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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Table of Contents

Appendices

Appendix A. Fisheries Research and Monitoring Plan
Appendix B. Supplemental Information for Vessel Transits in the Gulf of Mexico
Appendix C. Protected Species Mitigation and Monitoring Plan

Tables

Figures

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).

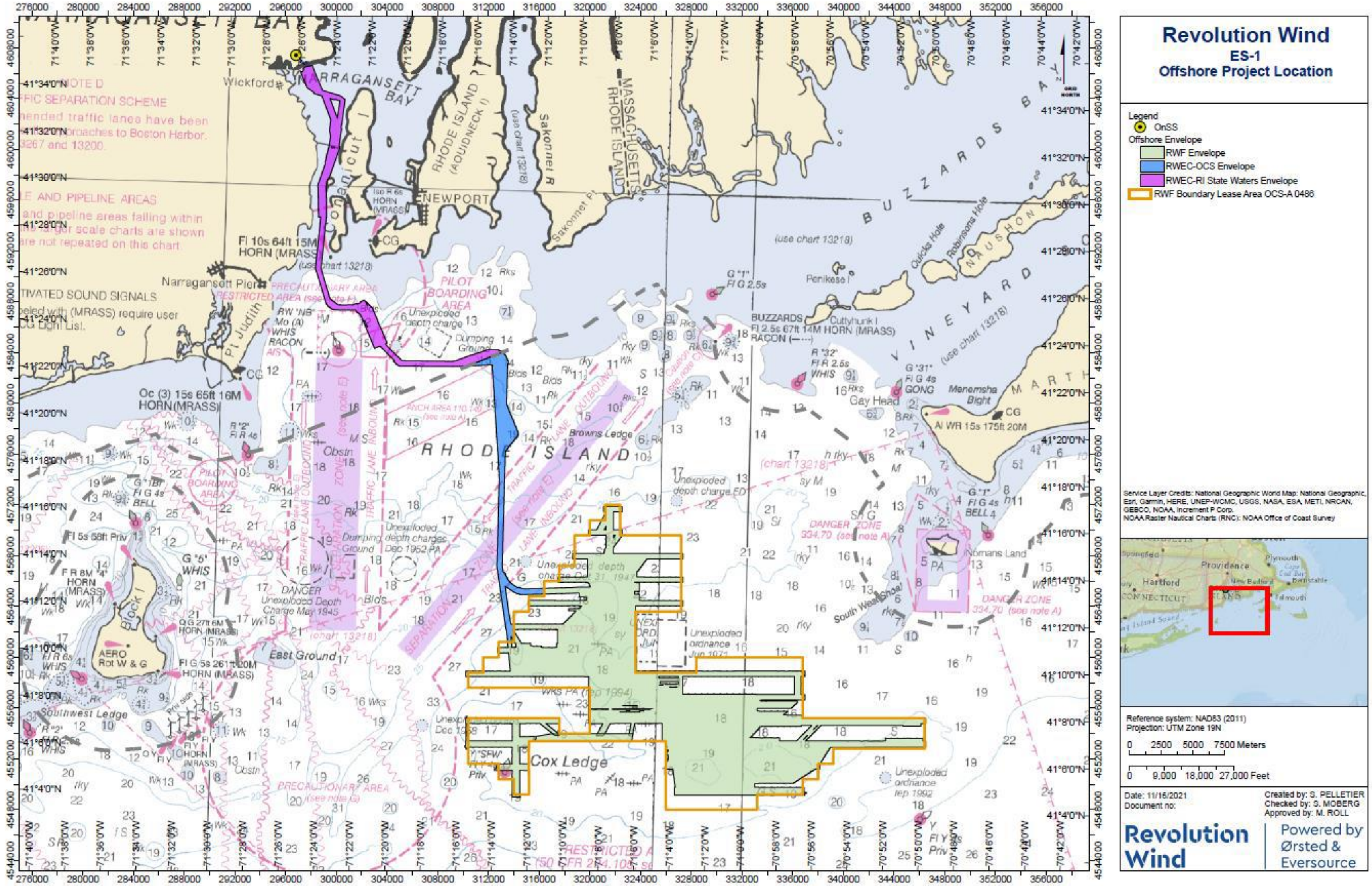

Figure 3.1. RWF and RWEC Lease Area and Vicinity (source: vhb 2022).

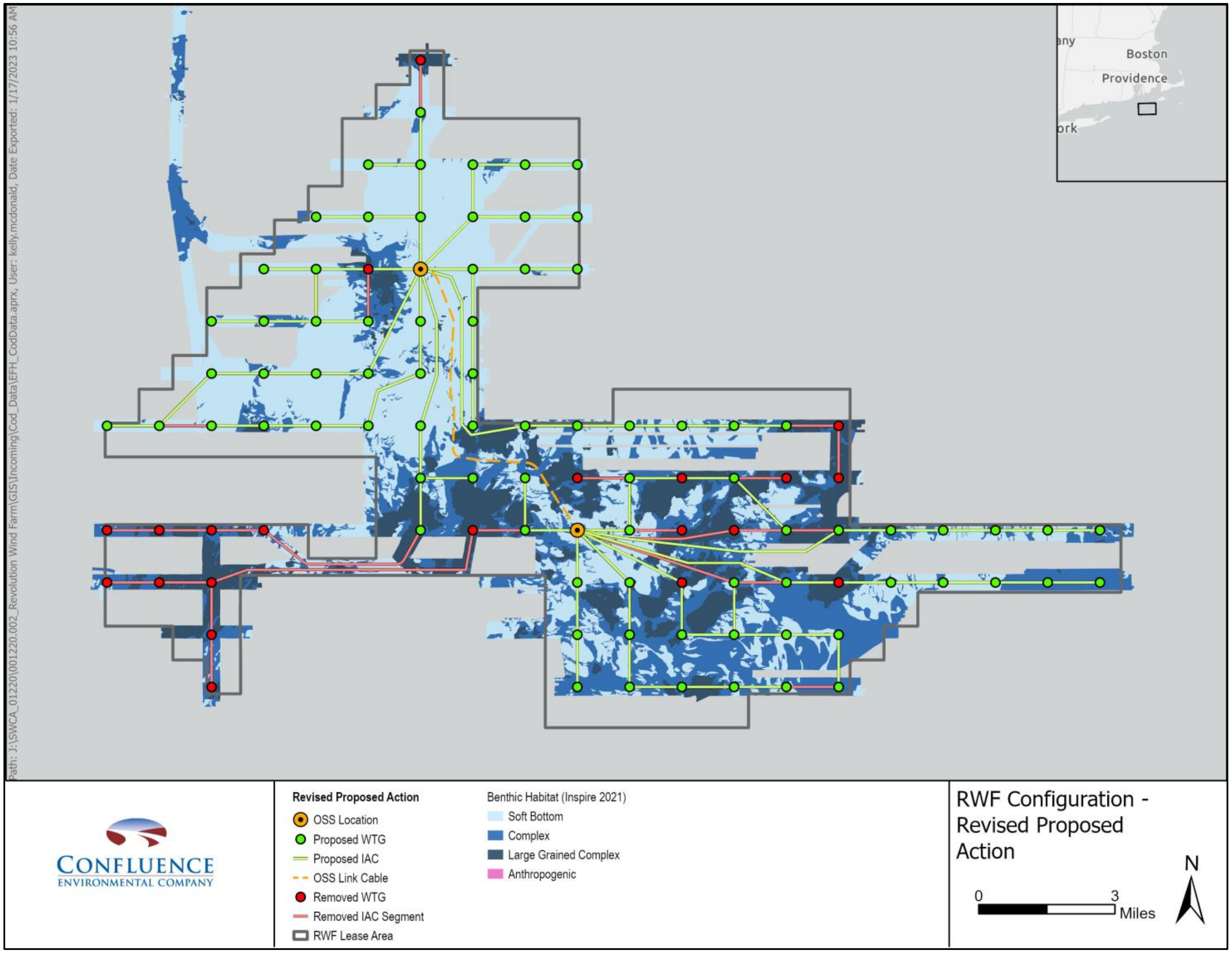

Figure 3.2. RWF Configuration Reflecting the Removal of 21 WTG Positions.

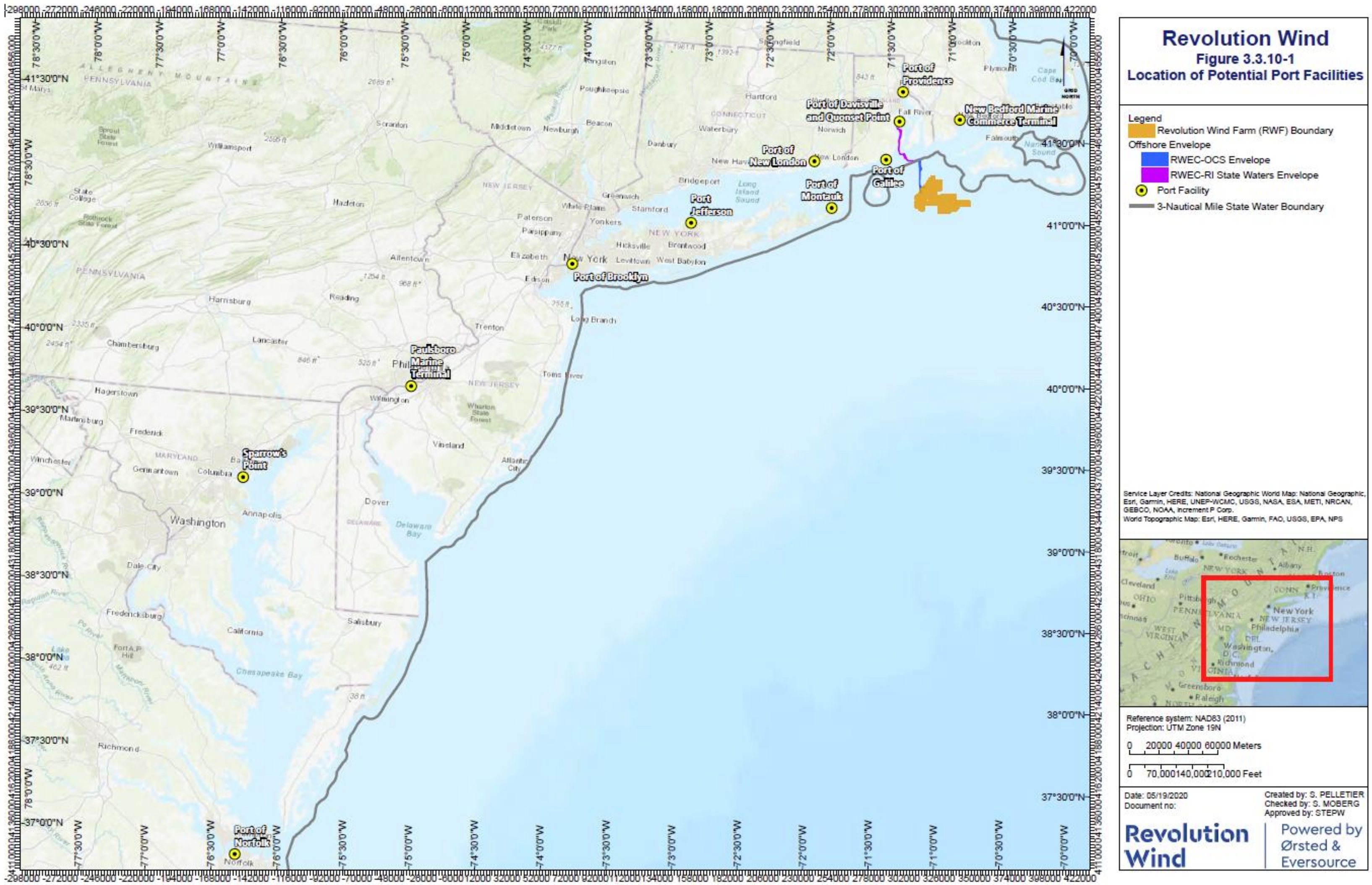

Figure 3.3. U.S. Port Facilities Under Consideration for Project Construction and Installation and O&M Support (the Port of Norfolk, Sparrow's Point, and Paulsboro Marine Terminal were removed from consideration in October 2022 [Revolution Wind 2022a]).

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)

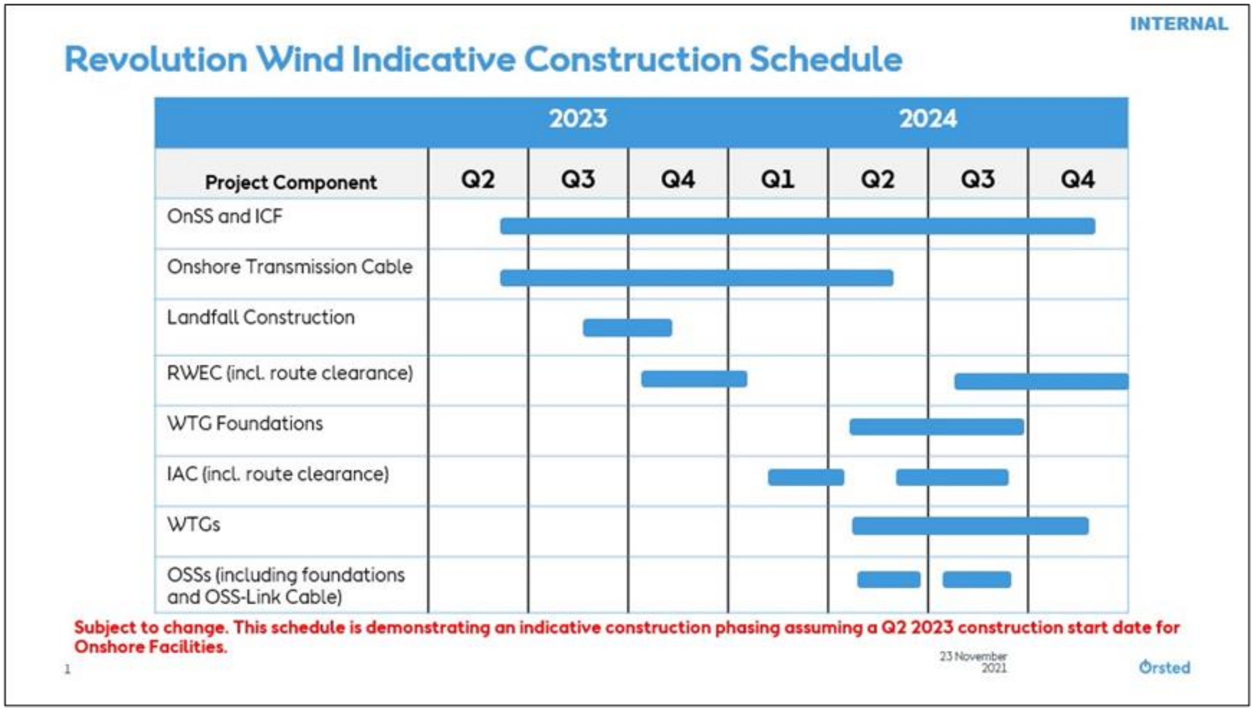

Figure 3.4. Revolution Wind Farm Indicative Construction Schedule.

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.

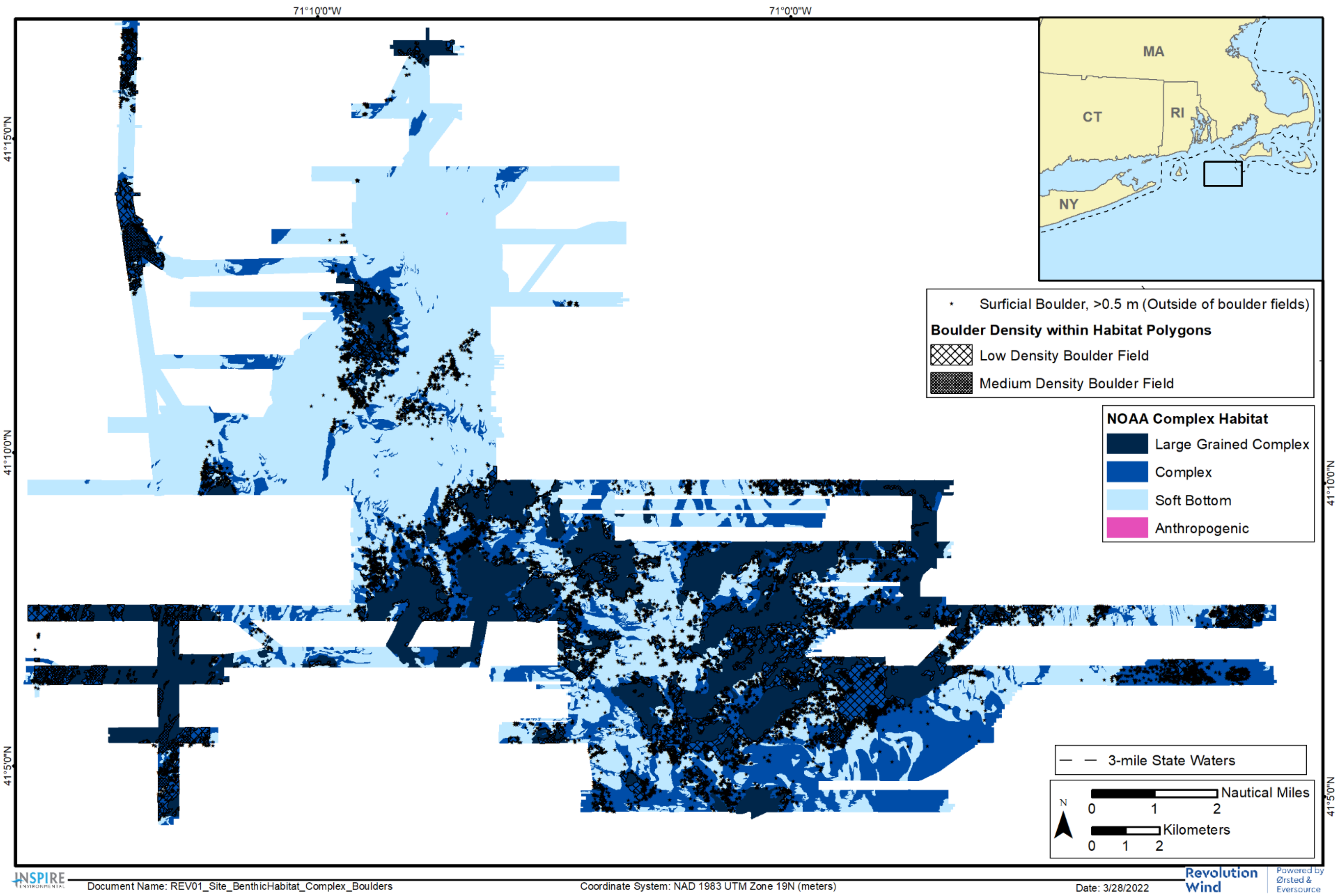

Figure 4.1. Benthic Habitat Composition within the RWF Project Footprint (source: Inspire Environmental 2021).

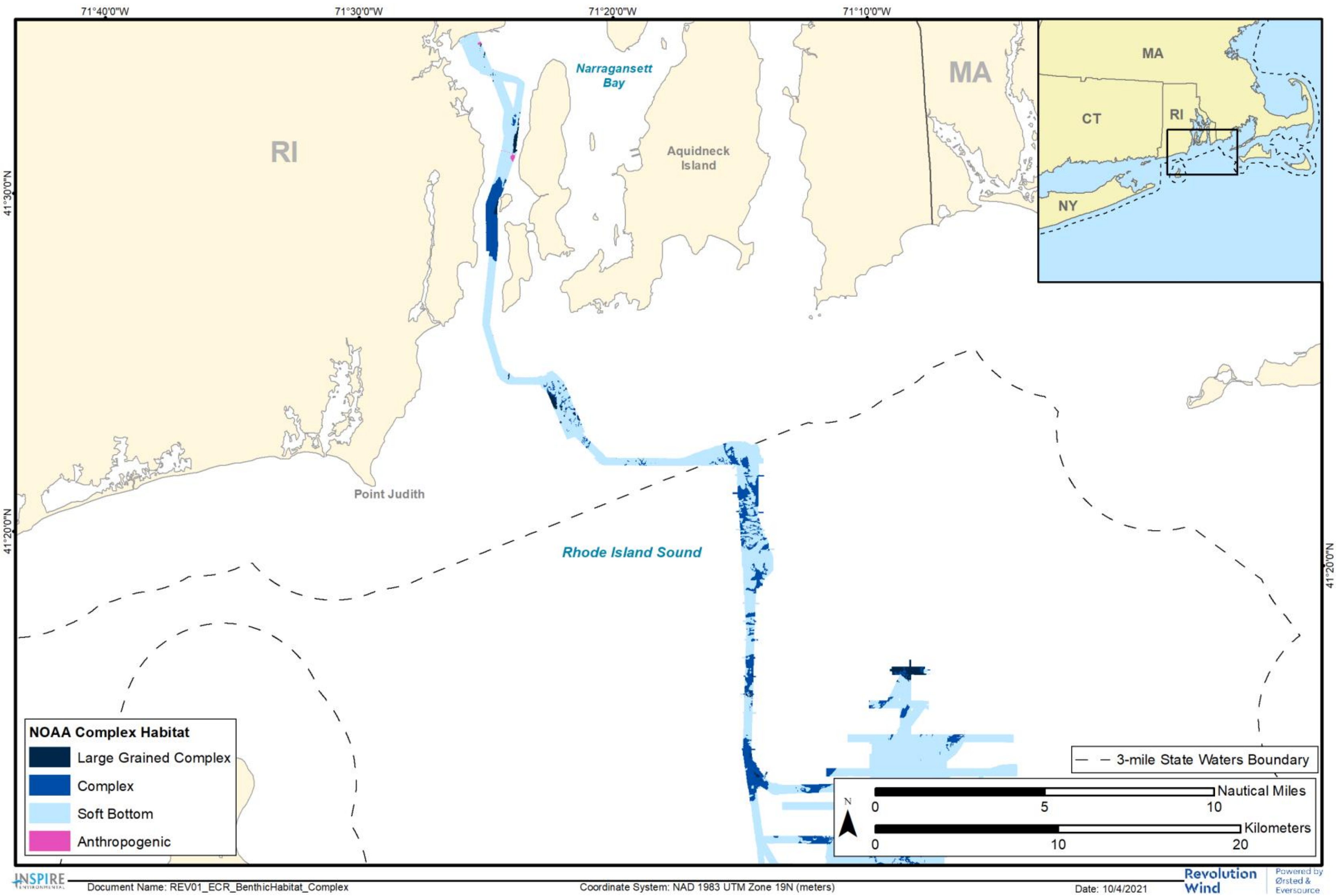

Figure 4.2. Benthic Habitat Composition within the RWEC Project Footprint (source: Inspire Environmental 2021).

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).

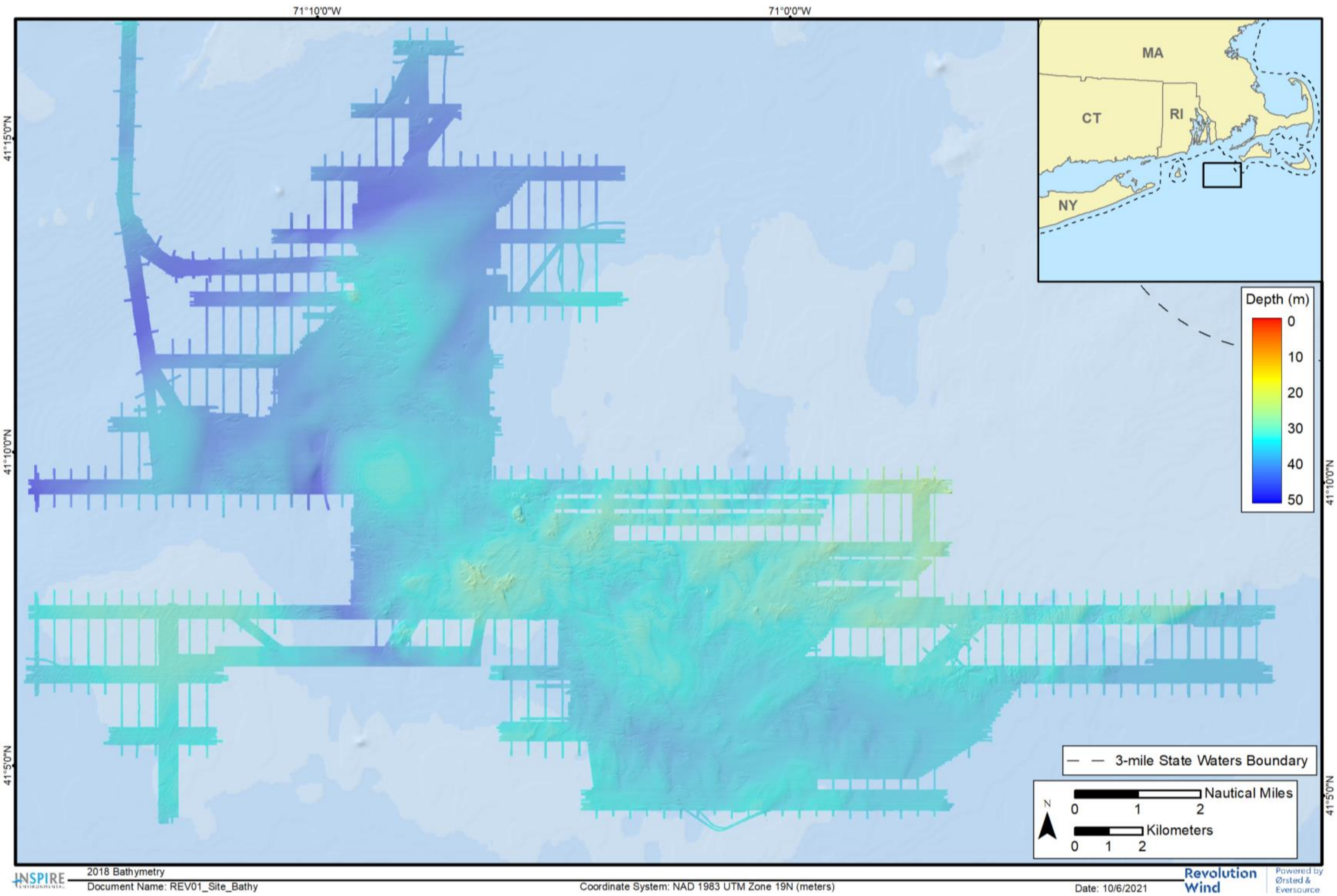

Figure 4.3. Bathymetric Conditions within the RWF Project Footprint (source: Inspire Environmental 2021).

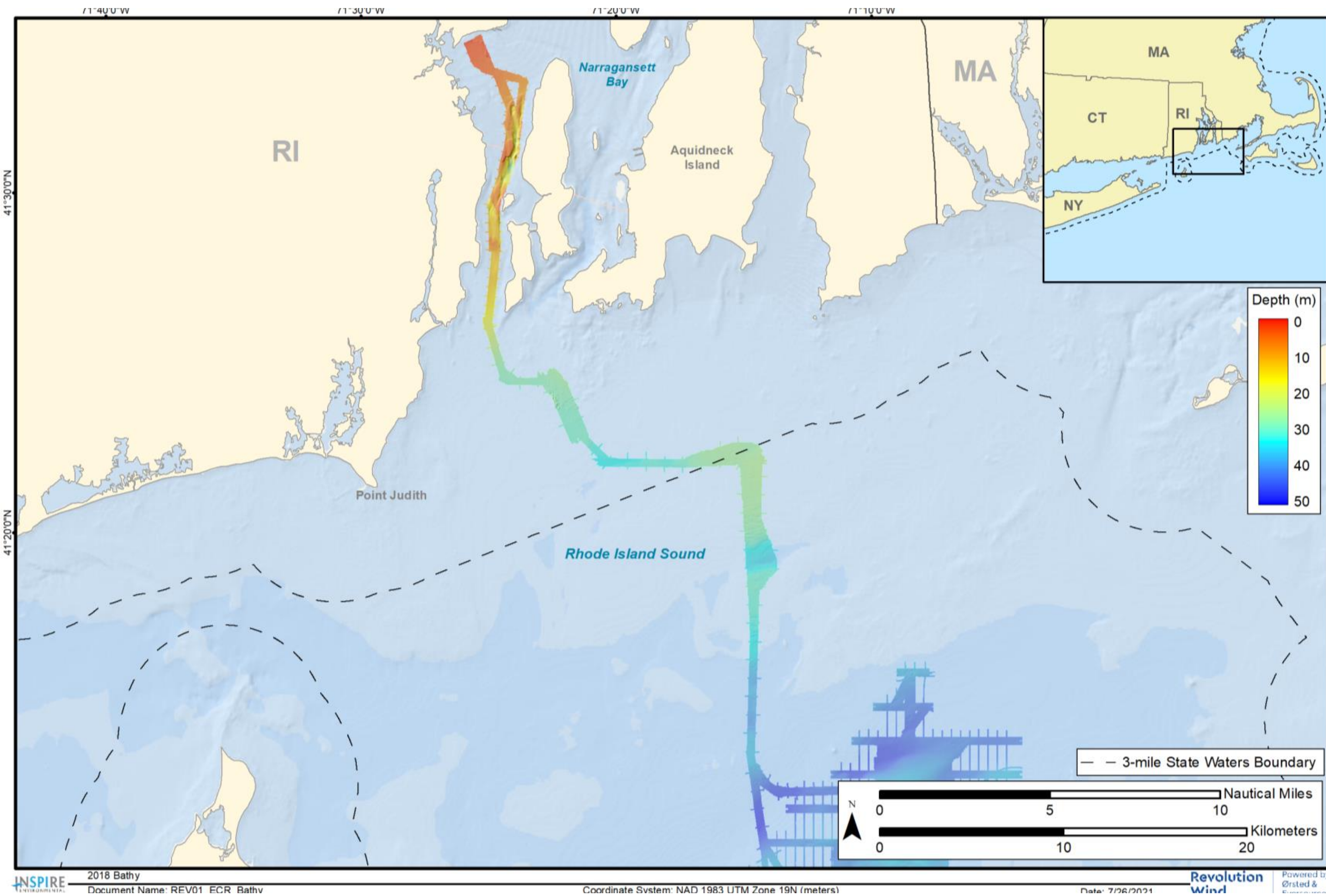

Figure 4.4. Bathymetric Conditions within the RWEC Project Footprint (source: Inspire Environmental 2021).

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.

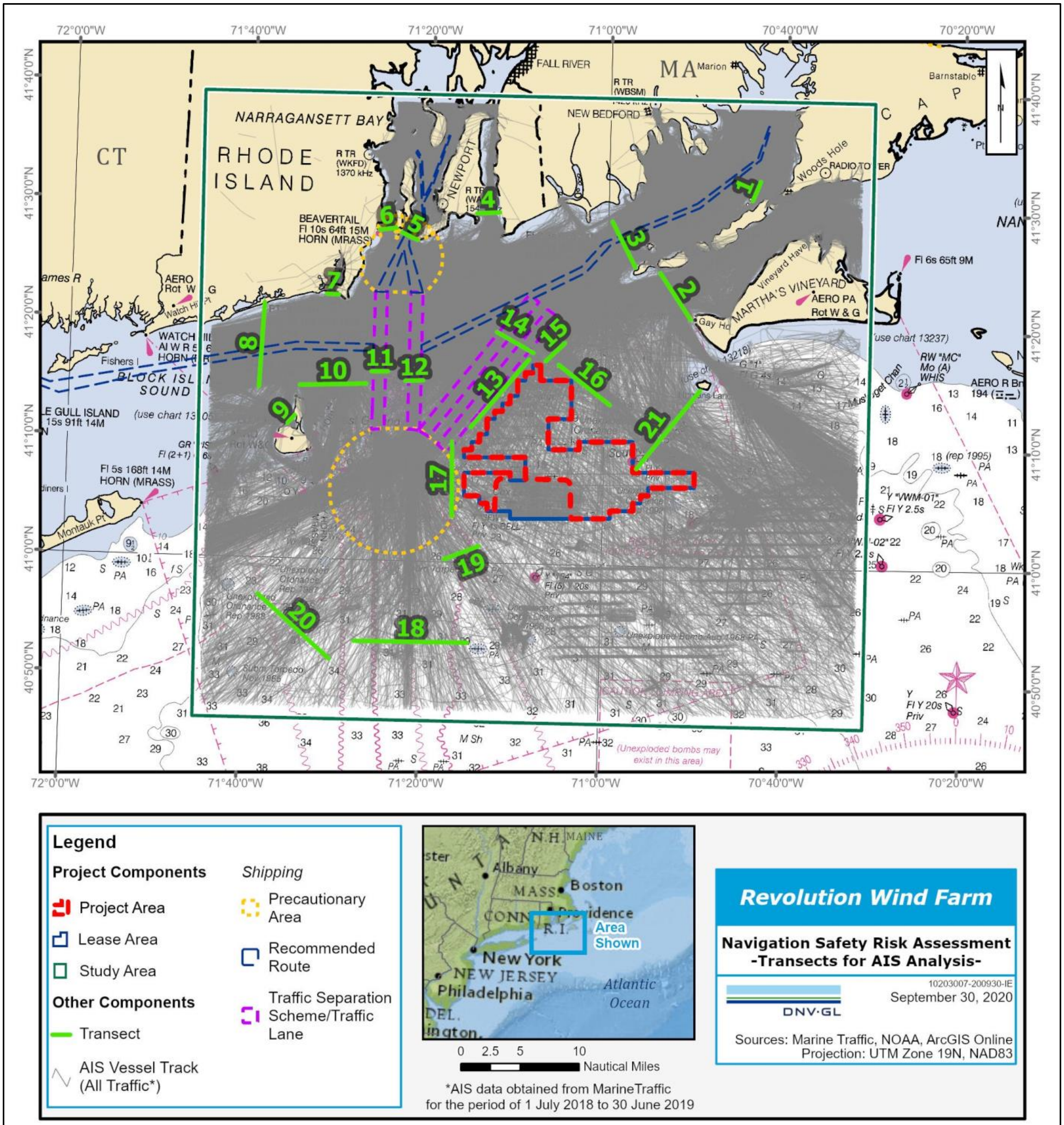

Figure 4.5. AIS Vessel Traffic Tracks for July 1, 2018 to June 30, 2019 and Analysis Cross Sections Used for Traffic Pattern Analysis (DNV GL 2020).

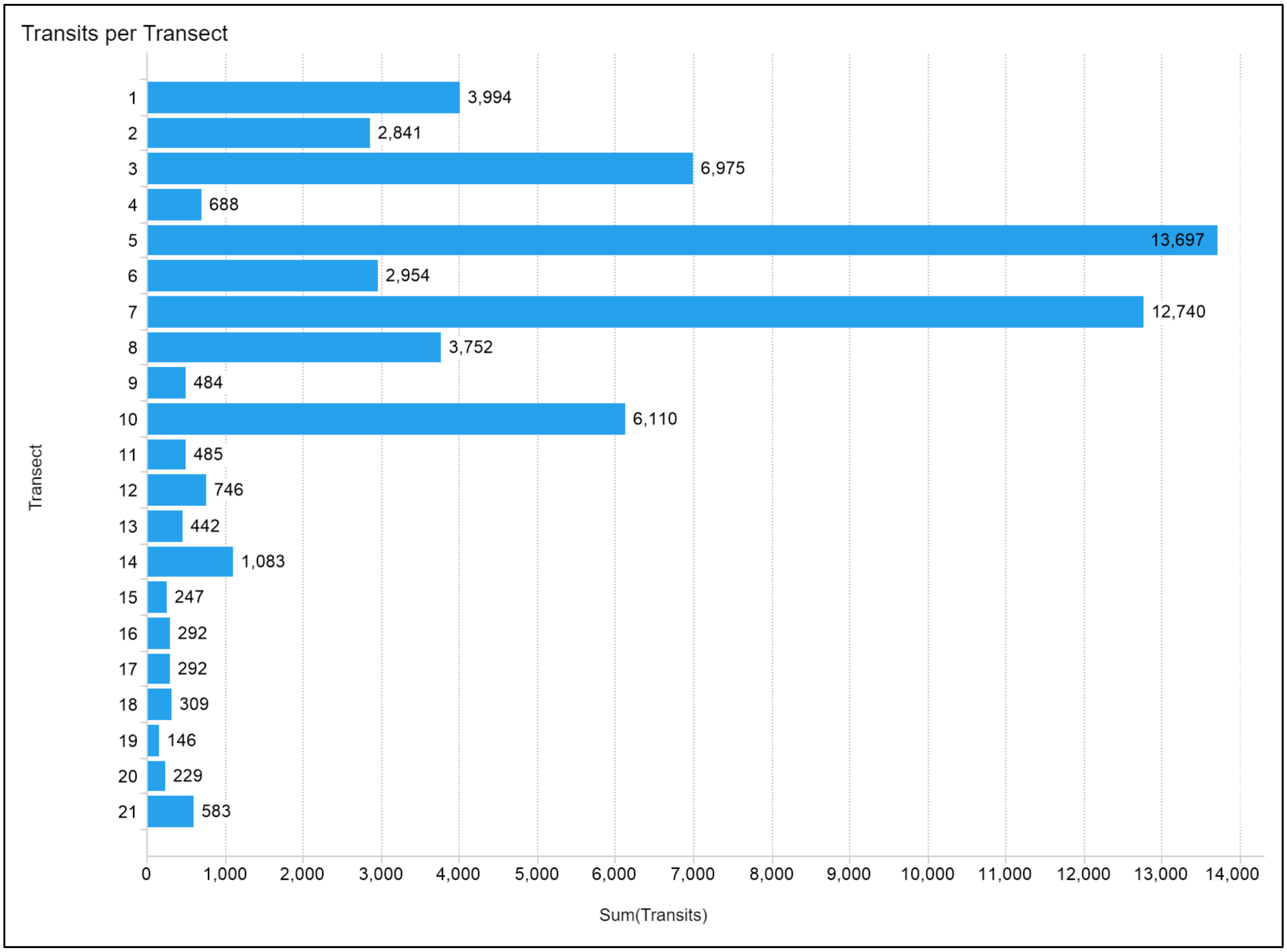

Figure 4.6. Vessel Transits from July 1, 2018, to June 30, 2019, by Analysis Cross Section, All Vessel Classes (DNV GL 2020).

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.

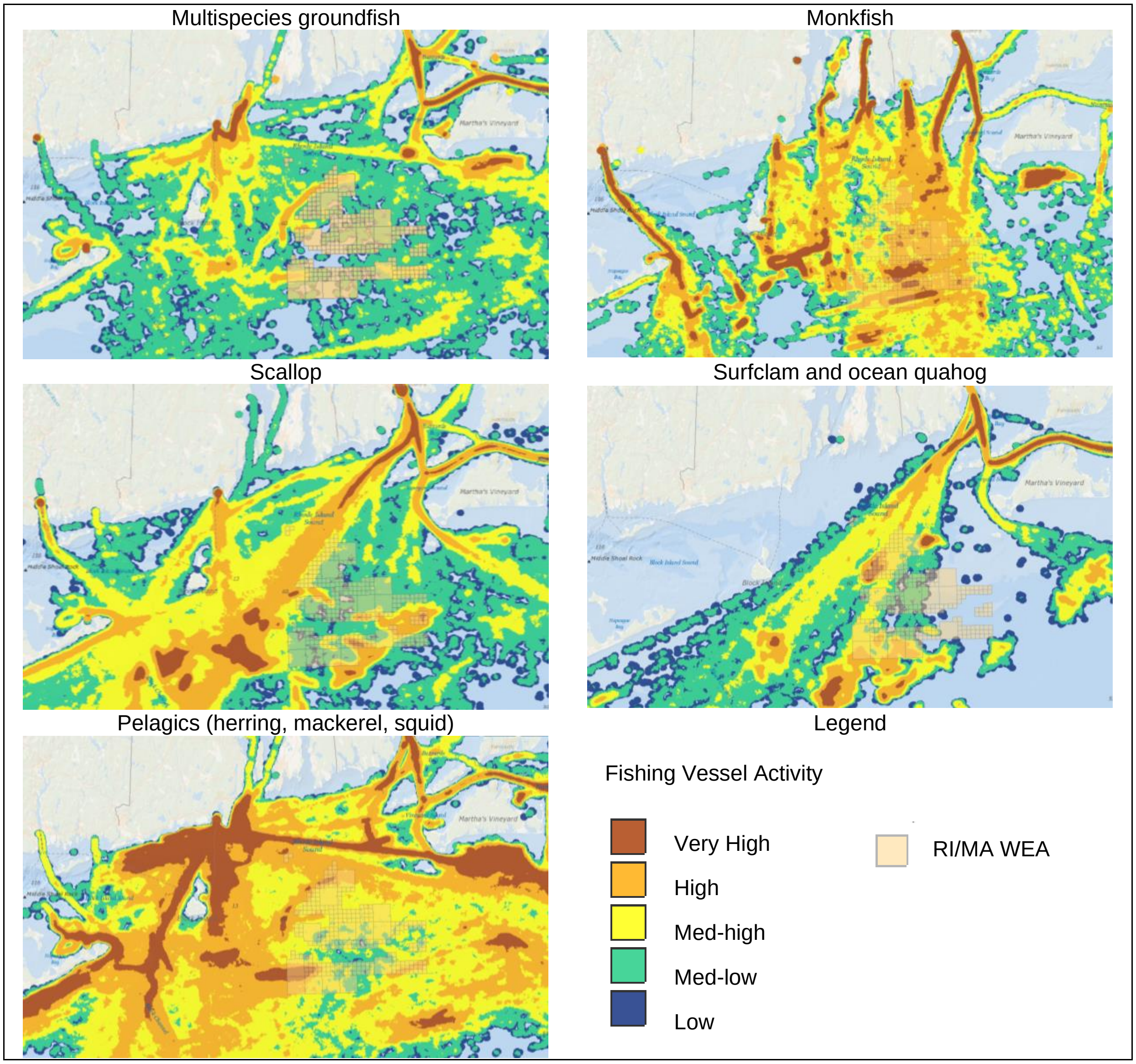

Figure 4.7. Commercial Fishing Vessel Activity in Proximity to the Lease Area by Fishery Type, 2018-2019 (DNV GL 2021).

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).

Species Status

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).

Occurrence in the Action Area and Vicinity

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.

<u>Feeding Behavior and Hearing</u>

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).

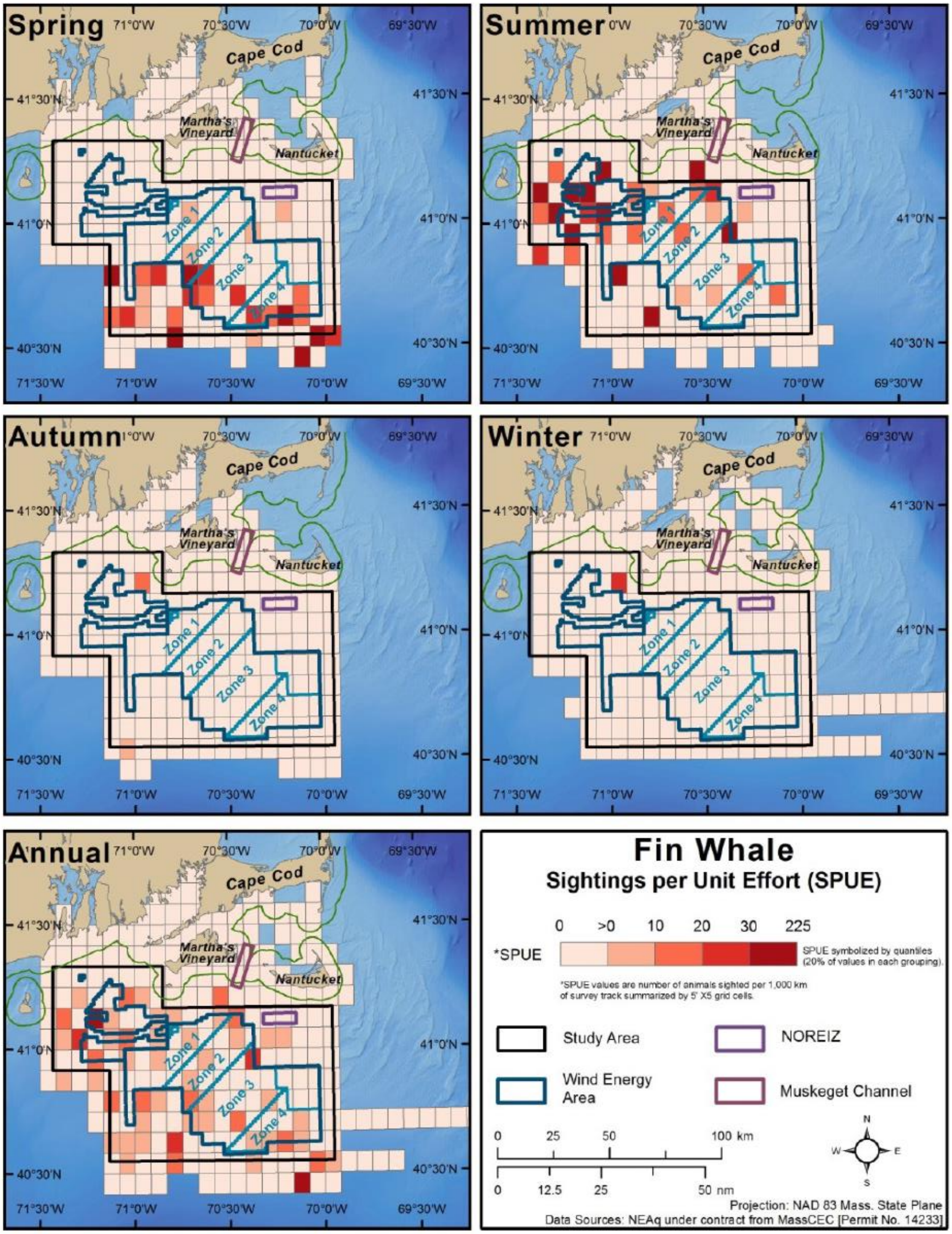

Figure 4.8. Fin Whale Seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

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).

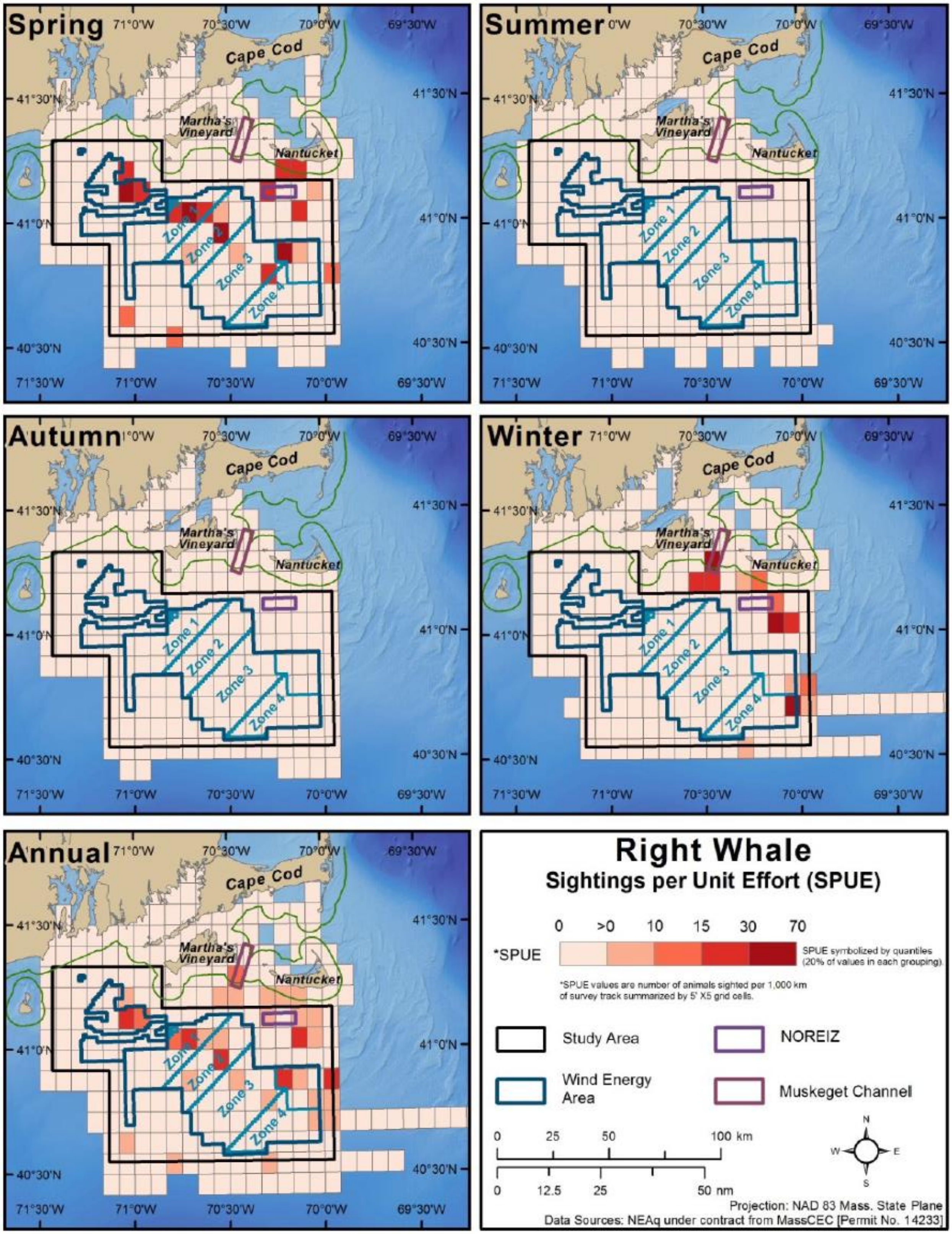

Figure 4.9. NARW Seasonal Sightings per Unit Effort in the RI/MA WEA, 2011 to 2015 (Kraus et al. 2016).

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.

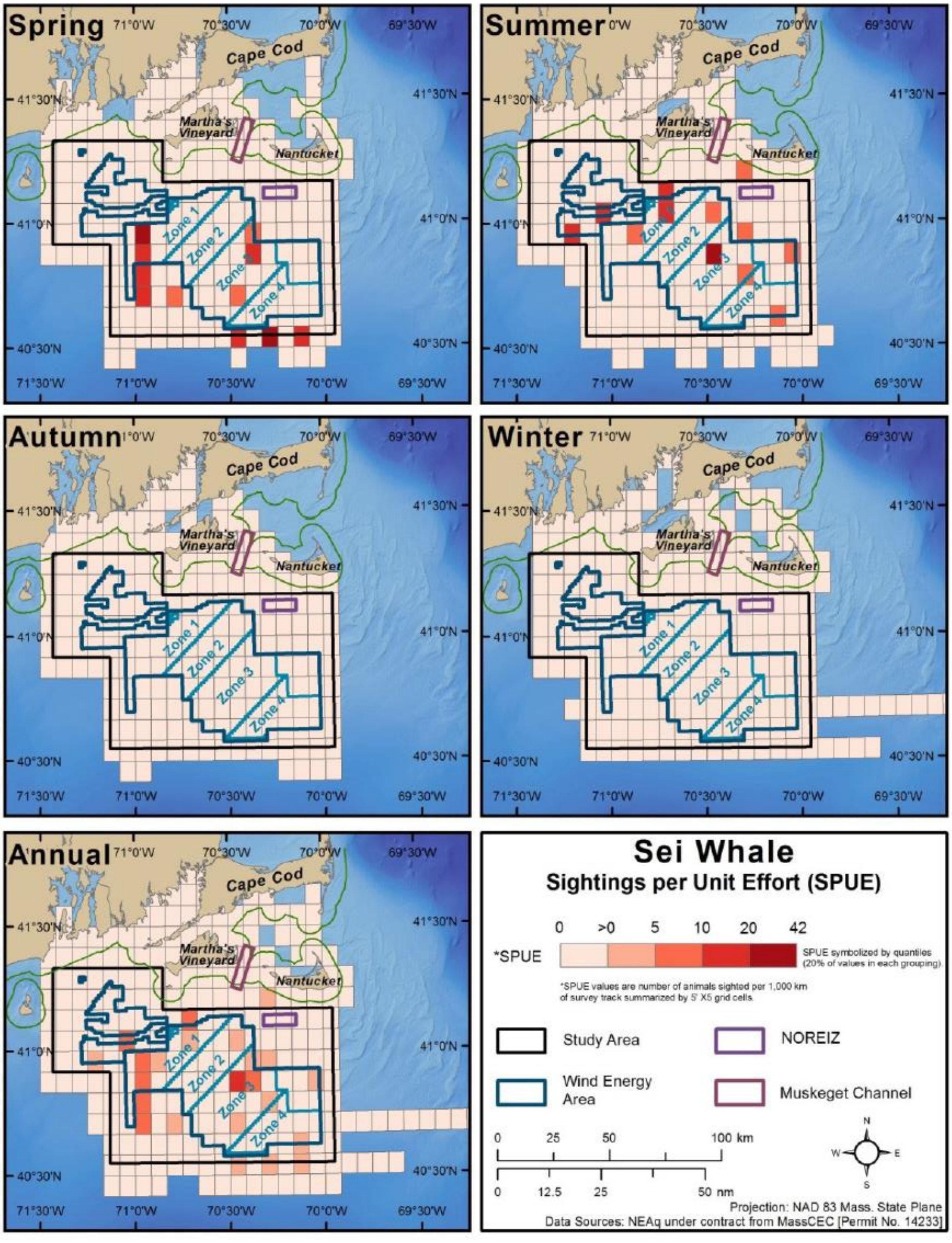

Figure 4.10. Sei Whale Seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

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.

<u>Feeding Behavior and Hearing</u>

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.

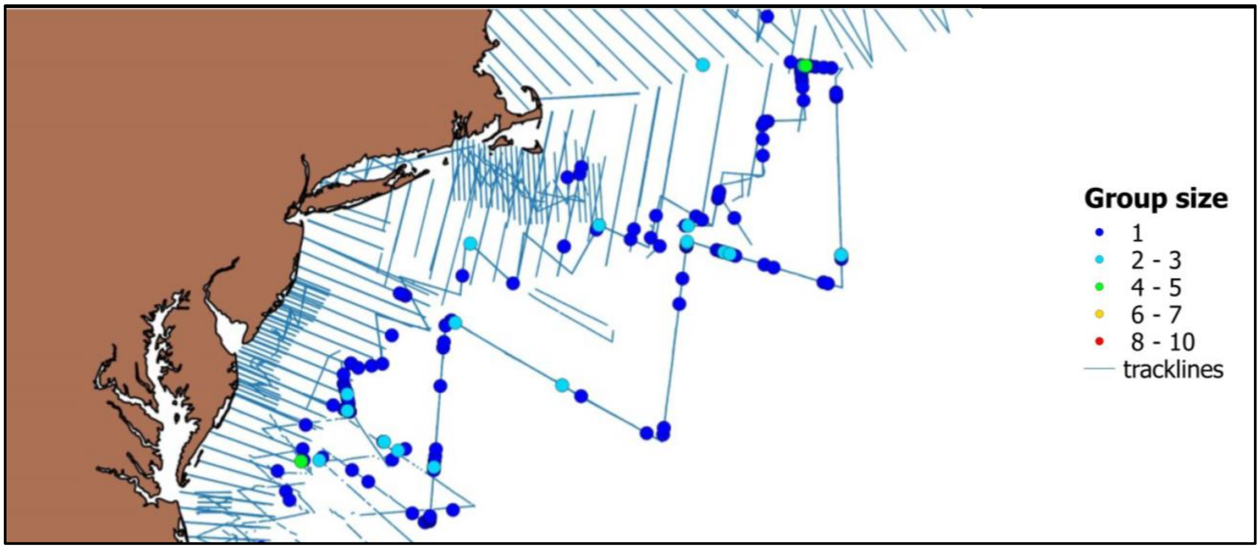

Figure 4.11. Sperm Whale Sightings in the North Atlantic Outer Continental Shelf and Vicinity during 2010 to 2013 Atlantic Marine Assessment Program for Protected Species Aerial Surveys (NEFSC and SEFSC 2018).

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.

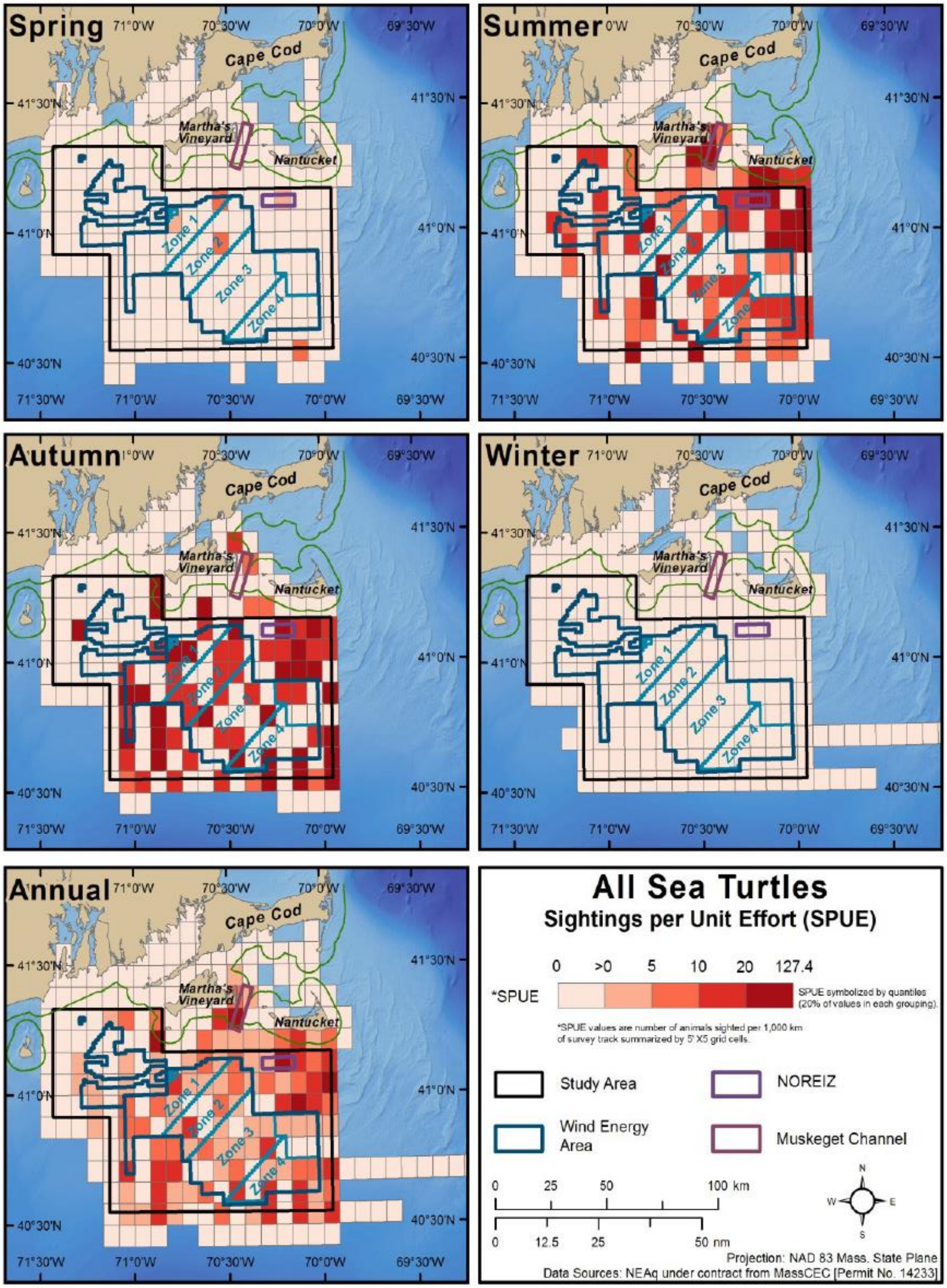

Figure 4.12. Seasonal Sightings per Unit Effort for All Sea Turtle Species in the RI/MA WEA (Kraus et al. 2016).

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.

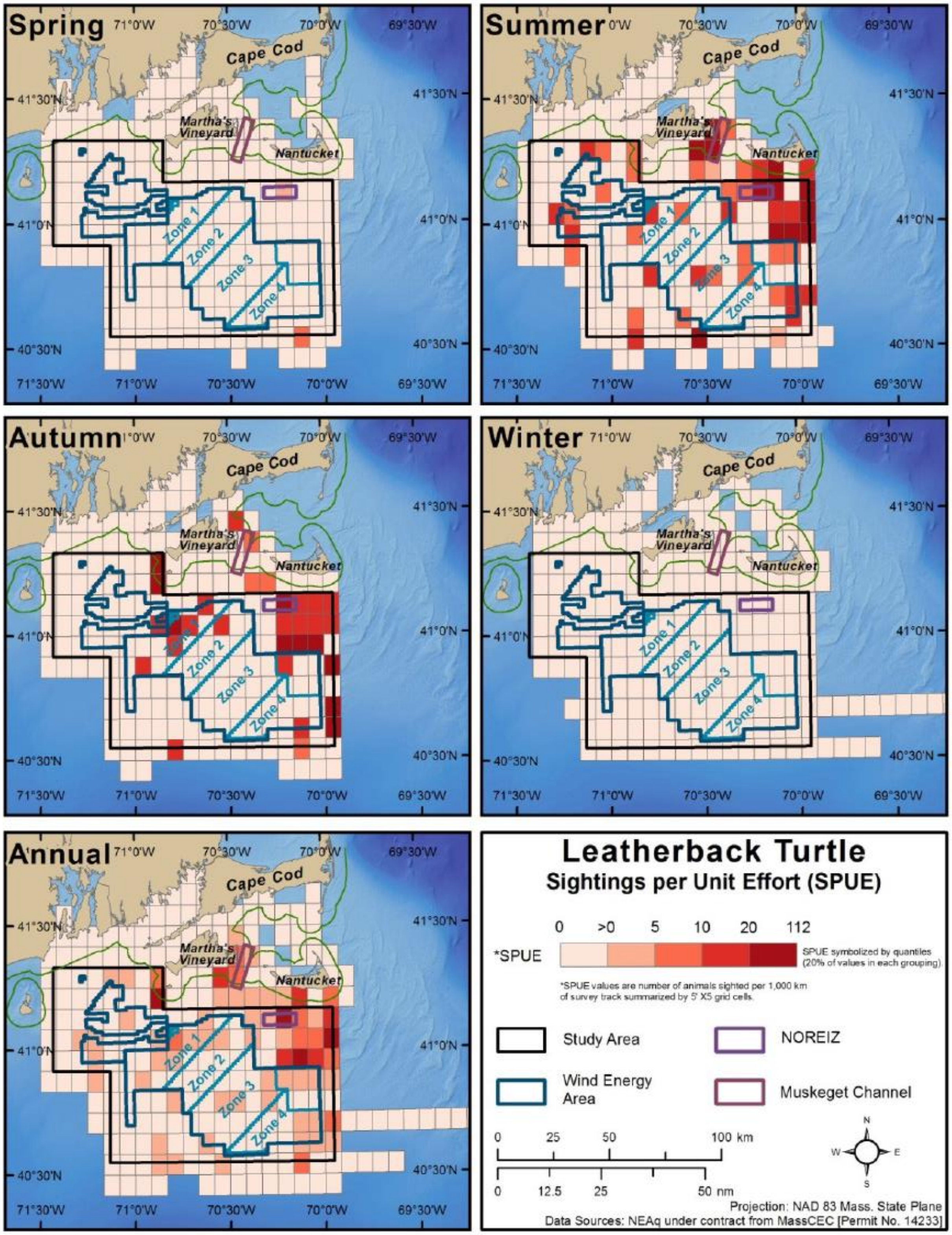

Figure 4.13. Leatherback sea turtle seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

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.

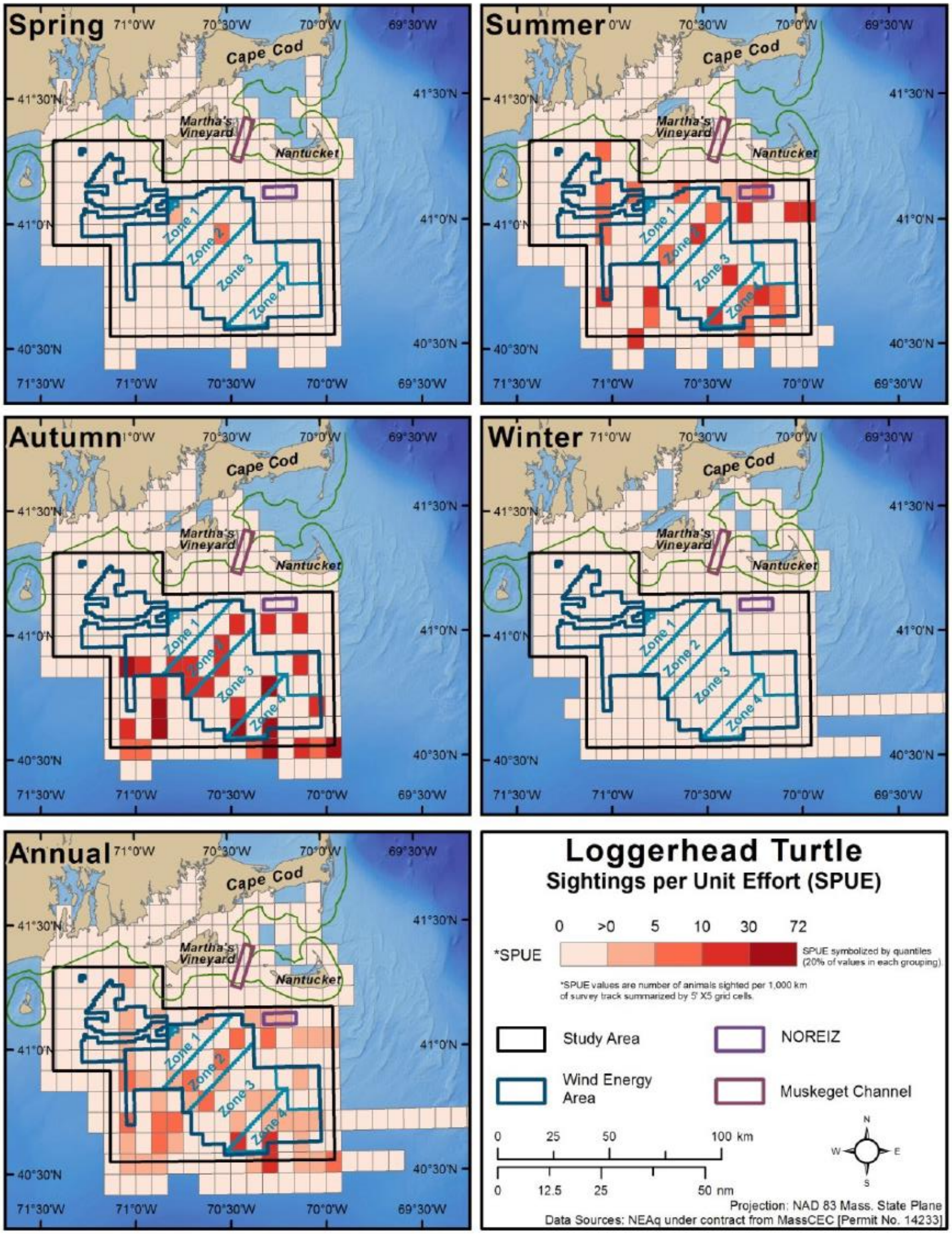

Figure 4.14. Loggerhead Sea Turtle Seasonal Sightings per Unit Effort in the RI/MA WEA (Kraus et al. 2016).

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 μPa^2·s
		Cumulative SEL (non-impulsive)	199‡	SEL dB re 1 μPa^2·s
		Peak injury (impulsive)	219‡	dB re: 1 μPa
		PTS SEL (UXO detonation)	183¥	SEL dB re: 1 μPa^2
	Behavioral disturbance	Behavioral (impulsive)	160†	dB re: 1 μPa
		TTS SEL (impulsive)	168‡	SEL dB re 1 μPa^2·s
		TTS SEL (UXO detonation)	168¥	SEL dB re 1 μPa^2
		Behavioral (non-impulsive)	120†	dB re 1 μPa^2·s
MFCs‡ Sperm whale	Permanent hearing injury	Cumulative SEL (impulsive)	185‡	SEL dB re 1 μPa^2·s
		Cumulative SEL (non-impulsive)	198‡	SEL dB re 1 μPa^2·s
		Peak injury (impulsive)	230‡	dB re: 1 μPa
		PTS SEL (UXO detonation)	185¥	SEL dB re: 1 μPa^2
	Behavioral disturbance	Behavioral (impulsive)	160†	dB re: 1 μPa
		TTS SEL (impulsive)	170‡	SEL dB re 1 μPa^2·s
		TTS SEL (UXO detonation	170¥	SEL dB re 1 μPa^2
		Behavioral (non-impulsive)	120†	dB re: 1 μPa
All sea turtles	Permanent hearing injury	Cumulative SEL (impulsive)	204¥	SEL dB re 1 μPa^2·s
		Cumulative SEL (non-impulsive)	220¥	SEL dB re 1 μPa^2·s
		Peak injury (impulsive)	232¥	dB re: 1 μPa
		PTS SEL (UXO detonation	204¥	SEL dB re: 1 μPa^2
	Behavioral disturbance	Behavioral (all sources)	175¥	dB re: 1 μPa
		TTS SEL (impulsive)	189¥	SEL dB re 1 μPa^2·s
Atlantic sturgeon	Permanent hearing injury	Cumulative SEL	210*	SEL dB re 1 μPa^2·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 μPa^2·s
	Behavioral disturbance	Behavioral alteration	150§	dB re: 1 μPa
		TTS SEL (impulsive)	186¥	SEL dB re 1 μPa^2·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.

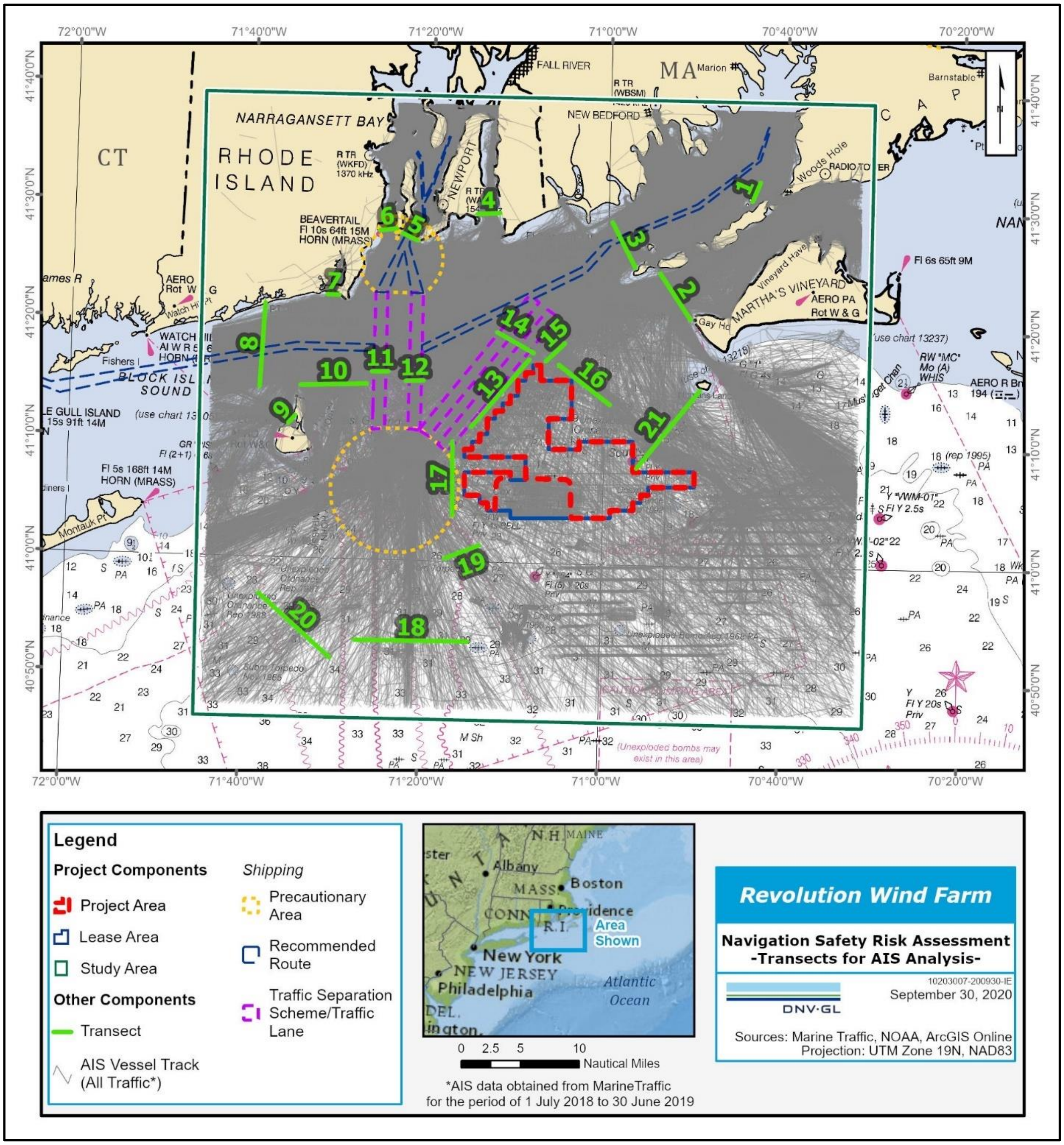

Figure 5.1. AIS Vessel Traffic Tracks for July 2018 to June 2019 and Analysis Transects Used for Traffic Pattern Analysis (DNV GL Energy USA, Inc. 2020).

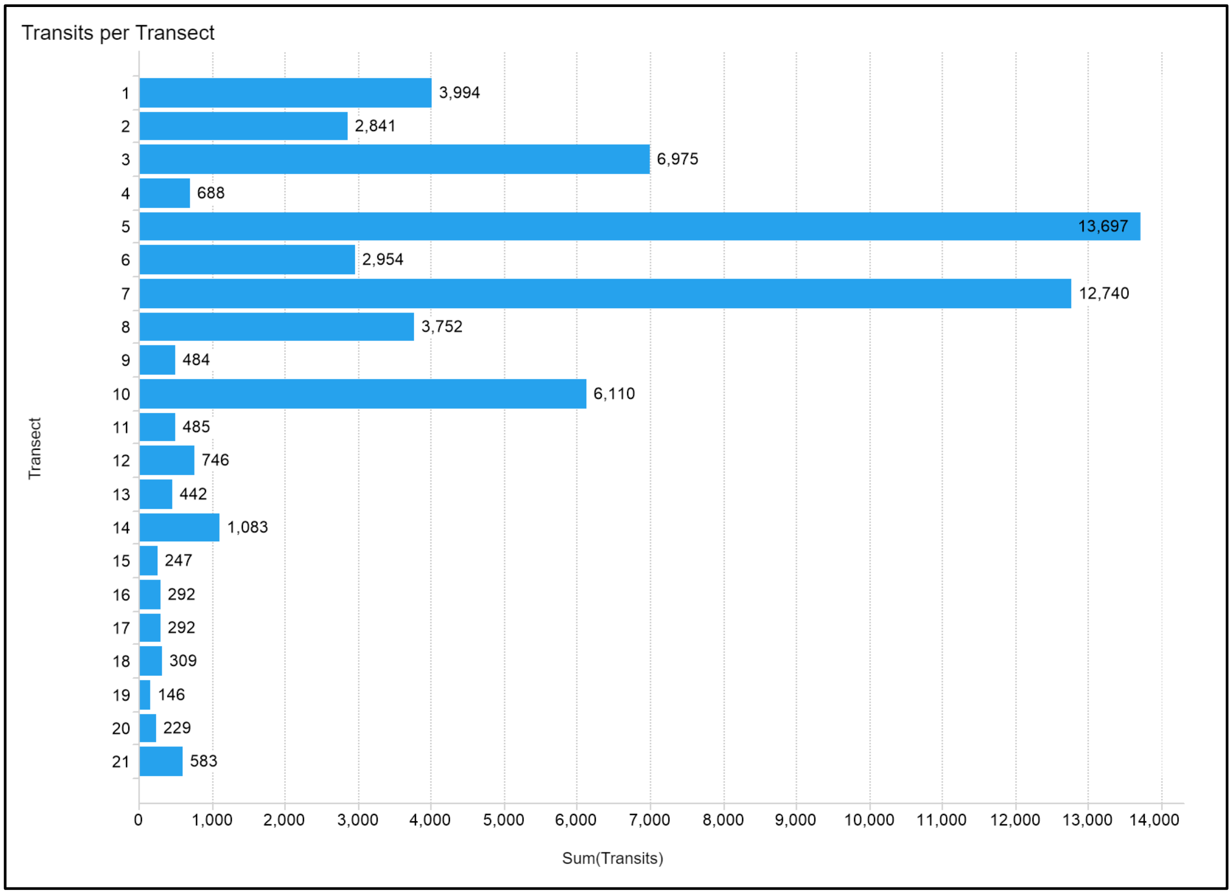

Figure 5.2. Vessel Transits of DNV GL Energy USA, Inc. (2020) Analysis Transects Used for Traffic Pattern Analysis from 2018 to June 2019.

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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