Ocean Wind
An Ørsted & PSEG project

Appendix AA - Protected Species Mitigation and Monitoring Plan (PSMMP)

Ocean Wind Offshore Wind Farm

Protected Species Mitigation and Monitoring Plan (PSMMP): Marine Mammals, Sea Turtles, and ESA- Listed Fish Species

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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)
dBBC	double big bubble curtain
DIFAR	Directional Frequency Analysis and Recording
DMA	Dynamic Management Area
DPS	Distinct Population Segment
E	Endangered
ECR	Export Cable Route(s)
ESA	Endangered Species Act
FR	*Federal Register*
ft	foot/feet
g	gram(s)
GPS	global positioning system
HD	high definition
HF	high-frequency
HRG	high-resolution geophysical
HSD	Hydro-sound Damper
Hz	Hertz
IHA	Incidental Harassment Authorization
IR	infrared
ISO	International Organization for Standardization
ITA	Incidental Take Authorization
ITR	Incidental Take Regulations
JASMINE	JASCO Animal Simulation Model Including Noise Exposure
kg	kilogram(s)
kHz	kilohertz
kJ	kilojoule(s)
km	kilometer(s)
Lease Area	BOEM-designated Renewable Energy Lease Area OCS-A 0498
$L_{E,24h}$	sound exposure level, cumulative 24 hours
LF	low-frequency
L_p	root mean square sound pressure
$L_{p,0\text{-pk}}$	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
Ocean Wind	Ocean Wind LLC
OCS	Outer Continental Shelf
OCW01	Ocean Wind 01

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	Ocean 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
U.S.	United States
USCG	United States Coast Guard
UXO	Unexploded Ordinance
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
Buffer Zone	An area added to any existing zone, usually prior to specific operations, to enhance the effectiveness of mitigation such that there is a buffer in space and time during which the mitigation can be applied
Clearance Zone	The area that must be visually 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 <200 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) 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
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 Harassment Authorization (IHA)	Authorization from NMFS per the MMPA for the “taking” of small numbers of marine mammals resulting from Project activities
Level A Zone	The area encompassed by the water from a sound source to an isopleth that meets a threshold at which onset of a permanent threshold shift (PTS) in hearing can occur
Level B Zone	The area encompassed by the water from a sound source to an isopleth that meets 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 any potential impacts on marine mammals that could result 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 and/or acoustically monitored for the presence of marine protected species
Offshore substation	Stations that collect and export the power generated by the WTGs, to be installed on either monopile or jacket foundations within the Ocean Wind 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	Ocean Wind Lease Area (OCS-A 0498) and associated export cable routes
Protected species observer (PSO)	NMFS-approved visual observers trained to monitor the area around 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 and 10 knots or less while transiting these areas to reduce the threat of vessel strikes on NARWs
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
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
Wind Farm Area	Maximum work area surrounding the Ocean Wind Lease Area (BOEM Lease OCS-A 0498)
Wind turbine generator (WTG)	A device that converts wind energy into electricity, to be installed on monopile foundations within the Ocean Wind Lease Area
Zone of influence (ZOI)	The area within which potential impacts on species are assessed and estimated

1. Introduction

This Protected Species Mitigation and Monitoring Plan (PSMMP, or Plan) is in place for high-resolution geophysical (HRG) survey, construction, and operations and maintenance (O&M) activities planned for the Ocean Wind LLC (Ocean Wind), a subsidiary of Orsted Wind Power North America LLC (Orsted), Ocean Wind Project (Project) located in the Bureau of Ocean Energy Management (BOEM) Lease Area Outer Continental Shelf (OCS)-A-0498 and associated Export Cable Routes (ECRs), referred to in this PSMMP as the Project area.

The purpose of this PSMMP is to provide protocols and guidelines for monitoring marine mammals and other federally protected species (sea turtles and Atlantic sturgeon [*Acipenser oxyrinchus oxyrinchus*]) through both visual and/or passive acoustic means during Project-related activities.

1.1 PSMMP Format

Protected species likely to occur in the Project area, and Project-specific activities, are presented in **Section 2** (marine mammals) and **Section 3** (sea turtles and fish) of this Plan. General Project standard conditions will follow those described in BOEM'S Lease for the Project.. The Project-specific sections consider the range of activities and potential impacts and permit conditions under which the work is being performed.

The protocols described in this Plan are designed to minimize impacts on protected species resulting from Project activities and document the occurrence of protected species in proximity to the Project area. Guidance for this Plan comes from various resources of agreed-upon mitigation measures and monitoring protocols (e.g., Baker *et al*. 2013; Shell Gulf of Mexico 2014) 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, sea turtles, and Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) potentially exposed to underwater sound levels that would constitute "take" under the Marine Mammal Protection Act or Endangered Species Act (ESA).

Subsequent sections of the Plan provide Project-specific details regarding the protocols that will be implemented during HRG surveys and construction.

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 sound impacts, and
- vessel strike avoidance measures as applicable for each activity.

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

In this Plan, the units of measure reported for construction activities are United States (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 U.S. customary and metric.

1.2 Ocean Wind Project Area

1.2.1 Applicable Project Area

The area covered by the Plan includes Lease Area OCS-A 0498, the Wind Farm Area, the Inshore Study Area ECR corridor, Offshore ECR corridor, and landfalls in relation to seal haul-out sites.

For the purposes of this Plan, the Project area is defined as the state and Federal waters of the Ocean Wind BOEM Lease Area (OCS-A-0498), which is a portion of the New Jersey Wind Energy Area (WEA), called the Wind Farm Area, and along the Inshore and Offshore ECR corridors associated with the Project leading to BL England and Oyster Creek (**Figure 1**)**Error! Reference source not found.**. Project activities include HRG surveys, construction, and O&M.

The boundaries of the Project area are depicted in **Figure 1** and consist of the following:

- Wind Farm Area: area where the turbines, array cables, offshore substations (OSS), OSS interconnector cables, and portions of the offshore export cables are located;
- Offshore ECR corridor and Project area: area in which the offshore export cable systems will be installed; and
- Inshore ECR corridor: area in which inshore export cable systems will be installed, including inshore export cables and grid connections.

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

- Up to 98 offshore wind turbines;
- Three offshore alternating current substations;
- Array cables linking the individual turbines to OSS;
- Substation interconnector cables linking the substations to each other; and
- Offshore export cables.

The Wind Farm Area, located within Federal waters, in the northeastern portion of the WEA, is approximately 277 square kilometers (68,450 acres), and is located approximately 13 nautical miles (nm, 15 statute miles) southeast of Atlantic City. The Wind Farm Area and the boundaries of the Project are depicted on **Figure 1**. The Offshore ECRs will be partially located in Federal waters and partially in New Jersey state waters. The Inshore ECRs will be located in New Jersey (**Figure 1**).

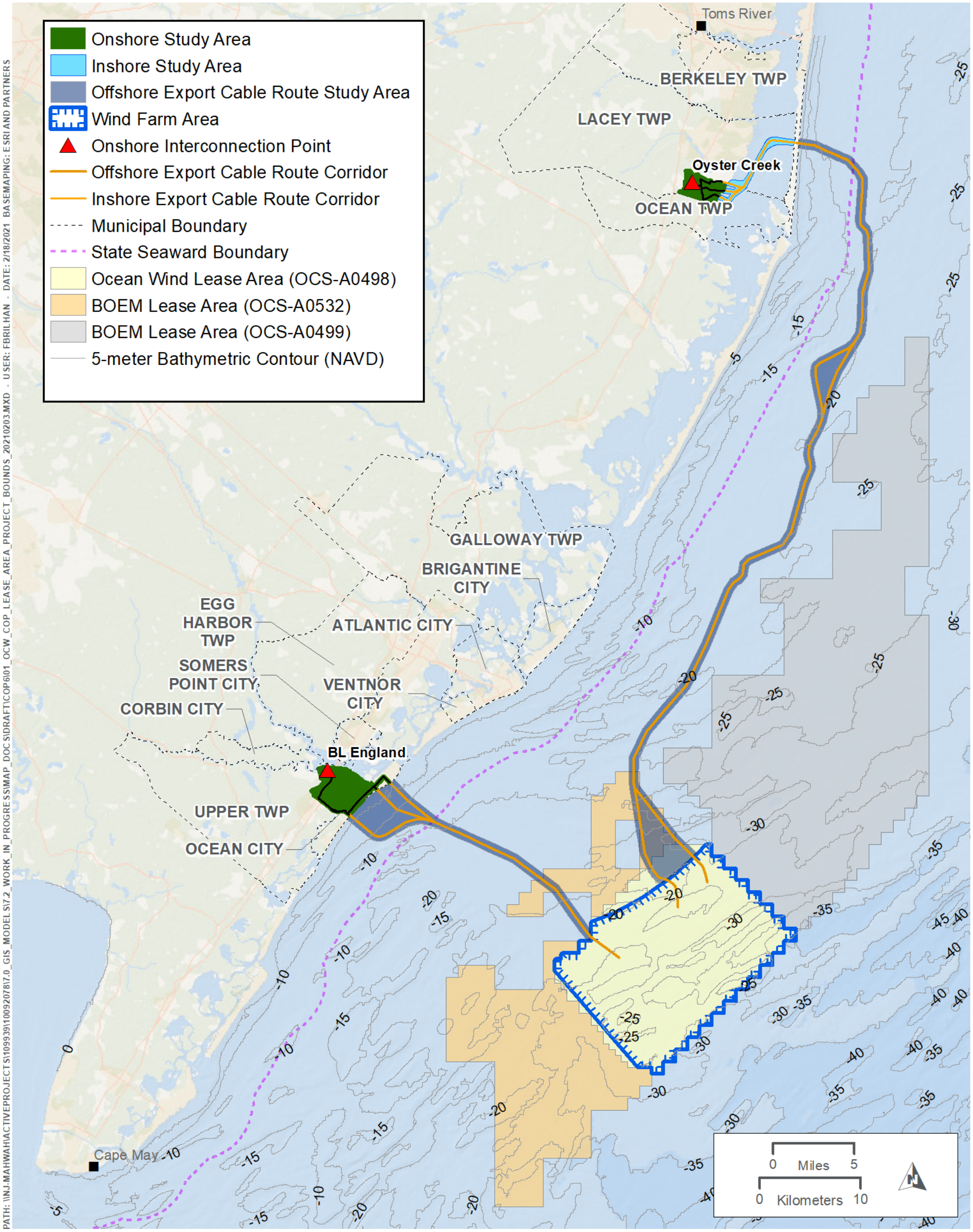

Figure 1. Site location and vicinity of the Ocean Wind Project.

2. Marine Mammals

Nineteen marine mammal species (**Table 1**) may occur or are expected or likely to occur (at least seasonally) in or transit near 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	Scientific Name	Stock	Occurrence in Project Area[a/]	ESA/MMPA Status[b/]	Estimated Abundance
Toothed Whales (Odontoceti)					
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	W. North Atlantic	Regular	NL	93,233
Atlantic spotted dolphin	*Stenella frontalis*	W. North Atlantic	Uncommon	NL	39,921
Common bottlenose dolphin	*Tursiops truncatus*	W. North Atlantic, Offshore	Regular	NL	62,851
		W. North Atlantic, Northern Migratory Coastal	Regular	NL/D; S	6,639
Risso's dolphin	*Grampus griseus*	W. North Atlantic	Uncommon	NL	35,215
Common dolphin	*Delphinus delphis*	W. North Atlantic	Regular	NL	172,974
Sperm whale	*Physeter macrocephalus*	North Atlantic	Uncommon	E; S	4,349
Long-finned pilot whale	*Globicephala melas*	W. North Atlantic	Rare	NL	39,215
Short-finned pilot whale	*Globicephala macrorhynchus*	W. North Atlantic	Uncommon	NL	28,924
Harbor porpoise	*Phocoena phocoena*	Gulf of Maine/Bay of Fundy	Regular	NL	95,543
Baleen Whales (Mysticeti)					
Common minke whale	*Balaenoptera acutorostrata*	Canadian East Coast	Common	NL	21,968
Blue whale	*Balaenoptera musculus*	W. North Atlantic	Not Expected	E; S	402 (minimum)
Fin whale	*Balaenoptera physalus*	W. North Atlantic	Regular	E/D; S	6,802
Humpback whale	*Megaptera novaeangliae*	Gulf of Maine	Regular	NL	1,396
North Atlantic right whale	*Eubalaena glacialis*	W. North Atlantic	Regular	E/D; S	368

Common Name	Scientific Name	Stock	Occurrence in Project Area[a/]	ESA/MMPA Status[b/]	Estimated Abundance
Sei whale	*Balaenoptera borealis*	Nova Scotia	Rare	E; S	6,292
True Seals (Phocidae)					
Gray seal	*Halichoerus grypus*	W. North Atlantic	Regular	NL	27,300
Harbor seal	*Phoca vitulina*	W. North Atlantic	Regular	NL	61,336
Harp seal	*Pagophilus groenlandicus*	W. North Atlantic	Rare	NL	76 million
Hooded seal	*Phoca groenlandica*	W. North Atlantic	Not Expected	NL	Unknown

Note: MMPA = Marine Mammal Protection Act; W = Western. Stocks and stock sizes were taken from the latest stock assessment report from NOAA Fisheries; Hayes *et al.* 2021 and NMFS 2021.

[a/] Regular = A species that occurs as a regular or normal part of the fauna of the area, regardless of how abundant or common it is; Common = occurring consistently in moderate to large numbers; Uncommon = not ordinarily encountered, unusual; Rare = A species that occurs in the area only sporadically; Not Expected = range includes the Project area and ECR area, but due to habitat preferences and distribution information, species are not expected to occur in the Project area and ECR area although records may exist for adjacent waters.

[b/] Endangered Species Act (ESA) status: Endangered (E), /MMPA status: Depleted (D). NL = not listed; indicates that the species is not listed under the ESA or designated as depleted under the MMPA. Under the MMPA, a strategic (S) stock is one for which the level of direct human-caused mortality exceeds Potential Biological Removal, or which is determined to be declining and likely to be listed under the ESA within the foreseeable future. Any species or stock listed under the ESA is automatically designated under the MMPA as depleted and as a strategic stock.

2.1 Standard Conditions for Mitigation and Monitoring

2.1.1 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 on marine mammals that could result from project activities.
- **Monitoring** – defined in two ways:
    - Mitigation monitoring associated with ***mitigation activities***. Mitigation monitoring is typically comprised of Protected Species Observers (PSOs) who visually and acoustically monitor specified zones (see Sections 2.2.1, 2.3.1, 2.4.1, 2.5.1, and 3.1.2.1) during project activities; and
    - 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.

2.1.1.1 Zone Definitions

Throughout this Plan, zones are described that identify either an impact range, or areas within which mitigation and/or monitoring occurs. The sizes of the zones and the actions (if necessary) taken within each zone will be Project-, species-, and activity-specific and are identified in each project activity section 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 the associated activity sections of that project's PSMMP and in applicable Appendices for other species. The zones applicable to this Project are defined below.

- Level A[1] Zone – the area encompassing the waters from a sound source to an isopleth that meets 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[2] or by exposure ranges[3]. Entry by an animal into the Level A zone will require mitigation measures to be taken except in cases where the Level A zone is larger than the shutdown zone (this scenario is not applicable to the Ocean Wind project). 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:
    - Cumulative sound exposure level (SEL_{cum}) and peak sound pressure level (SPL_{pk}) PTS thresholds as defined by the National Marine Fisheries Service (NMFS) (2018).
- Level B[4] Zone – the area encompassing the waters from a sound source to an isopleth that meets 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 to be taken. Marine mammals detected within this zone under the specified exposure conditions may constitute Level B take. 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 received root-mean-square sound pressure level (SPL_{rms}) of 160 decibels (dB) referenced to (re) 1 micropascal (µPa) when 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 as specified for species and activity 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 kilohertz (kHz); impact and vibratory pile driving). 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

[1] Level A refers to marine mammal harassment defined in the MMPA that could potentially cause PTS onset.

[2] Acoustic range: Range to acoustic thresholds calculated using only propagation modeling which assumes a stationary receiver.

[3] Exposure range: Ranges to acoustic thresholds calculated using acoustic modeling which considers animal movement and behavior.

[4] Level B refers to marine mammal harassment as defined in the Marine Mammal Protection Act (MMPA) that could potentially cause behavioral disturbance.

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 the 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 marine protected species. The monitoring zone represents the farthest extent practicable that can be monitored. There are no mitigation or visibility requirements associated with the monitoring zone; however, all species detected within the monitoring zone 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 on species are assessed and estimated. The ZOI would not be greater than the maximum Level B zone. While the ZOI may provide information to establish the other zones, it does not play an additional role in mitigation and monitoring during project activities.

2.1.2 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 2.3, 2.4, 2.5, and 2.6).

2.1.3 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 this Plan 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;
  - 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.

2.1.3.1 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. The Project will deploy a PSO team consisting of PSOs with appropriate skills and in sufficient numbers to meet mitigation and monitoring requirements. The PSO field team will have a lead monitor (Lead PSO) who will have experience in the northwestern Atlantic Ocean on similar projects. The PSO team will also have one PSO supervisor who may work in the field or shore side for the duration of the mitigation activities. 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 prior to the start of Project-related activities with the PSO provider and Project compliance representatives to review in detail the protected species expected in the Project area and associated regulatory requirements. This refresher training will be conducted shortly before the anticipated start of Project-related activities.

2.1.3.2 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 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 prior to the start of Project-related activities with the PSO provider and Project compliance representatives to review in detail the protected species expected in the Project area and associated regulatory requirements. This refresher training will be conducted shortly before the anticipated start of Project-related activities.

2.1.3.3 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 may be approved by NMFS on a case-by-case basis for limited, specific duties in support of approved, independent PSOs.

2.1.3.4 PSO and 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 will have the experience and skill set to manage the team of PSOs on that asset and to make decisions related to monitoring, including potential exposure assessments for each sighting as needed. This person 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 will provide daily sightings and mitigation summary reports to the designated Project Manager which is reported through to Project representatives for the previous day’s operations. Any subsequent changes made to any reports submitted by the Lead PSO will 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 and embedded

QA/QC processes with software such as Mysticetus (see Section 2.1.5.1) in the field on their asset. They are the primary representative of observations, reports, and mitigation actions taken by the PSO team.

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 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 will include the final responsibility for calling for a mitigation action.

Prior to the start of Project-related activities, the Lead PSO will work with the vessel captain and crew (i.e., operations team) on the vessel (the latter as applicable) to achieve compliance with 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 or rest, depending on onsite conditions (e.g., weather). 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.

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 Section 2.1.4.2). During activities with large monitoring zones, 25×150 millimeter (mm) "big eye" binoculars may be used. 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. 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 able and safe to do so.

2.1.4 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 devices [NVDs] 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 (two per vessel)
- 25x150-mm binoculars (“big eyes”)
- Personal computers/laptops/tablets (minimum of two on the primary vessel)
- Handheld GPS units (minimum of two per 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 a 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)
- NVDs
- Mounted infrared (IR) thermal imaging cameras
- PAM hydrophone arrays and/or corresponding monitoring stations
- Computer-based PSO data recording system

Specific equipment requirements for individual Project-related activities are provided in Sections 2.3 through Section 2.7. Descriptions of the primary hardware used during mitigation and monitoring activities for all phases of wind farm development are provided below in Section 2.1.4.1 through Section 2.1.4.3.

2.1.4.1 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 protection (Zitterbart *et al*. 2013, 2020; Smith *et al*. 2020). For this reason, the Project finds that use of IR thermal camera systems for mitigation 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.

2.1.4.2 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. In this way, NVDs are less dependent on temperature differentials necessary for the IR thermal camera systems. Their drawback, however, are their narrow fields of view and short effective ranges.

Equipment selected will be tailored to the sizes of the zones being monitored for the Project. Specifications for representative NVDs and IR thermal cameras 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.

2.1.4.3 PAM Systems

A PAM system is defined as any system or device that uses hydrophones or 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 are 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 (Van Parijs *et al.* 2009; Parks *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 Orsted projects are discussed in Section 2.1.4.3.1 and Section 2.1.4.3.3 and in Attachment 4.

2.1.4.3.1 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 priority of mitigation monitoring is the ability for compliance personnel to detect and spatially localize marine mammals such that a mitigation decision can be made in a matter of minutes. The complexity of acoustic detection and localization is further hindered by practical operational conditions that are common for mitigation monitoring, described further below.

The real-time requirement 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 monitor directly from the tow 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 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 which 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. One significant value of towed PAM systems, however, is their ability to work in unison with visual monitoring efforts along transects. 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. While towed PAM systems have a place in mitigation monitoring (e.g., in support of visual observation), alternative PAM systems are required 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. 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). A review for ASVs and AUVs was recently conducted by Verfuss *et al.* (2019). 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.

2.1.4.3.2 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.

2.1.4.3.3 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 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.

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 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.

2.1.5 Software and Informational Tools

During Project-related activities 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, Orsted's Marine Operation Centers vessel monitoring system, external sources of information such as Whale Alert (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 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 and the NMFS RWSAS.

2.1.5.1 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 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 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 is used by vessel crews to actively avoid animals.
- Automatic display of NMFS NARW DMAs on heads-up 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 inclinometer 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.

2.1.6 Recording

As part of all monitoring programs, PSOs, PAM operators, and crew members (as applicable) will record all sightings of marine mammals sighted 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 a 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 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 (CPA) 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 detection (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 place during that particular watch.

2.1.7 Reporting

The following situations would require immediate reporting to appropriate POCs:

- In the event of a sighting of a stranded, entangled, injured, or dead marine mammal, the sighting shall be reported within 24 hours to the NMFS RWSAS hotline as stipulated in Attachment 5.
- In the event a marine mammal is injured or killed as a result of Project activities, the vessel captain or PSO on board shall report immediately to NMFS Office of Protected Resources and Greater Atlantic Regional Fisheries Office no later than within 24 hours as stipulated in Attachment 5.
- Any NARW sightings will be reported as soon as possible, 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 include all variables required by the NMFS-issued Incidental Take Authorization (ITA) and BOEM Lease OCS-A 0498 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 summarizing the prior year's activities will be provided to NMFS and to BOEM on April 1 every calendar year summarizing the prior year's activities.

2.1.7.1 Post Construction HRG Survey Reports

Post construction, Ocean 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 Ocean 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.

2.1.8 Noise Mitigation Systems

Noise mitigation systems (NMS) 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.

There are two categories of NMS, primary and secondary. A primary NMS 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 NMS are not fully effective at eliminating all potentially harmful noise levels that can propagate from construction activities (e.g., $\geq$1 km), so a secondary NMS is typically employed to further mitigate pile driving noise. A secondary NMS 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.

Ocean Wind plans to use a combination of two NMS during impact installation of all piles: 1) an AdBm system (AdBm Technologies, Austin, Texas), and 2) a double big bubble curtain (dBBC). The AdBm system and dBBC are compatible as the dBBC will attenuate higher frequency noise, while the AdBm system will attenuate low frequency noise. The demonstrated effectiveness of these systems is described in Bellmann *et al*. (2020) (also see Section 1.4.1 of ITA application for more information). Brief descriptions of these proposed systems are as follows:

1. 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.
2. dBBC: A dBBC consists of flexible tubes fitted with special nozzle openings and installed in concentric rings on the seabed around the pile. Compressed air is forced through the nozzles producing a double layer of curtains 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.

There are other available systems (e.g., noise mitigation screens); however, these are not currently technically feasible for the Project because they are either in early stages of development or have yet to demonstrate their expected performance during field tests. Using the combined NMS approach described above, Ocean Wind is committed to achieving a minimum of 10 dB noise attenuation[5].

The configuration of any secondary NMS will optimize its efficacy based on the location, operations, and environmental and oceanographic parameters of the project. For the context of this report, the ***standard*** BBC 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.

2.1.9 Vessel Strike Avoidance Policy

The Project will implement a vessel strike avoidance policy for all vessels under contract to Orsted to reduce the risk of vessel strikes, and the likelihood of death and/or serious injury to marine mammals that may result from collisions with vessels. In addition to vessels transiting and working (e.g., HRG surveys, construction, and 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 have difficulty identifying the direction of the source of the vessel noise due to sound propagation characteristics in the marine

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[5] The combination of a dBBC and AdBm system shows a potential noise reduction of 17 dB to 20 dB (Bellmann et al. 2020).

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, in 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 respond with the appropriate action (e.g., change course, slow down or stop, steer away from the animal) to avoid striking marine mammals.
3. Vessel operators will monitor the Project's Situational Awareness System and as necessary, Whale Alert and the NMFS RWSAS for the presence of NARWs once every 4-hour 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 a10-knot speed restriction when entering or departing a port or place subject to U.S. jurisdiction, and in any SMA[6] during NARW migratory and calving periods from November 1 to April 30 (Mid-Atlantic SMAs specific to the Project area: ports of New York/New Jersey and the entrance to the Delaware Bay in the vicinity of the Project area) (**Figure 2** and **Figure 3**); also, in the following feeding areas as follows: from January 1 – May 15 in Cape Cod Bay; from March 1 – April 30 off Race Point; and from April 1 – July 31 in the Great South Channel.
6. All vessels will comply with the approved adaptive speed plan which will include additional measures including travel within established NARW Slow zones (see Attachment 6).
7. When whales are sighted, the vessel shall maintain a distance of 100 m or greater between the whale(s) and the vessel; for smaller cetaceans, a distance of 50 m or greater is best; for right whales this distance is 500 m.
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 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

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[6] 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-rightwhales#seasonal-management-areas---mid-atlantic

unable due to restricted movements, reduce speed and shift gears into neutral until the animal(s) has 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 whale listening network.

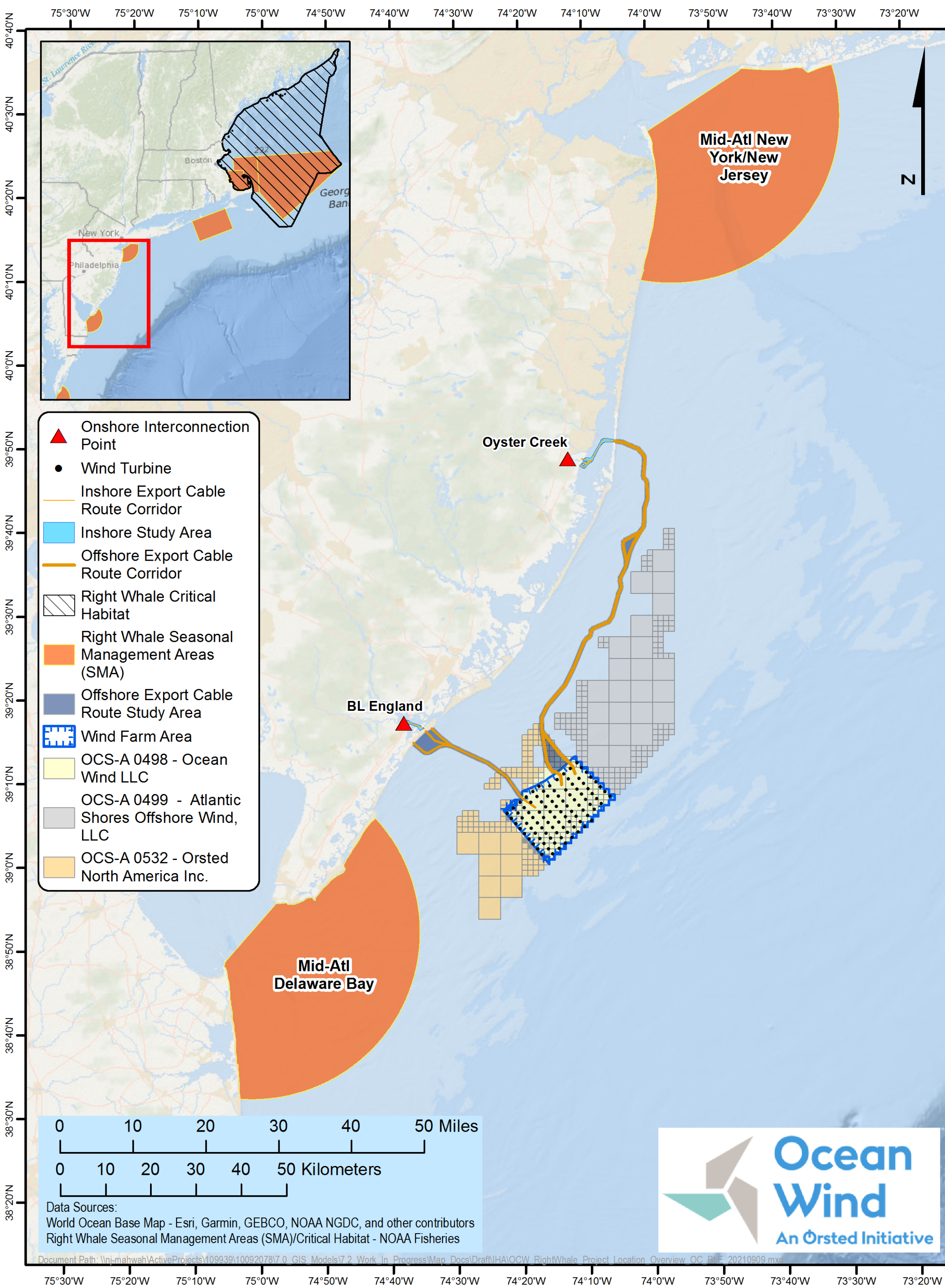


Figure 2. North Atlantic Right Whale Critical Habitat and Seasonal Management Areas.

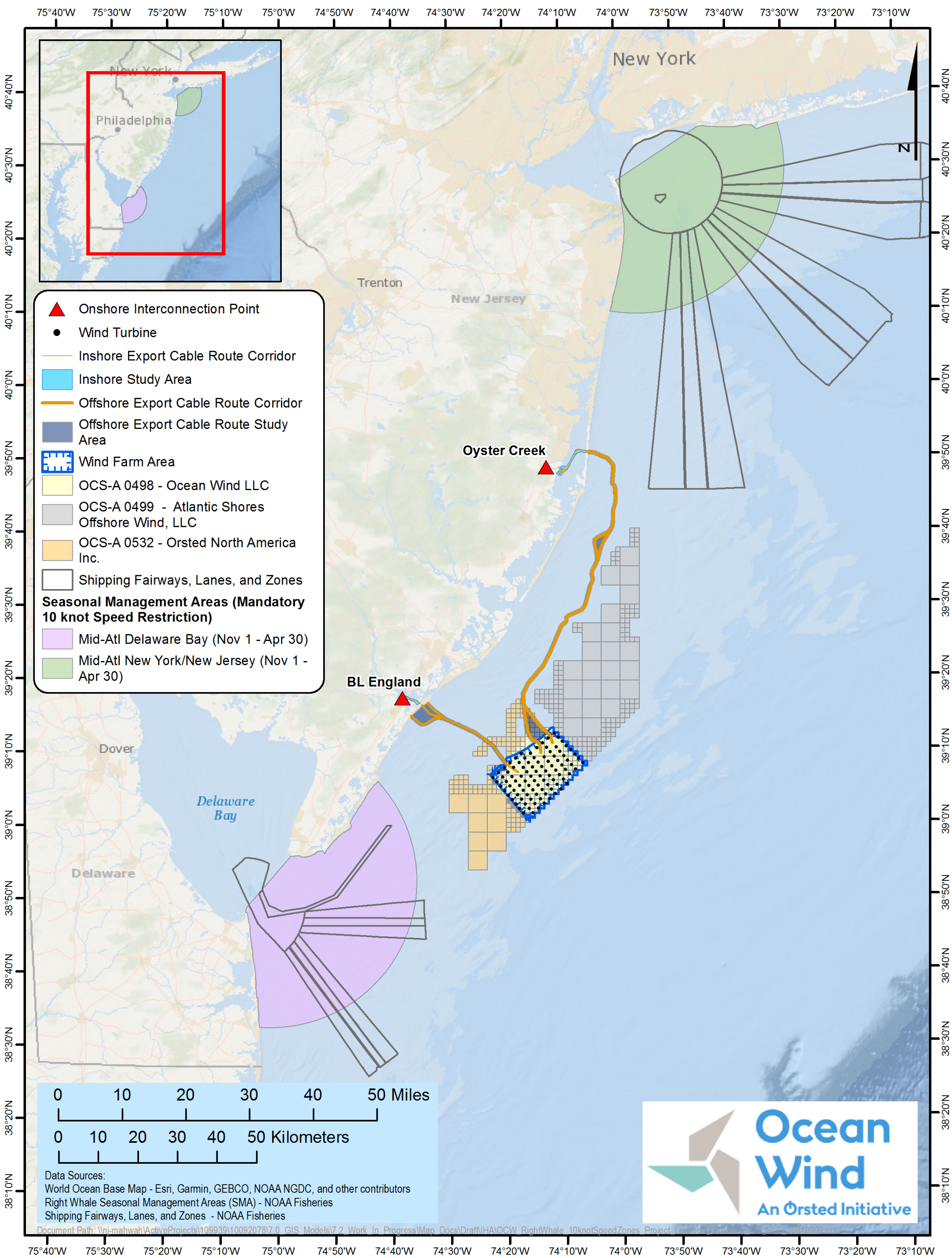


Figure 3. North Atlantic Right Whale Management Areas with Speed Restrictions.

2.2 HRG Survey Monitoring and Mitigation Plan

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

- Depth sounding (multibeam echosounders) 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 seabed, as well as any anomalous features;
- Shallow penetration sub-bottom profiling surveys to map the near surface stratigraphy (0 m to 10 m soils below seabed), and
- Medium penetration sub-bottom profiling (0 m to 70 m penetration).

HRG survey operations will be conducted over 24-hour periods. 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.

NOTE: 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.

2.2.1 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 4.**

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 (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, coastal	<1	<1			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

<table>
<tr><th>Species</th><th>Level A Zone (SEL) (m)</th><th>Level A Zone (PK) (m)</th><th>Level B Monitoring Zone, Boomers/Sparkers (m)</th><th>Level B Monitoring Zone, all other equipment (m)</th><th>Pre-start Clearance Zone (m)</th><th>Shutdown Zone (m)</th><th>Vessel Separation Distance (m)</th></tr>
<tr><td colspan="8">High-Frequency Cetaceans</td></tr>
<tr><td>Harbor porpoise</td><td>36.5</td><td>4.7</td><td>141</td><td>48</td><td>100</td><td>100</td><td>50</td></tr>
<tr><td colspan="8">Pinnipeds in Water</td></tr>
<tr><td>Gray seal</td><td><1</td><td><1</td><td rowspan="2">141</td><td rowspan="2">48</td><td>100</td><td>100</td><td>50</td></tr>
<tr><td>Harbor seal</td><td><1</td><td><1</td><td>100</td><td>100</td><td>50</td></tr>
</table>

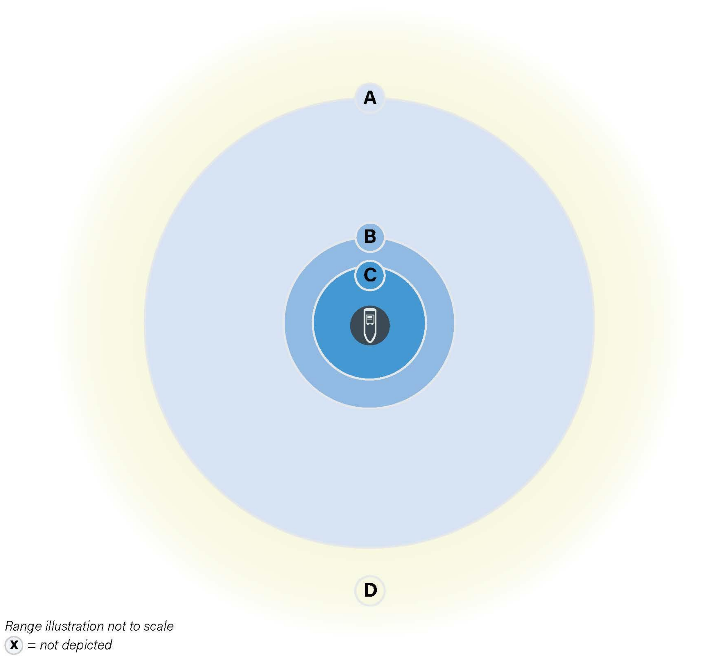
* = denotes species listed under the Endangered Species Act; SEL = sound exposure level in units of decibels referenced to 1 micropascal squared second; PK = peak sound pressure level in units of decibels referenced to 1 micropascal.

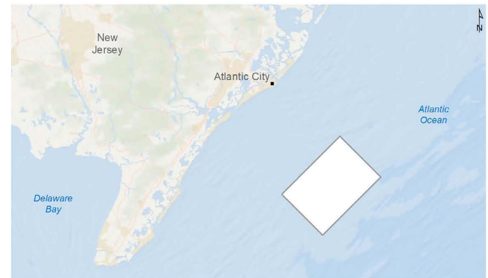
-- = no shutdown zone mitigation measures will be applied.

NOTE: All Level B monitoring, pre-start clearance, and shutdown zones are consistent with those listed in the Incidental Harassment Authorization issued to Ocean Wind in May 2021 for site characterization surveys (86 FR 26465).

Ocean Wind Mitigation and Monitoring Zones

High Resolution Geophysical Survey





Monitoring Platforms

Survey Vessel

Mitigation and Monitoring Zones [1,2]

A	North Atlantic Right Whale Clearance/Shutdown Zone	500 m
B	Level B Zone for Sparker Sources	141 m
C	Clearance / Shutdown Zone for Other Marine Mammals	100 m
D	Visual Monitoring Zone for Reporting	500+ m
X	Level B Zone for All Other Equipment	48 m
X	Level A Zone for HF Hearing Group (SEL_{cum})	36.5 m

[1] All mitigation and monitoring zones are inclusive of combined visual and acoustic monitoring effort.

[2] Other marine mammal clearance and exclusion zones < 100 m are not depicted. Refer to the ***Table of mitigation and monitoring zones for HRG*** for other zones.

	Standard Daytime Visual			Nighttime and Low Visibility		
	PSOs on watch	Reticle binoculars	Mysticetus data collection software system	PSOs on watch	Mounted thermal / IR camera system	Hand-held or wearable night vision devices
Survey Vessel	1	2	1	2	1	2

Figure 4. Marine Mammal Mitigation and Monitoring Zones for High-resolution Geophysical 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.

2.2.2 HRG Survey Monitoring and Mitigation Protocols

HRG surveys using sound sources that require mitigation per Lease or ITA conditions 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[7]. **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	Number 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
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.

2.2.2.1 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 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 SZs prior to initiation of HRG survey operations and will continue throughout the survey activity and/or while equipment operating below 180 kHz are in use.
- The PSOs will be responsible for visually monitoring and identifying marine mammals approaching or entering the established zones during survey activities.

[7] 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.

- It will be the responsibility of the Lead PSO on duty to communicate the presence of marine mammals as well as to communicate and enforce the action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate.

2.2.2.1.1 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.

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

2.2.2.1.3 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. Images from the cameras can be captured for review and to assist in 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.

2.2.2.2 Pre-Start Clearance

- PSOs will implement a 30-minute clearance period of the clearance zones 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 clearance zones 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 clearance zone.

- If a marine mammal is observed within its respective clearance zone during the pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting its respective clearance zone 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).

2.2.2.3 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.

The ramp-up procedure will not be initiated during periods of inclement conditions or if the clearance zones cannot be adequately monitored by the PSOs, using the appropriate visual technology for a 30-minute period. The ramp-up procedure will not be initiated during periods of inclement conditions or if the clearance zones cannot be adequately monitored by the PSOs, using the appropriate visual technology for a 30-minute period.

A ramp-up would begin with powering up the smallest acoustic HRG equipment at its lowest practical power output appropriate for the survey. When technically feasible, the power would then be gradually turned up and other acoustic sources added as able. Steps will not exceed 6 dB per 5-minute period.

Ramp-up activities will be delayed if a marine mammal(s) enters its respective clearance zone. Ramp-up will continue if the animal has been observed exiting its respective clearance zone 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).

2.2.2.4 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 4-hour shift during Project-related activities within, or adjacent to, SMAs and/or DMAs.

2.2.2.5 Shutdown Protocols

- An immediate shutdown of the applicable HRG survey equipment (i.e., select sources operating <180 kHz) will be required if a marine mammal is sighted at 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 can be initiated if the animal has been observed exiting its respective SZ within 30 minutes of the shutdown 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). Survey vessels may power down electromechanical equipment to lowest power output that is technically feasible for these species.

2.2.2.6 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 ramp-up procedures will be initiated as described in Section 2.2.2.3.

2.2.2.7 Vessel Strike Avoidance

The Project will follow vessel strike avoidance measures outlined previously in the Vessel Strike Avoidance Policy section (Section 2.1.9).

2.2.2.8 Vessel Speed Restrictions

The Project will follow vessel strike avoidance measures outlined previously in the Vessel Strike Avoidance Policy section (Section 2.1.9).

2.2.2.9 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.

2.2.3 HRG Survey Reporting

The Project will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.2.3.1 DMAs

DMAs will be reported across all vessels.

2.2.3.2 Injured and Dead Protected Species

The Project will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.3 Mitigation and Monitoring Plan for UXO Detonation

2.3.1 UXO 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 (COP Appendix R-2 [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 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]). Propagation modeling was performed using a sound speed profile representative of September, as this represented the most conservative noise propagation scenario (COP Appendix R-2). No UXO detonations are planned between January and April.

All mitigation and monitoring zones assume the use of an NMS resulting in a 10 dB reduction of noise levels (COP Appendix R-2; Bellman and Betke, 2021). Mitigation and monitoring zones specific to marine mammal hearing groups for the five different charge weight bins are presented in **Table 4** (assuming 10 dB mitigation) and **Table 5** (unmitigated scenario). 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 COP Appendix R-2. Non-auditory injury and PTS are considered Level A harassment, and TTS is considered Level B harassment. Because Ocean Wind has committed to no more than a single detonation event in any given 24-hour period, no behavioral modifications are anticipated (COP Appendix R-2). In all cases, the modeled distance to auditory injury (PTS) was greater than the distance to mortality and non-auditory injury thresholds (COP Appendix R-2), so all Level A distances presented are PTS. Four different sites (S1–S4; one within shallow depths representative of cable routes and the other three within depths representative of wind farm areas) ranging from 12–45 m were chosen to model the threshold distances for each of the five bins. PTS and TTS zones were calculated for each charge weight bin (E4–E12) by selecting the largest noise metric value across each of the four sites. Propagation modeling was performed using a sound speed profile representative of September, as this represented the most conservative noise propagation scenario (COP Appendix R-2). No UXO detonations are planned between January and April.

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

<table>
<tr><th rowspan="3">Species</th><th colspan="10">UXO Charge Weight[1]</th></tr>
<tr><th colspan="2">E4 (2.3 kg)</th><th colspan="2">E6 (9.1 kg)</th><th colspan="2">E8 (45.5 kg)</th><th colspan="2">E10 (227 kg)</th><th colspan="2">E12 (454 kg)</th></tr>
<tr><th>Pre-Start Clearance Zone[2] (m)</th><th>Level B Monitoring Zone[3] (m)</th><th>Pre-Start Clearance Zone (m)</th><th>Level B Monitoring Zone (m)</th><th>Pre-Start Clearance Zone (m)</th><th>Level B Monitoring Zone (m)</th><th>Pre-Start Clearance Zone (m)</th><th>Level B Monitoring Zone (m)</th><th>Pre-Start Clearance Zone (m)</th><th>Level B Monitoring Zone (m)</th></tr>
<tr><td colspan="11">Low-Frequency Cetaceans</td></tr>
<tr><td>Fin whale*</td><td rowspan="6">552</td><td rowspan="6">2,820</td><td rowspan="6">982</td><td rowspan="6">4,680</td><td rowspan="6">1,730</td><td rowspan="6">7,490</td><td rowspan="6">2,970</td><td rowspan="6">10,500</td><td rowspan="6">3,780</td><td rowspan="6">11,900</td></tr>
<tr><td>Minke whale</td></tr>
<tr><td>Sei whale*</td></tr>
<tr><td>Humpback whale</td></tr>
<tr><td>NARW*</td></tr>
<tr><td>Blue whale*</td></tr>
<tr><td colspan="11">Mid-Frequency Cetaceans</td></tr>
<tr><td>Sperm whale*</td><td rowspan="9">50</td><td rowspan="9">453</td><td rowspan="9">75</td><td rowspan="9">773</td><td rowspan="9">156</td><td rowspan="9">1,240</td><td rowspan="9">337</td><td rowspan="9">2,120</td><td rowspan="9">461</td><td rowspan="9">2,550</td></tr>
<tr><td>Atlantic white-sided dolphin</td></tr>
<tr><td>Atlantic spotted dolphin</td></tr>
<tr><td>Short-beaked common dolphin</td></tr>
<tr><td>Risso's dolphin</td></tr>
<tr><td>Bottlenose dolphin, coastal</td></tr>
<tr><td>Bottlenose dolphin, offshore</td></tr>
<tr><td>Long-finned pilot whale</td></tr>
<tr><td>Short-finned pilot whale</td></tr>
</table>

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)
High-Frequency Cetaceans										
Harbor porpoise	1,820	6,160	2,590	8,000	3,900	10,300	5,400	12,900	6,200	14,100
Phocid Pinnipeds										
Gray seal	182	1,470	357	2,350	690	3,820	1,220	5,980	1,600	7,020
Harbor seal										

* = denotes species listed under the Endangered Species Act; kg = kilograms; 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 COP Appendix R-2 [Hannay and Zykov 2021]) for the detonation of each charge weight bin.

[2] Pre-start clearance zones were calculated by selecting the largest 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 calculated by selecting the largest 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. Marine Mammal 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, coastal										
Bottlenose dolphin, offshore										
Long-finned pilot whale										
Short-finned pilot whale										

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)
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; kg = kilograms; 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 COP Appendix R-2 [Hannay and Zykov 2021]) for the detonation of each charge weight bin.

[2] Pre-start clearance zones were calculated by selecting the largest 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 based on the TTS threshold SEL noise metric. The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

2.3.2 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;
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 six to eight 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, and
- minimum distance allowed to the detonation location.

PAM operators may be located remotely/onshore. **Table 6** 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] PAM operator may be stationed on the vessel or at an alternative monitoring location and only one PAM team for all deployed PSO vessels.

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

2.3.2.1 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 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 conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods and post-detonation monitoring periods.

Acoustic monitoring will include, and extend beyond, the Large Whale Pre-Start Clearance Zone.

2.3.2.2 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 2.3.2.3) 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 2.3.2.3, will include, and extend beyond, the Large Whale Pre-Start Clearance Zone.

2.3.2.3 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 a 10 km radius around the source. PAM will be conducted in daylight 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.
- 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) who will be responsible for requesting the designated crewmember to implement the necessary mitigation procedures.

2.3.2.4 Pre-Start Clearance

- A 60-minute pre-start clearance period will be implemented prior to any UXO detonation. Visual PSOs will begin surveying the monitoring zone at least 60 minutes prior to the detonation event. PAM will also begin 60 minutes prior to the detonation event.
- The Large Whale Clearance Zone (**Tables 5** and **6**) must be fully visible for at least 60 minutes 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 minutes have elapsed without redetection for whales, including the NARW, or 15 minutes have elapsed without redetection of dolphins, porpoises, and seals.

2.3.2.5 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.
- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project area.

2.3.3 UXO Detonation Reporting

- Ocean Wind will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.3.3.1 Injured and Dead Protected Species

- Ocean Wind will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.3.4 Noise Attenuation for UXO Detonation

- Ocean Wind will use an NMS for all detonation events and is committed to achieving the modeled ranges associated with 10 dB of noise attenuation (see ITA application Section 1.4).

2.4 Construction Monitoring and Mitigation Plan for Impact Pile Driving

Up to 98 wind turbine generators (WTG) and three offshore substations (OSS) will be installed on either monopile foundations or jacket pile foundations using impact pile driving. Each OSS will have either a single 8/11-m diameter monopile foundation (as used for WTG foundations; a single steel pile that tapers from 8 m in diameter at the expected waterline to 11 m in diameter at the mudline) or a jacket foundation consisting of 16 2.44-m-diameter vertical pin piles installed with an impact hammer. The piled jackets will consist of 4 piles per corner (16 pin piles) per OSS. Up to three vertical pin piles will be installed each day during construction of the OSSs, and it is expected to take 4 hours per piling. Six days of installation per OSS foundation is anticipated. The pin piles will be driven to a maximum expected depth of 70 m (230 ft). 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.).

Mitigation and monitoring zones for impact pile driving were created for two different seasonal periods: *summer*, defined as May through November, and *winter*, defined as the month of December. 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.

2.4.1 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. The Level B monitoring zones, which will be applied to all marine mammal species, are based on the largest acoustic ranges for any piling scenario in a given season (flat R_{max}, 170 dB threshold). The Level A exposure ranges, Level B monitoring zone, mitigation zones, and vessel separation distances for impact pile driving during summer are provided in **Table 7** and displayed in **Figure 5**. The corresponding zones for winter are provided in **Table 8** and displayed in **Figure 6**. These zones and ranges are based on modeled piling scenarios for monopile and jacket pile installation for both seasonal periods (see Appendix A, Küsel *et al*. 2021, Tables 22, 23, J-11, J-12, J-15, and J-16) and assume 10 dB broadband noise attenuation. Mitigation zones established for all species, including the NARW, will be applied accordingly depending on the month 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. The sound field measurement plan is described in detail in Attachment 7.

To calculate the Level B monitoring zone for all marine mammals in summer, the maximum flat R_{max} 170 dB value for any foundation type, hammer energy, or penetration depth scenario (3.40 km, see Table H-25 in Appendix A) was selected and rounded up for PSO clarity. The same method was used to calculate the Level B monitoring zone for winter (3.77 km, see Table H-26 in Appendix A). Mitigation and monitoring zones for Level A harassment assume either one or two monopiles driven per day, and either two or three pin piles driven per day. When modeled injury threshold distances differed among these scenarios, the largest for each species group was selected for conservatism. The pre-start clearance zones for large whales, porpoise, and seals are based upon the maximum Level A zone for each group. The NARW zone was set equal to the Level B zone to avoid any unnecessary take (**Table 9**). The shutdown zones for large whales, NARW, porpoise, and seals are based upon the maximum Level A zone for each group.

Table 7. Threshold Ranges and Mitigation and Monitoring Zones[1,2] during Impact Pile Driving with 10 dB of Attenuation in Summer (May through November).

Species	Level A Zone (SEL_{cum})[3] (m)	Level A Zone (SPL_{pk}) (m)	Level B Monitoring Zone (m)	Pre-start Clearance Zone (m)[4]	Shutdown Zone (m)[5]	Vessel Separation Distance (m)
Low-Frequency Cetaceans						
Fin whale*	1,650	0	3,500	1,650	1,650	100
Minke whale	1,260	0	3,500	1,650	1,650	100
Sei whale*	1,360	0	3,500	1,650	1,650	100
Humpback whale	1,140	0	3,500	1,650	1,650	100
NARW*	1,370	0	3,500	See **Table 10**	See **Table 10**	500
Blue whale*[6]	1,650	0	3,500	1,650	1,650	100
Mid-Frequency Cetaceans						
Sperm whale*	0	0	3,500	1,650	1,650	100
Atlantic white-sided dolphin	0	0	3,500	NMS	NMS	50
Atlantic spotted dolphin	0	0	3,500	NMS	NMS	50
Short-beaked common dolphin	0	0	3,500	NMS	NMS	50
Risso's dolphin	0	0	3,500	NMS	NMS	50
Bottlenose dolphin, coastal	0	0	3,500	NMS	NMS	50
Bottlenose dolphin, offshore	0	0	3,500	NMS	NMS	50
Long-finned pilot whale	0	0	3,500	NMS	NMS	50
Short-finned pilot whale	0	0	3,500	NMS	NMS	50

Species	Level A Zone (SEL_{cum})[3] (m)	Level A Zone (SPL_{pk}) (m)	Level B Monitoring Zone (m)	Pre-start Clearance Zone (m)[4]	Shutdown Zone (m)[5]	Vessel Separation Distance (m)
High-Frequency Cetaceans						
Harbor porpoise	880	70	3,500	880	880	50
Pinnipeds in Water						
Gray seal	80	0	3,500	80	80	50
Harbor seal	60	0	3,500	80	80	50

* = denotes species listed under the Endangered Species Act; SEL_{cum} = cumulative sound exposure level; SPL_{pk} = peak sound pressure level; NMS = noise mitigation 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):

- 8/11-m (tapered) monopile with 10 dB broadband sound attenuation.
- Either one or two monopiles driven per day, and either two or three pin piles driven per day. When modeled injury (Level A) threshold distances differed among these scenarios, the largest for each species group was chosen for conservatism. To calculate the Level B zone, the maximum Flat R_{max} 170 dB value for any hammer energy or penetration depth scenario in summer conditions (3.40 km, see Table H-25 in Appendix A) was selected and rounded up for PSO clarity.

[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 Level A zone for each group. 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 group.

[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.

Table 8. Threshold Ranges and Mitigation and Monitoring Zones[1,2] during Impact Pile Driving with 10 dB of Attenuation in Winter (December only).

Species	Level A Zone (SEL_{cum})[3] (m)	Level A Zone (SPL_{pk}) (m)	Level B Monitoring Zone (m)	Pre-start Clearance Zone (m)[4]	Shutdown Zone (m)[5]	Vessel Separation Distance (m)
Low-Frequency Cetaceans						
Fin whale*	2,490	0	3,800	2,490	2,490	100
Minke whale	1,980	0	3,800	2,490	2,490	100
Sei whale*	2,190	0	3,800	2,490	2,490	100
Humpback whale	1,770	0	3,800	2,490	2,490	100
NARW*	2,030	0	3,800	See **Table 9**	See **Table 9**	500
Blue whale*[6]	2,490	0	3,800	2,490	2,490	100
Mid-Frequency Cetaceans						
Sperm whale*	0	0	3,800	2,490	2,490	100
Atlantic white-sided dolphin	0	0	3,800	NMS	NMS	50
Atlantic spotted dolphin	0	0	3,800	NMS	NMS	50
Short-beaked common dolphin	0	0	3,800	NMS	NMS	50
Risso's dolphin	0	0	3,800	NMS	NMS	50
Bottlenose dolphin, coastal	0	0	3,800	NMS	NMS	50
Bottlenose dolphin, offshore	0	0	3,800	NMS	NMS	50
Long-finned pilot whale	0	0	3,800	NMS	NMS	50
Short-finned pilot whale	0	0	3,800	NMS	NMS	50

Species	Level A Zone (SEL_{cum})[3] (m)	Level A Zone (SPL_{pk}) (m)	Level B Monitoring Zone (m)	Pre-start Clearance Zone (m)[4]	Shutdown Zone (m)[5]	Vessel Separation Distance (m)
High-Frequency Cetaceans						
Harbor porpoise	1,430	80	3,800	1,430	1,430	50
Pinnipeds in Water						
Gray seal	140	0	3,800	240	240	50
Harbor seal	240	0	3,800	240	240	50

* = denotes species listed under the Endangered Species Act; SEL_{cum} = cumulative sound exposure level; SPL_{pk} = peak sound pressure level; NMS = noise mitigation 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):

• 8/11-m (tapered) monopile with 10 dB broadband sound attenuation.

• Either one or two monopiles driven per day, and either two or three pin piles 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 scenario (3.49 km for fin whales) 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 Level A zone for each group. 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 group.

[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.

Table 9. NARW Clearance and Real-time PAM Monitoring Zones[1] during Impact Piling with 10 dB of Attenuation in Summer and Winter

Season	Minimum Visibility Zone[2]	PAM Clearance Zone (m)[3]	Visual Clearance Delay or Shutdown Zone (m)	PAM Clearance Delay or Shutdown Zone (m)
Summer	1,650	3,500	Any Distance	1,650
Winter	2,490	3,800	Any Distance	2,490

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

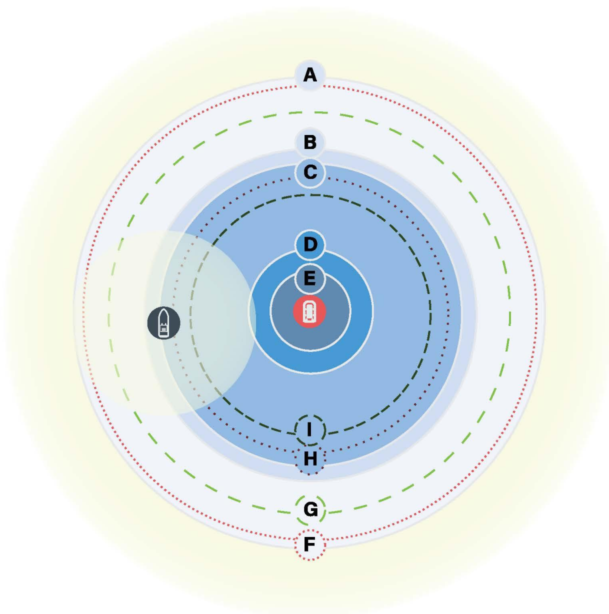
[2] The minimum visibility zones for NARWs are based upon the maximum Level A zones for the whale group.

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

Ocean Wind Mitigation and Monitoring Zones

Impact Pile Driving 8 - 11 m Monopile 10 dB Attenuation in Summer

HDR



Range illustration not to scale

(X) = not depicted

Monitoring Platforms

- Pile / Construction Vessel
- Secondary Vessel

Mitigation and Monitoring Zones [1,2]

	Zone	Distance
A	North Atlantic Right Whale Clearance Zone	3,500 m
B	Large Whale Clearance Zone	1,650 m
C	Large Whale Shutdown Zone	1,650 m
D	Harbor Porpoise Clearance Zone	880 m
D	Harbor Porpoise Shutdown Zone	880 m
E	Seal Clearance Zone	80 m
X	Seal Shutdown Zone	80 m

Monitoring Zones for Reporting [1]

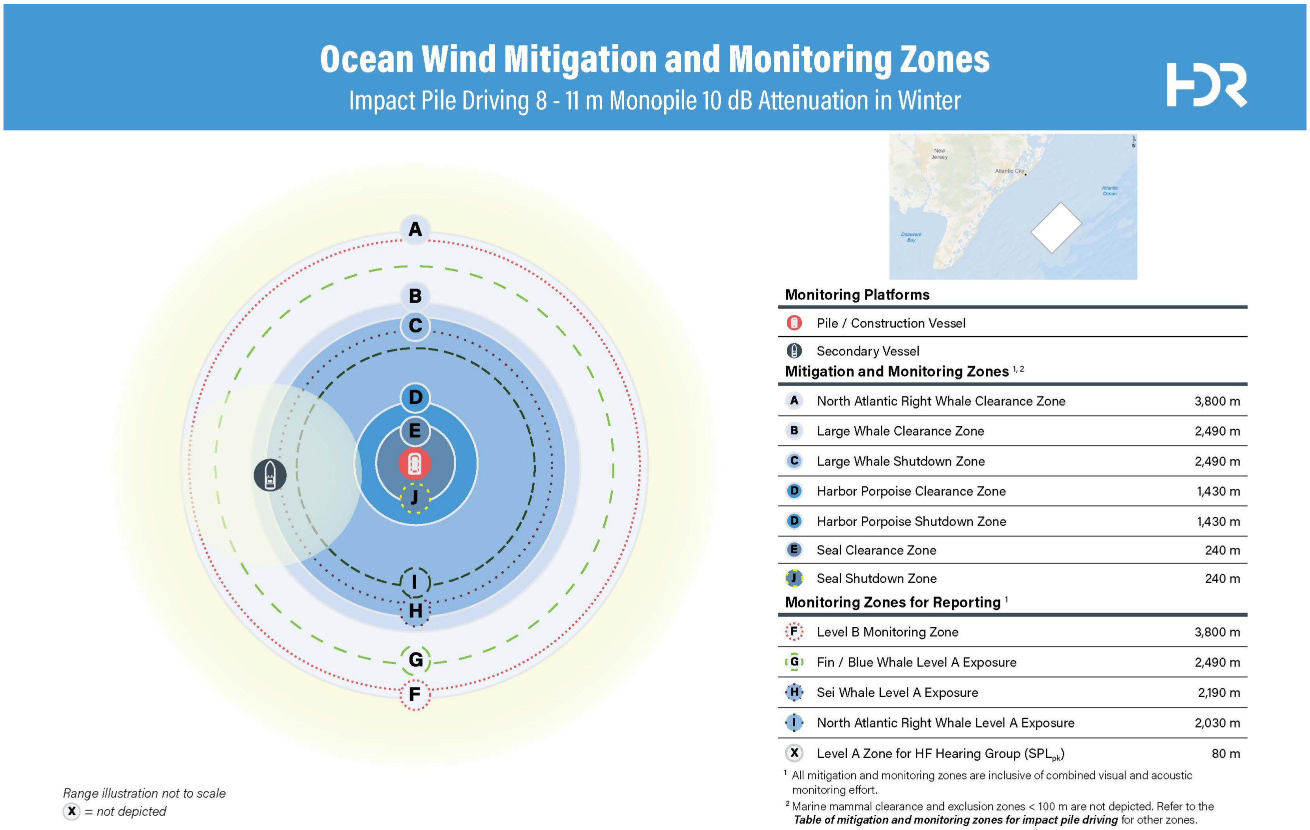
	Zone	Distance
F	Level B Monitoring Zone	3,500 m
G	Fin / Blue Whale Level A Exposure	1,650 m
H	Sei Whale Level A Exposure	1,360 m
I	North Atlantic Right Whale Level A Exposure	1,370 m
X	Level A Zone for HF Hearing Group (SPL_{pk})	70 m

[1] All mitigation and monitoring zones are inclusive of combined visual and acoustic monitoring effort.

[2] Marine mammal clearance and exclusion zones < 100 m are not depicted. Refer to the ***Table of mitigation and monitoring zones for impact pile driving*** for other zones.

	DAYTIME MONITORING							NIGHTTIME MONITORING					
	PERSONNEL		EQUIPMENT					PERSONNEL		EQUIPMENT			
	PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted "big eye" binoculars	Mounted thermal camera system	Monitoring station for real time PAM	Mysticetus data software	PSOs on hand-held NVD / IR	PAM operators on duty	Handheld NVD / IR	Mounted thermal camera system	Monitoring station for real time PAM	Mysticetus data software
# on Construction Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1
# on Secondary Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1

Figure 5. Marine Mammal Mitigation and Monitoring Zones during Impact Pile Driving in Summer.



	DAYTIME MONITORING							NIGHTTIME MONITORING					
	PERSONNEL		EQUIPMENT					PERSONNEL			EQUIPMENT		
	PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted "big eye" binoculars	Mounted thermal camera system	Monitoring station for real time PAM	Mysticetus data software	PSOs on hand-held NVD / IR	PAM operators on duty	Handheld NVD / IR	Mounted thermal camera system	Monitoring station for real time PAM	Mysticetus data software
# on Construction Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1
# on Secondary Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1

Figure 6. Marine Mammal Mitigation and Monitoring Zones during Impact Pile Driving in Winter.

2.4.2 Impact Pile Driving 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 vessel and on any secondary marine mammal monitoring vessels;
2. PAM operators and an associated mitigation PAM array in support of the visual PSOs;
3. NMSs; 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 Ocean Wind construction are described further in the following subsections. Impact pile driving may be initiated after dark[8] or during

[8] Pile installation will occur during daylight hours and during darkness when necessary. 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. New piles could be initiated after dark to meet schedule requirements.

reduced visibility periods following the protocols in Section 2.4.2.1 through Section 2.4.2.3 and include utilization of alternative monitoring methods.

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 10** 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 10. 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	
	Number on Construction Vessel	Number on Secondary Vessel	Number on Construction Vessel	Number 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.

2.4.2.1 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 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 a maximum of 4 hours 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. PSOs will monitor for 30 minutes before and after each piling event.
- During daytime observations, two PSOs on each vessel will monitor the 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 (**Tables 7** and **8**).
- The secondary vessel will be positioned and circling at the outer limit of the Large Whale SZ (**Figures 10** and **11**). 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 2.4.2.4) 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 2.4.2.4, will include, and extend beyond the Large Whale Pre-Start Clearance Zone.
- The NARW pre-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 (**Table 9**).

2.4.2.2 Daytime Periods of Reduced Visibility

- If the monitoring zone is obscured, the two PSOs on watch 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.

2.4.2.3 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. If a PSO is still unable to observe the required visual zones, piling will not occur.

2.4.2.4 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 for all monitoring periods of piling. A combination of alternative monitoring measures has been demonstrated to have comparable detection rates to daytime visual only detections (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:

- PSOs will acoustically monitor a zone that corresponds to the Level B zone for all marine mammals, as well as the NARW clearance zone, and also encompasses the Level A zones for all marine mammal species.

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

- 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.

- The PAM operator will inform the Lead PSO on duty of animal detections approaching or within applicable ranges of interest to the pile-driving activity via the data collection software system (i.e., Mysticetus or similar system) who will be responsible for requesting the designated crewmember to implement the necessary mitigation procedures.
- Acoustic monitoring during nighttime and low visibility conditions during the day will complement visual monitoring (e.g., PSOs and thermal cameras) and will cover an area of at least the Level B zone around each foundation.

2.4.2.5 Mitigation Measures during Impact Pile Driving

Mitigation measures implemented during a piling event include:

- pre-start clearance;
- ramp up or 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 11** and **Table 12** and detailed in Section 2.4.2.5.1 through Section 2.4.2.5.5 below.

Table 11. Summary of Mitigation Measures during Impact Pile Driving with a Noise Mitigation System in Summer (May through November).

	Piling with an NMS, 10 dB broadband attenuation				
	NARW	Large Whale	Delphinids	Harbor Porpoise	Seals
Pre-Start Clearance Zone[1]	3,300 m	2,000 m	N/A	1,100 m	N/A
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				
Shutdown Zone[2]	1,800 m	1,800 m	N/A	1,000 m	N/A

m=meters; min=minutes; NARW=North Atlantic right whale; NMS=Noise Mitigation System; N/A=no mitigation measures will be undertaken because either Level A take will be requested for these species, or the position of the NMS precludes Level A take entirely.

[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.

Table 12. Summary of Mitigation Measures during Impact Pile Driving with a Noise Mitigation System in Winter (December only).

	Piling with an NMS, 10 dB broadband attenuation				
	NARW	Large Whale	Delphinids	Harbor Porpoise	Seals
Pre-Start Clearance Zone[1]	3,800 m	2,490 m	N/A	1,430 m	N/A
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				
Shutdown Zone[2]	2,490 m	2,490 m	N/A	1,430 m	N/A

m =meters; min=minutes; NARW=North Atlantic right whale; NMS=Noise Mitigation System; N/A=no mitigation measures will be undertaken because either Level A take will be requested for these species, or the position of the NMS precludes Level A take entirely.

[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.

2.4.2.5.1 Pre-Start Clearance

A 60-minute pre-start clearance period 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 will begin at least 30-minutes prior to the start of piling. Other pre-clearance protocols include:

- The large whale clearance zone (2,000 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 ramp up.
- If a marine mammal is observed entering or within the relevant clearance zones prior to the initiation of pile driving activity, pile driving activity must be delayed.
- 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 redetection for whales, including the NARW, or 15 minutes have elapsed without redetection of dolphins, porpoises, and seals.

2.4.2.5.2 Ramp up (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 13**.

- Soft start of pile driving will not begin until the SZ has been cleared by the PSOs (and PAM operators when applicable).

- If any marine mammals are detected within the SZ prior to or during the soft start, activities will be delayed until the animal has been observed exiting the SZ or until an additional time period has elapsed with no further sighting.

Table 13. Generic Soft Start Procedure Overview.

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

2.4.2.5.3 Operations 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.

2.4.2.5.4 Shutdown Protocols

For reference, a generic piling procedure has been broken down into 3 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
    a. 125 blows/25 centimeters (cm) over an increment of 6 × 25 cm
    b. 200 blows/25 cm over an increment of 2 × 25 cm
    c. 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 after pile driving has commenced, an immediate shutdown of pile driving will be implemented unless Ocean Wind 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 below).

If shutdown is called for but Ocean Wind 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 Orsted’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 shut-down 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. Orsted 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 shut-down is not feasible because the shut-down 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, Orsted 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.

2.4.2.5.5 Pauses and Silent Periods

- The SZ 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, 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.

2.4.2.6 Vessel Strike Avoidance

- The Project will follow vessel strike avoidance measures outlined previously in the Vessel Strike Avoidance Policy section (Section 2.1.9).

2.4.2.6.1 Vessel Speed Restrictions

- The Project will follow vessel strike avoidance measures outlined previously in the Vessel Strike Avoidance Policy section (Section 2.1.9).

2.4.2.7 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.
- Members of the monitoring team must consult NMFS' NARW reporting systems for the presence of NARWs in the Project area.

2.4.3 Impact Pile Driving Reporting

- Ocean Wind will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.4.3.1 DMAs

- DMAs will be reported across all Project vessels.

2.4.3.2 Injured and Dead Protected Species

- The Project will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.4.4 Noise Attenuation for Impact Pile Driving

Ocean Wind will use a combination of two NMS during impact installation of all piles: 1) an AdBm system using large arrays of Helmholtz resonators and 2) a dBBC. Ocean Wind is committed to achieving the modeled ranges with a minimum of 10 dB of noise attenuation[9] (see ITA application Section 1.4).

2.4.5 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 an NMS. The measurement plan is provided in Attachment 7.

- The goals of the of field verification measurements using an NMS include verification of modeled ranges; and providing sound measurements of impact pile driving using International Organization for Standardization (ISO)-standard methodology to build data that are comparable among projects.

2.4.5.1 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**).

2.5 Construction Plan for Vibratory Pile Driving of Sheet Pile

Each sea-to-shore transition will include a new onshore transition vault, cable installed using open cut or trenchless methods (bore or horizontal directional drilling [HDD]) under the beach and intertidal water and may also include a temporary cofferdam located offshore beyond the intertidal zone. If Project conditions require a temporary cofferdam, it will be constructed as a sheet piled structure into the sea floor.

2.5.1 Vibratory Sheet Pile Driving Monitoring and Mitigation Zones

Table 14 provides the ranges to all thresholds and monitoring zones applied during vibratory sheet pile installation and removal for each cofferdam. No noise attenuation is proposed due to the short time period of the activities. 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 thresholds over a 24-hour

[9] The combination of a dBBC and AdBm system shows a potential noise reduction of 17 dB to 20 dB (Bellmann et al. 2020).

period. Exposure ranges (which were not modeled for vibratory sheet 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 14**. These zones and ranges are based on sound source characteristics generated using a practical spreading loss model and a source level of 165.0 dB re 1 µPa (JASCO 2021). Mitigation zones established for all species, including the 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 14. Threshold Ranges 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[5] (m)	Vessel Separation Distance (m)
Low-Frequency Cetaceans						
Fin whale*	86.7	N/A	10,000	150	100	100
Minke whale	86.7	N/A	10,000	150	100	100
Sei whale*	86.7	N/A	10,000	150	100	100
Humpback whale	86.7	N/A	10,000	150	100	100
NARW*	86.7	N/A	10,000	150	100	500
Blue whale*	86.7	N/A	10,000	150	100	100
Medium-Frequency Cetaceans						
Sperm whale*	7.7	N/A	10,000	150	100	100
Atlantic white-sided dolphin	7.7	N/A	10,000	150	50	50
Atlantic spotted dolphin	7.7	N/A	10,000	150	50	50
Short-beaked common dolphin	7.7	N/A	10,000	150	50	50
Risso's dolphin	7.7	N/A	10,000	150	50	50
Bottlenose dolphin, coastal	7.7	N/A	10,000	150	50	50
Bottlenose dolphin, offshore	7.7	N/A	10,000	150	50	50
Long-finned pilot whale	7.7	N/A	10,000	150	50	50
Short-finned pilot whale	7.7	N/A	10,000	150	50	50

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[5] (m)	Vessel Separation Distance (m)
High-Frequency Cetaceans						
Harbor porpoise	128.2	N/A	10,000	150	150	50
Pinnipeds in Water						
Gray seal	52.7	N/A	10,000	150	60	50
Harbor seal	52.7	N/A	10,000	150	60	50

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

[1] Zone sizes are based upon a practical spreading loss model and a source level of 165.0 dB re 1 µPa (JASCO 2021).

[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 acoustic ranges of species with no animal movement modeling applied.

[4] The pre-start clearance zones for large whales, porpoise, and seals are based upon the maximum Level A zone (128.2 m) and rounded up for PSO clarity.

[5] The shutdown zones for large whales (including NARW) and porpoise are based upon the maximum Level A zone for each group and rounded up for PSO clarity. Shutdown zones for other dolphins and pilot whales were set using precautionary distances.

2.5.2 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 cofferdam construction site. No PAM operations will be utilized due to the likelihood of masking effects of the vibratory sheet pile driving activities which will result in ineffective acoustic monitoring opportunities. **Table 15** provides the list of the personnel on watch and monitoring equipment available onboard the construction vessel.

Table 15. Personnel and Equipment Compliment for Monitoring Vessels during Vibratory Sheet 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

2.5.2.1 Visual Observation Protocols and Methods

2.5.2.1.1 Daytime Visual

- Visual monitoring will occur from the construction or support vessel to provide complete visual coverage of the marine mammal SZs during vibratory sheet pile installation and removal.
- During the pre-start clearance period (Section 2.5.2.2), throughout vibratory sheet pile installation and removal, and 30-minutes after piling is completed, two PSOs will always maintain watch on the construction vessel.
- 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 and monitoring requirements. A sample crew shift rotation is shown in Attachment 2.
- PSOs will visually monitor the SZs.
- During daytime observations one observer will monitor the SZ 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.

2.5.2.1.2 Daytime Visual during Periods of Low Visibility

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

2.5.2.2 Pre-Start Clearance

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

2.5.2.3 Operations Monitoring

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

2.5.2.4 Shutdown Protocols

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

2.5.2.5 Pauses and Silent Periods

- The SZ must be continuously monitored by PSOs during any pauses in vibratory sheet pile driving.
- If marine mammals are sighted within the respective SZ during a pause in vibratory sheet 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.

2.5.2.6 Vessel Strike Avoidance

- The Project will follow vessel strike avoidance measures outlined previously in the Vessel Strike Avoidance Policy section (Section 2.1.9).

2.5.2.6.1 Vessel Speed Restrictions

- The Project will follow vessel strike avoidance measures outlined previously in the Vessel Strike Avoidance Policy section (Section 2.1.9).

2.5.2.7 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.

2.5.3 Reporting for Vibratory Sheet Pile Driving

The Project will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.5.3.1 DMAs

DMAs will be reported across all vessels.

2.5.3.2 Injured and Dead Protected Species

The Project will follow reporting measures as stipulated in Section 2.1.7 and Attachment 8.

2.6 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 2.2. HRG surveys will be monitored using the visual techniques outlined in Section 2.4.

2.6.1 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 Section 2.1.9 Mitigations will be in place to reduce the threat of ship strikes, also described in detail in Section 2.1.9. 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. Acoustic monitoring and appropriate mitigations will be implemented as warranted during operations.

2.6.2 Passive Acoustic Monitoring for Operations

Most operations-related, non-construction activities are expected to consist of maintenance, support, and transport vessels. Types of marine mammal PAM appropriate for these activities 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.

2.6.2.1 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.

2.7 Regional Long-Term Monitoring of 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).

2.7.1 Bottom Deployed Autonomous Recorders

AARs are described in Section 2.6.2.1 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.

2.7.2 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.

3. Other Protected Species

3.1 Sea Turtles

3.1.1 Species Likely to Occur in the Project Area

Four sea turtle species (**Table 16**) may occur or are expected or likely to occur (at least seasonally) in or transit near the Project area. Two sea turtle species occurring in or near the Project area are listed as endangered under the ESA of 1973 (35 FR 12222; 73 FR 12024) (**Table 16**).

Table 16. Sea Turtle Species Potentially Occurring within the Regional Waters of the Western North Atlantic Outer Continental Shelf (OCS) and Project Area.

Species	Current Listing Status	Relative Occurrence in OCW01
Leatherback sea turtle (*Dermochelys coriacea*)	ESA Endangered	Common
Loggerhead sea turtle (*Caretta caretta*)	ESA Threatened	Common
Kemp's ridley sea turtle (*Lepidochelys kempii*)	ESA Endangered	Uncommon
Green sea turtle (*Chelonia mydas*)	ESA Threatened	Uncommon

Note: ESA = Endangered Species Act; OCW01 = Ocean Wind 01.

3.1.1.1 Acoustic Thresholds for Sea Turtles

Injury, impairment, and behavioral thresholds for sea turtles were developed for use by the U.S. Navy (Finneran *et al.* 2017) based on exposure studies (e.g., McCauley *et al.* 2000a). Dual criteria (PK and SEL) have been suggested for PTS and TTS, along with auditory weighting functions published by Finneran *et al.* (2017) used in conjunction with SEL thresholds for PTS and TTS. The behavioral threshold recommended in the NMFS Greater Atlantic Regional Fisheries Office (GARFO) acoustic tool (NMFS GARFO 2020) is an SPL of 175 dB re 1 µPa (McCauley *et al*. 2000a; Finneran *et al*. 2017) (**Table 17**).

Peak sound pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran *et al*. (2017) were used for the onset of PTS and TTS in sea turtles. Behavioral response thresholds for sea turtles were obtained from McCauley *et al*. (2000b).

Table 17. Acoustic Metrics and Thresholds for Sea Turtles Currently Used by NMFS GARFO and BOEM for Impact Pile Driving.

Faunal group	Injury		Impairment		Behavior
	PTS		TTS		
	L_{pk}	$L_{E,\ 24hr}$	L_{pk}	$L_{E,\ 24hr}$	L_{p}
Sea turtles [a, b]	232	204	226	189	175

L_{pk} – peak sound pressure (dB re 1 µPa), $L_{E;24hr}$ – sound exposure level, cumulative 24h (dB re 1 µPa^2·s), L_p – root mean square sound pressure (dB re 1 µPa).

PTS = permanent threshold shift; TTS = temporary threshold shift, which are recoverable hearing effects.

3.1.2 Construction

3.1.2.1 Construction Monitoring and Mitigation Zones

Monitoring and mitigation zones for sea turtles during impact pile driving are provided in **Table 18** and displayed in **Figure 7**. These zones and ranges are based on the JASCO Animal Simulation Model Including Noise Exposure (JASMINE) open-source marine mammal movement and behavior model (3MB; Houser 2006) and used to predict the exposure of animats (virtual sea turtles) to sound arising from sound sources in simulated representative surveys (see COP Appendix R-2). Animats are programmed to behave like the marine animals likely to be present in the survey area. The parameters used for forecasting realistic behaviors (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animat's modeled sound exposure levels are summed over the total simulation duration, such as 24 hours or the entire simulation, to determine its total received energy, and then compared to the assumed threshold criteria (COP Appendix R-2).

These zones and ranges are based on modeled piling scenarios for monopile and jacket pile installation (see COP Appendix R-2, Tables 24 and 25) and assume 10 dB broadband noise attenuation. Mitigation and monitoring zones established for sea turtles will be applied during all months of the year in which work is performed. Mitigation and monitoring zones implemented during the Project may be modified, with NMFS approval, based on measurements of the received sound levels during piling operations. The sound field measurement plan is described in detail in Attachment 7.

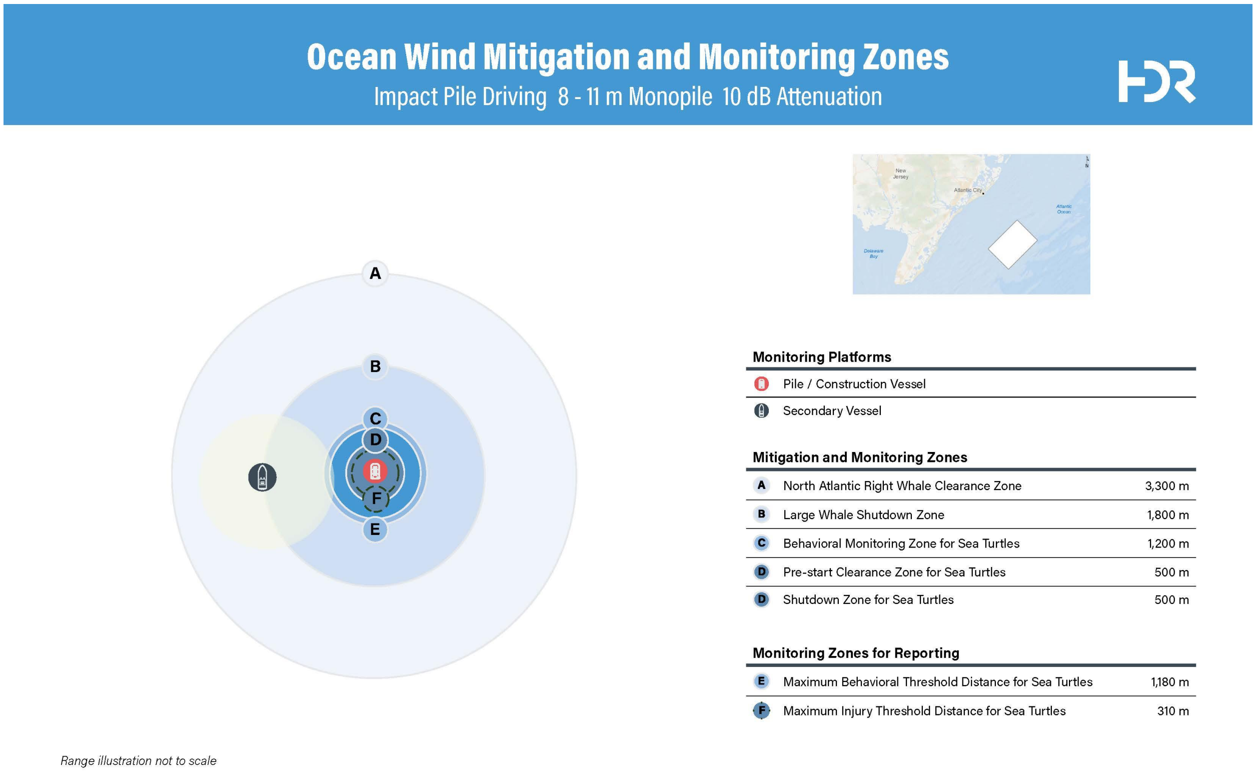
Noise modeling for impact pile driving assumed either one or two monopiles driven per day, and either two or three pin piles driven per day (COP Appendix R-2). Mitigation and monitoring zones shown in **Table 17** and **Figure 7** are based on the largest modeled zones in all of these scenarios for conservatism and rounded up for PSO clarity.

Sea turtle exposure ranges were not modeled for vibratory piling. Mitigation and monitoring protocols for sea turtles during vibratory piling are described in Section 3.1.3.2.

Table 18. Sea Turtle Threshold Ranges and Mitigation and Monitoring Zones (in meters) Associated

with Impact Pile Driving, Assuming 10 dB Mitigation.

Group	Maximum Behavioral Threshold Distance (m)	Behavioral Monitoring Zone (m)	Maximum Injury Threshold Distance (m)	Pre-start Clearance Zone (m)	Shutdown Zone (m)	Vessel Separation Distance (m)
Sea Turtles	1,180	1,200	310	500	500	50



	DAYTIME MONITORING							NIGHTTIME MONITORING					
	PERSONNEL		EQUIPMENT					PERSONNEL		EQUIPMENT			
	PSOs on watch	PAM operators on duty	Reticle binoculars	Mounted "big eye" binoculars	Mounted thermal camera system	Monitoring station for real time PAM	Mysticetus data software	PSOs on hand-held NVD / IR	PAM operators on duty	Handheld NVD / IR	Mounted thermal camera system	Monitoring station for real time PAM	Mysticetus data software
# on Construction Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1
# on Secondary Vessel	2	1	2	1	1	1	1	2	1	2	1	1	1

Figure 7. Sea Turtle mitigation and monitoring zones during impact pile driving. North Atlantic right whale zones are also shown for reference.

3.1.2.2 Construction Monitoring and Mitigation Protocols

Protocols and parameters for sea turtle monitoring during impact and vibratory pile driving will mirror those outlined in **Sections 2.4** and **2.5**. Mitigation measures to be implemented during a piling event include:

- pre-start clearance;
- ramp-up or soft-start of pile strikes;
- post-piling monitoring;

- pauses and silent periods; and
- shutdown protocols.

For sea turtles specifically, pre-clearance zones of 1,640 ft (500 m[10]) will be established and monitored during both impact and vibratory pile driving (**Table 17**). If a sea turtle is detected within the 500-m monitoring zone, the PSO will call a shutdown of pile-driving activities (as long as technically feasible and the cessation of equipment would not be a danger to human safety or a concern for structural failure) until the lead PSO verifies that the animals have left the monitoring zone, or 30 minutes have elapsed without a resighting of the animal by the lead PSO. If the active pile-driving sound source is ceased for a period of greater than 20 minutes for any reason other than encroachment of a sea turtle into the monitoring zone, the zone will again be cleared by the PSO team for at least 30 minutes followed again by a ramp-up or soft-start before active pile-driving can resume. Throughout the duration of all pile driving activity (impact and vibratory), a PSO will observe a behavioral monitoring zone of 1,200 m for all species of sea turtles and will initiate a shutdown protocol if a sea turtle encroaches or is observed within 500 m.

During nighttime impact pile-driving operations, PSOs will be equipped with night-vision equipment to monitor for protected marine species (see Attachment 3). For sea turtles in particular, PSOs will utilize IR and NVD technology, as PAM is not suitable for monitoring of sea turtles, due to turtles being largely non-vocal. IR imaging uses the radiance difference between an animal's cue at or above the water's surface and the ocean background. IR thermal camera performance is independent of daylight and is effective at distances exceeding 3 kilometers (km). NVDs work on a different principle than IR thermal cameras, by enhancing available light to provide an image (in this case, a sea turtle) that resembles viewing during higher light conditions. NVDs are less dependent on temperature differentials necessary for the IR thermal camera systems but have narrow fields of view and short effective ranges. Although sea turtles are ectothermic, meaning that their body temperature is dependent on that of the surrounding environment, they do have some capacity to retain heat, and are able to maintain body temperatures that are slightly higher than the surrounding environment (Standora *et al*. 1982; Sato 2014; Bostrom *et al*. 2017. Therefore, thermal imaging is in fact capable of detecting sea turtles (Snyder 2017). See Attachment 3 for more details on nighttime monitoring devices.

All vessel operators and crews will maintain a vigilant watch for sea turtles and slow down or stop their vessel to avoid striking an animal, and all vessels will maintain a separation distance of 164 ft (50 m) or greater from any sighting of a sea turtle.

3.1.2.2.1 Reporting Requirements

See Attachment 8 for detailed protected species reporting requirements.

3.1.2.2.2 Noise Attenuation for Impact Pile Driving

The Project will employ a Noise Mitigation System (NMS) during all impact piling events and is committed to achieving the modeled ranges associated with a minimum of 10 dB of noise attenuation. NMS are employed during pile driving activities to reduce the SPLs that are transmitted through the water in an effort to reduce distances to acoustic thresholds and minimize the acoustic impacts of pile driving.

There are two categories of NMS, primary and secondary. A primary NMS 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 NMS are not fully effective at eliminating all potentially harmful noise levels that can propagate from construction activities (e.g., >1 km), so a

[10] The 500-m monitoring zone will be reduced to 100-m during any required HRG surveys.

secondary NMS is typically employed to further mitigate pile driving noise. A secondary NMS 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 sounds waves and therefore deceases the distance over which higher energy sound is propagated through the water column. Primary NMS are still evolving and will be considered for mitigation when mature with demonstrated efficacy in commercial projects.

As noted in Sections 2.1.8 and 2.4.4, in addition to soft starts, Ocean Wind will use a combination of two NMS during impact installation of all piles: 1) an AdBm system and 2) a double big bubble curtain (dBBC) to achieve a minimum of 10 dB noise reduction[11]. A bubble curtain consists of a hose with nozzles, which is laid on the seabed to fully encompass the monopile foundation. During impact pile driving, the hose is connected to air compressors, causing air bubbles leave the hose nozzles and rise to the water surface, thus forming a bubble curtain (Water Proof Marine Consultancy & Services BV 2020). The demonstrated effectiveness of these systems is described in Lucke *et al*. (2011); Rustemeier *et al*. (2012); Bellman 2014, 2019, and Bellmann *et al*. (2020).

The configuration of any secondary NMS will optimize its efficacy based on the location, operations, and environmental and oceanographic parameters of the Project. For the context of this report, the ***standard*** NMS configuration is defined as one that has been professionally deployed and further optimized after initial deployment based on local conditions and in situ measurement results. As stated above, the Project is committed to achieving a minimum of 10 dB of noise attenuation using a standard NMS, which is equivalent to a 90 percent reduction in sound energy level.

3.1.2.2.3 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 an NMS. The measurement plan is provided in Attachment 7. The goals of the of field verification measurements using an NMS include verification of modeled ranges; and providing sound measurements of impact pile driving using International Organization for Standardization (ISO)-standard methodology to build data that are comparable among projects. Based on the sound field measurement results, the Project may request a modification of the clearance and/or SZs (see Attachment 7).

3.1.3 UXO Detonations

Acoustic modeling was undertaken to determine potential impacts to sea turtles from UXO detonations (COP Appendix R-2, **Section 2.3.1**). Modeling was based on previous underwater acoustic assessment work permitted by the U.S. Navy in concert with NMFS. Effects thresholds were evaluated based on three sound pressure metrics considered by the U.S. Navy and NMFS as indicators of injury and disturbance: peak pressure level, sound exposure level (SEL), and acoustic impulse. SPL was not evaluated for potential UXO detonations because it is not presently used by NMFS as an assessment criterion for sounds from explosive detonations. The modeling for this assessment used criteria for charge weights based on definitions created by the U.S. Navy (DoN 2017), which classified weapons and munitions into five bins based on similar characteristics and charge weight equivalent to trinitrotoluene, more commonly known as TNT. Five 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]). Propagation modeling was performed using a sound speed profile representative of September, as this represented the most conservative noise propagation scenario (COP Appendix R-2).

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[11] The combination of a dBBC and AdBm system shows a potential noise reduction of 17 dB to 20 dB (Bellmann et al. 2020).

Acoustic thresholds specific to sea turtles were developed for auditory injury (PTS), non-auditory injury and mortality, and behavioral disturbance assuming both mitigated and unmitigated scenarios (COP Appendix R-2). Proposed pre-start clearance zones and TTS monitoring zones for sea turtles, during both mitigated and unmitigated UXO detonation events, and for all five charge weight bins, are shown in **Tables 19** and **20,** respectively. In all cases, modeled thresholds for sea turtles were substantially smaller than those modeled for High Frequency cetaceans (i.e., porpoise) (see **Tables 4** and **5** of **Section 2.3)**.

Table 19. Sea Turtle 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)	TTS Monitoring Zone[3] (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)
Sea Turtles *	<50	203	54	448	159	870	348	1,780	472	2,250

* = denotes species listed under the Endangered Species Act; kg = kilograms; m = meters; TTS = Temporary Threshold Shift.

[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 COP Appendix R-2 [Hannay and Zykov 2021]) for the detonation of each charge weight bin.

[2] Pre-start clearance zones were calculated by selecting the largest distance to the Permanent Threshold Shift (PTS) threshold. The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

[3] TTS monitoring zones were calculated by selecting the largest distance to the TTS threshold. The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

Table 20. Sea Turtle 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)	TTS Monitoring Zone[3] (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)	Pre-Start Clearance Zone (m)	TTS Monitoring Zone (m)
Sea Turtles *	104	708	241	1,350	545	2,520	1,030	4,340	1,390	5,260

* = denotes species listed under the Endangered Species Act; kg = kilograms; m = meters; TTS = Temporary Threshold Shift.

[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 COP Appendix R-2 [Hannay and Zykov 2021]) for the detonation of each charge weight bin.

[2] Pre-start clearance zones were calculated by selecting the largest distance to the Permanent Threshold Shift (PTS) threshold. The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

[3] TTS monitoring zones were calculated by selecting the largest distance to the TTS threshold. The chosen values were the most conservative per charge weight bin across each of the four modeled sites.

As with marine mammals, sea turtle mitigation and monitoring measures during UXO detonations will include the following:

1. Pre-start clearance;
    a) Vessel-based visual PSOs and associated visual monitoring tools stationed on the primary monitoring vessel and on any additional 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. NMSs;
3. Post-detonation monitoring;
4. Acoustic measurement data collection to verify distances to regulatory or mitigation zones; and
5. All other monitoring and mitigation protocols applicable to UXO detonation as described in **Section 2.3.2**.

3.1.4 Operations

Visual monitoring will be employed to assess the potential impacts of the Project on sea turtles in the Project area. 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.

3.1.4.1.1 Visual Monitoring for Operations

It is expected that during O&M phases of the Project, regular maintenance involving vessel movement will occur. To reduce the threat of ship strikes to sea turtles, visual monitoring will be conducted following protocols described in **Section 2.1.9**. 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 that section, as appropriate. Appropriate mitigations will be implemented as warranted during operations, particularly if any of the specific maintenance activities have a noise-producing component.

3.2 Fish

3.2.1 Species Likely to Occur in the Project Area

Only one fish species occurs in or near the Project area that is listed as endangered under the ESA of 1973 (35 FR 12222; 73 FR 12024), the Atlantic sturgeon (**Table 21**).[12]

Hearing data for Atlantic sturgeon, in terms of hearing sensitivity and auditory structure, are lacking, but it is known that these fish rely primarily on particle motion to detect sounds (Lovell *et al.* 2005). The best available information indicates that Atlantic sturgeon are not capable of hearing noise in frequencies above 1,000 Hz (1 kHz) (Popper 2005), and therefore are categorized as hearing "generalists" or "non-specialists" (Popper 2005). Atlantic sturgeon also do not have an interconnection between the swim bladder and inner ear, but instead

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[12] As reported in the COP, Volume II, about 95 percent of all Atlantic sturgeon captured in sampling off New Jersey occurred in depths less than 66 ft (20 m) with the highest CPUE at depths of 33 ft to 49 ft (10 to 15 m) (Dunton et al. 2010); therefore, Atlantic sturgeon would rarely occur within the offshore Project Area.

have a physostomous swim bladder, which is a connection between the bladder and the alimentary canal, or gut (Halvorsen *et al*. 2012). This means that these fish are not only less sensitive to sound, but they are expected to be less susceptible to injury from impulsive sounds like those generated from impact pile driving activities due to the ability to expel air through the mouth when the bladder is under tension (Halvorsen *et al*. 2012).

Table 21. ESA-listed Fish Species Likely or Known to Occur in the Project Area.

Species	Distinct Population Segment (DPS)	Endangered Species Act Status
Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*)	New York Bight DPS, Chesapeake Bay DPS, South Atlantic DPS, Carolina DPS, and Gulf of Maine DPS	Endangered, Threatened (Gulf of Maine DPS only)

3.2.2 Standard Conditions for Mitigation and Monitoring

The current U.S. regulatory acoustic criteria for fish are summarized below:

- Injury thresholds (PK and SEL) were derived from the Fisheries Hydroacoustic Working Group (FHWG 2008) and Stadler and Woodbury (2009) for fish that are equal, greater than, or less than 2 grams (g).
- Injury thresholds (PK and SEL) were obtained from Popper *et al*. (2014) for fish without swim bladders, fish with swim bladders not involved in hearing, and fish with swim bladders involved in hearing.
- Behavioral thresholds for fish were developed by the NOAA Fisheries GARFO (Andersson *et al*. 2007; Wysocki *et al*. 2007; Mueller-Blenkle *et al*. 2010; Purser and Radford 2011)

3.2.3 Construction Mitigation and Monitoring Protocols

Both NMS and soft-start techniques will be employed during impact pile driving to mitigate impacts to fish.

NMS are employed during pile driving activities to reduce the SPLs that are transmitted through the water in an effort to reduce distances to acoustic thresholds and minimize the acoustic impacts of pile driving.

There are two categories of NMS, primary and secondary. A primary NMS 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 NMS are not fully effective at eliminating all potentially harmful noise levels that can propagate from construction activities (e.g., >1 km), so a secondary NMS is typically employed to further mitigate pile driving noise. A secondary NMS 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 sounds waves and therefore deceases the distance over which higher energy sound is propagated through the water column. Primary NMS are still evolving and will be considered for mitigation when mature with demonstrated efficacy in commercial projects.

During impact pile driving, the Project will employ a dBBC in combination with an AdBm system to achieve a minimum of 10 dB noise reduction. A bubble curtain consists of a hose with nozzles, which is laid on the seabed to fully encompass the monopile foundation. During impact pile driving, the hose is connected to air compressors, causing air bubbles leave the hose nozzles and rise to the water surface, thus forming a bubble curtain (Water Proof Marine Consultancy & Services BV 2020). The demonstrated effectiveness of these systems is described in Lucke *et al*. (2011); Rustemeier *et al*. (2012); Bellman 2014, 2019, and Bellmann *et al*. (2020).

The configuration of any secondary NMS will optimize its efficacy based on the location, operations, and environmental and oceanographic parameters of the Project. For the context of this report, the ***standard*** NMS configuration is defined as one that has been professionally deployed and further optimized after initial deployment based on local conditions and in situ measurement results. The Project is committed to achieving a minimum of 10 dB of noise attenuation using a combination of two standard NMS.

Soft start during impact piling is a mitigation technique that involves the gradual increase of hammer blow energy to allow marine life to leave the area. Soft starts will be employed on the Project such that, prior to the commencement of any impact pile driving (and any time following a cessation of 30-min or more), soft-start techniques will be implemented and will include at least 20 minutes of 4–6 strikes per minute at between 10–20 percent of the maximum hammer energy.

BOEM and NMFS will be notified within 24 hours if any evidence of a fish kill during construction activity is observed.

3.2.3.1 Acoustic Range Distances for Fish

For the calculation of acoustic distances where sound levels could exceed established fish regulatory thresholds, fish were considered to be static receivers (although some fish may move during pile driving) and were not modeled using simulated fish movement and behavior (animats) (COP Appendix R-2). Instead, distances to thresholds were determined using a maximum-over-depth approach to find the distance that encompasses at least 95 percent of the horizontal area expected to be ensonified at or above the specific levels (using thresholds from NMFS GARFO [2020] and Popper *et al*. [2014]). **Table 22** shows distances in m to the most conservative acoustic thresholds based on modeling of a monopile foundation using an IHC S-4000 hammer in summer conditions. More details along with additional tables with various construction scenarios and different levels of attenuation can be found in COP Appendix R-2, Section 4.5.

Table 22. Distances in Meters to the Acoustic Behavioral and Injury Thresholds for Impact Pile Driving for Five Fish Faunal Groups, with and without 10 dB Reduction.

Faunal Group	Metric	Distance to Threshold (meters)					
		Unmitigated			Mitigated 10 dB		
		Threshold	Behavioral (TTS[a])	Injury or Potential Mortality (PTS[b])	Threshold	Behavioral (TTS)	Injury or Potential Mortality (PTS)
Fish equal to or greater than 2 g	$L_{E,24hr}$	187	N/A	7,980	187	N/A	4,930
	L_{pk}	206	N/A	310	206	N/A	70
	L_p	150	8,290	N/A	150	5,180	N/A
Fish less than 2 g	$L_{E,24hr}$	183	N/A	9,500	183	N/A	6,060
	L_{pk}	206	N/A	310	206	N/A	70
	L_p	150	8,290	N/A	150	5,180	N/A
Fish without swim bladder	$L_{E,24hr}$	216	N/A	1,120	216	N/A	220
	L_{pk}	213	N/A	100	213	N/A	30
Fish: swim bladder not involved in hearing	$L_{E,24hr}$	203	N/A	3,440	203	N/A	1,520
	L_{pk}	207	N/A	290	207	N/A	70
Fish: swim bladder involved in hearing	$L_{E,24hr}$	203	N/A	3,440	203	N/A	1,520
	L_{pk}	207	N/A	290	207	N/A	70

L_{pk} = unweighted peak sound pressure (dB re 1 μPa); L_E = unweighted sound exposure level (dB re 1 μPa2·s); L_p= unweighted sound pressure (dB re 1 μPa); g = grams; N/A = not applicable.

[a] TTS = Temporary Threshold Shift

[b] PTS = Permanent Threshold Shift

Source: Blackstock *et al.* 2018; NMFS 2020d.

3.2.4 UXO Mitigation and Monitoring Protocols for Fish

Acoustic modeling was undertaken to determine potential impacts to fish from UXO detonations (COP Appendix R-2). Modeling was based on previous underwater acoustic assessment work permitted by the U.S. Navy in concert with NMFS, as well as guidance from Popper et al. (2014), which provides peak pressure thresholds for injury and mortality to fish. Injury to fish from exposures to blast pressure waves is attributed to compressive damage to tissue surrounding the swim bladder and gastrointestinal tract, which may contain small gas bubbles. Effects of detonation pressure exposures to fish have been assessed according to the L_{pk} limits for onset of mortality or injury leading to mortality due to explosives, as recommended by the American National Standards Institute (ANSI) expert working group (Popper et al. 2014) (COP Appendix R-2).

The analysis presented here did not quantitatively assess zones of non-injurious effects to fish from explosive detonations. This is because the Popper et al. (2014) guidelines (see COP Appendix R-2, Section 6.4) are by nature qualitative vs. quantitative. For fish species with swim bladders not used for hearing (including Atlantic sturgeon), the guidelines indicate high likelihood of recoverable impairment at near and intermediate distances but low levels of TTS at intermediate distances.

The modeling for this assessment used criteria for charge weights based on definitions created by the U.S. Navy (DoN 2017), which classified weapons and munitions into five bins based on similar characteristics and charge weight equivalent to trinitrotoluene, more commonly known as TNT. Five 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]). Propagation modeling was performed using a sound speed profile representative of September, as this represented the most likely time of year for UXO removal activities (COP Appendix R-2).

3.2.4.1 Fish Injury by Peak Pressure Distances (Unmitigated)

Table 23 provides onset of injury distances relevant for all fish groups. The unmitigated distances for mortality or injury likely to lead to mortality range from 145 m from the 2.3 kg charge to 847 m from the 454 kg charge. These distances are relevant for all modeled sites.

Table 23. Unmitigated Maximum Exceedance Distances for Onset of Injury for Fish Without and With a Swim Bladder due to Peak Pressure Exposures for Various UXO Charge Sizes. The Threshold of 229 dB re 1 µPa is the Minimum of the Threshold Range from Popper et al. (2014).

Species	Onset Injury L_{pk} (dB re 1 µPa)	All sites: Maximum distance to L_{pk} onset injury threshold exceedance (m)				
		E4 (2.3 kg)	E6 (9.1 kg)	E8 (45.5 kg)	E10 (227 kg)	E12 (454 kg)
All fish hearing groups	229	145	230	393	671	847

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); kg = kilograms; m = meters.

3.2.4.2 Fish Injury Distances for Peak Pressure with 10 dB Mitigation

Table 24 provides mitigated onset of injury for all fish groups. The unmitigated distances range from 49 m from the 2.3 kg charge to 290 m from the 454 kg charge. These values are relevant for all modeled sites.

Table 24. Mitigated Exceedance Distances for Onset of Injury for Fish Without and With a Swim Bladder due to Peak Pressure Exposures for Various UXO Charge Sizes With 10 dB Mitigation. Water Depth 50 m. The Threshold Of 229 dB re 1 µPa is from Popper et al. (2014).

Species	Onset injury L_{pk} (dB re 1 µPa)	All sites: Maximum distance to L_{pk} threshold exceedance (m)				
		E4 (2.3 kg)	E6 (9.1 kg)	E8 (45.5 kg)	E10 (227 kg)	E12 (454 kg)
All fish hearing groups	229	49	80	135	230	290

L_{pk} = unweighted peak sound pressure (dB re 1 µPa); kg = kilograms; m = meters.

Fish mitigation and monitoring measures during UXO detonations will include the use of an NMS and post-detonation monitoring for injured and/or dead fish. It is not possible to maintain pre-start clearance zones or conduct visual monitoring for fish prior to UXO detonations. Any fish kills involving protected species will be reported to the appropriate agencies as stipulated in Attachment 8.

4. Literature Cited

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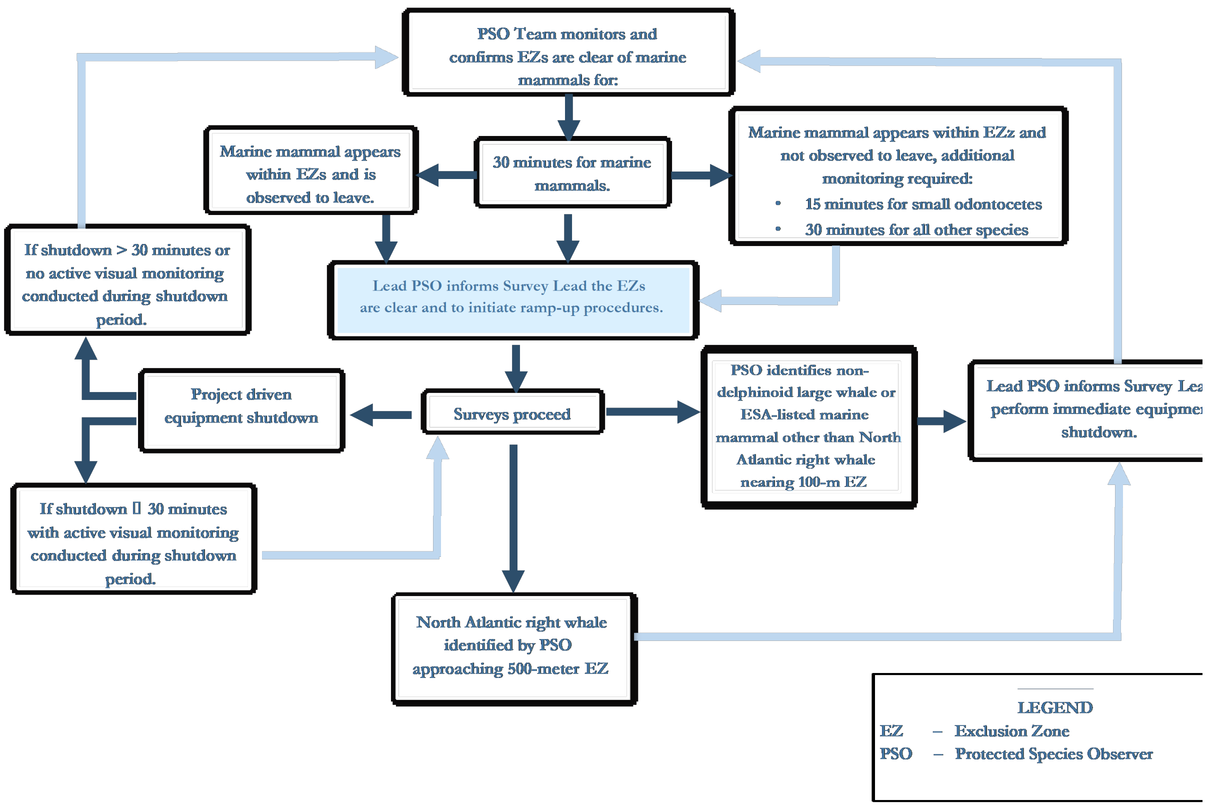
Attachment 1
PSO Communication Flow Diagram


PSO Team monitors and confirms EZs are clear of marine mammals for:
30 minutes for marine mammals.
Marine mammal appears within EZs and is observed to leave.
Marine mammal appears within EZz and not observed to leave, additional monitoring required:
• 15 minutes for small odontocetes
• 30 minutes for all other species
If shutdown > 30 minutes or no active visual monitoring conducted during shutdown period.
Lead PSO informs Survey Lead the EZs are clear and to initiate ramp-up procedures.
Project driven equipment shutdown
Surveys proceed
PSO identifies non-delphinoid large whale or ESA-listed marine mammal other than North Atlantic right whale nearing 100-m EZ
Lead PSO informs Survey Lea perform immediate equipme shutdown.
If shutdown □ 30 minutes with active visual monitoring conducted during shutdown period.
North Atlantic right whale identified by PSO approaching 500-meter EZ
LEGEND
EZ – Exclusion Zone
PSO – Protected Species Observer

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

Table 2-1. Example PSO Schedule: HRG Surveys.

	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
PSO Vessel																								
PSO1																								
PSO2																								
PSO3																								
PSO4																								
PSO5																								

Note: Darker shade represent "on effort" time. Lighter shade represents overflow for daylight hours.

Table 2-2. Example PSO Schedule: Impact Piling.

	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
Piling Vessel																								
PSO1																								
PSO2																								
PSO3																								
PSO4																								
PSO5																								
PSO6																								
PSO Vessel																								
PSO1																								
PSO2																								
PSO3																								
PSO4																								
PSO5																								
PSO6																								

PAM Station																								
PAM1																								
PAM2																								
PAM3																								
PAM4																								

Note: Shading represents “on effort” time.

Table 2-3. Example PSO Schedule: Vibratory (Cofferdam) Piling.

	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 Vessel																	
PSO1																	
PSO2																	
PSO3																	
PSO4																	
PSO5																	

Note: Blue shade represent “on effort” time. Green shade represents overflow for daylight hours.

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 coupledwith 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 CommandPro 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
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

Model[1]	Field of View (Degrees; or Horizx Vert)	Detector Type[2]	IR Focal Length	Resolution	Pan/Tilt
Rheinmetall AIMMMS	360 x 18	Cooled LW rotating line scanner	unknown	640 x 480	rotating line scanner giving 360° FOVand 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 Sciences 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

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-SOCI2	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-SoCI2 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"	Rechargeable 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	7 cm diameter x	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
															hydrophone option	23.3 cm length, 4.5 lbs		
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

Table 5-1. U.S. Coast Guard.

USCG District	Phone Numbers for Right Whale Sightings, or for Entangled, Stranded, Injured or Dead Marine Mammals	
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)	TBD by agency	TBD by agency
Greater Atlantic Regional Fisheries Office (GARFO)	TBD by agency	TBD by agency
Marine Mammal Stranding Program/Regional Stranding Coordinator (New England)	TBD by agency	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, Ocean 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 and regulations in place (e.g., NOAA Ship Strike Reduction Rule).
- **Approach Constraints**: Vessels will maintain, to the extent practicable, separation distances of 500 m for North Atlantic right whales, 100 m for other whales, and 50 m for dolphins, porpoises, seals, and sea turtles.
- **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**: Ocean 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. OCW'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:
    - Monitor the NMFS North Atlantic right whale reporting systems daily;
    - Monitor Coast Guard VHF Channel 16 throughout the day to receive notifications of any sighting; and
    - Monitor any existing real-time acoustic networks.

In addition to the above *Base Conditions*, Ocean Wind will implement a *Standard Plan,* or an *Adaptive Plan* as presented below. Ocean Wind intends for these plans to be interchangeable and implemented throughout both the construction and operations phases of the project. Ocean 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 NJ, NY, MD, DE, and VA) 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 Ocean Wind choose not to implement this *Adaptive Plan,* or a component of the *Adaptive Plan* is offline (e.g., equipment technical issues), Ocean 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 Ocean 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 Ocean 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 Ocean Wind obtains technical information that indicates a subsequent monopile is likely to produce larger sound fields, SFV will be conducted for those subsequent monopiles. Ocean 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.

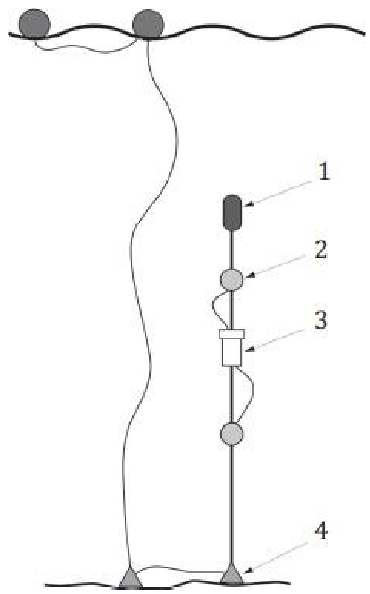


Figure 7-1. Principle sketch of hydrophone deployment. 1 is the float, 2 is the hydrophone, 3 is the recorder and 4 is the bottom weight(s). From ISO18406:2017.

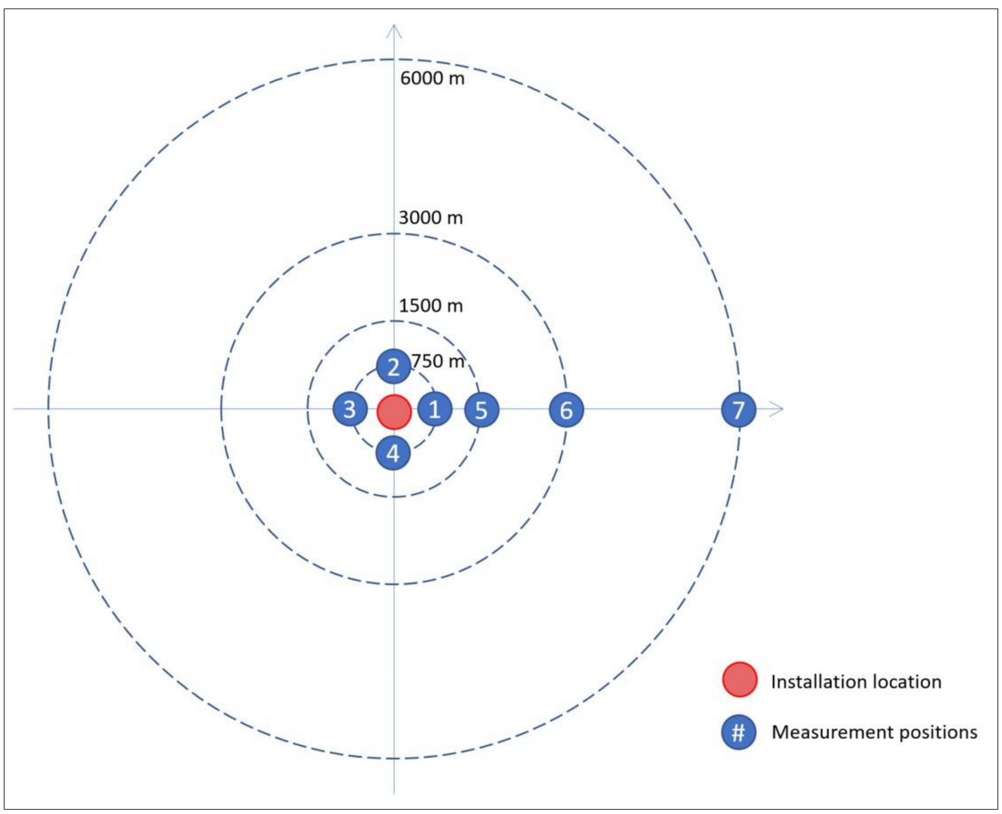


Figure 7-2 Sample sound field verification showing layout of proposed measurement locations. Specific locations are only examples and may change.

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

Ocean Wind will conduct SFV under the following circumstances:

Impact driving of the first three monopiles installed over the duration of the LOA;

If Ocean 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.

Ocean 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, Ocean 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, Ocean 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 Level B harassment thresholds are greater than the distances predicted by modeling assuming 10 dB attenuation, Ocean 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, Ocean 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, Ocean Wind may request a modification of the clearance and shutdown zones for impact pile driving. For a modification request to be considered by NMFS, Ocean 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. Ocean Wind will request modifications of zones based on the SFV results as detailed in the following section. **Modification of shutdown and monitoring zones**

Ocean 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, no pre-clearance or shutdown zones will

be implemented 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 **Section 2.7**, **Table 7**).

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 5** (**Section 2.7**). 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. 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
Injured or Dead Sea Turtle (non-activity cause)	TBD	As soon as feasible; no longer than 24 hours	DOI via email to BOEM (renewable_reporting@boem.gov); BSEE (protectedspecies@bsee.gov); NMFS GARFO (nmfs.gar.incidental-take@noaa.gov)	All
Injury/Death/Vessel Strike of Sea Turtle (caused by activity)	TBD	Immediate (and cease specified activity)	DOI via email to BOEM (renewable_reporting@boem.gov); BSEE (protectedspecies@bsee.gov); NMFS GARFO (nmfs.gar.incidental-take@noaa.gov)	All

Report	Content	Frequency	Method	Applicable Activity
Injured or Dead ESA-listed Fish (non-activity cause)	TBD	As soon as feasible; no longer than 24 hours	DOI via email to BOEM (renewable_reporting@boem.gov); BSEE (protectedspecies@bsee.gov); NMFS GARFO (nmfs.gar.incidental-take@noaa.gov)	All
Injury/Death/Vessel Strike of ESA-listed Fish (caused by activity)	TBD	Immediate (and cease specified activity)	DOI via email to BOEM (renewable_reporting@boem.gov); BSEE (protectedspecies@bsee.gov); NMFS GARFO (nmfs.gar.incidental-take@noaa.gov)	All
		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
		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

Report	Content	Frequency	Method	Applicable Activity
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

Ocean Wind
An Ørsted & PSEG project

Addendum 1
Alternative Monitoring Plan for Nighttime Pile Driving

Ocean Wind 1
An Ørsted & PSEG project

Ocean Wind 1 Offshore Wind Farm Project

Alternative Monitoring Plan for Nighttime Pile Driving

April 2023

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Appendix B: Summary Table of IR Studies
Appendix C: SeaPicket System Specifications
Appendix D: Beaufort Wind Force and Sea State Table

List of Acronyms

°	degrees
AOU	Area of Uncertainty
ASL	above sea level
BBS	Beaufort Sea State
BOEM	Bureau of Ocean Energy Management
C	Celsius
CPA	closest point of approach
DSLR	digital single-lens reflex
EO/IR	Electro-Optical/Infra-Red
ESA	Endangered Species Act
ITR	Incidental Take Regulation
km	kilometer
m	meters
NARW	North Atlantic right whale
NM	nautical mile
NVD	Night Vision Devices
Ocean Wind 1	Ocean Wind 1 Offshore Wind Farm

Orsted	Orsted Wind Power North America LLC
OSS	offshore substation
PAM	Passive Acoustic Monitoring
PSEG	Public Service Enterprise Group Renewable Generation LLC
PSO	Protected Species Observer(s)
PSSMP	Protected Species Monitoring and Mitigation Plan
SeaPicket	ThayerMahan SeaPicket bottom-mounted acoustic arrays
UE	unaided eye
USV	unmanned surface vehicle
WHOI	Woods Hole Oceanographic Institution
WTG	wind turbine generator

1. Introduction

This mitigation and monitoring plan describes the methods that will be used to monitor the pre-start clearance and shutdown zones in darkness to allow the installation of monopile foundations at night during construction of the Ocean Wind 1 Offshore Wind Farm (Ocean Wind 1, or Project). Ocean Wind, LLC (Ocean Wind), a subsidiary of Orsted Wind Power North America LLC (Orsted), and joint venture partner Public Service Enterprise Group Renewable Generation LLC (PSEG), hold the lease for the Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A-0498.

This monitoring plan is meant to supplement the existing Protected Species Monitoring and Mitigation Plan (PSMMP, HDR 2022), which describes the suite of monitoring and mitigation measures that will be implemented during the project, including foundation installations during daylight periods and other construction-related activities. The PSMMP also describes Standard Conditions that are applicable to all aspects of the monitoring program, such as Protected Species Observer (PSO) and Passive Acoustic Monitoring (PAM) operator qualifications, training requirements and responsibilities, data recording protocols and software, reporting procedures, and noise attenuation systems for foundation installations. These conditions would remain applicable to monitoring conducted for nighttime foundation installations, so they are not repeated here.

If nighttime pile driving based on the monitoring proposed in this plan is not approved or implemented, then the advanced systems described in this plan would not be used on the Project. Instead, the standard systems for daytime monitoring would be used, as described in the PSMMP. If nighttime pile driving based on the monitoring proposed in this plan is approved, it would be conducted throughout the foundation installation period, not just as a contingency if installations fell behind schedule.

2. Infrared Monitoring Systems

2.1 Summary of Previous Nighttime Monitoring Studies

Visual surveys conducted by PSOs are the primary method used to detect marine mammals within pre-start clearance and shutdown zones. In darkness or under poor visibility conditions (e.g., dense fog, rain, high sea states), PSOs have a reduced ability to make detections (Verfuss et al. 2018; Zitterbart et al. 2020). A number of studies have tested Night Vision Devices (NVDs) and Electro-Optical/Infra-Red (EO/IR) technology for marine mammal detection at night and to supplement PSO efforts during the day. However, the distance and accuracy with which marine mammals can be detected can vary considerably depending on the features of the IR equipment deployed, observation height above water, method or tool used to determine distance, observation platform stability (on land versus a moving vessel), and the environmental conditions present during testing. We identified, reviewed, and evaluated the available information to assess the effectiveness of IR sensors for marine mammal monitoring. Drawing from 31 studies, we summarize the performance of different NVD and EO/IR systems under varying environmental conditions (see Appendix B for a table summarizing key information from these studies). In reviewing these studies, we focus on the recorded detection distances for the large whale species (mysticetes) due to their larger shutdown zone sizes and sensitivity to low-frequency sounds produced during impact pile driving.

IR imaging-based systems are being increasingly utilized for the purpose of visually monitoring marine mammals at night and rely on detecting temperature differences between objects in the line of sight (e.g., the thermal energy from a whale's blow or body above the water surface). A number of IR-imaging devices are potentially available for nighttime monitoring (**Figure 1**). At one end of the spectrum, exist high-end, often military-grade IR devices that are equipped with a cooled sensor that keeps the unit at extremely cold temperatures (**Figure 1a**). These systems are typically fixed to a vessel or shore-based platform and boast some of the highest detection distances of devices available on the market. IR-imaging devices with uncooled sensors – like those utilized in some high-tech security cameras – are also available and have been used for marine mammal monitoring applications (**Figure 1c**). These devices are often more readily available and more affordable; however, the distance at which they can detect objects can be more limited. At the lower end of the spectrum, exists hand-held IR imaging binoculars and camcorders that are primarily manufactured for use in various hunting, wildlife spotting, and some military applications (**Figure 1d**). Although these devices come at reduced cost, the distance at which objects can be detected can be an order of magnitude lower than that of cooled IR systems. In a few cases, image intensifying NVDs have also been used for nighttime marine mammal monitoring. Unlike IR devices, which don't require any visible light to function, night vision technology relies on the amplification of visible light in the immediate vicinity. As a result, night vision is limited to detections at close distances as nearby light decreases with distance.

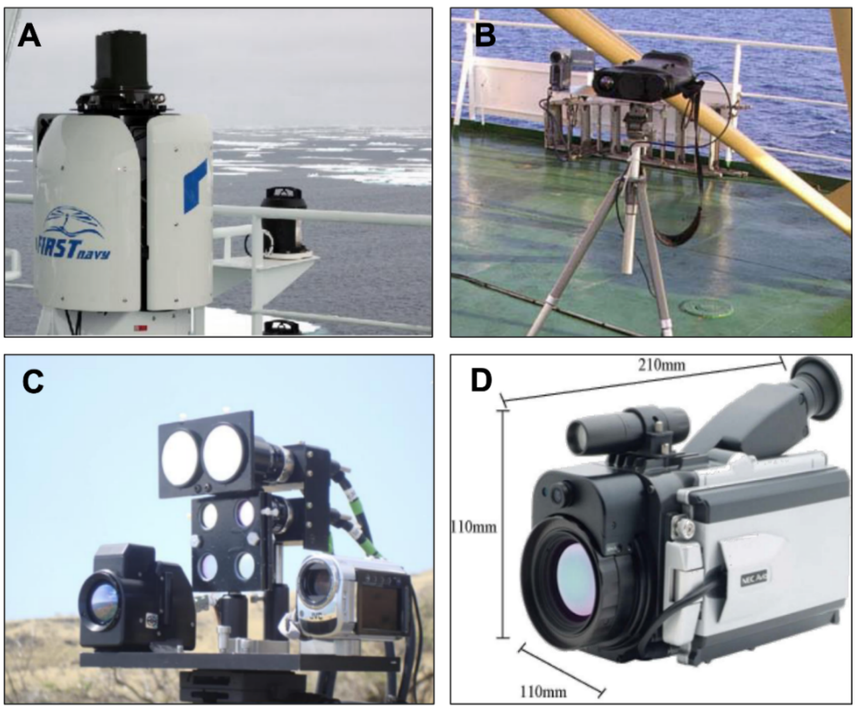

Figure 1. Examples of different IR sensors from each representative class; A) mounted First-Navy 360° thermal imaging device with a cooled sensor (Michel 2015); B) hand-held SAGEM MATIS medium-wavelength cooled Thermal Imaging device mounted on a tripod (Baldacci et al. 2005); C) MANTIS 4 uncooled long-wave IR sensor and commercial camera (Schoonmaker et al. 2008); D) Thermo Tracer TH9260 hand-held infrared camera by NEC/Avio IR Technologies (Yonehara et al. 2012).

High-end IR imaging systems with cooled sensors produce some of the highest detection distances and have thus received considerable investigation for marine mammal nighttime monitoring (**Table 1**). Of the devices available, the FirstNavy IR camera system (Rheinmetall Defense Electronics Co.) is the system that has been most widely tested (Burkhardt et al. 2012; Weissenberger and Zitterbart 2012; Boebel and Zitterbart 2013; Zitterbart et al. 2013; Boebel 2014; Michel 2015; Holst et al. 2017a; Smith et al. 2020; Zitterbart et al. 2020). This system scans 360 degrees (°) horizontally and uses a Sterling cooler to cool the cryogenic sensor to 84 Kelvin (-189°C). Zitterbart et al. (2020) showed that when deployed at a high vantage point (e.g., on a cliff edge at 51 meters (m) above sea level [ASL]), the FirstNavy system can detect some humpback whale cues out to ~10,000 m and reported a mean detection distance of ~2,000 m under good visibility conditions. Good visibility conditions are commonly defined as a Beaufort Sea State (BSS) ≤4 (winds <17–21 knots, waves <6–8 feet, whitecaps common with little to no spray; Appendix D) and little to no fog or rain. However, in instances where visibility conditions were reduced to <5,000 m mean detection distances of humpback whale cues were closer to ~500 m. Michel (2015) deployed the same IR system on the crow's nest of a research vessel (28 m) and reported baleen whale detection distances of up to 6,690 m. Also using the FirstNavy IR system, Holst et al. (2017a) were able to detect 90 percent of humpback whales detected by PSOs in daylight out to 3,000 m. In general, detection probability should be higher at night, when the contrast between the whale or whale blow and the surroundings is greater. Other IR devices with cooled sensors have been used to similar effect. For example, detection distances of up to 8,800 m have been reported using the Sagem Matis sensor (Baldacci et al. 2005), and up to 5,400 m using the U.S. Navy AN/KAS-IA sensor (Perryman et al. 1999). Many of these studies report the maximum distance that marine mammals were observed, but not the mean distance of observations. However, based on the few studies that have compared IR cameras to PSO sightings, it appears these systems are reliably effective (i.e., similar detection probabilities as daytime visual observations) to at least 2,000 m.

IR-imaging devices with uncooled sensors often result in shorter detection distances than those with cooled sensors (**Table 1**). However, there can also be a great deal of variability in detection range, depending on the type of uncooled imaging system. For example, Graber et al. (2011) tested the FLIR Thermovision A40M mounted on a lighthouse 13 m ASL and reported detection of killer whale fins at 75 m and blows out to 100 m. Horton et al. (2017) were able to detect whales out to 150 m with a hand-held FLIR A615 camera. In some cases, uncooled IR sensors have been reported to detect marine mammals at greater distances. For instance, Guazzo et al. (2019) reported they could reliably detect gray whales out to 2,100 m, and up to 5,800 m away with a FLIR F-606 camera mounted on a cliff at 28.1 m ASL. Schoonmaker et al. (2008) were able to detect humpback whales out to 12,000 m from a cliff edge with a MANTIS 4 long-wave IR camera system. However, positioning cameras high on the edge of cliffs like this is not practical for monitoring exclusion zones farther from the coast. Overall, uncooled IR camera systems appear to be capable of detecting marine mammals at similar rates as daytime visual observers within 1,000–2,000 m if a camera of adequate quality is selected and placed at a high vantage point.

We also reviewed studies where PSOs tested handheld IR and several NVDs during nighttime observations from a vessel at sea (Smultea and Holst 2003; Yonehara et al. 2012; Smultea et al. 2013; Holst 2017b; Smultea et al. 2020). Handheld IR devices have a more limited field of view, reducing the likelihood that brief events such as whale blows or surfacing will be detected (**Table 1**). These devices can also fail to function inside of the vessel's wheelhouse, or other areas where heat sources interfere with their effectiveness. Handheld units typically had the lowest detection rates for marine mammals when multiple technologies were tested together (Smultea et al. 2020). However, Yonehara et al. (2012) reported detection of sperm whales out to 350 m with a handheld IR device. Overall, few marine mammals were observed in studies testing handheld or wearable NVDs, making it difficult to establish the effective range of the equipment. Like handheld IR devices, NVDs are commonly used at lower heights, about sea level, and may have a more limited field of view, reducing the probability that they will detect marine mammals. Also, these devices are sensitive to light, and may not be useful in situations where vessel lights, or reflections off wheelhouse glass interfere with their operation. In the studies review, several groups of dolphins were spotted within 30 m of the vessel, and PSOs were able to detect small floating milk jugs out to a distance of 200–250 m (Smultea and Holst 2003; Holst 2017b). While handheld NVDs and IR devices are not effective in monitoring large exclusion zones, they are capable of detecting marine mammals within approximately 150–200 m of the vessel and may be useful to monitor closer to vessels as part of a suite of monitoring tools.

Table 1. Reported detection ranges of the reviewed cooled and uncooled IR systems.

Sensor Type	Sensor Make	Sensor Model	Species Group(s) Detected	Range of Detections (m)	Citations
Cooled	AN/KAS-IA (from US Navy)	AN/KAS-IA (from US Navy)	Mysticete	~500 - 5,400 m	Perryman et al. 1999
	FIRST- Navy, Rheinmetall Defense Electronics	Sterling Cooler	Mysticete, Pinniped	400 - 4,000 m	Weissenberger and Zitterbart 2012
			Mysticete	Up to 3,000 m	Burkhardt et al. 2012
				1,000 - 6,690 m	Michel 2015
				800 - 10,000 m	Zitterbart et al. 2020
				4,000 - 8,000 m	Zitterbart et al. 2013
			Mysticete, Delphinid	Not specified	Smith et al. 2020
			Not specified	3,700 - 5,500 m	Boebel and Zitterbart 2013
			Mysticete	0 - 5,000 m	Holst et al. 2017b
				2,000 - 10,000 m	Boebel 2014
	Handheld SAGEM MATIS	Sterling Cooler	Mysticete, Delphinid	Daytime Observations: 500 m - 8,800 m	Baldacci et al. 2005
	FLIR	HRC-Multisensor ThermVision 3000	Terrestrial Target	Fog cat I: 3,000 - 9,800 m Fog cat II: 540 m Fog cat IIIa: 294 m Fog cat IIIc: 92 m	FLIR n.s.
Uncooled	NEC/Avio IR Tech	Thermo Tracer TH9260	Mysticete	0-350 m	Yonehara et al. 2012
	MANTIS 4	Long wave IR sensor (8-12 um).	Mysticete	644 - 12,875 m	Schoonmaker et al. 2008
	Current Scientific Corporation	Night Navigator 3	Mysticete, Delphinid	Mysticetes = Up to 2,000 m Delphinid pods- Up to 1,000 m Individual Delphinid- 500 m	Current Scientific Corporation 2018
		Night Navigator 6030	Mysticete	20-2,000 m	Gauthier-Barrette 2019
		Night Navigator 2525	Mysticete, Delphinid, Pinniped	1 - 1,500 m	Smultea et al. 2020
	FLIR	PTZ-35-140 MS	Terrestrial Target	Fog cat I: 5,900 - 10,100 m Fog cat II: 2,400 m Fog cat IIIa: 293 m Fog cat IIIc: 87 m	FLIR n.s.
	FLIR Thermovision	A40M	Mysticete	42 - 162 m	Graber et al. 2011
	Toyon Research Corporation	FLIR F-606	Mysticete	479 m - 5,800 m	Guazzo et al. 2019
	FLIR Systems, Inc.	FLIR A615	Mysticete	Up to 150 m	Horton et al. 2017
	Seiche IR Dual Camera System	Not specified	Mysticete, Delphinid, Pinniped	1 - 1,500 m	Smultea et al. 2020
	NVTS	Reliant 640HD			

Environmental conditions can substantially impact the effectiveness of IR systems in detecting marine mammals during day and night (**Table 2**). One concern is that marine mammals may be less visible in warm waters where there is less contrast between their blow or body temperature and the surrounding environment. However, Horton et al. (2017) observed that whale blows tended to appear 3°C warmer than surrounding waters in both Hawaii and Alaska. Zitterbart et al. (2020) found that whale blows were perceptible in >70 percent of thermal images up to 3,000 m (3 kilometers [km]) with sea surface temperatures ranging from 10–25°C, and atmospheric temperatures from 12–21°C. This indicates that warm water and air temperatures do not necessarily create a significant impediment to IR marine mammal detection. Other environmental conditions, namely visibility (e.g., fog, precipitation), and BSS, can significantly alter the performance of IR systems. For instance, reduced IR detection distances have been reported as a result of precipitation events (Baldacci et al. 2005; Zitterbart et al. 2020; Smith et al. 2020). Similarly, as fog levels increase, a significant decrease in detection distance has been observed (FLIR n.d.). Periods with little to no fog have recorded detection distances up to 10,000 m, with detections decreasing to 90 m at the highest levels of fog (FLIR n.d.). Regardless of these considerations, IR systems still appear to outperform PSOs operating under similar poor visibility conditions (Zitterbart et al. 2020).

Table 2. Reported effects of environmental variables on IR sensor performance.

Variable	Effect(s)	Specific considerations	Citations
Temperature	Warm temperatures can reduce contrast between whales and their surroundings, reducing detection rates.	Whale blows tend to appear 3°C warmer than surrounding waters in both Hawaii and Alaska (1). Whale blows were perceptible in >70% of thermal images up to 3 km with sea surface temperatures ranging from 10–25°C, and atmospheric temperatures from 12–21°C (2).	1 = Horton et al. 2017, 2 = Zitterbart et al. 2020
Visibility	Low visibility caused by conditions such as fog or rain will reduce the distance at which whales can be detected.	If visibility conditions are <5 km mean detection distance was approximated at <500 m. If visibility conditions >7 km, mean detection increases to 2 km (1). Most of the highest max detections occurred during excellent visibility (e.g.,>10 km) (2,3).	1 = Zitterbart et al. 2020, 2 = Schoonmaker et al. 2008, 3 = Michel 2015
Sea State	Rough seas can reduce detectability and breaking waves with spray can lead to false detections.	Like daytime visual observations, effectiveness of IR systems can begin to decrease when sea states are above 2 or 3 (1). However, IR detection can outperform visual surveys during higher sea states (2).	1 = Baldacci et al. 2005, 2 = Michel 2015.
Wind	Strong surface winds can dissipate whale blows and reduce detectability.	Beaufort Sea State (BSS) ratings of <3 are optimal for maximizing detection distances (1,2). BSS >4 can affect perceptibility (1,2), although some reports of being able to detect whale blows reliably at BSS 4–6 do exist (3).	1 = Smith et al. 2020, 2 = Zitterbart et al. 2020 3 = Michel 2015
Humidity	High relative humidity might lead to the attenuation of signals in thermal images.	High relative humidity of up to 91 percent did not seem to limit high-end systems (1). Similarly, relative humidity ranging from 60–90 percent did not affect perceptibility of whales (2). Under extremely high humidity the optics of some IR systems fail when covered by condensed water vapor (e.g., the Sagem Matis Sensor) (3).	1 = Michel 2015, 2 = Zitterbart et al. 2020, 3 = Baldacci et al. 2005

Additional environmental conditions such as increased wind and wave height can also affect the performance of IR systems. Higher sea states involve more waves and spray, which often appear as “sea clutter” within the produced images. Specifically, breaking waves and spray make marine mammal detection difficult because thermal emission at the surface caused by the waves and spray can result in similar signatures to those produced by marine mammals or otherwise distract observers from actual marine mammal blows (Baldacci et al. 2005). As a result, detections using IR camera systems are most reliable at BSS’s <3, and greatly decline in BSS’s >5 (Baldacci et al. 2005; Smith et al. 2020), similar to a visual observer using the naked eye or binoculars. However, increased performance during higher BSSs can be achieved if the IR camera system is mounted on a well-stabilized platform (Baldacci et al. 2005; Zitterbart et al. 2020). Contrary to some previous studies, Michel (2015) reported little impact of weather on the detectability of large whale blows using a cooled IR system when BSSs were consistently between 4 and 6, and wind speeds between 13 and 24 knots with clear visibility (no fog or rain) (Michel 2015). During periods with rain, heavy fog, or high winds and waves, the use of an IR system is unlikely to improve the overall marine mammal detection rates. Should inclement weather impact the monitoring plan, a combination of IR monitoring with acoustic or other visual monitoring methods may be necessary to effectively monitor the shutdown and pre-start clearance zones.

2.2 ThayerMahan Demonstration Results

As summarized in the previous section, many of the more robust studies of marine mammal detection using IR systems involved the FirstNavy IR camera from Rheinmetall Defense Electronics Co. That system is very expensive and extremely difficult, if not impossible, to acquire at the present time, making it impractical to propose for conducting the required nighttime monitoring. Lower cost, off-the-shelf equipment with IR sensors that have the potential to provide similar detection abilities, especially cooled systems, have recently become available. Studies of several such systems were conducted to evaluate and compare their effectiveness at detecting marine mammals, primarily mysticete whales (ThayerMahan 2023). Summaries of the key methods and results from the two studies (spring and fall) are provided below with additional details available in the full report (ThayerMahan 2023).

Three IR cameras were selected for evaluation during the 2022 spring and fall studies. The spring study was primarily focused on acoustic systems and the IR data collected were relatively limited. Thus, the fall study was designed and carried out to inform unanswered questions regarding several IR camera system capabilities. The fall study included both systematic shore-based and opportunistic offshore tests from a vessel at sea. All three IR cameras, which are listed below, with specifications provided in Appendix A, are commercial off-the-shelf systems and readily available.

- Current Scientific Night Navigator 3050-VT Electro-Optical IR Camera (NN3050),
- Current Scientific Night Navigator 3025 Electro-Optical IR Camera (NN3025), and
- FLIR M364 LR IR Camera (FLIR M364).

To evaluate the capability of the three IR camera systems and a visual observer (during daylight periods), the ThayerMahan team conducted field demonstrations to quantify and compare performance relevant to mitigation zone monitoring. The following subset of the study objectives is included in this summary (ThayerMahan 2023).

<u>Shore-based testing using simulated whale blows at randomized locations:</u>

- **Objective 2:** Determine the maximum and average detection distances of simulated whale blows.
- **Objective 3:** Determine the raw detection rates and model predicted detection rates (using line-transect theory probability of detection models) for simulated whale blows detected during daylight and darkness.

Offshore testing from a vessel:

- **Objective 5:** Use IR cameras to detect marine mammals during daylight and darkness from a vessel at sea to evaluate effectiveness on true marine mammal targets and how environmental conditions (sea state, fog, and precipitation) affect detection with IR cameras.

The whale blow simulator used during shoreside testing was towed behind the unmanned surface vehicle (USV) Babou, which is a modified, low-profile, uncrewed jet ski with autonomous control capability. The USV can be controlled via pre-programmed waypoints or locally via remote control. The jet ski was shrouded with a canvas tarp that reduced the thermal signature of the USV (**Figure 2**) and helped mask the USV from detection by shore-based observers during the tests.

Figure 2. Thermal image of the USV Babou with (left) and without (right) the tarp. Both images collected during daylight.

Attached to the USV Babou, the whale blow simulator utilized the hot water exhaust from the USV's engine (at approximately 80–90°) to simulate a whale blow. The simulator takes the hot water and builds up pressure within a tubing system located on top of the jet ski. Upon remote control command from the chase boat, a remote actuated solenoid opens and expels the hot water upward. A diffuser located at the exit of the tubing creates a blow pattern. ThayerMahan engineers worked to simulate the size (approximately 5 m tall), duration (approximately 2–4 seconds), and thermal signature of the North Atlantic right whale (NARW) blow pattern. **Figure 3** provides a side-by-side comparison of simulated and true whale blows, accounted for scaling, field of view, and distance. One significant concern during study planning was that the USV might produce a significant thermal signature, allowing for unintended cueing of PSOs monitoring the IR cameras to the location of a likely blow. However, the thermal signature of the USV compares favorably to that of the body of a whale, as shown in **Figure 3**, as does the blow itself.

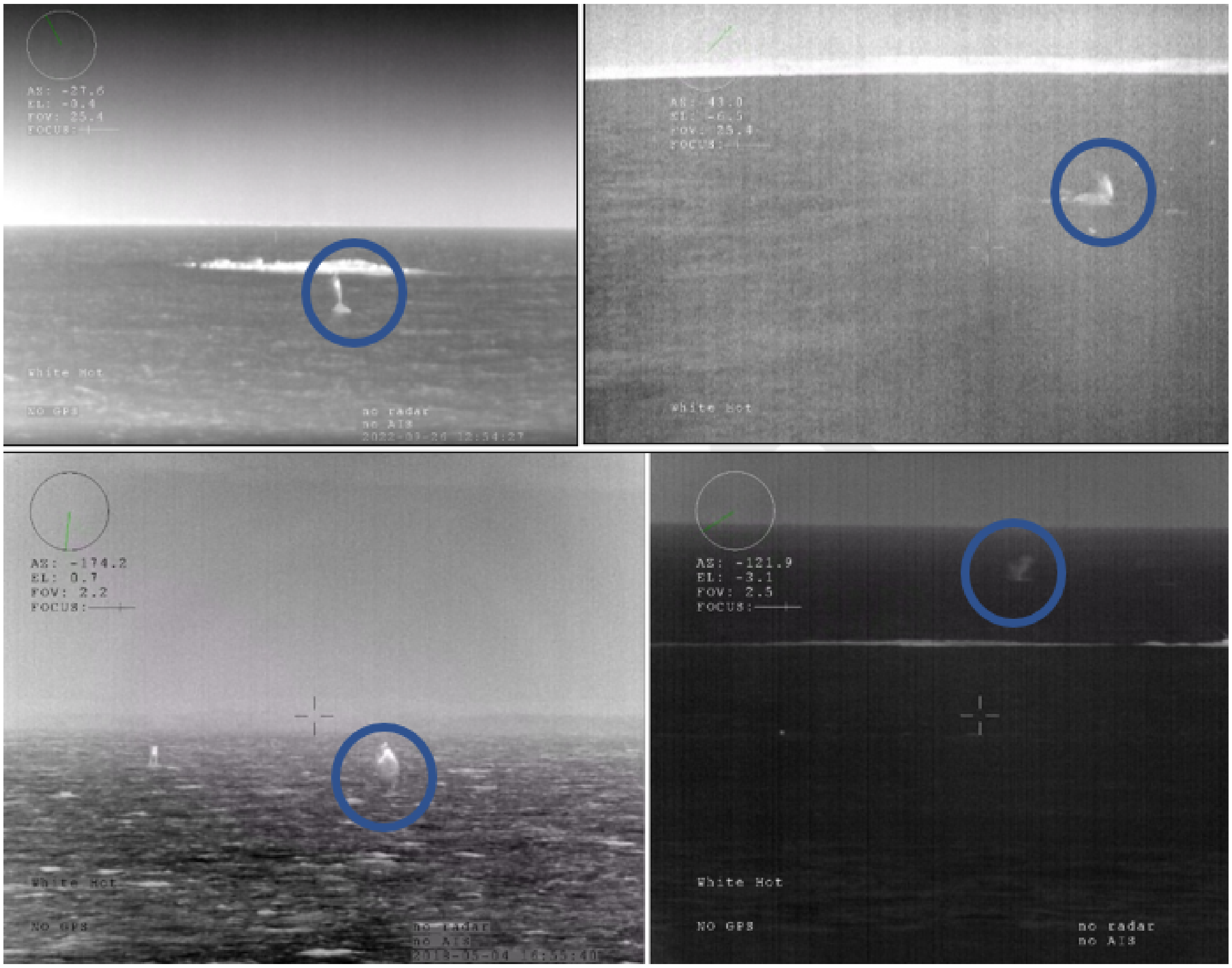

Figure 3. Side-by-Side comparison of simulated and true whale blows. Top panel: Simulated blow and the USV Babou at 174 m (left) and a humpback whale blow at 171 m as viewed on the NN3025 IR camera (25.4° FOV in both images). Bottom panel: Simulated blow at 2059 m (left) and an unidentified mysticete whale blow estimated at 2000 m (right) as viewed on the NN3050 IR camera (2.2° FOV left and 2.5° right). All four images were collected during daylight, with the camera zoomed in to the same/similar extent. Location of blows identified with blue circles.

2.2.1 Maximum Distance Testing

Maximum distance tests were conducted twice, once during daylight and once during darkness. In each test, the whale blow simulator transited a straight line towards the shore-based IR cameras and visual observers from a distance of 4.2 km (first test, daylight) and 7 km (second test, darkness) while producing a blow every 15–45 seconds. PSOs monitoring the IR systems kept the cameras pointed in the direction the simulator was coming from and recorded the first three blows that they detected.

The detection distances for the first three simulated blows observed during the inbound path toward the IR cameras and the visual observer (daylight only) are provided in **Table 3**. These distances are based on the simulator's location at the time of blow detection. The NN3050 detected simulated blows at the farthest distances during both tests, with the first blow detected at 4,212 m during daylight and 7,009 m during darkness. The NN3025, NN3050, and FLIR M364 detected simulated blows in darkness at farther distances than the Ocean Wind 1 minimum visibility distances in summer (1.65 km) and winter (2.50 km).

It should be noted that the two Current Scientific IR cameras were zoomed in on the simulator at the start of one or both maximum distance tests: the NN3050 was zoomed in (FOV 2.0°) for both tests and the NN3025 zoomed in (FOV 5.9°) for the test during darkness. The FLIR M364 IR camera zoomed in on the simulator only after first detecting a blow while zoomed out.

Table 3. Detection distances for the first three simulated blows observed during daylight and darkness for the three IR cameras and visual observer (daylight only). Distances based on simulator location at the time of blow detection.

<table>
<tr><th rowspan="3">Method</th><th colspan="8">Detection Distances for First Three Simulated Blows Observed (m)</th></tr>
<tr><th colspan="4">Daylight</th><th colspan="4">Darkness</th></tr>
<tr><th>Start Distance</th><th>1st</th><th>2nd</th><th>3rd</th><th>Start Distance</th><th>1st</th><th>2nd</th><th>3rd</th></tr>
<tr><td>FLIR M364</td><td rowspan="4">4212</td><td>699</td><td>576</td><td>526</td><td rowspan="3">7009</td><td>3736</td><td>3607</td><td>3297</td></tr>
<tr><td>NN3025</td><td>2055</td><td>2029</td><td>2017</td><td>5652</td><td>5471</td><td>5317</td></tr>
<tr><td>NN3050</td><td>4212</td><td>4095</td><td>4056</td><td>7009</td><td>6952</td><td>6805</td></tr>
<tr><td>Visual</td><td>4095</td><td>4056</td><td>3731</td><td colspan="4">n/a</td></tr>
</table>

2.2.2 Simulated Whale Blow Detection Testing

Whale blow simulation tests were the primary focus of the shore-based testing phase, with simulation tests conducted daily from September 27–30, 2022. The tests simulated protected species monitoring, specifically large whale monitoring, in a manner that allowed for the number and location of blows available for detection to be known (i.e., ground-truthed). The results provide a better understanding of the probability of detection at increasing distance for each system, as well as for a visual observer during daylight periods using unaided eyes (UE) with binoculars used for confirmation.

The location at which each series of simulated whale blows were generated was selected randomly from 160 possible locations within the maximum 5-km radius testing area shown in **Figure 4**. Of the 160 test locations, 10 percent were at distances ≤500 m, 45 percent at distances of 501–2,000 m, and 45 percent at distances ≥2,001 m. The number of blows produced, the time between successive blows, and the transit time between test locations were all randomized to prevent observers from predicting the location of the next blow.

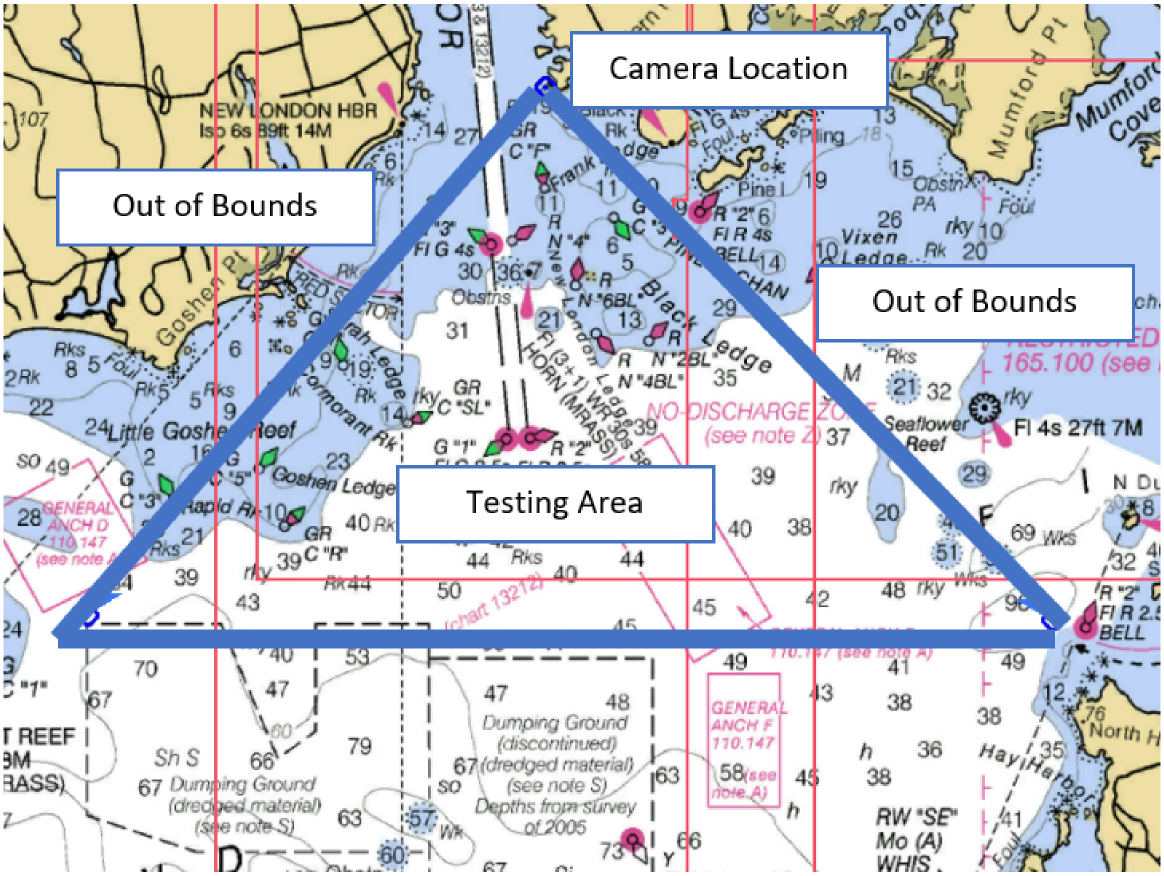

Figure 4. Testing area for whale blow simulation tests within the blue triangular boundaries in Groton, Connecticut. The furthest distance from the camera location at Eastern Point Beach is 5 km.

During the tests, all four PSOs (three IR camera PSOs and one visual PSO) were verbally notified in person or via handheld radio by the ThayerMahan test coordinator when to begin monitoring the test area. Upon receiving notification to begin, the IR camera PSOs moved the cameras to a predefined "home" position (preset single button command on the camera joysticks) oriented at Ledge Lighthouse and initiated scanning, while the visual PSO began scanning with the UE. Scanning of the test area continued until a simulated blow was detected. If the PSO detected the USV but did not detect a blow, the PSO was not permitted to stop the IR camera scan or count it as a detection. After detecting a simulated blow, PSOs could stop scanning and focus on the location of the blow. The visual PSO and the two PSOs monitoring the Current Scientific cameras (NN3025 and NN3050) recorded the detection, including number of blows, as well as the declination angle or distance and azimuth. The FLIR M364 camera lacked a function allowing determination of r distance and azimuth, so these data were not collected for this system. On completion of each test location, the PSOs monitoring the IR cameras oriented the cameras down toward the rocky bank at Eastern Point Beach, and the visual PSO stopped all seaward observations so that no one was cued toward the next test location.

The whale blow simulator began emitting simulated whale blows within one minute of the PSOs receiving notification to begin monitoring. The simulator remained on location for 3–10 minutes, emitting a simulated blow once every 15–45 seconds and producing 8–12 blows over two blow series (each series was composed of 4–6 simulated blows).

Eighty-two random whale blow simulation tests were conducted: 44 during daylight and 38 during darkness. Of the 82 tests completed, 12 percent were at distances ≤500 m, 37 percent at distances 501–2,000 m, and 51 percent at distances ≥2001 m. Apart from the ≤500 m distance bin, random whale blow simulation tests were split nearly 50:50 between daylight and darkness.

The NN3050 detected at least one simulated blow at 51 (62 percent) of the 82 test locations, followed by the visual observer at 34 (41 percent), FLIR M364 at 32 (39 percent), and NN3025 at 26 (32 percent). Observation of only a single blow was required to qualify as a detection for each test location. The visual observer recorded the most detections during daylight (n = 31, 70 percent of daylight test locations) and the fewest detections during darkness (n = 3, 8 percent of test locations during darkness). The NN3050 IR camera recorded the most detections during darkness (n = 24, 63 percent of test locations during darkness).

The visual observer and NN3050 detected simulated blows at the greatest distances during the random whale blow simulation tests. The visual observer detected simulated blows at 4,239 m during daylight, while the NN3050 detected blows at 5,091 m during darkness (**Table 4**). The maximum detection distance for the NN3050 increased by over 1,500 m from daylight to darkness. The average detection distance increased from daylight to darkness, and the NN3050 had the highest average detection distance overall at 1,943 m.

Table 4. Maximum (max.) and average (avg.) detection distances (m) for simulated whale blows detected during daylight and darkness on the three IR cameras and by the visual observer.

Ambient Condition	Simulated Whale Blow Detection Distances (meters)											
	FLIR M364			NN3025			NN3050			Visual Observer[1]		
	max.	avg.	n	max.	avg.	n	max.	avg.	n	max.	avg.	n
Daylight	2272	807	119	3419	1348	71	3419	1434	143	4239	1143	212
Darkness	2229	1335	81	3620	1430	55	5091	2481	135	630	386	19
Combined	2272	1021	200	3620	1384	126	5091	1943	278	4239	1081	231

The probability of detection for simulated whale blows for the four monitoring methods during daylight (day) and darkness (night) were compared using both raw and modeled detection probabilities.

Raw detection probabilities were calculated by dividing the number of tests in which at least one blow was detected by the total number of tests. The raw detection probability for simulated whale blows during the day was highest for the UE visual observer (0.70), followed by the NN3050 (0.61), FLIR M364 (0.43), and NN3025 (0.34). Similar results were observed for blow detection by the IR cameras at night, with slight decreases observed for the FLIR M364 (0.34) and NN3025 (0.29) and a slight increase for the NN3050 (0.63).

The probability of detection for simulated whale blow and USV vehicle detection was modeled separately for the four monitoring methods across distances out to 5,000 m using distance sampling methods (Buckland et al. 2001). The average probability of detection for each method is provided in **Figure 5**. Time of day (day versus night) did not significantly alter the average detection probability of simulated blows for the IR cameras. However, there was a significant difference between day (0.57) and night (0.11) for the visual observer (UE during the day and NVD at night). During the day, average detection probabilities for blows were similar for the visual observer (0.57) and NN3050 (0.53). At night, the average detection probability for the NN3050 (0.64) was highest compared to the FLIR M364 (0.33), NN3025 (0.30), and visual observer with NVD (0.11).

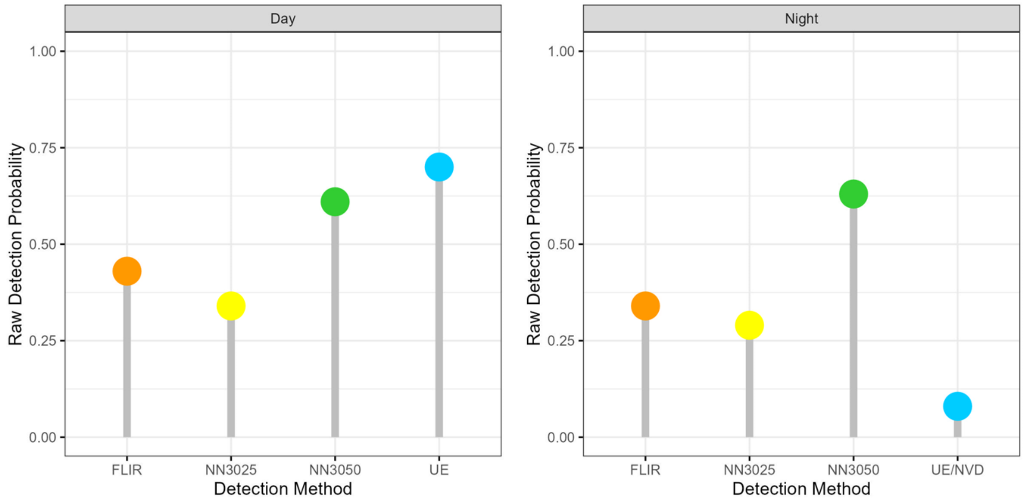

Figure 5. Average modelled detection probabilities for simulated whale blows for all four monitoring methods during the day and at night. The visual observer monitored with the unaided eye (UE) during the day and with a handheld night vision device (NVD) at night.

A detection function was fitted to the modeled probability of detection data across distances out to 5,000 m for simulated whale blows for each monitoring method (**Figure 6**). Detection functions for simulated whale blows were similar across distances between day and night for the FLIR M364 and NN3025. The shape of the day and night simulated blow detection function curves for the NN3050 were similar; however, the detection probability was consistently higher at night across distance. The detection functions for the NN3050, day and night, were most comparable to the visual observer daytime detection function. The probability of detection was higher for the NN3050 compared to the UE visual observer during daytime at distances greater than approximately 2,250 m at night and 3,400 m during daylight. At 2,000 m, the probability of a UE detection during the daylight and the probability of a NN3050 detection at night were nearly equal at 0.71 and 0.68, respectively.

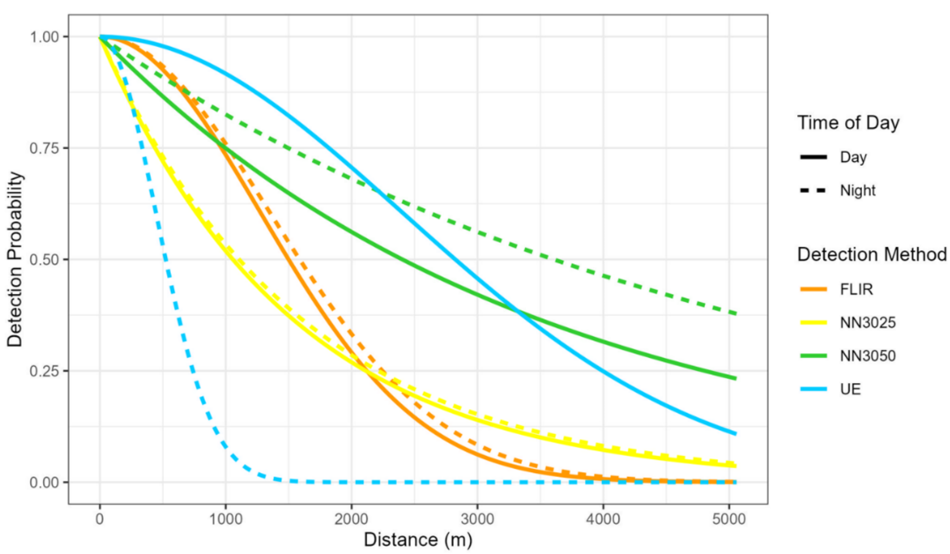

Figure 6. Detection functions for simulated blow detection for all methods, day (solid lines) and night (dashed lines).

2.2.3 Offshore Testing from Underway Vessel

The offshore phase of the fall demonstration was conducted in the Nantucket Shoals and Cape Cod areas on the vessel *Josephine Miller* October 7–24, 2022. The study area was moved from Nantucket Shoals to the Cape Cod area on October 8th after a review of detection data from WhaleMap.org indicated numerous, recent humpback whale sightings in the Cape Cod area.

The study area was composed of two survey regions, one for visual protected species monitoring from the *Josephine Miller* (Vessel Survey Box, **Figure 7**) and one for acoustic monitoring from the USV acoustic system (USV Survey Box; **Figure 7**). The *Josephine Miller* ran transect lines within the vessel survey box, breaking off the line as necessary for vessel traffic, fishing gear, and USV deployment or retrieval. Transect lines were run in different areas during darkness than daytime to avoid potential entanglement with the higher concentrations of fishing gear in the daylight survey area. This meant the relationship between the vessel and the highest concentration of whales was different between daylight and darkness, so direct comparisons between results from the two periods must be made with caution.

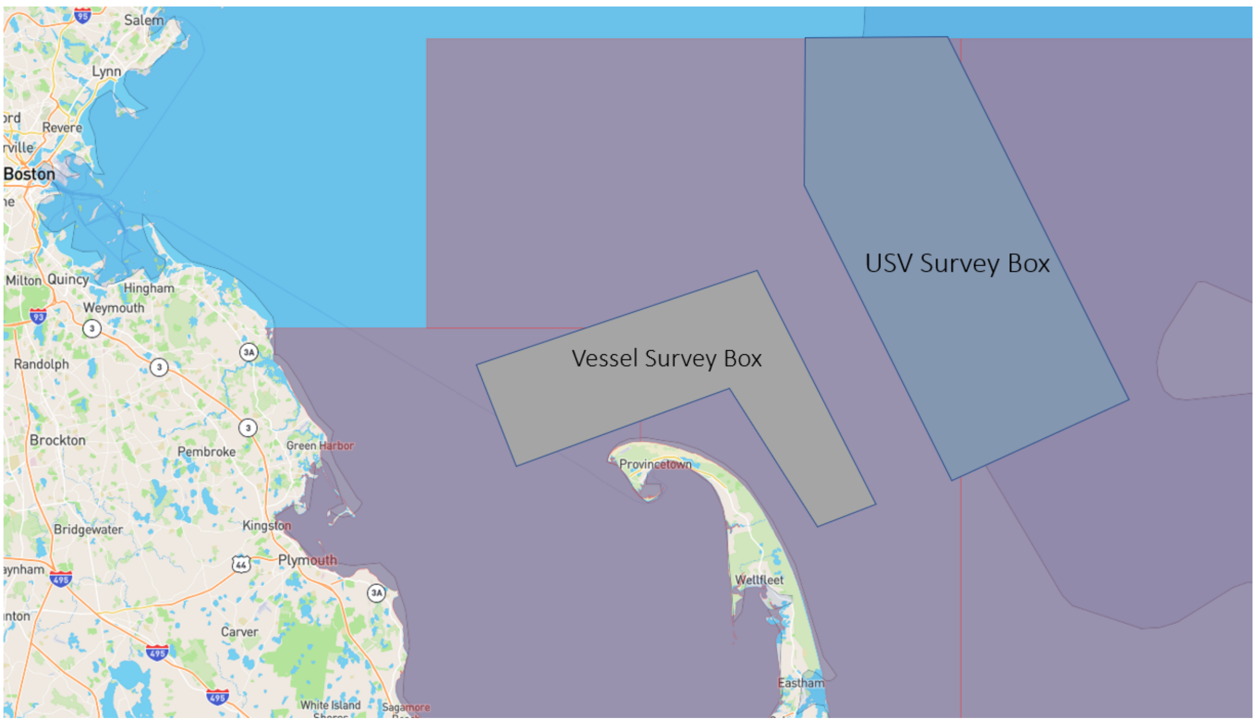

Figure 7. Offshore Testing study area off Cape Cod, MA. The study area was composed of two survey areas, one for visual monitoring from the *Josephine Miller* (Vessel Survey Box) and one for acoustic monitoring from the Outpost USV system (USV Survey Box). Acoustic monitoring is discussed in later sections

During offshore testing, the three IR cameras were mounted at a forward location on the flying bridge of the *Josephine Miller*. The cameras were stacked in vertical alignment on a mast approximately 13–14 m above the waterline. Visual protected species monitoring was conducted using the UE and/or IR cameras while the *Josephine Miller* was underway. The observer team consisted of nine PSOs. One PSO conducted visual observations with the UE during daylight, which was defined as the period between civil twilight rise and set (i.e., when the sun is higher than 6° below the horizon). Monitoring of the IR cameras was continuous during daylight and darkness, with three PSOs (one PSO per IR camera) monitoring simultaneously. PSOs rotated watch shifts every 1–4 hours to avoid observer fatigue, with a minimum 2-hour rest period after shifts of 4 hours following standard NMFS guidelines. Time on-watch for each observer did not exceed 12 hours in a 24-hour period.

Upon detecting a marine mammal, the PSO first assessed whether the detection required an avoidance maneuver to maintain the appropriate separation distances and/or to prevent a vessel strike. The PSO continued to visually monitor the marine mammal until it was no longer observed (or resighted), making note of the species, number of individuals, distance from the vessel, and behaviors. PSOs monitoring the IR cameras stopped the automatic scanning function and manually controlled the camera using a joystick. The PSO tracked the marine mammal on IR using the joystick until the animal was no longer detected (or resighted) on the camera. Photographs were collected whenever possible during the day using a Cannon EOS 77D digital single-lens reflex (DSLR) camera.

To minimize the possibility of introducing bias in the data (i.e., a PSO accidentally cues other PSOs to the presence of marine mammals due to their movement and/or behavior), PSOs on watch together were not permitted to communicate with each other while on shift. PSOs noted whether they were cued to a detection by another PSO (independence broken) in *Mysticetus,* the cloud-based onboard and onshore software for data recording, mapping, and sharing of marine mammal sightings. Barriers were installed between the IR camera stations to facilitate independence between PSOs monitoring from the same location. It was understood, however, that independence would be compromised for strike avoidance measures as required since these requests were relayed by radio to the bridge.

The PSO team recorded a combined total of 481 marine mammal detections: 134 by UE visual, 122 via the FLIR M364 IR, 102 by the NN3025 IR, and 123 via the NN3050 IR. Mysticete whale detections accounted for 82 percent of all detections and were primarily of humpback whales (n = 217, 45 percent) and unidentified mysticete whales (n = 146, 30 percent). NARWs were visually confirmed on four occasions: three in the Nantucket Shoals survey area and one in the Cape Cod survey area. Of the four NARW detections, two were concurrently observed on the IR cameras (once on the FLIR M364 and once on the NN3050).

Marine mammals were detected more often during daylight than darkness, with 369 (77 percent) detections recorded during daylight compared to 112 during darkness. Of those daylight detections, 36 percent were detected by the visual observer, 22 percent on the FLIR M364 IR, 19 percent on the NN3025 IR, and 23 percent on the NN3050 IR. All three IR cameras had an approximate 70 percent daylight to 30 percent darkness split in detections, likely reflecting the reduced number of marine mammals available for detection at night due to the vessel relocating away from fishing gear and higher concentrations of marine mammals during darkness.

The highest overall (daylight and darkness combined) detection rate was achieved by UE visual observations at 0.71 detections per hour of monitoring effort. The visual detection rate was more than double the overall detection rates for each of the three IR cameras (FLIR M364 0.33 detections/hour, NN3025 0.27 detections/hour, and NN3050 0.33 detections/hour). Detection rates were higher during daylight than during darkness for all four monitoring methods, which once again likely reflects the different availability of marine mammals for detection during day and night (**Figure 8**).

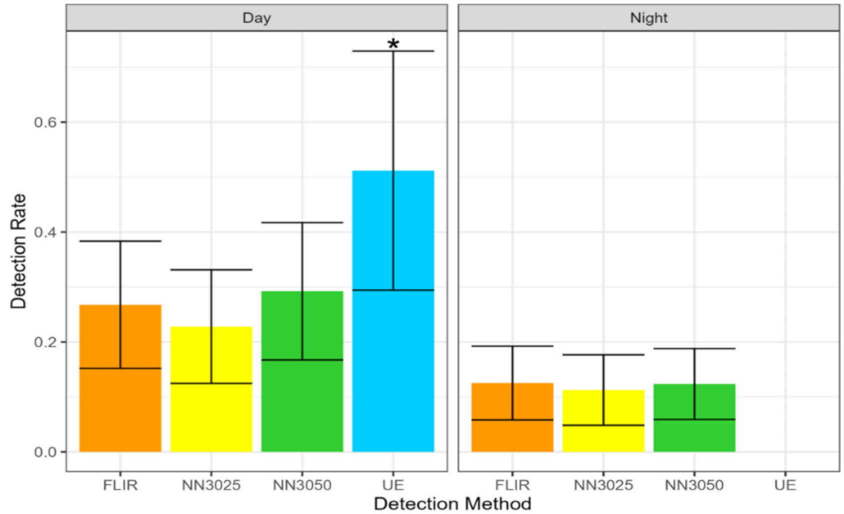

Figure 8. Mean detection rates (95 percent confidence intervals) of whales during daylight periods while monitoring offshore.

The higher daytime detection rate for the UE than the IR systems was likely caused by two main factors. First, the UE field of view is much larger than that of the IR systems, providing the visual observer with much greater opportunity for making detections. To test this, all detections from the IR systems were carefully reviewed, and any detections made by more than one IR system were counted only once to arrive at a total number of unique IR detections. These unique detections were used to calculate a combined detection rate from multiple IR cameras, effectively providing an expanded field of view from the IR systems. This pooled IR camera detection rate was not significantly different from the detection rate of a visual observer (**Figure 9**). The second reason is that IR systems tend to be less effective during daylight when the temperature difference between potential targets and the background is reduced. Therefore, using detection rates of IR systems during the day biases the rates downward, confounding the ability to make valid comparisons to visual detections.

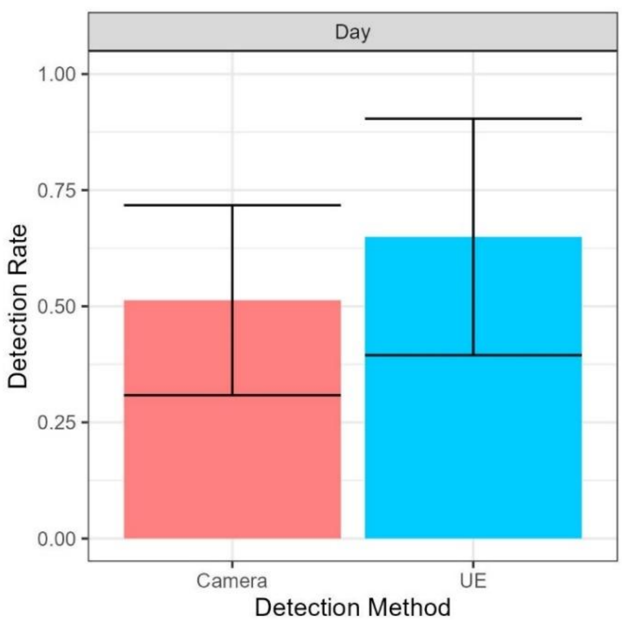

Figure 9. Detection rates with 95 percent confidence intervals for the three IR cameras combined and the visual PSO for all marine mammals (day detections only).

During the offshore testing, the maximum initial detection distances ranged from 2,000–4,709 m across the four monitoring methods, with the furthest distance achieved by UE visual observation during daylight (**Table 5**). The NN3025 and NN3050 IR cameras also detected marine mammals, specifically mysticete whales, at distances >4,000 m, with maximum distances of 4,276 m and 4,494 m, respectively, for the two IR cameras. In total, eight marine mammal detections were initially detected at distances >4,000 m: three by the NN3025, three by the NN3050, and two by UE visual detection. The overall (daylight and darkness combined) average initial detection distances for the three IR cameras were similar, differing by 140 m or less, but all were less than from UE visual observation.

Generalized linear mixed effects models were used to predict average detection distances while accounting for spatial and temporal variation. The visual observer had a significantly greater average predicted detection distance than the IR cameras during the day ($p < 0.01$; **Figure 10**). There was no significant difference in detection distance between the IR cameras during the day or at night. Caution should be used when interpreting average detection distances (from all four detection methods) during the offshore testing phase because the true distribution of available targets (marine mammal blows or bodies) is not known and was not necessarily uniform. Thus, mean detection distances may be influenced by the distribution of available targets and not necessarily reflect the true mean distance at which detections are probable for each method.

Table 5. Maximum (max.) and average (avg.) marine mammal detection distances (m) during daylight and darkness on the three IR cameras and by the visual observer using the unaided eye (UE).

Method	Marine Mammal Detection Distance (m)											
	Mysticete			Odontocete			Pinniped			All Marine Mammal Groups Combined		
	max.	avg.	n	max.	avg.	n	max.	avg.	n	max.	avg.	n
FLIR M364												
daylight	2000	780	70[1]	1000	325	6	n/a	n/a	0	2000	744	76[1]
darkness	2100	1023	21	1500	423	21	n/a	n/a	0	2100	723	42
combined	2100	836	91[1]	1500	402	27	n/a	n/a	0	2100	736	118[1]
NN3025												
daylight	4276	888	66[2]	700	n/a	1	99	n/a	1	4276	874	68[2]
darkness	2685	1325	16	1112	346	17	n/a	n/a	0	2685	821	33
combined	4276	973	82[2]	1112	366	18	99	n/a	1	4276	856	101[2]
NN3050												
daylight	4494	950	81	1361	723	5	n/a	n/a	0	4494	937	86
darkness	1640	783	13	2000	712	24	n/a	n/a	0	2000	737	37
combined	4494	927	94	2000	714	29	n/a	n/a	0	4494	877	123
Visual Observer												
daylight	4709	1427	123	2044	728	7	303	130	4	4709	1351	134

[1] Excludes four mysticete whale detections for which a detection distance was not reported.

[2] Excludes one mysticete whale detections for which a detection distance was not reported.

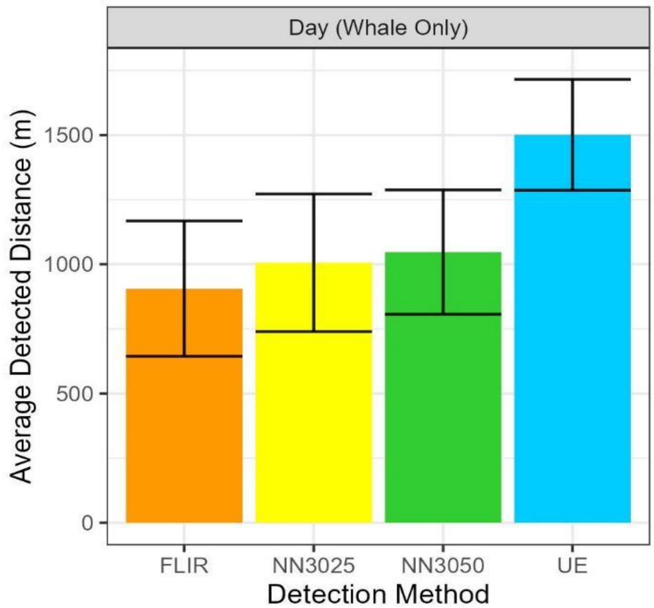

Figure 10. Average model predicted detection distances during daylight periods.

2.3 IR System Effectiveness Summary

The literature reviewed in Section 2.1 indicates that IR systems deployed at elevated locations on marine vessels can detect mysticete whales at long ranges and other marine mammals at shorter distances. Detections of large whales were commonly reported in the 1–3 km range, with occasional detections out to 5–10 km. Cooled IR sensors tend to provide better marine mammal detection capabilities over uncooled sensors. BSSs of 5 or greater as well as fog or rain significantly reduce detection probabilities for all IR sensors.

Testing of three commercially available IR systems in both controlled and at-sea scenarios yielded similar results as reported in previous studies. The controlled study using simulated whale blows demonstrated that the cooled IR camera had higher detection probabilities at increasing distance than the two uncooled cameras. At night, the cooled camera had nearly the same detection probability at 2 km as a visual observer during daylight. During at-sea testing in daylight, the rate of detections from the IR cameras was lower than the visual observer, likely because of the narrower field of view of the IR cameras. When the IR camera detections were pooled and duplicates removed (increasing the effective field of view of the IR cameras), the resulting sighting rate was not significantly different from the visual observer.

Based on the above findings the following definition of IR system effectiveness has been applied when designing the nighttime monitoring plan:

- Cooled IR cameras have an effective range of 2 km for mysticete whales under good environmental conditions.
- Uncooled IR systems have an effective range of 1 km for mysticete whales under good environmental conditions.
- Good environmental conditions are:
    - BSS ≤4 (Winds <17–21 knots; waves <6–8 feet, whitecaps common with little to no spray)
    - Visibility (daytime equivalent) ≥5 km
    - No more than light fog or rain (defined by when PSO using the IR systems determine their effectiveness has been compromised).

- More than one IR camera should be used whenever possible to increase the field of view being monitored at any one time.

3. Acoustic Monitoring System

3.1 Equipment

To provide long-range directional acoustic detections with the ability to localize marine mammal calls and deliver near-real-time information to PSOs, the project will use ThayerMahan SeaPicket bottom-mounted acoustic arrays (SeaPicket). SeaPicket systems consist of a Maritime Applied Physics Corporation (MAPCORP) 605S buoy with a flexible hose anchor and data line, a linear 32-channel acoustic hydrophone array laid on the bottom, and single point moored on the seafloor (**Figure 11**). Empirical demonstration of the detection capabilities of the 32-channel hydrophone array are available in Premus et al. (2022). The buoy will include data processing and communications electronics and a re-chargeable battery pack housed in watertight enclosures, with solar panels, communications antennae, and lights mounted on the superstructure. Additional specifications for the SeaPicket can be found in Appendix C.

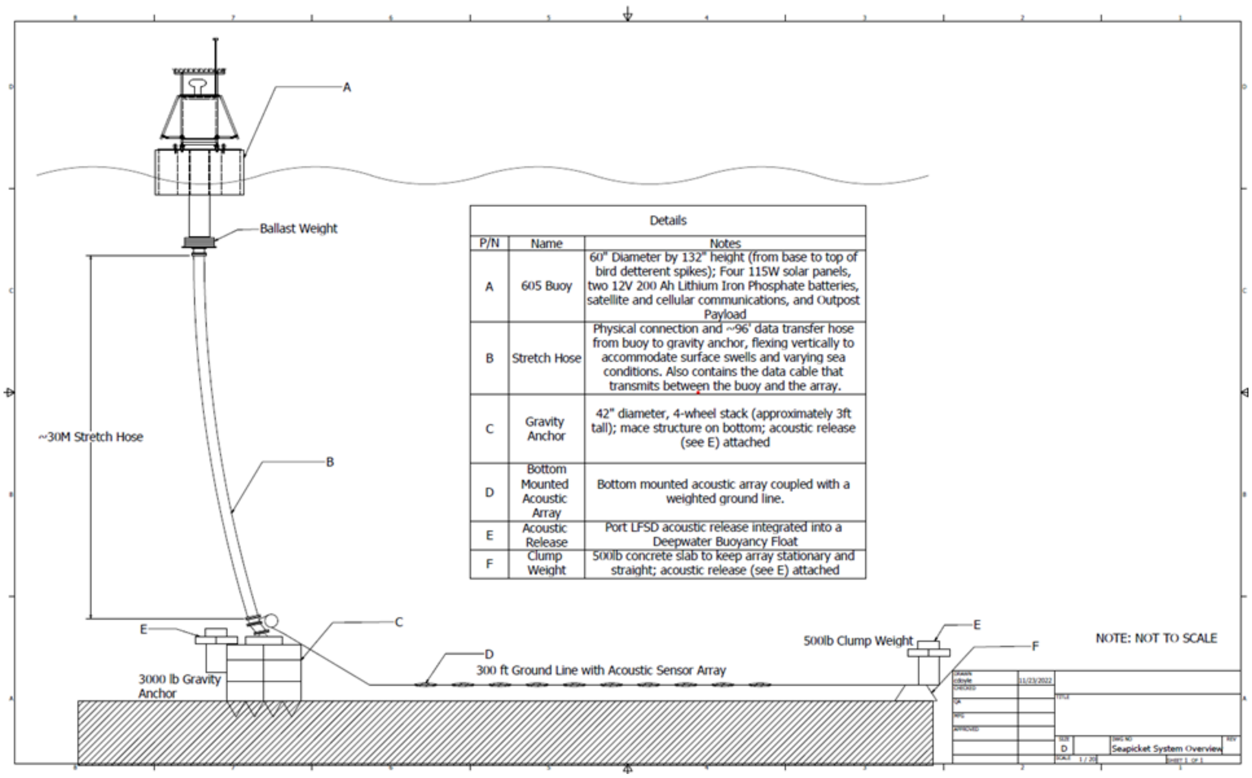

Figure 11. Schematic showing the components and deployment arrangement of the SeaPicket acoustic monitoring system.

During the spring demonstration project summarized in (ThayerMahan 2022, 2023), these systems were tested to show their ability to detect mysticete whale and other marine mammal calls. The SeaPicket systems, as well as a mobile acoustic array towed by a wave glider USV, provided directional whale acoustic detections at long ranges. Although we do not plan to use the USVs as part of this nighttime monitoring plan, the same acoustic sensor as the SeaPickets was installed onboard. In **Figure 12**, the acoustic information from the same marine mammal detection is shown for each system (SeaPickets: AVON and BRISTOL; wave glider: MARY R). An acoustic analyst reviewed the data and confirmed a positive marine mammal detection, and then used the directional information from each sensor to create an Area of Uncertainty within the Mission Data software (**Figure 13**). In this case, the location of the marine mammal call was determined to have come from within a 2 nautical mile (NM) (3.7 km) by 5 NM (9.3 km) ellipse.

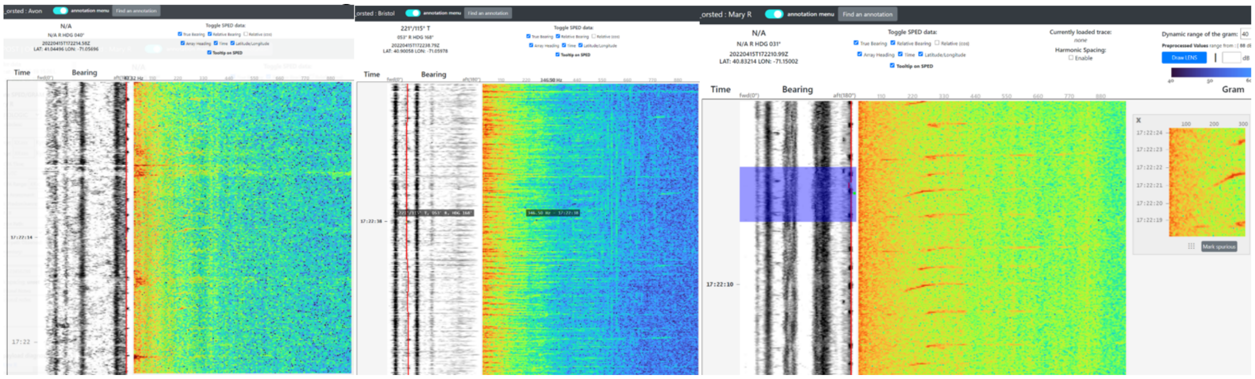

Figure 12. Simultaneous acoustic detection across three platforms (AVON, BRISTOL, and ELLEN). Note the bearing to each detection and that MARY R's system had an autodetection.

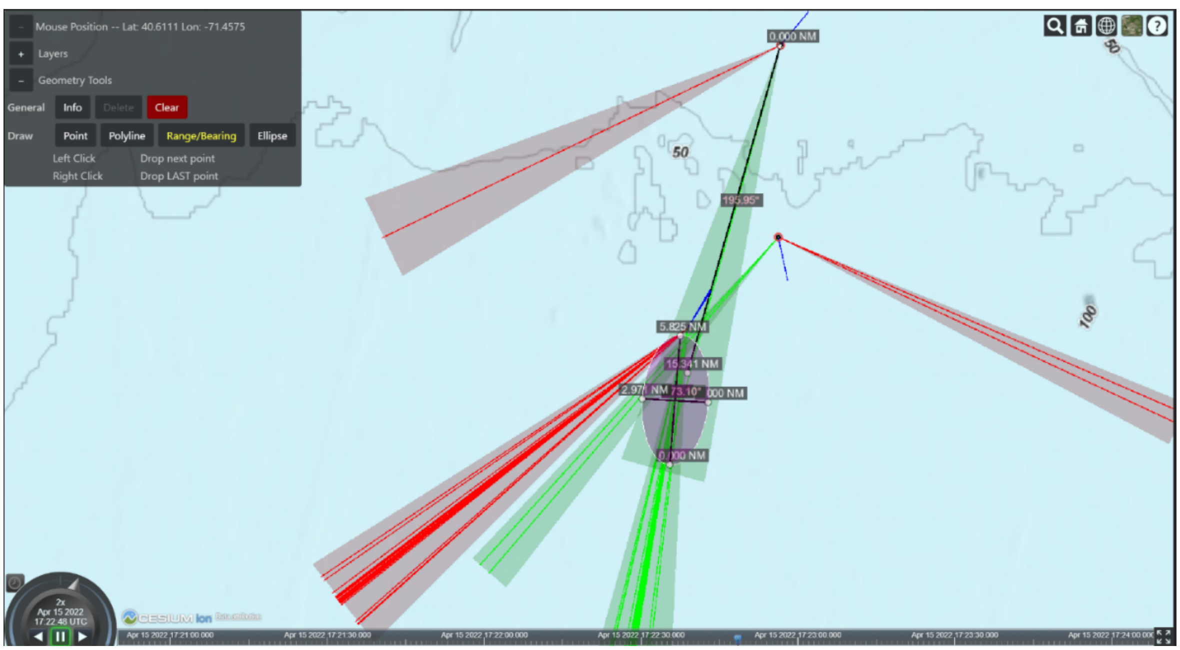

Figure 13. Localization using three sensors (AVON [SeaPicket], BRISTOL [SeaPicket], and MARY R [USV]). The distance to AVON was approximately 28 km, BRISTOL was approximately 13 km, and MARY R was approximately 9 km.

In another example, simultaneous detections on both MARY R (USV) and AVON (SeaPicket) produced an Area of Uncertainty (AOU) about 22 NM (40.7 km) from MARY R (**Figure 14**). Additionally, long-range detections of vocalizing whales by ThayerMahan acoustic systems were corroborated by independent monitoring assets deployed by other research organizations such as Woods Hole Oceanographic Institution (WHOI) and National Oceanic and Atmospheric Administration. **Figure 15** shows detections on the WHOI Martha's Vineyard Buoy, with near simultaneous detection by AVON (with some time difference due to distance). Of note, some additional biological transients down bearings were detected by AVON and not detected by the WHOI buoy.

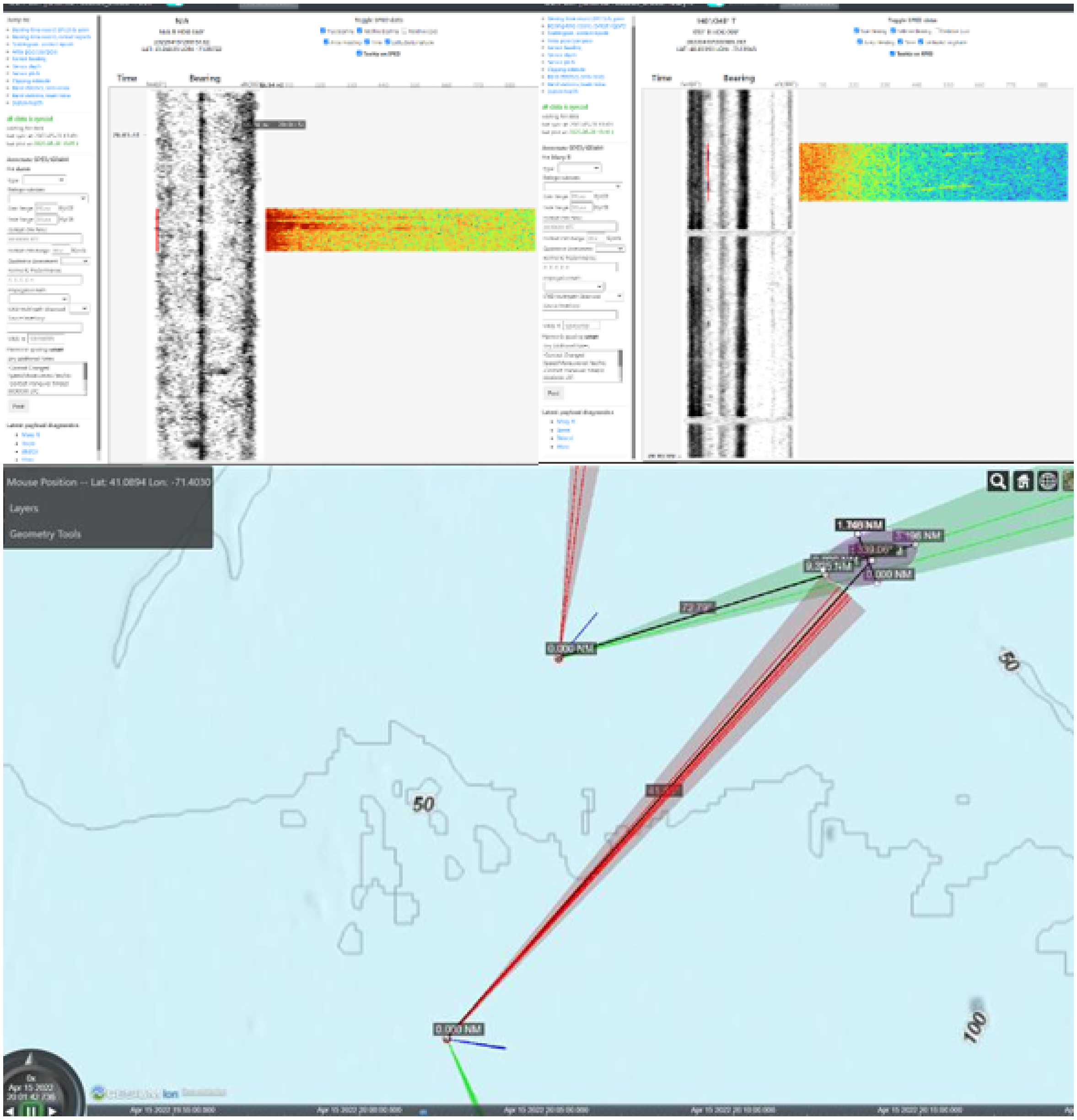

Figure 14. Simultaneous Detections on MARY R and AVON; detection distance estimated at approximately 22 NM from MARY R.

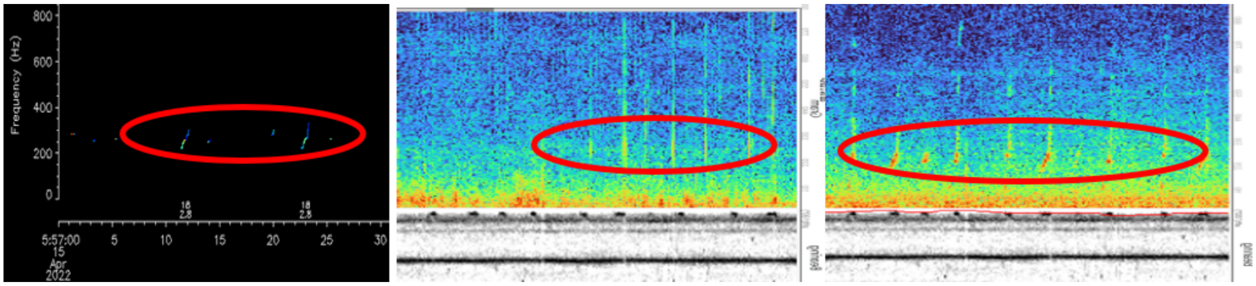

Figure 15. Spectrograms showing detections on 15 April 2022 from 05:57.00–05:57.30. Left panel - WHOI Martha's Vineyard Buoy; Middle panel: AVON Detections at bearing 200˚N – 240˚N; Right panel: AVON Detections at 075˚N.

4. Ocean Wind 1 Nighttime Monitoring Plan

4.1 Monitoring and Mitigation Zones

This section provides a brief summary of the relevant mitigation and monitoring zones for pile driving of wind turbine generator (WTG) and offshore substation (OSS) foundations during the Project. These are the same monitoring zones applicable to pile driving during daylight periods described in the PSMMP and Incidental Take Regulation (ITR) application. The relevant pile driving monitoring zones are summarized in **Table 6**, with additional details available in the PSMMP (HDR 2022). The visual clearance zones are based on the exposure ranges to Level A thresholds and also reflect the minimum visibility distances identified in the PSMMP and Draft ITRs (87 FR 64868). The NARW PAM clearance/monitoring zones for summer and winter specified in **Table 6** are equal to the Level B Monitoring Zones described in the PSMMP for those respective seasons. The localization of a NARW call within these zones will trigger a delayed start or shutdown of pile driving.

Table 6. Monitoring zones for impact pile driving.

Activity / Hearing Group	Visual Clearance Zone (m)		Minimum Visibility Zone (m)			NARW PAM Clearance Zone (m)	
	Summer (May-Nov)	Winter (Dec)	Summer (May-Nov)		Winter (Dec)	Summer (May-Nov)	Winter (Dec)
WTG/OSS Foundations[1]							
Low-frequency Cetaceans	1,650	2,490	1,650		2,500	3,500	3,800
Sperm Whales	1,650	2,490	1,650	2,500	-	-	-
Mid-frequency Cetaceans (non-sperm whale)	NMS	NMS	1,650		2,500	-	-
High-frequency Cetaceans	880	1,430	1,650		2,500	-	-
Pinnipeds	80	240	1,650		2,500	-	-

[1] Either one or two monopiles driven per day, and either two or three pin piles driven per day. When modeled injury (Level A) threshold distances differed among these scenarios, the largest for each species group was chosen for conservatism.
"NMS" = perimeter of the Noise Mitigation System
"- "= Not Applicable.

4.2 Nighttime Monitoring Methods

Nighttime monitoring of the pre-start clearance and shutdown zones will be accomplished using a combination of visual monitoring with multiple IR cameras and acoustic monitoring with SeaPicket systems. The IR cameras will provide visual detections of marine mammals, especially mysticete whales, that do not always vocalize. The acoustic systems will provide localized acoustic detections across a much larger area than can be monitored with the IR cameras. This large area monitoring of vocalizing mysticete whales, including the identification of some calls to species like NARW and humpbacks, will provide an indication of the location and number of different whales (or groups of whales) in the region, allowing for improved situational awareness by the monitoring team. Knowing the approximate location of vocalizing whales, especially in cases where they begin to approach visual monitoring zones around foundation installation locations, will allow IR camera monitoring to focus effort in areas with a higher probability of a whale surfacing. The combination of localized acoustic information and multiple IR cameras on each vessel platform will help to overcome the narrower field of view from IR cameras versus visual observers during daylight.

4.2.1 Visual Monitoring Using IR Cameras

IR cameras will be deployed as described below and monitored by PSOs at night. During daylight, PSOs will conduct visual watches from the vessel's Bridge or deck as described in the PSMMP, and the IR cameras will not be monitored. The following list specifies the IR monitoring methods to be used during installation of WTG monopile foundations during the summer (May– November) and winter (December) months.

- **Pile Installation Vessel (Stationary Vessel)**
  - Two Current Corp 3050 IR cameras (effective range = 2 km) each monitored by one PSO.
  - PSOs will use each camera to systematically scan a 180° field of view to provide 360° coverage around the pile driving location.
- **Secondary Monitoring Vessels (Underway Vessel)**
  - The shutdown zone/minimum visibility zone distance in summer months (May–November, 1.65 km) is smaller than the effective range of the 3050 IR camera stationed on the pile installation vessel (2 km); therefore, the use of secondary monitoring vessels is not necessary to maintain visual coverage of this zone. However, if the monitoring vessels are present and available, they will be employed and travel at ~6 knots along a circular path ~ 1.5 km from the pile driving location (**Figure 16**).
    - Each vessel will complete a circle every ~51 minutes (**Table 7**). The vessels will remain approximately opposite of each other on the circular path resulting in a monitoring vessel pass every ~25 minutes.
  - In winter, two monitoring vessels will travel at ~6 knots along a circular path ~2 km from the pile driving location (**Figure 17**).
    - Each vessel will complete a circle every ~68 minutes (**Table 7**). The vessels will remain approximately opposite of each other on the circular path, resulting in a monitoring vessel pass every ~34 minutes.
  - Each monitoring vessel will have two Current Corp 3025 IR cameras (effective range = 1 km) each monitored by one PSO.
  - PSOs will use each camera to systematically scan a 180° field of view on either side of the vessel (Port and Starboard), with an emphasis on the forward 90° since the vessel will be underway.
    - At a speed of 6 knots, the 1 km zone forward of each monitoring vessel will be within view for approximately 5.5 minutes (or 11 minutes if you also include the stern of the vessel). Combined, the two vessels will provide IR monitoring of the outer edge of the shutdown zone and beyond for approximately 16 percent of the time.

- **Sea Turtle Monitoring Vessels (Underway Vessel)**
  - In both summer and winter, one sea turtle monitoring vessel will travel at ~3 knots along a circular path ~500 m from the pile driving location (**Figure 16 and 17**).
    - The vessel will complete a circle every ~34 minutes (**Table 7**).
  - The sea turtle monitoring vessel will have two Current Corp 3025 IR cameras (effective range = 1 km) each monitored by one PSO.
  - PSOs will use each camera to systematically scan a 180° field of view on either side of the vessel (Port and Starboard), with an emphasis on the forward 90° since the vessel will be underway.

A map showing the pre-start clearance and shutdown zone as well as the PSO vessel path and IR monitoring coverage at a representative WTG foundation location in summer is shown in **Figure 16** and **17**.

The shutdown zone distance for an OSS monopile foundation installation in the summer (1.6 km, **Table 6**) is less than the effective range of the Current Corp 3050 IR cameras that will be used on the pile driving vessel; therefore, use of the additional PSO vessel is not necessary. However, if the PSO vessels are present and available, they may be used in the same manner as described for WTG installations in winter.

Table 7. Secondary monitoring vessel path specifications.

Foundation Type and Season	Radius (km)	Perimeter (km)	Time to complete one circle (minutes)	Vessel (n = 2) pass frequency (minutes)
Secondary Monitoring Vessels				
WTG/OSS Summer[1]	1.5	9.43	50.89	25.45
WTG/OSS Winter	2	12.57	67.85	33.93
Sea Turtle Monitoring Vessel				
WTG/OSS Year-round	0.5	3.14	33.92	N/A

[1] Given the fact that the shutdown zone/minimum visibility zone distance in summer is smaller than the effective range of the IR camera on the piling vessel, secondary monitoring vessels are optional in summer and will be used as available.

Recording of marine mammal sightings and notifications to other PSOs at night will occur in the same manner as described for daytime periods in the PSMMP (HDR 2022). Detections made by all observers will be entered into *Mysticetus* and be available to all other PSOs. Any detections within or near the shutdown zone will be communicated directly to the on-duty PSOs on the piling vessel (through radio, phone, or other immediate communications methods) so that any necessary mitigation measures can be implemented in a timely manner.

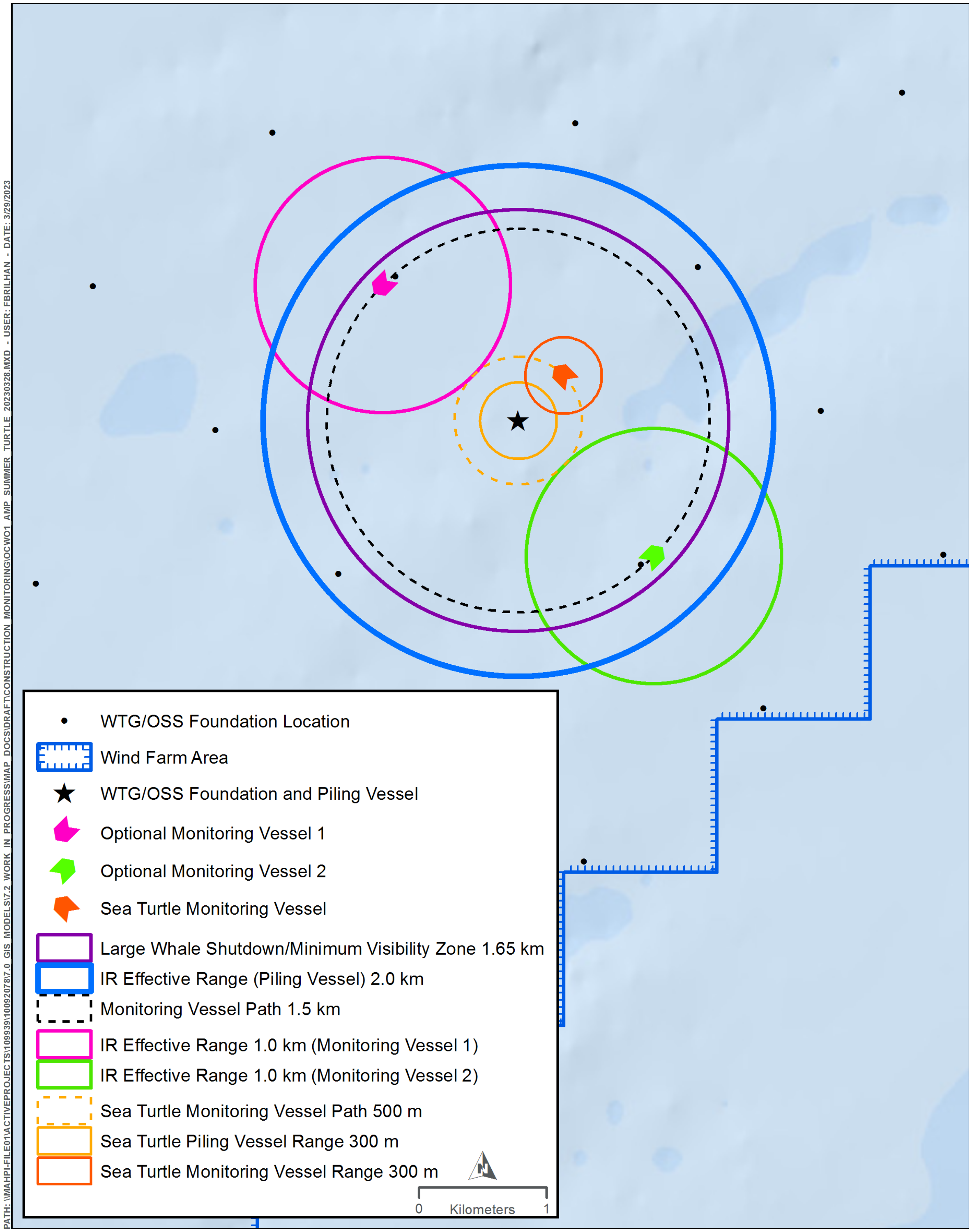

Figure 16. Map showing the pre-start clearance and shutdown zone at a representative WTG foundation location in summer, including the monitoring vessel path and IR effective ranges.

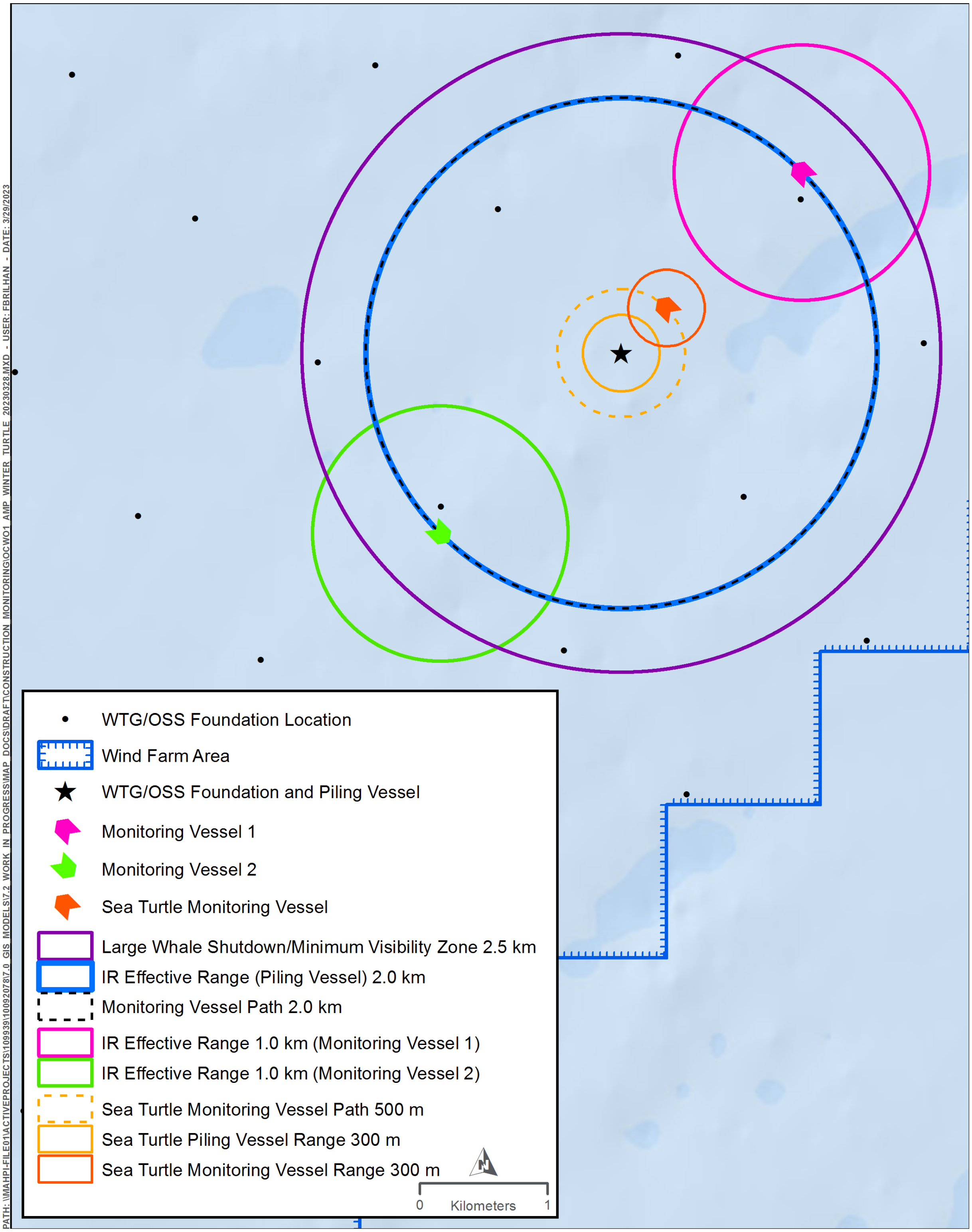

Figure 17. Map showing the pre-start clearance and shutdown zone at a representative WTG foundation location in winter, including the monitoring vessel path and IR effective ranges.

4.3 Acoustic Monitoring Methods

If nighttime pile driving is authorized and implemented, acoustic monitoring will be conducted using four SeaPicket systems described in Section 3. The deployment locations have been selected such that each system could remain deployed in a single location during the entire foundation installation period (**Figure 18**). This avoids the need to recover and redeploy the systems during the installation period. The number of systems and their locations means there is also significant overlap between the area being monitored by each system. This creates redundancy in monitoring coverage should a SeaPicket system fail and need to be replaced. Should nighttime pile driving not be authorized, standard omni-directional PAM systems with real time capability would be deployed and recovered at each foundation installation location (or group of nearby locations) as described in the PSMMP.

As described in ThayerMahan (2022) and ThayerMahan (2023), each SeaPicket system detects acoustic signals using a 32-channel acoustic array. Those data undergo onboard processing with relevant data then transmitted every five minutes to a shoreside command center via satellite communication. The onboard processing will include classifiers specifically developed to identify the NARW upcall and humpback whale (additional autodetection classifiers are in development). Using a web-based interface, PAM operators will be on duty shoreside to review and analyze incoming data. The PAM operators will classify and tag the data using the following hierarchy to create contact/detection reports:

1. Investigate all classifier alerts first.
    (1) Annotate classifier alerts for valid detections of marine mammal calls based upon the visual characteristics of the detection.
    (2) Look for other potential detections around auto-classified detections that could be potential missed detections and tag them if valid.
    (3) If the detection(s) was not valid, the PAM operators would not tag the data.
2. Evaluate non-classifier detections throughout the data. Look for distinct short-duration transients in data and interrogate them.
3. Tag transients that appear to be valid marine mammal detections. If unsure, tag as “biologic” and "other.
    (1) Synthesize and correlate the tagged line of bearing information to generate a contact report within MissionData (ThayerMahan’s Geo-based visualization software for acoustic sensors) that will automatically propagate to Mysticetus.
4. Once contact reports are pushed into the Mysticetus cloud database, the vessel-based computers running Mysticetus would sync, and acoustic detections would be visible to the vessel-based PSOs on a map display.
5. Coordinate with the Shoreside PSO located in the Command Center to validate reports are arriving on Mysticetus and, if necessary, initiate direct communications with vessel-based PSOs (via radio, phone, or other direct communication methods) to ensure any necessary mitigation actions are taken.

The 4 km acoustic buffer zone shown in **Figure 17** is based on the minimum acoustic monitoring zones required by NMFS in summer and winter (3.5 and 3.8 km respectively) and rounded up for consistency and conservatism. From the Proposed Rule for Ocean Wind 1: “*Acoustic monitoring during nighttime and low visibility conditions during the day will complement visual monitoring (e.g., PSOs and thermal cameras) and will cover an area of at least the Level B harassment zone around each foundation*” (87 FR 64868).

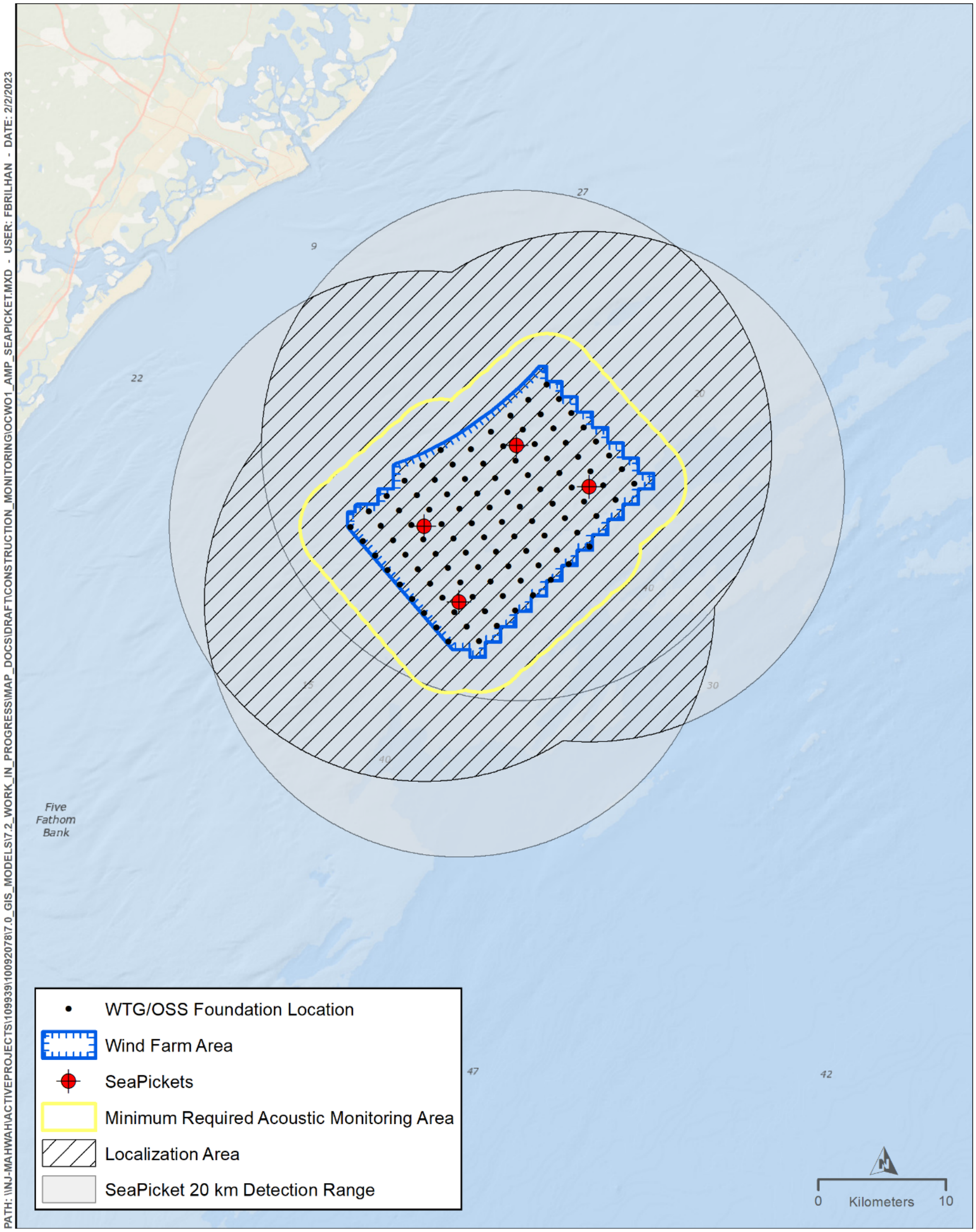

Figure 18. Map showing the deployment locations of 4 SeaPicket PAM systems to be deployed, the minimum (4 km) acoustic monitoring distance (yellow line), the area within which acoustic detections could be localized (striped), and the area within which marine mammal vocalizations could be detected (gray shading) assuming a 20 km detection range from each SeaPicket system.

4.4 Sea Turtles

The same animal movement modeling used to determine exposure ranges to marine mammal acoustic thresholds from pile driving of WTG and OSS foundations was also performed for sea turtles (COP Appendix AA). The results were used to establish monitoring and mitigation zones in the Marine Mammals, Sea Turtles, and ESA-Listed Fish Species PSMMP (COP Appendix AA) and are summarized here in **Table 8.**

Table 8. Sea turtle threshold ranges and mitigation and monitoring zones (in meters) associated with one or two WTG/OSS monopiles or two or three OSS pin piles installed in one day using impact pile driving and assuming 10 dB noise attenuation.

Foundation Type	Maximum Injury Threshold Distance (m)	Pre-start Clearance Zone (m)	Shutdown Zone (m)
WTG/OSS Monopile	310	500	500
OSS Pin Pile	310	500	500

When a sea turtle surfaces to breathe, its shell has only minimal contact with or extension above the water surface. Turtles do raise their heads above the water surface when breathing, but these movements are typically very short in duration. Since sea turtles are ectotherms, the head and shell are very similar in temperature to the surrounding sea water, and exhaled air will not have been warmed as much as air from a marine mammal's lungs. The amount of air exhaled will also be quite small in comparison to that of a marine mammal. For these reasons, IR cameras are not expected to be useful in detecting sea turtles. PSOs were directed to watch for and record sea turtles during the spring and fall demonstration projects. None were detected visually or using the IR cameras.

Although there are reports of sea turtles generating sounds while nesting (Mrosovsky 1972; Cook and Forrest 2005), they are not known to vocalize or otherwise create sounds while underwater. Therefore, passive acoustic monitoring is not expected to aid in the detection of sea turtles within shutdown zones.

In daylight, sea turtle observations are typically limited to within a few hundred meters of large vessels. For example, Hauser et al. (2008) reported the closest point of approach (CPA; which was typically also the initial detection distance) of sea turtles to a seismic survey vessel where the observer height above sea level was 12.3 m. The mean CPA when seismic sounds were not being produced was 427 m (n = 46, range 313–615 m), while the mean CPA when seismic sounds were being produced was 377 m (n = 83, range 169–518 m). Shorter mean CPA distances were reported from the same vessel during a separate survey, with a mean CPA of 159 m (n = 77, range 98–352) when the seismic source was active and 118 m (n = 69, range 50–352) when the source was not active (Holst and Smultea 2008). With the elevated observation platform provided by a large commercial vessel, we believe sea turtles can be reliably detected at least 300–500 m from the vessel during daylight.

At night, sea turtle detection distances are likely to be reduced, and IR cameras and passive acoustic monitoring are not expected to provide any advantages. However, if nighttime pile driving of foundations were to take place, the installation vessel would illuminate the vessel deck, pile, pile gripper, and surrounding work areas for safety reasons using vessel deck lights. The light produced would also cover the water surface within hundreds of meters of the pile. Berge et al. (2020) and Ludvigsen et al. (2018) indicate that deck lighting can illuminate surface waters out to 200 m around and below research vessels, which are much smaller in size than the proposed piling vessel. This lighting is expected to be sufficient to allow detection of sea turtles using the naked eye or with NVDs within 200–300 m. To monitor the exclusion zone, two PSOs would conduct visual observations with the naked eye and NVDs (if PSOs determine that the artificial light does not render them ineffective) during the pre-start clearance period and throughout pile driving.

An additional sea turtle monitoring vessel will be used to increase sea turtle detection efficacy during nighttime piling. This vessel will circle the pile being installed at a 500 m distance (**Figures 16 and 17**) during summer and winter nighttime piling events, which is the extent of the pre-clearance and shutdown zones (**Table 8**). The overlap between piling vessel PSO visual and NVD detection distances as well as the PSO coverage on the sea turtle monitoring vessel will more than adequately cover sea turtle pre-clearance and shutdown zones associated with impact piling. While sea turtle densities are expected to be extremely low in winter months (Table 14 in Küsel et al. 2022), Ocean Wind 1 will continue to monitor for sea turtles using this additional vessel even in winter months when sea turtle densities approach zero.

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Appendix A: Specifications of the 3 IR Camera Systems Tested

Current Scientific Night Navigator (NN) 3025 Camera Specifications

Thermal Camera	
Sensory Type	Uncooled Long-Wave Infrared (LWIR), 8-12µm
Resolution	640x480 pixels, 30fps
Field of View	25° to 5.9°
Digital Zoom	4x
Detection Range	NATO Target >7km
Payload Specification	
Stabilization	Gyro and video stabilization
Pan Range	Continuous 360° AZ rotation
Tilt Range	+/-90° elevation movement, including stow position
Weight	≤25 kg [55lbs]
Dimensions	427mm H x 273mm W [17in H x 11in W]
System Interface	
Video Output	HD-SDI
Video Streaming	RTSP H.264 with Picture-in-Picture or 2 simultaneous video streams
Control	Over IP network
Radar/AIS	ARPA target, radar cursor, AIS target tracking over NMEA 0183 via RS422 or RS232 or Network
Features	
Environmental	Designed to MIL-STD 810
Operational Temperature	-20° C to +50° C
Video Tracking	Optional
Control Options	Video integrated into UI/Control only UI/ Compact Controller/ Rugged Rigid Grip/ 2-Button Joystick
Third Party Interface	Protocol for integration into navigation system/video management system/ C2
Video Recording	Network recording of two video streams on VMS or dedicated NVR
Power Requirements	
Voltage	24 to 36VDC
Max. Consumption	320W

Ocean Wind 1
An Ørsted & PSEG project

Current Scientific NN3050 Camera Specifications

Thermal Camera	
Sensory Type	Cooled Mid-Wave Infrared (MWIR), 3-5µm
Resolution	640x512 pixels, 30fps
Field of View	28° to 2°
Digital Zoom	4x
Detection Range	NATO Target >14km
Lens f/# (focal length/clear aperture)	5.5
Payload Specification	
Stabilization	Gyro and video stabilization
Pan Range	Continuous 360° AZ rotation
Tilt Range	+/-90° elevation movement, including stow position
Weight	≤25 kg [55lbs]
Dimensions	427mm H x 273mm W [17in H x 11in W]
System Interface	
Video Output	HD-SDI
Video Streaming	RTSP H.264 with Picture-in-Picture or 2 simultaneous video streams
Control	Over IP network
Radar/AIS	ARPA target, radar cursor, AIS target tracking over NMEA 0183 via RS422 or RS232 or Network
Features	
Environmental	Designed to MIL-STD 810
Operational Temperature	-20° C to +50° C
Video Tracking	Included
Control Options	Video integrated into UI/Control only UI/ Compact Controller/ Rugged Rigid Grip/ 2-Button Joystick
Third Party Interface	Protocol for integration into navigation system/video management system/ C2
Video Recording	Network recording of two video streams on VMS or dedicated NVR
Power Requirements	
Voltage	24 to 36VDC
Max. Consumption	320W

FLIR M364C LR Camera Specifications

Thermal Camera	
Focus	Fixed 12 ft (3 m) to infinity
Image Processing	FLIR Proprietary Digital Detail Enhancement
Detection Type	Uncooled LWIR 640X512 Vox Microbolometer
E-Zoom	4 x continuous
Field of View	24° x 18°
Focal Length	18 mm
Video Refresh Rate	30 Hz or <9 Hz
System Specifications	
Analog Video Connector	BNC
Analog Video Output	NTSC/PAL User Settable
ClearCruise IR Analytics	Yes, with Raymarine Axiom
Current	Peak 10.0 A
Firefighter Mode	No
Gyro Stabilized	Yes
HD-SDI Lossless Video Output	Yes
Network Video Output	Two, Independent H.264/MJPEG Network Video Streams
ONVIF Conformance	Profile S
Operating Voltage Range	-10% to 30% of Nominal Supply Range
Pan-Tilt Adjustment Range	360° Continuous Pan +/- 90° Tilt
Power Consumption	41 W (typical) 56 W (max)
Environmental	
Automatic Window Defrost	Standard at Power-Up
EMI	IEC60945
Lighting Protection	Near Strike at 2kV
Operating Temperature Range	-13° F to + 131° F (-25° C to +55° C)
Salt Mist	IEC60945
Sand and Dust Ingress	Mil-Std-810E or IP6X
Shock	15g vertical, 9 g horizontal
Storage Temperature Range	-22° F to +158° F (-30° C to +70° C)
Vibration	IEC60945
Water Ingress	IPX6 (heavy seas, power jets of water)
Wind	100 knots (115.2 MPH)
Physical	
Size	Camera: 8.7” (222 mm) x 12.9” (328 mm) / Camera with Top-Down Riser: 10.0” (254 mm) x 14.4” (366 mm)
Weight	Camera: 13.9 lbs (6.3kg) / Camera with Top-Down Riser: 14.9lbs (6.8 kg)

Appendix B: Summary Table of IR Studies

Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
Handheld SAGEM MATIS (Medium wavelength Advanced Thermal Imaging System)	Sterling Cooler	Cooled	**Wide Field of View** Horizontal FOV = 9° Vertical FOV = 6° **Narrow Field of View** Horizontal FOV = 3° Vertical FOV = 2°	14 m	Mysticete Delphinid	Daytime Observations: 500 m–8,800 m	8,800 m	Beaufort Sea State (BSS) = 0.5–4.5 Wind Speed = 1–16 kts Sea Surface Temperature (SST) = 25.6–28.5°C	Baldacci et al. 2005
FIRST-Navy, Rheinmetall Defense Electronics	ns[1]	Cooled	Horizontal FOV = 360° Vertical FOV = 18°	ns	Mysticete	2,000–10,000 m	10,000 m (including daytime and nighttime observations)	SST = 22–24°C.	Boebel 2014
FIRST-Navy, Rheinmetall Defense Electronics	ns	Cooled	ns	ns	ns	3,700–5,500 m	ns	Ns	Boebel and Zitterbart 2013
FIRST-Navy, Rheinmetall Defense Electronics	Sterling Cooler	Cooled	Horizontal FOV = 360° Vertical FOV = 18°	ns	Mysticete	Up to 3,000 m	3,000 m	ns	Burkhardt et al. 2012

[1] Not Stated

Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
Agema	Thermovision 880	MCT liquid nitrogen cooled	ns	8 m above the sea surface	Mysticete	~150 m	~1,000 m for blue whale blow	Daytime period with overcast, calm seas, and slow rolling waves. Some high fog, swells, and rain. BSS = 0–5 White caps and winds with a BSS of 5 AT = 2.5–13°C. SST = 2.7–10.1°C.	Cuyler et al. 1992
FLIR	HRC - Multisensor	Cooled	ns	ns	Terrestrial Target	Fog cat I: 3,000–9,800 m Fog cat II: 540 m Fog cat IIIa: 294 m Fog cat IIIc: 92 m	9,800 m	Varying levels of fog -Even with temperature differences of 10°C (which I imagine are way higher than the temp differences for marine mammals).	FLIR n.d.
FLIR	ThermoVision 3000	Cooled	ns	ns	Terrestrial Target	Fog cat I: 3,000–9,800 m Fog cat II: 540 m Fog cat IIIa: 294 m Fog cat IIIc: 92 m	9,800 m	Varying levels of fog -Even with temperature differences of 10°C (which I imagine are way higher than the temp differences for marine mammals).	FLIR n.d.
FIRST-Navy, Rheinmetall	Sterling Cooler	Cooled to 84 K	Horizontal FOV = 360°	ns	Mysticete	0–5,000 m	~5,000 m	BSS = 3–6 Although the 90 percent cloud cover obscured most of the	Holst et al. 2017b

Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
Defense Electronics			Vertical FOV = 18°					moonlight, some moonlight was apparent.	
Teledyne FLIR	Thermosight	Cooled	ns	ns	Mysticete	Up to 804 m	804 m	Extremely low-light conditions with no moonlight	Kraus and Habloom 2016
FIRST-Navy, Rheinmetall Defense Electronics	Sterling Cooler	Cooled to 84 K	**System**: Horizontal FOV = 360° Vertical FOV = 18° **Study**: Usable FOV = 290° (obstruction from crow's nest)	28.5 m	Mysticete	1,000–6,690 m	6,690 m	Sea Surface Temperature (SST): -0.5–0.1°C. BSS = 4–6 Mean wind speeds: 13–24 knots Visibility = above 10,000 m Humidity = Up to 91%	Michel 2015
AN/KAS-IA (from US Navy)	AN/KAS-IA (from US Navy)	Super-cooled	3.4 x 6.8° magnification 3X	22 m	Mysticete	~500–5,400 m	5,400 m	Study restricted sampling to periods of good weather. Nonetheless, increased wind speeds reduced detection rates.	Perryman et al. 1999
FIRST-Navy, Rheinmetall Defense Electronics GmbH, RDE	Sterling Cooler	Cooled to 84 K	FOV = 244.5° (from −120.9–123.6°, where 0° is looking forward)	7.8 m above the sea surface	Mysticete Delphinid	Closest sighting distance listed = 90 m; however, study was not largely focused on detection distances	ns	Minimal precipitation BSS of 2–3 resulted in the greatest IR detection rates and decreased once wind force >4 Highest detection rates when visibility was >4 km Highest detection rates when ocean and air temps are both at 18°C.	Smith et al. 2020

Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
First- Fast InfraRed Search and Track	ns	Cooled	Horizontal FOV = 360° vertical FOV = 18°	24.5 m above sea level	Mysticete Delphinid Pinniped		7,000 m	ns	Weisseberger et al. 2011
FIRST- Navy, Rheinmetall Defense Electronics	Sterling Cooler	Cooled	Horizontal FOV = 360° Vertical FOV = 18°	24.5 m above sea level	Pinniped Mysticete	400–4,000 m	4,000 m	ns	Weissenberger and Zitterbart 2012
FIRST-Navy, Rheinmetall Defense Electronics	Sterling cooler	Cooled to 84 K	Horizontal FOV = 360° Vertical FOV = 18°	28.5 m above the sea surface	Mysticete	4,000–8,000 m	8,000 m	SST = -1.8 to +22.7°C (predominantly between -1.8 to +10°C) BSS = 0–7 Heavily biased towards polar water temperatures with only 5 encounters having occurred in waters warmer than 15°C	Zitterbart et al. 2013
FIRST-Navy, Rheinmetall Defense Electronics	Sterling Cooler	Cooled to 84 K	Subtropical FOV = 80° Temperate FOV = 198°	North Stadbroke Island = 51.3 m Cape Race = 26 m Poipu Shores = 16 m Princeville = 49.8 m	Mysticete	800–10,000 m	10,000 m	BSS = 1–5 Humidity, fog, and breaking waves **NSI (subtropical):** Air temp (AT) = 17.16 +/- 1.68 C, SST = 21.84 +/- 0.94; **CR (temperate):** AT = 13.21 +/1 1.99, SST = 14.32 +/- 1.55 C. **PO (Tropical):** AT = 21.83 +/- 2.62 C, SST 25.72 +/- 0.41 C **PR (Tropical):** SST 24.98 +/- 0.20 C.	Zitterbart et al. 2020

Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
Current Scientific Corporation	Night Navigator 3	Cooled and Uncooled Options	**Uncooled**: FOV = 20° with an incidence angle of 6.8°, **Cooled**: FOV = 25°	ns	Mysticete Delphinid	Mysticetes = Up to 2,000 m Delphinid pods- Up to 1,000 m Individual Delphinid- 500 m	2,000 m	ns	Current Scientific Corporation 2018
FLIR	M-324 XP	Uncooled vanadium oxide (VOx) detector sensitive to long-wave infrared (LWIR) thermal energy	Radial view of 360°	17.25 m above the water when the ship's draft is 4.5 m.	Delphinid (sperm whale)	450 – 1,300 m	1,300 m	Wind = Up to 100 knots AT = range from -25°C to +55°C.	Cameron et al. 2012
FLIR	PTZ-35-140 MS	longwave uncooled microbolometer detector.	ns	ns	Terrestrial Target	Fog cat I: 5,900–10,100 m Fog cat II: 2,400 m Fog cat IIIa: 293 m Fog cat IIIc: 87 m	10,100 m	Varying levels of fog -Even with temperature differences of 10°C (which I imagine are way higher than the temp differences for marine mammals).	FLIR n.s

Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
Current Scientific Corporation-Night Navigator 6030	LWIR	Uncooled	Horizontal FOV = 25° Vertical FOV = 4.3°	ns	Mysticete	20–2,000 m	2000	Rain, drizzle, fog	Gauthier-Barrette 2019
FLIR Thermovision	A40M	Uncooled	FOV = 37 ° incidence angle = 72 °	13 m above the sea surface	Mysticete	42–162 m	162 m (Twilight)	clear skies, calm seas, and wind speed of 0–4 m/s. AT 10–27°C humidity = 43–85% (maximum recorded during the nighttime)	Graber et al. 2011
FLIR	FLIR F-606	Uncooled	Horizontal FOV = 6.2° Vertical FOV = 5°	28.1 m	Mysticete	479–5,800 m	5,800 m	Ideal conditions with minimal humidity, haze, or choppy seas (high BSS)	Guazzo et al. 2019
FLIR Systems, Inc.	FLIR A615	Uncooled	Horizontal FOV = 25◦ Vertical FOV = 19◦	2 –10 m	Mysticete	Up to 150 m	150 m	ns	Horton et al. 2017
MANTIS 4	Long wave IR sensor (8–12 um).	Uncooled	Multiple fields of view used, degrees not specified.	Not specified, but camera was positioned high on a cliff.	Mysticete	644–12,875 m	12,875 m	Not explicitly reported, but images provided in paper imply that visibility was excellent.	Schoonmaker et al. 2008

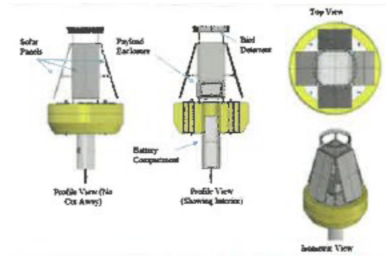
Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
Current Scientific Corporation	Night Navigator 2525	Uncooled	44.2º to 10.4º continuous optical zoom	ns	ns	ns	ns	ns	Smultea 2020
Seiche IR Dual Camera System	Not Specified	Uncooled	ns	ns	ns	ns	ns	ns	Smultea 2020
NVTS	Reliant 640HD	Uncooled	40mm: 15.5 x 11.6°	ns	ns	1–1,000 m	1,500 m	ns	Smultea 2020
NEC/Avio IR Tech	Thermo Tracer TH9260	Uncooled	Horizontal FOV = 25◦ Vertical FOV = 19◦	Handheld ~ 2 m	Mysticete	0–350 m	350 m	AT 28.1–33.5°C. SST 27–30.5 .	Yonehara et al. 2012
ITT Industries - Night Vision Device	Night Quest NQ220 (handheld)	N/A	ns	8.5 m above the sea surface	ns	250 m	250 m	BSS = 3 Cloud Cover = 90%	Holst 2003
ITT Industries - Night Vision Device	Night Quest NQ220. Generation 3 binoculars	N/A	3 x Magnification lens	Handheld ~ 9 m	No marine mammals detected at the site.	Observers could spot milk jugs up to 150 meters away.	Observers could spot milk jugs up to 150 meters away.	BSS = 4 40% cloud cover ~17 knot winds	Holst 2004
ns	ns	ns	FOV = 40°	11–14.4 m above the sea surface	Delphinids		30 m	BSS = 1–4	Holst et al. 2017a
ns	ns	ns	ns	shore based	Mysticete	ns	10,000 m	ns	Boebel and Zitterbart 2014
Seiche CMS	ns	ns	ns	ns	Mysticete	Up to 4,000 m	4,000 m	ns	Seiche, LTD. 2020 (website)

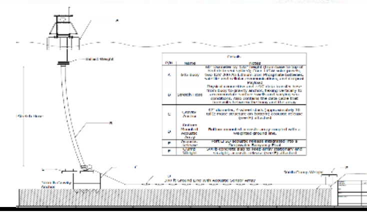
Sensor Make	Sensor Model	Cooled or Uncooled	Sensor Field of View (degrees)	Mounted Camera Height (meter [m] above sea level)	Species Group(s) Detected (Mysticete, Delphinid, or Pinniped)	Range of Detections (m)	Maximum Detection (m)	Environmental Conditions during Detections used in Mean or Max Calculations	Citations
ns	ns	ns	ns	ns	ns	1–1,500	ns	ns	Sjaardema et al. 2015
Toyon Research Corporation	ns	ns	ns	ns	Mysticete	ns	ns	ns	Sullivan 2016

Appendix C: SeaPicket System Specifications

SeaPicket Description

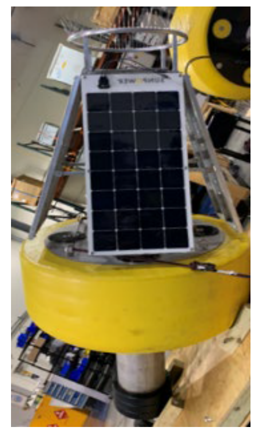
Overall System Function	Buoy based acoustic detection system
Sea State	Survive up to Sea State 6
Water Depths	50-250 feet of water
Acoustic Detection Ranges	Depending upon deployment location and background noise; from 10 nm to 20 nm
Acoustic Detection Targets	Commercial Vessels, Recreational Vessels, Pile Driving, Marine Life; ability to differentiate based on high array gain
Data Reporting Periodicity	Up to real-time reporting, but depends upon customer requirements
System Endurance	90 to 180 Days during winter, depending upon reporting requirements of customer

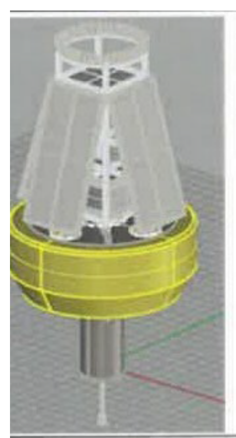




Buoy

Hull Dimensions	60" Diameter by 132" height (from base to top of bird deterrent spikes)
Weight	634lbs (919lb with payloads and ballast)
Material	Hull: Cross-linked polyethylene foam, polyurea coating with 316 stainless steel deck and hardware Tower: Marine grade 5052 aluminum





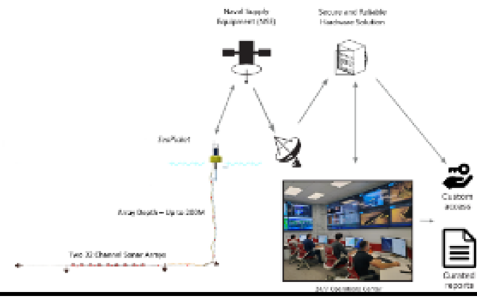
Power Systems

Function	Generation and storage of power to all onboard system
Generation	Four (4), 115W 12V DC, marine grade semiflexible solar panels with wet-mate connector
Storage	Two 12V 200Ah Lithium Iron Phosphate Batteries

Location	Batteries: Center Well of Buoy; Solar Panels on exterior

Communications Systems

Function	Provide communications (payload, control systems)
Sat Comms	Cell modem, Hughes, 9202 BGAN; Starlink, (depending upon distance from shore and customer requirements



Mooring System (Single Point Design)

Function	Physical connection & data transfer hose from SeaPicket buoy to gravity anchor, flexing vertically to accommodate surface swells and varying sea conditions. Also contains the data cable that transmits between the buoy and the array.
Size	Approx. 3” in diameter; length varies with depth but typically 96’ in length for 100’ deployment depth
Material	Proprietary rubber compound https://www.eomoffshore.com/_files/ugd/9aa783_354e9e6b724b47a8a8e4cd60908ecda1.pdf

Clump Weight

Function	Provide bottom weight that maintains position on the sea floor
Size	42" Diameter, 4-wheel Stack (approximately 3ft tall)
Weight	3300 lbs. dry; 2800 lbs. wet
Material	Steel Gravity Anchor with Bottom Mace; railroad wheel anchors

Anchor Weights

Function	Hold acoustic array in place on ocean floor
Weight	400 lbs.

**Note: For Dual Point, double all quantities listed*

Appendix D: Beaufort Wind Force and Sea State Table

Wind Force	Description	Wind Speed			Specifications	Wave Height (m)		Sea State
		Km/h	Mph	Knots		Avg	Max	
0	Calm	<1	<1	<1	Smoke rises vertically. Sea like a mirror	--	--	0
1	Light Air	1-5	1-3	1-3	Direction shown by smoke drift but not by wind vanes. Sea rippled	0.1	0.1	1
2	Light Breeze	6-11	4-7	4-6	Wind felt on face; leaves rustle; wind vane moved by wind. Small wavelets on sea	0.2	0.3	2
3	Gentle Breeze	12-19	8-12	7-10	Leaves and small twigs in constant motion; light flags extended. Large wavelets on sea	0.6	1.0	3
4	Moderate Breeze	20-28	13-18	11-16	Raises dust and loose paper; small branches moved. Small waves, fairly frequent white horses	1.0	1.5	3-4
5	Fresh Breeze	29-38	19-24	17-21	Small trees in leaf begin to sway; crested wavelets form on inland waters. Moderate waves, many white horses	2.0	2.5	4
6	Strong Breeze	38-49	25-31	22-27	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty. Large waves, extensive foam crests	3.0	4	5
7	Near Gale	50-61	32-38	28-33	Whole trees in motion; inconvenience felt when walking against the wind. Foam blown in streaks across the sea	4.0	5.5	5-6
8	Gale	62-74	39-46	34-40	Twigs break off trees, generally impedes progress. Wave crests begin to break into spindrift	5.5	7.5	6-7
9	Strong Gale	75-88	47-54	41-47	Slight structural damage (chimney pots and slates removed). Wave crests topple over, and spray affects visibility	7.0	10.0	7
10	Storm	89-102	55-63	48-55	Seldom experienced inland; trees uprooted; considerable structural damage. Sea surface is largely white	9.0	12.5	8
11	Violent Storm	103-117	64-72	56-63	Very rarely experienced, accompanied by widespread damage. Medium-sized ships lost to view behind waves. Sea covered in white foam; visibility seriously affected	11.5	16.0	8
12	Hurricane	118+	73+	64+	Devastation. Air filled with foam and spray, very poor visibility	14+	---	9

Source: https://www.rmets.org/metmatters/beaufort-wind-scale