Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean: Preliminary Summary of Field Tagging Efforts off the Pacific Northwest in Summer 2018

Prepared for:
Commander, U.S. Pacific Fleet, and Commander, Naval Sea Systems Command

Submitted to:
Naval Facilities Engineering Command Southwest (NAVFAC SW)
under Cooperative Ecosystem Studies Unit (CESU), Department of the Navy (DON)
Cooperative Agreement No. N62473-17-2-0001

Prepared by:
Bruce R. Mate, Daniel M. Palacios, C. Scott Baker, Barbara A. Lagerquist, Ladd M. Irvine, Tomas Follett, and Debbie Steel

Oregon State University, Marine Mammal Institute
Hatfield Marine Science Center
2030 SE Marine Science Drive
Newport, OR 97365

27 March 2019

Suggested Citation:

Mate, B.R., D.M. Palacios, C.S. Baker, B.A. Lagerquist, L.M. Irvine, T. Follett, and D. Steel. 2019. Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean: Preliminary Summary of Field Tagging Efforts off the Pacific Northwest in Summer 2018. Prepared for Commander, U.S. Pacific Fleet, and Commander, Naval Sea Systems Command. Submitted to Naval Facilities Engineering Command Southwest, San Diego, California, under Cooperative Ecosystem Studies Unit (CESU), Department of the Navy (DON) Cooperative Agreement No. N62473-17-2-0001. 27 March 2019.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27-03-2019	-Monitoring report	August 2018 - December 2018

4. TITLE AND SUBTITLE
HUMPBACK WHALE TAGGING IN SUPPORT OF MARINE MAMMAL MONITORING ACROSS MULTIPLE NAVY TRAINING AREAS IN THE PACIFIC OCEAN: PRELIMINARY SUMMARY OF FIELD TAGGING EFFORTS OFF THE PACIFIC NORTHWEST IN SUMMER 2018

5a. CONTRACT NUMBER
N62470-15-D-8006

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Bruce R. Mate
Daniel M. Palacios
C. Scott Baker
Barbara A. Lagerquist
Ladd M. Irvine
Tomas Follett
Debbie Steel

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Oregon State University, Hatfield Marine Science Center, Newport, OR

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Commander, U.S. Pacific Fleet, 250 Makalapa Dr. Pearl Harbor, HI
Commander, Naval Sea Systems Command, San Diego, CA

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The purpose of this Cooperative Agreement between Naval Facilities Engineering Command Southwest (NAVFAC SW) and Oregon State University (OSU) is to support marine mammal studies in compliance with the Letters of Authorization and Biological Opinions issued by the National Marine Fisheries Service (NMFS) to the Navy for activities in all Pacific Ocean testing and training range complexes. With regard to humpback whales, in 2016 NMFS divided the global population into fourteen Distinct Population Segments (DPS) for purposes of listing under the Endangered Species Act (ESA). Four DPS were designated for the North Pacific based on the location of distinct breeding areas (Federal Register 2016a, b): "Western North Pacific", "Hawaii", "Mexico", and "Central America". The corresponding ESA status is "Endangered" for both the Western North Pacific (estimated at 1,066 animals; Wade 2017) and the Central America DPS (estimated at 783 animals; Wade 2017); "Threatened" for the Mexico DPS (estimated at 2,806 animals; Wade 2017); and "Not Listed" for the Hawaii DPS (estimated at 11,571 animals; Wade 2017) (Federal Register 2016a, b).

The available information indicates that three of these DPSs, Hawaii, Mexico, and Central America, are primarily found along the western coast of North America during the summer-fall feeding season. During this season, these DPSs occur in somewhat distinct feeding aggregations, with Hawaii animals being found in Southeast Alaska and northern British Columbia; Mexico animals being found off northern Washington-southern British Columbia; and Central America animals being found off California and Oregon (Bettridge et al. 2015). However, some degree of mixing of DPSs occurs in the feeding areas, with Hawaii whales also being found throughout the Gulf of Alaska, the Aleutian Islands, and eastern Russia; and Mexico whales also being found off California and Oregon, as well as in the northern and western Gulf of Alaska and the Bering Sea (Bettridge et al. 2015). Finally, animals from the Western North Pacific DPS may also be present in small numbers in these areas (Bettridge et al. 2015). This mixing of DPSs in the feeding areas complicates unequivocal assignment of individuals to breeding stock for management purposes without further information. As a result, there is a need for data on occurrence and habitat use by these different DPSs in the feeding grounds, and their overlap with shipping traffic, fishing grounds, and areas of military operation, so that management agencies can prioritize actions and to mitigate potential impacts from these activities.

Through the use of satellite telemetry, genetic analyses, and photo-identification (photo-ID), this Cooperative Ecosystem Studies Unit (CESU) agreement option seeks to provide greater detail on which humpback whale sub-populations use the Navy activity areas in the North Pacific Ocean. Satellite tag deployments occurred in the Strait of Juan de Fuca as well as off the outer Washington and Oregon coasts in the summer of 2018 to track the migrations of humpback whales throughout the Pacific basin for multiple weeks to multiple months after deployment. This Preliminary Summary provides an overview of field survey methodologies for work conducted in Washington and Oregon in summer 2018 under this CESU agreement, including the type and number of tags deployed and initial summaries of the data collected through 12 December 2018.

15. SUBJECT TERMS
Monitoring, marine mammals, baleen whales, tagging, biopsy, genetics, Northwest Training Range Complex

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
			UU	14	Department of the Navy
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified			**19b. TELEPONE NUMBER (*Include area code)*** 808-471-6391

Introduction

The purpose of this Cooperative Agreement between Naval Facilities Engineering Command Southwest (NAVFAC SW) and Oregon State University (OSU) is to support marine mammal studies in compliance with the Letters of Authorization and Biological Opinions issued by the National Marine Fisheries Service (NMFS) to the Navy for activities in all Pacific Ocean testing and training range complexes. With regard to humpback whales, in 2016 NMFS divided the global population into fourteen Distinct Population Segments (DPS) for purposes of listing under the Endangered Species Act (ESA). Four DPS were designated for the North Pacific based on the location of distinct breeding areas (Federal Register 2016a, b): "Western North Pacific", "Hawaii", "Mexico", and "Central America". The corresponding ESA status is "Endangered" for both the Western North Pacific (estimated at 1,066 animals; Wade 2017) and the Central America DPS (estimated at 783 animals; Wade 2017); "Threatened" for the Mexico DPS (estimated at 2,806 animals; Wade 2017); and "Not Listed" for the Hawaii DPS (estimated at 11,571 animals; Wade 2017) (Federal Register 2016a, b).

The available information indicates that three of these DPSs, Hawaii, Mexico, and Central America, are primarily found along the western coast of North America during the summer-fall feeding season. During this season, these DPSs occur in somewhat distinct feeding aggregations, with Hawaii animals being found in Southeast Alaska and northern British Columbia; Mexico animals being found off northern Washington-southern British Columbia; and Central America animals being found off California and Oregon (Bettridge et al. 2015). However, some degree of mixing of DPSs occurs in the feeding areas, with Hawaii whales also being found throughout the Gulf of Alaska, the Aleutian Islands, and eastern Russia; and Mexico whales also being found off California and Oregon, as well as in the northern and western Gulf of Alaska and the Bering Sea (Bettridge et al. 2015). Finally, animals from the Western North Pacific DPS may also be present in small numbers in these areas (Bettridge et al. 2015). This mixing of DPSs in the feeding areas complicates unequivocal assignment of individuals to breeding stock for management purposes without further information. As a result, there is a need for data on occurrence and habitat use by these different DPSs in the feeding grounds, and their overlap with shipping traffic, fishing grounds, and areas of military operation, so that management agencies can prioritize actions and to mitigate potential impacts from these activities.

Through the use of satellite telemetry, genetic analyses, and photo-identification (photo-ID), this Cooperative Ecosystem Studies Unit (CESU) agreement option seeks to provide greater detail on which humpback whale sub-populations use the Navy activity areas in the North Pacific Ocean. Satellite tag deployments occurred in the Strait of Juan de Fuca as well as off the outer Washington and Oregon coasts in the summer of 2018 to track the migrations of humpback whales throughout the Pacific basin for multiple weeks to multiple months after deployment. This Preliminary Summary provides an overview of field survey methodologies for work conducted in Washington and Oregon in summer 2018 under this CESU agreement, including the type and number of tags deployed and initial summaries of the data collected through 12 December 2018.

Study Goals

With this project, OSU seeks to track humpback whale movement between or through Pacific Navy range complexes, and to collect photo-IDs and genetic samples (taken during tag placement) to further help delineate the sub-populations (DPS). In addition, tag data will provide details on dive durations, feeding activity, home range and core areas by DPS, and behavioral characteristics when on or off a range. Specifically, the goals of the summer 2018 field efforts were to:

- Attach Telonics RDW-665 Dive Monitoring (DM) satellite tags (equipped with depth sensors, accelerometers, and rapid orientation-change detection software) to nine humpback whales to monitor diving behavior and activity levels.
- Attach Telonics RDW-665 Dive Duration Plus (DUR+) satellite tags (equipped with accelerometers and rapid orientation-change detection software, but not depth sensors) to 15 humpback whales to monitor dive duration and activity levels.
- Attach a Wildlife Computers Mk-10 Advanced Dive Behavior (ADB) tag (equipped with accelerometers, magnetometers, depth and temperature sensors) to one humpback whale to collect high-resolution archival dive and behavior data for a better understanding of the whale's fine-scale feeding behavior.
- Attach a Wildlife Computers SPOT6 Location-Only satellite tag to either a blue or fin whale encountered during humpback tagging operations in the Pacific Northwest to monitor long-term movements, in support of another Navy-funded project concurrently being executed by OSU with blue and fin whales in southern and central California, by extending the geographic range of where animals are tagged.

Additionally, through the collection of biopsy samples and genetic analyses of tagged whales, this study will provide:

- Sex determination,
- Individual identification using mitochondrial haplotype sequencing and nuclear microsatellite loci, including matching with individually identifying photographs and tissue samples from whales previously sampled, and
- DPS identification using mitochondrial haplotype sequencing and nuclear microsatellite loci, with population structure analysis, including comparison to existing published databases for humpback whales in the Pacific Ocean.

Summary of Fieldwork

Washington Field Effort (1-20 August 2018):

Participants: Ladd Irvine (chief scientist/tagging from 1-9 August), Craig Hayslip (photography), Barbara Lagerquist (chief scientist/boat driver/data recorder from 10-21 August), Kyle Miliken (biopsy collection), Ken Serven (boat driver, data recorder from 1-9 August; tagging from 10-21 August).

The science team arrived in Neah Bay, Washington, the evening of 31 July, moved into the hotel and prepared for tagging the next day. Tags were deployed from a 6.7-m rigid-hulled inflatable boat. Every following day of the field effort was spent on the water with the exception of 4 and 5 August, when a failure of the raw-water impeller caused the tagging boat's engine to overheat (subsequent repair lasted through 5 August), and 11 August because of heavy fog all day. The science team traveled home to Oregon on 21 August.

Conditions were challenging for the duration of field work with heavy fog (visibility < 100 m) often occurring in the morning and extending into the afternoon on some days. Whales, while relatively abundant, seemed to form large aggregations (10+ whales) for only short periods of time and the location of those aggregations moved around from day to day. Whales often occurred on the Canadian side of the Channel, and were quite secretive and difficult to see when dispersed and more solitary. Much of the first half of the field effort was spent working near Swiftsure Bank, northwest of Neah Bay, where large groups of surface-feeding whales were encountered, but typically dispersed by 12:00 pm. The remainder of the time was mostly spent working waters between Tatoosh Island and Neah Bay. Waters to the east of Neah Bay were searched on multiple occasions to as far as Pillar Point, east of Sekiu, when fog limited operations to the west. However, very few whales were encountered. A total of 20 whales were tagged (1 ADB, 9 DM, 10 DUR+ tags; Table 1).

Biopsies were collected from 19 of the 20 tagged whales (Table 1). Because the existing number of humpback whale biopsy samples currently available from the Pacific Northwest for genetic analyses is very low compared to other regions of the West Coast, we made additional efforts to obtain biopsy samples of animals that could not be tagged for various reasons. Biopsies were collected from an additional five humpback whales that were considered too small to tag, and also from a sixth whale during a failed tagging attempt, in which the tag missed its target.

Oregon Field Effort (6-8 September 2018):

Participants: Ladd Irvine (chief scientist/tagging), Craig Hayslip (photography), Tomas Follett (small-boat driving), Kyle Milliken (biopsy collection), John McClung (photography).

Six tags (1 SPOT6 and 5 DUR+) were deployed off Oregon from 6 to 8 September, using a 6.7-m rigid-hulled inflatable boat and making day trips out of Newport (Table 2). Tagging and biopsy collection was conducted in an identical manner to the Washington field effort. On 6 September, nine fin whales, six humpback whales, and two blue whales were encountered approximately 23 km off Cape Foulweather, 18 km north of Newport. One tag was deployed on a fin whale (Wildlife Computers SPOT6 Location-Only

tag) and a biopsy sample was collected (Table 2). Twenty-six humpback whales were encountered in the same area on 7 September and three DUR+ tags were deployed. Forty humpback whales were encountered on 8 September approximately 44 km west of Newport and two DUR+ tags were deployed. Biopsies were collected from all five of the tagged humpback whales (Table 2). An additional biopsy was collected on 8 September from an adult humpback (untagged) after the last tag was deployed.

Preliminary Results

Twenty humpback whales were tagged (10 DUR+ tags, 9 DM tags, 1 ADB tag) out of Neah Bay, Washington, between 3 and 18 August 2018, and five humpback whales (5 DUR+ tags) and one fin whale (SPOT6 tag) were tagged out of Newport, Oregon, between 6 and 8 September 2018. Argos satellite locations were received from all 25 tags deployed on humpback whales (Tables 1 and 2). Tracking periods for all 15 DUR+ tags (deployed in both Washington and Oregon) ranged from 9.2 to 110.6 days (mean = 35.1 days [d], standard deviation [SD] = 28.3 d). Tracking periods for the nine DM tags ranged from 6.7 to 52.1 d (mean = 24.2 d, SD = 14.0 d). Minimum distance traveled averaged 2,122 kilometers (km) (SD = 1,210 km) for DUR+ tags and 1,335 km (SD = 621 km) for DM tags. The ADB tag transmitted for 12.5 d (one day before it was to release and float to the surface) and 590 km, after which we didn't hear from it. Presumably the tag came off the whale while still attached to its housing and sank to the seafloor. The tag was designed to release from its housing after detecting a constant depth for 24 hours (h), so would ultimately surface again after sinking, but either the release procedure failed or the tag was positioned (or trapped) on the seafloor in such a way that prevented it from separating from its housing and surfacing.

Washington Tagging

Locations for humpback whales tagged off Washington ranged over 26 degrees of latitude, from the northern tip of Vancouver Island, British Columbia, Canada, to just south of Magdalena Bay, on the west coast of Baja California, Mexico (Figure 1). Tracking periods for these whales ranged from 6.7 to 110.6 d. The individual with the widest range (whale #5790; hereafter whales are referred to by their tag number) was tagged off Neah Bay, and tracked for 37 d in the Strait of Juan de Fuca, after which it moved west out of the Strait to continental shelf waters approximately 50-90 km off Cape Flattery, Washington. While three single transmissions were received from this whale in November, there was a 66-d gap in locations before one last location was received off Magdalena Bay, Baja California, Mexico, on 3 December. We have no evidence that this location (Argos location class 0) was erroneous, especially as animals from this population are expected to migrate along Baja California at this time of the year. Gaps in coverage of various durations are not unusual, and can be caused by a number of factors, including kelp or some other material covering the wet/dry sensor on the tag and preventing it from transmitting for a period of time.

The vast majority of locations for humpback whales tagged off Washington occurred between Pillar Point, 40 km east of Neah Bay, and approximately 30 km west of Cape Flattery, with the densest area of locations over Swiftsure Bank, approximately 25 km northwest of Cape Flattery (Figure 2). Seven whales had locations east of Pillar Point, four of which traveled as far east as Port Angeles, two traveled as far

as Victoria, Vancouver Island, and one traveled up into the Strait of Georgia, northwest of Vancouver, British Columbia.

Oregon Tagging

Locations for humpback whales tagged off Oregon ranged over 5 degrees of latitude, from the Columbia River mouth at the border of Oregon and Washington to just north of Cape Mendocino in northern California (Figure 3). Tracking periods for these whales ranged from 9.2 to 60.2 d. The densest concentration of locations was over the continental shelf edge west of Stonewall Bank, between Newport and Waldport on the central Oregon coast, with a secondary concentration along the shelf edge south of Heceta Bank, between Waldport and Coos Bay.

The fin whale (whale #5882) was tracked for 36.7 d and a minimum distance of 1,963 km (Table 2, Figure 4). It remained off the central Oregon coast for the first 12 d of its tracking period, after which there was a 10-d gap in locations. Whale #5882 was then located approximately 250 km west of Queen Charlotte Sound, between Vancouver Island and Haida Gwaii, British Columbia, over deep oceanic waters. It spent 10 d in this area before heading southwest, with its last location (on 12 October) approximately 90 km west of the Hesquiat Peninsula, on the central west coast of Vancouver Island (Figure 4).

Planned Analyses

The following analyses are ongoing and their results will be presented in the Final Report:

- Genetic sex determination and population identity, as it relates to the recently designated DPS.
- Matching of identification photographs of tagged whales to existing photo-ID databases to extend the information available for each tagged individual, including DPS assignment if available.
- Assessment of the number of satellite locations occurring inside versus outside Navy activity areas and Biologically Important Areas (BIAs) for each whale track, with the percentage of locations inside reported as a proportion of the total number of locations obtained for each whale.
- Residence time within Navy activity areas and BIAs for each whale track estimated from interpolated locations at regular intervals.
- Kernel density home ranges and core areas of use for each track, using the least-squares cross-validation bandwidth selection method.
- Diving patterns and foraging behaviors, using the sensor data from the ADB, DM, and DUR+ tags.
- Ecological/oceanographic characteristics of the areas visited by the tagged whales to increase our understanding of habitat requirements.

References

Bettridge, S., C.S. Baker, J. Barlow, P.J. Clapham, M. Ford, D. Gouveia, D.K. Mattila, R.M. Pace III, P.E. Rosel, G.K. Silber, and P.R. Wade. 2015. Status Review of the Humpback Whale (*Megaptera novaeangliae*) Under the Endangered Species Act. NOAA Technical Memorandum NMFS-SWFSC-540. National Marine Fisheries Service, La Jolla, California. 240 pp.

Federal Register. 2016a. Department of Commerce, NOAA, 50 CFR Parts 223 and 224, Endangered and Threatened Species; Identification of 14 Distinct Population Segments of the Humpback Whale (*Megaptera novaeangliae*) and Revision of Species-Wide Listing. Vol. 81, No. 174, 62260-62320, Thursday, September 8, 2016.

Federal Register. 2016b. Department of the Interior, Fish and Wildlife Service, 50 CFR Part 17, Endangered and Threatened Wildlife and Plants; Identification of 14 Distinct Population Segments of the Humpback Whale and Revision of Species-Wide Listing. Vol. 81, No. 245, 93639-93641, Wednesday, December 21, 2016.

Wade, P.R. 2017. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas – revision of estimates in SC/66b/IA21. Paper SC/A17/NP11 presented to the IWC Workshop on the Comprehensive Assessment of North Pacific Humpback Whales, 18-21 April 2017, Seattle, USA. 9pp. Available at https://archive.iwc.int/.

Table 1. Deployment and performance data for 20 satellite-monitored radio tags deployed on humpback whales off Washington during August 2018.

Tag#	Deployment Date	Latitude (degrees North)	Longitude (degrees West)	Tag Type	Sex	Tracking Duration (d)	# Filtered Locations	Distance (km)
4177	3-Aug-18	48.459	124.914	ADB	Male	12.5	244	590
5801	6-Aug-18	48.451	124.945	DM	Male	17.0	104	1,046
5838	6-Aug-18	48.458	124.834	DM	Male	30.6	199	1,525
5883	7-Aug-18	48.462	124.873	DM	Female	15.5	134	963
10825	8-Aug-18	48.375	124.979	DM	Male	52.1	297	2,531
10836	8-Aug-18	48.474	124.930	DM	Male	20.2	145	1,273
10839	10-Aug-18	48.447	124.713	DM	Female	35.4	305	1,659
23029	10-Aug-18	48.459	124.686	DM	Female	28.4	247	1,671
23033	10-Aug-18	48.463	124.680	DM	Unknown	6.7	47	288
23039	10-Aug-18	48.452	124.623	DM	Male	11.4	72	1,057
				Mean DM		**24.2**	**172**	**1,335**
				SD DM		**14.0**	**95**	**621**
5640	10-Aug-18	48.418	124.594	DUR+	Male	39.2	221	3,215
5654	12-Aug-18	48.429	124.627	DUR+	Unknown	45.0	255	2,359
5700	13-Aug-18	48.474	124.664	DUR+	Female	39.0	270	1,933
5709	13-Aug-18	48.480	124.746	DUR+	Male	16.4	100	1,520
5650	14-Aug-18	48.440	124.596	DUR+	Male	13.0	79	1,068
5719	14-Aug-18	48.446	124.621	DUR+	Female	13.9	123	1,254
5726	14-Aug-18	48.442	124.680	DUR+	Male	25.2	196	1,685
5790	14-Aug-18	48.437	124.615	DUR+	Male	110.6	155	4,808
5823	17-Aug-18	48.446	124.600	DUR+	Male	73.9	303	3,491
5923	18-Aug-18	48.437	124.714	DUR+	Male	34.0	245	2,451
				Mean DUR+		**41.0**	**195**	**2,378**
				SD DUR+		**30.5**	**77**	**1,166**

KEY: ADB = Wildlife Computers Mk-10 Advanced Dive Behavior tag; DM = Telonics RDW-665 Dive-Monitoring tag; DUR+ = Telonics RDW-665 Dive Duration Plus tag (no depth); km = kilometer(s); # = number.

Table 2. Deployment and performance data for satellite-monitored tags deployed on humpback whales and a fin whale off Oregon during September 2018.

Tag#	Deployment Date	Latitude (degrees North)	Longitude (degrees West)	Tag Type	Sex	Tracking Duration (d)	# Filtered Locations	Distance (km)
Humpback Whales								
10834	7-Sep-18	44.780	124.358	DUR+	Male	18.0	74	1,333
23030	7-Sep-18	44.791	124.375	DUR+	Male	16.5	104	1,164
23032	7-Sep-18	44.794	124.376	DUR+	Male	12.3	74	1,039
23035	8-Sep-18	44.647	124.618	DUR+	Male	60.2	273	3,815
23041	8-Sep-18	44.658	124.607	DUR+	Male	9.2	58	698
				Mean DUR+		**23.2**	**117**	**1,610**
				SD DUR+		**20.9**	**89**	**1,254**
Fin Whale								
5882	6-Sep-18	44.797	124.371	SPOT6	Female	36.7	103	1,963

KEY: DUR+ = Telonics RDW-665 Dive Duration Plus tag (no depth); km = kilometer(s); SPOT6 = Wildlife Computers SPOT6 Location-Only tag; # = number.

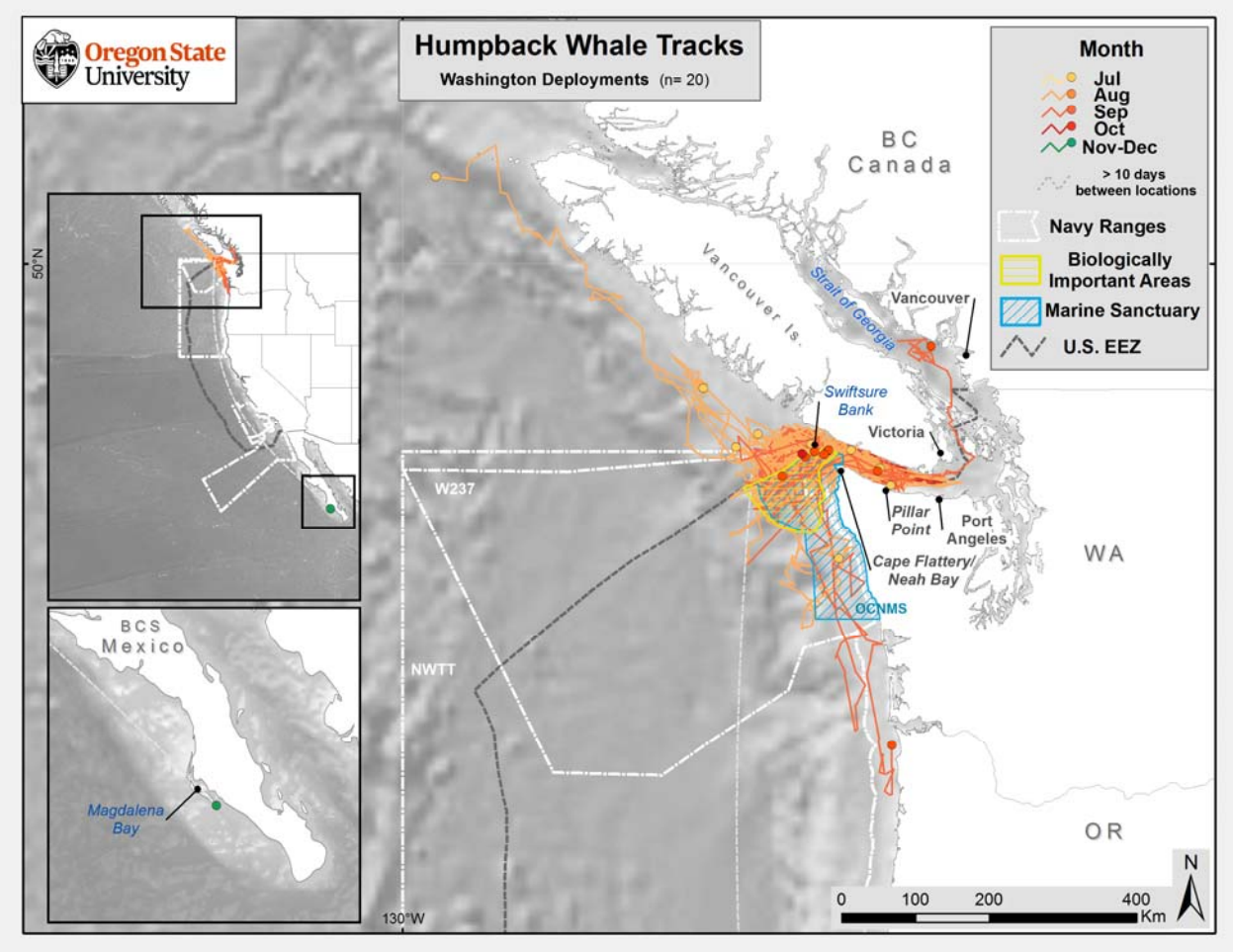

Figure 1. Satellite-monitored tracks of humpback whales tagged off Washington in August 2018. Top left inset shows the full extent of tracks and the bottom left inset shows a close-up of Baja California, Mexico, where one whale was last located on 3 December 2018. On the main map, a solid circle associated with a track indicates where the tag was last located. Circle color corresponds to month, as shown in the legend. The Olympic Coast National Marine Sanctuary (OCNMS) is indicated by the hatched polygon in blue and the northern Washington BIA by the hatched polygon in yellow.

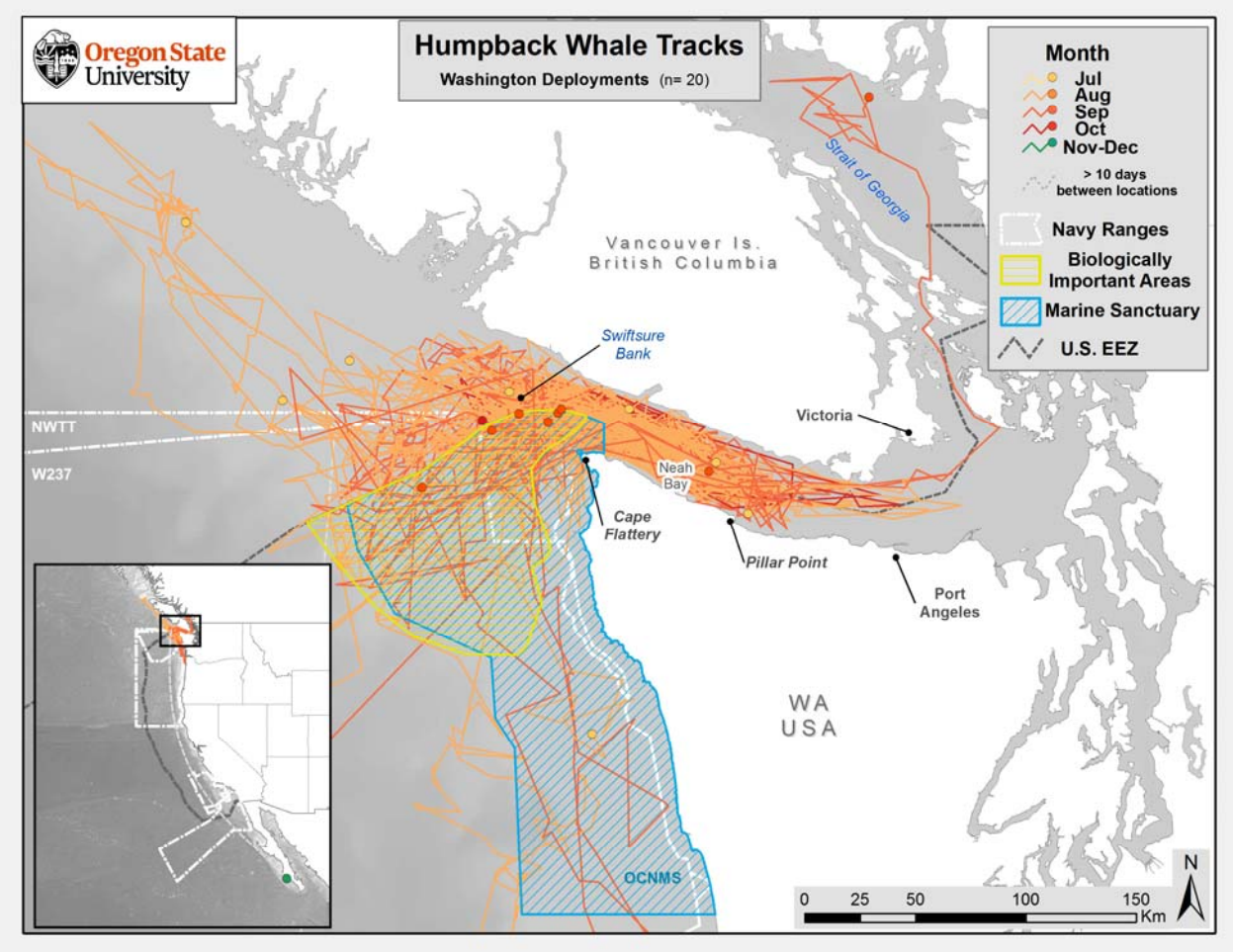

Figure 2. Satellite-monitored tracks of humpback whales tagged off Washington in August 2018, showing a close-up view of tracks in and around the Strait of Juan de Fuca. The Olympic Coast National Marine Sanctuary (OCNMS) is indicated by the hatched polygon in blue and the northern Washington BIA by the hatched polygon in yellow.

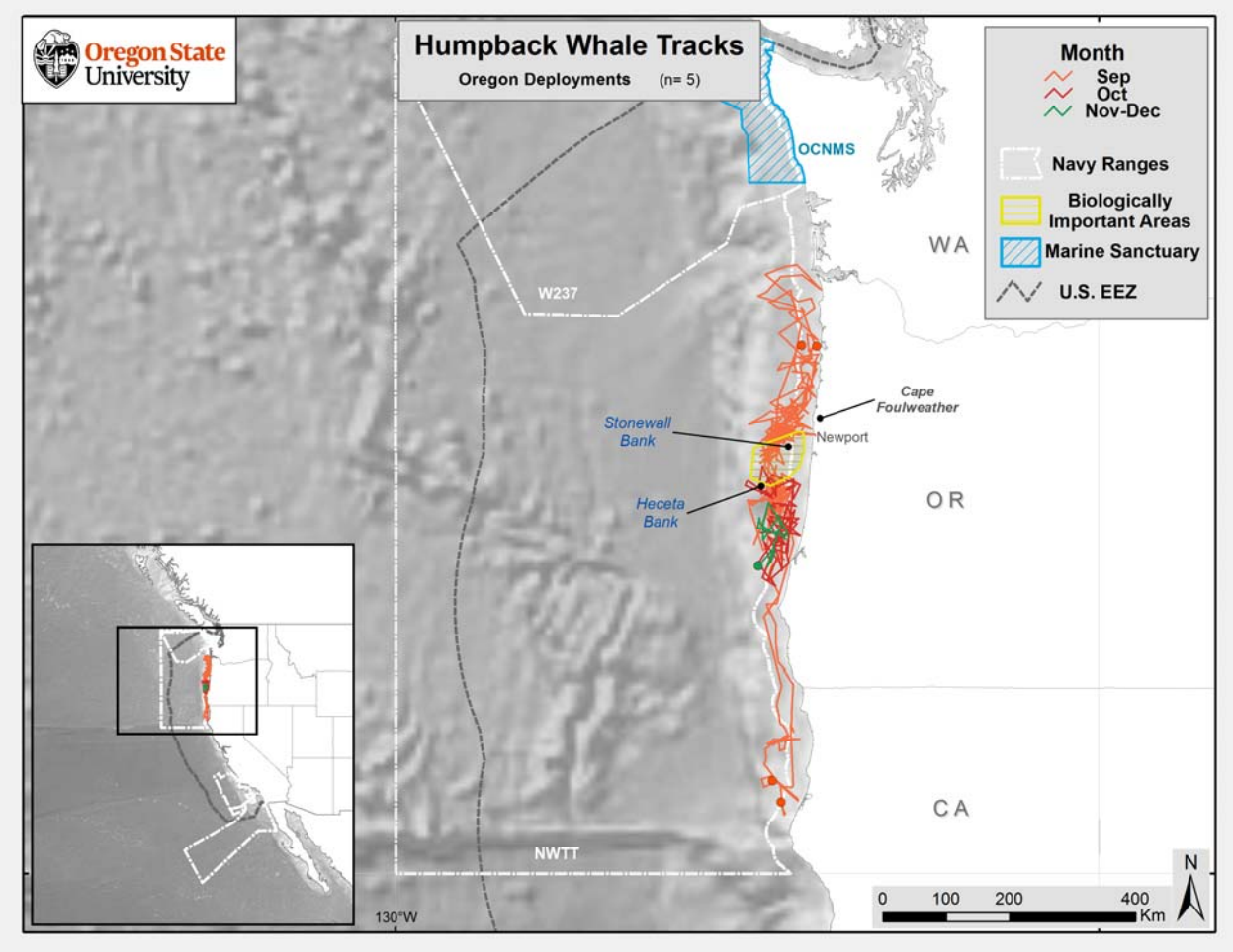

Figure 3. Satellite-monitored tracks of humpback whales tagged off Oregon in September 2018. The Olympic Coast National Marine Sanctuary (OCNMS) is indicated by the hatched polygon in blue and the Stonewall and Heceta Bank BIA by the hatched polygon in yellow.

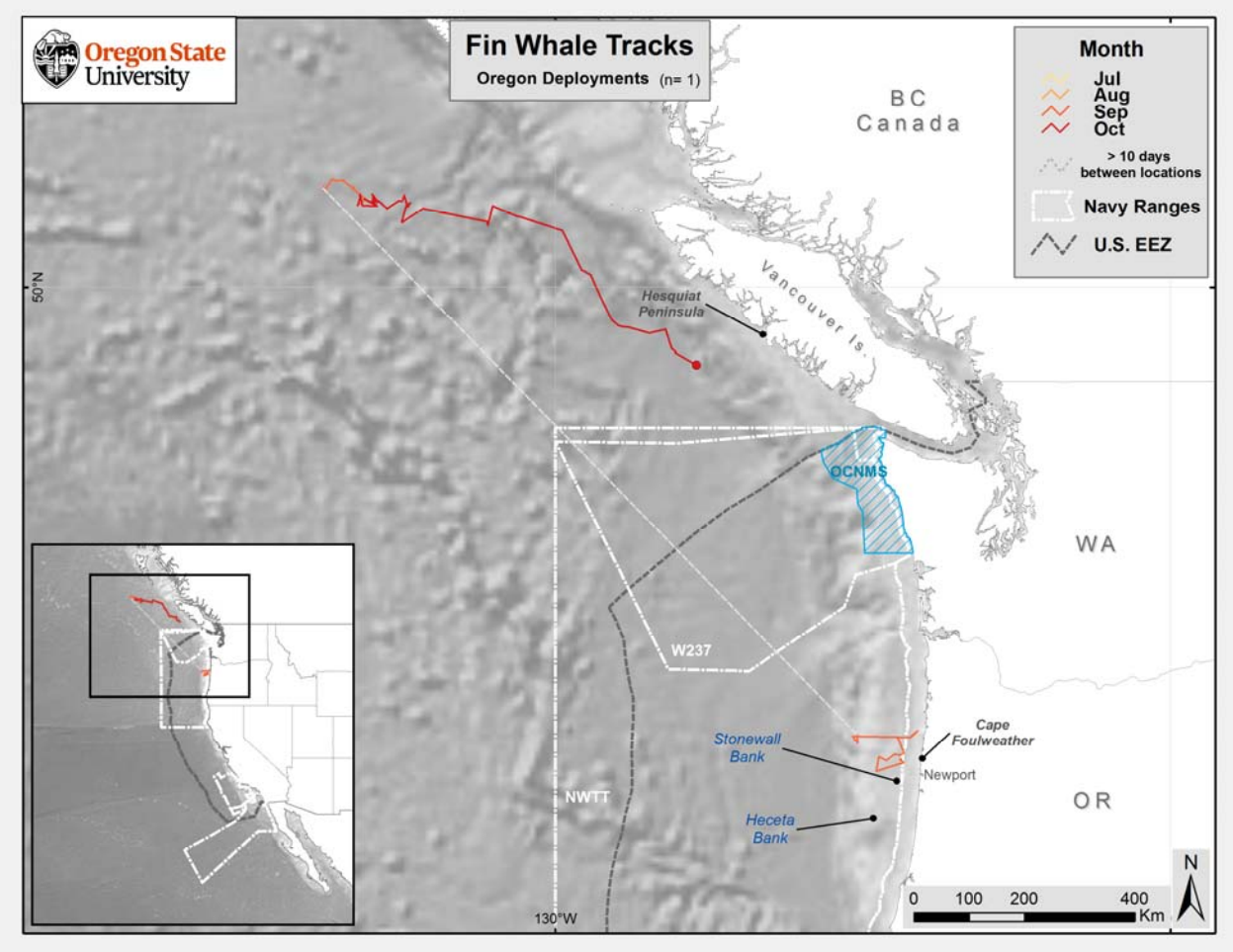

Figure 4. The 36.7-d satellite-monitored track of a fin whale tagged off Oregon in September 2018. The 10-d gap in locations after the first 12 d of its tracking period is indicated by the dashed white line. The Olympic Coast National Marine Sanctuary (OCNMS) is indicated by the hatched polygon in blue.