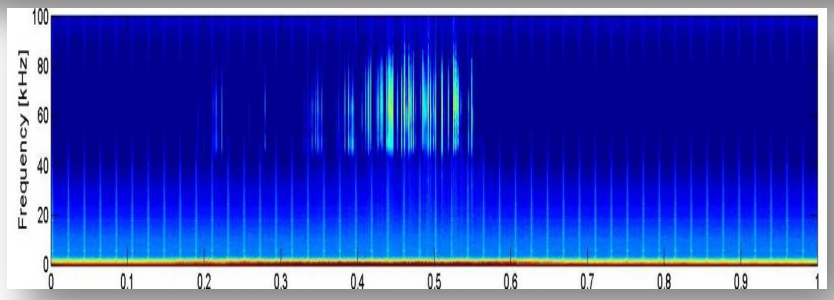
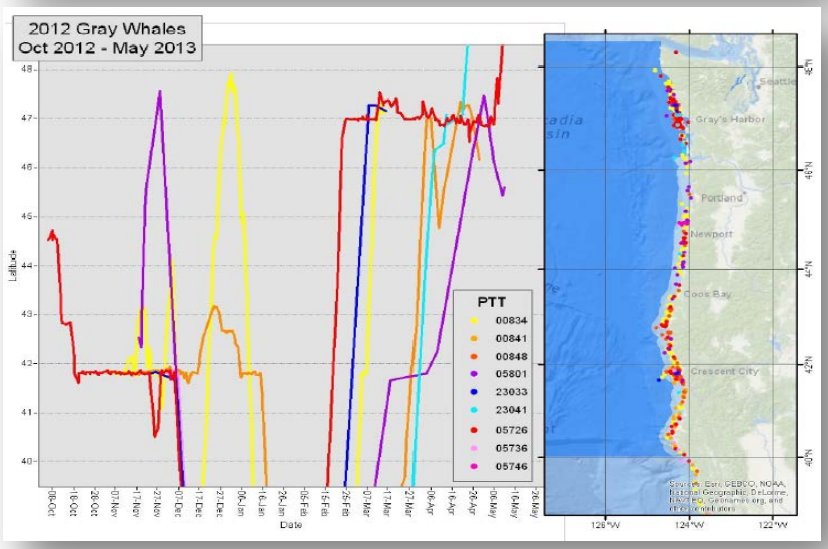
Comprehensive Marine Species Monitoring Report For the U.S. Navy's Northwest Training Range Complex

2011-2014





July 1, 2014

Cover Photos: Photograph of Southern Resident killer whale K25 with satellite tracking tag attached 29 December 2012 (Photo by Candice Emmons, NMFS ESA Permit No. 16363-01) (*top*); Echolocation sequence of Stejneger's beaked whale in a Long Term Spectral Averages from Debich et al. 2014 (*center*); and Latitude of locations from Pacific Coast Feeding Group gray whales tagged with satellite transmitters plotted vs. date (map of the locations shown on the right side of the figure) (Figure 2 from Mate 2013) (*bottom*).

In Support Of
Letter of Authorization
Under The Marine Mammal Protection Act
And
Incidental Take Statement
Under the Endangered Species Act
For Incidental Harassment of Marine Mammals Resulting From
U.S. Navy Training Activities
In The Northwest Training Range Complex

Comprehensive

Marine Species Monitoring Report

For the U.S. Navy's

Northwest Training Range Complex

2011-2014

Prepared in Accordance With
50 C.F.R. §218.115(l)

Submitted By
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Submitted To
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Monitoring Team and Performers- The Northwest Training Range Complex Navy funded Compliance Monitoring team is comprised of non-Navy civilian academic and contract scientists.

Marine mammal tagging effort conducted by Cascadia Research Collective, Olympia, Washington, led by Greg Schorr, Erin Falcone, and Dr. John Calambokidis; by Oregon State University led by Dr. Bruce Mate, and by the Alaska Fisheries Science Center, NOAA Fisheries led by Dr. Bob Long.

Passive acoustic monitoring conducted by Marine Physical Laboratory, Scripps Institution of Oceanography at University of California San Diego, led by Dr. John Hildebrand

EXECUTIVE SUMMARY

Below is a broad assessment of accomplishments from Navy-funded monitoring conducted from 2011 to May 2014 for the Navy's Northwest Training Range Complex (NWTRC):

1) Passive Acoustic Monitoring: Long-term fixed passive acoustic monitoring is an effective way to determine seasonal species-specific occurrence of vocalizing and potentially foraging animals. It does not account for non-vocalizing animals. Passive acoustic monitoring can also be used to record natural and anthropogenic sounds leading to better assessment of ambient noise conditions.

By the summer of 2014, Navy funded passive acoustic monitoring will have been ongoing off the coast of Washington State for close to 10 years. Navy research funding and reporting occurred from 2004-2010 (Oleson et al. 2009, Oleson and Hildebrand. 2012). Under NWTRC compliance monitoring from 2011-2014, over 27,000 hours of passive acoustic data has been collected from two passive acoustic devices on the shelf and slope Department of the Navy 2011, 2012, 2013a).

Specific passive acoustic monitoring observations include:

- Passive acoustic monitoring made only few, highly infrequent detections of U.S. Navy active mid-frequency sonar from two fixed monitoring sites off the Washington coast. From 2008 to 2013, passive sensors only detected four to seven days per year from temporally separated mid-frequency sonar events lasting at most a few hours in duration. This is consistent with the a) overall infrequent use of at-sea sonar training in the NWTRC as compared to other Navy range complexes, and b) the general tendency for unit-level sonar and explosive training to occur further offshore, sometimes >50 miles.

- Passive acoustic monitoring has the potential, via expanded analysis tools, to begin addressing the possible impacts of anthropogenic sources on marine mammal vocalization and echolocation, with the assumptions that changes in vocalizations and echolocation rates are indicative of behavioral changes. However, this kind of analysis is better suited for those areas where the Navy in-water training occurs more frequently such as Southern California or Hawaii vice the more limited Navy in-water training within the NWTRC.

Future National Marine Fisheries Service (NMFS) and Navy adaptive management should be conducted with an eye toward reviewing the relevance of continued data collection. Toward that end, the Navy in 2014-2015 will focus on analysis from just one NWTRC passive device (slope site).

2) Satellite tracking: Satellite tracking tags can be an effective indicator of marine mammal distribution and movement patterns at short (days-weeks) and long (months-year) time scales (Department of the Navy 2011, 2012, 2013a, Schorr et al 2013, Mate 2013, Mate et al. 2014).

The Navy believes for future NWTRC tagging efforts from 2014 forward, longer term tags are preferred for continued monitoring. Long term tags will not only provide information on baleen whale distributions in terms of local bathymetric features, but also allow determination of percentages of time individuals spend within and outside of the NWTRC.

In particular, certain offshore sub-areas within NWTRC are more likely to have in-water Navy training events as compared to the rest of the NWTRC. Therefore, comparisons of baleen whale residence times and area restricted searches (potential foraging metric) in sub-areas of the NWTRC can be valuable in comparing potential baleen whale interactions or lack of interactions with Navy training events.

Summary of tagging:

- Navy funded gray whale projects from 2011-2013 in NWTRC provided valuable distribution information.

3) Future Efforts: To support the need for longer term tracking of additional cetacean species following the success of the gray whale tagging, the Navy funded a new large scale tagging effort for blue and fin whales. The focus of this study will be movement patterns and residency pattern of blue and fin whales along the U.S. West Coast, including within NWTRC. This project was funded in spring 2014 for a planned summer 2014 field season. Initial data from this tagging effort should be available by summer 2015.

Finally, as the Navy prepares for future study question-based monitoring within the Pacific Northwest, the Navy funded a new study in the spring of 2014 to model offshore movements of Southern Resident killer whales. Work will be performed by scientists affiliated with NMFS' Northwest Fisheries Science Center (NWFSC).

This project will occur from fall to spring 2015 and involve the: a) deployment of 15 bottom-mounted acoustic monitoring devices, b) purchase of four (4) satellite tracking tags for eventual attachment to Southern Resident killer whales, c) and development of a new state-space model to predict Southern Resident killer whale offshore movement and habitat. Model development will be started concurrently with the 2014-2015 field data collection. Previously collected NWFSC passive acoustic and tagging data from the past two years of offshore Southern Resident effort will be used to initiate model development.

Table ES-1. Monitoring Plan Metrics Accomplished In The NWTRC Through May 2014.

Metric	November 2011 to May 1, 2014
Navy Funded Opportunistic /Fully Funded Marine Mammal Tagging	1) Multiple Cetacean species: Ten (10) Andrews-style LIMPET (Low Impact Minimally Percutaneous External Transmitter) tags were purchased by the Navy and supplied to researchers at Cascadia Research Collective for use within a collaborative study of marine mammal movement patterns within offshore waters of Washington State. All ten (10) Navy funded tags were deployed from 2011-2012 within offshore waters of Washington State. Satellite tags were deployed during collaborative field efforts with the Washington Department of Fish and Wildlife and supported with funding from NMFS' Alaska Regional Office and Southwest Fisheries Science Center. In total, over 21 tags were attached (see Schorr et al. 2013 and Section 2.2 in this report) 2) Gray whales: 17 Telonics ST-15 ultra-high frequency location only tags and 14 Wildlife Computer Spot-5 tags were purchased by the Navy as well as associated field work by Oregon State University. Tags were attached to Pacific Coast Feeding Group gray whales from October to November 2012, and in October 2013 (see Mate 2013, Mate et al. 2014 and Section 2.2 in this report). 3) Baleen (blue and fin) whales: Up to 24 location-only SPOT-5 tags and 8 newly designed Advance Dive Behavior tags are planned for attachment in summer 2014. While tagging location will be in Southern California, the goal is to study and document blue and fin whale movements along the entire U.S. West Coast including Navy range areas like the Southern California Range Complex and NWTRC (See Section 2.2 in this report). 4) Pinnipeds: Funded in late 2013, the tagging of 30 California sea lions is set to begin in fall 2014 at two selected Navy facilities in Puget Sound. Year-round haulout counts at multiple Navy waterfront facilities is also ongoing (see Section 2.4).
Deploy Two Long-term Passive Acoustic Monitoring (PAM) Devices	Two (2) High-frequency Acoustic Recording Packages (HARP) from Scripps Institute of Oceanography were funded by the Navy for deployment at offshore Washington State locations and monitored under previous Navy Research funding from 2004-2010. Under the NWTRC monitoring plan and associated U.S. Pacific Fleet funding, the two devices have been in place from November 2011 to present. Through March 2013, the last series analyzed so far, over 27,000 hours of passive acoustic data have been analyzed for baleen whale calls; toothed whale calls/whistles/echolocation clicks; and anthropogenic sounds. These devices have been continuously maintained and data analyzed for the duration of this period. Analysis confirmed detection of four baleen whale species (blue whales, fin whales, gray whales, humpback whales); and seven toothed whale species. Ship and boat noise was common anthropogenic sound at both sites.
Future New Study Question Projects starting in fall 2014: "*What is the distribution, residency time, and spatial extent of Southern Resident killer whale winter movements off the coasts of Washington, Oregon, and northern California, and relationship of this movement to NWTRC*?" Navy-funded study in spring of 2014 on "**Modeling the Distribution of Southern Resident Killer Whales in the Pacific Northwest**."	

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1.0 INTRODUCTION

The United States Navy (Navy) developed Range Complex-specific Monitoring Plans under the Navy Monitoring Program to provide marine mammal and sea turtle monitoring as required under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973.

The U.S. Pacific and Atlantic Fleets marine species monitoring programs are composed of a collection of "range-specific" monitoring plans each developed as part of the MMPA/ESA authorization process. The Fleets individual plans establish specific monitoring requirements for each range complex based on a set of effort-based metrics.

This report summarizes Navy-funded monitoring within the Navy's Northwest Training Range Complex (NWTRC) conducted between 2011 and May 1, 2014.

This document is an cumulative report summarizing to the best extent practical monitoring program results, prepared in accordance with 50 CFR §218.115(l) and National Marine Fisheries Service (NMFS) Letter of Authorization (NMFS 2012) for NWTRC.

1.1 Report Overview

This report is comprised of four main sections:

- Introduction
- Compliance Monitoring Summary
- Future Direction (≥ 2014)
- Conclusion

The "Introduction" contains the report overview and brief background of NWTRC.

The "Compliance Monitoring Summary" discusses scientific contribution and major results from U.S Pacific Fleet funded Compliance Monitoring under the MMPA and ESA authorizations for the NWTRC. Fleet funded Compliance Monitoring is directly tied to the monitoring objectives and metrics NMFS approved in the original NWTRC Monitoring Plan (Department of the Navy 2010a). Additional Navy funded projects during this reporting period are also described.

The "Future Direction" section presents some of the Navy's new follow-on monitoring being funded in 2014 with expected work to continue through May 2015 and beyond.

The "Conclusion" summarizes lessons learned from 2011-2014 Navy funded monitoring and reiterates the new study-centric nature of subsequent monitoring.

1.2 NWTRC Background

The NWTRC is part of the Navy's Northwest Training and Testing study area which serves as maneuver water space for ships and submarines to conduct training and to transit (**Figure 1-1**). NWTRC extends from the Strait of Juan de Fuca in the north, to approximately 50 nm (92.6 km) south of Eureka, California in the south, and from the coast line of Washington, Oregon, and California westward to 130° West longitude. The southern boundary of the range complex is at 40° N latitude, which corresponds to the northern boundary of Mendocino County in Northern California (Department of the Navy 2010b).

For range management and scheduling purposes, the NWTRC is divided into numerous subcomponent training areas, the most important one being Warning Area 237 (W-237). Although the NWTRC extends to the coastline of Washington, Oregon, and Northern California, no training that involves live explosives is conducted within 3 nm of shore. Sonar training is also conducted in deeper offshore waters. Historically, as well as projected for the future, other training within 12 nm seldom if ever occurs off the coast of Oregon and Northern California (Department of the Navy 2010b).

The Navy's follow-on environmental documentation, the Northwest Training and Testing (NWTT) Draft Environmental Impact Statement/Overseas Environmental Impact Statement, formally acknowledges this historic trend with the redesignation of the NWTT study area as seaward of the 12 nm limit off the Oregon and northern California coasts (**Figure 1-1**).

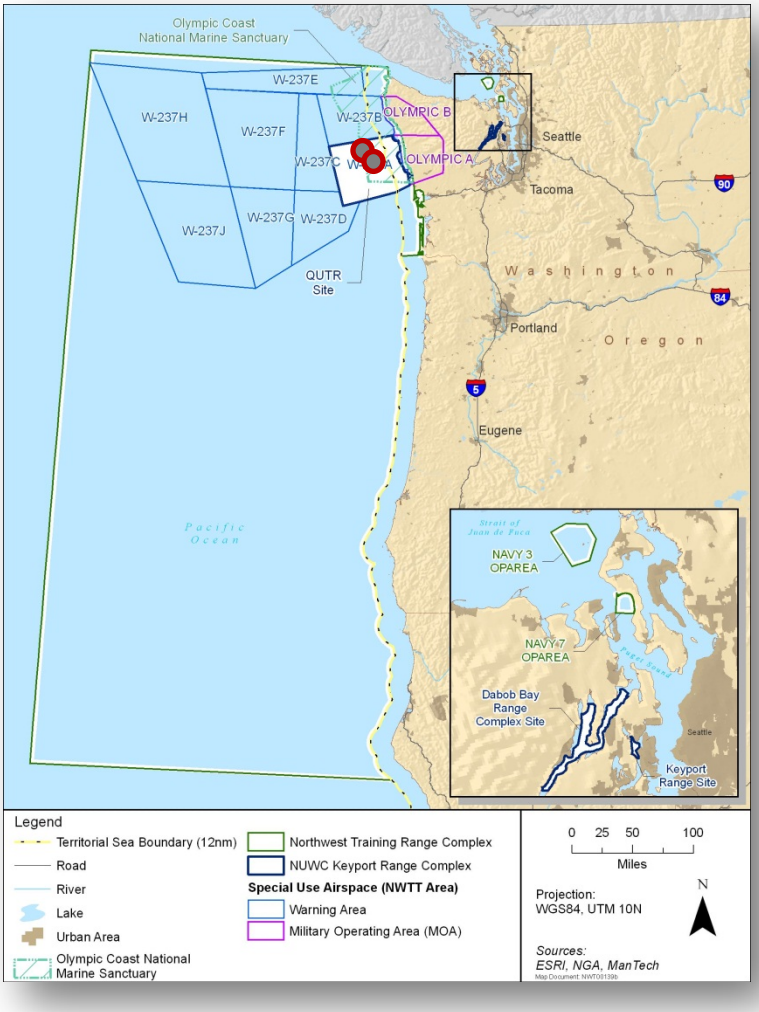

Figure 1-1. NWTRC Complex showing NWTT study area boundaries and W-237 training at-sea training area.
(Approximate location of bottom-mounted Compliance Monitoring passive acoustic devices shown in red circles)

2.0 COMPLIANCE MONITORING SUMMARY

This Section provides a summary from 2011 to May 2014 of Navy funded NWTRC compliance monitoring with a focus on the scientific contributions and major results from each research element.

At the beginning of the NWTRC monitoring program in 2011, it quickly became apparent that from a logistics perspective (distances from land, funding, limited amount of Navy in-water training occurring, etc.) and scientific perspective (availability of previous data for comparison), not all parts of the NWTRC could be effectively and safely studied within the time frame of this program (2011-2015). Therefore, the NWTRC monitoring program focused on key Navy training areas off Washington State (e.g., W-237) (**Figure 1-1**).

In terms of this comprehensive report for 2011-2014, the Navy has maintained through May 2014 the same approximate level of commitment in terms of annual metrics for Compliance monitoring technologies and resources as was originally established in 2011.

2.1 Navy Compliance Monitoring Overview

Current NWTRC compliance monitoring completed from 2011 through May 2014 consisted of the below research elements which has been relatively consistent over the course of the monitoring period:

- Marine mammal tagging; and
- Passive Acoustic Monitoring (PAM): two (2) bottom mounted devices deployed offshore of Washington State.

Additionally, although not part of the NWTRC Compliance Monitoring, the Navy does summarize efforts from other Navy-funded research studies within the Pacific Northwest, as information is available.

The following sections as well as Table ES-1 describe and summarize results by research element (tagging, passive acoustics).

2.2 Tagging

One of the initial NWTRC monitoring metrics was to begin contributing to regional marine mammal tagging on an opportunistic basis. As discussed in the subsequent sections, the focus on tagging as a research tool grew from opportunistically contributing to ongoing projects funded by other agencies into several Navy only funded projects related to tagging marine mammals.

Opportunistic Large Whale Tagging

(G. Schorr, E. Falcone, J. Calambokidis, Cascadia Research Collective)

In the winter of 2011, the Navy purchased 10 satellite tracking tags for 2011-2012 field deployments. Tags were the Andrews-style LIMPET (Low Impact Minimally Percutaneous External Transmitter), which could be set in either the location-only Spot-5 configuration or the location/dive data Mk10-A configuration (Wildlife Computers, Redmond, Washington), and programmed on a species-specific transmission schedule, based on 1) surfacing behavior and 2) prior transmission data from previous deployments. The Navy purchased these satellite tracking tags as part of the NWTRC Compliance Monitoring. However, the tags were deployed opportunistically during field efforts associated a collaborative project with the Washington Department of Fish and Wildlife and NMFS addressing marine mammal distribution and habitat use off Oregon and Washington (Schorr et al. 2012 as provided for Department of the Navy 2012).

The tag track history for four tags deployed between February 2011 and September 2011 were detailed in the Navy's 2012 NWTRC annual monitoring report (Schorr et al. 2012, Department of the Navy 2012). In continued support of the NWTRC Compliance Monitoring, from 2012 through 2013 Cascadia Research Collective in partnership with the Washington Department of Fish and Game attached additional tracking tags.

For the entire period 2011 through 2013, as summarized by Schorr et al. (2013):

"*During the course of field work, 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. 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[1]) for killer whales.*"

[1] As of the time of report completion for Schorr et al 2013.

Key findings from this opportunistic tagging project include:

- LIMPET tagging over periods from 1 day to several months can provide useful information on the short-to-medium scale movement patterns of marine mammals related to some ocean features.
    - Fin whales tags (n=11 tags) in general were most commonly associated with the outer shelf edge [grand median distance to shore of 44 miles and 4,350 feet depth (72 km and 1,326-m)]. These were from tag durations of 1-76 days. One fin whale with a longer duration tag displayed movement along the entire U.S. West Coast (Schorr et al. 2013).
    - Humpback whales tags which lasted from 2-15 days (n= 5 tags) suggest individuals spent time both on and off the shelf edge.
    - One of two killer whales from the offshore stock (n= 2 tags) traveled over 5,384 miles (8,665 km) moving from off of Washington to Alaska (**Figure 2-1**).

- Opportunistically funded tagging efforts provided the Navy with a way to leverage our investment and to participate in regional studies without any one agency funding the full cost of the project. However, study design and analysis not directly funded by the Navy may not always focus on study questions of importance to the Navy under the NWTRC monitoring plan.

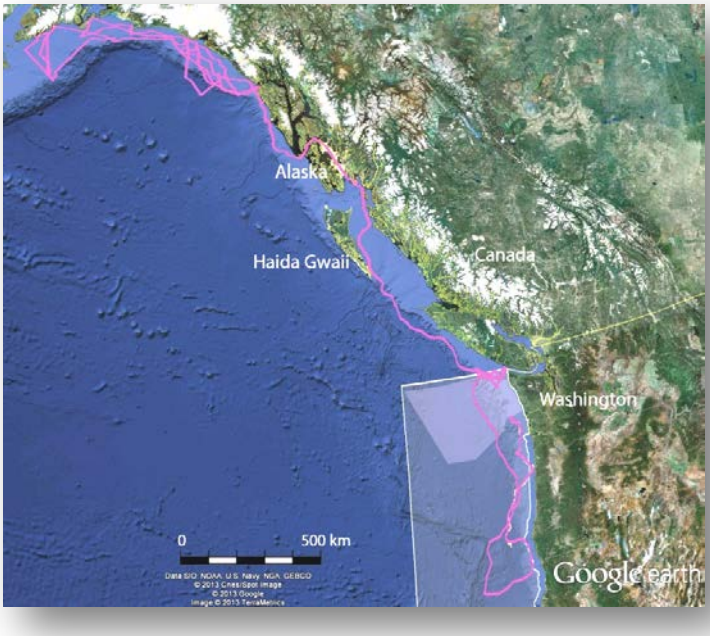

Figure 2-1. Tag tracks from two killer whales from the offshore stock through 23 May 2013.
(From Schorr et al. 2013)

Large Gray Whale Tagging in the Pacific

(B. Mate, Oregon State University)

Starting in 2012 and continuing in 2013, the Navy funded long-term satellite tracking studies primarily focused on animals from the Pacific Coast Feeding Group of Eastern Pacific gray whales. The goal of this effort was to document gray whale movement patterns in relation to the nearshore and offshore areas within the NWTRC.

Two types of satellite tags were used: the Telonics ST-15 ultra-high frequency location only tags described in Mate et al. (2007) and Wildlife Computer Spot-5 tags. While manufactured differently, Spot-5 tags are functionally identical to the ST-15 tags, having the same physical configuration (size, shape, and external components) and providing the same form of data.

Three (3) ST-15 and eight (8) SPOT-5 tags were attached to Pacific Coast Feeding Group gray whales from October to November 2012. Results from these tags were previously reported in Mate 2013 as part of the NWTRC 2013 annual reporting (Navy 2013). Mate et al. 2014 summaries six (6) additional SPOT5 tags attached to gray whales in October 2013.

Figure 2-2. Photograph of Eastern Pacific gray whale on January 27, 2013 with a SPOT-5 satellite tracking tag attached

Photo obtained 148 days after initial tagging in fall of 2012. Photo by Craig Hayslip, Oregon State University and taken under NMFS permit No. 369-1757

Key findings from the 17 tags attached to gray whales under this study include:

- Gray whales were tracked consistently for periods up to 159+ days although this maximum time was merely the review cutoff time to prepare reporting. Some tags continued to transmit for longer periods. A critical point to note is that no whale was injured or impaired by tag attachment, which is confirmed by subsequent re-sightings of various individuals (**Figure 2-2**).

- Most whales predominantly used the narrow continental shelf area along the Washington, Oregon, and northern California coasts while in the vicinity of NWTRC [range = 500 yards to 23 miles (0.4–38 km)]. Due to their narrow coastal distribution and because sonar and explosive training typically occurring much further offshore, generally off the continental shelf (**Figure 2-3**), this research indicates that gray whales within the NWTRC are less likely to be impacted by Navy training.

- Long-term satellite tag tracking provide a valuable and useful research tool in helping to define the at-sea distribution of large whales. The success of these two tagging seasons directly led to an expanded follow-on Navy funded tagging study discussed below.

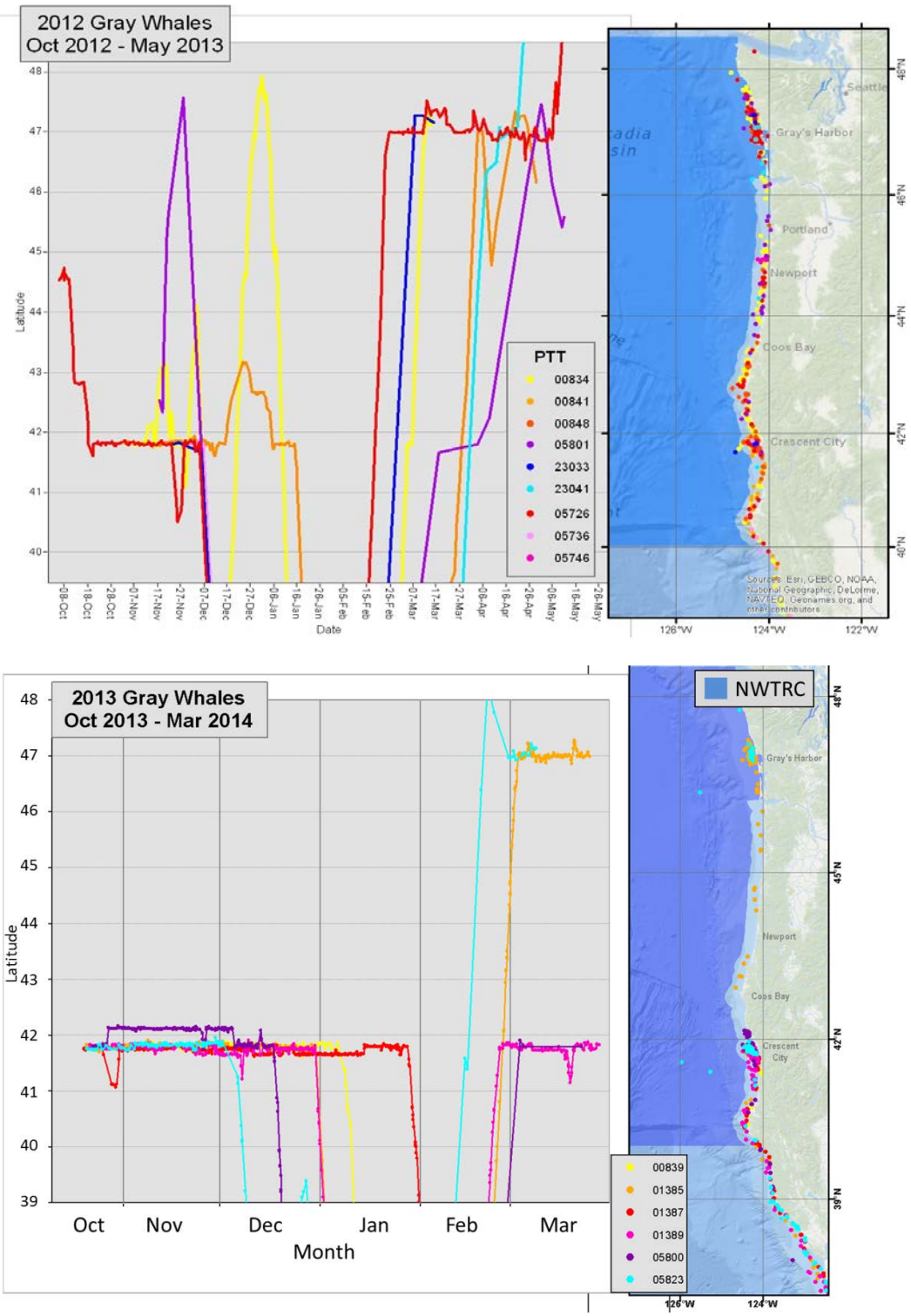

Figure 2-3. (*Top*) "Latitude of locations from Pacific Coast Feeding Group (PCFG) gray whales tagged with satellite transmitters plotted vs. date (map of the locations shown on right side of figure)" (From Mate 2013); (*Bottom*) "Site tenacity (showing consistency and movement within the feeding range and season) and migratory timing of October 2013-tagged PCFG gray whales, with latitudes of locations through March 2014, plotted vs date (left). The right-side map shows the locations color-coded by tag number to show the coastal nature of tagged whale movements in relation to NWTRC areas, shown in dark blue."
(From Mate et al 2014)

<new 2014 start> Baleen (Blue and Fin) Whale Tagging in Southern California in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas (Southern California Range Complex, Northwest Training Range Complex, and Gulf of Alaska Temporary Maritime Activities Area)

(B. Mate, Oregon State University)

In 2014, the Navy funded a long term study to document blue and fin whale occurrence, distribution, movement, and residency times along the U.S. West Coast and Gulf of Alaska. In particular, this study will seek to acquire new scientific data to address the question of:

> **"What are the movement patterns, occurrence, and residence time of blue and fin whales within Navy training and testing areas along the US West Coast as compared to patterns within the rest of the Pacific Ocean?"**

The same tagging technology and techniques as reported in Mate et al. (2007), Mate (2013) and Mate et al. (2014) will be employed during a field season starting in the summer of 2014. Specific study objectives include: 1) determining blue and fin whale distribution and habitat use through deployment of location-only satellite tags, 2) determining blue and fin whale behavior changes over time by individual and between individuals over the course of several weeks using Advanced Dive Behavior (ADB) tags[2]; and 3) conducting an analysis using existing similar blue whale tag data from 1994-2009 (Bailey et al. 2009, Irvine et al. in press) combined with new tag track data collected from 2014 and beyond. The Navy's intent is to expand this into a multi-year effort to allow the gathering of a larger data set of animal movements.

The upcoming 2014 field season will attempt to attach 12 SPOT-5 location only tags and 4 ADB tags to blue whales and 12 SPOT-5 location only tags and 4 ADB tags to fin whales. Analysis of animal tag tracks over their range from this and subsequent years will include a switching state-space model similar to one reported in Bailey et al. (2009). This kind of analysis can help with defining potential foraging events and areas based on determining Area Restricted Searching (ARS) along a given track. Dr. Mate stated that: "ARS behavior is thought to represent foraging and animals may engage in ARS intermittently or in persistent bouts for portions of a track; the areas where the latter occur are ~50 km in radius (range = 10-360 km) and animals spend ~21 d in them (range = 3-115 d), presumably in extended foraging (Bailey et al. 2009). During winter months ARS behavior may also be typical of reproductive behavior in a similarly centralized area."

Information, data analysis as available, and other results from this project will be included in the Navy's 2015 and beyond range complex annual monitoring report.

[2] "The newly developed Advanced-Dive-Behavior (ADB) pop-up tags collect high-resolution measurements of movements in three dimensions, as well as 3-axis accelerometer data that identify lunges to monitor foraging effort. The satellite-linked component of this tag is capable of acquiring updated satellite sensor data every 10 seconds (while the tag is at the surface) and GPS quality (160 m error radius) locations to supplement those collected by the Argos system. The ADB tags collect high-resolution (1 Hz) time-depth data, and have a magnetometer, which combined with three-axis accelerometer provide full-body orientation data. Tags detach at a pre-programed time by "burning" a wire release so the tag can float to the surface, be retrieved, and more detailed data download than can be transmitted via satellite." (text courtesy of B. Mate).

2.3 Passive Acoustic Monitoring

(J. Hildebrand, A. Širović, S. Baumann-Pickering, Scripps Institution of Oceanography)

Background- The Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego designs, fabricates, calibrates, deploys, and analyzes data from bottom-deployed high frequency acoustic recording packages (HARP). In general, a HARP records marine mammal vocalizations, echolocation clicks, and anthropogenic sounds between 10 Hz-100 kHz. The length of deployment has increased over the years with improvements to battery design and storage capacity. Currently, a typical deployment can last for up to eight months on continuous duty cycle. As part of Navy funded Compliance Monitoring, two bottom-mounted HARPs were deployed starting in 2011-2012 (**Figure 2-4**). These locations have been part of previous Navy research funded HARP deployments from July 2004 through 2010 (Oleson et al. 2009, Oleson and Hildebrand 2012)

Within the NWTRC, one HARP is in deeper water on the shelf slope within Quinault Canyon (QC) at a depth of 2,132 ft (650 m) and a second on the continental shelf off Cape Elizabeth (CE) at a depth of 387 ft (118 m)(**Figure 2-4**). For the NWTRC deployments, the HARPs were located on the seafloor with their hydrophone suspended 33 ft (10 m) above the seafloor.

Cumulatively for the period 2011 to May 2014, over 27,000 hours of passive acoustic data have been obtained from the two deployed HARPs. This data series has not always been continuous, especially for the shelf HARP which has been subject to fisheries interaction and unforeseen equipment difficulties. Debich et al. 2014 provides the technical analysis for the latest period available (2012-2013)[3]. Kerosky et al. 2013 summarized the preceding analytical period.

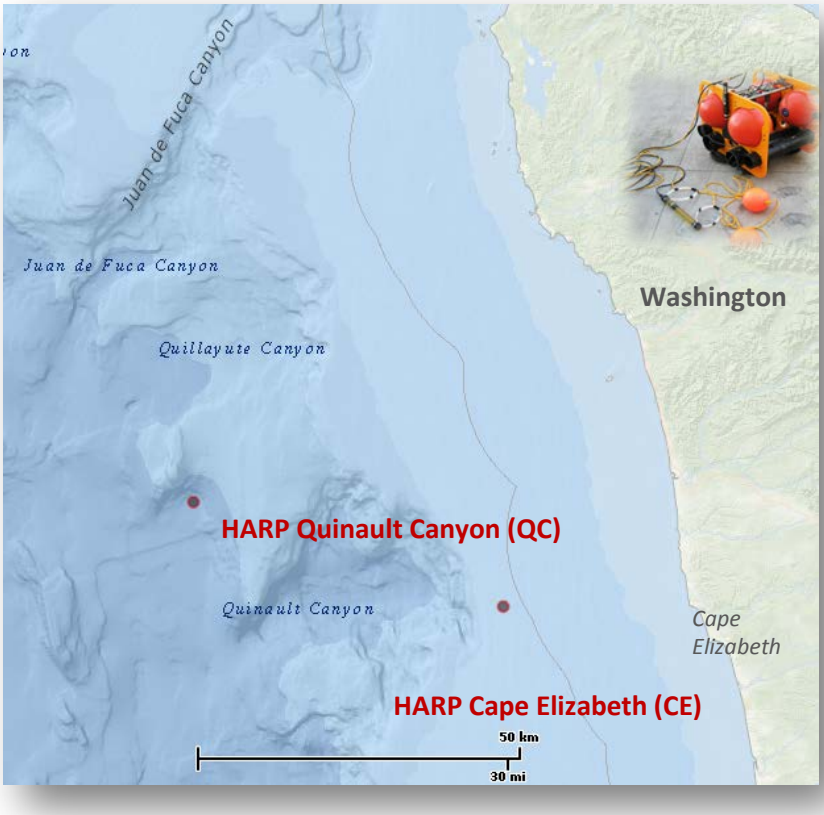

Figure 2-4. Location of Navy funded bottom-mounted high-frequency acoustic recording packages (HARP) off Washington State.
(Upper right picture courtesy of Scripps Institution of Oceanography

[3] Given the need to deploy the HARPs for periods up to 8-10 months, there is a corresponding lag in the data available for analysis for the NWTRC annual reports and when the HARPs are next field serviced with data retrieved for future analysis

Major observations by sound category from the multi-year HARP deployments from 2011-2014 are summarized by Scripps below:

"*Baleen whale- Three species of endangered baleen whales were commonly detected during the monitoring period: blue whales, fin whales, and humpback whales. Most calls from these species were recorded during the fall and winter months, with lower call levels during the spring. There was some spatial variability in their presence, with humpback whale calls more commonly detected on the shelf site, fin whales more common at the slope site, and blue whale calls found equally at both sites. In June 2013, the first detections of the some North Pacific right whale calls were made. The first minke whale calls were also detected during the fall of 2012 and spring 2013.*

Toothed whale- Commonly detected toothed whales at both sites were Pacific-white sided dolphins, Risso's dolphins, and sperm whales, as well as unidentified dolphins, likely comprised of short-beaked common dolphin and northern right whale dolphins. No obvious seasonal patterns were observed except for unidentified dolphins that occurred more frequently in fall and winter with a second shorter peak in early summer. Killer whales were acoustically encountered throughout the year but overall less often than the above mentioned odontocetes. Unidentified porpoises, likely Dall's porpoise based on more frequent visual sightings in the recorder vicinity (Oleson et al. 2009, Oleson and Hildebrand 2012) , were reported from the shelf site with no distinct seasonal pattern. Three species of beaked whales (Stejneger's, Baird's, and Cuvier's beaked whales) were acoustically encountered in all years at the slope site only. Stejneger's beaked whales were the most abundant beaked whales, less frequently detected over the summer months, possibly showing a seasonal migration out of the range area for at least some individuals. Baird's beaked whales appeared to be in higher numbers in early winter and early summer, which may indicate a latitudinal, seasonal passing through the range. Cuvier's beaked whales were detected in lowest numbers with no apparent seasonal pattern. Blainville's beaked whale signals were acoustically encountered in March 2011.

Anthropogenic sound- The slope site is subjected to regional commercial shipping (about 20% of hourly time windows), and long-range noise propagation from shipping in the North Pacific elevates the monthly average ambient noise at this site to 81-83 dB re: µPa2 /Hz at low frequency. The shelf site is subject to local small boat noise, but is less subject to long-range propagation of commercial shipping noise with monthly average ambient noise of 76-82 dB re: µPa2 /Hz at low frequency.

Mid-frequency active sonar was detected during infrequent (4 to 7 days per year), temporally separated events, lasting at most a few hours in duration. Individual ping received levels varied from 108-148 dB re:1 µPa. Explosions occurred intermittently, with periods of intense events [4]. Most explosions occurred during daylight hours and in some instances periods with explosions were correlated with local fisheries activities (e.g. fall Coho and Chinook salmon season).

[4] Navy classified and unclassified annual reporting to NMFS from 2011-2014 confirmed no large high-explosive items (bombs, missiles) were used in-water within the NWTRC for the period November 2010 to May 2014 (Department of the Navy 2011, 2012, 2013b, 2014). Only a limited number of surface ship gun projectiles were used offshore in 2013 (n= 4 high explosive 5" shells) (Department of the Navy 2013b). Navy explosive training would not normally occur near the two HARP locations, therefore the underwater explosive events detected by the HARPs cannot be attributed to the Navy.

2.4 Other Navy funded Monitoring In Addition To Current NWTRC Metrics

During the period covered by this comprehensive report (2011-2014) several other opportunistic studies became available that the Navy elected to fund. These studies contribute new scientific information useful to future Navy environmental and species-specific impact analysis.

<new 2013 start> Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities (2013-2015)

(B. DeLong, National Marine Mammal Laboratory, Alaska Fisheries Science Center)

There are significant scientific data gaps in identifying the location of local foraging areas and documenting the percentage of time pinniped species haul out near Puget Sound naval facilities. The numbers of animals observed hauled-out can be corrected into a population estimate by applying an estimate of the proportion of tagged animals that are hauled out at the time of the census. Satellite-linked dive recorders can be used to assess location of foraging activity and describe the diving behavior as well as record when the animal is hauled-out.

Sea lion males will be instrumented with pelage-mounted satellite tags (n=30 tags) in the fall of 2014 which are expected to remain on the animal until their next molt in July of August 2015. Data from this study will provide a correction factor that can be applied to counts of animals hauled-out to estimate the total number of animals using the Navy facility, provide monthly proportion of animals in the water, and describe regional marine foraging habitats and animal foraging behavior.

In particular, integration of improved haulout percentages will lower over-predictive modeled takes which currently, due to lack of regional data, assume all pinniped species are always in-water for purposes of assessing exposures to training and testing activities.

Information to be reported from this project will include:

1. Census data of adult males that haulout at Naval Station Everett, Puget Sound Naval Shipyard (Naval, and Naval Base Kitsap-Bangor.

2. Monthly correction factors for count data from census locations by species if appropriate.

3. Geographical distribution and foraging behavior of California sea lion adult males in inland waters of Washington (and Steller sea lions if tagged).

4. Migration and foraging behavior of California sea lions in coastal Washington, Oregon and California (and Steller sea lions, if tagged).

Results from this project will be included in the Navy's 2015 NWTRC annual monitoring report and subsequent reports, if needed.

<new 2013 start> Marine Mammal Aerial Surveys Conducted in the Pacific Northwest, Inland Puget Sound Waters

(M. Smultea, Smultea Environmental Sciences)

The purpose of this Navy-funded survey was to 1) collect data to estimate densities and abundance of marine mammals in the inland Puget Sound waters for species with sufficient sightings, 2) Document the distribution and habitat use of each species observed; and 3) Document and describe behaviors seen without performing focal follows.

Based on a successful survey in 2013, the Navy will be funding an additional four similar aerial surveys in 2014.

The 2014 technical report on the status of this project is available in Smultea et al. (2014).

Figure 2-5. Harbor porpoise mother/calf pair photographed 1 September 2013.
Photo by M. Smultea under NOAA Permit No.15569; From Smultea et al. (2014).

<new 2013 start> Aerial Surveys of Pinniped Haulout Sites in the Pacific Northwest Inland Waters

(S. Jeffries, Washington State Department of Fish and Wildlife)

The purpose of this Navy-funded project is to conduct aerial surveys of the waters from the Strait of Juan de Fuca to Puget Sound in order to 1) provide estimates of seasonal abundance for seals and sea lions; 2) identify seasonal distribution patterns for seals and sea lions; 3) collect data to determine seal and sea lion densities; and 4) provide harbor seal abundance data needed by NMFS to prepare a Stock Assessment Report for the Washington Inland Waters Stock of harbor seal.

Additionally, information from these surveys will be used to update the 13 year old previous estimates in the Washington Department of Fish and Wildlife' pinniped atlas (Jeffries et al. 2000).

The 2014 technical report on the status of this project is available in Jefferies (2014) while the preceding 2013 report is available in Jeffries (2013).

Figure 2-6. Aerial view of Steller sea lions, California sea lions, and harbor seals hauled out on floats in Clam Bay adjacent to Navy's Manchester Fuel Depot, 8 November 2013.
Photo by Steven Jeffries, WDFW, under NOAA Permit No. 13430; From Jeffries 2014.

3.0 FUTURE DIRECTION

3.1 Revised Monitoring Program Approach (≥ May 2014)

The current Navy monitoring program in NWTRC was been focused on effort-based metrics (deployment days and items, tags deployed and results, etc.) agreed to in consultations between NMFS and Navy (Navy 2010a).

For planning of future NWTRC soon to be Northwest Training and Testing (NWTT) monitoring, the Navy with NMFS concurrence is instituting a shift away from a metric-based monitoring approach that was applicable from 2011-2015.

Instead, a region-specific and species specific study question format will be built so that the question itself will drive selection of the best technology to address that question by individual participating researchers.

One of the first study questions the Navy is proposing for NWTT will be:

> *"***What is the distribution, residency time, and spatial extent of Southern Resident killer whale winter movements off the coasts of Washington, Oregon, and northern California, and relationship of this movement to NWTT***?"*

The Navy had an opportunity in 2014 to team with NMFS' Northwest Fisheries Science Center (NWFSC) to fund continued and new research on the offshore distribution of the Southern Resident killer whale. Previous related NWFSC effort is described in Hanson et al. (2013).

This work will directly contribute to the Navy's new NWTT study question so the decision was made to fund the effort described below earlier than 2015 so that new devices could be installed in the summer-fall of 2014.

Overall Navy investment in this pending new monitoring start is approximately $439,000.

<pending new start> Modeling the Distribution of Southern Resident Killer Whales in the Pacific Northwest

(Brad Hanson, NMFS' Northwest Fisheries Science Center)

Integrating animal movement data with other sources of information, such as diet, has proved valuable in efforts to better understanding behavior, foraging patterns, and scaling of processes from the individual to population level. Considering how these spatial processes operate on different scales is particularly important when the threats to a population are also spatially distributed. These threats may be anthropogenic, habitat-related, or related to the spatial distribution of resources, such as prey. There are a variety of methods available to quantify the spatial aspects of habitat use by animals in marine environments, including traditional approaches such as shipboard surveys, and more recently developed tools such as acoustic recorders and satellite tags. The latter allow for a more innovative and cost effective approach to address data gaps.

Autonomous passive acoustic recorders can provide important information on the distribution of cetaceans. Although these archival instruments can provide months of detection data for a particular location, one limitation to these devices is their short detection range, which is only a few kilometers of medium–sized cetacean given the peak frequency vocalizations. Additionally, the units are typically duty-cycled to lengthen the deployment and it is possible that whales could be missed while the unit is turned off. An additional potential bias of these instruments is that cetaceans do not always produce sounds and thus, they may not be detected. Furthermore, ambient noise from both natural (e.g., wind and rain), and anthropogenic (ship noise) may also reduce the detection range of passive acoustic recorders. The use of multiple recorders distributed throughout an area can function as a grid, potentially allowing determination of movement patterns by analyzing the duration in between detections at multiple recorders. However, in many cases the duration between detections may far exceed the time required for animals to travel between recorders and the path the animal took during this time gap cannot be resolved.

Conversely, satellite-linked tags deployed on cetaceans can provide multiple, relatively unbiased locations per day, however, these deployments are usually short in duration, typically on the order of weeks. In addition, working with raw satellite data presents a number of challenges and limitations: (1) time stamps between locations are never uniform, (2) locations are measured with varying degrees of precision, and (3) movement patterns may be affected by unseen behavioral patterns (travelling, foraging) or environments that an animal experiences (but is not directly observed). Consequently, whereas acoustic recorder data are spatially biased, individuals tagged with satellite-linked tags are temporally biased.

While each of these data types can be analyzed independently, we propose analyzing both data types simultaneously in a hierarchical framework. Bayesian state-space movement models have been widely used for the analysis of satellite tracking data, but these models have not been used to verify other types of monitoring data, such as acoustic recorder detections. By analyzing both data streams in a single framework, we aim to

create more precise estimates of animal locations that are less spatially and temporally biased than either of the data types considered alone. Analyzing these data in a state-space framework allows the inclusion of covariates, incorporation of measurement error uncertainty (imperfect detections, or uncertainty associated with satellite measurements), and potential switching between behavioral states. Reasonable model covariates would include (1) depth, (2) distance to shore, and (3) distance to nearest large freshwater input (because anadromous salmon represent a large portion of the diet of resident killer whales).

To accomplish this project NWFSC will bring together three unique, but intersecting, data sets.

NWFSC began deployment of autonomous acoustic recorders in 2006 in three locations in Washington State; two off Cape Flattery and one off Westport. This array of recorders was expanded to seven locations along the continental shelf in 2008 to include Newport Oregon, Ft. Bragg, and Pt. Reyes, California. The recorders used were Ecological Acoustic Recorders (EARs) and were programed to record at a sample rate of 25 kHz for 30 seconds every 10 minutes for one year. Southern Resident killer whales were detected on 131 days between 2006 and 2011 (Hanson et al. 2013) which far exceeded all visual sightings collected to date. Most of these detections were from the Cape Flattery (approximately 10 and 20 Miles offshore), Westport, and Columbia River recorders (124). The greatest number of detections (57) occurred in 2011 (Hanson et al. 2013). In 2012, an additional forty detections were documented (Northwest Fisheries Science Center, unpublished data). Recorders have been recovered from the 2012-2013 monitoring season and thus overlap with the deployment of a satellite-linked transmitter on a Southern Resident killer whale in winter 2013 that ranged widely on the outer coast.

On 29 December 2012 the Northwest Fisheries Science Center deployed a Wildlife Computers Spot-5 location only satellite- linked tag in the on a Southern Resident killer whales (adult male K25) in Puget Sound (Tag was in Low Impact Minimally Percutaneous External-electronics Transmitter configuration deployed on dorsal fin with electronics external). The transmitter provided several locations per day for the 93 day duration of signal contact. The whale's track locations clearly show that K pod (K pod has always been observed as a discrete group) traveled within the range of detection to all seven acoustic recorders. In addition, the whales spent a considerable amount of time off the Washington coast.

Figure 2-7. Photograph of Southern Resident killer whale K25 with satellite tracking tag attached 29 December 2012.
Photo by Candice Emmons, NMFS ESA Permit No. 16363-01

As noted previously, one of the uncertainties associated with cetaceans like killer whales is that the probability of animals vocalizing is unknown, and may vary depending on behavioral state (resting, foraging, Holt et al. 2013) and time of day. Thus, data collected from acoustic recorders need to be adjusted to account for imperfect detections. This probability of vocalizing can be directly informed from acoustic data collected concurrently with visual sightings on the cruise. An additional approach to estimating the probability of vocalizing (or the probability of not vocalizing) is that if the probability of an animal (or group of animals) being in given location (based on output from state space movement model described above) is known, and the probability of an animal not vocalizing given its' presence is known, NWFSC can estimate the probability of vocalizing.

Consequently, by analyzing the pattern of movements from the satellite data in relation to the data collected on the acoustic recorders from January through March 2013, and accounting for the variability in the whales detectability, based vocal behavior and ambient noise levels, the area density from the location data and the movement trajectories can be used to "fill in" the likelihood of whales occurring in areas along the coast in other seasons or years based on the location and sequence of these detections. Developing a Bayesian space-state model of the occurrence of endangered Southern Resident killer whales will inform a plan for deploying the optimal number of acoustic recorders in locations of highest whale occurrence, assuming the past occurrence patterns are indicative of typical movement patterns. This effort will make the deployment of acoustic recorders more efficient in future monitoring efforts. Specific accomplishments to be achieved under this Navy-funded project include:

- Review all acoustic recordings for marine mammal vocalizations or echolocation clicks, particularly Southern Resident killer whales, data collected on acoustic recorders during 2012-2013.
- Estimate the probability of detection based on a review of vocalization activity collected on the towed hydrophone array during the 2013 cruise and from a state space model comparing satellite-linked locations with acoustic recorder detections.
- Improve identification of Southern Resident killer whale coastal distribution by increasing sample size of detections in and adjacent to Pacific Northwest Navy ranges by deploying an additional 10 acoustic recorders[5] and acquiring four additional satellite-linked tags for deployment in fall, winter, and spring.
- Develop state-space models of Southern Resident killer whale occurrence off the Washington coast.
- Develop a cost efficient strategy for the deployment of acoustic recorders in and adjacent to the Navy's NWTRC.

A status update on this project will be included in the Navy's 2015 NWTRC annual report.

[5] NMFS'NWFSC already has five (5) autonomous acoustic recorders moorings. Navy would fund acquisition, assembly, deployment, and analysis of an additional 10 other recorders for a total of 15 autonomous acoustic recorders moorings from 2014 to 2015.

3.2 Navy Compliance Monitoring For the NWTRC 2014-2015

For the fifth and final year of Navy Compliance Monitoring within the NWTRC (May 2, 2014 to November 2015), the Navy with NMFS concurrence during annual adaptive management meetings is restructuring the NWTRC monitoring metrics, so that at the end of the final year of monitoring (May 2, 2014 to May 1, 2015) there is an end focus on marine mammal tagging vice continued passive acoustic data collection.

Given continued fishery interaction and high shelf currents leading to equipment difficulties, along with the renewed focus on baleen whale tagging and new Southern Resident killer whale research, the Navy will only report on deployment and data analysis from one long-term bottom-mounted passive acoustic device, the slope HARP-QC discussed in Section 2.3. The shelf HARP-CE will be retrieved. Instead, a greater focus will be placed on results from the U.S. West Coast blue and fin whale tag as it relates to the NWTRC/NWTT, and on the start of the new Southern Resident killer whale study by NWFSC (**Table 3-1**).

Table 3-1. Navy Proposed NWTRC Compliance Monitoring For Year 5 Compared To Preceeding Effort.

Monitoring Technique	Implementation and Transition	
	Year 4 (May 2, 2013-May 1, 2014)	Year 5 (May 2, 2014-November 2015)
Marine Mammal Tagging	Initiate contracting with focus on baleen whale tagging to prioritize blue whales and fin whales. Report results on FY13 funded study and resulting tagging through May 2014.	Purchase additional tags and continue collecting tag track data on blue whales and fin whales. Tag attachment will start in the summer of 2014 in Southern California. Tag tracks will be displayed for movements along the entire US West Coast including NWTRC Annual reporting of progress.
Passive Acoustic Monitoring	Present data analysis from two Navy funded offshore passive acoustic monitoring devices	Continue deployment of one (1) bottom-mounted passive acoustic device at the slope site (HARP-QC discussed in Section 2.3) Annual reporting of detections.
2014-2015 Study Question New Start	-	Begin new study: " **Modeling the Distribution of Southern Resident Killer Whales in the Pacific Northwest** " discussed in Section 3.1

4.0 CONCLUSION

The Navy met or exceeded all NMFS-Navy agreed to compliance monitoring metrics within the NWTRC from 2011 to May 2014 (**Table ES-1**). In addition to offshore projects involving long-term passive acoustic monitoring and opportunistic or directed marine mammal tagging, the Navy from 2012-2014 also funded and conducted several marine mammal studies within Puget Sound for multiple species (Department of the Navy 2013a, Jeffries 2013, Jeffries 2014, Smultea et al. 2014).

Long-term fixed passive acoustic monitoring is an effective way to determine seasonal species-specific occurrence of vocalizing and potentially foraging animals. It does not account for non-vocalizing animals. Passive acoustic monitoring can also be used to record natural and anthropogenic sounds leading to better assessment of ambient noise conditions. Passive acoustic monitoring has potential via expanded analysis to begin addressing possible impacts of anthropogenic sources on marine mammal vocalization and echolocation, with the assumptions that changes in vocalizations and echolocation rates are indicative of behavioral changes. However, this kind of analysis is better suited for those areas where the Navy in-water training occurs more frequently such as Southern California or Hawaii vice the more limited Navy in-water training within the NWTRC.

Satellite tracking tags can be an effective indicator of marine mammal distribution and movement patterns at short (days-weeks) and long (months-year) time scales. Longer term tag tracks are needed in order to better determine baleen whale distributions in terms of bathymetric features, and to determine what percentage of time individuals spend within the NWTRC and outside of the NWTRC.

Finally, the Navy is beginning to transition NWTRC compliance monitoring away from strictly metric-based accomplishments (i.e., number of devices deployed, # of tags attached), to a more region-specific and species-specific format. To that end two new ecological based studies have been initiated in 2014. One study using passive acoustic tools, satellite tagging, and advanced modeling will attempt to refine predictions of offshore occurrence and locations for Southern Resident killer whales. Another new study using satellite location tags and advanced modeling will detail long-term blue and fin whale occurrence, migration, and local residency patterns along the U.S. West Coast including within and outside of NWTRC.

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