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

Annual Report
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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 17 days of survey effort from 3 September 2021 to 15 November 2021, 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 ancillary projects funded by the U.S. Navy's Living Marine Resources program, we had 127 sightings of cetaceans, including 16 sightings totaling 44 Cuvier's beaked whales and 42 sightings totaling 67 fin whales. Preliminary reconciliation of identification photographs of Cuvier's beaked whales from directed effort and two opportunistic sightings in 2021 included at least 30 unique individuals, which were sighted on up to three different days during the year. Twelve of these whales (40%) had previous sighting histories at SOAR, including two females that were sighted with their first calves in the study. Identification photos of fin whales from directed and opportunistic data collection in 2020 (n = 93), as well as opportunistic collections from earlier years that had not been previously submitted to our catalog (n = 201), were processed in 2021. This collection brings our US West Coast fin whale catalog to 1,250 individuals, of which 760 have sighting histories in Southern California. Nine genetic samples were collected in 2021, four from Cuvier's beaked whales and five from fin whales.

Labor originally intended to support 2021 field effort was partially re-tasked (in consultation with the Navy) to analyses of previously collected data, given the relatively limited data collected in 2020 and 2021. These included a comparison of 25 Cuvier's tracks using three data filtering methods (none, Douglas Distance-Angle-Rate (DAR) filter, and the Freitas Speed-Distance-Angle (SDA) filter) and two spatial movement models (the Continuous-Time Correlated Random Walk {CTCRW} and the continuous time state-spaced model 'foieGras') that have been used to standardize Argos location data from numerous marine mammals, as well as a comparison of the modeled locations and FastLoc GPS positions for three tags that provided both location data types. We found that applying the DAR filter to raw Argos location data produced the most consistent tracks between the two models at three different time steps, and that applying the DAR filter and then modeling positions with CTCRW produced location estimates that were most similar to GPS positions from the tag.

Introduction

The United States (US) Navy uses the Southern California (SOCAL) portion of the Hawaii-Southern California Training and Testing area, 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, 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 occurrence on SOAR since 2006. The primary focus of these studies is to support long-term surveys of Cuvier's beaked whales and fin whales using photo-identification (photo-ID) 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. These efforts have included demographic assessments, foraging ecology, and behavioral responses to MFAS for several key species which often provide insights into cumulative impacts that might otherwise not show up in acoustic or visual density data (Whitehead and Gero, 2015). 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 studies documented generally high cetacean diversity on SOAR year-round, with some seasonal fluctuations (Falcone and Schorr, 2014). 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. A recent Office of Naval Research (ONR)-supported analysis (Moore et al., 2017) 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, and Booth et al. (2017) suggest photo-ID and biopsy are critical tools for accurately monitoring population health. Most recently, simulations by Curtis et al. (2020) show the probability of detecting abundance changes is currently low but will greatly improve through continued monitoring and increased effort. As the surveys progressed, research expanded to incorporate 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 individual site fidelity to the Southern California Bight (SCB) for several species, including Cuvier's beaked whales on SOAR and fin whales in the greater SCB (Falcone et al., 2009, 2017a; 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 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). 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., 2017a). 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 and abundance/density estimations of beaked whales and Endangered Species Act (ESA) listed baleen whales within the Navy's SOCAL?

Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species, or stock (with focus on 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 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 photo-ID images, biopsy samples, and deploy Low Impact Minimally Percutaneous External-electronics Transmitting (LIMPET) tags (Schorr et al., 2019).

Since fieldwork continued to be impacted by the COVID-19 pandemic in 2021, some project funds were re-allocated from fieldwork to analyses of previously collected data, the preliminary results of which are included here. 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 2021.* 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) *A comparison of several commonly used movement models for standardizing lower resolution locations data from satellite tagged Cuvier's beaked whales.* Cuvier's beaked whales are notoriously challenging to obtain high-quality Argos location data from (e.g. Quick et al., 2019; Schorr et al., 2017). This is due to the limited time these whales typically spend at the surface and the long periods that separate them, which in turn limit the number of messages that can be sent during a single satellite overpass. This results in predominantly poor quality Argos location estimates that often have very large error radii, sometimes encompassing an area larger than SOAR (Schorr et al., 2014). These spatial errors can be reduced through the use of Fastloc GPS LIMPET tags, but this higher quality spatial data comes at a cost to transmitting dive data, again given the limited opportunities to send messages (Schorr et al., 2017). Movement models are frequently employed to generate more frequent location estimates from sparse Argos track data, and while the modeled data are often referred to as more 'accurate location estimates', these movement models are all highly reliant on the quality of the Argos location estimates upon which they are based. Here, we use previously collected movement data from Cuvier's beaked whales tagged at SOAR to conduct a comparison of two prominent cetacean movement models: the continuous-time correlated random walk (hereafter "CTCRW") model (Johnson et al., 2008) and the continuous-time state-space (hereafter "foieGras") model (Jonsen et al., 2020).

3) *An assessment of data throughput as a function of tag programming.* 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), again due to the limited time these whales typically spend at the surface. 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). Adding sensors to the tags (e.g., Fastloc GPS) exacerbate data transmission and reception challenges (Schorr et al., 2017). Within the SOCAL TR, 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). Here, we assess the message throughput of 25 previously deployed dive-reporting LIMPET tags from SOCAL (Falcone et al., 2017b; Schorr et al., 2017, 2014) to better quantify message reception rates both with, and without the land-based Argos Receiving stations. We will then assess message generation and reception probabilities for different programming regimes. The goal of this exercise is to identify the optimal programming regime for Cuvier's beaked whale LIMPET tags at SOCAL to maximize dive data resolution and minimize data gaps to greatest extent possible. From there, we plan to down sample the high-resolution dive data collected from LMR-funded Sound & Motion Recording and Transmitting (SMRT) tags to the resolution of

LIMPET tag data, and assess if we would still detect the coarse-scale behavioral changes associated with MFA exposure that are evident in the complete, high-resolution records.

4) Finally, we provide draft copies of two pending publications based on cumulative photo-ID data from fin whales and Cuvier's beaked whales that have been collected and processed in part by Fleet-sponsored research. The first of these 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. The second is a multi-regional comparison of scarring density and pigmentation patterns in 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.

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 of species where this methodology is being employed by ourselves or collaborators (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 tips 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 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 Falcone and Schorr (2014) 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.

This year, two retrospective analyses were completed using the Cuvier's beaked whale and fin whale catalogs. Manuscripts detailing the results are currently in press with anticipated publication dates in 2022 in a two-part special edition of the journal *Mammalian Biology* focused on photo-identification. Please refer to the manuscripts themselves for photo data processing methods specific to these analyses (Appendices 3 and 4).

Analyses of Previously Collected Tag Data

A comparison of movement models for Cuvier's beaked whale Argos location data

We used Argos location data from 25 Cuvier's beaked whales previously LIMPET tagged at SCORE to compare the performance of the CTCRW and foieGras movement models with different data filtering methods. We applied each of three different prefiltering methods (detailed below) to the source data and used each model to predict tracks for each tag at three fixed time intervals (30 mins, 6 hrs, and 24 hrs), using the distances between concurrent predicted locations from the two models to characterize the uncertainty between them. We then compared kernel density home ranges estimated using the six combinations of modeling and pre-filtering methods. Finally, we used data from three tags that provided both Fastloc GPS and Argos location estimates, remodeled their Argos data to estimated locations at the same times as GPS locations, and assessed which model estimated locations closer to the Fastloc GPS positions, which are assumed to be closest to the animal's true position (Dujon et al., 2014).

Each movement model was fit using the following prefiltering methods: (1) "None", the entire, unfiltered Argos location track was retained, (2) "DF"- the Argos locations were filtered using the Douglas Argos-filter's distance-angle-rate filter (Douglas et al., 2012), and (3) "SDA"- the Argos locations were filtered using the Freitas speed-distance-angle filter (Freitas et al., 2008). The DAR filter parameters (Douglas et al., 2012) were set as follows: MINRATE = 15 km/hr, RATECOEF = 25, MAXREDUN = 3 km, KEEP_LC = 2. SDA filter parameters (Freitas et al., 2008) were adjusted to best match those used in the DAR filter: maximum speed = 15 km/hr, maximum step length = 3 km, and minimum turning angle = 2.47 degrees (equivalent to angle calculated in DAR filter with RATECOEF of 25 and a 3 km distance between locations).

Models were run in RStudio (v1.4.1717) using the crawl and foieGras R packages (Johnson and London, 2016; Jonsen and Patterson, 2020) and both incorporated Argos error ellipses into model fitting. To facilitate foieGras model convergence for animals with Argos tracks that were difficult to fit, the psi parameter was set to NA for all individuals.

To estimate home ranges, we used modeled tracks at 24 hr time steps only to reduce autocorrelation, and limited inputs to Argos data that had been filtered to remove erroneous locations estimates (i.e., we did not use unfiltered data). Home ranges were estimated at 95% and 50% levels using kernel density estimation with an ad hoc smoothing parameter estimator from the adehabitatHR R package (Calenge, 2006).

For the comparison of concurrent modeled and Fastloc GPS positions, GPS positions were filtered to include only those with residual values less than or equal to 35 (Dujon et al., 2014) and a time error of less than +/-3 seconds. Both models were run using all three prefiltering methods.

Results and Discussion

Survey Effort and Sightings

Our 2021 survey schedule was again impacted by the COVID-19 pandemic until the fall when we were able to resume regularly scheduled surveys. A total of 17 days of on-water surveys were conducted for this project from September to November, with most survey effort occurring within SOAR (Table 1). One survey day each in September and November were cancelled due to inclement weather. To ensure safe offshore operations after an extended period of limited use, we dedicated two days in September to vessel and equipment maintenance and conducted a coastal survey as a field test.

Seventeen additional survey days in April and November were conducted for an ancillary project (Figure 2, Table 2). The percentage of time by project within Navy range boundaries are presented in Table 3. During all survey effort in the region in 2021, 127 sightings of 10 cetacean species were recorded (Figure 3, Table 1, Appendix 1). Species sighted included: Cuvier's beaked whales, fin whales, humpback whales, minke whales, Bryde's whale (*Balaenoptera brydei*), blue whales (*Balaenoptera musculus*), Risso's dolphins, bottlenose dolphins, Dall's porpoise (*Phocoenoides dalli*), and common dolphins.

Cuvier's beaked whales were sighted in the deep waters of the San Nicolas Basin to the west of San Clemente Island in both September and November (Figure 4, Figure 6, Table 4). Surveys in April were entirely coastal and focused on tagging fin whales, as inclement weather offshore precluded work at SOAR. Fin whales were also sighted north and west of San Clemente Island, during November surveys (Figure 4, Figure 5, Figure 6, Table 5).

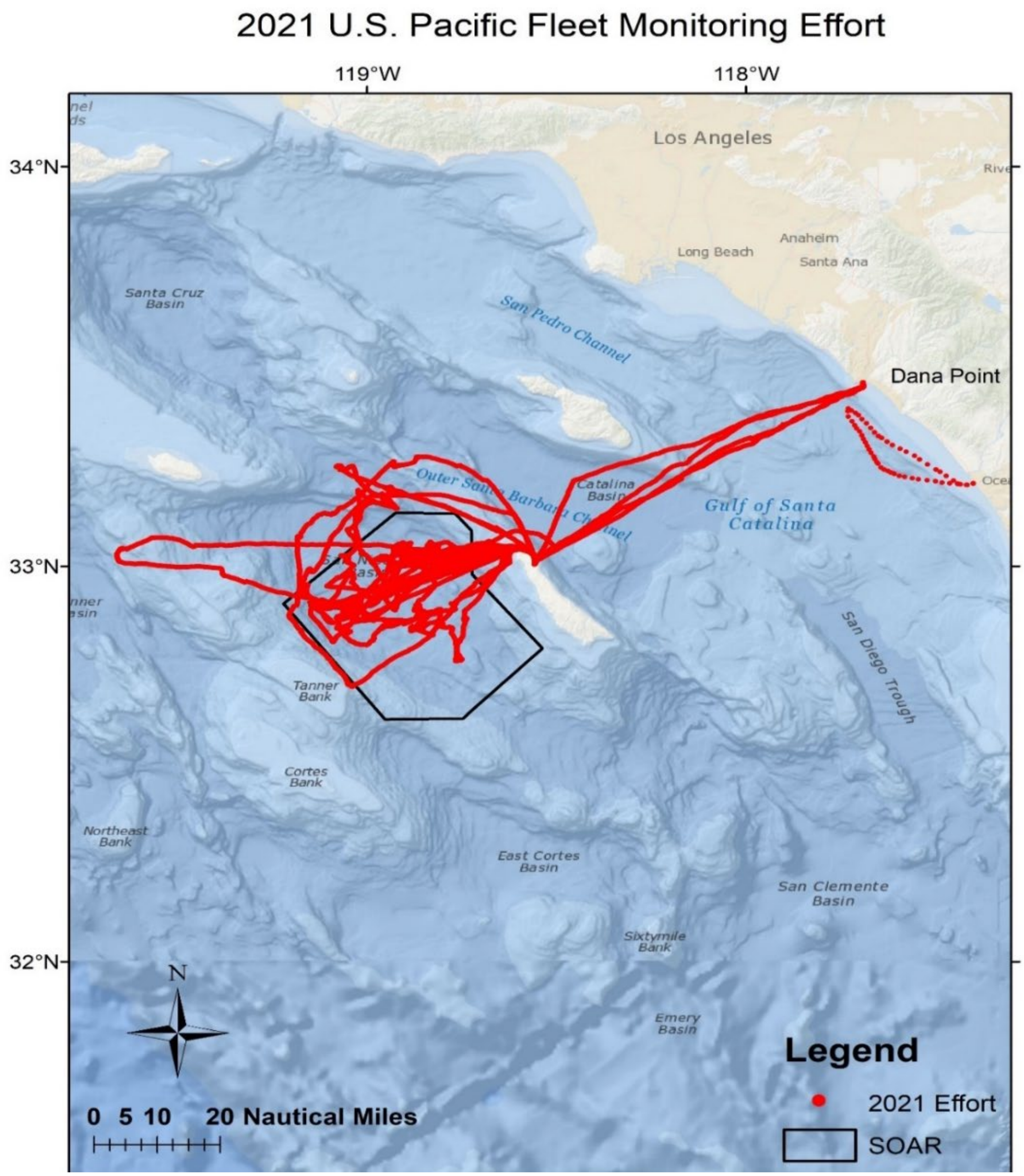


Figure 1. Vessel track lines from U.S. Pacific Fleet Monitoring surveys conducted from 3 September 2021 through 15 November 2021. SOAR = Southern California Anti-submarine Warfare Range. Prepared by B. Rone

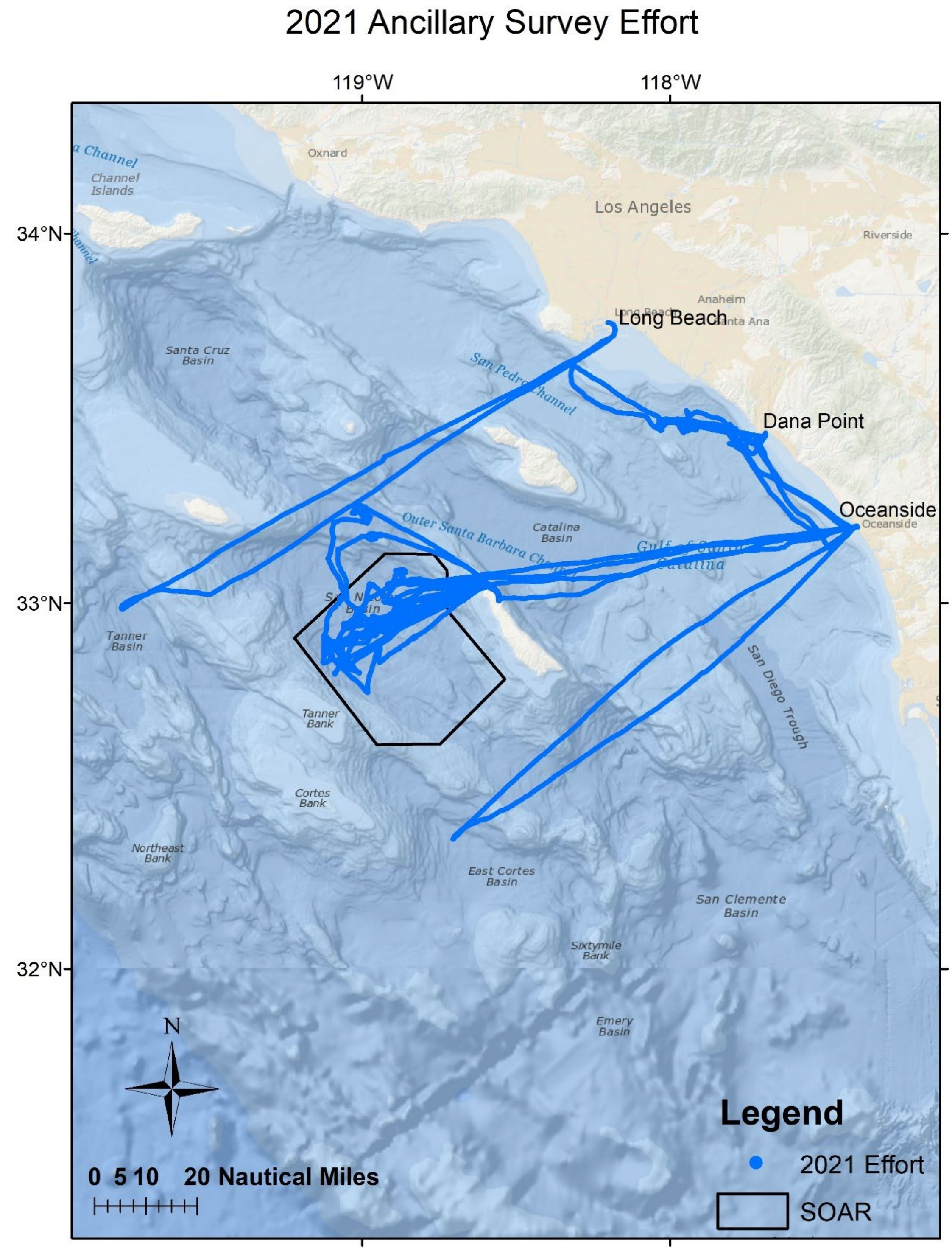


Figure 2. Vessel track lines from ancillary surveys conducted in April and November 2021. SOAR = Southern California Anti-submarine Warfare Range. Prepared by B. Rone

Table 1. Summary of U.S. Pacific Fleet Monitoring survey effort by day, September-November 2021, 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
9/3/2021	1	3.8	49.0	3	0	0
9/5/2021	1	4.2	53.5	3	0	0
9/6/2021	1	10.2	80.2	5	0	0
9/7/2021	1	11.9	101	7	0	0
9/8/2021	1	9.9	125	5	0	0
9/9/2021	1	10.3	106	7	1	0
9/10/2021	1	9.5	79.0	2	0	0
9/11/2021	1	2.8	53.0	1	0	0
11/6/2021	1	3.5	59.6	0	0	0
11/7/2021	1	9.8	69.8	3	0	0
11/8/2021	1	10.3	105	4	0	0
11/9/2021	1	10.1	89.2	3	0	0
11/11/2021	1	10.5	72.2	4	0	0
11/12/2021	1	10.3	128	6	0	0
11/13/2021	1	9.9	89.1	2	0	0
11/14/2021	1	9.7	78.2	9	0	0
11/15/2021	1	2.3	52.3	3	0	0
Totals: 17		**138.9**	**1390.1**	**67**	**1**	**0**

[1]Hrs = hours

[2]nm = nautical miles

Table 2. Summary of ancillary survey effort by day from April-November 2021, 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
4/15/2021	1	6.3	69.5	4	0	0
4/16/2021	1	5.7	45.0	5	0	0
4/17/2021	1	6.9	79.8	4	0	0
4/19/2021	1	5.9	64.3	2	1	1
11/5/2021	1	2.8	69.5	4	0	0
11/6/2021	1	9.9	68.1	4	0	0
11/7/2021	1	9.8	81.9	5	1	2
11/8/2021	1	10.3	99.5	10	1	0
11/9/2021	1	10.0	96.8	4	1	0
11/11/2021	1	10.4	80.0	4	0	1
11/12/2021	1	10.2	87.9	3	2	1
11/13/2021	1	9.7	74.0	1	2	2
11/14/2021	1	9.8	89.9	5	0	1
11/15/2021	1	5.8	117	0	0	0
11/19/2021	1	6.6	149	3	0	0
11/21/2021	1	8.1	192	2	0	0
11/24/2021	1	7.5	169	0	0	0
Totals: 17		**135.6**	**1633.2**	**60**	**8**	**8**

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

Table 3. 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	14%	97%	63%
Ancillary*	12%	90%	51%

[1]SOCAL = Southern California Range Complex
[2]SOAR = Southern California Anti-submarine Warfare Range
*percentages will change slightly after survey 24 November 2021 is uploaded and calculated.

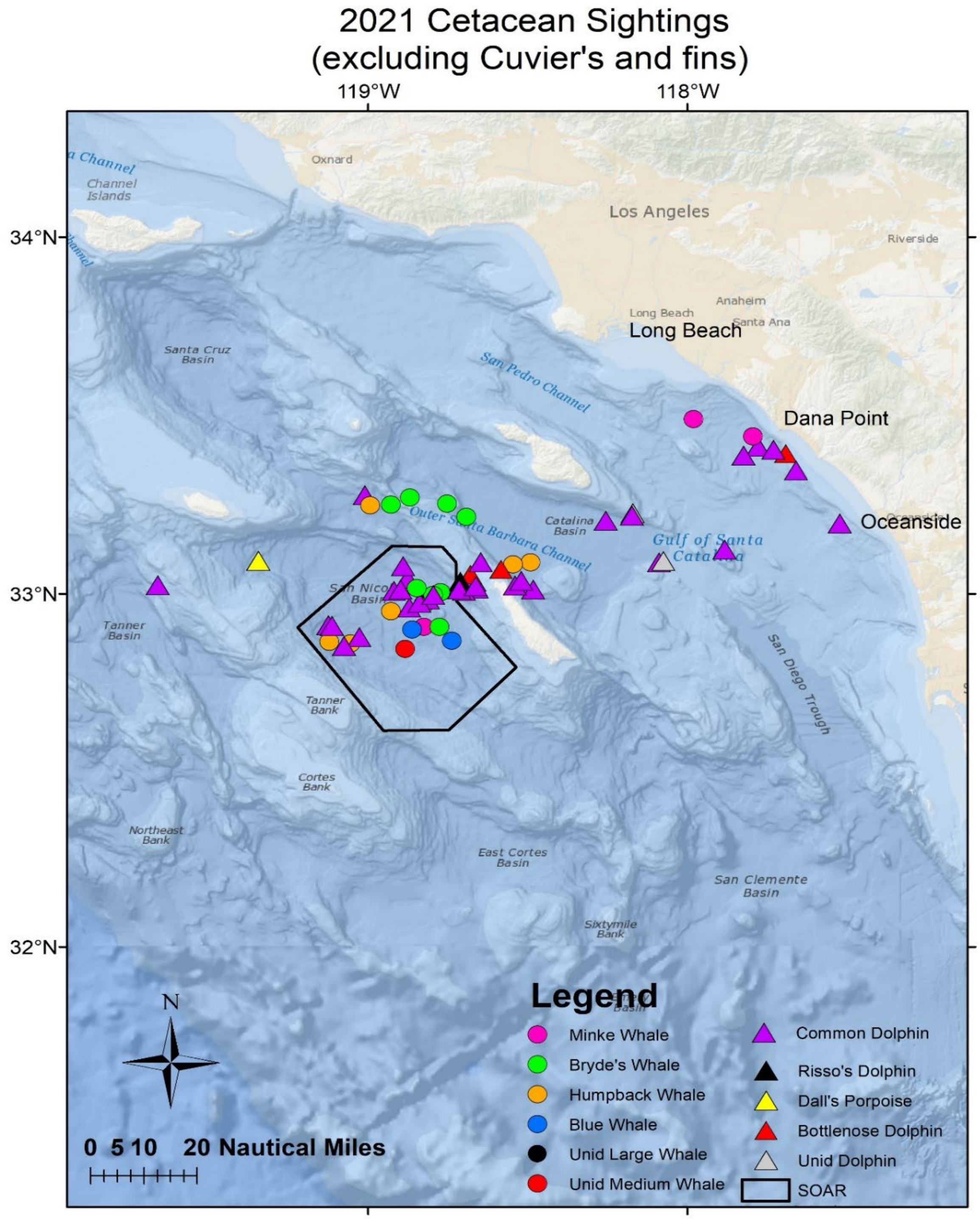


Figure 3. Sighting locations of cetaceans (except Cuvier's beaked whales and fin whales) by species from surveys conducted in 2021. SOAR = Southern California Anti-submarine Warfare Range. Prepared by B. Rone

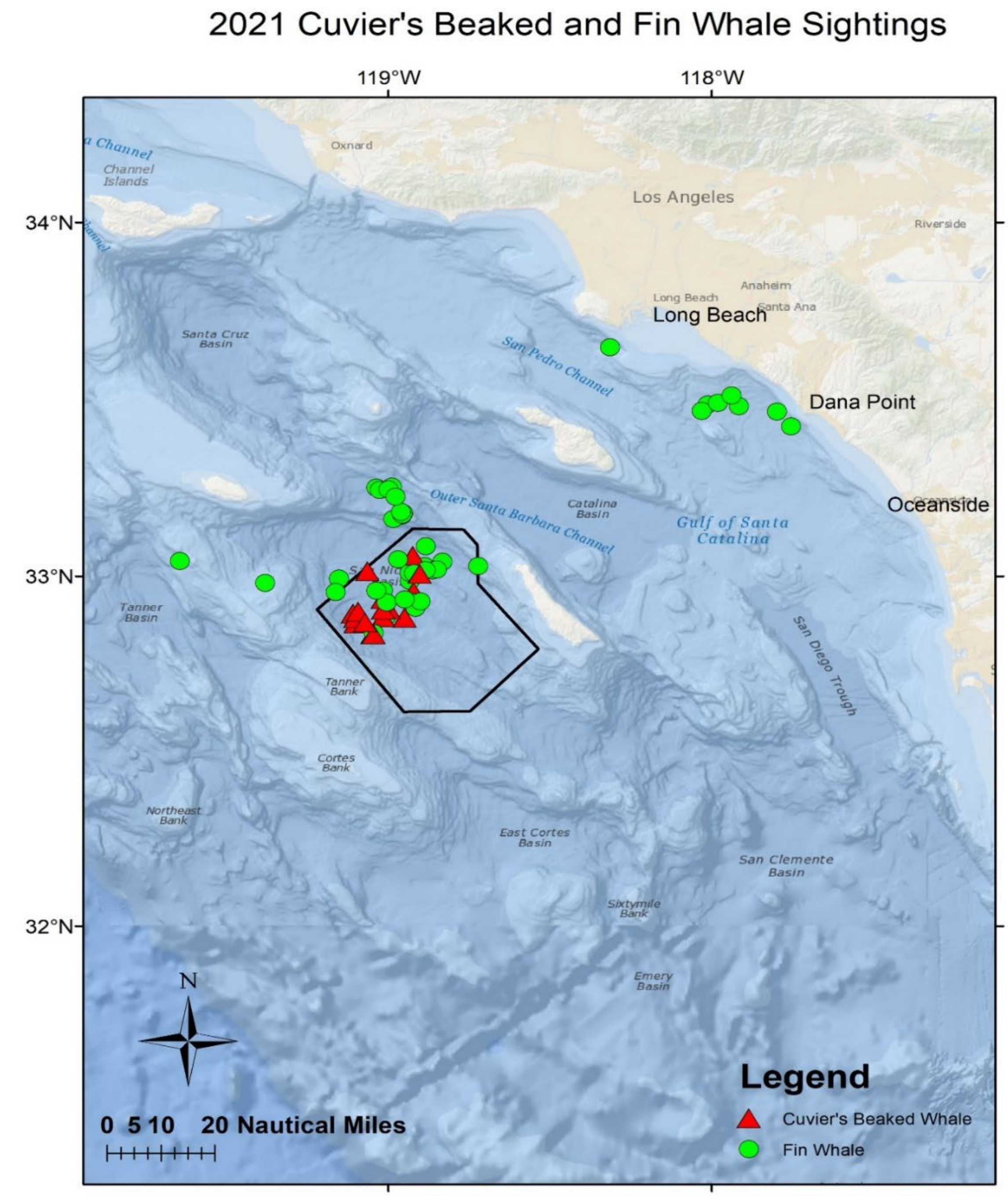


Figure 4. Cuvier's beaked whale and fin whale sightings from surveys conducted in 2021. The Southern California Anti-submarine Warfare Range (SOAR) is outlined in black. Prepared by B. Rone.

2021 Seasonal Cuvier's Beaked and Fin Whale Sightings

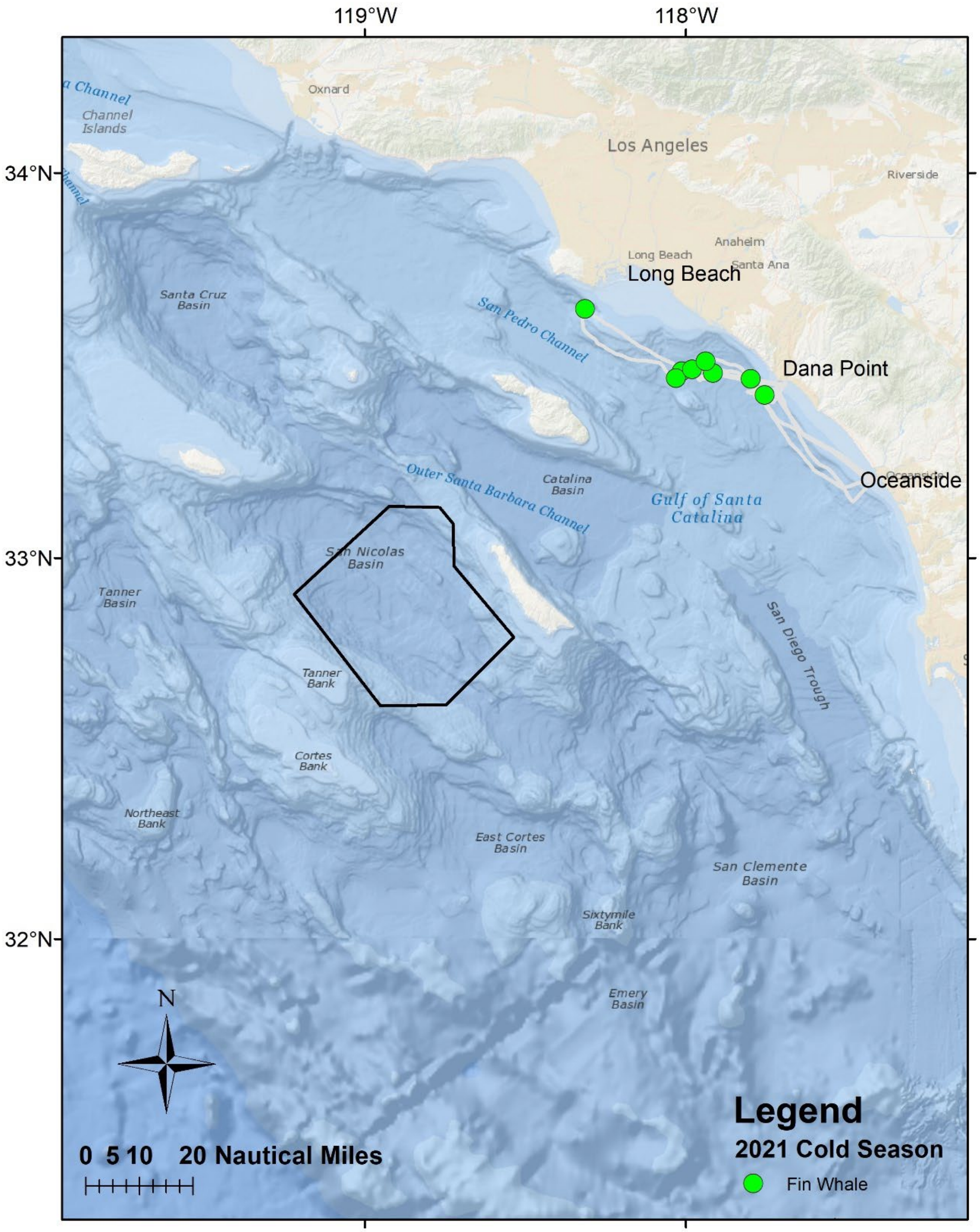


Figure 5. Cold season (January – May) locations of fin whales from surveys conducted along the coast in 2021. Vessel tracklines shown in gray. Prepared by B. Rone.

2021 Seasonal Cuvier's Beaked and Fin Whale Sightings

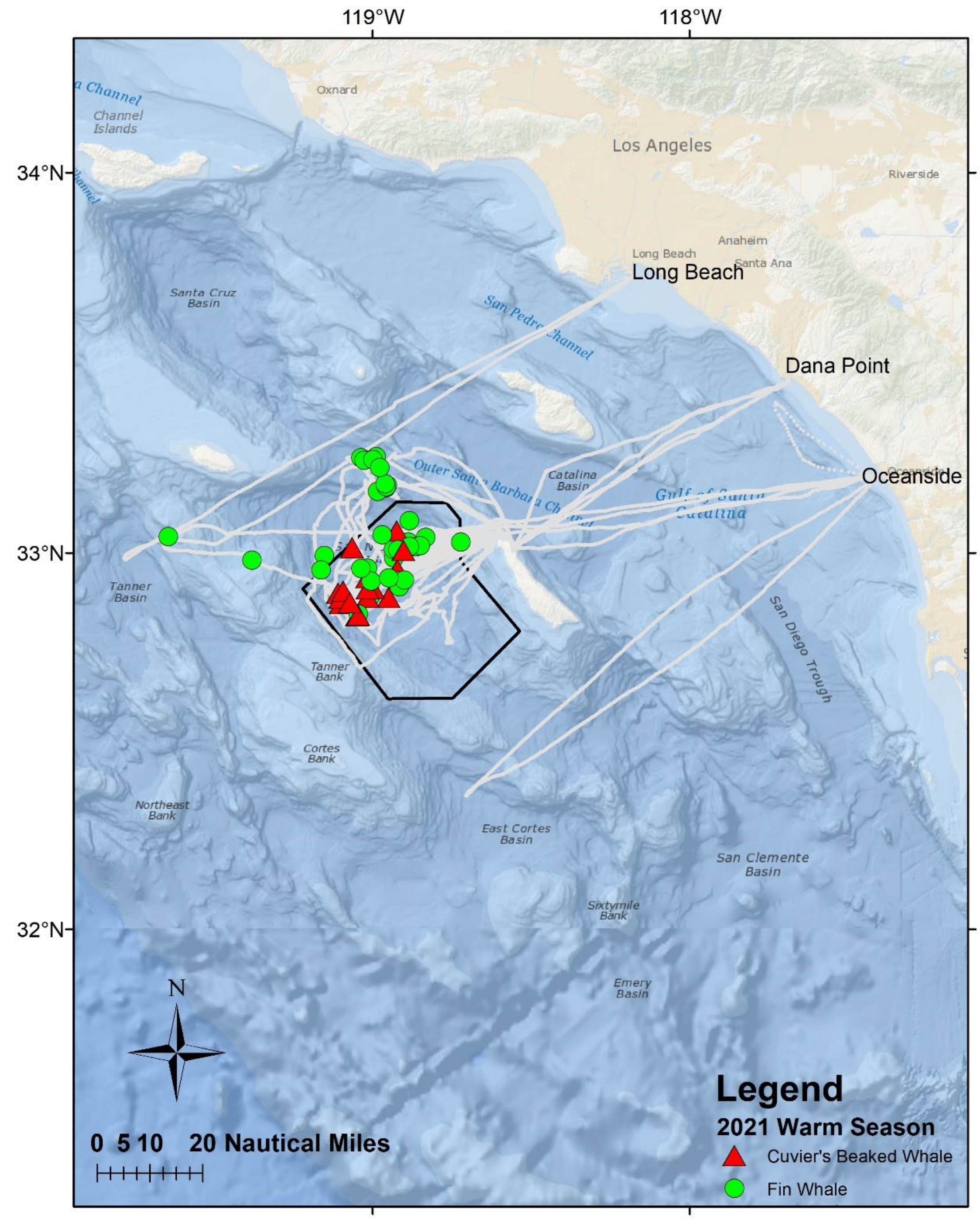


Figure 6. Warm season (June – November) locations of Cuvier’s beaked and fin whale sightings from surveys conducted in 2021. Vessel tracklines shown in gray. SOAR = Southern California Anti-submarine Warfare Range. Prepared by B. Rone

Table 4**.** Data collection summary for Cuvier's beaked whale sightings in 2021.

Date	Sighting	Estimated Group Size	Number of Calves	Unique IDs	Biopsies Collected	Tags Deployed
9/6/2021	PHO-3	1	0	1	0	0
9/7/2021	PHO-6	3	0	3	0	0
11/6/2021*	PHO-1	2	0	0	0	0
11/9/2021*	PHO-2	1	0	0	0	0
11/11/2021*	PHO-3	2	0	0	0	0
11/11/2021	PHY-4	3	0	3	0	1
11/12/2021*	PHY-2	2	1	2	2	0
11/12/2021*	PHY-3	4	0	4	0	1
11/13/2021*	PHO-1	2	0	2	2	2
11/13/2021	PHY-1	3	0	3	0	0
11/14/202*	PHY-5	3	1	3	0	1
11/14/2021*	PHY-3	2	1	2	0	0
11/14/2021	PHO-6	4	0	4	0	0
11/14/2021	PHO-5	5	1	5	0	0
Total: 14		**37**	**4**	**32**	**4**	**5**

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

Table 5**.** Data collection summary for fin whale sightings in 2021.

Date	Sighting	Estimated Group Size	Number of Calves	Estimated IDs	Biopsies Collected	Tags Deployed
4/15/2021*	PHO-3	1	0	1	0	0
4/16/2021*	PHO-2	1	0	1	0	0
4/16/2021*	PHO-3	1	0	1	0	0
4/16/2021*	PHO-5	1	0	0	0	0
4/17/2021*	PHO-4	1	0	1	0	0
4/17/2021*	PHO-1	1	0	0	0	0
4/17/2021*	PHO-3	1	0	1	0	0
4/19/2021*	PHO-1	1	0	1	1	1
9/9/2021	PHO-5	1	0	1	0	0
9/9/2021	PHO-7	1	0	1	1	0
9/9/2021	PHO-6	1	0	1	0	0
11/6/2021*	PHO-2	1	0	1	0	0
11/6/2021*	PHO-4	2	0	2	0	0
11/7/2021*	PHO-4	6	0	6	1	2
11/7/2021	PHY-3	1	0	1	0	0
11/7/2021	PHY-1	3	0	0	0	0
11/7/2021	PHY-2	2	0	1	0	0
11/7/2021	PHY-3	3	0	1	0	0
11/7/2021	PHY-1	1	0	0	0	0

11/8/2021	PHY-2	5	0	3	0	0
11/8/2021*	PHO-3	1	0	1	0	0
11/8/2021*	PHO-2	2	0	2	0	0
11/8/2021	PHY-4	1	0	1	0	0
11/8/2021	PHY-3	3	0	3	0	0
11/8/2021	PHY-2	1	0	1	0	0
11/8/2021*	PHO-1	2	0	3	0	0
11/8/2021*	PHO-5	2	0	2	1	0
11/9/2021	PHY-6	5	0	4	1	0
11/9/2021*	PHO-7	2	0	2	0	0
11/9/2021*	PHO-9	1	0	1	0	0
11/9/2021*	PHO-4	3	0	0	0	0
11/9/2021	PHY-2	1	0	1	0	0
11/11/2021*	PHY-1	1	0	0	0	0
11/11/2021*	PHY-3	1	0	0	0	0
11/11/2021	PHO-3	1	0	1	0	0
11/11/2021*	PHY-3	1	0	1	0	0
11/12/2021	PHO-2	1	0	1	0	0
11/12/2021	PHO-4	1	0	0	0	0
11/13/2021	PHY-2	1	0	1	0	0
11/14/2021	PHO-4	1	0	1	0	0
11/14/2021	PHO-3	1	0	1	0	0
11/14/2021	PHO-8	1	0	1	0	0
Total: 43		**68**	**0**	**34**	**5**	**3**

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

Photo-Identification and Biopsy Sampling

Cuvier’s Beaked Whales

Photo-IDs and biopsy samples from focal species collected during all efforts are summarized in Table 4 and Table 5. Four tissue samples were collected from Cuvier’s beaked whales in 2021, all from the darts of detached archival tags. All identification photos of Cuvier’s beaked whales collected in Southern California in 2021 were internally reconciled and compared to our historical catalog. This included 39 identifications during surveys at SOAR and eight opportunistic identifications made by whale watch boats operating from San Diego. These identifications represented an estimated 30 unique individuals, which were identified up to three times during the study year. Twelve (40%) of these individuals had been sighted in Southern California in a previous year, with sighting histories ranging from 2.0 to 14.1 years in length (Table 6).

There were four sightings of three different mother-calf pairs, all in November 2021. None of these mother-calf pairs had been sighted together previously, though two of the mothers have been sighted previously at SOAR, one as early as 2007, though never with an attendant calf. The third mother appears to be new to the study. This brings the total number of mother-calf pairs that have been identified together at SOAR since 2006 to 32.

Sightings of mother-calf pairs remain among the most valuable data from this study, as they are crucial to estimating vital rates 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 collaborated with researchers from two other regional studies of Cuvier's beaked whales to test whether appearance traits visible in standard identification photographs of the species are diagnostic of sex across distant populations. This manuscript is in press with *Mammalian Biology* with an anticipated publication date of March 2022. The abstract is provided here, and the final draft, once released by the journal, will be provided as Appendix 3:

> *Recent research on Cuvier's beaked whales (Ziphius cavirostris) from the Mediterranean has demonstrated that sexes can be visibly distinguished in photos using sex-linked patterns of scarring density and pigmentation, even at age classes which are notoriously difficult to differentiate. Being able to apply this research to other populations would allow for better monitoring of population demographics and vital rates globally. This study uses Photo Identification Captures (PICs) of known-sex, adult Cuvier's beaked whales from three regions (Southern California, USA; Guadalupe Island, Mexico; and the Mediterranean Sea, Italy) to evaluate geographic variation in sex-linked patterns of scarring density and pigmentation. Standardized scarring density measurements from typical photo-ID views and Generalized Linear Models (GLM) were used to identify scarring density thresholds for sex at each region and for all regions combined to predict the sex of individuals. Scarring densities did not differ significantly among regions and thresholds calculated from any region correctly predicted the sex in other regions 92 to 98% of the time. An agglomerative cluster analysis with complete linkage identified three distinct pigmentation clusters in each of the three regions, with one being indicative of sex. This study supports that scarring density is indicative of sex for this species, improves the predictive capacity of this metric inter-regionally, and provides a reliable method to estimate the sex of whales in a typical photo-ID catalog, thus supporting vital rate assessments for this data deficient species.*

Table 6**.** Summarized sighting histories for 12 individual Cuvier's beaked whales that were resighted in Southern California in 2021.

ID	First Sighting	Last Sighting	Encounters	Year Span
10	10/24/2007	11/14/2021	3	14.07
26	10/25/2007	11/13/2021	5	14.06
30	10/26/2007	9/7/2021	3	13.88
32	8/2/2008	11/14/2021	12	13.29
49	10/17/2008	11/18/2021	4	13.10
92	6/28/2010	11/14/2021	5	11.39
103	5/2/2011	11/14/2021	12	10.55
104	7/23/2011	11/13/2021	8	10.32
186	1/9/2015	11/14/2021	3	6.85
198	1/11/2016	11/12/2021	3	5.84
236	3/29/2018	11/14/2021	2	3.63
280	11/12/2019	11/14/2021	2	2.01

Fin Whales

Fin whales were sighted both coastally and on and near SOAR during 2021, with the highest encounter rate in 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 2020 and prior years that were processed in 2021.

This year we processed a total of 294 total fin whale identifications. This collection included just 93 identifications from 2020, due primarily to limited effort during the first year of the COVID-19 pandemic; the remainder were delayed opportunistic contributions from 2012-2019 (n=201) with most data from 2016-2018. This annual batch brought the total number of processed fin whale identifications in our collection to 4,234, which includes 3,052 sightings of 1,250 unique individuals. Fin whale photographs collected during the 2021 season, including 58 identifications from Navy-funded surveys in Southern California, are currently being compiled and will be reconciled with opportunistic data from the year and then compared to the historical catalog once 2021 opportunistic contributions are submitted to us in 2022.

Southern California remains the focal region for our fin whale photo-ID study, with a catalog now totaling 760 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 movements and residency patterns of whales in this study through 2019 is in press with *Mammalian Biology*, with anticipated publication in Spring 2022. The abstract is below, and once the final draft is approved by the journal it will be provided as an Appendix:

> *Fin whales (Balaenoptera physalus) along the western United States are managed as a single stock whose range overlaps with the California Current System (CCS). We used sighting histories of 932 individual fin whales photographed in the CCS from 1987 to 2018 to investigate movements and residency patterns within and among latitudinal regions. While 167 whales (18%) were sighted in multiple years, only 4 were documented in both the northern and southern CCS, with a boundary at 38.5°N. A permutation test of annual recaptures suggested movements among latitudinal regions of the CCS occurred significantly less than expected if whales moved freely within current stock boundaries. Fifteen whales were sighted in 6-10 different years on an average of 30 different days (range 8-101 days each), all in the heavily sampled Southern California Bight (SCB). There, we used lagged identification rates (LIR) to assess whether the probability of resighting an individual over time differed from random values for the region overall, within and beyond 25 km of the mainland, and by season. Our results suggest that the SCB is used seasonally by whales from the larger CCS stock but is also home to a smaller, year-round resident subpopulation. This latter group increasingly uses the nearshore waters of the SCB, where they are exposed to significantly elevated levels of anthropogenic activity.*

Five biopsy samples were collected from fin whales in 2021, bringing the total number of fin whale samples collected by MarEcoTel since 2016 to 34. Fin whale samples have been collected throughout research by us and collaborators for many years, and 88 individuals in the catalog have been genetically sexed to date (40 female and 48 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).

Analysis of Previously Collected Tag Data

Cuvier's beaked whale movement model comparison

The 25 Cuvier's beaked whales tagged at SCORE from 2010-2017 returned a total of 6,692 Argos locations and 339 FastLoc GPS positions deployments (Table *7*). An assessment of the distances between concurrent predicted location estimates from the two models suggested DF Distance-Angle-Rate filtering (Douglas et al., 2012) best removes questionable locations, which, in turn, leads both the CTCRW and foieGras models to return the most similar location estimates at all timesteps analyzed (Figure 7, Table 8). While the SDA-filtered data did not estimate locations as consistently between the two models as the DF filtered data, it performed better against itself as the time-step increased (i.e., the distance between concurrent location estimates from SDA-filtered datasets in each model was reduced with increasing time steps), while the unfiltered data performed worse as the time step got longer (Table 8). DF-filtered data at a 24 hr time step produced nearly equivalent home range estimates for both modelling methods (Figure 8).

The effectiveness of the DF filter was also supported by shorter average distances between locations predicted by both the CTCRW and foieGras models and concurrent GPS location estimates (Figure 9, Figure 10).

These results indicate that for Cuvier's beaked whales with limited home ranges, the preferred filtering method for Argos data prior to modeling is the Distance-Angle-Rate filter from Douglas et al. (2014), regardless of which model is used. The CTCRW model appears to perform better than the foieGras model, regardless of how the data is filtered prior to modeling, and provides location estimates closer to the FastLoc GPS locations.

Table 7. Summary of location data from 25 LIMPET tags deployed on Cuvier's beaked whales at SCORE from 2010 to 2017. Note that the deployment location is included as an LC3 for each whale.

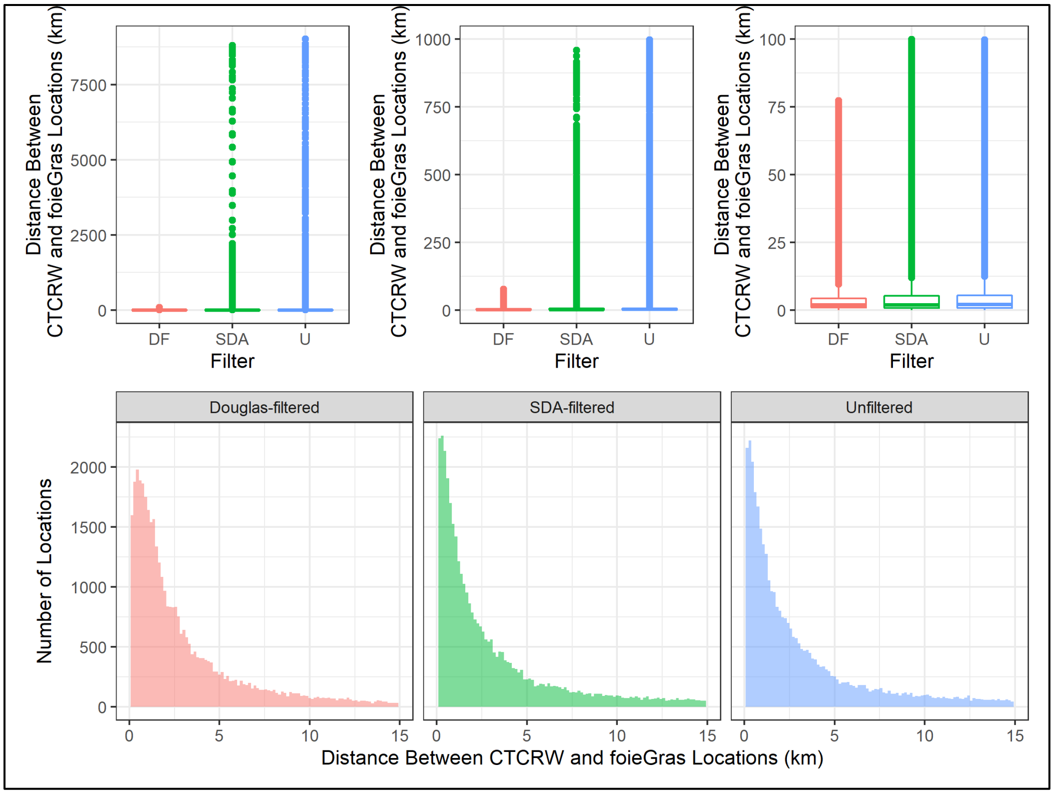
			Argos Locations by Class						
Tag ID	**Deployment Date**	**Total Argos Locations**	**3**	**2**	**1**	**A**	**B**	**Z**	**Total GPS Positions**
ZcTag010	2010-06-29	415	2	12	69	68	120	1	0
ZcTag011	2010-06-29	456	3	5	64	59	148	17	0
ZcTag014	2011-01-06	188	3	4	16	29	85	4	0
ZcTag015	2011-01-06	592	8	32	160	63	120	5	0
ZcTag016	2011-01-06	540	1	19	86	54	155	3	0
ZcTag017	2011-07-23	109	2	2	23	12	33	0	0
ZcTag019	2012-01-15	148	2	1	26	24	34	2	0
ZcTag020	2012-01-15	302	4	5	62	36	69	1	0

ZcTag021	2013-03-29	306	5	12	53	34	115	0	0
ZcTag022	2013-03-30	195	1	2	17	28	91	2	0
ZcTag023	2013-03-30	62	2	1	12	10	18	1	0
ZcTag024	2014-01-04	93	1	4	15	11	49	1	0
ZcTag025	2014-01-04	76	2	2	13	9	30	1	0
ZcTag026	2014-01-07	475	3	17	93	66	172	4	0
ZcTag027	2014-01-07	650	4	18	133	91	209	0	0
ZcTag028	2014-01-11	435	5	19	67	68	154	4	0
ZcTag032	2014-10-05	379	2	3	48	58	133	6	0
ZcTag034	2015-01-03	132	4	5	20	19	37	2	0
ZcTag035	2015-01-06	101	1	1	5	11	61	1	0
ZcTag036	2015-01-09	339	2	16	75	40	86	1	0
ZcTag037	2015-01-09	116	1	4	18	15	38	2	0
ZcTag045	2016-01-11	361	1	2	2	42	264	2	0
ZcTag052	2016-11-11	27	1	2	2	5	3	0	62
ZcTag053	2017-01-08	103	3	1	8	16	40	0	209
ZcTag058	2017-07-25	92	1	0	5	19	35	5	68
Total:		6692	64	189	1092	887	2299	65	339

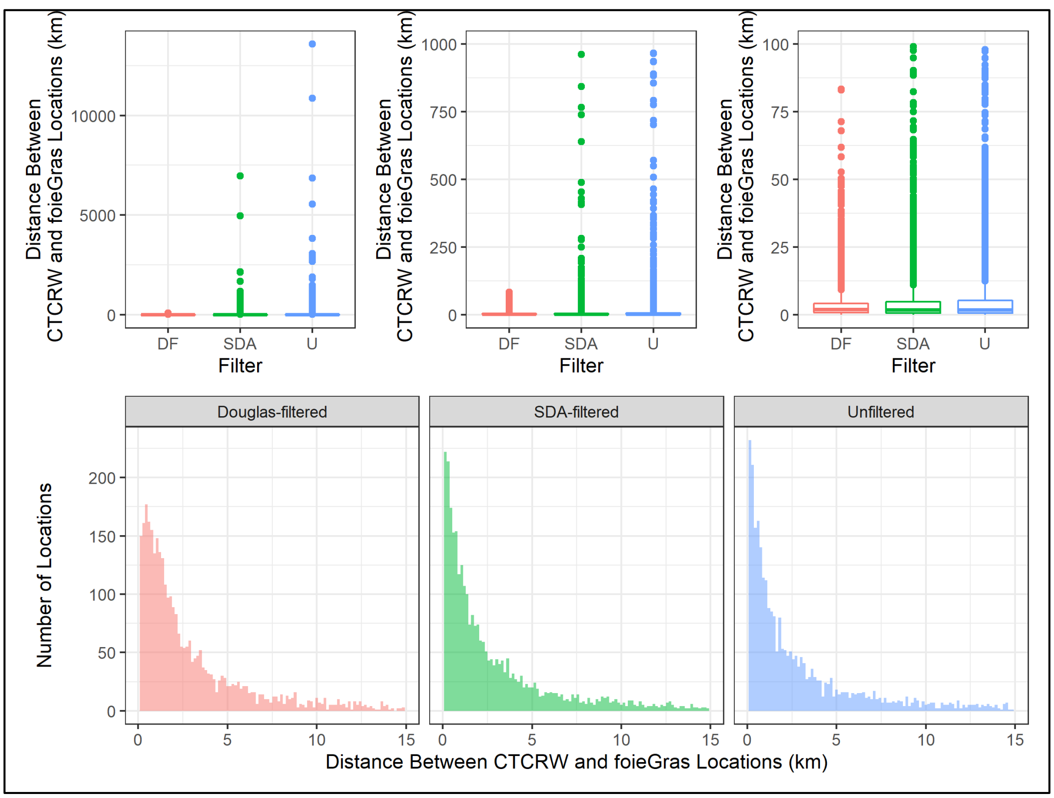
Table 8. Distances between concurrent location estimates predicted by the CTCRW and foieGras models as a function of pre-filtering method: Unfiltered, SDA-filtered, or Douglas-Filtered. All distributions were heavily right skewed.

	Mean (SD) Distance (km) Between Modeled Location Estimates		
Pre-filtering Method	**30 min Timesteps**	**6 hr Timesteps**	**24 hr Timesteps**
Douglas-filtered	3.874 (6.153)	3.791 (6.233)	3.775 (7.053)
SDA-filtered	16.852 (211.208)	14.091 (166.841)	9.881 (53.286)
Unfiltered	29.637 (318.102)	34.812 (374)	54.346 (561.12)

A


Distance Between CTCRW and foieGras Locations (km)
Filter
DF
SDA
U
Douglas-filtered
SDA-filtered
Unfiltered
Number of Locations
Distance Between CTCRW and foieGras Locations (km)

B


Distance Between CTCRW and foieGras Locations (km)
Filter
DF
SDA
U
Douglas-filtered
SDA-filtered
Unfiltered
Number of Locations
Distance Between CTCRW and foieGras Locations (km)

C

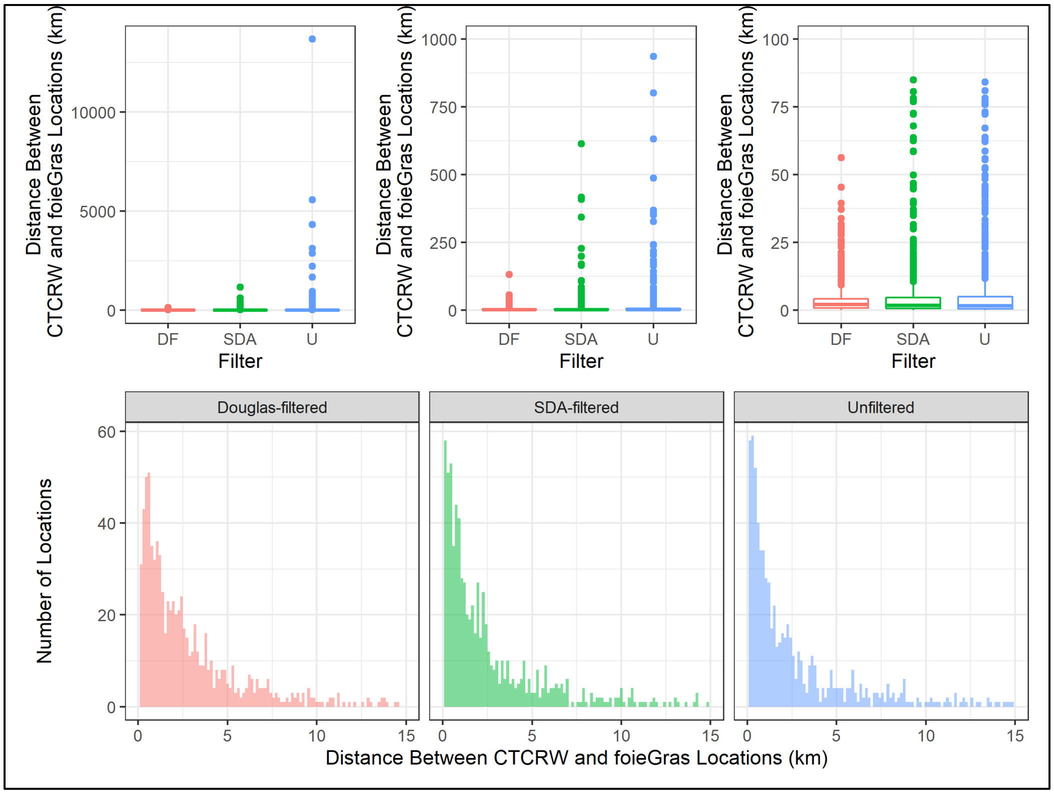


Figure 7. Distribution of distances between concurrent locations from the foieGras and CTCRW models at three different timesteps; A) 30 minutes, B) 6 hours, C) 24 hours. For each timestep, the upper plots are box plots of distance by pre-filtering method (DF = Douglas Filter, SDA = Speed-Distance-Angle, U = unfiltered), with the scale of the y-axis progressively zoomed from left to right to provide both the full scope of the differences and better resolution within closer distances. The lower plots are histograms of distances between concurrent locations within 15 km of each other, which comprised the majority of the dataset. Both the SDA-Filtered and Unfiltered data are more right-skewed than the Douglas filtered. Prepared by D. Sweeney.

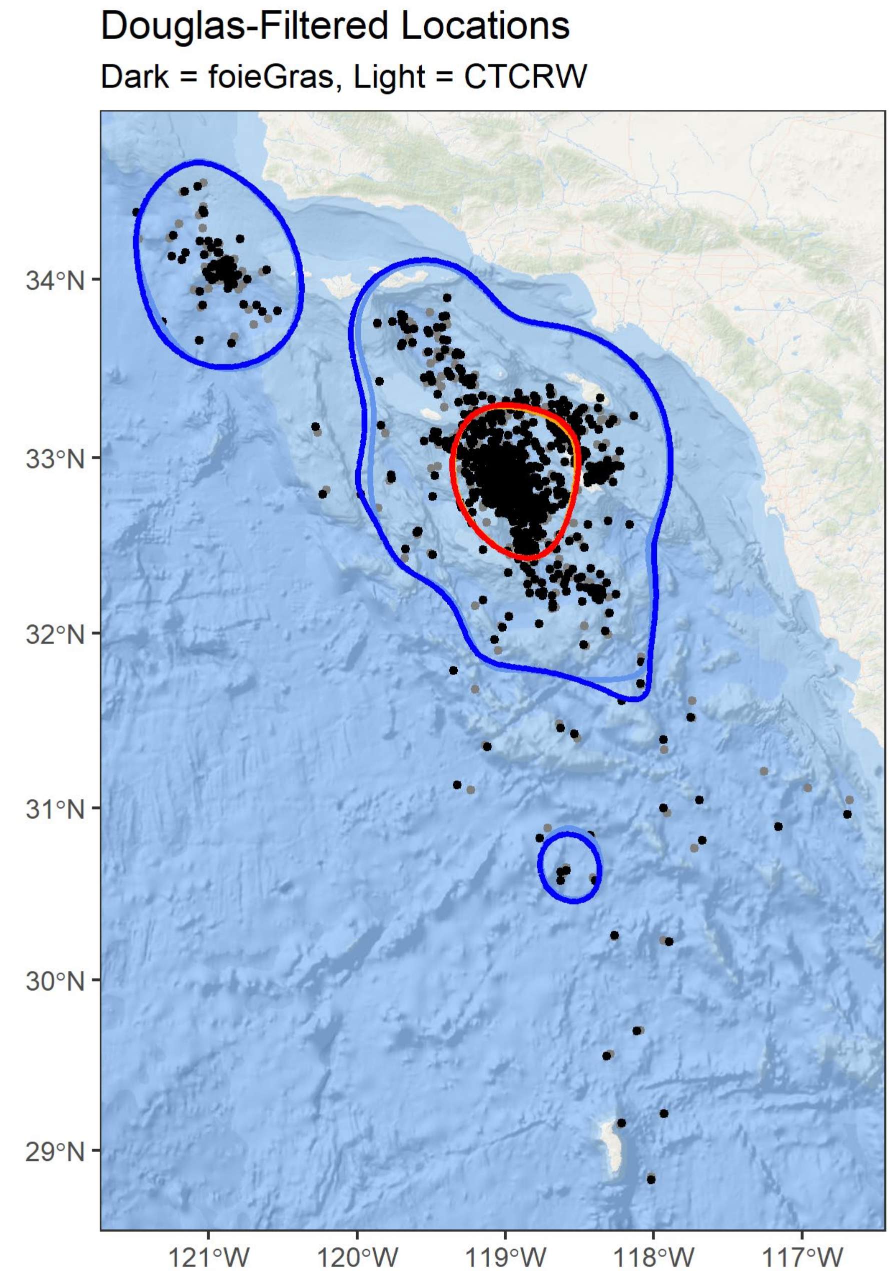


Figure 8. Home range estimates from the foieGras and CTCRW modeled locations based on DF-data at a 24 hr time step. Blue lines represent the 95% kernel density estimates and red lines the 50% kernel density estimates; the lighter-shaded CTCRW home range lines overlap almost entirely with those from the foieGras model and are not typically visible. Prepared by D. Sweeney.

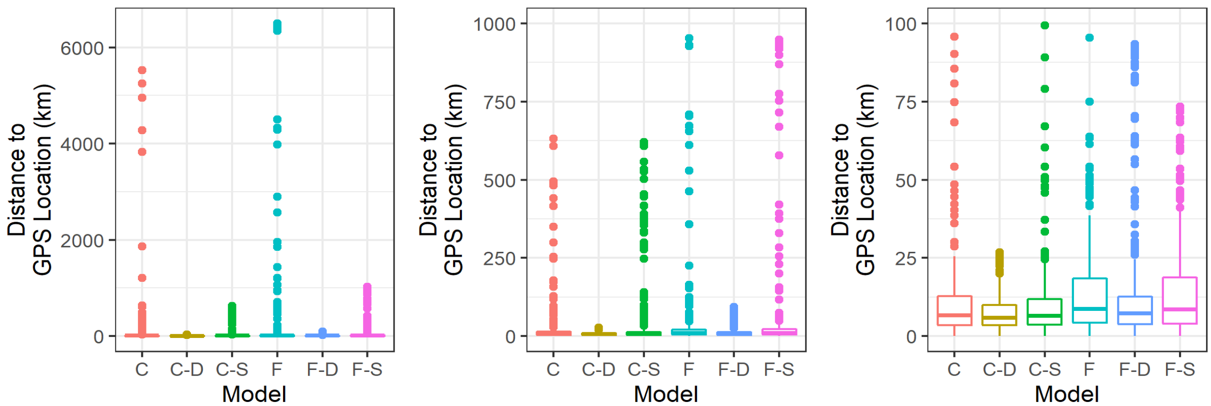


Figure 9. *Boxplots showing the distribution of distances between modeled location estimates and GPS positions.* Plots progressively zoom in on the vertical axis to better show the distribution around the median and inter-quartile range. Horizontal axis model abbreviations are shown as follows: C = CTCRW model with unfiltered Argos data, C-D = CTCRW model with Douglas Filter (DF) pre-filtering, C-S = CTCRW model with SDA pre-filtering, F = foieGras with unfiltered data, F-D = foieGras model with DF pre-filtering, F-S = foieGras model with SDA pre-filtering. Prepared by D. Sweeney.

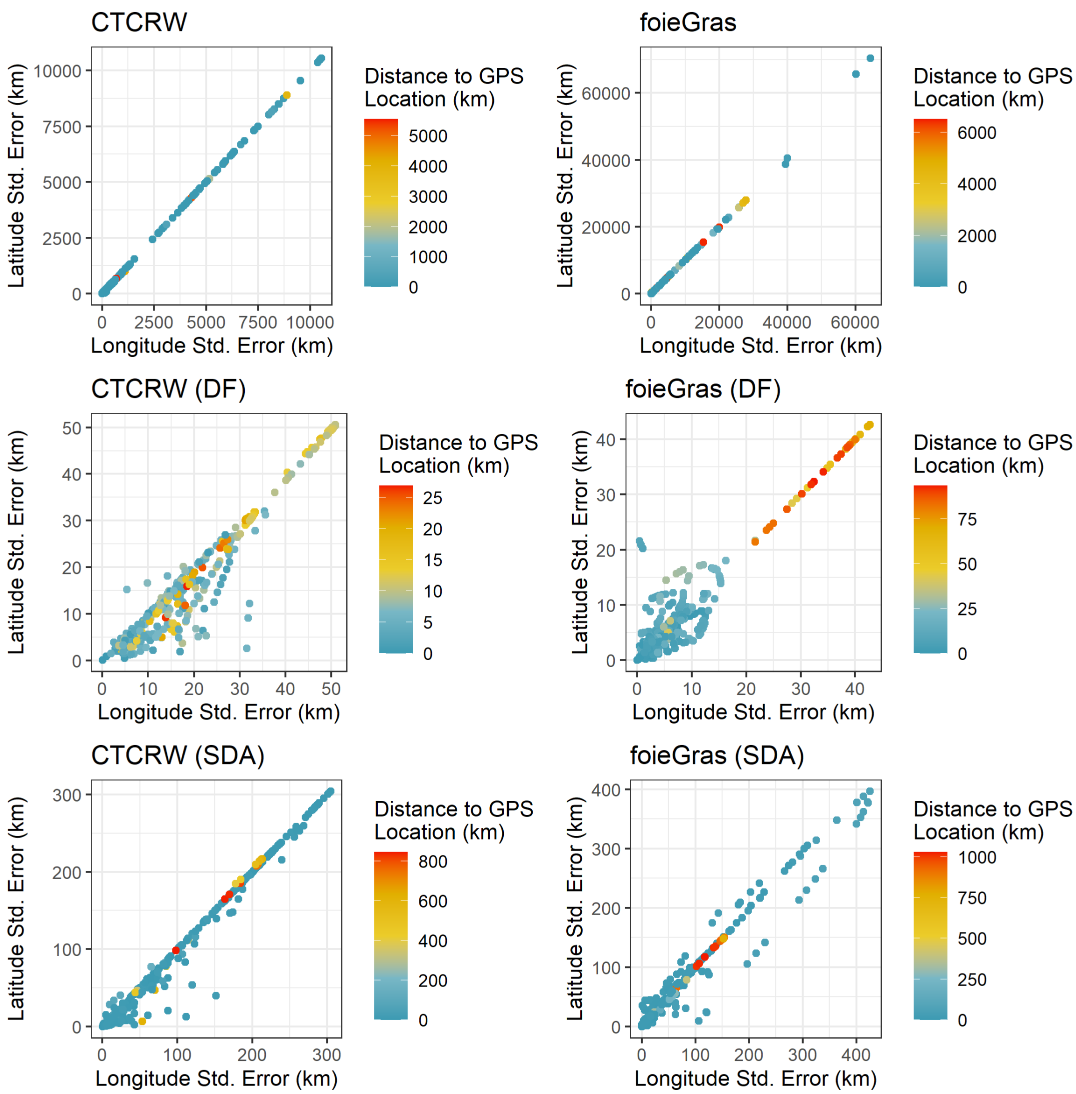


Figure 10. Plots of the Standard Errors for CRCRW (left column) and foieGras (right column), with modeled locations matching the timestamp of Fastloc GPS locations. The top row of data represents the results from the unfiltered Argos data, middle row is the Douglas Filtered Argos data (DF) and the bottom row is the Frietas filtered data (SDA). Points are colored by how far each point is from the concurrent Fastloc GPS location. The scales between the two columns are not equal due to the difference in Standard Errors between the models.

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Appendices

Appendix 1. Sighting details from effort conducted in 2021 including effort from Pacific Fleet Monitoring and the ancillary effort.

Date	Common Name	Latitude	Longitude	Group Size	Est IDs	Samples Collected	Tags Deployed
4/15/2021	Fin Whale	N33 27.96	W117 47.99	1	1	0	0
4/15/2021	Common Dolphin	N33 11.87	W117 31.43	300	-	-	-
4/15/2021	Minke Whale	N33 26.55	W117 47.78	1	0	0	-
4/15/2021	Common Dolphin	N33 20.80	W117 39.65	30	-	-	-
4/16/2021	Common Dolphin	N33 24.29	W117 43.86	300	-	-	-
4/16/2021	Fin Whale	N33 30.70	W117 56.37	1	1	0	0
4/16/2021	Fin Whale	N33 29.46	W117 58.96	1	1	0	0
4/16/2021	Minke Whale	N33 29.47	W117 58.96	1	1	0	0
4/16/2021	Fin Whale	N33 28.90	W117 55.02	1	0	0	0
4/17/2021	Fin Whale	N33 29.16	W118 00.89	1	1	0	0
4/17/2021	Fin Whale	N33 38.85	W118 18.97	1	0	0	0
4/17/2021	Fin Whale	N33 28.09	W118 01.93	1	1	0	0
4/17/2021	Common Dolphin	N33 28.11	W118 01.93	-	-	-	-
4/19/2021	Fin Whale	N33 25.45	W117 45.36	1	1	1	1
4/19/2021	Bottlenose Dolphin	N33 23.66	W117 41.53	18	0	0	-
9/3/2021	Common Dolphin	N33 15.61	W117 29.92	70	-	-	-
9/3/2021	Common Dolphin	N33 13.55	W117 73.88	55	-	-	-
9/3/2021	Leatherback Turtle	N33 17.63	W117 40.66	1	-	-	-
9/5/2021	Common Dolphin	N33 01.42	W118 32.43	50	-	-	-
9/5/2021	Common Dolphin	N33 13.22	W118 10.44	250	-	-	-
9/5/2021	Common Dolphin	N33 02.22	W118 31.25	75	-	-	-
9/6/2021	Cuvier's Beaked Whale	N32 52.08	W119 04.33	1	1	0	0
9/6/2021	Brydes's Whale	N32 54.36	W118 46.64	2	1	0	-
9/6/2021	Common Dolphin	N33 00.70	W118 53.90	75	-	-	-
9/6/2021	Brydes's Whale	N33 00.94	W118 50.93	3	3	0	-

9/6/2021	Common Dolphin	N32 51.15	W119 04.53	20	-	-	-
9/7/2021	Brydes's Whale	N32 59.80	W118 47.83	2	1	0	-
9/7/2021	Common Dolphin	N32 59.81	W118 47.77	40	-	-	-
9/7/2021	Common Dolphin	N32 54.58	W119 06.76	8	-	-	-
9/7/2021	Common Dolphin	N32 54.67	W119 07.46	100	-	-	-
9/7/2021	Common Dolphin	N32 52.67	W119 01.64	100	-	-	-
9/7/2021	Cuvier's Beaked Whale	N32 53.95	W119 05.61	3	3	0	0
9/7/2021	Brydes's Whale	N33 00.26	W118 46.49	2	2	0	-
9/8/2021	Brydes's Whale	N33 13.00	W118 41.57	1	1	0	-
9/8/2021	Blue Whale	N32 52.01	W118 44.33	1	1	-	-
9/8/2021	Brydes's Whale	N33 15.19	W118 45.23	1	1	0	-
9/8/2021	Brydes's Whale	N33 15.04	W118 55.75	2	2	0	-
9/8/2021	Brydes's Whale	N33 16.23	W118 52.19	1	0	0	-
9/9/2021	Fin Whale	N32 57.52	W119 02.30	1	1	0	0
9/9/2021	Common Dolphin	N33 00.78	W118 42.90	300	-	-	-
9/9/2021	Fin Whale	N32 59.55	W119 09.18	1	1	1	0
9/9/2021	Common Dolphin	N32 58.47	W118 50.33	150	-	-	-
9/9/2021	Common Dolphin	N33 01.25	W118 39.80	150	-	-	-
9/9/2021	Fin Whale	N32 57.23	W119 09.77	1	1	0	0
9/9/2021	Common Dolphin	N32 57.66	W118 52.26	250	-	-	-
9/10/2021	Unid Medium Cetacean	N32 50.66	W118 53.10	1	-	-	-
9/10/2021	Blue Whale	N32 53.93	W118 51.78	2	2	0	-
9/11/2021	Common Dolphin	N33 12.36	W118 15.34	700	-	-	-
11/5/2021	Common Dolphin	N33 07.46	W117 53.08	3	-	-	-
11/5/2021	Unid Dolphin	N33 05.55	W118 04.55	40	-	-	-
11/5/2021	Common Dolphin	N33 05.29	W118 05.40	40	-	-	-
11/5/2021	Common Dolphin	N33 00.70	W118 28.97	15	-	-	-
11/6/2021	Fin Whale	N33 00.50	W118 55.26	1	1	0	0
11/6/2021	Cuvier's Beaked Whale	N33 00.34	W118 54.22	2	0	0	0

11/6/2021	Common Dolphin	N33 04.67	W118 53.44	45	-	-	-
11/6/2021	Fin Whale	N33 05.09	W118 53.10	2	2	0	0
11/7/2021	Fin Whale	N33 00.96	W118 53.09	5	5	0	2
11/7/2021	Fin Whale	N33 00.91	W118 51.85	1	1	0	0
11/7/2021	Fin Whale	N32 55.98	W118 57.00	3	0	0	0
11/7/2021	Humpback Whale	N32 57.00	W118 55.77	3	0	-	-
11/7/2021	Fin Whale	N33 01.11	W118 51.02	2	1	0	0
11/7/2021	Fin Whale	N32 54.57	W118 55.03	3	1	0	0
11/7/2021	Elephant Seal	N32 56.64	W118 54.92	1	-	-	-
11/7/2021	Fin Whale	N32 55.64	W118 54.05	1	0	0	0
11/8/2021	Risso's Dolphin	N33 02.04	W118 42.71	2	0	0	0
11/8/2021	Fin Whale	N33 15.04	W119 02.25	5	3	0	0
11/8/2021	Fin Whale	N33 10.89	W118 57.68	1	1	0	0
11/8/2021	Fin Whale	N33 02.41	W118 50.03	2	2	0	0
11/8/2021	Bottlenose Dolphin	N33 03.29	W118 40.80	10	0	0	-
11/8/2021	Fin Whale	N33 01.67	W118 43.35	1	1	0	0
11/8/2021	Common Dolphin	N32 59.05	W118 48.78	20	-	-	-
11/8/2021	Unid Large Cetacean	N32 58.29	W118 49.69	2	-	-	-
11/8/2021	Fin Whale	N33 13.48	W118 58.72	3	3	0	0
11/8/2021	Fin Whale	N33 14.77	W119 00.03	1	1	0	0
11/8/2021	Fin Whale	N33 15.19	W118 59.37	2	3	0	0
11/8/2021	Humpback Whale	N33 14.92	W118 59.66	1	0	-	-
11/8/2021	Fin Whale	N33 14.61	W119 01.68	2	2	1	0
11/8/2021	Common Dolphin	N33 05.38	W118 38.84	80	-	-	-
11/9/2021	Common Dolphin	N33 01.57	W118 40.67	8	-	-	-
11/9/2021	Fin Whale	N33 10.69	W118 57.30	5	4	1	0
11/9/2021	Fin Whale	N33 09.72	W118 59.11	2	2	0	0
11/9/2021	Cuvier's Beaked Whale	N33 00.84	W119 03.93	1	0	0	0
11/9/2021	Fin Whale	N32 55.55	W118 55.08	1	1	0	0
11/9/2021	Fin Whale	N33 10.46	W118 57.44	1	1	0	0
11/11/2021	Fin Whale	N32 50.24	W119 02.75	1	0	0	0
11/11/2021	Fin Whale	N33 02.83	W118 58.20	1	0	0	0
11/11/2021	Humpback Whale	N32 58.42	W118 49.26	5	0	-	-
11/11/2021	Cuvier's Beaked Whale	N32 50.09	W119 02.76	3	3	0	1

11/11/2021	Cuvier's Beaked Whale	N32 56.07	W119 01.00	2	0	0	0
11/11/2021	Fin Whale	N32 55.45	W119 00.35	1	1	0	0
11/11/2021	Fin Whale	N32 57.54	W119 01.04	1	1	0	0
11/12/2021	Common Dolphin	N33 00.50	W118 41.99	500	-	-	-
11/12/2021	Common Dolphin	N33 02.56	W118 52.60	125	-	-	-
11/12/2021	Fin Whale	N33 02.56	W119 38.72	1	1	0	0
11/12/2021	Common Dolphin	N33 01.43	W119 39.54	30	-	-	-
11/12/2021	Cuvier's Beaked Whale	N32 54.30	W119 01.00	4	4	0	1
11/12/2021	Cuvier's Beaked Whale	N32 52.85	W119 06.09	2	2	1	0
11/12/2021	Humpback Whale	N32 51.59	W119 03.39	2	0	-	-
11/12/2021	Fin Whale	N32 58.79	W119 22.86	1	0	0	0
11/13/2021	Cuvier's Beaked Whale	N32 52.96	W119 00.96	3	3	0	0
11/13/2021	Fin Whale	N32 53.04	W119 00.40	1	1	0	0
11/13/2021	Cuvier's Beaked Whale	N32 51.91	W119 06.04	2	2	1	2
11/14/2021	Fin Whale	N32 59.15	W118 56.02	1	1	0	0
11/14/2021	Common Dolphin	N33 00.50	W118 55.17	50	-	-	-
11/14/2021	Cuvier's Beaked Whale	N33 03.45	W118 55.48	5	5	0	0
11/14/2021	Cuvier's Beaked Whale	N32 57.30	W118 55.35	4	4	0	0
11/14/2021	Fin Whale	N33 01.66	W118 53.31	1	1	0	0
11/14/2021	Harbor Seal	N33 02.09	W118 40.84	1	-	-	-
11/14/2021	Common Dolphin	N33 02.05	W118 40.01	2	-	-	-
11/14/2021	Fin Whale	N33 00.52	W118 56.08	1	1	0	0
11/14/2021	Cuvier's Beaked Whale	N32 52.92	W118 57.02	2	2	0	0
11/14/2021	Cuvier's Beaked Whale	N32 53.61	W119 06.57	3	3	0	1
11/14/2021	Common Dolphin	N33 01.47	W118 42.69	40	-	-	-
11/14/2021	Humpback Whale	N32 51.87	W119 07.32	1	0	-	-
11/14/2021	Minke Whale	N32 54.41	W118 49.58	1	1	0	-
11/14/2021	Common Dolphin	N33 00.90	W118 39.61	400	-	-	-

11/15/2021	Common Dolphin	N33 23.36	W117 49.50	125	-	-	-
11/15/2021	Unid Dolphin	N33 13.60	W118 10.33	15	-	-	-
11/15/2021	Common Dolphin	N33 24.80	W117 46.78	750	-	-	-
11/19/2021	Humpback Whale	N33 05.29	W118 29.54	1	0	-	-
11/19/2021	Humpback Whale			1	0	-	-
11/19/2021	Bottlenose Dolphin	N33 04.14	W118 35.02	10	0	0	-
11/21/2021	Dall's Porpoise	N33 05.57	W119 20.58	3	-	-	-
11/21/2021	Common Dolphin	N33 16.66	W119 00.61	350	-	-	-

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

Appendix 3. Multi-regional Comparison of Scarring and Pigmentation Patterns in Cuvier's Beaked Whales