Revolution Wind Farm and Revolution Wind Export Cable – Development and Operation

Biological Assessment

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For the National Marine Fisheries Services

U.S. Department of Interior
Bureau of Ocean Energy Management
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Acronyms and Abbreviations

µPa	micropascal
AIS	Automatic Identification Systems
ALARP	As Low as Reasonably Practicable
AMAPPS	Atlantic Marine Assessment for Protected Species
Applicant	Revolution Wind LLC
BA	Biological Assessment
BACI	Before-After Control-Impact
BAG	Before-After-Gradient
BBC	Big Bubble Curtain
BIA	biologically important area
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BSEE	Bureau of Safety and Environmental Enforcement (BOEM)
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
cm	centimeters
CMECS	Coastal and Marine Ecological Classification Standard
COP	Construction and operations plan
CPS	Cable Protection System
CTV	crew transport vessel
dB	decibels
DPS	distinct population segment
DoN	U.S. Department of the Navy
EIS	Environmental Impact Statement
EFP	Exempted Fishing Permit
EMF	electromagnetic field
EPM	environmental protection measure
ESA	Endangered Species Act
FR	Federal Register
FRMP	Fisheries Research Monitoring Plan
GARFO	NMFS Greater Atlantic Fisheries Resource Office
ha	hectares
HDD	horizontal directional drill
HSD	Hydro-Sound Damper
HMS	highly migratory species
HRG	high-resolution geophysical

HVAC	high-voltage alternating current
Hz	hertz
IAC	inter-array cable
IPF	Impact Producing Factor
ITR	Incidental Take Regulations
kg	kilograms
kHz	kilohertz
kJ	kilojoule
km	kilometer
km^2	square kilometer
kV	kilovolt
L_{pk}	peak sound pressure level, expressed in dB re 1 µPa
L_{rms}	root-mean-square sound pressure level, expressed in dB re 1 µPa
L_E	sound exposure level, expressed in dB re 1 μPa^2 s
LFC	low-frequency cetacean
LOA	Letter of Authorization
m	meter
MA WEA	Massachusetts Wind Energy Area
MARCO	Mid-Atlantic Regional Council on the Ocean
MEC/UXO	Munitions and Explosives of Concern/Unexploded Ordnance (MEC/UXO)
MFC	mid-frequency cetacean
mG	milligauss
mg/L	milligrams per liter
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MSA	Magnuson-Stevens Fishery Conservation and Management Act
m/s	meters per second
mV/m	milliVolts per meter
MW	megawatt
MWA	maximum work area
NARW	North Atlantic right whale
NCCA	National Coastal Condition Assessment
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
nm	nautical miles
nm^2	square nautical miles
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NYMRC	New York Marine Rescue Center
O&M	operations and maintenance
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OCS	Outer Continental Shelf
OSRP	oil spill response plan

OSS	offshore substation
PAM	Passive Acoustic Monitoring
PATON	public aids to navigation
PBF	physical and biological feature
PDC	project design criteria
PDE	Project Design Envelope
ppm	parts per million
Proposed Action	draft COP for the RWF and RWEC
PSMMP	Protected Species Mitigation and Monitoring Plan
PSO	Protected Species Observer
PTS	permanent threshold shift (resulting in permanent hearing injury)
RARMS	Risk Assessment with Risk Mitigation Strategy
RI/MA WEA	Rhode Island/Massachusetts Wind Energy Area
rms	root-mean-square
RWEC	Revolution Wind Export Cable
RWEC – F	Revolution Wind Export Cable – federal waters
RWEC – RI	Revolution Wind Export Cable – Rhode Island state waters
RWF	Revolution Wind Farm
SAV	submerged aquatic vegetation
SEL	sound exposure level
SESC	Soil Erosion and Sediment Control
SNECVTS	Southern New England Cooperative Ventless Trap Survey
SOV	service operations vessel
SPCC	spill prevention, control, and countermeasures
SPL	sound pressure levels
SPUE	sightings per unit effort
SPCC	spill prevention, control, and countermeasures
SRKW	Southern Resident Killer Whale
STSSN	Sea Turtle Stranding and Salvage Network
TJBs	Transition Joint Bays
TP	Transition Piece
TSS	total suspended solids
TTS	temporary and recoverable loss of hearing sensitivity
UME	Unusual Mortality Event
USACE	U.S. Army Corps of Engineers
USC	United States Code
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UXO	unexploded ordnance
VMS	Vessel Monitoring System
WEA	Wind Energy Area
WTG	wind turbine generator

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1.0 Introduction

The Energy Policy Act of 2005, Public Law No. 109-58, added Section 8(p)(1)(C) to the Outer Continental Shelf Lands Act, which grants the Secretary of the Interior the authority to issue leases, easements, or rights-of-way on the Outer Continental Shelf (OCS) for the purpose of renewable energy development (43 USC. 1337(p)(1)(C)). The Secretary delegated this authority to the former Minerals Management Service (MMS), now the Bureau of Ocean Energy Management (BOEM). On April 22, 2009, BOEM (formerly the Bureau of Ocean Energy Management, Regulation, and Enforcement [BOEMRE]) promulgated final regulations implementing this authority at 30 Code of Federal Regulations (CFR) 585.

This document is a biological assessment (BA) of effects to endangered and threatened species and designated critical habitat listed under the Endangered Species Act (ESA) from the proposed construction and installation, operations and maintenance (O&M), and decommissioning of the Revolution Wind Farm (RWF) and Revolution Wind Export Cable (RWEC) Project (the Project) on the OCS offshore of Rhode Island and Massachusetts. This BA addresses effects to listed species and designated critical habitat under the jurisdiction of the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the ESA. The activities being considered include all proposed federal actions associated with the construction and installation, O&M, and decommissioning of the proposed Project including approving the construction and operations plan (COP) for Revolution Wind. The BA accompanies a request to initiate formal consultation with NMFS.

Revolution Wind, LLC (Revolution Wind or the Applicant), has submitted the July 2022 draft COP for the RWF and RWEC to BOEM for review and approval. Consistent with the requirements of 30 CFR 585.620 to 585.638, COP submittal occurs after BOEM grants a lease for the proposed project and the Applicant completes all studies and surveys defined in their site assessment plan. This BA relies on the most current information available for the Project. The Proposed Action includes two major components, the RWF and the RWEC as summarized below and described in Section 3.

This version of the BA reflects comments received from NMFS on three previous submissions. A draft BA was submitted to NMFS April 25, 2022, and NMFS provided comments in June 2022. A revised BA was submitted to NMFS on August 29, 2022, and NMFS provided another round of comments. In October 2022, the lessee of Revolution Wind informed BOEM and NMFS of its intention to use only 79 of the 100 WTG positions identified in the project design envelope. The lessee determined that 21 of the 100 WTG positions were unsuitable for foundation installation due to geotechnical constraints. On November 1, 2022, BOEM submitted a further revised BA. In a letter dated 11/17/22, NMFS declined to initiate consultation on the BA and requested that BOEM either revise the proposed action or provide additional information on the 21 dismissed WTG positions.

This revision has adjusted the proposed action for the ESA consultation and reflects a reduction of the footprint of the project. The COP describes a RWF of up up to 100 wind turbine generators (WTGs or turbines) with a nameplate capacity of 8 megawatts (MW) to 12 MW per turbine, 2 offshore substations (OSSs) and a submarine transmission cable network connecting the WTGs (inter-array cables [IACs]) to the OSSs. The proposed action for this ESA consultation, by comparison, proposes 79 WTG monopiles instead of 100 WTGs and two OSS monopiles. Because 21 fewer WTGs are proposed, there is also shorter distance of IACs connecting the WTGs to the OSSs that would be constructed. This BA also reflects updated information from the lessee on seabed preparation methodologies. Therefore, for several project activities potential effects to ESA-listed species and habitats from construction and installation, O&M, and decommissioning of the project under the revised proposed action would be similar in magnitude but reduced in extent compared to the proposed action described in previous versions of the BA. The effect determinations have not changed from the previous version of the BA.

2.0 Regulatory Background and Consultation History

BOEM completed an Environmental Assessment and BA on the Issuance of Leases for Wind Resource Data Collection on the Outer Continental Shelf Offshore within the Rhode Island/Massachusetts Wind Energy Area (RI/MA WEA) and the Massachusetts WEA (MA WEA) in 2013 and associated site characterization and site assessment activities that could occur on those leases, including the Lease Area. The RI/MA WEA consists of two lease areas: the north lease area (OCS-A 0486) is approximately 97,500 acres, and the south lease area (OCS-A 0487) is approximately 67,250 acres. The Proposed Action is located entirely within the north lease area (i.e., BOEM's Renewable Energy Lease Number OCS-A 0486, referred to as "Lease Area" in this report), excluding the portion dedicated to the South Fork Wind project.

2.1 Action Agencies and Regulatory Authorities

The lead federal agency for the Project is the Bureau of Ocean Energy Management. BOEM has the authority to regulate activities associated with the production, transportation, or transmission of renewable energy resources on the OCS under the OCS Lands Act (43 United States Code [USC] 1337). Pursuant to this authority, BOEM must ensure that any approval activities are safe, conserve natural resources on the OCS, are undertaken in coordination with relevant federal agencies, provide a fair return to the United States, and are compliant with all applicable laws and regulations.

BOEM issued a Lease to Revolution Wind on October 1, 2013, for development of a renewable energy facility. Revolution Wind has submitted a COP for approval by BOEM that considers the construction and installation, O&M, and decommissioning of the project. Additionally, BOEM has approved a request from Revolution Wind for an easement covering the portion of the RWEC work corridor traversing federal waters.

2.2 Environmental Permits and Regulatory Compliance

Under BOEM's renewable energy regulations, the issuance of leases and subsequent approval of wind energy development on the OCS is a phased decision-making process. BOEM's wind energy program occurs in four distinct phases: 1) Planning and analysis; 2) lease issuance; 3) approval of the applicant's survey and assessment plan for their issued lease area; and 4) review and approval of the COP. Phases 1 through 3 have already been completed for the RWF and RWEC.

The Proposed Action addresses Phase 4 of the renewable energy process. The Applicant has completed site characterization activities and has developed a COP in accordance with BOEM regulations. BOEM is consulting on the proposed approval of the COP for the RWF and RWEC, as well as other permits and approvals from other agencies that are associated with the approval of the COP. BOEM is the lead federal agency for purposes of Section 7 consultation; the other action agencies are the Bureau of Safety and Environmental Enforcement (BSEE), the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency (EPA), the U.S.

Coast Guard (USCG), and the NMFS Office of Protected Resources. The USACE regulates project-related dredging and fill placement required for project construction (i.e., installation of the RWEC) in state waters under Section 404 of the Clean Water Act, and installation of structures in navigable waters of the United States (i.e., installation of the RWEC and RWF) under Section 10 of the Rivers and Harbors Act. In addition, BOEM consults with state agencies to comply with the Coastal Zone Management Act and National Historic Preservation Act. The completion of all regulatory compliance and permitting for the Proposed Action is anticipated by October 6, 2023. A summary of required compliance actions and permits, current status, and anticipated dates of completion is provided in Table 1.1.

The USACE regulates work that is authorized or permitted through Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. Revolution Wind has applied for authorization from the USACE to construct up to 100 offshore WTGs, scour protection around the base of the WTGs, two OSSs, IACs connecting the WTGs to the OSSs, the OSS-link cable connecting the OSSs, and the two RWEC cables. The export cable route would originate from the OSS and connect to the electric grid in North Kingstown, Washington County, Rhode Island. Revolution Wind submitted the pre-construction notification/application to USACE on June 3, 2022, and it was deemed complete on August 18, 2022 (USACE file number NAP-2017-00135-84). BOEM and BSEE will enforce COP conditions and ESA terms and conditions on the OCS.

The “OCS Air Regulations,” presented in 40 CFR 55, establish the applicable air pollution control requirements, including provisions related to permitting, monitoring, reporting, fees, compliance, and enforcement, for facilities subject to Section 328 of the Clean Air Act; the EPA issues OCS air permits. Emissions from Project activities on the OCS would be permitted as part of an OCS air permit and must demonstrate compliance with National Ambient Air Quality Standards (NAAQS). Revolution Wind submitted an initial OCS Air Permit application to EPA on May 1, 2022, and the application was deemed complete on October 5, 2022. EPA issuance of a final permit decision is anticipated for July 31, 2023.

The USCG administers the permits for private aids to navigation (PATONs) located on structures positioned in or near navigable waters of the United States. PATONs and federal aids to navigation, including radar transponders, lights, sound signals, buoys, and lighthouses, are located throughout the Project area. USCG approval of additional PATONs during construction of the WTGs and OSSs, and along the offshore export cable corridor, would be required. These aids serve as a visual reference to support safe maritime navigation. Federal regulations governing PATONs are presented in 33 CFR 66 and address the basic requirements and responsibilities. Revolution Wind plans to request PATON authorization in 2022.

The Marine Mammal Protection Act of 1972 (MMPA) as amended and its implementing regulations (50 CFR 216) allow, upon request, the incidental take of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographic region. Incidental take is defined under the MMPA (50 CFR

216.3) as, “harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal. This includes, without limitation, any of the following: The collection of dead animals, or parts thereof; the restraint or detention of a marine mammal, no matter how temporary; tagging a marine mammal; the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; and feeding or attempting to feed a marine mammal in the wild.”

Revolution Wind submitted an initial request for authorization to take marine mammals incidental to Project construction activities to NMFS on October 21, 2021. NMFS deemed this application complete on February 28, 2022. NMFS’s issuance of an MMPA Incidental Take Authorization is a major federal action and, in relation to BOEM’s action, is considered a connected action (40 CFR 1501.9(e)(1)). The purpose of the NMFS action—which is a direct outcome of Revolution Wind’s request for authorization to take marine mammals incidental to specified activities associated with the Project (e.g., pile driving)—is to evaluate Revolution Wind’s request under requirements of the MMPA (16 USC 1371(a)(5)(D)) and its implementing regulations administered by NMFS and to decide whether to issue the authorization.

Concurrent with this application, Revolution Wind submitted a request for a rulemaking and Letter of Authorization (LOA) pursuant to Section 101(a)(5) of the MMPA and 50 CFR 216 Subpart I to allow for the incidental harassment of marine mammals resulting from the following construction activities: installation of WTGs and OSSs; installation and removal of cofferdams at the export cable sea-to-shore transition point; potential detonations of unexploded ordinance (UXO); and performance of pre- and post-construction high-resolution geophysical (HRG) operating at less than 180 kilohertz (kHz) (LGL 2022a). The MMPA LOA request includes permitted take for Project construction activities that could cause acoustic disturbance to marine mammals pursuant to 50 CFR 216.104. The application was reviewed and considered complete on February 28, 2022. NMFS published a Notice of Receipt in the Federal Register on March 21, 2022. Publication of the proposed Incidental Take Authorization in the Federal Register is currently schedule for November 17, 2022. Final issuance of the Incidental Take Authorization is anticipated on August 1, 2023. In addition to consultation and coordination with state and federal agencies, Executive Order (EO) 13175 commits federal agencies to engage in government-to-government consultation with tribal nations, and Secretarial Order No. 3317 requires U.S. Department of the Interior agencies to develop and participate in meaningful consultation with federally recognized tribal nations where a tribal implication may arise. A June 29, 2018, memorandum outlines BOEM’s current tribal consultation policy (BOEM 2018). This memorandum states that “consultation is a deliberative process that aims to create effective collaboration and informed Federal decision-making” and is in keeping with the spirit and intent of the National Historic Preservation Act (NHPA) and National Environmental Policy Act (NEPA), executive and secretarial orders, and U.S. Department of the Interior policy (BOEM 2018). BOEM implements tribal consultation policies through formal government-to-government consultation, informal dialogue, collaboration, and engagement.

BOEM conducted government-to-government consultations with the Narragansett Indian Tribe, the Mashantucket Pequot Tribal Nation, and the Mohegan Tribe of Indians of Connecticut in an overview of planned offshore wind development projects off southern New England in August 2018. BOEM has consulted with the Mashpee Wampanoag Tribe, Mashantucket Pequot Tribal Nation, and Wampanoag Tribe of Gay Head (Aquinnah), the Delaware Tribe of Indians, and the Delaware Nation on the Proposed Action and continues to consult with these and other tribes on developments in offshore wind. Additional government-to-government consultations are planned for the future.

Table 1.1. Summary and Status of Environmental Regulatory Compliance and Permits Required for the Proposed Action.

Jurisdiction	Agency/Regulatory Authority	Cooperating Agency Status	Permit/Approval/Consultations	Status
Federal	Advisory Council on Historic Preservation	Participating agency	None	Not applicable
Federal	BOEM	Lead federal agency	COP approval	Original COP filed with BOEM on October 30, 2020; COP update provided on April 29, 2021; COP update provided on December 15, 2021; COP update provided on July 21, 2022
Federal	National Park Service	Participating agency	None	Not applicable
Federal	U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service	Cooperating agency	Letter of authorization (LOA) for Incidental Take Regulations (ITR) under MMPA Essential fish habitat (EFH) consultation Endangered Species Act (ESA) consultation	Petition for ITR received and deemed complete on February 28, 2022, and published in the Federal Register on March 28, 2022 Incidental take permit authorization anticipated by August 1, 2023 Initiation of EFH consultation planned by February 8, 2023 ESA consultation – This document, initiation of ESA consultation planned by January 31, 2023
Federal	U.S. Department of Defense, U.S. Army Corps of Engineers	Cooperating agency	Clean Water Act Section 404/Rivers and Harbors Act of 1899 Section 10 Individual Permit	Permit File #: NAE-2020-00707. Pre-construction notification (PCN) filed on June 3, 2022, complete PCN received by USACE on August 18, 2022. Public comment period September 2 to October 17, 2022. Target date for final verification and permit decision, October 5, 2023
Federal	U.S. Department of Defense	Participating agency	None	Not applicable

Jurisdiction	Agency/Regulatory Authority	Cooperating Agency Status	Permit/Approval/Consultations	Status
Federal	U.S. Department of Transportation, Federal Aviation Administration	Participating agency	Obstruction evaluation/airport airspace analysis	Planned
Federal	U.S. Department of Homeland Security, U.S. Coast Guard	Cooperating agency	Private Aids to Navigation Permit	Planned
Federal	U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement	Cooperating agency	None	Not applicable
Federal	U.S. Department of the Navy	Participating agency	None	Not applicable
Federal	U.S. Environmental Protection Agency	Cooperating agency	Outer Continental Shelf Air Permit	Notice of Intent to apply for OCS Air Permit, May 5, 2020 Initial permit application submitted, May 1, 2022 Complete permit application submitted, October 5, 2022 Anticipated issuance of final decision for OCS Air Permit approval, July 31, 2023.
Federal	U.S. Fish and Wildlife Service	Participating agency	ESA consultation	Biological assessment deemed complete by USFWS 11/25/22
Rhode Island	State of Rhode Island Coastal Resources Management Council	Cooperating agency	Coastal Zone Management Act (CZMA) Consistency Certification Category B Assent/Submerged lands license Permit to Alter Freshwater Wetlands in the Vicinity of the Coast Application for Marine Dredging and Associated Activities	Filed on June 7, 2021 Filed on July 1, 2021 Filed on July 1, 2021 Filed on July 1, 2021

Jurisdiction	Agency/Regulatory Authority	Cooperating Agency Status	Permit/Approval/Consultations	Status
Rhode Island	State of Rhode Island Department of Environmental Management	Cooperating agency	Section 401 and State Water Quality Certification/Rhode Island Pollutant Discharge Elimination System Construction General Permit (filed concurrently) Application for Marine Dredging and Associated Activities (see above) Category B Assent and Submerged Lands Lease Permit to Alter Freshwater Wetlands in the Vicinity of the Coast	Filed on August 3, 2021
Massachusetts	Commonwealth of Massachusetts Office of Coastal Zone Management	Cooperating agency	CZMA Consistency Certification	Filed on June 7, 2021
Massachusetts	Connecticut State Historic Preservation Office, Connecticut Department of Economic and Community Development	Not applicable	National Historic Preservation Act (NHPA) Section 106 consultation	Consultation initiated with SHPO, April 30, 2021 Planned completion by June 6, 2023
Rhode Island	Rhode Island Historical Preservation & Heritage Commission	Not applicable	NHPA Section 106 consultation	Consultation initiated with SHPO, April 30, 2021 Planned completion by June 6, 2023
New York	New York State Division for Historic Preservation	Not applicable	NHPA Section 106 consultation	Consultation initiated with SHPO, April 30, 2021 Planned completion by June 6, 2023
Massachusetts	Massachusetts Historical Commission	Not applicable	NHPA Section 106 consultation	Consultation initiated with SHPO, April 30, 2021 Planned completion by June 6, 2023

3.0 Proposed Action

The proposed action is the construction and installation, O&M, and decommissioning of an offshore wind energy facility on the Atlantic OCS in the RI/MA WEA. Regarding decommissioning, BOEM would require Revolution Wind to develop a decommissioning plan for agency approval prior to the end of project life. That federal action would be subject to independent environmental and regulatory review, considering the environmental baseline conditions and ESA-listed species status present at that time. As such, the decommissioning analysis presented herein is preliminary and based on the information currently available.

The proposed action includes two major components, the RWF and the RWEC. The RWF includes up to 79 WTGs[1]with a nameplate capacity of 8 MW to 12 MW per turbine, two OSSs and a submarine transmission cable network connecting the WTGs (IACs) to the OSS, all of which will be located in the Lease Area (i.e., BOEM Renewable Energy Lease Area OCS-A 0486), located within the RI/MA WEA. The Lease Area is located in federal waters of the OCS, with the closest edge of the Lease Area approximately 15 miles (24.1 kilometers [km], 13 nautical miles [nm]) southeast of Rhode Island. The proposed location of the RWF and the RWEC installation corridor are shown in Figure 3.1. The RWF also includes use of an existing O&M facility that will be located onshore at a commercial port facility. Currently, Revolution Wind is considering the Port of Montauk at Montauk in East Hampton, New York or Port of Davisville-Quonset Point in North Kingston, Rhode Island as the O&M facility sites, with the former potentially serving as a central O&M hub for multiple offshore wind energy facilities. Additionally, a new Onshore Substation (OnSS) Interconnection Facility (ICF) and associated interconnection circuits located adjacent and connecting to the existing Davisville Substation in North Kingstown, Rhode Island has been identified by Revolution Wind. No specific port improvements are included in the Proposed Action.

The RWEC is a HVAC electric cable that will connect the RWF to the electric grid in North Kingstown, Rhode Island. The RWEC includes both offshore and onshore segments. Offshore, the RWEC is located in federal waters (RWEC – OCS) and Rhode Island State territorial waters (RWEC – RI) and will be buried to a target depth of 4 to 6 feet below the sea floor.

These components are differentiated in the project description and effects analysis where appropriate to clarify the potential impacts of the action on ESA-listed species.

3.1 Description of Proposed Action

Revolution Wind has elected to use a Project Design Envelope (PDE) approach for describing the Proposed Action consistent with BOEM policy. For the ESA consultation analysis, BOEM

1 In October 2022, the lessee of Revolution Wind informed BOEM and NMFS of its intention to use only 79 of the 100 WTG positions identified in the project design envelope in the COP. The lessee cited engineering and technical challenges which led to the dismissal of 21 of the 100 WTG positions.

assumes that Revolution Wind would select the design alternative resulting in the greatest potential impact on the environment. For example, Revolution Wind has indicated they would install up to 79 WTGs between 8 MW and 12 MW as well as two OSSs. BOEM is therefore considering the effects of installing 79 12 MW WTGs and two OSSs for this ESA consultation because that design alternative would result in the most extensive potential effects on listed species and the environment.

The RWEC is a HVAC electric cable that will connect the RWF to the mainland electric grid in Rhode Island. The RWEC includes both offshore and onshore components and a sea-to-shore transition point. The offshore component, referred to hereafter as the RWEC-OCS, is located in federal waters on the outer continental shelf and extends from the RWF to Rhode Island territorial waters boundary. The RWEC-RI component extends from this boundary to the sea-to-shore transition point. The two RWEC circuits will total 83.3 miles in length (23 and 18.6 miles for each RWEC-OCS and RWEC-RI segment per circuit, respectively).

The onshore underground segment of the export cable (RWEC–Onshore) will be located in North Kingston, Rhode Island. The RWEC–RI will be connected to the RWEC–Onshore via a sea-to-shore transition where the offshore and onshore cables will be spliced together. The RWEC includes an onshore substation and new Interconnection Facility to link the RWEC to The Narragansett Electric Company d/b/a National Grid Davisville Substation. The Interconnection Facility will be in the town of North Kingston, Rhode Island. The construction and O&M of the onshore segments of the RWEC and the onshore substation would have no measurable effects on marine or nearshore habitats and are not considered further in this BA.

The RWF would use an existing onshore O&M facility, composed of office space for the operations center, warehouse and shop space for tools and replacement equipment, and a berthing area for crew transport vessels (CTVs). The O&M facility would be located on an existing commercial marina property located in either Port of Montauk on Long Island, NY or at Port of Davisville—Quonset Point in Rhode Island. Both areas are currently developed and would require no in-water construction and installation elements. O&M facility development would therefore have no effect on ESA-listed species or critical habitat and is not considered further in this consultation.

PDE parameters for the RWF and RWEC construction and installation activities are summarized in Table 3.1. RWF and RWEC O&M activities are summarized in Table 3.2. A combination of methods will be used to install the RWEC and the RWF inter-array and OSS-link cables. These comprise a range of seabed preparation activities, specifically boulder and debris clearance, and cable installation methods, specifically jet and/or mechanical plow installation and targeted dredging. Project construction and installation, O&M, and decommissioning methods, and proposed environmental protection measures (EPMs), are described in the following sections. The proposed location of RWF WTG and OSS foundations, and the indicative location of the OSS-link and IAC cable segments are shown in Figure 3.2. Several U.S. Atlantic coastal ports are under consideration to support aspects of project construction and installation. These ports are identified in Figure 3.3. No port improvements are being considered as part of the proposed action.

Table 3.1. Summary of RWF and RWEC Construction and Installation by Design Alternative.

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Design Alternative	Effect
RWF construction and installation	Turbine selection/spacing	Installation disturbance area	WTG size	8 MW - 12 MW	--
			Number of turbines	8 MW - 12 MW	79
			Rotor height above mean sea level	8 MW	646 feet (197 meters) at peak 94 feet (29 meters) minimum
				12 MW	873 feet (266 meters) at peak 151 feet (46 meters) minimum
			Spacing	8 MW - 12 MW	1.15 linear miles (1.85 km, 1 nautical mile [nm]) – may vary up to 500 feet with micrositing
	Monopile foundation installation	Habitat alteration, physical disturbance	Number of monopiles	79 39-foot (12-meter monopile) Two 15-meter OSS monopiles	59.0 acres (23.9 hectares), occupied by foundations and scour protection, additional 5.7 acres occupied by cable protection systems (0.07 acres per foundation)
			Foundation construction footprint	79 WTGs 2 OSSs	Total for 81 monopiles: Seabed preparation - 583 acres (236 hectares) Vessel anchoring (overlaps seabed prep) - 2,496 acres (1,010 hectares)
			Installation method	12-meter WTG monopiles 15-meter OSS monopiles	WTG 4,000 kilojoules (kJ) impact hammer 10,740 strikes/pile 220 minutes/pile installing 3 piles/day OSS 4,000 kilojoules (kJ) impact hammer 11,563 strikes/pile 380 minutes/pile over 1-2 days total
	Vessel Traffic	Noise	Number of vessels	All	61
			Vessel source level[1]	All	150–180 dB re 1 μPa-m
	Inter-array cable (IAC) construction and installation	Physical disturbance, turbidity, entrainment	Total corridor length	All	116.1 linear miles (187 km/ 101 nm)
			Installation method	All	Cable trenching/burial (jet plow) 4- to 6-feet (1.2- to 1.8-meter) depth
			Short-term disturbance	All	1,694 acres (686 hectares
			Long-term habitat conversion (exposed cable protection)	All	55.5 acres (22.5 hectares)
			Total suspended sediments (TSSs)	All	>100 mg/L above background
			Area exposed to sediment deposition ≥ 10 mm	All	204 acres (83 hectares)
	OSS-link cable construction and installation	Physical disturbance, turbidity, entrainment	Total corridor length	All	9.3 miles
			Installation method		Cable trenching/burial (jet plow), 4- to 6-feet (1.2- to 1.8-meter) depth. Approximately 40 pull-ahead anchoring events required for installation, totaling 1.4 acres (0.6 hectare) of impacts.
			Short-term disturbance		110 acres (45 hectares)
			Permanent habitat conversion (exposed cable protection)		4.4 acres (1.8 hectares)
			Total suspended sediments (TSSs)		>100 mg/L above background
			Area exposed to sediment deposition ≥ 10 mm		8.6 acres (3.5 hectares)

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Design Alternative	Effect
RWF operation		Operational electromagnetic field (EMF) (IAC)	Transmission voltage	8 MW	72 kilovolts (kV) IAC
				12 MW	72 kV IAC
				OSS Link	275 kV OSS Link
			Magnetic field**	All	Buried cable at depth of 3.3 feet (1 meter), 57 mG at seabed, 17 mG 3.3 feet (1 meter) above seabed Surface-laid cable, 522 mG at seabed, 35 mG 3.3 feet (1 meter) above seabed
			Induced electrical field**	All	Buried cable at depth of 3.3 feet (1 meter), 2.1 mV/m at seabed, 1.3 mV/m 3.3 feet (1 meter) above seabed Surface-laid cable, 5.4 mV/m at seabed, 1.7 mV/m 3.3 feet (1 meter) above seabed
RWEC	Export cable construction and installation	Construction and installation disturbance area	Total corridor length	All	88 linear miles (142 km, 76 nm) combined total, 48 and 40 linear miles (77 and 64 km, 43 and 34 nm) respectively
			Installation method	All	Cable trenching/burial, 4- to 6-foot (1.2- to 1.8-meter) target depth along approximately 21 combined miles of RWEC route. Approximately 190 pull ahead anchoring events required for RWEC installation, totaling 11.6 acres (4.7 hectares) of seabed impacts.
			Short-term disturbance area	All	RWEC-OCS 535 acres (217 hectares) RWEC-RI 592 acres (240 hectares)
			TSS	All	Maximum concentration >500mg/L, concentrations exceeding 100 mg/L up to 19 hours following disturbance
			Area exposed to sediment deposition ≥ 10 mm	All	3,186 acres (1,289 hectares)
			Activity duration		8 months
			Long-term habitat conversion (secondary cable protection)	All	60.6 acres (24.5 hectares)
		Vessel traffic	Number of vessels	All	18
			Vessel source levels[1]	All	150-180 dB re 1 μPa
	Sea-to-shore transition construction and installation	Cofferdam/gravity cell construction and installation/removal+	Cofferdam/Gravity Cell footprint	All	0.084 acres (0.034 hectare) total, 0.042 acre (0.017 hectare)/cofferdam
			Sheetpile size	All	Z-Type typical
			Piles per day	All	4-6
			Total pile driving days (including removal)	All	56
			Construction and installation duration	All	12 weeks
	Sea-to-shore transition Construction and installation	No Containment	Dredged HDD exit pit	All	0.042 acre (0.017 hectare)
			Underwater noise (suction dredging)	All	172-192 dB re 1 μPa-m
			Construction and installation duration	All	12 weeks
	Operations	Operational EMF	Transmission voltage	12 MW	275 kV
			Induced magnetic field**	All	Buried cable at depth of 3.3 feet (1 meter), 147 mG at seabed, 41 mG 3.3 feet (1 meter) above seabed Surface-laid cable, 1,071 mG at seabed, 91 mG 3.3 feet (1 meter) above seabed

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Design Alternative	Effect
			Induced electrical field**	All	Buried cable at depth of 3.3 feet (1 meter), 4.4 mV/m at seabed, 2.3 mV/m 3.3 feet (1 meter) above seabed Surface-laid cable, 13 mV/m at seabed, 3.5 mV/m 3.3 feet (1 meter) above seabed

Notes:

dB = decibels, EMF = Electromagnetic field, kJ = Kilojoules, mG = Milligauss, mV/m = Millivolts per meter, TSS = Total suspended solids

† Estimated total for general construction vessel anchoring impacts within a 656-foot (200-meter) radius around each foundation comprising approximately 31.1 acres/foundation. These impacts overlap jackup vessel (21.1 acres), seabed preparation (731 acres), and foundation, scour, and cable protection system installation impacts (80 acres).

+A temporary casing pipe or no containment are also being considered. The temporary cofferdam would have the greatest extent of impact, and thus is considered here

‡ Total comprises 72.8 acres of foundation and scour protection, and 7.1 acres of cable protection system impact extending beyond the scour protection footprint.

*Magnetic field and electrical field values assume measurement at the seabed.

**EMF associated cables were modeled assuming a burial depth of 3.3 feet. Target burial depth will be 4-6 feet.

[1] Source: Denes et al. 2021, Kusel 2022

Table 3.2. Summary of RWF and RWEC O&M Activities.

Project Component	Effect Mechanism	Measurement Parameter	Design Alternative	Effect
RWF O&M	Operational electromagnetic field (EMF) (IAC)	Transmission voltage	8 MW	72 kilovolts (kV) IAC
			12 MW	72 kV IAC
			OSS Link	275 kV OSS Link
		Magnetic field*	All	Buried cable at depth of 3.3 feet (1 m), 57 milligauss (mG) at sea floor, 17 mG 3.3 feet (1 m) above sea floor Surface-laid cable, 522 mG at sea floor, 35 mG 3.3 feet (1 m) above sea floor
		Induced electrical field*	All	Buried cable at depth of 3.3 feet (1 m), 2.1 milliVolts per meter (mV/m) at sea floor, 1.3 mV/m 3.3 feet (1 m) above sea floor Surface-laid cable, 5.4 mV/m at sea floor, 1.7 mV/m 3.3 feet (1 m) above sea floor
RWEC O&M	Operational EMF	Transmission voltage	12 MW	275 kV
	Operational EMF	Induced magnetic field*	All	Buried cable at depth of 3.3 feet (1 m), 147 mG at sea floor, 41 mG 3.3 feet (1 m) above sea floor Surface-laid cable, 1,071 mG at sea floor, 91 mG 3.3 feet (1 m) above sea floor
		Induced electrical field*	All	Buried cable at depth of 3.3 feet (1 m), 4.4 mV/m at sea floor, 2.3 mV/m 3.3 feet (1 m) above sea floor Surface-laid cable, 13 mV/m at sea floor, 3.5 mV/m 3.3 feet (1 m) above sea floor

*EMF associated with the RWEC and IAC was calculated assuming 3.3 feet (1 m) burial depth. Both the RWEC and IAC would have a target burial depth of 4-6 feet (1.2-1.8 m).

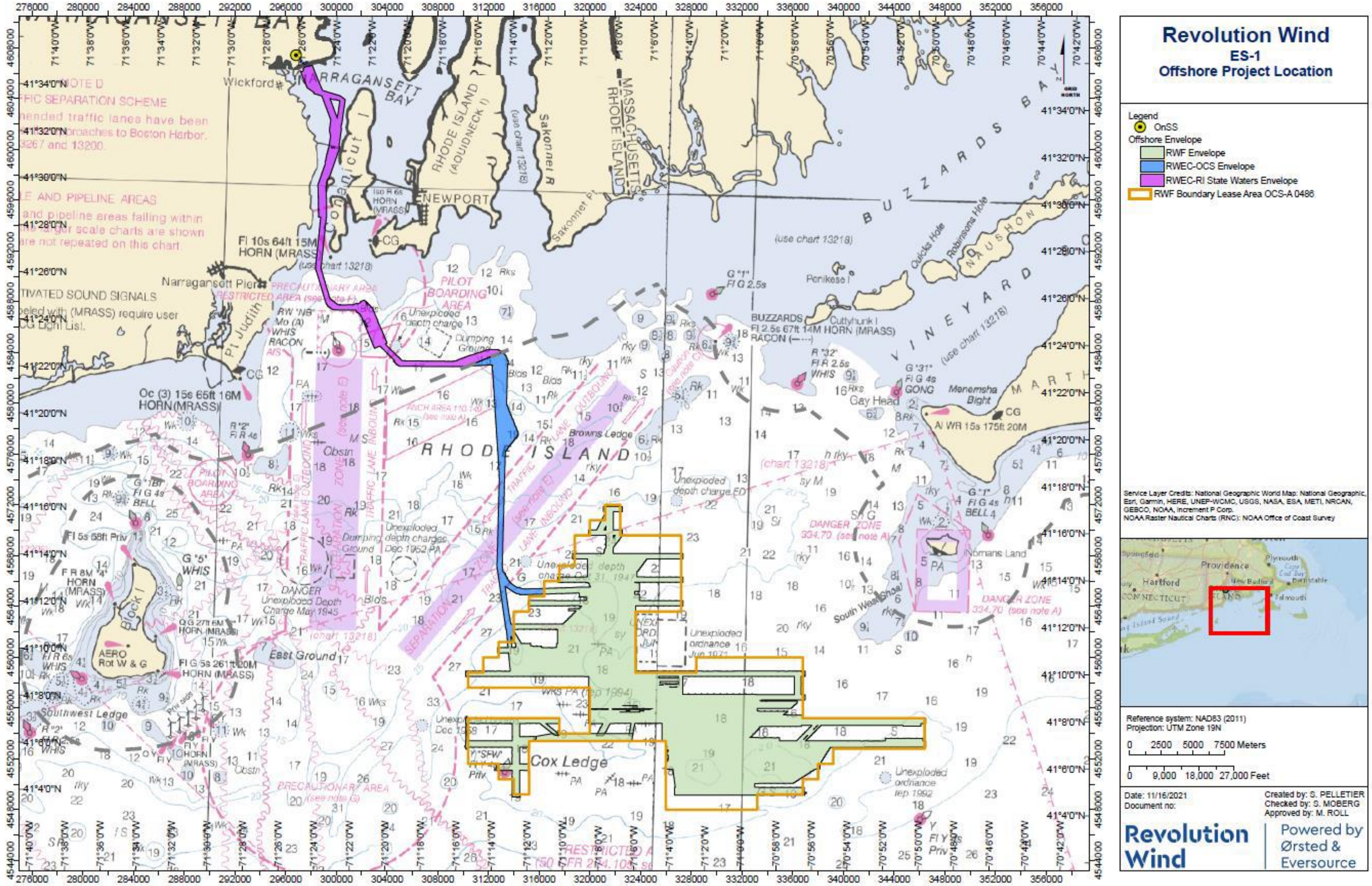

Figure 3.1. RWF and RWEC Lease Area and Vicinity (source: vhb 2022).

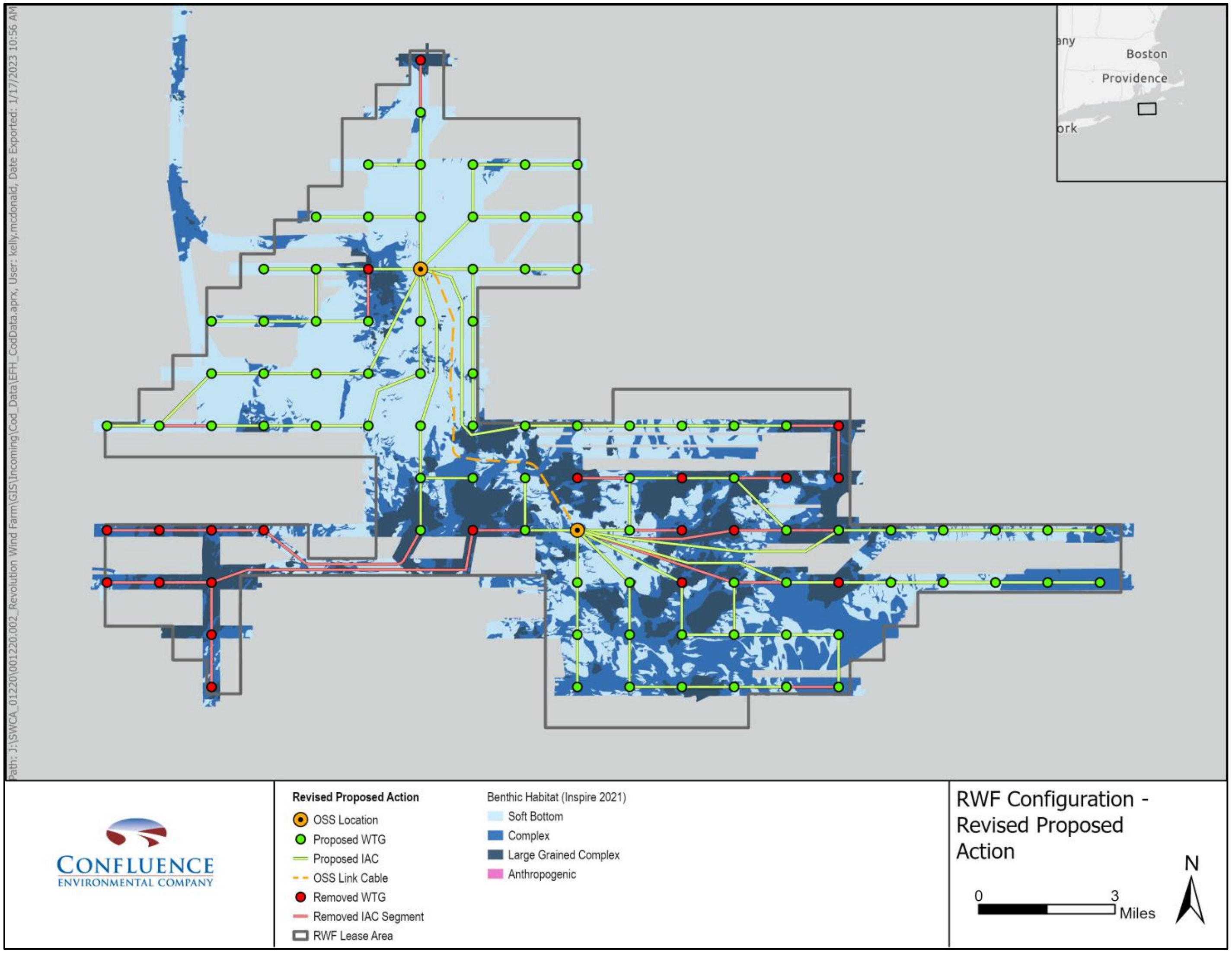

Figure 3.2. RWF Configuration Reflecting the Removal of 21 WTG Positions.

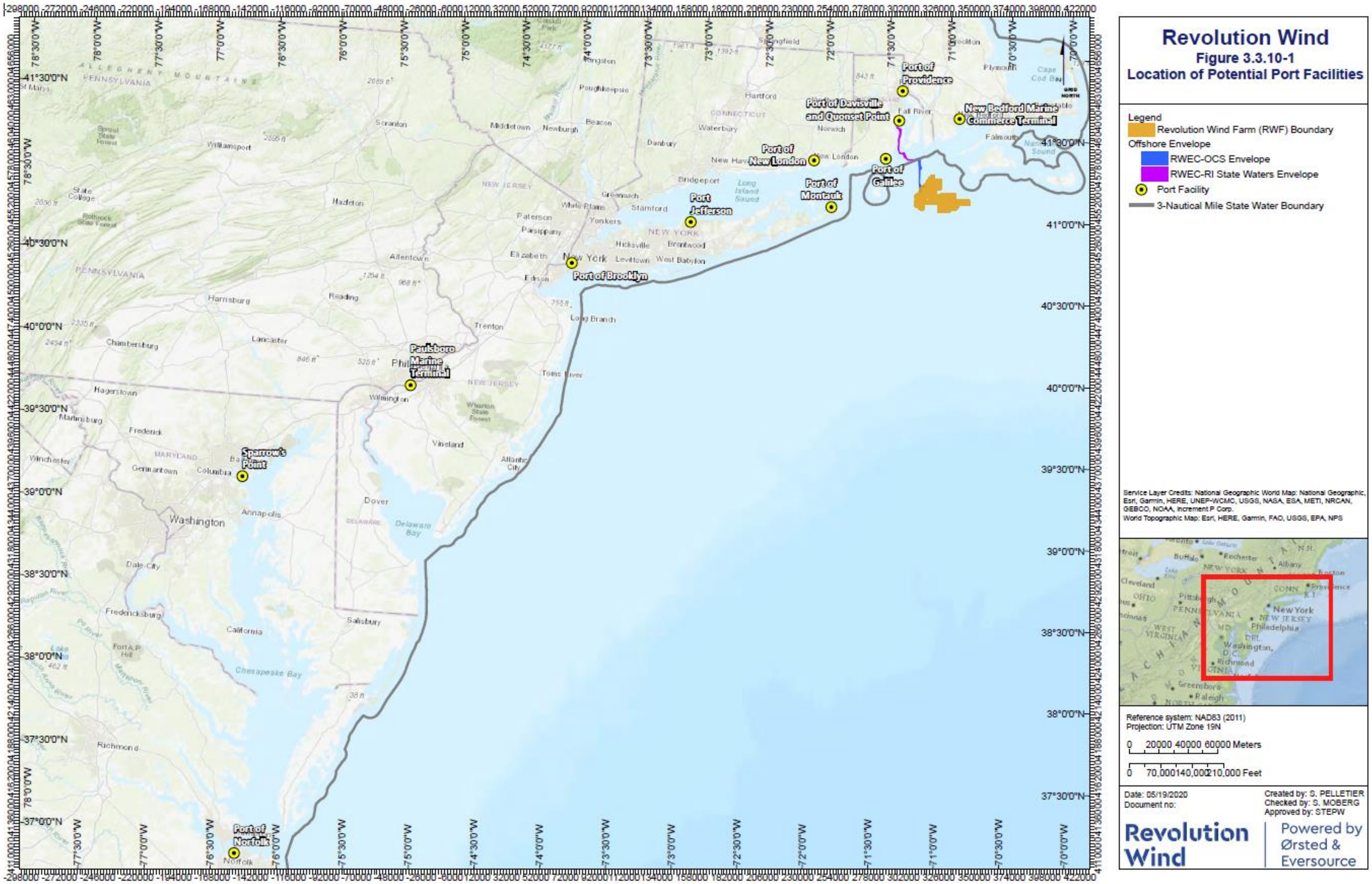

Figure 3.3. U.S. Port Facilities Under Consideration for Project Construction and Installation and O&M Support (the Port of Norfolk, Sparrow's Point, and Paulsboro Marine Terminal were removed from consideration in October 2022 [Revolution Wind 2022a]).

3.1.1 Indicative Project Schedule

Construction and installation of the RWF would begin as early as 2023 with the installation of the onshore components and initiation of sea floor preparation activities. Construction and installation of offshore components of the RWF would occur between 2023 and 2024. During this period, construction and installation would continue 24 hours a day as weather and other conditions allow to minimize the overall timeline to complete construction and installation of the project and the associated period of potential impact from construction and installation on marine species. The timing and duration of specific activities may be modified by voluntary impact avoidance measures, seasonal restrictions, and other measures used to avoid and minimize impacts on sensitive species and the environment. EPMs proposed by Revolution Wind include implementing seasonal restrictions, "soft-start" measures, shut-down procedures, and marine mammal and sea turtle monitoring protocols to halt pile driving and other intense noise producing activities when protected species are present (see Section 3.5).

The total number of construction and installation days for each project component would depend on several factors, including environmental conditions, planning, construction and installation logistics. The general construction and installation schedule is provided in Table 3.3 and summarized in Figure 3.4. This schedule is an estimate, based on several assumptions, including the estimated timeframe in which permits are received, anticipated regulatory seasonal restrictions, environmental conditions, planning, and logistics. Revolution Wind has also identified an indicative schedule for maintenance and inspection survey activities during project O&M, which is summarized in Table 3.4.

Table 3.3. Anticipated Installation Schedule for Revolution Wind Farm and Revolution Wind Export Cable Containing Activities Addressed in the Application.

Proposed Action Element	Construction and Installation Milestone	Activity Duration	Activity Frequency	Anticipated Timeframe
RWF	Monopile foundation installation	5 months	Limited primarily to daylight hours, with specific exceptions as indicated	2023
RWF	Inter-array and OSS-link cable installation	5 months	24-hours/day	2023
RWF	WTG installation	8 months	24-hours/day	2023
RWF	OSS installation	8 months	24-hours/day	2023
RWF and RWEC	HRG Surveys	12 months	24-hours/day	2023
RWEC	Onshore interconnection facility	18 months	24-hours/day	2023-2024
RWEC	Sea-to-shore transition	12 months	24-hours/day	2023-2024
RWEC	Offshore cable installation	8 months	24-yhours/day	2023
RWEC	Onshore cable installation	12 months	24-hours/day	2023-2024
RWEC	HRG Surveys	12 months	24-hours/day	2023

Table 3.4. Routine Maintenance Activity Schedule for Revolution Wind Farm and Revolution Export Cable.

Proposed Action Element	Maintenance/Survey Activity	Indicative Frequency
OSSs	Routine service of electrical components (each OSS)	20 per year
OSSs	Electrical inspections (each OSS)	2 per year
OSSs	Scheduled maintenance (each OSS)	Annual
OSSs	Minor corrective and preventative equipment maintenance (each OSS)	5 per year
OSSs	Major corrective and preventative equipment maintenance (each OSS)	2 per lifetime
RWEC, IAC and OSS-link cable	HRG survey of sea floor (i.e., bathymetry, cable burial depth, cable protection)	Four planned inspection events on the following approximate schedule: 1) Immediately following installation 2) 1 year after commissioning 3) 2 to 3 years after commissioning 4) 5 to 8 years after commissioning
WTG and OSS foundations	Above water inspection and maintenance (Visual inspections for deterioration of coating system, inspection of corrosion, damage within the splash zone, reading of meters, inspection of alarm logs, etc.)	Annually
WTG and OSS foundations	Sea floor survey (Video inspections to identify changes in bathymetry, evidence of scour, etc.)	Approximate schedule: 1) 1 year after commissioning 2) 2 to 3 years after commissioning 3) 5 to 8 years after commissioning 4) Additional surveys as needed depending on findings of above
WTG and OSS foundations	Subsea inspections (Diver and video surveys to detect, measure and record deterioration that affects structural integrity, including inspection of corrosion, minor maintenance activities that can be performed without outage/ reduced power production)	Every 3 to 5 years or as needed based on identified risk
WTG and OSS foundations	Major maintenance – above water line	Every 8 years
WTG and OSS foundations	Corrective maintenance – above water line (Coating repair, inspection of corrosion and maintenance, maintenance activities that can be performed without outage/reduced power production)	As needed
WTGs	Routine service and safety surveys	Annual
WTGs	Oil and lubrication system maintenance	Annual
WTGs	Visual blade inspections	Annual
WTGs	Electrical/mechanical fault rectification	As needed
WTGs	Major component replacement	As needed
WTGs	End of warranty inspections	End of warranty period (manufacturer-dependent)

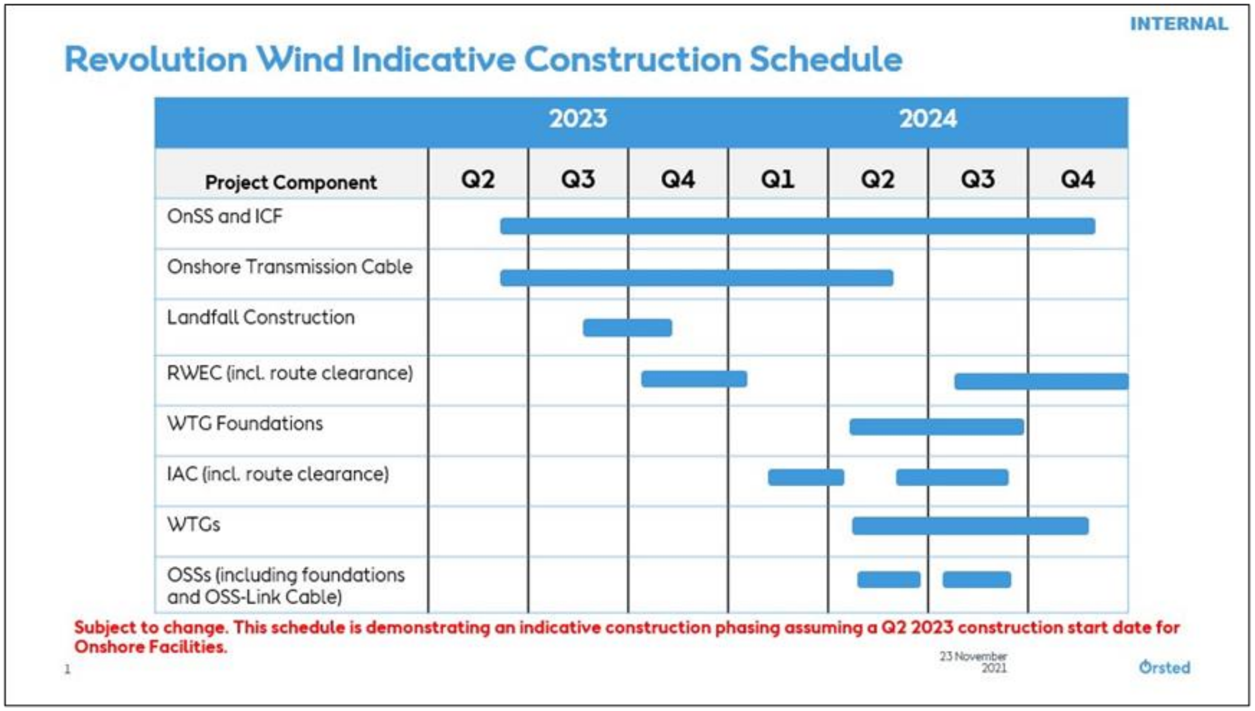

Figure 3.4. Revolution Wind Farm Indicative Construction Schedule.

3.2 Action Area

The ESA defines the action area as "all areas to be affected by the federal action and not merely the immediate area involved in the action" (50 CFR 402.02). The Proposed Action comprises all activities associated with the construction and installation, O&M, and decommissioning of the RWF and RWEC and the transport of construction vessels, materials, and equipment from specified ports in Rhode Island and New York identified for project O&M. The action area also includes vessel transit routes from additional port facilities in Massachusetts, Rhode Island, Connecticut, and New York that may be used for offshore construction support, component assembly and fabrication, crew transfers, surveys and monitoring, and logistics (vhb 2022; Revolution Wind 2022a). If needed, construction vessels may also originate and/or transport project components and equipment directly to the Lease Area from other unspecified ports on the U.S. Atlantic coast, the Gulf of Mexico, Europe, or other worldwide ports. Potential Project vessel transit activities originating from ports in the Gulf of Mexico are discussed in Appendix B.

In summary, the action area comprises several distinct components, including components that are explicitly defined in the COP or supporting information provided by Revolution Wind and components that may be required but are not fully defined (e.g., vessel transits to/from distant ports). These components and their consideration in this BA are described below.

3.2.1 Upland Component of the Action Area

The upland component of the action area comprises the following project elements:

- The geographic extent of effects to upland habitats from the construction and installation and O&M of the upland segments of the RWEC, RWEC sea-to-shore transition vaults, and the onshore substation and grid interconnection facility in North Kingston, Rhode Island; and,
- The geographic extent of effects to upland habitats from construction and installation and O&M footprint of O&M facilities developed at the Port of Davisville-Quonset Point, Rhode Island.

The upland segments of the RWEC and onshore substation and associated construction and installation and O&M impacts are confined entirely to the terrestrial environment and would have no measurable effect on freshwater or marine habitats. The ESA-listed species under NMFS jurisdiction that occur in proximity to this component of the action area are entirely aquatic. Therefore, project effects on the upland component of the action area are not considered further in this BA.

3.2.2 Marine Component of Action Area

The marine component of the action area comprises the following project elements:

- The geographic extent of effects from the construction and installation and O&M of the RWF;

- The geographic extent of effects from the construction and installation and O&M of the RWEC; and,

- Construction and installation and O&M vessel activity within or directly associated with the RWF and RWEC, including foundation and cable installation, HRG surveys, and construction survey and monitoring vessel activity.

The marine component of the action area comprises the RWF Lease Area, the RWEC installation corridor, and water column and benthic habitats affected by project construction and installation and O&M impacts. These habitats include the areas affected by construction-related underwater noise from foundation installation and UXO detonation, vessel activity as described above, sea floor disturbance and habitat alteration, construction-related suspended sediment and water quality impacts, operational electromagnetic field (EMF) effects, operational underwater noise, and reef and hydrodynamic effects. The evaluation of impacts includes effects to listed species and designated critical habitat resulting from these project elements in this component of the action area. The RWF, approved RWEC work corridor, and vicinity are shown in Figures 3.1 and 3.2. Figure 3.2 also displays the proposed distribution of WTG and OSS foundations and the indicative configuration of the IAC and OSS-link cable.

Underwater noise from impact pile driving used for RWF foundation installation, vibratory pile driving used for RWEC sea-to-shore transition construction, and potential UXO detonation within the RWF and along the RWEC installation corridor are the most geographically extensive effects associated with this component of the action area. The affected area is defined by the largest distance required to attenuate construction and installation noise below established behavioral effects thresholds for ESA-listed species that occur in the vicinity of this component of the action area. The maximum extent of underwater noise impacts from RWF construction comprises the area within an approximate 6-mile (10-km) radius of each RWF monopile foundation. This estimate assumes the use of sound attenuation technologies capable of achieving a 10 decibel (dB) reduction in source sound intensity (see Tables 3. Within Narragansett Bay, vibratory pile driving noise generated during sea-to-shore transition construction would exceed behavioral effects thresholds up to approximately 42,650 feet (8.1 miles) from the source, limited by the geographic confines of this enclosed embayment. And an irregular area bounded by the shoreline of Narragansett Bay within an underwater line of site of the RWEC sea-to-shore transition location.

The exact number, size, and location of UXOs that require detonation in place is not currently known. Revolution Wind has conservatively estimated up to 16 1,000-pound (454-kilograms [kg]) devices may be encountered that require detonation in place. However, the lessee intends to work around the UXO and avoid detonation if possible. Underwater noise exceeding behavioral effects thresholds for one or more ESA-listed species could extend in an irregular radius up to 8.4 miles from each detonation site. This estimate assumes the use of sound attenuation technologies capable of achieving a 10-dB reduction in source sound intensity.

All other impacts comprising this component of the action area are contained within the area defined by construction-related underwater noise impacts.

3.2.3 Vessel Traffic Component of the Action Area

The vessel traffic component of the action area comprises the following project elements:

- Construction and installation vessel transit routes between the RWF and RWEC and identified ports on the U.S. Atlantic coast
- Potential construction and installation vessel transit routes between the RWF and/or RWEC and yet to be identified ports in the U.S. Gulf of Mexico (Appendix B)
- Potential construction and installation vessel transit routes between the RWF and/or RWEC and yet to be identified European or worldwide ports

The vessel traffic component of the action area is defined by the geographic extent of underwater noise effects above established behavioral effects thresholds from vessel engines and HRG surveys. This area encompasses other effects associated with vessel activity, specifically risk of injury and mortality from vessel strike, and other effects associated with vessel presence, including visual disturbance, lighting effects, and anchoring disturbance. Excepting vessel related effects occurring on traffic routes between distant ports and the RWF and RWEC corridor, all of these effects are contained within the marine component of the action area.

Revolution Wind has identified existing port facilities located in Massachusetts, Rhode Island, Connecticut, and New York that would be used to support offshore construction, assembly and fabrication, crew transfers, surveys and monitoring, O&M, and logistics (vhb 2022; Revolution Wind 2022a). These ports are shown in Figure 3.3. Vessel transit routes between these ports are included in the marine component of the action area. Revolution Wind has estimated the anticipated number of vessel trips by vessel class to regional ports during project construction, and the anticipated number of annual vessel trips to designated ports during project O&M. In response to a request from BOEM for more specific information about ports planned for construction support, Revolution Wind (2022a) removed the Port of Norfolk, Sparrow's Point, and Paulsboro Marine Terminal from consideration in October 2022. Vessel transit routes to these ports have therefore been removed from the action area. In addition, vessels transporting certain components or equipment that may travel to the Lease Area could originate from the Gulf of Mexico, Europe, or elsewhere in the world.

Vessel transit corridors between the RWF and distant ports are reasonably certain to occur and comprise the most geographically extensive component of the action area. This component is distinct and considered separately from the activities comprising the marine component of the action area, specifically RWF and RWEC construction and O&M. Vessel transit routes to identified ports that are likely to be used during project construction can be defined with reasonable certainty. Similarly, while potential ports in the Gulf of Mexico are not currently known, probable ports and vessel transit routes can also be inferred with reasonable certainty (Appendix B). The potential effects of vessel transit routes on the environment and the methods used to define the physical extent of these effects are described in Section 5. In contrast, the likelihood of construction vessels traveling from European or other worldwide ports are not currently known. Therefore, potential vessel transit routes cannot be defined with reasonable certainty outside of U.S. federal waters. Therefore, the effects analysis is restricted to potential transit routes within U.S. federal waters.

No upgrades or modifications to any existing port facilities are proposed as part of the Proposed Action. Future upgrades or modifications to regional ports supporting the development of the U.S. offshore wind industry and other maritime industries in general may occur, but any such improvements would be separate actions that are not interrelated or interdependent to the proposed action.

3.3 Activities Considered

Activities considered were categorized by action area component and project phase (i.e., construction and installation, O&M, or decommissioning).

As stated in Section 3.2.1, the ESA-listed species and designated critical habitat considered in this BA do not occur in the upland component of the action area, and the impacts associated with this component of the action area would have no measurable effect on freshwater or marine habitats. Therefore, project effects on the upland component of the action area are not considered further in this BA.

The activities considered in this BA are those associated with the effects that comprise the marine and vessel traffic components of the action area, as described in Sections 3.2.2 and 3.2.3, respectively.

3.3.1 Foundation Types

Construction and Installation

For the RWF, several types of foundation types were considered and evaluated for both the WTGs and the OSS foundations. In the end, 39-foot (12-m) monopiles were selected for the 79 WTGs and 49-foot (15-m) monopiles were selected for the two OSS.

Prior to conducting sea floor preparations, for confirmed munitions of concern/unexploded ordinances (MEC/UXO) where avoidance is not possible, in-situ disposal will be done with low-order (deflagration), high-order (detonation) methods, cutting the MEC/UXO to extract the explosive components, or through relocation (“lift and shift”) (vhb 2022). The “lift and shift” operations would relocate MEC/UXO to another suitable location on the sea floor within the marine component of the action area or previously designated disposal areas for either wet storage or disposal through low- or high-order methods. Due to the substantial pre-construction surveys that have been and will continue to be undertaken to locate and remedy confirmed MEC/UXO, during construction and installation the likelihood of an unanticipated MEC/UXO encounter is very low (vhb 2022).

The exact number, size, and location of UXOs present in the Lease Area and RWEC corridor are not currently known. Avoidance of UXOs is the preferred mitigation methodology in adherence with the as low as reasonably practicable (ALARP) process. For the purpose of this BA, Revolution Wind has conservatively estimated that up to 16 1,000-pound (454 kg) devices may be encountered during project construction that require detonation in place. In-situ detonation activities would take place between May 1 and November 30 to align with protective work timing restrictions for ESA-listed marine mammals (see Tables 3.16 and 3.17). UXO detonations would be limited to one device per day, meaning that detonation impacts would be dispersed across the marine component of the action area over 16 separate days. UXO detonation sound attenuation technologies capable of achieving a 10-dB reduction in source sound intensity. Further information related to surveys for MEC/UXO, as well as the assessment of risk and risk mitigation strategy, is discussed in Section 3.3.4, below.

Prior to placement of the monopile foundations and scour protection, sea floor preparation would be conducted to identify and remove anthropogenic debris and clear large boulders to ensure the foundation site is suitable for installation. Revolution Wind (vhb 2022) estimates that sea floor preparation may be required around each WTG and OSS foundation, affecting approximately 7.2 acres around each monopile, for a total of 731 acres (296 ha).

The following two techniques may be used to relocate/remove surface or partially embedded boulders and debris during installation of the RWEC (vhb 2022).

- Boulder Grab: A grab is lowered to sea floor, over the targeted boulder. Once “grabbed”, the boulder is relocated away from the RWEC route.

- Boulder Plow: Boulder clearance is completed by a high-bollard pull vessel, with a towed plow generally forming an extended V-shaped configuration, splaying from the rear of the main chassis. The V-shaped configuration displaces any boulders to the extremities of the plow, thus establishing a clear corridor. Multiple passes may be required.

Foundations would be installed following completion of these operations. Foundations would be driven to target embedment depths using impact pile driving. The maximum impact hammer energies would be 4,000 kJ and target embedment depths for 39-foot (12-m) monopiles would be 164 feet (30-50 m). Installation of a single monopile foundation is estimated to normally require approximately 1 to 4 hours (12 hours maximum) of pile driving. Daytime pile driving is assumed, but nighttime pile driving could potentially occur. Up to three monopile foundations would be installed in a 24-hour period, with up to 21 monopiles installed every 7 days using one installation vessel. Installation of the WTG monopiles is expected to be completed in a single 5-month campaign (a 5-month period between May 1 and December 31; no WTG installation will occur between January 1 and April 30). This assumes installation of up to three WTG monopiles installed in a 24-hour period and two OSS monopiles installed per day under the most aggressive possible schedule, for the purpose of assessing potential underwater noise exposure. Nighttime pile driving may occur under certain conditions[2], and mitigation measures are incorporated to appropriately minimize the risks associated with this activity. Additionally, since January to April is when NARW are present in the region in higher numbers, the potential impacts from pile driving to this species would increase. Alternatively, if the installations were to occur within the same May-December period during daylight only but extend across multiple seasons, there would be an overall increase in vessel traffic, which would increase potential impacts to NARW and other marine mammals. For these reasons the ability to conduct nighttime impact pile driving of monopile foundation during periods when the fewest number of NARW are likely to be present in the region is expected to result in the lowest overall impact of the project on marine mammals, including NARW (LGL 2022).

The OSS foundation installation is expected to occur within a 1- to-2-week period and may occur concurrently with the WTG installation.

The typical monopile foundation and WTG installation sequence is summarized in Table 3.5.

Table 3.5. Summary of Monopile Foundation and WTG Installation.

Activity/Action	Installation Details
Foundation Delivery	Monopiles may be transported directly to the Lease Area for installation or to the construction staging port. Monopiles [and Transition Pieces (TPs) if used] are transported to site by an installation vessel or a feeder barge.
Foundation Setup	At the foundation location, the main installation vessel upends the monopile in a vertical position in the pile gripper mounted on the side of the vessel. The hydraulic hammer is lifted on top of the pile to commence pile driving.
Pile Driving	Piles are driven until the target embedment depth is met, then the pile hammer is removed and the monopile is released from the pile gripper.
TP Installation (if used) or Secondary Structures Installation	Once the monopile is installed to the target depth, the TP or separate secondary structures would be lifted over the pile by the installation vessel. If used, the TP would be bolted to the monopile.
Foundation Completion	Once installation of the monopile and TP is complete, the vessel moves to the next installation location.
Tower and Nacelle Installation	The jack-up construction vessel is loaded with WTG towers, nacelles, and blades on a customized gantry. The jack-up construction vessel moves into position next to the foundation and lifts the tower into place on the foundation using an onboard crane. Once the tower is secured to the foundation, the WTG nacelle is lifted into place and bolted to the top of the tower. This activity requires precision crane work and can only be conducted under no or low wind conditions. The schedule is therefore weather dependent.

[2] Nighttime pile driving may be required under specific circumstances where foundation installation takes longer than anticipated and delaying installation until daylight could present risks to safety and/or structural stability.

Activity/Action	Installation Details
WTG blade installation	Each WTG blade is lifted from the jack-up vessel gantry into position with its mounting point on the nacelle. The blade is centered and aligned with mounting points on the nacelle and secured by bolting it to the nacelle housing. This activity requires precision crane work and can only be conducted under no or low wind conditions. The schedule is therefore weather dependent.

Source: Revolution Wind COP (vhb 2022)

Scour protection would be installed around each foundation to prevent sea floor erosion and scour from natural hydrodynamic processes. Scour protection may be installed before or after the foundations are installed and may consist of placement of a filter layer, rock placement (most common), mattress protection, sandbags, and/or rock bags. Rock placement typically includes a rock armor layer placed over a filter layer. The filter layer can either be installed before or after the foundation. Using heavier rock material, with a wider gradation, can avoid the need for a filter layer and only require a single layer of scour protection.

The quantity of scour protection required would vary based on site conditions and would be determined based on detailed design of the foundation, consideration of geotechnical data, metocean data, water depth, maintenance strategy, agency coordination, stakeholder concerns, and cost. Scour protection would impact approximately 0.7 acre centered on each WTG and OSS monopile, ranging from 2.3 to 4.6 feet (0.7 to 1.4 m) in height above the sea floor.

Up to two OSSs would be installed to support the maximum project design capacity, each with a maximum nominal capacity of 440 MW. Each OSS would have a platform containing the electrical components necessary to collect the power generated by the WTGs (via the IAC), transform it to a higher voltage for transmission and transport to the Project's onshore electricity infrastructure (via the export cables). The purpose of the OSSs is to stabilize and maximize the voltage of the power generated offshore, reduce the potential electrical losses, and transmit electricity to shore.

Though the OSSs would be unmanned, they may include installed facilities to accommodate maintenance crews such as break rooms, bathrooms, locker facilities, and general storage rooms for equipment. There would not be any running water facilities on the platform and wastewater would be collected in holding tanks and removed from the OSS by transfer to a crew transfer vessel or services O&M vessel. Solid waste would also be removed by such vessels and brought to shore for proper disposal.

Each OSS would require various oils, fuels, and lubricants to support O&M. Sulfur hexafluoride (SF_6) would also be used for insulation purposes. Table 3.6 provides a summary of the maximum quantities of these materials potentially required for each OSS. The spill containment strategy for each OSS consists of preventive, detective, and containment measures (vhb 2022). The OSSs will be designed with a minimum of 110 percent of secondary containment of all identified oils, grease, and lubricants. Additionally, OSS devices containing SF6 will be equipped with integral low-pressure detectors to detect SF_6 gas leakages should they occur (vhb 2022).

Table 3.6. Summary of the Maximum Potential Quantities of Oils, Fuels, Lubricants and SF_6 per OSS.

OSS Equipment	Material	Maximum Quantity per OSS
Transformers and Reactors	Transformer Oil	79,252 gallons (300,000 liters)
Generators	Diesel Fuel	52,834 gallons (20,000 liters)
Medium and High-Voltage Gas-insulated Switchgears	SF_6*	40 pounds (18 kg)
Crane	Hydraulic Oil	317 gallons (1,200 liters)

* SF_6 (sulfur hexafluoride) gas would be used for electrical insulation in some switchgear components
Source: Revolution Wind COP (vhb 2022)

The anticipated construction and installation sequence for the OSS is summarized in Table 3.7 below. It is anticipated that OSS installation and commissioning may require up to 9 months, not including cable pull-in.

Table 3.7. Summary of OSS Construction and Installation Sequence.

Activity/Action	Construction and Installation Summary
Foundation Delivery and Installation	Each OSS would be supported by 15-m monopile foundations. Delivery and installation would be similar to the monopile foundation described in Table 3.2, above.
Topside Installation	The topside platform, including the transformer module and switchgear, would be assembled as a single unit prior to being transported to the Lease Area via a heavy transport vessel or barge. This expedites the lift of the module onto the foundation. The lift would commence using a suitable installation vessel and the topside platform would be lowered onto the preinstalled foundation. The topside is then secured into position by use of grouted, bolted, or welded connection. This step would occur following installation of the OSS foundation.
Commissioning	Once the OSS topside is secured to the foundation, the RWEC, OSS-link cable, and IAC would be connected. Communication systems would be set-up with the shore, as well as lighting, firefighting system, etc. Once all systems are enabled, the electrical systems would be commissioned using back-feed (i.e., electricity is fed to the OSS from the onshore grid via the export cables). When completed, the OSS is operational.

Operations and Maintenance (O&M)

A summary of the WTG maintenance activities and the maximum frequency at which they may occur is provided in Table 3.8, below.

Table 3.8. Summary of WTG Maintenance Activities.

Maintenance/Survey Activity	Indicative Frequency
Routine Service & Safety Surveys/Checks	Annual
Oil and HV Maintenance	Annual
Visual Blade Inspections (Internal and External)	Annual
Fault Rectification	As needed
Major Replacements	As needed
End of Warranty Inspections	At end of warranty period

Source: Revolution Wind COP (vhb 2022)

A summary of the WTG and OSS foundation maintenance activities and the anticipated frequency at which they may occur is provided in Table 3.9.

Table 3.9. Foundation Maintenance Activities.

Maintenance/Survey Activity	Indicative Frequency
Above Water Inspection & Maintenance	Annual
Sea Floor Survey	At 1 year after commissioning, 2-3 years after commissioning and 5-8 years after commissioning. Frequency thereafter would depend on the findings of the initial surveys.
Subsea Inspection (to detect, measure record deterioration that could affect structural integrity)	3-5 years or defined based on risk
Major Maintenance	Every 8 years
Corrective Maintenance	As needed
End of Warranty Inspections	At end of warranty period

Source: Revolution Wind COP (vhb 2022)

Each WTG would require various oils, fuels, and lubricants to support O&M. Sulfur hexafluoride (SF_6) would also be used for insulation purposes. Table 3.10 provides a summary of the maximum quantities of these materials potentially required for each WTG (vhb 2022). The spill containment strategy for each WTG comprises similar preventive, detective, and containment measures to those described for the OSSs. These measures include 100 percent leakage-free joints to prevent leaks at the connectors; high pressure and oil level sensors that can detect both water and oil leakage; and integrated retention reservoirs capable of containing 110 percent of the volume of potential leakages at each WTG. Additionally, WTG switchgear containing SF_6 will be equipped with integral low-pressure detectors to detect SF_6 gas leakages should they occur (vhb 2022).

Table 3.10. Summary of the Maximum Potential Quantities of Oils, Fuels, Lubricants and SF_6 per WTG.

WTG System/Component	Material	Maximum Quantity per WTG
WTG Bearings, Yaw, and Pitch Pinyons	Grease	343 gallons (1,300 liters)
Hydraulic Pumping Unit, Hydraulic Pitch Actuators, Hydraulic Pitch Accumulators	Hydraulic Oil	528 gallons (2,000 liters)
Drive Train Gearbox (if applicable), Yaw/Pitch Drives Gearbox	Gear Oil	582 gallons (2,200 liters)
Blades and Generator Accumulators	Nitrogen	104 cubic yards (80 cubic meters)
High-Voltage Transformer	Transformer Silicon/Ester Oil	1,850 gallons (7,000 liters)
Emergency Generator	Diesel Fuel	793 gallons (3,000 liters)
Switchgear	SF_6*	Up to 13 pounds (6 kg)
Tower Damper and Cooling System	Glycol/Oil/Coolants	3,434 gallons (13,000 liters)

* SF_6 (sulfur hexafluoride) gas would be used for electrical insulation in some switchgear components
Source: Revolution Wind COP (vhb 2022)

Maintenance activities would be planned for periods of low wind and good weather (typically during spring and summer seasons), mostly during daylight hours. The WTGs would remain operational when not shut down for maintenance or when wind speeds are above or below operational cutoff thresholds (vhb 2022).

Certain O&M activities may require the use of either a jack-up vessel or anchored barge. A jack-up vessel is a vessel equipped with legs, or spud anchors that can lift the vessel above the sea level. Standing firmly on the sea floor, the vessels can operate safely while maintaining position without being impacted by the waves and currents. An anchored barge is simply a barge with anchors to allow safe operations while maintaining position. These activities would result in a short-term disturbance of the sea floor similar to or less than what is anticipated during construction.

Decommissioning

The RWF and RWEC would be decommissioned and removed when these facilities reach the end of their approximately 35-year operating period. Under 30 CFR 585 and commercial Renewable Energy Lease OCS-A 0486, Revolution Wind would be required to remove or decommission all facilities, projects, cables, pipelines, and obstructions and clear the sea floor of all obstructions created by the proposed Project. All facilities would need to be removed 15 feet (4.6 m) below the mudline (30 CFR 585.910(a)). Absent permission from BOEM, Revolution Wind would have to achieve complete decommissioning within 2 years of termination of the lease and reuse, recycle, or responsibly dispose of all materials removed. Revolution Wind has submitted a decommissioning plan as part of the COP.

Implementation procedures for the decommissioning would generally entail removal of the RWF and RWEC infrastructure. For both WTGs and OSSs, decommissioning would be a “reverse installation” process, with turbine components or the OSS topside structure removed prior to foundation removal. WTG components and the OSSs will be disconnected and will be removed using a jack-up lift vessel or a derrick barge. Cables will be removed, in accordance with BOEM regulations (30 CFR 585, Subpart 1). A material barge would transport components to a recycling yard where the components would be disassembled and prepared for reuse and/or recycling for scrap metal and other materials (vhb 2022).

The foundations will be cut by an internal abrasive water jet cutting tool at 15 feet below the sea floor and returned to shore for recycling in the same manner described for the WTG components and the OSSs. Revolution Wind will clear the area after all components have been decommissioned to ensure that no unauthorized debris remains on the sea floor. Onshore decommissioning requirements will be subject to state/local authorizations and permits (vhb 2022).

Revolution Wind will be required to complete decommissioning within 2 years of the termination of its lease. Revolution Wind will submit a decommissioning application prior to any decommissioning activities. BOEM would conduct a NEPA assessment at that time, which could result in the preparation of a NEPA document. Decommissioning may not occur for all Project components as the result of this NEPA document. However, all analysis assume that decommissioning would occur as described in this section (vhb 2022). It is assumed similar types of vessels used to construct the project would be employed for decommissioning. This process would emphasize the recovery of valuable materials for recycling.

Although decommissioning is described here and in the COP, the Project would be decommissioned in accordance with a detailed decommissioning plan that would be developed in compliance with applicable laws, regulations, and best management practices (BMPs) at that time (vhb 2022). Specific procedures would be developed when the decommissioning is scheduled to ensure potential impacts ESA-listed species and critical habitats are considered, appropriate EPMs are identified, and implementation procedures to avoid and minimize impacts to those species are incorporated. Decommissioning may require a separate and independent ESA Section 7 Consultation.

3.3.2 Vessel and Aircraft Types

Construction and installation, O&M, and decommissioning of the project would require the support of various vessels and helicopters, as described below.

Construction and Installation

Revolution Wind COP (vhb 2022) has identified various vessels and helicopters that would be required to construct the Project. For each vessel type the route plan for the vessel operation area would be developed to meet industry guidelines and best practices in accordance with International Chamber of Shipping guidance. Each vessel would have operational Automatic Identification Systems (AIS), which would be used to monitor the number of vessels and traffic patterns for analysis and compliance with vessel speed requirements. Each vessel would operate in accordance with applicable rules and regulations for maritime operation within U.S. and federal waters. Additionally, project vessels would adhere to vessel speed restrictions as appropriate in accordance with National Oceanic and Atmospheric Administration (NOAA) requirements. Similarly, all aviation operation, including flying routes and altitude, would be aligned with relevant stakeholders (e.g., Federal Aviation Administration).

Aerial surveys associated with monitoring for protected species during MEC/UXO detonation are typically limited by low cloud ceilings, aircraft availability, survey duration, and Health, Safety and Environment 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 zone.

Table 3.11 summarizes the various vessels associated with project-related offshore construction and installation. Table 3.12 summarizes the number of vessels, number of trips, operational speeds, and vessel drafts associated with project-related offshore construction and installation. Table 3.13 identifies the regional ports under consideration for various project construction and O&M activities. The specific distribution of construction trips identified in Table 3.12 to each of the ports identified in Table 3.13 has not been specified at this time.

Table 3.11. Vessels Required for Offshore Construction and Installation.

Type of Vessel	# of Vessels	Foundations	OSS	RWEC	IAC	OSS-Link Cable	WTGs
Accommodation Jack-up Vessel	1	X					X
Boulder Clearance Vessel	2	X		X	X	X	
Bubble Curtain Vessel	1	X	X				X
Crew Transport Vessel (CTV)	6	X	X	X	X	X	X
Nearshore Barge	1			X			
Rock Installation Vessel	1	X					
Helicopter	1-2	X					
Foundation Supply Vessel	3	X	X				
Foundation Installation Vessel	1		X				
Array Installation (cable laying vessel)	1				X		
Array Cable Burial	1				X		
Service Operations Vessel (SOV)	1			X	X	X	X
Pre-lay Grapnel Vessel	4			X	X	X	
Safety Vessel	2	X	X	X	X	X	X
Scout Vessel	6	X	X	X	X	X	X
Survey Vessel	1			X	X	X	
PSO Vessel	4	X					
Cable Lay Vessel (export)	1			X		X	
Walk to Work Vessel	1			X	X	X	

Table 3.12. Number of Vessels and Vessel Trips Required for Project Construction and Installation, and Typical Operational Speeds, and Draft by Vessel Type.

Vessel Type	Ports to be Used	Number of Vessels Used for Construction	Maximum Number of Round Trips‡	Typical Operational Speed (knots)	Approximate Vessel Draft (m)
Accommodation Jack-up Vessel	Quonset Port Jefferson	1	1	7	6.5
Array Cable Burial Vessel		1	9	11 (2.4)±	5
Bubble Curtain Vessel		1	20	11.5	7
Export Cable Lay Vessel		1	9	12 (2.4)±	5
Crew Transport Vessel		6	870	23	2
Barge – Nearshore		1	3	4	7
Foundation Installation Vessel		1	22	7	13.5
Foundation Supply Vessel		3	65	10	7
Pre-lay Grapnel Run Vessel		4	6	11	7
Boulder clearance vessel		2	26	11	7
PSO Vessel		4	80	12.5	5
Rock Installation Vessel		1	6	6.5	8
Safety Vessel	Quonset Port Jefferson	2	100	23	2
Scout Vessel		6	100	12.5	5
Service Operations Vessel		1	1	22	7.5
Survey Vessel		1	11	12.5	5
Walk to Work Vessel		1	22	22	7.5

‡ Vessel trips are rips between the RWF and RWEC corridor and area ports used for project construction (Revolution Wind 2022a). Trip distance would vary depending on the specific port of call, with one way trip distances ranging from an average of approximately 71 miles to 175 miles to Davisville RI and Brooklyn NY, respectively. Trip distances were calculated using the methods described by Tech Environmental (2021).

± Speeds shown are general transit speeds and typical speeds during cable installation in parentheses. The majority of cable installation vessel operations would occur at installation speed.

Table 3.13. Regional Ports Under Consideration for Various Construction and O&M Activities.

State	Port	Approximate Travel Distance to RWF (miles)‡	Project Element: Construction – Crew Mobilization, Surveys, Monitoring	Project Element: Construction – WTG and OSS Tower and Components	Project Element: Construction – Foundation Staging and Advanced Component Fabrication	Project Element: Construction Hub and/or O&M Support	Project Element: O&M – Electrical Monitoring and Support§
New York	Montauk	48	--	--	--	●	--
	Port Jefferson	113	●	--	--	●	--
	Brooklyn	175	--	--	--	●	--
Rhode Island	Providence	56	●	●	●	--	●
	Davisville – Quonset Point	41	●	--	--	●	--
	Galilee	31	--	--	--	●	--
Connecticut	New London	54	●	●	--	--	--
Massachusetts	New Bedford Marine Commerce Terminal	34	●	●	--	--	--

Symbols: ● = port considered for this element, -- = port not considered for this element.

‡ Approximate distance from center of RWF to identified port assuming straight line travel to navigation lane entry (Tech Environmental 2021). Travel distance to Port Jefferson, Brooklyn, Providence, and Galilee estimated using similar methods.

§ Monitoring of power transmission and transmission cable performance. O&M vessels may not dispatch from this port.

Operations and Maintenance (O&M)

Revolution Wind COP (vhb 2022) has also identified various vessels to support O&M, as identified in Table 3.14 below. Typical draft and operational speeds for these vessel types are expected to be similar to those for equivalent vessels used during construction, as described above in Table 3.12. CTVs would make approximately 52 round trips to the RWF each year, or one per week, over the life of the project (Tech Environmental 2021). The service operations vessel (SOV) would make an estimated 26 trips per year to the RWF on an as-needed basis (Tech Environmental 2021; Revolution Wind 2022c). This would equate to an estimated 2,730 O&M vessel round trips over the 35-year life of the project, averaging approximately 82 miles round trip from the O&M port facility in Davisville, RI, and 96 miles round trip. As with construction and installation, all O&M vessels would operate in accordance with applicable rules and regulations for maritime operation within U.S. and federal waters. Shared CTVs, vessels servicing multiple offshore wind projects, and daughter craft may make an additional 13 and 10 trips to or within the RWF each year, respectively. Helicopters may also be used for aerial inspections.

Table 3.14. Vessels Required and Anticipated Trips Per Year for Offshore O&M by Project Component.

Activity Type	Vessel Type	Anticipated Trips per Year	Foundations	OSS	RWEC	IAC	OSS-Link Cable	WTGs
Routine (e.g., annual maintenance, troubleshooting, inspections)	SOV	26	X	X	X	X	X	X
	Daughter Craft	10	X	X				X
	CTV	52	X	X				X
	Shared CTV	13	X	X	X	X	X	X
Non-Routine (e.g., major components exchange)	Jack-up Vessel	As needed		X				X
	Cable-lay/Cable Burial Vessel	As needed			X	X	X	
	Support Barge	As needed		X	X	X	X	X

Decommissioning

Revolution Wind COP (vhb 2022) has indicated that the project would have an operational life of approximately 35 years. The decommissioning plan is described in more detail below. The number and type of vessels required for project decommissioning would be similar to those used during project construction, with the exception that impact pile driving would not be required. As such, while the same class of vessel used for foundation installation may be used for decommissioning, that vessel would not be equipped with an impact hammer. At minimum, BOEM would require Revolution Wind to completely remove all WTG and OSS components and their support towers as described above. Monopile foundations would be removed or cut off 15 feet below the mudline using a cable saw or equivalent technology, and the surrounding scour protection would be removed from the sea floor. All materials would be recovered to the extent practicable for recycling and reuse.

3.3.3 Cable Types

Construction and Installation

The Proposed Action would include three cable networks, the IAC, OSS-link and the RWEC. These cable networks would be installed in offshore areas, which include an IAC, which would carry electrical current produced by the WTGs to the OSSs. An OSS-link that would transfer electrical current between the two OSSs, and the RWEC that would carry electrical current from each OSS to the On-Shore Substation. Installation of the three cable networks will require hydraulic plow (i.e., jet-plow and mechanical plow) or similar technology for displacing sediments to allow for cable burial.

Sea floor preparation associated with cable installation would include activities such as boulder clearance. A pre-lay grapnel run will also be completed to clear cable routes of possible obstructions (e.g., derelict fishing nets, lobster pots, cables, rope, or other debris) prior to installation. Once complete, the sea floor would be prepared for cable installation by removing boulders and flattening large ripples and megaripples. Sea floor preparation will occur within a 131-foot (40-m)-wide corridor along submarine cable routes and within a 656-foot (200-m)-radius around WTG and OSS foundation locations.

The following two techniques may be used to relocate/remove surface or partially embedded boulders and debris during installation of the RWEC.

- Boulder Grab. A grab is lowered to sea floor, over the targeted boulder. Once “grabbed,” the boulder is relocated away from the RWEC route.
- Boulder Plow. Boulder clearance is completed by a high-bollard pull vessel, with a towed plow generally forming an extended V-shaped configuration, splaying from the rear of the main chassis. The V-shaped configuration displaces any boulders to the extremities of the plow, thus establishing a clear corridor. Multiple passes may be required.

The IAC network would be up to approximately 155 miles (250 km). The IAC network would be 72 kV HVAC IAC, which would comprise a series of cable strings that interconnect a small grouping of WTGs to the OSSs. The IAC, as well as the OSS-link and RWEC, would consist of three bundled copper or aluminum conductor cores surrounded by layers of cross-linked polyethylene insulation and various protective armoring and sheathing to protect the cable from external damage and keep it watertight. A fiber optic cable would also be included in the interstitial space between the three conductors and would be used to transmit data from each of the WTGs to the Supervisory Control and Data Acquisition system for continuous monitoring of the IAC.

The IAC would include multiple segments that extend 155 miles, connecting WTGs to the two OSS. The IAC segments would be installed within a 131-foot (40-m) wide corridor between the WTGs. Burial of the IAC would typically target a depth of 4 to 6 feet (1.2 m to 1.8 m) below sea floor. Depth for the IAC would be determined based on an assessment of sea floor conditions, mobility and risk of interaction with external hazards such as fishing gear and vessel anchors, as well as the Cable Burial Risk Assessment (COP App F; vhb 2022). Installation of the IAC would generally follow similar sequence as described for the RWEC, below, with the following two exceptions:

- After pre-lay cable surveys and sea floor preparation activities are completed, a cable-laying vessel would be pre-loaded with 66-kilovolt (kV) transmission cable for the IAC. Prior to the first end-pull, the cable would be fitted with a Cable Protection System (CPS) and the cable would be pulled into the WTG or OSS. The vessel would then move towards the second WTG (or OSS). Cable laying and burial may occur simultaneously using a jet plow or similar lay and bury tool, or the cable may be laid on the sea floor and then trenched post-lay. Alternatively, a trench may be pre-cut prior to cable installation. The pull and lay operation, inclusive of fitting the cable with a CPS, is then repeated for the remaining IAC lengths, connecting the WTGs and OSSs together.

- The IAC would typically not require in-field joints; thus, "Joint Construction," as described for the RWEC, would generally not be required. However, joints may be used if a cable segment is damaged during installation and requires repair.

The RWEC would transfer electricity from the OSSs to the Onshore Transmission Cable at the Transition Joint Bays (TJBs). The TJBs would be the transition from the RWEC to the Onshore Transmission Cable. Two TJBs would be required. The RWEC corridor would traverse both federal and Rhode Island State waters (see Figure 3.1). The RWEC would consist of two 275-kV HVAC submarine cables, each originating at a respective OSS. Both are routed to show along parallel tracks within a single approximately 1,312-foot (400-m) wide right-of-way corridor extending from the northwest side of the RWF northward to landfall in North Kingstown, Rhode Island.

Offshore, the RWEC would include two cables installed within a 1,312-foot (400-m) right-of-way corridor. Within this right-of-way corridor, an approximately 131-foot (40-m)-wide disturbance corridor would be required for each cable, inclusive of any required boulder clearance. Note that prior to any sea floor preparation or disturbance required for cable installation, MEC/UXO will be addressed, as described previously for WTG and OSS foundations in Section 3.3.1. The full extent of the 131-foot (40-m)-wide disturbance corridor would not be impacted by installation of the RWEC. The extent of disturbance would vary depending on benthic conditions and installation method (i.e., burial, cable protection). Because of its length, the RWEC will require installation of two offshore submarine joints. Joint construction may include an inline or omega joint depending on the joint location and sea floor conditions. Omega joints would require an expanded 673-foot (205-m)-wide disturbance corridor at the joint locations. Up to four omega joints (two per RWEC cable) are anticipated.

Burial of the RWEC would be approximately 4-6 feet deep (1-2 m) below sea floor. Burial depth may be deeper in some areas based on an assessment of sea floor conditions, sea floor mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a Cable Burial Risk Assessment. Where burial cannot occur, or depth not achieved, or where cable crosses other cables/pipelines, additional cable protection methods may be used (e.g., rock berms/bags, concrete mattresses). Revolution Wind assumes up to 10 percent of the route for each cable comprising the RWEC will require additional protection measures. The location of the RWEC and associated cable will be provided to NOAA’s Office of Coast Survey after installation is completed so that they may be marked on nautical charts. Target burial depths at specific locations will be formalized in the FDR/FIR. One or more of the following cable protection solutions may be used for secondary cable protection:

- **Rock Berm** – involves dumping or placing rock overtop and/or surrounding the cable.
- **Concrete Mattresses** – composed of cast concrete blocks interlinked to form a flexible, articulated mat, which can be placed on the sea floor over a cable.
- **Fronded Mattresses** – concrete mattress with “fronds” that are designed to slow down current and naturally allow sediment to deposit and blanket the mattress.
- **Rock Bags** – rock-filled mesh bags placed over the cable.

The aerial sea floor impact footprint estimates for cable installation presented in Section 5.4 reflect all anticipated construction-related sea floor disturbance. The sequence of events required for RWEC construction and installation would include pre-lay cable surveys, sea floor preparation, cable installation, joint construction, cable installation surveys, cable protection and connection to the OSSs. Construction of the RWEC would require approximately 8 months. Table 3.15 below briefly summarizes construction phases (vhb 2022).

Table 3.15. Summary of RWEC Construction and Installation Sequence.

Activity	Construction and Installation Summary
Pre-Lay Cable Surveys	Prior to installation, geophysical surveys would be performed to check for debris and obstructions that may affect cable installation

Activity	Construction and Installation Summary
Seabed Preparation	Seabed preparation would include boulder clearance and removal of debris any Out of Service Cables. Boulder clearance trials may be performed prior to wide-scale seabed preparation activities to evaluate efficacy of boulder clearing techniques. Proposed boulder clearance methods comprise an ROV guided boulder grab, WROV boulder skid, and a boulder plow. Boulder plow use would be limited to two 6.2 mile (10 km) RWEC segments.
Pre-Lay Grapnel Run	PLGR runs would be undertaken to remove any seabed debris along the export cable route. A specialized vessel would tow a grapnel rig along the centerline of each cable to recover any debris to the deck for disposal at a permitted onshore location.
Cable Installation	The offshore cable-laying vessel would move along the pre-determined route within the established corridor towards the OSSs. Cable laying and burial may occur simultaneously using a lay and bury tool, or the cable may be laid on the seabed and then trenched post-lay. Alternatively, a trench may be pre-cut prior to cable installation. Cable lay and burial trials within the 131-ft (40-m) wide disturbance corridor may be performed prior to main cable installation activities to test equipment. A jet plow or mechanical plow may be used for cable installation. Both types of equipment would produce similar crushing and burial effects, benthic habitat disturbance, and suspended sediment impacts. The water intake for the jet plow would cause entrainment impacts on pelagic eggs and larvae, whereas the mechanical plow would not.
Joint Construction	Installation of the RWEC would require offshore subsea joints due to the length of the RWEC (up to two per cable). The joints would be located within the 131-ft (40-m) wide disturbance corridor. The subsea joint would be protected by marinized housing approximately four times the cross-sectional diameter of the cable. The joint housing would be protected using similar methods to those described below for Cable Protection. In case of repair due to damage additional joints may be required during construction and installation.
Cable Installation Surveys	Cable installation surveys would be required, including pre- and post-installation surveys, to determine the actual cable burial depth. Depending on the instruments selected, type of survey, length of cable, etc. the survey would be completed by equipment mounted to a vessel and/or remote operated vehicle.
Cable Protection	Cable protection in the form of rock berms, rock bags and/or mattresses would be installed as determined necessary by the Cable Burial Risk Assessment, and where the cable crosses existing submarine assets. Cable protection would be installed from an anchored or dynamic positioning support vessel that would place the protection material over the designated area(s).
Connection to OSS and WTGs	Export cable ends would be pulled into each WTG and OSS foundation via a J-tube connected to the monopile foundation and secured. Cable protection systems would be installed on top of foundation scour protection. A portion of the cable protection system would extend beyond the scour protection footprint, resulting in 0.07 acre of additional seabed impacts at each foundation.

Source: VHB (2022)

The RWEC would transition from offshore to onshore using Horizontal Directional Drilling (HDD) methodology. The HDD methodology would involve drilling underneath the sea floor using a drilling rig positioned onshore in the landfall envelope; the maximum design envelope for the HDD methodology includes excavation of two exit pits (one per cable), each measuring 182 feet x 113 feet x 14 feet (55 m x 34 m x 4 m). A cofferdam would be erected around each exit pit to allow construction and installation to occur in the dry and manage sediment, potentially contaminated soils, and bentonite. Each cofferdam would be approximately 182 feet x 113 feet x 14 feet to align with HDD exit dimensions. The types of cofferdams considered include sheet pile and gravity cell. Each exit pit would be excavated by dredge to expose the HDD exit point allowing for landfall connection. All dredge spoils would be contained on a barge and used to backfill the excavated areas inside each cofferdam.

Two alternative methods are being considered for sea-to-shore construction. A casing pipe could be installed using a combination of vibratory and impact pile driving. The HDD would drill into the end of the casing pipe, completely enclosing the exit point within the pipe. This method would require no cofferdam containment. The casing pipe would require a minimal amount of low-intensity impact pile driving and far less vibratory pile driving than cofferdam installation. No dredging would be required, therefore TSS impacts would be limited. A no containment method is also being considered, which would have the HDD conduit terminate in a dredged HDD exit pit lined with rock bags to maintain the side wall slope (vhb 2022). The exit pit dimensions for the no containment method would be similar to those proposed for the cofferdam method. This method would produce the most extensive TSS impacts resulting from the Proposed Action. The sheet pile cofferdam installation would produce the most intense and extensive underwater noise impacts of the options evaluated; therefore, this construction option is evaluated in this BA.

Vessels required to support the HDD operations would include a shallow draught barge or jack-up vessel (vhb 2022). The specific quantity of dredge spoils produced during HDD activities has not been quantified but can be generally estimated from cofferdam dimensions. All dredge spoils will be contained on a barge and used to backfill the exit pit and return the bed surface to pre-project contours after construction is complete.

OSS Link Cable

The two OSSs would be connected by a 9-mile (15-km)-long 275kV HVAC OSS-link cable. The OSS-link cable allows for electricity transmission to be balanced between RWEC circuits. OSS-link cable installation methods would be similar to those described below for the RWEC.

Operations and Maintenance (O&M)

Revolution Wind would employ a proprietary state-of-the-art asset management system to inspect offshore transmission assets including the OSS (electrical components), RWEC, IAC, and OSS-link cable. This system provides real-time data on the condition of individual project components, allowing for rapid identification of faults and predictive scheduling of inspections and/or maintenance activities.

A summary of the OSS related maintenance activities and the anticipated frequency at which they may occur is provided in Table 3.16, below. For the most part these routine maintenance activities would not result in stressors that could affect ESA-listed species beyond the vessel trips required to transit between the O&M Facility and the RWF. Sea floor surveys are the exception and could result in stressors that could affect ESA-listed species such as underwater noise and side-scan sonar, which are evaluated in Section 5.2.1 Vessels and Section 5.1.3 Geotechnical and Geophysical Surveys, respectively.

Table 3.16. Foundation Maintenance Activities.

Maintenance/Survey Activity	Indicative Frequency
Routine Service of Electrical Components	20 per year
Electrical Inspections	2 per year
Scheduled Maintenance of OSS Components	Annual
Sea Floor Survey (i.e., bathymetry, cable burial depth, cable protection)	Immediately following installation, then 1 year after commissioning, 2-3 years after commissioning and 5-8 years after commissioning.
Minor Corrective and Preventative Maintenance of OSS Equipment	5 per year
Major Corrective and Preventative Maintenance of OSS Equipment	2 per lifetime

Source: Revolution Wind COP (vhb 2022)

Decommissioning

Revolution Wind COP (vhb 2022) has indicated that the project would have an operational life of approximately 35 years. At the end of operational life, the project would be removed in accordance with a detailed decommissioning plan. That plan would comply with all applicable laws, regulations and BMPs in place at that time. The decommissioning and removal plan would incorporate new technologies that may be developed and adhere to all permit and regulatory requirements, all of which are anticipated to change over the life of the project. That may include a separate ESA consultation and regulatory review process for the decommissioning phase of the project. At minimum, BOEM would require Revolution Wind to completely remove all transmission cables would from the sediment to the extent practicable and remove all associated cable protection from the sea floor. Any cable segments that cannot be fully extracted would be cut off using a cable saw and buried at least 4 to 6 feet below the mudline. All remaining components would be completely removed from the environment and collected for recycling of valuable metals and other materials.

3.3.4 Surveys

High-Resolution Geophysical Surveys

HRG surveys would be conducted prior to construction and installation to finalize design and support micrositing of project features where applicable. HRG surveys use a combination of sonar-based methods to map shallow geophysical features. Up to 10,755 miles of pre-construction surveys would be conducted to support Project installation and micrositing. HRG surveys will be conducted intermittently during the construction period to identify any sea floor debris. A maximum of four total vessels will be used for surveys, and operations will occur on a 24-hour basis, although some vessels may only operate during daylight hours (~12-hour survey vessels). While the final survey plans will not be completed until construction contracting commences, HRG surveys could occur during any month of the year and would require a maximum of 248 total vessel days (LGL 2022a).

Revolution Wind estimates that up to 9,509 linear miles of pre-construction HRG surveys would occur over 219 days, averaging approximately 48 miles of exposure each day at a typical vessel speed of 2.2 knots (LGL 2022a). Up to 2,365 linear miles of post-construction HRG surveys could be conducted each year for the first 4 years of project operations to ensure transmission cables are maintaining desired burial depths. This equates to approximately 54 days of HRG survey activity per year. Post-construction HRG surveys could occur during any month of the year and would be used to evaluate benthic habitat condition and ensure transmission cables remain buried to desired depths. HRG survey equipment is typically towed behind a moving survey vessel attached by an umbilical cable. HRG survey vessels move slowly, with typical operational speeds of less than approximately 4 knots.

Intermittent geophysical surveys would be conducted prior to and during construction to identify any sea floor debris or MEC/UXO, and cultural and historical resources. Surveys for UXO/MEC will be performed by certified technicians prior to and during excavation activities in accordance with applicable guidance. Revolution Wind will first implement a MEC/UXO Risk Assessment with Risk Mitigation Strategy (RARMS) designed to evaluate and reduce risk in accordance with the ALARP risk mitigation principle. The RARMS consists of a phased process beginning with a Desktop Study and Risk Assessment that identifies potential sources of MEC/UXO hazard based on charted MEC/UXO locations and historical activities, assesses the baseline (pre-mitigation) risk that MEC/UXO pose to the Project, and recommends a strategy to mitigate that risk to ALARP (vhb 2022). Due to the substantial pre-construction surveys that have been and will continue to be undertaken to locate and remedy confirmed MEC/UXO (either by avoidance or removal), during construction the likelihood of an unanticipated MEC/UXO encounter is very low. Revolution Wind will work with BOEM to identify appropriate response actions, which may include developing an emergency response plan, conducting MEC/UXO-specific safety briefings, retaining an on-call MEC/UXO consultant, or other measures (vhb 2022).

Based on the type of equipment used previously for site assessment, the probable types of HRG equipment used for construction and design support and UXO identification would include multi-beam echosounders, side-scan sonars, sub-bottom profilers, medium penetration sub-bottom profilers, ultra-short baseline positioning equipment, and single or dual magnetometers. The equipment types used to date are as follows: Geometrics G-882 cesium-vapor marine magnetometers utilizing a Geometrics transverse gradiometer frame; Edgetech FS4200 dual frequency (300/600 kHz Compressed High Intensity Radiated Pulse (CHIRP) side-scan sonar, and; two sub-bottom profilers—a four-transducer array system utilizing Massa TR-1057D Sub-Bottom Profiler transducers and an MPS Sparker (Fugro 2020). The equipment selected would be comparable to those use during previous surveys conducted in the region, which have been assessed for the potential for impacts (CSA Ocean Sciences Inc. 2018, 2020 and Feehan and Daniels 2018, as cited in vhb 2022).

Revolution Wind would deploy passive acoustic monitoring (PAM) buoys or autonomous PAM devices to record ambient noise, marine mammals, and cod vocalizations in the Lease Area before, during, and after construction for at least 3 years to monitor construction and operational noise. The archival recorders must have a minimum capability of detecting and storing acoustic data on anthropogenic noise sources, marine mammals, and cod vocalizations in the Lease Area. The total number of PAM stations and array configuration will be determined in coordination with cooperating agencies. Monitoring will be conducted using the data collection, processing methods, and visualization metrics developed by the Atlantic Deepwater Ecosystem Observatory Network (ADEON) for the U.S. Mid- and South Atlantic OCS (see https://adeon.unh.edu/).

BOEM has completed a programmatic ESA consultation with NMFS for HRG surveys and other types of survey and monitoring activities supporting offshore wind energy development (NMFS 2021a). A description and the acoustic characteristics of representative HRG survey equipment and buoy mooring design and installation parameters can be found in the BA for that consultation and are incorporated by reference here (BOEM 2021a). The outcome of that consultation determined that the type of HRG surveys proposed in the COP and the use of PAM monitoring systems are not likely to adversely affect threatened or endangered species when specified project design criteria (PDCs) and BMPs are implemented. BOEM would require Revolution Wind to comply with all relevant programmatic survey and monitoring PDCs and BMPs. These requirements and the BOEM (2021b) programmatic effect determinations for these activities are incorporated by reference.

Fisheries Research Monitoring Plan

Revolution Wind is proposing to implement the Fisheries Research Monitoring Plan (FRMP) as part of the Proposed Action (Revolution Wind and Inspire Environmental 2021). This document is included as Appendix A to this document. The FRMP employs a variety of survey methods to evaluate the effect of RWF construction and installation and O&M on benthic structure and function, invertebrates, and finfish. The FRMP will adhere to NOAA guidance on float and anchor design to avoid marine mammal entanglement risk. Gear types will be the same as regularly used in commercial fisheries designed to minimize bycatch, particularly Atlantic sturgeon. Commercial fishing vessels will be employed for the surveys, which would otherwise be participating in commercial fisheries. The following survey methods will be implemented as part of the FRMP:

(1) Ventless trap surveys used in a Before-After Control-Impact (BACI) and Before-After-Gradient (BAG) to evaluate changes in the distribution and abundance of lobster and Jonah crab in the RWF and adjacent reference areas, and Jonah crab, lobster, whelk (Buccinidae) and finfish along the RWEC corridor and adjacent reference areas.

- Location: Ventless traps will be set at two impact locations within the RWF and two reference locations adjacent to the RWF to the east and west (See Appendix

A, Figure 10). Sites within each location will be randomly selected using the spatially balanced sampling approach employed in the Southern New England Cooperative Ventless Trap Survey (SNECVTS) survey (Collie and King 2016).

- Frequency: 12 times per month for 7 months each for 2 years prior to, during, and a minimum of 2 years following completion of Project construction and installation. The frequency/duration of post-construction monitoring is subject to change based on guidance being developed cooperatively through the Responsible Offshore Science Alliance (ROSA). Revolution Wind is currently anticipating 5 years of monitoring total (2 years of pre-construction, 1 year of construction and 2 years of post-construction monitoring).

- Timing: The goal is to initiate sampling in May or June, similar to the start of sampling in the South Fork Wind Farm. Performing surveys in both project areas will increase the ability to detect regional changes in these invertebrate resources.

- Duration: The standard soak time will be 5 nights, which is consistent with local fishing practices, and the protocols used on the SNECVTS survey. The target soak time will remain consistent throughout the duration of the survey. Traps will be baited with locally available bait (likely skate), and the bait type will be recorded for each trawl.

- Intensity: Each trawl will be configured with 10 traps. The BACI survey will employ a combination of six ventless traps, and four standard vented traps on each trawl. The BAG survey will employ 10 ventless traps. Each set of traps will be attached to a ground line, with each ground line end linked to up-and-down lines (or end line) that are attached to floats. These floats and end lines are used to haul the ground line and traps, referred to in its entirety as a "trawl." There will be four ventless traps and two vented traps on each ground line, spanning over 400 feet of ground line, with traps separated from each other by approximately 80 feet.

- Equipment type: A single parlor trap that is 16 inches high, 40 inches long, and 21 inches wide with 5-inch entrance hoops and constructed with 1-inch square rubber-coated 12-gauge wire that is consistent with traps used in the ASMFC and SNECVTS ventless trap surveys. The trap is constructed with a disabling door that closes off the entrance during periods when the trap is on the bottom but not sampling.

(2) Otter trawl surveys to assess abundance and distribution of target fish and invertebrate species within the RWF. Trawls may impact a variety of finfish species. Surveys will be conducted on a seasonal basis in summer, fall, winter, and spring (see Appendix A). The

sampling methodology and trawl gear were designed to be complementary to the NEAMAP trawl survey (Bonzek et al. 2008, 2017).

- Location: Randomly selected trawl sites in one impact and two reference survey areas. The impact survey area is located in the northern half of the RWF where substrate conditions are suitable for benthic trawling. The reference survey areas are located to the west of the impact survey areas (see Appendix A, Figure 6).

- Frequency: Four times per year for 2 years prior to and a minimum of 2 years following completion of project construction and installation.

- Timing: Trawl survey will be carried out on a seasonal basis, with four surveys each year. In order to achieve temporal overlap with Northeast Fisheries Science Center (NEFSC) trawl survey, the seasons for the RWF surveys will be defined as:

    - Winter (December, January, and February)

    - Spring (March, April, and May)

    - Summer (June, July and August)

    - Fall (September, October, November)

  To the extent practicable, concerted efforts will be made to ensure that the timing of the RWF trawl survey coincides with the NEFSC spring and fall bottom trawl surveys (vhb 2022).

- Intensity: A sample size of 15 trawl tows in each impact and reference survey area will be targeted per season each year. Trawl locations within each area will be randomly selected. The proposed seasonal sampling intensity equates to an annual sampling target of 180 tows per year across the RWF Project and reference areas. Planned duration of each tow is 20 minutes, not including set and retrieval time.

- Equipment: NEAMAP survey net is a 400 x 12-centimeter (cm) three-bridle four-seam bottom trawl, and the net is paired with Thyboron, Type IV 168 cm (66 inch [in]) trawl doors. A 2.5-cm (1-inch) knotless cod end liner will be used to sample marine taxa across a broad range of size and age classes.

(3) Acoustic Telemetry: Revolution Wind will provide funding, equipment, and support to expand ongoing acoustic telemetry survey efforts in and in proximity to the RI/MA WEA. Partnering entities include the Massachusetts Division of Marine Fisheries, University of Massachusetts Dartmouth School for Marine Science and Technology, NOAA, Woods Hole Oceanographic Institution, the Nature Conservancy, INSPIRE

Environmental and the Anderson Cabot Center for Ocean Life (ACCOL) at the New England Aquarium. These efforts are monitoring the presence and persistence of Atlantic cod, highly migratory species (HMS), and other fish species of interest within and in proximity to MA/RI WEA. Revolution Wind has funded the purchase of six VR2W telemetry receivers to complement the existing receiver array, deployment of an additional 150 acoustic transmitters for HMS, and will fund and additional 5 years of data collection for these ongoing survey efforts.

(4) Benthic Monitoring: Revolution Wind will monitor impacts and changes to hard-bottom and soft-bottom habitat in response to construction disturbance and habitat modification. Hard bottom monitoring will focus on measuring changes in percent cover, species composition, and volume of macrofaunal attached communities using a combination of acoustic survey and remotely operated vehicle imaging techniques. Targeted high-resolution acoustic surveys (side-scan sonar [SSS] and multibeam echosounder [MBES]) will be conducted over the selected IAC corridors prior to boulder relocation and again after all construction is complete to map boulder locations within the survey areas. Survey areas will include existing undisturbed boulder distributions in selected areas adjacent to the IAC corridor to facilitate comparison between disturbed and undisturbed sites. Post-construction surveys will be compared to existing MBES and SSS data to identify the survey areas. Soft-bottom monitoring will employ sediment profile imaging and plan view (SPI/PV) survey techniques.

- Location: Stratified random selections of WTGs and cable segments within each stratum.
- Frequency:
    - Hard-bottom: Surveyed at 1-, 2-, 3-, and 5-years post-construction
    - Soft-bottom: WTG-associated sites surveyed at 1-, 2-, 3-, and 5-years post-construction; cable-associated surveyed at 1-, 2-, and 3-years post-construction, with additional years as needed if significant differences between reference and control sites are present in year 3.

These surveys involve similar methods to and would complement other survey efforts conducted by various state, federal, and university entities supporting regional fisheries research and management.

The scientific contractor will apply for a Magnuson-Stevens Fishery Conservation and Management Act (MSA) LOA or an Exempted Fishing Permit (EFP) from NOAA Fisheries in order to use the hired fishing vessels as a scientific platform and conduct scientific sampling that is not subject to the Atlantic Coastal Fisheries Cooperative Management Act, MSA, and fishery regulations in 50 CFR 648 and 697. All survey activities will be subject to rules and regulations outlined under the MMPA and ESA. Efforts will be taken to reduce marine mammal, sea turtle, and seabird injuries and mortalities caused by incidental interactions with sampling gear. All gear restrictions, closures, and other regulations set forth by take reduction plans (e.g., Harbor Porpoise Take Reduction Plan, Atlantic Large Take Whale Reduction Plan, etc.) will be adhered to as with typical scientific fishing operations to reduce the potential for interaction or injury. The requirements described in the Atlantic Large Whale Take Reduction Plan (NOAA 2021a) for the trap and pot fisheries will be followed. At a minimum, the following measures will be used to avoid interactions between the ventless trap survey and marine mammals:

- No buoy line will be floating at the surface.
- All sampling gear will be hauled at least once every 30 days, and all gear will be removed from the water at the end of each sampling season (November).
- All groundlines will be constructed of sinking line.
- Fishermen contracted to perform the field work will be encouraged to use knot-free buoy lines.
- To reduce the potential for moderate or significant risk to right whales (should an entanglement occur) buoy/end lines with a breaking strength of <1,700 pounds will be used. All buoy lines will use weak links that are chosen from the list of NMFS approved gear. This may be accomplished by using whole buoy line that has a breaking strength of 1,700 pounds; or buoy line with weak inserts that result in line having an overall breaking strength of 1,700 pounds.
- All buoys will be labeled as research gear, and the scientific permit number will be written on the buoy. All markings on the buoys and buoy lines will be compliant with the regulations, and all buoy markings will comply with instructions received by staff at NOAA Greater Atlantic Regional Fisheries Office Protected Resources Division.
- Any lines or trawls that go missing will be reported to the NOAA Greater Atlantic Regional Fisheries Office Protected Resources Division as soon as possible.

3.4 Description of Impact Producing Factors

Impact Producing Factors (IPFs) have been identified for activities related to construction and installation, O&M, and decommissioning of the project. Listed species exposure to these IPFs and severity of effects are discussed in Section 5. Table 3.17 identifies the IPFs relevant to project construction and installation, O&M, and decommissioning that are likely to contribute to adverse effects on one or more listed species, the associated project phases and duration of those effects, and their definable geographic extent and identifies the sub-section in Section 5 where the analysis of the effects of the IPF are provided.

Table 3.17. Project Activities, Associated IPFs and Location of Discussion in Section 5.

Impact Producing Factor	Sub-Section where Effects Analysis is provided in Section 5	Occurrence and Duration for Pre-construction Project Phase‡	Occurrence and Duration for Construction Project Phase‡	Occurrence and Duration for O&M Project Phase‡	Occurrence and Duration for Decommissioning Project Phase‡	Geographic Extent and Severity of Effects Contributing to Likely to Adversely Affect Determination: Whales	Geographic Extent and Severity of Effects Contributing to Likely to Adversely Affect Determination: Sea Turtles	Geographic Extent and Severity of Effects Contributing to Likely to Adversely Affect Determination: Marine Fish
Underwater noise – Impact pile driving	5.1.1	--	ST	--	--	Low frequency cetaceans (LFCs) Hearing injury: 33 to 8,727 feet from source Behavioral/auditory masking effects: 11,516 to 12,336 feet from source Mid-frequency cetaceans (MFCs) Hearing injury: N/A Behavioral/auditory masking effects: 12,041 feet from source	All species Hearing injury: 0 to 820 feet from source Behavioral effects: 1,903 to 3,182feet from source	Atlantic sturgeon Hearing injury: 3,458 feet from source Behavioral effects: 14,403 to 34,987 feet from source Giant manta ray Hearing injury: 354 to 3,458 feet from source Behavioral effects: 14,403 to 34,987 feet from source
Underwater noise – Vibratory pile driving	5.1.2	--	ST	--	--	Discountable	All species Hearing injury: 102 feet from source (assuming 24 hours of exposure) Behavioral effects: 175 feet from source	Atlantic sturgeon Hearing injury: Unlikely to occur Behavioral effects: 2.556 feet from source Giant manta ray Hearing injury: Unlikely to occur Behavioral effects: 2,225 feet from source
Underwater noise – Geotechnical and geophysical surveys	5.1.3	ST	ST	--	--	Discountable	Discountable	Atlantic sturgeon and Giant manta ray Hearing injury: Discountable Behavioral effects: 16 to 2,572
Underwater noise – Cable laying	5.1.4	--	ST	--	--	LFCs Hearing injury: 367 feet from source (24-hour exposure) Behavioral/auditory masking effects: 48,077 feet from source MFCs Hearing injury: 115 feet from source (24-hour exposure) Behavioral/auditory masking effects: 44,236 feet from source	All species Hearing injury: Unlikely to occur Behavioral effects: Unlikely to occur	Atlantic sturgeon Hearing injury: Unlikely to occur Behavioral effects: 443 feet from source Giant manta ray Hearing injury: Unlikely to occur Behavioral effects: 443 feet from source
Other noise impacts – Vessels	5.2.1	ST	ST	Pi	ST			
Other noise impacts – UXO detonation	5.1.1, 5.9.4	ST	--	--	--	LFCs Hearing injury: 466 to 14,009 feet from source Behavioral/masking effects: 8,629 to 44,291 feet from source MFCs Hearing injury: 138 to 1,755 feet from source Behavioral/masking effects: ,243 to 9,613 feet from source	All species Hearing injury: 689 to 1,699 feet from source Behavioral effects: 8,235 feet from source	All species Hearing injury: 161 to 951 feet
Other noise impacts – Helicopters	5.2.2	--	ST	Pi	ST	Insignificant	Insignificant	Not applicable
Other noise impacts – WTGs	5.2.3	--	--	Pc	--	All species Behavioral/auditory masking effects: Up to 120 feet from source	Insignificant	Insignificant
Vessel traffic – Strike risk	5.3.1	ST	ST	Pi	ST	All species 23 percent increase in mid- to large-size vessel traffic relative to action area baseline during construction and installation and decommissioning Minimal increase in vessel trips relative to action area baseline during O&M		Insignificant
Vessel traffic – Discharges and emissions	5.3.2	ST	ST	Pi	ST	Insignificant	Insignificant	Insignificant
Habitat disturbance – Geotechnical and geophysical surveys	5.4.1	ST	--	--	--	Insignificant	Insignificant	Insignificant

Impact Producing Factor	Sub-Section where Effects Analysis is provided in Section 5	Occurrence and Duration for Pre-construction Project Phase‡	Occurrence and Duration for Construction Project Phase‡	Occurrence and Duration for O&M Project Phase‡	Occurrence and Duration for Decommissioning Project Phase‡	Geographic Extent and Severity of Effects Contributing to Likely to Adversely Affect Determination: Whales	Geographic Extent and Severity of Effects Contributing to Likely to Adversely Affect Determination: Sea Turtles	Geographic Extent and Severity of Effects Contributing to Likely to Adversely Affect Determination: Marine Fish
Habitat disturbance – Fisheries and habitat surveys and monitoring	5.4.2	ST	ST	LT	ST	Non-discountable risk of entanglement injury, but insignificant relative to action area baseline	Non-discountable risk of injury or mortality from entanglement	Non-discountable risk of incidental bycatch mortality
Habitat disturbance – Habitat conversion and loss	5.4.3	ST	ST-LT	P	LT	Insignificant	Insignificant	Insignificant0
Habitat disturbance – Turbidity	5.4.4	--	ST	ST	ST	Insignificant	Insignificant	Insignificant
Habitat disturbance – Physical presence of structures	5.4.5, 5.4.6	--	ST	Pc	ST	Reef and hydrodynamic effects associated with 102 offshore structures. Geographic extent of effects may range from localized within the RWF maximum work area to area-wide shifts in planktonic forage distribution.	Reef and hydrodynamic effects associated with 102 offshore structures. Geographic extent of effects may range from localized within the RWF maximum work area to area-wide shifts in planktonic forage distribution.	Reef and hydrodynamic effects associated with 102 offshore structures. Geographic extent of effects may range from localized within the RWF maximum work area to area-wide shifts in planktonic forage distribution.
Habitat disturbance – Electromagnetic field and substrate heating effects	5.4.7	--	--	Pc	--	Insignificant and discountable	Insignificant	Insignificant and/or discountable
Habitat disturbance – Lighting effects	5.4.8	ST	ST	Pc	ST	Insignificant	Insignificant	Insignificant
Habitat disturbance – OSS water withdrawal/entrainment effects	5.4.9	--	--	--	--	No water withdrawals proposed for substation operations	No water withdrawals proposed for substation operations	No water withdrawals proposed for substation operations
Air emissions – Vessels	5.5.1	ST	ST	Pi	ST	Insignificant and discountable	Insignificant and discountable	Not applicable
Air emissions – Foundation installation	5.5.2	--	ST	--	--	Insignificant and discountable	Insignificant and discountable	Not applicable
Port modifications	5.6	--	--	--	--	No port modifications are proposed for O&M facility development	No port modifications are proposed for O&M facility development	No port modifications are proposed for O&M facility development
Other effects – Shifts or displacement of other ocean users	5.8.1	ST	ST	Pc	ST	Unknown	Unknown	Unknown
Unanticipated events – Foundation failure	5.9.1, 5.9.2	--	--	ST	--	Discountable	Discountable	Discountable
Unanticipated Events – Oil spills and chemical releases	5.9.3	--	--	ST	--	Discountable	Discountable	Discountable

‡ Duration definitions: -- = does not occur during project phase; ST = short-term effect (<2 years); LT = long-term effect (>2 years); Pi = permanent (life of project), intermittent; Pc = permanent, continuous.

3.5 Environmental Protection and Mitigation Measures

The Proposed Action would employ site-specific design criteria to avoid and minimize environmental impacts, including impacts to federally protected species and their designated critical habitat. Many of the design criteria include the development of BMPs related to project construction and installation, and O&M activities. These measures, which are considered part of the Proposed Action, are referred to as environmental protection measures (EPMs). EPMs proposed by Revolution Wind are summarized in Table 3.18.

In addition to EPMs, BOEM has identified additional mitigation measures that will be required to avoid and minimize impacts to ESA-listed species. Other regulatory agencies (i.e., USACE, NMFS, USFWS) may impose additional measures to avoid and minimize environmental impacts through the permitting and regulatory process. These measures and associated reporting requirements, where relevant, are identified in Table 3.19.

Table 3.18. EPMs Included as Part of the Proposed Action Relevant to Avoidance and Minimization of Adverse Impacts to ESA-listed Species and Habitats.

EPM Number	Proposed Project Phase	EPM	Description	Resource Area Affected	BOEM's Identification of the Anticipated Enforcing Agency	Expected Effects
Provided in COP Table 4.7-2						
Fin-1	Construction and installation	Cable burial risk assessment	To the extent feasible, installation of the IAC, OSS-link cable, and RWEC will occur using equipment such as mechanical cutter, mechanical plow, or jet plow. The feasibility of cable burial equipment will be determined based on an assessment of sea floor conditions and the Cable Burial Risk Assessment.	Finfish and essential fish habitat	Revolution Wind	This measure would minimize the footprint and disturbance to benthic habitat required for installation of the IAC, OSS-link cable and RWEC.
Fin-2	Construction and installation	TOY restrictions	Based on the coordination with RIDEM and NOAA NMFS to date, in general, offshore site preparation for and installation of the RWEC-RI north of the Convention on the International Regulations for Preventing Collisions at Sea ("COLREGS") line of demarcation will occur between the day after Labor Day and February 1 to avoid and minimize impacts to winter flounder (*Pseudopleuronectes americanus*) and shellfish. Revolution Wind will continue to coordinate with RIDEM and NOAA NMFS regarding TOY restrictions through the permitting process and will adhere to requirements imposed by these agencies.	Finfish and essential fish habitat	Revolution Wind	TOY restrictions would avoid and minimize construction and installation related impacts to protected species.
Fin-3, MM-8, and ST-8	Construction and installation	Cable burial risk assessment	To the extent feasible, the RWEC, IAC, and OSS-link cable will typically target a burial depth of 4 to 6 feet (1.2 to 1.8 m) below sea floor. The target burial depth will be determined based on an assessment of sea floor conditions, sea floor mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a site-specific Cable Burial Risk Assessment.	Finfish and essential fish habitat	Revolution Wind	Cable burial will minimize risk to the RWEC, IAC and OSS-Line cables, as well as minimize potential EMF related effects on benthic oriented species.
Fin-4	Construction and installation	Cable burial risk assessment	DP vessels will be used for installation of the IACs, OSS-link cable, and RWEC to the extent practicable.	Finfish and essential fish habitat	Revolution Wind	DP vessels will not require anchoring, which will avoid impacts to benthic habitats and benthic oriented species and
Fin-5	Preconstruction	Anchoring plan	A plan for vessels will be developed prior to construction to identify no-anchorage areas to avoid documented sensitive resources.	Finfish and essential fish habitat	Revolution Wind	Will minimize and avoid impacts to sensitive habitats and species associated with those habitats.
Fin-6	Preconstruction, construction and installation, and post-construction	Fisheries and benthic monitoring studies	Revolution Wind is committed to collaborative science with the commercial and recreational fishing industries pre-, during, and post-construction. Fisheries and benthic monitoring studies are being planned to assess the impacts associated with the Project on economically and ecologically important fisheries resources. These studies will be conducted in collaboration with the local fishing industry and will build upon monitoring efforts being conducted by affiliates of Revolution Wind at other wind farms in the region.	Finfish and essential fish habitat	Revolution Wind	Will ensure impacts to commercially important fisheries, as well as protected species, are avoided and minimized.
Fin-7, MM-5, and ST-5	Construction and installation, O&M, and decommissioning	Spill prevention and control measures	Revolution Wind will require all construction and operations vessels to comply with regulatory requirements related to the prevention and control of spills and discharges.	Finfish and essential fish habitat	Revolution Wind	Will reduce the risk of a spill and environmental exposure to potentially harmful materials
Fin-8, MM-6, and ST-6	Construction and installation, O&M, and decommissioning	OSRP	Accidental spill or release of oils or other hazardous materials will be managed through the OSRP.	Finfish and essential fish habitat	Revolution Wind	Will reduce the risk of a spill and environmental exposure to potentially harmful materials

EPM Number	Proposed Project Phase	EPM	Description	Resource Area Affected	BOEM's Identification of the Anticipated Enforcing Agency	Expected Effects
Fin-9	Construction and installation	Soft start before pile driving	A ramp-up or soft start will be used at the beginning of each pile segment during impact pile driving and/or vibratory pile driving to provide additional protection to mobile species in the vicinity by allowing them to vacate the area prior to the commencement of pile-driving activities.	Finfish and essential fish habitat	Revolution Wind	Will avoid and minimize potential impacts from underwater noise, providing time for protected species to move away from pile driving activities.
Fin-10	Construction and installation and O&M	Lighting minimization	Construction and operational lighting will be limited to the minimum necessary to ensure safety and compliance with applicable regulations.	Finfish and essential fish habitat	Revolution Wind	Will avoid and minimize potential distribution, behavioral and habitat use related effects associated with artificial lighting.
Fin-11, MM-7, and ST-7	Construction and installation, O&M, and decommissioning	Marine debris awareness training	All vessels will comply with USCG and EPA regulations that require operators to develop waste management plans, post informational placards, manifest trash sent to shore, and use special precautions such as covering outside trash bins to prevent accidental loss of solid materials. Vessels will also comply with BOEM lease stipulations that require adherence to NTL 2015-G03, which instructs operators to exercise caution in the handling and disposal of small items and packaging materials, requires the posting of placards at prominent locations on offshore vessels and structures, and mandates a yearly marine trash and debris awareness training and certification process.	Finfish and essential fish habitat	Revolution Wind	Will avoid and minimize potential effects related to discharge of waste and debris.
Fin-12	Construction and installation	TOY restrictions	Revolution Wind will continue to coordinate with RIDEM and NOAA NMFS regarding TOY restrictions through the permitting process and will adhere to requirements imposed by these agencies.	Finfish and essential fish habitat	Revolution Wind	TOY restrictions would avoid and minimize construction and installation related impacts to protected species.
Fin-13, MM-9, and ST-9	Construction and installation, post-construction and installation monitoring	Gear identification	To facilitate identification of gear on any entangled animals, all trap/pot gear used in the surveys would be uniquely marked to distinguish it from other commercial or recreational gear.	Finfish and essential fish habitat	Revolution Wind, BOEM, BSEE, and NMFS	Will support efforts to ensure project-related surveys are not resulting in entanglements of protected species.
Ben-8	Construction and installation	Submerged aquatic vegetation (SAV) study	A preconstruction SAV survey will be completed to identify any new or expanded SAV beds. The Project design will be refined to avoid impacts to SAV to the greatest extent practicable.	Benthic habitat and invertebrates	Revolution Wind	Avoid and minimize impacts to sensitive habitats.
MM-1	Construction and installation	Establishment of exclusion and monitoring zones for impact pile driving	Exclusion and monitoring zones for marine mammals and sea turtles will be established for impact and vibratory pile-driving activities.	Marine mammals	Revolution Wind	Avoid and minimize impacts to protected species during project activities.
MM-2, and ST-2	Construction and installation	Impact and vibratory pile-driving mitigation measures	The following measures will be implemented for impact and vibratory pile-driving activities. These measures will include seasonal restrictions, soft-start measures, shutdown procedures, marine mammal and sea turtle monitoring protocols, the use of qualified and National Oceanic and Atmospheric Administration (NOAA)-approved Protected Species Observers, and noise attenuation systems such as bubble curtains, as appropriate.	Marine mammals	Revolution Wind	Avoid and minimize impacts to protected species during project activities.
MM-3, and ST-3	Construction and installation, O&M, and decommissioning	Vessel speed restrictions	Vessels will follow NOAA guidelines for marine mammal and sea turtle strike avoidance measures, including vessel speed restrictions.	Marine mammals	Revolution Wind	Avoid and minimize impacts to protected species during project activities.
MM-4, and ST-4	Construction and installation, O&M, and decommissioning	Marine mammal, sea turtle, and marine debris awareness training	All personnel working offshore will receive training on marine mammal and sea turtle awareness and marine debris awareness.	Marine mammals	Revolution Wind	Avoid and minimize impacts to protected species during project activities.

EPM Number	Proposed Project Phase	EPM	Description	Resource Area Affected	BOEM's Identification of the Anticipated Enforcing Agency	Expected Effects
MM-10	Construction and installation and post-construction and installation	MMPA application measures	Revolution Wind is committed to minimizing impacts to marine mammal species through a comprehensive monitoring and mitigation program. The mitigation measures identified in the MMPA petition for ITR to be implemented include, but are not limited to, the following: 1. Noise attenuation through use of a noise mitigation system; 2. Seasonal restrictions; 3. Standard PSO training and equipment requirements; 4. Visual monitoring; including low visibility monitoring tools; 5. Passive acoustic monitoring; 6. Establishment and monitoring of shutdown zones 7. Pre-start clearance; 8. Ramp-up (soft-start) procedures; 9. Operations monitoring; 10. Operational shutdowns and delay; 11. Sound source measurements of at least one foundation installation 12. Survey sighting coordination; 13. Vessel strike avoidance procedures; and 14. Data recording and reporting procedures.	Marine mammals	BOEM and BSEE	Collectively these measures minimize the potential for adverse effects to ESA listed species through defining and implementing monitoring and shutdown protocols.
ST-1	Construction and installation	Establishment of exclusion and monitoring zones for impact pile driving	Shutdown and clearance zones for marine mammals and sea turtles will be established for impact and vibratory pile-driving activities.	Sea turtles	Revolution Wind	Establishing shutdown and clearance zones will avoid and minimize impacts to protected sea turtles.

* For additional details on these mitigation and monitoring measures refer to Appendix B, Protected Species Mitigation and Monitoring Plan

Table 3.19. Additional Mitigation, Monitoring and Reporting Measures Required by BOEM.

Mitigation, Monitoring and Reporting Measure Number	Proposed Project Phase	Mitigation or Monitoring Measure	Description	Expected Effect
1	Construction and installation, O&M, and decommissioning	Marine debris awareness training	The Lessee would ensure that vessel operators, employees, and contractors engaged in offshore activities pursuant to the approved COP complete marine trash and debris awareness training annually. The training consists of two parts: (1) viewing a marine trash and debris training video or slide show (described below); and (2) receiving an explanation from management personnel that emphasizes their commitment to the requirements. The marine trash and debris training videos, training slide packs, and other marine debris related educational material may be obtained at https://www.bsee.gov/debris or by contacting BSEE. The training videos, slides, and related material may be downloaded directly from the website. Operators engaged in marine survey activities would continue to develop and use a marine trash and debris awareness training and certification process that reasonably assures that their employees and contractors are in fact trained. The training process would include the following elements: • Viewing of either a video or slide show by the personnel specified above; • An explanation from management personnel that emphasizes their commitment to the requirements; • Attendance measures (initial and annual); and • Recordkeeping and the availability of records for inspection by DOI. By January 31 of each year, the Lessee would submit to DOI an annual report that describes its marine trash and debris awareness training process and certifies that the training process has been followed for the previous calendar year. The Lessee would send the reports via email to BOEM (at renewable_reporting@boem.gov) and to BSEE (at marinedebris@bsee.gov).	Decrease the loss of marine debris which may represent entanglement and/ingestion risk
2	Construction and installation	Marine debris elimination	Marking: Materials, equipment, tools, containers, and other items used in OCS activities which are of such shape or properly secured to prevent loss overboard. All markings must clearly identify the owner and must be durable enough to resist the effects of the environmental conditions to which they may be exposed.	Decrease the loss of marine debris which may represent entanglement and/ingestion risk
3	Construction and installation	Incorporate MMPA requirements	The measures required by the final MMPA ITR would be incorporated into COP approval, and BOEM and/or BSEE will monitor compliance with these measures.	Incorporation of mitigation measures designed to reduce impacts to listed and non-listed marine mammals
4	Construction, O&M, and decommissioning	Passive acoustic monitoring (PAM)	Use PAM buoys or autonomous PAM devices to record ambient noise, marine mammals, and cod vocalizations in the Lease Area before, during, and immediately after construction (at least 3 years of operation) to monitor Project noise. The archival recorders must have a minimum capability of detecting and storing acoustic data on anthropogenic noise sources (such as vessel noise, pile driving, WTG operation, and whale detections), marine mammals, and cod vocalizations in the Lease Area. Monitoring would also occur during the decommissioning phase. 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 to accomplish both monitoring during constructions, and also meet post-construction monitoring needs. Results must be provided within 90 days of construction completion and again within 90 days of the 1-year, 2-year, and 3-year anniversary of collection. The underwater acoustic monitoring must follow standardized measurement and processing methods and visualization metrics developed by the Atlantic Deepwater Ecosystem Observatory Network (ADEON) for the U.S. Mid- and South Atlantic OCS (see https://adeon.unh.edu/). At least two buoys must be independently deployed within or bordering the Lease Area or one or more buoys must be deployed in coordination with other acoustic monitoring efforts in the RI/MA and MA WEAs.	Incorporation of mitigation measures designed to reduce Project noise impacts to listed and non-listed marine mammals and fish
5	Construction and installation	PAM plan	BOEM, BSEE, and USACE would ensure that Revolution Wind prepares a PAM Plan that describes all proposed equipment, deployment locations, detection review methodology and other procedures, and protocols related to the required use of PAM for monitoring. This plan would be submitted to NMFS, BOEM and BSEE (at OSWsubmittals@bsee.gov) for review and concurrence at least 90 days prior to the planned start of pile driving.	Ensure the efficacy of PAM placement for appropriate monitoring
6	Construction and installation	Pile driving monitoring plan	BOEM would ensure that Revolution Wind prepare and submit a *Pile Driving Monitoring Plan* to NMFS and BSEE (at OSWsubmittals@bsee.gov) for review and concurrence at least 90 days before start of pile driving. As part of the plan, no pile installation will occur from January 1 to April 30 to avoid times of year when NARW are present in higher densities in the project action area.	Ensure adequate monitoring and mitigation is in place during pile driving.
7	Construction and installation	PSO coverage	BOEM, BSEE, and USACE would ensure that PSO coverage is sufficient to reliably detect marine mammals and sea turtles at the surface in clearance and shutdown zones to execute any pile driving delays or shutdown requirements. If, at any point prior to or during construction, the PSO coverage that is included as part of the proposed action is determined not to be sufficient to reliably detect ESA-listed whales and sea turtles within the clearance and shutdown zones, additional PSOs and/or platforms would be deployed. Determinations prior to construction would be based on review of the *Pile Driving Monitoring Plan*. Determinations during construction would be based on review of the weekly pile driving reports and other information, as appropriate.	Ensure adequate monitoring zones

Mitigation, Monitoring and Reporting Measure Number	Proposed Project Phase	Mitigation or Monitoring Measure	Description	Expected Effect
8	Construction and installation	Shutdown and clearance zones for marine mammals	Per the petition for ITR, the following summer and winter shutdown zones were requested for WTG and OSS installation, assuming a summer (April – November) and winter (December – March) sound speed profile determined from the modeling conducted by LGL (2022a): WTG [and OSS] summer distances – April – November: Mysticete whales (LFCs): 2,300 m [1,600 m] NARW visual detection: any distance [same] NARW acoustic detection:3,900 m [4,100 m] Sperm whale: 2,300m [1,600 m] WTG [and OSS] winter distances – December – March: Mysticete whales (LFCs): 4,400 m [2,700 m] NARW visual detection: any distance [same] NARW acoustic detection:4,400 m [4,700m] Sperm whale: 4,400m [2,700] *Note that shutdown zones and clearance zones are the same. Also, marine mammal shutdown zones would be applied to sea turtles.*	Ensures that shutdown and clearance zones are sufficiently conservative.
9	Construction and installation	Sound field verification	BOEM, BSEE, and USACE would ensure that if the clearance and/or shutdown zones are expanded, PSO coverage is sufficient to reliably monitor the expanded clearance and/or shutdown zones. Additional observers would be deployed on additional platforms for every 1,500 m that a clearance or shutdown zone is expanded beyond the distances modeled prior to verification. To validate the estimated sound field, sound field verification measurements will be conducted during pile driving of the first three monopiles installed over the course of the Project, with noise attenuation activated. A Sound Field Verification Plan will be submitted to NMFS, BOEM, and BSEE for review and approval at least 90 days prior to planned start of pile driving. This plan will describe how Revolution Wind will ensure that the first three monopile installation sites selected for sound field 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 sound field verification. This plan will also include methodology for collecting, analyzing, and preparing SFV data for submission to NMFS. The plan will describe how the effectiveness of the sound attenuation methodology will be evaluated based on the results. In the event that Revolution Wind obtains technical information that indicates a subsequent monopile is likely to produce larger sound fields, SFV will be conducted for those subsequent monopiles.	Ensure adequate monitoring of clearing zones
10	Construction and installation	Shutdown zones and clearance zone adjustment	BOEM, BSEE, and NMFS may consider adjustments in the pre-start clearance and/or shutdown zones based on the initial sound field verification (SFV) measurements. Revolution Wind will provide the initial results of the SFV measurements to NMFS in an interim report after each monopile installation for the first three piles as soon as they are available but no later than 48 hours after each installation. Revolution Wind will conduct a SFV to empirically determine the distances to the isopleths corresponding to Level A harassment and Level B harassment thresholds, including at the locations corresponding to the modeled distances to the Level A harassment and Level B harassment thresholds. If initial SFV measurements indicate distances to the isopleths are less than the distances predicted by modeling assuming 10-dB attenuation, Revolution Wind may request a modification of the clearance and shutdown zones for impact pile driving. For a modification request to be considered by NMFS, Revolution Wind must have conducted SFV on at least three piles to verify that zone sizes are consistently smaller than predicted by modeling. If initial SFV measurements indicate distances to the isopleths are greater than the distances predicted by modeling, Revolution Wind will implement additional sound attenuation measures prior to conducting additional pile driving. Additional measures may include improving the efficacy of the implemented noise attenuation technology and/or modifying the piling schedule to reduce the sound source. If modeled zones cannot be achieved by these corrective actions, Revolution Wind will install an additional noise mitigation system 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.	Ensures that shutdown and clearance zones are sufficiently conservative.
11	Construction and installation	Clearance zone for sea turtles	BOEM, BSEE, and USACE would ensure that Revolution Wind monitors the full extent of the area where noise would exceed the 175 dB re 1 μPa^2 threshold for sea turtles for the full duration of all pile driving activities and for 30 minutes following the cessation of pile driving activities and record all observations in order to ensure that all take that occurs is documented.	Ensures adequate monitoring of sea turtle take
12	Construction and installation, O&M, and decommissioning	Reporting of all NARW sightings	If a NARW is observed at any time by PSOs or personnel on any Project vessels, during any Project-related activity or during vessel transit, Revolution Wind must report the sighting information to NMFS as soon as feasible and no later than within 24 hours after conclusion of the detection event (the time, location, and number of animals) via the WhaleAlert app (http://www.whalealert.org/); NMFS Right Whale Sighting Advisory System hotline (phone).	Ensures adequate monitoring and reporting of NARW sightings

Mitigation, Monitoring and Reporting Measure Number	Proposed Project Phase	Mitigation or Monitoring Measure	Description	Expected Effect
13	Construction and installation, O&M, and decommissioning	Vessel strike avoidance measures for sea turtles	Between June 1 and November 30, Revolution Wind would have a trained lookout posted on all vessel transits during all phases of the Project to observe for sea turtles. The trained lookout would communicate any sightings, in real time, to the captain so that the requirements in (e) below can be implemented. a. The trained lookout would monitor https://seaturtlesightings.org/ prior to each trip and report any observations of sea turtles in the vicinity of the planned transit to all vessel operators/captains and lookouts on duty that day. b. The trained lookout would maintain a vigilant watch and monitor a Vessel Strike Avoidance Zone (500 m) at all times to maintain minimum separation distances from ESA-listed species. Alternative monitoring technology (e.g., night vision, thermal cameras, etc.) would be available to ensure effective watch at night and in any other low visibility conditions. If the trained lookout is a vessel crew member, this would be their designated role and primary responsibility while the vessel is transiting. Any designated crew lookouts would receive training on protected species identification, vessel strike minimization procedures, how and when to communicate with the vessel captain, and reporting requirements. c. If a sea turtle is sighted within 100 m or less of the operating vessel's forward path, the vessel operator would slow down to 4 knots (unless unsafe to do so) and then proceed away from the turtle at a speed of 4 knots or less until there is a separation distance of at least 100 m at which time the vessel may resume normal operations. If a sea turtle is sighted within 50 m of the forward path of the operating vessel, the vessel operator would shift to neutral when safe to do so and then proceed away from the turtle at a speed of 4 knots. The vessel may resume normal operations once it has passed the turtle. d. Vessel captains/operators would avoid transiting through areas of visible jellyfish aggregations or floating sargassum lines or mats. In the event that operational safety prevents avoidance of such areas, vessels would slow to 4 knots while transiting through such areas. e. All vessel crew members would be briefed in the identification of ESA-listed species of sea turtles and in regulations and best practices for avoiding vessel collisions. Reference materials would be available aboard all Project vessels for identification of sea turtles. The expectation and process for reporting of sea turtles (including live, entangled, and dead individuals) would be clearly communicated and posted in highly visible locations aboard all Project vessels, so that there is an expectation for reporting to the designated vessel contact (such as the lookout or the vessel captain), as well as a communication channel and process for crew members to do so. f. The only exception is when the safety of the vessel or crew necessitates deviation from these requirements on an emergency basis. If any such incidents occur, they must be reported to NMFS and BSEE within 24 hours. g. If a vessel is carrying a PSO or trained lookout for the purposes of maintaining watch for North Atlantic right whales (NARW), an additional lookout is not required and this PSO or trained lookout must maintain watch for whales, giant manta rays, and sea turtles.	Minimizes risk of vessel strikes to sea turtles
14	Construction and installation	Sampling gear	All sampling gear would be hauled out at least once every 30 days, and all gear would be removed from the water and stored on land between survey seasons to minimize risk of entanglement.	Minimizes risk of entanglement
15	Construction and installation	Lost survey gear	If any survey gear is lost, all reasonable efforts that do not compromise human safety would be undertaken to recover the gear. All lost gear would be reported to NMFS (nmfs.gar.incidental-take@noaa.gov) and BSEE (OSWIncidentReporting@bsee.gov) within 24 hours of the documented time of missing or lost gear. This report would include information on any markings on the gear and any efforts undertaken or planned to recover the gear.	Promotes recovery of lost gear
16	Construction and installation	Training	At least one of the survey staff onboard the trawl surveys and ventless trap surveys would have completed NEFOP observer training (within the last 5 years) or other training in protected species identification and safe handling (inclusive of taking genetic samples from Atlantic sturgeon). Reference materials for identification, disentanglement, safe handling, and genetic sampling procedures would be available on board each survey vessel. BOEM and BSEE would ensure that Revolution Wind prepares a training plan that addresses how this requirement would be met and that the plan is submitted to NMFS in advance of any trawl or trap surveys. This requirement is in place for any trips where gear is set or hauled.	Promotes proper identification and handling of protected species.
17	Construction and installation	Sea turtle disentanglement	Vessels deploying fixed gear (e.g., pots/traps) would have adequate disentanglement equipment (i.e., knife and boathook) onboard. Any disentanglement would occur consistent with the Northeast Atlantic Coast STDN Disentanglement Guidelines at https://www.reginfo.gov/public/do/DownloadDocument?objectID=102486501 and the procedures described in "Careful Release Protocols for Sea Turtle Release with Minimal Injury" (NOAA Technical Memorandum 580; https://repository.library.noaa.gov/view/noaa/3773).	Requires disentanglement of sea turtles caught in gear

Mitigation, Monitoring and Reporting Measure Number	Proposed Project Phase	Mitigation or Monitoring Measure	Description	Expected Effect
18	Construction and installation	Sea turtle/Atlantic sturgeon identification and data collection	Any sea turtles or Atlantic sturgeon caught and/or retrieved in any fisheries survey gear would first be identified to species or species group. Each ESA-listed species caught and/or retrieved would then be properly documented using appropriate equipment and data collection forms. Biological data, samples, and tagging would occur as outlined below. Live, uninjured animals should be returned to the water as quickly as possible after completing the required handling and documentation. a. The Sturgeon and Sea Turtle Take Standard Operating Procedures would be followed (https://media.fisheries.noaa.gov/dammigration/sturgeon_&_sea_turtle_take_sops_external.pdf). b. Survey vessels would have a passive integrated transponder (PIT) tag reader onboard capable of reading 134.2 kHz and 125 kHz encrypted tags (e.g., Biomark GPR Plus Handheld PIT Tag Reader) and this reader be used to scan any captured sea turtles and sturgeon for tags. Any recorded tags would be recorded on the take reporting form (see below). c. Genetic samples would be taken from all captured Atlantic sturgeon (alive or dead) to allow for identification of the DPS of origin of captured individuals and tracking of the amount of incidental take. This would be done in accordance with the Procedures for Obtaining Sturgeon Fin Clips (https://media.fisheries.noaa.gov/dammigration/ sturgeon_genetics_sampling_revised_june_2019.pdf). a. Fin clips would be sent to a NMFS approved laboratory capable of performing genetic analysis and assignment to DPS of origin. To the extent authorized by law, BOEM is responsible for the cost of the genetic analysis. Arrangements would be made for shipping and analysis in advance of submission of any samples; these arrangements would be confirmed in writing to NMFS within 60 days of the receipt of this ITS. Results of genetic analysis, including assigned DPS of origin would be submitted to NMFS within 6 months of the sample collection. b. Subsamples of all fin clips and accompanying metadata forms would be held and submitted to a tissue repository (e.g., the Atlantic Coast Sturgeon Tissue Research Repository) on a quarterly basis. The Sturgeon Genetic Sample Submission Form is available for download at: https://www.fisheries.noaa.gov/new-england- midatlantic/consultations/section-7-take-reporting-programmaticsgreater-atlantic). d. All captured sea turtles and Atlantic sturgeon would be documented with required measurements and photographs. The animal's condition and any marks or injuries would be described. This information would be entered as part of the record for each incidental take. A NMFS Take Report Form would be filled out for each individual sturgeon and sea turtle (download at: https://media.fisheries.noaa.gov/2021-41507/Take%20Report%20Form%20 07162021.pdf?null) and submitted to NMFS as described below.	Requires standard data collection and documentation of any sea turtle/Atlantic sturgeon caught during surveys

Mitigation, Monitoring and Reporting Measure Number	Proposed Project Phase	Mitigation or Monitoring Measure	Description	Expected Effect
19	Construction and installation	Sea turtle/Atlantic sturgeon handling and resuscitation guidelines	Any sea turtles or Atlantic sturgeon caught and retrieved in gear used in fisheries surveys would be handled and resuscitated (if unresponsive) according to established protocols and whenever at-sea conditions are safe for those handling and resuscitating the animal(s) to do so. Specifically: a. Priority would be given to the handling and resuscitation of any sea turtles or sturgeon that are captured in the gear being used, if conditions at sea are safe to do so. Handling times for these species should be minimized (i.e., kept to 15 minutes or less) to limit the amount of stress placed on the animals. b. All survey vessels would have copies of the sea turtle handling and resuscitation requirements found at 50 CFR 223.206(d)(1) prior to the commencement of any on-water activity (download at: https://media.fisheries.noaa.gov/ dammigration/sea_turtle_handling_and_resuscitation_measures.pdf). These handling and resuscitation procedures would be carried out any time a sea turtle is incidentally captured and brought onboard the vessel during the proposed actions. c. If any sea turtles that appear injured, sick, or distressed, are caught and retrieved in fisheries survey gear, survey staff would immediately contact the Greater Atlantic Region Marine Animal Hotline at 866-755-6622 for further instructions and guidance on handling the animal, and potential coordination of transfer to a rehabilitation facility. If unable to contact the hotline (e.g., due to distance from shore or lack of ability to communicate via phone), the USCG should be contacted via VHF marine radio on Channel 16. If required, hard-shelled sea turtles (i.e., non- leatherbacks) may be held on board for up to 24 hours following handling instructions provided by the Hotline, prior to transfer to a rehabilitation facility. d. Attempts would be made to resuscitate any Atlantic sturgeon that are unresponsive or comatose by providing a running source of water over the gills as described in the Sturgeon Resuscitation Guidelines (https://media.fisheries.noaa.gov/dammigration-miss/Resuscitation-Cards-120513.pdf). e. Provided that appropriate cold storage facilities are available on the survey vessel, following the report of a dead sea turtle or sturgeon to NMFS, and if NMFS requests, any dead sea turtle or Atlantic sturgeon would be retained on board the survey vessel for transfer to an appropriately permitted partner or facility on shore as safe to do so. f. Any live sea turtles or Atlantic sturgeon caught and retrieved in gear used in any fisheries survey would ultimately be released according to established protocols and whenever at-sea conditions are safe for those releasing the animal(s) to do so.	Ensures the safe handling and resuscitation of sea turtles and Atlantic sturgeon following established protocols
20	Construction and installation	Take notification	GARFO PRD would be notified as soon as possible of all observed takes of sea turtles, and Atlantic sturgeon occurring as a result of any fisheries survey. Specifically: a. GARFO PRD would be notified within 24 hours of any interaction with a sea turtle or sturgeon (nmfs.gar.incidental- take@noaa.gov and BSEE at protectedspecies@bsee.gov). The report would include at a minimum: (1) survey name and applicable information (e.g., vessel name, station number); (2) GPS coordinates describing the location of the interaction (in decimal degrees); (3) gear type involved (e.g., bottom trawl, gillnet, longline); (4) soak time, gear configuration and any other pertinenFt gear information; (5) time and date of the interaction; and (6) identification of the animal to the species level. Additionally, the e-mail would transmit a copy of the NMFS Take Report Form (download at: https://media.fisheries.noaa.gov/2021-07/Take%20Report%20Form%20 07162021.pdf?null) and a link to or acknowledgement that a clear photograph or video of the animal was taken (multiple photographs are suggested, including at least one photograph of the head scutes). If reporting within 24 hours is not possible due to distance from shore or lack of ability to communicate via phone, fax, or email, reports would be submitted as soon as possible; late reports would be submitted with an explanation for the delay. b. At the end of each survey season, a report would be sent to NMFS that compiles all information on any observations and interactions with ESA-listed species. This report would also contain information on all survey activities that took place during the season including location of gear set, duration of soak/trawl, and total effort. The report on survey activities would be comprehensive of all activities, regardless of whether ESA-listed species were observed.	Establishes procedures for immediate reporting of sea turtle/Atlantic sturgeon take
21	Construction and installation, O&M, and decommissioning	Monthly/ annual reporting requirements	BOEM and BSEE would ensure that Revolution Wind submits regular reports (in consultation with NMFS) necessary to document the amount or extent of take that occurs during all phases of the proposed action. Details of reporting would be coordinated between Revolution Wind, NMFS, BOEM and BSEE. All reports would be sent to: nmfs.gar.incidental- take@noaa.gov and BSEE at OSWsubmittals@bsee.gov.	Establishes reporting requirements and timing to document take and operator activities

Mitigation, Monitoring and Reporting Measure Number	Proposed Project Phase	Mitigation or Monitoring Measure	Description	Expected Effect
22	Construction and installation, O&M, and decommissioning	Vessel strike avoidance plan measures	BOEM will require Revolution Wind to comply with measures and reporting outlined in the final Vessel Strike Avoidance Plan per the MMPA LOA for ITR. These measures would be applied during the term of the MMPA LOA (5-years), and beyond as appropriate for O&M and decommissioning.	Ensures vessel strikes are avoided and minimized.
23	Construction and installation	Alternative Monitoring Plan (AMP) for Pile Driving	The Lessee must not conduct pile driving operations at any time when lighting or weather conditions (e.g., darkness, rain, fog, sea state) prevent visual monitoring of the full extent of the clearance and shutdown zones. Nighttime pile driving may not occur without prior approval of an AMP. This includes not initiating pile driving earlier than 1 hour after civil sunrise or later than 1.5 hours prior to civil sunset. The Lessee must submit an AMP to BOEM and NMFS for review and approval at least 6 months prior to the planned start of pile-driving. This plan may include deploying additional observers, alternative monitoring technologies such as night vision, thermal, and infrared technologies, or use of PAM and must demonstrate the ability and effectiveness to maintain all clearance and shutdown zones during daytime as outlined below in Part 1 and nighttime as outlined in Part 2 to BOEM's and NMFS's satisfaction. The AMP must include two stand-alone components as described below: • Part 1 – Daytime when lighting or weather (e.g., fog, rain, sea state) conditions prevent visual monitoring of the full extent of the clearance and shutdown zones. Daytime being defined as one hour after civil sunrise to 1.5 hours before civil sunset. • Part 2 – Nighttime inclusive of weather conditions (e.g., fog, rain, sea state). Nighttime being defined as 1.5 hours before civil sunset to one hour after civil sunrise. If a protected marine mammal or sea turtle is observed entering or found within the shutdown zones after impact pile-driving has commenced, the Lessee would follow shutdown procedures outlined in the Protected Species Mitigation Monitoring Plan (PSMMP; Appendix B). The Lessee would notify BOEM and NMFS of any shutdown occurrence during piling driving operations within 24 hours of the occurrence unless otherwise authorized by BOEM and NMFS. The AMP should include, but is not limited to the following information: • Identification of night vision devices (e.g., mounted thermal/IR camera systems, hand-held or wearable NVDs, IR spotlights), if proposed for use to detect protected marine mammal and sea turtle species. • The AMP must demonstrate (through empirical evidence) the capability of the proposed monitoring methodology to detect marine mammals and sea turtles within the full extent of the established clearance and shutdown zones (i.e., species can be detected at the same distances and with similar confidence) with the same effectiveness as daytime visual monitoring (i.e., same detection probability). Only devices and methods demonstrated as being capable of detecting marine mammals and sea turtles to the maximum extent of the clearance and shutdown zones will be acceptable. • Evidence and discussion of the efficacy (range and accuracy) of each device proposed for low visibility monitoring must include an assessment of the results of field studies (e.g., Thayer Mahan demonstration), as well as supporting documentation regarding the efficacy of all proposed alternative monitoring methods (e.g., best scientific data available). • Procedures and timeframes for notifying NMFS and BOEM of Revolution Wind's intent to pursue nighttime pile-driving. • Reporting procedures, contacts and timeframes. BOEM may request additional information, when appropriate, to assess the efficacy of the AMP.	Establishes requirement for nighttime impact pile driving approval
24	Construction and installation, O&M, and decommissioning	Data collection BA BMPs	BOEM and BSEE would ensure that all Project Design Criteria and Best Management Practices incorporated in the Atlantic Data Collection consultation for Offshore Wind Activities (June 2021) shall be applied to activities associated with the construction, maintenance, and operations of the Revolution Wind Project as applicable.	Incorporates previously determined best management practices to reduce the likelihood of take of listed species during surveys, vessel operations, and maintenance in the Atlantic OCS.

Mitigation, Monitoring and Reporting Measure Number	Proposed Project Phase	Mitigation or Monitoring Measure	Description	Expected Effect
25	Construction and installation	Scour and cable protection	BOEM should require scour and cable protection within complex habitats of the Lease Area to use natural, rounded stone of consistent grain size to match existing conditions. Scour and cable protection placed within soft-sediment habitats should incorporate natural, rounded cobble and boulders that does not inhibit epibenthic growth and provides three- dimensional complexity, both in height and in interstitial spaces, as technically and economically feasible. Concrete mattresses should not be permitted to be used as scour protection within hard bottom and structurally complex habitats, and any required use of concrete mattresses for cable protection should be mitigated through the addition of natural, rounded stone. Should the use of any engineered stone be necessary, it should be designed and selected to provide three-dimensional structural complexity that creates a diversity of crevice sizes. BOEM should require that the applicant provide descriptions and specifications for any proposed engineered stone for agency comment and review prior to final design selection.	Ensures impacts to benthic habitat and species are avoided and minimized.
26	Construction, O&M	Vessel speed restriction	All vessels, regardless of size, would comply with a 10-knot speed restriction in any Seasonal Management Area (SMA), Dynamic Management Area (DMA), or Slow Zone*.	Reduces the risk of vessel strikes.
27	Construction and installation	Safety zone during cable installation	BOEM and BSEE would ensure that Revolution Wind coordinates with the U.S. Coast Guard in advance of export cable installation to develop a navigation safety plan, which may include: establishing a safety zone around the cable laying vessel(s); monitoring plan; mitigation plan; schedule; private aids to navigation; and, local notice to mariners.	Reduces risk of vessel collision or allision.
28	Construction and installation, O&M, and decommissioning	Anchoring plan	Given the extent of complex habitats in the RWF, BOEM should require the applicant to develop an anchoring plan to ensure anchoring is avoided and minimized in complex habitats during construction and maintenance of the Project. This plan should specifically delineate areas of complex habitat around each turbine and cable locations, and identify areas restricted from anchoring. Anchor chains should include mid-line buoys to minimize impacts to benthic habitats from anchor sweep where feasible. The habitat maps and inshore maps delineating eelgrass habitat adjacent to the O&M facility should be provided to all cable construction and support vessels to ensure no anchoring of vessels be done within or immediately adjacent to these complex habitats. The anchoring plan should be provided for our review and comment prior to BOEM approval.	Reduces the risk of anchoring impacts to sensitive species and habitats.
29	Construction and installation	MEC/UXO Disposal	For MEC/UXO that are positively identified in proximity to planned activities on the sea floor, several alternative strategies will be considered prior to detonating the MEC/UXO in place. These may include relocating the activity away from the MEC/UXO (avoidance), moving the MEC/UXO away from the activity (lift and shift), cutting the MEC/UXO open to apportion large ammunition or deactivate fused munitions, using shaped charges to reduce the next explosive yield of an MEC/UXO (low-order detonation), or using shaped charges to ignite the explosive materials and allow them to burn at a slow rate rather than detonate instantaneously (deflagration). Only after these options are considered would a decision to detonate the MEC/UXO in place be made. If deflagration is conducted, mitigation and a monitoring measure would be implemented as if it was a high order detonation based on MEC/UXO size. For detonations that cannot be avoided due to safety considerations, a number of mitigation measures will be employed by Revolution Wind. No more than a single MEC/UXO will be detonated in a 24-hour period. LGL (2022a) outlined several mitigation measures, including: • Monitoring equipment • Pre-start clearance • Visual monitoring • Acoustic monitoring • Use of noise attenuation devices capable of achieving a minimum of 10 dB of sound source attenuation • Seasonal restrictions, limiting detonation activities to the period from May 1 to November 30 • Post MEC/UXO detonation monitoring, and • Sound measurements	Reduces the risk to protected species and sensitive habitats

* On August 1, 2022, NMFS published a proposed rule for changes to NARW vessel speed regulations to further reduce the likelihood of mortalities and serious injuries from vessel collisions (87 Federal Register [FR] 46921. If the proposed rule becomes final, BOEM would require appropriate restrictions per area.

4.0 Environmental Conditions in the Action Area

This section describes the existing habitat conditions in the marine component of the action area including the past and present impacts of all federal, state, or private actions and other human activities in an action area; the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early Section 7 consultation; and the impact of state or private actions that are contemporaneous with the consultation in process [50 CFR 402.02]. The analysis of potential project effects in the vessel traffic component of the action area is limited to vessel strike risk. As such, the characterization of existing conditions in this component of the action area is limited to existing vessel traffic. Further discussion and evaluation of the potential vessel routes from the Gulf of Mexico are provided in Appendix B.

The majority of the information about baseline conditions in the marine component of the action area is obtained from detailed surveys of the Lease Area conducted by Revolution Wind to inform COP development. Those surveys are the most current information available for characterizing the baseline condition of benthic habitats and are relied upon here supported by other appropriate sources of information where available to describe the entire action area.

The following discussion provides information on those elements of the environment relevant to the species covered in this BA and the project-related IPFs.

4.1 Sea Floor and Water Column Habitat Conditions

The marine component of the action area primarily extends from the RWF portion of the Lease Area located near Cox Ledge in Rhode Island Sound on the OCS of southern New England northward to the coastal nearshore of Rhode Island associated with the RWEC landing (Figure 3.1). This portion of the OCS is in the Virginian sub-province of the Northeast Atlantic Temperate Marine bioregion (Cook and Auster 2007). The marine component of the action area is divided into three subareas for describing the environmental baseline: the RWF, the section of the RWEC located in federal waters on the OCS (i.e., the RWEC-OCS), and the section of the RWEC located in Rhode Island state waters (i.e., RWEC-RI) (see Figure 3.1).

Marine ecosystems in this component of the action area are described using the Coastal and Marine Ecological Classification Standard (CMECS), a classification system based on biogeographic setting for the area of interest (FGDC 2012). CMECS provides a comprehensive framework for characterizing ocean and coastal environments and living systems using categorical descriptors for physical, biological, and chemical parameters relevant to each specific environment type (FGDC 2012). The CMECS biogeographic setting for the entire study area is the Temperate Northern Atlantic Realm, Cold Temperate Northwest Atlantic Province, Virginian Ecoregion. The CMECS aquatic setting, substrate, and biotic components for the three project subareas are described in Table 4.1. The environmental baseline for benthic habitats also incorporates updated recommendations from NOAA (2021) regarding mapping fish habitat.

The biotic component of CMECS classifies living organisms of the sea floor and water column based on physical habitat associations across a range of spatial scales. This component is organized into a five-level branched hierarchy: biotic setting, biotic class, biotic subclass, biotic group, and biotic community. The biotic subclass is a useful classification category for characterizing the aquatic ecosystem. Biotic component classifications in the RWF and RWEC footprints are defined by the dominance of life forms, taxa, or other classifiers observed in surveys of the site. In the case of photos, dominance is assigned to the taxa with the greatest percent cover in the photo (FGDC 2012).

Table 4.1. Coastal and Marine Ecological Classification Standard (CMECS) Aquatic Setting, Substrate Group, and Biotic Subclasses in the Marine Component of the Action Area.

Project Element	CMECS Component: Aquatic Setting - System	CMECS Component: Aquatic Setting - Subsystem	CMECS Component: Aquatic Setting - Tidal Zone	CMECS Component: Substrate Group	CMECS Component: Biotic Subclass
RWF and RWEC offshore	Marine	Offshore	Subtidal	• Gravel • Gravelly	▪ Soft Sediment Fauna ▪ Attached Fauna ▪ Inferred Fauna
RWEC nearshore	Marine	Nearshore	Subtidal	• Gravelly	▪ Soft Sediment Fauna ▪ Inferred Fauna

4.2 Sea Floor Conditions

Regional and WEA-specific benthic habitat mapping (Collie and King 2016; Mid-Atlantic Regional Council on the Ocean [MARCO] 2019) provide useful characterization of benthic habitat conditions in the Lease Area. The OCS within and surrounding the Lease Area is characterized by a gradually sloping sea floor from the shoreline to the RWF, which is located in waters less than approximately 164 feet (50 m) deep. The Mid-Atlantic Regional Council on the Ocean (MARCO 2019), BOEM (Guida et al. 2017), and Revolution Wind (Inspire Environmental 2021, Fugro 2020) have conducted large-scale general benthic habitat mapping within the RWF footprint and along the RWEC corridor. Inspire Environmental (2021) has collected extensive side scan sonar and backscatter data to determine site-specific benthic habitat conditions. Inspire Environmental (2020, 2021) has characterized substrate composition using CMECS (FGDC 2012) and mapped benthic habitat to support analysis of impacts on living marine resources following NMFS guidance.

For the purposes of analysis, these various macrohabitat types are consolidated into three groups: 1) large-grained complex habitat, 2) complex habitat, and 3) soft-bottomed. For the benthic habitat substrate, groups are based on sediment grain size and composition, and their associated uses by marine organisms. Habitat conversion impacts resulting from the Project are quantified in Section 5.5 using these three benthic habitat groups. These three benthic habitat types are defined as follows:

- Large-grained complex habitat: large boulders and bedrock

- Complex habitat: SAV, shell substrate, and sediments with >5 percent gravel of any size (pebbles to boulders; CMECS Substrate of Rock, Groups of Gravelly, Gravel Mixes, and Gravels). This category also includes habitats with a combination of soft bottom and complex features (i.e., heterogenous complex)
- Soft bottom habitat: Fine unconsolidated substrates (i.e., mud and/or sand).

All sea floor sediments with the exception of bedrock and large boulders are mobile to varying degrees and are continually reshaped by bottom currents (Butman and Moody 1983; Daylander et al. 2012) and biological activity. These processes form features like sandwaves, ripples, and depressions that are used by many different fish species (Langton et al. 1995). BOEM (2020) defines ripples as sediment waves less than 1.6 feet (0.5 m) high, mega-ripples are sediment waves between 1.6 and 4.9 feet (0.5 to 1.5 m) high, and sandwaves are sediment waves greater than 4.9 feet (1.5 m) high. These features are most prominent in soft-bottomed habitats but can occur in any benthic habitat type (Inspire Environmental 2021). Inspire Environmental (2020) characterized benthic habitat composition within the maximum work area (MWA) for the RWF and the RWEC route alternatives using these three habitat categories. The MWA is defined as the maximum area encompassing all bottom disturbing activities likely to result from project construction and installation. The distribution of complex, large-grained complex, heterogenous complex, and soft bottom benthic habitats within the RWF and RWEC footprints is shown in Figures 4.1 and 4.2, respectively. Small areas of anthropogenic habitat are present in the RWEC-RI (i.e., rubble from Jamestown Bridge) and the RWF (i.e., dredge material), but will not be affected by the project. The surveyed area and proportional distribution of benthic habitat types within these respective footprints are summarized in Table 4.2.

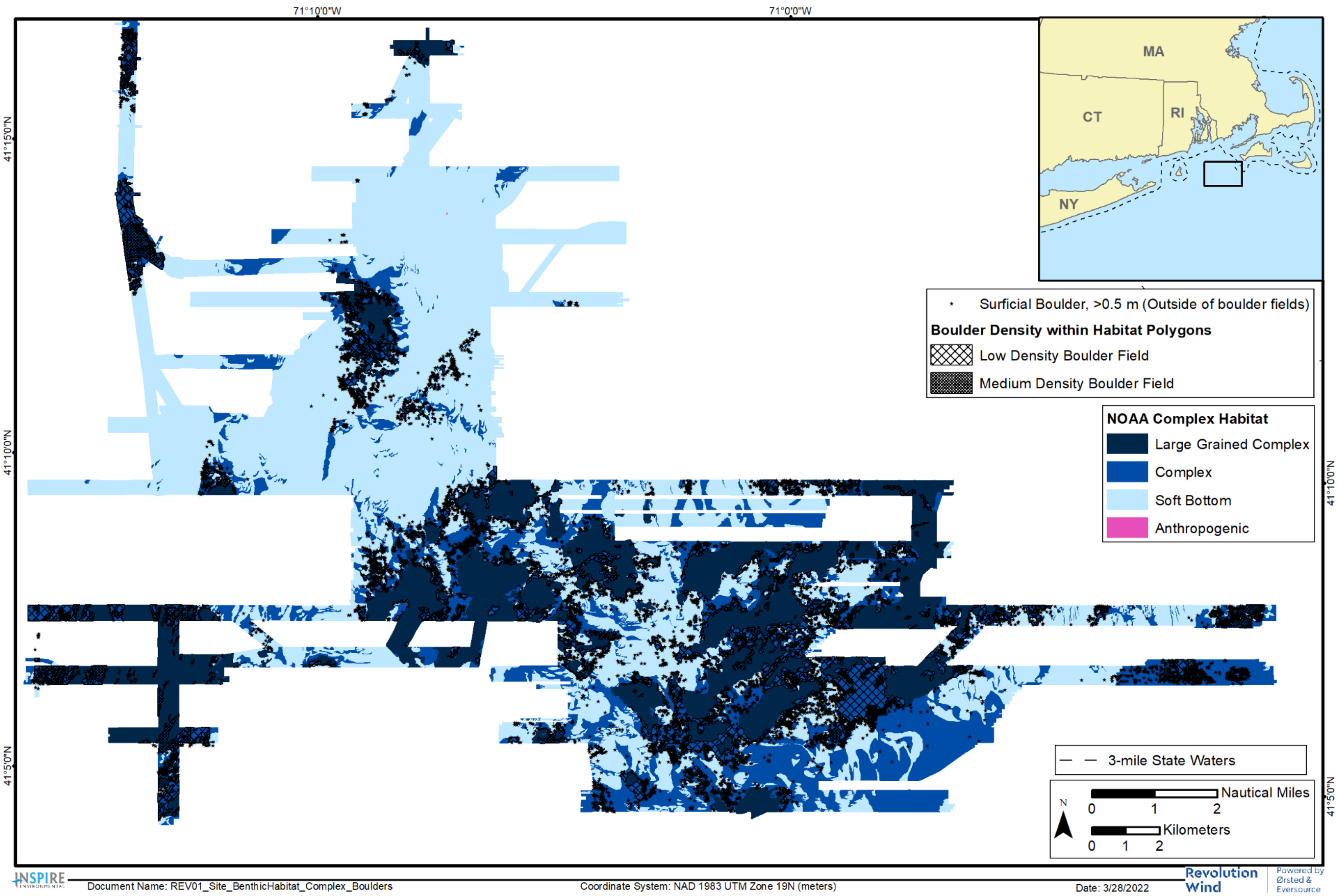

Figure 4.1. Benthic Habitat Composition within the RWF Project Footprint (source: Inspire Environmental 2021).

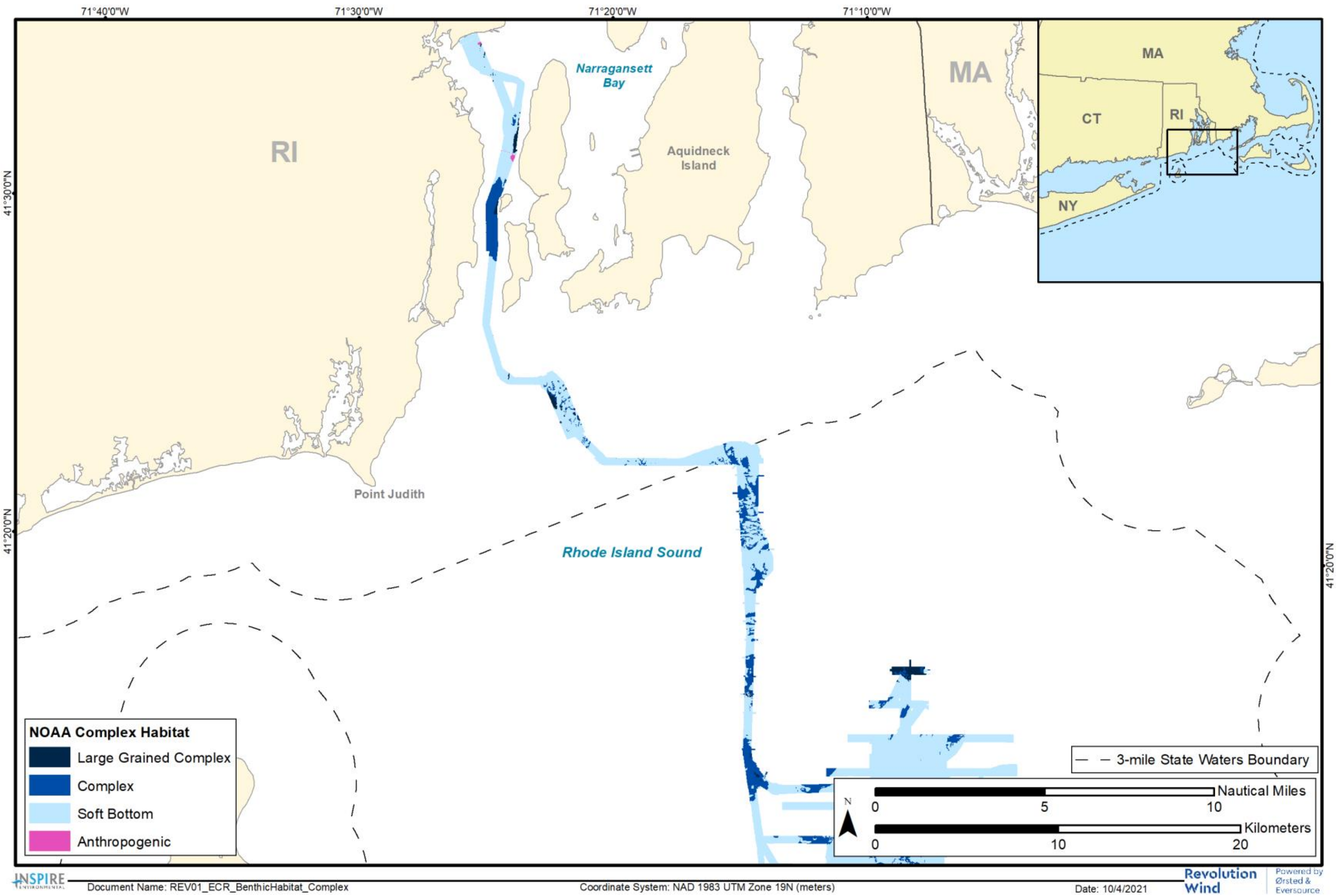

Figure 4.2. Benthic Habitat Composition within the RWEC Project Footprint (source: Inspire Environmental 2021).

Table 4.2. Total Survey Acres and Proportional Composition of Benthic Habitat Types in the RWF and RWEC MWAs.

Area	Survey Acres and Proportional Composition	Complex	Large-Grained Complex	Soft Bottomed	Total
Revolution Wind Farm					
Lease Area	Area – acres (ha)	950 (384)	605 (245)	1,609 (651)	3,164 (1,280)
	Percentage of Survey Area	30%	19%	51%	100%
Revolution Wind Export Cable – Outer Continental Shelf					
Cable Installation Corridor	Area – acres (ha)	178 (72)	5 (2)	358 (145)	541 (219)
	Percentage of Survey Area	33%	1%	66%	100%
Revolution Wind Export Cable – Rhode Island					
Cable Installation Corridor	Area – acres (ha)	128 (52)	0	658 (266)	786 (318)
	Percentage of Survey Area	16%	0%	84%	100%

4.3 Water Column Conditions

The aquatic component of the Lease Area is located in transitional waters that separate Narragansett Bay and Long Island Sound from the Atlantic OCS. The CMECS aquatic settings for the Lease Area are marine nearshore and marine offshore, respectively. Water depth in RWF ranges from approximately 80 feet to 165 feet (24 to 50 m) below mean lower low water (MLLW), with an average depth of approximately 115 feet (35 m) MLLW. Water depths along the RWEC corridor range from approximately 82 feet to 148 feet (25 to 45 m) below MLLW in the RWEC-OCS, and approximately 33 to 130 feet (10 to 40 m) below MLLW in the RWEC-RI. Revolution Wind (vhb 2022) had detailed bathymetric surveys of the RWF and RWEC footprints completed to support COP development, surveyed water depths within these Lease Area components are displayed in Figures 4.3 and 4.4, respectively.

The RWF and RWEC are located in temperate waters and, therefore, subjected to highly seasonal variation in temperature, stratification, and productivity. Overall, pelagic habitat quality within the RWF and offshore components of the RWEC is considered fair to good (USEPA 2015). Baseline conditions for water quality are further described below.

Section 4.2.4 of the COP details oceanographic conditions in the RWF, RWEC, and surrounding area. Circulation patterns in the Lease Area and vicinity are influenced by water moving in from Block Island Sound and the colder water coming in from the Gulf of Maine with a net transport of water from Rhode Island Sound towards the southwest and west. While the net surface transport is to the southwest and west, bottom water may flow toward the north, particularly during the winter (Rhode Island Coastal Resources Management Council [RI CRMC] 2010).

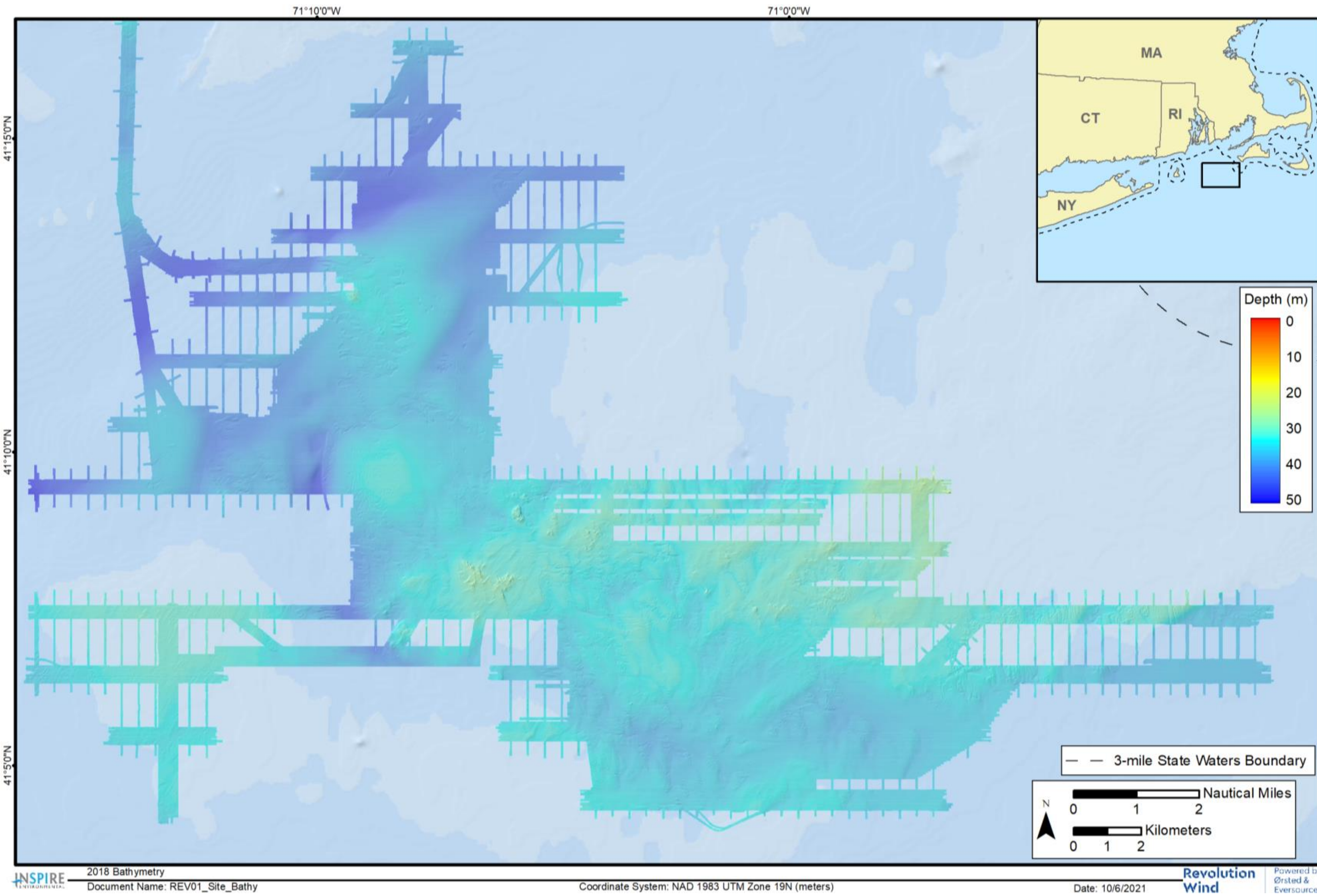

Figure 4.3. Bathymetric Conditions within the RWF Project Footprint (source: Inspire Environmental 2021).

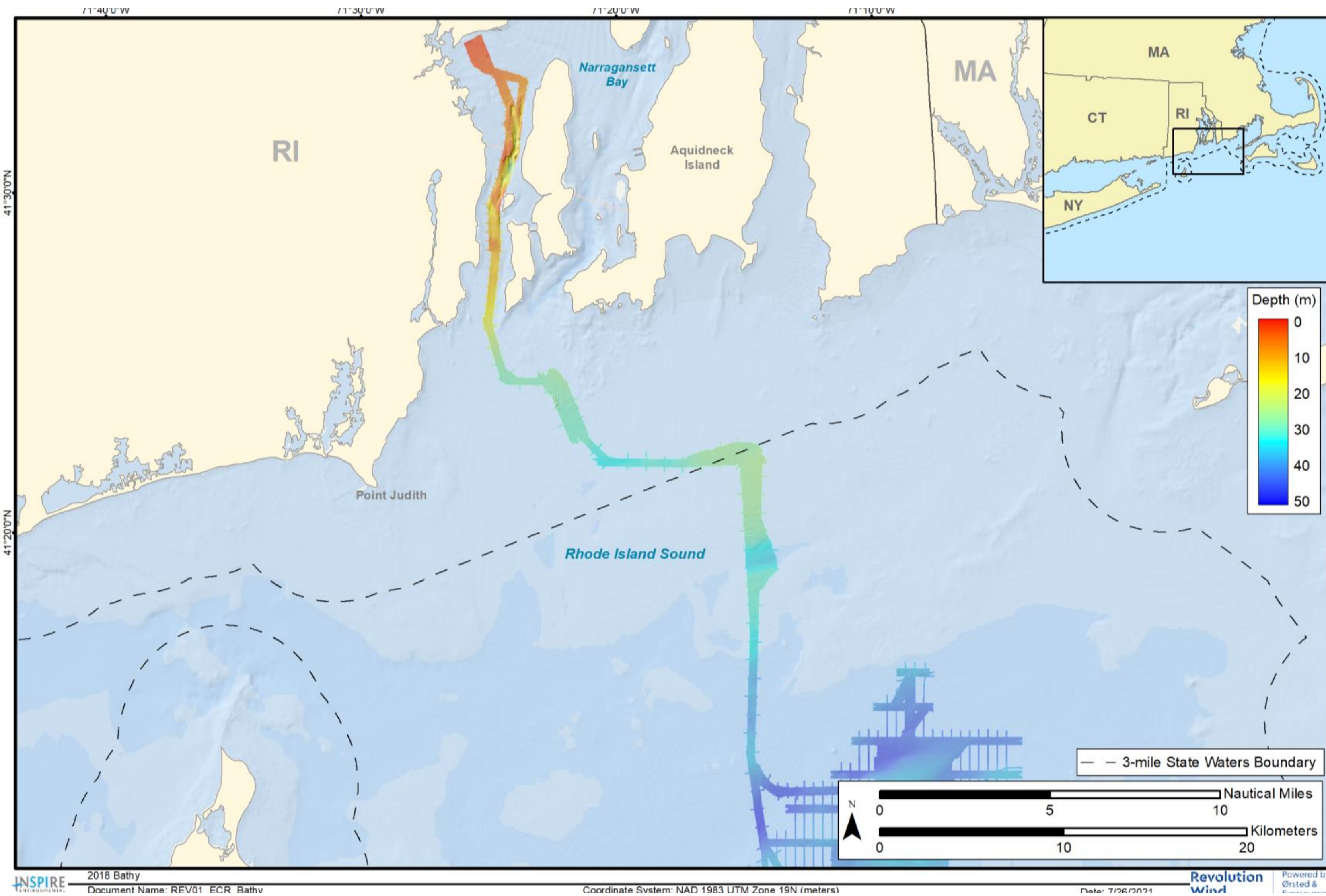

Figure 4.4. Bathymetric Conditions within the RWEC Project Footprint (source: Inspire Environmental 2021).

4.4 Underwater Noise

Kraus et al. (2016) surveyed the ambient underwater noise environment in the RI/MA WEA as part of a broader study of large whale and sea turtle use of marine habitats in this wind energy development area. The RWF lies within a dynamic ambient noise environment, with natural background noise contributed by natural wind and wave action, a diverse community of vocalizing cetaceans, and other organisms. Anthropogenic noise sources, including commercial shipping traffic in high-use shipping lanes in proximity to the marine component of the action area, also contributed ambient sound.

Ambient noise is all-encompassing sound at a given place, usually a composite of sound from many sources near and far (e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action and biological activity). The median 20 - 477 hertz (Hz) ambient underwater root-mean-square (rms) sound pressure levels within the RI/MA WEA measured from November 2011 to March 2015 varied from 101 to 110 dB re 1 µPa depending on location. This bandwidth was the focus of the calculation because it covers the vocalization frequencies of the species of interest to the study (fin, humpback right, sei and minke whales). The greatest ambient rms sound pressure levels reached as high as 125 dB re 1 µPa on the south-central edge of the RWF in proximity to the Narragansett Bay and Buzzards Bay shipping lanes (Kraus et al. 2016). Large marine vessel traffic on these and other major shipping lanes to the east (Boston Harbor), south (New York), and north (Rhode Island) are anticipated to be the dominant sources of underwater noise in the project vicinity. Large, deep draft vessels like container and cargo ships, cruise ships, tankers, and tugs typically account for over 99 percent of the baseline acoustic energy budget in the marine environment (Basset et al. 2012), meaning that these vessel classes typically account for the majority of underwater noise exposure experienced by fish and other marine organisms.

4.5 Water Quality

The RWF and RWEC-OCS are located in offshore marine waters where available water quality data are limited. Broadly speaking, ambient water quality in these areas is expected to be comparable to available data for the regional ocean environment, as this this area is subject to constant oceanic circulation that disperses, dilutes, and biodegrades anthropogenic pollutants from upland and shoreline sources (BOEM 2013).

The RWEC-RI is in coastal marine waters of Rhode Island, where available water quality data are also limited. The USEPA classified coastal water quality conditions nationally for the 2010 National Coastal Condition Assessment (NCCA) (USEPA 2015). The NCCA used physical and chemical indicators to rate water quality, including phosphorus, nitrogen, dissolved oxygen, salinity, water clarity, pH, and chlorophyll-a. The most recent National Coastal Condition Report rated coastal water quality from Maine to North Carolina as “good” to “fair” (USEPA 2012). This survey included four sampling locations near the RWF and RWEC, all of which were within Block Island Sound. USEPA (2015) rated all National Coastal Condition Report parameters in the fair to good categories at all four of these locations.

Narragansett Bay is heavily developed with historical inputs of pollution from industrial, commercial, and residential development. Water quality conditions in the Bay declined over the 10 years between 2008 and 2018 (Moss et al. 2019), including increasing water temperature and salinity and decreasing pH over this 10-year period. Steps to improve water quality in the Bay have been implemented and are ongoing, including improving wastewater treatment plants and reducing polluted runoff from development and roadways.

For the Section 7 consultation, TSS associated with bed disturbance is the pertinent water quality parameter likely to be measurably affected by the proposed action. Ocean waters beyond 3 miles (4.8 km) offshore typically have low concentrations of suspended particles and low turbidity. TSS in Rhode Island Sound from five studies cited in USACE (2004) ranged from 0.1 to 7.4 milligrams/liter (mg/L) TSS. Bottom currents may re-suspend silt and fine-grained sands, causing higher suspended particle levels in benthic waters. Storm events, particularly frequent intense wintertime storms, may also cause a short-term increase in suspended sediment loads (BOEM 2013).

4.6 Electromagnetic Fields (EMFs)

Potential EMF effects resulting from the Proposed Action would be limited to the immediate vicinity of the RWF and RWEC corridor. The natural magnetic field in this part of the marine component of the action area has a total intensity of approximately 510 to 512 milligauss (mG) at the sea floor, based on modeled magnetic field strength in October of 2022 (NOAA 2022a). The marine environment continuously generates additional ambient EMF. The motion of electrically conductive seawater through the Earth’s magnetic field induces voltage potential, thereby creating electrical currents. Surface and internal waves, tides, and coastal ocean currents all create weak induced electrical and magnetic fields. Their magnitude at a given time and location are dependent on the strength of the prevailing magnetic field, site, and time-specific ocean conditions. Other external factors like electrical storms and solar events can also cause variability in the baseline level of EMF naturally present in the environment (CSA Ocean Sciences 2019).

Following the methods described by Slater et al. (2010), a uniform current of 1 meter per second (m/s) flowing at right angles to the natural magnetic field in the marine component of the action area could induce a steady-state electrical field on the order of 51.5 microVolts per meter (µV/m). Modeled current speeds in the Lease Area are on the order of 0.1 to 0.35 m/s at the sea floor (Vinhateiro et al. 2018), indicating baseline current-induced electrical field strength on the order of 5 to 15 µV/m at any given time. Wave action will also induce electrical and magnetic fields at the water surface on the order of 10 to 100 µV/m and 1 to 10 mG, respectively, depending on wave height, period, and other factors. While these effects dissipate with depth, wave action will likely produce detectable EMF effects up to 185 feet (56 m) below the surface (Slater et al. 2010).

There are no submarine power and communications cables present within or in the vicinity of the RWF. Approximate cable paths near the RWF are depicted as the pink wavy lines on the nautical chart base layer used in Figure 3.1, above. While the type and capacity of those cables is not specified, the associated baseline EMF from these cables is not anticipated to have any measurable effects in the RWF and RWEC corridor. Gill et al. (2005) report that electrical telecommunications cables are likely to induce a weak EMF on the order of 1 to 6.3 microvolts μV) per meter within 3.3 feet (1 m) of the cable path. These effects would become indetectable within tens of feet of each cable path. Three telecommunications cables cross the RWEC RI. While the type and capacity of those cables is not specified, the associated baseline EMF effects are anticipated to be similar to those reported by Gill et al. (2005). Fiber-optic communications cables with optical repeaters would not produce EMF effects.

4.7 Artificial Light

Vessel lighting and navigational safety lights on buoys and meteorological towers are the only artificial lighting sources currently present in the marine component of the action area. Planned future offshore wind energy development would result in the placement of up to 3,008 offshore WTGs and OSS foundations on the mid-Atlantic OCS. The construction and installation and O&M of these structures would introduce new short-term and long-term sources of artificial light to the offshore environment in the forms of vessel lighting and navigation and safety lighting on offshore WTGs and OSS foundations. Maintenance vessel lighting and operational lighting on WTG and OSS foundations, in the forms of navigation, aircraft safety, and work lighting, would produce long-term lighting effects over the life of planned offshore wind projects. Land-based artificial light sources become more predominant approaching Narragansett Sound and within Narragansett Bay, with substantial residential, commercial, and industrial shoreline development.

BOEM has issued guidance for avoiding and minimizing artificial lighting impacts from offshore energy facilities (BOEM 2021b) and has concluded that adherence to these measures should effectively avoid adverse effects on marine mammals, sea turtles, fish, and other marine organisms (Orr et al. 2013). BOEM would require Revolution Wind and all future offshore energy projects to comply with this guidance.

BOEM (2021b) guidance for avoiding adverse effects from construction and structural lighting comprises the following measures:

- Turbines and towers should be painted with color no lighter than RAL 9010 Pure White and no darker than RAL 7035 Light Grey;
- Lighting should be minimized whenever and wherever possible, except as recommended by BOEM (2021b) for aviation and navigation safety, including number, intensity, and duration;

- Flashing lights should be used instead of steady burning lights whenever practicable, and the lowest flash rate practicable should be used for application to maximize the duration between flashes. BOEM recommends 30 flashes per minute to be a reasonable rate in most instances;

- Direct lighting should be avoided, and indirect lighting of the water surface should be minimized to the extent practicable once the wind facility is operational;

- Lighting should be directed to where it is needed, and general area floodlighting should be avoided;

- Area and work lighting should be limited to the amount and intensity necessary to maintain worker safety;

- Using automatic times or motion-activated shutoffs for all lights not related to aviation obstruction lighting (AOL) or marine navigation lighting should be considered; and

- AOL that is most conspicuous to aviators, with minimal lighting spread below the horizontal plane of the light but still within the photometric values of an FAA Type L-864 medium intensity red obstruction light, should be used.

In addition, Revolution Wind has indicated that they will follow BOEM (Orr et al. 2013) recommended best practices for avoiding and minimizing construction vessel lighting effects (see Table 3.18). These measures comprise:

- Limit number and intensity of lights, and amount of time lights are turned on to the minimum levels required for worker safety and efficiency.

- Avoid direct lighting of the water surface wherever practicable, limit the duration of water surface lighting to the minimum amount required for worker safety.

- Shield and direct lighting to limit light to where it is needed and avoid general area "floodlighting."

4.8 Vessel Traffic

The marine component of the action area supports considerable vessel traffic, ranging from thousands of large and small vessel trips per year near coastal areas and in and around major shipping lanes to dozens of vessel trips in the low-traffic areas in the RWF footprint (DNV GL 2020). DNV GL (2020) summarized vessel traffic in the vicinity of the proposed action based on AIS data from July 1, 2018, through June 30, 2019. The data include eight vessel classes: cargo/carrier, fishing, other and unidentified, passenger, pleasure, tanker, tanker – oil, and tug and service. Vessel lengths ranged from 17 m to 186 m, vessel beams ranged from 5 m to 31 m and vessel deadweight tonnage ranged from less than 137 metric tons to 47,573 metric tons

(DNV GL 2020). Most vessels sail between 8 and 12 knots. AIS data suggest that primarily fishing, other and unidentified, and pleasure vessels currently transit within the RWF. No military vessels operated in the Lease Area during this period. Between July 1, 2018, and June 30, 2019, there were 113,697 vessel crossings of a measurement line at the entrance of Narragansett Bay via East Passage. Approximately 75 percent of these crossings were pleasure vessels (58%) and Tug/Service vessels (21%). Fishing and other/unidentified vessels account for approximately 70 percent of the vessels that went into the RWF. The levels of vessel traffic observed by DNV GL (2020) for 2018 to 2019 is broadly consistent with the findings of the U.S. Coast Guard (USCG 2020) analysis of vessel traffic patterns in the same area for the period from 2015 through 2018. However, as described below, the levels of vessel traffic in the general vicinity increased significantly from 2015 to 2018 (USCG 2020).

DNV GL (2020) analyzed vessel traffic patterns in proximity to the proposed action to assess navigation safety risks using a two-step analysis. The first step relied on quantification of vessel transits through designated cross sections in proximity to the marine component of the action area using AIS data for all vessel classes. The second step relied on Vessel Monitoring System (VMS) data for fishing vessels. Fishing vessels commonly deactivate their AIS transponders when actively fishing to avoid revealing proprietary fishing areas. The VMS system provides location data used by NMFS to monitor fishing activity while maintaining confidentiality.

Figure 4.5 displays AIS vessel tracks and the 21 analysis cross sections in proximity to the proposed project footprint, regional traffic corridors, and port entrances. Vessel transits through each cross section during the study period are displayed in Figure 4.6. Vessel classes represented by these results include deep-draft commercial vessels (e.g., cargo/carriers and tankers), tugs/barges, service, fishing, passenger, and recreational vessels, and other or unspecified vessel types.

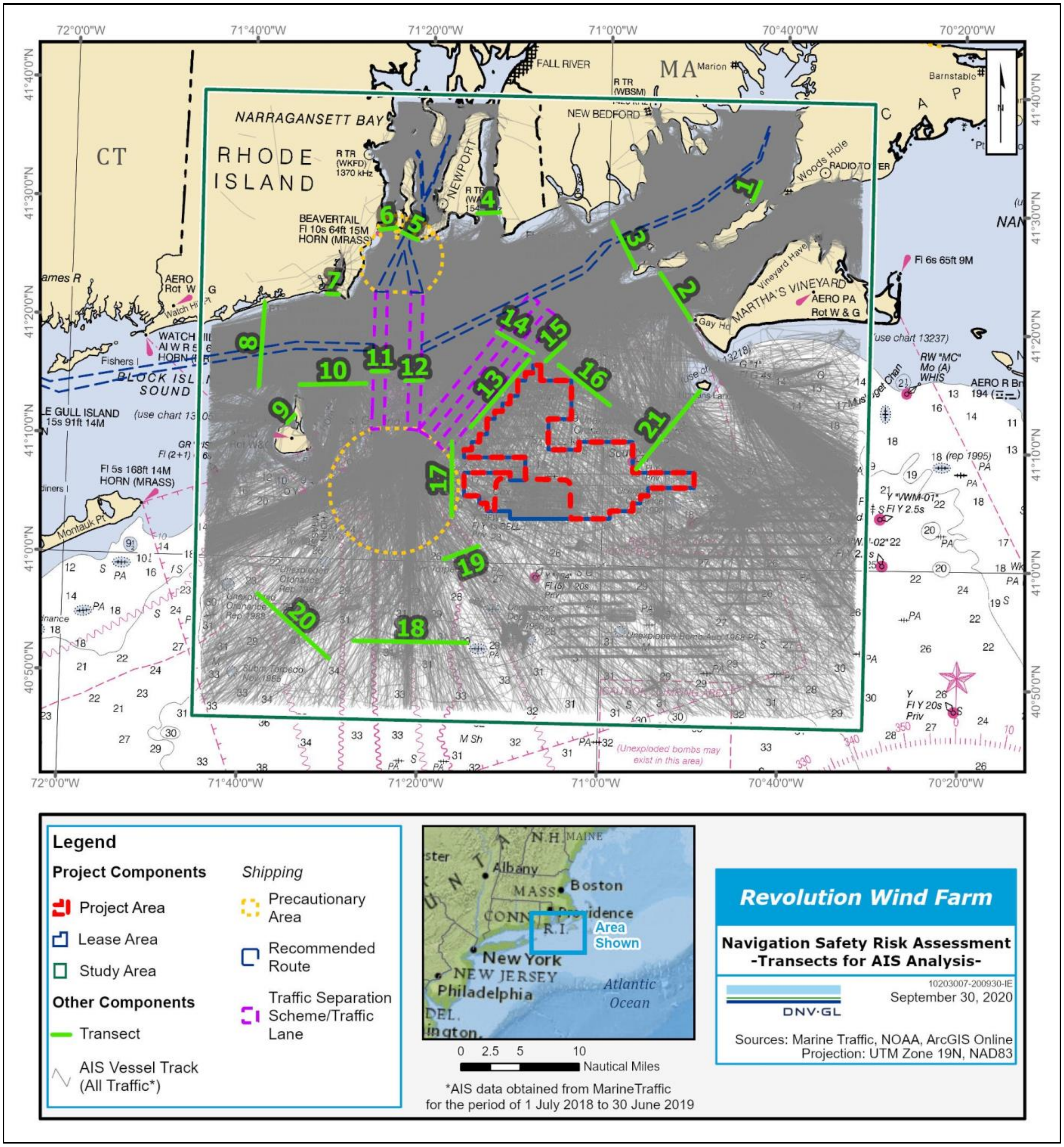

Figure 4.5. AIS Vessel Traffic Tracks for July 1, 2018 to June 30, 2019 and Analysis Cross Sections Used for Traffic Pattern Analysis (DNV GL 2020).

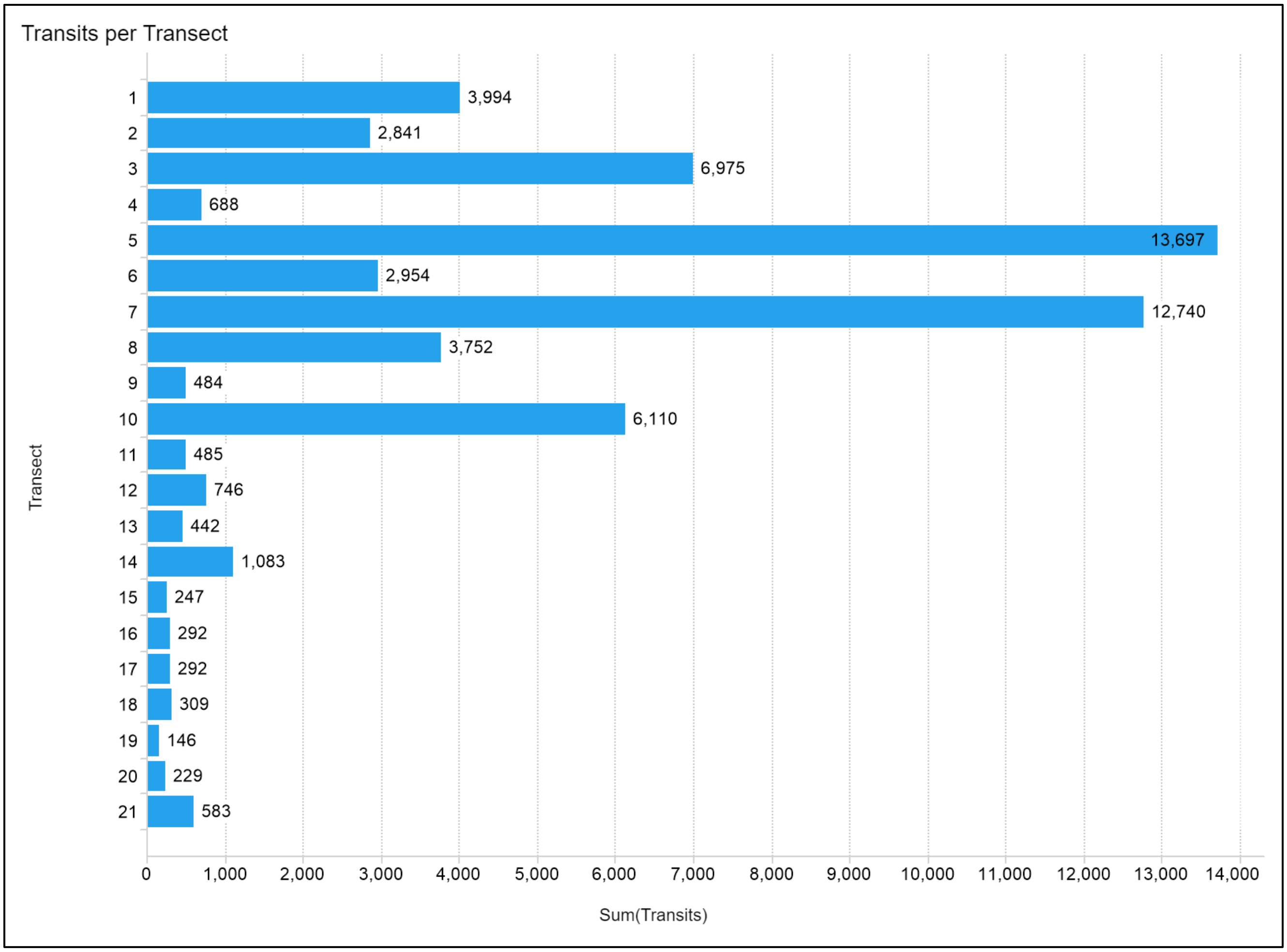

Figure 4.6. Vessel Transits from July 1, 2018, to June 30, 2019, by Analysis Cross Section, All Vessel Classes (DNV GL 2020).

As shown, the cross sections surrounding the Lease Area (13, 16, and 17) have relatively low annual traffic counts with less than 10 transits per day. The approach to Narragansett Bay (cross section 5) has a high level of vessel traffic consistent with the presence of several commercial and recreational port facilities and a major naval and coast guard facility.

DNV GL (2020) analyzed the proportional distribution of vessel types crossing each cross section. Approximately half of the vessel traffic transiting cross sections 13 and 16 is from fishing vessels, with "other/unidentified" vessels being the next largest contributor. Cross section 17, which captures vessels merging in and out of regional traffic separation zones, shows 30 percent of the tracks captured are from deep draft vessels (cargo/carrier and tankers). Approximately 69 percent of transits through cross section 19 are in cargo/carrier or tanker-oil products vessel categories. The USCG (2020) vessel traffic analysis also summarized vessel traffic by class in the RI/MA WEA and surroundings but did not use the transect based approach applied by DNV GL (2020). USCG data indicate a substantial increase in vessel traffic in the defined study area[3] from 2015 through 2018, as shown in Table 4.3.

Table 4.3. Monthly and Annual Vessel Transits by Vessel Class in the USCG (2020) MARIPARS Study Area, 2015 to 2018.

Year	Month	Cargo	Fishing	Other/ Not Available	Passenger	Pleasure Craft/ Sailing	Tanker	Tug/ Tow	All Vessel Classes
2015	Jan	79	77	58	216	9	30	36	505
2015	Feb	52	49	23	101	8	21	27	281
2015	Mar	54	109	35	55	12	27	48	340
2015	Apr	27	145	121	59	74	28	44	498
2015	May	34	245	293	103	182	27	40	924
2015	Jun	27	273	460	189	649	46	61	1,705
2015	Jul	30	325	625	242	1,258	22	65	2,567
2015	Aug	23	421	491	203	1,223	14	66	2,441
2015	Sep	34	414	269	302	613	30	38	1,700
2015	Oct	55	276	135	241	69	34	60	870
2015	Nov	55	276	253	241	69	34	60	988
2015	Dec	86	334	86	366	43	26	59	1,000
2015 Total		***556***	***2,944***	***2,849***	***2,318***	***4,209***	***339***	***604***	***13,819***
2016	Jan	18	104	28	47	6	8	22	233
2016	Feb	20	184	30	23	0	14	26	297
2016	Mar	24	298	39	22	0	15	25	423
2016	Apr	13	364	40	33	12	7	24	493
2016	May	53	914	227	141	216	19	46	1,616
2016	Jun	26	1,781	431	175	621	22	54	3,110
2016	Jul	36	2,243	474	279	1,450	27	75	4,584
2016	Aug	42	2,287	492	247	1,659	24	45	4,796
2016	Sep	37	2,408	303	215	545	31	64	3,603
2016	Oct	54	1,066	143	109	134	18	53	1,577
2016	Nov	64	809	101	76	40	35	89	1,214
2016	Dec	28	496	39	81	17	27	85	773
2016 Total		***415***	***12,954***	***2,347***	***1,448***	***4,700***	***247***	***608***	***22,719***
2017	Jan	48	544	38	79	2	42	89	842
2017	Feb	32	740	108	0	151	22	87	1,140

3 The MARIPARS study area is bounded by a rectangular area defined by the following corner coordinates: (1) 41°20′ N, 070°00′ W; (2) 40°35′ N, 070°00′ W; (3) 40°35′ N, 071°15′ W; (4) 41°20′ N, 071°15′ W.

Year	Month	Cargo	Fishing	Other/ Not Available	Passenger	Pleasure Craft/ Sailing	Tanker	Tug/ Tow	All Vessel Classes
2017	Mar	64	534	145	49	7	17	104	920
2017	Apr	62	1,241	219	180	46	27	57	1,832
2017	May	62	1,188	278	231	208	25	62	2,054
2017	Jun	25	1,365	496	203	668	30	34	2,821
2017	Jul	50	2,165	1,226	346	1,780	21	52	5,640
2017	Aug	120	1,652	1,746	462	2,206	40	56	6,282
2017	Sep	84	1,351	387	499	508	43	45	2,917
2017	Oct	52	1,352	293	326	239	12	66	2,340
2017	Nov	72	585	212	97	80	18	66	1,130
2017	Dec	32	512	189	169	13	31	75	1,021
2017 Total		***703***	***13,229***	***5,337***	***2,641***	***5,908***	***328***	***793***	***28,939***
2018	Jan	226	643	203	161	5	69	38	1,345
2018	Feb	151	604	300	146	19	62	28	1,310
2018	Mar	205	562	246	160	6	28	37	1,244
2018	Apr	110	1,310	582	249	46	47	68	2,412
2018	May	82	2,436	766	292	410	63	52	4,101
2018	Jun	32	3,145	1,009	381	1,589	23	43	6,222
2018	Jul	82	4,356	994	495	2,749	33	58	8,767
2018	Aug	71	3,713	898	462	3,121	24	59	8,348
2018	Sep	55	2,598	736	344	1,012	36	31	4,812
2018	Oct	107	2,334	666	287	249	48	60	3,751
2018	Nov	107	1,398	488	194	159	43	34	2,423
2018	Dec	110	1,275	564	186	41	36	34	2,246
Total – All Years		***1,338***	***24,374***	***7,452***	***3,357***	***9,406***	***512***	***542***	***46,981***

Analysis of VMS data for the Lease Area indicates a high level of commercial fishing activity within and in proximity to the project footprint. Fishing vessels typically do not follow the prescribed routes used by other commercial vessel types and route density patterns are more erratic (DNV GL 2020). Various commercial fishing gear/activity occurs within the RWF, including gillnet, bottom trawl, dredge, and pots/traps. The RWF has been sited in a relatively low-intensity fishing area but is surrounded by areas of high-intensity activity. The number of fishing vessels represented in these data is unclear but can be inferred from vessel trips entering the RWF Lease Area. In 2018 and 2019, 251 and 261 commercial fishing vessels made 5,369 and 4,230 vessel trips to or including the RWF, respectively (NMFS 2022a). Most of these vessels originate from regional ports in Rhode Island and Massachusetts (NMFS 2022a). A heatmap of various types of commercial fishing vessel activity in the marine component of the action area and vicinity is shown in Figure 4.7.

Routine and accidental releases of small amounts of petroleum during normal vessel operations accounts for chronic oil pollution in the world's oceans (IAFW n.d.; Hampton et al. 2003; Laws 1993; OSPAR 2010; Weise 2002). Small oil releases from tankers and cargo vessels commonly occur during bilge water discharge and normal engine operations. Illicit discharges from shipping traffic are also a global concern. Based on proximity to major shipping lanes and high vessel traffic, chronic low-level oil pollution is likely to be present throughout the marine component of the action area.

The Narragansett Bay watershed is heavily developed. The shoreline of the Bay is developed with commercial and industrial facilities and residential and urban development. Limited shoreline areas are undeveloped. The extent of development in and around Narragansett Bay contributes pollution to the waters of the Bay, including oil and other petroleum derived lubricants and fuels. Influent averaged between 9.59 parts per million (ppm) to 29.60 ppm.

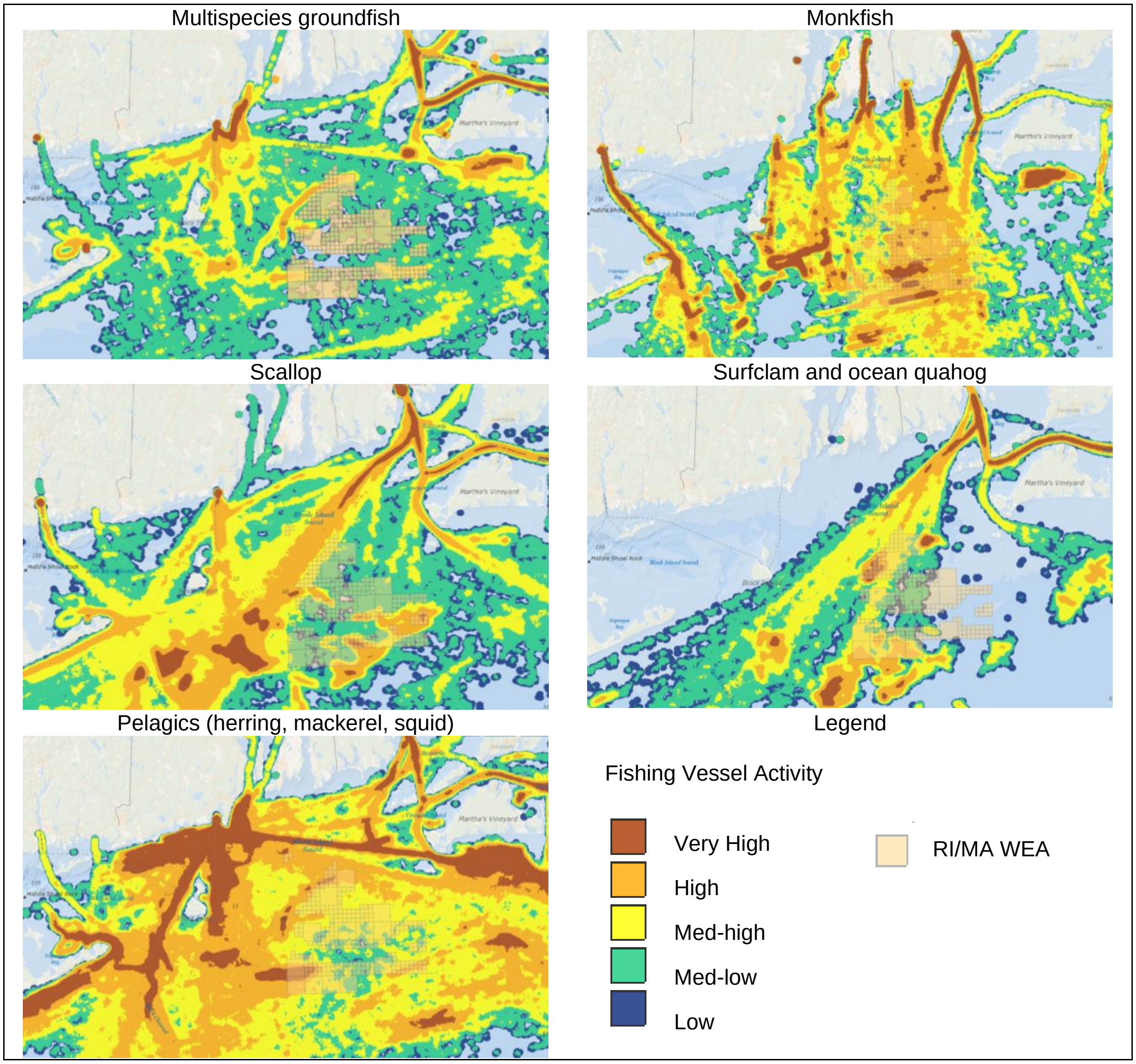

Figure 4.7. Commercial Fishing Vessel Activity in Proximity to the Lease Area by Fishery Type, 2018-2019 (DNV GL 2021).

4.9 Species and Critical Habitat Considered, but Discounted from Further Analysis

Several species and critical habitats have the potential to be affected only by interactions with vessels outside of the offshore wind farm, offshore export cable system, and supporting ports for the proposed Project. Primarily, these interactions may be associated with transits of vessels and the transport of components from Europe during construction of the Project. Existing Atlantic coast port facilities that have been identified as local ports to potentially support the Project in transporting materials to the Project area are described in Section 3.3.2. Potential Project vessel transit activities originating from ports in the Gulf of Mexico are discussed in Appendix B. Potential interactions with hawksbill sea turtle, Northeast Atlantic Ocean distinct population segment (DPS) of loggerhead sea turtle (the Northwest Atlantic Ocean DPS is analyzed in subsequent sections), Atlantic salmon (all DPSs), and oceanic whitetip shark are not expected in the Project area, but these species may be affected by transits from those distant port locations during construction and installation of the proposed Project. In other cases, the occurrence of the species, such as shortnose sturgeon, is so unlikely or rare that the potential for adverse effects is discountable. The stressors associated with the Proposed Action do not overlap with designated critical habitat for hawksbill sea turtles. Activities that overlap with critical habitat designated for the Northwest Atlantic Ocean DPS of loggerhead sea turtle and NARW are limited to vessel transits. BOEM has determined that the stressors associated with the Proposed Action are not likely to adversely affect designated critical habitat for these species.

Based on the rationale provided in the following sections, these species and critical habitats are discounted from further analysis in this BA.

4.9.1 Critical Habitat Designated for the North Atlantic Right Whale (NARW)

In 1994, NMFS designated critical habitat for the NARW population in the North Atlantic Ocean (59 FR 28805). This critical habitat designation included portions of Cape Cod Bay and Stellwagen Bank, the Great South Channel (each off the coast of Massachusetts), and waters adjacent to the coasts of South Carolina, Georgia, and the east coast of Florida. These areas were determined to provide critical feeding, nursery, and calving habitat for the North Atlantic population of NARWs.

In 2016, NMFS revised designated critical habitat for the NARW with two new expanded areas (81 FR 4838). The areas designated as critical habitat contains approximately 29,763 square nautical miles (nm^2) (102,084.2 square kilometers [km^2]) of marine habitat in the Gulf of Maine and Georges Bank region and off the Southeast U.S. coast from Florida to Cape Fear North Carolina. The physical and biological features (PBFs) essential to the conservation of NARW calving habitat, which provide calving area functions in this region are: (1) calm sea surface conditions of Force 4 or less on the Beaufort wind scale; (2) sea surface temperatures from a minimum of 44.6°F (7°C), and never more than 62.6°F (17°C); and (3) water depths of 19.7 to 91.9 feet (6 to 28 m) where these features co-occur over contiguous areas of at least 231 nm^2 (792.3 km^2) of ocean waters during the months of November through April. When these features are available, they are selected by NARW cows and calves in dynamic combinations that are suitable for calving, nursing, and rearing, and which vary, within the ranges specified, depending on factors such as weather and age of the calves (81 FR 4838).

These designated critical habitat units are outside of the marine component of the action area but could occur within the vessel transit component of the action area depending on which ports are ultimately used to support project constriction. However, vessel transits through critical habitat as a result of the Proposed Action will not affect the physical oceanographic conditions or modify the oceanographic features associated with NARW calving area functions (calm sea surface conditions of Force 4 or less on the Beaufort Wind Scale, sea surface temperatures, or water depths) when they occur from November through April. No effects of the Proposed Action were identified that would affect that ability of NARW cows and calves to select an area with these features, when they co-occur, within the ranges specified. The potential presence of a relatively small number of vessels is not expected to affect the selection of these critically important features by NARWs. As a precaution, and required by federal regulations, all vessels must maintain 1,640 feet (500 m) or greater from any sighted NARW. Compliance with this regulation aids in ensuring no adverse effects on the ability of whales to select an area with the co-occurrence of these features. On this basis, BOEM has concluded that vessel travel would have no effect on the NARW species critical habitat; therefore, NARW critical habitat is not considered further in this document.

4.9.2 Hawksbill Sea Turtle

Hawksbill sea turtles are a circumtropical species that in the Atlantic Ocean is most observed between 30°N and 30°S latitude. In the western Atlantic, hawksbills are typically found in the Caribbean Sea and the Gulf of Mexico off the coasts of Florida and Texas. No nesting beaches exist in the northeast United States and records of species occurrence in proximity to the marine component of the action area are rare. This species is likely to occur in the vessel traffic component of the action area, particularly in vessel transit routes in the Gulf of Mexico (Appendix B). The Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) database (Halpin et al. 2009) contains only six hawksbill turtle observation records for the region. These include two verified stranding records, both from Martha's Vineyard in 1911, and four shipboard survey records at and seaward of the shelf break to the east and south of the marine component of the action area. The species was not observed in recent, multi-year aerial and shipboard surveys of the RI/MA WEA and vicinity (Kraus et al. 2016). Therefore, while individual hawksbills could conceivably occur in the project vicinity, they would be extralimital and outside of their normal range.

The species could be encountered in the vessel traffic component action area associated with project vessels moving between the RWF and RWEC and potential ports in the Gulf of Mexico (Appendix B) and Southeast United States. Individual encounters with project vessels in the marine component of the action area is unlikely based on the low potential for occurrence in southern New England waters. Hawksbill sea turtle occurrence is more likely in portions of the vessel transit component of the action area, but the number of vessel transits to these distant ports would be limited. At-sea vessels transiting from non-local ports traveling greater than 10 knots (5.1 m/s) would employ protected species observers (PSOs) or NMFS-approved visual detecting devices. Given the low density of hawksbill sea turtles and the low number of vessel transits from non-local ports, the likelihood of an encounter resulting in a ship strike is very low. Additionally, the general mitigation and monitoring measures proposed in the Protected Species Mitigation and Monitoring Plan (Revolution Wind 2021) for all project vessels to watch out for and avoid all sea turtles would further reduce the chance of any adverse effects to the species from the Proposed Action. Therefore, due to its rarity in the action area, BOEM has concluded that the likelihood of the project affecting hawksbill sea turtle is discountable; therefore, the project would result in No Effect and this species is not considered further in this BA.

4.9.3 Critical Habitat Designated for the Northwest Atlantic Ocean DPS Loggerhead Sea Turtle

Designated critical habitat for the Northwest Atlantic Ocean DPS of the loggerhead sea turtle includes 38 occupied marine areas in the Atlantic Ocean and Gulf of Mexico that contain nearshore reproductive habitat, winter area, breeding areas, constricted migratory corridors, and/or *Sargassum* habitat (79 FR 39856). There is no designated critical habitat for this DPS located within the Project area. However, Project vessels may transit through the loggerhead overwintering, *Sargassum*, and migratory critical habitat if non-local ports are used (Appendix B).

The *Sargassum* critical habitat is designated in the Gulf of Mexico and along the southeastern United States (79 FR 39892). This area encompasses approximately 150,496 square miles (389,784 km^2) that begins its northern latitude roughly even with the Maryland Eastern Shore and extends south through the Straits of Florida until it reaches the Dry Tortugas. Though it is unlikely, potential exists for Project vessels using non-local ports to enter designated critical habitat during transit. *Sargassum* critical habitat features include: (1) convergence zones, surface-water down-welling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the *Sargassum* community in water temperatures suitable for the optimal growth of *Sargassum* and inhabitance of loggerheads; (2) *Sargassum* concentrations that support adequate prey abundance and cover; (3) available prey and other material associated with *Sargassum* habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods; and (4) sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone), and foraging and cover requirements by *Sargassum* for post-hatchling loggerheads (i.e., <33-foot [<10-m] depth). When these features are available, they support the development and foraging of young loggerheads.

The North Carolina Constricted Migratory Corridor critical habitat designated from the shoreline to the 656-foot (200-m) depth contour (continental shelf) surrounds the coastal waters of Cape Hatteras, North Carolina (79 FR 39890). Due to its proximity to shore, there is a very low likelihood of Project vessels entering migratory habitat unless vessels from non-local North Carolina ports are used. Loggerhead migratory critical habitat features include: (1) constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways; and (2) passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas. When these features are available, they create a narrow pinch point through which migrating loggerheads must pass.

The North Carolina winter concentration area consists of a northern portion and a southern portion designated winter habitat (79 FR 39890). The winter concentration area is bounded by the 65.6- and 328-foot (20- and 100-m) depth contours, with the northern extent beginning at Cape Hatteras, North Carolina, and stretching to Cape Fear, North Carolina. Like the migratory critical habitat, there is a very low likelihood of Project vessels entering winter concentration habitat unless vessels from non-local North Carolina ports are used. Loggerhead winter critical habitat features include: (1) water temperatures above 50°F (10°C) from November through April; (2) continental shelf waters in proximity to the western boundary of the Gulf Stream; and (3) water depths between 65.6 and 328 feet (20 and 100 m). When these features are available, they create suitable habitat for a high concentration of juveniles and adults during the winter months.

All Northwest Atlantic loggerhead critical habitat areas are outside of the Project area, but vessel transits from non-local ports through designated areas may occur. Potential Project vessel transit activities originating from ports in the Gulf of Mexico are discussed in Appendix B. However, vessel transits through loggerhead critical habitat due to the Proposed Action will not affect the physical oceanographic conditions or modify the oceanographic features associated with growth, migratory, and wintering area functions. No effects of the Proposed Action were identified to foraging habitat, the seafloor, or prey items. Further, no effects to sufficient prey availability or prey quality were identified because of the Proposed Action. Vessel transits due to the Proposed Action would not decrease water temperatures below 50°F (10°C) from November through April, alter habitat in continental shelf waters near the western boundary of the Gulf Stream, or change water depths between 65.6 and 328 feet (20 and 100 m). Though the vessel traffic component of the action area may overlap with the designated areas mentioned previously, the physical and oceanographic features of the habitat would not be affected in a manner that adversely impacts the critical habitat. On this basis, BOEM has concluded that vessel encounters would have no effect on the loggerhead turtle species critical habitat; therefore, loggerhead critical habitat is not considered further in this document.

4.9.4 Critical Habitat for all Listed DPSs of Atlantic Sturgeon

Five DPSs of Atlantic sturgeon were listed under the ESA in 2012 (77 FR 5880, 77 FR 5914): Chesapeake Bay (endangered), Carolina (endangered), New York Bight (endangered), South Atlantic (endangered), and Gulf of Maine (threatened). The final rule for Atlantic sturgeon critical habitat (all listed DPSs) was issued on August 17, 2017 (82 FR 39160). This rule includes 31 units, all rivers, occurring from Maine to Florida. No marine habitats were identified as critical habitat because the PBFs in these habitats essential for the conservation of Atlantic sturgeon could not be identified.

Critical habitat designations for the Atlantic sturgeon Gulf of Maine DPS encompasses seven rivers of Maine, New Hampshire, and Massachusetts. New York Bight DPS includes four rivers of Connecticut, Massachusetts, New York, New Jersey, Pennsylvania, and Delaware. Chesapeake Bay Atlantic sturgeon DPS critical habitat includes five main tributaries to the bay: the Potomac, Rappahannock, York, James, and Nanticoke Rivers. The Carolina DPS includes rivers of North Carolina and South Carolina, The South Atlantic DPS Atlantic sturgeon critical habitat is composed of nine rivers of South Carolina, Georgia, and Florida.

The only Project activity that may affect Atlantic sturgeon critical habitat are Project vessel transits within the vessel traffic component of the action area. Identified local ports for the Project include states with rivers in the Atlantic sturgeon New York Bight DPS. The vessel traffic component of the action area does not encompass tributaries and estuarine habitats of the Gulf of Maine, Chesapeake Bay, Carolina, and South Atlantic DPSs. Vessel transits from local ports would not travel through these three critical habitat DPSs and vessel transits from non-local ports would not travel through critical habitat of any Atlantic sturgeon DPS.

Vessel transits from local ports with rivers in the Atlantic sturgeon New York Bight DPS could potentially travel through critical habitat if the ports are located within or at the mouth of river systems designated as critical habitat for Atlantic sturgeon. Atlantic sturgeon critical habitat features include the following: temperature, salinity, dissolved oxygen, water depth, and barriers to passage. If vessel transit for the Project includes ports within Atlantic sturgeon critical habitat, vessel travel from existing ports would have no measurable effect on Atlantic sturgeon critical habitat features. On this basis, BOEM has concluded that vessel travel would have no effect on the Atlantic sturgeon species critical habitat; therefore, Atlantic sturgeon critical habitat is not considered further in this document.

4.9.5 Shortnose Sturgeon

Shortnose sturgeon (*Acipenser brevirostrum*) are amphidromous, meaning that they spawn and rear in freshwater and forage in both the estuary of their natal rivers and shallow marine habitats in close proximity to the estuary (Bain 1997; Fernandes et al. 2010). Shortnose sturgeon occur in the Northwest Atlantic but are typically found in freshwater or estuarine environments. Within the Mid-Atlantic region, shortnose sturgeon are found in the Delaware River and Hudson River estuaries (NOAA Fisheries 2018). Movement of shortnose sturgeon between rivers is rare, and their presence in the marine environment is uncommon. Therefore, the species is not expected to be found in the RWF component of the Project area. Occasional transient shortnose sturgeon could enter Narragansett Bay where the RWEC elements of the Project would occur and could be present during vessel transiting from Narragansett Bay. Overall, the likelihood of shortnose sturgeon occurrence in the action area is considered unlikely. BOEM has concluded that no aspect of the Proposed Action has the potential to result in detectable effects to shortnose sturgeon and this species is not considered further in this BA.

4.9.6 Gulf of Maine DPS Atlantic Salmon

The Gulf of Maine DPS (Androscoggin River, Maine north to the Dennys River, Maine) of Atlantic salmon (*Salmo salar*) are not known to occur in the RWF and RWEC. Smolts migrate from their natal river to foraging grounds in the Western North Atlantic off Canada and Greenland, and after one or more winters at sea, adults return to their natal river to spawn (Fay et al. 2006). Atlantic salmon are not known to occur in the marine component of the action area; the only portion of the action area that may overlap with their distribution is in the vessel traffic component of the action area on transit routes from Europe. There is no evidence of interactions between vessels and Atlantic salmon. Vessel strikes are not identified as a threat in the listing determination (74 FR 29344) or the recent recovery plan (NMFS and USFWS 2019), and there is no information to suggest that vessels in the ocean have any effects on migrating Atlantic salmon. Therefore, effects to Atlantic salmon are not expected even if migrating individuals co-occur with Project vessels moving between the Project site and ports in Europe.

4.9.7 Ocean Whitetip Shark

The oceanic whitetip shark (*Carcharhinus longimanus*) is typically found offshore in the open ocean, on the OCS, or around oceanic islands in water deeper than 604 feet (184 m). The species has a clear preference for open ocean waters between latitudes of 10°N and 10°S but can be found in decreasing numbers out to 30°N and 35°S, with abundance decreasing with greater proximity to continental shelves (Young et al. 2017). In the western Atlantic Ocean, oceanic whitetip sharks occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. In the central and eastern Atlantic Ocean, the species occurs from Madeira, Portugal, south to the Gulf of Guinea, and possibly in the Mediterranean Sea. There is a small chance that vessel transits and transport of Project components from Europe would interact with oceanic whitetip sharks in the vessel traffic component of the action area. Vessels at sea would not be expected to travel at reduced speeds. However, given the low density of oceanic whitetip sharks and the low number of vessel transits from non-local ports, the likelihood of an encounter resulting in a ship strike is very low. Vessel strikes are not identified as a threat in the status review (Young et al. 2017), listing determination (83 FR 4153), or the recovery outline (NMFS 2018a). There is no information to suggest that vessels in the ocean have any effects on oceanic whitetip sharks. Therefore, effects to this species are not expected even if migrating individuals co-occur with Project vessels.

4.10 Threatened and Endangered Species and Critical Habitat Considered for Analysis

Eleven ESA-listed species under NMFS jurisdiction have the potential to occur in the general vicinity of the proposed action and are known or likely to occur in the marine component of the action area. These species and their potential occurrence in the marine component of the action area are summarized in Table 4.4. Species known or likely to occur in the marine component of the action area, current status and threats, timing and use of the marine component of the action area and vicinity, and additional information pertinent to this consultation are described in the following sections.

Table 4.4. ESA-Listed Species with the Potential to Occur in the Marine Component of the Action Area.

Species	Listing Status	Critical Habitat Status	Occurrence in Action Area: Species	Occurrence in Action Area: Critical Habitat*
Marine Mammals				
Blue whale - (*Balaenoptera musculus*)	Endangered – 12/2/1970 35 FR 18319	Not designated	Yes	N/A
Fin whale – (*Balaenoptera physalus*)	Endangered – 12/2/1970 35 FR 12222	Not designated	Yes	N/A
Sei whale – (*Balaenoptera borealis*)	Endangered – 12/2/1970 35 FR 12222	Not designated	Yes	N/A
North Atlantic Ocean right whale – (*Eubalaena glacialis*)	Endangered – 12/2/1970 35 FR 18319	Designated – 1/27/2016 81 FR 4838	Yes	Yes
Sperm whale – (*Physeter macrocephalus*)	Endangered – 12/2/1970 35 FR 12222	Not designated	Yes	N/A
Marine Reptiles				
North Atlantic DPS Green sea turtle – (*Chelonia mydas*)	Threatened - 5/6/2016 81 FR 20057	Designated – 9/2/1998 63 FR 46693	Yes	No
Kemp's ridley sea turtle – (*Lepidochelys kempii*)	Endangered – 12/2/1970 35 FR 18319	Not designated	Yes	No
Leatherback sea turtle – (*Dermochelys coriacea*)	Endangered – 6/2/1970 35 FR 8491	Designated – 2/27/2012 77 FR 4169	Yes	No
Northwest Atlantic Ocean DPS Loggerhead sea turtle – (*Caretta caretta*)	Threatened – 9/22/2011 76 FR 58868	Designated – 7/10/2014 79 FR 39855	Yes	Yes
Fish				
Atlantic sturgeon – (*Acipenser oxyrinchus oxyrinchus*)	Endangered – 2/6/2012 77 FR 5913	Designated – 8/17/2017 82 FR 39160	Yes	
Chesapeake Bay DPS				No
Carolina DPS				No
New York Bight DPS				Yes
South Atlantic DPS				No
Gulf of Maine DPS				No
Rays				
Giant manta ray – (*Manta birostris*)	Threatened 2/21/18 83 FR 2916	Not designated	Yes	N/A

*N/A – Critical Habitat has not been designated. No – Critical Habitat has been designated, but does not occur in the marine component of the action area

The 11 ESA-listed species identified in Table 4.4 are described in Section 4.12.1. Information about species occurrence was drawn from several available sources. These include: a directed survey that characterized large whale and marine reptile occurrence in the RI/MA WEA sponsored by BOEM (Kraus et al. 2016; Quitana et al. 2019, O'Brien et al. 2020, 2021a, 2021b); a regional survey of marine species known or likely to occur in Rhode Island coastal and offshore waters (Kenney and Vigness-Raposa 2010); predictive seasonal models of marine mammal density by species along the Atlantic coast developed by the Marine-Life Data and Analysis Team (Curtice et al. 2019); aerial and shipboard species observation data collected by the Atlantic Marine Assessment Program for Protected Species (NEFSC and SEFSC 2018); and marine mammal stock assessments (Hayes et al. 2021). Additional species-specific sources of information are cited where appropriate.

4.11 Description of Critical Habitat Not in the Action Area

4.11.1 Green Sea Turtle North Atlantic DPS

Critical habitat was designated in 1998 (63 FR 46693). Critical habitat includes coastal waters of Puerto Rico. Critical habitat does not occur in the action area.

4.11.2 Leatherback Sea Turtle

Critical habitat was revised in 2012 (77 FR 4169). Critical habitat includes coastal waters of the Virgin Islands and the Pacific coast. Critical habitat does not occur in the action area.

4.12 Description of ESA-listed Species in the Action Area

4.12.1 Marine Mammals

Five marine mammal species listed under the ESA are known to occur in the marine component of the action area, all of which are large whales. These include the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), North Atlantic right whale (NARW) (*Eubalaena glacialis*), sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*). These species occur in the marine component of the action area and vicinity in varying densities by season (Kraus et al. 2016; NEFSC and SEFSC 2018; Quintana et al. 2019; O'Brien et al. 2021a; O'Brien et al. 2021b).

Estimated densities by species and month are shown in Table 4.5. The density estimates presented in Kusel et al. (2021) are from habitat-based density modeling of the entire Atlantic Exclusive Economic Zone (Roberts et al. 2016a, 2016b, 2017, 2018, 2021a, 2021b). Kusel et al. (2021) and LGL (2022a) used this density information to estimate potential NARW exposure to underwater noise impacts from the proposed action. Subsequent to these analyses, Roberts and Halpin (2022) released a revised NARW density model based on observations through 2020.

Species descriptions, status, likelihood of occurrence in the marine component of the action area, and information about feeding habits and hearing ability relevant to this effect analysis are provided in the following sections.

Table 4.5. Estimated Density (animals/100 km^2)‡ of ESA-Listed Whale Species in the Action Area and Vicinity by Month and Season (peak occurrence periods in bold).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Blue Whale**	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fin Whale	0.120	**0.110**	**0.115**	**0.223**	**0.197**	**0.210**	**0.244**	**0.230**	**0.203**	0.121	0.093	0.095
NARW	**0.345**	**0.424**	**0.467**	**0.532**	**0.175**	0.011	0.002	0.001	0.002	0.004	0.028	0.1532
Sei Whale	0.001	0.001	0.001	**0.021**	**0.020**	**0.012**	0.003	0.002	0.003	0.001	0.001	0.001
Sperm Whale	0.001	0.001	0.001	0.001	0.004	0.009	**0.025**	**0.021**	0.009	0.008	0.007	0.001

** Density estimates for blue whales LGL (2022a).
‡ Monthly density estimates for May to December from Kusel et al. (2021).

The North Atlantic OCS provides important habitats for several marine mammals, including the ESA-listed species considered in this consultation. LaBrecque et al. (2015) delineated biologically important areas (BIAs) for multiple marine mammal species, including fin whales, NARW, and sei whales in the vessel traffic and/or marine components of action area. For example, the BIA for sei whales includes habitats extending from Cape Cod southward to the edge of the continental shelf, likely encountering potential construction vessel transit routes from Europe (i.e., within the vessel traffic component of the action area). The BIA for NARW includes Georges Bank, also likely encountering vessel transit routes from Europe. The BIA for fin whales encompasses the RWF and surrounding waters in southern New England, meaning these important habitats overlap both the marine and vessel traffic components of the action area. While these BIAs remain important, their significance may change over time as a result of emerging ecological trends resulting from climate change. For example, NARW appears to be shifting northward in response to changes in marine ecosystem productivity caused by climate change (Meyer-Gutbrod et al. 2015, 2018). Numerous fish and invertebrate species are undergoing or likely to undergo changes in abundance and distribution shifts in response to climate change impacts (Hare et al. 2016; Rogers et al. 2019). Areas that are currently biologically important may become less so overtime, while currently unused areas may become more important. These changes are difficult to predict with certainty, requiring flexible and adaptive management to ensure species protection into the future (Meyer-Gutbrod et al. 2018).

Blue Whale

In the North Atlantic Ocean, the range of blue whales extends from the subtropics to the Greenland Sea. As described in the most recent stock assessment report, blue whales have been detected and tracked acoustically in much of the North Atlantic, with most of the acoustic detections around the Grand Banks area of Newfoundland and west of the British Isles (Hayes et al. 2021). Photoidentification in eastern Canadian waters indicates that blue whales from the St. Lawrence River, Newfoundland; Nova Scotia; New England; and Greenland all belong to the same stock, whereas blue whales photographed off Iceland and the Azores appear to be part of a separate population (CETAP 1982; Wenzel et al. 1988; Sears and Calambokidis 2002; Sears and Larsen 2002). The largest concentrations of blue whales are found in the lower St. Lawrence

Estuary (Lesage et al. 2007; Comtois et al. 2010), which is outside of the Project area. Blue whales do not regularly occur in the U.S Atlantic water near the coast and typically occur farther offshore in areas with depths of 328 feet (100 m) or more (Waring et al. 2011).

Migration patterns for blue whales in the eastern North Atlantic Ocean are poorly understood. However, blue whales have been documented in winter months off Mauritania in northwest Africa (Baines and Reichelt 2014); in the Azores, where their arrival is linked to secondary production generated by the North Atlantic spring phytoplankton bloom (Visser et al. 2011); and traveling through deepwater areas near the shelf break west of the British Isles (Charif and Clark 2009). Blue whale calls have been detected in winter on hydrophones along the mid-Atlantic ridge south of the Azores (Nieukirk et al. 2004).

Species Status

Blue whales have been listed as endangered under the ESA Endangered Species Conservation Act of 1969, with a recovery plan published under 63 FR 56911. No critical habitat has been designated for the blue whale. Blue whales are separated into two major populations (the North Pacific and North Atlantic populations) and further subdivided in stocks. The North Atlantic Stock includes mid-latitude (North Carolina coastal and open ocean) to Arctic waters (Newfoundland and Labrador). However, historical observations indicate that the blue whale has a wide range of distribution from warm temperate latitudes typically in the winter months and northerly distribution in the summer months. Blue whales are known to be an occasional visitor to U.S. Atlantic waters, with limited sightings. Whale-watchers off of Montauk Point, New York, were observed in August 1990. In the year of 2008, vocalization detections of blue whales were also observed 28 out of 258 days of recordings in the offshore areas of New York Bight. Population size of blue whales off the eastern coast of the United States is not known; however, a catalog count of 402 individuals from the Gulf of St. Lawrence is the minimum population estimate (NOAA Fisheries 2020).

Occurrence in the Action Area and Vicinity

The Western North Atlantic stock of blue whale is primarily distributed in the pelagic waters seaward of the continental shelf off the Grand Banks and Newfoundland, and in the Gulf of St. Lawrence. Individuals from this stock have only occasionally been observed in the US Exclusive Economic Zone, and only to the north of Massachusetts (Hayes et al. 2021; Waring et al. 2011). The species was not observed during an intensive, multi-year aerial and shipboard survey of the RI/MA WEA (Kraus et al. 2016). Based on known distribution and lack of observations in the vicinity, this species could potentially occur in the marine component of the action area during the operational life of the Proposed Action but the probability of occurrence during project construction and installation is low.

Blue whales are thought to occur seasonally within the vessel transit component of the action area in the spring and summer but, because of their rarity, overlap with vessel transits within the

Project area is not anticipated. Furthermore, the use of speed restrictions and lookouts during transit reduces the potential for impacts on blue whales. Given the low density of blue whales and the low number of vessel transits from non-local ports, the likelihood of an encounter resulting in a ship strike is low.

Fin Whale

Fin whales are a globally distributed baleen whale species found in the Atlantic, Pacific, and Southern Hemisphere (NMFS 2010a). Fin whales are listed at the species level under the ESA (35 FR 12222). Critical habitat has not been designated for this species. The International Whaling Commission has divided this species into discrete stocks by ocean basin, but the biological evidence for these stock definitions is mixed (Hayes et al. 2021). The Western North Atlantic stock is concentrated in the U.S. and Canadian Atlantic Exclusive Economic Zones from Cape Hatteras to Nova Scotia (Hayes et al. 2021) and is therefore the most likely source of individuals occurring in the marine component of the action area. Fin whales are the most commonly sighted large whale species in this region, accounting for 46 percent of all sightings in aerial surveys conducted from 1978 to 1982 (CETAP 1982; Hayes et al. 2021), and most large whale sightings in recent aerial and shipboard surveys (NEFSC and SWFSC 2018; Kraus et al. 2016). They are present throughout this region year-round, but abundance in specific locations varies by season (Hayes et al. 2021).

<u>Species Status</u>

Fin whales have been listed as endangered under the ESA since 1970 (35 FR 12222). Critical habitat has not been designated. The species is also on the International Union for Conservation of Nature Red List (Kenney and Vigness-Raposa 2010). The best available abundance estimate for the North Atlantic stock is 6,802 with a minimum population estimate of 6,029 (Hayes et al. 2020, 2021). These estimates are uncertain and likely low given the limitations of the survey. NMFS has not conducted a population trend analysis due to insufficient data (Hayes et al. 2020). The best available information indicates the gross annual reproduction rate is 8 percent, with a mean calving interval of 2.7 years (Hayes et al. 2020, 2021).

<u>Occurrence in the Action Area and Vicinity</u>

Fin whales commonly occur in the marine component of the action area. A portion of a well-known feeding ground partially overlaps this component of the action area and vicinity. This feeding area extends east from Montauk, Long Island, New York, to south of Nantucket (NMFS 2010; Kenney and Vigness-Raposa 2010) and is a well-known location where fin whales congregate in dense aggregations and sightings frequently occur (Kenney and Vigness-Raposa 2010). LaBrecque et al. (2015) delineated a BIA for fin whale feeding in an area extending from Montauk Point, New York, to the open ocean south of Martha’s Vineyard between the 49-foot (15-m) and 164-foot (50-m) depth contours. This BIA encompasses the RWF footprint. It is used extensively by feeding fin whales from March to October.

Fin whales are most commonly observed in the RI/MA WEA during summer months but could occur during any month of the year (Kraus et al. 2016; Quintana et al. 2019; O'Brien et al. 2021a; O'Brien et al. 2021b). The Marine-Life Data and Analysis Team (Curtice et al. 20192019) has assembled available data on fin whale occurrence to develop a model of monthly occurrence density off the Atlantic coast. Kusel et al. (2022) compiled these and other data to develop monthly density estimates in the marine component of the action area, which are summarized in Table 4.6. The collective findings of these efforts indicate that fin whales could occur during every month of the year. As shown in Table 4.6, aerial survey observations collected by Kraus et al. (2016) from 2011 through 2015 indicate peak fin whale occurrence in the marine component of the action area and vicinity in spring and summer. Estimated densities during this period range from 0.0020 to 0.0026 animals per km^2 (Curtice et al. 2019; Kusel et al. 2022). Fewer individuals were observed from September through March (Table 4.6), but acoustic monitoring suggests that the species is present in the region throughout the year (Kraus et al. 2016; Quintana et al. 2019; O'Brien et al. 2021a; O'Brien et al. 2021b). Fin whale sightings per unit effort (SPUE) by season in the RI/MA WEA and vicinity are displayed in Figure 4.8. SPUE is symbolized as the extrapolated number of individuals per 1,000 km of aerial survey observations, assigned to 5x5-minute latitude and longitude grid cells (Kraus et al. 2016). As shown, fin whales are most likely to be present in the marine component of the action area during spring and summer but could occur during any month of the year.

Table 4.6. Summary of ESA-Listed Marine Mammal Sightings and Estimated Number of Individuals Observed by Season in Aerial Surveys of the RI/MA WEA and Vicinity from 2011 to 2015.

Species	Winter (Dec – Feb) S	Winter (Dec – Feb) N	Spring (Mar – May) S	Spring (Mar – May) N	Summer (Jun-Aug) S	Summer (Jun-Aug) N	Fall (Sep-Nov) S	Fall (Sep-Nov) N
Fin Whale	1	1	35	60	49	92	2	2
NARW	25	54	35	91	0	0	0	0
Sei Whale	0	0	12	22	13	19	0	0
Sperm Whale	0	0	0	0	3	8	1	1

Source: Kraus et al. (2016)
S = Number of sightings (definite and probable identifications); N = Number of individuals sighted.

Feeding Behavior and Hearing

The species returns annually to established feeding areas and fasts during migration between feeding and calving grounds. The OCS adjacent to New England supports established summer feeding areas for this species (LaBreque et al. 2015). Fin whales in the North Atlantic feed on krill (*Meganyctiphanes norvegica* and *Thysanoessa inermis*) and schooling fish such as capelin (*Mallotus villosus*), herring (*Clupea harengus*), and sand lance (*Ammodytes* spp.), captured by skimming or lunge feeding (Borobia et al. 1995). Several studies suggest that distribution and movements of fin whales along the east coast of the United States is influenced by the availability of sand lance (Kenney and Winn 1986; Payne et al. 1990).

Fin whales and other baleen whales belong to the LFC marine mammal hearing group, which have a generalized hearing range of 7 hertz (Hz) to 35 kHz (NMFS 2018b). Peak hearing sensitivity of fin whales ranges from 20 to 150 Hz (Erbe 2002).

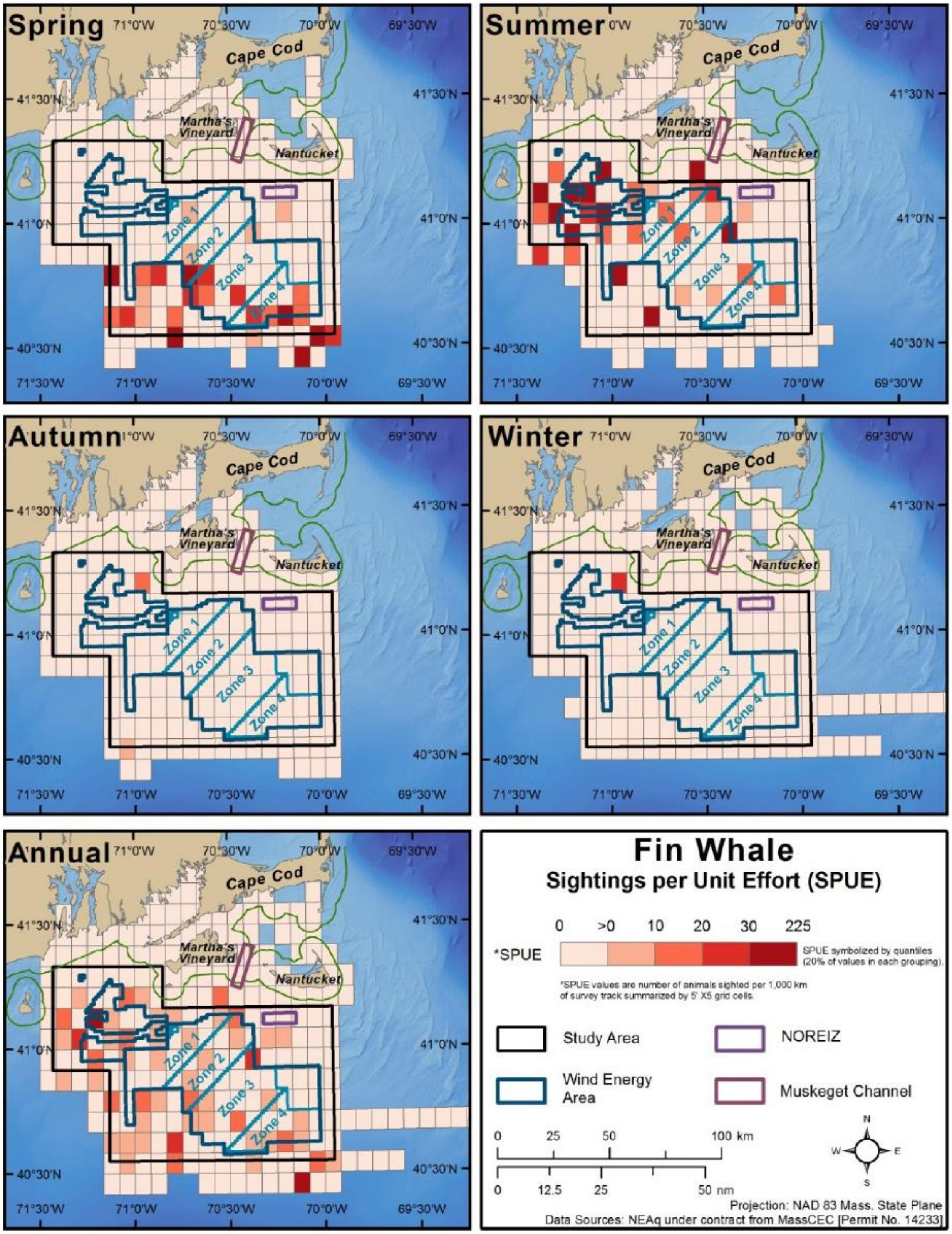

Figure 4.8. Fin Whale Seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

North Atlantic Right Whale (NARW)

The NARW is a large baleen whale, ranging between 45 and 55 feet in length and weighing up to 70 tons at maturity, with females being larger than males. The NARW is recognized to be a separate species from the Southern right whale (*Eubalenia australis*), separated into distinct populations in the northern Atlantic and Pacific Oceans. The Western Atlantic population, what is known as the NARW, ranges from calving grounds in coastal waters of the southeastern United States to primary feeding grounds off New England, the Canadian Bay of Fundy, the Scotian Shelf, and the Gulf of St. Lawrence. During spring and summer months, NARW migrate north to the productive waters of the northeast region to feed and nurse their young. Within the northeast region feeding habitats have been observed off the coast of Massachusetts, at Georges Bank, the Great South Channel, in the Gulf of Maine and over the Scotian Shelf (Waring et al. 2011). These feeding and calving habitats are considered high-use areas for the species. While high-use areas have been established for the NARW, frequent travel along the east coast of the United States is common. Satellite tags have shown NARW making round-trip migrations to an area off the southeastern United States and back to Cape Cod Bay at least twice during the winter (Waring et al. 2011).

Species Status and Critical Habitat

NARW have been listed as endangered under the ESA since 1970 (35 FR 18319). The species was nearly driven to extinction by commercial whaling efforts over more than three centuries. The historical size of the Western Atlantic population is uncertain but likely numbered in the thousands to tens of thousands based on documented harvest rates between 1530 and 1600 (Reeves et al. 2007). The population has modestly rebounded after the cessation of commercial whaling, increasing from an estimated low of approximately 260 individuals in 1990 to approximately 403 to 429 by 2020 (Hayes et al. 2021). The latter estimates are uncertain however and could range from 345 to 369 (Pettis et al. 2021; Pace 2021). The population continues to face threats from other anthropogenic stressors including vessel strike and fishing gear entanglement (Hayes et al. 2021). An Unusual Mortality Event (UME) was established for NARW in June 2017 due to elevated strandings along the Northwest Atlantic Ocean coast, especially in the Gulf of St. Lawrence region of Canada. The preliminary cumulative total number of animals in the NARW UME in both Canada and United States has been updated to 53 individuals to include both the confirmed mortalities (dead stranded or floaters) (n=34) and seriously injured free-swimming whales (n=19) (NOAA 2022b).

Occurrence in the Action Area and Vicinity

The Mid-Atlantic Bight is an important migratory corridor for NARW traveling between summer feeding and winter calving grounds on the northern and southern Atlantic coasts. LaBreque et al. (2015) defined five BIAs in Atlantic waters of New England: 1) June and July, and October to December feeding on Jeffreys Ledge northeast of Gloucester, MA; 2) February to April feeding in Cape Cod Bay and Massachusetts Bay; 3) April to June feeding in the Great South Channel and northern edge of Georges Bank; 4) November to January mating in the central Gulf of Maine, and; 5) a November and December, and March and April migratory corridor from central Florida to northern Cape Cod. The latter includes the nearshore zone to the edge of the continental shelf in the New York Bight, overlapping the marine component of the action area. NARWs in this area may be migrating, feeding, socializing, and/or nursing calves.

Ongoing BOEM-funded and related surveys of the RI/MA WEA and vicinity (Kraus et al. 2016; Quintana et al. 2019; O'Brien et al. 2021a; O'Brien et al. 2021b) indicate that NARW whales were most likely to be present in the RI/MA WEA during winter and early spring and are virtually absent from July through November, consistent with observed migratory behavior. NARW are unlikely to be present from July through November when they are concentrated in summer feeding areas north and east of Cape Cod. However, the potential for occurrence during these months cannot be discounted as available information suggests that this species may migrate throughout the North Atlantic OCS during the calving season (Kyrzystan et al. 2018). Kusel et al. (2021) compiled monthly NARW density estimates developed by Roberts et al. (2021b) to estimate potential marine mammal exposure to construction-related underwater noise levels (see Table 4.6). Collectively this information indicates this species could occur in the marine component of the action area from December through June, with the highest probability of occurrence extending from January through April.

NARW SPUE in the RI/MA WEA and vicinity by season from 2011 to 2015 are provided in Figure 4.9. All sightings were located to the east and outside of the RWF footprint. Subsequent sightings reported by Quintana et al. (2019), O'Brien et al. (2021a), and O'Brien et al. (2021b) generally comport with the observations over this earlier period.

Feeding Behavior and Hearing

The NARW is primarily planktivorous, preferentially targeting certain calanoid copepod species, primarily the late juvenile developmental stage of *Calanus finmarchicus*. This species occurs in dense patches and demonstrates both diel and seasonal vertical migration patterns (Baumgartner et al. 2011). Baumgartner et al. (2017) investigated NARW foraging ecology in the Gulf of Maine and southwestern Scotian Shelf using archival tags. Diving behavior was variable but followed distinct patterns correlated with the vertical distribution of forage species in the water column. Importantly, they found that NARWs spent 72 percent of their time within 33 feet (10 m) of the surface. While NARWs are always at risk of ship strike when breathing, they are hard to detect due to black coloring, no dorsal fin, and the tendency to forage near to but below the surface for extended periods substantially increases this risk (Baumgartner et al. 2017).

NARW and other baleen whales belong to the LFC marine mammal hearing group, which have a generalized hearing range of 7 Hz to 35 kHz (NMFS 2018b). The theoretical hearing range of this species is 10 Hz to 22 kHz based on modeling and anatomical analysis of inner ear structure

(Parks et al. 2007). Peak hearing sensitivity of NARW is most likely between 100 Hz and 400 Hz based on recorded vocalization patterns (Erbe 2002). NARW produce a variety of acoustical signals spanning the 20 Hz to 22 kHz sound spectrum but most vocalization used for intraspecific communication occurs at lower frequencies ranging from 50 Hz to 600 Hz (Matthews and Parks 2021).

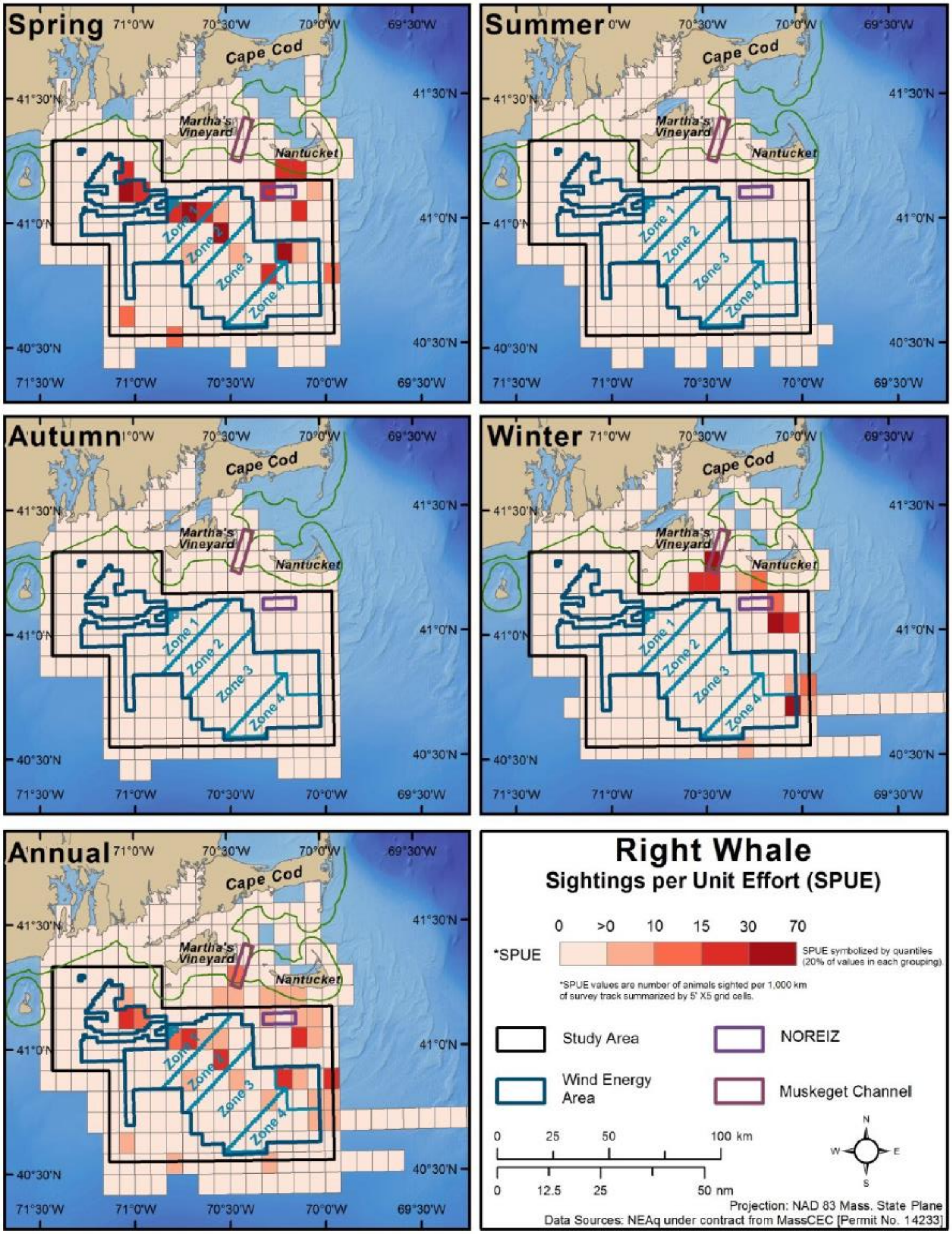

Figure 4.9. NARW Seasonal Sightings per Unit Effort in the RI/MA WEA, 2011 to 2015 (Kraus et al. 2016).

Sei Whale

The sei whale is a large baleen whale species found in subtropical, temperate, and subpolar waters around the globe, most commonly observed in temperate waters at mid-latitudes. The movement patterns of sei whales are not well known, but they are typically observed in deeper waters far from the coastline. The species is notable for its unpredictable distribution, concentrating in specific areas in large numbers for a period and then abandoning those habitats for years or even decades. The breeding and calving areas used by this species are unknown (Hayes et al. 2021).

Species Status

Sei whales have been ESA-listed as endangered at the species level since the passage of the act in 1970 (35 FR 12222). Critical habitat has not been designated. This species was subjected to intense commercial whaling pressure during the 19th and 20th centuries, with an estimated 300,000 animals killed for their meat and oil. Commercial whaling ended for this species in 1980, but limited scientific whaling continues today in Iceland and Japan. The average spring abundance estimate for the Nova Scotia stock of sei whales is 6,292, based on surveys conducted from 2010 through 2013 (Hayes et al. 2021).

Occurrence in the Action Area and Vicinity

Sei whales are somewhat regularly observed in the Gulf of Maine, and on Georges Bank and Stellwagen Bank during the summer. These appear to be core feeding areas at the southern end of the species range in the North Atlantic. Baumgartner et al. (2011) reported multiple sei whale observations during springtime in the Great South Channel from 2004 to 2010, suggesting that these whales are relatively common in the region. LaBrecque et al. (2015) defined a May to November feeding BIA for sei whales that extends from the 82-foot (25-m) contour off coastal Maine and Massachusetts east to the 656-foot (200-m) contour in central Gulf of Maine, including the northern shelf break area of Georges Bank, the Great South Channel, and the southern shelf break area of Georges Bank from 328 to 6,562 feet (100 to 2,000 m). This feeding BIA does not overlap the marine component of the action area.

While most commonly observed in deep waters at the edge of the continental shelf, sei whales periodically move into shallow waters on the continental shelf or even inshore when abundant zooplankton blooms are available (Hayes et al. 2021). The species is most likely to occur in the marine component of the action area during one of these periods. Kraus et al. (2016) observed an unusually large number of sei whales during aerial and acoustic surveys of the RI/MA WEA and vicinity that were conducted from 2011 through 2015. Several individuals were observed in the study area from March through June, with peaks in May and June, at a mean abundance ranging from 0 to 26 animals (Stone et al. 2017). Quintana et al. (2019) observed a large concentration of sei whales in the area in April, May, and July of 2017 peaking at 29 individuals in May, but none were observed in 2018. O'Brien et al. (2020, 2021a, 2021b) observed several sei whales 40 miles or more to the southeast of the RWF in 2019 but none were observed in the study area in 2020. These variable findings illustrate the transient use of this component of the action area by this species.

Kusel et al. (2021) compiled cetacean density data for the marine component of the action area and vicinity from available data sources and developed composite monthly density values. As shown in Table 4.6, the assembled data indicate that sei whale density in this component of the action area is generally low but with a distinct peak in May and June at densities ranging from 0.00001 to 0.0002/ km^2. Sei whale SPUE in the RI/MA WEA and vicinity from 2011 to 2015 are displayed by season in Figure 4.10. As shown, sightings were generally concentrated to the south and east of the RWF. This is consistent with the findings of the Northeast Large Pelagic Survey effort (Kraus et al. 2016; Quintana et al. 2019; O'Brien et al. 2021a; O'Brien et al. 2021b; Stone et al. 2017), which recorded scattered observations in the RI/MA WEA and vicinity in March and April, and multiple observations in May and June. This distribution suggests that sei whales are likely to occur in the marine component of the action area and vicinity between March and June if recent patterns of habitat use continue.

Feeding Behavior and Hearing

Sei whales are a fast-swimming, highly mobile species that range widely on an annual basis (Waring et al. 2011). The species is notable for its unpredictable distribution, concentrating in specific areas in large numbers for a period and then abandoning those habitats for years or even decades (Hayes et al. 2021). The species is typically associated with deeper water, and sightings in U.S. Atlantic waters are typically centered on mid-shelf and the shelf edge and slope (Olsen et al. 2009). Sei whales usually travel alone or in small groups of two to five animals, occasionally in groups as large as 10 (Waring et al. 2011).

Potential species occurrence in the marine component of the action area is likely to be closely tied to feeding behavior and seasonal availability of preferred prey resources. Sei whales in the North Atlantic preferentially prey on calanoid copepods, particularly *C. finmarchicus*, over all other zooplankton species (NMFS 2011; Prieto et al. 2014), demonstrating a clear preference for copepods between June and October, with euphausiids constituting a larger part of the diet in May and November (NMFS 2011; Prieto et al. 2014). The prey preferences of sei whales closely resemble those of NARW, particularly where the two species overlap (Waring et al. 2011).

Sei whales and other baleen whales belong to the LFC hearing group of marine mammals, which have a generalized hearing range of 7 Hz to 35 kHz (NMFS 2018b). It is recognized that marine mammal hearing is an evolving science. Improved understanding (e.g., Southall et al. 2019) may lead to future refinements of species-specific hearing ranges and sound sensitivity thresholds. Sei whales use sound for communication with other sei whales.

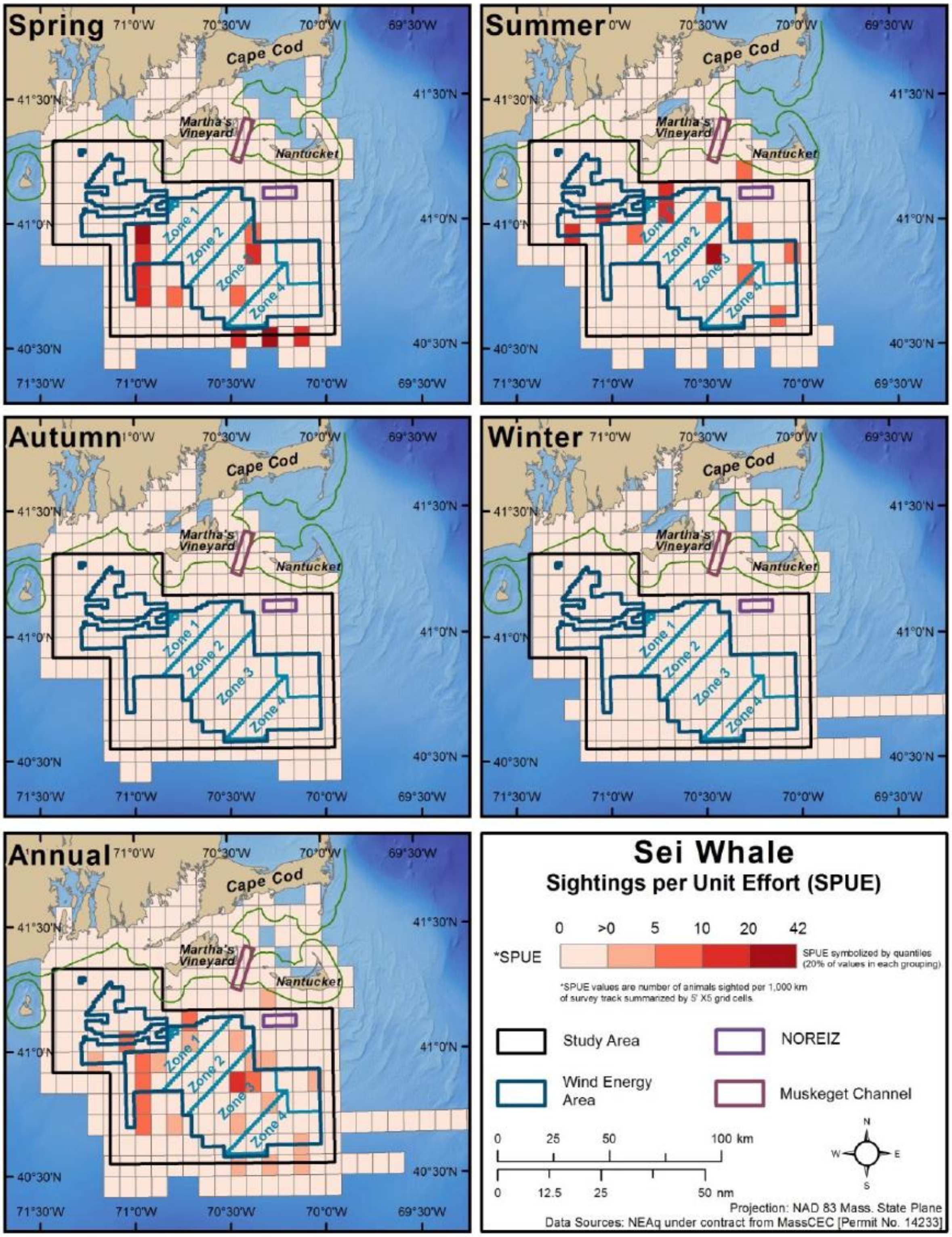

Figure 4.10. Sei Whale Seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

Sperm Whale

The sperm whale is the largest member of the order Odontocetes, or toothed whales, and the largest predator on Earth. The species is found in tropical, subtropical, and ice-free temperate ocean regions around the globe. They are most commonly observed in association with continental shelf margins and marine canyons with depths greater than 2,000 feet and are rarely observed in waters less than 1,000 feet deep (NMFS 2010b). Geographic distribution appears to be linked to social structure. Females and juveniles tend to congregate in static social groups in subtropical waters, while males range widely from the tropics to high latitudes and breed across social groups (Waring et al. 2011). Sperm whales in the Northern Atlantic display sufficient genetic isolation from other Atlantic groupings to justify their identification as a breeding stock, but insufficient data are available to determine a definitive population structure (Waring et al. 2015). Sperm whales in the marine component of the action area and vicinity are most likely members of this stock or transient males.

Species Status

Sperm whales have been listed as endangered under the ESA since the initial passage of the act (35 FR 8491). Critical habitat has not been designated. The species was subjected to intense commercial whaling pressure during the 18th, 19th, and early 20th centuries, resulting in a prolonged and severe decline in abundance. Sperm whale populations are rebuilding after the cessation of commercial whaling on the species; the primary threats today are ship collisions and fishing gear entanglement (Waring et al. 2015). The most recent abundance estimates for the North Atlantic is 4,349 (Hayes et al. 2021).

Occurrence in the Action Area and Vicinity

North Atlantic sperm whales display a distinct seasonal distribution. In winter females and juveniles congregate in large groups east and northeast of Cape Hatteras. In spring, the center of distribution shifts northward throughout the central portion of the Mid-Atlantic Bight and the southern portion of Georges Bank. In summer this distribution expands to include areas east and north of Georges Bank and into the Northeast Channel region. They remain in this broad area through the fall, concentrating in greatest abundance along the continental shelf south of New England (NMFS 2010b, 2015; Scott and Sadove 1997). Notably, this summer and fall distribution extends into relatively shallow waters on the continental shelf including the marine component of the action area and vicinity (Waring et al. 2015; Scott and Sadove 1997).

Historical sightings data from 1979 to 2020 indicate that sperm whales may occur within and in proximity to the RI/MA WEA during summer and fall in relatively low to moderate numbers (North Atlantic Right Whale Consortium 2018). Kraus et al. (2016) recorded four sperm whale sightings in the RI/MA WEA and vicinity between 2011 and 2015 (see Table 4.6). Three of the four sightings occurred in August and September of 2012, and one occurred in June 2015. Due to the limited sample size, Kraus et al. (2016) were not able to calculate SPUE or estimate abundance in the study area and specific sighting locations were not provided. Quintana et al. (2019) observed no live and one dead sperm whale in 2017 and 2018. O'Brien et al. (2021a, 2021b) observed an estimated six sperm whales in the RI/MA WEA and vicinity in 2019 and none in 2020. Due to the limited number of observations in each of these surveys, these researchers were not able to calculate SPUE or estimate abundance in the study area and specific sighting locations were not provided. Sperm whale sightings in the region during AMAPPS aerial surveys conducted from 2010 to 2013 are shown in Figure 4.11.

Kusel et al. (2022) compiled cetacean density data for the marine component action area and vicinity from available data sources and developed composite monthly density values. As shown in Table 4.6, the assembled data indicate that sperm whale density in the marine component of this component of the action area is generally low but with a distinct peak in July and August at densities ranging from 0.00024 to 0.00031/ km^2. Density models developed by Curtice et al. (2019) indicate this species is likely to occur in the marine component of the action area at low densities between June and November, with the highest probability of occurrence in July and August. The species is unlikely to be present from December through April.

Feeding Behavior and Hearing

Sperm whales are predatory specialists known for hunting prey in deep water. The species is amongst the deepest diving of all marine mammals. Males have been known to dive 3,936 feet (1,200 m) while females dive to at least 3,280 feet (1,000 m); both can continuously dive for over an hour. Sperm whales are also relatively fast swimmers, capable of speeds up to 9 m/s or 20 miles per hour (Aoki et al. 2007). The species preferentially target squid, which comprise at least 70 percent of typical diet (Kawakami 1980; Pauly et al. 1998). Sperm whales are also known to prey on bottom-oriented organisms including octopus, fish, shrimp, crab, and sharks (Leatherwood et al. 1988; Pauly et al. 1998). Sperm whales occurring in the marine component of the action area are likely targeting smaller squid, crustaceans, and fish common to the shallow waters of the OCS.

Sperm whales belong to the MFC marine mammal hearing group, which have a generalized hearing range of 150 Hz to 160 kHz (NMFS 2018b). Peak hearing sensitivity of stranded sperm whales neonate ranges from 5 to 20 kHz based on auditory brainstem response to recorded stimuli (Ridgway and Carder 2001). Sperm whales use sound for communication with other sperm whales as well as echolocation of prey resources.

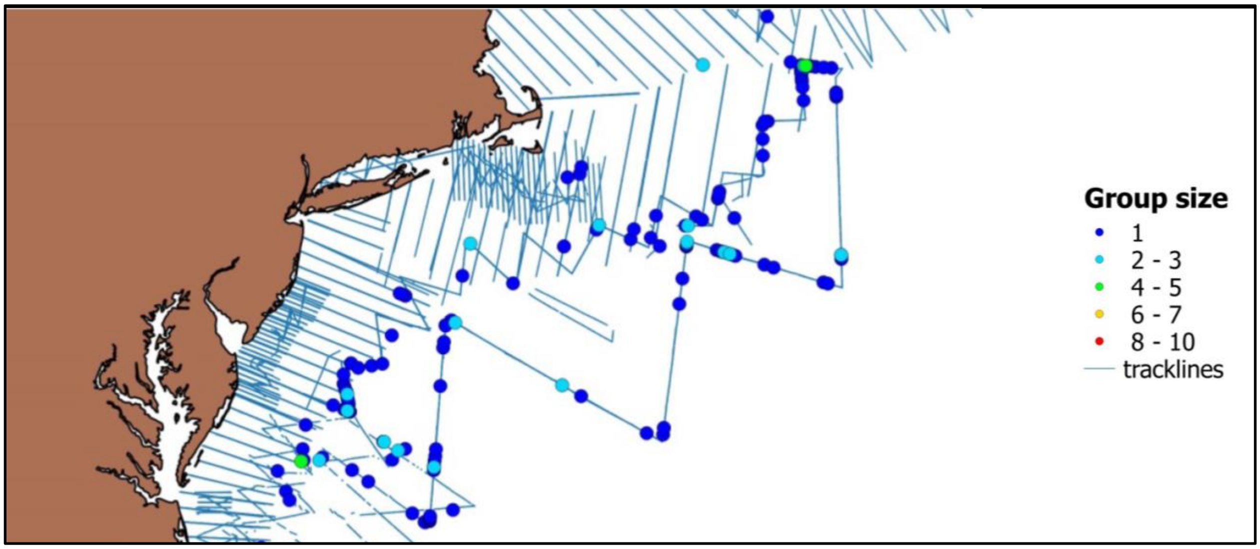

Figure 4.11. Sperm Whale Sightings in the North Atlantic Outer Continental Shelf and Vicinity during 2010 to 2013 Atlantic Marine Assessment Program for Protected Species Aerial Surveys (NEFSC and SEFSC 2018).

4.12.2 Sea Turtles

Four marine reptile species listed under the ESA are known to occur in the Western North Atlantic within or in proximity to the marine component of the action area. These include the north Atlantic DPS of green sea turtle (*Chelonia mydas*), the Kemp's ridley sea turtle (*Lepidochelys kempii*), the Northwest Atlantic Ocean DPS of loggerhead sea turtle (*Caretta caretta*), and leatherback sea turtle (*Dermochelys coriacea*). Information about species occurrence in the marine component of the action area was obtained from various sources, including aerial surveys (Kraus et al. 2016; NEFSC and SEFSC 2018; North Atlantic Right Whale Consortium 2018), regional historical data (Kenney and Vigness-Raposa 2010), and sea turtle stranding records from the OBIS-SEAMAP database (Halpin et al. 2009).

LGL (2022b) compiled estimated seasonal densities for Kemp's ridley, leatherback, and loggerhead and green sea turtles in the marine component of the action area. These estimates, provided in Table 4.7, are approximate and reflect the limitations of current survey methods, which include variable adult detection rates under different weather conditions, poor juvenile detection ability, and incomplete coverage of nearshore habitats used by juveniles and subadults.

Kraus et al. (2016) also conducted aerial surveys of sea turtle occurrence in the RI/MA WEA and vicinity from 2011 through 2015. Sea turtle sightings and number of individuals sighted by season in aerial surveys of the RI/MA WEA are summarized in Table 4.8. SPUE for all sea turtle species in the marine component of the action area and vicinity are displayed graphically in Figure 4.12. Species descriptions, status, likelihood of occurrence in this component of the action area, and information about feeding habits and hearing ability relevant to this effect analysis are provided in the following sections.

Table 4.7. Estimated Seasonal Densities (animals/km^2) of ESA-Listed Turtles in the Action Area and Vicinity.

Species	Winter (Dec – Feb)	Spring (Mar – May)	Summer (Jun – Aug)	Fall (Sep – Nov)
Kemp's ridley sea turtle	0.00925	0.00925	0.00925	0.00925
Leatherback sea turtle	0.00588	0.00588	0.00630	0.00873
Loggerhead sea turtle	0.035	0.035	0.00206	0.00755
Green sea turtle	0.00925	0.00925	0.00925	0.00925

Seasonal density estimates compiled by Denes et al. (2021).

Table 4.8. Summary of ESA-Listed Sea Turtle Sightings and Estimated Number of Individuals Observed by Season in Aerial Surveys of the RI/MA WEA and Vicinity from 2011 to 2015.

Species	Winter (Dec – Feb) S	Winter (Dec – Feb) N	Spring (Mar – May) S	Spring (Mar – May) N	Summer (Jun-Aug) S	Summer (Jun-Aug) N	Fall (Sep-Nov) S	Fall (Sep-Nov) N
All turtles‡	0	0	6	8	146	155	133	140
Kemp's ridley sea turtle	0	0	2	3	1	1	4	5
Leatherback sea turtle	0	0	2	2	92	98	59	62
Loggerhead sea turtle	0	0	2	3	31	32	45	52

Source: Kraus et al. (2016)

S = Number of sightings (definite and probable identifications); N = Number of individuals sighted.

‡ Includes identified and unidentified sightings.

The suitability of North Atlantic OCS sea turtle foraging habitats is shifting as a result of current climate change trends. For example, pelagic foraging habitats for leatherback sea turtles in the north Atlantic are strongly associated with the 59°F (15°C) isotherm which is shifting northward at a rate of approximately 124 miles (200 km) per decade (McMahon and Hays 2006). Other sea turtle species are likely to shift their range in response to changing temperature conditions and changes in the distribution of preferred prey (Hawkes et al. 2009). Numerous fish and invertebrate species on the North Atlantic OCS are currently undergoing, or likely to undergo, changes in abundance and distribution in response to climate change impacts (Hare et al. 2016; Rogers et al. 2019). The implications of these range shifts are difficult to predict and will likely vary by species. For example, loggerhead sea turtles exhibit a high degree of dietary flexibility (Plotkin et al. 1993; Ruckdeschel and Shoop 1988; Seney and Musick 2007) and may more readily adapt to changes in ecosystem structure than dietary specialists like leatherbacks (Hawkes et al. 2009).

North Atlantic DPS Green Sea Turtle

The green sea turtle is the largest of the hard-shelled sea turtles, growing to a maximum length of approximately 4 feet (1.2 m) and weighing up to 440 pounds (200 kg) (NMFS and USFWS 1991). The species inhabits tropical and subtropical waters around the globe. They are most commonly observed feeding in shallow waters of reefs, bays, inlets, lagoons, and shoals that are abundant in algae or marine grass, such as eelgrass (NMFS and USFWS 2007a). Individuals display fidelity for specific nesting habitats, which are concentrated in lower latitudes well south of the marine component of the action area. The primary breeding areas in the United States are located in southeast Florida (NMFS and USFWS 1991). In summer, the distribution of foraging subadults and adults can expand to include subtropical waters at higher latitudes. Juveniles and subadults are occasionally observed in Atlantic coastal waters as far north as Massachusetts (NMFS and USFWS 1991), including Long Island Sound and Cape Cod Bay (CETAP 1982). This indicates that green sea turtles may occur in the marine component of the action area and are likely to occur in the vessel transit component of the action area, particularly on vessel transit routes on the southern U.S. Atlantic coast and in the Gulf of Mexico.

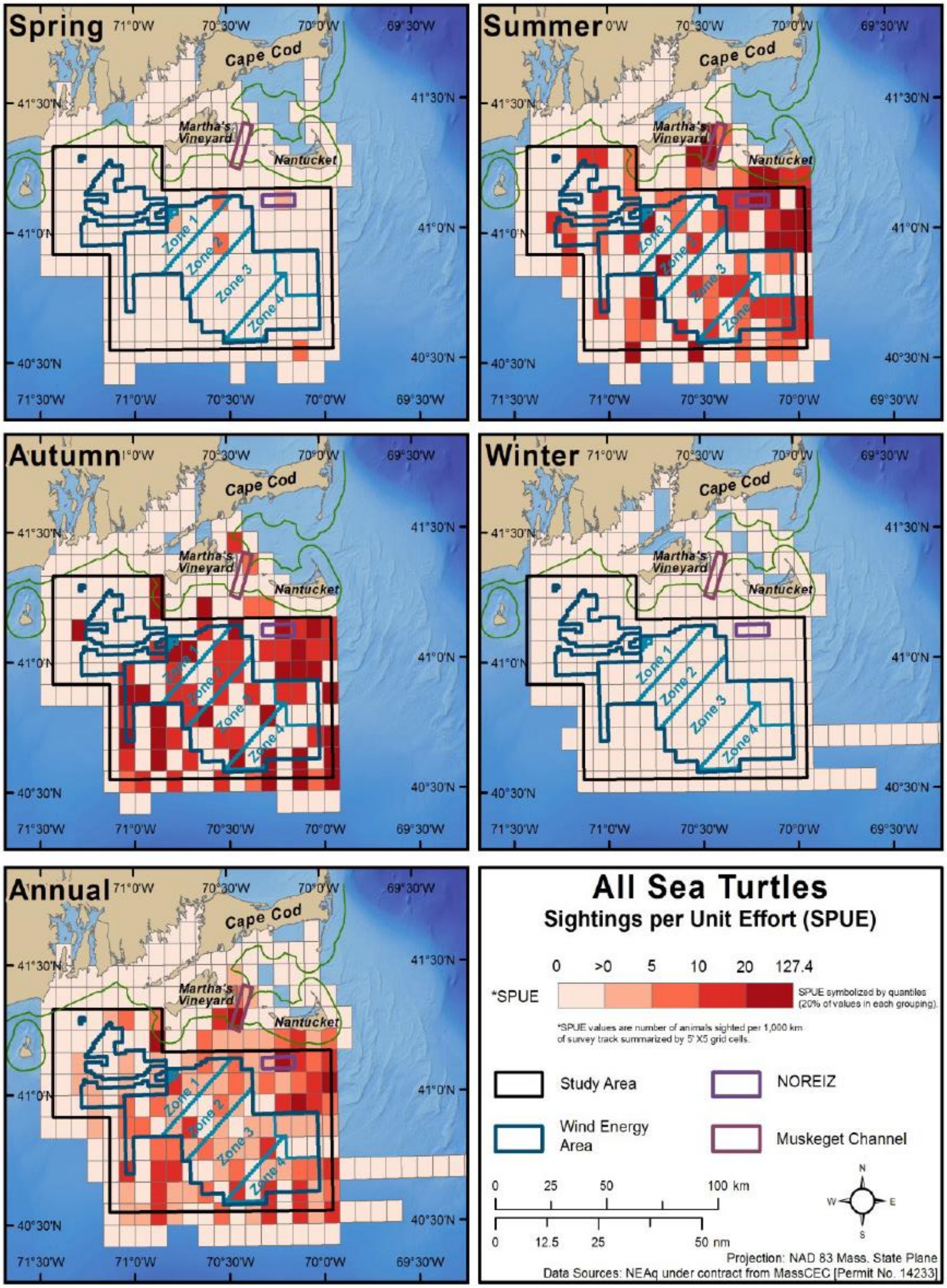

Figure 4.12. Seasonal Sightings per Unit Effort for All Sea Turtle Species in the RI/MA WEA (Kraus et al. 2016).

Species Status

The green sea turtle was originally listed under the ESA in 1978 as threatened across its range. The listing was subsequently updated in 2016 (81 FR 20057), confirming threatened status across the range, with specific breeding populations in Florida and the Pacific Coast of Mexico listed as endangered (NMFS 2011). Critical habitat was designated on October 2, 1998 (63 FR 46693) in the waters off the islands of Puerto Rico. The species was listed on the basis of population declines resulting from egg harvesting, incidental mortality in commercial fisheries, and nesting habitat loss. Current threats to the species include nesting habitat degradation and artificial lighting effects resulting from coastal development, and degradation and loss of seagrass and marine algae foraging resources. Illegal harvest of eggs and mature adults and incidental fisheries mortality remain significant threats, particularly outside the U.S. Predation on depleted population groups and diseases (e.g., fibropapillomatosis) are also emerging risks (NMFS and USFWS 2007a).

Occurrence in the Action Area and Vicinity

Based on feeding and habitat preferences green sea turtles are less likely to occur in the marine component of the action area than the other turtle species addressed in this consultation, at least as adults. They are likely to occur in portions of the vessel traffic component of the action areas. This species is typically observed in U.S. waters in the Gulf of Mexico or coastal waters south of Virginia (USFWS 2021). Juveniles and subadults are occasionally observed in Atlantic coastal waters as far north as Massachusetts (NMFS and USFWS 1991), including the waters of Long Island Sound and Cape Cod Bay (CETAP 1982). Kenney and Vigness-Raposa (2010) recorded one confirmed sighting within the RI/MA WEA in 2005. The Sea Turtle Stranding and Salvage Network (STSSN) reported one offshore and 20 inshore green sea turtle stranding's between 2017 and 2019, and green sea turtles are found each year stranded on Cape Cod beaches (NMFS STSSN 2021; WBWS 2018). Five green turtle sightings were recorded off the Long Island shoreline 10 to 30 miles southwest of the RI/MA WEA in aerial surveys conducted from 2010-2013 (NEFSC and SEFSC 2018). However, given the relative abundance of observations farther to the south, adult green sea turtles are likely an infrequent visitor to the area at best. This conclusion is supported by the lack of green sea turtle observations recorded in an intensive aerial survey of the RI/MA WEA from October 2011 to June 2015 (Kraus et al. 2016). However, the aerial survey methods used in the region to date are unable to reliably detect juvenile turtles, sight several unidentified turtles, and do not cover the shallow nearshore habitats most commonly used by this species. Denes et al. (2019) did not attempt to estimate green sea turtle density in the RI/MA WEA to support modeling of hydroacoustic impacts.

Juvenile green sea turtles represented 6 percent of 293 cold-stunned turtle stranding records collected in inshore waters of Long Island Sound from 1981 to 1997 (Gerle et al. 1998). These and other sources of information indicate that juvenile green turtles occur at least periodically in shallow nearshore waters of Long Island Sound and the coastal bays of New England (Morreale et al. 1992).

Based on the available information, green sea turtle occurrence in the marine component of the action area appears to be unlikely but cannot be ruled out. They would most likely occur as juveniles or subadults in the shallow coastal waters Rhode Island and Massachusetts and in Narragansett Sound.

Feeding Behavior and Hearing

Green turtles spend the majority of their lives in coastal foraging grounds including open coastline waters (NMFS and USFWS 2007a). Green turtles often return to the same foraging grounds following periodic nesting migrations (Godley et al. 2002). However, some green sea turtles remain in the open ocean habitat for extended periods, and possibly never recruit to coastal foraging sites (Pelletier et al. 2003). Once thought to be strictly herbivorous, more recent research indicates that this species also forages on invertebrates including jellyfish, sponges, sea pens, and pelagic prey while offshore, and sometimes in coastal habitats (Heithaus et al. 2002).

Piniak et al. (2016) studied hearing sensitivity in green sea turtles and determined species hearing range extends from 50 Hz to 1.6 kHz, with the greatest sound sensitivity from 200 Hz to 400 Hz. The scientific understanding of how green turtles use sound and hearing is not well developed. Recent evidence suggests that sea turtles produce vocalizations that could be used for intra-specific communication (Charrier et al. 2022).

Kemp’s Ridley Sea Turtle

The Kemp’s ridley is one of the smallest of sea turtle species. Adults can weigh between 70.5 and 108 pounds (32 and 49 kg) and reach up to 24 to 28 inches (60 to 70 cm) in length (NMFS and USFWS 2007b). The preferred diet of the Kemp’s ridley sea turtle is crabs, although they may also prey on fish, jellyfish, and mollusks (NMFS and USFWS 2007b). Kemp’s ridley turtles are most commonly found in the Gulf of Mexico and along the U.S. Atlantic coast. The species is coastally oriented, rarely venturing into waters deeper than 160 feet (50 m). They are primarily associated with mud and sand-bottomed habitats where primary prey species are found (NMFS and USFWS 2007b). Most nesting areas are in the Western Gulf of Mexico, primarily Tamaulipas and Veracruz, Mexico. Some nesting occurs periodically in Texas and few other states, occasionally extending up the Atlantic coast to North Carolina.

Species Status

The Kemp’s ridley sea turtle was listed as endangered at the species level with the passage of the ESA in 1970 (35 FR 18319). The species has experienced large population declines due to egg harvesting, loss of nesting habitat to coastal development and related human activity, bycatch in commercial fisheries, vessel strikes, and other anthropogenic and natural threats. The species began to recover in abundance and nesting productivity since conservation measures were initiated following listing. However, since 2009 the number of successful nests has declined markedly (NMFS and USFWS 2015). Potential explanations for this trend, including the Deepwater Horizon oil spill in 2010, have proven inconclusive, suggesting that the decline in nesting may be due to a combination of natural and anthropogenic stressors (Caillouet et al. 2018). Population models indicate a persistent reduction in survival and/or nesting adult recruitment, suggesting that the species is not recovering. Current threats include incidental fisheries mortality, ingestion, and entanglement in marine debris, and vessel strikes (NMFS and USFWS 2015).

Occurrence in the Action Area and Vicinity

Juvenile and subadult Kemp's ridley sea turtles are known to travel as far north as Long Island Sound and Cape Cod Bay during summer and fall foraging (NMFS, USFWS and SEAMARNAT 2011). Visual sighting data is limited because this small species is difficult to observe using aerial survey methods (Kraus et al. 2016), and most surveys do not cover its preferred shallow bay and estuary habitats. However, Kraus et al. (2016) recorded six observations in the RI/MA WEA over 4 years, all in August and September of 2012. The sighting data were insufficient for calculating SPUE for this species (Kraus et al. 2016). Other aerial surveys efforts conducted in the region between 1998 and 2017 have observational records of species occurrence in the waters surrounding the RI/ME WEA during the fall (September to November) at densities ranging from 10 to 40 individuals per 1,000 km (North Atlantic Right Whale Consortium 2018; NEFSC and SEFSC 2018). Juvenile Kemp's ridley turtles represented 66 percent of 293 cold-stunned turtle stranding records collected in inshore waters of Long Island Sound from 1981 to 1997 (Gerle et al. 1998).

The STSSN reported six offshore and 69 inshore Kemp's ridley sea turtle strandings between 2017 and 2019 (NMFS STSSN 2021) and the New York Marine Rescue Center (NYMRC) has documented stranding of 620 Kemp's ridley sea turtles within New York state waters between 1980 and 2018 (NYMRC 2021). Cold-stunned Kemp's ridley sea turtles are often found stranded on the beaches of Cape Cod (Lui et al. 2019; WBWS 2019). Based on this information, juvenile and subadult Kemp's ridley sea turtle could potentially occur in the marine component of the action area from July through September, perhaps as late as October. The highest likelihood of occurrence is in coastal nearshore areas adjacent to the RWEC corridor. Occurrence in the offshore portion of the marine component of the action area is also possible but unlikely with increasing distance from shore. Kusel et al. (2021) estimated that Kemp's ridley sea turtles occur in this component of the action area and vicinity at a low density of 0.006 individuals/km^2 across all months for the purpose of hydroacoustic impact modeling (see Table 4.7).

Feeding Behavior and Hearing

Kemp's ridley sea turtles are most likely to occur in the marine component of the action area as juveniles foraging in inshore waters. Kemp's ridley sea turtles are generalist feeders that prey on a variety of species (including crustaceans, mollusks, fish, jellyfish, and tunicates) and forage on aquatic vegetation. The species is also known to ingest natural and anthropogenic debris (Burke et al. 1993, 1994; Witzell and Schmid 2005). Crabs compose the majority of the diet of juveniles foraging in New York state waters (Burke et al. 1993, 1994; Morreale et al. 1992; Morreale and Standora 1998).

Dow Piniak et al. (2012) concluded that sea turtle hearing is generally confined to lower frequency ranges below 1.6 kHz, with the greatest hearing sensitivity between 100 and 700 Hz, varying by species. Bartol and Ketten (2006) determined that Kemp's ridley hearing is more limited, ranging from 100 to 500 Hz, with greatest sensitivity between 100 and 200 Hz. The scientific understanding of how Kemp's Ridley turtles use sound and hearing is not well developed.

Leatherback Sea Turtle

The leatherback sea turtle is the largest sea turtle in the world and one of the largest living reptiles (NMFS 2012). Adults can reach up to 2,000 pounds (900 kg) in weight and over 6 feet (2 m) in length (NMFS 2012; NMFS and USFWS 2007c). The species has unique characteristics that distinguish it from other sea turtles. Instead of bony plates, it has carapace consisting of a leather-like outer layer of oil-saturated connective tissue covering a nearly continuous layer of small dermal bones (NMFS and USFWS 1992). Unlike other predatory sea turtles with crushing jaws, the leatherback has evolved a sharp-edged jaw for consuming soft-bodied oceanic prey such as jellyfish and salps (NMFS 2012).

The leatherback is the most globally distributed sea turtle species, ranging broadly from tropical and subtropical to temperate regions of the world's oceans (NMFS and USFWS 1992). The species spawns on tropical and subtropical beaches. Breeding habitat in the United States is concentrated in southeastern Florida from Brevard County south to Broward County (NMFS and USFWS 1992; USFWS 2015). Leatherbacks are a pelagically oriented species, but they are often observed in coastal waters along the U.S. continental shelf (NMFS and USFWS 1992). Leatherbacks have been sighted along the entire coast of the eastern United States from the Gulf of Maine in the north and south to Puerto Rico, the Gulf of Mexico, and the U.S. Virgin Islands (NMFS and USFWS 1992).

Species Status

The leatherback sea turtle was listed as endangered at the species level with the passage of the ESA in 1970 (35 FR 18319). Primary threats to the species include illegal harvesting of eggs, nesting habitat loss, and shoreline development. In-water threats include incidental catch and mortality from commercial fisheries, vessel strikes, anthropogenic noise, marine debris, oil pollution and predation by native and exotic species (NMFS and USFWS 1992).

Occurrence in the Action Area and Vicinity

Leatherback sea turtles are commonly observed in the marine component of the action area and vicinity, and given their broad distribution are also certain to occur throughout the vessel transit component of the action area as well. The high observation frequency in the marine component of the action area compared to other turtle species is a function of their broad distribution and large body size. Leatherbacks are a predominantly pelagic species that ranges into cooler waters at higher latitudes than other sea turtles, and their large body size makes the species easier to observe in aerial and shipboard surveys. The Cetacean and Turtle Assessment Program (CETAP) regularly documented leatherback sea turtles on the outer continental shelf between Cape Hatteras and Nova Scotia during summer months in aerial and shipboard surveys conducted from 1978 through 1988. The greatest concentrations were observed between Long Island and the Gulf of Maine (Shoop and Kenney 1992). AMAPPS surveys conducted from 2010 through 2013 routinely documented leatherbacks in the marine component of the action area and surrounding waters during summer months (NEFSC and SEFSC 2018). Leatherbacks were the most frequently sighted sea turtle species in monthly aerial surveys of the RI/MA WEA from October 2011 through June 2015. Kraus et al. (2016) recorded 153 observations (161 animals) in monthly aerial surveys, all between May and November, with a strong peak in the fall (see Table 4.7). The STSSN reported 19 offshore and 77 inshore leatherback sea turtle stranding's between 2017 and 2019, the highest number among all turtle species reported (NMFS STSSN 2021). Kraus et al. (2016) data indicated that leatherbacks would be the most abundant sea turtle species in the RWF and RWEC, which is consistent with the other information on sea turtle occurrence in the vicinity presented here. Leatherback SPUE in the RI/MA WEA and vicinity from 2011 to 2015 are displayed by season in Figure 4.13. As shown, the majority of observations were clustered to the east of the marine component of the action area south of Nantucket Island; however, several summer observations were recorded in immediate proximity to the RWF.

Based on this information, leatherback sea turtles are likely to occur in the marine component of the action area between May and November, with the highest probability of occurrence from August through October. This species is likely to occur in the vessel traffic component of the action area year around.

Feeding Behavior and Hearing

Leatherback sea turtles from nesting areas in the southern United States, Central and South America, and the Caribbean migrate to the open ocean waters of the North Atlantic OCS in spring and early summer to feed, spending up to 4 months in the region before returning south in fall. Leatherbacks are dietary specialists, feeding almost exclusively on jellyfish, siphonophores, and salps, and their migratory range is closely tied to the availability of pelagic prey resources (Eckert et al. 2012; NMFS and USFWS 1992). James et al. (2005) studied migratory behavior using satellite tags and observed that the timing of southerly migration ranges widely, extending from mid-August to mid-December, but with a distinct peak in October. The continental slope to the east and south of Cape Cod and the OCS south of Nantucket appear to be hotspots, where several tagged turtles congregated to feed for extended periods. The latter comports with Kraus et al. (2016), who recorded the majority of their leatherback sightings in the same area (see Figure 4.13). The migratory corridors between breeding and northerly feeding areas appear to vary widely, with some individuals traveling through the OCS and others using the open ocean far from shore (James et al. 2005).

Dow Piniak et al. (2012) determined that the hearing range of leatherback sea turtles extends from approximately 50 to 1,200 Hz, which is comparable to the general hearing range of turtles across species groups. Leatherbacks greatest hearing sensitivity is between 100 and 400 Hz. The scientific understanding of how leatherback turtles use sound and hearing is not well developed.

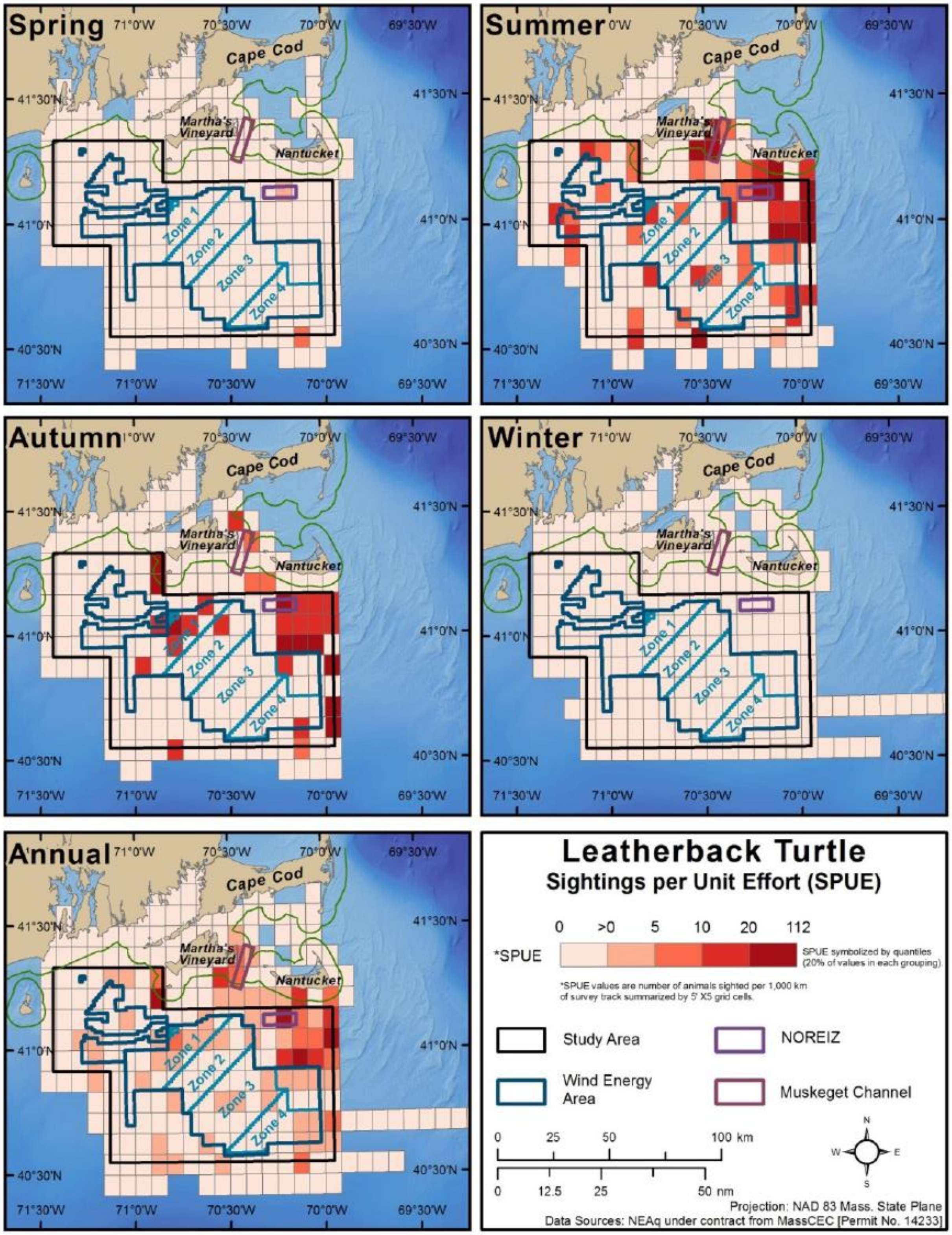

Figure 4.13. Leatherback sea turtle seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

Northwest Atlantic Ocean DPS Loggerhead Sea Turtle

The loggerhead sea turtle is a globally distributed species found in temperate and tropical regions of the Atlantic, Pacific, and Indian oceans (NMFS and USFWS 2008). Loggerheads are the most common sea turtle species observed in offshore and nearshore waters along the U.S east coast, and virtually all these individuals belong to the Northwest Atlantic Ocean DPS. The majority of loggerhead sea turtles nesting in the eastern United States occurs from North Carolina through southwest Florida. Some nesting also occurs in southern Virginia and along the Gulf of Mexico coast westward into Texas (NMFS and USFWS 2008). Foraging loggerhead sea turtles' range widely—they have been observed along the entire Atlantic coast of the United States as far north as the Gulf of Maine (Shoop and Kenney 1992). The loggerhead is distinguished from other sea turtle species by a relatively large head with powerful jaws evolved for capturing and crushing hard-shelled organisms (NMFS 2012). It preys on crustaceans, mollusks, jellyfish, small finfish, and other marine organisms (NMFS and USFWS 2008).

Species Status

The Northwest Atlantic Ocean DPS of the loggerhead sea turtle was listed as federally threatened under the ESA effective October 24, 2011 (76 FR 58868). Critical habitat was designated on July 10, 2014 (79 FR 39855). Factors affecting the conservation and recovery of this species include beach development, related human activities that damage nesting habitat, and light pollution (NMFS and USFWS 2008). In-water threats include bycatch in commercial fisheries, vessel strikes, anthropogenic noise, marine debris, legal and illegal harvest, oil pollution, and predation by native and exotic species (NMFS and USFWS 2008).

Occurrence in the Action Area and Vicinity

In southern New England loggerhead sea turtles can be found seasonally, primarily during summer and fall months when surface temperatures range from 44.6º and 86º Fahrenheit (7º and 30º Celsius) (Kenney and Vigness-Raposa 2010; Shoop and Kenney 1992). Loggerheads are absent from southern New England during winter months (Kenney and Vigness-Raposa 2010; Shoop and Kenney 1992). During the CETAP surveys, one of the largest observed aggregations of loggerheads was documented in shallow shelf waters northeast of Long Island (Shoop and Kenney 1992). The STSSN reported six offshore and 58 inshore loggerhead sea turtle strandings between 2017 and 2019 (NMFS STSSN 2021). In New York state waters, the NYMRC documented 816 strandings of loggerhead sea turtles from 1980 to 2018 (NYMRC 2021). Winton et al. (2018) estimated densities using data from 271 satellite tags deployed on loggerhead sea turtles between 2004 and 2016 and found that tagged loggerheads primarily occupied the continental shelf from Long Island, New York, south to Florida, but relative densities in the RI/MA WEA increased during the period between July and September. Loggerheads were most frequently observed in areas ranging from 72 to 160 feet (22 and 49 m) deep. Over 80 percent of all sightings were in waters less than 262 feet (80 m), suggesting a preference for relatively shallow OCS habitats (Shoop and Kenney 1992). Juvenile loggerheads are prevalent in the nearshore waters of Long Island from July through mid-October (Morreale et al. 1992; Morreale and Standora 1998), accounting for over 50 percent of live strandings and incidental captures (Morreale and Standora 1998).

The loggerhead was the most frequently observed sea turtle species in 2010 to 2013 AMAPPS aerial surveys of the Atlantic continental shelf. Large concentrations were regularly observed in proximity to the RI/MA WEA (NEFSC and SEFSC 2018). Kraus et al. (2016) observed loggerhead sea turtles within the RI/MA WEA in the spring, summer, and fall, with the greatest density of observations in August and September. Loggerhead SPUE in the RI/MA WEA and vicinity from 2011 to 2015 is displayed by season in Figure 4.14. Kusel et al. (2021) estimated a species density ranging from 0.084 individuals/km^2 in winter and spring and a peak of 0.755 individuals/km^2 in fall (Table 4.7).

Collectively, the available information indicates that loggerhead sea turtles are likely to occur in the marine component of the action area as adults, subadults, and juveniles from the late spring through early fall. The highest probability of occurrence is in August and September.

Feeding Behavior and Hearing

The loggerhead turtle has powerful beak and crushing jaws specially adapted to feed on hard-bodied benthic invertebrates, including crustaceans and mollusks. Mollusks and crabs are primary food items for juvenile loggerheads (Burke et al. 1993). While loggerheads are dietary specialists, the species demonstrates the ability to adjust their diet in response to changes in prey availability in different geographies (Plotkin et al. 1993; Ruckdeschel and Shoop 1988). For example, loggerheads in the Gulf of Mexico feed primarily on crabs but sea pens are also a major part of the diet. Loggerheads in Chesapeake Bay, Virginia, primarily targeted horseshoe crabs (*Limulus polyphemus*) in the early to mid-1980s but subsequently shifted their diet to blue crabs in the late 1980s, and then to finfish from discarded fishery bycatch in the mid-1990s (Seney and Musick 2007).

Martin et al. (2012) and Lavender et al. (2014) used behavioral and auditory brainstem response methods to identify the hearing range of loggerhead turtles. Both teams identified a generalized hearing range from 50 Hz to 1.1 kHz, with greatest hearing sensitivity between 100 Hz and 400 Hz. The scientific understanding of how loggerhead turtles use sound and hearing is not well developed.

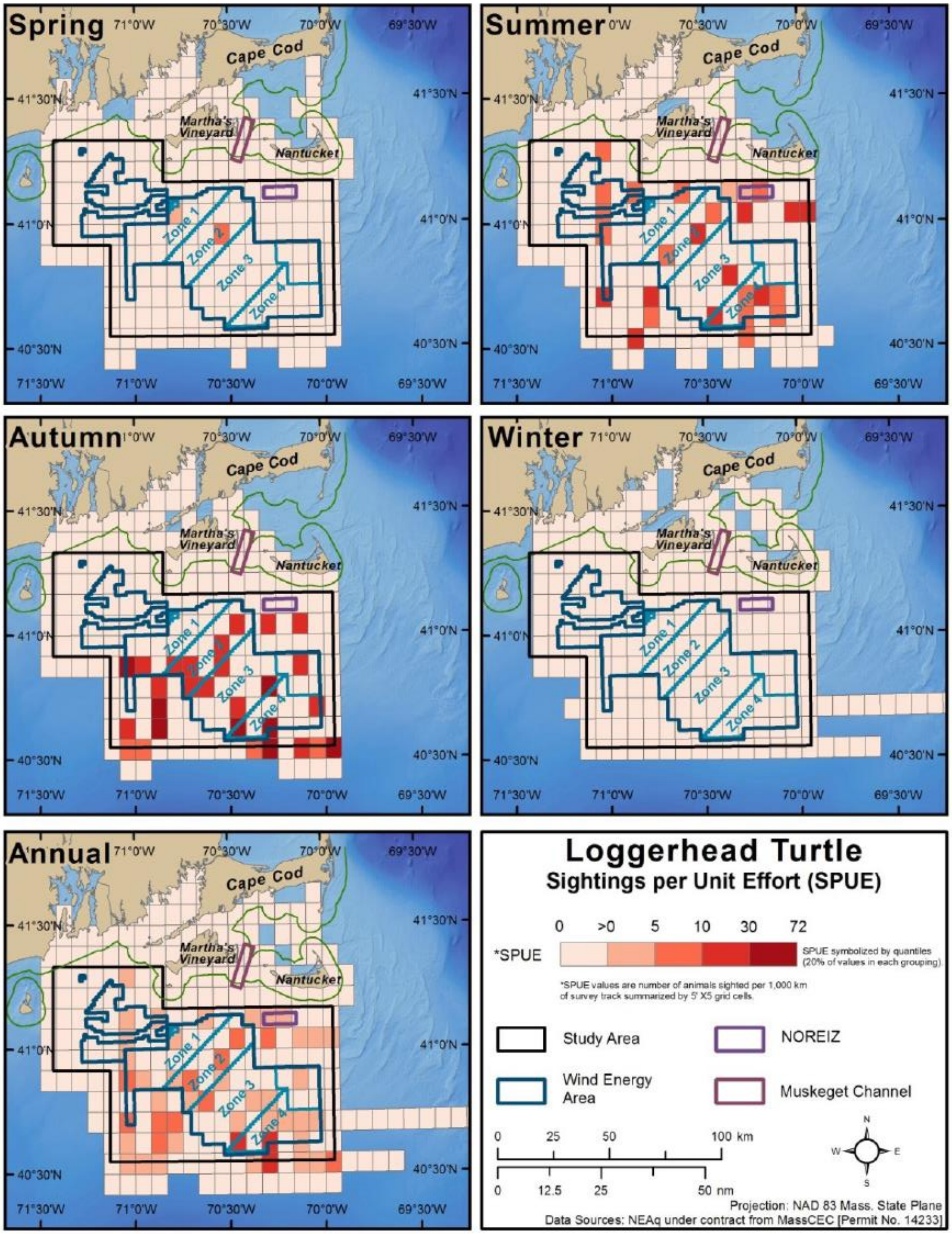

Figure 4.14. Loggerhead Sea Turtle Seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

4.12.3 Marine Fish

Two ESA-listed fish species occur in the marine component of the action area: the Atlantic sturgeon (*Acipenser oxyrinchus*; five listed DPS) and the giant manta ray (*Manta birostris*). The former is relatively common in the North Atlantic OCS and uses the marine and portions of the vessel traffic components of the action area and associated demersal habitats for foraging and migration to and from natal rivers, while the latter is uncommon, with the North Atlantic OCS representing the northern end of its range. Species descriptions, status, likelihood of occurrence in the marine component of the action area, and information about feeding habits and hearing ability relevant to this effect analysis are provided in the following sections.

The biology, migratory behaviors, and feeding habits of sturgeon and manta ray influence potential exposure and sensitivity to the effects of the proposed action as well as their sensitivity to regional trends. Adult and subadult Atlantic sturgeon range widely across the Atlantic OCS from Florida to Canada (Erickson et al. 2011; Savoy et al. 2017), feeding primarily on benthic invertebrates and small fish on or near the sea floor. They appear to congregate in areas providing favorable foraging conditions (Stein et al. 2004a, 2004b) and exhibit dietary flexibility and can adapt to changing prey availability (Guilbard et al. 2007; Johnson et al. 1997). Manta rays are pelagic filter feeders whose distribution is correlated with zooplankton abundance, meaning that regional distribution is determined by both suitable water temperatures and seasonal secondary productivity (Miller and Klimovich 2017). Therefore, the potential for occurrence in the marine component of the action area is strongly influenced by seasonal and interannual variation in oceanographic conditions.

These biological differences suggest different sensitivity to current ecological trends. Ecological community structure is likely to shift significantly if climate change effects intensify (Hare et al. 2016). Sturgeon on the North Atlantic OCS are near the center of a relatively broad range and have greater physiological and dietary flexibility to adapt to changing conditions. In contrast, manta rays are more likely to display changes in distribution in response to shifts in temperature regime and prey abundance. While difficult to predict with certainty, those shifts are likely to be of similar magnitude to those displayed by other planktivorous marine species like NARW (Meyer-Gutbrod et al. 2015) and leatherback sea turtles (McMahon and Hays 2006).

Atlantic Sturgeon

The Atlantic sturgeon is a large (up to 14 feet or 4.3 m, reaching weights up to 600 pounds or 270 kg), long-lived (up to 60 years), estuarine-dependent, anadromous species that historically spawned in medium to large rivers on the U.S. Atlantic coast from Labrador to Florida (ASSRT 2007). The current range of freshwater spawning habitat extends from the St. Lawrence River in Quebec to the Satilla River in Georgia (Fritts et al. 2016; Savoy et al. 2017). The marine range for the five DPSs is all marine waters, including coastal bays and estuaries, from Labrador Inlet, Labrador, Canada to Cape Canaveral, FL (77 FR 5913).

Species Status

Five separate DPSs of Atlantic sturgeon were listed under the ESA in 2012 (77 FR 5913): Chesapeake Bay (endangered), Carolina (endangered), New York Bight (endangered), South Atlantic (endangered), and Gulf of Maine (threatened). The species has suffered population declines across its range as a result of historical overfishing, and degradation of freshwater and estuarine habitats by human development (77 FR 5913). Bycatch mortality, water quality degradation, lack of adequate state and/or federal regulatory mechanisms, and dredging activities remain persistent threats. Some populations were impacted by unique stressors, such as habitat impediments and apparent ship strikes (77 FR 5913).

Occurrence in the Action Area and Vicinity

Atlantic sturgeon demonstrate strong spawning habitat fidelity and extensive migratory behavior (Savoy et al. 2017). Adults and subadults[1] migrate extensively along the Atlantic coastal shelf (Erickson et al. 2011; Savoy et al. 2017), and all life stages use the coastal nearshore zone as a migratory corridor between river systems (ASSRT 2007; Eyler et al. 2009). Erickson et al. (2011) found that adults remain in nearshore and shelf habitats ranging from 6 to 125 feet (2 to 38 m) in depth, preferring shallower waters in summer and fall and deeper waters in the winter and spring. Data from capture records, tagging studies, and other research efforts (Damon-Randall et al. 2013; Dunton et al. 2010; Stein et al. 2004a, 2004b; Zollett 2009) indicate the potential for occurrence in the marine component of the action area during all months of the year. Individuals from every Atlantic sturgeon DPS have been captured in the Virginian marine ecoregion (Cook and Auster 2007; Damon-Randall et al. 2013), which extends from Cape Lookout, North Carolina, to Cape Cod, Massachusetts (see Table 4.9).

Stein et al. (2004a, 2004b) reviewed 21 years of sturgeon bycatch records in the North Atlantic OCS to identify regional patterns of habitat use and association with specific habitat types. Atlantic sturgeon were routinely captured in waters within and in immediate proximity to the marine component of the action area, most commonly in waters ranging from 33 to 164 feet (10 to 50 m) deep. Sturgeon in this area were most frequently associated with coarse gravel substrates within a narrow depth range, presumably associated with depth-specific concentrations of preferred prey fauna.

Collectively, this information indicates that Atlantic sturgeon are likely to occur in the marine component of the action area as subadults and adults,[4] and that individuals from every extant DPS could potentially be present in this component of the action area during any month of the year. This species is also likely to occur in the portion of the vessel traffic component of the action area associated with identified project ports on the U.S. Atlantic coast.

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[4] Subadults are defined as sexually immature individuals between 30 and 59 inches (760 to 1,500 mm) total length; adults are defined as sexually mature individuals greater than 59 inches (1,500 mm) (NOAA 2018b).

Table 4.9. Proportional distribution of Atlantic sturgeon by DPS in observer program Mixed Stock Analysis results from the Virginian Marine Ecoregion (Kazyak et al. 2021).

Atlantic Sturgeon Population	Proportional Distribution in Ecoregion
Canadian populations (not listed)	~1%
Gulf of Maine DPS (threatened)	~2%
New York Bight DPS (endangered)	~39%
Chesapeake Bay DPS (endangered)	~14%
Carolina DPS (endangered)	~34%
South Atlantic DPS (endangered)	~15%

Feeding Behavior and Hearing

Atlantic sturgeon are opportunistic predators that feed primarily benthic invertebrates but will adjust their diet to exploit other types of prey resources when available. For example, Johnson et al. (1997) found that polychaetes composed approximately 86 percent of the diet of adult Atlantic sturgeon captured in the New York Bight. Isopods, amphipods, clams, and fish larvae composed the remainder of the diet, with the latter accounting for up to 3.6 percent of prey composition in some years. In contrast, Guilbard et al. (2007) observed that small fish comprised up to 38 percent of subadult Atlantic sturgeon diet in the St. Lawrence River estuarine transition zone during summer, but less than 1 percent in fall. The remainder of the diet consisted primarily of amphipods, oligochaetes, chironomids, and nematodes with the relative importance of each varying by season.

Sturgeons may use hearing to aid in migration and to search for prey. Male sturgeon vocalize during spawning, suggesting that these species use sounds to find potential mates (Fay and Popper 2000; Meyer et al. 2010). Sturgeon have a generalized hearing range from 50 Hz to approximately 700 Hz, with greatest sensitivity between 100 and 300 Hz (Lovell et al. 2005; Meyer et al. 2010). Like other sturgeons, Atlantic sturgeon have a swim bladder that is physiologically isolated from the inner ear (Lovell et al. 2005; Meyer et al. 2010; Popper 2005).

Meyer et al. (2010) and Lovell et al. (2005) studied the auditory system morphology and hearing ability of lake sturgeon, a closely related species. The Ascipenseridae have a well-developed inner ear that is independent of the swim bladder.

Giant Manta Ray

The giant manta ray is a large-bodied, planktivorous ray in the family Mobulidae. A defining characteristic of the species is its large mouth fringed by long cephalic fins. The giant manta ray is distinguished from the reef manta ray (*M. alfredi*), another manta ray species that occurs in U.S. waters by its tendency range widely and forage in lower productivity pelagic waters whereas the latter maintains a more resident distribution in nearshore tropical habitats. In the temperate zone giant manta rays are commonly found in offshore oceanic waters and near productive coastlines. In waters off the U.S. east coast the species is commonly found in waters from 66 to 72°F (19 to 22°C) (Miller and Klimovich 2017).

In the Atlantic Ocean giant manta rays have been documented as far north as Rhode Island (Gudger 1922).

Species Status

The giant manta ray was listed as threatened under the ESA in 2018 (83 FR 2916). Critical habitat has not been designated. There are no current or historical estimates of global abundance for this species. The greatest number identified from four known regular aggregation sites ranges from 180 to 1,500. Very little information is available for the Atlantic populations of this species. However, groups as large as 500 have been observed in aerial surveys off the Florida coast, indicating the probable presence of large population groups in the region (Miller and Klimovich 2017).

While the giant manta ray is globally distributed, individual populations are scattered and fragmented. The species also has a low reproductive rate, producing an average of one offspring every 2 to 5 years. Reproductive isolation, low productivity, and the tendency for fragmented populations to aggregate in large groups makes the species vulnerable to short-term population declines and unsustainable exploitation (CITES 2013). Manta rays are both targeted and caught as bycatch in commercial fisheries worldwide (Couturier et al. 2012; Lawson et al. 2017). They are harvested for their gill rakers and gill plates, which are marketed to various countries in Asia for their reported medicinal qualities (Lawson et al. 2017). Commercial exploitation and incidental fishery mortality are the primary threats to the species (Lawson et al. 2017). Because the species is wide ranging, populations from areas with strong management protections may still be at risk when migrating to other parts of the globe. Climate change, ocean pollution (particularly plastic waste), and inadequate regulatory mechanisms are important secondary threats (Miller and Klimovich 2017).

Occurrence in the Action Area and Vicinity

Giant manta rays are commonly found in waters from 66 to 72°F (19 to 22°C) in Atlantic waters (Miller and Klimovich 2017), temperatures that commonly occur in the marine component of the action area. While the region doesn't support well-established feeding areas, Lawson et al. (2017) defined a species range that extends northward to the Gulf of Maine, and commonly used areas extending north to Massachusetts. Sighting records in the region are rare, but historical records document manta ray captures in waters off New Jersey and Block Island (Gudger 1922). While the established species range and presence of suitable water temperatures on the North Atlantic OCS indicate that the species could potentially occur in the marine component of the action area, the probability of occurrence during construction and installation is likely low. However, the potential for occurrence in this component of the action area over the operational lifespan of the RWF and RWEC cannot be discounted. Based on general distribution, this species is likely to occur throughout the majority of the vessel transit component of the action area.

Feeding Behavior and Hearing

Giant manta rays primarily feed on planktonic organisms such as euphausiids, copepods, mysids, decapod larvae and shrimp, with small fish a periodic but rare component of the diet (Miller and Klimovich 2017). Species occurrence is strongly correlated with zooplankton abundance, meaning that regional distribution is determined by both suitable water temperatures and seasonal secondary productivity. The species demonstrates a degree of feeding site fidelity, often returning to productive areas on an annual basis (Miller and Klimovich 2017). However, there are no regularly observed feeding areas in Atlantic coastal waters. The species was historically believed to feed solely during daylight hours only near the surface, but recent evidence indicates that the species also forages nocturnally and over a broad depth profile (Couturier et al. 2012).

Manta rays belong to the Elasmobranchii, a subclass of fishes that include the sharks, skates, rays, and related extinct fishes. Elasmobranchs lack swim bladders or any other kind of hearing specialization and can only detect the particle motion component of sound (Casper 2006). Sharks elicit behavioral responses to sounds, indicating that sound plays a role in prey identification and perhaps other aspects of biology (Hueter et al. 2012). The biological significance of hearing in rays in general and manta rays in particular is not well understood. Rays have well-developed inner ears that provide limited hearing ability restricted to a relatively low frequency range extending from approximately 40 to 800 Hz (Casper 2006; Hueter et al. 2012; Myrberg 2001; Popper and Fay 1977). Based on the hearing range of other ray species (Casper 2006), manta ray hearing is most likely ranges from 100 to 1,000 Hz, with peak hearing ability between 100 and 300 Hz.

Information about the hearing ability of elasmobranchs in general and rays in particular is relatively limited. Sharks and rays lack swim bladders and have physiologically similar hearing organs. As such, these species would be expected to have generally similar hearing ranges across species groups. The hearing abilities of a few shark and ray species have been examined in scientific studies.

4.13 Climate Change Considerations

Global climate change is altering water temperatures, circulation patterns, and oceanic chemistry at global scales. Several marine species, including fish, invertebrates, and zooplankton—prey resources for marine mammals—have shifted northward in distribution over the past several decades (NOAA 2021). Ocean acidification, also a function of climate change, has negatively affected some zooplankton species (PMEL 2020). Numerous fish and invertebrate species are undergoing or likely to undergo changes in abundance and distribution shifts in response to climate change impacts (Hare et al. 2016; Rogers et al. 2019). Marine mammals and sea turtles are modifying their behavior and distribution in response to these broader observed changes (Davis et al. 2017, 2020; Hayes et al. 2020, 2021; Hawkes et al. 2009; Meyer-Gutbrod et al. 2015, 2018). These trends are expected to continue, with complex and potentially adverse consequences for many marine species, including federally protected marine mammals, sea turtles and fish.

5.0 Effects of the Action

Effects were considered relative to the likelihood of species exposure based on occurrence in the marine component of the action area as described in Sections 4.10 and 4.12, and the magnitude of project-related effects on the environment relative to established effects thresholds and the range of environmental baseline conditions described in Section 4.

5.1 Construction Noise Impacts

The proposed action will produce short-term construction and installation-related underwater noise above levels that may potentially impact listed species. Potential sources include impact and vibratory pile driving during construction and installation, detonation of UXO, HRG survey equipment, and construction and installation vessel noise. Noise generated during O&M and decommissioning of WTGs are discussed below in Section 5.2.

Potential take of listed species from exposure to behavioral and injury-level noise impact thresholds (Table 5.1) would be restricted to the distances presented in Table 5.2 below, with the extent and severity of effects dependent on the timing of the activity relative to occurrence, the type of noise impact, and species-specific sensitivity. Revolution Wind conducted project-specific modeling to characterize the area affected by underwater noise from impact driving, and construction and installation vessel operation, and to estimate the number of each ESA-listed species likely to be exposed to injury and behavioral level effects from these noise sources. The results of this modeling effort were used to develop the effects analysis presented in this BA and are described below. LGL (2022a) modeled the potential extent of underwater noise impacts associated with vibratory and pneumatic hammer pile driving used during sea-to-shore transition construction. The ensonified area exceeding the 120-dB behavioral effects threshold for marine mammals would extend a maximum of 8 miles (13 km) from the construction site, bounded by the geographic confines of Narragansett Bay.

Kusel et al. (2021) and Hannay and Zykov (2021) modeled maximum underwater noise levels likely to be produced by impact pile driving activities and UXO detonation. They used a refined noise attenuation model that factors in multiple parameters affecting noise propagation in the marine environment, producing an accurate estimate of potential effects. The PDE assumptions used in this analysis are as follows:

- Up to 79, 12-m WTG monopile foundations:
    - Installation is anticipated to require approximately 10,740 pile strikes over approximately a 220-minute period for each pile, using an impact hammer operating at 4,000 kJ, assuming 10-dB noise attenuation.
    - Up to three monopiles installed in a given 24-hour period.
- Up to two 15-m OSS monopile foundations:

- Installation is anticipated to require approximately 11,563 pile strikes over approximately a 380-minute period for each pile, using an impact hammer operating at 4,000 kJ, assuming 10-dB noise attenuation.
- Up to two monopiles installed in a 24-hour period.

- UXO Detonation: Detonation of up to 16 1,000-pound (454 kg) warheads during construction and installation.[5]
  - Worst-case scenario considered by LGL (2022a, 2022b) based on likelihood of UXO encounters in the RWF and RWEC corridor.
  - LGL (2022a, 2022b) assumed that UXOs would be distributed such that the sound fields from detonation would not overlap.
- Sheet pile cofferdam: Vibratory hammer installation of Z-type steel sheet piles 9 m (30 feet) into the sediment at the sea-to-shore transition.
- Construction and installation vessels: Noise levels produced by typical construction and installation related vessels were modeled for injury and behavior thresholds.

Kusel et al. (2021) and Hannay and Zykov (2021) used these assumptions to estimate source noise levels and calculate the distance required to attenuate project noise to established injury and behavioral-level effects thresholds for different species groups based on site-specific substrate and oceanographic conditions in the marine component of the action area and vicinity. Denes et al. (2020) previously analyzed the potential effects of construction and installation vessel noise for the South Fork Wind project. Reference noise source levels from that report are relevant to this analysis and are presented herein, since both projects are likely to use the same types/classes of construction and installation vessels. The lessee has identified sixteen UXOs that are consistent with the areas' historic use as a World War II firing range. The lessee expects to leave each UXO undisturbed and route around them, which is the safest alternative for all ocean users and is the alternative preferred by federal and state authorities (First Coast Guard District Local Notice to Mariners 2023). The locations of all confirmed UXOs were provided to the United States Coast Guard. The cable route will be routed around the sixteen identified UXOs and no UXO detonations are planned.

The biological effects thresholds used in this assessment reflect the current guidance and best available science (FHWG 2008; NMFS 2018b, 2019; DoN 2017; Popper et al. 2014). Source level biological effect thresholds for ESA-listed species and prey organisms are shown in Table 5.1, and modeled attenuation distances to peak injury, cumulative injury and behavioral

5 The precise number, size, and location of UXOs likely to be encountered that could require detonation is not presently known. Hannay and Zykov (2021) and LGL (2022a) assumed that a worst-case scenario up to 16 1,000-pound devices may encountered in the RWF and RWEC corridor that cannot be safely relocated and have to be detonated. The lessee will make efforts to avoid UXO detonation.

thresholds for each species groups are summarized in Table 5.2. Marine mammal effect distance calculations reflect frequency weighting for each hearing group. Noise-related effects on each listed-species group are discussed in the following sections.

Table 5.1. Underwater Noise Exposure Thresholds for Permanent Hearing Injury and Behavioral Disruption by Species Hearing Group.

Species Hearing Group	Type of Effect	Type of Exposure	Threshold	Relative Units
LFCs‡ Blue whale Fin whale Sei Whale NARW	Permanent hearing injury	Cumulative SEL (impulsive)	183‡	SEL dB re 1 μPa²·s
		Cumulative SEL (non-impulsive)	199‡	SEL dB re 1 μPa²·s
		Peak injury (impulsive)	219‡	dB re: 1 μPa
		PTS SEL (UXO detonation)	183¥	SEL dB re: 1 μPa²
	Behavioral disturbance	Behavioral (impulsive)	160†	dB re: 1 μPa
		TTS SEL (impulsive)	168‡	SEL dB re 1 μPa²·s
		TTS SEL (UXO detonation)	168¥	SEL dB re 1 μPa²
		Behavioral (non-impulsive)	120†	dB re 1 μPa²·s
MFCs‡ Sperm whale	Permanent hearing injury	Cumulative SEL (impulsive)	185‡	SEL dB re 1 μPa²·s
		Cumulative SEL (non-impulsive)	198‡	SEL dB re 1 μPa²·s
		Peak injury (impulsive)	230‡	dB re: 1 μPa
		PTS SEL (UXO detonation)	185¥	SEL dB re: 1 μPa²
	Behavioral disturbance	Behavioral (impulsive)	160†	dB re: 1 μPa
		TTS SEL (impulsive)	170‡	SEL dB re 1 μPa²·s
		TTS SEL (UXO detonation	170¥	SEL dB re 1 μPa²
		Behavioral (non-impulsive)	120†	dB re: 1 μPa
All sea turtles	Permanent hearing injury	Cumulative SEL (impulsive)	204¥	SEL dB re 1 μPa²·s
		Cumulative SEL (non-impulsive)	220¥	SEL dB re 1 μPa²·s
		Peak injury (impulsive)	232¥	dB re: 1 μPa
		PTS SEL (UXO detonation	204¥	SEL dB re: 1 μPa²
	Behavioral disturbance	Behavioral (all sources)	175¥	dB re: 1 μPa
		TTS SEL (impulsive)	189¥	SEL dB re 1 μPa²·s
Atlantic sturgeon	Permanent hearing injury	Cumulative SEL	210*	SEL dB re 1 μPa²·s
		Peak injury (impulsive)	207*	dB re: 1 μPa
		Peak injury (UXO detonation)	229*	dB re: 1 μPa
	Recoverable injury	Cumulative SEL	203*	SEL dB re 1 μPa²·s
	Behavioral disturbance	Behavioral alteration	150§	dB re: 1 μPa
		TTS SEL (impulsive)	186¥	SEL dB re 1 μPa²·s

Species Hearing Group	Type of Effect	Type of Exposure	Threshold	Relative Units
Giant manta ray	Permanent hearing injury	Cumulative SEL	219*	SEL dB re 1 μPa^2·s
		Peak injury (impulsive)	213*	dB re: 1 μPa
		Peak injury (UXO detonation)	229¥	dB re: 1 μPa
	Recoverable injury	Cumulative SEL	216*	SEL dB re 1 μPa^2·s
	Behavioral disturbance	Behavioral alteration	150§	dB re: 1 μPa
		TTS SEL (impulsive)	186*	SEL dB re 1 μPa^2·s

‡ NMFS (2018b)
† NMFS (2019)
¥ DoN (2017), marine mammal thresholds are frequency-weighted by hearing group
* Popper et al. (2014)
§ GARFO (2020)

Table 5.2. Distance Required to Attenuate Underwater Construction and Installation Noise Below Injury and Behavioral Effect Thresholds by Activity and Hearing/Species Groups.

Construction and Installation Activity	Species Group	Exposure Distance to Peak Injury Threshold (feet)	Exposure Distance to Cumulative Injury Threshold (feet)	Exposure Distance to Behavioral Effect Threshold (feet)
12-m WTG monopile foundation installation*	LFCs	33	954-8,727	11,909-12,336
	MFCs	--	0-66	12,041
	Sea turtles	--	98-689	1,903-2,920
	Fish–swim bladder not involved in hearing (Atlantic sturgeon)	69-371	2,470-3,638	14,403-34,987
	Fish–no swim bladder (manta ray)	13-59	604-856	14,403-34,987
	Fish–eggs & larvae	69-371	2,470-3,638	--
15-m OSS Monopile foundation installation*	LFCs	<33	3,084-5,873	11,516-11,877
	MFCs	--	--	11,909
	Sea turtles	--	0-820	2,362-3,182
	Fish-swim bladder not involved in hearing (Atlantic sturgeon)	125-299	2,756-3,458	15,157-35,722
	Fish–no swim bladder (manta ray)	33-62	617-797	15,157-35,722
	Fish–eggs & larvae	299	3,458	--

Construction and Installation Activity	Species Group	Exposure Distance to Peak Injury Threshold (feet)	Exposure Distance to Cumulative Injury Threshold (feet)	Exposure Distance to Behavioral Effect Threshold (feet)
Sea to shore transition construction†	LFCs	Not applicable (N/A)	4,823-12,696	3,018-31,955
	MFCs	N/A	—0-754	3,018-31,955
	Sea turtles	N/A	102	175
	Fish-swim bladder not involved in hearing (Atlantic sturgeon)	N/A	--	2,556
	Fish–no swim bladder (manta ray)	N/A	--	2,225
	Fish–eggs & larvae	N/A	N/A	N/A
Construction and installation vessel operation‡,*	LFCs	N/A	367	48,077
	MFCs	N/A	115	44,236
	Sea turtles	N/A	--	--
	All fish (TTS-temporary loss of hearing sensitivity)	N/A	--	443
	All fish (behavioral)	N/A	--	--
UXO Detonation§	LFCs	466-2,776	883-14,009	8,629-44,291
	MFCs	138-846	167-1,755	1,243-9,613
	Sea turtles	689	1,699	8,235
	All Fish (onset of injury)	2,779	--	--
	Fish–eggs & larvae (injury or mortality)	49-1,384	--	--
HRG Surveys¥	LFCs	N/A	5	463
	MFCs	N/A	<3	463
	Sea turtles	689	1,699	8,235
	All Fish		--	16 (TTS) 2,572 (Behavioral)
	Fish–eggs & larvae (injury or mortality)		--	--

* Data from Kusel et al. (2021). Values shown are the range of maximum modeled effect threshold distances across all modeled species in each hearing group estimates for summer installation difficult installation of a 12-m WTG monopiles and a 15-m OSS monopiles using an IHC S-4000 impact hammer with 10-dB attenuation. Installation scenario for 12-m monopile is 10,740 strikes/pile at installation rate of tthree piles/day. Installation scenario for 15-m monopile is 11,563 strikes/pile at installation rate of one pile/day. All piles installed with a 4,000-kJ hammer with an attenuation system achieving 10-dB sound source reduction.

† Lower end of range assumes sheet pile cofferdam installed using a vibratory hammer, as modeled by LGL (2022a). Upper end of range assumes installation of casing pipe using pneumatic hammer. Threshold distances shown do not consider geographic confinement by surrounding shorelines of Narragansett Bay, which limit sound propagation to a maximum of approximately 8.1 miles (13 km) from the source.

‡ Kusel et al. (2021) considered use of dynamic positioning thrusters by construction and installation vessels qualitatively. This analysis did not consider the timing, frequency, and duration of noise from background vessel traffic in and near the Lease Area. Noise levels produced by construction and installation vessels are expected to be similar to these background sources.

¥ HRG survey values are maximum threshold distances for each hearing group for the loudest type of equipment likely to be employed, as reported by LGL (2022a).

§ The range of values shown are the minimum and maximum threshold distances for detonation of UXOs ranging in size from 5 to 1,000 pounds at four modeled sites with 10 dB of sound attenuation (Hannay and Zykov 2021; LGL 2022b). The 1,000-pound UXO is the largest potential explosive device potentially occurring in the Maximum Work Area.

Peak and cumulative permanent threshold shift (PTS; causes permanent injury to hearing sensitivity) threshold distances were calculated by Hannay and Zykov (2021) for detonation of 5- to 1,000-pound UXOs with 10 dB of sound attenuation. NOAA uses the larger cumulative threshold distance to assess potential PTS and temporary and recoverable loss of hearing sensitivity (TTS) exposure resulting from UXO detonation (Hannay and Zykov 2021). PTS injury and TTS exposure acreages could occur anywhere within a 46,139 to 567,221-acre zone of potential exposure within and around the maximum work area for the RWF and RWEC, varying by hearing group and type of exposure. The location of detonation impacts and actual likelihood of exposure would depend on where UXOs are encountered.

5.1.1 Impact Pile Driving

Kusel et al. (2021) modeled the distance required to attenuate underwater noise from impact pile driving to defined effect thresholds for marine mammals, sea turtles, and fish at different locations within the Project area under a range of seasonal conditions. They also estimated the reduction in distance to threshold resulting from the use of sound attenuation systems. The results used in this BA assume the use of sound attenuation systems capable of achieving a 10-dB reduction in source noise levels. The three noise attenuation system technologies considered for the project include the following (Revolution Wind 2022b):

- Big Bubble Curtain (BBC), which consists of a flexible tube fitted with special nozzle openings and installed on the sea floor around the pile. Compressed air is forces through the nozzles producing a curtain of rising, expanding bubbles. These bubbles effectively attenuate noise by scattering sound on the air bubbles, absorbing sound, or reflecting sound off the air bubbles.

- Hydro-Sound Damper (HSD), which is a system that consists of a fish net holding different sized elements arranged at various distances from each other that encapsulates the pile. HSD elements can be foam plastic or gas-filled balloons. Noise is reduced as it crosses the HSD due to reflection and absorption by air spaces contained in the elements.

- AdBm Technologies Helmholtz resonator, which is a system that consists of large arrays of Helmholtz resonators, or air-filled 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.

Revolution Wind is committed to achieving the modeled ranges with 10 dB of noise attenuation using a single BBC paired with an additional noise attenuation device (Revolution Wind 2022b). The range of modeled threshold distances for installation of 100 12-m WTG monopiles and two 15-m OSS monopiles are presented above in Table 5.2. Impacts to ESA listed species from this stressor are described below by species group.

Marine Mammals

Cetaceans have well-adapted acoustical and hearing abilities which they rely on for communication, foraging, mating, predator avoidance, and navigation (Madsen et al. 2006; Weilgart 2007). The proposed action includes several elements (e.g., pile driving, vessel operation, and WTG operation) that produce underwater noise that could affect marine mammals. These potential effects range in severity from short-term auditory masking, to increased stress, to permanent injury depending on the nature and intensity of the noise source, and proximity and duration of exposure (Bain and Dahlheim 1994; NMFS 2018b; Rolland et al. 2012; Southall et al. 2007; Williams et al. 2015). Underwater noise can have adverse effects on marine mammals even in the absence of overt injury or observable behavioral effects. For example, background noise levels in proximity to busy shipping lanes may disrupt NARW communication ability and have been associated with increased stress hormone levels in NARW, potentially contributing to immune suppression and depressed reproductive success (Hatch et al. 2012; Rolland et al. 2012).

NMFS has released updated technical guidance for assessing the effects of underwater noise on marine mammals (NMFS 2018b). This guidance considers noise exposure capable of causing a permanent loss of hearing sensitivity, referred to as a permanent threshold shift (PTS), to be the onset of physical injury and relies on the current state of the science to define sound exposure thresholds sufficient to cause PTS in different marine mammal species. Different taxa are sensitive to different frequencies of sound, and therefore may be more or less prone to injury level noise effects depending on the nature and intensity of the noise source. The ESA-listed baleen whales (Mystecetes) considered in this assessment belong to the LFC hearing group, which are most sensitive to sound in the 10- to 35-Hz range. The ESA-listed sperm whale belongs to the MFC hearing group, which are most sensitive to sound in the high Hz to hundreds of kHz range (Southall et al. 2007). Species-specific hearing and communication frequencies are provided where available in Section 5.1. BOEM is relying on the current NOAA guidance to assess underwater noise impacts, but we recognize that marine mammal hearing is an evolving science. Improved understanding (e.g., Southall et al. 2019) may lead to future refinements of species-specific hearing ranges and sound sensitivity thresholds.

The areas exposed to behavioral and injury-level noise effects to marine mammals from impact pile driving vary depending on the type of exposure (i.e., single strike, cumulative) and marine mammal hearing group. For example, an individual LFC (e.g., NARW) would have to be within 33 feet (10 m) of active pile driving to be injured by peak noise from a single pile strike. Injury-level exposure to single pile strikes is unlikely given that marine mammals are unlikely to approach within 16 feet of construction and installation activity and PSOs would be on station to halt construction and installation activities if this did occur. In contrast, LFCs that remain within 954 to 8,727 feet of WTG installation over an entire 6- to 12-hour pile driving session on a given construction and installation day could experience permanent cumulative hearing injury. This is a low-probability scenario given the likelihood of behavioral avoidance and the level of protection provided by the PSO monitoring and EPM protocol, but the potential for injury-level exposure cannot be completely ruled out given the size of the effect area.

Sperm whales belong to the MFC hearing group, which is relatively insensitive to pile driving noise. Individuals would have to come as close as 66 feet (20 m) of WTG monopile installation to experience permanent cumulative hearing injury. This also is an unlikely scenario considering that PSOs would easily be able to halt work before a sperm whale ever approached that close to pile driving activities. Additionally, the likelihood of behavioral avoidance of construction and installation vessel noise and activity, combined with high swimming speeds, would allow an individual whale to rapidly move outside of the effect threshold area.

LGL (2022a) developed estimates of the number of marine mammals that could be exposed to potential adverse noise-related effects to support MMPA compliance for the Proposed Action. These results are summarized in Table 5.3. They used an exposure model developed by Kusel et al. (2021) to estimate the number of individuals by species that could be exposed to PTS, TTS, and other short-term physiological and behavioral effects from construction and installation noise exposure. The modeled exposure scenario for each species assumed an aggressive construction and installation schedule of up to three WTG monopiles installed per day for 27 days during the highest density month of species occurrence in the area.

The values reported in Table 5.3 are based on estimated species density in the marine component of the action area during the months when construction and installation activities are expected to occur, considering the use of a noise attenuation system capable of achieving at least a 10-dB reduction in sound source level, timing restrictions to protect NARW, clearance zone monitoring using PSOs and PAM, night vision equipment and infrared/thermal technology during nighttime pile driving, soft starts, and shutdown procedures. Infrared technology appears to be as effective for detecting marine mammals at night as visual monitoring during daylight (Verfuss et al. 2018 Guazzo et al. 2019). The project will establish pre-start clearance zones and shutdown zones. Pre-start clearance zones are defined as the area that must be visually and/or acoustically clear of protected species of marine mammal prior to starting an activity. Clearance zones may also be implemented after a shutdown in sound-producing activities prior to restarting. The size of the clearance zone will be specific to activity and species or hearing group and dependent on permit conditions. The shutdown zone is defined as the area in which a noise source must be shut down or other active mitigation measures must be implemented if a target species enters the zone. The size of the shutdown zone will be activity-specific and dependent on permit conditions. The shutdown zone may or may not encompass other zones and will be specific to species and/or faunal groups (Revolution Wind 2022b). Not all noise-producing activities have shutdown protocols. The specific shutdown protocols that have been defined are provided in Appendix C. See Section 3.5 and Appendix C for additional details on these mitigation measures.

Table 5.3. Estimated Number of Marine Mammals Experiencing Behavioral Effects from Year-by-Year Construction-Related Activities.

Functional Hearing Group	Species	Year 1 (construction)	Year 2 (construction)	Year 3 (O&M)	Year 4 (O&M)	Year 5 (O&M)	Current Stock Abundance	Number of Individuals Exposed as Percent of Stock Abundance
LFC	Blue Whale	3	1	1	1	1	402	1.7%
	Fin Whale	44	2	2	2	2	6,802	0.8%
	North Atlantic Right Whale	50	3	3	3	3	368	16.8%
	Sei Whale	20	2	2	2	2	6,292	0.4%
MFC	Sperm Whale	8	2	2	2	2	4,349	0.4%

Source: Hayes et al. (2021, 2022); LGL (2022a) and JASCO Applied Sciences (2022)
Note: Estimated number of individuals is based upon established TTS and behavioral thresholds. TTS thresholds were used to determine exposure estimates for UXO detonation, while all other exposure estimates are based on the established behavioral thresholds for intermittent and continuous noise.

As shown, LGL (2022a) has concluded that no ESA-listed marine mammal species are likely to be exposed to PTS-level effects from impact pile driving. PSO effectiveness will be enhanced using clearly defined requirements and guidance, including nighttime and low-visibility PSO protocols (Appendix C). However, several individual fin whales, sei whales, and NARWs could experience underwater noise exposure sufficient to cause TTS and/or behavioral effects. This type of sound exposure can have an array of adverse effects on marine mammals, even in the absence of overt observable behavioral responses. For example, a reduction in effective “communication space” caused by auditory masking can make it more difficult to locate companions and maintain social organization (Cholewiak et al. 2018). This can increase physiological stress, leading to impaired immune function and other chronic health problems (Hatch et al. 2012; Brakes and Dall 2016; Davis et al. 2017). While potentially significant, these kinds of effects are most associated with long-term changes in the ambient noise environment, specifically from chronic exposure to noise from increasing levels of marine vessel traffic. All construction and installation-related noise sources would cease once construction and installation is completed.

Effects on marine mammals from underwater noise impacts on prey organisms are likely to be unmeasurable based on the sensitivity of preferred forage species to underwater noise. Broadly speaking, the ESA-listed marine mammals occurring in the marine component of the action area feed primarily on zooplankton and invertebrates, with fish a variable but relatively minor component of the diet. The susceptibility of invertebrates to human-made sounds are unclear, and there is currently insufficient scientific basis to establish biological effects thresholds (NOAA 2016). The available research on the topic is limited and relatively recent (Carroll et al.

2016; Edmonds et al. 2016; Hawkins and Popper 2014; Pine et al. 2012; Weilgart 2018). The applicability of the fish egg and larvae threshold to invertebrate eggs and larvae is unclear. However, for a conservative estimate on the effects of underwater noise on invertebrates, the application of Popper et al. (2014) criteria for eggs and larvae to zooplankton has been applied, as described below.

Fin whales and sperm whales periodically feed on fish, with fin whales preferentially targeting schooling forage fish like sand lance and capelin when available in abundance. Kusel et al. (2021) modeled underwater noise attenuation distances from RWF construction and installation for a range of fish thresholds (Table 5.2). Effect distances vary depending on hearing group sensitivity and the threshold selected.

These results suggest some potential for short-term adverse effects on the availability of fish prey for fin whales and sperm whales. The significance of these effects is uncertain given the range of applicable injury thresholds and associated effect areas but are likely to be limited based the relatively small area of fish injury relative to the amount of foraging habitat available. However, considering the risk of potential adverse effects, the impact from impact pile driving is considered significant.

Sea Turtles

The biological significance of hearing in sea turtles is not well studied (Piniak et al. 2016; Popper et al. 2014). Sea turtle auditory organs appear to be specifically adapted to underwater hearing (Dow Piniak et al. 2012). Studies indicate that hearing in sea turtles is confined to lower frequencies, below 1,600 Hz; the range of highest sensitivity between 100 and 700 Hz (Dow Piniak et al. 2012), with some variation between species (Bartol and Ketten 2006; Dow Piniak et al. 2012; Martin et al. 2012; Piniak et al. 2016). Available information on species-specific hearing ranges and peak hearing sensitivity are summarized by species in Section 4.12.2. Exposure thresholds used to characterize underwater noise effects on sea turtles are summarized in Table 5.1.

The current literature and effect analysis guidance regarding sensitivity to underwater noise effects varies depending on the source. Popper et al. (2014) suggest staying below a peak threshold of 232 dB re 1 µPa, or a cumulative sound exposure level (SEL) threshold of 204 dB re 1 µPa^{2}s would likely protect sea turtles from physical injury from impulsive sounds. Blackstock et al. 2017 recommended a root mean squared sound pressure level (SPL) behavioral effects threshold of 175 dB re 1 µPa for impulsive sounds based on observed avoidance behavior during airgun blasts. The DoN (2017) defined a peak sound exposure threshold of 232 dB re 1 µPa and a cumulative SEL threshold of 210 dB re 1 µPa^{2}s for physical injury from impulsive sounds.

Kusel et al. (2021) modeled attenuation distances for impact pile driving to sea turtle effect thresholds defined by the DoN (2017). They considered a range of attenuation scenarios for impact pile driving. The 10-dB attenuation scenario results are the PDE analyzed in this BA. These results summarizing impacts due to the driving 79 39-foot (12-m) WTG monopiles and two 49-foot (15-

m) OSS monopiles for the project are presented in Table 5.2. Similarly, Hannay and Zykov (2021) modeled attenuation distances for UXO detonation and are also presented in Table 5.1. Turtles within 98-689 feet (30-210 m) of impact pile driving of 12-m monopiles and 0-820 feet (0-250 m) of impact driving 15-m monopiles could experience injury based on the DoN (2017) SEL threshold of 204 dB re 1 µPa^{2}s. The use of PSOs and other mitigation measures would effectively minimize the risk of exposure to injury-level effects.

In addition to modeling noise attenuation, Kusel et al. (2021) also used a proprietary exposure model to estimate the number of individuals of each ESA-listed species that could be exposed to injury and behavioral-level noise effects from impact pile driving. The model uses species-specific sea turtle density information for the North Atlantic OCS, and swimming speed and diving behavior parameters to characterize individual risk and duration of exposure to injury level effects. This analysis considered the same PDE scenario used for marine mammals, assuming 10 dB of attenuation. The results are presented in Table 5.4.

Table 5.4. Estimated Number of Sea Turtles Predicted to Receive Sound Levels Above Cumulative and Peak Injury and Behavioral Criteria from Impact Pile Driving all 79 WTG and Two OSS Proposed Piles, Assuming 10-dB Attenuation (Revolution Wind 2023).

Species	Cumulative Injury (L_E) ¥	Peak Injury (L_{pk}) ‡	TTS or Behavioral Effects (L_p)§
Kemp's ridley turtle	0.45	0	6.91
Leatherback turtle	0.5	0	5.95
Loggerhead turtle	0.59	0	14.02
Green turtle	1.07	0	7.51

‡ L_{pk} = Unweighted peak sound pressure level re: 1 µPa

¥ L_E = cumulative SEL re: 1 µPa^{2}s

§ Lp = SPL, toot mean squared sound pressure level re: 1 µPa

As shown, Kusel (2022) predicted that less than one individual of each ESA-listed sea turtle species would be exposed to injury from cumulative and single pile strike exposure under the 10-dB attenuation scenario. Loggerhead turtles face the greatest potential risk of injury-inducing cumulative sound exposure (SEL) at 0.8 individuals. These exposure estimates do not consider potential behavioral avoidance or the use of PSOs, shutdown procedures, and other EPMs intended to avoid and minimize impacts and would therefore be considered a worst case. However, the risk of injury makes the potential impact to sea turtles significant.

Kusel et al. (2022) modeled only one sea turtle behavioral effect threshold: the 175-dB re 1 µPa SPL threshold defined by Blackstock et al. (2017). Kusel (2022) estimated the number of individuals likely to be exposed to behavioral level noise effects using the density and behavioral modeling methods described above. They estimated that up to 0.09 Kemp's ridley, 0.8 leatherback, 3.3 loggerhead, and 0.9 green turtles could be exposed to sound levels that could result in behavioral effects from monopile installation (Table 5.4). Again, these exposure estimates do not consider the use of PSOs, shutdown procedures, and other EPMs intended to avoid and minimize impacts. Therefore, the number of individuals likely to be exposed to behavioral effects should be lower than the estimates presented here.

Underwater noise is unlikely to result in measurable effects on prey and forage availability for ESA-listed sea turtles occurring in the marine component of the action area. These species are primarily invertivores or, in the case of green sea turtles, omnivores. Invertebrates like crabs, jellyfish, and mollusks are insensitive to harmful underwater noise effects at the levels expected to result from the proposed action. Underwater noise could result in a short-term reduction in the availability of fish prey species, but these effects would be limited in extent and duration. While loggerhead and Kemp's ridley turtles may periodically prey on fish, they represent a minor component of a flexible and adaptable diet. Based on this information, underwater noise on forage resources for ESA-listed sea turtles is likely insignificant.

Marine Fish

Atlantic sturgeon and manta ray are hearing generalists. Sturgeon and rays also have different hearing sensitivities based on physiological differences in the structure of their hearing organs.

Kusel et al. (2021) and Hannay and Zykov (2021) modeled noise attenuation distances for impact pile driving and UXO detonation to relevant biological effects for fish without swim bladders (manta rays), and fish with swim bladders not involved in hearing (Atlantic sturgeon) under the 10-dB attenuation PDE scenario, per the interim criteria described by the Fisheries Hydroacoustic Working Group (FHWG 2008). These results are summarized in Table 5.2.

As shown in Table 5.2 above, manta rays and Atlantic sturgeon would have to be within 59 feet (18 m) and 371 feet (113 m) of impact pile driving of a 39-foot (12-meter) WTG monopile and 62 feet (19 m) and 299 feet (91 m) of an OSS monopile, respectively, to experience hearing injury from a single pile strike. Individual manta rays and Atlantic sturgeon would have to remain within 604-856 feet (184-261 m) and 2,470-3,638 feet (752-1,109 m) of three 39-foot (12-meter) WTG monopiles and 617-797 feet (188-243 m) and 2,756-3,458 feet (840-1,054 m) of two OSS monopiles, respectively, for the duration of impact hammer installation to experience cumulative injury. Behavioral effects, including avoidance, are likely to occur at much greater distance. Applying the 150-dB re 1 µPa fish behavioral SPL threshold (GARFO 2018), manta rays and Atlantic sturgeon within 14,403-34,987 feet (4,390-10,664 m) of impact pile driving could experience behavioral effects including avoidance (Kusel et al. 2021). Atlantic sturgeon distribution varies by season, but they are primarily found in shallow coastal waters (water depths of 20 m or less) during the summer months (May to September) and move to deeper waters (20–50 m) in winter and early spring (December to March) (Dunton et al. 2010).

As shown, impact pile driving used to install the RWF monopile foundations is the most intense source of noise resulting from the Project and would produce the most significant and extensive noise effects on fish. As shown in Table 5.2 above, potentially lethal noise effects on adult fish occur from 604 to 5,883 feet from each WTG monopile and 617 to 5,194 feet from each OSS monopile. Pile driving would produce noise above the 150-dB re 1 µPa behavioral effects threshold from 14,403 to 34,987 feet from each source, respectively.

The relative rarity of manta rays in the marine component of the action area and the likelihood of behavioral avoidance of construction and installation vessel noises render the likelihood of injury level exposure discountable for this species. While injury level exposure of individual sturgeon is improbable for the same reasons, the greater likelihood of occurrence in the marine component of the action area indicate that injury-level effects cannot be entirely ruled out. Atlantic sturgeon are likely to be exposed to construction and installation noise above the 150-dB re 1 µPa behavioral threshold based on the area of effect for impact and vibratory pile driving in habitats known or likely to be used by this species. Therefore, impacts to marine fish are considered potentially significant for Atlantic sturgeon and insignificant for manta ray.

While manta ray and Atlantic sturgeon occasionally eat small fish, both species feed primarily on invertebrates. Invertebrate sound sensitivity is restricted to particle motion, the effect of which dissipates rapidly such that any effects are highly localized to the immediate proximity (i.e., less than 1 m) from the noise source (Edmonds et al. 2016). This indicates that impact pile driving noise is unlikely to measurably impact the availability of suitable forage for either species. Similarly, while impact pile driving may temporarily reduce the abundance of forage fish, eggs, and larvae in the immediate proximity of pile driving activities, those effects would be limited in extent and are unlikely to affect the survival and fitness of any individuals of either species based on the minimal contribution of fish to their overall diet.

5.1.2 UXO Detonation

Hannay and Zykov (2022) modeled the distance required to attenuate underwater noise from UXO detonation to defined effect thresholds for marine mammals, sea turtles, and fish at different locations within the Project area under a range of seasonal conditions. They also estimated the reduction in distance to threshold resulting from the use of sound attenuation systems. The results used in this BA assume the use of sound attenuation systems capable of achieving a 10-dB reduction in source noise levels and that UXO would be detonated individually, and not simultaneously/concurrently. No UXO detonations are anticipated to occur. If an unexpected UXO detonation is required, it would only occur along the export cable corridor. Revolution Wind has conservatively estimated that up to 16 1,000-pound (454 kg) devices may require detonation in place. In-situ detonation activities would take place between May 1 and November 30 and would be limited to one device per day, meaning that detonation impacts would be dispersed across the marine component of the action area over 16 separate days.

The range of modeled threshold distances for detonation of up to 16 UXOs ranging in size from 5 to 1,000 pounds for the Project are presented above in Table 5.2; though no UXO detonations are anticipated to occur. Impacts to ESA listed species from this stressor are described below by species group.

Marine Mammals

The areas exposed to behavioral and injury-level noise effects to marine mammals from UXO detonation would vary depending on size of the device, its location, and the marine mammal hearing group the individual belongs to. For example, an individual LFC (e.g., NARW) could immediately experience PTS and injury if it were within 14,009 feet from detonation of a 1,000-pound UXO but would have to be within 883 feet from detonation of a 5-pound device to experience similar effects. By comparison, sperm whale, which are less sensitive to low frequency sound, would have to be within 165 to 1,755 feet from detonation of a 5-pound and a 1,000-pound UXO, respectively to experience PTS.

The number, size, and distribution of UXOs potentially occurring in the RWF and RWEC Lease Area are not currently known. LGL (2022a) evaluated potential marine mammal exposure to permanent and temporary injury and behavioral-level effects from UXO detonation of 13, 1,000-pound devices, the largest explosive devices likely to be encountered. This conservative scenario considered the implementation of all planned EPMs, including the use of a sound attenuation device capable of achieving at least 10 dB sound source reduction, timing restrictions to protect NARW, and clearance zone monitoring using PSOs (LGL 2022a). As feasible, Revolution Wind will use a noise attenuation system for all detonation events and is committed to achieving the modeled ranges associated with 10 dB of noise attenuation. If a noise attenuation system is not feasible, Revolution Wind will implement mitigation measures for the larger unmitigated zone sizes, with deployment of vessels or use of an aerial platform adequate to cover the entire clearance zone as defined above (LGL 2022a). See Appendix C for additional details on mitigations proposed for UXO detonations, including monitoring and mitigation protocols, pre-start clearance protocols, and reporting. LGL (2022a) determined that no ESA-listed marine mammals would experience exposure sufficient to cause permanent injury, but individuals of each species could experience TTS and/or behavioral effects. Therefore, the potential impact to marine mammals is considered insignificant. The number of individuals from each listed species potentially exposed to TTS and/or behavioral level effects is summarized in Table 5.5.

Table 5.5. Estimated Number of ESA-listed Marine Mammals Individuals* Experiencing Permanent Injury, Temporary Threshold Shift, or Behavioral Effects from a Worst-Case Scenario for UXO Detonation Exposure.

Functional Hearing Group	Species	PTS Cumulative Sound Exposure	PTS from Peak Sound Pressure Exposure	TTS or Physiological Behavioral Effects
LFCs	Blue whale	--	--	1
	Fin whale			10
	Sei whale	--	--	2
	NARW	--	--	8
MFC	Sperm whale	--	--	2

Source: LGL 2022a.

* Installation scenario assumes use of a noise attenuation system achieving 10 dB effectiveness but does not consider other EPMs. Values < 1 indicate a modeled exposure estimate of greater than 0 but less than 0.5 individual, which is considered a result of zero for regulatory purposes.

Sea Turtles

Hannay and Zykov (2022) used a similar model to estimate the threshold distances for PTS and TTS exposure from UXO detonation (Table 5.2). Turtles within 689 feet of UXO detonation could experience injury based on the threshold of 210 dB re 1 µPa2s. Turtles within 1,699 feet exposed to multiple UXO detonations in a single day could experience accumulated injury from based on 204 dB SEL re 1 µPa2s. Turtles within 8,235 feet of UXO detonation could experience behavioral impacts based on the threshold of 189 dB re 1 µPa2s.

Zykov (2022) used these threshold distances to estimate the number of individual sea turtles by species that could be exposed to PTS, TTS and behavioral effects from UXO detonation (Table 5.6). As stated, the number, size, and distribution of UXOs potentially occurring in the RWF and RWEC Lease Area are not currently known. Therefore Zykov (2022) considered the potential detonation of 13, 1,000-pound devices, the largest explosive devices likely to be encountered. The exposure scenario assumes that these devices are distributed such that the exposure areas would not overlap. Zykov (2022) determined that less than one individual leatherback and less than one individual loggerhead sea turtle could be exposed to PTS or TTS effects from UXO detonation in the RWEC corridor, and none would be exposed to these effects from detonations in the RWF. No Kemp's Ridley or green sea turtles are likely to be exposed to PTS or TTS effects in either area. Thus the potential impacts to sea turtles is considered insignificant from UXO detonation, but is still significant overall for underwater noise due to the effects of impact pile driving.

Table 5.6. Estimated Number of ESA-listed Sea Turtle Individuals Experiencing Permanent Injury, Temporary Threshold Shift, or Behavioral Effects from a Worst-Case Scenario for UXO Detonation Exposure.

Species	PTS Cumulative Sound Exposure	PTS or Injury from Peak Sound Pressure Exposure	TTS or Behavioral Effects
Kemp's ridley turtle	--	0.0	0.0
Leatherback turtle	--	0.1	0.8
Loggerhead turtle	--	0.1	0.7
Green turtle	--	0.0	0.0

Source: Zykov 2022.

Marine Fish

Revolution Wind anticipates that up to 16 UXOs ranging from 5 to 1,000 pounds in size may need to be detonated in place (LGL 2022a). The actual number and location of UXOs is not currently known, but the devices most likely to require detonation are along the RWEC corridor. UXO identified during preconstruction surveys that cannot be safely relocated could be detonated in place, producing intense underwater noise impacts. As stated, up to 16 individual detonations would take place on separate days between May 1 and November 30.

The threshold distances shown in Table 5.2 for UXO detonation effects on fish are for a 1,000-pounds device, the largest explosive analyzed by Hannay and Zykov (2021), assuming 10 dB of sound source attenuation. Detonation of 1,000-pound UXOs could injure or kill juvenile and adult fish within 2,779 feet (847 m) of the source. Numerical exposure estimates have not been developed for Atlantic sturgeon or manta ray. 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 outlined in Table 3.19.

The range of threshold distances for injury from UXO detonation are for devices ranging in size from 5 to 1,000-pound devices. Detonation of 1,000-pound UXOs could injure or kill prey organisms including adult fish and fish eggs and larvae up to 951 and 1,384 feet from the source, respectively. In general, mollusks and crustaceans are less sensitive to noise-related injury than many fish because they lack internal air spaces and are therefore less vulnerable to sound pressure injuries on internal organs than vertebrates (Popper et al. 2001). Most invertebrates are insensitive to hearing injury as they lack the specialized organ systems evolved by vertebrates to sense sound pressure (Popper et al. 2001). Current research suggests that some invertebrate species groups, such as cephalopods (e.g., octopus, squid), crustaceans (e.g., crabs, shrimp), and some bivalves (e.g., Atlantic scallop, Atlantic surfclam, ocean quahog) are capable of sensing sound through particle motion (Andre et al. 2011; Carroll et al. 2016; Edmonds et al. 2016; Hawkins and Popper 2014). Particle motion effects dissipate rapidly and are highly localized around the noise source, with detectable effects on invertebrates typically limited to within 3 to 6 feet of the source (Edmonds et al. 2016; Payne et al. 2007).

The impacts to spawning from detonation of UXOs will vary depending on when they occur and proximity to important spawning habitats. While mortality-level effects on fish eggs and larvae could occur, these impacts are likely to be insignificant overall because (1) the area of effect is small relative to the available habitat; and (2) the loss of individuals would likely be biologically insignificant relative to natural mortality rates for planktonic eggs and larvae across the geographic analysis area, which can range from 1 percent to 10 percent per day or higher (White et al. 2014).

Given the uncertainty of where UXO detonation will occur and that clearance zones cannot be maintained for fish, UXO detonation could potentially injure or kill individual Atlantic sturgeon. Insufficient data are available to estimate the number of individuals potentially exposed. Given their observed preference for shallower water in summer and fall (Erickson et al. 2011), the planned May to November window for UXO detonations would likely limit the potential for Atlantic sturgeon exposure to UXO detonation in the RWF. However, sturgeon may be present in shallower waters within and near the RWEC corridor during this period. Given the potential for UXO detonation in nearshore habitats during summer months, the potential for injury or mortality of individual animals cannot be discounted and is therefore considered potentially significant.

Manta ray occurrence in the marine component of the action area is rare at best. As such, the likelihood of individual manta rays being exposed to adverse noise effects from UXO detonation is discountable but is still insignificant overall for underwater noise due to the effects of impact pile driving.

5.1.3 Vibratory Pile Driving

Marine Mammals

LGL (2022a) modeled the distance to marine mammal injury and behavioral thresholds for vibratory pile driving and related sea-to-shore construction and installation activities, applying the thresholds for non-impulsive noise sources listed in Table 5.1. As discussed in Section 5.1, vibratory pile driving noise generated during sea-to-shore transition construction would be contained by the geographic confines of Narragansett Bay. Behavioral-level noise effects would extend from the source to all surrounding shorelines within the underwater ”line of sight.” The sound shading effect of the surrounding shorelines of Narragansett Bay would restrict the maximum distance vibratory pile-driving noise could travel to approximately than 42,650 feet (8.1 miles), limiting potential exposure to those marine mammal species that are likely to occur within this enclosed embayment. Vibratory pile-driving noise would be limited in duration and is expected to occur over 56 days (14 days for cofferdam installation and 14 days for cofferdam removal for each cable landfall for a total of 56 days). As such, the likelihood of ESA-listed marine mammal exposure to vibratory pile driving noise effects is low, especially within Narragansett Bay. No sperm whales are anticipated to occur in Narragansett Bay; however, LGL (2022a) did assume sperm whale presence at low density in their analysis for the petition for ITR, with an estimate of two MFC sperm whales exposed to potential noise levels that could result in behavior effects (LGL 2022a). No NARW, fin whale or sei whale are anticipated to be exposed to noise levels that could cause behavioral effects (LGL 2022a). Thus, the potential effect to marine mammals is considered insignificant.

Sea Turtles

LGL (2022a) characterized the underwater noise levels likely to be generated by vibratory pile driving and other potential pile driving methods (i.e., impact pile driving to install temporary casing pipe) used to construct the sea-to-shore transition site. Vibratory and other pile driving methods would not occur simultaneously. Temporary casing pipe would require up to 2 days of impact pile driving to install, which may be spread out over up to 8 days for each pipe, depending on the number of pauses required to weld additional sections onto the casing pipe (LGL 2022a). BOEM applied the injury and behavioral thresholds listed in Table 5.1 and sound source levels identified by LGL (2022a) to estimate the threshold distances for hearing injury and behavioral effects to sea turtles using the GARFO (2020) acoustics tool. Vibratory pile-driving noise is unlikely to exceed recommended sea turtle injury thresholds and would only exceed behavioral thresholds within 175 feet of the source as shown in Table 5.2. Given the limited spatial extent of these potential effects, sea turtles are more likely to respond to disturbance from construction and installation vessels staging on-site before pile driving begins. It is anticipated that no sea turtles will be exposed to PTS/TTS effects because individual sea turtles would have to remain within 175 feet of vibratory pile driving in Narragansett Bay for an extended period. This suggests that the potential for exposure for sea turtles to vibratory pile-driving noise is discountable.

Marine Fish

LGL (2022a) characterized the underwater noise levels likely to be generated by vibratory pile driving and other potential pile driving methods (i.e., impact pile driving to install temporary casing pipe) used to construct the sea-to-shore transition site. Vibratory and other pile driving methods would not occur simultaneously. Temporary casing pipe would require up to 2 days of impact pile driving to install, which may be spread out over up to 8 days for each pipe, depending on the number of pauses required to weld additional sections onto the casing pipe (LGL 2022a). BOEM applied the injury and behavioral thresholds listed in Table 5.1 and sound source levels identified by LGL (2022a) to estimate the threshold distances for hearing injury and behavioral effects to Atlantic sturgeon and manta ray using the GARFO (2020) acoustics tool. Vibratory pile driving would produce noise levels exceeding the SPL behavioral threshold of 150-dB re 1 µPa at distances up to 2,556 and 2,225 feet (775 and 135 m) for sturgeon and manta rays, respectively. As such, these effects would be entirely confined within Narragansett Bay and constrained by surrounding shorelines. Manta ray are unlikely to occur within Narragansett Bay; therefore, the likelihood of exposure to this noise source is discountable but is still considered insignificant overall for underwater noise due to the effect of impact pile driving. Atlantic sturgeon are expected to occur in Narragansett Bay and will be exposed to noise levels that exceed the SPL behavioral threshold of 150-dB re 1 µPa at distances up to 2,556 feet (775 m) during vibratory pile driving. Overall, the potential effect to Atlantic sturgeon from vibratory pile driving is considered insignificant but is still considered significant overall for underwater noise due to the effects of impact pile driving.

5.1.4 Geotechnical and Geophysical Surveys

Revolution Wind estimates that under the revised proposed action up to 9,509 linear miles of pre-construction HRG surveys would be performed, approximately 5,940 and 3,547 miles in the RWF and RWEC corridors, respectively. This equates to a combined 218 days of survey effort, 137 within the RWF and 81 within the RWEC averaging approximately 48 miles of exposure each day at a typical vessel speed of 2.2 knots (LGL 2022a). HRG survey activities could occur during any month of the year. Up to 2,365 linear miles of post-construction HRG surveys could be conducted each year for the first 4 years of project operations to ensure transmission cables are maintaining desired burial depths. This equates to approximately 54 days of HRG survey activity per year.

Marine Mammals

BOEM (2021b) reviewed underwater noise levels produced by the available types of HRG survey equipment as part of a programmatic biological assessment for this and other activities associated with regional offshore wind energy development. NMFS concurred with BOEM's determination that planned HRG survey activities using even the loudest available equipment types would be unlikely to injure or measurably affect the behavior of ESA-listed marine mammals, with the incorporation of specific PDC and BMPs for the protection of federally protected species. Specifically, the noise levels produced by HRG survey equipment are relatively low, meaning that an individual marine mammal would have to remain close to the sound source for extended periods of time to experience injury. This type of exposure is unlikely as the sound sources are continuously mobile and directional (i.e., pointed at the bottom). Moreover, consistent with BOEM requirements Revolution Wind has developed a protected species monitoring and mitigation plan (Revolution Wind 2022b) that includes PSO monitoring of species-specific clearance zones around HRG survey activities and mandatory shutdown procedures to further minimize exposure risk. These measures would effectively avoid the risk of PTS or TTS effects on marine mammals from HRG survey activities. While individual marine mammals may be exposed to HRG survey noise sufficient to cause behavioral effects, those effects would be short-term and unlikely to cause any perceptible long-term consequences to individuals or populations. Therefore, these effects would be insignificant.

LGL (2022a) modeled potential ESA-listed marine mammal exposure to injury and behavioral level effects from HRG survey activities under the proposed action. They applied the same methods and EPM effectiveness assumptions used to estimate exposure to harmful noise effects from impact pile driving and UXO detonation. They determined that injury level effects from exposure to HRG survey noise is unlikely to occur. Tables 5.7 and 5.8 present the number of marine mammals expected to experience TTS or behavioral effects from pre- and post-construction HRG survey activities, respectively.

Table 5.7. Estimated Number of Marine Mammals Experiencing a Temporary Threshold Shift or Behavioral Effects from Construction-related HRG Survey Activities

Functional Hearing Group	Species	Estimated Number of Individuals Exposed to Behavioral or TTS Level Noise Effects	NMFS Stock Abundance†	Number of Individuals Exposed as Percent of Stock Abundance
LFC	Blue Whale	1	402	1%
	Fin Whale	61	6,802	0.9%
	NARW	10	368	3.3%
	Sei Whale	3	6,292	<0.01%
MFC	Sperm Whale	8	4,349	0.2%

† Source: Hayes et al. 2021.

Table 5.8. Estimated Number of Marine Mammals Experiencing a Temporary Threshold Shift or Behavioral Effects from Post-Construction HRG Survey Activities (4 years total).

Functional Hearing Group	Species	Estimated Number of Individuals Exposed to Behavioral or TTS Level Noise Effects	NMFS Stock Abundance†	Number of Individuals Exposed as Percent of Stock Abundance
LFC	Blue Whale	4	402	1%
	Fin Whale	64	6,802	0.9%
	NARW	12	368	3.3%
	Sei Whale	8	6,292	0.01%
MFC	Sperm Whale	8	4,349	0.2%

† Source: Hayes et al. 2021.

Sea Turtles

HRG equipment operating at frequencies below 2,000 Hz (typically sub-bottom profilers) may be audible to sea turtles. Equipment such as echosounders and side-scan sonars operate at higher frequencies and would be outside the hearing range of sea turtles, therefore having no effect on these species. The equipment only operates when the vessel is moving along a survey transect, meaning that the ensonified area is intermittent and constantly moving. BOEM (2021b) evaluated potential underwater noise effects on sea turtles from HRG surveys and concluded there is no possibility of PTS in sea turtles from HRG sound sources because of the brief and intermittent disturbances that a vessel could have on individuals. Some HRG survey noise sources would exceed the behavioral effects threshold up to 300 feet from the source, depending on the type of equipment used, but given the limited extent of potential noise effects and the EPMs used in this Project (e.g., soft start measures, shutdown procedures, protected species monitoring protocols, use of qualified and NOAA-approved PSOs, and noise attenuation systems; Section 3.5), adverse impacts to sea turtles are unlikely to occur (BOEM 2021a). While behavioral exposures could occur, these would be limited in extent and temporary in duration (BOEM 2021a). Therefore, underwater noise impacts from HRG surveys are expected to be insignificant.

Marine Fish

HRG surveys would be conducted concurrent with monopile installation in both the RWF and the RWEC. HRG survey equipment is towed at a typical speed of 4 knots (1.9 km per hour) during operation, meaning that no individual area is continuously exposed to underwater noise (i.e., noise exceeding an established effect threshold) related to HRG surveys for more than approximately 20 minutes. HRG surveys would result in TTS in all fish extending 16 feet (5 m) and behavioral effects extending 2,572 feet (784 m) from the HRG survey equipment when in operation (BOEM 2021a). Therefore, underwater noise impacts from HRG surveys are expected to be insignificant.

5.2 Other Noise Impacts

5.2.1 Vessels

The number and classes of vessels anticipated to be used for Project construction and installation and O&M activities are described in Section 3.3.2, Tables 3.11, 3.12, and 3.14. Noise levels generated by larger construction and installation and O&M would have an approximate L_{rms} source level of 170 dB re 1 µPa-m (Denes et al. 2020). Smaller construction and installation and O&M vessels, such as CTVs, are expected to have source levels of approximately 160 dB re 1 µPa-m, based on observed noise levels generated by working commercial vessels of similar size and class (Kipple and Gabriele 2003; Takahashi et al. 2019).

The anticipated number of vessel trips required for project construction and installation is summarized in Table 3.12. Revolution Wind (Tech Environmental 2021) has estimated that Project O&M would involve up to four CTV and two SOV trips per month for wind farm O&M, or 2,730 vessel round trips over the life of the Project. These trips would originate either from an O&M facility located either in Montauk, New York, or Davisville, Rhode Island. One or more CTVs ranging from 62 to 95 feet in length would be purpose built to service the RWF over the life of the Project. SOVs are larger mobile work platforms, on the order of 215 to 305 feet long and 60 feet in beam, equipped with dynamic positioning systems used for more extensive, multi-day maintenance activities (Ulstein 2021). Larger vessels like those used for construction and installation could be required for unplanned maintenance, such as repairing scour protection or replacing damaged WTGs. Those activities would occur on an as-needed basis.

Marine Mammals

LGL (2022a) did not explicitly consider construction and installation and O&M vessel noise in their exposure assessment, concluding that injury level effects from vessel noise are unlikely. In general, vessel noise is unlikely to cause hearing injury in marine mammals because this would require prolonged exposure close to the source (i.e., remaining within 400 feet of a large vessel for 24 hours, per NOAA [2018]). This is an unlikely scenario. For example, an animal swimming at 2.5 miles per hour, the lower end of average swim speeds for the NARW (Baumgartner and Mate 2005), would travel 400 feet in less than 2 minutes. This animal would clear the zone of potential noise exposure around a stationary construction and installation vessel within approximately 4 hours. The likelihood and duration of exposure would be further reduced when construction and installation vessels are moving. Animals and vessels moving in relation to each other are likely to reduce the duration of exposure to potential behavioral and auditory masking effects.

While behavioral avoidance of anthropogenic noise sources has not been definitively proven, logic and available data (e.g., Dunlop et al. 2017; Ellison et al 2012; Southall et al. 2007) suggest that mobile marine mammals would avoid behavioral disturbances like those resulting from vessel noise. This means that the duration of any exposure to noise from slow-moving or closely clustered and stationary construction and installation vessels would be limited. It is also important to recognize that a substantial portion of construction and installation vessel activity would occur in areas with high existing levels of vessel traffic. As such, construction and installation vessels would contribute to, but may not substantially alter, ambient noise conditions generated by existing large vessel traffic. While some individual marine mammals could experience short-term behavioral and auditory effects from vessel noise exposure, these effects would be short term in duration and unlikely to cause measurable effects at the broader stock or population-level.

BOEM anticipates that underwater noise generated by O&M and monitoring vessels would overlap the hearing range of blue, fin, NARW, sei, and sperm whales (NMFS 2018; Southall et al. 2019) and would be audible to these species. However, in general vessel noise is unlikely to cause hearing injury in marine mammals because this would require prolonged exposure close to the source (i.e., remaining within 400 feet of a large vessel for 24 hours, per NOAA [2018]); therefore, vessel noise from O&M and monitoring activities is not expected to result in injury-level effects. Noise levels generated by the larger SOVs would be similar to those described previously for project construction and installation vessels and would result in short-term and relatively minor noise impacts that would occur periodically throughout the life of the project and are therefore considered insignificant.

Sea Turtles

While sea turtles would likely be able to detect construction and installation and O&M vessels in proximity, this would not necessarily translate to measurable effects. As shown in Table 5.2, vessel noise is unlikely to exceed injury and behavioral effects thresholds for sea turtles. Hazel et al. (2007) found that sea turtles’ reactions to approaching vessels are less acute at higher vessel speeds, increasing the chance of vessel-turtle collisions. In contrast, Samuel et al. (2005) indicated that vessel noise can affect sea turtle behavior, especially their submergence patterns. Sea turtles commonly react to approaching vessels with a startle response (diving or swimming away) that results in a short-term increase in stress levels and energy expenditure, but behavior typically returns to normal shortly after the stressor departs (NSF and USGS 2011). BOEM anticipates that the potential effects of noise from O&M vessels would elicit brief responses to the passing vessel that would dissipate once the vessel or the turtle left the area. For these reasons, BOEM anticipates that sea turtle exposure to vessel noise would be minimal to discountable, and responses if any, would be short-term, with individuals returning to normal behaviors once the vessel has passed. Additionally, the general mitigation and monitoring measures proposed in the Protected Species Mitigation and Monitoring Plan (Revolution Wind and Inspire Environmental 2021) for all project vessels to watch out for and avoid all sea turtles would further reduce the chance of any adverse effects to the species from the Proposed Action and impacts are therefore considered insignificant.

Marine Fish

Noise levels generated by construction and installation and O&M related vessels are below identified injury thresholds for all fish hearing groups, indicating that vessel noise is unlikely to cause injury-level effects on any fish species. Vessel noise levels may exceed the 150 dB re 1 µPa behavioral effects peak threshold in some cases, but those effects would be short-term due to the mobility of the fish and the mobile sound source and limited in extent to areas within a short distance of the project vessels. The low-frequency noise produced by the vessel engine could cause auditory masking effects. However, these effects must be considered against the baseline levels of vessel traffic. Commercial and recreational fishing activity in and around the RWF likely generates thousands of vessel trips and tens of thousands of operational hours within the marine component of the action area on an annual basis. Individual fish occurring in this component of the action area and vicinity are likely exposed to varying levels of vessel noise on a daily basis. In this context, O&M vessel use is not likely to measurably alter the ambient noise environment experienced by fish relative to the existing baseline. Therefore, potential impacts on fish from underwater noise from O&M vessels would likely be discountable.

5.2.2 Helicopters and Fixed Wing Aircraft

Project construction and installation, O&M, and decommissioning would involve the periodic use of helicopters for crew transport, inspection, and monitoring activities, and fixed wing aircraft for PSO monitoring during construction and installation and decommissioning. Aircraft use by project phase is described in Section 3.1.2. ESA-listed species exposure to aircraft and potential effects are described below.

Marine Mammals

In general, marine mammal behavioral responses to aircraft most commonly occur at distances of less than 1,000 feet and those responses are typically limited (Patenaude et al. 2002). BOEM would require all aircraft operations to comply with current approach regulations for any sighted NARWs or unidentified large whale. Current regulations (50 CFR 222.32) prohibit aircraft from approaching within 1,500 feet of NARW. BOEM expects that most aircraft operations would occur above this altitude limit except under specific circumstances (e.g., helicopter landings on service operations vessels). Aircraft operations could result in short-term behavioral responses, including short surface durations, abrupt dives, and percussive behaviors (i.e., breaching and tail slapping) (Patenaude et al. 2002), but BOEM does not expect that these exposures would result in measurable effects on marine mammals. With the implementation of altitude minimums, exposure of noises above PTS, TTS, and behavioral thresholds for all ESA-listed marine mammal species is considered extremely unlikely to occur and discountable. On this basis, noise and disturbance effects on marine mammals from aircraft operations are expected to be discountable due to protective regulations and short-term nature of the impact.

Sea Turtles

Currently, no published studies describe the impacts of aircraft overflights on sea turtles, although anecdotal reports indicate that sea turtles respond to aircraft at low altitude by diving (BOEM 2017). While helicopter traffic may cause some short-term behavioral reactions, including startle responses (diving or swimming away), altered submergence patterns, and a short-term stress response (BOEM 2017; NSF and USGS 2011; Samuel et al. 2005), these brief responses would be expected to dissipate once the aircraft has left the area. The potential effects of aircraft noise and disturbance on sea turtles are therefore expected to be discountable.

Marine Fish

Helicopter operations are not anticipated to have any measurable effect ("no effect") on Atlantic sturgeon or manta rays, particularly considering aircraft operations would adhere to protective regulations intended to avoid and minimize impacts to marine mammals.

5.2.3 Wind Turbine Generators (WTGs)

Operating WTGs produce audible underwater noise mostly in lower frequency bands. Typical operational rms sound pressure levels (SPL) produced by older-generation geared WTGs range from 110 to 130 dB re 1 μPa though sometimes louder under extreme operating conditions, with the greatest energy in the 12.5 to 500 Hz 1/3-octave bands, (Betke et al. 2004; Jansen and de Jong 2016; Madsen et al. 2006; Marmo et al. 2013; Nedwell and Howell 2004; Tougaard et al. 2009). These operational noise levels are generally comparable to ambient conditions recorded in the marine component of the action area but over a broader frequency band (see Section 4). Operational noise increases concurrently with ambient wind and wave noise, meaning that noise levels usually remain indistinguishable from background within a short distance from the source under typical operating conditions.

Revolution Wind has proposed WTGs with direct-drive turbine designs. Direct-drive turbine design eliminates the gears of a conventional WTG, which increases the speed at which the generator spins. Direct-drive generators are larger generators that produce the same amount of power at slower rotational speeds. Only one study of direct-drive turbines presented in Elliott et al. (2019) was available in the literature. The study measured SPLs of 114 to 121 dB re 1 μPa at 164.0 feet (50 m) for a 6-MW direct-drive turbine. Recent modeling conducted by Stöber and Thomsen (2021) and Tougaard et al. (2020) has suggested that operational noise from larger, current-generation WTGs would generate higher source levels (170 to 177 dB re 1 μPa-m for a 10-MW WTG in 19-knot [10 m/s] wind) than the range noted above from earlier research. However, the models were based on a small sample size, which adds uncertainty to the modeling results. In addition, modeling results were based on measured SPLs from geared turbines. Even though current turbine engines are larger, WTGs with direct-drive technology could reduce SPLs because they eliminate gears and rotate at a slower speed than the conventional geared generators.

Potential impacts on marine mammals, sea turtles and fish from WTG operational noise are evaluated below by species group.

Marine Mammals

As discussed in Section 5.1, cetaceans have well-adapted acoustical and hearing abilities which they rely on for communication, foraging, mating, predator avoidance, and navigation (Madsen et al. 2006; Weilgart 2007). The potential effects from WTG operational noise related activities are discussed below.

Operating WTGs produce audible underwater noise mostly in lower frequency bands. Typical operational rms sound pressure levels (SPL) produced by older-generation geared WTGs range from 110 to 130 dB re 1 µPa though sometimes louder under extreme operating conditions, with the greatest energy in the 12.5 to 500 Hz 1/3-octave bands, (Betke et al. 2004; Jansen and de Jong 2016; Madsen et al. 2006; Marmo et al. 2013; Nedwell and Howell 2004; Tougaard et al. 2009). These operational noise levels are generally comparable to ambient conditions recorded in the marine component of the action area but over a broader frequency band (see Section 4). Operational noise increases concurrently with ambient wind and wave noise, meaning that noise levels usually remain indistinguishable from background within a short distance from the source under typical operating conditions.

Madsen et al. (2006) concluded that the noise levels observed at operating wind farms would be unlikely to impair marine mammal hearing but could potentially disrupt the behavior of individuals in close proximity under low ambient noise conditions. Jansen and de Jong (2016) and Tougaard et al. (2009) concluded that marine mammals would be able to detect operational noise from WTGs within a few hundred meters, but the effects would be small. Long (2017) summarized observational data on marine mammal behavior around operating offshore renewable energy facilities in Scotland. He found no evidence of avoidance or other behavioral shifts but cautioned that the available data were too limited to make a definitive conclusion about potential long-term effects. More recently, Stober and Thomsen (2021) used monitoring data and modeling to estimate operational noise from 10 MW current generation direct-drive WTGs and more similar in size and technology to those proposed for Revolution Wind (i.e., turbines larger than most previously monitored) and concluded that these designs could generate higher operational noise levels than those reported in earlier research. This suggests that operational noise effects on marine mammals could be more intense and extensive than those considered herein but the findings have not been validated.

The potential for behavioral effects on marine mammals can be evaluated by estimating the area exposed to WTG L_{rms} operational noise above the 120 dB re 1 µPa behavioral effects threshold for non-impulsive noise sources (NMFS 2019). Applying the cylindrical spreading loss model (University of Rhode Island 2021) (spreading coefficient of 10 dB/decade of range), the range of operational levels reported by Tougaard et al. (2020) of 91-136 dB re 1µPa at a reference distance of 50 m (164 feet)[6] would attenuate below 120 dB re 1 µPa within approximately less than 1 foot to approximately 6,400 feet (0.1 to 1,950 m) of each turbine foundation. Peak operational noise levels occur during high wind periods when ambient noise levels are higher due to wave activity. As such, WTG operational noise would tend to scale with ambient conditions.

However, it is also probable that operational noise would change the ambient sound environment within the Lease Area in ways that could affect habitat suitability. This impact can be evaluated by estimating the area exposed to operational noise above the existing environmental baseline. Kraus et al. (2016) measured ambient noise conditions at three locations within and adjacent to the proposed RWF over a 3-year period and identified baseline levels of 102 to 110 dB re 1 µPa within a 20 – 477 Hz frequency band, which was chosen based on vocalization ranges of the whale species of interest to the study. Maximum operational noise levels typically occur at higher wind speeds when baseline noise levels are higher due to wave action. Applying the same approach described above, the operational range L_{rms} of 91 and 136 dB re 1 µPa at a reference distance of 50 m would attenuate to the 102 to 110 re 1 µPa baseline within approximately 6,063 feet (1,848 m) to 1,776 feet (541 m) of each turbine, respectively.

The low-frequency sounds produced by WTGs are within the range of hearing sensitivity and audible communication frequencies used by many species of marine mammals (NOAA 2018a), indicating that this impact mechanism could be a potential source of behavioral and auditory masking effects on marine mammal species. A reduction in effective communication space caused by auditory masking can make it more difficult to locate companions and maintain social organization (Cholewiak et al. 2018). This can increase physiological stress, leading to impaired immune function and other chronic health problems (Hatch et al. 2012; Brakes and Dall 2016; Davis et al. 2017). This localized, long-term impact would constitute a behavioral effect on marine mammals belonging to the LFC hearing group. Operational noise effects on marine mammals in other hearing groups would be insignificant because of the animals' lower sensitivity in the relevant frequencies.

Sea Turtles

As discussed in Section 5.1, the biological significance of hearing in sea turtles is not well studied (Piniak et al. 2016; Popper et al. 2014). The sound levels produced during WTG operation (see above under Marine Mammals) are below behavioral and injury thresholds used by NMFS to assess potential adverse effects on sea turtles. Popper et al. (2014) concluded that near-field exposure to continuous noise sources would be likely to illicit behavioral responses in sea turtles. This suggests that operational noise could cause a behavioral response in sea turtles that come in close proximity (i.e., within tens of meters per Popper et al. 2014) of WTG foundations, the nature and significance of those behavioral responses are uncertain. Despite this uncertainty, there is currently no basis to conclude that WTG operational noise would lead to

[6] WTG operational noise levels reported by Tougaard et al. (2020) were used to calculate an estimated range of operational noise levels at a reference distance of 50 meters applying the cylindrical spreading loss model.

adverse behavioral effects on sea turtles, therefore the potential impact to sea turtles is considered insignificant.

Marine Fish

The ESA-listed marine fish species known or likely to occur in the marine component of the action area, Atlantic sturgeon and manta ray, are hearing generalists that are relatively insensitive to sound when compared to fish species that are hearing specialists. Measured SPLs produced by operating WTGs often range from 110 to 130 dB re 1 µPa (Betke et al. 2004; Jansen and de Jong 2016; Madsen et al. 2006; Marmo et al. 2013; Nedwell and Howell 2004; Tougaard et al. 2009). As stated previously, continuous noise sources are not associated with injury level effects on the fish hearing groups containing manta ray and Atlantic sturgeon. Operational noise levels are also below the 150 dB re 1 µPa fish behavioral effects threshold. However, sturgeon may use hearing to aid in migration and to search for prey and males vocalize during spawning, suggesting that sturgeon use sound to find potential mates (Fay and Popper 2000; Meyer et al. 2010). Adult and subadult sturgeon have wide migratory ranges in the marine environment and are often widely dispersed (Ingram et al. 2019, Eyler et al. 2009, Erickson et al. 2011, Dunton et al. 2010 and 2015, and Damon-Randall et al. 2013), so it is unclear to what extent limited auditory masking may be an impediment to communication. Collectively, this information supports the conclusion that operational noise effects on manta rays and Atlantic sturgeon are expected to be insignificant.

5.3 Vessel Traffic Impacts

The RWF would require various types of vessels during construction and installation, O&M, and decommissioning as described above in Section 3.1.2. Construction and installation and decommissioning would involve the most intensive activity over a short-term period, whereas O&M-related vessel traffic would occur intermittently over the life of the project. Increase vessel traffic poses a risk of impacts to listed species from collision risk, vessel discharges, and exposure to air emissions.

In general, project-related vessel activities would represent a small increase in regional vessel traffic compared the baseline levels of vessel traffic in the marine component of the action area and vicinity (see Section 4.0 for summary of existing vessel traffic in the marine component of the action area), which includes thousands of vessel-transits each year as shown below in Figure 5.1 and Figure 5.2. The speeds and characteristics of project-related vessels are provided in Table 3.12, above. The USCG (2020) examined vessel traffic AIS track lines through the MA/RI WEA for years 2015-2018 and noted that annual vessel transit ranged from 13,000 to 46,900, with vessel density typically four times higher during the summer months than January/February and the majority of vessel traffic comprised of pleasure and fish vessels. Length of vessels ranged from 17 m up to 186 m. Beam of vessels ranged from 5 m up to 31 m. Deadweight tons of vessels ranged from less than 137 metric tons to 47,573 metric tons (DNV GL 2020) and most vessels sail between 8 knots and 12 knots. Construction and installation will involve approximately 60 vessels of various classes ranging from small inflatables to construction and installation vessels and barges up to 300 feet in length and helicopters (Table 3.11 and 3.12). Construction and installation vessels will operate in the marine component of the action area over a period of approximately 2 years. Revolution Wind (Tech Environmental 2021) has estimated that Project O&M would involve up to four CTV and two SOV trips per month for wind farm O&M, or 2,730 vessel trips over the life of the Project. These trips would originate either from an O&M facility located either in Montauk, New York, or Davisville, Rhode Island. One or more CTVs ranging from 62 to 95 feet in length would be purpose built to service the RWF over the life of the Project. SOVs are larger mobile work platforms, on the order of 215 to 305 feet long and 60 feet in beam, equipped with dynamic positioning systems used for more extensive, multi-day maintenance activities (Ulstein 2021). Larger vessels like those used for construction and installation could be required for unplanned maintenance, such as repairing scour protection or replacing damaged WTGs. Those activities would occur on an as-needed basis. O&M vessel use would therefore represent a minimal increase in regional vessel traffic over the life of the facility.

5.3.1 Risk of Vessel Strike

Vessel strikes are a known source of injury and mortality for cetaceans, sea turtles, and Atlantic sturgeon. Increased vessel activity in the marine component of the action area associated with construction and installation, O&M, and decommissioning of the proposed action poses a theoretical risk of increased collision-related injury and mortality for ESA-listed species.

Based on information provided by RWF (Tech Environmental 2021), BOEM estimates that project construction and installation would require up to 1,335 one-way trips by various classes of vessels between the RWF and regional ports in Rhode Island, Massachusetts, Connecticut, and New York over the 2-year construction and installation period. This equates to approximately 55 trips per month or 668 trips per year. The construction and installation vessels used for Project construction and installation are described in Table 3.11 and 3.12, and 10-3 in the COP and include jack-up WTG construction and installation vessels, foundation construction and installation vessels, supply vessels and feeder barges, bunkering vessels, cable-laying vessels, and various support craft. Typical large construction and installation vessels used in this type of project range from 325 to 350 feet in length, from 60 to 100 feet in beam, and draft from 16 to 20 feet (Denes et al. 2021).

Large construction and installation vessels and barges would account for an estimated 44 percent of these one-way trips, with the remainder comprising CTVs and other small support vessels. BOEM developed a representative analysis of construction and installation vessel effects on regional traffic volume by evaluating the potential increase in transits across a set of analysis cross sections relative to baseline levels of vessel traffic. These cross sections were developed by DNV GL (2020) to support the COP and are shown in Figure 4.6 with vessel transits by cross section provided in Figure 4.7, above.

Vessels used during project construction and installation would likely include cable-laying vessels (2), a rock-dumping vessel (1), jack-up installation vessels (1-2), material and feeder barges (6-12), tow tugs (2-6), and a fuel bunkering vessel (1) (see Table 3.11). These vessels would largely remain on station or travel at speeds well below 10 knots during construction and installation of the RWF and RWEC. Other vessels used during construction and installation include crew transports and inflatable support vessels used for PSO monitoring. These vessels are smaller and more maneuverable, posing a lower risk of collision with whales and sea turtles (see below).

Using the port of origin information provided by RWF (Tech Environmental 2021), the estimated 668 construction and installation vessel trips per year would cross transects 13-17 when leaving the RWF and could cross several different transects depending on the destination port. This would equate to a 28 percent increase in vessel transits across these transects. However, the AIS data used in transect analysis are not representative of vessels that lack AIS transponders (DNV GL. 2020). Similarly, these data are not representative of all commercial fishing activity, as fishing vessels periodically deactivate their AIS systems to avoid disclosing preferred fishing areas. Such vessels account for most of the vessel activity. For example, DNV GL (2020) estimated over 19,000 one-way trips per year by commercial fishing vessels between the RWF and area ports. When these vessel trips are included, project construction and installation would result in a 3.1 percent increase in vessel transits per year across transects 13-17. In summary, this assessment indicates that construction and installation vessels would likely increase vessel traffic to some degree, and large vessel traffic would measurably increase during the 2-year construction and installation period. This indicates the potential for increased risk of marine mammal collisions in the absence of planned mitigation measures and other requirements.

A small number of construction vessel trips may also originate from ports in the Gulf of Mexico, Europe, or other areas of the globe. The need for vessel trips from distant ports is not currently known, but the number of vessel trips is likely to be small (i.e., ten or less) and most likely to originate from the Gulf of Mexico. Revolution Wind (2022a) has estimated the number of vessel trips that could potentially originate from the Gulf of Mexico. An analysis of associated vessel strike risk from Gulf of Mexico ports is provided in Appendix B.

In general, O&M-related vessel activities would represent a small increase in regional vessel traffic compared to existing conditions. Project O&M may involve up to 10 larger vessels and thousands of smaller vessels, many of the latter comparable in size to the CTV, traveling through the areas between the windfarm and proposed O&M facility locations each month. O&M vessel use would therefore represent a minimal increase in regional vessel traffic over the life of the facility.

Revolution Wind has voluntarily committed to specific EPMs, including vessel timing and speed restrictions to avoid and minimize vessel-related risks to marine mammals and sea turtles.

BOEM has identified additional mitigation measures that would be required to avoid and minimize vessel collision risks to marine mammals and sea turtles. These measures are detailed in Section 3.5, Tables 3.18 and 3.19, respectively. BOEM expects that adherence to these measures will effectively avoid and minimize the risk of vessel strikes to ESA-listed species. A characterization of risks of vessel strike from project-related vessel activity on listed marine mammals, sea turtles, and fish species considered in this BA is provided in the following sections.

Marine Mammals

Vessel strike is relatively common with cetaceans (Kraus et al. 2005) and one of the primary causes of anthropogenic mortality in large whale species (Hayes et al. 2017; Hill et al. 2017; Waring et al. 2011, 2015; Laist et al. 2001; Rockwood et al. 2017; Schoeman et al. 2020) NARWs are particularly vulnerable to vessel strikes based on the distribution of preferred habitats near major shipping lanes and feeding and diving habits (Baumgartner et al. 2017). As many as 75 percent of known anthropogenic mortalities of NARWs likely resulting from collisions with large ships along the U.S. and Canadian eastern seaboard (Kite-Powell et al. 2007). Risk of injury resulting from a vessel strike is commensurate with vessel speed. The probability of a vessel strike increases as speeds increase above 10 knots (Kite-Powell et al. 2007; Conn and Silber 2013; Vanderlaan and Taggart 2007). Vessels operating at speeds exceeding 10 knots under poor visibility conditions have been associated with the highest risk for vessel strikes of NARWs (Vanderlaan and Taggart 2007). Collision risk decreases at speeds below 10 knots (Conn and Silber 2013), and when collisions do occur at these lower speeds, they are far less likely to result in serious injuries (Laist et al. 2001).

Project construction and installation and O&M vessels pose a potential collision risk to marine mammals, and the noise and disturbance generated by vessel presence could temporarily displace individual marine mammals from preferred habitats. Based on information provided by Revolution Wind (Tech Environmental 2021; Revolution Wind 2022a), BOEM estimates that Project construction and installation would require up to 1,335 one-way trips by various classes of vessels between the RWF and regional ports in Rhode Island, Massachusetts, Connecticut, and New York, over the 2-year construction and installation period. This equates to approximately 55 trips per month or 668 trips per year. A small number of vessel trips may originate from distant ports in the Gulf of Mexico, Europe, or elsewhere around the globe (see Appendix B). In addition, approximately 10,755 miles of preconstruction HRG surveys are anticipated to support micrositing of the WTG foundations and cable routes. HRG surveys could occur during any month of the year and would require a maximum of 248 total vessel days. The construction and installation vessels used for Project construction and installation are described in Tables 3.11 and 3.12 and include jack-up WTG installation vessels, foundation installation vessels, supply vessels and feeder barges, bunkering vessels, cable laying vessels, and various support craft. Typical large construction and installation vessels used in this type of project range from 325 to 350 feet in length, from 60 to 100 feet in beam, and draft from 16 to 20 feet (Denes et al. 2021).

Large construction and installation vessels and barges would account for an estimated 44 percent of these one-way trips, with the remainder comprising CTVs and other small support vessels. BOEM developed a representative analysis of construction and installation vessel effects on regional traffic volume by evaluating the potential increase in transits across a set of analysis cross sections relative to baseline levels of vessel traffic. These cross sections were developed by DNV GL Energy USA, Inc. (2020) to support the COP and are shown in Figures 5.1 and 5.2.

Using the port of origin information provided by Revolution Wind (Tech Environmental 2021), the estimated 484 construction and installation vessel trips per year would cross transects 13-17 when leaving the RWF and could cross several different transects depending on the destination port. This would equate to a 23 percent increase in vessel transits across these transects. However, the Automatic Identification System (AIS) data used in transect analysis do not include many recreational vessels that lack AIS transponders and commercial fishing vessels that deactivate their transponders when actively fishing. These two vessel classes account for the vast majority of vessel activity. For example, DNV GL (2020) estimated over 19,000 one-way trips per year by commercial fishing vessels between the RWF and area ports. When these vessel trips are included, Project construction and installation would result in a 2.1 percent increase in vessel transits per year across transects 13-17. Prior to the COVID-19 pandemic, vessel traffic in the region showed an increasing trend. The USCG (2020) documented 13,819 vessel transits in the MARIPARS study area in 2015 using AIS data. The number of transits increased in each successive year, reaching 46,981 trips in 2018. Large vessel transits in the tug/barge, cargo carrier, and tanker classes increased from 1,499 to 2,390 trips per year over the same period. By comparison, RWF construction and installation would require an estimated 644 trips by large construction and installation vessels (i.e., vessels with a draft of 7 m or greater) during the 2-year construction and installation period, or approximately 320 trips per year. In summary, this assessment indicates that construction and installation vessels would likely increase vessel traffic to some degree over baseline conditions, but the baseline conditions in any given year may vary. Large vessel traffic would measurably increase during the 2-year construction and installation period. This indicates the potential for increased risk of marine mammal collisions, but that risk is mitigated in part by typical vessel speeds during construction and installation, and by proposed risk avoidance and minimization measures.

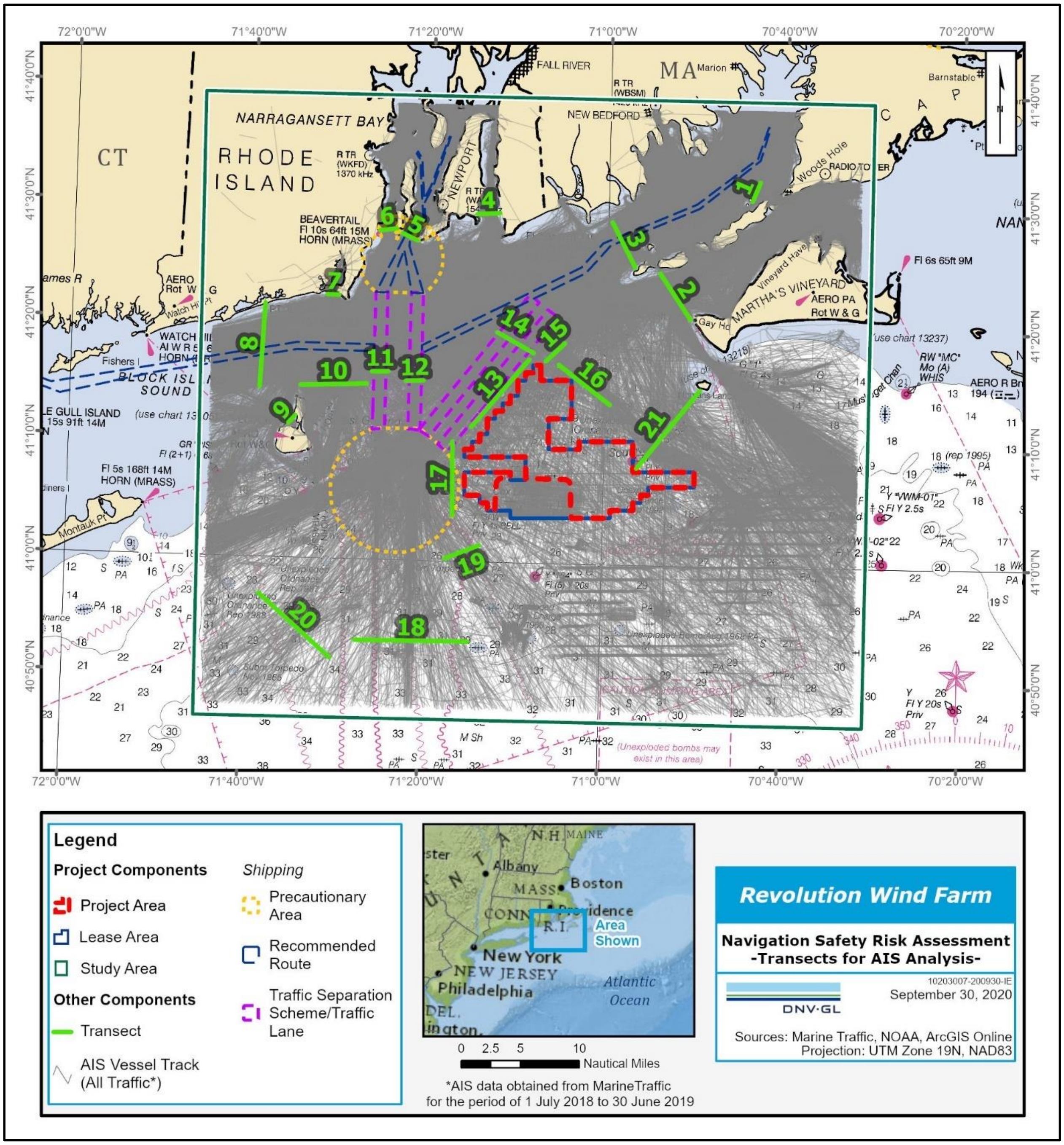

Figure 5.1. AIS Vessel Traffic Tracks for July 2018 to June 2019 and Analysis Transects Used for Traffic Pattern Analysis (DNV GL Energy USA, Inc. 2020).

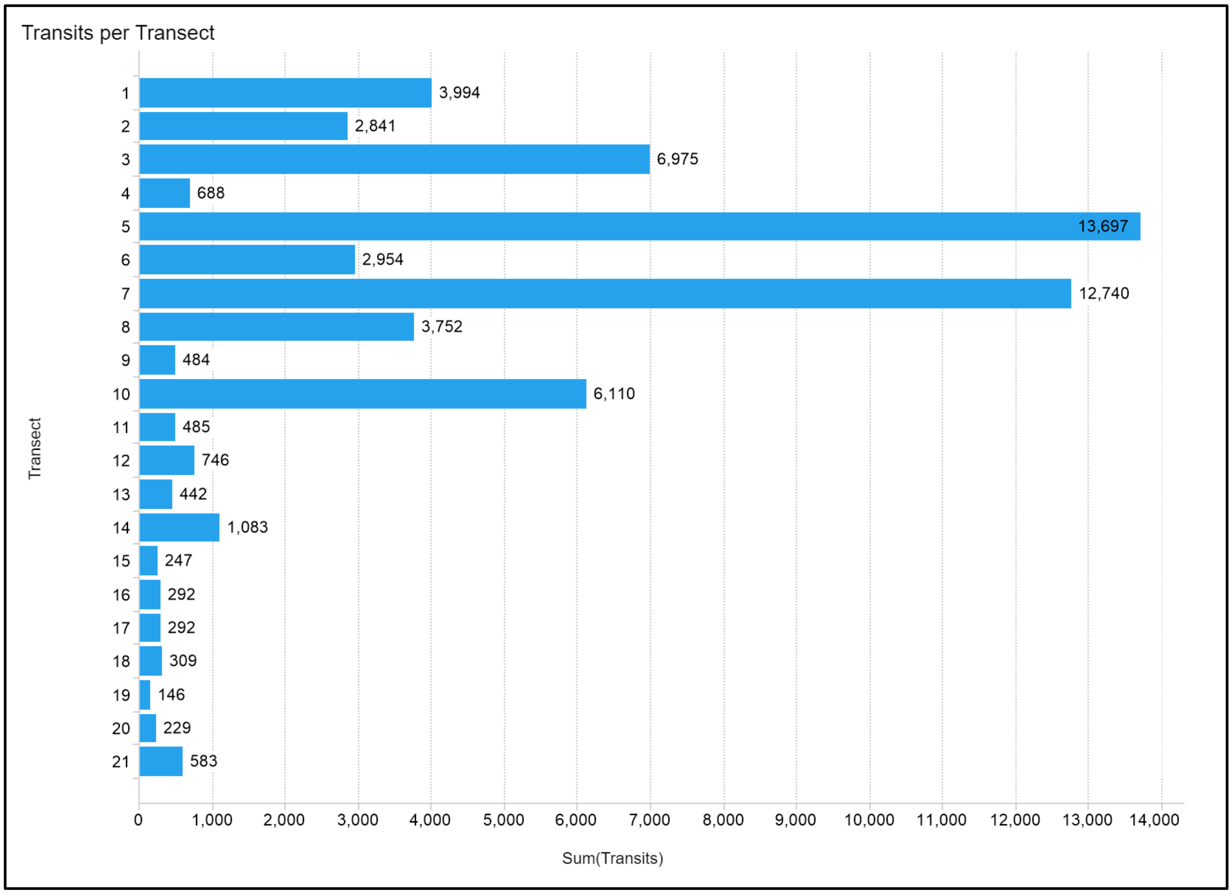

Figure 5.2. Vessel Transits of DNV GL Energy USA, Inc. (2020) Analysis Transects Used for Traffic Pattern Analysis from 2018 to June 2019.

As stated, the applicant has committed to a range of EPMs to avoid vessel collisions with marine mammals (see Table 3.18 – EPMs MM-3/ST-3 and MM-10). BOEM would also require additional mitigation measures to avoid and minimize impacts to ESA-listed species (see Table 3.19 – Measures 13, 22 and 26). These include strict adherence to NOAA guidance for collision avoidance and a combination of additional measures, speed restrictions to 10 knots or less for all vessels at all times between November 1 and April 30 and in all Dynamic Management Areas (DMAs), and use of a PAM system to alert vessels to potential marine mammal presence in real time. All vessel crews would receive training to ensure that these EPMs are fully implemented for vessels in transit. Once on station, the construction and installation vessels either remain stationary when installing the monopiles and WTG/OSS equipment or move slowly (i.e., at less than 10 knots) when traveling between foundation locations. Cable laying and HRG survey vessels also move slowly, with typical operational speeds of less than 1 knot and approximately 4 knots, respectively, and present minimal risk of collision-related injury.

The densities of most common species of marine mammals likely to occur in the RWF Lease Area and export cable route are low based on monthly mean density estimates developed by Roberts et al. (2016; 2017; 2018; 2020; 2021a). Project construction and installation would require an estimated maximum of 1,936 round trips for all vessel classes combined over the 2-year construction and installation period., Due to the low relative densities of those species vulnerable to collisions compared to where the majority of the population is, there is a low risk of a marine mammal vessel encounter. Although this would likely be an increase in vessel traffic in and around the MWA of approximately 2 percent a year, the operational conditions combined with planned EPMs and additional mitigation measures agreed upon through agency consultation would minimize collision risk. Because vessel strikes are not an anticipated outcome given the relatively low number of vessel trips relative to the environmental baseline, and EPMs and mitigation measures implemented to avoid encountering marine mammals, BOEM concludes vessel strikes are unlikely to occur and would be considered discountable.

The presence of construction and installation vessels and associated noise and disturbance could cause short-term displacement of marine mammals from preferred habitats. Temporary marine mammal displacement from offshore wind energy construction sites have been observed, apparently due to vessel-related disturbance, Long (2017). Habitat use within the affected areas returned to normal after construction and installation was completed, indicating that construction-related displacement effects would be short term in duration. On this basis, BOEM concludes vessel displacement effects on marine mammals could occur, but the biological significance of that displacement is uncertain.

Sea Turtles

Changes in vessel traffic resulting from the proposed action are a potential source of adverse effects on sea turtles. Propeller and collision injuries from boats and ships are common in sea turtles and an identified source of mortality (Hazel et al. 2007; Shimada et al. 2017). Hazel et al. (2007) also reported that individuals may become habituated to repeated exposures over time, when not accompanied by an overt threat. Project construction and installation vessels could collide with sea turtles, posing an increased risk of injury or death to individual sea turtles.

Based on information provided by Revolution Wind (Tech Environmental 2021), BOEM estimates that Project construction and installation would require up to 1,335 one-way trips by various classes of vessels between the RWF and regional ports in Rhode Island, Massachusetts, Connecticut, and New York, over the 2-year construction and installation period. This equates to approximately 55 trips per month or 668 trips per year. A small number of vessel trips may originate from distant ports in the Gulf of Mexico, Europe, or elsewhere around the globe (see Appendix B). In addition, approximately 10,755 miles of preconstruction HRG surveys are anticipated to support micrositing of the WTG foundations and cable routes. HRG surveys could occur during any month of the year and would require a maximum of 248 total vessel days. The construction and installation vessels used for Project construction and installation are described in Table 3.3.10-3 in the COP and include jack-up WTG installation vessels, foundation installation vessels, supply vessels and feeder barges, bunkering vessels, cable laying vessels, and various support craft. Typical large construction vessels used in this type of project range from 325 to 350 feet in length, from 60 to 100 feet in beam, and draft from 16 to 20 feet (Denes et al. 2021).

Large construction vessels and barges would account for an estimated 44 percent of these one-way trips, with the remainder comprising CTVs and other small support vessels. BOEM developed a representative analysis of construction vessel effects on regional traffic volume by evaluating the potential increase in transits across a set of analysis cross sections relative to baseline levels of vessel traffic. These cross sections were developed by DNV GL Energy USA, Inc. (2020) to support the COP and are shown in Figure 5.1, above.

Using the port of origin information provided by Revolution Wind (Tech Environmental 2021; Revolution Wind 2022a), the estimated 668 construction and installation vessel trips per year would cross transects 13-17 when leaving the RWF and could cross several different transects depending on the destination port. This would equate to a 28 percent increase in vessel transits across these transects. However, the Automatic Identification System (AIS) data used in transect analysis do not include many recreational vessels and virtually all commercial fishing vessels when actively fishing. These vessel types account for the vast majority of vessel activity. For example, DNV GL Energy USA, Inc. (2020) estimated over 19,000 one-way trips per year by commercial fishing vessels between the RWF and area ports. When these vessel trips are included, Project construction and installation would result in a 3.1 percent increase in vessel transits per year across transects 13-17. In summary, this assessment indicates that construction and installation vessels would likely increase vessel traffic to some degree, and large vessel traffic would measurably increase during the 2-year construction and installation period. This indicates the potential for increased risk of sea turtle collisions in the absence of planned EPMs and other requirements.

A small number of construction vessel trips may also originate from ports in the Gulf of Mexico, Europe, or other areas of the globe. The need for vessel trips from distant ports is not currently known, but the number of vessel trips is likely to be small (i.e., ten or less) and most likely to originate from the Gulf of Mexico. Revolution Wind (2022a) has estimated the number of vessel trips that could potentially originate from the Gulf of Mexico. An analysis of associated vessel strike risk from Gulf of Mexico ports is provided in Appendix B.

Implementation of a range of EPMs and Mitigation, Monitoring and Reporting Measures to avoid vessel collisions (see Table 3.18 – EPMs MM-3/ST-3 and MM-10 as well as Table 3.19 – Measures 13, 22 and 26) are expected to minimize the risk of collisions with sea turtles. These include strict adherence to NOAA guidance for collision avoidance and a combination of additional measures, including speed restrictions to 10 knots or less for all vessels at all times between November 1 and April 30 and speed restrictions to 10 knots or less in DMAs. All vessel crews would receive training to ensure these EPMs are fully implemented for vessels in transit. Once on station, the construction and installation vessels either remain stationary when installing the monopiles and WTG/OSS equipment or move slowly (i.e., at less than 10 knots) when traveling between foundation locations. Cable laying and HRG survey vessels also move slowly, with typical operational speeds of less than 1 and approximately 4 knots, respectively.

Sea turtles are likely to be most susceptible to vessel collision in coastal foraging areas crossed by construction and installation vessels traveling between the RWF and offshore RWEC and area ports. Hazel et al. (2007) indicated that sea turtles may not be able to avoid being struck by vessels at speeds exceeding 2 knots, and collision risk increases with increasing vessel speed. Habituation to noise may also increase the risk of vessel collision. However, avoidance behaviors observed suggest that a turtle's ability to detect an approaching vessel is more dependent on vision than sound, although both may play a role in eliciting behavioral responses. Construction and installation vessel speeds could periodically exceed 10 knots during transits to and from area ports, posing an incremental increase in collision risk relative to baseline levels of vessel traffic. During construction and installation, vessels generally either remain stationary when installing the monopiles and WTG/OSS equipment or move slowly (i.e., at less than 10 knots) when traveling between foundation locations. Cable-laying vessels move slowly, on the order of 3 to 30 miles per day, with a maximum speed of approximately 1.2 miles per hour.

Project EPMs and mitigation measures include the implementation of NOAA vessel guidelines for marine mammal and sea turtle strike avoidance measures, including vessel speed restrictions (see measures referenced above in Table 3.18 and 3.19). These measures are intended to minimize the risk of vessel strikes, however the likelihood of sea turtle injury or mortality resulting from project-related vessel strikes over the 2-year construction and installation period may be potentially significant, except green sea turtle which based on the relative rarity of green sea turtles in the marine component of the action area the potential impact from vessel strikes is considered insignificant for this species.

Marine Fish

Sturgeon and manta ray are also vulnerable to vessel collisions, but the risk is less clear. In the case of sturgeon, vessel strikes are an identified source of mortality in riverine habitats (Balazik et al. 2012), but the translation of this risk to open ocean environments is speculative at best.

CSA Ocean Sciences (2022) indicate that in general, the potential for Atlantic sturgeon to be struck by a vessel is high and vessel strikes are a relatively common occurrence. Between 2005 and 2008, surveys in the Delaware estuary reported a total of 28 Atlantic sturgeon mortalities, of which 50 percent were the result of an apparent vessel strike (Brown and Murphy 2010). Similarly, five Atlantic sturgeon were reported to have been struck by commercial vessels within the James River, Virginia, in 2005, and one strike per 5 years is reported for the Cape Fear River, North Carolina. Most strikes occurred near busy ports where entrance channels narrow, or a significant portion of estuary and river habitat is transited by commercial vessels entering a port (Brown and Murphy 2010).

Vessel traffic during construction and installation of the RWF would result in a temporary increase vessel traffic, representing a very small contribution in overall vessel traffic in the already heavily trafficked region. Larger construction and installation vessels will generally transit to the work location and remain in the area until installation is complete. These large vessels will move slowly and over short distances between work locations (CSA Ocean Sciences 2022).

Transport vessels will travel between several ports and the RWF over the course of Project construction and installation. These vessels will range in size from smaller crew transport boats to tug and barge vessels. Smaller vessels will also be used for routine maintenance related trips during the O&M phase (CSA Ocean Sciences 2022).

The Project-related increase in vessel traffic during construction and installation is not expected to be significant when compared to all other vessel traffic within the region, and most construction and installation vessels will be slow moving. Additionally, the implementation of vessel strike avoidance measures such as speed restrictions (see measures referenced above in Table 3.18 and 3.19) will further reduce the risk of collisions with Atlantic sturgeon. In the unlikely event that an Atlantic sturgeon is struck, and injury or mortality occurs, the risk of population-level impacts would be greater given the Endangered status of this population. Impacts from vessel strikes are considered direct and short-term for Atlantic sturgeon during the construction and installation and decommissioning phases, given the relatively short, 18-month duration anticipated for each. Vessels used during the O&M phase will be generally smaller but will require more trips between port and the RWF throughout the 20- to 35-year operational life of the project, so impacts during O&M would be direct and long-term (CSA Ocean Sciences 2022). While EPMs and Mitigation, Monitoring and Reporting Measures will be implemented to avoid and minimize the risk of vessel strikes on Atlantic sturgeon, the risk cannot be discounted and may be potentially significant over the life of the project.

Manta rays are also vulnerable to boat strikes (CITES 2013; Deakos et al. 2011), particularly reef manta rays due to their typical distribution in nearshore areas with more vessel traffic. Risks to pelagic giant manta rays are less clear but vessel collisions are identified as one of several global species management concerns (CITES 2013). Given that manta rays are more surface oriented and therefore vulnerable to vessel strikes, the low frequency of occurrence in the marine component of the action area would suggest that the likelihood of vessel strikes is insignificant.

5.3.2 Vessel Discharges and Air Emissions

Project vessels also pose a potential risk of accidental spills during routine fuel transfers, and the possibility of environmentally damaging spills resulting from accidental collisions with other vessels or structures. As stated in Section 4.0, chronic low-level oil pollution associated with marine vessel traffic is likely to be present throughout the marine component of the action area and vicinity based on proximity to major shipping lanes and regular vessel traffic. Revolution Wind would prepare and adhere to strict spill prevention, control, and countermeasures (SPCC) procedures during all project phases consistent with BOEM and USCG regulations, effectively minimizing the risk of substantial amounts of hydrocarbons entering the marine environment. Marine debris are a known source of adverse effects on marine mammals and sea turtles (Laist 1997; NOAA-MDP 2014). BOEM prohibits the discharge or disposal of solid debris into offshore waters during any activity associated with the construction and installation and operation of offshore energy facilities (30 CFR 250.300). The USCG similarly prohibits the dumping of trash or debris capable of posing entanglement or ingestion risk (MARPOL, Annex V, Pub. L.100–220 (101 Stat. 1458)).

Given the low potential for spills and minimal likelihood of measurable effects relative to baseline levels of oil pollution from existing vessel traffic in the marine component of the action area and vicinity, the risk to marine mammals from project-related petroleum spills is considered discountable. Marine debris are a known source of adverse effects on marine mammals and sea turtles (Laist 1997; NOAA-MDP 2014). BOEM prohibits the discharge or disposal of solid debris into offshore waters during any activity associated with the construction and installation and operation of offshore energy facilities (30 CFR 250.300). The USCG similarly prohibits the dumping of trash or debris capable of posing entanglement or ingestion risk (MARPOL, Annex V, Pub. L.100–220 (101 Stat. 1458)). Given these restrictions, the proposed action poses no measurable risk to marine mammals, sea turtles or fish from trash and debris.

As stated above for construction and installation, it is similarly acknowledged that air emissions from operational vessels and equipment could result in impacts to federally protected marine mammals and sea turtles, but the magnitude (i.e., frequency, timing, duration and extent) of the impact cannot be quantified. However, BOEM has determined that impacts to protected species from air emissions are likely to be unmeasurable and therefore insignificant.

5.4 Habitat Survey Impacts

5.4.1 Geotechnical and Geophysical Surveys

HRG surveys would be conducted concurrent with monopile installation in both the RWF and the RWEC. Revolution Wind estimates that up to 9,509 linear miles of pre-construction HRG surveys would occur over 218 days, averaging approximately 48 miles of exposure each day at a typical vessel speed of 2.2 knots (LGL 2022a). Up to 2,365 linear miles of post-construction HRG surveys could be conducted each year for the first 4 years of project operations to ensure transmission cables are maintaining desired burial depths. This equates to approximately 54 days of HRG survey activity per year. Underwater noise impacts and disturbance and collision risk associated with vessel traffic are the only biologically significant impacts potentially resulting from HRG survey activity. Related effects on ESA-listed species associated are discussed in Sections 5.1.3 and 5.3, respectively.

5.4.2 Fisheries and Habitat Surveys and Monitoring

Revolution Wind is proposing to implement the FRMP included in Appendix A as part of the proposed action. The proposed survey methods, frequency, intensity, and equipment types are summarized in Section 3.3.4. The FRMP will adhere to NOAA guidance on float and anchor design to avoid marine mammal entanglement risk. Gear types will be the same as regularly used in commercial fisheries designed to minimize bycatch, particularly Atlantic sturgeon.

No gillnets are proposed as part of this FBMP. Details on the number of traps, anticipated soak time, and trawling parameters are provided in Appendix A. These surveys involve similar methods to and would complement other survey efforts conducted by various state, federal, and university entities supporting regional fisheries research and management.

Should any interactions with protected species occur, the contracted scientists will follow the sampling protocols described for the Northeast Fisheries Observer Program (NEFOP) in the Observer On-Deck Reference Guide (Northeast Fisheries Science Center 2016). If any protected species are captured alive during the ventless trap survey, documentation and live release of those animals will take priority over sampling the rest of the catch. Reporting of interactions with marine mammals, such as small cetaceans and pinnipeds, will be dependent on the type of permit or approval (i.e., EFP or MSA LOA) issued to the applicant; once the permit/approval type has been specified, Revolution Wind will contact NMFS-PRD for guidance on reporting procedures. Protocols for handling live or deceased protected species of sea turtles, sturgeon, or marine mammals will be dependent on the type of permit or approval (i.e., EFP or MSA LOA) issued to the applicant, and in accordance with health and safety procedures.

Once the permit type has been specified, Revolution Wind will contact NMFS-PRD for guidance on handling protocols. Table 3.19 (measures 16, 18 and 19) provides the proposed protocols for the safe handling and reporting of protected species to avoid and minimize adverse effects. Entangled large whales or interactions with sea turtle species will be reported immediately to NOAA's stranding hotline via telephone (866-755-NOAA) and interactions with sturgeon species will be reported immediately to NOAA via the incidental take reporting email (incidental.take@noaa.gov); a follow up detailed written report of the interaction (i.e., date, time, area, gear, species, and animal condition and activity) will be provided to the NMFS Greater Atlantic Regional Fisheries Office (nmfs.gar.incidental-take@noaa.gov) within 24 hours. Any biological data collected during sampling of protected species will be shared as part of the written report that is submitted to the NMFS Greater Atlantic Regional Fisheries Office. Any genetic samples obtained from sturgeon will be provided to the NMFS-PRD.

Marine Mammals

The trawl and ventless trap surveys would target specific invertebrate and finfish species, using methods and equipment commonly employed in regional commercial fisheries. Survey methods, equipment types, and proposed sampling frequency and intensity are described in Section 3.3.4.

As discussed, the FRMP would adhere to the gear requirements described in the Atlantic Large Whale Take Reduction Plan (NOAA 2021a). These requirements would avoid and minimize the risk of marine mammal entanglement in ventless trap buoy lines. As such, the likelihood of injury or mortality of ESA-listed marine mammals is not anticipated. As stated previously, the survey effort would be conducted by contract fishing vessels that would otherwise likely be engaged in commercial fishing activities. As such, the survey effort is unlikely to result in a measurable change in the amount of fishing gear present in the marine component of the action area at any given time (see Section 5.7). Therefore, the potential risk posed by survey activities is likely insignificant relative to the existing baseline.

The risk of whale entanglement in trawl survey gear is negligible. The slow trawl speeds and relatively short (20 minute, not including set and retrieval time) tow durations limit the likelihood of gear interactions and entanglement. Observations during mobile gear use have shown that entanglement or capture of large whale species by trawl gear is extremely rare (NMFS 2016). Therefore, risks to marine mammals from this survey component are considered insignificant.

Sea Turtles

The weak rope and link requirements described above ventless traps are unlikely to reduce entanglement risk to sea turtles (NOAA 2021a). Therefore, turtles could become entangled in sampling gear. Turtles could also be inadvertently captured as bycatch in trawl survey equipment. If alive when encountered, entangled or incidentally captured turtles would be freed and returned to the environment where practicable but the potential for sea turtle mortality cannot be discounted. Specific protocols related to the safe and limited handling of protected species captured during surveys are described in Table 3.19 (measures 16, 18 and 19). Incorporation of these protocols will avoid and minimize potential impacts to sea turtles inadvertently captured in survey gear. With incorporation of handling protocols for protected species and risk posed be survey vessels, the risk posed by survey activities is likely insignificant.

Marine Fish

Sturgeon and giant manta ray are unlikely to become incidentally captured or entangled in the ventless traps and associated float lines. These species could be incidentally captured in trawl gear, with the likelihood of encounters commensurate with species distribution and frequency of occurrence. Given their general rarity and infrequent occurrence in the marine component of the action area, and the slow trawl speeds and relatively short tow durations (approximately 20 minutes) the likelihood of giant manta ray encounters with FRMP trawl surveys is considered insignificant.

In contrast, individual Atlantic sturgeon have been incidentally captured and injured in trawl-based monitoring surveys conducted for the adjacent South Fork Wind project. BOEM (pers. comm. 2022) reported that three individual Atlantic sturgeon were incidentally captured in six trawl surveys from May 16 to July 16, 2022, and were released with minor injuries. Given the similarity in monitoring methods and locations between these adjacent projects, these findings indicate that the trawl surveys are likely to result in some incidental take of this species. It is not possible to precisely estimate the number of Atlantic sturgeon likely to be injured or killed over the duration of the FRMP. However, simple extrapolation from the reported findings for the South Fork Windfarm project suggests that 12 or more individuals could be incidentally captured each year. The effects of those captures could range from temporary stress and minor injury to mortality and would therefore be a significant impact on Atlantic sturgeon.

Effects to Prey and/or Habitat

Organisms captured during surveys would be removed from the environment for scientific sampling and, where practicable, commercial use. Other species of finfish may also be impacted by sampling activities. For example, benthic fish may be injured or killed when survey equipment contacts the sea floor or inadvertently captured as bycatch. Non-target fish would be returned to the environment where practicable, but some of these organisms would not survive. While the FBMP would result in unavoidable impacts to individual fish, the extent of habitat disturbance and number of organisms affected would be small in comparison to the baseline level of impacts from commercial fisheries and would not measurably impact the viability of any species at the population level. As stated, the commercial fishers contracted to participate in the survey effort would likely otherwise be engaged in commercial fishing that would actively remove target finfish and shellfish from the environment. As such, the FRMP is unlikely to result in a measurable change in the availability of prey and forage resources for ESA-listed species in the marine component of the action area. Therefore, effects to prey resources would be insignificant.

Project-related surveys and monitoring could also affect fish and fish habitat managed under the Magnuson-Stevens Fisheries Conservation and Management Act. The potential effects of the project on EFH are addressed in the EFH Assessment prepared for the RWF.

5.5 Habitat Disturbance/Modifications

The discussion below relates to habitat disturbance and modification related to project construction and installation, O&M, and decommissioning.

5.5.1 Habitat Conversion and Loss

The Proposed Action would result in the long-term to permanent disturbance and modification of sea floor habitats resulting from the presence of monopile foundations, boulder scour protection, and cable protection installed on exposed segments of the IAC, OSS-link, and RWEC. In addition, sea floor preparation activities that relocate boulders would redistribute complex benthic habitat and cause long-term impacts to benthic habitat structure by damaging habitat-forming organisms that associate with these habitat types. These habitat modifications would permanently alter habitats used by ESA-listed species. In addition, the presence of the monopile foundations in the water column would permanently modify pelagic habitats used by ESA-listed marine mammals and sea turtles. Vessel anchoring may also result in long-term to permanent habitat modification impacts where anchoring disturbs and relocates boulders. A summary of the extent and estimated distribution by benthic habitat type of short- to long-term habitat disturbance impacts from project construction and installation is provided in Table 5.9. A summary of long-term to permanent habitat modification impacts by benthic habitat type resulting from the installation of WTG and OSS foundations and associated scour and cable protection is provided in Table 5.10.

Table 5.9. Acres of Benthic Habitat Disturbance from Revolution Wind Export Cable, Offshore Substation-Link Cable, and Inter-Array Cable Installation and Vessel Anchoring and Proportional Distribution of Impacts by Habitat Type

Alternative	Maximum Construction Disturbance Footprint (acres)*	Large-Grained Complex (%)	Complex (%)	Soft Bottom (%)
Proposed Action with 79 WTG positions	4,291	6.7%	25.9%	67.4%
Total for 100 WTG positions	6,656	14.9%	27.3%	57.8%

* Estimated maximum extent of seafloor disturbance, including overlapping impacts occurring at different points in time.

Table 5.10. Acres of Benthic Habitat Disturbance from Wind Turbine Generator and Offshore Substation Foundation Installation and Proportional Distribution of Impacts by Benthic Habitat Type.

Alternative	Seafloor Preparation Footprint (acres)*	Monopile Foundations and Scour Protection (acres)†	Large-Grained Complex	Complex	Soft Bottom
Proposed Action with 79 WTG positions	583	64.7	5.4%	30.5%	64.1%
Total for 100 WTG positions	734	81.4	19.0%	29.7%	51.3%

* Revolution Wind estimates that seafloor preparation could be required within approximately 23% of a 656-foot radius around each WTG and OSS foundation, totaling 7.2 acres. The habitat composition shown is based on the mapped habitat composition within a circular seafloor preparation radius of 7.2 acres around each foundation location, and monopile footprints of 0.03 and 0.04 acre for the WTG and OSS foundations, respectively.

† Monopile footprints of 0.03 and 0.04 acre for the WTG and OSS foundations, respectively. An estimated 0.7 acre of rock scour protection would be placed in a circular area around each monopile. All monopile and scour protection impacts occur within the seafloor preparation footprint and are overlapping impacts. This total includes additional impacts from cable protection systems at WTG and OSS foundations that extend beyond the scour protection footprint (approximately 0.07 additional acre per foundation). These impacts will occur within the broader seafloor preparation footprint.

Marine Mammals

The WTG and RWEC OSS foundations would introduce complex three-dimensional structures to the water column that could potentially alter the normal behavior of aquatic organisms in the RWF. However, insufficient information is available to characterize how the presence of WTG foundations in the water column would affect the behavior of whales, fish, and other organisms

(Long 2017; Thompson et al. 2015). Long (2017) compiled several years of observer data for marine mammal and bird interactions with tidal and wave energy testing facilities in Scotland. Long (2017) was unable to identify any changes in marine mammal behavior or distribution associated with the presence of ocean energy structures once construction and installation was complete, concluding that the available data were insufficient to determine the presence or absence of measurable effects.

Sperm whales are known to prey on bottom-oriented organisms including octopus, fish, shrimp, crab, and sharks, suggesting that short-term construction and installation disturbance could affect the prey base for this species. The baleen whale species addressed in this consultation are pelagic filter feeders that do not forage in or rely on benthic habitats, although it is recognized that species such as fin whales periodically prey on forage fish such as herring that rely on benthic/complex habitats. As such, the disturbance and modification of complex habitats could lead to subsequent effects on foraging opportunities for marine mammals that rely on these resources. However, observations of fish community response to the development of other offshore wind facilities suggest there is little basis to conclude that habitat disturbance and modification would lead to a measurable long-term adverse effect on the availability of fish and invertebrate prey organisms. For example, monitoring studies of the Block Island Wind Farm and other European wind energy (Hutchison et al. 2020a; Methratta and Dardick 2019; Guarinello and Carey 2021) have documented increased abundance of demersal fish species that also prey on forage fish, likely attracted by increased biological productivity created by the reef effect these structures generate. While sea floor disturbance and habitat modification may result in changes in prey availability for some marine mammal species, these effects would be in short-term and localized and unlikely to have a measurable effect on the ability of marine mammals to find suitable prey elsewhere within their seasonal range. Therefore, the effects of the action on ESA-listed whales resulting from benthic habitat alteration are likely to be insignificant.

Sea Turtles

The disturbance and alteration of the sea floor is unlikely to measurably affect ESA-listed sea turtles. Leatherback sea turtles are dietary specialists, feeding almost exclusively on pelagic jellyfish, salps, and siphonophores, meaning they would not be measurably affected by benthic habitat alteration. While green, Kemp's ridley, and loggerhead sea turtles all feed on benthic organisms, short-term benthic habitat disturbances are unlikely to have measurable adverse effects on prey resources for these species. The project would avoid impacting submerged aquatic vegetation and would therefore avoid adversely affecting forage resources for green and Kemp's ridley turtles. While the project would have a short-term impact on benthic prey resources, those effects would be short-term and limited to a fraction of the overall marine component of the action area and an even smaller fraction of suitable foraging habitat in nearshore and offshore areas of the Atlantic OCS. Given that the affected area is naturally dynamic and exposed to anthropogenic disturbance, the species that occur in this region already adjust foraging behavior based on prey availability. Kemp's ridley and green sea turtles are omnivorous species with flexible diets, and loggerhead sea turtles readily target new prey species to adapt to changing conditions. Given the limited amount of foraging habitat exposed to construction and installation disturbance, the short-term nature of these effects, and the ability of these species to adjust their diet in response to resource availability, the resulting adverse effects of benthic disturbance on these species would be discountable.

Marine Fish

Sea floor preparation and cable installation activities in soft-bottomed habitats would flatten depressions and ripples and mega-ripples, and damage structure provided by habitat forming organisms (e.g., amphipod tubes) in soft-bottomed benthic habitat. Manta rays are pelagically oriented and planktivorous; therefore, sea floor disturbance and modification are unlikely to have a measurable effect on this species and would be insignificant.

In contrast, sea floor disturbance and habitat modification would kill or displace sturgeon prey organisms such as worms, clams, amphipods, and other benthic infauna. These prey resources and supporting habitat features are expected to recover rapidly from sea floor preparation impacts, within 18 to 24 months following initial disturbance through natural sediment transport processes and recolonization from adjacent habitats. This conclusion is supported by knowledge of regional sediment transport patterns (Butman and Moody 1983; Daylander et al. 2012), observed recovery rates from sea floor disturbance at the nearby BIWF (HDR 2020), and recovery rates from similar bed disturbance impacts observed in other regions (de Marignac et al. 2009; Dernie et al. 2003; Desprez 2000). These short-term effects would be limited in extent relative to the amount of foraging habitat available within the migratory and foraging range of individual Atlantic sturgeon. Given the limited extent of effects and the likelihood of rapid recovery to baseline benthic community conditions, the effects of project construction and installation on sea floor and water column habitat conditions are likely to be discountable.

In contrast, OSS and WTG foundations, foundation scour protection, and cable protection placed in soft-bottomed habitat would permanently modify those habitats, making them less suitable for sturgeon prey. In total, approximately 130 acres of soft-bottomed habitat would be permanently modified by new novel structures. However, some portion of that impact may be offset by approximately 1,700 acres of boulder relocation within cable installation corridors. Boulder displacement may convert some portion of that area may into accessible soft-bottomed habitat available to sturgeon and their prey. Given the limited extent of these short- and long-term impacts relative to the amount of suitable foraging habitat available in the marine component of the action area and over the broad range of this highly migratory species in general, the impacts of habitat disturbance and modification on Atlantic sturgeon are likely to be insignificant.

5.5.2 Dredging

Dredging would be required as part of the Proposed Action for the construction and installation of the RWEC at the sea-to-shore transition site.

The affected portions of the cable installation corridor would be dredged to allow for RWEC installation to a target depth of 4 to 6 feet beneath the natural surface scour depth at each location. Once sea floor preparation is complete the jet plow would then be used to install the RWEC to the target burial depth.

Marine Mammals

Marine mammals are not expected to be directly affected by Project-related dredging activities (i.e., impinged, entrained or captured), but could be affected indirectly in other ways, including an increase in turbidity (Section 5.5.3) or vessel strikes (Section 5.3.1). The overall effect of dredging on marine mammals would be insignificant.

Sea Turtles

Sea floor preparation during construction and installation will involve boulder clearance. Dredging may be required in the HDD pits at landfall areas of Narragansett Bay to allow vessel access for export cable installation. These activities could affect ESA-listed sea turtles through impingement, entrainment, and capture associated with dredging and boulder clearance techniques. As mentioned in Section 3.3.3, cable installation will require hydraulic plow (i.e., jet-plow), mechanical plow, or similar technology for displacing sediments to allow for cable burial. Boulder clearance may occur both inshore and offshore within the RWF and RWEC for cable installation.

Direct impacts to sea turtles from dredging, especially for entrainment, typically result in severe injury or mortality (Dickerson et al. 2004; USACE 2020). Sea turtles may be crushed during placement of the draghead on the seafloor, impinged if unable to escape the draghead suction and become stuck, or entrained if sucked through the draghead. Of the three direct impacts, entrainment most often results in mortality. Sea turtles are most often able to escape from the oncoming draghead of a hydraulic dredge due to the slow speed that the draghead advances (up to 3 miles per hour or 4.4 feet/second [1.4 m/s]; NMFS 2020). During swimming and surfacing, sea turtles are highly unlikely to interact with the draghead and are most vulnerable when foraging or resting on the seafloor. The potential capture of sea turtles in the dredging equipment could occur but unlikely given the limited amount of dredging proposed. There are no known large aggregation areas or areas where turtles would be expected to spend large amounts of time stationary on the bottom where they could be entrained in a suction dredge. Estimates of sea turtle take associated with dredging have been one sea turtle per 3.8 million cubic yards of dredged sand (Michel et al. 2013, in USACE 2022). As dredging is only proposed for the sea-to-shore transition, the total estimate of the volume of project-related dredge material is significantly lower than the amount estimated to result in the take of one sea turtle.

Furthermore, the Project would employ a trained lookout posted on all vessel transits between June 1 and November 30 (see Table 3.19, measure 13), including inshore where sea turtles are known to be more vulnerable to dredging, further decreasing the risk of impingement or entrainment of sea turtles during suction dredging activities. The risk of injury or mortality of individual sea turtles resulting from dredging necessary to support offshore wind Project construction and installation would be low and population-level effects are unlikely to occur. Since there is a low risk of interactions with dredges and the mitigation and monitoring measures that will be implemented, the likelihood of a sea turtle becoming entrained in a dredge associated with the Proposed Action is considered unlikely and discountable.

Marine Fish

Impacts from dredging during construction and installation could affect ESA-listed marine fish through impingement, entrainment, and capture associated with mechanical and hydraulic dredging techniques. Dredging may be required in the HDD pits at landfall areas of Narragansett Bay to allow vessel access for export cable installation.

Dredging during construction and installation could carry a variety of impacts on Atlantic sturgeon related to injury and mortality associated with dredging techniques as well as impacts to prey. The risk of interactions between sturgeon and mechanical dredges is thought to be highest in areas where large numbers of sturgeon are known to aggregate. There are no known areas of sturgeon aggregations within the proposed areas for dredging for the Project. The risk of capture may also be related to the behavior of the sturgeon in the area. Given the rarity of sturgeon in the area to be dredged, the co-occurrence of an Atlantic sturgeon and dredging activity is unlikely. As such, entrapment of sturgeon during the temporary performance of mechanical dredging operations is also unlikely. Due to their bottom foraging and swimming behavior adult Atlantic sturgeon have been known to become entrained in hydraulic-cutterhead dredges as they move across the sea floor (Novak et al. 2017; Balazik et al. 2020; NMFS 2022b). Given the need for a sturgeon to approach within 1 m of the dredge head to become entrained, the limited use of dredging proposed, and the lack of attraction or deterrence relationship observed between Atlantic sturgeon and dredges, the likelihood of effects to Atlantic sturgeon from Project dredging is considered low (Balazik et al. 2020; NMFS 2022b). Thus, the likelihood of an Atlantic sturgeon becoming entrained in a mechanical dredge associated with the Proposed Action is considered discountable.

Atlantic sturgeon prey upon small bottom-oriented fish such as the sand lance, mollusks, polychaete worms, amphipods, isopods, and shrimp, with polychaetes and isopods being the primary and important groups consumed in the Project area (Smith 1985; Johnson et al. 1997; Dadswell 2006). Sand lance could become entrained in a hydraulic dredge due to their bottom orientation and burrowing within sandy sediments that require clearing by the Project. Reine and Clarke (1998) found that not all fish entrained in a hydraulic dredge are expected to die. Studies summarized in Reine and Clarke (1998) indicate a mortality rate of 37.6 percent for entrained fish. Given the size of the area where dredging will occur and the short duration of dredging, benthic infauna and epifauna will likely experience 100 percent mortality. However, given the size of the area where dredging will occur; the short duration of dredging; the loss of benthic invertebrates and sand lance will be small, temporary, and localized; and the opportunistic feeding nature of Atlantic sturgeon, it is expected that any impact of the loss of Atlantic sturgeon prey items will be so small that it cannot be meaningfully measured, evaluated, or detected. Therefore, dredging impact on Atlantic sturgeon is expected to be insignificant**.**

5.5.3 Turbidity

In-water construction and installation of the RWF and RWEC is likely to result in effects such as elevated levels of suspended sediments in the immediate proximity of bed-disturbing activities like placement of scour protection, vessel anchoring, and burial of the RWEC, OSS-link, and IAC. Project O&M and decommissioning would also disturb the sea floor, producing suspended sediment effects similar in nature to those produced during project construction and installation. In the case of O&M, sea floor disturbance associated with anchoring and maintenance activities would be periodic and limited in extent. The extent of potential sea floor disturbance during decommissioning is unknown, but suspended sediment impacts would likely be similar to those produced during project construction and installation.

Cable installation during project construction and installation would produce the most extensive measurable suspended sediment impacts on the surrounding environment. Cable installation would generate localized plumes of suspended sediments with maximum TSS concentrations ranging from 50 to 100 mg/L extending from 1,296 feet (395 m) to 853 feet (260 m) from IAC installation activities and from 1,542 feet (470 m) to 1,476 feet (450 m) for the RWEC and OSS installation in federal waters (RPS 2021). TSS concentrations ranging from 50 to 100 mg/L for RWEC installation in Rhode Island state waters will extend from 4,528 feet (1,380 m) to 4,134 feet (1,260 m), respectively. Most listed species are unlikely to occur in Rhode Island state waters, where the TSS concentrations and most extensive sediment plumes would occur. Modeling results indicate that TSS concentrations greater than 100 mg/L do not persist in any given location outside of Narragansett Bay for longer than three hours (RPS 2021). RPS (2021) estimated that sediment plumes would resettle and TSS concentrations would return to background levels within approximately 5 hours of disturbance. Sediments at the sea-to-shore transition site have a greater concentration of silts that require longer to settle out of the water column. TSS concentrations above 100 mg/L would persist around the sea-to-shore transition site for over 24 hours. All sediment impacts would be localized around the source of disturbance and intermittent in association with the duration of bed-disturbing activities. For example, TSS effects would occur downcurrent of the jet plow, moving along each cable corridor at the speed of the cable laying vessel.

The model-based estimate of potential suspended sediment effects may be overestimated. Elliot et al. (2017) monitored TSS levels during construction and installation of the nearby Block Island Windfarm offshore energy facility. The observed TSS levels were far lower than model, dissipating to baseline levels within meters of disturbance. In contrast, the RWEC corridor is routed through areas with more extensive mud where higher TSS concentrations are likely to occur. However, given that both the modeled and observed TSS effects would be short-term in duration, the projected effects on ESA-listed marine mammal, reptile, and fish species in the marine component of the action area are likely to be relatively minor in magnitude and short-term. Supporting rationale for this conclusion is provided in the following sections.

Marine Mammals

The NMFS Atlantic Region has developed a white paper on turbidity and TSS effects on ESA-listed species for the purpose of compiling information in support of Section 7 consultations (Johnson 2018). They concluded that elevated TSS could result in adverse effects on listed whale species under specific circumstances (e.g., high TSS levels over long periods during dredging operations), but insufficient information is available to make ESA effect determinations. In general, marine mammals are not subject to impact mechanisms that injure fish (e.g., gill clogging, smothering of eggs and larvae) so injury-level effects are unlikely. Direct behavioral impacts, including avoidance or changes in behavior, increased stress, and short-term loss of foraging opportunity could potentially occur but only at excessive TSS levels (Johnson 2018). Todd et al. (2015) postulated that dredging and related turbidity impacts could affect the prey base for marine mammals, but the significance of those effects would be highly dependent on site-specific factors. Small-scale changes from one-time, localized activities are not likely to have measurable effects and would therefore be insignificant.

As stated, anticipated TSS levels are limited in magnitude, short-term in duration, and likely to be within the range of baseline variability in the marine component of the action area within those portions of the RWEC in federal waters and the OSS-link and IAC corridors, therefore the resulting effects on ESA-listed marine mammals would likely be unmeasurable. In RWEC-RI state waters, the extent of TSS concentrations will be greater, but it is unlikely that listed marine mammals will occur in these areas, therefore the resulting effects in state waters would be insignificant.

Sea Turtles

NMFS has concluded that, while scientific studies and literature are lacking, the effects of elevated TSS on ESA-listed sea turtles are likely to be similar to the expected effects on marine mammals (Johnson 2018). Direct physical or lethal effects are unlikely to occur because sea turtles are air-breathing and land-brooding, and therefore do not share the physiological sensitivities of susceptible organisms like fish and invertebrates. Turtles may alter their behavior in response to elevated TSS levels (e.g., moving away from an affected area). They may also experience behavioral stressors, like reduced ability to forage and avoid predators. However, turtles are migratory species that forage over wide areas and will likely be able to avoid short-term TSS impacts that are limited in severity and extent without consequence. Moreover, many sea-turtle species routinely forage in nearshore and estuarine environments with periodically high natural turbidity levels. Therefore, short-term exposure to elevated TSS levels is unlikely to measurably inhibit foraging (Michel et al. 2013). Given that anticipated TSS levels are expected to be within the range of variability in the marine component of the action area, the resulting effects on ESA-listed sea turtle species would likely be unmeasurable and therefore discountable.

Marine Fish

Studies of the effects of turbid water on fish suggest that concentrations of suspended solids can reach thousands of milligrams per liter before an acute reaction is expected (Wilber and Clarke 2001). Directed studies of sturgeon TSS tolerance are currently lacking, but sturgeons as a group, are adapted to living in naturally turbid environments like large rivers and estuaries (Johnson 2018). While it is difficult to generalize across species, many estuarine-oriented fish species can tolerate turbidity levels in excess of 1,000 mg/L for short periods (1 to 2 days) without injury or noticeable sublethal effects (Wilber and Clark 2001). TSS plumes >100 mg/L could persist up to 36 hours in the inshore portions of the RWEC corridor (RPS 2021). This suggests that sturgeon could tolerate TSS levels produced by the proposed action without injury. Given that Atlantic sturgeon are adapted to naturally turbid environments and the projected effects are within the range of baseline variability, the effects of elevated TSS levels on this species are likely to be unmeasurable and therefore insignificant.

No specific information about manta ray TSS tolerance was identified in the literature, but some inferences can be drawn from behavioral research. As obligate filter feeders that focus on zooplankton, manta rays are commonly found in areas with high natural turbidity associated with primary and secondary productivity (Rohner et al. 2013). Their strong association with naturally turbid conditions makes this species difficult to study using standard underwater video techniques (Fish et al. 2018). Giant manta rays are commonly observed in turbid estuaries on the Atlantic coast, including estuaries in Brazil with naturally high TSS levels (Medeiros et al. 2015). Additionally, while this information is indirect, the affinity for and prevalence in areas with naturally high turbidity indicates this species is relatively insensitive to TSS. This suggests that manta rays are unlikely to be affected by short-term TSS levels resulting from project construction and installation. Additionally, TSS modeling indicates that elevated TSS levels would be limited to within 2 m of the sea floor in areas disturbed by installation of the RWEC, OSS-Line and IAC. Manta rays are pelagic species, and thus are unlikely to be exposed to project-related elevated TSS concentrations and thus potential impacts associated with turbidity would be discountable.

5.5.4 Physical Presence of WTG and OSS Foundations on Listed Species

The effects of the physical presence of WTGs and OSSs on listed species are described below.

Marine Mammals

The presence of RWF monopile foundations (including WTGs and OSSs) over the life of the Project would modify pelagic habitats used by, and their presence could affect marine mammal behavior; however, the likelihood and significance of these effects are difficult to determine. Long (2017) compiled a statistical study of seal and cetacean (including porpoises and baleen whales) behavior in and around Scottish marine energy facilities. The study found evidence of displacement during construction and installation, but habitat use appeared to return to previous levels once construction and installation was complete and the projects were in operation. Long cautioned that observational evidence was limited for certain species and further research would be required to draw a definitive conclusion about operational effects. Delefosse et al. (2017) reviewed marine mammal sighting data around oil and gas structures in the North Sea and found no clear evidence of species attraction or displacement. Long (2017) found no observable long-term displacement effects on large whales, from a network of wave energy converters installed on the Scottish coast, but these findings may not be applicable to offshore wind structures.

The 102 RWF monopile foundations would be placed in a grid-like pattern with spacing of approximately 1.0 nm (ranging from 0.9 to 1.1 nm) between turbines. Based on documented lengths (Wynne and Schwartz 1999), the largest blue whale (110 feet [33 m]), NARW (59 feet [18 m]), fin whale (79 feet [24 m]), sei whale (59 feet [18 m]), and sperm whale (59 feet [18 m]) would fit end-to-end between two foundations spaced at 1 nm 100 times over. This simple assessment of spacing relative to animal size indicates that the physical presence of the monopile foundations is unlikely to create a potential barrier to the movement of large marine mammals.

As outlined above in Section 5.4.5, the enhanced biological productivity created by reef and hydrodynamic effects could indirectly affect marine mammals by changing the distribution and concentration of fish prey resources. Monopiles and scour protection would create an artificial reef effect (Degraer et al. 2020), likely leading to enhanced biological productivity and increased abundance and concentration of fish and invertebrate resources (Hutchison et al. 2020a). This could alter predator-prey interactions in and around the facility with uncertain and potentially beneficial or adverse effects on marine mammals.

Johnson et al. (2021) modeled potential hydrodynamic effects from windfarm development in the North Atlantic OCS suggests that full build-out of the RI/MA WEA could affect surface current patterns in ways that measurably affect how fish and invertebrate larvae are dispersed at local to regional scales. While the net impact of these interactions is difficult to predict, they are not likely to result in more than localized effects on the abundance and availability of zooplankton forage resources for marine mammals.

Collectively, the physical presence of structures would alter the character of the offshore environment in ways that could indirectly affect ESA-listed marine mammals. While it appears unlikely that offshore wind structures would create a barrier to marine mammal movement, they are likely to have localized effects on food web interactions in ways that could influence marine mammal behavior. When considered relative to the broader oceanographic factors that determine primary and secondary productivity in the region, localized changes in the abundance and distribution of prey and forage resources are not likely to measurably affect the availability of or access to these resources at regional scales. Changes in marine mammal behavior and distribution in response to localized effects could conceivably occur but are difficult to predict.

Therefore, on the basis of currently available information, the effects of structure presence on marine mammals are likely to be insignificant.

Sea Turtles

The WTG and OSS foundations and associated scour protection would result in a long-term conversion of existing complex and non-complex bottom habitat to new, stable, hard surfaces. Once construction and installation are complete, these surfaces would be available for colonization by sessile organisms and would draw species that are typically attracted to hard-bottom habitat (Causon and Gill 2018; Langhamer 2012). Given that sea turtles are highly mobile, and the structures are only 39 feet (12 m) in diameter and would be separated by approximately 1 nm, the structural alterations of the water column are unlikely to create a direct barrier to foraging, migration, or other behaviors of sea turtles. However, the presence of WTG structures could indirectly affect sea turtles by potentially altering prey distribution or promoting fish aggregations that attract or change the distribution of commercial and recreational fishing activity. This range of potential impacts is discussed in the following paragraphs.

The introduction of vertical structures like WTG and OSS foundations to the water column would create hydrodynamic and reef effects that could alter the distribution and abundance of prey and forage resources. Hydrodynamic effects detectable by turtles would be generally localized to within a relatively short distance from the structure (Miles et al. 2017); likely dissipating within 600 to 1,300 feet downcurrent of each monopile foundation. However, there is potential for regional impacts to wind wave energy, mixing regimes, and upwelling (van Berkel et al. 2020), and these changes in water flow caused by the presence of the WTG structures could influence sea turtle prey distribution at a broader spatial scale. The distribution of fish, invertebrates, and other marine organisms on the OCS is determined by the seasonal mixing of warm surface and cold bottom waters, which determines the primary productivity of the system (Chen et al. 2018; Lentz 2017; Matte and Waldhauer 1984). While the magnitude of these effects is uncertain, the presence of WTG structures could alter these dynamics in ways that could potentially increase primary productivity in the vicinity of the structures by disrupting vertical stratification and bringing nutrient-rich waters to the surface (Carpenter et al. 2016; Schultze et al. 2020; Johnson et al. 2021). However, changes in primary productivity may not translate to a beneficial increase in sea turtle prey abundance if the increased productivity is consumed by filter feeders (such as mussels) that colonize the surface of the structures (Slavik et al. 2019). Considering the largely localized nature of potential effects to primary production surrounding WTGs (van Berkel et al. 2020), the likelihood of broader benefits for sea turtles is minimal.

The ultimate effects of offshore structure development on ocean productivity, sea turtle prey species, and, therefore, sea turtles, are difficult to predict with certainty and are expected to vary by location, season, and year, depending on broader ecosystem dynamics. The addition of up to 102 new offshore foundations could increase sea turtle prey availability by creating new hard-bottom habitat, localized increases in the productivity of pelagic habitat, and/or by aggregating and increasing the abundance of certain fish and invertebrate prey and algal forage on and around foundations (Bailey et al. 2014 cited in English et al. 2017). Increased primary and secondary productivity in proximity to structures could also increase the abundance of jellyfish, a prey species for leatherback sea turtles (English et al. 2017; NMFS and USFWS 1992). The artificial reefs created by these structures form biological hotspots that could support species range shifts and expansions and changes in biological community structure (Degraer et al. 2020; Methratta and Dardick 2019; Raoux et al. 2017). In contrast, broadscale hydrodynamic impacts could lead to localized changes in zooplankton distribution and abundance (van Berkel et al. 2020). Hydrodynamic modeling conducted by Johnson et al. (2021) indicated project-related shifts in larval transport and settlement density, but these shifts are not expected to have broad scale impacts on invertebrate populations. There is considerable uncertainty as to how these localized ecological changes would affect sea turtles, and how those changes would interact with other human-caused impacts. The effect of these IPFs on sea turtles and their habitats could be positive or negative, varying by species, and their extent and magnitude is unknown. Recent studies have also found increased biomass for benthic fish and invertebrates, and possibly for pelagic fish, sea turtles, and birds, around offshore wind facilities (Pezy et al. 2018; Raoux et al. 2017; Wang et al. 2019), translating to potential increased foraging opportunities for sea turtle species. However, an increase in biomass could result in limited benefits to higher trophic levels, depending on species composition and prey preferences (Pezy et al. 2018).

Increased fish biomass around the structures could also attract commercial and recreational fishing activity, creating an elevated risk of injury or death from gear entanglement and ingestion of debris (Barreiros and Raykov 2014; Gregory 2009; Vegter et al. 2014; Nelms et al. 2016; Gall and Thompson 2015; Shigenaka et al. 2010). As noted above, lost/discarded fishing gear was associated with most sea turtle entanglements in a global review (Duncan et al. 2017). However, through implementation of EPMs and mitigation measures related to management of debris described in Section 3.5, Tables 3.18 and 3.19, the increase in entanglement risk is expected to be minimal. Further, the addition of structures could benefit sea turtles by locally increasing pelagic productivity and prey availability for sea turtles. The STSSN reported one offshore and 20 inshore green sea turtle strandings, 19 offshore and 77 inshore leatherback sea turtle strandings, six offshore and 58 inshore loggerhead sea turtle strandings, and six offshore and 69 inshore Kemp’s ridley sea turtle strandings between 2017 and 2019 (NMFS STSSN 2021). The overall impact to sea turtles is not expected to be measurable due to the patchy distribution of sea turtles within the RWF and RWEC and is therefore considered discountable. Potential long-term, intermittent impacts could persist until decommissioning is complete and structures are removed.

Marine Fish

The RWF is in the vicinity of, and overlaps Cox Ledge, an area of complex benthic habitat that supports several commercially and recreationally important species, as well as listed species including Atlantic sturgeon. The presence of monopiles, their foundations, and scour protection during Project O&M would create an artificial reef effect. The attractive effect of these artificial reefs on finfish is well documented (Degraer et al. 2020; Hutchison et al. 2020a; Kramer et al. 2015). In a meta-analysis of studies on wind farm reef effects, Methratta and Dardick (2019) observed an increase in the abundance of epibenthic and demersal fish species, while effects on pelagic species (i.e., manta ray) are less clear (Floeter et al. 2017; Methratta and Dardick 2019). While the RWF may reduce preferred soft-bottom foraging habitat for Atlantic sturgeon, the changes would be small in relation to the available habitat and could result in negative, beneficial, or neutral effects on foraging opportunities at the reef effect margin.

Johnson et al. (2021) determined that offshore wind development could affect larval dispersal patterns, leading to increases in larval settlement density in some areas and decreases in others. For Atlantic sturgeon these changes are not anticipated to translate to measurable effects. While these changes could result in planktonic prey distribution for manta ray, any change in prey distribution is not anticipated to be biologically measurable.

The RWF would be expected to produce measurable, localized hydrodynamic effects that would be expected to occur within 600 to 1,300 feet downcurrent of each monopile. Most research conducted to date has not been able to distinguish any hydrodynamic effects on fish populations from natural variability (van Berkel et al. 2020). While additional monitoring and research is needed, the likelihood of measurable regional effects on fish and fish populations from the RWF is minimal and therefore considered insignificant. This conclusion is based on the location of the Project in an area dominated by strong seasonal stratification (van Berkel et al. 2020), the relatively small number of monopile foundations, and the fact that modeled cumulative effects across the marine component of the action area are minor. In general, the potential effects to finfish resulting from the presence of structures are likely to vary by species. However, considerable uncertainty remains about the broader effects of this type of habitat alteration at population scales (Degraer et al. 2020). These effects could increase cumulatively when combined with those from other planned offshore energy developments in the future.

5.5.5 Electromagnetic Fields and Heat from Cables

Once the RWF is operational, the IAC, OSS-link cable, and RWEC would generate EMF effects whenever the project is generating sufficient electricity. Based on wind resource estimates provided by Revolution Wind the RWF would generate power almost continuously, with estimated operational times ranging from 85 to 94 percent varying by month. Power transmission through the cables would generate induced magnetic field and electrical field effects and substrate heating effects at and near the sea floor along their respective lengths. These effects would be most intense at locations where the cables cannot be buried and are laid on the bed surface covered by an armoring blanket. As mentioned previously, approximately 8.8 miles of the RWEC cable, 0.9-miles of the OSS-link and 15.5 miles of the IAC will not be buried and will be laid on the surface and will require cable protection.

Exponent Engineering, P.C. (Exponent 2021) modeled EMF effects on the marine environment from the following three cable configurations for the RWF and RWEC:

- IAC network (66 kV) connecting the WTGs to the two OSSs;
- OSS-link (275 kV) connecting the two OSSs, and;
- RWEC (275 kV) two parallel cable circuits connecting the OSSs to the landfall work area in North Kingston, Rhode Island.

For most of the route, the cables will be buried to a target depth of 4-6 feet (1.2 to 1.8 m) beneath the sea floor. Exponent (2021) modeled both the magnetic- and induced electric-field levels for each cable configuration, using conservative assumptions to ensure that the calculated levels represented the maximum potential magnitude of EMF effects that could occur under all operating conditions. In addition, Exponent (2021) conservatively assumed a burial depth of 3.3 feet (1 m) for buried cable segments, which is less than the proposed 4-to 6-foot target depth, meaning that the actual EMF effects at the sea floor surface above buried cable segments will likely be lower than the levels presented herein.

The two RWEC circuits will maintain a minimum separation distance of 140 to 166 feet (42 to 50 m) so were modeled in isolation from each other. In contrast, the IACs are likely to be closer together in some areas, and particularly on approach to the OSSs, so could account for potential additive effects for IACs near OSSs (Exponent 2021).

The results presented herein are representative of the EMF effects that could result from each IAC, the OSS-link and the RWECs. All cables would transmit electricity as HVAC at a frequency of 60 Hz, an important factor to consider when evaluating potential biological effects.

The following metrics are used to evaluate potential EMF effects:

- Magnetic field strength, measured in mG
- Electrical field strength, measured in milliVolts/meter (mV/m)
- Induced electrical field strength, receptor specific based on body size, measured in mV/m

The magnitude, extent, and duration of EMF effects from the RWF IAC and the RWEC are described below.

EMF effects must be considered in context with baseline EMF conditions within the Lease Area and vicinity. The earth's magnetic field strength in the vicinity of the RWF and RWEC at the sea floor is on the order of 512 to 514 mG (NOAA 2021). Following the methods described by Slater et al. (2010), a uniform current of 1 m/s flowing at right angles to the natural magnetic field in the marine component of the action area could induce a steady-state electrical field on the order of 51.5 µV/m (0.0515 mV/m). Modeled current speeds in this component of the action area are on the order of 0.1 to 0.35 m/s at the sea floor (Vinhateiro et al. 2018; RPS 2021), indicating baseline current-induced electrical field strength on the order of 5 to 15 μV/m (0.005 to 0.015 mV/m) at any given time. Wave action would also induce electrical and magnetic fields at the water surface on the order of 10 to 100 μV/m (0.01 to 0.1 mV/m) and 1 to 10 mG, respectively, depending on wave height, period, and other factors. Although these effects dissipate with depth, wave action would likely produce detectable EMF effects up to 184 feet (56 m) below the surface (Slater et al. 2010).

The IAC would be a 66-kV, 3-phase HVAC cable contained in grounded metallic shielding and buried to target depths of 4 to 6 feet (1.2 to 1.8 m). Cable segments that cross unavoidable hard substrates will not be buried and will be laid on the bed surface covered with a rock berm or concrete mattress for protection. Detectible EMF levels will be lower over segments of buried cable than over segments that are laid on the bed surface and covered with a rock berm or contract mattress. Calculated magnetic and electrical field effects for buried and exposed segments of the IAC for average loading are summarized in Table 5.11.

Hughes et al. (2015) and Emeana et al. (2016) evaluated the thermal effects of buried electrical transmission cables on the surrounding sea floor. They determined that the surrounding water would rapidly dissipate heat from exposed cable segments, resulting in minimal heat effects on the underlying substrates. In contrast, buried cables can increase the temperature of the surrounding sediments, with the magnitude and extent of heating effects varying depending on transmission voltage and sediment permeability. In medium to low permeability sediments (e.g., sand and mixed sand/mud), the typical buried HVAC electrical cable will heat the surrounding sediments within 1.3 to 2 feet (0.4 to 0.6 m) of the cable surface by +10 to 20°C above ambient conditions. Temperature effects diminished rapidly with distance beyond this distance, indicating that burial of the transmission cables to target depths of 4 to 6 feet (1.2 to 1.8 m) would avoid measurable substrate heating effects at the bed surface, except potentially at transition points between buried and exposed cable segments. Given that these areas would be covered by cable protection, ESA-listed species are unlikely to be exposed to any measurable substrate heating effects.

Table 5.11. Calculated Magnetic and Electrical Field Effects for Average Loading of the RWF IAC Measured 3.3 Feet (1 m) above Sea Floor.

Installation	Total Cable Length – statute miles (km, nm)	Magnetic Field At sea floor/1 m above sea floor	Electrical Field At sea floor/1 m above sea floor	Substrate Heating
Buried†	139 (233, 121)	57/17 mG	2.1/1.3 mV/m	+10 to +20°C within 0.4 to 0.6 m of cable
Surface-laid (assumes 1-foot of cable protection)	16 (16, 14)	522/35 mG	5.4/1.7 mV/m	

† RPS (2021) assumed a burial depth of 3.3 feet (1 m) for EMF modeling purposes.

The RWEC would be a 275-kV 3-phase AC cable operating at 60 Hz. Like the IAC, the RWEC would be contained in grounded metallic shielding to minimize electrical field effects and buried to target depths of 4 to 6 feet (1.2 to 1.8 m). Cable segments that cross existing transmission lines and unavoidable areas of hard substrate will not be buried and will be laid on the bed surface covered with a concrete blanket for protection. EMF effects in these areas will be greater than for buried cable segments.

Anticipated EMF and heat effects from the RWEC are summarized in Table 5.12. The potential heat effects are expected to be similar to those described above for the IAC, based on available research on the observed and modeled heating effects of buried undersea cables (Emeana et al. 2016; Hughes et al. 2015).

Table 5.12. Calculated Magnetic and Electrical Field Effects for Average Loading the RWEC Measured 3.3 Feet (1 m) above Sea Floor

Installation	Total Cable Length – statute miles (km, nm)	Magnetic Field At sea floor/1 m above sea floor	Electrical Field At sea floor/1 m above sea floor	Substrate Heating
Buried†	80 (133, 71)	147 mG/41 mG	4.4/2.3 mV/m	+10 to +20°C within 0.4 to 0.6 m of cable
Surface-laid (assumes 1-foot of cable protection)	18 (9, 5)	1,071 mG/91 mG	13/3.5 mV/m	

† RPS (2021) assumed a burial depth of 3.3 feet (1 m) for EMF modeling purposes.

The Project would generate EMF along the length of the IACs and offshore RWEC for the life of the Project until decommissioning. The effects of EMF would be most intense at locations where the RWEC cannot be buried and is laid on the bed surface covered by a stone or concrete armoring blanket. Approximately 8.8 miles of the RWEC cable, 0.9-miles of the OSS-link and 15.5 miles of the IAC will not be buried and will be laid on the surface and will require surface armoring. Exponent (2021) modeled EMF levels that could be generated by the RWEC, OSS-link and IAC. They estimated induced magnetic field levels ranging from 147 to 1,071 mG on the bed surface above the buried and exposed RWEC and OSS-link cables, and 57 to 522 mG above the IAC, respectively (Tables 5.11 and 5.12 above, respectively). Induced field strength would decrease rapidly with distance from the source, dropping below 100 mG within 3.3 feet of the sea floor directly above the cable. Induced magnetic field strength would fall effectively to 0 mG within 25 feet of the centerline of each cable segment. The only exception would occur at the RWEC landing location where the two cable corridors would approach to within 10 feet. Measurable magnetic field effects would extend between 25 to 50 feet from the outer edge of the combined cable path.

BOEM has conducted literature reviews and analyses of potential EMF effects from offshore renewable energy projects (CSA Ocean Sciences Inc. and Exponent 2019; Normandeau et al. 2011). These and other available reviews and studies (Gill et al. 2005; Kilfoyle et al. 2018) suggest that most marine species cannot sense very low-intensity electric or magnetic fields at the typical alternating-current power transmission frequencies associated with offshore renewable energy projects. The transmission cables could produce magnetic field effects above the 50-mG threshold at selected locations where full burial is not possible; these areas would be localized and limited in extent. Magnetic field strength at these locations would decrease rapidly with distance from the cable and drop to 0 mG within 25 feet. Peak magnetic field strength is below the theoretical 50-mG detection limit along the majority of cable length, only exceeding this threshold above the short-cable segments laid on the bed surface. Those EMF effects would dissipate below the 50-mG threshold 3.3 feet (1 m) of the sea floor, except for RWEC cable segments lying on the bed surface. Overall effects to federally protected marine mammals, sea turtles and fish are discussed below.

Marine Mammals

The magnetic field effects generated by exposed segments of the inter-array, RWEC and OSS-link cables are comparable in magnitude to earth’s natural magnetic field, which is on the order of 514 mG within the RWF. Background magnetic field conditions would fluctuate by 1 to 10 mG from the natural field effects produced by waves and currents. The maximum induced electrical field experienced by any organism close to the exposed cable would be no greater than 0.7 mV/m (Exponent 2021). As mentioned above, most marine species cannot sense low-intensity electric or magnetic fields generated by the 60-Hz HVAC power transmission cables commonly used in offshore wind energy projects. Normandeau et al. (2011) concluded that marine mammals are unlikely to detect magnetic field intensities below 50 mG, suggesting that these species would be insensitive to EMF effects from Project electrical cables. Project-related EMFs would drop below this threshold and would become undetectable within 3.3 feet (1 m) of the sea floor, except for RWEC cable segments lying on the bed surface. The area exposed to magnetic field effects greater than 50 mG would be small, extending less than 5 feet above the bed surface immediately over the exposed cable segment. The 50-mG detection threshold is theoretical and an order of magnitude lower than the lowest observed magnetic field strength resulting in observed behavioral responses (Normandeau et al. 2011). These factors indicate that the likelihood of marine mammals encountering detectable EMF effects is low, and any exposure would be below levels associated with measurable biological effects and therefore insignificant and discountable.

Sea Turtles

Normandeau et al. (2011) indicate that sea turtles are magnetosensitive and orient to the earth’s magnetic field for navigation, but they are unlikely to detect magnetic fields below 50 mG. The majority of RWEC and IACs would be buried 4-6 feet below the bed surface, reducing the magnetic field in the water column below levels detectable to turtles. Sea turtles may be able to detect induced magnetic fields within a few feet of cable segments lying on the bed surface. These cable segments would be relatively short (less than 100 feet long) and widely dispersed. Exponent (2021) concluded that the shielding provided by burial and the grounded metallic sheaths around the cables would effectively eliminate any induced electrical field effects detectable to turtles.

Heat from the buried RWEC and IACs could affect some benthic organisms that represent forage for turtles, but little is known about the potential change to substrate temperatures that transmission cables might have on the benthos (Taormina et al. 2018). Benthic effects are not expected to impact leatherback turtles as benthic prey are not typically included in their diet. Effects to algal cover (green sea turtle forage) and crustaceans, gastropods, crabs, and bivalves (loggerhead sea turtle forage) could conceivably affect sea turtle foraging opportunities. However, as noted above for marine mammals, the 50-mG detection threshold will extend less than 5 feet above the bed surface directly over the exposed cable The 50-mG detection threshold is theoretical and an order of magnitude lower than the lowest observed magnetic field strength resulting in observed behavioral responses (Normandeau et al. 2011). These factors indicate that the likelihood of sea turtles encountering detectable EMF effects is low, and any exposure would be below levels associated with measurable biological effects and therefore discountable. Measurable heating effects are not anticipated above buried cable segments. Measurable heating effects could occur at transition points between buried and exposed cable segments, but those areas will be impacted by cable protection, and thus not expected to have any measurable effect on sea turtles. EMF and substrate heating effects to sea turtles would therefore be insignificant.

Marine Fish

Atlantic sturgeon are electrosensitive but appear to have relatively low sensitivity to magnetic fields based on studies of other sturgeon species. Bevelhimer et al. (2013) studied behavioral responses of lake sturgeon to artificial EMF fields and identified a magnetic field detection threshold between 10,000 and 20,000 mG, well above the levels likely to result from the proposed action (i.e., 57 to 522 mG above the IAC and 147 to 1,071 mG on the bed surface above the buried and exposed RWEC and OSS-link). This indicates that Atlantic sturgeon are likely insensitive to magnetic field effects resulting from the proposed action.

Sturgeon may however be able to detect the induced electrical field generated by transmission cables. Atlantic sturgeon have specialized electrosensory organs capable of detecting electrical fields on the order of 0.5 mV/m (Gill et al. 2012; Normandeau et al. 2011). Exponent (2021) calculated that the maximum induced electrical field strength in Atlantic sturgeon from the RWF IAC and the RWEC would be 0.7 mV/m or less, slightly below the detection threshold for the species. However, this analysis only considered the field associated with buried cable segments. Based on magnetic field strength, the induced electrical field in sturgeon in proximity to exposed cable segments is likely to exceed the 0.5-mV/m threshold. This suggests that Atlantic sturgeon would likely be able to detect the induced electrical fields in immediate proximity to exposed cable segments. Sturgeon species have been reported to respond to low-frequency AC electric signals. For example, migrating Danube sturgeon (*A. gueldenstaedtii*) have been reported to slow down when crossing beneath overhead high voltage cables and speed up once past them (Gill et al. 2012). This is not a useful comparison, however, because overhead power cables are unshielded and generate relatively powerful induced electrical fields compared to shielded submarine cables. Insufficient information is available to associate exposure to induced electrical fields generated by submarine cables with measurable behavioral or physiological effects (Gill et al. 2012). However, it is important to note that natural electrical field effects generated by wave and current actions are on the order of 10 to 100 μV/m, many times stronger than the induced field generated by buried cable segments. Given the range of baseline variability and limited area of detectable effects relative to available habitat on the OCS, the effects of Atlantic sturgeon exposure to project-related EMF are therefore likely to be discountable.

Manta rays are elasmobranchs, a group of fishes with specialized electrosensory organs that allow these species to detect the low-intensity bioelectric signals generated by other aquatic organisms. Bedore and Kajiura (2013) reviewed the electrosensitivity of several elasmobranch species and determined detection thresholds ranging from 20 to 50 μV/m and detection distances of approximately 1.6 feet (50 cm) for the majority of species tested. It is important to note that these species primarily included predators that forage on benthic organisms. Manta rays are pelagic filter feeders that are presumably less reliant on their electrosensory organs to detect prey, suggesting they are likely on the lower end of this sensitivity range. Given that manta ray occurrence in the marine component of the action area is rare, and this species is most commonly distributed higher in the water column away from the sea floor, the likelihood of measurable effects on manta rays from exposure to project-related EMF is discountable.

As stated, Hughes et al. (2015) and Emeana et al. (2016) determined that heat from exposed cable segments would dissipate rapidly without measurably heating the underlying sediments. Hughes et al. (2015) and Emeana et al. (2016) also indicate that substrate heating effects from buried cable segments at the minimum depths proposed for the Project are unlikely to be measurable within 2 feet of the bed surface. Substrate heating effects could reach the bed surface at transition points between buried and exposed cable segments. However, these transition areas and exposed cable segments would be covered by cable protection, limiting fish access. Small fishes using the interstitial spaces within the mattresses may be able to detect some cable heating effects, but only within the transition zones described.

Atlantic sturgeon prey on benthic invertebrates that could be exposed to EMF, suggesting the potential for indirect effects on prey resources. The evidence for EMF effects on invertebrates is equivocal, varying considerably between species and based on the type and strength of EMF source (Albert et al. 2020; Hutchison et al. 2020b). Several studies have observed no apparent behavioral responses in crustaceans and mollusks at EMF field strengths similar to the highest levels likely to result from IAC, RWEC and OSS-link segments laid on the bed surface. A handful of studies have observed apparent physiological effects on clams, mussels, and worms after a few hours of exposure to EMF levels within the ranges described above, while other studies have observed no apparent effects on the same types of organisms from much higher exposures over longer periods. These contradictions are compounded by differences in study methods and the type of EMF exposure (i.e., from high-voltage direct current versus HVAC transmission), making it difficult to draw conclusions about the sensitivity of benthic infauna to EMF effects (Hutchison et al. 2020b).

Collectively, these findings indicate that long-term EMF effects on listed fish would likely be insignificant.

5.5.6 Lighting and Marking of Structures

RWF construction and installation vessels would introduce stationary and mobile artificial light sources to the marine component of the action area. Construction and installation and O&M lighting will be limited to the minimum necessary to ensure safety and compliance with applicable regulations. RWF will also use Aircraft Detection Lighting System (ALDS) (or similar system), pursuant to approval by the FAA and commercial and technical feasibility at the time of FDR/FIR approval. Each WTG will be marked and lit with both USCG and approved aviation lighting. Additionally, BOEM may require compliance with the marking and/or lighting recommendations identified in the FAAs Advisory Circular 70/7460-1L for WTGs beyond FAA jurisdiction given that BOEM does not current have prescriptive guidelines for air navigation safety, which includes guidelines and standards for marking and lighting obstructions affecting navigable airspace (vhb 2022).

Artificial light has been shown to alter the invertebrate epifauna and fish community composition and abundance in proximity to human-made structures (Davies et al. 2015; McConnell et al. 2010; Nightingale et al. 2006) and the vertical distribution of zooplankton in the water column (Orr et al. 2013). Artificial light in coastal environments is an established stressor for juvenile sea turtles, which use light to aid in navigation and dispersal and can become disoriented when exposed to artificial lighting sources, but the significance of artificial light in offshore environments is less clear (Gless et al. 2008). Collectively, these findings suggest the potential for effects on ESA-listed marine mammal, sea turtle, and fish species as a result of changes in the distribution of forage species and predator-prey dynamics.

Orr et al. (2013) summarized available research on potential operational lighting effects from offshore wind energy facilities, which would be the same or similar to those associated with construction and installation. They concluded that the direct and indirect operational lighting effects on marine mammal, marine turtle, and fish distribution, behavior, and habitat use were unknown but likely minor when recommended design and operating practices are implemented. Specifically, the use of low intensity, shielded directional lighting on structures, activating work lights only when needed, and using red navigation lights with low strobe frequency would reduce the amount of detectable light reaching the water surface to insignificant levels.

Consistent with BOEM guidance (Orr et al. 2013; BOEM 2021b) as described previously in Section 4.7 Artificial Lighting, construction and installation vessels and platforms would implement lighting design and operational measures to eliminate or reduce lighting impacts on the aquatic environment, including, but not limited to:

- Turbines and towers should be painted with color no lighter than RAL 9010 Pure White and no darker than RAL 7035 Light Grey;
- Lighting should be minimized whenever and wherever possible, except as recommended by BOEM (2021b) for aviation and navigation safety, including number, intensity, and duration;
- Flashing lights should be used instead of steady burning lights whenever practicable, and the lowest flash rate practicable should be used for application to maximize the duration between flashes. BOEM recommends 30 flashes per minute to be a reasonable rate in most instances;
- Direct lighting should be avoided, and indirect lighting of the water surface should be minimized to the extent practicable one the wind facility is operational;
- Lighting should be directed to where it is needed, and general area floodlighting should be avoided;
- Area and work lighting should be limited to the amount and intensity necessary to maintain worker safety;
- Using automatic times or motion-activated shutoffs for all lights not related to aviation obstruction lighting (AOL) or marine navigation lighting should be considered; and
- AOL that is most conspicuous to aviators, with minimal lighting spread below the horizontal plane of the light but still within the photometric values of an FAA Type L-864 medium intensity red obstruction light, should be used.

Revolution Wind has committed to using these EPMs to avoid and minimize artificial light effects from the construction and installation, and O&M of RWF to the minimum necessary to ensure safety and compliance with applicable regulations. Therefore, the effects of artificial light on ESA-listed species would be insignificant.

The O&M of the RWF would introduce stationary, intermittent artificial light sources in the form of navigation, safety, and work lighting. These light sources would remain in operation throughout the life of the project. BOEM (Orr et al. 2013) summarized available research on potential operational lighting effects from offshore wind energy facilities and developed design guidance for avoiding and minimizing lighting impacts on aquatic life, including marine mammals, sea turtles, and fish. They concluded that construction and operational lighting effects on the distribution, behavior, and habitat use by these species would likely be biologically insignificant if recommended design and operating practices are implemented. As discussed in above, the use of low intensity, shielded directional work lights that activate only when needed, and red navigation and aviation safety lights with low strobe frequency would reduce the amount of detectable light reaching the water surface. Consistent with BOEM guidance (Orr et al. 2013; BOEM 2021b), all offshore structures would implement lighting design and operational measures to eliminate or reduce lighting impacts on the aquatic environment. The Applicant has committed to using these EPMs to avoid and minimize artificial light effects from the operation of RWF. Light impacts from project decommissioning would be similar in nature to those described above for construction and installation. On this basis, lighting effects on ESA-listed species from project decommissioning would also be insignificant.

5.5.7 Offshore Substations (OSSs)

Once constructed, the OSSs would have no operational impacts on the environment aside from those described in Sections 5.5.3 and 5.8. The COP does not indicate that the OSSs would include cooling systems or any other feature requiring water withdrawals. Therefore, the OSSs would result in no significant effects beyond those described in the sections referenced above.

5.5.8 Decommissioning

Degraer et al. (2020) commented that the future decommissioning of offshore wind facilities could become controversial if the artificial reef effect they create is proven to provide productive habitat for highly valued fish and invertebrate species. While this potential is acknowledged, this BA considers decommissioning as a component of the Proposed Action as required by BOEM for COP approval. Project decommissioning would remove the monopile foundations and scour and cable protection from the environment, reversing the artificial reef effect provided by these structures. Portions of the Project footprint, primarily along the RWEC corridor, would return to near pre-Project conditions, as influenced by ongoing environmental trends. As described in Section 5.5.1, benthic recovery is a complex process that involves both the reformation of benthic features, such as biogenic depressions and sand ripples, and recolonization of disturbed areas by habitat-forming invertebrates. Soft-bottom benthic habitats would likely recover to full habitat function within 18 to 24 months of disturbance while full recovery of habitat-forming organisms on complex benthic habitats could take a decade or longer. Individual fish species (e.g., small fish sheltering in epibenthic structure on the monopiles) could be injured or killed during removal. The fish community that formed around the reef effect would be dispersed, and individuals that are unable to locate new suitable habitats might not survive. This effect could in turn disrupt foraging habits established by ESA-listed marine mammals, sea turtles, and ESA-listed fish species.

Marine Mammals

Habitat disturbance effects to marine mammals during decommissioning would likely yield similar short-term effects described for construction and installation. The removal of up to 102 WTG and OSS foundations and the IAC, OSS-link, and RWEC would result short-term to long-term disturbance of benthic habitat communities. Prey organisms targeted by sperm, fin, and sei whales, could be dispersed or displaced, with the time required for recovery likely similar to that described for project construction and installation in Section 5.5.1. There is no example of a large-scale offshore renewable energy project within the migratory range of the marine mammal species considered in this analysis. However, it is not expected that the reef effect resulting from the Proposed Action would increase the abundance and availability of prey and forage species for NARWs, fin whales, or sei whales, and sperm whales and blue whales (NMFS 2021b). Although reef effects may aggregate fish species and potentially attract increased predators, they are not anticipated to have any measurable effect on ESA-listed marine mammals. Based on the available information, it is expected that there may be an increase in abundance of schooling fish that sei or fin whales may prey on but that this increase would be so small that the effects to sei or fin whales cannot be meaningfully measured, evaluated, or detected. Because it is not expected that sperm or blue whales would forage in the Project area (due to the shallow depths), the physical presence of structures during O&M is not expected that any impacts to the forage base for sperm or blue whales would occur. The potential beneficial, yet not measurable, increase in aggregation of prey species of the fin and sei whale due to the reef effect would be removed following decommissioning.

Given the limited area affected and the lack of overlap with important benthic feeding habitats for ESA-listed cetaceans, and the short-term of the disturbance, effects from sea floor disturbance during decommissioning and subsequent loss of foraging opportunities from reef effect removal would be so small that they could not be measured, detected, or evaluated and would therefore be insignificant.

Sea Turtles

Habitat disturbance effects to sea turtles during decommissioning would likely yield short-term to long-term effects similar to those described for project construction and installation. Prey organisms and forage species targeted by sea turtles could be dispersed and/or permanently displaced. There is no example of a large-scale offshore renewable energy project within the migratory range of the sea turtle species considered in this BA. However, while the reef effect would likely increase the availability of forage and prey species within the RWF and vicinity, the affected area represents a miniscule portion of the migratory range and foraging habitat available to these species. As such, increases in prey and forage availability would be so small that the effects to ESA-listed sea turtles cannot be meaningfully measured, evaluated, or detected. Therefore, the loss of the potential beneficial, yet not measurable, prey and forage resources resulting from loss of the reef effect following decommissioning would likely be insignificant.

Marine Fish

Decommissioning of the Proposed Action would likely have no biologically significant effects on habitat suitability and the availability of planktonic for giant manta ray. This species migrates over a broad range and changes its distribution in response to the availability of planktonic prey organisms. Once decommissioned the hydrodynamic effects of the WTGs, and the WTG and OSS foundations would cease. This would in turn lead to local-scale shifts in the distribution of planktonic prey organisms, likely on the order of miles to tens of miles (Johnson et al. 2021). Effects of this scale would not be meaningful across the foraging range of the manta ray. On this basis, decommissioning effects on this species would be insignificant.

Atlantic sturgeon may benefit from the increased biological productivity generated by the reef effect around WTG and OSS foundations. As described in Section 5.5.3, the increased abundance of benthic infauna and other prey organisms could attract foraging adult and subadult Atlantic sturgeon that migrate to southern New England waters. Like the other species considered in this analysis however, this species is highly migratory and forages over broad ranges across the Atlantic OCS. While project decommissioning may lead to a localized loss of productive foraging habitat, this effect is unlikely to have a measurable impact on the ability of individual Atlantic sturgeon to find suitable foraging opportunities. Therefore, effects to Atlantic sturgeon from loss of the artificial reef effect due to project decommissioning would be insignificant.

5.6 Air Emissions

Once the Revolution Wind Project is operational, the WTGs, OSSs, and offshore and onshore cable corridors would not generate any measurable air pollutant emissions. However, vessels and equipment used in the construction and installation, O&M, and decommissioning phases of the Project would generate emissions that could affect air quality within the marine component of the action area. Most emissions would occur during Project construction within and near the RWF and RWEC route and would be temporary in duration. Additional emissions related to the Project could also occur at nearby ports used to transport material and personnel to and from the Project site.

To satisfy the requirements of 40 CFR 55, the Project will obtain an OCS Air Permit from the USEPA for Project-related emissions occurring within 25 miles of the center of the RWF. The OCS Air Permit/PSD/NNSR emissions include emissions from OCS sources, vessels meeting the definition of OCS Source (40 CFR 55.2), and vessels traveling to and from the Project when within 25 miles of the RWFs centroid (Tech Environmental 2021). Revolution Wind (Tech Environmental 2021) prepared an assessment of project emissions to support the application for this permit, and related air quality permits for state environmental protection agencies.

Construction and installation and O&M vessels are the primary source of Project-related emissions that could potentially affect ESA-listed marine mammals and sea turtles. ESA-listed fish species would not be exposed to airborne emissions and would therefore not be affected by this stressor. Most Project vessels are ocean-going ships and tugs powered by diesel engines with exhaust stacks that discharge emissions above the vessel. Small Project vessels, specifically the inflatable support vessels used by PSOs, are powered by outboard motors that discharge exhaust at the water surface. Summaries of estimated annual pollutant emissions during Project construction and installation and O&M are provided in Tables 5.13 and 5.14, respectively. The Proposed Action includes the following EPMs to minimize pollutant emissions associated with each Project phase: use of low sulfur fuels to the extent practicable; selecting vessels with low-emissions engines designed to reduce air pollution to the extent practicable; limiting engine idling time; and full compliance with international standards regarding air emissions from marine vessels.

Table 5.13. Summary of Offshore Emissions from Construction of the RWF and RWEC (constituent tons per year).

Source	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC	CO_2e
RWF-Rhode Island	169.5	711.7	24.1	23.3	2.2	14.8	56,604
RWEC-Rhode Island	19.0	78.2	2.6	2.5	0.3	1.4	5,216
RWF-OCS	941.9	3,854.1	125.5	121.3	12.3	80.6	264,307
RWEC-OCS	65.7	270.0	9.0	8.7	0.9	4.8	17,961
Total	**1,196.1**	**4,914**	**161.2**	**155.8**	**15.7**	**101.6**	**344,088**

Source: Tech Environmental (2021)

Notes:

RWF-Rhode Island = the portion of RWF construction emissions that would occur outside the OCS air quality permit area and within 15.5 miles of shore during transit to and from the Port of Providence and the Port of Davisville at Quonset Point.

RWEC-Rhode Island = the portion of RWEC construction emissions that would occur outside the OCS air quality permit area and within 15.5 miles of the Rhode Island shore.

RWF-OCS = the portion of RWF construction vessel emissions occurring within the OCS air quality permit area.

RWEC-OCS = the portion of RWEC offshore segment construction emissions that would occur within the OCS air quality permit area.

Table 5.14. Summary of Offshore Emissions from O&M of the RWF and RWEC (constituent tons per year).

Source	CO	NO_X	PM_{10}	$PM_{2.5}$	SO_2	VOC	CO_2e
RWF-New York	51.2	205.3	6.9	6.7	0.1	3.0	14,506
RWF-Rhode Island	3.3	13.0	0.4	0.4	0.0	0.3	1,001
RWF-OCS	207.6	847.7	27.4	26.6	0.6	12.4	57,820
Total	262.1	1,066	34.7	33.7	0.7	15.7	73,327

Source: Tech Environmental (2021)

Notes:

RWF-New York = the portion of RWF O&M emissions that would occur outside the OCS air quality permit area and within 15.5 miles from shore during transit to and from the Port of Montauk, Port Jefferson, and the Port of Brooklyn.

RWF-Rhode Island = the portion of RWF O&M emissions that would occur beyond the OCS air quality permit area and within 15.5 miles from shore during transit to and from the Port of Providence and the Port of Davisville at Quonset Point.

RWF-OCS = the portion of RWF emissions that would occur within the OCS air quality permit area.

Whales are particularly vulnerable to concentrated pollutant emissions, as they do not have sinuses to filter air and lack olfactory receptors that would allow them to sense and perhaps avoid vessel emissions. Additionally, whales spend much of their time diving, which increases air pressure in their lungs allowing for pollutants to enter their blood more rapidly than for non-diving animals at normal atmospheric pressure (B.C. Cetacean Sightings Network 2022). As diving animals, sea turtles are likely to experience similar exposure risk when diving. Lachmuth (2011) investigated exposure of Southern Resident Killer Whales (SRKWs) in the Puget Sound region to engine exhaust pollutants from whale-watching vessels. Prior to the implementation of protective regulations limiting vessel closure, SRKWs were commonly exposed to an average of 20 whale-watching vessels that would approach within 800 m for 12 hours/day. Lachmuth (2011) modeled potential exposure to atmospheric pollutants from whale watching vessel emissions and found that during low wind conditions in summer SRKW to CO and NO_2 could exceed human exposure thresholds. Under average whale-watching conditions, the doses of CO and NO_2 were equal to or just below those predicted to cause adverse health effects. However, under worst-case whale watching conditions, the doses of CO and NO_2 were 6.6 and 3.4 times higher, respectively, than those predicted to cause adverse health effects.

It must be noted however, that this exposure profile is related to specifically to historical whale watching vessel activity in SRKW habitat. These vessels actively pursued and remained in proximity to SRKWs for extended periods throughout the summer. These are unusual exposure conditions that are not indicative of potential marine mammal and sea turtle exposure to emissions from Project vessels. Project vessels would not intentionally pursue remain in close proximity to whales or sea turtles. While individual animals may periodically come into proximity to stationary or mobile Project vessels, it is unlikely that whales would remain close enough to those vessels long enough periods of time to experience an adverse level of exposure to vessel emissions. Additionally, per Section 3.5, protected species observers and exclusion and clearance zones for marine mammals are part of the Project and intended to avoid and minimize potential impacts (see Section 3.5 for further information).

Marine mammal and sea turtle exposures to air pollutant emissions during Project construction and installation and O&M are anticipated temporary and short-term in duration. Given the fact that vessel exhausts are located high above the water surface, and most vessel activity will occur in the open ocean where exhaust will be readily dispersed by steady winds, the likelihood of individual animals being repeatedly exposed to high concentrations of airborne pollutants from Project vessels and equipment is low. Given the types of activities and vessels needed for construction and installation and decommissioning (e.g., driving and removing piles, and laying and removing cable) are similar, it is assumed the effects to air quality from decommissioning are similar to those of construction and installation such that the air quality effects from the Proposed Action as a whole are still likely to be minor. At this time, there is no information on the effects of air quality on listed marine mammal and sea turtle species that may occur in the marine component of the action area. However, the OCS air quality permit is expected to include conditions designed to ensure that offshore air quality does not significantly deteriorate from baseline levels. On this basis, it is reasonable to conclude that any effects to listed marine mammals and sea turtles from these emissions will be so small that they cannot be meaningfully measured, detected, or evaluated and, therefore, are insignificant. ESA-listed fish species would not be exposed to airborne emissions, therefore this IPF would have no effect on Atlantic sturgeon and giant manta ray.

5.7 Port Modifications (e.g., O&M facilities)

No port modifications are anticipated to be required as part of the project. The project will use existing port facilities that will be developed to support other wind energy projects that will be operational by the time RWF is constructed and becomes operational.

5.8 Potential Shifts or Displacement of Ocean Users (vessel traffic, recreational and commercial fishing activity)

Construction and installation of offshore wind energy projects would require staging and installation vessels, including crew transfer, dredging, cable lay, pile driving, survey vessels, and potentially feeder lift barges and heavy lift barges. A more limited number of vessels would also be required for routine maintenance during the O&M phase. The additional vessel volume could cause vessel traffic congestion, difficulties with navigating, and an increased risk for collisions. These potential adverse impacts could cause some fishing and other vessel operators to change normal routes. See Section 5.3.1 Risk of Vessel Strike for further discussion of the risk of vessel strikes on marine mammals, sea turtles and marine fish.

In addition, once offshore wind energy projects are completed, some commercial fishermen could avoid the Lease Areas if large numbers of recreational fishermen are drawn to the areas by the prospect of higher catches. As discussed above, WTG and OSS foundations and associated scour protection could produce an artificial reef effect, potentially increasing fish and invertebrate abundance within a facility's footprint. If these concerns cause commercial fishermen to shift their fishing effort to areas not routinely fished, this could in theory alter ESA-listed species exposure to vessel traffic, but the available data suggest this is unlikely.

It is difficult to predict the ability of fishing operations displaced by Project construction and installation activities to locate alternative fishing grounds that would allow them to maintain revenue targets while continuing to minimize costs. However, the available data suggest the presence of alternative productive fishing grounds in proximity to the RWF and RWEC. The revenue intensity levels for many of the federally managed fisheries in large expanses of ocean within 20 nm of the Lease Area and offshore RWEC corridor are comparable to or higher than those within the two areas. This in turn indicates that displacement effects on commercial fisheries would be limited.

Based on data presented in Tables 5.15 and 5.16, it is possible to calculate the amount of commercial fishing revenue that would be exposed as a result of construction and installation activities in the Lease Area and along the offshore RWEC. As discussed above, estimates of revenue exposure represent the fishing revenue that would be foregone if fishing vessel operators cannot capture that revenue in a different location. Based on commercial fishing revenue data averaged over the 2008-2019 period, Tables 5.15 and 5.16 show the annual revenue at risk in the RWF and along the RWEC OCS during each year of the 2-year (2023–2024) Project construction and installation phase by federally managed fishery and gear type, respectively. While future fishery activity over the life of the project is uncertain, these results are likely indicative of potential effects of the life of the project. As shown, the largest impacts in terms of exposed revenue as a percentage of total revenue in the New England and Mid-Atlantic regions or as a percentage of total revenue would be in the American Lobster, Sea Scallop, and Mackerel, Squid, and Butterfish federally managed fisheries. The amount of commercial fishing revenue that would be exposed across all federally managed fisheries is estimated to be $1.42 million. The annual exposed revenue represents 0.15 percent of the average annual revenue for all federally managed and non–federally managed fisheries in the New England and Mid-Atlantic regions, and 0.99 percent of the average annual revenue for all federally managed and non–federally managed fisheries. Mid-water trawl, "all other," and pot gear would be the gear types most affected in terms of exposed revenue as a percentage of total revenue.

Table 5.15. Annual Commercial Fishing Revenue Exposed in the RWF and along the Offshore RWEC by Fishery (2008–2019).

Federally Managed Fishery	Peak Annual Revenue ($1,000s)	Average Annual Revenue ($1,000s)	Average Annual Revenue at Risk as a Percentage of Total Revenue in the Mid-Atlantic and New England Regions	Average Annual Revenue at Risk as a Percentage of Total Revenue
American Lobster	$507.7	$283.8	0.30%	3.64%
Atlantic Herring	$273.5	$102.9	0.40%	3.44%
Bluefish	$17.2	$8.7	0.68%	1.50%
Highly Migratory Species	$6.9	$2.2	0.10%	1.00%
Jonah Crab	$40.7	$23.2	0.24%	0.39%
Mackerel, Squid, and Butterfish	$324.4	$145.3	0.28%	0.94%
Monkfish	$210.0	$109.9	0.53%	1.46%
Northeast Multispecies (large mesh)	$117.0	$52.6	0.07%	2.20%
Northeast Multispecies (small mesh)	$193.3	$74.3	0.66%	2.63%
Sea Scallop	$409.9	$157.1	0.03%	0.32%
Skates	$175.9	$110.7	1.49%	3.09%

Federally Managed Fishery	Peak Annual Revenue ($1,000s)	Average Annual Revenue ($1,000s)	Average Annual Revenue at Risk as a Percentage of Total Revenue in the Mid-Atlantic and New England Regions	Average Annual Revenue at Risk as a Percentage of Total Revenue
Spiny Dogfish	$35.7	$15.7	0.53%	6.45%
Summer Flounder, Scup, Black Sea Bass	$133.5	$84.3	0.21%	0.77%
Other federally managed, non-disclosed species, and non–federally managed fisheries	$574.6	$248.0	0.26%	0.73%
All federally managed and non–federally managed fisheries	$1,707.8	$1,418.8	0.15%	0.99%

Source: Developed using data from NMFS (2021b, 2022a).
Notes: Revenue is adjusted for inflation to 2019 dollars. Peak annual revenue is calculated independently for all rows including the total row.

Other federally managed, non-disclosed species, and non–federally managed fisheries includes revenue from three federally managed fisheries: Surfclam / Ocean Quahog, Red Crab, and River Herring. In addition, it includes revenue from species in federally managed fisheries for which data could not be disclosed due to confidentiality restrictions, and revenue earned by federally permitted vessels operating in fisheries that are not federally managed.

Table 5.16. Annual Commercial Fishing Revenue Exposed in the Lease Area and Along the Offshore RWEC by Gear (2008–2019)

Gear Type	Peak Annual Revenue ($1,000s)	Average Annual Revenue ($1,000s)	Average Annual Revenue at Risk as a Percentage of Total Revenue in the Mid-Atlantic and New England Regions	Average Annual Revenue at Risk as a Percentage of Total Revenue in the RFA
Dredge-clam	$399.9	$121.1	0.20%	0.58%
Dredge-scallop	$417.6	$157.7	0.03%	0.33%
Gillnet-sink	$291.6	$197.4	0.66%	2.05%
Handline	$15.7	$3.7	0.08%	0.27%
Pot-other	$531.2	$345.3	0.30%	2.15%
Trawl-bottom	$658.9	$492.1	0.26%	1.14%
Trawl-midwater	$191.8	$98.1	0.52%	4.18%
All other gear*	$288.3	$70.1	0.15%	2.63%
All gear types	$1,707.8	$1,485.6	0.16%	1.03%

Source: Developed using data from NMFS (2021b, 2022a).
Notes: Revenue is adjusted for inflation to 2019 dollars. Peak annual revenue is calculated independently for all rows including the total row.
Gear types shown in italics indicate that fewer than 12 years, but more than 4 years of data were used to calculate the estimates. Otherwise, estimates are based on 12 years of data.

* Includes revenue from federally permitted vessels using longline gear, seine gear, other gillnet gear, and unspecified gear, as well as listed gear for years when they were not disclosed.

While revenue exposure estimates are not a perfect indicator the potential for displacement of fishery activity, they do provide a useful estimate of the scale of that displacement. While the RWF and RWEC corridors do support some level of commercial fishing activity, and that activity could be displaced during project construction and installation and the long-term presence of structures, the affected area provides only a small percentage of the total revenue by fishery and gear type. This indicates that displacement and relocation of commercial fishing activity by the RWF and RWEC would be minimal.

Marine Mammals

The long-term presence of WTG structures could displace marine mammals from preferred habitats or alter movement patterns, potentially changing exposure to commercial and recreational fishing activity. The evidence for long-term displacement is unclear and varies by species. For example, Long (2017) studied marine mammal habitat use around an ocean energy testing facility and found evidence of displacement during construction but habitat use appeared to return to normal during facility operation. He cautioned that these findings were not definitive and additional research was needed. In contrast, Tielmann and Carstensen (2012) observed clear long-term (greater than 10 years) displacement of harbor porpoises from commercial wind farm areas in Denmark. Displacement effects remain a focus of ongoing study (Kraus et al. 2019). Other studies have documented apparent increases in marine mammal density around wind energy facilities. For example, Russel et al. (2014) found clear evidence that seals were attracted to a European wind farm, apparently attracted by the abundant concentrations of prey created by the artificial reef effect.

Hayes et al. (2021) note that marine mammals are following shifts in the spatial distribution and abundance of their primary prey resources driven by increased water temperatures and other climate-related impacts. These range shifts are primarily oriented northward and toward deeper waters. The widespread development of offshore renewable energy facilities could facilitate climate change adaptation for certain marine mammal prey and forage species. The artificial reefs created by these structures form biological hotspots that could support species range shifts and expansions and changes in biological community structure (Degraer et al. 2020; Methratta and Dardick 2019; Raoux et al. 2017). In contrast, broadscale hydrodynamic impacts could alter zooplankton distribution and abundance (van Berkel et al. 2020). There is considerable uncertainty as to how these broader ecological changes would affect marine mammals in the future, and how those changes will interact with other human-caused impacts.

The presence of structures could also concentrate recreational fishing around foundations, potentially increasing the risk of marine mammal entanglement in both lines and nets and increasing the risk of injury and mortality due to infection, starvation, or drowning (Moore and van der Hoop 2012). Fisheries interactions are likely to have demographic effects on marine mammal species, with estimated global mortality exceeding hundreds of thousands of individuals each year (Read et al. 2006; Reeves et al. 2013; Thomas et al. 2016). These structures could also result in fishing vessel displacement or gear shift. The potential impact to marine mammals from these changes is uncertain. However, if a shift from mobile gear to fixed gear occurs, there would be a potential increase in the number of vertical lines, resulting in an increased risk of marine mammal interactions with fishing gear. In the Atlantic, bycatch and harmful interactions occur in various gillnet and trawl fisheries in New England and the mid-Atlantic coast, with hotspots driven by marine mammal density and fishing intensity (Lewison et al. 2014; Morin et al. 2018; NOAA 2021a; 86 FR 51970). Entanglement in fishing gear has been identified as one of the leading causes of mortality in NARW and could be a limiting factor in the species' recovery (Knowlton et al. 2012). Johnson et al. (2005) report that 72 percent of NARWs show evidence of past entanglements. Additionally, recent literature indicates that the proportion of NARW mortality attributed to fishing gear entanglement is likely higher than previously estimated from recovered carcasses (Pace et al. 2021). Entanglement could also be responsible for high mortality rates in other large whale species (Read et al. 2006). Abandoned or lost fishing gear could get tangled with foundations, reducing the chance that abandoned gear would cause additional harm to marine mammals and other wildlife, though debris tangled with WTG foundations could still pose a hazard to marine mammals.

While the potential for displacement effects is acknowledged, the likelihood and significance of adverse effects on ESA-listed marine mammals is at present unknown but likely insignificant.

Sea Turtles

Project constructon activities could result in some level of displacement of sea turtles out of the RWF and into areas higher levels of vessel traffic and/or recreational or commercial fishing activity. The presence of RWF structures could concentrate recreational and commercial fishing around foundations, which could indirectly increase the potential for sea turtle entanglement in both lines and nets (Gall and Thompson 2015; Nelms et al. 2016; Shigenaka et al. 2010). Entanglement in both lines and nets could lead to injury and mortality due to abrasions, loss of limbs, and increased drag, leading to reduced foraging efficiency and ability to avoid predators (Barreiros and Raykov 2014; Gregory 2009; Vegter et al. 2014). Between 2016 and 2018, 186 sea turtles were documented as hooked or entangled with recreational fishing gear, with the majority (179) recorded in Virginia (STSSN 2021). Reef effects resulting from presence of foundations are likely to lead to increased biological productivity and fish abundance in proximity to the RWF foundations. This may in turn attract recreational and for-hire fishing activity, which could in turn lead to an increased risk of entanglement or incidental capture in hook and line fisheries if sea turtles are attracted to the same areas.

If structures result in vessel displacement or gear shifts, the potential impact to sea turtles is uncertain. Increased risk would not be expected by vessel displacement due to the patchy distribution of sea turtles. However, it could result in a potential increase in the number of vertical lines in the water column if there is no commensurate reduction in fixed-gear types as compared to mobile gear. In such circumstances of a greater shift from mobile gear to fixed gear, there would be a potential increase in the number of vertical lines, resulting in an increased risk of sea turtle interactions with fishing gear. While the potential for these effects is acknowledged, the likelihood and significance is unclear at present but likely discountable.

Marine Fish

Commercial and recreational fishing activity may shift in response to RWF and RWEC construction and installation and the presence of RWF structures over the life of the project. The likelihood and extent of incidental catch of Atlantic sturgeon and manta ray resulting from shifts in fishing activity is currently unknown. Further, thousands of commercial and recreational vessel trips pass through the RI/MA WEA every year (see Section 5.3). Additionally, commercial and recreational fishing activity in and around the RWF likely generates hundreds of vessel trips and thousands of operational hours on an annual basis. As noted above, cod have continued to display high fidelity to spawning sites on Cox Ledge despite the ambient noise levels present in this environment. In this context, potential shifts in commercial and recreational fishing activity are not likely to significantly alter the ambient noise environment relative to the existing baseline and thus the impact is considered insignificant.

5.9 Unexpected/Unanticipated Events

Unexpected or unanticipated events, outside of events related to normal construction and installation, and O&M activities related to RWF and RWEC construction and installation, and O&M, as described previously, may include events such as the accidental spill or discharges, collision and allision with foundations, catastrophic failure of a WTG, and damage to an IAC or the RWEC from vessel anchors or commercial fishing gear.

Construction and installation, and O&M vessels pose a potential risk for project-related accidental spills. Small spills could occur during fuel transfers or collisions with other vessels or structures. The project would follow strict oil spill prevention and response procedures during all construction and installation, and O&M phases, effectively avoiding the risk of large spills. The RWF would be clearly marked on navigational charts and would maintain navigation safety lighting at all times, reducing risk of vessel allisions.

Bejarano et al. (2013) indicates the only incidents calculated to occur within the life of the Proposed Action are spills of up to 90 to 440 gallons (340.7 to 1,665.6 liters) of WTG fluid or a diesel fuel spill of up to 2,000 gallons (7,570.8 liters) with model results suggesting that such spills would occur no more frequently than once in 10 years and once in 10 to 50 years, respectively. However, this modeling assessment does not account for any of the spill prevention plans that will be in place for the Project which are designed to reduce risk of accidental spills or releases. Considering the predicted frequency of such events (i.e., no more than three WTG fluid spills over the life of the WTGs and no more than one diesel spill over the life of the Project), and the reduction in risk provided by adherence to USCG and BSEE requirements as well as adherence to the spill prevention plan both of which are designed to eliminate the risk of a spill of any substance to the marine environment; therefore, any fuel or WTG fluid spill is extremely unlikely and not reasonably certain to occur; as such, any exposure of listed marine mammals to any such spill is also extremely unlikely and not reasonably certain to occur. In the unlikely event of a spill, if a response was required by the EPA or the USCG, there would be an opportunity for the NMFS to conduct a consultation with the lead federal agency on the oil spill response which would allow the NMFS to consider the effects of any oil spill response on listed marine mammals in the marine component of the action area.

The risk of a spill in the extremely unlikely event of a collapse is limited by the containment built into the structures. As explained above, catastrophic loss of any of the structures is not reasonably certain to occur; therefore, the spill of oil from these structures is also not reasonably certain to occur. Modeling presented by BOEM (from Bejarano et al. 2013) indicates that there is a 0.01 percent chance of a “catastrophic release” of oil from the wind facility in any given year. Given the lifetime of this Project, the modeling supports the determination that such a release is not reasonably certain to occur and is thus considered discountable.

Catastrophic failure of a WTG could include failure of the monopile foundation or the turbine, such that the structure would need to be replaced. The likelihood of such a catastrophic failure is unlikely since WTG support structures (i.e., towers and foundations) will be designed to withstand 500-year hurricane wind and wave conditions, and the external platform level will be designed above the 1,000-year wave scenario. The OSSs will be designed to at least the 5,000-year hurricane wind and wave conditions in accordance with the American Petroleum Institute standards (vhb 2022), however such failure would require recovery, disposal, and replacement of the lost structure. The impacts associated with these activities would be similar to that described above. It is likely that such replacement would need some level of environmental review, such as evaluation of specific impacts to federally protected species and their designated critical habitat.

Damage to an IAC or the RWEC from vessel anchors is unlikely, however benthic habitat is dynamic and it is possible that a segment of cable could become exposed by sediment mobility and subsequently damaged by a vessel anchor or commercial fishing gear. Revolution Wind would continually monitor transmission cables to quickly identify faults and shut down power as needed. Replacement of any damaged segment of IAC or RWEC would have impacts similar to those described for cable installation.

6.0 Climate Change Considerations

Global climate change is altering water temperatures, circulation patterns, and oceanic chemistry at global scales and have affected habitat suitability for marine organisms across broad spatial scales. ESA-listed marine mammals, sea turtles, and finfish occurring in the marine component of the action area are likely to be affected by climate change impacts during the anticipated operational life of the proposed action. Anticipated impacts to these species are summarized below.

6.1 Marine Mammals

Global climate change is an ongoing risk to marine mammals. Hayes et al. (2021) note marine mammals are being forced to adapt to changes in the spatial distribution and abundance of their primary prey resources. The range of habitats for many finfish, invertebrate, and zooplankton species on the North Atlantic OCS are shifting northward and toward deeper waters in response to changes in temperature regime, acidification, and other climate-driven effects on the ocean environment (NOAA 2021; PMEL 2020). Marine mammals are modifying their behavior and distribution in response to these broader observed changes (Davis et al. 2017, 2020; Hayes et al. 2020, 2021). These trends are expected to continue, with complex and potentially adverse consequences for many marine mammal species. The potential implications of these and other related environmental changes for marine mammals, and the ways in which they are likely to interact with the effects of regional offshore wind development, are complex and uncertain. This is particularly true when evaluating potential effects at the scale of the action area. However, it is likely that some species are likely to adapt to these environmental changes more effectively than others. In contrast, populations that are already vulnerable, such as NARW, may face increased risk of extinction as a consequence of climate change and other factors. Due to the complexity around the effects of climate change on marine mammals, it is not possible to determine the nature, magnitude, or extent of potential long-term impacts on ESA-listed marine mammals that could result from climate change.

6.2 Sea Turtles

Global climate change is an ongoing potential risk to sea turtles, although the associated impact mechanisms are complex, not fully understood, and difficult to predict with certainty. Possible impacts to sea turtles likely to be worsened by climate change include increased storm severity and frequency; changes in nearshore habitat suitability caused by increased erosion from upland sources; exposure to disease; ocean acidification; and altered habitat, prey availability, ecology, and migration patterns (Hawkes et al. 2009).

However, some of these potential impacts could also contribute to potential benefits associated with the creation of artificial reef habitat and may represent an incrementally increasing impact over the life of the Project. The potential implications of these and other related environmental changes and how they interact with the effects of regional offshore wind development, are complex and uncertain. For example, the distribution of leatherback sea turtles in the North Atlantic is shifting northwards in response to changes in water temperature (McMahon and Hays 2006). Should this trend continue, it could lead to increased interactions between this species and offshore wind farms on the North Atlantic OCS, potentially magnifying the impacts and benefits described above. Over time, climate change, in combination with coastal and offshore development, would alter existing habitats, potentially rendering some areas unsuitable for certain species and more suitable for others.

6.3 Marine Fish

Global climate change is altering water temperatures, circulation patterns, and oceanic chemistry at global scales. These changes have affected habitat suitability for the finfish community of the geographic analysis area and surrounding region. For example, several finfish species have shifted in distribution to the northeast, farther from shore and into deeper waters, in response to an overall increase in water temperatures and an increasing frequency of marine heat waves (NOAA 2021). Warmer water could influence finfish migration and could increase the frequency or magnitude of disease (Brothers et al. 2016; Hoegh-Guldberg and Bruno 2010). Climate change is also contributing to shifts in finfish geographic ranges, individual fish health and viability, increased frequency of fatal marine heatwaves, and apparent reductions in marine productivity (NOAA 2021). These trends are expected to continue with or without the project and to what extent that project may affect the overall general trend cannot be quantified.

The relatively broad range of Atlantic sturgeon’s migratory and foraging habitat indicates the species has physiological and dietary flexibility that is likely to provide some ability to adapt to changing conditions. In contrast, manta rays are more likely to display changes in distribution in response to shifts in temperature regime and prey abundance. While difficult to predict with certainty, those shifts are likely to be of similar magnitude to those displayed by other planktivorous marine species like NARW (Meyer-Gutbrod et al. 2015) and leatherback sea turtles (McMahon and Hays 2006).

7.0 Conclusions and Effect Determinations

BOEM has concluded that the construction and installation, O&M, and decommissioning of the proposed RWF and RWEC project **may affect** and is **likely to adversely affect** all ESA-listed species under NMFS jurisdiction that are known to or could potentially occur in the action area, with the exception of the giant manta ray. The proposed action is not likely to adversely affect manta ray as the likelihood of their occurrence in the action area during construction and installation is discountable, and the best available information indicates that the operational effects of the action on these species would be insignificant. Therefore, the proposed action **may affect**, but is **not likely to adversely affect** this species. The supporting rationale for these effect determinations are summarized by species in Table 7.1 and described below. No designated critical habitat for NMFS ESA-listed species occurs in the action area; therefore, the proposed action will have **no effect** on critical habitat for these species.

Table 7.1. Effect Determination Summary for NMFS ESA-Listed Species Known or Likely to Occur in the Action Area for Each Activity (or Stressor).

Species	Construction - Underwater Noise	Construction – Vessel Traffic	Construction – Habitat Disturbance	Construction – Air Emissions	Surveys – HRG Surveys	Surveys – FRMP	Operations – Presence of Structures	Operations – Underwater Noise	Operations – Vessel Traffic	Operations – Displacement	Operations – Unanticipated Events	Effect Determination
Blue whale	S	D	I	I	I	I	I	I	D	I	I	May affect, likely to adversely affect
Fin whale	S	D	I	I	I	I	I	I	D	I	I	May affect, likely to adversely affect
NARW	S	D	I	I	I	I	I	I	D	I	I	May affect, likely to adversely affect
Sei whale	S	D	I	I	I	I	I	I	D	I	I	May affect, likely to adversely affect
Sperm whale	S	D	I	I	I	I	I	I	D	I	I	May affect, likely to adversely affect
North Atlantic DPS Green sea turtle	S	I	D	I	I	I	D	I	I	D	I	May affect, likely to adversely affect
Kemp's ridley sea turtle	S	S	D	I	I	I	D	I	S	D	I	May affect, likely to adversely affect
Leatherback sea turtle	S	S	D	I	I	I	D	I	S	D	I	May affect, likely to adversely affect
Loggerhead sea turtle – NW Atlantic Ocean DPS	S	S	D	I	I	I	D	I	S	D	I	May affect, likely to adversely affect
Atlantic sturgeon	S	S	I	I	I	S	I	I	S	I	I	May affect, likely to adversely affect
Giant manta ray	I	I	I	I	I	I	I	I	I	I	I	May affect, not likely to adversely affect

*NE-No Effect, I-Insignificant, D-Discountable, ID-Insignificant/Discountable, S-Significant

Based on the analysis in Section 5, the construction and installation, O&M, and decommissioning of the proposed action **may affect** and is **likely to adversely affect** NMFS ESA-listed species known to or potentially occurring in the action area. This conclusion is based on the following rationale:

(1) The proposed action **may affect** ESA-listed blue whale, fin whale, sei whale, NARW, sperm whale, North Atlantic DPS green sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, NW Atlantic Ocean DPS loggerhead sea turtle, and Atlantic sturgeon because these species are known to occur in the action area and will be exposed to the effects of project construction and installation, O&M, and decommissioning.

(2) The proposed action is **likely to adversely affect** blue whale, fin whale, NARW, and sei whale because:

- Individual animals could occur in the action area during construction and installation-related impact pile driving (May to November).
- Individuals of each species would be exposed to pile driving and UXO detonation noise sufficient to cause TTS and/or behavioral effects, including startling, displacement, cessation of feeding, and increased physiological stress.
- PSO monitoring, vessel speed restrictions, and related EPMs and mitigation measures may not prevent incidental exposure of individual whales to construction noise above behavioral thresholds.
- WTG operational noise would exceed the behavioral effects threshold for non-impulsive noise sources within up to 2,000 feet of each foundation under high wind conditions. This could potentially cause auditory masking effects that decrease the available communication space for marine mammals in the LFC hearing group.

(3) The proposed action is **likely to adversely affect** sperm whale because:

- Individual sperm whales could occur in the action area during construction-related impact pile driving.
- Individual animals are likely to be exposed to underwater noise from impact pile driving.
- PSO monitoring may not be able to prevent incidental exposure of individual whales to pile driving noise above behavioral thresholds.

- The proposed action is **likely to adversely affect** green, Kemp's ridley, leatherback, and NW Atlantic Ocean DPS loggerhead sea turtles because:

- These species are seasonally present in the action area at low densities. Project specific modeling indicates the likelihood of exposure to underwater noise impacts from project construction that exceed injury and behavioral effects thresholds is significant, but likely mitigated when PSO monitoring, clearance zone management, and other mitigation measures are considered.
- The risks of injury and mortality from construction and installation and O&M vessel strikes cannot be discounted and may be significant. Vessel speed restrictions, PSO monitoring, and other mitigation measures will avoid and minimize the risk.
- The operational effects of the RWEC on this species are expected to be biologically insignificant.
- Risk of injury or mortality resulting from fisheries surveys are expected to be insignificant.

(4) The proposed action is **likely to adversely affect** Atlantic sturgeon because:

- All listed DPSs of Atlantic sturgeon are known or could potentially occur in the action area as adults or subadults during any month of the year.
- Impact pile driving will produce underwater noise in excess of cumulative injury and behavioral-level thresholds up to approximately 0.3 and 7 miles from the source, respectively. Exposure to injury-level noise effects cannot be discounted.
- UXO detonation would exceed injury-level effect thresholds up to 0.6 miles from the source. Exposure to injury-level noise effects cannot be discounted since clearance zones cannot be used effectively for the protection of Atlantic sturgeon.
- Fisheries surveys could result in injury or mortality of Atlantic sturgeon.

(5) The proposed action is **not likely to adversely affect** manta ray because

- The likelihood of occurrence in the action area during construction and installation and exposure to construction and installation-related impacts on the environment is insignificant.
- The operational effects of the RWF on manta ray would be discountable.
- The operational effects of the RWEC on manta ray would be discountable.
- Risk of injury or mortality resulting from fisheries surveys is considered discountable.

The remaining effects of the proposed action on ESA-listed species are likely to be insignificant or discountable because:

- Other than underwater noise, construction and installation-related disturbance would be short-term in duration and within the range of environmental baseline conditions in the action area (e.g., suspended sediment plumes) and therefore discountable.
- Project-related vessel activity would not measurably change the level of collision risk along already-busy transit corridors. Vessel speed restrictions, PSO monitoring, and other mitigation measures would effectively minimize risk to ESA-listed marine mammals and sea turtles such that the risk of injury or death from vessel collisions would be discountable.
- There is no information to indicate that ESA-listed species would be measurably affected by the presence of WTG towers, scour protection, and cable armoring. These structures would not substantially alter marine habitat conditions for ESA-listed species in the action area and would therefore be insignificant.
- Operational EMF would be within the range of environmental baseline conditions in the action area, in most areas below species detectability thresholds, and therefore insignificant.

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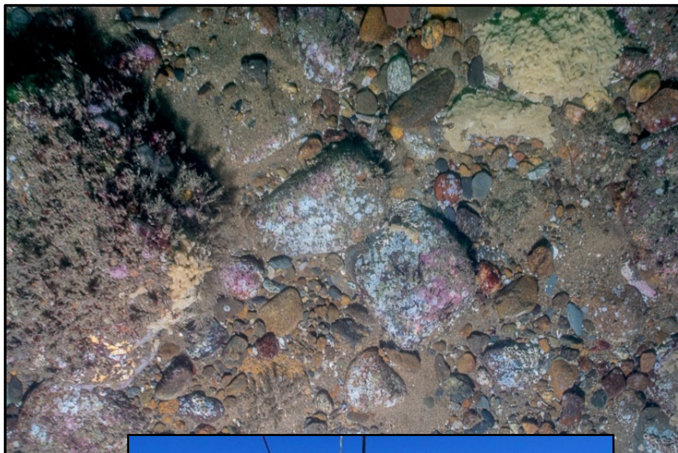
Appendix A – Fisheries Research and Monitoring Plan

Revolution Wind
Fisheries Research and Monitoring Plan

October 2021



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ACCOL	Anderson Cabot Center for Ocean Life
AIC	Akaike Information Criteria
AIS	Automatic Identification System
AC	Alternating current
ANOSIM	Analysis of Similarities
ANOVA	Analysis of Variance
aRPD	apparent redox potential discontinuity
ASMFC	Atlantic States Marine Fisheries Commission
BACI	Before-After-Control-Impact
BAG	Before-After-Gradient
BIWF	Block Island Wind Farm
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
CI	Confidence Interval
CPUE	Catch per Unit Effort
cm	centimeter
CMECS	Coastal and Marine Ecological Classification Standard
CPUE	Catch per unit effort
CTD	Conductivity Temperature Depth
CV	Coefficient of Variation
DMF	Division of Marine Fisheries
DSLR	Digital single-lens reflex
DVR	Digital video recorder
ECDF	Empirical Cumulative Distribution Function
EFH	Essential Fish Habitat
EFP	Exempted Fishing Permit
EMF	electromagnetic fields
ESA	Endangered Species Act
FAB	Fisheries Advisory Board
FGDC	Federal Geographic Data Committee
FMP	Fisheries Monitoring Plan
ft	feet

GLM	Generalized Linear Model
GAM	Generalized Additive Model
GPS	Global Positioning System
HD	High definition
HMS	Highly migratory species
HVTC	High voltage direct current
IAC	Inter-Array Cable
ICF	Interconnection Facility
INSPIRE	INSPIRE Environmental, LLC
IT IS	Integrated Taxonomy Information System
kg	kilogram
km	kilometer
kV	kilovolt
LED	Light-emitting diode
LOA	Letter of Acknowledgement
LPIL	Lowest possible identification level
MADMF	Massachusetts Division of Marine Fisheries
MA/RI WEA	Massachusetts/Rhode Island Wind Energy Area
MATOS	Mid-Atlantic Telemetry Observation System
MBES	Multibeam Echosounder
m	meter
mi	mile
mm	millimeter
MMPA	Marine Mammal Protection Act
NEAMAP	Northeast Area Monitoring and Assessment Program
NEFOP	Northeast Fisheries Observer Program
NEFSC	Northeast Fisheries Science Center
nMDS	Non-metric Multidimensional Scaling
NMFS	National Marine Fisheries Service
NMFS-PRD	National Marine Fisheries Service Protected Resources Division
NOAA	National Oceanic and Atmospheric Administration
NYSERDA	The New York State Energy Research and Development Authority
Ocean SAMP	Ocean Special Area Management Plan

OCS	Outer Continental Shelf
OnSS	Onshore Substation
OSS	Offshore Substation
OSW	Offshore Wind
PERMANOVA	Permutational Analysis of Variance
PV	Plan View
QA/QC	Quality Assurance/Quality Control
REFE	Reference Area East
REFS	Reference Area South
RI CRMC	Rhode Island Coastal Resources Management Council
RIDEM	Rhode Island Department of Environmental Management
RIVTS	RIDEM DMF Ventless Trap Survey
ROSA	Responsible Offshore Science Alliance
ROV	Remotely Operated Vehicle
RPD	Redox potential discontinuity
R/V	Research Vessel
RWEC	Revolution Wind Export Cable
RWEC–OCS	Revolution Wind Export Cable – Outer Continental Shelf
RWEC–RI	Revolution Wind Export Cable – Rhode Island State Waters
RWF	Revolution Wind Farm
SFW	South Fork Wind
SIMPER	Similarity Percentages
SNECVTS	Southern New England Cooperative Ventless Trap Survey
SOD	Sediment oxygen demand
SPI	Sediment Profile Imaging
SS	Systematic (random) sampling
SSS	Side-Scan Sonar
UHD	Ultra-High Definition
USBL	Ultra Short Baseline
VMS	Vessel Monitoring System
VTR	Vessel Trip Report
VTS	Ventless Trap Survey
WTG	Wind Turbine Generators

1.0 Introduction

Revolution Wind, LLC (Revolution Wind), a 50/50 joint venture between Orsted North America Inc. (Orsted)[1] and Eversource Investment, LLC (Eversource), proposes to construct and operate the Revolution Wind Farm Project (hereinafter referred to as the Project). The wind farm portion of the Project will be located in federal waters on the Outer Continental Shelf (OCS) in the designated Bureau of Ocean Energy Management (BOEM) Renewable Energy Lease Area OCS-A 0486 (Lease Area) (Figure 1)[2]. The Lease Area was awarded through the BOEM competitive renewable energy lease auction of the Wind Energy Area off the shores of Rhode Island and Massachusetts (MA/RI WEA). Other components of the Project will be located in state waters of Rhode Island and onshore in North Kingstown, Rhode Island. The Project will specifically include the following offshore and onshore components:

Offshore:

- up to 100 Wind Turbine Generators (WTGs) connected by a network of Inter-Array Cables (IAC);
- up to two Offshore Substations (OSSs) connected by an OSS-Link Cable; and
- up to two submarine export cables (referred to as the Revolution Wind Export Cable [RWEC]), generally co-located within a single corridor.

Onshore:

- a landfall location located at Quonset Point in North Kingstown, Rhode Island;
- up to two underground transmission circuits (referred to as the Onshore Transmission Cable), co-located within a single corridor; and
- a new Onshore Substation (OnSS), Interconnection Facility (ICF) and associated interconnection circuits located adjacent, and connecting to, the existing Davisville Substation in North Kingstown, Rhode Island.

The Project's components are grouped into four general categories: the Revolution Wind Farm (RWF), inclusive of the WTGs, OSSs, IAC, and OSS-Link Cable; the RWEC–OCS, inclusive of up to 25 miles (mi) (40 kiometers [km]) of the RWEC in federal waters; the RWEC–RI State Waters, inclusive of up to 23 mi (37 km) of the RWEC in state waters; and Onshore Facilities, inclusive of a Landfall Work Area, the Onshore Transmission Cable, and new OnSS and ICF (including associated interconnection circuits). Also, Figure 1 depicts the RWF Envelope and RWEC Envelope areas, which are based on the extent of geophysical data collection and indicate the area within which offshore Project infrastructure will be sited; seafloor impacts (including from vessel anchoring) will not extend beyond these areas. Revolution Wind assumes that all state and federal permits will be issued between Q1 and Q3 2023. Construction will begin as early as Q1 2023, beginning with the installation of the onshore components and initiation of seabed preparation activities (clearing of debris and obstructions).

This Fisheries Monitoring Plan (FMP) has been developed in accordance with recommendations set forth in "Guidelines for Providing Information on Fisheries for Renewable Energy Development

[1] Note that in October 2018, Deepwater Wind LLC was acquired by Orsted North America Inc.
[2] On January 10, 2020, a request was made to BOEM to segregate Lease Area OCS-A 0486 to accommodate both the Revolution Wind Farm Project and South Fork Wind Farm Project. The Revolution Wind Farm Project retained lease number OCS-A 0486 while a new lease number was assigned for the SFWF Project (OCS-A 0517).

on the Atlantic Outer Continental Shelf" (BOEM 2019), which state that a fishery survey plan should aim to:

- Identify and confirm which dominant benthic, demersal, and pelagic species are using the project site, and when these species may be present where development is proposed;
- Establish a pre-construction baseline which may be used to assess whether detectable changes associated with proposed operations occurred in post-construction abundance and distribution of fisheries;
- Collect additional information aimed at reducing uncertainty associated with baseline estimates and/or to inform the interpretation of research results; and
- Develop an approach to quantify any substantial changes in the distribution and abundance of fisheries associated with proposed operations.

Further, BOEM provides guidance related to specific survey gears that may be used to complete the fisheries monitoring including otter trawl, beam trawl, gillnet/trammel net, and ventless traps. BOEM guidelines stipulate that two years of pre-construction monitoring data are recommended, and that data should be collected across all four seasons. Consultations with BOEM and other agencies are encouraged during the development of fisheries monitoring plans. BOEM also encourages developers to review the existing data, and to seek input from the local fishing industry to select survey equipment and sampling protocols that are appropriate for the area of interest.

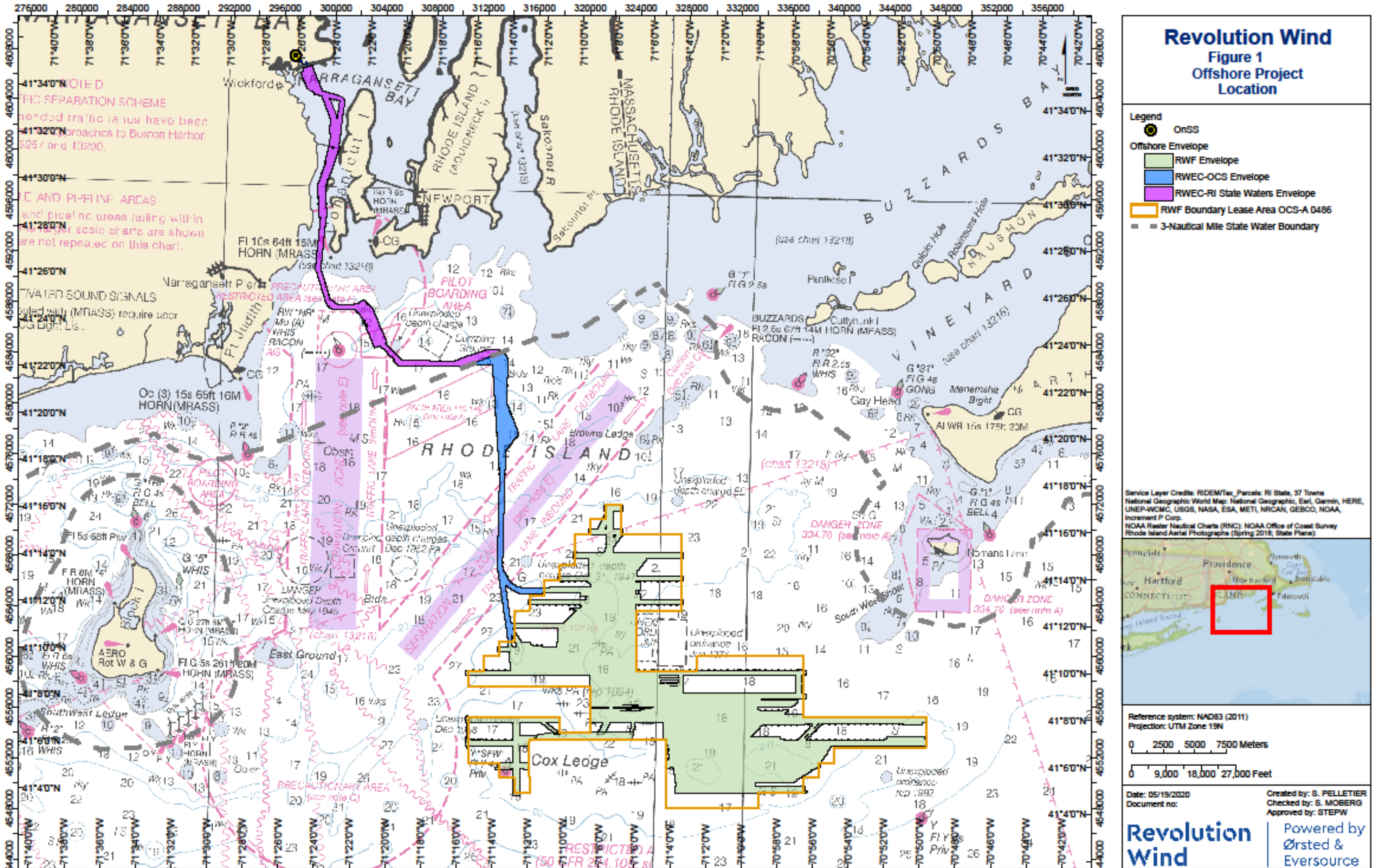


Figure 1. Map of the Project Area, including the Export Cable route

The Rhode Island Coastal Resources Management Council (RI CRMC) also set out monitoring guidelines as part of the Rhode Island Ocean Special Area Management Plan (Ocean SAMP; RICRMC 2010) which stipulate that RI CRMC shall work in conjunction with the Joint Agency Working Group to "determine requirements for monitoring prior to, during, and post construction. Specific monitoring requirements shall be determined on a project-by-project basis and may include but are not limited to the monitoring of: coastal processes and physical oceanography, underwater noise, benthic ecology, avian species, marine mammals, sea turtles, fish and fish habitat, commercial and recreational fishing, recreation and tourism, marine transportation, navigation and existing infrastructure, and cultural and historic resources." Further guidance from the RI CRMC (McCann et al. 2013) dictates that "[t]his assessment shall examine the relative abundance, distribution, and different life stages of these species at all four seasons of the year. This assessment shall comprise a series of surveys, employing survey equipment and methods that are appropriate for sampling finfish, shellfish, and crustacean species at the project's proposed location. Such an assessment shall be performed at least four times: pre-construction (to assess baseline conditions); during construction; and at two different intervals during operation. At each time this assessment must capture all four seasons of the year. This assessment may include evaluation of survey data collected through an existing survey program, if data are available for the proposed site."

This FMP was developed through an iterative process, and the survey protocols and methodologies were refined and updated based on feedback received from stakeholder groups. Revolution Wind met with numerous regulatory agencies and stakeholders during the development of this plan including; National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Bureau of Ocean Energy Management, Rhode Island Coastal Resources Management Council, Rhode Island Department of Environmental Management Division of Marine Fisheries, Massachusetts Division of Marine Fisheries, Massachusetts Office of Coastal Zone Management, and representatives from the Responsible Offshore Science Alliance and the Responsible Offshore Development Alliance.

Several revisions to the FMP were made based on the feedback received during meetings with agency staff. Power analyses were developed for both the trawl survey (Appendix 2) and the ventless trap survey (Appendix 3), and the power analyses were informed by an examination of contemporary fisheries independent data collected in proximity to the RWF. Cumulative prey curves were derived from the Block Island Wind Farm trawl survey data and used to determine the target sample sizes for stomach content analyses for the trawl survey. A distance-based sampling element was added to the plan for lobsters and Jonah crabs during the post-construction phase of the project, and additional protocols were added to better delineate the habitats at the RWF and reference areas. The proposed biological sampling protocols for lobsters and crabs were also modified to be consistent with the sampling protocols used by state agencies during their ventless trap surveys. The acoustic telemetry monitoring was also added to the monitoring plan in response to agency feedback, and the acoustic telemetry monitoring will allow for the examination of cause-effect relationships for Highly Migratory Species at the RWF and elsewhere in the MA/RI WEA. Following consultation with staff at the National Marine Fisheries Service (NMFS) Protected Resources Division several measures were added to the FMP to minimize the potential for interactions with protected species. Distance based sampling elements were incorporated into the sampling protocols for the benthic monitoring plan. Finally, at the request of agency scientists we have proposed to host annual workshops to better disseminate the monitoring results to local stakeholders, particularly members of the fishing industry.

Revolution Wind is committed to conducting sound, credible science using the following guiding principles:

- Producing transparent, unbiased, and clear results from all research

- Working with commercial and recreational fishermen to identify areas important to them
- Collecting long-term data sets to determine trends and develop knowledge
- Promoting the smart growth of the American offshore wind industry
- Focusing on maintaining access and navigation in, and around, our wind farms for all ocean users
- Completing scientific research collaboratively with the fishing community
- Being accessible and available to the fishing industry
- Utilizing standardized monitoring protocols when possible and building on and supporting existing fisheries research
- Sharing data with all stakeholder groups
- Maintaining data confidentiality for sensitive fisheries dependent monitoring data

2.0 Summary of Regional Fisheries Monitoring

Fishery dependent and independent data were considered throughout the development of this FMP. There are several longstanding fishery independent surveys in the vicinity of the Lease Area and along the RWEC which provide a time-series of information that can be used to characterize the regional fish and invertebrate communities prior to the start of offshore construction. In addition, several recent case studies provide high-resolution fisheries independent data for the Wind Energy Areas of southern New England. This section provides a brief synopsis of relevant fisheries-independent monitoring.

Data collected during the Northeast Fisheries Science Center (NEFSC) bottom trawl survey between 2003 and 2014 were synthesized to provide an overview of the species composition in each WEA (Guida et al. 2016). In the MA/RI WEA, little and winter skate were the dominant taxa across all seasons (Guida et al. 2016). Ocean pout, Atlantic herring, windowpane flounder, longhorn sculpin, and yellowtail flounder were dominant taxa during the cold season (i.e., winter and spring surveys), while longfin squid, scup, butterfish, northern sea robin, sea scallops, and spiny dogfish were dominant taxa during the fall surveys (Guida et al. 2016). Within the MA/RI WEA, black sea bass, Atlantic cod, ocean quahog, and sea scallops were noted as species that are commonly present and vulnerable to disturbance from the construction and operation of offshore wind farms. Friedland et al (2021) combined catch data from the NEFSC bottom trawl survey (1976-2018) with a suite of oceanographic data to create species distribution models that quantified the reliance of several species on habitats within wind energy lease areas.

Seasonal trawl surveys conducted by the Massachusetts Division of Marine Fisheries (MADMF) and the Rhode Island Department of Environmental Management (RIDEM) provide a time-series of relative abundance for fish and invertebrate resources in the nearshore waters of southern New England. Trawl surveys have also been carried out in Narragansett Bay for decades by the University of Rhode Island and RIDEM. The Northeast Area Assessment and Monitoring Program (NEAMAP) biannual trawl survey conducts sampling each spring and fall in shallow nearshore waters from Cape Hatters northward to Block Island Sound (Bonzek et al. 2017). Much of the information from these fishery-independent surveys is available through the Northeast Ocean Data Portal (http://www.northeastoceandata.org/). The Northeast Ocean Data Portal offers broad geographic coverage, enabling a characterization of the fish and invertebrate resources that may be present in the Lease Area, and also along the RWEC.

Walsh and Guida (2017) sampled during the spring within the MA/RI WEA using a two-meter (m) beam trawl and an otter trawl net (NEAMAP trawl survey) and compared the relative abundance, species composition, and length frequency distributions of fish and shellfish that were collected with each sampling gear. The beam trawl more effectively sampled juvenile and smaller fish and invertebrate prey species, while the otter trawl sampled a greater proportion of commercially important demersal and pelagic species. Walsh and Guida (2017) recommended that sampling occur throughout the year to characterize seasonal variation in the species assemblage and suggested that sampling with multiple gear types may provide a more holistic understanding of the fish and invertebrate community.

The Southern New England Cooperative Ventless Trap Survey (SNECVTS) was funded by BOEM to collect pre-construction information on the relative abundance, demographics and distribution of lobster and Jonah crab in the MA/RI WEA (Collie and King 2016). The lease areas were divided into sampling blocks, and sample locations were selected at random within each sampling block. Catches were processed using sampling protocols consistent with the Atlantic States Marine Fisheries Commission (ASMFC) protocols. Sampling occurred from May through November in 2014 and 2015, and another season of sampling occurred in 2018 (Collie and King 2016; http://www.cfrfoundation.org/sencvts). This survey provided high-resolution information on the relative abundance and spatial and temporal distribution of lobsters and Jonah crab within the MA/RI WEA and collected valuable information on important demographic parameters including sex ratios, shell disease, egg state and cull status.

From December 2015 through April 2016 Siemann and Smolowitz (2017) used scallop dredge surveys to characterize the distribution and habitat preferences of monkfish and flatfish in the southern New England lease areas and used video cameras mounted to a benthic sled to map habitat characteristics. Catches observed in the dredge survey were compared to samples from the NEFSC spring bottom trawl survey (2011 through 2015).

Malek (2015) used beam trawl and otter trawl survey tows, along with acoustics and seafloor video surveys to evaluate the fine-scale spatial structure of the demersal fish and invertebrate community in Block Island and Rhode Island Sounds. This study documented persistent seasonal variability in the fish and invertebrate community, illustrating the need for year-round monitoring to document the potential impacts from offshore wind development. Further, distinct species assemblages were identified, which were influenced by a combination of physical, oceanographic, and biological factors. This study identified summer flounder, silver hake, black sea bass, American lobster, and sea scallops as indicator species that should be considered when assessing the potential impacts of offshore wind development.

Additional data sources that characterize the pre-construction community composition in the area include:

- Industry-based trawl surveys for yellowtail flounder (Valliere and Pierce, 2007; Cadrin et al. 2013a) and winter flounder (Cadrin et al. 2013b) in southern New England.
- Trawl surveys and ventless trap surveys conducted to assess the impacts of the Block Island Wind Farm (CoastalVision 2013; Wilber et al. 2018).
- Fisheries independent surveys for the sea scallop resource including drop camera surveys (Bethoney et al. 2018), dredge surveys (Hart 2015), and towed-camera surveys (NEFSC 2010).

MADMF identified a list of priority species that could be considered as key assessment indicators of cumulative biological impacts associated with wind farm development (MADMF 2018). Their priority list was developed with consideration given to several metrics including, but not limited to commercial value, abundance in fishery-independent surveys, vulnerability to construction, and essential fish habitat (EFH). The species identified by MADMF (2018) were Atlantic cod, yellowtail flounder, winter flounder, summer flounder, monkfish, ocean pout, red hake, black sea bass, longfin squid, scup, Jonah crab, lobster, ocean quahog, sea scallop, bluefin tuna, little skate, winter skate, and sharks. MADMF (2018) also recommended that a range prey species be investigated for cumulative impacts, including sand lance, Atlantic herring, menhaden, and Atlantic mackerel.

Petruny-Parker et al., (2015) used input from a range of stakeholders to identify sampling tools, research needs, and best practices for monitoring of offshore wind development. The authors noted that sampling should be completed in collaboration with the local fishing industry and should employ a variety of gear types to target a range of species that may be impacted. Their report also identified a list of priority species to be considered during research and monitoring that included alewife, American lobster, Atlantic cod, Atlantic herring, Atlantic sturgeon, black sea bass, blueback herring, bluefish, blue mussels, butterfish, haddock, Jonah crabs, little/winter skates, longfin squid, mackerels, mako shark, menhaden, monkfish, ocean quahogs, pollock, red hake, sea scallops, scup, silver hake, spiny dogfish, striped bass, summer flounder, surf clams, thresher shark, tunas, winter flounder, and yellowtail flounder. Petruny-Parker et al., (2015) also highlighted the need for seasonal sampling prior to construction and recommended that two to three years of monitoring should occur prior to the commencement of offshore construction.

Regional monitoring studies have been recommended to better understand the cumulative impact of offshore wind development on marine resources and the fishing community, and there has been a call for developers to standardize their monitoring approaches to the extent practicable to help understand cumulative impacts of offshore wind development (McCann, 2012; MADMF 2018). While this FMP was developed with an emphasis on the species and fisheries that are most important to the Project Area, the monitoring tools and protocols described herein were selected to complement the regional monitoring described above, as well as planned and ongoing data collection efforts by Ørsted, other offshore wind developers, and state and federal agencies in the region.

3.0 Baseline Conditions

This section summarizes the existing conditions within the Lease Area and along the RWEC which were considered in development of this FMP. Complete detail regarding baseline conditions in the Lease Area and RWEC is available in the Project's Construction and Operations Plan (https://www.boem.gov/Revolution-Wind).

3.1 Habitat Considerations

Species with EFH designations for one or more life stages within the Lease Area and/or along the RWEC include the following[3]:

- New England Fish – Atlantic cod, Atlantic herring, wolfish, haddock, monkfish, ocean pout, pollock, red hake, silver hake, white hake, windowpane flounder, winter flounder, witch flounder, yellowtail flounder, little skate, and winter skate
- Mid-Atlantic Fish – butterfish, Atlantic mackerel, black sea bass, bluefish, scup, and summer flounder
- Invertebrates – sea scallop, Atlantic surfclam, longfin inshore squid, ilex squid, and ocean quahog
- Highly Migratory Species – albacore tuna, bluefin tuna, skipjack tuna, and yellowfin tuna
- Sharks – basking shark, blue shark, common thresher shark, dusky shark, sand tiger shark, shortfin mako shark, smoothhound shark complex, spiny dogfish, and white shark

3.2 Fishing Activity in The Region

Several fisheries and gear types operate in the RWF. From 2008 through 2019 the annual number of fishing trips that occurred within the RWF ranged from a low of 4,230 trips in 2019 to a high of 7,591 trips in 2008 (National Marine Fisheries Service[4]). Over the 12-year period from 2008 through 2019, the number of vessels that made at least one trip in the RWF ranged from 251 through 331. Fishing trips that occurred within the RWF lease area operated under several fishery management plans, with the summer flounder, scup, black sea bass being the most commonly represented FMP in the RWF lease area. Other fisheries management plans that commonly had active vessels within RWF during this time include: American lobster FMP, squid, mackerel, butterfish FMP, monkfish FMP, skate FMP, small-mesh multispecies FMP and the bluefish FMP. In 2019, the majority of trips within the RWF lease area were made by vessels with a home port in Pt. Judith, RI. Vessels from the following home ports made at least 100 trips within the RWF lease area in 2019: New Bedford, MA, Little Compton, RI, Newport, RI, Westport, MA and Menemsha, MA.

Commercial fishing activity in the RWF Project Area and along the RWEC was also characterized using Vessel Monitoring System (VMS) (e.g., Northeast Ocean Data Portal) and Vessel Trip Report (VTR) data, information provided in the Ocean SAMP (RICRMC 2010), through conversations with commercial fishermen, and based on input from Revolution Wind's fisheries liaisons.

[3] Technical Report - Essential Fish Habitat Assessment - Revolution Wind Offshore Wind Farm (boem.gov)
[4] https://www.greateratlantic.fisheries.noaa.gov/ro/fso/reports/WIND/WIND_AREA_REPORTS/Revolution_Wind.html#select_gear_types

From 2009 through 2017, the bottom trawl fishery accounted for the highest revenue and landings in the RWF (Table 1). VMS data indicates that the majority of groundfish effort from 2011 to 2016 was concentrated in the western and northern portion of the RWF. Other fisheries that routinely operate in the RWF include the pot fishery for lobsters and crabs, the sink gillnet fishery, the scallop dredge fishery, and the midwater trawl fishery. VMS data indicated that fishing for monkfish was widespread throughout the RWF. The herring and pelagic (herring/mackerel/squid) fisheries primarily operated on the western and northern portions of the RWF. Likewise, the dredge fisheries for surfclams and ocean quahogs primarily operated in the western and northern portions of the RWF. As with the other mobile gear fisheries, the scallop dredge fishery primarily operated in the western portion of the Lease Area, although there were also some small areas of high fishing effort along the southern border of the Lease Area, adjacent to the South Fork Wind Farm Project lease area. Spatial information on lobster effort is more limited due to a lack of VMS or Automatic Identification System (AIS) requirements, but the Ocean SAMP documents indicate that fixed gear if fished throughout the MA/RI WEA (RICRMC 2018). The for-hire recreational fishery mainly operates in the southwest portion of the MA/RI WEA, including Cox Ledge (RICRMC 2018). It is noted that fisheries dependent data is heavily influenced by fisheries management, including temporal and spatial closures that are designed to limit fishing mortality, protect sensitive habitats or activities (e.g., spawning) or fulfill another management objective. Therefore, the fisheries dependent data summarized within this section cannot be considered to be wholly representative of the underlying abundance and availability of species within the lease area, or along the cable route.

Table 1. A summary of federal VTR data, by gear type, for vessels fishing in the in the RWF area from 2009 to 2017 (INSPIRE Environmental 2020[5]).

	Annual Average Revenue and Landings from within RWF		Annual Average of Total Revenue and Landings		Percent of Total Gear Values from RWF	
Gear	Revenue	Landings	Revenue	Landings	% of Revenue	% of Landings
Bottom Trawl	330,811	805,298	10,345,534	17,650,034	3.20	4.56
Pot	309,044	97,245	45,170,421	23,622,011	0.68	0.41
Sink Gillnet	263,817	383,264	4,587,604	6,446,946	5.75	5.95
Dredge	174,324	20,636	35,344,833	15,083,131	0.49	0.14
All Others	45,641	380,191	1,630,016,690	1,281,322,761	<0.01	0.03
Midwater Trawl	25,900	259,659	2,388,786	19,750,762	1.08	1.32
By Hand	5,776	1,652	566,211	236,037	1.02	0.70

Source: NOAA Fisheries, 2019c.
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is in USD deflated to 2010 for consistency.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.
% = percent

Based on federal VTR data the species that generated the most revenue and landings to the fisheries operating in the RWF from 2009 to 2017 are summarized in Table 2. Lobsters accounted for the greatest revenue across this time period. Aside from lobsters, the species that provided the greatest revenue in the RWF Project Area were flatfish, hakes, Atlantic herring, scup, black sea bass, and squid.

5 [Commercial and Recreational Fisheries Technical Report - Revolution Wind Offshore Wind Farm (boem.gov)]

Table 2. A summary of federal VTR data, by species, for vessels fishing in the in the RWF area from 2009 to 2017 (INSPIRE Environmental 2020).

	Annual Average Revenue and Landings from within RWF		Annual Average of Total Revenue and Landings		Percent of Total Species Values in RWF	
Species	Revenue	Landings	Revenue	Landings	% of Revenue	% of Landings
Lobster, America	214,904	50,374	507,710,672	138,232,706	0.04	0.04
Flounders	88,240	33,976	53,080,045	23,015,911	0.17	0.15
Hakes	60,136	141,855	15,760,216	20,652,426	0.38	0.69
Herring, Atlantic	42,852	455,959	26,499,546	166,320,214	0.16	0.27
Scup	36,987	63,108	9,280,444	14,364,599	0.40	0.44
Squids	34,084	30,416	38,571,711	48,152,606	0.09	0.06
Sea Bass, Black	32,211	7,547	8,045,522	2,477,656	0.40	0.31
Whelk, Channeled	31,673	4,512	7,175,012	1,232,408	0.44	0.37
Mackerel, Atlantic	20,008	198,560	3,889,243	16,596,797	0.51	1.20
Dogfish, Spiny	14,296	81,592	3,619,191	18,787,974	0.40	0.43
Crab, Jonah	14,121	23,578	10,983,269	14,424,939	0.13	0.16
All Others	11,886	21,067	946,435,275	407,953,101	0.00	0.01
Butterfish	9,141	16,100	2,180,724	3,340,689	0.42	0.48
Bass, Striped	4,425	1,131	18,797,974	5,984,307	0.02	0.02
Bluefish	2,811	5,382	2,796,095	4,627,112	0.10	0.12
Tautog	381	128	926,176	273,651	0.04	0.05
Weakfish	263	142	319,712	207,805	0.08	0.07
Dogfish, Smooth	231	464	976,231	2,039,068	0.02	0.02
Bonito	191	86	112,986	53,480	0.17	0.16
Cunner	138	97	20,410	6,394	0.68	1.52
Spot	88	175	3,139,254	2,828,116	<0.01	0.01
Eel, Conger	40	61	49,241	68,105	0.08	0.09
Sea Robins	13	33	20,812	124,470	0.06	0.03
Whiting, King	1	1	902,941	810,033	<0.01	<0.01

Source: NOAA Fisheries, 2019c. ACCSP, 2019.
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is in USD deflated to 2010 for consistency.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.
% = percent

Based on federal VTR data, fishing vessels from Rhode Island and Massachusetts accounted for the majority of landings and revenue from the RWF area between 2009 and 2017 (Table 3).

Table 3. A summary of federal VTR data, by state, for vessels fishing in the in the RWF area from 2009 to 2017 (INSPIRE Environmental 2020).

	Annual Average Revenue and Landings from within RWF		Annual Average of Total Revenue and Landings		Percent of Total State Values in RWF	
State	Revenue	Landings	Revenue	Landings	% of Revenue	% of Landings
Rhode Island	613,467	949,843	83,808,376	83,061,985	0.73	1.14
Massachusetts	398,575	811,785	547,819,893	272,427,302	0.07	0.30
New York	41,704	24,420	53,395,207	30,909,690	0.08	0.08
All Others	16,773	9,274	558,828,937	725,429,171	<0.01	<0.01
Connecticut	9,138	7,218	16,183,340	8,793,496	0.06	0.08

Source: NOAA Fisheries, 2019c. ACCSP, 2019.
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is in USD deflated to 2010 for consistency.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.
% = percent

Several federally permitted fisheries are active along the RWEC route. The revenues and landings presented below were estimated using a 10 km-wide buffer around the RWEC, to provide a reasonable geographic extent for fisheries that may occur around the RWEC corridor. Based on VTR data, the gear types that generated the greatest revenues and landings along the RWEC were bottom trawl, mid-water trawl, pot, sink gillnet, dredge, and by hand (Table 4). VMS data indicate there was high density of effort from the northeast multispecies fishery along portions of the RWEC route, particularly in coastal areas near the southwestern portion of

Narragansett Bay. There are also areas of very high fishing activity for pelagic species (herring/mackerel/squid) along the RWEC route in coastal waters east of Narragansett and Point Judith. VMS data suggests there is little directed fishing for surf clams and ocean quahogs, and relatively low effort for sea scallops, along the RWEC route.

Table 4. A summary of federal VTR data, by gear type, for vessels fishing along the RWEC route from 2009 to 2017 (INSPIRE Environmental 2020).

	Annual Average Revenue and Landings from within RWEC Fisheries Study Corridor		Annual Average of Total Revenue and Landings		Percent of Total Gear Values in RWEC Fisheries Study Corridor	
Gear	Revenue	Landings	Revenue	Landings	% of Revenue	% of Landings
Bottom Trawl	781,301	2,186,189	10,345,534	17,650,034	7.55	12.39
Midwater Trawl	389,676	3,969,291	2,388,786	19,750,762	16.31	20.10
Pot	314,797	136,028	45,170,421	23,622,011	0.70	0.58
All Others	110,642	464,104	1,630,016,690	1,281,322,761	0.01	0.04
Sink Gillnet	99,834	213,070	4,587,604	6,446,946	2.18	3.31
Dredge	27,746	9,072	35,344,833	15,083,131	0.08	0.06
By Hand	3,293	1,356	566,211	236,037	0.58	0.57

Source: NOAA Fisheries, 2019c.
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is in USD deflated to 2010 for consistency.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.
% = percent

Herring generated the greatest revenue for federally permitted vessels fishing within the RWEC, followed by lobster, squid, flounders, and scup (Table 5). Federally permitted vessels with home ports in Rhode Island and Massachusetts accounted for the vast majority of landings and revenue within the RWEC (Table 6).

Table 5. A summary of federal VTR data, by species, for vessels fishing along the RWEC route from 2009 to 2017 (INSPIRE Environmental 2020).

	Annual Average Revenue and Landings from within RWEC Fisheries Study Corridor		Annual Average of Total Revenue and Landings		Percent of Total Species Values in RWEC Fisheries Study Corridor	
Species	Revenue	Landings	Revenue	Landings	% of Revenue	% of Landings
Herring, Atlantic	516,170	4,870,454	26,499,546	166,320,214	1.95	2.93
Lobster, America	253,817	63,112	507,710,672	138,232,706	0.05	0.05
Squids	168,823	157,838	38,571,711	48,152,606	0.44	0.33
Flounders	157,876	49,611	53,080,045	23,015,911	0.30	0.22
Scup	144,737	280,427	9,280,444	14,364,599	1.56	1.95
All Others	46,271	30,389	946,435,275	407,953,101	0.01	0.01
Butterfish	42,181	62,394	2,180,724	3,340,689	1.93	1.87
Hakes	37,112	86,198	15,760,216	20,652,426	0.24	0.42
Sea Bass, Black	27,692	7,820	8,045,522	2,477,656	0.34	0.32
Dogfish, Spiny	24,007	116,148	3,619,191	18,787,974	0.66	0.62
Bluefish	19,697	41,793	2,796,095	4,627,112	0.70	0.90
Mackerel, Atlantic	18,040	70,893	3,889,243	16,596,797	0.46	0.43
Whelk, Channeled	15,139	2,050	7,175,012	1,232,408	0.21	0.17
Crab, Jonah	14,732	28,633	10,983,269	14,424,939	0.13	0.20
Bass, Striped	12,950	3,528	18,797,974	5,984,307	0.07	0.06
Bonito	4,859	2,128	112,986	53,480	4.30	3.98
Tautog	3,728	1,495	926,176	273,651	0.40	0.55
Dogfish, Smooth	1,947	4,051	976,231	2,039,068	0.20	0.20
Weakfish	1,291	735	319,712	207,805	0.40	0.35
Whiting, King	986	1,132	902,941	810,033	0.11	0.14
Sea Robins	498	1,724	20,812	124,470	2.39	1.39
Tuna, Little	425	944	131,168	233,801	0.32	0.40
Eel, Conger	220	421	49,241	68,105	0.45	0.62
Cunner	106	49	20,410	6,394	0.52	0.77
Mackerel, Spanish	103	200	1,192,684	816,845	0.01	0.02
Whelk, Knobbed	101	64	1,041,479	647,789	0.01	0.01
Menhaden	51	309	35,974,035	410,014,306	<0.01	<.01
Sea Raven	45	37	2,734	2,213	1.65	1.67
Triggerfish	41	41	376,831	184,225	0.01	0.02
Eel, Species Not Specified	10	12	25	32	40.00	37.50
Sea Trout, Species Not Specified	0	141	592,033	273,277	0.00	0.05

Source: NOAA Fisheries, 2019c. ACCSP, 2019.
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is in USD deflated to 2010 for consistency.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.
% = percent

Table 6. A summary of federal VTR data, by state, for vessels fishing along the RWEC route from 2009 to 2017 (INSPIRE Environmental 2020).

	Annual Average Revenue and Landings from within RWEC Fisheries Study Corridor		Annual Average of Total Revenue and Landings		Percent of Total State Values in RWEC Fisheries Study Corridor	
State	Revenue	Landings	Revenue	Landings	% of Revenue	% of Landings
Rhode Island	1,216,027	2,928,234	83,808,376	83,061,985	1.45	3.53
Massachusetts	329,573	3,203,699	547,819,893	272,427,302	0.06	1.18
All Others	55,981	74,826	558,828,937	725,429,171	0.01	0.01
Maine	22,593	141,941	540,523,922	252,863,406	<0.01	0.06
New York	357	137	53,395,207	30,909,690	<0.01	<0.01

Source: NOAA Fisheries, 2019c. ACCSP, 2019.
Notes:
Values are sorted from largest to smallest revenue values for landings data.
Landings are reported in landed pounds.
Revenue is in USD deflated to 2010 for consistency.
"Total" revenue and landings values refer to all fishing activity as reported by VTRs for fisheries active in state and federal waters from Maine to North Carolina.
% = percent

A number of fisheries also occur in state waters along the RWEC route. In statistical area 539, the greatest landings by state-only permitted vessels from Rhode Island occurred in the pot and trap fisheries, followed by fixed nets, hook and line, otter trawls, and gillnets (Table 7). The species with the greatest landings by state-only permitted vessels from Rhode Island from 2009 through 2017 were scup, channeled whelk, menhaden, summer flounder, skates, striped bass, and black sea bass.

Table 7. A summary of landings, by statistical area, for state-only permitted vessels from Rhode Island from 2009 to 2017 (INSPIRE Environmental 2020).

	Average Pounds Landed per Year (2009-2018)			Total Pounds Landed (2009-2018)			Total Pounds Landed in Rhode Island State Waters (2009-2018)	% Pounds Landed out of Total Rhode Island State Waters, by Gear		
	Statistical Areas			Statistical Areas				Statistical Areas		
Gear Category	538	539	611	538	539	611		538	539	611
By Hand, Diving Gear		5,345			42,759		44,209		96.7	
By Hand, No Diving Gear		45,760			366,078		366,559		99.9	
Dip Nets		7,866			62,925		64,272		97.9	
Dredge		130			520		520		100.0	
Gill Nets		202,887			1,623,097		1,635,066		99.3	
Hand Line		2,242			17,939		18,297		98.0	
Hook and Line	359	388,116	13,033	1,795	3,881,157	117,301	4,013,013	<0.1	96.7	2.9
Long Lines		1,880			13,158		13,177		99.9	
Other Fixed Nets		540,644			4,325,156		4,325,177		100.0	
Other Trawls		32,655			195,930		195,930		100.0	
Otter Trawls		324,192			2,593,534		2,600,214		99.7	
Pots and Traps, Lobster		58,494	2,413		526,445	19,302	546,357		96.4	3.5
Pots and Traps, Other		14,249			128,238		128,274		100.0	
Pots and Traps		757,048	35,295		6,813,434	317,659	7,138,933		95.4	4.4
Rakes		4,629			32,405		32,428		99.9	
Spears		3,217			25,735		26,095		98.6	

Source: ACCSP, 2019.
Notes:
Values reflect pounds landed caught in statistical subareas relevant to RWF and RWEC.
Confidential information was redacted from the ACCSP data set.
Blank cells indicate those years when the fishing area had no reported landings or redacted confidential landings.
Average pounds landed were calculated as an arithmetic mean, using the sum of pounds landed and the count of distinct years, ignoring zero years.

4.0 Survey Methods

Revolution Wind will implement multiple fisheries monitoring surveys as part of this FMP. The first element of the monitoring plan is a trawl survey at the RWF and nearby reference areas. Two ventless trap surveys will be executed at the RWF. A Before-After-Control-Impact (BACI) ventless trap study will occur at the RWF and two nearby reference areas before, during, and after construction. In addition, a ventless trap survey will be executed within the RWF using a gradient design during the operational phase. A Before-After-Gradient (BAG) ventless trap survey will also be executed along the RWEC route in Rhode Island state waters during all three phases of the Project. An acoustic telemetry monitoring project, focused on blue sharks, bluefin tuna, and shortfin mako sharks will occur with the RWF, and other adjacent Ørsted lease sites during all three phases of the Project. Finally, a benthic monitoring plan focused on both soft-bottom and hard-bottom habitats will occur within the RWF and along the RWEC. The survey designs and protocols are described below. These surveys will occur in close collaboration with the local commercial fishing industry.

4.1 Trawl Survey

4.1.1 Survey Design

Revolution Wind will coordinate with a local university, research institution or private contractor to execute a seasonal (i.e., four sampling events per year, approximately three months apart) trawl survey using an asymmetrical BACI experimental design. The trawl survey will be conducted in collaboration with a commercial trawl vessel with extensive experience fishing in this region. An otter trawl survey is an appropriate sampling tool for the Lease Area because this gear can effectively sample several of the commercially important fish and invertebrate species present in the area. In addition, the trawl fishery is active within the RWF area, and this gear type generates the greatest revenue within the Lease Area (Table 1). The trawl survey will effectively sample for multiple species, including groundfish (e.g., winter flounder, windowpane flounder, yellowtail flounder, Atlantic cod), monkfish, skates (e.g., winter and little skates), red hake, longfin squid, and others.

In order to maximize the utility of the monitoring, the trawl survey will utilize the sampling gear and protocols of the NEAMAP survey. The use of standardized survey methods will allow the data collected at RWF and the reference areas to be evaluated at multiple spatial scales (e.g., project specific scale and regional scale) in conjunction with information obtained through other regional trawl surveys (e.g., NEFSC, NEAMAP, and Vineyard Wind trawl surveys).

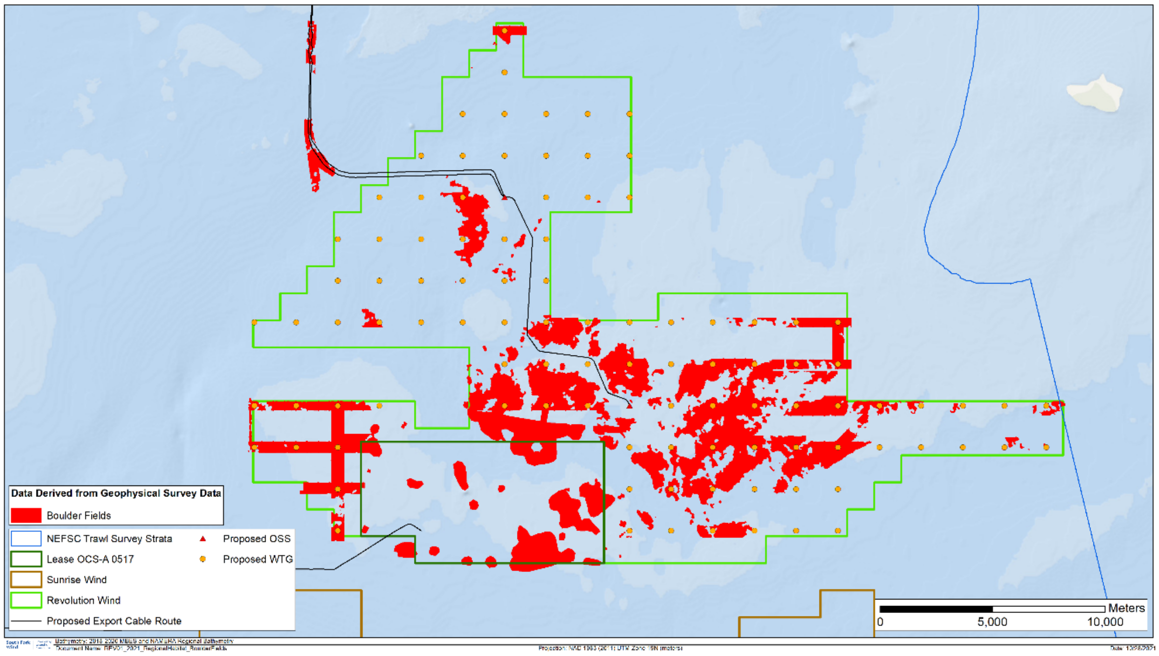
The primary objective of the pre-construction monitoring is to investigate the relative abundance (i.e., kilogram [kg]/tow) of fish and invertebrate resources in the RWF Project Area ("RWF impact") and reference areas ("control") over time. The pre-construction trawl survey monitoring will also collect demographic information on fish and invertebrates including size structure, fish condition, diet, and reproductive status. The target is to complete two years of sampling (i.e., eight seasonal trawl surveys) prior to the commencement of offshore construction, with the intention to begin sampling in the winter of 2021. Sampling will continue during project construction, and a minimum of two years of monitoring will be completed following offshore construction. However, the duration of post-construction monitoring will also be informed by ongoing guidance for offshore wind monitoring that is being developed cooperatively through the Responsible Offshore Science Alliance (ROSA).

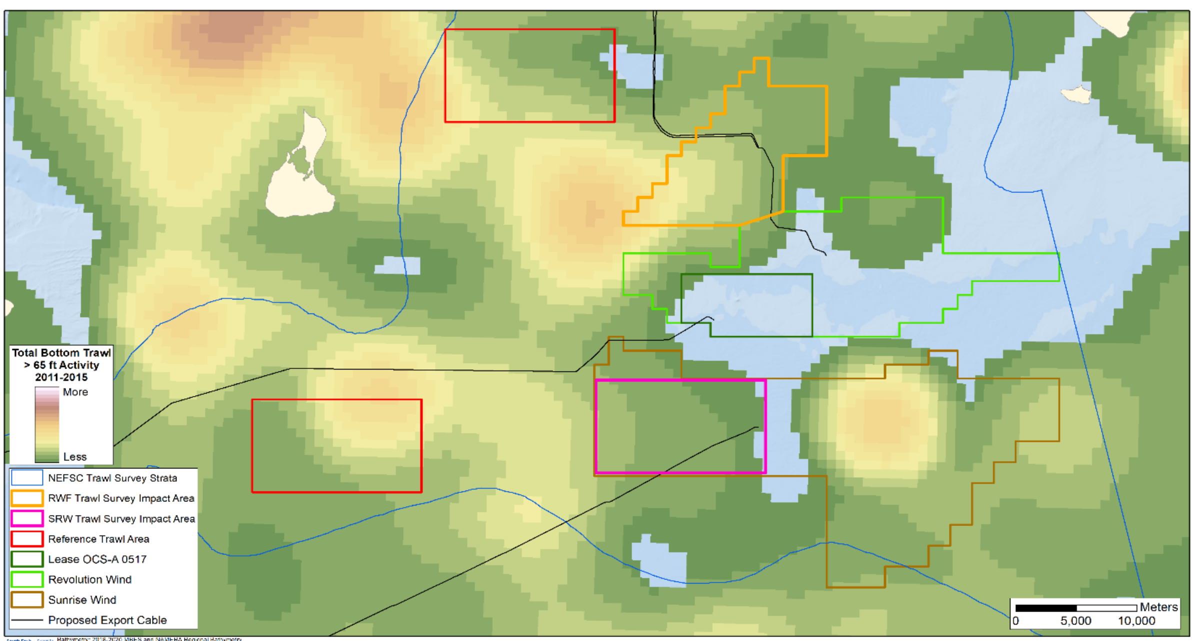
The primary objective of monitoring during construction and operation is to determine whether the construction and operational activities associated with the Project lead to a change in the relative abundance of fish and invertebrates within the Project Area. Another objective is to determine whether the construction and operational activities lead to a change in the demographics of these resources. The use of an asymmetrical BACI sampling design will allow for quantitative comparisons of relative abundance and demographics to be made before and after construction, and between the reference and RWF Project areas (Underwood 1992; Smith et al. 1993). Further, the replication of sampling across both time and space increases the ability to demonstrate that a change in abundance was caused by a human activity (Underwood 1992).

The sampling methodology and trawl gear were designed to be complementary to the NEAMAP trawl survey (Bonzek et al. 2008, 2017). By using the same sampling gear and protocols as the NEAMAP survey, the data collected through this monitoring effort can be more directly compared to fisheries-independent data collected across the broader region. NEAMAP trawl survey gear will also be employed within other Ørsted lease areas (e.g., Sunrise Wind and Ocean Wind), and South Fork Wind is also completing a trawl survey using a NEAMAP survey net along the South Fork Export Cable route in New York state waters. Further, to achieve consistency amongst developers, the survey methods and trawl net are consistent with the pre-construction data being collected by Vineyard Wind in their lease areas. To the extent practicable, concerted efforts will be made to ensure that the timing of the RWF trawl survey coincides with the NEFSC spring and fall bottom trawl surveys when the research vessel (R/V) Bigelow is operating in southern New England.

4.1.2 Sampling Stations

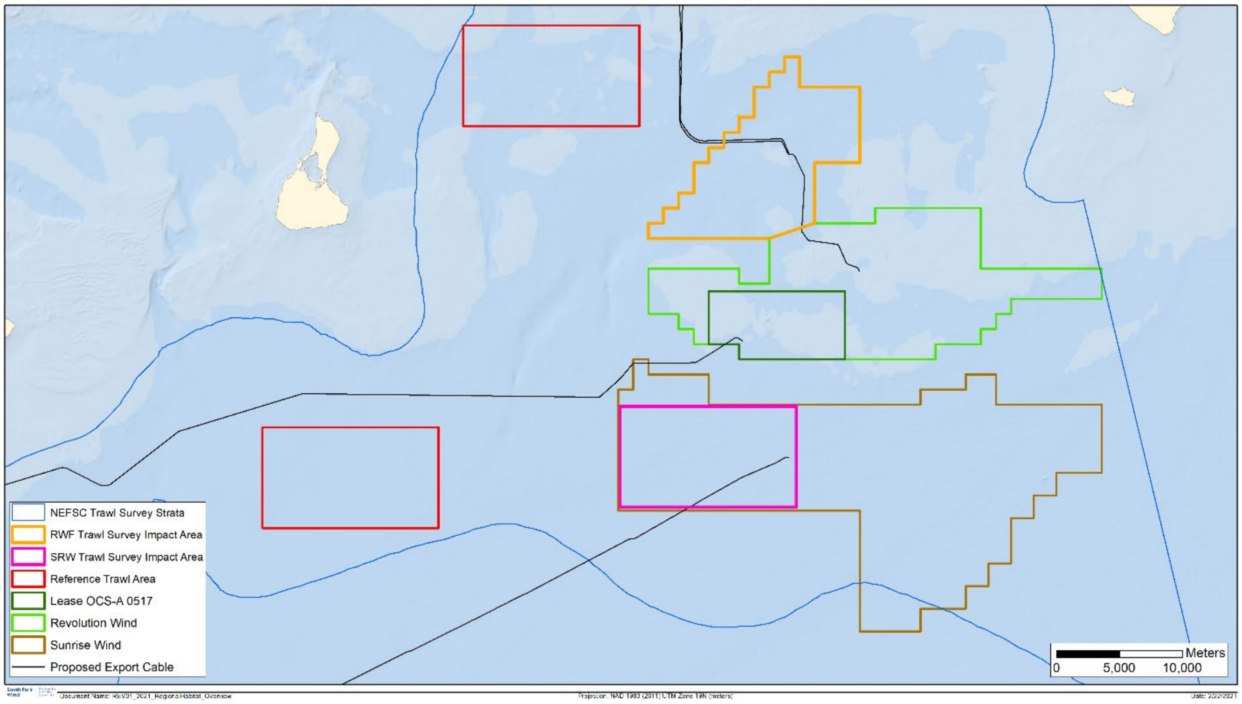
Benthic habitat data from Ørsted site investigation surveys were considered along with input from local fishermen to determine the areas within the RWF lease area that can be sampled safely and effectively using the NEAMAP trawl survey net. High-resolution geophysical surveys were conducted by Ørsted within the RWF and South Fork Wind (SFW) lease areas, and along the RWEC corridor, and these surveys located boulder fields throughout much of the southeastern and southwestern portion of the RWF lease site (Figure 2). Local fishermen also provided input that mobile gear fishing effort is primarily concentrated in the northern portion of the lease site, which is supported by VTR data from the otter trawl fleet in this region from 2011 through 2015 (Figure 3). Based on this information, it will not be feasible to safely and efficiently execute a trawl survey throughout the entire RWF lease area. Therefore, the RWF Project area for the trawl survey will be limited to the northern portion of the RWF lease area (Figure 4), which encompasses an area of approximately 125 km^2.



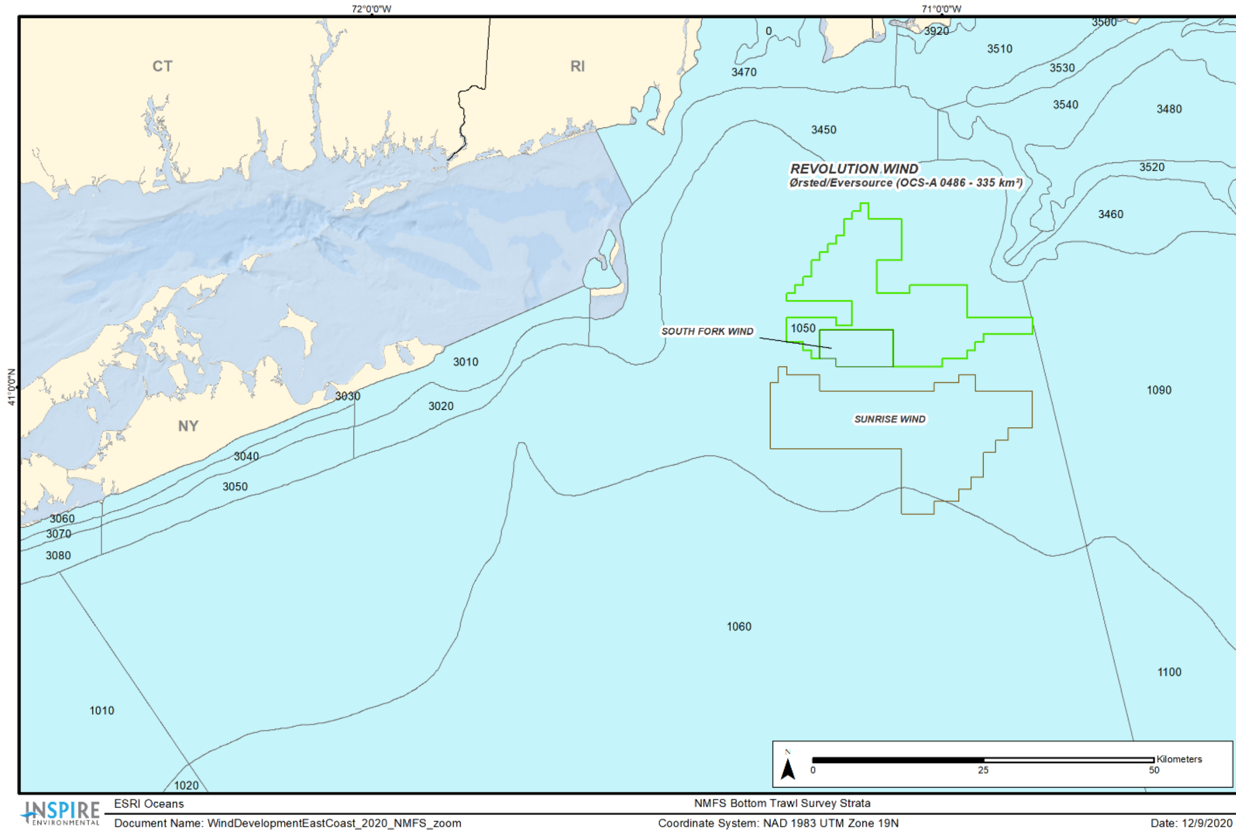


[6].

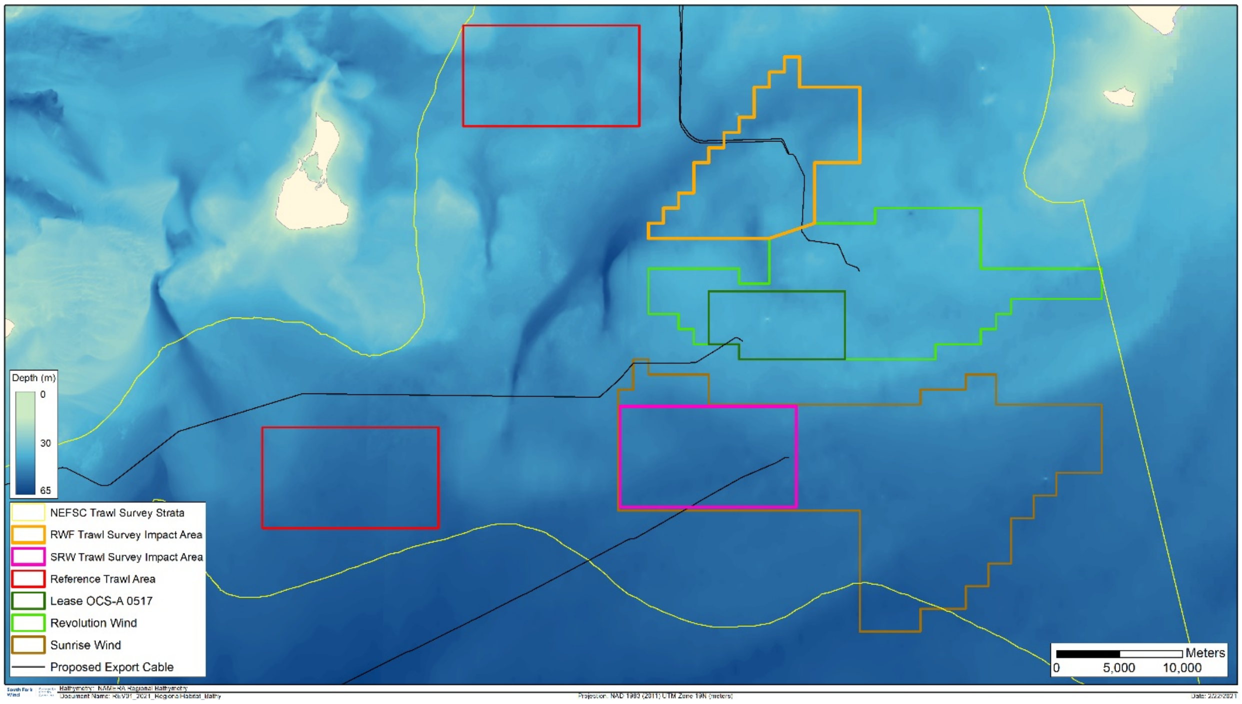
[6] https://portal.midatlanticocean.org/static/data_manager/metadata/html/CASMetadata.html



The trawl survey will be executed using an asymmetrical BACI design, and trawl survey observations from the reference areas will serve as a regional indicator of relative abundance for fish and invertebrate species in an area outside of the direct influence of the Project and other offshore wind development. Two reference areas (Figure 4) were selected after considering several sources of information. Firstly, the location of the RWF was evaluated relative to the survey strata used on the NEFSC trawl survey. The NEFSC trawl survey is the only regional trawl survey with spatial coverage that overlaps the RWF lease area, and the RWF lease area is located entirely within NEFSC trawl survey stratum 1050 (Figure 5). Stratum 1050 covers an area of approximately 5,213 km^2, and includes waters ranging from 27 to 55 m in depth (Politis et al. 2014). The entire RWF lease area is approximately 335 km^2, while the northern portion of the lease area where the trawl survey will occur is approximately 125 km^2. In an effort to maintain consistency with the stratification employed on the NEFSC survey, the reference areas were also sited within trawl survey 1050. Based on bathymetric data provided by the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010), the depth within the RWF trawl survey Project area ranges from 33 to 48 m, and the mean depth is 39 m (Figure 6). The depth within the northern reference area ranges from 21 to 41 m (mean depth = 36 m), while depths in the southern reference area range from 41 to 55 m (mean depth = 50 m).



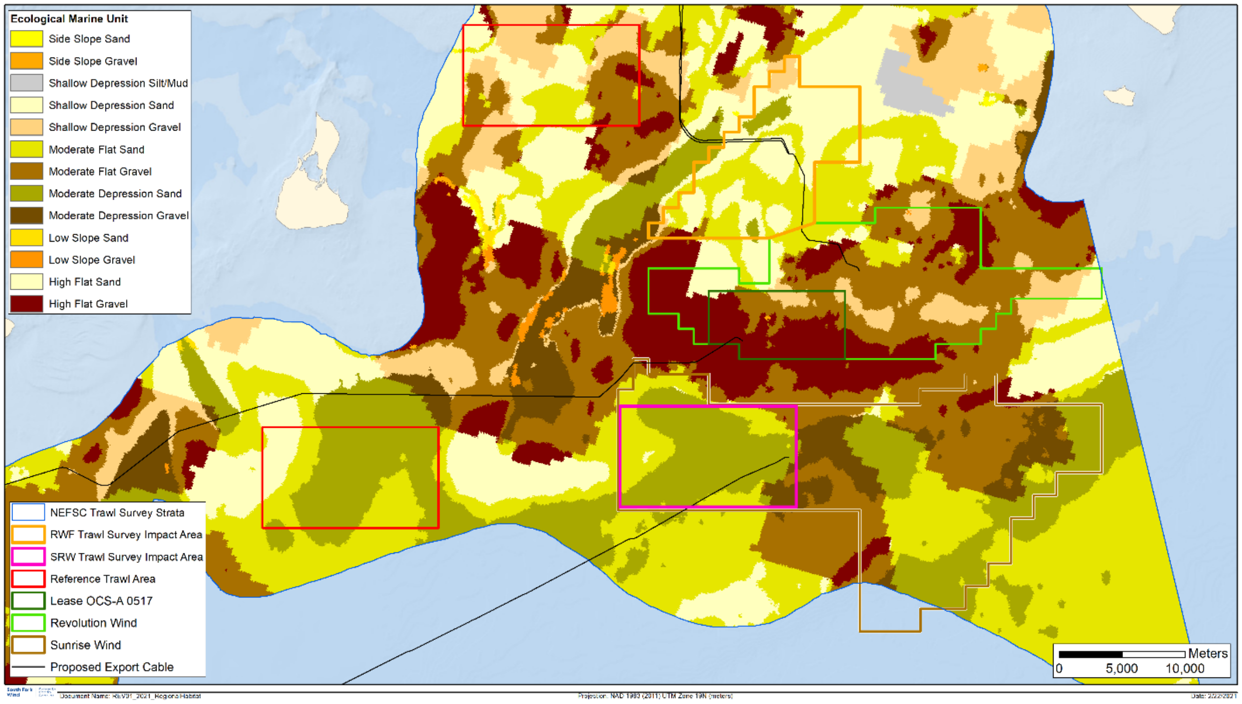
Consideration was also given to the benthic habitat present in the RWF Project area, and reference areas were selected with similar benthic habitats as the RWF Project area. Based on benthic habitat data provided from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010), the substrates within the planned footprint of the RWF trawl survey are diverse and include: moderate flat sand, shallow depression sand, moderate depression sand, shallow depression gravel, moderate flat gravel, and high flat gravel (Figure 7), along with isolated boulder fields that were mapped during the Ørsted site investigation surveys (Figure 2). The benthic habitats within the northern reference area include: shallow depression gravel, moderate flat gravel, moderate flat sand, high flat gravel, and high flat sand. The habitats within the southern reference area are slightly less diverse, and are primarily comprised of shallow depression sand, moderate flat sand, and moderate depression sand.



VTR data from 2011 to 2015 for trawl vessels >65 feet (ft) in length from the Mid-Atlantic Ocean Data Portal[7] indicate that a low to moderate amount of trawl activity occurred within the RWF trawl survey Project area. Similar amounts of trawling activity were generally observed within the northern and southern reference areas (Figure 3).

Care was also taken to ensure that the reference areas would not coincide with locations that are currently planned for future offshore wind development. Similarly, reference areas were not sited in locations that intersected with export cable routes. Modifications to the locations of the reference areas may be considered based on input received from the local fishing industry, as well as the scientific contractor or fishermen that are selected to execute the trawl survey.

[7] https://portal.midatlanticocean.org/static/data_manager/metadata/html/CASMetadata.html



Consistent with the study design used by Vineyard Wind during their trawl survey, a spatially balanced design will be used to assign random tow locations within the RWF Project and reference areas during each seasonal survey. The RWF Project and reference areas will each be divided into 15 grid cells, and one randomly chosen location will be sampled within each grid cell during each seasonal trawl survey. The spatially balanced design will ensure that sampling effort is distributed throughout the RWF Project and reference areas. Within the RWF Project area and the reference areas, the sampling density associated with each seasonal survey will be one station per 8.3km^2. The order in which the reference areas and the RWF trawl survey Project area are surveyed will be randomized prior to the start of each survey.

The location of trawl sampling stations may be subject to change due to the presence of fixed gear (e.g., lobster pots), or other factors that may preclude a randomly selected location from being sampled safely. Therefore, alternate sampling locations will be randomly chosen within each grid cell for each seasonal survey. If a primary sampling location is found to be untrawlable based on the captain's professional judgement, sampling will instead occur at one of the randomly selected alternate sampling locations. If any marine mammals are sighted in the vicinity of a trawl tow, sampling will be delayed at that location in order to minimize the risk of an interaction. Revolution Wind will work with the scientific contractor(s) and captain and crew of the trawl vessel(s) to evaluate whether activities associated with cable installation (e.g., cable cover), or other construction activities, will RWF impact the execution of the trawl survey after the RWF is constructed.

A power analysis was conducted using trawl survey data from the Block Island Wind Farm (BIWF) and NEFSC trawl survey datasets (Appendix 2). NEFSC trawl survey data from 2010 through 2018 were obtained from Phil Politis (personal communication), and only tows from Stratum 1050 were used to inform the power analysis. From 2010 through 2018, the NEFSC trawl survey sampled in the spring and fall. Therefore, monthly catch data from the two reference sites sampled during the BIWF trawl survey were also reviewed to determine the extent to which the seasonal NEFSC trawl survey captured intraannual biomass peaks for different species of interest. Power analysis represents the relationships among the four variables involved in statistical inference: sample size (N), effect size, and type I (α) and type II (β) error rates (Cohen 1992). Of primary interest for this study is the interaction between temporal and spatial variables, specifically the contrast between the temporal change at the RWF Project site and the average temporal change at the reference sites (Equation 2 in Appendix 2). Power curves were constructed to demonstrate how statistical power for the interaction contrast varies as a function of the variance in the catch data, the effect size (i.e., the percent change at the RWF Project site relative to the reference sites), sample size (i.e., number of trawl tows per area in each season), and the number of reference sites that are sampled (Figures 7-8 in Appendix 2). When analyzing for changes in relative abundance, we will aim to achieve a statistical power of at least 0.8, which is generally considered to be the minimum standard for scientific monitoring (Cohen 1992). This ensures that the monitoring will have a probability of at least 80% of detecting an effect of the stated size when it is actually present. A single alpha (0.10) was used for the power analysis, and the power analysis was completed assuming two years of pre-construction and post-construction monitoring will be completed.

A sample size of 15 trawl tows per area will be targeted per season in each year. Based on the results of the power analysis (Appendix 2, Figure 7), this level of sampling is expected to have at least 80% power to detect a 33% temporal decrease for those species with Coefficient of Variation (CVs) ≤ 1.2, and approximately a 40% temporal decrease for species with CVs ≤ 2.0. Further, the use of an asymmetrical BACI design, with two rather than one reference areas, leads to gains in power for a given level of sampling intensity in the RWF Project area (Appendix 3, see Figure 8). An examination of the NEFSC and BIWF trawl survey data indicates that most species exhibited moderate to high levels of interannual and intraannual (e.g., seasonal or monthly) variability in catch rates (Appendix 2, Figures 2-6 and Table 4). Given the magnitude of variability in catch rates that will likely be exhibited in the RWF trawl survey, it is not practicable to attempt to capture a small effect size (e.g., 25%) for fish and invertebrate species. Moreover, this power analysis assumes that the variance in the catch rates during the RWF trawl survey will be similar to the variance observed during the BIWF and NEFSC trawl surveys. Following the first year (i.e., four seasonal sampling events) of trawl survey data the observed variability will be calculated for abundant species in the catch. The achievable effect sizes will also be identified following the first year of the survey, once the realized magnitude of variability is better understood, and once regional guidance regarding target effect sizes has been formalized through ROSA. Given the predicted power of the study design for the anticipated magnitude of variability (i.e., range of CVs from 0.8 to 2.0), the sample sizes proposed for the first year of the trawl survey are robust.

The proposed seasonal sampling intensity equates to an annual sampling target of 180 tows per year across the RWF Project and reference areas. For comparative purposes, from 2010 through 2018, the NEFSC trawl survey completed four or five tows in Stratum 1050 during each spring and fall trawl survey (i.e., eight to ten tows per year).

4.1.3 Trawl Survey Methods

The scientific contractor that is selected to perform the monitoring will apply for a Letter of Acknowledgement (LOA) or an Exempted Fishing Permit (EFP) from National Oceanic and Atmospheric Administration (NOAA) Fisheries in order to use the hired fishing vessel as a scientific platform and conduct scientific sampling that is not subject to the Atlantic Coastal Fisheries Cooperative Management Act, Magnuson-Stevens Fishery Conservation and Management Act, and fishery regulations in 50 Code of Federal Regulations (CFR) parts 648 and 697. All survey activities will be subject to rules and regulations outlined under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). Efforts will be taken to reduce marine mammal, sea turtle, and seabird injuries and mortalities caused by incidental interactions with fishing gear. For example, we will delay deploying trawl gear if marine mammals are sighted in the vicinity of the sampling station. All gear restrictions, closures, and other regulations set forth by take reduction plans (e.g., Harbor Porpoise Take Reduction Plan, Atlantic Large Take Whale Reduction Plan, etc.) will be adhered to as with typical scientific fishing operations to reduce the potential for interaction or injury.

The trawl survey will be carried out on a seasonal basis, with four surveys planned for each year. From 2010 through 2018 the NEFSC Spring survey sampled in stratum 1050 in March, April and May, while the NEFSC Fall trawl survey sampled stratum 1050 in September and October. In order to achieve temporal overlap with the NEFSC trawl survey, the seasons for the RWF trawl survey will be defined as follows:

- 'Winter' survey months: December, January, and February
- 'Spring' survey months: March, April, and May
- 'Summer' survey months: June, July, and August
- 'Fall' survey months: September, October, and November.

To the extent practicable, concerted efforts will be made to ensure that the timing of the RWF trawl survey coincides with the NEFSC spring and fall bottom trawl surveys when the R/V Bigelow is operating in southern New England. Within a seasonal sampling event, the replicate tows within the RWF Project and control areas will be completed within as few days as possible, given practical constraints imposed by weather or other factors (e.g., mechanical issues with vessel).

The trawl survey will be executed using the trawl net that was designed by the Northeast Trawl Advisory Panel for the NEAMAP trawl survey. The NEAMAP survey net is a 400 x 12 centimeter (cm) three-bridle four-seam bottom trawl, and the net is paired with Thyboron, Type IV 168 cm (66 inch [in]) trawl doors (Bonzek et al. 2017). Several aspects of the net design make it an appropriate tool for sampling a wide range of species and size classes. The trawl is designed to achieve a relatively large vertical opening, and the use of a 'flat sweep' (i.e., 8 cm (3 inches) cookie groundgear) allows that net to maintain close contact with the bottom and sample effectively for species that are closely associated with the benthos. A 2.5 cm (1 inch) knotless cod end liner will be used to sample marine taxa across a broad range of size and age classes.

Net mensuration equipment will be used during the survey to provide the captain and scientific crew with real-time information on door spread, wing spread, and headrope height. This information also allows the area swept (km^2) to be calculated for each tow, which is needed in order to estimate absolute abundance. In order to promote consistency amongst samples, we will work with the scientific contractor selected to execute the survey to establish a set of gear performance criteria to objectively compare the observed trawl geometry against the optimal geometry (e.g., Bonzek et al. 2017). The position, heading, and speed of the vessel will be monitored throughout each tow using a software program that is integrated with a Global Positioning System (GPS) unit (e.g., NEFSC Fisheries Logbooks Data Recording System, or similar). A temperature logger attached to the trawl net will be used to record bottom temperature continuously (e.g., every 30 seconds) during trawling.

Similar to the methods employed on the NEAMAP survey and other regional surveys (e.g., MADMF biannual trawl survey), all tows will be completed during daylight hours, and the target tow duration will be 20 minutes. The relatively short tow duration is also expected to minimize the potential for interactions with protected species and marine mammals. A target tow speed range of 2.9 to 3.3 knots will be used. The amount of wire set with each trawl to achieve the target net geometry will be left to the professional judgement of the captain, dependent upon the depth and the *in-situ* conditions.

Animals collected in each trawl sample will be sorted, identified to the species level, weighed, and enumerated consistent with the sampling approach of NEAMAP. Taxonomic guides that can be utilized to assist with species identification include *NOAA's Guide to Some Trawl-Caught Marine Fishes* (Flescher 1980), *Bigelow and Schroeder's Fishes of the Gulf of Maine* (Collette and Klein-MacPhee 2002), Kells and Carpenter's (2011) *Field Guide to Coastal Fishes from Maine to Texas.* Species will be identified consistently with the Integrated Taxonomy Information System (ITIS). The following information will be collected for each trawl that is sampled; catch per unit effort (CPUE), species diversity, and size structure of the catch. All species captured will be documented for each valid trawl sample. If any protected species are captured during trawling, the sampling and release of those animals will take priority over sampling the rest of the catch. When large catches occur, sub-sampling may be used to process the catch, at the discretion of the lead scientist. The three sub-sampling strategies that may be employed are adapted from the NEAMAP survey protocols and include straight subsampling by weight, mixed subsampling by weight, and discard by count sampling (Bonzek et al. 2008). The type of sub-sampling strategy that is employed will be dependent upon the volume and species diversity of the catch.

The biomass (weight, kg) of each species will be recorded on a motion-compensated marine scale that has been calibrated according to the manufacturer's specifications and used to calculate CPUE. Length will be recorded for the dominant species (i.e., most commonly encountered species), and priority species, in the catch. To assess the condition of individual organisms, up to 100 individuals of each species (and size class) will be measured (to the nearest cm) and weighed on a motion-compensated balance. Length (e.g., total length, fork length) will be recorded for each species consistent with the measurement type specified in the Northeast Observer Program Biological Sampling Guide. After sampling, all catch will be returned to the water as quickly as possible to minimize incidental mortality.

Biological samples will be collected for the commercial finfish species of primary interest in the reference and RWF Project areas. In order to be consistent with the regional trawl surveys, a length-stratified design will be used to ensure samples are collected across all size and age classes for each species. The following list of priority species will be considered for biological sampling, but the list may be modified based on input from regional stakeholders and feedback from the scientific contractor(s) selected to perform this work; Atlantic cod, American lobster, black sea bass, summer flounder, winter flounder, Atlantic herring, monkfish, and yellowtail flounder. Biological sampling will include measuring the length and weight of individuals, and macroscopic evaluation of sex and maturity stage consistent with the sex and maturity classification used by the Northeast Fisheries Science Center (Burnett et al. 1989). Sex and maturity stage collected during the seasonal trawl surveys can be considered alongside of other fisheries independent data and used to inform the spatiotemporal distribution of spawning within the area, and the maturity data can also be considered when evaluating the relative condition of individual fish, as sex and maturity stage can influence relative condition (Galloway and Munkittrick 2006; Wuenschel et al. 2009). In addition, up to 100 Atlantic cod will be opportunistically tagged with acoustic transmitters to support the BOEM-funded Atlantic cod spawning study (see Section 4.3.1) Biological sampling for lobsters will follow the protocols described in Section 4.2.5 of this document.

Following seven years of data collection during the Block island Wind Farm trawl survey, INSPIRE Environmental (2021) recommended that future diet composition studies concentrate sampling efforts on a small number of focal species with different trophic niches, rather than trying to characterize changes in prey composition for a wide range of species. Following that recommendation, stomach content analysis will be performed for two recreationally and commercially important species, black sea bass and summer flounder, to examine their prey composition and evaluate whether diet composition changes between the Project Area and reference areas prior to and after construction. An examination of catch rates from the NEFSC bottom trawl survey and the BIWF trawl survey (Appendix 2) indicate that the catch rates of these species are likely to be sufficient to allow for comprehensive sampling of diet composition. Due to their behavior and biological characteristics, better understanding whether the development of offshore wind affects the diet of these two species is of ecological importance.

Both black sea bass and summer flounder were identified as potentially serving as "key assessment indicator species" to understand the ecological impacts associated with offshore wind development (MADMF 2018). Malek (2015) identified both summer flounder and black sea bass as indicator species that should be considered when assessing the potential impacts of offshore wind development. Black sea bass and summer flounder were also noted as priority research species by Petruny Parker et al., (2015) and the Northeast Regional Habitat Assessment Prioritization Working Group (NMFS 2015). In addition, Guida et al., (2016) identified black sea bass as a species that was vulnerable to construction within the MA/RI Wind Energy Area. A recent modeling study (Friedland et al. 2021) that used 43 years of data from the NEFSC trawl survey found that black sea bass are highly dependent on habitats in the wind energy areas during the spring and fall, while summer flounder are highly dependent on these habitats in the fall, making these species good candidates for further investigation related to their diet composition and feeing behavior.

Black sea bass are characterized as opportunistic benthic omnivores, which consume a range of food including crustaceans, mollusks, and fish (Bigelow and Schroeder 1953; Kendall 1977; Drohan et al. 2007). Black sea bass are strongly associated with structured habitats including rocky reefs, cobble and rock fields, mussel beds, and stone coral patches (Drohan et al. 2007), and monitoring results from Block Island Wind Farm demonstrated an increased abundance of black sea bass near the turbine foundations following construction (HDR 2019). This observation has led some stakeholders to express consternation about potential local increases in black sea bass abundance, out of concern that black sea bass will consume juvenile lobsters within the wind farm site following construction.

Adult summer flounder have been characterized as opportunistic feeders that prey primarily on fish and invertebrates, with the following fish species included in their diet; windowpane flounder, winter flounder, pipefish, menhaden, bay anchovy, red hake, silver hake, scup, Atlantic silverside, sand lance, bluefish, weakfish, and mummichogs (Packer et al. 1999, and references therein). Summer flounder have also been reported to feed on a variety of benthic invertebrates including small bivalve and gastropod mollusks, small crustaceans, marine worms, sand dollars, and squid (Packer et al. 1999, and references therein). Summer flounder was recognized as a species with the potential to experience a negative impact due to the conversion of soft-bottom habitat to hard bottom habitat associated with the foundations, and associated scour protection8.

Up to 10 animals will be sacrificed for stomach content analyses from each trawl that is sampled, with no more than five individuals of either species sampled from a single trawl. The target sampling intensity is to analyze 200 samples per species, in each area, during the two-year pre-

[8] Technical Report - Essential Fish Habitat Assessment - Revolution Wind Offshore Wind Farm (boem.gov)

construction sampling period. Cumulative prey curves provide an estimate of how prey diversity increases as a function of sample size and can help determine the sampling levels needed to adequately characterize diet composition (Chipps and Garvey 2007). Cumulative prey curves were derived for summer flounder and black sea bass based on stomach content analysis performed during the BIWF trawl survey. For summer flounder, the prey curves were created by time period (baseline and operation) and area (BIWF impact and reference sites) combinations and demonstrate that approximately 40 samples were needed within each combination of time and area factors to characterize their prey composition (Figure 8), although not all prey curves approached the asymptote at the same rate. For black sea bass, stomach contents were only monitored during the final (i.e., post-construction) year of the trawl survey, but the prey curves suggest that approximately 40 samples should be sufficient to adequately characterize their diet in each area and time period (Figure 9). By focusing stomach sampling on summer flounder and black sea bass, it is anticipated that the Revolution trawl survey will collect hundreds of samples for each species in both the impact and reference areas across all the three phases of the project, allowing for a rigorous examination of changes in diet composition over time. Each fish sampled for stomach content analysis will be measured (to the nearest cm) and weighed (to the nearest gram) individually before the stomach is removed to permit assessment of relative condition. All prey items will be identified to the lowest possible identification level (LPIL), counted, and weighed. Following the first year of pre-construction monitoring, cumulative prey curves will be produced to evaluate whether the sampling intensity should be modified in subsequent years.

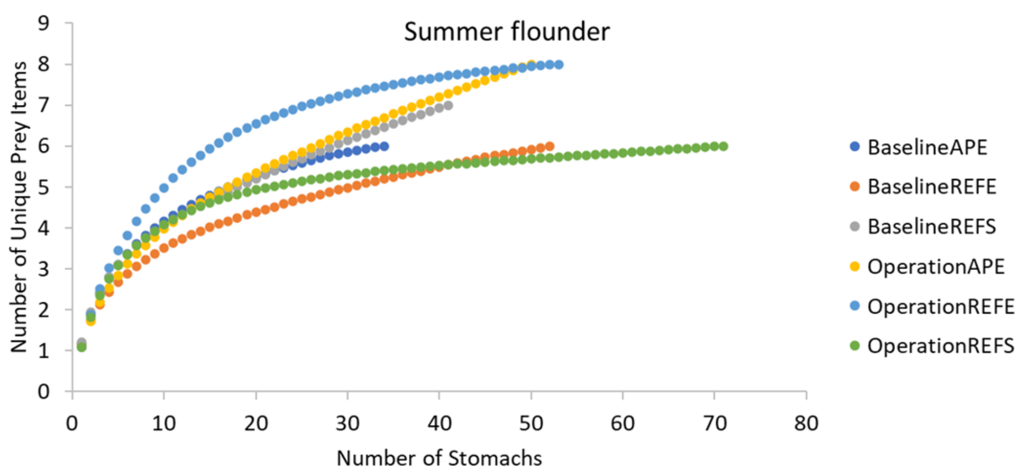


Figure 8. Cumulative prey curves for summer flounder observed during the BIWF trawl survey, in the RWF Area of Potential Effect (APE) and reference areas East and South (REFE and REFS) during the baseline and operation monitoring periods. Figure provided by INSPIRE Environmental (in progress).

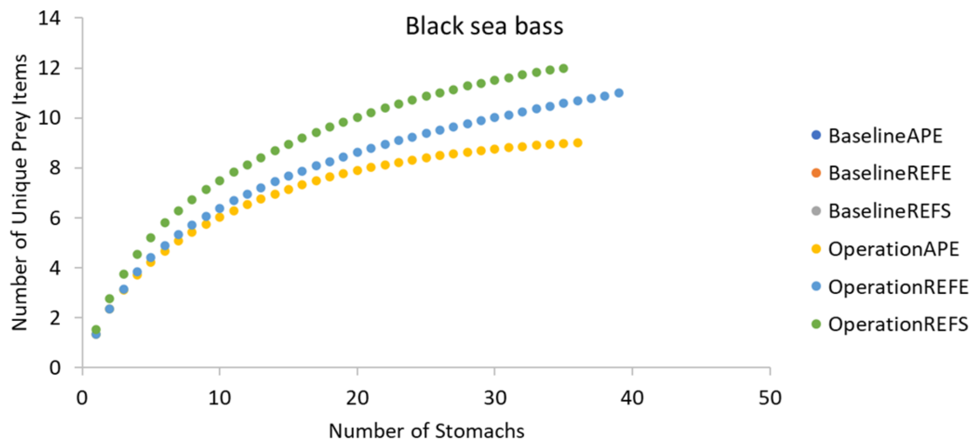


Figure 9. Cumulative prey curves for black sea bass observed during the BIWF trawl survey, in the RWF impact area (APE) and reference areas (REFE and REFS) during the operation monitoring period. Figure provided by INSPIRE Environmental (in progress).

Hydrographic data will be collected at each trawl station. A Conductivity Temperature Depth (CTD) sensor (or similar) will be used to sample a vertical profile of the water column at each trawl station. The CTD profile may be obtained at the start or end of the tow, at the discretion of the chief scientist. Bottom water temperature will be recorded at regular intervals (e.g., every 30 seconds) throughout the duration of each tow either using a temperature logger mounted on the trawl net or using temperature sensors that are part of the net mensuration hardware.

Should any interactions with protected species (e.g., marine mammals, sea birds, sea turtles, sturgeon) occur, the contracted scientists will follow the sampling protocols described for the Northeast Fisheries Observer Program (NEFOP) in the Observer On-Deck Reference Guide (Northeast Fisheries Science Center 2016). If any protected species are captured during trawling, the sampling and release of those animals will take priority over sampling the rest of the catch. Reporting of interactions with marine mammals, such as small cetaceans and pinnipeds, will be dependent on the type of permit (i.e., EFP or LOA) issued to the project; once the permit type has been specified, Revolution Wind will contact National Marine Fisheries Service Protected Resources Division (NMFS-PRD) for guidance on reporting procedures. Additionally, protocols for handling live or deceased protected species of sea turtles, sturgeon, or marine mammals will be dependent on the type of permit (i.e., EFP or LOA) issued to the project. Once the permit type has been specified, we will contact NMFS-PRD for guidance on handling protocols. Entangled large whales or interactions with sea turtle species will be reported immediately to NOAA's stranding hotline via telephone (866-755-NOAA) and interactions with sturgeon species will be reported immediately to NOAA via the incidental take reporting email (incidental.take@noaa.gov); a follow up detailed written report of the interaction (i.e., date, time, area, gear, species, and animal condition and activity) will be provided to the NMFS Greater Atlantic Regional Fisheries Office (incidental.take@noaa.gov) within 24 hours. Any biological data collected during sampling of protected species will be shared as part of the written report that is submitted to the NMFS Greater Atlantic Regional Fisheries Office, and any genetic samples obtained from sturgeon will be provided to the NMFS Greater Atlantic Regional Fisheries Office Protected Resources Division. Due to the potential for communicable diseases all physical sampling and handling of marine mammals and seabirds will be limited to the extent Ørsted health and safety assessments and plans allow.

4.1.4 Trawl Station Data

The following data will be collected during each sampling effort:

- Station number
- Latitude and longitude at the start and end of the tow
- Time at the start and end of the tow
- Vessel speed and heading
- Water depth at the start and end of the tow
- Wind speed
- Wave height
- Weather conditions (e.g., cloud cover, precipitation)
- Tow speed
- Gear condition/performance code at the end of the tow
- Oceanographic data, as collected using a CTD and a temperature logger (see Section 4.1.3).

4.1.5 Data Management and Analysis

All field data will be reviewed for errors before being transcribed into a relational database. Quality control checks will be performed on database tables by running standardized, systematic queries to identify anomalous data values and input errors. Species names (common and scientific) will be verified and tabulated for consistency. All data used in analysis will be exported from the relational database.

Annual reports containing catch data will be prepared after the conclusion of each year of sampling and shared with State and Federal resource agencies. One final report will also be produced synthesizing the findings of the pre- and post-construction evaluations. We will also coordinate with our scientific Contractor(s) to disseminate the annual monitoring results through a webinar or an in-person meeting, and this meeting will also offer an open forum for federal, state, and academic scientists to ask questions or provide feedback on the data collection protocols. Likewise, following each year of monitoring we will coordinate with the Contractor(s) to host an industry workshop to disseminate the results of the monitoring activities to local fishing industry members. Although all interested stakeholders will be invited to the industry workshop, concerted efforts will be made to ensure that members of the Rhode Island Fishermen's Advisory Board (FAB) and the Massachusetts Fisheries Working group attend.

The first two years of trawl surveys will allow for characterization of the pre-construction fish and invertebrate community structure in both the Project Area and reference areas. For the pre-construction monitoring the results presented in annual reports will focus on descriptive and quantitative comparisons of the fish and invertebrate communities in the Project Area and the reference areas to describe spatial, seasonal, and annual differences in relative abundance, species composition, frequency of occurrence for each species (e.g., presence/absence), and demographic information for individual fish such as length, weight, diet, and relative condition. For the dominant (i.e., most abundant) species in the catch, relative abundance will be compared amongst the reference and RWF Project areas using descriptive statistics (e.g., mean, range) and length frequency data will be compared among areas using descriptive statistics, graphical techniques (empirical cumulative distribution function [ECDF] plots), and appropriate statistical tests (e.g., the Kolmogorov-Smirnoff test, cluster sampling). Species composition will be compared amongst the RWF Project and reference areas using a Bray-Curtis Index and multivariate techniques (e.g., analysis of similarities [ANOSIM]).

By continuing sampling during and after construction, the trawl survey will allow quantification of any detectable changes in relative abundance, demographics, or community structure associated with proposed operations. The BACI design for this survey plan allows the catch of numerically dominant species to be compared between the before and after construction periods in the two treatment types (reference and RWF Project areas), using appropriate statistical modeling. The use of reference areas will ensure that broader regional changes in demersal fish and invertebrate community structure will be captured and delineated from potential impacts of the proposed Project. Analyses presented in the final synthesis report will focus on identifying changes in the fish community in the RWF Project Area between pre-, during, and post-construction that did not also occur at the reference areas that could be attributed to either construction or operation of the wind turbines.

The primary research question to be addressed is what magnitude of difference in the temporal changes in relative abundance are observed between the reference and RWF Project areas. This question will be addressed using point estimates and 90% confidence intervals (CIs) contrasting the temporal changes between areas. This research question can also be framed using the following null and two-tailed alternative hypotheses:

- $H_{\varnothing}$ - *Changes in relative abundance (catch per unit effort [CPUE]) between time periods (before and after) will be statistically indistinguishable between the reference and RWF Project areas.*
- H_1 - *Changes in CPUE between time periods (before and after) will be statistically different between the reference and RWF Project areas.*

In this design, there are multiple years within each time period and multiple sites within the Control treatment. Area will represent a fixed factor in the model with three levels (i.e., RWF impact area, and each reference area), which will be crossed with year, also a fixed factor. Environmental covariates (e.g., temperature, depth, and salinity) can also be included in the abundance model, either as linear or quadratic factors. The data logger attached to the trawl net will be used to record bottom temperature continuously during each tow, and the mean temperature for each tow will be included in the abundance model. The salinity at each tow will be informed by the CTD deployment, and depth will be calculated based on the average depth recorded at the start and end of the tow. The benthic habitat data provided by Greene et al., (2010) will be used to classify the dominant habitat present in each grid cell, allowing benthic habitat to be treated as a random effect within the model. Model selection will be conducted using Akaike Information Criteria (AIC) and residual diagnostics, and forward and backward stepwise elimination will be used to select the most parsimonious model (Venable and Ripley, 2002).

This asymmetrical BACI design is not suited to analysis with a simple two-factor Analysis of Vairance (ANOVA) model; instead Generalized Linear Models (GLMs) or Generalized Additive Models (GAMs) will be used to describe the data and estimate the 90% CI on the BACI contrast. The interaction contrast that will be tested is the difference between the temporal change (i.e., average over the post-operation period minus the average over the pre-operation period) at the windfarm and the average temporal change at the reference areas. A statistically significant impact would be indicated by a 90% CI for the estimated interaction contrast that excludes zero changes. A 90% confidence level is proposed to increase the power of the tests, i.e., increase the probability of identifying a significant impact of wind farm operation. This approach provides 90% confidence in the two-tailed hypothesis of "no difference", and 95% confidence in each of the one-tailed hypotheses (i.e., change at the Reference areas is less than at the windfarm, and change at the Reference areas is greater than at the windfarm).

If desired, absolute abundances estimates can be derived for commonly sampled species. Estimation of absolute abundance will require assumptions regarding the efficiency of the survey gear and the availability of species to the trawl. Tow speed and tow duration collected by the chief scientist can be combined with the trawl geometry data collected using the net mensuration sensors to estimate the area swept during each tow.

Length frequency data for the dominant species in the catch will be analyzed. The first question to be addressed is how the size structure of these species change over time (before vs. after construction). The second question to be addressed is how the size structure of these species varies between areas (Project Area vs. reference areas). To answer both questions, length frequency data will be compared between times and locations for common species using descriptive statistics (e.g., range, mean) and graphical and statistical comparisons using ECDFs, a Kolmogorov-Smirnov test (Sokal and Rohlf 2001), or another appropriate method such as cluster sampling (Nelson 2014) based on the characteristics of the data.

For priority species that are subject to detailed biological sampling, fish condition will be compared between areas, and across time, to examine whether fish condition is influenced by the construction and operation of the Project. For commonly sampled species, condition indices (Jakob et al. 1996) will be calculated for individual fish as its residual from the $\log_{10}$-$\log_{10}$ regressions of mass (kg) to length (cm). For each species the fish condition data will be fit with a GAM or GLM that best describes the data, and the 90% CI will be estimated for the relevant spatial and temporal contrasts. Given the migratory nature of many of the species that will be investigated, and the uncertainty of where these species have foraged, a change in fish condition may not necessarily be considered as an impact attributable to the construction and operation of the wind farm. However, this information can be evaluated to consider whether fish condition (a proxy for fish health) changes over time and between areas after the wind farm is constructed.

Species composition will also be compared between areas and time periods to examine whether the construction and operation of the wind farm led to changes in the species composition within the Project Area. This research question can be examined using the following null ($H_{\varnothing}$) and two-tailed hypotheses (H_1):

- $H_{\varnothing}$ - *Changes in species composition between time periods (before and after) will be statistically indistinguishable between the reference and RWF Project areas.*

- H_1 - *Changes in species composition between time periods (before and after) will be statistically different between the reference and RWF Project areas.*

Species composition will be compared before and after construction using a Bray-Curtis Index and multivariate techniques (e.g., Permutational ANOVA [PERMANOVA], ANOSIM). Additional data analyses will be performed as appropriate based on the nature of the data that is collected (i.e., models will be fit to the data using appropriate error distribution).

For diet data, the primary question that will be asked is whether the prey composition of focal species changes following the construction of the wind farm. This research question can be addressed for each species using the following null and two-tailed hypotheses:

- *$H_\varnothing$ - Changes in prey composition between time periods (before and after) will be statistically indistinguishable between the reference and RWF Project areas.*
- *H_1 - Changes in prey composition between time periods (before and after) will be statistically different between the reference and RWF Project areas.*

Seasonal diet data for focal species will be obtained from stomach contents, and prey composition will be calculated separately for each species as the mean proportional contribution (W_k) of each prey item (Buckel et al. 1999a; Bonzek et al. 2008) by season and area, where:

$$\%W_k = \frac{\sum_{i=1}^{n} M_i q_{ik}}{\sum_{i=1}^{n} M_i} * 100$$

$$q_{ik} = \frac{w_{ik}}{w_i},$$

and where

n is the total number of trawl tows that collected the fish species of interest,

M_i is the sample size (counts) of that predator species in trawl sample *i*,

w_i is the total weight of all prey items in the stomachs of all fish analyzed from trawl sample *i*, and

w_{ik} is the total weight of prey type *k* in these stomachs.

Potential seasonal differences in prey composition will be explored for each focal species using multivariate techniques (e.g., PERMANOVA, Non-metric Multidimensional Scaling [nMDS], ANOSIM, and Similarity Percentages [SIMPER]). A stomach fullness index (FI) will be calculated for each fish analyzed. The difference between full and empty stomach weights will be determined to obtain the total weight of food (FW). The ingested food weight (FW) is expressed as a percentage of the total fish weight according to a formula defined by Hureau (1969) as cited by Ouakka et al., 2017.

FI = FW / fish weight x 100

Following the first complete year of trawl sampling (e.g., completion of four seasonal sampling events), cumulative prey curves (Chipps and Garvey 2007) will be used to assess the adequacy of the sampling for diet data. For each species, the cumulative number of prey types will be plotted against the number of stomachs examined. The point at which the curves reach the asymptote can be used to estimate the minimum number of stomachs that are needed to adequately characterize the prey composition (Chipps and Garvey 2007), and if necessary this information can be used to refine sample sizes in subsequent years.

Beyond the analyses described above, additional analyses will focus on evaluating the comparability of the RWF trawl survey data with observations from other trawl surveys in the region, including the NEFSC and NEAMAP trawl surveys, as well as observations from trawl surveys completed at other lease sites (e.g., Vineyard Wind trawl survey). They use of the NEAMAP sampling protocols and trawl net will help facilitate these comparisons, which will provide valuable regional context to further evaluate whether the results observed at the wind farm are due to offshore wind development, or whether they are indicative of broader regional trends. These comparisons can be made at a variety of scales (e.g., lease site, NEFSC sampling strata, or stock area) as appropriate for the species and biological index of interest. The additional analyses may include an evaluation of several indices, including relative abundance, fish condition, and size structure.

An adaptive sampling strategy will be employed, whereby data collected early in the study will be analyzed to assess statistical power and modify the sampling scheme or sampling intensity as needed (Field et al. 2007). Upon completion the first four seasonal surveys, the power analysis will be updated to evaluate the power of the sampling design. A measure of variability associated with the relative abundance estimates for the dominant species in the catch will be calculated and the *a priori* power analysis (i.e., Appendix 2) will be updated with these estimates. Power curves will be used to demonstrate how statistical power varies as a function of effect size and sample size (i.e., number of trawl samples per area). When analyzing changes in the relative abundance of dominant species in the catch, we will aim to attain a statistical power of at least 0.8 to ensure that the monitoring will have a probability of at least 80% of detecting an effect of the stated size when it is actually present. A two-tailed alpha of 0.10 will be evaluated during the power analysis. There is a direct relationship between the magnitude of the effect size and the statistical power of the analysis, with greater power associated with larger effect sizes. The results of the power analysis will be considered and can be used to modify the monitoring protocols in subsequent years. The decision to modify sampling will be made after evaluating several criteria including the amount of variability in the data, the statistical power associated with the study design, and the practical implications of modifying the monitoring protocols.

4.2 RWF Ventless Trap Survey – Lobsters and Crabs

American lobster and Jonah crab are targeted by commercial fishermen in New England and the Mid-Atlantic. Lobsters are jointly managed by the NMFS and the ASMFC, while Jonah crab are managed by the ASMFC. The American lobster was recognized as a priority species for monitoring in the MA/RI WEA (McCann 2012; Petruny-Parker et al. 2015; Malek 2015; MADMF 2018), and Jonah crabs were also identified as an indicator species by MADMF (2018). From 2009 to 2018, lobsters were the most valuable target species in the RWF (Table 2). Jonah crabs, which represent an expanding fishery in southern New England (Truesdale et al. 2019), generated the 11th most revenue from the RWF area over the same period (Table 2). Lobsters and crabs may not always be sampled effectively by a trawl survey (Petruny-Parker et al. 2015). Therefore, a ventless trap survey is proposed to address the question of whether the construction and operation of the RWF has any detectable effects on the relative abundance and demographics of lobsters, Jonah crabs, and rock crabs.

The primary objective of the pre-construction monitoring is to investigate the relative abundance of lobster, Jonah crab, and rock crab in both the RWF ventless trap survey impact and reference areas. The pre-construction monitoring will also collect demographic information including size structure, sex ratios, reproductive status, and shell disease. This survey is also expected to encounter several structure-associated finfish species as bycatch, such as black sea bass, tautog, and scup. Two years of sampling (i.e., 12 monthly sampling events, 7 months per year) will be targeted before the commencement of offshore construction, with the goal to initiate sampling in May or June of 2022. The pre-construction data will supplement baseline information that was collected in 2014, 2015, and 2018 through the Southern New England Cooperative Ventless Trap Survey (SNECVTS) (Collie and King 2016). Ventless trap monitoring will continue during the construction phase, and a minimum of two years of monitoring will be completed following offshore construction, but the duration of post-construction monitoring may also be informed by guidance for offshore wind monitoring that is being developed cooperatively through the Responsible Offshore Science Alliance (ROSA).

The primary objective of monitoring after construction is to determine whether the operational activities associated with the Project lead to a significant change in the relative abundance of lobsters, Jonah crabs, and rock crabs within the Project Area. Another objective is to determine whether the construction and operational activities lead to a significant change in the demographics of these species. The use of an asymmetrical BACI sampling design will allow for quantitative comparisons of relative abundance and demographics to be made before and after construction, and between reference and impact areas (Underwood 1992; Smith et al. 1993).

The ventless trap survey is designed to be as compatible as practicable with other fisheries independent surveys in the region. This sampling will build off prior sampling efforts in the MA/RI Wind Energy Area under the SNECVTS in 2014, 2015, and 2018 (Collie and King 2016), and the proposed biological sampling protocol is informed by the methods used by the ASMFC and other regional groups to monitor lobster and crab resources in the region (Wahle et al. 2004; O'Donnell et al. 2007; Geraldi et al. 2009). A ventless trap survey using the same protocols in the adjacent South Fork Wind (SFW) Project lease area began in May 2021 and is also being executed using an asymmetrical BACI design. Performing ventless trap surveys in both lease areas will increase the ability to detect regional changes in these invertebrate resources. All ventless trap sampling in SFW and RWF will occur on commercial lobster vessels that are chartered for the monitoring surveys.

4.2.1 BACI Survey Design and Procedures

The study will be conducted using an asymmetrical BACI design with quantitative comparisons made before and after construction and between the reference and RWF Project areas (Underwood 1994). Data collected at the reference areas will serve as a regional index of lobster, Jonah crab, and rock crab abundance in an area outside of the direct influence of the Project and other offshore wind development.

RWF ventless trap survey impact areas were identified within the RWF lease area (Figure 10). Mobile gear fisheries are active within the northern portion of the lease area, therefore, this area was originally excluded from the ventless trap study in order to minimize any potential gear conflicts with the mobile gear fishery. After receiving input from fisheries stakeholders that identified the northern portion of the lease area as important to the lobster industry, the northern impact area was included in the design. The northern RWF ventless trap survey impact area is approximately 52km^2, and depth in the area ranges from 33 to 46m (mean = 39m) and the southern RWF ventless trap survey impact area is approximately 51km^2, and depth in the area ranges from 30 to 39m (mean = 35m). Data from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010) indicate that the benthic habitat within the RWF ventless trap survey impact areas includes high flat gravel, moderate flat gravel, shallow depression gravel, shallow depression sand, and moderate flat sand (Figure 11), and Orsted geophysical surveys have also documented boulder fields within the RWF ventless trap survey impact areas (Figure 2).

Input from local lobster fishermen and our scientific research partners was used to select two reference areas for the SFW ventless trap survey (Figure 10). The reference areas are each approximately 55 km^2. Diverse habitats are present within the reference areas (Figure 11). Habitats within the western reference area include high flat gravel, moderate flat gravel, moderate flat sand, and shallow depression sand, while habitats in the eastern reference area include high flat gravel, moderate flat gravel, shallow depression gravel, moderate flat sand, shallow depression sand, and shallow depression silt/mud. Depths in both the eastern and western reference areas range from 30 to 39m (mean = 35m; Figure 12). When siting the reference areas consideration was also given to the proximity of the reference areas relative to offshore wind development that is planned in the future. Given the similarities in depth and habitat between the SFW reference areas and the RWF ventless trap survey impact area, along with the desire to minimize the number of vertical lines in the water to reduce the risk of interactions with protected species, the same reference areas will be utilized for both the RWF and SFW ventless trap surveys.

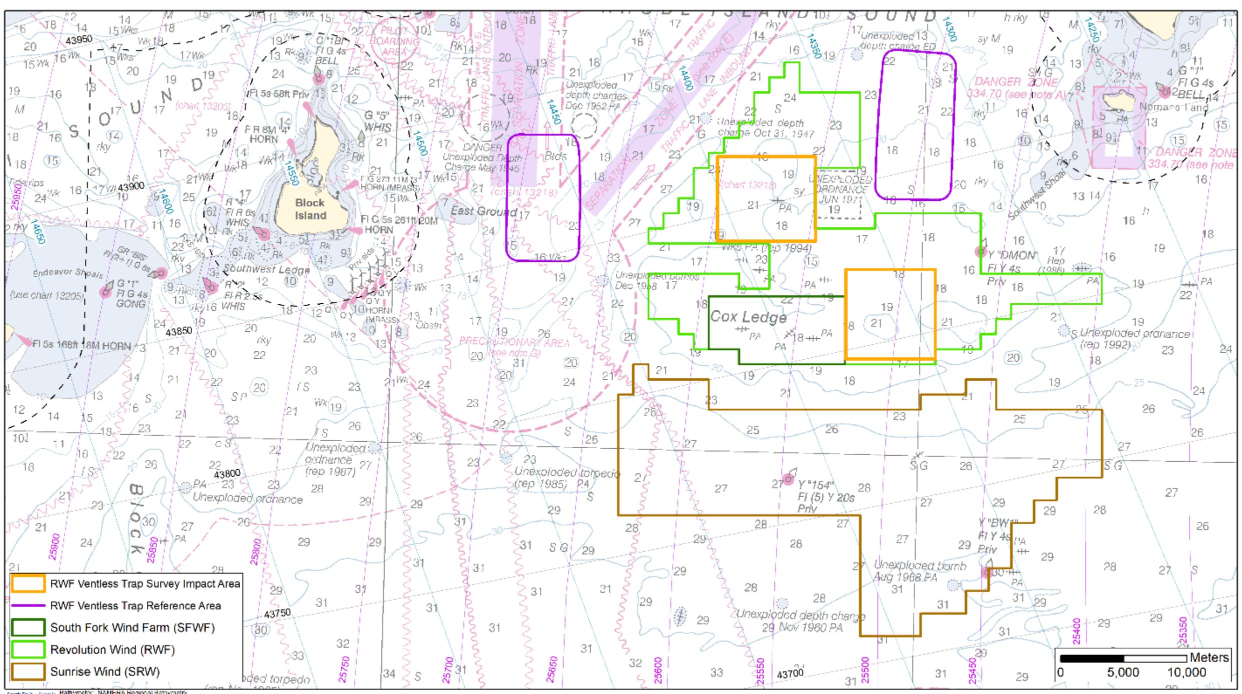


Figure 10. Proposed RWF ventless trap survey impact and reference areas.

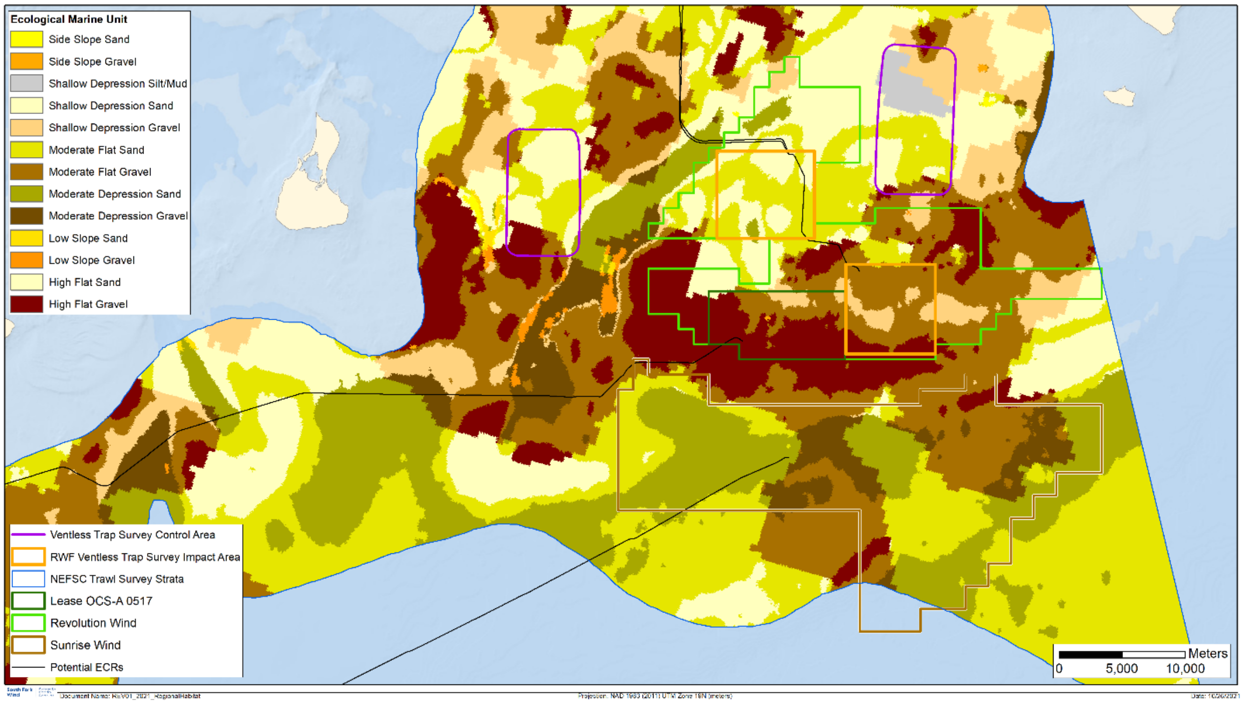


Figure 11. Benthic habitats within the RWF ventless trap survey impact area, and within the reference areas. Benthic habitat data was derived from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010).

The spatially balanced sampling approach utilized during the SNECVTS survey (Collie and King 2016) will be utilized within the RWF ventless trap survey impact areas and the reference areas. The RWF ventless trap survey impact areas will be divided into fifteen equally sized grid cells (with effort distributed between the two areas and all data pooled), and each grid cell will be further divided into equally sized aliquots (Figure 13). As was described in the South Fork Wind Farm Fisheries Research and Monitoring Plan (South Fork Wind, LLC and INSPIRE Environmental 2020), the eastern and western reference areas will be divided into ten grid cells, and each grid cell will be further divided into equally sized aliquots. Through consultation with local industry members, a subset of the aliquots within each grid cell will be identified as suitable sampling areas based on the desire to minimize gear conflicts with fishermen in the area. One aliquot will be randomly selected for sampling in each grid cell at the start of the year. An alternative aliquot will also be selected within each grid cell, and the alternative aliquot will be sampled if needed based on local conditions (e.g., to avoid gear conflicts). This design allows for broad sampling coverage of each area, while also allowing for random site selection to occur within each grid cell. Within the reference and RWF ventless trap survey impact areas, the same aliquot will be resampled throughout each year with a new aliquot randomly selected in each grid cell the following year. For the BACI study, sampling at the reference areas will follow the sample protocols during all three phases of the monitoring (before, during, and after construction).

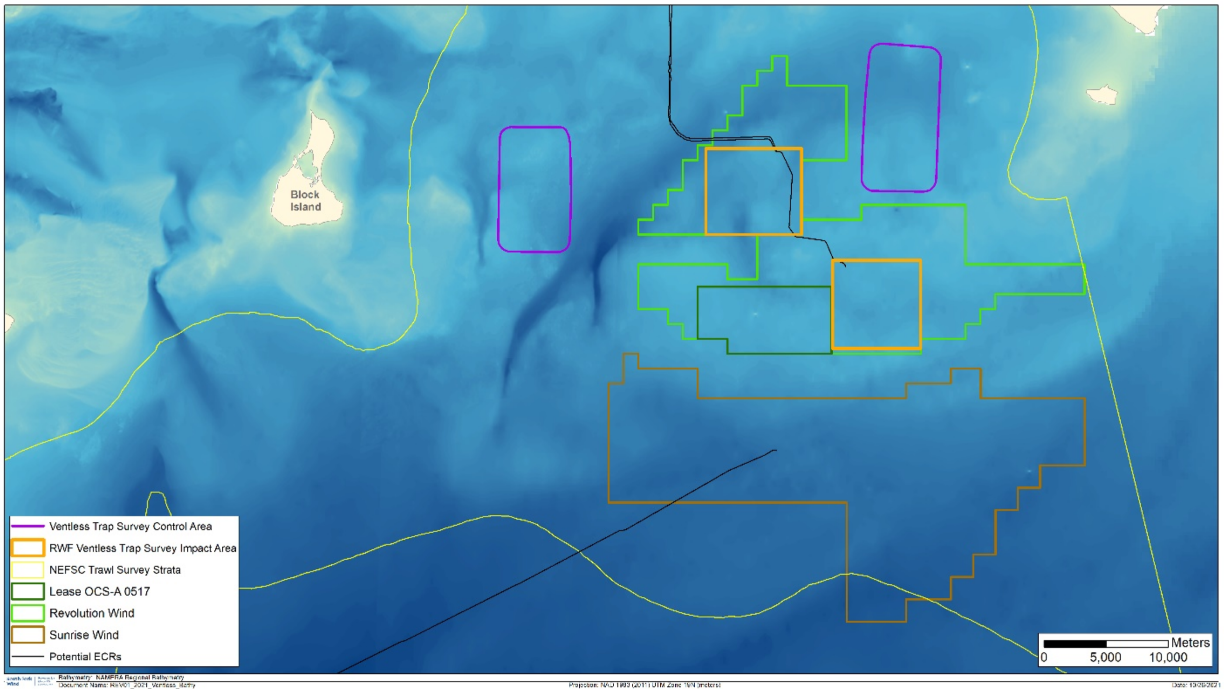


Figure 12. **Bathymetric map of the RWF lease area, the RWF ventless trap survey impact area, and the planned reference areas for the ventless trap survey. Bathymetric data is shown in meters and was derived from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010).**

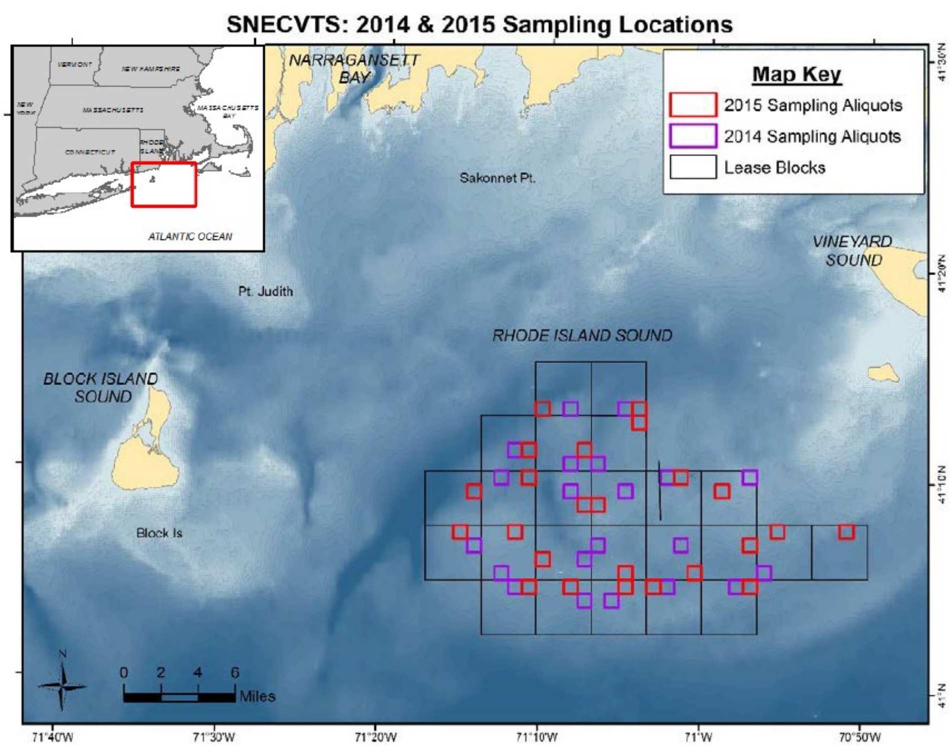


Figure 13. **Example of the station selection method employed during the Southern New England Cooperative Ventless Trap Survey. The study area was stratified into 24 sampling grid cells, and each grid cell was further divided into aliquots. One aliquot from each grid was randomly selected for sampling in each year. Figure from Collie and King (2016).**

To achieve consistency with the ASMFC and SNECVTS protocols, the sampling stations will be selected randomly at the start of each year of sampling and remain fixed for the remainder of the year. This sampling approach keeps the station occupied, reduces time that is spent moving traps between locations, and is similar to the routine operations of lobstermen in the region (Collie and King 2016). To minimize gear interactions with other user groups in these areas, the lead scientist will work with the captain to ensure that the gear is set in accordance with local fishing practices. Revolution Wind will work with the scientific contractor(s) to evaluate whether activities associated with cable installation (e.g., cable cover), or other construction activities, will RWF ventless trap survey impact the execution of the ventless trap survey.

Benthic habitat type is known to influence the distribution and abundance of lobsters and Jonah crab (e.g., Geraldi et al. 2009; Collie and King 2016). Along with input from local fishermen, benthic habitat data from the Northwest Atlantic Marine Ecoregional Assessment (Greene et al. 2010) was used to inform the location of the reference areas and evaluate benthic habitat within the RWF ventless trap survey impact area. Habitat data was also collected within the RWF using geotechnical and geophysical surveys, as well as optical methods (Sediment Profile and Plan View Imaging [SPI/PV]), and this information will be used to produce a detailed habitat map of the RWF area. This habitat map will be used to further classify benthic habitat at each location that is sampled within the RWF ventless trap impact area. However, similar high-resolution habitat data from geophysical surveys will not be available for the reference areas. Given that the trawl locations will remain fixed across each year of sampling, and that each trawl has a limited spatial footprint, *in-situ* observations will be used to further characterize the benthic habitat at each sampling location in the reference areas. A variety of approaches may be used to characterize benthic habitat in the reference areas including grab sampling, optical techniques (e.g., underwater video or still imagery), or side-scan sonar (e.g., Collie and King 2016), and we will work with our scientific research partner to determine which method will be most suitable. These *in situ* habitat observations can be used to supplement the benthic habitat data provided by Greene et al., (2010), and better inform habitat classifications within the reference areas. The influence of habitat type will be investigated as a covariate during model fitting when examining changes in relative abundance over time in the reference areas and the RWF ventless trap survey impact areas (see Section 4.2.7).

A power analysis was conducted (see Appendix 3) to inform the pre-construction sample sizes for the RWF ventless trap study. The power analysis utilized relative abundance data for lobsters, Jonah crabs, and rock crabs that was collected during the SNECVTS in 2014, 2015 and 2018. Bootstrapping techniques (R=5000 bootstrap replicates) were used to characterize the variability in the catch rates observed during the SNECVTS. The range of coefficients of variation (CVs) estimated through bootstrapping were used in the power analysis.

Power analysis represents the relationships among the four variables involved in statistical inference: sample size (N), effect size, and type I (α) and type II (β) error rates (Cohen 1992). Power curves were constructed to demonstrate how statistical power varies as a function of the effect size (or percent decrease at the wind farm), sample size (e.g., number of trawls per area), level of variability (CV values), and the duration of post-construction monitoring (Figure 3 in Appendix 3). When analyzing changes in the relative abundance of lobster, Jonah crab, and rock crab, we will aim to achieve a statistical power of at least 0.8, which is generally considered to be the minimum standard for scientific monitoring (Cohen 1992). This ensures that the monitoring will have a probability of at least 80% of detecting an effect of the stated size when it is actually present. A two-tailed alpha of 0.10 was used for the power analysis. Based on the results of the power analysis, a sample size of 15 trawls in the impact area will be targeted in each year, paired with 10 trawls in each of the reference areas. While statistical power is optimized for a given sampling intensity when sample sizes are equal among all areas, this slight imbalance in sampling intensity amongst areas does not lead to substantial reductions in power for the RWF monitoring (see Figure 4 in Appendix 3), particularly when GLMs are used to model the abundance data.

This analysis assumes that the variance in the catch rates during the RWF survey will be within the range of variances used from the SNECVTS (Table 2, Appendix 3). Under the assumption that the CV for Jonah crabs will be 0.4, if two years of post-construction monitoring is completed at this level of sampling, the study design is expected to have at least an 80% probability of detecting at least a 33% relative decrease in the abundance of Jonah crabs (i.e., the abundance of Jonah crabs decreases by 33% at RWF, and remains unchanged at the reference areas). For lobsters, assuming the observed CV is 0.6, the study design is expected to be have at least an 80% probability of detecting at least a 40% change in relative abundance. However, for rock crabs, which exhibited greater variability in catch rates during the SNECVTS, this study design is anticipated to only have the statistical power to detect larger changes in relative abundance (e.g., ~50% - 75%) between the RWF ventless trap survey impact and reference areas. If the duration of post-construction monitoring is extended to three or four years, the statistical power associated with this sampling intensity is expected to increase (Appendix 3, Figures 3 and 4). Following the first year (i.e., June-November 2022) of ventless trap survey data the observed variability will be calculated. The achievable effect sizes will also be identified following the first year of the survey, once the realized magnitude of variability is better understood, and once regional guidance regarding effect sizes has been formalized through ROSA.

4.2.2 Gradient Study Design and Procedures

In addition to the proposed BACI sampling, a gradient sampling design will also be incorporated within the RWF ventless trap survey impact area during the operational phase of the project. The purpose of the gradient sampling design is to assess whether lobsters, Jonah crabs, or rock crabs occur in higher abundance near the foundation locations, relative to other locations within the RWF ventless trap survey impact area. While some previous offshore wind monitoring studies have investigated the influence of distance from turbine foundations on the abundance and diversity of fish (e.g., Bergstrom et al. 2013), to the best of our knowledge, similar distance-based sampling has not been performed for lobsters or crabs. The foundations and scour protection will provide lobsters and crabs with novel and complex habitat that may offer shelter from predators, and these structure-oriented species may be attracted to the foundations and scour protection (Krone et al. 2017; Roach et al. 2018). Methratta (2020; Table 1) classified 'habitat provision via turbine structures' and 'attraction to turbine foundations' as 'local effects', which were hypothesized to occur at a spatial scale of 10s to 100s of meters.

Consistent with the study design of the BACI ventless trap survey, the sampling stations will be selected randomly at the start of each year of sampling and the sampling locations will remain fixed for the remainder of the year. To minimize gear interactions with other user groups in these areas, the lead scientist will work with the captain to ensure that the gear is set in accordance with local fishing practices.

At the start of each year of monitoring during the operation period, four foundation locations in the RWF ventless trap survey impact area will be selected at random, and ten trap trawls of ventless traps will be intentionally set with the mid-point of the trawl as close to the foundation as possible (accounting for safety and logistical concerns). Assuming there is 30.5 m (100 ft) between adjacent ventless traps in a trawl, if the midpoint of the trawl were set proximate to a foundation, two ventless traps would each sample at a distance of approximately 15m from the foundation (on either side of the foundation). The next two ventless traps on the trawl would sample at a distance of 45m, and the next two ventless traps would both sample at a distance of 75m, and so on. The start and end locations of each trawl, and the orientation of the trawl, will be recorded (see Section 4.2.6) so it will be possible to approximate the distance of each trap on the trawl relative to the nearest turbine foundation. This design should produce eight traps (two traps at each of the four foundation locations) at five distance intervals ranging from approximately 15m to 140m from a foundation.

4.2.3 Ventless Trap Methods – BACI Survey

The ventless trap survey will be executed using a local lobster vessel(s) with scientists onboard to process the catch. The fishing vessel(s) will be contracted to conduct the sampling using a single parlor trap that is 16 inches high, 40 inches long, and 21 inches wide with 5-inch entrance hoops and constructed with 1-inch square rubber coated 12-gauge wire that is consistent with traps used in the ASMFC and SNECVTS ventless trap surveys. The trap is constructed with a disabling door that closes off the entrance during periods when the trap is on the bottom but not sampling. Trawls will be configured with ten traps on each trawl, which is consistent with the gear configuration used in the SNECVTS (Collie and King 2016). For the BACI survey, a combination of ventless and vented traps will be used to survey juvenile and adult lobster and crabs. Each trawl will be comprised of six ventless traps (V), and four standard vented traps (S), in the following pattern V-S-V-S-V-V-S-V-S-V, consistent with the gear configuration used on the SNECVTS (Collie and King 2016). The fishermen participating in the SFW ventless trap study have provided feedback that because of the weak-links that will be used in the end lines of the trawls, and the depths of the study site, a minimum spacing of 30.5 m (100 ft) will be needed between traps to ensure safety for the crew and scientists while the gear is being hauled.

It is acknowledged that the use of ten trap trawls is inconsistent with the ventless trap monitoring that is carried out by the state agencies through ASMFC, and also the ventless trap monitoring being completed by Vineyard Wind. However, there are several reasons to deviate from the monitoring protocols being completed by other groups. Fishing ten rather than six traps per trawl increases the area fished and will likely decrease the variance associated with the relative abundance estimates, which in turn will increase the statistical power of the design. Further, without increasing the number of trawls and end-lines in the water, fishing with six trap trawls, rather than ten trap trawls, would reduce the number of ventless traps that are sampled by 40%. This would, in turn provide less information about changes in the local lobster population. Local fishermen (RI FAB members) provided input that fishing longer trawls (ten traps rather than six traps) should reduce the likelihood of gear losses during the study. While the potential for gear loss associated with six trap trawls may be mitigated by placing additional anchors on the end lines, the captains participating in the SFW ventless trap survey expressed concern that this would lead to safety issues during haulback, because of the weak-link buoy lines being used on the survey. Similarly, the captains expressed concerns that the trap spacing used on the ASMFC ventless trap surveys (60 ft) may also lead to unsafe conditions while the gear is being hauled, due to the weak-links in the buoy lines. Therefore, consistent with the SNECVTS protocols, the study will be executed using ten trap trawls, in order to minimize the potential for gear losses, to increase the area sampled by each trawl, and to increase the number of traps that are sampled for each vertical line in the water. The spacing between individual pots on each trawl will be consistent with the spacing used at the SFW lease site and reference sites.

Pre-construction sampling will occur twice per month from May through November. However, the Project has been advised by staff at the Greater Atlantic Regional Fisheries Office (GARFO) Protected Resources Division that the survey cannot operate from December through May unless we are able to partner with a local lobster vessel and complete the survey using traps that are already allocated to the fishery, in order to minimize the risk of protected species interactions. RWF will attempt to partner with a local lobster fisherman and execute the survey using their trap tags to avoid placing additional gear in the water beyond what is already permitted to the fishery. However, if this cannot be accomplished, then the survey will instead sample from June through November, in order to avoid sampling during the month of May. The proposed sampling period of May through November was derived from industry feedback and to establish consistency with existing regional surveys, and the sampling is consistent with the ventless trap monitoring at SFW. The standard soak time will be five nights, which is consistent with local fishing practices, and the protocols used on the SNECVTS survey. Compared to the ASMFC surveys, the SNECVTS used a longer soak time because lower densities of lobsters were expected offshore compared with inshore areas of Maine and Massachusetts, and because of the logistics of sampling offshore (Collie and King 2016). The target soak time will remain consistent throughout the duration of the survey. Traps will be baited with locally available bait (likely skate), and the bait type will be recorded for each trawl. Each randomly selected location will be sampled twice per month. At the start of each monthly sampling event, the lobsterman will retrieve and bait the traps. After the five-day soak period, the traps will be hauled, the catch will be processed for sampling, and the traps will be rebaited for another five-night soak. A disabling door will be used to ensure that the traps are not actively fishing between sampling periods. Each survey event will be managed by a team of qualified scientists including a lead scientist with experience performing lobster research. The catch will be removed from the traps by the vessel crew for processing. The lead scientist will be responsible for the collection and recording of all data. The catch from the ventless trap survey will not be retained for sale by the participating vessels, and all animals will be returned to the water as quickly as possible once the sampling is completed.

The scientific contractor will apply for a LOA or an EFP from NOAA Fisheries in order to use the hired fishing vessels as a scientific platform and conduct scientific sampling that is not subject to the Atlantic Coastal Fisheries Cooperative Management Act, Magnuson-Stevens Fishery Conservation and Management Act, and fishery regulations in 50 CFR parts 648 and 697. All survey activities will be subject to rules and regulations outlined under the MMPA and ESA. Efforts will be taken to reduce marine mammal, sea turtle, and seabird injuries and mortalities caused by incidental interactions with sampling gear. All gear restrictions, closures, and other regulations set forth by take reduction plans (e.g., Harbor Porpoise Take Reduction Plan, Atlantic Large Take Whale Reduction Plan, etc.) will be adhered to as with typical scientific fishing operations to reduce the potential for interaction or injury. The requirements described in the Atlantic Large Whale Take Reduction Plan (NOAA 2018b) for the trap and pot fisheries will be followed. At a minimum, the following measures will be used to avoid interactions between the ventless trap survey and marine mammals:

- No buoy line will be floating at the surface.
- All sampling gear will be hauled at least once every 30 days, and all gear will be removed from the water at the end of each sampling season (November).
- All groundlines will be constructed of sinking line.

- Fishermen contracted to perform the field work will be encouraged to use knot-free buoy lines.
- To reduce the potential for moderate or significant risk to right whales (should an entanglement occur) buoy/end lines with a breaking strength of <1700lbs will be used. All buoy line will use weak links that are chosen from the list of NMFS approved gear. This may be accomplished by using whole buoy line that has a breaking strength of 1700lbs; or buoy line with weak inserts that result in line having an overall breaking strength of 1700lbs.
- All buoys will be labeled as research gear, and the scientific permit number will be written on the buoy. All markings on the buoys and buoy lines will be compliant with the regulations, and all buoy markings will comply with instructions received by staff at NOAA Greater Atlantic Regional Fisheries Office Protected Resources Division.
- Any lines or trawls that go missing will be reported to the NOAA Greater Atlantic Regional Fisheries Office Protected Resources Division as soon as possible.

4.2.4 Ventless Trap Methods – Gradient Survey

As described for the BACI ventless trap survey, the gradient survey will also be executed using a local lobster vessel(s) with scientists onboard to process the catch. Consistent with traps used in the ASMFC and SNECVTS ventless trap surveys, the fishing vessel(s) will be contracted to conduct the sampling using a single parlor trap that is 16 inches high, 40 inches long, and 21 inches wide with 5-inch entrance hoops and constructed with 1-inch square rubber coated 12-gauge wire. The spacing between the traps in each trawl will be consistent with the spacing used on the BACI survey. Trawls will be configured with ten traps on each trawl, but unlike the BACI survey, the trawls will be comprised of ten ventless traps, and no standard traps. The rationale to execute the gradient study using only ventless traps comes from monitoring data collected during the Block Island Wind Farm survey. The results from Block Island Wind Farm demonstrated that ventless traps typically have higher catch rates and sample a wider range of size classes than standard traps, and therefore provide more information on the abundance and demographics of the local lobster and crab population (e.g., INSPIRE Environmental, 2018b). With only ventless traps used, trap type will not need to be considered as a covariate in analysis of the data; this will allow the greatest inference from the fewest number of lines in the water.

Sampling for the gradient survey will occur on the same monthly schedule (May – November) as the post-construction BACI survey, but the timing of the survey may need to be modified to June through November dependent upon our ability to execute the survey using traps that are already allocated to the fishery (see Section 4.2.3). The standard soak time will be five nights, which is consistent with local fishing practices, and the protocols used on the SNECVTS survey. The target soak time will remain consistent throughout the duration of the survey. Traps will be baited with locally available bait (likely skate), and the bait type will be recorded for each trawl. Each randomly selected foundation location will be sampled twice per month. At the start of each monthly sampling event, the lobsterman will retrieve and bait the traps. After the five-day soak period, the traps will be hauled, the catch will be processed for sampling, and the traps will be rebaited for another five-night soak. A disabling door will be used to ensure that the traps are not actively fishing between sampling periods. Each survey event will be managed by a team of qualified scientists including a lead scientist with experience performing lobster research. The catch will be removed from the traps by the vessel crew for processing. The lead scientist will be responsible for the collection and recording of all data. The catch from the ventless trap survey will not be retained for sale by the participating vessels, and all animals will be returned to the water as quickly as possible once the sampling is completed.

As described for the BACI survey (Section 4.2.3) the scientific contractor will apply for a LOA or an EFP from NOAA Fisheries in order to use the hired fishing vessels as a scientific platform and conduct scientific sampling that is not subject to the Atlantic Coastal Fisheries Cooperative Management Act, Magnuson-Stevens Fishery Conservation and Management Act, and fishery regulations in 50 CFR parts 648 and 697. All survey activities will be subject to rules and regulations outlined under the MMPA and ESA, and the same measures described in Section 4.2.3 will be used to minimize the potential for incidental interactions with sampling gear.

4.2.5 Biological Sampling

During both the BACI survey, and the post-construction gradient survey, the catch will be processed in a manner consistent with the ASMFC and SNECVTS ventless trap surveys. Sampling will occur at the trap level, which will allow for the catch rates to be standardized in the event that traps are lost or damaged. The following data elements will be collected for each trap sampled during the survey; total number and biomass of individuals sampled, number and biomass for each species, and length frequency distribution of dominant invertebrate species (lobster, Jonah crab, and rock crab). Fish will be measured to the nearest cm, consistent with the species-specific measurement type (e.g., total length, fork length) described in the Northeast Observer Program Biological Sampling Guide. After sampling, all catch will be returned to the water as quickly as possible to minimize incidental mortality.

Biological data for individual lobsters will be sampled consistently with the protocols used by the MADMF and RIDEM during their ventless trap surveys. Data collected for individual lobsters will include:

- Carapace length: Measured to the nearest millimeter (mm) using calipers.
- Sex: Determined by examining the first pair of swimmerets.
- Eggs: Examine the underside of the carapace for the presence or absence of eggs. The gross egg stage will be characterized according to the following categories:
    - Absent
    - Brown (partially developed with eyespot present and will hatch in this calendar year)
    - Green (newly spawned with no eyespot present)
    - Green with eyes (small eyespot present, but will not hatch in this calendar year)
- V-notch status: present or absent (according to the LCMA2 definition)
- Cull status: Examine the claws for condition (claws missing, buds, or regenerated).

- Incidence of shell disease: Shell disease will be characterized according to four categories:
    - Absent
    - Light (1-10% of the shell)
    - Moderate (11-50%)
    - Heavy (> 50%).
    - Mortality: alive or dead

Biological information will also be collected for Jonah crabs and rock crabs. All of the crabs will be sampled from two randomly selected traps (one ventless and one vented) in each trawl, in order to investigate the different selectivities of both trap types. Sampling all of the crabs in the trap can also help avoid potential biases associated with subsampling, whereby smaller crabs may be underrepresented in the subsample. For the other eight traps in the trawl, counts and weights will be recorded for Jonah crabs and rock crabs, and up to ten crabs per trap will be subsampled for biological information. The following data elements will be recorded for each rock crab and Jonah crab that is sampled:

- Carapace width: Measured to the nearest mm using calipers.
- Sex: Determined by examining the width of the abdomen (apron). For female crabs, it is noted that there will be small differences in the width of the abdomen between mature and immature animals.
- Ovigery status: Presence/absence of eggs. Egg color recorded for females with eggs present.

Incidence of shell disease: Shell disease will be characterized according to four categories:

Absent

Light (1-10% of the shell)

Moderate (11-50%)

Heavy (> 50%).

- Cull status: Examine the claws for condition (claws missing, buds, or regenerated)
- Mortality: alive or dead

Hydrographic data will be collected at each trawl that is sampled. A Conductivity Temperature Depth (CTD) sensor will be used to sample a vertical profile of the water column at each ventless trap sampling location, following the methods used by the CFRF/WHOI Shelf Research Fleet (Gawarkiewicz and Malek Mercer 2019). The CTD profile may be collected either before the first trap in each trawl is hauled, or after the last trap in the trawl is hauled, at the discretion of the chief scientist. Bottom water temperature will be recorded at regular intervals (e.g., every 30 minutes) throughout the sampling period using a temperature logger mounted to an interior trap on each trawl. Sea state and weather conditions will be recorded from visual observations. Air temperature may be downloaded from a local weather station if not available onboard.

Should any interactions with protected species (e.g., marine mammals, sea birds, sea turtles, sturgeon) occur, the contracted scientists will follow the sampling protocols described for the Northeast Fisheries Observer Program (NEFOP) in the Observer On-Deck Reference Guide (Northeast Fisheries Science Center 2016). If any protected species are captured during the ventless trap survey, the sampling and release of those animals will take priority over sampling the rest of the catch. Reporting of interactions with marine mammals, such as small cetaceans and pinnipeds, will be dependent on the type of permit (i.e., EFP or LOA) issued to the applicant; once the permit type has been specified, we will contact NMFS-PRD for guidance on reporting procedures. Additionally, protocols for handling live or deceased protected species of sea turtles, sturgeon, or marine mammals will be dependent on the type of permit (i.e., EFP or LOA) issued to the applicant. Once the permit type has been specified, we will contact NMFS-PRD for guidance on handling protocols. Entangled large whales or interactions with sea turtle species must be reported immediately to NOAA's stranding hotline via telephone (866-755-NOAA) and interactions with sturgeon species will be reported immediately to NOAA via the incidental take reporting email (incidental.take@noaa.gov); a follow up detailed written report of the interaction (i.e., date, time, area, gear, species, and animal condition and activity) must be provided to the NMFS Greater Atlantic Regional Fisheries Office (incidental.take@noaa.gov) within 24 hours. Any biological data collected during sampling of protected species will be shared as part of the written report that is submitted to the NMFS Greater Atlantic Regional Fisheries Office. Any genetic samples obtained from sturgeon will be provided to the NMFS-PRD. Due to the potential for communicable diseases all physical sampling and handling of marine mammals and seabirds will be limited to the extent Orsted health and safety assessments and plans allow.

4.2.6 Ventless Trap Station Data

The following data will be collected during each sampling effort:

- Station number
- Start latitude and longitude
- Direction of the trawl
- Start time and date
- Start water depth
- End latitude and longitude
- End time
- End water depth
- Wind speed
- Wind direction
- Wave height
- Air temperature
- Type of bait that was used
- Comments regarding damage to any of the traps

- Hydrographic data, as collected using the CTD and temperature logger (see Section 4.2.2).

4.2.7 Data Management and Analysis

All field data will be reviewed for errors before being transcribed into a relational database. Quality control checks will be performed on database tables by running standardized, systematic queries to identify anomalous data values and input errors. Species names (common and scientific) will be verified and tabulated for consistency. All data used in analysis will be exported from the relational database. Annual reports containing catch and biological data will be prepared after the conclusion of each year of sampling and shared with state and federal agencies. One final report will also be produced synthesizing the findings of the pre- and post-construction evaluations. Revolution Wind will also coordinate with our scientific Contractor(s) to disseminate the annual monitoring results through a webinar or an in-person meeting, and this meeting will also offer an open forum for state, federal, and academic scientists to ask questions or suggest revisions to the data collection protocols. Likewise, following each year of monitoring we will coordinate with the Contractor(s) to host an industry workshop to disseminate the results of the monitoring activities to local fishing industry members.

The pre-construction monitoring data will be analyzed to evaluate the spatial and seasonal patterns of relative abundance of lobster, Jonah crab and rock crabs in the RWF ventless trap impact area and reference areas. Prior to construction, results reported in annual reports will focus on comparing relative abundance, size frequencies, and demographic parameters between the Project and reference areas. For lobster, Jonah crab, and rock crab, CPUE (average annualized catch per trawl) will be compared amongst the Project and reference areas using descriptive statistics (e.g., mean, variance and range); and length frequency data by species will be compared among areas using descriptive statistics, graphical techniques (eCDF plots), and appropriate statistical tests (e.g., Kolmogorov-Smirnoff tests or cluster sampling). Sex ratios will be reported for each sampling event and compared amongst areas. The abundance and distribution of lobster, Jonah crab, and rock crab will be mapped each month, and descriptive statistics will be used to report on monthly trends in biological information such as shell disease or egg status.

The ventless trap survey will supplement the available pre-construction data on lobster and crab resources in the adjacent SFW site (i.e., SNECVTS survey dataset). Given that both studies will be carried out using identical trawl configurations, catch rates can be compared at the trawl level. Collie and King (2016) used GAM's that included covariates such as temperature and habitat to evaluate the spatial and temporal variability of lobster and Jonah crab catches throughout the SNEVTS area. These analyses will be repeated to include the RWF ventless trap data, to investigate changes in relative abundance over time, and to better evaluate how catch per unit effort is influenced by abiotic conditions. Pre-construction biological data collected at RWF in 2021 and 2022 can also be compared to information collected through SNECVTS to investigate interannual and intraannual differences in demographic parameters (e.g., shell disease, length frequency).

Sampling during and after construction will allow for quantification of changes in the relative abundance and demographics of the lobster and crab resources due to construction activities as well as operation of the windfarm. The BACI design for this survey plan allows CPUE to be compared between the before and after construction periods in the two treatment types (reference areas and RWF ventless trap survey impact area), using appropriate statistical modeling. The use of reference areas will ensure that regional changes in the abundance and demography of lobsters and crabs are accounted for when assessing the potential impacts of the proposed Project. For lobster, Jonah crab, and rock crab, the primary research question is the magnitude of difference in the temporal changes in relative abundance that are observed between the Project and reference areas. This question can be answered using the following hypotheses:

- $H_{\emptyset}$ - *Changes in relative abundance in both the reference and RWF ventless trap survey impact areas will be statistically indistinguishable between time periods (before and after).*
- H_1 - *Changes in CPUE will not be the same at the reference and RWF ventless trap survey impact areas between time periods (before and after; two-tailed).*

In the asymmetrical BACI design, there are multiple years within each time period and multiple sites within the Control treatment. Area will represent a fixed factor in the model with three levels (i.e., RWF ventless trap survey impact area, and each reference area), which will be crossed with year, also a fixed factor. Environmental covariates (depth, temperature, and salinity) will be recorded at the level of each trawl that is sampled, and can also be included in the abundance model, either as linear or quadratic factors. Depth will be recorded as the average depth observed at the start and end of the trawl. Bottom temperature observations will be recorded *in situ* while the trawl is deployed, and the mean temperature observed during the soak time can be evaluated in the model. Habitat type will be classified for each trawl, using either *in situ* observations (e.g., underwater video, side-scan sonar) or habitat maps derived from Orsted high-resolution geophysical and benthic surveys, and treated as a random effect within the model. Model selection will be conducted using AIC, and forward and backward stepwise elimination will be used to select the most parsimonious model (Venable and Ripley, 2002). Residuals will be examined using diagnostic plots to further investigate model fit.

The design is not suited to analysis with a simple two-factor ANOVA model; instead GLMs or GAMs will be used to describe the data and estimate the 90% CI on the BACI contrast. GLMs or GAMs will be used to estimate the catch in each area and year. The interaction contrast that will be tested is the difference between the temporal change (i.e., average over the post-operation period minus the average over the pre-operation period) at the RWF ventless trap survey impact area and the average temporal change at the reference areas. A statistically significant impact would be indicated by a 90% CI for the estimated interaction contrast that excludes zero.

Spatial and temporal patterns in the biological data for lobsters (shell disease, sex ratios, reproductive status) will be summarized and reported. Similar to the methods described for relative abundance, GLMs or GAMs may also be used to test for the magnitude of the difference in the temporal change between the Project and reference areas for the biological parameters that will be collected (e.g., shell disease, cull status). This research question can be addressed using the following hypotheses:

- $H_{\emptyset}$ - *Changes in demographic parameters (e.g., shell disease) in both the reference and RWF ventless trap survey impact areas will be statistically indistinguishable between time periods (before and after).*
- H_1 - *Changes in demographic parameters (e.g., shell disease) will not be the same at the reference and RWF ventless trap survey impact areas between time periods (before and after).*

GLMs or GAMs will be used to describe the data and estimate the 90% CI on the interaction contrast. The interaction contrast that will be tested is the difference between the temporal change (i.e., average over the post-operation period minus the average over the pre-operation period) at the RWF ventless trap survey impact area and the average temporal change at the reference areas. A statistically significant RWF ventless trap survey impact would be indicated by a 90% confidence interval for the estimated interaction contrast that excludes zero.

The power analysis for measuring changes in relative abundance will be reevaluated after the first year of the RWF ventless trap survey. The power calculations and resulting power curves use the SNECVTS dataset to make implicit assumptions regarding the expected variance in the catch rates for lobsters, Jonah crabs and rock crabs. In practice, the variance for these species in the RWF ventless trap survey may be greater or smaller than was observed during SNECVTS. Therefore, after one full year of sampling has been completed, the observed variance in catch rates (e.g., CVs) will be calculated for each species and the survey performance will be evaluated.

During the operational phase, the data collected from the gradient study design will be used to examine the influence of distance from a turbine foundation on the relative abundance of lobsters, Jonah crabs, and rock crabs. Relative abundance data will be investigated at the trap level, permitting an examination of fine-scale differences in abundance. By recording the start and end location of each trawl, and the orientation of the trawl, it will be possible to estimate the distance of each trap to the nearest turbine foundation. For the strings of ventless traps that are set adjacent to the turbines (gradient design) scatterplots can be used to graphically investigate the relationship between catch rates (dependent variable), and the distance of each trap from the nearest foundation (independent variable). These graphical relationships will help elucidate the distance at which crustaceans may be attracted to, or repelled from, the foundations. Rank correlation analysis can be used to determine if there is a significant association between proximity to the turbine foundation and the catch rates. Spatial representation of the catch data can potentially be overlaid on habitat maps of the area to investigate possible influence of habitat on catch rates. Catch rates that are observed in the ventless traps that are set adjacent to the turbine (gradient design) can also be compared to the catch rates in ventless traps deployed throughout the RWF ventless trap impact area (BACI design).

Beyond the analyses described above, additional analyses will focus on evaluating the comparability of the RWF ventless trap survey data with observations from other ventless trap surveys in the region, including the ventless trap surveys completed by state agencies through ASMFC, as well as observations from ventless trap surveys completed at other lease sites (e.g., Vineyard Wind ventless trap survey). Given that we are proposing to use 10 trap trawls, rather that the six trap trawls used during some other surveys, the relative abundance data (average annualized catch per trawl) will need to be standardized in order to facilitate appropriate comparisons with these other regional surveys. Conducting biological sampling at the trap level during the RWF ventless trap survey will help to facilitate those comparisons. Biological data for lobsters and crabs will be collected using protocols that are consistent with the ASMFC sampling protocols. Comparing relative abundance and demographics between the RWF survey and other ventless trap surveys in the region will provide greater context to evaluate whether the results observed at RWF are due to offshore wind development, or whether they are indicative of broader regional trends. These comparisons can be made at a variety of scales (e.g., lease site, sampling strata, stock area) as appropriate for the species and biological indices of interest.

4.3 Acoustic Telemetry – Highly Migratory Species

Passive acoustic telemetry can monitor animal presence and movements across a range of spatial and temporal scales. For instance, each acoustic receiver provides information on the presence of tagged individuals on the scale of tens to hundreds of meters. Acoustic receivers also offer continuous monitoring, allowing for behavior, movements, and residence of tagged individuals to be investigated at a fine temporal scale (e.g., minutes to hours) and in relation to cyclical events (e.g., day/night, tide, etc.). By leveraging observations collected across individual receivers, and receiver arrays, telemetry can also monitor animal presence and movement over a broad spatial (tens to hundreds of kilometers) and temporal (e.g., months to years) extent. Therefore, passive acoustic telemetry is an ideal technology to monitor presence, residency, and movements of species within Wind Energy Areas (WEAs) and to evaluate short and long-term impacts of wind energy projects on these parameters.

The use of passive acoustic telemetry has grown dramatically over the past decade and continues to grow each year (Hussey et al. 2015; Freiss et al. 2021). As a result of this rapid growth, hundreds to thousands of acoustic receivers are deployed each year in the northwest Atlantic from the Gulf of St. Lawrence to the Gulf of Mexico, each of which is capable of detecting the thousands of active transmitters that are currently deployed on at least 40 species including, among many others, sturgeon, striped bass, sea turtles, sharks, bluefin tuna, and black sea bass.

Acoustic telemetry has been used to investigate the behavior and movements of fish species in offshore wind areas. Reubens et al., (2013) monitored juvenile cod residency patterns, habitat use, and seasonal movement at the C-Power offshore wind farm in the North Sea and found that the majority of cod aggregated near the foundations and were resident within the wind farm for extended periods of time in the summer and autumn. Winter et al., (2010) tagged sole (n=40) and cod (n=47) with acoustic transmitters and tracked their movements within the Egmond aan Zee windfarm and a nearby reference area and concluded that sole did not exhibit avoidance of the windfarm, nor did they appear to be attracted to the foundations. Instead, seasonal movements were interpreted as occurring at spatial scales larger than the wind farm. Karama et al., (2020) monitored tagged Japanese yellowtail (a highly mobile species) and red sea bream around an offshore wind turbine near the Goto Islands (Japan) over the course of a year and found that both species exhibited low affinity and residency around the turbine throughout all seasons. Acoustic telemetry has also been used to evaluate the interactions of marine organisms with power transmission cables. Klimley et al., (2017) monitored the movements of green sturgeon and salmon smolts in relation to the Trans Bay Cable within the San Francisco Estuary and concluded that the Cable did not impact the migration success of either species. Similarly, Westerberg and Lagenfelt (2008) studied the movements of European eels in the Baltic Sea around an AC power cable and observed that the swimming speed of the eels was reduced near the cable, but that the cable did not act as an impediment to migration.

Acoustic telemetry is also recognized as a valuable tool to collect data on the presence, distribution, and seasonal movements of fish species in and around WEAs. Recently, BOEM has funded several studies to collect baseline data using acoustic telemetry for species such as sturgeon, striped bass, and winter skate, as well to investigate the seasonal movements and spawning behavior of cod within the MA/RI WEAs. The cod telemetry project commenced in 2019 and is being conducted by a group of researchers from the Massachusetts Division of Marine Fisheries, University of Massachusetts Dartmouth School for Marine Science and Technology, NOAA, Woods Hole Oceanographic Institution, and the Nature Conservancy. Atlantic cod has been recognized as a priority species for offshore wind monitoring by several groups (e.g., NMFS 2015; Petruny Parker et al. 2015; MADMF 2018), and cod have been identified as a species that is vulnerable to disturbance from the construction and operation of offshore wind farms (Guida et al. 2016). In 2020, INSPIRE Environmental and the Anderson Cabot Center for Ocean Life (ACCOL) at the New England Aquarium received funding through the Massachusetts Clean Energy Center (MassCEC) to use acoustic telemetry to monitor the presence and persistence of Highly Migratory Species (HMS) at popular recreational fishing grounds within the MA/RI WEA. The project is focusing on monitoring bluefin tuna, shortfin mako sharks, and blue sharks, which are three of the most commonly captured and targeted species by the offshore recreational community in southern New England (NOAA 2019) and were identified as priority species for monitoring the potential impacts of offshore wind in the MA/RI WEA (MADMF 2018). Shortfin mako sharks and tuna were also identified by Petruny Parker et al., (2015) as priority species for monitoring, and Essential Fish Habitat is present within the study area for all three of the Highly Migratory Species.

This monitoring effort will build off of these baseline studies and expand the acoustic telemetry project by including five additional years of data collection, the addition of receivers to the telemetry array, and the deployment of an additional 150 acoustic transmitters for Highly Migratory Species.

The primary objectives associated with the acoustic telemetry monitoring are as follows:

- Objective 1: Evaluate changes in HMS presence, residency, and movements between pre-construction, construction, and post-construction.
- Objective 2: Evaluate HMS connectivity among Ørsted lease sites.
- Objective 3: Monitor tagged HMS at spatial scales greater than the Ørsted project areas

4.3.1 Acoustic Telemetry Methods

Ørsted, through the SFW project, has already provided financial support to both the cod and HMS acoustic telemetry studies. SFW provided funds to the cod telemetry project team to purchase six additional VR2W receivers, which permitted the maintenance of their full receiver array. SFW also purchased mooring equipment (e.g., line, buoys, anchors, etc.) to retrofit the receiver moorings for the cod telemetry study to help minimize the loss of receivers and allow the project to meet its monitoring objectives. SFW also provided financial support to the HMS telemetry project to purchase, deploy, and maintain four VR2-AR receivers year-round, which will bolster the resolution of the broader MA/RI WEA acoustic receiver array, particularly during the cod spawning season. As part of the Ørsted ECO-PAM project, an acoustic receiver was deployed near SFW (41.06N 70.83W) in July 2020, and that receiver is maintained by Mark Baumgartner at Woods Hole Oceanographic Institute.

With MassCEC support, fifteen acoustic receivers were deployed in July 2020 at three popular recreational fishing sites within the MA/RI WEAs identified through a previous recreational fishing survey carried out by the ACCOL (Kneebone and Capizzano 2020). These receivers were deployed strategically and in conjunction with the Atlantic cod receiver array, to maximize spatial coverage for both projects. For-hire tagging trips using local charter vessels were conducted in 2020 and will be continued in 2021 to target and tag 20 individuals of each of the three HMS species listed above (60 tags in total).

The current HMS receiver array will be expanded from 17 to 36 receivers starting in the spring or summer of 2022 and will achieve monitoring across all three Ørsted lease sites within the MA/RI WEA (Figure 14). The array will be comprised of 13 Vemco VR2-AR (acoustic release) receivers that were purchased through the INSPIRE Environmental/ACCOL MassCEC project, 4 VR2-AR receivers previously purchased by Ørsted, and 19 additional VR2-AR receivers that will be purchased specifically for this project in Q4 2021 or Q1 2022 with financial support from Ørsted. The full receiver array will be maintained year-round continuously through 2026. This will permit monitoring throughout the pre-construction, construction, and post-construction periods of the Revolution Wind, Sunrise Wind, and South Fork Wind projects. The receivers will also gather valuable pre-construction data at popular recreational fishing grounds within the OCS-A 500 lease area.

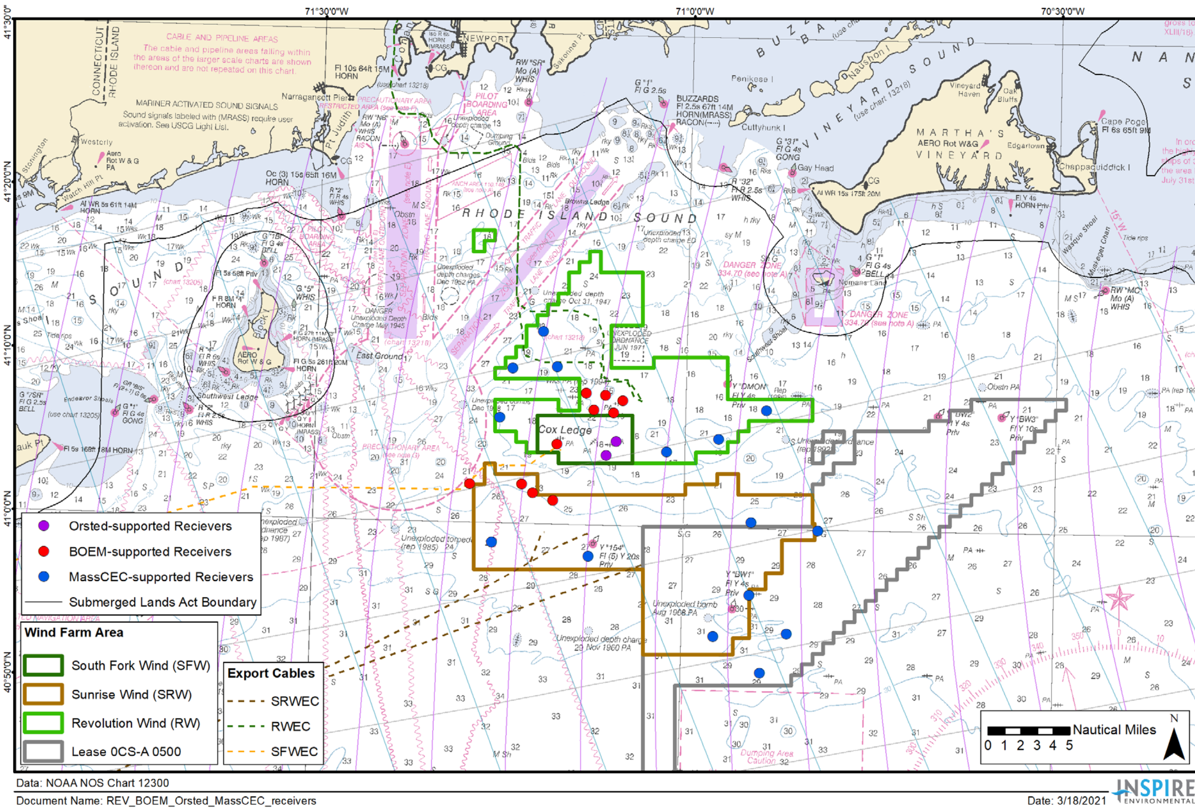


Figure 14. **Current locations of acoustic receivers within Orsted lease sites. The receiver array will be expanded to 36 locations starting in 2022.**

Receivers will remain in the water year-round to provide monitoring during the presumed cod spawning period of December through March (Cadrin et al. 2020; Dean et al. 2020). The existing 17 HMS receiver stations established in 2020 (Figure 14) will be retained, and an additional 19 receiver stations will be selected in collaboration with cod researchers to optimize monitoring for all species. BOEM funding for the cod study is expected to end in 2022, however, Ørsted will purchase 100 additional acoustic tags to be deployed on cod caught on the trawl survey to extend the life of the project. The HMS receiver array will continue to allow for monitoring of tagged cod, and all detections of tagged cod will be shared with that research team.

Vemco model VR2-AR receivers will be rigged using standard procedures outlined by Vemco for benthic deployment https://www.oceans-research.com/wp-content/uploads/2016/09/vr2ar-deploy-tips.pdf). Ropeless technology (AR Buoys) was selected to minimize risks to marine mammals and other protected species. VR2-ARs will be maintained using a Vemco VR-100 unit and transponding hydrophone that were purchased using MassCEC funding.

Acoustic receiver download and maintenance trips will be conducted in the spring and fall of each year of the project. During each trip, receivers will be summoned, downloaded, and cleaned of any biofouling. They will be re-rigged and re-deployed at sea. Receiver deployment and maintenance will be done primarily in collaboration with a local commercial fishing vessel.

Acoustic receivers will monitor for the presence of the 60 Vemco V16 high power transmitters that were/will be deployed on HMS as part of the 2020 – 2021 MassCEC project, as well as an additional 150 transmitters that will be deployed from 2023 – 2025 on HMS (target of 50 transmitter releases per year) as part of this monitoring plan. These transmitters will emit unique, coded signals every 60 – 120 seconds and have an estimated battery life ranging from 1000 – 2500 days, depending upon the specifications of the transmitters. Therefore, long-term monitoring of HMS will occur throughout and beyond the duration of the project (2026). VR2-AR receivers will also monitor and record water temperature and ambient noise every hour throughout the entirety of the study.

The VR2-AR receivers will also opportunistically collect detection data from the thousands of marine organisms including fish, invertebrates, sharks, sea turtles and marine mammals that are currently being tracked in the northwest Atlantic using acoustic transmitters. At present, the majority of acoustic receivers deployed in southern New England are located close to shore, often in estuaries. Therefore, establishing a high-resolution and long-term acoustic receiver network in the offshore waters of the continental shelf will help fill spatial gaps in acoustic telemetry monitoring, and provide valuable data to supplement the dozens of ongoing telemetry studies in the region.

HMS will be tagged both internally and externally with acoustic transmitters. Bluefin tuna and smaller sharks will be tagged internally, and larger sharks will be tagged externally. External transmitters will be rigged on stainless, multi-strand cable and implanted into the dorsal musculature of the fish with a small titanium anchor. Internal transmitters will be implanted using standard surgical techniques outlined in our approved New England Aquarium Animal Care and Use Protocol.

4.3.2 Data Analysis and Data Sharing

Scope of monitoring - Due to the highly mobile nature and anticipated large home range of HMS, monitoring will occur in aggregate over the Revolution Wind, Sunrise Wind, and South Fork Wind project areas. Data aggregation will serve as a more biologically and ecologically appropriate manner to examine impacts on species that can use large areas of the southern New England region over variable periods of time (e.g., days to months). Accordingly, the data analyses described below will be performed, at a minimum, using all acoustic detection data collected by the 36 receivers deployed in the Revolution Wind, Sunrise Wind, and South Fork Wind project areas. Finer-scale monitoring of HMS activity within each individual project area will be accomplished if sufficient data are available over the time series.

Additional data sources - Acoustic telemetry has recently been adopted as a multi-species monitoring platform throughout several MA/RI and MA offshore wind leases. Thus, monitoring opportunities under this plan will be bolstered and expanded through collaboration, cooperation, and data sharing with ongoing projects funded by other developers/entities. Efforts will be made to establish working relationships or formal agreements among various telemetry projects to maximize the amount of data that will be included in this monitoring plan. For example, detection data from acoustic transmitters that are deployed on HMS as part of non-Ørsted monitoring projects may be used in this monitoring plan contingent upon the establishment of a data sharing agreement with the entity that purchased the transmitter. Similarly, detection data for Ørsted transmitters that are logged by receivers deployed in other MA/RI or MA lease areas may be included in the analyses outlined in this monitoring plan. The potential for data sharing and cooperation across projects will become more apparent over time as data sharing agreements are reached amongst developers. However, there is great potential to establish acoustic telemetry as a regional monitoring platform across numerous lease areas during the project period (2021 – 2026).

Data Analysis - The detection data will be compiled after each download and analyzed with the overall goal of establishing information on species presence and persistence across the Ørsted lease areas in the MA/RI WEA. Several metrics will be analyzed including short- and long-term presence, site fidelity (i.e., residency/persistence), fine- and broad-scale movement patterns, and inter-annual presence (i.e., whether individuals return to the receiver array each year). Deliverables will include detailed detection history plots for each tagged individual that depict all detections logged for an animal by individual receivers, as well as by all receivers, over each year of monitoring. Summary tables and figures will be generated that describe: the total number of receivers an individual and/or species was detected on in the broader receiver array as well as in each project area, the number of times each fish was detected by each receiver, movements between individual receivers and project areas, and monthly/seasonal/annual patterns in presence and persistence in relation to environmental conditions (e.g., sea surface or bottom water temperature, photoperiod).

To examine animal home range, we will estimate individual and species' utilization distribution using statistical analyses such as the Brownian Bridge Movement Model (e.g., Dean et al. 2014; Zemeckis et al. 2019) or a spatial point process model (Winton et al. 2019), both of which are effective when used with passive acoustic telemetry data. Connectivity and movements between receiver locations will be examined using a network analysis, which has been used previously to examine movements and space use with passive acoustic telemetry data (e.g., Lea et al. 2016). Analytical techniques for telemetry data are constantly evolving, therefore, we will also consider using novel statistical methods to analyze our data, such as state-space or multi-state models, should they become available during the course of the study. As appropriate, we will integrate information on sea surface temperature, bottom water temperature (measured hourly by each receiver), season (or month), water depth, photoperiod, and substrate type into all analyses to examine the influence of physical processes and environmental conditions on each metric.

The acoustic telemetry data can be evaluated across a range of spatial scales, depending on the scale of interest. To examine the factors that influence presence/absence of HMS at individual or groups of receivers, individual project areas, or the broader acoustic receiver array, we will construct a series of logistical regressions. Regressions will test whether a series of fixed or mixed effects (e.g., water temperature, month, photoperiod, distance from construction location, distance from inter-array cable or export cable, etc.) influence the presence or absence of a species (the response variable). External data collected on ambient noise levels may be included in these regressions, as appropriate.

To examine potential effects of construction and operation on HMS, all analyses will be structured around the following objectives and hypotheses:

Objective 1: Evaluate changes in HMS presence, residency, and movements between pre-construction, construction, and operation.

HMS presence in the southern New England has been documented to be driven by environmental (e.g., water temperature, photoperiod) or biological/physiological (e.g., ontogeny, thermal tolerance) factors. Thus, the presence, persistence, and movements of HMS in the Revolution Wind, Sunrise Wind, or South Fork Wind project lease areas likely varies naturally from month to month or year to year.

Accordingly, we will establish baseline, pre-construction levels for several standard metrics related to the presence/residency and movements for each species throughout the entire HMS receiver array including: minimum, maximum, and mean annual/seasonal residency times, presence in relation to environmental conditions (e.g., surface and bottom water temperature), nature of movement (e.g., long-term presence vs. transit/migratory corridor), and inter-annual patterns in presence/residency or movement (e.g., present in acoustic array annually, or sporadic, inconsistent presence over multiple years). These metrics will serve as the basis by which to examine the impacts (if any) of construction and operation of the Projects.

To examine impacts of construction or operation, the aforementioned metrics will be created for each species during the construction and operations (if appropriate) phases of each project. For example, decreased residency times or the avoidance of an area that is otherwise biologically or environmentally-suitable for a species may be an indication of spatial displacement resulting from construction or operational activities. In contrast, more frequent detection (observation) or extended residency times of HMS in certain areas may be indicative of aggregation in response to the presence of fixed structures such as wind turbines.

H_0: HMS presence and movements are driven by environmental features (e.g., water temperature, prey distribution) and animal biology or physiology and are not affected by construction or operation of offshore wind turbines or the presence and activity of electrical transmission cables.

Objective 2: Evaluate HMS connectivity among Ørsted lease sites.

Given the differing construction timelines of the Revolution Wind, Sunrise Wind, and South Fork Wind projects, individual acoustic receivers will be monitoring locations that are at different stages of project development (e.g., pre-construction, construction, operation). To examine potential effects of construction or operation on HMS presence and movements in adjacent Ørsted lease sites/project areas that are at an earlier stage of development, we will calculate the metrics outlined in Objective 1 for all projects in a given phase. For example, if construction has begun in South Fork Wind, we will compare the standard metrics for South Fork Wind to those of Revolution Wind and Sunrise Wind (which will still be in the pre-construction phase). If appropriate, we will employ the aforementioned logistic regression to test whether proximity to the construction site (e.g., linear distance away) impacts presence or avoidance for individual animals, or for species.

H_0: HMS presence and movements are driven by environmental features (e.g., water temperature, prey distribution) and animal biology or physiology and are not affected by construction or operation of offshore wind turbines or the presence and activity of electrical transmission cables.

Objective 3: Monitor tagged HMS at spatial scales greater than the Ørsted project areas

In addition to the local-scale acoustic monitoring achieved by the proposed HMS receiver array, regional or broad-scale movement data will be accomplished through data sharing with related

HMS monitoring projects in other offshore wind lease areas, and through regional telemetry data sharing programs (e.g., MATOS, see Data Sharing section below). Our first priority will be to establish data sharing agreements with other developers that have established acoustic telemetry monitoring frameworks for HMS. Sharing transmitter metadata and acoustic detection data across projects will permit 1) the monitoring of a larger number of HMS in the Ørsted acoustic array, and 2) the monitoring of HMS tagged under this monitoring plan that are detected in adjacent receiver arrays in MA/RI or MA WEAs. Such data sharing will enable monitoring on a more regional level, which is more appropriate for highly mobile fishes, such as HMS, and this regional scale monitoring will help to elucidate cumulative impacts for these species. We will adjust the statistical tests and analyses presented herein to incorporate all available data and adjust the spatial and temporal extent of this broader monitoring plan as appropriate.

Participation in regional telemetry data sharing networks will allow us to obtain detection data from our tagged animals wherever else they are detected in the greater Atlantic region. Any detection data obtained through our participation in regional telemetry data sharing networks will be incorporated into our analyses as appropriate, particularly to examine the distribution and movements of species beyond the confines of Ørsted lease areas. Information on the presence of tagged HMS beyond the receiver array (in the Ørsted project areas) will be particularly important to evaluate whether the lack of detection/observation of an individual (or species) is due to the avoidance of the area (i.e., presence in some other region) or tag loss or mortality (i.e., lack of detection of a tag over extended periods provides evidence of tag shedding or mortality). This analysis will also help to better understand connectivity between offshore wind development areas and adjacent habitats throughout the Northwest Atlantic.

Data sharing - All detection data from Atlantic cod that were tagged as part of the BOEM-funded telemetry study will be provided to the Principal Investigators of that study, and the data can be evaluated to evaluate several metrics including site fidelity, residence times, and spatial distribution of cod throughout the Sunrise Wind, South Fork Wind, and Revolution lease areas. The high-resolution data collected using acoustic telemetry can be utilized to improve the understanding of cod habitat use and spawning behavior in the region. The year-round deployment of the receiver array will improve monitoring during the winter cod spawning season, which is a time period that is not well sampled by the existing fishery independent surveys, and for which there is limited fishery-dependent data collected for the recreational fishery. Given that the cod transmitters have an expected battery life of 1400 days, cod detections should be recorded throughout the duration of the study. Maintaining the receiver array over several years will provide valuable information of spawning site fidelity, interannual variability of habitat use, and the influence of offshore wind development on cod behavior.

All detection data for other species recorded by the acoustic receivers in this Project will be distributed to researchers through participation in regional telemetry networks such as the Ocean Tracking Network or the Mid-Atlantic Acoustic Telemetry Network (MATOS). We will compile any detection data that we collect for transmitters that are not deployed as part of this HMS monitoring effort and disseminate that information to the tag owners every six months (it is the policy of regional data sharing programs that the 'owner' of the data is the entity that purchased and deployed the transmitter, not the entity that detected it on their receiver). We will also approach each transmitter's owner to request the inclusion of their data (i.e., metadata on the species detected, number of detections, amount of time the animal was detected in our receiver array, etc.) in any analyses performed. Ultimately, participation in these large data sharing networks will increase both the spatial and temporal extent of monitoring for species tagged as part of this research effort and permit the collection of data on the presence and persistence of other marine species tagged with acoustic transmitters (e.g., Atlantic sturgeon, striped bass, white sharks) in and around Ørsted lease sites at no additional cost. If a large amount of detection data is obtained for a given species over the course of monitoring, we will engage in conversations with the owner(s) of detected transmitters to explore the potential of adding those species to this monitoring plan. Thus, the choice to use acoustic telemetry in our monitoring framework provides the potential to expand the monitoring efforts described herein beyond HMS and Atlantic cod.

Due to the proven ability of acoustic telemetry to monitor a large number of animals over variable spatial and temporal extents, this technology has already been adopted in several wind energy-related projects along the US east coast. Given this, there is growing potential for coordination and data sharing (as well as cost sharing) across projects. However, in order to achieve efficient and successful coordination and data sharing, project leaders need to be aware of ongoing telemetry projects in the region and establish data sharing plans before or during the early stages of projects. To promote collaboration and coordination, a workshop is planned in Q4 2021 to bring developers and users of acoustic telemetry together and establish a set of 'best practices' for coordination and data sharing. From this workshop, a white paper will be drafted and published to serve as the basis for data sharing among offshore wind telemetry projects moving forward.

4.4 State Water Ventless Trap Survey – Export Cable

Revolution Wind will collaborate with researchers at the Rhode Island Department of Environmental Management Division of Marine Fisheries (RIDEM DMF) to execute a ventless trap study for lobsters, crabs, and fish in Rhode Island state waters along the RWEC route. RIDEM DMF will contract a local lobster vessel to execute the sampling.

The cable route passes to Quonset Point from the offshore wind farm through federal and Rhode Island state waters. These waters provide habitat to a variety of commercially, ecologically, and culturally valuable fish and invertebrate species. Submarine cable installation can disturb sensitive habitats during construction and generate electromagnetic fields (EMF) during operation. Habitat disruption may include physical disturbance and increased turbidity, pollution, and noise, which are considered to be short-term impacts. EMF is generated for the life of the operation and is thus considered long-term impacts; however, uncertainty remains regarding the impacts of EMF (Taormina et al. 2018).

Physical disturbance to benthic habitats during installation or from cable mattressing will directly affect the species utilizing such habitat, while EMF may affect resident species and those transiting through the area. Given potential exposure, EMF sensitivity and habitat preference, species of primary interest include American lobster (*Homarus americanus*), Jonah crab (*Cancer borealis*), whelk (channeled: *Busycotypus canaliculatus*, knobbed: *Busycon carica*), black sea bass (*Centropristis striata*), and tautog (*Tautoga onitis*). American lobsters have demonstrated to be magnetoreceptive and exhibit an exploratory response over a high voltage direct current (HVDC) cable (Hutchison et al. 2020a), suggesting that benthic invertebrates should be focal species for future EMF work. Black sea bass and tautog are important species in both the commercial and recreational fisheries in southern New England that are typically associated with complex bottom habitats and not often well represented in trawl survey catches. There is also a significant pot fishery for these species and scup (*Stenotomus chrysops*) in the region.

The RIDEM DMF began a lobster ventless trap survey in 2006 as part of a regional effort to provide fisheries-independent abundance indices for juvenile lobsters (McManus et al. 2021). As part of this survey, lobster abundances are monitored in Rhode Island state waters (Narragansett Bay, Rhode Island Sound, and Block Island Sound). The RIDEM DMF Ventless Trap Survey (RIVTS) provides a substantial baseline dataset with which to compare cable survey results. However, given the stratification and random sampling nature of the survey design, this dataset alone is not sufficient for assessing prospective impacts from the cable. For this reason, a dedicated cable VTS is needed, but we propose to use similar sampling methodology to the RIVTS to provide regional comparison for the state waters and leverage overlapping spatiotemporal datasets when possible.

Considering the target species and the area to be sampled, a ventless lobster pot survey with some similarities to the RIVTS methodology will be carried out prior to, during, and after installation of the RWEC. This allows for additional RIVTS baseline data collected throughout Rhode Island state waters to be considered alongside cable-specific data collection and analysis. This survey will also include acoustic receivers attached to select lobster pots to evaluate area usage by tagged species, including various elasmobranchs and highly migratory species. The methods proposed herein have been developed using input from local fishermen, and may be refined following additional input from the fishing industry, namely the RI CRMC FAB.

4.4.1 Survey Design and Methods

The study will be conducted using a Before-After-Gradient (BAG) experimental design for direct effects, where samples occur along a spatial gradient with increasing distance from the cable. Use of a BAG design eliminates the need for identification of representative control areas and allows for assessment of spatial scale. Distance from the RWEC can be incorporated as an independent variable in analyses to explore changes in spatial relationships over time (Methratta 2020).

Sampling will occur twice per month at four locations at fixed locations along the cable route; locations will be selected based on depth strata, habitat type, and fishing industry input. Industry input will be essential in avoiding gear conflicts. Sediment type will also be considered in the selection of sampling locations; harder substrates may be associated with a lower likelihood of cable burial achieving target depth. At least one of the stations selected with industry input will be situated at or adjacent to an area where at least one of the cables did not, or is not expected to, achieve target burial depth. The number of locations and samples was evaluated using a power analysis and it was determined that a 10% change in lobster abundance would be detectible at greater than a 0.9 statistical power in both vented and ventless traps, which were evaluated independently (Appendix 4).

At each of the four sampling stations three six-pot trawls will be laid parallel to the cables (to the extent practicable) with the first trawl set between the two cables (or as close to the two cables as possible). The two additional trawls will be set in parallel from the first trawl (Figure 15). The trawl set on top of one cable or between the cables will serve as the impact distance bin, the trawls at 15 - 30 m distance will serve as the medium gradient, and the trawls 50 m or more away as the largest gradient, which is situated outside the EMF signal or sediment plume. These distances were selected based on modeled EMF outputs from the proposed cable design outlined in the Revolution Wind Construction and Operations Plan (Exponent, 2021). Setting trawls at the correct distance bins will come with some level of error; however, the survey will leverage the expertise of the commercial fishing captain to get as close to the target sampling locations as possible. These proposed distance bins are preliminary at this time and will be discussed with the fishing industry to determine feasibility of setting trawls at the desired spatial resolution.

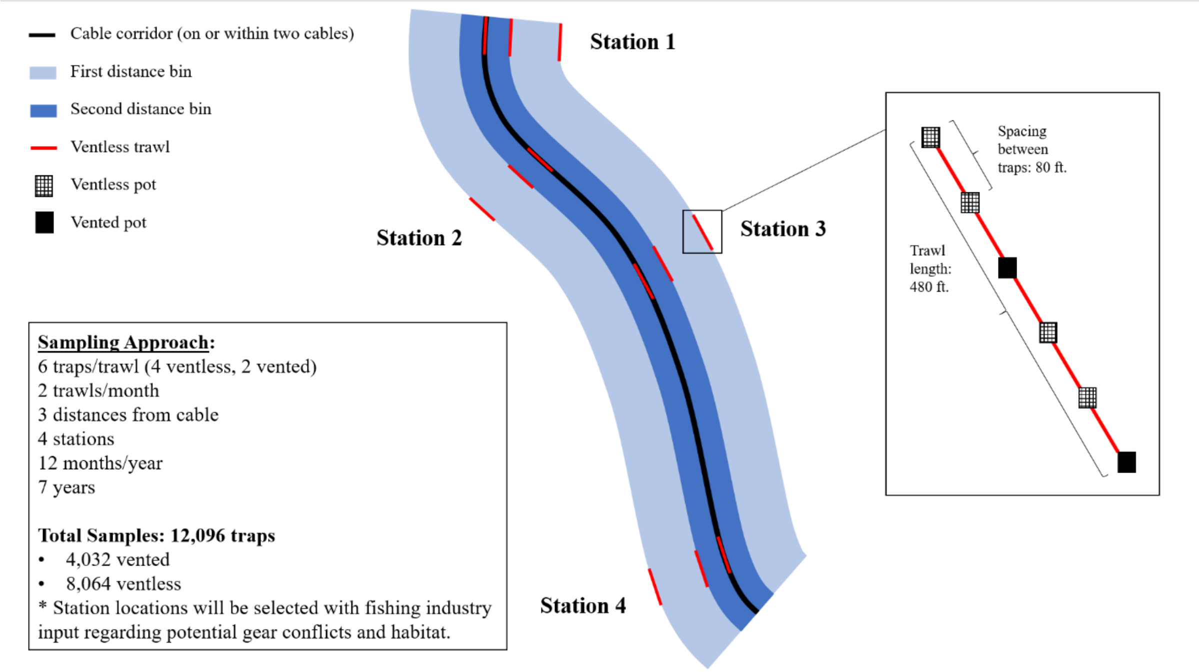


Figure 15. Sampling design schematic. Cable route, distance bins, and station locations are not representative of the actual experimental design but are presented to help conceptualize the study design. Sampling stations will alternate which side (east or west) of the RWEC the trawls are set on.

If at any time during sampling a trawl position is found to have poor conditions for setting fish pots (e.g., gear conflicts, high risk of the gear loss due to boat traffic) it may be moved to an alternative location within the same distance bin from the cables, as well as habitat and depth strata. Whether a trawl should be moved will be at the discretion of the vessel captain.

At each sampling station, lobster traps will be set to estimate CPUE for lobsters, Jonah crabs, and other species of interest to the recreational and commercial fishery. The gear at each station will comprise lobster traps (Figure 16) attached to a ground line, with each ground line end linked to up-and-down lines (or end line) that are attached to floats. These floats and end lines are used to haul the ground line and traps, referred to in its entirety as a ‘trawl’. There will be four ventless traps and two vented traps on each ground line, spanning over 400 ft of ground line, with traps separated from each other by approximately 80 ft (just under 14 fathoms). In the RIVTS, each trawl has three ventless traps, and three vented traps in an alternating pattern. Ventless traps are generally used to assess sublegal (or recruit) lobster abundances, while vented traps are used to compare abundances between ventless traps and a commercial trap (i.e., vented trap). However, given the focus of the proposed cable survey is to assess potential changes in abundance of lobster and other target species, each trawl will consist of four ventless and two vented pots. In the RIVTS, the vents are 5 ¾ inches wide and 1 15/16 inches tall, corresponding to vent regulations of Lobster Management Area 1, and as used in the MA VTS. Vents for the proposed cable survey could match that of Lobster Management Area 2 (5 ¾ inches wide and 2 inches tall), given the desire to also understand potential impacts to commercial catch. The RIVTS operates during the summer months in RI state waters. Sampling has been intended for the months of June, July, and August; however, in years where funding constraints delayed the project, sampling occurred in July, August, and September. In the case of proposed cable monitoring, a longer sampling period may be necessary to evaluate any potential changes in target species’ abundance in relation to the transport cables. Therefore, cable VTS sampling will occur all twelve months per year.

Lobster traps will be baited with bait chosen by the commercial fishing participant, per the RIVTS approach. The selection is typically the result of bait availability and/or using bait that will break down well and "fish" effectively. While bait types have varied through time for the RIVTS, the most common bait type that has been used is skates. Traps will be baited and left for five nights (i.e., 5-night soak). Each station will be sampled twice per month, following a typical schedule of baiting traps (sample day one), sampling traps and rebaiting them five days later (sample day two), and another sampling of traps five days after that and leaving the traps on site but not fishing (sample day three). Since gear will be left in the water while not fishing, gear rotation (or cooking pots) will be built into the sampling regime to avoid severe fouling on cages that may prevent traps from fishing correctly.

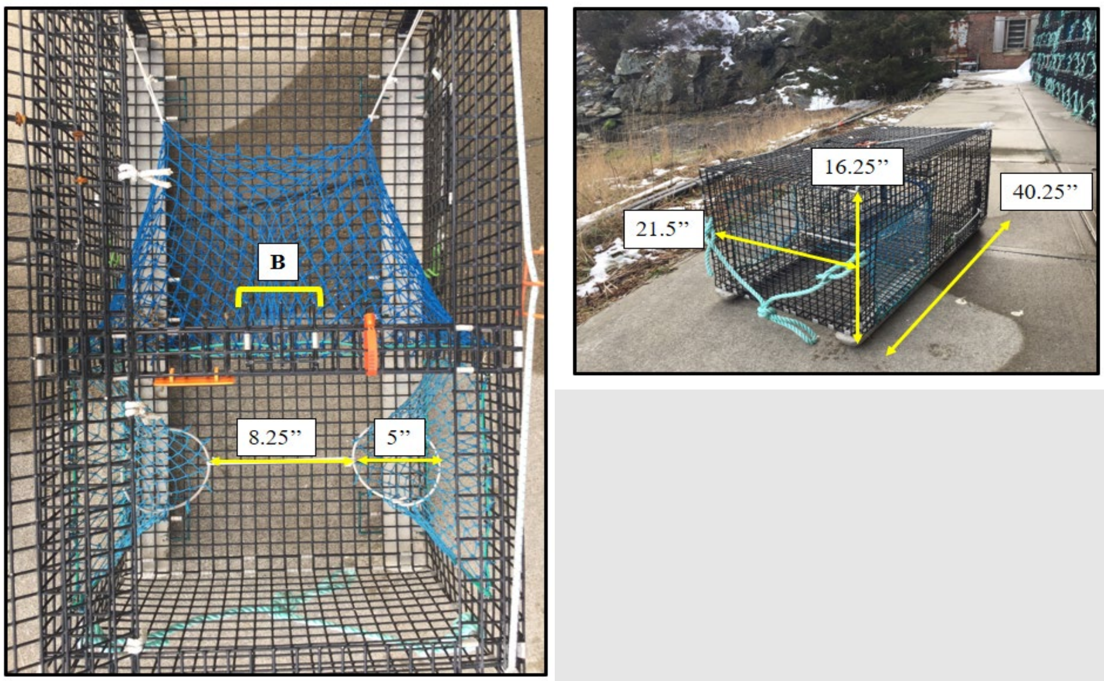


Figure 16. General trap configurations for a RIVTS trap. 'B' signifies where the bait is strung and hung into the kitchen. Length dimensions are in inches.

Acoustic receivers will also be attached to one trawl per station, on the trawl closest to the cables. These receivers will collect data during soak times and while gear is left unbaited in the water between sampling periods. Acoustic data collected will provide valuable information on tagged species utilization of the area before, during, and after construction, as well as during wind farm operation. A variety of electrosensitive species (i.e., elasmobranchs and highly migratory species) have been tagged in other studies and may move throughout the survey area. Elasmobranch species including white, sand tiger, and sandbar sharks, as well as winter skate have all been identified on the RIDEM acoustic receiver network. Other tagged species of interest documented in RI waters include Atlantic sturgeon, striped bass, and river herring. Furthermore, recent regional studies have tagged Atlantic cod, bluefin tuna, blue sharks, and shortfin mako sharks (see Section 4.3) which may also be detected if they move through the area. Starting in June 2021, striped bass, black sea bass, winter flounder, skates, and summer flounder will be tagged along the south coast of Long Island with acoustic transmitters as part of long-term telemetry study to investigate the potential impacts of the South Fork Wind export cable. Added acoustic receivers will broaden the suite of species addressed through the VTS and will collect data on area usage by other target species.

4.4.2 Biological Sampling

The catch will be sorted by species. All specimens from each trap (both fishes and invertebrates) will be identified, enumerated, and measured for size (when appropriate and with few exceptions). All catch data will be recorded at the trap level. Lobsters will have a suite of biological data collected. Lobster count, carapace length (mm), and sex will be recorded. Lobster conditions will also be recorded: shell hardness, shell disease state, egg stage for females bearing eggs, cull status (or claw damage), and V-notch presence (Table 8). Jonah and rock crab will be sexed, measured by carapace width (mm), presence/absence of eggs, molt condition, and shell disease state will be recorded. Fork length will be recorded for all fishes with a forked tail. Total length will be measured for all other fishes. Miscellaneous invertebrates (e.g., worms, hermit crabs, snails, spider crabs) will be counted but not measured. Any trap malfunctions or odd characteristics will be noted during the hauls.

Table 8. Lobster conditions

Condition	Stages
Shell hardness	Hard shell (3); Newly molted, paper shell (2); Soft shell (1)
Shell disease state	No disease (0); Less than 10% body coverage of disease (1); 11-50% coverage (2); >50% coverage (3)
Egg stage (for females bearing eggs)	Old, brown; new, dark green; gray/green; light gray/green with blue eyespots; tan/yellow with black eyespots; dead eggs; spent (formerly egg-bearing); unfertilized
Cull status (or claw damage)	Missing one or both claws; one or both claws small (recently regenerated); one or both claws limb buds; any combination of the above claw conditions
V-notch presence	Old or new v-notch, filled in (>1/8 inch or <1/8 inch); re-notched

Bottom temperature will be measured using HOBO temperature loggers attached to one of the middle traps in each trawl to record water temperature continuously throughout the survey period to understand how seasonal patterns in the catch correspond to environmental conditions.

A subset of lobsters and Jonah crabs will also be tagged with t-bar (anchor) and cinch tags, respectively. If anchor tags are used, lobsters greater than 40 mm in carapace length will be tagged using Floy anchor tags (inserted using a hypodermic needle, per the methods of Courchene and Stokesbury (2011). The anchor tags are retained during molting and will contain a unique identification number and a phone number for reporting recaptures. Knuckle tags may not be retained when crabs molt. Tagging will allow for evaluation of movement patterns of lobsters and crabs within seasons. RIDEM staff will consult with the Massachusetts Division of Marine Fisheries regarding tagging methods given their past experience tagging with the Atlantic Offshore Lobstermen's Association.

4.4.3 Ventless Trap Station Data

The following data will be collected during each sampling effort:

- MM/DD/YYYY
- Depth
- Station number
- Start latitude and longitude
- End latitude and longitude
- Sediment type
- Soak time
- Bait type used
- Bottom temperature
- Start time and date
- Start water depth
- End time and date
- Wind speed
- Wind direction
- Wave height
- Air temperature

4.4.4 Data Management and Analysis

The BAG ventless trap survey will provide pre-construction data on lobster and crab resources in the proposed cable route. The pre-construction monitoring data will be used to evaluate the spatial and seasonal patterns of relative abundance of lobster and Jonah crab in the area. The BAG survey design with sampling at increasing distances from the cables may also allow for characterization of pre-construction community structure of fish species associated with the cable area while examining the spatial scale of impacts on the surrounding habitat and associated fish species. Sampling during and after construction will allow for quantification of any changes in the relative abundance and demographics of the lobster and crab resources.

Analysis of the pre-construction data will be performed in accordance with the BOEM fishery guidelines. Input from the local fishing industry will be considered in the design of data analysis.The spatial distribution of the lobster and crab resources will be assessed for both years of pre-construction monitoring. Catch per unit effort statistics will be summarized for both lobster and Jonah crab, and length frequency distributions will be examined. Catch rates and length frequency distributions will also be provided for black sea bass, tautog, and scup. Regression tools, such as GLMs, GAMs, or mixture models of these (e.g. GLMMs, GAMMS), will be used to examine the influence of biotic and abiotic factors on the catch rates and distribution of lobster and Jonah crab. Spatial and temporal patterns in the biological data for lobsters (shell disease, sex ratios, reproductive status) will be summarized and reported. Results may be compared alongside RIVTS data to address representativeness to regional trends.

Acoustic receiver data will be analyzed and will be shared with the researchers that tagged each respective organism via the Mid-Atlantic Acoustic Telemetry Observation System (MATOS). Detection data can also be used to describe phenology of tagged species (i.e., ingress and egress during and after cable installation).

Crustacean tag data may be analyzed using a variety of geospatial methods in R, Python, or ArcGIS. Mapping and analysis of catch locations of tagged lobsters may help to determine variations in distribution and movement patterns.

Data collected through this survey effort and associated metadata will be accessible to the public via standard data request guidelines through the State of Rhode Island. Only data that have undergone quality assurance/quality control (QA/QC) and are considered final will be available for request.

4.5 Benthic Monitoring

Installation and operation of Offshore Wind (OSW) projects can disturb existing benthic habitats and introduce new habitats. The level of impact and recovery from disturbance can vary depending on existing habitats at the site (Wilhelmsson and Malm 2008; HDR 2020). Physical disturbance associated with cable and foundation installation can temporarily affect sediment and boulders, removing or damaging existing fauna. Over time (~3-10 years), the introduction of novel hard substrata (WTG surfaces, scour protection layers, and cable protection layers) can lead to extensive biological growth on the introduced surfaces with a complex pattern analogous to shoreline intertidal to subtidal zonation (artificial reef effect, Petersen and Malm 2009; Ruebens et al. 2013; Degraer et al. 2020). Depending on the community composition and density, this biological growth may lead to substantial shifts in the transfer of energy from the water column to other compartments of the ecosystem including the sediments and upper trophic levels.

Observations from existing OSW projects lead to four prevailing hypotheses of likely benthic effects:

1. Introduction of novel surfaces that extend from the intertidal to the seafloor (foundations and scour protection layers) will develop epifauna that vary with depth and change over time.

2. Relocation of existing natural hard bottom habitats (boulders) will alter physical habitat characteristics (rugosity, complexity, density) with potential for rapid colonization of relocated boulders.

3. Enrichment of seafloor conditions from the WTG artificial reef effect will lead to fining and higher organic content of surrounding soft bottom habitats, within 3-10 years (1-250 m from WTG).

4. Physical disturbance of soft sediments from cable installation will temporarily disrupt function of infaunal community with rapid return to pre-disturbance conditions.

The consequences of these predicted effects may affect the role of soft and hard bottom habitats in providing food resources, refuge, and spawning habitat for commercial fish and shellfish species (Reubens et al. 2014; Krone et al. 2017). This operational monitoring plan is organized according to these four prevailing hypotheses and describes the overall approach to tracking changes in both the hard bottom and soft bottom habitats associated with OSW development. A comprehensive outline of the benthic monitoring plan, including the hypotheses, sampling schedule, and general approach for each component is provided in Figure 17.

Hard bottom habitat monitoring, at turbine foundations, scour protection layers, and relocated boulders, will focus on measuring changes in percent cover, species composition and volume of macrofaunal attached communities (native and non-native species groups) and physical characteristics (rugosity, boulder density). These parameters will serve as proxies for resulting changes in the complex food web, specifically abundance, diversity and biomass (conversion from volume). It is expected that increased biomass of filter feeders inhabiting the novel OSW hard surfaces will facilitate the export of organic material from the water column to the benthos and to higher trophic levels.

Soft bottom habitat monitoring will focus on measuring physical factors and indicators of benthic function (bioturbation and utilization of organic deposits, Simone and Grant 2020), which will serve as a proxy for capturing functional changes in the community composition. It is expected that the introduction of fines and organic content sourced from the epibenthic community on the WTGs will support increased deposit feeding benthic invertebrate communities in the soft sediments around the WTGs. The monitoring approach can support rapid data collection and analysis, will provide quantitative data, and lead to effective management actions (mitigation). This monitoring plan is not designed to answer research questions about specific causes and effects on individual species.

Hard Bottom Habitats

Novel Surfaces
WTGs SPL

Hypothesis: epifaunal community will vary with water depth (zonation with light and tide); successional development over time

Approach: Use ROV/video to measure changes in % cover, identify key or dominant species, and volume (biomass), compare across depths and habitat strata

Design: stratified random selection of WTGs within benthic habitat strata [same WTGs and soft bottom]; locations need to coordinate with Fisheries design (some where trawls some where ventless)

Y0 – late summer after construction
Y1- ROV/video
Y2- ROV/video
Y3- ROV/video
Y5 – ROV/video

Native Hard Bottom
Undisturbed vs Relocated Boulders

Hypothesis: relocating boulders will alter the physical characteristics of that hard bottom (increase rugosity, complexity, boulder density); potential for rapid re-colonization of epifauna on relocated boulders

Approach: Use ROV/video to document long-term changes in physical characteristics (rugosity, density, orientation); measure changes in percent cover, identify key or dominant species; compare with undisturbed community

Design:
MBES/ROV within 12 mo prior to seabed prep
MBES within 1 mo post seabed prep
Y0 – ROV/video, late summer after construction
Y1- ROV/video
Y2- ROV/video
Y3- ROV/video
Y5 – TBD, If relocated boulders have coverage and composition comparable to undisturbed boulders no further monitoring required. If coverage and composition deviate on average more than 20% continue monitoring at defined intervals until < 20% difference

Soft Bottom Habitats

WTG-associated

Hypothesis: WTG epifaunal growth will result in sediment fining and higher organic content in surrounding soft bottom, this will support deposit feeding benthic inverts. Effects will decrease with increasing distance from WTG.

Approach: Use SPI/PV to measure changes in benthic function over time and with distance from WTGs

Design: stratified random selection of WTGs within benthic habitat strata; BAG design at each selected WTG;

Pre seabed prep – within 6 mo prior
Y0 – late summer after construction
Y1 – SPI/PV
Y2 – SPI/PV
Y3 – SPI/PV
Y5 – SPI/PV

Cable-associated

Hypothesis: After initial physical disturbance during construction, soft sediment community function expected to return to pre-conditions

Approach: Use SPI/PV to measure changes in benthic function over time and with distance from cable centerline

Design: stratified random selection of cable segments within benthic habitat strata; BAG at each selected cable segment

Y0 – late summer after construction
Y1 – SPI/PV
Y2 – SPI/PV
Y3+ – TBD, after RWEC installation if benthic function indistinguishable from baseline and no difference with distance from cable line, no further monitoring required.

Figure 17. Summary of the benthic monitoring plan including hypotheses, approach, and sampling schedules for each component

4.5.1 Hard Bottom Monitoring

The hard bottom monitoring will include an examination of two habitat components: novel surfaces and relocated boulders. The primary objective of the hard bottom survey is to measure changes over time of the nature and extent of macrobiotic cover of hard bottom associated with OSW development. Specifically, the epifaunal growth on novel hard surfaces (turbine foundations, scour protection layers) will be monitored over time. In addition, the recolonization of boulders relocated during seafloor preparation for cable installation will be assessed by comparing with epifaunal communities on nearby undisturbed boulder areas. Macrofaunal percent cover, identification of key and dominant species, and the relative abundance of native and non-native organisms will be documented using a Remotely Operated Vehicle (ROV) and video surveying approach. Distinguishing non-native organisms will likely require physical sampling for accurate identification, which will be facilitated by a sampling arm attached to the ROV.

It is expected that the epifaunal community that colonizes the WTG foundations will vary with water depth, dictated by the availability of light and tides, similar to zonation patterns commonly observed at rocky intertidal habitats. Previous studies have found biological growth has led to dense accumulations of filter feeding mussels on the turbine foundations followed by amphipods, tunicates, sponges and sea anemones in the subtidal in Europe (De Mesel et al. 2015) and at the BIWF (HDR 2020; Wilber et al. 2020; Hutchison et al. 2020b). Other studies have tracked and documented vertical zonation of epibenthic communities along the surface of wind turbine structures (Bouma and Lengkeek 2012; Hiscock et al. 2002; HDR 2020). At any given depth of the WTG foundation structure, the epifaunal species composition is expected to develop successionally, with rapid opportunistic organisms pioneering the site and being replaced by more long-lived established species. Tracking the changes in species composition and density (percent cover) will inform predictions about changes in prey availability to fish and will be integrated with results of the stomach content data obtained during the fisheries monitoring surveys.

The secondary objective of the hard bottom survey is to characterize changes to the physical attributes of habitats in areas disturbed by seabed preparation for installation and construction. The following metrics will be examined; rugosity, boulder height, and boulder density. Preparation of the seafloor (i.e., boulder relocation) for installation of the WTGs and IAC is expected to create clusters of natural hard bottom habitat subject to epifaunal recolonization. These discrete areas will likely have increased rugosity and boulder density which can provide structural complexity and refuge for finfish and decapods. These physical habitat attributes, which are not expected to return to pre-project conditions, have direct links to the level of use of these habitats by commercial finfish and decapods. This survey objective will be accomplished using a high-resolution acoustic surveying approach.

4.5.1.1 Hard Bottom Survey Design Overview

An acoustic and ROV video survey is planned to monitor hard bottom substrata within subareas of the RWF project area. These substrata include introduced novel habitats (turbine foundations, scour protection layers), disturbed natural hard bottom habitats (relocated boulders), and undisturbed natural hard bottom habitats. The same turbines that will be selected for the soft sediment survey will be monitored as part of the hard bottom survey (stratified random design, with benthic habitats as strata, see Section 4.5.2.6). This will help facilitate synthesis between the degree of enrichment in the surrounding soft sediments and the epifaunal community composition and density colonizing the turbine foundations at any given time and location. The sampling schedule for this component will mirror the WTG soft bottom habitat monitoring schedule (Figure 17). Monitoring using ROV and video at the novel habitats will occur after construction is complete during late summer/fall timeframe, and sampling will be repeated at time intervals of 1, 2, 3, and 5 years after construction. Sampling will occur during late summer or fall to capture peak biomass and diversity of benthic organisms in alignment with previous studies. Existing benthic data from the North Atlantic in the vicinity of the RWF project site were primarily collected in late summer or fall (August to November), when biomass and diversity of benthic organisms is greatest (Deepwater Wind South Fork 2020; HDR 2020; NYSERDA 2017; Stokesbury 2013, 2014; LaFrance et al. 2010, 2014). Benthic habitats, particularly hard bottom habitats, in the northwest Atlantic are generally stable with little seasonality in the absence of physical disturbance or organic enrichment (Steimle 1982; Reid et al. 1991; Theroux and Wigley 1998; HDR 2020).

The selection of undisturbed hard bottom and relocated boulders will involve the use of the forthcoming habitat mapping results and directed acoustic surveys and is described in more detail below (Section 7.2.4). For this component of the hard bottom monitoring, Multibeam Echosounder (MBES) and side-scan sonar (SSS) surveys will be used to map hard bottom habitat (as informed by the habitat mapping results) within 12 months before construction/installation (timed to avoid conflict with other surveying activities in the project area) and again within one month after seabed preparation is complete (Figure 17). The acoustic survey area will be selected based on these detailed before-after acoustic maps, areas with modified boulder density (boulders > 1 m in diameter) will be identified to form the sampling frames for the ROV video and imaging survey, as well as to characterize overall changes to the physical habitat attributes within the areas surveyed. Time series video monitoring at the undisturbed and relocated boulder habitats will be conducted approximately one month after seabed preparation (i.e., boulder relocation) has been completed, and again at 1, 2, and 5 years post construction (Figure 17). This design is based on an understanding of the rate of macrobiotic colonization of recently disturbed hard bottom habitat (Guarinello and Carey 2020; De Mesel et al. 2015; Coolen et al. 2018), and detailed information of the distribution of hard bottom benthic habitat within the RWF project area.

4.5.1.2 Acoustic and ROV Approach

To accomplish the objectives of the hard bottom monitoring, high resolution acoustic data and video imagery captured using an ROV will be employed. Multibeam acoustic data will be used to map the physical characteristics of the boulder habitats prior to and after boulder relocation. Video imagery will be used to document epifaunal community characteristics on the hard surfaces (WTGs, scour protection layers, undisturbed boulders and relocated boulders).

State of the art underwater video at predefined depth intervals along the turbine foundations will capture high resolution images that will be analyzed using photogrammetry methods. Photogrammetry is the process in which imagery is interpreted to provide detailed information about the physical objects observed in space. Photogrammetry generates high-resolution, photo-realistic 3D models from static images captures from multiple perspectives. By digitally reconstructing segments of the WTG foundations at predefined depth intervals, the resulting model can be analyzed for quantitative variables including percent cover, standing biomass, and abundance of individual taxa of interest. Collecting imagery and constructing spatial photogrammetric models of segments of the WTGs soon after construction will provide initial reference conditions that can be used to track biological changes over time following subsequent years of data collection. Biological data obtained through photogrammetry will be used to estimate ecological functions including secondary production, and physiological rates such as biodeposition associated with the epifaunal community. These biological processes have implications to the transfer of energy to higher trophic levels and to the sediments at the base of the WTGs. This approach will provide an estimate of the increase in standing stock biomass at the basal trophic levels where filtering feeding epifauna (e.g., blue mussels, sea squirts) exist. This information can inform ecosystem models that seek to understand how these changes to the basal trophic level may alter food web dynamics, objectives that are beyond the scope of this monitoring plan.

4.5.1.3 Sampling Stations – Novel Surfaces

The same turbines that will be selected for the soft sediment survey will be monitored as part of the hard bottom survey (stratified random design, with benthic habitats as strata, see Section 4.5.2). Benthic habitat mapping results, that are forthcoming, will inform the number of strata (distinct benthic habitats); within each habitat strata triplicate WTGs will be randomly selected. Within one month after WTGs have been installed, an ROV will be used to collect reference images of the underwater surface of the turbine foundations. The survey will be repeated at annual intervals indicated in Figure 17, coinciding with the soft bottom SPI/PV survey. These visual surveys of the foundations will occur around the circumference of the structures and at different elevations from the sediment surface (including the scour protection layer) to the water surface. Data will be collected on the percent cover of macrofauna and macroalgae, composition of native and non-native organisms, and distribution of key suspension feeding organisms that could contribute to benthic enrichment (e.g., mussels, tunicates, tube-building amphipods, etc.). This information on the epifaunal community will be considered as explanatory variables for the magnitude and range of benthic enrichment observed in the soft bottom habitat surrounding the turbines.

4.5.1.4 Sampling Stations – Disturbed and Undisturbed Boulders

The primary objective for this component of the hard bottom survey is to measure changes over time in the nature and extent of macrobiotic cover of hard bottom in both disturbed and undisturbed boulder areas. A secondary objective is to characterize overall changes to the physical attributes of the hard bottom habitat resulting from seabed preparation for cable installation. To accomplish these goals, detailed before-after acoustic maps will be used to identify subareas within the two targeted areas of the RWF with pre-existing and modified boulder density (boulders > 1 m in diameter) to form the undisturbed and disturbed sampling frames for the ROV survey, as described in Section 4.5.1 (Figure 17).

Benthic habitats at the RWF include areas with scattered boulders and cobbles on sandy substrata (Glacial Moraine A). Within the areas targeted for seafloor preparation (IAC routes), directed acoustic surveys will be conducted prior to and after seafloor preparation activities are completed. Detailed maps derived from these acoustic data will be used to identify areas where boulders were undisturbed after seafloor preparation and areas where boulders were relocated directly adjacent to the prepared IAC route (i.e., disturbed hard bottom). A single sampling frame will be identified within each of the selected disturbed and undisturbed boulder areas; selection will be based on habitat type, derived from ongoing habitat mapping at the RWF, and will consist of two replicates per habitat type where seafloor preparation occurred (Figure 18). A systematic random sample of 20 boulders will occur within each sampling frame of paired disturbed/undisturbed areas, as described in more detail below. This type of non-probability (opportunistic) sampling will provide macrobiotic cover within these areas but does not allow inference to the windfarm in general.

The sampling will be conducted at regular distance intervals within each sampling frame (5 m wide and 200 m or more in length) within each selected area (one each in disturbed/undisturbed areas with at least two targeted WTGs within each habitat with boulders), placed to capture sufficient density of boulders. The ROV will progress along the centerline of each frame sampling boulders at 10m intervals until approximately 20 boulder samples have been obtained. The final target sample size will be informed by the results of the boulder relocation survey that will be performed at South Fork Wind. Boulders may not be present at every planned distance interval, so sampling will progress as follows: the ROV will search within the 5m width of the sampling area in order to find a boulder to sample; the closest boulder to the target interval will be sampled, and the 10m interval will be reset. At each boulder, a photo image of a minimum 0.5m x 0.5m field of view of the visible portions of the boulder will be collected from which percent cover will be estimated and native/non-native species will be identified. Data collected to inform the habitat characteristics for each sampling frame will include: rugosity and percent hard bottom to soft bottom from the acoustic surveys; height of boulder, percent cover of native and non-native species, and species composition from the ROV survey.

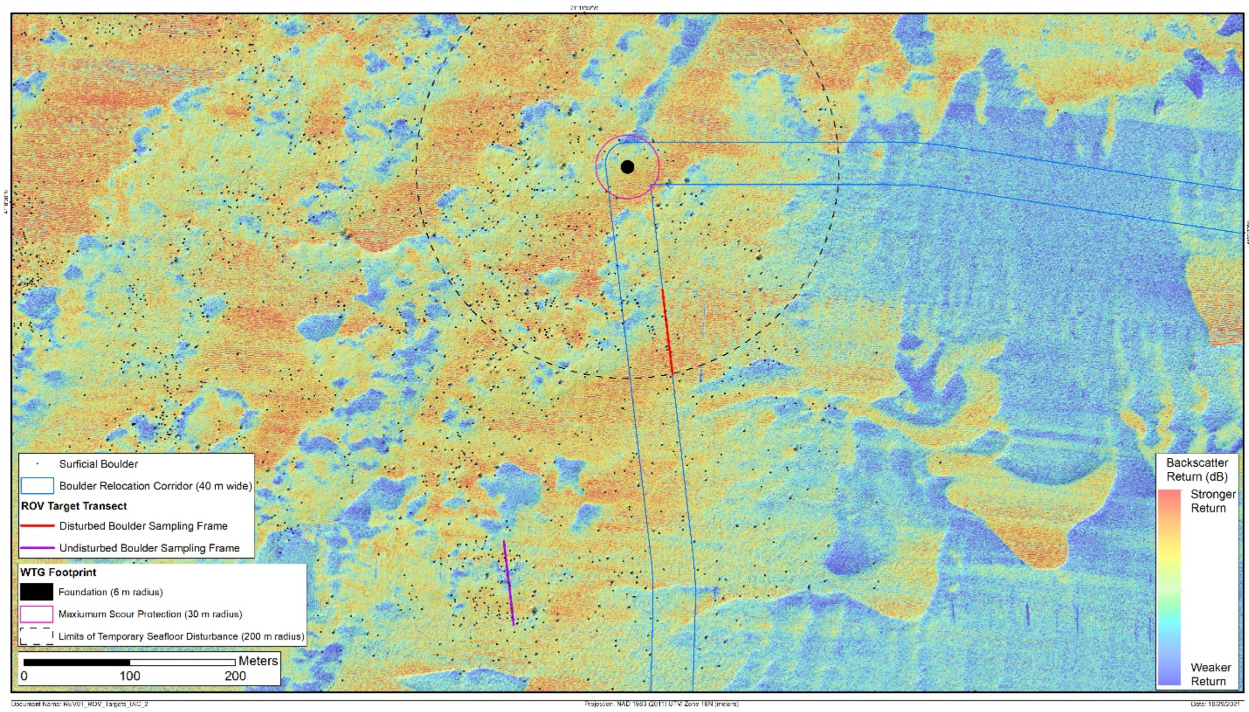


Figure 18. Example hard bottom benthic survey sampling design along the IAC at a WTG.

4.5.2 Soft Bottom Monitoring

The overall objective of the soft bottom monitoring survey is to measure potential changes in the benthic function of soft bottom habitats over time and with distance from the base of the WTGs and RWEC centerline. Specifically, benthic functioning of the soft bottom habitats will be captured by documenting physical parameters (grain size major mode) and biological factors (bioturbation and utilization of organic material) with a SPI/PV system. It is expected that the epibenthic community that colonizes the WTG foundations will supply organic matter to the sediments below through filtration, biodeposition, and general deposition of detrital biomass. This organic material sourced from the activity of the epibenthic community on the turbine foundations will likely alter the infaunal community activity, increasing sediment oxygen demand and promoting the activity of deep-burrowing infauna. The effects of the WTG foundation on the surrounding soft sediment habitat are expected to decrease with increasing distance from the WTG.

SPI/PV provides an integrated, multi-dimensional view of the benthic and geological condition of seafloor sediments and will support characterization of the function of the benthic habitat, physical changes, and recovery from physical disturbance following the construction and during operation of RWF and RWEC. Additionally, PV data will characterize surficial geological and biotic (epifaunal) features of hard-bottom areas within the sampling area but will not replace a dedicated hard bottom monitoring survey (Section 4.5.1). In addition to characteristics associated with site assessment and Coastal and Marine Ecological Classification Standard (CMECS) descriptors, the SPI/PV system will collect quantitative data on measurements associated with physical and biological changes related to benthic function (bioturbation and utilization of organic material) that might result from construction and operation of RWF. Details of these measurements are in Section 4.5.5.2 and are standard tools for assessment of response to disturbance and enrichment (Germano et al. 2011).

4.5.2.1 Survey Design Overview

The soft bottom habitat monitoring will be conducted using a BAG survey design to determine the spatial scale of potential impacts on benthic habitats and biological communities within the RWF site (Section 4.5.2.3) and along the RWEC (Section 4.5.2.4). A single benthic survey will be conducted in late summer (August to October) six months prior to the start of seabed preparation for construction to document benthic habitats prior to potential disturbance at WTGs and the IACs. It is expected that final locations of the WTG's and habitat distribution within the lease area will be known prior to the six-month period before construction so sampling sites can be selected for the survey. The benthic habitats along the RWEC are already documented in sufficient detail, and no additional pre-construction benthic monitoring will be conducted. Subsequent surveys will be conducted in the same seasonal time frame at one-year intervals, for three years, and five years after completion of construction (Figure 17). Sampling will occur during late summer or fall to capture peak biomass and diversity of benthic organisms in alignment with previous studies. Existing benthic data from the North Atlantic in the vicinity of the RWF project site were primarily collected in late summer or fall (August to November), when biomass and diversity of benthic organisms is greatest (Deepwater Wind South Fork 2020; HDR 2020; NYSERDA 2017; Stokesbury 2013, 2014; LaFrance et al. 2010, 2014). Benthic habitats in the northwest Atlantic are generally stable with little seasonality in the absence of physical disturbance or organic enrichment (Steimle 1982; Reid et al. 1991; Theroux and Wigley 1998; HDR 2020). Further details on the survey designs associated with the sampling at the base of the WTGs and along the RWEC are provided in Sections 4.5.2.3 and 4.5.2.4, respectively.

4.5.2.2 SPI/PV Approach

SPI/PV will be used as the monitoring approach for the soft sediment habitat surveys to capture potential changes in sediments in relation to sediment fining and organic material processing. The SPI and PV cameras are state-of-the-art monitoring tools that capture benthic ecological functioning within the context of physical factors through high-resolution imagery over several meters of the seafloor (plan view) and the typically unseen, sediment–water interface (profile) in the shallow seabed. The SPI/PV imagery approach is more cost effective and comprehensive than benthic infaunal sampling approaches. Analysis costs for benthic biological characterization using SPI/PV can be up to 75% lower than those of infaunal abundance counts derived from grab samples, this approach supports higher spatial density as a result.

In addition to allowing for greater spatial resolution facilitated through lower operating costs compared to sediment grab samples, SPI/PV imagery provides the ability to document aspects of the sediment architecture that is entirely missed during benthic infaunal sample collection. This spatial and contextual information, such as oxygen penetration depths (apparent redox potential discontinuity [aRPD] depth), infaunal bioturbation depths, and small-scale grain size vertical layering are critical pieces to assessing the ecological functioning of soft sediment habitats. Specifically, ecological functions related to organic matter processing, secondary production, and the forage-value of the benthic community are of particular importance when assessing impacts of OSW development on soft sediment habitats. Taxonomic analysis of sediment grab samples provides information on the benthic community composition (specifically, which species are there) and infaunal abundances at any given location and time. But, without making substantial inferences to relate presence and species counts to activity, the sediment grab approach is severely limited in its ability to assess impacts of OSW development to soft sediment functioning. Further, given the inherently dynamic and patchy nature of infaunal populations, benthic community count data generally requires extensive replication, substantial transformations for normalization, and overextending inferences to relate species composition to function. SPI/PV imagery provides an effective snapshot of the overall ecological health and condition of the sediments as reflected and integrated over time and space by the continuous activity of the infaunal and epifaunal communities present (Germano et al. 2011). It is this holistic community activity, not necessarily the identity of community members, that requires careful assessment to determine impacts of OSW on soft sediment habitats.

4.5.2.3 Sampling Stations – Turbine Foundation Bases

The objective for the soft bottom benthic survey at the base of the turbine foundations is to measure changes over time in the benthic habitat and physical structure of sediments along a spatial gradient. This survey was designed to investigate the hypothesis that colonization by epifaunal filter feeders on the turbines will result in changes to the surrounding soft bottom benthic habitat by supplying organic matter to the sediment through filtration, biodeposition, and general deposition of detrital material. Enrichment of soft bottom habitats from the artificial reef effect is expected to be most pronounced down current and weaker up current. It is expected that evidence of sediment enrichment will dissipate with distance from the WTG bases.

To accomplish the objective of this survey, data will be collected before and after installation and operation of RWF using a BAG survey design with statistical evaluation of the spatial and temporal changes in the benthic habitat (Underwood 1994; Methratta 2020). This BAG design is based on an understanding of the complexities of habitat distribution at RWF (habitat mapping report results pending), and an analysis of benthic monitoring results from European wind farms and the RODEO study at BIWF (HDR 2020; Coates et al. 2014; Dannheim et al. 2019; Degraer et al. 2018; LeFaible et al. 2019; Lindeboom et al. 2011). The proposed BAG survey design eliminates the need for a reference area, as this design is focused on sampling along a spatial gradient within the area of interest rather than using a control location that may not be truly representative of the conditions within the area of interest (Methratta 2020). This design also allows for the examination of spatial variation within the wind farm and does not assume homogeneity across sampling stations (Methratta 2020).

SPI/PV surveys have been previously conducted within the RWF and along the RWEC to provide detailed assessment of benthic habitat for EFH consultation (INSPIRE 2020b; habitat mapping effort is in progress). The detailed information on habitat distribution at RWF will be used to design the surveys specified in this and the following section (RWEC sampling). By design, the turbine locations at RWF will be sited to avoid placement in close proximity of hard bottom habitat. Preliminary mapping of habitat types within 200 m of each planned RWF turbine location include predominantly sand and muddy sand (67%), coarse sediment (24%), and mud and sandy mud (6%) (Figure 19). The soft bottom benthic survey will focus only on these mobile sediment classes (cumulatively making up 97% of the 200 m WTG buffers), while hard bottom areas (e.g., glacial moraine with boulders and cobbles) between turbines will be addressed in a separate survey (Section 4.5.1). Sampling transects will be specifically sited to avoid adjacency to the IAC route; monitoring the potential effects of a buried power cable is the focus of a separate survey (Section 4.5.2.4).

A stratified random sample of turbines will be selected, with the strata determined by soft bottom habitat type (e.g., sand and muddy sand, mud and sandy mud, and coarse sediment). The selection of turbines will be made once the habitat mapping results are complete for RWF (anticipated in the summer or fall of 2021), with a minimum of three turbines sampled in each of the three soft bottom habitat strata. The selected turbines, transect positions, and distance bands will remain fixed for the duration of the survey (see below).

It is expected that the most pronounced sediment enrichment and impacts from WTGs on the surrounding soft sediment habitats will occur in alignment with the prevailing currents in the area, and as such the station design will consider these currents. Current meter data collected for the RI Ocean SAMP indicated that monthly mean currents near RWF are relatively strong from March through October and generally to the west-southwest (Ullman and Codiga 2010). Two belt transects (25 m wide) of SPI/PV stations will be established to the northeast (up current) and southwest (down current) of each of the selected turbine locations to avoid IAC locations (Figure 20). If additional current data is available prior to construction the alignment will be adjusted. Pre-construction transects will begin at the center point of the planned WTG foundation with two stations at equal intervals up to the maximum planned extent of the scour protection area and then at intervals of 0-10 m, 15-25 m, 40-50 m, 90-100 m, 190-200 m, and 900 m extending outward from the edge of the scour protection area (i.e., a single station at each of eight distance intervals in two directions from each turbine sampled; Figure 20). Post-construction transects will repeat this design at the same turbines and the same sampling intervals. These distances were chosen based on recent research indicating that effects of turbines on the benthic environment occur on a local scale (e.g., Lindeboom et al. 2011; Coates et al. 2014; Degraer et al. 2018; HDR 2020). The turbines are proposed to be built in a regular grid pattern, with 1 nautical mile spacing between adjacent turbines. The maximum sampling distance (900 m) was selected to cover half of the (diagonal) distance between adjacent turbines. These 900 m stations characterize habitat changes over time within the wind farm in general, representing potential cumulative effects of the wind farm in aggregate but are not directly associated with the enrichment hypothesis adjacent to the turbines.

Eight replicate SPI/PV image pairs will be collected at each station; results from six replicate pairs with suitable quality images will be aggregated to provide a summary value for each metric by station.

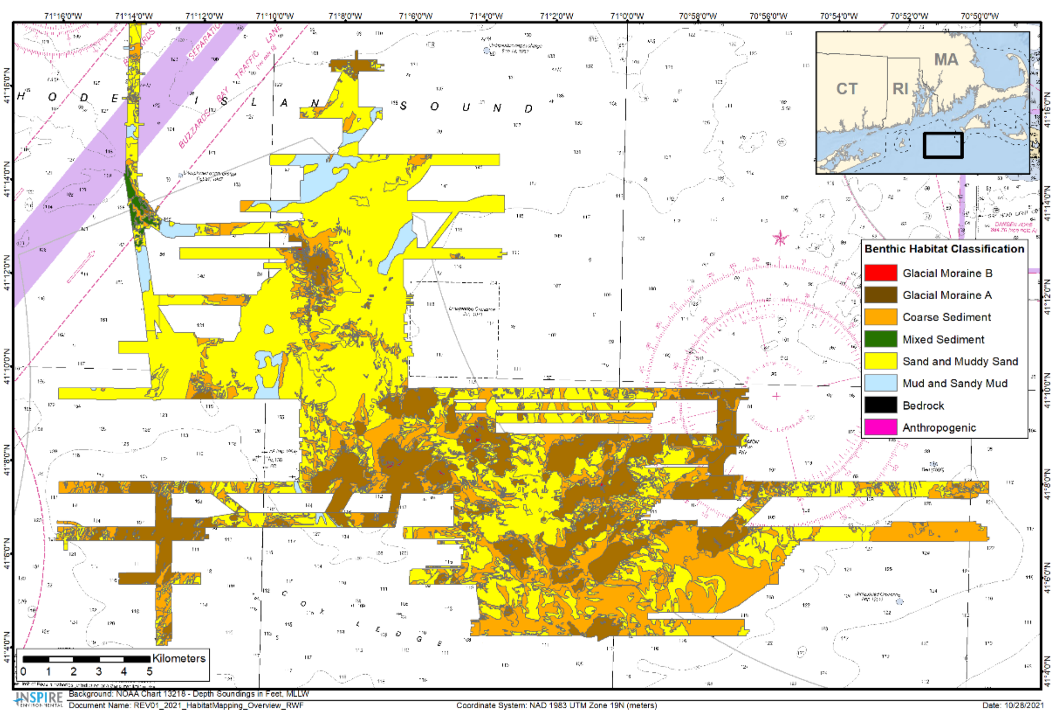


Figure 19. Seafloor sediment map around planned turbine and cable installations. For the soft bottom benthic survey, turbine foundations will be selected from this set in three habitat types: coarse sediment, sand and muddy sand, and mud and sandy mud.

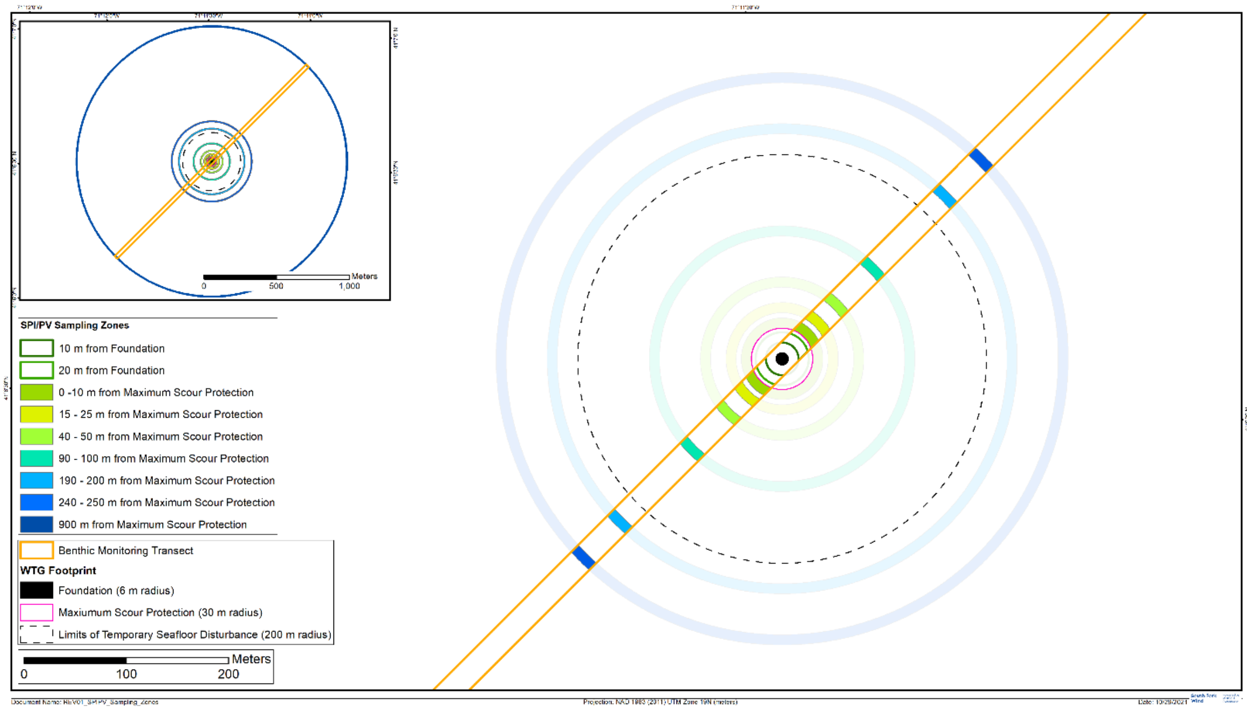


Figure 20. **Proposed soft bottom benthic survey sampling distances.**

4.5.2.4 Sampling Stations – Export Cable (RWEC)

The objective for the soft bottom benthic survey along the RWEC is to examine the effects of installation and operation of an export cable on the benthic habitat over time and along a spatial gradient with distance from the cable centerline. Any effects of installation and operation of the cable are expected to be roughly equivalent along the length of the cable within similar benthic habitat types. The primary effect of cable installation in the corridor is physical disturbance of the sediment with minor sediment resuspension and temporary loss of infauna. Some effects associated with the installation may be altered by dredging or trawling activities as well as bottom sediment transport from tides and waves. The sampling design is intended to estimate effects along a spatial gradient away from the cable and will not estimate mean changes along the entire RWEC route. Any potential impacts of the cable on soft bottom habitats are expected to decrease over time after installation and with distance from the RWEC.

To accomplish the goals of this survey, SPI/PV data will be collected after installation and during operation of the RWEC at selected locations, using a BAG design like that proposed for the turbine foundations (Section 4.5.2.3) (Underwood 1994; Methratta 2020). The benthic habitats along the RWEC are already documented in sufficient detail, and no additional pre-construction benthic monitoring will be conducted. Details describing the BAG design approach and its value in evaluating potential temporal and spatial changes following construction are provided in the section above (Section 4.5.2.3).

The soft bottom survey sample design will focus on representative sections of the RWEC based on four mapped habitat types: coarse sediment, mixed sediment, sand and muddy sand, mud and sandy mud (Figure 21). Areas of coarse sand with > 30% cobbles or boulders will be avoided, as monitoring the effects of boulder relocation will be addressed in the hard bottom survey (Section 4.5.1). A 25 m wide belt transect will be laid perpendicular to the cable route at triplicate locations within each benthic habitat stratum along the RWEC (Figure 22). At each transect, a total of 16 stations will be sampled. Near the centerline these stations will be distributed 10 m apart and the distance intervals between stations will increase with distance from the centerline (Figure 22; Eight replicate SPI/PV image pairs will be collected at each station; results from six replicate pairs with suitable quality images will be aggregated to provide a summary value for each metric by station. More details of habitat distribution and replicate locations will be provided after the habitat mapping report results are completed.

Sampling along the RWEC will occur within the year post installation (Y0) and at year 1 and year 2 during operation. After year 2, if benthic function measured with SPI/PV is indistinguishable from baseline conditions, and no difference is observed with distance from cable centerline, no further monitoring will occur. Alternatively, if benthic function is impaired (aRPD and or successional stage) and differences along the RWEC persist compared with baseline and with distance from cable centerline, monitoring will continue at defined intervals until the benthos resemble baseline conditions or are no longer impaired.

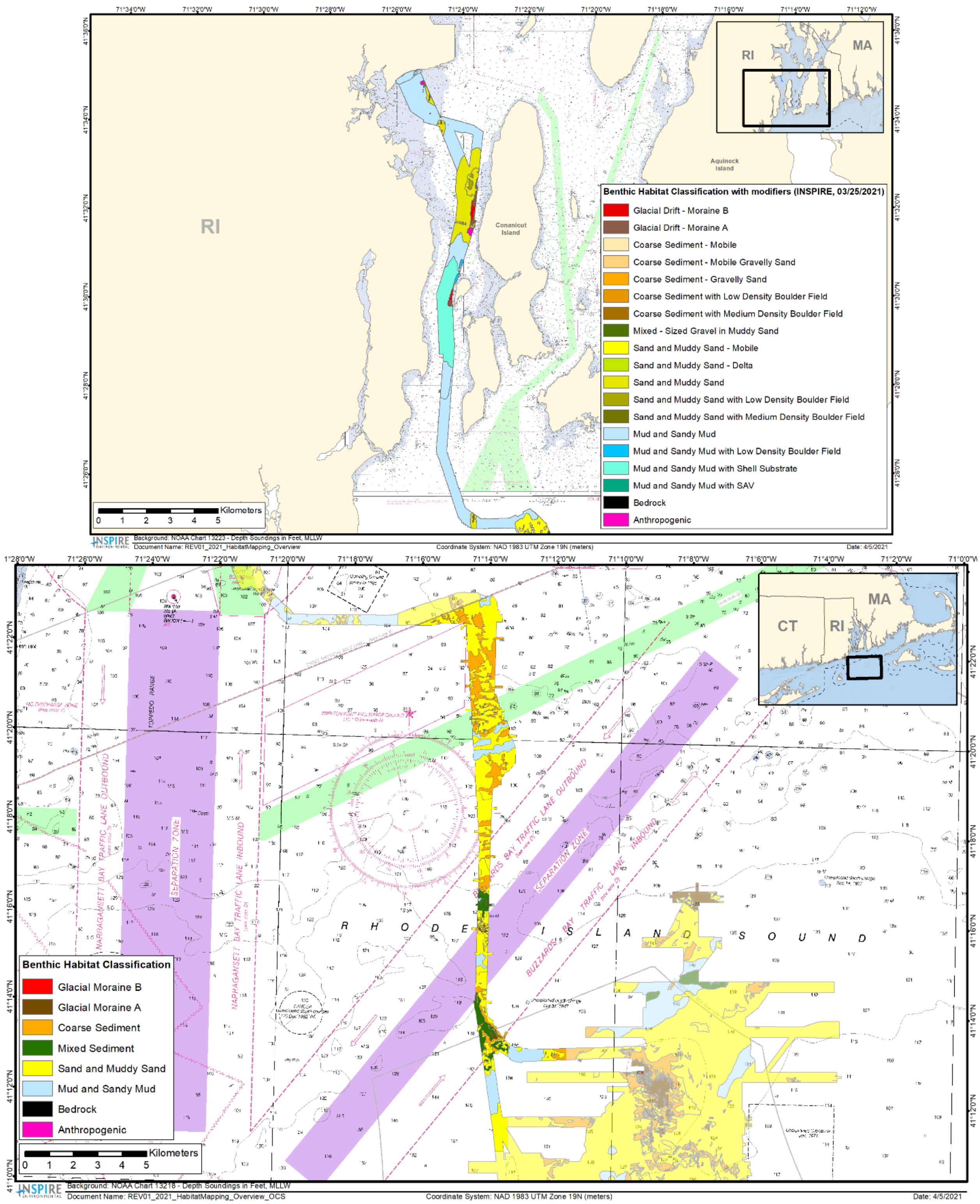


Figure 21. Distribution of benthic habitats along the RWEC that were mapped during geophysical surveys conducted by Fugro and benthic assessment surveys conducted by INSPIRE.

Figure 22. Proposed soft bottom benthic survey sampling design within one habitat along the RWEC with black dots indicating SPI/PV stations situated along transect perpendicular to the RWEC.

4.5.3 Overview of Field Methods

The Field Lead Scientist will ensure that samples are taken according to the established protocols and that all forms, checklists, field measurements, and instrument calibrations are recorded correctly during the field sampling. For-hire vessels will be selected based on criteria including survey suitability, experience, safety record, knowledge of the area, and cost. All survey activities will be conducted with strict adherence to Ørsted health and safety protocols to reduce the potential for environmental damage or injury.

Accurate vessel heading and differential position accuracy within a meter will be achieved using a V102 Hemisphere vector antenna (or equivalent) on the vessel. During mobilization, the navigator will conduct a positional accuracy check on the antenna by placing the antenna on a known GPS point and ensuring the antenna's position falls within a meter of the known coordinates. During operations, HYPACK Ultralite software will receive positional data from the antenna in order to direct the vessel to sampling stations.

4.5.3.1 SPI/PV Field Data Collection

By combining SPI and PV paired imagery, the SPI/PV sampling approach allows for the assessment of benthic functioning over a spatial scale of several square meters at each station. PV images provide a much larger field-of-view than SPI images, or sediment grab samples, and provide valuable information about the landscape ecology and sediment topography in the area where the pinpoint "optical core" of the SPI is taken. Distinct surface sediment layers, textures, or structures detected in SPI can be interpreted considering the larger context of surface sediment features captured in the PV images. The scale information provided by the underwater lasers allows for accurate organismal density counts and/or percent cover of attached epifaunal colonies, sediment burrow openings, larger macrofauna and/or fish which are missed in the SPI cross section. A field of view is calculated for each PV image and measurements are taken of specific parameters outlined in the survey workplan.

The SPI/PV surveys associated with the Soft Bottom Monitoring components (at the RWF and along the RWEC) will be conducted from research vessel(s) with scientists onboard to collect images utilizing a SPI/PV camera system. Collecting seafloor imagery does not require disturbance of the seafloor or collection of physical samples. Once the vessel is within a five meter radius of the target location, the SPI/PV camera system will be deployed to the seafloor. As soon as the camera system contacts the seafloor the navigator will record the time and position of the camera electronically in HYPACK as well as the written field log. This process will be repeated for the targeted number of SPI/PV replicates per sampling station. Results from the targeted number of replicates with suitable quality images will be aggregated to provide a summary value for each metric by station (mean, median, or maximum depending on the metric, see Section 4.5.5). After all stations have been surveyed the navigator will export all recorded positional data into a Microsoft Excel© spreadsheet. The Excel sheet will include the station name, replicate number, date, time, depth, and position of every SPI/PV replicate.

Acquisition and quality assurance/quality control of high-resolution SPI images will be accomplished using a Nikon D7100 or D7200 digital single-lens reflex (DSLR) camera with a 24.1-megapixel image sensor mounted inside an Ocean Imaging Model 3731 pressure housing system. An Ocean Imaging Model DSC PV underwater camera system, using a Nikon D7100 or D7200 DSLR, will be attached to the SPI camera frame and used to collect PV photographs of the seafloor surface at the location where the SPI images are collected. The PV camera housing will be outfitted with two Ocean Imaging Systems Model 400 37 scaling lasers. Co-located SPI and PV images will be collected during each "drop" of the system. The ability of the PV system to collect usable images is dependent on the clarity of the water column, while the ability of the SPI system to collect usable images is dependent upon the penetration of the prism.

4.5.3.2 Acoustic and Video Collection

Targeted high-resolution acoustic surveys (SSS and MBES) will be conducted over the selected IAC corridors prior to boulder relocation and again after all construction has been completed to map boulder locations within the survey areas. Survey areas will include existing undisturbed boulder distributions in selected areas adjacent to the IAC corridor to facilitate comparison between disturbed and undisturbed boulders. Existing MBES and SSS data will be used to define the survey areas (Figures 18 and 19).

High resolution video and still images will be acquired at targeted hard bottom areas and turbine foundations with a compact remotely operated video system (ROV) comparable to a Seatronics Valor ROV (https://geo-matching.com/rovs-remotely-operated-underwater-vehicles/valor). The positioning components of the ROV would include a surface differential positioning system, an Ultra Short Baseline (USBL), as well as ROV-mounted motion and depth sensors. The USBL transceiver will communicate with acoustic beacons mounted onto the ROV allowing for the vehicle's depth and angle in relation to the transceiver to be known. Adding in the motion and depth sensors on the ROV, all this information will be connected into the ROV navigation software simultaneously tracking both the vessel's position and the ROV's position accurately.

In addition to accurate ROV positioning components, the vehicle will be equipped with powerful thrusters in both horizontal and vertical directions, creating confidence for operating in areas with higher currents. The vehicle will also be equipped with several pilot aids including, auto heading, auto depth, and auto hover. Using these tools, the ROV cameras can focus on any specifically selected habitat features during the survey allowing for better visual observations by scientists. The ROV will also allow location of boulders independent of the vessel and without relying on the vessel speed. With an umbilical and ROV operator controls, the hard bottom habitats can be mapped thoroughly in a shorter time span than could be accomplished using a towed video system.

The ROV will supply live video feed to the surface using high definition (HD) video and ultra-high definition (UHD) still cameras. One pair of cameras will be downward facing to observe and capture high resolution images of seafloor surface conditions while another pair will face forward to collect data on vertical surfaces and avoid collisions. High lumen light-emitting diode (LED) lights will be mounted onto the ROV frame to increase visibility and aid in species identification. With sufficient lighting the images transferred to the surface will be clear, allowing for real time observations and adaptive sampling. The recorded video will be transferred to the surface through the ROV's umbilical and recorded using a Digital SubSea Edge digital video recorder (DVR) video inspection system (or equivalent). The system will provide simultaneous recording of both high-definition cameras as well as the ability to add specific transect data overlays during operations. The data overlay will include ROV position, heading, depth, date and time as well as field observations.

High resolution underwater imagery can provide preliminary information about the identity of encrusting fauna, including non-native organisms (Figure 23). However, because some species such as *Didemnum vexillum* require microscopic investigation to accurately identify, samples will be collected to confirm species identified in the still images. The ROV will contain a manipulator arm and basket to collect voucher specimens of encrusting species to ensure accurate identification. The option to collect a specimen sample for identification, will be made by the chief scientist, who will be familiar with the potential non-native organisms in the area. The chief scientist will consult the National Estuarine and Marine Exotic Species Information System, a database maintained by the Smithsonian Environmental Research Center, when determining the need for a voucher specimen.

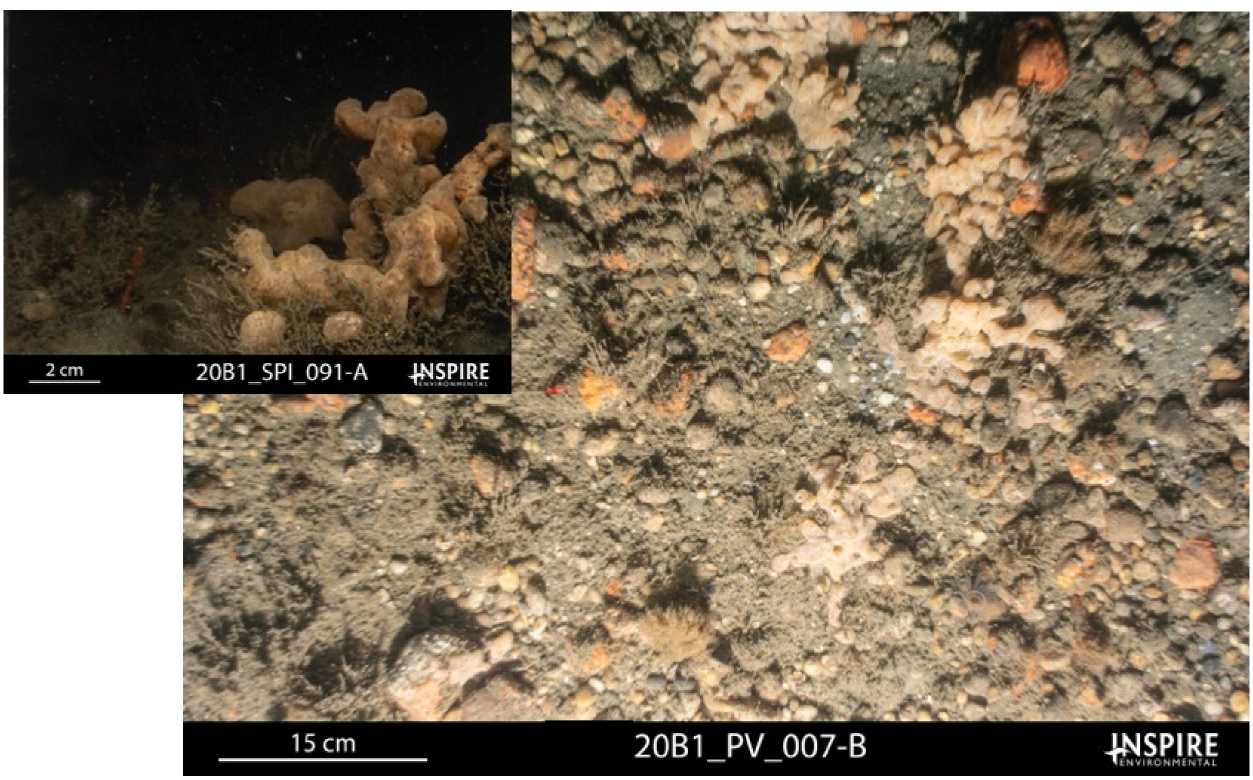


Figure 23. Examples of high resolution SPI and PV imagery of an encrusting organism that is potentially *D. vexillum*, a non-native colonial tunicate

4.5.4 Data Entry and Reporting

Data management and traceability is integral to analysis and accurate reporting. The surveys will follow a rigorous system to inspect data throughout all stages of collection and analysis to provide a high level of confidence in the data being reported. Following data entry, all digital logs will be proofread using the original handwritten field log. This review will be performed by someone other than the data entry specialist.

SPI and PV image QC checks include comparison of date/time stamps embedded in the metadata of every SPI and PV image to the field log and navigation times to ensure that all images are assigned to the correct stations and replicates. Computer-aided analysis of SPI/PV images will be conducted to provide a set of standard measurements to allow comparisons among different locations and surveys. Measured parameters for SPI and PV images will be recorded in Microsoft Excel© spreadsheets. These data will be subsequently checked by senior scientists as an independent quality assurance/quality control review before final interpretation. Spatial distributions of SPI/PV parameters will be mapped using ArcGIS.

During field operations, daily progress reports will be reported through whatever means are available (email, text, phone). Upon completion of the survey all analyzed images as well as a data report with visualizations will be provided. Options for optimal data sharing including images, video, and analysis results will be considered and determined at a future date. Possible delivery methods include an Azure database, a secure fileshare, and/or an interactive popup map. Interactive popup maps allow users to explore still and video imagery concurrent with acoustic data, project-specific boundaries and locations (e.g., WTGs, IAC), and interpretative data obtained from the imagery (e.g., presence of non-native taxa).

4.5.5 Data Analysis

4.5.5.1 Hard Bottom Video and Acoustics

Video imagery will be reviewed during acquisition and observations will be logged to document biological species and geological features for each video transect. An experienced video analyst will view logs, photos and videos and confirm or add annotations. The video system will have the capability of taking still images from all the input video signals to document features of interest.

For the disturbed versus undisturbed boulder survey, specific physical hard bottom habitat characteristics will be summarized using the acoustic dataset. For each sampling frame the following metrics will be mapped and quantified; rugosity, boulder height and the ratio of hard bottom to soft bottom habitat. Video from the ROV will provide additional quantitative details of habitat characteristics and quality, including categorical levels for the presence of fish and decapods, presence of refuge and surrounding substrata (sediment type), and the percent cover of emergent fauna.

For the wind turbine foundation survey, the focus of the analysis will be biological features, identifying any non-native organisms, identifying the key epifauna inhabiting the novel substrate, and quantifying the biomass of the dominant members of the epifaunal communities. Biomass estimation will be achieved through photogrammetry methodology as described in Section 4.5.1.2.

4.5.5.2 Soft Bottom SPI/PV

Seafloor geological and biogenic substrates captured in SPI/PV imagery will be described using the Coastal and Marine Ecological Standard (CMECS; FGDC 2012). The Substrate and Biotic components of CMECS will be used to characterize the sediments and biota observed in the SPI/PV imagery. Replicate images taken at each station will be summarized to a single value per analytical metric per station (e.g., predominant CMECS Substrate Subgroup, maximum infaunal successional stage, maximum and median feeding void depth, and mean aRPD depths). Measurement and interpretation of these indicators are presented in previous benthic assessment report for RWF (INSPIRE 2020b). Additionally, the benthic macrohabitat (*sensu* Greene et al. 2007) types gleaned from the SPI/PV imagery of the project area will be described. Differences in abiotic and biotic composition of macrohabitats will be compared between pre- and post-construction surveys. In particular, species composition and total percent cover of attached fauna on the scour mat and changes in benthic community with distance from the scour protection layer will be evaluated.

SPI/PV provides a more holistic assessment of benthic functioning that captures the relationship between infauna and sediments compared with infaunal abundance assessments using sediment grab sampling (Germano et al. 2011; see Section 7.2.2). Although infaunal abundance and density measurements are not generated from SPI/PV analysis, other metrics that will be collected as part of the benthic biological assessment include lists of infaunal and epifaunal species, the percent cover of attached biota visible in PV images, presence of sensitive and non-native species, and the infaunal successional stage (Pearson and Rosenberg 1978; Rhoads and Germano 1982; Rhoads and Boyer 1982).

Indicators of benthic function (bioturbation and utilization of organic material) include infaunal succession stage, feeding voids, methane, *Beggiatoa* and the depth of apparent redox potential discontinuity (aRPD depth). Of these, the successional stage and aRPD depth have the strongest predictive power for benthic functional response to physical disturbance and organic enrichment (Germano et al. 2011) and will be the key metrics used during the soft bottom surveys.

Infaunal successional stage describes the biological status of a benthic community and is useful in quantifying the biological recovery after a disturbance. Organism–sediment interactions in fine-grained sediments follow a predictable sequence of development after a major disturbance (Pearson and Rosenberg 1978; Rhoads and Germano 1982; Rhoads and Boyer 1982). This continuum is divided subjectively into four stages: Stage 0, indicative of a sediment column that is largely devoid of macrofauna, occurs immediately following a physical disturbance or in close proximity to an organic enrichment source; Stage 1 is the initial recolonizing tiny, densely populated polychaete assemblages; Stage 2 is the start of the transition to head-down deposit feeders; and Stage 3 is the mature, equilibrium community of deep-dwelling, head-down deposit feeders. The presence of feeding voids in the sediment column is evidence of an active Stage 3 community. If the level of organic enrichment exceeds the capacity of the benthic community to consume the deposits the successional stage will revert to Stage 1, aRPD depths will be visible but very shallow, and eventually methane and *Beggiatoa* will appear as diagnostic conditions of organic over enrichment (Germano et al. 2011).

The aRPD depth is a measure of the depth within the sediment column where dissolved oxygen concentrations are depleted. This depth is dependent on several factors but is largely determined by the amount of organic matter load to the sediments (organic matter decomposition consumes oxygen) and the amount of bioturbation by macrofaunal organisms (bioturbation mixes oxygen from surface waters deep into the sediments). With SPI analysis, the aRPD depth is described as "apparent" because of the potential discrepancy between where the sediment color shifts and the complete depletion of dissolved oxygen concentration occurs. In sandy sediments that have very low sediment oxygen demand (SOD), the sediment may lack a visibly reduced layer even if a redox potential discontinuity (RPD) is present. Because the determination of the aRPD requires distinction of optical contrast between oxidized and reduced particles, it is difficult, if not impossible, to determine the depth of the aRPD in well-sorted sands of any size that have little to no silt or organic matter in them. When using SPI technology on sand bottoms, estimates of the mean aRPD depths are often indeterminate with conventional white light photography. It is expected that as sediments surrounding the WTGs will increase in organic enrichment and fines, the aRPD will become more 'apparent' and provide a quantitative measure of enrichment. The aRPD has been shown to be a sensitive and specific indicator of hypoxic conditions experienced over the preceding 1 day to 4 weeks (Shumchenia and King 2010), and to be correlated to concurrent *in situ* dissolved oxygen concentrations (Sturdivant et al. 2012).

4.5.5.3 Summary of Statistical Analyses

For the hard bottom datasets (systematic random sampling design), a comparison between disturbed (e.g., novel structure, re-located boulders) and undisturbed (natural) hard bottom will be made using the 90% confidence interval for select metrics gleaned from the video footage (Table 9). The biological features obtained from the video footage will focus on habitat quality characteristics and include the relative abundance of native versus non-native taxa present, and the biomass of emergent fauna. For both the hard bottom boulder survey and turbine survey, growth of macrobiotic cover will be summarized for each sampling frame from observations taken with the ROV. The metrics that will be assessed for each sampling frame include mean macrobiotic cover and relative abundance of native vs. non-native species and species composition (identified to the LPIL). Estimates of the BACI contrast (i.e., the difference between the temporal change in mean cover values at disturbed sites and the temporal change in means at undisturbed sites) will be reported as a mean difference with the 90% confidence interval. Temporal changes in the community composition (with organisms identified to the LPIL) will be contrasted between disturbed and undisturbed sampling frames using exploratory multivariate techniques (e.g., nMDS). Additional exploratory graphical displays will be used to visualize and describe spatial and temporal patterns in the data.

For the soft bottom datasets (BAG design at the base of the turbines and at selected locations along the RWEC), data analysis will include exploratory multivariate approaches (e.g., non-metric multidimensional scaling, nMDS) to identify patterns among responses (SPI/PV metrics, e.g., aRPD, successional stage, feeding voids, presence of methane or *Beggiatoa*) and predictors (e.g., quantitative or categorical epifaunal/epifloral cover estimates on the turbine foundations; and distance from the turbine). Covariates in the model for the turbine foundation dataset will include habitat type (categorical) and direction (categorical); variability among turbines will provide site-wide random error. For individual metrics that are consistently measured across stations (e.g., aRPD), parametric or non-parametric regression (e.g., generalized modeling such as GLM or GAM; or regression trees) will be applied if the data prove to be sufficient and appropriate for these tools. Additionally, graphical methods and descriptive statistics will be used to assess changes in the SPI/PV metrics over time and as a function of distance and direction from the turbines. These graphical techniques may help to elucidate the spatial scale at which the greatest changes in benthic habitat quality occur.

Table 9. Summary of planned statistical analyses for the benthic monitoring surveys at RWF.

Survey	Report Section	Area	Design Type	Design Overview	Design details	Metrics of Interest	Research Question	Post-Construction Statistical Methods
Impact Analyses								
Hard Bottom Surveys	7.1.3	Novel Surfaces	SS	WTGs; random samples stratified by habitat type; single season.	**Sampling frame** =turbines with mobile sediment classes up/down current **Observational unit** = imaged quadrat (at systematically sampled intervals within frame) **Response variable** = macrobiotic cover, relative abundance of native vs non-native. **Error variance** = among samples within same area	**ROV**: cover (macrobiota, relative abundance of native vs. invasive).	What is the magnitude of difference in mean response with depth and across introduced hard bottom (WTGs) , at each survey event?	Estimate 90% CI on the difference of means for discrete depth intervals and WTG's blocked by habitat type, at each survey event. Compare the temporal profiles between depths and WTGs by habitat type
Hard Bottom Surveys	7.1.4	Disturbed and Undisturbed Boulders	SS	Disturbed and Undisturbed along IAC; random samples; single season.	**Sampling frame** = Boulders within Disturbed and Undisturbed hardbottom **Observational unit** = imaged quadrat (on systematically sampled boulders within frame) **Response variable** = macrobiotic cover, relative abundance of native vs invasive **Error variance** = among samples within same treatment (disturbed/ undisturbed) and area	**ROV**: cover (macrobiota, relative abundance of native vs. invasive)	What is the magnitude of difference in mean response between disturbed and undisturbed areas, at each survey event?	Estimate 90% CI on the difference of means for disturbed and undisturbed areas, at each survey event. Compare the temporal profiles between disturbed and undisturbed areas.
Soft Bottom Surveys	7.2.3	RWF	BAG	Impact only (no reference sites); stns at distances ranging from ~10m to ~900m from turbines; 2 directions from each turbine along prevailing current; single season	**Sampling frame** = turbines with mobile sediment classes up/down current **Observational unit** = SPI/PV station (turbines randomized first survey event, then fixed throughout study; stations randomized every survey; replicate images are subsamples) **Response variable** = mean or max per station depending on metric. **Error variance** = among stations at the same distance-direction (turbines provide replication)	**SPI**: aRPD, Successional Stage, penetration, methane, beggiatoa **PV**: cover (macrobiota, shells, cobble), presence/absence of sensitive or invasive species	What is the pattern of temporal change in metrics relative to direction and/or distance from turbine?	Fit a parametric generalized model (e.g., GLM, GLMM or GAM) or non-parametric regression tree that best describes the data. Compare the temporal profiles across spatial gradients. Calculate similarity between stations; graphically depict relationships between stations from different years, directions, or distances with nMDS.
Soft Bottom Surveys	7.2.4	RWEC	BAG	Impact only (no reference sites); stns at distances ranging from ~5m to ~1km from cable; > 3 transects within each habitat stratum.	**Sampling frame** = soft bottom areas of RWEC **Observational unit** = SPI/PV station (transects randomized first survey event, then fixed throughout study; stations randomized every survey; replicate images are subsamples) **Response variable** = mean or max per station depending on metric. **Error variance** = among stations at the same distance-direction (transects provide replication)	**SPI**: aRPD, Successional Stage, penetration, methane, beggiatoa **PV**: cover (macrobiota, shells, cobble), presence/absence of sensitive or invasive species,	What is the pattern of temporal change in metrics relative to distance from export cable?	Fit a parametric generalized model (e.g., GLM, GLMM or GAM) or non-parametric regression tree that best describes the data. Compare the temporal profiles across spatial gradients. Calculate similarity between stations; graphically depict relationships between stations from different years, directions, or distances with nMDS.

5.0 Data Sharing Plan

Fisheries monitoring data will be shared with regulatory agencies and interested stakeholders upon request. Data sharing will occur on an annual cycle, which may be unique to each survey, and all data will be subject to rigorous quality assurance and quality control criterion prior to dissemination.

Individuals seeking access to the data will be asked to provide a formal data request. As part of the data request, a brief proposal will be required which includes a description of the data that is being requested (e.g., survey type, timeframe, geographic boundaries), the intended use of the data, a list of coauthors and their affiliations, and details regarding the anticipated products of the work (e.g., stock assessment, fishery management plan, reports, manuscripts). Data Access Conditions and Protocols are also being developed, which will outline specific conditions associated with obtaining access to the data. Raw data (i.e., station level catch, biological data, and environmental data) can be requested, and will be distributed, provided that the criteria outlined in the Data Access Conditions and Protocols are met. In most cases, we anticipate that data requests can be accommodated electronically on an individual basis, and that individuals requesting data access will be given a unique username and password, which will be used to securely facilitate electronic data transfers.

Revolution Wind acknowledges that regional guidance related to data sharing for fisheries monitoring studies is being developed cooperatively through ROSA. To that end, the data sharing agreement outlined above will likely evolve over time as regional guidance is developed.

As stated above, Revolution Wind will also coordinate with our scientific Contractor(s) to disseminate monitoring results through a webinars or in-person meetings, offering an open forum for state, federal, and academic scientists to ask questions or suggest revisions to the data collection protocols. Likewise, following each year of monitoring we will coordinate with the Contractor(s) to host an industry workshop to disseminate the results of the monitoring activities to local fishing industry members.

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APPENDIX 1: Overlap Between High-Resolution Geophysical Surveys and Fisheries Monitoring Surveys

High-Resolution Geophysical (HRG) surveys are conducted by wind energy developers for site investigation to inform engineering and design, as well as for archaeological assessments and benthic habitat mapping. These surveys are also required by the Bureau of Ocean Energy Management (BOEM) for offshore wind development activities. Some stakeholders have raised the question about whether any spatial and temporal overlap of HRG surveys with fisheries monitoring surveys could bias the results of the pre-construction fisheries monitoring.

Seismic air guns, which studies have shown can influence the distribution and catch rates of commercially important marine fish (e.g., Lokkeborg and Soldal, 1993; Engas et al., 1996), are not used during HRG surveys for offshore wind development. Instead offshore wind HRG surveys employ a variety of equipment types, other than seismic air guns, as summarized in Table 1. Offshore wind HRG equipment operate at a range of frequencies. The acoustic characteristics of HRG survey equipment used during offshore wind development are well known. Table 1 includes all equipment authorized for use under the approved 2019 Ørsted IHA application and incorporates data from a recent study funded by BOEM to independently measure and verify the noise levels and frequencies of HRG equipment (Crocker and Fratantonio, 2016). Additional field studies have been conducted and are in review. Well established audiograms have been used to understand the hearing sensitivities for a number of species of fish (Table 2). Fish have been classified into four groupings based on their physiology and their presumed hearing sensitivity (Hawkins et al., 2020). Of the HRG equipment that is commonly employed in offshore wind HRG surveys, non-airgun sub bottom profilers known as ‘sparkers’ and ‘boomers’ operate at the lowest frequency range, and thus are most relevant to assess further for any potential to impact the distribution and behavior of fish in the region, based on their hearing sensitivity. For this reason, HRG equipment commonly used in offshore wind surveys have been studied by BOEM.

In the BOEM Final Programmatic Environmental Impact Statement (EIS) for Geological and Geophysical Surveys in the Gulf of Mexico, several alternatives were considered, which included >180,000 km of non-airgun HRG surveys using equipment such as boomers, sparkers, CHIRP sub-bottom profilers, side-scan sonars and multibeam echosounders. For all alternatives, the EIS concluded that non-airgun HRG equipment would have little to no measurable impacts on fisheries resources, Essential Fish Habitat, on commercial and recreational fisheries, and on benthic communities (BOEM, 2017). The Vineyard Wind Supplemental EIS concluded that impacts of HRG survey noise to finfish, invertebrates and Essential Fish Habitat were negligible (BOEM, 2020).

Ørsted does not plan to use ‘sparkers’ and/or ‘boomers’ in the Revolution Wind lease area in 2021. However, this equipment may be used for a brief period (e.g., one month) at the Revolution Wind site in 2022 to map subsurface boulders. While the HRG equipment is likely to change over time, Ørsted commits that seismic air guns will never be used for site investigations surveys on the SFW or Revolution Wind farms.

Given the lack of temporal overlap and minimal spatial overlap that are anticipated to occur between the low frequency HRG surveys (e.g., boomers and sparkers) and the REV fisheries monitoring surveys, we do not anticipate there to be any impacts on the results of the fisheries monitoring surveys. In addition, the reference areas for the REV fisheries monitoring studies will be located well outside of the Revolution Wind lease areas, in areas that have not been directly surveyed using HRG equipment. The Ørsted site investigations team records the time, date, and location that each piece of HRG equipment is deployed during site investigations surveys, and this information can be considered in the context of the fisheries monitoring results, as appropriate.

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Table 1. Summary of the operating frequencies and source levels of HRG equipment from the 2019 Ørsted IHA application and issued authorization.

Representative HRG Survey Equipment	Range of Operating Frequencies (kHz)	Baseline Source Level a/	Representative RMS_{90} Pulse Duration (millisec)	Pulse Repetition Rate (Hz)	Primary Operating Frequency (kHz)
USBL & Global Acoustic Positioning System (GAPS) Transceiver					
Sonardyne Ranger 2 transponder b/	19-34	200 dB_{RMS}	300	1	26
Sonardyne Ranger 2 USBL HPT 5/7000 transceiver b/	19 to 34	200 dB_{RMS}	300	1	26
Sonardyne Ranger 2 USBL HPT 3000 transceiver b/	19 to 34	194 dB_{RMS}	300	3	26.5
Sonardyne Scout Pro transponder b/	35 to 50	188 dB_{RMS}	300	1	42.5
Easytrak Nexus 2 USBL transceiver b/	18 to 32	192 dB_{RMS}	300	1	26
IxSea GAPS transponder b/	20 to 32	188 dB_{RMS}	20	10	26
Kongsberg HiPAP 501/502 USBL transceiver b/	21 to 31	190 dB_{RMS}	300	1	26
Edgetech BATS II transponder b/	17 to30	204 dB_{RMS}	300	3	23.5
Shallow Sub-Bottom Profiler (Chirp)					
Edgetech 3200 c/	2 to 16	212 dB_{RMS}	150	5	9
EdgeTech 216 b/	2 to 16	174 dB_{RMS}	22	2	6
EdgeTech 424 b/	4 to 24	176 dB_{RMS}	3.4	2	12
EdgeTech 512 b/	0.5 to 12	177 dB_{RMS}	2.2	2	3
Teledyne Benthos Chirp III - TTV 170 b/	2 to 7	197 dB_{RMS}	5 to 60	4	3.5
GeoPulse 5430 A Sub-bottom Profiler b/, e/	1.5 to 18	214 dB_{RMS}	25	10	4.5
PanGeo LF Chirp b/	2 to 6.5	195 dB_{RMS}	481.5	0.06	3
PanGeo HF Chirp b/	4.5 to 12.5	190 dB_{RMS}	481.5	0.06	5
Parametric Sub-Bottom Profiler					
Innomar SES-2000 Medium 100 c/	85 to 115	247 dB_{RMS}	0.07 to 2	40	85
Innomar SES-2000 Standard & Plus b/	85 to 115	236 dB_{RMS}	0.07 to 2	60	85
Innomar SES-2000 Medium 70 b/	60 to 80	241 dB_{RMS}	0.1 to 2.5	40	70
Innomar SES-2000 Quattro b/	85 to 115	245 dB_{RMS}	0.07 to 1	60	85
PanGeo 2i Parametric b/	90-115	239 dB_{RMS}	0.33	40	102
Medium Penetration Sub-Bottom Profiler (Sparker)					
GeoMarine Geo-Source 400J d/	0.2 to 5	212 dB_{Peak} 201 dB_{RMS}	55	2	2
GeoMarine Geo-Source 600J d/	0.2 to 5	215 dB_{Peak} 205 dB_{RMS}	55	2	2
GeoMarine Geo-Source 800J d/	0.2 to 5	215 dB_{Peak} 206 dB_{RMS}	55	2	2
Applied Acoustics Dura-Spark 400 System d/	0.3 to 1.2	225 dB_{Peak} 214 dB_{RMS}	1.1	0.4	1
GeoResources Sparker 800 System d/	0.05 to 5	215 dB_{Peak} 206 dB_{RMS}	55	2.5	1.9

Table 1 continued.

Representative HRG Survey Equipment	Range of Operating Frequencies (kHz)	Baseline Source Level a/	Representative RMS_{90} Pulse Duration (millisec)	Pulse Repetition Rate (Hz)	Primary Operating Frequency (kHz)
Medium Penetration Sub-Bottom Profiler (Boomer)					
Applied Acoustics S-Boom 1000J b/	0.250 to 8	228 dB_{Peak} 208 dB_{RMS}	0.6	3	0.6
Applied Acoustics S-Boom 700J b/	0.1 to 5	211 dB_{Peak} 205 dB_{RMS}	5	3	0.6

Notes:

a/ Baseline source levels were derived from manufacturer-reported source levels (SL) when available either in the manufacturer specification sheet or from the SSV report. When manufacturer specifications were unavailable or unclear, Crocker and Fratantonio (2016) SLs were utilized as the baseline:

b/ source level obtained from manufacturer specifications

c/ source level obtained from SSV-reported manufacturer SL

d/ source level obtained from Crocker and Fratantonio (2016)

e/ unclear from manufacturer specifications and SSV whether SL is reported in peak or rms; however, based on SLpk source level reported in SSV, assumption is SLrms is reported in specifications.

The transmit frequencies of sidescan and multibeam sonars for the 2019 marine site characterization surveys operate outside of marine mammal functional hearing frequency range.

It is important to note that neither Crocker and Farantino (2016), nor HRG manufacturer technical specifications report source levels in terms of the RMS_{90}, which is the metric required in assessment to the distance of NOAA Fisheries Level B harassment thresholds. Therefore, careful consideration should be made when attempting to make such direct comparisons. As shown in Crocker and Farantino, the pulse duration may also be a function of HRG operator settings.

Table 2. Summary of available information regarding the hearing sensitivities for fish species that are commonly encountered in the northwest Atlantic.

Species/Species Group	Family	Order	Sound Detection	Sensitivity
American eel	Anguillidae	Anguilliformes	Swim bladder close but not connecting to ear; Hearing by particle motion and pressure	Hawkins et al. 2020 Group 3 Up to 1-2 kHz
Alewife/herring/menhaden	Clupeidae	Clupeiformes (includes anchovies)	Weberian ossicles connecting swim bladder to ear; Hearing by particle motion and pressure	Hawkins et al. 2020 Group 4 Up to 3-4 kHz Alosinae detect to over 100 kHz
Cod/Pollock/Haddock/Hake	Gadidae	Gadiformes	Swim bladder close but not connecting to ear; Hearing by particle motion and pressure	Hawkins et al. 2020 Group 3 Up to 1-2 kHz
Mako sharks/mackerel sharks	Lamnidae	Lamniformes	No air bubble; Particle motion only	Hawkins et al. 2020 Group 1 Well below 1 kHz
Monkfish/goosefish	Lophiidae	Lophiiformes		unknown
Bluefish	Pomatomidae	Perciformes		unknown
Sea bass/groupers	Serranidae			unknown
Striped bass	Moronidae			unknown
Sand lance	Ammodytidae			unknown
Tautog	Labridae			unknown
Tunas/mackerels/albacores	Scombrinae		Swim bladder far from ear; Particle motion only	Hawkins et al. 2020 Group 2 Up to 1 kHz
Billfish/swordfish	Xiphiidae			unknown
Flounders/flatfish/sole/halibut	Pleuronectidae	Pleuronectiformes	No air bubble; Particle motion only	Hawkins et al. 2020 Group 1 Well below 1 kHz
Skates/rays	Rajidae	Rajiformes	No air bubble; Particle motion only	Hawkins et al. 2020 Group 1 Well below 1 kHz
Spiny dogfish	Squalidae	Squaliformes	No air bubble; Particle motion only	Hawkins et al. 2020 Group 1 Well below 1 kHz

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APPENDIX 2: Power Analysis for Trawl Survey of Fish and Invertebrates

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EXA Data and Mapping

1.0 Introduction

For the trawl survey, an asymmetrical BACI design is planned for the Revolution Wind Farm (RWF) project area. The RWF trawl survey will use NEAMAP survey gear and sampling protocols and is intended to capture a range of benthic and pelagic fish species, as well as commercially important invertebrate species.

This appendix covers two topics:

1. A review of existing trawl survey datasets in the vicinity of RWF project area, including data from the NEFSC trawl survey (Politis et al., 2014) and data collected in the reference areas during the BIWF trawl survey (Wilber et al., 2020). These datasets were evaluated to establish the proximate range of a meaningful effect size in measuring change over time, as well as reasonable ranges for interannual and intraannual variability (i.e., the coefficient of variation [CV]) to use in the power analyses.
2. A power simulation study for a BACI design and analysis contrasting fish/invertebrate biomass (kg/tow) between an impact area and reference areas. Effect sizes and CVs were derived from the NEFSC and BIWF trawl survey datasets (topic 1 above).

2.0 Power Analysis Elements

A statistical power analysis requires specification of the following:

- Study design specifics (e.g., number of replicates, number of sites, number of seasons/sampling events, sampling duration before and after construction), and their structure (e.g., random trawls as independent replicates within each site and sampling event, or fixed trawls nested within sites and repeatedly sampled over time).
- The statistical model, which is determined by the study design (previous bullet) and characteristics of the data (e.g., catch data as biomass might be modeled with a generalized linear or additive model with normal errors and a log-link; catch data as counts might be modeled with a generalized linear or additive model with Poisson errors, or with a negative binomial if the count data are over-dispersed; presence/absence data might be modeled with logistic regression and binomial errors).

A statistical power analysis relates the following four elements; given three of these elements, the fourth can be estimated:

- **Effect size (Δ)** is a measure of change in the data that the study design and modelling approach will be used to estimate. Measures of effect size can be summarized in a number of different ways (e.g., Durlak 2009); standardized effect sizes such as the magnitude of difference expressed as a percent of the standard deviation are useful for comparisons across studies. These can be difficult to understand, however; and when the unit of measure itself is meaningful (e.g., catch ratios) it is more useful to present results in terms of unstandardized effect sizes. For the purposes of this appendix, unstandardized effect sizes are expressed as the temporal change at the impact site relative to temporal change at the reference sites. Since this value is not standardized to variance, power for relative change values is evaluated across a range of variance estimates.

Statistical analysis of this OSW monitoring data from the BACI design will focus on the BACI interaction contrast between period and location, which is specified as a contrast (differences on the log-scale; ratios on the original scale) between the temporal change at the Reference site(s) and the temporal change at the Impact site, with responses averaged across seasons and years within each period, and over multiple sites within each location type (Eq. 1). The relative proportional change (PC) at the impact site is the proportional change between periods of the mean catch per tow at the Impact site relative to the proportional change between periods of the mean catch per tow at the Reference site(s).

$$\text{Interaction Contrast} = \frac{(\bar{X}_{Reference,After}/\bar{X}_{Reference,Before})}{(\bar{X}_{Impact,After}/\bar{X}_{Impact,Before})} \qquad \text{[Eq. 1]}$$

$$\text{Proportional Change (PC)} = \left[\frac{(\bar{X}_{Impact,After}/\bar{X}_{Impact,Before})}{(\bar{X}_{Reference,After}/\bar{X}_{Reference,Before})} - 1\right] \qquad \text{[Eq. 2]}$$

For example, a PC of –0.33 (-33%) could represent a 33% decrease in catch at the impact site and no change at the reference site(s) (i.e., (1-0.33)/1 -1 = -0.33). The same PC could represent any number of ratios. This PC of -0.33 could also represent a 50% decrease at the impact site and a 25% decrease at the reference site (i.e., (1-0.5)/(1-0.25) - 1 = 0.5/0.75-1= -0.33); or a 20% decrease at the impact site and 20% increase at the reference (i.e., 0.8/1.2-1 = -0.33); or other similar combinations that yield a PC value of -0.33.

In the context of statistical power analysis, a threshold effect size considered to be meaningful (Δ_M) is specified and the probability this difference would be statistically significant at the designated α, is the power (power = 1-β, where β is the type II error). Outside of statistical power analysis, observed effect size or level of change is a way of summarizing the metric of interest that can be compared across studies, and is not inherently tied to statistical significance or statistical power. In fact, the observed proportional changes among reference areas are used to establish what constitutes a meaningful threshold effect size or level of proportional change (Δ_M) for impact studies.

- **Power (1-β**, where β is the Type II error**)** is the probability of rejecting the null hypothesis when the difference in the data exceeds a threshold effect size (Δ_M). In the BACI design setting, it is the probability of finding the interaction BACI contrast to be statistically significant (e.g., Eq.1 is significantly different from one for a model fit on the log-scale) when a proportional change of size Δ_M is present in the populations.
- **Alpha (α)** is the Type I error, or the probability of rejecting the null hypothesis in error because the true difference is null. The value α is typically fixed, at 0.05 or 0.10 (95% or 90% confidence). For power estimated through simulations, α is estimated as the percent of significant outcomes when the proportional change imposed on the data was 0. For this study, α = 0.10 was used for the two-tailed null hypothesis which allows us

to say whether results (Eq. 1) are significantly greater than or less than one (the one-tailed hypotheses), with 95% confidence (α = 0.05) on each side.

- **Sample size** encompasses the number of sites, replicates, and time periods that are sampled and determines the degrees of freedom for the statistical tests. In this analysis, the overall design was set (i.e., 1 impact site and 2 reference sites; 2 years of monitoring before and after construction, and 4 seasonal trawl surveys per year) and sample size refers to the number of tows per season in each area. Precision for the annual estimates can be improved by appropriate survey timing (i.e., surveys are timed to not miss the seasonal peaks in biomass/abundance), using consistent survey methods, and greater replication (tows per season, years per period, or areas per location). All else being equal, as replication increases, the precision estimates for the model parameters increase. This will result in higher power for a specific level of change, or a smaller detectable level of change for a specific level of power.

3.0 Review Existing Datasets

3.1 NEFSC

Station level catch data from the NEFSC trawl survey was provided by Phil Politis. The data request was limited to species of recreational and commercial importance that were expected to occur in Strata 1050. The NEFSC (Politis et al., 2014) trawl dataset was used to establish 1) a proximate range of proportional change over time, and 2) the expected distributional form for the catch as biomass and reasonable variance estimates. The NEFSC dataset was screened to only include:

- tows from Stratum 1050, which includes the location for the RWF project (Figure 1).
- selected species of commercial and recreational importance (Table 1).

This NEFSC survey design included four to five (random) replicate tows per season in survey strata 1050 from Spring (late March to early May) and Fall (late September to early October) in the years 2010 to 2018, with replicate tows for each season generally occurring on the same day. This dataset provides an adequate representation of the spatial variance among tows during each survey event (i.e., the within-season variability) for this approximately 5,100 km^2 stratum and provides estimates of the natural levels of inter-annual changes in catch. The NEFSC trawl survey is limited to spring and fall. Therefore, monthly data from the Block Island Wind Farm (BIWF) trawl survey were also reviewed (Section 3.2) to determine the extent to which the seasonal NEFSC trawl survey captured intraannual biomass peaks for different species of interest. Given that biomass and abundance can vary substantially throughout the course of the year within the proposed Project area, it is important to ensure that this intraannual variability is accounted for when estimating the expected variance for the species of interest in the seasonal trawl survey.

The tows in the NEFSC dataset are at a lower spatial density than what is planned for the RWF trawl survey. We expect the NEFSC estimates of spatial variance to be conservatively high relative to the variance expected from the RWF monitoring, because the RWF survey will occur over a smaller spatial area, so less spatial heterogeneity may be expected amongst replicate tows. The RWF trawl survey will maintain the same spatial sampling densities within the impact and the reference areas (i.e., the three areas will all be the same size, and within the boundaries of Stratum 1050).

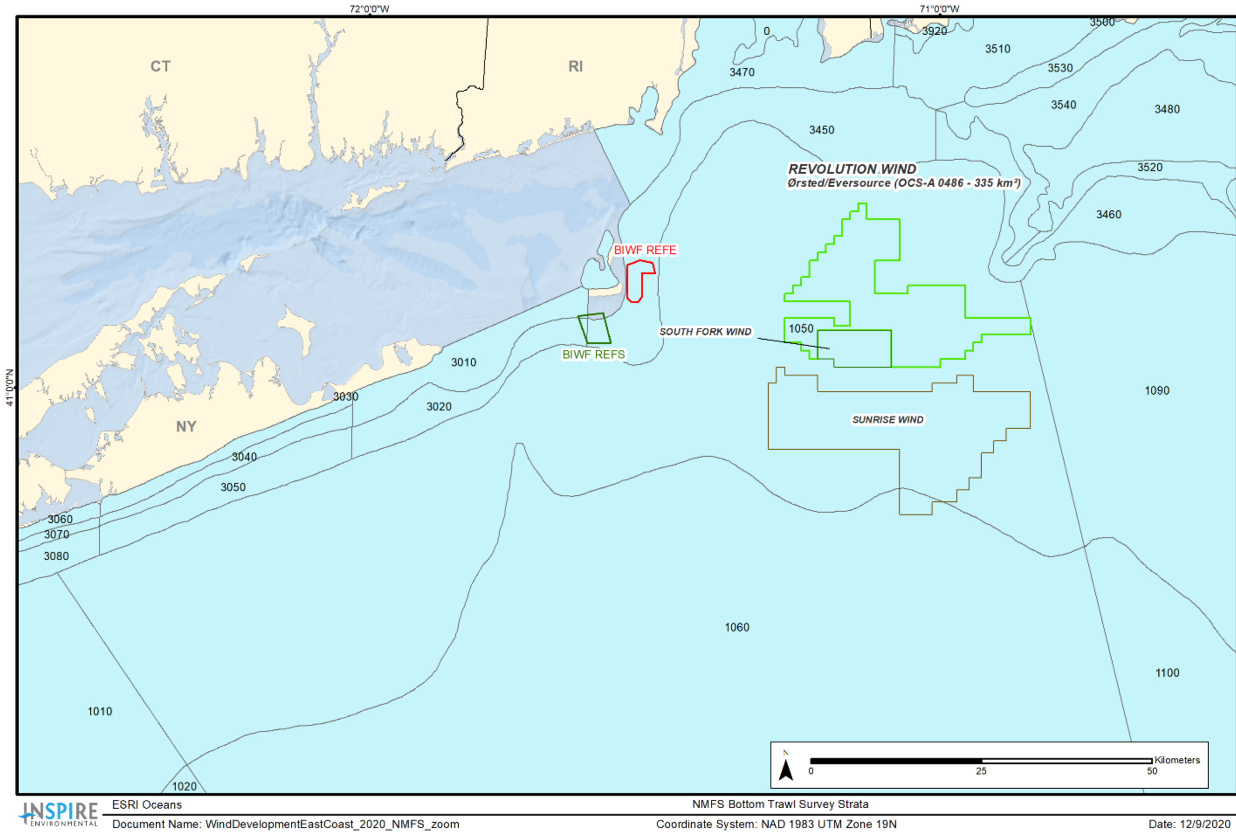


Figure 1. Map of NEFSC strata and the Revolution Wind project area. Trawl survey data sampled in strata 1050 from 2010-2018 were used in the analysis. The reference sites used in the BIWF Trawl survey (REFE and REFS) are also shown for reference.

Table 1. Summary of total catch (biomass, kg) for individual fish and invertebrate species from the NEFSC trawl survey (Politis et al., 2014) sampled in Stratum 1050 from 2010 through 2018. These catch data were used in this analysis.

Species	Total biomass (kg)
Longfin squid	523
Little skate	6422
Summer flounder	507
Windowpane flounder	119
Winter skate	2709
Winter flounder	481
Butterfish	587
Atlantic herring	580
Black sea bass	276
Silver hake	576
Scallop	418
Yellowtail flounder	277
Scup	1471
Red hake	29

Species	Total biomass (kg)
Atlantic mackerel	17
Goosefish	124
Bluefish	50
Atlantic menhaden	0
Channeled whelk	0
Knobbed whelk	0
Spanish mackerel	0
Tautog	0
Minimum	0
Maximum	6422
Median	276

To demonstrate the seasonal variability in mean catch rates in stratum 1050, a summary of the mean catch per tow (kg) for the species shown in Table 1 is presented by season and year in Figure 2.

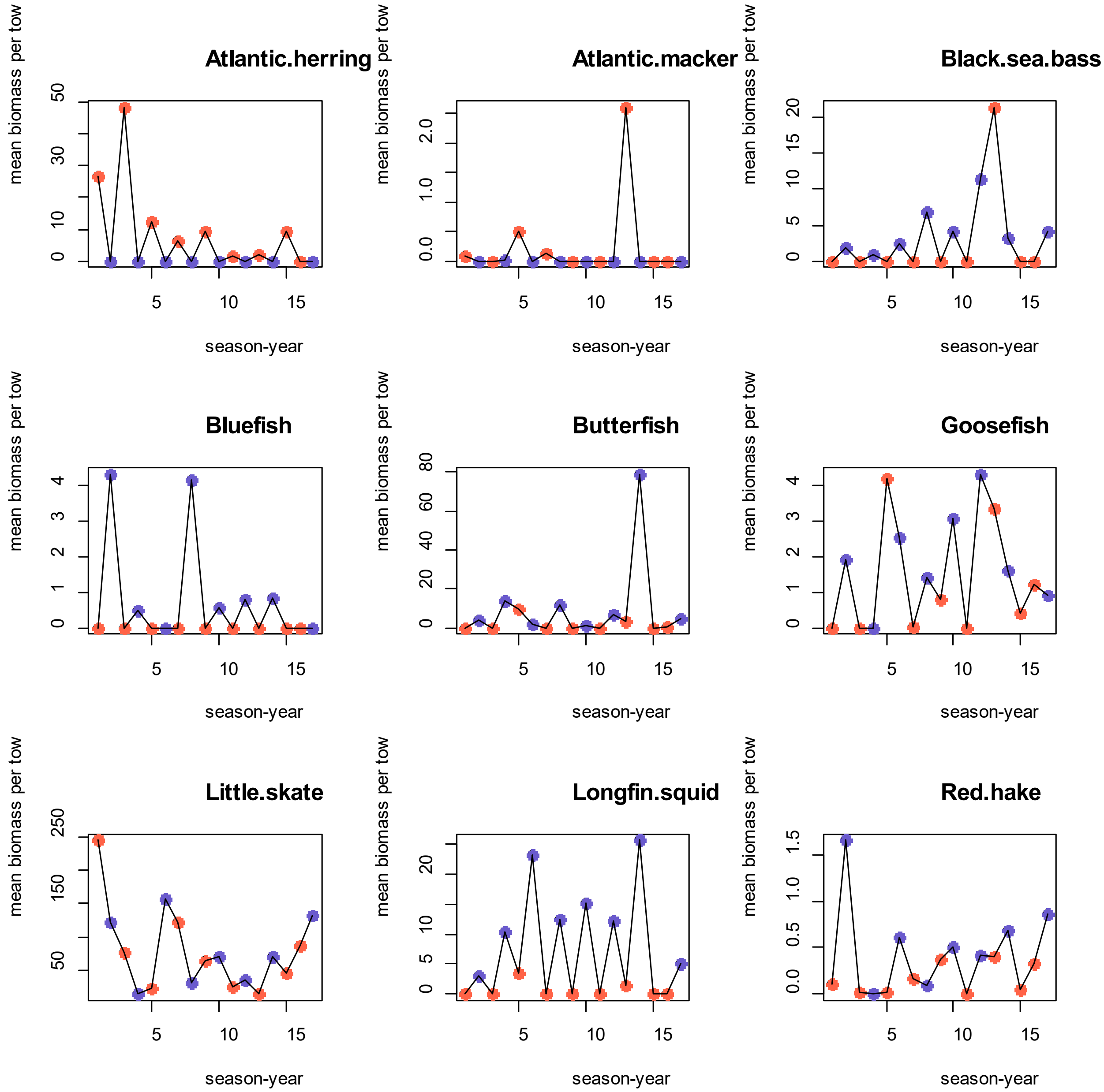
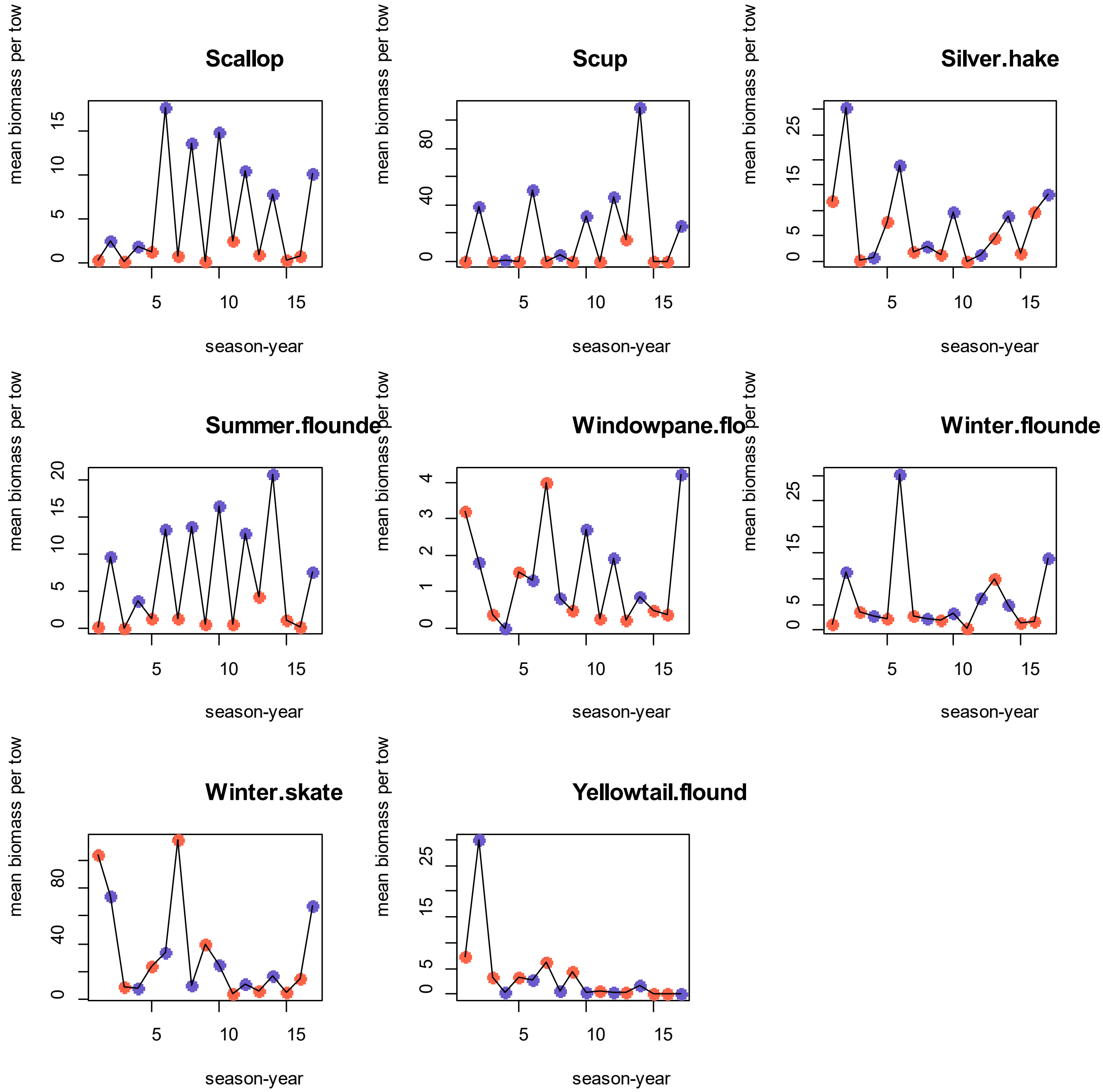


Figure 2a. Mean seasonal catch per tow (kg) across season and year, for selected species (Atlantic herring to Red hake) sampled in strata 1050 during the NEFSC seasonal trawl survey from 2010 through 2018. The orange dots represent spring surveys, blue dots represent fall surveys.



3.2Block Island Wind Farm Trawl Survey Data

Intraannual variation in catch rates (kg/tow) were examined for several species from the monthly trawl survey that occurred over seven years at the two reference areas used in the Block Island Wind Farm (BIWF) monitoring. The monthly BIWF trawl survey data were reviewed to determine the extent to which the NEFSC trawl surveys, which are limited to spring and fall, may miss intraannual biomass peaks. The monthly means from seven years are plotted in Figure 3 (REFE area) and Figure 4 (REFS area) for the species of primary commercial and recreational interest. Monthly variation in catch rates was observed at a relatively fine spatial scale (i.e., between the two reference sites) for some species in the BIWF trawl survey, such as windowpane flounder and little skate, which illustrates the advantages that can be gained by using multiple reference sites to monitor changes in abundance over time.

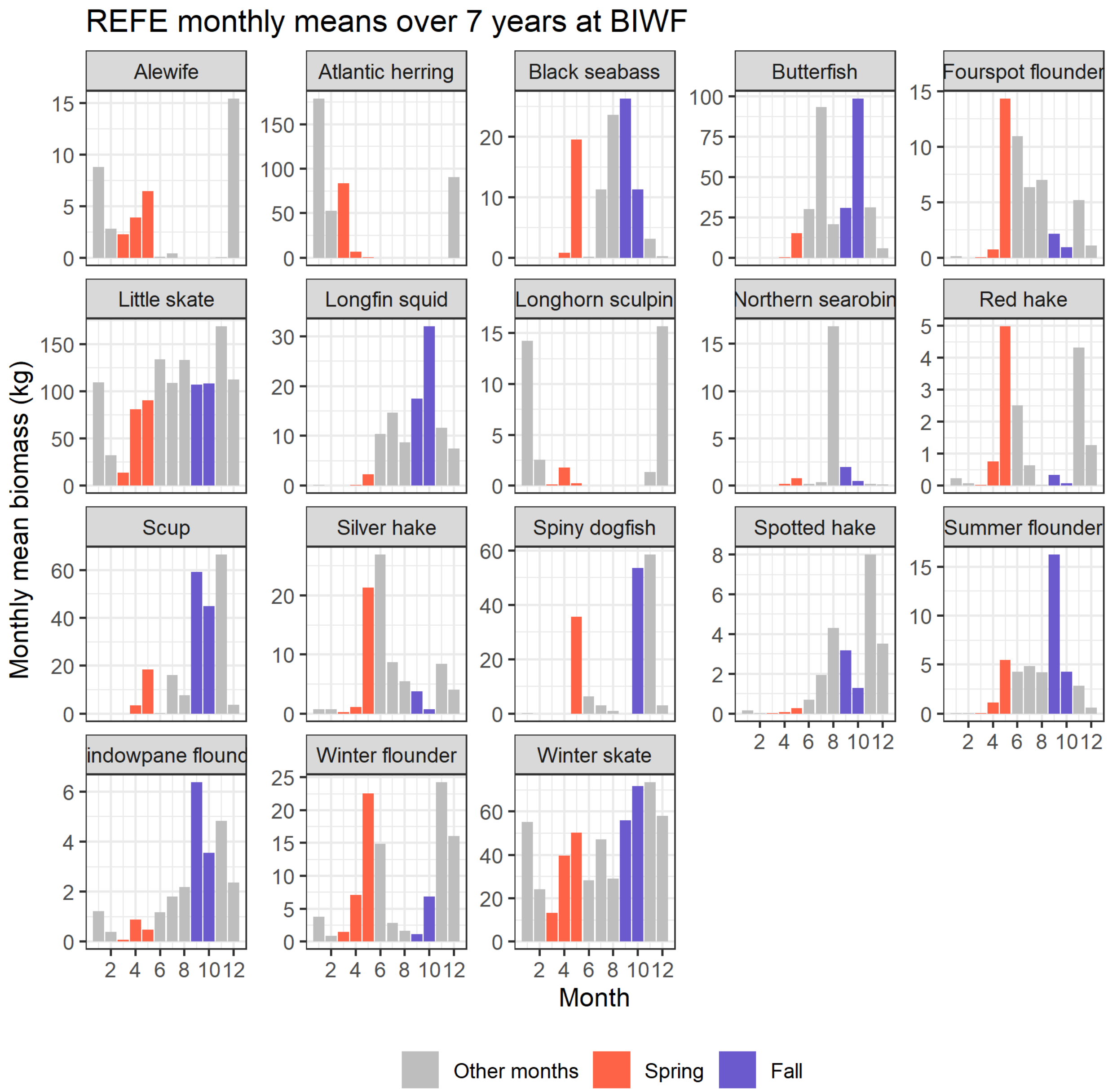


Figure 3. Monthly mean biomass (kg) averaged over seven years (from October 2012 to September 2019) for dominant species from the eastern reference area (REFE) from the BIWF trawl survey monitoring. The months that were also sampled in the NEFSC trawl survey are colored orange (spring) and blue (fall).

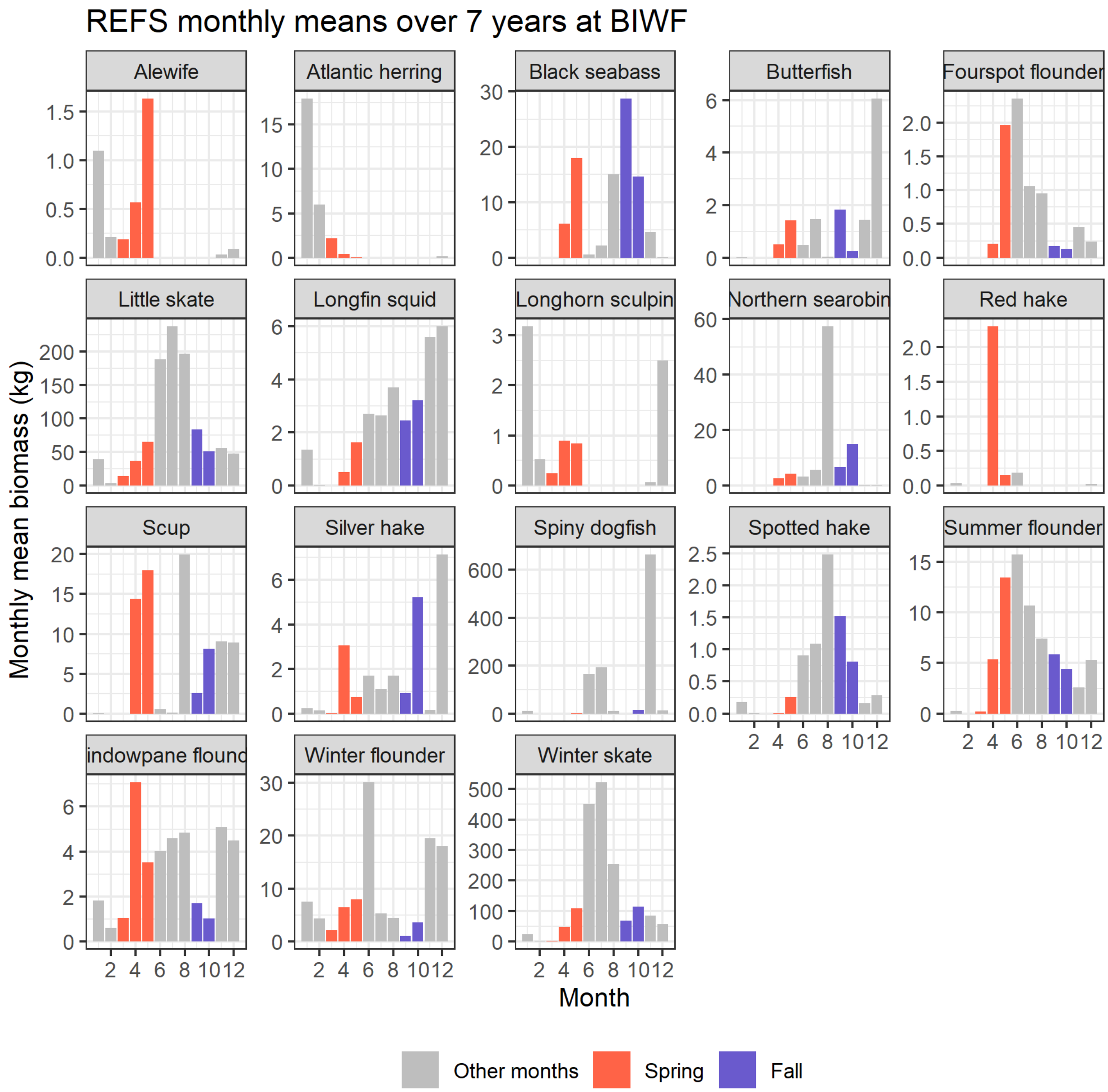


Figure 4. Monthly mean biomass from October 2012 to September 2019 (averaged over seven years) for dominant species from the southern reference area (REFS) from the BIWF trawl survey monitoring. The months that were also sampled in the NEFSC trawl survey are colored orange (spring) and blue (fall).

3.3Reference Effect Sizes

Using the NEFSC and BIWF reference datasets, the proportional change in mean annual biomass (averaged across seasons) between subsequent 2-year time periods, was calculated as:

$$Reference\ Proportional\ Change = (\bar{X}_{2,3}/\bar{X}_{0,1} - 1) \qquad \text{[Eq. 3]}$$

where

$\bar{X}_{0,1}$ = The two year mean from all seasons in years *i* and *i+1*.

$\bar{X}_{2,3}$ = The two year mean from all seasons in years *i*+2 and *i*+3.

For [Eq. 3] note that for the NEFSC dataset, *i*= 2010 through 2014, the annual means were calculated from data from two seasons per year, and where *i* =2014, the mean from 2014 and 2015 was compared to mean from 2016 and 2018 (due to incomplete sampling in 2017). For BIWF REFE and REFS datasets, *i*= 2012 through 2015, and the annual means were calculated from data from four seasons per year (the months January, April, July, and September were subsampled from the monthly time series).

The ranges of relative percent change (proportion x 100) from these extant datasets provide context for generating realistic effect sizes (PC values) to be used in the power calculations. Results are summarized for the NEFSC dataset in Table 2 and Figure 5, and for BIWF Reference areas in Table 2 and Figure 6. The effect sizes or percent change values [derived from Eq. 3] have a natural lower bound of -100%, and an unlimited upper bound.

Table 2. Summary of effect sizes as percent change (100 x Eq. 3) by species for reference area datasets from NEFSC and BIWF (results sorted by median value).

	NEFSC (n=9)			BIWF Reference Areas (n=8)		
Species	**Minimum**	**Median**	**Maximum**	**Minimum**	**Median**	**Maximum**
Spiny dogfish		n/a		-98%	-85%	7250%
Atlantic herring	-81%	-75%	-41%	-91%	-36%	17%
Yellowtail flounder	-76%	-61%	-35%		n/a	
Longhorn sculpin		n/a		-90%	-60%	-5%
Bluefish	-67%	-39%	837%		n/a	
Winter skate	-78%	-38%	90%	-52%	-16%	105%
Silver hake	-54%	-36%	98%	-50%	812%	1690%
Little skate	-51%	-27%	58%	-46%	-29%	56%
Windowpane flounder	-42%	-23%	94%	-56%	-31%	42%
Alewife		n/a		-75%	-22%	1170%
Fourspot flounder		n/a		-56%	-20%	41%
Butterfish	-53%	-15%	663%	-89%	-1%	299%
Scallop	-32%	-11%	497%		n/a	
Goosefish	-21%	1%	165%		n/a	
Longfin squid	-26%	17%	127%	-37%	-14%	3%
Summer flounder	7%	22%	101%	-56%	-16%	73%
Red hake	-32%	33%	78%	-38%	154%	Inf
Scup	-28%	41%	362%	-23%	176%	811%
Winter flounder	-75%	89%	162%	-33%	-5%	25%
Spotted hake		n/a		-62%	175%	1590%
Black sea bass	80%	232%	258%	-71%	47%	629%
Northern sea robin		n/a		62%	334%	2360%
Atlantic mackerel	-100%	458%	Inf		n/a	

Minimum	-100%	-75%	-41%	-98%	-85%	-5%
Median	-51%	-11%	114%	-56%	-15%	105%
Maximum	80%	458%	837%	62%	812%	7250%

n/a=not available. The NEFSC summaries are presented only for those species requested by Orsted from NEFSC. The BIWF summaries are presented for species included in the RI CRMC's Ocean Special Area Management Plan (OSAMP) of recreational and commercial species of concern and/or which had sufficient catch to allow for estimation of relative effect sizes.

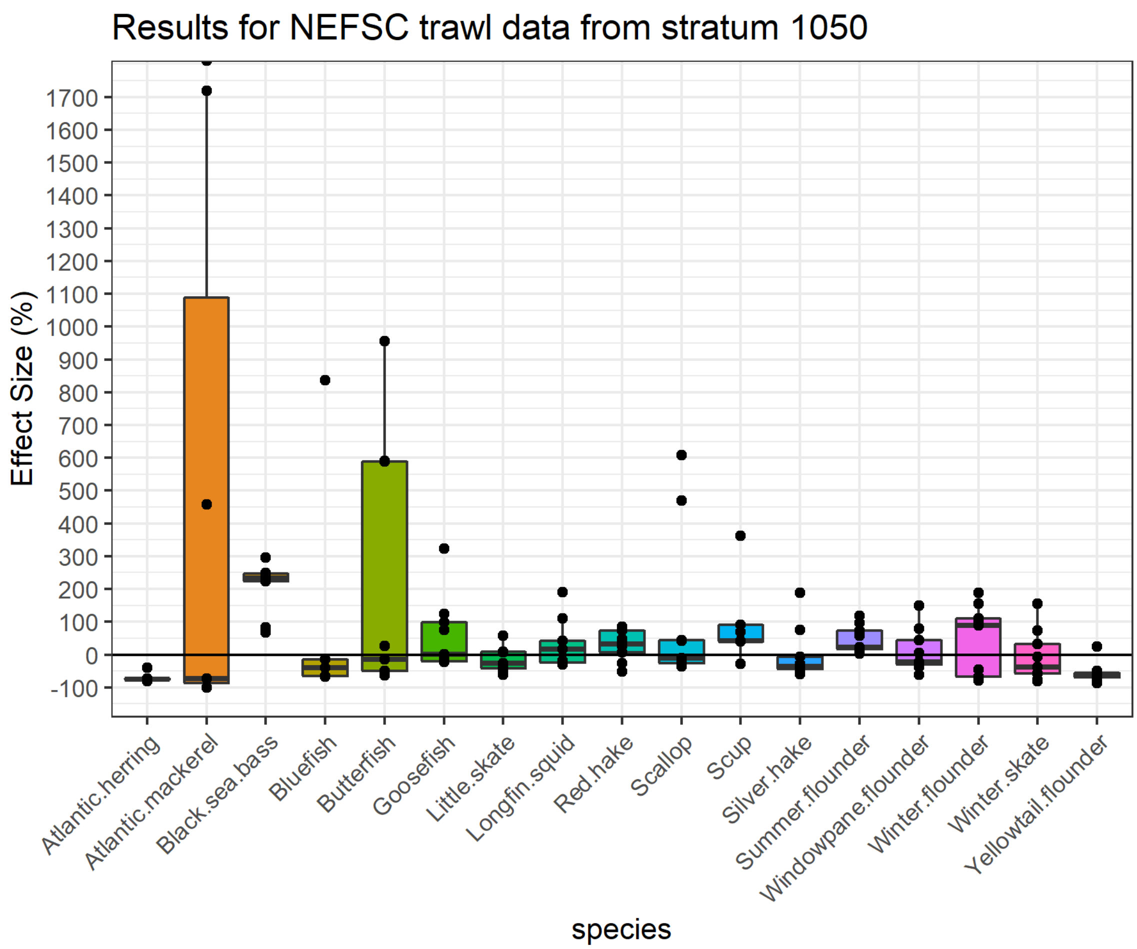


Figure 5. Boxplots showing the distribution of effect sizes as relative percent change (100 x Eq. 3) by species for NEFSC dataset (2010 – 2018). Scale of y-axis was truncated to -100% to 1700% to allow greater distinction of the values less than zero.

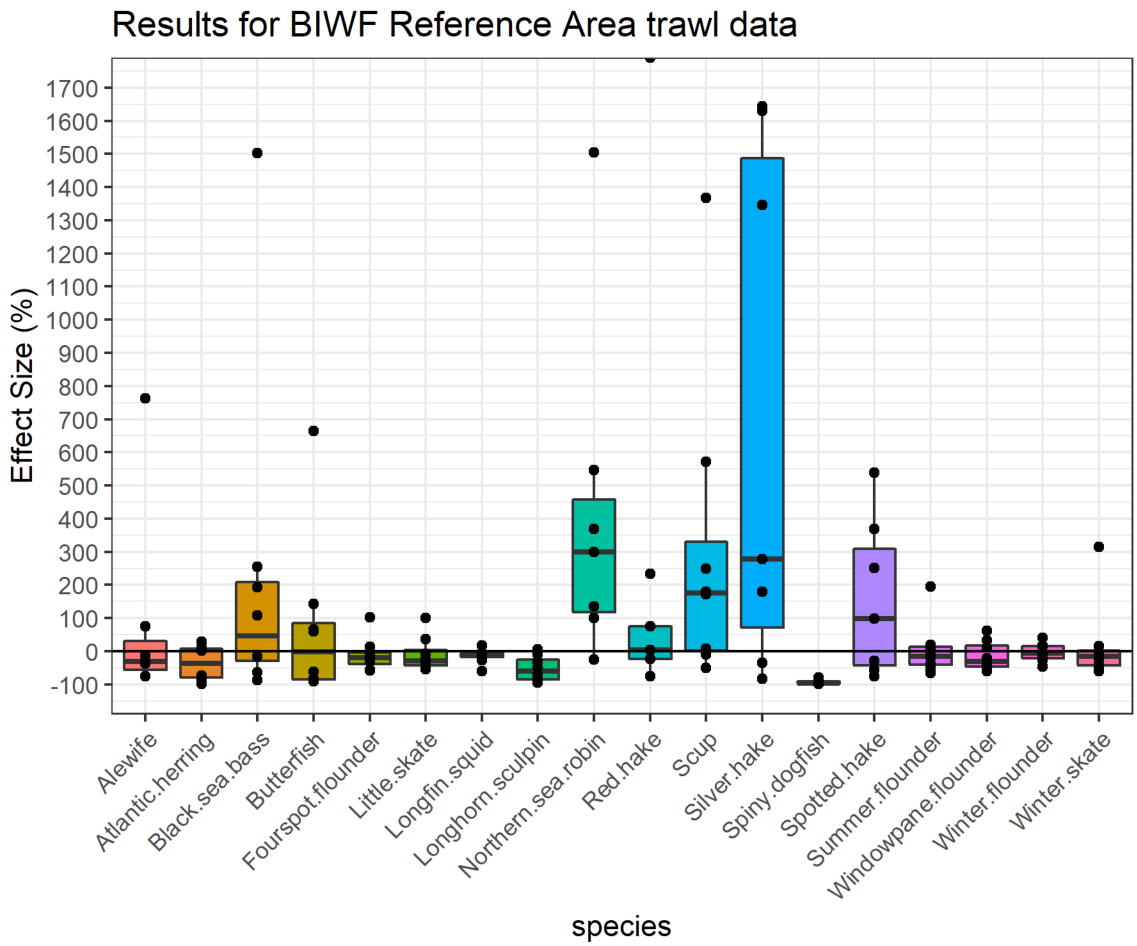


Figure 6. Boxplots showing the distribution of effect sizes as relative percent change (100 x Eq. 3) by species for BIWF reference areas (2012/2013 – 2018/2019). Scale of y-axis was truncated to -100% to 1700% to allow greater distinction of the values less than zero.

Over the nine-year period for the NEFSC dataset, nine of the 17 species had decreases in more years than increases (median values < 0) with median relative percent decreases ranging from -11% to -75%. For the BIWF Reference area dataset over the seven-year period 12 of the 18 species had decreases in more years than increases, with median relative percent decreases ranging from -1% to -85%.

The results demonstrate the substantial interannual variability that can occur for many species in the region, particularly when survey data are analyzed on a fine spatial scale (which reduces the number of observations). The data suggest that it may be reasonable to attempt to detect effect sizes on the order of 50% for some species (e.g., longfin squid), but for other species that display greater interannual variability (e.g., butterfish) detecting anything smaller than a 50% relative change may not be possible given practical constraints and the underlying natural variability in abundance and availability associated with those populations.

3.4 Coefficient of Variation

Catch (kg) per tow is naturally bounded by zero and the distribution tends to be skewed with most catches around the median value and large catches in a few tows, approximating a lognormal distribution. The NEFSC biomass data from replicate tows within a single season in Stratum 1050 were too sparse to adequately test this (n=4 to 5 per season within Strata 1050), but the data generally fit this description. For the lognormal distribution, the standard deviation (SD) is proportional to the mean and the coefficient of variation (CV = SD/mean) on the original scale is used to summarize variability in catch rates independent of the mean. A summary of the seasonal CV values for the NEFSC dataset is shown in Table 4. For conservative sample size estimates in the power analyses (Section 4.0), the observed range of median to maximum CV values across seasons, years, and species were used (0.8 to 2.2)

Table 4. Summary of seasonal variance estimates for catch (biomass, kg) for the individual fish and invertebrate species from NEFSC trawl survey (Politis et al., 2014) in Stratum 1050 that were used in this analysis.

	Seasonal Coefficients of Variation (CVs) Summarized across Seasons and Years			
Species	**Number of Seasons with Catch**	**Minimum**	**Median**	**Maximum**
Longfin squid	10	0.4	0.8	1.4
Little skate	17	0.4	0.9	1.6
Summer flounder	17	0.4	0.9	2.2
Windowpane flounder	16	0.3	1.0	1.8
Winter skate	17	0.4	1.1	1.9
Winter flounder	17	0.8	1.2	1.8
Butterfish	11	0.6	1.3	2.0
Atlantic herring	12	0.8	1.3	2.2
Black sea bass	13	0.6	1.4	2.2
Silver hake	17	0.8	1.4	2.1
Scallop	17	0.8	1.5	2.2
Yellowtail flounder	16	0.6	1.5	2.2
Scup	10	0.7	1.6	2.2
Red hake	16	0.8	1.7	2.2
Atlantic mackerel	5	1.7	1.8	2.0
Goosefish	14	0.9	1.8	2.2
Bluefish	6	1.5	2.1	2.2
Minimum	5	0.3	0.8	1.4
Median	16	0.7	1.4	2.2
Maximum	17	1.7	2.1	2.2

4.0 Power Analysis

4.1 The Study Design and Model

An asymmetrical BACI design was tested in this power analysis, with the design variables as specified in Table 5. For comparison, a symmetrical BACI (i.e., one impact and one reference area) was evaluated for power using a limited scenario (i.e., a single CV).

Table 5. Design for Revolution Wind trawl survey power simulation study

Set study design variables
• Impact Areas = 1 impact area
• Reference Areas = 2 control/reference areas
• Habitat Strata = 1

• Frequency = four seasons per year
• Number of years Before impact = 2 • Number of years After impact = 2
Variables altered in the power analysis
• Number of replicate (random) trawls per season in each area (n): 5, 10, 12, 14, 16, 20, 30, 40
• Proportional Change (PC) of Impact / Reference : -25%, -33%, -40%, -50%, -70% (Section 3.3) and 0% (for Type I error)
• CVs: 0.8, 1.0, 1.2, 1.4, 1.8, 2.2 (Section 3.4)
• A two-tailed α = 0.10

For a saturated model that estimates the mean catch (kg) for each season, year, and location, the BACI interaction contrast is described as

$$\left(\bar{X}_{Impact,Before} - \bar{X}_{Impact,After}\right) - \left(\bar{X}_{Control,Before} - \bar{X}_{Control,After}\right) \quad \text{[Eq.42]}$$

where

$\bar{X}_{Impact,Period}$ = The two-year log-scale mean biomass per tow (kg) from the Impact area, averaged across four seasons in all years of the *Period* (Before or After).

$\bar{X}_{Control,Period}$ = The two-year log-scale mean biomass per tow (kg) averaged across the two Reference areas, and four seasons in all years of the *Period* (Before or After).

4.2 Simulation methods

The power analysis used a simulation approach to generate significance values for a range of CV estimates, effect sizes (PC values), and a range of sample sizes (Table 5). Given the substantial intraannual variability that is present amongst the fish populations in the region (Figures 2, 3, and 4), accounting for seasonality is important when estimating statistical power. Therefore, seasonality for this four season sampling design was imposed as two seasons with the same mean catch per tow μ, and the other two seasons having mean 0.25μ (a 75% decrease). Note that this is just one of several permutations that could be used to simulate the seasonal variability that is anticipated to be present in the trawl survey catch rates. The effect size (PC) was imposed on every season during the After period. Note that proportional changes on the original scale become additive changes on the log-scale; consequently, log-scale changes are a function only of the PC value and do not depend on the starting mean value. Code was written in (R Core Team 2020) to conduct the simulations; the R code is included as an addendum to this appendix.

For a given CV, PC, and sample size (n), the following steps were performed m=1000 times:

1. From a log-normal distribution with mean μ and CV, simulate *n* values of catch data for 2 seasons in each year of the Before period, for all Impact and Reference areas. Repeat with mean 0.25μ for the other 2 seasons of each year of the Before period, for all Impact and Reference areas.
2. Repeat step 1 for each year of the After period for the two Reference areas.
3. Repeat step 1 for each year of the After period for the Impact area, but with a reduced mean equal to (1+PC)μ for 2 seasons, and mean 0.25 x (1+PC)μ for the other 2 seasons.

4. Fit the saturated model to the log-transformed biomass data (i.e., a separate coefficient for every area-period-season-year).

5. Calculate the BACI interaction contrast, and save the p-value.

6. Repeat m=1000 times for 1000 simulation replicates.

7. Count the number of times out of m that the p-value was < 0.10, and store this simulated power estimate for that combination of CV, PC, and n.

Repeat Steps 1-7 for each combination of CV, PC, and n.

4.3 Results

The simulation power results for a design with one impact and two reference areas are shown in Table 6 and Figure 7. Using an asymmetrical BACI design with two reference areas increases the statistical power of the survey design when compared to a BACI approach that relies on a single reference area (Figure 8).

Table 6. Simulated power for the BACI interaction contrast within a saturated model (see text) for a range of variance (CV), effect sizes (% change), and sample sizes (n) per season per area, and using a two-tailed α = 0.10 and a design with one impact and two reference areas. The 0% change illustrates the type I error. Results with power 80% and above are shaded.

% Change	Sample Size (n)	CV=0.8	CV=1.0	CV=1.2	CV=1.4	CV=1.8	CV=2.2
0	5	0.10	0.10	0.13	0.12	0.12	0.09
0	10	0.09	0.11	0.10	0.11	0.10	0.10
0	20	0.10	0.11	0.10	0.11	0.09	0.09
0	30	0.11	0.11	0.10	0.09	0.10	0.10
0	40	0.09	0.10	0.09	0.10	0.11	0.09
-25%	5	0.46	0.35	0.29	0.29	0.22	0.20
-25%	10	0.66	0.53	0.49	0.41	0.33	0.31
-25%	20	0.92	0.80	0.73	0.66	0.55	0.48
-25%	30	0.98	0.94	0.86	0.80	0.69	0.62
-25%	40	1	0.96	0.94	0.89	0.79	0.73
-33%	5	0.66	0.54	0.46	0.42	0.35	0.30
-33%	10	0.91	0.80	0.72	0.66	0.54	0.47
-33%	20	1.00	0.97	0.92	0.88	0.79	0.71
-33%	30	1	1	0.90	0.97	0.92	0.86
-33%	40	1	1	1	0.99	0.97	0.94
-40%	5	0.85	0.71	0.63	0.56	0.46	0.43
-40%	10	0.98	0.92	0.88	0.81	0.72	0.63
-40%	20	1	1	0.99	0.97	0.91	0.89
-40%	30	1	1	1	1	0.99	0.96
-40%	40	1	1	1	1	1	0.99
-50%	5	0.97	0.92	0.86	0.80	0.65	0.60
-50%	10	1	1	0.99	0.96	0.91	0.85
-50%	20	1	1	1	1	0.99	0.98
-50%	30	1	1	1	1	1	1
-50%	40	1	1	1	1	1	1

-70%	5	1	1	1	0.99	0.98	0.94
-70%	10	1	1	1	1	1	1
-70%	20	1	1	1	1	1	1
-70%	30	1	1	1	1	1	1
-70%	40	1	1	1	1	1	1

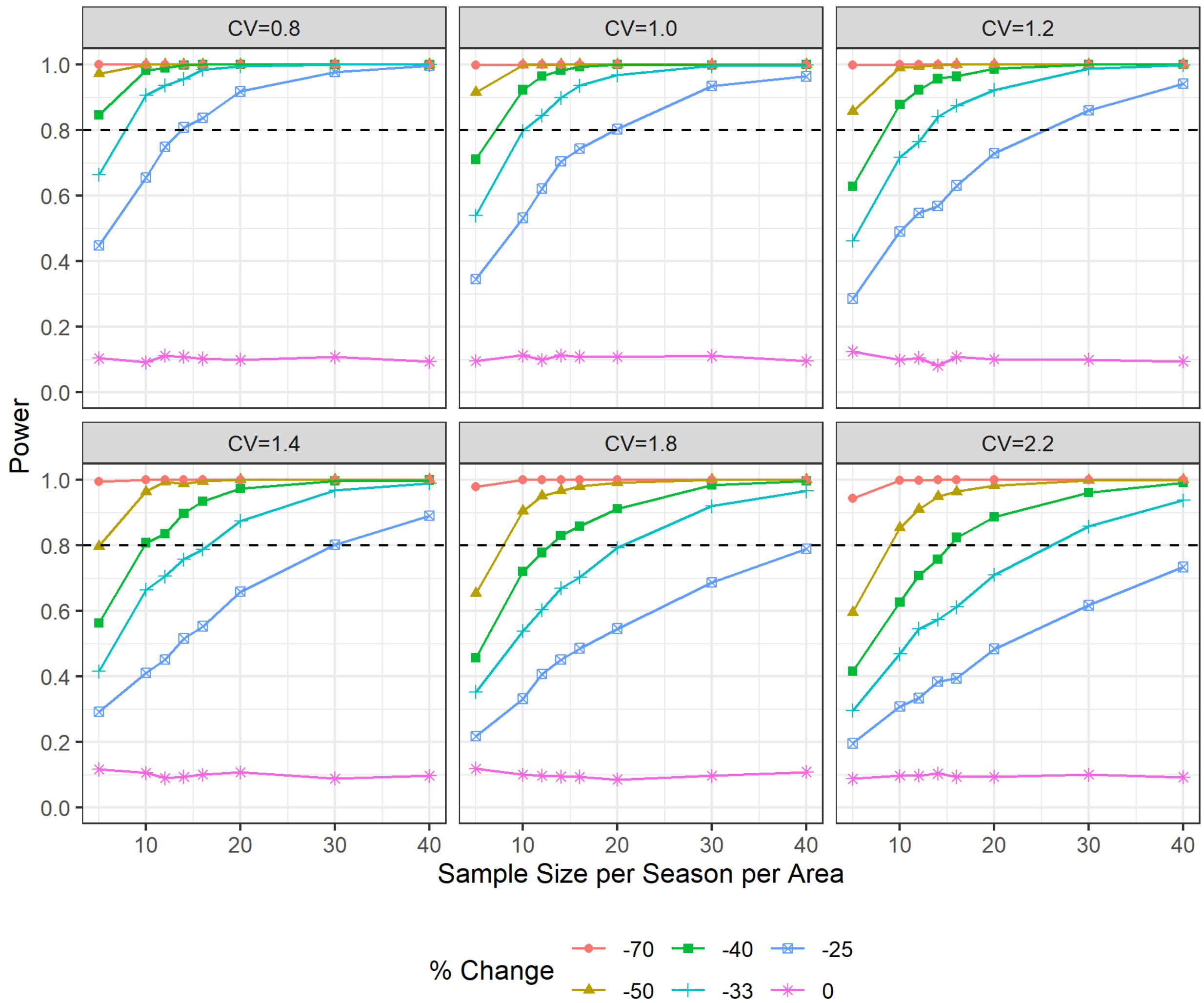


Figure 7. Power curves for the BACI interaction contrast within a saturated model (see text) for a range of variance (CV), effect sizes (negative % Change) and seasonal sample sizes in each area (n), and using a two-tailed α = 0.10. The 0% change illustrates the type I error.

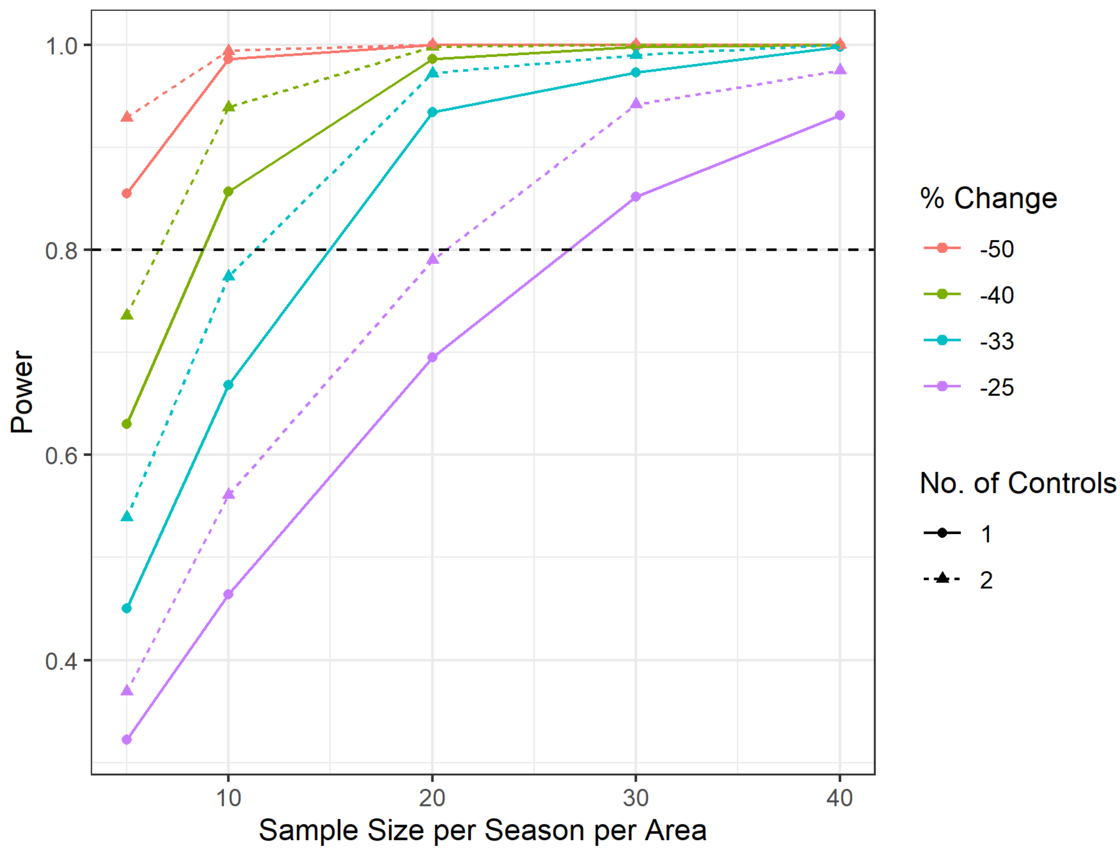


Figure 8. Power curves to illustrate the differences in power between designs with one or two reference areas for a range of effect sizes (negative % Change), and a single CV = 1.0.

5.0 Summary and Conclusions

- Data from regional trawl surveys demonstrate that fish species in the region generally exhibit moderate to high levels of natural variability (both seasonal and annual), especially when the data are analyzed on a relatively small spatial scale, which limits the number of observations.
- Given the underlying variability in catch rates that will likely be exhibited in the RWF trawl survey, it is not practicable to attempt to document a small effect size (e.g., 25% relative decrease) for fish and invertebrate species.
- For species that may be expected to demonstrate lower median CV's (e.g., 0.8-1), a seasonal sampling intensity of 10 tows/area would yield >80% power of detecting an effect size of 33% relative decrease or greater.
- For species that may be expected to demonstrate higher median CV's (e.g., 1.2 – 1.4), a seasonal sampling intensity of 10 tows/area would yield >80% power of detecting an effect size of 40% relative decrease or greater.
- For species that demonstrate higher variability in trawl survey catch rates (e.g., CVs > 1.4) a seasonal sampling intensity of 10 tows/area would only be capable of detecting larger changes in catch rates (e.g., ≥50% relative decrease).
- Including a second reference site improves the statistical power of the design for a given level of sampling intensity.
- This power analysis will be re-visited after the first year of the RWF trawl survey. The observed CV values will be evaluated to determine whether sampling intensity needs to be modified to achieve the desired level of statistical power.

- Simulation results indicate that taking conservatively higher sample sizes in the first year and adapting to a lower sampling effort in subsequent years (e.g., 15 tows the first year and 10 tows in subsequent years) results in a marginal increase in power (i.e., power increases from 80% to 81% for CV=1 and PC=-33%) compared to sampling 10 tows in every year. On the other hand, taking fewer samples in the first year and adapting to greater sampling effort in subsequent years (e.g., 10 tows the first year and 15 tows in subsequent years) results in a small decrease in power (i.e., power is reduced from 93% to 90% for CV=1 and PC=-33%) compared to sampling 15 tows every year.

6.0References

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R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Wilber, D., L. Read, M. Griffin, and D. Carey. 2020. *Block Island Wind Farm Demersal Fish Trawl Survey Synthesis Report – Years 1 to 6, October 2012 through September 2018.* Technical report prepared for Deepwater Wind, Providence, RI. 80 pp.

Addendum – R Script for the Statistical Power Simulation.

```
############################################################################
## R code to simulate power for contrast-BACI approach
## libraries
        library(tidyverse)
        library(EnvStats)       #for rlnormAlt
        library(ggplot2)
        library(emmeans)

############## SIMULATE BACI DESIGN AND TEST OF COMPLEX INTERACTION (a planned contrast)
# Population means and applying percent change:
#    pop1.a and pop1.b = baseline distribution is lognormal(mean, sd); two seasons indicated by a,b
#        - applies to both impact and reference in each of the BEFORE years
#        - applies to reference in each of the AFTER years (i.e., reference remains stable over time)
#    pop2.a and pop2.b = distribution altered by the percent change (PC)
#        - mean.pop2.x = (1-PC)*mean.pop1.x
#        - applies to impact area in each of the AFTER years
# Seasonality
#        - assume 4 seasons sampled
#        - assume 2 of the seasons have mean = 0.25*mean of other 2 seasons
# Balanced design, i.e., n samples from each season, year, and area
# MODEL fit as aov(log(response) ~ grp.pd.seas.yr) [fully saturated model; most conservative]
# LINEAR CONTRAST averages the logscale differences of means using emmeans function
#
# Notes about how this formulation of the problem is more generic than it appears:
#        - applying the same mean to each year within each period is equivalent to saying that the
#         assumed mean is the grand mean across years. Differences between years does not
#         affect results.
#        - if the reference is not stable over time, and instead changes between the BEFORE and
#           AFTER periods, then the % change applied to impact area is relative to the % change
#            at reference.
#######################
n.sims <- 1000
foo.num <- as.numeric(rep(NA,n.sims*6*5*6)) ## = n.sims x #effect sizes (PC) x #samp.size x #CVs
baciContr.pwrsim <- data.frame(expand.grid(PC=c(0, 0.25,0.33, 0.4, 0.5, 0.7),
        samp.size=c(5,10,20,30,40), cv=c(0.8, 1.0, 1.2, 1.4, 1.8, 2.2), mean=c(80),
        sim=1:n.sims), baci.p=foo.num)
baciContr.pwrsim <- arrange(baciContr.pwrsim, PC, samp.size, cv, mean, sim)
#set total number of seasons sampled before in each area
 b <- 4*2
#set total number of seasons sampled after in each area
 a <- 4*2
#set number of controls:
 n.c <- 2
## loop it:
my.mean <- 80                 #different values were tested; did not affect results.
for (m in 1:6) {              #alternative cv values
 my.cv <- c(0.8, 1.0, 1.2, 1.4, 1.8, 2.2)[m]
 for (k in 1:6) {             #alternative effect sizes or relative % change (PC)
```

```
 PC <- c(0, 0.25,0.33, 0.4, 0.5, 0.7)[k]
 for (j in 1:5) {                    #sample sizes
  samp.size <- c(5,10,20,30,40)[j]
  #create a design matrix:
  foo.data.df <- data.frame(expand.grid(location=c("CtrlA", "CtrlB","Impact"),
        period=c("Before","After"), year=1:2, season=c("spring","summer","fall","winter"),
        rep=1:samp.size), value=as.numeric(rep(NA,samp.size*(b+a)*(n.c+1))))
  foo.data.df <- arrange(foo.data.df, location, period, year, season, rep)
  foo.data.df$grp.pd.seas.yr <- factor(with(foo.data.df,
        paste(substring(location,1,5),period,season,year)))
  for (i in 1:n.sims){              #simulate data
   foo.data.df$value[foo.data.df$period=="Before" & (foo.data.df$season == "fall" |
        foo.data.df$season=="summer")] <-
        rlnormAlt((n.c+1)*(b/2)*samp.size, mean=my.mean, cv=my.cv)
   foo.data.df$value[foo.data.df$period=="Before" & (foo.data.df$season == "winter" |
        foo.data.df$season=="spring")] <-
        rlnormAlt((n.c+1)*(b/2)*samp.size, mean=0.25*my.mean, cv=my.cv)
   foo.data.df$value[foo.data.df$period=="After" & (foo.data.df$location=="CtrlA" |
        foo.data.df$location =="CtrlB") & (foo.data.df$season == "fall" |
        foo.data.df$season=="summer")] <-
        rlnormAlt(n.c*(a/2)*samp.size, mean=my.mean, cv=my.cv)
   foo.data.df$value[foo.data.df$period=="After" & (foo.data.df$location=="CtrlA" |
        foo.data.df$location=="CtrlB") & (foo.data.df$season == "winter" |
        foo.data.df$season=="spring")] <-
        rlnormAlt(n.c*(a/2)*samp.size, mean=0.25*my.mean, cv=my.cv)
   foo.data.df$value[foo.data.df$period=="After" & foo.data.df$location=="Impact" &
        (foo.data.df$season == "fall" | foo.data.df$season=="summer")] <-
        rlnormAlt((a/2)*samp.size, mean=my.mean*(1-PC), cv=my.cv)
   foo.data.df$value[foo.data.df$period=="After" & foo.data.df$location=="Impact" &
        (foo.data.df$season == "winter" | foo.data.df$season=="spring")] <-
        rlnormAlt((a/2)*samp.size, mean=0.25*my.mean*(1-PC), cv=my.cv)

###fit saturated linear model on log-scale
 foo.aov2 <- aov(log(value) ~ 0+grp.pd.seas.yr, data=foo.data.df)
 foo.t2 <- emmeans(foo.aov2, ~ grp.pd.seas.yr)
 foo.contr <- contrast(foo.t2, list(baci.contrast=c(rep(c(rep(1/n.c,a), rep(-1/n.c,b)), n.c), rep(-1,a),
        rep(1,b))))
  ###test the BACI interaction contrast and save p-value:
  baciContr.pwrsim$baci.p[baciContr.pwrsim$mean == my.mean & baciContr.pwrsim$cv == my.cv &
        baciContr.pwrsim$PC == PC & baciContr.pwrsim$samp.size == samp.size &
        baciContr.pwrsim$sim==i] <- as.data.frame(foo.contr)$p.value
}}}}

#summarize simulated power (with alpha = 0.10)
my.alpha <- 0.1
baciContr.pwrsim.All.10.summ <- baciContr.pwrsim.All %>% group_by(mean, cv, PC, samp.size) %>%
  filter(baci.p <= my.alpha) %>% count(mean, cv, PC, samp.size, name="Power")
 #turn counts into proportion
 baciContr.pwrsim.All.10.summ$Power <- baciContr.pwrsim.All.10.summ$Power/n.sims
 #separate factor variable for the facet labels (mean.cv):
```

```
baciContr.pwrsim.All.10.summ$cv.factor <- factor(baciContr.pwrsim.All.10.summ$cv,
        levels=c(0.30, 0.60, 0.75, 1.00, 1.25, 1.50, 1.75, 2.00),
        labels=c("CV=0.3", "CV=0.6", "CV=0.75", "CV=1.0", "CV=1.25", "CV=1.5", "CV=1.75", "CV=2.0"))
## PLOT:
ggplot(subset(baciContr.pwrsim.All.10.summ, mean==80), aes(x=samp.size, y=Power,
        colour=factor(PC*100), shape=factor(PC*100)), facets=~cv.factor) +
  facet_wrap(~cv.factor)+
  geom_point() + geom_line() +
  geom_hline(yintercept=0.8, colour="black",linetype="dashed")+
  theme_bw() + theme(legend.position="bottom") +
  labs(colour="% Change", shape="% Change", x="Sample Size per Season per Area") +
  ggtitle("Power for saturated model: log(biomass) ~ Location.Pd.Season.Year [alpha=0.1]\nDesign: 4
        seasons x 2 yrs before and after; 2 controls and 1 impact")
ggsave("power curves.png", width=7, height=6, units="in")
#####################################################
```

APPENDIX 3: Power Analysis for Lobster and Crab Ventless Trap Survey – Revolution Wind Farm

Prepared by: Lorraine Brown Read
Exa Data and Mapping

Introduction

For the ventless trap survey, a BACI design is planned to sample lobsters, Jonah crabs and rock crabs within the Revolution Windfarm (RWF) Project Area and two selected reference areas. For this ventless trap survey, the trap size/configuration and trawl layout will be identical to that used by the University of Rhode Island and the Commercial Fisheries Research Foundation in the Southern New England Cooperative Ventless Trap Survey (SNECVTS). The SNECVTS datasets from 2014 and 2015 (Collie and King 2016) and 2018 (personal communication from Michael Long to Greg DeCelles) were queried to assess the residual variance estimates of lobster, Jonah crab and rock crab catch for use in this power analysis. The relationships between effect size (or magnitude of change) and statistical power for the specific BACI contrast of interest was estimated under several alternative hypotheses about changes in abundance in the Project Area relative to the reference areas, a single two-tailed alpha of 0.10, and three different design alternatives were considered (i.e., two, three, or four years post-construction).

1.0 Data and Assumptions

The survey design employed in the Project Area (also referred to as Impact area) will utilize 10-trap trawls configured identical to the trawls used in the SNECVT survey (Collie and King 2016), and the trawls planned for monitoring at South Fork Wind (SFW). The SNECVT survey in 2014 and 2015 sampled three times per month over 6 months (May – October) each year; in 2018 they sampled two times per month over 7 months (May – November). The RWF ventless trap survey will sample similar to the 2018 design of twice per month over 7 months (May – November). In these power calculations, it was assumed that the RWF survey design will be balanced with an equal number of trawls in each of the project and reference areas in each year. If the design is altered to have a different number of trawls at the reference areas than in the Project Area, the effect on power is minor as long as the imbalance is mild to moderate. The design will randomly set trawl locations during the first sampling event of each year and hold those locations fixed throughout the year, with locations re-randomized the following year. The response variable in this design is annual average catch, expressed in this appendix as catch per trap (CPUE).

Details about the SNECVTS design:

- Each SNECVTS trawl was comprised of 10 traps, with six ventless (V) and four vented (or standard, S) using the following pattern: V-S-V-S-V-V-S-V-S-V. The trawl layout for the RWF survey will be identical.
- Aliquot represents the random station location within each lease block where a 10-trap trawl was set. The same locations were fished throughout the year, and new locations were randomly selected the next year. A similar approach will be used in the RWF survey.

Data summaries were derived from the SNECVTS database as follows:

- The Lobsters table was queried, and the total lobster catch per 10-trap trawl was tallied. The Lobsters table only recorded non-zero catch, so zero catch trawls were added to the analysis table for trawls that were present in the Trawls table and absent in the Lobsters table.

- The final catch is summarized as average catch (number of lobsters) per trap (averaged over both trap types). The RWF survey will use the same trawl configuration as the SNECVT survey. Results may easily be converted to average catch per 10-trap trawl by multiplying catch results by 10.

- Similar queries were done on the bycatch tables for each year to obtain estimates for the Jonah and rock crab catch.

In the SNECVTS study, there were 24 aliquots sampled per year across the SNECVTS study area; the RWF footprint spans the entire SNECVTS study area excluding the five aliquots that constitute the SFW project area; the RWF Ventless Trap Survey Impact Area spans only the eastern portion of the SNECVTS study area (those collected by the F/V Happy Hours) as summarized below:

RWF (n=19 per year):	All aliquots EXCEPT: 2014: 14, 15, 20, 21, and 22 2015: 38, 39, 44, 45, and 46 2018: 62, 63, 68, 69, and 70
RWF Ventless Trap Survey Impact Area: (n=8 per year)	Only these aliquots: 2014: 10,11,16,17, 18,19, 23, 24 2015: 34,35,40,41, 42,43, 47,48 2018: 58,59, 64,65,66,67, 71,72

In the SNECVTS study, each aliquot was fished three times per month over 6 months (May-October) during 2014 and 2015, and twice per month over 7 months (May-November) during 2018. For this analysis, annualized average catch per trap was calculated for each aliquot. The database did not have information on missing/compromised traps, so all trawls were assumed to have 10 traps and catch per trawl was divided by 10 to estimate the annual average catch per trap (CPUE). Mean and variability across aliquots were summarized by year for the entire SNECVT survey area, and for the subset of aliquots present within the RWF in its entirety, and the RWF Ventless Trap Survey Impact Area footprint (Table 1). The CPUE data followed a lognormal distribution both for the SNECVTS dataset and the BIWF ventless trap dataset (2013-2018; Wilber et al., 2020), so this power analysis assumes a lognormal distribution for the data, and uses the coefficient of variation (CV on the original scale) as the estimate of variability.

Table 1. Summary of mean, standard deviation, and coefficient of variation (CV) for average catch of lobster and crab per trap (averaged over both trap types) in the SNECVTS dataset.

		Lobster			Jonah Crab			Rock Crab		
Group	**Summary Statistic**	**2014**	**2015**	**2018**	**2014**	**2015**	**2018**	**2014**	**2015**	**2018**
All (n=24)	Mean	2.49	2.10	1.98	7.29	4.91	12.8	3.57	4.34	3.05
	Std Dev	1.60	0.83	0.95	3.27	1.84	5.39	3.59	4.11	2.46
	CV	64%	40%	48%	45%	37%	42%	100%	95%	80%
RWF (n=19)	Mean	2.76	2.19	2.20	6.70	4.93	13.5	3.96	4.56	3.52
	Std Dev	1.68	0.88	0.92	2.31	2.07	5.85	3.94	4.59	2.56
	CV	61%	40%	42%	35%	42%	43%	100%	101%	73%
RWF Project Area (n=8)	Mean	3.42	2.49	2.74	5.65	4.10	10.10	4.40	6.63	3.89
	Std Dev	2.31	1.2	1.17	1.78	2.37	4.57	5.85	6.62	2.22
	CV	68%	48%	43%	32%	58%	45%	133%	100%	57%

The RWF ventless trap survey is designed to sample twice per month for 7 months. Bootstrapping from the SNECVTS dataset was used to estimate the CV for a bimonthly survey design, as well as to demonstrate how the CV is affected by increasing sample size (number of trawls). The temporal patterns of catch in both the SNECVT and BIWF surveys indicated that peak abundance had not always passed as of October, so sampling through November should result in variance estimates that are less than the values estimated here because a longer sampling period will ensure that estimates of the annual average is complete for all trawls. The bootstrap estimates from the SNECVTS database used the following approach:

- Sample two dates per month (without replacement) to reflect the design planned for RWF and estimate an annual mean per trawl. Note: for 2014-2015 the means represent catch between May and October; for 2018, the means represent catch between May and November.
- Sample k=5 trawls (with replacement) for each year from the entire SNECVTS study area (n=24) and from the RWF area (n=19) or RWF Ventless Trap Survey Impact Area (n=8). Repeat for k=5, 6, 7, 8 trawls.
- Calculate the CV from the bootstrapped dataset for the entire SNECVTS study area, the RWF, and the RWF Ventless Trap Survey Impact Area.
- Repeat process 5000 times. The 50TH (median), 75th and 90th percentiles (Table 2) represent moderate to conservative (high) CV values for subsequent power analysis.

Table 2. Table of CVs from bootstrap resampling (R=5000) of results on entire SNECVTS study area, entire RWF, and RWF Project Area, sampling 2 dates per month and drawing 5, 6, 7, or 8 trawls per year.

	SNECVTS study area (n=24)			RWF (n=19)			RWF Ventless Trap Survey Impact Area (n=8)		
	Percentile			Percentile			Percentile		
Trawl Count	**50th**	**75th**	**90th**	**50th**	**75th**	**90th**	**50th**	**75th**	**90th**
Lobsters									
5 Trawls	0.43	0.50	0.57	0.41	0.48	0.54	0.47	0.54	0.60
6 Trawls	0.44	0.51	0.57	0.42	0.48	0.54	0.48	0.54	0.60
7 Trawls	0.45	0.51	0.57	0.42	0.48	0.53	0.48	0.54	0.59
8 Trawls	0.46	0.51	0.57	0.43	0.48	0.53	0.49	0.54	0.58
Jonah crabs									
5 Trawls	0.39	0.44	0.49	0.39	0.45	0.49	0.40	0.46	0.50
6 Trawls	0.39	0.44	0.49	0.40	0.44	0.48	0.41	0.46	0.50
7 Trawls	0.40	0.44	0.49	0.40	0.44	0.48	0.41	0.46	0.49

	SNECVTS study area (n=24)			**RWF (n=19)**			**RWF Ventless Trap Survey Impact Area (n=8)**		
	Percentile			**Percentile**			**Percentile**		
Trawl Count	**50th**	**75th**	**90th**	**50th**	**75th**	**90th**	**50th**	**75th**	**90th**
8 Trawls	0.40	0.44	0.48	0.40	0.44	0.47	0.42	0.45	0.49
Rock crabs									
5 Trawls	0.61	0.75	0.88	0.62	0.76	0.89	0.69	0.82	0.95
6 Trawls	0.63	0.78	0.90	0.64	0.78	0.91	0.72	0.86	0.98
7 Trawls	0.65	0.80	0.92	0.67	0.81	0.93	0.74	0.89	0.99
8 Trawls	0.68	0.82	0.94	0.69	0.82	0.94	0.77	0.91	1.00

For all species, the median values for the RWF Project Area changed very little when the number of trawls increased from 5 to 8. The 90th percentile CV values for the lobster and Jonah crabs had increases of 0.13 or less from the median values, indicating stability in the bootstrap estimates due to consistency in the underlying dataset. The rock crab results showed more variability between the median and 90th percentile CV values, with increases in CV values as the sample size increased, likely due to the influence of a single high catch in the 2014 and 2015 (Figure 1). Across all three species, the range of median to 90th percentile values of CVs in the RWF Project Area is [0.40, 1.00], with Jonah crabs having smaller observed CV and rock crabs greater CV, relative to lobsters.

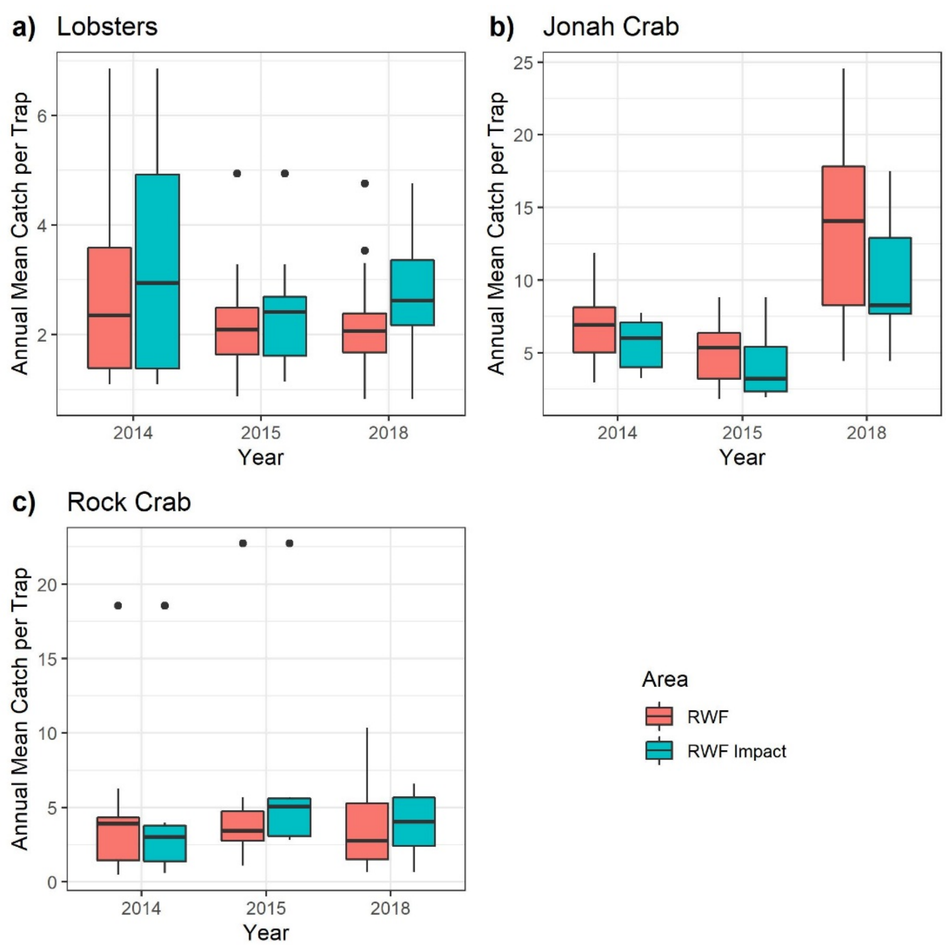

Figure 1. Distribution of the annual mean catch per trap (CPUE) for the SNECVTS data within the entire RWF (n=19 aliquots) and the RWF Ventless Trap Survey Impact Area (n=8 aliquots).

2.0 Methods

A power analysis is specific not only to study design and statistical model, but also the hypothesis of interest. The interaction null and two-tailed alternative hypotheses of primary interest associated with the ventless trap survey are as follows:

$H_Ø$: Changes in CPUE between time periods (before and after) will be statistically indistinguishable between the reference and impact areas.

H_1: Changes in CPUE between time periods (before and after) will be statistically different between the reference and impact areas.

The null hypothesis equates to an interaction contrast describing the (log-scale) difference between the temporal change at the windfarm and the temporal change at the reference sites. Using linear differences on the log-scale (the scale in which the model is fit) equates to proportional change (ratios) on the original measurement scale. Representing changes in CPUE as proportional rather than linear on the measurement scale is a more meaningful way to understand changes across different groups that might have widely different Baseline values. For example, a decrease of 10 fish in the average catch is a much more substantive impact for a species with a Baseline average of 20 fish than it is for a species with a Baseline average of 100 (i.e., a 50% decrease versus a 10% decrease).

The study design has 2 years nested within each time period (before/after), and 2 reference sites and an impact site within treatment. For the purposes of this power analysis, a saturated model was fit to each simulated dataset which provides an estimate of mean CPUE for each year and location. For the primary contrast comparing the temporal changes between the windfarm and reference sites, the difference on the log-scale is expressed as

$$\Delta_1 = \delta_{Reference} - \delta_{RWF} \qquad \text{[Eq. 1]}$$

where:

$\delta_{Reference} = \bar{X}_{Reference,A} - \bar{X}_{Refernce,B}$ is the temporal difference in log-scale average catch at the reference sites (two-year average from the "After" (operation) period minus two-year average from the "Before" (baseline) period, with the two reference sites averaged within each period).

$\delta_{RWF} = \bar{X}_{RWF,A} - \bar{X}_{RWF,B}$ is the temporal difference in log-scale means at the RWF Ventless Trap Survey Impact Area (two-year average from the "After" period minus two-year average from the "Before" period).

The magnitude of change is expressed as a proportional change between periods of the mean CPUE at the RWF Ventless Trap Survey Impact Area relative to the proportional change of mean CPUE at the Reference site(s). This relative percent change is expressed as:

$$\frac{(\bar{X}_{Impact,After}/\bar{X}_{Impact,Before})}{(\bar{X}_{Reference,After}/\bar{X}_{Reference,Before})} \qquad \text{[Eq. 2]}$$

For example, a relative percent change of 0.67 could represent a 33% decrease in catch at the impact site (a temporal ratio of 0.67) and no change at the reference site(s) (a temporal ratio of 1) (i.e., 0.67/1 = 0.67). The same value could represent any number of ratios. This relative percent change of 0.67 could also represent a 50% decrease at the impact site and a 25%

decrease at the reference site(s) (i.e., 0.5/0.75 = 0.67; or a 20% decrease at the impact site and a 20% increase at the reference site(s) (i.e., 0.8/1.2 = 0.67); or other similar combinations that yield a 67% ratio of relative change[9].

The design variables evaluated in this power analysis are specified in Table 3.

Table 3. Design for Revolution Wind ventless trap survey power simulation study

Set study design variables
• Impact Areas = 1 impact area
• Reference Areas = 2 control/reference areas
• Habitat or Distance Strata = 1
• Frequency = 2x per month for 7 months (May – November) per year
• Number of years Before impact = 2
• A two-tailed $\alpha = 0.10$
Variables altered in the power analysis
• Number of years After impact = 2, 3, 4
• Number of replicate (random) trawls per year in each area (n): 6, 8, 10, 12, 14, 16, 20
• Relative Percent Change (PC): -33%, -50%, -75% and 0% (for Type I error)
• Variability as CV: 0.4, 0.5, 0.6, 1.0 (see Table 2)

The power analysis used a simulation approach to generate significance values for a range of CV estimates and effect sizes, and a range of sample sizes.

For a given CV, PC, and sample size (n), the following steps were performed m=1000 times:

1. From a log-normal distribution with mean μ and CV, simulate *n* values of catch data in the RWF Ventless Trap Survey Impact Area, both Reference areas, and in each year of the Before period.
2. Repeat step 1 (same μ and CV) for each year of the After period for the two Reference areas.
3. Repeat step 1 for each year of the After period for the RWF Ventless Trap Survey Impact Area, but with mean catch in the windfarm equal to $(1+PC)\mu$.
4. Fit the saturated model to the log-transformed catch data (i.e., a separate coefficient for every area-period-year).
5. Calculate the BACI interaction contrast, and save the p-value.
6. Repeat m=1000 times for 1000 simulation replicates.

[9] Changes are expressed as relative decreases because a decline in windfarm catch relative to reference is presumed to be the main direction of concern. Because of the asymmetry of ratios, a 33% relative decrease at the windfarm (relative percent change of 0.67) is a bigger change than a 33% relative increase (relative percent change of 1.33). For example, a 33% relative decrease in the numerator (0.67/1) is equivalent to a 50% relative increase in the denominator (1/1.5). When evaluating results, consider that power for any percentage decrease is higher than power for the same percentage increase.

7. Count the number of times out of m that the p-value was < 0.10, and store this simulated power estimate for that combination of CV, PC, and n.

Repeat Steps 1-7 for each combination of CV, PC, and n.

3.0 Results

The simulation power results for a design with one impact and two reference areas and other design details as indicated in Table 3 are shown in Table 4 and Figure 3.

Table 4. Simulated power for the BACI interaction contrast within a saturated model (see text) for a range of variance (CV), relative percent decrease at the windfarm, and sample sizes (n) per area. All simulations summarized here use two years post-operation, and a two-tailed α = 0.10 and a design with one impact and two reference areas. The 0% change illustrates the type I error. Results with power 80% and above are shaded.

% Change	Sample Size (n)	CV=0.4	CV=0.5	CV=0.6	CV=1.0
0	6	0.10	0.09	0.09	0.09
0	8	0.09	0.12	0.11	0.10
0	10	0.11	0.10	0.11	0.10
0	12	0.10	0.10	0.10	0.08
0	14	0.09	0.11	0.09	0.10
0	16	0.11	0.10	0.10	0.09
0	20	0.10	0.10	0.12	0.10
-33%	6	0.66	0.52	0.44	0.24
-33%	8	0.77	0.66	0.50	0.29
-33%	10	0.86	0.72	0.56	0.35
-33%	12	0.90	0.77	0.65	0.39
-33%	14	0.93	0.83	0.71	0.43
-33%	16	0.96	0.86	0.75	0.46
-33%	20	0.98	0.92	0.82	0.54
-50%	6	0.97	0.90	0.78	0.47
-50%	8	0.99	0.96	0.91	0.61
-50%	10	1.00	0.98	0.94	0.68
-50%	12	1.00	0.99	0.97	0.75
-50%	14	1.00	1.00	0.99	0.79
-50%	16	1.00	1.00	0.99	0.84
-50%	20	1.00	1.00	1.00	0.91
-75%	6	1.00	1.00	1.00	0.96
-75%	8	1.00	1.00	1.00	0.98
-75%	10	1.00	1.00	1.00	1.00
-75%	12	1.00	1.00	1.00	1.00
-75%	14	1.00	1.00	1.00	1.00
-75%	16	1.00	1.00	1.00	1.00
-75%	20	1.00	1.00	1.00	1.00

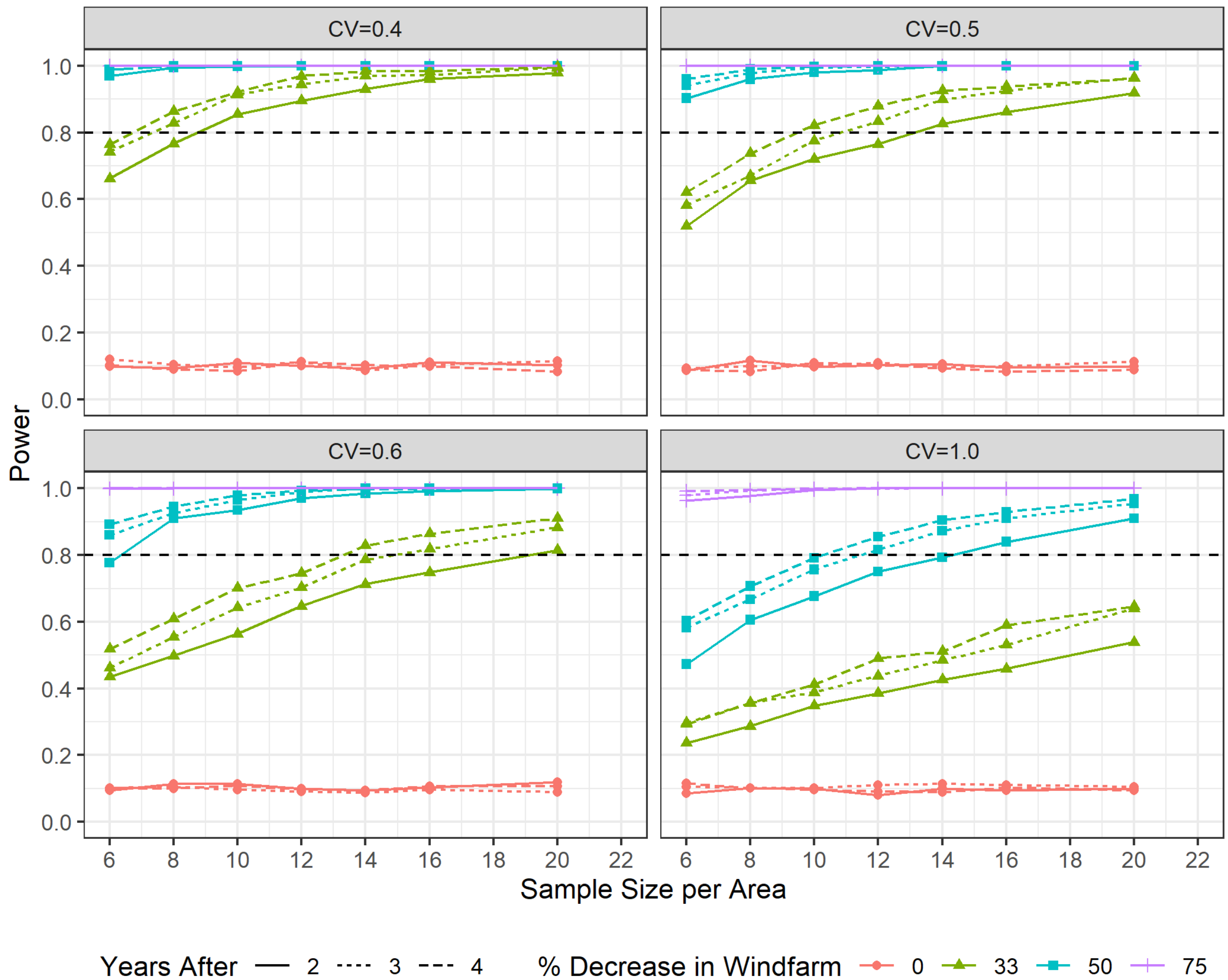

Figure 3. Power versus sample size (number of trawls) per area and year for a range of relative percent decreases and CVs (see Table 3), using a study design with single impact and two reference areas for 2 years before and 2, 3, and 4 years after operation, and a two-tailed α= 0.10.

Table 5. Power estimates contrasted between a balanced (15 trawls everywhere) and unbalanced survey design (15 trawls at the windfarm and 10 trawls at the two reference areas). Power results shown for a range of variance (CV), relative percent decrease at the windfarm (% Change). Simulations used two years before and two years post-operation, and a two-tailed α = 0.10.

% Change	Sample Size in the Two Reference Areas	Sample Size in the Wind Farm	CV=0.4	CV=0.5	CV=0.6	CV=1.0
-33%	10	15	0.92	0.80	0.68	0.39
-33%	15	15	0.95	0.85	0.74	0.44
-40%	10	15	0.99	0.94	0.77	0.54
-40%	15	15	0.99	0.96	0.76	0.63
-50%	10	15	1.00	1.00	0.84	0.76
-50%	15	15	1.00	1.00	0.90	0.86
-75%	10	15	1.00	1.00	0.98	1.00
-75%	15	15	1.00	1.00	0.99	1.00

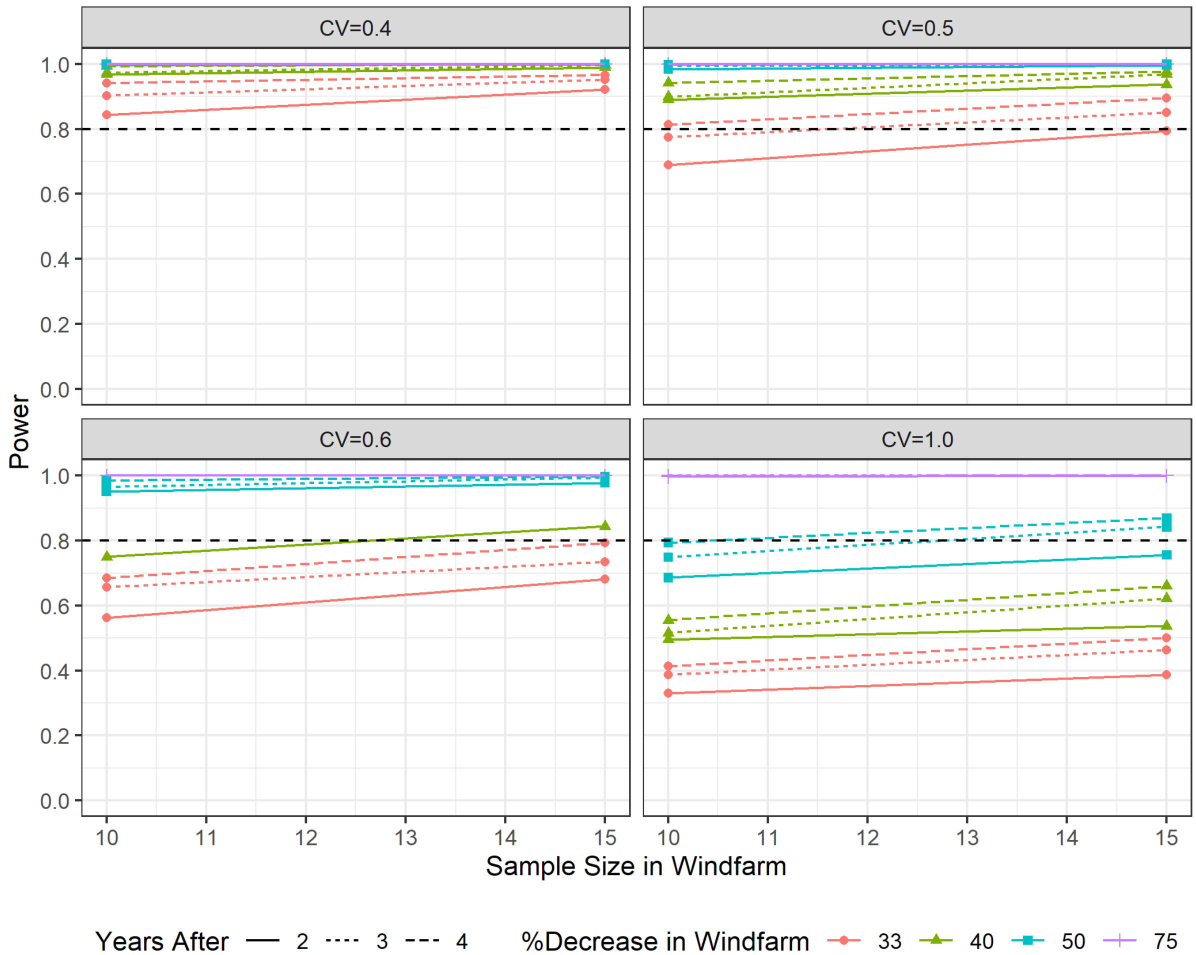

Figure 4. Power for an unbalanced design using 10 trawls in each reference area each year; and 10 or 15 trawls in the windfarm each year for a range of relative percent decreases and CVs (see Table 3), using a study design with single impact and two reference areas for 2 years before and 2, 3, and 4 years after operation, and a two-tailed α= 0.10.

4.0 Summary and Conclusions

Based on the variances observed during the SNECVT Survey, catch rates of lobsters and Jonah crabs are expected to have lower variability when compared to rock crabs (Table 2). The CV values for lobsters and Jonah crabs may be expected to have CVs between 0.4 and 0.6, while the CV values for rock crabs may be as high as 1.0. Therefore, for a given level of sampling effort, the RWF ventless trap monitoring study is anticipated to have greater power to detect changes in the relative abundance of lobsters and Jonah crabs between the reference and impact sites, and lower power for rock crabs. In other words, the study design will have the ability to detect smaller changes in relative abundance for lobsters and Jonah crabs between the reference and impact sites.

- Data from the SNECVT Survey demonstrate that Jonah crabs have lower levels of variability (0.4 to 0.5); lobsters have slightly higher levels of variability (0.5 to 0.6), and rock crabs have the greatest variability (0.7 to 1.0) (Table 2).

- For a design with two years post-operation, 14-16 trawls per area are expected to detect small effect sizes (<33% decrease) with at least 80% power when CVs are 0.5 or less; whereas slightly larger effect sizes can be detected for populations with CVs of 0.6, while the same level of sampling effort is expected to detect >50% decrease for the most variable populations (CV = 1.0; Table 4 and Figure 3).
- Each additional year post-operation is expected to increase power by approximately 5% (Figure 3) relative to a survey design with two years post-operation.
- With two years post-operation, an unbalanced design with 10 trawls per year in each of the two reference areas and 15 trawls per year in the project area is expected to decrease power by less than 5% for CVs ≤ 0.5 relative to a balanced design with 15 trawls in all three areas per year. The decrease in power for an unbalanced design relative to a balanced design is greater for larger CVs, and smaller percent change values (Table 4).

5.0 References

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APPENDIX 4: Power Analysis for Before-After-Gradient Ventless Trap Survey in Rhode Island State Waters

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Purpose

To test for an acceptable sample size at which differences can be detected between sampling groups given variances from existing RIVTS data. Multiple methods were tested and are described below. All methods focus on achieving a power level of 0.9, at a 0.1 effect size and a 0.05 significance level.

Approach 1 – Differences in Means (ventless data only)

Methods

Data Subsetting

Using R software, existing RIVTS data from 2006 to 2020 were subsetted to include only ventless lobster pots (all vented pots were omitted from further analysis). To refine the dataset to only samples collected in close proximity to the proposed cable route, a proximity analysis was conducted in ArcGIS. Sample sites within 300 m of the cable corridor over the entire time series were selected for further analysis in order to refine data and analyses of which most reflect the region proposed for sampling.

Data Simulation

All further analyses were conducted at the individual trap level in R, using lobster catch per unit effort, or CPUE (number of lobsters per pot), as the target metric.

Analysis

Differences in means between the actual catch and the two simulated catches were calculated and pooled standard deviations (square root of the average of the two group standard deviations) were created. The pwr package in R was used to calculate sample sizes for two-group independent sample t-tests.

Results

A sample size of 314 traps within groups should be sufficient to detect a 10% change in lobster CPUE with a 0.9 power level and a significance level of 0.05 (Table 1, Figures 1-2). Trap groupings could be within time periods or within distance bins; this is discussed in more detail in the conclusion. Therefore, at least 314 traps are necessary within each group, which could be configured in a variety of ways.

Table 1. Power analysis results using a t-test to evaluate difference in means of actual catch and simulated data

Power	N (within groups)	Alpha	Effect Size	Difference in Means
				1.4423
0.8	59.3	0.05	0.2	
0.9	79.1	0.05	0.2	1.4423
0.8	234.4	0.05	0.1	0.7212
0.9	313.4	0.05	0.1	0.7212

Approach 2 – Generalized Linear Model (ventless data only)

Methods

Data Subsetting and Simulation

The methods used in approach 1 were used here as well.

Analysis

The pwr package in R was used to calculate sample sizes for GLMs.

Results

Using a GLM power analysis approach, the minimum sample size within "groups" is 159 in order to achieve a power of 0.9 at an effect size of 0.1.

Table 2. Sample size needed within groups as dictated by power analysis of different GLM requirements

Power	Degrees of Freedom	Effect Size	Significance Level	N
0.8	4	0.2	0.05	65
0.9	4	0.2	0.05	82
0.8	4	0.1	0.05	125
0.9	4	0.1	0.05	159

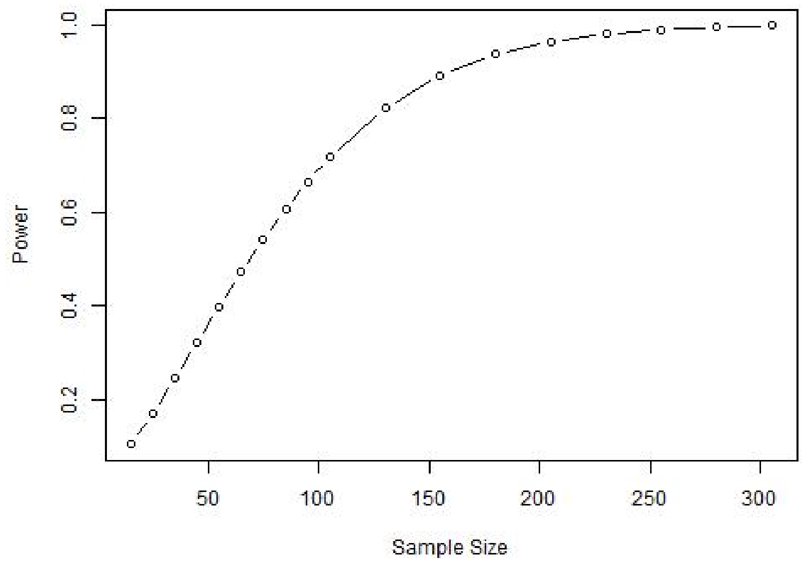

Figure 1. Power as a function of sample size with an effect size of 0.1 and a significance level of 0.05 (GLM approach)

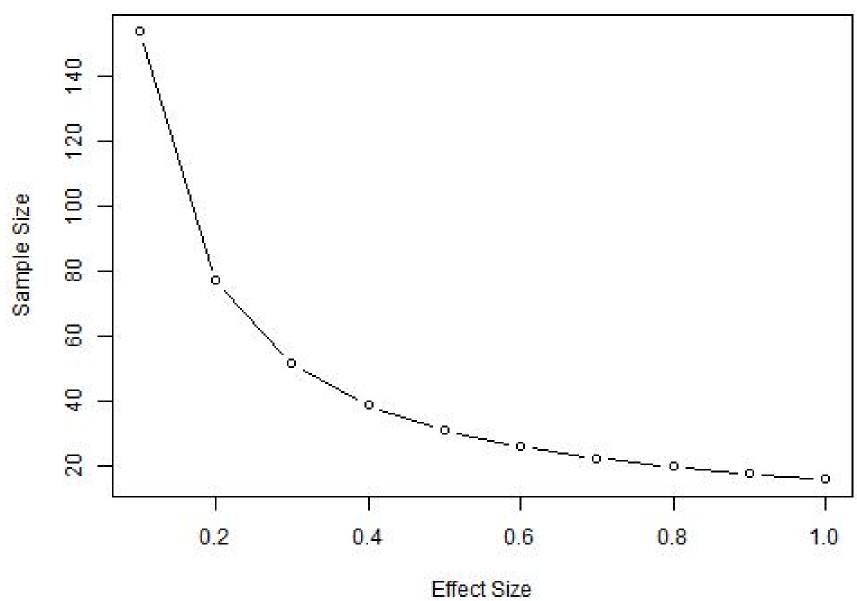

Figure 2. Sample size as a function of effect size with a power of 0.9 and a significance level of 0.05 (GLM approach)

Approach 3 – Simulated Generalized Linear Mixed Models (ventless and vented data analyzed independently)

Methods

Data Subsetting

Data were subset in the same manner as for Approach 1. However, the subsetting method was repeated for vented pots separately.

Data Simulation

Sampling with replacement (sample function in R) was used to randomly expand the spatially-subsetted RIVTS ventless pot data to exceed the maximum possible sample size for ventless posts (maximum of: 4 traps/trawl * 2 trawls/month/site * 3 distance bins * 4 stations * 12 months/year * 7 years = 8,064 traps). For further analysis, it was assumed that 4 stations would be used, each with 3 distance bins. Ten sample sizes were tested: 501, 1002, 2001, 3000, 4002, 5001, 6000, 7002, 8001, and 9000. Sample sizes needed to be divisible by three to ensure equal sampling across distance bins (i.e., a sample size of 501 equates to 167 traps per distance bin). For each sample size, 1000 model simulations were conducted; the sample size of 9000 was the exception, for which only 354 model iterations were done due to slow processing time.
For each individual simulation, a randomly stratified sample of the target sample size was pulled from the full resampled dataset; the sample was stratified by depth bins, used as a proxy for station. The data were then stratified further into three groups, one for each distance bin (a column was added to represent respective distance bin from the impact area or cable route). Finally, the catch column (lobsters/trap or CPUE) was modified for two of the distance bins. For distance bin 1 (assumed closest to the cable), catch was multiplied by 0.9 to represent a 10% reduction in catch, testing for an effect size of 0.1. Next, distance bin 2 catch was multiplied by 0.95 to represent a 5% reduction in catch. Distance bin 3 catch was unmodified.

This process was repeated using the vented data, and with different sample sizes based on the 2-vented pots per trawl design. Nine sample sizes were tested: 252, 501, 1002, 1500, 2001, 2502, 3000, 3501, and 4002.

Analysis

For each of the 1000 simulated datasets per sample size, the simulated data were analyzed using a negative binomial zero-inflated generalized linear mixed model (GLMM). Simulated catch per trap was the dependent variable (rounded down to the nearest integer) and distance bin was the independent, fixed effect variable. Sampling station, year, and month were included as random variables to account for random variability associated with seasonality, location, and year. The glmmTMB package was used to run the following model, where CatchNum refers to the simulated catch:

$$\textit{model <- glmmTMB (CatchNum} \sim \textit{Dist\_bin + (1|Station) + (1|Year) + (1|Month), data = sim\_dat, ziformula =} \sim\textit{1, family = nbinom2)}$$

GLMMs do not provide meaningful p-values for model covariates. As such, a likelihood ratio test was used to get a p-value associated with the distance bin covariate by testing model significance against a model without the target covariate. The p-value was exported to a table containing sample size, simulation number out of 1000, and p-values for all models conducted.

Following completion of model iterations, the proportion of significant p-values (or cases in which the null hypothesis was rejected with 95% probability; p-value <=0.05), relative to the total number of iterations per sample size was calculated. This proportion was interpreted as the statistical power as described by Johnson et al. (2015) (Figure 3).

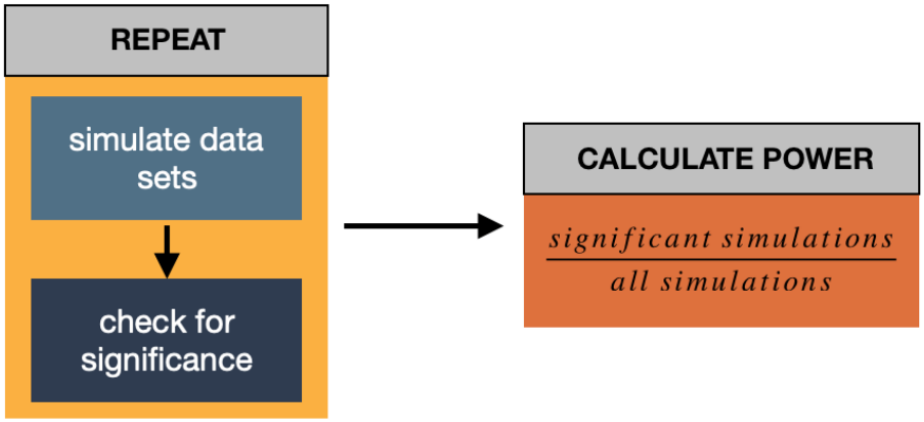

Figure 3. Shared principle of all simulation-based power analyses solutions, as described in Kumle et al. (in prep).

Results

Table 3. GLMM power analysis output for ventless pots. The proposed sample size is currently 8,064. Model runs on sample size of 9000 were halted prematurely due to extensive processing time.

Sample Size	# Significant Models	# Simulations	Power
501	336	1000	0.336
1002	660	1000	0.66
2001	925	1000	0.925
3000	988	1000	0.988
4002	1000	1000	1
5001	1000	1000	1
6000	1000	1000	1
7002	1000	1000	1
8001	1000	1000	1
9000	354	354	1

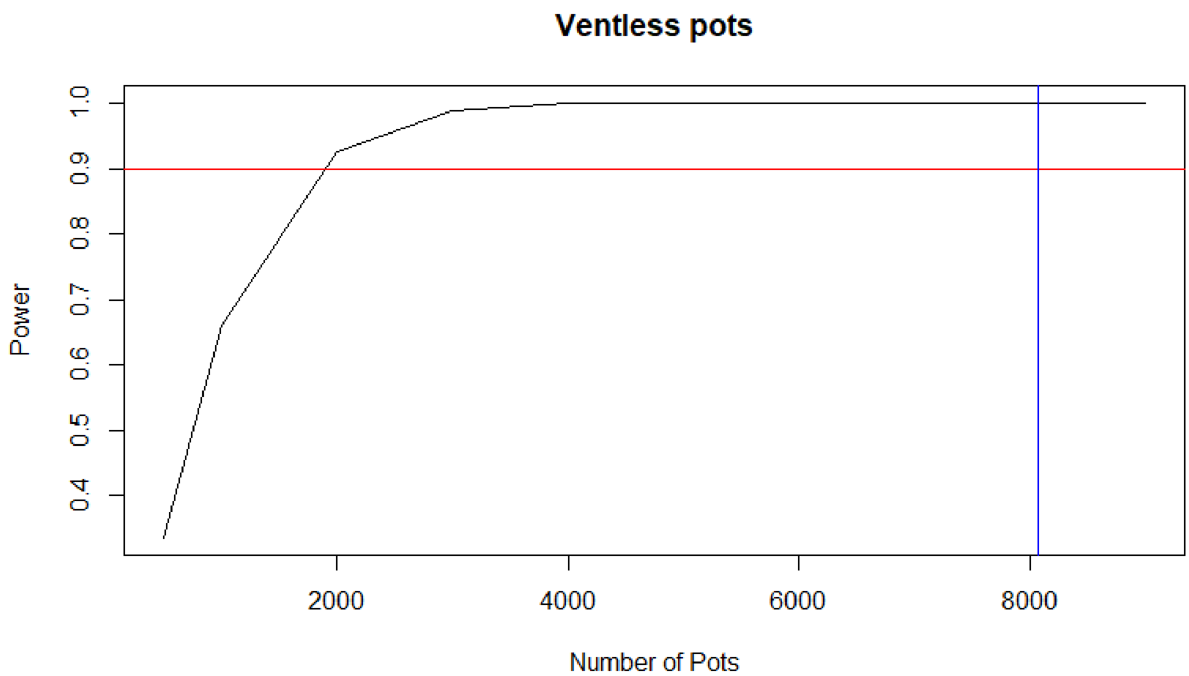

Figure 4. Power as a function of sample size for ventless pots. The red line represents the target power of 0.9. The blue line represents the proposed sample size.

Table 4. GLMM power analysis output for vented pots. The proposed sample size is currently 4,032.

Sample Size	# Significant Models	# Simulations	Power
252	187	999	0.187187187
501	337	1000	0.337
1002	668	1000	0.668
1500	828	1000	0.828
2001	940	1000	0.94
2502	975	1000	0.975
3000	994	1000	0.994
3501	997	1000	0.997
4002	999	1000	0.999

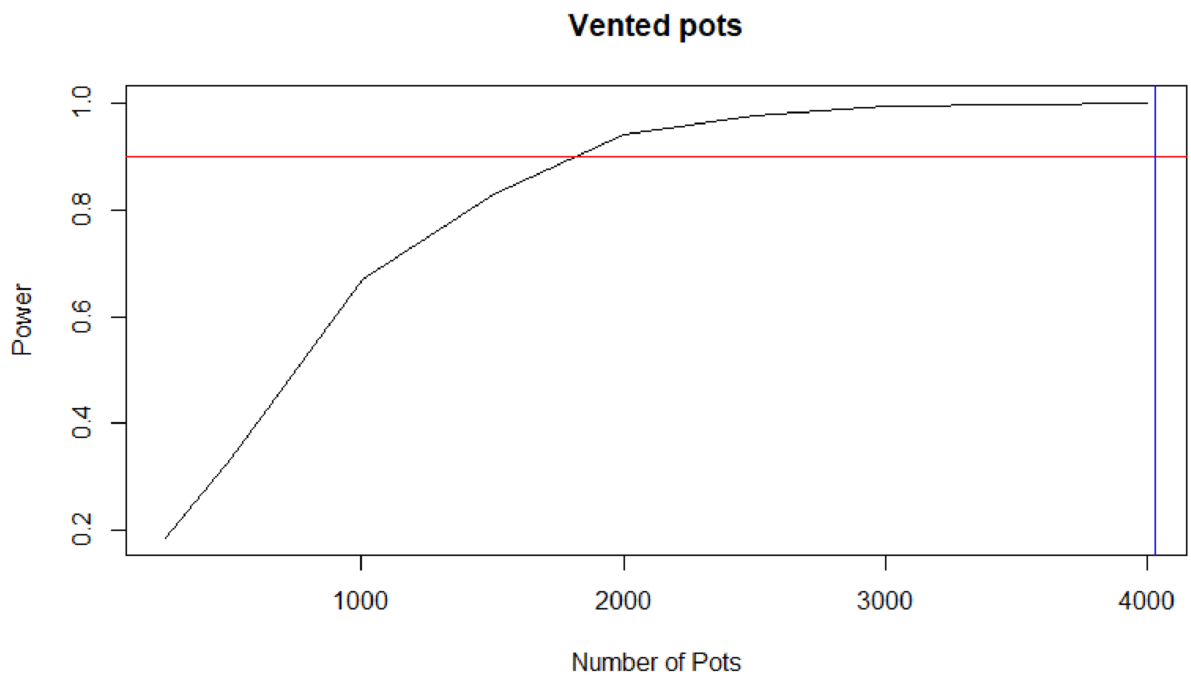

Figure 5. Power as a function of sample size for vented pots. The red line represents the target power of 0.9. The blue line represents the proposed sample size.

Conclusion

At this time, it is unknown whether EMF impacts to target species (i.e., lobster) are the same across depths, locations, and seasons. The data simulation process utilized here assumes that these impacts are equal, independent of time of year or location. Additionally, the data used to conduct the simulations are exclusively summer data (there are no fall or spring samples included). Therefore, the variance of the lobster catch data to be collected year-round may differ from that of the data used for power analyses.
For ventless pots, the first two methods utilized suggest a minimum of 314 and 159 pots within groups, respectively (either time period or distance bin). If target groups are “before” and “after” cable installation, and assuming twelve months of sampling per year and two samples per month per sampling location, then three distance bins will produce a large enough sample size to achieve target detection levels for both vented and ventless pots (Tables 4 and 5). If distance bins (distance from cables/disturbance area) are the target groups, four sampling locations will also be sufficient, as all individual groups exceed 314 (Tables 6-7).

The GLMM simulation approach assumed using 3 distance bins and 4 stations. A sample size of 2001 overall achieved a greater than 0.9 statistical power level for vented (0.94) and ventless pots (0.92), which were simulated independently. Therefore, the current design of 8,064 ventless and 4,032 vented pots (12,096 total pots) will achieve target power levels: a 10% change in catch will be detectible at greater than a 90% power level, with 95% confidence.

Table 4. Ventless traps per sampling period, assuming 4 stations and 4 traps per trawl

	Number of traps per sampling period		
Number of distance bins	**Before (2 yr) + During (1 yr) = 3 yr**	**After (4 yr)**	**Total (7 yr)**

3	3,456	4,608	8,064
4	4,608	6,144	10,752

Table 5. Vented traps per sampling period, assuming 4 stations and 2 traps per trawl

	Number of traps per sampling period		
Number of distance bins	**Before (2 yr) + During (1 yr) = 3 yr**	**After (4 yr)**	**Total (7 yr)**
3	1,728	2,304	4,032
4	2,304	3,072	5,376

Table 6. Ventless traps per station, assuming 3 distance bins and 4 traps per trawl

	Number of traps per sampling distance	
Number of stations	**Annual**	**Total (7 yr)**
4	1,152	8,064
5	1,440	10,080

Table 7. Vented traps per station, assuming 3 distance bins and 2 traps per trawl

	Number of traps per sampling distance	
Number of stations	**Annual**	**Total (7 yr)**
4	576	4,032
5	720	5,040

References

Brooks ME, Kristensen K, van Benthem KJ, Magnusson A, Berg CW, Nielsen A, Skaug HJ, Maechler M, Bolker BM (2017). "glmmTMB Balances Speed and Flexibility Among Packages for Zero-inflated Generalized Linear Mixed Modeling." The R Journal, 9(2), 378– 400. https://journal.r-project.org/archive/2017/RJ-2017-066/ index.html.

Johnson, P. C. D., Barry, S. J. E., Ferguson, H. M., & Müller, P. (2015). Power analysis for generalized linear mixed models in ecology and evolution. Methods in Ecology and Evolution, 6(2), 133–142. https://doi.org/10.1111/2041-210X.12306

Kumle, L., Vo, M. L-H., & Draschkow, D. (in preparation). Estimating power in linear and generalized linear mixed models: an open introduction and tutorial in R.

R Code for Simulated GLMM Approach

```
options(scipen=999)
##########################
##########################
# Cable VTS Power Analysis
##########################
##########################
setwd("Folder")
load("VTS_RI_Proc_52320.RData")
```

```
require(sf)
require(simr)
require(lme4)
require(splitstackshape)
require(rgdal)
require(MASS)
require(glmmTMB)

st_layers("ExportCables_V3_Orsted_NAD832011_19N_20191203.kml")
cables<-st_read("ExportCables_V3_Orsted_NAD832011_19N_20191203.kml")
st_write(cables,dsn="ExportCables_V3_Orsted_NAD832011_19N_20191203",driver= "ESRI
Shapefile",'Cables.shp')

# Selected only cells that overlap with the buffered zone
# Exported the overlap as a new shapefile to select only trawls within those cells
cells<-readOGR(dsn ="300mCells.shp",layer="300mCells")
coordinates(Sites)<-c("Longitude","Latitude")
proj4string(Sites)<-"+proj=longlat +datum=NAD83 +no_defs +ellps=GRS80 +towgs84=0,0,0"
overlap<-Sites[cells,]
overlap<-as.data.frame(overlap)

# Merge site location data to trawls and then to traps
subTrawl<-merge(overlap,Trawls,by="SiteId")
subTraps<-merge(subTrawl,Traps,by="TrawlId")
ventless<-subset(subTraps,Trap_Type=="Ventless")
vented<-subset(subTraps,Trap_Type=="Ventless")

##############################################################################
# Conduct analysis twice: 1st for ventless pots
##############################################################################

# Create depth bins as standing for station for now (4 10m bins)
ventless$Station<-ifelse(ventless$Depth.x<10,"0-10m",ifelse(ventless$Depth.x>=10 &
ventless$Depth.x<20,"10-20m",ifelse(ventless$Depth.x>=20 & ventless$Depth.x<30,"20-
30m","30-40m")))

# Clean up data
ventless<-ventless[!names(ventless) %in%
c("TrapConfig","Exclude.y","Depth.y","Exclude.x","Groundline","NeighboringGear","Comme
nt","Latitude.y","Longitude.y","Habitat")]
Trips2<-Trips[,c("TripId","Month")]
ventless<-merge(ventless,Trips2,by="TripId")

# Characterize existing data
quart1<-quantile(ventless$CatchNum)[2]
hist(ventless$CatchNu)
# Check for over-dispersion in the data
var(ventless$CatchNum)
mean(ventless$CatchNum)
# Data overdispersed (variance larger than the mean in our dependent variable) -
likely due to all the 0s
# Use a 0-inflated negative binomial instead
# Proposed formula: formula <- CatchNum ~ Distance_Bin + Before_After + (1|Station) +
(1|Year) + (1|Month)

# Build maximum dataset
# 4 stations, 3 distance bins, 2 trawls/month, 4 traps/trawl, 12 months/year, 7 years
maxTraps<-4*3*2*4*12*7
counts<-table(ventless$Station)
probs<-counts/sum(counts)
stat1<-subset(ventless,Station=="0-10m")
stat2<-subset(ventless,Station=="10-20m")
```

```
stat3<-subset(ventless,Station=="20-30m")
stat4<-subset(ventless,Station=="30-40m")
simDat1<-stat1[sample(1:nrow(stat1),round(maxTraps*probs[1]),replace=TRUE), ]
simDat2<-stat2[sample(1:nrow(stat2),round(maxTraps*probs[2]),replace=TRUE), ]
simDat3<-stat3[sample(1:nrow(stat3),round(maxTraps*probs[3]),replace=TRUE), ]
simDat4<-stat4[sample(1:nrow(stat4),round(maxTraps*probs[4]),replace=TRUE), ]
simDat<-rbind(simDat1,simDat2)
simDat<-rbind(simDat,simDat3)
simDat<-rbind(simDat,simDat4)
remove(simDat1,simDat2,simDat3,simDat4,stat1,stat2,stat3,stat4)

# Sample sizes all divisible by three so that bins can be applied equally
sampleSizes<-c(501, 1002, 2001, 3000, 4002, 5001, 6000, 7002, 8001, 9000)

ventless_results<-data.frame()

for (num in sampleSizes){

  for (i in 1:1000){

    # Simulate data where catch decreases closer to the "cable"
    # First need to generate a random assortment of distance bins in the available
data
    newDat<-simDat[sample(1:nrow(simDat)),]
    newDat$Dist_bin<-as.factor(rep(1:3,nrow(newDat)/3))

    # 10% Reduction in closest bin and 5% reduction in middle bin; no change for
furthest bin (should be set beyond EMF signal based on BIWF data)
    newDat$Sim_Catch<-ifelse(newDat$Dist_bin ==
1,0.9*newDat$CatchNum,ifelse(newDat$Dist_bin ==
2,0.95*newDat$CatchNum,1.0*newDat$CatchNum))

    if (num>nrow(newDat)){

    }
    else {
      modDat<-stratified(newDat,"Dist_bin",num/3) # Pull stratified sample (same # of
each bin)
    }

    try({
      model<-glmmTMB(floor(Sim_Catch) ~ Dist_bin + (1|Station) + (1|Year) + (1|Month),
data=modDat, ziformula = ~1, family = nbinom2)
      outvalue<-drop1(model,test="Chisq") #Liklihood ratio test to get P-value
    },silent=T)
    ventless_results<-
rbind(ventless_results,(t(as.data.frame(c(num,outvalue$`Pr(>Chi)`[2])))))
    print(paste("Sample size ", num, "- Run ", i, " out of 1000"),sep="")

    remove(outvalue)

  }
}

ventless_results2<-ventless_results

colnames(ventless_results2)<-c("N","PVal")
ventless_results2$Sig<-ifelse(ventless_results2$PVal<=0.05,1,0)
aggDat_ventless<-aggregate(Sig~N,ventless_results2,FUN=sum)
colnames(aggDat_ventless)<-c("N","Significant")
aggDat_ventless2<-aggregate(Sig~N,ventless_results2,FUN=length)
colnames(aggDat_ventless2)<-c("N","Count")
power_ventless<-merge(aggDat_ventless,aggDat_ventless2)
```

```
power_ventless$Power<-power_ventless$Significant/power_ventless$Count

# Save outputs
write.csv(ventless_results2,"GLMM_TMB_Model_Outputs_12mon_VL.csv")
write.csv(power_ventless,"GLMM_TMB_Power_12mon_VL.csv")
pwrPlot<-plot(power_ventless$Power~power_ventless$N)
jpeg('GLMM_Pwr_Plot_12mon_VL.jpg')
plot(power_ventless$Power~power_ventless$N)
dev.off()

##############################################################################
# Repeat for vented pots
##############################################################################

# Create depth bins as standing for station for now (4 10m bins)
vented$Station<-ifelse(vented$Depth.x<10,"0-10m",ifelse(vented$Depth.x>=10 &
vented$Depth.x<20,"10-20m",ifelse(vented$Depth.x>=20 & vented$Depth.x<30,"20-30m","30-
40m")))

# Clean up data
vented<-vented[!names(vented) %in%
c("TrapConfig","Exclude.y","Depth.y","Exclude.x","Groundline","NeighboringGear","Comme
nt","Latitude.y","Longitude.y","Habitat")]
Trips2<-Trips[,c("TripId","Month")]
vented<-merge(vented,Trips2,by="TripId")

# Characterize existing data
quart1<-quantile(vented$CatchNum)[2]
hist(vented$CatchNu)
# Check for over-dispersion in the data
var(vented$CatchNum)
mean(vented$CatchNum)
# Data overdispersed (variance larger than the mean in our dependent variable) -
likely due to all the 0s
# Use a 0-inflated negative binomial instead
# Proposed formula: formula <- CatchNum ~ Distance_Bin + Before_After + (1|Station) +
(1|Year) + (1|Month)

# Build maximum dataset
# 4 stations, 3 distance bins, 2 trawls/month, 2 traps/trawl, 12 months/year, 7 years
maxTraps<-4*3*2*2*12*7
counts<-table(vented$Station)
probs<-counts/sum(counts)
stat1<-subset(vented,Station=="0-10m")
stat2<-subset(vented,Station=="10-20m")
stat3<-subset(vented,Station=="20-30m")
stat4<-subset(vented,Station=="30-40m")
simDat1<-stat1[sample(1:nrow(stat1),round(maxTraps*probs[1]),replace=TRUE), ]
simDat2<-stat2[sample(1:nrow(stat2),round(maxTraps*probs[2]),replace=TRUE), ]
simDat3<-stat3[sample(1:nrow(stat3),round(maxTraps*probs[3]),replace=TRUE), ]
simDat4<-stat4[sample(1:nrow(stat4),round(maxTraps*probs[4]),replace=TRUE), ]
simDat<-rbind(simDat1,simDat2)
simDat<-rbind(simDat,simDat3)
simDat<-rbind(simDat,simDat4)
remove(simDat1,simDat2,simDat3,simDat4,stat1,stat2,stat3,stat4)

# Sample sizes all divisible by three so that bins can be applied equally
sampleSizes<-c(252, 501, 1002, 1500, 2001, 2502, 3000, 3501, 4002)

vented_results<-data.frame()

for (num in sampleSizes){
```

```
  for (i in 1:1000){

    # Simulate data where catch decreases closer to the "cable"
    # First need to generate a random assortment of distance bins in the available
data
    newDat<-simDat[sample(1:nrow(simDat)),]
    newDat$Dist_bin<-as.factor(rep(1:3,nrow(newDat)/3))

    # 10% Reduction in closest bin and 5% reduction in middle bin; no change for
furthest bin (should be set beyond EMF signal based on BIWF data)
    newDat$Sim_Catch<-ifelse(newDat$Dist_bin ==
1,0.9*newDat$CatchNum,ifelse(newDat$Dist_bin ==
2,0.95*newDat$CatchNum,1.0*newDat$CatchNum))

    if (num>nrow(newDat)){

    }
    else {
      modDat<-stratified(newDat,"Dist_bin",num/3) # Pull stratified sample (same # of
each bin)
    }

    try({
      model<-glmmTMB(floor(Sim_Catch) ~ Dist_bin + (1|Station) + (1|Year) + (1|Month),
data=modDat, ziformula = ~1, family = nbinom2)
      outvalue<-drop1(model,test="Chisq") #Liklihood ratio test to get P-value
    },silent=T)
    vented_results<-
rbind(vented_results,(t(as.data.frame(c(num,outvalue$`Pr(>Chi)`[2])))))
    print(paste("Sample size ", num, "- Run ", i, " out of 1000"),sep="")

  }
}

vented_results2<-vented_results
colnames(vented_results2)<-c("N","PVal")
vented_results2$Sig<-ifelse(vented_results2$PVal<=0.05,1,0)
aggDat_vented<-aggregate(Sig~N,vented_results2,FUN=sum)
colnames(aggDat_vented)<-c("N","Significant")
aggDat_vented2<-aggregate(Sig~N,vented_results2,FUN=length)
colnames(aggDat_vented2)<-c("N","Count")
power_vented<-merge(aggDat_vented,aggDat_vented2)
power_vented$Power<-power_vented$Significant/power_vented$Count

# Save outputs
write.csv(vented_results2,"GLMM_TMB_Model_Outputs_12mon_vented.csv")
write.csv(power_vented,"GLMM_TMB_Power_12mon_vented.csv")
pwrPlot<-plot(power_vented$Power~power_vented$N)
jpeg('GLMM_Pwr_Plot_12mon_vented.jpg')
plot(power_vented$Power~power_vented$N)
dev.off()
```

Appendix B – Supplemental Information for Vessel Transits in the Gulf of Mexico

Revolution Wind Farm and Revolution Wind Export Cable – Development and Operation

APPENDIX B
Supplemental Information for Vessel Transits in the Gulf of Mexico

October 2022

For the National Marine Fisheries Services

U.S. Department of Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

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Tables

1.0 Introduction

This report presents supplemental analysis for the biological assessment (BA) prepared for the Revolution Wind Farm (RWF) and Revolution Wind Export Cable (RWEC) Project (Project). Specifically, this report assesses potential impacts associated with Project vessel traffic that may originate from the Gulf of Mexico to Endangered Species Act (ESA) -listed species under National Marine Fisheries Service (NMFS) jurisdiction. Only ESA-listed species that occur in the Gulf of Mexico and potential vessel traffic from Gulf of Mexico ports are assessed in this report. ESA-listed species that occur in the Project action area outside the Gulf of Mexico and all other potential impacts associated with other components of the Project, including potential vessel traffic from ports outside of the Gulf of Mexico, are addressed in the BA (Confluence Environmental Company 2022).

Overall, several existing Atlantic coast port facilities have been identified as local ports to potentially support the Project in transporting materials to the Project area. Vessels not transporting material from these local ports may travel with components and equipment directly to the Project area from non-local locations such as the Gulf of Mexico. While project contracts are not in place, the types of vessels, numbers of vessels, and numbers of vessel trips required for the construction and installation of the Project have been estimated and identified in the BA. Most vessel operations are expected to originate and return to local ports servicing the Project in the Project area.

Vessels that will not be transporting construction material from local ports may travel directly to the Project area from locations that will be determined prior to construction. For planned operations and maintenance activities, local ports are expected to be used and the use of non-local ports in the Gulf of Mexico is not anticipated. During construction, it is anticipated that a total of only 33 vessel trips could potentially occur between non-local ports in the Gulf of Mexico and the Project area. While no specific Gulf of Mexico non-local ports have been identified for construction support, the travel distance from the Project area to the Gulf of Mexico region can be estimated from broad vessel traffic patterns observable in Automatic Identification Systems data (BOEM et al., 2022). The minimum travel distance from the Project area to an observable area of traffic separation approximately 150 miles due west of Key West, Florida is approximately 1,550 miles. Travel distance from this point to Gulf of Mexico non-local ports ranges from approximately 475 miles (to the Port of Mobile, Alabama) to 850 miles (to the Port of Corpus Christi, Texas). This equates to total travel distances ranging from 1,925 to 2,400 miles.

NMFS ESA-listed species occurring in the Gulf of Mexico are presented in Table 1. For reference to the other geographic regions where these listed species may occur, Table 1 indicates if the species also occurs in other areas between port locations and the Project area that have been further analyzed in the BA. Table 2 summarizes the estimated various vessels and trips associated with Project construction that potentially may originate from the non-local ports in the Gulf of Mexico. At this time specific vessels and Gulf of Mexico ports have not been selected for Project construction activity. Typical vessel operational knot speeds and vessel drafts for Project construction vessels are identified in Table 3.10 in the BA.

Table 1. Threatened and Endangered Species that May Occur in Vessel Transit Areas between Ports of Origin and the Project Area

Species	Scientific Name	Listing Status	Potential Occurrence Port of Origin Routes		
			Gulf of Mexico	Europe	Atlantic Coast
Sea Turtles					
Green sea turtle North Atlantic DPS	*Chelonia mydas*	Threatened	X	—	X
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	X	—	X
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	X	—	X
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	X	X	X
Loggerhead sea turtle Northwest Atlantic Ocean DPS	*Caretta caretta*	Threatened	X	X	X
Fish, Rays, Sharks					
Smalltooth sawfish U.S. DPS	*Pristis pectinata*	Endangered	X	—	—
Gulf sturgeon	*Acipenser oxyrinchus desotoi*	Threatened	X	—	—
Nassau grouper	*Epinephelus striatus*	Threatened	X	—	—
Giant manta ray	*Manta birostris*	Threatened	X	X	X
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	X	X	—
Corals					
Boulder star coral	*Orbicella franksi*	Threatened	X	—	—
Elkhorn coral	*Acropora palmata*	Threatened	X	—	—
Lobed star coral	*Orbicella annularis*	Threatened	X	—	—
Mountainous star coral	*Orbicella faveolata*	Threatened	X	—	—
Pillar coral	*Dendrogyra cylindrus*	Threatened	X	—	—
Rough cactus coral	*Mycetophyllia ferox*	Threatened	X	—	—

Species	Scientific Name	Listing Status	Potential Occurrence Port of Origin Routes		
			Gulf of Mexico	Europe	Atlantic Coast
Staghorn coral	*Acropora cervicornis*	Threatened	X	—	—
Whales					
Blue whale	*Balaenoptera musculus*	Endangered	X	X	X
Fin whale	*Balaenoptera physalus*	Endangered	X	X	X
North Atlantic right whale	*Eubalaena glacialis*	Endangered	X	X	X
Rice's whale	*Balaenoptera ricei*	Endangered	X	—	—
Sei whale	*Balaenoptera borealis*	Endangered	X	X	X
Sperm whale	*Physeter macrocephalus*	Endangered	X	X	X
Notes: DPS=Distinct Population Segment					

Table 2. Estimated Gulf of Mexico Vessel Types and Trips Required for Offshore Construction.

Type of Vessel	Total # of Trips [a]
Service Operations Vessel #1	2
Service Operations Vessel #2	1
Heavy Transport Vessel #1	2
Heavy Transport Vessel #2	2
Heavy Transport Vessel #3	2
Heavy Transport Vessel #4	2
DP2 Platform Supply Vessel #1	2
DP2 Platform Supply Vessel #2	2
DP2 Platform Supply Vessel #3	2
Nearshore Barge	2
Support Barge	2
Primary/Lead Tug	2
Tail Tug	2
Survey Vessel	2
PLGR Vessel	2
Bunkering Vessel	2
Wind Turbine Generator Installation Vessel	2
Total Trips	**33**

[a] Total Vessel Trip counts do not account for unforeseen circumstances, such as repairs that may require the vessel to return to the Gulf of Mexico.

2.0 Species Analysis

This section provides species-specific analysis of potential impacts to ESA-listed species associated with Project vessel traffic that may originate from the Gulf of Mexico.

Overall, similar to the analysis of potential vessel transits from local ports discussed in the BA, the number of Gulf of Mexico non-local ports under consideration does not increase the number of vessel trips that are likely to occur but may affect the location and length of the transits. In addition, no upgrades or modifications at an existing Gulf of Mexico non-local port facility specific to the Project are anticipated and any upgrades or modifications would serve to support other maritime industries in general. Vessels from these Gulf of Mexico non-local port facilities would also be utilized to serve other maritime industries if they are not a component of the Project.

Finally, individual Gulf of Mexico port facilities annually service thousands of vessels and import and export millions of tons of goods and materials. The vast majority of Gulf of Mexico port facility vessel traffic consists of cargo and container ships, tankers, commercial fishing boats, passenger ships, and recreational yachts and boats. The vessel types anticipated to be associated with Project construction and operation and maintenance activities are in a vessel category that make up a small percentage of overall port vessel use.

2.1 Coral Species

The listed species of corals (Table 1) are not expected to occur within Gulf of Mexico ports or established vessel channels which are routinely dredged. Known coral reef areas and designated critical habitat of ESA-listed coral species such as the Flower Gardens Banks and the Florida Keys National Marine Sanctuaries are protected from anchoring and other potential vessel impacts and are located in deeper water that would not be impacted by potential hull and propeller impacts from vessel operations. Therefore, potential impacts to listed corals are discountable.

2.2 Blue, Sei, Fin, and North Atlantic Right Whales

Blue whale (*Balaenoptera musculus*), sei whale (*Balaenoptera borealis*), fin whale (*Balaenoptera physalus*), and North Atlantic right whale (*Eubalaena glacialis*) have been reported in the Gulf of Mexico on rare occasions. These whale species are considered extralimital in the Gulf of Mexico. Hence, they are not documented as inhabitants of the Gulf of Mexico in NMFS' stock assessment reports (Hayes et al. 2021). There is no designated critical habitat for blue, sei, and fin whale species and no designated critical habitat for North Atlantic right whales in the Gulf of Mexico.

The risk of overlap of these species with potential Project vessel traffic is considered to be extremely unlikely to occur. In addition, Project mitigation measures include the implementation of NOAA vessel guidelines for marine mammal and sea turtle strike avoidance measures, including vessel speed restrictions. These measures would effectively avoid and minimize the likelihood of vessel strike, such that the likelihood of injury or mortality to these whale species is discountable. See the BA for additional information and assessment of potential impacts to these listed whale species in the action area outside the Gulf of Mexico.

2.3 Giant Manta Ray, Oceanic Whitetip Shark, and Smalltooth Sawfish,

Vessel strikes of elasmobranch species, in general, are extremely rare. Giant manta rays (*Manta birostris*) are found in open water, feeding over reefs, or visiting shallow-water cleaning stations in certain areas. Oceanic whitetip sharks (*Carcharhinus longimanus*) tend to prefer the deeper ocean waters where there is no likelihood of vessel strike. Although oceanic whitetips have been observed in waters as shallow as 120 feet (36 meters) and along coastlines, they tend to only hunt in these waters if they are near a continental shelf where they still have access to deeper waters. There is no designated critical habitat for giant manta rays and oceanic whitetip sharks.

Smalltooth sawfish (*Pristis pectinata*) vessel encounters would be rare, and their designated critical habitat is outside the anticipated areas of vessel transit routes. Small, juvenile smalltooth sawfish are generally restricted to estuarine waters of peninsular Florida, whereas larger adults have a broader distribution and could be found in the southeastern Gulf of Mexico.

There is a very small likelihood that giant manta rays, oceanic whitetip sharks, and smalltooth sawfish would be expected to occur within the Gulf of Mexico vessel transit areas and occur at or near the surface at the same time vessels associated with the Project may be present. Additionally, only 33 estimated trips between the Gulf of Mexico non-local ports and the Project area may potentially occur over the lifetime of the Project. This low likelihood of interaction results in an unlikely occurrence of a vessel strike to one of these species. Based on the best available information on vessel strike risks associated with the Project, the risk of vessel strikes with a giant manta ray, oceanic whitetip shark, or smalltooth sawfish is extremely unlikely to occur and the potential effects from vessel strikes is considered to be discountable. See the BA for additional information and assessment of potential impacts to the giant manta ray species in the action area outside the Gulf of Mexico.

2.4 Nassau Grouper

Nassau grouper (*Epinephelus striatus*) are not likely to be at risk of vessel strikes from vessel transits through the Straits of Florida. The risk of a vessel strike resulting from the Project is also considered discountable because vessel strikes of marine fish offshore are rare events in general and not considered a threat to Nassau grouper. There is no designated critical habitat for Nassau grouper. While it is possible that the presence of vessels may result in a short-term behavioral response from this species (e.g., startle, dive), the effects are not expected to result in any injury or reduced fitness of individuals. Therefore potential effects to Nassau grouper from vessel strikes are discountable.

2.5 Gulf Sturgeon

NMFS reports there have been two definitive deaths of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) from 2015-2017 due to vessel strike (Panama City FWS unpublished data as referenced in National Marine Fisheries Service 2020). Gulf sturgeon may be found in rivers, estuaries, and nearshore habitats from Texas to Florida. Any vessel trips originating from Gulf of Mexico non-local ports west of the mouth of the Mississippi River from Louisiana or Texas will not impact Gulf sturgeon since the species does not occur there. Therefore, trips originating from non-local ports east of the Mississippi River could potentially expose Gulf sturgeon to vessels. Additionally, ports and shallow navigation channels are expected to be the areas of highest risk for vessel interaction with this benthic-dwelling species. Designated critical habitat for Gulf sturgeon is located within several Gulf of Mexico river systems east of the Mississippi River and in the estuary habitat at the mouths of these systems.

A study on the similar species Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) concluded that with the assumed behavioral modification to vessel noise, mortalities are likely caused by deep-draft ocean cargo ships (Balazik et al. 2012). Potential vessel strike impacts to Atlantic sturgeon are also assessed in the BA. The number of vessels originating from the Gulf of Mexico non-local ports in support of construction of the Project is expected to be low and most trips may occur from ports west of the Mississippi where the primary ports associated with oil and gas operations are located. Therefore, it is anticipated that the low number of estimated vessel trips (a total of 33 over the lifetime of the project) and low amount of expected overlap with vessel operations with Gulf sturgeon results in a discountable chance of adverse effects occurring.

2.6 Sea Turtles

In general, all species of sea turtles are susceptible to vessel strike, but this susceptibility is likely dependent upon a number of factors including geographic area, water depth, species surface patterns, and number of vessel trips. For example, hawksbill sea turtles (*Eretmochelys imbricata*) could be present in vessel transit area originating or returning to ports in the Gulf of Mexico, but despite their potential presence, their densities are expected to be rare around port areas in the Gulf of Mexico and in the deeper water transit routes expected to be taken by vessels, compared to other sea turtle species. Loggerhead sea turtle (*Caretta caretta*) designated critical habitat is located within potential vessel transit routes for the Project. Designated critical habitat for green (*Chelonia mydas*), hawksbill, and leatherback (*Dermochelys coriacea*) sea turtles are outside the potential areas of vessel transit routes and there is no designated critical habitat for Kemp's ridley sea turtle (*Lepidochelys kempii*).

Considering only 33 estimated construction trips between the Gulf of Mexico and the Project area may potentially occur over the lifetime of the project, the likelihood of encountering and striking a sea turtle in the Gulf of Mexico is extremely low based on the low level of vessel activity expected relative to the overall vessel transit. This low likelihood of interaction results in an unlikely occurrence of a vessel strike to any species of sea turtle. In addition, Project mitigation measures include the implementation of NOAA vessel guidelines for marine mammal and sea turtle strike avoidance measures, including vessel speed restrictions. These measures would effectively avoid and minimize the likelihood of vessel strike. Based on the best available information, the risk of vessel strikes with sea turtles in the Gulf of Mexico is extremely unlikely to occur and will be discountable. See the BA for additional information and assessment of potential impacts to the sea turtle species in the action area outside the Gulf of Mexico.

2.7 Sperm and Rice's Whales

Vessel strikes are a well-documented threat to large whales worldwide. The probability of a vessel strike increases significantly as speeds increase above 10 knots (Conn and Silber 2013; Kite-Powell et al. 2007; Laist et al. 2001; Vanderlaan and Taggart 2007). For sperm whales (*Physeter macrocephalus*), there are no known recent strikes in the Gulf of Mexico but historically there is one possible lethal strike, which occurred in 1990, and there is the possibility of at least one non-lethal vessel strike of a sperm whale based on photographs taken by a protected species observer (National Marine Fisheries Service 2020). In addition, the U.S. Navy USS BUCKLEY reported striking a whale in the Gulf of Mexico (report to NMFS on June 25, 2001). Sperm whales and Rice's whales (*Balaenoptera ricei*) could potentially occur in the vessel transit route between Gulf of Mexico non-local ports on the way toward the Straits of Florida and to the Project area or on a return trip in vessels that do not remain in the Project area. Sperm whale occurrence is more diverse throughout deep waters of the Gulf of Mexico and may overlap with vessel transit areas. Rice's whale distribution is much smaller and limited to the eastern area of the Gulf of Mexico in depths between about 330 feet (100 meters) and about 1,310 feet (400 meters). Most vessels would likely originate from ports west of the mouth of the Mississippi River and would not overlap with Rice's whales. There is no designated critical habitat for sperm or Rice's whales.

The 33 total potential construction trips between the Gulf of Mexico and the Project area over the lifetime of the Project are very low as compared to total regional vessel trips. Project mitigation measures include the implementation of NOAA vessel guidelines for marine mammal and sea turtle strike avoidance measures, including vessel speed restrictions. These measures would effectively avoid and minimize the likelihood of encountering and striking whales, such that the likelihood of sperm or Rice's whale injury or mortality is discountable. See the BA for additional information and assessment of potential impacts to the sperm whale species in the action area outside the Gulf of Mexico.

3.0 Conclusion

In conclusion, the overall number of vessel trips between the Gulf of Mexico and the Project area is expected to be very low over the lifetime of the Project (33 total construction trips estimated). In addition, the vessel types anticipated to be associated with Project construction and operation and maintenance activities are in a vessel category and frequency that make up a small percentage of overall port vessel transit activity. There are no or very limited reports of vessel strikes to listed species from total baseline vessel activities. Considering the number of vessel trips associated with the Project, species occurrences, and species-specific risk factors, the potential for vessel strikes on listed species in the Gulf of Mexico is insignificant (locally) or discountable (from outside the region).

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Revolution Wind Farm and Revolution Export Cable – Offshore Wind Energy Project

Biological Assessment—Addendum

March 23, 2023

For the National Marine Fisheries Service

U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

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Acronyms and Abbreviations

APE	Area of Potential Effect
ASV	Autonomous surface vessel
BA	Biological Assessment
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
BRK	Port of Brooklyn, NY
COLREGS	International Regulations for Preventing Collisions at Sea, 1972
COP	Construction and Operations Plan
CTV	Crew transport vessel
DMA	Dynamic Management Area
DPS	Distinct population segment
DVS	Port of Davisville, RI
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EO/IR	Electro Optical/Infrared
EPM	Environmental protection measure
ESA	Endangered Species Act
ft	feet
FRMP	Fisheries Research and Monitoring Plan
HDD	horizontal directional drill
HMS	Highly migratory species
IAC	Inter-Array Cable
ITR	Incidental Take Regulation request (Marine Mammal Protection Act)
JFF	Port of Jefferson, NY
km	kilometer
Lat	latitude
Long	longitude
m	meters
MEC/UXO	Munitions, Explosives of Concern/Unexploded Ordnance
MMPA	Marine Mammal Protection Act
MON	Port of Montauk, NY
NARW	North Atlantic right whale
NAS	Noise attenuation system
NBD	Port of New Bedford, MA
NFK	Port of Norfolk, VA
NLD	Port of New London, CT
NMFS	National Marine Fisheries Service
O&M	Operations and Maintenance
OCS	Outer Continental Shelf
OSS	offshore substation
OSS-link	offshore substation link cable
PAM	Passive Acoustic Monitoring
PLB	Paulsboro Marine Terminal, NJ
PRV	Port of Providence, RI
PSMMP	Protected Species Monitoring and Mitigation Plan
PSO	Protected species observer
Q1, Q2, Q3, Q4	Annual quarter (Jan-Mar, Apr-June, Jul-Sep, Oct-Dec)
QNC	Cashman Shipyard, Quincy, MA
QST	Quonset Point, RI
Revolution Wind	Revolution Wind, LLC
RI	Rhode Island
RIDEM	Rhode Island Department of Environmental Management
RI/MA WEA	Rhode Island/Massachusetts Wind Energy Area
ROV	remotely operated vehicle
RWEC	Revolution Wind Export Cable
RWF	Revolution Wind Farm
SAV	submerged aquatic vegetation

SMA	Seasonal Management Area
SPP	Port of Sparrow's Point, MD
TBD	to be determined
TSS	total suspended sediment
UXO	unexploded ordnance
WTG	wind turbine generators

1.0 Introduction

BOEM has prepared this addendum to the *Revolution Wind Farm and Revolution Wind Export Cable – Development and Operation: Biological Assessment*, dated January 30, 2023 (the Biological Assessment or BA), in response to a list of requests for clarification and additional information received by letter from the National Marine Fisheries Service (NMFS) on February 16, 2023. BOEM has organized the information requests in this letter into a comment and response matrix, which is provided in the following section. All information requests are addressed in this matrix and, where indicated, in revised figures included as attachments to this addendum.

Certain requests in the February 16, 2023, letter ask for additional information and analysis of potential impacts to benthic habitat and habitats used by prey species. The *Revolution Wind Farm and Revolution Wind Export Cable – Development and Operation: Essential Fish Habitat Assessment* (BOEM 2023a), referred to hereafter as the EFH Assessment, provides a detailed characterization of baseline conditions and potential effects on these resources. The EFH Assessment was submitted to NMFS on February 3, 2023. BOEM submitted an addendum to the EFH Assessment (BOEM 2023b) to NMFS on March 21, 2023, addressing a request for additional information and clarification received from NMFS on February 17, 2023. These documents are incorporated by reference in response to specific comments addressed in this addendum.

2.0 Project Schedule Revisions

Revolution Wind has developed a revised project schedule[1], which BOEM is providing this revised schedule to clarify our responses to NMFS's information request as Figure 1. The timing of construction activities that are likely to or could affect ESA-listed species are as follows:

- Landfall construction: Includes sea-to-shore transition construction. In-water work will begin in Q3 2023 and will be completed by February 1, 2024, to comply with February 1 to August 30 restrictions on dredging and seabed clearance activities North of the COLREGS line for state important species (defined in RI CRMC Category B Assent Final Decision, issued on February 8, 2023).

- RWEC installation: Begins mid Q3 2024, completed in late Q4 2025. Construction schedule in state waters subject to the above timing restrictions.

1 The lessee has submitted an updated Construction and Operations Plan (COP) to BOEM for review. This March 2023 version of the COP contains updates based on requests for information received from BOEM during preparation of NEPA and consultation documents. This addendum includes any new information available from the lessee as of March 2023, including any information presented in the March 2023 version of the COP. As soon as the COP has been completely reviewed, it will be replace the current version on BOEM's website: https://www.boem.gov/renewable-energy/state-activities/revolution-wind-farm-construction-and-operations-plan.

- IAC installation: Route clearance and seabed preparation for cable installation will begin in Q1 2024 and will be completed by mid-Q2 2024. Cable installation will begin in mid-Q3 2024 and will be completed by the end of that year.

- WTG installation: Will commence in Q2 2024 and will be completed by mid-Q4 2024.

- OSS installation: Route clearance and seabed preparation will begin in late Q2 2024 and will be completed by early Q3 2024. Foundation and OSS installation will occur in Q3 to Q4 2024. OSS-link installation will occur in Q1 2025.

Figure 1. Indicative construction schedule for the Revolution Wind Farm and Revolution Wind Export Cable.

3.0 USACE Role

NMFS requested clarification of the United States Army Corps of Engineers's (USACE) role in enforcement. The language on page 3 of the January 2023 version of the BA should be replaced with the following language provided by the USACE:

> Under Section 404 of the Clean Water Act (33 U.S.C. 1344), USACE regulates the discharge of dredged or fill material into the waters of the United States (WOTUS). The USACE's 404 jurisdiction in tidal waters extends from the high tide line to the limits of the territorial seas (see 33 CFR § 328.4). The limit of jurisdiction in the territorial seas is measured from the baseline in a seaward direction a distance of three nautical miles. For the purposes of the proposed project, the shoreward limit of WOTUS would be the high tide line of Narragansett

Bay in North Kingstown, RI where the cables within the RWEC would make landfall. Proposed work subject to authorization under Section 404 would include the discharge of dredged or fill material related to cable installation and the placement of hard armoring for cable protection within the portions of the RWEC inside the limits of the USACE's Section 404 jurisdiction.

Under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C.§ 403), the USACE regulates construction of any structures and work that are located in or that affect "navigable waters of the U.S." In tidal waters, the shoreward limit of navigable waters extends to the mean high water line while the seaward limit coincides with the limit of the territorial seas. The USACE's authority to prevent obstructions to navigation in navigable waters of the United States was extended to artificial islands, installations, and other devices located on the seabed, to the seaward limit of the outer continental shelf, by section 4(f) of the Outer Continental Shelf Lands Act of 1953 as amended (43 U.S.C. 1333(e) and 33 CFR 320.2). Structures subject to Section 10 jurisdiction on the RWF include the WTGs, scour protection around the base of the WTGs, two OSSs, IACs connecting the WTGs to the OSSs, and the OSS-link cables connecting the OSSs. Structures and work subject to Section 10 jurisdiction within the RWEC include the proposed export cables, dredging and seabed preparation associated with cable installation, hard armoring for cable protection, and dredging associated with the HDD pits. Revolution Wind submitted an individual permit application to USACE for the proposed work on June 3, 2022, and it was deemed complete on August 18, 2022 (USACE file number NAE-2020-00707).

USACE would be responsible for enforcement and compliance on all permit conditions in the USACE authorization. This would include EPMs and Mitigation and Monitoring Measures proposed in this BA that would be included in BOEM's FEIS and would be adopted in the joint ROD. In Table C-2 of Attachment C of this Addendum, BOEM has identified the anticipated enforcement agencies for each of these measures. USACE would also incorporate any biological opinions (BOs) associated with the project into its final permit decision and would include the following permit condition regarding the BO: "This Corps permit does not authorize you to take an endangered species. The enclosed NMFS BO contains mandatory terms and conditions to implement the reasonable and prudent measures that are associated with "incidental take" that is also specified in the BO. Your authorization under this Corps permit is conditional upon your compliance with all of the mandatory terms and conditions associated with incidental take of the attached BO, and any future BO that replaces it, which terms and conditions are incorporated by reference in this permit. Failure to comply with the terms and conditions associated with incidental take of the operative BO, where a take of the listed species occurs, would constitute an unauthorized take, and it would also constitute non-compliance with your Corps permit. NMFS is the appropriate authority to determine compliance with the terms and conditions of its BO, and with the ESA.

4.0 Responses to Information Requests

The comment and response matrix providing the additional information and clarification requested by NMFS is presented below as Table 1.

Table 1. BOEM responses to NMFS comments and requests for additional information received February 16, 2023 on the Revolution Wind Biological Assessment.

Comment/ Request #	BA Page #	Comment	Response
1	general	Nighttime pile driving/activities are not clearly or consistently addressed through the BA. The Description of the Proposed Action section, Mitigation/Monitoring Measures and the Effects of the Proposed Action inconsistently describe if/how nighttime activities will occur. We consider these high-risk activities that will require thorough and detailed assessment in the BA. Additionally, the Description of the Proposed Action section states that project activities will occur 24 hours per day, however, consideration of any project activities during nighttime hours is not considered in the Effects of the Proposed Action. It is also unclear what mitigation and monitoring measures will be implemented during nighttime hours and for which activities. The Proposed Mitigation, Monitoring, and Reporting Measures section and Effects of the Proposed Action section should address any applicable measures and the effects of these activities, respectively. More information needs to be provided in the BA to clarify under what conditions BOEM would consider allowing nighttime pile driving and how carrying out monitoring at night may or may not reduce the effectiveness of the proposed mitigation measures. In particular, in any instance where measures are relied on to avoid or reduce an effect (e.g., exposure of sea turtles to single strike noise levels that could cause injury and exposure to North Atlantic right whales to noise above the level A harassment threshold), a thorough explanation of how these same conclusions can be reached if pile driving occurs in the dark must be provided.	Revolution Wind is not proposing to conduct continuous impact pile driving 24-hours per day. Revolution Wind anticipates that installation of each monopile foundation would require up to 4 hours of impact pile driving, which equates to a maximum of 12 discontinuous hours of pile driving in any given 24-hour period at the stated maximum installation rate of three WTG or two OSS monopiles per day. Applying the strikes per pile assumptions presented in the BA, this equates to approximately 32,220 strikes for WTG installation and 23,126 strikes for OSS installation occurring over a maximum of 12 hours in any given 24-hour period. Foundation installation could theoretically be completed in less than 30 days at maximum installation rates. However, the project schedule allocates 5 months to provide the flexibility needed to accommodate vessel availability, weather delays, environmental protection measure implementation, compliance with mitigation measures, and other factors. As such, during any given week pile driving may or may not occur on a daily basis. The noise exposure analysis and individual animal exposure estimates presented in the BA are consistent with the information presented in the MMPA ITR application (LGL 2022). The exposure estimates and incidental take request presented in the ITR consider the effectiveness of planned mitigation measures, including the methods proposed for nighttime monitoring. In response to prior requests from NMFS and BOEM, Revolution Wind has submitted a report titled “Assessing Advanced Technology to Support an Option for Nighttime Monopile Installation” (ThayerMahan 2023). This report assesses the suitability and effectiveness of advanced technologies for detect marine mammals (particularly whales) at nighttime based on 1) a comprehensive review of current literature on the effectiveness of Electro Optical/Infrared (EO/IR) camera systems and Passive Acoustic Monitoring (PAM) systems during night operations, 2) controlled shore-based field testing of EO/IR camera systems under daylight and nighttime conditions using a whale blow

Comment/ Request #	BA Page #	Comment	Response
			simulator, and 3) at-sea opportunistic field testing of electro-optical/infrared camera systems and PAM systems to assess monitoring effectiveness during low visibility and nighttime conditions. Though nighttime conditions appear to currently be the main focus. These experiments were designed to demonstrate the ability to maintain high standards for marine species protection during nighttime operations using newly available technologies. The report is currently under review by NMFS and BOEM staff, and Orsted is developing Alternative Monitoring Plans that include the use of the monitoring technologies for projects currently under review (Revolution Wind, Sunrise Wind, and Ocean Wind) and will be submitted to both agencies. Revolution Wind presented a summary of the methods and findings of this report to BOEM and NMFS staff in an online meeting on March 16, 2023.
2	general	It is not clear what conclusion you are reaching about shortnose sturgeon. Please clarify if you are making a “not likely to adversely affect” determination or a “no effect” determination for shortnose sturgeon.	BOEM has reached a “no effect” determination for shortnose sturgeon.
3	general	The discussion about the overlap between vessel traffic and critical habitat designated for Atlantic sturgeon is unclear. It appears that travel between the identified ports and the project area would not result in any transits in designated critical habitat; however, text on pg. 92 states that such travel is possible. This will need to be resolved.	Thank you for your comment. This discrepancy is attributable to conflicting project information received immediately prior to BA submittal. Based on updated information from the lessee, Revolution Wind is considering the Paulsboro Marine Terminal (Delaware River, New Jersey) for construction support. A revised summary of ports under consideration for construction and O&M support is provided as Attachment A to this addendum. With the exception of the Paulsboro Marine Terminal, all of the ports under consideration for construction and/or O&M support and associated vessel routes share no overlap with currently designated critical habitat for Atlantic sturgeon (82 FR 39160). The Paulsboro Marine terminal lies within designated Atlantic sturgeon critical habitat in the Delaware River. No port improvements or modifications to associated mooring areas or navigation channels are proposed, therefore there will be no project-related effects on the habitat access, habitat composition, and water quality components of critical habitat. Construction vessel traveling to and from this port would generate underwater noise in estuarine critical habitat. A review of representative

Comment/ Request #	BA Page #	Comment	Response
			noise levels generated by project vessels is provided in BA Section 5.2.1. Project vessels could generate noise above behavioral effects thresholds for fish within a short distance (<450 feet) of the main navigation channel. This portion of the Delaware River migratory corridor is 3,000 feet or more wide, indicating that noise from individual project vessels would be unlikely to create an acoustic barrier that would impede the movement of adult sturgeon to and from spawning sites, physical feature (3)(i) of critical habitat. The Paulsboro Marine Terminal is located approximately downstream from several other major regional port facilities, including the Philadelphia Naval Yard and the Port of Philadelphia, the latter being one of the top 25 busiest ports in the nation in terms of cargo volume (USDOT 2023). Numerous large vessels accessing these and other nearby facilities transit the lower Delaware River on a daily basis. In this context, project-related vessel traffic is unlikely to measurably alter baseline underwater noise conditions in this component of Atlantic sturgeon critical habitat.
4	general	We note that the consideration of giant manta rays in this BA appears to be inconsistent with consideration of the species in other BAs in nearby lease areas. While we agree that Giant Manta Rays may be present along some vessel transit routes, based on Farmer et al. (2022), it appears to be extremely unlikely that any giant manta rays would be present in the lease area or along the cable corridors. We would be happy to discuss this with you further.	Noted, thank you for your comment. The analysis presented is consistent with the BA for the South Fork Wind project. BOEM will review and consider NMFS assessment of potential manta ray occurrence in the biological opinion.
5	general	As noted in the description of the action area, it must include all vessel transit routes. The BA is still unclear on the extent of the action area as it states vessel transits will occur from Europe or “elsewhere in the world.” Clarifying the geographic region where vessel traffic will occur is needed in order to define the action area and subsequent listed species accurately.	Ports in the Gulf of Mexico, Europe, the east coast of Canada, or Asia could be used for construction support. No specific ports have been identified to date, as port selection will be determined by vessel availability, chartering terms, and other factors that will not be known until the project proceeds to the construction process. A description of potential vessel transit routes from distant ports, identification of ESA-listed species known or potentially occurring in these transit routes, and an assessment of the potential effects of vessel traffic on these species is provided in Attachment B to this addendum.

Comment/ Request #	BA Page #	Comment	Response
6	general	The number of estimated UXOs/MECs in the BA is inconsistent with the proposed MMPA Incidental Take Regulations (ITR) (see 87 FR 79072, December 23, 2022). The BA states there are an estimated 16 UXOs/MECs but the proposed ITR addresses the planned detonation of 13. We would like to discuss this discrepancy and how best to move forward. Additionally, the mitigation/monitoring measures related to UXO/MEC detonation listed in Table 3.19 are very vague, please provide the specific language of the measures (e.g., rather than just stating "visual monitoring" identify the required sea turtle and marine mammal clearance zones, PSO requirements, etc.).	Regarding the 16 vs 13 UXOs, the lessee has stated that based on the available data collected to date, the Project will continue to request take for 13 detonations, as stated within the ITR application and MMPA Draft Rule. Revolution Wind has concluded that the 16 confirmed UXOs identified can be safely avoided by rerouting RWEC installation within BOEM's approved installation corridor. However, the UXO surveys conducted to date are not comprehensive. Revolution Wind believes that additional devices could be discovered during construction or pre-construction surveys, therefore the need for UXO detonation cannot be ruled out. Revolution Wind is requesting take coverage for up to 13 detonations to adequately address this risk. The project would attempt to mitigate emergent finds using other measures (e.g., lift and shift, cable rerouting) before resorting to detonation, but does maintain that 13 detonations are necessary for take coverage. Mitigation measures for UXO detonation are summarized in Attachment C.
7	general	Appendix B describes BOEM's consideration of effects for vessel traffic in the Gulf of Mexico. However, it does not appear to consider effects of traffic along the U.S. South Atlantic coast to the project area. Additional analysis that includes consideration of this portion of the vessel traffic routes is necessary to support the conclusions made in the BA.	Appendix B in the BA considers vessel routes within the Gulf of Mexico (GOM) and between the GOM and the project area. However, it only introduces ESA-listed species that are not already considered in the BA. Please see Attachment B for a revised assessment of construction vessel traffic to distant ports. The effects of traffic along the U.S. South Atlantic coast was considered in the BA (e.g., sections 4.9 and 4.10).
8	general	Also, please note that there are a number of examples in the Effects of the Action section where impact conclusions are missing, unclear, or are described in a way that is inconsistent with ESA terminology. For example, on p. 147 the BA states, "Overall, the potential effect to Atlantic sturgeon from vibratory pile driving is considered insignificant but is still considered significant overall for underwater noise due to the effects of impact pile driving." While we interpret this to mean that you have determined that effects of vibratory pile driving are insignificant, you anticipate adverse effects to Atlantic sturgeon from other noise sources, we encourage you to describe conclusions more clearly in future BAs. Despite this confusing or missing text, we recognize that table 7.1 includes a complete description of BOEM's	Noted. Thank you for your feedback.

Comment/ Request #	BA Page #	Comment	Response
		conclusions regarding anticipated effects to listed species. We are interpreting "significant" in this table to mean "adverse" (i.e., not insignificant or discountable). In future BAs, please ensure that ESA terminology is used consistently throughout the BA.	
9	4	Clarify the role of USACE in enforcing compliance with project conditions (e.g., is this limited to conditions of any permits issued by the USACE) and ESA terms and conditions. Additionally, please clarify which agency is responsible for enforcing compliance with COP conditions and ESA terms and conditions in State waters.	The USACE has provided updated language to clarify their role in enforcement (see Section 3.0). Table C-2 in Attachment C lists anticipated enforcement agencies for mitigative measures, which includes the USACE when within their jurisdiction.
10	4	Confirm if Revolution Wind requested a PATON authorization in 2022.	No PATON was submitted on behalf of Revolution Wind in 2022. A PATON will be submitted prior to construction.
11	10	Confirm the proposed operational period (years) for the proposed project.	The BA states on subsequent pages (e.g., pages 35, 37, 43, and 166) that the operational life is approximately 35 years. For analysis purposes, BOEM assumes that the proposed Project would have an operating period of up to 35 years. Revolution Wind's lease with BOEM (Lease OCS-A 0486) has an operations term of 25 years that commences on the date of COP approval (see 30 CFR 585.235(a)(3)). Revolution Wind would need to request and be granted an extension of its operations term from BOEM, 30 CFR 585.425-585.429, in order to operate the proposed Project for 35 years. While Revolution Wind has not made such a request, this BA uses the longer period in order to avoid possibly underestimating any potential effects.
12	20	Clarify if the installation schedule is still accurate with monopile, OSS, WTG, and cable installation occurring in 2023.	Per Section 3.2 of the Revolution Wind COP, construction is anticipated to begin in Q3 of 2023. Monopile, OSS, WTG, and cable installation (exclusive of the HDD landfall) will all occur in 2024.
13	25/26	The description of the "Vessel Traffic Component of the Action Area" is unclear relative to vessel traffic to foreign ports. Yet to be identified ports in the Gulf of Mexico and Europe are mentioned and create a reasonable action area, however, the inclusion of "elsewhere in the world" is problematic in defining the action area. The BA goes on to state that the effects analysis is restricted to transit routes in U.S. federal waters, however, that is inconsistent with the	Please see Attachment B for a revised assessment of construction vessel traffic to distant ports.

Comment/ Request #	BA Page #	Comment	Response
		defined action area. If European or "other worldwide" ports are considered part of the proposed action, the effects of those activities need to be considered.	
14	26	Clarify that the proposed action includes 79 tapered 7/12-m monopiles to support WTGs and two tapered 7/15-m monopiles to support two OSSs. As written, the BA appears to only describe the maximum diameter of the piles.	Correct, the monopiles and OSS are tapered with a diameter range of 6-12 m for the WTG and 6-15 m for the OSS.
15	27	Clarify if the location identified in the "lift and shift" scenario for UXO/MEC disposal is within the lease area or elsewhere in the action area.	Lift and shift activities are anticipated to take place only where avoidance is not possible within both the lease and the export cable route, utilizing disposal areas within the APE. There are no specific disposal areas in the APE or the lease as a whole. Revolution Wind would examine the area near the UXO requiring lift and shift (lift and shift does not normally occur over large distances) and determine a designated area that does not pose a hazard to other infrastructure, marine archaeological feature, or other resources with a designated avoidance buffer.
16	27	Clarify if the 12 hours of pile driving is the maximum for a single monopile or the maximum for three monopiles installed in a 24-hour period.	Typical WTG monopile installation is anticipated to require 1 - 4 hours of impact pile driving per pile. Thus, 12 hours of impact pile driving is the maximum anticipated duration for installation of three monopiles in a 24-hour period.
17	28	As noted above, clarify if nighttime pile driving is considered part of the proposed action or if nighttime pile driving will only occur in instances where foundation installation takes longer than anticipated and delaying installation until daylight would present risks to safety and/or structural stability. There are a number of statements about nighttime pile driving throughout the BA that appear to be in conflict with each other. For example, footnote 2 on pg. 28 states that nighttime pile driving would only occur where foundation installation would take longer than anticipated while the text at the top of the page that implies that routine nighttime pile driving is planned.	Please see the response to comment #1. Revolution Wind is proposing conduct nighttime pile driving as needed to provide the schedule flexibility necessary to complete construction. Nighttime pile driving would only under during conditions where clearance zones can be effectively monitored to avoid and minimize adverse effects on ESA listed species. Orsted conducted an evaluation of available technologies and prepared a report of findings on their effectiveness and limitations (ThayerMahan 2023). NMFS has received this report and NMFS staff attended a virtual presentation summarizing these findings on March 16, 2023.
18	28	Clarify if concurrent pile driving is being proposed, such that one monopile and one OSS monopile (or two monopiles) would be installed at the same time. It is not clear if the text before table 3.5 is just stating that monopiles and OSSs	Revolution Wind is not proposing concurrent pile driving for RWF installation. No concurrent installation of WTG and/or OSS monopiles will occur and only one impact hammer will be operational at any given time. Sea-to-shore construction (including any associated pile driving) would

Comment/ Request #	BA Page #	Comment	Response
		could be installed during the same 1-2 week period or that they could be installed simultaneously.	occur earlier on the project schedule. While separated in time, the sound field generated by this activity also shares no overlap with the future sound field generated by WTG and OSS foundation installation.
19	28	Clarify if the maximum impact scenario is three WTG monopiles per day AND two OSS monopiles per day or three WTG monopiles per day OR two OSS monopiles per day. Additionally, clarify if this scenario is still feasible if nighttime pile driving is not authorized and how the effects of pile driving would or would not change if nighttime pile driving does not occur.	BOEM confirms that a maximum of 3 WTGs OR 2 OSS could be installed per day (i.e., a maximum of three foundation piles per day). There is no separate schedule assuming no nighttime pile driving authorization. Should no nighttime pile driving be authorized, the assumption remains the same that up to three monopiles may be installed over a discontinuous 12-hour period during daylight hours.
20	30	A description of planned operation and maintenance activities for the OSS(s) is missing. Additionally, please clarify if the estimate of 52 CTV round trips annually is based on planned weekly maintenance activities or if this is a best estimate of frequency based on the “as needed” activities listed on Table 3.8 (noting that there are no activities identified in the table with a weekly frequency).	A description of planned operation and maintenance activities is provided in Table 3.9 of the BA. It represents the best available information on operations and maintenance and aligns with the information available in the COP. The 52 CTV round trips is the best available estimate of O&M frequency for this vessel class.
21	33	Unmitigated detonations are not mentioned in the effects analysis for UXOs and would be inconsistent with the activities described in the MMPA proposed ITR. As such, an explanation of why unmitigated detonations are mentioned is necessary. If unmitigated detonations are possible/planned, further discussion with us and our MMPA team is necessary.	No unmitigated detonations are proposed. As stated in the BA, Revolution Wind has identified 16 UXOs on the RWEC corridor to date. Subsequent to BA submittal, Revolution Wind determined that all 16 of these devices can be avoided without the need for detonation by rerouting RWEC installation. However, BOEM recognizes that additional devices could be discovered prior to or during construction and some of these devices may need to be detonated in place. Consistent with the ITR, BOEM is requesting incidental take coverage for detonation of up to 13 devices to account for this risk. For all UXO detonations, Revolution Wind will employ a noise attenuation system or systems capable of achieving a minimum 10-dB reduction in noise intensity. Technologies under consideration include big bubble curtain, Hydro-Sound Damper, and the AdBm Heimholz resonator.
22	35	Table 3.12 appears to be incomplete as the “Ports to be Used” column is filled out for only two of the rows and not all of the ports identified in Table 3.13 are included. While we understand that the exact number of trips to each port is not currently known, please provide the best reasonable	Please see Attachment A for currently available information on ports under consideration, the number of vessels and vessel trips by class, and representative vessel specifications.

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		estimate of the maximum estimated trips per potential port. Additionally, please add vessel length to Table 3.12.	
23	35-36	Clarify if Tables 3.11 and 3.12 incorporate the information in Appendix B or if that should be considered in addition to the information listed in the two tables. If the latter, vessel length, speed, and draft is needed for the vessel traffic described in Appendix B. Note that vessel types in Appendix B do not match all the vessel types in Table 3.12.	Please see Attachment A for currently available information on ports under consideration, the number of vessels and vessel trips by class, and representative vessel specifications.
24	35	Clarify if Table 3.12 includes potential vessel transits from Europe or "elsewhere in the world." Based on the text in the BA we understand that this would be no more than 10 trips between the project site and European ports. As indicated above, clarification is necessary regarding "elsewhere in the world."	Please see Attachment B for currently available information on distant ports, ESA-listed species occurrence in potential transit routes, and an assessment of potential impacts from vessel traffic.
25	37	Clarify the round trip distance for O&M trips from Davisville (note the sentence that states, "This would equate to an estimated 2,730 O&M vessel round trips over the 35-year life of the project, averaging approximately 82 miles round trip from the O&M port facility in Davisville, RI, and 96 miles round trip.) Additionally, clarify if all O&M vessel trips will originate from Davisville, RI; if not please include the additional ports that will be used.	Please assume all O&M vessel trips will originate from Davisville, RI (Quonset Point) at a round trip distance of 82 miles. Other facilities would only be used as backup ports.
26	35-37	Clarify if fisheries/benthic survey vessel usage is incorporated in Tables 3.12 and 3.14	Please see Attachment A for currently available information on ports under consideration, the number of vessels and vessel trips by class, and representative vessel specifications.
27	37	Please include the following information for all project vessels anticipated to be used in the O&M and Decommissioning phases: number and types of project vessels to be used, size (length, beam, draft, deadweight tons) speed, and operational speeds (maximum and average). This information is necessary to assess effects of vessel traffic on ESA-listed species. Additional information about necessary vessel/aircraft information and vessel strike analysis can be found in the ESA Information Needs	Please see Attachment A for currently available information on ports under consideration, the number of vessels and vessel trips by class, and representative vessel specifications.

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		document. Similar information should be provided for any aircraft and uncrewed systems usage.	
28	38	Please consider including in the BA the recent information shared by Orsted during the seafloor preparation presentations. These presentations provided greater specificity about the proposed activities; this additional detail would help to clarify the likely effects of these activities on listed species.	This information has been incorporated into the EFH Assessment for the project, and an addendum to that assessment addressing new and updated information. Those two documents are incorporated by reference. Seabed preparation impacts from foundation and cable installation are addressed in Sections 5.1.1.2 and 5.1.2.4 of the EFH Assessment, respectively. New information provided by Revolution Wind identifying the locations where specific cable installation methods will be used is summarized in Section 2 of the EFH addendum.
29	38	Clarify how large ripples and megaripples will be flattened and the approximate area impacted.	Revolution Wind has determined that leveling of ripples and megaripples will not be required for cable installation. Some flattening of these features may result from operation of the boulder plow and other cable trenching devices (e.g., the hydrojet and mechanical plows). The affected area is the estimated acres of benthic habitat impacts by habitat type from cable installation, which is incorporated by reference from the Essential Fish Habitat Assessment (see EFH Section 5.1.2.4, Tables 5.7 and 5.8). As documented, bedform features in soft-bottomed habitat are expected to recover in 18 to 24 months through natural sediment transport processes.
30	41	Please provide additional information (operational speed, water intake rate, intake opening size) on the water intake for the jet plow to inform our assessment of the risk of entrainment to prey species.	The March 2023 addendum to the EFH assessment summarizes currently available information on proposed cable installation technologies and where they will be employed. Only some of these technologies, i.e., the hydrojet and capjet, have hydraulic intakes. The mechanical plow, boulder plow, and mechanical cutter do not. Typical water intake rates for commercially available hydrojet technologies range from 800 to 3,000m³ per hour based on reported specifications (e.g., https://www.prysmiangroup.com/en/markets/generation-transmission-and-distribution/installation-capabilities-and-submarine-solutions/installation-capabilities). Hydrojet intakes are screened to avoid and minimize entrainment of small fish but will entrain smaller organisms. Inspire Environmental (2018) evaluated potential hydrojet entrainment effects on planktonic organisms assuming an intake rate of 1,400 m³/hour at a speed over ground of 1,600 to 3,200 meters per day, which is usefully

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			representative of the available range of technologies. This equates to an intake rate of approximately 33,600 m³ per 24-hour workday. They determined that entrainment mortality from South Fork Wind project construction would impact less than 0.001 percent of the total zooplankton and ichthyoplankton abundance within a 25,270 hectare study area, as defined by a 15 to 25 km-wide buffer around the inter-array and export cable installation corridors. Inspire Environmental (2020) concluded that entrainment mortality rates from Revolution Wind construction would be similar to those from South Fork Wind construction, scaled to the proportion of overall cable length where this type of equipment is used.
31	41	Clarify what type of dredge will be used for cofferdam installation.	The seabed within the cofferdams would be dredged using a backhoe excavator deployed from a barge. The dredged material would be retained on a barge and used as backfill when construction is completed.
32	41	Additional information is needed about the sheet pile installation methods proposed for the sea-to-shore transition. Clarify if only sheet piles will be used, how many piles will be installed, duration of pile driving per day, and provide any other relevant project information. Additionally, clarify if goal posts will be installed to support the casing pipes. If so, additional project details are needed to describe those activities.	The HDD exit pit locations are in the nearshore zone in soft bottom habitat composed of mud and sandy mud. Proposed exit pit coordinates are as follows: HDD Exit Pit (East) Lat: N041° 34' 57.99" Long: W071° 25' 30.86" HDD Exit Pit (West) Lat: N041° 34' 56.75" Long: W071° 25' 32.10" No SAV or other sensitive habitat features are present in this area, as documented in the EFH Assessment and the Benthic Habitat Mapping Report (Inspire Environmental 2023, included as Appendix A to the EFH Assessment. Revolution Wind will avoid construction in state waters during the peak SAV growing season (i.e., July 1 to September 1), to minimize potential TSS and sediment deposition effects associated with sea-to-shore transition construction.

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			Revolution Wind is considering four potential HDD exit pit construction methods: • Casing pipe method: The HDDs would be directed into a casing pipe driven diagonally into the seabed. No dredging required for this construction method. The casing pipes would be installed using a pneumatic hammer deployed from a barge. Each pipe would be supported by up to six "goal posts," each comprising two vertical sheet piles driven into the substrate with a horizontal crossbeam. The goal post vertical sheet piles would be installed using vibratory hammer. Each vertical pile would be approximately 30 m (100 ft) long, by 0.6 m (2 ft) wide, by 2 cm (1 in) thick. Installation of the 44 goal post sheet piles would require approximately 6 days, assuming 7 piles installed per day, and 30 minutes of vibratory hammer operation per pile during the 7 a.m. to 6 p.m. construction period permitted by local noise ordinance (North Kingstown, RI Ord. No. 83-3(a)). Once sea-to-shore transition construction is complete the vertical goal post sheet piles would be removed using a vibratory hammer. The estimated duration of hammer operation for removal would be approximately the same as for installation. • Uncontained dredging: HDD exit pits will be dredged using a backhoe excavator and Venturi eductor device. No temporary construction structures would be used so no pile driving would be required. Once sea-to-shore transition construction is complete the HDD exit pits would be backfilled with the original dredged material. • Sheet pile cofferdam: The HDD exit pits will be contained within temporary sheetpile cofferdams. Once constructed, the seabed within the cofferdams will be dredged using a backhoe excavator deployed from a barge. Each cofferdam would measure 50 m (164 ft) long, by 10 m (33 ft) wide, and would extend 3 to 4 m (10 to 14 ft) above the water surface. Assuming standard sheet pile dimensions of 30 m (100 ft) long, by 0.6 m (2 ft) wide, by 2 cm (1 in) thick, this equates to approximately 197 sheet piles per cofferdam. Each cofferdam would require approximately 14 days to install at an installation rate of 14 sheet piles per day. Approximately 30 minutes of vibratory hammer operation would be required per pile, or 7 total hours during the 7 a.m. to 6 p.m. construction period permitted by local noise ordinance

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			(North Kingstown, RI Ord. No. 83-3(a)). Concurrent pile driving is not being proposed; therefore installation of both cofferdams would require 28 days. Once sea-to-shore transition construction is complete, the HDD exit pits would be backfilled with the original dredged materials and the cofferdam sheet piles would be removed using a vibratory hammer. The estimated duration of hammer operation for cofferdam removal would be approximately the same as for installation (i.e., 30 minutes/pile, 14 piles/day, 14 days/cofferdam, 28 days total). • Gravity cofferdam: HDD exit pits contained within pre-constructed cofferdams lowered onto the seabed from a barge and held in place by weight. No pile driving is required for installation or removal. Once constructed, the seabed within the cofferdams will be dredged using a backhoe excavator deployed from a barge. No temporary construction structures would be used so no pile driving would be required. Once sea-to-shore transition construction is complete, the HDD exit pits would be backfilled with the original dredged materials and the cofferdams would be lifted onto a barge for demobilization.
33	41	Clarify if 10 percent (similar to the RWEC) of the OSS link route will require additional cable protection measures.	Cable protection will be required on up to 10 percent of the OSS-link route. As stated, the precise locations where cable protection will be required are not currently known. Post-construction HRG surveys will be used to identify locations where cable burial to desired target depths of 4 to 6 feet has not been achieved. Revolution Wind will assess the need for cable protection at each location based on site-specific risk factors, including sediment mobility, and the likelihood of cable disturbance by vessel anchoring, fishing activity, and other activities. BOEM is providing a clarification regarding RWEC cable protection. Revolution Wind initially estimated that up to 10 percent of RWEC circuit length would require cable protection where post-construction surveys determine burial to desired target depths has not been achieved. Subsequent to submittal of the BA on January 30, 2023, Revolution Wind decreased this estimate to 5 percent of route length for each RWEC circuit. These specific locations where cable protection will be required are not currently known for the same reasons described above.

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			In addition to the above, cable protection will be required at seven known locations where the RWEC crosses buried utilities identified during pre-construction surveys. The indicative locations for the crossing points are displayed on the Revolution Wind pop-up viewer and are as follows: - U.S. Army/RI (abandoned water main): Lat 41.506918, Long -71.409197 - Verizon (telecommunications cable): Lat 41.492481, Long -71.408455 - Verizon (telecommunications cable): Lat 41.491883, Long -77.4084 - Verizon (telecommunications cable): Lat 41.488649, Long -71.408158 - Unknown (TBD): Lat 41.488341, Long -71.408144 - Unknown (TBD): Lat 41.487651, Long -71.408103 - Unknown (TBD): Lat 41.431417, Long -71.407095 Cable protection requirements at these locations comprise an additional 9.5 percent of RWEC route length. Therefore, the total amount of RWEC cable protection required at currently known and unknown locations will comprise approximately 14.5 percent of route length.
34	44	Clarify if HRG surveys will continue during the O&M phase or just prior to, during, and immediately after construction.	Revolution Wind will conduct HRG surveys before, during, and immediately after construction in years 1-5. The Year 1 survey effort is projected at 9,559 km over 137 days. Following construction (i.e., in Years 2–5), Revolution Wind anticipates to survey 2,117 km over 31 days per year.
35	44	NMFS 2021a did not assess the deployment of PAM buoys, it considered the deployment of meteorological buoys. Please provide additional information about the proposed PAM buoys, including number and mooring type.	Revolution Wind is proposing to deploy four PAM buoys for construction monitoring. The buoys would be placed approximately equidistant on a 5000m radius circle centered around each foundation site before pile driving begins. The buoys will be relocated to each new foundation site as construction proceeds. Revolution Wind will most likely deploy autonomous or moored-remote PAM devices, including sonobuoy arrays or similar retrievable buoy systems. Revolution Wind is not considering seafloor cabled anchoring systems. Attachment 4 of the Protected Species Mitigation and Monitoring Plan (included as Appendix C of the BA) provides a thorough description of the PAM systems under consideration.

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			BOEM notes that NMFS has applied NMFS (2021) PDC 6 terms and conditions to PAM buoy deployment in prior Section 7 consultations (see Section 7.5.1 of the Biological Opinion for the South Fork Offshore Energy Project, GARFO-2021-00353). BOEM assumes that similar terms and conditions will apply to the Revolution Wind project, with modifications as appropriate at NMFS discretion.
36	46	Clarify how many traps will be used for the BACI and BAG surveys. The BA states ten traps will be used for each survey, but later in the paragraph states that there will be four ventless traps and two vented traps, which would be only six traps per trawl.	BOEM confirms that each survey trawl will comprise six ventless traps, and four standard vented traps. BACI and BAG trap surveys in the lease area will both use 10-trap trawls spanning 900 feet of groundline, with traps separated from each other by approximately 100 feet. Details of this plan are provided in the BA as Appendix A – Fisheries Research and Monitoring Plan.
37	46	The Fisheries Research and Monitoring Plan mentions a State Waters Ventless Trap Survey but it is not mentioned in this section. Please clarify if this survey is part of the proposed action.	The state waters ventless trap survey is conducted by the Rhode Island Department of Environmental Management (RIDEM) as an extension of their existing and long running lobster survey program. BOEM has determined that this ongoing activity is the sole responsibility of RIDEM and would continue regardless of the approval decision for the proposed action; as such, BOEM has determined these surveys are not part of the proposed action and they not considered further in the BA. However, the data generated by RIDEM's survey program will inform the findings of the FRMP (see Appendix A of the FRMP, provided as Appendix A to the BA).
38	47	Confirm if the acoustic telemetry study across the Orsted/Eversource lease sites was already included in the South Fork BA and subsequent biological opinion as the BA states that Revolution Wind is providing additional funding/receivers to ongoing survey efforts. Additionally, clarify if capture of animals for the telemetry survey is part of the proposed action and if so, describe the survey methods, timing, duration, and target species.	The target species for the HMS acoustic telemetry study are blue fin tuna, blue sharks, and shortfin mako, although other HMS species (e.g., marlin) may be tagged opportunistically if captured during tagging trips. The methods are those referenced within Section 4.3.1 of the Revolution Wind Fisheries Research and Monitoring Plan (Appendix Y of the Revolution Wind COP). This study deployed 17 acoustic receivers in the Revolution Wind lease area in May 2022, and those receivers will remain at those locations through December 2026. Additionally, acoustic receivers were also deployed in South Fork Wind (n=2) and Sunrise Wind (n=13) lease areas in May 2022 as part of the HMS telemetry study. Due to Project constraints, a total of 32 receivers rather than the 36 referenced in the Plan are deployed. As stated in the Plan, ropeless technology (AR Buoys) was selected to minimize risks to marine mammals and other

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			protected species. In total, 150 transmitters were acquired and tagging efforts will occur in summer of 2023 and continue through 2025. All tagged animals will be collected using rod and reel, and procedures will follow the New England Aquarium Animal Care and Use Protocols. This Project will utilize the same tagging methodology and technology as the South Fork Wind Project and is intended to increase the detection and tracking capabilities of this regional acoustic telemetry network. The fundamental difference of the Revolution Wind study is centered around the objective analysis of these data to assess the spatial distribution and behavior of HMS tagged animals across a broader range than was initially focused on with South Fork.
39	51	Note that Table 3.17 still mentions 102 foundations.	BOEM apologies for this oversight and confirms that the proposed action includes the installation of up to 79 WTGs and 2 OSS.
40	54	Table 3.18 contains broad mitigation and monitoring measures proposed by Revolution Wind and refers to Appendix B - Protected Species Mitigation and Monitoring Plan (actually Appendix C) for more details. However, the PSMMP only contains additional details about measures for marine mammals. If Table 3.18 is only going to be a summary of proposed measures, the relevant details must be provided in an appendix. Alternatively, the complete text of the measures should be included in the table. For example, Table 3.18 states that "shutdown and clearance zones for marine mammals and sea turtles will be established…" but does not say how big those zones will be, duration of monitoring, number of PSOs, etc. Additionally, please ensure the table reflects the most up to date measures proposed in the proposed MMPA ITR (https://www.fisheries.noaa.gov/action/incidental-take-authorization-revolution-wind-llc-construction-revolution-wind-energy) or incorporate those by reference. Please also clarify what it means for Revolution Wind to be the "anticipated enforcing agency" this seems to be highly problematic for the developer to be in charge of enforcing measures.	Correct, the February 2022 PSMMP is provided as Appendix C to the Biological Assessment. We regret the editorial error. Current mitigation measures proposed for protection of ESA-listed species are provided as Attachment C to this addendum.

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41	57	Additional relevant details are needed for some mitigation and monitoring measures listed in Table 3.19 as they do not all contain complete information or are unclear. For example, measure #8 states marine mammal shutdown zones would be applied to sea turtles; however, that seems to be impractical given the likely detection distance for sea turtles. Please describe the planned shutdown and clearance zones and monitoring plans with specifics. As indicated above, please provide the specific language of the measures for UXO/MEC detonations (e.g, rather than just stating "visual monitoring" identify the required sea turtle and marine mammal clearance zones, PSO requirements, etc.). Additionally, clarify if BOEM is applying all the vessel strike avoidance measures in the proposed MMPA ITR to the O&M and decommissioning phases, the BA states they would be applied "as appropriate."	Current mitigation measures proposed for protection of ESA-listed species are provided as Attachment C to this addendum.
42	57	Confirm if there are any time of year restrictions for any dredging or clearance activities for large ripples and megaripples	Revolution Wind has determined that seabed leveling and dredging will not be required as part of seabed preparation for cable installation (dredging will be used for sea-to-shore transition construction as described above in the response to request #32). Some incidental leveling of ripples and megaripples would result from operation of the boulder plow and other cable trenching equipment. These effects would occur within benthic impact footprint for cable installation activities described in the BA and this addendum. The only time of year restriction identified to date applies to dredging and seabed clearance activities in RI state waters as follows: • Feb 1 to Aug 30: North of the COLREGS line for state important species. (Defined in RI CRMC Category B Assent Final Decision, issued on February 8, 2023).
43	57	Clarify if any mitigation/monitoring measures are proposed during the pile driving installation of the cofferdam/sheet piles/goal posts.	Current mitigation measures proposed for protection of ESA-listed species are provided as Attachment C to this addendum.
44	58	Please incorporate the plan (PAM Plan, Pile Driving Monitoring Plan, etc.) submittal timing from the Sunrise BA,	NMFS's request is noted. At this time, BOEM is not changing the submission deadline beyond 90 days for these plans. BOEM notes the

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		all of these plans should be submitted 180 days in advance rather than 90 days.	draft ITR for Revolution Wind cites 180 day submission deadlines. Assuming this does not change in the final ITR, the lessee would need to comply with the earlier deadline. The level of detail needed for a review is unlikely to be available 180 days out from the planned start of an activity. The language regarding timing of plan submission in the BA has not been revised.
45	133/146/147	The estimates of pile driving noise and distances to thresholds of concern associated with the sea-to-shore transition site were developed using a tool that has been replaced. Please provide us with estimates of noise from pile installation at the sea-to-shore installation using the NMFS Multi-Species Pile Driving Calculator. The calculator and a PowerPoint presentation providing an overview and instruction is available on NMFS website (https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance, scroll to the bottom under “Other NMFS Acoustic Thresholds and Tools”).	To clarify, BOEM did not use the GARFO noise impact assessment tool to generate the threshold distances presented in the BA. We reported modeled threshold distances developed by Revolution Wind/JASCO to support the COP and ITR. JASCO used the GRLWEAP/PDSM/FWRAM models, and the MONM model, respectively, to estimate threshold distances for pneumatic hammer (casing pipe installation) and vibratory hammer (sheet pile installation) operation. The BA reports the minimum and maximum modeled threshold distances for all species in each hearing group across all conditions and pile driving methods. The models used by JASCO provide a far more accurate representation of potential noise impacts than the generalized formulae used in the NMFS multi-species calculator. Therefore, we do not believe it is necessary revise the estimated distances to thresholds using the updated NMFS tool.
46	170	Section 5.5 of the BA is missing consideration of effects from habitat disturbance from UXO/MEC detonations and seafloor preparation activities (i.e. boulder plow, depressions, ripples and megaripple flattening). Consideration of the effects of entrainment risk to prey species due to the jetplow are also missing.	BOEM has incorporated the EFH Assessment by reference. Section 5.1.1.3 of the EFH Assessment presents an analysis of the effects to the seabed habitat from UXO/MEC denotations and seabed preparation activities. An analysis of entrainment risk to prey species is provided in Section 5.1.2.4.
47	176	Clarify which sea-to-shore construction method was considered for the turbidity analysis.	The TSS and sediment deposition impact analysis is based on modeled impacts of uncontained dredging of the two HDD exit pits using a backhoe excavator and venturi eductor device. This would be the most impactful of the four sea-to-shore transition construction methods under consideration. The analysis provided in the BA relies on the suspended sediment plume and deposition modeling results in the Hydrodynamic and Sediment Transport Modeling Report (RPS 2022), presented as COP Appendix J.
48	general	We have identified a number of additional mitigation measures that we encourage BOEM to consider incorporating into the proposed action. These include	Thank you for your comment. BOEM is not proposing any additional mitigation measures at this time.

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		incorporating measures to limit the potential for pile driving in December, requiring that ropeless/on-demand gear be used for ventless trap surveys, and incorporating measures to reduce the risk of vessel strike to Rice's whales during transits in the Gulf of Mexico (set of measures can be provided).	

5.0 References

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ThayerMayhan (ThayerMahan Inc.). 2023. *Assessing Advanced Technology to Support an Option for Nighttime Monopile Installation.* Prepared for Orsted/Eversource by ThayerMahan, Inc. Groton, CT.

USDOT (U.S. Department of Transportation). 2023. *Port Performance Freight Statistics Program: Annual Report to Congress.* USDOT Bureau of Transportation Statistics. Washington, DC: January, 2023.

Attachment A – Revised Summary of Vessel Traffic and Vessel Specifications by Class, and Regional Ports Under Consideration for Construction Support

This attachment summarizes currently available information requested by NMFS related to construction vessel traffic for the Revolution Wind project. NMFS has requested detailed information about the classes of vessels proposed for project construction, and the number of vessels, planned number of trips between the Lease Area and regional ports, and specifications (i.e., length, beam, draft, tonnage, and typical operational speed) for each class. BOEM has obtained all currently available information from the lessee, supplemented with additional commercially available information for the various vessel classes operating in the offshore wind industry. This information is presented in Tables A-1 and A-2 below.

Table A-1 summarizes the following:

- Vessel classes proposed for RWF and RWEC construction.
- The number of vessels, estimated number of round trips between the Lease Area and regional ports, and associated construction element by vessel class
- Indicative vessel size and operational speed specifications by vessel class
- Currently identified ports under consideration for construction support by vessel class, which comprise:
    - New York: Port of Montauk (MON), Port Jefferson (JFF), Port of Brooklyn (BRK)
    - Rhode Island: Port of Providence (PRV), Port of Davisville, and Quonset Point (DVS, QST),
    - Connecticut: Port of New London (NLD),
    - Virginia: Port of Norfolk (NFK),
    - Massachusetts: New Bedford Marine Commerce Terminal (NBD), Cashman Shipyard (Quincy, MA; QNC),
    - Maryland: Sparrow's Point (SPP),
    - New Jersey: Paulsboro Marine Terminal (PLB)

The information in the first two bullets was obtained from the lessee in March 2023. No specific vessels have been selected for project construction at this time. BOEM is providing specifications for representative vessels in each vessel class obtained from several available sources (Boskalis 2020, 2022; Buljan 2023; HGIM 2020; Marine Traffic 2023; Memija 2023; BOEM 2022; Ørsted 2023; Prysmian Group 2018; Seaway 2022; Skopljak 2022; Wärtsilä 2023).

Vessel types used for project O&M and the anticipated number of O&M trips per year are identified in Table 3.14 in the main body of the BA. As shown, routine maintenance activities would be conducted by crew transport and service operations vessels (CTVs and SOVs, respectively). Non-routine maintenance may be conducted by the same types of jack-up vessels, cable laying vessels, and large material and support barges used for project construction. Therefore, the representative vessel specifications provided in Table A-1 for each of these vessel classes can also be used to evaluate potential impacts from O&M vessel traffic.

Table A-2 identifies regional ports currently (as of March 2023) under consideration by Revolution Wind for project construction support. This list includes ports that were previously under consideration for construction support but are not currently identified in Table A-1. The number of vessels and distribution of vessel trips between ports is subject to change as project planning proceeds.

Table A-1. Vessel classes proposed for project construction, number of vessels and anticipated number of vessel trips required for project construction, and indicative specifications by vessel class.

Vessel Type	Number of Vessels	Vessel Trips	Anticipated Ports[‡]	Construction Element						Representative Specifications by Class				
				Foundations	OSS	RWEC	IAC	OSS-Link	WTGs	Length ft (m)	Beam ft (m)	Draft ft (m)	Operating Speed (knots)	Tonnage[†]
Anchor Handling Tug	2	50	QST	●	--	●	--	●	--	98 (30)	49 (15)	23 (7)	4	345 GT
Boulder Clearance Vessel	2	13	PRV, QST, DVS, NBD	●	●	●	●	●	--	312 (70)	66 (20)	23 (7)	23	3,285 LT
Bubble Curtain Vessel	1	20	PRV	●	--	--	--	--	--	295 (90)	66 (20)	23 (7)	23	4,900 T
Cable Burial Vessel	1	6	PRV, QST, DVS, NBD	--	--	--	●	●		328 (100)	98 (30)	16 (5)	2.4	12,200 Te
Cable Burial Vessel - Remedial	1	1	PRV, QST, DVS, NBD	--	--	●	--	--	--	328 (100)	98 (30)	16 (5)	2.4	12,200 Te
Cable Lay & Burial Vessel (Export)	1	5	PRV, QST, DVS, NBD	--	--	●	--	--	--	427 (130)	98 (30)	16 (5)	2.4	10,800 Te
Cable Lay Vessel (Barge)	1	3	PRV, QST, DVS, NBD, QNC	--	--	●	--	--	--	400 (122)	110 (33.5)	25 (7.6)	2.4	10,000 Te
Cable Laying Vessel	1	6	PRV, QST, DVS, NBD	--	--	--	●	●	--	459 (140)	95 (30)	16 (5)	2.4	10,000 Te
Crew Transfer Vessel (CTV)	6	870	JFF, PRV, QST, DVS, NBD, NLD	●	●	●	●	●	●	98 (30)	36 (11)	10 (3)	23	235 GT
DP2 Construction Vessel	2	7	PRV	--	--	●	●	●	--	758 (231)	160 (49)	33 (10)	11	60,825 GT
Fall Pipe Vessel	1	6	PRV	●	--	--	--	--	--	531 (162)	125 (38)	21 (6.4)	13	28,734 T

Vessel Type	Number of Vessels	Vessel Trips	Anticipated Ports‡	Construction Element						Representative Specifications by Class				
				Foundations	OSS	RWEC	IAC	OSS-Link	WTGs	Length ft (m)	Beam ft (m)	Draft ft (m)	Operating Speed (knots)	Tonnage†
Fuel Bunkering Vessel	1	8	To be determined	--	--	--	--	--	●	295 (90)	62 (19)	17 (5.2)	10	3,500 T
Guard Vessel/Scout Vessel	6	8	PRV, QST, DVS, NBD, New York or Asia	●	●	●	●	●	--	90 (27)	33 (10)	16 (5)	12	700 T
Heavy Lift Installation Vessel	1	1	NLD, QST	●	--	--	--	--	--	787 (240)	164 (50)	44 (13.5)	10	61,000 T
Heavy Lift Installation Vessel (Secondary Steel)	1	1	NLD, QST	●	--	--	--	--	--	787 (240)	164 (50)	44 (13.5)	10	61,000 T
Heavy Transport Vessel	5	26	NLD, QST, Canada or Asia	●	●	--	--	--	--	715 (218)	141 (43)	33 (10)	13.5	50,000 Te
Helicopter	1-2	76	DVS	●	●	--	--	--	●	n/a	n/a	n/a	n/a	n/a
Jack-Up Installation Vessel	1	20	NLD, QST	--	--	--	--	--	●	459 (140)	131 ft (40)	23 (7)	10	8,000 T
Lift Boat – Jack-Up Accommodation Vessel	1	1	JFF, QST	●	●	●	●	●	●	787 (240)	164 (50)	23 (7)	10	61,000 T
Platform Supply Vessel	3	85	PRV	●	--	--	--	--	--	300 (92)	69 (21)	21 (6.5)	11.5	6,200 T
Pre-lay Grapnel Run Vessel	2	6	PRV, QST, DVS, NBD, New York or Gulf of Mexico	--	--	●	●	●	--	262 (80)	66 (20)	23 (7)	23	2,400 GT

Vessel Type	Number of Vessels	Vessel Trips	Anticipated Ports‡	Construction Element						Representative Specifications by Class				
				Foundations	OSS	RWEC	IAC	OSS-Link	WTGs	Length ft (m)	Beam ft (m)	Draft ft (m)	Operating Speed (knots)	Tonnage†
PSO Noise Monitoring Vessel	4	80	PRV	●	--	--	--	--	--	295 (90)	66 (20)	23 (7)	23	4,900 T
Safety Vessel	2	100	JFF, QST	●	●	●	●	●	●	90 (27)	33 (10)	16 (5)	12	700 T
Service Operations Vessel (SOV)	2	7	JFF, QST	●	●	●	●	●	●	268 (82)	59 (18)	24 (7.5)	23	4,100 T
Supply Barge	1	4	PRV, QST, DVS, NBD, New York or Gulf of Mexico	●	--	●	●	●	--	300 ft (91)	44 (13.4)	17 (5)	4	5,480 T
Supply Vessel	1	30	PRV	●	●	●	●	●	●	348 (106)	72 (22)	31 (9.4)	12	6,000 GT
Survey Vessel	1	11	PRV, QST, DVS, NBD, New York or Gulf of Mexico	--	--	●	●	●	--	164 (50)	39 (12)	23 (7)	18	235 GT
Tow Tug	5	29	QST	●	--	--	--	--	●	148 (45)	49 (15)	23 (7)	4	450 GT

Symbols: ● = vessel used for this element, -- = vessel not used for this element.

‡ Potential ports in New York comprise the Ports of Montauk, Jefferson, and Brooklyn. Some vessels may deploy to the project area from currently unidentified ports in the Gulf of Mexico, Canada, and Asia. Potential vessel trips and transit routes for undetermined distant ports are addressed in Attachment B.

† GT = gross tonnage; ITC = International Convention on Tonnage Measurement; LT = long ton; T = imperial tons; Te = metric tonne

Table A-2. Regional ports under consideration for project construction and O&M support.

State	Port†	Approximate Travel Distance to RWF (miles)	Construction Crew Mobilization, Surveys and Monitoring	WTG Component Staging	Foundation Staging, Advanced Component Fabrication	General Construction and/or O&M Hub	O&M - Electrical Monitoring and Support§
New York	MON	48	--	--	--	●	--
	JFF	113	●	--	--	●	--
	BRK	175	--	--	--	●	--
Rhode Island	PRV	56	●	●	●	--	●
	DVS, QST	41	--	--	--	●	--
Connecticut	NLD	54	●	●	--	--	--
Virginia	NFK	408	--	●	--	--	--
Massachusetts	NBD	34	●	●	--	--	--
	QNC	195	--	--	--	●	--
Maryland	SPP	581	--	--	●	--	--
New Jersey	PLB	325	--	--	●	--	--

Symbols: ● = port considered for this element, -- = port not considered for this element.

† MON = Port of Montauk, JFF = Port Jefferson, BRK = Port of Brooklyn, PRV = Port of Providence, DVS = Port of Davisville , QST = Quonset Point, NLD = Port of New London, NFK = Port of Norfolk, NBD = New Bedford Marine Commerce Terminal, QNC = Cashman Shipyard (Quincy, MA), SPP = Sparrow's Point, PLB = Paulsboro Marine Terminal

‡ Approximate distance from center of RWF to identified port assuming straight line travel to navigation lane entry (Tech Environmental 2021). Travel distance to Port Jefferson, Brooklyn, Providence, and Cashman Shipyard estimated using similar methods.

§ Monitoring of power transmission and transmission cable performance. O&M vessels may not dispatch from this port.

In addition to the ports shown on this table, vessels used for construction and/or transporting materials may initially travel to the project area from distant ports in Canada, the Gulf of Mexico, Europe, or Asia. These vessels may call on these or other regional ports for inspections, crew transfers, and bunkering before arriving at the Lease Area. Vessel trips from distant ports not listed in this table are discussed in Attachment B to this addendum.

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Attachment B – Analysis of Effects to Listed Species from Vessel Traffic to/from Ports Outside the United States

This attachment summarizes currently available information about potential construction vessels used to construction of Revolution Wind Farm (RWF) and Revolution Wind Export Cable (RWEC), that may originate from currently unidentified ports in the United States and elsewhere in the world. This report assesses potential impacts associated with Project vessel traffic that could originate from yet to be identified ports in the Gulf of Mexico, Canada, Europe, and Asia to Endangered Species Act (ESA) -listed species under National Marine Fisheries Service (NMFS) jurisdiction. Only ESA-listed species that occur along possible vessel routes and potential vessel traffic from foreign ports are assessed in this report. ESA-listed species that occur in the Project action area and all other potential impacts associated with other components of the Project, including potential vessel traffic from domestic ports, are addressed in the BA and Attachment A to this addendum.

1.0 Possible Regions of Origin

Attachment A summarizes the ports under consideration for construction support by vessel class, the total number of vessel trips between these ports by vessel class, and estimated travel distance between these ports and the project area. The ports by vessel class identified Table A-1 can be divided into the following categories:

- Identified ports in RI, MA, CT, and NY
- Other potential ports in NY (Montauk, Brooklyn)
- Other east coast ports identified in the COP (Sparrow's Pt., MD; Paulsboro Marine Terminal, NJ; Norfolk, VA)
- Ports to be determined in the Gulf of Mexico (GOM)
- Ports to be determined in Canada
- Ports to be determined Europe and/or Asia

Vessel trips to currently known or likely ports identified in the COP are described in Attachment A. Related effects to ESA listed species from vessel trips to and from these ports are addressed in the BA. Appendix B in the BA describes currently planned vessel trips to ports to be identified in the Gulf of Mexico and potential effects to ESA listed species in vessel travel corridors. That assessment considered up to 33 potential vessel trips to four yet to be identified ports. As shown in Table A-1, pre-lay grapnel run vessels, supply barges, and survey vessels are the vessel classes most likely to embark from GOM ports. Revolution Wind has decreased the maximum number of vessel trips identified in Appendix B to the BA as potentially originating from the GOM from

33 to 21. However, this number could increase or decrease, depending on the port of origin for the fuel bunkering vessel and how other vessel trips are distributed between the GOM and other identified potential ports.

Vessels that do not originate from the ports identified in Attachment A, Tables A-1 and A-2, or from ports in the GOM may travel with components and equipment directly to the Project area from currently unknown ports on the east coast of Canada, ports on the North Sea or Baltic Sea in Europe, or ports in Asia (Japan, South Korea, Taiwan, or mainland China). A maximum and probable number of trips by vessel class originating from each region can be inferred from Table A-1 and reflects the best available information at this time. This information is summarized in Table B-1.

Table B-1. Vessel classes for Revolution Wind construction and estimated number of vessel trips potentially originating from ports outside the United States.

Vessel Class	Region(s) of Origin	Number of Vessel Trips Over 2-year Project Construction Period		Representative Specifications by Class				
		Maximum Possible	Likely	Length ft (m)	Beam ft (m)	Draft ft (m)	Operating Speed (knots)	Tonnage†
Fuel bunkering vessel	Unknown	8	8	295 (90)	62 (19)	17 (5.2)	10	3,500 T
Heavy transport vessel	Canada or Asia	26	6	715 (218)	141 (43)	33 (10)	13.5	50,000 Te
Guard/ Scout Vessel	Asia	8	1	90 (27)	33 (10)	16 (5)	12	700 T

NMFS ESA-listed species occurring along potential travel routes from ports abroad to the Project area are listed in Table B-2. Vessels traveling from ports in Asia may take one of 3 possible routes; through the Suez Canal and the Mediterranean, around South Africa via the Cape of Good Hope, or across the Pacific and through the Panama Canal and the Caribbean Sea and/or GOM.

Table B-2. Threatened and Endangered Species that May Occur in Vessel Transit Areas between Ports of Origin and the Project Area

Species	Scientific Name	Listing Status	Potential Occurrence Port of Origin Routes			
			Gulf of Mexico	Europe	Atlantic Coast	Asia
Sea Turtles						
Green sea turtle	*Chelonia mydas*	Threatened	●	--	●	●
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	●	--	●	●
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered	●	--	●	●
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	●	●	●	●
Loggerhead sea turtle	*Caretta caretta*	Threatened	●	●	●	●
Olive ridley sea turtle	*Lepidochelys olivacea*	Threatened	--	●	●	●
Fish, Rays, Sharks						
Atlantic salmon, Gulf of Main DPS	*Salmo salar*	Endangered	--	--	●	--
Gulf sturgeon	*Acipenser oxyrinchus desotoi*	Threatened	●	--	--	--
Chinese sturgeon	*Acipenser sinensis*	Endangered	--	--	--	●
Common angelshark	*Squatina squatina*	Endangered	--	●	--	●
Common guitarfish	*Rhinobatos rhinobatos*	Threatened	--	●	--	●
Giant manta ray	*Manta birostris*	Threatened	●	●	●	●
Green sawfish	*Pristis zijsron*	Endangered	--	--	--	●
Narrow sawfish	*Anoxypristis cuspidate*	Endangered	--	--	--	●
Nassau grouper	*Epinephelus striatus*	Threatened	●	--	--	●
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	●	●	--	●
Sawback angelshark	*Squatina aculeata*	Endangered	--	--	--	●

Species	Scientific Name	Listing Status	Potential Occurrence Port of Origin Routes			
			Gulf of Mexico	Europe	Atlantic Coast	Asia
Scalloped hammerhead shark	*Sphyrna lewini*	Endangered	--	●	●	●
Smalltooth sawfish	*Pristis pectinate*	Endangered	●	--	--	●
Corals				--	--	
Boulder star coral	*Orbicella franksi*	Threatened	●	--	--	●
Elkhorn coral	*Acropora palmata*	Threatened	●	--	--	●
Lobed star coral	*Orbicella annularis*	Threatened	●	--	--	●
Mountainous star coral	*Orbicella faveolata*	Threatened	●	--	--	●
Pillar coral	*Dendrogyra cylindrus*	Threatened	●	--	--	●
Rough cactus coral	*Mycetophyllia ferox*	Threatened	●	--	--	●
Staghorn coral	*Acropora cervicornis*	Threatened	●	--	--	●
Acropora globiceps	*Acropora globiceps*	Threatened	--	--	--	●
Acropora pharaonis	*Acropora pharaonis*	Threatened	--	--	--	●
Acropora retusa	*Acropora retusa*	Threatened	--	--	--	●
Acropora rudis	*Acropora rudis*	Threatened	--	--	--	●
Acropora speciosa	*Acropora speciosa*	Threatened	--	--	--	●
Acropora tenella	*Acropora tenella*	Threatened	--	--	--	●
Euphyllia paradivisa	*Euphyllia paradivisa*	Threatened	--	--	--	●
Isopora crateriformis	*Isopora crateriformis*	Threatened	--	--	--	●
Montipora australiensis	*Montipora australiensis*	Threatened	--	--	--	●
Pavona diffluens	*Pavona diffluens*	Threatened	--	--	--	●
Porites napopora	*Porites napopora*	Threatened	--	--	--	●

Species	Scientific Name	Listing Status	Potential Occurrence Port of Origin Routes			
			Gulf of Mexico	Europe	Atlantic Coast	Asia
Seriatopora aculeata	*Seriatopora aculeata*	Threatened	--	--	--	●
Seals and Sea Lions						
Mediterranean monk seal	*Monachus monachus*	Endangered	--	--	--	●
Ringed seal – Baltic subspecies	*Phoca hispida*	Endangered	--	●	--	--
Spotted seal	*Phoca largha*	Endangered	--	--	--	●
Whales						
Blue whale	*Balaenoptera musculus*	Endangered	--	●	●	●
False killer whale	*Pseudorca crassidens*	Endangered	--	--	--	●
Fin whale	*Balaenoptera physalus*	Endangered	--	●	●	●
Humpback whale – Western North Pacific DPS	*Megaptera novaeangliae*	Endangered	--	--	--	●
North Atlantic right whale	*Eubalaena glacialis*	Endangered	--	●	●	●
Rice's whale	*Balaenoptera ricei*	Endangered	●	--	--	--
Sei whale	*Balaenoptera borealis*	Endangered	--	●	●	●
Southern right whale	*Eubalaena australis*	Endangered	--	--	--	●
Sperm whale	*Physeter macrocephalus*	Endangered	●	●	●	●

2.0 Species Analysis

This section provides species-specific analysis of potential impacts to ESA-listed species associated with Project vessel traffic that may originate from ports abroad.

Overall, similar to the analysis of potential vessel transits from local ports discussed in the BA, the number of non-local ports under consideration does not increase the number of vessel trips that are likely to occur but may affect the location and length of the transits. In addition, no upgrades or modifications at existing non-local port facility specific to the Project are anticipated and any upgrades or modifications would serve to support other maritime industries in general. Vessels from these non-local port facilities would also be utilized to serve other maritime industries if they are not a component of the Project.

Finally, individual foreign port facilities annually service thousands of vessels and import and export millions of tons of goods and materials. The vast majority of foreign port facility vessel traffic consists of cargo and container ships, tankers, commercial fishing boats, passenger ships, and private recreational vessels. The vessel types anticipated to be associated with Project construction and operation and maintenance activities are in a vessel category that make up a small insignificant percentage of overall port vessel use.

2.1 Coral Species

The listed species of corals (Table B-2) are not expected to occur within international ports or established vessel channels which are routinely dredged. Known coral reef areas and designated critical habitat of ESA-listed coral species are protected from anchoring and other potential vessel impacts. Such protected areas are in waters that would not be part of transit routes for large vessels and would therefore not be impacted by potential hull and propeller impacts from vessel operations.

Vessels traveling from ports in Europe would not cross any potential coral habitat. Vessels traveling from Asia could encounter coral habitat in 3 areas depending on the travel route: the Caribbean Sea and Gulf of Mexico, the Coral Triangle of Southeast Asia, and the Red Sea. As above, major shipping lanes are physically separated from coral reef habitat. Potential impacts to listed corals are therefore discountable.

2.2 Cetaceans

Blue whale (*Balaenoptera musculus*), false killer whale (*Pseudorca crassidens*), sei whale (*Balaenoptera borealis*), fin whale (*Balaenoptera physalus*), sperm whale (*Physeter macrocephalus*), and humpback whale (*Megaptera novaeangliae*) commonly occur in the open ocean and may be present in Atlantic Ocean vessel transit routes between Europe and the United States. Other global populations could occur in all potential vessel transit routes between Asia and the United States, including passage through the Panama or Suez Canals. Southern right whale (*E. australis*) have a circumpolar distribution in the Southern Ocean and the southernmost regions of the Atlantic, Indian, and Pacific Oceans. This species would only be exposed to project-related vessel traffic in the unlikely event that vessels traveled to the project area from Asia using southerly routes around Cape Horn or the Cape of Good Hope.

Based on currently available information, a maximum of less than 50 vessel trips could originate from ports in Europe or Asia. More likely, less than 20 vessel trips would originate from these regions over the two-year construction period. The commercial vessels used for project construction are unlikely to remain idle in the absence of the proposed action; these vessels would likely be contracted to other projects in the global marketplace. Even if every vessel originated from the same region and traveled the same route to the project area, the proposed action would result in a negligible increase in baseline levels of vessel traffic. In this context, BOEM considers the risk of an individual marine mammal encounter with project vessels in open ocean transit routes to be discountable.

Appendix B to the BA evaluated the potential effects of up to 33 construction vessel trips to the Gulf of Mexico. As stated, Revolution Wind has reduced that estimate to 21 vessel trips but has not specified which of up to four potential ports could be used. As such, the analysis presented in Appendix B to the BA remains applicable to the reduced number of vessel trips presented here. Sperm whales and Rice's whales (*Balaenoptera ricei*) could potentially occur in the vessel transit route between Gulf of Mexico non-local ports on the way toward the Straits of Florida and to the Project area or on a return trip in vessels that do not remain in the Project area. Sperm whale occurrence is more diverse throughout deep waters of the Gulf of Mexico and may overlap with vessel transit areas. Rice's whale distribution is much smaller and limited to the eastern area of the Gulf of Mexico in depths between about 330 feet (100 meters) and about 1,310 feet (400 meters). Most vessels would likely originate from ports west of the mouth of the Mississippi River and would not overlap with Rice's whales. There is no designated critical habitat for sperm or Rice's whales.

The current estimate of up to 21 potential construction trips between the Gulf of Mexico and the Project area over the lifetime of the Project are very low as compared to total regional vessel trips. Project mitigation measures include the implementation of NOAA vessel guidelines for marine mammal and sea turtle strike avoidance measures, including vessel speed restrictions. These measures would effectively avoid and minimize the likelihood of encountering and striking whales, such that the likelihood of sperm or Rice's whale injury or mortality is discountable. See the BA for additional information and assessment of potential impacts to the sperm whale species in the action area outside the Gulf of Mexico.

The Revolution Wind project area is located in habitats known to be used by the North Atlantic right whale (NARW, *Eubalaena glacialis*). As such, the species is likely to occur in all vessel transit routes that originate within the project area. The refined vessel traffic estimates presented in Attachment A increase the total number of vessel trips to 1,375 (consolidating barge and tow-tug trips) compared to the 1,351 presented in the January 30, 2023 version of the BA. This equates to approximately 12 additional vessel trips per year over the two-year construction period. BOEM concludes that this modest increase in vessel traffic would not substantively change the findings of the vessel traffic impact analysis for any marine mammal species presented in the BA. However, we are revising this analysis to incorporate potential effects on designated critical habitat for NARW.

Proposed vessel transit routes to and from the Cashman Shipyard, a facility in Quincy, MA, and transit routes from potential ports in Canada would or could travel through designated critical habitat for this species. It is not possible for vessels traveling to the project area from Cashman Shipyard to avoid travel through NARW critical habitat Unit 1, the Northeastern U.S. Foraging Area, which covers the entirety of and extends seaward of the Gulf of Maine to the boundary of the U.S. Exclusive Economic Zone (EEZ) (81 FR 4838). In addition, Revolution Wind estimates that some portion of up to 26 heavy transport vessel trips required for project construction could originate from unknown ports in Canada (see Attachment A, Table A-1). Vessels originating from Canadian ports could select transit routes that avoid critical habitat Unit 1 but may elect not to for economic reasons. Vessel transit routes to other identified or currently unknown ports are unlikely to transit NARW critical habitat Unit 2. This unit comprises the Southeastern U.S. Calving Area, located along the southern U.S. Atlantic Coast between Cape Fear and Cape Canaveral. Unlike Unit 1, the most probable vessel transit routes between the project area and the GOM or Panama Canal are located seaward of Unit 2 (BOEM, NOAA, and USCG 2022).

As defined in 81 FR 2838, the physical and biological features of right whale calving habitat that are essential to the conservation of NARW are: (1) Calm sea surface conditions of Force 4 or less on the Beaufort Wind Scale; (2) sea surface temperatures from a minimum of 7 °C, and never more than 17 °C; and (3) water depths of 6 to 28 meters, where these features simultaneously cooccur over contiguous areas of at least 231 nm^2 of ocean waters during the months of November through April. When these features are available, they are selected by right whale cows and calves in dynamic combinations that are suitable for calving, nursing, and rearing, and which vary, within the ranges specified, depending on factors such as weather and age of the calves. Project-related vessel traffic to and from the Cashman Shipyard and potential ports in Canada would have no measurable effect on the physical and biological features of designated NARW critical habitat. Therefore, the proposed action would have no effect on critical habitat for this species.

2.3 Seals

Ships traveling from ports in the Baltic or North Sea may pass through the range of the ESA-listed Baltic subspecies of ringed seal (*Phoca hispida*). Likewise, vessels traveling from some ports in Japan or South Korea may cross the habitat of spotted seal (*Phoca larga*). Any ships traveling from Asia through the Suez Canal and Mediterranean Sea may encounter Mediterranean monk seal (*Monachus monachus*) habitat. As with cetaceans, NOAA vessel guidelines to minimize marine mammal strikes would effectively avoid and minimize the likelihood of vessel strikes for pinniped species along international transit routes. The likelihood of injury or mortality to ESA-listed pinniped species is therefore discountable.

2.4 Fish, Rays, and Sharks

Several bony fish species have ranges that may overlap with vessel traffic from ports abroad, but they are extremely unlikely to interact directly with ships traveling to the Project area. Chinese sturgeon (*Acipenser sinesnsis*) are amphidromous, meaning they spawn and rear in freshwater and forage in both the estuary of their natal rivers and shallow marine habitats in close proximity to the estuary. While vessels traveling from ports in mainland China may overlap with the documented range of this species, the extremely low number of individuals makes any threat to Chinese sturgeon discountable.

Atlantic salmon (*Salmo salar*) are anadromous, meaning they spawn and rear in freshwater and migrate to the ocean to mature to adulthood. Gulf of Maine DPS of Atlantic salmon (*Salmo salar*) are likely to occur in potential vessel transit routes from ports of origin on the east coast of Canada. Vessel strikes have not been identified as a risk factor for this species. In theory, up to 26 vessel trips to the project area could originate from Canadian ports. The likely number is far lower – 6 or less. These vessels would travel on established travel corridors supporting thousands of vessel trips per year (BOEM, NOAA, and USCG 2022). Given the limited risk of vessel strikes and the diminishingly small increase in baseline vessel traffic conditions attributable to the project, project-related vessel strikes pose an insignificant and discountable risk to the Gulf of Maine DPS of Atlantic salmon.

Nassau grouper (*Epinephelus striatus*) are not likely to be at risk of vessel strikes from vessel transits through the Straits of Florida enroute from the Panama Canal. The risk of a vessel strike resulting from the Project is also considered discountable because vessel strikes of marine fish offshore are rare events in general and not considered a threat to Nassau grouper. There is no designated critical habitat for Nassau grouper. While it is possible that the presence of vessels may result in a short-term behavioral response from this species (e.g., startle, dive), the effects are not expected to result in any injury or reduced fitness of individuals. Therefore, potential effects to Nassau grouper from vessel strikes are discountable.

Vessel strikes of elasmobranch species, in general, are extremely rare. Giant manta rays (*Manta birostris*) are found in open water, feeding over reefs, or visiting shallow-water cleaning stations in certain areas. Oceanic whitetip sharks (*Carcharhinus longimanus*) and scalloped hammerhead sharks (*Sphyrna lewini*) tend to prefer the deeper ocean waters where there is no likelihood of vessel strike. Although oceanic whitetips have been observed in waters as shallow as 120 feet (36 meters) and along coastlines, they tend to only hunt in these waters if they are near a continental shelf where they still have access to deeper waters. There is no designated critical habitat for giant manta rays, oceanic whitetip sharks, or scalloped hammerhead sharks.

Smalltooth sawfish (*Pristis pectinata*) vessel encounters would be rare, and their designated critical habitat is outside the anticipated areas of vessel transit routes. Small, juvenile smalltooth sawfish are generally restricted to estuarine waters of peninsular Florida, whereas larger adults have a broader distribution and could be found in the southeastern Gulf of Mexico.

Common angelshark (*Squatina squatina*), common guitarfish (*Rhinobatos rhinobatos*), green sawfish (*Pristis zijstron*), narrow sawfish (*Anoxypristis cuspitata*), and sawback angelshark (*Squatina aculeata*) are all bottom-dwelling predators. While their geographic ranges may overlap with surface vessel traffic from Asia through the Suez or Panama canals, there is very low probability of direct interaction between vessels and any of these elasmobranch species. Impacts on these species is therefore discountable.

In addition to the species identified above, gulf sturgeon (*Acipenser oxyrinchus desotoi*) are likely to occur in vessel transit routes originating from potential project ports on the Gulf of Mexico. Potential effects to this species from this component of vessel traffic are addressed in Appendix B to the Biological Assessment. Vessels traveling to the project area through the Panama Canal are likely to use deepwater shipping lanes between Florida and the northern coast of Cuba in the southern Gulf of Mexico (BOEM, NOAA, and USCG 2022). These routes are outside of known and probable marine habitats for gulf sturgeon, which are concentrated in nearshore and estuarine waters less than 40 feet deep in the northern Gulf of Mexico less than 40 feet deep (Ross et al. 2009).

Overall, there is a very small likelihood that the fish species listed above would be expected to occur within the Gulf of Mexico, Mediterranean Sea, Caribbean Sea, or open ocean vessel transit areas and occur at or near the surface at the same time vessels associated with the Project may be present. Additionally, only a small number of trips between international ports and the Project area may potentially occur over the lifetime of the Project. This low likelihood of interaction results in an unlikely occurrence of a vessel strike to one of these species. Based on the best available information on vessel strike risks associated with the Project, the risk of vessel strikes with a giant manta ray, oceanic whitetip shark, smalltooth sawfish is extremely unlikely to occur and the potential effects from vessel strikes is considered to be discountable. See the BA for additional information and assessment of potential impacts to the giant manta ray species in the action area outside the international transit routes discussed herein.

2.5 Sea Turtles

In general, all species of sea turtles are susceptible to vessel strike, but this susceptibility is likely dependent upon a number of factors including geographic area, water depth, species surface patterns, and number of vessel trips. For example, hawksbill sea turtles (*Eretmochelys imbricata*) could be present in vessel transit area originating or returning to ports in the Gulf of Mexico, Europe, or Asia. This species is rare and expected to be present at low densities and in the deeper water transit routes from distant ports compared to other sea turtle species. Loggerhead sea turtle (*Caretta caretta*) designated critical habitat is located within potential vessel transit routes for the Project. Designated critical habitat for green (*Chelonia mydas*), hawksbill, and leatherback (*Dermochelys coriacea*) sea turtles are outside the potential areas of vessel transit routes and there is no designated critical habitat for Kemp’s ridley sea turtle (*Lepidochelys kempii*).

Considering few estimated construction trips between the ports abroad and the Project area may potentially occur over the lifetime of the project, the likelihood of encountering and striking a sea turtle in the Gulf of Mexico, Caribbean Sea, Mediterranean Sea, or open Indian, Atlantic, or Pacific Ocean is extremely low based on the low level of vessel activity expected relative to the overall vessel transit. This low likelihood of interaction results in an unlikely occurrence of a vessel strike to any species of sea turtle. In addition, Project mitigation measures include the implementation of NOAA vessel guidelines for marine mammal and sea turtle strike avoidance measures, including vessel speed restrictions. These measures would effectively avoid and minimize the likelihood of vessel strike. Based on the best available information, the risk of vessel strikes with sea turtles for vessels traveling from international ports is extremely unlikely to occur and will be discountable. See the BA for additional information and assessment of potential impacts to the sea turtle species in the action area.

3.0 Conclusion

In conclusion, the overall number of vessel trips between the international ports and the Project area is expected to be very low over the lifetime of the Project. In addition, the vessel types anticipated to be associated with Project construction and operation and maintenance activities are in a vessel category and frequency that make up a small percentage of overall port vessel transit activity. There are no or very limited reports of vessel strikes to listed species from total baseline vessel activities. Considering the number of vessel trips associated with the Project, species occurrences, and species-specific risk factors, the potential for vessel strikes on listed species in international or foreign waters is insignificant (locally) or discountable (from outside the region).

4.0 Reference

BOEM, NOAA, and USCG (Bureau of Ocean Energy Management, National Oceanic and Atmospheric Administration, and U.S. Coast Guard). 2022. AccessAIS. Web-based AIS data viewer. Available at: **https://marinecadastre.gov/accessais/**. Accessed: October 25, 2022.

Ross, S.T., W.T. Slack, R.J. Heise, M.A. Dugo, H. Rogillio, B.R. Bowen, P. Mickle, and R.W. Heard. 2009. Estuarine and coastal habitat use of Gulf Sturgeon (*Acipenser oxyrinchus desotoi*) in the North-Central Gulf of Mexico. *Estuaries and Coasts* 32: 360-374.

Attachment C – Planned Monitoring, and Mitigation Measures

1.0 Introduction

This attachment describes planned mitigation and monitoring measures to avoid and minimize impacts to ESA-listed species from the construction and O&M of the Revolution Wind project. The mitigation measures described in this attachment comprise the environmental protection measures (EMPs) proposed by the lessee in the COP, and additional known or anticipated mitigation requirements imposed by BOEM and other regulatory agencies. The intent of this attachment is to provide additional detail requested by NMFS regarding how these EPMs and mitigation measures will be implemented.

EPMs are defined as:

- Design mitigation measures, monitoring, or other activities proposed by Revolution Wind to avoid and minimize adverse effects from project construction and O&M on ESA-listed species.
- EPMs are part of the proposed action and are considered in the analysis of effects to ESA-listed species.

Mitigation measures comprise:

- The methods used to implement EPMs and other mitigation requirements.
- The personnel, equipment, and protocols that will implement these methods (e.g., construction crew members that install and operate sound attenuation devices).
- Procedures used to implement mitigation measures (e.g., shutdown protocols for impact pile driving and/or vessel speed restrictions when marine mammals are detected).

Monitoring measures comprise the following:

- The protected species observers (PSOs) who monitor clearance and shutdown zones and issue alerts when protected species are or may be present.
- The visual and acoustic equipment used by PSOs to monitor the project area and surroundings for protected species presence in or near pre-clearance and shutdown zones.
- Monitoring areas, pre-clearance and shutdown zones, and communication protocols for mitigation measure implementation.
- The data collection and reporting methods used to document mitigation measure implementation and, where necessary, protected species occurrence.

Additional mitigation is defined as:

- Other known or anticipated measures required by BOEM and/or other regulatory agencies via NMFS to avoid and minimize adverse effects on ESA-listed and other protected species.
- Additional mitigation measures are not part of the proposed action and have not been considered in the analysis of effects to ESA-listed species.

EPMs and associated mitigation and monitoring measures applicable to ESA-listed species listed in Table C-1. EPMs were obtained from the Protected Species Monitoring and Mitigation Plan (PSMMP, Revolution Wind 2022), the Petition for Incidental Take Regulations (ITR, LGL 2022), the Fisheries and Benthic Monitoring Plan (Inspire Environmental 2022), the COP, additional information provided by Revolution Wind, and the Cooperating Agency review version of the Revolution Wind Final Environmental Impact Statement. These EPMs were supplemented with additional information where available. Revolution Wind (2022) has indicated that a separate PSMMP detailing proposed mitigation and monitoring measures for sea turtles and other protected species (i.e., Atlantic cod) is currently in development. This document will be provided to BOEM as an addendum to the COP. BOEM will make this plan available to NMFS after internal review and approval is complete.

In addition to the EPMs listed in Table C-1, BOEM is proposing mitigation measures to further avoid and minimize impacts to ESA-listed species and provide clear protocols for monitoring and reporting incidental take. These additional mitigation measures are listed in Table C-2.

Table C-1. EPMs proposed by Revolution Wind to Avoid and Minimize Effects on ESA-listed and other Protected Species.

E3PM #	EPM	Description	Project Phase	Anticipated Effect
1	PSO/ Passive acoustic monitoring (PAM) training and requirements	Dedicated personnel may be required for carrying out mitigation and monitoring efforts onboard Project vessels. These roles are generally required to be filled by NMFS-approved and BOEM-accepted PSOs and passive acoustic monitoring (PAM) operators. Personnel in the field have a responsibility to support these activities and will receive Project -specific training. A Permits and Environmental Compliance Plan (PECP) manual which will include the PSMMP will be prepared to describe species expected to occur in the Project Area, monitoring and mitigation measures, data collection and reporting measures, equipment specifications, etc. The Project will conduct standardized pre-activity environmental awareness training for all crew members. 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 including: • At least one PSO must have prior experience performing the duties of a PSO during construction activity pursuant to a NMFS-issued incidental take authorization; and • Other PSOs may substitute other relevant experience, education, or training for prior experience performing duties of a PSO during construction activity pursuant to a NMFS-issued take authorization. The PSO team will comprise a sufficient number of individuals with appropriate skills necessary to meet all mitigation and monitoring requirements. The lead monitor (Lead PSO) will identified by the applicant for approval by NMFS prior to initiation of monitoring activities. The Lead PSO will have experience on similar projects in the northwestern Atlantic Ocean. The PSO team may also include a supervisor who may work in the field or shore side to provide additional support as needed for the duration of monitoring and mitigation activities. The supervisor will facilitate communication between PSOs and other parties involved in project construction. All PSOs will have relevant experience on similar projects and suitable expertise with monitoring software and equipment. In addition to PECP training, all PSOs will also complete a two-day training and refresher session. The two-day training will review the protected species anticipated to occur and associated regulatory requirements. The refresher session will be tailored to the specific needs and composition of the PSO team.	Construction	PSOs and PAM operator training will facilitate avoidance and minimization of potential adverse effects to ESA-listed species from vessel interactions, HRG surveys, UXO detonation, and pile driving by ensuring monitoring and mitigation measure effectiveness.
2	Recording and reporting – Data recording protocols	PSOs, PAM operators, and crew members (as applicable) will record all sightings of marine mammals and other protected species observed anywhere within an applicable monitoring zone. For mitigation monitoring, data on all PSO observations will be recorded based on standard PSO data collection requirements and specific permit conditions. A data collection software system (e.g., Mysticetus ™ or similar software) will be used to record and collate data obtained from visual and acoustic observations during mitigation monitoring. The PSOs and PAM operators will enter the data into the selected data entry program installed on field laptops/tablets. PSO data records will include, but are not limited to: • The presence and location (if determinable) of any ESA-listed marine mammal or sea turtle detected by PSOs, PAM operators, or crew members. • Identification of marine mammal species, numbers of individuals, and behaviors as able. PAM detections are rarely suitable for enumeration or behavior of animals unless verified by visual detections. • Detections will be annotated with information regarding vessel activity, environmental conditions, and by other operational parameters (e.g., number of vessels in areas, equipment start and stop times, operational duration, etc.). • Size of all regulatory and monitoring zones. • Implementation of vessel strike avoidance measures. • Implementation of clearance, ramp-up and soft start, and shutdown measures as applicable for shutdown and monitoring zones. • Implementation of specific NARW mitigation measures. • • Observations of any potential injured or dead protected species. The following information about each protected species detection will be carefully and accurately recorded: • Species, group size, age/size/sex categories (if determinable), and physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals; • Behavior when first sighted and during any subsequent sightings; • Heading (if consistent), bearing, and distance from observer; • Location of confirmed acoustic detections within Project Area (if PAM operator is able to localize the animal); • Tracks of marine mammals derived from PAM systems if accurate localization is attainable; • Entry of animal into any regulatory or monitoring zones and duration in those zones; • Closest point of approach to the applicable activities and/or vessels and assets;	Construction, O&M, decommissioning	Clear data management and reporting protocols will provide for accurate tracking of potential adverse effects to ESA-listed species from vessel interactions, HRG surveys, UXO detonation, and pile driving. This will help to ensure monitoring and mitigation measure effectiveness.

E3PM #	EPM	Description	Project Phase	Anticipated Effect
		• Apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.) with annotations regarding animal headings, pace, or other information that could help assess changes in behavior; • Time, location, speed, and Project activity/active sound sources in operation; • How the animal was detected (i.e., with what monitoring method) and if the animal was detected by any other monitoring method; and • Mitigation measures requested and implemented (if any). At regular intervals and at each detection the following information will be recorded by PSOs and PAM operators when the information is determinable: • Sea state, visibility, and sun glare; • Noise performance of PAM systems and effective detection ranges for species; • Vessel or Project activities and location (if mobile); • PSO shift changes; • Monitoring equipment being used; and • Any NARW SMA or DMAs placed during that particular watch.		
3	Recording and reporting – Reporting requirements	The following situations would require immediate reporting to appropriate POCs: • If a stranded, entangled, injured, or dead protected species is observed, the sighting shall be reported within 24 hours to the NMFS RWSAS hotline. • In the event a protected species is injured or killed as a result of Project activities, the vessel captain or PSO on board shall call for an immediate cessation of all activities until NMFS Office of Protected Resources (OPR) is able to review the circumstances of the incident and determine what, if any, additional measures are appropriate to ensure compliance. Additionally the vessel captain or PSO on board shall report immediately to: • NMFS OPR (301-427-8401) and Greater Atlantic Regional Fisheries Office no later than within 24 hours; • NOAA Fisheries Marine Mammal and Sea Turtle Stranding and Entanglement Hotline (866-755-6622) or alternative electronic reporting systems as approved by the NOAA stranding program, as well as the U.S. Coast Guard. • Any NARW sightings should be reported as soon as feasible and no later than within 24 hours to the NMFS RWSAS hotline or via the Whale Alert Application. Data and Final Reports will be prepared using the following protocols: • 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 shutdown zones (SZs), monitoring effort, environmental conditions, and Project-related activity will be provided after field operations and reporting are complete. This database will undergo thorough quality checks and included all variables required by the NMFS-issued Incidental Take Authorization (ITA) and BOEM Lease OCS-A 0486 and will be required for the Final Technical Report due to BOEM and NMFS. • During construction, weekly reports briefly summarizing sightings, detections, and activities will be provided to NMFS and BOEM on the Wednesday following a Sunday-Saturday period. • Final reports will follow a standardized format for PSO reporting from activities requiring marine mammal mitigation and monitoring. • An annual report will be provided to NMFS and to BOEM on April 1 every calendar year summarizing the prior year's activities. • A draft and final HRG survey report will be submitted to BOEM and NMFS post-construction and every year following the completion of O&M HRG surveys. The final report must address any comments on the draft report provided to Revolution Wind by BOEM and NMFS. The report must include a summary of survey activities, all PSO and incident reports, and an estimate of the number of listed marine mammals or sea turtles observed and/or taken during these survey activities.	Construction, O&M, decommissioning	Same as above
4	General PSO measures	The following visual observation protocols will be implemented by all PSOs employed on Project vessels: • Visual monitoring of established clearance and SZs 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 clearance and SZs 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.	Construction, O&M, Decommissioning	These measures ensure that PSOs can effectively monitor for marine wildlife and that the appropriate agencies are contacted in the event of a NARW sighting. Collectively these measures minimize the

E3PM #	EPM	Description	Project Phase	Anticipated Effect
		• The PSOs will begin observation of clearance zones (CZs) prior to initiation of HRG survey operations and will continue observation of the shutdown throughout the survey activity and for 30 minutes following cessation of the survey activity using equipment operating below 180 kHz. • The PSOs will be responsible for visually monitoring and identifying marine mammals approaching or entering the established zones during survey activities. • PSOs will systematically scan with the naked eye and a 7 x 50 reticle binocular, supplemented with night-vision equipment when needed. • When monitoring at night or in low visibility conditions, PSOs will monitor for marine mammals and other protected species using night-vision goggles with thermal clip-ons, a hand-held spotlight, and/or a mounted thermal camera system. • Activities with larger monitoring zones will use 25 x 150 mm "big eye" binoculars. • The PSO(s) on duty will be responsible to communicate the presence of marine mammals as well as to communicate the recommended mitigation action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate. • Vessel personnel will be instructed to report any sightings to the PSO team as soon as they are able, and it is safe to do so. • Members of the monitoring team will consult with NMFS' North Atlantic right whale reporting system for the presence of North Atlantic right whales in the Project area. • If a NARW is involved in any of the above-mentioned incidents, then the vessel captain or PSO onboard should also notify the Right Whale Sighting Advisory System (RWSAS) hotline immediately and no later than within 24 hours. • PSOs will monitor Mystecetus (or similar data system) and/or appropriate data systems for DMAs established within their survey area. • PSOs will also monitor the NMFS NARW reporting systems including Whale Alert and RWSAS once every PSO shift during Project-related activities within, or adjacent to, seasonal management areas (SMAs) and/or dynamic management areas (DMAs). It will be the responsibility of the PSO(s) on duty to communicate the presence of protected species as well as to communicate the recommended mitigation action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate.		potential for adverse effects to ESA-listed species.
5	PSO protocols for normal and low visibility conditions	The lead PSO will determine if conditions warrant implementing reduced visibility protocols. Under normal visibility conditions, visual monitoring will be conducted as follows: • 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. Under nighttime or low visibility conditions, visual monitoring will be conducted as follows: • Two PSOs will remain on watch during pre-clearance periods, all operations, and for 30 minutes following use of HRG sources operating below 180 kHz. • Each PSO should use the most appropriate available technology (e.g., EO/IR camera and/or night vision device) and viewing locations to monitor clearance and SZs and maintain appropriate vessel separation distances.	Construction, O&M, Decommissioning	These measures ensure that PSOs can effectively monitor for marine wildlife and that the appropriate agencies are contacted in the event of a NARW sighting. Collectively these measures minimize the potential for adverse effects to ESA-listed species.
6	Vessel Strike Avoidance Policy – General Measures	The Project will implement a vessel strike avoidance policy for all vessels under contract to Ørsted to reduce the risk of vessel strikes and the potential of death and/or serious injury to marine mammals. In addition to vessels transiting and working (e.g., HRG surveys, construction, O&M) within the Project Area, there will be vessels transiting to and from the Project Area transporting materials, equipment, and personnel. All vessels will comply with the vessel strike avoidance measures as specified below, except under extraordinary circumstances when complying with these requirements would put the safety of the vessel or crew at risk. 1. Vessel operators and crews shall receive protected species identification training. This training will cover sightings of marine mammals and other protected species known to occur or which have the potential to occur in the Project Area. It will include training on making observations in both good weather conditions (i.e., clear visibility, low wind, low sea state) and bad weather conditions (i.e., fog, high winds, high sea states, glare). Training will include not only identification skills but information and resources available regarding applicable federal laws and regulations for protected species. It will also cover any Critical Habitat requirements, migratory routes, seasonal variations, behavior identification, etc. 2. Vessel operators and crews will maintain a vigilant watch for marine mammals and other protected species and change course or respond with the appropriate action (e.g., slow down) to avoid striking marine mammals. 3. Vessel operators will monitor the Project's Situational Awareness System and the Coast Guard VHF Channel 16 as well as the Whale Alert and the NMFS RWSAS for the presence of NARWs once every PSO shift during Project-related activities. 4. All vessels will comply with NMFS regulations and speed restrictions and state regulations as applicable for NARW. 5. All vessels 65 ft (20 m) or longer subject to the jurisdiction of the U.S. will comply with the 10-knot speed restriction when entering or departing a port or place subject to U.S. jurisdiction. This includes any vessel 65 ft or longer travelling in any NARW seasonal management area (SMA) when speed restrictions are in effect.	Construction, O&M, decommissioning	Training of crew and personnel would minimize the potential for adverse effects to ESA-listed species by increasing the effectiveness of mitigation and monitoring measures through educational and training materials and avoiding vessel interactions with ESA-listed species.

E3PM #	EPM	Description	Project Phase	Anticipated Effect
7	Vessel separation distances	Vessels will maintain, to the extent practicable, separation distances of: • >500 m distance from any sighted NARW or unidentified large marine mammals during impact pile driving; • >100 m from all other whales for all other construction activities; • >50 m (54 yards) for dolphins, porpoises, seals, and sea turtles. Specific requirements that will be implemented should an animal enter the vessel separation distance are outlined below in EPMs 8, 9, and 10.	Construction, O&M, decommissioning	This mitigation and monitoring measure would minimize the potential for adverse effects on marine mammals and sea turtles resulting from vessel interactions.
8	Vessel strike avoidance – Base conditions	All personnel working offshore will receive training on marine mammal, sea turtle, and Atlantic sturgeon awareness and vessel strike avoidance measures. All vessels will adhere to current NOAA vessel guidelines for approach distances and mandatory measures stipulated in regulations governing the approach to North Atlantic Right Whales and the Right Whale Speed Rule. (Note: Voluntary measures within a DMA are addressed separately in the Standard and Adaptive Plan detailed below). Approach Constraints • All species o No vessels underway will divert or alter course in order to approach marine mammals under observation. o Any vessel underway must avoid excessive speed or abrupt changes in direction. o When a marine mammal(s) is sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distances • Exceptions: o Limitations on approach do not apply where compliance would create an imminent and serious threat to a person, vessel, or aircraft o Limitations on approach do not apply when approaching to investigate an entanglement or injury, or to assist in the disentanglement or rescue of a whale, provided that permission is received from NMFS or a NMFS designee prior to the approach o Limitations on approach do not apply to the extent that a vessel is restricted in her ability to maneuver, and because of the restriction, cannot comply with the limitation on approach. • North Atlantic Right Whale o By regulation (50 CFR §224.103(c)), approach (including by interception) within 500 yards (460 m) of a right whale by vessel, aircraft, or any other means is prohibited. o If within 500 yards (460 m) of a right whale: (1) If underway, a vessel must steer a course away from the right whale and immediately leave the area at a slow safe speed; o Exceptions stated in the “All Species” section above are applicable for NARW. • Other Large Whales o Vessel speeds will immediately be reduced to 10 knots or less when any large whale, mother/calf pair, or large assemblage of non-delphinoid cetaceans is observed within 100 m of a vessel underway. o All vessels must maintain a minimum separation distance of 100 m from sperm whales and non-NARW baleen whales. If one of these species is sighted within 100 m of an underway vessel, that vessel must shift the engine to neutral. Engines must not be engaged until the whale has moved outside of the vessel’s path and beyond 100 m. • Dolphins, porpoises, seals o All vessels must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all delphinoid cetaceans and pinnipeds. If a delphinoid cetacean or pinniped is sighted within 50 m of an underway vessel, that vessel must shift the engine to neutral. Engines must not be engaged until the animal(s) has moved outside of the vessel’s path and beyond 50 m. o Exception to separation distance and shifting engines to neutral for delphinoid cetaceans and pinnipeds that approach the vessel (e.g., bow-riding dolphins).	Construction, O&M, decommissioning	This mitigation and monitoring measure would minimize the potential for ship strikes and impacts to marine mammals. Communication between Project vessels would further reduce potentially adverse effects by alerting vessels to the presence of marine mammals in the area.
9	Vessel strike avoidance – Standard plan	Implement Base Conditions described above. • **Between November 1st and April 30th**: Vessels of all sizes will operate port to port (from ports in NY, CT, RI and MA) at 10 knots or less. Vessels transiting from other ports outside those described will operate at 10 knots or less when within any active Seasonal Management Area (SMA) or within Lease Area and RWEC corridor. • **Year Round**: Vessels of all sizes will operate at 10 knots or less in any Dynamic Management Areas (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	Construction, O&M, decommissioning	This mitigation and monitoring measure would minimize the potential for ship strikes and impacts to NARW by implementing special measures in SMAs and DMAs.

E3PM #	EPM	Description	Project Phase	Anticipated Effect
		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.		
10	Vessel strike avoidance – Adaptive plan	The Standard Plan outlined above will be adhered to except in cases where crew safety is at risk, and/or labor restrictions, vessel availability, costs to the project, or other unforeseen circumstance make these measures impracticable. To address these situations, an Adaptive Plan will be developed in consultation with NMFS to allow modification of speed restrictions for vessels. Should Revolution Wind choose not to implement this Adaptive Plan, or a component of the Adaptive Plan is offline (e.g., equipment technical issues), Revolution Wind will default to the Standard Plan (described above). The Adaptive Plan will not apply to vessel subject to speed reductions in SMAs as designated by NOAA's Vessel Strike Reduction Rule. Proposed measures may include: Implement Base Conditions described above. **Year Round:** A semi-permanent acoustic network comprising near real-time bottom mounted and/or mobile acoustic monitoring platforms will be installed such that confirmed North Atlantic right whale detections are regularly transmitted to a central information portal and disseminated through the situational awareness network. • The transit corridor and WDA will be divided into detection action zones. o 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).	Construction, O&M, decommissioning	This mitigation and monitoring measure would minimize the potential for ship strikes and impacts to NARW by implementing adaptive measures in response to observed conditions.
11	Long-term monitoring – marine mammals	• Pre-construction marine mammal surveys will provide a baseline set of data for comparison against the monitoring efforts during construction. • Post-construction marine mammal surveys will provide for an assessment of the potential long-term impacts of the Project. • Survey will involve a combination of visual and acoustic monitoring techniques	Pre-Construction, Construction, O&M, Decommissioning	These surveys can be used to assess the potential long-term impacts that the Project may have on marine mammal populations in the Offshore Wind Area.
12	Operational monitoring – Marine mammals	• Visual monitoring and PAM for marine mammals will occur during vessel transits to and from the Project area as described above under vessel speed restrictions (standard and adaptive plans)	Construction, O&M, decommissioning	This mitigation and monitoring measure would minimize the potential for adverse effects on marine mammals and sea turtles resulting from vessel interactions.
13	Long-term Monitoring - Turtles	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.	Pre-Construction, Construction, O&M, Decommissioning	These surveys can be used to assess the potential long-term impacts that the Project may have on turtle populations in the Offshore Wind Area.
14	Level A and Level B harassment zone verification	Revolution Wind will conduct SOUND FIELD VERIFICATION under the following circumstances: • Impact driving of the first three monopiles installed over the duration of the LOA; • If Revolution Wind obtains technical information that indicates a subsequent monopile is likely to produce larger sound fields; and	Construction	These measures can be used to evaluate the potential for level A and B harassment levels to be achieved during impact

<table>
<tr><th>E3PM #</th><th>EPM</th><th>Description</th><th>Project Phase</th><th>Anticipated Effect</th></tr>
<tr><td></td><td></td><td>At least three monopiles of the same size if a reduction to the clearance and/or SZs is requested.
Revolution Wind will conduct a SOUND FIELD VERIFICATION 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 SOUND FIELD VERIFICATION Plan. As a secondary method, Revolution Wind may also estimate distances to Level A harassment and Level B harassment thresholds by extrapolating from in situ measurements at multiple distances from the monopile, including at least one measurement location at 750 m from the pile</td><td></td><td>pile driving as accurately as possible and to highlight potential for changes to SZs if necessary.</td></tr>
<tr><td>15</td><td>Modification of shutdown and monitoring zones</td><td>Revolution Wind may request a modification to the size of shutdown and monitoring zones based on the results of pile measurements. The zones will be determined as follows:
The large whale pre-start CZ will be calculated as the radius of the maximum Level A
exposure range of any mysticete.
The right whale pre-start CZ will be equal to the marine mammal Level B zone.
The large whale, including right whale, SZ will be calculated as the radius of the maximum Level A exposure range of any mysticete.
The harbor porpoise and seal pre-start CZ and SZ will be determined as the extent of the level A exposure range.
For all mid-frequency cetaceans other than sperm whales, the pre-start clearance and SZs will effectively be the perimeter of the NMS because the physical placement of the NMS will preclude take (i.e., the Level A zone is smaller than the distance of the NMS from the pile)
In the case of expanded clearance and SZs, zone monitoring will be achieved through a combined effort of passive acoustic monitoring and visual observation. Based on the sound field verification results, the secondary vessel will be placed at the outer limit of the subsequent Large Whale SZ defined in the PSMMP. No additional PSOs or PSO vessels are proposed to visually monitor the expanded zones.</td><td>Construction</td><td>These mitigation measures allow for the SZs to modified to better represent actual risks to marine wildlife from noise generating activities once sufficient evidence is present to permit such a change.</td></tr>
<tr><td>16</td><td>Impact pile driving time of year restriction</td><td>No pile installation will occur from 01 January to 30 April to avoid the times of year when NARW are present in higher densities.</td><td>Construction</td><td>Time-of-year restrictions for impact pile- driving activities would minimize and avoid potential adverse effects to ESA- listed species, specifically NARW, that are more likely to occur in the area during that time period.</td></tr>
<tr><td>17</td><td>Noise attenuation systems (NAS) during impact pile driving</td><td>The Project will use a primary and secondary NAS system for all impact piling events, composed of a combination of two devices (e.g., bubble curtain, hydro-damper) to reduce noise propagation during monopile foundation pile driving. Revolution Wind is committed to achieving a minimum of 10 dB noise attenuation for all impact pile driving activities.</td><td>Construction</td><td>Attenuation of sound pressure levels would reduce the area of underwater noise effects to ESA- listed whales, sea turtles, Atlantic sturgeon, manta ray, and the prey they feed upon during impact pile driving.</td></tr>
<tr><td>18</td><td>Impact pile driving – General monitoring and mitigation protocols for impact pile driving</td><td>There are four primary mitigation and monitoring efforts associated with impact pile driving:
Vessel-based visual PSOs and associated visual monitoring tools stationed on the construction and any secondary marine mammal monitoring vessels will monitor at night for marine mammals and other protected species using night-vision goggles with thermal clip-ons and a hand-held spotlight;
PAM operators and an associated mitigation PAM array in support of the visual PSOs;
Noise attenuation systems(NAS); and
Acoustic measurement data collection to verify distances to regulatory or mitigation zones.
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. PSO and PAM monitoring personnel and equipment available onboard the construction vessel and the secondary monitoring vessel. Personnel and equipment requirements for this activity are listed below:<table><tr><th rowspan="2">Personnel and Equipment</th><th colspan="2">Standard Daytime</th><th colspan="2">Monitoring for Nighttime and Low Visibility</th></tr><tr><th>Number on Construction Vessel</th><th>Number on Secondary Vessel</th><th>Number on Construction Vessel</th><th>Number on Secondary Vessel</th></tr></table></td><td>Construction</td><td>This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
</table>

E3PM #	EPM	Description					Project Phase	Anticipated Effect
		Reticle binoculars	2	2	0	0		
		Visual PSOs on watch	2	2	2	2		
		PAM operators on duty[1]	1	1	1	1		
		Mounted thermal/IR camera system[1]	1	1	1	1		
		Mounted “big-eye” binocular	1	1	0	0		
		Monitoring station for real time PAM system[2]	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		
19	Impact pile driving – Daytime visual monitoring, normal visibility	• 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. • It is expected the full complement of PSOs will not always be required (i.e., full coverage will be in place during piling activities, however, in between piling events, the PSO team can consist of only one PSO on duty). Piling is anticipated to take approximately 1-4 hours (12 hours maximum) per piling event (i.e., 4 hours at a given foundation location) after which the construction vessel moves away to a new location for the next piling event. • During daytime observations, two PSOs on each vessel will monitor the CZ and SZ with the naked eye and reticle binoculars. One PSO will periodically scan outside the SZ using the mounted big eye binoculars. • PSOs will visually monitor, the maximum Level A zone which constitutes the pre-start CZ . This zone encompasses the maximum Level A exposure ranges for all marine mammal species. • The secondary vessel will be positioned and circling at the outer limit of the Large Whale SZ. • PSOs stationed on the secondary vessel will ensure the outer portion of the SZs and prestart CZ are visually monitored. • There will be a PAM operator on duty (see Section 6.2.3) conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods, piling, and postpiling monitoring periods. • Acoustic monitoring, as described in Section 6.2.3, will extend beyond the Large Whale Pre-Start CZ. • The NARW pre-start CZ will be monitored visually out to the extent of the Large Whale SZ and acoustically out to the extent of the Level B zone.					Construction	This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.
20	Impact pile driving – Daytime visual monitoring, reduced visibility	• If the monitoring zone is obscured, the two PSOs on watch on each vessel will continue to monitor the SZ utilizing thermal camera systems and PAM. • During nighttime or other low visibility conditions, two PSO on each vessel will monitor the SZ with the mounted EO/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.					Construction	This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.
21	Impact pile driving – Nighttime visual monitoring	Revolution Wind has conducted a test project demonstrating the effectiveness of proposed PAM, EO/IR, and NVD equipment and methods for nighttime monitoring of clearance and shutdown zones (ThayerMayhan 2023). Revolution Wind presented a summary of methods and findings from this study to BOEM and NMFS in an online webinar on March 16, 2023. Revolution Wind is preparing a nighttime monitoring plan detailing proposed personnel, equipment, and protocols and will submit this plan for review and approval by BOEM and NMFS no later than 90 days prior to initiating project construction. These protocols and methods include, but are not limited to:					Construction	This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine

<table>
<tr><th>E3PM #</th><th>EPM</th><th>Description</th><th>Project Phase</th><th>Anticipated Effect</th></tr>
<tr><td></td><td></td><td>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.</td><td></td><td>mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
<tr><td>22</td><td>Impact pile driving – PAM</td><td>PAM systems will be used to supplement visual monitoring during reduced visibility and nighttime conditions.
PAM should begin at least 30-minutes prior to the start of piling.
One PAM operator on duty during both daytime and nighttime/low visibility 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.
PAM operator will monitor during all pre-start clearance periods, piling, and post-piling monitoring periods (daylight, reduced visibility, and nighttime monitoring).
Real-time PAM systems require at least one PAM operator 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.
PSOs will acoustically monitor designated monitoring zones for all marine mammals, as well as the NARW specific CZ .
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.
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 PAM CZ .</td><td>Construction</td><td>This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
<tr><td>23</td><td>Impact pile driving – General mitigation measures</td><td>Mitigation measures implemented during a piling event include:
Pre-start clearance;
Soft start of the pile strikes;
Post-piling monitoring;
Shutdowns, and
Monitoring during unforeseen pauses in piling
Summary of mitigation measures during WTG impact pile driving with a noise attenuation system in Summer (May through November).<table><tr><th>Measure</th><th>NARW</th><th>Other LFC</th><th>Sperm Whale</th><th>Sea Turtles</th></tr><tr><td>Monitoring zone – WTG installation</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>>3,900 m</td></tr><tr><td>Monitoring zone – OSS installation</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>>4,100 m</td></tr><tr><td>Pre-start clearance and shutdown zone – WTG installation</td><td>Visual - Any distance PAM clearance/ shutdown – 3,900 m</td><td>3,900 m</td><td>2,300 m</td><td>500 m</td></tr><tr><td>Pre-start clearance and shutdown zone – OSS installation</td><td>Visual - Any distance PAM clearance/ shutdown – 4,100 m</td><td>1,600 m</td><td>1,600 m</td><td>500 m</td></tr></table></td><td>Construction</td><td>This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
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<tr><th>E3PM #</th><th>EPM</th><th>Description</th><th>Project Phase</th><th>Anticipated Effect</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><td>Clearance duration</td><td>60 min visual monitoring, 60 min PAM monitoring; zone must be clear for 30 min</td></tr>
<tr><td>Soft start</td><td>All piles</td></tr>
<tr><td>Post-piling monitoring</td><td>30 minutes</td></tr>
</table>
Summary of mitigation measures during WTG impact pile driving with a noise attenuation system in Winter (December only).
<table>
<tr><th>Measure</th><th>NARW</th><th>Other LFC</th><th>Sperm Whale</th><th>Sea Turtles</th></tr>
<tr><td>Monitoring zone – WTG installation</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>n/a</td></tr>
<tr><td>Monitoring zone – OSS installation</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>10,000 m (PAM)</td><td>n/a</td></tr>
<tr><td>Pre-start clearance and shutdown zone – WTG installation</td><td>Visual - Any distance PAM clearance/ shutdown – 4,400 m</td><td>4,400 m</td><td>4,400</td><td>n/a</td></tr>
<tr><td>Pre-start clearance and shutdown zone – OSS installation</td><td>Visual - Any distance PAM clearance/ shutdown – 4,700 m</td><td>2,700 m</td><td>2,700 m</td><td>n/a</td></tr>
<tr><td>Clearance duration</td><td colspan="4">60 min visual monitoring, 60 min PAM monitoring; zone must be clear for 30 min</td></tr>
<tr><td>Soft start</td><td colspan="4">All piles</td></tr>
<tr><td>Post-piling monitoring</td><td colspan="4">30 minutes</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>24</td><td>Impact pile driving - Pre-start clearance measures</td><td>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 monitoring will also begin at least 30-minutes prior to the start of piling.
• The large whale CZ (2,300 m or as modified) must be fully visible for at least 30 minutes prior to commencing ramp-up.
• All marine mammals must be confirmed to be out of the CZ prior to initiating soft start.
• If a marine mammal is observed entering or within the relevant CZs prior to the initiation of pile driving activity, pile driving activity will be delayed.
• An acoustic detection localized to a position within the CZ will trigger a delay.
• A NARW sighted at any distance will trigger a delay.
• Impact pile driving may commence when either the marine mammal(s) has voluntarily left the respective CZ and been visually confirmed beyond that CZ, or, when 30 minutes have elapsed without re-detection for whales, including NARW; or 15 minutes have elapsed without re-detection of dolphins, porpoises, and seals.</td><td>Construction</td><td>This monitoring measure would minimize the potential for adverse effects on marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
<tr><td>25</td><td>Impact pile driving - Soft start measures</td><td>Every monopile installation will begin with a soft start procedure of a minimum of 20-minute duration.
• Soft start of pile driving will not begin until the CZ has been cleared by the visual PSO (and PAM operators when applicable).
• If any marine mammals are detected within the applicable CZ prior to or during the soft start, activities will be delayed until the animal has been observed exiting the CZ or until an additional time period has elapsed with no further sighting.
• Generic soft start measures as follows:
o Percent of maximum impact hammer blow energy: 10 to 20%.
o Monopile blow energy: 600-800 kJ.
o Strike rate: 4-6 strikes/min.
o Duration: Minimum of 20 minutes or greater until vertical pile stability is secured.</td><td>Construction</td><td>This monitoring measure would minimize the potential for adverse effects on marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
<tr><td>26</td><td>Impact pile driving - Post-activity monitoring</td><td>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.</td><td></td><td>This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and</td></tr>
</table>

E3PM #	EPM	Description	Project Phase	Anticipated Effect
				monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.
27	Impact pile driving – Shutdown protocols	Impact pile driving procedures follow three 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. Refusal criteria is defined as: (i) 125 blows/25 centimeters (cm) over an increment of 6 × 25 cm (ii) 200 blows/25 cm over an increment of 2 × 25 cm (iii) 325 blows/25 cm over an increment of 1 × 25 cm. 3) The hammer drives the pile to target penetration. If a marine mammal is entering or within the respective SZs (or a NARW sighted at any distance) after pile driving has commenced, an immediate shutdown of pile driving will be implemented unless Revolution Wind and/or its contractor determines shutdown is not feasible. After a shutdown, pile driving must only be initiated once all SZs are confirmed by PSOs to be clear of marine mammals and sea turtles for the minimum species-specific time periods. After a shutdown is implemented: • The SZ and CZ will be continuously monitored by PSOs and PAM during any pauses in pile driving. • If marine mammals or sea turtles are sighted within a SZ during a pause in piling, resumption of pile driving will be delayed until the animal(s) has moved outside the shutdown or when 30 minutes have elapsed without redetection for whales, including the NARW, or 15 minutes have elapsed without redetection of sea turtles. Shutdown procedures will be superseded only when they present 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 imminent risk scenarios that could defer a pile shutdown, pile refusal and pile instability. If either of these scenarios prevent shutdown, the hammer will operate at reduced energy to minimize impacts to protected species while maintaining safety.	Construction	This monitoring measure would avoid unacceptable risks to property and safety while minimizing adverse effects on marine mammals, sea turtles, and ESA-listed fish from impact pile driving.
28	Impact pile driving - Sound field verification	• 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. • Seven measurement positions will be established around each WTG and OSS foundation, four positioned equidistant at a 750 m radius, and one position at 1,500, 3,000, and 6,000 m. • Each measurement position will consist of two hydrophones at approximately mid-depth and 2 meters above the seafloor. Deployment will be made using a heavy weight as anchor - to prevent equipment drifting (typically total ballast weight exceeding 100 kg). • 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. • 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.	Construction	This mitigation measure ensures that noise level data collected during sound field verification is consistently collected at the highest possible standard using up to date methodology. In turn this allows for implemented mitigation to be optimally effective.
29	Impact pile driving - 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. • DMAs will be reported across all Project vessels. • See additional details regarding reporting is provided below under "Reporting"	Construction	This monitoring measure would ensure monitoring of mitigation effectiveness and compliance. The data gathered could be used to evaluate impacts and potentially lead to additional mitigation measures, if required.
30	Vibratory pile driving	Visual monitoring protocols will be in place for all vibratory sheet pile installation and removal. All observations will take place from one of the construction vessels stationed at or near the sheet piling location. PAM is not proposed because it is likely to be ineffective due to masking effects. Personnel and equipment used for vibratory pile driving are as follows:	Construction	This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the

<table>
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<tr><td></td><td></td><td><table>
<tr><th>Personnel and Equipment</th><th># on Construction Vessel</th></tr>
<tr><td>PSOs on watch</td><td>2</td></tr>
<tr><td>Reticle binoculars</td><td>2</td></tr>
<tr><td>Mounted thermal/IR camera system</td><td>1</td></tr>
<tr><td>Mounted “big-eye” binocular</td><td>1</td></tr>
<tr><td>Hand-held or wearable NVDs</td><td>2</td></tr>
<tr><td>IR spotlights</td><td>2</td></tr>
<tr><td>Data collection software system</td><td>1</td></tr>
<tr><td>PSO-dedicated VHF radios</td><td>2</td></tr>
<tr><td>Digital single-lens reflex camera equipped with 300-mm lens</td><td>1</td></tr>
</table></td><td></td><td>required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
<tr><td>31</td><td>Vibratory pile driving – Daytime visual monitoring, normal visibility</td><td>• Visual monitoring will occur from the construction vessel to provide complete visual coverage of clearance and SZs during vibratory sheet pile installation and removal.
• Two PSOs will maintain watch on the construction vessel during the pre-start clearance period throughout vibratory pile installation and removal, and 30-minutes after piling is completed.
• Two PSOs will conduct observations concurrently. The total number of observers will be dictated by the personnel necessary to adhere to standard schedule and rest requirements while meeting Project mitigation monitoring requirements.
• PSOs will visually monitor the CZ and SZs.
• One observer will monitor the CZ and SZs with the naked eye and reticle binoculars. One PSO will monitor in the same way but will periodically scan outside the SZ using the mounted big eye binoculars.</td><td>Construction</td><td>Same as above</td></tr>
<tr><td>32</td><td>Vibratory pile driving – Daytime visual monitoring, reduced visibility</td><td>During daytime low visibility conditions, one PSO will monitor the CZ and SZs with the mounted IR camera while the other maintains visual watch with the naked eye / binoculars.</td><td>Construction</td><td>Same as above</td></tr>
<tr><td>33</td><td>Vibratory pile driving – Nighttime visual monitoring</td><td>Landfall construction activities, including vibratory pile driving, will not take place at night. Construction activities are prohibited between 6 p.m. and 7 a.m. by local noise ordinance (North Kingstown, RI Ord. No. 83-3(a)).</td><td>n/a</td><td>n/a</td></tr>
<tr><td>34</td><td>Vibratory pile driving – Monitoring, clearance, and shutdown zones</td><td><table>
<tr><th>Measure</th><th>NARW</th><th>Other Large Whales</th><th>Sea Turtles</th></tr>
<tr><td>Pre-start clearance zone</td><td>100 m</td><td>100 m</td><td>50 m</td></tr>
<tr><td>Shutdown zone</td><td>100 m</td><td>100 m</td><td>50 m</td></tr>
<tr><td>Clearance duration</td><td colspan="3">30 min visual monitoring; zone must be clear for 30 min</td></tr>
<tr><td>Post-piling monitoring</td><td colspan="3">30 minutes</td></tr>
</table></td><td>Construction</td><td>This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
<tr><td>35</td><td>Vibratory pile driving – Pre-start clearance and operational monitoring</td><td>• PSOs will monitoring the CZ for 30 minutes prior to start of vibratory pile driving.
• If a protected species is observed entering or within the CZ piling cannot commence until the animal has exited the CZ or time has elapsed since the last sighting (30 minutes for large whales, 15 minutes for sea turtles and small odontocetes).
• PSOs will continue to survey SZs using visual protocols throughout the vibratory pile driving and for a minimum of 30 minutes after piling has been completed.</td><td>Construction</td><td>Same as above</td></tr>
<tr><td>36</td><td>Vibratory pile driving – Shutdown protocol</td><td>• If a protected species is observed entering or within the respective SZs after sheet pile installation has commenced, a shutdown will be implemented as long as health and safety is not compromised.
• SZs must be continuously monitored by PSOs during any pauses in vibratory pile driving.
• If protected species are sighted within a respective SZ during a pause in vibratory pile driving, activities will be delayed until the animal(s) has moved outside the SZ or when 30 minutes have elapsed without redetection for large whales, including the NARW, or 15 minutes have elapsed without redetection of sea turtles or small odontocetes.</td><td>Construction</td><td>Same as above</td></tr>
</table>

<table>
<tr><th>E3PM #</th><th>EPM</th><th>Description</th><th>Project Phase</th><th>Anticipated Effect</th></tr>
<tr><td>37</td><td>Vibratory pile driving – Sound source verification</td><td>Received sound measurements will be collected during vibratory pile driving at the landfall construction site. The measurement plan will be similar to that described for impact pile driving in EPM #28, which is designed to collect data on approximate source levels, the directionality of the sounds produced, and transmission loss in at least one direction.
The number and location of recorders may be reduced to measurements conducted in open water locations due to the presence of nearby land.
The distances at which acoustic recorders are placed from the landfall construction will be determined based on the modeled distances to the acoustic thresholds for vibratory pile driving.
The goals of the field verification measurements include verification of modeled ranges to the harassment threshold isopleths and providing sound measurements of vibratory pile driving using ISO (2017) standard methods for comparison among projects and informing future operations.</td><td>Construction</td><td>Same as above</td></tr>
<tr><td>38</td><td>HRG surveys – Visual observation protocols and methods</td><td>The following visual observation protocols will be implemented by all PSOs employed on Project vessels:
Visual monitoring of the established clearance, shutdown, and monitoring zone will be performed by PSO teams on each survey vessel.
Observations will take place from the highest available vantage point on all the survey vessels. General 360° scanning will occur during the monitoring periods, and target scanning by the PSO will occur if cued to a marine mammal. PSOs will adjust their positions appropriately to ensure adequate coverage of the entire shutdown and monitoring zones around the respective sound sources.
PSOs will work in shifts such that no one PSO will work more than 4 consecutive hours without a 2-hour break or longer than 12 hours during any 24-hour period.
The PSOs will begin observation of the CZs prior to initiation of HRG survey operations and will continue observation of the SZs throughout the survey activity and for 30 minutes following cessation of the survey activity using equipment operating below 180 kHz.
The PSOs will be responsible for visually monitoring and identifying marine mammals approaching or entering the established zones during survey activities.
It will be the responsibility of the PSO(s) on duty to communicate the presence of marine mammals as well as to communicate the recommended mitigation action(s) that are necessary to ensure mitigation and monitoring requirements are implemented as appropriate.</td><td>Construction and O&M</td><td>This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.</td></tr>
<tr><td>39</td><td>HRG surveys – Monitoring, clearance and shutdown zones</td><td><table><tr><th>Measure</th><th>NARW</th><th>Other LFCs</th><th>Sperm Whales</th><th>Sea Turtles</th><th></th></tr><tr><td>Pre-start clearance zone</td><td>500 m</td><td colspan="2">100 m</td><td>100 m</td><td>100 m</td></tr><tr><td>Shutdown zone</td><td>500 m</td><td colspan="2">100 m</td><td>100 m</td><td>100 m</td></tr></table></td><td>Construction and O&M</td><td>Same as above</td></tr>
<tr><td>40</td><td>HRG surveys – Daytime visual protocols</td><td>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 protected species.</td><td>Construction and O&M</td><td>Same as above</td></tr>
<tr><td>41</td><td>HRG surveys – Nighttime and low visibility visual protocols</td><td>Visual monitoring during nighttime surveys or periods of low visibility will utilize the following protocols:
The lead PSO will determine if conditions warrant implementing reduced visibility protocols.
Two PSOs on watch during pre-clearance periods, all operations, and for 30 minutes following use of HRG sources operating below 180 kHz
Each PSO should use the most appropriate available technology (e.g., IR camera and NVD) and viewing locations to monitor the clearance and SZs and maintain vessel separation distances.</td><td>Construction and O&M</td><td>Same as above</td></tr>
<tr><td>42</td><td>HRG surveys – Autonomous surface vehicle</td><td>Should an autonomous surface vessel (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 camera will be installed on the mother vessel facing forward and angled in a direction so as to provide a field of view ahead of the vessel and around the ASV.
PSOs will be able to monitor the real-time output of the camera on hand-held iPads or tables. Images from the cameras can be captured for review and to assist it verifying species identification.
A monitor will also be installed on the bridge displaying the real-time picture from the thermal/HD camera installed on the front of the ASV itself, providing an additional forward field of view of the craft.
Night-vision goggles with thermal clip-ons, as mentioned above, and a hand-held spotlight will be provided such that PSOs can focus observations in any direction around the mother vessel and/or the ASV.</td><td>Construction and O&M</td><td>Same as above</td></tr>
</table>

E3PM #	EPM	Description	Project Phase	Anticipated Effect
43	HRG surveys – Pre-start clearance	• PSOs will implement a 30-minute clearance period of the CZ immediately prior to the initiation of equipment ramp-up. • The CZ must be visible using the naked eye or appropriate visual technology during the entire clearance period for operations to start. If the CZ are not visible, source operations <180 kHz may not commence. • Ramp-up may not be initiated if any protected species is detected within its respective CZ. • If a protected species is observed within its respective CZ during the pre-start clearance • period, ramp-up may not begin until the animal(s) has been observed exiting its respective • CZ or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for sea turtles and 30 minutes for all other species).	Construction and O&M	Same as above
44	HRG surveys – Ramp up	• Where technically feasible, a ramp-up procedure will be used for HRG survey equipment capable of adjusting energy levels at the start or re-start of HRG survey activities. Ramp-up procedures provide additional protection to marine mammals near the Project Area by allowing them to vacate the area prior to the commencement of survey equipment use at full power. • The ramp-up procedure will not be initiated during periods of inclement conditions or if the CZs cannot be adequately monitored by the PSOs, using the appropriate visual technology for a 30-minute period immediately prior to ramp up. • Ramp-up will begin with the power of the smallest acoustic equipment at its lowest practical power output. When technically feasible the power will then be gradually turned up and other acoustic sources added in a way such that the source level would increase gradually. • Ramp-up activities will be delayed if a protected species enters its respective CZ. Ramp up will continue if the animal has been observed exiting its respective CZ or until an additional time period has elapsed with no further sighting (i.e., 15 minutes for sea turtles and 30 minutes for all other species).	Construction and O&M	Same as above
45	HRG surveys – Operations monitoring	• PSOs will monitor Mysticetus (or similar data system) and/or appropriate data systems for DMAs established within their survey area. • PSOs will also monitor the NMFS NARW reporting systems including Whale Alert and RWSAS once every PSO shift during Project-related activities within, or adjacent to, SMAs and/or DMAs.	Construction and O&M	Same as above
46	HRG surveys – Shutdown protocols	• Shutdown of impulsive, non-parametric HRG survey equipment other than CHRIP sub-bottom profilers operating at frequencies <200 kHz is required if a marine mammal is sighted at or within its respective shutdown zone. • The vessel operator must comply immediately with any call for shutdown by the Lead PSO. Any disagreement between the Lead PSO and vessel operator should be discussed only after shutdown has occurred. • Subsequent restart of the survey equipment will not be initiated until either the marine mammal(s) that triggered the shutdown has voluntarily left and been visually confirmed beyond the relevant CZ, or when 30 minutes have elapsed without re-detection (for marine mammals) or 15 minutes have elapsed without re-detection (for sea turtles). • If the acoustic source is shut down for reasons other than mitigation (e.g., mechanical difficulty) for less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant observation and no detections of any marine mammal have occurred within the respective SZs. • If the acoustic source is shut down for a period longer than 30 minutes or PSOs were unable to maintain constant observation, then pre-start clearance and ramp-up procedures will be initiated.	Construction and O&M	Same as above
47	UXO detonation – General 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 CZ >5 km associated with unmitigated detonation: Aerial based visual observers conducting pre-start surveys of the CZ. 2) PAM operators and an associated mitigation PAM array in support of the visual PSOs; 3) NMSs as feasible; 4) Post-detonation monitoring; 5) Acoustic measurement data collection to verify distances to regulatory or mitigation zones, and; 6) Monitoring and mitigation protocols applicable to UXO detonation, as described below. There will be a team of 6 - 8 visual and acoustic PSOs on monitoring vessels. The number of vessels will depend on the size of the zones to be monitored. A single vessel is anticipated to adequately cover a radius of 2,000 m. There will be a team of four to eight visual and acoustic PSOs on each monitoring vessel. The number of vessels will be sufficient to observe the maximum CZ 100% of the time and be determined by:	Construction	This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.

<table>
<tr><th>E3PM #</th><th>EPM</th><th>Description</th><th>Project Phase</th><th>Anticipated Effect</th></tr>
<tr><td></td><td></td><td>the detonation category and associated CZ size,
use of NMS (as feasible), and
minimum distance allowed to the detonation location.
PAM operators may be located remotely/onshore.</td><td></td><td></td></tr>
<tr><td>48</td><td>UXO detonation – Personnel requirements</td><td>Personnel and equipment for marine monitoring vessels used for UXO detonation are as follows.
<table>
<tr><th>Personnel and Equipment</th><th># on Construction Vessel</th></tr>
<tr><td>Visual PSOs on watch</td><td>2</td></tr>
<tr><td>PAM operators on duty</td><td>1</td></tr>
<tr><td>Reticle binoculars</td><td>2</td></tr>
<tr><td>Monitoring station for real time PAM system</td><td>1</td></tr>
<tr><td>Data collection software system</td><td>1</td></tr>
<tr><td>PSO-dedicated VHF radios</td><td>2</td></tr>
<tr><td>Digital single-lens reflex camera equipped with 300-mm lens</td><td>1</td></tr>
</table></td><td>Construction</td><td>Same as above</td></tr>
<tr><td>49</td><td>UXO detonation - Monitoring and clearance zones</td><td>Mitigation and monitoring zones for UXO detonation based on device size by protected species hearing group:
<table>
<tr><th rowspan="2">Hearing Group</th><th colspan="5">Pre-start Clearance Zone by UXO Device Size</th></tr>
<tr><th>E4 (2.3 kg)</th><th>E6 (9.1 kg)</th><th>E8 (45.5 kg)</th><th>E10 (227 kg)</th><th>E12 (454 KG)</th></tr>
<tr><td>Low frequency cetaceans</td><td>RWEC: 600 m
Lease Area: 400 m</td><td>RWEC: 1,000 m
Lease Area: 800 m</td><td>RWEC: 1,800 m
Lease Area: 1,600 m</td><td>RWEC: 3,000 m
Lease Area: 3,000 m</td><td>RWEC: 3,800 m
Lease Area: 3,700 m</td></tr>
<tr><td>Mid frequency cetaceans</td><td>RWEC: 50 m
Lease Area: 50 m</td><td>RWEC: 80 m
Lease Area: 50 m</td><td>RWEC: 200 m
Lease Area: 100 m</td><td>RWEC: 400 m
Lease Area:400 m</td><td>RWEC: 500 m
Lease Area: 500 m</td></tr>
<tr><td>Sea turtles</td><td>RWEC: 50 m
Lease Area: 50 m</td><td>RWEC: 80 m
Lease Area: 50 m</td><td>RWEC: 200 m
Lease Area: 100 m</td><td>RWEC: 400 m
Lease Area:400 m</td><td>RWEC: 500 m
Lease Area: 500 m</td></tr>
</table></td><td>Construction</td><td>Same as above</td></tr>
<tr><td>50</td><td>UXO detonation – Visual monitoring, vessel-based</td><td>Visual monitoring will be conducted from the primary monitoring vessel, and additional vessels in cases where the mitigation zone cannot be covered by a single vessel. Daytime visual monitoring is defined by the period between civil nautical twilight rise and set for the region. No nighttime UXO detonation will be conducted. Daytime monitoring protocols are as follows:
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.
During daytime observations, two PSOs on each vessel will monitor the CZs with the naked eye and reticle binoculars. One PSO will periodically scan outside the CZs using the mounted big eye binoculars.
PSOs will visually monitor the maximum Low Frequency (Large Whale) Level A zone which constitutes the pre-start CZ. 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 CZs.
There will be a PAM operator on duty (see Section 6.2.3) conducting acoustic monitoring in coordination with the visual PSOs during all pre-start clearance periods and post-detonation monitoring periods.</td><td>Construction</td><td>Same as above</td></tr>
</table>

E3PM #	EPM	Description	Project Phase	Anticipated Effect
		• Acoustic monitoring will include, and extend beyond, the Large Whale pre-start CZ.		
51	UXO detonation – Visual monitoring, aerial alternative	Aerial monitoring may be used under specific circumstances, e.g., the discovery of large UXOs having clearance areas that cannot be monitored effectively from a surface vessel. Aerial monitoring will be used to provide complete visual coverage of clearance areas under these circumstances, 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 CZ. • PSOs will monitor the CZs 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 CZ. This zone encompasses the maximum Level A exposure ranges for all ESA-listed marine mammals. • 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 CZ.	Construction	Same as above
52	UXO detonation – 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-start CZs. PAM operators will acoustically monitor a zone that encompasses a minimum of 10 km radius around the source. PAM will be conducted in the daylight only as no UXO will be detonated during nighttime hours. PAM devices proposed for monitoring during UXO detonation activities are not likely to be towed from the vessel, but rather will be independent (e.g., autonomous or moored remote) stations located around the area to be monitored. The specific placement of PAM devices or systems will be determined based on the final mitigation zones determined in the regulatory review process. The following PAM protocols will be followed for UXO detonation events: • A PAM operator will be stationed on at least one of the dedicated monitoring vessels in addition to the PSOs; or located remotely/onshore. • PAM operators will complete specialized training for operating PAM systems prior to the start of monitoring activities. • All on-duty PSOs will be in contact with the PAM operator on-duty, who will monitor the PAM systems for acoustic detections of marine mammals that are vocalizing in the area. • For real-time PAM systems, at least one PAM operator will be designated to monitor each system by viewing data or data products that are streamed in real-time or near real-time to a computer workstation and monitor located on a Project vessel or onshore. No archival recording systems will be used. • The PAM operator will inform the Lead PSO on duty of animal detections approaching or within applicable ranges of interest to the detonation activity via the data collection software system (i.e., Mysticetus or similar system). The Lead PSO will be responsible for requesting the designated crewmember to implement a delay in UXO detonation.	Construction	Same as above
53	UXO detonation – Pre-start clearance	A 60-min pre-start clearance period will be implemented prior to any UXO detonation. Visual PSOs will begin surveying the monitoring zone at least 60 min prior to the detonation event. PAM will also begin 60 min prior to the detonation event. • The Large Whale CZ must be fully visible for at least 60 min immediately prior to commencing detonation. • All marine mammals must be confirmed to be out of the CZ prior to initiating detonation. • If a marine mammal is observed entering or within the relevant CZs 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 CZ and been visually confirmed beyond that CZ, or, when 60 min have elapsed without redetection for whales, including the NARW, or 15 min have elapsed without redetection of sea turtles, dolphins, porpoises, and seals.	Construction	Same as above
54	UXO detonation – Noise attenuation system	As feasible, Revolution Wind will use a NAS for all detonation events and is committed to achieving the modeled ranges associated with 10 dB of noise attenuation (LGL 2022). If a NAS system is not feasible, Revolution Wind will implement mitigation measures for the larger unmitigated zone sizes, with deployment of vessels or use of an aerial platform adequate to cover the entire CZ (see EPM #51).	Construction	This mitigation measure would avoid and minimize adverse impacts to ESA-listed marine mammals, sea turtles, and fish from UXO detonation, where practicable.
55	UXO detonation – Sound measurements	Received sound measurements will be collected during UXO detonations. The measurement plan will be similar to that described for impact pile driving (see EPM #28), which is designed to collect data on approximate source levels, the directionality of the sounds produced, and transmission loss in at least one direction. The distances at which acoustic recorders are placed from the UXO detonation will be determined based on the modeled distances to Level A and Level B thresholds for the applicable UXO size being detonated.	Construction	This monitoring measure would not minimize the potential for adverse effects but would ensure the effectiveness of the required mitigation and

E3PM #	EPM	Description	Project Phase	Anticipated Effect
		The goals of the field verification measurements include verification of modeled ranges to the Level A harassment and Level B harassment isopleths and providing sound measurements of UXO detonations using ISO standard methodology (ISO 2017) for comparison among projects and informing future operations		monitoring measures for marine mammals, sea turtles, and ESA-listed fish from impact pile driving.
56	Fisheries and benthic habitat monitoring – General measures	Revolution Wind is partnering with scientists from Commercial Fisheries Research Center to execute the survey. CFRF has applied for an Exempted Fishing Permit from NOAA Fisheries to use the hired fishing vessels to conduct scientific sampling that is not subject to the Atlantic Coastal Fisheries Cooperative Management Act, Magnuson-Stevens Fishery Conservation and Management Act, and fishery regulations in 50 CFR parts 648 and 697. However, the EFP was not approved, and the commencement of the survey has been delayed as the project team seeks to obtain the necessary scientific research permits to execute the survey. Fisheries monitoring was designed in accordance with recommendations set forth in “Guidelines for Providing Information on Fisheries for Application for Renewable Energy Development on the Atlantic Outer Continental Shelf” (BOEM 2019) and consideration to the Responsible Offshore Science Alliance (ROSA) Offshore Wind Project Monitoring Framework and Guidelines. All survey activities will be subject to rules and regulations outlined under the MMPA and ESA. Efforts will be taken to reduce marine mammal, sea turtle, and seabird injuries and mortalities caused by incidental interactions with sampling gear. All gear restrictions, closures, and other regulations set forth by take reduction plans (e.g., Harbor Porpoise Take Reduction Plan, Atlantic Large Take Whale Reduction Plan, etc.) will be adhered to as with typical scientific fishing operations to reduce the potential for interaction or injury.		
57	Fisheries and benthic habitat monitoring – Ventless trap surveys	Revolution Wind will follow requirements described in the Atlantic Large Whale Take Reduction Plan (NOAA 2018) for the trap and pot fisheries. At a minimum, the following measures will be used to avoid interactions between the ventless trap survey and marine mammals: • No buoy line will be floating at the surface. • All sampling gear will be hauled at least once every 30 days, and all gear will be removed from the water at the end of each sampling season (November). • All groundlines will be constructed of sinking line. • Fishermen contracted to perform the field work will be encouraged to use knot-free buoy lines. • To reduce the potential for moderate or significant risk to right whales (should an entanglement occur) buoy/end lines with a breaking strength of <1700lbs will be used. All buoy line will use weak links that are chosen from the list of NMFS approved gear. This may be accomplished by using whole buoy line that has a breaking strength of 1700lbs; or buoy line with weak inserts that result in line having an overall breaking strength of 1700lbs. • All buoys will be labeled as research gear, and the scientific permit number will be written on the buoy. All markings on the buoys and buoy lines will be compliant with the regulations, and all buoy markings will comply with instructions received by staff at NOAA Greater Atlantic Regional Fisheries Office Protected Resources Division. • Any lines or trawls that go missing will be reported to the NOAA Greater Atlantic Regional Fisheries Office Protected Resources Division as soon as possible.	Pre-construction, Construction, O&M	This mitigation measure would avoid the potential for adverse effects on marine mammals and sea turtles from fisheries monitoring activities.
58	Fisheries and benthic habitat monitoring – Ventless trap surveys	• Marine mammal monitoring will be conducted by the captain and/or a member of the scientific crew before, during, and after haul back. • Trawl operations will commence as soon as possible once the vessel arrives on station; the target tow time will be limited to 20 minutes. • Revolution Wind will initiate marine mammal watches (visual observation) within 1 nautical mile (1852 meters) of the site 15 minutes prior to sampling. • If a marine mammal is sighted within 1 nautical mile (1,852 meters) of the planned sampling station in the 15 minutes before gear deployment, Revolution Wind will delay setting the trawl until marine mammals have not been resighted for 15 minutes or Revolution Wind may move the vessel away from the marine mammal to a different section of the sampling area. If, after moving on, marine mammals are still visible from the vessel, Revolution Wind may decide to move again or to skip the sampling station. • Revolution Wind will maintain visual monitoring effort during the entire period of time that trawl gear is in the water (i.e., throughout gear deployment, fishing, and retrieval). If marine mammals are sighted before the gear is fully removed from the water, (i.e., prior to haul back) the vessel will slow its speed and steer away from the sighted animal in order to minimize potential interactions. Further mitigating actions can be taken following consultation with and guidance from the NMFS Protected Resources Division. • Revolution Wind will open the codend of the net close to the deck/sorting area to avoid damage to animals that may be caught in gear. • Gear will be emptied as close to the deck/sorting area and as quickly as possible after retrieval. • Trawl nets will be fully cleaned and repaired (if damaged) before setting again.	Pre-construction, Construction, O&M	This mitigation measure would avoid the potential for adverse effects on marine mammals from fisheries monitoring activities

E3PM #	EPM	Description	Project Phase	Anticipated Effect
		• Revolution Wind does not anticipate and is not requesting take of marine mammals incidental to research trawl surveys but, in the case of a marine mammal interaction, the Marine Mammal Stranding Network will be contacted immediately.		
59	Fisheries and benthic habitat monitoring – Acoustic telemetry surveys	• No specific mitigation relevant to this type of survey • Vessel mitigation measures outlined above for all Project vessels will be employed while collecting samples.	Pre-construction, Construction, O&M	n/a

Table C-2. Additional mitigation, monitoring, and reporting measures proposed by BOEM, BSEE, and USACE.

Measure #	Measure	Description	Project Phase	Anticipated Enforcement Entity
1	Marine debris awareness training	The Lessee would ensure that vessel operators, employees, and contractors engaged in offshore activities pursuant to the approved COP complete marine trash and debris awareness training annually. The training consists of two parts: (1) viewing a marine trash and debris training video or slide show (described below); and (2) receiving an explanation from management personnel that emphasizes their commitment to the requirements. The marine trash and debris training videos, training slide packs, and other marine debris related educational material may be obtained at https://www.bsee.gov/debris or by contacting BSEE. The training videos, slides, and related material may be downloaded directly from the website. Operators engaged in marine survey activities would continue to develop and use a marine trash and debris awareness training and certification process that reasonably assures that their employees and contractors are in fact trained. The training process would include the following elements: • Viewing of either a video or slide show by the personnel specified above; • An explanation from management personnel that emphasizes their commitment to the requirements; • Attendance measures (initial and annual); and • Recordkeeping and the availability of records for inspection by DOI. By January 31 of each year, the Lessee would submit to DOI an annual report that describes its marine trash and debris awareness training process and certifies that the training process has been followed for the previous calendar year. The Lessee would send the reports via email to BOEM (at renewable_reporting@boem.gov) and to BSEE (at marinedebris@bsee.gov).	Construction, O&M, and decommissioning	BOEM, the Bureau of Safety and Environmental Enforcement (BSEE), and USACE
2	Marine debris elimination	Marking: Materials, equipment, tools, containers, and other items used in OCS activities which are of such shape or properly secured to prevent loss overboard. All markings must clearly identify the owner and must be durable enough to resist the effects of the environmental conditions to which they may be exposed.	Construction and post-construction	BOEM, BSEE, and USACE
3	Incorporate LOA requirements	The measures required by the final MMPA Letter of Authorization (LOA) for Incidental Take Regulations would be incorporated into COP approval, and BOEM and/or BSEE will monitor compliance with these measures.	Construction and post-construction	BOEM and BSEE
4	PAM monitoring methods	Use PAM buoys or autonomous PAM devices to record ambient noise, marine mammals, and cod vocalizations in the Lease Area before, during, and immediately after construction (at least 3 years of operation) to monitor Project noise. The archival recorders must have a minimum capability of detecting and storing acoustic data on anthropogenic noise sources (such as vessel noise, pile driving, WTG operation, and whale detections), marine mammals, and cod vocalizations in the Lease Area. Monitoring would also occur during the decommissioning phase. 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 to accomplish both monitoring during constructions, and also meet post-construction monitoring needs. Results must be provided within 90 days of construction completion and again within 90 days of the 1-year, 2-year, and 3-year anniversary of collection. The underwater acoustic monitoring must follow standardized measurement and processing methods and visualization metrics developed by the Atlantic Deepwater Ecosystem Observatory Network (ADEON) for the U.S. Mid- and South Atlantic OCS (see https://adeon.unh.edu/). At least two buoys must be independently deployed within or bordering the Lease Area or one or more buoys must be deployed in coordination with other acoustic monitoring efforts in the RI and MA Lease Areas.	Construction, O&M, and decommissioning	BOEM, BSEE, and NMFS
5	PAM plan	BOEM, BSEE, and USACE would ensure that Revolution Wind prepares a PAM Plan that describes all proposed equipment, deployment locations, detection review methodology and other procedures, and protocols related to the required use of PAM for monitoring. This plan would be submitted to NMFS, BOEM and BSEE (at OSWsubmittals@bsee.gov) for review and concurrence at least 180 days prior to the planned start of pile driving. EFH conservation recommendations for PAM would be incorporated into the plan, and BOEM and/or BSEE will monitor compliance with these measures.	Construction, post-construction monitoring	BOEM, BSEE, and NMFS
6	Pile driving restrictions	BOEM would restrict pile driving from January through April, with addition of December with contingencies. Revolution Wind would be required to develop an adaptive acoustic monitoring plan for spawning Atlantic cod from November through March, including restrictions on Project activities if Atlantic cod aggregations indicative of spawning are detected.	Construction	BOEM, BSEE, and USACE
7	Pile driving monitoring plan	BOEM would ensure that Revolution Wind prepare and submit a *Pile Driving Monitoring Plan* to NMFS and BSEE (at OSWsubmittals@bsee.gov) for review and concurrence at least 180 days before start of pile driving.	Construction	BOEM, BSEE, and NMFS
8	PSO coverage	BOEM, BSEE, and USACE would ensure that PSO coverage is sufficient to reliably detect marine mammals and sea turtles at the surface in clearance and SZs to execute any pile driving delays or shutdown requirements. If, at any point prior to or during construction, the PSO coverage that is included as part of the proposed action is determined not to be sufficient to reliably detect ESA-listed whales and sea turtles within the clearance and SZs, additional PSOs and/or platforms would be deployed. Determinations prior to construction would be based on review of the *Pile Driving Monitoring Plan*. Determinations during construction would be based on review of the weekly pile driving reports and other information, as appropriate.	Construction	BOEM, BSEE, and USACE

Measure #	Measure	Description	Project Phase	Anticipated Enforcement Entity
9	Sound field verification	BOEM, BSEE, and USACE would ensure that if the clearance and/or SZs are expanded, PSO coverage is sufficient to reliably monitor the expanded clearance and/or SZs. Additional observers would be deployed on additional platforms for every 1,500 m that a clearance or SZ is expanded beyond the distances modeled prior to verification. To validate the estimated sound field, sound field verification measurements will be conducted during pile driving of the first three monopiles installed over the course of the Project, with noise attenuation activated. A Sound Field Verification Plan will be submitted to NMFS, BOEM, and BSEE for review and approval at least 90 days prior to planned start of pile driving. This plan will describe how Revolution Wind will ensure that the first three monopile installation sites selected for sound field 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 sound field verification. This plan will also include methodology for collecting, analyzing, and preparing sound field verification data for submission to NMFS. The plan will describe how the effectiveness of the sound attenuation methodology will be evaluated based on the results. In the event that Revolution Wind obtains technical information that indicates a subsequent monopile is likely to produce larger sound fields, sound field verification will be conducted for those subsequent monopiles.	Construction	BOEM, BSEE, USACE, and NMFS
10	Shutdown zones and clearance zone adjustment	BOEM, BSEE, and NMFS may consider adjustments in the pre-start clearance and/or SZs based on the initial sound field verification (sound field verification) measurements. Revolution Wind will provide the initial results of the sound field verification 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. Revolution Wind will conduct a sound field verification 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. If initial sound field verification measurements indicate distances to the isopleths are less than the distances predicted by modeling assuming 10 dB attenuation, Revolution Wind may request a modification of the clearance and SZs for impact pile driving. For a modification request to be considered by NMFS, Revolution Wind must have conducted sound field verification on at least three piles to verify that zone sizes are consistently smaller than predicted by modeling. If initial sound field verification measurements indicate distances to the isopleths are greater than the distances predicted by modeling, Revolution Wind will implement additional sound attenuation measures prior to conducting additional pile driving. Additional measures may include improving the efficacy of the implemented noise attenuation technology and/or modifying the piling schedule to reduce the sound source. If modeled zones cannot be achieved by these corrective actions, Revolution Wind will install an additional noise mitigation system to achieve the modelled ranges. Each sequential modification will be evaluated empirically by sound field verification. Additionally, in the event that sound field verification 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 SZs and associated monitoring measures.	Construction	BOEM, BSEE, USACE, and NMFS
11	Monitoring zone for sea turtles	BOEM, BSEE, and USACE would ensure that Revolution Wind monitors the full extent of the area where noise would exceed the 175 dB re 1 μPa^2 threshold for sea turtles for the full duration of all pile driving activities and for 30 minutes following the cessation of pile driving activities and record all observations in order to ensure that all take that occurs is documented.	Construction	BOEM, BSEE, and USACE
12	Reporting of all NARW sightings	If a NARW is observed at any time by PSOs or personnel on any Project vessels, during any Project-related activity or during vessel transit, Revolution Wind must report the sighting information to NMFS as soon as feasible and no later than within 24 hours after conclusion of the detection event (the time, location, and number of animals) via the WhaleAlert app (http://www.whalealert.org/); NMFS Right Whale Sighting Advisory System hotline (phone); and PR.ITP.MonitoringReports@noaa.gov.	Construction, O&M, and decommissioning	BOEM, BSEE, USACE, and NMFS
13	Vessel strike avoidance measures for sea turtles	Between June 1 and November 30, Revolution Wind would have a trained lookout posted on all vessel transits during all phases of the Project to observe for sea turtles. The trained lookout would communicate any sightings, in real time, to the captain so that the requirements in (e) below can be implemented. a. The trained lookout would monitor https://seaturtlesightings.org/ prior to each trip and report any observations of sea turtles in the vicinity of the planned transit to all vessel operators/captains and lookouts on duty that day. b. The trained lookout would maintain a vigilant watch and monitor a Vessel Strike Avoidance Zone (500 m) at all times to maintain minimum separation distances from ESA-listed species. Alternative monitoring technology (e.g., night vision, thermal cameras, etc.) would be available to ensure effective watch at night and in any other low visibility conditions. If the trained lookout is a vessel crew member, this would be their designated role and primary responsibility while the vessel is transiting. Any designated crew lookouts would receive training on protected species identification, vessel strike minimization procedures, how and when to communicate with the vessel captain, and reporting requirements. c. If a sea turtle is sighted within 100 m or less of the operating vessel's forward path, the vessel operator would slow down to 4 knots (unless unsafe to do so) and then proceed away from the turtle at a speed of 4 knots or less until there is a separation distance of at least 100 m at which time the vessel may resume normal operations. If a sea turtle is sighted within 50 m of the forward path of the operating vessel, the vessel operator would shift to neutral when safe to do so and then proceed away from the turtle at a speed of 4 knots. The vessel may resume normal operations once it has passed the turtle. d. Vessel captains/operators would avoid transiting through areas of visible jellyfish aggregations or floating sargassum lines or mats. In the event that operational safety prevents avoidance of such areas, vessels would slow to 4 knots while transiting through such areas. e. All vessel crew members would be briefed in the identification of ESA-listed species of sea turtles and in regulations and best practices for avoiding vessel collisions. Reference materials would be available aboard all Project vessels for identification of sea turtles. The expectation and process for reporting of	Construction, O&M, and decommissioning	BOEM, BSEE, and USACE

Measure #	Measure	Description	Project Phase	Anticipated Enforcement Entity
		sea turtles (including live, entangled, and dead individuals) would be clearly communicated and posted in highly visible locations aboard all Project vessels, so that there is an expectation for reporting to the designated vessel contact (such as the lookout or the vessel captain), as well as a communication channel and process for crew members to do so. f. The only exception is when the safety of the vessel or crew necessitates deviation from these requirements on an emergency basis. If any such incidents occur, they must be reported to NMFS and BSEE within 24 hours. g. If a vessel is carrying a PSO or trained lookout for the purposes of maintaining watch for North Atlantic right whales, an additional lookout is not required and this PSO or trained lookout must maintain watch for whales, giant manta rays, and sea turtles.		
14	Vessel speed restriction	BOEM will require Revolution Wind to comply with NMFS's vessel strike avoidance and reporting measures included in the final MMPA ITR and ESA Biological Opinion.	Construction, O&M	BOEM, BSEE, and USACE
15	Sampling gear	All sampling gear would be hauled out at least once every 30 days, and all gear would be removed from the water and stored on land between survey seasons to minimize risk of entanglement.	Construction, post-construction monitoring	BOEM and BSEE
16	Lost survey gear	If any survey gear is lost, all reasonable efforts that do not compromise human safety would be undertaken to recover the gear. All lost gear would be reported to NMFS (nmfs.gar.incidental-take@noaa.gov) and BSEE (OSWIncidentReporting@bsee.gov) within 24 hours of the documented time of missing or lost gear. This report would include information on any markings on the gear and any efforts undertaken or planned to recover the gear.	Construction, post-construction monitoring	BOEM, BSEE, and NMFS
17	Training	At least one of the survey staff onboard the trawl surveys and ventless trap surveys would have completed NEFOP observer training (within the last 5 years) or other training in protected species identification and safe handling (inclusive of taking genetic samples from Atlantic sturgeon). Reference materials for identification, disentanglement, safe handling, and genetic sampling procedures would be available on board each survey vessel. BOEM and BSEE would ensure that Revolution Wind prepares a training plan that addresses how this requirement would be met and that the plan is submitted to NMFS in advance of any trawl or trap surveys. This requirement is in place for any trips where gear is set or hauled.	Construction, post-construction monitoring	BOEM, BSEE, and NMFS
18	Sea turtle disentanglement	Vessels deploying fixed gear (e.g., pots/traps) would have adequate disentanglement equipment (i.e., knife and boathook) onboard. Any disentanglement would occur consistent with the Northeast Atlantic Coast STDN Disentanglement Guidelines at https://www.reginfo.gov/public/do/DownloadDocument?objectID=102486501 and the procedures described in "Careful Release Protocols for Sea Turtle Release with Minimal Injury" (NOAA Technical Memorandum 580; https://repository.library.noaa.gov/view/noaa/3773).	Construction, post-construction monitoring	BOEM, BSEE, and NMFS
19	Sea turtle/Atlantic sturgeon identification and data collection	Any sea turtles or Atlantic sturgeon caught and/or retrieved in any fisheries survey gear would first be identified to species or species group. Each ESA-listed species caught and/or retrieved would then be properly documented using appropriate equipment and data collection forms. Biological data, samples, and tagging would occur as outlined below. Live, uninjured animals should be returned to the water as quickly as possible after completing the required handling and documentation. a. The Sturgeon and Sea Turtle Take Standard Operating Procedures would be followed (https://media.fisheries.noaa.gov/dammigration/sturgeon_&_sea_turtle_take_sops_external.pdf). b. Survey vessels would have a passive integrated transponder (PIT) tag reader onboard capable of reading 134.2 kHz and 125 kHz encrypted tags (e.g., Biomark GPR Plus Handheld PIT Tag Reader) and this reader be used to scan any captured sea turtles and sturgeon for tags. Any recorded tags would be recorded on the take reporting form (see below). c. Genetic samples would be taken from all captured Atlantic sturgeon (alive or dead) to allow for identification of the DPS of origin of captured individuals and tracking of the amount of incidental take. This would be done in accordance with the Procedures for Obtaining Sturgeon Fin Clips (https://media.fisheries.noaa.gov/dammigration/ sturgeon_genetics_sampling_revised_june_2019.pdf). i. Fin clips would be sent to a NMFS approved laboratory capable of performing genetic analysis and assignment to DPS of origin. To the extent authorized by law, BOEM is responsible for the cost of the genetic analysis. Arrangements would be made for shipping and analysis in advance of submission of any samples; these arrangements would be confirmed in writing to NMFS within 60 days of the receipt of this ITS. Results of genetic analysis, including assigned DPS of origin would be submitted to NMFS within 6 months of the sample collection. ii. Subsamples of all fin clips and accompanying metadata forms would be held and submitted to a tissue repository (e.g., the Atlantic Coast Sturgeon Tissue Research Repository) on a quarterly basis. The Sturgeon Genetic Sample Submission Form is available for download at: https://www.fisheries.noaa.gov/new-england- midatlantic/consultations/section-7-take-reporting-programmaticsgreater-atlantic). d. All captured sea turtles and Atlantic sturgeon would be documented with required measurements and photographs. The animal's condition and any marks or injuries would be described. This information would be entered as part of the record for each incidental take. A NMFS Take Report Form would be filled out for each individual sturgeon and sea turtle (download at: https://media.fisheries.noaa.gov/2021-41507/Take%20Report%20Form%20 07162021.pdf?null) and submitted to NMFS as described below.	Construction, post-construction monitoring	BOEM, BSEE, USACE, and NMFS

Measure #	Measure	Description	Project Phase	Anticipated Enforcement Entity
20	Sea turtle/Atlantic sturgeon handling and resuscitation guidelines	Any sea turtles or Atlantic sturgeon caught and retrieved in gear used in fisheries surveys would be handled and resuscitated (if unresponsive) according to established protocols and whenever at-sea conditions are safe for those handling and resuscitating the animal(s) to do so. Specifically: a. Priority would be given to the handling and resuscitation of any sea turtles or sturgeon that are captured in the gear being used, if conditions at sea are safe to do so. Handling times for these species should be minimized (i.e., kept to 15 minutes or less) to limit the amount of stress placed on the animals. b. All survey vessels would have copies of the sea turtle handling and resuscitation requirements found at 50 CFR 223.206(d)(1) prior to the commencement of any on-water activity (download at: https://media.fisheries.noaa.gov/ dammigration/sea_turtle_handling_and_resuscitation_measures.pdf). These handling and resuscitation procedures would be carried out any time a sea turtle is incidentally captured and brought onboard the vessel during the proposed actions. c. If any sea turtles that appear injured, sick, or distressed, are caught and retrieved in fisheries survey gear, survey staff would immediately contact the Greater Atlantic Region Marine Animal Hotline at 866-755-6622 for further instructions and guidance on handling the animal, and potential coordination of transfer to a rehabilitation facility. If unable to contact the hotline (e.g., due to distance from shore or lack of ability to communicate via phone), the USCG should be contacted via VHF marine radio on Channel 16. If required, hard-shelled sea turtles (i.e., non- leatherbacks) may be held on board for up to 24 hours following handling instructions provided by the Hotline, prior to transfer to a rehabilitation facility. d. Attempts would be made to resuscitate any Atlantic sturgeon that are unresponsive or comatose by providing a running source of water over the gills as described in the Sturgeon Resuscitation Guidelines (https://media.fisheries.noaa.gov/dammigration-miss/Resuscitation-Cards-120513.pdf). e. Provided that appropriate cold storage facilities are available on the survey vessel, following the report of a dead sea turtle or sturgeon to NMFS, and if NMFS requests, any dead sea turtle or Atlantic sturgeon would be retained on board the survey vessel for transfer to an appropriately permitted partner or facility on shore as safe to do so. f. Any live sea turtles or Atlantic sturgeon caught and retrieved in gear used in any fisheries survey would ultimately be released according to established protocols and whenever at-sea conditions are safe for those releasing the animal(s) to do so.	Construction, post-construction monitoring	BOEM, BSEE, USACE, and NMFS
21	Take notification	GARFO PRD would be notified as soon as possible of all observed takes of sea turtles, and Atlantic sturgeon occurring as a result of any fisheries survey. Specifically: a. GARFO PRD would be notified within 24 hours of any interaction with a sea turtle or sturgeon (nmfs.gar.incidental- take@noaa.gov and BSEE at protectedspecies@bsee.gov). The report would include at a minimum: (1) survey name and applicable information (e.g., vessel name, station number); (2) GPS coordinates describing the location of the interaction (in decimal degrees); (3) gear type involved (e.g., bottom trawl, gillnet, longline); (4) soak time, gear configuration and any other pertinent gear information; (5) time and date of the interaction; and (6) identification of the animal to the species level. Additionally, the e-mail would transmit a copy of the NMFS Take Report Form (available at: https://media.fisheries.noaa.gov/2021-07/Take%20Report%20Form%20 07162021.pdf) and a link to or acknowledgement that a clear photograph or video of the animal was taken (multiple photographs are suggested, including at least one photograph of the head scutes). If reporting within 24 hours is not possible due to distance from shore or lack of ability to communicate via phone, fax, or email, reports would be submitted as soon as possible; late reports would be submitted with an explanation for the delay. b. At the end of each survey season, a report would be sent to NMFS that compiles all information on any observations and interactions with ESA-listed species. This report would also contain information on all survey activities that took place during the season including location of gear set, duration of soak/trawl, and total effort. The report on survey activities would be comprehensive of all activities, regardless of whether ESA-listed species were observed.	Construction, post-construction monitoring	BOEM, BSEE, USACE, and NMFS
22	Data collection BA BMPs	BOEM and BSEE would ensure that all Project Design Criteria and Best Management Practices incorporated in the Atlantic Data Collection consultation for Offshore Wind Activities (June 2021) shall be applied to activities associated with the construction, maintenance and operations of the Revolution Wind Project as applicable. https://www.boem.gov/pdcs-and-bmps-atlantic-data-collection-11222021	Construction, O&M, and decommissioning	BOEM and BSEE
23	Monthly/ annual reporting requirements	BOEM and BSEE would ensure that Revolution Wind submits regular reports (in consultation with NMFS) necessary to document the amount or extent of take that occurs during all phases of the proposed action. Details of reporting would be coordinated between Revolution Wind, NMFS, BOEM and BSEE. All reports would be sent to: nmfs.gar.incidental- take@noaa.gov and BSEE at OSWsubmittals@bsee.gov.	Construction, O&M, and decommissioning	BOEM, BSEE, and NMFS
24	Vessel strike avoidance plan measures	BOEM will require Revolution Wind to comply with NMFS's vessel strike avoidance and reporting measures included in the final MMPA ITR and ESA Biological Opinion.	Construction, O&M, and decommissioning	BOEM, BSEE, USACE, and NMFS
25	Vessel speed restriction	BOEM will require Revolution Wind to comply with NMFS's vessel speed restriction and reporting measures included in the final MMPA ITR and ESA Biological Opinion.	Construction, O&M	BOEM, BSEE, USACE, and NMFS

2.0 References

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