# Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean: Preliminary Summary of Field Tagging Effort off the US West Coast in Summer-Fall 2017

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**14. ABSTRACT**

Previous tagging studies have shown that humpback whales from Hawaii migrate north into the Gulf of Alaska, with some turning west towards Russia and others transiting east towards southeast Alaska (Mate et al. 2007), while tagging in the Revillagigedo Islands off Mexico has shown migratory destinations in the Gulf of Alaska, British Columbia, and possibly the Aleutian Islands (Lagerquist et al. 2008). These results indicate that North Pacific humpback whales spend time in Navy activity areas in the Gulf of Alaska and the Pacific Northwest (including more local areas like Behm Canal, the inland and offshore waters of Washington, the offshore waters of Oregon, or the offshore waters of northern California). However, it is unknown what portion of each humpback DPS is present in these locations or the proportion of time they spend in them.

Through the use of satellite telemetry and genetic analyses, this project will provide greater detail on which sub-populations of humpback whales use the Navy activity areas in the North Pacific Ocean. Satellite tag deployments will occur off California and Oregon/Washington (summer/fall 2017) and Hawaii (winter/spring 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 California and Oregon/Washington in Summer-Fall 2017 under this Cooperative Agreement, including the type and number of tags deployed and initial summaries of the data collected through 3 December 2017.

Fourteen tags (7 dive monitoring [DM] and 7 dive duration monitoring [DUR]) were deployed off southern and central California from 21 July to 4 August. Five DUR tags were deployed off Oregon/Washington during 14 September to 16

October. Argos satellite locations were received from all but one of the 19 tags deployed on humpback whales. Tracking periods for DUR tags ranged from 27.0 to 84.7 days (mean = 52.2 days, standard deviation [SD] = 22.4 days, n = 11). Tracking periods for DM tags ranged from 0.3 to 51.6 days (mean = 12.9 days, SD = 17.9 days, n = 7). Minimum distance traveled averaged 2,006 km (SD = 1415 km) for DUR tags and 443 km (SD = 395 km) for DM tags.

Locations for humpback whales tagged in California ranged over 11 degrees of latitude, from the Santa Barbara Channel in southern California to Pacific City on the central Oregon coast . The individual with the widest movement range (Tag # 10822) was tracked for 85 days between Pigeon Point, central California, and Pacific City, Oregon, with a distance between northern- and southernmost locations of more than 900 km. The single humpback whale tagged off Southern California in the Santa Barbara Channel (Tag # 830) ranged from the eastern Santa Barbara Channel to an area off Big Sur, California, with most locations over continental shelf edge and slope waters. The majority of locations for humpbacks tagged off central California were over continental shelf waters between Año Nuevo and Bodega Bay on the central California coast. The humpback whale that traveled into central Oregon took an offshore route on the way north, over continental slope and abyssal plain waters, and a more inshore route on the way south back to California, mainly over continental slope and continental rise waters. This whale reached a maximum distance offshore of approximately 200 km.

Argos satellite locations for humpback whales tagged in Oregon and Washington ranged over 10 degrees of latitude, from just south of Point Arena, northern California, to Vancouver Island, British Columbia. The individual with the longest range (Tag # 1387) was tracked between Cape Blanco, southern Oregon, and Barkley Sound, Vancouver Island, with a distance between northern- and southernmost locations of more than 715 km. One of the tags deployed off Newport, Oregon (Tag #23043), generated three transmissions but provided no locations. One other tag (Tag #1387) was still transmitting at the time of report preparation on 3 December. The area off the Columbia River mouth in northern Oregon and southern Washington was heavily used by two whales (Tag #23034, tagged near there, and Tag #1387, tagged off Newport). Most locations in this area were near the continental shelf edge or over continental slope waters. The two whales tagged near Cape Blanco, in southern Oregon, (Tags #4174 and #10838) spent most of their time over continental shelf waters with extended periods of time off Trinidad Head and Eureka, northern California. Two tagged whales also had excursions offshore over deep abyssal plain waters, with one whale traveling over 170 km offshore (Tag #1387) and one traveling over 120 km offshore (Tag #10838).

Analyses are ongoing and will be provided in the Final Report.

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# Introduction

The purpose of this Cooperative Agreement between NAVFAC 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 and the Central America DPS, "Threatened" for the Mexico DPS, and "Not Listed" for the Hawaii DPS (Federal Register 2016a, b). As a result, there is an urgent need for information on areas of high use by whales from these different DPSs, and their overlap with shipping traffic, fishing grounds, and areas of military operation, in order to prioritize management actions to mitigate the impact from these activities.

Previous tagging studies have shown that humpback whales from Hawaii migrate north into the Gulf of Alaska, with some turning west towards Russia and others transiting east towards southeast Alaska (Mate et al. 2007), while tagging in the Revillagigedo Islands off Mexico has shown migratory destinations in the Gulf of Alaska, British Columbia, and possibly the Aleutian Islands (Lagerquist et al. 2008). These results indicate that North Pacific humpback whales spend time in Navy activity areas in the Gulf of Alaska and the Pacific Northwest (including more local areas like Behm Canal, the inland and offshore waters of Washington, the offshore waters of Oregon, or the offshore waters of northern California). However, it is unknown what portion of each humpback DPS is present in these locations or the proportion of time they spend in them.

Through the use of satellite telemetry and genetic analyses, this project will provide greater detail on which sub-populations of humpback whales use the Navy activity areas in the North Pacific Ocean. Satellite tag deployments will occur off California and Oregon/Washington (summer/fall 2017) and Hawaii (winter/spring 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 California and Oregon/Washington in Summer-Fall 2017 under this Cooperative Agreement, including the type and number of tags deployed and initial summaries of the data collected through 3 December 2017.

# Study Goals

With this project, OSU seeks to track humpback whale movement between or through Pacific Navy range complexes and to collect genetic samples (taken during tag placement) to further help delineate the sub-populations (DPS). In addition, tag data will provide detail on dive duration, feeding activity, speed of transit between range complexes, home range and core areas by DPS, and behavioral characteristics when on or off a range. Specifically, the type and number of tags to be deployed at each site include:

- 10 Telonics RDW-665 Dive Monitoring (DM) satellite tags (equipped with depth sensors, accelerometers, and lunge-detection software) to monitor detailed diving and foraging behaviors.
- 10 Telonics RDW-640 Dive Duration Monitoring (DUR) satellite tags to monitor longer-term movements and dive durations

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
- 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

### California Field Effort (21 July – 5 August 2017):

Participants: Barbara Lagerquist (chief scientist/small boat driver), Craig Hayslip (photography), Ken Serven (tagging), Will Sheehy (data collection), Kyle Milliken (biopsy collection).

Fourteen (14) tags (7 DM and 7 DUR) were deployed off southern and central California from 21 July to 4 August, using the 25.6 m R/V *Pacific Storm* as a movable base of operations which launched the tagging vessel using an onboard crane. Tags were deployed from a 6.7-m long rigid-hulled inflatable boat using an air powered applicator from a distance of 1.5-4 m. Biopsy samples were collected using a crossbow typically on the same surfacing as the tag was deployed.

Tagging operations were initially conducted in the northeast portion of the Santa Barbara Channel on 21 and 22 July. Approximately 10-12 humpback whales were encountered on 21 July and 1 DUR tag was deployed. Only three humpback whales were encountered on 22 July, one of which was too small to tag. The other two whales were behaving evasively and the weather deteriorated in the afternoon, so no tags were deployed. Due to the low occurrence of whales in the area, on 27 July the decision was made to move operations to central California.

The *Pacific Storm* reached Pillar Point Marina, in Half Moon Bay, in the early evening of 28 July. The remaining days of the field effort were spent operating from Pillar Point Marina, returning to the dock each night. Tagging operations were conducted approximately 13 to 15 nautical miles west-southwest of Pillar Point Marina on 30 and 31 July. Approximately 40-50 humpback whales were encountered each day and seven tags were deployed (3 DM and 2 DUR on 30 July; 1 DM and 1 DUR on 31 July). Tagging operations were conducted approximately 8 to 10 nautical miles northwest of Half Moon Bay on 3

August. We encountered approximately 15 to 20 humpback whales and four tags were deployed (2 DM and 2 DUR). The majority of time on 4 and 5 of August was spent out near the 100-fathom line, approximately 20 nautical miles from shore. Eight to 12 humpback whales were encountered on 4 August and two tags were deployed (1 DM and 1 DUR). Four to six humpback whales were encountered on 5 August, but no tags were deployed, due to the evasive behavior of the whales.

## Oregon/Washington Field Effort (14 September – 16 October 2017):

Participants: Ladd Irvine (chief scientist/tagging), Daniel Palacios (chief scientist/biopsy collection) Barbara Lagerquist (biopsy collection/small-boat driving), Craig Hayslip (photography), Ken Serven (tagging), Tomas Follett (small-boat driving).

Five (5) tags (DUR only) were deployed off Oregon using a 6.7-m rigid-hulled inflatable boat and making day trips from a variety of local ports based on weather and availability of whales. Tags and biopsy samples were deployed in an identical manner to the California field effort. High winds and/or fog often limited tagging operations as whales were typically 15-20+ miles from the closest port. We had hoped to work out of Newport, OR, for the duration of the Oregon field effort; however local reports and an aerial survey indicated whales were limited. On 14 September, a tagging trip was conducted from Newport and only one humpback whale was seen and subsequently tagged with a DUR tag. A report of larger numbers of whales to the south led to a shift in operations to Charleston, OR, on 16 September, where 15-20 scattered whales were observed; however no tags were deployed due to patchy dense fog and evasive whales. The weather deteriorated until 27-28 September, when additional reports of whales led to tagging operations out of Brookings and Gold Beach, OR. Approximately 6-8 humpbacks were observed southwest of Brookings and a much larger, though widely scattered group (25-30 whales) was found southwest of Cape Blanco. Across both days, two DUR tags were deployed and another biopsy was collected from a whale that was too small to tag.

To find whales and better weather, we moved our field operations farther north in the Pacific Northwest region to the mouth of the Columbia River, where one of the tagged whales had traveled. Tagging was conducted from Ilwaco, WA, on 4-5 October. About 12-15 whales were observed on each day; however they were very widely scattered, diving irregularly, generally small, and very wary. The tagging vessel was rarely able to approach within 50 m. Across both days, one DUR tag was deployed and another whale was biopsied but not tagged.

Tagging was next conducted out of Newport, OR, on 16 October, as the weather in other areas was poor. Only one pair of humpbacks was encountered, and we were able to deploy a DUR tag on one of them. The weather subsequently deteriorated and tagging operations were terminated at the start of November as the likelihood of good weather and finding whales was extremely limited.

## Preliminary Results

Argos satellite locations were received from all but one of the 19 tags deployed on humpback whales (Table 1). Tracking periods for DUR tags ranged from 27.0 to 84.7 days (mean = 52.2 days, standard deviation [SD] = 22.4 days, n = 11). Tracking periods for DM tags ranged from 0.3 to 51.6 days (mean = 12.9 days, SD = 17.9 days, n = 7). Minimum distance traveled averaged 2,006 km (SD = 1415 km) for DUR tags and 443 km (SD = 395 km) for DM tags (Table 1).

Locations for humpback whales tagged in California ranged over 11 degrees of latitude, from the Santa Barbara Channel in southern California to Pacific City on the central Oregon coast (Figure 1). The individual with the widest movement range (Tag # 10822) was tracked for 85 days between Pigeon Point, central California, and Pacific City, Oregon, with a distance between northern- and southernmost locations of more than 900 km. The single humpback whale tagged off Southern California in the Santa Barbara Channel (Tag # 830) ranged from the eastern Santa Barbara Channel to an area off Big Sur, California, with most locations over continental shelf edge and slope waters (Figure 1). This whale's 44-day-long track did not intersect with those of other tagged humpbacks in central California or Oregon/Washington. The majority of locations for humpbacks tagged off central California were over continental shelf waters between Año Nuevo and Bodega Bay on the central California coast. The humpback whale that traveled into central Oregon took an offshore route on the way north, over continental slope and abyssal plain waters, and a more inshore route on the way south back to California, mainly over continental slope and continental rise waters. This whale reached a maximum distance offshore of approximately 200 km.

Argos satellite locations for humpback whales tagged in Oregon and Washington ranged over 10 degrees of latitude, from just south of Point Arena, northern California, to Vancouver Island, British Columbia (Figure 2). The individual with the longest range (Tag # 1387) was tracked between Cape Blanco, southern Oregon, and Barkley Sound, Vancouver Island, with a distance between northern- and southernmost locations of more than 715 km. One of the tags deployed off Newport, Oregon (Tag #23043), generated three transmissions but provided no locations. One other tag (Tag #1387) was still transmitting at the time of report preparation on 3 December. The area off the Columbia River mouth in northern Oregon and southern Washington was heavily used by two whales (Tag #23034, tagged near there, and Tag #1387, tagged off Newport). Most locations in this area were near the continental shelf edge or over continental slope waters. The two whales tagged near Cape Blanco, in southern Oregon, (Tags #4174 and #10838) spent most of their time over continental shelf waters with extended periods of time off Trinidad Head and Eureka, northern California. Two tagged whales also had excursions offshore over deep abyssal plain waters, with one whale traveling over 170 km offshore (Tag #1387) and one traveling over 120 km offshore (Tag #10838).

## 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 using state-space models.
- Kernel home ranges and core areas of utilization within Navy activity areas and BIAs for each track, using the least-squares cross-validation bandwidth selection method.
- Diving patterns and foraging behaviors in relation to Navy activity areas and BIAs, using the sensor data from the DM and DUR tags.
- Ecological/oceanographic characteristics of the areas visited by the tagged whales to increase our understanding of habitat requirements.

## References

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.

Lagerquist, B.A., Mate, B.R., Ortega-Ortiz, J.G., Winsor, M. and Urbán-Ramirez, J. 2008. Migratory movements and surfacing rates of humpback whales (*Megaptera novaeangliae*) satellite tagged at Socorro Island, Mexico. Marine Mammal Science 24: 815–830.

Mate, B.R., Mesecar, R., Lagerquist, B., 2007. The evolution of satellite-monitored radio tags for large whales: One laboratory's experience. Deep-Sea Research II 54, 224–247. doi:10.1016/j.dsr2.2006.11.021

**Table 1. Summary of information for 19 satellite-monitored tags deployed on humpback whales off California, Oregon, and Washington during summer/fall 2017. Tags deployed were Telonics RDW-665 Dive Monitoring (DM) tags or Telonics RDW-640 Duration Only (DUR). Genetic analysis of biopsy samples is ongoing so no sex information is listed. One tag (Tag # 1387) was still transmitting at the time of report preparation.**

| Tag # | Locality | Date (Local Time [UTC-7]) | Lat | Lon | Tag Style | Biopsy | ID Photo Collected | Days Transmitting | # Filtered Locs | Distance (km) |
|---|---|---|---|---|---|---|---|---|---|---|
| 830 | SB Channel, CA | 7/21/17 12:53 | 34.312 | -119.685 | DUR | Yes | Yes | 44.4 | 82 | 845 |
| 833 | Half Moon Bay, CA | 7/30/17 11:08 | 37.374 | -122.707 | DM | Yes | Yes | 16.3 | 79 | 626 |
| 834 | Half Moon Bay, CA | 7/30/17 11:49 | 37.371 | -122.703 | DUR | Yes | Yes | 81.9 | 264 | 3,139 |
| 838 | Half Moon Bay, CA | 7/30/17 13:06 | 37.373 | -122.703 | DM | Yes | Yes | 3.9 | 33 | 273 |
| 10822 | Half Moon Bay, CA | 7/30/17 15:17 | 37.361 | -122.689 | DUR | Yes | Yes | 84.7 | 215 | 3,245 |
| 840 | Half Moon Bay, CA | 7/30/17 16:24 | 37.368 | -122.688 | DM | Yes | Yes | 3.8 | 35 | 198 |
| 10842 | Half Moon Bay, CA | 7/31/17 10:04 | 37.369 | -122.678 | DUR | Yes | Yes | 40.2 | 140 | 1,156 |
| 848 | Half Moon Bay, CA | 7/31/17 14:57 | 37.349 | -122.653 | DM | Yes | Yes | 4.2 | 32 | 216 |
| 1389 | Half Moon Bay, CA | 8/3/17 9:35 | 37.565 | -122.601 | DUR | Yes | Yes | 51.0 | 125 | 1,184 |
| 2083 | Half Moon Bay, CA | 8/3/17 13:57 | 37.569 | -122.653 | DM | Yes | Yes | 0.3 | 3 | 32 |
| 1390 | Half Moon Bay, CA | 8/3/17 15:28 | 37.568 | -122.668 | DUR | Yes | Yes | 68.7 | 209 | 1,356 |
| 4173 | Half Moon Bay, CA | 8/3/17 17:13 | 37.586 | -122.660 | DM | Yes | Yes | 10.2 | 45 | 552 |
| 23038 | Half Moon Bay, CA | 8/4/17 14:51 | 37.291 | -122.781 | DUR | Yes | Yes | 27.0 | 111 | 1,018 |
| 4175 | Half Moon Bay, CA | 8/4/17 17:49 | 37.293 | -122.773 | DM | Yes | Yes | 51.6 | 99 | 1,207 |
| 1387 * | Newport, OR | 9/14/17 19:44 | 44.697 | -124.581 | DUR | Yes | Yes | 79.8 | 390 | 5,388 |
| 4174 | Coos Bay, OR | 9/27/17 23:31 | 42.633 | -124.672 | DUR | Yes | Yes | 31.7 | 115 | 731 |
| 10838 | Gold Beach, OR | 9/28/17 21:29 | 42.631 | -124.677 | DUR | No | Yes | 32.6 | 198 | 1,973 |

| Tag # | Locality | Date (Local Time [UTC-7]) | Lat | Lon | Tag Style | Biopsy | ID Photo Collected | Days Transmitting | # Filtered Locs | Distance (km) |
|---|---|---|---|---|---|---|---|---|---|---|
| 23034 | Ilwaco, WA | 10/4/17 19:14 | 46.220 | -124.444 | DUR | No | Yes | 32.7 | 168 | 2,028 |
| 23043 ** | Newport, OR | 10/16/17 20:32 | 44.688 | -124.455 | DUR | Yes | Yes | 0.1 | 0 | 0 |
| | | | | | | | SUM | 665.0 | | 25,167 |
| | | | | | | | AVERAGE | 36.9 | | 1,398 |
| | | | | | | | MAX | 84.7 | | 5,388 |
| | | | | | | | MIN | 0.3 | | 32 |

* Still transmitting as of 3 December 2017; ** Tag # 23043 excluded from summary below

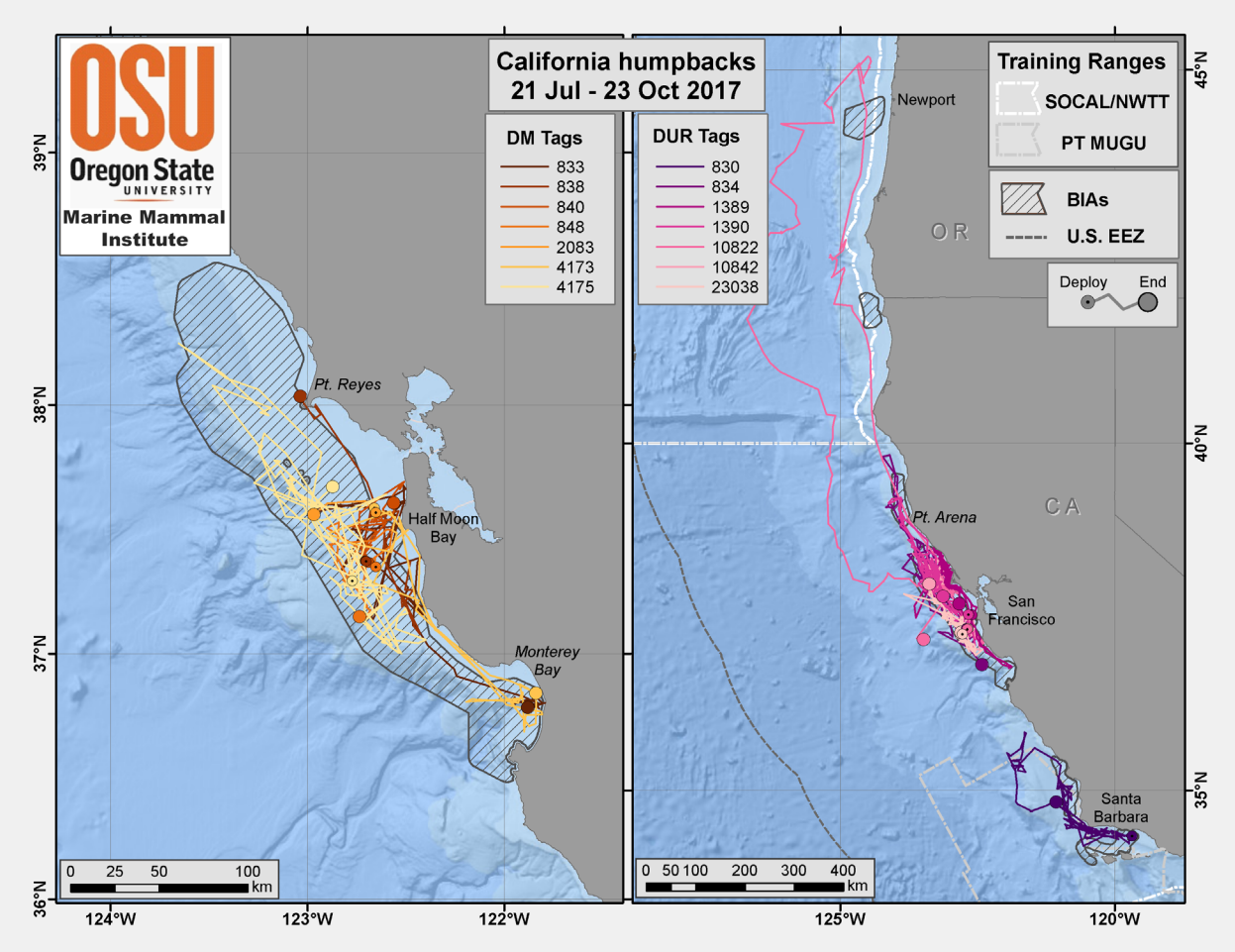


Figure 1: Tracks of humpback whales tagged off central and southern California during July-August 2017. Tracks for Telonics RDW-665 Dive Monitoring (DM) tags are presented in the left panel and tracks for Telonics RDW-640 Dive Duration Monitoring (DUR) tagged whales are presented in the right panel. The last transmission received for these tags was on 23 October 2017.

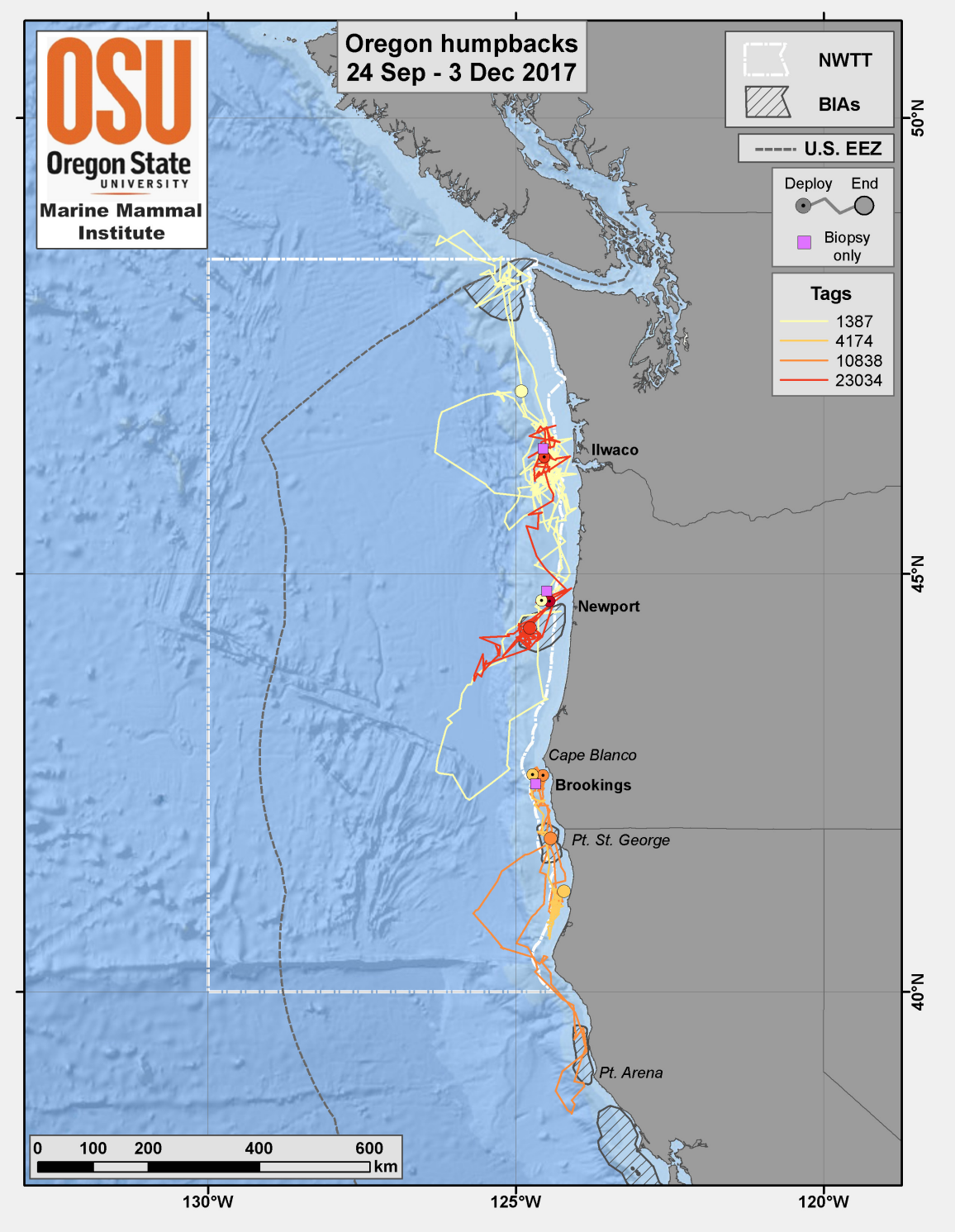


Figure 2: Tracks of humpback whales tagged off Oregon and Washington during September-October 2017. All tags were Telonics RDW-640 Dive Duration Monitoring (DUR) tags. Tag # 1387 was still transmitting as of 3 December 2017.

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