Summary of Tag Deployments on Cetaceans off Washington May 2010 to May 2013

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Prepared by:

Greg Schorr,
Erin Falcone, and
John Calambokidis,
Cascadia Research,
218 1/2 W 4th Ave.,
Olympia, WA 98501

Prepared for:

Commander, Pacific Fleet
Pearl Harbor, Hawaii

Submitted to:

Naval Facilities Engineering Command,
Northwest (NAVFAC NW)
Silverdale, WA 98315-1101

Naval Facilities Engineering Command,
Pacific (NAVFAC PAC)
Pearl Harbor, HI 96860-3134

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Photo credit:

Two fin whales (*Balaenoptera physalus*), one with LIMPET tag attached to dorsal fin, in waters off Washington State, 19 July 2012. Taken by John Calambokidis, Cascadia Research, under NOAA Permit No. 16111.

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Acronyms and Abbreviations

hr	hour(s)
km	kilometer(s)
LIMPET	Low Impact Minimally Percutaneous External Transmitter
m	meter(s)
min	minute(s)
Navy	U.S. Navy
NOAA	National Oceanic and Atmospheric Administration
PCFG	Pacific Coast Feeding Group
U.S.	United States
WDFW	Washington Department of Fish and Game
NWTRC	Northwest Training Range Complex
OBS	ocean bottom seismometers

1. Introduction

The United States (U.S.) Navy (Navy) provided support for the purchase of satellite tags to be deployed opportunistically during other ongoing projects by Cascadia Research.

This report summarizes the results of deployments within the Northwest Training Range Complex (NWTRC) conducted in conjunction with existing survey efforts off Washington and also includes results from additional deployments on the same species funded with other sources and which are best reported together.

The Navy has designated a number of areas for use in training operations along the West Coast. Much of the NWTRC and the W-237 warning area (**Figure 1**) include habitat that is important to a number of marine mammal species (e.g. Calambokidis et al. 2004, Wiles 2004, Schorr et al. 2011). Much of the NWTRC falls in remote areas where data collection can be very difficult. There is a paucity of information concerning the population identity, density, seasonality, and movements of many of these species in and around designated ranges. These include several cetacean species and populations which are federally listed as endangered or threatened, and thus detailed knowledge of their movements and habitat use in these training ranges is of great importance.

Recent developments in the field of cetacean satellite telemetry have improved the collection of medium to long term movements, habitat use, and in some cases diving behavior, of whales and dolphins. These methods are particularly valuable in regions where remoteness and/or predominantly poor weather conditions limit the utility of stand-alone visual surveys.

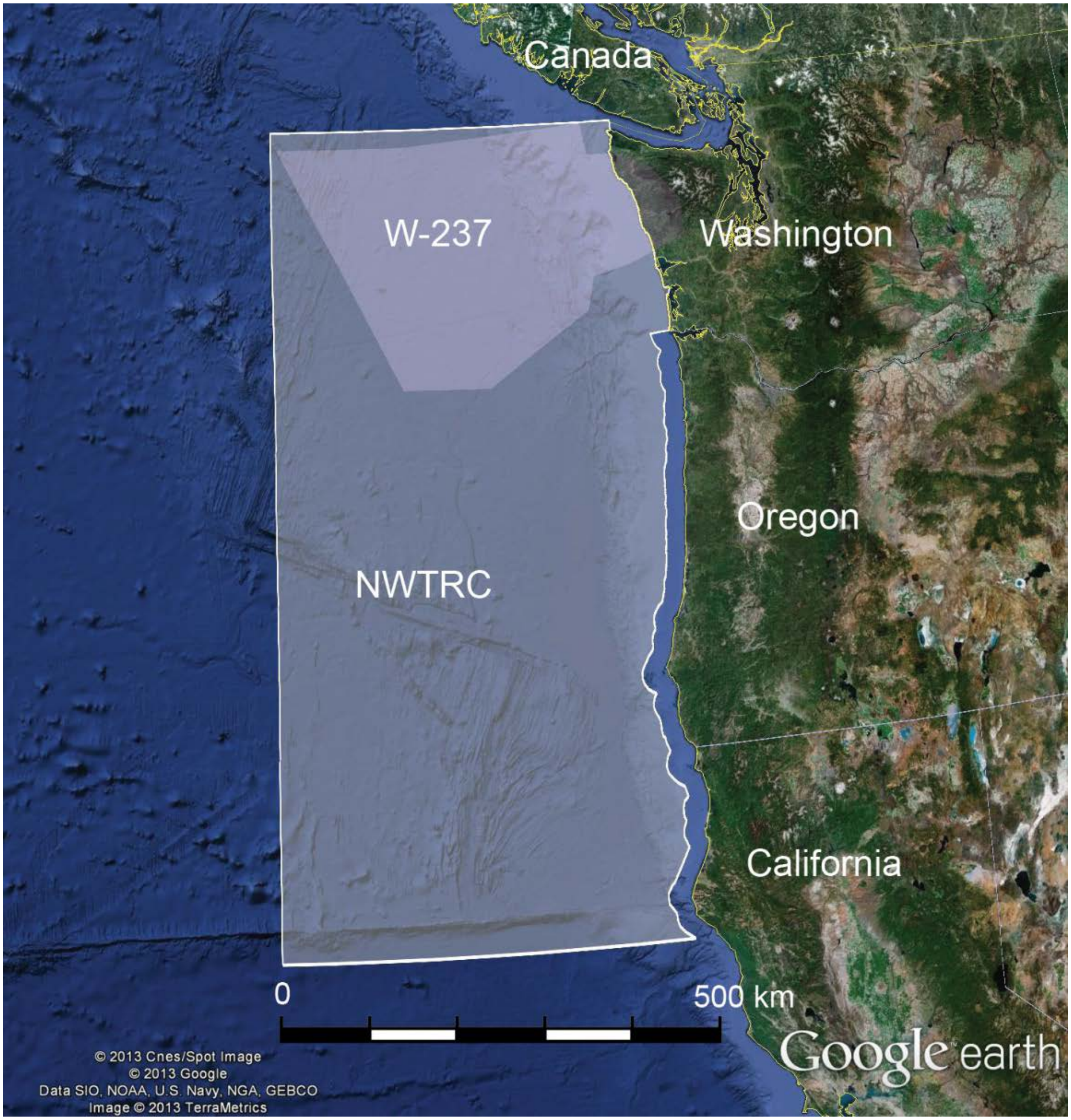

Figure 1. Overview map.

The boundary of the NWTRC is outlined in white and shaded white, the W-237 warning area, where most ship-based training occurs, is highlighted in pink.

2. Materials and Methods

Vessels departed from Westport in Grays Harbor and La Push, WA. Small boat surveys were conducted using 6–7 meter (m) rigid-hulled inflatable boats specifically modified for tagging operations. Satellite tags were deployed during field efforts associated with grants for fin whale research from the National Oceanic and Atmospheric Administration (NOAA)/Alaska Regional Office and the Southwest Fisheries Science Center, and a collaborative project with the Washington Department of Fish and Wildlife (WDFW) addressing marine mammal distribution and habitat use off Oregon and Washington.

The tags used were the Andrews-style LIMPET (Low Impact Minimally Percutaneous External Transmitter, (see Andrews et al. 2008 and Schorr et al. 2009 for details), in either the location-only Spot5 configuration or the location/dive data Mk10-A configuration (Wildlife Computers, Redmond, Washington). Tag programming was species-specific, with transmission schedules based on surfacing behavior and transmission data from previous deployments, where available. Attachment durations for this type of tag vary both within and between species; however, attachments of up to 220 days have been observed for this tag (Cascadia Research, unpublished data). Thus, programming included a duty cycle to maximize high resolution movement data during the expected attachment period (usually daily for 50 days), then transmit intermittently to prolong battery life while providing lower resolution data should the tag remain in place for longer periods. The duty cycle usually transitioned from daily to every other day, then every third day, and finally every fifth day for the longest deployments.

Data was obtained from the Argos system and processed with the Douglas Argos-Filter v. 7.08 (available at http://alaska.usgs.gov/science/biology/spatial/douglas.html) using two independent methods: distance between consecutive locations, and rate and bearings among consecutive movement vectors. Argos positions from the highest location classes (3 and 2) were automatically retained given the small positional error associated with these classes. Maximum rate of movement between consecutive points was set at 10 kilometers/hour (km/hr) for gray, 15km/hr for humpback and 20 km/hr for fin and killer whales (Douglas et al. 2012, author's personal experience). Depth, slope, distance from shore, and determination of points inside specific training ranges were determined for all locations which passed the Douglas Argos-filter in Mysticetus (Entiat River Technologies, Preston, Washington).

3. Results and Discussion

During the course of field work associated with the projects mentioned above, a total of 21 tags were deployed on four different species off the Washington coast (one tag was lost), ten of which were Navy-funded under this contract. Sixteen of these tags were location-only and five provided location/depth. Transmission durations ranging from 0–72 days, though one tag deployed in March 2013 is still transmitting (**Tables 1, 2**). Average species-specific tag duration was 19.2 days (range = 1.3–71.6, n = 11) for fin whales, 4.7 (range = 2.9–6.8, n = 3) for gray whales, 8.1 (range = 2.5–15.6, n = 5) for humpback whales, and 41.5 (range = 6.3–76*, n = 2 with one tag still transmitting) for killer whales.

Table 1. Deployment summary for LIMPET satellite tags off Washington 2010–2013.

Two tag types deployed: Location only (L), and a Location and Dive-Depth recording tag (L/D).

Species	Tag ID	Date Deployed	Transmission Duration (Days)	Latitude Deployed	Longitude Deployed	Tag Type	Deploy Funder
Gray Whale	Er Tag 001	5/31/2012	2.9	47.97	-124.71	L	Navy/WDFW Sec 6
Gray Whale	Er Tag 002	5/31/2012	4.4	47.98	-124.72	L	Navy/WDFW Sec 6
Gray Whale	Er Tag 003	5/31/2012	6.8	47.98	-124.72	L	Navy/WDFW Sec 6
Humpback Whale	Mn Tag 002	9/6/2011	11.4	46.91	-124.75	L	Navy/WDFW Sec 6
Humpback Whale	Mn Tag 003	5/31/2012	2.5	46.50	-124.98	L/D	Navy/WDFW Sec 6
Humpback Whale	Mn Tag 004	5/31/2012	6.8	48.13	-125.15	L/D	Navy/WDFW Sec 6
Humpback Whale	Mn Tag 005	6/15/2012	15.6	47.97	125.39	L/D	Navy/WDFW Sec 6
Humpback Whale	Mn Tag 006	7/19/2012	4.3	46.86	-124.63	L/D	Navy/WDFW Sec 6
Fin Whale	Bp Tag 017	5/6/2010	2.4	46.88	-125.09	L	NOAA
Fin Whale	Bp Tag 018	5/6/2010	71.6	46.81	-124.97	L	NOAA
Fin Whale	Bp Tag 019	5/6/2010	4.9	46.81	-124.99	L	NOAA
Fin Whale	Bp Tag 020	5/9/2010	23.7	46.41	-124.92	L	NOAA
Fin Whale	Bp Tag 023	2/10/2011	27.0	46.49	-124.90	L	NOAA
Fin Whale	Bp Tag 024	2/10/2011	4.1	46.72	-124.94	L	NOAA
Fin Whale	Bp Tag 025	2/10/2011	3.9	46.72	-124.93	L	NOAA
Fin Whale	Bp Tag 044	7/19/2012	23.5	46.95	-124.99	L	Navy/WDFW Sec 6
Fin Whale	Bp Tag 054	3/9/2013	6.7	46.54	-124.78	L	Navy/WDFW Sec 6
Fin Whale	Bp Tag 055	3/9/2013	1.3	46.49	-124.85	L	Navy/WDFW Sec 6
Fin Whale	Bp Tag 056	3/9/2013	42.3	46.50	-124.78	L	Navy/WDFW Sec 6
Killer Whale	**Oo Tag 038**[a]	3/8/2013	**76.0**[a]	46.86	-124.91	L	Navy/WDFW Sec 6
Killer Whale	Oo Tag 041	3/8/2013	6.3	46.91	-124.80	L/D	Navy/WDFW Sec 6

Notes:

[a] Tag is still transmitting. Transmission duration calculated as of 23 May 2013.

[b] Four additional tags purchased under the HDR/Navy Task Order were used in SOCAL in September 2011 for Risso's dolphins, but are not included in this report.

Table 2. Movement and habitat use details by Tag ID.

% Locations (Locs) were calculated for the Northwest Training Range (NWTRC) and W-237 warning area. Cumulative minimum horizontal displacement is likely an under representation of the true distance covered by an individual, as it is calculated as a straight line between Argos locations and does not account for any vertical displacement (diving).

Tag ID	No. Locations which passed the filter	%Locs In NWTRC	%Locs In W237	Cumulative minimum horizontal displacement (km)	Median distance to deployment (km) (max)	Median Depth (m) (Range)	Median Slope (degrees) (Range)	Median Distance to shore (km) (Range)
Er Tag 001	31	100%	100%	57	2 (5)	28 (9-32)	0.4 (0-4)	1.1 (0.2-3)
Er Tag 002	62	100%	100%	162	3 (10)	29 (1-34)	0.1 (0-4.4)	1.3 (0-6.3)
Er Tag 003	93	100%	100%	203	3 (22)	30 (5-39)	0.1 (0-14.5)	1.7 (0.1-7.3)
Mn Tag 002	115	100%	52%	721	27 (134)	373 (99-1628)	1.1 (0-14.3)	56.6 (28.7-82.2)
Mn Tag 003	27	100%	22%	92	19 (38)	1480 (1003-1916)	2.5 (0.1-14.3)	82.5 (71.3-93.1)
Mn Tag 004	111	88%	47%	509	33 (92)	160 (39-499)	0.4 (0-12.4)	22.4 (7.7-47.7)
Mn Tag 005	212	100%	100%	767	88 (119)	189 (80-1214)	0.9 (0-41.7)	45.6 (22.4-63.7)
Mn Tag 006	61	100%	79%	291	40 (78)	103 (41-220)	0.2 (0-5.6)	32.8 (13.9-41.2)
Bp Tag 017	31	35%		129	12 (40)	796 (628-2067)	1.4 (0.1-33.8)	74.2 (65.4-116.9)
Bp Tag 018	196	27%	8%	5444	1688 (1971)	1903 (432-4680)	1.9 (0-37)	100.2 (31.4-340.6)
Bp Tag 019	0	-		-	-	-	-	-
Bp Tag 020	235	100%	0%	1835	447 (647)	2673 (645-3150)	0.9 (0-50.3)	75.1 (35.7-139.1)
Bp Tag 023	161	16%	5%	1750	366 (539)	1903 (139-2515)	2.3 (0-15.7)	67.7 (32.2-133.5)
Bp Tag 024	0	-		-	-	-	-	-
Bp Tag 025	11	100%	64%	247	57 (208)	1076 (570-2537)	3.7 (0.8-26)	67.2 (60.4-127.5)
Bp Tag 044	265	100%	3%	1854	329 (487)	2487 (420-3916)	1.3 (0-46.5)	94.6 (52.6-212.6)
Bp Tag 054	78	100%	0%	489	132 (163)	424 (204-1594)	0.7 (0-13)	45 (25.9-74.9)
Bp Tag 055	18	100%	0%	96	13 (25)	1273 (826-2012)	2.5 (0.1-16)	72 (57.1-86.4)
Bp Tag 056	265	100%	75%	2016	68 (114)	1316 (196-2173)	2.7 (0.1-55)	72.0 (37-122)
Oo Tag 038[a]	345	35%	8%	8665	1195 (2187)	213 (4-3409)	0.6 (0-20.7)	45.1 (0.6-224.8)
Oo Tag 041	104	94%	0%	680	211 (469)	413 (64-3077)	0.2 (0-9.4)	53.8 (7.2-110.6)

Note: [a]Tag is still transmitting, so movement and habitat use details are subject to change. Details for these animals were calculated through 23 May 2013.

Gray Whales

Three gray whales were tagged near La Push, Washington with location-only tags on 31 May 2012. Tags transmitted for 3–7 days (**Table 1, Figure 2**). Many gray whales preferentially feed on their right side (Woodward and Winn 2006), so all tagging was done on the left side of the dorsal ridge to reduce the risk of tag dislodgment during feeding. While follow up photographs were not obtained directly after transmissions ceased, it is likely that the foraging behavior of gray whales led the tags to be physically removed by contact with the bottom despite left-side placement.

These gray whales were of particular interest because the timing of deployments were still within the migration period but there was a concentration of whales in this area north of La Push that appeared to be feeding. While the duration of the transmissions (3–7 days) was fairly short, they did confirm these whales were not migrating and almost exclusively stayed in a very localized area consistent with feeding. One whale did shift slightly north to the area off Cape Alava, another known gray whale feeding area, before transmissions ended. All the tagged whales remained very close to shore throughout the transmission period, and in a median water depth of 29 m (**Table 2**) also consistent with a feeding depth for gray whales (Calambokidis et al. 2004).

A feeding aggregation of about 200 gray whales, sometimes called seasonal residents and more recently the Pacific Coast Feeding Group (PCFG), feed in the Pacific Northwest from northern California to SE Alaska in spring through fall (Calambokidis et al. 2002, 2011). Recent genetics analysis has revealed significant differences in mtDNA haplotype distributions between PCFG and other gray whale feeding areas farther north (Frasier et al. 2011, Lang et al. 2011, in prep). Generally a 1 June cut-off has been used to separate the time period of likely PCFG whale presence from that of migrating gray whales, although clearly there is overlap among these. Two of the whales that were tagged were known by photo-identification: 1) CRC-813, a known PCFG whale with more than 57 confirmed sightings going back to 2004, and seen every year since in the Pacific Northwest primarily off the northern Washington coast, the Strait of Juan de Fuca and southern Vancouver Island; and 2) CRC-1176 a known individual but not confirmed to be part of the PCFG, seen previously in 2009 in spring off south and west Vancouver Island, and in January 2011 off northern California (Cascadia Research, unpublished data).

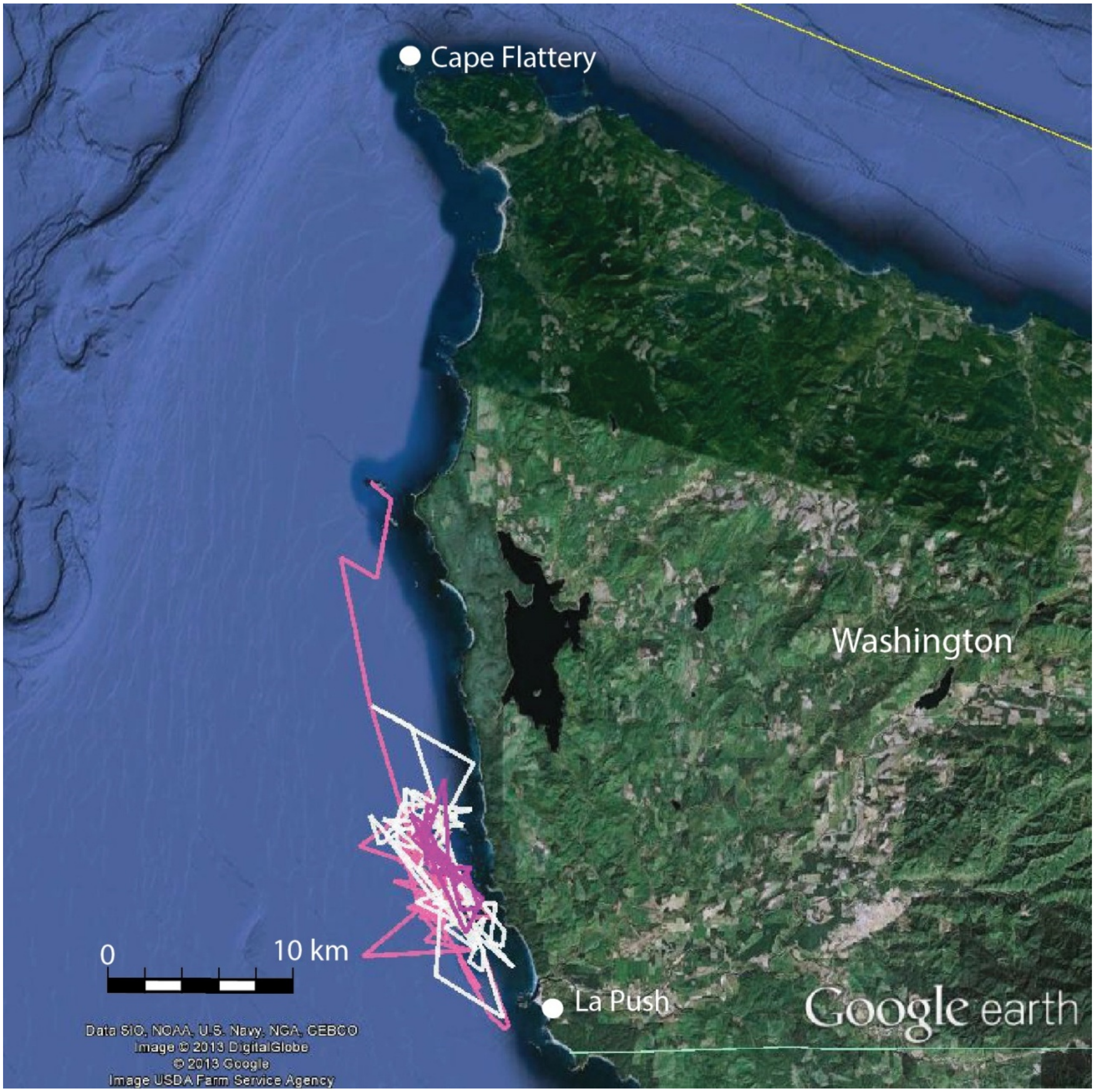

Figure 2. Map showing movements of three gray whales tagged near the northern tip of Washington.

Humpback Whales

Five humpback whales were tagged in 2011 and 2012. Median transmission duration was 7 days (range = 3–16). Two tags were deployed offshore of La Push, and three were deployed offshore of Westport. Movement data suggests individuals spent time both on and off the shelf edge (**Figure 3**). Grand median water depth utilized was 189 m (range = 39–1,916), and distance to shore was 46 km (range = 8–93) (**Table 2**). Individuals spent between 0 and 79 percent of their time within the Navy's W-237 warning area.

Four of the tags deployed were dive reporting Mk10-A LIMPET tags, recording a total of 20 days of dive data in addition to movements. Dives were recorded only if they exceeded 20 m in depth and 1 minute (min) in duration, resulting in 2,850 dives (**Table 3**). Grand mean dive depth was 51.8 m (range = 18.3–81) with a maximum dive depth of 272 m. Grand mean dive duration was 3.9 min (range = 2.4–6.7); the longest dive recorded was 15.1 min. The time between qualifying dives (Surface Duration) averaged 6.3 min, with a maximum time between dives of 5.4 hours (**Table 3, Figure 4**).

Table 3. Behavior log summary details by Tag ID from the Mk10-A tagged humpback whales.

Tag ID	*N*	Dive Depth (m)			Dive Duration (min)			Surface Duration (min)		
		Average	*Sd*	Max.	Average	*Sd*	Max.	Average	*Sd*	Max.
Mn Tag 003	165	183	9.1	68	2.4	0.9	5.2	4.6	7.6	58.4
Mn Tag 004	400	81.2	61.7	256	6.7	3.2	15.1	9.3	22.7	223.6
Mn Tag 005	1855	80	67.1	272	4.0	2.5	12.5	6.0	20.8	321.0
Mn Tag 006	430	27.7	12.9	132	2.7	1.5	9.7	5.1	11.3	86.8

Humpback whale feeding areas extend from California north to Alaskan waters and over to the western North Pacific generally on shelf and slope waters (Calambokidis et al. 2008, Barlow et al. 2011, Rosa et al 2012). These somewhat discrete feeding aggregations show little interchange based on photo-ID (Calambokidis et al. 2008) and genetics (Baker et al. 1998, 2008) although whales sometime migrate to overlapping winter breeding areas (Calambokidis et al. 2001 and 2008). Humpback whales off California and Oregon appear to be part of one feeding aggregation that is fairly distinct from an aggregation that feeds off Washington and southern British Columbia (Calambokidis et al. 1996, 2000, 2001, 2004, and 2008).

The feeding area off Washington has not been as well studied as off California and the current satellite tag data provide important information on habitat use. While the tag deployment durations were short, a common problem with tags deployed on humpback whales, the data gathered illustrate the association between humpback whales and the shelf and shelf edge as well as some of the underwater canyons especially the Juan de Fuca Canyon off northern Washington, similar to previous vessel-based surveys (Calambokidis et al. 2004 and 2011). The behavior logs from the depth satellite tags also provide some of the first data on feeding behavior of humpback whales in this region (**Table 3**).

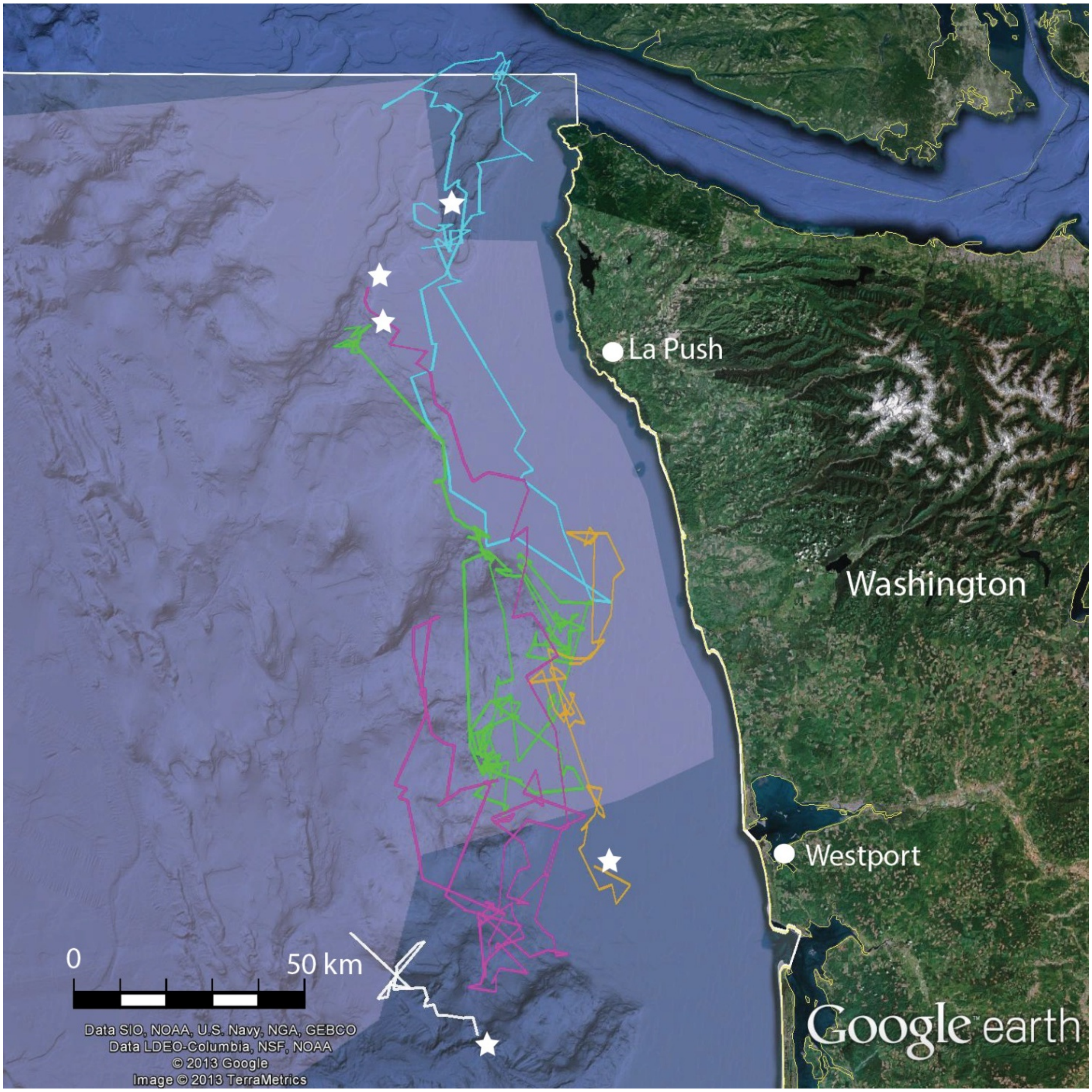

Figure 3. Map showing movements of five tagged humpback whales.

White stars indicate tagging location. Track legend: Pink = Mn Tag 002, White = Mn Tag 003, Blue = Mn Tag 004, Green = Mn Tag 005, and Orange = Mn Tag 006. Pink shaded area denotes the W-237 warning area. The boundary of the NWTRC is outlined in white.

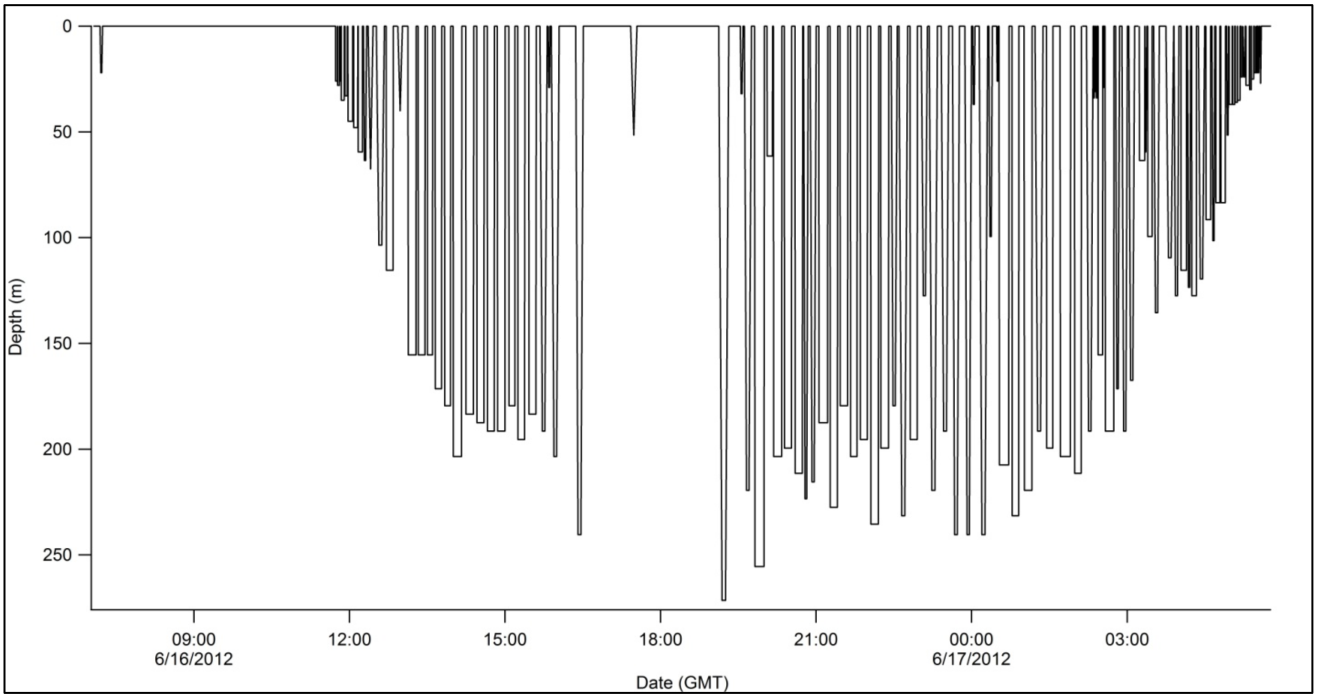

Figure 4. Behavior Log dive record from Mn Tag 005.

Deeper dives during daylight hours are likely foraging dives. Where dives did not exceed 20 m for more than 1 min, the behavior log represents those as all time at the surface. Extended surface time could represent resting/logging, socializing, surface lunge feeding, or other behavior.

Fin Whales

Fin whale populations in the North Pacific remain poorly understood relative to those of humpback, blue, and gray whales. This is due in large part to their preference for deeper waters (Schorr et al. 2010 and 2011 and this data), which usually puts them west of the broad continental shelf edge along the US West Coast and beyond the reach of more regular coastal marine mammal surveys. Most published data on North Pacific fin whales has come from three sources: historical whaling records (Mizroch et al. 2009 provides a comprehensive review of these), large-scale, line-transect visual surveys (Barlow and Forney 2007, Moore and Barlow 2011), and acoustic monitoring (Watkins et al. 2000, Stafford et al. 2009). Line-transect surveys through fin whale habitat are expensive to conduct and are usually seasonally and geographically constrained, thus they are conducted infrequently and usually only during summer and fall. Much acoustic data on fin whales in the Pacific has come from the use of the US Navy's Sound Surveillance System array to monitor vast ocean regions for the low-frequency vocalizations of large whales. In addition, work from National Marine Fisheries Service cruises using sonobuoys has been done (Jones et al. 2011).

Recently, fin whale acoustic detections have been made on ocean bottom seismometers (OBS) along the Endeavour segment of the Juan de Fuca Ridge, offshore of the Pacific Northwest (Wilcock et al. 2012, Weirathmueller et al. 2013). Soule and Wilcock (2013) were able to track vocalizing fin whales via the same OBS. From August to October, fin whales were detected predominantly heading to the northwest. Tracks from November to March displayed slower swimming speeds, tendency to meander, and fin whales were headed predominantly to the south.

Within the shelf and slope region offshore of Washington, Oleson and Hildebrand (2012) noted that fin whale calls were most commonly detected in 2010 between September and April, were among the most commonly recorded calls detected on more than 90 percent of days during 4 months (October, December, January, and February), and were absent in May and June. Correspondingly, under continued work at the same site, in 2011 peak fin whale calling occurred in fall and winter with low calling during the summer (Širović et al. 2012).

In combination, these data have suggested that fin whales are increasing in the North Pacific since whaling was banned in the late 1970s (Stafford et al. 2009, Moore and Barlow 2011), and that fin whales appear to be distributed throughout their range year-round (Stafford et al. 2009). There are several indications that distinct populations of fin whales exist in the western and eastern North Pacific that may undertake long seasonal migrations similar to other balaenopterids, though there also appears to be several non-migratory local populations (Mizroch et al. 2009). Ultimately, these visual and acoustic survey methods do not provide the resolution necessary to confidently delineate stocks and describe movement patterns within them, which appear to be complex (Mizroch et al. 2009).

The U.S. National Marine Fisheries Service presently manages North Pacific fin whales as three stocks based on available data, all of which remain on the Endangered Species List. Fin whales along the U.S. West Coast are considered part of the California-Oregon-Washington stock (Carretta et al. 2013) and considered distinct from the Northeast Pacific stock that is primarily distributed throughout Alaskan waters. Prior to recent tagging and photo-identification studies by Cascadia (Schorr et al. 2010 and 2011, Falcone et al. 2011), there was little or no data on the movements of individual fin whales within and beyond these putative stock boundaries. Given the apparent complexity of fin whale stock structure, the identity and movements of fin whales along the coast of Washington are of particular interest given the potential for overlap between these two management units, especially if one or both are migratory.

Cascadia Research has conducted marine mammal surveys along the coast of Washington since the mid-1990s, both independently using small vessels launched daily from shore (predominantly the ports of Westport and La Push) and as part of occasional collaborative large-vessel surveys with the Olympic Coast National Marine Sanctuary and the Southwest Fisheries Science Center, which often extended further west than small vessel surveys are capable of reaching. These large-scale U.S. West Coast surveys between 1991 and 2008 reported fin whale sightings from the shelf break across the abyssal plain out to several hundred miles (Carretta et al. 2013).

From 2004 through 2009, monthly marine mammal surveys were undertaken (weather permitting) that included an approximately 50-km transect along the shelf edge between the Quinalt and Grays Harbor canyons (Calambokidis et al. 2011). The majority of all surveys off Washington reached shelf edge waters, yet fin whales were sighted on only 3 days prior to 2009. Since then, fin whale sightings have increased considerably off the Washington coast, particularly in winter and spring (Cascadia Research, unpublished data). This is likely related to several factors, including a potential increase in abundance, a potential shift in fin whale distribution, and a shift in survey effort slightly south and west of previous focal areas in response to these fin whale detections. This increase in fin whale detections has provided the first opportunities to collect fin whale movement data in this region of interest.

Movements obtained from fin whales tagged in 2012–2013 are similar to those described in Schorr et al. 2010 and 2011, with fin whales most commonly using waters associated with the outer shelf edge (grand median distance to shore of 72 km, and 1,326-m depth [**Table 2**]). Overall, 75 percent of the fin whale locations received were within the NWTRC, with 19 percent occurring within the W-237 warning area (**Figures 5 and 6**).

Based on satellite telemetry, fin whales were present in the NWTRC for 7 out of the 7 months tags were transmitting, with locations received February through August. Telemetry data, combined with sightings (Calambokidis et. al 2011, Cascadia Research unpublished data) and acoustic detections (Oleson and Hildebrand 2012), demonstrate that fin whales have been documented in the NWTRC all months of the year, and their presence may be increasing. Three whales with transmission durations greater than 21 days (Bp Tag 020, 044, and 056) (**Table 1**), remained in the NWTRC for the entire duration of tag transmission. Bp Tag 056, tagged just south of the W-237 boundary (**Figure 6**) remained within 68 km of the tagging location for the entire 42.3-day transmission period. One hundred percent of locations were within the NWTRC and 75 percent were within W-237 (**Table 2**). Localized movements for periods of this duration suggest that at least some fin whales are not simply migrating through the area, but are utilizing habitat within the NWTRC for extended periods of time, even during seasons generally associated with migration and use of lower latitude breeding areas for other baleen whales.

Fin whales have the highest rate of ship strike mortality among baleen whale species along the US West coast, despite that their sighting rates are among the lowest and their distribution is predominantly outside coastal waters where ship traffic is most concentrated (Douglas et al. 2008, Calambokidis et al. 2010). While a similar number of gray whales have been ship struck, mortalities attributed to ship strikes represent a small fraction of the total number of gray whale strandings recorded. Most documented fin whale ship strikes have involved large commercial vessels, however the design of these ships often traps the whale upon the bow where it can be recovered when the ship reaches port- whales fatally injured by collisions with other types of vessels in offshore waters are much less likely to be detected. Given the slower recovery of west coast fin whale populations to date, the risk ship strikes present to them throughout their range should not be discounted (Douglas et al. 2008, Calambokidis et al. 2010, Carretta et al. 2013). While Navy vessels represent a small percentage of vessel traffic relative to commercial ship traffic, the serious injury/mortality of two fin whales struck by Navy vessels in Southern California in 2009 (National Marine Fisheries Service, Southwest Region Stranding Database), despite current Navy monitoring and mitigation efforts, demonstrates that this risk is relevant to Navy vessels in the NWTRC. Assuming large ship traffic (commercial and Navy) remains constant, if fin whale density is increasing in this area (either due to increasing abundance or a change in distribution), risk of ship strikes are likely to increase.

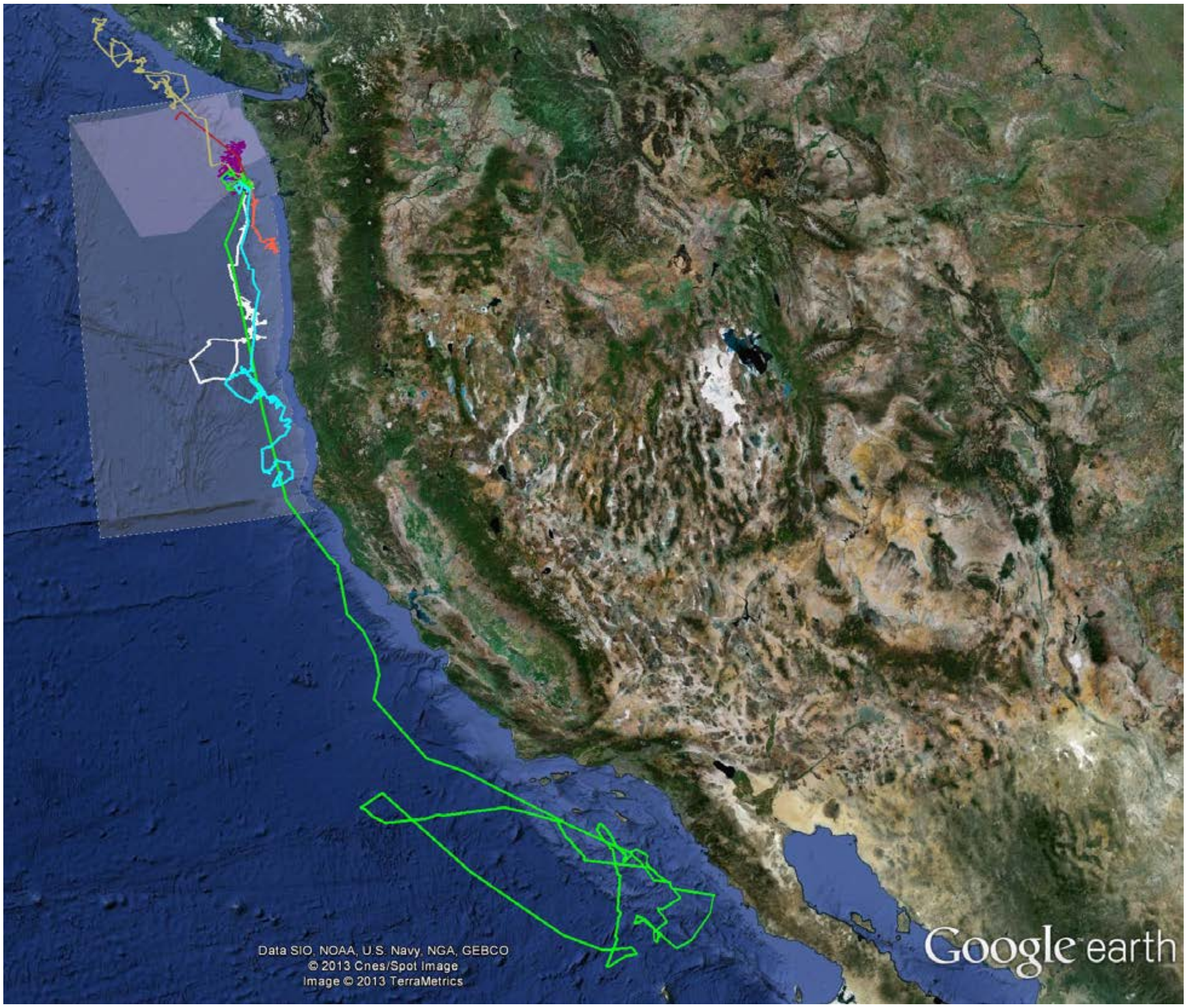

Figure 5. Map showing the full extent of movements by tagged fin whales.

*Deployment locations of tags are displayed in Figure 5. Track Legend: Bp Tag 017 = Blue, Bp Tag 018 = Green, Bp Tag 020 = Light Blue, Bp Tag 023 = Tan, Bp Tag 025 = Red, Bp Tag 044 = White, Bp Tag 054 = Orange, Bp Tag 055 = Pink, Bp Tag 056 = Maroon. Note that tracks from individuals with short transmission durations (**Table 1**) are generally hidden behind other tracks. NWTRC is outlined in white, W-237 warning area is shaded pink.*

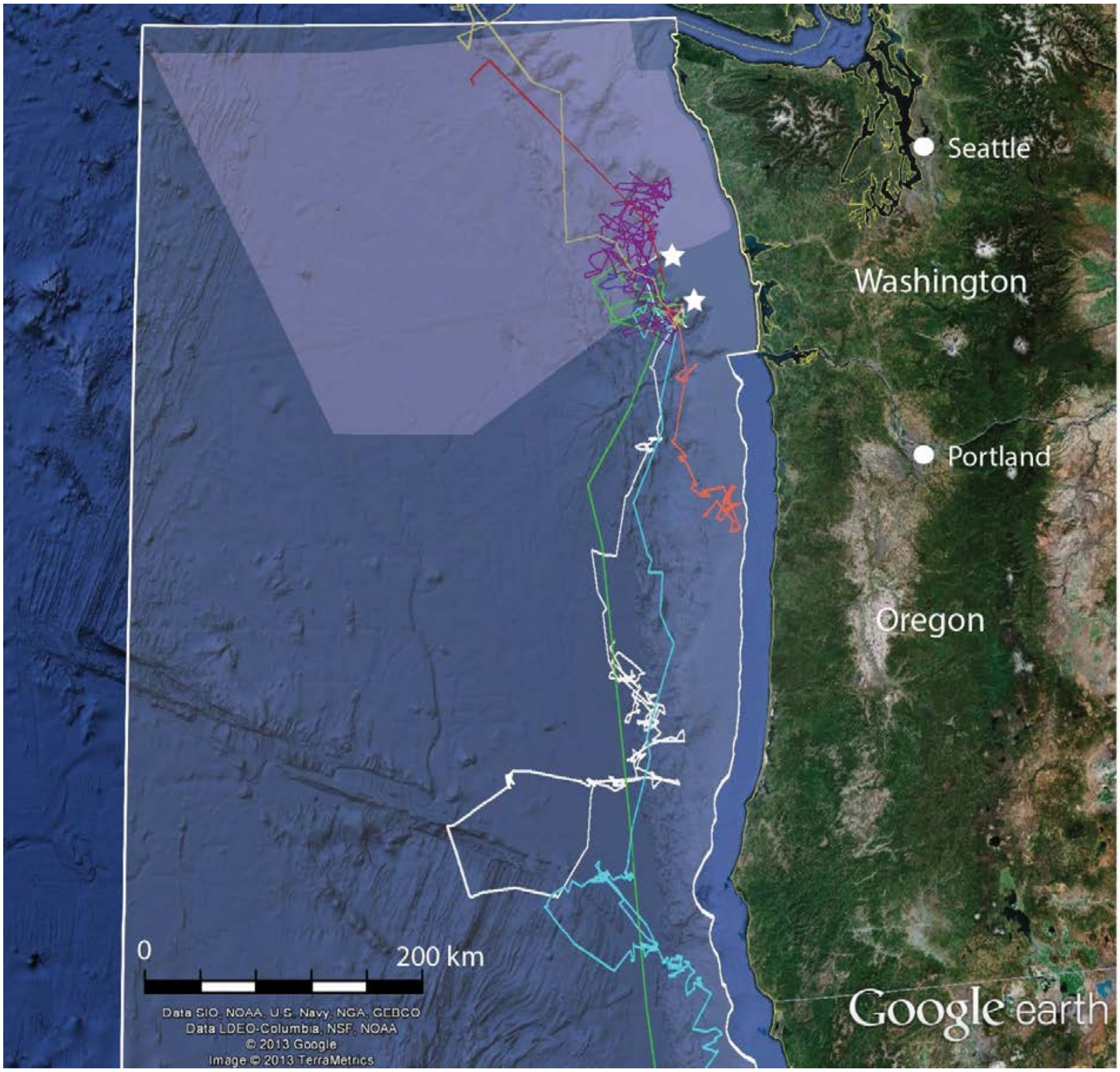

Figure 6. Map showing movements by tagged fin whales from northern Washington to Southern Oregon.

*All tags were deployed in the vicinity of the two white stars. Track Legend: Bp Tag 017=Blue, Bp Tag 018=Green, Bp Tag 020=Light Blue, Bp Tag 023=Tan, Bp Tag 025=Red, Bp Tag 044 = White, Bp Tag 054 = Orange, Bp Tag 055=Pink, Bp Tag 056=Maroon. Note that tracks from individuals with short transmission durations (**Table 1**) are generally hidden behind other tracks. NWTRC is outlined in white, W-237 warning area is shaded pink.*

Killer Whales

On 8 March 2013, in coordination with a NOAA Northwest Fisheries Science Center cruise, a group of killer whales from the Eastern North Pacific Offshore stock was encountered in Grays Harbor Canyon, Washington. Two satellite tags were deployed by Cascadia Research during this encounter, with one tag still transmitting at the time of this report (**Table 1**). Offshore killer whales are encountered far less frequently than other stocks, likely due to their primary use of offshore waters compared to transient or resident ecotypes (e.g., Dalheim et al. 2008, Carretta et al. 2013).

While in the NWTRC, tagged whales primarily spent their time on the continental slope, or well offshore of the shelf edge (**Figure 7**). In-shore excursions were made off the central coast of Oregon, and in the west entrance to the straights of Juan de Fuca. Once north of Vancouver Island, movements were associated much more closely with the shelf and near-shore waters. Oo Tag 038 began an inshore track at the south end of Haida Gwaii (Queen Charlotte Islands), and an excursion into inland waters in southeast Alaska before returning to offshore waters. Median water depth utilized was 313 m (range = 4–3,409) and median distance to shore was 49.5 km (range = 0.6–224.8) (**Table 2**). Cumulative Horizontal displacement for Oo Tag 038 is 8,665 km as of 23 May 2013, with the tag still transmitting at the time of this report's submission.

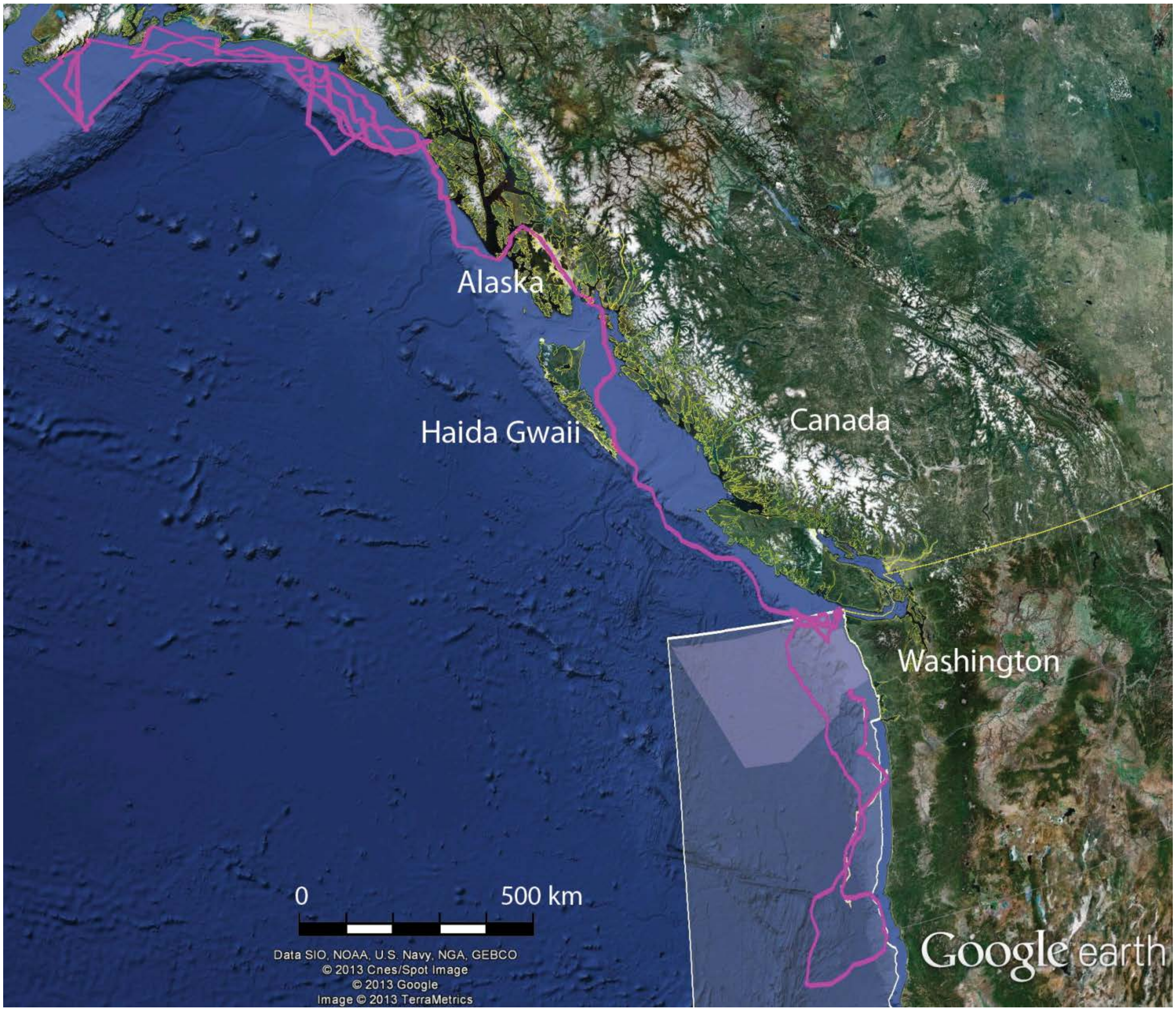

Figure 7. Map showing movements of two tagged killer whales.

Oo Tag 038 (pink) is still transmitting at the time of this report; the track represents movements through 23 May 2013. Note the 6.3 day track of Oo Tag 041 (beige) is mostly hidden behind the track of Oo Tag 038. While in the NWTRC, whales utilized the near-shore shelf waters (represented by the lighter blue bathymetry) as well as offshore waters (darker blue bathymetry). White outlined area indicates the NWTRC and the lighter pink area is the W-237 warning area.

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