

Progress Report

GULF OF ALASKA NAVY TRAINING AREA ACOUSTIC MOORINGS AND ANALYSIS

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14. ABSTRACT The Gulf of Alaska (GOA) provides important habitat for many endangered marine mammal species and is an area of considerable commercial importance for the fishing and shipping industries and of great significance for military activities. As such, the GOA is an area of interest of various US government agencies (e.g., the US Navy [USN], the National Marine Fisheries Service [NMFS], and the Bureau of Ocean Energy Management (BOEM)) tasked with monitoring anthropogenic impacts. For example, the GOA contains the USN Temporary Maritime Activities Area (TMAA) and Western Maneuver Area (WMA) and is included in BOEM's oil spill trajectory modeling from oil and gas exploration occurring in nearby regions (Ji et al., 2016). In recent years, vessel surveys have been conducted in the upper GOA to assess the distribution and to estimate density and abundance of cetacean species (e.g., Rone et al., 2017; Zerbini et al., 2007, 2023). In addition, acoustic moorings have been deployed in the northern GOA to assess seasonal occurrence and better understand population identity of cetaceans in the region (Wright et al., 2025). Information produced by these studies are needed to support the preparation of environmental planning documents for government agencies.		

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The killer whale (*Orcinus orca*) is an apex predator with an important ecological role in the GOA ecosystem (Dahlheim et al., 2008). Three different killer whale ecotypes, characterized by unique behaviors, diets, and social structure occur in the region (Zerbini et al., 2007; Dahlheim et al., 2008; Ford and Ellis, 2014): resident, transient (Bigg's), and offshore. These ecotypes are genetically distinct (Parsons et al., 2013) and can be distinguished by morphological characteristics as well as acoustic signatures (Foote and Nystuen 2008). Resident killer whales primarily feed on fish, live in relatively large, stable matrilineal pods and are highly vocal. Unlike residents, transient killer whales feed on marine mammals, travel in smaller groups, and tend to be quieter to avoid alerting their prey. Offshore killer whales are the less known of the three ecotypes in the GOA. They typically feed on schooling fish and sharks and travel in large groups.

The seasonal occurrence and the abundance of killer whale ecotypes is poorly known. While vessel-based density and abundance of this species have been estimated for different bathymetric habitats (e.g., inshore and offshore) in the GOA (Rone et al., 2017; Crance et al., 2021; Zerbini et al., 2023), computing ecotype-specific estimates has been challenging because of the difficulty in determining the identity of each killer whale pod seen during the abundance surveys.

Therefore, research to assess the occurrence, acoustic characteristics, and proportion of killer whale ecotypes in different habitats in the GOA is needed to apportion existing density estimates of killer whales to each ecotype and to allow for better determination of ecotype-specific calls in the recordings obtained from long-term acoustic moorings.

Other cetacean species, especially endangered large whales, occur in the GoA (Rone et al., 2017). New estimates of abundance from these species (e.g., fin [*Balaenoptera physalus*] and humpback whales [*Megaptera novaeangliae*]) would provide updated information on the occurrence and density of whales in the regions and could potentially be integrated with existing data to compute estimates of trends in abundance to inform management decisions. In addition, other less known species of cetaceans may be present in the GoA, especially in offshore waters. They typically include deep-diving species such as sperm whales (*Physeter macrocephalus*) and beaked whales (*Family Ziphiidae*).

15. SUBJECT TERMS

Acoustic monitoring, vessel survey, harbor porpoise, Behn Canala, densities, Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA)

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1. Background

The Gulf of Alaska (GOA) provides important habitat for many endangered marine mammal species and is an area of considerable commercial importance for the fishing and shipping industries and of great significance for military activities. As such, the GOA is an area of interest of various US government agencies (e.g., the US Navy [USN], the National Marine Fisheries Service [NMFS], and the Bureau of Ocean Energy Management [BOEM]) tasked with monitoring anthropogenic impacts. For example, the GOA contains the USN Temporary Maritime Activities Area (TMAA) and Western Maneuver Area (WMA) and is included in BOEM's oil spill trajectory modeling from oil and gas exploration occurring in nearby regions (Ji et al., 2016).

In recent years, vessel surveys have been conducted in the upper GOA to assess the distribution and to estimate density and abundance of cetacean species (e.g., Rone et al., 2017; Zerbini et al., 2007, 2023). In addition, acoustic moorings have been deployed in the northern GOA to assess seasonal occurrence and better understand population identity of cetaceans in the region (Wright et al., 2025). Information produced by these studies are needed to support the preparation of environmental planning documents for government agencies.

The killer whale (*Orcinus orca*) is an apex predator with an important ecological role in the GOA ecosystem (Dahlheim et al., 2008). Three different killer whale ecotypes, characterized by unique behaviors, diets, and social structure occur in the region (Zerbini et al., 2007; Dahlheim et al., 2008; Ford and Ellis, 2014): resident, transient (Bigg's), and offshore. These ecotypes are genetically distinct (Parsons et al., 2013) and can be distinguished by morphological characteristics as well as acoustic signatures (Foote and Nystuen 2008). Resident killer whales primarily feed on fish, live in relatively large, stable matrilineal pods and are highly vocal. Unlike residents, transient killer whales feed on marine mammals, travel in smaller groups, and tend to be quieter to avoid alerting their prey. Offshore killer whales are the less known of the three ecotypes in the GOA. They typically feed on schooling fish and sharks and travel in large groups.

The seasonal occurrence and the abundance of killer whale ecotypes is poorly known. While vessel-based density and abundance of this species have been estimated for different bathymetric habitats (e.g., inshore and offshore) in the GOA (Rone et al., 2017; Crance et al., 2021; Zerbini et al., 2023), computing ecotype-specific estimates has been challenging because of the difficulty in determining the identity of each killer whale pod seen during the abundance surveys. Therefore, research to assess the occurrence, acoustic characteristics, and proportion of killer whale ecotypes in different habitats in the GOA is needed to apportion existing density estimates of killer whales to each ecotype and to allow for better determination of ecotype-specific calls in the recordings obtained from long-term acoustic moorings.

Other cetacean species, especially endangered large whales, occur in the GoA (Rone et al., 2017). New estimates of abundance from these species (e.g., fin [*Balaenoptera physalus*] and humpback whales [*Megaptera novaeangliae*]) would provide updated information on the occurrence and density of whales in the regions and could potentially be integrated with existing data to compute estimates of trends in abundance to inform management decisions. In addition, other less known species of cetaceans may be present in the GoA, especially in offshore waters. They typically include deep-diving species such as sperm whales (*Physeter macrocephalus*) and beaked whales (Family Ziphiidae).

2. Objectives

Project goals and objectives

The main goal of this study is to design and conduct a vessel-based visual and passive acoustic monitoring survey to provide the Navy with seasonal occurrence and density of cetaceans in the GOA and the Navy's TMAA and WMA. The survey will be conducted in partnership with the Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration (AFSC/NOAA). Emphasis will be given to assess the occurrence and estimate density of endangered large whales and to document the occurrence of killer whale ecotypes in coastal and offshore waters in the northern GOA. The survey will be designed to maximize detections of killer whales and to collect information key for ecotype determination (e.g., photographs, biopsy and eDNA samples) and to record the acoustic behavior of the groups seen. This information will be used to improve existing estimates of density and abundance of this species in the northern GOA and to better understand the seasonal distribution of killer whales from past and current year-round passive acoustic monitoring. If possible, satellite transmitters will be deployed to describe habitat use and better understand occupancy patterns of the different ecotypes in waters off the GOA. Photographs and samples (biopsy and eDNA) of other key species (e.g., humpback and fin whales) will be obtained whenever feasible. Finally, incidental sightings of other marine mammal species (cetaceans, pinnipeds, and sea otters) will be documented.

The proposed project will support the Navy's efforts to:

- A. Determine which marine mammals (including ESA-listed species) are present within the Navy's GOA TMAA and WMA.
- B. Assess the occurrence and estimate killer whale ecotype-specific density within and near the TMAA and WMA.
- C. Determine the seasonality and possible movement patterns of marine mammals within these Navy training activities areas.
- D. Apply passive acoustic tools and techniques for detection and classification of marine mammals.
- E. Assess occurrence and density of cetacean species within and near the TMAA and WMA.

The project's specific objectives include:

- 1. Review existing visual and acoustic information on the occurrence of killer whales in the GOA to design a vessel survey that maximizes the encounter rate of this species in the summer of 2026.
- 2. Conduct a vessel survey in the GOA to collect visual, acoustic, and molecular data required to determine ecotype identity of killer whale sightings and, if feasible, to deploy satellite transmitting tags to evaluate killer whale ecotype-specific habitat use.
- 3. Design and conduct a systematic line transect survey to occur in July and August of 2026, suitable to support cetacean species density estimates for the GOA TMAA and WMA areas. This survey is expected to overlap or be conducted in conjunction with the killer whale-specific effort above. Data collected from this effort shall be similar and comparable to past Navy and NMFS vessel-based surveys to estimate density and abundance of marine mammals (e.g. GOALS and PACMAPPS) and may include both visual and acoustic survey data.
- 4. Integrate existing data (e.g., visual surveys conducted by NOAA/NMFS/AFSC in 2009, 2013, 2015, and 2021, and the acoustic moorings) to estimate ecotype-specific seasonal occurrence, density, and abundance of killer whales near and within the TMAA.

5. Analyze and add to the year-round seasonal occurrence information of cetaceans recorded at the three acoustic recorder moorings sites deployed by AFSC since 2023, by providing results from recorders deployed between 2024 and 2026.
6. Combine these new mooring results with other recordings collected concurrently (by AFSC) along the WGOA shelf to investigate whether any movement patterns for any species can be identified.
7. Continue to develop methods for identifying killer whale signals to ecotype within these Navy training activities areas and provide recommendations for future research.
8. Assess data to determine if acoustic abundance or density information can be derived, and/or identify biological or data limitations (unknown call rates; unknown call localization, need for additional behavioral information, etc.), and provide recommendations for future research.
9. Provide year-round occurrence information for anthropogenic sources at those mooring sites.
10. Provide seasonal measurements of median noise spectral percentiles at those mooring sites.
11. Analyze visual sighting data to create density layers for all possible cetacean species.
12. Process 2009, 2013, 2015, 2021, and 2026 Survey data from GOA in a way that the Navy can use for NAEMO modeling.
13. Review and provide input to model results that ManTech creates for the Developing Habitat-Based Density Models for Cetaceans in the North Pacific Ocean project.
14. Produce technical and interim reports, and draft manuscripts.

3. Progress towards specific objectives

The present report covers the period since the beginning of the project (contract awarded in September 2025) and January 2026.

Objective 1: Review existing visual and acoustic information on the occurrence of killer whales in the GOA to design a vessel survey that maximizes the encounter rate of this species in the summer of 2026.

Information on killer whale sightings from various surveys in the northern Gulf of Alaska (Zerbini et al., 2007; Rone et al., 2017) have been reviewed to assist in survey design. The previously analyzed archival Gulf of Alaska passive acoustic data results (Figure 1, red circles; Figure 2; Table 1) support our plans to conduct the survey in the summer (Jun-Aug); the percentage of days with killer whale detections was consistent throughout the year (Berchok et al., 2025).

Objective 2: Conduct a vessel survey in the GOA to collect visual, acoustic, and molecular data required to determine ecotype identity of killer whale sightings and, if feasible, to deploy satellite transmitting tags to evaluate killer whale ecotype-specific habitat use.

A request for proposals was developed by CICOES/UW and AFSC/NOAA to charter a research vessel for the cruise. The RFP was published on the University of Washington (UW) Funding Opportunities website on December 30, 2025, and remained open until January 30, 2026. At the time of the preparation of this report UW had received four bids and is currently in the process of evaluating the proposals. Once evaluation is completed, the exact cruise dates and the survey design (which will depend on vessel schedule and location) will be finalized. We now have received enough new crates of sonobuoys from our Navy suppliers to be able to conduct passive acoustic monitoring throughout both legs of the survey.

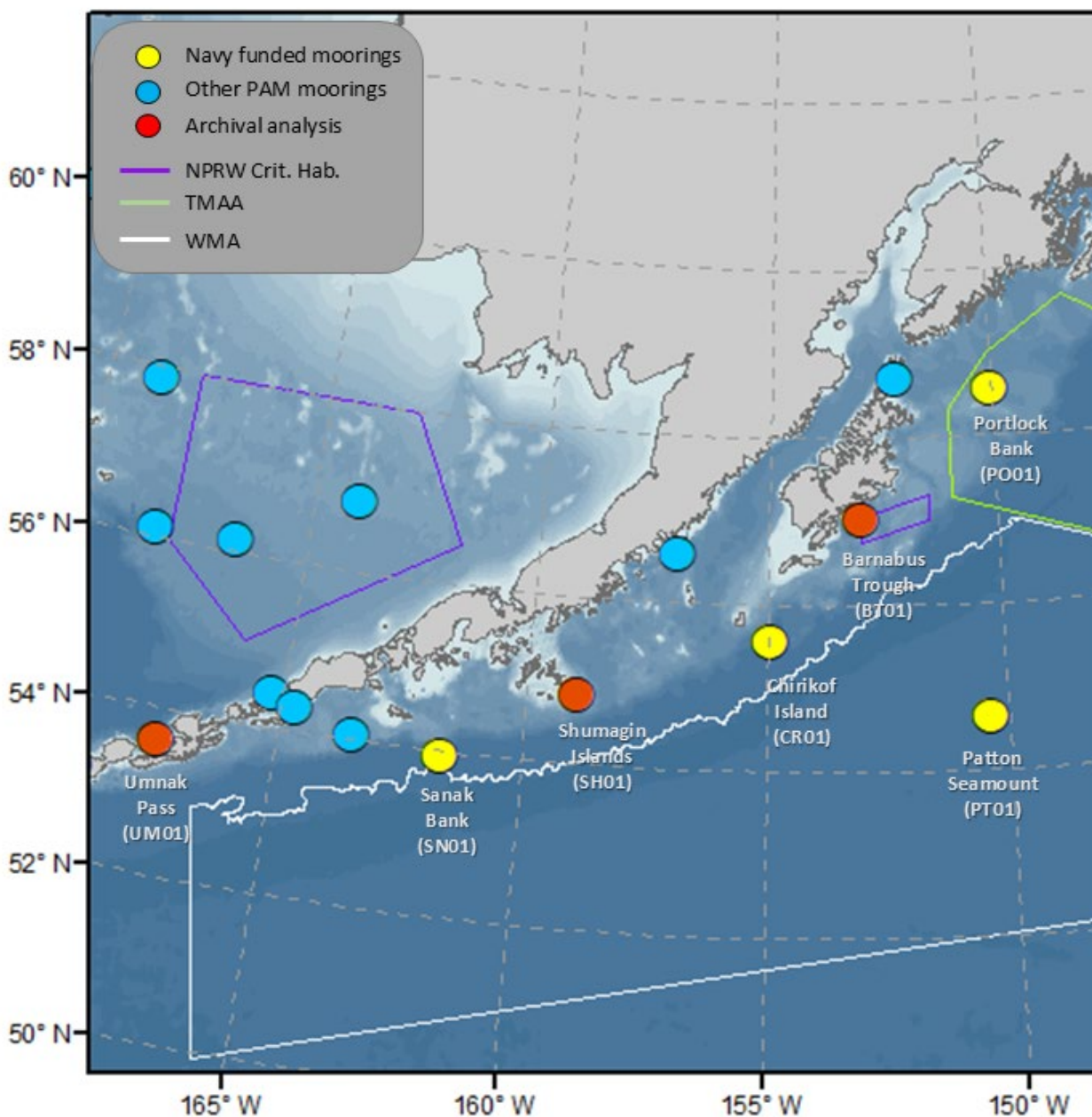


Figure 1. Long term mooring sites. Yellow circles = Mooring deployments funded by the Navy; red circles = archival moorings chosen for high-frequency analysis and for investigation of killer whale ecotypes; blue circles = other long-term passive acoustic recorder moorings. Purple outlines represent North Pacific right whale critical habitat. See Table 1 for deployment information.

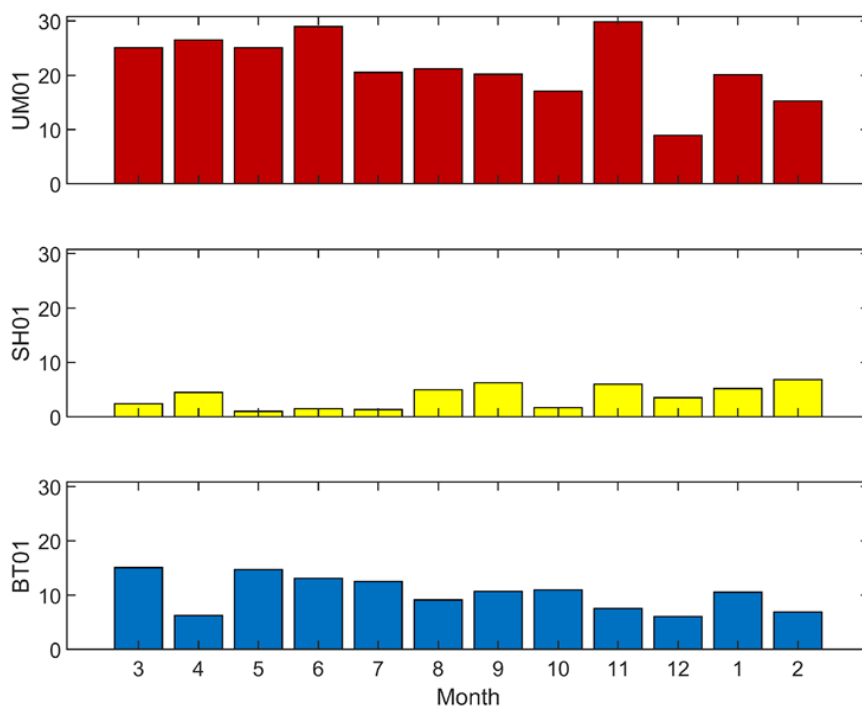


Figure 2. Killer whale monthly calling activity (presented as a percentage of 10-minute time intervals per month with calls, adjusted for recording effort) detected at all three archival mooring sites. Top row: Umnak Pass. Middle row: Shumagin Islands. Bottom row: Barnabas Trough. See Figure 1 for map of locations. Note: x-axis starts in March.

Table 1. Long term mooring deployment information. AU = AURAL M2, ST = Soundtrap ST600, FP = Fpod, dFP = deep-rated Fpod, MC = Microcat; * indicates the recorder failed.

Mooring	Type	Date/Time deployed (UTC)	Date/Time recovered (UTC)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Instruments				
							AU	ST	FP	dFP	MC
UM01	Archival	5/1/19 19:22	5/14/21 16:20	53.630	-167.399	95	x				
SH01	Archival	10/1/19 2:21	9/22/20 17:04	54.850	-158.998	74	x				
BT01	Archival	10/2/19 6:27	9/24/20 16:31	57.031	-152.987	79	x				
SN01	Deep	8/18/23 17:08	9/16/24 20:55	53.973	-161.668	423	x	x	x		x
CR01	Deep	8/17/23 6:52	9/19/24 22:35	55.572	-154.974	406	x	x	x		x
PT01	Deep	9/11/23 16:07	8/4/24 3:00	54.637	-150.353	747	x	x	x	x	x
SN01	Deep	9/17/24 1:21	9/12/25 19:51	53.971	-161.663	436	x	x	x		
CR01	Deep	9/20/24 3:17	9/13/25 22:58	55.572	-154.975	400	x*	x	x		
SN01	Deep	9/13/25 0:43	-	53.969	-161.664	431	x	x	x		
CR01	Deep	9/14/25 1:06	-	55.570	-154.975	399	x	x	x		
PO01	Shelf	6/14/25 17:23	-	58.566	-149.991	116	x	x	x		

Objective 3: Design and conduct a systematic line transect survey to occur in 2026, suitable to support cetacean species density estimates for the GOA TMAA and WMA areas. This survey is expected to overlap or be conducted in conjunction with the killer whale-specific effort above. Data collected from this effort shall be similar and comparable to past Navy and NMFS vessel-based surveys to estimate density and abundance of marine mammals (e.g. GOALS and PACMAPPS) and may include both visual and acoustic survey data.

Progress toward Objective 2 applies here.

Objective 4: Integrate existing data (e.g., visual surveys conducted by NOAA/NMFS/AFSC in 2009, 2013, 2015, and 2021, and the acoustic moorings) to estimate ecotype-specific seasonal occurrence, density, and abundance of killer whales near and within the TMAA.

Visual data from previous AFSC/NOAA surveys have been collated and are formatted for analysis. Once the 2026 survey data are processed the visual survey data will be integrated to compute killer whale ecotype-specific estimates of density. From the three archival mooring sites previously analyzed (see Objective 1), over 29,600 individual killer whale calls were extracted. These are currently being ranked for quality, classified, and matched to ecotype based on the call library created for this project.

Objective 5: Analyze and add to the year-round seasonal occurrence information of cetaceans recorded at the three acoustic recorder moorings sites deployed by AFSC since 2023, by providing results from recorders deployed between 2024 and 2026.

Data analyses are conducted separately for low, mid-, and high frequency species (for details see Berchok et al. 2025). The low and high frequency passes will be automated using Artificial Intelligence/Machine Learning models developed through our in-house software *INSTINCT* (Woodrich and Berchok, 2020). We are currently investigating whether our fin whale detector can differentiate between fin and sei whales.

SN01 and CR01 were retrieved and redeployed on 13 and 14 September 2025, respectively, during the EcoFOCI fall mooring cruise on the NOAA Ship Oscar Dyson. In addition, a new mooring was deployed by the NOAA ship Fairweather at Portlock Bank on 14 June 2025 prior to Exercise Northern Edge, scheduled for summer 2025. The Portlock Bank mooring (PO01, see Fig. 1) will remain deployed collecting data until its retrieval this summer during the 2026 GoA survey.

The manual processing of data for the detection of mid-frequency species (in this area will include North Pacific right, humpback, gray, and minke whales, and generic pinniped sounds) have been completed for all three moorings recovered in 2024 (Figure 1, Table 1; CR01, SN01, PT01). Analyses for high frequency species (e.g., killer whales, beaked whales, killer whales, dolphins, and porpoise) are ongoing. Click detectors and Long-Term Spectral Averages (LTSA's) have been run on all 2023-24 mooring deployments, and results are currently being QA/QC'ed. Data recovered in 2025 are currently with the Navy data screeners for review.

Objective 6: Combine these new mooring results with other recordings collected concurrently (by AFSC) along the WGOA shelf to investigate whether any movement patterns for any species can be identified.

Awaiting further completion of Objective 5.

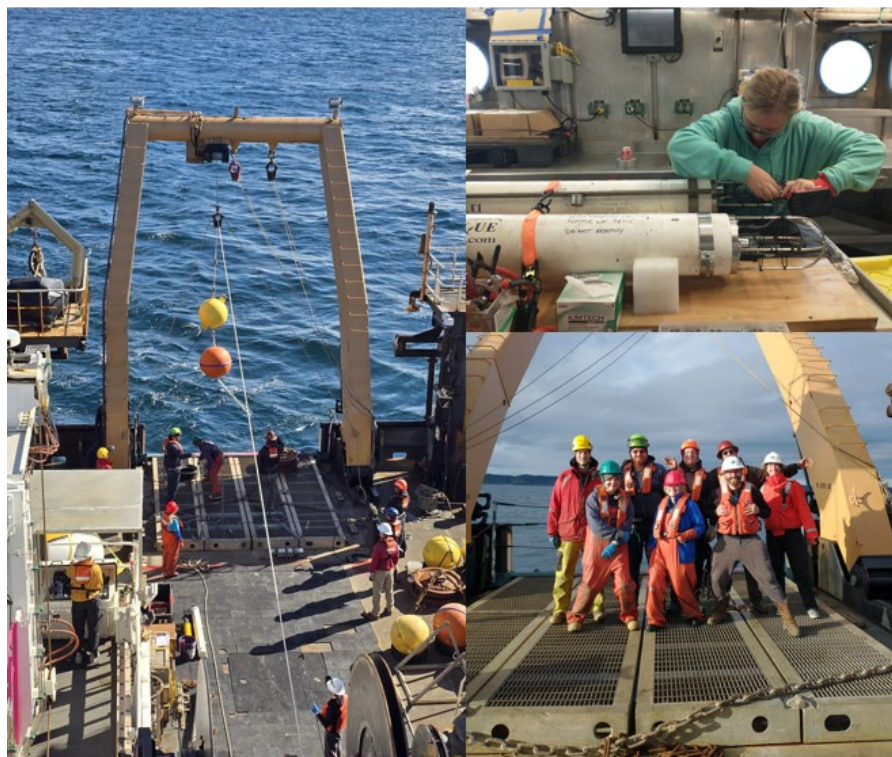


Figure 3. Photos from the 2025 Fall Mooring Cruise on the NOAA Ship Dyson (25Aug-18Sep 2025). Clockwise from left: deployment of Chirikof Island mooring, Sophia Wagner closing up newly refurbished AURAL recorder, NOAA/UW mooring techs and Dyson deck crew after last deployment of cruise (from left to right: Ryan McCabe, Catherine Berchok, Alex Steele, Sophia Wagner, John Swenson, Scott Doyle, Luis Candela, and Eve Cullerton).

Objective 7: Continue to develop methods for identifying killer whale signals to ecotype within these Navy training activities areas and provide recommendations for future research.

See acoustics part of Objective 4. The call library being compiled for the ecotype analysis consists of both published and unpublished killer whale calls that have previously been attributed to ecotype with visual confirmation. Any calls that do not match to the call library are assigned to a new call type, which is described and, when possible (i.e. occur within close temporal proximity to known calls), assigned to an ecotype. This call library will be used during the survey to identify calls detected on the sonobuoys. It is expected that the concurrent visual/acoustic components of the survey will allow for more unmatched calls to be attributed to ecotype.

Objective 8: Assess data to determine if acoustic abundance or density information can be derived, and/or identify biological or data limitations (unknown call rates; unknown call localization, need for additional behavioral information, etc.), and provide recommendations for future research.

Progress on Objective 8 will follow completion of Objective 6.

Objective 9: Provide year-round occurrence information for anthropogenic sources at those mooring sites.

See Objective 5; vessels, seismic airgun, and other anthropogenic signals are analyzed as part of the mid-frequency band, and so are completed for the three moorings recovered in 2024. Data recovered in 2025 are currently with the Navy data screeners for review.

Objective 10: Provide seasonal measurements of median noise spectral percentiles at those mooring sites.

Progress on Objective 10 will follow completion of Objective 6. To generate seasonal soundscape measurements, we plan to process the acoustic data using the PyPAM (Python passive acoustic analysis for Passive Acoustic Monitoring) software package (Wall et al., 2025). As part of the National Marine Fisheries Service Strategic Initiative, our national passive acoustics group is working on developing a seamless workflow where noise metrics will be automatically generated when data/metadata are ingested into the archive at NOAA's National Centers for Environmental Information (NCEI). This process works for a small set of recorders and is now being expanded to include other recorder types this year. Once available we will use this process to generate median power spectral density percentiles at each mooring site and season to characterize the ambient soundscape. This work is being done concurrently with the Navy project and benefits the project, and is conducted at no cost to the Navy

Objective 11: Analyze visual sighting data to create density layers for all possible cetacean species.

This objective will be addressed once the cruise is completed after the summer of 2026.

Objective 12: Process 2009, 2013, 2015, 2021, and 2026 Survey data from GOA in a way that Navy can use for NAEMO modeling.

Data from 2009, 2013, 2015 and 2021 has been formatted and data from the 2026 survey will be processed once the survey is completed.

Objective 13: Review and provide input to model results that ManTech creates for the Developing Habitat-Based Density Models for Cetaceans in the North Pacific Ocean project.

The 2009, 2013, 2015 and 2021 data are being reviewed. UW is working with ManTech (Dr. E. Becker) to finalize formatting of the data for consistency with previous spatial analysis. The 2026 data will be prepared once the vessel survey is completed.

Objective 14: Produce technical and interim reports, and draft manuscripts.

This is the first interim report of this project. Additional progress reports, a cruise report and draft manuscript will be provided in the future.

4. Future work

Logistical preparations for the marine mammal survey are also underway, including finishing the survey vessel contract, purchasing of equipment, testing and programming of instruments, ensuring the rigid hull inflatable boat (RHIB) and winch are serviced and fully operational, and securing visual observers and passive acoustic techs for the survey.

Moorings will be retrieved and/or redeployed on one of two surveys occurring this summer and fall. Several of the Gulf of Alaska moorings will be serviced (i.e., retrieved and redeployed) during this upcoming marine mammal survey on the charter vessel. This survey will likely take place between mid-July and early September, with final dates (final date will be determined in the next two weeks). However,

the EcoFOCI fall mooring cruise is also occurring 4 August to 1 September on the NOAA Ship Bell M. Shimada, with the remaining Gulf of Alaska moorings serviced during that survey. Currently, the plan is for Portlock Bank to be retrieved during the marine mammal survey, with CR01 and SN01 to be serviced during the EcoFOCI fall mooring cruise.

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