

# Offshore Gray Whale Satellite Tagging in the Northwest Training Range Complex (NWTRC)

## Final Report



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**Cover Photo:** Gray whale (*Eschrichtius robustus*) photographed by Craig Hayslip under NMFS permit 369-1757. Copyright Oregon State Marine Mammal Institute.

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## Acronyms and Abbreviations

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CPF	Commander, Pacific Fleet
ESA	Endangered Species Act
ft	foot/feet
km	kilometer(s)
LC	location class
m	meter(s)
NWTRC	Northwest Training Range Complex
ONR	Office of Naval Research
PCFG	Pacific Coast Feeding Group
PTT	Platform Transmitting Terminal
SPOT	Smart Position and Temperature
U.S.	United States

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## 1. Introduction

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To comply with regulatory requirements, the United States (U.S.) Navy (Pacific Fleet) funded this multi-year monitoring project as part of the Navy's Marine Species Monitoring Program. The purpose of this study was to understand the offshore distribution of gray whales and the potential for overlap with Navy activities.

The Navy operates in several range complexes throughout the Pacific Ocean including the Northwest Training Range Complex (NWTRC) where the eastern North Pacific population of gray whales occurs. Within this population, there is a small subset of gray whales that make up the Pacific Coast Feeding Group (PCFG). The PCFG gray whales do not migrate to the Arctic during the summer feeding season. Individuals of the PCFG are sighted repeatedly in multiple years at locations ranging from northern California to southeast Alaska from late spring through fall (Calambokidis et al. 2002, Swartz et al. 2006).

Although this population of gray whales (including the PCFG) is no longer listed as endangered under the Endangered Species Act, they are federally protected under the Marine Mammal Protection Act and the two groups are managed as a single population. However, it is unknown if gray whales in the PCFG are demographically separate from the larger eastern North Pacific population as very little is known about the movements of the PCFG whales.

This project was conducted to identify PCFG gray whale movements in and around the Pacific Northwest in association with the offshore areas of the U.S. Navy's NWTRC.

A total of 17 tags were funded from two Navy sources and were deployed on gray whales in the fall of 2012 and 2013. As these data are best reported together, this report presents data from satellite tags deployed on six gray whales in 2013 and includes data from the 11 tags previously deployed in 2012.

## 2. Methods

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### **2.1 Satellite Tags**

All tagging efforts were conducted from a small 6.4-meter (m) rigid hull inflatable boat. In the field, PCFG gray whales were identified as gray whales that were present in typical PCFG summer habitat (i.e., off northern California and Oregon) and not exhibiting migratory behavior (i.e., directionally oriented seasonal travel). Identification photos were taken of all tagged whales and were later compared to Cascadia Research Collective's catalogue of PCFG whales to confirm the whales as being part of the PCFG. Candidates for tagging were selected based on visual estimates of size (> 9 m in length) and good body condition (i.e., a normal amount of subcutaneous fat present in the post-cranial, scapular, and lateral flank body regions, and not overly infested with external parasites) (Bradford et al. 2012). Approaches were made on all available candidate whales but, due to either high sea states or the whale's response to the vessel, not all approaches resulted in a tag deployment. Wildlife Computers Smart Position and Temperature (SPOT5) tags were used with the same physical configuration (e.g., size, shape, and external components) as have been used on other large whale species (Mate et al. 2007). Tags were deployed using an Air Rocket Transmitter System following the methods described in Mate

et al. (2007). Tags were deployed from distances of 2 to 4 m with 90 to 100 pounds per square inch in the applicator's 70-cubic centimeter pressure chamber.

The choice of an appropriate transmission period (duty cycle) depends entirely upon the study objectives. Since one of the goals for this study was to capture daily movements of PCFG gray whales within the NWTRC, tags were programmed to transmit only when out of the water, and during four 1-hour periods per day to maximize battery life. The 1-hour transmission periods were scheduled to coincide when a satellite was most likely to be overhead to receive the transmission. Tags were programmed to transmit every day, and they carried sufficient battery capacity to function for over 1 year using the programmed duty cycle.

## **2.2 Argos tracking**

Tagged whales were tracked using the Argos satellite-based system that assigns a location quality to each location, which depends, among other things, on the number and temporal distribution of transmissions received per satellite pass (Mate et al. 2007). The error associated with each Argos satellite location is reported as one of six possible location classes (LCs) ranging from < 200 m (LC = 3) to > 5 kilometers (km) (LC = B; Vincent et al. 2002). Received locations were filtered to remove locations that occurred on land, and a maximum swim-speed filter (Austin et al. 2003, Freitas et al. 2008) was applied to remove locations that would have required the whale to move at an unreasonably fast speed (i.e., > 8 km/hour). Received locations that fell within the latitudinal range of the NWTRC were isolated from the tracks and the water depths, distances from shore, and numbers of locations falling inside the NWTRC were calculated for each tag. Thus-filtered Argos locations were plotted on a North American Albers Equal Area Conic projection to map tracked whales in this report.

## **3. Results**

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Argos-monitored satellite radio tags were attached to six PCFG gray whales from 19–23 October 2013. Three of those tags (#1385, #1389, and #5800) were still transmitting on 18 March 2014 when the data were summarized for this report. All tags were deployed near Crescent City, California, due to a low number of gray whales encountered along the Oregon coast. Messages were received from all six tags, and average tag duration as of 18 March 2014 was 139.8 days, with three tags still transmitting (**Table 1**). Overall, the locations received to date from the tagged whales were almost exclusively near-shore and not located in the NWTRC (**Table 2**). The whales did not linger near any submarine canyons or other underwater features, remaining entirely in waters over the continental shelf. Out of all received locations within the NWTRC latitudinal range, 111 locations (average of 6 percent of locations/whale) were within the NWTRC. The whales predominantly used the narrow continental shelf area along the Oregon coast which is not included in the NWTRC. Two whales (tag #1385 and #5823) were responsible for all of the locations inside the NWTRC, but the majority of their locations remained on the continental shelf, occupying the northerly portion of the NWTRC where it reaches all the way to

the coastline (**Figures 1 through 7**)<sup>1</sup>. One of these whales (tag #1385, **Figure 2**) appears to have migrated north and offshore (maximum distance from shore of 22.9 km off Grays Harbor, Washington) through the part of the NWTRC area that comes all the way to shore along the Washington coast. The second whale (tag #5823, **Figure 6**) had three locations farther offshore within the NWTRC and south of Crescent City (maximum 135 km). However, the Argos locations for both whales beyond 19 km from shore were of poor quality (**Figure 8**), calculated from few messages/orbit and thus prone to large errors, especially in longitude (Vincent et al. 2002). The locations farthest from shore for tag #5823 are also separated by 2 to 5 days, so there is no way to draw inferences from recent adjacent locations. Combined with the high near-shore preference observed for the other tagged whales, we therefore have little confidence in the offshore track of tag #5823 and think its offshore transit of the NWTRC is unlikely due to Argos locational errors.

In the fall of 2012, Argos-monitored satellite radio tags were attached to 11 PCFG gray whales. Three tags were deployed near Newport, Oregon and the rest were deployed near Crescent City, California. Mate (2013) includes tag data results collected through March 2013. However, several 2012 tags continued to transmit through October 2013, past the date of the Mate (2013) summary report submission, and these results (i.e., tag data from April through October 2013) are included in this document.

Including the full extent of 2012 tracks did not change the overall trend of the data. Average tag duration for 2012 increased to 128 days (**Table 1**), but use of the NWTRC by tagged gray whales only increased slightly, with an average of 7.9 percent of locations/whale occurring in the NWTRC (**Table 2**). The tagged whales continued to use areas on the continental shelf and very close to shore (range = 0.4–38.1 km, see **Figures 9 through 13**).

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<sup>1</sup> Tag deployment date and location is marked in the figures by a green box, and the last received location is indicated by a red box. Received locations are represented by black circles. Yellow lines indicate a straight path between two sequential transmissions but may not represent the true path of the whale. White dashed line connect consecutive locations with large gaps (> 2 weeks) between them and do not represent the true path of the whale. As of 18 March 2014, tags #1385, #1389, and #5800 were still transmitting.

**Table 1. Tag deployment dates and tracking durations as of 18 March 2014 for PCFG gray whales tagged with satellite transmitters in fall 2012 and 2013.**

PTT #	Tag Type	Date Deployed	Most Recent Transmission	# Days Tracked	# Transmission Used	Distance (km)	Funding Source
839	SPOT5	23-Oct-13	13-Feb-14	112.8	341	3,623	CPF
1385*	SPOT5	19-Oct-13	18-Mar-14	149.6	729	7,240	CPF
1387	SPOT5	20-Oct-13	13-Mar-14	144	655	4,082	CPF
1389*	SPOT5	21-Oct-13	18-Mar-14	147.8	713	6,208	CPF
5800*	SPOT5	22-Oct-13	17-Mar-14	145.2	412	5,925	CPF
5823	SPOT5	20-Oct-13	09-Mar-14	139.2	311	7,210	CPF
			<b>Overall 2013 Mean</b>	<b>139.8</b>	<b>526.8</b>	<b>5,714.7</b>	
5726**	ST-15	04-Oct-12	20-Jun-13	258.6	406	8,466	ONR
5736	ST-15	15-Nov-12	23-Feb-13	99.7	102	3,158	CPF
5746	ST-15	08-Oct-12	20-Oct-12	11.5	12	87	ONR
			<b>2012 ST-15 Mean</b>	<b>123.3</b>	<b>173.3</b>	<b>3903.7</b>	
832	SPOT5	14-Nov-12	tag unresponsive	0	n/a	n/a	CPF
834	SPOT5	02-Nov-12	15-Mar-13	132.7	324	10,396	ONR
841	SPOT5	03-Nov-12	20-Dec-12	46.6	150	1,497	ONR
848**	SPOT5	02-Nov-12	29-Apr-13	177.1	181	6,183	ONR
5650	SPOT5	14-Nov-12	tag unresponsive	0	n/a	n/a	CPF
5801**	SPOT5	03-Nov-12	20-Oct-13	350.5	322	9,980	ONR
23033	SPOT5	03-Nov-12	17-Mar-13	133.3	90	5,609	ONR
23041**	SPOT5	03-Nov-12	23-May-13	200.2	47	6,535	ONR
			<b>2012 SPOT5 Mean</b>	<b>130.1</b>	<b>185.7</b>	<b>6700.0</b>	
			<b>Overall 2012 Mean</b>	<b>128.2</b>	<b>181.6</b>	<b>5767.9</b>	
<b>Total Tags = 17 (2 unresponsive)</b>							

\*Tag is still transmitting as of 18 March 2014

\*\* These tags transmitted beyond the 2013 report (Mate, 2013) summarizing data up until 18 March 2013 and their complete tracks are shown in **Figures 9-12**, with a complete PCFG track summary in **Figure 13**.

Key: PTT = Platform Transmitting Terminal; SPOT = Smart Position and Temperature; CPF = Commander, Pacific Fleet; ONR = Office of Naval Research

**Table 2. Water depth at animal locations, distance to shore, and the number of locations recorded inside the NWTRC for portions of PCFG gray whale satellite tracks that fell within the latitudinal range of the NWTRC. Tags were deployed in fall 2013. There is doubt about the validity of the locations beyond 19 km from shore, which were derived from poor quality Argos locations.**

Tag#	2013						
	839	1385	1387	1389	5800	5823	Average
Count of Locations	0	89	0	0	0	22	55.5
% of All Locations	0.0%	12.0%	0.0%	0.0%	0.0%	7.0%	9.5%
<b>Water Depth (m) at Locations of Transmission</b>							
Minimum	0	1.0	0	0	0	6.0	3.5
Maximum	0	164.0	0	0	0	3100.0	1632.0
Mean	0	30.8	0	0	0	383.1	206.9
Standard Deviation	0	24.3	0	0	0	895.2	459.8
<b>Distance to Shore (km) at Locations of Transmission</b>							
Minimum	0	0.1	0	0	0	2.3	1.2
Maximum	0	22.9	0	0	0	135.3	79.1
Mean	0	6.3	0	0	0	19.8	13.0
Standard Deviation	0	3.5	0	0	0	36.5	20.0

**Table 3. Water depth at animal locations, distance to shore for each location, and the number of locations recorded inside the NWTRC for PCFG gray whales satellite-tagged in fall 2012. All values have been updated to reflect the full extent of the whale’s track.**

Tag#	2012									Average
	834	841	848	5801	23033	23041	5726	5736	5746	
Count of Locations	40	0	8	35	4	5	114	0	0	34.3
% of All Locations	13%	0%	4%	11%	4%	11%	28%	0%	0%	11.8%
<b>Water Depth (m) at Locations of Transmission</b>										
Minimum	4.7	0	7.0	2.0	13.4	7.0	4.0	0.0	0.0	6.3
Maximum	707.5	0	104.0	214.0	841.1	4.0	3508.0	0.0	0.0	896.4
Mean	39.3	0	41.7	41.2	226.5	25.4	31.0	0.0	0.0	67.5
St. Dev.	107.6	0	28.3	37.1	354.9	14.1	21.3	0.0	0.0	93.9
<b>Distance to Shore (km) at Locations of Transmission</b>										
Minimum	0.8	0	0.6	0.4	2.7	1.9	1.2	0.0	0.0	1.3
Maximum	30.7	0	12.5	11.5	38.1	8.6	15.3	0.0	0.0	19.4
Mean	6.3	0	6.0	6.0	13.0	5.5	5.8	0.0	0.0	7.1
St. Dev.	4.9	0	4.2	3.9	14.6	2.6	2.6	0.0	0.0	5.5

## 4. Discussion

Because the tags were deployed in the fall, movements of the whales near the NWTRC were relatively limited prior to migration, but are assumed to represent foraging effort (Calambokidis et al. 2002; Swartz et al. 2006). Migration was recorded for all six tagged whales and was characterized by continuous near-shore movement southward until the whales had left the NWTRC boundary area. Prior to south-bound migration, all six whales remained near the tagging location, except for one whale that moved about 40 km north prior to that migration. Northward migratory travel generally followed a similar pattern to the southerly migration, with the whales remaining close to shore and moving continuously until reaching various areas off the Oregon and Washington coastline. Only two of the six tagged whales had locations recorded in the NWTRC the following spring, although one whale may have transited through the NWTRC during its northward migration. Given that this transit was represented by only three locations, it is possible that location error may have exaggerated the whale’s distance from shore during its northward migration.

It is important to note that, in the maps provided, received locations are represented by dark circles. Yellow lines connecting the locations do not represent the actual route traveled; rather it is a way to chronologically connect consecutive locations for easier visual interpretation. There are portions of the tracks where the yellow lines make it appear that the whales crossed portions of the NWTRC. However, given the animals’ apparent strong preference for near-shore habitat,

it may be that the whales followed a less direct route and did not actually enter into the NWTRC. Pseudo-locations were used (but not shown on the map) to make the yellow track line go around, rather than across land when connecting consecutive locations. Some of the tags transmitted intermittently, in some cases, going weeks between locations. In those cases, locations were connected with white dashed lines to maintain the chronology of the locations without implying that we know the exact route traveled by the whale.

In conclusion, the whales tagged in 2013, like those tagged in 2012, continue to show a very strong preference for shallow, near-shore habitat and also never ventured far from shore. These whales did not appear to use any canyons or underwater features preferentially, and were rarely, if ever, found in the NWTRC more than 19 km from shore.

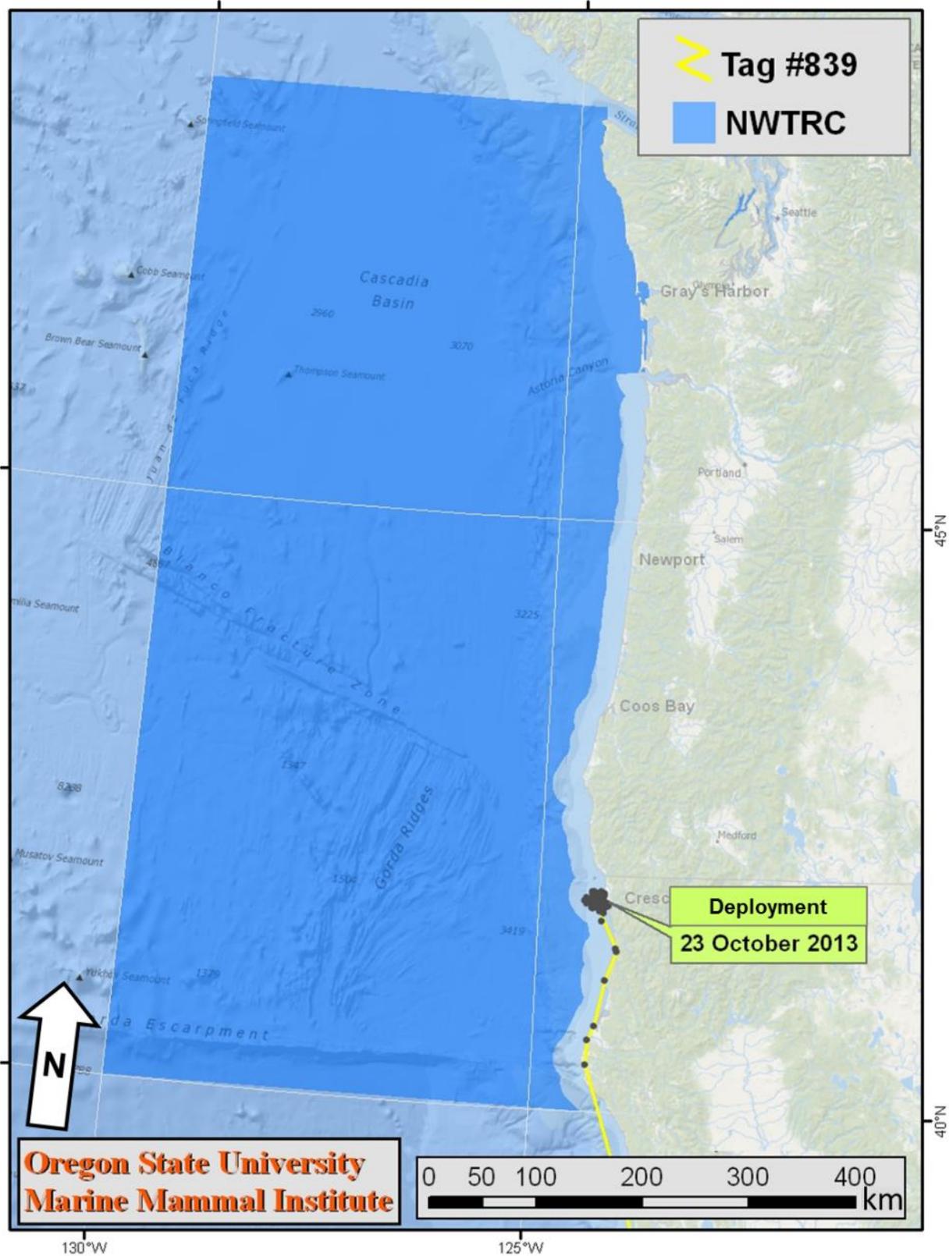


Figure 1. Movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #839 in fall 2013. The last location (13 February 2014) was south of the NWTRC and not shown.

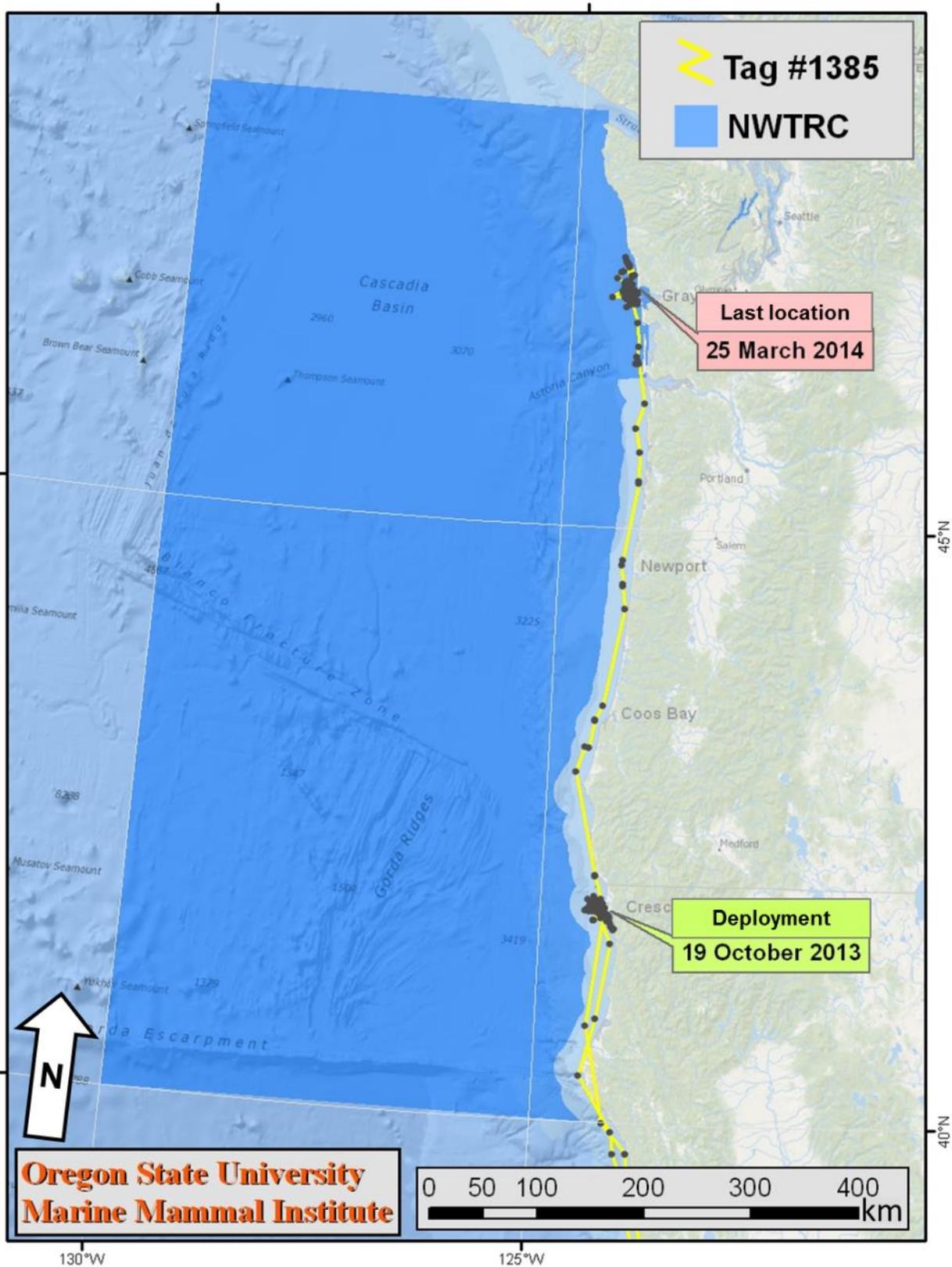


Figure 2. Movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #1385 in fall 2013.

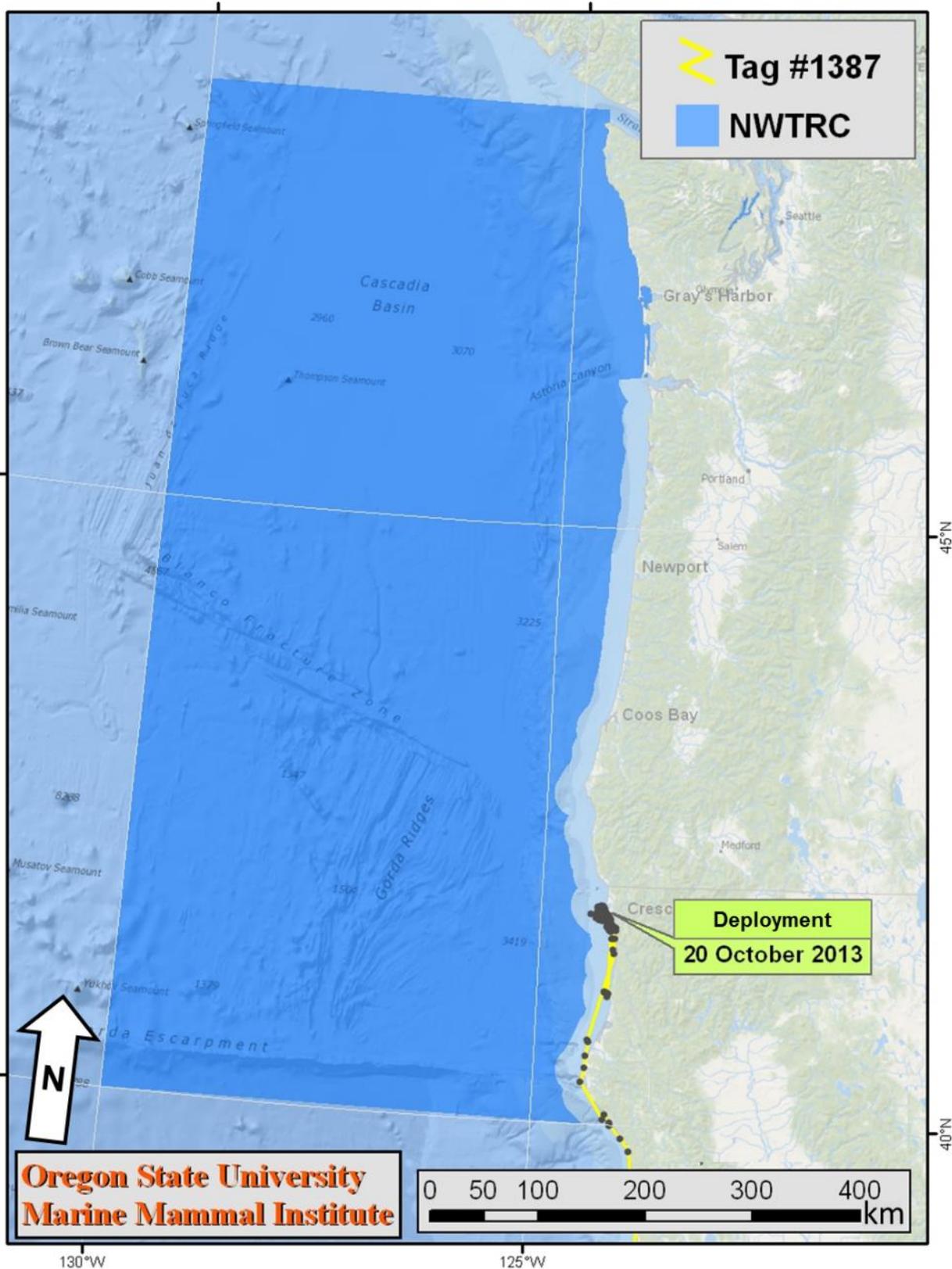


Figure 3. Movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #1387 in fall 2013. The last location (13 March 2014) was south of the NWTRC and not shown.

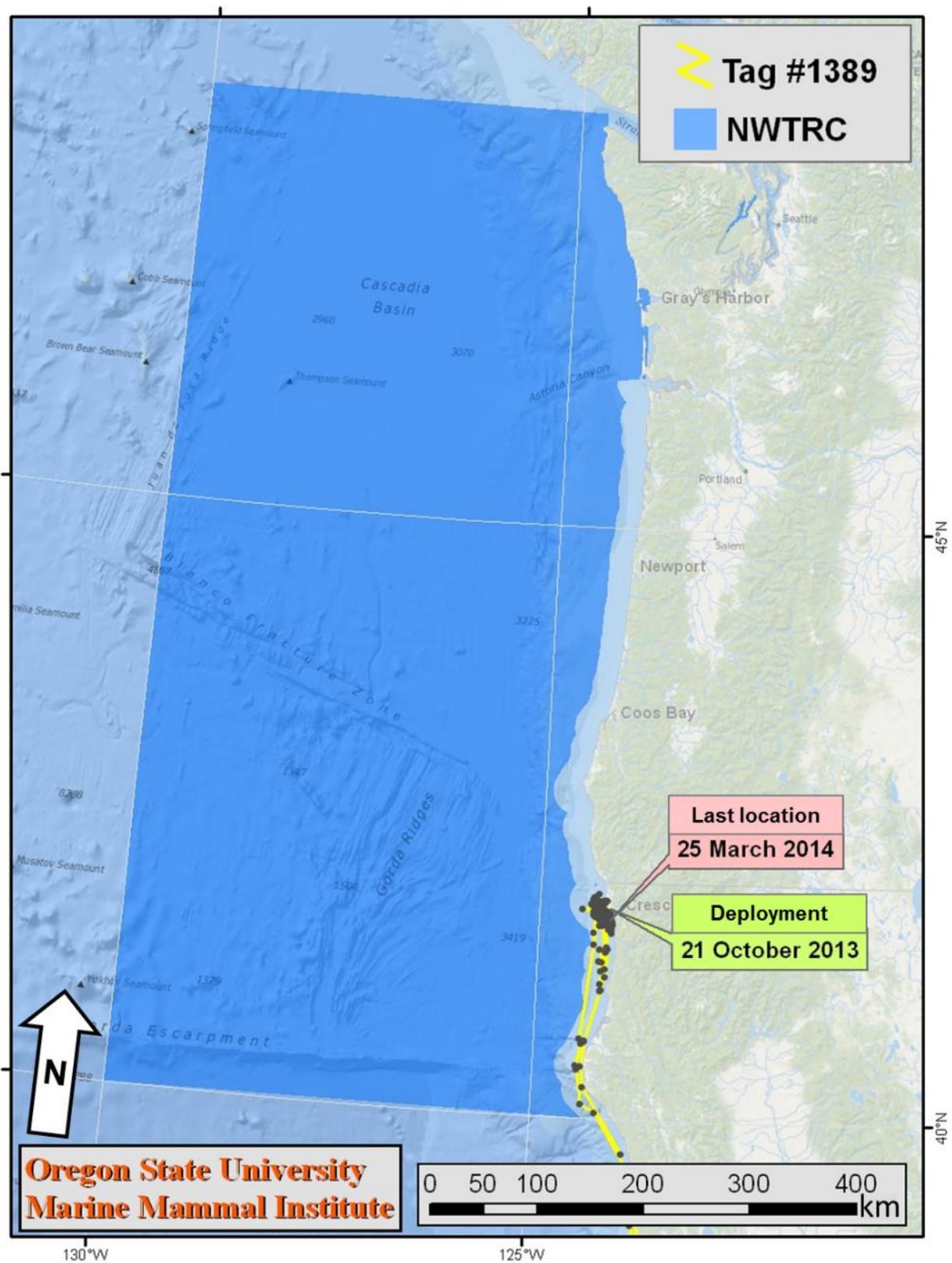


Figure 4. Movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #1389 in fall 2013.

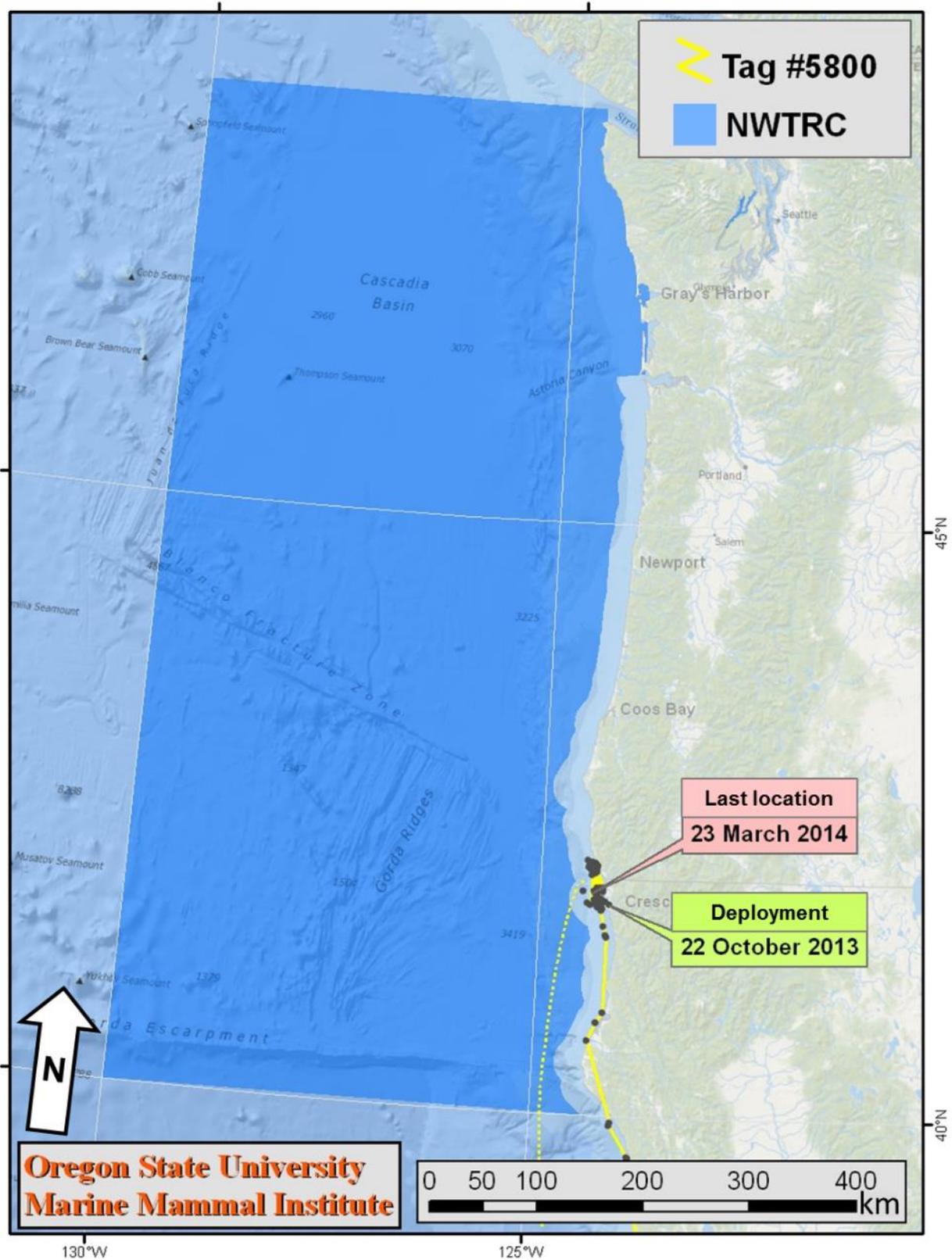


Figure 5. Movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #5800 in fall 2013.

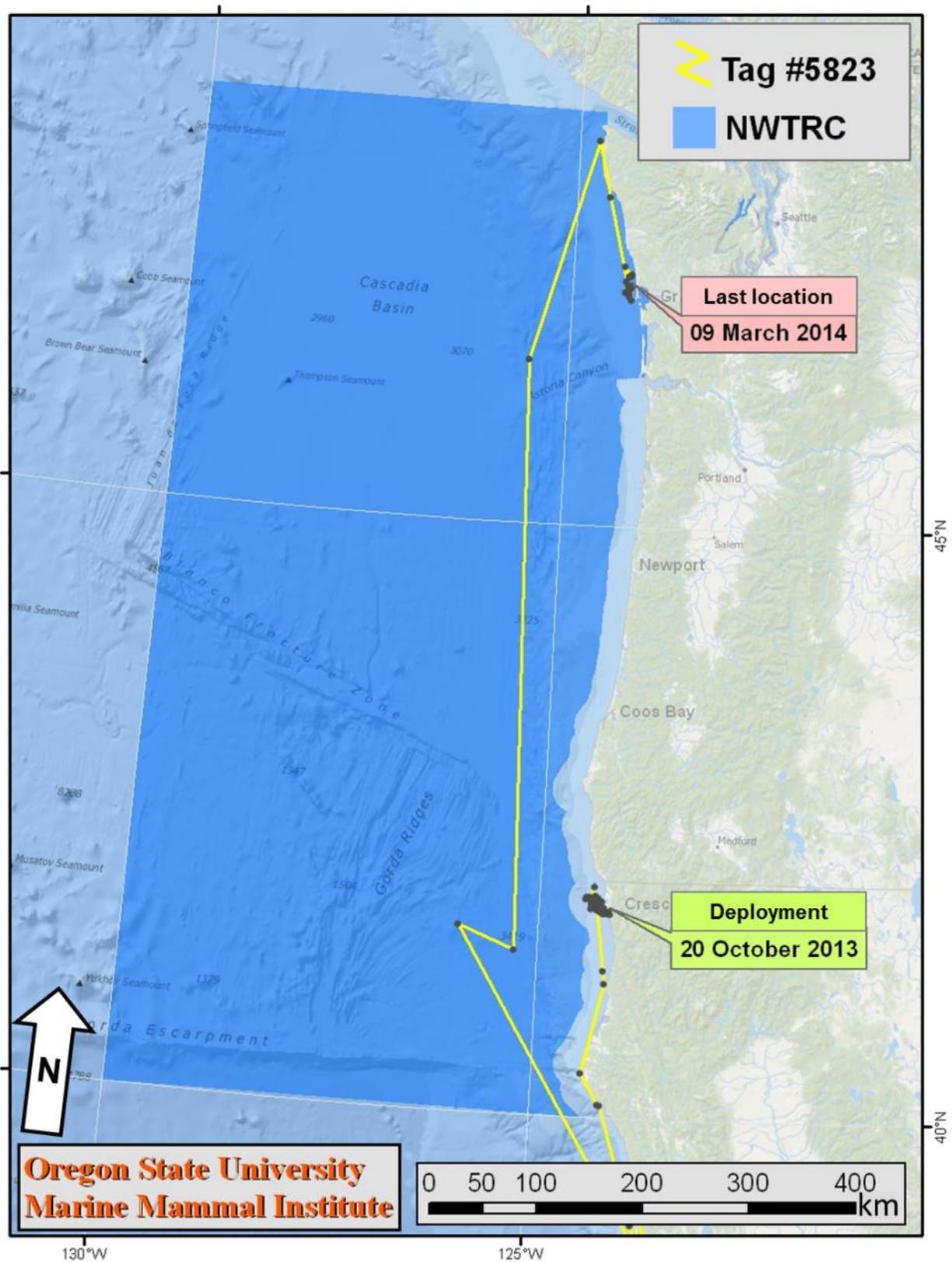
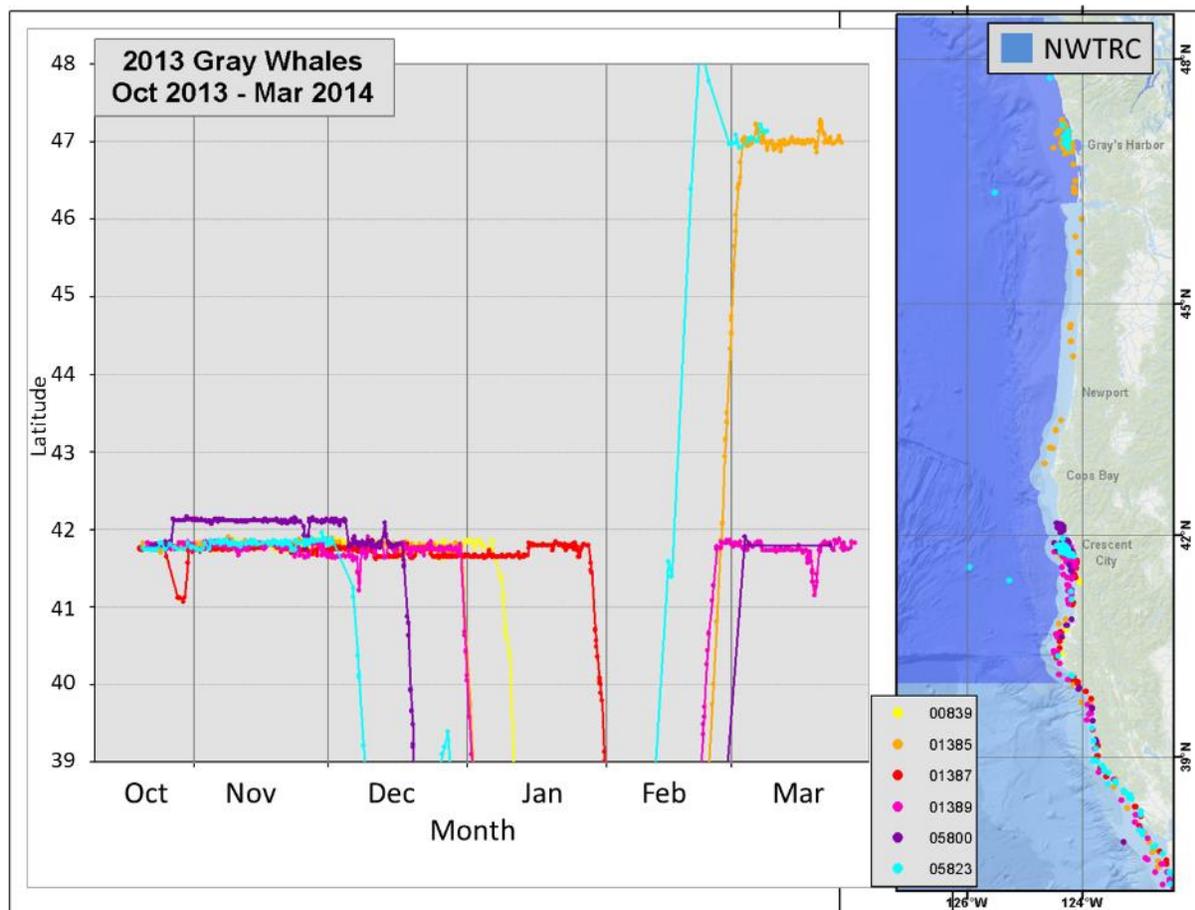


Figure 6. Movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter # 5823 in Fall 2013.



**Figure 7. Site tenacity (showing consistency and movement within the feeding range and season) and migratory timing of October 2013-tagged PCFG gray whales, with latitudes of locations through March 2014, plotted vs date (left). The right-side map shows the locations color-coded by tag number to show the coastal nature of tagged whale movements in relation to NWTRC areas, shown in dark blue.**

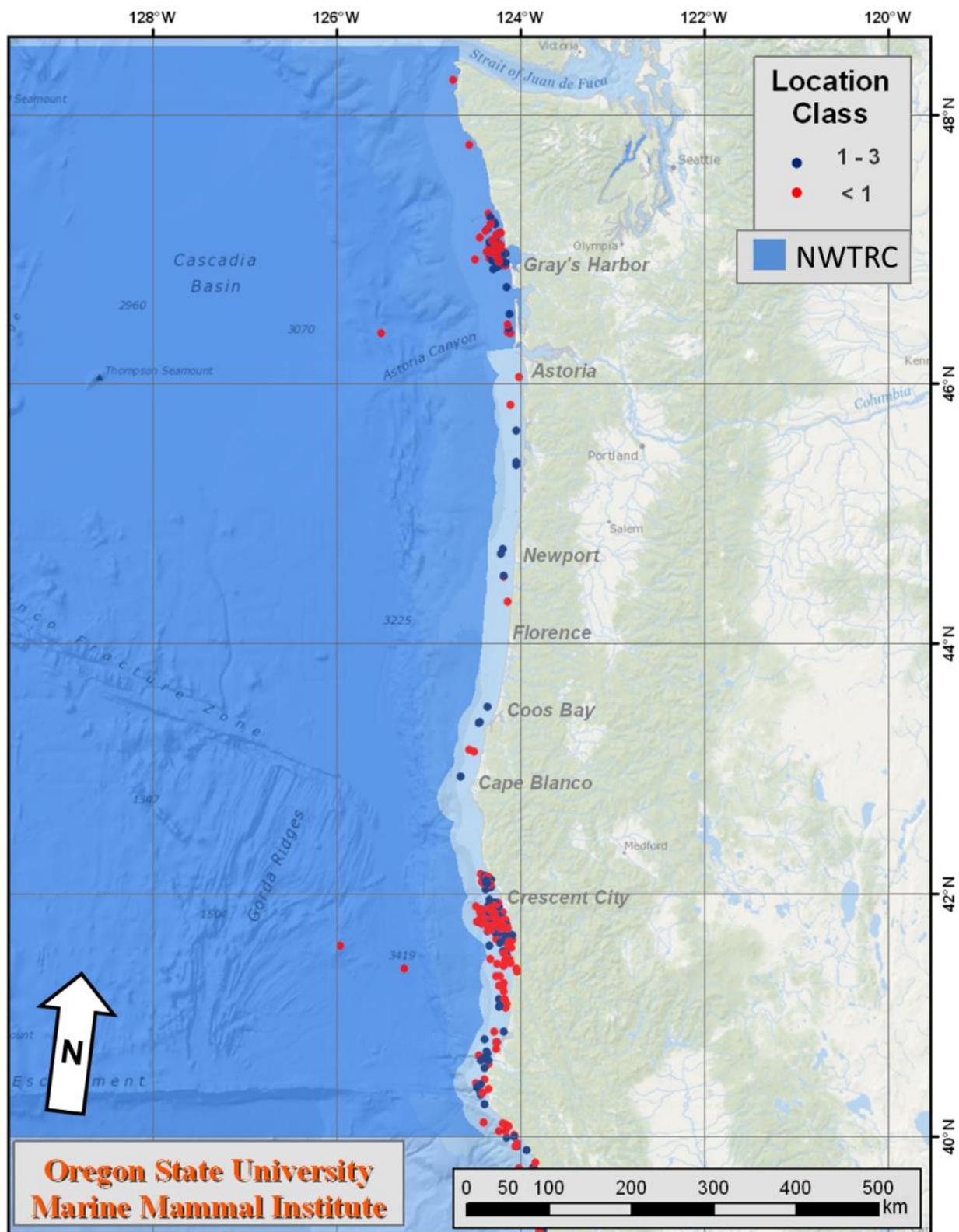


Figure 8. Locations from PCFG gray whales tagged with satellite transmitters in fall 2013. Blue dots are high-quality locations and red dots are low-quality locations. The NWTRC is shown in dark blue.

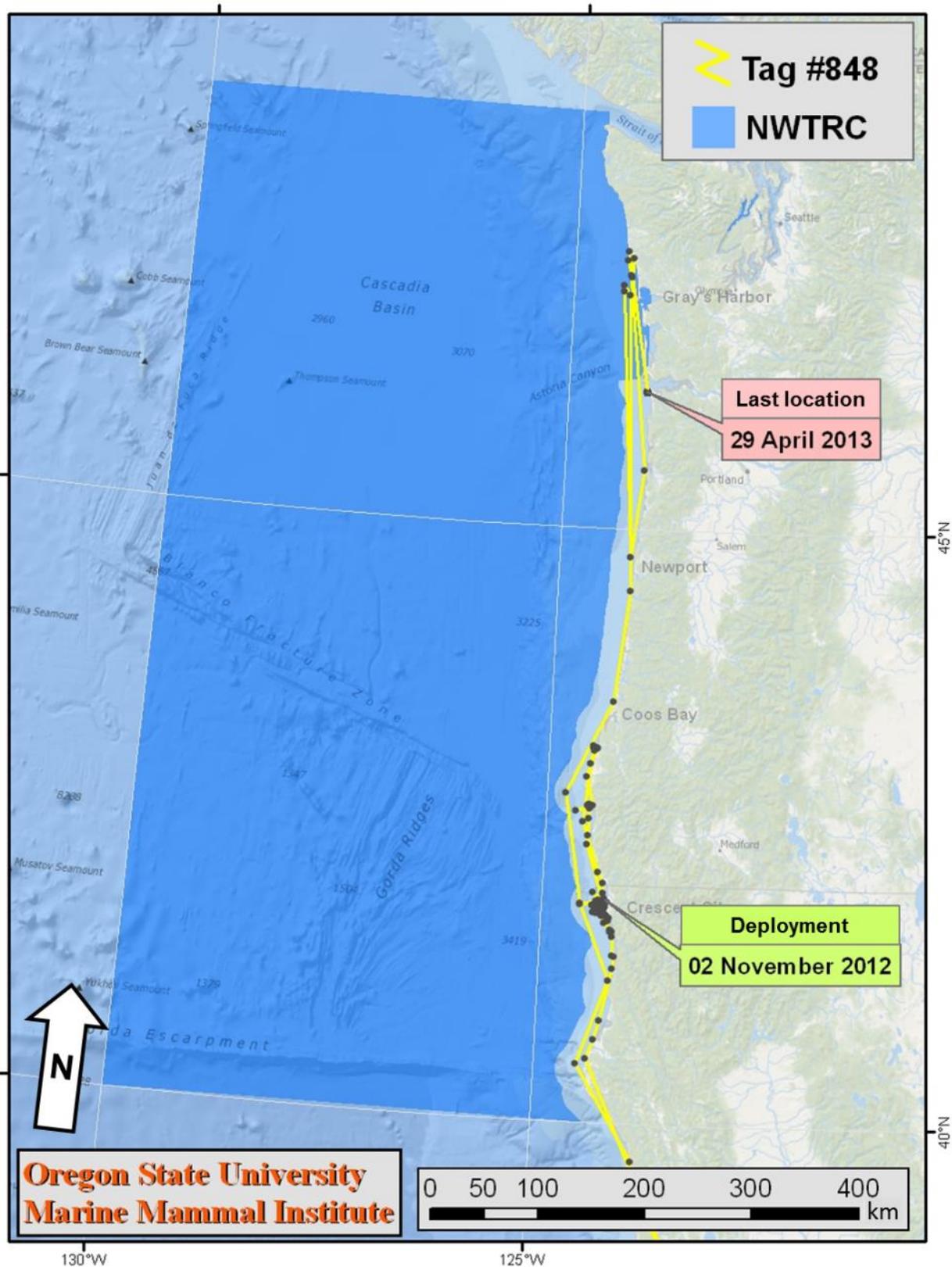


Figure 9. Full movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #848 in fall 2012 (updated from Mate [2013]).

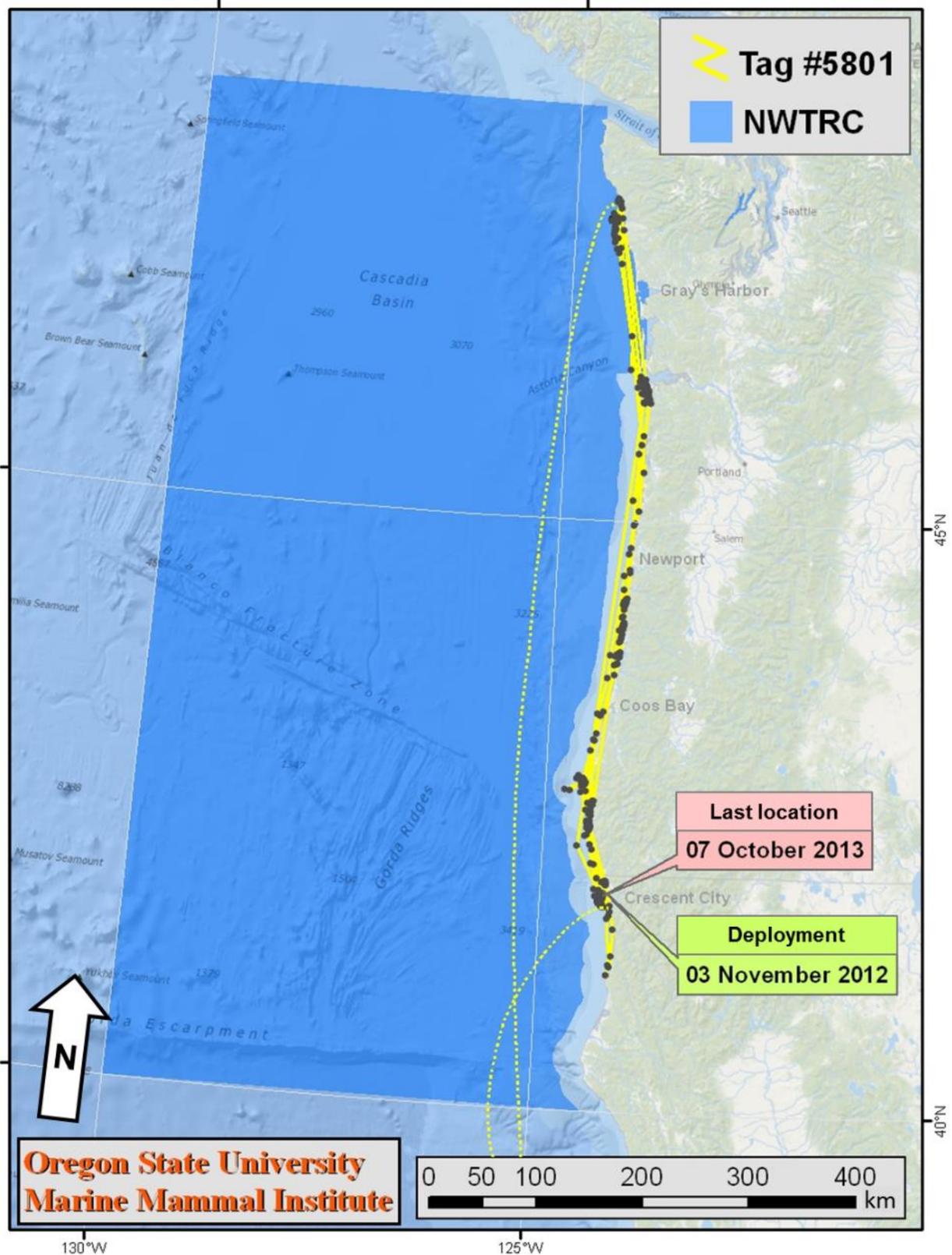
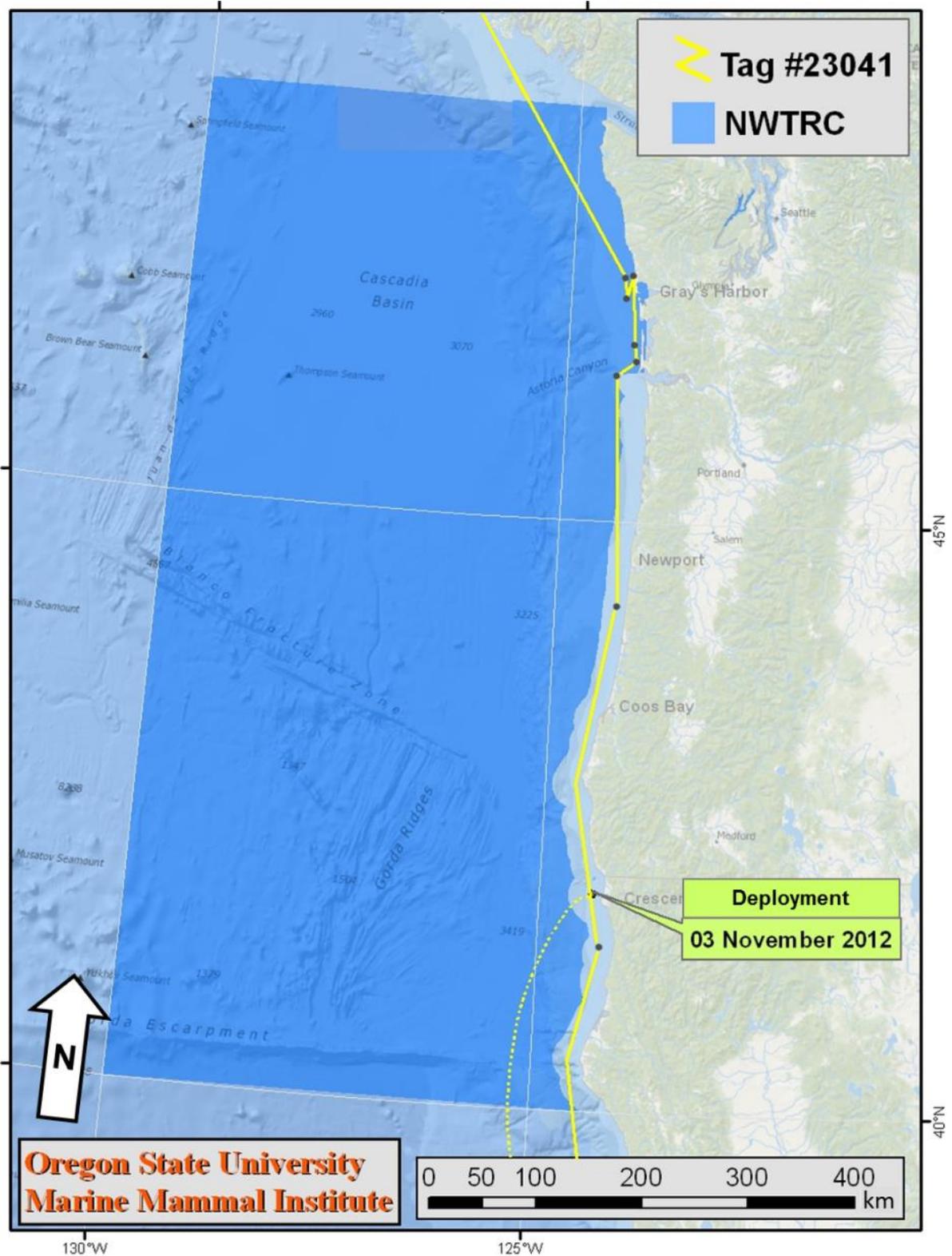


Figure 10: Full movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #5801 in Fall 2012 (updated from Mate [2013]).



**Figure 11: Full movements near the NWTRC (shown in dark blue) of a Pacific Coast Feeding Group (PCFG) gray whale tagged with satellite transmitter #23041 in fall 2012 (updated from Mate [2013]). The last location (23 May 2013) was north of the NWTRC and is not shown.**

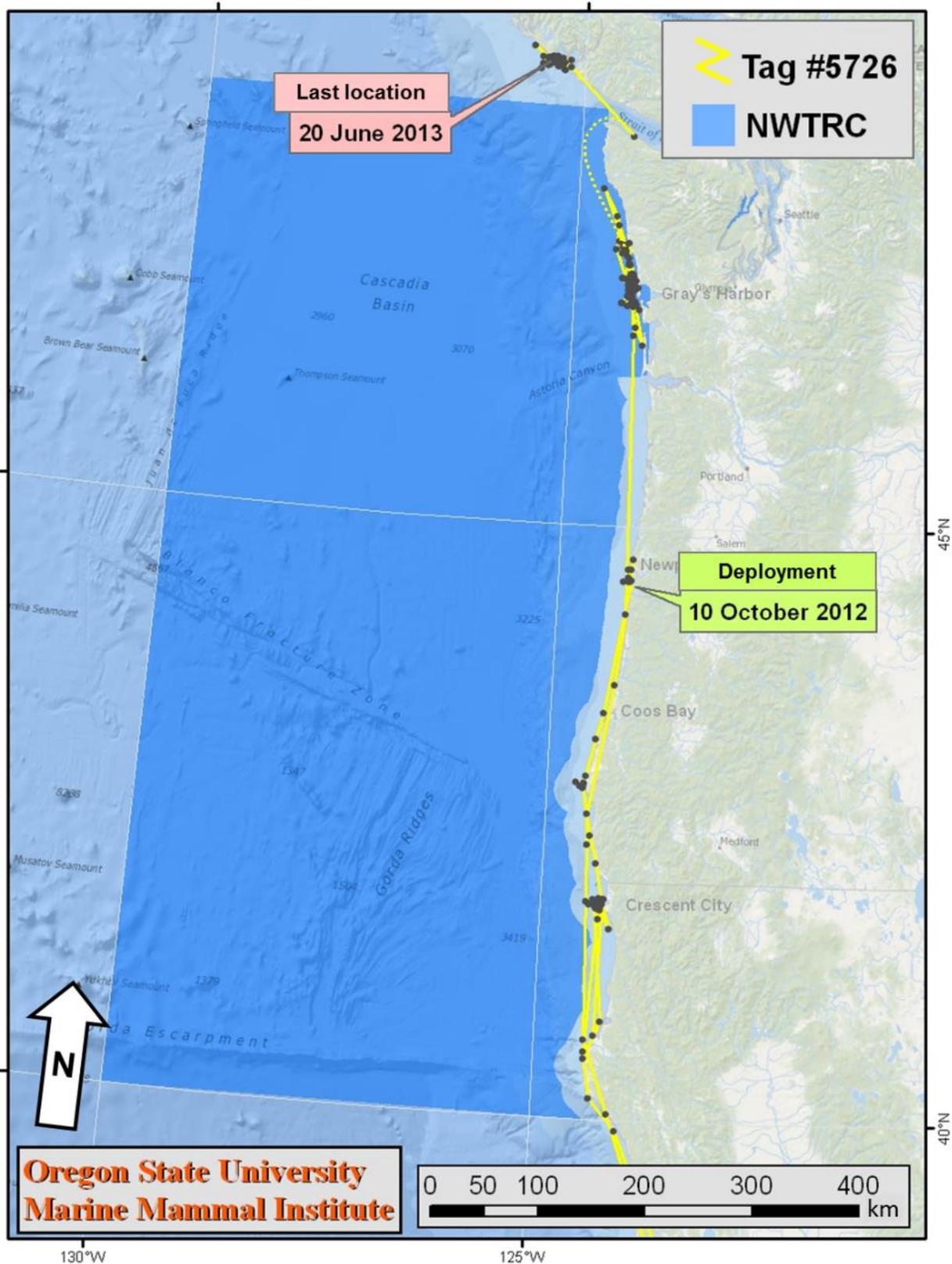
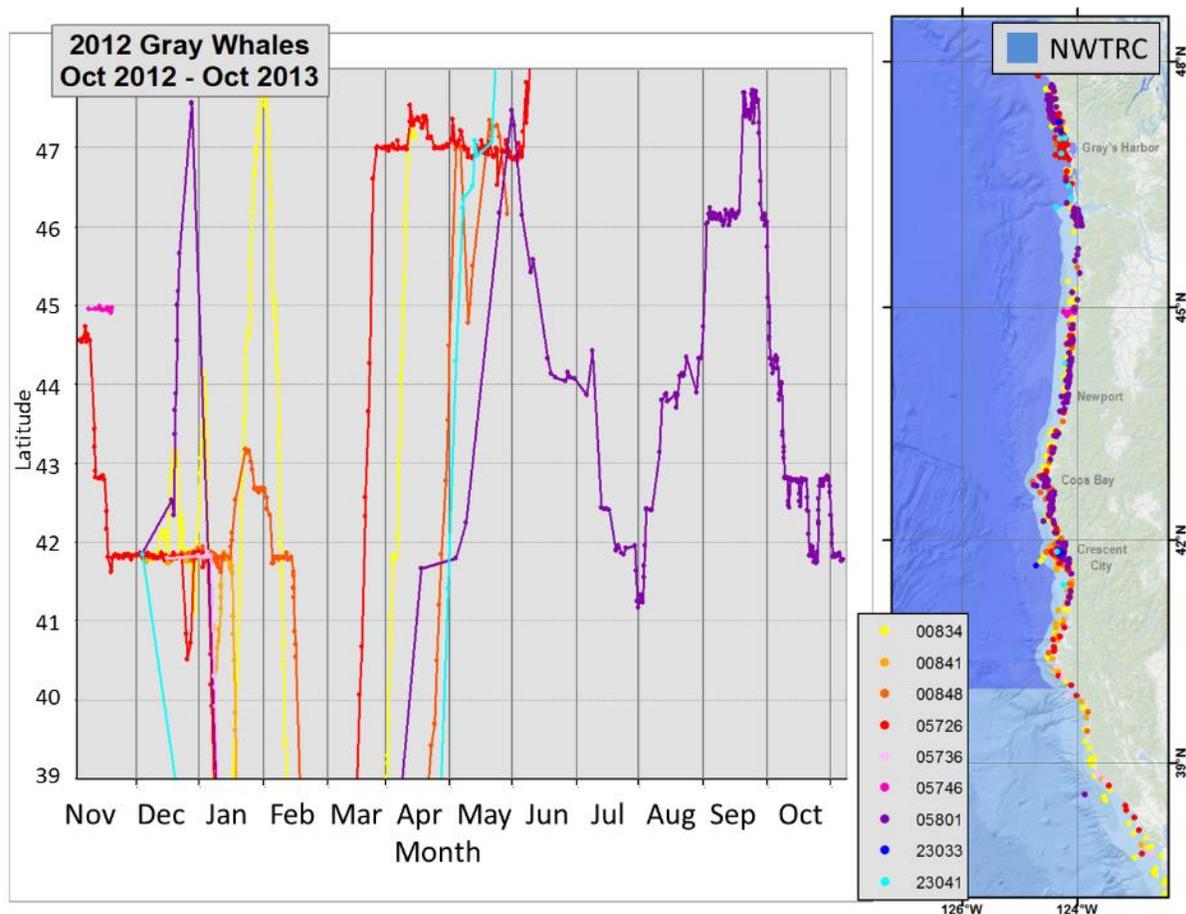


Figure 12. Full movements near the NWTRC (shown in dark blue) of a PCFG gray whale tagged with satellite transmitter #5726 in fall 2012 (updated from Mate [2013]).



**Figure 13. Site tenacity (showing consistency and movement within the feeding range and season) and migratory timing of fall 2012-tagged PCFG gray whales with latitudes plotted vs date (left). The right-side map shows the locations color-coded by tag number to show the coastal nature of tagged whale movements in relation to NWTRC areas (shown in dark blue). This figure has been updated from Mate, 2013 to reflect the complete tracks of whales tagged in 2012.**

## 5. Acknowledgements

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