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

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Table of Contents

List of Tables

List of Figures

Abstract

The Southern California Range Complex (SOCAL) is one of the United States (US) Navy's most active training areas, particularly concerning the use of 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 28 days of survey effort from 2 January 2019 to 17 November 2019, 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 and fin whales. With combined effort from ancillary projects funded by the US Navy's Living Marine Resources (LMR) program, we had 224 sightings of cetaceans, including 39 sightings of 95 Cuvier's beaked whales and 23 sightings of 41 fin whales. Reconciliation of identification photographs revealed 56 unique individual Cuvier's beaked whales were sighted on an average of 1.6 days each in 2019; 27 of these whales were previously identified in SOCAL, with sighting histories of up to 12 years. There were seven sightings of five Cuvier's beaked whale mother and calf pairs. Thirteen genetic samples were collected, including five from Cuvier's beaked whales, seven from fin whales, and one from a minke whale. There were forty-six environmental DNA (eDNA) samples collected for an ancillary project funded by the Office of Naval Research, but which will provide key data for monitoring efforts. Two tags were deployed under this project– one Spot5 on a fin whale and one MK10A on a Risso's dolphin. Data analyses was completed on these, plus previous tag deployments in the region. Home range analyses indicated that Risso's dolphins utilize the entire Southern California Bight, and Cuvier's beaked whales have a preference for the west sides of Catalina Basin and the San Nicolas Basin within SOAR, with both species spending the majority of their time within one or more of the training ranges.

Following on previous findings that Cuvier's extend their time between deep (presumed foraging) dives in response to Navy sonar exposure, we analyzed previously collected tag data with overlapping sonar data to assess how much time it takes for Cuvier's to return to a 'baseline' deep dive rate after exposure. Initial results indicate that foraging dive cycle time returns to at, or just below, average immediately following the exposed dive cycle, but the rate is much more constrained in variability than data collected further away from sonar and the implications of this are not yet understood. Continued focus on photo-identification, biopsy sampling, and the movement and habitat use of Cuvier's beaked whales and fin whales will help elucidate population structure for these species, an important element of any management and mitigation strategies.

Introduction

The United States (US) Navy manages the Southern California Range Complex (SOCAL) a collection of nearshore and offshore training areas that include much of the navigable water from Santa Barbara Island, California (CA), to northern Baja California, Mexico, and 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 (Figure 1).

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 on cetacean species assemblages, distribution and demographics, foraging ecology, and behavioral responses to MFAS on and around SOAR since 2006. In the beginning, the primary objective of these surveys was to provide visual verification of acoustic marine mammal detections on the SOAR hydrophone array in conjunction with the Marine Mammal Monitoring on Navy Ranges (M3R) program (Falcone et al., 2009; Falcone and Schorr, 2014, 2011; Moretti et al., 2006). These studies documented a high diversity of species on SOAR year-round, with some seasonal fluctuations in diversity and density (Falcone & Schorr 2014). Photo-ID studies of both Cuvier's beaked whales and fin whales were initiated to better understand the structure of these poorly known populations. As the surveys progressed, a major goal became the deployment of dive-reporting satellite tags to study both the distribution and diving behavior of both these species, and to assess any changes associated with MFAS use.

Both satellite tagging and photo-ID data from these studies have indicated high site fidelity within the Southern California Bight for several species, including Cuvier’s beaked whales on SOAR and fin whales in the greater Southern California Bight (Falcone et al., 2009, 2017; Scales et al., 2017; Schorr et al., 2014). Both findings were somewhat unexpected. Fin whales were believed to range broadly along the US West Coast with no population substructure. 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 species, and beaked whales in general, have been involved in atypical-mass strandings in association with MFAS in other regions of the world (Bernaldo de Quirós et al., 2019; Cox et al., 2006; D’Amico et al., 2009) and avoidance of SOAR to some degree was anticipated due to documented sensitivity to MFAS (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 intense Navy training is critical to effective management, including realistic estimation of takes.

Navy Benefits

The primary focus of these surveys is to support long-term studies using photo-identification and genetics to elucidate population size, structure, and trends, which can in turn provide a particularly robust basis for assessing population-level impacts of Navy training. Demographic data, including the age-sex class structure of the population, often provide insights into cumulative impacts on long-lived species that might not show up in acoustic or visual density data (e.g., Whitehead & Gero 2015).

A recent Office of Naval Research (ONR)-supported analysis (Moore et al., 2017) determined that long-term photo-identification provided the best power to detect an actual decline in the Cuvier's beaked whale population at SOAR if one were occurring, and Booth et al. (2017) suggest photo-identification and biopsy are critical tools for accurately monitoring population health. Further, there are specific inputs to Population Consequences of Disturbance (PCoD) 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.

The continued deployment of satellite tags on species of interest within the SCORE region will continue to elucidate overlap of movements and habitat use of different species of cetacean within the range complex.

Methods

Field Data Collection

Surveys were conducted using 7.5m and 6.5m rigid-hulled inflatable boats (RHIB), each powered by two outboard motors and equipped with a raised bow pulpit. Prior to October, surveys were conducted using a single RHIB. In October and November, surveys were conducted using two RHIBs. The RHIB(s) 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(s) 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 7-14 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(s) 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 or baleen whales.

Sighting data were collected using a custom-built MS 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 for species where this methodology is being employed during this study or by collaborators (beaked, fin, blue, humpback, minke, and killer whales; bottlenose and Risso's dolphins). Remote tissue biopsies were collected from species of interest both to this study (beaked and fin whales) and on behalf of collaborators at the Southwest Fisheries Science Center (SWFSC) for use in ongoing assessments of offshore populations and stress hormone analyses. Additionally, a limited number of satellite tags were deployed on species which regularly inhabit the training range, and which may be impacted by training activities in order to provide additional information on distribution, behavior, and overlap with Navy activities.

Surveys conducted under the two Awards addressed in this report are collectively referred to as 'Fleet Monitoring' efforts, as they are conducted as part of the Navy's Integrated Comprehensive Monitoring Program (ICMP). Additional surveys in 2019 were conducted as part of an LMR-funded project. During both survey efforts, water samples were collected in the footprint of Cuvier's beaked whales for an environmental DNA (eDNA) study in collaboration with Oregon

State University (OSU) Cetacean Conservation and Genomics Laboratory (PI Scott Baker) funded by the Office of Naval Research (ONR). Survey effort conducted for Fleet Monitoring, LMR, and ONR are summarized separately and sighting data and photo-ID sections are combined.

Photo-ID

All photos collected during surveys were tagged with metadata including basic survey and sighting information using ACDSee Pro image management software. Individual identification photographs of fin whales and beaked whales were further processed and compared to existing photo-ID catalogs curated by MarEcoTel using methods described in Falcone and Schorr (2014) to build photographic sighting histories.

Satellite tagging

Satellite tags deployed as part of the Fleet Monitoring effort were of the Low-Impact Minimally Percutaneous External-electronics Transmitting (LIMPET) tag format (Wildlife Computers, Redmond, WA). Tags were deployed following the method described in Schorr et al. 2014. Location data from both current and previously-deployed tags were re-processed by Argos using the Kalman filtering method (Lopez et al., 2014) in 2019, then run through the Douglas Argos Filter in Movebank (Douglas et al., 2012) following Schorr et al. (2014) and Scales et al. (2017). FastGPS location data from GPS LIMPET tags (deployed under previous Navy or Environmental Security Technology Certification Program funded projects), Lander II and SMRT tags (deployed under a concurrent LMR project) were filtered following the method from Dujon et al. (2014).

Home Range Analyses

Home range analyses were conducted using locations estimated from Risso's dolphins tagged from 2009-2019) and Cuvier's beaked whales tagged from 2008 – 2017. For periods where more than one position estimate was generated per day, an average daily position was used in order to minimize autocorrelation bias in home range calculations (Heide-Jørgensen et al., 2002).

For whales with duty-cycled programming, one pseudo-location was added midway along the track between the surrounding days' averaged locations, allowing for data to have an equivalent temporal resolution which should partially reduce bias in the kernel density estimation due to sample size differences (Dalla Rosa et al., 2008).

Based on previous analysis of photo-ID and tag movements (Schorr et al., 2017), home ranges were calculated separately for Cuvier's beaked whales tagged in the Catalina Basin and the San Nicolas Basin.

Overlap with Navy Sonar

Falcone et al. (2017) suggested that Cuvier's beaked whales extend the time between deep, presumed foraging dives during or immediately after exposure to MFAS. To assess how long it takes whales to return to a 'baseline' foraging rate after exposure to MFAS, we analyzed changes in Inter-Deep-Dive-Interval (IDDI) as a function of time since last sonar exposure using the same set of diving data, modeled movements, and concurrent sonar use data as the Falcone et al. (2017) study.

A brief summary of methods for determining dive type, applying a movement model, and compilation of sonar data is provided here, but see Schorr et al. (2014) and Falcone et al. (2017) for full details. K-means cluster analyses were performed on the dives from each whale using dive depth and duration to classify individual dives as either "deep" or "shallow". The IDDI was calculated as the time between the end of one deep dive and the start of the next deep dive.

Argos location estimates were passed through the Douglas Argos-filter algorithm's (Douglas et al., 2012) distance-angle-rate method following Schorr et al. (2014). After filtering, all retained locations were fit by a continuous-time correlated random walk model (Johnson et al., 2008) using the *crawl* package in R (Johnson and London, 2018; R Core Team, 2019) to estimate each whale's position every 30 minutes. The solar elevation was calculated for each IDDI using the modelled animal location closest in time to the start of the IDDI using the *solartime* package in R (Wutzler, 2018). Using the solar elevations, we classified the time of day for each IDDI as follows: day (solar elevation greater than 12 degrees), night (solar elevation less than -12 degrees), dusk (solar elevation between 6 and -12 degrees), and dawn (solar elevation between 6 and -12).

IDDIs were assigned a sequence number based on sonar exposure history. An IDDI sequence value of zero was assigned to any dive cycle (defined as the period consisting of a deep dive and the subsequent IDDI) with coincident high- or mid-power sonar use within 100 km of the whale's location following Falcone et al. (2017), which suggested that IDDI increases when whales are exposed to sonar during the dive cycle within this distance. Sonar exposures with an emergent land mass between the whale and the source, as determined using an etopo2v2 bathymetry grid (ArcGIS v. 10.3.1.) were excluded. The IDDI sequence number incremented by 1 with each successive dive cycle that did not include qualifying sonar use. Dive cycles that included data gaps (i.e. periods of behavior data that were not successfully received by a satellite) were excluded from the analysis, and IDDIs that occurred after a data gap and before the next exposure were not sequenced.

We calculated the closest distance between the whale and any qualifying sonar source, the percent overlap (proportion of minutes during which any qualifying sonar was in use), and the types of sonar used (high-power sonar from ships, mid-power sonar from helicopters, or both) for each exposed dive cycle. All distances were calculated with the distVincentyEllipsoid() function in the *geosphere* package in R (Hijmans, 2019) using the location of the sonar source at the start of the sonar bout and the modeled animal location of the whale closest in time to the start time of the sonar bout. If two animal location estimates were of equal time difference from the start time of the sonar bout, the average distance between the two source distances was taken.

We created a generalized additive model (GAM) using the *mgcv* package in R (Wood, 2011) with IDDI duration as the response. The model was fit with a gamma error distribution and a log link function, and the model's smoothing parameter estimation method was set to REML (restricted maximum likelihood). In order to allow the smoothing parameter estimation to remove terms from the model completely if necessary, the GAM input of "select" was set as TRUE. The model included three categorical predictors: time of day, sonar type used during the most recent exposed dive cycle, and the IDDI sequence number. Smooth terms were also included in the model for deep dive duration, distance to closest sonar source, and percent sonar overlap. These smooth terms were fit using shrinkage cubic regression splines with five dimensions of the bases. A random effect term (Tag ID) was also included in the model to account for differences between whales, using smooth functions as shrinkage cubic regression splines with a basis dimension of five.

Model selection was carried out using an analysis of variance where significant predictor terms were kept if they had a p-value less than 0.05. Model prediction plots were created to display the effects of significant predictors on the response variables. The fixed terms used in the creation of all prediction plots are specified in each figure's caption.

Because the model requires sonar use to have occurred within the tag record, tag data prior to the first coincident exposure were not included in the model but can provide a valuable baseline to compare these results against. To assess this, we reviewed diving behavior from tags deployed in early January in 2011, 2014, and 2015 (n = 8). These behavioral data follow long periods of time where sonar isn't active due to the Holiday season and a range maintenance period. Sonar was confirmed absent during the period of these tags using the same methods outlined in Falcone et al. (2017).

Results and discussion

Survey effort and sightings

A total of 28 daily surveys were conducted for this project in five different months of 2019, with most survey effort occurring within SOAR (Table 1, Figure 1). Twelve survey days under this project were cancelled due to inclement weather conditions. Fleet Monitoring effort was supported by two awards in 2019, one managed by the NUWC and the other managed by the Cooperative Ecosystem Studies Unit (CESU), which went into effect in October.

An additional 30 daily surveys were conducted in the same area for an ancillary project (Table 2, Figure 2). The percentage of time by project within Navy range boundaries are presented in Table 3.

During all survey effort in the region in 2019, 224 sightings of twelve cetacean species were recorded (Figure 3, Table 1, Table 2, Appendix 1).

Cuvier’s beaked whales were sighted in the deep waters of the San Nicolas Basin, located to the west of San Clemente Island, in all months when effort was undertaken (Figure 4, Figure 5, Figure 6, Table 4).

Fin whales were sighted on the west, north, and east side of the island. They were sighted in January-March and again in October-November but were absent from the survey area during the July effort (Figure 4, Figure 5, Figure 6, Table 5).

Table 1. Summary of Fleet Monitoring survey effort by day, January-November 2019, with associated data collection details. CESU support began with the October 2019 effort.

Date	Vessels	Survey Effort (Hrs)	Survey Dist (nm)	Total Sightings	Biopsies	eDNA	Tags
1/2/2019	1	3.1	51.9	1	0	0	0
1/3/2019	1	11.1	65.4	5	0	0	0
1/4/2019	1	11.3	66.3	9	0	0	1
1/5/2019	1	6.4	59.1	4	0	0	0
1/7/2019	1	3.2	32.5	4	0	0	0
1/9/2019	1	6.8	77	5	0	0	0
1/12/2019	1	1.1	11.5	3	0	0	0
1/17/2019	1	2.7	52.1	0	0	0	0
3/3/2019	1	2.7	29.8	2	0	0	0
3/5/2019	1	10.4	94.2	17	0	0	0
3/7/2019	1	6.6	49.9	8	0	0	0
3/10/2019	1	11.6	88.3	10	2	4	0
3/11/2019	1	2.4	52.4	7	0	0	0
7/18/2019	1	2.7	52.9	1	0	0	0
7/19/2019	1	7.5	78.4	5	0	0	1
7/22/2019	1	11.0	85.8	5	0	0	0
7/23/2019	1	6.4	69.5	3	0	0	0
7/24/2019	1	2.6	53.1	2	0	0	0
10/4/2019	1	2.8	52.7	0	0	0	0
10/5/2019	1	10.5	72.9	6	1	1	0
10/6/2019	1	11.3	89.5	5	1	1	0
10/12/2019	1	10.7	82.3	4	3	4	0
10/14/2019	1	0.3	51.8	0	0	0	0
11/9/2019	1	4.0	52.8	0	0	0	0
11/10/2019	1	8.3	59.2	2	0	0	0
11/11/2019	1	10.7	87.2	3	0	0	0
11/12/2019	1	10.7	80.8	2	0	6	0
11/17/2019	1	11.1	91.6	5	0	4	0
Totals: 28		**189.8**	**1790.9**	**118**	**7**	**20**	**2**

Table 2. Summary of ancillary survey effort by day, January-November 2019 with associated data collection details.

Date	Vessels	Survey Effort (Hrs)	Survey Dist (nm)	Total Sightings	Biopsies	eDNA	Tags
1/8/2019	1	11.6	88.6	5	2	0	1
1/11/2019	1	9.0	82.2	5	0	0	1
1/13/2019	1	10.7	81.8	5	1	0	1
1/14/2019	1	8.6	118	1	0	0	0
1/23/2019	1	7.4	152	0	0	0	0
2/28/2019	1	2.9	53	2	0	0	0
3/1/2019	1	10.9	86.2	7	0	0	0
10/4/2019	1	3.3	61.1	2	0	0	0
10/5/2019	1	10.1	108	5	0	0	0
10/6/2019	1	11.4	109	6	0	2	0
10/7/2019	2	14.6	122.3	6	1	0	0
10/10/2019	2	22.0	158.2	12	1	0	0
10/11/2019	2	22.0	222.3	16	0	5	0
10/12/2019	1	10.7	92.1	7	0	5	2
10/13/2019	2	19.9	155.2	6	0	7	0
10/14/2019	1	2.7	60.8	1	0	0	0
10/21/2019	1	9.7	176	0	0	0	0
10/22/2019	1	5.0	81	0	0	0	0
11/9/2019	1	3.1	60.9	1	0	0	0
11/10/2019	1	8.8	83.2	1	0	0	0
11/11/2019	1	11.8	91	3	0	6	1
11/12/2019	1	11.0	111	3	0	2	0
11/13/2019	1	2.8	52.8	0	0	0	0
11/16/2019	1	10.4	83.7	7	0	6	0
11/18/2019	1	5.7	136	3	0	0	0
11/24/2019	1	7.3	164	2	0	0	0
Totals: 30		**253.3**	**2790**	**106**	**5**	**33**	**6**

Table 3. Percentage of effort spent within US Navy range boundaries.

	Pt. Mugu Sea Range	**SoCal Range Complex**	**SOAR**
Fleet Monitoring	1.84%	98.4%	67.8%
Ancillary	5.2%	96.8%	64.2%

Table 4. Details of Cuvier's beaked whale sightings in 2019.

*Tags deployed includes those funded by the LMR Program, and provided here for movement habitat use reference.

Date	Sighting	Est. Group Size	Num Calves	Unique IDs	Biopsies Collected	Tags Deployed*
1/3/2019	PHO-3	4	0	4	0	0
1/4/2019	PHO-4	3	1	3	0	0
1/4/2019	PHO-6	4	2	4	0	0
1/4/2019	PHO-8	1	0	1	0	0
1/8/2019	PHO-3	3	0	2	0	0
1/11/2019	PHO-4	4	0	4	0	1
1/13/2019	PHO-3	4	0	4	1	1
3/1/2019	PHO-4	1	0	0	0	0
3/1/2019	PHO-5	5	1	5	0	0
3/5/2019	PHO-9	1	0	1	0	0
3/10/2019	PHO-5	3	0	2	0	0
2/10/2019	PHO-8	2	1	2	0	0
7/22/2019	PHO-5	1	0	0	0	0
10/5/2019	PHY-5	1	0	1	0	0
10/6/2019	PHO-4	1	0	0	0	0
10/6/2019	PHO-6	1	0	1	0	0
10/6/2019	PHY-5	4	0	4	0	0
10/11/2019	PHY-5	2	0	2	0	0
10/11/2019	PHY-7	2	1	2	0	0
10/12/2019	PHO-4	1	0	1	0	1
10/12/2019	PHO-5	2	0	3	0	0
10/12/2019	PHO-6	2	0	2	0	1
10/12/2019	PHY-2	4	0	4	3	0
10/13/2019	PHO-3	2	0	2	0	0
10/13/2019	PHO-4	1	0	1	0	0
10/13/2019	PHO-5	1	0	1	0	0
11/11/2019	PHO-2	3	0	3	0	0
11/11/2019	PHO-3	1	0	1	0	1
11/12/2019	PHO-2	2	0	2	0	0
11/12/2019	PHO-3	1	0	0	0	0
11/12/2019	PHY-1	4	1	4	0	0
11/16/2019	PHO-2	2	0	2	0	0
11/16/2019	PHO-3	2	0	0	0	0
11/16/2019	PHO-6	4	0	4	0	0
11/16/2019	PHO-7	4	0	4	0	0
11/17/2019	PHO-1	4	0	4	1	1
11/17/2019	PHO-2	1	0	0	0	0
11/17/2019	PHO-3	1	0	1	0	0
11/17/2019	PHO-4	2	0	2	0	0
Total: 39		**91**	**7**	**83**	**5**	**6**

Table 5. Details of fin whale sightings in 2019.

*One tag deployed was funded by the LMR Program and provided here for movement and habitat use reference.

Date	Sighting	Est. Group Size	Num Calves	Est. IDs	Biopsies Collected	Tags Deployed*
1/4/2019	PHO-2	2	0	2	0	1
1/8/2019	PHO-4	4	0	7	2	1
1/9/2019	PHO-5	1	0	0	0	0
1/13/2019	PHO-2	1	0	1	0	0
3/5/2019	PHO-12	1	0	0	0	0
3/5/2019	PHO-7	1	0	1	0	0
3/10/2019	PHO-7	2	0	0	0	0
3/10/2019	PHO-4	4	0	4	2	0
10/5/2019	PHY-4	2	0	0	0	0
10/5/2019	PHY-6	3	0	3	1	0
10/6/2019	PHY-2	1	0	1	0	0
10/7/2019	PHO-5	1	0	0	0	0
10/7/2019	PHO-2	1	0	1	0	0
10/7/2019	PHY-1	3	0	3	1	0
10/10/2019	PHO-5	1	0	1	0	0
10/10/2019	PHO-6	1	0	1	0	0
10/10/2019	PHO-7	2	0	1	0	0
10/10/2019	PHY-3	4	0	4	1	0
10/10/2019	PHY-1	1	0	1	0	0
10/11/2019	PHO-6	1	0	0	0	0
10/12/2019	PHO-3	1	0	0	0	0
10/12/2019	PHY-3	2	0	2	0	0
11/9/2019	PHO-1	1	0	0	0	0
11/18/2019	PHO-2	2	0	2	0	0
Total: 24		**43**	**0**	**35**	**7**	**2**

Photo-Identification and biopsy sampling

Cuvier's beaked whales

Cuvier's beaked whales were encountered during all field efforts, though sighting rates were lower in January, March, and July than in October and November, due at least in part to operating a second vessel during these later surveys and weather conditions. In the 443 hours of combined effort, 39 sightings totaling 91 whales were made, for an overall average of one sighting per 11.4 hours of effort. Median group size was two, with a range of one to five individuals. Photo-IDs and biopsy samples collected during all efforts are summarized in Table 4.

All identification photos of Cuvier's beaked whales collected in Southern California in 2019 (inclusive of all areas regardless of Navy range designation) were internally reconciled and compared to our historical catalog. This included the 83 successful identifications during combined survey effort at SOAR and seven opportunistic identifications made by collaborators from the SWFSC during an unrelated effort. These 90 identifications represented 56 unique individuals, who were photographed on an average of 1.6 days each (range 1-5). Twenty-seven (48%) of these individuals had been sighted in Southern California in a previous year, with sighting histories ranging from six months to twelve years in length (Table 6).

There were seven sightings of five different mother-calf pairs in 2019, one of which was first sighted together in 2018. Two mother-calf pairs were sighted together on more than one day. Their joint sighting histories each spanned approximately 9 months by the end of 2019, which is well below the maximum documented mother-calf association of 3.5 years for this population. Two mothers had sparse sighting histories spanning 10 and 12 years. Their 2019 calves are the first we have documented during this study.

The five biopsy samples collected from Cuvier's beaked whales during this study year brings the total number of samples archived since collection began at SOAR in 2006 to 17. While biopsy was not a priority for many of these years, the increased focus on biopsy sampling supported by this program is greatly improving this dataset. These samples are collected in collaboration with the SWFSC for both population genetics (SWFSC) and sex determination (MarEcoTel). We use these data to support ongoing efforts to evaluate population health using vital rates as a proxy. Recent advances in sample processing techniques may soon provide additional metrics of population health, such as comparative stress assessment with whales from regions not subject to frequent training exercises via hormonal or other genetic markers.

In addition to these samples, we began collection of eDNA water samples from the footprints of Cuvier's beaked whales at SOAR in 2017, as part of a partnership with OSU. To date we have collected 76 eDNA samples, and as this technique is refined it may also serve to augment our understanding of this population.

Both photo-ID and biopsy data are being used to derive other key vital rates for this population, particularly those that can be strong indicators of population health, and that are inputs into

PCoD models being developed to predict long-term effects of chronic exposure to MFAS. These include the calving interval (or, indirectly, the proportion of calves to reproductive age females at a given point in time), calf survival, weaning, and sex-specific maturity rates. Biopsy samples can be used to help elucidate stock structure (key for understanding cumulative impacts), assess stress and pregnancy status, amongst other metrics. Biopsy samples collected at SOAR will be compared to samples collected from Isla Guadalupe as part of a collaboration with researchers in Mexico, primarily funded by ONR. Because only a small proportion of the population has been genetically sampled, we have been working toward standardized methods of age and sex classification individuals from photographs alone. This approach was pioneered using photographs of Cuvier's beaked whales from the Mediterranean Sea (Coomber et al., 2016; Rosso et al., 2011). We piloted an adaptation of these published methods for use on whales from California through an ONR-supported project (Falcone et al., 2018). Results were highly promising, and thus in 2019 we partnered with the authors of the Mediterranean studies to host a Cuvier's beaked whale age-sex classification workshop at the World Marine Mammal Conference in Barcelona, Spain, December 2019. The goal of this workshop was to lay the groundwork for a global standard of age-sex classification from photos so that all researchers maintaining photo-ID collections of Cuvier's beaked whales can derive comparable vital rate estimates for their study populations, thus providing our first insights into these important but virtually unknown elements of beaked whale ecology.

While some of the requisite data remain sparse and thus these estimates are uncertain, we derived several preliminary vital rates for the population of Cuvier's beaked whales at SOAR and presented them at the World Marine Mammal Conference 2019, along with the workshop (Falcone et al., 2019). Females appear to produce a calf roughly every four years. Calves likely remain closely associated with their mother for approximately two years, and then wean and gradually disperse in their third year. Whales appear to retain juvenile appearance from ages 4-7 years, sexually maturing through ages 7-10 years, at which point they attain adult appearance.

A manuscript titled "Abundance, survival, and annual rate of change in Cuvier's beaked whales (*Ziphius cavirostris*) on a Navy sonar range" by K. Alexandra Curtis et al. was submitted to the journal *Royal Society Open Science* in 2019, and is in final review with an anticipated publication date in Spring 2020. This manuscript, which expands upon the power analysis performed under a previous ONR award (Moore et al., 2017) incorporated our Cuvier's photo-ID data from M3R surveys at SOAR through 2018 to provide the first robust estimates of these key demographic rates for this population.

Table 6. Summarized sighting histories for 27 individual Cuvier's beaked whales identified in 2019 and any previous year.

ID	First Sighting	Last Sighting	Encounters	Year Span
5	10/23/2007	1/13/2019	6	11.2
7	10/23/2007	11/17/2019	10	12.1
14	10/24/2007	6/1/2019	6	11.6
19	10/24/2007	10/11/2019	4	12.0
27	10/25/2007	3/10/2019	6	11.4
39	8/3/2008	1/3/2019	6	10.4
40	8/3/2008	10/12/2019	5	11.2
46	8/3/2008	10/6/2019	7	11.2
77	11/11/2009	10/12/2019	2	9.9
87	9/27/2010	10/12/2019	3	9.0
94	6/28/2010	11/12/2019	4	9.4
132	3/30/2013	11/12/2019	10	6.6
148	1/6/2014	11/16/2019	4	5.9
150	1/6/2014	10/12/2019	4	5.8
175	1/7/2015	11/17/2019	3	4.9
186	1/9/205	1/3/2019	2	4.0
187	1/9/2015	11/17/2019	11	4.9
191	10/5/2014	3/1/2019	6	4.4
197	1/11/2016	1/13/2019	3	3.0
206	4/6/2016	10/13/2019	5	3.5
218	7/24/2017	10/12/2019	4	2.2
223	7/25/2017	11/17/2019	2	2.3
237	3/29/2018	11/11/2019	3	1.6

Fin whales

Fin whales were sighted in and around SOAR again in 2019, as whales continue to move back into the Southern California Bight after a marked decrease during the El Niño conditions of 2016-2017. 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 photo-ID from 2018 that were processed in 2019.

We processed 319 total fin whale identifications from 2018 into our archive, bringing the total number of fin whale identifications in our collection to 3,782 as of the end of that year. This included 42 whales photographed by MarEcoTel during surveys supported by Fleet Monitoring and related efforts, 45 whales photographed by SWFSC during a large-scale cetacean assessment survey from northern Mexico to southern British Columbia, and 40 whales photographed by Cascadia Research Collective off Southern and Central California during other research. The remaining identifications were all provided by citizen scientists in Southern California, with the majority (183) coming to us via Aquarium of the Pacific and the HappyWhale app.

While all photos received were reconciled internally and compared to the historical fin whale catalog, 94 (29.5%) were not matched historically and of insufficient quality to constitute a new ID. The remaining photos represented 123 unique individuals, which were identified on an average of 1.57 days each in 2018 (range 1-11 days). For the 30 individuals sighted on more than one day that year, the average span from first to last annual sighting was 72 days (range 1-309). Forty-four of 123 whales were sighted prior to 2018, with sightings in 4.3 different years on average (range 2-10 years). These sightings spanned an average 6.1 years from first to last date (range 2-23 years) (Table 7).

Currently, Southern California remains the focal region for our fin whale photo-ID study, with a catalog now totaling 693 individuals. While extra-regional sampling remains more limited, these collections are growing, and our US West Coast catalog now includes 132 individuals sighted off Central California, 172 individual sighted between Northern California and the US-Canada border, and a smaller number of individuals seen off northern Mexico and Southern British Columbia. Individual sighting histories continue to suggest that fin whales do not mix freely throughout the putative US West Coast stock boundaries, and that some animals exhibit year-round residency to the Southern California region. Only five of the 44 whales sighted in 2018 with previous sighting histories have been sighted outside Southern California, and two of these have been sighted exclusively in other regions (Northern California and Washington). The other three have been sighted in both Southern and Central California, which may represent a region of seasonal overlap between population segments.

Seven biopsy samples were collected from fin whales in 2019, bringing the total number of fin whale samples collected by MarEcoTel since 2016 to 27. Fin whale samples have been collected in the course of other research by us and collaborators for many years, and at this point 108 whales in our catalog have had at least one tissue sample collected. Eighty-one whales in the catalog have been genetically-sexed (37 female and 44 male), allowing us to begin to assess whether there are sex-based differences in sighting history or movement patterns for those whales that have been both sexed and satellite-tagged. All fin whale samples from this project are archived for use in a variety of larger scale genetic assessments by the SWFSC.

Table 7. Summarized annual sightings histories for fin whales sighted in 2018 and any previous year.

ID	Total Years Sighted	First Year	Last Year	Year Span
66	2	2008	2018	10
252	7	1995	2018	23
291	5	2009	2018	9
304	5	2009	2018	9
307	6	2009	2018	9
308	6	2009	2018	9
323	8	2009	2018	9
324	4	2009	2018	9
326	8	2009	2018	9
351	8	2010	2018	8
353	9	2010	2018	8
354	10	2009	2018	9
368	7	2010	2018	8
380	9	2010	2018	8
387	4	2010	2018	8
427	3	2011	2018	7
430	7	2011	2018	7
434	4	2011	2018	7
456	6	2012	2018	6
460	3	2012	2018	6
483	2	2012	2018	6
512	7	2012	2018	6
529	2	2012	2018	6
541	2	2013	2018	5
546	4	2012	2018	6
587	4	2013	2018	5
598	5	2013	2018	5
628	2	2013	2018	5
630	5	2013	2018	5
700	3	2014	2018	4
790	2	2015	2018	3
796	2	2015	2018	3
808	2	2015	2018	3
857	2	2015	2018	3
873	2	2015	2018	3
874	3	2014	2018	4
905	3	2014	2018	4
907	3	2014	2018	4
959	2	2016	2018	2
977	3	2016	2018	2
1042	2	2017	2018	1
1056	2	2017	2018	1
1061	2	2017	2018	1
1075	2	2017	2018	1

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. The tags deployed during Fleet Monitoring efforts are being analyzed in conjunction with data from other projects (e.g. Schorr et al. 2014, Falcone et al. 2017, Scales et al. 2017) in order to improve sample size and broaden context. Therefore, only basic summary information is provided here.

Two satellite tags purchased by this contract were deployed during 2019, one each on a fin whale and Risso's dolphin. Transmission durations were 17.4 and 11.3 days, respectively (Table 8, Figure 7). A map of the fin whale track is not included in this report due to the poor transmission performance of the tag. Despite an ideal placement (i.e., position on fin, flush to dorsal surface), the tag only provided five positions over the course of the 17 transmission days. The cause of this poor performance could not be determined but may have been due to behavior (e.g. not bringing the dorsal fin above the water when surfacing), or poor battery status, as the few status messages received from the tag indicated low voltage. Data from these two tags, as well as those deployed under Fleet Monitoring efforts in 2017 and 2018, are available on the Animal Telemetry Network (ATN)

Seven additional tags were deployed in 2019 during other Navy-funded work at SOAR: one on a fin whale and six on Cuvier's beaked whales. All were dart-attached archival tags designed to collect high-resolution behavioral data to support enhanced sonar response assessments. These tags were programmed to release from 6-12 days after deployment, depending on tag type and other circumstances (e.g. weather forecasts, future range access). Actual transmission durations for these tags ranged from 0.34-12.4 days (Table 8). In general, the movements of these whales were consistent with those seen previously, where Cuvier's beaked whales preferentially used SOAR, though one animal did move south in Mexican waters during the deployment period (Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14).

During the nearly 12 days of transmissions, the Risso's dolphin (Gg-20190719-102468, Figure 7) spent time in the Catalina, Santa Monica, and San Pedro basins, ultimately returning to the nearshore waters of Catalina Island at the time of last transmission. Movement and dive data from this individual will be combined with previous Risso's dolphin deployments for a manuscript planned for submission in 2020.

Fin whale Bp-20190108-173188 (Figure 8) was tagged on the northwest corner of the SOAR range. The animal remained in the area for two days before moving west into Tanner Basin and then south and southeast through it. Data from this high-resolution dart-attached archival tag will be used to support behavioral response studies.

Additionally, two peer-reviewed papers were published in 2019 using diving and movement data from fin whales tagged during previous Navy-funded projects. One paper (Keen et al., 2019a) explored the differences in diel diving behavior of fin whales within the Southern California Bight, and the other (Keen et al., 2019b) addressed the risk of ship strikes to fin whales, particularly focusing on diel differences. Both papers were published open-source and copies are available at: http://www.marecotel.org/publications.html.

Table 8. Satellite tags deployed Navy-funded efforts in 2019 (note, one fin whale tag and all Cuvier's beaked whale tags were deployed during Living Marine Resource-supported efforts).

Tag ID	Species	Tag Type	Date	Trans. Dur. (days)
Bp-20190104-94786	Fin Whale	Spot5	1/4/2019	17.40
Gg-20190719-102468	Risso's Dolphin	Mk10-A	7/19/2019	11.30
Bp-20190108-173188	Fin Whale	Lander II	1/8/2019	5.51
Zica-20190111-173186	Cuvier's Beaked Whale	Lander II	1/11/2019	9.06
Zica-20190113-151361	Cuvier's Beaked Whale	SMRT	1/13/2019	0.53
Zica-20191012-144029	Cuvier's Beaked Whale	SMRT	10/12/2019	5.90
Zica-20191012-145101	Cuvier's Beaked Whale	SMRT	10/12/2019	6.94
Zica-20191111-94810	Cuvier's Beaked Whale	SMRT	11/11/2019	12.43
Zica-20191117-195993	Cuvier's Beaked Whale	SMRT	11/17/2019	0.34

Home Range Analyses

Home range estimates were calculated using data from 27 tag deployments on Cuvier's beaked whales from 2008-2017 and from 16 tag deployments on Risso's dolphin from 2009-2019. From these tag deployments, 6,828 and 2,222 locations were obtained from Cuvier's beaked whales and Risso's dolphins respectively. Cuvier's beaked whale locations were obtained from all months of the year, while Risso's dolphin locations were obtained from all months except October and December. Of the 6,828 Cuvier's beaked whale locations, 984 were from tags deployed on whales in the Catalina Basin and the rest were from whales tagged in the San Nicolas Basin. After following the methods mentioned above to find average locations and handle data when the tags were duty cycling, 1,012 Cuvier's beaked whale locations (107 for Catalina Basin and 905 for San Nicolas Basin) and 186 Risso's dolphin locations were used in the creation of the 50% and 95% home range estimates.

The 50% and 95% home range estimates for tagged Risso's Dolphins and Cuvier's beaked whales are provided in Figure 15, Figure 16, Figure 17, Figure 18. Risso's dolphins tagged in Southern California appear to utilize the entire Southern California Bight, but the area encompassed by the 50% home range is generally centered around the outer islands and basins (Figure 15). However, it should be noted that all these tags were deployed in the outer waters of the Bight, and if there is inshore-offshore population structure, these results may be biased.

Though based on just two tag deployments lasting 48 and 58 days, the home range of Cuvier's beaked whales tagged in the Catalina Basin (Figure 16) suggests a preference for the west side of the basin, a pattern similar to that seen in the San Nicolas Basin. The entire 95% home range for Cuvier's beaked whales tagged within the Catalina Basin were within SOCAL. Of note, many locations from the Catalina tags were within, or adjacent to, an area frequently used for testing Directional Command Activated Sonobuoy Systems (DICASS).

The 50% home range boundary for Cuvier's tagged within the San Nicolas Basin encompasses almost the entire SOAR range, which is in turn almost entirely within SOCAL (Figure 17 and Figure 18). More than half of the 95% home range area is within SOCAL, while an additional 45% lies within the Pt Mugu Sea Range.

Overlap with Navy sonar

Nineteen tags deployed on Cuvier's beaked whales in and around SOAR between 2010 and 2015 were available for this analysis. Of those tags, fifteen had overlapping bouts of high-power or mid-power sonar (Table 9). These fifteen tags recorded dive data for a total of 479.3 days. There was a combined 10.8 total days of known sonar use during these deployments (approximately 10.3 days of high-power and 0.5 days of mid-power). Tag IDs 14 and 24 were not included in our models because sonar never occurred during a dive cycle for which we had a complete behavioral record (i.e. no data gaps), thus prohibiting us from creating IDDI sequences following sonar exposures.

The best-fit model included the following predictors: time of day, dive duration, closest sonar exposure distance, and IDDI sequence (number of dive cycles since the last exposure). In this model, IDDIs with concurrent sonar use (i.e. sequence number = 0) were elevated, with total duration strongly predicted by distance to the nearest source (Figure 19), as described in Falcone et al. (2017). All subsequent unexposed IDDIs were predicted to be significantly shorter than exposed IDDIs, and close to the mean unexposed IDDI (110.0 min, st. dev. = 56.2). There was some indication that IDDI may fall below average in the first four dive cycles following exposure (Figure 1). The 95% confidence intervals for the predicted IDDIs tended to increase as the number of dives since the last exposed deep dive increased, becoming quite wide due, at least in part, to sparseness of data beyond 30 dives cycles post-exposure (approximately 3.9 days) and other sources of variation in IDDI and (Figure 19).

The best-fit model included time of day as a significant predictor of IDDI (Figure 20). IDDIs that began during dawn (solar elevation between 6 and -12 degrees between midnight and noon) were significantly longer than IDDIs occurring at any other time of the day. Figure 21 demonstrates the high degree of variability in IDDI, within and between individuals, and the strong time-of-day effect across eight whales that are free of sonar effects. During this period, daytime IDDIs averaged 115.0 minutes (st. dev. = 45.7), nighttime IDDIs averaged of 105.6 minutes (st. dev. 48.9), IDDIs during dusk averaged 91.2 minutes (st. dev. 47.9), and dawn IDDIs averaged 161.4 minutes (st. dev. 35.7).

These results confirm that IDDI is elevated during concurrent sonar use within 100 km, but that this effect does not appear to persist beyond the exposed dive cycle once sonar use ceases (Figure 19). There is a weak signal suggesting IDDI falls below average (and thus deep dive frequency increases) in the four dive cycles following exposure, climbs slightly at the fifth dive cycle, and then returns to average. While the significance of this apparent "recovery" pattern is hard to determine given the increasing spread of IDDI data beyond 10 dive cycles post-exposure, the unusually constrained confidence intervals in the immediate post-exposure period do suggest this is a real effect in the data. Data from the pre-exposure period in January (Figure 21), further suggest that wide variability in IDDI duration is normal in an unexposed state, and that the unusually tight intervals around the predicted IDDIs immediately following exposure are atypical (Figure 19).

It should be noted that we consider deep dive rate a proxy for foraging effort, but we are not able to independently confirm the presence or efficacy of foraging during these deep dives via these tag sensors. Vocal rate data from M3R may be able to provide some insights into changes in foraging effort post-exposure, as will data from more advanced tags with accelerometers and acoustic sensors that have been deployed since. Cuvier's beaked whales may change their foraging strategy following exposed dive cycles without significantly increasing deep dive frequency or duration. A detailed review of dive cycles, including both dive and surfacing parameters, immediately following the most prolonged periods without apparent foraging (i.e. the upper 95% percentile of IDDI) is warranted to see if a recovery trend becomes more apparent in the most extreme circumstances, an effect that may be masked in this large-scale analysis. These results also highlight the need for a more comprehensive review of periods where exposures occur nearly continuously over longer periods (e.g., more than 1 day) to assess the effect of cumulative exposures on subsequent dive cycles.

Table 9. Summary of tag deployments and coincident Mid-Frequency Active sonar use.

			Number of bouts		Median and range bout durations (mins)		Median and range distances between sonar platform and whale (km)	
Tag ID	Deploy date	Tag dur. (days)	High-power	Mid-power	High-power	Mid-power	High-power	Mid-power
14	1/6/2011	20.1	24	10	37 (0-235)	9 (1-15)	51 (14-82)	22 (11-38)
15	1/6/2011	67.8	50	54	114 (3-1439)	6 (0-39)	50 (19-99)	44 (17-99)
16	1/6/2011	87.2	97	87	109 (0-1439)	8 (0-1418)	59 (13-100)	36 (11-100)
19	1/15/2012	11.1	2	6	737 (34-1439)	9 (0-13)	40 (29-51)	23 (20-27)
20	1/15/2012	25.5	17	11	110 (34-1439)	10 (0-15)	48 (7-99)	37 (32-64)
21	3/29/2013	47.2	16	22	57 (9-216)	7 (0-81)	42 (13-88)	18 (10-83)
22	3/30/3013	23.8	13	15	59 (10-216)	10 (0-81)	32 (19-94)	15 (10-25)
23	3/30/3013	5.8	3	0	117 (42-129)	NA	51 (20-94)	NA
24	1/4/2014	11.0	2	0	23 (2-45)	NA	59 (59-59)	NA
26	1/4/2014	46.6	44	82	60 (2-445)	6 (1-39)	52 (25-98)	54 (27-82)
28	1/7/2014	48.2	40	91	59 (2-445)	6 (1-119)	60 (22-90)	23 (6-98)
34	1/3/2015	16.1	2	40	23 (20-26)	6 (0-52)	45 (28-62)	11 (3-27)
35	1/7/2015	13.5	2	26	23 (20-26)	7 (0-36)	39 (21-58)	25 (16-53)
36	1/9/2015	41.9	29	96	43 (2-449)	6 (0-36)	56 (8-91)	32 (2-68)
37	1/9/2015	13.4	12	38	28 (2-91)	6 (0-36)	26 (6-100)	19 (2-32)

Acknowledgements

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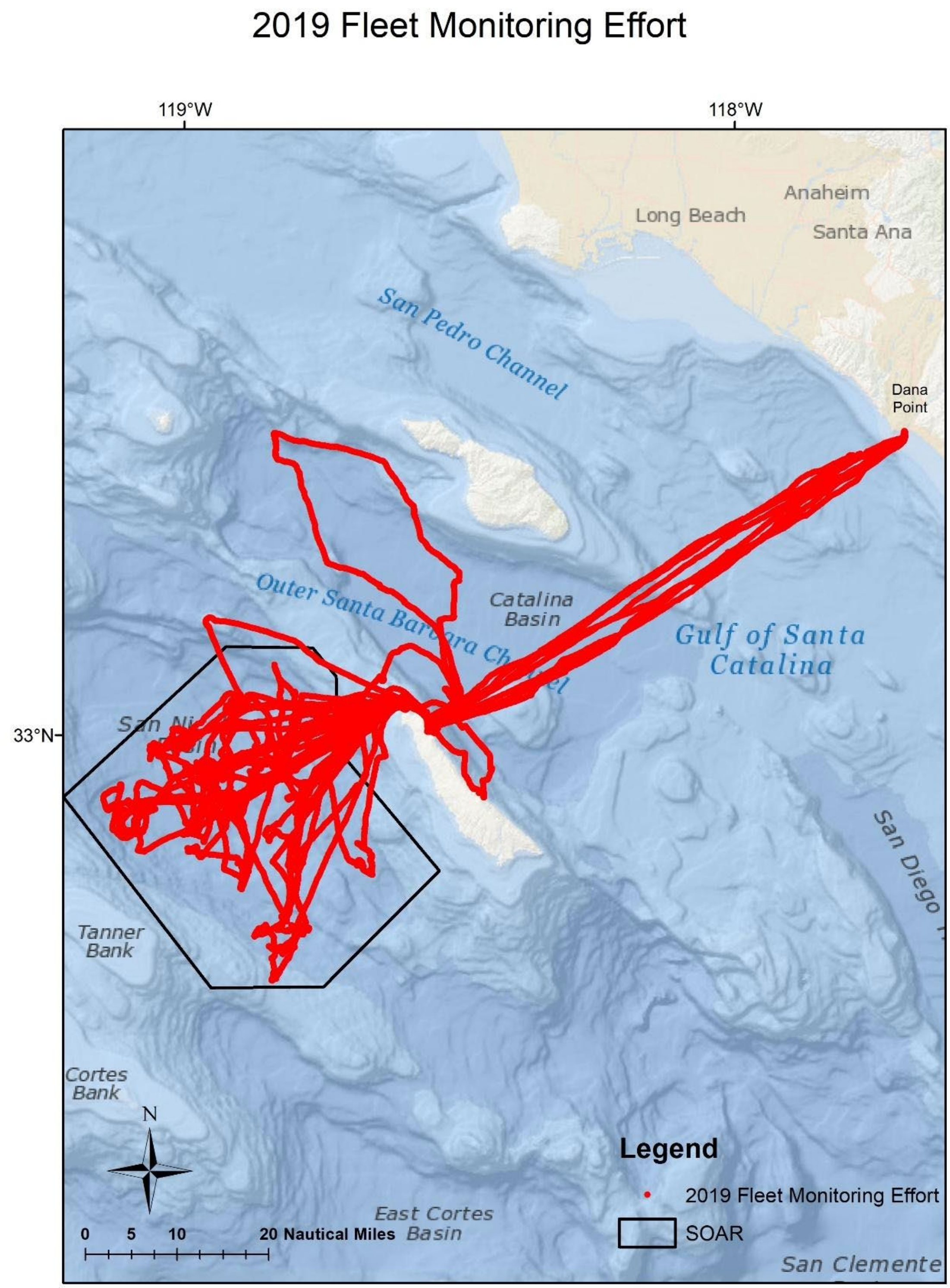

Figure 1. Vessel track lines from Fleet Monitoring surveys conducted from 2 January 2019 through 17 November 2019.

SOAR = Southern California Anti-submarine Warfare Range
Prepared by B. Rone

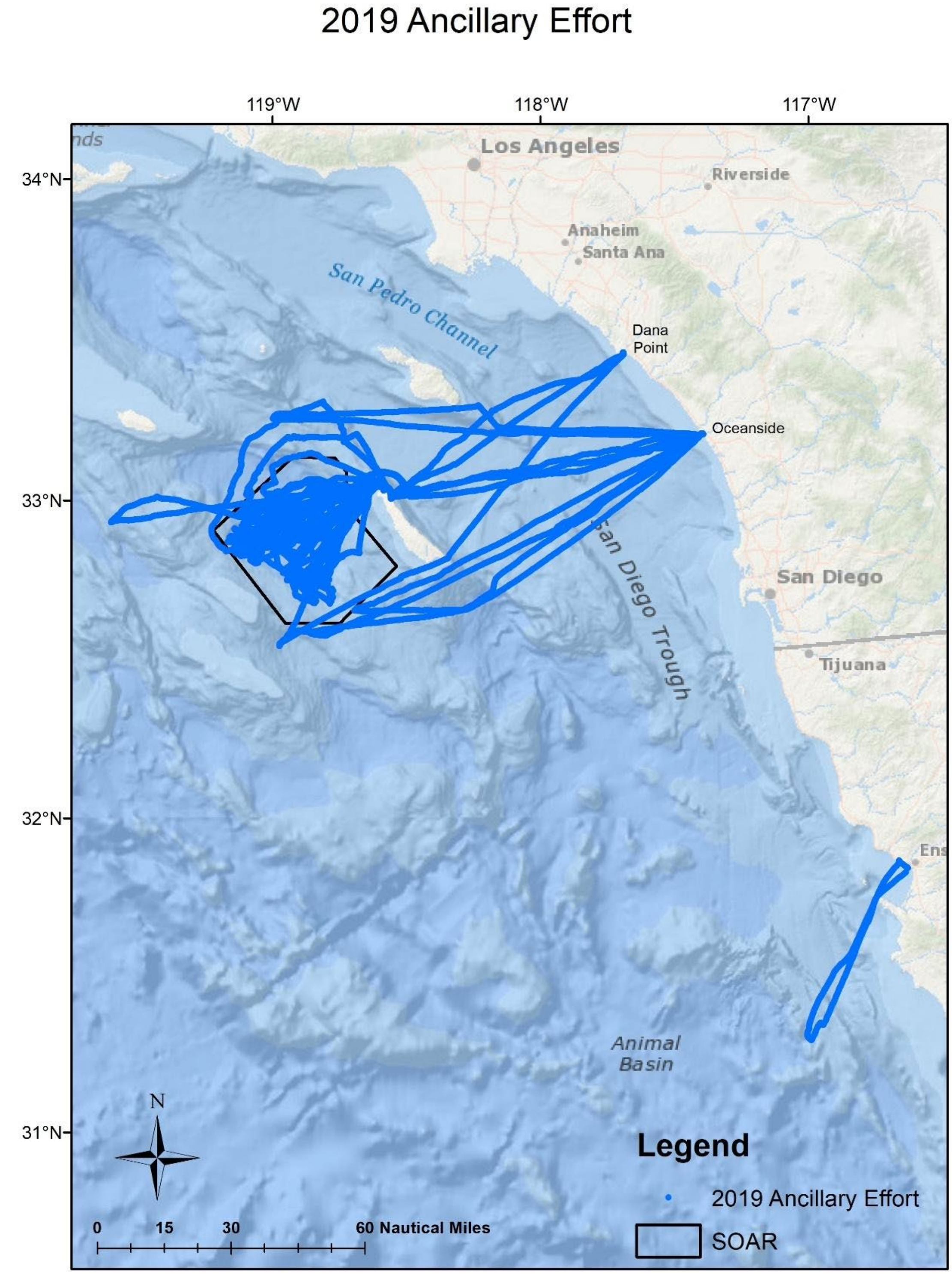

Figure 2. Vessel track lines from ancillary surveys conducted 8 January 2019 through 24 November 2019.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

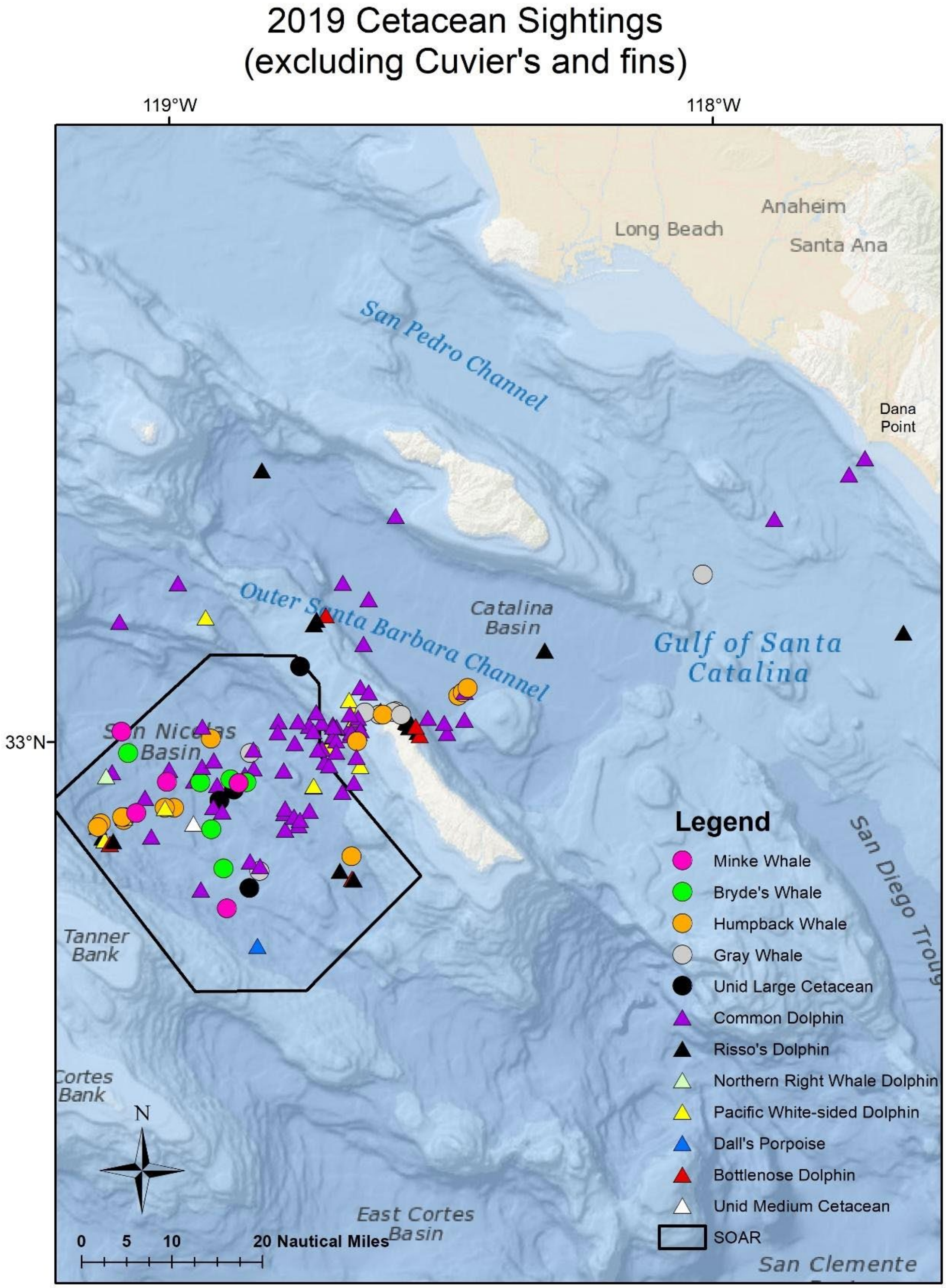

Figure 3. Sighting locations of cetaceans (except Cuvier's beaked whales and fin whales) by species from surveys conducted in 2019.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

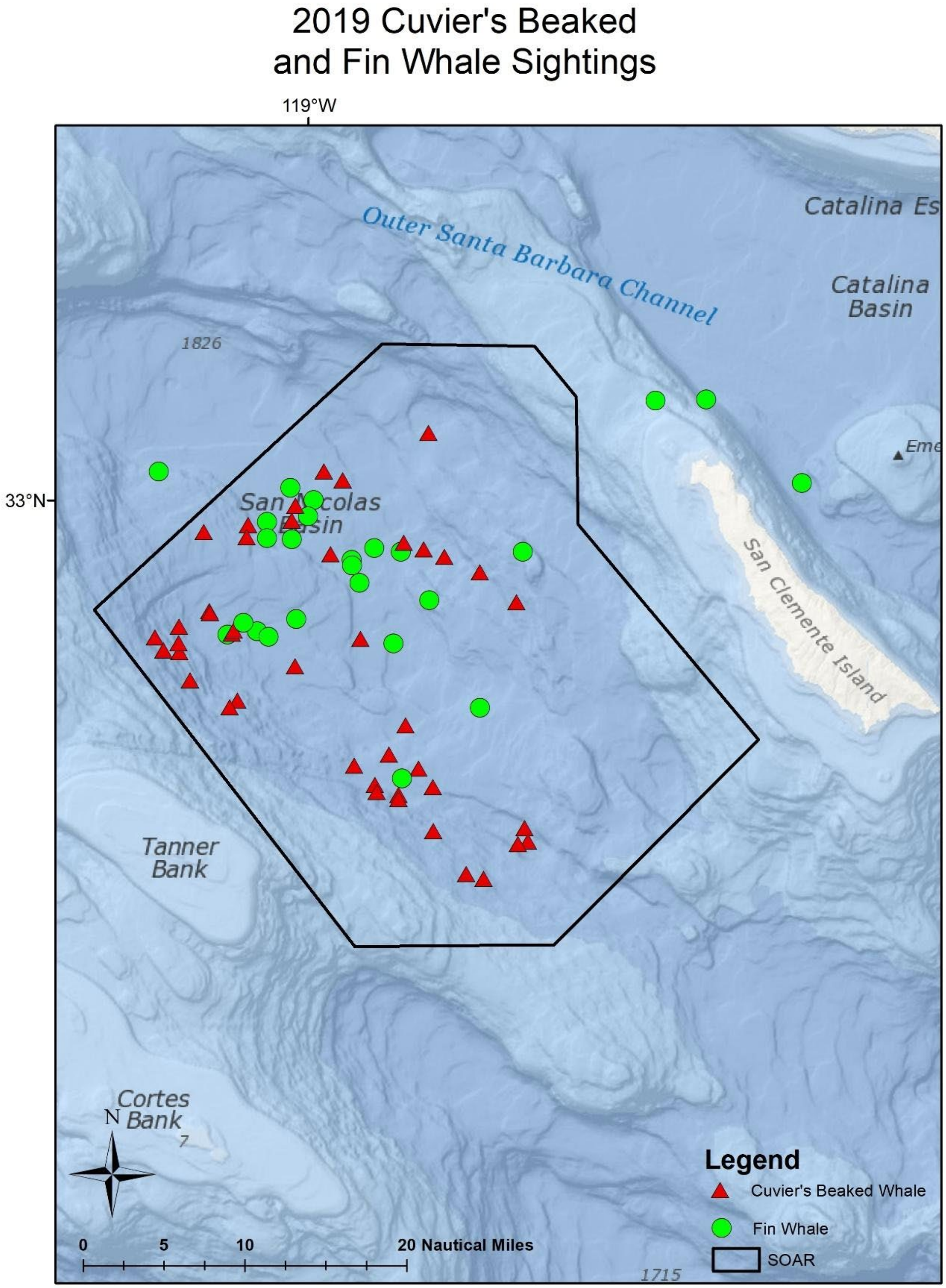

Figure 4. Cuvier's beaked and fin whale sightings from surveys conducted in 2019.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone.

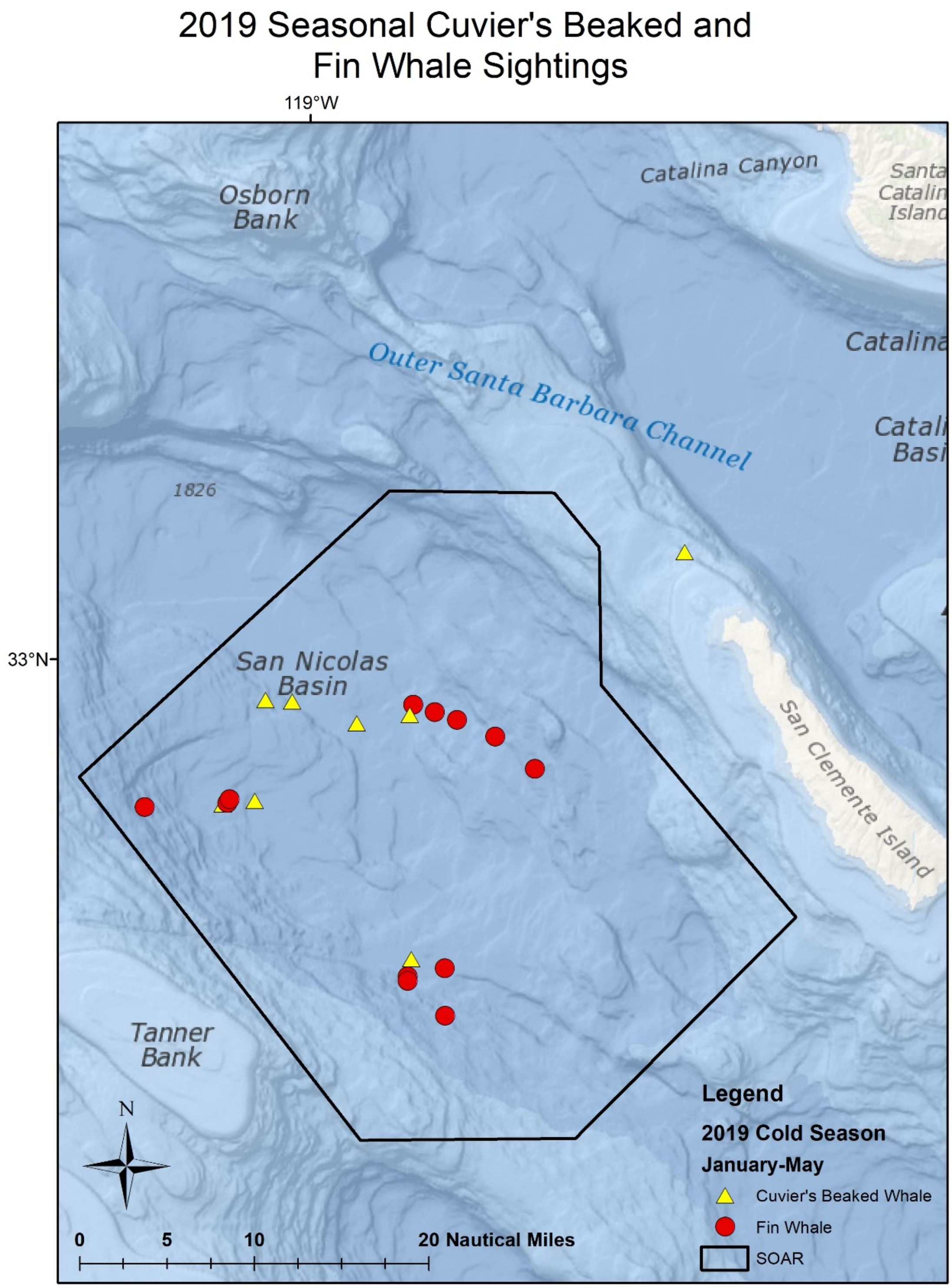

Figure 5. Cold season (January – May) locations of Cuvier's beaked whales and fin whale sightings from surveys conducted in 2019.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

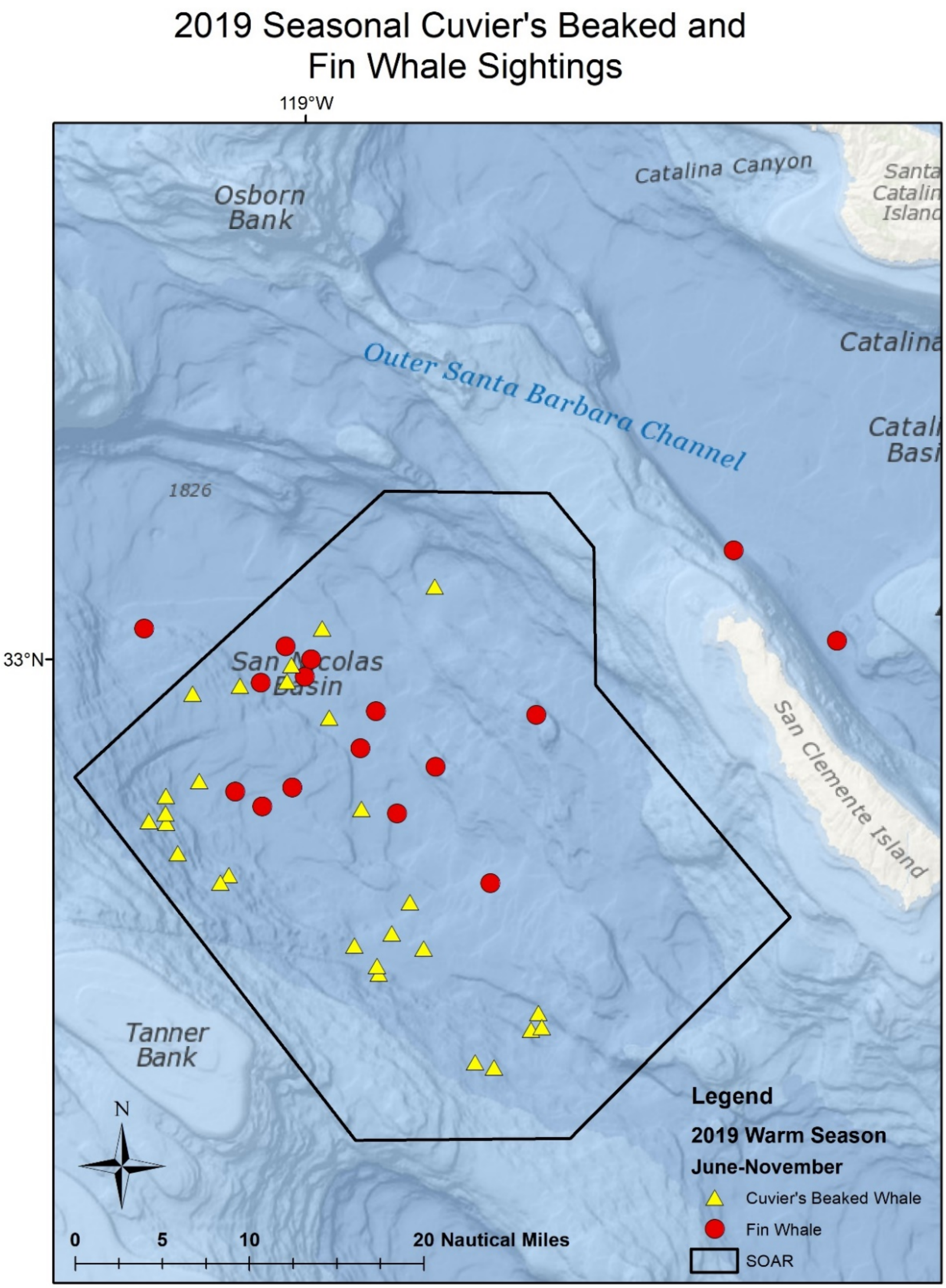

Figure 6. Warm season (June – November) locations of Cuvier's beaked whales and fin whale sightings from surveys conducted in 2019.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

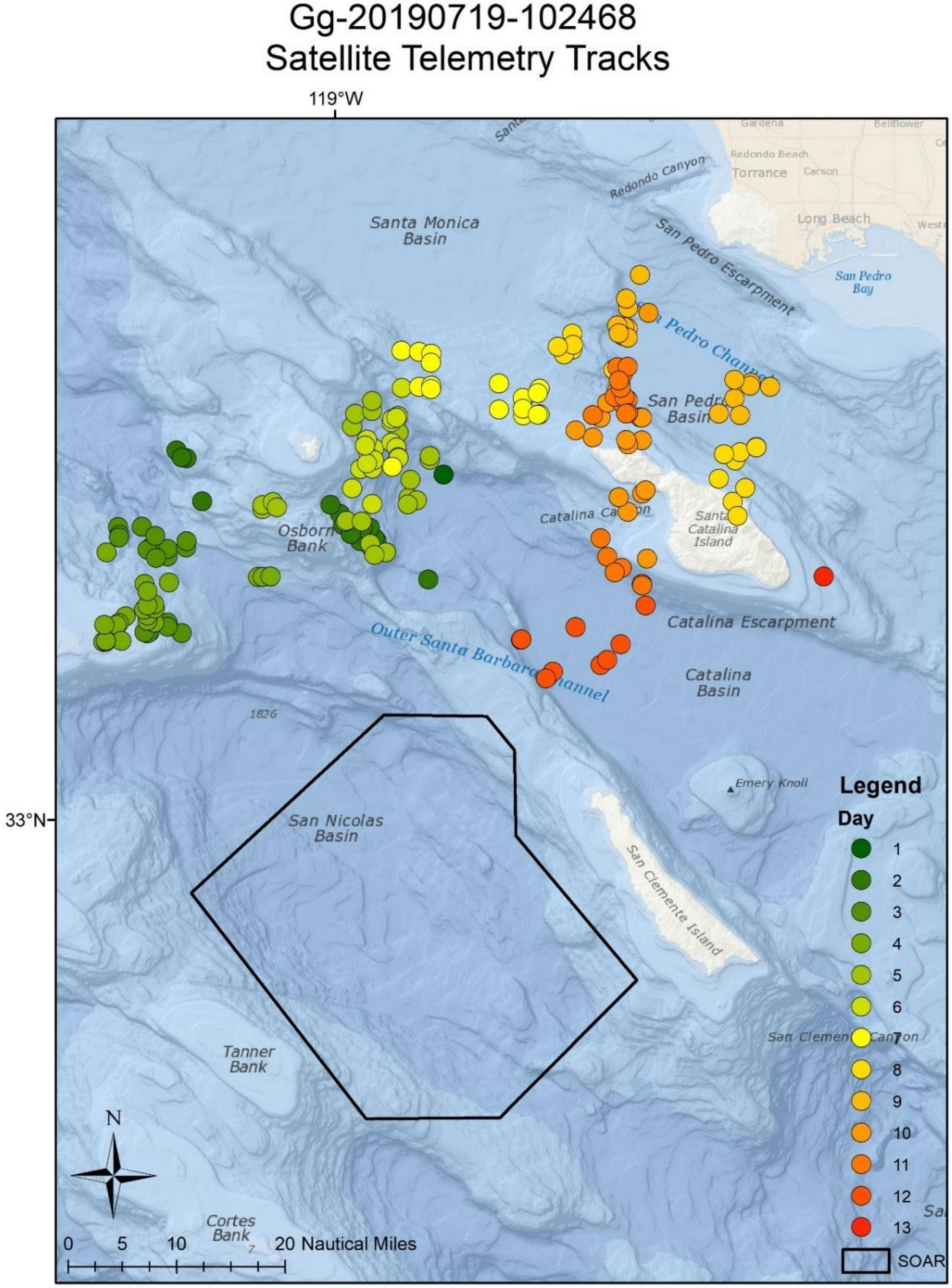

Figure 7. Satellite telemetry tracks from a tagged Risso's dolphin deployed as part of the Fleet Monitoring study.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

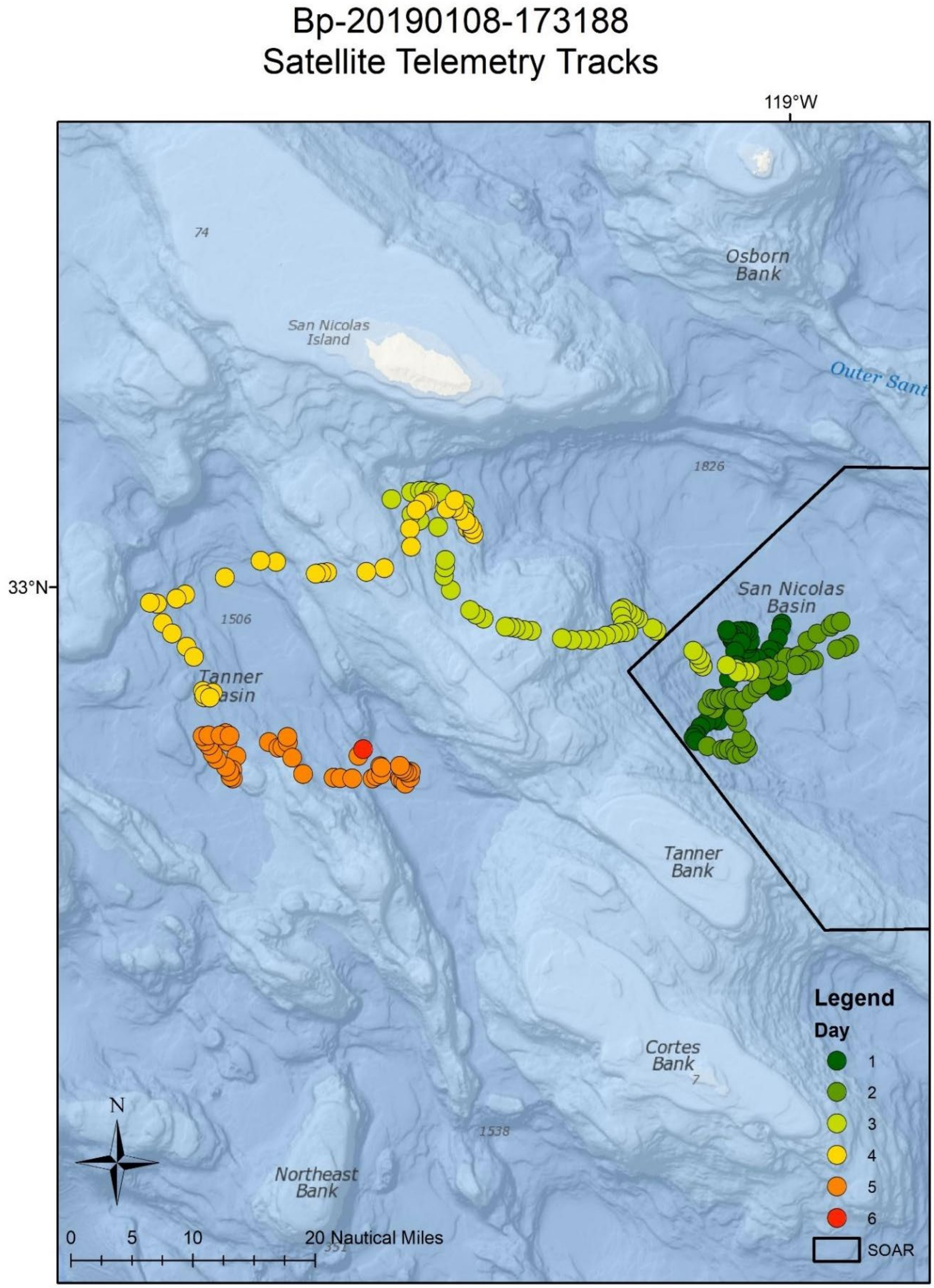

Figure 8. Satellite telemetry tracks from a tagged fin whale deployed as part of an ancillary project funded by a Living Marine Resources study.

SOAR = Southern California Anti-submarine Warfare Range
Prepared by B. Rone.

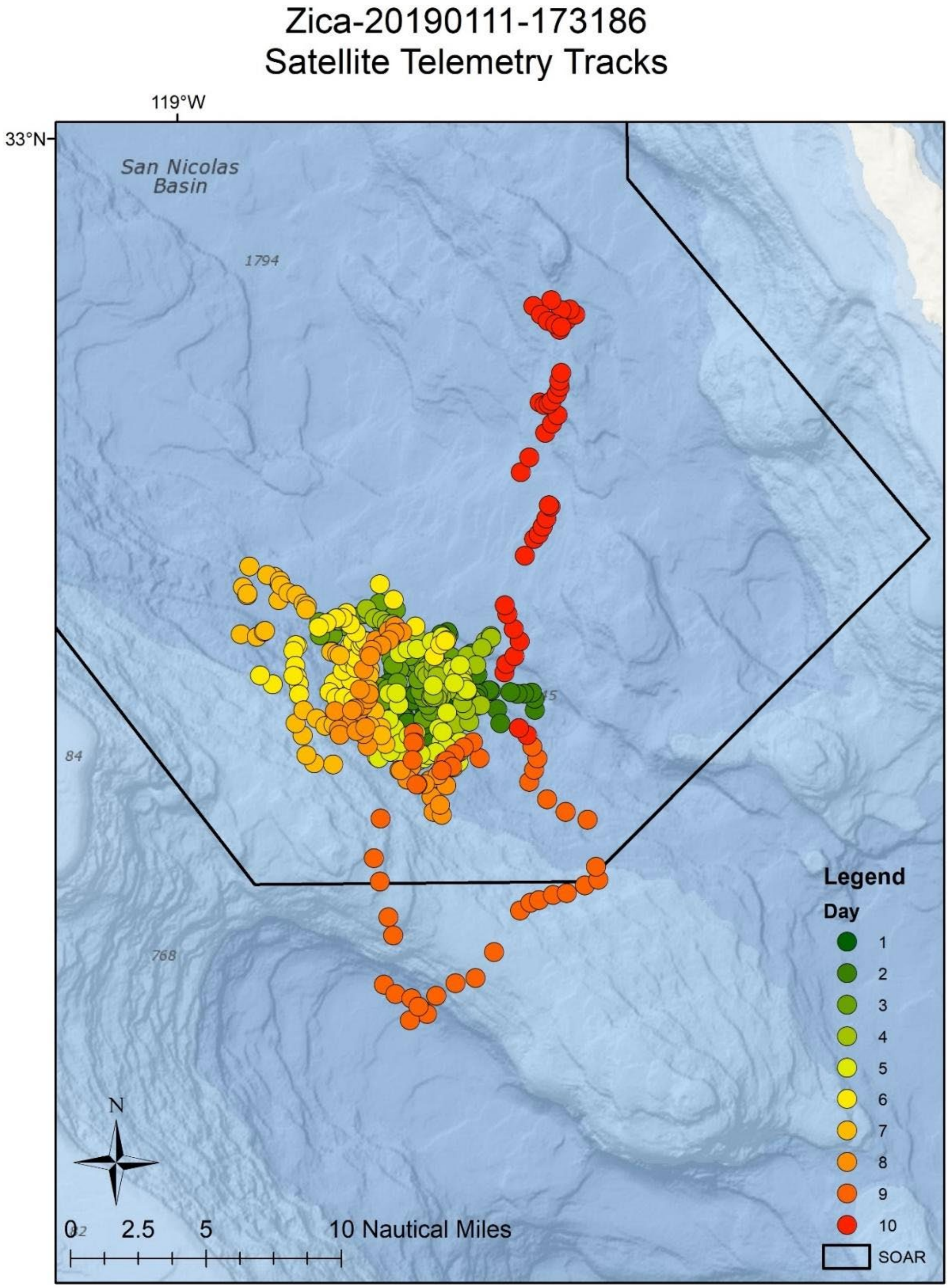

Figure 9. Satellite telemetry tracks from a tagged Cuvier's beaked whale deployed as part of an ancillary project funded by a Living Marine Resources study.

SOAR = Southern California Anti-submarine Warfare Range
Prepared by B. Rone

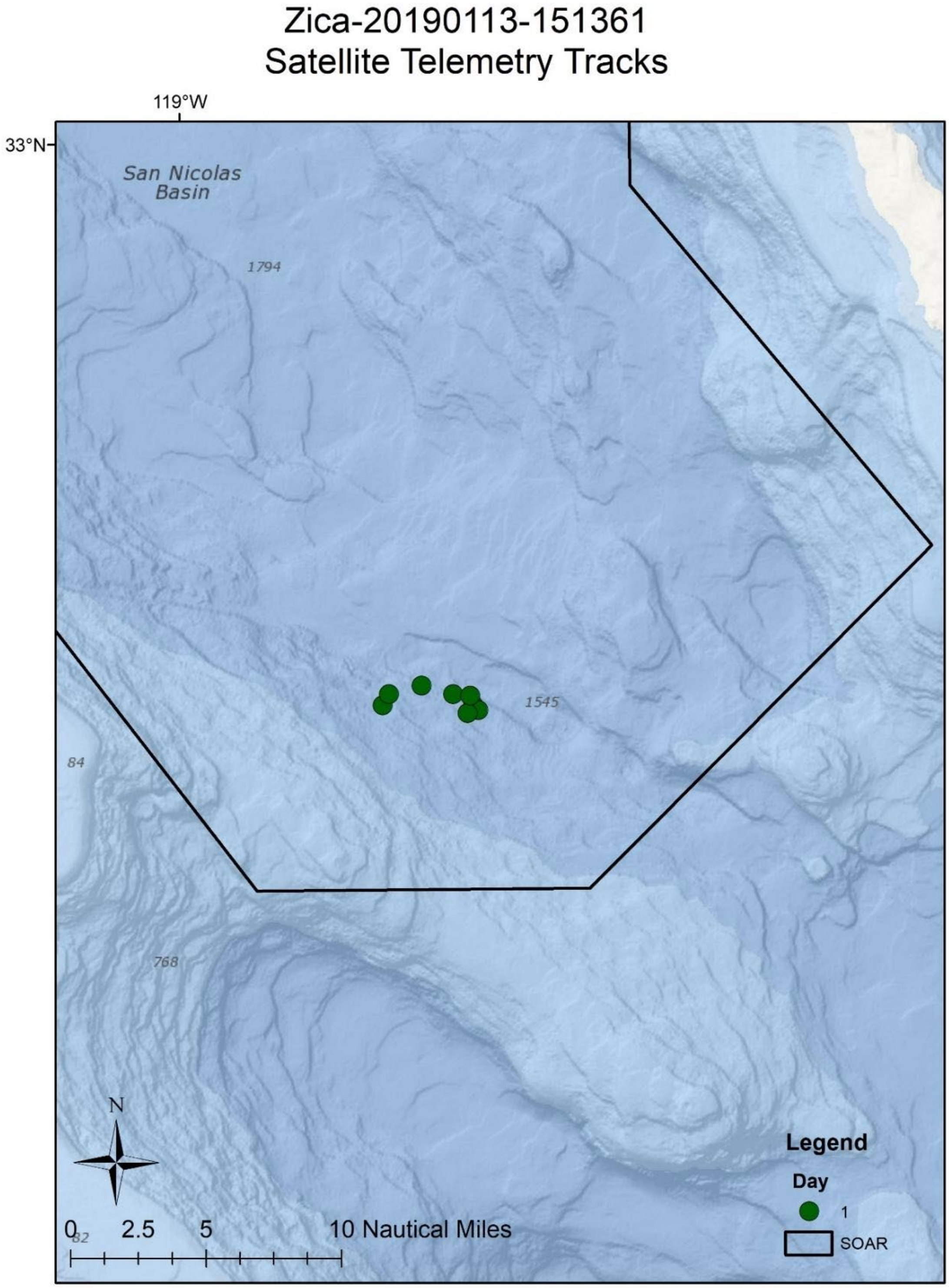

Figure 10. Satellite telemetry tracks from a tagged Cuvier's beaked whale deployed as part of an ancillary project funded by a Living Marine Resources study.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

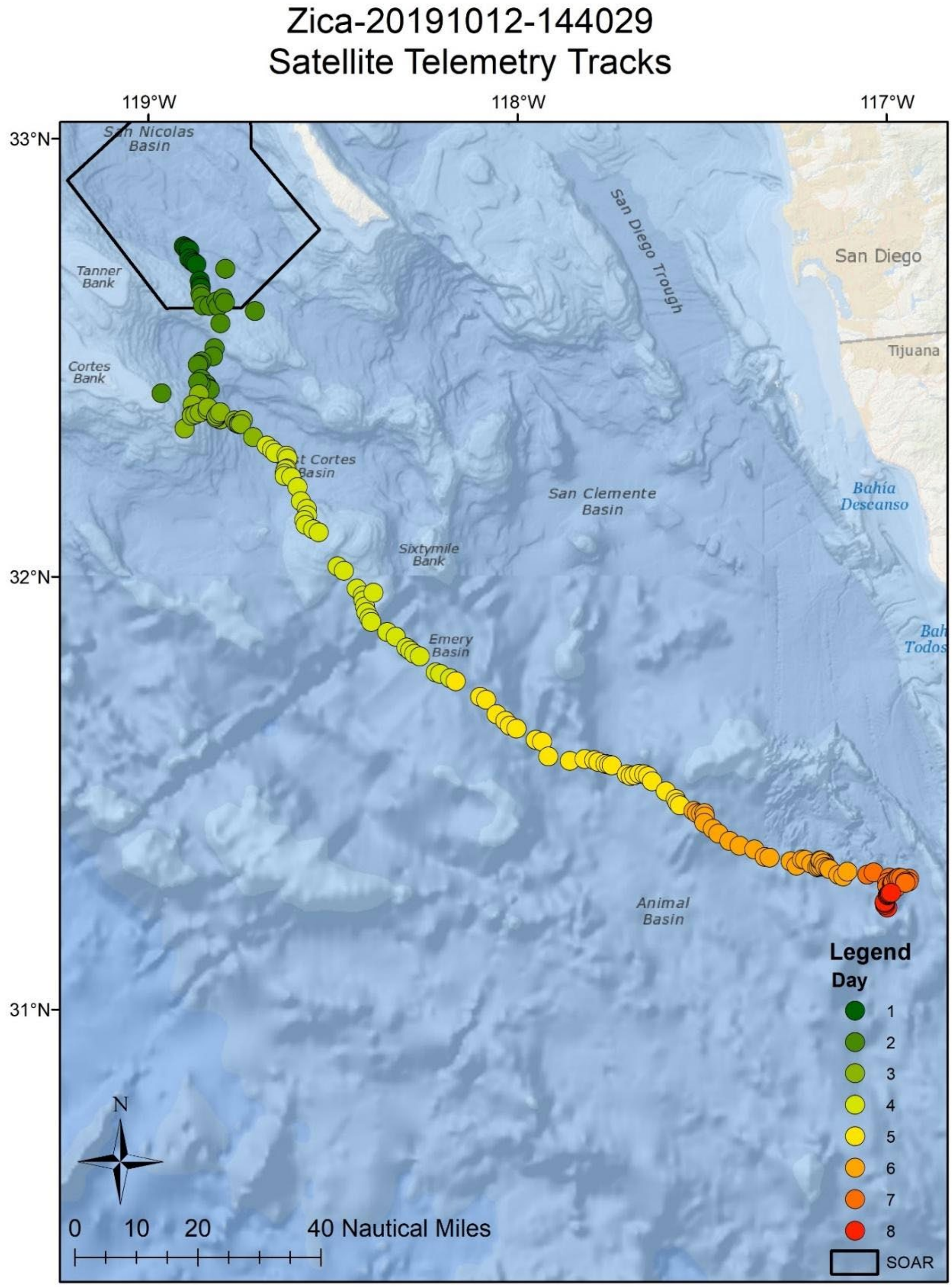

Figure 11. Satellite telemetry tracks from a tagged Cuvier's beaked whale deployed as part of an ancillary project funded by a Living Marine Resources study.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

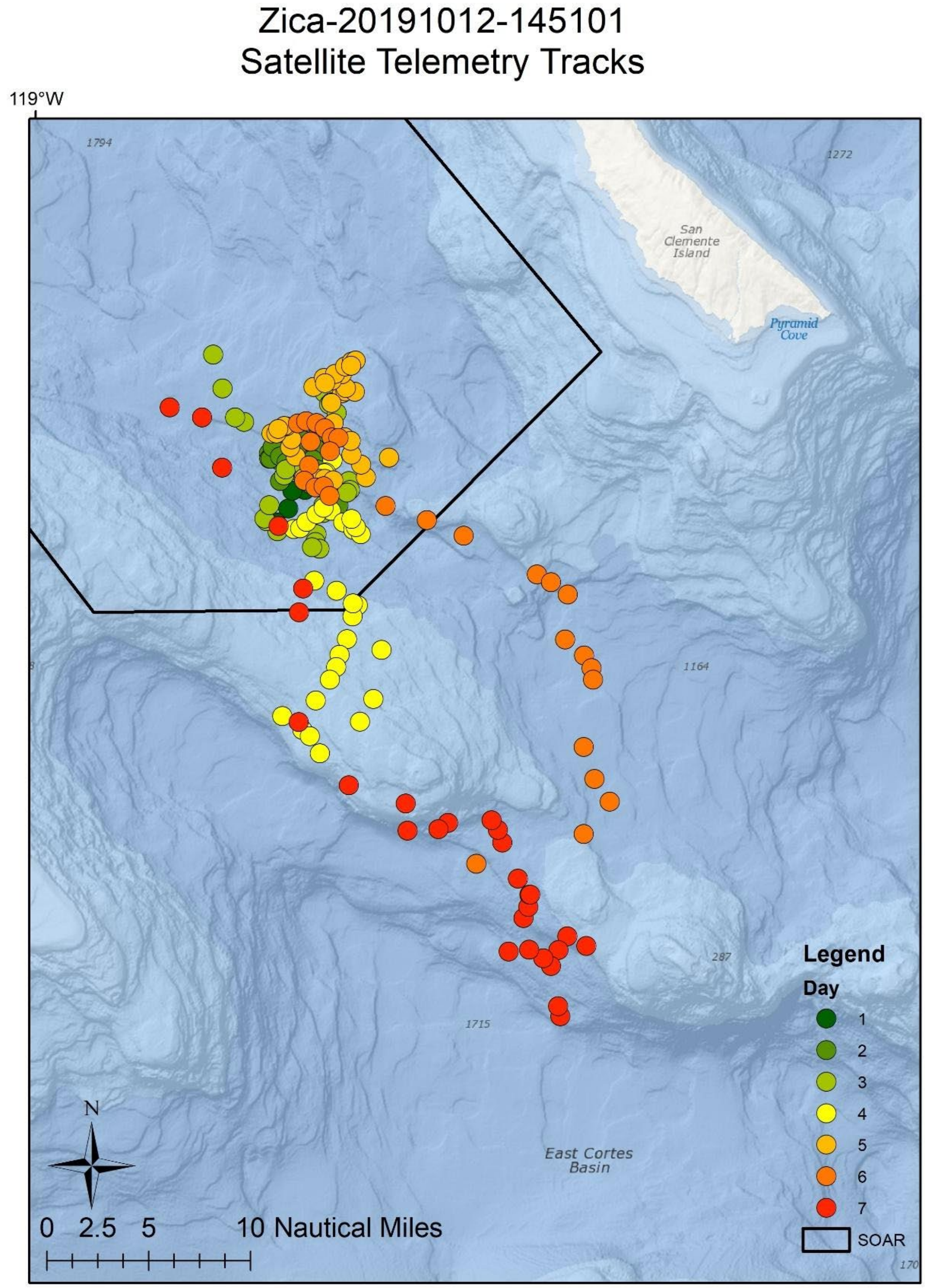

Figure 12. Satellite telemetry tracks from a tagged Cuvier's beaked whale deployed as part of an ancillary project funded by a Living Marine Resources study.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

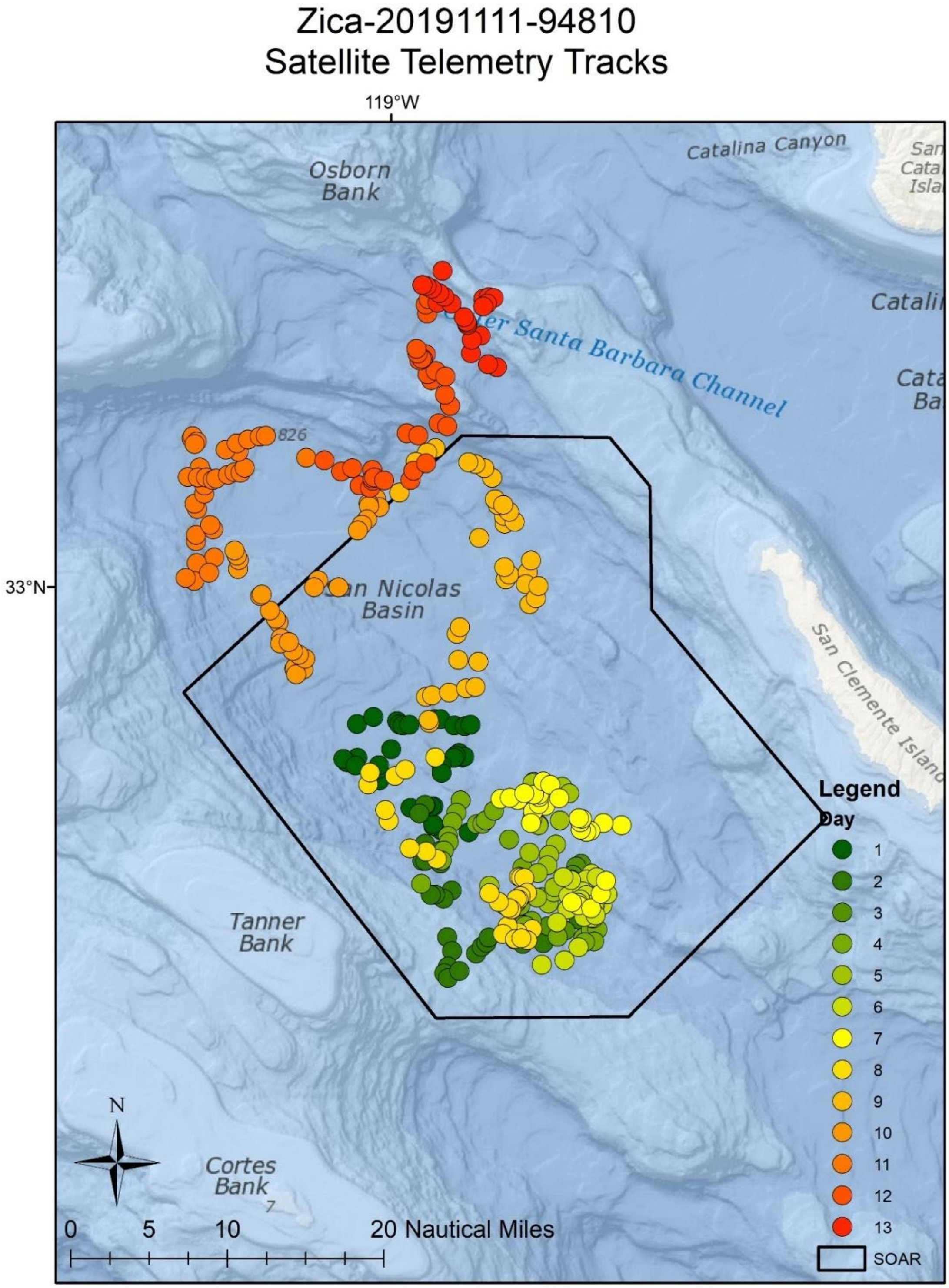

Figure 13. Satellite telemetry tracks from a tagged Cuvier's beaked whale deployed as part of an ancillary project funded by a Living Marine Resources study.

SOAR = Southern California Anti-submarine Warfare Range
Prepared by B. Rone

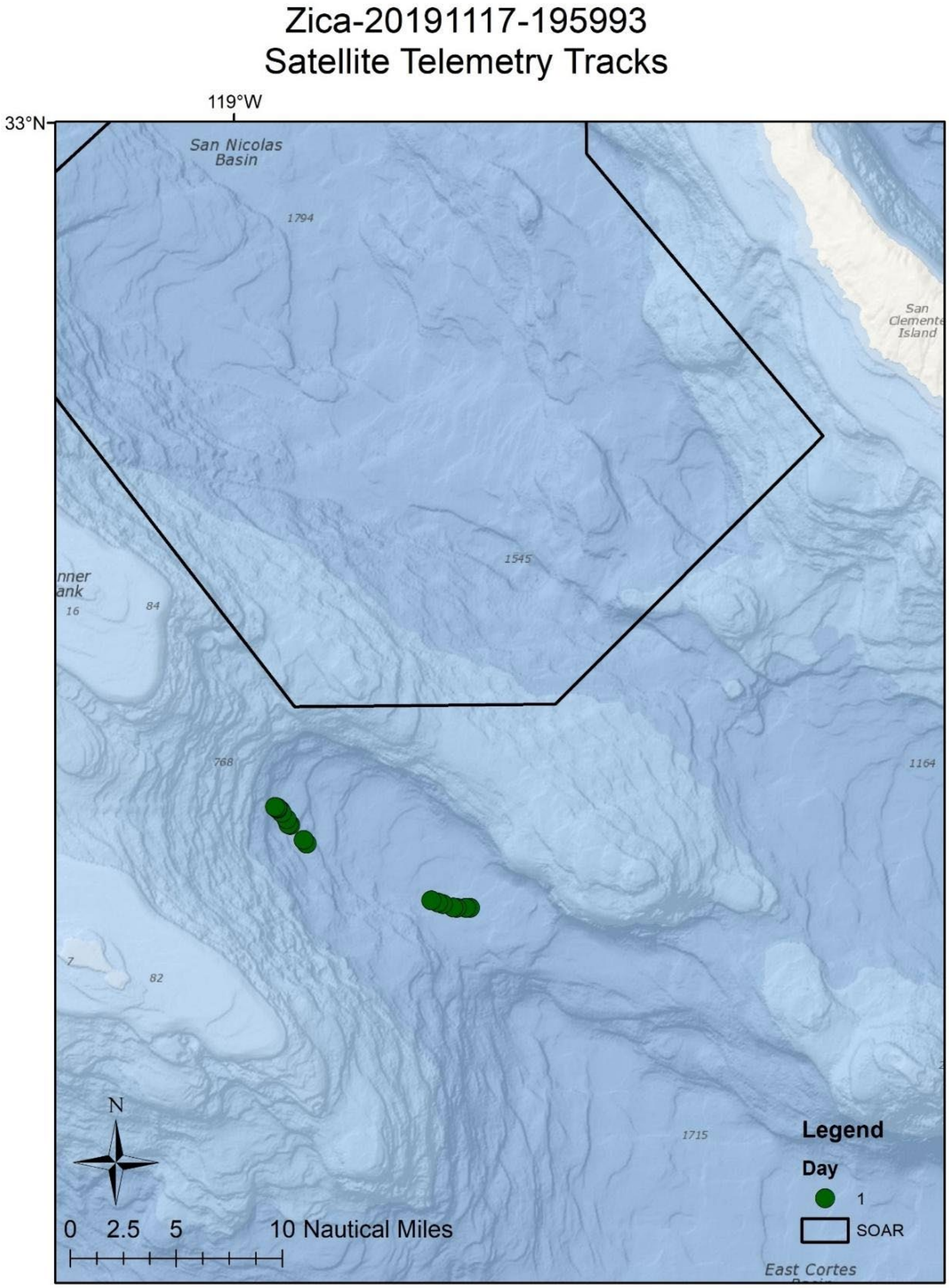

Figure 14. Satellite telemetry tracks from a tagged Cuvier's beaked whale deployed as part of an ancillary project funded by a Living Marine Resources study.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

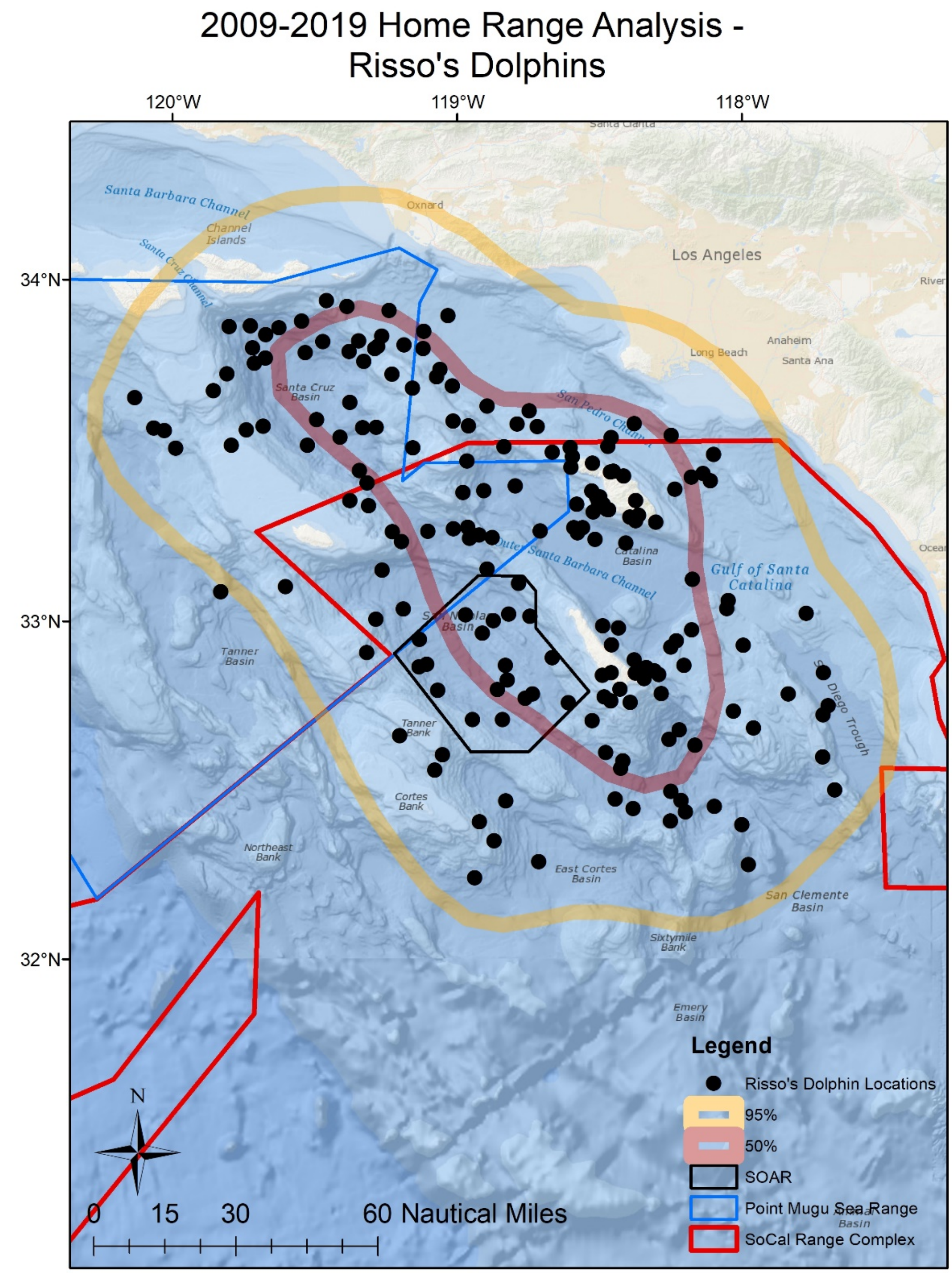

Figure 15. Home range analysis from satellite telemetry locations of Risso's dolphins tagged during Fleet Monitoring and ancillary projects.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

2014 Home Range Analysis -
Cuvier's Beaked Whales Tagged in Catalina Basin

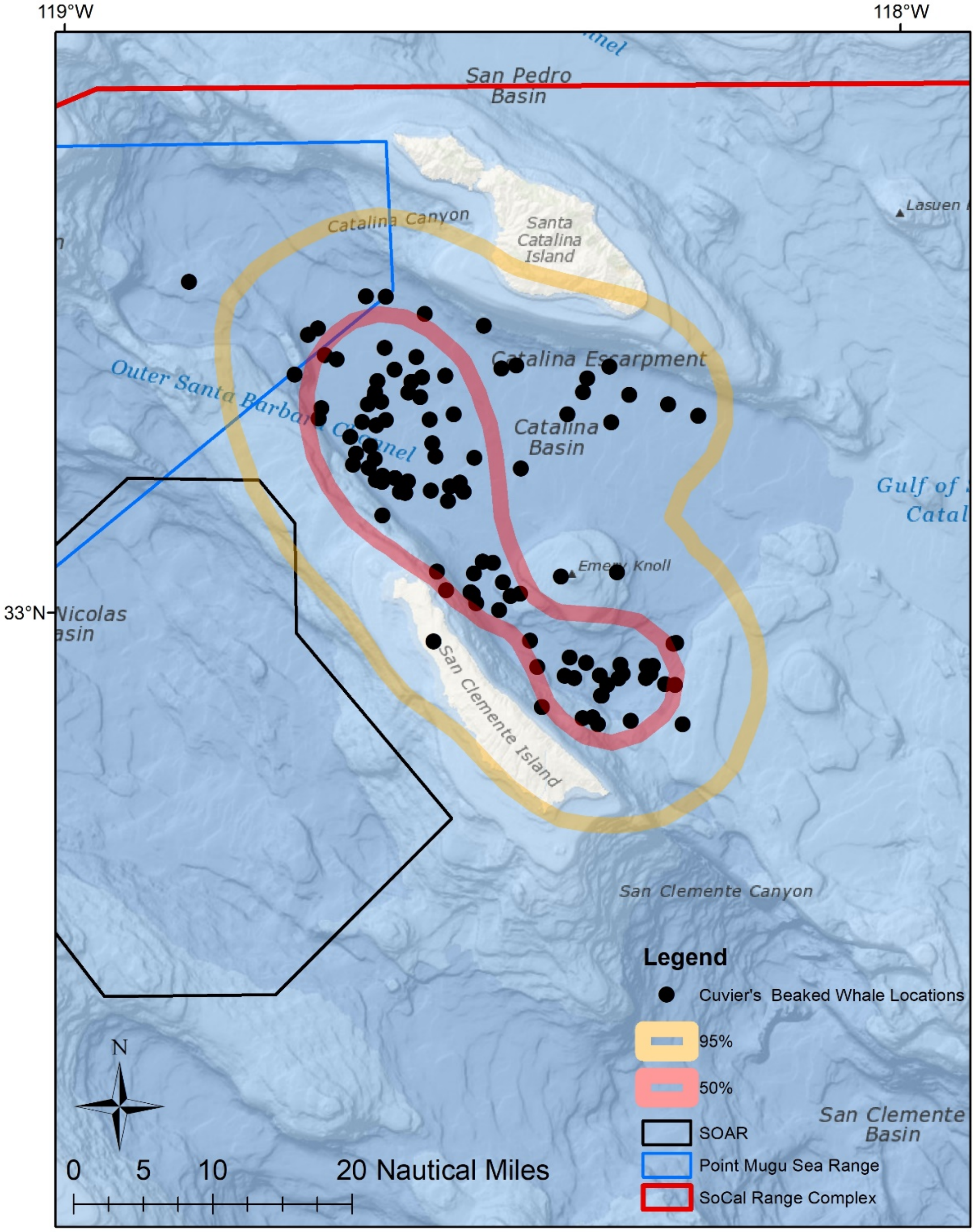

Figure 16. Home range analysis from satellite telemetry locations of two Cuvier's beaked whales tagged during Fleet Monitoring and ancillary projects.

SOAR = Southern California Anti-submarine Warfare Range
Prepared by B. Rone

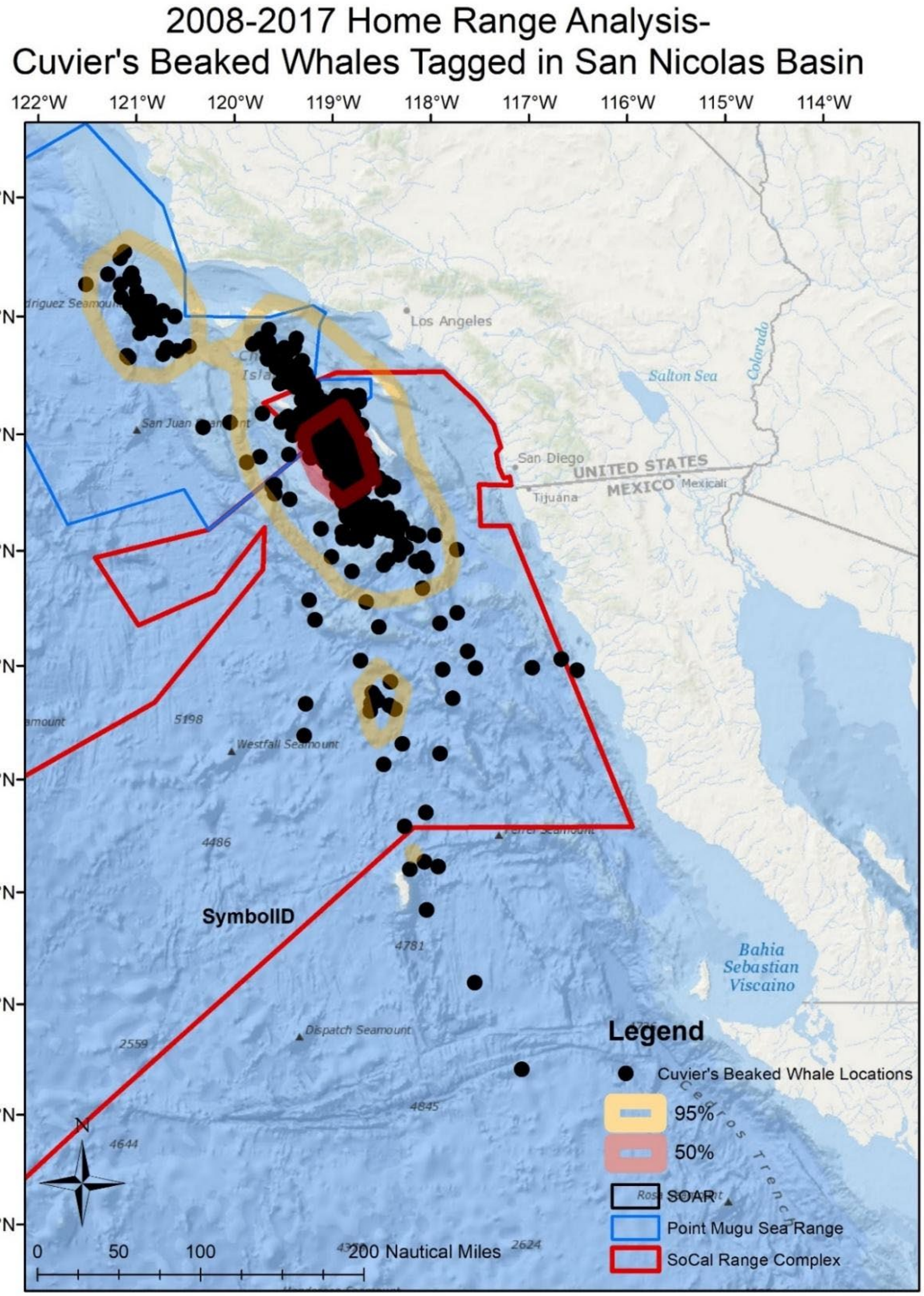

Figure 17. Home range analysis from satellite telemetry locations of Cuvier's beaked whales tagged during Fleet Monitoring and ancillary projects.

SOAR = Southern California Anti-submarine Warfare Range
Prepared by B. Rone

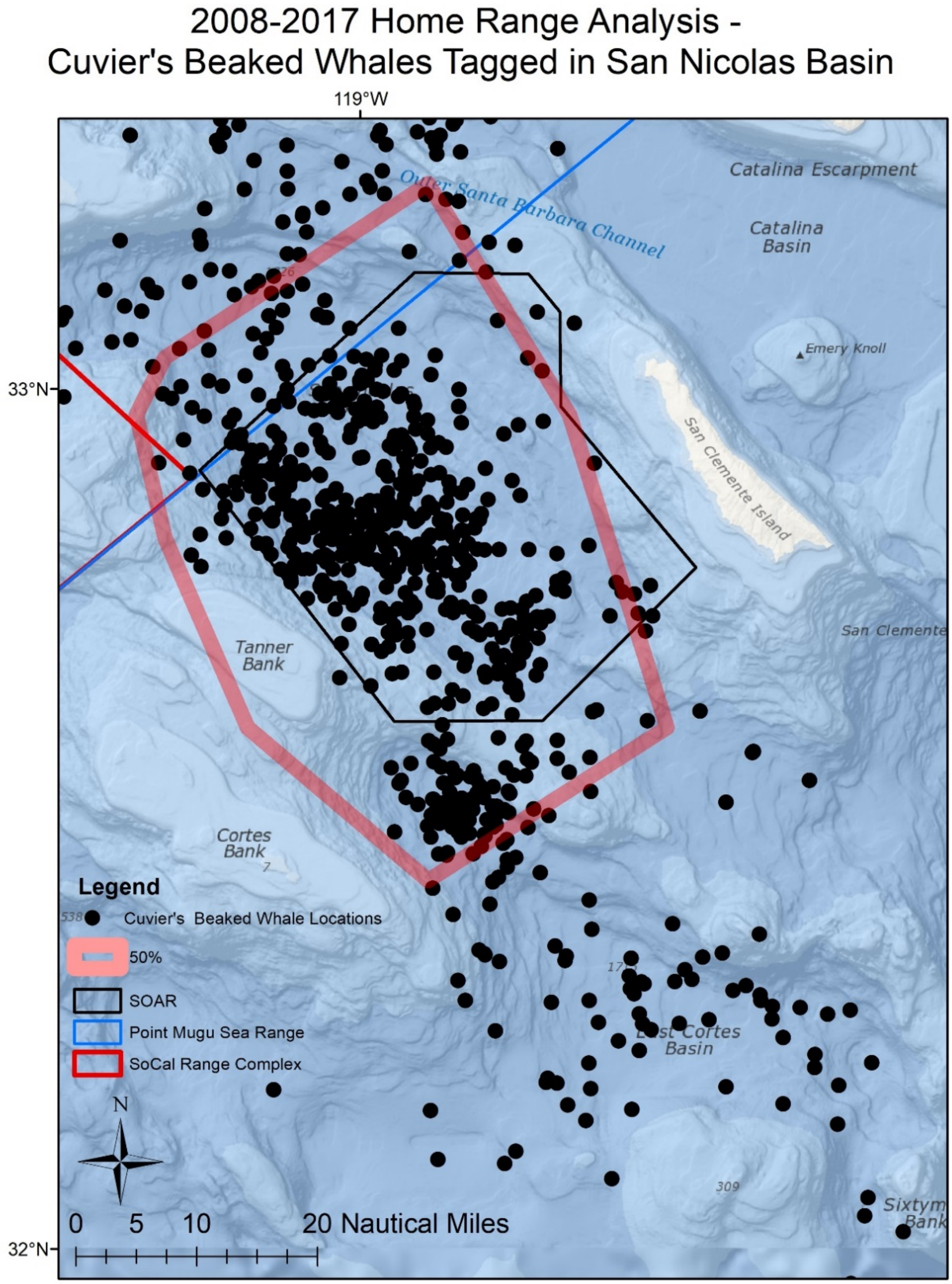

Figure 18. Zoomed in map of the home range analysis within San Nicolas Basin from satellite telemetry locations of Cuvier's beaked whales tagged during Fleet Monitoring and ancillary projects.

A preference for the center to western portion of the Basin / SOAR range can be identified.

SOAR = Southern California Anti-submarine Warfare Range

Prepared by B. Rone

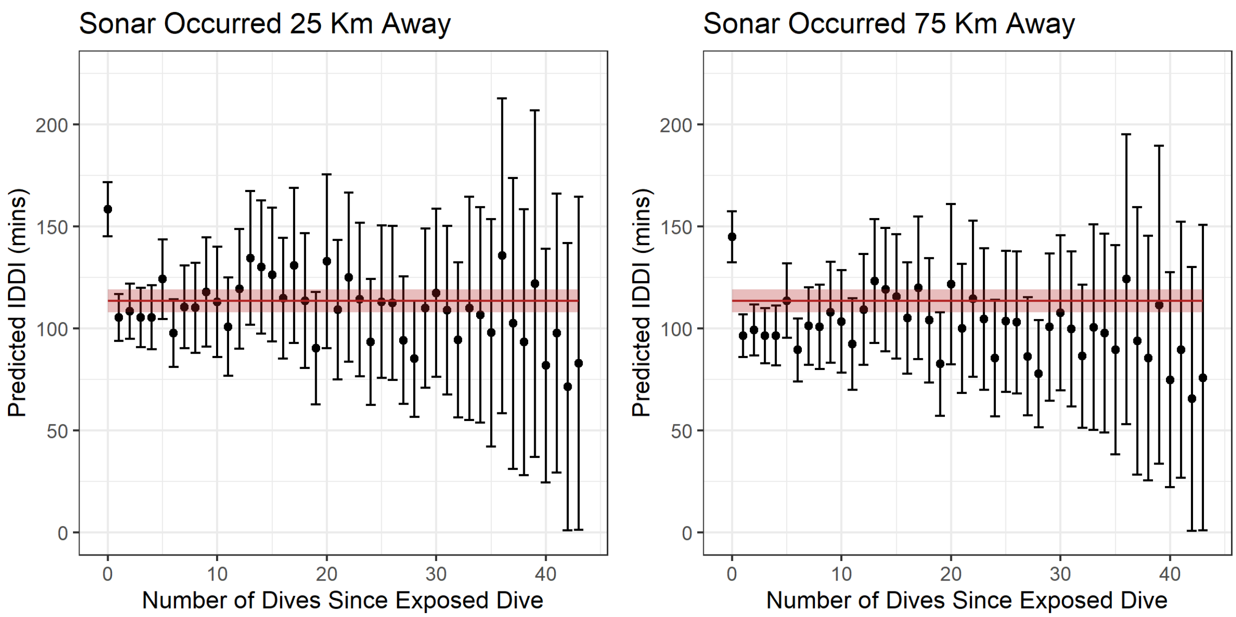

Figure 19. Prediction plots of the best fit model for IDDI as a function of the number of dives cycles since the last exposed dive cycle.

Two figures are shown: one predicting IDDIs when the closest sonar bout during the last exposed dive was 25 km away from the whale, and the other where the sonar occurred 75 km away from the whale. Fixed terms include deep dive duration set to 65.2 minutes (median duration in modelled dataset) and time of day set to daytime. Error bars represent the 95% confidence intervals, with the overall mean and 95% confidence intervals show in red.

Prepared by D. Sweeney

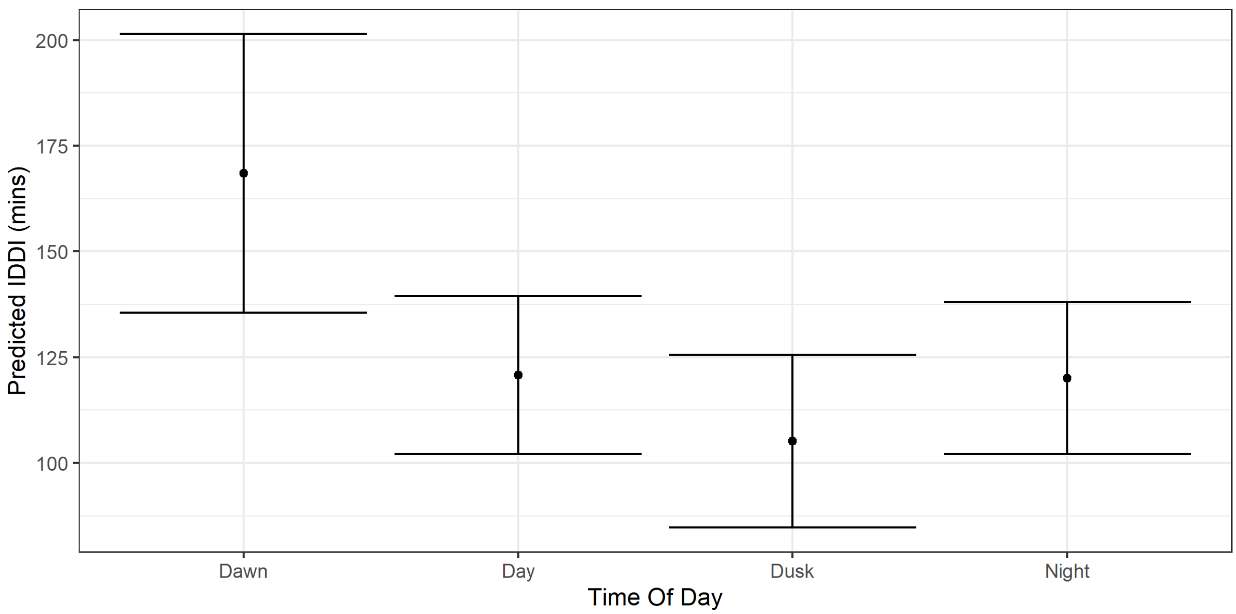

Figure 20. Model prediction plot of best-fit IDDIs as a function of the time of day.
Fixed terms include dive duration set to 65.2 minutes (median duration in modelled dataset) and dive since last exposed dive was set to 5. Error bars represent the 95% confidence intervals.
Prepared by D. Sweeney

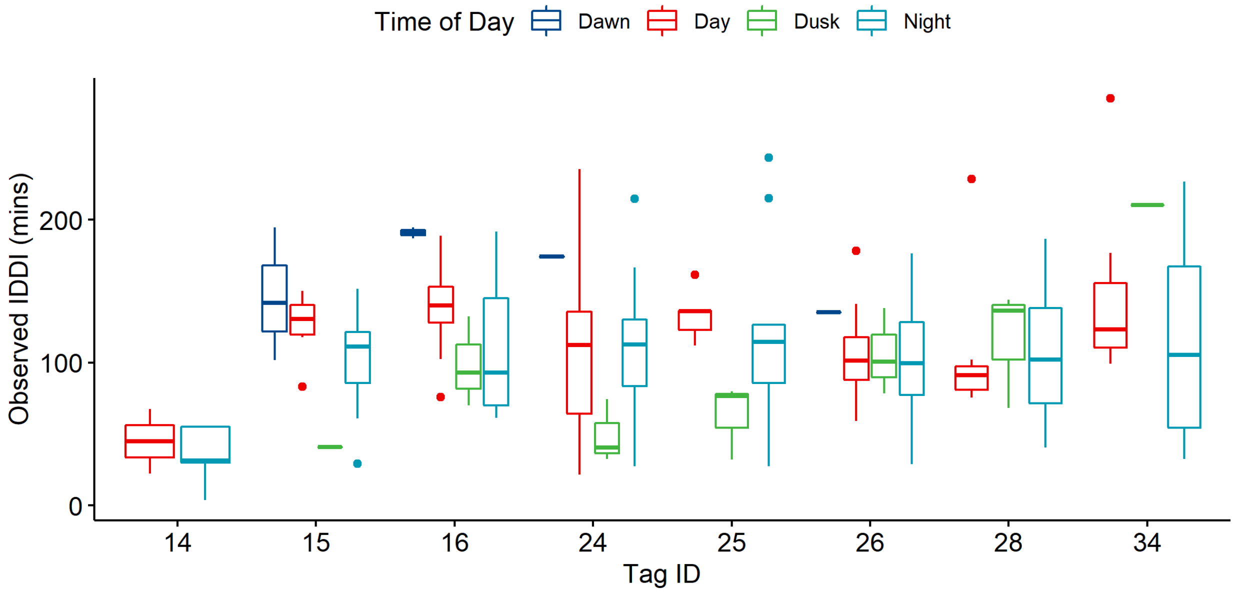

Figure 21. Boxplots of observed IDDIs prior to the first sonar exposure for individuals tagged in early January, by individual and time of day.

Dots represent IDDIs that fall more than1.5 times the inter-quartile outside beyond than the first and third quartiles. The daytime outlier for Tag ID 28 was 3 times the inter-quartile range greater than the third quartile.

Prepared by D. Sweeney

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Appendices

Appendix 1. Sighting details from effort conducted in 2019, including effort from Fleet Monitoring and the ancillary effort.

Date	Common Name	Lat	Long	Group Size	Est ID's	Biopsies Collected	Tags Deployed
02-Jan-19	Delphinus species	N33 26.18	W117 43.24	600	0	0	0
03-Jan-19	Delphinus species	N32 58.13	W118 42.86	100	0	0	0
03-Jan-19	Pacific White-sided Dolphin	N32 59.51	W118 42.54	3	0	0	0
03-Jan-19	Delphinus species	N32 53.84	W118 47.23	75	0	0	0
03-Jan-19	Cuvier's Beaked Whale	N32 54.70	W118 47.19	4	4	0	0
03-Jan-19	Delphinus species	N32 53.40	W118 47.30	180	0	0	0
04-Jan-19	Fin Whale	N32 56.90	W118 57.37	2	2	0	1
04-Jan-19	Gray Whale	N32 58.94	W118 51.10	2	0	0	0
04-Jan-19	Cuvier's Beaked Whale	N32 56.27	W118 49.45	3	3	0	0
04-Jan-19	Cuvier's Beaked Whale	N32 57.06	W118 51.64	4	4	0	0
04-Jan-19	Delphinus species	N32 56.95	W118 51.68	180	0	0	0
04-Jan-19	Cuvier's Beaked Whale	N32 57.45	W118 52.92	1	1	0	0
04-Jan-19	Delphinus species	N33 01.37	W118 41.55	20	0	0	0
04-Jan-19	Delphinus species	N33 01.60	W118 41.97	35	0	0	0
04-Jan-19	Delphinus species	N32 57.52	W118 50.70	250	0	0	0
05-Jan-19	Humpback Whale	N33 00.26	W118 55.43	1	0	0	0
05-Jan-19	Delphinus species	N33 01.79	W118 43.19	15	0	0	0
05-Jan-19	Delphinus species	N33 01.73	W118 33.61	4	0	0	0
05-Jan-19	Pacific White-sided Dolphin	N33 02.74	W118 39.71	10	0	0	0
07-Jan-19	Risso's Dolphin	N33 01.39	W118 33.52	10	0	0	0
07-Jan-19	Risso's Dolphin	N33 01.38	W118 33.49	38	0	0	0
07-Jan-19	Pacific White-sided Dolphin	N33 02.67	W118 36.42	8	0	0	0
07-Jan-19	Delphinus species	N33 00.12	W118 41.60	28	0	0	0
08-Jan-19	Delphinus species	N32 57.70	W118 56.43	250	0	0	0
08-Jan-19	Delphinus species	N33 01.50	W118 44.59	12	0	0	0
08-Jan-19	Fin Whale	N32 57.96	W119 01.06	4	4	2	1
08-Jan-19	Pacific White-sided Dolphin	N33 02.13	W118 39.53	8	0	0	0
08-Jan-19	Cuvier's Beaked Whale	N32 52.89	W119 09.51	3	2	0	0
09-Jan-19	Fin Whale	N33 05.13	W118 38.61	1	1	0	0
09-Jan-19	Delphinus species	N32 51.89	W118 47.22	40	0	0	0
09-Jan-19	Delphinus species	N32 55.39	W118 40.92	25	0	0	0
09-Jan-19	Pacific White-sided Dolphin	N33 03.87	W118 40.17	25	0	0	0
09-Jan-19	Delphinus species	N33 05.04	W118 38.95	40	0	0	0
11-Jan-19	Delphinus species	N32 53.08	W118 46.23	25	0	0	0
11-Jan-19	Dall's Porpoise	N32 41.08	W118 50.27	2	0	0	0
11-Jan-19	Cuvier's Beaked Whale	N32 42.84	W118 52.32	4	4	0	1
11-Jan-19	Delphinus species	N32 53.64	W118 44.55	17	0	0	0
11-Jan-19	Delphinus species	N32 57.82	W118 42.36	8	0	0	0

Date	Common Name	Lat	Long	Group Size	Est ID's	Biopsies Collected	Tags Deployed
12-Jan-19	Risso's Dolphin	N33 01.63	W118 33.29	6	0	0	0
12-Jan-19	Risso's Dolphin	N33 00.91	W118 32.59	30	6	0	0
12-Jan-19	Bottlenose Dolphin	N33 00.60	W118 32.37	10	5	0	0
13-Jan-19	Delphinus species	N32 56.24	W118 39.63	600	0	0	0
13-Jan-19	Delphinus species	N32 59.29	W118 43.58	300	0	0	0
13-Jan-19	Fin Whale	N32 45.57	W118 54.25	1	1	0	0
13-Jan-19	Cuvier's Beaked Whale	N32 45.13	W118 52.33	4	4	1	1
13-Jan-19	Gray Whale	N33 02.45	W118 34.44	1	0	0	0
14-Jan-19	Northern Right Whale Dolphin	N32 56.79	W119 06.98	30	0	0	0
28-Feb-19	Bottlenose Dolphin	N33 15.73	W118 11.74	3	0	0	0
28-Feb-19	Delphinus species	N33 25.63	W117 44.36	1500	0	0	0
01-Mar-19	Delphinus species	N33 01.28	W118 40.12	80	0	0	0
01-Mar-19	Cuvier's Beaked Whale	N32 44.73	W118 54.46	1	0	0	0
01-Mar-19	Bottlenose Dolphin	N33 02.74	W118 35.75	6	0	0	0
01-Mar-19	Cuvier's Beaked Whale	N32 44.51	W118 54.47	5	5	0	0
01-Mar-19	Minke Whale	N32 44.54	W118 53.66	1	1	0	0
01-Mar-19	Unid Large Cetacean	N32 46.43	W118 51.19	1	0	0	0
01-Mar-19	Gray Whale	N32 48.00	W118 50.09	2	0	0	0
03-Mar-19	Delphinus species	N33 00.81	W118 29.35	300	0	0	0
03-Mar-19	Gray Whale	N33 02.79	W118 35.04	3	0	0	0
05-Mar-19	Humpback Whale	N32 53.02	W119 05.24	1	0	0	0
05-Mar-19	Fin Whale	N32 53.01	W119 05.03	1	0	0	0
05-Mar-19	Pacific White-sided Dolphin	N32 53.02	W119 05.03	17	0	0	0
05-Mar-19	Bottlenose Dolphin	N32 50.55	W119 06.59	5	4	0	0
05-Mar-19	Humpback Whale	N32 52.44	W119 07.61	1	0	0	0
05-Mar-19	Risso's Dolphin	N32 51.11	W119 07.41	180	53	0	0
05-Mar-19	Pacific White-sided Dolphin	N32 50.87	W119 07.14	4	0	0	0
05-Mar-19	Pacific White-sided Dolphin	N33 00.50	W118 41.99	6	0	0	0
05-Mar-19	Delphinus species	N32 57.36	W118 47.41	700	0	0	0
05-Mar-19	Humpback Whale	N32 53.85	W118 59.53	1	0	0	0
05-Mar-19	Humpback Whale	N32 53.87	W119 00.52	1	0	0	0
05-Mar-19	Delphinus species	N33 00.54	W118 41.89	70	0	0	0
05-Mar-19	Fin Whale	N32 53.19	W119 03.21	1	1	0	0
05-Mar-19	Cuvier's Beaked Whale	N32 53.08	W119 04.77	1	1	0	0
05-Mar-19	Humpback Whale	N32 52.72	W119 05.05	1	0	0	0
05-Mar-19	Humpback Whale	N32 53.01	W119 05.03	3	0	0	0
05-Mar-19	Pacific White-sided Dolphin	N32 53.87	W119 00.51	15	0	0	0
07-Mar-19	Gray Whale	N33 02.51	W118 36.86	2	0	0	0
07-Mar-19	Delphinus species	N32 55.87	W118 44.10	60	0	0	0
07-Mar-19	Pacific White-sided Dolphin	N32 55.92	W118 44.07	5	0	0	0
07-Mar-19	Pacific White-sided Dolphin	N32 57.77	W118 38.92	18	8	0	0
07-Mar-19	Humpback Whale	N32 49.37	W118 39.93	2	1	0	0
07-Mar-19	Risso's Dolphin	N32 47.26	W118 39.66	16	15	0	0

Date	Common Name	Lat	Long	Group Size	Est ID's	Biopsies Collected	Tags Deployed
07-Mar-19	Risso's Dolphin	N32 48.03	W118 41.17	50	30	0	0
07-Mar-19	Bottlenose Dolphin	N32 47.32	W118 39.82	8	4	0	0
10-Mar-19	Cuvier's Beaked Whale	N32 57.79	W118 54.14	2	1	0	0
10-Mar-19	Delphinus species	N33 01.00	W118 44.12	800	0	0	0
10-Mar-19	Fin Whale	N32 57.31	W118 54.33	2	0	0	0
10-Mar-19	Minke Whale	N32 53.39	W119 03.70	2	1	0	0
10-Mar-19	Cuvier's Beaked Whale	N32 53.26	W119 04.64	3	3	0	0
10-Mar-19	Fin Whale	N32 58.02	W119 02.60	4	3	2	0
10-Mar-19	Delphinus species	N33 01.41	W118 56.37	35	0	0	0
10-Mar-19	Delphinus species	N33 01.39	W118 41.93	60	0	0	0
10-Mar-19	Gray Whale	N33 02.71	W118 38.46	3	0	0	0
10-Mar-19	Gray Whale	N33 02.74	W118 35.32	1	0	0	0
11-Mar-19	Risso's Dolphin	N33 08.45	W118 18.58	14	0	0	0
11-Mar-19	Humpback Whale	N33 04.24	W118 28.12	1	0	0	0
11-Mar-19	Gray Whale	N33 15.44	W118 01.14	1	0	0	0
11-Mar-19	Humpback Whale	N33 04.97	W118 27.10	1	0	0	0
11-Mar-19	Delphinus species	N33 04.66	W118 27.43	300	0	0	0
11-Mar-19	Humpback Whale	N33 04.54	W118 27.62	2	0	0	0
11-Mar-19	Delphinus species	N33 24.69	W117 44.97	25	0	0	0
18-Jul-19	Delphinus species	N33 20.60	W117 53.21	150	0	0	0
19-Jul-19	Bottlenose Dolphin	N33 01.43	W118 32.84	20	0	0	0
19-Jul-19	Delphinus species	N33 13.19	W118 38.00	65	0	0	0
19-Jul-19	Delphinus species	N33 14.71	W118 40.86	35	0	0	0
19-Jul-19	Risso's Dolphin	N33 25.07	W118 49.81	7	7	0	1
19-Jul-19	Delphinus species	N33 20.86	W118 35.04	450	0	0	0
22-Jul-19	Delphinus species	N32 55.51	W118 51.49	35	0	0	0
22-Jul-19	Cuvier's Beaked Whale	N32 48.32	W118 54.04	1	0	0	0
22-Jul-19	Bottlenose Dolphin	N33 02.77	W118 39.99	13	0	0	0
22-Jul-19	Delphinus species	N33 01.94	W118 42.16	10	0	0	0
22-Jul-19	Risso's Dolphin	N33 02.78	W118 39.71	6	0	0	0
23-Jul-19	Delphinus species	N32 56.38	W118 55.51	80	0	0	0
23-Jul-19	Delphinus species	N32 58.69	W118 55.69	350	0	0	0
23-Jul-19	Bottlenose Dolphin	N33 03.60	W118 39.58	17	12	0	0
24-Jul-19	Bottlenose Dolphin	N33 25.47	W117 47.43	65	50	0	0
24-Jul-19	Delphinus species	N33 25.46	W117 45.77	1	1	0	0
04-Oct-19	Delphinus species	N33 02.03	W118 27.42	100	0	0	0
04-Oct-19	Delphinus species	N33 01.76	W118 29.67	40	0	0	0
05-Oct-19	Delphinus species	N32 48.93	W118 51.12	35	0	0	0
05-Oct-19	Bryde's Whale	N32 58.95	W119 04.59	1	1	0	0
05-Oct-19	Delphinus species	N32 54.84	W119 02.69	65	0	0	0
05-Oct-19	Delphinus species	N32 46.33	W118 56.52	45	0	0	0
05-Oct-19	Delphinus species	N32 52.29	W118 45.74	19	0	0	0
05-Oct-19	Delphinus species	N32 55.99	W118 54.73	10	0	0	0

Date	Common Name	Lat	Long	Group Size	Est ID's	Biopsies Collected	Tags Deployed
05-Oct-19	Delphinus species	N32 56.39	W118 57.26	30	0	0	0
05-Oct-19	Delphinus species	N32 57.44	W119 00.03	120	0	0	0
05-Oct-19	Fin Whale	N32 58.86	W119 02.59	2	2	0	0
05-Oct-19	Cuvier's Beaked Whale	N32 58.71	W119 03.77	1	1	0	0
05-Oct-19	Fin Whale	N32 59.98	W118 59.71	3	3	1	0
06-Oct-19	Bryde's Whale	N32 51.89	W118 55.41	1	1	0	0
06-Oct-19	Bottlenose Dolphin	N33 02.86	W118 36.70	30	0	0	0
06-Oct-19	Bryde's Whale	N32 48.24	W118 54.03	1	1	0	0
06-Oct-19	Cuvier's Beaked Whale	N32 49.62	W119 04.41	3	1	0	0
06-Oct-19	Delphinus species	N33 01.79	W118 39.22	1200	0	0	0
06-Oct-19	Cuvier's Beaked Whale	N32 49.26	W119 04.89	1	1	0	0
06-Oct-19	Delphinus species	N32 59.28	W118 50.75	400	0	0	0
06-Oct-19	Fin Whale	N32 57.50	W118 55.98	1	1	0	0
06-Oct-19	Cuvier's Beaked Whale	N32 53.44	W119 08.03	3	2	0	0
06-Oct-19	Minke Whale	N32 56.26	W119 00.28	1	1	1	0
06-Oct-19	Bryde's Whale	N32 56.24	W118 56.62	1	1	0	0
07-Oct-19	Unid Large Cetacean	N32 55.56	W118 52.90	1	1	0	0
07-Oct-19	Fin Whale	N32 54.81	W118 52.57	1	0	0	0
07-Oct-19	Delphinus species	N33 02.73	W118 43.78	30	0	0	0
07-Oct-19	Fin Whale	N33 00.61	W119 01.16	1	1	0	0
07-Oct-19	Bryde's Whale	N32 56.23	W118 51.53	1	0	0	0
07-Oct-19	Fin Whale	N32 59.15	W119 00.06	3	3	1	0
10-Oct-19	Delphinus species	N32 59.90	W118 46.16	150	0	0	0
10-Oct-19	Bottlenose Dolphin	N33 01.91	W118 33.82	10	0	0	0
10-Oct-19	Delphinus species	N32 59.39	W118 43.16	150	0	0	0
10-Oct-19	Unid Large Cetacean	N32 54.56	W118 54.50	1	0	0	0
10-Oct-19	Delphinus species	N32 53.98	W118 55.14	80	0	0	0
10-Oct-19	Fin Whale	N32 53.83	W119 00.79	1	1	0	0
10-Oct-19	Fin Whale	N32 52.91	W119 02.49	1	1	0	0
10-Oct-19	Fin Whale	N32 53.63	W119 04.06	2	1	0	0
10-Oct-19	Fin Whale	N32 55.71	W118 56.88	4	3	1	0
10-Oct-19	Bryde's Whale	N32 56.50	W118 53.29	1	0	0	0
10-Oct-19	Fin Whale	N32 57.31	W118 46.80	1	0	0	0
10-Oct-19	Delphinus species	N32 53.55	W118 54.17	60	0	0	0
11-Oct-19	Delphinus species	N33 11.12	W119 05.52	5	0	0	0
11-Oct-19	Delphinus species	N32 51.21	W119 02.01	500	0	0	0
11-Oct-19	Fin Whale	N33 01.46	W119 09.27	1	0	0	0
11-Oct-19	Delphinus species	N33 14.66	W118 59.07	60	0	0	0
11-Oct-19	Risso's Dolphin	N33 11.28	W118 43.75	20	15	0	0
11-Oct-19	Bottlenose Dolphin	N33 11.69	W118 42.73	3	0	0	0
11-Oct-19	Delphinus species	N33 01.88	W118 45.81	25	0	0	0
11-Oct-19	Delphinus species	N33 09.04	W118 38.58	5	0	0	0
11-Oct-19	Risso's Dolphin	N32 50.78	W119 06.22	25	0	0	0

Date	Common Name	Lat	Long	Group Size	Est ID's	Biopsies Collected	Tags Deployed
11-Oct-19	Bottlenose Dolphin	N33 10.86	W118 44.05	12	0	0	0
11-Oct-19	Risso's Dolphin	N33 10.86	W118 44.05	30	25	0	0
11-Oct-19	Pacific White-sided Dolphin	N33 11.49	W118 56.02	4	0	0	0
11-Oct-19	Cuvier's Beaked Whale	N32 58.35	W119 06.50	2	2	0	0
11-Oct-19	Delphinus species	N32 57.18	W119 06.34	60	0	0	0
11-Oct-19	Cuvier's Beaked Whale	N33 01.48	W118 59.08	3	3	0	0
11-Oct-19	Minke Whale	N33 00.90	W119 05.29	2	2	0	0
12-Oct-19	Delphinus species	N32 59.08	W118 41.60	60	0	0	0
12-Oct-19	Fin Whale	N32 49.23	W118 49.44	1	0	0	0
12-Oct-19	Cuvier's Beaked Whale	N32 44.88	W118 55.81	1	1	0	1
12-Oct-19	Cuvier's Beaked Whale	N32 46.24	W118 57.21	2	2	0	0
12-Oct-19	Cuvier's Beaked Whale	N32 42.99	W118 46.68	2	2	0	1
12-Oct-19	Delphinus species	N32 48.48	W118 50.02	100	0	0	0
12-Oct-19	Delphinus species	N33 00.61	W118 39.99	25	0	0	0
12-Oct-19	Fin Whale	N32 52.57	W118 54.78	2	2	0	0
12-Oct-19	Cuvier's Beaked Whale	N32 57.19	W118 58.66	4	4	0	0
12-Oct-19	Minke Whale	N32 56.15	W118 52.36	1	0	0	0
12-Oct-19	Delphinus species	N32 52.77	W118 45.60	200	0	0	0
13-Oct-19	Cuvier's Beaked Whale	N32 59.72	W119 00.83	1	1	0	0
13-Oct-19	Delphinus species	N33 00.88	W118 39.93	100	0	0	0
13-Oct-19	Delphinus species	N32 58.28	W118 55.08	100	0	0	0
13-Oct-19	Cuvier's Beaked Whale	N32 54.15	W119 06.11	2	2	0	0
13-Oct-19	Cuvier's Beaked Whale	N32 58.94	W119 01.07	1	1	0	0
13-Oct-19	Delphinus species	N33 00.88	W118 48.04	80	0	0	0
14-Oct-19	Risso's Dolphin	N33 10.08	W117 38.98	7	7	0	0
09-Nov-19	Fin Whale	N33 00.88	W118 29.58	1	0	0	0
10-Nov-19	Delphinus species	N33 02.21	W118 39.19	6	0	0	0
10-Nov-19	Delphinus species	N33 01.91	W118 47.94	250	0	0	0
10-Nov-19	Delphinus species	N33 02.55	W118 40.10	20	0	0	0
11-Nov-19	Cuvier's Beaked Whale	N32 46.08	W118 53.24	3	3	0	0
11-Nov-19	Cuvier's Beaked Whale	N32 46.81	W118 55.07	1	1	0	1
11-Nov-19	Delphinus species	N33 00.81	W118 39.09	100	0	0	0
11-Nov-19	Humpback Whale	N33 02.51	W118 36.46	2	0	0	0
11-Nov-19	Risso's Dolphin	N33 01.85	W118 33.82	20	0	0	0
11-Nov-19	Unid Medium Cetacean	N32 52.43	W118 57.36	1	0	0	0
12-Nov-19	Cuvier's Beaked Whale	N32 45.24	W118 55.92	1	0	0	0
12-Nov-19	Delphinus species	N33 01.08	W118 38.90	50	0	0	0
12-Nov-19	Cuvier's Beaked Whale	N32 52.80	W118 56.83	2	2	0	0
12-Nov-19	Cuvier's Beaked Whale	N33 03.49	W118 52.61	4	4	3	0
12-Nov-19	Unid Large Cetacean	N33 06.93	W118 45.60	2	0	0	0
16-Nov-19	Cuvier's Beaked Whale	N32 52.13	W119 07.99	2	0	0	0
16-Nov-19	Humpback Whale	N33 00.05	W118 39.29	1	0	0	0

Date	Common Name	Lat	Long	Group Size	Est ID's	Biopsies Collected	Tags Deployed
16-Nov-19	Cuvier's Beaked Whale	N32 50.67	W119 07.33	2	2	0	0
16-Nov-19	Delphinus species	N32 52.15	W119 07.90	700	0	0	0
16-Nov-19	Humpback Whale	N32 52.09	W119 07.92	2	0	0	0
16-Nov-19	Cuvier's Beaked Whale	N32 52.22	W119 08.99	4	4	0	0
16-Nov-19	Cuvier's Beaked Whale	N32 52.59	W119 08.04	4	4	0	0
17-Nov-19	Cuvier's Beaked Whale	N32 40.61	W118 50.30	4	4	1	1
17-Nov-19	Cuvier's Beaked Whale	N32 40.36	W118 49.22	1	0	0	0
17-Nov-19	Cuvier's Beaked Whale	N32 42.17	W118 47.09	2	2	0	0
17-Nov-19	Cuvier's Beaked Whale	N32 42.31	W118 46.48	1	1	0	0
17-Nov-19	Delphinus species	N32 58.57	W118 39.35	125	0	0	0
18-Nov-19	Delphinus species	N33 02.21	W118 31.45	6	0	0	0
18-Nov-19	Fin Whale	N33 05.21	W118 35.48	2	2	0	0
18-Nov-19	Delphinus species	N33 04.56	W118 38.02	8	0	0	0
24-Nov-19	Delphinus species	N33 13.09	W117 49.92	45	0	0	0
24-Nov-19	Delphinus species	N33 16.50	W118 32.25	165	0	0	0

Appendix 2. List of Acronyms

ATN	Animal Telemetry Network
CA	California
CESU	Cooperative Ecosystem Studies Unit
eDNA	environmental DNA
GAM	generalized additive model
GPS	Global Positioning System
ICMP	Integrated Comprehensive Monitoring Program
IDDI	Inter-Deep-Dive-Interval
LMR	Living Marine Resources
LIMPET	Low-Impact Minimally Percutaneous External –electronics Transmitting
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
OSU	Oregon State University
PCoD	Population Consequences of Disturbance
ROC	Range Operation Center
RHIB	rigid-hulled inflatable boat
SCORE	Southern California Offshore Range
SOCAL	Southern California Range Complex
SWFSC	Southwest Fisheries Science Center
US	United States