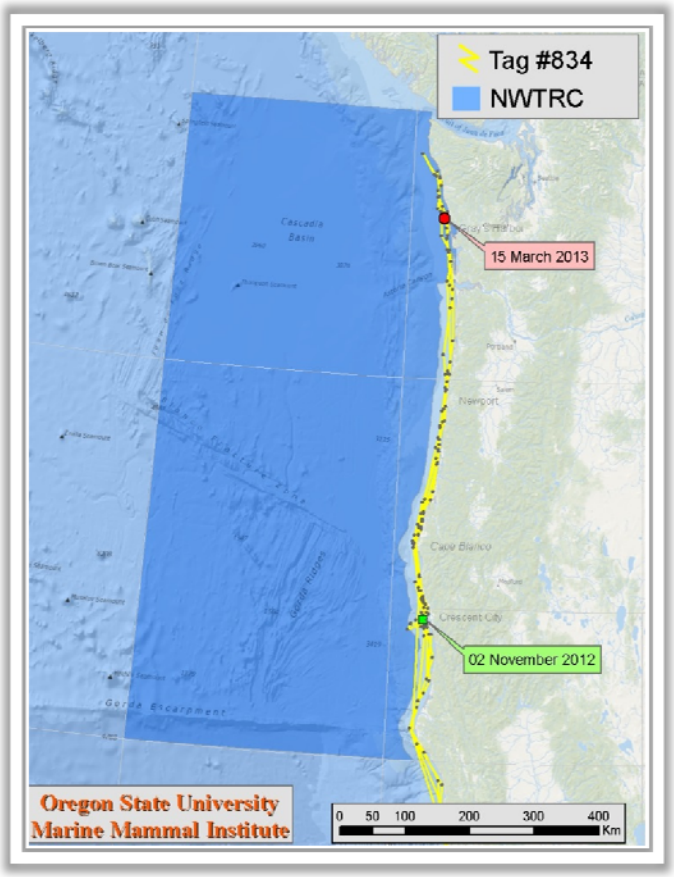
Final Report:
Offshore Gray Whale Satellite Tagging in the Pacific Northwest

Annual Report for Contract No. N62470-10-D-3011 – CTO JP02



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.

Table of Contents

Figures

Tables

Acronyms and Abbreviations

EIS/OEIS	Environmental Impact Statement/Overseas Environmental Impact Statement
km	kilometer(s)
LC	location class
m	meter(s)
Navy	U.S. Navy
NWTRC	Northwest Training Range Complex
OSU	Oregon State University
PCFG	Pacific coast feeding group

1. Offshore Gray Whale Satellite Tagging in NWTRC

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1.1 Introduction

Pacific coast feeding group (PCFG) gray whales are a group of eastern North Pacific gray whales which do not migrate up to the arctic during the summer feeding season. Individuals have been repeatedly sighted 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). This report presents preliminary data from a satellite tagging project conducted to identify PCFG gray whale movements in and around the Pacific Northwest in association with the United States Navy's (Navy) Northwest Training Range Complex (NWTRC).

1.2 Methods

Satellite Tags

All tagging efforts were conducted from a small 7-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 (off northern California and Oregon) and not exhibiting migratory behavior (directed travel south in the late fall). ID photos were taken of all tagged whales and were later compared to PCFG ID catalogues 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 (Bradford et al. 2012). Approaches were made on all available candidate whales but, due to sea state or the whale's response to the vessel, not all approaches were successful. Two types of satellite tags were used: the Telonics ST-15 ultra-high frequency "location only" tags described in Mate et al. (2007) and Wildlife Computer Spot-5 tags. While manufactured differently, the Spot-5 tags were functionally identical to the ST-15 tags, having the same physical configuration (size, shape, and external components) and providing the same form of data. Tags were deployed using an air-powered applicator following the methods described in (Mate et al. 2007). Tags were deployed from distances of 2–4 m with 90–100 psi in the applicator's 70 cc pressure chamber.

The choice of an appropriate transmission period (duty cycle) depends entirely upon the study goals. Since one of the goals for this study was to capture daily movements of PCFG gray whales within the NWTRC, both types of 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. Different duty cycles were used for ST-15 and Spot-5 tags due to different hardware configurations limiting the possibilities for the ST-15. The ST-15 tags were programed to transmit every other day to conserve battery power because having tracks longer than 1 year can be important to determine if individual whales have the same geographic preferences year after year, or whether any differences can be tied to changes in environmental conditions.

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 (> 8 km/hour). Received locations that fell within the latitudinal range of the NWTRC were isolated from animal tracks, water depth, and distance from shore. The number of locations falling inside the NWTRC was then calculated for each tag.

1.3 Results

Argos-monitored satellite radio tags were attached to 11 PCFG gray whales during fall 2012. Three tags were deployed near Newport, Oregon and the rest were deployed near Crescent City, California. Three of the tags deployed were the ST-15 'location only' tags (transmitter made by Telonics [Mesa, Arizona] and assembled at Oregon State University (OSU) with OSU-designed housings) and the other eight were Spot-5 tags (made at Wildlife Computers as a potted transmitter/battery assembly and then fitted at OSU with OSU-designed attachments and entry components).

Messages were received from nine tags, though half had intermittent gaps in their transmissions. As of 12 April 2013 average tag duration was 121 days with four tags still transmitting (**Table 1**). Overall, the locations received to date from 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 on the continental shelf. A total of 129 locations (average of 7 percent of locations per whale), out of all received locations within the NWTRC latitudinal range, 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 (tags 834 and 5726) were responsible for over 92 percent of the locations inside the NWTRC but even they remained on the continental shelf, occupying the northerly portion of the NWTRC where it reaches all the way to the coastline (**Figures 1 A–I, Figure 2)**[1]. The location furthest from shore was 38 km from shore. However, Argos locations are prone to larger longitudinal errors than latitudinal errors (Vincent et al. 2002) as described in the Methods. Thus, the locations further from shore were almost exclusively poor quality locations (**Figure 3**) and all of the good quality locations were within 15 km of shore. It is therefore reasonable to generalize the tagged PCFG gray whales as having a preference for the near-shore in the NWTRC.

[1] Tag deployment date and location is marked in the figures by a green box, and the last received location is indicated by a red circle. Received locations are represented by black circles. All lines indicate only the chronology of sequential transmissions and do not represent the true path of the whale. White dashed lines, however, connect consecutive locations with large gaps (> 2 weeks) between them. These appear to involve an offshore route, but are drawn this way to not obscure the nearshore data (shown as yellow lines) and likewise do not represent the true path of the whale. As of the writing of this report, tags #848, #5726, #5801 and #23041 were still transmitting.

Table 1: Tag deployment dates and tracking duration as of 12 April 2013 for Pacific Coast Feeding Group gray whales tagged with satellite transmitters in the fall of 2012.

PTT	Tag Type	Date Deployed	Most Recent Transmission	# Days Tracked	# Transmission Used	Dist.(km)
00832	SPOT5	14-Nov-12	*tag unresponsive*	0	*n/a*	*n/a*
00834	SPOT5	2-Nov-12	15-Mar-13	132.7	327	10,396
00841	SPOT5	3-Nov-12	20-Dec-12	46.6	150	1,497
00848	SPOT5	2-Nov-12	12-Apr-13*	160.1	177	5,821
05650	SPOT5	14-Nov-12	*tag unresponsive*	0	*n/a*	*n/a*
05801	SPOT5	3-Nov-12	12-Apr-13*	159.3	20	5,115
23033	SPOT5	3-Nov-12	17-Mar-13	133.3	90	5,609
23041	SPOT5	3-Nov-12	12-Apr-13*	159.2	33	4,483
		SPOT5	*Subtotal*	*791.2*	*797*	*32,922*
05726	ST-15	4-Oct-12	12-Apr-13*	189.4	262	6,963
05736	ST-15	15-Nov-12	23-Feb-13	99.7	102	3,158
05746	ST-15	8-Oct-12	20-Oct-12	11.5	12	87
		ST-15	*Subtotal*	*300.6*	*376*	*10,207*
			Total	**1091.8**	**1,173**	**43,129**

* Tag is still transmitting

Table 2: Water depth at each location, distance to shore for each location, and the number of locations recorded inside the NWTRC for portions of Pacific Coast Feeding Group gray whale satellite tracks that fell within the latitudinal range of the NWTRC.

Locations in NWTRC										
Tag#	834	841	848	5801	23033	23041	5726	5736	5746	Average
Count of locations	40	0	3	2	4	1	79	0	0	14
% of all locations	13%	0%	2%	10%	4%	3%	31%	0%	0%	7%
Water Depth (m) at Locations of Transmission										
Minimum	4.69	0.00	31.07	19.30	13.40	15.96	10.77	0.00	0.00	10.58
Maximum	707.52	0.00	44.16	32.22	841.08	15.96	43.75	0.00	0.00	187.19
Mean	39.29	0.00	39.63	25.76	226.49	15.96	23.03	0.00	0.00	41.13
ST Dev	107.59	0.00	6.06	6.46	354.88	0.00	7.61	0.00	0.00	53.62
Distance to shore (km) at Locations of Transmission										
Minimum	0.78	0.00	6.85	5.09	2.68	3.30	2.49	0.00	0.00	2.35
Maximum	30.66	0.00	12.57	11.11	38.08	3.30	13.66	0.00	0.00	12.15
Mean	6.34	0.00	10.64	8.10	12.99	3.30	5.50	0.00	0.00	5.21
Standard Deviation	4.86	0.00	2.68	3.01	14.55	0.00	2.05	0.00	0.00	3.02

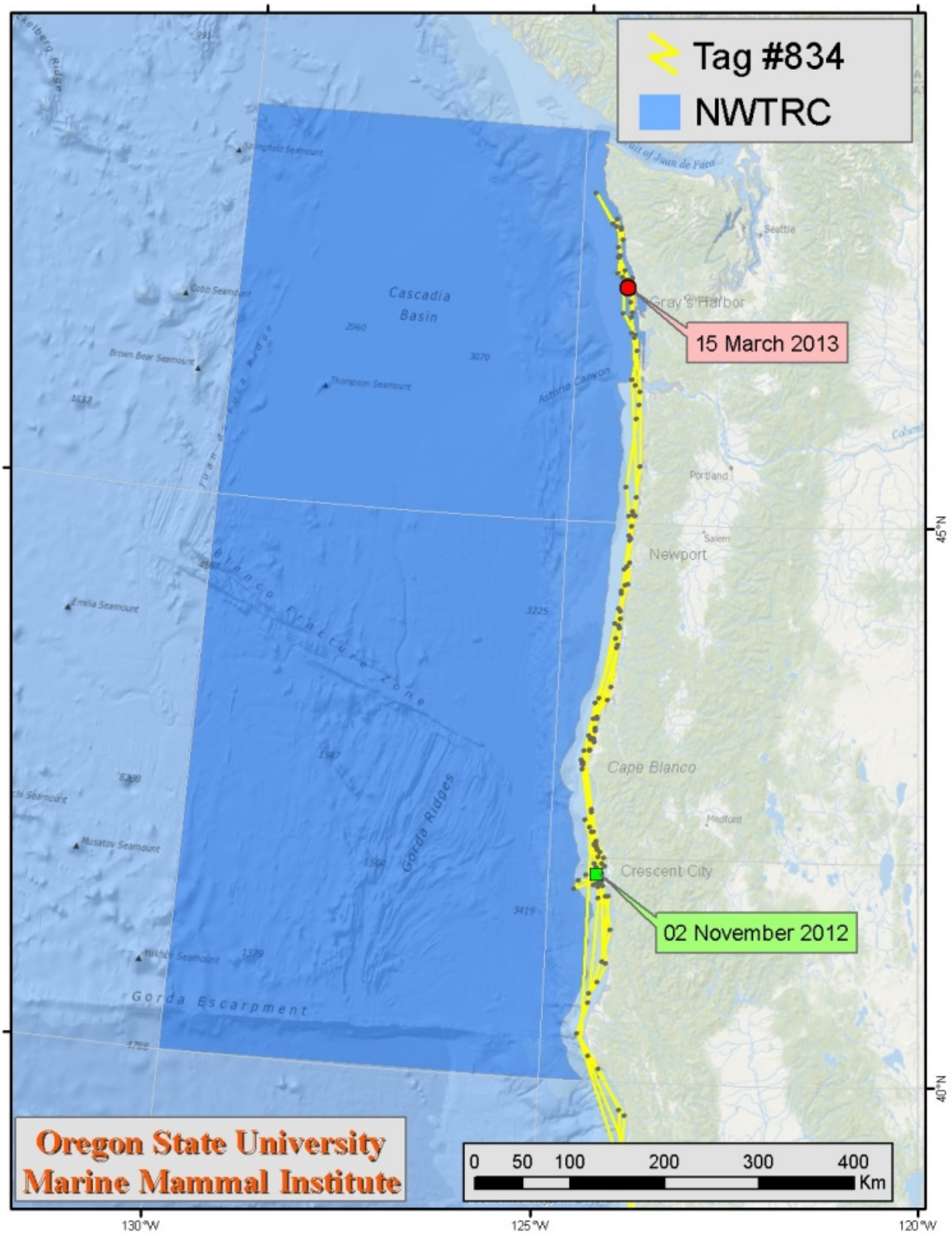

Figure 1A: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #834.

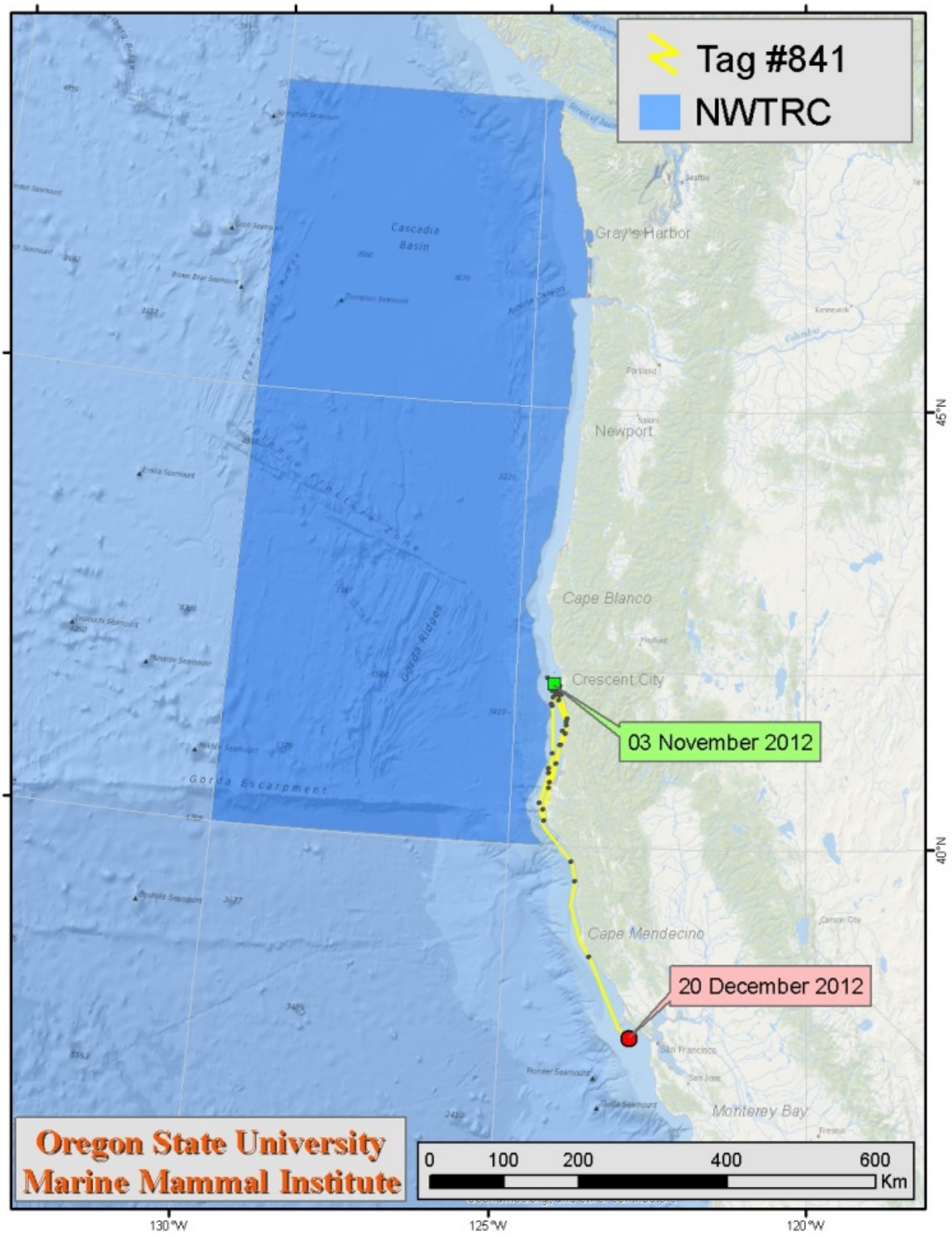

Figure 1B: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #841.

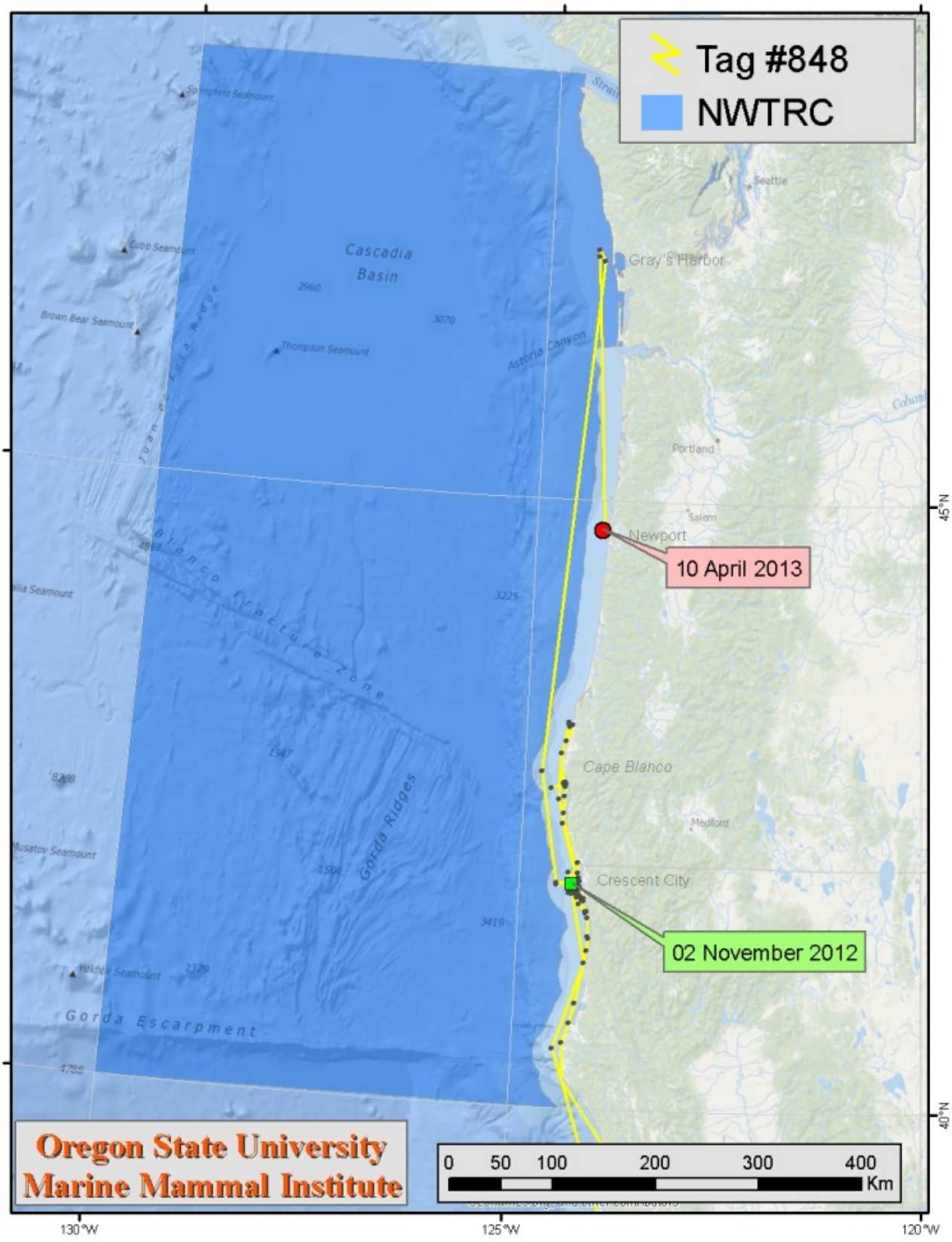

Figure 1C: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #848.

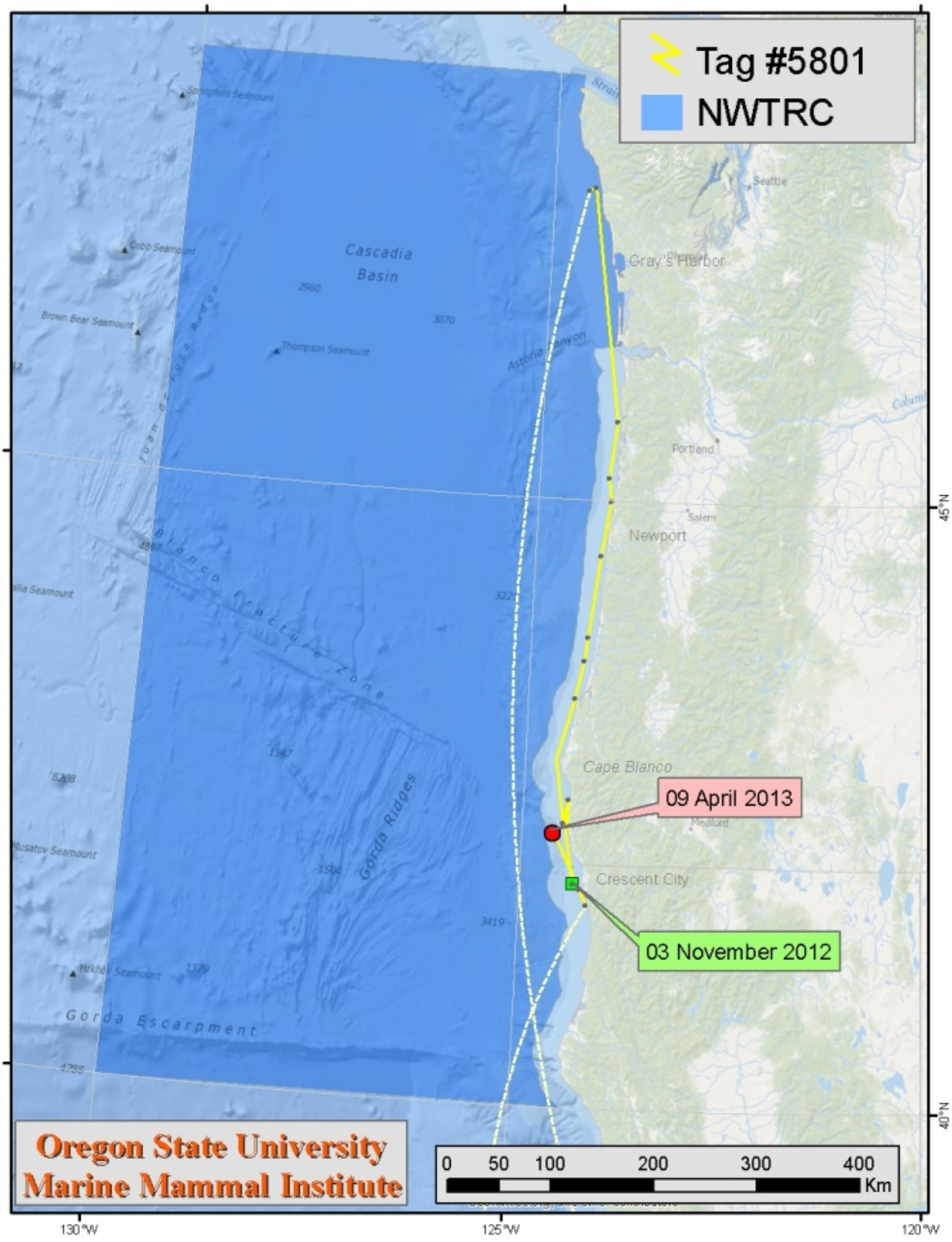

Figure 1D: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #5801

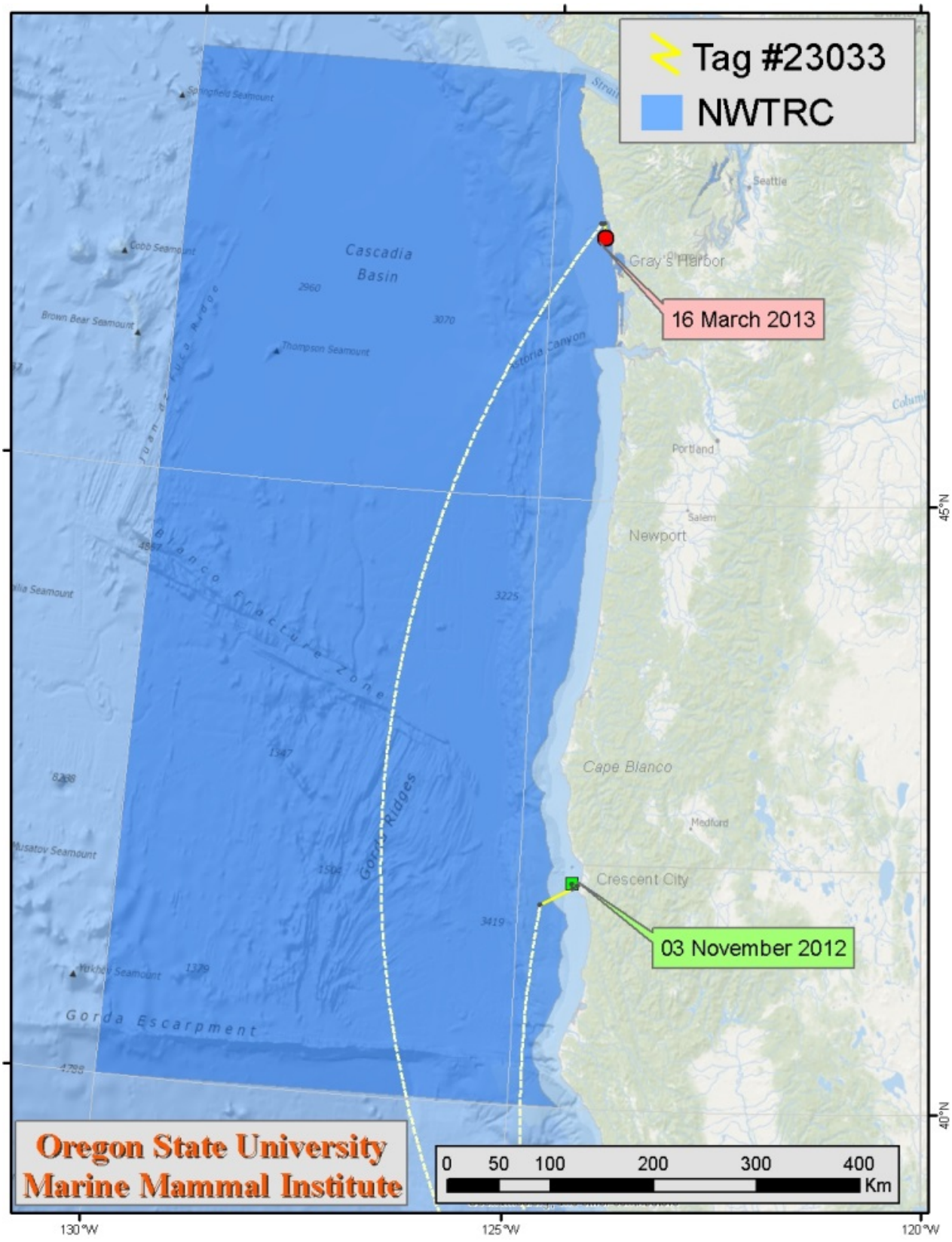

Figure 1E: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #23033.

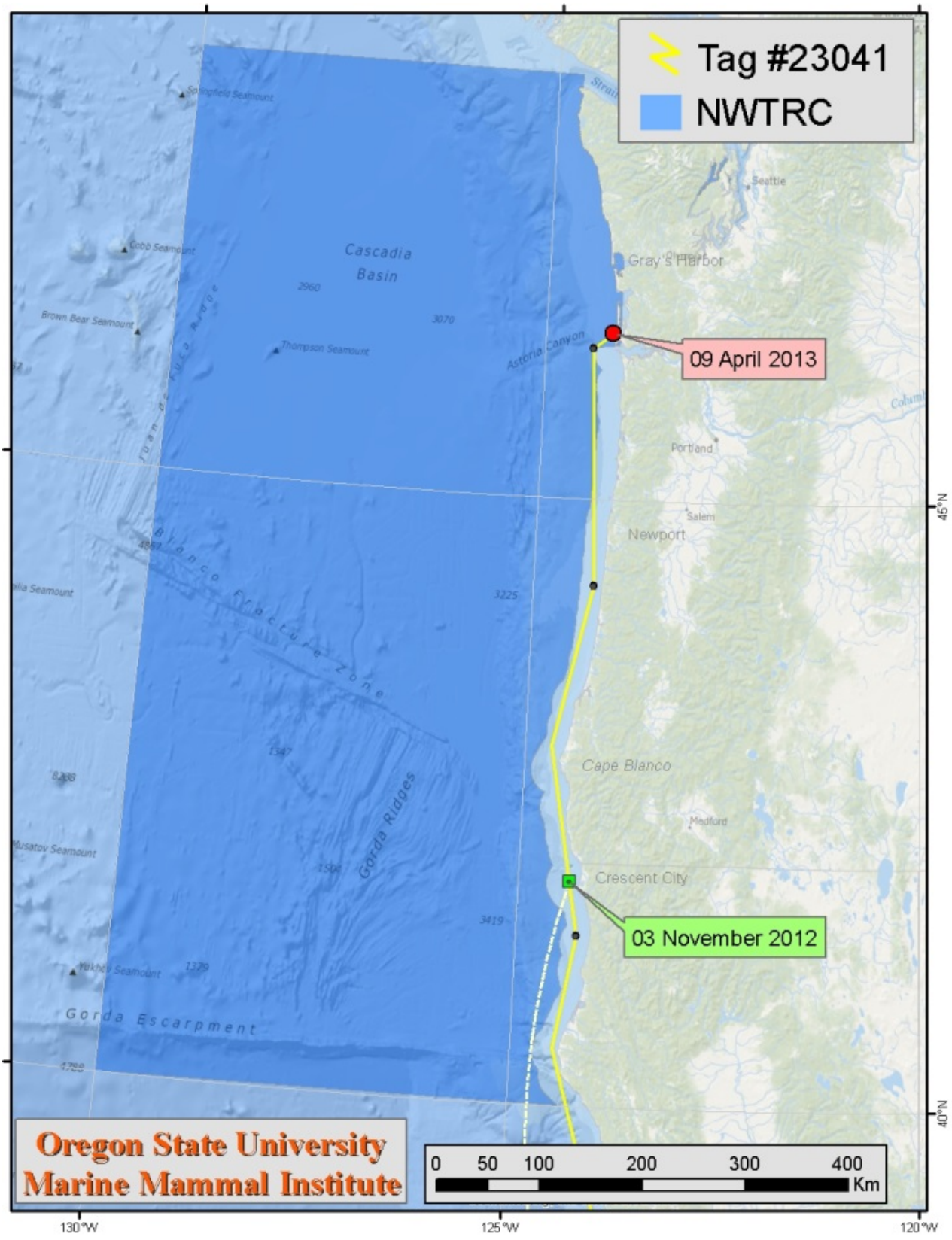

Figure 1F: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #23041.

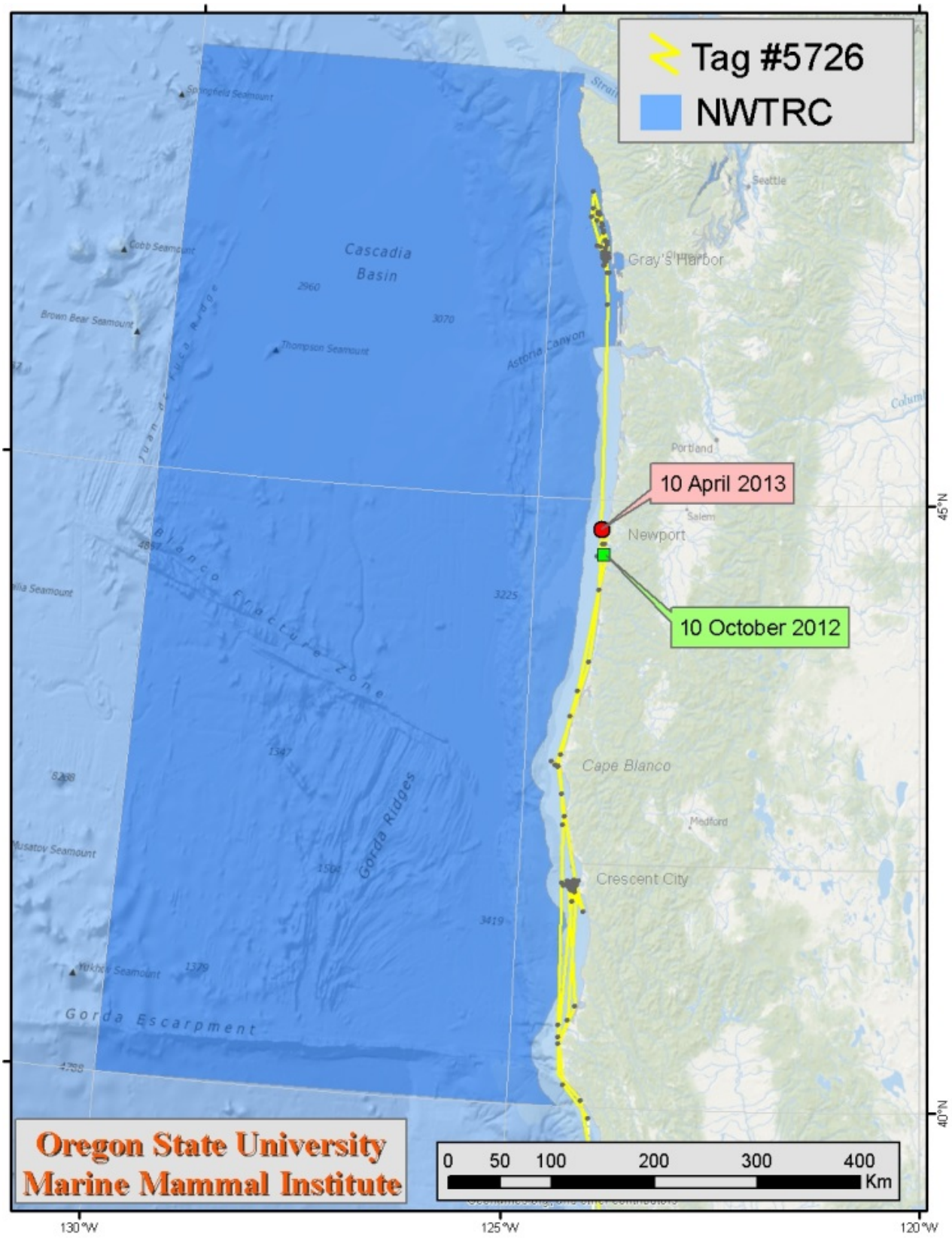

Figure 1G: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #5726.

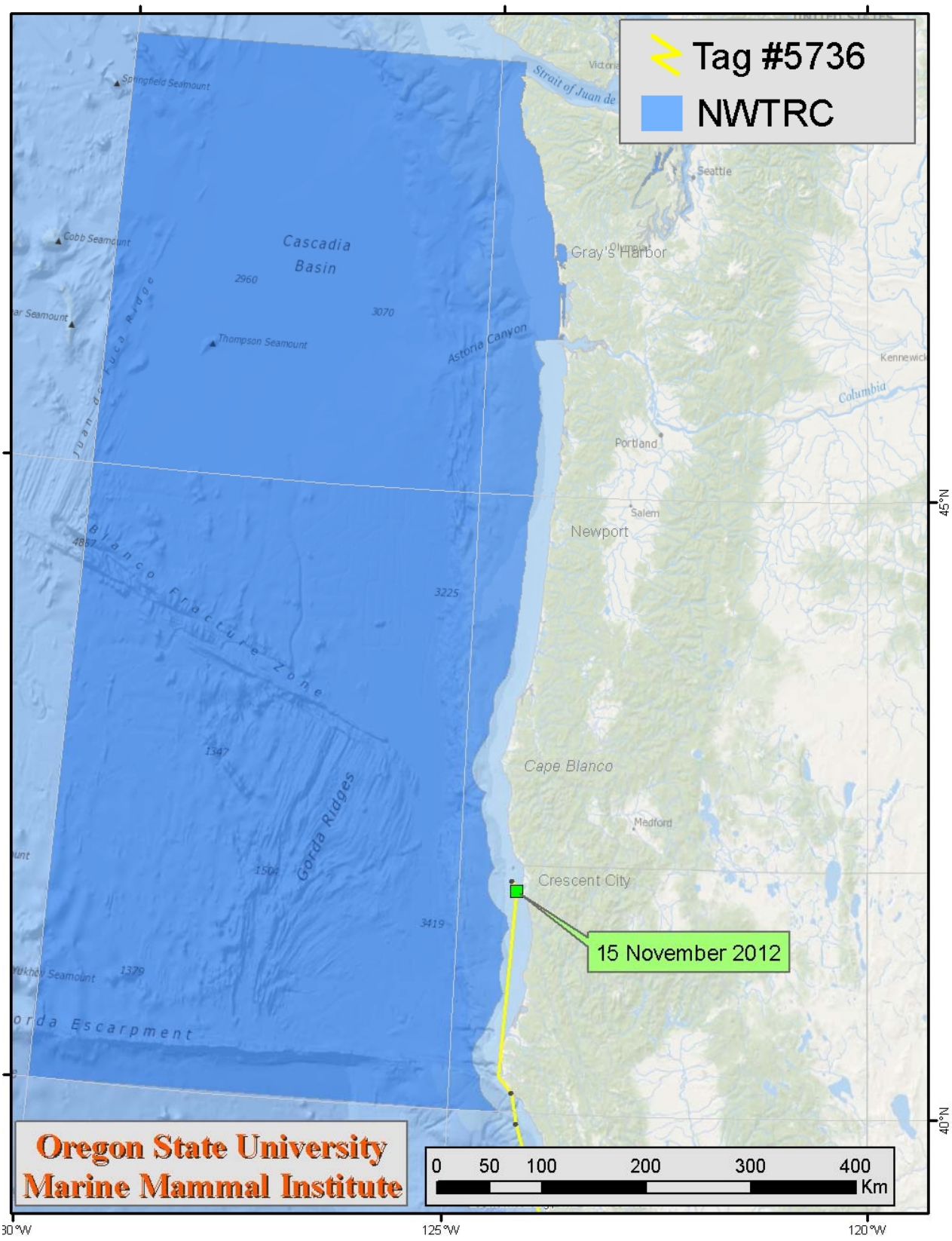

Figure 1H: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #5736.

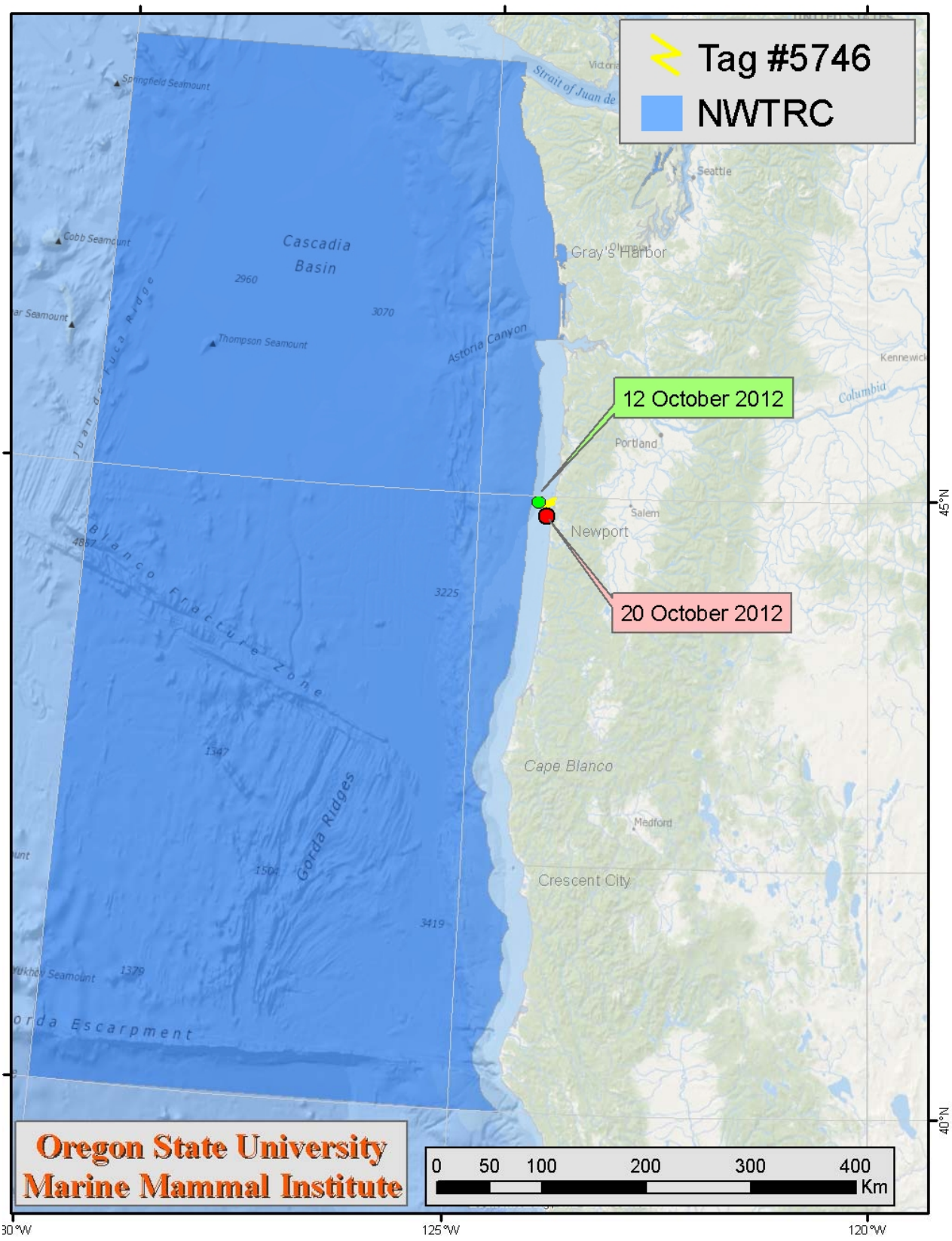

Figure 1I: Movements near the NWTRC of a Pacific coast feeding group (PCFG) gray whale tagged with satellite transmitter #5746.

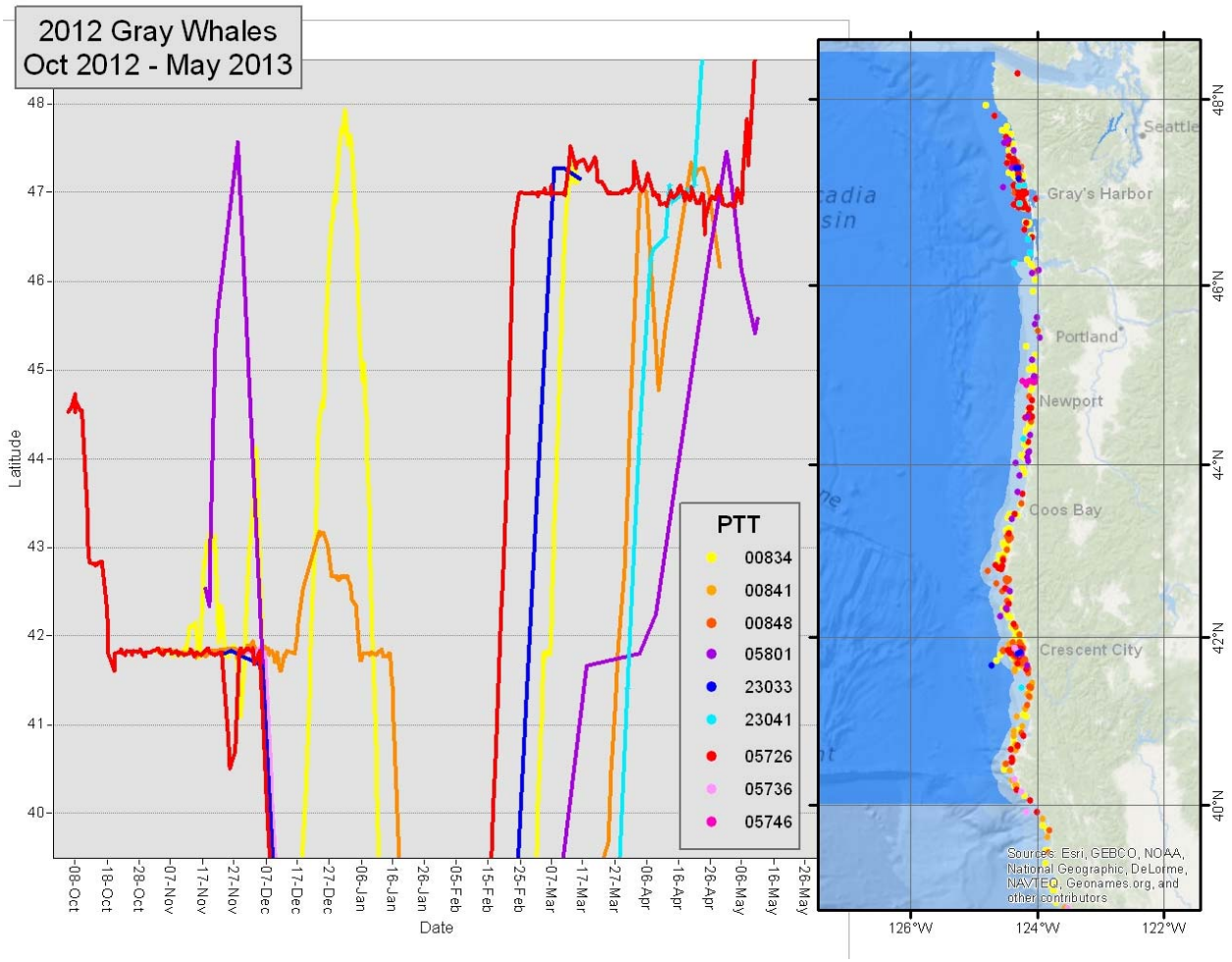

Figure 2: Latitude of locations from Pacific coast feeding group (PCFG) gray whales tagged with satellite transmitters plotted vs. date (a map of the locations is shown on the right side of the figure).

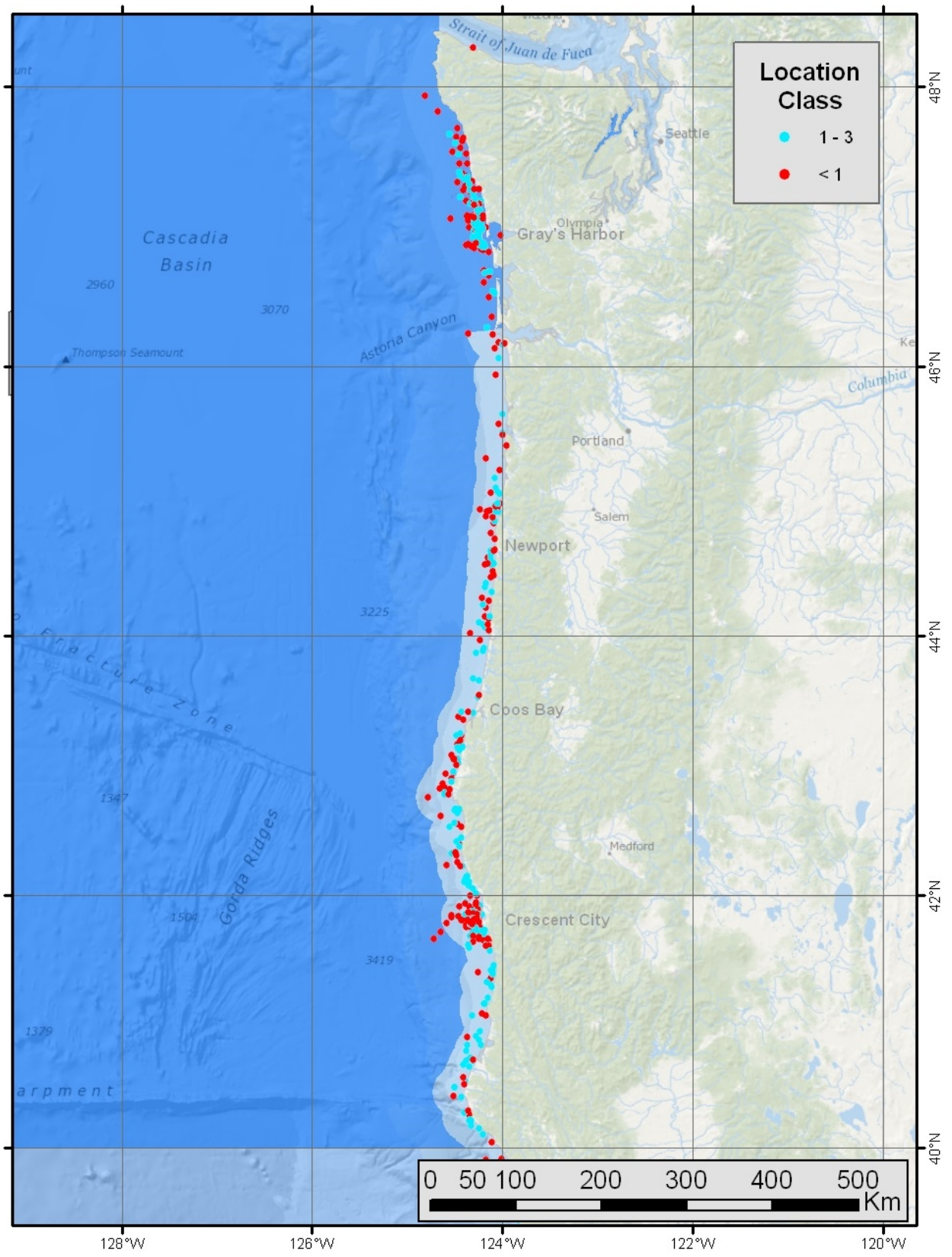

Figure 3: Locations from Pacific coast feeding group (PCFG) gray whales tagged with satellite transmitters (blue dots = high quality locations, red dots = low quality locations).

1.4 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 seven of the tagged whales and was characterized by continuous near-shore movement southward until the whales had left the NWTRC boundary area. We received locations from six of the tags in the NWTRC the following spring. Northward migratory travel 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.

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 their strong preference for near-shore habitat, it is likely 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. These lines were drawn in the offshore area merely to avoid obscuring nearshore data.

In conclusion, the whales that were tagged showed very strong preference for shallow, near-shore habitat and never ventured far from shore. They 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.

1.5 Acknowledgements

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