

LARGE WHALE TAGGING IN SUPPORT OF MARINE MAMMAL MONITORING ACROSS MULTIPLE NAVY TRAINING AREAS IN THE PACIFIC OCEAN

A Supplemental Synopsis of Whale Tracking Data in the Vicinity of the Gulf of Alaska Temporary Maritime Activities Area

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Abstract

Since 2012, Oregon State University (OSU) has been conducting tagging and tracking studies on large whales in support of the U.S. Navy's efforts to meet regulatory requirements for marine mammal monitoring under the Endangered Species Act and the Marine Mammal Protection Act. The primary goal of these studies has been to determine whale movement patterns, occurrence, and residence times within several Navy training and testing areas in the Pacific Ocean, as reported extensively in a series of previous Technical Reports. Although no tagging was done within the Gulf of Alaska Temporary Maritime Activities Area (TMAA), and no whales tagged by OSU in other Navy training and testing areas during these studies were tracked to the TMAA, data from other OSU efforts indicated that previously tagged whales have occurred within the TMAA. Here we provide a brief synopsis of OSU's tagging studies in the North Pacific Ocean, focusing on whale occurrence within and in the vicinity of the TMAA. Four species are addressed: humpback whales (*Megaptera novaengliae*), gray whales (*Eschrichtius robustus*), blue whales (*Balaenoptera musculus*), and fin whales (*B. physalus*).

Of 255 humpback whales tracked by OSU from 1995 to 2019, only one was tracked within the TMAA. This whale was tagged at the Revillagigedo Archipelago, Mexico, in February 2003. Additionally, the track of one whale tagged in Southeast Alaska in July 1997 crossed the southeast corner of the TMAA but reported no locations within it. Five other humpback whales tagged in Hawaii were tracked on trajectories toward the Gulf of Alaska, but their tags stopped transmitting before they reached their migratory destinations. One untagged whale photographed in Hawaii in 2015 had been encountered previously in the TMAA in July 2013. Eight additional whales photographed in Hawaii in 2015 and 2019 have been encountered in Prince William Sound, Alaska, both before and after our sampling, suggesting the possibility of travel through the TMAA during their migrations.

Of 69 gray whales tracked by OSU from 1996 to 2013, three were tracked within the TMAA and the tracks of two more whales crossed its boundary. These five whales were tagged at Ojo de Liebre Lagoon, Mexico, in 2005. An additional five whales tagged in Ojo de Liebre Lagoon were tracked migrating from the western coast of North America to the eastern Aleutian Islands and into the Bering and Chukchi Seas, but large data gaps in their tracks precluded an examination of their northbound route across the Gulf of Alaska, including the TMAA.

Finally, of 241 blue whales, 46 fin whales, and one blue/fin hybrid whale tracked by OSU from 1993 to 2018, only one fin whale tagged in California in 2006 had locations within the TMAA in January and February 2007. No blue whales were tracked within the TMAA and only one whale, tagged in California in 2007, came within 260 km of the southeastern corner of the TMAA.

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1. Introduction

Since 2012, Oregon State University (OSU) has been conducting tagging and tracking studies on large whales in support of the U.S. Navy's efforts to meet regulatory requirements for marine mammal monitoring under the Endangered Species Act and the Marine Mammal Protection Act. The primary goal of these studies has been to determine whale movement patterns, occurrence, and residence times within several Navy training and testing areas in the Pacific Ocean using satellite tracking technologies, as reported extensively in a series of previous Technical Reports (Mate 2013, Mate et al. 2018a, b, 2019, Palacios et al. 2020a, b, c). Although no tagging has been done within the Gulf of Alaska Temporary Maritime Activities Area (TMAA), and no whales tagged by OSU in other Navy training and testing areas during these studies have been tracked to the TMAA, data from other OSU efforts indicates that previously tagged whales have occurred within the TMAA.

This supplemental report provides a brief synopsis of OSU's tagging studies in the North Pacific Ocean, focusing on whale occurrence within and in the vicinity of the TMAA, based on Argos satellite-derived locations. In this context, we provide a review of all of OSU's large whale tracking datasets, including both Navy-funded studies as well as OSU's historical tagging efforts. In some cases, animals had locations reporting *inside* the TMAA, while in others their tracks *crossed* the TMAA boundary, but no actual locations were reported inside of it. Four species are addressed in this report: humpback whales (*Megaptera novaengliae*), gray whales (*Eschrichtius robustus*), blue whales (*Balaenoptera musculus*), and fin whales (*B. physalus*). For complete details of the methods and results of these studies, the reader is referred to the Technical Reports and other literature that has resulted from these efforts.

2. Humpback whales

OSU conducted tagging operations on humpback whales at various locations in the North Pacific Ocean from 1995 to 2019. Of 256 whales tracked (**Table 1**), **only one was tracked within the TMAA**, a calf tagged at Socorro Island, Revillagigedo Archipelago, Mexico, as documented by Lagerquist et al. (2008). The calf was tagged on 10 February 2003 and tracked for 149 days, during which it migrated, presumably accompanied by its mother, to the northern Gulf of Alaska and was located in the TMAA for the final month of its tracking duration (see **section 2.3.** for further detail). **One other whale, tagged in Southeast Alaska in July 1997, was tracked crossing the southeast corner of the TMAA** during its last two locations (see **section 2.1.** for further detail).

During the conduct of tagging work, OSU routinely collects photographs for individual identification (photo-ID) of whales that we approach, regardless of whether we tag them or not. We have undertaken significant efforts to upload these photo-IDs to the online resource "Happywhale" (<https://happywhale.com/org/169>), which provides automated matching to a large database of photographs collected by citizen scientists and researchers. Here we also report the results of this matching effort, in the context of whales that we have photographed and that have also been photographed in the TMAA and adjacent areas, although for the latter we cannot know if these whales swam through the TMAA.

2.1. U.S. West Coast, Southeast Alaska, and eastern Aleutians tagging 1997-2019

A total of 137 humpback whales were tagged in California, Oregon, Washington, or Alaska (including operations in Southeast Alaska and in the eastern Aleutian Islands) between 1997 and 2019, of which 133 tags provided tracks. However, **no track locations occurred within the TMAA** (Mate et al. 2018b, Palacios et al. 2019, 2020a, b), **and only the track of one whale crossed the southeast corner of the range**. This latter whale, tagged in Southeast Alaska on 11 July 1997, was tracked leaving Southeast Alaska on 30 November 1997 and heading southwest into the Gulf of Alaska. The whale's track crossed the southeast corner of the TMAA during its last two locations on 1 December 1997 (11:08:02 GMT) and 2 December 1997 (16:15:49 GMT) (**Figures 1 and 2**).

2.2 Hawaii tagging 1995-2019

A total of 126 humpback whales were tagged in Hawaii from 1995 to 2019, providing tracks for 105 whales. **None of these whales were tracked within any Navy training areas along the U.S. West Coast or in the Gulf of Alaska** (Mate et al. 2019, Palacios et al. 2020c).

Of the 12 whales that were tracked from Hawaii to a feeding area, seven were tracked to northern British Columbia/southeastern Alaska, one was tracked to southern British Columbia, and four were tracked to the eastern Aleutian Islands (**Figure 1**; Mate et al. 2019, Palacios et al. 2019, 2020c). One of the latter four whales continued on to the Kamchatka Peninsula, Russia, while another traveled to the western end of the Aleutian Island chain off Kamchatka, then to the Bowers Basin in the southwestern Bering Sea, and ultimately north into the Gulf of Anadyr, Russia, just south of the Bering Strait.

Partial migrations from Hawaii to a feeding area were tracked for 25 whales, of which 22 presumed destinations could be identified based on the whale's trajectory (Mate et al. 2019, Palacios et al. 2019, 2020c). Of these, eight whales were on a trajectory toward the eastern Aleutian Islands, six were headed toward northern British Columbia/southeastern Alaska, five were headed toward the Gulf of Alaska, and three were headed toward Southern British Columbia/Northern Washington (**Figure 1**; Palacios et al. 2020c).

2.3. Mexico tagging 1998, 2003

Eighteen humpback whales were tagged in Mexico in 1998 and 2003, providing tracks for all 18 whales. Seven whales were tagged off San Jose del Cabo, Baja California Peninsula, in 1998, but the tracking periods for these tags were very short (**Figure 1**; OSU, unpublished data). An additional 11 whales were tagged off Socorro Island, Revillagigedo Archipelago, in 2003 (Lagerquist et al. 2008). A calf, tagged off Socorro Island on 10 February 2003 and assumed to be traveling with its mother throughout its entire tracking period, was tracked into the Gulf of Alaska, after a 49-day migration (**Figure 1**; Lagerquist et al. 2008). The calf's track passed within approximately 50 km of the eastern edge of the TMAA on 12 May 2003 before heading to the Alaskan coast north of Chichagof Island (**Figure 2**). The whale was then tracked traveling northwest along the coastline to Portlock Bank, approximately 130 km southeast of the tip of the Kenai Peninsula. **Locations for this whale occurred in the northern part of the TMAA** from 9 June 2003 (01:46:02 GMT) until the end of its tracking duration on 9 July 2003 (22:54:11 GMT).

2.4. Photo-ID

One whale photo-IDed (but not tagged) during our January 2015 tagging season in Hawaii was matched in Happywhale to an encounter within the TMAA on 16 July 2013. This whale (along with 22 others appearing in Happywhale), was identified during a 2013 NOAA research cruise in the TMAA (Rone et al. 2014).

Eight additional whales from our Hawaii tagging seasons in 2015 and 2019 have been encountered in Prince William Sound (PWS), both before and after our work in Hawaii. Two of these whales were also encountered in Resurrection Bay on the Kenai Peninsula. The TMAA lies on a direct line from Hawaii to PWS but given the limitations of photo-ID we don't know if these whales passed through the TMAA during their migrations. Three of the eight whales were tagged during our March 2019 season in Hawaii; one (tag # 2019HI-05648) had a trajectory toward PWS, one had a trajectory toward Kodiak Island (tag # 2019HI-02083), and the third whale's (tag # 2019HI-02082) tag stopped transmitting before the whale left Hawaii (**Figure 1**).

3. Gray whales

A total of 73 gray whales were tagged in the North Pacific from 1994 to 2013, providing tracks for 69 whales (**Table 2**). Tag deployments took place in Oregon and California in 1994, 2009, 2012, and 2013 (37 tags), in Mexico in 1996 and 2005 (29 tags), and in Russia in 2010 and 2011 (7 tags). **No whales tagged in Oregon and California were tracked within the TMAA. Two whales tagged in Mexico had locations within the TMAA, and the track of one additional individual crossed the TMAA. Finally, one whale tagged in Russia had locations within the TMAA during its southbound migration and one other individual crossed the TMAA during its northbound track** (see sections 3.2. and 3.3. for further detail).

3.1. Oregon and California tagging 1994, 2009, 2012-2013

Thirty-seven gray whales were tagged in Oregon and California from 1994 to 2013, providing tracks for 33 whales. **None of these whales were tracked within the TMAA** (Mate 2013, Mate et al. 2014, Lagerquist et al. 2019).

3.2. Mexico tagging 1996, 2005

A total of 29 gray whales were tagged in coastal lagoons in Baja California, Mexico: 12 whales in San Ignacio Lagoon in 1996 and 17 whales in Ojo de Liebre Lagoon in 2005, providing tracks for all 29 whales. Of the whales tagged in 1996, only one was tracked on a partial migration from San Ignacio Lagoon to north of San Francisco (Mate and Urbán-Ramirez 2003). **Two of the whales tagged in 2005 had locations within the TMAA during their southbound migrations;** one whale (tag #2005MX-00829) had two locations in the TMAA on 12 January 2006, and the other whale (tag #2005MX-00833) had one location in the TMAA on 21 December 2005. **The track of one additional whale (tag #2005MX-00830) crossed the TMAA on its northbound migration sometime between 17 and 29 May 2005 (Table 3, Figure 3; OSU, unpublished data).** It should be noted here that all these locations were of low quality (Argos location class "B" derived from one message) with the potential for error radii on the order of tens of kilometers. Additionally, there were relatively large gaps in coverage between some of the locations (5.5 to 14 days). It is possible that the whales did not travel through the TMAA as shown but

took a more coastal route across the northern Gulf of Alaska. The more complete tracks of other gray whales support both coastal (northbound track of a whale tagged in Russia; see **section 3.3**) and offshore routes (southbound routes of three whales tagged in Russia; see **section 3.3**) in the Gulf of Alaska.

Five gray whales tagged in Ojo de Liebre Lagoon, including two of the whales mentioned above (tag #2005MX-00829 and 2005MX-00833), were tracked from the western coast of North America to the eastern Aleutian Islands or the Bering and Chukchi Seas (OSU, unpublished data). However, missing data in their tracks prevented an examination of their northbound route across the Gulf of Alaska, including through the TMAA (**Table 4**).

3.3. Russia tagging, 2010-2011

Seven gray whales were tagged at Sakhalin Island, Russia, in 2010 and 2011 (Mate et al. 2015), providing tracks for all seven whales. **One of these whales had ten locations within the TMAA** (from 30-31 December 2011) **during its southbound migration to Mexico, and the northbound (return) track of one other whale crossed the TMAA** (from 29 March 2012 to 1 April 2012; **Figure 3**). The latter whale passed approximately 600 to 700 km south of the TMAA (26 to 31 December 2011) on its southbound migration to Baja California, Mexico (Mate et al. 2015). A third whale tagged in Russia passed approximately 300 to 400 km south of the TMAA (22-25 January 2011) as it traveled southeast across the Gulf of Alaska on a heading toward the Washington coast (**Figure 3**; Mate et al. 2015).

4. Blue and fin whales

A total of 274 blue whales, 46 fin whales, and one blue/fin hybrid whale were tagged in the Eastern North Pacific from 1993 to 2018, providing tracks for 241 blue, 46 fin, and one hybrid whales. Both blue and fin whales were tagged primarily in southern and central California, with additional blue whale tagging occurring in the Gulf of California, Mexico (Mate et al. 2018a). Additionally, three blue whales were tagged in the Costa Rica Dome (Mate et al. 2018a), one fin whale was tagged off Oregon (Palacios et al. 2020a), and the blue/fin hybrid whale was tagged in southern California (Mate et al. 2018a).

Only one of 46 tracked fin whales had locations within the TMAA (Figure 4). This whale, tagged on 14 September 2006, spent most of the fall and winter of 2006/2007 in the offshore waters west of Vancouver Island and Haida Gwaii, British Columbia, and Southeast Alaska. Sixteen of this whale's locations occurred within the southeast corner of the TMAA, on 23 and 27 January 2007 and from 8 to 14 February 2007 (**Figure 4**; Mate et al. 2018a). **No blue whales were tracked within the TMAA** and only one, tagged on 7 September 2007, traveled north of Vancouver Island, coming within approximately 260 km of the southeastern corner of the TMAA on 9 November 2007 as it traveled in a clockwise loop through the Gulf of Alaska (**Figure 4**; Mate et al. 2018a). The blue/fin hybrid was only tracked in southern and central California (Mate et al. 2018a).

Finally, in March 2001 OSU deployed 11 tags on fin whales in the Gulf of California, Mexico, providing tracks for nine whales (Jiménez-López et al. 2019). These fin whales are believed to belong to a separate population that is resident year-round of the Gulf of California, and therefore are not included in the 46

fin whale tags listed above for the Eastern North Pacific. The tagged whales were tracked into late summer and none of them left the Gulf (Jiménez-López et al. 2019).

5. Acknowledgements

Tagging studies on blue, fin, and humpback whales from 2014 through 2019 were funded by the U.S. Navy, Commander, Pacific Fleet, under the Navy's Marine Species Monitoring Program, through agreements administered by Naval Facilities Engineering Command (NAVFAC) Southwest. Blue, fin, and humpback whale work in California and Oregon from 2014 to 2017 was funded through an agreement with HDR, Inc. under Contract No. N62470-15-D-8006-17F4016. Humpback whale work in Hawaii, Oregon, and Washington from 2018 to 2019 was funded through CESU Cooperative Agreements No. N62473-17-2-0001 and No. N62473-19-2-0002. We thank Andrea Balla-Holden and Chip Johnson for serving as Representatives for Commander, Pacific Fleet; Jessica Bredvik and Reagan Pablo at NAVFAC for serving as the Technical Representative and the Agreement Administrator of this Cooperative Agreement, respectively; and Kristen Ampela at HDR for technical/contractual support and project managements.

Tagging efforts on blue, fin, and humpback whales prior to 2014 benefitted from partial support by the U.S. Navy's Office of Naval Research; private donors to the OSU Marine Mammal Institute; the Pacific Life Foundation; and the Makana Aloha Foundation. Complete acknowledgements can be found in Mate et al. (2018a, b, 2019) and Palacios et al. (2019, 2020a, b, c).

Gray whale tagging in Oregon and California in 2009, 2012, and 2013 was funded by the Office of Naval Research; the U.S. Navy, Commander, Pacific Fleet; the International Whaling Commission; the International Union for the Conservation of Nature; Exxon Neftgas; and private donors to the OSU Marine Mammal Institute. Gray whale tagging in Russia was funded by the International Whaling Commission; Exxon Neftgas Limited; Sakhalin Energy Investment Company; the Office of Naval Research; and private donors to the OSU Marine Mammal Institute. Gray whale tagging in Mexico was funded by private donors to the OSU Marine Mammal Institute.

Tagging activities were conducted under the authorization of NMFS Marine Mammal Protection Act (MMPA)/Endangered Species Act (ESA) Research/Enhancement Permits as follows: No. 841 (1993 to 1998), No. 369-1440 (1999 to 2004), No. 369-1757 (2005 to 2013), No. 14856 (2013 to 2018) and No. 21585 (2018 to 2023). OSU IACUC permits authorizing the research were as follows: No. 2284 (1999 to 2002), No. 2715 (2002 to 2005), No. 3158 (2005 to 2008), No. 3657 (2008 to 2011), No. 4118 (2011 to 2014), No. 4495 (2014 to 2017), and No. 4884 (2016 to 2019).

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Table 1. Summary of the number of tags deployed and the number of tracks obtained for humpback whales tagged by OSU in the North Pacific from 1995 to 2019.

Tagging Region	Hawaii	U.S. Contiguous West Coast	Southeast Alaska	Eastern Aleutians	Mexico
No. tags deployed	126	85	47	5	18
No. whales tracked	105	81	47	5	18
Years	1995-2000, 2015, 2018, 2019	2004-2005, 2016-2019	1997, 2014-2015	2008	1998, 2003

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Table 2. Summary of the number of tags deployed and the number of tracks obtained for gray whales tagged by OSU in the North Pacific from 1994 to 2013.

Tagging Region	Oregon and California	San Ignacio Lagoon and Ojo de Liebre Lagoon, Mexico	Sakhalin Island, Russia
No. tags deployed	37	29	7
No. whales tracked	33	29	7
Years	1994, 2009, 2012-2013	1996, 2005	2010-2011

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Table 3. Dates of locations within the TMAA and start and end dates of track segments crossing the TMAA for gray whales tagged in Ojo de Liebre Lagoon, Mexico, in 2005.

Tag #	Tagging Date	No. Locations in TMAA	TMAA Start Date (Time, GMT)	TMAA End Date (Time, GMT)	Migration Phase
2005MX-00829	3/25/2005	2	1/12/2006 (14:00:31)	1/12/2006 (14:21:51)	Southbound
2005MX-00830	3/25/2005	0	5/17/2005 (11:48:32)*	5/29/2005 (22:51:34)*	Northbound
2005MX-00833	3/25/2005	1	12/21/2005 (14:07:23)		Southbound

* As no locations occurred within the TMAA for this whale, dates presented here represent the start and end points of the segment of the whale's track that crossed the TMAA. Actual time spent by this whale within the TMAA would have occurred sometime between these dates if the animal indeed crossed the TMAA.

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Table 4. Dates and locations of gaps in tracking data during northbound migration for gray whales tagged in Ojo de Liebre Lagoon, Mexico, in 2005.

Tag #	Tagging Date	Gap Start Location	Gap Start Date	Gap End Location	Gap End Date
2005MX-00829	3/25/2005	Baja California	5/1/2005	Bering Sea	6/9/2005
2005MX-00833	3/25/2005	Oregon	5/3/2005	Russia	6/9/2005
2005MX-00839	3/24/2005	Oregon	5/5/2005	Chukchi Sea	6/18/2005
2005MX-04173	3/23/2005	Baja California	4/25/2005	Eastern Aleutians	6/9/2005
2005MX-04176	3/25/2005	British Columbia	5/15/2005	Bering Sea	6/9/2005

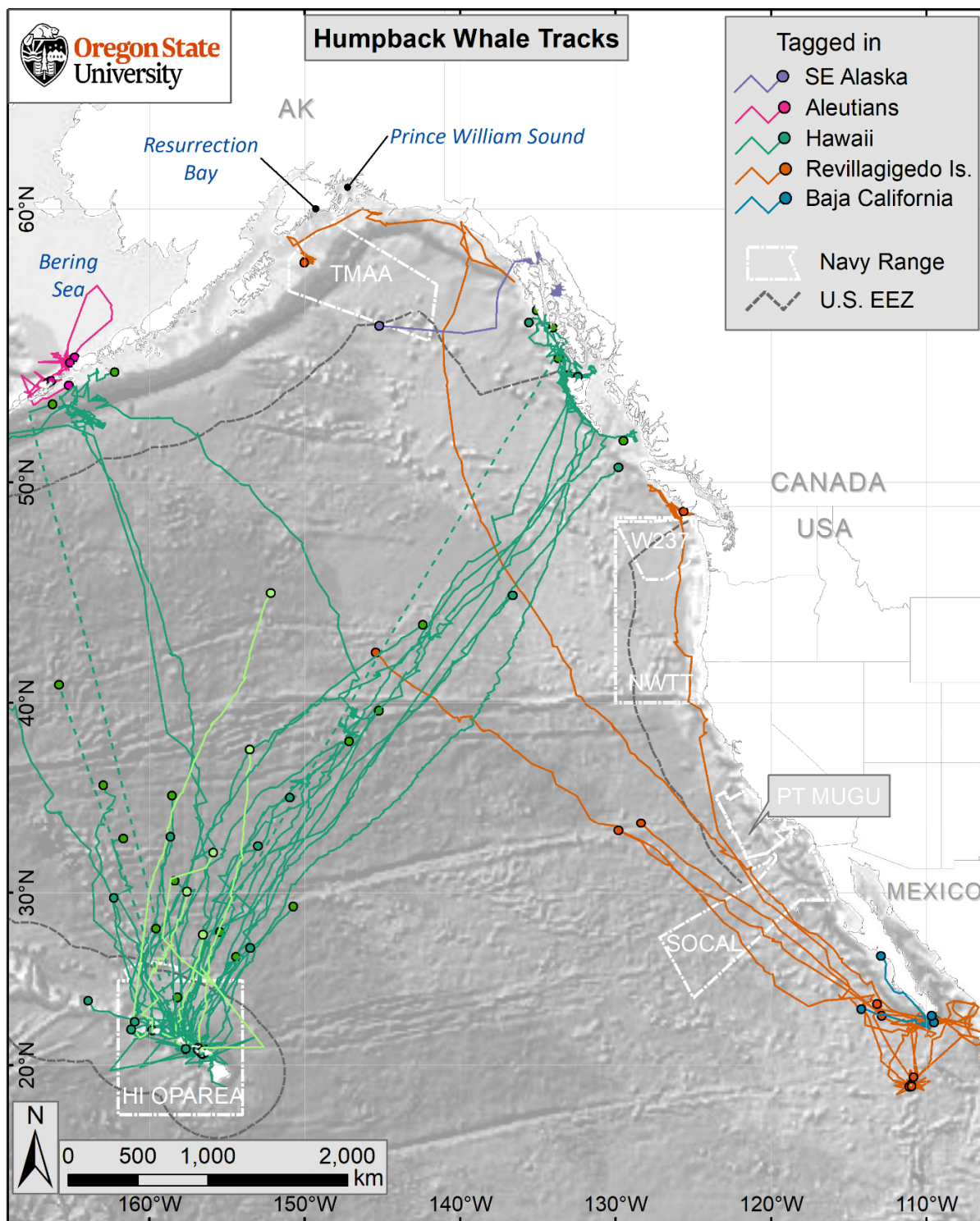


Figure 1. Satellite-monitored tracks of humpback whales tagged in the North Pacific from 1995 to 2019, highlighting movements in or near the TMAA. Light green partial migration tracks are shown for whales tagged in Hawaii that have photo-ID connections to Prince William Sound, suggesting possible travel through the TMAA en route. Note that of the 256 whales tracked (see Table 1), only a selection of tracks is shown here to reduce clutter.

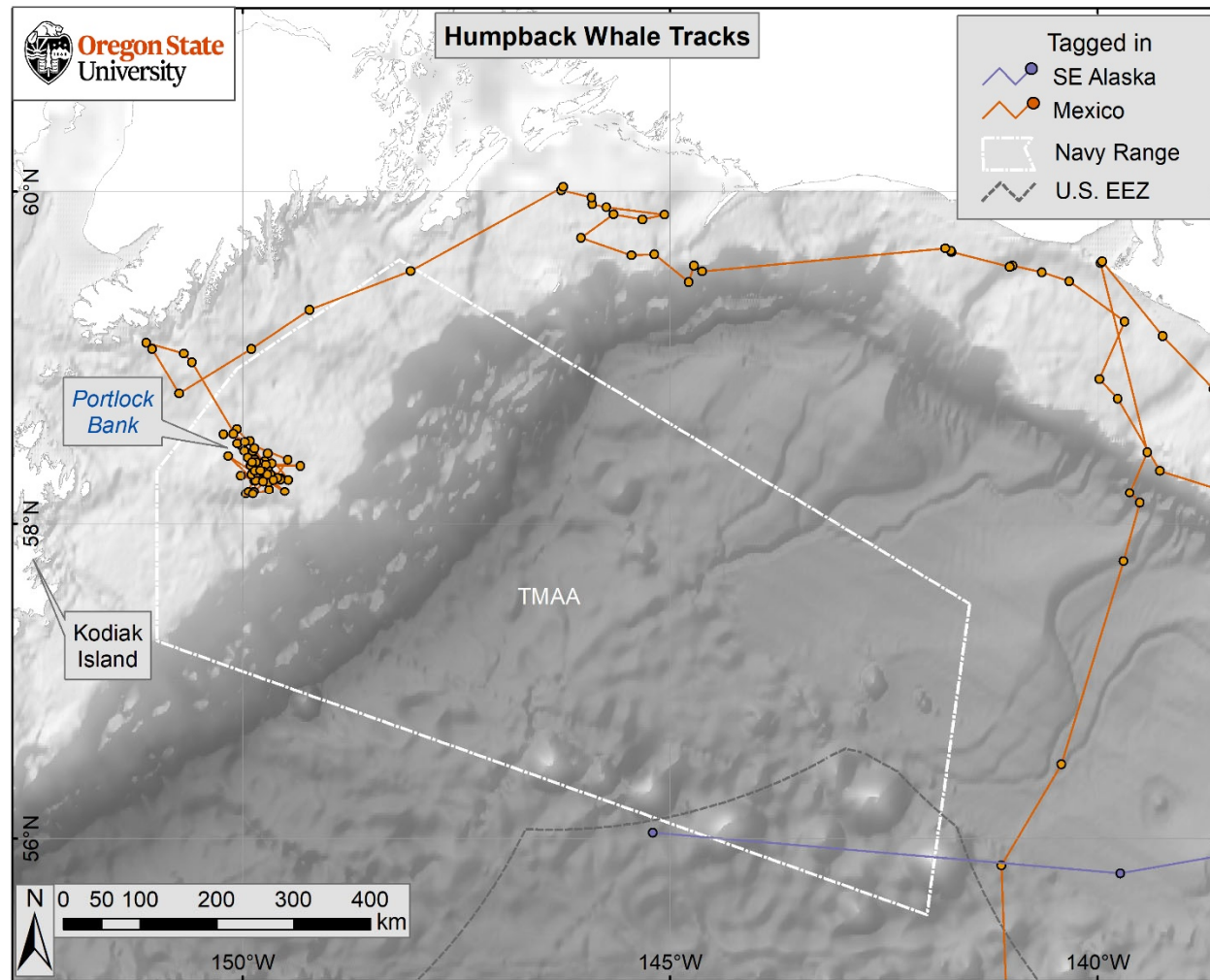


Figure 2. Satellite-monitored tracks of two humpback whales tagged in the North Pacific, highlighting movements in or near the TMAA, for a calf tagged at Socorro Island, Mexico in February 2003 (orange track) and an adult tagged in Southeast Alaska in July 1997 (purple track). The calf's track shown here covers the period from 12 May to 9 July, with the last month occurring within the TMAA, and the adult's track covers the period from 1 to 2 December 1997.

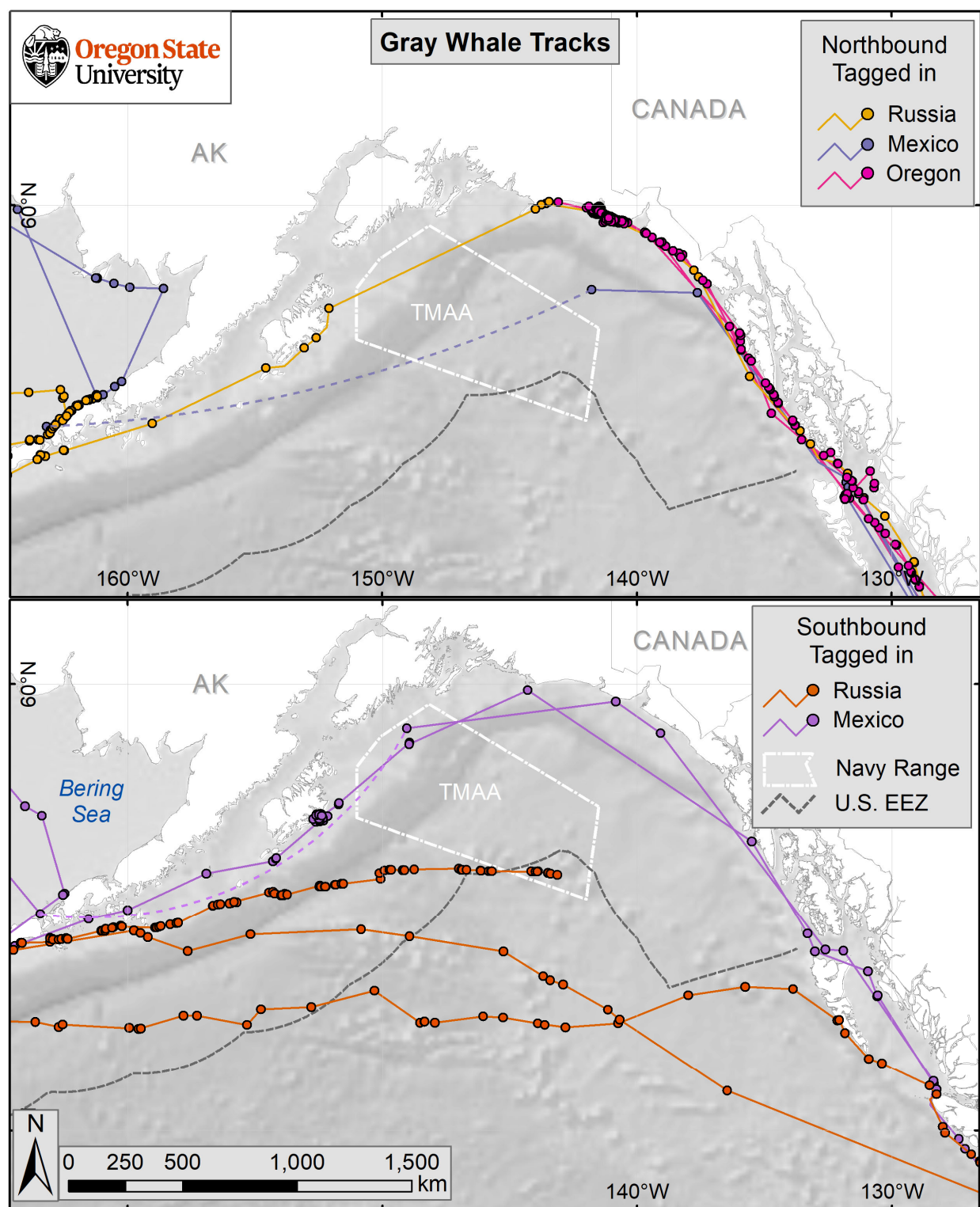


Figure 3. Satellite-monitored tracks of gray whales tagged in the North Pacific in 2005, 2010, and 2011, highlighting northbound (upper panel) and southbound (lower panel) migration movements in or near the TMAA. Dashed lines represent portions of tracks for which there were large gaps in locations (> 12 days).

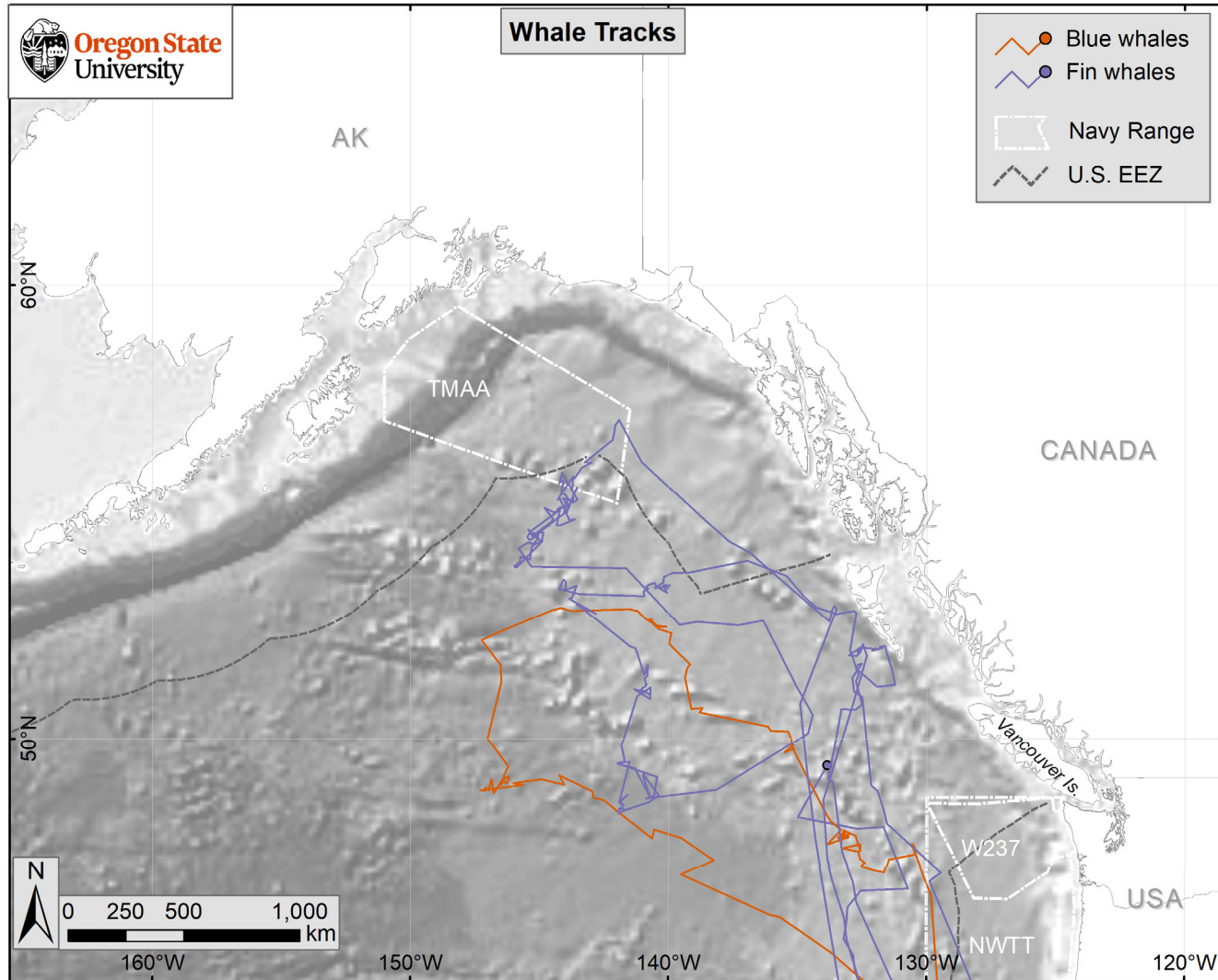


Figure 4. Satellite-monitored tracks of a blue and fin whale tagged in California in 2006, highlighting movements in or near the TMAA. The purple circle shows the last location for the fin whale.