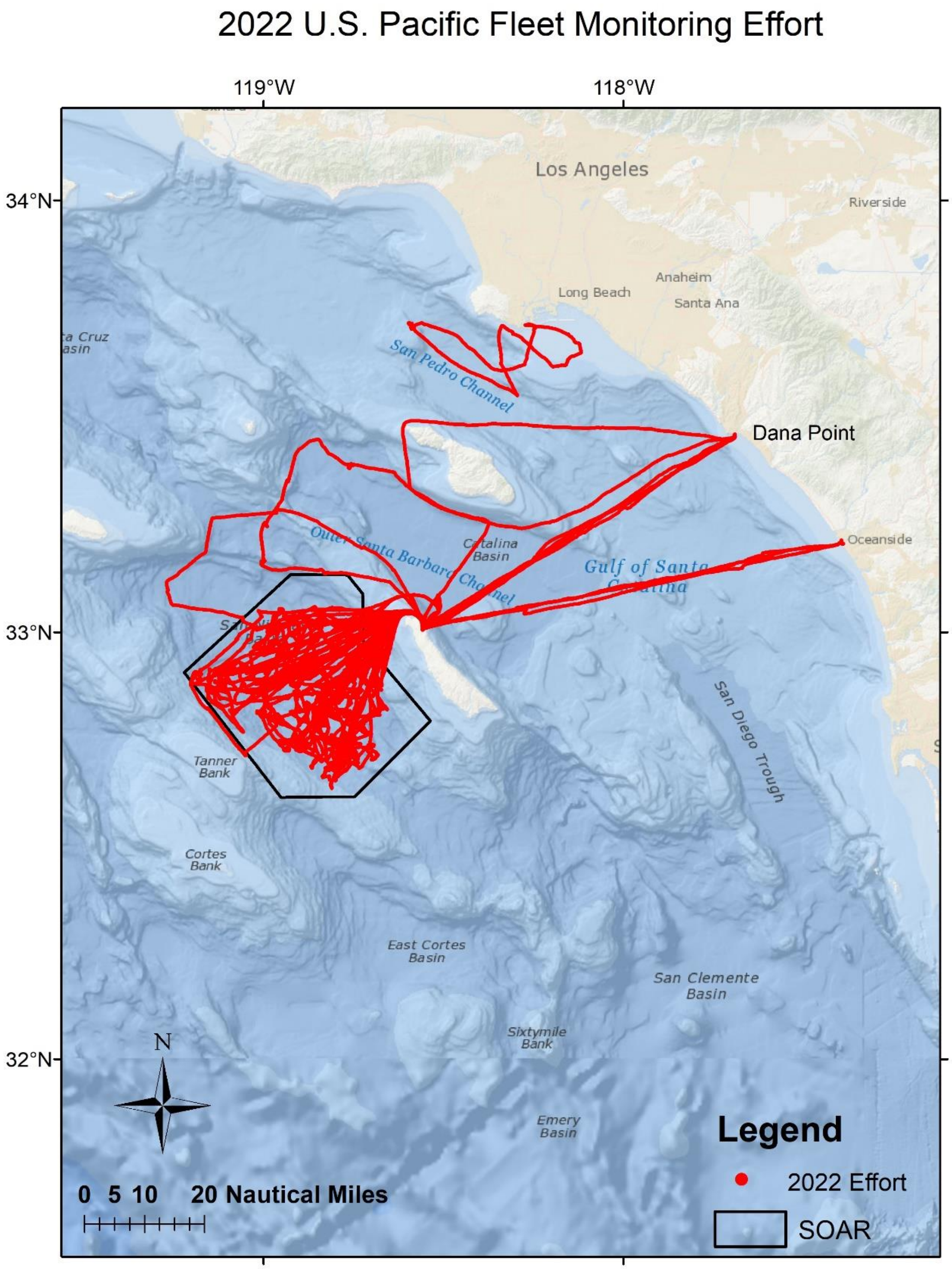

Figure 1. Vessel track lines from U.S. Pacific Fleet Monitoring surveys conducted from 6 January 2022 through 26 November 2022. SOAR = Southern California Ant-submarine Warfare Range. Prepared by B. Rone.

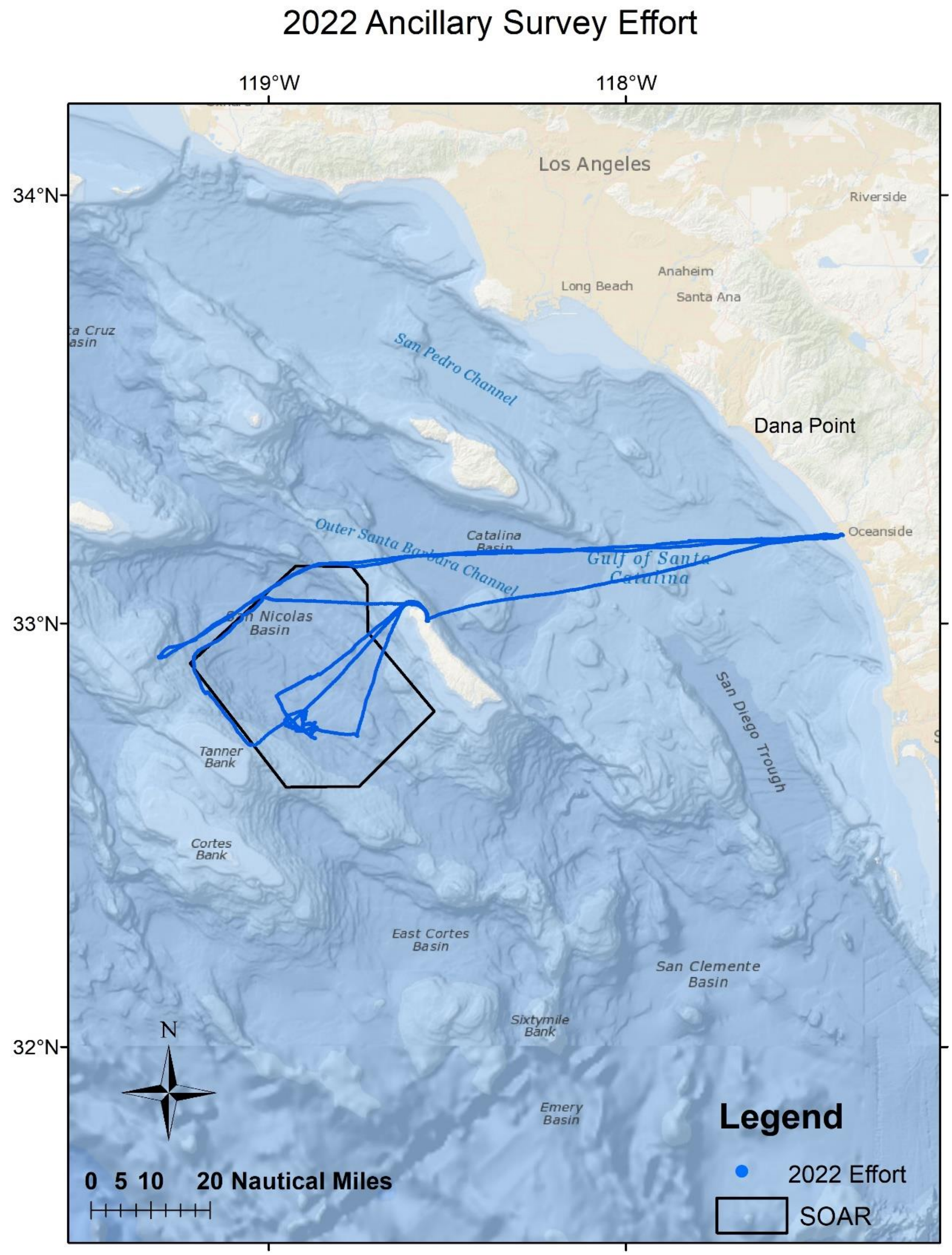

Figure 2. Vessel track lines from ancillary surveys conducted in January 2022. Prepared by B. Rone.

Table 2**.** Summary of U.S. Pacific Fleet Monitoring survey effort by day, January-November 2022, with the number of cetacean sightings, biopsies collected, and tags deployed.

Date	Vessels	Survey Effort (Hrs)[1]	Survey Dist. (nm)[2]	Total Sightings	Biopsies	Tags
1/6/2022	1	2.7	54.1	3	0	0
1/8/2022	1	9.4	79	4	2	0
1/9/2022	1	10.1	88.7	8	1	0
1/10/2022	2	18.5	190	9	0	0
1/12/2022	1	10.2	97	4	0	0
1/13/2022	2	20.7	165.7	8	0	0
1/14/2022	2	19.8	165.9	7	0	2
1/16/2022	2	21.6	156.5	6	0	1
1/17/2022	2	22.6	183.4	7	0	1
1/18/2022	2	4.8	112.2	10	0	0
2/27/2022	1	4.0	53.4	11	0	0
2/28/2022	1	11.2	95.9	15	0	0
3/1/2022	1	11.3	99.3	9	0	0
3/2/2022	1	11.4	93.9	5	0	0
3/3/2022	1	2.6	51.8	4	0	0
3/6/2022	1	7.3	83.7	3	0	0
3/7/2022	1	8.4	106	4	0	0
6/10/2022	1	7.4	124	7	0	0
6/11/2022	1	9.4	89.9	4	3	0
6/12/2022	1	8.7	79.7	5	0	0
6/14/2022	1	10.1	100	9	1	0
6/15/2022	1	8.9	82.6	6	1	0
6/16/2022	1	8.8	119	9	0	0
6/17/2022	1	2.6	52	1	0	0
11/19/2022	1	3.0	63.2	1	0	0
11/20/2022	1	8.7	69	8	0	1
11/21/2022	1	9.3	71	3	0	2
11/22/2022	1	8.3	57.3	9	0	0
11/23/2022	1	11.0	80.5	6	0	0
11/24/2022	1	10.8	76	4	0	0
11/25/2022	1	10.8	66	3	0	0
11/26/2022	1	2.7	60.4	2	0	0
Totals: 32	**38**	**316.7**	**3067.1**	**194**	**8**	**7**

[1]Hrs = hours

[2]nm = nautical miles

Table 3**.** Summary of ancillary survey effort by day from January 2022, with the number of cetacean sightings, biopsies collected, and tags deployed.

Date	Vessels	Survey Effort (Hrs)[1]	Survey Dist (nm)[2]	Total Sightings	Biopsies	Tags
1/8/2022	1	2.8	60.0	1	0	0
1/9/2022	1	10.4	78.8	7	1	0
1/12/2022	1	9.8	106.0	11	0	1
1/20/2022	1	10.3	228.0	4	0	0
Totals: 4	**4**	**33.3**	**472.8**	**23**	1	**1**

[1]Hrs = hours
[2]nm = nautical miles

Table 4**.** Percentage of effort spent within U.S. Navy range boundaries by project.

	Point Mugu Sea Range	**SOCAL[1] Range Complex**	**SOAR[2]**
Pacific Fleet Monitoring	3%	97%	73%
Ancillary	16%	93%	47%

[1]SOCAL = Southern California Range Complex
[2]SOAR = Southern California Anti-submarine Warfare Range

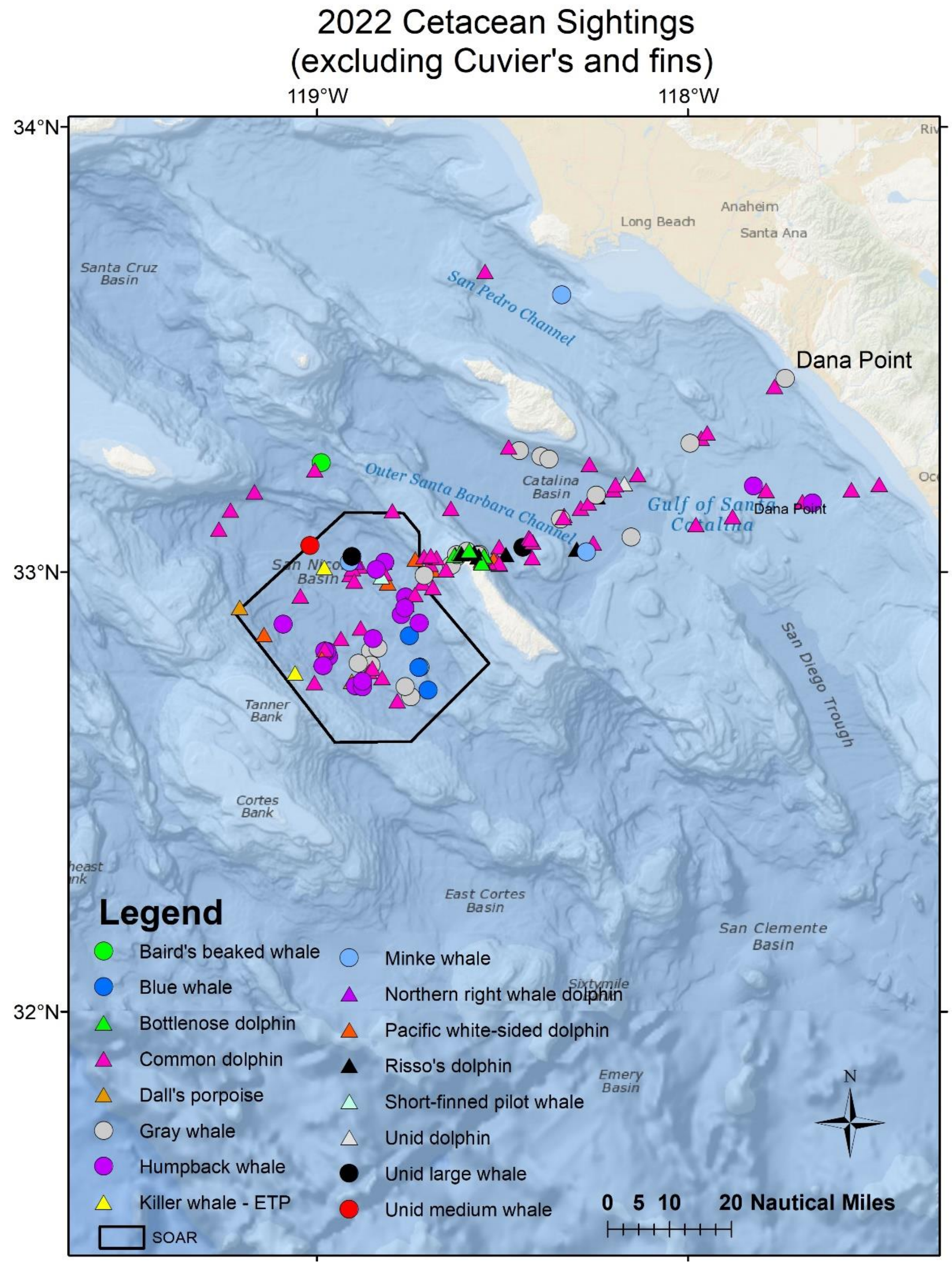

Figure 3. Sighting locations of cetaceans other than Cuvier's beaked whales and fin whales by species from surveys conducted in 2022. SOAR = Southern California Anti-submarine Warfare Range. Prepared by B. Rone.

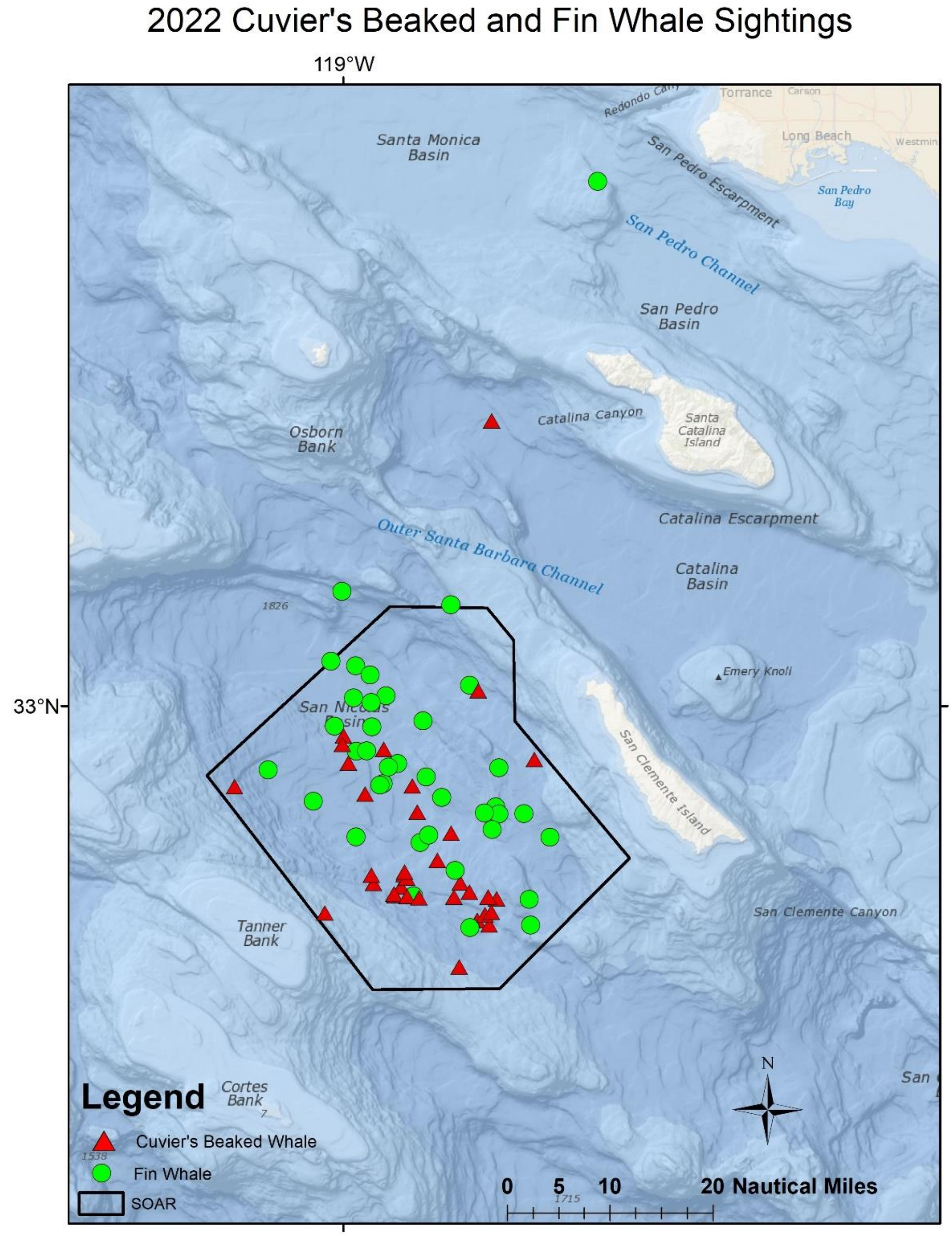

Figure 4. Cuvier's beaked whale and fin whale sightings from surveys conducted in 2022. The Southern California Anti-submarine Warfare Range (SOAR) is outlined in black. Prepared by B. Rone.

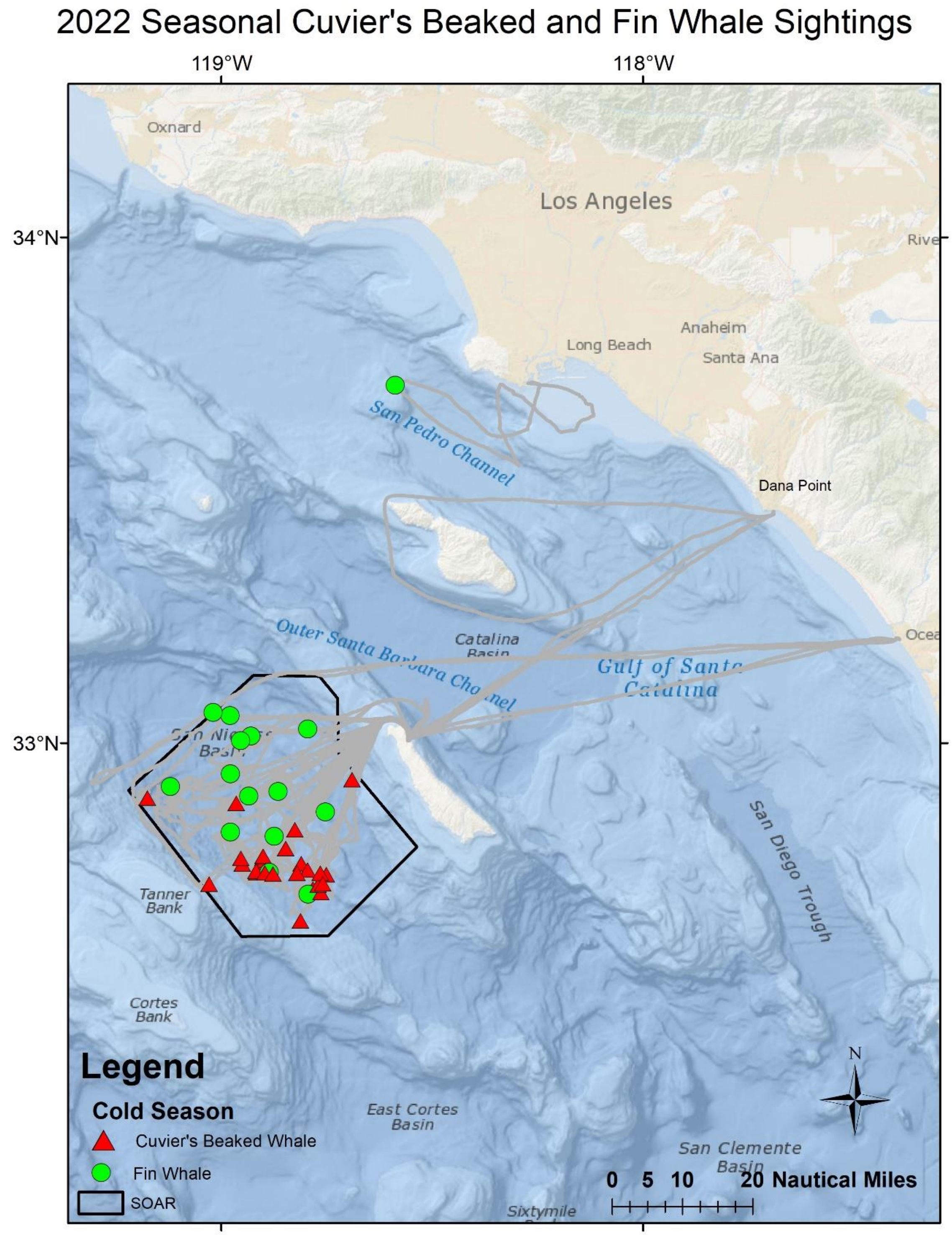

Figure 5. Cold season (January – May) locations of Cuvier's beaked and fin whales in 2022. Vessel track lines shown in gray. Prepared by B. Rone.

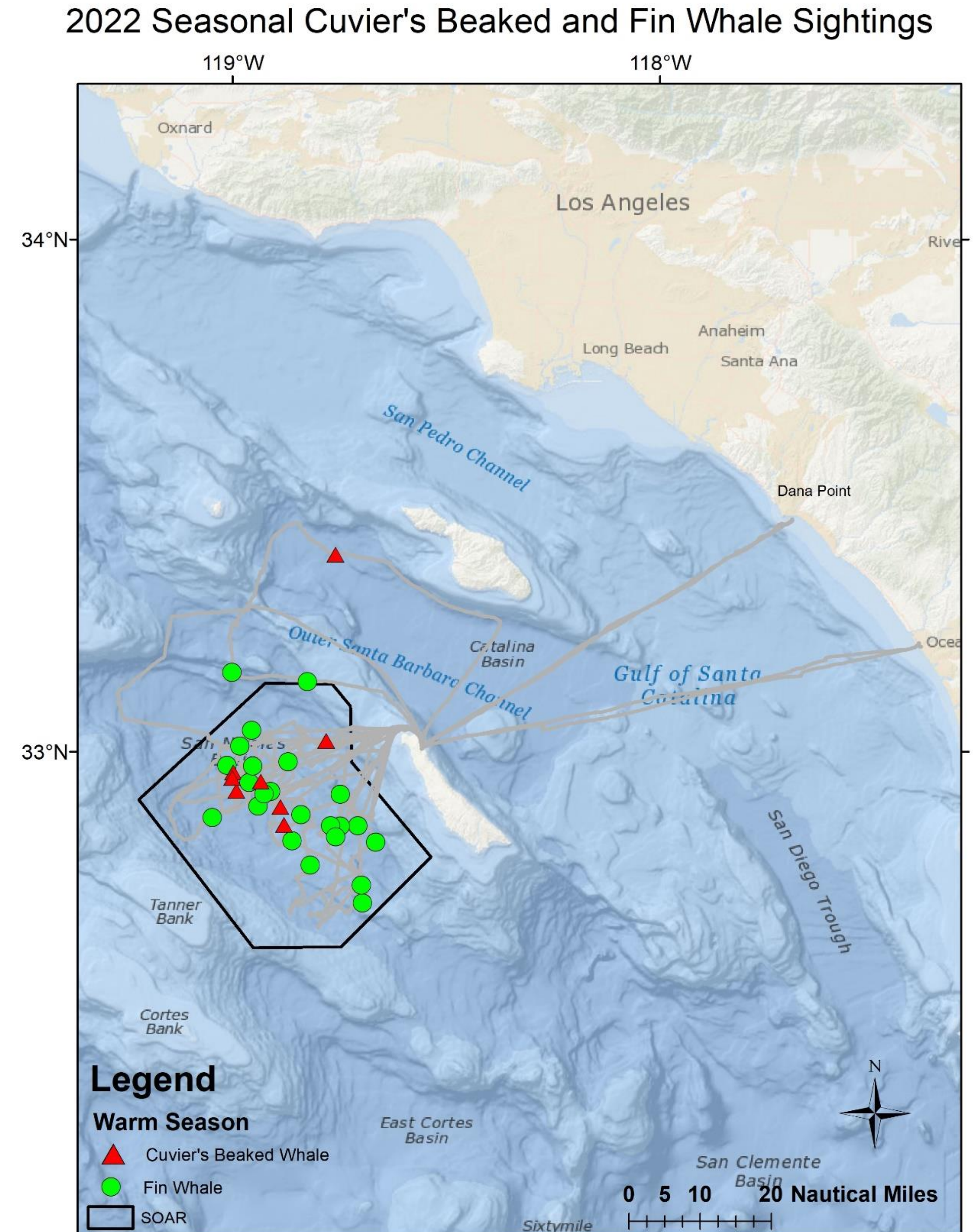

Figure 6. Warm season (June – November) locations of Cuvier's beaked and fin whale sightings from surveys conducted in 2022. Vessel track lines shown in gray. SOAR = Southern California Anti-submarine Warfare Range. Prepared by B. Rone

Table 5**.** Data collection summary for Cuvier's beaked whale sightings in 2022.

Date	Sighting	Estimated Group Size	Number of Calves	Unique IDs	Biopsies Collected	Tags Deployed
1/9/2022	PHO-8	3	0	0	0	0
1/9/2022*	PHY-7	5	0	5	1	0
1/12/2022*	PHO-2	1	0	0	0	0
1/12/2022*	PHO-6	3	0	3	0	1
1/12/2022*	PHO-7	3	0	2	0	0
1/12/2022	PHY-1	4	0	4	0	0
1/12/2022	PHY-2	1	0	0	0	0
1/13/2022	PHO-1	5	0	4	0	0
1/13/2022	PHO-2	5	2	5	0	0
1/13/2022	PHO-4	4	0	4	0	0
1/13/2022	PHY-1	5	0	4	0	0
1/14/2022	PHO-2	1	0	0	0	0
1/14/2022	PHO-4	3	0	3	0	1
1/16/2022	PHO-2	5	0	5	0	0
1/16/2022	PHO-3	1	0	1	0	1
1/16/2022	PHY-2	3	0	2	0	0
1/16/2022	PHY-3	2	0	2	0	0
1/17/2022	PHO-2	3	0	3	0	0
1/17/2022	PHO-4	5	0	5	0	1
1/17/2022	PHY-1	2	1	2	0	0
2/28/2022	PHY-10	4	0	5	0	0
2/28/2022	PHY-9	2	0	0	0	0
3/2/2022	PHY-3	5	0	3	0	0
6/12/2022	PHO-2	2	1	1	0	0
6/14/2022	PHO-5	5	0	6	0	0
11/20/2022	PHO-4	1	0	1	0	0
11/20/2022	PHO-8	3	0	3	0	0
11/21/2022	PHO-3	7	0	7	0	2
11/23/2022	PHO-6	4	0	0	0	0
11/25/2022	PHO-2	1	0	0	0	0
11/25/2022	PHO-3	2	0	2	0	0
Total Sightings: 31		100	4	82	1	6

* surveys conducted under funding from Living Marine Resources (LMR).

Table 6**.** Data collection summary for fin whale sightings in 2022.

Date	Sighting	Estimated Group Size	Number of Calves	Estimated IDs	Biopsies Collected	Tags Deployed
1/8/2022	PHO-3	3	0	3	2	0
1/9/2022	PHO-3	3	0	3	0	0
1/9/2022	PHO-6	1	0	0	0	0
1/9/2022	PHO-7	3	0	2	1	0
1/10/2022	PHO-5	1	0	1	0	0
1/10/2022	PHO-6	1	0	0	0	0
1/12/2022*	PHO-10	1	0	0	0	0
1/12/2022*	PHO-11	1	0	1	0	0
1/14/2022	PHO-1	1	0	1	0	1
1/14/2022	PHY-1	2	0	2	0	0
1/14/2022	PHY-3	2	0	1	0	0
2/28/2022	PHY-12	2	0	2	0	0
3/1/2022	PHY-6	2	0	0	0	0
3/1/2022	PHY-9	1	0	0	0	0
3/6/2022	PHY-1	1	0	1	0	0
6/10/2022	PHO-4	1	0	1	0	0
6/11/2022	PHO-1	4	1	4	2	0
6/11/2022	PHO-3	3	1	3	0	0
6/11/2022	PHO-4	1	0	1	1	0
6/12/2022	PHO-3	1	0	0	0	0
6/12/2022	PHO-5	1	0	1	0	0
6/14/2022	PHO-8	2	0	2	0	0
6/14/2022	PHO-9	1	0	1	0	0
6/15/2022	PHO-1	1	0	1	1	0
6/15/2022	PHO-3	2	1	2	0	0
6/15/2022	PHO-5	1	0	1	0	0
6/16/2022	PHO-4	1	0	1	0	0
6/16/2022	PHO-5	1	0	0	0	0
11/20/2022	PHO-7	1	0	1	0	0
11/21/2022	PHO-1	1	0	1	0	0
11/21/2022	PHO-2	4	0	2	0	0
11/22/2022	PHO-5	1	0	0	0	0
11/22/2022	PHO-7	1	0	0	0	0
11/22/2022	PHO-8	2	0	2	0	0
11/23/2022	PHO-4	1	0	1	0	0
11/23/2022	PHO-5	2	0	2	0	0
11/24/2022	PHO-1	1	0	0	0	0
11/24/2022	PHO-2	1	0	0	0	0
Total Sightings: 38		60	3	44	7	1

*indicates surveys conducted under funding from Living Marine Resources (LMR).

Photo-Identification and Biopsy Sampling

Cuvier's Beaked Whales

Photo-IDs, biopsy samples, and tags from Cuvier's beaked whales in 2022 are summarized in Table 6**.** Data collection summary for fin whale sightings in 2022.. One tissue sample was collected from the darts of a detached archival tag. All identification photos of Cuvier's beaked whales in 2022 were internally reconciled and compared to our historical catalog. This included 106 identifications during surveys at SOAR and eight opportunistic identifications made by a whale watch boat operating in Monterey Bay, off the central California coast. These identifications represented 56 unique individuals, 28 of which (50%) had been sighted in Southern California in a previous year, with sighting histories ranging from 0.2 to 14.3 years in duration (Table *7*). Our catalog now totals 313 individuals, including 15 individuals photographed opportunistically in the Monterey Bay area. Only one of those individuals from central California has been resighted, and both sightings occurred in the same region.

There were four mother-pairs identified on SOAR in 2022, including one pair (IDs 302 and 303) which was first sighted together on SOAR in November 2021. One mother (ID 103) was sighted with her third calf of the study and another (ID 187) with her second. Both females were last sighted with their previous calves in 2018. The fourth mother was a female first identified in 2019, now with her first calf of the study. These bring the total number of mother-calf pairs observed at SOAR to 36 since the study began, a third of which were sighted together on more than one day. The longest known association of a mother and calf was ID 103 with her calf first observed in 2014 (ID 149); the pair were sighted together repeatedly over 4.9 years.

Sightings of mother-calf pairs remain among the most valuable data from this study, as they are crucial to estimating vital rates such as calving interval and time to weaning for this population. However, given the generally low sighting rates of beaked whales, these data are inevitably sparse. Several approaches to estimating population level impacts to beaked whales from naval activities require sex-linked sighting history data from as many individuals in the population as possible and being sighted with a calf has historically been one of only two ways to confirm the sex of an adult female in the population. The other is genetic sampling, opportunities for which are also limited. This year we published the results of a regional comparison of pigmentation and scarring density data from Cuvier's beaked whales at three different study sites to validate a method for more accurately estimating the age class and sex of most whales in a photo-ID study using photos alone. The manuscript is provided as Attachment 1.

Table 7**.** Summarized sighting histories for 28 individual Cuvier's beaked whales that were resighted in Southern California in 2022. An asterisk denotes females that were sighted with a calf this year.

ID	First Date	Last Date	Encounters	Year Span
5	23-Oct-07	17-Jan-22	7	14.25
7	23-Oct-07	16-Jan-22	11	14.24
26	25-Oct-07	20-Nov-22	6	15.08
30	26-Oct-07	28-Feb-22	5	14.35
49	17-Oct-08	21-Nov-22	5	14.10
81	28-Jun-10	21-Nov-22	7	12.41
92	28-Jun-10	17-Jan-22	6	11.56
103*	02-May-11	12-Jun-22	13	11.12
123	14-Jan-12	14-Jan-22	3	10.01
126	05-Jan-13	02-Mar-22	5	9.16
132	30-Mar-13	12-Jan-22	12	8.79
138	31-Jul-13	28-Feb-22	3	8.59
153	07-Jan-14	14-Jun-22	2	8.44
169	03-Jan-15	21-Nov-22	5	7.89
184	08-Jan-15	28-Feb-22	2	7.15
187*	09-Jan-15	16-Jan-22	14	7.02
199	11-Jan-16	13-Jan-22	3	6.01
206	06-Apr-16	20-Nov-22	7	6.63
231	05-Jan-18	13-Jan-22	4	4.02
238	30-Mar-18	17-Jan-22	3	3.81
239	31-Mar-18	02-Mar-22	4	3.92
250	19-Nov-18	28-Feb-22	3	3.28
257	04-Jan-19	14-Jun-22	4	3.44
276	12-Oct-19	16-Jan-22	4	2.27
279*	11-Nov-19	17-Jan-22	3	2.19
302	14-Nov-21	13-Jan-22	2	0.16
303	14-Nov-21	13-Jan-22	2	0.16
307	18-Nov-21	21-Nov-22	2	1.01

Fin Whales

Fin whales were sighted on and near SOAR during all survey efforts in 2022, with the highest encounter rates in January, June, and November. Our photo-ID studies of this wide-ranging species are heavily augmented by contributions from citizen scientists and collaborating researchers. These contributions can be large, and we often receive them well into the year after the photos were collected; therefore, this report contains results of fin whale photographs from 2021 and prior years that were processed into our collection in 2022. Processing of identifications from 2022, including 44 from Navy-funded surveys, is underway now.

This year we processed a total of 295 new fin whale identifications primarily from 2021, but with a small number of late contributions from previous years (2009, 2018-2020). This annual batch brought the total number of processed fin whale identifications in our collection to 4,576, which includes 3,254 sightings of 1,281 unique individuals.

Southern California remains the focal region for our fin whale photo-ID study, with a catalog now totaling 798 individuals that have been identified there since the late 1980s, though the majority have been sighted over the last 15 years. This includes individuals who have been identified on dozens of days (max = 109 days), and in up to eleven different years. A manuscript detailing the long-term movements and residency patterns of whales in this study through 2018 was published in *Mammalian Biology* in 2022; a copy is provided as Attachment 2. This analysis provides evidence that Southern California hosts a small year-round resident population of fin whales, in addition to providing seasonal habitat and a migratory corridor for whales from a larger population that predominantly uses the offshore waters extending from Point Conception to the US-Canada border.

Seven biopsy samples were collected from fin whales in 2022, bringing the total number of fin whale samples collected by MarEcoTel since 2016 to 41. Fin whale samples have been collected by us and collaborators for many years, and 93 individuals in the catalog have now been genetically sexed (40 female and 53 male). All fin whale samples from this project are archived for use at SWFSC and have been used in a variety of population level genetic assessments in recent years (e.g., Archer et al., 2020, 2019, 2013).

Satellite Tagging

While photo-ID and biopsy are the primary focus of this work, satellite tags were deployed on whales in and around SOAR to help elucidate individual movement patterns and habitat use, document time spent on the range, and assess behavior and possible behavioral changes associated with training exercises.

Table 8. Satellite tags deployed during Navy-funded efforts in 2022.

Tag ID	Species	Tag Type	Date	Trans. Dur. (days)
Zica-20220112-195994*	Cuvier's Beaked Whale	SMRT	1/12/2022	6.74
Bp-20220114-194278	Fin Whale	SPLASH10A	1/14/2022	11.0
Zica-20220114-164618	Cuvier's Beaked Whale	SPLASH10F	1/14/2022	63.6
Zica-20220116-202440	Cuvier's Beaked Whale	SPLASH10F	1/16/2022	45.8
Zica-20220117-202436	Cuvier's Beaked Whale	SPLASH10F	1/17/2022	12.8
Gm-20221120-220817	Short-finned Pilot Whale	SPLASH10F	11/20/2022	23.9
Zica-20221121-202439	Cuvier's Beaked Whale	SPLASH10F	11/21/2022	11.2
Zica-20221121-220816	Cuvier's Beaked Whale	SPLASH10F	11/21/2022	11.9

*Deployed during a Living Marine Resources-supported effort.

Tags deployed during Fleet Monitoring efforts will continue to be combined with those deployed during other efforts and analyzed collectively to address specific questions (e.g., Schorr et al. 2014, Falcone et al. 2017, Scales et al. 2017). Therefore, we provide a general summary of findings from 2022 deployments here.

Median LIMPET tag duration for Cuvier's beaked whales was 12.8 days (range = 11.2–63.6 days) (Table 8). Most whales remained in the greater San Nicolas Basin region throughout their deployment, as is most typical of whales tagged there (Figure 7, Figure 9, Figure 11). Zica-20221121-202439 and Zica-20221121-220816, two adult males tagged in the same group on SOAR, remained in close proximity to one another and their tagging location throughout the deployment (Figure 11, Figure 12). In contrast, after spending just under two weeks within the San Nicolas Basin, Zica-20220114-164618 headed south along the Baja California Peninsula, passing through the Cedros Trench and ultimately travelling over 1500 km southeast from tagging location before turning back north shortly before the tag ceased transmitting (Figure 8). This is the longest documented movement by a Cuvier's beaked whale tagged at SOAR, and helps us understand the potential range of the less resident individuals who appear to visit our study site (Curtis et al., 2021). Interestingly, while most of the previously tagged whales who have moved south into Mexican waters have not been sighted at SOAR more than once in the study, this individual was tentatively matched to a juvenile that was photographed at SOAR once in 2012. While the limited number of markings on the whale as a juvenile and the pigmentation changes that occur with the onset of sexual maturity make this match uniquely challenging, it is almost certainly the same whale based on the limited marks and fin shape, and provides one of the first examples of documented re-use of the region by a whale with known extensive ranging patterns.

Tagged in November 2022 while travelling northward, a short-finned pilot whale headed offshore to the area around the San Juan Seamount before continuing to head north along the shelf break and into pelagic waters, with the tags last transmission occurring 300 km off the California-Oregon border (Figure *14*). This is the second northernmost documentation of pilot whales along the US West Coast (Carretta et al., 2019), and the northernmost during the cold season.

After spending the first few days on SOAR, the only fin whale tagged in 2022 (Bp-20220114-194278) moved south and inshore of San Clemente Island and into the nearshore waters of the Northern Baja California Peninsula at the time of last transmission (Figure 13).

Dive and surface behaviors recorded by the five Cuvier's beaked whales LIMPET tagged in 2022 are summarized below (Table 9 and

Table *10*). Dive depths and durations were bimodal, and inter-deep dive intervals (IDDIs) were correlated with the durations of the deep, presumed foraging dives that precede them, as is typical for this species (Figure 15) (Schorr et al., 2014). The deepest dive, which was recorded by Zica-20220114-164618 during its transit through Mexican waters, reached 3119.5 m, although the average deep dive depth across all five tags was 1487.5 m. It should be noted that while the tag with the depth recorded at 3119.5 m showed no issues with the pressure sensor in the dives following the deepest dive, these transducers have not been independently tested for accurate reporting below 3000 m. The remaining tags all remained in or near the San Nicolas Basin, and thus their maximum dives were constrained by the local bathymetry to approximately 1800 m. The surfacings between most dives (93%) lasted less than 5 min, and as has been previously reported for whales tagged in this region (Schorr et al., 2014), the surfacings that immediately preceded deep dives were typically longer than others. The exception to this were single surfacings between two deep dives; these occurred infrequently (n=14 from two tagged whales) but were the longest surfacings on average. We recorded 63 surfacings longer than 30 min, the longest of which lasted 115.6 min and was the only surfacing between two deep dives. These whales conducted a deep, presumed foraging dive every 118.4 mins on average.

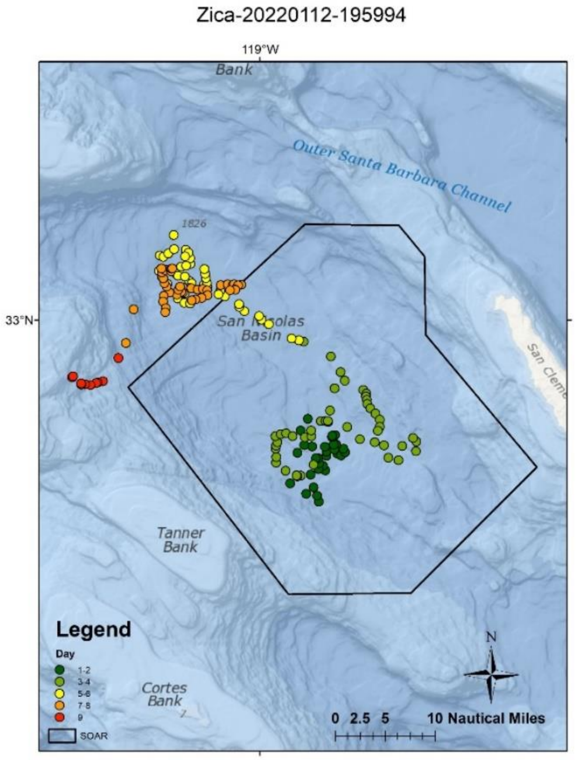

Figure 7. Fastloc GPS track from a Cuvier's beaked whale tagged during an ancillary project funded by a Living Marine Resources study. Prepared by B. Rone

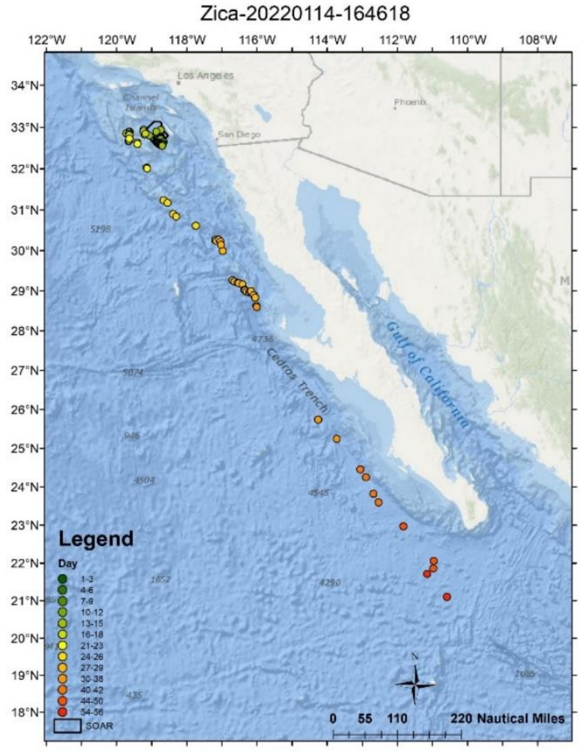

Figure 8. Fastloc GPS track from a Cuvier's beaked whale tagged under Fleet Monitoring effort in 2022. This whale moved the largest distance from tagging location for any Cuvier's tagged at SOAR to date. Prepared by B. Rone

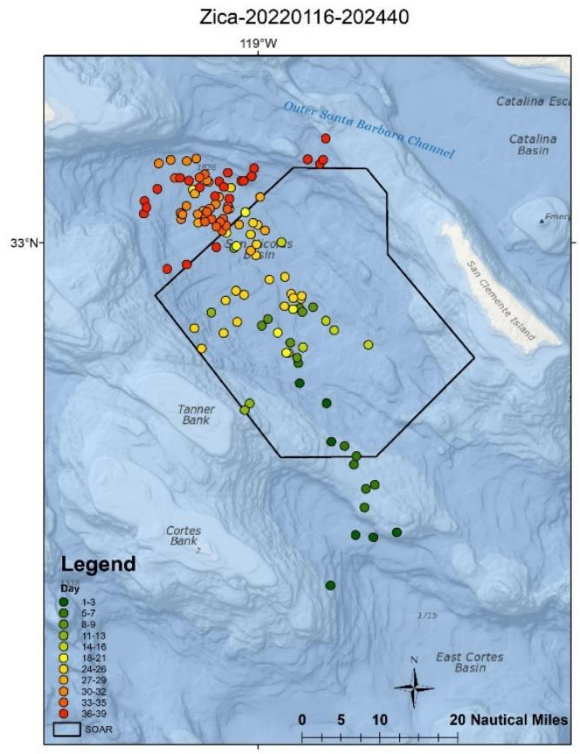

Figure 9. Fastloc GPS track from a Cuvier's beaked whale tagged under Fleet Monitoring effort in 2022. Prepared by B. Rone.

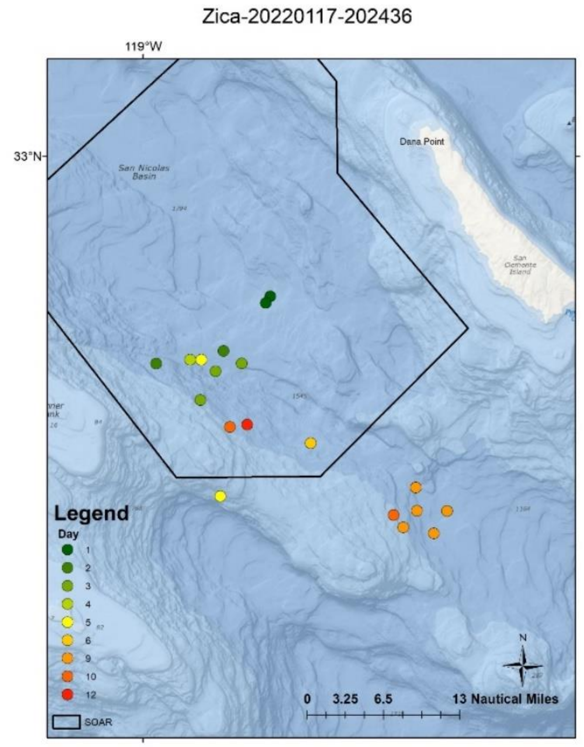

Figure 10. Fastloc GPS track from a Cuvier's beaked whale tagged under Fleet Monitoring effort in 2022. Prepared by B. Rone.

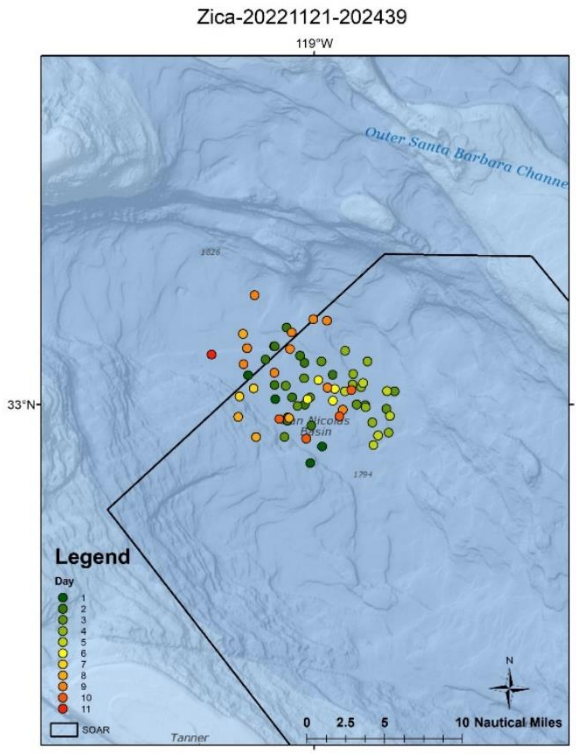

Figure 11. Fastloc GPS track from a Cuvier's beaked whale tagged under Fleet Monitoring effort in 2022. This whale was associated with Zica-20221121-220816 (Figure 12) when tagged. Prepared by B. Rone.

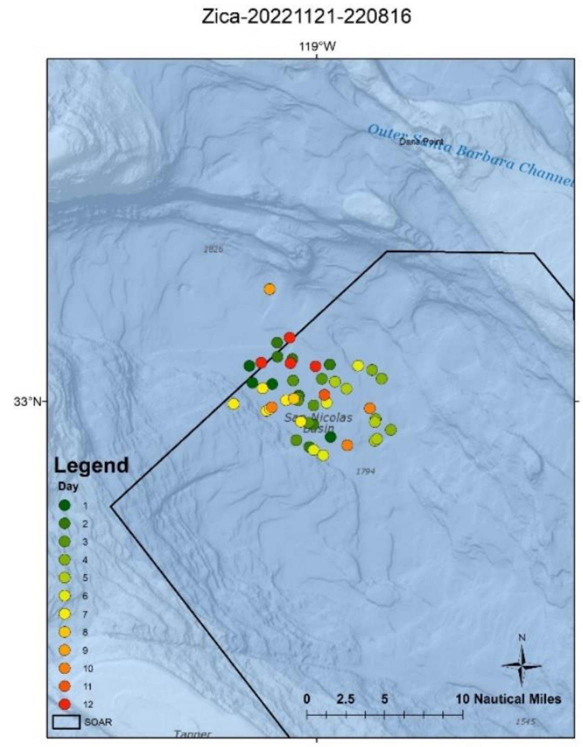

Figure 12. Fastloc *GPS* track from a Cuvier's beaked whale tagged under Fleet Monitoring effort in 2022. This whale was associated with Zica-20221121-202439 (Figure *11*) when tagged. Prepared by B. Rone.

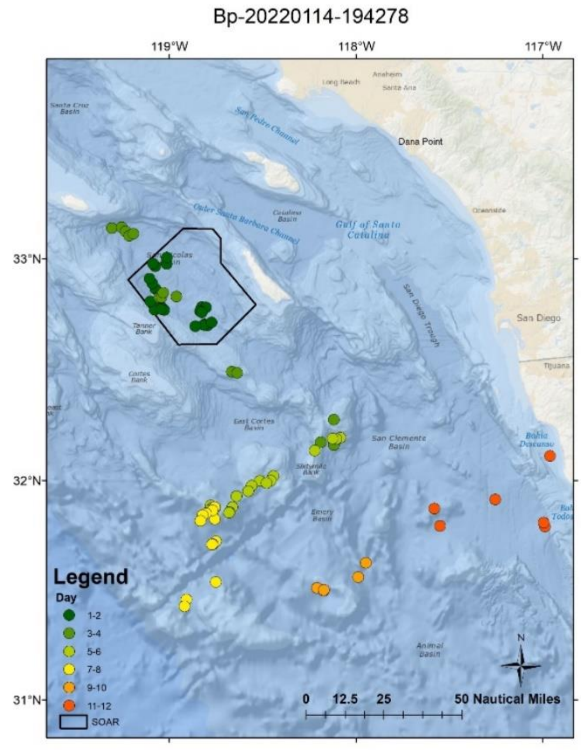

Figure 13. Fastloc GPS track from a fin whale tagged under Fleet Monitoring effort in 2022. Prepared by B. Rone.

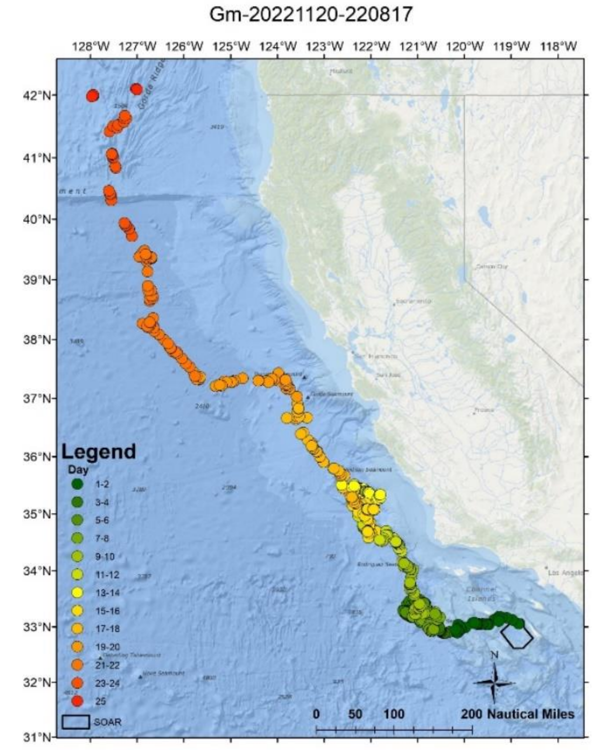

Figure 14. Fastloc GPS track from a short-finned pilot whale tagged under Fleet Monitoring effort in 2022. This track includes unfiltered Argos data and will be updated for the final report. Prepared by B. Rone.

Table 9. Summarized dive statistics for the five Cuvier's beaked whale LIMPET tags deployed in 2022. K-means classification was used to identify deep, presumed foraging dives, and shallow, presumed non-foraging dives.

Tag ID	K-means Class	Number of Dives	Mean Duration (mins)	Duration Range (mins)	Mean Depth (m)	Depth Range (m)	Mean IDDI (mins)	IDDI Range (mins)
Zica-20220114-164618	Deep	405	70.41	38.6-139.9	1390.79	375.5-3119.5	113.31	1.93-554
	Shallow	1692	23.48	2.7-57.27	301.49	49.5-1011.5	NA	NA
Zica-20220116-202440	Deep	333	68.17	38.67-121.13	1588.1	671.5-1871.5	128.14	1.4-514.13
	Shallow	1553	23.55	2.37-56.43	301.38	51.5-1071.5	NA	NA
Zica-20220117-202436	Deep	88	67.83	48.33-94.07	1221.59	591.5-1743.5	114.25	31.47-327.9
	Shallow	341	25.32	1.83-51.7	268.45	49.5-591.5	NA	NA
Zica-20221121-202439	Deep	55	65.3	47.27-96.9	1767.43	1011.5-1871.5	103.67	43.4-249.27
	Shallow	260	19.7	4.2-38.93	255.42	79.5-543.5	NA	NA
Zica-20221121-220816	Deep	42	64.91	49.3-83.97	1805.21	1231.5-1871.5	104.21	38.27-258.17
	Shallow	208	19.58	1.03-47.57	239.26	49.5-719.5	NA	NA

Table 10. Summary statistics for surfacings from the five Cuvier's beaked whale LIMPET tag deployments from 2022. Surfacings are classified to type based on where they occurred within the IDDI: FSS = first surfacing series after a deep dive, ISS = intermediate surfacing between two shallow dives, TSS = terminal surfacing before the next deep dive, OSS = only surfacing series between two deep dives, USS = unknown surfacing due to data gap.

TagID	Surfacing Type	Number of Surfacings	Mean Duration (mins)	Duration Range (mins)
Zica-20220114-164618	FSS	382	3.78	0.03-55.07
	ISS	1265	2.67	0.2-45
	OSS	10	61.87	1.93-115.6
	TSS	388	6.93	1.5-86.7
	USS	53	3.54	0.17-30.67
Zica-20220116-202440	FSS	328	2.75	0.2-62.27
	ISS	1224	2.61	0.03-66.2
	OSS	4	29.35	1.87-85.7
	TSS	327	5.42	0.2-102.77
	USS	4	17.2	2.07-62.17
Zica-20220117-202436	FSS	86	3.88	1.63-31.77
	ISS	250	3.08	0.03-70.33
	TSS	88	5.16	2.23-27.83
	USS	4	2.57	1.6-3.17
Zica-20221121-202439	FSS	54	2.14	0.67-2.87
	ISS	195	1.84	0.03-13.2
	TSS	52	5.03	1.83-31.7
	USS	13	1.74	0.17-2.73
Zica-20221121-220816	FSS	38	2.07	1.2-2.83
	ISS	156	2.17	0.03-34.7
	TSS	42	6.15	0.03-68.9
	USS	13	1.86	0.63-2.77

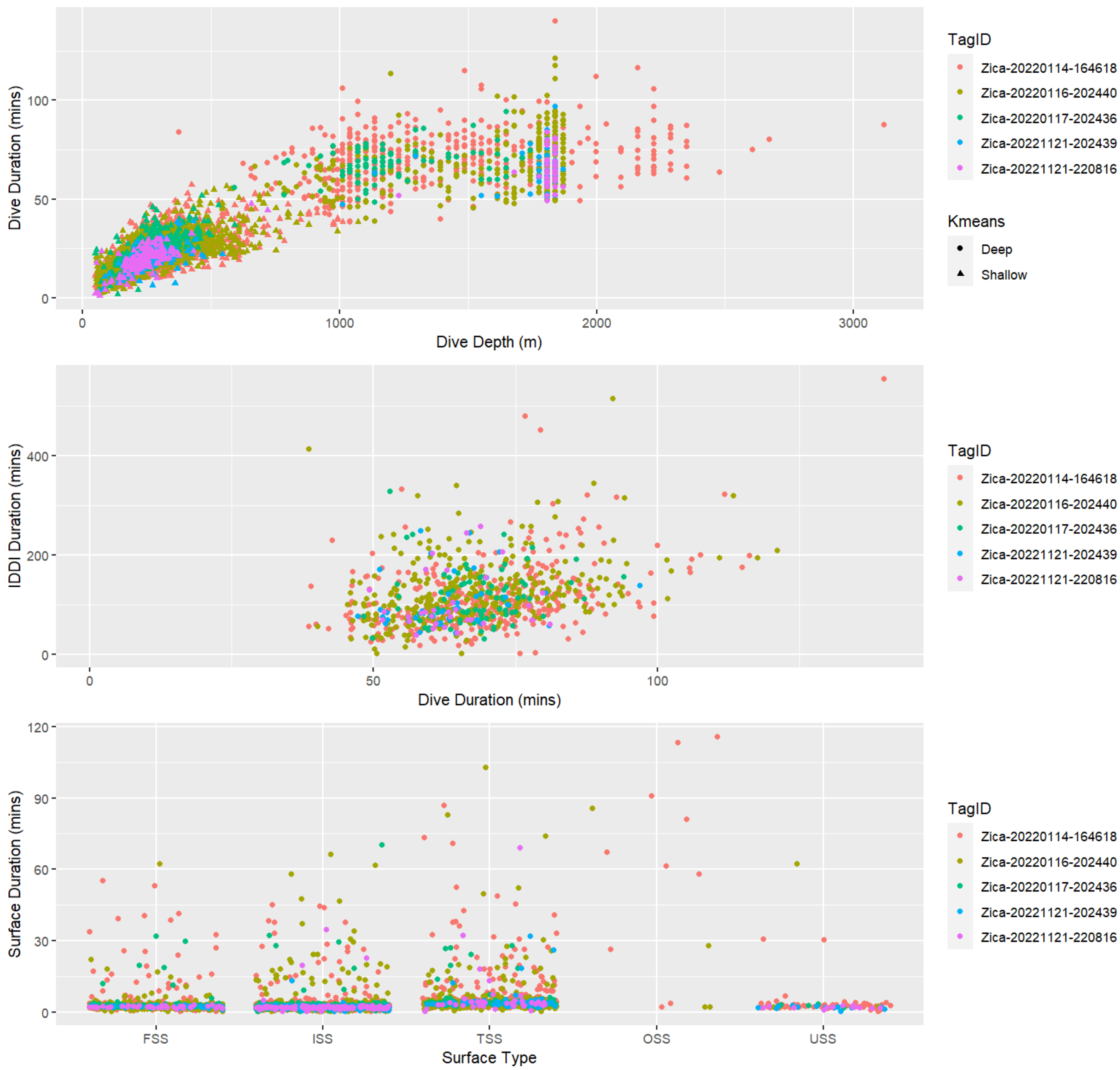

Figure 15. Overview of dive and surfacing data from the five Cuvier's beaked whale LIMPET tag deployments from 2022. Points are colored by individual (TagID) in each panel. TOP: A scatter plot of dive depth by dive duration demonstrates the generally bimodal pattern of shallow and deep dives in this species. MIDDLE: A scatter plot of deep dive duration by IDDI demonstrates the loose correlation in these values, with longer deep dives typically associated with longer IDDIs. BOTTOM: A scatter plot of surfacing durations by surfacing type. Surfacing type is a function of position in the dive cycle: FSS = first surfacing series after a deep dive, ISS = intermediate surfacing between two shallow dives, TSS=terminal surfacing before the next deep dive, OSS=only surfacing series between two deep dives, USS=unknown surfacing due to data gap. Prepared by D. Sweeney.

Analysis of Previously Collected Tag Data

Assessment of the SPLASH10-F LIMPET tag on Cuvier's beaked whales

Two tags with similar deployment characteristics were compared to see if rep rate improve data throughput. Despite the 15s rep rate tag transmitting for 7 additional hours each day (due to increased satellite availability in 2017), both tags had messages received by a similar number of satellite overpasses (92 vs 98, a 6.7% difference) (Table 11). While this number is hard to compare due to major differences in satellite availability, within available overpasses, the tag with the 10s rep rate sent 71.3% more messages, with each overpass receiving two additional messages on average. Overall, the tag with the 10s rep rate transmitted more total messages per day (not to be confused with message reception), despite the lower number of transmitting hours. Within the received messages, the reduced rep rate, along with the other possible factors, allowed for a 19.8% increase in Argos locations, and a 77.6% increase in data messages received (includes status, dive data, GPS). However, despite the increase in data throughput with the 10s rep rate, only 26% of successful GPS snapshots were received, along with an estimated 75% of Behavior Log messages. While much of the increase in message transmission is likely due to the increased rep rate (the theoretical number of times the tag could transmit in a surface series increases by an average of four in a two minute surface series), some of the increase could have come from the decrease in Fastloc attempts from 3 to 1 per hour (Table *1*. FastLoc LIMPET tag deployment and programming parameters. Tx=Transmission, Attach. = Attachment.

Table 11. Comparison of message reception rates between a 15s and 10s repetition rate tag, corrected for transmission duration. Tx = Transmission, hrs = hours, msgs = messages, avg = average, locs = locations.

Tag ID	Rep Rate	# of Tx hrs	# of sat. overpass	Total msgs	Msgs / pass (avg)	Tx/Day (avg)	# Argos Locs	# Data msgs
ZcTag059	15	21	92	295	3.2	175	81	116
Zica-202440	10	14	98	505	5.2	211	97	206

Including data collected by the shore-based Argos receiving station for the 10s rep rate tag, the total number of messages received increases by 82-260% over the satellite only data (exact numbers are difficult to determine as many messages may be received by both Mote antennas at the same time, creating duplicate messages). This leads to a corresponding increase in data messages, including receiving 99% of all Behavior Log messages, but still only 26.3% of successful GPS snapshots . In addition to the tag collecting significantly more GPS locations than were received, there were a significant number of failed GPS attempts. Reviewing data from the four longest duration GPS LIMPET tags, there is a trend towards a high % of snapshot failures (where the tag fails to capture data from enough satellites), with only one tag having less than 15%, and the rest having over 65% of snapshots result in failures (Table 12). Finding a method to reduce failed snapshots would increase tag performance, as the tag can not transmit during the time period it is processing a snapshot.

One big question when we increased the repetition rate to 10s on a whale, is what would happen to our expected battery life given the rapid cycling of the 2x ½ AA batteries +HLC? We analyzed the total number of transmissions and end battery voltage for four tags that transmitted more than 40 days, three with 10s rep rates and one with a 12s rep rate (Table 12). Transmission end count ranged from 9890-16478, and battery voltage from 2.86 – 3.38v, with three of the tags likely having stopped transmitting due to low voltage.

Table 12. Comparison of tag performance for four tags in 2021 and 2022 that transmitted for more than 40 days. Tx = Transmission, Dur. = duration, Batt = battery, Volt = voltage.

Tag ID	rep rate	Tx Dur. (days)	End Batt Volt	End Tx Count	Probable Reason For End Tx	% Failed GPS snapshots
Zica-164609	12	58.0	3.18	12458	Likely Low Voltage	14.1%
Zica-164618	10	63.6	3.38	16478	Attachment	65.7%
Zica-202440	10	45.8	3.18	9890	Likely Low Voltage	69.7%
Zica-196788	10	55.3	2.86	13084	Low Voltage	84.7%

This suggests that while the new version of the tag can transmit on average of 55 days with a 10s rep rate using the current setting, adding any battery taxing tasks (e.g., increasing GPS locations, increasing number of hours transmitting per day) will shorten the overall transmission life of the tag. Interestingly, the tag with the longest transmission duration, also had the highest number of total transmissions and still had an end battery voltage level within 'normal' range. Follow up is needed with the manufacturer to see if there are known variations within the batteries or the HLC that might account for this substantial difference in performance. A bench test, while never a replacement for real-world data, might help at least elucidate if the 10 s rep rate is taxing batteries or the HLC differently, or if there are variations within the components that lead to inconsistent total transmission life.

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Appendices

Appendix 1. Sighting details from effort conducted in 2022 including effort from U.S. Pacific Fleet Monitoring and the ancillary effort.

Date	Common Name	Latitude	Longitude	Group Size	Est IDs	Samples Collected	Tags Deployed
1/6/2022	Common dolphin	N33 07.66	W118 20.06	25	0	0	0
1/6/2022	Common dolphin	N33 01.46	W118 30.91	2	0	0	0
1/6/2022	Unid large whale	N33 03.29	W118 26.76	1	0	0	0
1/8/2022	Fin whale	N32 47.44	W118 54.08	3	3	2	0
1/8/2022	Common dolphin	N32 58.48	W118 43.01	18	0	0	0
1/8/2022	Common dolphin	N33 03.91	W118 15.35	160	0	0	0
1/8/2022	Gray whale	N33 02.34	W118 33.83	6	0	0	0
1/8/2022	Pacific white-sided dolphin	N33 00.30	W118 41.38	60	0	0	0
1/9/2022	Fin whale	N33 01.72	W118 46.14	3	3	0	0
1/9/2022	Fin whale	N32 55.06	W119 06.18	3	2	1	0
1/9/2022	Fin whale	N33 00.73	W118 55.74	1	0	0	0
1/9/2022	Common dolphin	N32 50.93	W118 56.19	32	0	0	0
1/9/2022	Common dolphin	N32 52.41	W118 52.99	17	0	0	0
1/9/2022	Common dolphin	N33 01.07	W118 41.76	15	0	0	0
1/9/2022	Common dolphin	N33 00.78	W118 53.16	40	0	0	0
1/9/2022	Common dolphin	N32 56.51	W118 45.78	3	0	0	0
1/9/2022	Common dolphin	N32 59.63	W118 54.71	25	0	0	0
1/9/2022	Gray whale	N33 02.01	W118 37.46	3	0	0	0
1/9/2022	Pacific white-sided dolphin	N32 56.57	W118 45.73	35	0	0	0
1/9/2022	Humpback whale	N32 56.55	W118 45.74	2	0	0	0
1/9/2022	Cuvier's beaked whale	N32 52.80	W118 57.93	3	0	0	0

1/9/2022	Cuvier's beaked whale	N32 43.95	W118 52.86	5	5	1	0
1/10/2022	Fin whale	N32 54.19	W118 51.98	1	0	0	0
1/10/2022	Fin whale	N33 01.19	W118 57.66	1	1	0	0
1/10/2022	Common dolphin	N33 01.92	W118 54.17	100	0	0	0
1/10/2022	Common dolphin	N33 01.28	W118 49.24	75	0	0	0
1/10/2022	Pacific white-sided dolphin	N33 01.31	W118 49.28	10	0	0	0
1/10/2022	Pacific white-sided dolphin	N32 58.50	W118 48.61	8	0	0	0
1/10/2022	Pacific white-sided dolphin	N33 01.70	W118 44.12	15	0	0	0
1/10/2022	Killer whale - ETP	N32 46.27	W119 03.57	1	0	0	0
1/10/2022	Humpback whale	N33 01.27	W118 49.08	2	0	0	0
1/12/2022	Fin whale	N33 03.63	W119 00.71	1	1	0	0
1/12/2022	Fin whale	N33 03.60	W119 01.25	1	0	0	0
1/12/2022	Common dolphin	N32 44.96	W119 00.46	20	0	0	0
1/12/2022	Gray whale	N33 00.88	W118 38.33	1	0	0	0
1/12/2022	Dall's porpoise	N32 45.12	W118 54.41	8	0	0	0
1/12/2022	Dall's porpoise	N32 55.17	W119 12.55	4	3	0	0
1/12/2022	Unid medium whale	N33 03.53	W119 01.22	1	0	0	0
1/12/2022	Cuvier's beaked whale	N32 43.12	W119 01.82	3	3	0	0
1/12/2022	Cuvier's beaked whale	N32 46.26	W118 57.28	3	3	0	1
1/12/2022	Cuvier's beaked whale	N32 45.24	W118 54.42	1	1	0	0
1/12/2022	Cuvier's beaked whale	N32 44.28	W118 45.14	1	0	0	0
1/12/2022	Cuvier's beaked whale	N32 45.15	W118 53.50	4	4	0	0
1/12/2022	Cuvier's beaked whale	N32 45.97	W118 53.87	1	0	0	0

1/12/2022	Cuvier's beaked whale	N32 45.06	W118 53.26	4	4	0	0
1/13/2022	Common dolphin	N32 42.44	W118 47.07	4	20	0	0
1/13/2022	Gray whale	N33 02.20	W118 33.99	2	0	0	0
1/13/2022	Gray whale	N32 49.23	W118 51.37	2	0	0	0
1/13/2022	Cuvier's beaked whale	N32 44.90	W118 48.08	5	5	0	0
1/13/2022	Cuvier's beaked whale	N32 40.94	W118 49.68	5	5	0	0
1/13/2022	Cuvier's beaked whale	N32 43.01	W118 46.72	4	4	0	0
1/13/2022	Cuvier's beaked whale	N32 48.83	W118 51.25	5	4	0	0
1/13/2022	Cuvier's beaked whale	N32 45.01	W118 47.55	5	4	0	0
1/14/2022	Fin whale	N32 41.65	W118 47.41	1	1	0	1
1/14/2022	Fin whale	N32 52.65	W118 57.55	2	1	0	0
1/14/2022	Fin whale	N32 51.84	W118 43.66	2	2	0	0
1/14/2022	Gray whale	N32 49.62	W118 50.21	2	0	0	0
1/14/2022	Gray whale	N32 42.97	W118 44.89	4	0	0	0
1/14/2022	Cuvier's beaked whale	N32 42.69	W118 45.05	3	3	0	1
1/14/2022	Cuvier's beaked whale	N32 41.18	W118 48.84	1	1	0	0
1/15/2022	Common dolphin	N33 03.40	W118 30.58	20	0	0	0
1/16/2022	Gray whale	N32 59.49	W118 42.71	1	0	0	0
1/16/2022	Gray whale	N32 47.03	W118 43.38	2	0	0	0
1/16/2022	Cuvier's beaked whale	N32 44.72	W118 49.70	2	2	0	0
1/16/2022	Cuvier's beaked whale	N32 44.21	W118 54.25	5	5	0	0
1/16/2022	Cuvier's beaked whale	N32 44.77	W118 55.32	1	1	0	1
1/16/2022	Cuvier's beaked whale	N32 44.14	W118 46.19	3	3	0	0

1/17/2022	Gray whale	N32 44.39	W118 45.82	4	0	0	0
1/17/2022	Gray whale	N32 47.30	W118 51.34	2	0	0	0
1/17/2022	Gray whale	N32 47.56	W118 53.40	2	0	0	0
1/17/2022	Cuvier's beaked whale	N32 50.26	W118 53.40	5	5	0	1
1/17/2022	Cuvier's beaked whale	N32 55.18	W118 41.60	2	2	0	0
1/17/2022	Cuvier's beaked whale	N32 45.17	W118 46.68	3	3	0	0
1/18/2022	Common dolphin	N33 01.04	W118 30.48	120	0	0	0
1/18/2022	Common dolphin	N33 06.41	W117 58.75	12	0	0	0
1/18/2022	Common dolphin	N33 01.90	W118 25.22	300	0	0	0
1/18/2022	Common dolphin	N33 07.52	W117 52.80	15	0	0	0
1/18/2022	Common dolphin	N33 11.14	W117 33.60	160	0	0	0
1/18/2022	Gray whale	N33 07.14	W118 20.63	2	0	0	0
1/18/2022	Gray whale	N33 04.70	W118 09.25	3	0	0	0
1/18/2022	Risso's dolphin	N33 03.05	W118 18.03	3	0	0	0
1/18/2022	Risso's dolphin	N33 10.16	W118 14.68	65	25	0	0
1/18/2022	Pacific white-sided dolphin	N33 01.63	W118 31.47	35	0	0	0
1/20/2022	Common dolphin	N33 11.03	W117 47.36	180	0	0	0
1/20/2022	Common dolphin	N33 08.29	W118 47.82	200	0	0	0
1/20/2022	Common dolphin	N33 11.86	W117 29.08	15	0	0	0
1/20/2022	Humpback whale	N33 11.59	W117 49.44	1	0	0	0
2/27/2022	Common dolphin	N33 07.38	W118 20.17	30	0	0	0
2/27/2022	Common dolphin	N33 18.11	W117 57.85	7	0	0	0
2/27/2022	Common dolphin	N33 08.67	W118 17.37	600	0	0	0

2/27/2022	Common dolphin	N33 18.82	W117 56.90	15	0	0	0
2/27/2022	Common dolphin	N33 09.31	W118 16.14	5	0	0	0
2/27/2022	Common dolphin	N33 11.11	W118 12.09	20	0	0	0
2/27/2022	Common dolphin	N33 13.17	W118 08.13	20	0	0	0
2/27/2022	Gray whale	N33 26.14	W117 44.27	1	0	0	0
2/27/2022	Gray whale	N33 17.37	W117 59.71	3	2	0	0
2/27/2022	Risso's dolphin	N33 02.33	W118 29.48	25	12	0	0
2/27/2022	Unid dolphin	N33 11.95	W118 10.30	40	0	0	0
2/28/2022	Fin whale	N32 44.40	W118 54.05	2	2	0	0
2/28/2022	Common dolphin	N32 56.92	W118 44.21	12	0	0	0
2/28/2022	Common dolphin	N32 46.46	W118 51.59	8	0	0	0
2/28/2022	Common dolphin	N32 55.59	W118 45.70	75	0	0	0
2/28/2022	Gray whale	N33 02.30	W118 37.45	2	0	0	0
2/28/2022	Humpback whale	N32 48.44	W118 58.16	2	2	0	0
2/28/2022	Humpback whale	N32 49.15	W118 58.43	3	2	0	0
2/28/2022	Humpback whale	N32 49.24	W118 58.78	1	0	0	0
2/28/2022	Humpback whale	N32 44.45	W118 53.84	3	0	0	0
2/28/2022	Humpback whale	N32 50.91	W118 51.00	2	0	0	0
2/28/2022	Humpback whale	N32 54.16	W118 46.41	1	1	0	0
2/28/2022	Humpback whale	N32 44.35	W118 52.68	1	0	0	0
2/28/2022	Humpback whale	N32 55.08	W118 45.86	2	2	0	0
2/28/2022	Cuvier's beaked whale	N32 44.51	W118 52.90	4	5	0	0
2/28/2022	Cuvier's beaked whale	N32 44.35	W118 52.68	2	2	0	0

3/1/2022	Fin whale	N32 48.19	W118 59.24	2	0	0	0
3/1/2022	Fin whale	N32 56.30	W118 51.18	1	0	0	0
3/1/2022	Common dolphin	N32 46.93	W118 51.10	40	0	0	0
3/1/2022	Common dolphin	N32 48.07	W118 59.18	30	0	0	0
3/1/2022	Common dolphin	N32 49.45	W118 58.77	35	0	0	0
3/1/2022	Gray whale	N33 02.77	W118 35.79	3	0	0	0
3/1/2022	Pacific white-sided dolphin	N32 48.17	W118 59.27	10	0	0	0
3/1/2022	Humpback whale	N32 45.10	W118 52.67	2	0	0	0
3/1/2022	Humpback whale	N32 47.20	W118 59.07	2	0	0	0
3/2/2022	Common dolphin	N33 00.43	W118 54.27	10	0	0	0
3/2/2022	Northern right whale dolphin	N33 01.30	W118 53.78	30	0	0	0
3/2/2022	Pacific white-sided dolphin	N32 51.48	W119 08.61	7	0	0	0
3/2/2022	Humpback whale	N32 52.85	W119 05.51	3	0	0	0
3/2/2022	Cuvier's beaked whale	N32 53.42	W119 10.58	5	6	0	0
3/3/2022	Common dolphin	N33 11.80	W118 11.75	75	0	0	0
3/3/2022	Common dolphin	N33 04.07	W118 25.14	5	0	0	0
3/3/2022	Common dolphin	N33 01.17	W118 30.56	8	0	0	0
3/3/2022	Gray whale	N33 10.39	W118 14.86	2	0	0	0
3/6/2022	Minke whale	N33 37.41	W118 20.45	1	0	0	0
3/6/2022	Fin whale	N33 42.50	W118 35.34	1	1	0	0
3/6/2022	Common dolphin	N33 40.60	W118 32.84	46	0	0	0
3/7/2022	Common dolphin	N33 14.59	W118 15.95	150	0	0	0
3/7/2022	Gray whale	N33 16.37	W118 27.33	2	0	0	0

3/7/2022	Gray whale	N33 15.62	W118 23.83	3	0	0	0
3/7/2022	Gray whale	N33 15.24	W118 22.51	2	0	0	0
6/10/2022	Fin whale	N32 54.10	W118 54.37	1	1	0	0
6/10/2022	Common dolphin	N33 25.12	W117 46.04	200	0	0	0
6/10/2022	Common dolphin	N33 04.63	W118 25.78	15	0	0	0
6/10/2022	Common dolphin	N33 01.29	W118 32.33	20	0	0	0
6/10/2022	Common dolphin	N32 59.81	W118 49.16	15	0	0	0
6/10/2022	Common dolphin	N33 01.89	W118 40.70	8	0	0	0
6/10/2022	Common dolphin	N32 56.73	W119 02.76	25	0	0	0
6/11/2022	Blue whale	N32 43.88	W118 42.07	1	1	0	0
6/11/2022	Fin whale	N32 51.28	W118 42.53	1	1	1	0
6/11/2022	Fin whale	N32 42.94	W118 41.13	4	4	2	0
6/11/2022	Fin whale	N32 44.20	W118 41.99	3	3	0	0
6/12/2022	Fin whale	N32 58.34	W119 00.89	1	0	0	0
6/12/2022	Fin whale	N32 53.24	W118 56.98	1	1	0	0
6/12/2022	Common dolphin	N33 01.59	W118 33.44	12	0	0	0
6/12/2022	Killer whale - ETP	N33 00.55	W118 58.83	3	3	0	0
6/12/2022	Cuvier's beaked whale	N32 58.21	W119 00.91	2	2	0	0
6/14/2022	Baird's beaked whale	N33 14.76	W118 59.39	6	6	1	0
6/14/2022	Fin whale	N33 08.67	W118 50.63	1	1	0	0
6/14/2022	Fin whale	N33 10.05	W118 59.95	2	2	0	0
6/14/2022	Common dolphin	N33 16.91	W118 29.05	20	0	0	0
6/14/2022	Common dolphin	N33 01.33	W118 33.34	12	0	0	0

6/14/2022	Common dolphin	N33 13.81	W119 00.40	8	0	0	0
6/14/2022	Pacific white-sided dolphin	N33 01.89	W118 33.13	3	0	0	0
6/14/2022	Bottlenose dolphin	N33 02.17	W118 32.99	12	0	0	0
6/14/2022	Cuvier's beaked whale	N33 23.42	W118 45.36	5	7	0	0
6/15/2022	Blue whale	N32 46.96	W118 43.56	1	1	0	0
6/15/2022	Fin whale	N32 51.08	W118 49.43	1	1	0	0
6/15/2022	Fin whale	N32 45.14	W118 51.19	2	2	0	0
6/15/2022	Fin whale	N32 49.48	W118 39.76	1	1	1	0
6/15/2022	Common dolphin	N32 45.62	W118 49.51	8	0	0	0
6/15/2022	Risso's dolphin	N33 02.16	W118 33.86	80	25	0	0
6/16/2022	Fin whale	N32 56.32	W118 57.77	1	1	0	0
6/16/2022	Fin whale	N32 52.20	W119 02.94	1	0	0	0
6/16/2022	Common dolphin	N32 58.73	W118 53.99	23	0	0	0
6/16/2022	Common dolphin	N33 02.07	W118 42.73	20	0	0	0
6/16/2022	Common dolphin	N33 08.36	W119 14.04	50	0	0	0
6/16/2022	Common dolphin	N33 02.19	W118 41.63	3	0	0	0
6/16/2022	Common dolphin	N33 10.85	W119 10.16	10	0	0	0
6/16/2022	Common dolphin	N33 05.78	W119 15.90	40	0	0	0
6/16/2022	Common dolphin	N33 08.61	W118 38.41	20	0	0	0
6/17/2022	Common dolphin	N33 04.45	W118 25.52	12	0	0	0
11/19/2022	Minke whale	N33 02.66	W118 16.47	1	1	0	0
11/20/2022	Fin whale	N32 58.75	W118 52.02	1	1	0	0
11/20/2022	Risso's dolphin	N33 02.33	W118 37.68	18	0	0	0

11/20/2022	Short-finned pilot whale	N32 59.33	W118 49.63	10	10	0	1
11/20/2022	Humpback whale	N33 00.30	W118 50.49	1	0	0	0
11/20/2022	Bottlenose dolphin	N33 02.24	W118 37.81	8	0	0	0
11/20/2022	Bottlenose dolphin	N33 02.54	W118 36.96	25	0	0	0
11/20/2022	Cuvier's beaked whale	N32 55.15	W118 59.13	3	3	0	0
11/20/2022	Cuvier's beaked whale	N33 00.40	W118 47.50	1	1	0	0
11/21/2022	Fin whale	N32 57.99	W118 56.84	4	2	0	0
11/21/2022	Fin whale	N32 54.99	W118 55.67	1	1	0	0
11/21/2022	Cuvier's beaked whale	N32 58.64	W118 58.93	7	7	0	2
11/22/2022	Blue whale	N32 51.26	W118 45.11	1	1	0	0
11/22/2022	Fin whale	N32 51.17	W118 44.95	1	0	0	0
11/22/2022	Fin whale	N32 49.78	W118 45.96	2	2	0	0
11/22/2022	Fin whale	N32 54.95	W118 44.33	1	0	0	0
11/22/2022	Common dolphin	N33 00.30	W118 39.19	30	0	0	0
11/22/2022	Risso's dolphin	N33 02.43	W118 36.68	12	0	0	0
11/22/2022	Risso's dolphin	N33 02.00	W118 33.96	60	0	0	0
11/22/2022	Risso's dolphin	N33 01.18	W118 33.36	75	0	0	0
11/22/2022	Bottlenose dolphin	N33 01.21	W118 33.38	19	0	0	0
11/23/2022	Fin whale	N32 50.31	W118 45.74	1	1	0	0
11/23/2022	Fin whale	N32 49.46	W118 51.75	2	2	0	0
11/23/2022	Risso's dolphin	N33 02.56	W118 34.63	40	0	0	0
11/23/2022	Humpback whale	N32 53.02	W118 43.54	1	0	0	0
11/23/2022	Bottlenose dolphin	N33 02.93	W118 35.40	24	0	0	0

11/23/2022	Cuvier's beaked whale	N32 51.34	W118 52.84	4	0	0	0
11/24/2022	Minke whale	N33 01.29	W118 54.82	1	0	0	0
11/24/2022	Fin whale	N33 00.61	W118 59.05	1	0	0	0
11/24/2022	Fin whale	N33 02.49	W118 57.44	1	0	0	0
11/24/2022	Unid large whale	N33 02.05	W118 54.38	1	0	0	0
11/25/2022	Common dolphin	N32 57.87	W118 41.26	10	0	0	0
11/25/2022	Cuvier's beaked whale	N32 57.11	W118 56.79	2	2	0	0
11/25/2022	Cuvier's beaked whale	N32 54.33	W118 53.45	1	0	0	0
11/26/2022	Common dolphin	N33 09.52	W117 41.51	35	0	0	0
11/26/2022	Humpback whale	N33 09.34	W117 39.92	2	0	0	0

Appendix 2. List of Acronyms

ESA	Endangered Species Act
GPS	Global Positioning System
km	kilometer
LIMPET	Low Impact Minimally Percutaneous External-electronics Transmitting
LMR	Living Marine Resources
m	meter
M3R	Marine Mammal Monitoring on Navy ranges
MarEcoTel	Marine Ecology and Telemetry Research
MFAS	Mid-frequency active sonar
NUWC	Naval Undersea Warfare Center
ONR	Office of Naval Research
ROC	Range Operation Center
RHIB	Rigid-hulled inflatable boat
SCB	Southern California Bight
SCORE	Southern California Offshore Range
SD	Standard deviation
SOAR	Southern California Anti-submarine Warfare Range
SMRT	Sound Motion Recording and Telemetry
SOCAL	Southern California Range Complex
SWFSC	Southwest Fisheries Science Center
US	United States

Attachments

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