Protected Species Mitigation and Monitoring Plan (PSMMP): Marine Mammals

Revolution Wind, LLC

Revolution Wind | Powered by Ørsted & Eversource

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List of Abbreviations and Acronyms

µPa	microPascal(s)
re 1 µPa	referenced to a pressure of 1 microPascal
AAR	autonomous acoustic recorder
ASV	autonomous surface vehicle
AUV	autonomous underwater vehicle
BBC	big bubble curtain
BO	Biological Opinion
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
cm	centimeter(s)
COP	Construction and Operations Plan
CPA	closest point of approach
CTV	crew transfer vessel
D	depleted
DASBRS	Drifting Autonomous Spar Buoy Recorders
dB	decibel(s)
DIFAR	Directional Frequency Analysis and Recording
DMA	Dynamic Management Area
E	Endangered
ECR	Export Cable Route
ESA	Endangered Species Act
FR	*Federal Register*
ft	foot/feet
GPS	global positioning system
HD	high definition
HF	high-frequency
HRG	high-resolution geophysical
HSD	Hydro-sound Damper
Hz	hertz
ITA	Incidental Take Authorization
IR	infrared
kg	kilogram(s)

kHz	kilohertz
kJ	kilojoule(s)
km	kilometer(s)
Lease Area	BOEM-designated Renewable Energy Lease Area OCS-A 0486
$L_{E,24h}$	sound exposure level, cumulative 24 hours
LF	low-frequency
$L_{p,0\text{-pk}}$	peak sound pressure level
m	meter(s)
MF	mid-frequency
min	minute(s)
mm	millimeter(s)
MMPA	Marine Mammal Protection Act
NARW	North Atlantic right whale
NL	not listed
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NMS	Noise Mitigation System
NVD	night-vision device
O&M	operations and maintenance
OCS	Outer Continental Shelf
Orsted	Orsted Wind Power North America LLC
OSS	offshore substation
PAM	passive acoustic monitoring
PECP	Permits and Environmental Compliance Plan
PK	peak sound pressure level
POC	point of contact
Project	Revolution Wind Offshore Wind Farm Project
PSMMP, or Plan	Protected Species Mitigation and Monitoring Plan
PSO	Protected Species Observer(s)
PTS	permanent threshold shift
QA	quality assurance
QC	quality control
rms	root mean square
ROD	Record of Decision

RWSAS	Right Whale Sighting Advisory System
S	strategic
SEL	sound exposure level
SFV	sound field verification
SMA	Seasonal Management Area
SNR	Signal to Noise Ratio
SOV	service operation vessel
SPL	sound pressure level
SPL_{rms}	root-mean-square sound pressure level
SZ	shutdown zone
TTS	temporary threshold shift
UHF	ultra-high frequency
USCG	United States Coast Guard
VHF	very high frequency
WDA	Wind Development Area
WEA	Wind Energy Area
WTG	wind turbine generator
ZOI	Zone of Influence

Glossary

Acoustic Monitoring Zone	The body of water around an activity that is acoustically monitored for the presence of marine mammals
Acoustic range	Range to acoustic thresholds calculated using acoustic modeling which assumes a stationary receiver and only considers sound propagation
Autonomous acoustic recorder (AAR)	Self-contained acoustic recording device designed for long-term deployment and data collection
Autonomous surface vehicle (ASV)	Unmanned surface vehicle or boat operated without a crew onboard
Clearance zone (CZ)	The area that must be visually and/or acoustically clear of protected species prior to starting an activity that produces sound at frequencies and amplitudes that could result in Level A or Level B exposures (e.g., HRG sources with operating frequencies <180 kHz; impact and vibratory pile driving)
Construction and Operations Plan (COP)	Plan submitted to BOEM by developers as required by 30 CFR part 585 to describe all planned facilities proposes for construction and use for the Project, along with all proposed activities including the proposed construction activities, commercial operations, and conceptual decommissioning plans for all planned facilities, including onshore and support facilities
Dynamic Management Area (DMA)	Areas established by NMFS to protect North Atlantic right whales (NARWs) from potential vessel strikes in which a voluntary speed restriction of 10 knots or less is encouraged while transiting through these areas
Ecological monitoring	Used to assess the effectiveness of mitigation measures within the context of long term or ecosystem-based assessments outside of any mitigation requirements
Shutdown Zone (SZ)	The area in which equipment shut down or other active mitigation measures must be applied once a source is active if a protected species is sighted inside the corresponding zone
Exposure range	Ranges to acoustic thresholds calculated using acoustic modeling which considers animal movement and behavior
Hydrophone	Microphone/audio recorder designed for use underwater
Incidental Take Authorization (ITA)	Authorization from NMFS per the MMPA for the "taking" of small numbers of marine mammals resulting from Project activities
Level A Zone	The area of water ensonified by a sound source to an acoustic isopleth defined as a threshold at which onset of a permanent threshold shift (PTS) in hearing can occur
Level B Zone	The area of water ensonified by a sound source to an acoustic isopleth defined as a threshold at which onset of a behavioral disturbance can occur
Mitigation	The set of personnel, equipment and protocols that are in place to minimize the risk of potential impacts to marine mammals from project activities
Mitigation monitoring	Typically comprised of PSOs who visually and acoustically monitor specified zones, during Project activities

Monitoring zone	The body of water around an activity that is visually monitored for the presence of marine protected species
Noise Mitigation System	Any device or suite of devices that reduces pile driving sound levels that are transmitted through the water. Primary systems reduce the source levels produced by the pile and secondary systems reduce the propagated sound levels of the piling.
Offshore substation (OSS)	Stations that collect and export the power generated by the WTGs, to be installed on monopile foundations within the RW Lease Area
Passive acoustic monitoring (PAM)	Real-time monitoring using an underwater recorder during Project activities for the presence of marine mammal vocalizations
Project Area	RW Lease Area (OCS-A 0486) and associated export cable routes
Protected species observer (PSO)	NMFS-approved visual observers trained to monitor the area around a vessel or platform during Project activities for the presence of protected species and implement appropriate mitigation as necessary
Record of decision (ROD)	Decision issued by BOEM following review of the COP which described their decision, any alternatives considered, and plans for mitigation and monitoring, as necessary
Seasonal Management Area (SMA)	Areas established by NMFS along the U.S. east coast at certain times throughout the year in which all vessels greater than 65 ft are required to travel at 10 knots or less while transiting these areas to reduce the threat of vessel strikes on NARWs
Sound field verification (SFV)	Acoustic measurements taken in the field of specific Project activities used to verify modeling results and confirm the monitoring and mitigation methods implemented for the Project are appropriate
Unexploded Ordinance (UXO)	Any sort of military ammunition or explosive ordnance which has failed to function as intended and may still pose a risk of detonation
Wind Farm Area	Maximum work area surrounding the Revolution Wind Lease Area (BOEM Lease OCS-A 0486)
Wind turbine generator (WTG)	A device that converts wind energy into electricity, to be installed on monopile foundations within the RWF Lease Area
Zone of influence (ZOI)	The area within which potential impacts to species are assessed and estimated

1 Introduction

This protected species mitigation and monitoring plan (PSMMP) is in place for high-resolution geophysical (HRG) survey, construction, and operations and maintenance (O&M) activities planned for Revolution Wind LLC's Revolution Wind Farm (RWF) located in the Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A-0486 and the associated Revolution Wind Export Cable (RWEC) herein referred to in this PSMMP as the Project Area. Revolution Wind, LLC (Revolution Wind) (formerly DWW Rev I, LLC) is a joint venture between Ørsted North America Inc. and Eversource Investment, LLC.

The purpose of this PSMMP is to provide protocols and guidelines for mitigation and monitoring activities to minimize potential impacts on marine mammals through both visual and passive acoustic means during Project-related activities. The PSMMP also serves as Section 11 (Mitigation Measures to Protect Marine Mammals and their Habitat) of the Application for Rulemaking and letter of Authorization for the Revolution Wind Project. The PSMMP provides consistency in the monitoring and mitigation methods employed across all Ørsted and Ørsted partnership wind projects in the Atlantic Outer Continental Shelf (OCS) and all development and operational phases. A PSMMP will be developed for each project.

1.1 PSMMP Format

Marine mammals[1] likely to occur in the Project area are presented in **Section 0** of this Plan. Standard conditions applicable to all Projects are presented in **Sections 3** of this Plan; while Project-specific activities will be reflected in **Section 4** and beyond as applicable. The Project-specific sections consider the range of activities and potential impacts; the biological and ecological information about species likely to occur within the Revolution Wind Project area; and permit conditions under which the work is being performed.

The protocols described in the Plan are designed to minimize impacts on marine mammals resulting from Project activities and document the occurrence of marine mammals in proximity to the Project area. Guidance for this plan comes from various resources of agreed-upon mitigation measures and monitoring protocols (Baker et al. 2013) as well as previous survey plans, ongoing agency reviews and coordination, and regulatory standard requirements where applicable.

The described monitoring and mitigation methods in each section of the Plan focus on marine mammals potentially exposed to underwater sound levels that would constitute "take" under the Marine Mammal Protection Act (MMPA). Subsequent sections of the Plan provide Project-specific details regarding the protocols that will be implemented during:

- High resolution geophysical (HRG) surveys
- UXO removal
- Construction, and
- Operations and Maintenance

Each activity section is designed to be used as a reference to the required measures that will be implemented during the corresponding activity including:

- designating mitigation and monitoring zones,
- defining measures related to potential impacts from underwater sounds, and

[1] A separate version of this PSMMP outlines proposed mitigation and monitoring measures for other marine protected species (e.g., fish and sea turtles) in addition to marine mammals. This document is in development and will be provided to BOEM as an addendum to the Construction and Operations Plan for Revolution Wind.

- vessel strike avoidance measures as applicable for each activity.

Users should reference this Plan to confirm that all agreed and regulatory measures are being implemented using the accepted methods and practices. Additionally, sections are included that address longer term and marine mammal monitoring initiatives that are associated with specific projects or are in development through broader Ørsted and Ørsted partnership activities.

In this Plan, the units of Measure reported for construction activities are U.S. customary units, which are typically used in construction. Units of measure for scientific information, including acoustics, are metric. When appropriate, units are reported as both US customary and metric.

2 Marine Mammals Likely to Occur in the Project Area

Sixteen marine mammal species and/or stocks (Table 1) can be expected to reside, traverse, or routinely visit the Project Area. Five marine mammal species occurring in or near the Project area are listed as endangered under the ESA of 1973 (35 *Federal Register* (FR) 12222; 73 FR 12024) (Table 1). All marine mammals are protected under the MMPA.

Table 1: Marine Mammal Species in the Project Area for Which Level A and/or Level B Take is Requested.

Common name; species name; and stock	**MMPA and ESA Status[a]**	**Relative Occurrence in the RWF[b]**	**Relative Occurrence in the RWEC[b]**	**Seasonality in Offshore Project Area[b]**	**Abundance[d] (NOAA Fisheries best available)**
Mysticetes (baleen whales)					
Blue Whale *Balaenoptera musculus musculus* Western North Atlantic Stock	ESA Endangered MMPA Depleted and Strategic	Uncommon	Uncommon	Spring and summer	402
Fin Whale *Balaenoptera physalus physalus* Western North Atlantic Stock	ESA Endangered MMPA Depleted and Strategic	Common	Common	Year-round, but mainly spring and summer	6,802
Humpback Whale *Megaptera novaeangliae* Gulf of Maine Stock	MMPA Non-strategic	Common	Common	Year-round, but mainly spring and early summer (March to July)	1,396
Minke Whale *Balaenoptera acutorostrata acutorostrata* Canadian East Coast Stock	MMPA Non-strategic	Common	Common	Mainly spring and summer	21,968
North Atlantic Right Whale *Eubalaena glacialis* Western Atlantic Stock	ESA Endangered MMPA Depleted and Strategic	Common	Common	Year-round, but mainly winter and spring (December-April)	368

Common name; species name; and stock	MMPA and ESA Status[a]	Relative Occurrence in the RWF[b]	Relative Occurrence in the RWEC[b]	Seasonality in Offshore Project Area[b]	Abundance[d] (NOAA Fisheries best available)
Sei Whale *Balaenoptera borealis borealis* Nova Scotia Stock	ESA Endangered MMPA Depleted and Strategic	Regular	Uncommon	Spring and summer (March to July)	6,292
Odontocetes					
Atlantic Spotted Dolphin *Stenella frontalis* Western North Atlantic Stock	MMPA Non-strategic	Uncommon	Uncommon	Summer and fall	39,921
Atlantic White-Sided Dolphin *Lagenorhynchus acutus* Western North Atlantic Stock	MMPA Non-strategic	Common	Common	Year-round, but more abundant in the spring and summer	93,233
Common Bottlenose Dolphin *Tursiops truncatus truncatus* Western North Atlantic Offshore Stock	MMPA Non-strategic	Common	Common	Year-round	62,851
Common Dolphin *Delphinus delphis* Western North Atlantic Stock	MMPA Non-strategic	Common	Common	Year-round, but more abundant in summer	172,974
Harbor Porpoise *Phocoena phocoena* Gulf of Maine/Bay of Fundy Stock	MMPA Non-strategic	Common	Common	Year-round, but less abundant in summer	95,543
Pilot Whale, Long-Finned *Globicephalus melas* Western North Atlantic Stock	MMPA Depleted and Strategic	Common	Uncommon	Year-round, with peak occurrence in the spring	39,215
Risso's Dolphin *Grampus griseus* Western North Atlantic Stock	MMPA Non-strategic	Common	Uncommon	Year-round, but more abundant in summer	35,215
Sperm Whale *Physeter macrocephalus* North Atlantic Stock	ESA Endangered MMPA Depleted and Strategic	Common	Common	Year-round, but mainly summer and fall	4,349
Pinnipeds					
Gray Seal *Halichoerus grypus atlantica* Western North Atlantic Stock	MMPA Non-strategic	Regular	Regular	Year-round	27,300

Common name; species name; and stock	MMPA and ESA Status[a]	Relative Occurrence in the RWF[b]	Relative Occurrence in the RWEC[b]	Seasonality in Offshore Project Area[b]	Abundance[d] (NOAA Fisheries best available)
Harbor Seal *Phoca vitulina vitulina* Western North Atlantic Stock	MMPA Non-strategic	Regular	Regular	Year-round, with peak abundance (April to May)	61,336

ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act; Project Area = includes the Revolution Wind Farm (RWF), Revolution Wind Export Cable (RWEC) – Outer Continental Shelf (OCS) and RWEC – Rhode Island (RI) state waters, and Onshore Facilities; SGCN = Species of Greatest Conservation Need.

NA = Not Applicable and/or insufficient data available to determine seasonal occurrence in the offshore project area.

a. Special status accorded by the US Endangered Species Act (ESA), NMFS (Hayes et al. 2019, 2020), and Rhode Island Endangered Species Act (RI.gov 2021).

b. Occurrence and seasonality were mainly derived from(Kenney and Vigness-Raposa 2010; Kraus et al. 2016) .

c. Habitat descriptions from the 2019 Marine Mammal Stock Assessment Report (Hayes et al. 2019).

d. "Best Available" abundance estimate is from the 2019 Marine Mammal Stock Assessment Report, published by NMFS on the Federal Register on 27 November 2019 (84 FR 65353); the 2020 Marine Mammal Stock Assessment Report (Hayes et al. 2020); and the draft 2021 Marine Mammal Stock Assessment Report (Hayes et al. 2021).

e. Abundance estimates are from habitat-based density modeling of the entire Atlantic EEZ from (Roberts et al. 2016; Roberts et al. 2017; Roberts et al. 2018; Roberts et al. 2020, 2021)

f. Under management jurisdiction of United States Fish and Wildlife Service rather than National Marine Fisheries Service and therefore not included in 2019 or the 2020 Stock Assessment Report; currently no reliable abundance estimate is available for this population

g. Mesoplodont beaked whale abundance estimate accounts for all undifferentiated beaked whale species within the Western Atlantic (Hayes et al. 2019)

3 Standard Conditions for Mitigation and Monitoring

3.1 Defining Mitigation and Monitoring

For purposes of the Plan, mitigation and monitoring are defined as follows:

- **Mitigation** – defined as the set of personnel, equipment, and protocols that are in place to minimize the risk of any potential impacts to marine mammals that could result from Project activities.
- **Monitoring** – defined in two ways:

1) Mitigation monitoring associated with ***mitigation activities***. Mitigation monitoring is typically comprised of protected species observers (PSOs) who visually and acoustically monitor specified zones (**Section 5.1, 6.1, 7.1)**, during Project activities for the purposes of implementing mitigation measures; and
2) Ecological Monitoring to ***assess the effectiveness of mitigation measures***. Ecological monitoring is used within the context of long-term or ecosystem-based assessments outside of any mitigation requirements. While the same or similar methods and equipment as mitigation monitoring may be used, ecological monitoring typically addresses different questions or actions than mitigation monitoring. In this context, we use the term ecological monitoring in the Plan to differentiate the two monitoring regimes.

3.1.1 Zone Definitions

Throughout this Plan, zones are described that identify either an impact range, or areas within which mitigation and/or monitoring occurs. The size of the zones and the mitigation measures (if necessary) taken within each zone will be Project-, species-, and activity-specific and are identified in **Sections 5, 6, 7,** and **8** for marine mammals. Not all zones may be incorporated for all projects or activities. If additional zones are necessary for a project outside of the standard conditions, they will be defined in **Sections 5, 6, 7**, and **8** for Revolution Wind's PSMMP and in applicable Appendices for other species. The zones applicable to this Project are defined below.

- **Level A Zone** – the area encompassing the waters from a sound source to an isopleth defined by a threshold at which the **onset of a permanent threshold shift (PTS)** can occur. Level A zones may result from an instantaneous exposure, exposure over a 24-hour period, exposure to a single-strike or pulse, or other defined metric. Level A zones may be calculated or modeled, and their extent can be defined by acoustic ranges or by exposure ranges[2]. Entry by an animal into the Level A zone may or may not require mitigation measures be taken. Marine mammals detected between the sound source and the outer range limit of the Level A zone under the specified exposure conditions may constitute Level A exposure. Unless otherwise stated, the Level A zones for marine mammals use the following metrics:
    - Frequency-weighted cumulative sound exposure level (SEL_{cum}) and unweighted peak sound pressure level (SPL_{pk}). PTS thresholds as defined by the National Marine Fisheries Service (NMFS) (NMFS 2018).
- **Level B Zone** – the area encompassing the waters from a sound source to an isopleth defined by a threshold at which **onset of a behavioral disturbance can occur**. Level B zones may result from an instantaneous exposure, exposure to a single-strike or pulse, or other defined metric. Level B zones may be calculated or modeled, and their extent can be defined by acoustic ranges or by exposure ranges. Entry by an animal into the Level B zone may or may not require mitigation measures be taken. Marine mammals detected within this zone under the specified exposure conditions may constitute Level B exposure. Unless otherwise stated, the Level B zones for marine mammals use the following metrics:
    - Level B zone encompasses the distance from the sound source to an unweighted root-mean-square sound pressure level (SPL_{rms}) of 160 decibels (dB) referenced to (re) 1 micropascal (µPa) from impulsive or sweep sources are considered; and an unweighted SPL_{rms} of 120 dB re 1 µPa when non-impulsive sources are considered (NMFS 2019).
- **Pre-start Clearance Zone** – the area that must be visually and/or acoustically clear of protected species of marine mammal **prior to starting an activity**. Clearance zones may also be implemented after a shutdown in sound-producing activities prior to restarting the source. The size of the clearance zone is dependent on the activity and permit conditions. The clearance zone will be specific to species and/or faunal groups and may be larger than the species/faunal group-specific shutdown zone (SZ) (described below).
- **Shutdown Zone (SZ)** – the area in which a noise source must be shut down, or other active mitigation measures must be implemented **once a source is active**. The size of the SZ is dependent on the activity and permit conditions. The SZ may or may not encompass other zones. SZs will be specific to species and/or faunal groups.

- **Monitoring Zone** – encompasses the **waters around an activity to be visually and/or acoustically monitored** for the presence of protected species of marine mammals. The monitoring zone represents the farthest extent practicable that can be monitored for marine mammals. There are no mitigation or visibility requirements associated with the monitoring zone; however, all species detected within the monitoring will be recorded. The minimum size of the monitoring zone will help inform the appropriate monitoring methods that will be employed during activities. Monitoring zones can be considered an area of situational awareness for the project that carry no specific regulatory requirements.
- **Zone of Influence (ZOI)** – this is not a defined area for mitigation or monitoring purposes; rather, it is the area within which potential impacts to species are assessed and estimated. The ZOI would not be greater than the maximum Level B zone. While the ZOI provides the needed information to establish the other zones, it does not play an additional role in mitigation and monitoring during Project activities.

3.2 Permits and Agreements

Permits and agreements pertaining to the Project will define and modify the mitigation and monitoring requirements through the various stages of the permitting process. The permits and agreements in place for the Project are detailed in the individual Project activity sections (See **Sections, 5, 6, 7**, and **8**).

3.3 Personnel

Dedicated personnel may be required for carrying out mitigation and monitoring efforts onboard Project vessels. These roles are generally required to be filled by NMFS -approved and BOEM-accepted PSOs and passive acoustic monitoring (PAM) operators.

Personnel in the field have a responsibility to support these activities and will receive Project -specific training. A Permits and Environmental Compliance Plan (PECP) manual which will include the PSMMP will be prepared to describe species expected to occur in the Project Area, monitoring and mitigation measures, data collection and reporting measures, equipment specifications, etc.

The Project will conduct standardized pre-activity environmental awareness training for all crew members (e.g., PECP training). The training will summarize the PECP and other relevant topics including:

- The responsibilities of each party;
- Definition of the chains of command;
- Communication procedures;
- An overview of monitoring purposes;
- Review of operational procedures;
- Personnel training on mitigation requirements upon detection of a marine mammal(s);
- Procedures for sighting, reporting, and protection of marine mammals and other protected species;
- General review of protected species anticipated in the region; and
- Review of additional environmental requirements and awareness elements relevant to the Project.

3.3.1 Protected Species Observers

Protected species observers (PSOs) will, at a minimum, meet the observer standards outlined in Baker et al. (2013) and will have the appropriate approvals from NMFS for conducting PSO duties during wind farm activities including:

- At least one PSO must have prior experience performing the duties of a PSO during construction activity pursuant to a NMFS-issued incidental take authorization; and
- Other PSOs may substitute other relevant experience, education (degree in biological science or related field), or training for prior experience performing duties of a PSO during construction activity pursuant to a NMFS-issued take authorization.

The Project will deploy a PSO team consisting of PSOs with appropriate skills and in sufficient numbers to meet all mitigation and monitoring requirements.

The PSO field team will have a lead monitor (Lead PSO), designated and identified by the applicant to be approved by NMFS. The Lead PSO will have experience in the northwestern Atlantic Ocean on similar projects. The PSO team may also have one PSO supervisor who may work in the field or shore side for the duration of the mitigation activities to provide additional support to the Lead PSO and PSO team. The PSO supervisor would also facilitate the communication between PSOs and other shore side project parties. The remaining PSOs will have previous PSO experience on similar projects and the ability to work with the relevant software and equipment.

In addition to the PECP training indicated above, PSOs will also complete a two-day training and refresher session with the PSO provider and Project compliance representatives. The two-day training will review in detail the protected species expected in the Project Area and associated regulatory requirements and it will be conducted shortly before the anticipated start of Project activities. The refresher session will be tailored to the needs of the particular PSO teams and will consider what field projects the PSOs have recently been on.

3.3.2 Passive Acoustic Monitoring Operators

If real-time PAM is employed as a mitigation monitoring protocol, a PAM operator or PAM team will be deployed. PAM operators will have the qualifications and relevant experience to meet the needs of the PAM program including safe deployment and retrieval of equipment as necessary, set-up and monitoring of acoustic processing software, and knowledge in detecting and localizing marine mammal vocalizations. Like the PSO team, the PAM team will have a lead monitor (PAM Lead) who will have experience in the Northwestern Atlantic Ocean on similar projects. The remaining PAM operators will have previous PAM experience on similar projects and the ability to work with the relevant software and equipment. Resumes for all PAM team members will be submitted to NMFS for review and approve prior to the start of mitigation monitoring activities.

In addition to the PECP training indicated above, PAM operators will also complete a two-day training and refresher session with the PSO provider and Project compliance representatives. The two-day training will review in detail the protected species expected in the Project Area and associated regulatory requirements and it will be conducted shortly before the anticipated start of Project activities. The refresher session will be tailored to the needs of the particular PAM teams and will consider what field projects the PAM operators have recently been on.

3.3.3 Environmental Compliance Monitor

PSOs will be employed by a third-party provider. However, non-third-party observers who act as environmental compliance monitors in support of a Lead PSO will be approved by NMFS on a case-by-case basis for limited, specific duties in support of approved, independent PSOs. Environmental compliance monitors would support Lead PSOs during shallow water HRG activities.

3.3.4 PSO & PAM Operator Responsibilities

Prior to Project commencement, senior-level Lead PSOs will be designated for each team of PSOs on each asset (i.e., Project vessel or platform). These individuals shall have the experience and skill set to manage the team of PSOs on that asset and to make decisions related to mitigation and monitoring, including potential exposure assessments for each sighting as needed. The Lead PSO will be the single point-of-contact (POC) for PSO activities on that specific asset. The Lead PSO for each asset will report to the PSO Project Manager or Vessel Project Manager. The Lead PSOs shall provide daily sightings and mitigation summary reports to the designated Orsted Compliance Manager which is reported through to Project representatives for the previous day's operations. Changes to data logs may occur if errors are discovered during QA/QC steps. Revolution Wind will utilize Mysticetus software for its data error checks to reduce the possibility for such changes to occur. Any subsequent changes made to any reports submitted by the Lead PSO shall be documented in a change log and the review and acceptance by the Lead PSO noted. The Lead PSO is also responsible for quality assurance (QA)/quality control (QC) and management of data collection utilizing electronic data collection software and embedded QA/QC processes therein. They are the primary representative of observations, reports, and mitigation actions taken by the PSO team. Any PSO or PAM operator on duty will have authority to delay the start of operations or to call for a shutdown based on their observations or acoustic detections.

The PSO supervisor will oversee data collection at the highest level of all the PSO and PAM teams. The Lead PSOs and PAM Leads will be responsible for communicating to the vessel and client POCs (Revolution Wind/Orsted) directly or through agreed upon Project Management intermediaries and will ensure that the communication protocols established for the Project are maintained at all times and that all personnel are trained on the communication protocols (**Attachment 1**). These communication duties shall include the final responsibility for calling for a mitigation action.

Prior to the start of Project activities, the Lead PSO will work with the vessel captain and crew (i.e., operations team) on the asset to achieve compliance with all applicable regulatory documents and provide training when necessary to the vessel captain and crew.

Following established BOEM and NMFS standards, the PSO/PAM team(s) will work in designated shifts during monitoring. For PSOs, shifts will be set up such that no individual will work more than 4 consecutive hours without a 2-hour break, or longer than 12 hours during any 24-hour period. The Project will provide each PSO with one 8-hour break per 24-hour period to sleep. An example rotation is provided in **Attachment 2**. Actual rotations will be Project-, activity-, and vessel-specific, and implemented rotations will be documented with the Project's final PSO report. New or inexperienced PSOs will be paired with an experienced PSO qualified to mentor new PSOs so that the quality of marine mammal observations and data recording is kept consistent.

For PAM operators, minimum standard shifts are typically restricted to no more than 3 hours, but can be reduced if NMFS or BOEM directs a shorter shift. Typically, there is a "floater" PAM operator on the vessel who can rotate in to allow the PAM operator on shift to rest or eat. In some cases where vessels work under 24-hour operations, 4-hour PAM operator rotations may be scheduled. In the cases where PAM systems are monitored remotely (i.e., shore side) alternative rotations to the above may be requested on a case-by-case basis.

The combined PSO and PAM team will conduct monitoring efforts onboard Project vessels and, in some cases, shore side for remote and autonomously monitored systems. At all times during monitoring efforts, at least one dedicated vessel will be used to monitor for marine mammals relative to the activity

being conducted. Autonomous, remotely operated systems may also be deployed to support the monitoring program. It is expected that during most activities, monitoring will take place from more than one platform.

The PSOs will watch for marine mammals from the best available vantage point on the vessels. Ideally this vantage point is a stable, elevated platform from which the PSOs have an unobstructed 360° view of the water. The PSOs will systematically scan with the naked eye and 7x50 reticle binoculars, supplemented with night-vision equipment when needed (see below). During activities with large monitoring zones, 25X 150 millimeter (mm) "big eye" binoculars may be used. All vessel personnel are provided the guidance "*If you see something, say something*" and are responsible for reporting to the PSO team any opportunistic sightings made as soon as they are able and it is safe to do so.

3.4 Equipment

The PSOs will be equipped with reticle binoculars and will have the ability to estimate distances to marine mammals located in proximity to their respective zones using range finders. Digital single-lens reflex camera equipment will be used to record sightings and verify species identification. During night operations, night-vision equipment (night-vision goggles with thermal clip-ons) and infrared (IR) technology will be used (**Attachment 3**). Position data will be recorded using hand-held or vessel global positioning system (GPS) units for each sighting. Recent studies have also concluded that the use of IR thermal imaging technology may allow for the detection of marine mammals at night as well as improve the detection during all periods with automated detection algorithms (Weissenberger et al. 2011; Smith et al. 2020; Zitterbart et al. 2020).

The exact equipment complement used by the PSO/PAM team will vary by the activity, mitigation and monitoring requirements, and observation platform constraints. Additional equipment may be added as necessary. The PSO/PAM team will typically use some combination of the following equipment for observation efforts:

- 7x50 reticle binoculars;
- 25x150 "big eye" binoculars;
- Personal computers/laptops/tablets (minimum of two on the primary vessel)
- Handheld GPS units (minimum of two on the primary vessel);
- High-definition digital single-lens reflex cameras with a minimum 300-mm zoom lens to record sightings and verify species identification, as possible (one per vessel);
- Hard drives to back up data (data will also be backed up daily to secure internet cloud location at least once per day or as often as internet access is available) (minimum of two per vessel);
- Laser rangefinder (one per vessel);
- Rangefinder stick (one per vessel);
- Night vision devices (NVDs);
- Mounted IR thermal imaging cameras;
- PAM hydrophone arrays and/or corresponding monitoring stations
- Computer-based PSO data recording system.

Specific equipment requirements for individual Project activities are provided after **Section 5 through Section 8**. Descriptions of the primary hardware used during mitigation and monitoring activities for all phases of wind farm development are provided in the following subsections.

3.4.1 IR Thermal Camera Systems

Studies have indicated that IR thermal camera performance is independent of daylight and has demonstrated effectiveness ranges exceeding 3 km. Results of studies demonstrate that IR thermal imaging can be used for reliable and continuous marine mammal monitoring (Zitterbart et al. 2013; Smith et al. 2020; Zitterbart et al. 2020). For this reason, the Project finds that use of IR thermal camera systems for mitigation and monitoring purposes warrants additional application in the field as both a stand-alone tool and in conjunction with other alternative monitoring methods (e.g., night vision binoculars, PAM, visual monitoring). See **Table 3** in **Attachment 3** for a summary of available systems.

3.4.2 Night Vision Devices

Night Vision Devices (NVDs) work on a different principle than IR thermal cameras. NVDs enhance available light to provide an image of what is being viewed through the device in such a way that it resembles viewing during higher light conditions (Smultea et al. 2021). In this way, NVDs are less dependent on temperature differentials necessary for the IR thermal camera systems. However, NVDs have a narrow field of view and a relatively short effective range (Smultea et al. 2021).

Equipment used by PSOs will be tailored to the size of the zones being monitored on each part of the Project. Specifications for representative NVD and IR thermal camera will be provided for individual projects as needed. Specific NVD and IR thermal camera equipment models will be subject to availability. See **Table 4** in **Attachment 3** for a summary of available systems.

3.4.3 PAM Systems

A PAM system is defined as any system or device that uses hydrophones, arrays of hydrophones, or other sensors (e.g., vector sensors such as Directional Frequency Analysis and Recording devices [DIFAR] capable sonobuoys) to detect sounds produced by marine mammals. A review of PAM systems that are under consideration is provided in **Attachment 4** which gives a general overview of the different types of applicable PAM systems including some of their advantages and disadvantages.

Within environmental impact statements and mitigation guidelines, there is often a general presumption that animal vocalizations will be consistently detected regardless of operator experience or background noise conditions encountered (Ludwig et al. 2016; Verfuss et al. 2018; Barkaszi and Kelly 2019). Impact estimates and risk assessments also rely on the assumption that animals within an SZ will be detected and localized immediately, so that sound exposures over certain criteria thresholds can either be avoided or enumerated (Verfuss et al. 2018; Barkaszi and Kelly 2019). In reality, detection performance at a given distance can be highly variable due to variability in the frequency, amplitude, directionality, and repetition rate of marine mammal vocalizations; as well as the continually changing background noise levels that effectively reduce the ability to detect signals generated within a monitoring zone (Parks et al. 2009; Van Parijs et al. 2009; Andriolo et al. 2018; Clausen et al. 2019; Thode and Guan 2019). Furthermore, localization, when required, often relies on the detection of multiple high quality signals. When the detection performance of signals is diminished, the actual time required to localize an animal or group of animals might be prolonged or impossible (Barkley et al. 2016; Abadi et al. 2017; Thode and Guan 2019). The types and configurations of PAM systems considered for all monitoring on Ørsted and Ørsted Partnership projects are discussed in **Sections 3.4.3** and Section **3.4.3.3** and in **Attachment 4**.

3.4.3.1 PAM Systems for Real-Time Mitigation Monitoring

PAM is widely used to monitor mitigation zones around vessels and other platforms during survey and installation activities that could negatively impact marine mammals. The primary goal of mitigation monitoring with PAM is to allow compliance personnel to detect and spatially localize marine mammals such that a mitigation decision can be made in a short period of time (seconds to minutes). However, the complexity of acoustic detection and localization is hindered by practical operational conditions that are commonly encountered during mitigation monitoring, described further below.

The requirement for real-time detection and localization limits the types of PAM technologies that can be used to those systems that are either cabled, satellite, or radio-linked. The system chosen will dictate the design and protocols of the PAM operations. Seafloor cabled PAM systems are not considered here, due to high installation and maintenance costs, environmental issues related to cable laying, permitting, and other reasons.

Towed PAM systems are cabled hydrophone arrays that are deployed from a vessel and typically monitored by personnel on that vessel. By and large, towed PAM systems are the mainstay of mitigation PAM applications due to the relatively low cost, high mobility, and ease and reliability of operation. However, the main challenge of a towed PAM system is the fact that it is usually towed from a vessel that may not be fit-for-purpose and that may also be towing other equipment, operating sound sources, and is working in patterns that are permit and Project-driven rather than driven by acoustic monitoring needs. All of these challenges can result in less-than-optimal conditions in which to employ PAM systems. In particular, detection and localization of low-frequency signals (e.g., baleen whale calls) can be challenging in many commercial deployment configurations because of masking caused by vessel sounds. One significant value of towed PAM systems, however, is their ability to work in unison with visual monitoring efforts. The ability to coordinate call types and call rates with visually detected species and group sizes provides important information for analyzing data from non-towed systems used for other types of monitoring. While towed PAM systems have a place in mitigation monitoring (e.g., in support of visual observation), alternative PAM systems are more appropriate for long-range and low frequency signal monitoring.

Mobile and hybrid PAM systems utilizing autonomous surface vehicles (ASVs) and radio-linked autonomous acoustic recorders (AARs) shall be considered when they can meet monitoring and mitigation requirements in a cost-effective manner. Mobile systems are defined here as systems that are not fixed (e.g., moored or bottom-mounted) at one location. Examples of mobile systems include autonomous underwater vehicles (AUVs), ASVs, and drifting PAM buoys. A review for ASVs and AUVs was recently conducted by Verfuss et al. (2019). Examples of drifting PAM buoys include sonobuoys, the Que-phone, Drifting Autonomous Spar Buoy Recorders (DASBRS), and SonarPoint (in the drifter configuration). Due to their drifting nature, these systems are typically deployed in pelagic environments, or for very short periods (e.g., sonobuoys). Real-time (e.g., radio-linked) PAM buoys can be used for regional monitoring of large areas and have an advantage over AARs in that they can telemeter data to shore or a monitoring station nearby in real, or near real-time. Examples of real-time PAM buoys are also provided in **Attachment 4**.

3.4.3.2 Placement of Mitigation PAM Systems

Ideally, deployment of a mitigation PAM array will be outside the perimeter of the SZ to optimize the PAM system's capability to monitor for the presence of animals potentially entering these zones. The total number of PAM stations and array configuration will depend on the size of the zone to be monitored, the

amount of noise expected in the area, and the characteristics of the signals being monitored. There is no single optimal array configuration for all animal call types or noise conditions.

In general, large cetaceans such as baleen whales that produce relatively loud, low-frequency vocalizations can be monitored with a few hydrophones that can be separated by several hundreds of meters or more, whereas smaller cetaceans such as toothed whales and dolphins produce shorter, lower level signals (e.g., whistles, echolocation clicks) that require hydrophones to be spaced more closely, tens of meters to less than a meter apart, and thus may require more hydrophones in an array.

Using closely-spaced clusters of hydrophones (i.e., an array) or vector sensors will allow the direction and, in some cases, the range to vocalizing animals to be estimated. However, this approach adds greater complexity and costs to both the hardware and software, can reduce reliability of the system, and can make real-time monitoring and mitigation difficult for PAM operators. Of course, detection and localization of animals is only possible if they are vocally active.

3.4.3.3 PAM Systems for Ecological Monitoring

The type of system chosen for any ecological monitoring programs will depend on the monitoring priorities (i.e., species and areas to be monitored), the environment (e.g., water depths), bottom fishing (e.g., trawling) in the area to be monitored, and other factors which contribute to detection probabilities.

AARs are a good option for long-term ecological monitoring. AARs are available in a variety of configurations and specifications (**Attachment 4**) (Sousa-Lima et al. 2013). Typically, AARs are deployed on the seafloor for some period of time from several days, weeks, months, up to one year. They are later retrieved from the seafloor, and the data are downloaded. An acoustic release device is typically used to release the recorder from the seafloor, however, grappling methods can also be used in some shallow water environments (usually 50 meters [m] or less). Some shallow water systems can also be retrieved with divers, but this approach is becoming less common due to safety issues and availability of more reliable and low-cost release devices. Once retrieved, the recording devices can be serviced, the data downloaded, and then re-deployed for additional missions. One major disadvantage of AARs over other PAM systems is that the recorders must be periodically retrieved in order to access the data because they record and store data internally and therefore are not capable of real-time monitoring. However, due to their autonomous nature, an advantage of these systems is that an infinite variety of deployment configurations are possible.

Most AARs consist of a single omni-directional hydrophone, and therefore it is not possible to obtain bearings or localizations to sound sources from this type of single device. However, other advanced systems utilize a directional hydrophone/sensor (e.g., DIFAR), or multiple hydrophones connected to a single multi-channel recorder (e.g., a hydrophone array) and thus can localize. In some systems, multiple AAR units can be precisely time-synchronized (e.g., using an acoustic pinger or electronic cable), so that bearings can be obtained and in some deployment configurations localizations of sound sources is thus possible. If an animal or tightly clustered group of animals (e.g., a small pod of dolphins) vocalize consistently through time, it may also be possible to track their movements. In general, the more hydrophones that receive the calls, the higher certainty there will be in the animal locations and tracks, until the increased complexity of processing multiple channels of data in real time becomes an issue.

One downside of AARs is that if a failure occurs (e.g., electronic malfunction, flooding, or a failure to retrieve them) significant volumes of data can be lost. This issue is of particular concern for long-term deployments. Also, the data storage and batteries required for extended deployment periods increase the size and costs of these systems.

There is also a cost associated with deployment and retrieval which typically requires a vessel with a hoist, A-frame, or other heavy machinery. The size of the vessel required depends on size and ease of deployment of the AAR system. Some smaller systems can be deployed from a small boat or rigid-hulled inflatable boat, while others might require a large and costly research or other type of vessel with an A-frame. Finally, the fact that data must be post-processed results in additional analysis expense. However, depending on the level of and type of processing, this approach is usually cheaper (per unit of data collected) than real-time monitoring, which typically requires experienced and relatively costly personnel working on vessels or platforms at sea.

There are also hybrid systems that have some components of both real-time and autonomous systems. For example, many types of real-time systems also record data internally, so they can function both as a real-time system, and as autonomous recorders in case the radio or satellite link is not reliable. Some hybrid systems only send status reports or whale-call detection summaries to shore or a vessel nearby via the radio or satellite-link.

The optimal system will depend on cost considerations, the target species, the length of deployment desired, and a variety of other factors. It is important to realize that there is no single system that is capable of mitigation and monitoring of all species of marine mammals for all areas and noise conditions, so it is possible that several systems, or combinations of systems will be needed.

3.5 Software and Informational Tools

When a marine mammal is detected (either visually or acoustically), data will be collected using software designed for such collection. Software systems exist or are being developed that allow for real-time or near real-time uploads into internet-based cloud storage systems, enabling that information to be downloaded by other vessels or PSOs/PAM operators in the area. This regular and ongoing sharing of sighting data and acoustic detections across platforms will integrate into a Project-wide *Situational Awareness System* that will also include, as feasible, Ørsted's Marine Operation Centers vessel monitoring system, external sources of information such as WhaleAlert (http://www.whalealert.org/) and the interactive map of North Atlantic Right Whale (NARW) sightings (NOAA Right Whale Sighting Advisory System (RWSAS)) (https://apps-nefsc.fisheries.noaa.gov/psb/surveys/MapperiframeWithText.html), detections from external sources of sighting information such as any existing North Atlantic right whale (NARW) Listening Network detections, 3rd party sightings, and any designated and overlapping designated seasonal and dynamic management areas (SMA and DMA).

The overall goal will be to create a Common Operating Picture (i.e., the ability to describe current conditions or species presence in real time or near real time) viewable by Project personnel across multiple project assets and provide a mechanism to manage multiple assets or activities throughout the Project Area in a systematic way. The system as named supports increased situational awareness of marine mammals and facilitates active whale avoidance (Gende et al. 2019) which is an *active and adaptive* mitigation approach for marine mammal monitoring and supports quick decision making for vessel operators, Project crew, or PSO/PAM operators during Project activities.

As a secondary measure, at least once per 4 hours (or as otherwise requested by the Project), PSOs will check additional available information sources including Whale Alert.

3.5.1 Mysticetus Software

Mysticetus™ (https://www.mysticetus.com) is field-tested technology specifically designed to facilitate PSO operations and enhance protective measures for marine mammals. Mysticetus provides a standardized data collection system customized for data collection protocols specified by the Project across all vessel operators and PSO providers. The standardized data collection includes monitoring effort, Project updates, and animal detection data forms and can be updated as needed. Some of the Mysticetus capabilities that enhance Project situational awareness include:

- Real-time graphical display of all relevant information from all boats in the network and 3rd party data feeds defined by the Project.
- Graphically displayed content includes current SZs and CZs around work boats, work zones, and survey areas.
- Display that enables instantaneous mitigation decision support features including display of sighting distances and prediction paths of both animals and vessels, enabling informed PSO decisions for survey path adjustment, operational shutdowns, clearance delays, etc.
- Instantaneous sharing of sightings and alerting between all Mysticetus stations in the network (i.e., any animal sighted by any observer shows up on the maps of all nearby Project vessels) creates a multiplying effect of "eyes on water," and can be used by vessel crews to actively avoid animals.
- Automatic display of NMFS NARW DMAs on display map.
- Standardized QA and reporting processes and tools for all PSOs, regardless of which PSO provider or vessel sub-contractor they work for.
- Email and text message instant alerts in the case of sightings of dead, injured, or entangled animals, as well as all NARW sightings.
- Automatic, accurate localization of sighted animals based on reticle binoculars or clinometer readouts, including deck and PSO eye height, taking into account curvature of the earth.
- IR thermal camera integration of video recording, animal localization support, effort, etc.
- PAM integration and the recording of PAM effort and acoustic detections to Project-specified data collection standards.

3.6 Recording

As part of all monitoring programs, PSOs, PAM operators, and crew members (as applicable) will record all sightings of marine mammals observed anywhere within the monitoring zone. For mitigation monitoring, data on all PSO observations will be recorded based on standard PSO data collection requirements and specific permit conditions. A data collection software system (e.g., Mysticetus ™ or similar software) will be used to record and collate data obtained from visual and acoustic observations during mitigation monitoring. The PSOs and PAM operators will enter the data into the selected data entry program (e.g. Mysticetus or a similar software) installed on field laptops/tablets. PSO data records will include:

- The presence and location (if determinable) of any marine mammal detected by PSOs, PAM operators, or crew members.

- Identification of marine mammal species, numbers of individuals, and behaviors as able. PAM detections are rarely suitable for enumeration or behavior of animals unless verified by visual detections.
- Detections will be annotated with information regarding vessel activity, environmental conditions, and by other operational parameters (e.g., number of vessels in areas, equipment start and stop times, operational duration, etc.).
- Size of all regulatory and monitoring zones.
- Implementation of vessel strike avoidance measures.
- Implementation of clearance, ramp-up and soft start, and shutdown measures as applicable for shutdown and monitoring zones.
- Implementation of specific NARW mitigation measures.
- Observations of any potential injured or dead protected species (e.g., stranding events).

The following information about each marine mammal detection will be carefully and accurately recorded:

- Species, group size, age/size/sex categories (if determinable), and physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals;
- Behavior when first sighted and during any subsequent sightings;
- Heading (if consistent), bearing, and distance from observer;
- Location of confirmed acoustic detections within Project Area (if PAM operator is able to localize the animal);
- Tracks of marine mammals derived from PAM systems if accurate localization is attainable;
- Entry of animal into any regulatory or monitoring zones and duration in those zones;
- Closest point of approach to the applicable activities and/or vessels and assets;
- Apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.) with annotations regarding animal headings, pace, or other information that could help assess changes in behavior;
- Time, location, speed, and Project activity/active sound sources in operation;
- How the animal was detected (i.e., with what monitoring method) and if the animal was detected by any other monitoring method; and
- Mitigation measures requested and implemented (if any).

At regular intervals and at each detection the following information will be recorded by PSOs and PAM operators when the information is determinable:

- Sea state, visibility, and sun glare;
- Noise performance of PAM systems and effective detection ranges for species;
- Vessel or Project activities and location (if mobile);
- PSO shift changes;
- Monitoring equipment being used; and
- Any NARW SMA or DMAs placed during that particular watch.

3.7 Reporting

The following situations would require immediate reporting to appropriate POCs:

- If a stranded, entangled, injured, or dead protected species is observed, the sighting shall be reported within 24 hours to the NMFS RWSAS hotline (see **Attachment 5**).
- In the event a protected species is injured or killed as a result of Project activities, the vessel captain or PSO on board shall call for an immediate cessation of all activities until NMFS Office of Protected Resources (OPR) is able to review the circumstances of the incident and determine what, if any, additional measures are appropriate to ensure compliance. Additionally the vessel captain or PSO on board shall report immediately to (see **Attachment 5***)*:
    - NMFS OPR (301-427-8401) and Greater Atlantic Regional Fisheries Office no later than within 24 hours;
    - NOAA Fisheries Marine Mammal and Sea Turtle Stranding and Entanglement Hotline (866-755-6622) or alternative electronic reporting systems as approved by the NOAA stranding program, as well as the U.S. Coast Guard.
- Any NARW sightings should be reported as soon as feasible and no later than within 24 hours to the NMFS RWSAS hotline or via the Whale Alert Application.

Data and Final Reports will be prepared using the following protocols (see **Attachment 8**):

- All vessels will utilize a standardized data entry format.
- A QA/QC'd database of all sightings and associated details (e.g., distance from vessel, behavior, species, group size/composition) within and outside of the designated SZs, monitoring effort, environmental conditions, and Project-related activity will be provided after field operations and reporting are complete. This database will undergo thorough quality checks and included all variables required by the NMFS-issued Incidental Take Authorization (ITA) and BOEM Lease OCS-A 0486 and will be required for the Final Technical Report due to BOEM and NMFS.
- During construction, weekly reports briefly summarizing sightings, detections, and activities will be provided to NMFS and BOEM on the Wednesday following a Sunday-Saturday period.
- Final reports will follow a standardized format for PSO reporting from activities requiring marine mammal mitigation and monitoring.
- An annual report will be provided to NMFS and to BOEM on April 1 every calendar year summarizing the prior year's activities.

3.7.1 Post-Construction HRG Survey Reports

Post construction, Revolution Wind will provide to BOEM and NMFS a final report annually for HRG survey activities. The final report must address any comments on the draft report provided to Revolution Wind by BOEM and NMFS. The report must include a summary of survey activities, all PSO and incident reports, and an estimate of the number of listed marine mammals observed and/or taken during these survey activities.

3.8 Noise Attenuation Systems

Noise attenuation systems (NAS) are employed during pile driving activities to reduce the sound pressure levels that are transmitted through the water in an effort to reduce ranges to acoustic thresholds and minimize acoustic impacts resulting from pile driving activities.

There are two categories of NAS, primary and secondary. A primary NAS is used to reduce the level of noise produced by the pile driving activities at the source, typically by adjusting parameters related to the pile driving methods or the impulse produced by a hammer strike. However, primary NAS are not fully effective at eliminating all harmful noise levels that can propagate from construction activities, so a secondary NAS is typically employed to further mitigate pile driving noise.

A secondary NAS is a device or devices employed to reduce the noise as it is transmitted through the water (and through the seabed) from the pile. The noise is typically reduced by some sort of physical barrier that either reflects or absorbs sound waves and therefore decreases the distance over which higher energy sound is propagated through the water column.

Primary NAS are still evolving and will be considered for mitigation when matured with demonstrated efficacy in commercial projects (e.g., blue piling). There are generally three types of secondary NAS considered for impact pile driving within the PSMMP. The final selection of the single or suite of technologies that comprise the NAS will be dependent upon the pile and environmental characteristics of the piling location. The demonstrated effectiveness of these systems is described in Bellmann et al. (2020). The three NAS technologies considered for the Project include:

- Big bubble curtain (BBC):
  - A BBC consists of a flexible tube fitted with special nozzle openings and installed on the seabed around the pile. Compressed air is forced through the nozzles producing a curtain of rising, expanding bubbles. These bubbles effectively attenuate noise by scattering sound on the air bubbles, absorbing sound, or reflecting sound off the air bubbles.
- Hydro-Sound Damper (HSD):
  - An HSD system consists of a fish net holding different sized elements arranged at various distances from each other that encapsulates the pile. HSD elements can be foam plastic or gas-filled balloons. Noise is reduced as it crosses the HSD due to reflection and absorption by air spaces contained in the elements.
- AdBm, Helmholz resonator:
  - The AdBm system consists of large arrays of Helmholtz resonators, or air fill containers with an opening on one side that can be set to vibrate at specific frequencies to absorb noise, deployed as a "fence" around pile driving activities.

There are other available systems, however, these may not be technically feasible for the Project (e.g., noise mitigation screen), are either in early stages of development, or have yet to demonstrate their expected performance during field tests and are therefore not being currently considered for use during construction of the Revolution Wind Project. Although Orsted believes 10 dB can be achieved with a single BBC, Revolution Wind is committed to achieving the modeled ranges with 10 dB of noise attenuation using a single BBC paired with an additional noise attenuation device or dBBC.

The configuration of any secondary NAS will optimize its efficacy based on the location, operations, and environmental and oceanographic parameters of the project. For the context of this PSMMP, the

standard BBC (as compared to prior wind farm deployments) configuration is defined as a BBC that has been professionally deployed and further optimized after initial deployment based on local conditions and *in-situ* measurement results.

3.9 Vessel Strike Avoidance Policy

The Project will implement a vessel strike avoidance policy for all vessels under contract to Ørsted to reduce the risk of vessel strikes and the potential of death and/or serious injury to marine mammals. In addition to vessels transiting and working (e.g., HRG surveys, construction, O&M) within the Project Area, there will be vessels transiting to and from the Project Area transporting materials, equipment, and personnel. A Project-specific vessel strike avoidance plan is provided in **Attachment 6**.

Marine mammals may not be able to avoid vessels, especially fast-moving ones, and may even have difficulty identifying the location and direction of travel of the vessel due to sound propagation characteristics in the marine environment. All vessels will comply with the vessel strike avoidance measures as specified below, except under extraordinary circumstances when complying with these requirements would put the safety of the vessel or crew at risk.

1. Vessel operators and crews shall receive protected species identification training. This training will cover sightings of marine mammals and other protected species known to occur or which have the potential to occur in the Project Area. It will include training on making observations in both good weather conditions (i.e., clear visibility, low wind, low sea state) and bad weather conditions (i.e., fog, high winds, high sea states, glare). Training will include not only identification skills but information and resources available regarding applicable federal laws and regulations for protected species. It will also cover any Critical Habitat requirements, migratory routes, seasonal variations, behavior identification, etc.
2. Vessel operators and crews will maintain a vigilant watch for marine mammals and other protected species and change course or respond with the appropriate action (e.g., slow down) to avoid striking marine mammals.
3. Vessel operators will monitor the Project's *Situational Awareness System* and the Coast Guard VHF Channel 16 as well as the Whale Alert and the NMFS RWSAS for the presence of NARWs once every PSO shift during Project-related activities.
4. All vessels will comply with NMFS regulations and speed restrictions and state regulations as applicable for NARW.
5. All vessels 65 ft (20 m) or longer subject to the jurisdiction of the U.S. will comply with the 10-knot speed restriction when entering or departing a port or place subject to U.S. jurisdiction. This includes any vessel 65 ft or longer travelling in any SMA[3] during NARW migratory and calving periods from November 1 to April 30. The Mid-Atlantic SMAs specific to the Project area include ports of New York/New Jersey and the entrance to the Delaware Bay in the vicinity of the Project area. The same speed restriction will apply to vessels travelling within important feeding areas including Cape Cod Bay from January 1 – May 15, off of Race Point from March 1 – April 30, and in the Great South Channel from April 1 – July 31.

[3] Compliance Guide for Right Whale Ship Strike Reduction Rule (50 CFR 224.105), available at: https://www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales#seasonal-management-areas---mid-atlantic

6. All vessels will comply with the approved adaptive speed plan which will include additional measures when vessels are travelling through established NARW Slow zones (See **Attachment 6**).
7. When whales are sighted, the vessel shall maintain a distance of 91 m (100 yards) or greater between the whale(s) and the vessel; for smaller cetaceans or sea turtles, a distance of 45 m (50 yards) or greater is best; for right whales this distance is 457 m (500 yards).
8. All attempts shall be made to remain parallel to the animal's course when a travelling marine mammal is sighted in proximity to the vessel in transit. All attempts shall be made to reduce any abrupt changes in vessel direction until the marine mammal has moved beyond its associated separation distance (as described above).
9. If an animal or group of animals is sighted in the vessel's path or in close proximity to it, or if the animals are behaving in an unpredictable manner, all attempts shall be made to divert away from the animals or, if unable due to restricted movements, reduce speed and shift gears into neutral until the animal(s) have moved beyond the associated separation distance (with the exception of voluntary bow riding dolphin species).

Additionally, all vessel operators will be briefed to ensure they are familiar with the measures listed above and discussed throughout this Plan. The Project will continue to support external initiatives to further mitigate marine traffic impacts and currently is a supporter of the Whale Alert system and is investing in development and advancement of the whale listening network.

4 Revolution Wind Farm Project Area

4.1 Applicable Project Area

The area covered by the PSMMP includes Lease Area OCS-A 0486, the Wind Farm Area, the RWEC, transit corridors, and cable landfall locations.

For the purpose of this Plan, the Project area is defined as state and federal waters of the Revolution Wind BOEM Lease Area OCS-A 0486, which is a portion of the Rhode Island/Massachusetts Wind Energy Area (RI-MA WEA) and Massachusetts Wind Energy Area (MA WEA) (Figure 1). Project activities include construction, HRG surveys, UXO detonations, and O&M.

The boundaries of the Project area depicted in (Figure 1) consist of the following:

- Revolution Wind Farm (RWF): area where the turbines (WTGs), array cables, offshore substation(s) (OSS), and OSS interconnector cables
- Revolution Wind Export Cable (RWEC): area in which the offshore export cable systems will be installed and the cable landfall installation

The key components of the Project for offshore infrastructure are as follows:

- Up to 100 WTGs connected by a network of inter-array cables
- Up to two OSSs connected by OSS-link cable
- Up to two export cables

The RWF is located within federal waters, in both the RI-MA WEA and the MA-WEA. The RWEC will traverse both federal and state territorial waters of Rhode Island, extending up to approximately 50 mi

(80 km) from the RWF to the Landfall Work Area at Quonset Point in North Kingstown, Rhode Island (Figure 1).

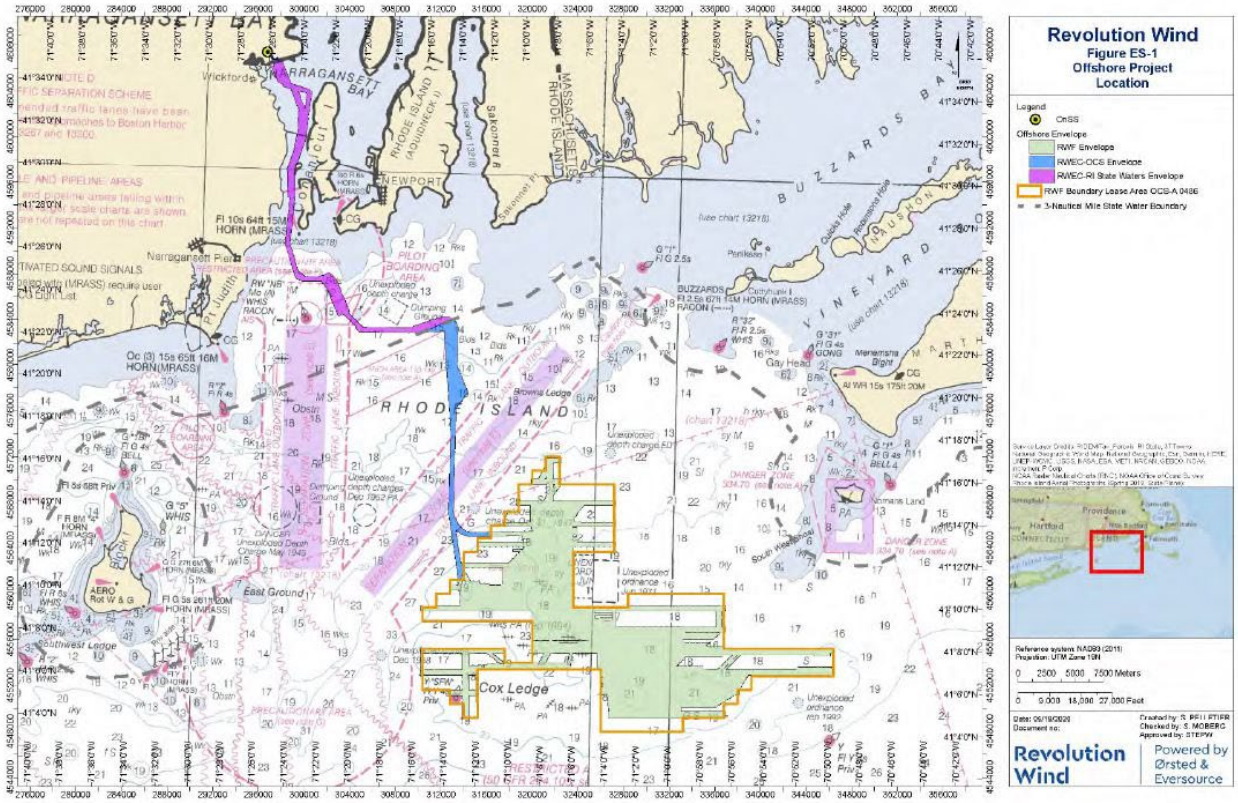


Figure 1. Location of the RWF within Lease Area OCS-A 0486 and the RWEC.

5 HRG Survey Monitoring and Mitigation

HRG survey activities may be required during construction and O&M phases of the Project. During such surveys, activities would include, but are not limited to:

- Depth sounding (multibeam depth sounders) to determine site bathymetry and elevations/seafloor morphology;
- Seafloor imaging (side-scan sonar surveys) for seabed sediment classification purposes to identify natural and man-made acoustic targets resting on the bottom as well as any anomalous features;
- Shallow-penetration Sub-bottom profiling surveys to map the near surface stratigraphy (0 m to 10 m below seabed); and
- Medium penetration sub-bottom profiling (0 m to 70 m below seabed)

When underway, HRG survey operations will be conducted 24-hours per day, although some vessels may only operate during daylight hours (12-hour survey days). To provide survey flexibility, specific locations and vessel numbers to be utilized for such surveys will be determined at the time of contractor selection.

The mitigation procedures outlined in this section have evolved from protocols and procedures that have been previously implemented for similar offshore wind projects HRG surveys within the Lease Area and approved by NMFS. Unless otherwise specified, the following mitigation measures apply to HRG survey activities for this Project. The mitigation and monitoring for HRG surveys apply only to sound sources with operating frequencies below 180 kHz. There are no mitigation or monitoring protocols required for sources operating >180 kHz.

5.1 HRG Survey Monitoring and Mitigation Zones

The monitoring and mitigation zones established in ITAs, lease conditions, and best practices are provided in **Table 2** and displayed in **Figure 2**.

Table 2: Standard monitoring and mitigation zones established for HRG survey activities.

Species	Level A Zone (SEL) (m)	Level A Zone (PK) (m)	Level B Monitoring Zone, Boomers/Sparkers (m)	Level B Monitoring Zone, all other equipment (m)	Pre-start Clearance Zone[1] (m)	Shutdown Zone (m)	Vessel Separation Distance (m)
Low-Frequency Cetaceans							
Fin whale*	1.5	<1	141	48	100	100	100
Minke whale	1.5	<1			100	100	100
Sei whale*	1.5	<1			100	100	100
Humpback whale	1.5	<1			100	100	100
North Atlantic right whale*	1.5	<1			500	500	500
Blue whale*	1.5	<1			100	100	100
Medium-Frequency Cetaceans							
Sperm whale*	<1	<1	141	48	100	100	100
Atlantic white sided dolphin	<1	<1			100	--	50
Atlantic spotted dolphin	<1	<1			100	--	50
Short-beaked common dolphin	<1	<1			100	--	50
Risso's dolphin	<1	<1			100	100	50
Bottlenose dolphin, offshore	<1	<1			100	--	50
Long-finned pilot whale	<1	<1			100	100	50
Short-finned pilot whale	<1	<1			100	100	50
High-Frequency Cetaceans							
Harbor porpoise	36.5	4.7	141	48	100	100	50
Pinnipeds in Water							
Gray seal	<1	<1	141	48	100	100	50
Harbor seal	<1	<1			100	100	50

* = denotes species listed under the Endangered Species Act; SEL = sound exposure level in units of decibels referenced to 1 micropascal squared second PK = peak sound pressure level in units of decibels referenced to 1 micropascal.
[1] Pre-start clearance zones for ESA-listed species may change based on the final Biological Opinion.
A dash "-" means no shutdown zone mitigation measures will be applied.

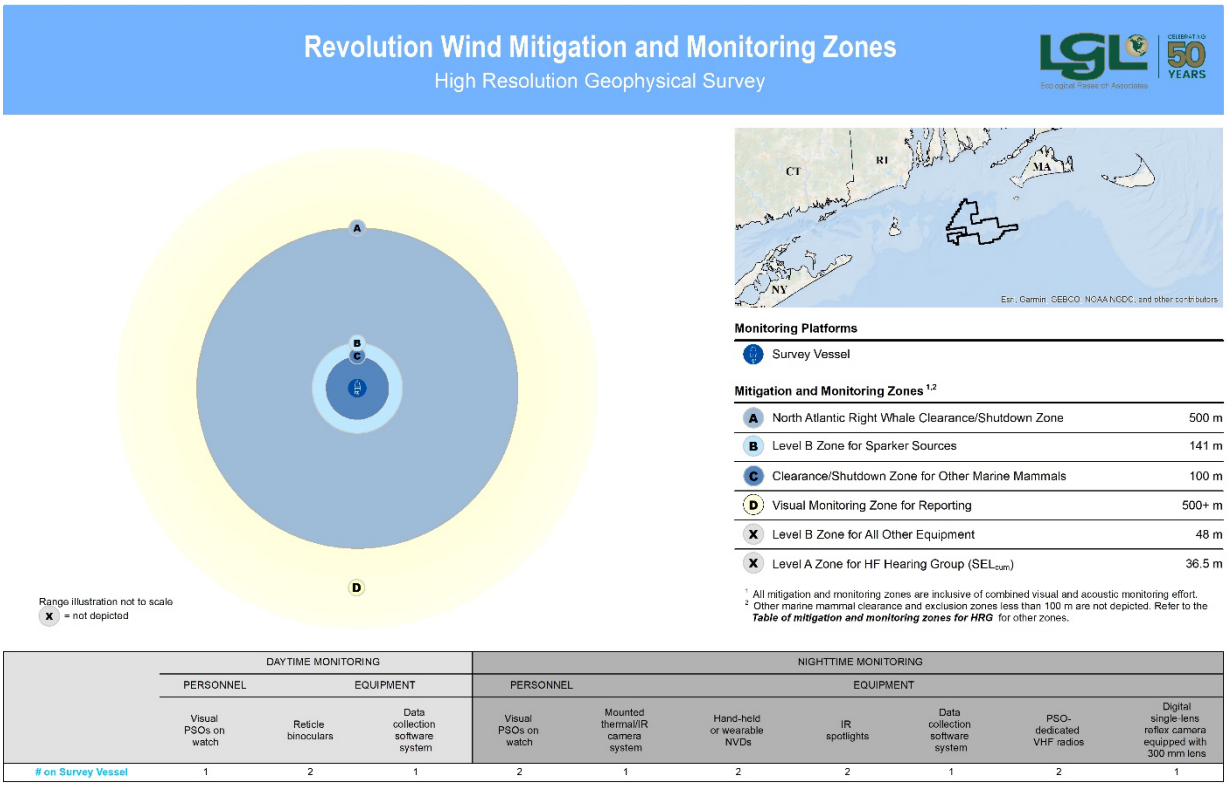


Figure 2: *Marine Mammal Mitigation and Monitoring Zones for HRG Surveys*.

Note to Figure: All large whales have a shutdown zone of 100 m except the NARW, which has a 500-m shutdown zone. Sperm whales, Risso's dolphins, and pilot whales have a 100-m shutdown zone, but there is no shutdown zone for other delphinids.

5.2 HRG Survey Monitoring and Mitigation Protocols

HRG surveys using sound sources that require mitigation per the BOEM Lease (below 180 kHz) are subject to the mitigation and monitoring protocols described in the following subsections.

There will be four to six visual PSOs on all 24-hr survey vessels, and two to three visual PSOs on all 12-hour survey vessels[4]. **Table 3** provides the list of the personnel on watch and monitoring equipment available onboard each HRG survey vessel.

Table 3: Personnel and equipment compliment for monitoring vessels during HRG surveys.

Item	# on Survey Vessel
PSOs on watch (Daytime)	1
PSOs on watch (Nighttime)	2
Reticle binoculars	2
Mounted thermal/IR camera system	1
Hand-held or wearable NVD	2

[4]A 24-hour vessel is considered any vessel expected to conduct operations after daylight hours; a 12-hour vessel is considered a vessel that conducts operations during daylight hours only.

IR spotlights	2
Data collection software system	1
PSO-dedicated VHF radios	2
Digital single-lens reflex camera equipped with 300-mm lens	1

IR = infrared; NVD = night vision devices; PSO = protected species observer; VHF = very high frequency.

5.2.1 Visual Observation Protocols and Methods

The following visual observation protocols will be implemented by all PSOs employed on Project vessels:

- Visual monitoring of the established CZs and SZs and monitoring zone will be performed by PSO teams on each survey vessel.
- Observations will take place from the highest available vantage point on all the survey vessels. General 360° scanning will occur during the monitoring periods, and target scanning by the PSO will occur if cued to a marine mammal. PSOs will adjust their positions appropriately to ensure adequate coverage of the entire shutdown and monitoring zones around the respective sound sources.
- PSOs will work in shifts such that no one PSO will work more than 4 consecutive hours without a 2-hour break or longer than 12 hours during any 24-hour period.
- The PSOs will begin observation of the CZs prior to initiation of HRG survey operations and will continue observation of the SZs throughout the survey activity and for 30 minutes following cessation of the survey activity using equipment operating below 180 kHz.
- The PSOs will be responsible for visually monitoring and identifying marine mammals approaching or entering the established zones during survey activities.
- It will be the responsibility of the PSO(s) on duty to communicate the presence of marine mammals as well as to communicate the recommended mitigation action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate.

5.2.1.1 Daytime Visual

The following protocols will be applied to visual monitoring during daytime surveys:

- One PSO on watch during pre-clearance periods and all source operations.
- PSOs will use reticle binoculars and naked eye to scan the monitoring zone for marine mammals.

5.2.1.2 Nighttime and Low Visibility Visual Observations

Visual monitoring during nighttime surveys or periods of low visibility will utilize the following protocols:

- The lead PSO will determine if conditions warrant implementing reduced visibility protocols.
- Two PSOs on watch during pre-clearance periods, all operations, and for 30 minutes following use of HRG sources operating below 180 kHz.

- Each PSO should use the most appropriate available technology (e.g., IR camera and NVD) and viewing locations to monitor the CZs and SZs and maintain vessel separation distances.

5.2.1.3 ASV Operations

Should an ASV be utilized during surveys, the following procedures will be implemented:

- PSOs will be stationed aboard the mother vessel to monitor the ASV in a location which will offer a clear, unobstructed view of the ASV's shutdown and monitoring zones.
- When in use, the ASV will be within 800 m (2,625 ft) of the primary vessel while conducting survey operations.
- For monitoring around an ASV, if utilized, a dual thermal/high definition (HD) camera will be installed on the mother vessel facing forward and angled in a direction so as to provide a field of view ahead of the vessel and around the ASV.
- PSOs will be able to monitor the real-time output of the camera on hand-held iPads or tables. Images from the cameras can be captured for review and to assist it verifying species identification.
- A monitor will also be installed on the bridge displaying the real-time picture from the thermal/HD camera installed on the front of the ASV itself, providing an additional forward field of view of the craft.
- Night-vision goggles with thermal clip-ons, as mentioned above, and a hand-held spotlight will be provided such that PSOs can focus observations in any direction around the mother vessel and/or the ASV.

5.2.2 Pre-Start Clearance

- PSOs will implement a 30-minute clearance period of the CZs immediately prior to the initiation of equipment ramp-up.
- The CZs must be visible using the naked eye or appropriate visual technology during the entire clearance period for operations to start. If the CZs are not visible, source operations <180 kHz may not commence.
- Ramp-up may not be initiated if any marine mammal(s) is detected within its respective CZ.
- If a marine mammal is observed within its respective CZ during the pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting its respective CZ or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other species).

5.2.3 Ramp-up

- Where technically feasible, a ramp-up procedure will be used for HRG survey equipment capable of adjusting energy levels at the start or re-start of HRG survey activities. Ramp-up procedures provide additional protection to marine mammals near the Project Area by allowing them to vacate the area prior to the commencement of survey equipment use at full power.
- The ramp-up procedure will not be initiated during periods of inclement conditions or if the CZs cannot be adequately monitored by the PSOs, using the appropriate visual technology for a 30-minute period immediately prior to ramp up.

- Ramp-up will begin with the power of the smallest acoustic equipment at its lowest practical power output. When technically feasible the power will then be gradually turned up and other acoustic sources added in a way such that the source level would increase gradually.
- Ramp-up activities will be delayed if a marine mammal(s) enters its respective CZ. Ramp-up will continue if the animal has been observed exiting its respective CZ or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for small odontocetes and 30 minutes for all other species).

5.2.4 Operations Monitoring

- PSOs will monitor Mysticetus (or similar data system) and/or appropriate data systems for DMAs established within their survey area.
- PSOs will also monitor the NMFS NARW reporting systems including Whale Alert and RWSAS once every PSO shift during Project-related activities within, or adjacent to, SMAs and/or DMAs.

5.2.5 Shutdown Protocols

- An immediate shutdown of the applicable HRG survey equipment (i.e., select sources operating at frequencies <180 kHz) will be required if a marine mammal is sighted at the perimeter of or within its respective SZ.
- The vessel operator must comply immediately with any call for shutdown by the Lead PSO. Any disagreement between the Lead PSO and vessel operator should be discussed only after shutdown has occurred.
- Subsequent restart of the survey equipment will not be initiated until either the marine mammal(s) that triggered the shutdown has voluntarily left and been visually confirmed beyond the relevant clearance zone, or when 30 minutes have elapsed without re-detection (for mysticetes, sperm whales, Risso's dolphins and pilot, whales) or 15 minutes have elapsed without re-detection (for all other marine mammals).

5.2.6 Pauses And Silent Periods

- If the acoustic source is shut down for reasons other than mitigation (e.g., mechanical difficulty) for less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant observation and no detections of any marine mammal have occurred within the respective SZs.
- If the acoustic source is shut down for a period longer than 30 minutes or PSOs were unable to maintain constant observation, then pre-start clearance and ramp-up procedures will be initiated as described in **Section 5.2.2 and 5.2.3**.

5.2.7 Vessel Strike Avoidance

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 3.9**).

5.2.7.1 Vessel Speed Restrictions

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 3.9**).

5.2.8 Data Recording

- All data recording will be conducted using Mysticetus or similar software.
- Operations, monitoring conditions, observation effort, all marine mammal detections, and any mitigation actions.
- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project Area as previously described.

5.3 HRG Survey Reporting

- The Project will follow reporting measures as described in **Section 3.7 and Attachment 8**.

5.3.1 DMAs

- DMAs will be reported across all vessels.

5.3.2 Injured and Dead Protected Species

- The Project will follow reporting measures as described in **Section 3.7 and Attachment 8.**

6 Mitigation and Monitoring Plan for UXO detonation

6.1 Mitigation and Monitoring Zones

Mitigation zones for UXO detonation presented here are based on the results of underwater sound propagation modeling specialized for this noise source (Hannay and Zykov 2021). Modeling was undertaken to estimate the threshold distances for onset of TTS and PTS for all functional hearing groups of marine mammals using the frequency-weighted SEL metric, for a selection of charge weights spanning all potential UXO types that may be encountered. Non-auditory injury (mortality and slight lung injury) threshold distances were modeled using the peak pressure (PK) metric, for five species groups based on body mass. The modeling for this assessment used criteria for charge weights based on definitions created by the U.S. Navy (DoN (U.S. Department of the Navy) 2017), which classified weapons and munitions into five bins based on similar characteristics and charge weight equivalent to trinitrotoluene, more commonly known as TNT. The charge weight bins were categorized and labeled as follows (2.3 kg [E4]; 9.1 kg [E6]; 45.5 kg [E8]; 227 kg [E10]; 454 kg [E12]). In this location, sound speed profiles change little with depth, so these environments do not have strong seasonal dependence. The propagation modeling was performed using a sound speed profile representative of September, which is slightly downward refracting and therefore conservative, and also represents the most likely time of year for UXO removal activities (Hannay and Zykov 2021). No UXO detonations are planned from December through April.

All mitigation and monitoring zones assume the use of an NAS resulting in a 10 dB reduction of noise levels. Mitigation and monitoring zones specific to marine mammal hearing groups for the five different charge weight bins are presented in Table 4**.** The full suite of threshold distances for non-auditory injury (impulse metric), as well as PTS and TTS (PK and SEL metrics) are presented in Hannay and Zykov (2021). Non-auditory injury and PTS are considered Level A harassment, and TTS is considered Level B harassment. Because Revolution Wind has committed to no more than a single detonation event in any given 24-hour period, no behavioral harassment is anticipated (Hannay and Zykov 2021). Four different sites (S1–S4; two within shallow depths along the export cable route and two from inside the lease area) ranging from 12-45 m water depth were chosen to model the threshold

distances for each of the five bins. PTS and TTS distances were calculated for each charge weight bin (E4–E12) and mitigation and monitoring zones were determined by selecting the largest distance to the respective thresholds from across each of the four sites.

Table 4: Mitigation and Monitoring Zones Associated with UXO Detonation of Binned Charge Weights, with a 10 dB Noise Mitigation System.

Species	UXO Charge Weight[1]									
	E4 (2.3 kg)		E6 (9.1 kg)		E8 (45.5 kg)		E10 (227 kg)		E12 (454 kg)	
	Pre-Start Clearance Zone[2] (m)	Level B Monitoring Zone[3] (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)
Low-Frequency Cetaceans										
Fin whale*	560	280	1,000	440	1,750	750	3,000	1,300	8,800	3,800
Minke whale										
Sei whale*										
Humpback whale										
NARW*										
Blue whale*										
Mid-Frequency Cetaceans										
Sperm whale*	50	90	80	140	760	230	350	390	470	500
Atlantic white-sided dolphin										
Atlantic spotted dolphin										
Short-beaked common dolphin										
Risso's dolphin										
Bottlenose dolphin, offshore										
Long-finned pilot whale										
Short-finned pilot whale										
High-Frequency Cetaceans										
Harbor porpoise	1,850	950	2,600	1,500	3,900	4,850	5,400	8,250	6,200	10,400
Phocid Pinnipeds										
Gray seal	190	160	460	260	700	450	1,220	750	1,600	950
Harbor seal										

* = denotes species listed under the Endangered Species Act; m = meters;

[1] UXO charge weights are groups of similar munitions defined by the U.S. Navy and binned into five categories (E4-E12) by weight (equivalent weight in TNT). For this assessment, four project sites (S1-S4) were chosen and modeled (see (Hannay and Zykov 2021), **Appendix B**) for the detonation of each charge weight bin.

[2] Pre-start clearance zones were determined by selecting the largest distance to a Level A threshold (the larger of either the PK or SEL noise metric). The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

[3] Level B monitoring zones were determined by selecting the largest distance to the TTS threshold (the larger of either the PK or SEL noise metric). The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

Table 5: Mitigation and Monitoring Zones Associated with Unmitigated UXO Detonation of Binned Charge Weights.

Species	UXO Charge Weight[1]									
	E4 (2.3 kg)		E6 (9.1 kg)		E8 (45.5 kg)		E10 (227 kg)		E12 (454 kg)	
	Pre-Start Clearance Zone[2] (m)	Level B Monitoring Zone[3] (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)	Pre-Start Clearance Zone (m)	Level B Monitoring Zone (m)
Low-Frequency Cetaceans										
Fin whale*	1,710	7,340	2,810	10,300	4,880	13,900	7,520	17,500	8,800	19,300
Minke whale										
Sei whale*										
Humpback whale										
NARW*										
Blue whale*										
Mid-Frequency Cetaceans										
Sperm whale*	214	1,520	385	2,290	714	3,490	1,220	5,040	1,540	5,860
Atlantic white-sided dolphin										
Atlantic spotted dolphin										
Short-beaked common dolphin										
Risso's dolphin										
Bottlenose dolphin, offshore										
Long-finned pilot whale										
Short-finned pilot whale										
High-Frequency Cetaceans										
Harbor porpoise	4,300	11,200	5,750	13,400	7,810	16,000	12,775	19,100	16,098	20,200
Phocid Pinnipeds										
Gray seal	804	4,200	1,310	6,200	2,190	9,060	3,740	12,000	4,520	13,300
Harbor seal										

* = denotes species listed under the Endangered Species Act; m = meters;

[1] UXO charge weights are groups of similar munitions defined by the U.S. Navy and binned into five categories (E4-E12) by weight (equivalent weight in TNT). For this assessment, four project sites (S1-S4) were chosen and modeled (see (Hannay and Zykov 2021), **Appendix B**) for the detonation of each charge weight bin.

[2] Pre-start clearance zones were determined by selecting the largest distance to a Level A threshold (the larger of either the PK or SEL noise metric). The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

[3] Level B monitoring zones were determined by selecting the largest distance to the TTS threshold (the larger of either the PK or SEL noise metric). The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

6.2 UXO Monitoring and Mitigation Protocols

There are six primary mitigation and monitoring efforts associated with UXO detonation:

1. Pre-start clearance;
    a) Vessel-based visual PSOs and associated visual monitoring tools stationed on the primary monitoring vessel and on any additional marine mammal monitoring vessels (when monitoring zones with radii greater than 2,000 m may require an additional monitoring vessel);
    b) Alternate Plan for clearance zones >5 km associated with unmitigated detonation: Aerial-based visual observers conducting pre-start surveys of the clearance zone.
2. PAM operators and an associated mitigation PAM array in support of the visual PSOs;
3. NMSs as feasible;
4. Post-detonation monitoring;
5. Acoustic measurement data collection to verify distances to regulatory or mitigation zones; and
6. Monitoring and mitigation protocols applicable to UXO detonation are described further in the following subsections.

There will be a team of 6 - 8 visual and acoustic PSOs on monitoring vessels**.** The number of vessels will depend on the size of the zones to be monitored. A single vessel is anticipated to adequately cover a radius of 2,000 m. There will be a team of four to eight visual and acoustic PSOs on each monitoring vessel. The number of vessels will be sufficient to observe the maximum clearance zones 100% of the time and be determined by:

- the detonation category and associated clearance zone size,
- use of NMS (as feasible), and
- minimum distance allowed to the detonation location.

PAM operators may be located remotely/onshore**.** Error! Reference source not found. provides the list of the personnel on watch and the PSO and PAM monitoring equipment available onboard the primary vessel and the additional vessel.

Table 6: Personnel and Equipment Use for all Marine Mammal Monitoring Vessels during Pre-start Clearance and Post-detonation Monitoring.

Item	Standard Daytime	Monitoring for Nighttime and Low Visibility
	Number on each PSO Vessel	
Visual PSOs on watch	2	N/A
PAM operators on duty[1]	1	
Reticle binoculars	2	
Mounted "big-eye" binocular	1	
Monitoring station for real time PAM system[2]	1	
Data collection software system	1	
PSO-dedicated VHF radios	2	
Digital single-lens reflex camera equipped with 300-mm lens	1	

PSO = protected species observer; VHF=very high frequency.

[1]The selected PAM system will transmit real time data to PAM monitoring stations on the vessels and/or a shore side monitoring station.

6.2.1 Visual Monitoring: Vessel

Visual monitoring will be conducted from the primary monitoring vessel, and additional vessels in cases where the mitigation zone cannot be covered by a single vessel. Daytime visual monitoring is defined by the period between civil nautical twilight rise and set for the region. The intent of the visual monitoring program is to provide complete visual coverage of the UXO clearance zones using the following protocols:

- During the pre-start clearance period and 60-minutes after the detonation event, two PSOs will maintain watch at all times on the primary vessel; likewise, two PSOs will also maintain watch during the same time periods from the additional vessel. During the pre-start clearance period and 60-minutes after the detonation event, two PSOs will maintain watch at all times on the primary vessel; likewise, two PSOs will also maintain watch during the same time periods from the additional vessel.
- The total number of observers will be dictated by the personnel necessary to adhere to standard shift schedule and rest requirements while still meeting mitigation monitoring requirements for the Project. A sample crew rotation is provided in Attachment 2.
- During daytime observations, two PSOs on each vessel will monitor the clearance zones with the naked eye and reticle binoculars. One PSO will periodically scan outside the clearance zones using the mounted big eye binoculars.
- PSOs will visually monitor the maximum Low Frequency (Large Whale) Level A zone which constitutes the pre-start clearance zone. This zone encompasses the maximum Level A exposure ranges for all marine mammal species except harbor porpoise, where Level A take has been requested due to the large zone sizes associated with High Frequency cetaceans.
- The number of vessels deployed will depend on monitoring zone size and safety set back distance from detonation. A sufficient number of vessels will be deployed to provide 100% temporal and spatial coverage of the clearance zones.
- There will be a PAM operator on duty (see Section 6.2.3) conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods and post-detonation monitoring periods.
- Acoustic monitoring, as described in Section 6.2.3, will include, and extend beyond, the Large Whale pre-start clearance zone.

6.2.2 Visual Monitoring: Aerial Alternative

Aerial surveys are typically limited by low cloud ceilings, aircraft availability, survey duration, and HSE considerations and therefore are not considered feasible or practical for all detonation monitoring. However, some scenarios may necessitate the use of an aerial platform. For unmitigated detonations with clearance zones greater than 5 km, deployment of sufficient vessels may not be feasible or practical. For these events, visual monitoring will be conducted from an aerial platform. The intent of the aerial visual monitoring is to provide complete visual coverage of the UXO clearance zones using the following protocols:

- During the pre-start clearance period and 60-minutes after the detonation event as flight time allows, two PSOs will be deployed on an aerial platform.

- Surveys will be conducted in a grid with 1 km line spacing, encompassing the clearance zone.
- PSOs will monitor the clearance zones with the naked eye and reticle binoculars.
- Aerial PSOs may exceed 4-hour watch duration but will be limited by total flight duration not likely to exceed 6 hours.
- PSOs will visually monitor the maximum Low-Frequency (Large Whale) Level A zone which constitutes the pre-start clearance zone. This zone encompasses the maximum Level A exposure ranges for all marine mammal species except harbor porpoise, where Level A take has been requested due to the large zone sizes associated with High-Frequency cetaceans.
- There will be a PAM operator on duty (see Section **Error! Reference source not found.**) conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods and post-detonation monitoring periods.
- Acoustic monitoring, as described in Section 6.1.3, will include, and extend beyond, the Large Whale Pre-Start Clearance Zone.

6.2.3 Passive Acoustic Monitoring

Acoustic monitoring will be conducted prior to any UXO detonation event in addition to visual monitoring in order to ensure that no marine mammals are present in the designated pre-clearance zones. PAM operators will acoustically monitor a zone that encompasses a minimum of 10 km radius around the source. PAM will be conducted in the daylight only as no UXO will be detonated during nighttime hours.

PAM devices proposed for monitoring during UXO detonation activities are not likely to be towed from the vessel, but rather will be independent (e.g., autonomous or moored remote) stations located around the area to be monitored. The specific placement of PAM devices or systems will be determined based on the final mitigation zones determined in the regulatory review process. As detailed in Attachment 4**,** there are multiple available PAM systems with demonstrated capability for monitoring and localizing marine mammal calls, including large whales, within the proposed monitoring and mitigation zones (e.g., sonobuoy arrays or similar retrievable buoy systems).

The following PAM protocols will be followed for UXO detonation events:

- It is expected there will be a PAM operator stationed on at least one of the dedicated monitoring vessels in addition to the PSOs; or located remotely/onshore.
- PAM operators will complete specialized training for operating PAM systems prior to the start of monitoring activities.
- All on-duty PSOs will be in contact with the PAM operator on-duty, who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area.
- For real-time PAM systems, at least one PAM operator will be designated to monitor each system by viewing data or data products that are streamed in real-time or near real-time to a computer workstation and monitor located on a Project vessel or onshore. No archival recording systems will be used.
- The PAM operator will inform the Lead PSO on duty of animal detections approaching or within applicable ranges of interest to the detonation activity via the data collection software system (i.e., Mysticetus or similar system). The Lead PSO will be responsible for requesting the designated crewmember to implement a delay in UXO detonation.

6.2.4 Pre-Start Clearance

A 60-min pre-start clearance period will be implemented prior to any UXO detonation. Visual PSOs will begin surveying the monitoring zone at least 60 min prior to the detonation event. PAM will also begin 60 min prior to the detonation event.

- The Large Whale clearance zone (See distances to low-frequency cetacean thresholds in **Table 4 and Table 5)** must be fully visible for at least 60 min immediately prior to commencing detonation.
- All marine mammals must be confirmed to be out of the clearance zone prior to initiating detonation.
- If a marine mammal is observed entering or within the relevant clearance zones prior to the initiation of detonation activity, the detonation must be delayed.
- The detonation may commence when either the marine mammal(s) has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, when 60 min have elapsed without redetection for whales, including the NARW, or 15 min have elapsed without redetection of dolphins, porpoises, and seals.

6.2.5 Data Recording

- All data recording will be conducted using Mysticetus or similar software.
- Operations, monitoring conditions, observation effort, all marine mammal detections, any mitigation actions, as well as any other reporting requirements prescribed by NMFS will be recorded.
- Members of the monitoring team must consult NMFS' NARW reporting systems for presence of NARWs in the Project area.

6.3 UXO Detonation Reporting

- Revolution Wind will follow reporting measures as stipulated in **Section 3.7 and Attachment 8**

6.3.1 Injured and Dead protected species

- Revolution Wind will follow reporting measures as stipulated in **Section 3.7 and Attachment 8**

6.4 Noise Attenuation for UXO Detonation

- As feasible, Revolution Wind will use a NAS for all detonation events and is committed to achieving the modeled ranges associated with 10 dB of noise attenuation (see ITA application **Section 6.3.2**). If a NAS system is not feasible, Revolution Wind will implement mitigation measures for the larger unmitigated zone sizes, with deployment of vessels or use of an aerial platform adequate to cover the entire clearance zones.

6.5 Sound Measurements during UXO Detonations

Received sound measurements will be collected during UXO detonations. The measurement plan will be similar to that described for impact pile driving provided in **Attachment 7**, which is designed to

collect data on approximate source levels, the directionality of the sounds produced, and transmission loss in at least one direction. The distances at which acoustic recorders are placed from the UXO detonation will be determined based on the modeled distances to Level A and Level B thresholds for the applicable UXO size being detonated.

- The goals of the field verification measurements include: verification of modeled ranges to the Level A harassment and Level B harassment isopleths and providing sound measurements of UXO detonations using International Organization for Standardization (ISO)-standard methodology (ISO 2017) for comparison among projects and informing future operations.

7 Construction Monitoring and Mitigation Plan for Impact Pile Driving

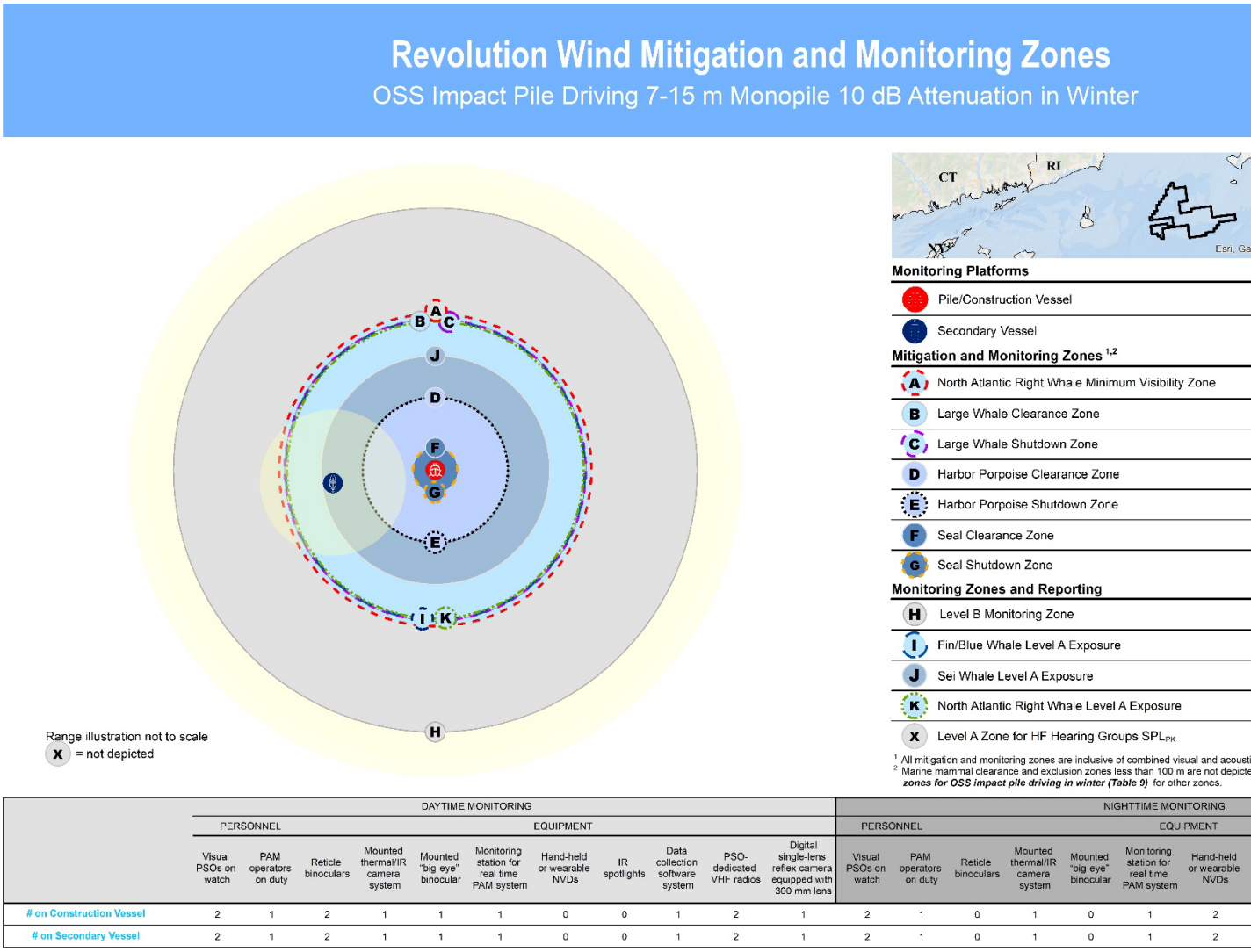
Up to 100 wind turbine generators (WTG) and up to two (2) offshore substations (OSS) will be installed on monopile foundations using impact pile driving. Each WTG foundation will have a maximum diameter of 12 m, while OSS foundations will include a maximum diameter of 15 m. Impact pile driving for both the WTG foundations and the OSS foundations will take approximately 1-4 hours (6 to 12 hours maximum) to install a single monopile foundation. After completion of the pile-driving activities for each foundation, the installation vessel will move to the next position and a secondary vessel will complete installation (i.e., attachment of external and internal platforms, commissioning, etc.).

Monitoring and mitigation zones are based on the results of underwater sound propagation modeling, which took seasonal sound speed profiles into account and defined summer as May through November, and winter as December through April (See Appendix A). No impact pile driving is planned for the months of January through April.

7.1 Impact Pile Driving Monitoring and Mitigation Zones

Mitigation and monitoring zones for Level A harassment are based on modeled, species-specific exposure ranges. The maximum exposure range was chosen for any piling scenario in a given season (summer and winter). The Level B acoustic ranges, which will be applied to all marine mammal species, are based on the R95% acoustic range for any piling scenario in the given season (unweighted R95% 160 dB threshold). The Level A exposure and acoustic ranges and Level B acoustic ranges along with the summer mitigation zones for both WTG and OSS foundations are provided in **Table 7** and **Table 9** and displayed in **Figure 3** and **Figure 5**. The corresponding zones for winter are provided in **Table 8** and

Table 10 and displayed in **Figure 4 and**



	DAYTIME MONITORING											NIGHTTIME MONITORING						
	PERSONNEL		EQUIPMENT									PERSONNEL		EQUIPMENT				
	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs
# on Construction Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2
# on Secondary Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2

Figure 6. These zones and ranges are based on the modeled monopile installation for both seasonal periods (Küsel et al. 2021) and assume 10 dB broadband noise attenuation. Mitigation zones established for all species, including NARW (See **Table 11**), will be applied accordingly depending on the month in which work is performed. Level A and Level B harassment zones implemented during the Project may be modified in consultation with and approval by NMFS, based on measurements of the received sound levels during piling operations. The sound field measurement plan is described in **Attachment 7**.

To calculate the Level B monitoring zones for WTG and OSS monopile foundations for all marine mammals in summer (May through November), the unweighted flat R95% 160 dB value each foundation type with a hammer energy of 4000 kJ (3.88 km and 4.1 km for WTG and OSS foundations respectively see Table H-1 and H-2 in Appendix A) was selected. The same method was used to calculate the Level B monitoring zone for winter (December only) (4.271 km and 4.698 for WTG and OSS foundations respectively see Tables H-3 and H-4 in Appendix A). Mitigation and monitoring zones for Level A harassment for WTG foundations assume three monopiles driven per day, and OSS foundations assume one monopile per day. The pre-start clearance zones for large whales, porpoise, and seals are based upon

the maximum non-humpback whale Level A zone for each hearing group. The North Atlantic right whale (NARW) zone was set equal to the Level B zone to avoid any unnecessary take (Tables 7-11). The shutdown zones for large whales, NARW, porpoise, and seals are based upon the maximum non-humpback Level A zone for each hearing group.

Table 7: Threshold ranges and mitigation and monitoring zones[1 2] during WTG impact pile driving in Summer (May through November).

Species	Level A Zone (m) (SEL_{cum})[3]	Level A Zone (m) (SPL_{pk})	Monitoring and mitigation zones in meters (m)[2]			Vessel Separation Distance (m)
			Level B Zone	Monitoring Zone	Pre-start Clearance and Shutdown Zone[4]	
Low-frequency Cetaceans						
Fin whale*	2,230	≤10	3,833	>3,900	2,300	100
Minke whale	1,510	≤10	3,833	>3,900	2,300	100
Sei whale*	1,810	≤10	3,833	>3,900	2,300	100
Humpback whale	2,660	≤10	3,833	>3,900	2,300	100
North Atlantic right whale*	1,930	≤10	3,833	See Table 11	See Table 11	500
Blue whale*[6]	2,230	≤10	3,833	>3,900	2,300	100
Mid-frequency Cetaceans						
Sperm whale*	-	≤10	3,833	>3,900	2,300	100
Atlantic spotted dolphin	-	≤10	3,833	>3,900	NAS[7]	50
Atlantic white-sided dolphin	-	≤10	3,833	>3,900	NAS	50
Common dolphin	-	≤10	3,833	>3,900	NAS	50
Risso's dolphin	10	≤10	3,833	>3,900	NAS	50
Bottlenose dolphin	-	≤10	3,833	>3,900	NAS	50
Long-finned pilot whale	-	≤10	3,833	>3,900	NAS	50
High-frequency Cetaceans						
Harbor porpoise	1,340	160	3,833	>3,900	1,400	50
Phocid Pinnipeds in Water						
Gray seal	440	≤10	3,833	>3,900	500	50
Harbor seal	240	≤10	3,833	>3,900	500	50

* = denotes species listed under the Endangered Species Act; dB = decibel; SEL_{cum} = cumulative sound exposure level SPL_{pk} = peak sound pressure level. NAS= Noise Attenuation System.

[1]Zones are based upon the following modeling assumptions:
8/12-m monopile installation with10 dB broadband noise attenuation from a noise mitigation system.
three monopiles driven per day

[2] Zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation.

[3] The Level A zone represents the exposure ranges of species derived from animal movement modeling.

[4] The pre-start clearance zone for large whales, porpoise, and seals is based upon the maximum non-humpback whale Level A zone rounded up for PSO clarity. The North Atlantic right whale zone was set equal to the Level B zone to avoid any unnecessary take;

[5] The shutdown zone for large whales (including North Atlantic right whale), porpoise, and seals is based upon the maximum Level A zone and rounded up for PSO clarity.

[6]No Level A exposures were calculated for blue whales resulting in no expected Level A exposure range; therefore, the exposure range for fin whales was used as a proxy due to similarities in species.

[7] Noise attenuation systems (NAS) are employed during pile driving activities to reduce the sound pressure levels that are transmitted through the water in an effort to reduce ranges to acoustic thresholds and minimize acoustic impacts resulting from pile driving activities.

Table 8: Threshold ranges and mitigation and monitoring zones[1] [2] during WTG impact pile driving in Winter (December only).

Species	Level A Zone (m) (SEL_{cum})[3]	Level A Zone (m) (SPL_{pk})	Monitoring and mitigation zones in meters (m)[2]			Vessel Separation Distance (m)
			Level B Zone	Monitoring Zone	Pre-start Clearance and Shutdown Zone[4]	
Low-frequency Cetaceans						
Fin whale*	4,380	≤10	4,271	>4,400	4,400	100
Minke whale	3,450	≤10	4,271	>4,400	4,400	100
Sei whale*	3,670	≤10	4,271	>4,400	4,400	100
Humpback whale	6,290	≤10	4,271	>4,400	4,400	100
North Atlantic right whale*	3,970	≤10	4,271	See Table 11	See Table 11	500
Blue whale*[6]	4,380	≤10	4,271	>4,400	4,400	100
Mid-frequency Cetaceans						
Sperm whale*	-	≤10	4,271	>4,400	4,400	100
Atlantic spotted dolphin	-	≤10	4,271	>4,400	NAS[7]	50
Atlantic white-sided dolphin	-	≤10	4,271	>4,400	NAS	50
Common dolphin	-	≤10	4,271	>4,400	NAS	50
Risso's dolphin	-	≤10	4,271	>4,400	NAS	50
Bottlenose dolphin	-	≤10	4,271	>4,400	NAS	50
Long-finned pilot whale	-	≤10	4,271	>4,400	NAS	50
High-frequency Cetaceans						
Harbor porpoise	2,330	160	4,271	>4,400	2,400	50
Phocid Pinnipeds in Water						
Gray seal	810	≤10	4,271	>4,400	900	50
Harbor seal	500	≤10	4,271	>4,400	900	50

* = denotes species listed under the Endangered Species Act; SELcum = cumulative sound exposure level; SPLpk = peak sound pressure level; NAS = noise attenuation system (i.e., the physical placement of the bubble curtain will preclude take in cases where the Level A zone is smaller than the distance of the NMS from the pile).

[1] Zones are based upon the following modeling assumptions (see Appendix A for details):

- 7/12-m (tapered) monopile with 10 dB broadband sound attenuation.

Three monopiles driven per day

When modeled injury (Level A) threshold distances differed among these scenarios, the largest for each species group was chosen for conservatism. Likewise, the largest modeled behavioral threshold distance for any was used to calculate the monitored Level B zone for all marine mammal species.

[2] Zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation (but not to monitor vessel separation distance).

[3] The Level A zone represents the exposure ranges of species derived from animal movement modeling.

[4] The pre-start clearance zones for large whales, porpoise, and seals are based upon the maximum non-humpback whale Level A zone for each and rounded up for PSO clarity. The NARW pre-start clearance zone was set equal to the Level B zone to avoid any unnecessary take.

[5] The shutdown zones for large whales (including NARW), porpoise, and seals are based upon the maximum Level A zone for each and rounded up for PSO clarity.

[6] No Level A exposures were calculated for blue whales resulting in no expected Level A exposure range; therefore, the exposure range for fin whales was used as a proxy due to similarities in species.

[7] Noise attenuation systems (NAS) are employed during pile driving activities to reduce the sound pressure levels that are transmitted through the water in an effort to reduce ranges to acoustic thresholds and minimize acoustic impacts resulting from pile driving activities.

Table 9: Threshold ranges and mitigation and monitoring zones during OSS impact pile driving in Summer (May through November).

Species	Level A Zone (m) (SEL_{cum})[3]	Level A Zone (m) (SPL_{pk})	Monitoring and mitigation zones in meters (m)[2]			Vessel Separation Distance (m)
			Level B Zone	Monitoring Zone	Pre-start Clearance and Shutdown Zone[4]	
Low-frequency Cetaceans						
Fin whale*	1,570	≤10	4,100	>4,100	1,600	100
Minke whale	940	≤10	4,100	>4,100	1,600	100
Sei whale*	1,220	≤10	4,100	>4,100	1,600	100
Humpback whale	1,790	≤10	4,100	>4,100	1,600	100
North Atlantic right whale*	1,250	≤10	4,100	See Table 11	See Table 11	500
Blue whale*[6]	1,570	≤10	4,100	>4,100	1,600	100
Mid-frequency Cetaceans						
Sperm whale*	-	≤10	4,100	>4,100	1,600	100
Atlantic spotted dolphin	-	≤10	4,100	>4,100	NAS[7]	50
Atlantic white-sided dolphin	-	≤10	4,100	>4,100	NAS	50
Common dolphin	-	≤10	4,100	>4,100	NAS	50
Risso's dolphin	-	≤10	4,100	>4,100	NAS	50
Bottlenose dolphin	-	≤10	4,100	>4,100	NAS	50
Long-finned pilot whale	-	≤10	4,100	>4,100	NAS	50
High-frequency Cetaceans						
Harbor porpoise	830	110	4,100	>4,100	900	50
Phocid Pinnipeds in Water						
Gray seal	370	≤10	4,100	>4,100	400	50
Harbor seal	10	≤10	4,100	>4,100	400	50

* = denotes species listed under the Endangered Species Act; SELcum = cumulative sound exposure level; SPLpk = peak sound pressure level; NAS = noise attenuation system (i.e., the physical placement of the bubble curtain will preclude take in cases where the Level A zone is smaller than the distance of the NMS from the pile).

[1] Zones are based upon the following modeling assumptions (see Appendix A for details):

- 7/15-m (tapered) monopile with 10 dB broadband sound attenuation.

One monopile driven per day

When modeled injury (Level A) threshold distances differed among these scenarios, the largest for each species group was chosen for conservatism. Likewise, the largest modeled behavioral threshold distance for any was used to calculate the monitored Level B zone for all marine mammal species.

[2] Zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation (but not to monitor vessel separation distance).

[3] The Level A zone represents the exposure ranges of species derived from animal movement modeling.

[4] The pre-start clearance zones for large whales, porpoise, and seals are based upon the maximum non-humpback whale Level A zone for each and rounded up for PSO clarity. The NARW pre-start clearance zone was set equal to the Level B zone to avoid any unnecessary take.

[5] The shutdown zones for large whales (including NARW), porpoise, and seals are based upon the maximum Level A zone for each and rounded up for PSO clarity.

[6] No Level A exposures were calculated for blue whales resulting in no expected Level A exposure range; therefore, the exposure range for fin whales was used as a proxy due to similarities in species.

[7] Noise attenuation systems (NAS) are employed during pile driving activities to reduce the sound pressure levels that are transmitted through the water in an effort to reduce ranges to acoustic thresholds and minimize acoustic impacts resulting from pile driving activities.

Table 10: Threshold ranges and mitigation and monitoring zones during OSS impact pile driving in Winter (December only).

Species	Level A Zone (m) (SEL_{cum})[3]	Level A Zone (m) (SPL_{pk})	Monitoring and mitigation zones in meters (m)[2]			Vessel Separation Distance (m)
			Level B Zone	Monitoring Zone	Pre-start Clearance and Shutdown Zone[4]	
Low-frequency Cetaceans						
Fin whale*	2,680	≤10	4,698	>4,700	2,700	100
Minke whale	1,810	≤10	4,698	>4,700	2,700	100
Sei whale*	2,050	≤10	4,698	>4,700	2,700	100
Humpback whale	3,560	≤10	4,698	>4,700	2,700	100
North Atlantic right whale*	2,660	≤10	4,698	See Table 11	See Table 11	500
Blue whale*[6]	2,680	≤10	4,698	>4,700	2,700	100
Mid-frequency Cetaceans						
Sperm whale*	-	≤10	4,698	>4,700	2,700	100
Atlantic spotted dolphin	-	≤10	4,698	>4,700	NAS[7]	50
Atlantic white-sided dolphin	-	≤10	4,698	>4,700	NAS	50
Common dolphin	-	≤10	4,698	>4,700	NAS	50
Risso's dolphin	-	≤10	4,698	>4,700	NAS	50
Bottlenose dolphin	-	≤10	4,698	>4,700	NAS	50
Long-finned pilot whale	-	≤10	4,698	>4,700	NAS	50
High-frequency Cetaceans						
Harbor porpoise	1,250	80	4,698	>4,700	1,300	50
Phocid Pinnipeds in Water						
Gray seal	370	≤10	4,698	>4,700	400	50
Harbor seal	110	≤10	4,698	>4,700	400	50

* = denotes species listed under the Endangered Species Act; SELcum = cumulative sound exposure level; SPLpk = peak sound pressure level; NAS = noise attenuation system (i.e., the physical placement of the bubble curtain will preclude take in cases where the Level A zone is smaller than the distance of the NMS from the pile).

[1] Zones are based upon the following modeling assumptions (see Appendix A for details):

- 7/15-m (tapered) monopile with 10 dB broadband sound attenuation.

One monopile driven per day

When modeled injury (Level A) threshold distances differed among these scenarios, the largest for each species group was chosen for conservatism. Likewise, the largest modeled behavioral threshold distance for any was used to calculate the monitored Level B zone for all marine mammal species.

[2] Zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation (but not to monitor vessel separation distance).

[3] The Level A zone represents the exposure ranges of species derived from animal movement modeling.

[4] The pre-start clearance zones for large whales, porpoise, and seals are based upon the maximum non-humpback whale Level A zone for each and rounded up for PSO clarity. The NARW pre-start clearance zone was set equal to the Level B zone to avoid any unnecessary take.

[5] The shutdown zones for large whales (including NARW), porpoise, and seals are based upon the maximum Level A zone for each and rounded up for PSO clarity.

[6] No Level A exposures were calculated for blue whales resulting in no expected Level A exposure range; therefore, the exposure range for fin whales was used as a proxy due to similarities in species.

[7] Noise attenuation systems (NAS) are employed during pile driving activities to reduce the sound pressure levels that are transmitted through the water in an effort to reduce ranges to acoustic thresholds and minimize acoustic impacts resulting from pile driving activities.

Table 11: NARW Clearance and Real-time PAM Monitoring Zones[1] during Impact Piling in Summer (May through November) and Winter (December only).

Season	Minimum Visibility Zone[2]	Visual Clearance Delay and shutdown (m)	PAM Monitoring Zone (km)	PAM Clearance Zone (m)[3]	PAM Shutdown Zone (m)
Summer WTG	2,300	Any Distance	10	3,900	2,300
Winter WTG	4,400	Any Distance	10	4,400[4]	4,400
Summer OSS	1,600	Any Distance	10	4,100	1,600
Winter OSS	2,700	Any Distance	10	4,700	2,700

[1] Revolution Wind may request modification to zones based on results of sound field verification.

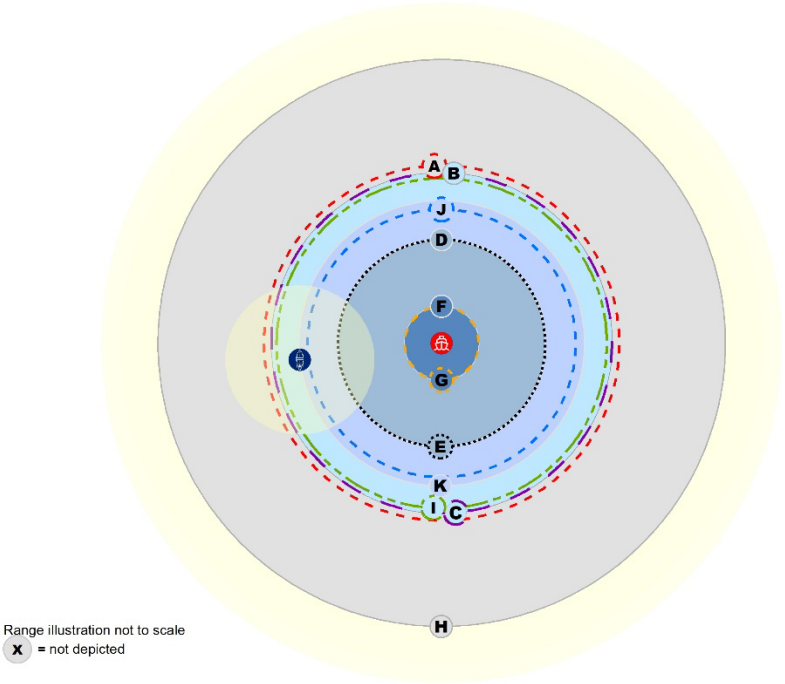
[2] The minimum visibility zones for NARWs are based upon the maximum non-humpback whale Level A zones for the whale group rounded up for PSO clarity.

[3] The PAM pre-start clearance zone was set equal to the Level B zone to avoid any unnecessary take.

[4] The Level A zone for NARW was less than the Level B zone, so the Level B zone has been used for all distances.

Revolution Wind Mitigation and Monitoring Zones

Impact Pile Driving 7-12 m Monopile 10 dB Attenuation in Summer



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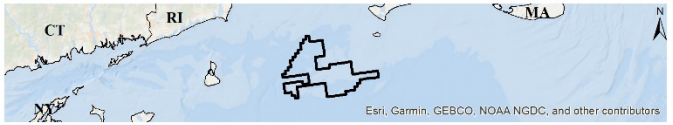


Monitoring Platforms

Pile/Construction Vessel	
Secondary Vessel	

Mitigation and Monitoring Zones [1,2]

A	North Atlantic Right Whale Minimum Visibility Zone	2,300 m
B	Large Whale Clearance Zone	2,300 m
C	Large Whale Shutdown Zone	2,300 m
D	Harbor Porpoise Clearance Zone	1,400 m
E	Harbor Porpoise Shutdown Zone	1,400 m
F	Seal Clearance Zone	500 m
G	Seal Shutdown Zone	500 m

Monitoring Zones and Reporting

H	Level B Monitoring Zone	3,833 m
I	Fin/Blue Whale Level A Exposure	2,230 m
J	Sei Whale Level A Exposure	1,810 m
K	North Atlantic Right Whale Level A Exposure	1,930 m
X	Level A Zone for HF Hearing Groups SPL_{PK}	160 m

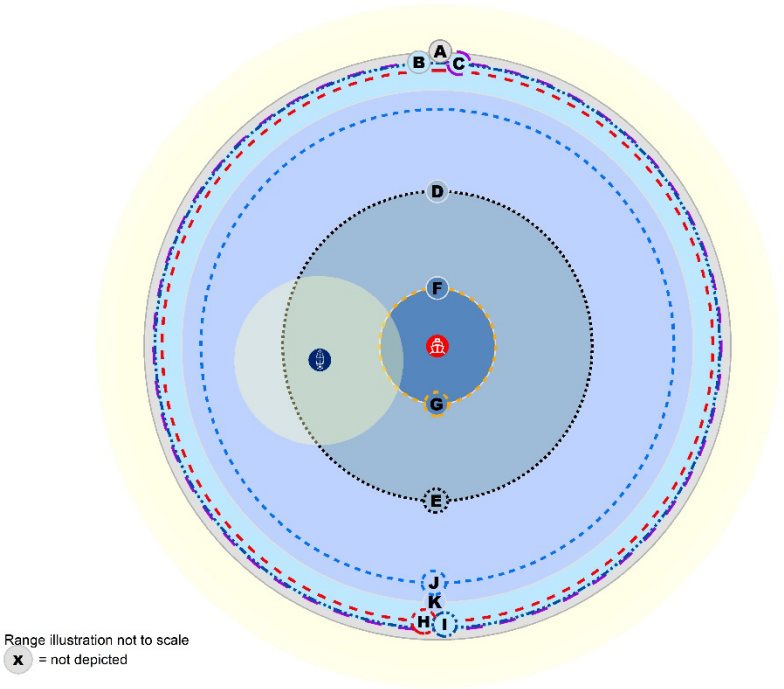
[1] All mitigation and monitoring zones are inclusive of combined visual and acoustic monitoring effort.
[2] Marine mammal clearance and exclusion zones less than 100 m are not depicted. Refer to the ***Table of mitigation and monitoring zones for WTG impact pile driving in summer (Table 6)*** for other zones.

	DAYTIME MONITORING											NIGHTTIME MONITORING										
	PERSONNEL		EQUIPMENT									PERSONNEL		EQUIPMENT							
	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens
# on Construction Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0
# on Secondary Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0

Figure 3: Marine Mammal Mitigation and Monitoring Zones during WTG Impact Pile Driving in Summer (May through November).

Revolution Wind Mitigation and Monitoring Zones

Impact Pile Driving 7-12 m Monopile 10 dB Attenuation in Winter



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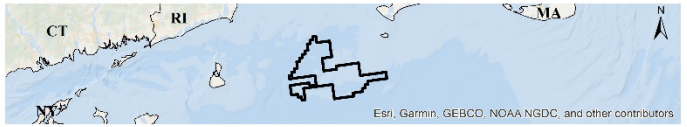


Monitoring Platforms

Pile/Construction Vessel	
Secondary Vessel	

Mitigation and Monitoring Zones [1,2]

A	North Atlantic Right Whale Minimum Visibility Zone	4,400 m
B	Large Whale Clearance Zone	4,400 m
C	Large Whale Shutdown Zone	4,400 m
D	Harbor Porpoise Clearance Zone	2,400 m
E	Harbor Porpoise Shutdown Zone	2,400 m
F	Seal Clearance Zone	900 m
G	Seal Shutdown Zone	900 m

Monitoring Zones and Reporting

H	Level B Monitoring Zone	4,271 m
I	Fin/Blue Whale Level A Exposure	4,380 m
J	Sei Whale Level A Exposure	3,670 m
K	North Atlantic Right Whale Level A Exposure	3,970 m
X	Level A Zone for HF Hearing Groups SPL_{PK}	160 m

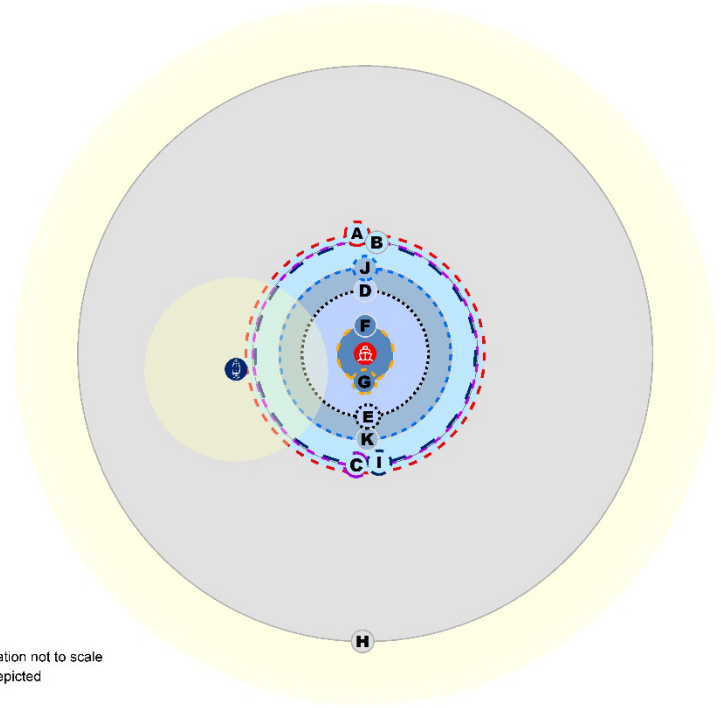
[1] All mitigation and monitoring zones are inclusive of combined visual and acoustic monitoring effort.
[2] Marine mammal clearance and exclusion zones less than 100 m are not depicted. Refer to the ***Table of mitigation and monitoring zones for WTG impact pile driving in winter (Table 7)*** for other zones.

	DAYTIME MONITORING											NIGHTTIME MONITORING										
	PERSONNEL		EQUIPMENT									PERSONNEL		EQUIPMENT								
	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens
# on Construction Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0
# on Secondary Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0

Figure 4: Marine Mammal Mitigation and Monitoring Zones during WTG Impact Pile Driving in Winter (December only).

Revolution Wind Mitigation and Monitoring Zones

OSS Impact Pile Driving 7-15 m Monopile 10 dB Attenuation in Summer



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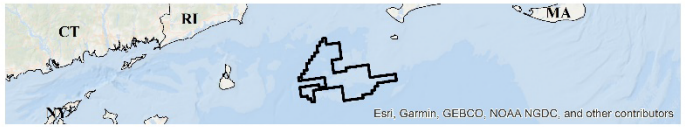


Monitoring Platforms

Pile/Construction Vessel	
Secondary Vessel	

Mitigation and Monitoring Zones [1,2]

A	North Atlantic Right Whale Minimum Visibility Zone	1,600 m
B	Large Whale Clearance Zone	1,600 m
C	Large Whale Shutdown Zone	1,600 m
D	Harbor Porpoise Clearance Zone	900 m
E	Harbor Porpoise Shutdown Zone	900 m
F	Seal Clearance Zone	400 m
G	Seal Shutdown Zone	400 m

Monitoring Zones and Reporting

H	Level B Monitoring Zone	4,100 m
I	Fin/Blue Whale Level A Exposure	1,570 m
J	Sei Whale Level A Exposure	1,220 m
K	North Atlantic Right Whale Level A Exposure	1,250 m
X	Level A Zone for HF Hearing Groups SPL_{PK}	110 m

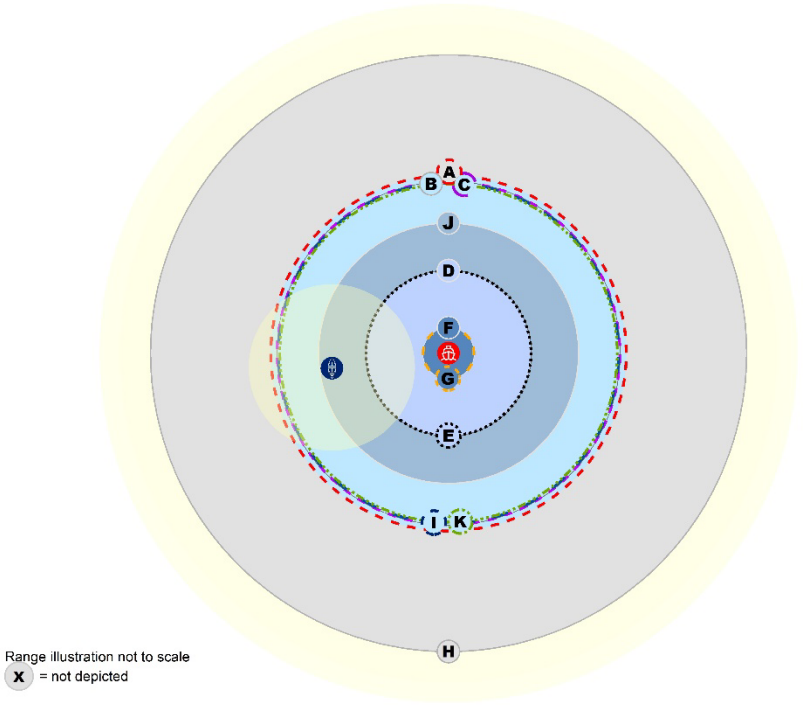
[1] All mitigation and monitoring zones are inclusive of combined visual and acoustic monitoring effort.
[2] Marine mammal clearance and exclusion zones less than 100 m are not depicted. Refer to the ***Table of mitigation and monitoring zones for OSS impact pile driving in summer (Table 8)*** for other zones.

	DAYTIME MONITORING											NIGHTTIME MONITORING										
	PERSONNEL		EQUIPMENT									PERSONNEL		EQUIPMENT								
	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens
# on Construction Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0
# on Secondary Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0

Figure 5: Marine Mammal Mitigation and Monitoring Zones during OSS Impact Pile Driving in Summer (May through November).

Revolution Wind Mitigation and Monitoring Zones

OSS Impact Pile Driving 7-15 m Monopile 10 dB Attenuation in Winter



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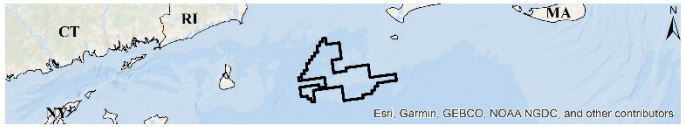


Monitoring Platforms

Pile/Construction Vessel	
Secondary Vessel	

Mitigation and Monitoring Zones [1,2]

A	North Atlantic Right Whale Minimum Visibility Zone	2,700 m
B	Large Whale Clearance Zone	2,700 m
C	Large Whale Shutdown Zone	2,700 m
D	Harbor Porpoise Clearance Zone	1,300 m
E	Harbor Porpoise Shutdown Zone	1,300 m
F	Seal Clearance Zone	400 m
G	Seal Shutdown Zone	400 m

Monitoring Zones and Reporting

H	Level B Monitoring Zone	4,698 m
I	Fin/Blue Whale Level A Exposure	2,680 m
J	Sei Whale Level A Exposure	2,050 m
K	North Atlantic Right Whale Level A Exposure	2,660 m
X	Level A Zone for HF Hearing Groups SPL_{PK}	80 m

[1] All mitigation and monitoring zones are inclusive of combined visual and acoustic monitoring effort.
[2] Marine mammal clearance and exclusion zones less than 100 m are not depicted. Refer to the ***Table of mitigation and monitoring zones for OSS impact pile driving in winter (Table 9)*** for other zones.

	DAYTIME MONITORING											NIGHTTIME MONITORING										
	PERSONNEL		EQUIPMENT									PERSONNEL		EQUIPMENT								
	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens	Visual PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Monitoring station for real time PAM system	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens
# on Construction Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0
# on Secondary Vessel	2	1	2	1	1	1	0	0	1	2	1	2	1	0	1	0	1	2	2	1	2	0

Figure 6: Placeholder for a figure of the Marine Mammal Mitigation and Monitoring Zones during OSS Impact Pile Driving in Winter (December only).

7.2 Impact Pile Driving Project Monitoring and Mitigation Protocols

There are four primary mitigation and monitoring efforts associated with impact pile driving:

1) Vessel-based visual PSOs and associated visual monitoring tools stationed on the construction and any secondary marine mammal monitoring vessels will monitor at night for marine mammals and other protected species using night-vision goggles with thermal clip-ons and a hand-held spotlight;
2) PAM operators and an associated mitigation PAM array in support of the visual PSOs;
3) Noise attenuation systems (NAS); and
4) Acoustic measurement data collection to verify distances to regulatory or mitigation zones.

Monitoring and mitigation protocols applicable to impact pile driving activities during RWF construction are described further in the following subsections. Impact pile driving may be initiated after dark or during reduced visibility periods following the protocols in **Sections 7.2.1** through **7.2.4** and include utilization of alternative monitoring methods. Pile driving during nighttime hours could potentially occur when a pile installation is started during daylight and, due to unforeseen circumstances, would need to be finished after dark.

There will be a team of six to eight visual and acoustic PSOs on the pile driving vessel, and a team of four to eight visual and acoustic PSOs on any secondary marine mammal monitoring vessel (secondary vessel). PAM operators may be located remotely/onshore. Table 12 provides the list of the personnel on watch and the PSO and PAM monitoring equipment available onboard the construction vessel and the secondary vessel.

Table 12: Personnel and equipment use for all marine mammal monitoring vessels during pre-start clearance, impact pile driving, and post piling monitoring.

Item	Standard Daytime		Monitoring for Nighttime and Low Visibility	
	# on Construction Vessel	# on Secondary Vessel	# on Construction Vessel	# on Secondary Vessel
Visual PSOs on watch	2	2	2	2
PAM operators on duty[1]	1	1	1	1
Reticle binoculars	2	2	0	0
Mounted thermal/IR camera system[2]	1	1	1	1
Mounted "big-eye" binocular	1	1	0	0
Monitoring station for real time PAM system[3]	1	1	1	1
Hand-held or wearable NVDs	0	0	2	2
IR spotlights	0	0	2	2
Data collection software system	1	1	1	1
PSO-dedicated VHF radios	2	2	2	2
Digital single-lens reflex camera equipped with 300-mm lens	1	1	0	0

IR = infrared; NVD = night vision device; PSO = Protected Species observer; VHF=very high frequency.
[1] PAM operator may be stationed on the vessel or at an alternative monitoring location.

[2] The camera systems will be automated with detection alerts that will be checked by a PSO on duty; however, cameras will not be manned by a dedicated observer.
[3] The selected PAM system will transmit real time data to PAM monitoring stations on the vessels and/or a shore side monitoring station.

7.2.1 Daytime Visual Monitoring

Visual monitoring will occur from the construction vessel and a secondary vessel. Daytime visual monitoring is defined by the period between nautical twilight rise and set for the region. The intent of the visual monitoring program is to provide complete visual coverage of the clearance zone during the clearance period prior to pile driving and the SZs during impact pile driving using the following protocols:

- During the pre-start clearance period, throughout pile driving, and 30-minutes after piling is completed, two PSOs will maintain watch at all times on the construction vessel; likewise, two PSOs will also maintain watch during the same time periods from the secondary vessel.
- The total number of observers will be dictated by the personnel necessary to adhere to standard shift schedule and rest requirements while still meeting mitigation monitoring requirements for the Project. A sample crew rotation is provided in **Attachment 2**.
- It is expected the full complement of PSOs will not always be required (i.e., full coverage will be in place during piling activities, however, in between piling events, the PSO team can consist of only one PSO on duty). Piling is anticipated to take approximately 1-4 hours (12 hours maximum) per piling event (i.e., 4 hours at a given foundation location) after which the construction vessel moves away to a new location for the next piling event.
- During daytime observations, two PSOs on each vessel will monitor the clearance zone and SZ with the naked eye and reticle binoculars. One PSO will periodically scan outside the SZ using the mounted big eye binoculars.
- PSOs will visually monitor, the maximum Level A zone which constitutes the pre-start clearance zone. This zone encompasses the maximum Level A exposure ranges for all marine mammal species.
- PSOs will visually monitor the harbor porpoise, pinniped, and dolphin SZs **Table 7, Table 8, Table 9**, and **Table 10** .
- The secondary vessel will be positioned and circling at the outer limit of the Large Whale SZ (**Figures 3-6).**
- PSOs stationed on the secondary vessel will ensure the outer portion of the SZs and pre-start clearance zone are visually monitored.
- There will be a PAM operator on duty (see **Section 6.2.3**) conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods, piling, and post-piling monitoring periods.
- Acoustic monitoring, as described in **Section 6.2.3,** will extend beyond the Large Whale Pre-Start Clearance Zone.
- The NARW pre-start clearance zone will be monitored visually out to the extent of the Large Whale SZ and acoustically out to the extent of the Level B zone.

7.2.2 Daytime Periods of Reduced Visibility

- If the monitoring zone is obscured, the two PSOs on watch on each vessel will continue to monitor the SZ utilizing thermal camera systems and PAM.
- During nighttime or other low visibility conditions, two PSO on each vessel will monitor the SZ with the mounted IR camera and available handheld night vision as able.
- All on-duty PSOs will be in contact with the PAM operator on-duty who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area.

7.2.3 Nighttime Visual: Construction and Secondary Vessel

- During nighttime operations, visual PSOs on-watch will rotate in pairs: one observing with an NVD and one monitoring the IR thermal imaging camera system. There will also be a PAM operator on duty (see next section) conducting acoustic monitoring in coordination with the visual PSOs.
- The mounted thermal cameras may have automated detection systems or require manual monitoring by a PSO.
- PSOs will focus their observation effort during nighttime watch periods within the SZs and waters immediately adjacent to the vessel.
- If possible, deck lights will be extinguished or dimmed during night observations when using the NVDs (strong lights compromise the NVD detection abilities); alternatively, if the deck lights must remain on for safety reasons, the PSO will attempt to use the NVDs in areas away from potential interference by these lights.

7.2.4 Passive Acoustic Monitoring

Since visual observations within the applicable SZs can become impaired at night or during daylight hours due to fog, rain, or high sea states, visual monitoring with thermal and NVDs will be supplemented by PAM during these periods. A PAM operator will be on watch during all pre-start clearance, piling operations and post monitoring periods. A combination of alternative monitoring measures, including PAM, has been demonstrated to have comparable detection rates (although limited to vocalizing individuals) to daytime visual detections for several species (Smith et al. 2020).

PAM devices proposed for monitoring during Project impact pile driving activities are not likely to be towed from the vessel, but rather will be independent (e.g., autonomous or moored remote) stations located around the area to be monitored. The specific placement of PAM devices or systems will be determined based on the final mitigation zones determined in the regulatory review process. As detailed in **Attachment 4** there are multiple available PAM systems with demonstrated capability for monitoring and localizing marine mammal calls, including large whales, within the proposed monitoring and mitigation zones (e.g. sonobuoy arrays or similar retrievable buoy systems).

PAM will be used to monitor the following zones during piling:

- PAM operators will acoustically monitor a zone that encompasses the Level B zone for all marine mammals, which also encompasses the NARW clearance zone and Level A zones for all marine mammal species.

In general, the following monitoring protocols related to PAM will be followed for this Project:

- A PAM operator will be stationed on at least one of the dedicated monitoring vessels in addition to the PSOs; or the PAM operator may be located remotely/onshore if the PAM system allows for remote monitoring.
- PAM operators will complete specialized training for operating PAM systems prior to the start of monitoring activities.
- All on-duty PSOs will be in contact with the PAM operator on-duty, who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area.
- For real-time PAM systems, at least one PAM operator will be designated to monitor each system by viewing data or data products that are streamed in real-time or near real-time to a computer workstation and monitor located on a Project vessel or onshore.
- The PAM operator will inform the PSOs on duty, who will be responsible for requesting that the Lead PSO implement the necessary mitigation protocols of, at least, probable or confirmed, detections of all of marine mammals, and possible detections of NARW via the data collection software system (i.e., Mystcetus or similar system).
- Acoustic monitoring during nighttime and low visibility conditions during the day will complement visual monitoring (e.g., visual PSOs and thermal cameras) and will cover an area of at least the SZ around each foundation.

7.2.5 Mitigation Measures During Impact Pile Driving

Mitigation measures implemented during a piling event include:

- Pre-start clearance;
- Soft start of the pile strikes;
- Post-piling monitoring;
- Shutdowns, and
- Monitoring during unforeseen pauses in piling

The parameters of these mitigation measures are summarized in **Table 13, Table 14,**

Table 15**,** and **Table 16** for summer (May through November) and winter (December only) mitigation measures respectively and detailed in **Section 7.2.5.1** through **7.2.5.5** below.

Table 13: Summary of mitigation measures during WTG impact pile driving with a noise attenuation system in Summer (May through November).

	Piling with an NAS, 10 dB broadband attenuation				
	NARW	Large Whale	Delphinids	Harbor Porpoise	Seals
Pre-Start Clearance and Shutdown Zone[1 2]	At any distance[3]	2,300 m	N/A	1,400 m	500 m
Clearance Duration	60 min visual monitoring, 60 min PAM monitoring; zone must be clear for 30 min				
Soft Start	All Piles				
Post-piling monitoring	30 min				

m=meters; min=minutes; NARW=North Atlantic right whale; NAS=Noise Attenuation System
[1] Clearance and Shutdown zones will be monitored using a combination of visual and acoustic methods.
[2] Shutdowns may be initiated by either visual or acoustic detection. Only acoustic detections that meet criteria (e.g. localization) for determining that the call originated inside the given zone will be considered for mitigation.
[3]The NARW visual clearance delay and shutdown zone will occur at any distance.

Table 14: Summary of mitigation measures during WTG impact pile driving with a noise attenuation system in Winter (December only).

	Piling with an NAS, 10 dB broadband attenuation				
	NARW	Large Whale	Delphinids	Harbor Porpoise	Seals
Pre-Start Clearance and Shutdown Zone[1 2]	At any distance[3]	4,400 m	N/A	2,400 m	900 m
Clearance Duration	60 min visual monitoring, 60 min PAM monitoring; zone must be clear for 30 min				
Soft Start	All Piles				
Post-piling monitoring	30 min				

m=meters; min=minutes; NARW=North Atlantic right whale; NAS=Noise Attenuation System
[1] Clearance and Shutdown zones will be monitored using a combination of visual and acoustic methods.
[2] Shutdowns may be initiated by either visual or acoustic detection. Only acoustic detections that meet criteria (e.g. localization) for determining that the call originated inside the given zone will be considered for mitigation.
[3]The NARW visual clearance delay and shutdown zone will occur at any distance.

Table 15: Summary of mitigation measures during OSS impact pile driving with a noise attenuation system in Summer (May through November).

	Piling with an NAS, 10 dB broadband attenuation				
	NARW	Large Whale	Delphinids	Harbor Porpoise	Seals
Pre-Start Clearance and Shutdown Zone[1 2]	At any distance[3]	1,600 m	N/A	900 m	400 m
Clearance Duration	60 min visual monitoring, 60 min PAM monitoring; zone must be clear for 30 min				
Soft Start	All Piles				
Post-piling monitoring	30 min				

m=meters; min=minutes; NARW=North Atlantic right whale; NAS=Noise Attenuation System
[1] Clearance and Shutdown zones will be monitored using a combination of visual and acoustic methods.
[2] Shutdowns may be initiated by either visual or acoustic detection. Only acoustic detections that meet criteria (e.g. localization) for determining that the call originated inside the given zone will be considered for mitigation.
[3]The NARW visual clearance delay and shutdown zone will occur at any distance.

Table 16:Summary of mitigation measures during OSS impact pile driving with a noise attenuation system in Winter (December only).

	Piling with an NAS, 10 dB broadband attenuation				
	NARW	Large Whale	Delphinids	Harbor Porpoise	Seals
Pre-Start Clearance and Shutdown Zone[1 2]	At any distance[3]	2,700 m	N/A	1,300 m	400 m
Clearance Duration	60 min visual monitoring, 60 min PAM monitoring; zone must be clear for 30 min				
Soft Start	All Piles				
Post-piling monitoring	30 min				

m=meters; min=minutes; NARW=North Atlantic right whale; NAS=Noise Attenuation System
[1] Clearance and Shutdown zones will be monitored using a combination of visual and acoustic methods.
[2] Shutdowns may be initiated by either visual or acoustic detection. Only acoustic detections that meet criteria (e.g. localization) for determining that the call originated inside the given zone will be considered for mitigation.
[3]The NARW visual clearance delay and shutdown zone will occur at any distance.

7.2.5.1 Pre-Start Clearance

A 60-minute pre-start clearance period that will be implemented for impact pile driving activities. Visual PSOs will begin surveying the monitoring zone at least 60 minutes prior to the start of pile driving. PAM monitoring will also begin at least 30-minutes prior to the start of piling.

- The large whale clearance zone (2,300 m or as modified) must be fully visible for at least 30 minutes prior to commencing ramp-up.
- All marine mammals must be confirmed to be out of the clearance zone prior to initiating soft start.
- If a marine mammal is observed entering or within the relevant clearance zones prior to the initiation of pile driving activity, pile driving activity will be delayed.

- An acoustic detection localized to a position within the CZ(s) will trigger a delay.
- A NARW sighted at any distance will trigger a delay.
- Impact pile driving may commence when either the marine mammal(s) has voluntarily left the respective clearance zone and been visually confirmed beyond that clearance zone, or, when 30 minutes have elapsed without re-detection for whales, including NARW; or 15 minutes have elapsed without re-detection of dolphins, porpoises, and seals.

7.2.5.2 Soft Start

Every monopile installation will begin with a soft start procedure of a minimum of 20-minute duration. The soft start procedure is detailed in Table 17.

- Soft start of pile driving will not begin until the CZ has been cleared by the visual PSO (and PAM operators when applicable).
- If any marine mammals are detected within the applicable CZ prior to or during the soft start, activities will be delayed until the animal has been observed exiting the CZ or until an additional time period has elapsed with no further sighting.

Table 17: Generic soft start procedure overview.

% of max hammer blow energy	Soft Start
	10–20%
Monopile blow energy	600–800 kJ
Strike Rate	4–6 strikes/min
Duration	Minimum of 20 minutes or greater until pile verticality/self-stability is secured.

kJ=kilojoule.

7.2.5.3 Post-Piling Monitoring

- PSOs will continue to survey the monitoring zone using visual and acoustic protocols throughout the pile installation and for a minimum of 30 minutes after piling has been completed.

7.2.5.4 Shutdown Protocols

For reference, a generic piling procedure has been broken down into three different steps where blows, strike ratio and duration envelopes are defined. The Piling Procedure follows these general criteria:

1. The piling schedule (and therefore resulting sound field) does not exceed the maximum scenario modelled for regulatory authorizations.
2. Refusal criteria is not exceeded
   (i) 125 blows/25 centimeters (cm) over an increment of 6 × 25 cm
   (ii) 200 blows/25 cm over an increment of 2 × 25 cm
   (iii)325 blows/25 cm over an increment of 1 × 25 cm.
3. The hammer drives the pile to target penetration.

If a marine mammal is entering or within the respective SZs (or a NARW sighted at any distance) after pile driving has commenced, an immediate shutdown of pile driving will be implemented unless RW

and/or its contractor determines shutdown is not feasible due to an imminent risk of injury or loss of life to an individual; or risk of damage to a vessel that creates risk of injury or loss of life for individuals.

There are two scenarios, approaching pile refusal and pile instability, where this imminent risk could be a factor (*See Deferred Shutdown Scenarios*).

If shutdown is called for but RW and/or its contractor determines shutdown is not feasible due to risk of injury or loss of life, reduced hammer energy must be implemented.

After a shutdown, pile driving must only be initiated once all SZs are confirmed by PSOs to be clear of marine mammals for the minimum species-specific time periods.

Deferred Shutdown Scenarios: Scenarios that would prevent shutdown of piling operations typically have a low likelihood of occurrence based on Ørsted's extensive pile driving experience and low occurrence of these situations.

Scenario 1: **Pile Refusal**: The pile driving sensors indicate the pile is approaching refusal, and a shutdown would lead to a stuck pile which then poses an imminent risk of injury or loss of life to an individual, or risk of damage to a vessel that creates risk for individuals.

Risk Likelihood/Mitigation: Each pile is specifically engineered to manage the sediment conditions at the location at which it is to be driven, and therefore designed to avoid and minimize the potential for piling refusal. Ørsted uses these pre-installation engineering assessments and design together with real-time hammer log information during installation to track progress and continuously judge whether a stoppage would cause a risk of injury or loss of life. Due to this advanced engineering and planning, circumstances under which piling could not stop if a shutdown is requested are very limited.

Scenario 2: Pile Instability: For a specified project and installation vessel, weather conditions criteria will be established that determine when a piling vessel would have to "let go" of a pile being installed for safety reasons. A pile may be deemed unstable and unable to stay standing if the piling vessel were to "let go". During these periods of instability, the lead engineer may determine a shutdown is not feasible because the shutdown combined with impending weather conditions may require the piling vessel to "let go" which then poses an imminent risk of injury or loss of life to an individual, or risk of damage to a vessel that creates risk for individuals.

Risk Likelihood/Mitigation: To reduce the risk that a requested shutdown would not be possible due to weather, Ørsted actively assesses weather, using two independent forecasting systems. Initiation of piling also requires a *Certificate of Approval* by the Marine Warranty Supervisor. In addition to ensuring that current weather conditions are suitable for piling, this *Certificate of Approval* process considers forecasted weather for 6 hours out and will evaluate if conditions would limit the ability to shut down and "let go" of the pile. If a shutdown is not feasible due to pile instability and weather, piling would continue only until a penetration depth sufficient to secure the pile is achieved. As piling instability is most likely to occur during the soft start period, and soft start cannot commence till the Marine Warranty Supervisor has issued a Certificate of Approval that signals there is a current weather window of at least 6 hours, the likelihood is low for the pile to not achieve stability within the 6-hour window inclusive of stops and starts.

7.2.5.5 Pauses and Silent Periods

- The SZ and clearance zone must be continuously monitored by PSOs and PAM during any pauses in pile driving.

- If marine mammals are sighted within the SZ during a pause in piling, resumption of pile driving will be delayed until the animal(s) has moved outside the SZ or when 30 minutes have elapsed without redetection for whales, including the NARW, or 15 minutes have elapsed without redetection of dolphins, porpoises, and seals. Vessel Strike Avoidance
- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 3.9**)

7.2.5.6 Vessel Speed Restrictions

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 3.9**)

7.2.6 Data Recording

- All data recording will be conducted using Mysticetus or similar software.
- Operations, monitoring conditions, observation effort, all marine mammal detections, and any mitigation actions will be recorded as well as any other reporting requirements prescribed by NMFS.
- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project Area.
  - Mysticetus will alert PSOs of any new sightings posted to the Mysticetus map. In addition, Mysticetus maintains "watch dogs" which will ensure the electronic link to NMFS-SAS and other 3rd party sources remains active.

7.3 Impact Pile Driving Reporting

- Revolution Wind will follow reporting measures as described in **Section 3.7 and Attachment 8**.

7.3.1 DMAs

- DMAs will be reported across all Project vessels.

7.3.2 Injured and Dead Protected Species

- The Project will follow reporting measures as described in **Section 3.7 and Attachment 8**.

7.4 Noise Attenuation for Impact Pile Driving

- The Project will use a NAS for all piling events and is committed to achieving the modeled ranges associated with 10 dB of noise attenuation (See **ITA Application Section 6.3.2**).

7.5 Sound Measurements during Impact Pile Driving

Received sound measurements will be collected during driving of the first three monopiles installed over the course of the Project using a NAS. The measurement plan is provided in **Attachment 7.**

- The goals of the field verification measurements using an NAS include: verification of modeled ranges and the distances to the Level A harassment and Level B harassment isopleths; and providing sound measurements of impact pile driving using International Organization for Standardization (ISO)-standard methodology to build data that are comparable among projects (ISO 2017).

7.5.1 Potential modification of Clearance Zones and SZs

- Based on the sound field measurement results the Project may request a modification of the clearance and/or SZs (see **Attachment 7**).

8 Construction Plan for Vibratory Pile Driving of Sheet Pile

The sea-to-shore transition will include a new onshore transition vault, cable installed using horizontal directional drilling under the beach and intertidal water. Construction activities may include the temporary installation of a casing pipe, supported by sheet pile "goal" posts. Installation of casing pipe would be completed using pneumatic pipe ramming equipment while installation of sheet pile for goal posts or a cofferdam would be completed using a vibratory pile driving hammer. If project conditions require a temporary cofferdam, it will be constructed as a sheet piled structure into the sea floor or a gravity cell structure placed on the sea floor.

8.1 Monitoring and Mitigation Zones

Table 18 provides the ranges to all thresholds and monitoring zones applied during vibratory sheet pile installation and removal of each goal post or cofferdam. No noise attenuation is proposed due to the short time period of the activities and relatively low source levels. No Level A exposures are expected from vibratory sheet pile installation or removal; however acoustic ranges were modeled for reference. The Level A ranges are acoustic ranges and therefore represent the maximum distance at which a stationary receiver (i.e., animal) could exceed SEL_{cum} thresholds over a 24-hour period. Exposure ranges (which were not modeled for vibratory pile driving) are expected to be small enough such that no Level A exposures are anticipated.

The Level A acoustic ranges, Level B acoustic range, Level B monitoring zone, mitigation zones, and vessel separation distances for vibratory sheet pile driving are provided in **Table 18**. To estimate distances to Level A and Level B thresholds acoustic modeling was recently performed for the Sunrise Wind project at that project's anticipated HDD exit pit location approximately 0.5 mi (800 m) offshore of Long Island, New York near Smith Point. This location has similar water depths and shallow substrate conditions as found at the landfall location in Narragansett Bay so the modeling results are expected to be applicable to the Revolution Wind project. Modeling methods were the same as those summarized above for impact pile driving of monopile foundations, including the use of GRLWEAP, PDSM and FWRAM models. Mitigation zones established for all species, including NARW, will be applied during all months of the year in which work is performed. Monitoring zones implemented during the Project may be modified, with NMFS approval based on measurements of the received sound levels during piling operations.

Table 18: Distances to Level A and Level B isopleths and mitigation and monitoring zones[1] [2] during Project vibratory sheet pile driving.

Species	Level A Acoustic Range[3] (SEL_{cum}) (m)	Level A Acoustic Range (SPL_{pk}) (m)	Level B Acoustic Range/Monitoring Zone (m)	Pre-start Clearance Zone[4] (m)	Shutdown Zone[4] (m)	Vessel Separation Distance (m)
Low-Frequency Cetaceans						
Fin whale*	5	N/A	9,740	200	10	100
Minke whale	5	N/A	9,740	200	10	100
Sei whale*	5	N/A	9,740	200	10	100
Humpback whale	5	N/A	9,740	200	10	100
NARW*	5	N/A	9,740	200	10	500
Blue whale*	5	N/A	9,740	200	10	100
Medium-Frequency Cetaceans						
Sperm whale*	N/A	N/A	9,740	200	10	100
Atlantic white sided dolphin	N/A	N/A	9,740	200	10	50
Atlantic spotted dolphin	N/A	N/A	9,740	200	10	50
Short-beaked common dolphin	N/A	N/A	9,740	200	10	50
Risso's dolphin	N/A	N/A	9,740	200	10	50
Bottlenose dolphin, offshore	N/A	N/A	9,740	200	10	50
Long-finned pilot whale	N/A	N/A	9,740	200	10	50
High-Frequency Cetaceans						
Harbor porpoise	190	N/A	9,740	200	200	50
Pinnipeds in Water						
Gray seal	10	N/A	9,740	200	50	50
Harbor seal	10	N/A	9,740	200	50	50

* = denotes species listed under the Endangered Species Act; SEL_{cum} = cumulative sound exposure level; SPL_{pk} = peak sound pressure level; NA= not applicable (i.e., Level A take will be requested for these species so no shutdown will be implemented).

[1] Zone monitoring will be achieved using visual observation

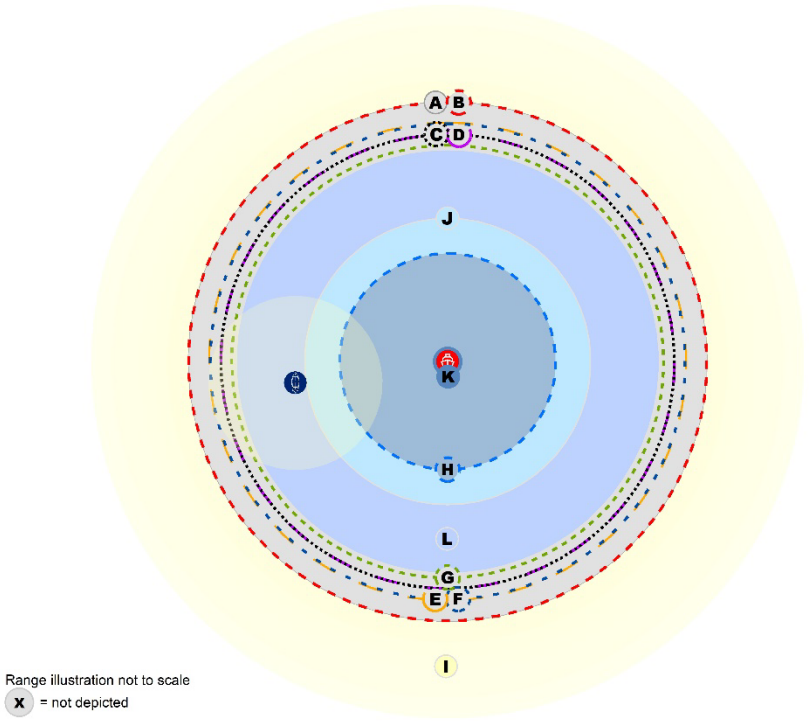
[2] The Level A zone represents the acoustic ranges of species with no animal movement modelling applied

[3] The pre-start clearance zones for all marine mammals are based upon the maximum Level A zone (190 m) and rounded up for PSO clarity.

[4] The shutdown zones for large whales (including NARW) are based upon the maximum Level A zone for each group and rounded up for PSO clarity.

Revolution Wind Mitigation and Monitoring Zones

Vibratory Sheet Pile Driving



Range illustration not to scale

X = not depicted

Monitoring Platforms	
Pile/Construction Vessel	
Secondary Vessel	
Mitigation and Monitoring Zones [1,2]	
A Large Whale Clearance Zone	100 m
B Large Whale Shutdown Zone	100 m
C Mid-Frequency Cetacean Clearance Zone	100 m
D Mid-Frequency Cetacean Shutdown Zone	100 m
E Harbor Porpoise Clearance Zone	100 m
F Harbor Porpoise Shutdown Zone	100 m
G Seal Clearance Zone	100 m
H Seal Shutdown Zone	50 m
Monitoring Zones and Reporting	
I Level B Monitoring Zone	10,000 m
J Low-Frequency Cetacean Level A Exposure	66.2 m
K Mid-Frequency Cetacean Level A Exposure	5.9 m
L High-Frequency Cetacean Level A Exposure	97.8 m
X Level A Zone for HF Hearing Groups SPL_{PK}	N/A m

[1] All mitigation and monitoring zones are inclusive of combined visual and acoustic monitoring effort.
[2] Refer to the ***Table of mitigation and monitoring zones for vibratory sheet pile driving in (Table 13)*** for other zones.

	DAYTIME MONITORING								
	PERSONNEL	EQUIPMENT							
	PSOS on watch	Reticle binoculars	Mounted thermal/IR camera system	Mounted "big-eye" binocular	Hand-held or wearable NVDs	IR spotlights	Data collection software system	PSO-dedicated VHF radios	Digital single-lens reflex camera equipped with 300 mm lens
# on Construction Vessel	2	2	1	1	2	2	1	2	1

Figure 7: Marine Mammal Mitigation and Monitoring Zones during Vibratory Pile Driving.

8.2 Vibratory Sheet Pile Driving Project Monitoring and Mitigation Protocols

Visual monitoring protocols will be in place for all vibratory sheet pile installation and removal. All observations will take place from one of the construction vessels stationed at or near the sheet piling location. No PAM operations will be utilized due to the likelihood of masking effects of the vibratory pile driving activities which will result in ineffective acoustic monitoring opportunities. **Table 19** provides the list of the personnel on watch and monitoring equipment available onboard the construction vessel.

Table 19: Personnel and equipment compliment for monitoring vessels during vibratory pile driving.

Item	# on Construction Vessel
PSOs on watch	2
Reticle binoculars	2
Mounted thermal/IR camera system	1
Mounted "big-eye" binocular	1
Hand-held or wearable NVDs	2
IR spotlights	2
Data collection software system	1
PSO-dedicated VHF radios	2
Digital single-lens reflex camera equipped with 300-mm lens	1

IR = infrared; NVD = night vision device; PSO = protected species observer; VHF = very high frequency.

8.2.1 Visual Observation Protocols and Methods

8.2.1.1 Daytime Visual

- Visual monitoring will occur from the construction vessel to provide complete visual coverage of the marine mammal CZ and SZs during vibratory sheet pile installation and removal.
- Two PSOs will maintain watch on the construction vessel during the pre-start clearance period (**Section 7.2.1**), throughout vibratory pile installation and removal, and 30-minutes after piling is completed.
- Two PSOs will conduct observations concurrently. The total number of observers will be dictated by the personnel necessary to adhere to standard schedule and rest requirements while meeting Project mitigation monitoring requirements. A sample crew shift rotation is shown in **Attachment 2**.
- PSOs will visually monitor the CZ and SZs.
- One observer will monitor the CZ and SZs with the naked eye and reticle binoculars. One PSO will monitor in the same way but will periodically scan outside the SZ using the mounted big eye binoculars.

8.2.1.2 Daytime Visual during Periods of Low Visibility

- During daytime low visibility conditions, one PSO will monitor the CZ and SZs with the mounted IR camera while the other maintains visual watch with the naked eye / binoculars.

8.2.1.3 Nighttime Visual

- Construction at the landfall site will not occur at night.

8.2.2 Pre-Start Clearance

- PSOs will monitoring the clearance zone for 30 minutes prior to start of vibratory pile driving.
- If a marine mammal is observed entering or within the CZ piling cannot commence until the animal has exited the CZ or time has elapsed since the last sighting (30 minutes for large whales, 15 minutes for dolphins, porpoises, and pinnipeds).

8.2.3 Operations Monitoring

- PSOs will continue to survey the SZ using visual protocols throughout the vibratory pile driving and for a minimum of 30 minutes after piling has been completed.

8.2.4 Shutdown Protocols

- If a marine mammal is observed entering or within the respective SZs after sheet pile installation has commenced, a shutdown will be implemented as long as health and safety is not compromised.

8.2.5 Pauses and Silent Periods

- The SZ must be continuously monitored by PSOs during any pauses in vibratory pile driving
- If marine mammals are sighted within the respective SZ during a pause in vibratory pile driving, activities will be delayed until the animal(s) has moved outside the SZ or when 30 minutes have elapsed without redetection for whales, including the NARW, or 15 minutes have elapsed without redetection of dolphins, porpoises, and seals.

8.2.6 Vessel Strike Avoidance

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 3.9**).

8.2.6.1 Vessel Speed Restrictions

- The Project will follow vessel strike avoidance measures outlined previously in the *Vessel Strike Avoidance Policy* section (**Section 3.9**)

8.2.7 Data Recording

- All data recording will be conducted using Mysticetus software.
- Operations, monitoring conditions, observation effort, all marine mammal detections, mitigation actions, and any other recording requirements prescribed by NMFS.

- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project Area.

8.3 Reporting

- The Project will follow reporting measures as described in **Section 3.7 and Attachment 8**.

8.3.1 DMAs

DMAs will be reported across all vessels.

8.3.2 Injured and Dead Protected Species

- The Project will follow reporting measures as described in **Section 3.7 and Attachment 8**

8.4 Sound Measurements during Vibratory Pile Driving

Received sound measurements will be collected during vibratory pile driving at the landfall construction site. The measurement plan will be similar to that described for impact pile driving provided in **Attachment 7**, which is designed to collect data on approximate source levels, the directionality of the sounds produced, and transmission loss in at least one direction. The number and location of recorders may be reduced to measurements conducted in open water locations due to the presence of nearby land. The distances at which acoustic recorders are placed from the landfall construction will be determined based on the modeled distances to the acoustic thresholds for vibratory pile driving.

- The goals of the field verification measurements include: verification of modeled ranges to the harassment threshold isopleths and providing sound measurements of vibratory pile driving using International Organization for Standardization (ISO)-standard methodology (ISO 2017) for comparison among projects and informing future operations.

9 Operations Mitigation and Monitoring Protocols

Long-term visual and PAM efforts will be employed to assess the potential impacts of the Project on protected species in the Project area and support the *Vessel Strike Avoidance Plan*. Pre-construction surveys will provide a baseline set of data for comparison against the monitoring efforts during construction. Using the same monitoring methodologies during post-construction, surveys will provide for an assessment of the potential long-term impacts of the Project. Several different methodologies will be employed to assess Project-related impacts including vessel-based visual surveys as well as PAM efforts via both static and non-static deployment methodologies.

Activities occurring during operations that require monitoring for marine mammals will follow the protocols outlined in **Section 5**. HRG surveys will be monitored using the visual techniques outlined in **Section 6**.

9.1 Visual Monitoring for Operations

It is expected that during operations and maintenance phases of the Project, regular maintenance will occur. This will typically involve vessel movement. Crew transfer vessels (CTVs) will transport

people and equipment continuously back and forth from Port to station, and service operation vessels (SOVs) will remain in the immediate vicinity of the operation and move crew in close transits around the area. During these two types of activities, visual monitoring will occur following protocols described in Sections **5.2.1**, **6.2.1**, and **6.2.2**. Mitigations will be in place to reduce the threat of ship strikes. These are described in detail in **Section 3.9**. In the event that there may need to be other than routine maintenance (e.g., blade replacement or nacelle work), the same visual methods and protocols will be applied as discussed in **Section 5**, as appropriate. Acoustic monitoring and appropriate mitigations will be implemented as warranted during operations.

9.2 Passive Acoustic Monitoring for Operations

Most operations-related, non-construction activities are expected to consist of maintenance, support, and transport vessels. Appropriate types of PAM for marine mammals during these activities may include the use of towed hydrophone arrays and static PAM buoys for activities that are fixed and restricted to a well-defined area. See Table 1 provided in **Attachment 4** for some examples of systems that could be used.

9.2.1 Autonomous Acoustic Recorders and Moored PAM Buoys

Operational monitoring using PAM requires systems that are intended to operate for relatively long periods of time (e.g., months to years) and are capable of monitoring marine mammals over relatively large areas (e.g., the entire Lease Area or possibly beyond). Examples of suitable hardware systems include autonomous recorder arrays, radio-linked PAM buoy, ASVs (e.g., wave-gliders), or some combination of these systems (e.g., "hybrid" systems). The relative costs and general advantages versus disadvantages of each of these are described below. As discussed previously, cabled systems are not considered here.

AARs are available in a variety of configurations and specifications (**Attachment 4**) (Sousa-Lima et al. 2013). Typically, AARs are deployed on the seafloor for a period of time ranging from several days, weeks, or months to up to 1 year. They are later retrieved from the seafloor, and the data are downloaded. An acoustic release device is typically used to release the recorder from the seafloor; however, grappling methods can also be used in some shallow water environments (usually 50 m or less). Some shallow water systems can also be retrieved by divers, but this approach is becoming less common with more reliable and low-cost release devices and also due to safety issues. Once retrieved, the recording devices can be serviced, the data downloaded, and the devices then re-deployed for additional missions. A major disadvantage of AARs over other systems is that because they record and store data internally, the recorders must be retrieved in order to access the data. Therefore, AARs are not capable of real-time monitoring. However, due to their autonomous nature, an advantage of these systems is that an infinite variety of deployment configurations is possible.

Most autonomous recorders consist of a single omni-directional hydrophone; therefore, it is not possible to obtain bearings or localizations to sound sources from this type of single device. However, other advanced systems utilize a directional (e.g., DIFAR) hydrophone/sensor, or multiple hydrophones connected to a single multi-channel recorder (e.g., a hydrophone array) and thus can localize. In some systems, multiple AAR units can be precisely time-synchronized (e.g., using an acoustic pinger or electronic cable) so that bearings can be obtained, and, in some deployment configurations, localization of sound sources is thus possible (**Attachment 4**).

One downside of autonomous recorder systems is that if a failure occurs (e.g., electronic malfunction, flooding, or a failure to retrieve them), significant volumes of data can be lost. This issue is of particular concern for long-term deployments. Also, the data storage and batteries required for extended deployment periods increase the sizes and costs of these systems. Finally, there is a cost associated with deployment and retrieval, which typically requires a vessel with a hoist, A-frame, or other heavy machinery. The size of vessel required depends on the size and ease of deployment of the AAR system. Some smaller systems can be deployed from a small boat or rigid-hulled inflatable boat, while others might require a large and costly research or other vessel with an A-frame. Finally, the fact that data must be post-processed results in an additional analysis expense. However, depending on the level of and type of processing, this approach is usually less expensive (per unit of data collected) than real-time monitoring, which typically requires experienced and relatively costly personnel working on vessels or platforms at sea.

Real-time (e.g., radio-linked) PAM buoys can be used for regional monitoring of large areas and have an advantage over AARs in that they can telemeter data to shore or a monitoring station nearby in real, or near real-time. Examples of real-time PAM buoys are provided in **Attachment 4**.

There are also hybrid systems that have some components of both real-time and autonomous systems. For example, many types of real-time systems also record data internally, so they can function both as real-time systems, and as autonomous recorders in case the radio or satellite link is not reliable. Some hybrid systems only send status reports or whale-call detection summaries to shore or a vessel nearby via the radio or satellite link. The optimal system will depend on cost considerations, the target species, the length of deployment desired, and a variety of other factors. The details of the operational monitoring system used will be determined once the goals, priorities, and requirements of the regional PAM are known. It is important to realize that there is no single system that is capable of mitigation and monitoring of all species of marine mammals for all areas and noise conditions, so it is possible that several systems, or combinations of systems, will be needed.

10 Regional Long-Term Monitoring Impacts

Regional monitoring systems are defined here as ones that are intended to operate for long periods of time (e.g., months to years in mission duration) and are capable of monitoring marine mammals in the entire Lease Area and possibly beyond. PAM-based systems can be deployed for periods of months to years, and, depending on the species and environments being monitored, can monitor relatively large areas (e.g., tens to hundreds of square kilometers for some of the larger species of whales). Examples of the types of hardware systems include AAR arrays, radio-linked PAM buoy arrays, autonomous underwater vehicles (AUV; e.g., Slocum glider), ASVs (e.g., wave-gliders), or some combination of these systems (e.g., "hybrid" systems) (Attachment 4). Although cabled PAM devices are a possible option for long-term PAM, they are not considered here (e.g., high installation and maintenance costs, environmental issues related to cable laying, permitting).

10.1 Bottom Deployed Autonomous Recorders

AARs are described in **Section 3.4.3** and are a good option for long-term monitoring. The type of system chosen will depend on the monitoring priorities (species and areas to be monitored), the

environment (e.g., water depths), bottom fishing (e.g., trawling) in the area to be monitored, and other factors. Several systems and their capabilities are provided in **Attachment 4**, **Table 4-2**.

10.2 Autonomous Mobile PAM

Mobile systems are defined here as systems that are not fixed (e.g., moored or bottom deployed) at one location. Examples of mobile systems include AUVs, ASVs, and drifting PAM buoys. Examples of drifting PAM buoys include sonobuoys, the Que-phone, Drifting Autonomous Spar Buoy Recorders (DASBRS), and SonarPoint (in the drifter configuration). Due to their drifting nature, these systems are typically deployed in pelagic environments, or for very short periods (e.g., sonobuoys). Because the Lease Area is a fixed region that needs to be monitored for relatively long periods of time (months to years), drifting buoys are not considered a good option for PAM of marine mammals in this area. Therefore, drifting PAM buoys are not considered further. A review for ASVs and AUVs was recently conducted by Verfuss et al. (2019). If an autonomous mobile PAM system is selected to be used for long-term monitoring, details of the protocols will be provided along with the system's capabilities and specifications.

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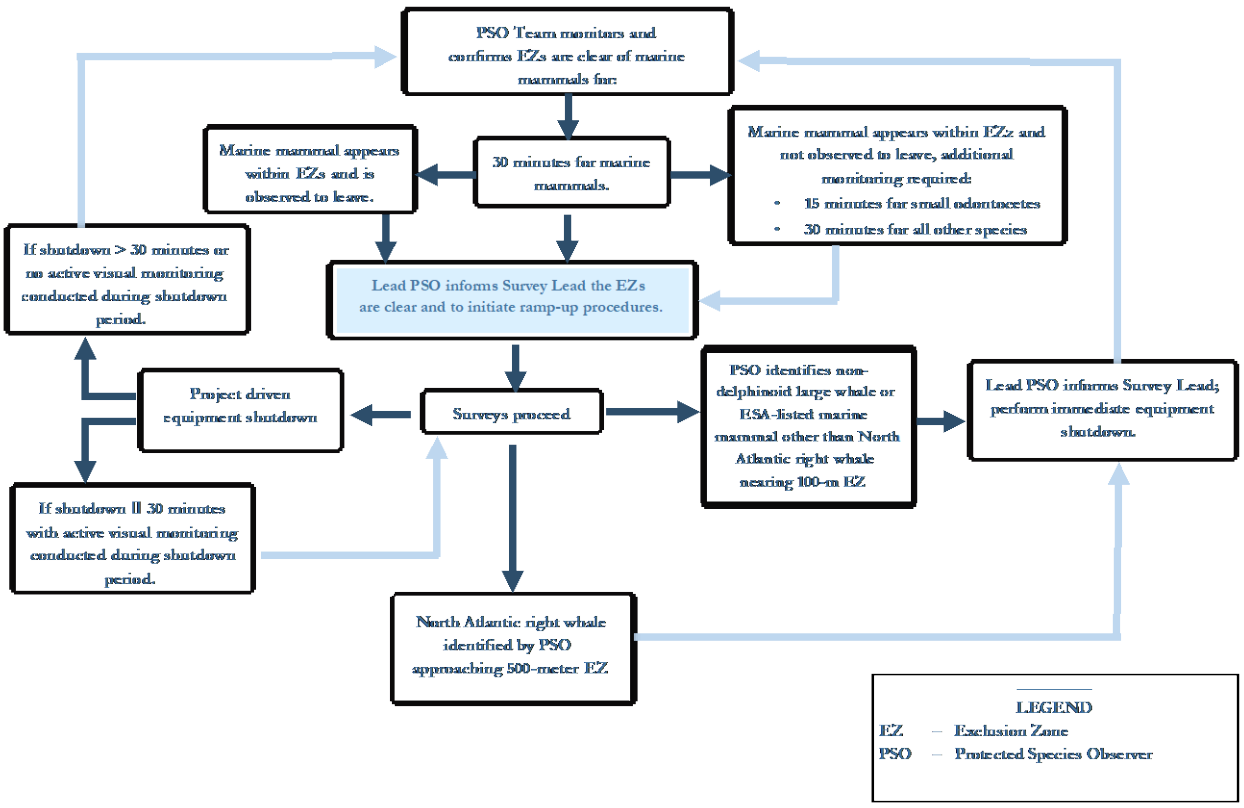
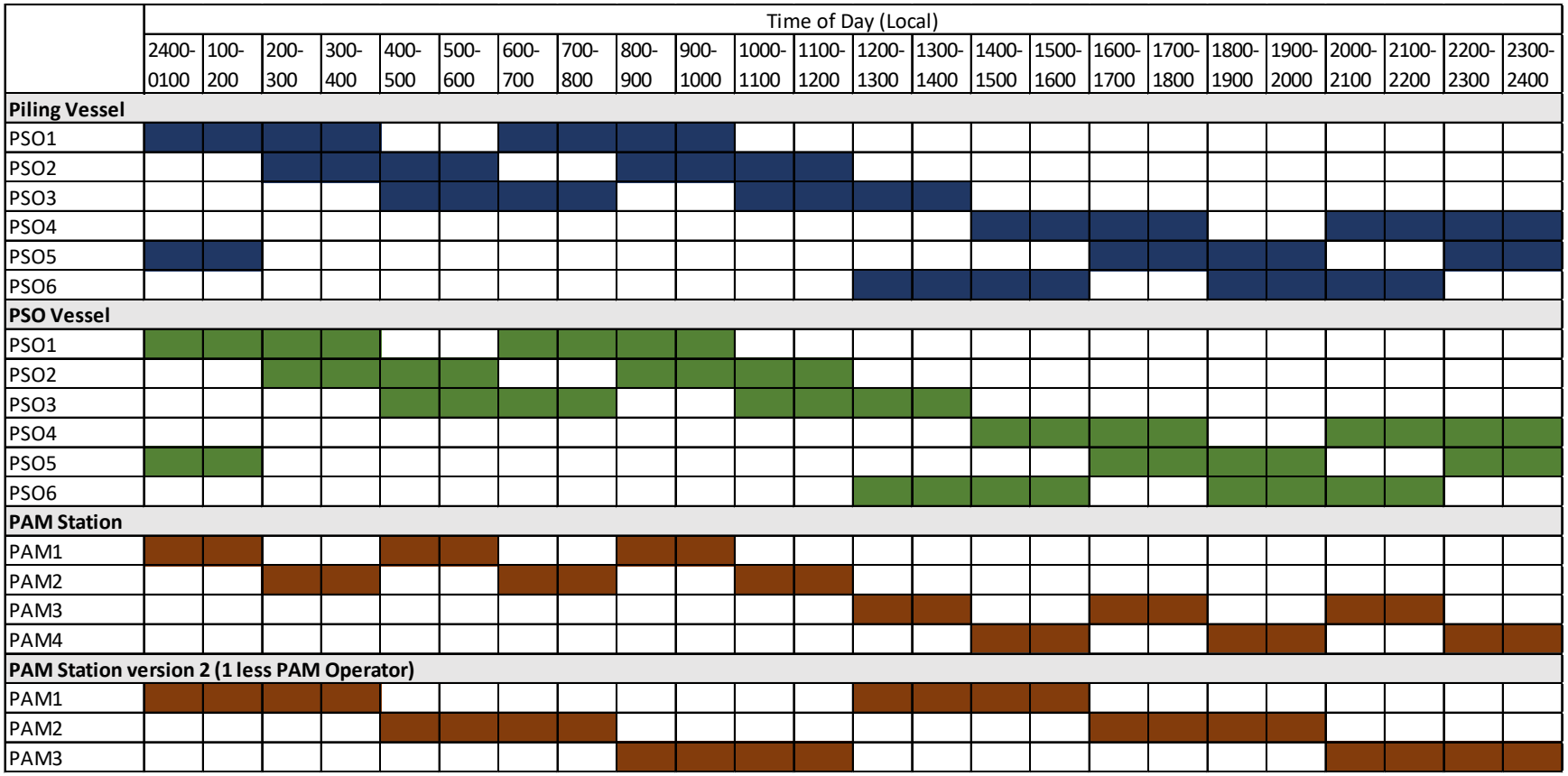
Attachment 1: PSO Communication Flow Diagram

Attachment 1: PSO Communication Flow Diagram



Attachment 2: Examples of Observation Zones and PSO/PAM Team Configurations

Attachment 2: Examples of Observation Zones and PSO/PAM Team Configurations



Example PSO and PAM operator schedules for monitoring during foundation installation pile driving.

	Time of Day (Local)																							
	2400-0100	100-200	200-300	300-400	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100	2100-2200	2200-2300	2300-2400
HRG Vessel																								
PSO1																								
PSO2																								
PSO3																								
PSO4																								
PSO5																								

Example PSO schedule for monitoring during HRG surveys.

	Time of Day (Local)																
	400-500	500-600	600-700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-1900	1900-2000	2000-2100
Piling Vessel / PSO Vesel																	
PSO1																	
PSO2																	
PSO3																	
PSO4																	
PSO5																	

Example PSO schedule for monitoring during pile driving at the landfall construction site. PSO observations indicated by green cells would only be necessary if pile driving occurred on days with longer daylight periods.

Attachment 3: Review of NVD Systems

Attachment 3: Review of NVD Systems

Table 3-1. Technical specifications of infrared (IR) systems selected for review (presented in alphabetical order).[1]

Model[1]	Field of View (Degrees; or Horizx Vert)	Detector Type[2]	IR Focal Length	Resolution	Pan/Tilt
AGM-HS Gen 3 Hand Select Night Vision Monocular	40°	Uncooled LW planar	26 mm	64-72 lp/mm[3]	N/A
Current Scientific Corporation Night Navigator 2526	8.3 - 52.5° Choice of multiple lenses available	Uncooled LW planar	25 - 75 mm 3X optical zoom	640 x 480 1280x1024 expected in year 2021	Variable 360° pan at 40° per second, tilt -90° / +30°
Current Scientific Corporation NN6056	1.7 - 32.2°	Cooled MW	22 X optical zoom	640x512	
Current Scientific Corporation NN8000	180/360° FOV	Uncool LW coupled with Cooled MW	Uncooled – fixed 52.5° Cooled Varying	Uncooled 1280x1024 cooled up to 1280x1024	Uncooled 360° continuous Cooled 360° with a seek rate of 90° per second
FLIR M400 Thermal Machine Camera	6 - 18°	Uncooled LW planar	35 - 105 mm 4X optical & 4X digital zoom	640 x 480	variable 360°, +/- 90° tilt
FLIR Ocean Scout 640	18 x 14	Uncooled LW planar	4X digital zoom	640 x 512	N/A
FLIR MD625 Thermal Imager	25 x 20	Uncooled LW planar	25 mm 4X zoom	640 x 480	N/A
FLIR M324XP	24 x 18	Uncooled LW planar	19 mm 2X zoom	320 x 240	360° pan +/- 90° tilt
FLIR Armasight Command Pro 336	13 x 10	Uncooled LW planar	25 mm 4X zoom	640 x 480	N/A
FLIR ThermaCam Ex series	45 x 34	Uncooled LW planar	unknown, no zoom	120 x 90	N/A
NVTS Reliant 640HD	15.5 x 11.6	Uncooled LW planar	40 mm 4X digital zoom	640 x 480	360° pan -15x90 reversible

Model[1]	Field of View (Degrees; or Horizx Vert)	Detector Type[2]	IR Focal Length	Resolution	Pan/Tilt
NVTS Guardian 4HD	25.5 x 21	Uncooled LW Planar	15 – 300 mm 20X optical zoom	640 x 512	360° pan -60 x 70 reversible
Rheinmetall AIMMMS	360 x 18	Cooled LW rotating line scanner	unknown	640 x 480	rotating line scanner giving 360° FOV and 12° tilt
Seiche HD Thermal Camera	18°	Uncooled LW planar	4X digital zoom	640 x 480	120° pan
Seiche Dual Camera System (supersedes HD Thermal above)	Six options - 7.5 mm to 50 mm fixed	Uncooled LW planar	8 X digital zoom	640x480	+/- 168° pan -90 x 25
Xenics	4.2 - 42° range of lenses	Cooled MW planar	Up to 210 mm	640 x 480	fixed

[1] Listed is published information. Omissions are due to either manufacturer or research data not readily available.

[2] Most uncooled planar-based detectors are Vanadium Oxide (VoX) long–wavelength (*i.e.*, 7.5–14µm) microbolometer, thermal sensitivity of <0.05°C unless noted otherwise.

[3] lp/mm: a metric for resolution indicated as 'line pairs per millimeter'.

Source:(Smultea et al. 2021).

Table 3-2. Technical specifications of night vision device (NVD; i.e., low-light amplifying/enhancing) imaging systems known to be in use for detecting cetaceans at sea.

Model	FOV (Degrees)	Detector type	Focal length	Resolution	Pan/Tilt
ATN PVS7-3 night vision goggles	60°	Unknown	27 mm	64 lp/mm	N/A
Electrophysics Astroscope[1]	Depends on lens type used	Unknown	Depends on lens type used	Depends on lens type used	N/A

[1] Manufacturer data currently unavailable at the time of this writing. This device is mentioned here to acknowledge its recent use for sea-based mitigation work(e.g., Lee and Nenadovic, 2017).

Attachment 4: Review of PAM Systems

Attachment 4: Review of PAM Systems

Table 4-1. PAM Hardware Specifications and Capabilities.

PAM HARDWARE SPECIFICATIONS AND CAPABILITIES TABLE Last updated 9-Oct 2019																		
Manufacturer/Provider	System name/ Model(s)	System Type	Data Viewable in Real-Time?	Modular/ multiple hydrophone types?	Calibrated?	Type of Calibration	Multi- Channel (Y/N/UNK)	Max # of channels	Max Sample Rate (kHz)	Bitrate (resolution)	Dynamic Range (dB)	Max Storage Capacity (TB)	Max Battery Duration	Max Depth (m)	Form Factor	Dimensions	Battery Type	Deployment Vessel
WHOI (Baumgartner)	DMON Buoy	AAR, RTB	Y (near-r-t)	Y (LF, MF, HF)	Can be	NR	Y	3	500 kHz	16 bits	NR	32 GB	up to 18 months	200	NR	NR	Alkaline	>70 ft.
WHOI (Baumgartner)	Robots4whales Waveglider	ASV, RTB	Y (near-r-t)	Y (LF, MF, HF)	Can be	NR	Y	3	500 kHz	16 bits	NR	32 GB	up to 4 months	1,000	NR	NR	Lithium	Any
Cornell-BRP (Klinck)	Rockhopper (formerly MARU)	AAR	N	custom	Y	UNK	N	NA	380	24-bit	UNK	10.5 TB	6 months (@ 200 kHz sample rate)	3,500	Spherical	UNK	Lithium	Small Boat (RHIB)
Cornell-BRP (Klinck)	AutoBuoy	AAR, RTB	Y	UNK	UNK	UNK	UNK	NA	UNK	16-bit	UNK	NA	UNK	moored, so limited to shallow water	Large Buoy	UNK	UNK	Large ship
JASCO Applied Sciences	AMARG4	AAR	N	Y: 4	UNK	UNK	Y	4 acoustic, 7 oceanographic sensors	8-512 kHz	24-bit	UNK	10 TB	18 months	6,700	spherical	43.2 cm^3	D-cell	UNK
JASCO Applied Sciences	SPARBuoy	AAR, RTB	Y (near-r-t)	Y (LF, MF, HF)	Can be	NR	Y	16	512 kHz	24-bit	NR	10 TB	up to 6 months	200	cylindrical	NR	Alkaline or Lithium?	>70 ft
JASCO Applied Sciences	3M Observer Buoy	AAR, RTB	Y (near-r-t)	Y (LF, MF, HF)	Can be	NR	Y	16	512 kHz	24-bit	NR	10 TB	up to 18 months	200	NR	NR	Alkaline or Lithium?	>70 ft
JASCO Applied Sciences	0.6M Observer Buoy	AAR, RTB	Y (near-r-t)	Y (LF, MF, HF)	Can be	NR	Y	16	512 kHz	24-bit	NR	10 TB	up to 18 months	200	NR	NR	Alkaline or Lithium?	>70 ft
JASCO Applied Sciences	Datamaran Observer-Saildrone	USV, RTB	Y (near-r-t)	Y (LF, MF, HF)	Can be	NR	Y	16	512 kHz	24-bit	NR	6 TB	up to 4 months	1,000	Catamaran	NR	Alkaline or Lithium?	>70 ft
JASCO Applied Sciences	Waveglider Observer	USV, RTB	Y (near-r-t)	Y (LF, MF, HF)	Can be	NR	Y	16	512 kHz	24-bit	NR	6 TB	up to 4 months	200	Waveglider	NR	Alkaline or Lithium?	>70 ft
SMRU Consulting	CAB	AAR, RTB	Y	Y	Y	Individual	Y	Up to 3 per CAB Platform	500	UNK	UNK	1 TB	2-3 weeks	45	Cylndrical	110 cm × 56 cm	Lithium	Small Boat
RTSYs	Resea	AAR	N	Y	Y	Individual?	Y	4	3hz-500 kHz	24-bit	>100 dB	2 TB	UNK	700	cylindrical	12 cm × 32 cm	alkaline or Li-SOCl2	Small Boat
RTSYs	Multhy	AAR	N	Y	Y	Individual?	Y	16	3hz to 500 kHz	24-bit	>100 dB	2 TB	UNK	700	cylindrical	55 cm × 12 cm	rechargable battery pack	UNK
RTSYs	Sylence	AAR	N	Y	UNK	UNK	N	1	39 kHz to 1250 kHz	16 or 24-bit	UNK	128 GB	45 days, possibly more	200	cylindrical	12 cm × 55 cm	18 alkaline or Li-SoCl2 D cell	small boat
Seiche Ltd.	Autonaut PAM	ASV	Y	Y	Y	electro- acoustic (full system)	Y	4	500	16-bit	90	4 TB	months	20 (customizable tow cable length)	Vessel	5 m × 0.8 m	24 V lead- acid	ship / slipway / beach
Seiche Ltd.	Modular buoy system	RTB	Y	Y	Y	electro- acoustic (full system)	Y	4	500	16-bit	90	essentially unlimited as data recorded are at the telemetry receiver station	20 h (lead-acid), 80 h (lithium)	customizable cable length	Buoy		12 V lead- acid or lithium	ship
Seiche Ltd. / ASV Global	ASV PAM	USV (motorized)	Y	Y	Y	electro- acoustic (full system)	Y	4	500	16-bit	UNK	4 TB	several days; limited by fuel capacity of USV	220 (customizable tow cable length)	UNK	models available from 4-12 m LOA	110-240 V invertor	ship / slipway / beach
Greenridge Sciences	ASAR	AAR	N	UNK	UNK	1 omni-directional, 2 directional	Y	3	1 kHz	16-bit	UNK	60 GB	116 days, continuous recording, no data compression	100	UNK	26" × 26" square base, ~26" high (includes frame)	custom alkaline D- cell battery pack	UNK
Greeneridge Sciences	DASAR	AAR	N	UNK	UNK	1 omni-directional, 2 directional	Y	2	up to 96 kHz	16-bit	UNK	2 TB	200 days for 1-channel continuous recording @ 96 kHz sample rate, assuming 60% data compression; 100 days for 2-channel continuous recording @ 96 kHz sample rate, assuming 60% data compression	750 (2,100 without transponders)	UNK	35" × 8" (60" long with frame)	custom alkaline C- cell battery pack	UNK
Greeneridge Sciences	DASAR-CI	AAR	N	UNK	UNK	3 omni-directional	Y	3	5 kHz	16-bit	UNK	512 GB	145 days, continuous recording, no	100	UNK	triangular base w/57" sides, 20"	5 rechargeable batteries	UNK

PAM HARDWARE SPECIFICATIONS AND CAPABILITIES TABLE Last updated 9-Oct 2019																		
Manufacturer/Provider	System name/ Model(s)	System Type	Data Viewable in Real-Time?	Modular/ multiple hydrophone types?	Calibrated?	Type of Calibration	Multi- Channel (Y/N/UNK)	Max # of channels	Max Sample Rate (kHz)	Bitrate (resolution)	Dynamic Range (dB)	Max Storage Capacity (TB)	Max Battery Duration	Max Depth (m)	Form Factor	Dimensions	Battery Type	Deployment Vessel
													data compression			high (includes frame)		
Wildlife Acoustics	Song Meter 4 (SM4) Series	AAR	N	Y (hydrophones by HTI)	Y	UNK	Y	2	96 kHz	16-bit		1 TB (2x 512 SD cards)	400 days (duty cycled?)	UNK	Cylindrical	UNK	Alkaline or NiHM (4 D cell)	
DBV Technologies	Customized	AAR, RTB	P	UNK	Y	UNK	Y	UNK	User defined	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK
DesertStar Systems	SonarPoint / Multiple models& configurations	AAR, RTB**	Y*	Y	Y	Y	Y (units can be time-synchronized)	UNK	415 kHz	16-bit	95 dB	8 TB (up to 8 SD cards)	For -8 (eight slot/quad battery) version: 115 days @ 25kHz sample rate, 96 days @ 100kHz sample rate, 56 days @ 416 kHz sample rate	300 or 1,000	cylindrical	6.5"L x 2.5"D (-2 version), 15.7"L x 2.5"D (-8 version)	Rechargeable lithium ion	small boat
Ocean Instruments	SoundTrap ST300	AAR, RTB	N	UNK	Y	Factory OCR Calibration Certificate, self-calibration check, pistonphone coupler available	UNK	UNK	STD Model: 20 to 60 Hz; HF model: 20 to 150 Hz	16-bit	UNK	256 GB	70 days	500	Cylindrical	200mm x 60mm	D-cell batteries	UNK
Ocean Instruments	SoundTrap ST4300	AAR	N	Y	Yes	Self-calibration check	Y	4	288 kHz x 4; 20 Hz - 90 kHz ± 3 dB	4 x 16-bit SAR	UNK	128 GB	30 Days	500	Cylindrical	200mm x 60mm	D-cell batteries	UNK
Ocean Instruments	SoundTrap ST500	AAR	N	UNK	Yes	Factory calibration certificate	UNK	UNK	288 kS/sec; 20 Hz – 90 kHz	16-bit	UNK	1 TB	180 Days	500	Cylindrical	350mm x 100mm	D-cell batteries	UNK
SIO/UCSD	HARP	AAR	N	Y, custom	Y	UNK	Can Be	UNK	>400 kHz	UNK	UNK	>1 TB	Several months	>1000	Cylindrical	Depends on platform used	Lithium Batteries	Large Vessel with A- frame
MTE	AURAL-M2	AAR	N	UNK	UNK	UNK	UNK	UNK	10 to 16,384 kHz	16-bit	UNK	1 TB	365 days	300	Cylindrical	5.75" x 35.375" or 47.375" or 70"	12V Zinc	UNK
MTE	µAURAL	AAR	N	UNK	UNK	UNK	UNK	UNK	UNK	24-bit	UNK	32 GB	300 hours	100	Cylindrical	3" x 18"	Rechargeabl e NiMH	UNK
Thayer-Mahan	Outpost	ASV	Y		Y	J-9 Projector Calibration	Y	32 / 64 (1)	2.52 kHz	25.2	109	4 TB	>1 year (2)	183 (3)	Linear Array	38.4 / 76.8 m acoustic section	Li-ion	Various
Autonomous Marine Systems Inc. (AMS)	Datamaran	ASV	Yes	Y	Y	N/A	Y	No limit	Whatever the attached PAM equipment is capable of. The DM can transmit 4 channel, 24 bit, 100kHz sampled acoustic waveforms to shore when within 200 km	24 bit	Depends on specific hydrophone + pre-amp system selected	Practically unlimited. Tens of TBs	Unlimited as 1980Watt PV panel name-plate rating and 3072WHr battery capacity available	Can tow array at 100 ft	Catamaran (See website for dimensions of equipment that can be located inside hulls of Datamaran)	1m x 0.2m x 0.2 m?	N/A	UNK
RS Aqua	Orca	AAR, RTB	Y	1 to 5	Y	Multipoint frequency response	Y	5	384	16-bit	95.5	4 TB	155 days (continuous recording)	3,500	Cylindrical with cabled hydrophone option	17.8 cm diameter, 28 - 77.5 cm length, 6.7 - 39 kg	Alkaline or Lithium	UNK
RS Aqua	Porpoise	AAR, RTB	Y (both real time and autonomous options)	1	N	Single point frequency response	N	1		24 bit	110	4 TB	293 days continuous recording	2,000	Cylindrical with cabled hydrophone option	7 cm diameter x 23.3 cm length, 4.5 lbs	Alkaline or Lithium	UNK

PAM HARDWARE SPECIFICATIONS AND CAPABILITIES TABLE Last updated 9-Oct 2019																		
Manufacturer/Provider	System name/ Model(s)	System Type	Data Viewable in Real-Time?	Modular/ multiple hydrophone types?	Calibrated?	Type of Calibration	Multi- Channel (Y/N/UNK)	Max # of channels	Max Sample Rate (kHz)	Bitrate (resolution)	Dynamic Range (dB)	Max Storage Capacity (TB)	Max Battery Duration	Max Depth (m)	Form Factor	Dimensions	Battery Type	Deployment Vessel
Liquid Robotics/SMRU Instrumentation/Teledyne-Reson	Blackbeard (AWG)	ASV	Y (only spectral band metrics that are sent in small burst data report; wav audio files not available in real-time)	1	Y (possible to add more hydrophones)	calibration by Reson and SAIL	Yes	4	500 kHz	24-bit	UNK	512 GB	>1 month	10	liquid robotics waveglider towing decimus towbody		lithium-ion	small boat
Ocean Sonics	IcListen AF(L)	AAR	Y*	Y (Ocean Sonics Hydrophones)	Y	UNK	N	1	512 kHz	16 or 24 bit	106	128 GB	10 hr	200 or 3,500 (plastic or titanium housing)	Cylindrical	48 x 165 mm	UNK	small boat
Ocean Sonics	IcListen AF	AAR	Y*	Y (Ocean Sonics Hydrophones)	Y	UNK	N	1	512 kHz	16 or 24 bit	106	129 GB	10 hr	201 or 3,500 (plastic or titanium housing)	Cylindrical	49 x 165 mm	UNK	small boat
Ocean Sonics	IcListen HF(L)	AAR	Y*	Y (Ocean Sonics Hydrophones)	Y	UNK	N	1	512 kHz	16 or 24 bit	95	130 GB	10 hr	202 or 3,500 (plastic or titanium housing)	Cylindrical	50 x 165 mm	UNK	small boat
Ocean Sonics	IcListen HF	AAR	Y*	Y (Ocean Sonics Hydrophones)	Y	UNK	N	1	512 kHz	16 or 24 bit	95	131 GB	10 hr	203 or 3,500 (plastic or titanium housing)	Cylindrical	51 x 165 mm	UNK	small boat
Ocean Sonics	IcListen X2	AAR	Y*	Y (Ocean Sonics Hydrophones)	Y	UNK	N	1	512 kHz	16 or 24 bit	95	132 GB	10 hr	204 or 3,500 (plastic or titanium housing)	Cylindrical	52 x 165 mm	UNK	small boat
Ocean Sonics	IcListen R-Type	AAR	Y*	Y (Reson Hydrophone)	UNK	UNK	N	1	512 kHz	16 or 24 bit	90	133 GB	10 hr	900	Cylindrical	53 x 165 mm	UNK	small boat
Loggerhead Instruments	Snap	AAR	N	Y (3 hydrophone models from HTI)	Y	UNK	N	1	96 kHz	UNK	Depends on gain settings and hydrophones	128 GB	8 days (continuous); 190 days (10min on/off duty cycled)		Cylindrical	16 x 2.875"	3 alkaline D-cell batteries	small boat
Loggerhead Instruments	LS1 Multi-Card Recorder	AAR	N	Y (HTI Hydrophones)	Y	UNK	Y (Stero possible)	2	97 kHz	UNK	Depends on gain settings and hydrophones	256 GB (expandable)	50 days (continuous)	300	Cylindrical	17"x4.5"	12 alkaline D-cell batteries	small boat
Loggerhead Instruments	LS1x Multi-Card Recorder	AAR	N	Y (HTI Hydrophones)	Y	UNK	Y (Stero possible)	2	98 kHz	UNK	Depends on gain settings and hydrophones	256 GB (expandable)	100 days? (LS1X has 2x battery capacity of LS1)	3,000 (aluminum housing)	Cylindrical	25"x4.5"	24 alkaline D-cell batteries	small boat
Loggerhead Instruments	Medusa	RTB (noise calculations)	Y	UNK	UNK	UNK	N	1	44.1 kHz	UNK	UNK	64 GB	UNK	1m?	Cylindrical	24" x 3"	lithium ion (8x 5Ah; Rechargeable)	small boat
MSEIS	WISDOM Data	RTB	Y	Y, high and low sensitivity options	Upon request	Dependent on customer requirement	Y	4	1000 kHz	16 bit	Dependent on hydrophones used	120 GB (expandable)	40+ hours in darkness, indefinite when solar powered	TBC	Cylindrical buoy	1250mm diameter x 2.5m height above water	2x 12V SLA 22Ah	Deployment by crane

Legend/Abbreviations:				
	N	No	UNK	unknown or unavailable
	Y	Yes	AAR	Autonomous Acoustic Recorder
	P	Possible	RTB	Radio Telemetered (Moored, Acoustic) Buoy
	TR	Terabyte	GB	Gigabyte
	kHz	kilohertz	dB	decibel(s)
	NR	No response to request	AUV	Autonomous Underwater Vehicle
	NA	Not applicable or relevant	ASV/USV	Autonomous Surface Vehicle/Unmanned Surface Vehicle (e.g., waveglider)

Information compiled by Tom Norris, Biowaves Inc.

Table 4-2. PAM Technology monitoring types.

			Monitoring Type				
			Mitigation		Regional Long-Term	Tracking	
PAM Technology	Vehicle		Pile Driving	OTHER?		Local	Regional
PAM	Autonomous Recorders and Real-time Systems	Seafloor			X	X	P
		Moored	X	X	X	X	P
	Passively (buoyancy/ wind) powered AV	AUV		X	P		
		ASV	P	X	P	P	P
	Drifter		P	X	P	P	P

X = capable of monitoring

P = possible under certain conditions or circumstances (e.g., low currents or sea states, or if numerous devices are deployed and data can be integrated)

Attachment 5: Protected Species Reporting Contact Information for the Project

Attachment 5: Protected Species Reporting Contact Information for the Project

Table 5-2. National Marine Fisheries Service.

USCG District	Phone Numbers for Right Whale Sightings, or for Entangled, Stranded, Injured or Dead Marine Mammals	
US Coast Guard	TBD	TBD

Table 5-2. National Marine Fisheries Service.

NMFS Contact	Phone Number and email for Right Whale Sightings, or for Entangled, Stranded, Injured or Dead Marine Mammals	
Office of Protected Resources (OPR)	301-427-8401	TBD by agency
Greater Atlantic Regional Fisheries Office (GARFO)	TBD by agency	TBD by agency
Marine Mammal and Sea Turtle Stranding and Entanglement Hotline Program/Regional Stranding Coordinator (New England)	866-755-6622	TBD by agency

Table 5-3. BOEM.

NMFS Contact	Phone Number and email for Right Whale Sightings, or for Entangled, Stranded, Injured or Dead Marine Mammals	
BOEM Offshore Wind Division	TBD by agency	TBD by agency

Attachment 6: Vessel Strike Avoidance Plan

Attachment 6: Vessel Strike Avoidance Plan

To mitigate potential impacts of vessel strikes, Revolution Wind will adhere to the following *Base Conditions*.

Base Conditions:

- **Training***:* All personnel working offshore will receive training on marine mammal, sea turtle, and Atlantic sturgeon awareness and vessel strike avoidance measures.
- **Speed/Approach Constraints**: All vessels will adhere to current NOAA vessel guidelines for approach distances and mandatory measures stipulated in regulations governing the approach to North Atlantic Right Whales and the Right Whale Speed Rule. (Note: Voluntary measures within a DMA are addressed separately in the Standard and Adaptive Plan detailed below).
- **Approach Constraints**: Vessels will avoid marine mammals as described below:
    - All species
        - For all marine mammal observations, all vessels underway must not divert or alter course in order to approach.
        - Any vessel underway must avoid excessive speed or abrupt changes in direction.
        - When a marine mammal(s) is sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distances (e.g., attempt to remain parallel to the animal's course).
        - Exceptions:
        - Limitations on approach do not apply where compliance would create an imminent and serious threat to a person, vessel, or aircraft
        - Limitations on approach do not apply when approaching to investigate an entanglement or injury, or to assist in the disentanglement or rescue of a whale, provided that permission is received from NMFS or a NMFS designee prior to the approach
        - Limitations on approach do not apply to the extent that a vessel is restricted in her ability to maneuver, and because of the restriction, cannot comply with the limitation on approach.
    - North Atlantic Right Whale
        - By regulation (50 CFR §224.103(c)), approach (including by interception) within 500 yards (460 m) of a right whale by vessel, aircraft, or any other means is prohibited.
        - If within 500 yards (460 m) of a right whale: (1) If underway, a vessel must steer a course away from the right whale and immediately leave the area at a slow safe speed;
        - Exceptions stated in the "All Species" section above are applicable for NARW.
    - Other Large Whales
        - Vessel speeds will immediately be reduced to 10 knots or less when any large whale,

mother/calf pair, or large assemblage of non-delphinoid cetaceans is observed near (within 100 m) an underway vessel.

- All vessels must maintain a minimum separation distance of 100 m from sperm whales and non-NARW baleen whales. If one of these species is sighted within 100 m of an underway vessel, that vessel must shift the engine to neutral. Engines must not be engaged until the whale has moved outside of the vessel's path and beyond 100 m.
- Exceptions stated in the "All Species" section above are applicable for large whales.

o Dolphins, porpoises, seals

- All vessels must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all delphinoid cetaceans and pinnipeds. If a delphinoid cetacean or pinniped is sighted within 50 m of an underway vessel, that vessel must shift the engine to neutral. Engines must not be engaged until the animal(s) has moved outside of the vessel's path and beyond 50 m.
- Exception to separation distance and shifting engines to neutral for delphinoid cetaceans and pinnipeds that approach the vessel (e.g., bow-riding dolphins).
- Exceptions stated in the "All Species" section above are applicable for dolphins, porpoises and seals.

- **Monitoring/Mitigation**: Vessel operators and crew will maintain a vigilant watch for marine mammals and sea turtles, and slow down or maneuver their vessels as appropriate to avoid a potential intersection with a marine mammal or sea turtle.
- **Situational Awareness/Common Operating Picture**: Revolution Wind will establish a situational awareness network for marine mammal and sea turtle detections through the integration of sighting communication tools such as Mysticetus, Whale Alert, WhaleMap, etc. Sighting information will be made available to all project vessels through the established network. REV's Marine Coordination Center will serve to coordinate and maintain a Common Operating Picture. In addition, systems within the Marine Coordination Center, along with field personnel, will:
  - o Monitor the NMFS North Atlantic right whale reporting systems daily;
  - o Monitor Coast Guard VHF Channel 16 throughout the day to receive notifications of any sighting; and
  - o Monitor any existing real-time acoustic networks.

In addition to the above *Base Conditions*, Revolution Wind will implement a *Standard Plan,* or an *Adaptive Plan* as presented below. Revolution Wind intends for these plans to be interchangeable and implemented throughout both the construction and operations phases of the project. Revolution Wind will submit a final *NARW Vessel Strike Avoidance Plan* at least 90 days prior to commencement of vessel use that details further the Adaptive Plan and specific monitoring equipment to be used. The plan will, at minimum, describe how PAM, in combination with visual observations, will be conducted to ensure the transit corridor is clear of NARWs. The plan will also provide details on the vessel-based observer protocols on transiting vessels.

Standard Plan:

- Implement *Base Conditions* described above.

- **Between November 1st and April 30th**: Vessels of all sizes will operate port to port (from ports in NY, CT, RI and MA) at 10 knots or less. Vessels transiting from other ports outside those described will operate at 10 knots or less when within any active SMA or within the Wind Development Area (WDA), including the lease area and export cable route.
- **Year Round:** Vessels of all sizes will operate at 10 knots or less in any DMAs.
- **Between May 1st and October 31st**: All underway vessels (transiting or surveying) operating at >10 knots will have a dedicated visual observer (or NMFS approved automated visual detection system) on duty at all times to monitor for marine mammals within a 180° direction of the forward path of the vessel (90° port to 90° starboard). Visual observers must be equipped with alternative monitoring technology for periods of low visibility (e.g., darkness, rain, fog, etc.). The dedicated visual observer must receive prior training on protected species detection and identification, vessel strike minimization procedures, how and when to communicate with the vessel captain, and reporting requirements. Visual observers may be third-party observers (i.e., NMFS-approved PSOs) or crew members.

Adaptive Plan:

The Standard Plan outlined above will be adhered to except in cases where crew safety is at risk, and/or labor restrictions, vessel availability, costs to the project, or other unforeseen circumstance make these measures impracticable. To address these situations, an *Adaptive Plan* will be developed in consultation with NMFS to allow modification of speed restrictions for vessels. Should Revolution Wind choose not to implement this *Adaptive Plan,* or a component of the *Adaptive Plan* is offline (e.g., equipment technical issues), Revolution Wind will default to the *Standard Plan* (described above). The *Adaptive Plan* will not apply to vessel subject to speed reductions in SMAs as designated by NOAA's Vessel Strike Reduction Rule.

Proposed measures may include:

Implement *Base Conditions* described above.

- **Year Round**: A semi-permanent acoustic network comprising near real-time bottom mounted and/or mobile acoustic monitoring platforms will be installed such that confirmed North Atlantic right whale detections are regularly transmitted to a central information portal and disseminated through the situational awareness network.
    - The transit corridor and WDA will be divided into detection action zones.
    - Localized detections of NARWs in an action zone would trigger a slow-down to 10 knots or less in the respective zone for the following 12 h. Each subsequent detection would trigger a 12-h reset. A zone slow-down expires when there has been no further visual or acoustic detection in the past 12 h within the triggered zone.
    - The detection action zones size will be defined based on efficacy of PAM equipment deployed and subject to NMFS approval as part of the *NARW Vessel Strike Avoidance Plan.*
- **Year Round**: All underway vessels (transiting or surveying) operating >10 knots will have a dedicated visual observer (or NMFS approved automated visual detection system) on duty at all times to monitor for marine mammals within a 180° direction of the forward path of the vessel (90° port to 90° starboard). Visual observers must be equipped with alternative monitoring technology for periods of low visibility (e.g., darkness, rain, fog, etc.). The dedicated visual observer must receive prior training on protected species detection and identification, vessel strike minimization procedures, how and when to communicate with the vessel captain, and reporting requirements. Visual observers may be third-party observers (i.e., NMFS-approved

PSOs) or crew members.

- **Year-round**: any DMA is established that overlaps with an area where a project vessel would operate, that vessel, regardless of size when entering the DMA, may transit that area at a speed of >10 knots. Any active action zones within the DMA may trigger a slow down as described above.
- If PAM and/or automated visual systems are offline, the *Standard Plan* measures will apply for the respective zone (where PAM is offline) or vessel (if automated visual systems are offline).

Attachment 7: Sound Field Verification Plan

Attachment 7: Sound Field Verification Plan

Introduction

This underwater noise measurement plan for sound field verification (SFV) is proposed in connection with the planned foundation installation activities for Revolution Wind.

Purpose

The aim of the proposed measurement exercise is to obtain a dataset that can be used to verify prognosed sound levels submitted in underwater noise assessment and used as input to predict ranges to acoustic thresholds that may result in injury or behavioral disruption of marine mammals, sea turtles and/or fish near the construction area. It is, therefore, necessary to conduct underwater noise measurements to verify the prognosed sound levels were comparable/lower than those measured in field and any estimated animal exposures were accurate/conservative enough. Impact pile driving is considered as the installation method for the proposed measurement plan. Amendments to the plan for other installation methods are discussed in the end of this document.

Specifics of the measurement plan

All measurements will be performed according to the ISO 18406:2017 standard. The foundation installation noise will be measured using omnidirectional hydrophones capable of measuring frequencies between 20 Hz and 20 kHz. The hydrophone signals will be verified before deployment and after recovery by means of a pistonphone calibrator on deck or similar method. Each measurement position will consist of two hydrophones at approximately mid depth and 2 m above the seafloor. Deployment will be made using a heavy weight as anchor - to prevent equipment drifting (typically total ballast weight exceeding 100 kg) – as depicted in **Figure 7-1**. Deployment and retrieval position of each hydrophone will be recorded using hand-held GPS equipment, or alternative precise method. The hydrophones will be placed at various distances from the installation location as depicted in **Figure 7-2**.

The equipment, methodology, placement, and analysis will be the same for all pile measurements. Output results will include sound pressure level and frequency context. Measurements will be conducted in a detailed configuration at the beginning of installation. An example of the measurement configuration is provided in **Figure 7-2.**

To validate the estimated sound field, SFV measurements will be conducted during pile driving of the first three monopiles installed over the course of the project, with noise attenuation activated. A SFV Plan will be submitted to NMFS for review and approval at least 90 days prior to planned start of pile driving. This plan will describe how Revolution Wind will ensure that the first three monopile installation sites selected for SFV are representative of the rest of the monopile installation sites and, in the case that they are not, how additional sites will be selected for SFV. This plan will also include methodology for collecting, analyzing, and preparing SFV data for submission to NMFS. The plan will describe how the effectiveness of the sound attenuation methodology will be evaluated based on the results.

In the event that Revolution Wind obtains technical information that indicates a subsequent monopile is likely to produce larger sound fields, SFV will be conducted for those subsequent monopiles. Revolution Wind will provide the initial results of the SFV measurements to NMFS in an interim report after each monopile installation for the first three piles as soon as they are available but no later than 48 hours after each installation.

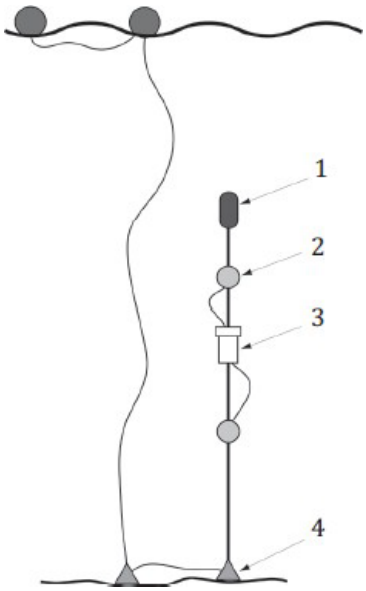


Figure 7-1. Principle sketch of hydrophone deployment. 1 is the float, 2 is the hydrophone, 3 is the recorder and 4 is the bottom weight(s). From ISO18406:2017.

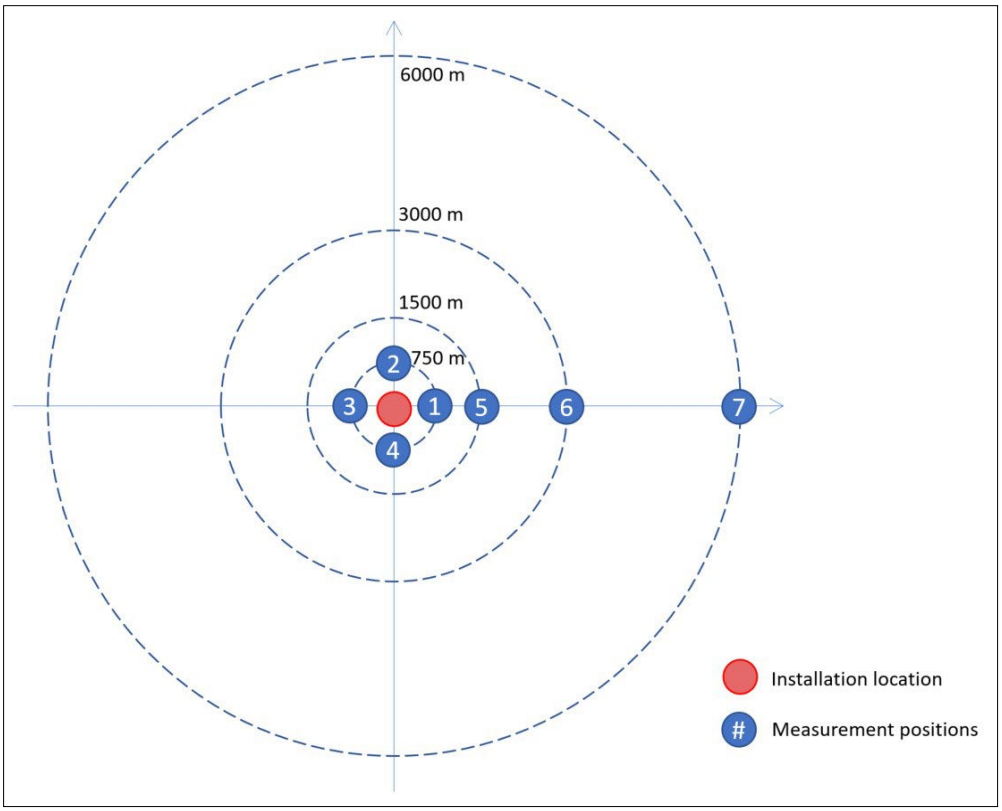


Figure 7-2 Sample sound field verification showing layout of proposed measurement locations. Specific locations are only examples and may change.

Level A Harassment and Level B Harassment Zone Distance Verification for impact pile driving of WTG foundations

Revolution Wind will conduct SFV under the following circumstances:

- Impact driving of the first three monopiles installed over the duration of the LOA;
- If Revolution Wind obtains technical information that indicates a subsequent monopile is likely to produce larger sound fields; and
- At least three monopiles of the same size if a reduction to the clearance and/or shutdown zones is requested.

Revolution Wind will conduct a SFV to empirically determine the distances to the isopleths corresponding to Level A harassment and Level B harassment thresholds, including at the locations corresponding to the modeled distances to the Level A harassment and Level B harassment thresholds, or as agreed to in the SFV Plan. As a secondary method, Revolution Wind may also estimate distances to Level A harassment and Level B harassment thresholds by extrapolating from in situ measurements at multiple distances from the monopile, including at least one measurement location at 750 m from the pile.

For verification of the distance to the Level B harassment threshold, Revolution Wind will report the measured or extrapolated distances where the received levels SPL_{rms} decay to 160 dB, as well as integration time for such SPL_{rms}. If initial SFV measurements indicate distances to the isopleths corresponding to Level A harassment and/or Level B harassment thresholds are greater than the distances predicted by modeling assuming 10 dB attenuation, Revolution Wind will implement additional sound attenuation measures prior to conducting additional pile driving. Initial additional measures may include improving the efficacy of the implemented noise attenuation technology and/or modifying the piling schedule to reduce the sound source. If modeled zones cannot be achieved by these corrective actions, Revolution Wind will install an additional NMS to achieve the modelled ranges. Each sequential modification will be evaluated empirically by SFV. Additionally, in the event that SFV measurements continue to indicate distances to isopleths corresponding to Level A harassment and Level B harassment thresholds are consistently greater than the distances predicted by modeling, NMFS may expand the relevant clearance and shutdown zones and associated monitoring measures.

If initial SFV measurements indicate distances to the isopleths corresponding to the Level A harassment and Level B harassment thresholds are less than the distances predicted by modeling assuming 10 dB attenuation, Revolution Wind may request a modification of the clearance and shutdown zones for impact pile driving. For a modification request to be considered by NMFS, Revolution Wind must have conducted SFV on at least 3 piles to verify that zone sizes are consistently smaller than predicted by modeling. If a subsequent piling location is selected that was not represented by previous locations (e.g., substrate composition, water depth), SFV will be conducted. Revolution Wind will request modifications of zones based on the SFV results as detailed in the following section.

Modification of shutdown and monitoring zones

Revolution Wind may request a modification to the size of shutdown and monitoring zones based on the results of pile measurements. The zones will be determined as follows:

- The large whale pre-start clearance zone will be calculated as the radius of the maximum Level A exposure range of any mysticete.
- The right whale pre-start clearance zone will be equal to the marine mammal Level B zone.
- The large whale, including right whale, shutdown zone will be calculated as the radius of the maximum Level A exposure range of any mysticete.

- The harbor porpoise and seal pre-start clearance zone and shutdown zone will be determined as the extent of the level A exposure range.
- For all mid-frequency cetaceans other than sperm whales, the pre-start clearance and shutdown zones will effectively be the perimeter of the NMS because the physical placement of the NMS will preclude take (i.e., the Level A zone is smaller than the distance of the NMS from the pile) (see **Table 7** of the PSMMP).

In the case of expanded clearance and shutdown zones, zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation. Based on the results of the SFV measurements, the secondary vessel will be placed at the outer limit of the subsequent Large Whale Shutdown Zone as displayed in **Figure 3** of the PSMMP. No additional PSOs or PSO vessels are proposed to visually monitor the expanded zones.

The placement of PAM will sufficiently cover any expanded clearance or shutdown zones. As described in the PSMMP, the total number of PAM stations and array configuration will depend on the size of the zone to be monitored, the amount of noise expected in the area, and the characteristics of the signals being monitored. Acoustic monitoring will include and extend beyond the Large Whale Pre-Start Clearance Zone. Orsted will be prepared to flex the PAM configuration to be capable of monitoring the resulting measured (SFV) zone up to the maximum potential Level B zone.

Attachment 8: Reporting Plan

Attachment 8: Reporting Plan

Introduction

The following tables provide a comprehensive schedule of reporting for various outputs of data collected for specified activities.

Table 1: Protected Species Reporting

Report	Content	Frequency	Method	Applicable Activity
Immediate/Within 24 -48 Hours				
Injured or Dead Marine Mammals (non-activity cause)	TBD	As soon as feasible; no longer than 24 hours	Via Whale Alert; NMFS SAS (phone); PR.ITP.MonitoringReports@noaa.gov	All
Injury/Death/Vessel Strike of Marine Mammals (caused by activity)	TBD	Immediate (and cease specified activity)	NMFS SAS (phone); PR.ITP.MonitoringReports@noaa.gov; NMFS OPR (301-427-8401)	All
NARW Visual Sighting	TBD	As soon as feasible; no longer than 24 hours	Via Whale Alert; NMFS SAS (phone); PR.ITP.MonitoringReports@noaa.gov	All
NARW Acoustic Detection (confirmed)	TBD	As soon as feasible; no longer than 24 hours	nmfs.pacmdata@noaa.gov or via Whale Alert; PR.ITP.MonitoringReports@noaa.gov	Piling and Detonation
Interim Sound Field Verification Report	TBD	Within 48 hours of each pile and detonation measured	PR.ITP.MonitoringReports@noaa.gov	Piling and Detonation
Weekly				
Weekly PSO/PAM Report	daily start and stop of all pile-driving activities, the start and stop of associated observation periods by PSOs, details on the deployment of PSOs, a record of all detections of marine mammals, any mitigation actions (or if mitigation actions could not be taken, provide reasons why), and details on the noise attenuation system(s) used and its performance; vessel transits; and piles installed	Wednesday following a Sun-Sat week.	PR.ITP.MonitoringReports@noaa.gov and nmfs.pacmdata@noaa.gov	Construction Activity Only

Report	Content	Frequency	Method	Applicable Activity
Final /Annual Reports				
Final (Draft) SFV Report	TBD	Within 90 days of completion of activities	PR.ITP.MonitoringReports@noaa.gov	Piling and Detonation
Final NARW Acoustic Detection Data	Detection data and metadata	90 days after completion of Piling activity	PR.ITP.MonitoringReports@noaa.gov and nmfs.pacmdata@noaa.gov	Piling and Detonation
Annual: Annual (Draft) Visual and Acoustic Monitoring Report	TBD; Summarized by activity type (e.g. piling, onshore installation works; Detonation and HRG)	April 1st of each year of the Rule, provide report of prior calendar year	PR.ITP.MonitoringReports@noaa.gov	All ITA Activity

Table 2: Administrative Reporting

Report	Frequency	Method	Applicable Activity
PSO CVs	Prior to initiation of project activities	TBD	All
Required Training Documentation	Prior to initiation of project activities	TBD	All