Guadalupe Fur Seal Population Census and Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean, 2018-2019

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Guadalupe fur seals (*Arctocephalus townsendi*) at Punta Sur, Guadalupe Island, México. Photo credit: J.D. Harris, NOAA Fisheries, Marine Mammal Laboratory, California Current Ecosystem Program. SEMARNAT permit number SGPA/DGVS/002460/18.

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14. ABSTRACT
Guadalupe fur seals (Arctocephalus townsendi or A. philippii townsendi), listed as threatened under the U.S. Endangered Species Act (ESA), were thought to be extinct in the early 1900s. The population has increased since rediscovery of this species in 1949 but is currently approximately 80% less than the pre-exploitation level. As the population continues to recover, Guadalupe fur seals are increasingly common in their historical range extending from central México to Washington State. However, relatively little is known about this species compared with other more abundant pinnipeds that also use the California Current System. Accurate and current population estimates are lacking because censuses at the only rookery have been sparse and sporadic, and there is a paucity of data on the at-sea movements of this species because few individuals have been tracked using telemetry instruments. The goal of this project, therefore, is to better understand Guadalupe fur seal abundance, behavior, distribution, and habitat use and determine the degree to which this recovering population uses U.S. Navy training and testing ranges in the North East Pacific. In 2018, censuses were performed at both the main rookery (Guadalupe Island, México) and the primary recolonization site (San Benito Archipelago, México) during the breeding season, and satellite tags were deployed on adult females (n = 15), juvenile females (n = 10), and juvenile males (n = 10) at Guadalupe Island during the non-breeding season. In 2018, the number of fur seals observed at Guadalupe Island almost doubled compared to the last census in 2010, but at San Benito Archipelago, fewer fur seals were counted than any other year during the breeding season since 2007. From November 2018-April 2019, Guadalupe fur seals broadly used the California Current System (20-42°N, 112-130°W), primarily north of Guadalupe Island and offshore of the continental shelf break, but remained

<800 km from the west coast of North America with mostly nocturnal diving to depths <60 m. Adult females were distributed farther offshore and had greater spatial segregation among individuals. Juvenile animals intensely used three areas: (1) 50-250 km offshore of central California, extending from Point Conception to San Francisco Bay (both sexes), (2) up to 300 km south-southeast of Guadalupe Island (females only), and (3) ~100 km offshore of Magdalena Bay, Baja California Sur. One adult female used the U.S. Navy Northwest Training and Testing (NWTT) Area (3% overlap), whereas there was 42% overlap between the area used by all 35 fur seals and the Southern California (SOCAL) Range Complex (10% of this within the nearshore portion of the range with water depths <2,000 m). Guadalupe fur seals had greater use of the Southern California Anti-submarine Warfare Range (SOAR; 87% overlap) and the Point Mugu Sea Range (PMSR), both the overall area (99% overlap) and the nearshore portion of the range with water depths <2,000 m (38% overlap). This species appeared to primarily use the SOCAL Range as a transit corridor between Guadalupe Island and foraging grounds farther to the north, but there was significant juvenile seal use of the PMSR (>80% overlap), primarily in water depths >2,000 m, that appeared to be linked to foraging activity. As the first year in a multiyear study, these 2018-2019 results improve our understanding of Guadalupe fur seal abundance, behavior, and use of U.S. Navy training and testing ranges in the North East Pacific, and additional census and telemetry data collected in subsequent years will further elucidate population trends and interannual and seasonal variability in habitat use and movement patterns.

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Monitoring, visual surveys, vessel surveys, marine mammals, Guadalupe fur seal, tagging, Southern California Range Complex

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Acronyms and Abbreviations

ESA	Endangered Species Act
GCP	Great-circle Path
GMT	Greenwich Mean Time
GPS	Global Positioning System
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWTT	Northwest Training and Testing Area
PMSR	Point Mugu Sea Range
RSI	Relative Search Index
SOAR	Southern California Anti-submarine Warfare Range
SOCAL	Southern California Range Complex
UD	Utilization Distribution

Abstract

Guadalupe fur seals (*Arctocephalus townsendi* or *A. philippii townsendi*), listed as threatened under the U.S. Endangered Species Act (ESA), were thought to be extinct in the early 1900s. The population has increased since rediscovery of this species in 1949 but is currently approximately 80% less than the pre-exploitation level. As the population continues to recover, Guadalupe fur seals are increasingly common in their historical range extending from central México to Washington State. However, relatively little is known about this species compared with other more abundant pinnipeds that also use the California Current System. Accurate and current population estimates are lacking because censuses at the only rookery have been sparse and sporadic, and there is a paucity of data on the at-sea movements of this species because few individuals have been tracked using telemetry instruments. The goal of this project, therefore, is to better understand Guadalupe fur seal abundance, behavior, distribution, and habitat use and determine the degree to which this recovering population uses U.S. Navy training and testing ranges in the North East Pacific. In 2018, censuses were performed at both the main rookery (Guadalupe Island, México) and the primary recolonization site (San Benito Archipelago, México) during the breeding season, and satellite tags were deployed on adult females (n = 15), juvenile females (n = 10), and juvenile males (n = 10) at Guadalupe Island during the non-breeding season. In 2018, the number of fur seals observed at Guadalupe Island almost doubled compared to the last census in 2010, but at San Benito Archipelago, fewer fur seals were counted than any other year during the breeding season since 2007. From November 2018-April 2019, Guadalupe fur seals broadly used the California Current System (20-42°N, 112-130°W), primarily north of Guadalupe Island and offshore of the continental shelf break, but remained <800 km from the west coast of North America with mostly nocturnal diving to depths <60 m. Adult females were distributed farther offshore and had greater spatial segregation among individuals. Juvenile animals intensely used three areas: (1) 50-250 km offshore of central California, extending from Point Conception to San Francisco Bay (both sexes), (2) up to 300 km south-southeast of Guadalupe Island (females only), and (3) ~100 km offshore of Magdalena Bay, Baja California Sur. One adult female used the U.S. Navy Northwest Training and Testing (NWTT) Area (3% overlap), whereas there was 42% overlap between the area used by all 35 fur seals and the Southern California (SOCAL) Range Complex (10% of this within the nearshore portion of the range with water depths <2,000 m). Guadalupe fur seals had greater use of the Southern California Anti-submarine Warfare Range (SOAR; 87% overlap) and the Point Mugu Sea Range (PMSR), both the overall area (99% overlap) and the nearshore portion of the range with water depths <2,000 m (38% overlap). This species appeared to primarily use the SOCAL Range as a transit corridor between Guadalupe Island and foraging grounds farther to the north, but there was significant juvenile seal use of the PMSR (>80% overlap), primarily in water depths >2,000 m, that appeared to be linked to foraging activity. As the first year in a multiyear study, these 2018-2019 results improve our understanding of Guadalupe fur seal abundance, behavior, and use of U.S. Navy training and testing ranges in the North East Pacific, and additional census and telemetry data collected in subsequent years will further elucidate population trends and interannual and seasonal variability in habitat use and movement patterns.

Introduction

The Guadalupe fur seal (*Arctocephalus townsendi* or *A. philippii townsendi*), similar to other fur seals, was hunted to near extinction for its thick fur until the early 1900s (Hubbs 1956). Pre-exploitation there may have been as many as 200,000 Guadalupe fur seals (Hubbs 1979). Despite federal protection in the U.S. and México since the 1970s, this species has not recovered as rapidly as other pinnipeds (*e.g.,* northern elephant seals) that also use the California Current System. The population increased at an average annual rate of 5.9% from 1984-2013, but still is approximately 80% less than the pre-exploitation level with a population estimate of 34,000-44,000 individuals in 2013 (Garcia-Aguilar et al. 2018). Currently, Guadalupe fur seals are the only pinnipeds inhabiting the California Current System that are protected by the U.S. Endangered Species Act (ESA; listed as "threatened" since 1985) and catalogued as endangered by Mexican law (Norma Oficial Mexicana 2010).

As the population continues to recover, these animals are increasingly common in their historical range extending from central México to Washington State (Stewart 1981, Seagars 1984, Hanni et al. 1997, Aurioles-Gamboa et al. 1999, Lambourn et al. 2012, Ortega-Ortiz et al. 2019). This pelagic species rarely comes ashore on the North American mainland, and the main rookery for this species is Guadalupe Island, México (29.05ºN, 118.28ºW), a remote island that is approximately 450 km southwest of San Diego, California. San Benito Archipelago, México (28.30ºN, 115.59ºW) is an important recolonization site for Guadalupe fur seals, but births at this archipelago and islands off the U.S. coast (*e.g.,* San Miguel Island) still are uncommon (currently <50 documented births on islands other than Guadalupe Island each year; Aurioles-Gamboa et al. 2010, Elorriaga-Verplancken et al. 2016b). This population has experienced periodic increased strandings (*i.e.,* washed ashore sick or injured) in the U.S., and NOAA Fisheries has declared two Guadalupe fur seal Unusual Mortality Events in the last 12 years, one in Oregon and Washington from 2007-2009 and one that began in 2015, is ongoing in California, and expanded to include Oregon and Washington in 2019 (Lambourn et al. 2012, NOAA Fisheries 2019).

Despite their protected status and increasing numbers over the last four decades, until recently, relatively little was known about this species. Guadalupe fur seal population monitoring efforts have been sparse and sporadic at Guadalupe Island with only 17 censuses documented over the 58-year period from 1955-2013 (Hernández-Camacho and Trites 2018, Garcia-Aguilar et al. 2018). Population monitoring has been more consistent at San Benito Archipelago. As of 2015, 10 censuses were conducted during the breeding season (summer) since the species was rediscovered at this site in 1997 (a 19-year period; Maravilla-Chavez and Lowry 1999, Aurioles-Gamboa et al. 2010, Sierra-Rodríguez 2015, Elorriaga-Verplancken et al. 2016b).

There also is a paucity of data on the at-sea distribution, behavior, and habitat use of this species because few Guadalupe fur seals have been tracked using satellite telemetry instruments. Telemetry instruments were deployed on only 12 Guadalupe fur seals between 1992 and 2014 (3 animals captured on Guadalupe Island and 9 stranded animals; Lander et al. 2000, Gallo-Reynoso et al. 2008, Norris unpublished data). Satellite tracking of Guadalupe fur seals has increased during the ongoing Unusual Mortality Event in California with 72 individuals tagged between 2015 and 2017 (43 animals captured on Guadalupe Island and 29 stranded animals; Norris unpublished data). Of these individuals tracked prior to 2018, only 28 were juveniles or adults ≥2 years old (Gallo-Reynoso et al. 2008, Norris unpublished data).

With insufficient data available on some key aspects of Guadalupe fur seal biology and ecology, the spatiotemporal overlap of this ESA-listed species with heavily human-impacted areas that are used for specific purposes, and may expose these animals to various threats, is poorly understood. This includes Guadalupe fur seal occurrence, abundance, and distribution in multiple U.S. Navy training and testing areas in the California Current System, which include the Southern California (SOCAL) Range Complex that is immediately north of Guadalupe Island and the Northwest Training and Testing (NWTT) Study Area that extends from northern California to Washington State. Therefore, the goal of this study is to improve our understanding of Guadalupe fur seal abundance, behavior, distribution, and habitat use and determine the degree to which this recovering population uses U.S. Navy training and testing ranges in the North East Pacific.

Methods

Population Surveys

We conducted a Guadalupe fur seal population survey at San Benito Archipelago, México from July 11-14, 2018 (Figures 1-2). For the three islands in this archipelago, land-based surveys were used for all areas of the coastline accessible by foot (all of Middle Island and most of West Island). Surveys from a small boat <50 m from shore were used when land-based surveys were not possible (all of East Island and a small section of West Island). All counts were performed by the same individual to maintain consistency with previously collected Guadalupe fur seal census data at San Benito Archipelago (Elorriaga-Verplancken et al. 2016b).

The population survey at Guadalupe Island, México was conducted from July 30-August 4, 2018 (Figures 1 and 3). Boat-based surveys were used for the entire island, excluding Punta Sur (surveyed on foot), as well as four nearby islets and all rocky outcrops. All non-pups were counted and classified by the individual with the most experience assigning Guadalupe fur seals to demographic groups during visual surveys. Two other observers counted all pups, and these counts were repeated or averaged for sections of the coastline with significant differences between the two counters because pinniped population size frequently is extrapolated from pup counts.

Various correction factors can be applied to pinniped count data to account for animals missed during visual surveys. A correction factor based on substrate type during boat-based surveys has been used to estimate Guadalupe fur seal abundance at Guadalupe Island (García-Capitanachi et al. 2017). Therefore, we recorded substrate types: large boulder, medium boulder, high platform, low platform, pebble beach, and wall (Figure 4; García-Capitanachi et al. 2017).

Summer (June-August) was selected for these surveys to coincide with the breeding season, which is when the most animals are on land (Gallo-Reynoso 1994). Because many more pups are born at Guadalupe Island than San Benito Archipelago, the surveys were conducted at the end of the breeding season at Guadalupe Island to count as many pups across the two sites as possible. In addition, the time between the surveys at the two sites was as short as was logistically possible. Animals were classified into five demographic groups based on morphology and behavior: adult males, subadult males, adult females, juveniles (both sexes), and pups (both sexes) with an unknown category for individuals that could not be identified (Gallo-Reynoso 1994).

Telemetry Data Collection and Analyses

Animal Handling and Selection

In November 2018, 15 adult female, 10 juvenile female, and 10 juvenile male Guadalupe fur seals were captured at Punta Sur, Guadalupe Island (Table 1). This location was selected because of its accessibility and because it has the greatest density of fur seals. Once captured using a modified hoop net, animals were manually restrained in the net until a cone was placed over the head to administer isoflurane gas anesthesia. Anesthesia averaged 31 min (range: 25-43 min) and was performed by a veterinarian with pinniped anesthesia experience. A satellite-linked time-depth recorder (SPLASH10-F-297 tag, 130 g, 86x55x26 mm or SPLASH10-F-238 tag, 217 g, 105x56x30 mm; Wildlife Computers, Redmond, WA) was attached to the dorsal pelage of each seal using 10-min epoxy resin (ITW Devcon, Danvers, MA; Figures 5-6). The larger 238 tag has twice the battery power of the 297 tag, but all other components are identical for two tag models. The larger tag model was attached to animals weighing >43.5 kg (*i.e.*, tag weight <0.5% animal body weight). Plastic identification tags were attached to the trailing edge of both fore-flippers of each animal (same number on both flippers); and weight, morphometric measurements, blood, fur, one vibrissa, and swabs (nasal, rectal, and genital) also were collected from all satellite-tagged animals for health and trophic ecology studies. Juvenile and adult females were differentiated between using lactation/nursing status and/or body size, and when possible, pups were captured along with their mothers, weighed, and sampled.

Many of the adult and juvenile animals observed in November were molting. We ensured animals had completed their molt before proceeding with anesthesia and satellite tagging. Silver fur indicated the animal had recently molted, and we pulled on the undercoat and guard hair at multiple sites on the animal's body, and particularly at the satellite tag application site, to make sure no hair easily came out.

Satellite Instrument Programming

The SPLASH10-F tags collected and transmitted Argos and Fastloc^{TM} global positioning system (GPS) locations, as well as dive depth histogram data. Tags were programmed to optimize transmission of high-quality GPS location data throughout the day. The 297 tags were programmed to transmit messages 300 times per day via the Argos Data Collection and Location Service during periods with the greatest satellite coverage for the area we expected this species to use (02:00-05:59 and 16:00-18:59 Greenwich Mean Time; GMT). The 238 tags were programmed with a daily transmission allowance of 350 during these periods: 02:00-05:59, 14:00-14:59, and 16:00-18:59 GMT because of their greater battery power. All other tag settings were the same for both tag models with transmissions attempted every 45 s during seal surfacings ("wet" mode) and every 90 s after the tag wet/dry sensor was dry for ≥5 min ("haulout" mode). To conserve battery power, transmissions paused when the tag was dry for ≥48 h. GPS locations were attempted at 4-h intervals with a maximum of one successful (signal received by ≥4 satellites) and four failed transmissions per hour (maximum of 24 attempts and 6 successful transmissions per day). These tags also collected dive data every 1 s for dives >2 m in depth and >20 s in duration, with transmitted dive depth data binned into 14 frequency histograms (upper bin limit: 4, 8, 12, 16, 20, 25, 30, 40, 60, 80, 100, 150, 200, and >200 m) for four 6-h periods (start times: 01:00, 07:00, 13:00, and 19:00 GMT; or 17:00, 23:00, 05:00, and 11:00 local time of GMT -8 h). The tags transmitted messages collected over the previous two days with GPS locations transmitted as the top priority.

Horizontal Spatial Use Analyses

Erroneous GPS locations with residuals >35 and that exceeded a maximum swim speed of 2.5 m/s, if locations were <5 km apart, were removed (>96.7% of GPS locations retained per individual; McConnell et al. 1992, Freitas et al. 2008, Dujon et al. 2014, Norris et al. 2017; Table 2). Argos locations categorized as invalid (Location Class Z) or extremely inaccurate (>4 deviations from the mean; Argos 2016), and those that were >100 m inland of the mainland North American coastline, excluding all islands, also were removed before combining these with the filtered GPS locations. This combined track was filtered to remove Argos locations only based on swim speed (>2.5 m/s, if locations were <5 km apart, and >6 m/s, regardless of distance between locations) and both location types, with Argos locations preferentially removed over GPS locations, based on path tortuosity (removed locations with turn angle >155º, if incoming and outgoing path was >5 km, or >165º, if incoming and outgoing path was >2.5 km; McConnell et al. 1992, Freitas et al. 2008, Norris et al. 2017). On average, 13% of Argos locations exceeded the speed/distance thresholds, and 4% of locations exceeded the turn angle/distance thresholds (Table 2).

Filtered GPS-Argos tracks were interpolated using the hermite spline method on a 3-h and 4-h interval to obtain an equal sampling interval (Tremblay et al. 2006). The average interval between filtered GPS and Argos locations was 3.6 ± 0.1 h (Table 2). Therefore, the 3-h interval resulted in slight over-sampling (Fieberg et al. 2010, Tremblay et al. 2006), but this interval allowed the location data to be temporally resolved with the histogram dive data (6-h periods) while still representing fine-scale movements.

Tracks interpolated on both the 3-h and 4-h interval, as well as filtered un-interpolated tracks, were used to calculate foraging trip statistics. Trips were separated into departures from Guadalupe Island that were <2 d and ≥2 d in duration. Locations ≤200 m of Guadalupe Island were considered on-land. For trips lasting <2 d, only maximum trip distance across all departures was calculated. For trips lasting ≥2 d, maximum and total trip distances, relative search index (RSI; defined as the total trip distance divided by maximum trip distance), mean travel rate, trip duration, and duration ashore were determined (Call et al. 2008). Maximum trip distance was calculated as the great-circle path (GCP) from where the incoming or outgoing path, whichever resulted in the shortest or most conservative distance estimate, intersected with the 200-m island buffer to the farthest location for each trip. Total trip distance was the sum of straight-line distances between consecutive locations for each trip, starting and ending at the 200-m buffer, and RSI indicates the degree of path tortuosity along each trip with values closer to 1 indicating less tortuosity or search effort. Mean travel rate was calculated as total distance divided by trip duration. Duration ashore was the time between trips ≥2 d that included time on land and on short <2-d duration trips. Mean trip statistics were calculated for each individual then averaged for each group to account for unequal number of trips among individuals. Only complete roundtrips (*i.e.*, returned to the island) were used to determine individual and group means; unless an individual made only one trip, then the single trip was included. The three tracks (3-h interpolated, 4-h interpolated, and un-interpolated) appeared almost identical visually, and there were little differences in trip statistics among these tracks. Therefore, only results for the 3-h interpolated track are reported.

At-sea horizontal spatial use was examined using the grid cell method because it is transparent and allows for more precise utilization distributions (UDs) than other similar methods (*e.g.*, kernel density estimators), given the increased transmission rate and spatial accuracy of GPS data (Kie et al. 2010, Maxwell et al. 2011, 2013, Rosenbaum et al. 2014). These UDs represent relative frequency of occurrence with each 10% isopleth containing an increasing proportion of locations (Keating and Cherry 2009). For each individual, the number of 3-h interpolated locations per grid cell was normalized to proportions using total number of interpolated at-sea locations, excluding locations ≤200 m of Guadalupe Island. These proportions were sorted from largest to smallest and converted to cumulative proportions with all cells with the same proportions summed together.

Group UDs (adult female, juvenile female, juvenile male, and all animals) were generated by averaging proportions per individual and converting these to cumulative proportions. Because interpolated locations were used, number of locations per cell also give residence time (*i.e.*, each location represents 3 h). Additionally, the proportion of animals per cell was calculated.

A grid cell size of 0.25° × 0.25° was used, similar to Maxwell and colleagues (2013) that covered a similar geographic area in the California Current System, as the optimal balance between making grid cells as small as possible to examine fine-scale movements and large enough to produce smooth contours that minimized gaps between used cells (Maxwell et al. 2011). Additionally, grid cells were positioned by dividing Guadalupe Island in half with two cells latitudinally and centering these two cells on the island longitudinally to minimize the number of cells with land.

These individual and group UDs were overlaid with the U.S. Navy NWTT Study Area and SOCAL Range Complex, as well as the Southern California Anti-Submarine Warfare Range (SOAR) and Point Mugu Sea Range (PMSR). The SOCAL Range Complex was divided into two areas at the 2,000 m depth contour that approximately represents greater (<2,000 m water depth) and lesser (>2,000 m water depth) Navy operations, and the SOAR area was used to represent one of many ranges around San Clemente Island, California. Total home range area, defined as to 100% UD isopleth, and percentage overlap between the fur seal group home ranges and each Navy range was determined (*i.e.*, calculated as the area of each Navy range divided by the animal group home range area in each Navy range). At least two grid cell vertices had to be present within the Navy range for a cell to be considered overlapping.

All animals were retained in the analyses because all tags transmitted long enough for the animals to reach distant foraging grounds on one or more trips. Additionally, telemetry data processing and analyses were conducted in MATLAB 9.6 using custom-written and built-in codes. Geospatial data were analyzed and displayed using the Mercator projection and World Geodetic System 1984 reference ellipsoid in MATLAB's Mapping Toolbox 4.8. For all results, means were reported along with standard error (SE).

Dive Behavior Analyses

The 14 dive depth frequency histograms were condensed into eight bins (upper bin limits: 4, 8, 12, 16, 20, 30, 60, and >60 m) to reduce the number of bins with zero values and simplify interpretation without losing the resolution necessary to investigate among-group differences in diving activity. Number of dives to each of the eight pooled bins, as well as the number of messages with zero dives (*i.e.*, on land or no diving exceeded the dive definition thresholds), were calculated for each 6-h period and individual. Proportion of dives per pooled bin was calculated for each message, excluding periods with no dives, to standardize for differences in number of messages transmitted across individuals. Mean depth frequency histograms were compared qualitatively among the three groups (adult females, juvenile females, and juvenile males) and for all animals combined.

Dive data also were linked to the 3-h interpolated tracks, and each location was categorized as having no associated dive data, no diving activity, and diving activity. Histogram periods with at least four dives >8 m were defined as having diving activity based on dive bout definitions for northern fur seals (Kuhn et al. 2010) and the nighttime dive depth of various squid species in the California Current System (rarely <10 m; Bazzino et. 2010, Gilly et al. 2006).

Results

Population Estimate

At San Benito Archipelago, 84% of the animals were juveniles, and few mom-pup pairs observed (Table 3). It is unlikely that the timing of these surveys in mid-July resulted in missing too many mom-pup pairs because little breeding has been observed at this site in recent years, even with year-round monitoring (Elorriaga-Verplancken et al. 2016b). Guadalupe fur seal density was greatest on the north side of West Island (Figure 2, land section 3). Survey methods and total survey time were similar to those of previous studies (13.6 h for 2018 survey vs. 15.5 h for 2010 survey; no substrate-based correction factors; García-Capitanachi et al. 2017).

Most Guadalupe fur seal pups had been born by late July and represented 51% of the total number of animals counted at Guadalupe Island (Table 4). However, by late July, most adult males already had departed the rookery and were underrepresented in our census data, but this demographic typically comprises a small proportion of the population. Substrate types often were mixed and changed frequently during the surveys (every ~100 m in some areas). In these cases, we used the more conservative substrate type category (*i.e.*, the substrate with the lesser correction factor from García-Capitanachi et al. 2017). Therefore, the majority of the shoreline was classified as medium boulders during our surveys (*i.e.*, mixed large and medium boulders). Our survey methods differed from other Guadalupe fur seal census efforts at Guadalupe Island because we had two individuals counting pups and traveled more slowly during our boat-based surveys (Borjes Flores pers. comm.). However, the total survey time (32.7 h) was similar to previous studies (32.5 h; García-Capitanachi et al. 2017). Because of differences in survey methods, we did not apply substrate-based correction factors, and instead only corrected for the number of adult females using the number of pups (1:1 ratio) for both sites.

Foraging Behavior, Habitat Use, and Navy Range Overlap

Animal Tracking Overview

Juvenile males (mass = 27.3 ± 1.3 kg, length = 116.5 ± 2.1 cm, girth = 71.7 ± 1.4 cm) and females (mass = 26.7 ± 1.6 kg, length = 118.7 ± 2.3 cm, girth = 70.5 ± 1.4 cm) captured for satellite tagging had similar body sizes and were smaller than adult females (mass = 49.8 ± 2.3 kg, length = 144.1 ± 1.3 cm, girth = 89.7 ± 2.0 cm; Table 1). Eight adult females, most of which were smaller females (<43.5 kg), were captured with their pups (mass = 12.2 ± 1.3 kg; Table 5). Although the sample size is very small, two of the largest lactating females (59.2 and 66.0 kg) had the smallest pups (8.8 and 6.9 kg, respectively) with all other pups captured with their mothers weighing >10 kg (Table 5).

Satellite transmissions were received November 2018 through April 2019, and tracking durations ranged from 28-145 d (80.2 ± 5.2 d) with slightly longer tracking durations for juvenile females (87.1 ± 6.3 d) than adult females (78.8 ± 9.4 d) and juvenile males (75.4 ± 10.2 d; Table 1, Figure 7). After filtering, there were approximately seven locations per day across individuals (range: 4-10 filtered locations/d; Table 2). Typically, two GPS locations were successfully transmitted daily, and a majority of Argos locations (74.4 ± 1.0%) were Location Class A and B, for which location accuracy estimation are not generated (<4 messages received per satellite pass). Locations were concentrated (60.9 ± 2.0%) between hours 02:00-05:59 GMT (18:00-22:59 local time of GMT -8 h) each day.

Horizontal Spatial Use

Overall, in the winter and spring (2018-2019), Guadalupe fur seals broadly used the California Current System (20-42°N, 112-130°W) <800 km offshore of the west coast of North America (Figure 8). The majority of animals (n = 27, or 77% of tagged animals) traveled north of Guadalupe Island into waters off California (Appendices 1-3). Only adult (n = 3) and juvenile (n = 2) females exhibited resident behavior with four to seven at-sea trips having maximum distances from Guadalupe Island of <550 km. These five resident seals and three juvenile males were the only animals that spent a significant amount of time south of the island (23% of the tagged animals).

Adult females were distributed farther from shore (up to 800 km) than juvenile females (<500 km from shore) and males (<400 km from shore; Figures 9-11). In fact, 80% of adult females were found exclusively in deep-water habitat (seafloor depth >2,000 m) compared with 40% for juvenile females and 10% for juvenile males. Furthermore, only six fur seals (17% of the tagged animals), all of which were juvenile males, spent a small portion of time in continental-shelf waters (seafloor depth <200 m). Approximately half of the animals (n = 18) were found along the continental shelf break (~200 m) and over slope waters (defined here as a seafloor depth of 200-2,000 m) for portions of the tracking period.

Several large, and numerous small, areas were used most intensely by the fur seals, reflecting individual and group spatial use patterns (Figure 12). Five grid cells adjacent to the island had the greatest concentration of individuals, and an approximately 200-km-wide band extending from 300 km south of Guadalupe Island to offshore of central California (San Francisco Bay Area) had 5-14 individuals per cell with most other cells used by ≤4 individuals (Figure 13). There was spatial segregation among adult females, with many females concentrated in areas that were not used by other females (Figure 14, Appendix 1). As a result, the home range of the adult females was 40% larger than the home ranges of the juvenile seals, and the areas used more intensely by adult females were dispersed across much of their home range (*i.e.*, many areas with UD isopleths <70%; Table 6). There was, however, greater spatial overlap among the three resident adult females and among juvenile female and male seals. Juvenile females and males used two areas most intensely (Figures 15-16). Both sexes primarily used an area 50-250 km offshore of central California, extending from Point Conception to San Francisco Bay. In addition, juvenile female habitat use was concentrated in an area up to 300 km south-southeast of Guadalupe Island, and juvenile males had greater use of an area approximately 100 km offshore of Magdalena Bay, Baja California Sur.

Adult females had the greatest travel rate, covering an average of 63.2 ± 4.2 km/d, compared with juvenile females (55.7 ± 4.2 km/d) and males (51.5 ± 1.9 km/d; Table 7). Across all individuals, total distances were approximately three times longer than maximum trip distances, and there was similar searching effort per trip (RSI: 2.9 ± 0.1). Eleven adult females, most of which were lactating or observed nursing 4-month-old pups in November, made multiple foraging trips from Guadalupe Island (Table 8). In addition to the three resident adult females, two other individuals in this group had short-distance trips (<100 km maximum distances). Five adult females traveled >1,000 km north of Guadalupe Island, and the two largest females, that had the smallest pups in November, traveled the farthest from the island (maximum trip distances: 1,352-1,667 km) with over 5,500 km covered in >68 trip days (84-77 km/d; Appendix 1). On average, adult female foraging trips were more than one month in duration (31.2 ± 4.3 d; range = 2.1-49.1 d) and separated by 6.1 ± 1.0 consecutive days ashore and/or on short trips (departures from the island lasting <2 d).

Whereas most juvenile females (n = 7) returned to Guadalupe Island one or more times, most juvenile males (n = 8) dispersed from the island in the late winter and did not return during the tracking period (November through April; Appendices 2-3). As a result, trip durations were longer for juvenile males (53.2 ± 8.1 d) compared with females (42.8 ± 6.5 d). Greater than half of the juvenile animals (n = 13) traveled >1,000 km from Guadalupe Island (maximum distances: 1,009-1,276 km; Tables 9-10). Juvenile males dispersed up to 1,154 km south of Guadalupe Island, and as a group, had the greatest latitudinal distribution (north-south distance of 2,430 km), maximum trip distances (944 ± 96 km), and total trip distances (2,681 ± 416 km).

Overlap with Navy Ranges

Seventeen percent of the tagged animals, that almost exclusively used habitat south of Guadalupe Island, had little or no spatial overlap with U.S. Navy training and testing areas. The other 29 animals used the Navy ranges offshore of southern California to varying degrees (Table 11). One Guadalupe fur seal, the largest adult female tagged, briefly used the southernmost region of the NWTT Area, 250-350 km offshore of northern California (3% home range overlap for this individual, adult females, and all animals with the NWTT Area). No other adult or juvenile fur seals tagged as part of this study traveled north of 40°N from November through April.

Guadalupe fur seals primarily used the SOCAL Range Complex offshore of the continental slope but did not use the portion of this range >800 km from the California coast. There were relatively high concentrations of locations within some portions of the SOCAL Range, as indicated by UD isopleths <70%, especially northwest of Guadalupe Island. However, this concentration of locations appeared to be primarily linked to transiting to and from the island based on path straightness through the SOCAL Range and greater path tortuosity and more intense spatial use farther north of the SOCAL Range. The home ranges of adult and juvenile females overlapped with the SOCAL Range (25% and 28%, respectively) more than that of juvenile males (18%), and only juvenile animals used the continental slope region (seafloor depth <2,000 m) of the SOCAL Range. Overall, 42% of the SOCAL Range was used by Guadalupe fur seals, with 10% of this over the continental slope region. Additionally, one juvenile female and one juvenile male used the SOAR.

There was a greater degree of overlap between Guadalupe fur seal habitat use and PMSR with 67% of this area used by adult females, 85% used by juvenile females, 80% used by juvenile males, and 99% used by all individuals combined. Juvenile seals appeared to use much of the PMSR, especially in water depths >2,000 m, for foraging based on the high concentration of locations (UD isopleths <70%) and greater path tortuosity offshore of central California. Across groups and all seals combined, 16-38% of this PMSR overlap was in waters <2,000 m deep.

Diving Behavior

At Guadalupe Island, sunset ranged from 17:00-19:20 (local time, GMT -8 h) and sunrise ranged from 06:00-07:00 over the five-month tracking period. There was a strong diel pattern in diving activity across all individuals and groups, both in terms of the number of dives and depth of those dives (Figures 17-20; Appendices 4-6). Greater than 80% of diving activity occurred around dusk and throughout the night (hours 17:00-04:49 local time), approximately 15% of dives occurred around dawn and during the morning (hours 05:00-10:49 local time), and only around 3% of dives occurred during the afternoon (between hours 11:00-16:59 local time). In addition, approximately 70% of dive messages (range = 29-96%) received during the afternoon (11:00-16:59) contained no dives (*i.e.*, for the entire period, the individual was on-land and/or diving did not exceed 2 m in depth and 20 s in duration).

Although there was significant individual variability in the proportion of dives to each depth range across the three groups, the majority of dives across all periods and individuals were <60 m, particularly for juveniles (<8% of dives deeper than 60 m; Figures 17-20; Appendices 4-6). Adult females, especially the three that were resident to Guadalupe Island, more frequently dove deeper than juvenile fur seals (Figure 18). These three resident and two other non-resident adults had 13-20% of dives >60 m between 23:00-04:59 and/or 11:00-16:59 (local time), and one of the resident adult females was the only individual with substantial daytime diving (20% of diving occurred from 11:00-16:59 local time with ~45% of these dives >30 m). Juvenile females most frequently dove to 4-12 m (>46% of dives), and juvenile males most frequently dove to 4-16 m (>43% of dives; Figures 19-20). Only six fur seals recorded dives >200 m; four of which were resident adult and juvenile females. The diving activity of the other animals did not exceed: 80 m for five individuals (1 adult, 4 juveniles), 100 m for 11 individuals (1 adult, 10 juveniles), and 150 m for 13 individuals (9 adults, 4 juveniles).

Combining the histogram dive data with the 3-h interpolated track highlighted that one or more diving bout, defined as at least four dives >8 m, occurred along most portions of the individual tracks and were not restricted to areas with greater use as indicated by the UDs (Appendices 7-9). Many portions of the tracks categorized as having diving bouts appeared to be periods where the animal was transiting based on the lack of directional changes along the path (*i.e.*, straight path over long distances). Most notably, although many animals appeared to primarily transit through the offshore area (>2,000 m water depth) of the SOCAL Range Complex, diving bouts were observed along these transiting zones for most animals.

Discussion and Conclusions

Population Trend

Prior to this study, the last complete Guadalupe fur seal population survey was performed in 2010, during which 13,327 individuals (3,183 pups) were counted at Guadalupe Island and 2,503 individuals (8 pups) were counted at San Benito Archipelago (García-Capitanachi et al. 2017). Pup counts at Guadalupe Island, last collected in 2013 (4,924 pups), were used to produce a population estimate of 34,000-44,000 individuals in 2013 (García-Aguilar et al. 2018). In addition, a similar population estimate of approximately 41,000 individuals (CI = 35,779-46,877) was made in 2017 based on data collected through 2010 at Guadalupe Island and through 2015 at San Benito Archipelago (Hernández-Camacho and Trites 2018). Because a variety of correction factors and methodologies have been applied to generate Guadalupe fur seal population estimates, it is difficult to compare the 2018 counts with these two most recent population estimates. Therefore, we compared the raw counts from 2018 to those of 2010 (all animals) and 2013 (pups only) at Guadalupe Island. Based on these data, from 2010-2018, the population growth rate at Guadalupe Island was 8.8% per year with near doubling of the total number of animals counted, and an ~170% increase in the number of pups counted from 2013-2018.

Although these comparisons indicate that the Guadalupe fur seal population has increased, there was a five-year data gap during which no abundance estimates are available. At the same time, persistent, widespread anomalously warm waters across the North East Pacific Ocean caused unprecedented ecosystem-level effects, including dramatic shifts in species distribution and abundance and mass strandings and mortalities related to prey limitation (Cavole et al. 2016, McClatchie et al. 2016, Morgan et. al 2019, Sanford et al. 2019). Guadalupe fur seals were impacted by this 2014-2016 marine heatwave in ways that likely imply greater population-level effects. These included increased strandings in California (nearly 400 fur seals stranded, primarily because of prey limitation, between 2015-2019 compared with 45 stranded in the preceding five years), unprecedented records of emaciated individuals in the southern Gulf of California in 2015-2016, significantly decreased neonate weights and survival in 2015, and increased foraging effort of lactating females in 2015 (Amador-Capitanachi et al. in press; Elorriaga-Verplancken et al. 2016a, 2016b; Gálvez et al. 2019; NOAA Fisheries 2019).

In addition, San Benito Archipelago continues to be the primary recolonization site for Guadalupe fur seals with increasing numbers of animals from 1997-2009, but pup production has remained relatively constant through 2018 with only 9-28 pups observed each year (Aurioles-Gamboa et al. 2010, Elorriaga-Verplancken et al. 2016b, García-Capitanachi et al. 2017). Abundance has decreased significantly at this site since 2009 (peak = 5,271 individuals) with fewer animals counted during the 2018 breeding season than any other survey over the last decade. Thus, Guadalupe fur seal abundance appeared to be increasing at Guadalupe Island while abundance was decreasing at San Benito Archipelago. With these opposing population trajectories, recurrent Unusual Mortality Events along the U.S. west coast, and persistent warm water anomalies in the California Current System in recent years, ongoing annual population monitoring at Guadalupe Island and San Benito Archipelago are necessary to generate accurate and current population estimates and trends for Guadalupe fur seals.

Foraging Behavior, Habitat Use, and Navy Range Overlap

Many otariid foraging behavior studies have focused on tracking lactating females less than two months after parturition but rarely later during lactation (*e.g.,* Arnould and Hindell 2001, Beauplet et al. 2004). Similarly, the one published Guadalupe fur seal telemetry study tracked females (n = 3) nursing pups <1 month old, and their foraging trips lasted 14.4 ± 8.3 d and were 441 ± 151 km from the island with most diving to depths <30 m (Gallo-Reynoso et al. 2008). The lactating females tagged during this study were nursing pups that were four to nine months old. At four-months of age, pups were beginning to shed their *in utero* downy fur (no waterproofing) for their full coat (downy underfur with waterproofing guard hair). After this molt, pups may feed on their own in the nearshore waters as a supplement to milk prior to weaning at nine months of age, as has been documented for other fur seals (Rand 1955, Horning and Trillmich 1997). Even if pups were supplementing their diet later during lactation, the foraging range of the females tracked during this study were some of the longest distance and duration trips recorded for lactating fur seals. Only those of subantarctic fur seals (*Arctocephalus tropicalis*) breeding on Amsterdam Island, which is an oceanic island like Guadalupe Island, were similar (Beauplet et al. 2004). In this species, with 1-2-month-old pups, maternal foraging trips were up to 18 d in duration and 849 km from the island, and with 5-8-month-old pups, complete trips were up to 34 d in duration and up to 1,695 km from the island (Beauplet et al. 2004). In contrast to fur seals that breed on islands on the continental shelf, the oceanic location of Guadalupe Island likely contributes to the extensive foraging range and offshore distribution of Guadalupe fur seals, especially adult females that must return to the island to nurse their pups.

In addition, until recently, juvenile behavior was largely unknown across most species, but as more juvenile animals are tracked using telemetry instruments, immature animals often are found to have different habitat use and movement patterns than adults (*e.g.,* Sterling and Ream 2004, Riotte-Lambert and Weimerskirch 2013, McHuron et al. 2018). This also was found in the current study with juvenile fur seals concentrated in some areas that were not used at all (offshore of Magdalena Bay, Baja California Sur) or as extensively (offshore of central California) by adult females. In addition, because juveniles were distributed closer to shore than adult females, these younger animals used portions of the U.S. Navy training and testing ranges in southern California to a greater extent, especially nearshore areas with seafloor depth <2,000 m. Therefore, including tagging of juvenile animals in the current study provided a more comprehensive assessment of Guadalupe fur seal distribution and use of U.S. Navy ranges. Because marine predator at-sea distribution and movement patterns vary seasonally and interannually, additional satellite tracking across demographic groups, seasons, and years and examining the relationship between telemetry data and oceanographic features, such as fronts and eddies, is necessary to better understand Guadalupe fur seal spatial use patterns and percentage overlap with U.S. Navy ranges.

Similar to other fur seal species, Guadalupe fur seals exhibited diel diving activity with almost all diving occurring at night as they feed on squid and other prey that migrate vertically (*e.g.,* Croxall et al. 1985, Georges et al. 2000). One goal of this study was to integrate dive depth with the animal tracks to better understand Guadalupe fur seal vertical and horizontal distribution inside and outside U.S. Navy training and testing areas. Because only histogram dive data were collected, rather than full or partial time-depth recordings, the dive bout definition used in this study (at least 4 dives >8 m within a 6-h period) may not have accurately differentiated between areas with and without foraging activity. However, Guadalupe fur seals almost exclusively used surface waters (≤2 m) during daytime hours with shallow diving (<60 m) at night from November to April with brief periods on shore at Guadalupe Island. The shallow vertical distribution of this species likely impacts the amount of U.S. Navy activity they may be exposed to, and analyses are ongoing to further refine the dive bout definition and better quantify diving activity along Guadalupe fur seal tracks as part of this multiyear study.

Although data collection is ongoing and further analyses are planned, the results of this study already are revising our understanding of Guadalupe fur seal abundance, distribution, behavior, and habitat use within U.S. Navy training and testing ranges in the North East Pacific. For example, this ESA-listed species preferentially used oceanic habitat (>2,000 m water depth) rather than nearshore habitat (<2,000 m water depth) as was indicated in the 2015 Pacific Navy Marine Species Density Database (U.S. Department of the Navy 2015). Therefore, this ongoing study is providing census and telemetry data that have not been available previously but are critical to more accurately quantify and describe Guadalupe fur seal occurrence and movement patterns across the California Current System and in areas where Navy training and testing activities occur.

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Figures

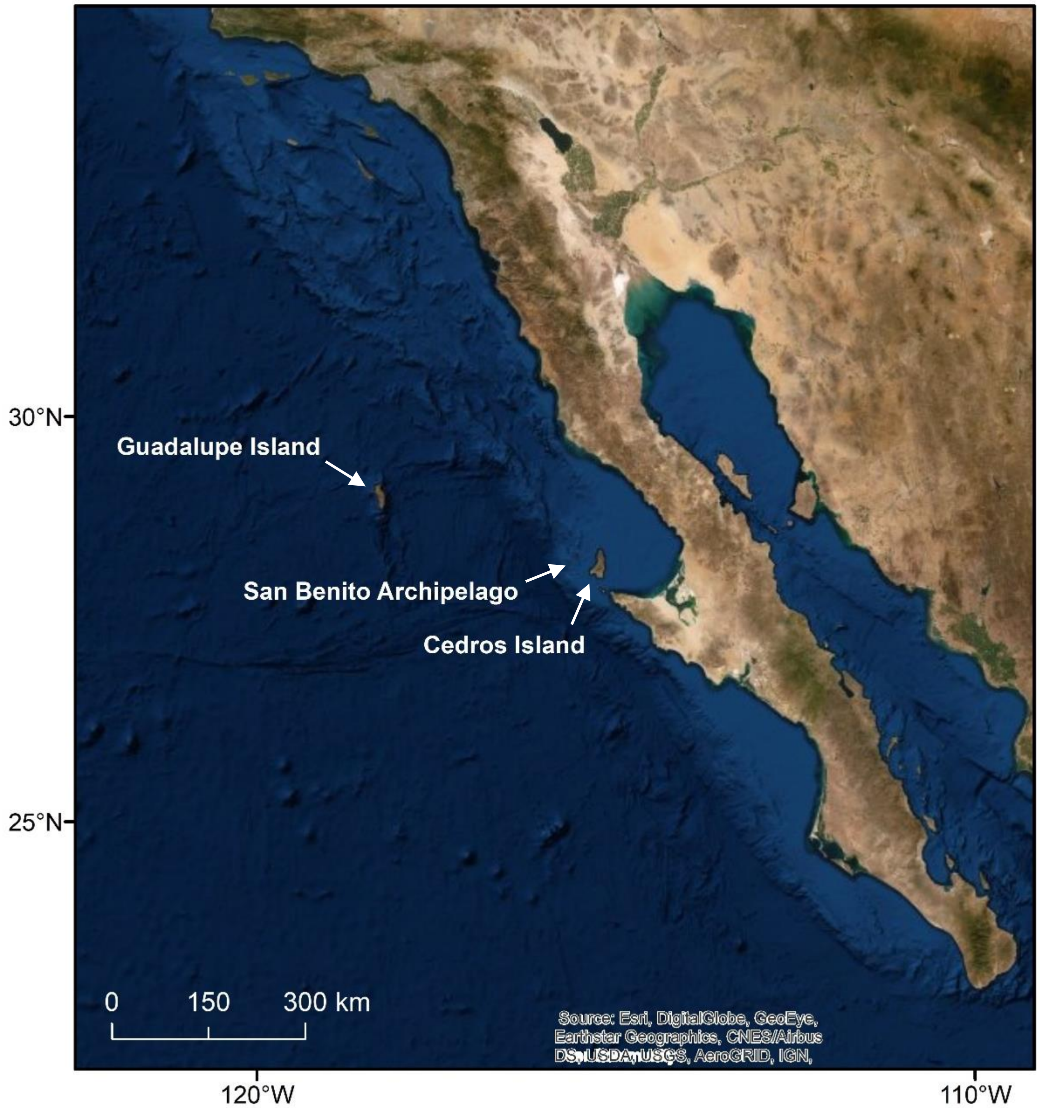

Figure 1. Map of the two study sites, Guadalupe Island and San Benito Archipelago, offshore of the Baja California Peninsula, México. San Benito Archipelago is comprised of three small islands near Cedros Island.

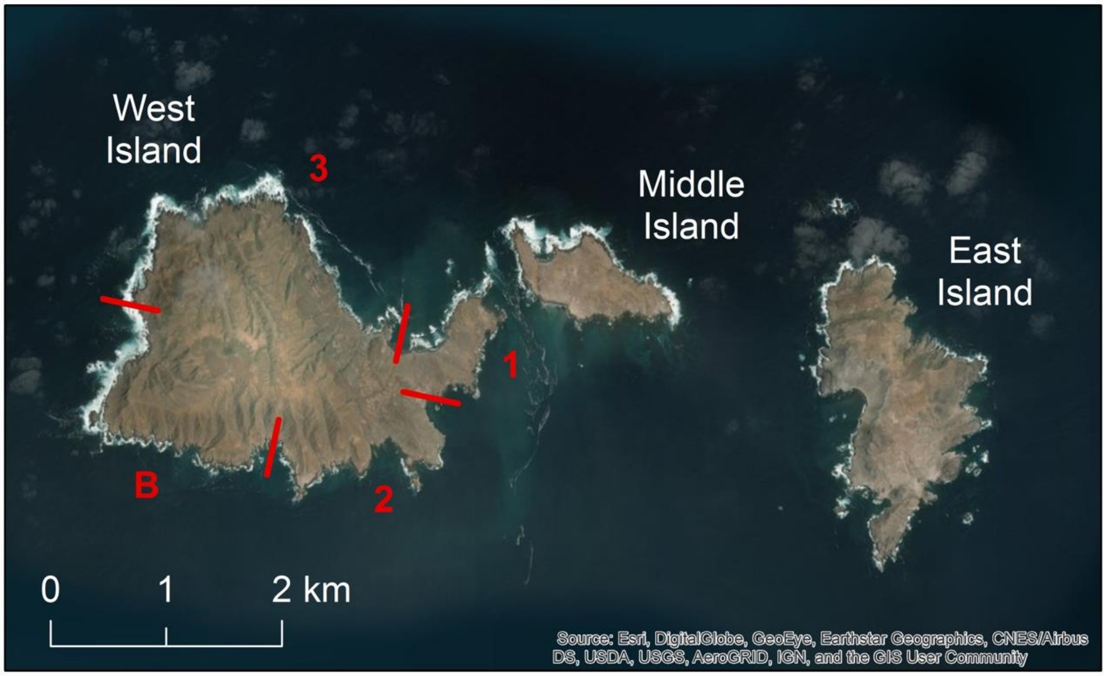

Figure 2. Map of San Benito Archipelago. The three land (sections 1-3) and boat (B) surveys are indicated for West Island.

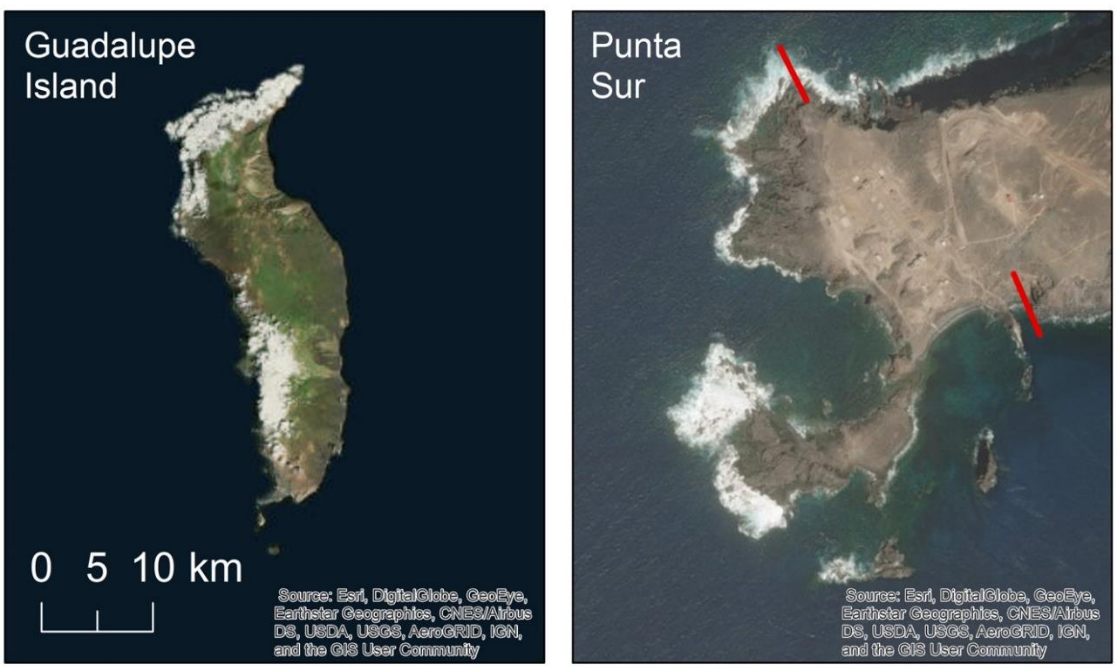

Figure 3. Map of Guadalupe Island. Boat-based surveys were used to count Guadalupe fur seals, except the southern tip (Punta Sur, demarcated by the red lines) was surveyed on foot.

Figure 4. Six substrate types recorded during boat-based surveys at Guadalupe Island.

Figure 5. Photograph of juvenile male Guadalupe fur seal with a SPLASH10-F-297 satellite transmitter attached.
(Permit #: SGPA/DGVS/002460/18; Photo credit: Jeff Harris)

Figure 6. Photograph of adult female Guadalupe fur seal with a SPLASH10-F-238 satellite transmitter attached.
(Permit #: SGPA/DGVS/002460/18; Photo credit: Jeff Harris)

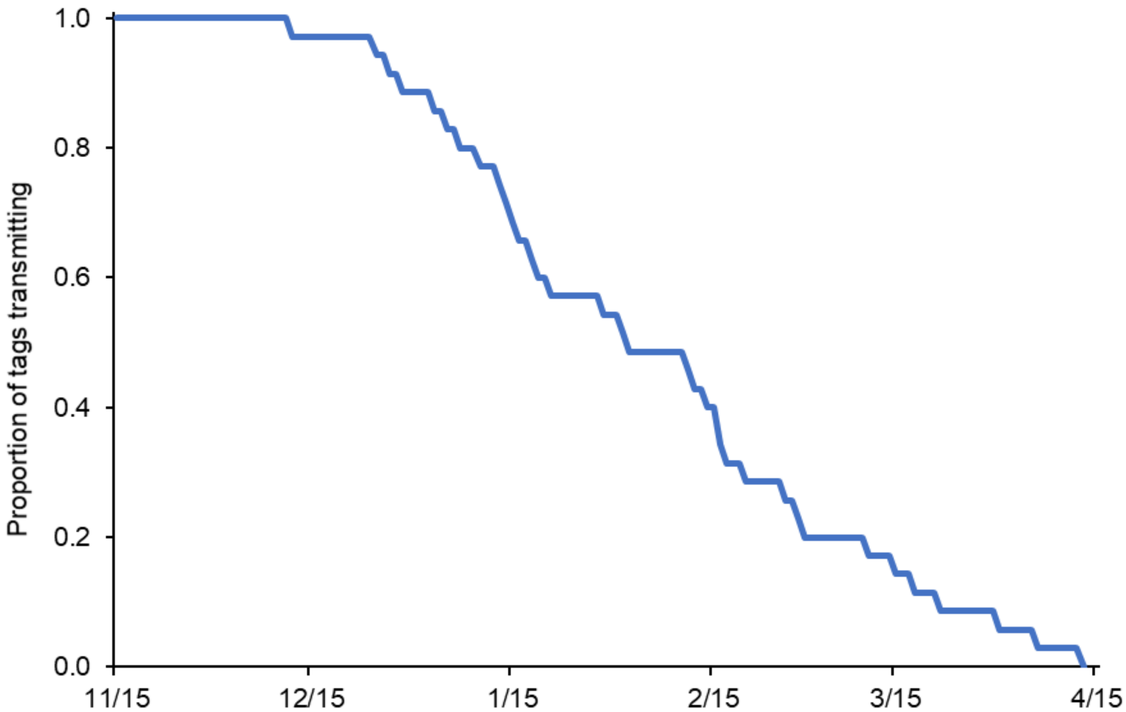

Figure 7. Proportion of satellite tags transmitting each day from November 2018 through April 2019.

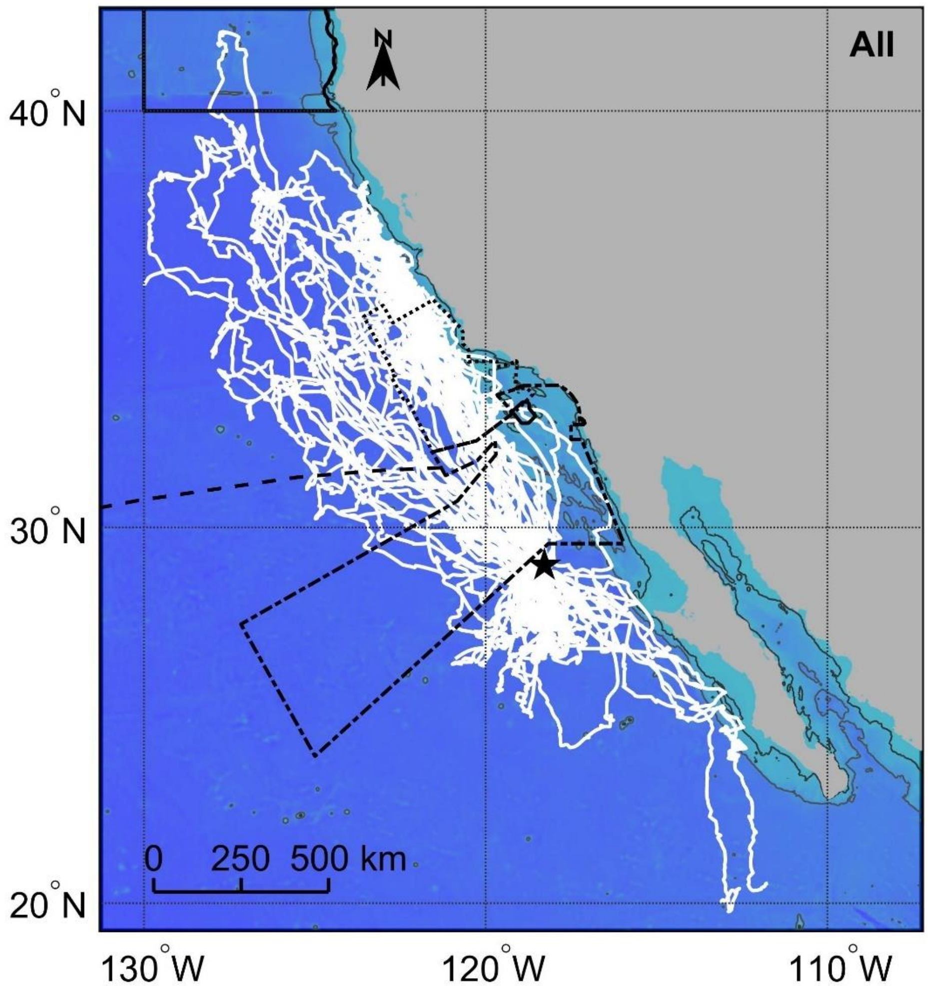

Figure 8. Three-hour interpolated tracks for 35 Guadalupe fur seals. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.
(Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

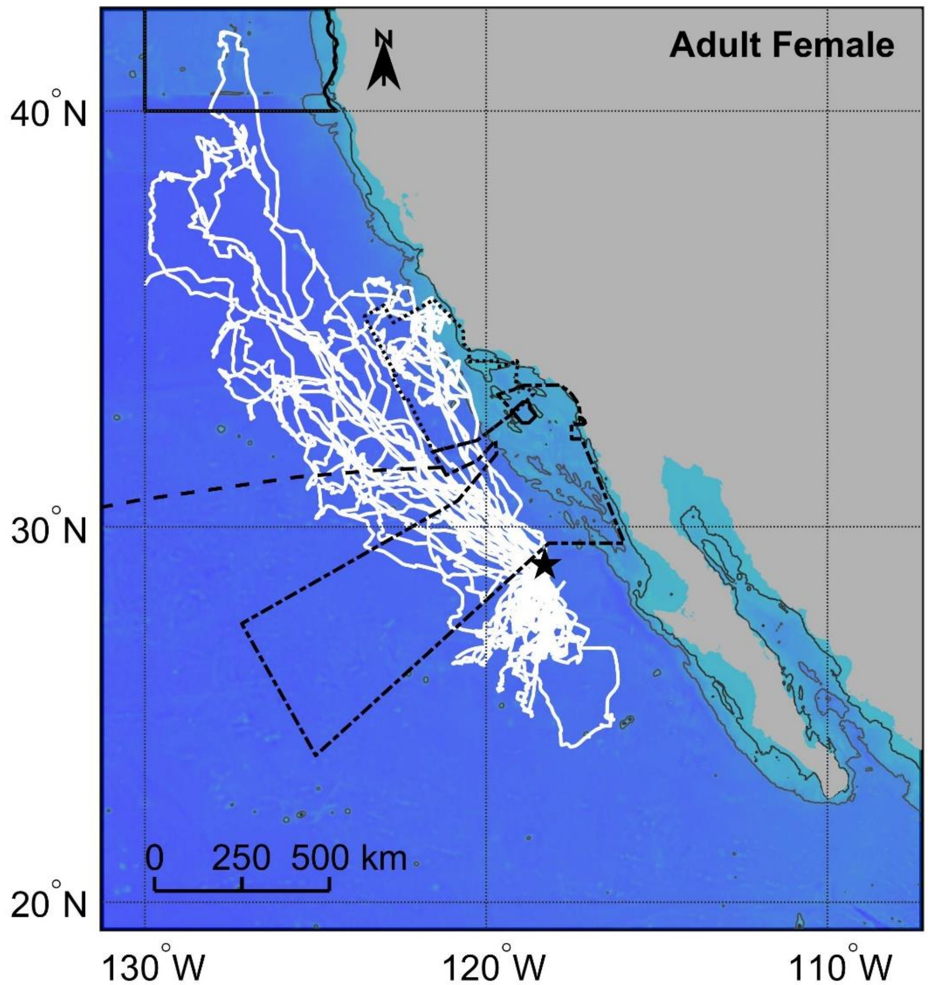

Figure 9. Three-hour interpolated tracks for 15 adult female Guadalupe fur seals. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.
(Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

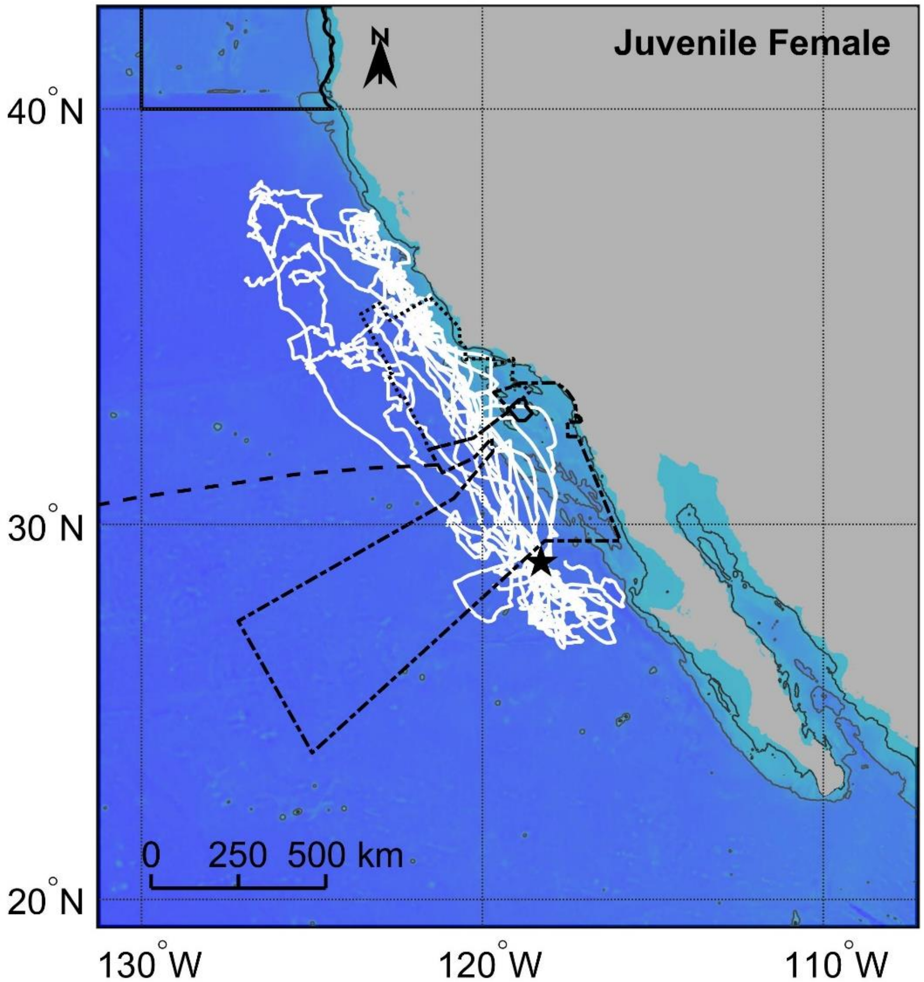

Figure 10. Three-hour interpolated tracks for 10 juvenile female Guadalupe fur seals. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.
(Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

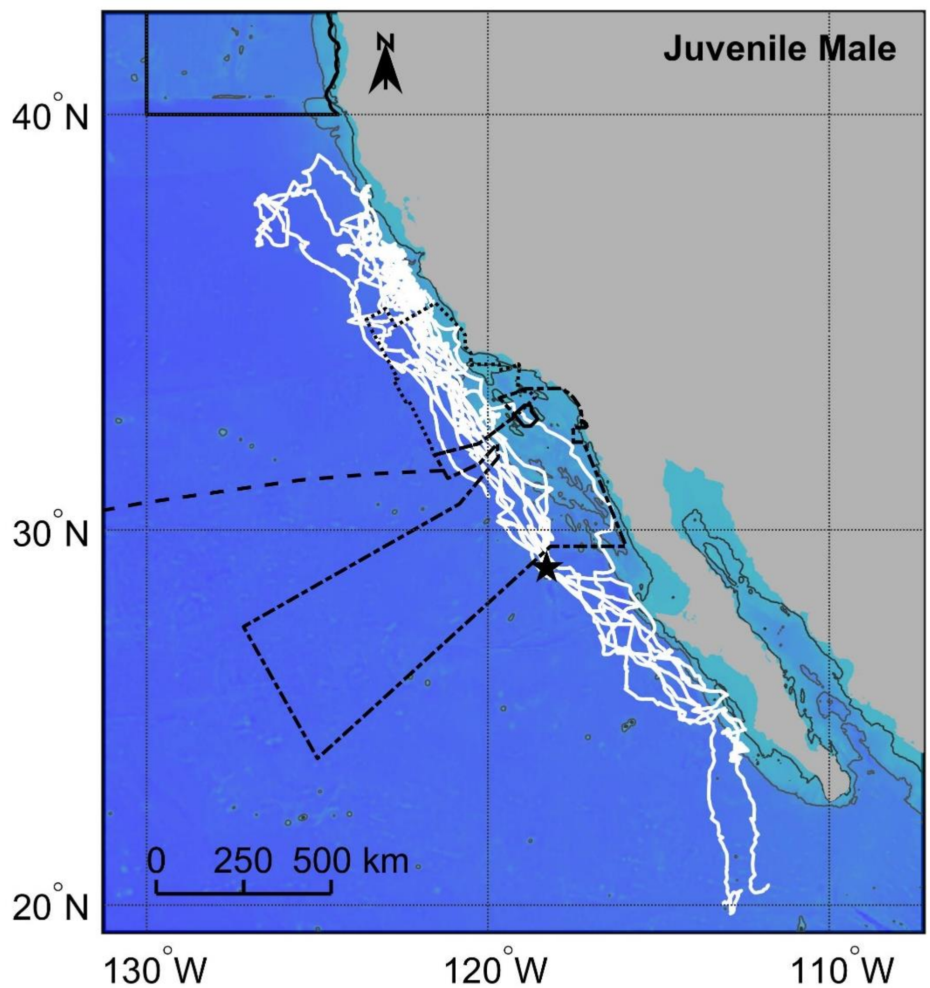

Figure 11. Three-hour interpolated tracks for 10 juvenile male Guadalupe fur seals. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.
(Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

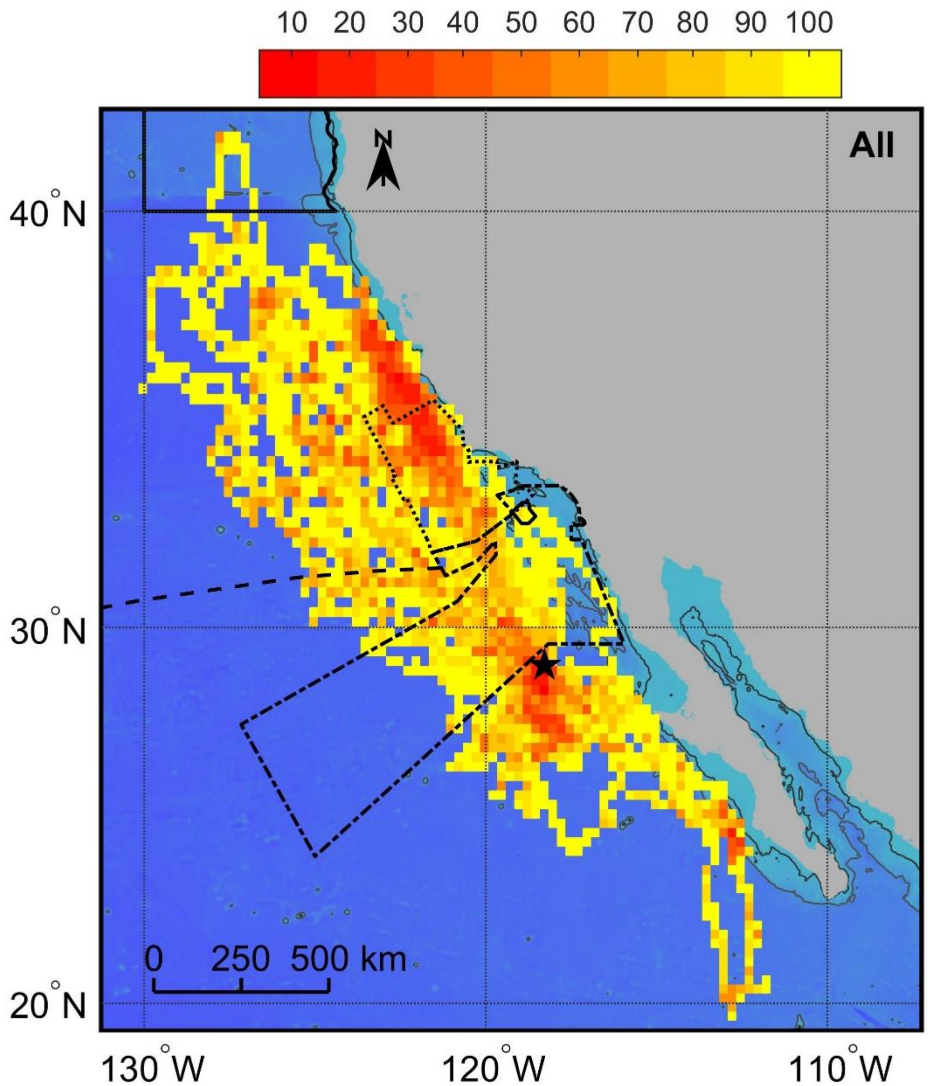

Figure 12. Utilization distribution (UD), in 10% increments, for 35 Guadalupe fur seals. Red to yellow shading represents more to less intensely used areas. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

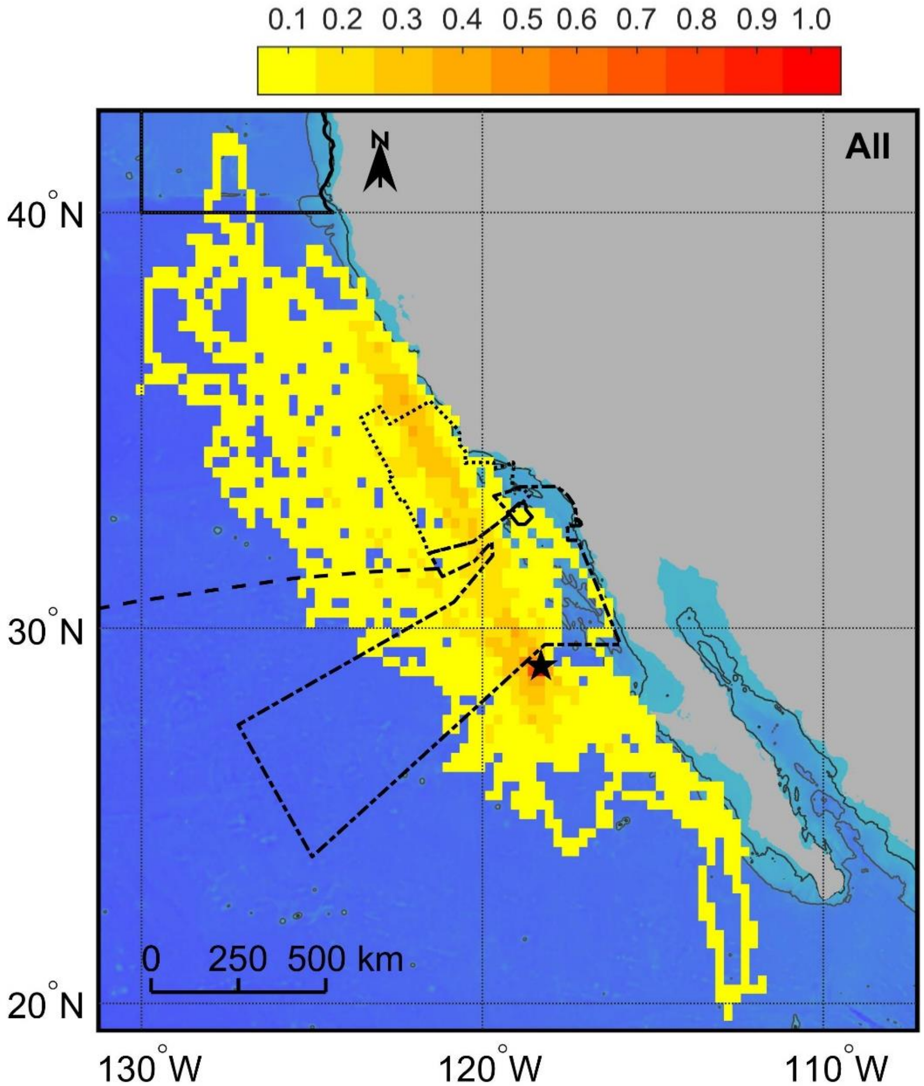

Figure 13. Proportion of 35 Guadalupe fur seals that used each cell. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.
(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

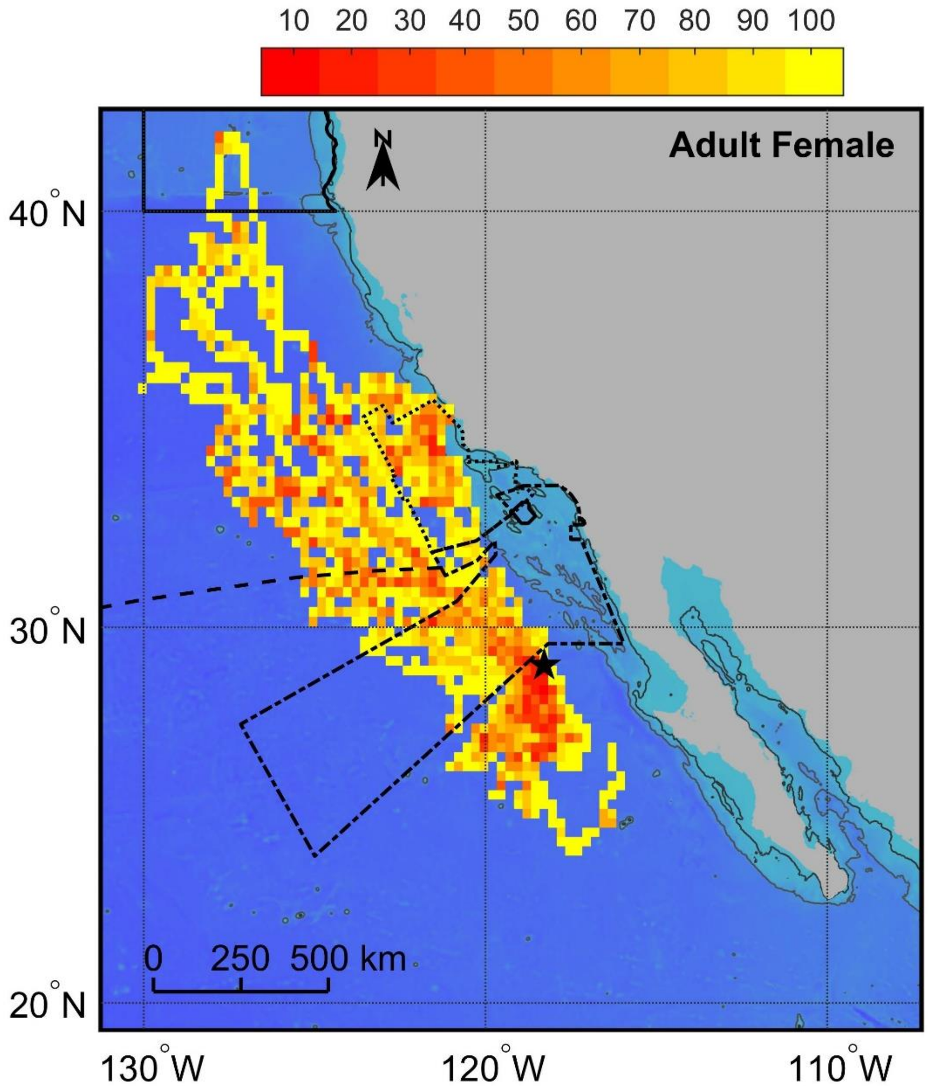

Figure 14. Utilization distribution (UD), in 10% increments, for 15 adult female Guadalupe fur seals. Red to yellow shading represents more to less intensely used areas. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.
(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

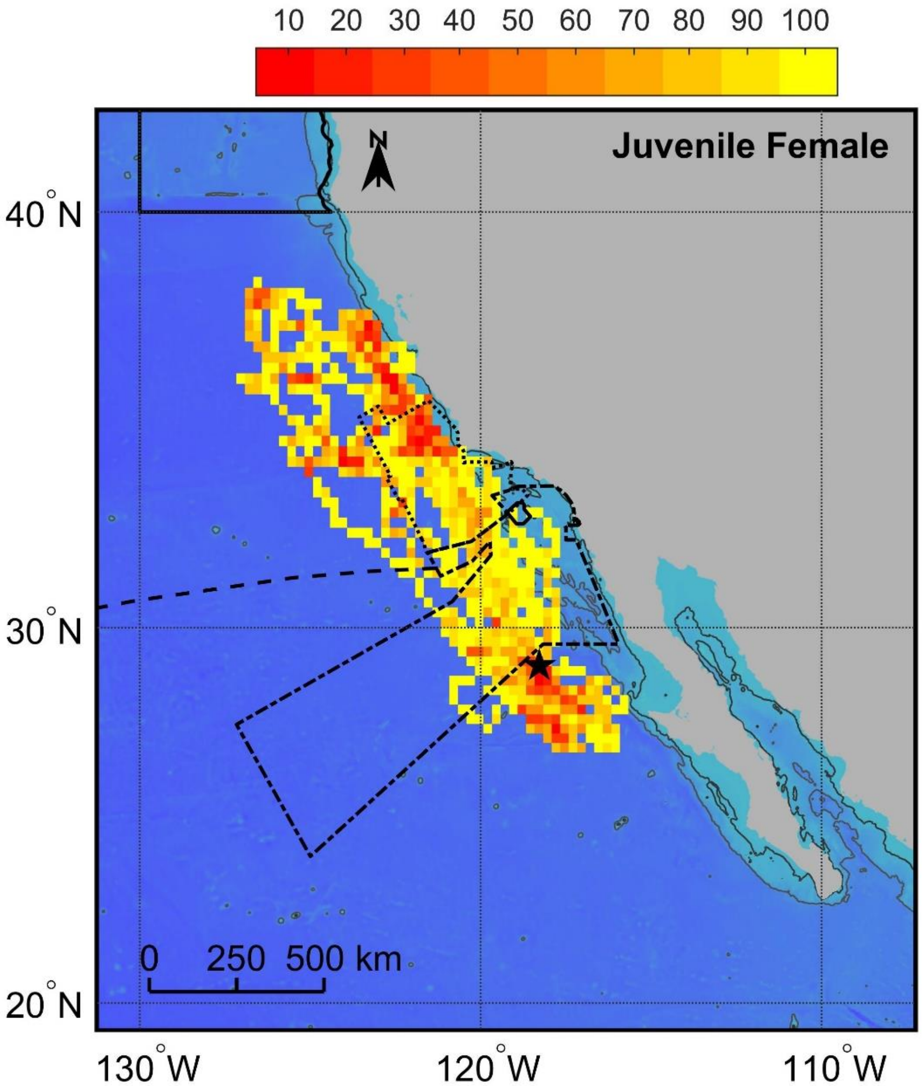

Figure 15. Utilization distribution (UD), in 10% increments, for 10 juvenile female Guadalupe fur seals. Red to yellow shading represents more to less intensely used areas. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

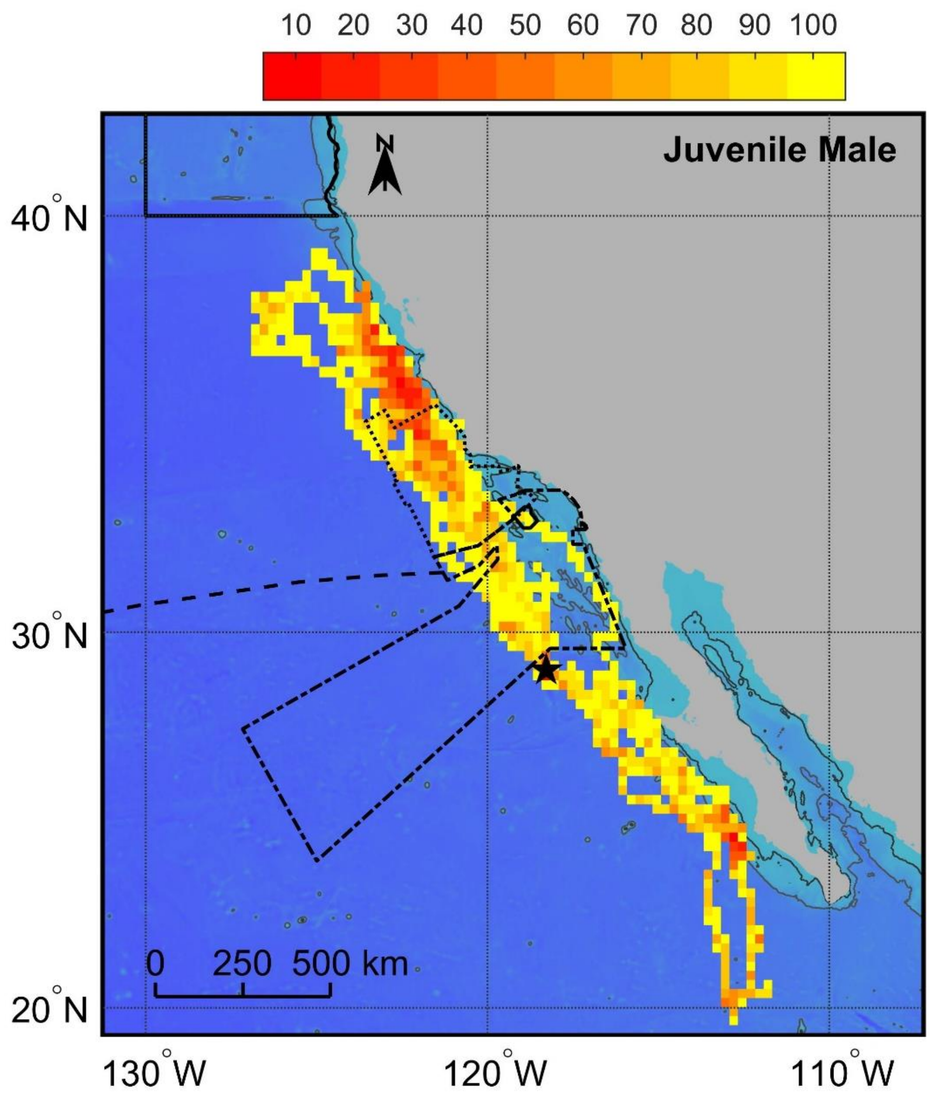

Figure 16. Utilization distribution (UD), in 10% increments, for 10 juvenile male Guadalupe fur seals. Red to yellow shading represents more to less intensely used areas. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)

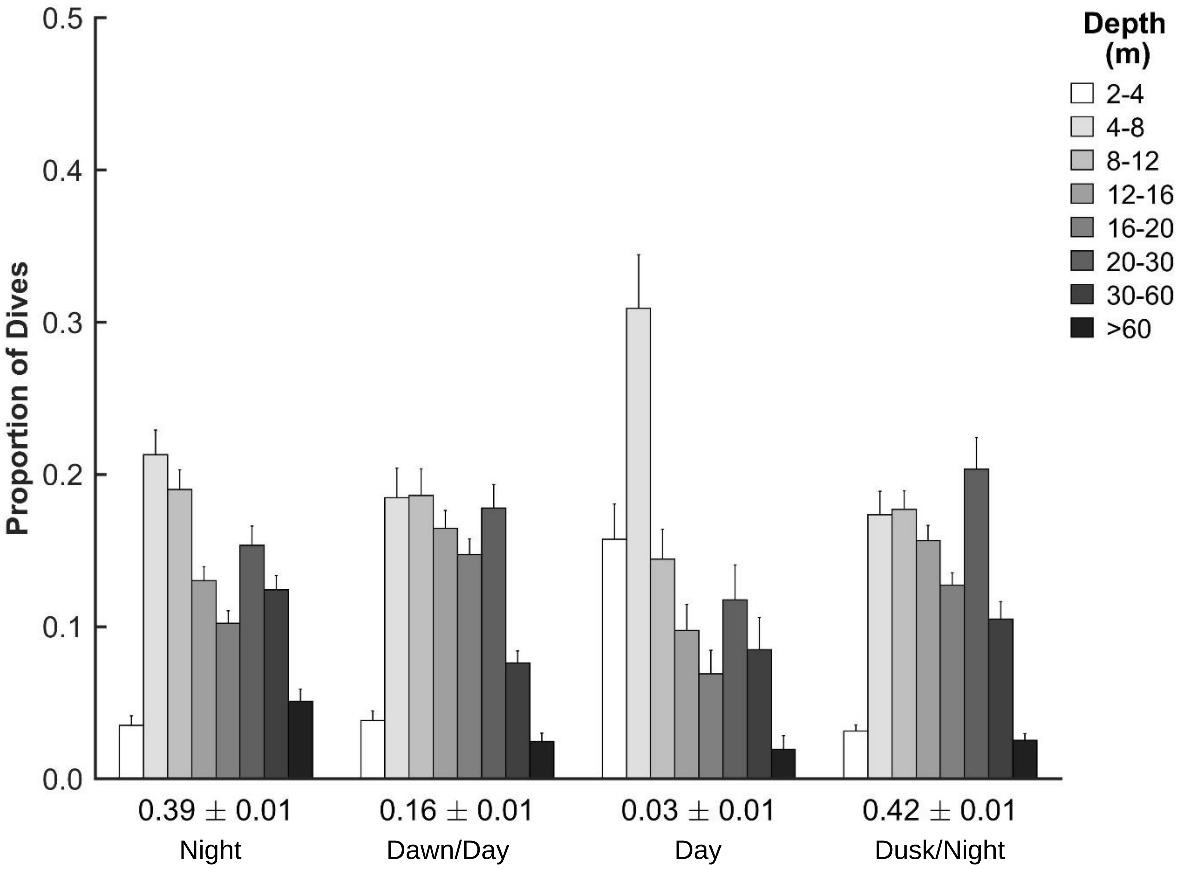

Figure 17. Proportion of dives to each depth bin across four 6-h periods for 35 Guadalupe fur seals. Mean ± SE proportion of dives per period (each histogram block) provided along the x-axis with times of each period from left to right: 23:00-04:59, 05:00-10:59, 11:00-16:59, and 17:00-22:59 local time of GMT -8 h.

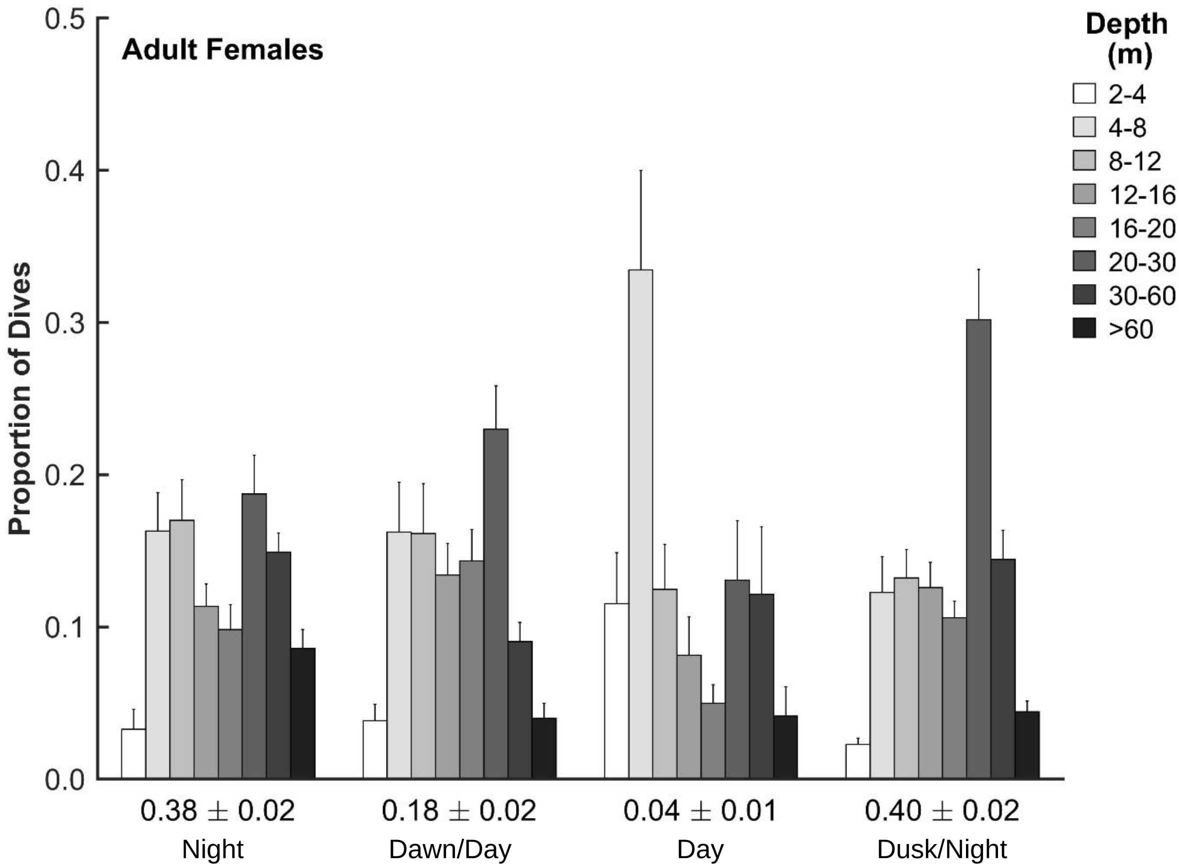

Figure 18. Proportion of dives to each depth bin across four 6-h periods for 15 adult female Guadalupe fur seals. Mean ± SE proportion of dives per period (each histogram block) provided along the x-axis with times of each period from left to right: 23:00-04:59, 05:00-10:59, 11:00-16:59, and 17:00-22:59 local time of GMT -8 h.

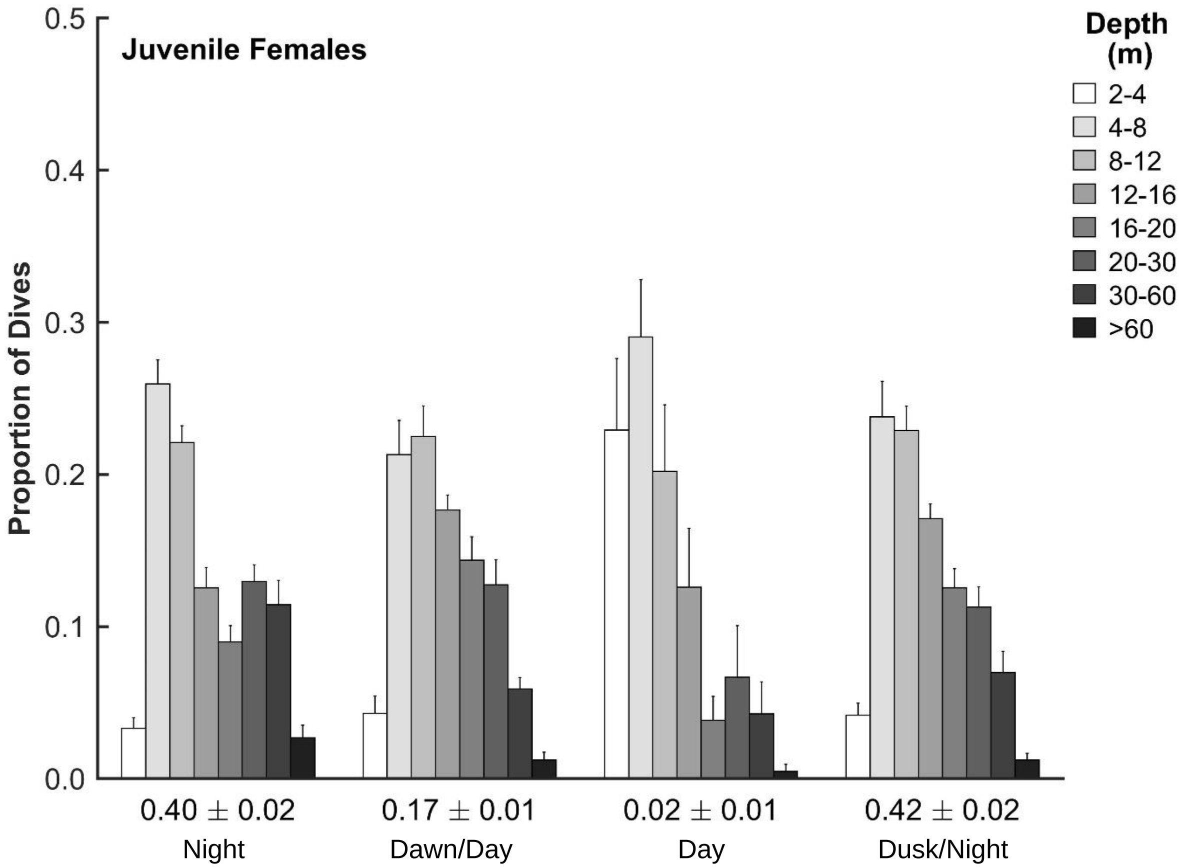

Figure 19. Proportion of dives to each depth bin across four 6-h periods for 10 juvenile female Guadalupe fur seals. Mean ± SE proportion of dives per period (each histogram block) provided along the x-axis with times of each period from left to right: 23:00-04:59, 05:00-10:59, 11:00-16:59, and 17:00-22:59 local time of GMT -8 h.

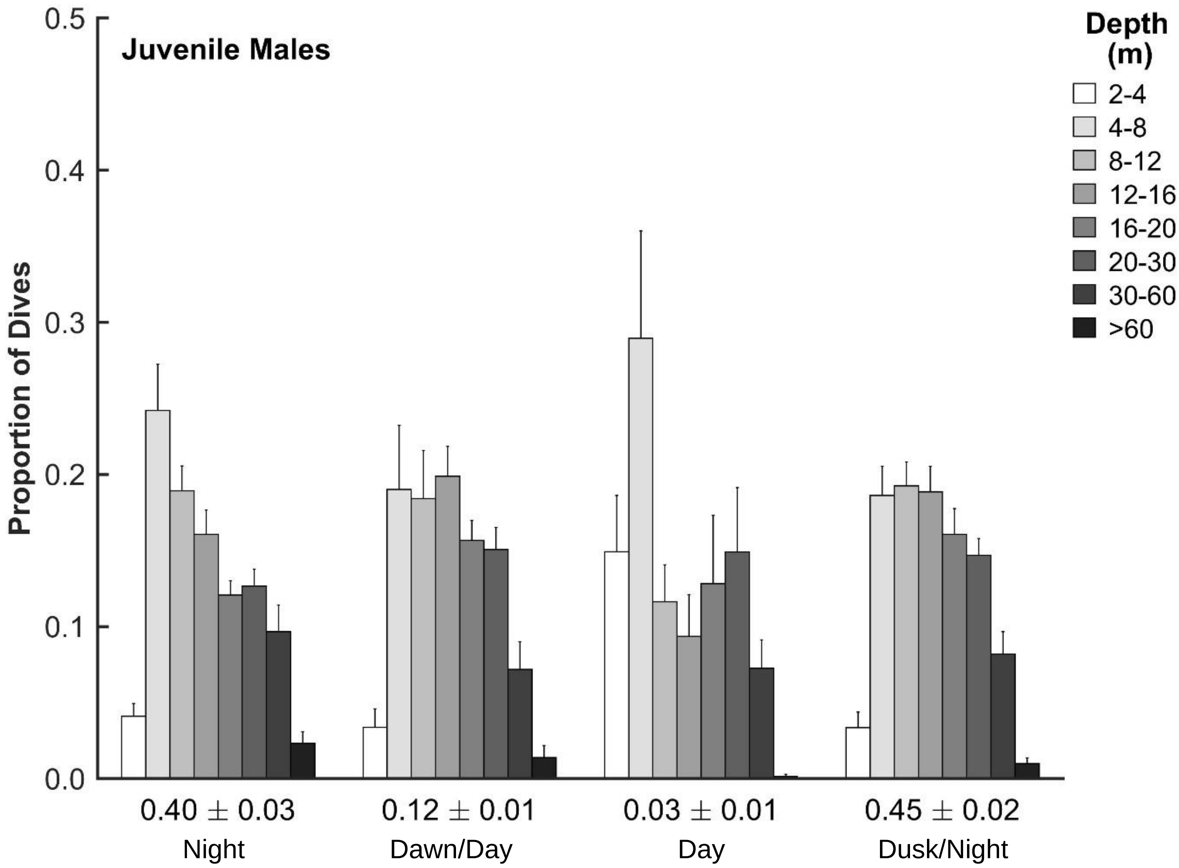

Figure 20. Proportion of dives to each depth bin across four 6-h periods for 10 juvenile male Guadalupe fur seals. Mean ± SE proportion of dives per period (each histogram block) provided along the x-axis with times of each period from left to right: 23:00-04:59, 05:00-10:59, 11:00-16:59, and 17:00-22:59 local time of GMT -8 h.

Tables

Table 1. Tagging summary for 35 Guadalupe fur seals captured at Guadalupe Island in November 2018. Age classes: adult (A) and juvenile (J). Platform transmitting terminals (PTT) 177364-177373 are SPLASH10-F-238 tags (n = 10) and 177374-177398 are SPLASH10-F-297 tags (n = 25). SN = serial number assigned by the tag manufacturers (Wildlife Computers)

Age class	Sex	Mass (kg)	Length (cm)	Axillary Girth (cm)	Flipper tag #	Satellite tag PTT	Satellite tag SN	Tagging Date	Last transmission date	Transmission duration (d)
A*	F	61.0	153	97.5	80V	177364	18A0268	11/15/2018	01/03/2019	49
A	F	43.9	140	83.0	81V	177365	18A0269	11/15/2018	12/29/2018	44
A	F	47.2	140	90.0	82V	177366	18A0270	11/15/2018	02/17/2019	94
A	F	54.6	141	95.0	84V	177367	18A0271	11/16/2018	12/14/2018	28
A	F	45.1	143	87.0	88V	177368	18A0272	11/17/2018	01/28/2019	72
A	F	66.0	150	105.5	91V	177369	18A0273	11/17/2018	02/12/2019	87
A	F	53.4	148	95.0	98V	177370	18A0274	11/19/2018	12/26/2018	37
A*	F	58.6	148	94.0	99V	177371	18A0275	11/19/2018	02/02/2019	75
A	F	59.2	149	98.0	109V	177372	18A0276	11/21/2018	02/28/2019	99
A	F	54.5	150	88.0	112V	177373	18A0277	11/22/2018	12/27/2018	35
J	M	22.8	113	67.0	77V	177374	18A0298	11/15/2018	01/16/2019	62
A	F	43.5	142	87.0	78V	177375	18A0299	11/15/2018	03/22/2019	127
J	M	30.3	119	78.0	79V	177376	18A0300	11/15/2018	01/10/2019	56
J	F	29.6	128	70.0	83V	177377	18A0301	11/16/2018	01/14/2019	59
J	F	23.6	118	67.0	86V	177378	18A0302	11/16/2018	02/17/2019	93
J	F	21.4	108	67.0	85V	177379	18A0304	11/16/2018	01/20/2019	65
A	F	40.5	139	81.0	87V	177380	18A0305	11/16/2018	02/28/2019	104
J	F	22.8	119	66.0	89V	177381	18A0317	11/17/2018	03/11/2019	114
J	M	29.6	118	75.0	90V	177382	18A0318	11/17/2018	02/01/2019	76
J	F	23.9	115	70.0	92V	177383	18A0319	11/17/2018	02/13/2019	88
A	F	39.6	139	81.0	93V	177384	18A0320	11/18/2018	04/01/2019	134
A	F	35.7	138	81.0	94V	177385	18A0321	11/18/2018	01/18/2019	61
J	F	36.2	130	79.0	95V	177386	18A0341	11/18/2018	02/14/2019	88
J	M	26.0	110	73.5	96V	177387	18A0323	11/18/2018	01/14/2019	57
J	F	32.8	122	75.5	97V	177388	18A0324	11/18/2018	02/26/2019	100
J	M	28.5	115	73.5	100V	177389	18A0326	11/19/2018	01/19/2019	61
J	M	23.0	109	67.5	101V	177390	18A0327	11/19/2018	01/06/2019	48
J	M	22.9	116	64.0	102V	177391	18A0328	11/20/2018	04/14/2019	145
J	F	24.0	107	71.5	103V	177392	18A0329	11/20/2018	02/19/2019	91
A	F	43.5	142	82.0	104V	177393	18A0330	11/20/2018	04/05/2019	136
J	M	28.1	124	70.0	106V	177394	18A0331	11/20/2018	01/05/2019	46
J	M	35.6	130	75.0	107V	177395	18A0332	11/21/2018	03/18/2019	117
J	F	23.6	119	65.5	108V	177396	18A0333	11/21/2018	01/20/2019	60
J	M	26.1	111	73.0	110V	177397	18A0334	11/21/2018	02/15/2019	86
J	F	29.2	121	73.0	111V	177398	18A0335	11/21/2018	03/14/2019	113

* Based on body size, lactation/nursing status unknown.

Table 2. Filtered location data summary. The number of global position system (GPS) and combined GPS and Argos locations retained after transit speed (TS) and turn angle (TA) filtering for each individual, indicated by the unique platform transmitting terminal (PTT). Transmission interval is the time between consecutive locations after filtering, location class (LC) A/B have no accuracy estimation, and % combined is the proportion of GPS and Argos locations generated between hours 02:00-05:59 (GMT = Greenwich Mean Time).

PTT	# locations retained			Transmision interval (h)		% Argos LC A/B	% Combined, 02:00-05:59 GMT	Mean daily locations
	GPS (TS)	Combined (TS)	Combined (TA)	GPS	Combined			
177364	147	513	497	7.7	2.3	0.69	0.57	10
177365	84	347	331	12.1	3.1	0.69	0.57	7
177366	109	638	609	20.0	3.6	0.77	0.60	6
177367	41	157	144	14.6	4.5	0.76	0.52	5
177368	105	490	469	15.6	3.6	0.80	0.53	6
177369	196	932	912	10.3	2.2	0.74	0.57	10
177370	59	243	234	14.0	3.7	0.70	0.49	6
177371	176	599	576	9.9	3.1	0.72	0.58	8
177372	138	787	756	16.9	3.1	0.77	0.64	8
177373	54	251	237	15.0	3.4	0.74	0.56	7
177374	100	320	308	14.5	4.8	0.79	0.69	5
177375	286	907	853	10.4	3.5	0.73	0.72	7
177376	179	475	457	7.3	2.9	0.70	0.65	8
177377	133	451	428	10.4	3.2	0.75	0.77	7
177378	180	670	649	11.9	3.4	0.69	0.65	7
177379	79	262	242	17.1	6.3	0.83	0.70	4
177380	142	577	546	17.1	4.5	0.81	0.69	5
177381	262	972	935	10.2	2.9	0.66	0.63	8
177382	206	641	612	8.5	2.9	0.74	0.63	8
177383	142	568	539	14.2	3.8	0.79	0.68	6
177384	207	804	750	15.1	4.2	0.79	0.70	6
177385	107	390	378	13.3	3.8	0.73	0.69	6
177386	162	542	504	12.7	4.1	0.70	0.65	6
177387	131	443	433	9.9	3.1	0.77	0.67	7
177388	248	965	938	9.4	2.5	0.63	0.67	9
177389	108	390	376	13.1	3.8	0.81	0.78	6
177390	131	429	423	8.6	2.7	0.63	0.62	9
177391	367	1,216	1,176	9.2	2.9	0.71	0.63	8
177392	206	676	654	10.4	3.3	0.73	0.65	7
177393	220	992	956	14.6	3.4	0.71	0.71	7
177394	56	236	226	18.9	4.8	0.82	0.76	5
177395	216	783	741	12.7	3.7	0.79	0.72	6
177396	130	423	400	11.0	3.6	0.77	0.65	7
177397	197	754	728	10.3	2.8	0.79	0.72	8
177398	200	693	650	13.3	4.1	0.70	0.63	6

Table 3. Number of Guadalupe fur seals observed at San Benito Archipelago during summer 2018. Raw counts (total, uncorrected) of adult females were corrected using the number of pups because more pups were counted than adult females.
[table removed from this version]

Table 4. Number of Guadalupe fur seals observed at Guadalupe Island during summer 2018. For boat-based surveys, substrate type was recorded. Raw counts (total, uncorrected) of adult females were corrected using the number of pups because more pups were counted than adult females.
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Table 5. Mass of eight approximately 4-month-old pups capture along with their mother. PTT = platform transmitting terminal of dam's satellite tag

PTT	Dam mass (kg)	Pup mass (kg)
177369	66	6.9
177370	53.4	13.8
177372	59.2	8.8
177375	43.5	13.1
177380	40.5	10.8
177384	39.6	17.0
177385	35.7	16.7
177393	43.5	10.4

Table 6. Home range areas (km^2) for each group and all seals combined.

	Adult Female	Juvenile Female	Juvenile Male	All
Home Range Area	617,566	404,274	379,792	944,689

Table 7. Foraging trip statistics for each group. Means were calculated for each individual for complete trips ≥2 d only (*i.e.*, returned to the island), unless the individual did not return to the island during the tracking period (*i.e.*, single "incomplete" trip ≥2 d was included), then across individuals within a group, along with standard error, for: trip duration, duration ashore, maximum and total trip distance, and relative search index (RSI). Travel rate was similarly calculated, but across all (complete and incomplete) trips ≥2 d. The total distance traveled across all trips ≥2 d was summed (sum distance) and the maximum distance from Guadalupe Island for trips <2 d was determined for each individual then the mean was calculated across individuals within a group. For each group, the maximum for each metric across all individuals is in parentheses, with complete trips included for each as is described for means.

	Duration (d)		Distance (km)			RSI	Travel Rate (km/d)	Trips <2 d Max Distance (km)
	Trip	Ashore	Maximum	Total	Sum			
Adult Female	31.2 ± 4.3 (49.1)	6.1 ± 1.0 (9.7)	795 ± 114 (1,667)	2,070 ± 295 (4,134)	3,951 ± 412 (6,657)	2.9 ± 0.2 (5.2)	63.2 ± 4.2 (101.9)	4.8 ± 1.3 (16.9)
Juvenile Female	42.8 ± 6.5 (61.4)	8.7 ± 1.8 (21.2)	771 ± 126 (1,273)	2,325 ± 373 (3,833)	3,514 ± 297 (4,877)	3.1 ± 0.2 (4.7)	55.7 ± 4.2 (96.9)	13.2 ± 4.0 (42.4)
Juvenile Male	53.2 ± 8.1 (75.0)	12.1 ± 1.2 (20.4)	944 ± 96 (1,260)	2,681 ± 416 (4,090)	3,155 ± 559 (7,300)	2.8 ± 0.3 (3.2)	51.5 ± 1.9 (65.9)	8.1 ± 1.6 (17.1)

Table 8. Foraging trip statistics for 15 adult female Guadalupe fur seals. Means were calculated for each individual for complete trips ≥2 d only (*i.e.*, returned to the island), unless the individual did not return to the island during the tracking period (*i.e.*, single "incomplete" trip ≥2 d was included), for: trip duration, duration ashore, maximum and total trip distance, and relative search index (RSI). In addition, travel rate was calculated across all (complete and incomplete) trips ≥2 d, total distance traveled across all trips ≥2 d was summed (sum distance), and maximum distance from Guadalupe Island for trips <2 d was determined for each individual. PTT = platform transmitting terminal

PTT	**# Trips**	**Duration (d)**		**Distance (km)**			**RSI**	**Travel Rate (km/d)**	**Trips <2 d Max Distance (km)**
		Trip	**Ashore**	**Maximum**	**Total**	**Sum**			
177364	2*	31.5	6.3	1,115	2,911	3,493	2.6	97.2	2.4
177365	3*	16.3	3.1	436	1,083	2,271	2.6	52.2	2.5
177366	1*	81.9	12.7	939	4,105	4,105	4.4	50.1	2.2
177367	1*	20.0	8.2	1,085	1,415	1,415	1.3	70.9	5.4
177368	3*	28.6	2.8	505	1,752	3,949	3.9	56.5	4.6
177369	2*	49.1	9.5	1,497	4,134	5,756	2.8	84.3	2.9
177370	1*	28.8	8.8	1,063	1,950	1,950	1.8	67.6	1.9
177371	3*	28.3	3.8	524	1,726	3,784	3.5	55.5	2.0
177372	2*	43.1	6.5	1,667	3,903	6,657	2.3	77.2	3.1
177373	1*	20.6	14.5	937	1,513	1,513	1.6	73.4	16.9
177375	4	29.1	2.1	275	1,147	4,588	4.4	40.5	14.3
177380	3*	25.7	4.8	583	1,696	5,099	3.1	56.4	1.2
177384	6*	20.5	1.9	281	881	5,466	3.2	44.1	1.4
177385	2	26.5	3.6	775	1,991	3,981	2.6	74.8	1.5
177393	7*	18.3	3.3	248	849	5,229	3.4	46.6	9.8

* Did not return to Guadalupe Island on last trip

Table 9. Foraging trip statistics for 10 juvenile female Guadalupe fur seals. Means were calculated within each individual for complete trips ≥2 d only (*i.e.*, returned to the island), unless the individual did not return to the island during the tracking period (*i.e.*, single "incomplete" ≥2 d trip was included), for: trip duration, duration ashore, maximum and total trip distance, and relative search index (RSI). Travel rate was similarly calculated, but across all (complete and incomplete) trips ≥2 d , total distance traveled across all trips ≥2 d was summed (sum distance), and maximum distance from Guadalupe Island for trips <2 d was determined for each individual. PTT = platform transmitting terminal

PTT	#	Duration (d)		Distance (km)			RSI	Travel Rate	Trips <2 d Max
	Trips	Trip	Ashore	Maximum	Total	Sum		(km/d)	Distance (km)
177377	1*	56.3	2.9	1,136	2,646	2,646	2.3	47.0	--
177378	3*	33.9	6.4	699	2,055	4,597	3.3	63.8	12.9
177379	1*	49.6	16.0	1,009	2,538	2,538	2.5	51.1	1.6
177381	4*	28.6	6.5	485	1,570	4,877	3.2	59.0	42.4
177383	2*	61.4	8.3	1,104	3,455	4,053	3.1	57.5	11.8
177386	7	6.8	5.6	105	320	2,237	3.1	35.7	13.9
177388	2*	57.8	20.1	1,273	3,833	4,046	3.0	81.6	10.2
177392	2*	59.8	11.6	838	3,453	4,096	4.1	68.1	10.2
177396	1*	59.2	1.5	862	2,714	2,714	3.1	45.8	0.7
177398	5	14.3	7.7	200	666	3,331	3.2	46.9	15.2

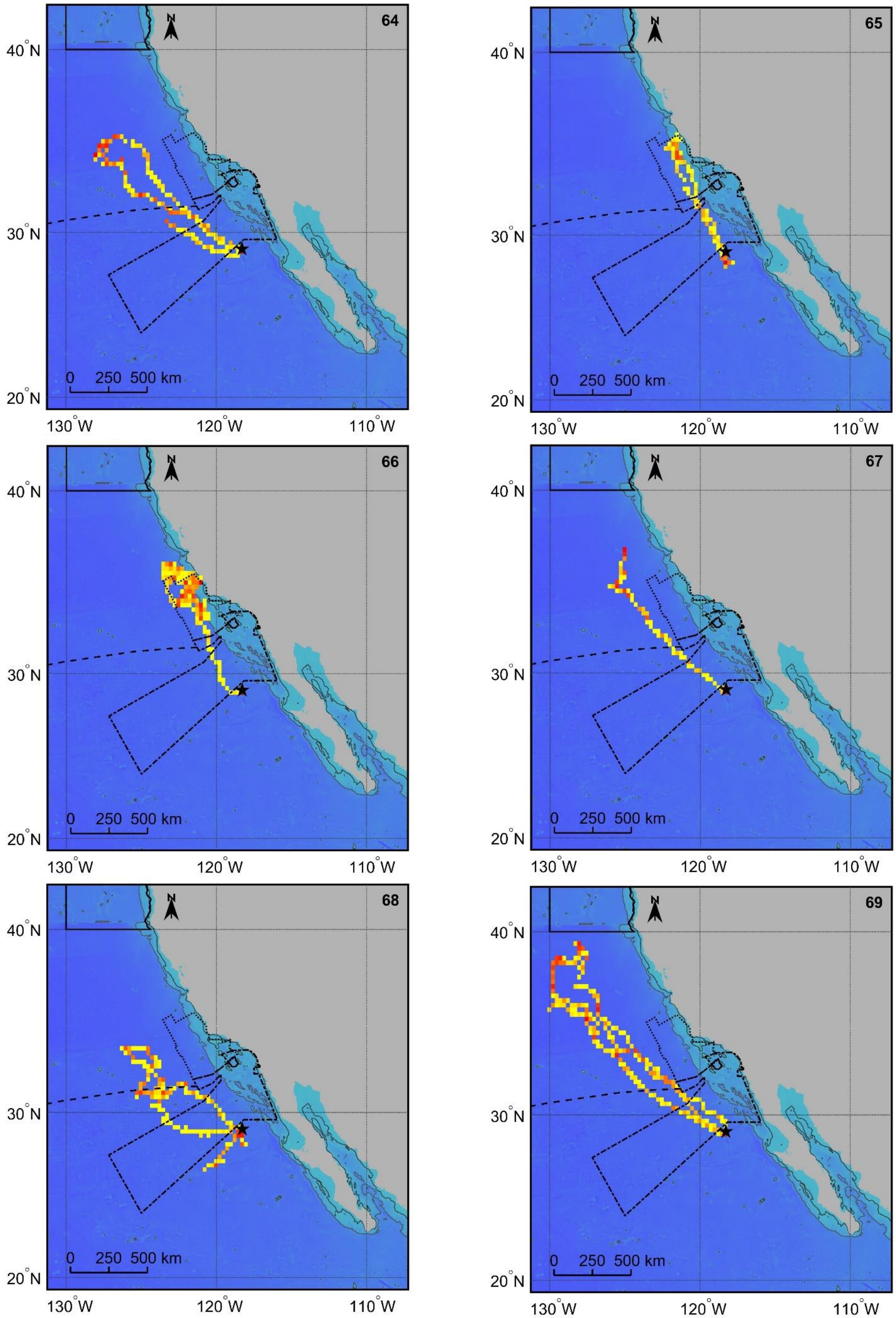
Table 10. Foraging trip statistics for 10 juvenile male Guadalupe fur seals. Means were calculated within each individual for complete trips ≥2 d only (*i.e.*, returned to the island), unless the individual did not return to the island during the tracking period (*i.e.*, single "incomplete" ≥2 d trip was included), for: trip duration, duration ashore, maximum and total trip distance, and relative search index (RSI). Travel rate was similarly calculated, but across all (complete and incomplete) trips ≥2 d , total distance traveled across all trips ≥2 d was summed (sum distance), and maximum distance from Guadalupe Island for trips <2 d was determined for each individual. PTT = platform transmitting terminal

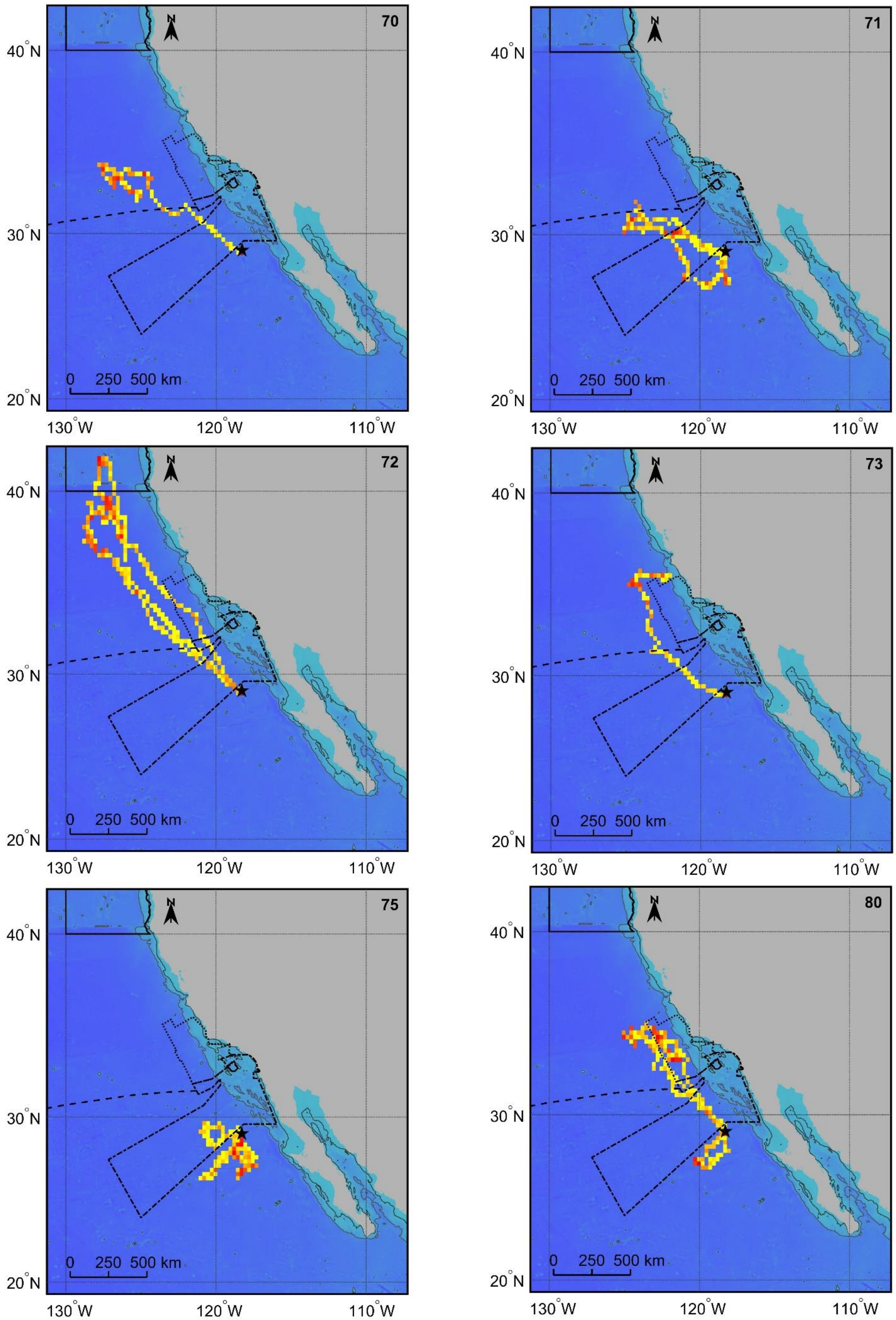
PTT	#	Duration (d)		Distance (km)			RSI	Travel Rate	Trips <2 d Max
	Trips	Trip	Ashore	Maximum	Total	Sum		(km/d)	Distance (km)
177374	1*	46.7	16.0	861	2,366	2,366	2.7	50.7	3.2
177376	2*	7.5	12.8	180	428	1,956	2.4	61.4	8.1
177382	1*	54.7	21.4	906	2,581	2,581	2.8	47.2	6.1
177387	1*	47.1	10.7	1,106	2,572	2,572	2.3	54.6	8.1
177389	1*	50.2	11.0	1,129	2,856	2,856	2.5	56.9	3.7
177390	1*	39.3	8.9	1,142	1,842	1,842	1.6	46.8	17.1
177391	2*	75.0	8.9	1,260	4,090	7,300	3.2	57.6	14.4
177394	1*	35.8	10.9	783	1,608	1,608	2.1	44.9	11.1
177395	1	100.4	9.2	1,015	5,145	5,145	5.1	51.3	7.8
177397	1*	75.7	11.0	1,058	3,326	3,326	3.1	43.9	1.3

Table 11. Percentage overlap between four U.S. Navy training and testing areas and each group of Guadalupe fur seals and all seals combined. This was calculated as the area of each Navy range divided by the animal group home range area in each Navy range. The percentage of the SOCAL Range Complex and PMSR over seafloor depths <2,000 m (continental slope) used by Guadalupe fur seals was calculated separately. No animals used the slope portion of the NWTT Area, and SOAR is entirely over the continental slope.

	Adult Female	**Juvenile Female**	**Juvenile Male**	**All**
NWTT	3	0	0	3
SOCAL, all	25	28	18	42
SOCAL, slope	0	7	6	10
PMSR, all	67	85	80	99
PMSR, slope	16	33	30	38
SOAR	0	29	87	87

Appendices

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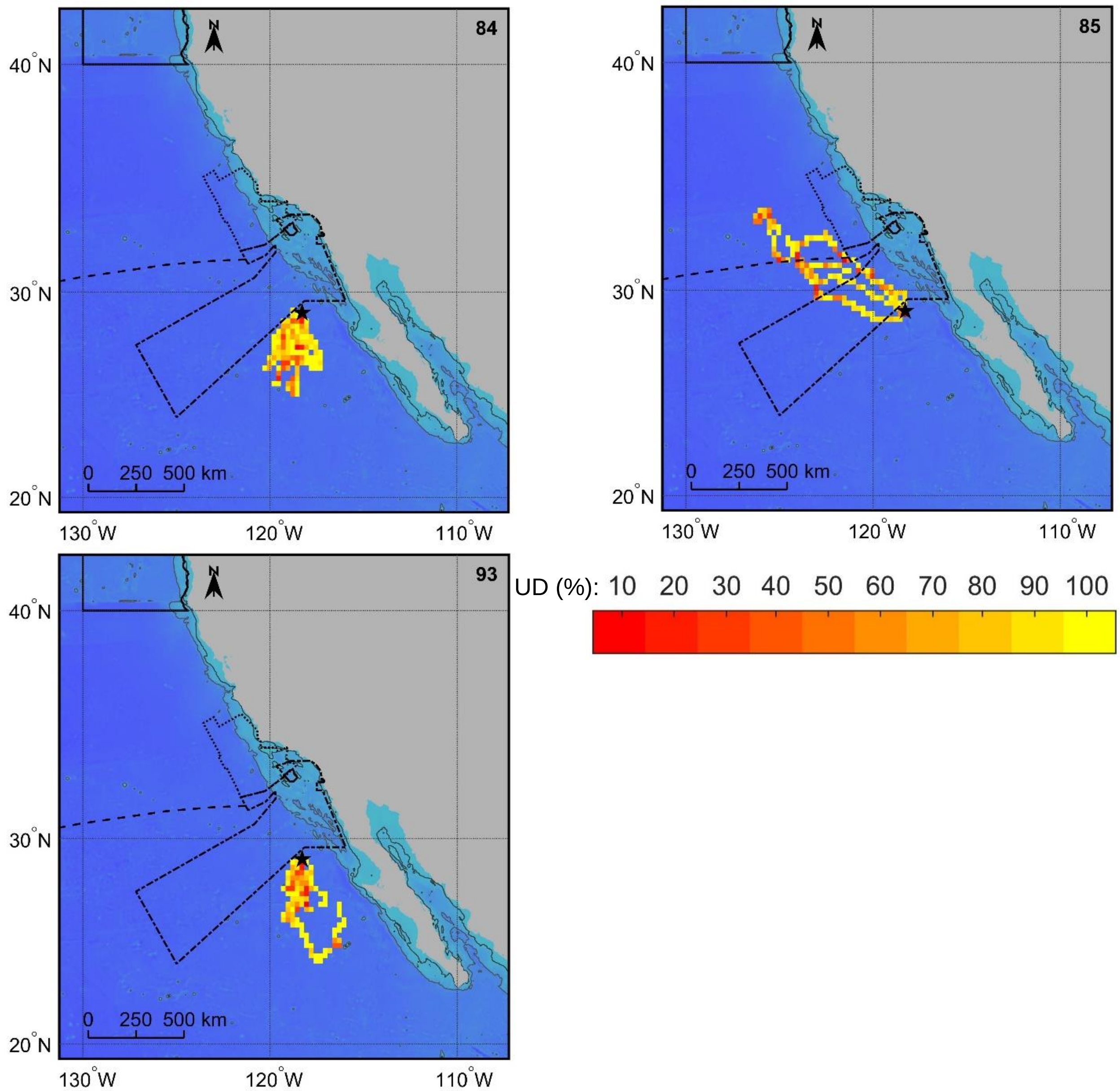
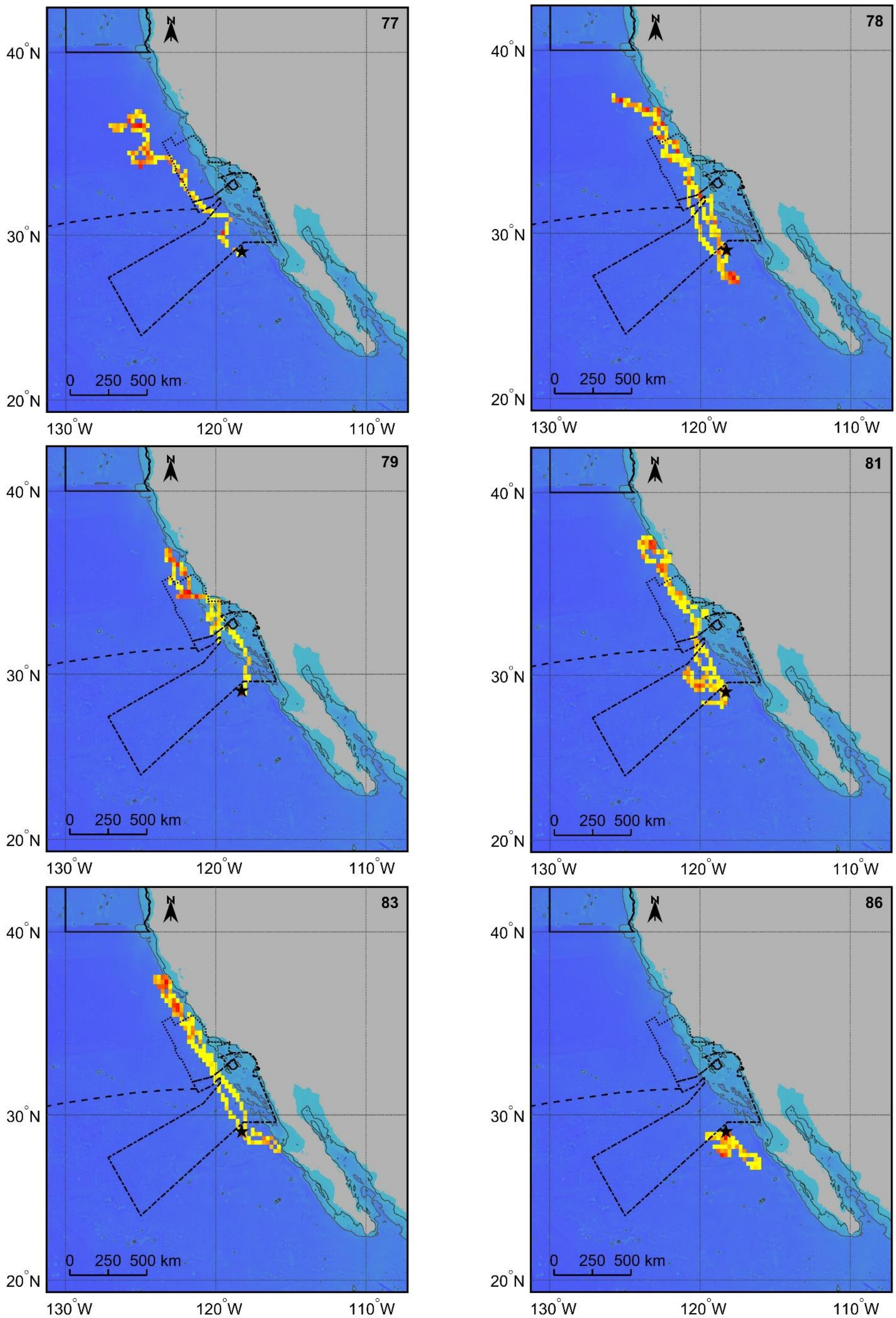
72
73
75
80
N
40°N
30°N
20°N
130°W
120°W
110°W
0 250 500 km



Appendix 1. Utilization distribution (UD) for each adult female Guadalupe fur seal. Red to yellow shading represents more to less intensely used areas, and last two digits of platform transmitting terminal (PTT) number indicate individual. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)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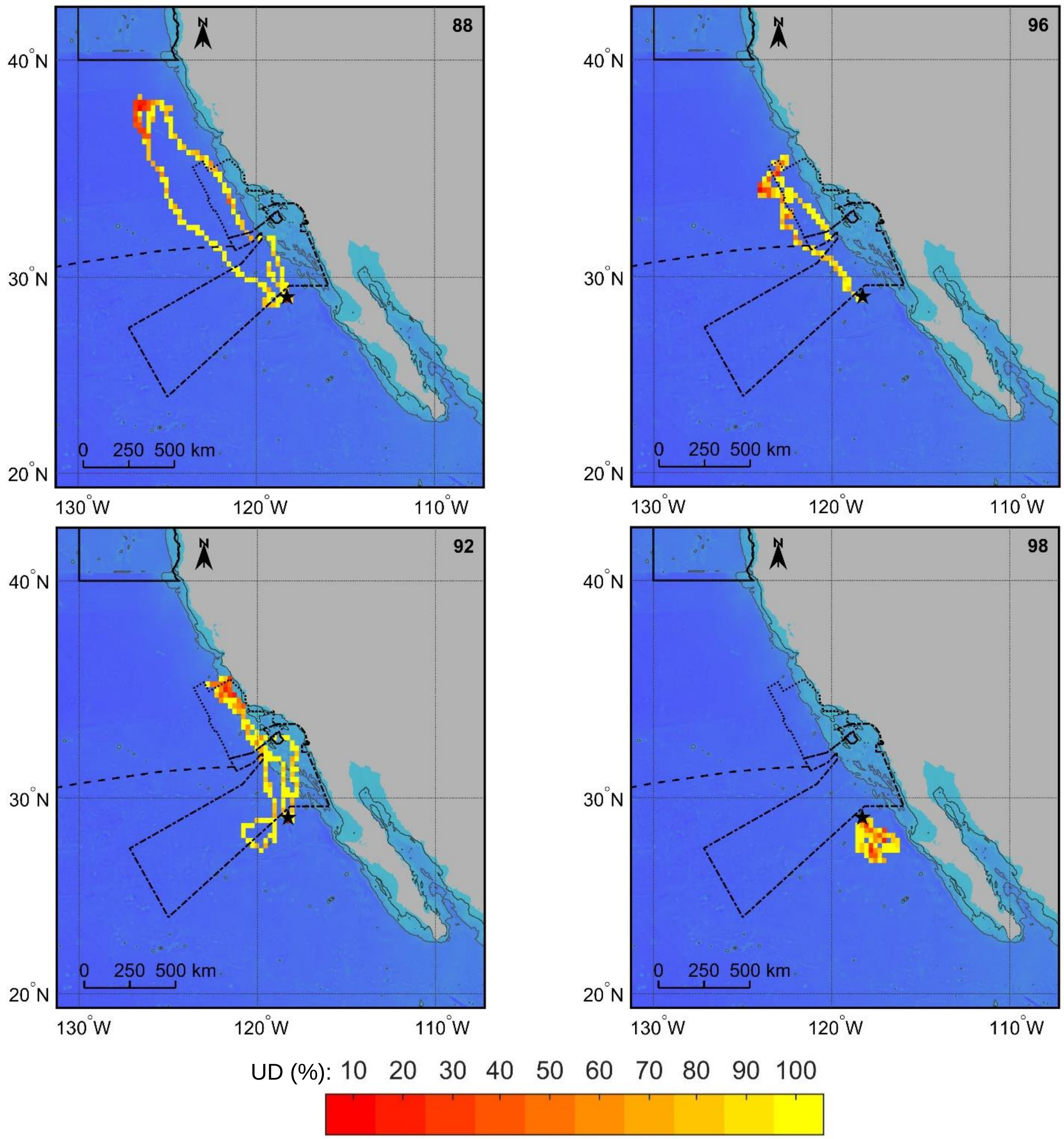
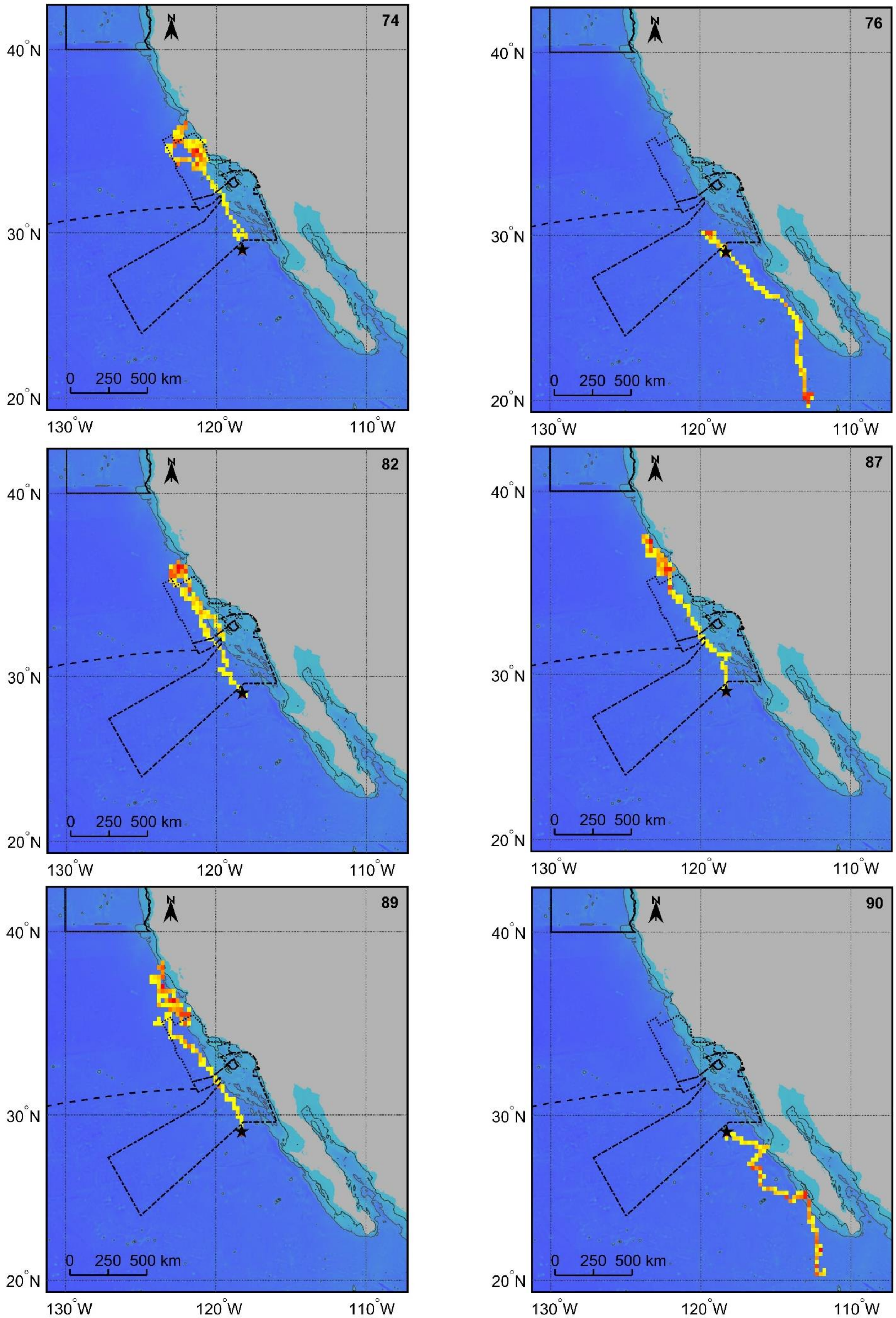
79
81
83
86
N
40°N
30°N
20°N
130°W
120°W
110°W
0 250 500 km



Appendix 2. Utilization distribution (UD) for each juvenile female Guadalupe fur seal. Red to yellow shading represents more to less intensely used areas, and last two digits of platform transmitting terminal (PTT) number indicate individual. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)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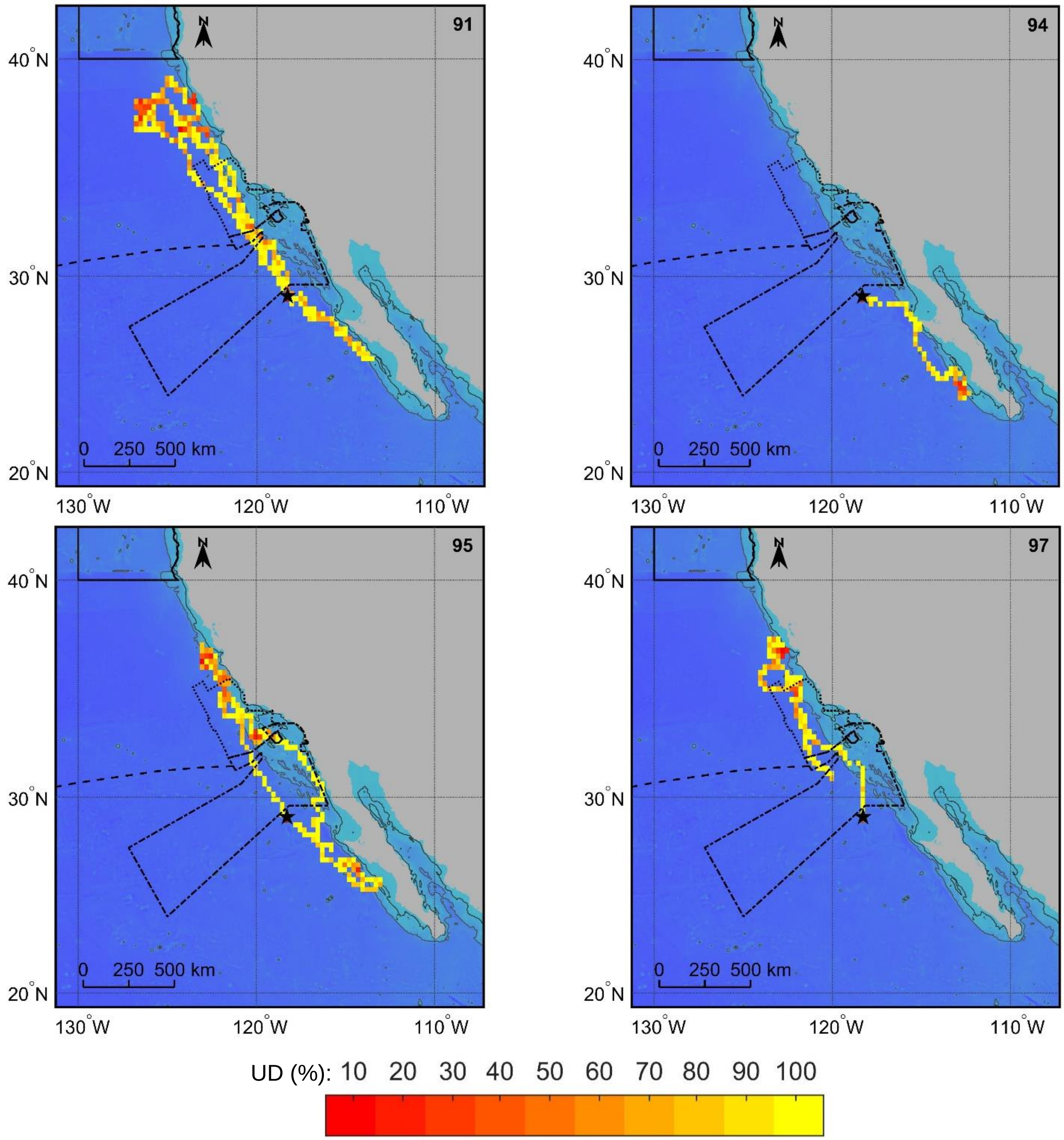
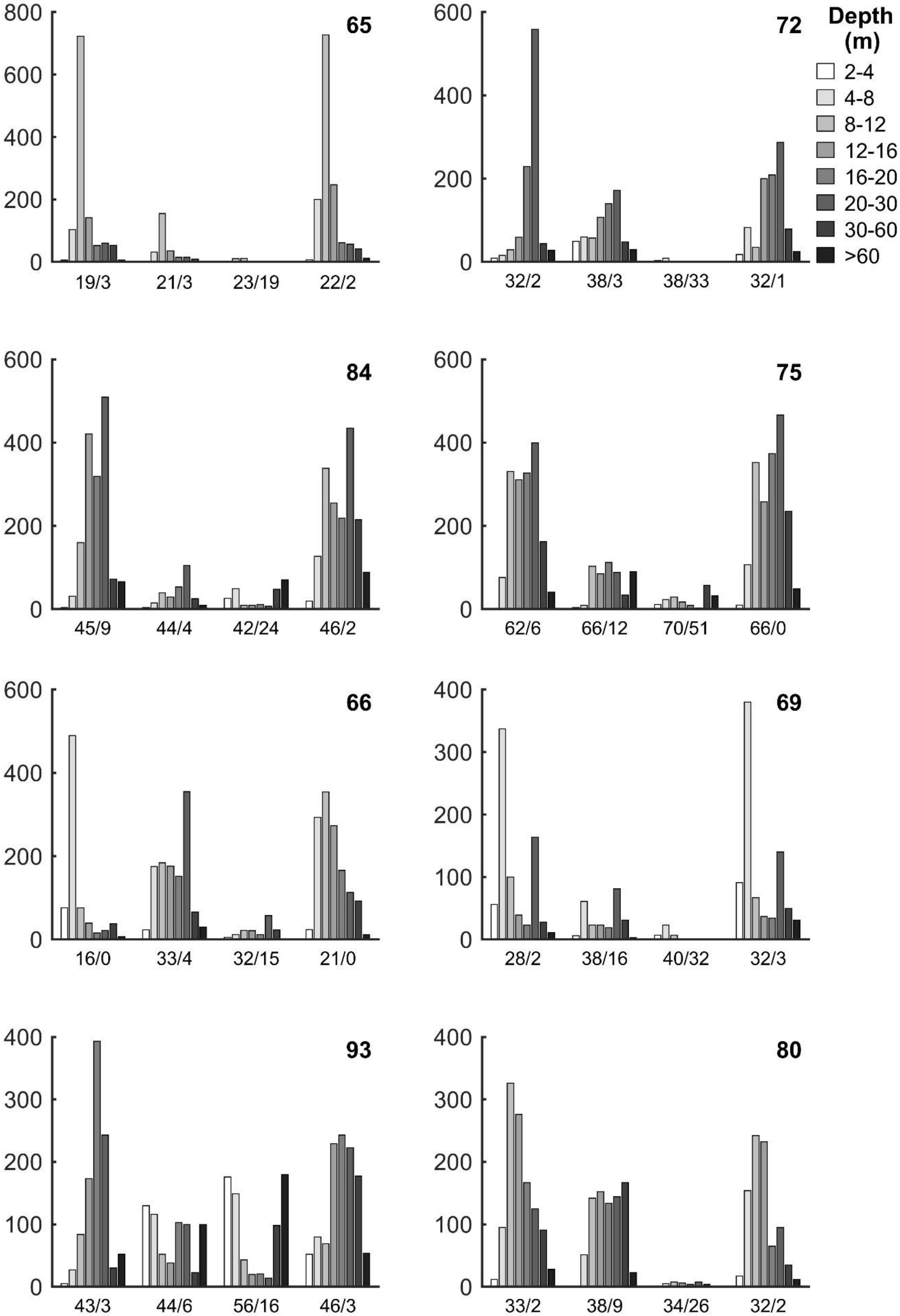
82
87
89
90
N
40°N
30°N
20°N
130°W
120°W
110°W
0 250 500 km



Appendix 3. Utilization distribution (UD) for each juvenile male Guadalupe fur seal. Red to yellow shading represents more to less intensely used areas, and last two digits of platform transmitting terminal (PTT) number indicate individual. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)


65
19/3
21/3
23/19
22/2
72
32/2
38/3
38/33
32/1
Depth (m)
2-4
4-8
8-12
12-16
16-20
20-30
30-60
>60
84
45/9
44/4
42/24
46/2
75
62/6
66/12
70/51
66/0
66
16/0
33/4
32/15
21/0
69
28/2
38/16
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80
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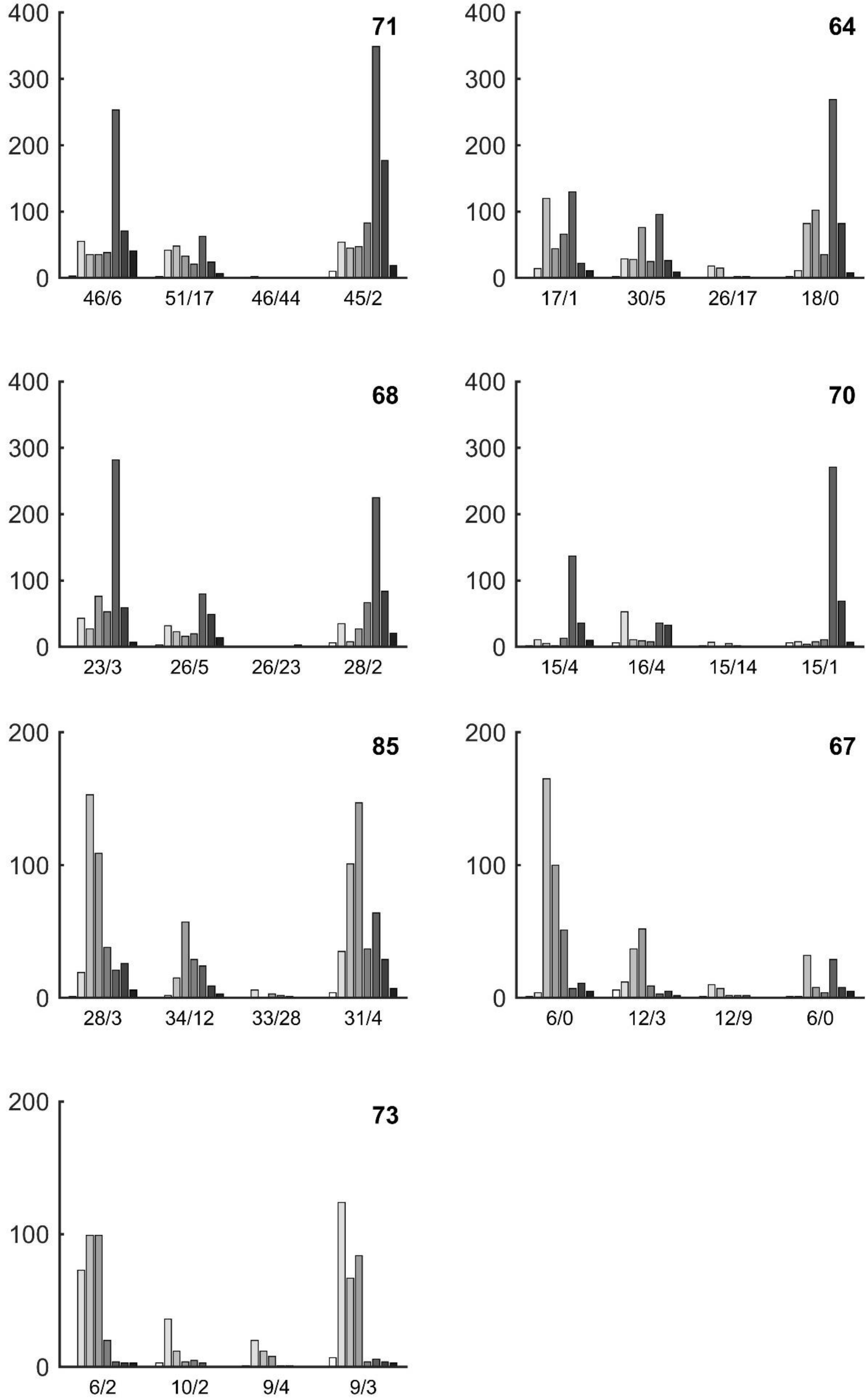
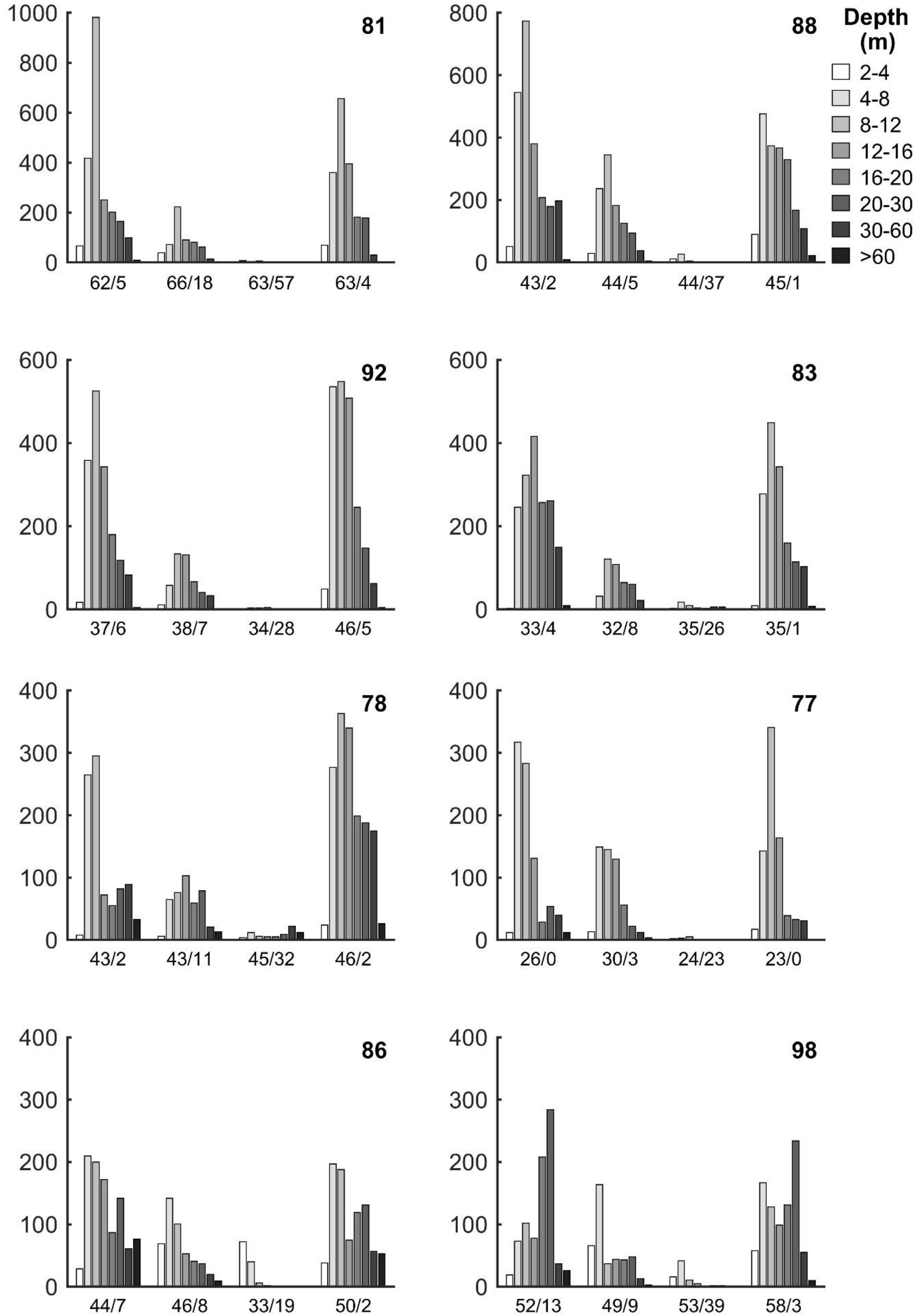
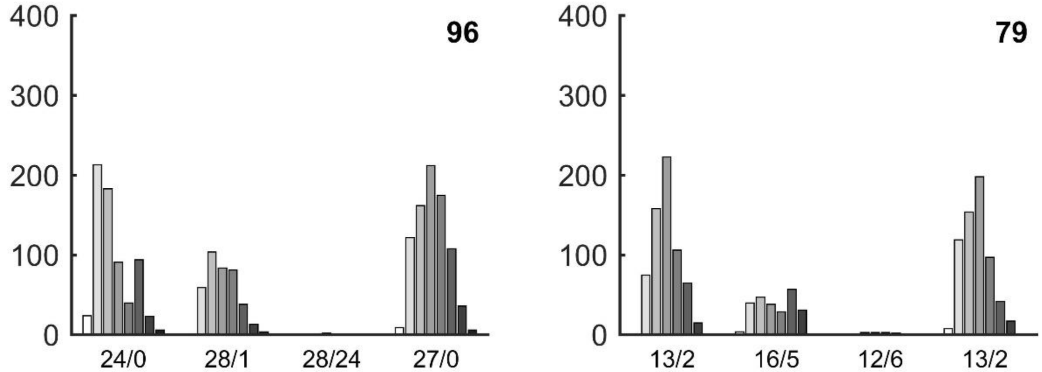
38/9
34/26
32/2

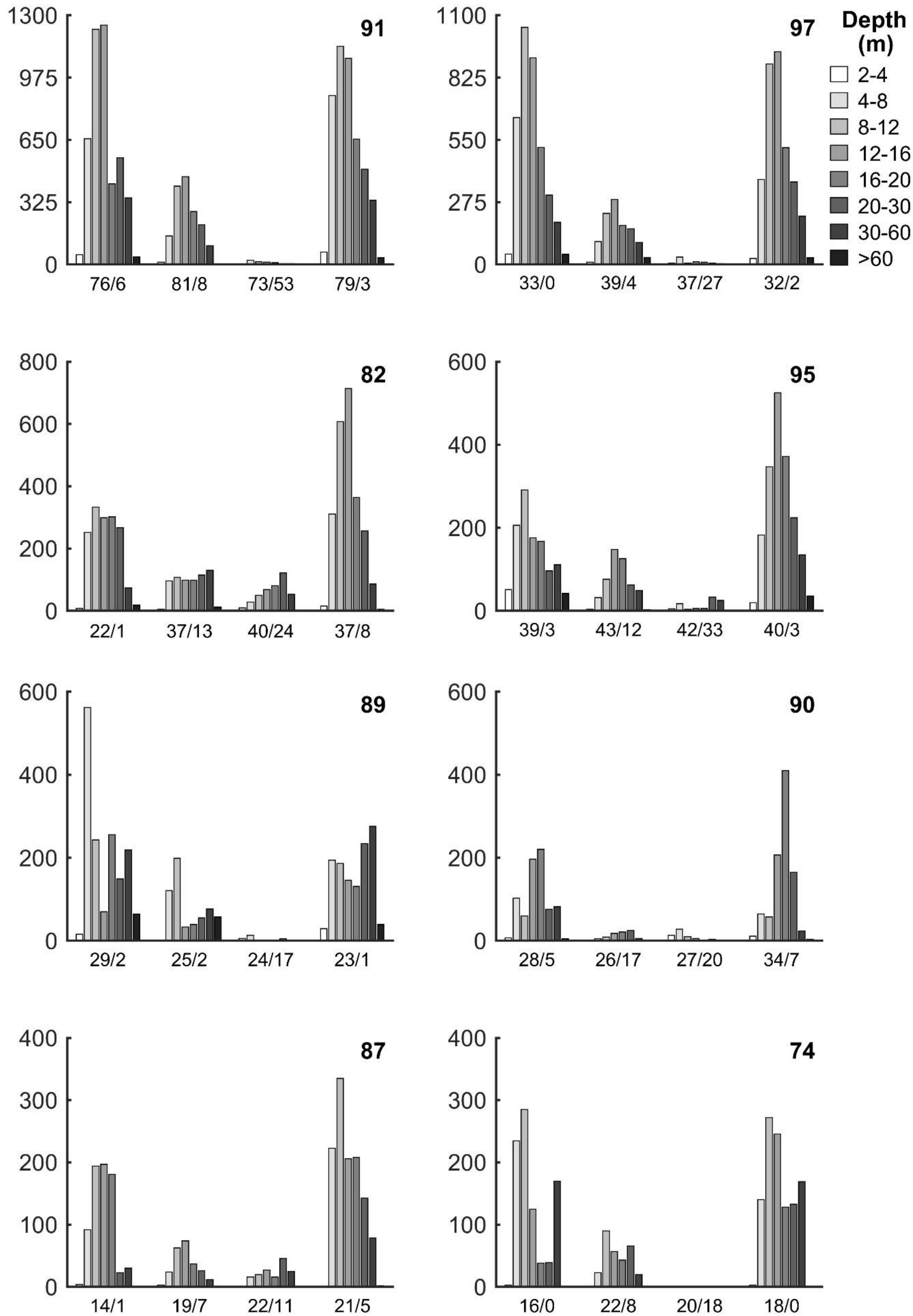


Appendix 4. Number of dives to each depth bin across four 6-h periods for each adult female. Total number of messages/number of messages with no dives are indicated below the x-axis. Last two digits of platform transmitting terminal (PTT) number indicate individual. Start times of each period from left to right: 23:00, 05:00, 11:00, and 17:00 local time of GMT -8 h.


81
62/5
66/18
63/57
63/4
88
43/2
44/5
44/37
45/1
Depth (m)
2-4
4-8
8-12
12-16
16-20
20-30
30-60
>60
92
37/6
38/7
34/28
46/5
83
33/4
32/8
35/26
35/1
78
43/2
43/11
45/32
46/2
77
26/0
30/3
24/23
23/0
86
44/7
46/8
33/19
50/2
98
52/13
49/9
53/39
58/3



Appendix 5. Number of dives to each depth bin across four 6-h periods for each juvenile female. Total number of messages/number of messages with no dives are indicated below the x-axis. Last two digits of platform transmitting terminal (PTT) number indicate individual. Start times of each period from left to right: 23:00, 05:00, 11:00, and 17:00 local time of GMT -8 h.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1300
975
650
325
0
76/6
81/8
73/53
79/3
97
1100
825
550
275
0
33/0
39/4
37/27
32/2
Depth (m)
2-4
4-8
8-12
12-16
16-20
20-30
30-60
>60
82
800
600
400
200
0
22/1
37/13
40/24
37/8
95
600
400
200
0
39/3
43/12
42/33
40/3
89
600
400
200
0
29/2
25/2
24/17
23/1
90
600
400
200
0
28/5
26/17
27/20
34/7
87
400
300
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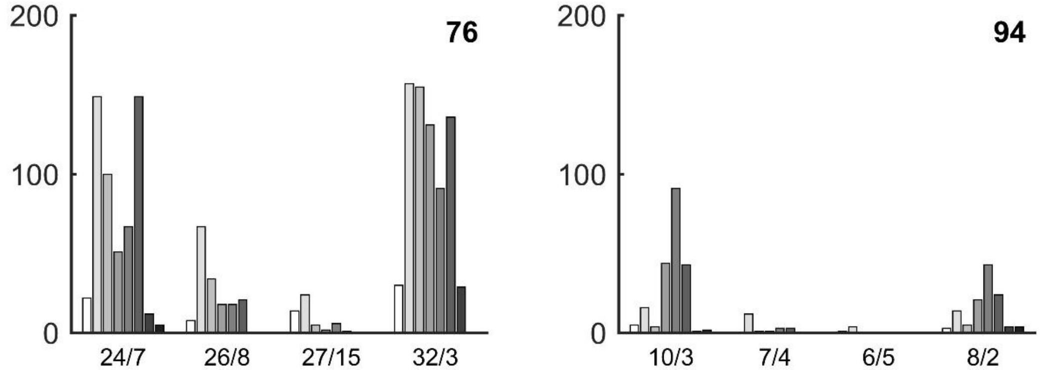
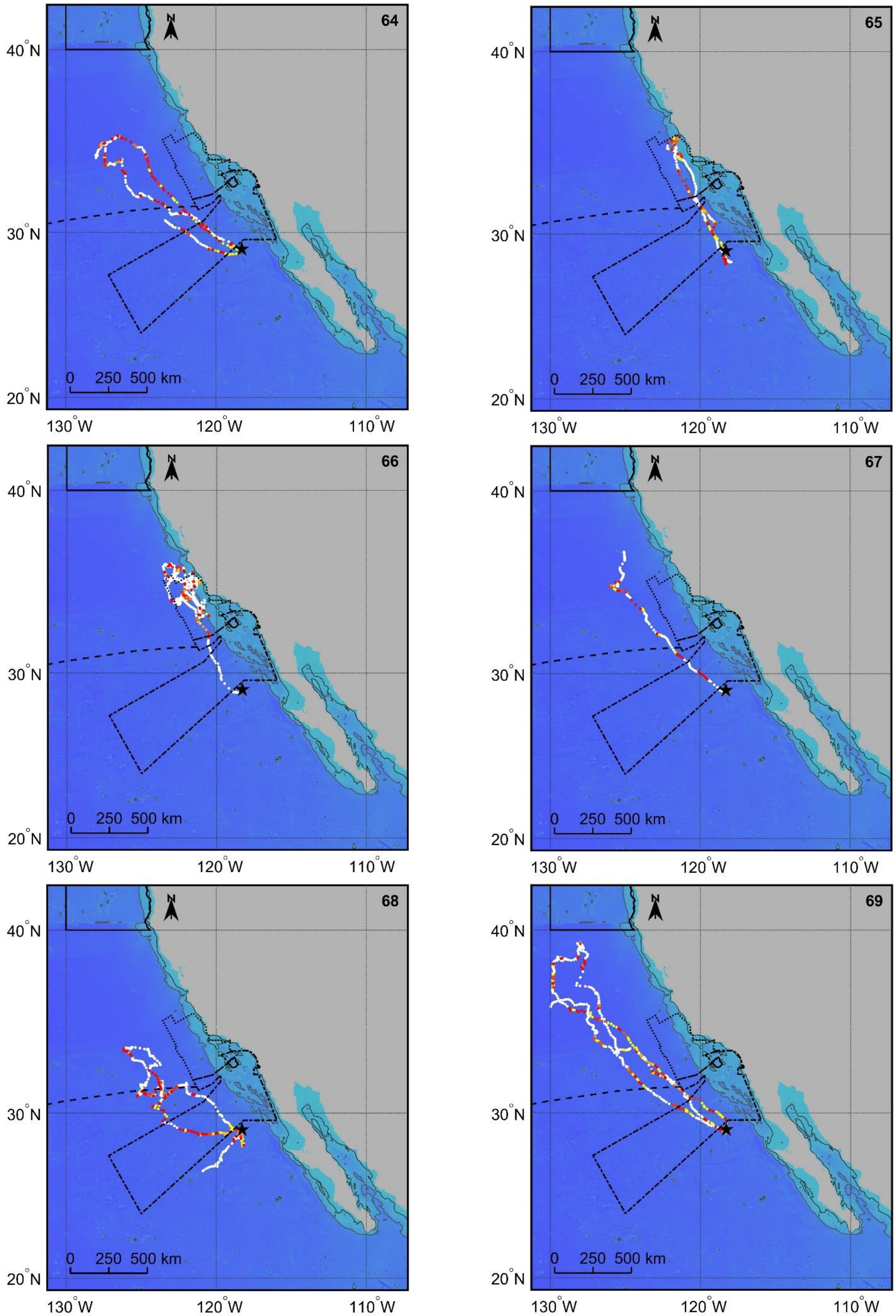
22/8
20/18
18/0



Appendix 6. Number of dives to each depth bin across four 6-h periods for each juvenile male. Total number of messages/number of messages with no dives are indicated below the x-axis. Last two digits of platform transmitting terminal (PTT) number indicate individual. Start times of each period from left to right: 23:00, 05:00, 11:00, and 17:00 local time of GMT -8 h.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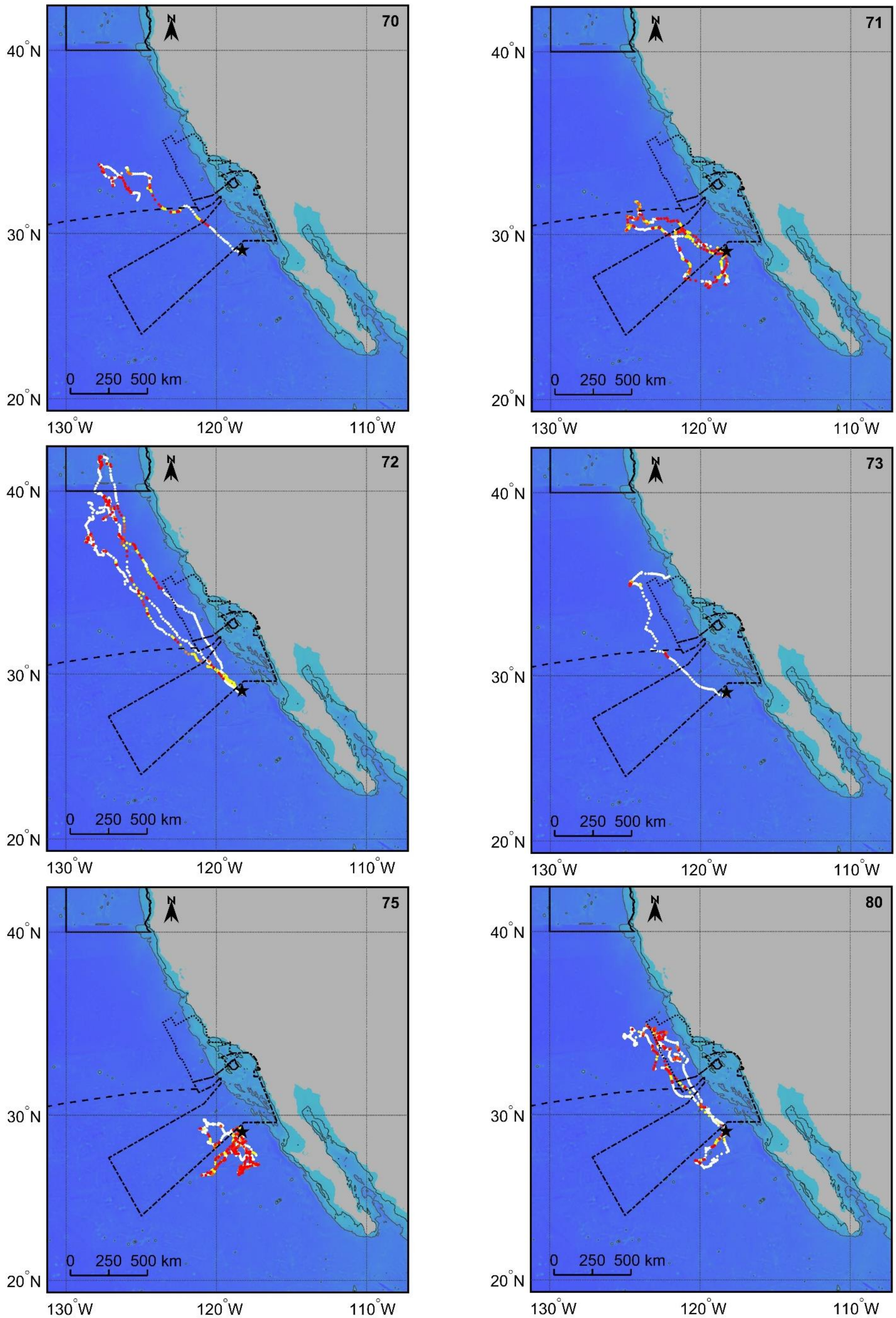
130°W
120°W
110°W
0 250 500 km
N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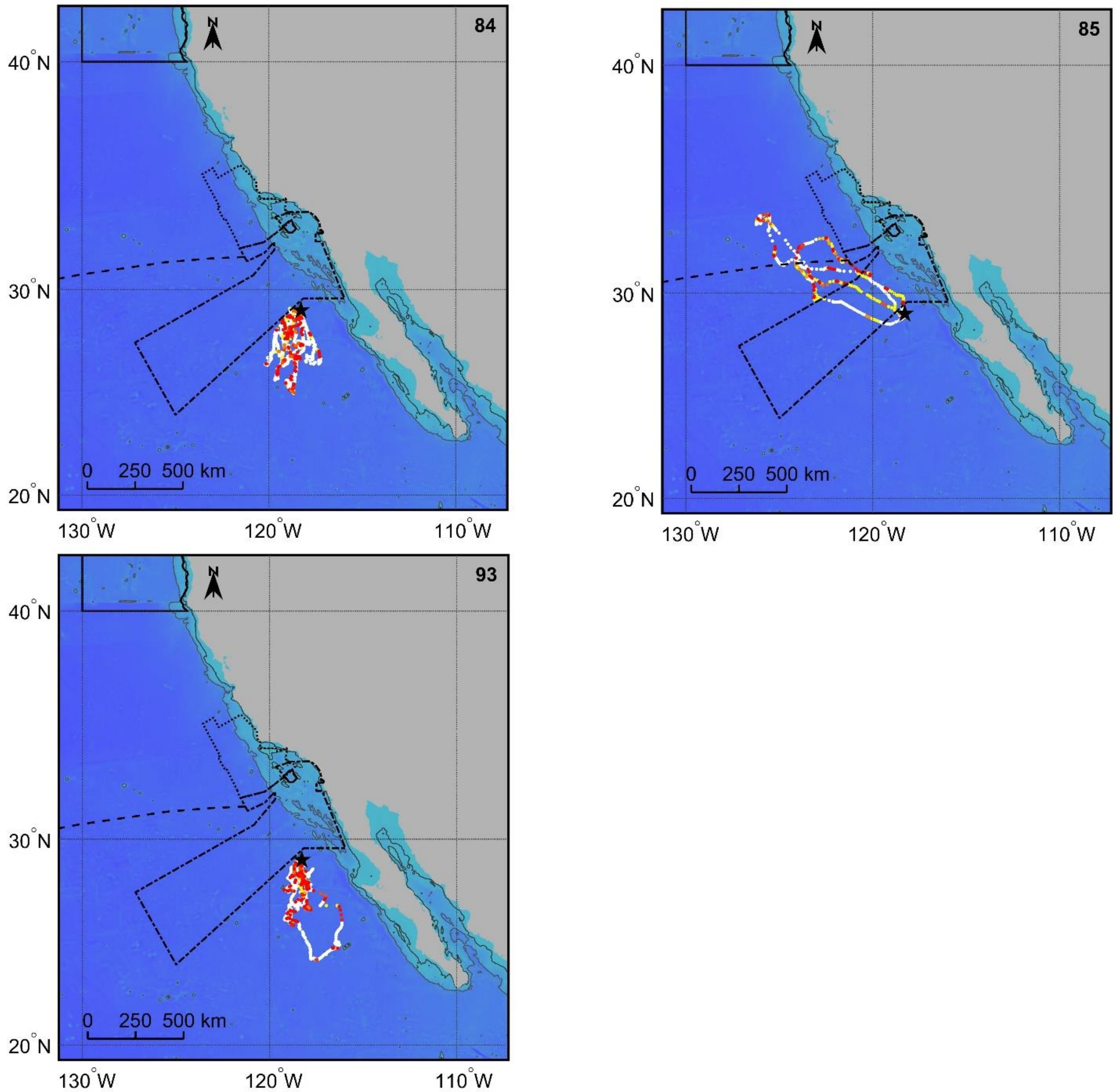
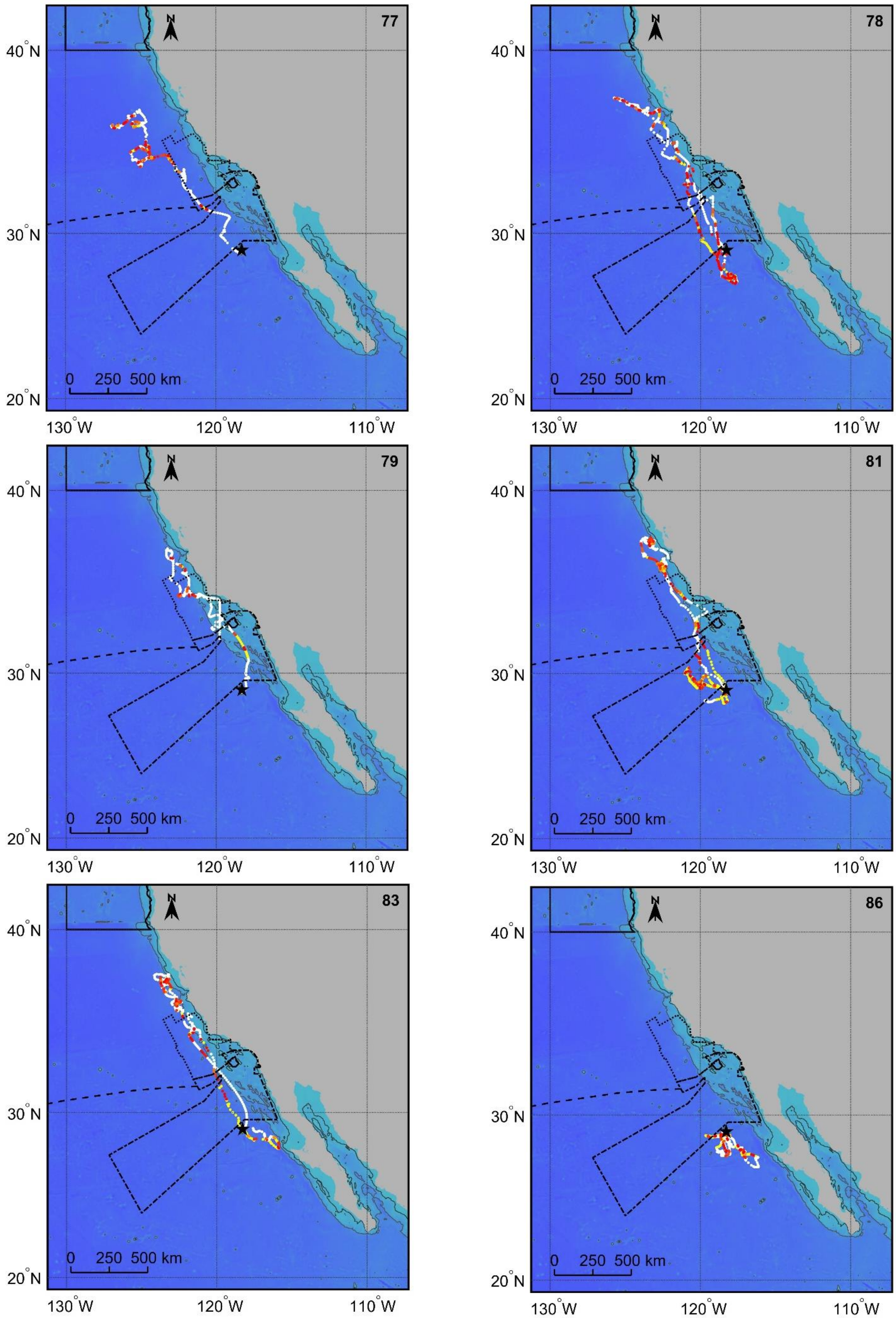
120°W
110°W
0 250 500 km



Appendix 7. Three-hour interpolated tracks linked to histogram data for each adult female Guadalupe fur seal. White locations are periods with no dive data, yellow locations have <4 dives >8 m over a 6-h period (no diving), and orange to red locations have an increasing proportion of dives (at least 4) >8 m over a 6 h period (≥1 diving bout). Last two digits of platform transmitting terminal (PTT) number indicate individual. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)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86
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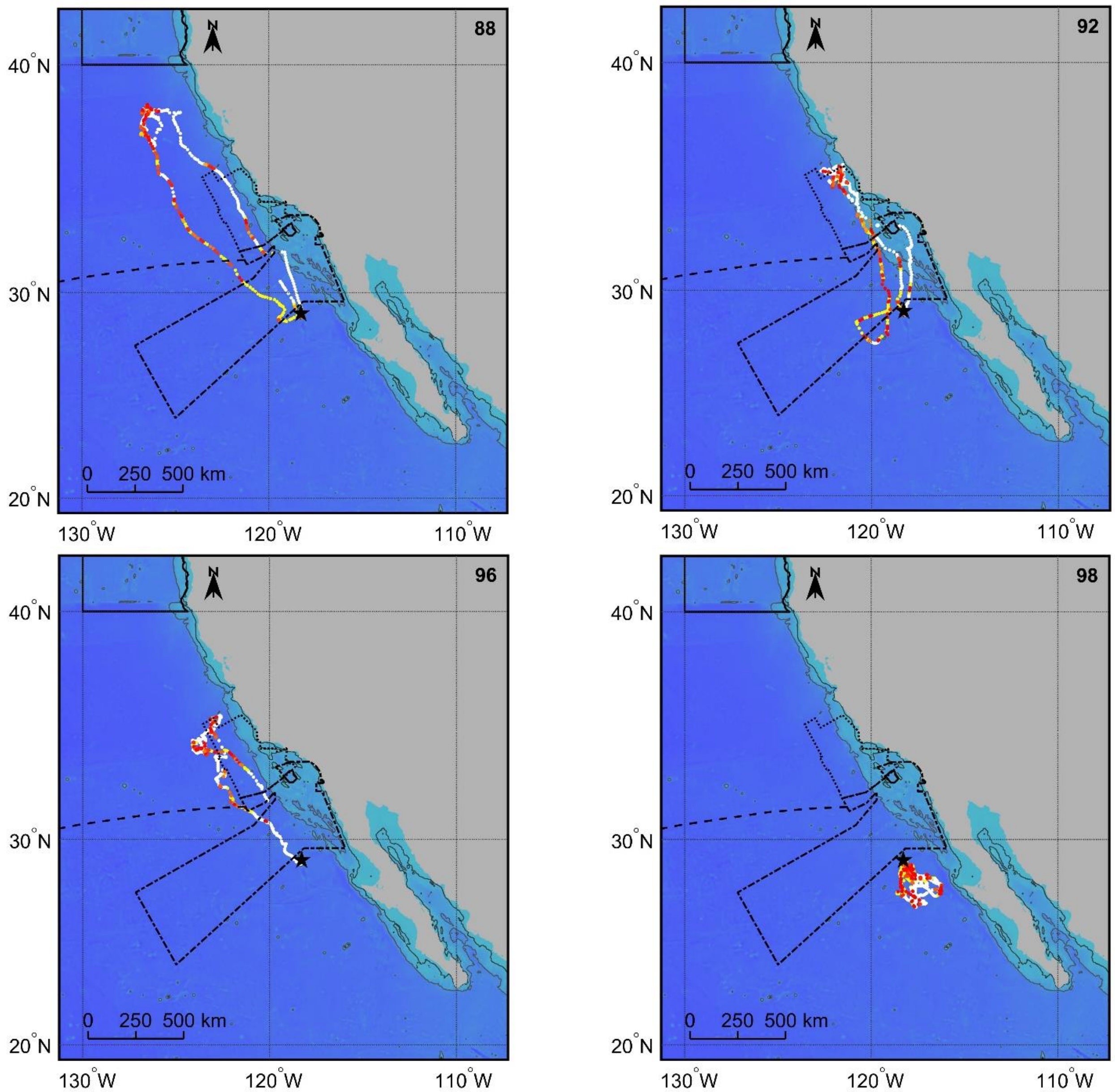
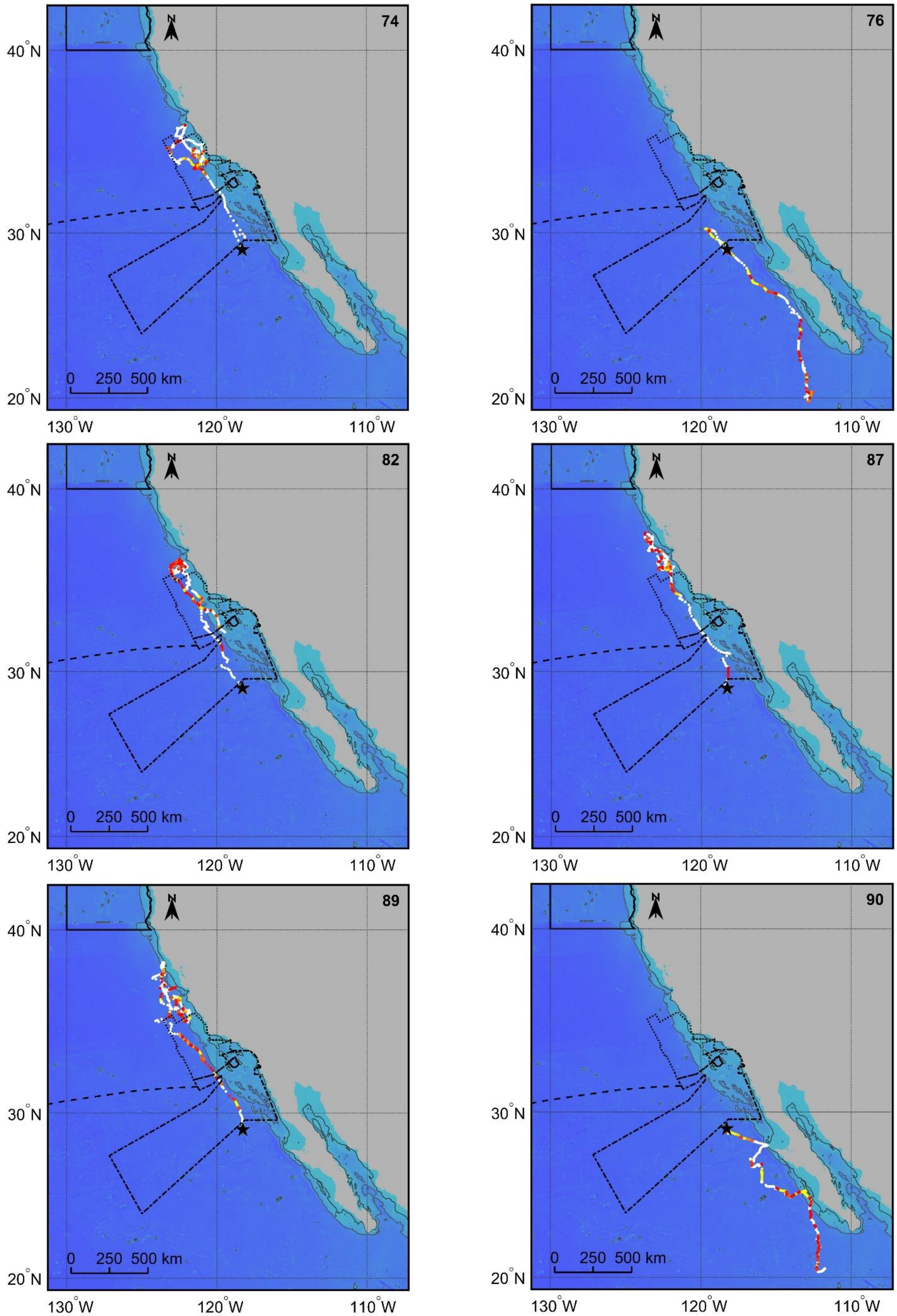
30°N
20°N
130°W
120°W
110°W
0 250 500 km
N



Appendix 8. Three-hour interpolated tracks linked to histogram data for each juvenile female Guadalupe fur seal. White locations are periods with no dive data, yellow locations have <4 dives >8 m over a 6-h period (no diving), and orange to red locations have an increasing proportion of dives (at least 4) >8 m over a 6 h period (≥1 diving bout). Last two digits of platform transmitting terminal (PTT) number indicate individual. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.
(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)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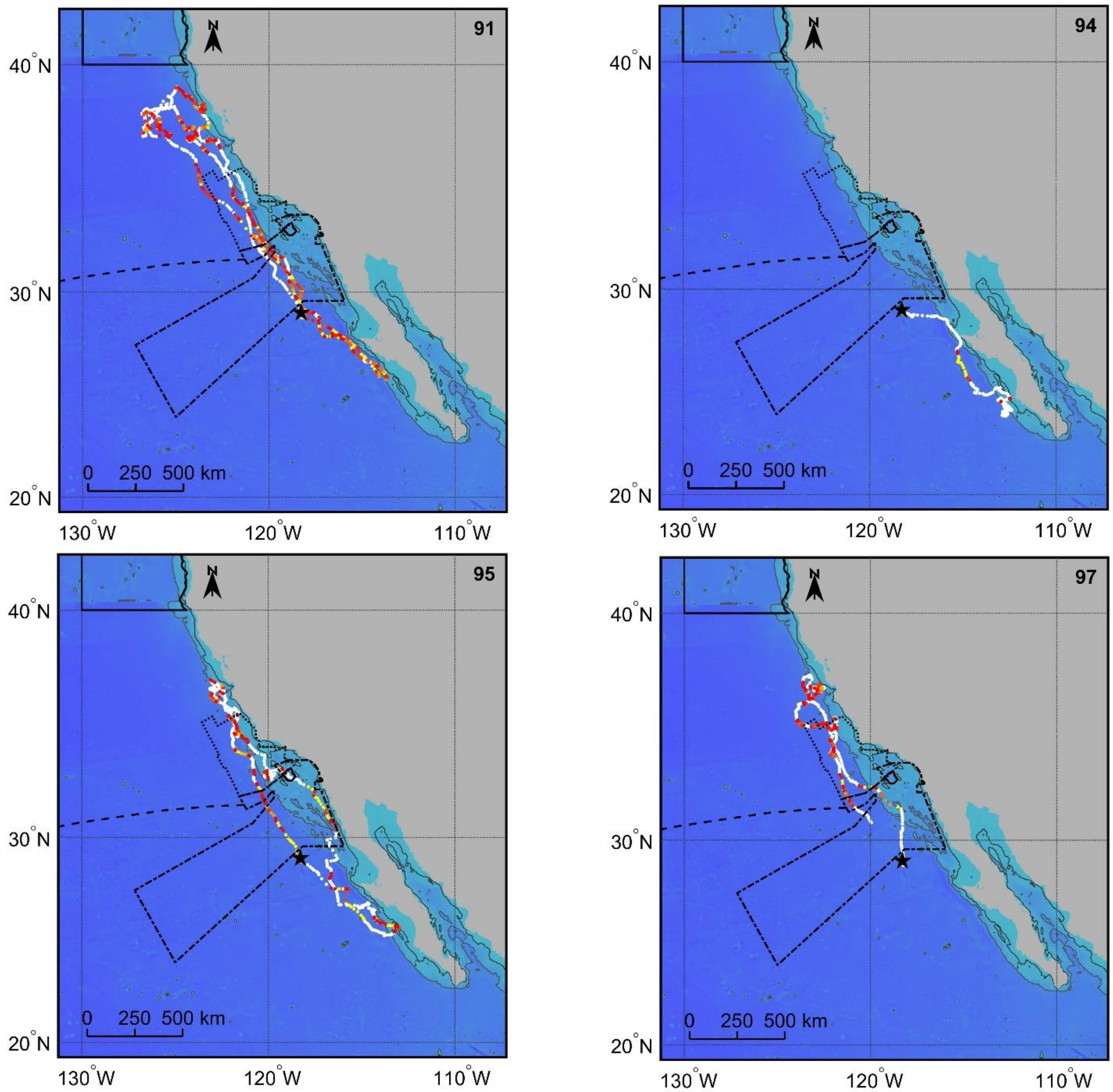
87
89
90
40°N
30°N
20°N
130°W
120°W
110°W
0 250 500 km
N



Appendix 9. Three-hour interpolated tracks linked to histogram data for each juvenile male Guadalupe fur seal. White locations are periods with no dive data, yellow locations have <4 dives >8 m over a 6-h period (no diving), and orange to red locations have an increasing proportion of dives (at least 4) >8 m over a 6 h period (≥1 diving bout). Last two digits of platform transmitting terminal (PTT) number indicate individual. Four U.S. Navy ranges are indicated by black outlines: NWTT Area (solid line), PMSR (dotted line), SOCAL Range (dotted-dashed line), and SOAR (solid line) with the Hawaii-Southern California Range Complex Transit Corridor indicated by the dashed line.

(Grid cell size is 0.25° × 0.25°; Bathymetric depths <2,000 m indicated by light blue shading; 2,000 m isobath indicated by the light grey line; 200 m isobath indicated by the dark grey line; black star marks location of Guadalupe Island at 29.03ºN, 118.28ºW)