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Distribution and Movements of Sperm Whales in the Eastern North Pacific and Eastern Tropical Pacific, from Photo-ID Data, 1984-2026

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ABTRACT

This study examines the distribution and movements of sperm whales (*Physeter macrocephalus*) in the eastern North Pacific and eastern tropical Pacific using photo-ID data from a recently compiled photo-ID catalog. The majority of photo-IDs were collected during research cruises conducted by NOAA Fisheries' Southwest Fisheries Science Center between 1991 and 2024. Additional identification photographs were obtained opportunistically by citizen scientists, naturalists, and researchers on other survey platforms between 1984 and 2026. The 107 photo-identified whales in the catalog were compared to an Alaska catalog (SEASWAP), to the catalog of whales from the Galápagos Islands and surrounding waters maintained by the Whitehead Laboratory, and to a collection of photographs from Hawaii and the Mariana Islands held by NOAA Fisheries' Pacific Islands Science Center. Results from comparisons within and among catalogs revealed the following matches. Within U.S. waters there were five individuals with intra-annual matches and there was one intra-annual resight in the Gulf of California. Three whales were resighted inter-annually (2 to 7-year intervals) in the Gulf of Alaska, all within a few hundred nmiles of their first location. Four whales from the Gulf of California had inter-annual resight intervals of four years and less than 60 nmiles from their original location. One whale photographed off Peru in October (spring) was photographed nine months later in July (winter) 704 nmiles to the south. Off the central California coast and in the southern California Bight, 10 whales (all identified as male) had 78 confirmed intra- and inter-annual resightings from 2 to 17 years. Two pairs, consisting of a large male and subadult male, were both observed together on multiple occasions over two years, revealing repeated use of California waters by males, and a remarkable degree of site fidelity and social fidelity. This study provides an opportunity for further collaboration and photo comparison, supports the NH Sub-committees interest in the potential for assessing eastern North Pacific sperm whales, and promotes understanding of the distribution, movement, habitat use, and ecology of sperm whales in the region. Photos from this study are publicly available in Flukebook and Happywhale.

INTRODUCTION

Status

Sperm whales are listed throughout their range as endangered under the Endangered Species Act (ESA) and depleted under the U.S. Marine Mammal Protection Act (MMPA). They are listed globally as Vulnerable by the International Union for the Conservation of Nature (IUCN) and are listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES).

Sperm whales were targeted during two periods of commercial whaling that peaked in the 1840s and 1960s and largely ended in the mid-1980s with the International Whaling Commission's moratorium on commercial whaling. The hunt was global in scale, with over 300,000 sperm whales estimated to have been killed in the North Pacific during the 20th century alone (Rocha *et al.*, 2014; Ivashchenko *et al.*, 2014).

Today, sperm whales are a species of conservation concern because of both historical and contemporary anthropogenic impacts, including ship strikes, fishery interactions, pollutants, plastics, noise, and climate change. Efforts by the National Marine Fisheries Service (NMFS) to assess conservation status and to mitigate current threats relies on the best available information on movements, population structure, and trends. These efforts are complicated by the species' wide distribution, nomadic nature, and hierarchical social structure.

Habitat, Life History and Social Structure

In the Pacific, the foundation of female social structure consists of long-term social units of approximately 10.4 (range = 3-24, SD =6.23) females and their dependent young; some, none, or all of which may be close relatives (Christal *et al.*, 1998; Mesnick *et al.*, 2003; Whitehead, 2003; Whitehead *et al*., 2011). Units may travel with one or more other units forming temporary "groups" (Whitehead *et al.*, 1991; Whitehead and Kahn, 1992) which, in turn, are structured into acoustic clans (Rendell and Whitehead, 2003; Hersh *et al.*, 2022).

Males leave their natal units between 4 and 21 years of age and form "bachelor groups." As they mature, they disperse from these groups and the largest males tend to be solitary (Best, 1979).

In the North Pacific, females and their dependent young typically occur at latitudes less than 40° and are occasionally found at latitudes up to 50°N (Rice, 1989). Males move to higher latitudes to feed, returning to lower latitudes to mate (Rice, 1989).

Stock Structure

For the purposes of managing sperm whales in U.S. waters, under the MMPA, NMFS delineates sperm whales in the eastern north Pacific into three stocks: 1) California, Oregon and Washington waters, 2) the waters around the Hawaiian Islands, and 3) the North Pacific (Alaska) stock (Carretta *et al.*, 2024). Sperm whales of the eastern tropical Pacific (ETP) are not a

U.S. stock but are part of historical NOAA survey areas and include important regions for sperm whales.

Sperm whales found in the California Current are genetically distinct from those from Hawaii and the ETP, indicative of demographic independence, based on analysis of single-nucleotide polymorphisms, microsatellites, and mitochondrial (mt) DNA (Mesnick *et al.*, 2011). The genetic analyses also provide some support for the demographic independence of the Hawaii stock, with mtDNA, but are inconclusive at this time. The North Pacific stock appears to have widespread genetic origin: some large males on Alaskan feeding grounds appear to return to the region of their birth to mate but share high latitude feeding grounds with males from other populations (Mesnick *et al.*, 2011). It is hypothesized that the whales of the ETP constitute a single stock (Carretta *et al.*, 2024 based on Dufault and Whitehead, 1995; Jaquet *et al.*, 2003).

Movements

Both males and females are known to travel great distances in the Pacific Ocean basin with males covering longer distances than females (Kasuya and Miyashita, 1988; Mizroch and Rice, 2013; Straley *et al.*, 2014; Wild *et al*., 2024).

In the eastern North Pacific, Discovery mark data from 1949 to 1976 showed females traveling distances over 1,000 km (621 nmi) from southern California into the eastern North Pacific and movements between Hawaii and the eastern and central North Pacific (Mizroch and Rice, 2013). Whitehead et al.'s (2008) 15-year photo-ID study of sperm whales in the ETP showed groups of females and immatures making regular movements between the Galápagos Islands and Panama, Ecuador, and Peru. Eight individuals moved from the Galápagos to the Gulf of California, and one individual from Panama to the Gulf of California, a distance of 3,800 km (2,632 nmi).

Movement patterns of mature males in the eastern North Pacific remain unclear with respect to when, how often, and where mature male sperm whales migrate for purposes of mating (Whitehead, 2003; Whitehead *et al.*, 2008). Satellite data from 29 adult males tagged in southeast Alaska showed five animals that moved south along the west coast of North America to areas offshore of southern California and central Mexico, with one male moving into the Gulf of California, before the tags stopped transmitting (Straley *et al.*, 2014; Wild *et al.*, 2024). Discovery mark data showed males traveling distances of up to 5,000 km (3,107 nmi) from central Mexico and southern California into the eastern North Pacific and wide tracks longitudinally across the basin (Mizroch and Rice, 2013).

The objectives of this study were to aid in the understanding of the distribution, movement, and ecology of sperm whales inhabiting the eastern North Pacific and ETP, especially males; and to support the management and conservation of sperm whales under the MMPA and the ESA.

METHODS

The SWFSC has conducted shipboard visual line-transect cetacean abundance surveys since 1986 (Kinzey *et al*., 2000; Jackson *et al.*, 2003). The cruises were conducted off the U.S. West Coast and Alaska, the ETP, and within the Gulf of California. During SWFSC visual line-transect surveys, date, time, latitude and longitude, species, group size and composition, and behavior were recorded for all cetacean sightings, including sperm whales.

Photographs of sperm whales were obtained opportunistically during the surveys as time permitted. Photographs were not obtained from every sighting, and not all individuals of a group were photographed. Thirty-five mm SLR film cameras using both black and white negative and color slide films were used through 2003; after 2003 digital SLR cameras were used almost exclusively. Black and white negative and color slide films were scanned into digital format for analysis. When possible, biopsy sampling was conducted concurrent with photography, and biopsy sample numbers were linked to identification photographs. (See Mesnick *et al.*, 2011 for detailed biopsy methods.) Samples were analyzed for sex determination inferred using single-nucleotide polymorphisms, microsatellites and mitochondrial DNA.

Scientists from the Grupo de Investigación y Conservación de Mamíferos Marinos, Mexico, provided photographs, date, and location data of sperm whales that they encountered while conducting research near Guadalupe Island off of the west coast of Baja California.

The identification photographs of sperm whales collected during the research cruises conducted by the SWFSC form the basis of a new catalog (Loomis *et al*., in press).

Additional photographs were obtained from staff (naturalists) and independent photographers (citizen scientists) that collected photographs while aboard commercial whale watching cruises or private vessels off the central and southern California coast. Location and observational data were also provided. These contributed photographs were added to the catalog and metadata were examined and collated by ASJ. Permission was granted for the use of these photos by all sources. Recapture data obtained from these sources were confirmed by ASJ from a photo or videographic capture and represent the most conservative estimates of recaptures of identified individuals.

To be included in the SWFSC catalog, photographs had to be sufficiently high resolution to show the unique shape of the trailing edge, from the ventral side, with enough clarity to differentiate it from other individuals. Photographs were not scored for distinctiveness. Photographs of unique whales were compared by eye within and between years to identify any recaptures. Photographs lacking date or location data were excluded from the catalog.

Comparisons within the SWFSC identification photographic collection were conducted by eye. Comparisons of the SWFSC catalog with other identification photographs from the region were conducted by eye and with machine learning algorithms within Flukebook and Happywhale

when the comparison catalog was available on these platforms[1]. Flukebook[2] and Happywhale[3] are two large language model web-based tools commonly used by researchers for photo-ID (Schneider *et al.*, 2018; Blount *et al.*, 2022).

Photographs from the central Pacific (Pacific Islands Fisheries Science Center (PIFSC), unpub.), and Southeast Alaska Sperm Whale Avoidance Project (SEASWAP) 2003–2017 (Wild, unpub.), were compared by eye. Comparisons with the SEASWAP catalog were also conducted using Flukebook and Happywhale. Flukebook was exclusively used to compare the SWFSC catalog with identified whales from the Galápagos Islands and ETP 2013–2024 (Whitehead *et al.*, unpub.).

This SWFSC catalog is uploaded into Flukebook in its entirety. The catalog can be searched by username noaa.swfsc and identified individuals can be searched by identification number (e.g. SWFSC-123).

RESULTS AND DISCUSSION

SWFSC researchers documented a total of 809 groups of sperm whales sighted on cruises from 1990-2024 (Figure 1).

Group Composition

Group composition was determined by visual observation for each sighting. “Mixed groups” of females (ca. 11 m / 36 ft) and dependent young were identified by their cohesiveness and (sometimes) the presence of calves or juveniles. Very large (ca. 15 m / 50 ft), solitary individuals were considered to be adult males. “Bachelor groups” were defined by their intermediate or large body size and individuals being loosely aggregated in singles or pairs over a large area. Designation of groups in the field was not always possible, and composition was noted as “undetermined” in those cases. Of the 84 photo-identifications obtained on NOAA surveys:

- Forty-seven of the photo-identifications were obtained from mixed groups.
- Eighteen photo-identifications were obtained from groups of large, solitary males.
- One photo-identified individual was a large male sampled from a mixed group.
- One photo-identified individual was obtained from a possible bachelor group.
- The remaining 17 photo-identifications were from groups of undetermined composition.

Sex of Photographed Whales

Of the SWFSC identified whales, twelve individuals were linked with a biopsy result to determine sex. There were four females and eight males. Of the females, three were adults and one was a sub-adult; one was sampled in the Gulf of California, and three in ETP. Of the eight

[1] Flukebook’s MiewID algorithm tested on sperm whale ventral fluke images yielded results of 97-99% accuracy (Otarashvili *et al.,* 2024). Happywhale achieved a 97-99% accuracy tested on humpback whale ventral fluke images (Patton *et al.,* 2023).
[2] Flukebook. Available at https://www.flukebook.org/
[3] Happywhale. Available at https://happywhale.com/home

males, two were in the ETP (including one that was sampled in the ETP among a female group), four were in the Gulf of Alaska and Aleutian Islands, and two were off the U.S. West Coast. The remaining whales were not sampled or did not yield a positive result in the genetic analysis (Mesnick *et al.*, 2011).

Photographs of 107 individual sperm whales meeting the quality and data criteria were identified. The photo-identified whales were located throughout the eastern North Pacific and eastern tropical Pacific (Figure 2), consisting of 12 from the Gulf of Alaska and Aleutian Islands, 40 from the U.S. West Coast, four from Hawaii and Pacific Islands, and 51 from the ETP. Two photographs from cruises crossing into the western Aleutian Islands in the western Pacific are included (Figure 2, insert).

Intra-Annual Matches

There were six intra-annual matches within the SWFSC catalog. Two matches are described below, and the remaining four were found in the citizen science data collected off central and southern California (Table 1).

- Whale **SWFSC-018** was first photographed on Sep 29, 1995, in the southern Gulf of California (26.8502, -111.3942), and was recaptured on October 19, 1995, (27.1813, -111.5952), a distance of 41.7 km (22.5 nmi) north of the first sighting (Figure 3).

- Whale **SWFSC-101** was first photographed Aug 18, 2014, off Oregon (45.9517, -129.6888), and recaptured on Sep 13, 2014, off the Oregon-California border (41.6657, -130.5113), 489 km (264 nmi) south of the first sighting (Figure 4).

Inter-Annual Matches

A comparison of the 107 SWFSC ID photographs conducted with the catalog of Alaska SEASWAP (Wild, unpub.) resulted in three matches. No matches were found between the SWFSC catalog and the NOAA PIFSC photographs collected from the Hawaiian EEZ and the Marianas EEZ (PIFSC, unpub.). Comparisons with the catalog of the ETP (Whitehead *et al*., unpub.) were conducted using Flukebook. Apart from five matches previously identified to the Whitehead catalog (see Matches to the Whitehead Lab Galápagos Islands catalog below), no new matches were discovered. However, results of comparisons conducted solely using computer vision algorithms need to be validated by conducting a visual comparison. Work on this is currently underway.

Matches to the Alaska SEASWAP Catalog

Three whales identified in the 2004 SWFSC survey of the Gulf of Alaska (GOA) were recaptured by SEASWAP again in the GOA in subsequent years.

- Whale **SWFSC-058** (GOA-020) was first seen Oct 16, 2004, at 57.82883, -137.2568 and recaptured Aug 18, 2011, at 56.60282, -135.8258, a distance of 161 km (87 nmi.).

- Whale **SWFSC-061** (GOA-036) was first seen June 13, 2004, at 58.91933, -141.0443 and recaptured May 26, 2006, at 56.58933, -136.0635, a distance of 359 km (194 nm).
- Whale **SWFSC-119** (GOA-037) was first seen June 13, 2004, at 58.96517, -141.0553 and recaptured Aug 02, 2009, at 59.25, -146.8517, a distance of 335 km (181 nmi).

Matches to the Whitehead Lab Galápagos Catalog

Photographs from the SWFSC catalog match to five identified individuals from the Whitehead Lab catalog of whales in the ETP and the Gulf of California (Whitehead *et al.*, unpub.).

- Four whales photographed by SWFSC in the Gulf of California on Sep 23, 1995, were recaptured in 1998, as first reported by Jaquet *et al.* (2003). Three of these whales were photographed again on June 27, 1998, within 96 km (51.8 nmi) of the first sighting, and the fourth whale on July 16, 1998, 26 km (14 nmi) from the first sighting. All locations were in the Gulf of California.

- Whale **SWFSC-033** was first photographed on Oct 27, 1999, by the SWFSC off Peru (-13.6962, -77.756), and was recaptured by the Whitehead Lab on July 27, 2000, off the coast of Chile (-22.0503, -71.0485), a distance of 1,305 km (704.6 nmi) (Figures 5).

Individuals with Multiple Recaptures off the Central California Coast and in the Southern California Bight

Photographs collected by SWFSC, citizen scientists, and naturalists from whale watching and private vessels operating off the central California coast and in the southern California Bight showed intra- and inter-annual recaptures of 10 whales as identified by photo-ID (Figure 6, Table 1). Six of these individuals had confirmed inter-annual recaptures—from 2 to 17 years—within the area; the remaining 4 were recaptured in the same year. All 10 of these whales have been identified as likely males by visual estimation of body size. The following are whales with more than one recapture:

1. SWFSC-076 (“Doublescoop”) was recaptured 13 times from 1984 to 1991.
2. SWFSC-085 (“Mango”) was recaptured 6 times from 1996 to 2013.
3. SWFSC-126 was recaptured 4 times in 2016.
4. SWFSC-132 was recaptured 2 times in 2020.
5. SWFSC-133 (“Papaya”) was recaptured 35 times from 2016 to 2025.
6. SWFSC-137 ("Coconut") was recaptured 3 times in 2023.
7. SWFSC-138 was recaptured 3 times in 2025.
8. SWFSC-139 (“Guava”) was recaptured 9 times from 2023 to 2025.
9. SWFSC-140 (“Kiwi”) was recaptured 8 times from 2024 to 2025.
10. SWFSC-141 (“Fig”) was recaptured 5 times from 2023 to 2026.

In addition, many of these previously photographically identified and recognizable males were observed on multiple additional occasions in this area by trained naturalists when no photo-ID was captured.

Two pairs of photo-identified whales were observed together on multiple occasions: SWFSC-124 ("Big Guy") and SWFSC-076 ("Doublescoop") were seen together 6 times during 1989 and 1990, and SWFSC-139 ("Guava") and SWFSC-140 ("Kiwi") were seen together 6 times during 2024 and 2025 (ASJ and KJL, pers. obs.). In each case, the association was between a large male ("Big Guy" and "Guava"), and a smaller male ("Doublescoop" and "Kiwi").

The large number of sightings and recaptures of male sperm whales in California waters, and resightings of the same pairs of males, over multiple years in this relatively small area was a surprising finding on multiple levels. The results reflect the regular effort and value of citizen scientists on whale watching vessels and reveal a remarkable level of site fidelity and social fidelity among males.

Relatively little is known about movements, residency, and associations patterns of adult male sperm whales. Early work on this topic has been conducted by Letteval *et al.* (2002), Whitehead (2003), Mizroch and Rice (2013), Straley *et al.* (2014), Kobayashi *et al.* (2020), Dickson *et al.* (2021), and Wild *et al.* (2024). Adult reproductive males have been shown to be solitary (Best, 1979; Lettevall *et al.* 2002; Whitehead, 2003), however, data supported by photo-ID suggest that they may form pairs from two to at least five years, and forage in close proximity to one another (Kobayashi *et al*., 2020; Wild *et al.*, 2024). This is the first documented indication that the southern California Bight is used as a feeding ground for mature and subadult males.

Summary and Next Steps

This study provides a catalog of 107 photo-identified sperm whales in the waters of the eastern North Pacific and eastern tropical Pacific. Photos are publicly available in Happy Whale and Flukebook. This study lends support to the IWC's NH Sub-committee consideration of the feasibility of undertaking an assessment of sperm whales in the eastern North Pacific/California Current (SC/69B/NH/02, SC/70/NH/XX) and promotes understanding of the distribution, movement, habitat use. and ecology of sperm whales in the region.

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REFERENCES

Arnbom, T. M. 1987. Individual photographic identification: A key to the social organization of sperm whales. M.S. thesis, 118 p. Memorial Univ. of Newfoundland, St. John's, NL. https://research.library.mun.ca/4096/.

Best, P. B. 1979. Social organization in sperm whales, *Physeter macrocephalus*. *In* Behavior of marine animals: Current perspectives in research (Howard E. Winn and Bori L. Olla, Eds.), p. 227–89. Springer, Boston, MA. https://doi.org/10.1007/978-1-4684-2985-5_7.

Blount, D., S. Gero, J. Van Oast, J. Parham, C. Kingen, B. Scheiner, T. Stere, *et al.* 2022. Flukebook: an open-source AI platform for cetacean photo identification. Mammalian Biology 102: 1005–1023. https://doi.org/10.1007/s42991-021-00221-3

Carretta, J. V., E. M. Oleson, K. A. Forney, A. L. Bradford, K. Yano, D. W. Weller, A. R. Lang, R. Aimée, J. Baker, A. Orr, J. Anthony, B. Hanson, J. E. Moore, M. Wallen, and R. L. Brownell Jr. 2024. U.S. Pacific marine mammal stock assessments: 2023. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-SWFSC-704. https://doi.org/10.25923/aqdn-f357

Christal J., H. Whitehead, and E. Lettevall. 1998. Sperm whale social units: variation and change. Canadian Journal of Zoology 76(8): 1431-1440. DOI:10.1139/cjz-76-8-1431

Dickson, T., W. Rayment, M. Guerra, and S. Dawson. 2021. Multi-decadal observations of the size structure of sperm whales at Kaikōura, New Zealand. New Zealand Journal of Marine and Freshwater Research 57(1): 63–74. https://doi.org/10.6084/m9.figshare.15135932.v1

Dufault, S., and H. Whitehead. 1995. An assessment of changes with time in the marking patterns used for photoidentification of individual sperm whales, *Physeter macrocephalus*. Marine Mammal Science 11(3): 335–43. https://doi.org/10.1111/j.1748-7692.1995.tb00289.x.

Hersh, T. A., S. Gero, L. Rendell, M. Cantor, L. Weilgart, M. Amano, S. M. Dawson, E. Slooten, C.M. Johnson, I. Kerr, R. Payne, A. Rogan, R. Antunes, O. Andrews, E. L. Ferguson, C.A. Hom-Weaver, T. F. Norris, Y. M. Barkley, K. P. Merkens, E. M. Oleson, T. Doniol-Valcroze, J. F. Pilkington, J. Gordon, M. Fernandes, M. Guerra, L. Hickmott, and H. Whitehead. 2022. Evidence from sperm whale clans of symbolic marking in non-human cultures. Proceedings of the National Academy of Sciences U.S.A. 119(37): e2201692119. https://doi.org/10.1073/pnas.2201692119.

Ivashchenko, Y., R. Brownell, and P. J. Clapham. 2014. Distribution of Soviet catches of sperm whales (*Physeter macrocephalus*) in the North Pacific. Endangered Species Research 25: 249-263. https://doi.org/10.3354/esr00641.

Jackson, A. R., T. Gerrodette, S. J. Chivers, M. S. Lynn, P. A. Olson, and S. Rankin. 2003. Marine Mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA Ships McArthur II and David Starr Jordan, July 29 - December 10, 2003. https://repository.library.noaa.gov/view/noaa/3701.

Jaquet, N., D. Gendron, and A. Coakes. 2003. Sperm whales in the Gulf of California: Residency, movements, behavior, and the possible influence of variation in food supply. Marine Mammal Science 19(July): 545–62. https://doi.org/10.1111/j.1748-7692.2003.tb01320.x.

Kasuya, T., and T. M. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. *In* The Scientific Reports of the Whales Research Institute 39: 31-76. https://www.icrwhale.org/pdf/SC03931-75.pdf

Kinzey, D., P. A. Olson, T. Gerrodette. 2000. Marine mammal data collection procedures on research ship line-transect surveys by the Southwest Fisheries Science Center. NOAA/NMFS/SWFSC, Admin. Rpt. LJ-00-08.

Kobayashi, H., H. Whitehead, M. Amano. 2020. Long-term associations among male sperm whales (*Physeter macrocephalus*). PLoS One 15(12): e0244204. https://doi.org/10.1371/journal.pone.0244204.

Lettevall, E., C. Richter, N. Jaquet, E. Slooten, S. Dawson, H. Whitehead, J. Christal, and P. M. Howard. 2002. Social structure and residency in aggregations of male sperm whales. Canadian Journal of Zoology, 80(7): 1189–1196. https://doi.org/10.1139/z02-102

Loomis, K. J., Olson, P. A., Schulman-Janiger, A., Barlow, J., Moore, J. E., and Mesnick, S. L. In press. Sperm whales of the eastern North Pacific and eastern tropical Pacific: Photo-identification catalog, 1989-2025. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-XX.

Mesnick, S. L., K. Evans, B. L. Taylor, J. Hyde, S. Escorza-Treviño, and A. E. Dizon. 2003. Sperm whale social structure: Why it takes a village to raise a child. *In* Animal Social Complexity: Intelligence, Culture, and Individualized Societies (F. B. M. de Waal & P. L. Tyack, eds.), p. 170–174. Harvard University Press, Cambridge, MA. https://doi.org/10.4159/harvard.9780674419131.

Mesnick, S. L., B. L. Taylor, F. I. Archer, K. K. Martien, S. Escorza Treviño, B. L. Hancock-Hanser, S. C. Moreno Medina, V. L. Pease, K. M. Robertson, J. M. Straley, R. W. Baird, J. Calambokidis, G. S. Schorr, P. Wade, V. Burkanov, C. R. Lunsford, L. Rendell, P. A. Morin . 2011. Sperm whale population structure in the Eastern and Central North Pacific inferred by the use of single-nucleotide polymorphisms, microsatellites and mitochondrial DNA. Molecular Ecology Resources 11(s1): 278–98. https://doi.org/10.1111/j.1755-0998.2010.02973.x.

Mizroch, S. A., and D. W. Rice. 2013. Ocean nomads: Distribution and movements of sperm whales in the north pacific shown by whaling data and discovery marks. Marine Mammal Science 29(2): 136–135. https://doi.org/10.1111/j.1748-7692.2012.00601.x

Mullin, K. D., L. Steiner, C. Dunn, D. Claridge, L. González García, J. Gordon, and T. Lewis. 2022. Long-range longitudinal movements of sperm whales (*Physeter macrocephalus*) in the North Atlantic Ocean revealed by photo-identification. Aquatic Mammals 48(1): 3-8. https://doi.org/10.1578/am.48.1.2022.3.

Otarashvili V., J. Holmberg, T. Subramanian, and J. Leveson. 2024. Flukebook – Continuing advancements in multispecies AI. International Whaling Commission report SC/69B/PH/07

Patton, P. T., T. Cheeseman, K. Abe, T. Yamaguchi, W. Reade K. Southerland, A. Howard, E. M. Oleson, J. B. Allen, E. Ashe, A. Athayde, R. W. Baird, C. Basran, E. Cabrera, J. Calambokidis, J. Cardoso, E. L. Carroll, A. Cesario, B. J. Cheney, and L. Bejder. 2023. A deep learning approach to photo–identification demonstrates high performance on two dozen cetacean species. Methods in Ecology and Evolution 14: 2611–2625. https://doi.org/10.1111/2041-210X.14167

Rendell, L. E., H. Whitehead. 2003. Vocal clans in sperm whales (*Physeter macrocephalus*). Proc. Biol. Sci. 270(1512): 225-31. https://doi.org/10.1098/rspb.2002.2239

Rice, D. W. 1989. Sperm whale *Physeter macrocephalus Linneaus*, 1758. *In* Handbook of marine mammals (S. H. Ridgway & R. J. Harrison eds.), p. 177-233. Academic Press, United Kingdom.

Rocha, R. C., P. J. Clapham, Y. V. Ivashchenko. 2014. Emptying the oceans: A summary of industrial whaling catches in the 20th century. Fish. Bull. 76(4): 37-48. https://doi.org/10.7755/MFR.76.4.3.

Schneider S, G. W. Taylor, S. Linquist, S. C. Kremer. 2019. Past, present and future approaches using computer vision for animal re-identification from camera trap data. Methods Ecol. Evol. 2019 10(4): 461–470. https://doi.org/10.1111/2041-210X.13133

Straley, J. M., G. S. Schorr, A. M. Thode, J. Calambokidis, C. R. Lunsford, E. M. Chenoweth, V. M. O'Connell, and R. D. Andrews. 2014. Depredating sperm whales in the Gulf of Alaska: Local habitat use and long distance movements across putative population boundaries. Endangered Species Research 24(2): 125–35. https://doi.org/10.3354/esr00595

Whitehead, H., S. Waters and T. Lyrholm. 1991. Social organization in female sperm whales and their offspring: constant companions and casual acquaintances. Behavioral Ecology and Sociobiology 29: 385-389. https://doi.org/10.1007/BF00165964

Whitehead, H. and B. Kahn. 1992. Temporal and geographical variation in the social structure of female sperm whales. Canadian Journal of Zoology 70(11): 2145-2149. https://doi.org/10.1139/z92-289

Whitehead, H. 2003. Sperm whales: Social evolution in the ocean. 431 p. Univ. of Chicago Press, Chicago, IL

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau. 2008. Movements of sperm whales in the tropical Pacific. Marine Ecology Progress Series 361: 291-300. https://doi.org/10.3354/meps07412

Whitehead, H., R. Antunes, S. Gero, S. N. P. Wong, D. Engelhaupt, and L. Rendell. 2011. Multilevel societies of female sperm whales (*Physeter macrocephalus*) in the Atlantic and Pacific: Why are they so different? International Journal of Primatology 33: 1142-1164. https://doi.org/10.1007/s10764-012-9598-z

Whitehead, H., M. Shin. 2022. Current global population size, post-whaling trend and historical trajectory of sperm whales. Scientific Reports 12(1): 19468. https://doi.org/10.1038/s41598-022-24107-7.

Wild, L. A., F. J. Mueter, J. M. Straley, and R. D. Andrews. 2024. Movement and diving behavior of satellite-tagged male sperm whales in the Gulf of Alaska. Frontiers in Marine Science 11 (September): 1394687. https://doi.org/10.3389/fmars.2024.1394687.

Table 1. Individuals off the central and southern California coast with multiple recaptures. Recapture dates represent all sightings with photographic matches to the identification photo. These identification photos were collected by citizen scientists operating off the California Coast (1984—2026) and SWFSC.

SWFSC ID	Date of identification photo	Dates of recaptures	Total sightings confirmed by photo-ID
SWFSC-076 “Doublescoop”	12/22/91	02/28/84, 01/04/85, 10/26/86, 02/01/88, 02/03/88, 02/06/88, 02/10/88, 01/02/89, 03/11/89, 02/10/90, 02/12/90, 04/04/90	13
SWFSC-085 “Mango”	09/01/10	01/13/96, 8/16/10*, 08/08/11, 12/02/13, 12/13/13	6
SWFSC-126	10/20/16	10/01/16, 10/11/16, 10/13/16	4
SWFSC-132	01/26/20	02/01/20	2
SWFSC-133 "Papaya"	10/27/21	12/05/16, 08/12/19, 01/24/20, 01/26/20, 01/27/20, 02/01/20, 10/07/21, 10/26/21, 10/28/21, 11/11/21, 08/16/22, 08/18/22, 08/19/22, 08/22/22, 08/27/22, 08/28/22, 09/06/22, 06/04/23, 06/08/23, 06/10/23, 06/11/23, 06/12/23, 07/10/23, 07/28/23, 07/29/23, 08/06/23, 08/11/23, 09/13/23, 04/09/24, 06/02/24, 06/03/24, 07/14/24, 07/31/24, 06/02/25	35
SWFSC-137 "Coconut"	06/03/23	06/04/23, 06/09/23	3
SWFSC-138	01/01/25	01/03/25, 01/26/25	3
SWFSC-139 “Guava”	09/16/25	06/03/23, 06/04/23, 06/09/23, 07/30/24, 06/08/25, 09/07/25, 09/14/25, 09/18/25	9
SWFSC-140 "Kiwi"	09/13/25	07/30/24, 11/22/24, 06/08/25, 09/07/25, 09/14/25, 09/16/25, 09/18/25	8
SWFSC-141 “Fig”	06/23/25	9/2/2023, 09/14/25, 11/27/25, 01/31/26	5

*Collected by SWFSC

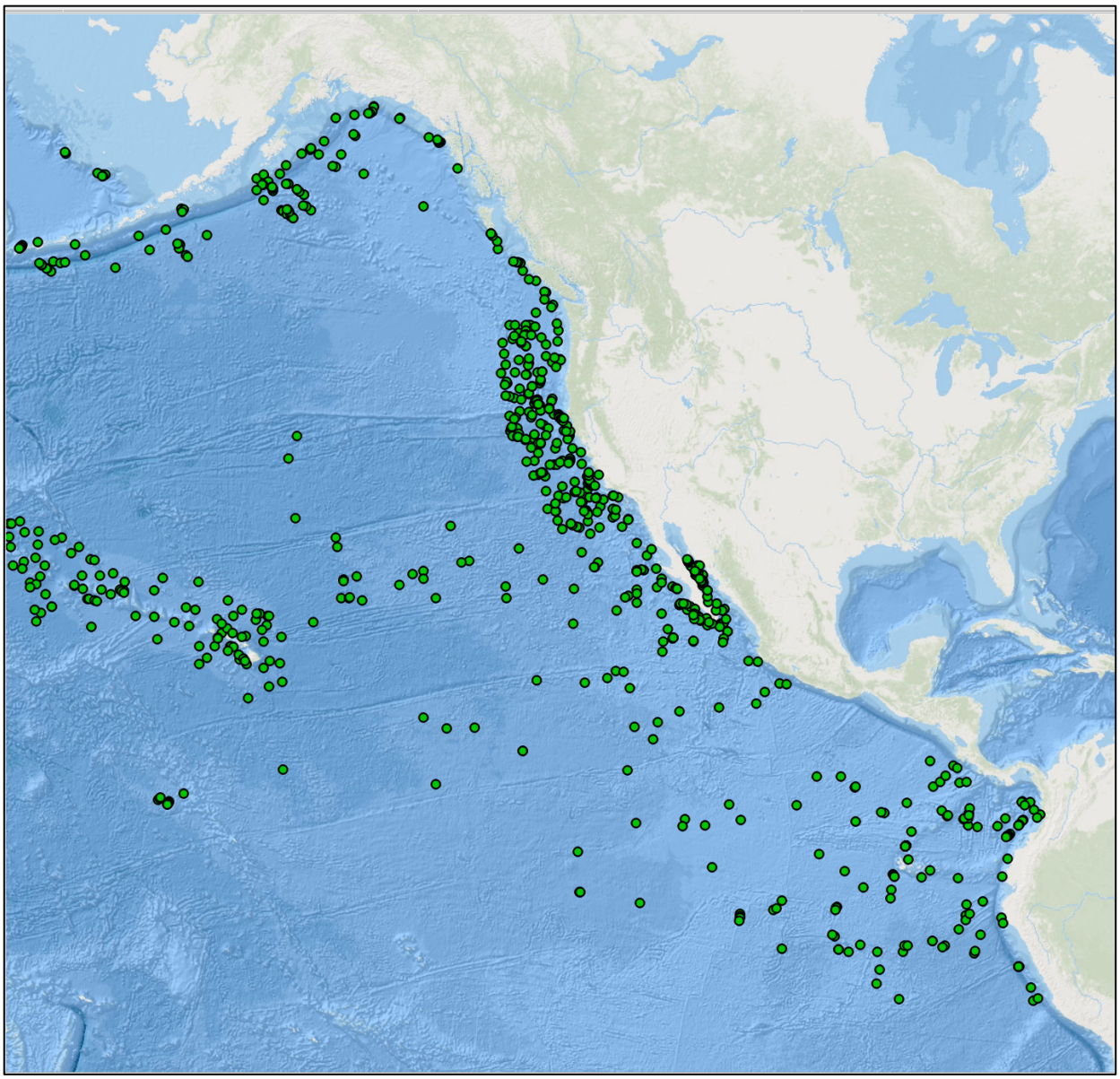

Figure 1. Locations of the 809 sperm whale sightings (green circles) recorded during SWFSC research cruises from 1990–2024.

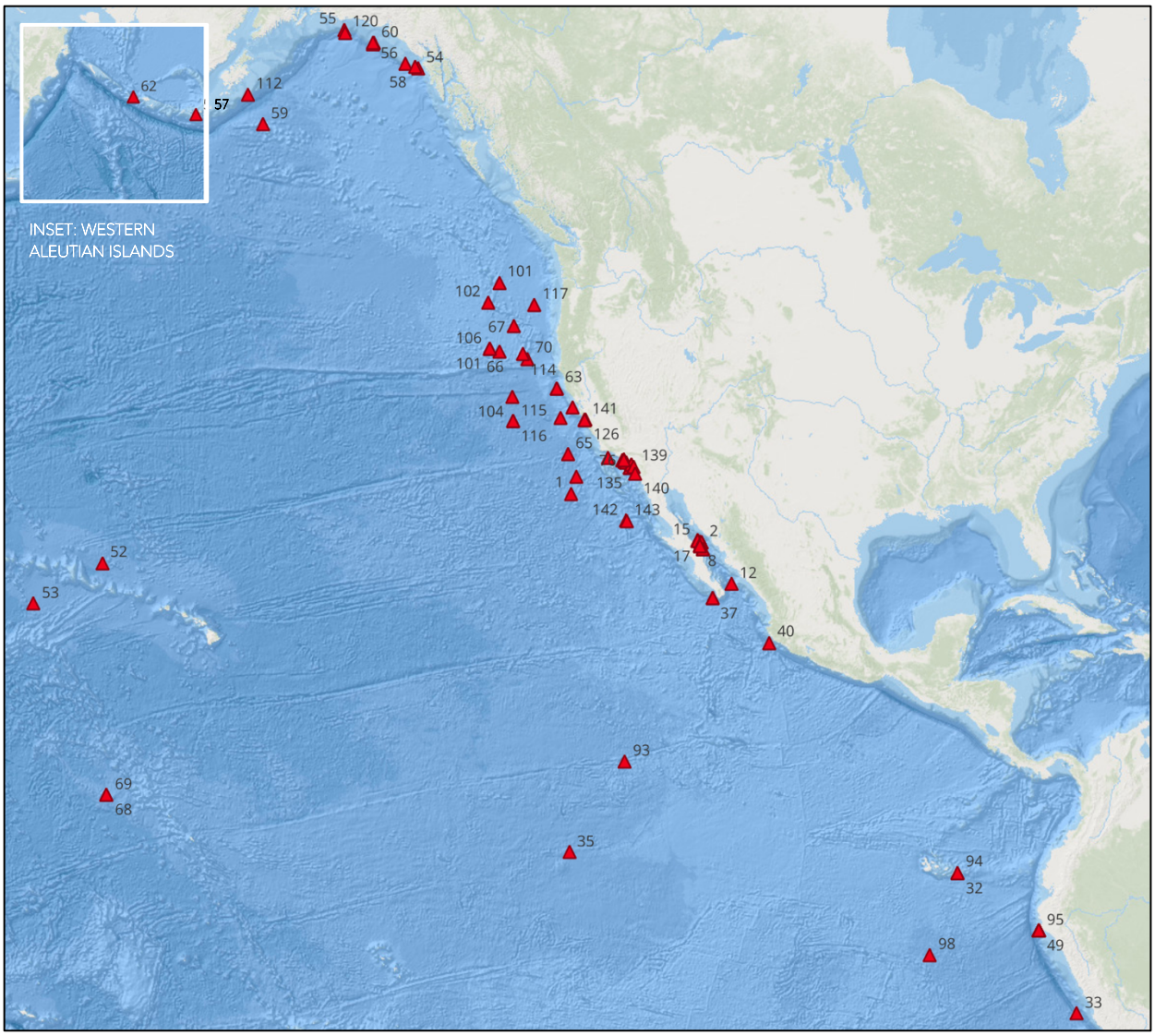

Figure 2. Locations of best photo-ID of individuals in the SWFSC sperm whale catalog (red triangles). Insert represents two photographs captured in the Western Pacific off the Western Aleutian Islands.

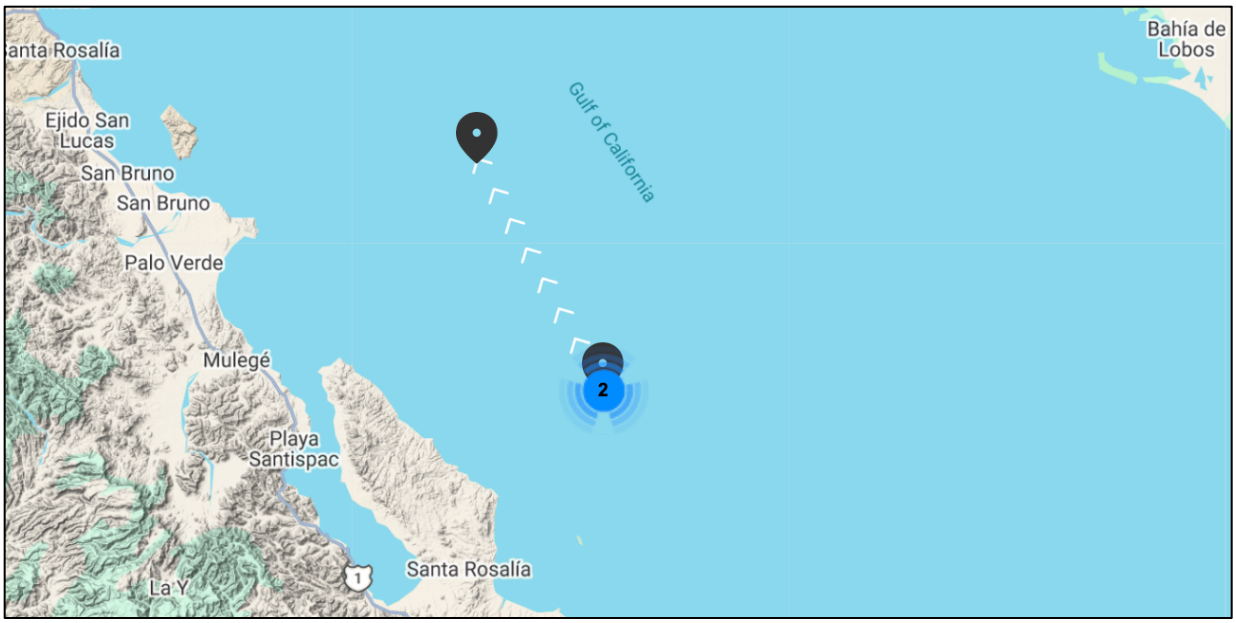

Figure 3. Track of SWFSC-018 in the Gulf of California. SWFSC-018 was first photographed on Sep 29, 1995, in the southern Gulf of California, and was recaptured on October 19, 1995, a distance of 41.7 km (22.5 nmi). Map: Flukebook.

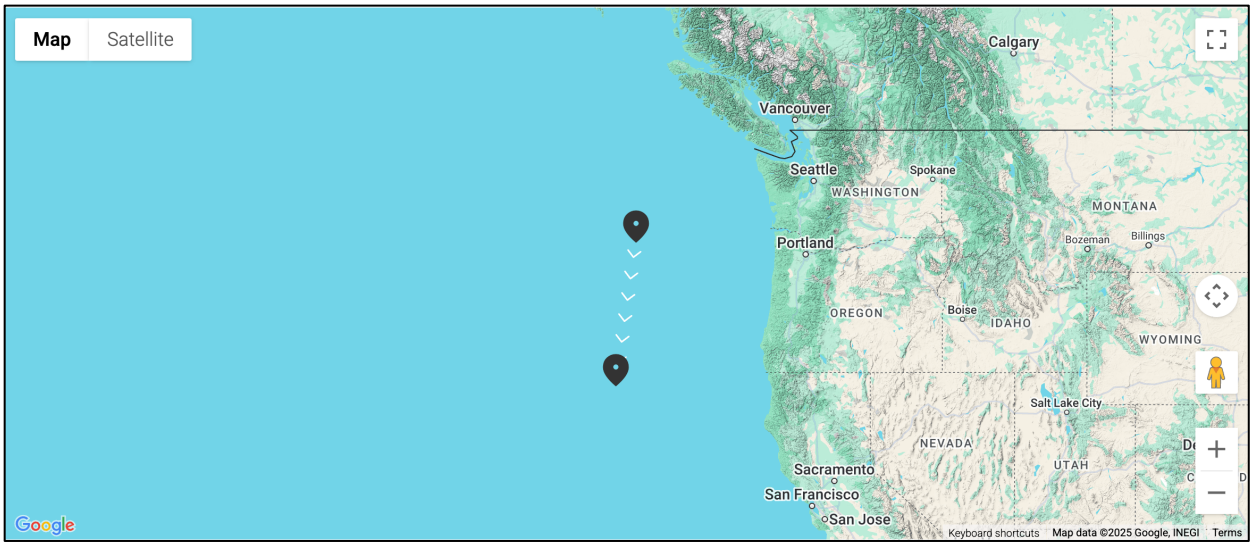

Figure 4. Track of SWFSC-101 of U.S. West Coast. SWFSC-101 was first photographed Aug 18, 2014, off Oregon, and recaptured on Sep 13, 2014, 489 km (264 nmi) from the first sighting. Map: Flukebook.

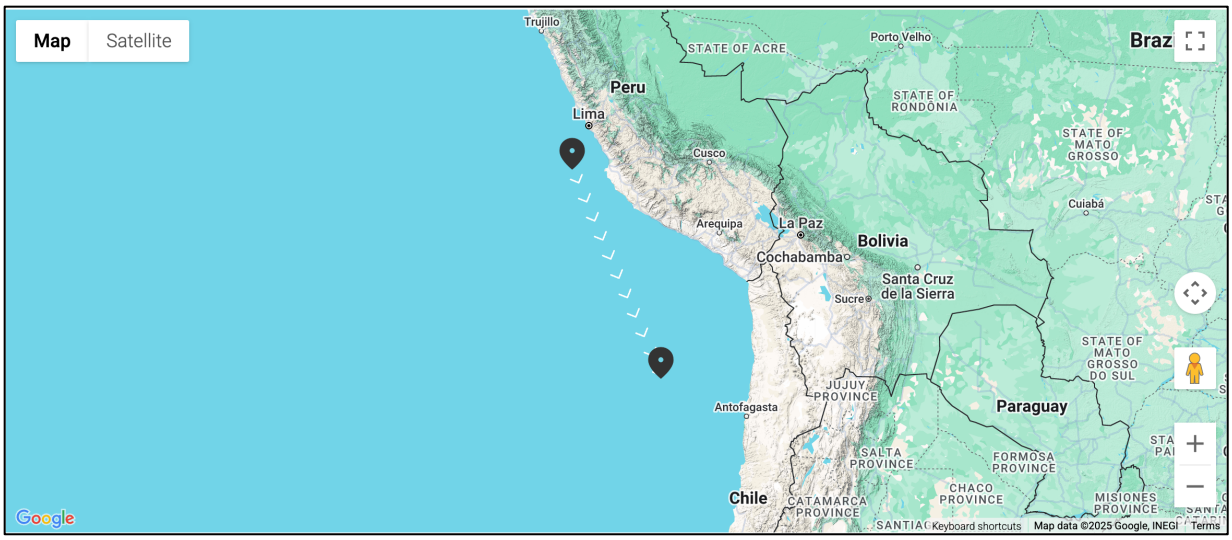

Figure 5. Track of SWFSC-033. First photographed by SWFSC off the coast of Peru Oct 27, 1999, SWFSC-033 was recaptured off the coast of Chile nine months later, 1,305 km (705 nmi) south of the first sighting. This individual was photographed 10 times in the same area between July 22 and July 28, 2000, by the Whitehead Lab. Map: Flukebook.

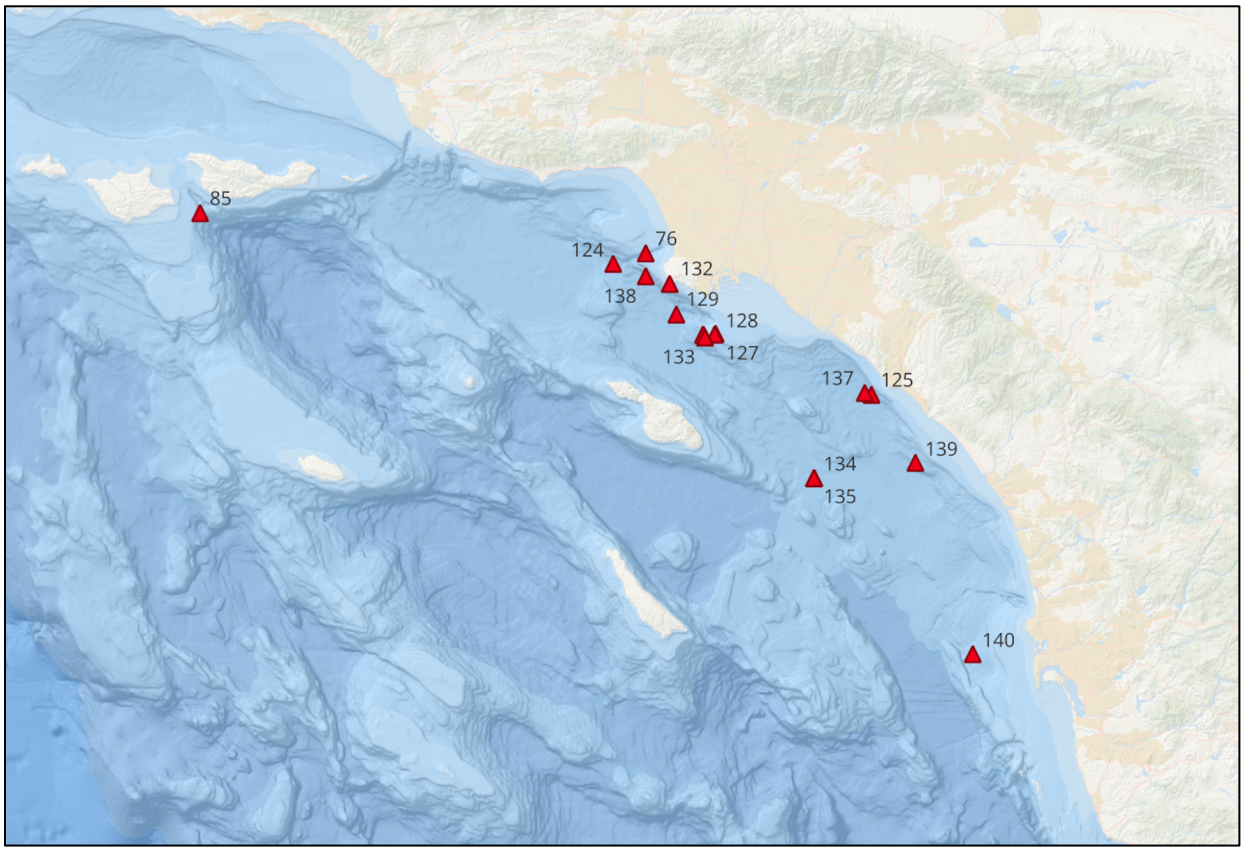

Figure 6. Locations of the best identification photo of each individual captured in the southern California Bight. Ten individuals captured in the southern California Bight and the central coast were recaptured multiple times over multiple years by citizen scientists on recreational cruises operating from the California coast.