Distribution and demographics of fin whales in the Southern California Bight

Final Report
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Erin A. Falcone, Erin L. Keene, Brenda K. Rone, and Gregory S. Schorr

Marine Ecology and Telemetry Research
2468 Camp McKenzie Tr NW
Seabeck, WA 98380
(206) 931-4638
gschorr@marecotel.org

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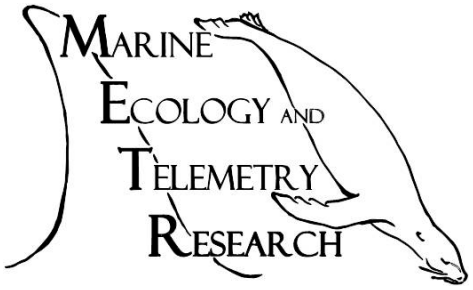

Summary

This report summarizes fin whale (*Balaenoptera physalus*, *Bp*) photographs collected both during small-vessel surveys for cetaceans in the Southern California Bight (SCB) by Marine Ecology and Telemetry Research (MarEcoTel) and numerous contributor photographs from along the US West Coast during 2016, and compares them back to the fin whale catalog for the US West Coast. Additionally, tag deployments conducted on fin whales during related research projects are also summarized. The purpose of this contract was to support the continuation of ongoing photo-identification and satellite deployments on endangered *Bp* with the goal of continuing to tease out data to support the determination of a regional sub-population of *Bp* in Southern California and to further define demographics and habitat use.

Introduction

The SCB is renowned for both the density and diversity of marine life it supports. More than 20 species of cetacean occur in the region. Some are present year-round, while others are seasonal migrants, passing through or present in larger numbers at certain times of year. While numerous studies have focused on species that are common along the populous coastal areas, there have been few dedicated studies of cetaceans in the outer waters of the SCB that lie to the south and west of the Channel Islands.

Photo-identification studies have proven invaluable in defining the population size and structure and movement patterns of a variety of cetacean species in Southern California, most notably Cuvier's beaked whales (Falcone and Schorr, 2014), blue and humpback whales (Calambokidis and Barlow, 2004), and coastal bottlenose dolphins (Defran and Weller, 1999). Long-term photo-identification studies are the most robust method for determining long-term population consequences of disturbance to a population (Booth et al., 2017).

The use of photo-ID to study *Bp* in the region was limited prior to 2010, due primarily to their offshore distribution and low and/or unpredictable sighting rates. Individual *Bp* in this region are also much more subtly marked than other populations where photo-ID has been used to describe populations (e.g. Agler et al., 1993)). However, with good quality photographs it has been demonstrated that there is sufficient variation in the shape of the dorsal fin and marks on the fin and body to reliably identify most individuals over periods of at least several years, and for the more distinctive individuals, much longer (Falcone and Schorr, 2014; Falcone et al., 2011). Work at SCORE has supported the first regular collection of photographs from offshore aggregations of *Bp*, which have been noted to occur more frequently in the outer waters of the SCB particularly in warmer months, when most previous cetacean surveys were conducted (Falcone and Schorr, 2014; Forney and Barlow, 1998).

While photographic methods can provide some insights into extra-regional movements, either through comparisons to catalogs from other areas or in some cases from the occurrence of geographically variable marks or parasites (Falcone and Schorr, 2014; Falcone et al., 2011), these results are inherently effort-biased and coarse. For this reason, satellite telemetry is an ideal complement to photo-identification. Tag deployments provide unbiased movement records for individuals over periods of weeks and months. These data can better characterize habitat use and residency patterns in areas of interest, such as around SCORE, much more robustly than sporadic visual surveys. Telemetry data also avoid the behavioral and geographic limits of passive acoustic data (where presence can only be determined within the instrumented range when animals are vocally active). Finally, the movements of tagged individuals can help to inform assumptions related to population range that underlie the statistical methods used to estimate population parameters from photo-identification data. Recent work by Scales et al. (2017) using

Bp telemetry data collected on SCORE and in the greater SCB area identified the California Current System (CCS) as a hotspot of year-round habitat suitability for *Bp* with extended residency at the individual level within the SCB. This pattern was further supported by photo-identification, visual, and acoustic research within this region (cite). Collectively, many findings to date suggest the presence of two subpopulations using the CCS: one that remains resident in the SCB year-round with seasonal changes in local distribution and one that ranges offshore (Scales et al., 2017).

Currently, *Bp* found along the US West coast are managed as a single stock (Carretta et al., 2017). However, a combination of recent research, including stratification of acoustic calls (e.g. Širović et al., 2013), genetic research (Archer et al., 2013), photo-ID (Falcone and Schorr, 2016), and satellite telemetry (Scales et al., 2017), all suggest some level of site-fidelity and the possibility of distinct population segments within the region. Understanding stock structure is key to understanding the risk any impacts may have to a population, and is critical to determining the Potential for Biological Removal (PBR). A study by Rockwood et al. (2017) corroborated the hypothesis put forward by Scales et al. (2017) that large whales, in particular *Bp* are at an increased risk of ship strike threat on the West Coast including the SCB. With additional exposure to Navy training, it is critical to understand the ecology, behavior, structure, and population dynamics of this endangered species for effective management, including realistic estimation of takes. It can also provide an important comparison to unexposed populations in other regions.

Bp research was initiated in 2010 after several successful pilot surveys in the preceding years identified the SCB as potentially important habitat for *Bp* (Falcone and Schorr, 2014). Through an ongoing partnership with the Naval Undersea Warfare Center's (NUWC) Marine Mammal Monitoring on Ranges (M3R) program (Moretti et al., 2006), we have been able to collect some of the first detailed information on the demographic status and distribution of *Bp* within the SCB using photo-identification and satellite telemetry.

Methods

Processing-- Photo Identification

All *Bp* photographs collected during surveys and received from contributors were reviewed, and the best identification photos of each individual within each group sighted were compiled, along with sighting information such as the location, group composition, and any collateral data collected (e.g. samples, tag deployments) into a Microsoft Access database. The complete set of fin whale identification records from 2016 was then sent to a species-specific Microsoft Access digital cataloging system, where they were reconciled internally and compared to the existing catalog of individuals from previous years and other regions. Individuals not previously identified were compared a second time, and those determined to be new to the collection were assigned new identification numbers for future tracking, and added to the photographic catalog. The ID numbers of all identifications that received one, (either previously or new in 2016) were then updated back into the sighting and identification database for further analysis (See Falcone and Schorr, 2014 for additional information).

Satellite tag data

The tags deployed were of the Low Impact Minimally Percutaneous External-electronics Transmitter (LIMPET), SPOT6 and SPLASH10-F design (Andrews et al., 2008; Schorr, G.S. et al., 2017). We used the Douglas Argos Filter to remove implausible Argos location estimates (Douglas et al., 2012) with the user-defined filter parameters outlined in Table 1. For the SPLASH10-F, all GPS locations with 5 or more satellites and a residual of <35 were retained (Schorr et al., 2017).

Table 1. User-defined settings in the Douglas Filter (Douglas *et al.* 2012).

Species	Min-rate	Max-redun	Rate-coef	KeepLC
Bp	20	3	25	2

Results and discussion

Photo-Identification

As of the end of 2016, the MarEcoTel fin whale catalog currently contains 929 individual fin whales photographed at locations from Northern Baja California to Northern British Columbia, though the majority of these whales (575) were sighted exclusively in Southern California.

Fin whale sightings were noticeably low during dedicated MarEcoTel surveys in 2016, which logged only 24 sightings. These low sighting rates may be related to the strong El Niño conditions which continued through early 2016. Opportunistic contributions of fin whale sighting data and photographs collected by other researchers, whale watch organizations, etc. from 2016 dramatically improved the sample, however, adding 294 sightings of fin whales to the study.

A total of 311 individual whales were photographed, resulting in 230 successful identifications (i.e. photos of sufficient quality to identify an individual) of 118 individual whales. The majority (76%) of these identifications came from within the SCB (Figure 1, Table 2). Forty individual whales (34%) photographed in 2016 had been documented in previous years, with the longest sighting history spanning nineteen years.

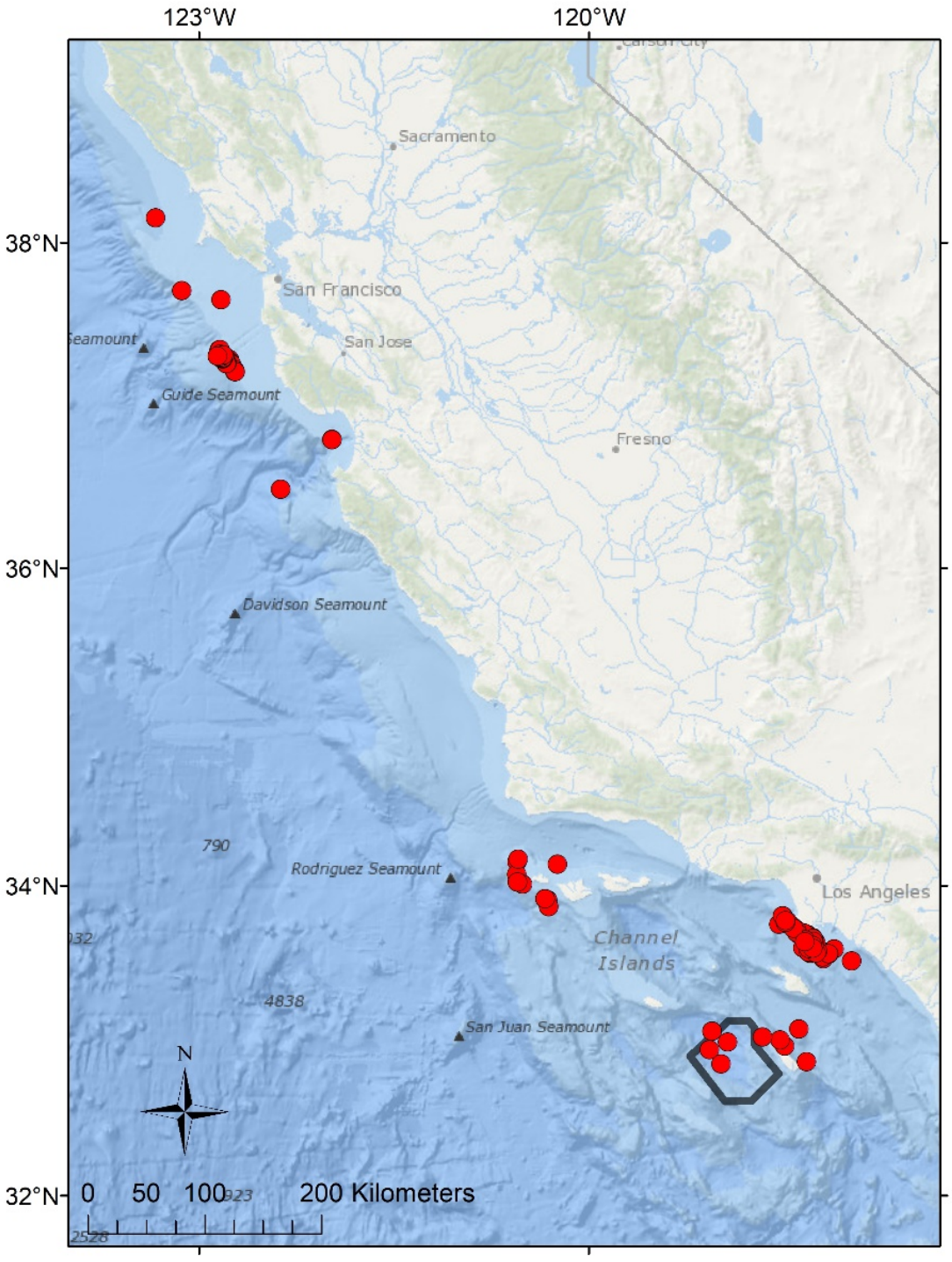

Figure 1. Map showing the location of all fin whale identifications from 2016.

Table 2. 2016 fin whale identifications by sub-area.

Sub-area	Unique IDs
Washington	2
Southern-Central California	2
Northern-Central California	40
Southern California	140

Resighting data continue to suggest that there is a year-round resident sub-population of fin whales using the Southern California Bight, which potentially overlaps with a larger, more broadly ranging west coast population. As of 2016, 127 (22%) of 590 individual fin whales identified in Southern California had multi-year sighting histories, with sightings in up to eight different years and spanning as many as 21 from the first to last sighting. This subset of high-residency individuals tends to frequent the nearshore waters, particularly in winter, where they are regularly sighted by whale watching operators that contribute photos to this study. These valuable opportunistic photos have allowed us to document that some whales are present for extended periods within the years when they are sighted, with some individuals present in Southern California year-round. In the case of 2016, despite the lower overall sightings of fin whales, seven individual whales were seen in more than one season with two individuals documented during every season except Fall (Figure 2). One of these individuals was documented multiple times in each season (a total of 27 days). The lack of sightings in fall is consistent with satellite telemetry work from non El Niño years which indicates animals move into the more outer reaches of the SCB, which are less sampled, during summer and fall.

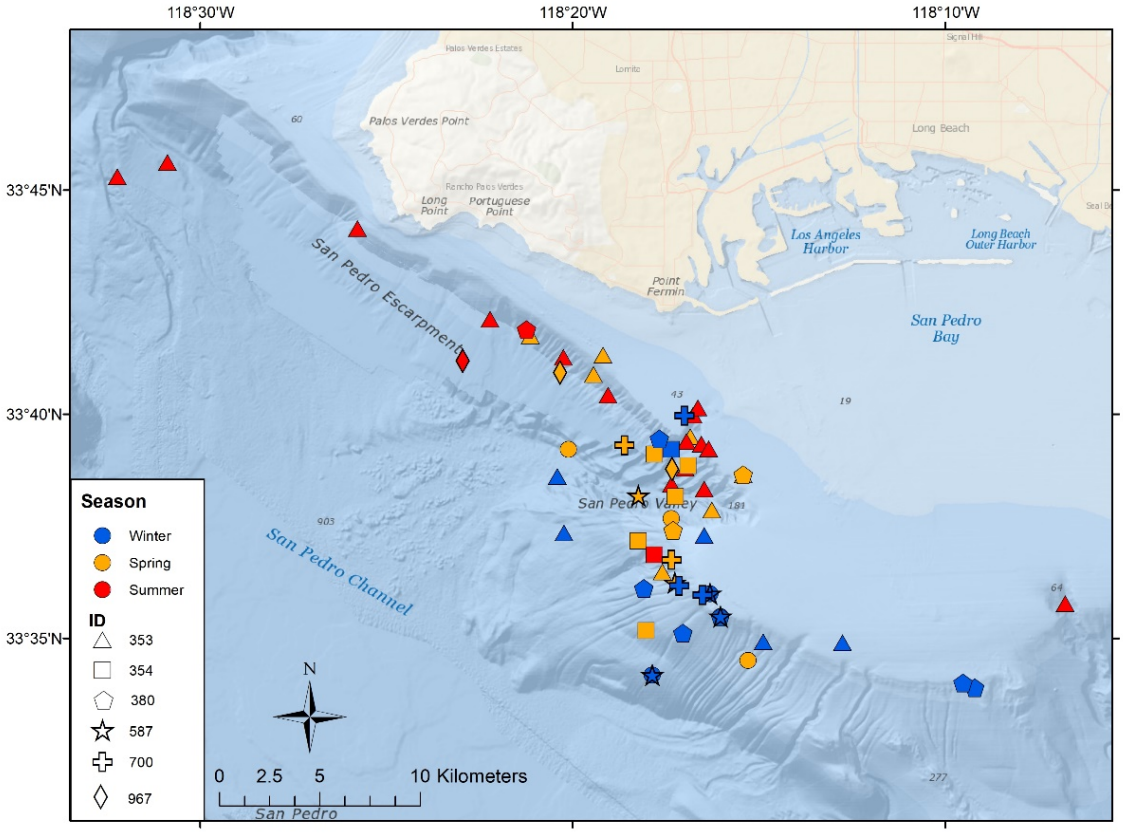

Figure 2. Map showing the locations of the seven whales (identified by symbol) who were identified in multiple seasons during 2016. Symbol colors represent the different seasons.

While photographic samples from outside the SCB are more limited, extra-regional movements are documented relatively infrequently, and certainly much less than would be expected if the US West Coast population were truly homogeneous. Movements within the SCB are common, and tend to corroborate the seasonal distribution patterns for fin whales in this region suggested via satellite telemetry (Scales et al., 2017). Both tagging and photo-ID suggest that whales tend to range broadly through the outer waters of the SCB in summer and adjacent months, then contract their range inshore during winter and early spring (Figure 3).

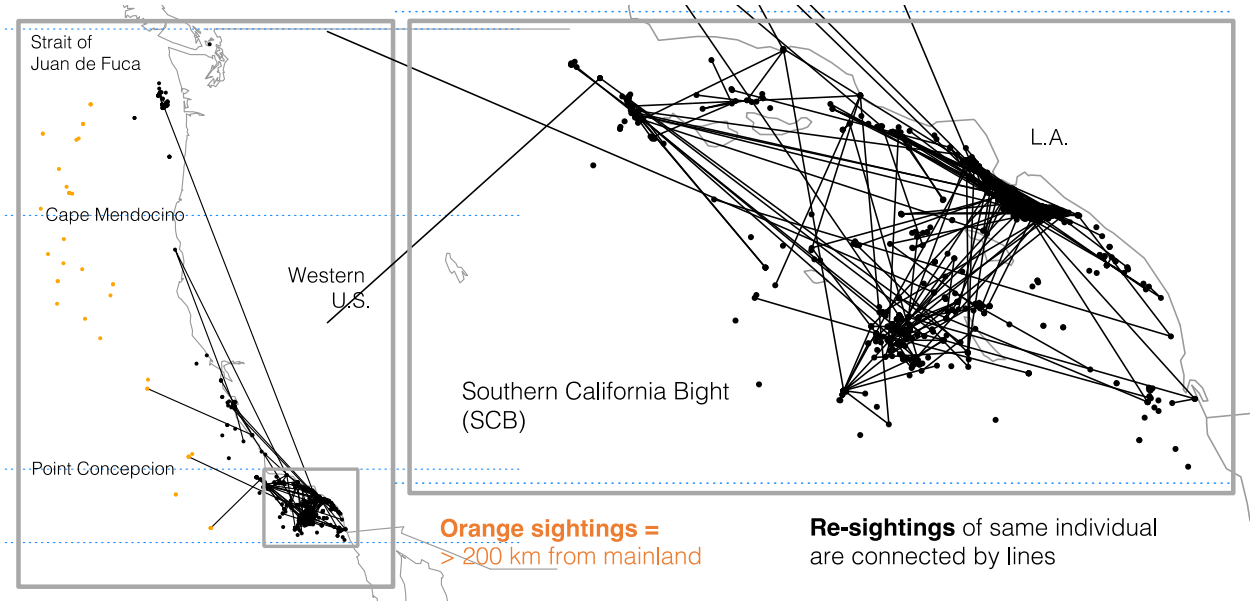

Figure 3. Map demonstrating extra-regional movements (left) and movements within the SCB. Lines connect re-sightings of individual whales through 2015.

In addition to the low sighting rates documented in 2016, many of the whales photographed appeared to be in poor body condition (Figure 4), possibly reflecting challenging foraging conditions during the El Niño.

Figure 4. A photograph of ID 380 in poor body condition. Note the lateral narrowing below the dorsal fin and the prominent ridge along the spine. This whale has a very extensive sighting history in the SCB and was sighted there on nine different days from February to December 2016.

Mark-recapture work

Differential residency of whales in the study is one source of heterogeneity that complicates the use of mark-recapture models to estimate demographic parameters for fin whales in this region. In addition to ecological factors driving distribution of fin whales in and out of heavily samples areas within the SCB (Scales et al., 2017), individual distinctiveness is highly variable and influences recapture rates. Roughly half of whales in the SCB lack distinguishing notches or disfigurements on the dorsal fin, which are the

only marks in this species that are known be reliable identifiers across many years (more than roughly 5). For these minimally-marked individuals, matches must be confirmed using pigmentation patterns and marks on the body that are often transient or vary drastically in appearance as a function of photo quality. Thus individual distinctiveness, mark type, and photo quality need to also be incorporated into a successful mark-recapture modeling effort, and an analysis is presently underway to characterize the temporal stability of different mark types in this population. Due to the complexity of these data, we are currently developing partnerships with several statisticians to assist in the analysis of a robust mark-recapture estimate.

Satellite Telemetry

Three satellite tags were deployed on fin whales during 2016 by MarEcoTel as part of ancillary projects (Table 3). Two tags were deployed within the SCB and one was deployed in Monterey Bay. BpTag075 transmitted for 23.3 days, though only two locations were received during that time, likely due to the animal's surfacing behavior (not raising the dorsal fin clear of the water regularly enough for successful uplinks). BpTag076, also only transmitted for a short time, with all movements confined to the area near where the animal was tagged in Monterey Bay, CA (Figure 5). BpTag074 transmitted for 31.4 days, with all movements occurring inshore within the SCB (Figure 6).

Table 3. Deployment details for the three satellite tags deployed on fin whales in 2016 as part of ancillary projects.

TagID	Tagging Date	Tx Dur. (Days)	Locality	Tag Type
BpTag074	3/1/2016	31.4	LA	SPLASH10-F
BpTag075	4/12/2016	23.3	LA	Spot6
BpTag076	10/3/2016	6.7	Monterey	Spot6

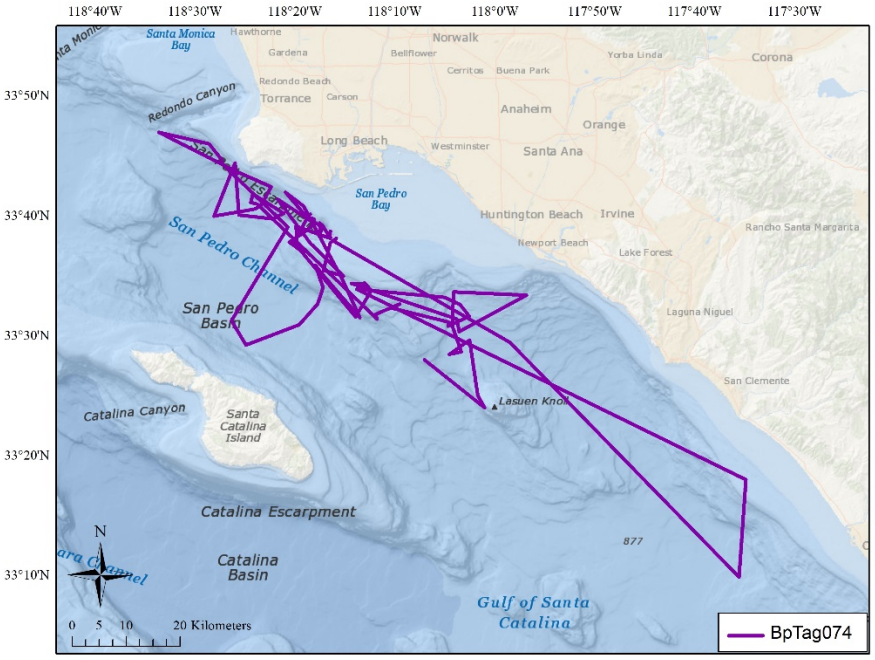

Figure 5. Filtered GPS tracks of BpTag074 deployed in the SCB in March 2016. Similar to previous satellite telemetry work and photo-ID, this individual stayed in near-shore waters during the month of March.

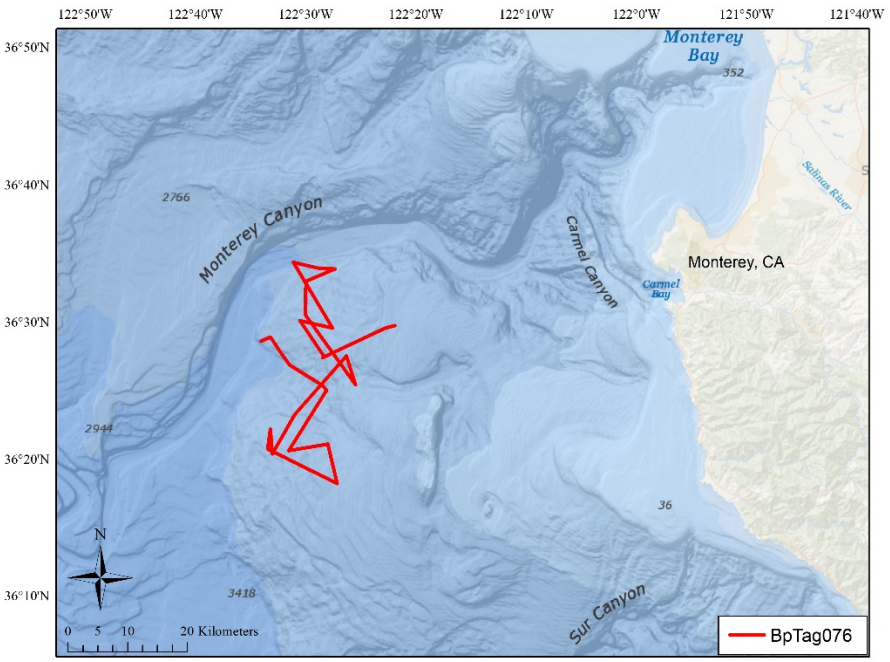

Figure 6. Argos trackline of BpTag076, tagged near Monterey Bay, CA, which transmitted for just 7 days.

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