Naval Base Kitsap-Bangor
Explosives Handling Wharf 2

Year 1 Marine Mammal Monitoring Report (2012–2013)

BANGOR, WASHINGTON

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Naval Facilities Engineering Command

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ACRONYMS AND ABBREVIATIONS

APE	American Piledriving Equipment
BSS	Beaufort sea state
cfm	cubic feet per minute
cm	centimeters
CMP	Construction Monitoring Program
dB	decibel
°F	degrees Fahrenheit
EHW-1	Explosives Handling Wharf #1
EHW-2	Explosives Handling Wharf #2
ESA	Endangered Species Act
ft	foot/feet
GPS	global positioning system
IHA	Incidental Harassment Authorization
km	kilometers
m	meters
MC	monitoring coordinator
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
mph	miles per hour
NBK	Naval Base Kitsap
NMFS	National Marine Fisheries Service
PPP	personal protective equipment
PSB	Port Security Barrier
RMS	root mean square
µPa	micropascal
SPL	sound pressure level
TPP	Test Pile Program
WRA	Waterfront Restricted Area

Table of Contents

ACRONYMS AND ABBREVIATIONS.. INSIDE FRONT COVER

SECTION 1 INTRODUCTION...3

SECTION 2 METHODS 4

SECTION 3 RESULTS 26

SECTION 4 RECOMMENDATIONS...65

SECTION 5 LIST OF PREPARERS..66

SECTION 6 REFERENCES...67

Tables

Table 1. Project Staff 7
Table 2. Summary of Monitoring Effort...11
Table 3. Acoustic Results from Impact Pile Driving...28
Table 4. Acoustic Results from Vibe Pile Driving 32
Table 5. Total Number of Unique Animals and Sightings by Species (Primary Surveys)...........45
Table 6. Total Number of Unique Animals and Sightings by Species (Delta Pier) 45
Table 7. Total Number of Unique Animals and Sightings by Species (Outside Boat) 46
Table 8. Summary of Unique Marine Mammal Sightings During Pile Installation and Removal Activities (Primary Surveys)..47
Table 9. Summary of Unique Marine Mammal Sightings During Pile Installation and Removal Activities (Outside Boat)...48
Table 10. Summary of Observed Level B Harassment Takes 48
Table 11. Summary of Level B Harassment Takes Per Production Pile 49
Table 12. Missed Takes in the Unmonitored Area of the Behavioral Harassment Zone 50
Table 13. California Sea Lion Behaviors by Construction Type: Outside Boat..........................57
Table 14. Steller Sea Lion Behaviors: Outside Boat 59

Figures

Figure 1. Vicinity Map...5
Figure 2. Project Area 6

Figure 3. Typical Observer Monitoring Platforms During Marine Mammal Monitoring 10
Figure 4. Marine Mammal Monitoring Zones for Impact and Vibratory Pile Driving 14
Figure 5. Modeled Vibratory Harassment Zone for Marine Mammals 15
Figure 6. Year 1 Indicator and Production Pile Location 24
Figure 7. All California Sea Lion Sightings 41
Figure 8. All Harbor Porpoise Sightings 42
Figure 9. All Harbor Seal Sightings 43
Figure 10. All Steller Sea Lion Sightings 44
Figure 11a. Sightings by Sea State 51
Figure 11b. Sightings by Weather Condition 51
Figure 12a. California Sea Lion Behaviors Before During and After Construction: Primary 53
Figure 12b. California Sea Lion Behaviors By Construction Type: Primary 53
Figure 13a. Harbor Seal Behaviors Before During and After Construction: Primary 54
Figure 13b. Harbor Seal Behaviors By Construction Type: Primary 54
Figure 14. California Sea Lion Behaviors: Delta Pier 55
Figure 15. Steller Sea Lion Behaviors: Delta Pier 56
Figure 16. Harbor Porpoise Behaviors Before and During Construction: Outside Boat 58
Figure 17a. Harbor Seal Behaviors Before, During and After Construction: Outside Boat 59
Figure 17b. Harbor Seal Behaviors By Construction Type: Outside Boat 59
Figure 18. Relative Motion of Marine Mammals by Construction Event 60
Figure 19. Air and Water Temperature for duration of the EHW-2 CMP 63
Figure 20. Maximum Beaufort Sea State for the duration of the EHW-2 CMP. 64
Figure 21. Wind Speed for the duration of EHW-2 CMP 65

Appendices

A. Department of the Navy Trident Support Facilities Explosives Handling Wharf (EHW-2) Final Marine Mammal Monitoring Plan
B. Marine Mammal Sighting Form and Data Codes
C. Pile Survey Table
D. Bubble Curtain Specifications
E. Weather Conditions
F. MC Times
G. Marine Mammal Sightings
H. Revised Bubble Curtain Specifications

Section 1 Introduction

This report summarizes the Year 1 marine mammal monitoring effort implemented for the Trident Support Facilities Explosives Handling Wharf #2 (EHW-2) Construction Monitoring Program (CMP) that occurred from 28 September 2012 to 14 February 2013 at Naval Base Kitsap (NBK) at Bangor. The purpose of the EHW-2 CMP is to provide marine mammal and marbled murrelet monitoring during pile installation required to construct the new wharf (DoN 2012). The program included hydro-acoustic monitoring to evaluate noise attenuation techniques and to determine the distance(s) at which sound pressure levels (both airborne and underwater) from the project met established thresholds where sound may result in injury or behavioral disturbance to marine mammals.

Marine mammal monitoring for the Year 1 EHW-2 CMP occurred from 28 September 2012 to 14 February 2013. Work consisted of marine mammal monitoring during indicator pile driving activities (piles that were installed and removed to collect geotechnical and sound propagation data) and EHW-2 production pile driving activities (piles that were permanently installed as part of the EHW-2 structure). Marine mammal monitoring also occurred for piles installed for a temporary support pier that was used to support pile driving equipment used to install piles for the project. Acoustic monitoring occurred from 28 September 2012 to 19 January 2013 during production pile driving activities.

The marine mammal monitoring performed for this project was intended to meet all requirements of applicable permits and consultations conducted to be in compliance with the Marine Mammal Protection Act (MMPA) permit and Endangered Species Act (ESA). Marine mammal monitoring performed for this project followed procedures and requirements in the EHW-2 Marine Mammal Monitoring Plan (Monitoring Plan; **Appendix A**). The Monitoring Plan was developed in coordination with the National Marine Fisheries Service (NMFS) to ensure compliance with the terms and conditions of the Incidental Harassment Authorization (IHA) issued for in-water construction (NMFS 2012). The Monitoring Plan included the requirement that a marine mammal monitoring report be prepared and submitted to the Navy. This document is meant to satisfy that reporting requirement.

Section 2 Methods

Project Area

NBK at Bangor, Washington is located on the Hood Canal approximately 20 miles (32.19 kilometers [km]) due west of Seattle, Washington (**Figure 1**). NBK at Bangor provides berthing and support services to U.S. Navy submarines and other fleet assets. The EHW-2 site was located within the Waterfront Restricted Area (WRA) at NBK at Bangor, immediately south of the existing Explosives Handling Wharf #1 (EHW-1) structure (**Figure 2**). Marine mammal monitoring was focused within this area and the waters immediately adjacent to the WRA, where sound pressure levels associated with pile installation and removal activities could potentially be transmitted at levels that could affect marine mammals.

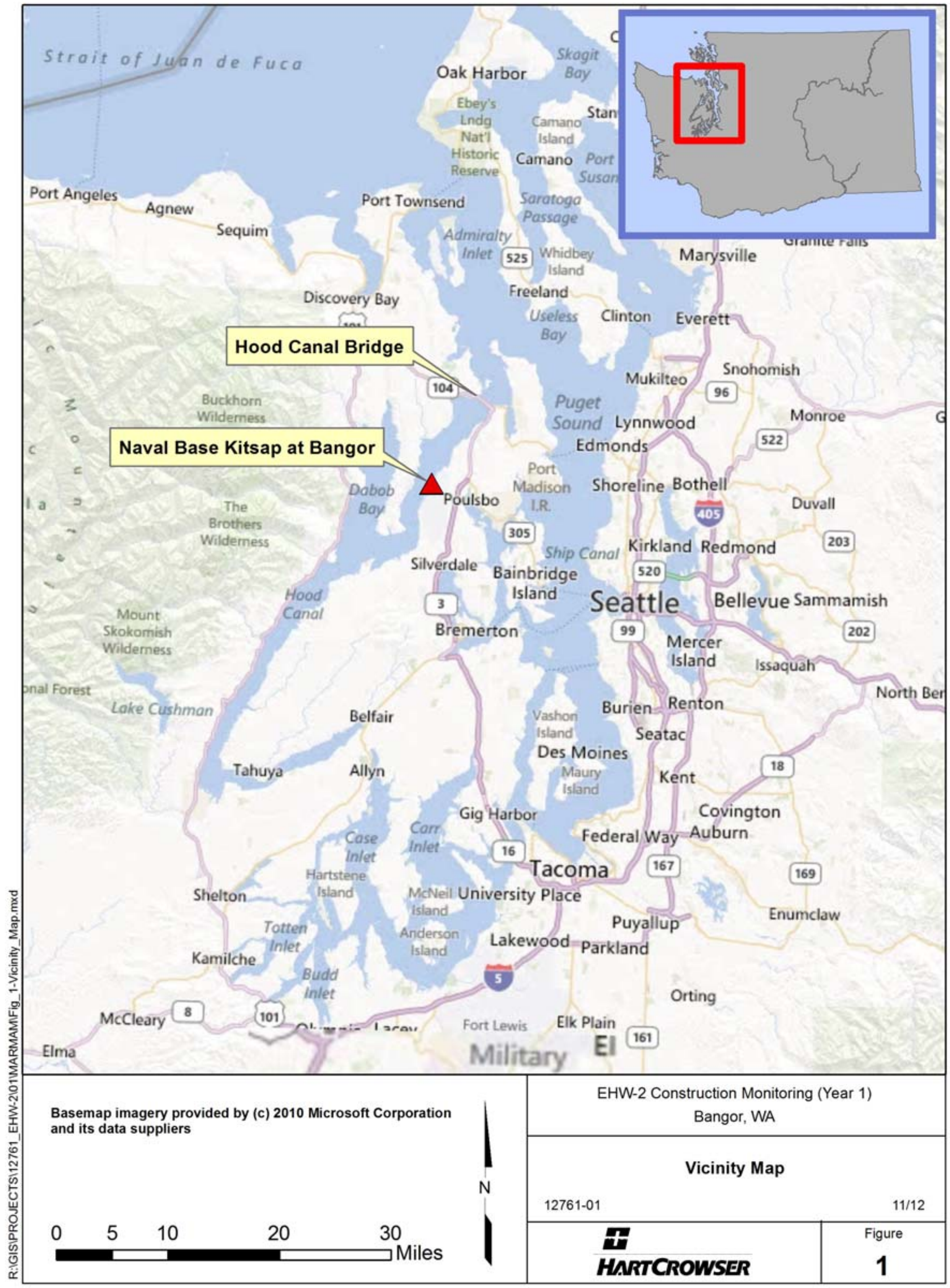


Figure 1. Vicinity Map

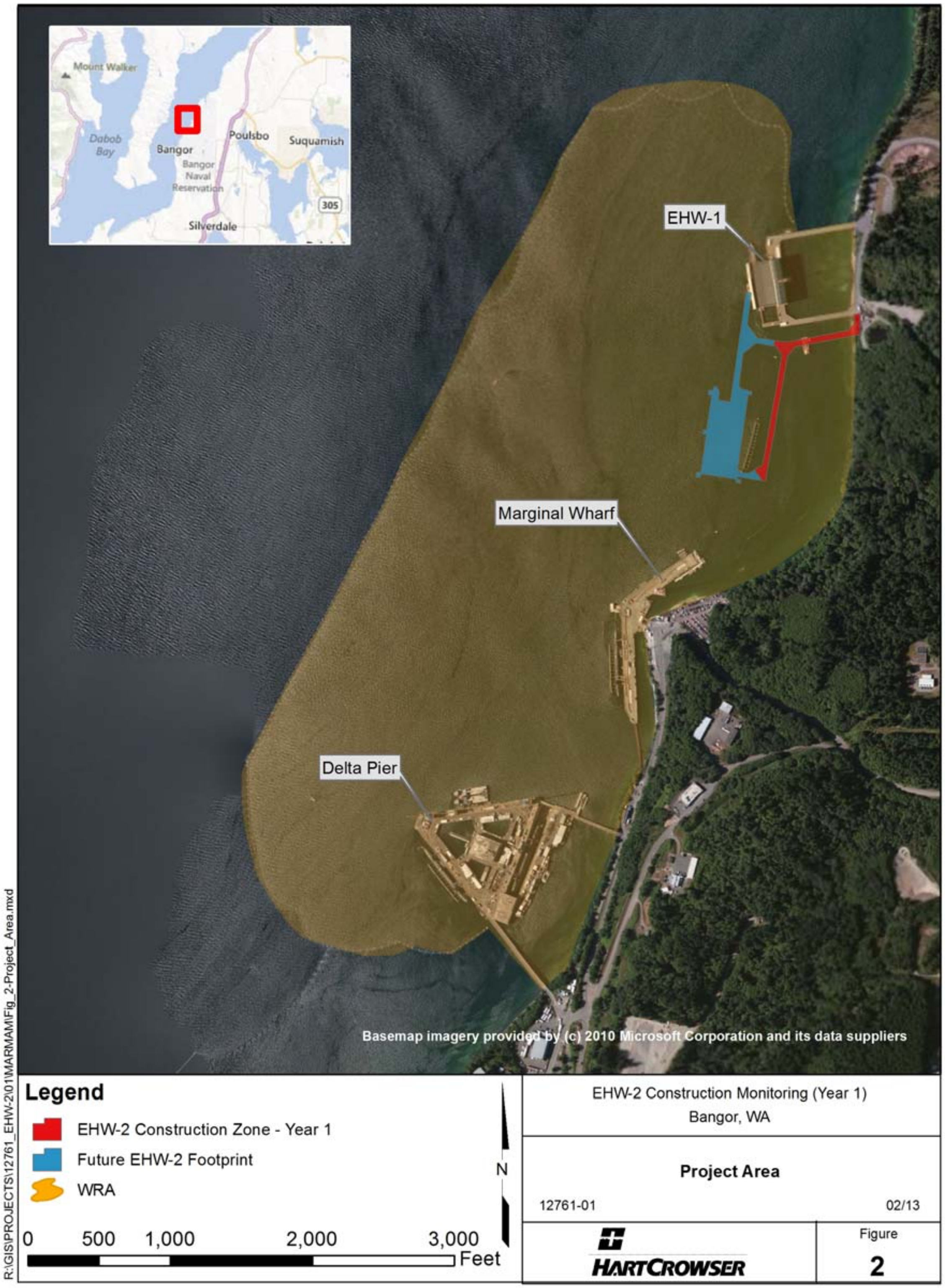


Figure 2. Project Area

Project Staffing

Staff for the EHW-2 CMP (**Table 1**) included the Project Managers, the Monitoring Coordinator (MC), Marbled Murrelet Observers, Marine Mammal Observers (MMOs), and acoustic technicians. All MCs and MMOs were experienced in marine mammal identification, and had extensive knowledge of the biology and behavior of locally occurring marine species. With few exceptions, all MCs and MMOs had been observers for the 2011 Test Pile Program (TPP) for NBK at Bangor, and/or the 2011/2012 EHW-1 Pile Replacement Project monitoring efforts. The team of acoustic technicians had prior experience conducting acoustic monitoring during pile driving construction projects and most had monitored pile driving during the TPP. All marine mammal observers were dedicated to that task and served no other function while conducting observations.

Table 1. Project Staff

Name	Role(s)	Company
Hans Hurn	Project Manager / MC	Hart Crowser
Jeff Barrett	Project Manager / MC	Hart Crowser
Jason Stutes	MC	Hart Crowser
Jon Houghton	MC	Hart Crowser
Michelle Havey	MC	Hart Crowser
Andrew Kaparos	MMO	Hart Crowser
Brian Payne	MMO	Hart Crowser
Caanan Cowles	MMO	Hart Crowser
Emily Duncanson	MMO	Hart Crowser
Jim Starkes	MMO	Hart Crowser
Kelsey Donahue	MMO	Hart Crowser
Kerry Hosken	MMO	Hart Crowser
Paula von Weller	MMO	Hart Crowser
Pete Heltzel	MMO	Hart Crowser
Steve Hall	MMO	Hart Crowser
James Reyff	Acoustician	Illingworth & Rodkin
Jared McDaniel	Acoustician	Illingworth & Rodkin
Jordan Roberts	Acoustician	Illingworth & Rodkin

Name	Role(s)	Company
Josh Carmen	Acoustician	Illingworth & Rodkin
Keith Pommerenck	Acoustician	Illingworth & Rodkin
Ryan Pommerenck	Acoustician	Illingworth & Rodkin

Marine Mammal Monitoring Platforms

The Monitoring Plan required that MMOs be positioned at the best practicable vantage points, taking into consideration security, safety, and space limitations on the waterfront. A minimum of two monitors were used for marine mammal monitoring (one MC dedicated to monitor the shutdown zone and one monitor focused on observations on the buffer zone; **Figure 3**). Typically, the MC was stationed with an additional MMO to monitor the shutdown zone. This allowed the MC to effectively coordinate with observers and the pile driving foreman. Additional MMOs were used to monitor the shutdown zone as needed. If more than one pile was being driven simultaneously, additional MMOs were assigned to observe the shutdown zone of each pile. During the acoustic monitoring period, the deckhand (trained MMO) on the far-field acoustic boat served as an additional MMO whenever not filling duties as the acoustic deckhand.

Vessel-based Monitoring. Vessels were used as observation platforms and for transportation to barges and acoustic sampling locations. These boats included two 32-foot (9.8-meter [m]) fiberglass-hulled Bayliners, which were used as the primary monitoring platforms for MMOs, and several other smaller aluminum and steel hull vessels used for transportation of personnel and equipment. Both fiberglass vessels were used during the acoustic monitoring period, while only one vessel was required for the remainder of the project. Vessels were equipped with VHF radios and depth sounders. All captains were United States Coast Guard certified and were familiar with the Puget Sound waterways and the unique characteristics of the region. MMO monitoring vessels were equipped with elevated observation platforms, which provided maximum viewing capability. The MMO monitoring vessels' observation platforms were approximately 3 to 4 m (9.8 to 13.1 feet [ft]) above the water line.

Pier- and Barge-based Monitoring. The MC was typically located on the construction barge or the construction pier, and also served as an additional MMO as needed from that relatively stationary location. Occasionally, when pile driving occurred off the construction pier, the best safe monitoring platform for the MC was atop the bank on the shore. The MC was typically 5–20 m (16–66 ft) from the pile, and at all times had a full view of the shutdown zone. The MC was positioned in close proximity to the construction foreman or in the foreman's line-of-sight, and each pile driving event was communicated between the foreman and MC. The MC would transmit the pile specifications and other details to the observers, vessel captains, and acoustic personnel, all of whom monitored the same radio channel. The MC logged pile driving times and related construction activities for each pile. This served as the basis for marine mammal sightings data quality control.

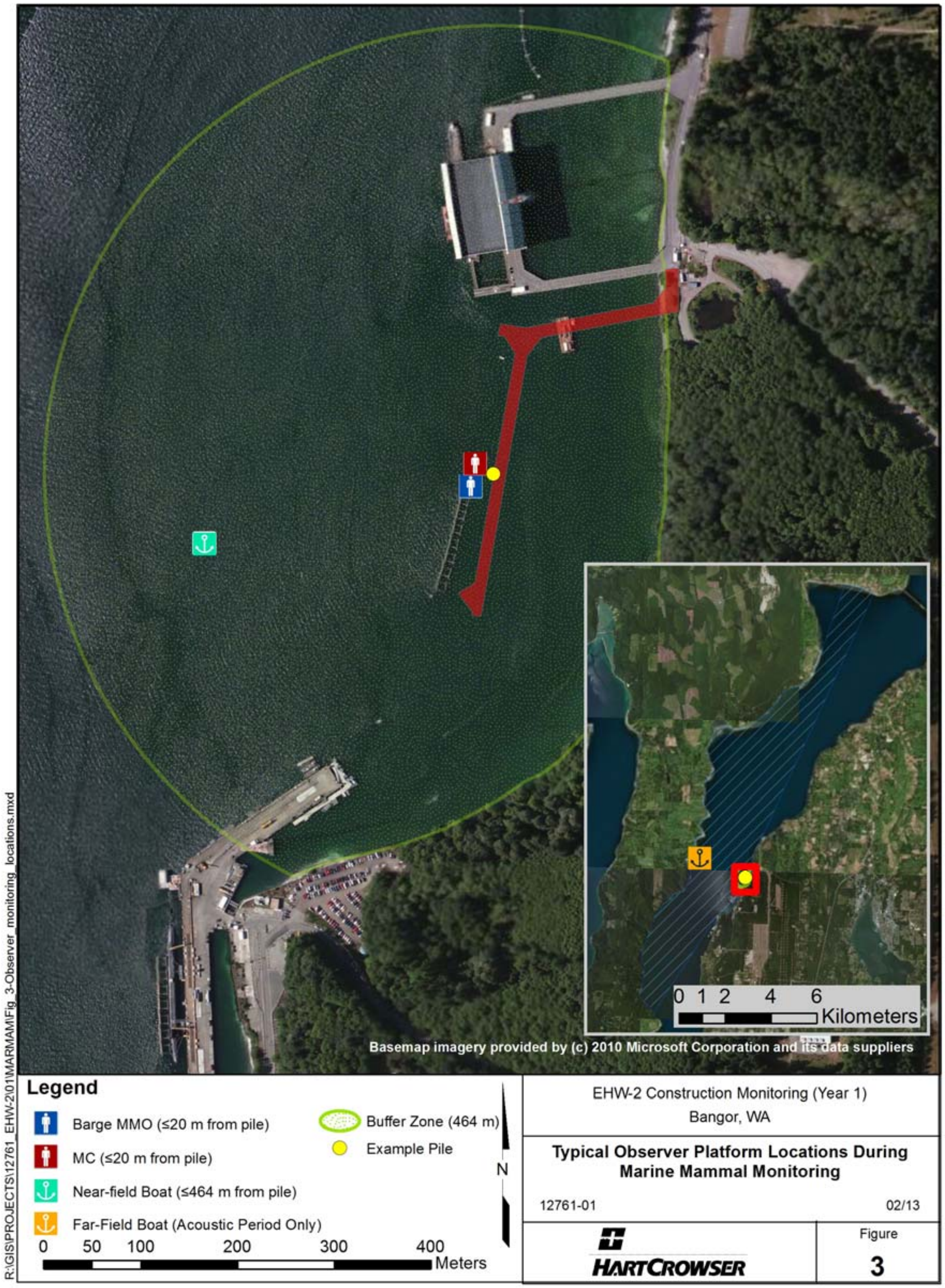


Figure 3. Typical Observer Monitoring Platforms During Marine Mammal Monitoring

Monitoring Summary

In total, the Navy completed 530 hours, 50 minutes of marine mammal surveys on 80 construction days during the course of the Year 1 EHW-2 CMP (**Table 2**).

Table 2. Summary of Monitoring Effort

Date	Start Time (hh:mm)	End Time (hh:mm)	Total Time (hh:mm)
Construction Monitoring			
9/28/2012	10:12:00 AM	2:29:00 PM	4:17
10/1/2012	7:51:00 AM	3:14:00 PM	7:23
10/2/2012	7:39:00 AM	11:51:00 AM	4:12
10/4/2012	7:24:00 AM	11:09:00 AM	3:45
10/5/2012	7:38:00 AM	3:30:00 PM	7:52
10/10/2012	7:30:00 AM	11:15:00 AM	3:45
10/11/2012	10:20:00 AM	4:49:00 PM	6:29
10/12/2012	8:05:00 AM	4:05:00 PM	8:00
10/15/2012	8:55:00 AM	11:13:00 AM	2:18
10/16/2012	7:30:00 AM	5:05:00 PM	9:35
10/17/2012	8:12:00 AM	5:01:00 PM	8:49
10/29/2012	11:03:00 AM	1:57:00 PM	2:54
10/30/2012	10:05:00 AM	3:17:00 PM	5:12
10/31/2012	8:15:00 AM	3:10:00 PM	6:55
11/1/2012	8:54:00 AM	3:41:00 PM	6:47
11/16/2012	8:00:00 AM	4:46:00 PM	8:46
11/19/2012	9:25:00 AM	2:02:00 PM	4:37
11/20/2012	7:30:00 AM	3:30:00 PM	8:00
11/21/2012	7:30:00 AM	3:18:00 PM	7:48
11/26/2012	10:25:00 AM	3:00:00 PM	4:35
11/27/2012	7:30:00 AM	3:30:00 PM	8:00
11/28/2012	7:32:00 AM	3:06:00 PM	7:34
11/29/2012	9:02:00 AM	1:44:00 PM	4:42
11/30/2012	8:05:00 AM	3:17:00 PM	7:12
12/3/2012	7:42:00 AM	2:45:00 PM	7:03
12/4/2012	7:45:00 AM	3:55:00 PM	8:10
12/5/2012	8:45:00 AM	2:02:00 PM	5:17
12/6/2012	9:00:00 AM	3:14:06 PM	6:14
12/7/2012	7:30:00 AM	4:00:00 PM	8:30
12/10/2012	7:52:00 AM	3:26:00 PM	7:34
12/11/2012	8:30:00 AM	2:40:00 PM	6:10
12/12/2012	7:45:00 AM	11:45:00 AM	4:00
12/13/2012	10:35:00 AM	2:16:00 PM	3:41
12/14/2012	8:02:00 AM	9:56:00 AM	1:54
12/14/2012	1:12:00 PM	3:25:00 PM	2:13
12/17/2012	8:22:00 AM	3:26:00 PM	7:04

12/18/2012	8:22:00 AM	2:59:00 PM	6:37
12/19/2012	9:25:00 AM	2:27:00 PM	5:02
12/20/2012	1:35:00 PM	3:57:31 PM	2:22
12/21/2012	8:15:00 AM	2:16:00 PM	6:01
12/26/2012	11:48:00 AM	3:28:40 PM	3:40
12/27/2012	8:40:13 AM	4:15:42 PM	7:35
12/28/2012	8:20:56 AM	3:59:47 PM	7:38
12/31/2012	8:20:00 AM	3:02:23 PM	6:42
1/2/2013	8:08:00 AM	3:00:00 PM	6:52
1/3/2013	7:58:00 AM	4:00:00 PM	8:02
1/4/2013	7:58:00 AM	3:45:00 PM	7:47
1/5/2013	8:14:00 AM	3:23:00 PM	7:09
1/6/2013	8:29:28 AM	2:33:00 PM	6:03
1/7/2013	7:59:00 AM	4:23:00 PM	8:24
1/8/2013	8:00:00 AM	4:28:00 PM	8:28
1/9/2013	8:00:00 AM	4:19:00 PM	8:19
1/10/2013	7:56:00 AM	3:43:00 PM	7:47
1/11/2013	7:45:00 AM	4:30:00 PM	8:45
1/12/2013	7:35:00 AM	4:45:00 PM	9:10
1/14/2013	8:20:00 AM	3:45:00 PM	7:25
1/15/2013	7:50:00 AM	9:30:00 AM	1:40
1/15/2013	9:30:00 AM	4:45:00 PM	7:15
1/16/2013	7:50:00 AM	4:40:00 PM	8:50
1/17/2013	8:45:00 AM	3:45:00 PM	7:00
1/18/2013	7:50:00 AM	4:25:00 PM	8:35
1/19/2013	7:50:00 AM	4:39:00 PM	8:49
1/21/2013	8:19:22 AM	4:46:22 PM	8:27
1/22/2013	7:49:00 AM	4:28:00 PM	8:39
1/23/2013	8:00:00 AM	4:49:00 PM	8:49
1/24/2013	8:00:00 AM	4:31:00 PM	8:31
1/25/2013	8:40:00 AM	4:00:00 PM	7:20
1/28/2013	8:05:00 AM	2:40:00 PM	6:35
1/29/2013	8:15:00 AM	3:21:00 PM	7:06
1/30/2013	7:50:00 AM	2:37:00 PM	6:47
2/5/2013	8:40:00 AM	2:49:00 PM	6:09
2/6/2013	7:30:00 AM	11:45:10 AM	4:15
2/7/2013	8:00:00 AM	5:10:00 PM	9:10
2/8/2013	8:15:00 AM	4:20:00 PM	8:05
2/9/2013	8:18:00 AM	4:10:40 PM	7:52
2/10/2013	8:13:00 AM	4:51:00 PM	8:38
2/11/2013	9:00:00 AM	3:34:00 PM	6:34
2/12/2013	8:45:00 AM	3:12:00 PM	6:27
2/13/2013	9:00:00 AM	2:10:00 PM	5:10
2/14/2013	8:30:00 AM	3:28:00 PM	6:58
TOTAL			**530:50**

Monitoring Zones

The analysis of TPP acoustic data, and modeling results presented within the draft Environmental Impact Statement, Biological Assessment, and the IHA were used to develop the shutdown and buffer zones for pile installation and removal activities associated with the EHW-2 CMP. While the acoustic zones of influence varied among the different diameter piles and types of installation and removal methodologies, shutdown and buffer zones were based on the modeled maximum zone of influence for all pile installation and removal activities. Monitoring of these zones and the implementation of other minimization measures, such as the use of sound attenuation devices, were designed to reduce the impacts of underwater sound from pile driving and removal on marine mammals.

Shutdown Zone. The shutdown zone included all areas where the underwater sound pressure levels (SPLs) were anticipated to equal or exceed the Level A (injury) Harassment criteria for marine mammals (180 decibels referenced to 1 micropascal [dB re 1 µPa] isopleths for cetaceans; 190 dB re 1µPa isopleths for pinnipeds; Figure 4). For vibratory pile installation and removal, monitoring was conducted for a 10-m (32.8-ft) shutdown zone (Level A Harassment) surrounding each pile for the presence of marine mammals before, during, and after pile operations. For impact pile installation, monitoring was conducted for a 20-m (65.6-ft) shutdown zone for pinnipeds and an 85-m (278.9-ft) shutdown zone for cetaceans. The 10-m shutdown zone was also monitored during other activities with the potential to affect marine mammals, including movement of a barge to the pile location and the removal or insertion of a pile from the water column via a crane ("dead pull" and "stabbing," respectively).

Buffer Zone. Although a buffer zone (Level B harassment, 120 dB isopleth) for vibratory pile removal was predicted to have an area of 41.4 square kilometers (km^2; 16.0 square miles), monitoring an area of that size would have been impractical (Figure 5). Instead, MMOs used the NMFS-approved 464-m (1522-ft) radius buffer zone (160 dB isopleths) as a guideline for placement of marine mammal monitoring platforms during vibratory pile driver activity (Figure 4; DoN 2012). However, all identifiable marine mammals, regardless of whether inside or outside the 464-m zone, were recorded.

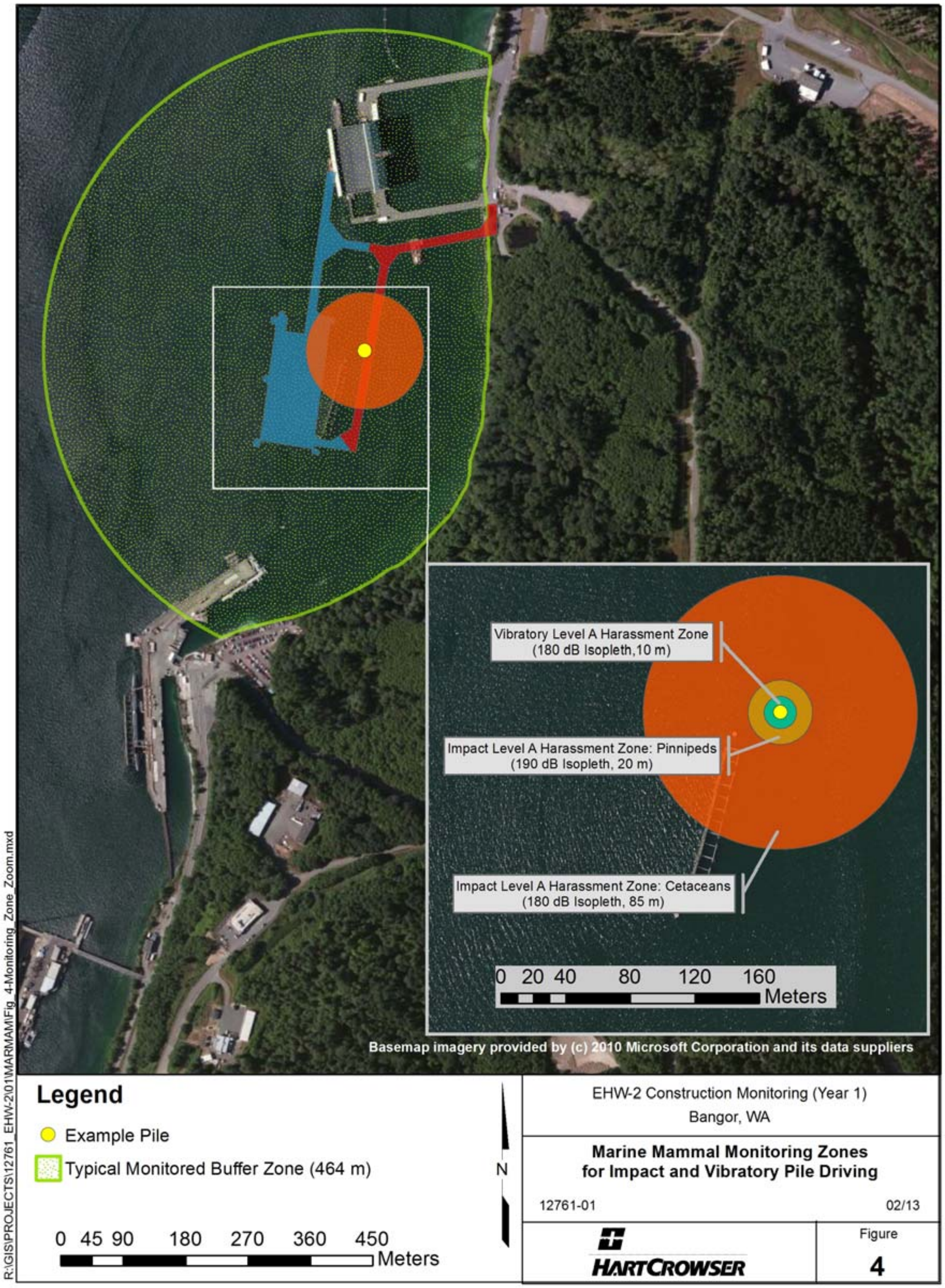


Figure 4. Marine Mammal Monitoring Zones for Impact and Vibratory Pile Driving

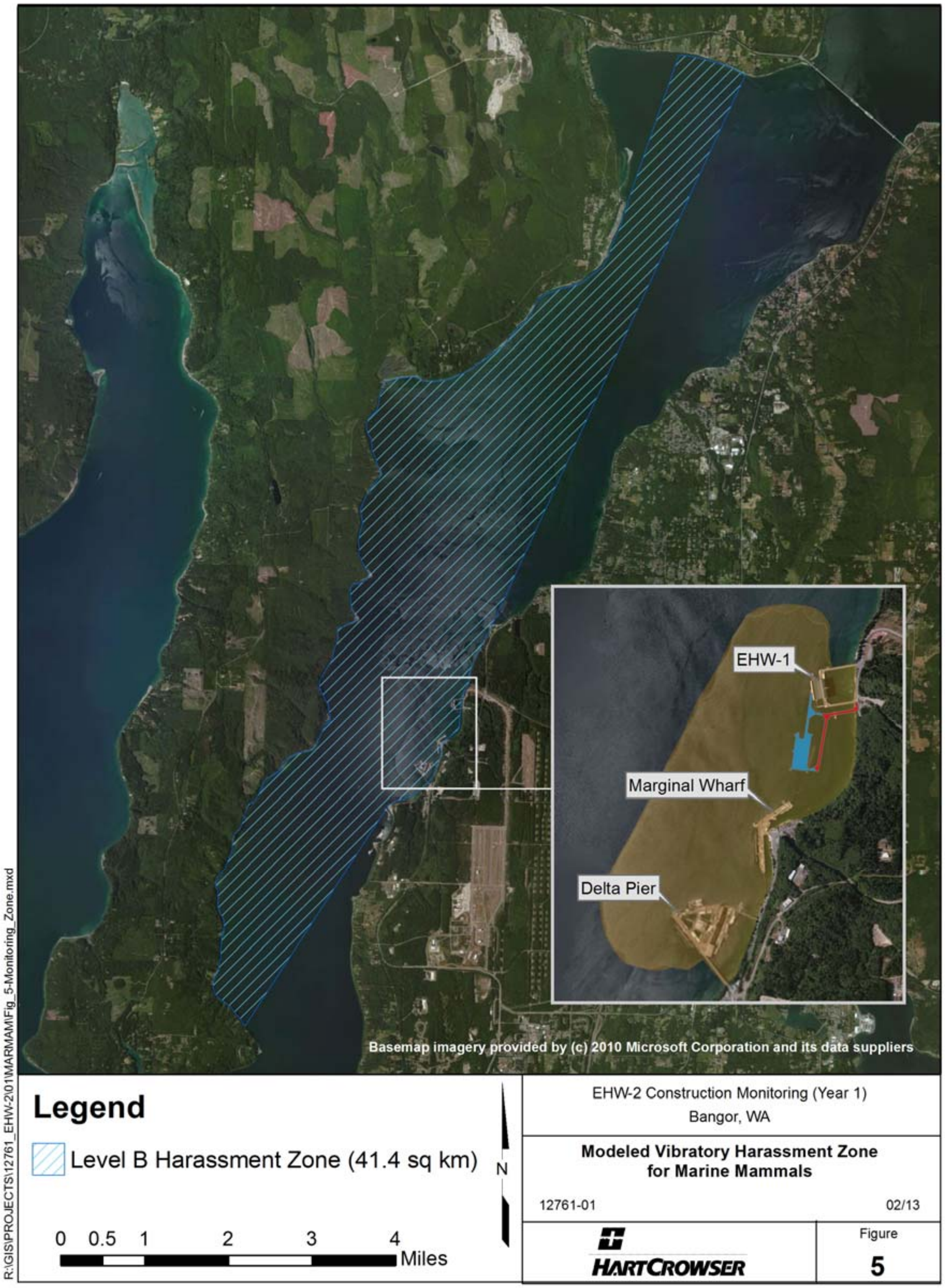


Figure 5. Modeled Vibratory Harassment Zone for Marine Mammals

Observer Monitoring Locations

In order to monitor buffer and shutdown zones, MMOs were positioned at various vessel-, pier-, and land-based vantage points, taking into consideration security, safety, and space limitations at the NBK at Bangor waterfront. One monitoring vessel was positioned inside the WRA, in addition to the construction-related vessels (i.e., barges, tugs, etc). One vessel was stationed outside the WRA during the acoustic monitoring period for acoustic and marine mammal monitoring. Inside the WRA, MMOs were also frequently placed on the construction barge, construction pier, and shore bank to monitor each shutdown zone. The MC was stationed on or near the construction barge, and served as an additional MMO when needed.

The following vessel locations (**Figure 3**) were identified to provide adequate visual coverage during all construction activities:

Near-field Vessel Location. One MMO was stationed on a vessel monitoring platform within the buffer zone in the WRA. Acousticians also used the near-field vessel during the acoustic monitoring phase. During the acoustic monitoring phase, the near-field vessel was stationary. At other times, the vessel moved within the WRA as needed to provide adequate coverage of the buffer zone. In addition to monitoring the buffer zone, the near-field boat was also used as required to provide additional MMO coverage for the shutdown zone and to aid marbled murrelet monitors during impact pile driving.

Far-Field Vessel Location. During the acoustic monitoring period, one MMO was stationed on a vessel outside the WRA and monitored for marine mammals while not filling acoustic monitoring responsibilities. This MMO served as a supplemental monitor for the Level B Harassment Zone.

Monitoring Techniques

Pile installation and removal activities occurred intermittently throughout each construction day. In order to best characterize marine species occurrence and behavior in the area, MMOs surveyed throughout the day, regardless of whether or not pile driving was occurring at that time. Therefore, data gathered on construction days includes observations made during construction and non-construction periods. Construction monitoring began at least 15 minutes prior to the initiation of pile driving (pre-construction monitoring) and ended 30 minutes after completion of all pile driving (post-construction monitoring). Pile driving was not initiated until the shutdown zone was clear of marine mammals. Observers recorded time, number of animals, behavior, distance and bearing to the animal(s), and distance to pile for each sighting using the standardized Marine Mammal Sightings form (**Appendix B**). This form was digitally reproduced for the beginning of production pile driving, allowing MMOs to enter data directly into a database using handheld tablet computers. A sheet of data codes was supplied to each MMO as a reference to project-specific codes for construction type, weather, and marine mammal species and behavior (**Appendix B**). At the end of each day, all digitized sightings underwent a rigorous quality control process before being appended to the primary database. Prior to digitizing the Marine Mammal Sightings form, sighting sheets were manually recorded. At the end of each day all forms were collected, scanned, and the data manually entered into the electronic database, generally within 24 hours. Other standard MMO equipment included personal protective equipment (PPE), binoculars with rangefinders, a GPS unit, a VHF radio, a clipboard, and a marine mammal identification guide. The required PPE for all observers while on site was a personal flotation device, hard hat, steel toe boots, and hearing protection.

To minimize the probability of multiple observers counting a single animal (and thereby potentially overestimating takes), sightings were tracked on a continuous basis by an observer on one monitoring platform, and then "handed off" to an observer on a second vessel if the animal(s) headed in the direction of the second monitoring platform. Observers kept detailed sighting data and, whenever possible, indicated in their field notes if an animal was a re-sight.

Every attempt was made to protect marine mammals from Level A (injury) Harassment via the use of sound attenuation devices and continuous monitoring of the behavioral harassment and near-field injury zones. Monitoring coverage of the Level A shutdown zone was consistently excellent. It was not always possible to have 100% coverage of the Level B (behavioral) harassment zone during vibratory pile driving/removal due to the large area involved, the presence of construction barges and vessels, and the limited number of monitoring vessels. The efficacy of visual detection of marine mammals depended on several factors, including the observer's ability to detect the animal, the environmental conditions (visibility and sea state), and the position of the monitoring platforms. Pile driving was halted when a marine mammal was sighted within or approaching the shutdown zone during pile driving activities.

Visual Monitoring Protocol

Pre-Construction Monitoring. Prior to the start of pile operations, the shutdown and buffer zones were monitored for at least 15 minutes to document the presence of marine mammals. The following monitoring methodology was implemented prior to commencing pile installation/ removal activities:

- MMOs monitored the shutdown zone and buffer zones. They ensured that no marine mammals were seen within the shutdown zone before pile driving began.
- If marine mammals were present within or approaching the shutdown zone prior to pile driving, monitoring continued and the start of pile driving was delayed until the animals left the shutdown zone voluntarily and had been visually confirmed beyond the shutdown zone, or if 15 minutes had elapsed without re-detection of the animal.
- If marine mammals were not within the shutdown zone (i.e., if the zone was deemed clear of marine mammals), the observers radioed the Monitoring Coordinator who then notified the pile driving foreman that pile driving could commence.
- If marine mammals were detected within the buffer zone, pile driving and removal or other in-water construction activities (activities not involving a pile driver, but having the potential to affect marine mammals; e.g., "stabbing" the pile) were not delayed, but observers monitored and documented the behavior of marine mammals that remained in the buffer zone.
- The MMO stationed outside the WRA during the acoustic monitoring period looked for the presence of marine mammals and radioed to near-field observers if marine mammals were traveling toward the near-field.
- Marine Mammal Sightings forms were used to document observations (**Appendix A**).

During Construction Monitoring. The shutdown and buffer zones were monitored throughout the time required to install or remove a pile and during other in-water construction activities. The following monitoring methodology was implemented during pile operations:

- If a marine mammal was observed entering the buffer zone an "exposure" was recorded and behaviors documented. However, that pile segment would be completed without cessation unless the animal entered or approached the shutdown (injury) zone, at which point all pile installation/removal activities associated with that rig were halted. The observers immediately radioed to alert the MC who alerted the pile driving foreman. This action required an immediate "all-stop" to pile operations. Shutdown at one pile driving location did not necessarily trigger shutdowns at other locations where pile driving was occurring simultaneously.

- Under certain construction circumstances where initiating the shutdown and clearance procedures could result in an imminent concern for human safety, the Monitoring Plan provided that the shutdown provision would be waived. The shutdown provision was not waived during the Year 1 EHW-2 CMP.

- Pile installation/removal activities were delayed until the animal voluntarily left the shutdown zone and had been visually confirmed beyond the shutdown zone, or 15 minutes had passed without re-detection of the animal.

- During the pile driving delay, monitoring continued to be conducted and pile driving did not resume until the shutdown zone had been deemed clear of all marine mammals.

- Once marine mammals were no longer detected within the shutdown zone, the observers radioed the MC that activities could re-commence.

- If marine mammals were detected outside the shutdown zone, the observers continued to monitor these individuals and recorded their behavior, but pile driving proceeded. Any marine mammals detected outside the shutdown zone after pile driving was initiated continued to be monitored and their behaviors recorded.

- Marine Mammal Sighting forms were used to document observations (**Appendix B**).

- Any monitoring boats engaged in marine mammal monitoring maintained speeds equal to or less than 10 knots.
- Experienced marine mammal observers were trained to accurately verify species sighted.
- Observers used binoculars and the naked eye to search continuously for marine mammals.
- In case of fog or reduced visibility, the observers had to be able to see the shutdown and buffer zones; otherwise, pile driving was not initiated until visibility in these zones improved to acceptable levels.
- During impact pile driving, marbled murrelet monitoring protocols were run concurrently with the above described monitoring efforts.

Post-Construction Monitoring. Monitoring of the shutdown and buffer zones continued for 30 minutes following completion of pile installation and removal activities. The post-monitoring period was not required for other in-water construction. These monitoring efforts focused on observing and reporting unusual or abnormal behavior of marine mammals. During these efforts, if any injured, sick, or dead marine mammals were observed, the U.S. Navy was to notify NMFS immediately. No injured, sick, or dead marine mammals were observed during post-construction monitoring during the Year 1 EHW-2 CMP. Monitoring results were noted on the Marine Mammal Sighting form (**Appendix B**).

Acoustic Monitoring

For more detailed acoustic monitoring methods, please see Illingworth and Rodkin (2013). Acoustic monitoring was conducted during impact and vibratory installation and removal activities associated with the EHW-2 CMP in order to determine the actual distances to the underwater and airborne thresholds for marine mammals and pinnipeds. These included the 190-dB re 1µPa RMS, 180-dB re 1µPa RMS, 160-dB re 1µPa RMS, and 120-dB re 1µPa RMS underwater isopleths, and the 100-dB re 20 µPa and 90-dB re 20 µPa unweighted airborne isopleths. Unless otherwise stated, underwater sound pressure is defined as SPL in dB re 1 µPa.

Airborne sound pressure is defined as SPL in dB re 20 μPa. The injury and behavioral harassment thresholds for marine mammals are defined as follows:

Underwater Injury Zones:

a. 180 dB RMS isopleth for cetaceans

b. 190 dB RMS isopleth for pinnipeds

Underwater Behavioral Harassment Zones:

a. 160 dB RMS for marine mammals during impact pile driving

b. 120 dB RMS for marine mammals during vibratory driving

Airborne Behavioral Harassment Zones:

a. 100 dB RMS for all pinnipeds except harbor seals, during impact and vibratory pile driving

b. 90 dB RMS for harbor seals, during impact and vibratory pile driving.

Hydrophones/microphones were placed at varying distances and depths as appropriate to accurately capture sound propagation characteristics in the EHW-2 CMP area. Ambient underwater and airborne conditions in the absence of construction activities were recorded for comparison. The U.S. Navy's Acoustic Monitoring Plan provides the specific details of the acoustic monitoring requirements and protocol for both underwater and airborne sounds from the EHW-2 CMP.

Stationary Hydrophones. All sound level meters (SLMs) were calibrated to the hydrophone response with the pistone phone signal at the beginning of each day. The response of SLMs to the calibration tone was noted in field logbooks and logged by the SLM, which was downloaded after each day with a pile driving event. A backup SLM was used to collect limited data in case of a recording failure, which occurred on a few occasions.

A stationary 2-channel hydrophone recording system was suspended from the pile driving barge approximately 10 m (33 ft) from each pile. One hydrophone was placed mid-depth and the other closer to the bottom. Depth of the hydrophones with respect to the bottom varied due to tidal changes and current effects. The hydrophones recorded continuously during pile driving and the data were analyzed after the completion of the project.

In addition to the hydrophone array on the barge, two-channel stationary hydrophone arrays were deployed near the Toandos Peninsula at approximately 1800 to 2400 m (5,905 to 7,875 ft) from the pile, one to the north and south. These sets of hydrophones hung from anchored rafts and recorded continuously during pile driving. One hydrophone was suspended at approximately mid-depth at mean water depth and the other at a position approximately 0.61 m (2.0 ft) above the bottom at low tide.

Vessel-Based Hydrophones and Microphones. One monitoring vessel was equipped with a two-channel hydrophone array which was used inside the WRA to monitor near-field and real-time isopleths. The SLMs attached to these hydrophones collected data in real time. The RMS sound pressure level was measured for each pile strike at each position. This was measured using the "impulse" setting on the sound level meter that provides the maximum RMS over a 35-milli-second period for each second that impact pile driving occurred. The maximum impulse level occurring over each second of impact pile driving was reported. Use of the 35-millisecond impulse level provides a slight overestimate of the RMS, since the pulse duration is typically 50 to 100 milliseconds, with most energy confined to 30 to 50 milliseconds. The monitoring vessel was also equipped with an airborne microphone to record airborne sounds.

Stationary Microphones. For each pile being driven, a stationary microphone was located on the pile driving barge at approximately 15.2 m (50 ft) from the pile to record airborne sound levels. In addition, one land-based microphone was placed on shore west of the jobsite trailer. The land-based microphone was placed according to ease of access given topography and security restrictions. All airborne data were recorded and analyzed after completion of the project.

Piles and Pile Driving Equipment

Pile Descriptions. During the EHW-2 CMP, 170 production steel piles (piles that will remain as part of the EHW-2 structure) were driven by vibratory and impact hammers. Additionally, indicator piles, temporary construction trestle piles (referred to as TT piles in Appendix F), and falsework (referred to as "temp" piles in Appendix F) were also installed and removed with vibratory and impact hammers (impact only occurred on indicator piles). Production piles ranged in diameter from 24 to 36 inches (0.61 to 0.92 m). Indicator piles, temporary construction trestle piles, and template pin piles ranged in size from 24 to 48 inches (0.61 to 1.22 m) in diameter (**Figure 6, Appendix C**).

Pile Driving Equipment. Pile driving equipment was provided and operated by EHW Constructors pile driving crews. Two vibratory (American Piledriving Equipment [APE] 400 and APE 600) and two impact hammers (APE D80 and APE D100) were used during the project, though only one impact hammer was in operation at any time.

The APE 400 and APE 600 have drive forces of 361 tons and 556 tons, respectively. Impact hammers APE D80 and APE D100 were rated for 198,450 ft-pounds (lbs) and 248,063 ft-lbs, respectively. The APE 400 was used on 24-inch piles, while APE 600 was used for 36- and 48-inch piles, as well as a few 24-inch piles. Similarly, APE D80 was used to impact 24-inch piles. The APE D100 was used to impact 36- and 48-inch piles (**Figure 6, Appendix C**). In total, there were 160 instances where piles were driven with an impact hammer, and therefore required formal monitoring for marbled murrelets. Marbled murrelet monitoring methods and findings are presented in a separate report (Hart Crowser 2013).

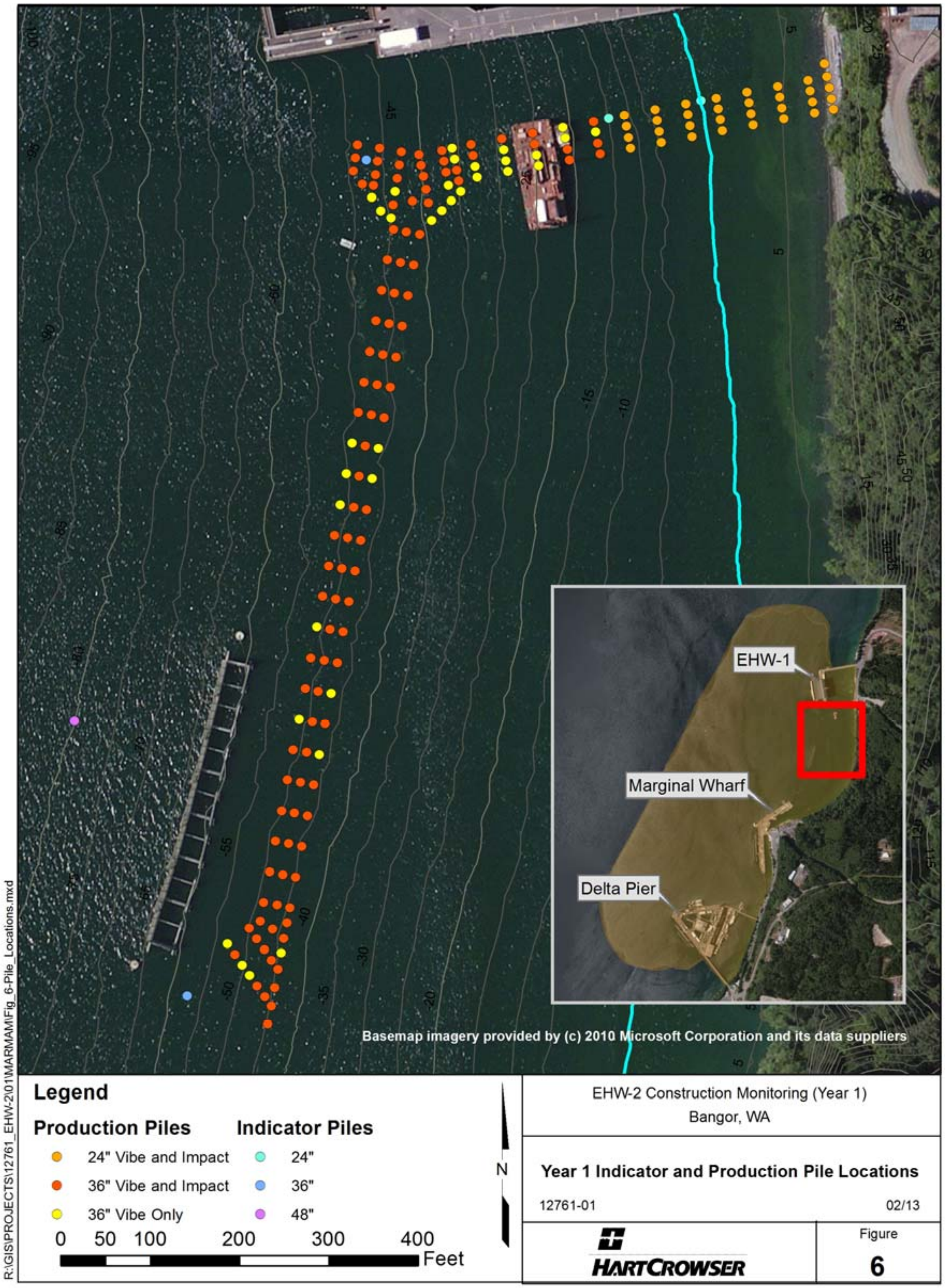


Figure 6. Year 1 Indicator and Production Pile Location

A sound attenuation bubble curtain was utilized during all impact driving events (see **Appendix D** for design specifications of air bubble curtain sound attenuation system). The bubble curtain was turned off for a period during the impact driving of one indicator pile to allow pile driving crews to access the impact driver and force shutdown when the remote shutoff failed. During this instance, the pile driving crew unsuccessfully attempted to shut down the pile driving hammer for several minutes before determining that the only way to shut down the hammer was to approach the hammer with a boat to transfer personnel to the actively firing hammer. The construction crew determined that this could not be conducted safely without shutting off the bubble curtain for approximately five minutes as the boat approached the pile and transferred a person onto the hammer, where he was subsequently able to manually shut it down. Marine mammal monitoring continued throughout the entire pile driving period, including the bubble curtain shutdown period. The bubble curtain was designed with an adjustable number of rings placed no further than 15 feet (4.6 m) apart, and were constructed of 3-inch (7.6-centimeter [cm]) diameter pipe rolled into a circle 4 feet, 10 inches (1.5 m) in diameter. Vent holes were 1/16-inch (0.16-cm) diameter in three sets with a set of center top holes and two additional sets of holes set 45 degrees to the inside and outside of the ring. The top sets of holes were spaced 1 inch apart (2.5 cm) and the inside/outside sets were spaced 3 inches (7.6 cm) apart around the ring. Each ring was required to pass approximately 501 cubic feet per minute (cfm) (14.2 cubic meters per minute) of oil-free air to meet the requirements.

Environmental Data

Environmental parameters were measured at intervals inside the WRA from Marginal Wharf. An Kestrel 4000 anemometer was used to determine wind speed and air temperature. A HOBO Water Temperature Pro Data Logger was deployed to collect water temperatures. Visual observations of wave height, wind direction, and weather conditions were also included in the sightings data (**Appendix E**). On several days, weather data was not collected due to weather meter malfunction, loss due to high winds, and the inability to access the monitoring location on the pier due to security restrictions.

Section 3 Results

The MC logged pile driving times and related construction activities for each pile, which served as the basis for marine mammal sightings data quality control (**Appendix F**). MC pile times were also used by Illingworth and Rodkin for acoustic analysis.

Acoustic Results

In general, underwater and airborne sound measurements collected at the construction barge, approximately 10–15 m from the pile driving activity, provided the best acoustic data for construction, since it was the closest location to pile activity. However, sound measurements were taken in multiple locations inside and outside the WRA (Illingworth and Rodkin 2013), and distances to various sound thresholds for marine mammals were calculated using data from all available sources. For more detailed acoustic monitoring results, please see Illingworth and Rodkin, 2013.

Impact Pile Driving Acoustics. During the Year 1 EHW-2 CMP, impact pile driving occurred on 136 piles over the course of 19 days(see **Appendix C** for all impact driving dates and blow counts for each pile). A total of 23,527 strikes were used to drive the piles for an average of 1,238 strikes per day (max 3,420 strikes) and 173 strikes per pile (max 1,060 strikes). The number of pile strikes per event ranged from 21 to 617 strikes. The maximum duration of impact pile driving events was 54 minutes during an event consisting of 84 dead blows and 15 minutes for a normal impact drive (soft start and continuous impact). Dead blows are single strikes to a pile at less than full force. These strikes (2-5) are typical when the hammer is started during cold weather following several days without use. The event with 84 dead blows was unique, and likely indicated a secondary problem with the hammer, rather than just cold weather operation. Impact events averaged three minutes in duration.

The distances to the underwater injury (shutdown) zone isopleths (pinnipeds, 190 dB RMS re 1 µPa; cetaceans, 180 dB RMS re 1 µPa) and the underwater behavioral disturbance (level B harassment) zone isopleths (160 dB RMS re 1 µPa) are provided in **Table 3**. Distances to the marine mammal airborne disturbance thresholds (90 dB RMS re 20 µPa [unweighted] for harbor seals and 100 dB RMS re 20 µPA [unweighted] for all other pinnipeds) are also provided in

Table 3 when available. The calculated isopleths were typically dependent on the pile size and water depth, but also varied from pile to pile.

The distance to the 160 dB isopleth, the behavioral disturbance zone, ranged from <20 m to 1,501 m (**Table 3**) and averaged 446 m from the pile. The wide variation in the distance to the 160 dB RMS isopleth was likely influenced by differences in pile sizes, the depth and type of the substrate, and variations in bubble curtain performance. Of the 72 impact pile driving events monitored, there were 30 where the maximum 160-dB levels extended beyond the 464-m buffer zone. In four of the 30 events, the distance to the 160 dB RMS isopleth was within 1,000 m.

The distance to the maximum RMS level of 180 dB, the injury zone for cetaceans, ranged from <10 m to 100 m (**Table 3**) and averaged 36 m from the pile. The distance to the 180 dB isopleth extended beyond the 85-m shutdown zone for cetaceans during two of the drives (**Table 3**). However, the enlarged injury zones did not result in any unauthorized cetacean takes. No cetaceans were sighted within the WRA during Year 1 EHW-2 CMP monitoring. The port security barrier (PSB) fence, which appears to exclude cetaceans from the WRA, extends 500 m to 700 m from the shoreline, well beyond the farthest distance to the 180 dB threshold.

Table 3. Acoustic Results from Impact Pile Driving

Date	Start Time	End Time	Pile	Specifications	Number of Strikes	Distance (m) to Isopleth (RMS): Underwater			Distance (m) to Isopleth (RMS): Airborne	
						190 dB	180 dB	160 dB	100 dB	90 dB
10/12/2012	10:51:52	10:56:33	TT-4S	36"x65.5'	28	<10	27	405	-	-
10/30/2012	11:08:18	11:17:01	TT-7.5TD	24"x80'	239	<10	17	248	-	-
10/30/2012	11:55:18	12:03:54	TT-7.5TD	24"x80'	88	<10	17	262	-	-
10/30/2012	14:34:40	14:46:38	TT-10TD	24"x90'	155	<10	27	398	-	-
10/31/2012	10:07:14	10:15:53	TT-21.5J	36"x124'	87	11	41	614	-	-
10/31/2012	15:04:38	15:09:30	TT-56H.5	36"x129'	100	14	55	827	-	-
11/1/2012	9:24:12	9:52:51	TT-10.5A	24"x95'	47	<10	24	362	-	-
11/1/2012	11:41:15	11:44:49	TT-7.5TD	24"x80'	36	<10	17	255	-	-
11/1/2012	15:06:33	15:10:09	TT-56H.5	36"x125'	39	26	100	1501	-	-
11/16/2012	16:00:09	16:14:45	TT-13.5R	48"x190'	43	14	23	53	-	-
11/19/2012	10:58:12	12:00:43	TT-13.5R	48"x190'	93	<10	17	254	-	-
11/19/2012	12:39:05	12:52:16	TT-13.5R	48"x190'	33	11	43	652	-	-
11/19/2012	13:05:32	13:15:40	TT-13.5R	48"x190'	345	14	52	774	-	-
11/19/2012	13:16:12	13:28:30	TT-13.5R	48"x190'	615	13	49	728	-	-
11/27/2012	13:12:08	13:29:52	T10-D	24"x93'	154	<10	32	479	16	51
11/27/2012	13:55:13	13:58:04	T10-C	24"x93'	126	10	39	589	19	60
11/27/2012	14:18:11	14:26:18	T10-B	24"x93'	163	10	39	578	19	60
11/27/2012	14:43:05	14:43:05	T10-A	24"x93'	29	<10	17	261	20	63

Date	Start Time	End Time	Pile	Specifications	Number of Strikes	Distance (m) to Isopleth (RMS): Underwater			Distance (m) to Isopleth (RMS): Airborne	
						190 dB	180 dB	160 dB	100 dB	90 dB
1/9/2013	11:38:37	11:52:14	T10-B	24"	190	<10	<10	138	26	82
1/9/2013	13:05:21	13:21:07	T10-C	24"	483	<10	16	239	19	60
1/9/2013	13:49:09	13:49:53	T10-D	24"	27	<10	21	310	19	60
1/9/2013	14:25:05	14:26:36	T10-A	24"	65	<10	14	207	20	63
1/9/2013	15:04:01	15:23:55	T9-C	24"	617	<10	32	479	21	65
1/9/2013	15:39:44	15:48:40	T9-B	24"	354	<10	35	530	20	64
1/10/2013	8:55:24	9:10:09	T9-D	24"x91'	310	<10	29	437	23	73
1/10/2013	9:56:10	10:18:52	T9-A	24"x91'	298	<10	28	417	22	69
1/10/2013	10:33:36	10:40:13	T8-D	24"x85'	263	<10	27	400	25	79
1/10/2013	10:53:54	10:57:08	T8-C	24"x85'	126	<10	17	250	22	71
1/10/2013	11:10:31	11:15:37	T8-B	24"x85'	198	<10	18	273	24	77
1/10/2013	11:26:35	11:33:50	T8-A	24"x85'	273	<10	19	284	24	75
1/10/2013	12:38:22	12:51:24	T7-A	24"x85'	391	<10	29	429	22	71
1/10/2013	12:58:27	13:10:37	T7-B	24"x85'	334	<10	16	235	23	74
1/10/2013	13:19:48	13:19:48	T7-C	24"x85'	234	<10	13	197	22	71
1/10/2013	13:39:00	13:46:34	T7-D	24"x85'	236	<10	22	323	20	64
1/10/2013	14:16:49	14:20:25	T6-D	24"x81'	144	<10	<10	113	19	61
1/10/2013	14:27:35	14:31:43	T6-C	24"x81'	157	<10	<10	79	21	65
1/10/2013	14:40:50	14:46:25	T6-B	24"x81'	212	<10	11	168	22	69
1/10/2013	14:55:02	15:12:11	T6-A	24"x81'	244	<10	<10	108	22	71
1/11/2013	10:09:10	10:14:13	T4-A	24"x80'	279	<10	<10	11	19	61
1/11/2013	10:19:16	10:32:28	T4-B	24"x80'	323	<10	<10	7	22	68
1/11/2013	10:37:49	10:45:32	T4-C	24"x80'	298	<10	<10	9	19	59
1/11/2013	10:50:15	10:54:42	T4-D	24"x80'	178	<10	<10	11	19	60
1/11/2013	11:02:12	11:08:29	T5-D	24"x80'	137	<10	<10	20	17	52
1/11/2013	11:23:50	11:27:56	T5-C	24"x80'	168	<10	<10	19	18	56
1/11/2013	11:37:00	11:40:38	T5-B	24"x80'	151	<10	<10	42	17	55
1/11/2013	11:48:00	11:51:42	T5-A	24"x80'	148	<10	<10	64	18	56
1/11/2013	14:07:17	14:10:07	T9-A	24"x91'	298	11	45	677	-	-
1/11/2013	14:24:38	14:25:12	T10-A	24"	134	<10	16	236	-	-

Date	Start Time	End Time	Pile	Specifications	Number of Strikes	Distance (m) to Isopleth (RMS): Underwater			Distance (m) to Isopleth (RMS): Airborne	
						190 dB	180 dB	160 dB	100 dB	90 dB
1/17/2013	10:06:10	10:18:00	T16-B	36"	242	<10	20	295	16	50
1/17/2013	11:14:58	11:25:54	T15-D	36"	198	<10	28	416	10	32
1/17/2013	11:36:37	11:42:53	T15-C	36"	245	<10	25	376	10	32
1/17/2013	12:16:05	12:21:13	T16-A	36"	197	<10	20	295	14	46
1/17/2013	13:15:49	13:19:55	T17-B	36"	156	10	39	584	23	73
1/17/2013	13:32:33	13:39:06	T17-C	36"	254	11	43	644	17	55
1/17/2013	13:48:32	13:50:57	T17-D	36"	92	12	46	689	17	53
1/17/2013	15:09:16	15:11:54	T18-0A.9	36"	110	12	52	775	19	60
1/18/2013	10:43:13	10:50:41	T28-G	36"	141	13	53	802	22	69
1/18/2013	11:04:26	11:05:03	T20-NA2	36"	22	13	55	826	27	87
1/18/2013	11:30:28	11:30:28	T20-B	36"	64	19	71	1071	25	78
1/18/2013	11:51:55	11:53:30	T20-C	36"	63	10	41	614	23	73
1/18/2013	13:05:11	13:06:46	T20-D	36"	59	13	50	755	19	61
1/18/2013	13:16:26	13:18:37	T21-D	36"	87	15	57	855	23	72
1/18/2013	13:30:32	13:33:06	T21-C	36"	104	22	84	1258	15	49
1/18/2013	13:47:55	13:49:39	T21-B	36"	67	12	47	698	21	68
1/18/2013	14:02:34	14:04:12	T18-A	36"	64	<10	29	436	23	72
1/18/2013	14:32:13	14:41:19	T18-B	36"	232	11	45	675	18	56
1/19/2013	9:03:38	9:10:12	T20-NA2	36"	61	10	41	622	24	75
1/19/2013	9:29:22	9:31:08	T21-J	36"	67	12	49	731	19	61
1/19/2013	10:17:10	10:18:46	T21-A	36"	62	12	50	752	21	67
1/19/2013	10:32:40	10:33:22	T21.5-J	36"	25	19	72	72	22	69
1/19/2013	11:08:19	11:09:07	T22-B	36"	32	<10	38	568	20	65
1/19/2013	11:38:43	11:39:27	T22-C	36"	30	23	89	1340	21	67

The distance to the maximum RMS level of 190 dB, the injury zone for pinnipeds, ranged from <10 m to 26 m (**Table 3**) and averaged 14 m from the pile. The distance to the 190 dB isopleth extended beyond the 20-m shutdown zone for pinnipeds during three of the drives (**Table 3**). However, the enlarged injury zones did not result in any unauthorized pinniped takes. No pinnipeds were sighted within 26 m of the pile during any Year 1 EHW-2 CMP impact driving event (the closest pinniped observed during impact pile driving was 35 m from the pile).

The airborne behavioral harassment thresholds for pinnipeds were 90 dB (harbor seals only) and 100 dB (all other pinnipeds). No injury thresholds exist for marine mammals exposed to airborne sound, and no behavioral harassment or injury threshold exists for cetaceans exposed to airborne sound. Typically, airborne acoustic monitoring was executed concurrently with hydroacoustic monitoring.

Based on the measurement of average unweighted RMS L_{max} levels and applying a 20 Log_{10} propagation rate, the 90 dB airborne behavioral disturbance zone extended up to 27 m from the pile, well within the 464-m buffer zone (therefore, marine mammals were exposed to underwater behavioral disturbances before reaching the airborne isopleth). The 100 dB airborne behavioral disturbance zone extended up to 87 m from the pile; again well within the 464 m buffer zone.

Vibratory Pile Driving Acoustics. During the Year-1 EHW-2 CMP, vibratory pile driving occurred on 164 production piles over the course of 75 days. Vibratory hammers were utilized for nearly 71 hours to drive the piles for an average of four minutes, thirty-one seconds per pile. The maximum duration of vibratory pile driving events was 44 minutes.

The distances to the underwater behavioral disturbance (level B harassment) zone isopleth (120 dB RMS re 1 µPa) are provided in **Table 4**. Distances to the marine mammal airborne disturbance thresholds (90 dB RMS re 20 µPa [unweighted] for harbor seals and 100 dB RMS re 20 µPA [unweighted] for all other pinnipeds) are also provided in **Table 4**. Acoustic technicians were unable to calculate the exact distance to the underwater injury (level A) zone isopleth (180 dB RMS re 1 µPa) because the maximum sound level generated by vibratory driving did not exceed 180 dB at any acoustic monitoring position (Illingworth & Rodkin 2013). The calculated isopleth was typically dependent on the pile size and water depth, but also varied from pile to pile.

Table 4. Acoustic Results from Vibe Pile Driving

Date	Start Time	End Time	Pile	Specifications	Water Depth At Pile	Distance (m) to Isopleth (RMS): Underwater	Distance (m) to Isopleth (RMS): Airborne	
						120 dB	100 dB	90 dB
9/28/2012	10:41:35	12:00:13	TT-9S	36"x85'	16' (4.8m)	5330		
9/28/2012	13:17:40	13:59:04	TT-8S	36"x80'	18' (5.4m)	5255		
10/1/2012	9:08:33	9:42:17	TT-7S	36"x75'	11' (3.3m)	7175		
10/1/2012	10:42:08	11:15:37	TT-8N	36"x80'	13' (4m)	2890		
10/1/2012	12:42:59	13:06:39	TT-9N	36"x85'	16' (4.9m)	4660		
10/1/2012	14:04:44	14:44:35	TT-7N	36"x75'	7' (2.1m)	3310		
10/2/2012	8:25:20	8:44:18	TT-6S	36"x70'	9' (2.7m)	5670		
10/2/2012	9:21:28	9:44:45	TT-6N	36"x70'	9' (2.7m)	3860		
10/4/2012	8:27:56	8:47:33	TT-5S	36"x70'	9' (2.7m)	3700		
10/11/2012	15:22:16	15:41:05	TT-5N	36"x70'	9' (2.7m)	6230		
12/5/2012	13:18:03	13:31:56	TT-4S	36"x70'	5' (1.5m)	625		
10/5/2012	13:41:41	13:46:59	FTP1	24"x85'	21' (6.4m)	4300		
10/5/2012	14:42:17	14:47:58	FTP2	24"x85'	21' (6.4m)	3585		
10/5/2012	14:51:15	14:53:51	FTP3	24"x85'	21' (6.4m)	3220		
10/5/2012	14:58:41	15:00:12	FTP4	24"x85'	21' (6.4m)	3520		
10/10/2012	8:50:14	8:59:00	VS-1	36"x65.5'	8' (2.4m)	4060		
10/10/2012	9:31:25	9:38:52	VS-2	36"x65.5'	9' (2.7m)	2230		
10/10/2012	10:30:10	10:37:34	VS-3	36"x65.5'	15' (4.6m)	2660		
10/11/2012	14:16:09	15:21:01	TT-4S	36"x65.5'	8' (2.4m)	7360		
10/11/2012	15:22:16	15:41:05	TT-5N	36"x65.5'	8' (2.4m)	10250		
10/11/2012	15:48:18	16:06:18	TT-5S	36"x65.5'	8' (2.4m)	10250		
10/12/2012	11:51:40	12:03:09	TT-6N	36"x65.5'	6' (1.8m)	10250		
10/12/2012	12:48:35	13:01:10	TT-6S	36"x65.5'	8' (2.4m)	10250		
10/12/2012	13:08:26	13:21:25	TT-7N	36"x65.5'	10' (3.0m)	10250		
10/15/2012	9:14:42	9:27:37	TT-7S	36"x65.5'	9' (2.7m)	10250		
10/15/2012	9:54:25	10:11:02	TT-8S	36"x65.5'	11' (3.4m)	10250		
10/15/2012	10:13:40	10:23:35	TT-9S	36"x65.5'	19' (5.8m)	10250		
10/16/2012	13:26:30	13:46:30	TT-21.5J	36"x124'	56' (17.1m)	10250		
10/16/2012	15:56:01	16:34:08	TT-	36"x129'	72' (21.9m)	10250	-	-

Date	Start Time	End Time	Pile	Specifications	Water Depth At Pile	Distance (m) to Isopleth (RMS): Underwater	Distance (m) to Isopleth (RMS): Airborne	
						120 dB	100 dB	90 dB
			56H.5					
10/17/2012	9:41:05	10:22:50	TT-9S	36"x70'	24' (7.3m)	10250	-	-
10/17/2012	9:47:38	10:01:47	TT-8N	36"x80'	24' (7.3m)	1400	-	-
10/17/2012	10:05:36	10:16:15	TT-9N	36"x80'	25' (7.6m)	10250	-	-
10/17/2012	9:41:05	10:22:50	TT-9S	36"x70'	25' (7.6m)	10250	-	-
10/17/2012	13:26:00	15:42:47	TT-7.5TD	24"x82"	14' (4.3m)	2020	-	-
10/17/2012	13:26:00	15:42:47	TT-7.5TD	24"x82"	14' (4.3m)	10250	-	-
10/17/2012	16:25:16	16:30:46	TT-10TD	24"x82"	24' (7.3m)	10250	-	-
10/29/2012	11:23:05	11:32:36	TT-10.5A	24"x90'	21' (6.4m)	6310	-	-
10/29/2012	11:51:09	11:54:06	NWTP	24"x85'	21' (6.4m)	2960	-	-
10/29/2012	13:26:38	13:34:52	TT-8N	36"x80'	25' (7.6m)	1800	-	-
10/29/2012	13:37:31	13:41:39	TT-9N	36"x85'	25' (7.6m)	3980	-	-
11/16/2012	13:59:47	14:14:12	TT-13.5R	48"x190'	90' (27.41m)	10250		
11/27/2012	8:19:36	8:33:16	T10-D	24"x93'	27' (8.2m)	10250	17	54
11/27/2012	8:38:41	9:00:35	T10-C	24"x93'	27' (8.2m)	8990	19	60
11/27/2012	9:07:43	9:36:52	T10-B	24"x93'	27' (8.2m)	10250	20	64
11/27/2012	9:40:33	9:56:09	T10-A	24"x93'	27' (8.2m)	10250	26	83
11/28/2012	10:30:17	10:43:00	TT-1	36"	-	-	-	-
11/28/2012	9:13:53	9:21:48	TT-2	36"	-	-	-	-
11/28/2012	13:41:53	13:43:27	TT-2	36"	-	1450	-	-
11/29/2012	11:07:54	11:49:46	T9-D	24"x91'	25' (7.6m)	6350	16	50
11/29/2012	11:07:54	11:49:46	T9-D	24"x91'	25' (7.6m)	6500	12	37
11/29/2012	12:52:15	13:00:49	T9-B	24"x91'	25' (7.6m)	6000	42	132
11/29/2012	13:06:10	13:14:46	T9-A	24"x91'	25' (7.6m)	5600	22	70
11/30/2012	14:42:00	14:47:50	TT-5	36"	-	10250	-	-
12/3/2012	10:36:54	10:42:05	TT-2	36"	45' (13.7m)	2800	-	-
12/3/2012	11:22:25	11:27:07	TT-3	36"	45' (13.7m)	2800	-	-

Date	Start Time	End Time	Pile	Specifications	Water Depth At Pile	Distance (m) to Isopleth (RMS): Underwater	Distance (m) to Isopleth (RMS): Airborne	
						120 dB	100 dB	90 dB
12/3/2012	11:31:35	11:34:44	TT-4	36"	45' (13.7m)	2800	-	-
12/4/2012	10:20:54	11:53:02	T15-A	36"x102-110'	47' (14,4m)	1300	<10	23
12/4/2012	10:20:54	11:53:02	T15-A	36"x102-110'	47' (14.4m)	1300	23	72
12/4/2012	11:28:47	11:39:23	T15-D	36"x102-110'	47' (14,4m)	5600	18	58
12/4/2012	11:43:46	11:48:39	T15-B	36"x102-110'	47' (14.4m)	2800	25	79
12/4/2012	10:20:54	11:53:02	T15-A	36"x102-110'	47' (14.4m)	10250	28	89
12/4/2012	14:48:06	14:58:00	TT-1	36"	-	5300	0	0
12/4/2012	15:01:48	15:24:20	TT-2	36"	-	8900	0	0
12/4/2012	15:01:48	15:24:20	TT-2	36"	-	8900	-	-
12/5/2012	11:15:04	11:38:01	TT-4N	36"	4' (1.2m)	4200	15	48
12/5/2012	13:18:03	13:31:56	TT-4S	36"	4' (1.2m)	4300	16	51
12/6/2012	14:01:21	14:40:52	T9-C	24"	18' (5.5m)	3000	18	58
12/7/2012	9:05:04	14:48:54	TT-1	36"	-	1000	-	-
12/7/2012	9:05:04	14:48:54	TT-1	36"	-	800	-	-
12/11/2012	9:49:32	10:16:55	Temp-3	24”	-	5300	36	115
12/11/2012	9:49:32	10:16:55	Temp-3	24"	-	5900	11	35
12/11/2012	10:23:46	10:32:24	Temp-4	24”	-	-	24	77
12/11/2012	10:23:46	10:32:24	Temp-4	24"	-	9700	14	44
12/13/2012	12:43:30	12:56:55	TT-20.5	24"	52' (15.9m)	4000	-	-
12/13/2012	13:42:19	13:46:17	TT-20.5	24"	52' (15.9m)	4500	-	-
12/14/2012	8:18:05	9:26:40	TT-X	36"	-	-	-	-
12/14/2012	8:18:05	9:26:40	TT-X	36"	-	5700	-	-
12/17/2012	13:06:29	13:15:20	T16-G	36"	48' (14.6m)	8700	-	-
12/17/2012	13:27:18	13:48:28	TT-1.5C	36"	very shallow	2800	-	-
12/17/2012	14:31:54	14:37:50	T16-A	36"	48' (14.6m)	6900	-	-
12/17/2012	14:33:23	14:56:11	TT-1.5D	36"	very shallow	6100	-	-
12/18/2012	9:02:33	9:07:55	TT-1.5C	36"	15' (4.6m)	6700	22	71
12/18/2012	9:21:16	9:21:40	TT-1.5A	36"	15' (4.6m)	2400	-	-
12/18/2012	10:05:18	10:07:25	TT-1.5D	36"	15' (4.6m)	4900	27	85
12/18/2012	13:59:59	14:29:47	TT-Y	24"	15' (4.6m)	7600	26	81
12/18/2012	13:59:59	14:29:47	TT-Y	24"	15' (4.6m)	300	20	64

Date	Start Time	End Time	Pile	Specifications	Water Depth At Pile	Distance (m) to Isopleth (RMS): Underwater	Distance (m) to Isopleth (RMS): Airborne	
						120 dB	100 dB	90 dB
12/19/2012	10:45:23	11:52:52	TT-Y	24"	15' (4.6m)	10250	-	-
12/19/2012	10:45:23	11:52:52	TT-Y	24"	15' (4.6m)	9150	-	-
12/19/2012	13:46:55	13:56:36	TT-Z	24"	15' (4.6m)	-	-	-
12/20/2012	14:08:35	15:27:31	T8-A	24"	8' (2.4m)	4750	-	-
12/20/2012	14:43:15	15:08:29	T8-D	24"	8' (2.4m)	4750	-	-
12/20/2012	14:08:35	15:27:31	T8-A	24"	8' (2.4m)	10250	59	186
12/21/2012	9:03:06	9:40:14	T8-B	24"	11' (3.4m)	10250	42	133
12/21/2012	10:12:46	10:55:00	T8-C	24"	14' (4.3m)	10250	20	64
12/21/2012	13:04:06	13:15:24	T16-D	36"	54' (16.5m)	10250	0	0
12/21/2012	13:19:39	13:30:04	T16-C	36"	47' (14.3m)	10250	38	120
12/21/2012	13:38:01	13:46:55	T16-B	36"	47' (14.3m)	10250		
12/26/2012	13:55:30	14:11:52	T17-G	36"	-	10250	18	57
12/26/2012	14:15:38	14:24:25	T17-A	36"	-	10250	56	178
12/26/2012	14:28:10	14:37:34	T17-B	36"	-	10250	21	65
12/26/2012	14:40:51	14:48:14	T17-C	36"	-	10250	33	103
12/26/2012	14:52:09	14:58:18	T17-D	36"	-	10250	29	91
12/28/2012	14:58:41	15:06:50	T18-0A.9	36"	-	-	-	-
12/28/2012	14:32:31	14:52:25	T7-D	24"	-	-	-	-
12/28/2012	14:01:07	14:24:53	T7-A	24"	-	-	-	-
12/28/2012	15:11:09	15:18:59	T18-C	36"	-	-	-	-
12/28/2012	15:21:55	15:27:03	T18-D	36"	-	-	-	-
12/28/2012	14:01:07	14:24:53	T7-A	24"	-	-	-	-
12/28/2012	14:46:01	14:52:34	T18-G	36"	-	-	-	-
12/28/2012	14:32:31	14:52:25	T7-D	24"	-	-	-	-
12/28/2012	14:46:01	14:52:34	T18-G	36"	-	-	-	-
12/28/2012	14:58:41	15:06:50	T18-0A.9	36"	-	10250	-	-
12/28/2012	15:11:09	15:18:59	T18-C	36"	-	10250	-	-
12/31/2012	8:41:41	9:10:33	T7-C	24"	-	-	-	-
12/28/2012	15:21:55	15:27:03	T18-D	36"	-	10250	-	-

Date	Start Time	End Time	Pile	Specifications	Water Depth At Pile	Distance (m) to Isopleth (RMS): Underwater	Distance (m) to Isopleth (RMS): Airborne	
						120 dB	100 dB	90 dB
12/28/2012	15:23:40	15:23:45	T7-B	24"	-	-	-	-
1/2/2013	8:23:58	11:59:02	Temp-4	24"	57' (17.4m)	2500	-	-
1/2/2013	8:57:32	9:04:27	T18-A	36"	57' (17.4m)	1000	-	-
1/2/2013	9:09:30	9:14:03	T18-B	36"	57' (17.4m)	1000	-	-
1/2/2013	10:10:47	10:42:32	Temp-1	24"	57' (17.4m)	10250	47	148
1/2/2013	10:10:47	10:42:32	Temp-1	24"	57' (17.4m)	10250	30	94
1/2/2013	10:46:37	11:03:10	Temp-2	24"	57' (17.4m)	10250	30	96
1/2/2013	10:46:37	11:03:10	Temp-2	24"	57' (17.4m)	10250	40	126
1/2/2013	11:08:30	11:29:17	Temp-3	24"	57' (17.4m)	10250	33	105
1/2/2013	11:08:30	11:29:17	Temp-3	24"	57' (17.4m)	8250	26	81
1/2/2013	8:23:58	11:59:02	Temp-4	24"	57' (17.4m)	10250	44	140
1/2/2013	8:23:58	11:59:02	Temp-4	24"	57' (17.4m)	1300	45	143
1/3/2013	8:14:12	8:41:19	T6-D	24"	8' (2.4m)	1500	20	65
1/3/2013	10:00:31	10:26:59	T6-A	24"	6' (1.8m)	1500	14	44
1/3/2013	11:09:24	11:34:55	T6-C	24"	6' (1.8m)	1700	13	42
1/3/2013	11:40:50	12:06:28	T6-B	24"	6' (1.8m)	2500	18	58
1/4/2013	13:15:36	13:40:36	T5-C	24"	57' (17.4m)	800	20	62
1/4/2013	13:56:25	13:56:30	T5-B	24"	57' (17.4m)	-	-	-
1/4/2013	14:03:35	14:03:37	T5-D	24"	57' (17.4m)	-	-	-
1/4/2013	14:23:04	14:45:30	T5-A	24"	53' (16.2m)	900	15	46
1/5/2013	10:24:58	10:34:13	T20-NA1	36"	60' (18.3m)	10250	-	-
1/5/2013	14:48:55	14:53:12	T20-A	36"	60' (18.33m)	10250	-	-
1/5/2013	13:45:07	13:56:45	T20.5-G	36"	60' (18.3m)	9600	-	-
1/5/2013	14:00:53	14:09:31	T20-NA2	36"	60' (18.33m)	10250	-	-
1/5/2013	14:15:15	14:23:05	T20-B	36"	60' (18.33m)	9450	-	-
1/5/2013	14:27:46	14:35:18	T20-C	36"	60' (18.33m)	10250	-	-
1/5/2013	14:39:25	14:46:05	T20-D	36"	60' (18.33m)	8500	-	-
1/5/2013	14:48:55	14:53:12	T20-A	36"	60' (18.33m)	10250	-	-
1/7/2013	15:11:09	15:16:39	T22-B	36"x124'	65' (19.8m)	10250	111	350

Date	Start Time	End Time	Pile	Specifications	Water Depth At Pile	Distance (m) to Isopleth (RMS): Underwater	Distance (m) to Isopleth (RMS): Airborne	
						120 dB	100 dB	90 dB
1/7/2013	15:21:58	15:27:12	T22-C	36"x124'	65' (19.8m)	9500	40	126
1/7/2013	15:31:20	15:38:16	T22-D	36"x124'	65' (19.8m)	9250	113	357
1/8/2013	10:28:39	10:36:50	T21.5-J	36"x124'	64' (19.5m)	10250	-	-
1/9/2013	14:24:23	14:32:30	T31-H	36"x120'	60' (18.3m)	9000	52	164
1/9/2013	14:36:15	14:43:03	T31-G	36"x117'	60' (18.3m)	7750	38	119
1/9/2013	14:48:54	14:54:57	T30-H	36"x120'	60' (18.3m)	8000	137	433
1/9/2013	14:58:36	15:11:34	T30-G	36"x120'	60' (18.3m)	7750	121	382
1/9/2013	15:17:34	15:22:09	T29-H	36"x120'	60' (18.3m)	-	-	-
1/9/2013	15:25:11	15:31:31	T29-G	36"x120'	60' (18.3m)	8000	99	314
1/10/2013	10:01:01	10:13:38	T31-J	36"	60' (18.3m)	10250	58	184
1/10/2013	10:16:50	10:25:04	T30-J	36"	60' (18.3m)	8650	31	97
1/10/2013	10:31:38	10:45:09	T29-J	36"	60' (18.3m)	10250	47	149
1/11/2013	12:45:01	12:57:11	T34-H	36"x120'	56' (17.0m)	10250	-	-
1/11/2013	13:01:19	13:09:04	T34-G	36"x118'	56' (17.0m)	10250	-	-
1/11/2013	13:13:46	13:24:17	T33-H	36"x119'	56' (17.0m)	10250	-	-
1/11/2013	13:28:07	13:32:24	T33-G	36"x117'	56' (17.0m)	10250	-	-
1/11/2013	13:35:53	13:39:49	T32-H	36"x119'	56' (17.0m)	10250	-	-
1/11/2013	13:42:32	13:51:15	T32-G	36"x117'	56' (17.0m)	10250	-	-
1/11/2013	15:38:38	15:43:15	T34-J	26"x122'	55' (16.8m)	-	-	-
1/11/2013	15:46:38	15:51:12	T33-J	36"x121'	55' (16.8m)	-	-	-
1/11/2013	15:53:21	16:00:34	T32-J	36"x121'	55' (16.8m)	-	-	-
1/12/2013	12:53:41	13:36:20	TT-A	36"	20' (6.1m)	-	25	79
1/12/2013	14:47:39	13:10:55	TT-B	36"	20' (6.1m)	-	30	96
1/12/2013	14:47:39	13:10:55	TT-B	36"	20' (6.1m)	-	30	93
1/12/2013	12:53:41	13:36:20	TT-A	36"	20' (6.1m)	-	33	105
1/12/2013	12:53:41	13:36:20	TT-A	36"	20' (6.1m)	-	59	185
1/12/2013	15:52:29	16:00:19	T37-G	36"x120'	62' (18.9m)	10250	40	125
1/12/2013	16:02:56	16:06:23	T36-G	36"x120'	62' (18.9m)	10250	26	83
1/12/2013	16:09:09	16:14:36	T35-G	36"x118'	62' (18.9m)	10250	24	77
1/14/2013	10:08:15	10:15:46	T37-G	36"x120'	59' (18.0m)	5400	9	27
1/14/2013	10:19:11	10:33:12	T37-H	36"	59' (18.0m)	10250	15	46

Date	Start Time	End Time	Pile	Specifications	Water Depth At Pile	Distance (m) to Isopleth (RMS): Underwater	Distance (m) to Isopleth (RMS): Airborne	
						120 dB	100 dB	90 dB
1/14/2013	10:36:16	10:47:24	T36-G	36"x120'	59' (18.0m)	10250	17	53
1/14/2013	11:06:00	11:15:30	T36-H	36"	55' (16.8m)	10250	22	68
1/14/2013	11:18:52	11:22:40	T35-G	36"x118'	55' (16.8m)	10250	14	44

The distance to the 120 dB isopleth ranged from 300 m to 10,250 m (**Table 4**) and averaged 4,400 m from the pile for 36-in piles and 1,788 m from the pile for 24-in piles. The wide variation in the distance to the 120 dB RMS isopleth was likely influenced by differences in pile sizes and the depth and type of the substrate. Calculations of the 120 dB isopleth were difficult. During the EHW-2 CMP there was no effort to attempt to measure at distances farther than the two rafts (1800 to 2400 m [5,905 to 7,875 ft] from the project area). This was decided due to the difficulties of trying to measure the low levels during the TPP. During the EHW-2 CMP there were only a few days where these types of measurements may have been attempted, but in general, the background noise from the waves on the boat would have made those measurements useless.

Based on the measurement of average unweighted RMS L_{max} levels and applying a 20 Log_{10} propagation rate, the 90 dB airborne behavioral disturbance zone extended from 23 m to 433 m from the pile, and averaged 101 m from the pile. This, the airborne behavioral disturbance zone, was always located within the 464 m buffer zone. The 100 dB airborne behavioral disturbance zone extended from 7 m to 137 m from the pile and averaged 32 m from the pile.

Marine Mammal Sightings

Of the six marine mammal species that occur regularly in Hood Canal near the project area, four were observed during the Year 1 EHW-2 CMP: harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), Steller sea lion (*Eumetopias jubatus*), and harbor porpoise (*Phocoena phocoena*). The Steller sea lion was the only ESA-listed marine mammal observed during the Year 1 EHW-2 CMP. All marine mammals sighted in Hood Canal are regulated by NMFS.

Analyses of marine mammal sightings are presented in three groups: the marine mammal sightings made during construction monitoring of the buffer and shutdown zones sightings (Primary); sightings of marine mammals hauled out on submarines at Delta Pier, outside of the buffer zone (Delta Pier); and the sightings of animals in the 41.4-km^2 Level B harassment zone (Outside Boat). Sightings of Delta Pier marine mammal haul outs are presented separately as protocols were not in place to monitor Delta Pier until January 2013 (prior to January 2013, marine mammals on Delta Pier were occasionally observed from the Outside Boat), and monitoring of Delta Pier typically occurred only at the end of daily construction monitoring. Similarly, sightings for the larger Level B harassment zone are presented separately, as monitoring from the Outside Boat occurred for only that portion of the project when acoustic monitoring outside the WRA was occurring. The daily period and locations for marine mammal monitoring on the outside boat were affected by acoustic monitoring (which had priority in determining the boat's movements), travel time to and from the marina where the boat was based (Port Ludlow, 28.7 km [15.5 nautical miles] away) and safety considerations related to travel in darkness or rough sea conditions.

All Marine Mammal Sightings. All marine mammal sightings include those made during pile driving activities, and those made during down time (non-construction periods). Observers typically surveyed for marine mammals during the entire construction day (8–10 hours). All marine mammal sightings are presented in **Figures 7–10**.

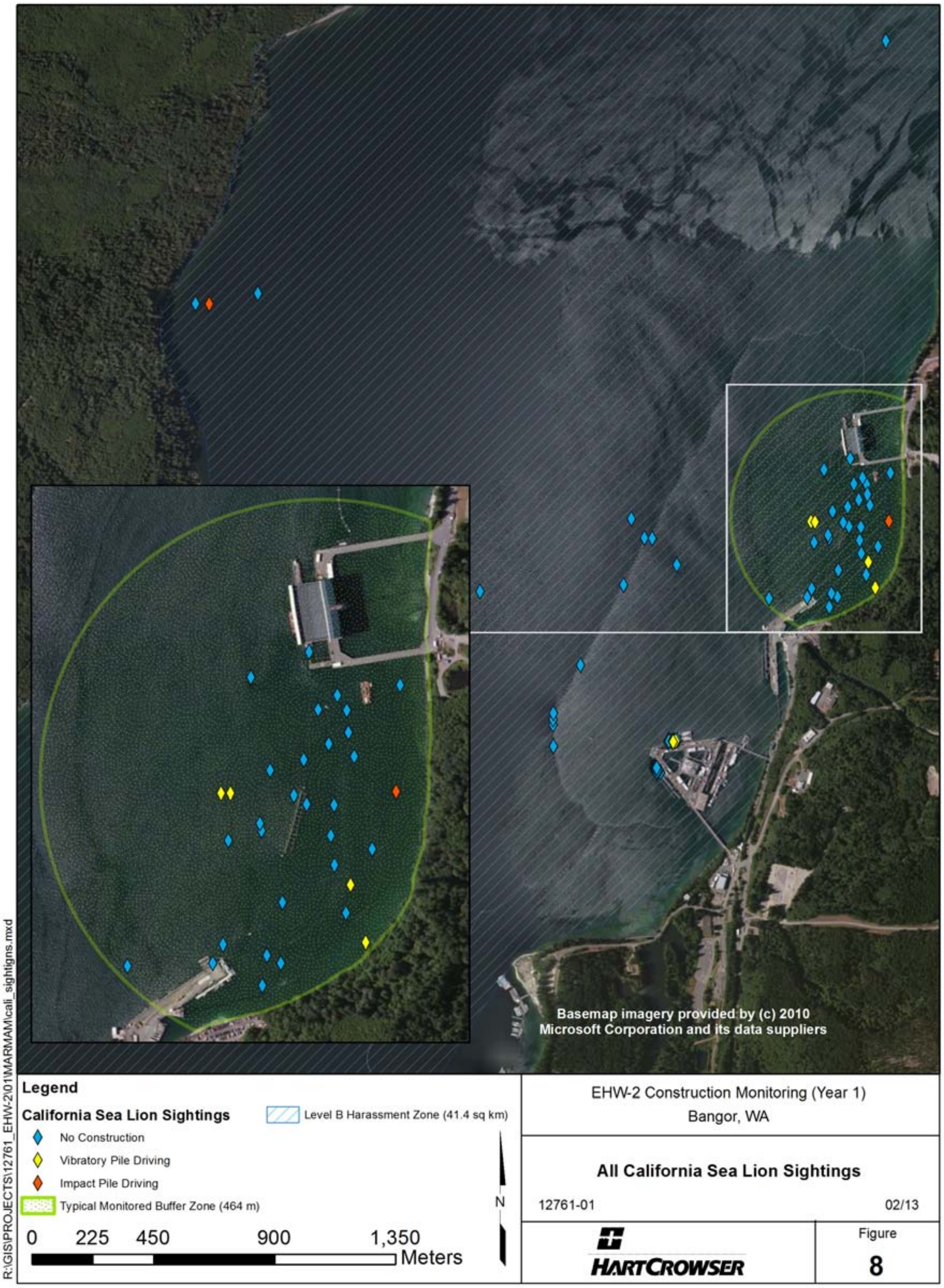


Figure 7. All California Sea Lion Sightings

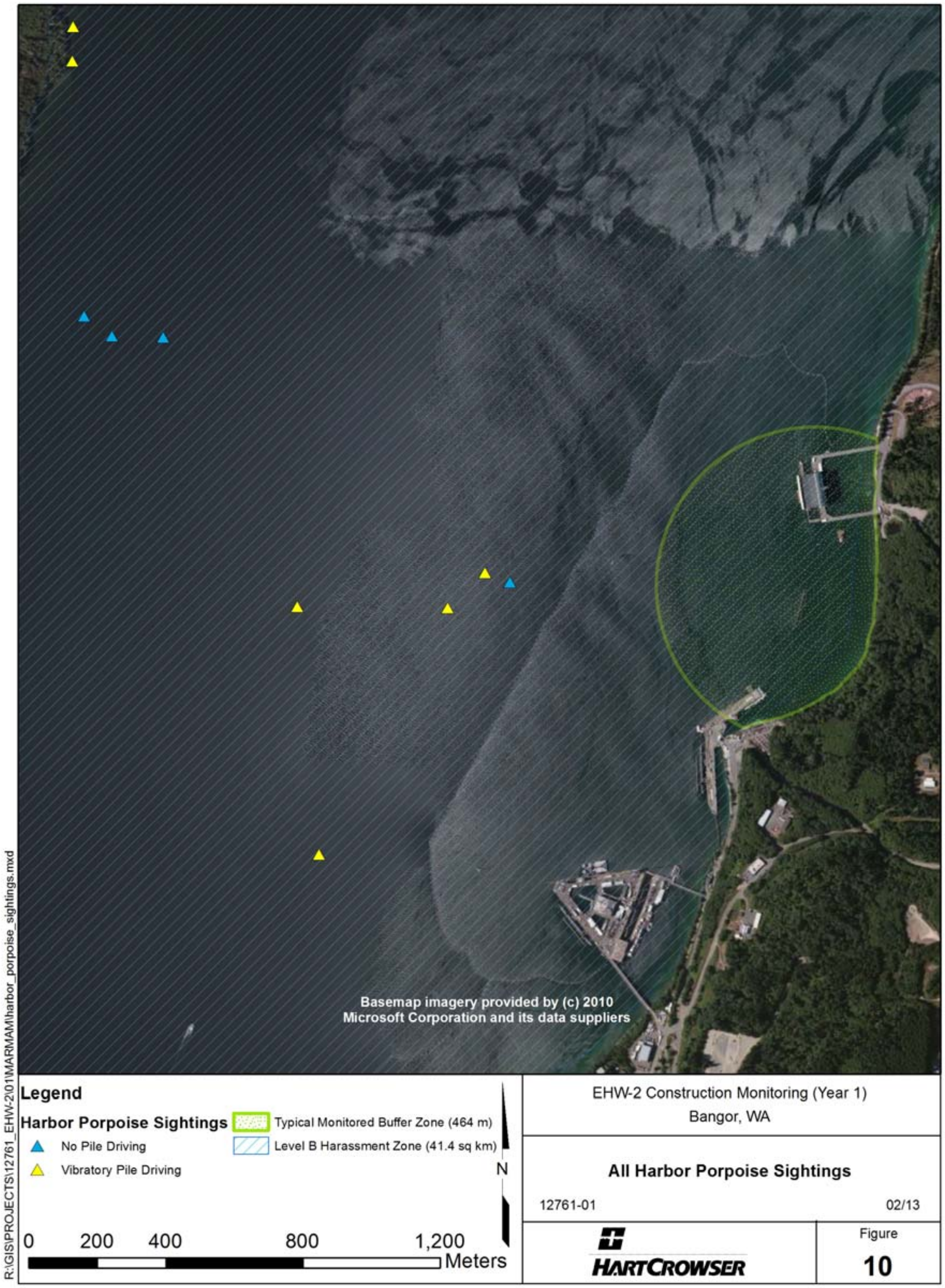


Figure 8. All Harbor Porpoise Sightings

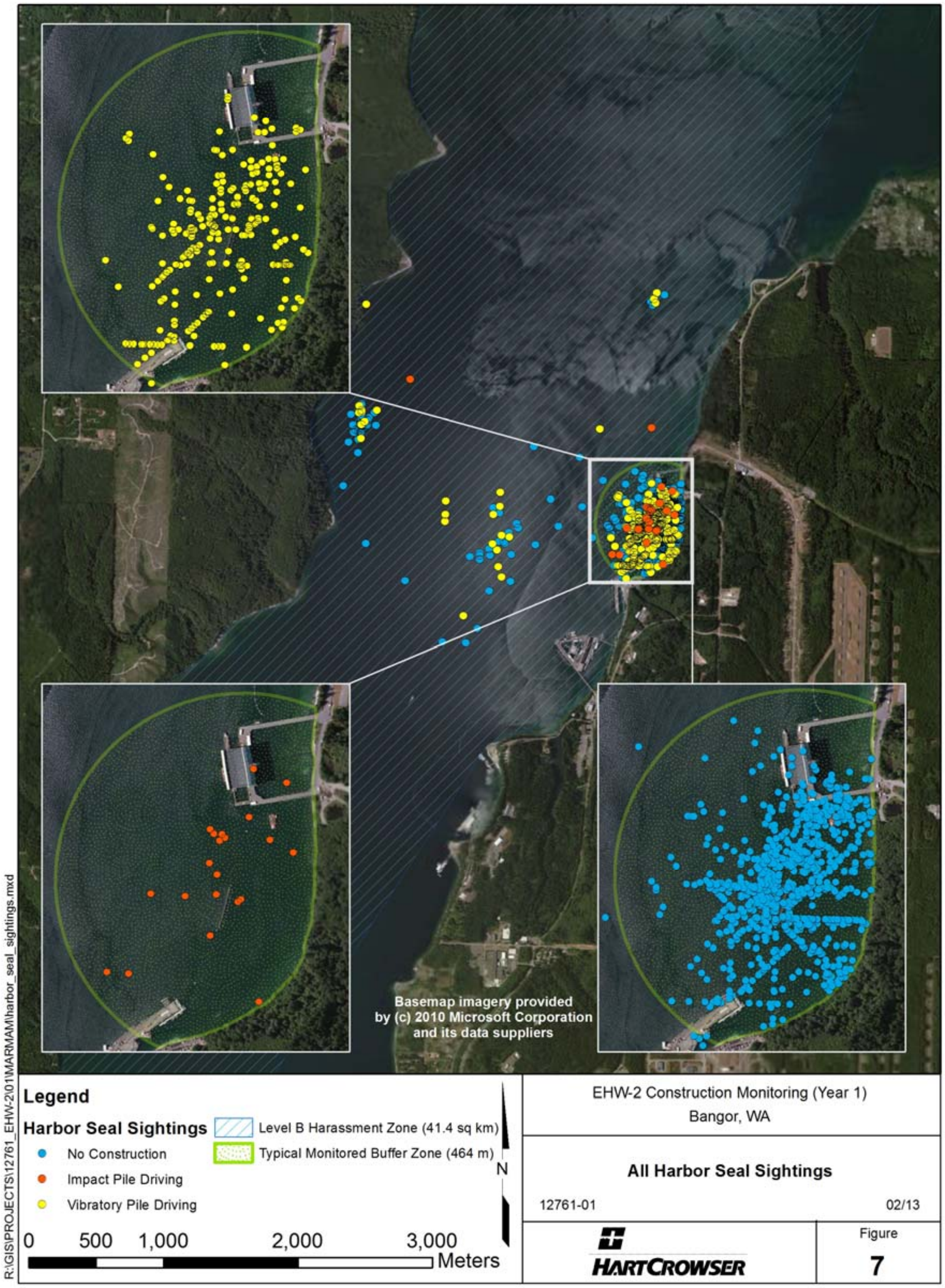


Figure 9. All Harbor Seal Sightings

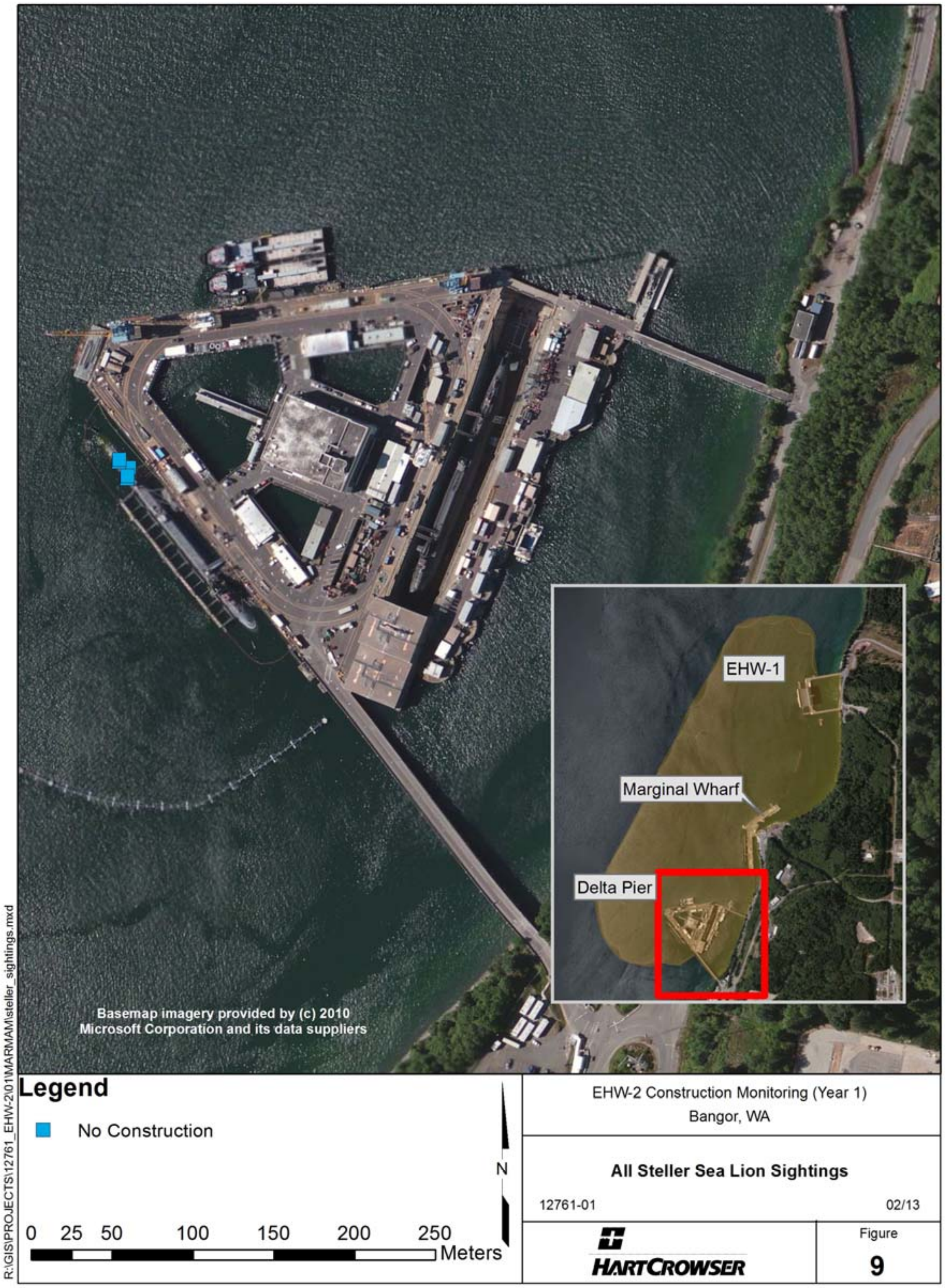


Figure 10. All Steller Sea Lion Sightings

Primary Surveys. A total of 969 sightings of 1,014 individual animals were observed during primary marine mammal surveys of the EHW-2 CMP (**Table 5, Appendix G**). During primary surveys, only two marine mammal species were sighted within the WRA during construction monitoring periods. These species were harbor seal and California sea lion. Of the two, harbor seals were the most abundantly seen marine mammal species. Harbor seals and California sea lions were primarily observed singularly, with mean group sizes of one for both species.

Table 5. Total Number of Unique Animals and Sightings by Species (Primary Surveys)

Species	Total # of Animals	Total # of Sightings	Mean Group Size	Min Group Size	Max Group Size
California Sea Lion	30	30	1	1	1
Harbor Seal	984	939	1.05	1	4
Total	**1014**	**969**	--	--	--

Delta Pier Surveys. A total of 33 sightings of 389 individual marine mammals were observed during surveys of Delta Pier (**Table 6, Appendix G**). Only two marine mammal species, the California sea lion and the Stellar sea lion, were sighted during surveys at Delta Pier. California sea lions were the more abundant of the two species. Steller sea lions were observed singularly or in pairs. California sea lions were observed hauled out in larger groups, with a mean group size of 12.8 animals.

Table 6. Total Number of Unique Animals and Sightings by Species (Delta Pier)

Species	Total # of Animals	Total # of Sightings	Mean Group Size	Min Group Size	Max Group Size
California Sea Lion	385	30	12.8	1	40
Steller Sea Lion	4	3	1.3	1	2
Total	**389**	**33**	--	--	--

Outside Boat Surveys. A total of 107 sightings of 262 individual marine mammals were observed during Outside Boat surveys of the 41.4 km^2 buffer zone (**Table 7, Appendix G**). Four species of marine mammals (California sea lion, harbor seal, harbor porpoise, and Steller sea lion,) were observed during the surveys, with harbor seal being the most frequently sighted species. On those occasions when the Outside Boat looked inside the WRA to scan for animals hauled out on the submarines, California sea lions were sighted in groups of up to 20 animals (mean group size of six animals). California sea lions were sighted in larger groups compared to other pinniped species as they were often observed hauled out on the PSB buoys and milling and resting in groups near the PSB buoys. Once the vessels left the area, several California sea lions were observed swimming towards Delta Pier. There were 10 observations of harbor porpoise during the Year 1 EHW-2 CMP all of which were from the Outside Boat surveys. The animals were most often observed in groups of up to ten individuals (mean group size of 5.7 animals). There were 73 harbor seal observations, typically of individual animals, but there were three occasions when the animals were observed in pairs. The few Steller sea lions observed always occurred individually and were predominantly observed resting on the submarines at Delta Pier during surveys by the Outside Boat into the WRA. There was one observation by the Outside Boat of a Stellar sea lion traveling north approximately 2500 meters from the construction area.

Table 7. Total Number of Unique Animals and Sightings by Species (Outside Boat)

Species	Total # of Animals	Total # of Sightings	Mean Group Size	Min Group Size	Max Group Size
California Sea Lion	126	21	6.0	1	20
Harbor Porpoise	57	10	5.7	1	10
Harbor Seal	76	73	1.0	1	2
Steller Sea Lion	3	3	1.0	1	1
Total	**262**	**107**	--	--	--

Marine Mammal Sightings During Pile Installation and Removal Activities. Pile installation and removal activities included installation and removal by vibratory and impact hammers including soft start. Therefore, there were four types of construction: vibratory pile driving (V), soft start vibratory pile driving (SSV), impact pile driving (I), and soft start impact (SSI) pile driving. Soft starts were intended to provide an opportunity for nearby marine animals to voluntarily leave the area, and thus avoid potential harassment or injury. More animals were observed during vibratory driving (2.8 animals sighted per hour) than during impact driving (1.4 animals sighted per hour). The marine mammal observers did not observe flight behaviors during impact driving, but anecdotally it appeared that marine mammals were more likely to leave the construction area and monitoring zone during impact pile driving than during vibratory pile driving. Three marine mammal species were observed during pile driving: harbor seal, harbor porpoise, and California sea lion. Although Steller sea lions were observed during the Year 1 EHW-2 CMP, none were observed during actual pile driving or removal events and none were observed inside the 464-m buffer zone at any time (**Figure 9**).

Prior to January 2013, Steller and California sea lions were observed at Delta Pier by the Outside Boat MMO. From January 2013 until the end of the Year 1 EHW-2 CMP, Delta Pier surveys were conducted by the inside boat at the end of the construction day. All sightings of animals observed on Delta Pier by the Outside Boat are presented in the "Outside Boat" analysis.

Primary Surveys. A total of 209 sightings of 218 marine mammals were observed during primary marine mammal surveys of pile installation and removal activities (impact and vibratory pile driving; **Table 8**; **Figures 7–10**). Harbor seals were by far the most frequently sighted species during impact and vibratory pile driving, accounting for 98% of all sightings.

Table 8. Summary of Unique Marine Mammal Sightings During Pile Installation and Removal Activities (Primary Surveys)

Species	Total # of Animals	Total # of Sightings	Mean Group Size	Min Group Size	Max Group Size	Construction Type*			
						SSV	V	SSI	I
California Sea Lion	4	4	1.00	1	1	--	3	--	1
Harbor Seal	214	205	1.06	1	3	19	179	5	11
TOTAL	**218**	**209**	**1.03**			**19**	**182**	**5**	**12**

*SSV= Vibratory Hammer Soft Start, V= Vibratory Driving, SSI= Impact Hammer Soft Start, I= Impact Hammer

Delta Pier Surveys. Because Delta Pier surveys typically took place following the end of construction activities, no sightings were made during pile installation or removal activities.

Outside Boat Surveys. A total of 30 sightings of 80 marine mammals occurred during Outside Boat surveys of pile installation and removal activities (**Table 9**). Harbor seals were the most frequently sighted species during construction activities, while harbor porpoise were observed in groups of 4 to 10 and were the largest population of animals sighted.

Table 9. Summary of Unique Marine Mammal Sightings During Pile Installation and Removal Activities (Outside Boat)

Species	Total # of Animals	Total # of Sightings	Mean Group Size	Min Group Size	Max Group Size	Construction Type*			
						SSV	V	SSI	I
California Sea Lion	22	4	4.0	1	20	--	21	1	--
Harbor Porpoise	36	5	7.2	4	10	--	36	--	--
Harbor Seal	22	21	1	1	2	--	17	1	4
TOTAL	**80**	**30**	**4.07**	**--**	**--**	**0**	**74**	**2**	**4**

*SSV= Vibratory Hammer Soft Start, V= Vibratory Driving, SSI= Impact Hammer Soft Start, I= Impact Hammer

Observed Exposures (Takes)

Injury and behavioral harassment takes were calculated based on marine mammals sighted during impact and vibratory pile driving for the Year 1 EHW-2 CMP. Takes were calculated by: (1) measuring sighting distance to the pile for all animals observed during construction activities, and (2) comparing this distance to underwater and airborne injury and behavioral harassment thresholds (based on EHW-2 acoustic data) on a per-species and per-pile basis (**Appendix G**). Distance to pile was estimated (typically verified using laser rangefinders) and recorded by observers on field data sheets. Whenever possible, observers noted if an animal was likely a resighting (**Appendix G**) and communicated with nearby observers in the field to "hand off" sightings of the same animal(s). This information was taken into account when calculating takes to avoid double-counting exposed animals. Takes are reported as the number of individuals observed and as the number of sightings within a given zone.

There were no sightings within the Level A Injury zone during the Year-1 EHW-2 CMP. The closest marine mammal was sighted 35 m from the pile. The total number of Level B Harassment takes for marine mammal during the Year-1 EHW-2 CMP is summarized in **Table 10**. Animal resightings are included in the table to provide a conservative estimate of takes.

Table 10. Summary of Observed Level B Harassment Takes

Species	Takes During Vibratory Driving	Takes During Impact Driving	Total Takes	Takes Per Day	Allowed Takes	Takes Allowed Per Day
CASL	24	2	26	0.36	5,070	26
HPOR	36	-	36	0.46	1,950	10
HSEA	215	21	236	3.29	10,530	54
STSL	-	-	-	-	390	2

No exceedances of any of the IHA-authorized Level B harassment take numbers occurred during the Year 1 EHW-2 CMP (NMFS 2012). No Dall's porpoise or killer whales were observed during construction (or at any other time) during the Year 1 EHW-2 CMP.

Takes were also calculated on a per-pile basis (all sightings per number of production piles driven) and summarized in **Table 11**. Values are higher for harbor seals as expected, given their higher observed abundance in the construction area.

Table 11. Summary of Level B Harassment Takes Per Production Pile

Species	Takes Per Pile
California Sea Lion	0.03
Harbor Porpoise	0.25
Harbor Seal	2.05
Steller Sea Lion	0.00

Extrapolated Exposures (Takes)

The calculated behavioral harassment zone during vibratory pile driving, defined as the marine area within the average distance to the 120 dB isopleth during the Year 1 EHW-2 CMP (calculated from the 4,400-m radius from the construction location), covered 20.3 km^2. Only a subset of this area was consistently monitored (464-m radius from the pile, or 0.68 km^2 as outlined in the monitoring plan). It is therefore appropriate to estimate the number of potential Level B marine mammal takes that may have occurred in the ensonified, but unmonitored, zone. TPP marine mammal density numbers were used to develop this extrapolation given the extensive monitoring of Hood Canal during that project. By contrast, the EHW-2 CMP Outside Boat monitored for only a subset of the days pile driving occurred, and the monitoring area for the Outside Boat was prioritized for acoustic monitoring rather than for marine mammal surveys. Therefore, extrapolated takes were calculated by multiplying the TPP density of marine mammals observed (total sightings per km^2 per hour) by the total unmonitored area inside the 120 dB isopleth (19.6 km^2). This product was then multiplied by the total time of vibratory pile driving during Year 1 EHW-2 CMP to arrive at the estimated numbers of takes in the unmonitored zone (**Table 12**). Because TPP density estimates were used, take extrapolations should be viewed with caution. In particular, the TPP and the Year 1 EHW-2 CMP monitoring programs spanned different periods (Aug.–Oct., and Sep.–Feb., respectively).

Table 12. Missed Takes in the Unmonitored Area of the Behavioral Harassment Zone

Species	Density Estimate (TPP)	Unmonitored Level B Harassment Zone (Area, km^2)	Estimated Abundance in the Unmonitored Area	EHW-2 CMP Total Vibratory Pile Driving Hours	Missed Takes (Estimated)
California Sea Lion	0.101	19.6	1.980	70.76	141
Harbor Porpoise	0.052		1.019		73
Harbor Seal	0.095		1.862		132
Steller Sea Lion	0.001		0.020		2

Marine Mammal Mitigation Procedures: Construction Delays and Shutdowns

If a marine mammal was observed in or approaching the shutdown zone, ongoing construction was to be stopped, and imminent construction was to be delayed. During the EHW-2 CMP there was one construction shutdown due to a marine mammal nearing the shutdown zone during pile driving activities. On 10 February 2013, a California sea lion was observed rapidly approaching the shutdown zone during vibratory pile driving. The MC stopped all construction with the California sea lion approximately 15 m to 20 m outside of the shutdown zone, and avoided Level A Harassment. Vibratory driving stopped for approximately 3.5 minutes and resumed once the California sea lion was observed well outside the shutdown zone. Additionally, there was a four-minute delay on 22 January 2013 due to a marbled murrelet that approached the zone and triggered a shutdown. There were no weather related shutdowns during the Year 1 EHW-2 CMP.

Marine Mammal Sightings and Environmental Conditions

Favorable weather persisted throughout construction, and shutdowns due to reduced visibility were not required at any time. Most marine mammal sightings were made in calm conditions with low wave height (**Figures 11a** and **11b**). Just over 97% (1079 of a total 1109) of marine mammal sightings were made during Beaufort sea state (BSS) conditions of 0–2 (winds at or below 6 knots; see **Appendix B** for the Beaufort scale). Sightings declined significantly at BSS 2 and above, with

2.1 sightings per day compared to 9.3 sightings per day during BSS 1 or less. All construction and marine mammal surveys occurred during sea states of BSS 4 (winds at or below 16 knots) or below. Favorable weather conditions (cloudy and sunny) occurred on 76% of construction days; 83% of all sightings occurred under those conditions. Glare on sunny days did not apparently limit sightings, as the proportion of sightings occurring on sunny days (17.9%) was higher than the proportion of sunny days (14%). Weather that produced reduced visibility (fog and rain) occurred on 24% of construction days; 17% of all sightings occurred under those conditions.

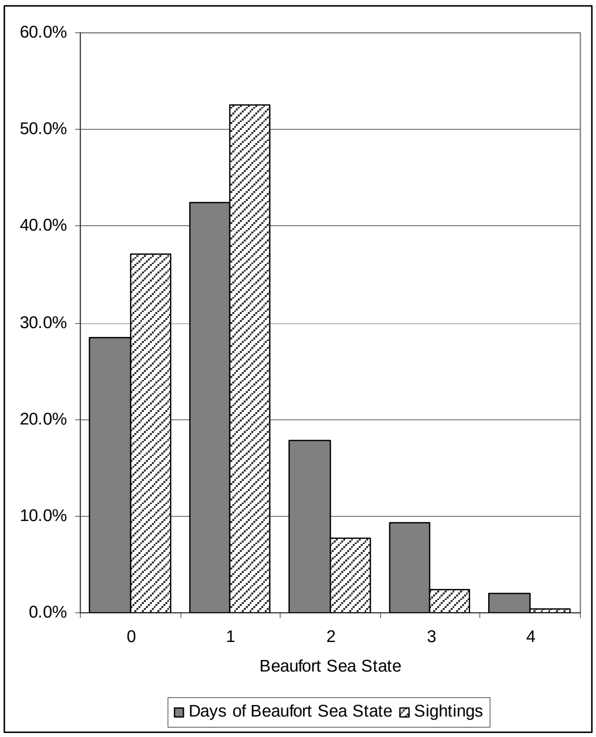


Figure 11a. Sightings by Sea State

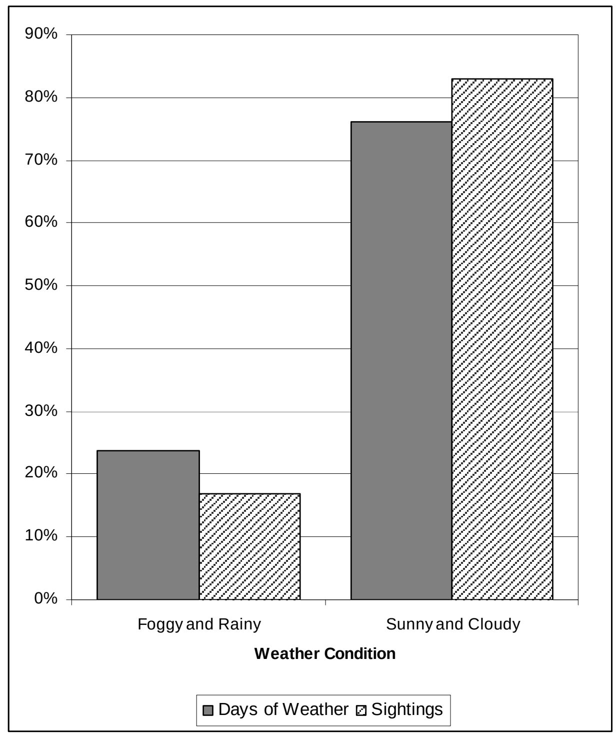


Figure 11b. Sightings by Weather Condition

Marine Mammal Behavior

Quantitative Analysis. Observers typically searched for marine mammals continuously. When animals were observed, data were recorded continuously (excluding restroom breaks in which monitors were sequentially rotated off and then back on to their monitoring locations) from the beginning of pre-watch until the end of the monitoring effort for the day (see **Table 2** for a summary of the monitoring effort). Behavior was recorded during both construction and non-construction periods (**Appendix G**). Behavioral analyses are reported separately by Primary, Delta Pier, and Outside Boat surveys and are presented by species where applicable. Behavior codes are found in **Appendix G**. The number of observed animals and the number of observed behaviors is not necessarily the same due to (1) instances where multiple animals were observed exhibiting the same behavior and (2) situations where individual animals performed multiple behaviors during a single observation.

Primary Surveys. Primary surveys of the buffer and shutdown zones occurred throughout the project, before, during and after all pile driving events. California sea lions and harbor seals were the only marine mammal species observed during Primary Surveys.

California Sea Lion. During pre-construction monitoring, California sea lions were observed “swimming” (50%, n=2); and “diving” and “chuffing” (each 25%, n=1); (**Figure 12a**). During construction, California sea lions were frequently observed “diving” (29%, n=14), “traveling” (27%, n=13), and “swimming” (21%, n=10). During post-construction monitoring, California sea lions were frequently observed “traveling” (23%, n=3), and “diving” (25%, n=2).

When analyzed by construction event type, California sea lions were frequently observed “diving” (29%, n=15), “traveling” (27%, n=14), and “swimming” (23%, n=12) during construction events other than pile driving (**Figure 12b**). During vibratory pile driving, California sea lions were most frequently observed “diving” and “traveling” (each 29%, n=2), but the sample size was very small. The one California sea lion observed during impact driving was “porpoising” parallel to the pile. Observers did not note any distress in this case.

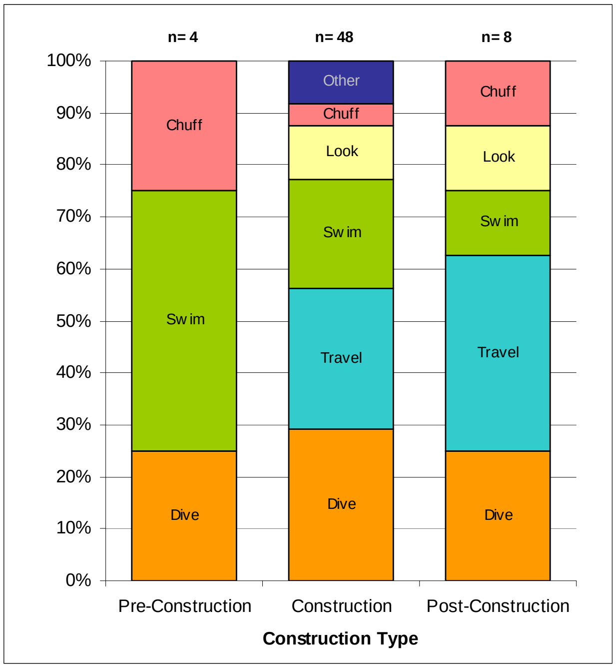


Figure 12a. California Sea Lion Behaviors Before During and After Construction: Primary

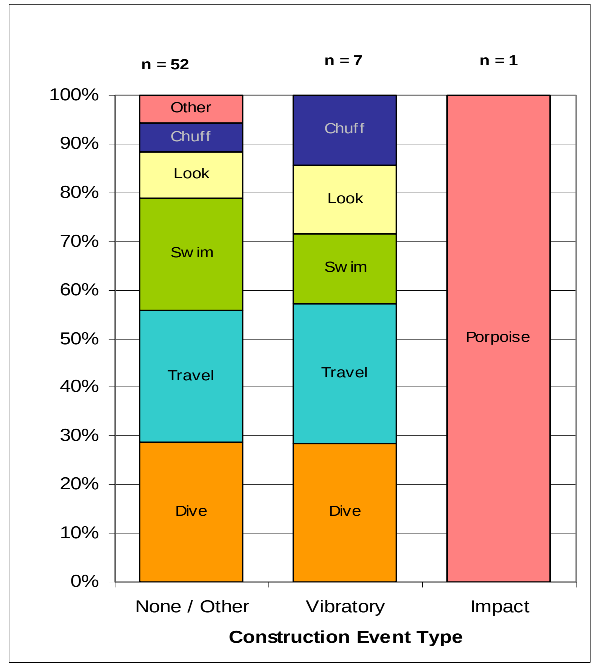


Figure 12b. California Sea Lion Behaviors By Construction Type: Primary

Harbor Seal. During pre-construction monitoring, Harbor seals were observed "swimming" (50%, n=2); and "diving" and "chuffing" (each 25%, n=1; **Figure 13a**). During construction, Harbor seals were frequently observed "diving" (29%, n=14), "traveling" (27%, n=13), and "swimming" (21%, n=10). During post-construction monitoring, Harbor seals were frequently observed "traveling" (23%, n=3), and "diving" (25%, n=2).

When analyzed by construction event type, Harbor seals were frequently observed "swimming" (23%, n=486), "diving" (22%, n=475), and "sinking" (19%, n=411) during construction other than pile driving (**Figure 13b**). During vibratory pile driving, Harbor seals were most frequently observed "sinking" (22%, n=136), "diving" (22%, n=131), and "swimming" (19%, n=125). During impact pile driving, Harbor seals were most frequently observed "swimming" (36%, n=14), "diving" (23%, n=9); "sinking" and "looking" (each 18%, n=7).

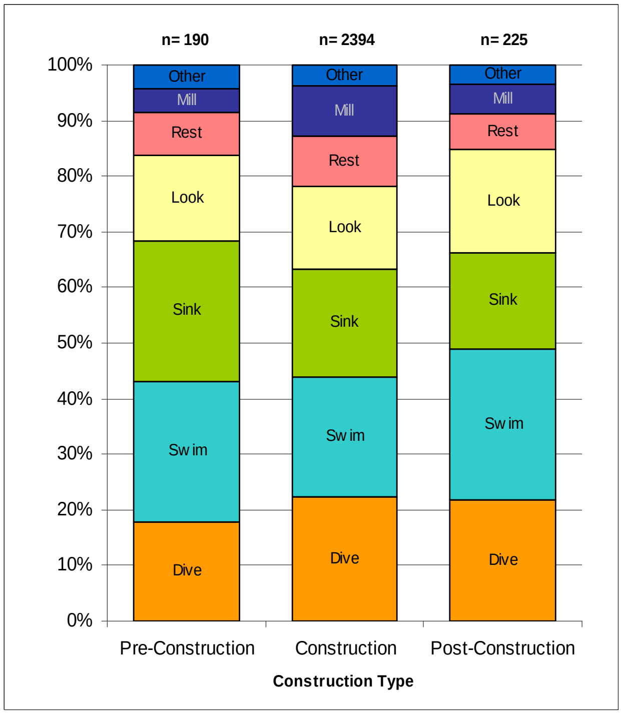


Figure 13a. Harbor Seal Behaviors Before During and After Construction: Primary

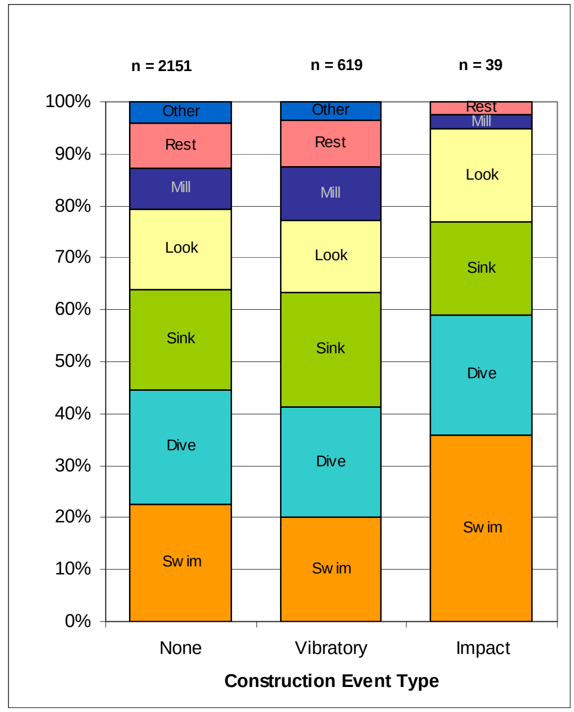


Figure 13b. Harbor Seal Behaviors By Construction Type: Primary

Harbor Porpoise and Steller Sea Lion. No harbor porpoise or Steller sea lions were observed during Primary Surveys.

Delta Pier Surveys. All Delta Pier surveys were conducted after construction activities concluded for the day and all sightings were of animals hauled out on Navy submarines. Only California sea lions and Steller sea lions were observed during these surveys. Secondary behaviors show no apparent trend in relation to weather condition or sea state.

California sea lions were most often seen "resting" (48.2%, n=344), "vocalizing" (16.0%, n=114), and "looking" (14.0%, n=100; **Figure 14**). Steller sea lions were only seen "resting" (66.7%, n=4) and "looking" (33.3%, n=2) while hauled out on the submarines (**Figure 15**).

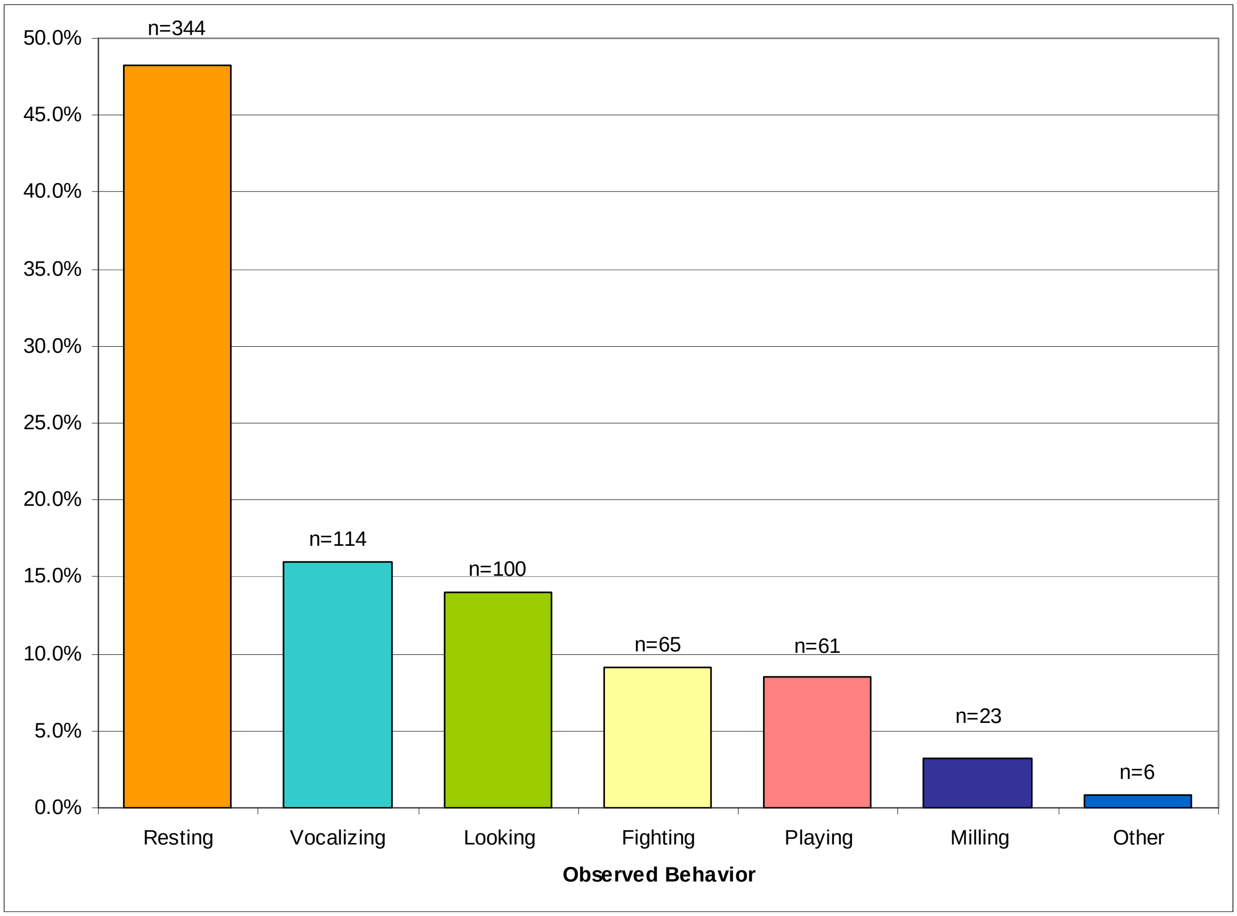


Figure 14. California Sea Lion Behaviors: Delta Pier

Figure 15. Steller Sea Lion Behaviors: Delta Pier

Outside Boat Surveys. Outside Boat surveys occurred only during a portion of the total acoustic monitoring period. Sightings included observations of marine mammals in the 41.4-km^2 Level B Harassment Zone, outside the WRA port security barrier. California sea lions, harbor porpoise, and harbor seals were observed during Outside Boat surveys. The only observations of harbor porpoise during the Year 1 EHW-2 CMP occurred during Outside Boat surveys of areas outside the WRA.

California Sea Lion. There were 12 California sea lion behaviors observed during Outside Boat surveys. Two California sea lion behaviors were observed during pre-construction monitoring, and ten during construction monitoring (**Table 13**). Perhaps due to the small sample size, behaviors were distributed somewhat evenly, with "diving" and "traveling" (each 17%, n=2) being the most frequently observed behaviors during construction monitoring. During pre-construction monitoring, California sea lions were observed "looking" and "milling" (each 50%, n=1). No California sea lions were observed during vibratory or impact driving.

Table 13. California Sea Lion Behaviors by Construction Type: Outside Boat

Behavior	Pre-Construction	Construction
Dive		2
Travel		2
Look	1	1
Chuff		1
Forage		1
Rest		1
Slap		1
Vocalize		1
Mill	1	

Harbor Porpoise. Harbor porpoise were only observed outside the WRA, and only during pre-construction and construction monitoring. During pre-construction monitoring, harbor porpoise were observed “swimming,” “foraging,” “changing direction,” and “diving,” each 25% of the time (each n=8; **Figure 16**). Foraging behavior in harbor porpoise was assumed to be occurring when animals stayed in a small area with repeated diving and surfacing from multiple directions within that area. During construction, harbor porpoise were observed “swimming” (68%, n=47) and “diving” (32%, n=22). There were no observations during post-construction monitoring.

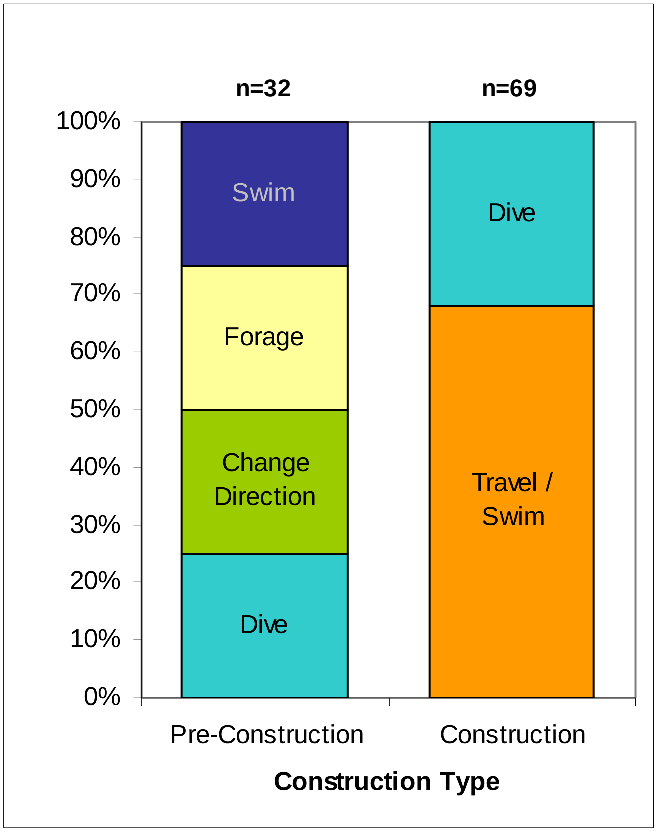
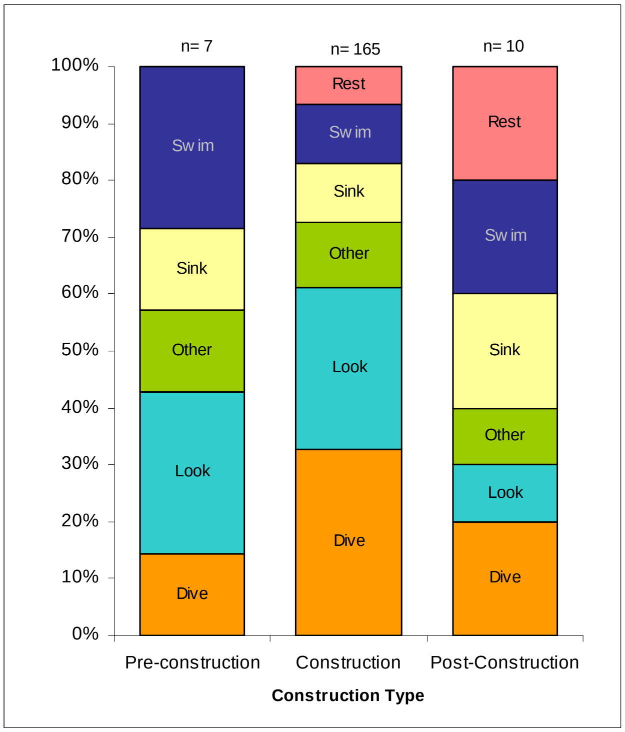


Figure 16. Harbor Porpoise Behaviors Before and During Construction: Outside Boat

Harbor Seal. Harbor seals were the most frequently observed marine mammal species by the Outside Boat. During pre-construction monitoring, harbor seals were most frequently observed "looking" and "swimming" (each 18%, n=2; **Figure 17a**). During construction monitoring, harbor seals were most frequently observed "diving" (24%, n=54); "looking" (21%, n=47); and "sinking" and "swimming" (each 8%, n=17).

When analyzed by construction event type, during all types, harbor seals were most frequently observed "diving" and "looking" (**Figure 17b**). However, the percentages of the most frequently observed behaviors changed with event type. During construction events other than pile driving, "diving" and "looking" each accounted for 27% of observed behaviors (each n=31). During vibratory driving events, "diving" was observed 36% of the time (n=21) and "looking" was observed 29% of the time (n=17). During impact driving events, "diving" was observed 50% of the time (n=5) and "looking" was observed 20% of the time (n=2).



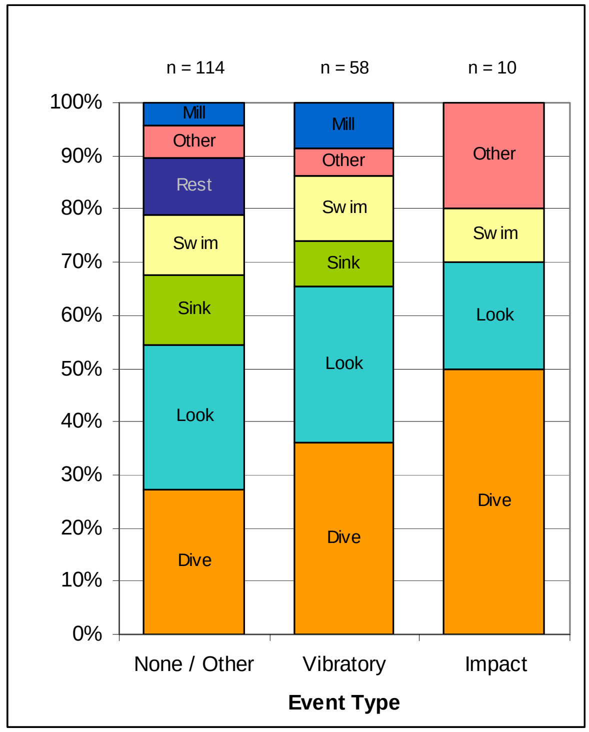


Figure 17a. Harbor Seal Behaviors Before, During and After Construction: Outside Boat	Figure 17b. Harbor Seal Behaviors By Construction Type: Outside Boat

Steller Sea Lion. Steller sea lions sighted by the Outside Boat were observed only during non-construction periods (**Table 14**). Steller sea lions were observed "resting" (60%, n=3) on the submarines, "travelling," and "vocalizing" (each 20%, n=1).

Table 14. Steller Sea Lion Behaviors: Outside Boat

Behavior	No Construction
Rest	3
Travel	1
Vocalize	1

Summary of Quantitative Analysis. During periods of construction other than pile driving events, marine mammals were most frequently observed swimming away from the pile (40%, n=209; **Figure 18**). During vibratory pile driving, marine mammals were most frequently observed moving parallel or having no relative motion to the pile (45%, n=139). There was also a slight increase in the percentage of animals that moved toward the pile during vibratory pile driving (24%, n=31) compared to non-pile driving periods (22%, n=118; **Figure 18**). During impact driving events, animals were most frequently observed moving away and/or moving parallel to or having no relative motion to the pile (each 43%, n =6). Marine mammals did not move toward the pile as frequently during impact pile driving (14%, n=2), as during vibratory driving (24%, n=31) or during periods of no pile driving (22%, n=118).

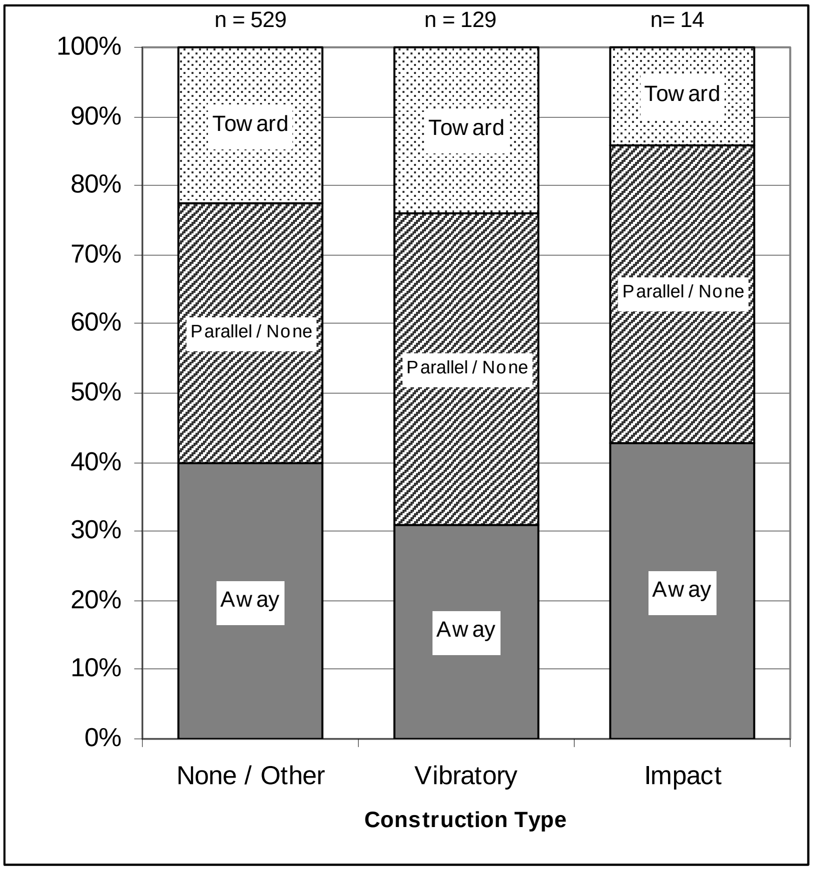


Figure 18. Relative Motion of Marine Mammals by Construction Event

California Sea Lion. California sea lion sightings in the buffer zone were rare. California sea lions were most frequently observed "swimming" and "traveling" during pre- and post-construction monitoring. They were also more frequently observed "swimming" and "traveling" during vibratory pile driving than during periods without pile driving. However, the small sample size of California sea lions makes identifying trends difficult.

Harbor Porpoise. Harbor porpoise were not observed within the WRA at any time during the Year 1 EHW-2 CMP and were only observed by acoustic deckhands/MMOs stationed on the

Outside Boat. Harbor porpoise were more likely to be seen "foraging" and "changing direction" during pre-construction monitoring and outside of vibratory pile driving events. The MMO who observed the harbor porpoise "foraging" described the behavior as animals remaining in a limited area and "changing direction often, appeared to be foraging," but the animals were not seen with food in their mouths. During vibratory pile driving, harbor porpoise were not observed "foraging" and generally travelled in one direction. However, due to harbor porpoise being visible at the surface for only brief moments, observers could have had a difficult time discerning behaviors and actions of harbor porpoise. This, combined with the shorter and less focused monitoring effort of the Outside Boat MMO (compared to the monitoring effort near the pile within the WRA and 464 m buffer zone), led to a small sample size of harbor porpoise behavioral observations which, in turn, makes it difficult to assess trends of behavioral changes (e.g., cessation of foraging activity) during vibratory pile driving.

Harbor Seal. Harbor seals were by far the most frequently sighted marine mammal species during the Year 1 EHW-2 CMP. Harbor seals displayed a wide range of behaviors, but were less likely to be observed "swimming" and more frequently observed "diving" during construction monitoring periods. Harbor seals were also more frequently observed "swimming" than "diving" as their ultimate behavior if they were inside the buffer zone rather than outside of the WRA.

Steller Sea Lion. The small sample size of Steller sea lions makes identifying trends difficult. Steller sea lions were only observed hauled out on or near the PSB and on submarines and never during pile driving.

Qualitative Behavioral Observations. MMOs made a number of qualitative observations on the movements and distribution of animals, and on the potential effects of pile driving activities on marine mammal behavior during the Year 1 EHW-2 CMP, in addition to the quantitative results presented above. In the areas where pile driving was conducted, almost all animals observed were in transit, generally moving along a north-south axis parallel to the shoreline. In addition, on several occasions 2 to 3 harbor seals were seen moving northward from the Marginal Wharf toward the EHW-1 structure within approximately 50 m from shore. These animals then dove or sank and were not further observed. Aside from these sightings, observations of pinnipeds were generally of single animals, of which the majority (>80%) were harbor seals.

On 11 October 2012, Hart Crowser was notified by the Navy of a dead California sea lion floating in the WRA. The dead animal was observed within the construction area later that afternoon and was being shadowed by a harbor seal. After Hart Crowser notified the Navy of the animal's whereabouts, the Navy came and inspected the deceased animal. The Navy then reported the stranding to NMFS, and responders from the Washington Department of Fish and Wildlife came to the site to perform a necropsy along with Navy biologists. The animal had been shot and its death was not related to the construction activities.

Understanding that subjective observations can be a useful adjunct to quantitative measurements, the MMOs were asked on a daily basis whether they had observed any behaviors consistent with injury, distress, or high speed flight from the construction area. For pinnipeds, they did not report any such observations. In addition, the MCs on many occasions asked the marine mammal observers to watch an individual seal or sea lion just as impact or vibratory driving commenced to look for any instantaneous change in behavior potentially associated with the onset of pile driving noise. In some cases, individual animals would submerge with the onset pile driving, or would begin swimming away from the construction site. However, in many other cases, individual animals did not exhibit any change in behavior with the onset of pile driving. Based on these qualitative observations the MMOs generally felt that the behaviors of harbor seals and California sea lions did not indicate adverse reaction to in-water construction activities. This is consistent with the quantitative analysis presented above.

The only observations made of cetaceans in conjunction with the onset of vibratory or impact events were traveling behaviors outside of the WRA. Qualitatively, the MMOs again did not report any behaviors consistent with injury, distress or high speed flight, nor did they report obvious changes in less acute behaviors.

Environmental Data

Environmental data are summarized in **Appendix E**. Average daily air temperatures ranged from 40 degrees Fahrenheit (° F) to 61° F for the duration of EHW-2 CMP (**Table 19**). Average weekly air temperatures fluctuated from 64° F in September to 51° F in January. Water temperatures fell from 54° F at the beginning of the project to 43° F over the course of the monitoring period. The lowest recorded weekly average water temperature was 40° F in the second week of December 2012. No correlation was found between air or water temperatures and frequency of marine mammal sightings.

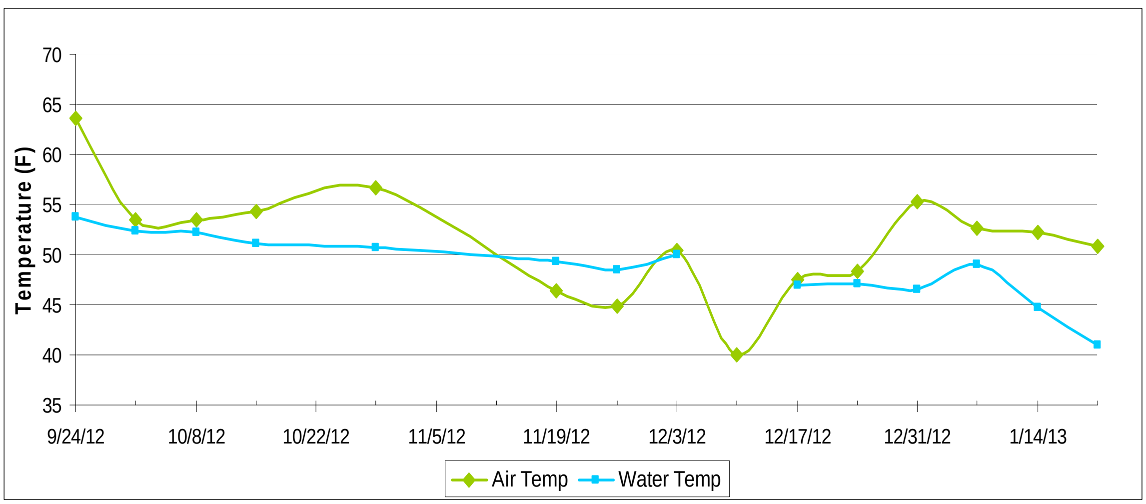


Figure 19. Air and Water Temperature for duration of the EHW-2 CMP

The Beaufort sea state reached a maximum weekly average of BSS 4 in December and January (**Figure 20**). However, 97% of sightings occurred during a BSS 0–2, while the smallest percentage of sightings occurred during a BSS 4 (**Figure 11a**). Due to the wind and wave stilling effects of the construction barges that were clustered around the pile being driven, the marine mammal observers consistently reported having clear view of the shutdown zone and nearer portions of the buffer zone during pile driving activities.

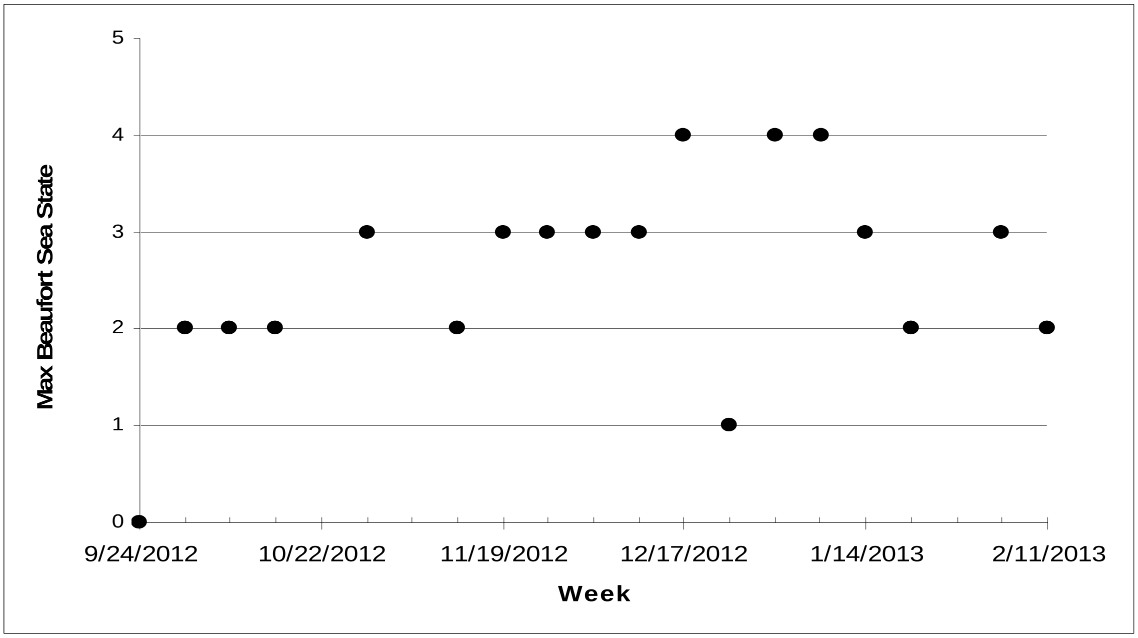


Figure 20. Maximum Beaufort Sea State for the duration of the EHW-2 CMP.

Wind speeds ranged between 0 miles per hour (mph) to 18.4 mph, but were in the range of 0 mph to 8 mph most days (Figure 21). There was no clear link between recorded wind speed and BSS (R^2=0.03073). For example, the highest wind speeds on 10 January were associated with a BSS range from 0–1. Observers found that localized wind "chop" rather than more regular waves were the primary determinant of the quality of viewing conditions. Similarly, wind direction was also important: winds from the east, southeast, and northeast could be strong but lacked the fetch to significantly affect the BSS in the WRA. This benefited observers in the WRA as conditions in this area were generally calmer than in adjacent areas of Hood Canal due, in part, to the location of the project area between EHW-1 and Marginal Wharf and in part, to the security fence, which provided a degree of shelter and dissipated wind and wave energy from the open waters of Hood Canal.

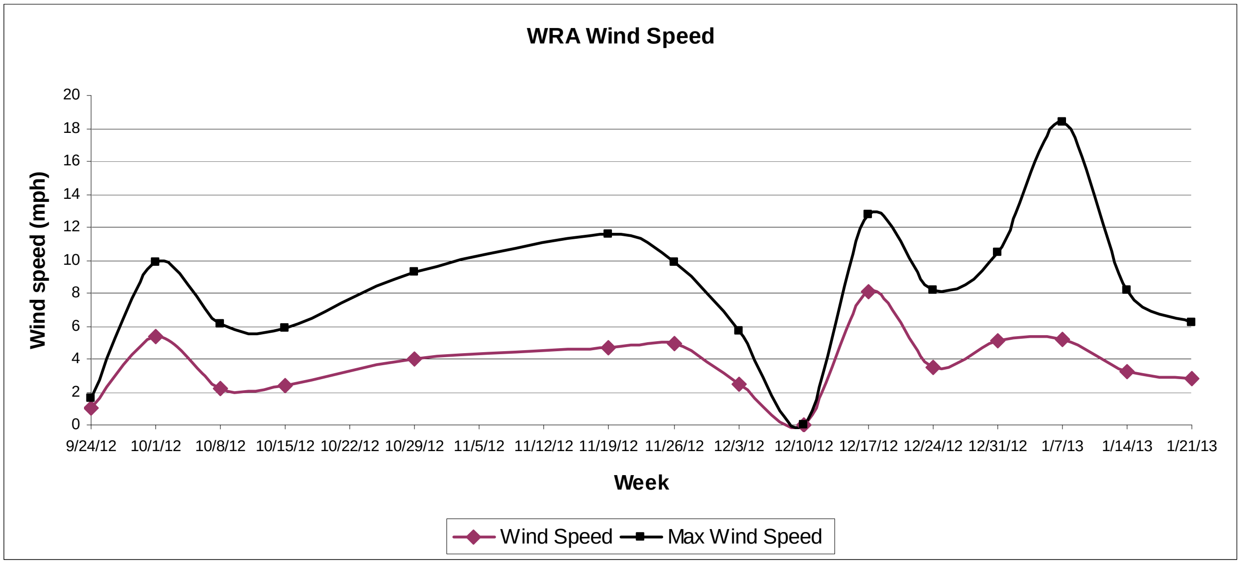


Figure 21. Wind Speed for the duration of EHW-2 CMP

Section 4 Recommendations

1. In order to ensure the effectiveness of the bubble curtain, crews should be trained to make certain the bottom ring rests on the seafloor. Crews must measure water depth throughout the day to account for tidal changes and adjust the bubble equipment accordingly.
2. The bubble curtain should be redesigned for ease of use and accurate monitoring of flow. During the Year 1 EHW-2 CMP, each ring was controlled separately and required pile driving crews to open valves to attain correct pressures to each ring. However, most of the flow gauges were not functional, so crews set the rings to a set pressure. Different pressure requirements needed to regulate flow at different depths were not acknowledged, so bubble curtain effectiveness suffered. Hart Crowser was informed that the bubble curtain would be redesigned for the Year 2 in-water field season to address these issues (**Appendix H**).
3. No harbor porpoise were sighted by MMOs based inside the WRA. Without the Outside Boat acoustic deckhand/MMO, there would be no sightings to evaluate behavioral changes of harbor porpoise during vibratory driving (**Figures 16a and 16b**). Behavior data from MMOs during both the TPP and Year 1 EHW-2 CMP suggest that harbor porpoise may be affected by vibratory driving (travelling in a straight line rather than

changing direction and or behaviors suggesting foraging). As MMOs inside the WRA are unlikely to sight cetaceans beyond the PSB, in order to capture harbor porpoise and other cetacean baseline behaviors and changes in behavior during pile driving it is recommend that supplemental MMO surveys be conducted outside the WRA at least periodically throughout the pile driving season.

4. Co-locating the MMO on the boat in the WRA with marbled murrelet observers worked well during the Year 1 EHW-2 CMP. It is recommended that future versions of the Marine Mammal and Marbled Murrelet Monitoring Plans formally include this approach.

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