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

Essential Fish Habitat Assessment

February 3, 2023

For the National Marine Fisheries Services

U.S. Department of Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs

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Acronyms and Abbreviations

µPa	micro-Pascal
$\mu Pa^2 s$	micro Pascal squared second
µT	micro-Tesla
µV/m	microvolts per meter
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
CFR	Code of Federal Regulations
CFE	Controlled Flow Excavation
CMECS	Coastal and Marine Ecological Classification Standard
COP	Construction and Operations Plan
CPS	cable protection system
CTV	crew transfer vessel
dB	decibel
dBA	A-weighted decibels
DEIS	Draft environmental impact statement
DP	dynamic positioning
EFH	Essential Fish Habitat
EMF	electromagnetic field
EPM	environmental protection measure
FEIS	Final environmental impact statement
FGDC	Federal Geographic Data Committee
FHWG	Fisheries Hydroacoustic Working Group
FMP	fisheries management plan
FRMP	Fisheries Research and Monitoring Plan
HAPC	Habitat Areas of Particular Concern
HDD	horizontal directional drill
HRG	high-resolution geophysical
HVAC	high voltage alternating current
Hz	hertz
IAC	Inter-Array Cable
IPF	impact-producing factor
kJ	kilojoule
km	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
Lease Area	BOEM Renewable Energy Lease Area OCS-A 0486 (Lease Area)
MARCO	Mid-Atlantic Regional Council on the Ocean
MEC/UXO	Munitions, Explosives of Concern/Unexploded Ordnance
mG	milligauss
mg/L	milligrams per liter
mm	millimeter
MLLW	mean lower low water
mV/m	millivolts per meter
MW	megawatt
MWA	maximum work area
NCCA	National Coastal Condition Assessment
nm	nautical mile
NMFS	National Marine Fisheries Service
NOAA Fisheries	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
O&M	Operations and Maintenance
OCS	Outer Continental Shelf
OSS	offshore substations
OSS-link	offshore substation link cable
PDE	project design envelope

PLGR	pre-lay grapnel run
Revolution Wind, LLC	Revolution Wind
RI/MA WEA	Rhode Island/Massachusetts Wind Energy Area
ROV	remotely operated vehicle
RWEC	Revolution Wind Export Cable
RWEC–OCS	RWEC within federal waters
RWEC–Onshore	RWEC onshore underground segment
RWEC–RI	RWEC within Rhode Island state waters
RWF	Revolution Wind Farm
SAV	submerged aquatic vegetation
Secretary	Secretary of the Interior
SOV	service operation vessel
SPI/PV	sediment profile and plan view imaging
TSS	total suspended sediment
TTS	temporary threshold shift
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
UXO	unexploded ordnance
WROV	work class remotely operated vehicle
WTG	wind turbine generators
YOY	young-of-year

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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, grants the Secretary of the Interior (Secretary) the authority to issue leases, easements, or rights-of-way on the Outer Continental Shelf (OCS) for the purpose of renewable energy development (43 U.S.C. § 1337(p)(1)(C)). The Secretary has delegated this authority to the former Minerals Management Service, 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 CFR 585.

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 2007 (16 United States Code 1801-1884), requires federal agencies to consult with the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) on activities that may adversely affect Essential Fish Habitat (EFH) for federally managed fisheries. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (Reid et al. 1999; NOAA 2018). NOAA Fisheries further clarified the terms associated with EFH (50 Code of Federal Regulations [CFR] 600.05-600.930 and 600.910) by the following definitions:

- **Waters:** Aquatic areas and their associated physical, chemical, and biological properties that are used by fish and, where appropriate, may include aquatic areas historically used by fish.
- **Substrate:** Sediments, hard bottoms, structures underlying the waters, and associated biological communities.
- **Necessary:** The habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem.
- **Spawning, breeding, feeding, or growth to maturity:** Stages representing a species' full life cycle.
- **Adverse effects:** May include direct or indirect physical, chemical, or biological alterations of the waters or substrate as well as the loss of and/or injury to benthic organisms, prey species, their habitat, and other ecosystem components. Adverse effects may be site-specific or habitat-wide impacts including individual, cumulative, or synergistic consequences of actions.

Revolution Wind, LLC (Revolution Wind), a 50/50 joint venture between Orsted North America Inc. and Eversource Investment, LLC, has secured the lease of the BOEM Renewable Energy Lease Area OCS-A0486 (Lease Area) and have submitted the draft Construction and Operations

Plan (COP) for the Revolution Wind Farm (RWF) and Revolution Wind Export Cable (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 Project and Revolution Wind completes all studies and surveys defined in their site assessment plan. BOEM's renewable energy development process is described in the following section. The most recent submittal is dated December 2021 and is consistent with the requirements of 30 CFR 585.620 to 585.638. Revolution Wind is working with BOEM to address additional information needs to finalize the COP.

The development of the COP for BOEM review and approval creates a federal nexus and the need for evaluation of the potential impacts to EFH per the Magnuson-Stevens Fishery Management Act. BOEM has responsibility as the lead federal agency to initiate an EFH consultation in compliance with the MSFCMA prior to approval, approval with conditions, or disapproval of the COP for the Project.

Consistent with the requirements of 30 CFR 585.620 to 585.638, COP submittal occurs after BOEM grants a lease for the Project and Revolution Wind completes all studies and surveys defined in their site assessment plan. BOEM's renewable energy development process is described in the following section. Revolution Wind is working with BOEM to address additional information needs to finalize the COP. BOEM completed an environmental assessment and EFH consultation on the issuance of leases for wind resource data collection on the OCS offshore within the Rhode Island/Massachusetts Wind Energy Area (RI/MA WEA), located approximately 15 statute miles (24.1 kilometers [km]) southeast of the Rhode Island coast in 2011, and on associated site characterization and site assessment activities that could occur on those lease areas, including the Lease Area for the Project. The Lease Area (OCS-A 0486) is located in the RI/MA WEA. A site assessment plan was submitted by Orsted & Eversource for site assessment studies of the Lease Area. BOEM transmitted its determinations regarding impacts to EFH to the NMFS in October 2017. NMFS concurred with BOEM that activities proposed in the site assessment plan were within the scope of the effects considered in the EFH consultation for the 2013 EA. Given that no sensitive habitats were impacted, and the project effects were short-term and localized, impacts to EFH were expected to be minimal. As a result, NMFS did not provide any additional EFH conservation recommendations for the site assessment plan, and none were required. BOEM is consulting on the proposed COP for the Project, 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 the EFH consultation. Other co-action agencies include the Bureau of Safety and Environmental Enforcement, and the U.S. Army Corps of Engineers (USACE). The USACE will adopt this EFH assessment for impacts resulting from the Proposed Action that are relevant to USACE permitting actions under Section 10 of the Rivers and Harbors Act of 1899 (RHA; 33 USC § 403) and Section 404 of the Clean Water Act (33 USC § 1344).

This revised EFH assessment provides a comprehensive description of the Proposed Action, defines the Project Area, describes EFH and EFH species potentially impacted by the Proposed Action, and provides an analysis and determination of how the Proposed Action may affect EFH and EFH species. The activities being considered include approving the COP for the construction, operation, maintenance, and conceptual decommissioning of the proposed Project. A separate environmental review EFH consultation may be conducted for Project decommissioning and it will be determined at that time if an EFH consultation is necessary.

BOEM submitted a draft EFH Assessment to NMFS and initiated consultation on the Proposed Action on April 25, 2022. NMFS provided comments and requested additional information via letter on June 24, 2022. A revised EFH Assessment was subsequently submitted to NMFS on August 29, 2022, which more fully described the Proposed Action and potential adverse effects of the proposed action on EFH. A comment response matrix was also transmitted to NMFS on August 29, 2022 and indicated how NMFS's comments were addressed and incorporated into the revised EFH Assessment. Upon review of the revised EFH Assessment, NMFS submitted additional comments and requests for revisions in an email to BOEM dated September 22, 2022. In October 2022, 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 cited engineering and technical challenges which led to the dismissal of 21 of the 100 WTG positions. After discussions with NMFS, BOEM decided to adjust the Proposed Action for the EFH consultation to 79 WTGs along with as associated reduction in inter-array length. This revised EFH Assessment addresses the additional comments received by NMFS in their email dated September 22, 2022 and incorporates changes to the Proposed Action for the EFH consultation.

2.0 Proposed Action

The proposed action is the approval of the COP for the RWF and RWEC, considering a revised configuration of the RWF that reflects engineering and technical challenges recently identified by Revolution Wind. The COP describes the proposed construction and installation, operations and maintenance, and decommissioning of an offshore wind energy facility on the mid-Atlantic OCS in the RI/MA WEA. The two major components of the action, the RWF and the RWEC, are shown in Figure 2.1 and described in the following sections. The RWF will be located in the Lease Area, part of the Rhode Island/Massachusetts Wind Energy Area (RI/MA WEA). The Lease Area is in federal waters of the OCS approximately 15 statute miles (24.1 kilometers [km], 13 nautical miles [nm]) southeast of the Rhode Island coast.

This assessment evaluates the impacts of the Project to determine whether it may adversely affect designated EFH for federally managed fisheries from the proposed construction and installation, operations and maintenance, and decommissioning of a commercial wind energy facility on the OCS offshore of New York, Rhode Island, and Massachusetts. Major project components are differentiated in the project description and effects analysis where appropriate to clarify the potential impacts of the action on EFH species and habitats. The information presented in this section to describe the proposed action relevant to EFH comes from the COP prepared for the RWF and RWEC (VHB 2022), modified to reflect new information received since revised COP submittal.

The revised COP submitted to BOEM in July 2022 considered a project design envelope consisting of up to 100 wind turbine generators (WTGs or turbines) with a nameplate capacity of 8 to 12 megawatts (MW) per turbine, two offshore substations (OSS), and a submarine transmission cable network connecting the WTGs (inter-array cables) to the OSS. Revolution Wind subsequently determined that 21 proposed WTG sites are unsuitable for foundation installation due to engineering and technical challenges. As such, the final design of the RWF could include 65 to 79 WTGs and 2 OSSs. Revolution Wind has indicated they are considering WTGs with nameplate capacities ranging from 8 to 12 MW, with the final design selection based on a number of factors. Each WTG foundation would use the same 12-meter (39-foot) diameter monopile foundation regardless of capacity.

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 cited engineering and technical challenges which led to the dismissal of 21 of the 100 WTG positions. In this assessment, BOEM is considering the effects of the construction, operations and maintenance (O&M), and conceptual decommissioning of a revised Proposed Action comprising the RWEC and an RWF consisting of 79 WTGs and 2 OSSs, the indicative inter-array cable (IAC) layout for this configuration, and the OSS-link, a load-balancing cable connecting the two OSSs. The RWEC configuration is the same as described in the COP. Several alternative RWF configurations are being considered in the Final Environmental Impact Statement (FEIS) for the

Proposed Action. Descriptions and figures of the alternative layout designs are provided in Section 6, including brief summaries of impacts to EFH compare with the Proposed Action.

The RWF would establish an Operations and Maintenance (O&M) facility at an existing commercial port facility that is currently developed and would service O&M needs for the RWF and other offshore wind energy projects. No in-water improvements or construction activities are proposed for O&M facility development as part of the Proposed Action. The onshore O&M facility components will be constructed in a developed industrial site and would result in no new measurable effects on marine or nearshore habitats. Thus, O&M facility construction and operations are not considered further in this EFH Assessment.

The RWEC is a high voltage alternating current (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 is made up of two parts: 1) the RWEC-OCS, which is located in federal waters on the outer continental shelf and extends from the RWF to Rhode Island territorial waters boundary, and 2) the RWEC-RI, which extends from the Rhode Island territorial waters 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 same RWEC configuration is proposed for each alternative configuration of the RWF considered in the FEIS.

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 designated EFH and are not considered further in this assessment.

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. These methods and associated benthic impact footprints are described in Section 2.2.2.

Revised project design envelope parameters for the RWF and RWEC are summarized in Table 2.1. Project construction and installation, operations and maintenance, and decommissioning methods, and proposed environmental protection measures (EPMs), are described in the following sections. In addition to the alternative design options being considered in the FEIS, other design alternatives being considered include the following:

- **Sea-to-Shore Transition:** The nearshore RWEC landfall connection and horizontal directional drilling (HDD) construction may require installation of a temporary casing pipe with supporting sheet pile goal posts or installation of a temporary cofferdam. The temporary cofferdam would be installed as either a gravity cell structure placed on the seabed using ballast weight or as sheet piles utilizing vibratory pile driving of the sheet piles.

- **Casing Pipe Installation:** If a temporary casing pipe is used for HDD, a casing pipe and up to six goal posts would be installed. The casing pipe would be installed by pneumatic hammer, which may take up to approximately 16 days. The goal posts, composed of two vertical sheet piles, would be installed by vibratory hammer, and may take up to approximately 6 days.

- **Cofferdam with Sheet Pile Installation:** If the cofferdam is installed using sheet pile, a vibratory hammer will be used to drive the sidewalls and endwalls into the seabed. Installation of a sheet pile cofferdam may take approximately up to 3 days. For HDD, the sidewalls and endwall will be driven to a depth of up to 30 ft (9.1 m); sections of the shoreside endwall will be driven to a depth of up to 6 ft (1.8 m) to facilitate the HDD entering underneath the endwall. After the sheet piles are installed, the inside of the cofferdam will be excavated to approximately 10 ft (3 m). After HDD operations are complete and duct are installed, piles will be removed, placed on the work barge, and hauled back to shore.

- **Cofferdam with Gravity Cell Installation:** If a gravity cell cofferdam is used, the cell will be lowered onto the seafloor by a crane that is on a barge. The sidewalls and seaside wall and end wall will be multi skinned to accommodate a rock ballast fill that will stabilize the cofferdam on the seabed. The gravity cell cofferdam may be of a multi-sectional design to allow transportation and assembly at the site. Assembled interior dimensions of the cofferdam will be similar to a sheet pile cofferdam with similar volumes of excavated sediment.

- **No Containment:** If no containment is used, the HDD conduit will terminate in a dredged HDD exit pit. The dredged exit pit will have sloped sides to maintain side walls and exit pit opening. Rock bags maybe installed in the exit pit to support excavation temporarily during drilling activities and cable installation. After the HDD operations are completed the HDD exit pit will be backfilled leaving the duct end uncovered for cable pull in operations.

2.1 Project Area

The project area comprises the Lease Area for the RWF, the RWEC, and all areas affected by the construction and installation, and operations and maintenance of these facilities, which includes coastal nearshore habitats in Rhode Island state waters, and ocean habitats in the RI/MA WEA on the OCS offshore of New York and Rhode Island, and Massachusetts. The Maximum Work Area (MWA) is a subset of the project area comprising the portion of the Lease Area wherein benthic habitat impacts from RWF installation and O&M would occur (VHB 2022). The RWEC corridor is the BOEM-approved corridor wherein benthic habitat impacts from cable installation and O&M activities may occur. Table 2.1 provides information on geographic extent of key elements of the project used to delineate the project area [i.e., underwater noise, physical disturbance, total suspended sediment (TSS), and electro-magnetic field (EMF) effects, and effects resulting from presence of structures]. The proposed RWF and RWEC corridor are shown in Figure 2.1. Additionally, Revolution Wind is evaluating the use of several existing port facilities located in Massachusetts, Rhode Island, Connecticut, and New York, to support offshore construction and installation as well as operations and maintenance. As stated, there are no specific port improvements proposed for O&M facility development under the Proposed Action.

The project area also includes a terrestrial component, comprising the onshore segments of the RWEC between the sea-to-shore transition site Quonset Point and an onshore substation connecting the RWEC to the regional electricity grid in North Kingstown, Rhode Island. No EFH is present within the terrestrial component of the project area and the construction and O&M of these onshore facilities will have no measurable effect on freshwater or marine habitats used by EFH species. Therefore, the terrestrial component of the project is not considered further in this assessment.

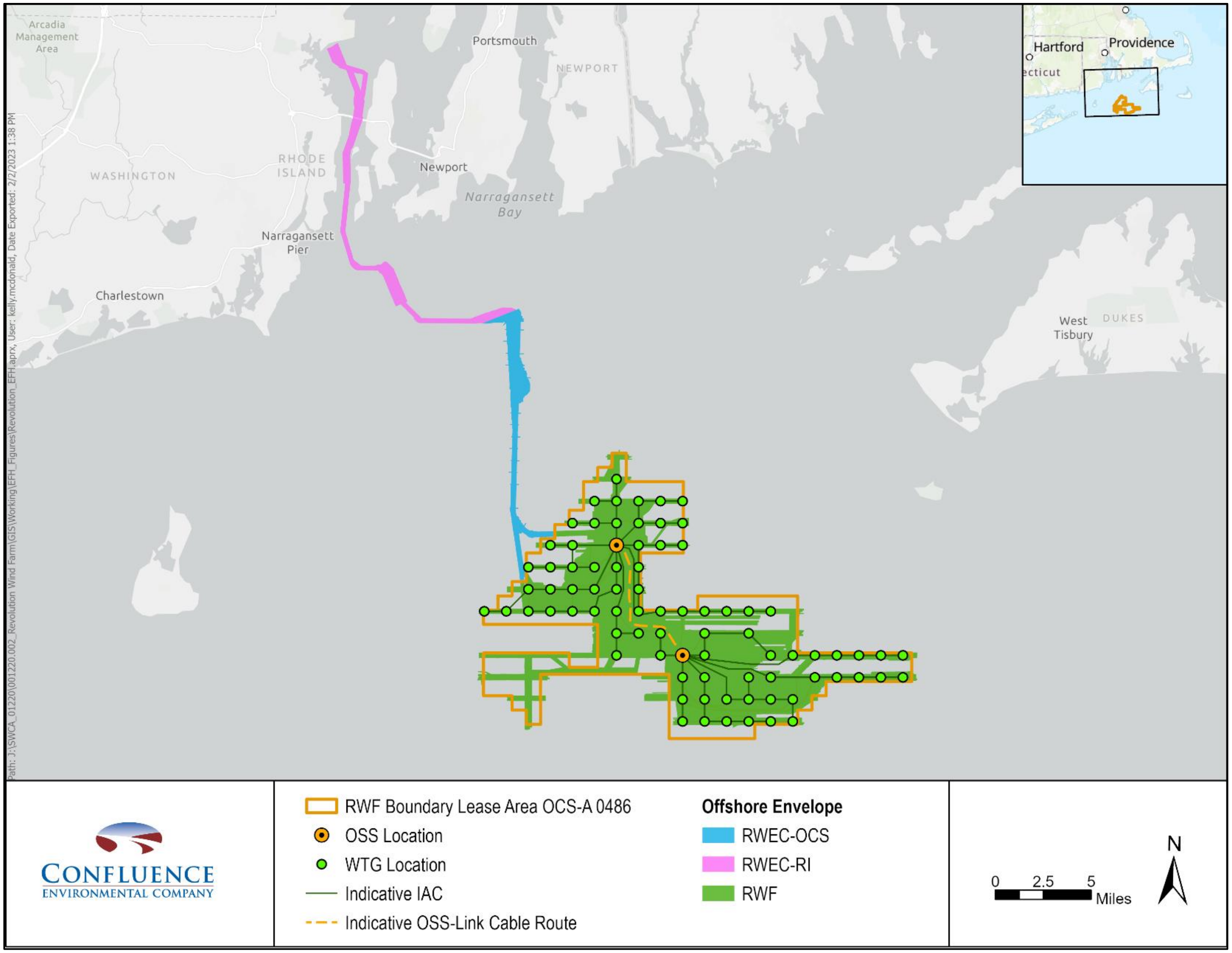

Figure 2.1. Location of RWF and RWEC Project Components Under the Proposed Action.

Table 2.1. Summary of RWF and RWEC Construction and Installation and Operations and Maintenance Parameters for the Proposed Action.

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
			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 60 to 240 minutes/pile installing 2 piles/day OSS 4,000 kilojoules (kJ) impact hammer 11,563 strikes/pile 60 to 240 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)

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Design Alternative	Effect
			Installation method	All	Cable trenching/burial (mechanical or jet plow) 4- to 6-feet (1.2- to 1.8-meter) depth
			Short-term disturbance	All	884 acres (358 hectares)
			Permanent 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 (mechanical or 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		41 acres (17 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)
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

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), 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.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 212 acres (86 hectares) RWEC-RI 546 acres (221 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	3,682 acres (1,490 hectares)
			Activity duration		8 months
			Permanent 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

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Design Alternative	Effect
	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
			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 et al. 2021

2.2 Construction and Installation

The construction and installation of the RWF and RWEC would result in short-term to permanent impacts on aquatic habitats in the nearshore and offshore waters of the mid-Atlantic OCS, and the nearshore estuarine waters of North Kingston, Rhode Island where the proposed RWF O&M facility would be sited (see Section 5). Project construction and installation methods and estimated quantities are described in the following section.

Construction and installation of the RWF would begin as early as 2023 with the installation of the onshore components and initiation of seabed 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 during pile driving activities. Mitigations that BOEM could impose include measures such as passive acoustic monitoring (PAM) of cod grunts during pile driving activities (see Section 6.2.1).

The total number of construction and installation days for each project component would depend on several factors, including environmental conditions, planning, and construction and installation logistics. The general construction and installation schedule is provided in Table 2.2 and summarized in Figure 2.2. 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.

Table 2.2. 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	Anticipated Timeframe
RWF	Monopile foundation installation	5 months	2023
	Inter-array and OSS-link cable installation	5 months	2023
	WTG installation	8 months	2023
	OSS installation	8 months	2023
RWEC	Onshore interconnection facility	18 months	2023-2024
	Sea-to-shore transition	12 months	2023-2024
	Offshore cable installation	8 months	2023
	Onshore cable installation	12 months	2023-2024

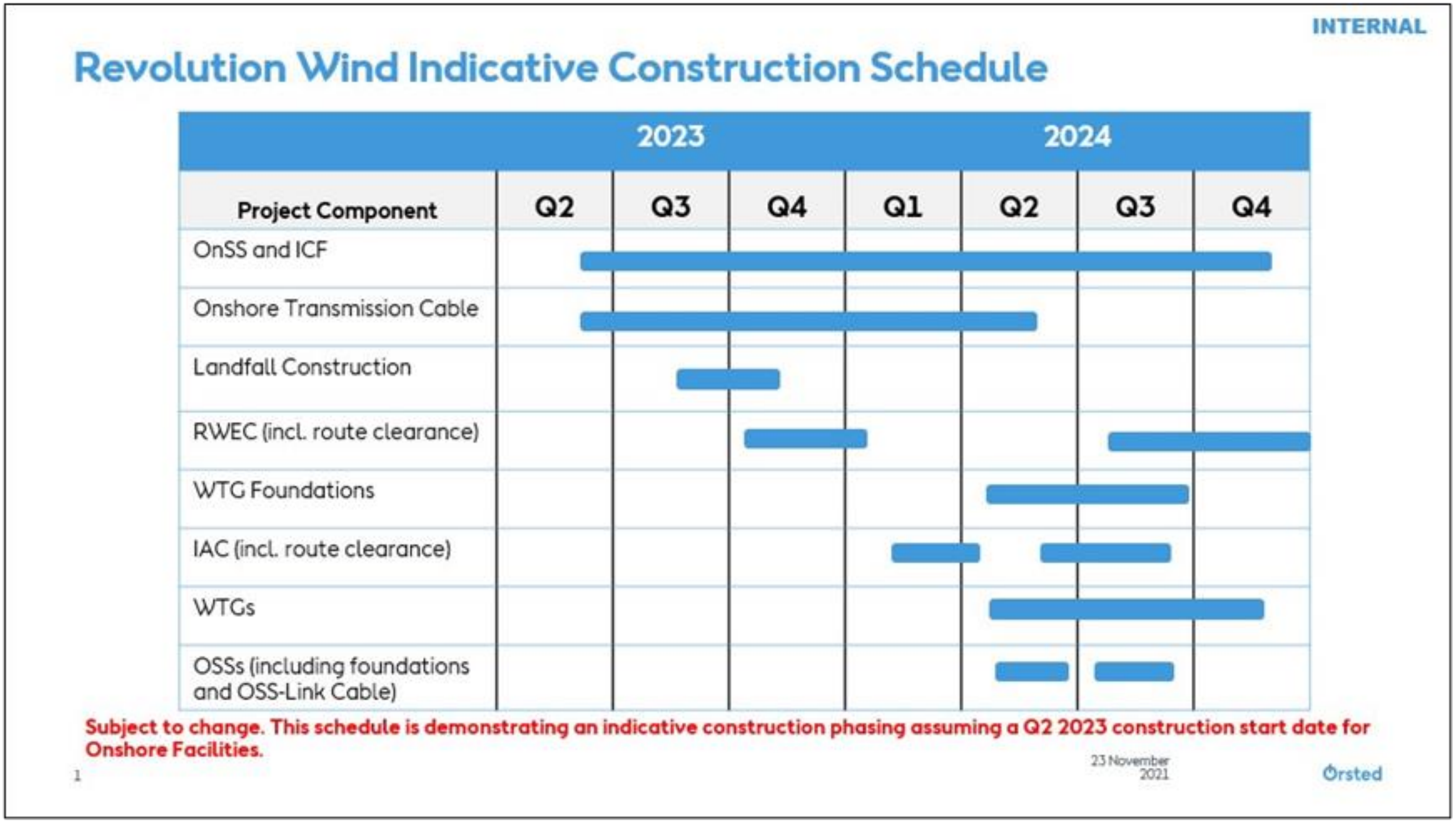

Figure 2.2 Revolution Wind Farm Indicative Construction Schedule.

2.2.1 Construction and Installation of WTG/OSS Structures and Foundations

Under the project design envelope described in the COP (VHB 2022), the RWF would comprise up to 100 WTG foundations and 2 OSSs. The project design envelope configuration of these features and associated IAC layout is shown in Figure 2.3. Under the revised proposed action, the RWF would comprise up to 79 WTGs and 2 OSSs. The revised RWF configuration is shown in Figure 2.4. The selected WTGs would be at least 8 MW and could be as large as 12 MW. Regardless of the capacity of the WTG (i.e., MW), the foundation type, foundation diameter, and extent of scour protection used would be the same. The WTGs would be mounted on tapered monopile foundations 12 meters (39 feet) in diameter at the base, driven up to 50 meters (164 feet) into the seabed using an impact hammer deployed on a specialized pile driving vessel, jack-up vessel, or heavy-lift barge. The two RWF OSSs would each be supported by a single 15-meter (49-foot) at largest diameter tapered monopile installed using similar construction and installation methods. The substations connect the RWF inter-array cable (IAC) network to the RWEC transmission line.

2.2.1.1 Vessel Activity

During construction, it is estimated that multiple vessels may operate concurrently at or in proximity to the Lease Area. Some of these vessels may maintain their position using DP thrusters during pile driving or other construction activities. The dominant underwater sound source on DP vessels arises from cavitation on the propeller blades of the thrusters. The noise power from the propellers is related to the number of blades, propeller diameter, and propeller tip speed. Sound levels generated by vessels under DP are dependent on the operational state and weather conditions. All vessels emit sound from propulsion systems while in transit. Non-project vessel traffic in the vicinity of the Lease Area includes recreational vessels, fishing vessels, cargo vessels, tankers, passenger vessels, and others. As such, fish in the general region are regularly subjected to vessel activity and would potentially be habituated to the associated underwater noise as a result of this exposure (Kusel et al. 2021). Installation of the OSS-Link is associated with the WTG and OSS construction and installation. DP vessels will be used for OSS-Link construction and installation to the extent feasible; if anchoring is required during OSS-Link construction and installation, it will occur within a 1,312-ft (400-m) wide corridor centered on the OSS-Link Cable. Anchors associated with cable laying vessels will have a maximum penetration depth of 15 ft (4.6 m).

Probable vessel classes used to construct the RWF monopiles include jack-up installation and feeder/supply vessels, crew transfer vessels (CTVs), material barges, feeder barges, tow tugs, anchor handling tugs, support vessels, rock installation vessel, bunkering vessel, and service operation vessels (SOVs). A rock installation vessel would be used to place scour protection, and cable-laying vessels would be used to place the inter-array cable. A fuel-bunkering vessel would remain on station to refuel construction and installation vessels and equipment. Transport vessels would be used to rotate construction and installation crews to and from area ports. Small support

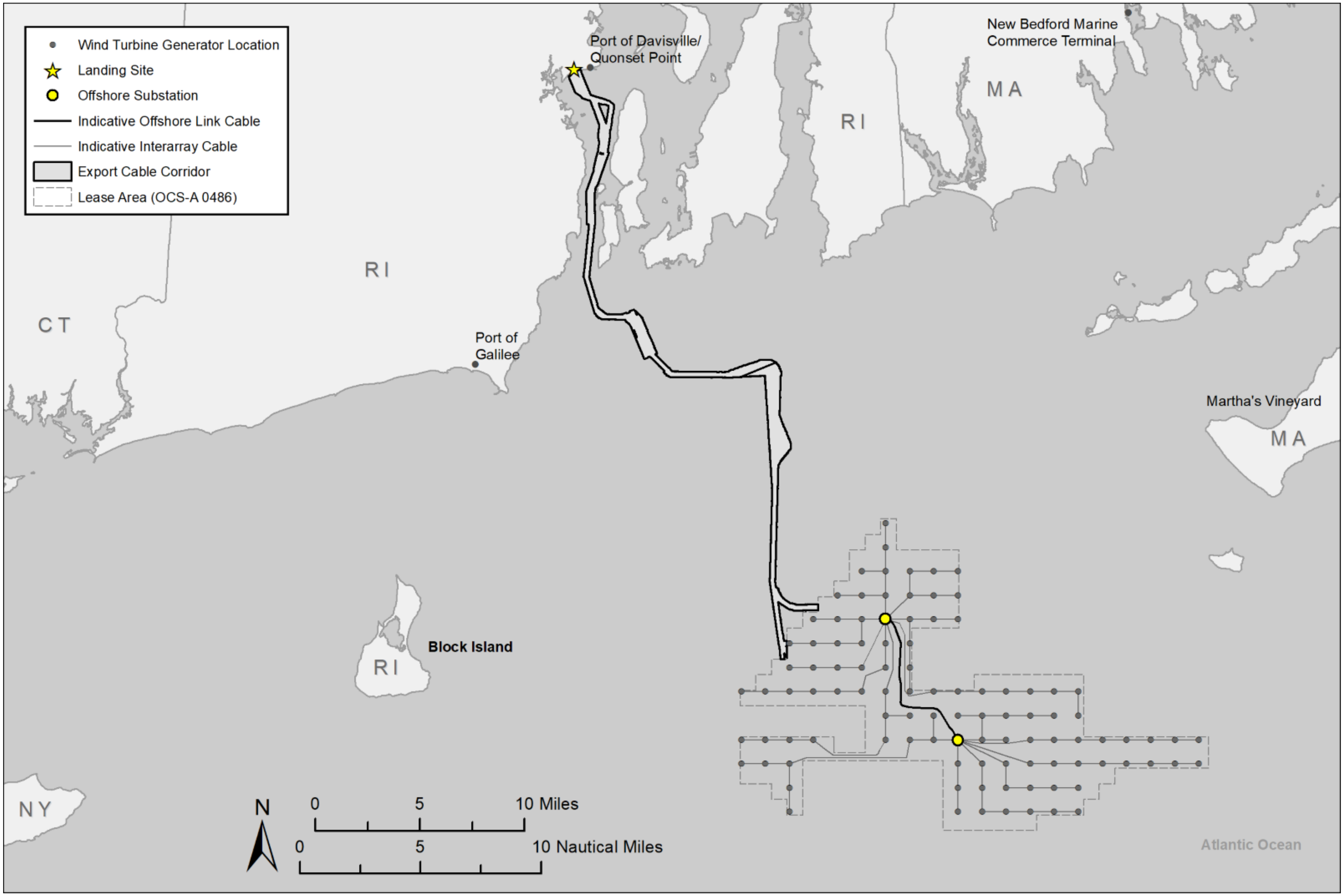

Figure 2.3. Project Design Envelope WTG and OSS Locations and Indicative IAC Layout (VHB 2022).

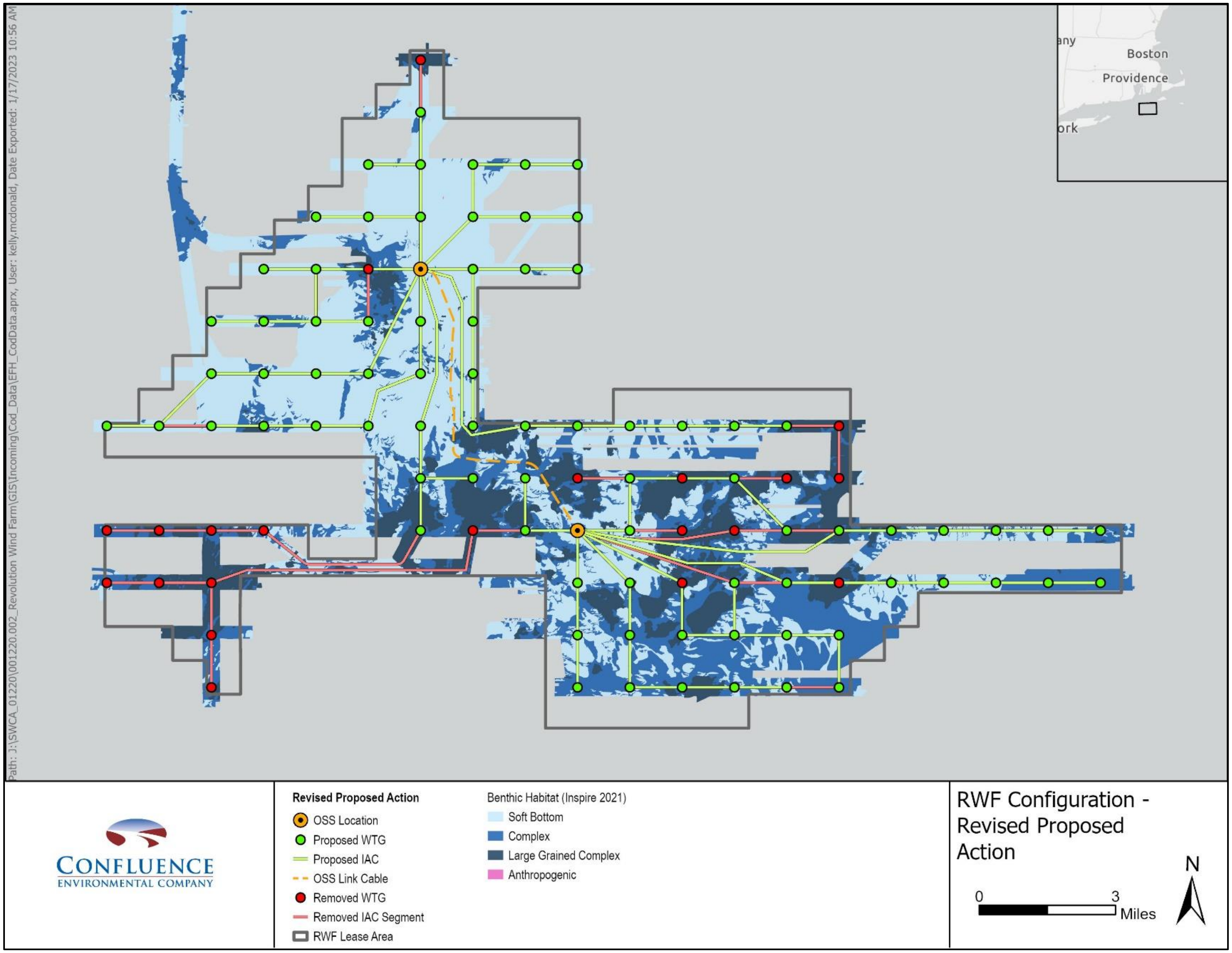

Figure 2.4. WTG and OSS Locations and Indicative IAC Layout Under the Revised Proposed Action.

vessels would be used for construction and installation monitoring. Construction and installation related vessels may be based in one or more ports, including: New York (Port of Montauk, Port Jefferson, Port of Brooklyn), and Rhode Island (Port of Davisville and Quonset Point, Port of Galilee). The total number of vessels required for offshore construction and installation elements are summarized in Table 2.3. The total number of vessel trips, vessel speeds and vessel draft is summarized in Table 2.4.

Table 2.3. Summary of Construction and Installation Vessels for Offshore Construction and Installation Elements.

Vessel Type	Number 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 2.4. Number of Vessels and Vessel Trips Required for Project Construction and Installation, and Typical Operational Speeds, and Draft by Vessel Type.

Vessel Type	Number of Vessels Used for Construction	Maximum Number of Round Trips‡	Typical Operational Speed (knots)	Approximate Vessel Draft (meters)
Accommodation Jack-up Vessel	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

Vessel Type	Number of Vessels Used for Construction	Maximum Number of Round Trips‡	Typical Operational Speed (knots)	Approximate Vessel Draft (meters)
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	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 trips between the Lease Area 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. Most cable installation vessel operations would occur at installation speed.

Project vessels will employ a variety of anchoring systems, which include a range of size, weight, mooring systems, and penetration depth (VHB 2022). Revolution Wind estimates that general vessel anchoring impacts could occur anywhere within a 656-foot (200-meter) radius around each foundation installation site, accounting for approximately 31 acres (12.5 hectares) of potential impacts per site. Jack-up vessels for foundation and WTG installation will include up to four spudcans with a maximum penetration depth of 52 feet (16 meters). Jack up will occur within the 656-foot (200-meter) seabed preparation radius around each foundation location. Seabed impacts from jackup vessel anchoring during project construction would total approximately 16.8 acres (6.8 hectares) of overlapping vessel anchoring impacts. During construction, vessels would require anchoring and spudding which could impact benthic environments. The Benthic Monitoring Plan, as discussed in Section 2.4, was developed in accordance with guidelines outlined by BOEM (2013) and identifies sensitive habitats, hardbottom habitat, and soft sediments. Revolution Wind would implement a BOEM-approved anchoring plan prior to the commencement of construction and installation activities to avoid and minimize anchoring related impacts to sensitive habitats, as discussed in Section 6.

2.2.1.2 Seabed Preparation

Seabed preparation for installation of WTG and OSS foundations would involve boulder clearance, and measures to avoid and, where necessary, address unexploded ordinance. Seabed preparation would be conducted prior to placement and installation of the monopile foundations. Prior to construction, the foundation locations would be micro-sited to avoid larger boulders and boulder clusters to minimize impacts to complex benthic habitat to the extent practicable. Boulders that cannot be avoided would be relocated to clear the seabed for Boulder and debris clearance would occur prior to WTG and OSS installation and would be completed by a support vessel based on pre-construction surveys.

Revolution Wind estimates that seafloor preparation could be required over approximately 23% of a 200-meter (656-foot) construction impact radius around each WTG and OSS foundation. This equates to approximately 7.1 acres of seabed preparation impacts per foundation. The distribution of these impacts by benthic habitat type is described in Section 5.1.1.3.

Revolution Wind estimates that seabed preparation for foundation installation will require relocating up to 2,133 boulders ranging from 2.3 to 6.6 feet (0.7 to 2 m) or more in diameter (Revolution Wind 2022a). Boulders will be relocated using a boulder grab (VHB 2022; Revolution Wind 2022a). The boulder grab is a specialized claw mounted on a remotely operated vehicle (ROV). The ROV is deployed from a vessel and guided to each boulder by video link. The maximum distance a boulder will be moved is approximately 36 ft (11 m) from its original location if the boulder is located on a cable centerline. The maximum distance a boulder will be moved is 600 ft if the boulder is located on a foundation centerpoint (Revolution Wind 2022a).

Revolution Wind anticipates that Munitions and Explosives of Concern/Unexploded Ordnance (MEC/UXO) may be encountered within the Lease Area and along the RWEC route. Revolution Wind (2022b) has identified 16 UXOs, ranging from 5 to 1,000 pounds in size within the RWEC corridor near the mouth of Narragansett Bay. Revolution Wind has determined that all 16 of UXOs identified to date can be avoided by shifting the RWEC route within the approved installation corridor (Orsted 2023). Avoidance is the preferred approach for MEC/UXO mitigation.

No UXOs have been identified within the Lease Area, but it is possible that additional devices could be encountered here and in the RWEC corridor during pre-construction surveys. The areas having the highest probability of device encounters are the central portion of the Lease Area and along the RWEC corridor in state waters approaching the entrance to Narragansett Bay (Ordtek 2021). Should additional UXOs be encountered, it is also possible that some may not be avoidable due to layout restrictions, presence of archaeological resources, or other factors that preclude micrositing (VHB 2022).

In such situations, confirmed MEC/UXO may be removed through in-situ disposal or physical relocation. Selection of a removal method will depend on the location, size, and condition of the confirmed MEC/UXO, and will be made in consultation with a MEC/UXO specialist and in coordination with the appropriate agencies (VHB 2022). In-situ disposal will be done with low noise methods like deflagration of the MEC/UXO or cutting the MEC/UXO to extract the explosive components. Any UXO/MEC detonation would be conducted using a sound attenuation device capable of achieving at least 10 decibels (dB) sound reduction. Where practicable the MEC/UXO might be relocated to a safer location through a "Lift and Shift" operation. Relocation sites may include a suitable location within the broader RWEC corridor or a designated disposal area. Relocated devices would either be secured for wet storage or disposal through low noise methods as described for in situ disposal.

2.2.1.3 Pile Driving

The WTG and OSS monopiles would be installed using an impact hammer with a maximum rated capacity of up to 4,000 kilojoules is assumed for this analysis. Impact pile-driving activities in the Lease Area would take place between May 1 and December 31, with additional timing constraints as needed for the protection of Endangered Species Act (ESA)-listed marine mammals and sea turtles.

For each WTG it is assumed 6,500 strikes over up to 220 minutes would be required for each pile, with up to three piles installed per day. For the OSSs it is assumed up to 11,500 strikes over 380 minutes would be required to install each OSS pile, with up to two days required to install both OSSs. It is assumed that multiple pile-driving rigs would operate simultaneously, such that up to three monopiles would be installed in a 24-hour period, and up to 81 monopiles piles would be installed over a single five-month campaign.

A ramp-up/soft-start method will be employed when beginning impact pile driving, along with a noise abatement system achieving minimum attenuation effectiveness of 10 decibels (dB) at a reference distance of 10 meters would be employed to minimize underwater noise impacts. Refer to Section 6 for further details regarding this applicant proposed EPM. Based on recent analysis of noise abatement systems (Bellmann et al. 2020), the 10 dB reduction level was conservatively chosen as an achievable sound reduction level when one noise abatement system is in use during pile driving. The noise abatement system could include a variety of technologies, including bubble curtains, evacuated sleeve systems, encapsulated bubble systems, or Helmholtz resonators.

2.2.1.4 Installation of Scour Protection

Scour protection in the form of rock blankets would be placed around each foundation to prevent seabed erosion and scour from natural hydrodynamic processes. An estimated 0.71-acres of rock scour protection would be placed on top of a filter layer of smaller rock around each of the 12-meter WTG and 15-meter OSS monopiles. The distribution of impacts from placement of scour protection is summarized by habitat type in Section 5.1.1.4. This distribution of impacts is a generalized estimate based on the average amount of scour protection anticipated per foundation. The amount of scour protection required around each foundation may vary depending on site conditions. The final configuration used would be determined based on site-specific geotechnical and oceanographic conditions, maintenance requirements, and consideration of agency and stakeholder concerns and cost.

Scour protection would be sloped such that the outer edge matches the natural grade of the seafloor to the extent practicable. Revolution Wind's engineering specifications for the proposed scour protection are as follows:

- Armor stone rock class LMA5/40.
- Particle Density 2.650 kg/m^3.
- Rock material must have been produced from blasted rock faces and may not be sourced from riverbed mining/extraction.
- Materials such as mudstone, shale, slate rock, or other soft stone that are likely to cleave during handling are not acceptable.
- The armor stone should be rounded or rectangular in shape and may not be flaky or elongated.

2.2.2 Construction and Installation of Offshore/Onshore and Inter-Array Cables

The Proposed Action includes three separate transmission cables: the RWEC; the IAC; and the OSS-link.

The RWEC comprises two parallel transmission cables installed within a 1,312-foot (400-meter) right-of-way corridor. Within this right-of-way corridor, an approximately 131-foot (40-meter)-wide disturbance corridor would be required for each cable, inclusive of any boulder clearance and pre-lay grapnel run (PLGR) impacts. The full extent of the 131-foot (40-meter)-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).

A displacement plow would be used to relocate boulders in two specific areas in zone RWEC-OCS where dense fields of larger boulders are present. A displacement plow is a Y-shaped tool composed of a boulder board attached to a plow. The plow is pulled along the seabed and scrapes the seabed surface pushing boulders out of the cable corridor, flattening sand ripples in the process. The plow is lightly ballasted to level the seabed without creating a deep depression. Multiple passes may be required dependent on the burial tool selected and seabed conditions. Where there are steep slopes, large obstructions occur, or boulder density is low, a subsea grab may be used.

Following seabed preparation, a jet-plow or mechanical plow would be used to install the cable. Both methods allow for a trench to be cut, and cables can simultaneously be installed and backfilled (VHB 2022).

Burial of the RWEC would be approximately 4-6 feet deep (1-2 meters) below seabed. Burial depth may be deeper in some areas based on an assessment of seabed conditions, seabed mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a Cable Burial Risk AssessmentWhere burial cannot occur, or depth achieved or cable cross other cables/pipelines, additional cable protection methods may be used (refer to Section 2.2.2.4 Cable Protection, below for further information).

The sequence of events required for RWEC construction and installation would include pre-lay cable surveys, seabed preparation, cable installation, joint construction, cable installation surveys, cable protection and connection to the OSSs. Construction of the RWEC would require approximately 8 months. A summary of cable construction phases is provided below in Table 2.5 below (VHB 2022). The general construction schedule for the project is provided in Figure 2.2.

Table 2.5. Summary of RWEC, IAC, and OSS-link 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
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.
Seabed Preparation	Seabed preparation would include boulder clearance and removal of debris or 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.
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	Post-installation surveys would be used 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.

Activity	Construction and Installation Summary
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 sea-to-shore transition would be constructed approximately 2,000 feet (610 meters) seaward of mean lower low water (MLLW). The two horizontal directional drill (HDD) cable ducts would each be 3 feet (0.9 meters) in diameter and approximately 0.6 miles (1,000 meters) in length. Each HDD cable would require an HDD exit pit, each measuring 164 feet x 33 feet x 10 feet (50 meters x 10 meters x 3 meters), located offshore in the intertidal area in waters approximately 13 feet (4 meters) deep. The specific distance offshore is still to be determined but would be located in an area where no SAV is present. Construction of the sea-to-shore transition may occur within a temporary gravity cell or sheetpile cofferdam, using a temporary casing pipe, or with no containment. Underwater noise specifications used to assess impacts to EFH species from pile driving activities are described

The no containment approach would result in the largest construction impact footprint and the most extensive suspended sediment impacts. This method would involve dredging of the HDD exit pit beyond the alternative cofferdam perimeters to create the shallow side slopes necessary to maintain the exit pit opening. The dredged materials would be stored on a hopper scow and used to backfill the excavated area once construction and installation is complete. The RWEC cables would then be pulled through their respective cable ducts to the onshore connection points.

The casing pipe method would require less dredging, would have the smallest seabed impact footprint, and would require less pile driving than the sheetpile cofferdam. The steel casing pipe would be 48- to 60-inches in diameter and approximately 300 feet in length. The pipe installation would be driven diagonally into the seafloor using small pneumatic impact hammer located on a barge offshore. The impact hammer would operate at approximately 18.6 kJ and installation would take approximately two hours to complete. Up to 8 steel sheet piles would need to be installed to support the casing pipe. These would be installed using a vibratory hammer and would produce similar impacts to cofferdam installation.

Two alternative cofferdam designs are being considered, gravity cell and sheetpile. Both approaches would involve placement of the cofferdams around the HDD exit pit locations and dredging to excavate the interior of the cofferdam to expose the exit pits. The gravity cell would be lowered into place from a barge using a crane. The sheetpile cofferdam would be constructed using approximately 200 18-inch (0.5-meter) interlocking steel sheetpiles installed using a vibratory hammer from a construction and installation barge. Cofferdam installation and removal would each require an estimated 18 hours of vibratory hammer operation over 56 days (14 days for installation and 14 days for removal for each of two cofferdams). Approximately 1.5 acres (0.61 hectare) of seafloor would be excavated within each cofferdam to a depth of 10 feet to 17 feet (3 meters to 5 meters) to expose the HDD cable ducts. The sea-to-shore transition cable would be threaded through the tunnel to the transition point and connected to the RWEC. The connected segments would then be sealed and reburied and the cofferdam removed. All excavated areas would then be backfilled using native materials as described above.

The IAC would include multiple segments that extend 155.3 miles, connecting the WTG array to the two OSS. The OSS-link cable would connect the two OSSs, extending 9.3 miles between foundations. The OSS-link and each IAC segment 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 seabed. Burial depths for the IAC and OSS-link would be determined based on an assessment of seabed conditions, mobility and risk of interaction with external hazards such as fishing gear and vessel anchors, as well as a site-specific Cable Burial Risk Assessment. Installation of the IAC and OSS-link would generally follow similar sequence as described for the RWEC, above, with the following two exceptions:

- After pre-lay cable surveys and seabed preparation activities are completed, a cable-laying vessel would be pre-loaded with 66-kilovolt (kV) transmission cable for the IAC, and a 275 kV cable for the OSS-link. Prior to the first end-pull, the cables 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 seabed 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 and OSS-link would 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.

Cable protection systems (CPS) used at IAC junction with the WTG foundations would result in additional 0.07 acre of construction impacts extending beyond the scour protection footprint at each foundation. These impacts would occur within and would overlap the anticipated 7.1 acres of seabed preparation impacts around each foundation. The CPS are J-tubes that support and protect the exposed segments of the IAC that extend from the WTG foundation to the seabed. The J-tubes extend to the perimeter of the scour protection where the ends are buried into the seabed (VHG 2021).

2.2.2.1 Vessel Activity

Vessels required for construction and installation of the RWEC and IAC are identified in Table 2.3 above. Vessel activity associated with the installation of the RWEC and IAC are summarized in previous section.

Project vessels used for WTG and OSS construction will employ a variety of anchoring systems, which include a range of size, weight, mooring systems, and penetration depth. While dynamic positioning vessels will generally be used for cable laying, pull ahead anchoring would be used in some instances. Revolution Wind estimates that up to 100 pull ahead anchoring events would be required for construction of the RWEC-RI, 150 events for the RWEC-OCS, and 40 events each for the RWEC segment connecting OSS-1 and OSS-2 and the OSS-link cable. Pull ahead anchoring is not anticipated for IAC construction. Anchors used by cable laying vessels will be approximately 14.8 feet by 18 feet (4.5 by 5.5 meters) in size with a maximum penetration depth of 15 feet (4.6 meters).

2.2.2.2 Seabed Preparation

Seabed preparation for cable installation will occur within a 131-ft (40-m) -wide corridor along submarine cable routes. Seabed preparation activities include PLGR to clear debris from the installation corridor, followed by boulder relocation. The methods proposed for each of these activities are described below.

The PLGR involves the use of a specialized anchor system designed to capture anthropogenic debris, such as derelict fishing gear, cables, and other materials that could foul or damage boulder clearance and cable installation equipment. PLGR will be conducted over the entire length of each cable corridor. The PLGR anchor system creates a disturbance corridor in the seabed approximately 4 feet (1 m) wide and 2 feet (0.5 m) deep. These impacts will occur completely within and will be entirely overlapped by seabed disturbance from subsequent boulder relocation and cable installation. Therefore, PLGR impacts are not quantified independently from these other activities.

The effective installation and burial of transmission cables will require the relocation of small to large boulders from cable installation corridors. Revolution Wind (2022a) has identified a total of 4,028 boulders within proposed cable installation corridors that will require relocation, 1,223, 2,777, and 28, within the RWEC, IAC, and OSS-link corridors, respectively. These boulders range from 2.3 to 6.6 feet (0.7 to 2 m) or more in diameter. Boulder clearance in cable corridors will primarily be conducted using a boulder grab with boulder plow use limited to the selected areas described below. Most clearance work will be conducted using a boulder grab of the same design described for foundation installation in Section 2.2.1.2. Boulders relocated using the grab may be placed 26 to 49 feet (8 to 15 meters) from the cable centerline. The boulder grab will be complemented by a Work Class ROV (WROV) equipped with a boulder pushing skid. The boulder skid will be used to relocate smaller boulders that are difficult to capture with the grab over short distances (less than 3 feet).

A boulder plow will be required to clear moderate-density boulder fields from two approximately 6.2 mile (10 km) long cable installation segments within the RWEC corridor between mile 28 to 35 where glacial moraine deposits are present (Revolution Wind 2022a) (see Figure 3.10, Section 3.5.6). The boulder plow is a steel chassis with an integrated trencher and two pairs of plow arms that is towed behind a high-bollard pull vessel. The plow arms form an extended V that displaces boulders to the edges of the plow corridor, establishing a clear pathway for cable installation. Multiple passes may be required to achieve full clearance (VHB 2022). The boulder plow will create a disturbance corridor up to 52 feet (16 m) wide, with a cleared area measuring up to 66 feet (20 m) wide. The maximum distance an individual boulder would be moved is approximately 26 to 33 feet (8 to 10 m) from its original location. The plow will create a 5 to 6.1 foot (1.5 – 2 m) deep trench down the center of the cleared area with two berms on either side. The outer berms will comprise boulders and other surface materials, and the inner berms will comprise spoils from the trench. The berms will be composed of boulders and fine sediment in a mixed layer no greater in thickness (height above the original seabed) than the maximum boulder diameter of 6.6 feet (2 m) (Revolution Wind 2022a). The berm spoils will be used to backfill the trench by running a backfill pass with the plow after cable installation is complete.

2.2.2.3 Trenching/Cable Installation

Various options for installation of submarine cables were considered, including placement on the seabed and burial beneath the seabed. Although placement on the seabed would minimize installation time and cost as well as potential sediment disturbance, Revolution Wind plans to bury the cable beneath the seabed. Burying the cable is a means of protecting it from potential damage cause by various external forces and minimizing the potential for interference with other marine uses. Burying the cable also minimizes the need for maintenance and associated potential for seabed disturbance. The target burial depths have been selected to balance the following design criteria: 1) physical conditions; 2) avoidance of physical damage from anchors, vessels, or other equipment that might penetrate the seabed; 3) avoidance and minimization of interference with other marine uses; and 4) to allow heat to flow away from the cable so that the temperature does not exceed the design basis of the cable.

Various installation methods for the cables were also considered, including jet plow, and mechanical plow. Due to the variability of surface and subsurface seabed conditions, a combination of cable installation methods may be used to install the cable at the target burial depth. Descriptions of the various methods that could be employed comprise the following as presented in the COP (VHB 2022):

- **Jet-Plow:** This technique involves the use of water jets to fluidize the soil temporarily opening a channel to enable the cable to be lowered under its own weight or be pushed to the bottom of the trench via a cable depressor. The cable is either installed simultaneously to cable lay operations or after the cable has been laid on the seabed. Typical types of jet-plows include towed jet sleds, tracked jet-trencher, or vertical injectors. Backfill of the trench is expected shortly after installation due to settlement of fluidized sediments and/or trench collapse. Immediately after installation a trench will likely be visible on the seabed as well as tracks/skids from the installation equipment.

- **Mechanical Plowing:** Two methods are being considered:

    - **Simultaneous lay and bury** involves pulling a jet or mechanical plow along the cable route to simultaneously lay and bury the cable. The plow's share cuts into the soil, opening a temporary trench which is held open by the side walls of the share, while the cable is lowered to the base of the trench via a depressor. This narrow trench infills itself behind the tool, primarily by collapse of the trench walls and/or by natural infill, usually over a relatively brief period. Some plows may use additional jets to fluidize the soil in front of the share. The plow pulling force is either provided by bollard pull (moving vessel) or winches (anchored vessel). Backfill of the trench is expected shortly after installation due to trench collapse. Immediately after installation a trench will likely be visible on the seabed as well as tracks/skids from the installation equipment.

    - **Pre-cut plowing** involves pre-cutting a trench in advance of the cable lay operations. Following cable lay, the trench is backfilled via an additional pass using the displaced material to provide sufficient protection to the cable. Trenching may require multiple passes. Pre-cut plowing is suitable to a range of soil conditions and is usually preferred over simultaneous lay and bury plowing when localized challenging ground conditions are expected (i.e., very hard soils and/or where subsurface boulder risk is high). The plow system proposed for boulder relocation in the RWEC is capable of simultaneous trenching and boulder relocation.

2.2.2.4 Cable Protection

The WTGs would be linked to the RWEC by the IAC, a series of transmission cables linking each of the WTGs to the OSS. The 155-linear-mile (250-km, 135-nm) IAC would have a transmission capacity of 72 kilovolts (kV). A deep-sea cable laying vessel would be used to trench and bury the cable to a target depth of 4 to 6 feet (1.2 meters to 1.8 meters) below the bed surface using standard cable burying techniques. The cable would then be reburied as the suspended sediments and side of the trench settle and collapse. Where bed features like boulder fields or bedrock outcroppings prevent burial, the cable would be laid on the bed surface and secondary cable protection would be used to protect the cable from damage. One of more of the following cable protection solutions may be used for secondary cable protection:

- **Rock Berm:** Rocks of different grade sizes are placed from a fall pipe vessel over the cable. Initially smaller stones are placed over the cable as a covering layer to protect the cable from larger rocks, followed by larger rocks. The rocks generally form a trapezoid, up to 4.9 feet (1.5 meters) above the seabed with a 2:1 gradient. This may vary depending on expected scour. The trapezoid shape is designed to protect against anchor drag as well as anchor drop. The length of the protection depends on the length of cable that is not buried or has not achieved target depth. Where rock placement is used for crossing another cable or utility, a separation layer may be laid on the seabed before rock placement.

- **Concrete Mattresses:** Typically composed of cast concrete blocks interlinked to form a flexible, articulated mat, which can be placed on the seabed over a cable. Mattresses generally have dimensions of 19.7 feet by 9.8 feet by 1 foot (6 by 3 by 0.3 meters). They are formed by interweaving a number of concrete blocks with rope and wire. They are lowered to the seabed on a frame. Once positioning over the cable has been confirmed, the frame release mechanism is triggered, and the mattress is deployed. The mattress placement process is repeated over the length of cable that requires additional protection. Mattresses provide protection from anchor drop but are less effective at protecting against anchor drag. Where mattresses are used for crossing another cable or utility, a separation layer must be laid on the seabed before mattress placement.

- **Fronded Mattresses:** Concrete mattress with "fronds" that are designed to slow down current and naturally allow sediment to deposit and blanket the mattress, promoting the formation of protective, localized sand berms. Buoyant fronds are built into the mattress and when deployed they float in the water column trapping sediment. Frond mattresses are installed following the same procedure as general mattress placement. The fronds floating in the water column can impede the correct placement of additional mattresses.

- **Rock Bags:** Rock bags consist of various sized rocks constrained within a rope or wire netting containment. They are placed using a crane and deployed to the seabed in the correct position. Rock bags are more appropriate for cable stability or trench scour related issues.

It is estimated that 10 percent of the 155-mile IAC network, 10 percent of the 9.3-mile OSS-link cable, 10 percent of 18.6-mile RWEC OCS cable route (for each cable), and 19.5 percent of the

RWEC RI cable route (for each cable) would require secondary cable protection. In total, approximately 139.1 acres of cable protection would be required over approximately 29 miles of cable route. Revolution Wind has indicated that typical cable protection would be approximately 39 feet (12 meters) wide (VHB 2022). In total, cable protection for these elements would total approximately 79 acres. Installation of cable protection would cause crushing, burial, and entrainment effects on EFH species, and long-term to permanent impacts on benthic habitat composition which would adversely affect EFH and EFH-designated species (see Sections 4, 5.1.2.4, and 5.1.3.1).

2.2.3 Port Facilities

O&M of the RWF would be managed from an existing onshore port/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 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.

2.3 Operations and Maintenance

RWF and RWEC operations and maintenance parameters pertinent to this assessment are described below and summarized in Table 2.1, above. The permanent impacts on the environment resulting from the presence of RWF structures, EMF and heat effects from the transmission cables, and the ongoing O&M of the RWF and RWEC are discussed in Section 5.

2.3.1 Revolution Wind Farm

The RWF would generate electricity whenever wind speeds exceed minimum operational cut-in for the selected WTG design alternative. The RWF would be remotely monitored and operated from an onshore facility. Various vessels would be used periodically for routine O&M and unplanned maintenance activities as needed (VHB 2022; Revolution Wind 2022b). The various vessels used for project O&M activities are identified in Table 2.6 below. As with construction and installation, all operations and maintenance vessels would operate in accordance with applicable rules and regulations for maritime operation within U.S. and federal waters.

Table 2.6. Vessels Required for Project O&M Elements.

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

RWF WTGs would be regularly inspected and maintained by service technicians delivered by a dedicated CTV from the O&M facility. CTVs would make approximately 52 round trips to the Lease Area each year, or one per week, over the life of the project (Revolution Wind 2022b). The service operations vessel (SOV) would make an estimated 26 trips per year to the Lease Area on an as-needed basis (Revolution Wind 2022b). 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. Shared CTVs, vessels servicing multiple offshore wind projects, and daughter craft may make an additional 13 and 10 trips to or within the Lease Area each year, respectively. Helicopters may also be used for aerial inspections. CTVs would not require anchoring, but SOVs may periodically need to be anchored to conduct specific O&M activities. O&M anchoring requirements have not been specified but will be detailed in the project anchoring plan submitted to NMFS. As discussed in Section 5.1.3, vessel anchoring for maintenance would avoid sensitive habitats to avoid significant impacts.

The monopile foundations are not expected to require maintenance over the lifetime of the project. Should unplanned maintenance of the WTGs be required, the associated vessel and activity requirements would be similar to those described for the construction and installation of an individual WTG (i.e., vessel noise and anchoring impacts). Catastrophic failure of monopile foundations from unanticipated events, such as a large vessel allision, could occur but is not anticipated. This type of unanticipated event would only result in the event of an accident or an emergency, and thus associated unplanned maintenance activities are not considered in this assessment.

2.3.2 Revolution Wind Export Cable

The RWEC would transmit electricity from the RWF to Rhode Island whenever the WTGs are in operations and maintenance throughout the anticipated 35-year lifespan of the project. Like the RWF, the RWEC would be remotely monitored from an onshore facility. Revolution Wind does not expect the RWEC to require planned maintenance but would maintain a stockpile of equipment and materials for emergency repairs as needed in the unlikely event of substation equipment failure or physical/mechanical damage to the transmission cable (e.g., by a ship anchor). Should unplanned maintenance or repairs be required, support vessels could travel directly to the site from any global port as determined by the availability of appropriate capabilities. Unplanned emergency maintenance activities are not addressed in this assessment.

As stated in the COP (VHB 2022), the RWEC, IAC, and OSS-Link Cable typically have no maintenance requirements unless a fault or failure occurs. To evaluate integrity of the assets, Revolution Wind intends to conduct an as-built survey/bathymetry survey along the entirety of the cable routes immediately following installation. Bathymetry surveys will be performed one year after commissioning, two to three years after commissioning, and five to eight years after commissioning. Survey frequency thereafter will depend on the findings of the initial surveys (i.e., site seabed dynamics and soil conditions). A survey may also be conducted after a major storm event (i.e., greater than 10-year event). Surveys of the cables may be conducted in coordination with scour surveys at the foundations.

Should the periodic bathymetry surveys indicate that the cables no longer meet an acceptable burial depth (as determined by the Cable Burial Risk Assessment), several options could be employed:

- Remedial burial;
- Secondary protection (rock protection, rock bags or mattresses); and/or
- Increased frequency of bathymetry surveys to assess the rate of natural reburial.

Revolution Wind anticipates that up to of 10 percent of the cable protection placed during installation may require replacement/remediation over the lifetime of the Project (VHB 2022). These activities will result in a short-term disturbance of the seabed similar to or less than what is anticipated during construction.

2.3.3 Port Modifications and Operations & Maintenance Facilities

The proposed action does not include any port O&M activities. As stated previously in Section 2.2.3, the RWF would establish an O&M facility at either the Port of Montauk on Long Island, NY or at Port of Davisville—Quonset Point in Rhode Island. Both port facilities are currently developed and would require no in-water construction and installation elements. In the case of Montauk, O&M dredging and related activities were addressed under the EFH assessment for the

South Fork Wind project. The Port of Davisville is a fully developed industrial port with an existing O&M program.

2.4 Surveys and Monitoring

2.4.1 Pre- and Post-Construction HRG Surveys

High-resolution geophysical (HRG) surveys would be conducted prior to project construction 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 9,509 linear miles of pre-construction surveys would be conducted to support project installation and micrositing. HRG surveys could occur during any month of the year and would require a maximum of 219 total vessel days (LGL 2022).

Up to 2,365 linear miles of O&M HRG surveys may be conducted in the Lease Area and RWEC corridor every year for up to 4 years following the completion of Project construction (LGL 2022). This equates to approximately 54 days of survey effort each year. Post-construction HRG surveys would be used to evaluate benthic habitat condition and ensure transmission cables remain buried to desired depths.

HRG survey equipment is 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. Underwater noise impacts on EFH species from HRG survey equipment are evaluated in Sections 5.1.2.1 and 5.1.2.4 .

2.4.2 Fisheries Research and Monitoring Plan

Revolution Wind is proposing to implement a Fisheries Research and Monitoring Plan (FRMP) as part of the proposed action (Revolution Wind and Inspire Environmental 2021). This plan would monitor benthic habitat conditions and the responses of indicator finfish and invertebrate species to habitat disturbances from the construction and continuing operation of the Proposed Action. Plan elements are described in the following sections.

2.4.2.1 Benthic Habitat Monitoring

The FRMP includes ongoing monitoring to document the extent of benthic habitat disturbance and impacts to associated biological communities resulting from the construction and installation of the project and the subsequent recovery of those resources. The benthic survey would study seafloor habitat and benthic communities in areas impacted by project construction and compare resulting changes to conditions in reference areas. Surveys would be conducted in all areas prior to construction, 1 and 3 years and, if necessary, 5 years post-construction.

Revolution Wind would monitor changes in benthic habitat conditions pre- and post-construction and installation using before-after-gradient and systematic random sampling study designs within a set of predefined survey transects in representative hard bottom and soft bottom habitats.

Benthic habitat monitoring methods are described in detail in the FRMP. The summary provided herein is intended to characterize potential impact mechanisms that could affect EFH and managed species (Revolution Wind and Inspire Environmental 2021).

Benthic survey activities would be conducted using a combination of high-resolution acoustic, video, and photographic imaging methods tailored to each habitat type. All survey equipment would be deployed from contracted scientific research vessels similar to those used to conduct ecological surveys used to support development of the COP (VHB 2022). Sediment profile and plan view imaging (SPI/PV) would be used to characterize existing conditions and changes in soft bottom benthic habitat prior to and following construction and installation of RWF monopiles, the IAC, OSS-link and RWEC. The SPI/PV equipment consists of a camera with two lenses that is lowered onto the seabed, capturing a plan view image as it is lowered as well as a profile view as it penetrates the bed surface, to collect an image of subsurface substrate composition. Following construction and installation, high-resolution imaging collected by remotely operated vehicle (ROV) will be used to monitor changes in benthic community composition on introduced hard surfaces within each RWF monopile transect. A multibeam echosounder, side-scan sonar, and ROV imaging would be used to create detailed maps of hard bottom benthic habitat structure and community composition in the inter-array cable survey frames prior to and following construction and installation. ROV imaging would be used to monitor benthic community composition following construction and installation (Revolution Wind and Inspire Environmental 2021).

Monitoring of soft bottom habitats would focus on physical changes in sediment composition and indicators of benthic function (e.g., bioturbation) to characterize potential changes in community composition (Revolution Wind and Inspire Environmental 2021). Monitoring of hard bottom habitats would focus on measuring changes in the abundance and diversity of habitat-forming organisms, percent cover, and physical characteristics as proxy indicators of changes in food web complexity. The spatial survey design described in the FRMP is summarized as follows:

- **RWF monopile foundations:** Eight survey transects would be established around selected monopile locations. Each transect would extend approximately 900 meters in each direction from the respective foundation center point, or approximately half the distance to the neighboring foundation. A total of 16 locations would be sampled along each transect during each event.

- **RWEC corridor:** Six survey transects would be established in soft bottom benthic habitat, evenly divided between areas of high and low bottom-disturbing commercial fishing activity. Each 25-meter-wide transect would extend approximately 1,000 meters perpendicular to either side of the cable pathway. A total of 16 locations would be sampled along each transect during each event.

- **Inter-array cable corridor (hard bottom benthic habitat disturbance monitoring):** Three sampling frames would be established in hard bottom benthic habitat within the Lease Area, one in an undisturbed reference location and two within the construction and installation–related disturbance footprint. These sites would be monitored to characterize physical impacts to hard bottom habitat, and damage to and the rate of recovery of habitat-forming organisms. Twenty boulders would be randomly sampled within each frame during each event.

Pre-construction and installation monitoring would occur at least 6 to 12 months prior to initial disturbance. Post-construction and installation monitoring in soft bottom benthic habitats is planned for in years 0, 3, and 5, with additional monitoring years to be determined as needed. Post-construction and installation monitoring of introduced hard surfaces around the monopiles is planned for years 0, 1, and 2. Post-construction and installation monitoring of hard bottom benthic habitat would occur within 1 month following construction and installation and would continue in years 0, 1 and 2. All monitoring surveys would be conducted once in late summer at each location during the period of maximum epifaunal growth.

The underwater noise effects generated by the proposed multibeam echosounder and side-scan sonar methods used for habitat monitoring are similar to, but of lower magnitude than, the HRG survey methods described in the project EFH assessment (Revolution Wind and Inspire Environmental 2021). As stated in that document, noise generated by this type of equipment is unlikely to have any measurable biological effect on any EFH species.

2.4.2.2 Fisheries Monitoring

RWF is proposing to implement the FRMP as part of the Proposed Action (Revolution Wind and Inspire Environmental 2021). The FRMP would employ a variety of survey methods to evaluate the effect of RWF construction and installation and operations and maintenance on finfish. The FRMP would adhere to NOAA guidance on float and anchor design to avoid marine mammal entanglement risk. Gear types would be the same as regularly used in commercial fisheries designed to minimize bycatch, particularly Atlantic sturgeon. Commercial fishing vessels would be employed for the surveys, which would otherwise be participating in commercial fisheries, and would likely reduce the amount of gear and fishing effort in the project area and vicinity. The35ollowingg survey methods either directly assess or could impact finfish and EFH:

- Ventless trap surveys to evaluate changes in the distribution and abundance of lobster and Jonah crab in the Lease Area and adjacent reference areas, and Jonah crab, lobster, whelk (Buccinidae) and finfish along the RWEC corridor and adjacent reference areas; these areas would be surveyed 12 times per month for 7 months each for 2 years prior to and at least 2 years following completion of project construction and installation (4 years total).

- Otter trawl surveys to assess abundance and distribution of target fish and invertebrate species within the Lease Area, trawls may impact a variety of finfish species, four times per year for 2 years prior to and at least 2 years following completion of project construction and installation.

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.

2.5 Project Decommissioning

Under 30 CFR Part 585 and commercial Renewable Energy Lease OCS-A 0498, Revolution Wind would be required to remove or decommission all facilities, projects, cables, pipelines, and obstructions and clear the seabed of all obstructions created by the proposed project. The RWF and RWEC would be decommissioned and removed when these facilities reach the end of their approximate 35-year operating period. Decommissioning activities will be completed within two years of termination of the lease. A separate EFH consultation would be conducted for the decommissioning phase of the project. Upon completion of the technical and environmental reviews, BOEM may approve, approve with conditions, or disapprove the lessee's decommissioning application. This process would include an opportunity for public comment and consultation with municipal, state, and federal management agencies. Revolution Wind would need to obtain separate and subsequent approval from BOEM to retire in place any portion of the proposed Project. Approval of such activities would require compliance under NEPA and other federal statues and implementing regulations. If the COP is approved or approved with modifications, Revolution Wind would have to submit a bond (or another form of financial assurance) that would be held by the U.S. government to cover the cost of decommissioning the entire facility in the event that Revolution Wind would not be able to decommission the facility.

It is likely that the same types of vessels used to construct the project would be employed for decommissioning. This process would emphasize the recovery of valuable materials for recycling. The WTGs would be removed and the monopiles cut-off below the seabed and recovered to a barge for transport. A cable laying vessel would be used to remove as much of the inter-array and RWEC transmission cables from the seabed as practicable to recover and recycle valuable metals. Cable segments that cannot be easily recovered would be left buried below the seabed or rock armoring.

3.0 Existing Environment

Revolution Wind conducted detailed surveys of the MWA for the Project to support preparation of the COP (VHB 2022) and this EFH assessment. The MWA covers the portion of the Lease Area where RWF installation impacts would occur, and the entirety of the RWEC installation corridor. The updated surveys represent the most current information available for characterizing baseline conditions for EFH within the MWA and are supported by other appropriate sources of information where available. Impacts to the benthic habitat component of EFH would be limited to the MWA and would occur only on a portion of the habitats contained within.

Aquatic ecosystems in the project area are described using the Coastal and Marine Ecological Classification Standard (CMECS), a classification system based on biogeographic setting for the area of interest (Federal Geographic Data Committee [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 project area and surroundings is the Temperate Northern Atlantic Realm, Cold Temperate Northwest Atlantic Province, Virginian Ecoregion (FGDC 2012).

The biotic component of CMECS classifies living organisms of the seabed 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, class, subclass, group, and community. The biotic subclass is a useful classification category for characterizing the aquatic ecosystem in the project area and vicinity. 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.

The general oceanographic environment in the project area and vicinity, underwater noise, water quality, and electromagnetic field (EMF) conditions, are described in Sections 3.1 through 3.4. Section 3.5 provides a detailed description of benthic habitat composition in the MWA.

3.1 Oceanographic Environment

The aquatic component of the project area is located in transitional waters that separate Narragansett Bay and Long Island Sound from the Atlantic OCS. The CMECS aquatic settings for the project area are marine nearshore and marine offshore, respectively. Water depth in the Lease Area ranges from approximately 80 feet to 165 feet (24 to 50 meters) below MLLW, with an average depth of approximately 115 feet (35 meters) MLLW. Water depths along the RWEC corridor range from approximately 82 feet to 148 feet (25 to 45 meters) below MLLW in the RWEC-OCS, and approximately 33 to 130 feet (10 to 40 meters) below MLLW in the RWEC-RI. Detailed bathymetric surveys of the RWF and RWEC footprints were completed to support COP development, surveyed water depths within these project area components are displayed in Figures 3.1 and 3.2, respectively.

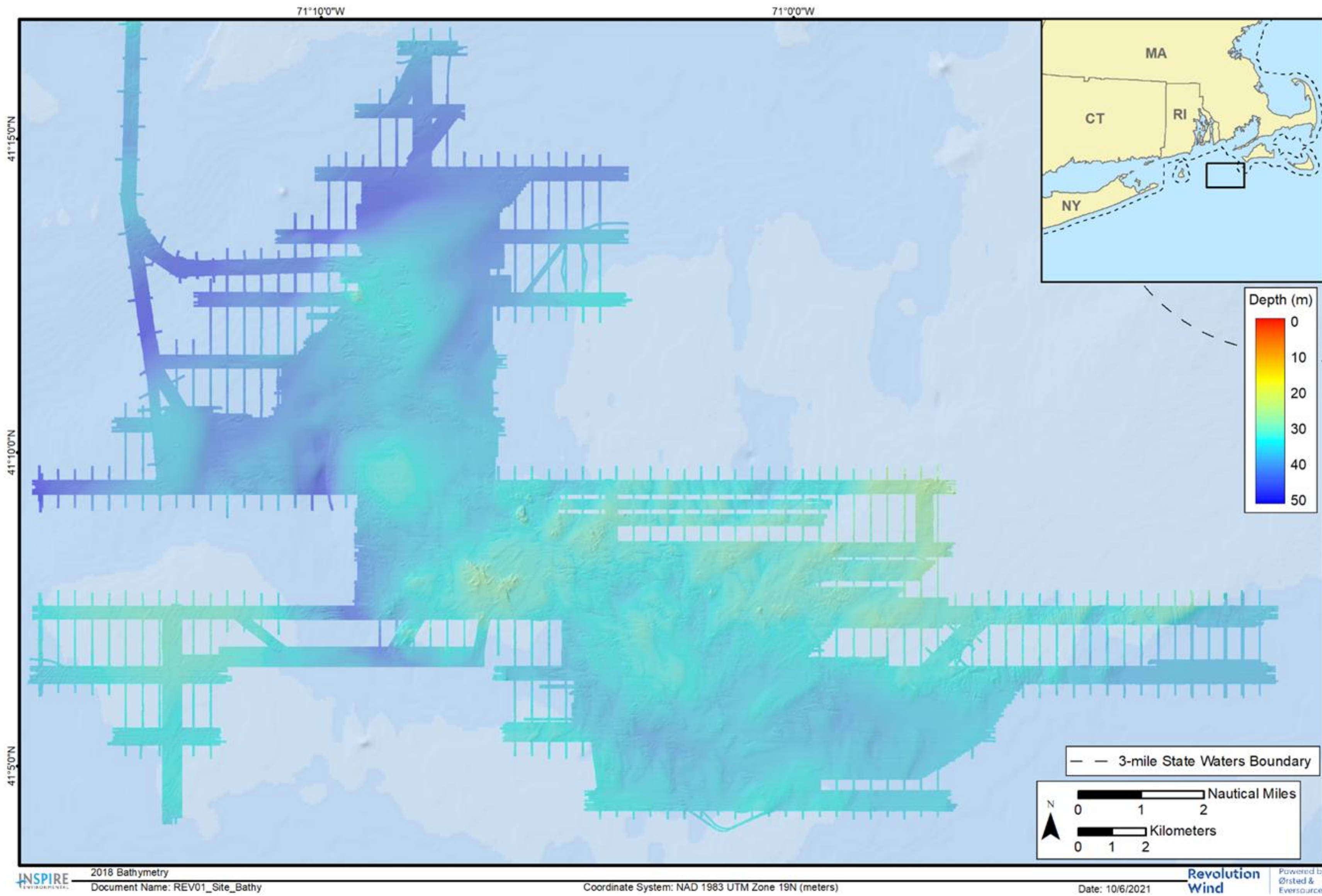

Figure 3.1. Surveyed Bathymetry within the Lease Area and Vicinity (Inspire Environmental 2021).

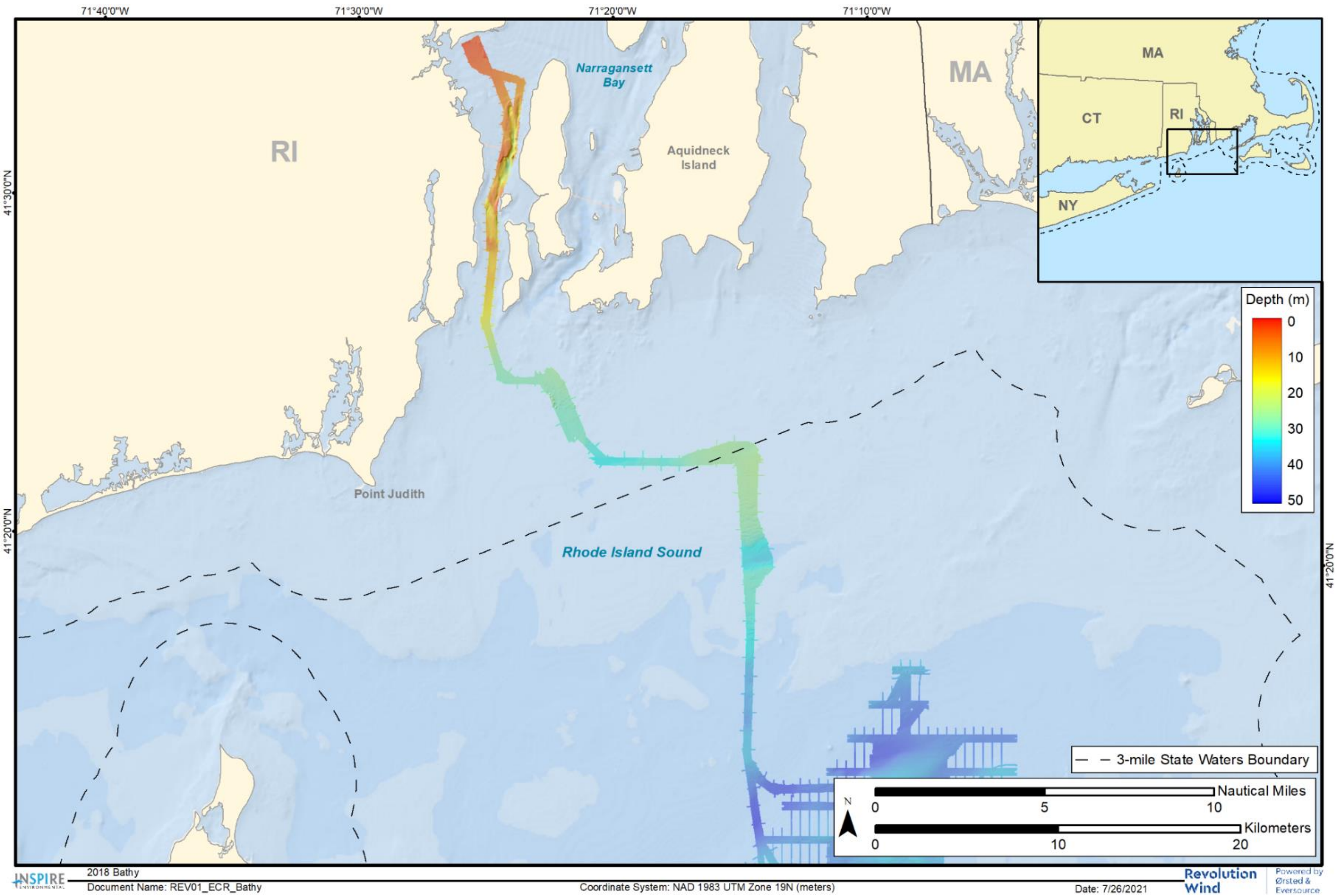

Figure 3.2. Surveyed Bathymetry within the RWEC Project Footprint and Vicinity (Inspire Environmental 2021).

Circulation patterns in the project area and vicinity are predominantly influenced by tidal exchange in from Block Island Sound and oceanic currents transporting colder water from the Gulf of Maine. The net transport of water in the project area and vicinity flows from the ocean to the east and from Rhode Island Sound to the north towards the southwest and west. Bottom water may flow toward the north, particularly during the winter (RICRMC 2010). The Lease Area 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 Lease Area and offshore components of the RWEC is considered fair to good (U.S. Environmental Protection Agency [USEPA] 2015).

3.2 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 Lease Area 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 project area, also contributed to ambient noise levels.

The median 20 – 477 hertz (Hz) ambient underwater route-mean-square (rms) sound pressure levels within the RI/MA WEA measured from November 2011 to March 2015 varied from 101 to 110 dB (decibels) re 1 µPa depending on location. The greatest ambient rms sound pressure levels reached as high as 125 dB re 1 µPa on the south-central edge of the Lease Area in proximity to the Narraganset Bay and Buzzards Bay shipping lanes (Kraus et al. 2016). 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). 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.

3.3 Water Quality

The surface waters within and adjacent to the MWA comprise Narragansett Bay (including the estuarine embayment and ports and harbors), nearshore coastal waters of Rhode Island (within 3 nm of shore), and federally administered marine waters greater than 3 miles offshore. Surrounding coastal water bodies include Block Island Sound and Rhode Island Sound. The marine environment within and surrounding the MWA are characterized by large seasonal variations in temperature, stratification, and productivity and are classified as temperate (Hazel

1970). Water currents in Zone RWEC-RI near the sea-to-shore transition flow predominantly southwest and northeast. Water currents in the coastal nearshore portion of Zone RWEC-RI, Zone RWEC-OCS, and in the Lease Area flow predominantly south and east (RPS 2021). Measured current speed along the RWEC corridor ranged up to approximately 0.2 m/s, increasing to approximately 0.4 m/s at the entrance to Narragansett Bay (RPS 2021). In general, salinity levels in the region have low variability. Salinity ranged from 29 to 32 practical salinity unit (psu) in Narragansett Bay and 32 to 33 psu in coastal offshore waters (NBEP 2017).

The Lease Area 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 generally representative of the regional ocean environment and subject to constant oceanic circulation that disperses, dilutes, and biodegrades anthropogenic pollutants from upland and shoreline sources (BOEM 2013). The RWEC-RI is located in coastal marine waters of Rhode Island where water quality data are similarly limited but some useful information is available. 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 phosphorous, nitrogen, dissolved oxygen, salinity, water clarity, pH, and chlorophyll a. The most recent National Coastal Condition Report (NCCR) rated coastal water quality from Maine to North Carolina as “good” to “fair” (USEPA 2015). This survey included four sampling locations near the Lease Area and RWEC, all of which were within Block Island Sound. USEPA (2015) rated all NCCR parameters in the fair to good categories at all four of these locations (USEPA 2015).

For the purpose of this EFH assessment, total suspended sediment (TSS) is the pertinent water quality parameter likely to be measurably affected by the project. Ocean waters beyond 3 linear miles (4.8 km, 2.6 nm) offshore typically have low concentrations of suspended particles and low turbidity. Turbidity in Rhode Island Sound from five studies cited in U.S. Army Corps of Engineers (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).

3.4 Natural and Anthropogenic Electromagnetic Fields

The natural magnetic field in the project area has a total intensity of approximately 512 to 517 milligauss (mG) or 51.2 to 51.7 micro-Tesla (μT) at the seabed, based on modeled magnetic field strength from 2014 through 2019 (NOAA 2018). The marine environment continuously generates additional ambient EMF effects. The motion of electrically conductive seawater through the Earth’s magnetic field induces voltage potential, creating electrical currents. Surface and internal waves, tides, and coastal ocean currents all create weak induced electrical and magnetic field effects. Their magnitude at a given time and location are dependent on the strength of the prevailing magnetic field, and site- and time-specific ocean conditions. Other external factors like electrical storms and solar events can also generate variable EMF effects.

Following 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 occurring within the Lease Area and the RWEC corridor could induce a steady-state electrical field on the order of 51.5 microvolts per meter (µV/m). Modeled current speeds in the Project Area are on the order of 0.1 to 0.35 m/s at the seabed (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 (0.1 to 1 µT), 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 meters) below the surface (Slater et al. 2010).

At least seven submarine power and communications cables are present within or in the vicinity of the RWEC. While the type and capacity of those cables is not specified, the associated baseline EMF effects can be inferred from available literature. Electrical telecommunications cables are likely to induce a weak EMF on the order of 1 to 6.3 µV/m within 3.3 feet (1 meter) of the cable path (Gill et al. 2005). Fiber-optic communications cables with optical repeaters would not produce EMF effects. EMF effects from submarine power cables would be similar in magnitude to those described for the Proposed Action but would vary depending on specific transmission load. For example, the two power cables supplying Nantucket Island at a typical load of 46 kV and 420 amps (Balducci et al. 2019).

3.5 Benthic Habitat Types in the Lease Area and REWC Maximum Work Area

Inspire Environmental (2021) surveyed benthic habitat conditions using a combination of high-resolution acoustic, video, and photographic imaging methods. Benthic habitat conditions were characterized consistent with NOAA (2021) recommendations for mapping fish habitat. The Inspire Environmental (2021) benthic habitat mapping report is attached as Appendix A. This document provides a detailed description of the habitat survey methods used and the survey results. These results are summarized herein for the purpose of EFH consultation.

High-resolution multibeam echosounders and side-scan sonar surveys were used characterize bathymetric conditions and substrate composition within the MWA. Sediment profile and plan view images (SPI/PV) were collected at 285 stations within the Lease Area and RWEC MWA in July 2019 (Inspire Environmental 2021). SPI/PV images were used to ground-truth sediment types, bedform dynamics, presence of sensitive habitats and taxa, and to characterize benthic biological communities.

The OCS within and surrounding the project area is characterized by a gradually sloping seabed from the shoreline to the Lease Area, which is located in waters ranging from approximately 82 to 164 feet (25 to 50 meters) deep. MARCO (2019), BOEM (Guida et al. 2017), and Revolution

Wind (Inspire Environmental 2021) have conducted large-scale general benthic habitat mapping within the Lease Area. Regional and WEA-specific benthic habitat mapping (Collie and King 2016; Mid-Atlantic Regional Council on the Ocean [MARCO] 2019) provide a general characterization of benthic habitat conditions, however this information is insufficient for characterizing existing habitats and potential impacts to EFH.

Inspire Environmental (2021) identified several benthic habitats, or macrohabitat types in the area of direct effects: 1) glacial moraine, 2) coarse sediment, 3) sand and muddy sand, 4) and mud and sandy mud. These habitat classifications are not consistent with Coastal and Marine Ecological Classification (FGDC 2012) standards for benthic substrate types. Therefore, for the purpose of this analysis, these macrohabitat types are consolidated into four benthic habitat categories consistent with NOAA (2021) benthic habitat mapping recommendations: 1) complex habitat, 2) large-grained complex habitat, 3) soft bottom, and 4) anthropogenic. These substrate groupings are based on predominant sediment grain size and composition, the presence of biogenic features and habitat forming organisms, and associated uses by marine organisms. Anthropogenic features represent a negligible component of benthic habitat, comprising less than 0.03% of total habitat area. Therefore, habitat conversion impacts resulting from the project are quantified in Section 5 using the three primary benthic habitat types that occur in the project area. These three benthic habitat types are defined as follows:

- **Large-grained complex habitat:** Large boulders and bedrock.
- **Complex benthic habitat:** Areas of submerged aquatic vegetation (SAV), shell substrate, and sediments with >5% 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 benthic habitat:** Fine unconsolidated substrates (i.e., mud and/or sand).

Glacial moraine and coarse sediment are categorized under complex habitat because boulders, cobbles, and pebbles dominate the sea floor in these areas, along with finer material (e.g., pebbles in a sand matrix), thus providing a heterogeneous variety of hard surfaces and fine material that are habitat for many different species. Sand/ muddy sand and mud/sandy mud areas lacking a substantial portion of coarse-grained sediment are categorized as soft bottom habitat. It is important to note that within an area categorized as soft bottom habitat there may be scattered (e.g., patchy) areas of gravels and small cobbles that constitute complex habitat.

In the process of developing project alternatives for the draft environmental impact statement (DEIS), BOEM worked collaboratively with NMFS to identify specific areas, or zones, within the Lease Area of greatest concern for potential adverse impacts on EFH. These habitat zones were used to define the Habitat Impact Minimization Alternative (Alternative C) and have been adapted to support the EFH assessment. The zones were modified to provide complete coverage of the MWA with contiguous internal boundaries. The modified zones are defined as follows:

- Zone RWF 1: Highest priority area for benthic habitat impact minimization within the Lease Area.
- Zone RWF 2: Second highest priority area for benthic habitat impact minimization within the Lease Area.
- Zones RWF 3a and RWF 3b: Third highest priority area for benthic habitat impact minimization within the Lease Area.
- Zone RWF 4: Lowest priority area for benthic habitat impact minimization.
- Zone RWEC-OCS: Portion of RWEC corridor in federal waters.
- Zone RWEC-RI: Portion of RWEC corridor in Rhode Island waters.

The habitat zones are used to organize the description of existing benthic habitat composition and structure within the MWA provided in the following sections. This organization supports the characterization of construction and O&M impacts on EFH based on the specific habitat features present within each zone. The habitat zones and the distribution of complex, large-grained complex, and soft bottom benthic habitats within each zone are displayed in Figures 3.3 and 3.4. The surveyed area and proportional distribution of benthic habitat types within each zone are summarized in Table 3.1.

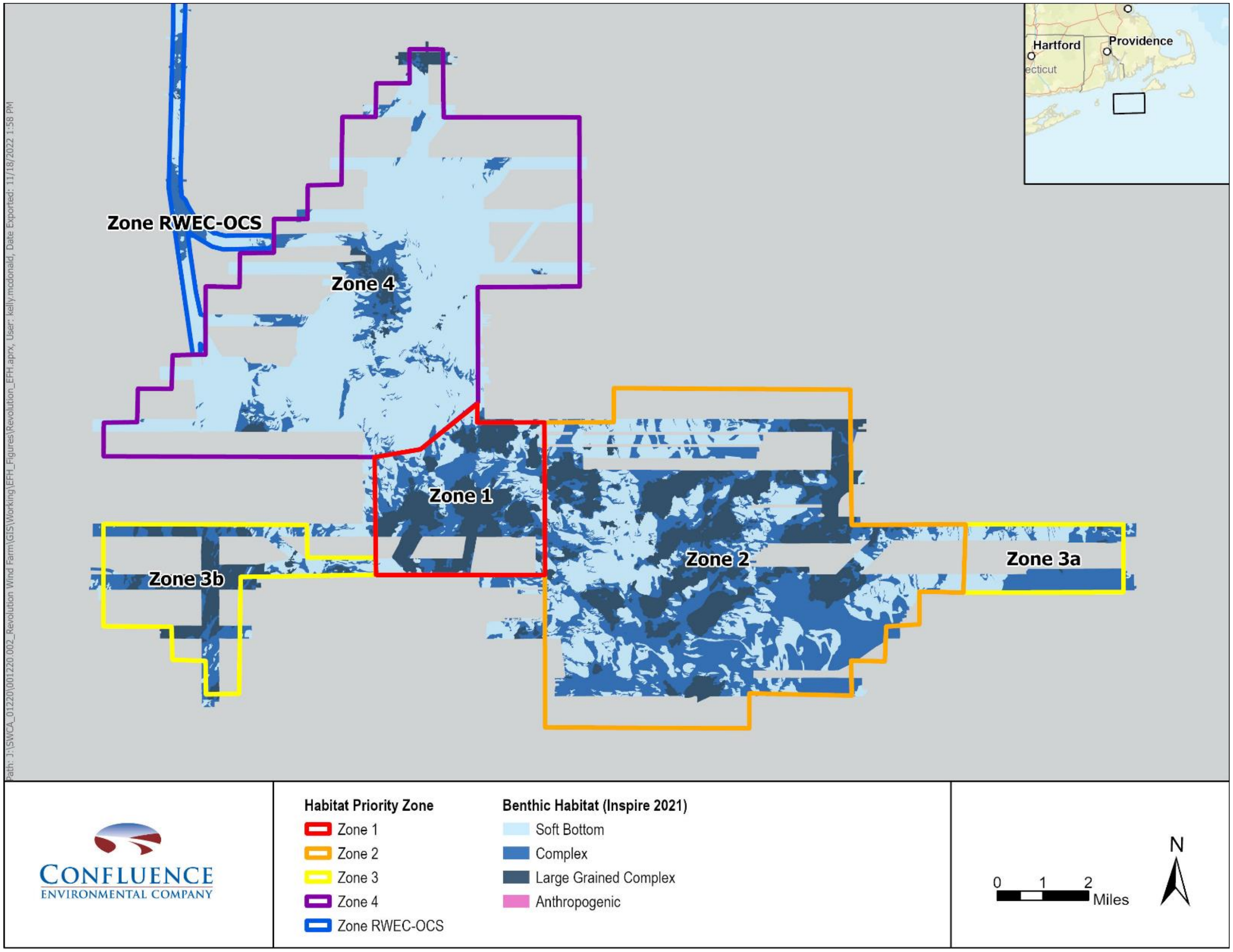

Figure 3.3. Habitat Zone Boundaries and Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats within the Lease Area (Inspire Environmental 2021).

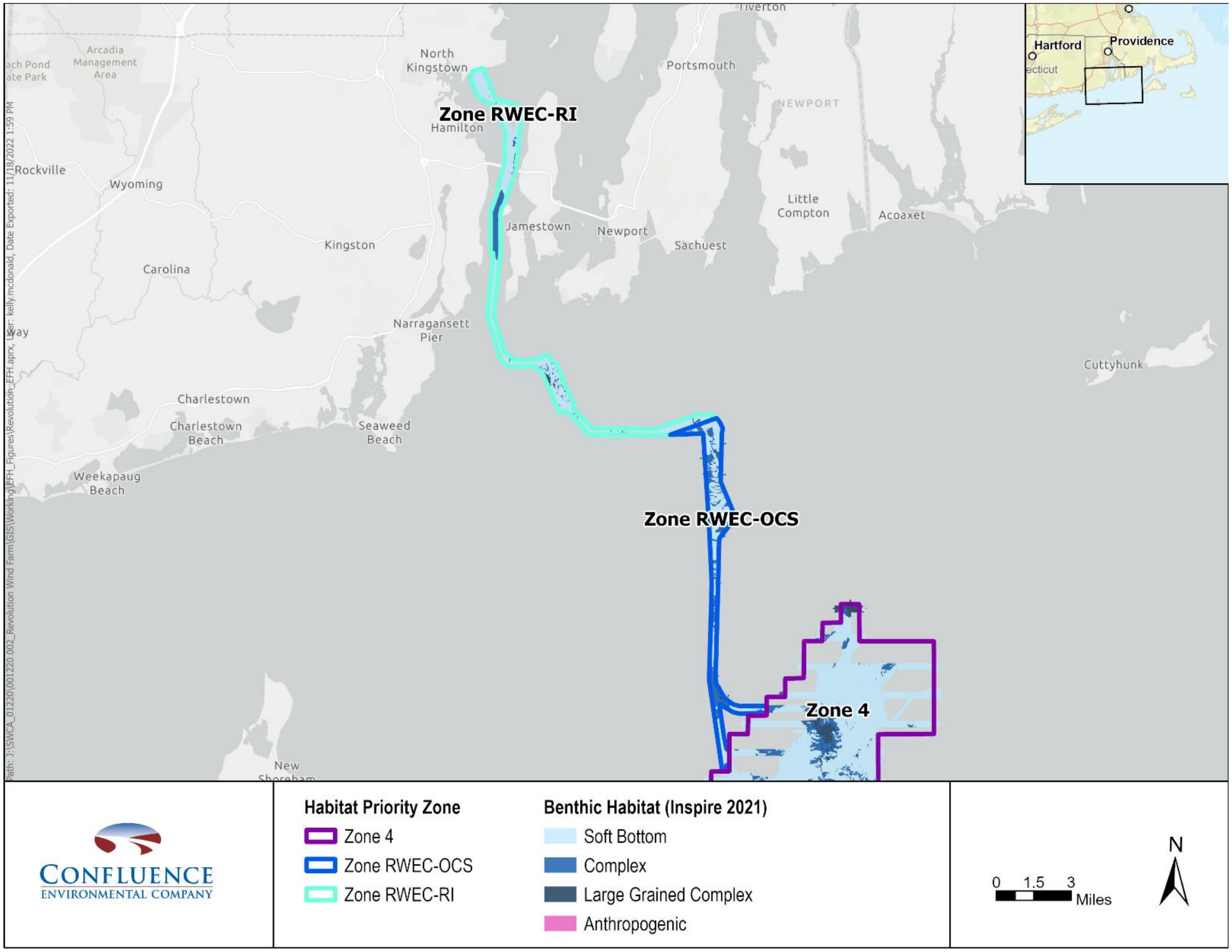

Figure 3.4. Habitat Zone Boundaries and Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats within the RWEC Project Footprint (Inspire Environmental 2021).

Table 3.1. Total Survey Acres and Proportional Composition of Benthic Habitat Types in the Lease Area and RWEC MWA.

Habitat Zone	Total Zone Acres	Total MWA Acres	Large-Grained Complex (% of MWA)	Complex (% of MWA)	Soft bottom (% of MWA)	Anthropogenic (% of MWA)
RWF 1	7,461	6,267	43.5%	31.0%	25.5%	0.0%
RWF 2	33,684	25,059	25.0%	40.7%	34.3%	0.0%
RWF 3a	3,334	1,793	1.1%	61.3%	37.6%	0.0%
RWF 3b	6,808	3,194	45.1%	37.6%	17.3%	0.0%
RWF 4	31,429	19,785	3.2%	10.7%	86.1%	0.0%
RWEC-OCS	4,460	4,460	0.7%	32.0%	67.3%	0.0%
RWEC-RI‡	5,627	5,627	3.1%	14.4%	82.1%	0.4%

‡ Includes the sea-to-shore transition site, which covers approximately 3.1 acres composed entirely of soft bottom benthic habitat.

The NOAA benthic habitat categories are useful for broadly characterizing the types of benthic habitats present, but each habitat type can represent a range of CMECS substrate classifications and can vary in the presence and extent of bedform features that contribute to habitat complexity. Inspire Environmental (2021) characterized the CMECS substate classes and subclasses observed in SPI/PV imagery. The CMECS substrate subclasses (FGDC 2012) observed in the MWA are summarized by habitat zone and NOAA benthic habitat type in Table 3.2. As shown, sandy gravel, gravelly sand, and varying forms of sand were the predominant CMECS substrate subclasses observed in each habitat zone.

Boulder fields, scattered boulders, sandwaves, and linear depressions are an important component of benthic habitat structure that contribute to habitat complexity. Inspire Environmental (2021) mapped the presence and distribution of these bedform features throughout the MWA. The extent and distribution of these features are summarized by habitat zone and NOAA benthic habitat category in Table 3.3.

Boulders, in the form of contiguous boulder fields and scattered boulders within otherwise soft bottom habitat are an important feature of benthic habitat, providing three-dimensional structure and substrate for attached fauna used as habitat by many EFH species. As shown in Table 3.3, medium-density (246 to 491 boulders per acre, or 100 to 199 boulders per 10,000 m^2) and/or low-density (50 to 245 boulders per acre, or 20 to 99 boulders per 10,000 m^2) boulder fields are prevalent throughout the Lease Area. Boulders are most prevalent in large-grained complex and complex habitats but also occur in soft bottom habitat in zones RWF 2 and 3b. Scattered boulders, defined as small clusters (<2,000 m^2 in area) or very low-density boulder fields (<20 boulders per 10,000 m^2), are prevalent throughout the entire Lease Area and RWEC and occur in every habitat type. The distribution of boulder fields and surficial boulders within each habitat zone are displayed in Figures 3.6 to 3.12 in the following sections.

Table 3.2. Distribution of CMECS substrates Observed in SPI/PV Data by Habitat Zone and Benthic Habitat Type.

Habitat Zone	Benthic Habitat Type	Percent of MWA	Number of SPI/PV Stations	Cobble	Pebble	Granule	Sandy Gravel	Gravelly Sand	Slightly Gravelly Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Shell Hash	Crepidula Reef Substrate
RWF 1	Large-grained complex	43.5%	8	0%	0%	0%	25%	50%	13%	0%	0%	13%	0%	0%	0%
	Complex	31.0%	10	0%	0%	0%	40%	30%	30%	0%	0%	0%	0%	0%	0%
	Soft bottom	25.5%	11	0%	0%	0%	0%	18%	9%	0%	36%	36%	0%	0%	0%
	Total	**100%**	**29**	**0%**	**0%**	**0%**	**21%**	**31%**	**17%**	**0%**	**14%**	**17%**	**0%**	**0%**	**0%**
RWF 2	Large-grained complex	25.0%	19	5%	0%	0%	37%	32%	16%	0%	5%	5%	0%	0%	0%
	Complex	40.7%	32	0%	0%	9%	6%	28%	38%	0%	16%	3%	0%	0%	0%
	Soft bottom	34.3%	28	0%	0%	0%	4%	4%	11%	0%	32%	50%	0%	0%	0%
	Total	**100%**	**79**	**1%**	**0%**	**4%**	**13%**	**20%**	**23%**	**0%**	**19%**	**20%**	**0%**	**0%**	**0%**
RWF 3a	Large-grained complex	1.1%	--	--	--	--	--	--	--	--	--	--	--	--	--
	Complex	61.3%	7	0%	0%	0%	0%	0%	86%	14%	0%	0%	0%	0%	0%
	Soft bottom	37.6%	4	0%	0%	0%	0%	0%	0%	0%	25%	75%	0%	0%	0%
	Total	**100%**	**11**	**0%**	**0%**	**0%**	**0%**	**0%**	**55%**	**9%**	**9%**	**27%**	**0%**	**0%**	**0%**
RWF 3b	Large-grained complex	45.1%	6	0%	0%	0%	50%	33%	17%	0%	0%	0%	0%	0%	0%
	Complex	37.6%	9	0%	0%	11%	56%	11%	0%	0%	0%	22%	0%	0%	0%
	Soft bottom	17.3%	1	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
	Total	**100%**	**16**	**0%**	**0%**	**6%**	**50%**	**19%**	**6%**	**0%**	**0%**	**19%**	**0%**	**0%**	**0%**
RWF 4	Large-grained complex	3.2%	1	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
	Complex	10.7%	9	0%	0%	11%	0%	33%	33%	11%	0%	11%	0%	0%	0%
	Soft bottom	86.1%	87	0%	0%	0%	0%	0%	1%	2%	21%	62%	14%	0%	0%
	Total	**100%**	**97**	**0%**	**0%**	**1%**	**1%**	**3%**	**4%**	**3%**	**19%**	**57%**	**12%**	**0%**	**0%**
RWEC-OCS	Large-grained complex	0.7%	--	--	--	--	--	--	--	--	--	--	--	--	--
	Complex	32.0%	7	14%	14%	0%	14%	0%	43%	14%	0%	0%	0%	0%	0%
	Soft bottom	67.3%	12	0%	0%	0%	0%	0%	17%	8%	25%	8%	42%	0%	0%
	Total	**100%**	**19**	**5%**	**5%**	**0%**	**5%**	**0%**	**26%**	**11%**	**16%**	**5%**	**26%**	**0%**	**0%**
RWEC-RI	Large-grained complex	3.1%	1	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%
	Complex	14.4%	7	0%	0%	0%	0%	0%	0%	14%	0%	14%	0%	57%	14%
	Soft bottom	82.1%	26	0%	0%	0%	0%	0%	4%	4%	4%	35%	54%	0%	0%
	Total	**100%**	**34**	**0%**	**0%**	**0%**	**0%**	**0%**	**6%**	**6%**	**3%**	**29%**	**41%**	**12%**	**3%**

Table 3.3. Presence and Estimated Acreage of Bedform Features by Habitat Zone and Benthic Habitat Type.

Habitat Zone	Bedform Feature	Total Feature Area in MWA (acres)	Feature Area in Large-Grained Complex Habitat (acres)	Feature Area in Complex Habitat (acres)	Feature Area in Soft bottom Habitat (acres)
RWF 1	Total mapped area	6,267	2,729	1,940	1,598
	Boulders - medium†	551	441	97	13
	Boulders - low†	702	230	394	79
	Mega-ripples	566	17	19	530
	Ripples	6,082	2,711	1,919	1,452
	Linear Depressions	1,087	--	14	1,073
	Trawl Scars	574	--	--	574
RWF 2	Total mapped area	25,059	6,271	10,200	8,587
	Boulders - medium†	1,682	1,044	584	54
	Boulders - low†	2,741	399	2,133	209
	Mega-ripples	7,258	689	508	6,062
	Ripples	24,626	6,219	10,075	8,332
	Linear Depressions	4,704	25	250	4,430
	Trawl Scars	17	--	--	17
RWF 3a	Total mapped area	1,793	21	1,099	674
	Boulders - medium†	79	13	62	4
	Boulders - low†	81	1	72	8
	Mega-ripples	195	--	--	195
	Ripples	1,773	21	1,084	669
	Linear Depressions	130	--	6	124
	Trawl Scars	--	--	--	--
RWF 3b	Total mapped area	3,194	1,440	1,202	553
	Boulders - medium†	414	166	244	166
	Boulders - low†	505	85	389	12
	Mega-ripples	677	182	97	398
	Ripples	3,134	1,439	1,161	534
	Linear Depressions	82	35	9	38
	Trawl Scars	77	--	38	39
RWF 4	Total mapped area	19,785	624	2,126	17,034
	Boulders - medium†	263	147	85	31
	Boulders - low†	471	49	283	139
	Mega-ripples	1,818	--	139	50
	Ripples	16,493	484	2,066	13,943
	Linear Depressions	13,864	2	90	13,772
	Trawl Scars	15,746	5	391	15,351
RWEC-OCS	Total mapped area	4,460	30	1,428	3,001
	Boulders - medium†	195	12	178	6
	Boulders - low†	221	0	213	8
	Mega-ripples	1,288	--	127	1,692
	Ripples	2,259	1	773	1,485
	Linear Depressions	1,123	--	122	1,002
	Trawl Scars	772	--	32	740
RWEC-RI‡	Total mapped area	5,627	175	808	4,619
	Boulders - medium†	63	49	5	9
	Boulders - low†	110	46	41	20
	Mega-ripples	--	--	--	1,288
	Ripples	2,117	11	150	1,956
	Linear Depressions	844	--	15	829
	Trawl Scars	2,503	--	622	1,881

‡ Includes the sea-to-shore transition site, which covers approximately 3.1 acres composed entirely of soft bottom benthic habitat. Zone area includes approximately 25 acres of anthropogenic habitat, not displayed in this table.

† Boulder field – medium = medium-density boulder field (246 to 491 boulders per acre, or 100 to 199 boulders per 10,000 m^2); Boulder field – low = low-density boulder field (20 to 99 boulders per acre, 20 to 99 boulders per 10,000 m^2).

Bedform (i.e., sandwaves, ripples, and mega-ripples) and biogenic features (e.g., linear depressions formed by fish and invertebrates) are other important features of benthic habitat. The presence and prevalence of trawl scars are also useful indicators of periodic anthropogenic disturbance of the seabed. Table 3.3 summarizes the mapped extent of bedform and biogenic features by habitat zone and NOAA benthic habitat category.

No sandwaves were identified within the Lease Area and RWEC, but extensive patches of ripples and mega-ripples are present in every habitat zone. Ripples are most prevalent within the Lease Area in complex habitats and in the RWEC-OCS in soft bottom habitats, while mega-ripples are prevalent in the Lease Area and RWEC-OCS in complex habitats primarily and secondarily in large-grained complex (in Lease Area) and complex (RWEC-OCS). Ripples are present along a limited portion of the RWEC-RI corridor (Inspire Environmental 2021). Linear depressions were observed in every habitat zone. These features are most prevalent in soft bottom habitat but were also observed in large-grained complex and complex habitat.

Inspire Environmental (2021) mapped trawl scar presence and extent throughout the MWA, which is summarized by habitat zone and NOAA benthic habitat type in Table 3.3. Trawl scars are visible features indicative of seabed disturbance by fishing gear. Bottom-disturbing commercial fishing methods like bottom trawls, scallop and clam dredges, and lobster pots are common fishing gear types used in the project area (VHB 2022). This type of bed disturbance was not observed in large-grained complex habitat but was rarely to commonly observed in complex and soft bottom habitats. In general, trawl scars were either absent or present in a small percentage of mapped habitats in zones RWF 1, RWF 2, RWF 3a, and RWF 3b. In contrast, trawl scars were prevalent throughout zones RWF 4, RWEC-OCS, and RWEC-RI, observed in 90, 25, and 40 percent of mapped soft bottom habitats, respectively (Table 3.2).

Fisheries using bottom gear in the New England and Mid-Atlantic management regions accounted for total annual revenues over $900 million between 2009 and 2018 (NMFS 2021). Chronic disturbance by commercial fishing activities can impact benthic community structure by reducing species diversity and increasing recovery time (Nilsson and Rosenberg 2003; Rosenberg et al. 2003).

The dominant CMECS biotic subclass (i.e., co-dominant subclass) associated with complex benthic habitat across the Lease Area and offshore RWEC is Attached Fauna (VHB 2022). The Attached Fauna subclass often co-occurs with the Soft Sediment Fauna subclass. Invertebrates classified as Attached Fauna maintain contact with hard substrate surfaces, including firmly attached, crawling, resting, interstitial, or clinging invertebrates. Attached invertebrates could be found on, between, or under rocks or other hard substrates or substrate mixes. These invertebrates use pedal discs, cement, byssal threads, feet, claws, appendages, spines, suction, negative buoyancy, or other means to stay in contact with the hard substrate and may or may not be capable of slow movement over the substrate. Invertebrates typically associated with the Attached Fauna subclass include sea anemones, barnacles, corals, mussels, oysters, some crabs, small shrimp, amphipods, starfish, and sea urchins (FGDC 2012). Economically important species, notably lobster and squid, are also associated with the Attached Fauna subclass. These hard substrate areas serve as important nursery habitat for juvenile lobster and substrate upon which squid lay their eggs.

Inspire Environmental (2021) collected a variety of data useful for characterizing the presence and distribution of biogenic and biotic features that contribute to benthic habitat composition and structure. This information includes the distribution and density of attached fauna on hard substrates and biogenic and biotic features in soft bottom habitat. Table 3.4 provides a summary of the percentage of stations by attached fauna coverage density category observed in SPI/PV imagery for each project component and benthic habitat type. While these data are generally useful for evaluating the distribution of attached fauna by habitat zone they must be interpreted with caution. The percent coverage metric is the maximum epifaunal coverage observed in the 3 image replicates at each SPI/PV site as the proportion of total image area. For example, an image having 25 percent coverage by cobbles that are completely covered by epifaunal organisms would be characterized as "Sparse (1 to <30%)".

Table 3.4. Attached Fauna Coverage Density Observed in SPI/PV Data by Habitat Zone and Benthic Habitat Type.

Habitat Zone	NOAA Mapping Type	Number of SPI/PV Stations	Complete (90-100%)	Dense (70 to <90%)	Moderate (30 to <70%)	Sparse (1 to <30%)	Trace (<1%)	None
RWF 1	Large-grained complex	8	13%	25%	25%	25%	0%	13%
	Complex	10	0%	10%	30%	10%	40%	10%
	Soft bottom	11	0%	0%	0%	18%	0%	82%
	Total	**29**	**3%**	**10%**	**17%**	**17%**	**14%**	**38%**
RWF 2	Large-grained complex	19	5%	16%	32%	21%	16%	11%
	Complex	32	0%	0%	0%	3%	28%	69%
	Soft bottom	28	0%	0%	0%	0%	14%	86%
	Total	**79**	**1%**	**4%**	**8%**	**6%**	**20%**	**61%**
RWF 3a	Complex	7	0%	0%	0%	0%	14%	86%
	Soft bottom	4	0%	0%	0%	0%	0%	100%
	Total	**11**	**0%**	**0%**	**0%**	**0%**	**9%**	**91%**
RWF 3b	Large-grained complex	6	33%	0%	0%	0%	50%	17%
	Complex	9	0%	0%	0%	11%	67%	22%
	Soft bottom	1	0%	0%	0%	0%	0%	100%
	Total	**16**	**13%**	**0%**	**0%**	**6%**	**56%**	**25%**
RWF 4	Large-grained complex	1	0%	0%	0%	100%	0%	0%
	Complex	9	0%	0%	11%	22%	11%	56%
	Soft bottom	87	0%	0%	0%	0%	6%	94%
	Total	**97**	**0%**	**0%**	**1%**	**3%**	**6%**	**90%**
RWEC-OCS	Complex	7	0%	14%	14%	14%	0%	57%
	Soft bottom	12	0%	0%	0%	0%	8%	92%
	Total	**19**	**0%**	**5%**	**5%**	**5%**	**5%**	**79%**

Habitat Zone	NOAA Mapping Type	Number of SPI/PV Stations	Complete (90-100%)	Dense (70 to <90%)	Moderate (30 to <70%)	Sparse (1 to <30%)	Trace (<1%)	None
RWEC-RI	Large-grained complex	1	0%	0%	0%	100%	0%	0%
	Complex	7	14%	0%	14%	43%	0%	29%
	Soft bottom	26	0%	0%	4%	8%	4%	85%
	Total	**34**	**3%**	**0%**	**6%**	**18%**	**3%**	**71%**

Attached fauna coverage in the maximum proportion of epifaunal coverage observed in sediment plan view images observed in three image replicates at each SPI/PV station. Epifaunal coverage is the percent of image area covered by visible epifaunal growth.

The dominant CMECS biotic subclass associated with soft bottom benthic habitats is Soft Sediment Fauna (VHB 2022). The Soft Sediment Fauna subclass includes any invertebrate that creates a permanent or semi-permanent home in the substrate. Invertebrates that move slowly over the sediment surface but are not capable of moving outside of the boundaries of the subclass within 1 day are also included. Most of the invertebrates associated with the Soft Sediment Fauna possess specialized organs for burrowing, digging, embedding, tube-building, anchoring, or locomotion in soft substrates. Invertebrates associated with the Soft Sediment Fauna subclass include worm-like invertebrates (e.g., oligochaetes, polychaetes, flatworms [Platyhelminthes], and nematodes [Nematoda]); burrowing amphipods, mysids, and copepods; crabs (Brachyura); sand dollars (Clypeasteroida); starfish (Asteroidea); and sea urchins (Echinoidea); bivalves (Bivalvia); snails (Gastropoda); burrowing anemones (Anthozoa); (FGDC 2012; VHB 2022; Inspire Environmental 2021). These species provide the prey base for several EFH species. Economically important species, including sea scallops, horseshoe crabs (Limulidae), surf clams, and the ocean quahog, are also associated with the Soft Sediment Fauna subclass.

Biogenic features were recorded throughout the Lease Area, RWEC-OCS and RWEC-RI in SPI/PV imaging. A total of 285 photographic stations were collected throughout the Lease Area and RWEC. At least some epifaunal species were observed at every station. Amphipod tubes were present at 264 of the 285 stations, burrows were present at 258 of the 285 stations, tracks were present at 183 of the 285 stations and seapens were present at 52 of the 285 stations. More sensitive taxa, including species of concern and possible non-native species, appear to be less prevalent. These features were absent from between 70 and 98 percent of the 285 SPI/PV sites (Inspire Environmental 2021). Tables 3.4 and 3.5 provide a summary of the biogenic and biotic features observed in SPI/PV imagery, respectively, for each project component and benthic habitat type.

Table 3.5. Percent of SPI/PV Stations with Observed Biogenic Features by Habitat Zone and Benthic Habitat Type.

Habitat Zone	Benthic Habitat Type	Number of SPI/PV Stations	Amphipod Tubes	Burrows	Tracks	Shell Hash	Hard Coral (non-reef)	Sea Scallop	Other Epifauna‡	Non-native Species¥
RWF 1	Large-grained complex	8	100%	100%	63%	75%	0%	0%	100%	50%
	Complex	10	60%	100%	60%	40%	0%	0%	100%	30%
	Soft bottom	11	100%	100%	91%	45%	0%	0%	91%	0%
	Total	**29**	**86%**	**100%**	**72%**	**52%**	**0%**	**0%**	**97%**	**24%**
RWF 2	Large-grained complex	19	100%	95%	42%	32%	21%	0%	95%	47%
	Complex	32	88%	100%	50%	59%	0%	0%	94%	6%
	Soft bottom	28	100%	93%	64%	36%	0%	0%	96%	0%
	Total	**79**	**95%**	**96%**	**53%**	**44%**	**5%**	**0%**	**95%**	**14%**
RWF 3a	Complex	7	86%	100%	71%	57%	0%	0%	43%	0%
	Soft bottom	4	100%	100%	75%	0%	0%	0%	100%	0%
	Total	**11**	**91%**	**100%**	**73%**	**36%**	**0%**	**0%**	**64%**	**0%**
RWF 3b	Large-grained complex	6	100%	83%	50%	67%	0%	0%	100%	17%
	Complex	9	100%	89%	33%	0%	0%	22%	89%	0%
	Soft bottom	1	100%	100%	0%	0%	0%	0%	100%	0%
	Total	**16**	**100%**	**88%**	**38%**	**25%**	**0%**	**13%**	**94%**	**6%**
RWF 4	Large-grained complex	1	0%	0%	100%	100%	0%	0%	100%	0%
	Complex	9	78%	89%	56%	56%	0%	11%	78%	11%
	Soft bottom	87	99%	90%	74%	51%	0%	1%	83%	0%
	Total	**97**	**96%**	**89%**	**72%**	**52%**	**0%**	**2%**	**82%**	**1%**
RWEC-OCS	Complex	7	71%	100%	14%	86%	0%	0%	100%	0%
	Soft bottom	12	100%	83%	67%	42%	0%	0%	100%	0%
	Total	**19**	**89%**	**89%**	**47%**	**58%**	**0%**	**0%**	**100%**	**0%**
RWEC-RI	Large-grained complex	1	0%	0%	100%	100%	0%	0%	100%	0%
	Complex	7	71%	43%	29%	86%	0%	0%	100%	0%
	Soft bottom	26	88%	85%	92%	54%	0%	0%	65%	0%
	Total	**34**	**82%**	**74%**	**79%**	**62%**	**0%**	**0%**	**74%**	**0%**

‡ Other epifauna covers a diverse array of species including amphipods, barnacles, crabs, corals, sponges, hydroids, tunicates, shrimps, and other organisms, (see Table 3.6 below).

¥ Possible *Botrylloides* sp. Observations.

Table 3.6. Percent of SPI/PV Stations with Habitat-forming Organisms by Habitat Zone and Benthic Habitat Type.

Habitat Zone	Benthic Habitat Type	Number of SPI/PV Stations	Barnacles	Bryo-zoans	Sea pens	Cerian-thus sp.	Other Anemones	Cory-morpha sp.	Other Hydroids	Mussels	Star Coral	Sponges
RWF 1	Large-grained complex	8	88%	0%	50%	0%	13%	0%	88%	0%	0%	63%
	Complex	10	70%	40%	60%	10%	10%	0%	80%	0%	0%	10%
	Soft bottom	11	18%	9%	18%	0%	0%	18%	27%	0%	0%	0%
	Total	**29**	**55%**	**17%**	**41%**	**3%**	**7%**	**7%**	**62%**	**0%**	**0%**	**21%**
RWF 2	Large-grained complex	19	89%	5%	68%	0%	11%	0%	63%	0%	21%	42%
	Complex	32	34%	3%	31%	3%	0%	3%	19%	0%	0%	0%
	Soft bottom	28	14%	4%	11%	0%	0%	21%	11%	0%	0%	0%
	Total	**79**	**41%**	**4%**	**33%**	**1%**	**3%**	**9%**	**27%**	**0%**	**5%**	**10%**
RWF 3a	Complex	7	14%	0%	14%	0%	0%	0%	0%	0%	0%	0%
	Soft bottom	4	0%	0%	0%	25%	0%	25%	0%	0%	0%	0%
	Total	**11**	**9%**	**0%**	**9%**	**9%**	**0%**	**9%**	**0%**	**0%**	**0%**	**0%**
RWF 3b	Large-grained complex	6	83%	0%	50%	0%	17%	0%	83%	0%	0%	17%
	Complex	9	78%	0%	33%	0%	0%	0%	56%	0%	0%	11%
	Soft bottom	1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Total	**16**	**75%**	**0%**	**38%**	**0%**	**6%**	**0%**	**63%**	**0%**	**0%**	**13%**
RWF 4	Large-grained complex	1	100%	100%	0%	0%	0%	0%	100%	0%	0%	0%
	Complex	9	33%	0%	33%	0%	0%	0%	44%	0%	0%	0%
	Soft bottom	87	1%	0%	2%	1%	0%	3%	7%	0%	0%	0%
	Total	**97**	**5%**	**1%**	**5%**	**1%**	**0%**	**3%**	**11%**	**0%**	**0%**	**0%**
RWEC-OCS	Complex	7	43%	0%	14%	0%	14%	0%	43%	0%	0%	14%
	Soft bottom	12	0%	0%	8%	0%	0%	8%	8%	0%	0%	0%
	Total	**19**	**16%**	**0%**	**11%**	**0%**	**5%**	**5%**	**21%**	**0%**	**0%**	**5%**
RWEC-RI	Large-grained complex	1	100%	0%	0%	0%	0%	0%	0%	0%	0%	100%
	Complex	7	29%	0%	0%	0%	0%	0%	71%	14%	0%	29%
	Soft bottom	26	8%	0%	0%	0%	0%	0%	4%	0%	0%	4%
	Total	**34**	**15%**	**0%**	**0%**	**0%**	**0%**	**0%**	**18%**	**3%**	**0%**	**12%**

3.5.1 Zone RWF 1

Zone RWF 1 encompasses approximately 7,641 acres in the center of the Lease Area (see Figure 3.3). Surveyed depths range from approximately 80 to 115 feet (24 to 35 meters) (see Figure 3.1). Approximately 6,267 acres (84 percent) in this zone are within the MWA and have been mapped by Inspire Environmental (2021) for the purpose of characterizing benthic habitat conditions. A total of 7 WTG foundations and approximately 12.4, 3.1, and 2.9 miles (20.0, 5.0, and 4.6 kilometers) of IAC, OSS-link, and RWEC, respectively, would be routed through Zone RWF 1. The mapped distribution of benthic habitats and approximate location of proposed project features within this zone are shown in Figure 3.5. The approximate extent of impacts from project construction and presence of structures and distribution by benthic habitat type are summarized in Table 3.7.

Table 3.7. Estimated Extent and Distribution of Habitat Impacts from Foundation and Cable Installation by Benthic Habitat Type within Habitat Zone RWF 1.

Project Component	Element	Total Acres	Proportion of Total Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft bottom Habitat
WTG foundations	Seabed preparation	50	0.7%	11.6%	49.5%	38.9%
	Foundations and scour protection†	4.9	0.07%	14.3%	50.2%	35.5%
IAC cable	Installation corridor‡	237	3.2%	19.3%	9.0%	71.7%
OSS-link	Installation corridor‡	46	0.6%	19.1%	53.1%	27.8%
RWEC (Circuit 2 pass through to OSS 2)	Installation corridor‡	49	0.7%	0.0%	44.1%	55.9%

† Benthic habitat impacts from foundation and scour protection would occur within and overlap the seabed preparation impact footprint.

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to an average of 75 feet (23 meters) where boulder clearance is required.

The MWA within Zone RWF 1 comprises approximately 43.5 percent large-grained complex habitat, 31 percent complex habitat, and 25.5 percent soft bottom habitat (Table 3.1). Medium and low-density boulder fields, scattered boulders, and bedform features (mega-ripples, ripples, and linear depressions) are prevalent (Table 3.3). As shown in Figure 3.5, contiguous large-grained complex and complex habitats comprise the majority of this zone, interspersed with a matrix of boulder fields, scattered boulders, and soft bottom habitats. Mobile bedforms are prevalent throughout this zone, with mega-ripples and/or ripples observed in over approximately 97 percent of mapped habitat (Table 3.3). These features were identified in 99 percent of mapped large-grained complex and complex habitats, respectively, and 91 percent of soft bottom habitats. Linear depressions were present on approximately 17 percent of the MWA, primarily in soft bottom habitat (67 percent of mapped soft bottom habitat) with limited distribution in complex habitats (present in 1 percent of mapped complex habitat). Collectively, these observations indicate that Zone RWF 1 comprises a diverse mixture of habitat types, including boulders intermingled with structurally complex sand and gravel substrates. Trawl marks were uncommon in Zone RWF 1 in comparison to the rest of the MWA, observed in 36 percent of mapped soft bottom habitat or 9 percent of total zone area (see Table 3.3).

Benthic habitat and sediment profile imagery were collected at 29 SPI/PV sites within Zone RWF 1, with 8, 10, and 11 sites distributed in areas mapped as large-grained complex, complex, and soft bottom habitat, respectively. This distribution of imagery provides a reasonable representation of biogenic and biotic features occurring in each of these habitat types within this zone. As summarized in Table 3.5, amphipod tubes, burrows, and tracks occur in all habitat types and were observed in SPI/PV imagery at 86, 100, and 72 percent of sites, respectively. Habitat-forming organisms such as barnacles, sea pens, hydroids, and sponges were prevalent in SPI/PV imagery. While these organisms were predominantly associated with large-grained complex and complex habitats they were also observed in areas classified as soft bottom habitat (see Table 3.5). Hard corals and mussels were not observed within this zone (see Tables 3.5 and 3.6). Non-native epifauna (possibly *Botrylloides* sp.) were observed in 50 and 30 percent of SPI/PV sites in large-grained complex and complex habitats, respectively (see Table 3.5).

Zone RWF 1 comprises primarily large-grained complex and complex habitat that provide suitable conditions for Atlantic cod spawning. Several studies of Atlantic cod spawning activity have been conducted within and in proximity to the Lease Area. The majority of observations in the Lease Area are concentrated within Zone RWF 1. Current understanding of cod spawning in the Lease Area and vicinity, including the mapped locations of observed spawning activity, is summarized in Section 4.1.

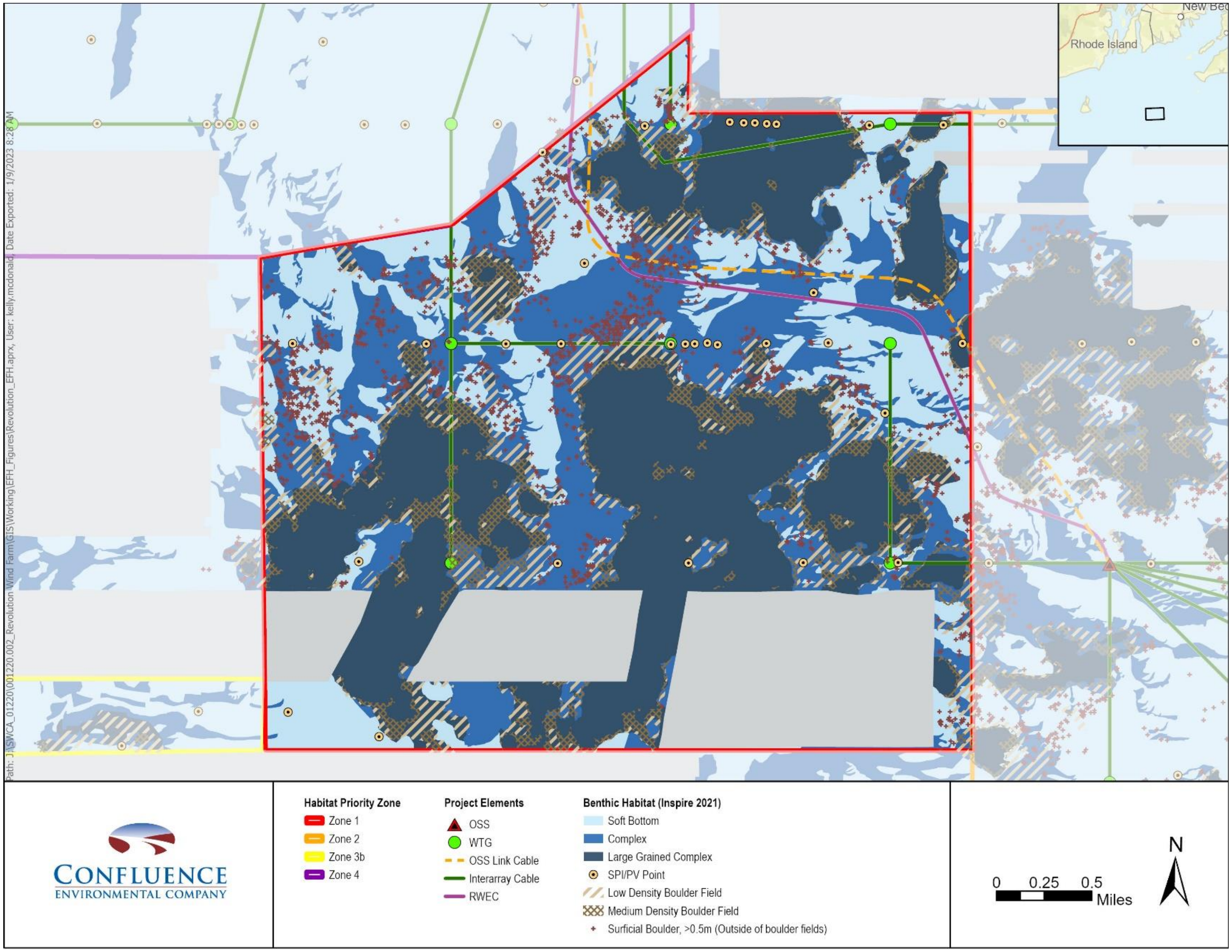

Figure 3.5. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats, Mapped Boulders and Boulder Fields, and Approximate Location of WTG Foundations and Cable Routes within Zone RWF 1.

3.5.2 Zone RWF 2

Zone RWF 2 encompasses approximately 33,684 acres and comprises the majority of the southern half of the Lease Area (see Figure 3.3). Surveyed depths range from approximately 82 to 115 feet (25 to 35 meters) (see Figure 3.1). Approximately 25,059 acres (74 percent) in this zone are within the MWA and have been mapped by Inspire Environmental (2021) for the purpose of characterizing benthic habitat conditions. A total of 39 WTG foundations, one OSS foundation, and an estimated 52.8, 1.3, and 1.6 miles (84.9, 2.1, and 1.0 kilometers) of IAC, OSS-link, and RWEC, respectively, are proposed in Zone RWF 2. The mapped distribution of benthic habitats and project features within this zone are shown in Figure 3.6. The approximate extent of impacts from project construction and presence of structures and distribution by benthic habitat type are summarized in Table 3.8.

Table 3.8. Estimated Extent and Distribution of Habitat Impacts from Foundation and Cable Installation by Benthic Habitat Type within Habitat Zone RWF 2.

Project Component	Element	Total Acres	Proportion of Total Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft bottom Habitat
WTG foundations	Seabed preparation	223	0.7%	7.8%	50.4%	41.8%
	Foundations and scour protection†	21.7	0.06%	6.2%	52.5%	41.3%
IAC cable	Installation corridor‡	695	2.1%	17.8%	34.9%	47.3%
OSS-link	Installation corridor‡	19	0.1%	34.2%	27.3%	38.5%
RWEC (Circuit 2 pass through to OSS 2)	Installation corridor‡	14	0.04%	0.0%	19.4%	80.6%

† Benthic habitat impacts from foundation and scour protection would occur within and overlap the seabed preparation impact footprint.

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to an average of 75 feet (23 meters) where boulder clearance is required.

The MWA within Zone RWF 2 comprises approximately 25.0 percent large-grained complex habitat, 40.7 percent complex habitat, and 34.3 percent is soft bottom (Table 3.1). Medium and low-density boulder fields, scattered boulders, and bedform features (mega-ripples, ripples, and linear depressions) are prevalent (Table 3.3). As shown in Figure 3.6, large-grained complex habitats are concentrated primarily in the center and northwestern corner of the zone, surrounded by a matrix of complex and soft bottom habitats interspersed with low-density boulder fields and scattered boulders. Medium-density boulder fields are less prevalent than in Zone RWF 1, and most are associated with large-grained complex habitat. In contrast, low-density boulder fields are extensive, occurring in approximately 11 percent of mapped habitat and 21 percent of complex habitats. Scattered surficial boulders are broadly distributed around the margins of these boulder fields. Swaths of complex and soft bottom habitat with relatively few boulders are present in the western portion and along the northern and southeastern edges of the zone (see Figure 3.6). Bedform features, are prevalent throughout this zone, with mega-ripples and/or ripples occurring on over approximately 98 percent of the MWA (Table 3.3). These features were identified in 99 percent of mapped large-grained complex and complex habitats, respectively, and 97 percent of soft bottom habitats. Linear depressions were present on approximately 19 percent of the MWA, primarily in soft bottom habitat (52 percent of mapped habitat type) with limited distribution in complex habitats (present in 2 percent of mapped complex habitat). Trawl marks were less prevalent than in Zone RWF 1, occurring on only 0.2 percent of mapped soft bottom habitats and not observed in other habitat types. Total mapped acreage and observed bedform acreage by benthic habitat type in Zone RWF 2 are summarized in Table 3.3.

Benthic habitat and sediment profile imagery were collected at 79 SPI/PV sites within Zone RWF 2, with 19, 32, and 28 sites distributed across areas mapped as large-grained complex, complex, and soft bottom habitat, respectively. This distribution of SPI/PV imagery provides a reasonable representation of biogenic and biotic features occurring in each of these habitat types within this zone. As summarized in Table 3.5, amphipod tubes, burrows, and tracks occur in all habitat types and were observed in SPI/PV imagery at 95, 96, and 53 percent of sites, respectively. Habitat-forming organisms such as barnacles, sea pens, hydroids, and sponges were prevalent in SPI/PV imagery. While these organisms were predominantly associated with large-grained complex and complex habitats, these species groups were also observed in areas classified as soft bottom habitat (see Table 3.6). Non-reef building hard corals and star corals were observed at 21 percent of SPI/PV sites in large-grained complex habitats within this zone (see Tables 3.5 and 3.6). Non-native epifauna were present but less commonly observed compared to Zone RWF 1. Non-native epifauna (possibly *Botrylloides* sp.) were observed in 47 and 6 percent of SPI/PV sites in large-grained complex and complex habitats, respectively (see Table 3.5).

There were relatively few observations of Atlantic cod spawning activity in Zone RWF 2 in comparison to Zone RWF 1. Current understanding of cod spawning in the Lease Area and vicinity, including the mapped locations of observed spawning activity, is summarized in Section 4.1.

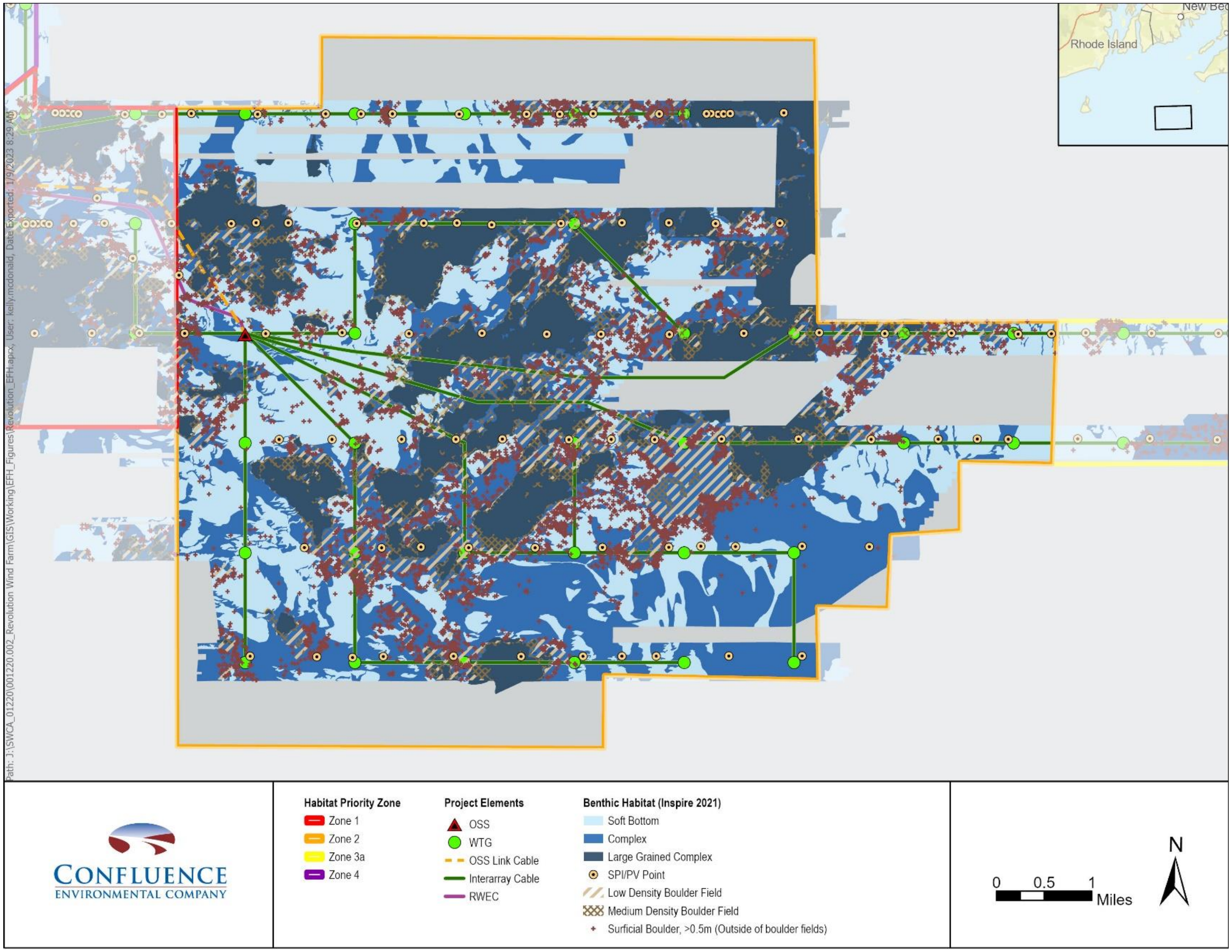

Figure 3.6. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats, Mapped Boulders and Boulder Fields, and Approximate Location of WTG Foundations and Cable Routes within Zone RWF 2.

3.5.3 Zone RWF 3a

Zone RWF 3a is located on the eastern-most portion of the Lease Area and encompasses approximately 3,334 acres (see Figure 3.3). Of this total, approximately 1,793 acres (53.8 percent) are within the MWA and have been mapped by Inspire Environmental (2021) for the purpose of characterizing benthic habitat conditions. Surveyed depths range from approximately 98 to 115 feet (30 to 35 meters) (see Figure 3.1). A total of 6 proposed WTG foundations and an estimated 6.0 miles (9.7 kilometers) of IAC would be placed within this zone. The mapped distribution of benthic habitats and project features within this zone are shown in Figure 3.7. The approximate extent of impacts from project construction and presence of structures and distribution by benthic habitat type are summarized in Table 3.9.

Table 3.9. Estimated Extent and Distribution of Habitat Impacts from Foundation and Cable Installation by Benthic Habitat Type within Habitat Zone RWF 3a.

Project Component	Element	Total Acres	Proportion of Total Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft bottom Habitat
WTG foundations	Seabed preparation	43	1.3%	6.4%	56.7%	36.9%
	Foundations and scour protection†	4.2	0.13%	10.5%	62.8%	26.7%
IAC cable	Installation corridor‡	76	2.3%	0.0%	45.6%	54.4%

† Benthic habitat impacts from foundation and scour protection would occur within and overlap the seabed preparation impact footprint.

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to an average of 75 feet (23 meters) where boulder clearance is required.

The MWA within Zone RWF 3a comprises approximately 1.1 percent large-grained complex habitat, 61.3 percent complex habitat, and 37.6 percent is soft bottom (Table 3.1). As shown in Figure 3.7, most of the mapped complex habitats are concentrated in a contiguous patch in the southeastern portion of the zone. This habitat feature is interspersed with patches of scattered boulders and low and medium-density boulder fields. The remainder of the southern portion of the zone is mostly soft bottom habitat with relatively few scattered boulders. The northern portion of the zone is a more diverse matrix of complex and soft bottom habitat and boulder fields. The only large-grained complex habitat and most of the medium-density boulder fields are concentrated in the northeastern corner of the zone, surrounded by a matrix of complex and soft bottom habitat and scattered boulders. Mobile bedforms are prevalent, with mega-ripples and/or ripples occurring over approximately 98 percent of the MWA. These features were identified in 100 percent of mapped large-grained complex habitat, and 99 percent of complex and soft bottom habitats, respectively. Linear depressions were present on approximately 7 percent of the MWA, primarily in soft bottom habitat (18 percent of mapped habitat type) with limited distribution in complex habitats (present in 1 percent of mapped complex habitat). Trawl marks were not observed on mapped habitats within this zone. Total mapped acreage and observed bedform acreage by benthic habitat type in Zone RWF 3a are summarized in Table 3.3.

Benthic habitat and sediment profile imagery were collected at 11 SPI/PV sites within Zone RWF 3a, 7 in complex habitat, 4 in soft bottom habitat, and none in large-grained complex habitat (Figure 3.7). While the number of SPI/PV sites within Zone RWF 3a is limited, they are distributed consistently with and are generally representative of overall habitat composition and therefore useful for characterizing the presence of biogenic and biotic features. Observed attached fauna density was low in comparison to zones RWF 1 and 2 (Table 3.4). However, biogenic features, i.e., amphipod tubes, burrows, and tracks, were observed in SPI/PV imagery at 91, 100, and 73 percent of sites, respectively (Table 3.5). In contrast with zones RWF 1 and RWF 2, barnacles, sea pens, hydroids, sponges and other habitat forming organisms were either absent or observed at only 1 SPI/PV in each habitat type (Table 3.6). Non-reef building hard corals and star corals were not observed in this zone (see Tables 3.5 and 3.6). Non-native epifauna were not observed (Table 3.5).

There have been no recorded observations of Atlantic cod spawning activity in Zone RWF 3a in surveys conducted to date. Current understanding of cod spawning in the Lease Area and vicinity, including the mapped locations of observed spawning activity, is summarized in Section 4.1.

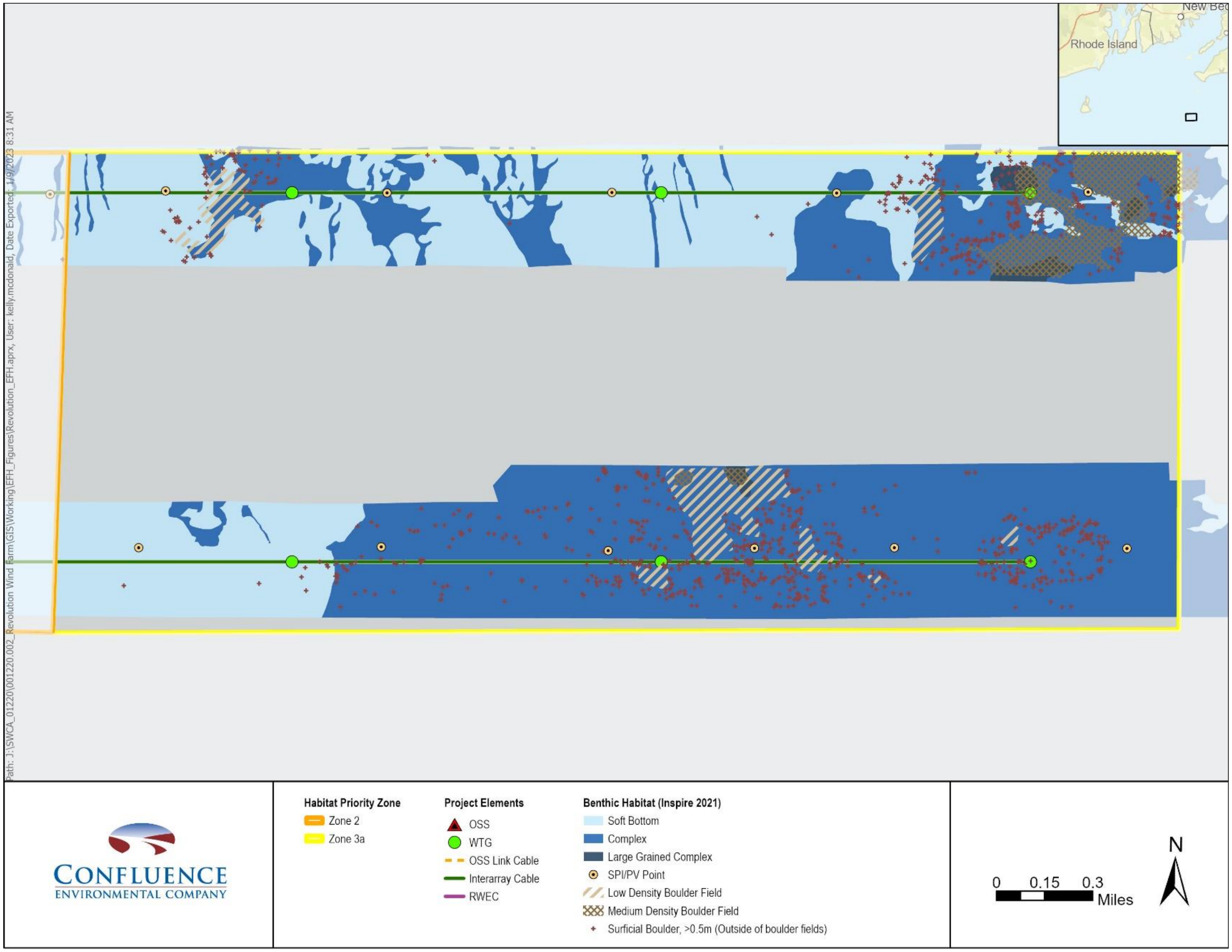

Figure 3.7. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats, Mapped Boulders and Boulder Fields, and Approximate Location of WTG Foundations and Cable Routes within Zone RWF 3a.

3.5.4 Zone RWF 3b

Zone RWF 3b is located on the western-most portion of the Lease Area and encompasses approximately 6,808 acres (see Figure 3.3). Of this total, approximately 3,194 acres (49.6 percent) are within the MWA and have been mapped by Inspire Environmental (2021) for the purpose of characterizing benthic habitat conditions. Surveyed depths range from approximately 82 to 98 feet (25 to 30 meters) (see Figure 3.1). The mapped distribution of benthic habitats and project features within Zone RWF-3b are shown in Figure 3.8. Revolution Wind has determined that geotechnical conditions within this zone are unsuitable, therefore no foundations or IAC cable would be installed within this zone, therefore no impacts to benthic habitat would occur (Table 3.10).

Table 3.10. Estimated Extent and Distribution of Habitat Impacts from Foundation and Cable Installation by Benthic Habitat Type within Habitat Zone RWF 3b.

Project Component	Element	Total Acres	Proportion of Total Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft bottom Habitat
WTG foundations	Seabed preparation	0	--	--	--	--
	Foundations and scour protection†	0	--	--	--	--
IAC cable	Installation corridor‡	0	--	--	--	--

† Benthic habitat impacts from foundation and scour protection would occur within and overlap the seabed preparation impact footprint.

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to an average of 75 feet (23 meters) where boulder clearance is required.

The MWA within Zone RWF 3b comprises approximately 45.1 percent large-grained complex habitat, 37.6 percent complex habitat, and 17.3 percent is soft bottom. As shown in Figure 3.8, a matrix of large-grained complex habitats and medium-density boulder fields is concentrated in the center of the zone, surrounded by a complex habitat interspersed with medium and low-density boulder fields and scattered batches of surficial boulders. Most of the soft bottom habitat is concentrated on the eastern portion of the zone, interspersed with patches of large-grained complex and complex habitats and boulder fields (Figure 3.8). As with zones RWF 1, RWF 2, and RWF 3a, mobile bedforms are prevalent, with mega-ripples and/or ripples occurring over approximately 98 percent of the MWA. These features were identified in 100 percent of mapped large-grained complex habitat, and 97 percent of complex and soft bottom habitats, respectively. Linear depressions were present on approximately 3 percent of the MWA, primarily in soft bottom habitat (7 percent of mapped habitat type) with limited distribution in complex habitats (present in 1 percent of mapped complex habitat). Trawl marks were observed in 7 and 3 percent of mapped soft bottom and complex habitats, respectively. Total mapped acreage and observed bedform acreage by benthic habitat type in Zone RWF 3b are summarized in Table 3.3.

Benthic habitat and sediment profile imagery were collected at 16 SPI/PV sites within Zone RWF 3b, 6 in large-grained complex, 9 in complex, and 1 in soft bottom habitat (Figure 3.8). The relative lack of sites in soft bottom habitat limits the ability to characterize the presence of biogenic and biotic features in this habitat type. As summarized in Table 3.5, amphipod tubes, burrows, and tracks occur in all habitat types and were observed in SPI/PV imagery at 100, 88, and 38 percent of sites, respectively. Barnacles, sea pens, and hydroids were prevalent or common in large-grained complex and complex habitats, but other habitat-forming organisms were relatively rare (see Table 3.6). Non-reef building hard corals and star corals were not observed in this zone (see Tables 3.5 and 3.6). Non-native epifauna were observed at 17 percent of SPI/PV locations in large-grained complex habitat (Table 3.5).

Some Atlantic cod spawning activity has been observed in Zone RWF 3b in surveys conducted to date, but the number and distribution of observations is small in comparison to the adjacent Zone RWF 1. Current understanding of cod spawning in the Lease Area and vicinity, including the mapped locations of observed spawning activity, is summarized in Section 4.1.

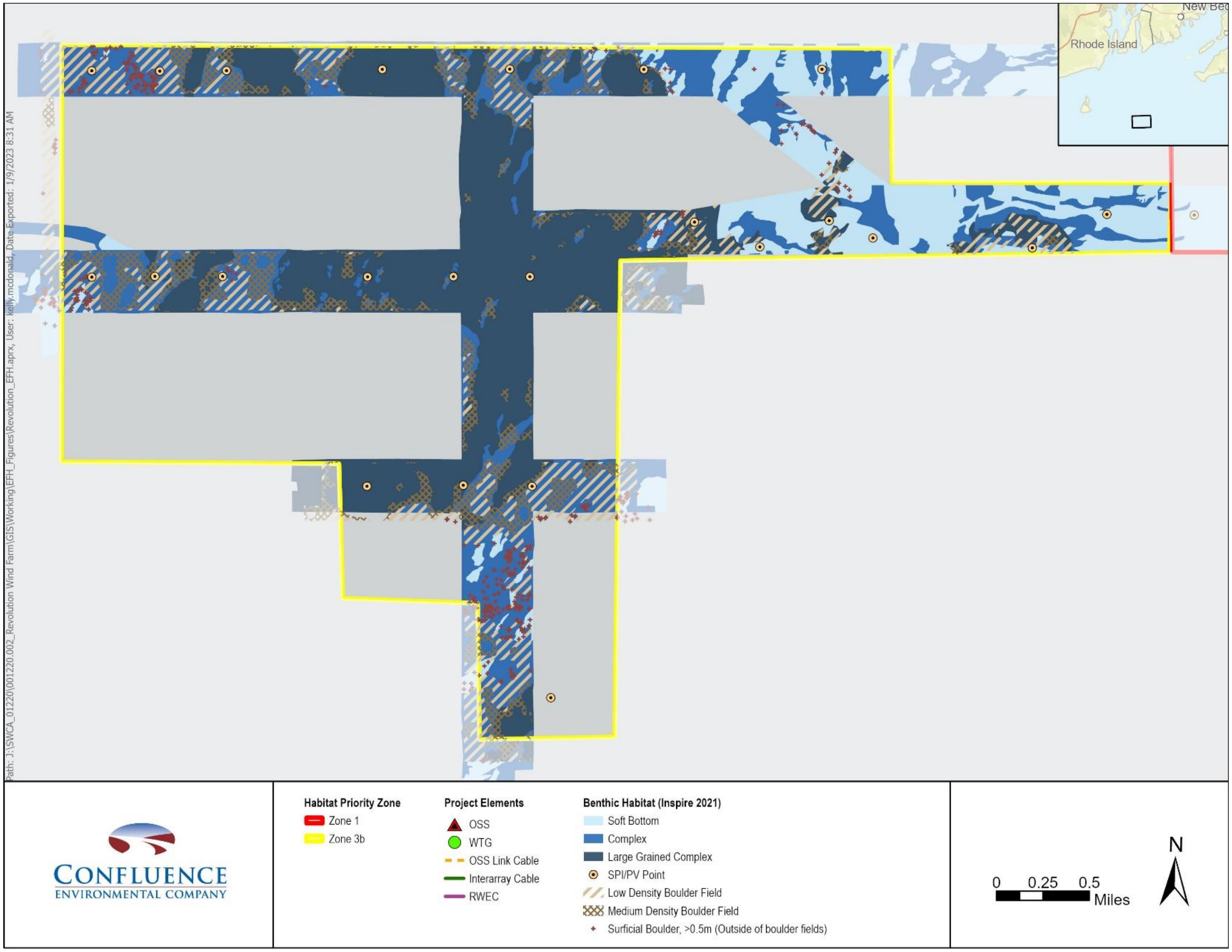

Figure 3.8. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats, Mapped Boulders and Boulder Fields, and Approximate Location of WTG Foundations and Cable Routes within Zone RWF 3b.

3.5.5 Zone RWF 4

Zone RWF 4 encompasses approximately 31,429 acres and comprises the majority of the northern half of the Lease Area (see Figure 3.3). Approximately 19,785 acres (63 percent) are within the MWA and have been mapped by Inspire Environmental (2021) for the purpose of characterizing benthic habitat conditions. Surveyed depths range from approximately 98 to 148 feet (30 to 45 meters) (see Figure 3.1). A total of 38 WTG foundations and one OSS foundation are proposed within this zone. An estimated 53.8, 3.7, and 11.1 miles (86.6, 6.0, and 17.9 kilometers) of IAC, OSS-link, and RWEC, respectively, would be routed through Zone RWF 4. The mapped distribution of benthic habitats and project features within this zone are shown in Figure 3.9. The approximate extent of impacts from project construction and presence of structures and distribution by benthic habitat type are summarized in Table 3.11.

Table 3.11. Estimated Extent and Distribution of Habitat Impacts from Foundation and Cable Installation by Benthic Habitat Type within Habitat Zone RWF 4.

Project Component	Element	Total Acres	Proportion of Total Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft bottom Habitat
WTG foundations	Seabed preparation	266	0.9%	2.0%	6.0%	92.0%
	Foundations and scour protection†	25.9	0.08%	2.7%	6.0%	91.3%
IAC cable	Installation corridor‡	681	2.2%	1.9%	11.3%	86.8%
OSS-link	Installation corridor‡	57	0.2%	0.0%	5.5%	94.5%
RWEC	Installation corridor‡	171	0.5%	0.1%	17.6%	82.3%

† Benthic habitat impacts from foundation and scour protection would occur within and overlap the gall impact footprint.

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to an average of 75 feet (23 meters) where boulder clearance is required.

The MWA within Zone RWF 4 comprises approximately 3.2 percent large-grained complex habitat, 10.7 percent complex habitat, and 86.1 percent is soft bottom (Table 3.1). As shown in Figure 3.9, complex habitats are concentrated in three distinct patches within this zone. The largest patch, located in the center of the zone, comprises a distinct block of large-grained complex surrounded by a matrix of complex habitat interspersed with medium and low-density boulder fields and scattered surficial boulders. This patch is largely surrounded by soft bottom habitat and a matrix of surficial boulders interspersed with complex habitat to the southeast. Smaller patches of large-grained complex habitat interspersed with boulders and boulder fields are present in the northern and southwestern edges of the MWA. Mobile bedforms are prevalent throughout Zone RWF 4 but are less extensive in comparison to the rest of the Lease Area. Mega-ripples and/or ripples were present over approximately 83 percent of mapped area, and in

77 percent of mapped large-grained complex habitat, 97 percent of complex habitat, and 81 percent of soft bottom habitat. Linear depressions were present on approximately 70 percent of the MWA, primarily in soft bottom habitat (81 percent of mapped soft bottom habitat) with limited distribution in complex habitats (present in 4 percent of mapped complex habitat). Trawl marks were commonly observed, occurring on 90 percent of mapped soft bottom, 18 percent of complex, and 1 percent of large-grained complex habitat. Total mapped acreage and observed bedform acreage by benthic habitat type in Zone RWF 4 are summarized in Table 3.3.

Benthic habitat and sediment profile imagery were collected at 97 SPI/PV sites within Zone RWF 4, with 1, 9, and 87 sites distributed across areas mapped as large-grained complex, complex, and soft bottom habitat, respectively. The relative lack of sites in large-grained complex habitat limits the ability to characterize the presence of biogenic and biotic features in this habitat type. As summarized in Table 3.5, amphipod tubes, burrows, and tracks occur in all habitat types and were observed in SPI/PV imagery at 96, 89, and 72 percent of sites, respectively. Habitat-forming organisms associated with hard substrates were more rarely observed in SPI/PV imagery, consistent with the predominant distribution of sites in soft bottom habitat (Table 3.6). Non-native epifauna were observed in 11 percent of SPI/PV imagery in complex habitats (Table 3.6).

Atlantic cod spawning activity was observed in Zone RWF 4 but there were relatively few observations in comparison to the adjacent Zone RWF 1. Current understanding of cod spawning in the Lease Area and vicinity, including the mapped locations of observed spawning activity, is summarized in Section 4.1.

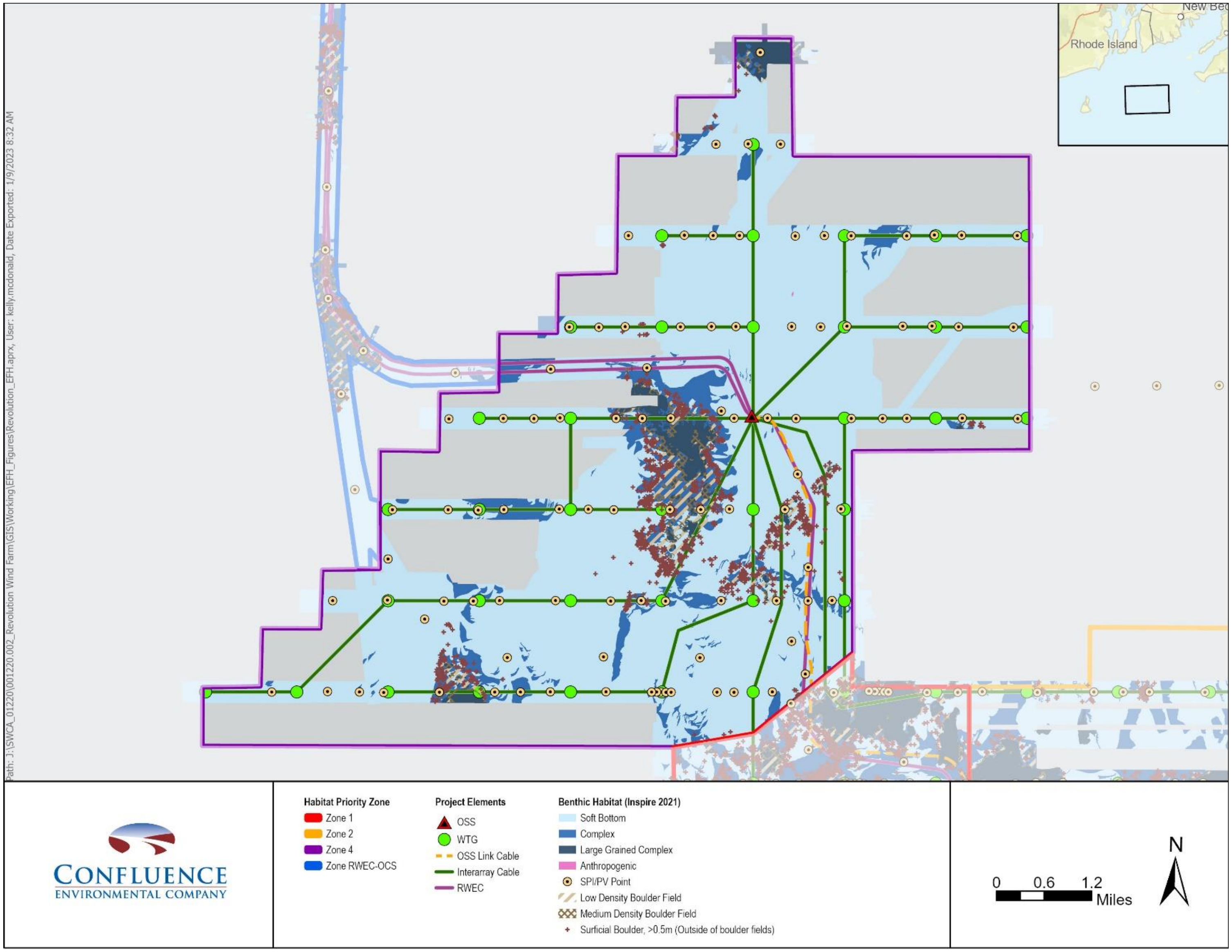

Figure 3.9. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats, Mapped Boulders and Boulder Fields, and Approximate Location of WTG Foundations and Cable Routes within Zone RWF 4.

3.5.6 Zone RWEC-OCS

Zone RWEC-OCS comprises the portion of the BOEM-approved RWEC installation corridor extending from the northwestern boundary of the Lease Area to Rhode Island state waters (see Figure 3.4). This zone encompasses approximately 4,460 acres, the entirety of which are in the MWA and have been mapped by Inspire Environmental (2021) for the purpose of characterizing benthic habitat conditions. Surveyed depths range from approximately 82 to 131 feet (25 to 40 meters) (see Figure 3.4). This portion of the RWEC comprises two parallel transmission cables, RWEC circuits 1 and 2, extending from the northwestern boundary of the Lease Area to the sea-to-shore transition site at Davisville-Quonset. The combined length of the two circuits within Zone RWEC-OCS is approximately 27.0 miles (43.4 km). The mapped distribution of benthic habitats and project features within this zone are shown in Figure 3.10. The approximate extent of impacts from project construction and distribution by benthic habitat type are summarized in Table 3.12.

Table 3.12. Estimated Extent and Distribution of Habitat Impacts from Foundation and Cable Installation by Benthic Habitat Type within Habitat Zone RWEC-OCS.

Project Component	Element	Total Acres	Proportion of Total Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft bottom Habitat
RWEC	Installation corridor‡	429	9.6%	1.1%	34.9%	64.0%

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to an average of 75 feet (23 meters) where boulder clearance is required.

The MWA within Zone RWEC-OCS comprises approximately 0.7 percent large-grained complex habitat, 32.0 percent complex habitat, and 67.3 percent soft bottom. As shown in Figure 3.10, complex and soft bottom habitats are interspersed throughout the zone, but the most complex habitat features appear to be concentrated in the southern portion of the cable corridor. The latter comprise two concentrated patches of complex habitat interspersed with low-density boulder fields and scattered surficial boulders. Boulder fields are virtually absent from the northern half of the zone. Medium density boulder fields associated with glacial moraine deposits are present between cable miles 28 to 35 within a broader matrix of soft bottom and complex habitat (Revolution Wind 2022a). Large boulder density is relatively high in this area compared to the remainder of the RWEC, IAC, and OSS-link installation corridors, necessitating the use of a boulder plow for seabed preparation. This section of the RWEC corridor is the only place where a boulder plow will be used for project construction.

Mobile bedforms are present within this zone but less prevalent in comparison to the Lease Area, with mega-ripples and/or ripples occurring over in approximately 60 percent of the zone. These features were identified in 2 percent of mapped large-grained complex habitat, and 61 percent of complex and soft bottom habitats, respectively. Linear depressions were present on approximately 25 percent of the MWA, primarily in soft bottom habitat (33 percent of mapped soft bottom habitat) with limited distribution in complex habitats (present in 9 percent of mapped complex habitat). Trawl marks were also present, occurring on 25 percent of mapped soft bottom and 2 percent of complex habitat. Total mapped acreage and observed bedform acreage by benthic habitat type in Zone RWEC-RI are summarized in Table 3.3. Two moderate density boulder field are present in the southern portion of this zone. These are the only parts of the project area where the boulder plow would be used for boulder relocation.

Benthic habitat and sediment profile imagery were collected at 19 SPI/PV sites within Zone RWEC-OCS, 7 in complex habitat, 12 in soft bottom habitat, and none in large-grained complex habitat. This distribution is consistent with and are generally representative of overall habitat composition in this zone, therefore these data useful for characterizing the presence of biogenic and biotic features. As summarized in Table 3.5, amphipod tubes, burrows, and tracks occur in all habitat types and were observed in SPI/PV imagery at 89, 89, and 47 percent of sites, respectively. Habitat-forming organisms associated with hard substrates were observed in SPI/PV imagery at 14 to 43 percent of SPI/PV sites in complex habitat, and at 8 percent (1 of 12 sites) of sites in soft bottom habitat (see Table 3.6), consistent with the presence of surficial boulders and shell and barnacle hash.

Atlantic cod spawning activity has been observed in Zone RWEC-OCS but only within a portion of the zone outside of the cable route where no construction activities are proposed. Current understanding of cod spawning in the Lease Area and vicinity, including the mapped locations of observed spawning activity, is summarized in Section 4.1.

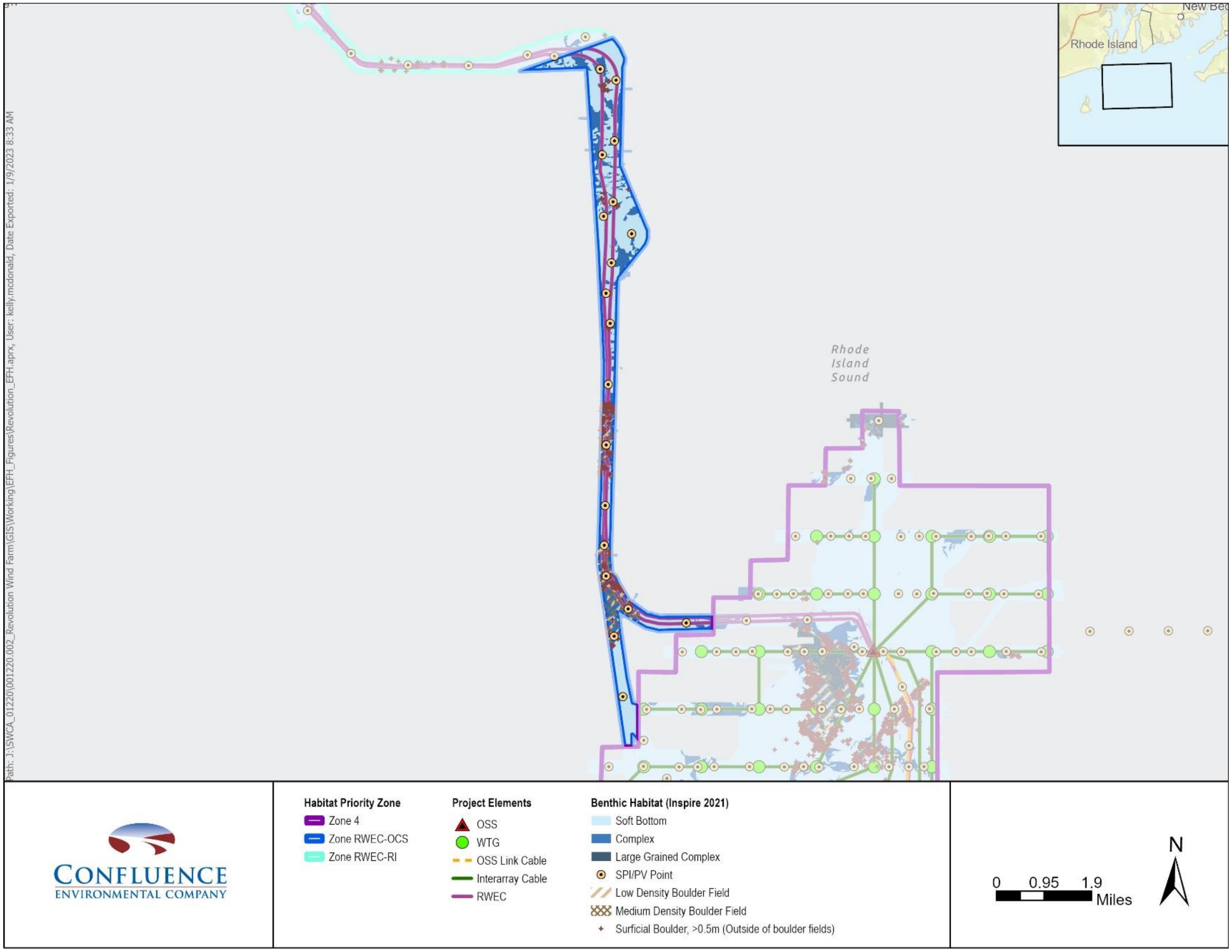

Figure 3.10. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats, Mapped Boulders and Boulder Fields, and Approximate Location of WTG Foundations and Cable Routes within Zone RWEC-OCS.

3.5.7 Zone RWEC-RI

Zone RWEC-RI comprises the portion of the BOEM-approved RWEC installation corridor extending from the northwest boundary of Zone RWEC-OCS to the sea-to-shore transition site at Davisville-Quonset, Rhode Island (see Figure 3.4). This zone encompasses approximately 5,627 acres, the entirety of which are in the MWA and have been mapped by Inspire Environmental (2021) for the purpose of characterizing benthic habitat conditions. The combined length of the two RWEC circuits within Zone RWEC-RI is approximately 43.6 miles (70.1 km). Surveyed depths range from approximately 3 feet (1 meter) at the shoreward edge of the sea-to-shore transition site to 98 feet (30 meters) in the offshore portion of the zone (see Figure 3.4). The mapped distribution of benthic habitats and project features within this zone are shown in Figure 3.11. The approximate extent of impacts from project construction and distribution by benthic habitat type are summarized in Table 3.13.

Table 3.13. Estimated Extent and Distribution of Habitat Impacts from Foundation and Cable Installation by Benthic Habitat Type within Habitat Zone RWEC-RI.

Project Component	Element	Total Acres	Proportion of Total Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft bottom Habitat
RWEC	Installation corridor‡	691	11.8%	0.0%	14.8%	85.2%

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to an average of 75 feet (23 meters) where boulder clearance is required. Approximately 1 acre of impacts would occur in habitats mapped as anthropogenic material (bridge demolition debris).

The MWA within Zone RWEC-OCS comprises approximately 3.1 percent large-grained complex habitat, 14.4 percent complex habitat, and 82.1 percent soft bottom. Anthropogenic substrates (from historical bridge demolition) comprise the remaining 0.4 percent of surveyed habitats. As shown in Figure 3.11, large-grained complex habitat is concentrated in two patches. One patch is located on the south-central edge of the lease area in a matrix of low-density boulder field and scattered surficial boulders. The other patch is located on the eastern edge of the zone immediately to the north of the Jamestown Verrazzano Bridge and surrounded by a matrix of complex habitat, low-density boulder field, and scattered surficial boulders. A large patch of complex habitat is present to the south of the bridge, associated with a bathymetric feature known as Slocumb Ledge (Figure 3.11).

Mobile bedforms are present within Zone RWEC-RI but less prevalent than in the RWEC-OCS and the Lease Area. Mega-ripples and/or ripples were identified in approximately 38 percent of the MWA, comprising 2 percent of mapped area in large-grained complex habitat, 19 percent of area in complex habitat, and 42 percent of soft bottom habitats. Linear depressions were present on approximately 15 percent of the MWA, primarily in soft bottom habitat (18 percent of mapped soft bottom habitat) with limited distribution in complex habitats (present in 2percent of mapped complex habitat). Shell hash was commonly observed, occurring in 86 and 54 percent of complex and soft bottom habitats, respectively. Trawl marks were prevalent, occurring in 44 percent of mapped habitats, including 41 percent of soft bottom and 77 percent of complex habitat. Total mapped acreage and observed bedform acreage by benthic habitat type in Zone RWEC-RI are summarized in Table 3.3.

Benthic habitat and sediment profile imagery were collected at 34 SPI/PV sites within Zone RWEC-RI, 1 in large-grained complex habitat, 7 in complex habitat, and 26 in soft bottom habitat. This distribution is consistent with and are generally representative of overall habitat composition in this zone, therefore these data are useful for characterizing the presence of biogenic and biotic features. As summarized in Table 3.5, amphipod tubes, burrows, and tracks occur in all habitat types and were observed in SPI/PV imagery at 82, 74, and 79 percent of sites, respectively. Habitat-forming organisms associated with hard substrates were less commonly observed compared to other zones, consistent with the prevalence of soft bottom habitats (see Table 3.6). Inspire Environmental (2021) conducted a towed video survey along 52 transect lines near the RWEC-RI landfall at Quonset Point. This survey focused on nearshore regions around the landfall where there was a higher probability of submerged aquatic vegetation (SAV) presence. Survey planning and analysis followed protocols as outlined in federal agency protocols (Colarusso and Verkade 2016) and in the RI Coastal Resources Management Council’s regulations in the Coastal Resources Management Program, or “Red Book”, (650-RICR-20-00-1 et seq.). Video transect data were analyzed to identify the presence or absence of SAV in each video file. Eelgrass (*Zostera marina*) beds were documented on portions of the nearshore margin of the landfall zone, outside of the seabed disturbance footprint for the sea-to-shore construction site. Eelgrass mapping methods are described in the Benthic Habitat Mapping report, provided as Appendix A of this EFH Assessment.

Portions of Zone RWEC-RI are in proximity to shellfish aquaculture lease areas authorized by the RI Department of Environmental Management (RIDEM). These lease areas are displayed in Figure 3.12. No equivalent information is available for naturally occurring shellfish beds, as RIDEM does not map or maintain geographic information on these resources.

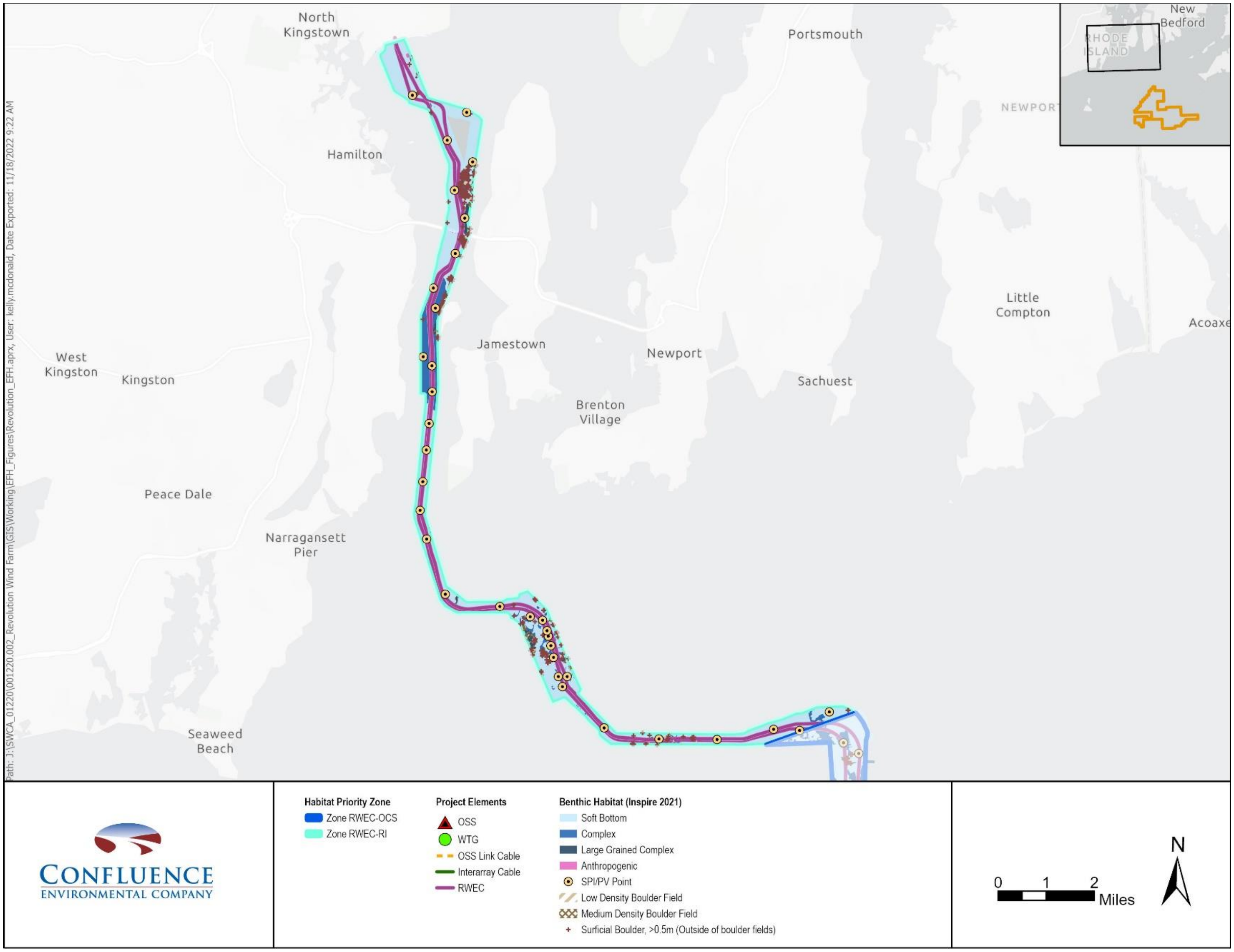

Figure 3.11. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats and Approximate Location of WTG Foundations and Cable Routes within Zone RWEC-RI.

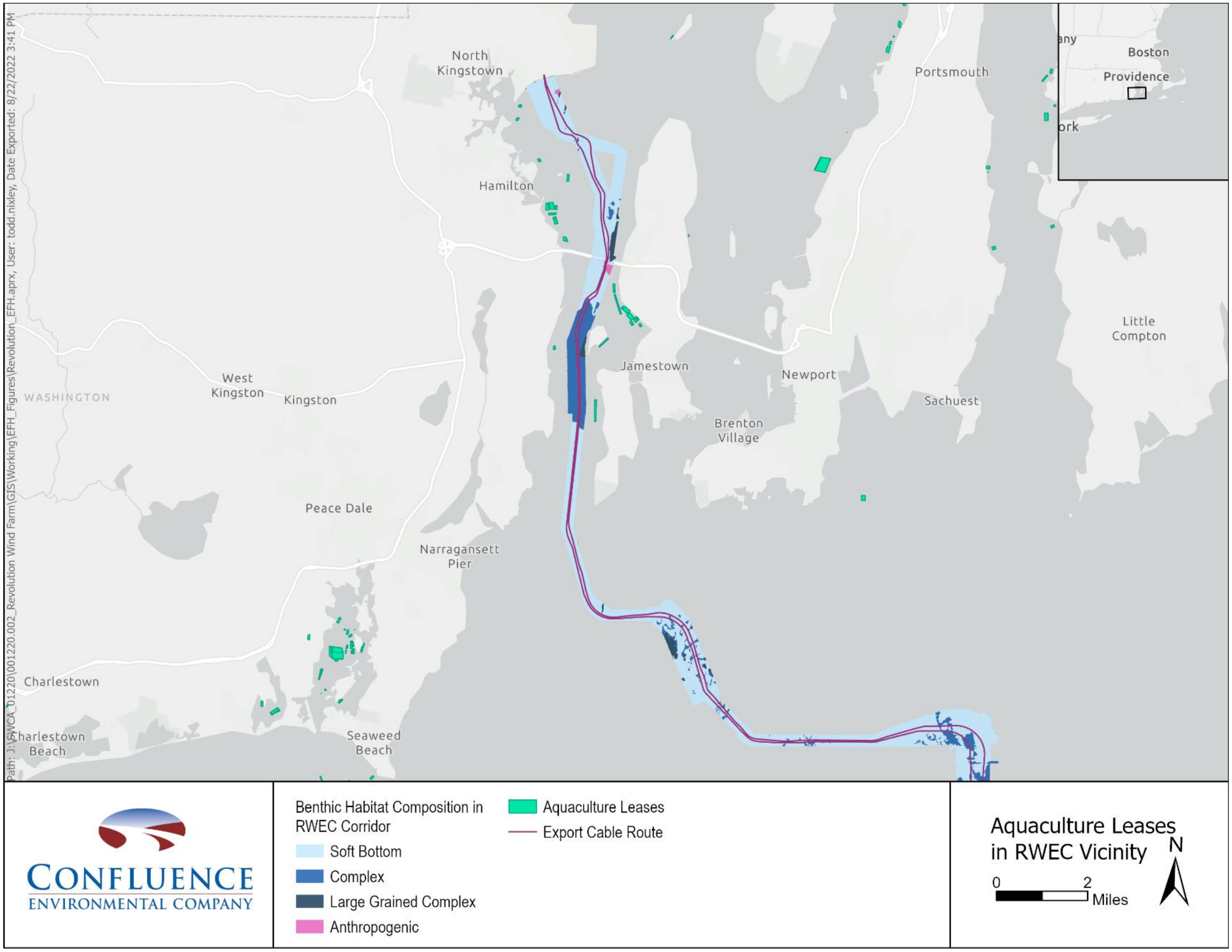

Figure 3.12. Location of Aquaculture Lease Areas in Proximity to Zone RWEC-RI.

4.0 Designated EFH

The project area and vicinity encompass portions of designated EFH for 40 different fish and invertebrate species, with the distribution of designated habitats varying by species and life stage. EFH species presence, occurrence by life stage and primary habitat association, and the likelihood, extent and duration of exposure to project-related impacts are characterized in Table 4.1. The EFH resources described herein are managed under several federal fishery management plans (FMPs), including the Sea Scallop FMP (NEFMC 2017a), Monkfish FMP (NEFMC 1998), Northeast Multispecies (large- and small-mesh) FMP (NEFMC and MAFMC 1985), Skate FMP, and Red Crab FMP (NEFMC 2017); Surfclam/Ocean Quahog FMP, Mackerel/Squid/Butterfish FMP, Spiny Dogfish FMP, Bluefish FMP, and River Herring FMP (MAFMC 2019); Highly Migratory Species FMP (NMFS 2006); and Lobster FMP, Jonah Crab FMP, Atlantic Herring FMP, and Summer Flounder/Scup/Black Sea Bass FMP (ASMFC 2022).

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Table 4.1. EFH Occurrence in the Project Area for Designated Fish and Invertebrate Species and Life Stages by Project Component.

Complex	Species Name	Life Stage	Habitat Association	Primary Prey Association	Timing of Occurrence												Exposure to Project Effects by Impact Category																							
																	Construction Noise & UXO			Crushing, Burial, Entrainment			TSS/ Sediment			Habitat Conversion			Operation Noise			EMF & Heat			Hydro-dynamic			Food Web		
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration
Gaddids	Atlantic cod	Eggs	S	B/E/D	▒	▓	▓	▓	▒					▒	▒	▒	█	█	░										░	░	▓				░	░	▓	░	░	▓
		Larvae	P	B/E/D			▒	▒	▒	▒							█	█	░				▓	█	░	▒	░	▓	░	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Juvenile	BC	Plank	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	█	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Adult	BC	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Spawning	BC/BS	Plank	▒	▓	▓	▓	▒						▒	▒	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
	Haddock	Eggs	S	B/E/D			▒	▓	▒								█	█	░										░	░	▓				░	░	▓	░	░	▓
		Larvae	S	B/E/D	▒	▒	▒	▓	▓	▒	▒						█	█	░										░	░	▓				░	░	▓	░	░	▓
		Juvenile	BC	Plank	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	█	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Adult	BC	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Spawning	BC	B/E/D	▒	▓	▓	▓	▒	▒							█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
	Pollock	Juvenile	BC/ BS	Plank	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	█	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Adult	BC	Pel	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Spawning	BC	B/E/D	▓	▓	▒	▒					▒	▒	▓	▓	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
	Red hake	Eggs	S	B/E/D					▒	▓	▓	▒	▒	▒	▒		█	█	░										░	░	▓				░	░	▓	░	░	▓
		Larvae	S	B/E/D					▒	▒	▒	▒	▓	▓	▒	▒	█	█	░										░	░	▓				░	░	▓	░	░	▓
		Juvenile	BS	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	█	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Adult	BS	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Spawning	BS	B/E/D					▒	▒	▓	▓	▒				█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
	Silver hake	Eggs	S	-	▒	▒	▒	▒	▒	▓	▓	▓	▓	▓	▒	▒	█	█	░										░	░	▓				░	░	▓	░	░	▓
		Larvae	S	Plank	▒	▒	▒	▒	▒	▒	▓	▓	▓	▒	▒	▒	█	█	░										░	░	▓				░	░	▓	░	░	▓
		Juvenile	BC/BS	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	█	░	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Adult	BC/BS	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	▒	░	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Spawning	BC/BS	-					▓	▓	▓	▓	▒	▒			█	█	░	▒	░	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
	White hake	Larvae	S	Plank					▒								█	█	░										░	░	▓				░	░	▓	░	░	▓
		Juvenile	P/BS	B/E/D					▒	▒	▒	▒	▒				█	█	░	█	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Adult	BS	-	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Spawning	BS	-				▒	▒								█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
Other finfish	Monkfish	Eggs	S	-			▒	▒	▒	▒	▒	▒	▒				█	█	░										░	░	▓				░	░	▓	░	░	▓
		Larvae	P	Plank			▒	▒	▒	▒	▒	▒	▒				█	█	░				▓	█	░	▒	░	▓	░	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Juvenile	BC	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	█	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Adult	BC	B/E/D	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Spawning	BC	B/E/D			▒	▒	▓	▓	▒	▒	▒				█	█	░	▒	▓	░	▒	█	░	▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓
	Bluefish	Eggs	P	-				▒	▒	▒	▒	▒					█	█	░							▒	░	▓	░	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Larvae	P	Plank				▒	▒	▒	▒	▒	▒				█	█	░							▒	░	▓	░	░	▓	▒	░	▓	░	░	▓	░	░	▓
		Juvenile	P	Pel					▒	▒	▒	▒	▒	▒			█	█	░							▒	░	▓	▒	░	▓	▒	░	▓	░	░	▓	░	░	▓

Complex	Species Name	Life Stage	Habitat Association	Primary Prey Association	Timing of Occurrence												Exposure to Project Effects by Impact Category																							
																	Construction Noise & UXO			Crushing, Burial, Entrainment			TSS/ Sediment			Habitat Conversion			Operation Noise			EMF & Heat			Hydro-dynamic			Food Web		
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration
		Adult	P	Pel																																				
	Black sea bass	Eggs	S	-																																				
		Larvae	BC	-																																				
		Juvenile	BC	B/E/D																																				
		Adult	BC	B/E/D																																				
	Butterfish	Eggs	P	-																																				
		Larvae	P	Plank																																				
		Juvenile	P/BS	Pel																																				
		Adult	P/BS	Pel																																				
	Scup	Eggs	P	-																																				
		Larvae	P	Plank																																				
		Juvenile	BS/BC	B/E/D																																				
		Adult	BS/BC	B/E/D																																				
	Ocean pout	Eggs	BC	-																																				
		Larvae	BC	B/E/D																																				
		Juvenile	BS	B/E/D																																				
		Adult	BS	B/E/D																																				
		Spawning	BC	-																																				
	Atlantic herring	Eggs	BC	-																																				
		Larvae	P	Plank																																				
		Juvenile	P	Plank																																				
		Adult	P	Plank																																				
		Spawning	BC	Plank																																				
Flatfish	Windowpane flounder	Eggs	S	-																																				
		Larvae	P	Plank																																				
		Juvenile	BS	B/E/D																																				
		Adult	BS	B/E/D																																				
		Spawning	BS	B/E/D																																				
	Winter flounder	Eggs	BS	-																																				
		Larvae	P/BS	Plank																																				
		Juvenile	BS	B/E/D																																				
		Adult	BS	B/E/D																																				
		Spawning	BS	B/EB/E/D																																				
	Witch Flounder	Eggs	S	-																																				
		Larvae	S	Plank																																				

Complex	Species Name	Life Stage	Habitat Association	Primary Prey Association	Timing of Occurrence												Exposure to Project Effects by Impact Category																							
																	Construction Noise & UXO			Crushing, Burial, Entrainment			TSS/ Sediment			Habitat Conversion			Operation Noise			EMF & Heat			Hydro-dynamic			Food Web		
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration
	Witch Flounder	Juvenile	BS	B/E/D																																				
		Adult	BS	B/E/D																																				
		Spawning	BS	B/E/D																																				
	Yellowtail flounder	Eggs	S	-																																				
		Larvae	S	Plank																																				
		Juvenile	BS	B/E/D																																				
		Adult	BS	B/E/D																																				
		Spawning	BS	B/E/D																																				
	Summer flounder	Eggs	P	-																																				
		Larvae	P	Plank																																				
		Juvenile	BS/ BC	Pel																																				
		Adult	BS/BC	Pel																																				
Highly Migratory Species	Atlantic mackerel	Eggs	P	-																																				
		Larvae	P	Plank																																				
		Juvenile	P	Pel																																				
		Adult	P	Pel																																				
		Spawning	P	Pel																																				
	Albacore Tuna	Juvenile	P	Pel																																				
		Adult	P	Pel																																				
	Atlantic Bluefin	Juvenile	P	Pel																																				
		Adult	P	Pel																																				
	Atlantic Skipjack	Juvenile	P	Pel																																				
		Adult	P	Pel																																				
	Atlantic Yellowfin	Juvenile	P	Pel																																				
		Adult	P	Pel																																				
Sharks	Sand tiger shark	Neonate/YOY	BC/BS	B/E/D																																				
		Juvenile	BC/BS	B/E/D																																				
	Sandbar shark	Neonate/YOY	BS	B/E/D																																				
		Juvenile	BS	B/E/D																																				
		Adult	BS	B/E/D																																				
	Smooth dogfish	Neonate	P	Pel																																				
		Juvenile	P	Pel																																				
		Adult	P	Pel																																				
	Spiny dogfish	Sub-Adult (f)	P	Pel																																				

Complex	Species Name	Life Stage	Habitat Association	Primary Prey Association	Timing of Occurrence												Exposure to Project Effects by Impact Category																							
																	Construction Noise & UXO			Crushing, Burial, Entrainment			TSS/ Sediment			Habitat Conversion			Operation Noise			EMF & Heat			Hydro-dynamic			Food Web		
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration	Exposure	Extent	Duration
		Sub-Adult (m)	P	Pel																																				
	Spiny dogfish	Adult (f)	P	Pel																																				
		Adult (m)	P	Pel																																				
Skates	Barndoor skate	Juvenile	BS/ BC	B/E/D																																				
		Adult	BS/ BC	B/E/D																																				
	Little Skate	Juvenile	BS/BC	B/E/D																																				
		Adult	BS/ BC	B/E/D																																				
	Winter skate	Juvenile	BS/ BC	B/E/D																																				
		Adult	BS/ BC	B/E/D																																				
Invertebrates	Atlantic sea scallop	Eggs	BC	Plank																																				
		Larvae	P/BC	Plank																																				
		Juvenile	BC	Plank																																				
		Adult	BC	-																																				
		Spawning	BC	Pel																																				
	Atlantic surfclam	Juvenile	BS	Pel																																				
		Adult	BS	Plank																																				
	Ocean quahog	Juvenile	BS	Plank																																				
		Adult	BS	-																																				
	Shortfin squid	Juvenile	P	Plank																																				
		Adult	P	Pel																																				
	Longfin squid	Eggs	BC	-																																				
		Juvenile	P	Pel																																				
		Adult	P	Pel																																				

KEY

Timing of Occurrence in Analysis Area
- Peak occurrence
- General occurrence
- Typically not present

Exposure
- Lethal
- Injury
- Behavioral
- Insignificant

Extent
- Large
- Moderate
- Small

Duration
- Long-term
- Short-term
- Permanent

Abbreviations: EMF = electromagnetic field; TSS = total suspended sediment; UXO = unexploded ordnance; YOY = young of year
Habitat Associations: BC = Benthic Complex; BS = Benthic Soft-bottom; P = Pelagic; S = Surface
Prey Associations (see Section 4.2.6): B/E/D = Benthic/Epibenthic/Demersal, Pel = Pelagic, Plank = Planktonic

4.1 Vulnerable Species and Life Stages

Many EFH species are highly mobile and pelagically oriented and therefore less susceptible to adverse effects from project construction and operation because they can leave a given area to avoid exposure to project impacts. However, certain EFH species and life stages of some species are more likely to be exposed to certain Project-related impacts because they are either immobile, slow moving, or planktonic. These include:

- Planktonic eggs and larvae of multiple fish and invertebrate species.
- Sessile or slow-moving benthic/epibenthic invertebrates (juvenile and adult bivalves, squid eggmops).
- Winter flounder eggs (adhesive and demersal in mud, sand, gravel, and SAV) and larvae are found in Mid-Atlantic estuaries in late winter through spring.

In addition to the above, the spawning Atlantic cod life stage is considered sensitive and vulnerable for the purpose of this EFH assessment. While juvenile and adult Atlantic cod are highly mobile, this species has demonstrated high fidelity to specific spawning sites in some studies, meaning they may return to the same location year after year (Dean et al. 2022). Atlantic cod exhibit courtship and spawning behavior, including vocalizations, primarily at night (Dean et al. 2014, Zemeckis et al. 2019), with peak spawning communication occurring approximately 4 – 6 hours after sunset (Zemeckis et al. 2019).

Southern New England, including Cox Ledge, is known to support cod spawning aggregations (Clucas et al. 2019) during the winter months, but the status of cod populations and spatiotemporal distribution of spawning in this region is not as well understood as other regions in the northwestern Atlantic (e.g., Gulf of Maine and Georges Bank). The infrequency of cod observed in fishery-independent trawl surveys contributes to the poor understanding of stocks in this region (Langan et al. 2020). However, there is information indicating that, unlike other spawning stocks, cod in southern New England have increased in abundance during the last 20 years (Langan et al. 2020) and cod in this region have shown a tendency to be distributed over larger areas (Loehrke 2014). Existing (DeCelles et al. 2017; Inspire Environmental 2018, 2019) and emerging (BOEM pers. comm. 2022) data also indicate that cod spawning occurs throughout the Southern New England region.

BOEM and other researchers have been conducting monitoring surveys in Southern New England, including within and around the Lease Area, to document cod spawning activity using acoustic telemetry, grunts detected using PAM at fixed stations and on gliders, and hook and line sampling to assess reproductive condition of adults. Recent unpublished results, including acoustic telemetry detections, spawning cod detections using PAM, and hook and line sampling and supporting information sources, are presented in Figure 4.1. Grunt detections recorded within the RWF zone 1 suggests that spawning is concentrated in November and December

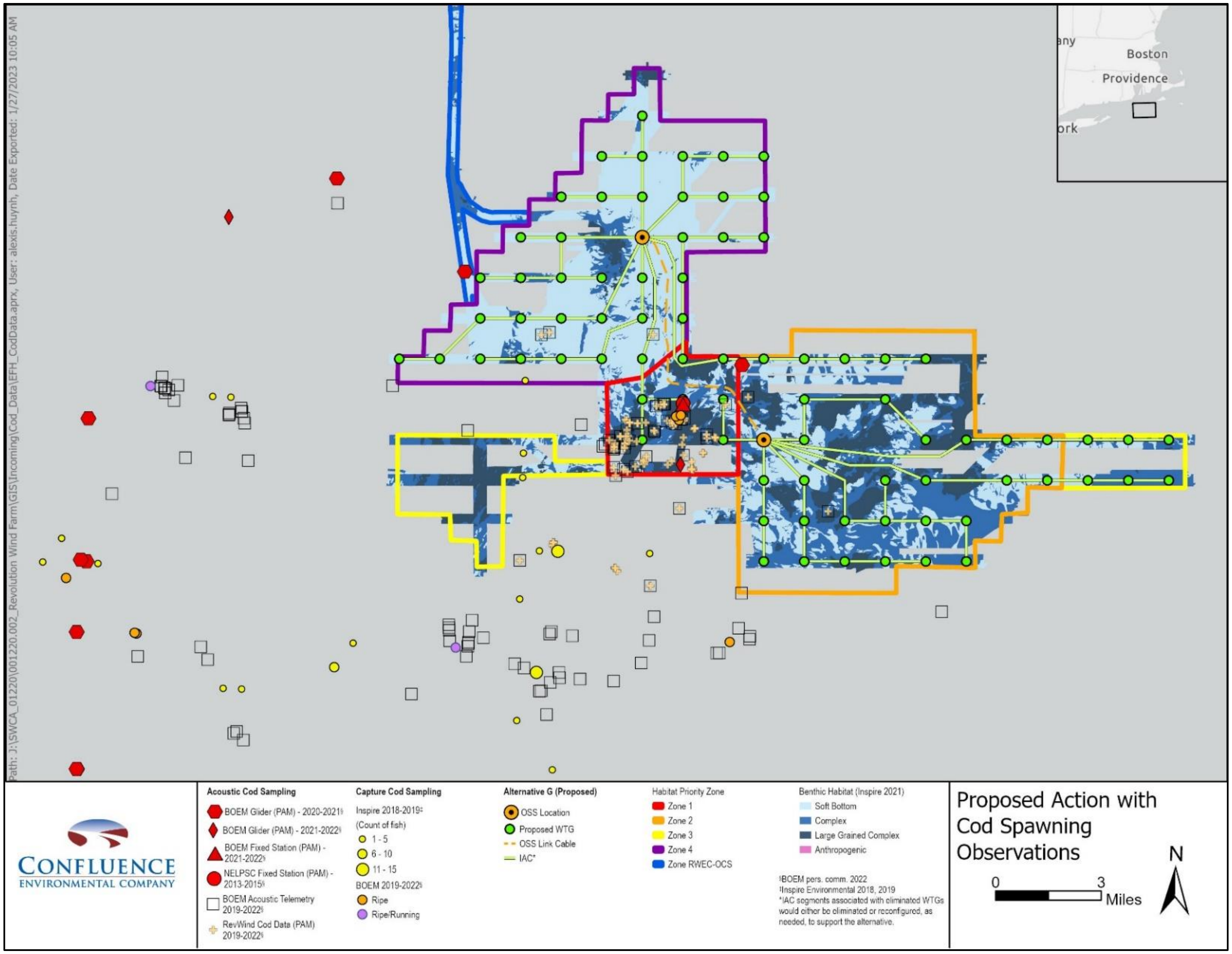

Figure 4.1. Spawning Atlantic Cod Detections Within the Lease Area and Vicinity Detected Using Fixed and Glider-Based PAM (BOEM pers. comm. 2022; Inspire Environmental 2018, 2019).

(BOEM pers. comm. 2022), and preliminary acoustic telemetry data within the Lease Area indicate that cod may exhibit site fidelity to this site over 3 consecutive years of monitoring (BOEM pers. comm. 2022).

Atlantic cod continue to be managed in U.S. waters as two units; the Gulf of Maine and the Georges Bank management units. An Atlantic Cod Stock Structure Working Group (ACSSWG) formed in 2018 recently carried out a multidisciplinary evaluation of cod structure in US waters and identified a number of mismatches between the current management units and biological stock structure. Using evidence from an evaluation of early life history characteristics, an examination of genetic analyses, fishermen's ecological knowledge, and tagging studies, the ACSSWG concluded that cod in southern New England represent a unique biological stock, with demographics that are largely independent of neighboring populations (McBride and Smedbol 2022). In general, tagging studies have indicated that spawning groups in southern New England are largely sedentary (Loehrke 2014) and exhibit a high degree of residency; although, some tagging efforts have indicated extensive movements of cod from the Great South Channel to the western Gulf of Maine, with some movement into southern New England (Wise 1963; O'Brien and Worcester 2009; Tallack 2009; 2011; Loehrke 2014; Lui 2019; McBride and Smedbol 2022). A subsequent Working Group convened by the New England Fisheries Management Council is currently reviewing the available data and evaluating whether cod in southern New England should be managed as a discrete stock. A decision to recognize cod in southern New England (and other regions in the Northeast) as a unique biological stock will have downstream fisheries management implications, including the development of new stock/population assessments, that would allow managers to better understand and work towards rebuilding Atlantic cod populations.

4.2 Habitat Areas of Particular Concern

Habitat Areas of Potential Concern (HAPC) are a subset of EFH designated habitats that are particularly important to certain species during one or more life stages. Three HAPCs are present in the project area. These include a new recently approved HAPC designation for Atlantic cod and other demersal fish species that encompasses the RI/MA WEA. HAPCs within and in proximity to the project area are described below.

4.2.1 Juvenile Atlantic Cod HAPC

HAPC for juvenile Atlantic cod is defined as intertidal and benthic structurally complex habitats to a maximum depth of 396 feet (120 m), including eelgrass, mixed sand and gravel, and rocky habitats (NEFMC 2017b). Juvenile inshore cod HAPC has been delineated in the broader RWEC-RI corridor as shown in Figure 4.2. The HAPC in question comprises: 1) patches of complex benthic habitat along the peripheral edge of the RWEC corridor, and 2) eelgrass beds in the nearshore zone adjacent to the sea-to-shore construction site. All mapped HAPC lies outside of the direct seabed disturbance footprint for cable installation and sea-to-shore transition construction but could be exposed to elevated TSS and suspended sediment deposition effects caused by these activities. Revolution Wind has included pre-construction surveys and mapping of sensitive habitat along the cable route to avoid impacts to sensitive habitat, including juvenile inshore cod HAPC. This EPM and other relevant mitigations that BOEM could impose are described in Section 6.1 and 6.2.1, respectively.

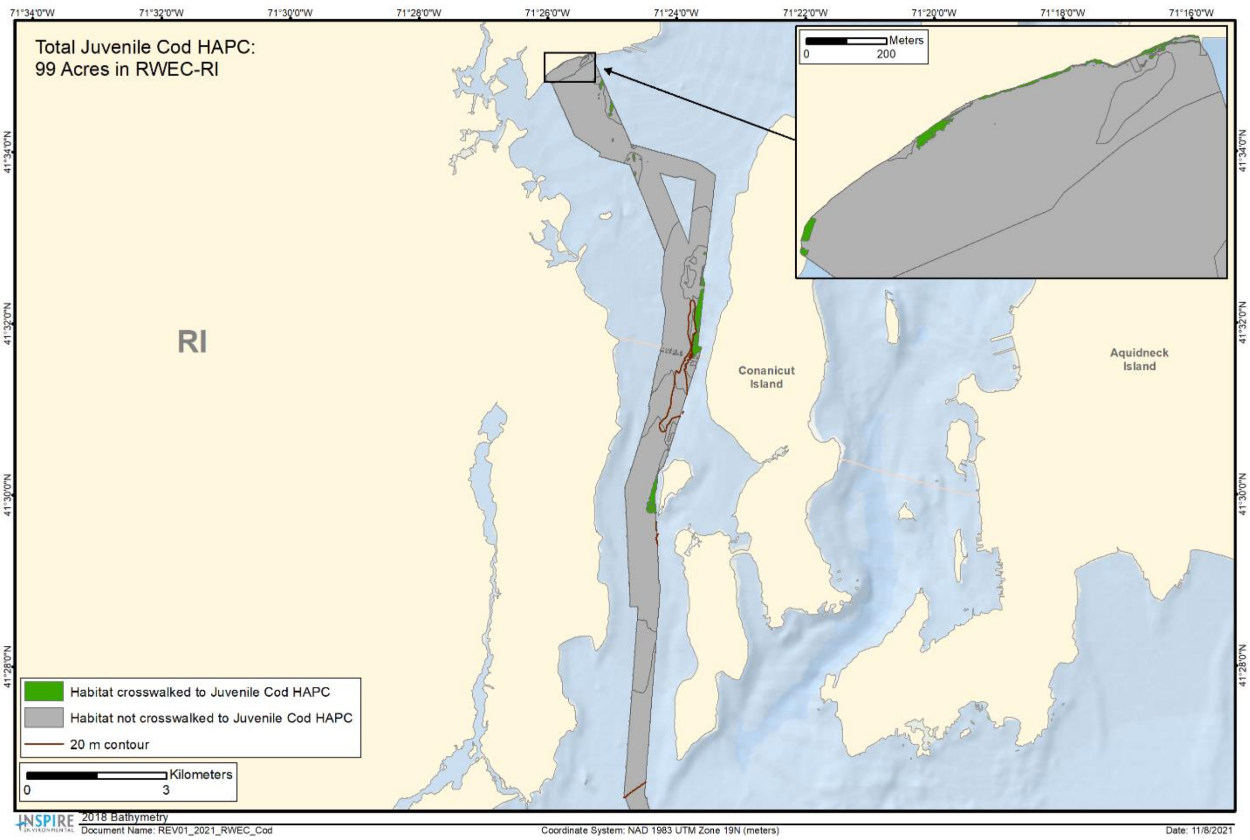

Figure 4.2. Identified Juvenile Inshore Cod HAPC Occurrence within the MWA for the RWEC-RI.

4.2.2 Summer Flounder HAPC

Summer flounder HAPC has not been mapped, but includes all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes (i.e., SAV) in any size bed, as well as loose aggregations found within currently designated adult and juvenile summer flounder EFH (MAFMC et al. 1998). In locations where native SAV species have been eliminated from an area, then exotic species are included.

4.2.3 Southern New England HAPC

On July 30, 2022, the New England Fishery Management Council (NEFMC) approved a new HAPC designation to address concerns over potential adverse impacts from offshore wind development on sensitive hard-bottom habitats and cod spawning activity. The Southern New England HAPC comprises all large-grained complex and complex benthic habitats wherever present within the area bounded by a 10-km (6.2-mile) buffer around the RI/MA and MA WEAs (Plante 2022), as shown in Figure 4.3. The designation is intended to protect high-value complex habitats within this area, emphasizing currently known and potentially suitable areas used by Atlantic cod for spawning (Bachman and Couture 2022; NEFMC 2022). This EFH designation was partially informed by the findings of a three-year, BOEM-funded study investigating the use of Cox Ledge and surroundings by spawning Atlantic cod (#AT-19-08) (BOEM pers. comm. 2021).

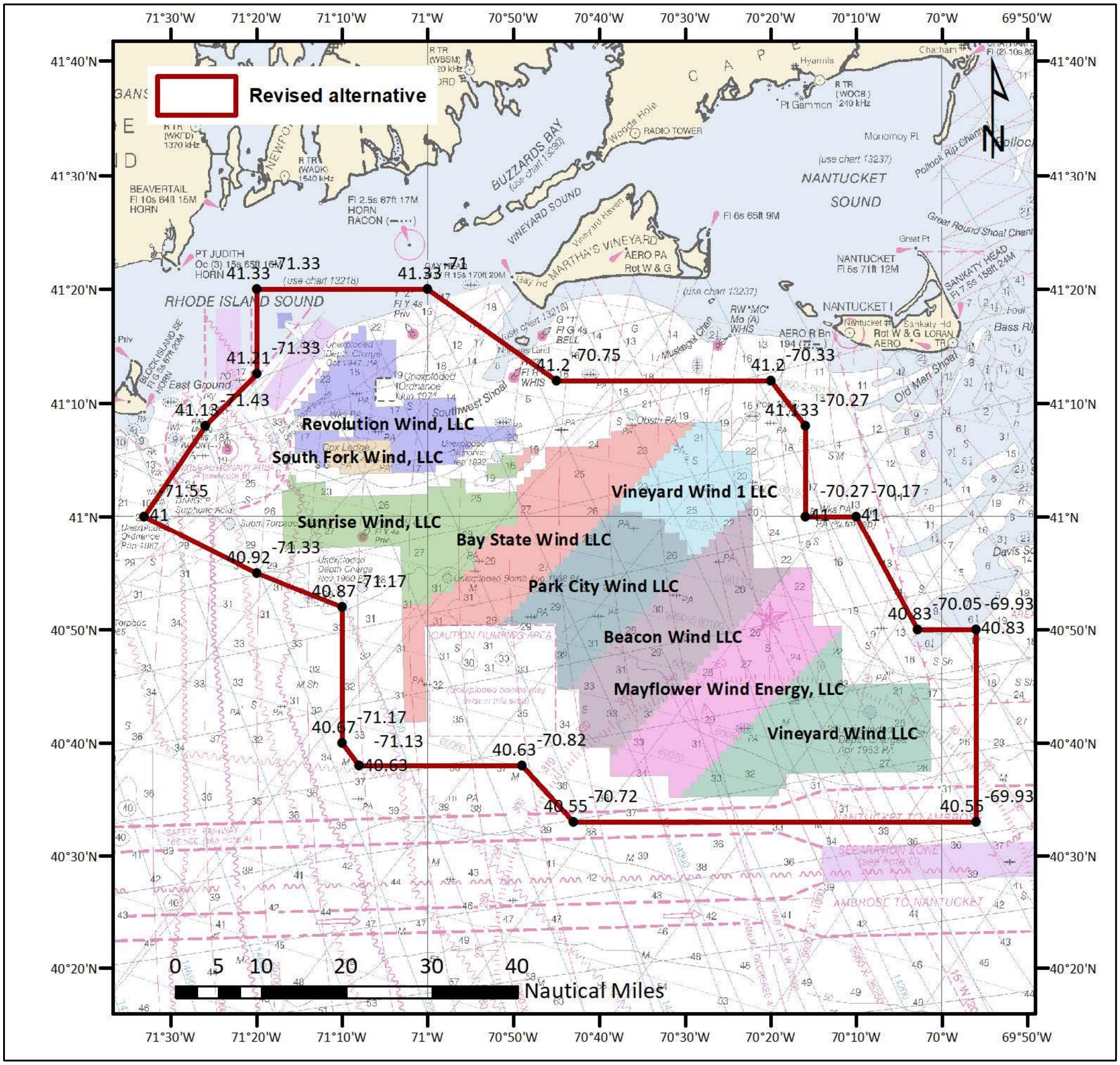

Figure 4.3. Proposed Southern New England HAPC Designation.

The designation would also apply to large-grained complex and complex benthic habitats used by Atlantic herring, Atlantic sea scallop, little skate, monkfish, ocean pout, red hake, silver hake, windowpane flounder, winter flounder, winter skate, and yellowtail flounder. This new HAPC designation has not yet been implemented and is pending final approval by NMFS. Two Habitat Alternative configurations have been developed by BOEM that would avoid and minimize impacts to this HAPC from the construction and operation of the RWF. This alternative is described in Section 6.2.

4.2.4 EFH Species Groups

For this EFH assessment, EFH species have been organized into groups based on species and/or life stage affinity for specific habitat types. Benthic/epibenthic species groups are organized into two habitat types (soft bottom or complex) based on the benthic habitat with which the species is most typically associated, with the potential for any species to be found in heterogenous complex as that habitat type could include both soft bottom and complex habitat. These species groups are based on the primary habitat associations presented in Table 4.1, and species and life stage mobility. Species group descriptions and example EFH species and life stages are provided below. The full list of species and their habitat associations in each group are listed in Table 4.1.

Certain primary prey species have been included as species groups because they are consumed by managed fish and invertebrate species as prey, and thus are a component of EFH.

4.2.4.1 Sessile Benthic/Epibenthic – Soft Bottom

This group includes slow-moving benthic/epibenthic species and/or life stages that associate with soft bottom habitat. This group also includes species that primarily associate with soft bottom habitat but may also use complex habitat. Examples include:

- Atlantic herring (eggs)
- Atlantic scallop (juveniles, adults)
- Atlantic surfclam (juveniles, adults)
- Flatfish (eggs and larvae of winter flounder)
- Longfin squid (eggs)
- Ocean pout (eggs, larvae)
- Ocean quahog (juveniles, adults)

4.2.4.2 Mobile Benthic/Epibenthic – Soft Bottom

This group includes the mobile juvenile and adult life stages of demersal fish species that associate primarily with or routinely use soft bottom habitat. Examples include:

- Flatfish (juveniles, adults)
- Monkfish (juveniles, adults)
- Ocean pout (juveniles, adults)
- Red hake (juveniles, adults)
- Scup (juveniles, adults)

- Sharks (neonates, juveniles, adults)
- Skates (neonates, juveniles, adults)
- Silver hake

4.2.4.3 Sessile Benthic/Epibenthic – Complex Habitat

This group includes sessile and slow-moving species and/or life stages that associate primarily with large-grained complex and complex benthic habitat. It also includes species and life stages that associate with heterogenous mixtures of complex and soft bottom habitat. Examples include:

- Atlantic cod (post-settlement larvae)
- Atlantic herring (eggs)
- Longfin squid (eggs)
- Atlantic scallop (settled eggs, larvae, juvenile, adult)
- Ocean pout (eggs and larvae)
- Pollock (eggs and larvae)

4.2.4.4 Mobile Benthic/Epibenthic – Complex Habitat

This group includes highly mobile species and/or life stages that associate primarily with large-grained complex and complex benthic habitat. It also includes species and life stages that associate with heterogenous mixtures of complex and soft bottom habitat. Examples include:

- Atlantic cod (juvenile, adult)
- Black sea bass (juvenile, adult)
- Monkfish (juvenile, adult)
- Red hake (juvenile, adult)
- Scup (juvenile, adult)
- Sharks (neonate, juvenile, adult)
- Silver hake (juvenile)

4.2.4.5 Pelagic

This group includes EFH species and life stages that are pelagically oriented, meaning they are found primarily in the water column and at mid-depth or near the surface. This group includes certain EFH species having pelagic eggs and larvae. Examples include:

- Albacore and Atlantic bluefin, skipjack, and yellowfin tunas (juvenile and/or adult)
- Atlantic butterfish (eggs, larvae, juvenile, adult)
- Atlantic herring (larvae, juvenile, adult)
- Atlantic mackerel (eggs, larvae, juvenile, adult)
- Bluefish (eggs, larvae, juvenile, adult)
- Longfin squid (larvae, juvenile, adult)

- Pollock (juvenile, adult)
- Pelagic eggs and larvae of other EFH finfish and invertebrate species (e.g., Atlantic cod eggs

4.2.5 Hearing Groups

For the purpose of analyzing acoustic impacts, EFH species have been organized into hearing groups as defined by Popper et al. (2014). Hearing groups used in this EFH assessment are described in Table 4.2.

Table 4.2. Hearing Groups Used to Assess Underwater Noise Impacts on EFH Species.

Hearing Group	Description	Examples	Sensitivity to Sound Pressure
Hearing specialists	Fish species having a swim bladder that is connected to the inner ear and involved in hearing.	Atlantic herring, black sea bass, gadids	These species have the highest hearing sensitivity and are the most likely to experience hearing injury from exposure to intense underwater sounds, as well as barotrauma injury to internal organs.
Hearing generalists	Fish species having a swim bladder that is not involved in hearing. These species are less reliant on hearing and have lower hearing sensitivity.	Bluefish, butterfish, scup, some tunas	Species have a swim bladder, but hearing is not connected to it or other associated gas chamber. Hearing relies primarily on detection of particle motion and associated organs are less susceptible to injury. Still susceptible to barotrauma injury.
Species without a swim bladder	Fish without swim bladder or hearing associated gas chamber.	Flatfish, monkfish, sharks, rays, some tunas	These fish species are the least sensitive to hearing and barotrauma injury from intense sound exposure.
Eggs and larvae	The eggs and larvae of fish and invertebrates	Virtually all EFH species except for live bearing sharks	Lack developed hearing organs and gas-filled internal organs. Low sensitivity to noise impacts
Invertebrates	Shellfish and cephalopods	Longfin squid, Atlantic scallop	Invertebrate species lack hearing organs and have no gas filled organ or chamber. Sensitive to particle motion effects within a few feet of the source but generally incapable of detecting sound pressure.

4.2.6 Prey Species

Prey species are those species consumed by EFH fish and invertebrate species and are thus a component of EFH. Impacts to prey species may indirectly lead to impacts to EFH and EFH species and life stages due to lost foraging opportunities or reduced foraging efficiency. For this EFH assessment, Prey organisms have been grouped into the classes as described below.

4.2.6.1 Pelagic Fish and Invertebrates (Pel)

Pelagic prey species include forage fish such as sand lance, anchovy, and river herring, as well as invertebrates such as squid. Sand lance (*Ammodytes* spp.) have been found to be prey species to at least 45 species of fish in the northwest Atlantic Ocean (Staudinger et al. 2020). Bay anchovy (*Anchoa mitchilli*), which is the most abundant of several anchovy species, may also be the most abundant fish species in the western north Atlantic (Houde and Zastrow 1991) and is an important trophic link between planktonic production and larger piscivores.

4.2.6.2 Benthic and Epibenthic Invertebrates and Demersal Fish (B/E/D)

Benthic, epibenthic, and infaunal invertebrates and demersal fish species provide both primary prey for and important trophic linkages to EFH species and their prey higher in the food chain. Invertebrates, including worm-like invertebrates (e.g., oligochaetes, polychaetes, flatworms [Platyhelminthes], and nematodes [Nematoda]), burrowing amphipods, mysids, copepods, crabs (Brachyura), sand dollars (Clypeasteroida), starfish (Asteroidea), sea urchins (Echinoidea), bivalves (Bivalvia), snails (Gastropoda) and burrowing anemonies (Anthozoa), provide the prey base for several EFH species. Likewise, demersal fish, such as juvenile cod, hake, flounder, pollock, ocean pout, and scup provide opportunistic feeding opportunities for a variety of predatory demersal EFH species.

4.2.6.3 Planktonic Organisms (Plank)

Planktonic organisms and the planktonic life stages of various fish and invertebrate species provide the primary prey base for a variety of EFH species. For example, certain calanoid copepods, such as *Calanus finmarchicus*, and the pelagic larval life stages of crab and lobster are preferentially targeted by many fish species having pelagic larval and juvenile life stages. Certain EFH species, such as Atlantic herring, are obligate filter feeders that feed on phytoplankton and zooplankton and in turn provide an important prey resource for other EFH species. Planktonic organisms are by definition relatively immobile. While some organisms are capable of migrating vertically within the water column in response to diurnal and seasonal cues, they are unable to move independently to avoid project-related impacts.

5.0 Effects to EFH

This section provides an analysis of the effects of the proposed action on designated EFH for managed species and life stages in the project area. As stated, the project area is composed of the maximum impact footprints resulting from the construction and O&M of the RWF and RWEC. These footprints are defined by the geographic extent of measurable short-term, long-term, and permanent effects from project construction and installation and operations and maintenance. Potential effects on EFH are evaluated in this section by determining if designated EFH occurs in the project area, and if the project is likely to impair the suitability of the affected habitat for the species and life stages in question. Adverse effects on EFH may include direct or indirect alteration of physical, chemical, or biological properties of the water column and/or substrates used by EFH species during their life cycle, impacts to pelagic and benthic prey organisms and their habitats, and other relevant ecosystem components. Adverse effects may be temporary (hours to days), short-term (<2 years), long-term (>2 years), or permanent (life of the project), site-specific or habitat-wide, and can result from the individual, cumulative, or synergistic consequences of actions (50 CFR § 600.910). If a project component is likely to result in a short-term, long-term, or permanent impairment of designated EFH for a managed species and life stage, this would constitute an adverse effect on EFH. In general, impacts associated with construction and installation are considered short-term impacts, although long-term and even permanent impacts can result from construction. Exceptions being seabed preparation and foundation installation. The long-term and permanent impacts are typically considered when evaluating O&M related activities.

This EFH effects analysis is organized by project phase and associated IPF to organize the duration of ecological impacts by the periods when they are likely to occur. Table 5.1 below provides an overview of impacts considered by project phase (i.e., construction and installation as well as operations and maintenance), project element, associated IPFs and IPF duration (i.e., short-term, long-term, permanent).

Table 5.1. EFH Effects Analysis Roadmap by Project Phase, IPF, Impact Source and IPF duration.

Project Phase	Impact Producing Factor	Sources	Duration	Analysis Sections
Construction	Construction noise	• Vessel noise • Pre-construction HRG surveys • Pile driving • UXO detonation	Short-term	5.1.1.1, 5.1.1.3, 5.1.1.4, 5.1.2.1, 5.1.2.3
	Crushing, burial, entrainment	• Vessel anchoring • Seabed preparation/boulder relocation • Installation of foundations and scour protection • Cable installation • Installation of cable protection	Short-term	5.1.1.1, 5.1.1.2, 5.1.1.5, 5.1.2.1, 5.1.2.2, 5.1.2.4, 5.1.2.5
	Suspended sediment, sediment deposition	• Vessel anchoring • Seabed preparation • Cable installation	Short-term	5.1.1.1, 5.1.1.2, 5.1.2.1, 5.1.2.2, 5.1.2.4
	Habitat disturbance and conversion	• Vessel anchoring • Seabed preparation/boulder relocation (soft bottom habitat) • Installation of foundations and scour protection • Cable installation • Installation of cable protection	Short-term to permanent	5.1.1.1, 5.1.1.2, 5.1.1.5, 5.1.2.1, 5.1.2.2, 5.1.2.4, 5.1.2.5
O&M	Habitat disturbance and conversion	• Seabed preparation/boulder relocation (complex habitat) • Presence of structures • Reef effects • Hydrodynamic effects	Long-term to permanent	5.1.3.1, 5.1.3.3, 5.1.4.2
O&M	Operational noise	• O&M and survey vessel noise • Sound generated by WTG operations • Post-construction HRG surveys	Short-term to permanent	5.1.3.2, 5.2.1
O&M	EMF/substrate heating effects	• Power transmission (IAC, OSS-link, RWEC)	Permanent	5.1.4.1
O&M	Bycatch and incidental take	• Fisheries and benthic habitat monitoring	Long-term intermittent	5.2.2

5.1 Construction and Installation, and Operation and Maintenance Activities

Project construction and installation will generally generate short-term, and generally direct effects on EFH through construction and installation noise; entrainment effects; and suspended sediments from seabed disturbance. Other construction activities will generally generate long-term to permanent effects on EFH through seabed preparation and foundation installation. These effects would occur intermittently at varying locations in the project area over the duration of project construction and installation. Depending on the nature, extent, and severity of each effect, this may reduce the suitability of EFH for managed species. This would constitute effects ranging from short-term, to long-term or permanent adverse effect on EFH.

The operations and maintenance of the RWF and RWEC would generally result in the long-term or permanent alteration of water column and benthic habitats within the construction and installation footprint. Those permanent, direct or indirect effects would last over the approximate 35-year lifespan of the project from the completion of construction and installation through decommissioning. For example, placement of boulder scour protection during construction would have a direct effect. But that boulder scour protection may develop into complex fisheries habitat over the life of the project, an indirect effect. Additionally, the benefits of maintaining that complex fisheries habitat may outweigh the removal of these features to return the habitat to its original condition. Those decisions and any associated direct and indirect effects on EFH would be addressed through separate consultation for project decommissioning.

The permanent impacts of project operations and maintenance that could alter the suitability of EFH for managed species are as follows:

- Alteration of water column and benthic habitat composition by monopile foundations, scour protection and cable protection.
- Operational noise effects on habitat suitability in the vicinity of the WTGs.
- EMF effects on benthic and demersal habitat suitability in the vicinity of the inter-array cable and RWEC.
- Hydrodynamic effects on pelagic habitat suitability in the vicinity of the monopile foundations.
- Food web effects resulting from permanent habitat alteration, including the colonization of new hard substrates introduced to the offshore environment.

5.1.1 Installation of WTG/OSS Structures/Foundations

Project construction and installation will generate short-term to long-term and potentially permanent, direct and indirect effects on EFH through vessel activity; seabed preparation and foundation installation; and installation of scour protection. These effects would occur intermittently at varying locations in the project area over the duration of project construction and installation. Depending on the nature, extent, and severity of each effect, this may reduce the suitability of EFH for managed species. This would constitute short-term to long-term and potentially permanent adverse effects on EFH.

The construction and installation of the RWF involves activities that would generate underwater noise exceeding established thresholds for mortality and permanent or short-term injury, temporary threshold shift (TTS), and behavioral effects. Underwater noise would render the affected habitats unsuitable for EFH species over the short-term and could have short-term impacts on prey availability for EFH species. The extent, duration, and severity of noise effects on EFH would vary depending on the noise source and the sensitivity of the affected EFH species and their prey to noise impacts during their life cycle. These effects are detailed by project component in the following sections (i.e., vessel activity, pile driving).

The assessment of noise impacts provided in the following sections emphasizes direct noise effects on EFH species based on the sensitivity of different hearing groups and life stages. However, these results are also applicable to prey resources important to EFH species. Fish eggs and larvae are prey and forage resources for some EFH species during certain life stages. Fish and invertebrates from any hearing group may provide prey for EFH species. Accordingly, short-term noise impacts that temporarily reduce habitat suitability for EFH species may also have localized effects on the availability of their prey resources. Individual prey organisms available to EFH species may increase or decrease depending on the nature of the noise effect and species-specific sensitivity. In contrast, short-term injury, auditory masking, or behavioral effects may limit the ability of EFH species to detect and locate prey organisms. A full accounting of these complex mechanisms is beyond the scope of this assessment, but in general, short-term noise impacts on prey organisms are considered an adverse effect on EFH.

5.1.1.1 Vessel Activity

The sections below evaluate the potential direct effects to EFH from vessel activities associated with the construction and installation of the WTG and OSS monopile foundations. Potential sediment suspension/redistribution related to vessel anchoring would be similar in magnitude but reduced in extent to those resulting from cable installation, described in Section 5.1.2 below.

Habitat Disturbance/Conversion

Revolution Wind has estimated that general construction vessel anchoring impacts could occur anywhere within a 656-foot (200 meter) radius around each foundation location. Anchor placement and retrieval, anchor chain sweep, and spud placement could cause habitat disturbance or conversion by disturbing or crushing habitat in the immediate area where anchors, chains, and spuds meet the seafloor, resulting in short-term to long-term direct impacts to EFH for sessile benthic/epibenthic species. Anchoring activities could also result in the crushing and burial of sessile or slow-moving benthic/epibenthic EFH species and/or life stages, resulting in direct, permanent (lethal), localized impacts to these species. The extent and severity of anchoring impacts would vary depending on the specific types of anchoring activity employed. For example, the derrick barge crane vessel used during monopile installation could disturb 9.1 acres during two placement of its 8-point, 12-ton delta flipper anchor at each foundation. In contrast, a barge that uses spud cans to hold position would produce a much smaller impact footprint. Some installation vessels would primarily use dynamic positioning systems to hold position and would not impact the seabed.

The precise extent and location of anchoring impacts anticipated at each foundation is not currently known as vessel positioning and anchoring requirements are affected by wind and current conditions in real time. The vessel anchoring plan developed by the applicant prior to the commencement of construction and installation activities (see applicant proposed EPM in Table 6.1) would be used to identify and avoid impacts to large-grained complex and complex benthic habitats to the greatest extent practicable. However, for the purpose of this consultation, BOEM assumes that the entirety of the 656-foot (200-meter) impact radius around each foundation could potentially experience some degree of anchoring disturbance. This equates to approximately 31 acres of anchoring disturbance at each of 81 monopile foundation sites, and 2,515 acres in total. In addition to general construction vessel anchoring, approximately 21.1 total acres of benthic habitat would be disturbed by jack-up vessel anchoring during foundation construction and installation. These impacts would occur within and overlap the general anchoring impact footprint described above, therefore the total extent of impacts from both anchoring activities is estimated at 2,515 acres. The anticipated distribution of anchoring impacts by habitat zone and benthic habitat type for foundation construction is summarized in Table 5.2. Benthic habitat in the areas where anchoring impacts could occur is composed of approximately 6.5% large-grained complex, 30.0% complex, and 63.5% soft bottom habitats.

Impacts to soft bottom benthic habitat are expected to recover within 18 to 24 months following initial disturbance via bedform recovery through natural sediment transport processes and recolonization by habitat-forming organisms from adjacent habitats. This estimate is based on regional sediment transport patterns characterized by Daylander et al. (2012), observed recovery rates from seabed 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). In contrast, anchoring activities in large-grained complex, complex, and heterogenous complex benthic habitats could change the composition of benthic habitat by creating furrows of soft bottom habitat through boulder and cobble substrates. This would permanently modify the distribution of substrates in the affected area, resulting in a long-term to permanent effects on benthic habitat composition. For example, anchor scars from Block Island windfarm construction created corridors of sandy soft bottom habitat through existing boulder fields that have persisted since the project was completed (Guarinello and Carey 2020). Depending on the types of organisms affected, damage to habitat-forming invertebrates on boulders and cobbles could take several years to decades to fully recover (Auster and Langton 1999; Collie et al. 2005; Tamsett et al. 2010). This would constitute a long-term effect on benthic habitat structure. Recent research conducted by the NEFSC and NEFMC (BOEM pers. comm. 2023a) determined that HAPC features for gaddids on Georges Bank recovered relatively quickly from damage by intensive scallop dredging activity. Near complete recovery of benthic epifauna, including habitat-forming organisms on boulders and cobbles, was achieved within 6 years of the disturbance. Given their proximity to the project area, these findings provide a useful basis for estimating the likely duration of effects of benthic habitat disturbance from anchoring disturbance and other construction-related activities.

Table 5.2. Estimated Acres and Proportional Distribution of Benthic Habitat Disturbance from Vessel Anchoring for Foundation Installation by Habitat Zone and NOAA Benthic Habitat Type.

Type of Anchoring	Habitat Zone	Maximum Construction Disturbance Footprint (acres)	Large-Grained Complex	Complex	Soft Bottom
General construction*	RWF 1	217	18.5%	44.4%	37.1%
	RWF 2	963	10.5%	50.0%	39.5%
	RWF 3a	186	3.5%	56.4%	40.1%
	RWF 3b	0	--	--	--
	RWF 4	1,148	1.4%	6.2%	92.4%
	Total	**2,515**	**6.5%**	**30.0%**	**63.5%**
Jack-up vessel†	RWF 1	1.4	11.6%	49.5%	38.9%
	RWF 2	6.4	8.1%	51.3%	40.6%
	RWF 3a	1.2	6.4%	57.6%	36.9%
	RWF 3b	0	--	--	--
	RWF 4	7.7	2.0%	5.5%	92.0%
	Total	**16.8**	**5.4%**	**30.5%**	**64.1%**

* General construction vessel anchoring would occur within a 656-foot radius around each foundation (COP Table 4.1.1-1). The total acreage and habitat composition shown represent the area in which seafloor impacts from general construction vessel anchoring could occur. Actual anchoring impacts would occur within a subset of this area and would avoid large-grained complex and complex habitat to the extent practicable. The acreage shown is the total area of the impact radii around each foundation, minus overlapping jack up vessel anchoring impacts.

† An estimated 16.8 acres of jack up vessel anchoring impacts based on an estimated 0.18 acre of seafloor impacts per vessel jack-up event. OSS foundations will require one jack-up event per installation. An estimated 85% of WTG installations will require one jack-up event and 15% will require two jack-up events. The distribution of the latter is unknown, therefore estimated impacts are distributed between zones based on the number of foundations proposed. These impacts would occur within and overlap with the general construction vessel anchoring and seafloor preparation footprints for foundation installation.

Medium- and low-density boulder fields present in large-grained complex and complex habitats within each lease area zone (See Section 3.5) are important EFH for several managed species present within the Lease Area, including Atlantic cod (adults and spawning adults), longfin squid (i.e., benthic egg mops), ocean pout (all life stages), winter flounder (adults), and monkfish (adults and juveniles). Damage caused to medium- and low-density boulder fields, as well as associated biogenic features and attached, habitat forming organisms (see Tables 3.5 and 3.6) that provide shelter, attachment surfaces, and prey resources for the aforementioned EFH species would incur direct, long-term impacts from anchors, anchor chains, and spuds as these habitats generally take several years to decades to fully recover (Auster and Langton 1999; Collie et al. 2005; Tamsett et al. 2010). EFH species could also incur short-term to long-term, indirect impacts from a loss of benthic epifauna/prey, such as crabs, shrimps, and sea stars, that were observed on boulders in SPI/PV imagery (see Table 3.5). Anchoring could also result in the direct mortality of immobile, longfin squid egg mops and damage and/or disturb nests guarded by ocean pout, a currently overfished species of federally managed finfish. Impacts to medium-and low-density boulder fields associated with vessel anchoring during WTG and OSS foundation construction and installation would primarily occur in RWF zones 1, 2, and 3b.

Anchors, anchor chains, and spuds could directly impact gravelly sand, sandy gravel, and slightly gravelly sand substrates, which are the dominant CMECS substrates found in large-grained complex and complex habitats within every lease area zone (See Section 3.5). Gravelly substrates are a preferred spawning substrate of Atlantic herring that deposit benthic eggs. The crushing of herring eggs would constitute an indirect impact to EFH species such as Atlantic cod, which feed on Atlantic herring, a species of commercially valuable schooling fish that is significantly below target population levels. Atlantic sea scallops (adults, juveniles, and larvae), a commercially valuable and relatively immobile, benthic species of invertebrates also inhabits gravelly sand, sandy gravel, and slightly gravelly sand substrates. This species would be vulnerable to both direct, permanent (crushing) and indirect, short-term (sedimentation and turbidity causing reductions in habitat quality) anchoring impacts. Hydroids, a prey item of Winter skates (adults and juveniles), that were observed in SPI/PV imagery (see Table 3.6) to be present on gravelly sand substrates could also be crushed; however, hydroids are ubiquitous organisms in ocean ecosystems. Lastly, shell hash substrates, a biogenic substrate present in both large-grained and complex habitats in every lease area zone (see Table 3.5) are important EFH for juvenile and larval red hake, young-of-the-year (YOY) and juvenile winter flounder, and larval and juvenile Atlantic sea scallops, which could be crushed or caused to flee these sheltering habitats. The southern red hake population, which includes the Lease Area, is currently overfished, but the current fishing rate established under a rebuilding plan promoted population growth.

Dominant bedform features and CMECS substrates within the soft bottom habitats in Lease Area habitat zones include ripples, linear depressions, trawl scars, and mega-ripples, and medium to fine sands, respectively. Winter flounder (larvae, YOY, juvenile, and adults) and winter skates (adults and juveniles) are soft bottom EFH species known to utilize medium to fine sandy substrates. Anchoring in these substrates could result in short-term (i.e., fleeing the area) or permanent (crushing of YOY winter flounder and/or attached hydroids) impacts to soft bottom associated EFH species and prey. Ripples and mega-ripples, which are important bedform features for soft bottom associated EFH species, including adult Atlantic cod (Gerstner 1998), that can be found sheltering in these areas from currents, could also be damaged. Similarly, damage to linear depressions that are present in all lease area zones would be problematic as these sheltering, EFH bedform features are utilized by adult red hake. As mentioned previously in this Section, soft bottom habitats and bedform features would be expected to recover relatively quickly (i.e., 18-24 months following disturbance).

Effects on EFH and EFH Species

- Direct
  - Short-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat when anchoring): EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Pelagic species groups; Prey Species – Benthic; Prey Species – Pelagic, Summer Flounder HAPC; Summer Flounder HAPC.
  - Permanent, localized crushing and burial of EFH species: Sessile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Prey –Benthic/Epibenthic species groups.
  - Long-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat during anchoring): EFH for Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Southern New England HAPC.
  - Short-term avoidance of anchoring activities by EFH species: Mobile Epibenthic/Benthic – Soft Bottom; Mobile Epibenthic/Benthic – Complex; Pelagic; Prey Species – Benthic and Prey Species – Pelagic species groups.
- Indirect
  - Short-term loss of benthic prey items: Mobile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Complex.

Underwater Noise

Construction and installation vessels would generate continuous underwater noise at various locations throughout the project area during RWF construction and installation. For the purposes of this analysis, vessels are assumed to generate effectively continuous underwater noise 24 hours a day for up to 8 months, from May through December 2023. These impacts would occur throughout the Lease Area and would overlap those associated with pile driving activities used during foundation installation. The geographic extent of these impacts is described in Section 5.1.1.3. Underwater noise from related activities like cable laying and boulder clearance are expected to produce noise levels comparable to vessel engine noise (Revolution Wind 2022c). BOEM considers boulder clearance and cable laying to be non-noise generating activities, therefore any noise-related effects are addressed as a component of the vessel noise impacts considered herein.

Vessel noise may interfere with feeding and breeding, alter schooling behaviors and migration patterns (Buerkle 1973; Olsen et al. 1983; Schwarz and Greer 1984; Soria et al. 1996; Vabø et al.

2002; Mitson and Knudsen 2003; Ona et al. 2007; Sarà et al. 2007), mask important environmental auditory cues (CBD 2012; Barber 2017), and induce endocrine stress response (Wysocki et al. 2006). Fish communication occurs mainly at lower sound frequencies (<1,000 hertz [Hz]) (Ladich and Myrberg 2006; Myrberg and Lugli 2006). Many fish species have unique vocalizations that allow for inter- and intra-species identification, and these low frequency vocalizations are generally not loud, usually approximately 120 dB re 1 µPa SPL with the loudest sounds reaching 160 dB re 1 µPa SPL (Normandeau Associates 2012). As such, anthropogenic sound sources that occur in lower frequency ranges could result in auditory masking effects. Vessel noise is a common source of low-frequency sound in the marine environment. Behavioral responses in fishes differ depending on species and life stage, with younger, less mobile age classes being the most vulnerable to vessel noise impacts (Popper and Hastings 2009; Gedamke et al. 2016).

Underwater sound from vessels can cause avoidance behavior, which has been observed for Atlantic herring (*Clupea harengus*) and Atlantic cod (*Gadus morhua*) and is a likely behavior of other species as well (Vabø et al. 2002; Handegard et al. 2003). Spawning cod present in the lease area (e.g., Zone RWF 1) would be exposed to elevated acoustic levels comparable to those eliciting a short term behavioral response in these studies. However, behavioral disturbance may not necessarily translate to significant adverse effects on activities like spawning. For example, McQueen et al. (2022) observed that exposure to seismic airgun noise did not cause displacement of Atlantic cod from their spawning grounds. They speculated that strong site affinity could explain the lack of a significant behavioral response to an otherwise intensive stressor. This suggests that exposure to underwater noise from vessels and other construction activities may not necessarily lead to significant adverse effects on behavior.

Such behavioral responses are likely to vary due to differences in sensitivity between species and other environmental factors (McQueen et al. 2022). Fish may respond to approaching vessels by diving towards the seafloor or by moving horizontally out of the vessel's path, with reactions often initiated well before the vessel reaches the fish (Ona et al. 2007; Berthe and Lecchini 2016). The avoidance of vessels by fish has been linked to high levels of infrasonic and low-frequency sound (approximately 10 to 1,000 Hz) emitted by vessels. Accordingly, it was thought that quieter vessels would result in less avoidance (and consequently quieter vessels would have a higher chance of encountering fish) (De Robertis et al. 2010). By comparing the effects of a quieted and conventional research vessel on schooling herring, it was found that the quieter vessel initiated a stronger and more prolonged avoidance reaction than the conventional vessel (Ona et al. 2007). In a comment to this publication, Sand et al. (2008) pointed out that fish are sensitive to particle acceleration and that the cue in this case may have been low-frequency particle acceleration caused by displacement of water by the moving hull. This could explain the stronger response to the larger, noise-reduced vessel in the study by Ona et al. (2007), which would have displaced more water as it approached.

Nedelec et al. (2016) investigated the response of reef-associated fish by exposing them in their natural environment to playback of vessel engine sounds. They found that juvenile fish increased hiding and ventilation rate after a short-term vessel sound playback, but responses diminished after long-term playback, indicating habituation to sound exposure over longer durations. These results were corroborated by Holmes et al. (2017) who also observed short-term behavioral changes in juvenile reef fish after exposure to vessel noise as well as desensitization over longer exposure periods. While sounds emitted by vessel activity are unlikely to injure fish, vessel sound has been documented to cause short-term behavioral responses (Holmes et al. 2017).

Analysis of vessel noise related to the Cape Wind Energy Project estimated that noise levels from construction vessels at 10 feet (3 meters) were loud enough to elicit an avoidance response, but not loud enough to do physical harm (MMS 2009). Pelagic species and life stages and prey species that occur high in the water column (e.g., Atlantic butterfish, Atlantic herring, Atlantic mackerel, bluefish, and some highly migratory pelagic species) would be the most likely impacted species by vessel and construction noise, although the behavioral avoidance impacts would be short-term. However, in inshore, shallow waters benthic species and life stages could also be impacted. Any disturbance they did experience would result in a short-term impact of avoidance of vessel noise. Demersal and benthic invertebrates are not anticipated to be impacted as a result of increased noise from vessels associated with construction of the proposed Project. Therefore, EFH-designated fish within the project area may initially exhibit a negative behavioral response to vessel activity; however, as vessel traffic increases throughout the previously discussed Project timeline, habituation to vessel noise by EFH-designated species is likely to occur. Project-related vessel noise would be intermittent and of short duration, so the overall impacts to fish are expected to be low.

Effects

- Direct
  - Short-term, local avoidance responses due to vessel noise: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex Habitat; Mobile Benthic/Epibenthic – Complex Habitat; Pelagic; Prey Species – Benthic/Epibenthic; Prey Species – Pelagic.
- Indirect
  - Short-term reduction in habitat quality for Southern New England HAPC.
  - Short-term reduction in habitat quality for juvenile inshore cod HAPC.
  - Short-term reduction in habitat quality for summer flounder HAPC.

Specific thresholds used to analyze potential impacts, and impacts by hearing group, are provided below.

Vessel Related Underwater Sound Effects on Eggs and Larvae

Continuous underwater noise from construction and installation vessels is unlikely to cause injury or mortality to eggs and larvae of marine fish and invertebrates (Popper et al. 2014). Underwater noise produced by HRG survey equipment falls below the instantaneous injury threshold for eggs and larvae. HRG surveys are mobile at a typical speed of 4 knots, meaning that planktonic eggs and larvae would not experience continuous exposure of sufficient duration to accumulate cumulative noise impacts.

Vessel Related Underwater Sound Effects on Fish with Swim Bladders Involved in Hearing (Hearing Specialists)

Underwater noise levels produced by HRG surveys and construction and installation vessel activity are unlikely to cause injury but may cause TTS and behavioral effects on hearing specialist fish species. The potential extent of TTS and behavioral level effects on this hearing group are as follows:

- Instantaneous TTS exposure: Within 16.4 feet (5 meters) of HRG survey equipment (cumulative effects unlikely).
- Cumulative TTS exposure (vessel noise): Within 184 feet [56 meters] of operating vessels).
- Behavioral effects exposure:
    - Vessel noise: Within 443 feet [135 meters] of operating vessels.
    - HRG surveys: Within 2,572 feet [784 meters] of HRG surveys.

Vessel Related Underwater Sound Effects on Fish without Swim Bladders Involved in Hearing (Hearing Generalists)

Underwater noise levels produced by HRG surveys and construction and installation vessel activity are unlikely to cause injury but may cause TTS and behavioral effects on hearing generalist fish species. The potential extent of TTS and behavioral level effects on this hearing group are as follows:

- Instantaneous TTS exposure: Within 16.4 feet [5 meters] of HRG survey equipment (cumulative effects unlikely).
- Cumulative TTS exposure (vessel noise): Within 184 feet [56 meters] of operating vessels.

- Behavioral effects exposure:
  - Vessel noise: Within 443 feet [135 meters] of operating vessels.
  - HRG surveys: Within 2,572 feet [784 meters] of HRG surveys.

Vessel Related Underwater Sound Effects on Fish with no Swim Bladder

Underwater noise levels produced by HRG surveys and construction and installation vessel activity are unlikely to cause injury but may cause TTS and behavioral effects on this hearing group. The potential extent of TTS and behavioral level effects on this hearing group are as follows:

- Instantaneous TTS exposure: Within 16.4 feet (5 meters) of HRG survey equipment (cumulative effects unlikely).
- Cumulative TTS exposure (vessel noise): Within 184 feet [56 meters] of operating vessels).
- Behavioral effects exposure:
  - Vessel noise: Within 443 feet [135 meters] of operating vessels.
  - HRG surveys: Within 2,572 feet [784 meters] of HRG surveys.

Vessel Related Underwater Noise Effects on Invertebrates

Invertebrate sensitivity to impulsive underwater noise is addressed in detail in Sections 5.1.1.3 and 5.1.1.4, which describe anticipated effects from exposure to UXO detonation and impact pile driving noise, respectively. HRG survey equipment produces less intense impulsive noise than these two noise sources. HRG surveys are also mobile, which reduces the duration of exposure to equipment noise. As such, injury level effects like those described for pile driving exposure appear unlikely. The equipment does not contact the substrate, so vibration-induced particle motion effects are unlikely to occur. As such, there is no basis to conclude that HRG survey noise would result in measurable behavioral effects on benthic invertebrates, or injury-level effects to sensitive invertebrate species. Squid within 6.6 feet [2 meters] of HRG survey equipment may exhibit temporary behavioral responses to particle motion effects for surveys of the Lease Area and alternative RWEC corridors.

Sediment Suspension

Revolution Wind modeled suspended sediment effects from bed disturbance associated with the construction and installation of the RWF and RWEC as part of the COP. These results are presented in COP Appendix J (RPS 2021) and summarized herein. RPS (2021) developed a 3-dimensional hydrodynamic model (HYDROMAP) that was used to simulate water levels, circulation patterns and water volume flux through the study area and to provide hydrodynamic input (spatially and temporally varying currents) for input to the sediment transport model. This model considered the concentration and extent of suspended sediment plumes resulting from the observed distribution of sediment types within the Lease Area and along the RWEC corridor. Modeled sediment grain sizes comprised coarse and fine sand, coarse and fine silt, and clay. The HYDROMAP model emulated the potential dispersal of suspended sediments from the disturbance of the different sediment types present throughout the project area in response to the typical range of current variability. Sediment deposition impacts for cable installation activities are described in detail in Section 5.1.2.4.

Only certain Project vessel activities, such as those associated with anchoring (e.g., anchor placement and retrieval, chain sweep, and/or spud placement) would likely result in sediment suspension, a concomitant increase in turbidity in the water column, and sedimentation. The specific extent of potential sediment impacts from vessel anchoring during foundation installation are unknown but are anticipated to be similar in intensity and reduced in extent relative to those resulting from the IAC installation. Anchoring related sediment impacts would occur within the same footprint as those from IAC installation, and while overlapping would occur at a different time. A summary of these impacts specific to anchoring activities is provided below. A detailed description of TSS and suspended sediment deposition effects on EFH species and habitats and the supporting rationale for the determinations provided below are provided in Section 5.1.2.3.

Sessile benthic/epibenthic EFH species have a range of susceptibility to sediment suspension, turbidity, and sedimentation based on life stage, mobility, and feeding mechanisms. Increases in sediment suspension and deposition may cause short-term adverse impacts to EFH due to a decrease in habitat quality for benthic species and life stage, with small sessile or slow-moving benthic EFH species and life stages (e.g., benthic eggs and larvae) experiencing greater impacts from deposition than larger, mobile species or life stages. Filter-feeding invertebrates could experience a reduction in feeding ability and food quality. Benthic prey species, such as clams in shellfish beds in Narragansett Bay, could experience short-term increases in turbidity and sedimentation, but would be expected to recover. Resuspended sediment in the water column would reduce the quality of EFH for mobile benthic/epibenthic and pelagic EFH species, but water column EFH would be expected to recover quickly following sedimentation. Temporary loss of foraging opportunities and displacement of mobile benthic/epibenthic and pelagic EFH species and pelagic prey species due to increased turbidity could also occur, but recovery would be expected following settlement of sediments. Refer to Section 5.1.1.1 for a more in-depth analysis of the benthic habitat types, associated biogenic features and habitat-forming organisms, and vulnerable EFH species present in each lease area zone. Based on the site-specific benthic habitat data available for each zone within the lease area (see Section 3.5), EFH species and life stages that would be most vulnerable to indirect impacts resulting from anchoring-induced sedimentation include the eggs and larvae of Atlantic herring, Atlantic sea scallops, red hake, winter flounder, and ocean pout.

<u>Effects</u>

- Direct
  - Short-term decrease in quality of EFH due to suspended sediments and increased turbidity: EFH for Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; and Pelagic species groups; Summer Flounder HAPC.
  - Short-term, local impacts due to sedimentation: Sessile Benthic/Epibenthic – Soft Bottom; Prey Species – Benthic.
- Indirect
  - Short-term loss of foraging opportunities: Mobile Epibenthic/Benthic – Soft Bottom; and Pelagic species groups.
  - Short-term decrease in quality of EFH in areas adjacent to Project activities for: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Summer Flounder HAPC; Prey Species – Benthic.

<u>Potential Introduction of Exotic/Invasive Species via Ballast</u>

Increased vessel traffic associated with offshore renewable energy construction and installation presents the potential for the inadvertent introduction of invasive species during discharge of ballast and bilge water. BOEM would require all project construction and installation vessels to adhere to existing state and federal regulations related to ballast and bilge water discharge, including U.S. Coast Guard (USCG) ballast discharge regulations (33 CFR 151.2025) and USEPA National Pollutant Discharge Elimination System Vessel General Permit standards, effectively avoiding the likelihood of non-native species invasions through ballast water discharge. Considering these requirements and the dispersed distribution of planned offshore energy facilities, existing water quality trends are likely to continue.

5.1.1.2 Seabed Preparation/Boulder Relocation/Dredging

Prior to installation of the RWF WTG and OSS foundations, the seabed around each foundation site would be prepared for construction by relocation of large boulders. This would result in both immediate crushing, burial, and entrainment impacts on EFH species and longer duration disturbance to habitat. This section considers the impacts to EFH species and habitats from short-term impacts associated with project construction. Construction related disturbance, specifically boulder relocation and the installation of foundations and scour protection, would also result in long-term to permanent impacts to EFH species and habitats by modifying the structure and composition of pelagic and benthic habitat. These long-term to permanent effects are addressed as a component of project operations in Section 5.1.3.1

RWF construction and installation would have the potential to crush, bury, or entrain EFH species utilizing benthic or epibenthic habitats within the permanent footprint of project infrastructure and the short-term construction and installation disturbance area. The anticipated estimated extent of benthic habitat exposed to these effects is summarized by habitat zone in Table 5.3. Construction and installation are expected to require approximately 10 months (five months for RWF and another five months for IAC installation), but the frequency of impacts would be intermittent during this period. Thus, crushing, burial, and entrainment effects would be limited in duration but could occur throughout the anticipated construction and installation window.

Table 5.3. Area Impacted by Seabed Preparation for WTG and OSS Foundation Installation and Proportional Distribution of Benthic Habitat Types in Area Where Impacts May Occur.

Habitat Zone	Maximum Construction Disturbance Footprint (acres)*	Disturbance as Percent of Zone Area	Percent of Disturbance in Large-Grained Complex Habitat	Percent of Disturbance in Complex Habitat	Percent of Disturbance in Soft Bottom Habitat
RWF 1	50	0.7%	11.6%	49.5%	38.9%
RWF 2	223	0.7%	7.8%	50.4%	41.8%
RWF 3a	43	1.3%	6.4%	56.7%	36.9%
RWF 3b	0	--	--	--	--
RWF 4	266	0.8%	2.0%	6.0%	92.0%
RWF Total	583	0.8%	5.4%	30.5%	64.1%

* Revolution Wind estimates that seafloor preparation could be required within approximately 23% of a 656-foot radius, or 7.1 acres, around each WTG and OSS foundation. The precise location of these impacts has not been specified; therefore, the proportional distribution of impacts is estimated by characterizing benthic habitat types within a 295-foot (90-meter) radius around each foundation.

The direct effects of crushing, burial, and entrainment impacts on EFH resulting from project construction and installation will vary depending on how benthic and near-bottom habitats exposed to these impacts are used by EFH species. EFH is divided into the following components for the purpose of this assessment:

- Bottom habitats used by EFH fish and invertebrate species having benthic or epibenthic eggs and larvae.
- Bottom habitats used by EFH fish species having benthic or epibenthic juvenile life stages.

- Bottom habitats used by EFH fish species that are benthic or epibenthic as adults.
- Bottom habitats used by EFH shellfish species.

The potential for crushing, burial, and entrainment impacts are limited to the permanent footprint of the project and associated short-term disturbance areas. Within these areas, benthic or epibenthic EFH species and/or life stages will be the primary groups affected, with secondary effects on EFH species and/or life stages that prey on benthic and epibenthic organisms. Pelagic species and/or life stages would not be at risk for lethal crushing or burial impacts but could be subject to entrainment effects. Only those life stages likely to be directly exposed to crushing, burial, or entrainment effects or associated effects on benthic prey species are addressed in this section. Crushing, burial, and entrainment exposure and associated effects on benthic prey organisms represent a short-term reduction in habitat suitability for EFH species.

Seabed preparation for foundation installation would also result in suspended sediment and sediment deposition. These impacts are anticipated to be similar in magnitude, but reduced in extent, to those described below in Section 5.1.2.3 for the installation of the IAC. Suspended sediment impacts would be limited to the 656-foot (200-meter) impact radius around each foundation. The distribution of benthic habitats impacted by sediment deposition effects would be the same as those described for seabed preparation in Table 5.3. Refer to Section 5.1.1.1 for an in-depth analysis of the benthic habitat types, associated biogenic features and habitat-forming organisms, and vulnerable EFH species and prey species present in each lease area zone. Based on the site-specific benthic habitat data available for each zone within the lease area (see Section 3.5), EFH species and life stages that would be most vulnerable to indirect impacts resulting from anchoring-induced sedimentation include the eggs and larvae of Atlantic herring, Atlantic sea scallops, red hake, winter flounder, and ocean pout.

<u>Effects on EFH and EFH Species</u>

- Direct
    - Short-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat when anchoring): EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Pelagic species groups; Prey Species – Benthic; Prey Species – Pelagic, Summer Flounder HAPC; Southern New England HAPC.
    - Permanent, localized crushing and burial of EFH species, resulting in mortality: Sessile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Prey –Benthic/Epibenthic species groups.

- Long-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat during anchoring): EFH for Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Southern New England HAPC.
- Short-term avoidance of anchoring activities by EFH species: Mobile Epibenthic/Benthic – Soft Bottom; Mobile Epibenthic/Benthic – Complex; Pelagic; Prey Species – Benthic and Prey Species – Pelagic species groups.

- Indirect
  - Short-term loss of benthic prey items: Mobile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Complex.

Effects on Habitats Used by Benthic, Epibenthic and Pelagic Eggs and Larvae

Benthic or epibenthic eggs that occur within the Lease Area could be exposed to lethal crushing, burial, or entrainment effects. This includes eggs and larvae of selected EFH species, and eggs and larvae that provide prey for EFH species. For example, the pelagic eggs and larvae of Atlantic cod and the pelagic eggs of red hake, two species of federally managed fish that are currently overfished and that have rebuilding plans in place, would be vulnerable to mortality from entrainment effects. The total spatial extent of these potential impacts is approximately 6,536 acres (2,645 hectares), including: seabed preparation (approximately 7.2 acres/monopile), monopile and scour protection installation (approximately 0.03-acres and 0.7-acres/monopile, respectively).

Crushing and burial impacts result from the placement of material on the substrate and would be lethal for benthic and epibenthic eggs and larvae that do not have the ability to avoid the area. For example, the benthic eggs and/or larvae of Atlantic herring, Atlantic sea scallops, longfin squid, winter flounder, red hake, and ocean pout, that are known to be associated with the variety of bedform features (e.g., low- and medium-density boulder fields and ripples) and CMECS substrate subgroup types (e.g., gravelly sand, sandy gravel, coarse sand, medium sand, and fine sand) present in each lease area zone (see Tables 3.5 and 3.6) would be vulnerable to crushing and burial. In addition, the eggs and larvae of these EFH species could be indirectly impacted via the crushing and burial of habitat-forming structures and biogenic features that provide attachment surfaces, shelter, and foraging opportunities. For example, shell hash and sea scallops, which are important biogenic features and EFH for red hake, were observed in SPI/PV imagery in every lease area zone and in almost every benthic habitat type (see Table 3.5). The following EFH species with benthic, epibenthic, or pelagic eggs or larvae that may be exposed to crushing, burial, or entrainment effects during RWF construction and installation:

- Atlantic cod (eggs, larvae)
- Haddock (eggs, larvae)
- Red hake (eggs, larvae)
- Silver hake (eggs, larvae)
- White hake (larvae)
- Monkfish (eggs, larvae)
- Bluefish (eggs, larvae)
- Black sea bass (eggs, larvae)
- Butterfish (eggs, larvae)
- Ocean pout (eggs, larvae)
- Scup (larvae)
- Atlantic herring (eggs, larvae)
- Longfin squid (eggs)
- Atlantic mackerel (larvae)
- Atlantic sea scallop (eggs)
- Summer flounder (eggs, larvae)
- Winter flounder (larvae)
- Windowpane flounder (eggs, larvae)
- Witch flounder (eggs, larvae)
- Yellowtail flounder (eggs, larvae)
- Atlantic sea scallop (larvae)

Effects on Habitats Used by Benthic and Epibenthic Juveniles

EFH species with benthic or epibenthic juveniles that occur within the Lease Areacould be exposed to lethal crushing, burial, or entrainment effects. Behavioral avoidance responses would be expected in juveniles with the ability to swim out of the active construction and installation area. Post-larval juveniles that lack a strong swimming ability would be unable to avoid the construction and installation area and would be subject to lethal effects. For example, larval and juvenile red hake are often found utilizing Atlantic sea scallops as sheltering habitat. Both juvenile red hake and Atlantic sea scallops (juveniles and adults) utilize the gravelly sand, sandy gravel, coarse sand, and medium sand substrates identified within each lease area zone. As such, juvenile red hake would be vulnerable to crushing, burial, and entrainment effects from seabed preparation for WTGs and OSSs. Juvenile monkfish, winter flounder, and ocean pout could also be vulnerable to lethal crushing, burial, and entrainment effects as these EFH species are found in association with gravelly sand, sandy gravel, coarse sand, medium sand substrates present in the project area.

- Butterfish (juvenile)
- Windowpane flounder (juvenile)
- Winter flounder (juvenile)
- Witch Flounder (juvenile)
- Yellowtail flounder (juvenile)
- Atlantic cod (juvenile)
- Black sea bass (juvenile)
- Haddock (juvenile)
- Monkfish (juvenile)
- Ocean pout (juvenile)
- Pollock (juvenile)
- Red hake (juvenile)
- Scup (juvenile)
- Silver hake (juvenile)
- White hake (juvenile)
- Barndoor skate (juvenile)
- Little Skate (juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile)
- Winter skate (juvenile)

Effects on Habitats Used by Benthic or Epibenthic Adult Fish

EFH species with benthic or epibenthic adults that occur within the Lease Areacould be exposed to lethal crushing, burial, or entrainment effects. Adults of EFH species in the area are likely to exhibit behavioral avoidance responses and would not be subject to lethal crushing, burial, or entrainment effects. However, during placement of material on the substrate, there is potential for adult fish utilizing benthic or epibenthic habitats to be crushed or buried. For example, ocean pout, monkfish, winter flounder, winter skates, little skates, Atlantic cod, and red hake are benthic or epibenthic EFH species known to be associated with the various bedform features (i.e., low- to medium-boulder fields, ripples, and linear depressions) and CMECS substrate subgroup types (e.g., gravelly sand, sandy gravel, coarse sand, medium sand, and fine sand) present in each lease area zone (see Tables 3.5 and 3.6) and subject to impacts from seabed preparation for WTG and OSS foundations. Ocean pout, a species of fish that guards benthic nests, could be seasonally vulnerable to being crushed or buried. Benthic invertebrates and other prey organisms targeted by these species and that have been observed in SPI/PV images in each zone (see Tables 3.5 and 3.6) within the lease area (e.g., barnacles, tunicates, sea pens, shrimp, crabs, amphipods, polychaetes, and hydroids) would be killed or otherwise rendered inaccessible by burial and entrainment effects. While unlikely, use of the jet plow during the inter-array cable installation could result in lethal entrainment of adult fish within the disturbance area. EFH species having benthic or epibenthic adult life stages that are known or likely to occur within the spatial extent of crushing, burial, and entrainment effects from RFWF construction and installation include:

- Summer flounder (adult)
- Windowpane flounder (adult, spawning)
- Winter flounder (adult, spawning)
- Witch Flounder (adult, spawning)
- Yellowtail flounder (adult, spawning)
- Atlantic cod (adult, spawning)
- Black sea bass (adult)
- Butterfish (adult)
- Haddock (adult, spawning)
- Monkfish (adult, spawning)
- Ocean pout (adult, spawning)
- Pollock (adult, spawning)
- Red hake (adult, spawning)
- Scup (adult)
- Silver hake (adult, spawning)
- White hake (adult, spawning)
- Atlantic herring (spawning)
- Barndoor skate (adult)
- Little skate (adult)
- Sandbar skate (adult)
- Spiny dogfish (adult, male)
- Winter skate (adult)

Effects on Habitats Used by Benthic Invertebrates

Benthic invertebrates present within the Lease Area could be subject to lethal crushing, burial, or entrainment effects. Individuals within the footprint of the monopiles or scour protection would be crushed or buried during installation. This includes EFH bivalve species, and benthic invertebrates prey resources for certain EFH fish species. Additionally, individuals along the alignment of the inter-array cable or in areas where vessels anchor would also experience lethal crushing or burial effects. Juveniles in the construction and installation area could also become entrained within the jet plow intake during the inter-array cable installation. EFH shellfish species and life stages potentially exposed to crushing, burial, or entrainment effects from RWF construction and installation include:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)

5.1.1.3 UXO Detonation

UXOs could be present within the Lease Area and/or RWEC corridor. UXO identified during preconstruction and installation surveys that cannot be safely relocated would be detonated in place, producing intense underwater noise impacts and benthic habitat disturbance within the blast footprint. In December 2022, Revolution Wind (2022a) reported they had identified 16 UXOs in the project area, all within the RWEC corridor. Orsted (2023) has determined that all 16 devices can be avoided by shifting the RWEC route within the approved installation corridor. Therefore, detonation will not be required for these devices.

It is probable that additional UXOs may be discovered in the Lease Area and RWEC corridor as pre-construction surveys continue (Revolution Wind 2022a). Ordtek (2021) accurately predicted the likelihood of UXO encounters in the RWEC corridor at the mouth and outside of Narragansett Bay. As stated, all 16 UXOs identified in the project area to date were found within this general area in zone RWEC-RI (Orsted 2023). Ordtek (2021) also determined a high likelihood of UXO presence in the central portion of the Lease Area. This suggests that additional devices could be encountered within the RWF foundation and cable installation footprints during pre-construction surveys.

On this basis, BOEM conservatively assumes that additional devices could be encountered within the Lease Area and RWEC that require detonation in place. These devices may range from 5 to 1,000 pounds in size. UXO detonation would occur within the impact footprint for subsequent seabed preparation, cable installation, and/or foundation installation impacts. The resulting substrate disturbance and displacement and damage to habitat-forming organisms would be similar to those from impacts from boulder clearance described for foundation and cable installation in Sections 5.1.1.2 and 5.1.2.4, respectively.

UXO detonation would result in intense sound pressure and particle motion effects with the potential to injure or kill fish and invertebrates and alter their behavior over broad distances. Hannay and Zykov (2022) modeled noise impacts likely to result from UXO detonation. They calculated the distances required to attenuate noise below applicable injury and behavioral thresholds for finfish defined by Popper et al. (2014). These thresholds are specific to barotrauma injury and are the same across all fish hearing groups, 229-234 dB re 1 µPa. The Hannay and

Zykov (2022) results can in turn be used to estimate the extent of EFH exposed to potentially adverse impacts from UXO detonation.

The results produced by Hannay and Zykov (2022) indicate that UXO detonation could kill EFH species within tens to thousands of feet of the source depending on the size of the device and species and life stage exposed. Hannay and Zykov (2022) estimated that adult and juvenile fish within 161 to 951 feet of could be injured or killed by detonation of 5- and 1,000-pound devices, respectively.

As stated, no UXOs have been identified within RWF zones 1 or 2 as of January 2023 but their potential occurrence cannot be discounted. These habitat zones encompass large areas of continuous, large-grained and complex habitats, including medium- and low-density boulder fields, that recent evidence has indicated support spawning cod (BOEM pers. comm. 2022). Direct mortality, disturbance of spawning cod aggregations, and damage to complex habitats (including attached fauna and epifauna present that support adult cod) could potentially result in negative impacts to Atlantic cod. UXOs detonated within the RWEC-RI could also negatively impact juvenile cod HAPC (i.e., areas with cobble and pebble substrates observed in SPI/PV imagery) present within the RWEC-RI. See Section 3.5 for more information regarding the specific benthic habitat (i.e., bedform features and CMECS classifications), as well as biogenic features and habitat-forming organisms found within the central portion of the Lease Area and the RWEC in Rhode Island state waters.

Popper et al. (2014) did not define impact thresholds for fish and invertebrate eggs and larvae, so threshold criteria were derived for this analysis from available literature. Keevan and Hempen (1997) determined that setbacks of 49, 213, and 656 feet would protect fish eggs and larvae from detonation effects for 1.1-, 22-, and 220-pound (0.5, 10, and 100 kg) devices, respectively. Extrapolating from this relationship, the threshold distance for injury to eggs and larvae from a 1,000-pound (454 kg) UXO, the largest device anticipated in the Maximum Work Area (Hannay and Zykov 2022; LGL 2022), is approximately 1,385 feet. Eggs and larvae within these threshold distances would be exposed to potential mortality-level effects from UXO detonation.

Underwater noise impacts to EFH from UXO detonation during seabed preparation for foundation installation are as follows:

Effects to EFH Species and Habitat

- Direct
    - Short-term, direct effects on EFH and EFH species and life stages for all hearing groups, with greatest impacts to species and life stages in the Hearing Specialist group.

- Short-term, direct effects on EFH of all Species Groups: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex Habitat; Mobile Benthic/Epibenthic – Complex Habitat; Pelagic; Prey Species –Benthic/Epibenthic; Prey Species – Pelagic.

5.1.1.4 Pile Driving

The potential direct effects of underwater sound on EFH from project related pile driving activities during installation of the WTG monopiles are evaluated below. To evaluate the potential effects of underwater sound on EFH, it is important to understand the sensitivity of EFH species and life-stages to underwater sound.

Popper et al. (2014) compiled available research on underwater noise effects on fish and other aquatic life and established thresholds for mortality and permanent injury, recoverable injury, and TTS for different types of noise sources based on life stages or hearing group specific sensitivity. NOAA (2016) identifies this resource as the current state of the science for characterizing underwater noise impacts on aquatic species.

Popper et al. (2014) have defined different thresholds for different fish species groups and life stages based on current understanding of sound sensitivity. Research on invertebrate sensitivity to underwater noise is more limited. Thresholds by sensitivity group are defined in the following sections. For evaluating direct effects on EFH, any area exposed to construction and installation-related underwater noise sufficient to cause lethal injury, recoverable injury, TTS, and/or behavioral effects is considered to be temporarily unsuitable for the affected fish or invertebrate species. This constitutes a short-term adverse effect on EFH lasting for the duration of the associated noise source.

The currently available underwater noise exposure thresholds for fish are based on the sound pressure component. Several fish species, notably those species in the hearing specialist group such as Atlantic cod, are also sensitive to the particle motion component of sound (Roberts and Elliot 2015; Popper and Hawkins 2018; Hawkins et al. 2021). Invertebrates, particularly benthic and epibenthic species are also able to detect vibration and particle motion effects transmitted through sediments (Roberts and Elliot 2015; Popper and Hawkins 2018; ; Hawkins et al. 2021). Impact pile driving can produce intense particle motion effects within a short distance of the pile surface and can transmit particle motion effects in low frequency bands (1 to 40 Hz) over broader distances through vibration of the seabed (Hawkins et al. 2021). Particle motion effects from substrate vibration caused by impact pile driving could be detectable to sensitive fish and invertebrate species on or within a few feet of the seabed potentially several thousand feet of the source (Hawkins et al. 2021). Particle motion effects are unlikely to cause injury to invertebrates or fish but could affect their behavior (Roberts and Elliot 2015; Hawkins et al. 2021). Fish and invertebrate EFH species that have benthic or epibenthic life stages, such longfin squid (eggs and adults), Atlantic herring (spawning adults and eggs), ocean pout (all life stages), little skates (all life stages), winter flounder (all life stages), red hake (juveniles and adults), monkfish (juveniles and adults), and winter skates (all life stages) would be vulnerable to particle motions effects and substrate vibrations created by pile driving. Depending on the distance to the source, the particle motion and substrate vibrations created from pile driving activity may cause mortality, physical injury, or cause more mobile individuals to flee suitable habitats, increasing the potential for predation. Spawning longfin squid that aggregate to spawn could be startled and potentially flee the area/cease spawning activity, which could indirectly affect other EFH species in the project area that prey on this species (e.g., Atlantic cod, pollock, haddock, silver hake, and flounder).

Popper and Hawkins (2018) conclude that Atlantic cod, and probably many other fish species in the hearing specialist group, are sensitive to both sound pressure and particle motion and use both aspects of sound to assess and orient themselves in the three-dimensional aquatic environment. This ability likely enables fishes to locate particular sources of sound, such as prey or potential mates, and may also assist them in identifying and locating sounds from a particular source within the general ambient noise environment. Anthropogenic sounds that interfere with the ability to detect sound pressure and particle motion could potentially interfere with this ability (Hawkins et al. 2021).

While these potential effects are acknowledged, exposure thresholds for the particle motion component of sound have yet to be developed for fish and invertebrates (Hawkins et al. 2021). As such, the potential effects on these species from the particle motion component of cannot be fully assessed at this time.

Underwater noise impacts to EFH from impact pile driving used during foundation installation are as follows:

<u>Effects to EFH Species and Habitat</u>

- Direct
  - Short-term, direct effects on EFH and EFH species and life stages for all hearing groups, with greatest impacts to species and life stages in the Hearing Specialist group.
  - Short-term, direct effects on EFH of all Species Groups: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex Habitat; Mobile Benthic/Epibenthic – Complex Habitat; Pelagic; Prey Species – Benthic/Epibenthic; Prey Species – Pelagic.

The specific thresholds used to evaluate underwater noise impacts from foundation installation, estimated sound attenuation distance to these thresholds, area affected for each hearing group threshold, and a summary of impacts to EFH species and habitats are summarized by hearing group in the following sections. This discussion includes the supporting rationale for the effects conclusions provided above.

Sound Exposure Thresholds by Hearing Group

Eggs and Larvae

Popper et al. (2014) defined eggs and larvae as a separate hearing group for the purpose of evaluating potential noise exposure thresholds on the basis that the sound sensitivity of these life stages is not well studied. Current understanding of noise impacts focuses on sensitivity to barotrauma and rectified diffusion injuries rather than hearing impacts. Noise effect thresholds for eggs and larvae used in this analysis are:

- Peak injury, lethal (L_{pk}): >207 dB re 1 µPa
- Cumulative injury, lethal ($L_{E, 24hr}$): >210 dB re 1 µPa^{2}s
- Recoverable injury: None defined
- TTS: None defined
- Behavioral effects: Not applicable

Hearing Specialists

Popper et al. (2014) identify specific injury thresholds for hearing specialist fish species. Hearing specialists are species such as Atlantic cod and other gadids that have a swim bladder that is directly connected to the inner ear through physiological structures or is in direct proximity to hearing organs and involved in hearing. Hearing specialization is often associated with intra-specific communication that can be disrupted by changes in the ambient noise environment. For example, spawning Atlantic cod communicate using low-frequency grunts to locate potential mates and signal fertility. Changes in ambient noise can interfere with communication and potentially disrupt spawning activity (Rowe and Hutchings 2006). Underwater noise sufficient to alter behavior or cause TTS could have disruptive effects on cod spawning (Dean et al. 2012), such as actively occurring pile-driving.

Popper et al. (2014) defined the following thresholds for instantaneous and cumulative injury, recoverable injury, and TTS effects. Popper et al. (2014) does not, however provide behavioral thresholds for fish so for impulsive sounds so the arbitrary criterion for behavioral effects established by NMFS (CalTrans 2020) is used herein. These thresholds are as follows:

- Peak injury, lethal (L_{pk}): >207 dB re 1 µPa
- Cumulative injury, lethal ($L_{E, 24hr}$): 207 dB re 1 µPa^{2}s
- Peak injury, recoverable (L_{pk}): >207 dB re 1 µPa
- Cumulative injury, recoverable ($L_{E, 24hr}$): 203 dB re 1 µPa^{2}s

- TTS ($L_{E,\,24hr}$): 186 dB re 1 µPa^{2}s
- Behavioral response (L_{rms}): 150 dB re 1 µPa

And for continuous noise sources like vessel engines and vibratory pile driving:

- Lethal injury: Unlikely to occur
- Cumulative injury, recoverable ($L_{E,\,48hr}$): 170 dB re 1 µPa^{2}s
- TTS ($L_{rms,\,12hr}$): 158 dB re: 1 µPa for 12 hr
- Behavioral response: not available

Hearing Generalists

Popper et al. (2014) identify specific injury thresholds for hearing generalist fish species. Hearing generalists are defined as those species having a swim bladder that is not directly involved with hearing. Popper et al. (2014) and FHWG (2008) define the following thresholds for instantaneous and cumulative injury, recoverable injury, TTS, and behavioral effects from exposure to impulsive noise sources like impact pile driving and HRG surveys:

- Peak injury, lethal (L_{pk}): >207 dB re 1 µPa
- Cumulative injury, lethal ($L_{E,\,24hr}$): 210 dB re 1 µPa^{2}s
- Peak injury, recoverable (L_{pk}): >207 dB re 1 µPa
- Cumulative injury, recoverable ($L_{E,\,24hr}$): 203 dB re 1 µPa^{2}s
- TTS ($L_{E,\,24hr}$): >186 dB re 1 µPa^{2}s
- Behavioral response (L_{rms}): 150 dB re 1 µPa

And for continuous noise sources like vessel engines and vibratory pile driving:

- Lethal injury: Unlikely to occur
- Cumulative injury, recoverable: Unlikely to occur
- TTS: Unlikely to occur
- Behavioral response (L_{pk}): not available

Fish with No Swim Bladder

Popper et al. (2014) identify specific injury thresholds for fish species that lack swim bladders and gas-filled organs that are particularly sensitive to overpressure injuries. Popper et al. (2014) and FHWG (2008) define the following thresholds for instantaneous and cumulative injury, recoverable injury, TTS, and behavioral effects from exposure to impulsive noise sources like impact pile driving and HRG surveys:

- Peak injury, lethal (L_{pk}): >213 dB re 1 µPa
- Cumulative injury, lethal ($L_{E,\,24hr}$): >219 dB re 1 µPa^{2}s
- Peak injury, recoverable (L_{pk}): >213 dB re 1 µPa

- Cumulative injury, recoverable ($L_{E,\ 24hr}$): >216 dB re 1 μPa^{2}s
- TTS ($L_{E,\ 24hr}$): much greater than (>>)186 dB re 1 μPa^{2}s
- Behavioral response (L_{rms}): 150 dB re 1 μPa

And for continuous noise sources like vessel engines and vibratory pile driving:

- Lethal injury: Unlikely to occur
- Cumulative injury, recoverable: Unlikely to occur
- TTS: Unlikely to occur
- Behavioral response: Unlikely to occur

Invertebrates

Noise thresholds for adult invertebrates have not been developed because of a lack of available data. In general, mollusks and crustaceans are less sensitive to noise-related injury than many fish because they lack internal air spaces and are less susceptible to over-expansion or rupturing of internal organs, the typical cause of lethal noise related injury in vertebrates (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., scallops, ocean quahog) are capable of sensing sound through particle motion (Carroll et al. 2016; Edmonds et al. 2016; Hawkins and Popper 2014; Mooney et al. 2010). Particle motion effects dissipate rapidly and are highly localized around the noise source. Studies of the effects of intense noise sources on invertebrates, similar in magnitude to those expected from Project construction and installation, found little or no measurable effects even in test subjects within 3.3 feet (1 meter) of the source (Edmonds et al. 2016; Payne et al. 2007).

Recent research on invertebrate sensitivity to sound is equivocal. Some studies have concluded that that repeated exposure to high-intensity sound pressure could lead to injury of sensory cells used for spatial orientation and predator and prey detection (Andre et al. 2011; Solé et al. 2018, 2022). These findings suggest that exposure to low frequency sound sources like impact and vibratory pile driving could negatively affect survival. Depending on sound intensity, those effects could occur up to 3,000 feet or more from the source (Solé et al. 2018, 2022). Jones et al. (2020, 2021) evaluated longfin squid sensitivity to high-intensity impulsive sound comparable to monopile installation. They observed that squid displayed behavioral responses to particle motion effects within 6.6 feet (2 meters) of high intensity impulsive noise comparable to that resulting from impact hammer installation of large steel foundation piles like those used in offshore wind energy projects. They further theorized that squid in proximity to the seabed might be able to detect particle motion from impact pile driving imparted through sediments “several hundred meters” from the source, eliciting short-term behavioral responses lasting for several minutes. However, Jones et al. (2020, 2021) also observed rapid habituation to experimental sound levels and found no statistically significant difference between exposure and control groups in observed ability to capture prey (Jones et al. 2021). Cones et al. (2022a, 2022b) found that pile driving noise can induce behavioral responses in squid, but short-lived disruptions in behavior and movement are likely to have minimal impacts on energetics and are therefore unlikely to lead to biologically significant effects. Ongoing research funded by BOEM (BOEM Pers. comm. 2023b) has observed no significant changes in reproductive behaviors, such as mate guarding, in longfin squid after habituation to underwater noise exposure comparable to impact pile driving.

Collectively, these findings suggest some potential for underwater noise impacts on EFH invertebrate species from impact pile driving and other intense underwater noise sources. These effects could range from short-term behavioral disturbance to potential injury leading to reduced survival. However, additional research is needed to understand the biological significance of these effects and no thresholds are available for quantifying the extent of potential impacts.

Based on the available evidence, BOEM is using the following exposure distances to evaluate noise effects on EFH for invertebrates:

- Injury-level effects to squid larvae:
    - Within 3,000 feet (914 meters) of impact pile driving.
- Squid behavioral effects:
    - Within 1,640 feet (500 meters) of impact pile driving.
    - Within 6.6 feet (2 meters) of HRG survey activities.
- Bivalve behavioral effects:
    - Within 26 feet (2 meters) of impact pile driving.

Potential Extent of Underwater Sound Impacts by Hearing Group

The extent of underwater noise from impact pile driving 12-meter WTG monopiles and 15-meter OSS monopiles for RWF construction and installation that exceeds the effect thresholds defined above are summarized below in Table 5.4 and shown graphically in Figure 5.1. The impact areas presented in Figure 5.1, below are a simplified approximation of the maximum extent of potential adverse effects on each fish and invertebrate species hearing group. This area likely misrepresents the actual extent of noise impacts for the following reasons:

- The estimated area of impact is a set of overlapping circles based on the maximum impact radius for each pile type around each foundation, assuming 1 pile per day installation.
- Ranges that overlap underrepresent potential animal exposure within the overlapping area.

- Acoustic ranges are not necessarily uniform in every direction, due to differences in bathymetry, substrate type, and other factors.

- Acoustic ranges may vary on any given day due to differences in water temperature, stratification patterns, and other factors.

As such, the impact area displayed in Figure 5.1 should be treated as a general representation of the maximum potential extent of combined noise impacts. Moreover, threshold distances presented for monopile installation in Table 5.4 assume that an individual fish would be exposed to the number of pile strikes required to install three monopiles. This is an unlikely exposure scenario as the affected fish would have to travel between and remain within the threshold distance of three WTG monopiles installations in a given construction day. Thus, these ranges are conservative.

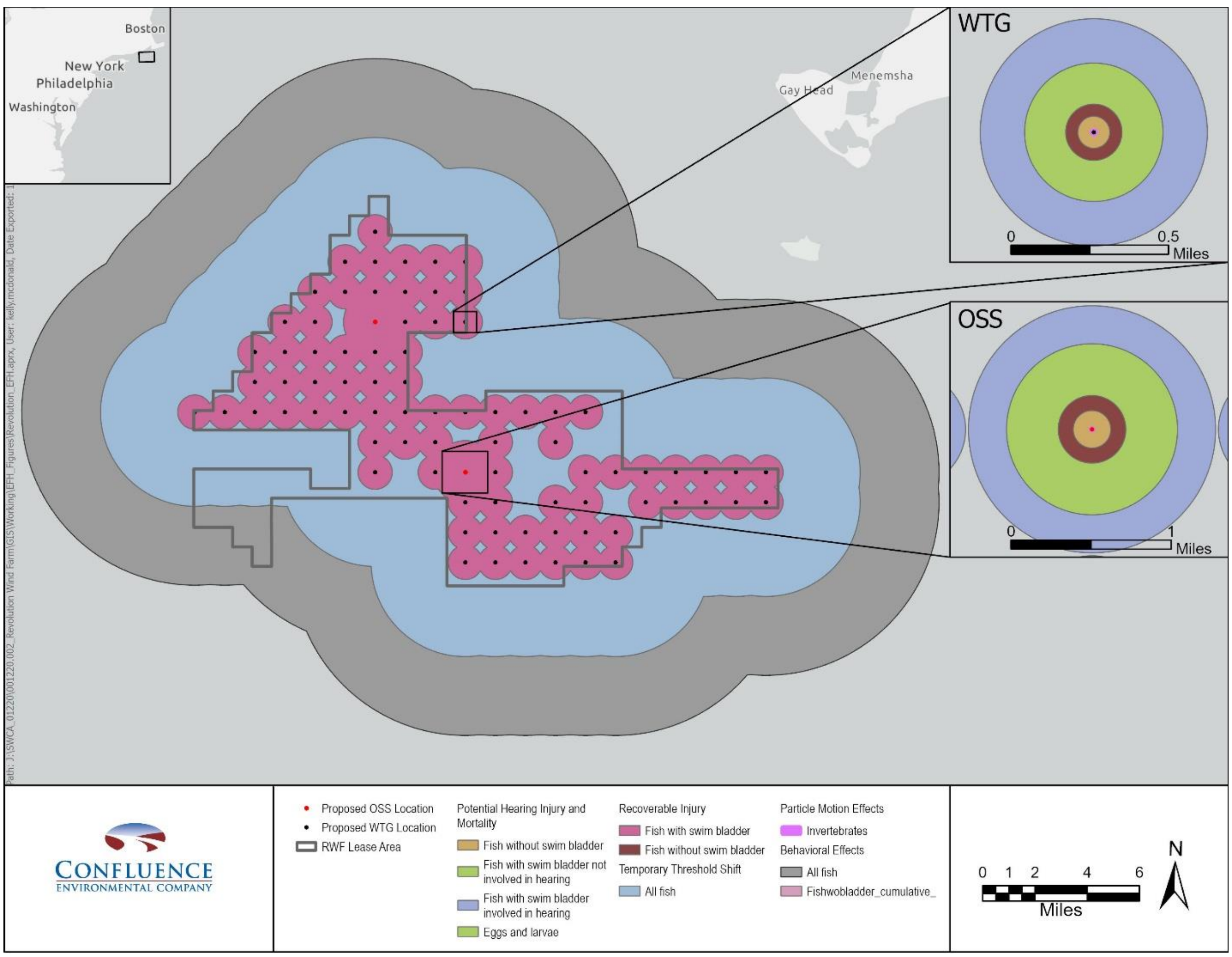

Figure 5.1. Approximate Area Exposed to Impact Pile Driving Noise Above Indicated Thresholds from WTG and OSS Installation by Fish Hearing Group.

Table 5.4. Distances to Underwater Noise Injury and Behavioral Thresholds by Fish Hearing Group and Exposure Type for Pile Driving Used for Wind Turbine Generator and Offshore Substation Foundation Installation, and RWEC Construction.

Activity†	Number of Sites	Total Days	Noise Exposure Type	Hearing Group	Exposure Threshold*	Range of Threshold Distances (feet)‡
12-meter WTG monopile foundation installation	100	33	Peak injury	Fish–Swim bladder involved in hearing	207	69-371
				Fish–Swim bladder not involved in hearing	207	69-371
				Fish–No swim bladder	213	13-59
				Eggs and larvae	207	69-371
			Cumulative Injury	Fish–Swim bladder involved in hearing	207	3,848-5,883
				Fish–Swim bladder not involved in hearing	210	2,470-3,638
				Fish–No swim bladder	219	604-856
				Eggs and larvae	210	2,470-3,638
				Cephalopod larvae	None established	3,000+
			TTS	All fish	186	23,094-43,842
			Behavioral effects	All fish	150	14,403-34,987
15-meter OSS monopile foundation installation	2	2	Peak injury	Fish–Swim bladder involved in hearing	207	125-299
				Fish–Swim bladder not involved in hearing	207	125-299
				Fish–No swim bladder	213	33-62
				Eggs and larvae	207	125-299
			Cumulative Injury	Fish–Swim bladder involved in hearing	207	3,885-5,194
				Fish–Swim bladder not involved in hearing	210	2,756-3,458
				Fish–No swim bladder	219	617-797
				Eggs and larvae	210	2,756-3,458

Activity†	Number of Sites	Total Days	Noise Exposure Type	Hearing Group	Exposure Threshold*	Range of Threshold Distances (feet)‡
				Cephalopod larvae	None established	3,000+
			TTS	All fish	186	20,623-38,625
			Behavioral effects	All fish	150	15,157-35,722
Temporary cofferdam installation	2	56	Behavioral effects	All fish	150	2,543
Casing pipe and support pile installation§	2	4	Behavioral effects	All fish	150	32,808

† Installation scenario for 12-m monopile is 6,500 strikes/pile at installation rate of three monopiles/day. Installation scenario for 15-m monopile is 8,000 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.

* Peak injury thresholds are SPL in dB re 1 μPa; cumulative injury thresholds are SEL in dB re 1 μPa^{2}·s for 12 hours of exposure; behavioral injury threshold is SPL in dB re 1 μPa.

‡ Threshold distances are the distance in feet from the sound source where the identified type of exposure could occur. WTG and OSS values are the range of threshold distances for monopile installation modeled by Kusel et al. (2021) across modeled sites and seasonal conditions. Values presented for the three WTG monopiles/day scenario are not presented in Kusel et al. (2021) and were provided to BOEM on request. Estimated exposure distances for injury to cephalopod larvae are inferred from Solé et al. (2018, 2022), no exposure thresholds have been established.

§ Values are estimated using the estimated source levels provided by Zeddies (2021) and the cylindrical spreading loss model for sound attenuation

Summary of Potential Pile Driving Related Underwater Noise Impacts by Hearing Group

Underwater Noise Impacts on Eggs and Larvae

Applying the noise impact thresholds defined above, the area of water column and benthic EFH for eggs and larvae exposed to potentially lethal instantaneous noise effects would extend up to 69-371 feet (21-113 meters) of sources of pile driving each 12-meter monopile. Cumulative injury level effects from repeated exposure to impact pile driving noise could occur within approximately 2,470 to 3,683 feet and 2,756 to 3,458 feet of WTG and OSS monopile installations, respectively. These effects would apply to both the eggs and larvae of EFH and eggs and larvae that provide prey for EFH species. The cumulative injury exposure area values are conservative, as planktonic eggs and larvae drift with the current and would not necessarily remain within the same exposure area over an entire 6- to 12-hour pile driving period.

The extent and consequences of underwater noise exposure on eggs and larvae are likely to vary for several reasons. The instantaneous injury exposure area (area within which modeled underwater noise from a single monopile installation is above the injury threshold for fish eggs and larvae) is relatively small (within a few thousand feet of each site). Stationary eggs and larvae within this area would likely experience higher than natural levels of mortality. However, eggs and larvae that drift with the current would not remain in the exposure area for extended periods, and the additional impacts would not likely be significant relative to natural mortality rates on the order of 1% to 10% per day (White et al. 2014).

EFH for eggs and larvae of the following species would be rendered temporarily unsuitable by short-term exposure to underwater noise from RWF construction and installation sufficient to cause injury or mortality-level effects:

- Atlantic cod
- Haddock (larvae only)
- Pollock
- Red hake
- Silver hake
- White hake
- Atlantic herring (larvae only)
- Atlantic mackerel
- Bluefish
- Butterfish
- Ocean pout (eggs only)
- Monkfish
- Bluefin tuna (larvae only)
- Summer flounder
- Windowpane flounder
- Witch flounder
- Yellowtail flounder
- Atlantic sea scallop

Underwater Noise Impacts on EFH Species in the Hearing Specialist Group

Construction and installation of the RWF would result in impulsive and continuous noise sources that exceed the effects thresholds for hearing specialist fish species defined above. The EFH for juvenile and adult fish belonging to the hearing specialist group would be affected. Hearing specialist fish that provide prey for EFH species would also be directly affected in the short-term. Water column and benthic EFH exposed to underwater noise in excess of potential lethal, recoverable injury, TTS, and behavioral effects are described by noise source for impact pile driving, HRG surveys, and vessel noise below.

Effects from the pile-driving two 12-meter monopiles:

- Potentially lethal:
    - Instantaneous injury: Up to approximately 69-371 feet (21-113 meters) of the source.
    - Cumulative injury: Up to approximately 3,848-5,883 feet (1,173-1,793 meters) of the source.
- Recoverable injury:
    - Instantaneous injury: Up to approximately 69-371 feet (21-113 meters) of the source.
    - Cumulative injury: Up to approximately 6,562-9,357 feet (2,000-2,852 meters) of the source.

- TTS and behavioral level:
    - TTS exposure: Up to approximately 23,094-43,842 feet (7,039-13,363 meters)] of the source.
    - Behavioral effects exposure: Up to approximately 14,403-34,987 feet (4,390-10,664 meters) of the source.

The cumulative exposure extents presented above assumes that an individual fish would remain within the exposure area over an entire 6- to 12-hour pile driving period.

The following EFH species belong to the hearing specialist group and have habitats that are likely to be adversely affected by underwater noise from construction and installation of the RWF:

- Atlantic cod (juvenile, adult, spawning)
- Pollock (juvenile)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile)
- Black sea bass (juvenile, adult)
- Bluefish (juvenile, adult)
- Monkfish (juvenile, adult, spawning)
- Atlantic herring (juvenile, adult, spawning)

Noise impacts on fish are likely to vary by species depending on general sensitivity to sound and how noise impacts overlap with sensitive life stages. Meekan et al. (2021) found no significant impacts to population, community structure, behavior, or distribution of demersal finfish in response to experimental exposure to seismic survey noise. Although this effort studied a different fish community in western Australia, the results may be instructive here. The finding of no significant impact on fish population biology or community structure suggests that, for many fish species, noise impacts are likely to be short term and localized. Noise impacts could be greater if they occur in important spawning habitat, occur during peak spawning periods, and/or result in reduced reproductive success in one or more spawning seasons, which could result in long-term effects to populations if one or more year classes suffer suppressed recruitment. Alteration of the ambient noise environment could interfere with this ability, leading to potentially significant effects varying by species.

For example, Atlantic cod, hake, and black sea bass belong to the hearing specialist group and rely on sound for communication and other important behaviors. Stanley et al. (2020) determined that noise from activities like impact pile driving could interfere with black sea bass communication during spawning but concluded that they would likely return to normal spawning behavior once the impact ceased. In contrast, other species such as Atlantic cod may be more sensitive to noise impacts. Atlantic cod may be sensitive to noise and other forms of disturbance during spawning. Atlantic cod rely on communication during spawning, using low-frequency grunts to locate potential mates and signal fertility (Rowe and Hutchings 2006). Cod may interrupt or abandon spawning when repeatedly exposed to intense disturbance (Andersson et al.

2017; Dean et al. 2012; Engås et al. 1996; Meuller-Blenke et al. 2010), but brief disturbance may not necessarily disrupt spawning. For example, Morgan et al. (1997) observed the dispersal of a spawning aggregation of Atlantic cod by the passage of a single bottom trawl for a brief period (approximately 1 hour), after which the aggregation returned to the affected area and resumed spawning. In another study, McQueen et al. (2022) observed that exposure to seismic airgun noise did not cause displacement of Atlantic cod from their spawning grounds. They speculated that strong site affinity could explain the lack of a significant behavioral response to an otherwise intensive stressor. These contrasting findings suggest that short-term periods of disturbance may not necessarily result in adverse effects on Atlantic cod spawning.

Alteration of the ambient noise environment could interfere with communication and alter behavior in ways that could disrupt localized cod spawning aggregations (Dean et al. 2012; Rowe and Hutchings 2006). Monopile installation is the most extensive noise impact and the most likely to cause this potential effect. Impact pile driving would occur from May through December. BOEM has documented the presence of spawning Atlantic cod within and in proximity to the Lease Area in November and December (Inspire Environmental 2019b), indicating that pile driving could occur when maturing and mature spawning cod are present in the vicinity of the Maximum Work Area.

Underwater Noise Impacts on EFH Species in the Hearing Generalist Group

Construction and installation of the RWF would result in impulsive and continuous noise sources that exceed the effects thresholds for hearing generalist fish species defined above. The EFH for juvenile and adult fish species belonging to this hearing group would be affected by behavioral and TTS level effects extending up to 43,842 feet (13,363 meters) of the source. Hearing generalist fish that provide prey for EFH species would also be temporarily affected. Water column and benthic EFH exposed to underwater noise in excess of potential lethal, recoverable injury, TTS, and behavioral effects are described by noise source for impact pile driving below.

Potentially lethal effects:

- Instantaneous injury: Up to approximately 69-371 feet (21-113 meters) of the source.
- Cumulative injury: Up to approximately 2,470-3,638 feet (753-1,109 meters) of the source.

Recoverable injury level effects:

- Instantaneous injury: Up to approximately 69-371 feet (21-113 meters) of the source.
- Cumulative injury: Up to approximately 6,562-9,357 feet (2,000-2,852 meters) of the source.

TTS and behavioral level effects:

- Effects are the same for all fish (see above for fish with swim bladder involved in hearing (hearing specialist).

The cumulative exposure area values presented above assume that an individual fish would remain within the same exposure area over an entire 2- to 4-hour pile driving period.

The following EFH species belong to the hearing generalist group and have habitats that are likely to be adversely affected by underwater noise from construction and installation of the RWF.

- Ocean pout (juvenile, adult, spawning)
- Butterfish (juvenile, adult)
- Scup (juvenile, adult)
- Albacore (juvenile, adult)
- Bluefin tuna (juvenile, adult)
- Skipjack tuna (juvenile, adult)
- Yellowfin tuna (juvenile, adult)

Underwater Noise Impacts on EFH Species in the Fish with No Swim Bladder Group

Impulsive and continuous noise sources from RWF construction and installation would exceed the effects thresholds for fish with no swim bladder defined above. The EFH for the juvenile and adult bony fishes and elasmobranch species belonging to this hearing group would be affected. Fish in this hearing group that provide prey for EFH species would experience similar effects. Water column and benthic EFH exposed to underwater noise in excess of potential lethal, recoverable injury, TTS, and behavioral effects are described by noise source for impact pile driving below.

Potentially lethal effects:

- Instantaneous injury: Up to approximately 13-59 feet (4-18 meters) of the source.
- Cumulative injury: Up to approximately 604-856 feet (184-261 meters) of the source.

Recoverable injury level effects:

- Instantaneous injury: Up to approximately 13-59 feet (4-18 meters) of the source.
- Cumulative injury: Up to approximately 879-1,378 feet [267-420 meters] of the source.

TTS and behavioral level effects:

- Effects are the same for all fish (see above for fish with swim bladder involved in hearing (hearing specialist).

The cumulative exposure area values presented above assume that an individual fish would remain within the same exposure area over an entire 6- to 12-hour pile driving period.

The following EFH species belong to the hearing group of fishes that lack a swim bladder and have habitats that are likely to be adversely affected by underwater noise from construction and installation of the RWF:

- Summer flounder (adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)
- Basking shark (neonate/young-of-year (YOY), juvenile, adult)
- Blue shark (neonate/YOY, juvenile, adult)
- Dusky shark (neonate/YOY, juvenile, adult)
- Common thresher shark (neonate/YOY, juvenile)
- Shortfin mako shark (neonate/YOY, juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (juvenile, adult)
- Tiger shark (juvenile, adult)
- White shark (neonate/YOY, juvenile)
- Smooth dogfish (neonate/YOY, juvenile, adult)
- Spiny dogfish (subadult, adult)

Underwater Noise Impacts on EFH Species in the Invertebrate Group

Invertebrates like squid, bivalves, worms, and crustaceans lack specialized hearing organs and gas-filled body cavities and sense sound in the form of particle motion rather than sound pressure (Carroll et al. 2016; Edmonds et al. 2016; Jones et al. 2020, 2021; Hawkins and Popper 2014; Payne et al. 2007). Popper et al. (2014) were unable to recommend useful particle motion thresholds for injury or behavioral-level effects because considerable uncertainty remains about invertebrate sensitivity to various aspects of sound (Popper and Hawkins 2018).

Current research indicates that many 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). Most research suggests that particle motion effects dissipate rapidly and are highly localized around the noise source, with detectable effects on invertebrates typically limited to within 3 to 30 feet of the source (Edmonds et al. 2016; Jézéquel et al. 2022; Payne et al. 2007). However, the implication that invertebrate sensitivity to sound would be similarly limited is complicated by the fact that substrate vibration can transmit detectable particle motion effects over greater distances. For example, Jézéquel et al. (2022) observed that substrate vibration from impact pile driving caused behavioral responses in Atlantic sea (giant) scallop, specifically rapid closing of shells in response to each pile strike, up to 26 feet (8 meters) from the source. No visible responses were observed at 164 feet (50 meters) from the source, indicating that these behavioral effects are generally localized to the vicinity of the disturbance. These findings, combined with the research cited above, indicate that infaunal organisms, such as clams, worms, and amphipods, could exhibit a behavioral response to vibration effects over a larger area than implied by particle motion.

Similarly, Jones et al. (2020, 2021) determined that longfin squid, an EFH species, can likely sense and exhibit behavioral responses to vibration from impact pile driving transmitted through sediments, potentially several hundred to several thousand feet from the source. They theorized that intense particle motion exposure could have temporary indirect effects (e.g., impaired ability to detect predators or prey) on squid. The consensus of the cited studies suggests that impact pile driving could produce behavioral effects on squid in proximity to the seabed (i.e., within 3.3 feet [1 meter]) extending up to approximately 1,640 feet [500 meters] from the source from RWF construction and installation.

Certain mollusks be more sensitive to sound related injury and behavioral effects that other invertebrate groups. Cephalopods, the group of species that includes cuttlefish and squid, use specialized cells called statocysts for balance and spatial orientation, and to detect particle motion signals indicating the presence of predators and prey. Statocysts appear to be susceptible to injury from intense sound exposure. Andre et al. (2011) observed damage to statocysts in squid exposed to 2 hours of continuous noise pulses ranging from 157 to 175 dB re 1 µPa. Solé et al. (2018, 2022) exposed various species of cephalopod larvae to underwater noise comparable to impact pile driving and observed similar statocyst injuries that were likely to negatively affect survival. Solé et al. (2022) found that exposure to impact pile driving noise above 170 dB re 1 μPa^2 caused observable damage to statocysts in cuttlefish larvae, and that those effects could be attributed to the sound pressure, (versus particle motion) component of noise. That damage resulted in an apparent reduction in survival and reduced response to predator stimuli in the developing larvae. Solé et al. (2018) observed similar statocyst damage in two species of squid exposed to maximum peak noise levels of 175 dB re 1 µPa. While Kusel et al. (2021) did not explicitly model exposure distances to these thresholds, their findings suggest that project-related impact pile driving could cause injury-level on cephalopods at distances on the order of 3,000 feet or more from each foundation site. Project-related impact pile driving would produce noise levels of this intensity potentially several thousand feet from the source.

Collectively, these findings suggest that certain invertebrates like squid could experience injury or behavioral effects from intense underwater noise exposure potentially several thousand feet from the source. Similarly, bivalves and other benthic infauna may also be susceptible to temporary behavioral effects from substrate vibration and particle motion effects within tens to potentially hundreds of feet from the source. While this potential is acknowledged, additional research is needed to establish the exposure thresholds necessary to determine the likelihood, extent, and severity of these potential effects.

The following EFH invertebrate species are likely to be exposed to impulsive noise sources from RWF construction and installation sufficient to temporarily alter their behavior:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)
- Longfin squid (eggs, juvenile, adult)

5.1.1.5 Installation of Foundations Scour Protection

Revolution Wind is considering WTGs ranging from between 8 MW to 12 MW capacity. Regardless of capacity, the WTGs would be installed on 12-meter (39-foot) diameter monopile foundations. This equates to an impact footprint of 0.03 acres for each foundation. The planned OSS foundations would each have a base diameter of 49 feet (15 meters), which equates to an impact area of 0.04 acres per monopile. Each monopile foundation would be surrounded by approximately 0.7 acres of rock scour protection, placed by a rock dumping vessel. Table 5.5 provides the area of impact for the RWF WTGs and OSS based on NOAA Habitat Complexity Categories. For subsequent discussion, the two OSS monopiles are considered in aggregate with the WTG monopiles, and the total footprint area is presented for 102 monopiles.

Table 5.5. Total Area Exposed to Habitat Disturbance During Monopile Foundation and Scour Protection Installation by NOAA Habitat Complexity Category.

Habitat Zone	Foundation Element	Number of Features	Feature Acres	Feature Percent of Zone Area	Proportion in Large-Grained Complex Habitat	Proportion in Complex Habitat	Proportion in Soft Bottom Habitat
RWF 1	WTG monopiles†	7	0.2	0.003%	14.3%	44.6%	41.1%
	Scour protection†,‡	7	4.7	0.07%	14.3%	50.4%	35.3%
RWF 2	WTG monopiles†	30	0.9	0.002%	6.3%	49.8%	43.9%
	OSS monopile†	1	0.04	0.0001%	--	--	100%
	Scour protection†,‡	31	20.8	0.06%	6.2%	52.6%	41.2%
RWF 3a	WTG monopiles†	6	0.2	0.005%	16.7%	52.6%	30.8%
	Scour protection†,‡	6	4.0	0.13%	10.2%	63.2%	26.6%
RWF 3b	WTG monopiles†	0	--	--	--	--	--
	Scour protection†,‡	0	--	---	--	--	--
RWF 4	WTG monopiles†	36	1.0	0.003%	2.7%	6.8%	90.5%
	OSS monopile†	1	0.04	0.0001%	--	100%	--
	Scour protection†,‡	37		0.08%	2.7%	5.9%	91.4%

† The habitat composition shown is based on the mapped habitat composition within a circular seafloor preparation radius within the proposed monopile footprints of 0.03 and 0.04 acre for the 12-meter and 15-meter diameter WTG and OSS foundations, respectively, and an estimated 0.71 acre of rock scour protection placed in a circular area around each monopile. The scour protection acreages include the monopile footprints (i.e., they represent total impact area).

‡ Cable protection system installation at WTG and OSS foundation installation would mostly overlap scour protection, but some benthic habitat disturbance would extend beyond the scour protection footprint (approximately 0.07 additional acre per foundation). These impacts will occur within the broader seafloor preparation footprint and are accounted for in seabed preparation as overlapping impacts.

The total spatial extent of impact includes the permanent footprint of the monopiles and scour protection (approximately 2.5 acres and 57 acres [1.0 hectares and 23 hectares], respectively), as well as seabed preparation including up to approximately 6.3 acres (2.5 hectares) per monopile. Total area impacted by monopile installation, scour protection, and seabed preparation would be approximately 582 acres (236 hectares). Inspire Environmental (2021) mapped benthic habitat using the NOAA CMECs classification and grouped those observed habitat types into the three NOAA habitat complexity categories: soft bottom, complex, and large grained complex. Based on the NOAA Habitat Complexity Categories mapped by Inspire Environmental (2021), it is assumed that of the 81 monopiles to be installed within the Lease Area; 64 percent would be in Soft Bottom Habitat, 30 percent would be in Complex Habitat, and 6 percent would be in Large-Grained Complex Habitat, based on the proportion of area of each Habitat Complexity Category mapped within the Lease Area. It is assumed the 582 acres (236 hectares) of seabed preparation would occur in Complex and Large-Grained Complex habitat categories mapped within the 75,907-acres of habitat present in RWF zones 1, 2, 3a, 3b, and 4, representing approximately 0.8 percent of total zone area. Potential impacts from crushing, burial, and direct disturbance could occur throughout the total footprint estimated for each option.Monopile installation will occur from a jack-up lift barge or derrick barge. Impacts related to vessel anchorage are addressed in Section 5.1.1.1. Specific crushing or burial impacts that may occur during monopile installation could result from boulder relocation when clearing the installation site or from the pile driving of the monopile itself, as it contacts the substrate. Scour protection, consisting of engineered rock, will be placed from a fall-pipe vessel or stone dumping vessel. This placement could crush or bury EFH species utilizing benthic or epibenthic habitat within the spatial extent defined above. Crushing and burial effects from this construction element would be similar in nature to those described for seabed preparation in Section 5.1.1.2 and would occur within the same impact footprint.

Effects on EFH and EFH Species

- Direct
    - Short-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat when anchoring): EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Pelagic species groups; Prey Species – Benthic; Prey Species – Pelagic, Summer Flounder HAPC; Summer Flounder HAPC.
    - Permanent, localized crushing and burial of EFH species: Sessile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Prey –Benthic/Epibenthic species groups.

- Long-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat during anchoring): EFH for Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Southern New England HAPC.
- Short-term avoidance of anchoring activities by EFH species: Mobile Epibenthic/Benthic – Soft Bottom; Mobile Epibenthic/Benthic – Complex; Pelagic; Prey Species – Benthic and Prey Species – Pelagic species groups.

- Indirect
  - Short-term loss of benthic prey items: Mobile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Complex.

In addition to the short-term effects, the presence of foundations and scour protection would constitute a permanent habitat conversion effect on the environment that will last for at least the life of the project. These permanent effects are considered an operational effect of the project and are addressed in Section 5.1.3.

5.1.2 Installation of Inter-array, OSS-link, and Export Cables

As mentioned previously, various installation methods for the cables are being considered, including jet plow or mechanical plow. Due to the variability of surface and subsurface seabed conditions, a combination of cable installation methods is likely to be used to install the cable at the target burial depth. Potential impacts related to cable installation would result from related vessel activity, trenching/cable installation, and cable protection. The potential impacts are discussed below.

5.1.2.1 Vessel Activity

Types of vessels required for cable installation are identified in Table 2.3 above. Vessel anchorage may be required during installation of the cables. If required, vessel anchoring would result in crushing or burial impacts.

Habitat Disturbance

The COP states that pull-ahead vessel anchoring used during cable installation would occur within a 1,312-foot (400-meter) wide corridor, centered on the cable routes. Revolution Wind estimates that pull-ahead anchoring during cable installation would result in an estimated 16.1 acres of seabed disturbance. Barges and construction vessels would also anchor at the RWEC sea-to-shore transition site. Cofferdam installation, dredging and sidecast, and vessel anchoring could result in crushing, burial, and entrainment effects. The spatial extent of these potential crushing, burial, and entrainment impacts for the sea-to-shore transition would be limited to the confines of the two cofferdams, which would result in impacts to approximately three acres (1.2 hectares), all of which would be located in soft bottom habitat. However, vessel and anchoring activity could potentially stress eelgrass beds located near the cable landfall zone but located outside the seabed disturbance area by causing an increase in turbidity and subsequent sedimentation. Eelgrass is a designated HAPC of juvenile Atlantic cod, and it is a refuge and nursery ground for many other commercially important finfish and shellfish such as YOY winter flounder (Kenworthy et al., 1988; Thayer et al., 1984). Effects may cause individuals to leave these favorable habitats that offer refuge from predators and foraging opportunities. Further, settling larvae attracted to eelgrass beds, such as larval Atlantic cod and winter flounder, could suffer mortality due to entrainment effects and be disproportionally impacted.

The extent of anchoring impacts from cable installation and distribution of impacts by habitat type are summarized Table 5.6. Anchoring impacts to benthic habitat and associated EFH species within the lease area is described in Section 5.1.1.1.

Table 5.6. Cable Installation Impacts and Proportional Distribution of Impacts by Benthic Habitat Type.

Construction Element	Habitat Zone	Maximum Construction Disturbance Footprint (acres)	Percent of Acres in Large-Grained Complex Habitat	Percent of Acres in Complex Habitat	Percent of Acres in Soft Bottom Habitat
Pull-ahead anchoring†	RWEC-OCS	5.4	0.9%	32.9%	66.2%
	RWEC-RI	9.4	0.0%	14.7%	85.1%
	RWF 1, 2, and 4	1.4	0.0%	21.6%	78.4%
	Total all zones	16.1	0.0%	21.4%	78.2%
Sea-to-shore transition	RWEC-RI	0.8	0%	0%	100%

† Pull-ahead anchoring impact estimate calculated using an anchor width of 18 feet (5.5 meters), typical drag lengths per set in sand and medium clay sediments for a 5 metric ton STEVIN Mk3 anchor (Vryhof 2018), and 200, 150, and 50 anchor sets during construction of the RWEC-RI, RWEC-OCS, and OSS-link cable, respectively. The precise distribution of OSS-link pull-ahead anchoring events in habitat zones RWF 1, 2, and/or 4 is not known. Therefore, the proportional distribution of impacts is based on the distribution of mapped sediment types along the OSS-link installation corridor.

Anchoring during cable installations would also occur along the export cable corridors in both state and federal waters. Impacts from anchoring (i.e., crushing, burial, and habitat disturbance/conversion) in the RWEC-RI would primarily occur in soft bottom habitats, which represent 82.1% of the MWA. Impacts from anchoring in the RWEC-OCS would primarily occur in soft bottom (67.3%) and complex (32%) habitats.

Dominant bedform features in soft bottom habitats within the RWEC-RI include mega-ripples, ripples, trawl scars, and linear depressions (see Table 3.3) and CMECS substrates consisted primarily of fine and very fine sands with some areas of medium and coarse sands. Biogenic features observed in SPI/PV imagery included amphipod tubes, burrows, tracks, shell hash, and other epifauna (i.e., gastropods, shrimp, moon snails, crabs, hydroids, paguroids). Habitat-forming organisms observed in SPI/PV imagery in soft bottom habitats were very minimal (i.e., some barnacles and hydroids observed).

As mentioned in Section 5.1.1.1, anchoring impacts to bedforms such as ripples and mega-ripples could occur and result in short-term, indirect disturbance/conversion impacts to EFH and EFH species within the project area. These features provide structural complexity, shelter, and opportunities for feeding and migration in high flow environments (Gerstner 1988). They may also play a role in mediating fish-prey interactions and provide shelter from predation (Auster et al., 2003). Alterations of these bedform features could impact EFH species present in the project area during sensitive life history stages that rely on their mediating effects. EFH species present in the project area that may utilize mega-ripples and ripples, as well as medium sands, coarse sands, fine sands, and very fine sands include Atlantic cod (adults), Atlantic herring (adults), Atlantic sea scallops (larvae, juveniles, and adults), little skates (eggs, juveniles, and adults), longfin squids (eggs and adults), monkfish (juveniles and adults), ocean pout (eggs, larvae, juveniles, and adults), red hake (larvae, juveniles, and adults), winter flounder (eggs, larvae, YOY, juveniles, and adults), and winter skates (juveniles and adults). Disturbances to linear depressions would disproportionally impact adult hake, which are often found in association with these bedform features.

Anchoring could result in short- to long-term disturbance/conversion impacts to EFH that support sensitive life stages of EFH species and crush or bury benthic eggs, larvae, and juveniles with limited mobility. For example, the benthic eggs of Atlantic herring, little skates, ocean pout, longfin squid, and winter flounder, as well as the juvenile stages of relatively immobile species like Atlantic sea scallops, would be vulnerable to mortality from crushing and burial impacts. These species and sensitive life stages are associated with the substrates (e.g., coarse to very find sands) and utilize biogenic features present in the RWEC-RI (i.e., shell hash, amphipod tubes, hydroids, and moon snail eggs) as refuges, attachment surfaces, and food sources.

Dominant bedform features in soft bottom habitats within the RWEC-OCS include mega-ripples, ripples, linear depressions, and trawl scars, and CMECS substrates consist of a matrix of gravelly sands to very fine sands. Biogenic features observed in SPI/PV imagery included amphipod tubes, burrows, tracks, shell hash, and other epifauna (i.e., sea stars, shrimps, crabs, tunicates, sand dollars, and hydroids). Observations of habitat-forming organisms in soft bottom habitats were limited in SPI/PV imagery (e.g., barnacles and hydroids attached to scattered gravel and cobbles in sandy and sand and mud habitats).

In complex habitats, ripples are the dominant bedform with some low- to medium-boulder fields, linear depressions, and trawl scars also present. The CMECS substrates in the RWEC-OCS are similar to those found in soft bottom habitats (i.e., gravelly sands to very fine sands with some granules). Biogenic features observed in SPI/PV imagery included amphipod tubes, burrows, tracks, shell hash, and other epifauna (i.e., amphipods). Habitat-forming organisms observed in

SPI/PV imagery in soft bottom habitats were very minimal (i.e., some barnacles and hydroids observed).

Anchoring impacts to bedform features (i.e., mega-ripples, ripples, and linear depressions) and EFH species associated with particular CMECS substrates present in both soft bottom and complex habitats within the RWEC-OCS would be similar to those described for the RWEC-RI. However, sand dollars were observed in soft bottom habitats within the RWEC-OCS. Sand dollars are a prey of juvenile winter flounder, a commercially valuable EHF species present in the project area, and they are a slow-moving benthic invertebrate that would be susceptible to crushing from anchoring.

The RWEC-OCS has a higher percentage of mapped medium- to low-density boulder fields than the RWEC-RI. Anchoring impacts to these bedform features would like those described in Section 5.1.1.1. In addition to the impacts described in Section 5.1.1.1, disturbed sediments from anchoring could deposit on boulders and result in the burial of benthic eggs (e.g., longfin squid and Atlantic herring), the loss or smothering of epifauna that provide both shelter, attachment surfaces, and prey (barnacles, sea pens, anemones, hydroids, and sponges observed in SPI/PV imagery), and inhibit the settlement of larvae. The proposed construction period (i.e., May through December) will overlap with peak invertebrate and shellfish spawning and/or settlement periods that generally occur between April 15 and October 15 (specific spawning timing dependent on species).

<u>Effects on EFH and EFH Species</u>

- Direct
  - Short-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat when anchoring): EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Pelagic species groups; Prey Species – Benthic; Prey Species – Pelagic, Summer Flounder HAPC; Summer Flounder HAPC.
  - Permanent, localized crushing and burial of EFH species: Sessile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Prey –Benthic/Epibenthic species groups.
  - Long-term disturbance/conversion of EFH (EPM for avoidance of sensitive habitat during anchoring): EFH for Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Southern New England HAPC.

    - Short-term avoidance of anchoring activities by EFH species: Mobile Epibenthic/Benthic – Soft Bottom; Mobile Epibenthic/Benthic – Complex; Pelagic; Prey Species – Benthic and Prey Species – Pelagic species groups.

- Indirect
    - Short-term loss of benthic prey items: Mobile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Complex.

Underwater Noise

The construction of the IAC, OSS-link, and RWEC is anticipated to require up to 13 overlapping months in 2023 and 2024. Underwater noise impacts from construction vessel activity would impact EFH species and their habitats within the Lease Area and along the RWEC corridor. This would include general vessel engine noise, and noise from HRG survey equipment used for pre-construction surveys. Underwater noise impacts from construction vessel engines and HRG survey activities would be similar to those described in Section 5.5.1 for foundation installation. These effects are summarized below.

Effects

- Direct
    - Short-term, local avoidance responses due to vessel noise: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex Habitat; Mobile Benthic/Epibenthic – Complex Habitat; Pelagic; Prey Species – Benthic/Epibenthic; Prey Species – Pelagic.
- Indirect
    - Short-term reduction in habitat quality for Southern New England HAPC.
    - Short-term reduction in habitat quality for juvenile inshore cod HAPC.
    - Short-term reduction in habitat quality for summer flounder HAPC.

See Section 5.1.1.1 for a detailed analysis of underwater noise impacts to EFH species and their habitats by hearing group.

Sediment Suspension/Redeposition from Anchoring Activities

Suspended sediment impacts from pull-ahead anchoring activities used during cable installation are anticipated to be similar to and contained within the limits of those resulting from cable installation in general. Those impacts are addressed in Section 5.1.2.4.

Potential Introduction of Exotic/Invasive Species via Ballast

Refer to Section 5.1.1 above for discussion of potential introduction of invasive species via vessel ballast.

5.1.2.2 Seabed Preparation/Boulder Relocation

Impacts from seabed preparation for cable installation, including PLGR and boulder relocation are considered to be a component of cable installation and are described in Section 5.1.2.4 below.

5.1.2.3 UXO Detonation

Impacts associated with UXO detonation required for construction of the IAC and RWEC are described in Section 5.1.1.4, above. As stated, Revolution Wind (Orsted 2023) has identified 16 UXOs in the project area, all within zone RWEC-RI. Orsted (2023) has determined that these devices can be avoided by shifting the cable route within the approved installation corridor. Accordingly, none of these devices will require detonation. However, BOEM assumes that additional UXOs could be encountered within the Lease Area and RWEC corridor and some of these devices may require detonation. Potential impacts to EFH are discussed in Section 5.1.1.3.

5.1.2.4 Cable Installation

This section considers the short-term impacts of cable construction and installation methods on EFH species and habitats. Long-term to permanent impacts on habitat composition and structure from boulder relocation and the installation of cable protection are considered operational impacts and the associated effects to EFH species are addressed in Section 5.1.3.1.

Habitat Disturbance and Alteration

Construction of the RWEC, IAC, and OSS-link cable would require boulder relocation, cable installation, and placement of cable protection. These activities would result in direct impacts to benthic habitat and associated EFH species and habitat features (see Section 3.5). Depending on the timing and location, these activities could result in the direct disturbance of biologically important uses of EFH (e.g., cod spawning activity on Cox Ledge). The estimated extent of these impacts is approximately 3,451 acres (1,397 hectares) based on the current route configurations described in the COP (VHB 2022). Thus, the maximum potential spatial extent of these impacts is approximately 4,141 acres (1,676 hectares).

Boulder relocation would be required along portions of the cable route prior to cable installation. Sandwave leveling would not be required. Boulder relocation could alter bedforms such as ripples and mega-ripples, resulting in short-term, indirect disturbance/conversion impacts to EFH and EFH species within the project area. As mentioned in Sections 5.1.1.1 and 5.1.2.1, these features provide structural complexity, shelter, and opportunities for feeding and migration in high flow environments (Gerstner 1988).

EFH species present in the project area that may utilize mega-ripples and ripples, as well as medium sands, coarse sands, fine sands, and very fine sands include Atlantic cod (adults), Atlantic herring (adults), Atlantic sea scallops (larvae, juveniles, and adults), little skates (eggs, juveniles, and adults), longfin squids (eggs and adults), monkfish (juveniles and adults), ocean pout (eggs, larvae, juveniles, and adults), red hake (larvae, juveniles, and adults), winter flounder (eggs, larvae, YOY, juveniles, and adults), and winter skates (juveniles and adults). Disturbances to linear depressions would disproportionally impact adult hake, which are often found in association with these bedform features.

Sandwaves and biogenic depressions are a component of juvenile and adult EFH used by red and silver hake. Seabed preparation and cable installation would flatten depressions and ripples and mega-ripples, and damage structure provided by habitat forming organisms, such as amphipod tubes, which were highly abundant in SPI/PV imagery data in soft bottom benthic habitat (see Table 3.5). Amphipods are important prey for several soft bottom EFH species and life stages including red hake (juveniles), winter flounder (YOY, juveniles, and adults), and winter skates (juveniles and adults), and impacts to these biogenic features could result in limited prey availability for these species and refuge from predators. These combined effects would reduce habitat suitability within the cable installation footprint for EFH species that associate with soft bottom habitat. Sandwaves are naturally dynamic features in soft bottom benthic habitats. As such, these habitat features are expected to recover rapidly from seabed preparation impacts, within 18 to 24 months following initial disturbance through natural sediment transport processes and recolonization by habitat-forming organisms 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 seabed 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).

Revolution Wind estimates that boulder relocation could be required along approximately 80 percent of the IAC, 60 percent of the OSS-link, and 40 percent and 70 percent of the RWEC-OCS and RWEC-RI routes, respectively. Boulders within 46 feet (14 meters) of cable centerlines would be relocated to the margins of the cable installation corridor using a towed plow to prepare the seabed for jet plowing. Boulders constitute complex benthic habitat; therefore, boulder relocation could potentially alter the composition of both the original and relocated habitat. Boulder relocation may result in effectively permanent alteration of benthic habitat where boulders are displaced into soft bottom habitat, or where boulders are removed exposing soft bottom habitats. This effect could occur along an unknown proportion of the total boulder relocation and seabed preparation area for each cable, which is summarized by cable and benthic habitat type in Table 5.7.

Table 5.7. Total Area of Potential Crushing, Burial, or Entrainment during IAC and OSS-link Installation by Habitat Zone and NOAA Habitat Complexity Category.

Cable	Habitat Zone	Total Cable Length (linear miles)	Estimated Impact Footprint (acres) ‡	Impact Percent of Total Zone Area	Percent of Acres in Large-Grained Complex Habitat	Percent of Acres in Complex habitat	Percent of Acres in Soft Bottom Habitat
IAC	RWF 1	14.3	109	1.5%	19.3%	9.0%	71.7%
	RWF 2	48.5	369	1.1%	17.8%	34.9%	47.3%
	RWF 3a	5.7	44	1.3%	0.0%	45.6%	54.4%
	RWF 3b	0	--	--	--	--	--
	RWF 4	47.6	362	1.2%	1.9%	11.3%	86.8%
	All zones	116.1	884	1.2%	10.7%	22.4%	66.9%
OSS-link	RWF 1	3.4	21.5	0.3%	19.1%	52.9%	28.0%
	RWF 2	1.6	10.0	0.03%	34.2%	27.3%	38.5%
	RWF 3a	0	--	--	--	--	--
	RWF 3b	0	--	--	--	--	--
	RWF 4	4.4	27.9	0.1%	0.0%	5.5%	94.5%
	All zones	9.3	59.4	0.1%	12.5%	26.6%	60.9%

Cable installation impact acreage based on estimated cable lengths presented in the COP (VHB 2022). Impact acreage per mile of cable length would vary depending on the proportion of cable length requiring seabed preparation (PLGR and boulder clearance) versus simple cable installation. The specific location and extent of seabed preparation is not currently known, therefore the estimated percentage of cable length affected by these activities is applied equally to each zone and habitat type.

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to 75 feet (23 meters) if boulder clearing is required.

Although, it is anticipated that the large majority of boulder relocation activity would occur in the Lease Area habitat zones with a highest proportion of low- to medium-density boulder fields (i.e., RWF zones 1, 2, 3b). The impacts from boulder relocation (i.e., crushing, burial, and direct and indirect disturbances to EFH species, life stages, and prey) within the Lease Area would be similar to those described for anchoring in Section 5.1.1.1. As with other construction-related activities, the benthic life stages of EFH species with limited to no mobility would be most vulnerable to boulder relocation (e.g., benthic eggs and larvae of Atlantic sea scallop, red hake, ocean pout, and winter flounder). Red hake and ocean pout would be vulnerable to impacts as red hake are and ocean pout are currently overfished.

Damage to habitat-forming invertebrates on relocated boulders and cobbles could take several years to decades to fully recover (Auster and Langton 1999; Collie et al. 2005; Tamsett et al. 2010) and would constitute a long-term and indirect impact to EFH species present in the project area as these features provide both refuge from predators, attachment surfaces, and foraging opportunities. For example, crabs and shrimps are epifauna that were commonly observed in SPI/PV imagery (see Table 3.5) and are a common prey items for many EFH species present in the project area (e.g., groundfish and longfin squid). This would constitute a long-term effect on benthic habitat structure. Long-term to permanent impacts on EFH species and habitats from boulder relocation are addressed in Section 5.1.3.1. Table 5.7 presents the estimated extent of benthic habitat impacts by NOAA Habitat Complexity Category resulting from installation of the IAC and OSS-link cable based on the proportions of each category mapped within the Lease Area. These estimates include impacts from seabed preparation, boulder relocation, and installation of cables and cable protection. The latter estimate includes approximately 1.4 acres of seabed impacts from pull ahead anchoring used during OSS-link installation. Cables will be installed to a depth of 4 to 6 feet (1.2 to 1.8 meters) via a mechanical plow or jet plow.

Table 5.8 presents the estimated acreage of benthic habitat impacts by NOAA Habitat Complexity Category resulting from RWEC installation. The acres by habitat type presented in Table 5.8 below are based the proportional composition by NOAA Habitat Complexity Category within the installation corridor for each RWEC circuit within the RWEC-OCS and RWEC-RI. These estimates include impacts from seabed preparation, boulder relocation, cable installation, including 40.8 acres of impacts for cable joint installation, and installation of cable protection. Cables will be installed to a depth of 4 to 6 feet (1.2 to 1.8 meters) using a mechanical plow or jet plow. The disturbance corridor for cable installation would be up to 75 feet (23 meters) within the general 131 feet (40 meters) wide installation corridor.

Table 5.8. Total Area of Potential Crushing, Burial, or Entrainment during RWEC Installation by NOAA Habitat Complexity Category.

Habitat Zone	Total Length (linear miles)	Estimated Impact Footprint (acres)‡	Impact Percent of Total Zone Area	Percent of Acres in Large-Grained Complex Habitat	Percent of Acres in Complex habitat	Percent of Acres in Soft Bottom Habitat
RWF 1	3.1	27	0.4%	0.0%	43.9%	56.1%
RWF 2	1.0	9	0.03%	0.0%	19.4%	80.6%
RWF 4	11.1	98	0.3%	0.1%	17.6%	82.3%
RWEC-OCS	27.0	239	5.3%	1.1%	34.9%	64.0%
RWEC-RI	43.6	386	6.6%	0.0%	14.7%	85.3%
All zones	85.8	759	0.8%	0.4%	22.6%	77.1%

Cable installation impact acreage based on estimated cable lengths presented in the COP (VHB 2022). Impact acreage per mile of cable length would vary depending on the proportion of cable length requiring seabed preparation (PLGR and boulder clearance) versus simple cable installation. The specific location and extent of seabed preparation is not currently known, therefore the estimated percentage of cable length affected by these activities is applied equally to each zone and habitat type.

‡ Acreages presented are for the 131-foot (40-meter) wide cable installation corridor. The actual impact width along this corridor would range from approximately 24 feet (7.5 meters) where the cable can be directly installed without seabed preparation to 75 feet (23 meters) if boulder clearing is required.

Short-term impacts to EFH resulting from cable installation include temporary loss of habitat suitability for individuals exposed to crushing, burial, and entrainment effects, and suspended sediment deposition. These effects are described in detail by EFH species group and habitat association in the following sections. Long-term to permanent impacts from cable installation on benthic habitat composition and structure are considered to be an operational effect on EFH and are addressed in Section 5.1.3.1.

Crushing, Burial and Entrainment

Seabed preparation and cable installation would result in direct impacts to EFH species through exposure to crushing, burial, and entrainment effects. Crushing and burial effects would primarily affect species and life stages in the Sessile Benthic/Epibenthic groups. These organisms are unable to escape the disturbance and would be subject to injury and mortality. Species and life stages in the Mobile Benthic/Epibenthic groups would experience short-term behavioral and displacement effects from exposure to disturbance. Pelagic eggs and larvae would be exposed to potential entrainment effects from the surface-oriented water intakes of the jet plow.

Crushing and burial impacts on EFH species and habitats could occur along the length of the RWEC alignment and within the disturbance areas associated with cable installation and boulder relocation. Entrainment effects could result from operation of the jet plow. Dredging and installation of the cofferdam at the sea-to-shore transition location could result in crushing, burial, or entrainment effects on EFH species and their prey. Construction and installation at the sea-to-shore transition is expected to occur within the estimated eight months required for the overall RWEC installation, anticipated to be between September 2023 and May 2024. Potential impacts during that time would be continuous but limited to the area of active construction and installation.

Effects to EFH Species and Habitats

- Direct
    - Short-term exposure of EFH species to behavioral disturbance, displacement, and direct injury and mortality from crushing and burial effects: Sessile Benthic/Epibenthic – Soft Bottom and Hard Bottom; Mobile Benthic/Epibenthic – Soft Bottom and Hard Bottom species groups.
    - Short-term exposure of eggs and larvae of EFH species in the Pelagic species group to mortality from entrainment effects.
    - Short-term decrease in quality of EFH in areas adjacent to Project activities for: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Prey Species – Benthic.
    - Short-term reduction in the availability and suitability of Summer Flounder HAPC; Juvenile Inshore Cod HAPC; Southern New England HAPC.

- Indirect
    - Short-term loss of foraging opportunities: Mobile Epibenthic/Benthic – Soft Bottom; Mobile Epibenthic/Benthic – Hard Bottom; and Pelagic species groups.

<u>Effects on Benthic/Epibenthic and Pelagic Egg and Larval Life Stages of EFH Species</u>

EFH species with benthic or epibenthic eggs or larvae that occur within the RWEC project area could be exposed to lethal crushing or burial effects. EFH species with pelagic eggs or larvae may be subject to lethal entrainment effects. Pelagic eggs and larvae of Atlantic cod and the pelagic eggs of red hake, two species of managed fish that are currently overfished and have rebuilding plans in place, would be vulnerable to mortality from entrainment effects. Along the RWEC route, cable laying, boulder relocation, and placement of cable protection would temporarily decrease the suitability of benthic and epibenthic habitat and could crush or bury eggs and larvae utilizing this habitat. CMECS substrates within large-grained and complex habitats in the RWEC-RI is largely comprised of shell hash, reef substrate (i.e., Crepidula reef substrate), and slightly gravelly sand (see Table 3.2). Gravel bottoms are preferred spawning substrates of Atlantic herring, which is a common prey item of commercially important EFH species (e.g., Atlantic cod and longfin squid) and are vulnerable to impacts from seabed preparation as this species is currently overfished. EFH for vulnerable, benthic life-stages of EFH species (e.g., larval Atlantic sea scallops, longfin squid egg mops, and the eggs and larvae of ocean pout—a currently overfish species) would be vulnerable to crushing, burial, and entrainments impacts associated with seabed preparation for cable laying. Damage to biogenic features (e.g., amphipod tubes and other epifauna) and habitat-forming organisms (e.g., barnacles, hydroids, mussels, and sponges) observed in SPI/PV imagery within the RWEC (see Tables 3.5 and 3.6, respectively) could indirectly impact the eggs and larvae of the aforementioned EFH species. These features provide refuge from predators, attachment surfaces, and foraging opportunities.

Entrainment impacts to pelagic eggs and larvae could result from use of the jet plow for the inter-array cable installation. It is assumed that all entrained eggs and larvae would be killed. The jet plow is anticipated to move at a rate of approximately 5,249 to 10,498 feet (1,600 to 3,200 meters) per day along the inter-array cable alignment and would withdraw approximately 1,400 m^3 of sea water per hour, or approximately 16,800 m^3 per day (assuming a 12-hour workday). Given the surface-oriented water intake, the volume withdrawn represents the amount of pelagic habitat rendered temporarily unsuitable. Although the jet plow intake will be screened to avoid and minimize entrainment of small fish, planktonic eggs and larvae of some EFH species, and their planktonic prey, may be entrained. Inspire Environmental (2020b) estimated less than 0.001 percent of the total zooplankton and ichthyoplankton abundance present in the study area would be killed through entrainment during construction and installation of the IAC. Entrainment effects could also occur during dredging at the RWEC sea-to-shore transition site.

EFH species with benthic, epibenthic, or pelagic eggs or larvae that may be exposed to crushing, burial, or entrainment effects during IAC, OSS-link, and RWEC construction and installation include:

- Atlantic cod (eggs, larvae)
- Haddock (eggs, larvae)
- Red hake (eggs, larvae)
- Silver hake (eggs, larvae)
- White hake (larvae)
- Monkfish (eggs, larvae)
- Bluefish (eggs, larvae)
- Black sea bass (eggs, larvae)
- Butterfish (eggs, larvae)
- Ocean pout (eggs, larvae)
- Scup (larvae)
- Atlantic herring (eggs, larvae)
- Longfin squid (eggs)
- Atlantic mackerel (eggs, larvae)
- Atlantic sea scallop (eggs)
- Summer flounder (eggs, larvae)
- Winter flounder (eggs, larvae)
- Windowpane flounder (eggs, larvae)
- Witch flounder (eggs, larvae)
- Yellowtail flounder (eggs, larvae)
- Atlantic sea scallop (larvae)

Effects on Juveniles of EFH Species in Mobile Benthic/Epibenthic Groups

See the impact analysis in this section under Habitat Disturbance and Alteration and the analysis in Section 5.1.2.1 describing the impacts from anchoring along the RWEC for more information regarding the impacts juvenile life stages could incur from seabed preparation. The impacts to juvenile EFH species present in the RWEC from anchoring described in Section 5.1.2.1 would be similar to the impacts from seabed preparation (i.e., crushing, burial, and entrainment effects) considered in this section.

EFH species with benthic or epibenthic juveniles that occur within the RWEC project area could be exposed to lethal crushing, burial, or entrainment effects. Larger juveniles would likely exhibit a behavioral avoidance response and swim out of the temporarily affected habitat. Juveniles unable to avoid the area would be subject to lethal crushing or burial effects.

Eggs, larvae, and juvenile fish will be entrained along the RWEC route and subject to lethal effects. Dredging at the sea-to-shore transition will also subject eggs, larvae, and juvenile fish to lethal effects of entrainment. Overall mortality of juvenile fish entrained during dredging is low (Wenger et al. 2017). EFH species with benthic or epibenthic juveniles that may be exposed to crushing, burial, or entrainment effects during RWEC construction and installation include:

- Butterfish (juvenile)
- Windowpane flounder (juvenile)
- Winter flounder (juvenile)
- Witch Flounder (juvenile)
- Yellowtail flounder (juvenile)
- Atlantic cod (juvenile)
- Black sea bass (juvenile)
- Haddock (juvenile)
- Monkfish (juvenile)
- Ocean pout (juvenile)
- Pollock (juvenile)
- Red hake (juvenile)
- Scup (juvenile)
- Silver hake (juvenile)
- White hake (juvenile)
- Barndoor skate (juvenile)
- Little Skate (juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile)
- Winter skate (juvenile)

Effects on Adults of EFH Species in Mobile Benthic/Epibenthic Groups

See the impact analysis in this section under Habitat Disturbance and Alteration and the analysis in Section 5.1.2.1 describing the impacts from anchoring along the RWEC for more information regarding the impacts adult life stages could incur from seabed preparation. The impacts to adult EFH species present in the RWEC from anchoring described in Section 5.1.2.1 would be similar to the impacts from seabed preparation (i.e., crushing, burial, and entrainment effects) considered in this section.

EFH species with benthic or epibenthic adult life stages present along the RWEC route may be subject to lethal crushing, burial, or entrainment effects. Adult fish would be likely to exhibit avoidance responses to exit the active construction and installation area but there is potential for lethal effects. Placement of cable protection and installation of the cofferdam could crush or bury adult fish unable to avoid the area. Impacts to EFH species and habitats from dredging provide a useful basis for evaluating potential impacts from cable installation activities. Evidence of dredging entrainment effects suggests that the mortality rate from these activities would be low (Wenger et al. 2017). For example, the mortality rate of estuarine fish entrained during a hopper dredging event was found to be 38 percent (Armstrong et al. 1982). Potential avoidance and the less than 100 percent mortality rate indicate that cable installation activities to EFH would likely have a minor effect on EFH species. EFH species having benthic or epibenthic adult life stages that are known or likely to occur within the spatial extent of crushing, burial, and entrainment effects from RWEC construction and installation include:

- Summer flounder (adult)
- Windowpane flounder (adult, spawning)
- Winter flounder (adult, spawning)
- Witch Flounder (adult, spawning)
- Yellowtail flounder (adult, spawning)
- Atlantic cod (adult, spawning)
- Black sea bass (adult)
- Butterfish (adult)
- Haddock (adult, spawning)
- Monkfish (adult, spawning)
- Ocean pout (adult, spawning)
- Pollock (adult, spawning)
- Red hake (adult, spawning)
- Scup (adult)
- Silver hake (adult, spawning)
- White hake (adult, spawning)
- Atlantic herring (spawning)
- Barndoor skate (adult)
- Little skate (adult)
- Sandbar skate (adult)
- Spiny dogfish (adult, male)
- Winter skate (adult)

Effects on EFH Invertebrate Species Benthic Invertebrates

Benthic invertebrates utilizing EFH within the RWEC project area could be subject to lethal crushing, burial, or entrainment effects. Crushing or burial due to cable laying or boulder location would likely be lethal to individuals within the footprint of the material placement. The surface-oriented jet plow intake could also render a portion of the pelagic habitat temporarily unsuitable and result in mortality for juveniles utilizing the habitat. EFH shellfish species and life stages potentially exposed to crushing, burial, or entrainment effects from RWF construction and installation include:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)

Suspended Sediment Deposition and Burial Effects

The construction of the RWEC, IAC, and OSS-link cable would disturb the seabed and release suspended sediments into the water column. This would result in short-term effects to water pelagic and benthic habitats and effects on EFH species ranging from behavioral disturbance and avoidance, short-term disruption of feeding and increased physiological stress, to potential lethal impacts on demersal eggs and larvae that are sensitive to burial effects.

Revolution Wind modeled suspended sediment effects from bed disturbance associated with the construction and installation of the RWF and RWEC as part of the COP. These results are presented in COP Appendix J (RPS 2021) and summarized herein. RPS (2021) used the HYDROMAP 3-dimensional hydrodynamic model to simulate water levels, circulation patterns and water volume flux through the study area and to provide hydrodynamic input (spatially and temporally varying currents) for input to the sediment transport model. Modeled sediment grain sizes comprised coarse and fine sand, coarse and fine silt, and clay. The following specific project features were modeled:

- **RWF inter-array cable:** A representative .1.4-linear-mile (2.25-km, 1.2-nm) segment excavated and reburied using a hydraulic trencher/mechanical plow.
- **RWEC:** Excavation and reburial of a 47.7-linear-mile (76.8-km, 41.5-nm) and 47.8-linear mile (76.9-km, 41.5-nm) sections of the RWEC. RWEC is comprised of two corridors.
- **RWEC sea-to-shore transition:** Excavation of the construction and installation site using a suction/vacuum dredge with side-cast into adjacent surface waters.

RPS modeled installation of approximately 1.4-representative linear miles of the inter-array cable segment representative of those sediment conditions anticipated to occur along the 155-linear-mile (250-km, 135-nm) length of the inter-array cable based on sediment samples collected during field studies performed for the project (Fugro 2019).

It is not possible to determine the exact area and distribution of habitats that would be exposed to suspended sediment and sediment deposition effects from seabed disturbance, as these impacts would be dependent on the specific tidal current conditions present at the timing of disturbance. For this analysis, the maximum extent of sediment impacts modeled by RPS (2021) was used to create a buffer around each transmission cable. The habitat composition of the buffered area was used to identify the potential distribution of sediment deposition impacts by habitat type. The anticipated extent of water column TSS and substrate burial effects are summarized in Table 5.9. The results present the anticipated TSS impacts from IAC, OSS-link, and RWEC installation by benthic habitat type. These estimates consider the average extent of sediment dispersal over a range of current conditions. The distribution of habitat types is based on the habitats present within a buffered impact corridor representing the maximum extent of TSS impacts. While this distribution is generally representative, the actual impacts by habitat type would vary depending on specific current conditions at the time and location of seabed disturbance.

As shown in Table 5.9, TSS concentrations exceeding 100 mg/L could extend hundreds to thousands of feet from the point of disturbance, with the most extensive impacts occurring along the RWEC route in areas with higher concentrations of mud and silt sediments. RPS (2021) determined that suspended sediments released into the water column would be rapidly dispersed by tidal currents, settling back to the seafloor within minutes to hours of the disturbance. The majority of water column effects would be limited to short-term TSS pulses below 100 mg/L. Higher TSS concentrations exceeding 100 mg/L would occur in areas where seafloor sediments have a greater proportion of mud and silt. TSS plumes caused by construction disturbance would dissipate quickly, with concentrations above 100 mg/L lasting no longer than 6 hours at any location (RPS 2021).

Table 5.9. Estimated Extent of Total Suspended Solid and Sediment Deposition Impacts and Proportional Distribution of Benthic Habitat Types Potentially Exposed to TSS and Sediment Deposition Impacts[§] from Inter-Array Cable, Offshore Substation-Link Cable, and Revolution Wind Export Cable Construction.

Project Element	Location	Length miles (km)	Area of Sediment Deposition Exceeding 0.004 inch (0.1 mm) – acres (hectares)	Area of Sediment Deposition Exceeding 0.04 inch (1.0 mm) – acres (hectares)	Area of Sediment Deposition Exceeding 0.4 inch (10 mm) – acres (hectares)	Maximum Extent of TSS Plumes Exceeding 50 mg/L – feet (meters)	Maximum Extent of TSS Plumes Exceeding 100 mg/L – feet (meters)	Large Grained Complex (%)	Complex (%)	Soft Bottomed (%)	Anthropogenic (%)
Inter-array cable*	OCS	116.1 (187)	15,066 (6,097)	7,570 (3,064)	204 (83)	1,209 (369)	932 (284)	10.7%	22.4%	66.9%	0%
OSS-link cable‡	OCS	9.3 (15)	1,444 (584)	918 (372)	9 (4)	1,209 (369)	932 (284)	12.5%	26.6%	60.9%	0%
RWEC #1 and #2, seabed preparation‡	OCS	16.8 (27)	5,760 (2,331)	2,539 (1,027)	1,078 (436)	4,494 (1,370)	3,067 (935)	0.8%	30.8%	68.5%	0%
	State	3.2 (5)	13,107 (5,304)	6,035 (2,442)	2,066 (836)	6,888 (2,099)	5,838 (1,779)	0.0%	14.7%	85.1%	0.2%
RWEC #1 and #2, installation‡	OCS	37.3 (60)	5,787 (2,342)	3,681 (1,490)	35 (14)	1,542 (470)	1,476 (450)	0.8%	30.8%	68.5%	0%
	State	46 (74)	8,035 (3,252)	4,672 (1,891)	0 (0)	3,764 (1,147)	2,345 (715)	0.0%	14.7%	85.1%	0.2%
Sea-to-shore transition†	State	n/a	35 (14)	20 (8)	7 (3)	1,460 (445)	1,312 (400)	0%	0%	100.0%	0%

* RPS (2021) did not estimate deposition acreage for the entire IAC. Sediment deposition and burial effects for IAC installation were estimated based on the modeled deposition acreage per mile for IAC, OSS-link cable, and RWEC segments in different substrate classes as reported by Inspire Environmental (2021), and the proportional distribution of IAC segments in each substrate class. Values presented are the average of modeled impacts for two tidal current scenarios.

‡ RPS (2021) modeled TSS impact estimates for RWEC #1 and the OSS-link combined. OSS-link values are estimated using the modeled deposition rate/mile for comparable substrate classes in the RWEC footprint. RWEC deposition area results are 2x the RPS (2021) results for RWEC #1 minus OSS-link deposition acres. RWEC #2 impacts are assumed to be similar to those from RWEC #1 because the routes travel through the same or similar substrate types.

† Assumes excavation and backfill of 5,881 cubic yards of sand and mud sediment at the HDD exit pit using an excavator and venturi eductor device (RPS 2021).

§ Distribution of impacts is an approximation based on habitat composition within the respective cable installation corridors. Actual habitat exposure would vary depending on current strength and duration at the time and location of disturbance.

For deposition, RPS (2021) summarized the total area exposed to sediment deposition at three thicknesses, 0.1 millimeter [mm], 1.0 mm, and 10.0 mm. They determined that fine sediment deposition from IAC construction could exceed 0.4 inch (10 mm) and 0.004 inch (0.1 mm) on up to 3,152 and 9,538 acres, respectively (Table 5.9). Burial depths from OSS-link cable construction could exceed 0.4 inch (10 mm) and 0.004 inch (0.1 mm) on up to 302 and 1,374 acres, respectively. Burial depths from RWEC construction could exceed 0.4 inch (10 mm) and 0.004 inch (0.1 mm) over 3,285 and 12,138 acres, respectively. As stated, the actual area of effect at a given moment during construction would be limited to the seafloor disturbance footprint within and adjacent to cable installation activities and the deposition zone downcurrent of the disturbance. IAC and OSS-link cable installation impacts would occur intermittently over a 5-month construction window while the RWEC installation would occur continuously over a period of approximately 8 months.

TSS concentrations of the magnitude and duration anticipated are below levels associated with measurable adverse effects on finfish (Wilber and Clarke 2001; Yang et al. 2017) and would therefore be negligible. Juvenile and adult finfish associated with benthic habitats are unlikely to be significantly affected by sediment deposition at the burial depths anticipated, but benthic eggs and larvae of some species could be harmed (Kjelland et al. 2015; Michel et al. 2013; Wilber and Clarke 2001). While sensitivity varies widely, the eggs and larvae of some species can be killed by as little as 0.4 inch (10 mm) of sediment deposition. The eggs of certain species, like winter flounder, are particularly sensitive and can be killed by burial depths less than 0.1 inch (3 mm) (Michel et al. 2013). While some adverse effects would undoubtedly occur, the extent of deposition and burial impacts is small relative to the amount of egg and larval settlement habitat available, and the duration of those impacts would be short term (hours to days). Invertebrates like burrowing bivalve clams and burrow-forming amphipods are highly tolerant to burial (Gingras et al 2008; Johnson 2018). More sedentary invertebrates that cannot move within the sediment column as quickly, such as small anemones and tube-dwelling worms, could exhibit stress or mortality if completely buried or exposed to repetitive burial events (Johnson 2018). Some invertebrate species and their eggs and larvae could be adversely affected by burial by as little as 0.4 inch (10 mm) of fine sediment (Wilber and Clarke 2001), but indicators of stress are typically associated with burial depths on the order of 2 inches or more (Johnson 2018).

The magnitude and duration of construction-related sediment effects must be considered in the context of the environmental baseline. The sand and mud substrates on the mid-Atlantic OCS are continually reshaped by bottom currents and sediment delivery from upland sources (Daylander et al. 2012). The prevalence of sediment ripples and mega-ripples throughout the Maximum Work Area is evidence of these dynamic conditions. This indicates that the benthic habitats and habitat forming organisms impacted by the project are regularly exposed to and therefore must be able to recover from burial by mobile sediments. Similarly, while eelgrass and SAV beds in proximity to the sea-to-shore transition site and in the vicinity of the RWEC RI corridor could be exposed to TSS effects from RWEC installation, these impacts would be short-term in duration and unlikely to adversely affect this component of complex habitat. Seagrasses and SAV in this environment have evolved in areas prone to periodic elevations in suspended sediment levels and have vertical structure that can accommodate levels of sediment deposition (Lewis and Erftemeijer 2006) greater than those anticipated from the Proposed Action.

The direct effects of projected TSS and suspended sediment impacts on EFH resulting from project construction and installation will vary depending on how benthic and near-bottom habitats exposed to these impacts are used by EFH species. EFH is divided into the following components for the purpose of this assessment:

- Bottom habitats used by EFH fish and invertebrate species having benthic or epibenthic eggs and larvae, and/or benthic or epibenthic eggs and larvae that provide prey for EFH species.

- Bottom habitats used by EFH fish species having benthic or epibenthic juvenile life stages, and/or benthic or epibenthic juvenile fish that provide prey for EFH species.

- Bottom habitats used by EFH fish species that are benthic or epibenthic as adults, and/or adult fish that provide prey for EFH species.

- Bottom habitats used by EFH shellfish species, and/or shellfish that provide prey for EFH species.

The modeled sediment plume from jet plow excavation and reburial remains close to the seabed and the maximum TSS concentrations in the plume are relatively modest, ranging from 10 to 500 mg/L depending on location and current conditions at the seabed. As a result, EFH species having surface oriented or mid-water pelagic life stages would not be exposed to these direct effects and would therefore not experience adverse effects during these life stages.

Potential effects on EFH species and habitats from suspended sediment exposure are summarized below. A detailed assessment of impacts sediment impacts to EFH species is provided for the IAC and OSS-link, and for the RWEC by species group in the following sections.

Effects to EFH Species and Habitats

- Direct
    - Short-term decrease in quality of EFH due to suspended sediments and increased turbidity: EFH for Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; and Pelagic species groups; Summer Flounder HAPC; Juvenile Inshore Cod HAPC; Southern New England HAPC.

    - Short-term, local impacts due to sedimentation: Sessile Benthic/Epibenthic – Soft Bottom;Prey Species – Benthic.

- Indirect
    - Short-term loss of foraging opportunities: Mobile Epibenthic/Benthic – Soft Bottom; and Pelagic species groups.
    - Short-term decrease in quality of EFH in areas adjacent to Project activities for: SessileBenthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; SummerFlounder HAPC; Prey Species – Benthic.

Suspended Sediment Effects from IAC and OSS-link Construction and Installation

The installation of the IAC and OSS-link cables would generate localized plumes of suspended sediments with maximum TSS concentrations ranging from 50 to 100 mg/L extending from 1,209 feet (369 meters) to 932 feet (284 meters) from installation activities, respectively (RPS 2021). Modeling results indicate that TSS concentrations greater than 100mg/L do not persist in any given location for greater than three hours (RPS 2021). RPS (2021) estimated that sediment plumes would resettle and TSS concentrations would return to background levels within approximately five hours of disturbance. Inter-array cable construction and installation would occur in 2023/24 and is expected to require approximately five months to complete. Sediment-producing activities would occur intermittently during this period as new cable segments constructed as each WTG foundation installation is completed.

Common CMECS substrate types within IAC and OSS-link areas include gravelly sand, sandy gravel, and slightly gravelly sand (complex and large-grain complex habitats). For soft bottom habitat, common substrate types include medium to fine sands, respectively (see Section 3.5). Bedform features include ripples, linear depressions, trawl scars, and mega ripples. See sections 3.5 for more information regarding specific bedform features, CMECS substrates, and associated biogenic and habitat-forming features present within each habitat zone.

Effects on Sessile Benthic/Epibenthic Eggs and Larvae

Benthic and epibenthic eggs and larvae that occur within the RWF construction and installation footprint could be exposed to elevated water column TSS concentrations and burial by deposition of suspended sediments from inter-array cable construction and installation. The estimated area affected by deposition from IAC installation would range from 35,798 acres (14,487 hectares) receiving 0.1 mm of deposition, 22,715 acres (9,192 hectares) receiving 1.0 mm of deposition to 217 acres (88 hectares) receiving 10 mm of deposition (RPS 2021). Various researchers have reviewed suspended sediment effects on the benthic life stages of various fish species (Kjelland et al. 2015; Michel et al. 2013; Wilber and Clarke 2001). While sensitivity varies widely, egg and larval life stages are particularly sensitive and can experience sublethal or lethal effects from as little as 0.4 inch (10 mm) of sediment deposition. Certain species, like winter flounder, are highly sensitive to sediment deposition and can experience mortality at burial depths less than 0.1 inch (3 mm) (Michel et al. 2013). EFH species with benthic or epibenthic eggs or larvae that are known or likely to occur within the range of potential TSS effects from RWF construction and installation include the following:

- Atlantic herring (eggs)
- Atlantic sea scallop (eggs and larvae)
- Little skate (eggs)
- Longfin squid (eggs)
- Ocean pout (eggs and larvae)
- Red hake (larvae)
- Winter flounder (eggs and larvae)

Sedimentation on gravels, a preferred spawning substrate for Atlantic herring, could directly negatively impact benthic Atlantic herring eggs and have resultant negative, indirect food-web effects to the commercially important Atlantic cod. Atlantic sea scallop eggs are heavier than seawater and are therefore likely to be found near benthic habitats. Their larvae are mainly found on gravel substrates, small rocks, and shells, which are all common CMECS substrates and biogenic features found throughout the leasing area (see Tables 3.2 and 3.5, respectively) . Red hake larvae are commonly found underneath or within the mantles of Atlantic sea scallops, utilizing them for shelter, and thus could also be negatively impacted by sedimentation indirectly through habitat loss, or directly through sediment deposition. Little skate (eggs), winter flounder (eggs and larvae), ocean pout (eggs and larvae), and longfin squid (eggs) all utilize sandy gravel, gravelly sand, and slightly gravelly sand, also rendering them vulnerable to sedimentation in leasing areas.

Effects on Juveniles in Mobile Benthic/Epibenthic EFH Species Groups

Benthic and epibenthic juvenile fish life stages that occur within the IAC and OSS-link construction and installation footprint could be exposed to elevated water column TSS concentrations and deposition of suspended sediments from inter-array cable construction and installation. Juvenile fish are expected to be able to avoid burial effects from sediment deposition and would primarily respond to elevated TSS concentrations in the water column. As described above, maximum TSS concentrations are expected to range from 50 to 100 mg/L within 1,209 feet (369 meters) to 932 feet (284 meters), respectively. Concentrations of this magnitude and duration are typically associated with behavioral avoidance and sublethal physiological effects on juvenile marine and estuarine fishes (Michel et al. 2013; Wilber and Clarke 2001). Juvenile fishes exposed to elevated TSS may temporarily cease feeding, abandon cover, and experience short-term physiological stress. The affected individuals may be more vulnerable to predation. EFH species with benthic or epibenthic juvenile life stages that are known or likely to occur within the range of potential TSS effects from RWF construction and installation include the following:

- Atlantic cod (juvenile)
- Pollock (juvenile)
- Red hake (juvenile)
- Silver hake (juvenile)
- White hake (juvenile)
- Black sea bass (juvenile)
- Monkfish (juvenile)
- Ocean pout (juvenile)
- Scup (juvenile)
- Windowpane flounder (juvenile)
- Winter flounder (juvenile)
- Witch Flounder (juvenile)
- Yellowtail flounder (juvenile)
- Barndoor skate (juvenile)
- Little skate (juvenile)
- Winter skate (juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile)

Like larval red hake, juvenile red hake utilize sea scallops for habitat and occupy gravelly sand, sandy gravel, slightly gravelly sand, and medium sand habitats that are found throughout the lease area. Negative effects from sedimentation could affect juvenile red hake either indirectly (via effects to Atlantic sea scallops) or directly, although it is expected that they would be able to avoid the burial effects of sedimentation. Ocean pout juveniles are found on a variety of substrate types but may indirectly be negatively impacted by sedimentation as they prey on small benthic organisms such as polychaetes, which could be smothered by sediment deposition. These same indirect effects from prey smothering may impact winter flounder juveniles, who prey on benthic organisms observed in SPI/PV imagery in the project area, such as sand dollars, bivalve siphons, polychaetes, and amphipods.

<u>Effects on Adults in Mobile Benthic/Epibenthic EFH Species Groups</u>

Benthic or epibenthic adult fish that occur within the IAC and OSS-link construction and installation footprint could be exposed to elevated water column TSS concentrations and deposition of suspended sediments from inter-array cable construction and installation. Adult fish are expected to be able to avoid burial effects from sediment deposition and would primarily respond to elevated TSS concentrations in the water column through behavioral avoidance. Short-term exposure to minor elevations in TSS (50 to 100 mg/L) is typically associated with behavioral avoidance in adult fishes and are below levels associated with sublethal physiological effects on adult marine and estuarine fishes (Michel et al. 2013; Wilber and Clarke 2001). EFH species having benthic or epibenthic adult life stages that are known or likely to occur within the range of potential TSS effects from RWF construction and installation include the following:

- Atlantic cod (adult, spawning)
- Red hake (adult, spawning)
- Silver hake (adult, spawning)
- Black sea bass (adult)
- Monkfish (adult, spawning)
- Ocean pout (adult, spawning)
- Scup (adult)
- Atlantic herring (spawning)
- Summer flounder (adult)
- Windowpane flounder (adult, spawning)
- Winter flounder (adult, spawning)
- Witch flounder (adult, spawning)
- Yellowtail flounder (adult, spawning)
- Barndoor skate (adult)
- Little skate (adult)
- Winter skate (adult)
- Sandbar shark (adult)
- Spiny dogfish (adult, male and female)

Adult Atlantic cod, while expected to avoid elevated TSS concentrations and depositions of suspended sediments, could be impacted indirectly through negative effects to their prey (e.g., shellfish, herring). Similar indirect effects could apply to other adult species that feed on benthic prey (particularly sessile benthic prey) that have been observed in SPI/PV images in each zone (see Tables 3.5 and 3.6) within the lease area (e.g., barnacles, tunicates, sea pens, shrimp, crabs, amphipods, polychaetes, and hydroids). This includes monkfish, ocean pout, winter flounder, and little skate adult stages.

Effects on Sessile Benthic/Epibenthic Invertebrates

Juvenile and adult Atlantic sea scallop, Atlantic surf clam, and ocean quahog could be exposed to elevated water column TSS and sediment deposition effects during RWF construction and installation. Benthic invertebrate prey resources for EFH species such as polychaetes, sand dollars, bivalve siphons, and amphipods may be similarly affected. In general, short-term exposure to TSS concentrations like those anticipated from inter-array cable installation are not associated with adverse effects on filter-feeding bivalves (USACE 2000; Wilber and Clarke 2001; Yang et al. 2017). In contrast, burial depths between 0.4 and 1.2 inches (10 and 30 mm) could result in sublethal to lethal effects on smaller juveniles or adults. Potential sublethal to lethal effects could occur on up to 22,715 acres (9,192 hectares) where burial depths could exceed 10 mm, and on up to 217 acres (88 hectares) where burial depths could exceed 0.1 mm. The resulting effects on EFH suitability would be short-term in duration, effectively ending immediately after suspended sediments have completely settled. EFH shellfish life stages potentially exposed to elevated TSS and sedimentation from RWF construction and installation are as follows:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)

Suspended Sediment Effects from RWEC Construction and Installation

RWEC construction and installation would generate localized plumes of suspended sediments with maximum TSS concentrations of 100 mg/L extending approximately 3,067 feet (935 meters) from RWEC-OCS and 5,838 feet (1,779 meters) from RWEC-RI construction and installation activities. TSS concentrations of 50 mg/L would extend approximately 4,494 feet (1,370 meters) from RWEC-OCS and 6,888 feet (2,099 meters) from RWEC-RI construction and installation activities. These direct effects would dissipate to background in approximately five hours (RPS 2021). RWEC construction and installation would occur in 2023/24 and is expected to require approximately eight months to complete. Sediment-generating activities would occur continuously throughout these periods but would be limited to the area immediately around the jet plow as it transits along the RWEC corridor. Common CMECS substrate types within large-grained and complex habitats in the RWEC-RI and RWEC-OCS include shell hash, reef substrate (i.e., Crepidula reef substrate), and slightly gravelly sand. Soft bottom habitats include a variety of sand types and largely consist of fine sand and very fine sand (see Table 3.2). For more information on benthic habitat types and bedform features present in the RWEC-RI and RWEC-OCS areas, see section 3.5.

Dredging and sidecast during construction and installation of the RWEC sea-to-shore transition would generate TSS concentrations reaching exceeding 500 mg/L in the immediate proximity of excavation, with concentrations exceeding 100 mg/L extending up to 1,312 feet (400 meters) from the disturbance (RPS 2021). Dredging activities would take place between September and the following May and would require 3 to 4 days to complete. RPS (2021) estimated that TSS concentrations more than 100 mg/L would dissipate to background levels within approximately six hours after the disturbance ceases.

<u>Effects on Sessile Benthic/Epibenthic Eggs and Larvae of EFH Species</u>

EFH species with benthic and epibenthic eggs and larvae that occur within the RWEC construction and installation footprint could be exposed to elevated water column TSS concentrations and burial by deposition of suspended sediments. The eggs and larvae of these other species that provide prey resources for EFH species could be similarly exposed. An estimated 42 acres (77 hectares) of benthic habitat could be exposed to fine sediment deposition depths of 10 mm, an estimated 8,463 acres (3,389 hectares) could be exposed to deposition depths of 1 mm, and an estimated 13,857 acres (5,608 hectares) could be exposed to deposition depths of 0.1 mm (RPS 2021). This total comprises both RWEC circuits in the RWEC-OCS, RWEC-RI, and the sea-to-shore transition.

The sensitivity of egg and larval life stages to sediment deposition effects varies widely between species, but the available research indicates that sublethal or lethal effects can result from as little as 0.4 inch (10 mm) of sediment deposition. Certain species, like winter flounder, are highly sensitive to sediment deposition and can experience mortality at burial depths less than 0.1 inch (3 mm) (Michel et al. 2013). On this basis, benthic habitats exposed to measurable burial depths from each of the RWEC route alternatives described above would be rendered temporarily unsuitable for the following EFH species having benthic or epibenthic eggs and larvae and are likely to occur in this component of the project area:

- Atlantic herring (eggs)
- Atlantic sea scallop (eggs and larvae)
- Little skate (eggs)
- Longfin squid (eggs)
- Ocean pout (eggs and larvae)
- Red hake (larvae)
- Winter flounder (eggs and larvae)

While gravel bottoms are preferred spawning substrates of Atlantic herring, their eggs are also found near substrates typical of the RWEC-RI and RWEC-OCS such as very fine sand and fine sand substrates (see Table 3.2). Atlantic herring would be vulnerable to smothering from sediment deposition associated with the RWEC construction and installation footprint. Other benthic, early life stages of EFH species (e.g., Atlantic sea scallop eggs and larvae, longfin squid eggs, and the eggs and larvae of ocean pout— a currently overfished species) would also be vulnerable to smothering via sediment disposition. Biogenic features (e.g., amphipod tubes and other epifauna) and habitat-forming organisms (e.g., barnacles, sea pens, hydroids, mussels, and sponges) observed in SPI/PV imagery within each RWEC zone could also be vulnerable to sedimentation/smothering. This could indirectly impact the eggs and larvae of the aforementioned EFH species as these features provide refuge from predators, food resources, and attachment/settlement surfaces.

Effects on Juveniles in Mobile Benthic/Epibenthic EFH Species Groups

Juvenile fish that use benthic and epibenthic habitats within the RWEC construction and installation footprint could be exposed to elevated water column TSS concentrations and deposition of suspended sediments from inter-array cable construction and installation. This includes juveniles of EFH species and juvenile fish that provide prey for other EFH species. Juvenile fish are expected to be able to avoid burial effects from sediment deposition and would primarily respond to elevated TSS concentrations in the water column. As described above, maximum TSS concentrations are expected to exceed 500 mg/L at selected locations. The highest concentration TSS plumes would not persist in any given location for more than three hours. TSS concentrations of 100 mg/L would extend approximately 3,067 feet (935 meters) from RWEC-OCS and 5,838 feet (1,779 meters) from RWEC-RI construction and installation activities. TSS concentrations of 50 mg/L would extend approximately 4,494 feet (1,370 meters) from RWEC-OCS and 6,888 feet (2,099 meters) from RWEC-RI construction and installation activities. TSS plumes would not persist in any given location for greater than five hours (RPS 2021).

TSS concentrations at the lower end of the modeled range are typically associated with behavioral avoidance, while the higher-end concentrations overlap with levels associated with sublethal physiological effects on juvenile marine and estuarine fishes, albeit over longer exposure periods (Michel et al. 2013; Wilber and Clarke 2001). Juvenile fishes exposed to elevated TSS may temporarily cease feeding and abandon cover, and experience short-term physiological stress. EFH species with benthic or epibenthic juvenile life stages that are known or likely to occur within the range of potential TSS effects from RWEC construction and installation include the following:

- Atlantic cod (juvenile)
- Pollock (juvenile)
- Red hake (juvenile)
- Silver hake (juvenile)
- White hake (juvenile)
- Black sea bass (juvenile)
- Monkfish (juvenile)
- Ocean pout (juvenile)
- Scup (juvenile)
- Windowpane flounder (juvenile)
- Winter flounder (juvenile)
- Witch flounder (juvenile)
- Yellowtail flounder (juvenile)
- Barndoor skate (juvenile)
- Little skate (juvenile)
- Winter skate (juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile)

Impacts to juvenile fish in the RWEC-RI and RWEC-OCS areas would be similar to those described earlier in this section for juveniles in the IAC and OSS-link areas, accounting for different concentrations and extent of TSS.

Effects on Adults in Mobile Benthic/Epibenthic EFH Species Groups

EFH species that are benthic or epibenthic as adults and are likely occur within the RWEC construction and installation footprint could be exposed to elevated water column TSS concentrations and deposition of suspended sediments from cable installation and sea-to-shore transition construction and installation. EFH species that prey on adult benthic and epibenthic species may also be exposed to short-term, direct effects on prey resources. Adult fish are expected to be able to avoid burial effects from sediment deposition and would primarily respond to elevated TSS concentrations in the water column through behavioral avoidance. Short-term exposure to TSS concentrations exceeding 1,000 mg/L has been associated with sublethal and behavioral avoidance effects on adult marine and estuarine fishes, while concentrations of less than 500 mg/L are more commonly associated with behavioral avoidance (Michel et al. 2013; Wilber and Clarke 2001). EFH species having benthic or epibenthic adult life stages that are known or likely to occur within the range of potential TSS effects from RWEC construction and installation include the following:

- Atlantic cod (adult, spawning)
- Red hake (adult, spawning)
- Silver hake (adult, spawning)
- Black sea bass (adult)
- Monkfish (adult, spawning)
- Ocean pout (adult, spawning)
- Scup (adult)
- Atlantic herring (spawning)
- Summer flounder (adult)
- Windowpane flounder (adult, spawning)
- Winter flounder (adult, spawning)
- Witch flounder (adult, spawning)
- Yellowtail flounder (adult, spawning)
- Barndoor skate (adult)
- Little skate (adult)
- Winter skate (adult)
- Sandbar shark (adult)
- Spiny dogfish (adult, male and female)

Impacts to adult fish in the RWEC-RI and RWEC-OCS areas would be similar to those described earlier in this section for adults in the IAC and OSS-link areas, accounting for different concentrations and extent of TSS.

Effects on Sessile Benthic/Epibenthic Invertebrates

Juvenile and adult Atlantic sea scallop, Atlantic surf clam, and ocean quahog could be exposed to elevated water column TSS and sediment deposition effects during RWEC construction and installation. Other benthic invertebrates that provide prey for EFH species may also be exposed to TSS and sediment deposition effects. Short-term exposure to the maximum TSS concentrations anticipated from RWEC installation (greater than 500 mg/L) are at the lower end of exposures associated with observed sublethal effects on filter-feeding bivalves, although those effects resulted over exposure periods lasting 24 hours or more (USACE 2000; Wilber and Clarke 2001; Yang et al. 2017). In contrast, burial depths 10 mm could result in sublethal to lethal effects on smaller juveniles or adults. For the RWEC, sublethal to lethal effects could occur on up to an estimated 42 acres (77 hectares) of benthic habitat exposed to fine sediment deposition depths of 10 mm, 8,463 acres (3,389 hectares) exposed to deposition of 1 mm, and 13,857 acres (5,608 hectares) exposed to deposition of 0.1 mm (RPS 2021). The resulting direct effects on EFH suitability would be short-term in duration, effectively ending immediately after suspended sediments have completely settled. EFH shellfish life stages potentially exposed to elevated TSS and sedimentation from RWEC construction and installation are as follows:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)

Underwater Sound

Underwater noise sources from RWEC construction and installation include the potential use of impact and vibratory pile driving at the sea-to-shore transition site, pre-construction HRG surveys of the cable installation corridors, vessel noise, and unexploded ordinance (UXO) detonation. This section focuses on noise impacts related specifically to impact and vibratory pile driving used at the sea-to-shore transition site.

The RWEC sea-to-shore transition would require approximately three days to construct. Two alternatives are being considered for the cofferdam used to construct this project feature: a gravity cell or a sheetpile structure installed using a vibratory hammer. The former would not produce any significant noise effects and is therefore not considered further. Vibratory installation of the sheetpile cofferdam would require approximately 3 days to complete, during which continuous underwater noise would occur intermittently as each sheetpile is placed. The sheetpiles would be removed when the sea-to-shore transition is completed, requiring a similar 3 days of vibratory hammer operation.

<u>Effects to EFH Species and Habitats</u>

- Direct
  - Short-term, direct effects on EFH and EFH species and life stages for all Hearing Categories,with greatest impacts to Hearing Category 3 species and life stages.
  - Short-term, direct effects on EFH of all Species Groups: Sessile Benthic/Epibenthic – SoftBottom; Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – ComplexHabitat; Mobile Benthic/Epibenthic – Complex Habitat; Pelagic; Prey Species –Benthic/Epibenthic; Prey Species – Pelagic.

The specific thresholds used to evaluate underwater noise impacts from foundation installation, estimated sound attenuation distance and area affected for each hearing group threshold, and a summary of impacts to EFH species and habitats are summarized by hearing group in the following sections.

Underwater noise impacts to EFH species from cable installation vessels, HRG surveys, and UXO detonation within the IAC and RWEC corridors are addressed elsewhere in this document. With regard to vessel noise, noise impacts from cable-laying vessels and the various construction and installation vessels used to complete the sea-to-shore transition would be similar to those described for foundation installation vessels in Section 5.1.1.1. However, the duration and timing of those impacts would differ. Vessels used for cable installation would generate effectively continuous underwater noise 24 hours/day during their respective construction and installation periods. In total, vessel operations associated with cable installation would take place over a discontinuous 13-month period in 2023 and 2024. The HRG survey totals described in Section 5.1.1.1 represent the total combined survey effort for the Lease Area and RWEC. The COP does not differentiate the amount of survey effort required for each component, therefore the associated impacts presented in Section 5.1.1.1 are inclusive of cable installation.

As stated, Revolution Wind has identified 16 UXOs within zone RWEC-RI, none requiring detonation in place (Orsted 2023). However, for the purpose of this assessment BOEM assumes that additional UXOs could be identified within the RWEC and Lease Area and that some of those devices may require detonation in place. The sound exposure estimates and effects to EFH species for described for UXO detonation in Sections 5.1.1.2 and 5.1.1.3 are also inclusive of cable installation impacts.

Underwater Sound Effects from Sea-to-Shore Transition Construction on Eggs and Larvae

Continuous noise sources like vibratory pile driving and vessel engines are unlikely to cause adverse effects on eggs and larvae. Popper et al. (2014) was unable to identify useful thresholds for evaluating potential injury or mortality effects from this type of noise source. On this basis, underwater noise effects from RWEC construction and installation on habitats used by eggs and larvae of EFH species and their prey are expected to be insignificant. The following EFH species are likely to be exposed to underwater noise from RWEC construction and installation during the egg and larval life stages:

- Atlantic cod
- Haddock (larvae only)
- Red hake
- Silver hake
- Black sea bass
- Atlantic herring (larvae only)
- Atlantic mackerel
- Bluefish
- Butterfish
- Ocean pout
- Atlantic herring
- Monkfish
- Scup (eggs only)
- Summer flounder
- Windowpane flounder
- Winter flounder
- Witch Flounder
- Yellowtail flounder
- Atlantic sea scallop
- Longfin squid

Underwater Sound Effects from Sea-to-Shore Transition Construction on EFH Species in the Hearing Specialist Group

Underwater noise from RWEC construction and installation is unlikely to exceed lethal injury thresholds for the hearing specialist group of fishes. Vibratory pile driving noise is likely to exceed thresholds sufficient to cause recoverable injury, TTS, and behavioral level effects on EFH species and prey organisms in the hearing specialist fish group. Water column and benthic EFH exposed to underwater noise in excess of potential recoverable injury, TTS, and behavioral effects are described by noise source for vibratory pile driving and vessel noise as follows.

- Vibratory pile driving noise:
    - Recoverable cumulative injury: 2.5 acres (1 hectare) (within 207 feet [63 meters] of source).
    - TTS: 45 acres (18 hectares) (within 781 feet [238 meters] of source).

- Behavioral effects: 420 acres (170 hectares) (within 2,556 feet [779 meters] of source).

- Cable-laying vessel noise:
  - Recoverable cumulative injury: Unlikely to occur (requires continuous exposure < 3.3 feet [1 meter] from mobile source).
  - TTS: Unlikely to occur (requires continuous exposure within approximately 39 feet (12 meters) of mobile source).
  - Behavioral: Within 443 feet [135 meters] of mobile source.

The following EFH species belong to the hearing specialist group and have habitats that are likely to be adversely affected by underwater noise from construction and installation of the RWEC:

- Atlantic cod (juvenile, adult, spawning)
- Haddock (juvenile, adult)
- Pollock (juvenile)
- Red hake (juvenile, adult)
- Silver hake (juvenile, adult)
- White hake (juvenile)
- Black sea bass (juvenile, adult)
- Bluefish (juvenile, adult)
- Monkfish (juvenile, adult)
- Atlantic herring (juvenile, adult)

<u>Underwater Sound Effects from Sea-to-Shore Transition Construction on EFH Species in the Hearing Generalist and Fish Without a Swim Bladder Groups</u>

Underwater noise from RWEC construction and installation is unlikely to exceed lethal injury thresholds for the hearing generalist group of fishes and fishes lacking a swim bladder. Vibratory pile driving noise is likely to exceed thresholds sufficient to cause recoverable injury, TTS, and behavioral level effects on hearing specialist fish species and prey organisms for EFH species belonging to this hearing group. Water column and benthic EFH exposed to underwater noise in excess of potential recoverable injury, TTS, and behavioral effects are described by noise source for vibratory pile driving and vessel noise as follows.

- Vibratory pile driving noise:
  - Recoverable cumulative injury: Unlikely to occur (noise source below threshold).
  - TTS: Unlikely to occur (noise source below threshold).
  - Behavioral effects: 420 total acres (170 total hectares) (within 2,556 feet [779 meters] of source).

- Cable-laying vessel noise:
    - Recoverable cumulative injury: Unlikely to occur (requires continuous exposure < 3.3 feet [1 meter] from mobile source).
    - TTS: Unlikely to occur (requires continuous exposure within 16.4 feet [5 meters] of mobile source).
    - Behavioral: Within 443 feet [135 meters] of mobile source.

The following EFH species belong to the hearing generalist group and have habitats that are likely to be adversely affected by underwater noise from construction and installation of the RWEC:

- Ocean pout (juvenile, adult, spawning)
- Scup (juvenile, adult)
- Butterfish (juvenile, adult)
- Atlantic mackerel (juvenile, adult, spawning)
- Atlantic bluefin (juvenile, adult)
- Atlantic yellowfin (juvenile, adult)
- Albacore (juvenile)
- Atlantic skipjack (adult)

The following EFH species belong to the group of fishes that lack a swim bladder and have habitats that are likely to be adversely affected by underwater noise from construction and installation of the RWEC:

- Summer flounder (juvenile, adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (juvenile, adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)
- Basking shark (neonate/YOY, juvenile)
- Blue shark (neonate/YOY, juvenile)
- Dusky shark (neonate/YOY, juvenile)
- Common thresher shark (neonate/YOY, juvenile)
- Shortfin mako shark (neonate/YOY, juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile, adult)
- White shark (neonate/YOY, juvenile)
- Smooth dogfish (neonate, juvenile, adult)
- Spiny dogfish (subadult, adult)

<u>Underwater Sound Effects from Sea-to-Shore Transition Construction on Invertebrates</u>

The consensus of the cited studies suggests that bivalves, and other benthic organisms within approximately 7 feet (2 meters) and squid within approximately 16 feet (5 meters) of vibratory pile driving may exhibit behavioral responses to particle motion effects, which equates to total exposure areas of 0.15 and 0.37 acre (0.06 and 0.15 hectare), respectively. Construction and installation vessel noise is unlikely to cause behavioral effects on invertebrates.

EFH for the following invertebrate species are likely to be exposed to vibratory pile driving noise from RWEC construction and installation sufficient to temporarily alter their behavior in designated habitat:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)
- Longfin squid (juvenile, adult)

5.1.2.5 Cable Protection

Cable protection, in the form of concrete mattresses or rock blankets, would be placed on exposed segments of the IAC, OSS-link, and RWEC that cannot be buried to desired depth. Cable protection would be approximately 39 feet (12 meters) wide, regardless of type. Cable protection would be required over an estimated 10 percent of the IAC, OSS-link, and RWEC OCS cable routes, and over an estimated 19.5 percent of the RWEC RI route. The latter includes cable protection required at seven identified crossings of existing submarine infrastructure (comprising telecommunications cables, water lines, and unidentified submarine cables). The total length of the exposed segments would be approximately 16 linear miles (26 km) for the IAC, approximately 1 linear mile (1.6 km) for the OSS-link, and approximately 4 and 2 linear miles (6 and 3 km, 3 and 2 nm) for each RWEC circuit in the RWEC-OCS and RWEC-RI, respectively. The distribution of impacts is summarized in Table 5.10 by NOAA Habitat Complexity Categories. The area totals presented comprise the estimated acreages presented in the COP (VHB 2022) for placement of 12-meter-wide cable protection blankets over these estimated lengths.

Placement of cable protection would occur within and overlap areas previously disturbed by seabed preparation and cable installation. Crushing and burial effects to EFH species and habitats within these affected acreages would be the same as those described in Section 5.1.2.3 for cable installation. Permanent habitat conversion impacts on EFH species and habitats resulting from the presence of cable protection are considered an operational effect of the Proposed Action and are described in Section 5.1.3.1.

Table 5.10. Habitat Conversion Impact Area from Boulder Relocation and Cable Protection by NOAA Habitat Complexity Category for the IAC, OSS-link, and RWEC-OCS and RWEC-RI Routes.

Cable Route	Affected Habitat Zones	Total Cable Protection Acres	Estimated Acres in Large-Grained Complex Habitat	Estimated Acres in Complex Habitat	Estimated Acres in Soft Bottomed Habitat
IAC	RWF 1, RWF 2, RWF 3a, RWF 3b, RWF 4	56	6	13	37
OSS-link	RWF 1, RWF 2, RWF 4	1	1	1	1
RWEC-OCS	RWF 1, RWF 2, RWF 4, RWEC-OCS	18	0	5	12
RWEC-RI	RWEC-RI	46	0	6	39

Impact acreage estimates are based on the proportion of total cable length requiring cable protection and cable protection width as presented in the COP (vhb 2022). The specific distribution of cable protection by habitat zone is not currently known, therefore impact acreage is proportionally distributed based on cable corridor composition.

5.1.3 Operations and Maintenance/Presence of Structures

Project operations and maintenance would result in long-term and permanent direct and indirect effects on the environment that could affect habitat suitability for managed species. Long-term direct and indirect effects are those effects expected to last at least 2 years or more while permanent impacts would extend through the 35-year life of the project or longer. These effects comprise:

- Long-term to permanent habitat disturbance and conversion effects resulting from boulder relocation during construction, and the presence of manmade structures in the environment.
- Permanent habitat alteration and associated effects on community structure and food web dynamics caused by reef effects.
- Permanent operational noise effects.
- Permanent alteration of dispersal patterns for planktonic eggs and larvae caused by hydrodynamic effects of structure presence.

The extent, severity, timing, and duration of long-term and permanent effects on aquatic habitats resulting from operation and maintenance of the RWF and the RWEC are described in the following sections.

The installation of the RWF and RWEC would alter water column and benthic EFH used by a variety of mid-Atlantic OCS fish and invertebrate species. The placement of the monopile foundations, excavation and reburial of transmission cables, placement of scour and cable protection, and relocation of unavoidable boulders along the inter-array cable and RWEC corridors would produce long-term and permanent effects on benthic habitat of varying significance and duration. In some cases, existing habitats will be converted to new habitat types and this habitat conversion would be effectively permanent.

The type, extent, and duration of potential habitat conversion effects on each of these habitat types are described by project component in the following sections.

5.1.3.1 Long-term Habitat Conversion Impacts from Seabed Preparation, and Presence of WTG and OSS Foundations and Cable Protection

The RWF would have permanent indirect effects on pelagic and benthic habitats on the mid-Atlantic OCS, resulting from the presence of the monopile foundations, boulder scour protection, and cable protection installed on exposed segments of the IAC, OSS-link, and RWEC. In addition, seabed 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. Impacts to EFH species and habitats are summarized as follows:

Effects to EFH Species and Habitats

- Direct
  - Long-term to permanent impacts to benthic habitats impacted by boulder relocation: EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Prey Species – Benthic; Summer Flounder HAPC; Southern New England HAPC.
  - Permanent habitat conversion impacts from the presence of structures and associated reef effects: EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Pelagic species groups; Prey Species – Benthic; Prey Species – Pelagic, Summer Flounder HAPC; Southern New England HAPC.
  - Permanent hydrodynamic impacts resulting from the presence of structures: EFH for species with Pelagic eggs and larvae.
- Indirect:
  - Permanent indirect impacts on EFH species through changes in habitat productivity resulting from reef effects and altered predator/prey relationships:

EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Pelagic species groups; Prey Species – Benthic; Prey Species – Pelagic, Summer Flounder HAPC; Southern New England HAPC.

- Potential permanent indirect impacts from establishment of non-native species promoted by reef effects: EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Pelagic species groups; Prey Species – Benthic; Prey Species – Pelagic, Summer Flounder HAPC; Southern New England HAPC.

The extent of long-term to permanent habitat disturbance and conversion effects from the RWF and RWEC are summarized by category in Table 5.11. These impacts are described in detail by species group in the following sections.

Table 5.11. Long-term Habitat Conversion Impact Area by Project Feature, Habitat Zone, and NOAA Habitat Complexity Category.

Project Feature	Element	Habitat Zone	Maximum Habitat Conversion Footprint (acres)*	Disturbance as Percent of Zone Area	Percent of Disturbance in Large-Grained Complex Habitat	Percent of Disturbance in Complex Habitat	Percent of Disturbance in Soft Bottom Habitat	Water Column (m^3)
WTG and OSS foundations	Seabed Preparation	RWF 1	50.3	0.7%	11.6%	49.5%	38.9%	N/A
		RWF 2	223.2	0.7%	7.8%	50.4%	41.8%	N/A
		RWF 3a	43.1	1.3%	6.4%	56.7%	36.9%	N/A
		RWF 3b	0	--	--	--	--	N/A
		RWF 4	266.3	0.8%	5.6%	7.1%	87.3%	N/A
		RWF Total	**583.0**	**0.8%**	**19.0%**	**29.7%**	**51.3%**	**N/A**
	Scour Protection±	RWF 1	5.4	0.07%	14.3%	50.2%	35.5%	N/A
		RWF 2	23.9	0.07%	6.2%	52.5%	41.3%	N/A
		RWF 3a	4.6	0.14%	10.5%	62.8%	26.7%	N/A
		RWF 3b	0	--	--	--	--	--
		RWF 4	28.5	0.09%	2.7%	6.0%	91.3%	N/A
		RWF Total	62.3	0.08%	5.6%	31.8%	62.6%	N/A
	Monopiles	RWF 1	0.2	0.003%	14.3%	44.6%	41.1%	9,233
		RWF 2	0.9	0.003%	6.3%	49.8%	43.9%	41,219
		RWF 3a	0.2	0.005%	16.7%	52.6%	30.8%	7,914
		RWF 3b	0	--	--	--	--	0
		RWF 4	1.0	0.003%	2.7%	6.8%	90.5%	49,133
		RWF Total	**2.9**	**0.003%**	**6.1%**	**29.9%**	**64.0%**	**107,499‡**
IAC, OSS-link, RWEC	Boulder Relocation	RWF 1	211	2.8%	16.4%	20.2%	63.4%	N/A
		RWF 2	529	1.6%	17.9%	34.4%	47.7%	N/A
		RWF 3a	60	1.8%	0.0%	14.8%	85.2%	N/A
		RWF 3b	0	--	--	--	--	--
		RWF 4	649	2.1%	1.5%	12.1%	86.4%	N/A
		RWEC-OCS	388	8.7%	1.1%	34.9%	64.0%	N/A
		RWEC-RI	479	8.2%	0.0%	14.8%	85.2%	N/A
		All Zones Total	**2,314**	**2.7%**	**6.4%**	**22.6%**	**71.0%**	**N/A**

Project Feature	Element	Habitat Zone	Maximum Habitat Conversion Footprint (acres)*	Disturbance as Percent of Zone Area	Percent of Disturbance in Large-Grained Complex Habitat	Percent of Disturbance in Complex Habitat	Percent of Disturbance in Soft Bottom Habitat	Water Column (m^3)
	Cable Protection†	RWF 1	9.3	0.11%	17.0%	21.0%	62.0%	N/A
		RWF 2	28.0	0.06%	17.7%	34.5%	47.8%	N/A
		RWF 3a	3.1	0.07%	0.0%	44.9%	55.1%	N/A
		RWF 3b	0	--	--	--	--	--
		RWF 4	34.9	0.08%	1.5%	12.3%	86.3%	N/A
		RWEC-OCS	17.9	0.31%	0.0%	14.8%	85.2%	N/A
		RWEC-RI	42.8	0.96%	1.1%	34.8%	64.1%	N/A
		All Zones Total	**116.2**	**0.13%**	**6.4%**	**22.7%**	**70.9%**	**N/A**

‡ Based on WTG and monopile foundation diameter assuming an average depth of 35 meters.

± Acreage estimates include 0.07 acre per foundation of additional habitat conversion effects from CPS extending beyond the scour protection footprint.

† Precise cable protection acreages required within each habitat zone are not currently known. Values are estimated based on total cable length within each zone, and the estimated percentage of cable length requiring protection as presented in the COP (vhb 2022).

Boulder Relocation

Boulder relocation during seabed preparation for foundation installation and cable installation would result in long-term to permanent impacts on benthic habitat composition and structure. Boulders associated with large-grained complex and complex benthic habitat would be relocated from an approximate 7.2-acre (2.9-hectare) footprint centered on each of the 81 monopile foundations. Boulder relocation would also be required over approximately 80 percent of the IAC installation corridor, 60 percent of the OSS-link corridor, 40 percent of the RWEC OCS, and 70 percent of the RWEC RI routes. In total, Revolution Wind (2022a) estimates that a total of 6,161 boulders ranging from 2.3 to 6.6 feet (0.7 to 2.0 meters) in diameter or greater would be relocated from foundation sites and cable installation corridors.

Seabed preparation and boulder relocation impacts would be distributed by NOAA Habitat Complexity Category as shown in Table 5.11. The acreages shown represent the area in which boulder relocation impacts may occur. The actual habitat footprint impacted by this activity would likely be less than these estimates. In total, boulder relocation associated with construction of the WTG and OSS foundations would impact up to 111 acres of large-grained complex and 173 acres of complex habitat, much of this area overlapping portions of Cox Ledge associated with Atlantic cod spawning (i.e., RWF zones 1 and 2) and general use by other EFH species that associate with these habitat types. Boulder relocation would occur within an estimated 2,314 acres of the RWEC, IAC, and OSS-link cable installation corridors. The distribution of cable protection impacts presented in Table 5.11 is an estimate based on the acres of cable protection required for each cable and the proportional distribution of cable length within each habitat zone. However, cable protection may not be distributed proportionally (e.g., it may be concentrated in areas where large-grained complex habitat is more prevalent), therefore the actual acreage of cable protection in each habitat zone may vary from the estimates presented here.

Boulder relocation could result in long-term to permanent impacts to benthic habitat composition and structure. Sessile habitat forming invertebrates, such as sponges and hydroids, that colonize boulders and cobbles are an important component of benthic habitat structure as they provide refuge from predators, attachment surface for benthic eggs, and foraging opportunities. EFH species that have benthic life stages associated with cobble habitats and attached fauna, such as juvenile cod, Atlantic sea scallops (larvae, juveniles and adults), Atlantic herring (spawning adults and eggs), longfin squid (eggs), and ocean pout (eggs, larvae, juveniles, and adults), and red hake (larvae and juveniles) would be indirectly vulnerable if damage to these substrates occur from boulder relocation. Damage to organisms associated with large-grained complex and complex habitats during seabed preparation could take several years to decades to fully recover (Auster and Langton 1999; Collie et al. 2005; Tamsett et al. 2010). This would constitute a long-term effect on benthic habitat structure. Boulder relocation may result in effectively permanent alteration of benthic habitat composition where boulders are displaced into soft bottom habitat, or where boulder removal leaves soft bottom habitat in their place. This effect could occur within an unknown proportion of the cable seabed preparation corridor and the seabed preparation footprint around the monopile foundations.

Reef Effects from Monopile Foundations and Scour Protection

The introduction of 81 monopile foundations and associated scour protection would alter pelagic habitats in the offshore OCS by introducing vertical hard surfaces into the water column. Each of the 79, 12-meter WTG monopile foundations and two, 15-meter OSS monopile foundations would have an operational footprint in benthic habitats of approximately 0.73-acres (0.3-hectares), including scour protection (0.03-acres for each monopile and 0.7-acres for scour protection). The distribution of these impacts by benthic habitat type is the same as described for structure installation in Table 5.3.

The monopiles would also add new hard surfaces to the water column, assuming an average water depth across the Lease Area of approximately 115 feet (38 meters). The ongoing presence of monopiles, their foundations, and scour protection during Project would create an artificial reef effect. Over time the monopiles would become colonized by sessile invertebrates, such as mussels, tunicates, anemones, and sponges, creating complex habitat. When placed in soft bottom habitat, these structures would effectively change the habitat type. When placed in large-grained complex or complex habitat, these structures would either alter the habitat type or modify benthic habitat structure through burial and damage to habitat-forming invertebrates. That habitat structure would recover and would evolve over time into functional benthic habitat as reef effects mature.

Habitat for invertebrates that colonize hard surfaces or associate with complex benthic habitat would increase. Epibenthic organisms (e.g., mussels and anemones) and crustaceans that prefer hard-bottom habitat (e.g., American lobster and crab) would gain habitat. The available evidence indicates that recovery of benthic habitat structure would begin quickly and would likely be relatively rapid, but full recovery of the community of habitat forming organisms could take several years to decades. For example, Degraer et al. (2020) have documented the development of diverse invertebrate communities on offshore wind structures around the globe. Hutchison et al. (2020a) documented the development of a diverse and biologically productive invertebrate community that developed on turbine foundations at the nearby BIWF within 3 years after construction. The structures were initially colonized by dense aggregations of mussels and barnacles, followed by corals, hydroids, anemones, and predatory invertebrates like crabs, sea stars, and snails. An invasive tunicate, already widespread and common in the region, is also present. Shell hash and detritus falling from the foundations changed the composition of and enriched the surrounding sediments, increasing biological productivity. These effects extended beyond the scour protection footprint surrounding each foundation. Similar artificial reef effects have been observed at other offshore wind facilities (Causon and Gill 2018; Degraer et al. 2020; Langhamer 2012; Taormina et al. 2018). While these findings indicate relatively rapid recovery of benthic community structure in general, some impacts may be longer lasting. Certain types of habitat-forming invertebrates, such as sponges and corals, are sensitive to disturbance and slow growing. These more sensitive species can take several years to fully recover and recolonize damaged habitats (Tamsett et al. 2010).

The attraction of finfish and other species to artificial reefs that form on offshore windfarms and other manmade structures is well documented (Degraer et al. 2020; Hutchison et al. 2020a; Kramer et al. 2015; Wilber et al. 2022). In a meta-analysis of studies on wind farm reef effects, Methratta and Dardick (2019) generally observed an increase in the abundance of epibenthic and demersal fish species, but less clear effects on pelagic species (Floeter et al. 2017; Methratta and Dardick 2019). Increased fish abundance can alter predator prey relationships. For example, Russel et al. (2014) observed that seals appear to concentrate foraging activity around WTG foundations, presumably to exploit the higher abundance and concentration of prey organisms associated with reef effects.

Hutchison et al. (2020b) and Wilber et al. (2022) documented similar fish responses to reef effects at the nearby BIWF. They observed a notable increase in the abundance of black sea bass, an EFH species, in proximity to the WTG foundations. This species is known to associate with complex benthic habitat and artificial reef structures and is clearly benefiting from the habitat and foraging opportunities created by the artificial reef effect. Several other fish species have also been observed in abundance, including EFH species like Atlantic cod, scup, bluefish, monkfish, winter flounder, and dogfish (Hutchison et al. 2020b; Wilber et al. 2022). Atlantic striped bass and tautog, highly valued commercial and recreational fish species, have also been observed in abundance around the structures (Hutchison et al. 2020b; Wilber et al. 2022). Similar changes in fish community structure would likely occur in the Lease Area as the reef effect matures. Degraer et al. (2020) indicate that the finfish community around artificial structures differs significantly from the surrounding natural habitat, as would be expected with the introduction of novel hard surfaces available for colonization by habitat forming organisms.

While this is a subject of ongoing inquiry, this indicates that although full recovery of complex benthic habitats damaged by Project construction could take a several years to decades, those impacts could be offset over a shorter period of time by beneficial reef effects to other species.

The Lease Area is in the vicinity of, and overlaps Cox Ledge, an area of complex benthic habitat that supports several commercially and recreationally important species. The observations at the BIWF and other European wind farms (Hutchison et al. 2020a; Methratta and Dardick 2019; Guarinello and Carey 2020) indicate that commercially valuable species like black sea bass, Atlantic cod, and pollock are likely to be attracted to the increased biological productivity these structures would create. While the available evidence to date suggests that the effects of long-term habitat alteration from wind farm development on finfish are generally beneficial at local and regional scales, considerable uncertainty remains about the potential for broader effects at population scales (Degraer et al. 2020). This could result in beneficial, neutral, or potentially negative effects. For example, increased feeding opportunities could translate to faster growth, increased fitness and survival, and increased reproductive success. Greater habitat productivity could also increase larval and juvenile survival within and around the affected habitats due to increased food availability and the protection offered by complex physical habitat. Wind farms could also create “ecological traps” that compel fish to remain in habitats that are unfavorable for spawning and larval survival (Degraer et al. 2020). The latter could also have negative consequences if vulnerable populations of fish are concentrated together with their predators and/or increased fishing effort. Habitat use of European wind farms by cod and pollock has largely been seasonal (Reubens et al. 2014), indicating that negative effects on migratory and spawning behavior is unlikely, at least for these species.

These new habitats could have a variety of indirect effects on fish and other aquatic species occurring in the vicinity. For example, pelagically oriented juvenile and adult fish may be attracted to the complex habitats formed on the vertical structures in search of cover and foraging opportunities. Surface and pelagically oriented eggs and larvae would be exposed to filter-feeding invertebrates in open water habitats where they did not previously exist. Fish concentrations around the monopile habitats may attract marine mammals and commercial and recreational fishers.

The net effect of monopile foundations on pelagic EFH is likely to be neutral to beneficial depending on species-specific responses, with the recognition that beneficial effects could be negated should these structures inadvertently promote the establishment of invasive species on the mid-Atlantic OCS. Artificial structures may also provide opportunities for range expansion by invasive species in conjunction with range shifts due to climate change (Degraer et al. 2020; Langhamer 2012; Schulze et al 2020), which would constitute a synergistic cumulative effect.

Permanent Effects on Species Groups Associated with Pelagic Habitats

The installation of 81 12-meter and 2 15-meter diameter monopile foundations would introduce approximately 107,500 m² of new hard surfaces to the water column, extending from the seabed to the water surface. These vertical structures would alter the character of pelagic habitats used by many EFH species and their prey and foraging resources. Over time these new hard surfaces will become colonized by sessile organisms, creating complex habitats that effectively serve as artificial reef.

The reef effect created by offshore structures like WTGs is well documented and can have an attractive effect on many marine species (Langhamer 2012; Peterson and Malm 2006; Ruebens et al 2013; Wilhelmsson et al. 2006). This can lead to localized increases in fish abundance and changes in community structure. In a meta-analysis of studies on windfarm reef effects, Methratta and Dardick (2019) observed an almost universal increase in the abundance of epibenthic and demersal fish species. However, effects on pelagic fish species are not well defined (Floeter et al. 2017; Methratta and Dardick 2019). On balance, the reef effect of offshore windfarms is likely to produce a neutral to beneficial effect on EFH. However, these beneficial effects could be offset if the colonizable habitats provided by offshore wind energy structures aggregate predators and prey, increasing predation risk, or provide opportunity for non-native species to establish (De Mesel et al. 2015; Gill et al. 2005; Raoux et al. 2017). The net effect of WTGs on pelagic EFH is likely to be neutral to beneficial depending on species-specific responses, with the recognition that beneficial effects could be negated should these structures inadvertently promote the establishment of invasive species on the mid-Atlantic OCS.

In addition to reef effects, the WTGs are likely to alter food web productivity and dynamics in ways that may be difficult to predict. Colonization of the new hard surface habitat typically begins with suspension feeders and progresses through intermediate and climax stages (6+ years) characterized by the codominance of plumose anemones and blue mussels (Degraer et al. 2020, Kerckhof et al. 2019). Suspension feeders can act as biofilters, transferring pelagic nutrient resources to the benthic community and decreasing pelagic primary productivity (Slavik et al. 2019). The trophic resources used by suspension feeders could include pelagic eggs or larvae of EFH species, as well as ichthyoplankton prey resources. This could result in a local decrease of eggs and larvae but is unlikely to impact the reproductive success of the affected species as a whole or have more than a localized effect on prey availability for EFH species. As noted above, the colonization of the WTGs could also attract fish due to the increase in resource availability and shelter. This aggregation and change in resource availability could lead to shifts in food web dynamics. While localized effects are possible, ecosystem modeling studies of a European windfarm showed little difference in key food web indicators before and after construction and installation (Raoux et al. 2017). Even though the biomass of certain taxa increased in proximity to the wind farm, trophic group structure was functionally similar between the before and after scenarios. Thus, largescale food web shifts are not expected due to the installation of WTGs and conversion of pelagic habitat to hard surface.

The following species and life stages have designated EFH in areas likely to experience insignificant to beneficial effects from the permanent alteration of pelagic habitats by the monopile foundations:

- Atlantic cod (eggs, larvae)
- Haddock (eggs, larvae)
- Red hake (eggs, larvae)
- Silver hake (eggs, larvae)
- Black sea bass (eggs)
- Bluefish (eggs, larvae, juvenile, adult)
- Butterfish (juvenile, adult)
- Scup (eggs, larvae)
- Atlantic herring (larvae, juvenile, adult)
- Atlantic mackerel (eggs)
- Albacore tuna (juvenile)
- Atlantic bluefin (juvenile, adult)
- Monkfish (eggs, larvae)
- Windowpane flounder (eggs, larvae)
- Winter flounder (eggs, larvae)
- Witch flounder (eggs, larvae)
- Yellowtail flounder (eggs, larvae)
- Basking shark (neonate/YOY, juvenile)
- Blue shark (neonate/YOY, juvenile)
- Dusky shark (neonate/YOY, juvenile)
- Common thresher shark (neonate/YOY, juvenile)
- Shortfin mako shark (neonate/YOY, juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile, adult)
- White shark (neonate/YOY, juvenile)
- Smooth dogfish (neonate, juvenile, adult)
- Spiny dogfish (subadult, adult)
- Smooth dogfish (neonate, juvenile, adult)
- Spiny dogfish (subadult [m/f], adult [m/f])
- Longfin squid (juvenile, adult)
- Shortfin squid (juvenile, adult)

Permanent Effects on Species Groups Associated with Complex and Large-Grained Complex Benthic Habitat

Long-term to permanent effects on large-grained complex and complex habitats would result from seabed preparation and boulder relocation for foundation and cable installation, and from placement of permanent structures that will remain in place throughout the life of the Project.

Placement of WTG and OSS monopile foundations, scour protection, and cable protection would modify and displace large-grained complex and complex habitats. A total of 24 monopile foundations would be placed in complex habitat and 5 in large-grained habitat, permanently displacing an estimated 0.7 acre (0.3 hectare) and 0.1 acre (0.05 hectare) of each habitat type, respectively. Placement of scour protection would displace an additional 18 acres (7 hectares) of complex and 3.2 acres (1.3 hectare) of large-grained complex benthic habitat would be modified by placement of scour protection the foundations.

An estimated 116.2 acres (47 hectares) of cable protection placed on exposed segments of the RWEC, IAC, and OSS-link cables. In addition to permanent impacts from structure presence, approximately 31.4 acres (12.7 hectares) of complex and 177 acres (72 hectares) of large-grained complex benthic habitat would be impacted by seabed preparation (i.e., boulder relocation) for foundation and cable installation. Revolution Wind (2022a) estimates that up to 6,161 boulders ranging in diameter from 2.2 to 6.6 feet (0.7 to 3 meters) diameter or larger will need to be relocated for project construction, 2,133 for foundation installation and 4,028 for cable installation. An estimated 173.2 and 110.7 acres (70.1 and 44.8 hectares) and 522.9 acres 148.1 acres (211.6 and 59.9 hectares) of complex and large-grained complex benthic habitat would be affected by boulder relocation for foundation and cable installation, respectively. Boulder relocation would also occur in soft bottom habitats, affecting approximately 299.1 and 1,624.9 acres (121.0 and 657.6 hectares) for foundation and cable installation, respectively. The distribution of seabed preparation impacts by habitat type will vary by habitat zone (see Table 5.11).

The boulder relocation process for foundation and cable installation is described in Sections 2.2.1.2 and 2.2.2.2, respectively. This process is likely to injure or kill encrusting organisms and damage biogenic structures that contribute to habitat complexity. Over time, the relocated boulders would be recolonized and newly introduced hard surfaces colonized by habitat-forming organisms, contributing to the habitat function provided by existing complex benthic habitat and the artificial reef effect provided by the RWF.

The projected increase in abundance of epibenthic and demersal fish species resulting from the reef effect (Methratta and Dardick 2019) suggests a beneficial expansion of available EFH for species associated with complex benthic habitat like Atlantic cod, black sea bass, and scup. However, it could take several years for the reef effect to develop before fully functional habitat status is achieved (Auster and Langton 1999; Collie et al. 2005; Tamsett et al. 2010). The concrete mattresses may take 3 to 12 months to fully cure after placement. Curing concrete can have surface pH levels as high as 11 or 12, rendering the surfaces of these structures toxic to sessile eggs, larvae, and invertebrates (Lukens and Selberg 2004). As such, the installation of these project features would result in a diminishing intermediate-term adverse effect on EFH lasting up to 10 years. At this point the additional 202.1 to 204.8 acres (81.8 to 82.9 hectares) of functional complex benthic habitat would constitute a beneficial increase in available EFH lasting for at least the remaining 20 years of project life. These features may or may not be removed when the project is decommissioned, depending on the habitat value they provide.

Potential indirect effects to the food web from the loss or modification of complex or potentially complex habitat would be limited to increases in biomass and slight shifts in community composition. Stable isotope analysis of colonizing organisms on wind turbines in the Belgian North Sea suggests that the trophic structure is differentiated by depth, likely associated with different food sources (Mavraki 2020; Mavraki et al. 2020). Around the base of the monopiles, colonizing organisms on the surface of the pile would likely enhance food availability and food web complexity through an accumulation of organic matter (Degraer et al. 2020; Mavraki et al. 2020). This accumulation could lead to an increased importance of the detritus-based food web but is unlikely to result in significant broad scale changes to the local trophic structure (Raoux et al. 2017). Modification of complex or potentially complex benthic habitat is not expected to significantly impact the food web for EFH species.

EFH for the following fish species and life stages would be adversely affected in the intermediate-term and beneficially affected permanently by the expansion of functional complex benthic habitat:

- Atlantic cod (juvenile, adult, spawning)
- Pollock (juvenile)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile, adult, spawning)
- Atlantic herring (eggs, spawning)
- Black sea bass (larvae, juvenile, adult)
- Ocean pout (eggs, larvae, spawning)
- Scup (juvenile, adult)
- Monkfish (juvenile, adult, spawning)
- Summer flounder (adult)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)
- Sand tiger shark (neonate/YOY, juvenile)
- Longfin squid (eggs)
- Atlantic sea scallop (eggs, larvae, juvenile, adult, spawning)

A portion of RWEC contains the habitat features of Habitat Areas of Particular Concern (HAPC) for inshore juvenile Atlantic cod but is outside of the range of currently designated HAPC range. Specifically, the construction and installation footprint for the sea-to-shore transition site contains complex benthic habitat in the nearshore zone at depths less than 66 feet (20 meters). While RWEC construction and installation would not impact inshore juvenile cod HAPC, this alternative could affect potentially valuable habitat features used by this life stage.

Permanent Effects on Species Groups Associated with Soft bottom Benthic Habitat

Soft bottom habitats within the Lease Area and RWEC corridor would be permanently displaced and/or modified by the placement of foundations and scour protection. Of the proposed 81 WTG and OSS foundations, 52 would be placed entirely or primarily in soft bottom benthic habitat, displacing approximately 1.5 acres (0.6 hectare) of habitat within the monopile footprints (see Table 5.11). These soft bottom habitats would no longer be available to EFH species for the entire 35-year life of the project through decommissioning when the foundations are removed.

As discussed in the previous section, these introduced hard surfaces would become colonized by sessile organisms and would evolve into functional complex benthic habitat over the course of approximately 10 years. The affected areas would be rendered unsuitable for species that use soft bottom benthic habitats during one or more life stages. Conversion or loss of soft bottom benthic habitat could influence the local food web by introducing habitat for colonizing organisms, including non-native species. Conversion of soft sediment habitat to complex, rocky habitat would support a different suite of species and could even aid in dispersal pathways through the "stepping-stone effect" (Adams et al. 2014). While the local food web may shift with the conversion of habitat, largescale effects to ecosystem trophic structure are not expected (Raoux et al. 2017). Impacts to the suitability of EFH for managed species due to food web effects is not anticipated.

RWF construction and installation would result in short-term term to effectively permanent adverse effects on EFH for the following species and life stages:

- Ocean pout (juvenile, adult)
- Scup (juvenile, adult)
- Summer flounder (adult)
- Red hake (juvenile, adult)
- Silver hake (juvenile, adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (juvenile, adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)
- Sand tiger shark (neonate/YOY, juvenile)
- Atlantic surf clam (adult)
- Ocean quahog (juvenile, adult)

5.1.3.2 Underwater Sound

Operational underwater noise sources resulting from the project include the RWF WTGs and maintenance vessels servicing the RWF. Underwater noise effects generated by these project elements are described below. Impacts to EFH species and habitats are summarized as follows:

Effects to EFH Species and Habitats

- Direct:
  - Permanent impacts from WTG operational noise on finfish behavior, may or may not be significant depending on species-specific sensitivity: EFH species in the Hearing Specialist group.
- Indirect:
  - Permanent behavioral effects on EFH prey species from WTG operational noise, may or may not be biologically significant depending on species-specific sensitivity and response: Prey Species – Benthic/Epibenthic; Prey Species – Pelagic.

Noise impacts from WTG operations and maintenance and the supporting rationale for these EFH effect determinations are described in the following sections.

WTG Operation and Maintenance

The RWF would produce continuous non-impulsive noise when the turbines are in operation, in the form of low-frequency sound transmitted from the direct drive generator through the steel monopile foundation into the environment. These noise effects would occur whenever the turbines are in operation over the 35-year lifespan of the project, interrupted only by periods where prevailing winds are below effective operational speed. The anticipated proportion of time that WTGs would generate underwater noise is summarized by month in Table 5.12.

Table 5.12. Estimated Percent of RWF Operational Time by Month, Based on Analysis of MetOcean Data.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. [%]	93.8	93.5	91.7	90.8	88.4	88.9	86.3	85.1	86.8	90.8	93.3	93.7
Std. Dev.	2.3	2.3	2.7	3.0	4.0	4.0	3.5	4.3	3.9	3.4	2.4	2.8

Source: Personal communication from Orsted on August 8, 2022 in response to an information request from BOEM.

The RWF would employ current generation direct-drive WTG designs that are generally associated with lower underwater noise levels than older-generation WTGs with gearboxes. Much of the currently available information on operational noise is based on monitoring of older-generation designs employed in European windfarms. Although useful for characterizing the general range of WTG operational noise effects, this information is not necessarily representative of the noise effects produced by current-generation direct-drive systems (Elliot et al. 2019; Tougaard et al. 2020). 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). 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.

More recently, Elliot et al. (2019) summarized findings from hydroacoustic monitoring of operational noise from the Block Island Wind Farm. The Block Island Wind Farm is composed of five Haliade 150 6-MW direct-drive WTGs on jacketed foundations located approximately 15 statute miles (24 km, 13 nm) west of the proposed RWF. Operational noise from the direct-drive WTGs at the Block Island Windfarm were generally lower than those observed for older generation WTGs. Elliot et al. (2019) presented a representative high operational noise scenario at an observed wind speed of 15 m/s (approximately 33 miles per hour). They determined that when measured at 50 m, the operating turbines produced 10-Hz to 8-kHz SPLs in the range of 110 to 125 dB re 1 μPa, occasionally reaching as high as 128 dB re 1 μPa, and rms particle acceleration levels in the range of 10 to 30 dB re 1 $\mu m/s^2$. These values are considered useful, and representative of the underwater noise effects likely to be produced during RWF operations. Revolution Wind will operate WTGs between 8MW to 12M, which are larger than the WTGs used for the Block Island Wind Farm.

The RWF operation would be expected to generate SPLs of approximately 110 to 125 dB re 1 µPa in the 10-Hz to 8-kHz frequency range and rms particle acceleration levels of approximately 10 to 30 dB re 1 $\mu m/s^2$ when measured at 50 meters. These noise effects are below injury and behavioral effects thresholds for all species, indicating that potentially significant underwater noise effects from RWF on habitat suitability would be restricted to a very small area around each monopile (Popper et al. 2014 and FHWG 2008).

Cod, other hearing specialist species, and some flatfish species are also potentially sensitive to particle motion effects. Elliot et al. (2019) compared available research on particle motion sensitivity in fish to observed detectable particle motion effects 164 feet (50 meters) from the foundations of the Block Island Windfarm during turbine operation. Their findings suggest that particle motion effects in the 1 to 6 kHz range could occasionally exceed the lower limit of observed behavioral responses in Atlantic cod and flatfish within these limits.

Popper and Hawkins (2018) conclude that Atlantic cod, and probably many other fish species in the hearing specialist group, are sensitive to both sound pressure and particle motion and use both aspects of sound to assess and orient themselves in the three-dimensional aquatic environment. This ability likely enables fishes to locate particular sources of sound, such as prey or potential mates, and may also assist them in identifying and locating sounds from a particular source within the general ambient noise environment. In theory, operational noise and particle motion effects from WTG operations could alter the background noise environment in ways that negatively impact the ability to characterize the ambient noise environment. Based on the documented use of the Block Island Wind Farm and surroundings (Guarinello and Carey 2020), operational noise effects has not dissuaded hearing specialist species from using these environments. Similar findings have been observed at European windfarms. For example, Bergström et al. (2013) documented an increase in the abundance of Atlantic cod and other demersal fish species around the foundations of a Swedish OSW farm, despite persistent operational noise levels sufficient to cause behavioral and auditory masking effects. Some degree of habituation to these operational noise and particle motion effects is to be anticipated. Bejder et al. (2009) argue that habituation of organisms to ongoing low-level disturbance is not necessarily a neutral or benign process. For example, habituation to particle motion effects could make individual fish or invertebrates less aware of approaching predators, or could cause masking effects that interfere with communication, mating or other important behaviors.

Collectively, these findings suggest that the RWF operations could have limited adverse effects on habitat suitability for EFH species within a certain distance of each monopile foundation. The extent of these effects is difficult to quantify as they are likely to vary depending on wind speed, water temperature, ambient noise conditions, and other factors.

Operational Noise Impacts on Fish in the Hearing Specialist Group

Potential adverse effects from WTG operational noise on habitat suitability for fish belonging to the hearing specialist group are estimated to extend up to 164 feet (50 meters) from each foundation. This equates to adverse effects on habitat suitability over approximately 202 acres (82 hectares) for the 12-meter monopiles, for the following EFH species and life stages:

- Atlantic cod (juvenile, adult, spawning)
- Haddock (juvenile, adult, spawning
- Pollock (juvenile)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile)
- Black sea bass (juvenile, adult)
- Atlantic herring (juvenile, adult, spawning)

Operational Noise Impacts on Selected Species in Other Hearing Groups

Potential adverse effects from WTG operational noise on habitat suitability for flatfish and invertebrate species that are potentially sensitive to particle motion and substrate vibration effects. The detectable extent of these effects is unknown is therefore assumed to be the same as that described for the extend up to 164 feet (50 meters) from each foundation. This equates to adverse effects on habitat suitability over approximately 202 acres (82 hectares) for the 12-meter monopiles, for the following EFH species and life stages:

- Bluefish (juvenile, adult)
- Monkfish (juvenile, adult, spawning)
- Atlantic herring (juvenile, adult, spawning)
- Summer flounder (juvenile, adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (juvenile, adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)
- Longfin squid (juvenile, adult)
- Shortfin squid (juvenile, adult)

RWEC Operation and Maintenance

The RWEC would produce no operational noise effects and would therefore have no associated effects on EFH through this impact mechanism.

Maintenance Vessel Operation

The RWF would be routinely serviced by maintenance crews transported from the O&M facility on a 95-foot-long CTV. The CTV would transit approximately 50 statute miles (80 km, 43 nm) between the O&M facility and the Lease Area approximately 7 times per month, or an estimated 2,500 vessel trips over the life of the project.

Underwater source SPLs produced by CTVs is estimated at 160-170 dB re 1 µPa-m. This value is based on observed noise levels generated by working commercial vessels of similar size and class to the CTVs (Kipple and Gabriele 2003; Takahashi et al. 2019). 160-170 dB re 1 µPa is below the injury thresholds described previously for all fish and invertebrate hearing groups, indicating that CTV noise is unlikely to cause injury-level effects on any fish species. An individual fish is unlikely to remain in proximity to a moving CTV for extended periods; therefore, this type of exposure is unlikely to occur. However, the noise levels generated by these smaller Project vessels are below the acoustic injury thresholds for fish are expected to only experience only short-term behavioral effects. The SOV would produce similar noise levels to those described by Denes et al. (2021) for construction vessels. Noise levels generated by the larger, SOVs would be similar to those described in Section 5.1 for Project construction vessels.

5.1.3.3 Hydrodynamic Effects

Hydrodynamic disturbance resulting from the broadscale development of large offshore wind farms is a topic of emerging concern because of potential indirect effects on local and regional oceanic responses (e.g., currents, temperature stratification) and related larval transport under typical seasonal conditions. The placement of monopiles and WTGs in the Lease Area has the potential to influence hydrodynamic conditions at both local and broader regional scales. These effects fall into two categories, changes in wind field downcurrent of the wind farm, affecting surface currents and wave formation, and turbulent mixing caused by the presence of the structures in the water column. The extent of these effects and resulting significance on biological processes are likely to vary considerably between different oceanographic environments (van Berkel et al. 2020).

A growing body of research has demonstrated that atmospheric effects offshore windfarms, specifically changes in the near surface wind field, could lead to observable effects on oceanographic conditions at scales ranging to tens of miles down field from windfarm sites (e.g., Christiansen et al. 2022; Raghukumar et al. 2022). Changes in the surface wind can in turn influence mixing and circulation patterns and associated biological processes (e.g., Daewel et al. in-press; Dorell et al. 2022; Floeter et al. 2022; Raghukumar et al. 2022). Monopile wakes have been observed and modeled at the kilometer scale (Cazenave et al. 2016; Vanhellemont and Ruddick 2014). Foundations disrupt current flow, creating tidal wakes and a turbulent mixing effect extending downcurrent from the structures. The presence of monopiles in the water column can introduce small-scale mixing and turbulence that can affect water column stratification under some circumstances (Carpenter et al. 2016; Floeter et al. 2017; Li et al. 2014; Schultze et al. 2020). This effect is muted in oceanographic environments that display strong seasonal stratification (Schultze et al. 2020), but the introduction of nutrients from depth into the surface mixed layer can lead to a local increase in primary production (Floeter et al. 2017). While impacts to current speed and direction decrease rapidly, there is evidence of hydrodynamic effects out to a kilometer away from a monopile including localized changes in circulation and stratification patterns, with potential implications for primary and secondary productivity and fish distribution (van Berkel et al. 2020).

The Mid-Atlantic Cold Pool is a mass of relatively cool water that forms on the Mid-Atlantic OCS in the spring and is maintained through the summer by stratification. The Cold Pool supports a diversity of marine fish and invertebrate species that are usually found farther north but thrive in the cooler waters it provides (Chen 2018; Lentz 2017). Changes in the size and seasonal duration of the cold pool over the past 5 decades are associated with shifts in the fish community composition of the Mid-Atlantic Bight (Chen 2018; Saba and Munroe 2019). Several lease areas within the RI/MA WEA are located on the approximate northern boundary of the cold pool. The potential indirect and cumulative effects of extensive wind energy development on features like the Cold Pool is a topic of emerging interest and ongoing research (Chen et al. 2016). Changes in Cold Pool dynamics resulting from future activities, should they occur, could conceivably result in changes in habitat suitability and invertebrate community structure, but the extent and biological significance of these potential indirect and cumulative effects are unknown.

Van Berkel et al. (2020) and Shultze et al. (2020) note that environments characterized by strong seasonal stratification are likely to be less sensitive to wind field and turbulent mixing effects on oceanographic processes. The Lease Area and surroundings are characterized by strong seasonal stratification in summer and fall, within increased mixing and deterioration of stratification driven by storms and changes in upwelling in late fall into winter (Chen 2018; Lentz 2017). On the Mid-Atlantic Bight, increased mixing could influence the strength and persistence of the Cold Pool, a band of cold, near-bottom water that exists at depth from the spring to fall. However, the turbulence introduced by monopile foundations is not expected to significantly affect the Cold Pool due to the strength of the stratification [temperature differences between the surface and the Cold Pool reach 10°C (Lentz 2017)]. Temperature anomalies created by mixing at each monopile would likely resolve quickly due to strong forcing towards stabilization (Schultze et al. 2020).

BOEM has conducted a modeling study to predict how planned offshore wind development in the RI/MA and Massachusetts WEAs could affect hydrodynamic conditions northern Mid-Atlantic Bight. Johnson et al. (2021) considered a range of development scenarios, including full buildout of both WEAs with a total of 1,063 WTG and OSS foundations. They determined that all scenarios would lead to small but measurable changes in current speed, wave height, and sediment transport in the northern Mid-Atlantic Bight. The resulting changes in current speed and wave height could influence larval transport and settlement and reduce bed shear stress thereby affecting sediment transport. Particle tracking, which integrates the overall effect of objects subjected to the effects of currents, showed variations on the order of ± 10 percent between the baseline condition (no off-shore wind farms) and the 12 MW full build-out scenario (1,063 WTG and OSS foundations). This is in line with the observed order of magnitude change in the depth averaged currents (Johnson et al. 2021). In addition, small changes in stratification could occur, leading to prolonged retention of cold water near the seabed within the WEAs during spring and summer.

Johnson et al. (2021) used an agent-based model to evaluate how these environmental changes could affect planktonic larval dispersal and settlement for three EFH species, summer flounder, silver hake, and Atlantic sea scallop. They determined that offshore wind development could affect larval dispersal patterns, leading to increases in larval settlement density in some areas and decreases in others, but would be unlikely to negatively impact population productivity for these species. Johnson et al. (2021) concluded that changes in larval distribution patterns on the order of miles or tens of miles are therefore unlikely to result in biologically significant effects on larval survival and recruitment. For example, in the case of sea scallops, larval dispersal to waters southwest of Block Island is predicted to increase while dispersal to waters south of Martha's Vineyard would decrease under all modeled scenarios (Johnson et al. 2021). These localized effects are unlikely to have a measurable population level effect on this species because sea scallop larvae originate both local and distant spawning areas and dispersed regionally over along a southwesterly gradient (Johnson et al. 2021). These dispersal patterns are driven by regional circulation patterns, which are generally consistent but vary annually (Chen et al. 2021; McCay et al. 2011; Munroe et al. 2018; Roarty et al. 2020; Zhang et al. 2015). In this context, localized shifts in larval transport and settlement density on the scale of miles to tens of miles are unlikely to lead to the development of significant population sinks. Even where they occur, localized changes larval recruitment may not necessarily translate to negative effects on adult biomass. For example, Atlantic sea scallops are prone to overcrowding and reduced growth rates in areas with high larval recruitment (Bethoney and Stokesbury 2019), therefore changes in dispersal that reduce overcrowding could lead to increased growth and abundance in specific areas.

While findings for these species are instructive, they are not necessarily representative of potential effects on all EFH species that rely on planktonic dispersal of eggs and larvae. The BOEM modeling results determined that small but measurable changes in current speed, wave height, and sediment transport would occur across the northern Mid-Atlantic Bight. As stated, hydrodynamic effects could change how the planktonic eggs and larvae of many marine species are dispersed across the region. Changing larval dispersal pathways can disrupt connectivity between populations and the processes of larval settlement and recruitment (Sinclair 1988). Unfavorable changes can create a condition where a reproductively isolated population is negatively affected by a prolonged reduction in larval survival (Sinclair 1988). This could result in negative impacts on species like Atlantic cod that return to the same spawning habitats year after year and rely on relatively consistent oceanographic conditions to disperse planktonic eggs to areas favorable for larval and juvenile survival (Dean et al. 2022). However, insufficient information is available to determine the source populations of cod larvae and juveniles occurring in Southern New England waters and it is uncertain if the area is fully supported by self-recruitment (NEFMC 2022). Further, cod spawning appears to occur throughout the

Southern New England region (DeCelles et al., 2017; BOEM pers. comm. 2022), which could help buffer against any potential impacts to planktonic eggs and larval transport. While hydrodynamic effects on these species could potentially be more significant, the available information does not suggest that such effects are likely.

Hydrodynamic effects on EFH resulting from project operations and maintenance vary depending on how pelagic and benthic habitats exposed to these impacts are used by EFH species. EFH is divided into the following components for the purpose of this assessment:

- Water column habitats used by pelagic eggs and larvae.
- Water column habitats used by pelagic juveniles and adults.
- Bottom habitats used by benthic-oriented juveniles and adults.
- Bottom habitats used by EFH shellfish species.

It is assumed that hydrodynamic effects would manifest outside the Lease Area, not just in the immediate area of the Lease Area. Given the 0.9-mile (1.6-km, 1-nm) separation between monopiles, these effects are expected to be relatively minor. These hydrodynamic effects would persist through the life of the Project until the monopile foundations are decommissioned and removed. This assessment focuses on life stages of EFH species and their prey organisms that would likely be exposed to hydrodynamic effects.

<u>Hydrodynamic Effects to Surface and Water Column Habitats used by Pelagic Eggs and Larvae</u>

The presence of RWF monopiles has the potential to reduce current speeds and introduce turbulence both at the local level and potential more broadly. Given their planktonic nature, altered circulation patterns could transport pelagic eggs and larvae out of suitable habitat, leading to reduced survival. These indirect effects would apply to EFH species that have or prey upon pelagic eggs and larvae. Any such indirect effects on egg and larval survival theoretically could be offset by increased primary productivity in the wake of the monopiles. Turbulence downcurrent of the monopiles could introduce nutrients to the surface mixed layer that promote primary production, increasing the forage base for pelagic larvae (Floeter et al. 2017). As stated, these offsetting effects would be highly localized and likely insignificant relative to the natural mortality rate of ichthyoplankton in general.

More broadly, a hydrodynamic modeling study conducted for BOEM (Johnson et al. 2021) determined that the presence of numerous offshore wind energy structures in the RI/MA and MA WEAs would lead to small but measurable changes in current speed, wave height, and sediment transport in the northern Mid-Atlantic Bight. These hydrodynamic effects are in turn likely to influence the dispersal of planktonic larvae within the WEAs and their surroundings, increasing larval settlement in some areas and decreasing it others (Johnson et al. 2021). Changing larval dispersal pathways can disrupt connectivity between populations and the processes of larval settlement and recruitment (Sinclair 1988). Large scale hydrodynamic changes could in theory create “sinks” or subpopulations that no longer contribute propagules to the overall regional population network. While some changes in dispersal patterns are likely to occur, and these impacts would be effectively permanent, lasting until the Project is decommissioned, the resulting effects are unlikely to be biologically significant.

As stated previously, there is evidence that the cod that spawn on and around Cox Ledge belong to a biologically unique stock, and that spawning cod in this region exhibit residency and spawning site fidelity (BOEM pers. comm., 2022); McBride and Smedbol 2022). BOEM acknowledges that hydrodynamic impacts could potentially lead to negative population-level effects on this species if significant quantities of larvae were unable to reach suitable nearshore nursery habitats, including grass beds and preferred substrates such as gravel, cobbles, and rocky habitats versus finer grained bottoms. However, the available SPI/PV imagery data for the Lease Area indicate that gravel and rocky substrates that could support juvenile cod are ubiquitous throughout the lease area and the export cable corridors (see Table 3.2). The BOEM hydrodynamic modeling study evaluated potential hydrodynamic effects of wind energy development on egg and larval dispersal for several commercially valuable fish and invertebrate species. Johnson et al. (2021) found that the partial and full buildout of the RI/MA and MA WEAs would lead to localized changes in planktonic egg and larval dispersal patterns, with less extensive effects at lower levels of buildout. While this study did not consider Atlantic cod, the findings for other fish and invertebrate species indicate that potential effects to larval dispersal patterns, expressed as changes in predicted larval settlement density, would shift at scales of the order of miles to tens of miles. They concluded that these localized effects are unlikely to be biologically significant at population levels for species like hake and scallops that spawn over broad areas across the region (Johnson et al. 2021). However, “source” and “sink” effects could occur for species that spawn in specific areas and rely on dispersal of larvae to favorable habitats. These effects could be positive, negative, or neutral, varying by species and depending on specific project effects.

The invertebrate species of the region are supported by numerous, distributed spawning areas from which larvae originate and are dispersed over broad distances along a southwesterly gradient consistent with regional circulation patterns (McCay et al. 2011; Zhang et al. 2015; Munroe et al. 2018). While project-related hydrodynamic effects may lead to localized shifts in larval transport, settlement, and abundance, these changes are unlikely to result in broader scale changes in invertebrate community composition (Johnson et al. 2021). This hydrodynamic influence would be removed when the Project is decommissioned, and larval dispersal patterns would shift in response to existing conditions and ongoing trends in environmental conditions. On balance, hydrodynamic effects on EFH species that have or prey upon pelagic eggs and larvae are expected to be neutral to beneficial. EFH species with pelagic eggs or larvae that are known or likely to occur within the Lease Area area include:

- Atlantic cod (eggs, larvae)
- Atlantic herring (larvae)
- Atlantic mackerel (larvae)
- Black sea bass (eggs)
- Bluefish (eggs, larvae)
- Butterfish (eggs, larvae)
- Haddock (eggs, larvae)
- Monkfish (eggs, larvae)
- Red hake (eggs, larvae)
- Scup (eggs, larvae)
- Silver hake (eggs, larvae)
- Smooth dogfish (neonate)
- Summer flounder (eggs, larvae)
- White hake (larvae)
- Windowpane flounder (eggs, larvae)
- Witch flounder (eggs, larvae)
- Yellowtail flounder (eggs, larvae)

<u>Hydrodynamic Effects to Water Column Habitats used by Pelagic Juveniles and Adults</u>

Pelagic juveniles and adults of EFH species utilizing water column habitats may experience localized hydrodynamic effects downcurrent of each RWF monopile. These indirect effects may be limited to decreased current speeds but could also include minor changes to seasonal stratification regimes. Pelagic juveniles and adults would likely exhibit a behavioral avoidance response away from any habitat with decreased suitability. This behavioral effect applies to EFH species and pelagic prey organisms. Hydrodynamic effects perceivable to juvenile and adult fish are expected to vary depending on seasonal and tidal hydrodynamic cycles. Regardless of variability, these indirect effects would be localized to within approximately 656 to 1,312 feet (200 to 400 meters) downcurrent from each monopile and would persist through the life of the Project. EFH species with pelagic juvenile or adult life stages that are known or likely to occur within the Lease Area include:

- Albacore tuna (juvenile, adult)
- Atlantic bluefin (juvenile, adult)
- Atlantic herring (juvenile, adult)
- Atlantic mackerel (juvenile, adult, spawning)
- Atlantic skipjack (juvenile, adult)
- Atlantic yellowfin (juvenile, adult)
- Bluefish (juvenile, adult)
- Longfin squid (juvenile, adult)
- Smooth dogfish (juvenile, adult)
- Spiny dogfish (subadult [f], subadult [m], adult [f], adult [m])

<u>Hydrodynamic Effects to Bottom Habitats used by Benthic-oriented Juveniles and Adults</u>

Benthic-oriented juveniles and adults of EFH species and their prey organisms may experience hydrodynamic effects of the RWF influencing local habitat suitability downcurrent of each monopile. Benthic-oriented juveniles and adults would likely exhibit a behavioral avoidance response away from any habitat with decreased suitability. These localized intermittent hydrodynamic effects would persist throughout the life of the Project. EFH species with benthic-oriented juvenile or adult life stages that are known or likely to occur within the Lease Area include:

- Atlantic cod (juvenile, adult, spawning)
- Haddock (juvenile, adult, spawning)
- Pollock (juvenile, adult, spawning)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile, adult, spawning)
- White hake (juvenile, adult, spawning)
- Atlantic herring (eggs, spawning)
- Summer flounder (adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (juvenile, adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)
- Black sea bass (larvae, juvenile, adult)
- Butterfish (juvenile, adult)
- Monkfish (juvenile, adult, spawning)
- Ocean pout (eggs, larvae, juvenile, adult, spawning)
- Scup (juvenile, adult)
- Longfin squid (eggs)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile, adult)
- Winter skate (juvenile, adult)

<u>Hydrodynamic Effects to Bottom Habitats used by EFH Shellfish</u>

Hydrodynamic effects of RFWF operations would be localized and largely insignificant for bottom habitat utilized by EFH shellfish. As noted in the section above on pelagic eggs and larvae, there is potential for hydrodynamic effects to influence dispersal of planktonic life stages. However, given the spawning strategy of these species, these minor indirect effects are not expected to influence reproductivity of the species. EFH shellfish species and life stages that utilize habitats that may be exposed to hydrodynamic effects include:

- Atlantic sea scallop (eggs, larvae, juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)

5.1.4 Operations and Maintenance/Presence of Inter-Array and Offshore/Onshore Cables

5.1.4.1 Power Transmission (EMF, heat)

The IAC, OSS-link cable, and RWEC would generate intermittent induced magnetic and electrical field effects and substrate heating effects whenever they are under power throughout the life of the project. Essentially, EMF and heat effects would occur whenever wind speeds are sufficient to turn the WTGs. As such, these effects are anticipated to be effectively permanent with brief interruptions during periods with no wind. These EMF effects may influence the behavior of certain EFH species and alter the suitability benthic and infaunal habitats and species associated with those habitats. EMF effects would cease immediately on Project decommissioning.

The project includes design measures to minimize EMF impacts. The project will employ HVAC transmission, which produces lower intensity EMFs than HVDC at a frequency (60 Hz) that is generally not detectable by electrosensitive organisms. All transmission cables 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) or deeper in soft bottom benthic habitat and other areas where burial is possible. Cable segments that cross unavoidable hard substrates and other offshore infrastructure would be laid on the bed surface covered with a concrete mattress or other form of cable armoring for protection. EMF effects in these areas would be greater than for buried cable segments. EMF levels diminish rapidly with distance and would become indistinguishable from baseline conditions within about 26 feet (8 m) of both buried and exposed cable segments (Exponent 2021).

The following thresholds are used to evaluate the potential for biologically significant EMF effects on EFH species and habitats:

- Benthic habitats used by EFH fish and invertebrate species having benthic or epibenthic eggs and larvae. Minimum physiological effect thresholds are defined as follows (Brouard et al. 1996):
    - Magnetic field: 1,000 mG (observed developmental delay)
    - Electrical field: > 500 millivolts per meter (mV/m)
- Bottom habitats used by benthic or epibenthic life stages of EFH finfish species. Minimum physiological effect thresholds are defined as follows (Armstrong et al. 2015; Basov 1999; Bevelhimer et al. 2013; Orpwood et al. 2015):
    - Magnetic field: > 1,000 mG
    - Electrical field: 20 mV/m

- Demersal habitats (from 3.3 to 26.2 feet [1 to 8 meters] off the seabed) used by pelagic life stages of EFH finfish and invertebrates:
    - Finfish: Same thresholds as above
    - Squid: > 800 mG (Love et al. 2015)
- Bottom habitats used by benthic and epibenthic life stages of EFH shark and skate species. Minimum effect thresholds are defined as follows (Bedore and Kajiura 2013; Hutchison et al. 2020; Kempster et al. 2013):
    - Magnetic field: Detection, unknown; behavioral, 250-1,000 mG (for HVDC transmission, responses species-specific)
    - Electrical field: Detection, 20-50 µV/cm (2-5 mV/m) for fields < 20 Hz, no response to electrical fields above 20 Hz
- Benthic and infaunal habitats used by EFH shellfish species, and benthic invertebrate prey organisms for EFH species

Exponent (2021) modeled the projected EMF effects from the IAC and RWEC under typical and maximum transmission conditions, using conservative assumptions to ensure that the potential impacts to sensitive species would not be underestimated. For example, the target burial depth for transmission cables is 4-6 feet (1.2 to 1.8 meters) beneath the seabed. Exponent (2021) conservatively assumed a burial depth of 3.3 feet (1 meter), meaning that EMF levels for buried cable segments are overestimated. Also, the two RWEC circuits are proposed to be separated by a least 166 feet (50 meters) so were modeled in isolation from each other. In contrast, the IACs and RWEC Landfall Cables are proposed to be closer together with minimum separation distances of approximately 9 feet (3 meters) and 49 feet (15 meters), respectively, so were modeled with both cables together to account for potential additive effects of two closely spaced cables (Exponent 2021).

The results presented herein are representative of the EMF effects that could result from each IAC segment and both RWECs. The transmission parameters for the RWEC and OSS-link cable are the same, therefore the results modeled for the former would apply to the latter. All cables would transmit electricity as HVAC at a frequency of 60 Hz, an important factor to consider when evaluating potential biological effects. Modeled maximum EMF effects for buried and exposed segments of each cable are summarized in Table 5.13.

The following metrics are used to evaluate potential EMF effects:

- Magnetic field strength, measured in mG/
- Electrical field strength, measured in mV/m.

- Induced electrical field strength, receptor specific based on body size, measured in mV/m.

In addition to EMF effects, the transmission cables would also heat the surrounding substrates. Hughes et al. (2015) and Emeana et al. (2016) evaluated the thermal effects of buried and exposed electrical transmission cables on the surrounding environment. They determined that heat from exposed cable segments would dissipate rapidly without measurably heating the underlying sediments. In contrast, the typical HVAC cable buried in sand and mixed sand and mud (i.e., soft bottom benthic habitat) can heat sediments within 1.3 to 2 feet (0.4 to 0.6 m) of the cable surface by +10 to 20 degrees Celsius (°C). Applying these findings, potential substrate heating effects from each transmission cable are summarized in Table 5.13.

Table 5.13. Modeled Electromagnetic Field Levels and Estimated Substrate Heating Effects for Buried and Exposed Cable Segments and Miles of Cable by Category.

Component	Installation	Total Cable Length – linear miles (km)	Magnetic Field (mG) At Seafloor	Magnetic Field (mG) 3.3 Feet above Seafloor	Electrical Field (mV/m) At Seafloor	Electrical Field (mV/m) 3.3 Feet above Seafloor	Substrate Heating
IAC	Buried to 3.3 feet	104.5 (169)	57	17	2.1	1.3	+10 to +20°C within 0.4 to 0.6 m of cable
	On bed surface	11.6 (19)	522	21	5.4	1.7	Negligible
OSS-link cable	Buried to 3.3 feet	8.4	147	41	4.4	2.3	+10 to +20°C within 0.4 to 0.6 m of cable
	On bed surface	0.9	1,071	91	13	1.6	Negligible
RWEC	Buried to 3.3 feet	70.6	147	41	4.4	2.3	+10 to +20°C within 0.4 to 0.6 m of cable
	On bed surface	12.7	1,071	91	13	1.6	Negligible

Note: mG = milligauss; mV/m = millivolt/meter.

EMF effects must be considered in context with baseline EMF conditions within the project area and vicinity. The earth's magnetic field strength in the vicinity of the Lease Area and RWEC at the seabed is on the order of 5,100 mG (NOAA 2018). 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 project area and vicinity could induce a steady-state electrical field on the order of 51.5 µV/m (0.0515 mV/m). Modeled current speeds in the project area and vicinity are on the order of 0.1 to 0.35 m/s at the seabed (Vinhateiro et al. 2018), 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 meters) below the surface (Slater et al. 2010).

Operational EMF and substrate heating effects on EFH species and habitats are summarized as follows:

Effects to EFH Species and Habitats

- Direct
  - Permanent insignificant to minor behavioral effects on selected electrically sensitive EFH species occurring in proximity to unburied segments of the IAC, RWEC, and OSS-link: EFH for Sessile Benthic/Epibenthic – Soft Bottom, Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Prey Species – Benthic; Summer Flounder HAPC; Southern New England HAPC.
  - Permanent adverse substrate heating effects on EFH shellfish species at transition points between buried and unburied cable segments where cables are less than 2 feet (0.6 meters) from the bed surface: EFH for Sessile Benthic/Epibenthic – Soft Bottom, Sessile Benthic/Epibenthic – Complex; Mobile Benthic/Epibenthic – Complex; Prey Species – Benthic; Summer Flounder HAPC; Southern New England HAPC.

The specific effects of each transmission cable on EFH species and the supporting rationale for these determinations are summarized in the following sections.

Inter-Array Cable

The inter-array cable would be a 66-kV, 3-phase HVAC design 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 meters). However, as mentioned above, Exponent (2021) assumed a conservative burial depth of 3.3 feet (1 meter) for evaluating EMF effects from buried cable segments. 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. EMF effects in these areas would be greater than for buried cable segments. Calculated magnetic and electrical field effects for buried and exposed segments of the inter-array cable for average loading are summarized in Table 5.13.

Hughes et al. (2015) and Emeana et al. (2016) evaluated the thermal effects of buried electrical transmission cables on the surrounding seabed. 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 significantly 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 meters) of the cable surface by +10 to 20°C above ambient conditions (Table 5.13). Temperature effects diminished rapidly with distance beyond these points, suggesting that burial of the transmission cables to target depths of 4 to 6 feet (1.2 to 1.8 meters) would avoid adverse thermal effects on EFH shellfish species.

The EMF and substrate heating effects of the inter-array cable on EFH will vary depending on the respective cable voltage, the position of the cable on the seabed (i.e., buried to target depth or laid on bed surface), and how EFH is used by different life stages of EFH species. Specifically, EFH species with life stages that are surface-oriented or use pelagic habitats more than approximately 30 feet (9 meters) of a cable path would not be exposed to EMF effects and would experience negligible effects on this habitat component. In contrast, EFH species that use bottom or near-bottom habitats along the potential cable paths during one or more life stages may be exposed to EMF effects. The significance of these potential effects is dependent on habitat use (i.e., likelihood of exposure), and species-specific sensitivity to magnetic and electrical fields and heating effects.

The inter-array cable would generate intermittent induced magnetic and electrical field effects throughout the life of the project, with the timing and duration of occurrence determined by wind speeds exceeding the operational kick-in threshold. The resulting effects on EFH would vary in intensity depending on the following factors:

- Position of the cable segment (i.e., buried to target depth or laid on the bed surface).
- Proximity of the affected habitat to the cable [i.e., benthic or epibenthic habitat within 3.3 feet (1 meter) of the seabed or surficial or mid-water pelagic habitats].
- Species-specific sensitivity to EMF effects.

<u>EMF Effects on Habitats Used by Benthic or Epibenthic Eggs and Larvae</u>

Several EFH species and fish and invertebrates that provide prey for EFH species have benthic eggs and larvae could settle in areas along the inter-array cable path, including both buried and exposed cable segments. The average induced magnetic and electrical fields generated by the inter-array cable are 57 mG and 2.1 mV/m at the seabed for segments of the inter-array cable that are buried and 522 mG and 5.4 mV/m at the seabed for segments of the inter-array cable that are surface-laid and covered with one foot of cable protection. Induced electrical field effects on eggs and larvae would be insignificant based on body size.

Species-specific data on egg and larval sensitivity to EMF effects is lacking. However, general research on fish sensitivity to magnetic and electrical fields suggests that the effects of EMF from the inter-array cable on benthic egg and larval EFH would be insignificant. For example, Levin and Ernst (1995) examined the timing of embryonic cell division during exposure to AC magnetic fields and found that magnetic field strengths of 34,000 mG changed the timing of cell division in developing embryos, but when the field strength was reduced by 50 percent, embryonic cell division rates were unchanged versus unexposed controls. Additionally, neither exposure caused an increase in embryonic mortality; however, minor developments effects were observed in sea urchin when exposed to 500 mG and 1,000 mG 60-Hz magnetic fields (Zimmerman et al. 1990).

Further, Cameron et al. (1985) determined that exposure to magnetic fields on the order of 1,000 mG magnetic field produced by a 60 Hz power source slowed medaka (*Oryzias latipes*) embryonic development; no significant effects on hatching rate, physical abnormalities, or survival were observed. Zebrafish (*Danio rerio*) embryos exposed to a 10,000 mG magnetic field produced by a 50-Hz power source also experiences some similar developmental delays (Skauli et al. 2000). Brouard et al. (1996) exposed rainbow trout (*Oncorhynchus mykiss*) embryos to electrical fields ranging as high as 5,000 mV/m and observed no evident effects on development or subsequent survival. Fey et al (2019) found that a 36-day exposure to 50-Hz EMF at 10,000 mG had no significant effects on larval mortality, hatching time, or larval growth, but did increase the rate of yolk sac absorption, which Fey et al (2019) hypothesized could affect future growth rates. Further, because fish eggs and larvae are largely passively distributed throughout the water column and undergo naturally high mortality, chronic exposures of embryos to EMF would affect only a tiny portion of the population, and thus would not result in a population-level effect (Exponent 2021). These findings indicate that the EMF effects of this project component on benthic EFH for the eggs and larvae would be insignificant.

The following EFH species have benthic, epibenthic, or near-bottom pelagic egg and larval life stages and are likely to be exposed to adverse EMF effects from the inter-array cable:

- Atlantic cod (larvae)
- Black sea bass (larvae)
- Bluefish (eggs and larvae)
- Butterfish (eggs and larvae)
- Monkfish (larvae)
- Ocean pout (eggs and larvae)
- Atlantic herring (larvae)
- Atlantic mackerel (larvae)
- Summer flounder (eggs and larvae)
- Windowpane flounder (larvae)
- Atlantic sea scallop (eggs and larvae)

<u>EMF Effects on Habitats Used by Epibenthic Finfish and Flatfish Species</u>

Several EFH species and their fish prey species use benthic or epibenthic habitats within 3.3 feet (1 meter) of the seabed during their life cycle that overlap with the inter-array cable path, including both buried and exposed cable segments. This indicates that EFH species and their prey could be exposed to the following EMF effects:

- Induced magnetic field: 17 to 35 mG at 3.3 feet (1 meter) above the seabed for buried and exposed cable segments at average loading, respectively.
- Electrical field: 1.3 to 1.7 mV/m at 3.3 feet (1 meter) above seabed for buried and exposed cable segments at average loading, respectively.

As with eggs and larvae, species-specific research on the magnetic and electrical field sensitivity is generally lacking. However, the preponderance of available research on a variety of fish species (e.g., Armstrong et al. 2015; Bevelhimer et al. 2013; Orpwood et al. 2015) indicates that the minimum magnetic field exposure threshold for observable effects on behavior exceeds 1,000 mG for most fish species. The minimum threshold for observable detection of electrical fields in electrosensitive fish species is on the order of 20 mV/m (Basov 1999). Each of these thresholds is an order of magnitude greater than the maximum potential EMF effect likely to result from inter-array cable operation. In a review of EMF effects produced by offshore wind energy, Copping et al. (2016) concluded that induced electrical fields on the order of those generated in fish in close proximity to the inter-array cable would have no observable effects on physiology or behavior.

On this basis, the EMF effects of inter-array cable operation on benthic and epibenthic habitats used by EFH finfish species and finfish prey organisms would be insignificant. The following EFH species use the affected habitat during juvenile, adult, and/or spawning life stages:

- Atlantic cod (juvenile, adult, spawning)
- Pollock (juvenile)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile, adult, spawning)
- White hake (juvenile)
- Black sea bass (juvenile, adult)
- Butterfish (juvenile, adult)
- Ocean pout (juvenile, adult, spawning)
- Scup (juvenile, adult)
- Atlantic herring (spawning)
- Monkfish (juvenile, adult, spawning)
- Summer flounder (adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (juvenile, adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)

<u>EMF Effects on Demersal Habitats Used by Pelagic Finfish Species</u>

Several pelagic EFH species may periodically use demersal habitats at or near 3.3 feet (1 meter) of the seabed during their life cycle. This may include habitats overlapping buried and exposed segments of the inter-array cable. Prey organisms for pelagic fish species may also occur within this EMF exposure zone. This indicates that these species could be exposed to the following EMF effects:

- Induced magnetic field: 17 to 35 mG at 3.3 feet (1 meter) above the seabed for buried and exposed cable segments at average loading, respectively.

- Electrical field: 1.3 to 1.7 mV/m at 3.3 feet (1 meter) above seabed for buried and exposed cable segments at average loading, respectively.

Applying the effect thresholds and rationale presented in the previous section, the EMF effects of inter-array cable operation on near-bottom pelagic habitats used by EFH finfish species would be insignificant. The following EFH species may periodically use the affected habitat during juvenile, adult, and/or spawning life stages:

- Albacore tuna (juvenile, adult)
- Atlantic bluefin (juvenile, adult)
- Atlantic skipjack (juvenile, adult)
- Atlantic yellowfin (juvenile, adult)
- Atlantic mackerel (juvenile, adult, spawning)
- Atlantic herring (juvenile, adult)
- Bluefish (juvenile, adult)

EMF Effects on Demersal Habitats Used by Pelagic Invertebrates

Two pelagic EFH invertebrate species, longfin squid and shortfin squid, may periodically use demersal habitats at or near 3.3 feet (1 meter) of the seabed during their life cycle. This may include habitats overlapping buried and exposed segments of the inter-array cable. Prey organisms within this zone would also experience EMF exposure. This indicates that these species could be exposed to the following EMF effects:

- Induced magnetic field: 17 to 35 mG at 3.3 feet (1 meter) above the seabed for buried and exposed cable segments at average loading, respectively.

- Electrical field: 1.3 to 1.7 mV/m at 3.3 feet (1 meter) above seabed for buried and exposed cable segments at average loading, respectively.

While directed studies are lacking, there is little evidence that cephalopods like squid are electromagnetically sensitive (Normandeau et al. 2011; Williamson 1995). Anecdotal observations suggest that EMF from submarine power cables has no effect on cephalopod behavior. Love et al. (2015) observed no differences in octopus predation on caged crabs placed immediately adjacent to a powered HVAC electrical cable producing induced magnetic fields ranging from 450 to 800 mG, and at a control site adjacent to an unpowered cable. The lack of effects on predation behavior suggests that cephalopods are insensitive to EMF effects of this magnitude. Given that the largest projected magnetic field effects from the inter-array cable are 1 to 2 orders of magnitude lower than these values, it is reasonable to conclude that the EMF effects of this project feature on EFH used by longfin squid would be insignificant.

EMF Effects on Demersal and Epibenthic Habitats Used by Skates and Sharks

Several EFH skate and shark species use demersal and epibenthic habitats overlapping the potential inter-array cable corridor during one or more life history stages. This indicates that these species may be exposed to the following EMF effects depending on their proximity to the seabed:

- Induced magnetic field: 17 to 35 mG at 3.3 feet (1 meter) above the seabed for buried and exposed cable segments at average loading, respectively.
- Induced magnetic field: 57 to 522 mG at the seabed for buried and exposed cable segments at average loading, respectively.
- Electrical field: 1.3 to 1.7 mV/m at 3.3 feet (1 meter) above seabed for buried and exposed cable segments at average loading, respectively.
- Electrical field: 2.1 to 5.4 mV/m at the seabed for buried and exposed cable segments at average loading, respectively.

Elasmobranchs are sensitive to EMFs, using specialized electrosensory organs to detect faint bioelectric signals emitted by prey. Sharks and rays demonstrate sensitivity to bioelectrical fields less than 1 mV/m (Adair et al. 1998; Ball et al. 2016; Bedore and Kajiura 2013; Kempster et al. 2013). However, it is important to recognize that most bioelectrical fields operate at frequencies on the order of 0.001 Hz to 5 Hz, and fields with frequencies greater than 20 Hz are beyond the detection range of most electrosensitive organisms (Bedore and Kajiura 2013). For example, Kempster et al. (2013) observed behavioral responses in bamboo shark (*Chiloscyllium plagiosum*) embryos exposed to electrical fields of 0.004 to 0.02 mV/m at 0.1 to 1.0 Hz, emulating the bioelectric fields generated by predators, but no response to the same field strength at 20 Hz. These findings indicate that the 60-Hz electrical fields generated by the inter-array cable would not be detectable by elasmobranchs.

The evidence for magnetic field sensitivity in sharks and rays is more variable. Orr (2016) exposed the benthic draughtsboard shark (*Cephaloscyllium isabellum*) to a 50-Hz magnetic field operating at 14,300 mG and found no observable effects on foraging behavior. In contrast, Hutchison et al. (2018; 2020) observed behavioral responses in little skate to induced magnetic fields on the order of 650 mG. The available research indicates that while the minimum magnetosensitivity of elasmobranchs is unknown, some species have exhibited observable behavioral responses to anthropogenic EMF at field strengths ranging between 250 and 1,000 mG (Hutchison et al. 2018, 2020; Normandeau et al. 2011). The induced electrical fields generated in even the largest individuals potentially exposed to these effects are less than those generated by muscular and nervous activity in living animals (~10 mV/m) and are therefore likely indetectable (Adair et al. 1998).

Based on the above findings, it is reasonable to conclude that the EMF effects of the inter-array cable on EFH used by epibenthic and demersal pelagic skates and sharks would be insignificant. The 60-Hz electrical fields generated by the cable are above the known detection frequency limit of 20 Hz, while the maximum induced magnetic field and induced electrical field effects are orders of magnitude below the known or probable detection limits of these species. EFH for the following epibenthic and demersal pelagic shark and ray species would be exposed to insignificant EMF effects from the inter-array cable:

- Blue shark (neonate/YOY, juvenile)
- Dusky shark (neonate/YOY, juvenile)
- Common thresher shark (neonate/YOY, juvenile)
- Shortfin mako shark (neonate/YOY, juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile, adult)
- White shark (neonate/YOY, juvenile)
- Smooth dogfish (neonate, juvenile, adult)
- Spiny dogfish (subadult and adult, male and female)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)

<u>EMF and Heat Effects on Benthic Invertebrates</u>

The inter-array cable corridor overlaps with EFH used by Atlantic sea scallop, Atlantic surf clam, and ocean quahog and these species are likely to be exposed to EMF and heat effects from inter-array cable operation. Benthic infauna that provide prey resources for EFH species would also be exposed to these effects. Shellfish EFH and benthic infauna that contribute to EFH are likely to be most susceptible to EMF effects because as these species are generally immobile and individuals occurring within measurable EMF are therefore likely to experience prolonged exposure. The available information on invertebrate sensitivity to EMF effects is equivocal (Albert et al. 2020). For example, Ottaviani et al. (2002) and Malagoli et al. (2003, 2004) observed apparent disruption of cellular processes in mussels exposed to induced 50-Hz magnetic fields ranging from 3 to 10 mG for as little as 15 minutes, and Stankevičiūtė et al. (2019) observed apparent genotoxic and cytotoxic effects in infaunal clams and worms after 12 days of exposure to a 10-mG field at 50 Hz. In contrast, Bochert and Zettler (2006) observed no apparent effects on physiological condition or gonad development in mussels exposed to a 37-mG DC magnetic field for over 90 days. Cada et al. (2011) observed no effects on the behavior of clams exposed to 360 mG for 48 hours.

The preponderance of evidence suggests that the inter-array cable could produce sufficient EMF to have potentially adverse effects on bivalve physiology. The maximum induced magnetic field generated of 522 mG at surface-laid cable would attenuate to background within approximately 26 feet (8 meters) of both the buried and exposed cable. Applying this value as a conservative physiological effect threshold over the entire 116.1 mile IAC corridor length, this would equate to approximately 366 acres (148 hectares) of bivalve EFH exposed to potentially significant EMF effects on habitat suitability. This conservative estimate is likely representative of the maximum potential extent of EMF effects on foraging habitat for EFH species that prey on benthic infauna.

In addition to EMF effects, buried segments of the inter-array cable would generate sufficient heat to raise the temperature of the surrounding sediments by as much as 10 °C to 20 °C above ambient within 1.3 to 2 feet (0.4 to 0.6 meter) of buried cable segments. Substrate temperature changes of this magnitude could adversely affect habitat suitability for juvenile and adult life stages of Atlantic surf clam and ocean quahog (Acquafredda et al. 2019; Harding et al. 2008), as well as other benthic infauna species. However, because the inter-array cable would be buried to a minimum depth of 4 to 6 feet (1.2 to 1.8 meters) along most of its length, heat effects from buried cable segments on benthic infauna would likely be insignificant. Cable segments at the transitions between fully buried and exposed cable segments would be buried at shallower depths, potentially exposing quahog and surf clam habitat and infaunal prey species to adverse thermal effects. Based on conceptual designs for the exposed cable segments (COP Appendix Q1), these shallow buried segments would account for approximately 10 percent of the 104.5 linear miles (169 km, 91 nm) of exposed cable length. This equates to approximately 33 acres (13 hectare) of benthic EFH exposed to potentially adverse thermal effects. Note however that suitability of these habitats for surf clam and quahog and benthic infauna in general would also be negatively affected by the overlying cable protection so the areal extents of these two impacts are not additive.

The following bivalve species and life stages may be exposed to potentially adverse effects on EFH resulting from EMF and heat effects from inter-array cable operation:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)

RWEC and OSS-link

The RWEC and OSS-link are 275-kV 3-phase AC cabled operating at 60 Hz. Like the IAC, the RWEC and OSS-link 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 meters). Exponent (2021) assumed a conservative burial depth of 3.3 feet (1 meter) for the purpose of modeling EMF effects. 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 and OSS-link cables are summarized in Table 5.13. The EMF and substrate heating effects of the RWEC and OSS-link on EFH will vary depending on the respective cable voltage, the position of the cable on the seabed (i.e., buried to target depth or laid on bed surface), and how EFH is used by different life stages of EFH species. The nature of these effects and the potential exposure of EFH used by fish and invertebrates occurring along the RWEC corridor, and the rationale used to analyze these effects, are similar to those described previously for the inter-array cable.

EMF Effects on Habitats Used by Benthic or Epibenthic Eggs and Larvae

Several EFH species have benthic eggs and larvae could settle in areas along the RWEC and OSS-link corridors, including both buried and exposed cable segments. The magnetic field and electrical field generated for average loading by the inter-array cable are 1,071 mG and 13 mV/m at the bed surface immediately adjacent to exposed cable segments, respectively. These fields diminish rapidly with distance, to 91 mG and 3.5 mV/m at 3.3 feet (1 meter) above the seabed. Induced electrical field effects on eggs and larvae could delay development, but would not be expected to affect hatching rates, physical abnormalities, or survival.

Applying the effect thresholds and rationale described previously for these life stages, the EMF exposure generated by the RWEC and OSS-link is similar in magnitude as the lower end of observed biological effect thresholds in fish and invertebrate eggs and larvae. On this basis, the EMF effects of the RWEC on EFH used by benthic and epibenthic eggs and larvae are likely to be insignificant. EFH species with habitats exposed to insignificant EMF effects from the RWEC are as follows:

- Atlantic cod (larvae)
- Atlantic herring (larvae)
- Atlantic mackerel (larvae)
- Black sea bass (larvae)
- Butterfish (eggs and larvae)
- Ocean pout (eggs and larvae)
- Monkfish (larvae)
- Summer flounder (eggs and larvae)
- Windowpane flounder (larvae)
- Atlantic sea scallop (eggs and larvae)
- Longfin squid (eggs)

EMF Effects on Habitats Used by Epibenthic Finfish and Flatfish Species

Several EFH species use benthic or epibenthic habitats within 3.3 feet (1 meter) of the seabed during their life cycle that overlap with the RWEC and OSS-link corridors, including both buried and exposed cable segments. Epibenthic fish species that provide prey for EFH species also use these habitats. This indicates that these species could be exposed to the following EMF effects:

- Induced magnetic field: 147 to 1,071 mG at seabed above buried and exposed cable segments, respectively.

- Electrical field: 4.4 to 13 mV/m at seabed above buried and exposed cable segments, respectively.

Applying the effect thresholds and rationale described previously for these life stages, the EMF exposure generated by the RWEC and OSS-link corridors are similar in magnitude as the lower end of observed biological effect thresholds in fish and invertebrate eggs and larvae. On this basis, the EMF effects of RWEC and OSS-link operation on benthic and epibenthic habitats used by EFH finfish species would be insignificant. The following EFH species use the affected habitat during juvenile, adult, and/or spawning life stages:

- Atlantic cod (juvenile, adult, spawning)
- Pollock (juvenile)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile, adult, spawning)
- White hake (juvenile)
- Black sea bass (juvenile, adult)
- Butterfish (juvenile, adult)
- Ocean pout (juvenile, adult, spawning)
- Scup (juvenile, adult)
- Atlantic herring (spawning)
- Monkfish (juvenile, adult, spawning)
- Summer flounder (adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (juvenile, adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)

<u>EMF Effects on Demersal Habitats Used by Pelagic Finfish Species</u>

Several pelagic fish species, including EFH species and their prey, may periodically use demersal habitats at or near 3.3 feet (1 meter) of the seabed near the RWEC and/or OSS-link cables during their respective life cycles. This may include habitats that overlap buried and exposed segments of the inter-array cable. This indicates that these species could be exposed to the following EMF effects:

- Induced magnetic field: 147 to 1,071 mG at seabed above buried and exposed cable segments, respectively.

- Electrical field: 4.4 to 13 mV/m at seabed above buried and exposed cable segments, respectively.

Applying the effect thresholds and rationale presented in the previous section, the EMF effects of RWEC operation on near-bottom pelagic habitats used by EFH finfish species and their prey organisms would be insignificant. The following EFH species may periodically use the affected habitat during juvenile, adult, and/or spawning life stages:

- Albacore tuna (juvenile, adult)
- Atlantic bluefin (juvenile, adult)
- Atlantic skipjack (juvenile, adult)
- Atlantic yellowfin (juvenile, adult)
- Atlantic mackerel (juvenile, adult, spawning)
- Atlantic herring (juvenile, adult)
- Bluefish (juvenile, adult)

<u>EMF Effects on Demersal Habitats Used by Pelagic Invertebrates</u>

One pelagic EFH invertebrate species, longfin squid, may periodically use demersal habitats at or near 3.3 feet (1 meter) of the seabed near the RWEC and/or OSS-link cables during its life cycle. This may include habitats overlapping buried and exposed segments of the RWEC corridor. This indicates that this species could be exposed to the following EMF effects:

- Induced magnetic field: 147 to 1,071 mG at seabed above buried and exposed cable segments, respectively.
- Electrical field: 4.4 to 13 mV/m at seabed above buried and exposed cable segments, respectively.

Longfin squid prey on fish and other invertebrates within this same effect area, indicating that effects described for fish and invertebrates in previous and following sections would apply to prey species. Applying the effect thresholds and rationale presented in the previous section, the EMF effects of RWEC and OSS-link operation on near-bottom pelagic habitats used by squid and their prey would be insignificant. Longfin squid may periodically use the affected habitat during the designated juvenile and adult life stages.

EMF Effects on Demersal and Epibenthic Habitats Used by Skates and Sharks

Several EFH skate and shark species use demersal and epibenthic habitats overlapping the potential RWEC and OSS-link corridors alternatives during one or more life history stages. This indicates that these species may be exposed to the following EMF effects depending on their proximity to the seabed:

- Induced magnetic field: 41 to 91 mG at 3.3 feet (1 meter) above the seabed for buried and exposed cable segments at average loading, respectively.
- Induced magnetic field: 147 to 1,071 mG at the seabed for buried and exposed cable segments at average loading, respectively.
- Electrical field: 2.3 to 3.5 mV/m at 3.3 feet (1 meter) above seabed for buried and exposed cable segments at average loading, respectively.
- Electrical field: 4.4 to 13 mV/m at the seabed for buried and exposed cable segments at average loading, respectively.

Applying the effect thresholds and rationale presented in the previous section, the EMF effects of RWEC and OSS-link operation on demersal and epibenthic habitats used by EFH shark and skate species and their prey organisms would be insignificant. The following EFH species may periodically use the affected habitat during juvenile, adult, and/or spawning life stages:

- Blue shark (neonate/YOY, juvenile)
- Dusky shark (neonate/YOY, juvenile)
- Common thresher shark (neonate/YOY, juvenile)
- Shortfin mako shark (neonate/YOY, juvenile)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile, adult)
- White shark (neonate/YOY, juvenile)
- Smooth dogfish (neonate, juvenile, adult)
- Spiny dogfish (subadult and adult, male and female)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)

<u>EMF and Heat Effects on Benthic Invertebrates</u>

The RWEC and OSS-link routes alternatives overlap with EFH used by Atlantic sea scallop, Atlantic surf clam, and ocean quahog, and these species are likely to be exposed to EMF and heat effects from RWEC and OSS-link operation. The preponderance of evidence suggests that the RWEC could produce sufficient EMF to have potentially adverse effects on invertebrate physiology. The maximum induced magnetic field generated of 1,071 mG would attenuate to background within 26 feet (8 meters) of both the buried and exposed cable. Applying this value as a conservative physiological effect threshold over the entire corridor length, this would equate to a total of approximately 630 acres (255 hectares) of bivalve and infaunal prey habitat exposed to potentially significant EMF effects for the RWEC.

Buried segments of the RWEC and OSS-link would generate sufficient heat to raise the temperature of the surrounding sediments by as much as 10 to 20 °C above ambient within 1.3 to 2 feet (0.4 to 0.6 meter) of buried cable segments. Temperature changes of this magnitude could adversely affect habitat suitability for juvenile and adult life stages of Atlantic surf clam and ocean quahog, and benthic infaunal prey species. However, because the RWEC and OSS-link would be buried to a minimum depth of 4 to 6 feet (1.2 to 1.8 meters) along approximately 90 percent of its length, heat effects on juvenile and adult clams and other benthic infauna over buried cable segments would likely be insignificant. Cable segments at the transitions between fully buried and exposed cable segments would be buried at shallower depths, potentially exposing quahog and surf clam habitat and other benthic infauna to adverse thermal effects. Based on conceptual designs for the exposed cable segments (COP Appendix Q1), these shallow buried segments would account for approximately 10 percent of exposed cable length. This equates to approximately 1.21 acre (0.5 hectare) of benthic EFH exposed to potentially adverse thermal effects on EFH for the RWEC and OSS-link. As stated however, these areas would be covered by concrete mattresses and rendered unsuitable habitat for benthic infauna, so the two effect areas are not additive.

The following bivalve species and life stages may be exposed to potentially adverse effects on EFH resulting from EMF and heat effects from inter-array cable operation:

- Atlantic sea scallop (juvenile, adult, spawning)
- Atlantic surf clam (juvenile, adult)
- Ocean quahog (juvenile, adult)

5.1.4.2 Cable Protection

The RWEC, IAC, and OSS-link would have permanent effects on complex, large-grained complex, and soft bottom benthic habitats resulting from boulder relocation and placement of cable protection. Some intermediate-term effects (6 months to 1 year) on soft bottom benthic habitats may also result from jet plow installation of the RWEC. Impacts from IAC and RWEC and OSS-link installation on soft bottom habitats are summarized in Tables 5.7 and 5.8, respectively. Long-term habitat conversion impacts on all habitat types resulting from presence of cable protection are summarized by habitat zone and habitat type in Table 5.11.

Permanent Effects on Complex and Large-Grained Complex Benthic Habitat

The placement of cable protection for exposed segments of the IAC, RWEC, and OSS-link cables and CPS around scour protection would result in the intermediate- to permanent modification of complex and large-grained complex habitats. An estimated 116.2 acres of cable protection would be placed within the Lease Area and RWEC corridor. Of this total, an estimated 7.4 acres (3.0 hectares) and 26 acres (10.5 hectares) of impacts would occur in large-grained complex and complex benthic habitat, respectively. The affected habitats would eventually be recolonized by habitat forming organisms, leading to increasing habitat complexity and improvement in habitat function over time. The total acres affected by foundations, scour protection, and cable protection and distribution of impacts by habitat type will vary by habitat zone (see Table 5.11) as follows:

- RWF Zone 1
  - Complex benthic habitat: Approximately 2.0 acres (0.8 hectare).
  - Large-grained complex habitat: Approximately 1.6 acres (0.6 hectare).
- RWF Zone 2
  - Complex benthic habitat: Approximately 9.7 acres (3.9 hectares).
  - Large-grained complex habitat: Approximately 5.0 acres (2.0 hectares).
- RWF Zone 3a
  - Complex benthic habitat: Approximately 1.4 acres (0.6 hectare).
  - Large-grained complex habitat: Approximately 0.5 acres (0.2 hectare).

- RWF Zone 4
    - Complex benthic habitat: Approximately 4.3 acres (1.7 hectares).
    - Large-grained complex habitat: 0 acres (0 hectares).
- RWEC-OCS:
    - Complex benthic habitat: Approximately 2.6 acres (1.1 hectares).
    - Large-grained complex habitat: 0 acres (0 hectares).
- RWEC-RI:
    - Complex benthic habitat: Approximately 14.9 acres (6.0 hectares).
    - Large-grained complex habitat: Approximately 0.5 acre (0.2 hectare).

Cable protection placed in complex and large-grained complex habitat would reduce the suitability of the affected habitat for an intermediate-term period lasting up to 10 years as artificial reef features mature. Placement of cable protection in soft bottom habitat would convert soft bottom habitat to complex habitat, with a similar lag period of up to 10 years before functional habitat status is achieved. The presence of cable protection would therefore result in a diminishing, intermediate-term adverse effect on EFH for species associated with complex benthic habitat lasting up to 10 years. At this point colonization of cable protection by habitat forming organisms would result in gradually improving habitat conditions for the remaining 20 to 25 years of project life. These effects would be reversed when cable protection is removed during project decommissioning.

EFH for the following fish species and life stages that associate with complex and large grained complex habitats would be adversely affected in the intermediate-term and beneficially affected permanently by the expansion of functional complex benthic habitat resulting from cable protection:

- Atlantic cod (juvenile, adult, spawning)
- Pollock (juvenile, adult, spawning)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile, adult, spawning)
- White hake (juvenile)
- Atlantic herring (eggs, spawning)
- Black sea bass (larvae, juvenile, adult)
- Ocean pout (eggs, larvae, spawning)
- Scup (juvenile, adult)
- Monkfish (juvenile, adult, spawning)
- Summer flounder (juvenile, adult)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)
- Sand tiger shark (neonate/YOY, juvenile)
- Longfin squid (eggs)
- Atlantic sea scallop (eggs, larvae, juvenile, adult, spawning)

Permanent Effects on Soft Bottom Benthic Habitat

The placement of cable protection in soft bottom habitats would result in the permanent conversion of those habitats to a new habitat type. Approximately 39.1 acres (15.8 hectares) of soft bottom benthic habitat would be permanently modified by placement of scour protection and CPS around the monopiles. An estimated 82.4 acres (33.3 hectares) of RWEC, IAC, and OSS-link cable protection would be placed in soft bottom habitat (see Table 5.11), effectively converting the affected areas to a new habitat type with novel hard surfaces available for colonization by habitat forming organisms. These impacts would be distributed by habitat zone as follows:

- RWF Zone 1: Approximately 5.8 acres (2.3 hectares).
- RWF Zone 2: Approximately 13.4 acres (5.4 hectares).
- RWF Zone 3a: Approximately 1.7 acres (0.7 hectares).
- RWF Zone 4: Approximately 30.1 acres (12.2 hectares).
- RWEC-OCS: Approximately 15.3 acres (6.2 hectares).
- RWEC-RI: Approximately 27.4 acres (11.1 hectares).

The affected areas would be rendered unsuitable for EFH species associated with soft bottom benthic habitats during one or more life stages. RWEC installation would therefore result in a permanent adverse effect on EFH lasting for at least the 35-year lifetime of the project. The concrete mattresses would likely be removed during RWEC decommissioning, restoring the affected area to soft bottom benthic habitat (the effects of cable protection removal would be addressed under a separate future EFH consultation for project decommissioning).

The RWEC and OSS-link routes were selected to minimize impacts to mobile mega-ripples and ripples on the seabed, as these features can unbury transmission cables. Jet plow installation of the RWEC may flatten depressions and small sand waves, temporarily reducing benthic habitat suitability of EFH for juvenile and adult red and silver hake within the cable plow footprint. Prey organisms that use these habitats would also be displaced, potentially affecting habitat suitability for EFH species. In contrast, trenching may leave behind short-term depressions that provide similar habitat function. The extent of these natural features is difficult to quantify, as they are continually reshaped by natural sediment transport processes. Natural recovery from anthropogenic disturbance is likely to occur within several months of the disturbance, depending on timing relative to winter storm events.

Further, conversion of soft bottom benthic habitat to complex benthic habitats could attract hard-bottom associated fish and invertebrates, both native and nonnative species. The introduction of artificial hard substrates can provide novel habitats that can provide opportunities for invasive species to become established (Taormina et al. 2018). However, the affected area would be small relative to all habitat zones combined and hard substrates, including approximately 26 acres (10.5 hectares) of anthropogenic surfaces, are already present throughout the project area. The 96.4 acres (33.3 hectares) of new hard surfaces introduced to soft bottom habitats, 42.7 acres (17.3 hectares) within the RWEC corridor, represents a miniscule proportion (approximately 0.27 percent) of available soft bottomed habitat within the Lease Area and RWEC corridor.

On this basis, construction and installation of the RWEC and OSS-link and associated cable protection would result in short-term to effectively permanent adverse effects on 96.4 acres of EFH for the following species and life stages:

- Ocean pout (juvenile, adult)
- Butterfish (juvenile, adult)
- Scup (juvenile, adult)
- Red hake (juvenile, adult, spawning)
- Silver hake (juvenile, adult, spawning)
- Summer flounder (adult)
- Windowpane flounder (juvenile, adult, spawning)
- Winter flounder (juvenile, adult, spawning)
- Witch flounder (juvenile, adult, spawning)
- Yellowtail flounder (juvenile, adult, spawning)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
- Winter skate (juvenile, adult)
- Sand tiger shark (neonate/YOY, juvenile)
- Atlantic surf clam (adult)
- Ocean quahog (juvenile, adult)

5.2 Project Surveys and Monitoring Activities

Project monitoring activities will include those activities described previously in Section 2.4. These activities include pre- and post-construction HRG surveys and impacts to EFH species from implementation of the FRMP.

5.2.1 Pre- and Post-Construction HRG Surveys

While HRG survey noise would exceed the behavioral effects threshold over a larger cumulative area (2,964,648 acres), the continuously moving HRG vessels would distribute those impacts over approximately 9,509 linear miles (15,304 km), approximately 5,940 and 3,547 miles (9,560 and 5,708 km) in the Lease Area and RWEC corridors, respectively. This equates to a combined 218 days of survey effort, 137 within the Lease Area and 81 within the RWEC. HRG surveys of the Lease Area would be conducted concurrent with monopile installation. Assuming that HRG survey effort is proportional to total transmission cable length in each habitat zone, this equates to approximately 21 days of pre-construction HRG survey effort in Zone RWF 1, 51 days in Zone RWF 2, 6 days in Zone RWF 3a, 0 days in Zone RWF 3b, 64 days in Zone RWF 4, and 29 and 47 days in zones RWEC-OCS and RWEC-RI, respectively. HRG survey vessels would operate 24 hours per day during any month of the year as required to complete the survey effort, however the timing of survey activities in specific habitat zones has not been specified.

Up to 2,365 linear miles (3,805 km) of post-construction HRG surveys could be conducted each year for the first four 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. Assuming that post-construction survey effort is also proportional to total transmission cable length, this would equate to approximately 5 days of post-construction HRG survey effort in Zone RWF 1, 13 days in Zone RWF 2, 1 day in Zone RWF 3a, 0 days in Zone RWF 3b, 16 days in Zone RWF 4, and 7 and 12 days in zones RWEC-OCS and RWEC-RI, respectively.

HRG survey equipment is towed at a typical speed of 4 knots (1.9 kilometers per hour) during operation, meaning that no individual area is continuously exposed to significant underwater noise (i.e., noise exceeding an established effect threshold) for more than approximately 20 minutes. The instantaneous behavioral effects exposure area around the HRG equipment would be considerably smaller, approximately 477 acres.

Underwater noise impacts from HRG survey activities are expected to be generally similar to those resulting from vessel engine noise, would be similar to those described in Section 5.1.1.1. As stated, exposure to HRG survey noise above behavioral effects thresholds could result in behavioral disturbances, including startling, avoidance, and disruption of feeding and spawning activity. Certain species, specifically Atlantic cod and Atlantic herring are sensitive to noise exposure during spawning. Vessel noise has been shown to disrupt spawning behavior in these species (Vabø et al. 2002; Handegard et al. 2003; Dean et al. 2022). As such, while HRG-related noise effects on habitat suitability are short-term in duration and the instantaneous area affected is relatively small, the resulting impacts on EFH species could vary in significance depending on the specific timing and location of survey activities. For example, HRG survey noise could theoretically have a negative effect on cod spawning if surveys were conducted in Zone RWF 1 and other areas used by spawning cod during peak spawning periods. However, current research indicates that noise exposure may not necessarily lead to adverse disruptive effects. For example, McQueen et al. (2022) observed that Atlantic cod exposed to seismic airgun noise suspended spawning activity when the stressor was present but resumed spawning at the same location within an hour of its removal. Noise levels generated by seismic airguns are much higher in intensity than those produced by the HRG survey equipment proposed for the project. This suggests that this stressor is unlikely to lead substantial adverse effects on spawning and other biologically important activities.

Effects

- Direct
    - Short-term, local avoidance responses due to vessel noise: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Sessile Benthic/Epibenthic – Complex Habitat; Mobile Benthic/Epibenthic –

Complex Habitat; Pelagic; Prey Species – Benthic/Epibenthic; Prey Species – Pelagic.

- Indirect
  - Short-term reduction in habitat quality for Southern New England HAPC.
  - Short-term reduction in habitat quality for juvenile inshore cod HAPC.
  - Short-term reduction in habitat quality for summer flounder HAPC.

See Section 5.1.1.1 for a detailed analysis of underwater noise impacts from HRG survey activities to EFH species and their habitats by hearing group.

5.2.2 Fisheries and Benthic Habitat Monitoring

The trawl and ventless trap survey methods implemented under the FRMP would target specific invertebrate and finfish species, using methods and equipment commonly employed in regional commercial fisheries. Organisms captured during surveys would be removed from the environment for scientific sampling and commercial use. Other species of finfish could also be impacted by sampling activities. For example, benthic fish could be injured or killed when survey equipment contacts the seabed or inadvertently captured as bycatch. Non-target fish would be returned to the environment where practicable, but some of these organisms would not survive. The use of traps and otter trawls could result in unavoidable impacts to habitat-forming invertebrates that comprise an important component of habitat for some EFH species. However, the extent of habitat disturbance and number of organisms affected would be comparable to and limited in extent relative to the baseline level of impacts from commercial fisheries. Randomized sampling distribution means that repeated disturbance of the same habitat is unlikely. As such, impacts to EFH from FRMP implementation would likely be short-term in duration. While the FRMP would result in unavoidable impacts on EFH through the intentional or incidental take of individual organisms, the number affected would similarly be small in comparison to commercial fisheries and would not measurably impact the viability of any EFH species or their prey organisms.

As discussed in Section 2.3.3, underwater noise effects generated during the benthic surveys are similar, but of lower magnitude than those generated during the HRG surveys and are unlikely to have any measurable biological effect on any EFH species. Similarly, impacts of the fisheries surveys would result in unavoidable impacts to individual fish, however 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 have a measurable impact on the viability of any species at the population level or available EFH.

5.3 Decommissioning Concept

At the end of authorized project life, the RWF and RWEC would be decommissioned and removed. Implementation procedures for the decommissioning will generally entail the complete removal of the RWF and RWEC infrastructure to the extent practicable. BOEM would require Revolution Wind to develop a decommissioning plan for agency approval. This federal action would be subject to an independent environmental and regulatory review process, including assessment of impacts to EFH species and habitats. Specific procedures will be developed when the decommissioning is scheduled to ensure potential impacts to EFH are considered, appropriate EPMs are identified, and implementation procedures to avoid and minimize impacts EFH are incorporated. Broadly speaking, decommissioning impacts to EFH would be similar in nature and extent to those associated with project construction, except that no impact pile driving would be required.

5.4 Cumulative and Synergistic Effects to EFH

BOEM has completed a study of IPFs on the North Atlantic OCS to consider in an offshore wind development cumulative impacts scenario (BOEM 2019). That study is incorporated in this document by reference. The study identifies cause-and-effect relationships between renewable energy projects and resources potentially affected by such projects. It further classifies those relationships into a manageable number of IPFs through which renewable energy projects could affect resources. It also identifies the types of actions and activities to be considered in a cumulative impact’s scenario. The study identifies actions and activities that may affect the same biological resources (e.g., EFH) as renewable energy projects and states that such actions and activities may have the same IPFs as offshore wind projects (BOEM 2021).

Cumulative projects and activities consist of 10 types of actions that were evaluated: 1) other offshore wind energy development activities; 2) undersea transmission lines, gas pipelines, and other submarine cables (e.g., telecommunications); 3) tidal energy projects; 4) marine minerals use and ocean dredged material disposal; 5) military use; 6) marine transportation; 7) fisheries use and management; 8) global climate change; and 9) oil and gas activities (BOEM 2021).

An estimated 25 offshore wind projects have been identified by (1 active state project, 15 active federal projects, and 9 future federal projects). BOEM assumes proposed offshore wind projects will include the same or similar components as the proposed Project: wind turbines, offshore and onshore cable systems, offshore substations, onshore O&M facilities, and onshore interconnection facilities. BOEM further assumes that other potential offshore wind projects will employ the same or similar construction and installation, operations and maintenance, and decommissioning activities as the proposed Project. However, future offshore wind projects would be subject to evolving economic, environmental, and regulatory conditions. Lease areas may be split into multiple projects, expanded, or removed, and development within a particular lease area may occur in phases over long periods of time. Research currently being conducted in combination with data gathered regarding physical, biological, socioeconomic, and cultural resources during development of initial offshore wind projects in the United States could affect the design and implementation of future projects, as could advancements in technology.

The other nine types of actions will result in similar potential impacts as offshore wind projects with differences in the magnitude of potential impacts to EFH in terms of timing, duration, and extent.

6.0 Avoidance, Minimization and Mitigation

This section outlines relevant environmental protection and mitigation measures that could be used to avoid and minimize adverse impacts on EFH species and habitats. EPMs are measures proposed by Revolution Wind and are considered part of the Proposed Action. These measures have been considered in the impact analysis for this project.

Mitigation measures are additional protective measures that will or are likely to be required by BOEM or other cooperating agencies to avoid and minimize impacts to EFH species and habitats.

6.1 Avoidance and Minimization Measures (EPMs)

Relevant EPMs contribution to avoiding and/or minimizing adverse effects on EFH, and supporting rationale are summarized by project component in Table 6.1.

Table 6.1. Relevant EPMs Identified by Revolution Wind for Construction and Installation, and Operations and Maintenance of the RWF, RWEC, as well as O&M Facility Operations.

Proposed EPMs to Avoid and Minimize Impacts to be implemented by Revolution Wind	RWF	RWEC	Expected Effects
The RWF and RWEC will be sited to avoid and minimize impacts to sensitive habitats (e.g., hard bottom habitats to the extent practicable.	x	x	Minimizes impacts to sensitive and slow to recover habitats utilized by hard-bottom associated EFH species.
To the extent feasible, installation of the IACs, OSS-Link Cable and RWEC will be buried using equipment such subsea cable trenchers such as jet trenchers or mechanical cutting trenchers, simultaneous lay and burial using a cable plow, or jet plow. The feasibility of cable burial equipment will be determined based on an assessment of seabed conditions and the Cable Burial Risk Assessment	x	x	Limits impacts to soft bottom EFH and EFH species by minimizing the extent and duration of direct habitat impacts and reducing suspended sediment effects on EFH species.
A boulder grab and specialized WROV boulder skid will be used for the majority of boulder relocation. The boulder plow will only be used on in two approximately 6.2-mile (10 km) RWEC segments.	x	x	Minimizes impacts to sensitive and slow to recover habitats utilized by hard-bottom associated EFH species.
DP vessels will be used for installation of the IACs, OSS-Link Cable, and RWEC to the extent practicable.	x	--	Limits impacts to soft bottom associated EFH and EFH species by minimizing the extent and duration of direct habitat impacts and reducing suspended sediment effects on EFH species.
A plan for vessels will be developed prior to construction and installation to identify no-anchorage areas to avoid documented sensitive resources.	x	x	Avoids adverse effects on benthic EFH from impacts to water quality.
Accidental spill or release of oils or other hazardous materials will be managed through the Oil Spill Response Plan (OSRP) (OSRP Appendix D).	x	x	Avoids and minimizes adverse effects on benthic and pelagic EFH from impacts to water quality.

Proposed EPMs to Avoid and Minimize Impacts to be implemented by Revolution Wind	RWF	RWEC	Expected Effects
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 (e.g., lobster, crabs) in the vicinity by allowing them to vacate the area prior to the commencement of pile driving activities.	x	--	The establishment of soft-start protocols would minimize the potential for adverse effects and warn animals of the pending pile driving activity in the area and allow them to leave before full hammer power is reached.
All vessels will comply with USCG and USEPA 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.	x	x	This measure would minimize the impact of waste generated on construction and installation and operations and maintenance related vessels.
HRG surveys and other site characterization methods would be used to identify, avoid, and minimize impacts to complex bottom habitats from RWF and RWEC construction to the extent practicable.	x	x	Consideration of benthic habitat would reduce impacts to sensitive habitats utilized by benthic EFH species.
Construction and installation, and operations and maintenance lighting will be limited to the minimum necessary to ensure safety and to comply with applicable regulations.	x	x	This measure would minimize impacts to primarily pelagic EFH and EFH species from artificial lighting.
To the extent feasible, the RWEC, IAC, and OSS-Link Cable will typically target a burial depth of 4 to 6 ft (1.2 to 1.8 m) below seabed. The target burial depth will be determined based on an assessment of seabed conditions, seabed mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a site-specific Cable Burial Risk Assessment.	x	x	This measure would minimize impacts to benthic EFH and EFH species from EMF.
Revolution Wind will require all construction and installation, and operations and maintenance vessels to comply with regulatory requirements related to the prevention and control of spills and discharges.	x	x	Avoids and minimizes adverse effects on benthic and pelagic EFH from impacts to water quality.
Exclusion and monitoring zones for marine mammals and sea turtles will be established for impact and vibratory pile driving activities.	x	x	Avoids and minimizes impacts from underwater noise during pile driving.
Environmental protection measures will be implemented for impact and vibratory pile driving activities. These measures will include seasonal restrictions, soft-start measures, shut-down procedures, marine mammal and sea turtle monitoring protocols, the use of qualified and NOAA approved protected species observers, and Noise Mitigation System (NMS) such as bubble curtains, as appropriate.	x	x	The reduction in sound pressure levels (SPLs) will reduce the area of effects to EFH species and the prey they feed upon.
All personnel working offshore will receive training on marine mammal and sea turtle awareness and marine debris awareness	x	x	Avoids and minimizes adverse effects on marine mammals but may reduce potential impacts to EFH from debris also.
At the landfall location, drilling fluids will be managed within a contained system to be collected for reuse as necessary. An HDD Contingency Plan will be prepared and implemented to minimize the potential risks associated with release of drilling fluids.	--	x	Avoids and minimizes adverse effects on benthic and pelagic EFH from impacts to water quality.
Timing restrictions to avoid noise impacts on North Atlantic right whale would also be protective for the majority of the cod spawning season. This includes the restriction of pile driving to the months of May to December; no pile driving will occur from January 1st to April 30th.	x	x	Protective of Atlantic cod.

6.2 Mitigation

In addition to EPMs proposed by Revolution Wind, BOEM is considering several additional mitigation measures to avoid and minimize adverse impacts to finfish and EFH. These measures fall into two categories:

- Specific mitigation measures identified by BOEM, as well as those identified by cooperating agencies as a condition of state and federal permitting or through agency-to-agency negotiations.
- Alternative project configurations that could avoid or minimize adverse impacts on EFH species and habitats.

Mitigation measures and alternative project configurations are described in the following sections.

6.2.1 Mitigation Measures

Currently known or anticipated mitigation measures proposed by BOEM and/or cooperating agencies that would avoid and minimize adverse impacts to EFH species and habitats are as follows:

- **Micrositing:** All WTG and OSS foundations would be positioned within micrositing windows to avoid impacts to large-grained complex and complex habitats to the extent practicable.
- **Anchoring plan:** BOEM would require Revolution Wind to develop an anchoring plan to avoid minimize adverse impacts on benthic habitat during project construction *and* from O&M activities throughout the life of the project. The anchoring plan would delineate sensitive large-grained complex and complex habitats, including eelgrass and kelp beds, and identify areas where anchoring activities are restricted.
- **Live and hard bottom impact monitoring**: The Lessee would develop and implement a monitoring plan for live and hard-bottom features that may be impacted by proposed activities. The monitoring plan would also include assessing the recovery time for these sensitive habitats. BOEM recommends that all monitoring reports classify substrate conditions following CMECS standards, including live bottoms (e.g., submerged aquatic vegetation and corals and topographic features. The plan would also include a means of recording observations of any increased coverage of invasive species in the impacted hard-bottom areas.
- **Live and hard bottom habitat mapping and avoidance:** Vessel operators would be provided with maps of sensitive hard-bottom habitat in OSW project area, as well as a proposed anchoring plan that would avoid or minimize impacts on the hard-bottom

habitat to the greatest extent practicable. These plans would be provided for all anchoring activity, including construction, maintenance, and decommissioning.

- **Intake screens on pump intakes for in-shore hydraulic dredges:** All hydraulic dredge intakes should be covered with a mesh screen or screening device that is properly installed and maintained to minimize potential for impingement or entrainment of fish species. The screening device on the dredge intake should prevent the passage of any material greater than 1.25” in diameter, with a maximum opening of 1.25”x 6”. Water intakes should be positioned at an appropriate depth to avoid or minimize the entrainment of eggs and larvae. Intake velocity should be limited to less than 0.5 ft/sec.

- **Scour and cable protection:** To the extent technically and economically feasible, the Lessee must ensure that all materials used for scour and cable protection consist of natural or engineered stone that does not inhibit epibenthic growth. The materials selected for protective purposes should mirror the natural environment and provide similar habitat functions.

- **Post-installation cable monitoring:** Revolution Wind would be required to inspect all cables after construction is completed to document exact location, burial depth, and post-installation benthic habitat conditions. Inspections would be completed within 6 months of project commissioning, annually for the first three years following construction, and as needed following major storm events. Monitoring reports would be submitted to BOEM within 45 days of survey completion.

- **Sound field verification:** Revolution Wind will develop and submit an acoustic monitoring and sound field verification plan to BOEM, USACE, and NMFS for review and written approval at least 90 days prior to initiating underwater noise producing construction activities.

- **Passive acoustic monitoring (PAM):** Revolution wind will prepare a passive acoustic monitoring (PAM) plan to record ambient noise and marine mammal and fish vocalizations within the Lease Area. This plan will include the deployment of moored or autonomous PAM devices capable of detecting the vocalizations of spawning Atlantic cod and, if necessary, other fish species as identified through coordination with cooperating agencies. Acoustic monitoring will be implemented prior to and throughout the construction period and will continue for at least 3 calendar years of Project operations after construction is complete. The archival recorders on these devices will, at minimum, have the capability to detect and store acoustic data on anthropogenic noise sources (such as vessel noise, pile driving, and WTG operation), marine mammals, and Atlantic cod vocalizations. Underwater acoustic monitoring will use standardized measurement methods and data processing and visualization metrics developed for the Atlantic Deepwater Ecosystem

Observatory Network for the U.S. Mid- and South Atlantic OCS (see https://adeon.unh.edu) and accepted industry best practices for regional monitoring. At least three PAM buoys will be independently deployed within or bordering the Lease Area, or one or more buoys will be deployed in coordination with other acoustic monitoring efforts in the RI and MA lease areas.

- **Pile driving restrictions:** BOEM would restrict pile driving from January through April, with addition of December with contingencies. Revolution Wind would be required to develop an adaptive acoustic monitoring plan for spawning Atlantic cod from November through March, including restrictions on Project activities if Atlantic cod aggregations indicative of spawning are detected.

- **Atlantic cod spawning monitoring plan:** At least 90 days prior to inter-array cable installation (e.g., boulder relocation, pre-cut trenching, cable crossing installation, cable lay and burial) and foundation site preparation (e.g., scour protection installation), BOEM would require the Lessee to provide DOI with a plan to monitor for Atlantic cod aggregations that are indicative of spawning behavior during the above-listed activities between November 1 and March 30 of each year (Plan). The objective of the Plan is to detect Atlantic cod aggregations and avoid or minimize the above-listed activities in any area with aggregations of Atlantic cod indicative of spawning behavior, as technically and economically feasible. The Lessee must include in the Plan details on detection thresholds (e.g., density and location) of spawning Atlantic cod aggregations that would trigger the adaptive management of activities described in this paragraph, including any restrictions on activities in any area with aggregations of Atlantic cod indicative of spawning behavior, and analysis of technical and/or economic infeasibility.

This list of mitigation measures is subject to change following the completion of cooperating agency review. The proposed measures may be refined, and additional measures may be included in the final set of mitigation measures required for the project.

6.2.2 Alternative Project Configurations that Could Avoid or Minimize Adverse Impacts to EFH

This section describes changes in the extent of impacts to EFH that would result under different RWF configurations considered in the FEIS. The alternatives considered in the FEIS are as follows:

- **Alternative A:** The no action alternative.

- Alternative B: The project design envelope presented in the COP, comprising 100 WTGs, 2 OSSs, the indicative IAC and OSS-link layout, and the RWEC. This is the Proposed Action considered in the FEIS.

- **Alternative C:** Also referred to as the Habitat Alternative, Alternative C considers two configurations designed to avoid and minimize impacts to large-grained complex and complex benthic habitats within the Lease Area by eliminating selected WTG foundation sites, with emphasis on habitats potentially used by Atlantic cod for spawning.

- **Alternative D:** Also referred to as the Transit Alternative. This alternative considers seven configurations that remove selected WTG foundations from the periphery of the Lease Area to reduce impacts on vessel transit corridors.

- **Alternative E:** Also referred to as the Viewshed Alternative. This alternative considers two configurations that would remove selected WTG foundations, primarily from Zone RWF 4, to minimize impacts on culturally important visual resources.

- **Alternative F:** This alternative considers the potential use of higher-capacity WTGs up to 14 MW. Alternative F would be implemented using one of the configurations described for Alternatives C-E and would support the purpose and need for the project using the configurations having a minimum feasible number of turbines.

- **Alternative G:** FEIS alternative configurations: This alternative considers three configurations comprising 65 WTG foundations sited on the 79 suitable foundation sites considered in this EFH assessment, 2 OSSs, indicative IAC layouts for each configuration, and the indicative RWEC and OSS-link cable layouts.

If the No Action Alternative were chosen, none of the impacts to habitats and associated EFH and prey species described in Section 3 would occur. This would avoid impacts to specific EFH species and habitats of concern. For example, habitat for spawning cod would remain undisturbed (e.g., no boulder clearance would occur) and there would be no potential disturbances to spawning cod aggregations from construction-related activities. Habitat for the southern population of red hake, which includes the Lease Area and RWEC corridor, would remain undisturbed. However, ongoing commercial and recreational fishing activity in these areas would continue to occur. These activities would continue to result in direct and indirect impacts to these EFH species and their habitats.

Alternative B would increase the total extent of impacts to EFH and increase the duration of construction related impacts compared to the Proposed Action. Depending on the specific configuration selected, Alternatives C, D, and E would increase or decrease impacts to EFH compared to the Proposed Action.

6.2.2.1 Alternative B – FEIS Proposed Action

Alternative B, the Proposed Action in the FEIS, is the project design envelope presented in the COP (VHB 2022). Alternative B comprises the full development of all 100 proposed WTG locations, A 155.1-mile IAC network, 2 OSSs, the OSS-link cable, and the RWEC. The proposed configuration of Alternative B is displayed in Figure 6.1. The projected extent of construction-related and long-term habitat alteration impacts to benthic habitat from the IAC and the distribution of those impacts under Alternative B compared to those resulting from the Proposed Action are presented in Table 6.2. The comparable extent of habitat impacts from the construction and long-term presence of the WTG and OSS foundations and associated scour protection are presented by benthic habitat type in Table 6.3.

As shown, under this alternative all 8 and all 40 potential WTG locations in RWF zones 1 and 2 would be developed, respectively, versus the 7 and 31 under the Proposed Action. Alternative B would result in the most extensive impacts to known and potential Atlantic cod spawning habitat based on the observed distribution of spawning activity (Figure 6.1). Alternative B would increase the total acreage of short-term and long-term to permanent impacts to benthic habitat relative to the Proposed Action, and the distribution of those impacts would be weighted more heavily towards large-grained complex habitat.

Table 6.2. 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 under the Proposed Action and Proposed Configurations for the Habitat Alternative.

Alternative	Maximum Construction Disturbance Footprint (acres)*	Large-Grained Complex (%)	Complex (%)	Soft Bottom (%)
Proposed Action	4,291	6.7%	25.9%	67.4%
Alternative B	5,247	14.9%	27.3%	57.8%

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

Table 6.3. Acres of Benthic Habitat Disturbance from Wind Turbine Generator and Offshore Substation Foundation Installation and Proportional Distribution of Impacts by Benthic Habitat Type for the Proposed Action and Proposed Configurations of the Habitat Alternative.

Alternative	Seafloor Preparation Footprint (acres)*	Monopile Foundations and Scour Protection (acres)†	Large-Grained Complex	Complex	Soft Bottom
Proposed Action	583	64.7	5.4%	30.5%	64.1%
Alternative B	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.

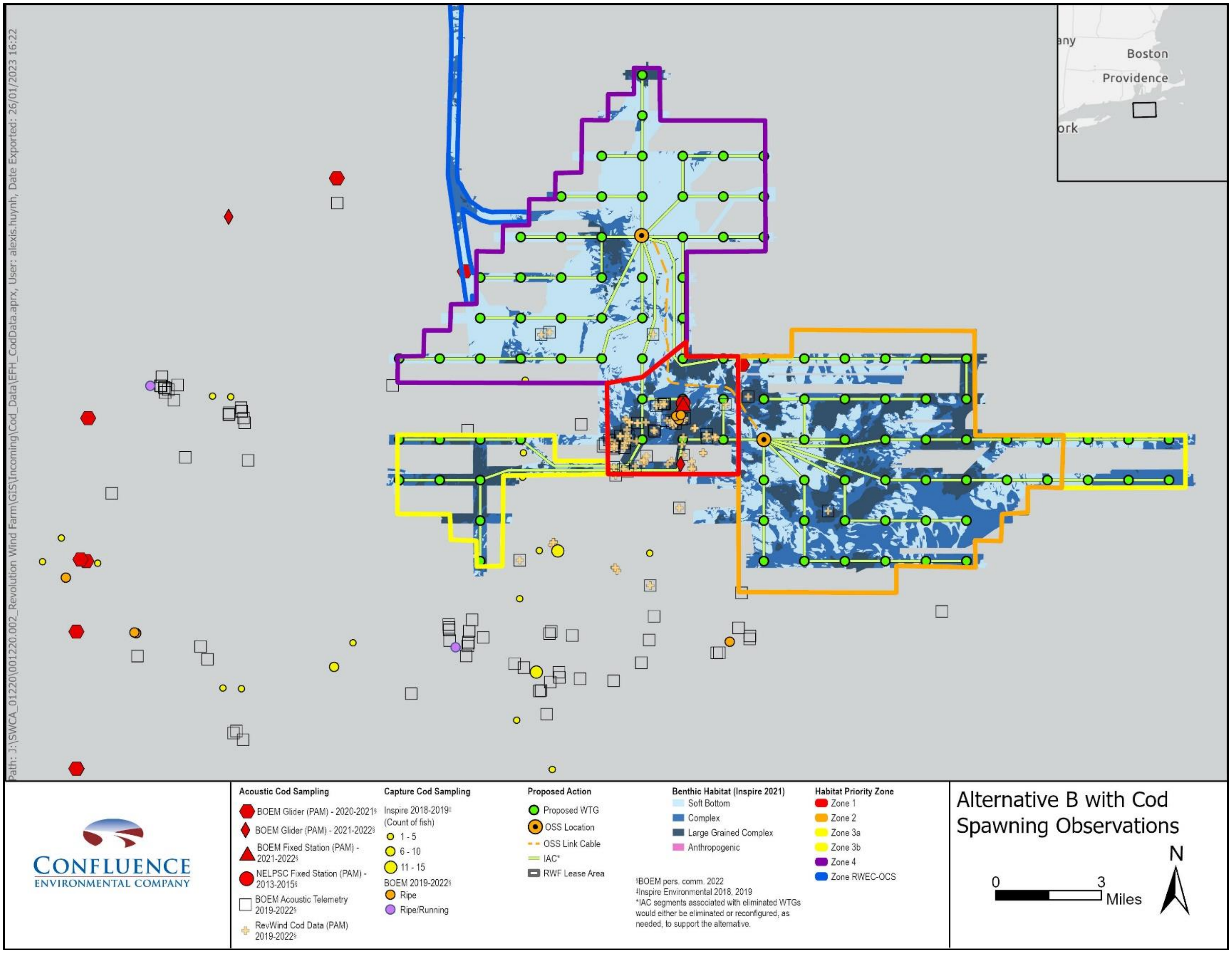

Figure 6.1. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative B.

6.2.2.2 Alternative C – Habitat Alternative

Alternative C (Habitat Impact Minimization Alternative), hereafter referred to as the Habitat Alternative, was developed in coordination with cooperating agencies to reduce impacts to complex fisheries habitats considered particularly vulnerable to permanent and long-term impacts, such as habitats associated with Atlantic cod spawning. The placement of WTGs would be supported by location-specific benthic and habitat characterizations conducted in close coordination with NMFS. Two alternative configurations are being considered:

- **Alternative C1:** Under this alternative configuration, up to 65 WTGs would be approved, 35 foundations and associated IAC segments would be eliminated.
- **Alternative C2:** Under this alternative configuration, up to 64 WTGs would be approved, 64 foundations and associated IAC segments would be eliminated.

Each configuration retains at least five “spare” WTG locations to allow for flexibility during installation.

Figures 6.2 and 6.3 display the proposed WTG locations that would be eliminated under Alternatives C1 and C2, respectively. Each figure displays benthic habitat composition at the removed and retained WTG foundation locations. The general distribution of observed Atlantic cod spawning activity in the Lease Area and vicinity is presented on each figure. Figures 6.4 and 6.5 display the proposed configurations for Alternatives C1 and C2, respectively, overlaid with multibeam backscatter and boulder density data. The projected extent of construction-related and long-term habitat alteration impacts to benthic habitat from the IAC and the distribution of those impacts under the Habitat Alternative compared to those resulting from the Proposed Action are presented in Table 6.4. The comparable extent of habitat impacts from the construction and long-term presence of the WTG and OSS foundations and associated scour protection are presented by benthic habitat type in Table 6.5.

As shown, Alternatives C1 and C2 would site no WTG foundations in Zone RWF 1 and 12 or 11 foundations, respectively, in Zone RWF 2. By comparison, the Proposed Action would site 7 WTG foundations in RWF zone 1 and 30 in RWF zone 2. The two proposed configurations of Alternative C would reduce the total extent of benthic habitat impacts relative to the Proposed Action but would maintain a broadly similar distribution of impacts by habitat type. However, the distribution of impacts by habitat zone varies between alternatives, with the Proposed Action producing more impacts in high priority habitats. Specifically, both configurations of Alternative C reduce the total acres of benthic habitat impacts in RWF zones 1 and 2 relative to the Proposed Action, and specifically avoid areas with high boulder density and strong backscatter return. As such, Alternative C would likely lead to less extensive impacts on identified cod spawning habitat compared to the Proposed Action.

Table 6.4. 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 under the Proposed Action and Proposed Configurations for the Habitat Alternative.

Alternative	Maximum Construction Disturbance Footprint (acres)*	Large-Grained Complex (%)	Complex (%)	Soft Bottom (%)
Proposed Action	4,291	6.7%	25.9%	67.4%
C1	3,597	6.2%	24.4%	69.4%
C2	3,542	7.4%	24.9%	67.7%

* Estimated maximum extent of seafloor disturbance, including overlapping impacts occurring at different points in time. IAC configurations for Alternatives C through E have not been developed. Therefore, the benthic habitat impacts presented for Alternative C are based on a hypothetical configuration that underestimates the likely extent and distribution of benthic habitat impacts and are presented here for comparison to impacts from Alternatives D and E. IAC impacts for these alternatives are based on the same assumption.

Table 6.5. Acres of Benthic Habitat Disturbance from Wind Turbine Generator and Offshore Substation Foundation Installation and Proportional Distribution of Impacts by Benthic Habitat Type for the Proposed Action and Proposed Configurations of the Habitat Alternative.

Alternative	Seafloor Preparation Footprint (acres)*	Monopile Foundations and Scour Protection (acres)†	Large-Grained Complex	Complex	Soft Bottom
Proposed Action	583	64.7	5.4%	30.5%	64.1%
C1	482	53.5	9.7%	23.5%	66.8%
C2	475	52.7	11.7%	24.3%	64.0%

* 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.

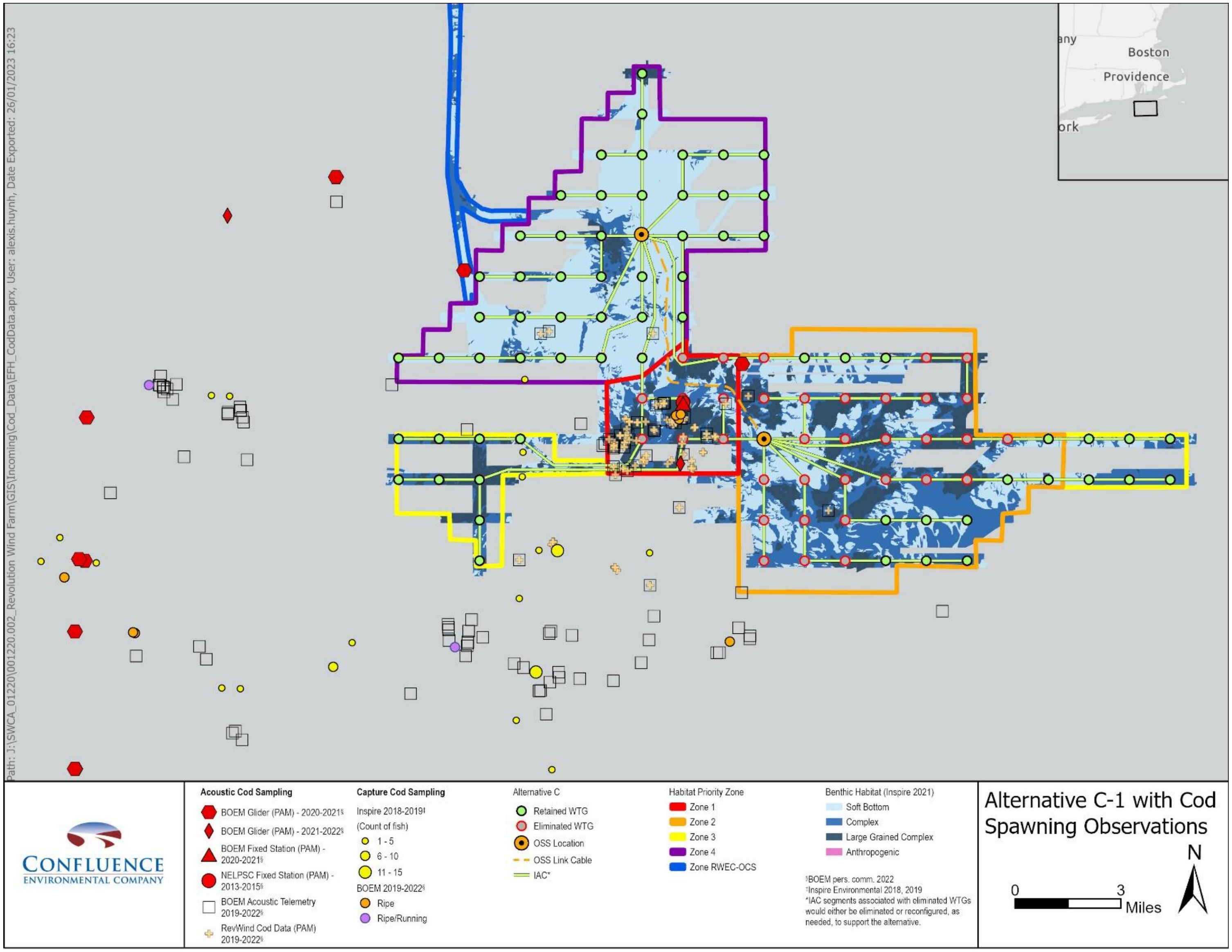

Figure 6.2. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative C1.

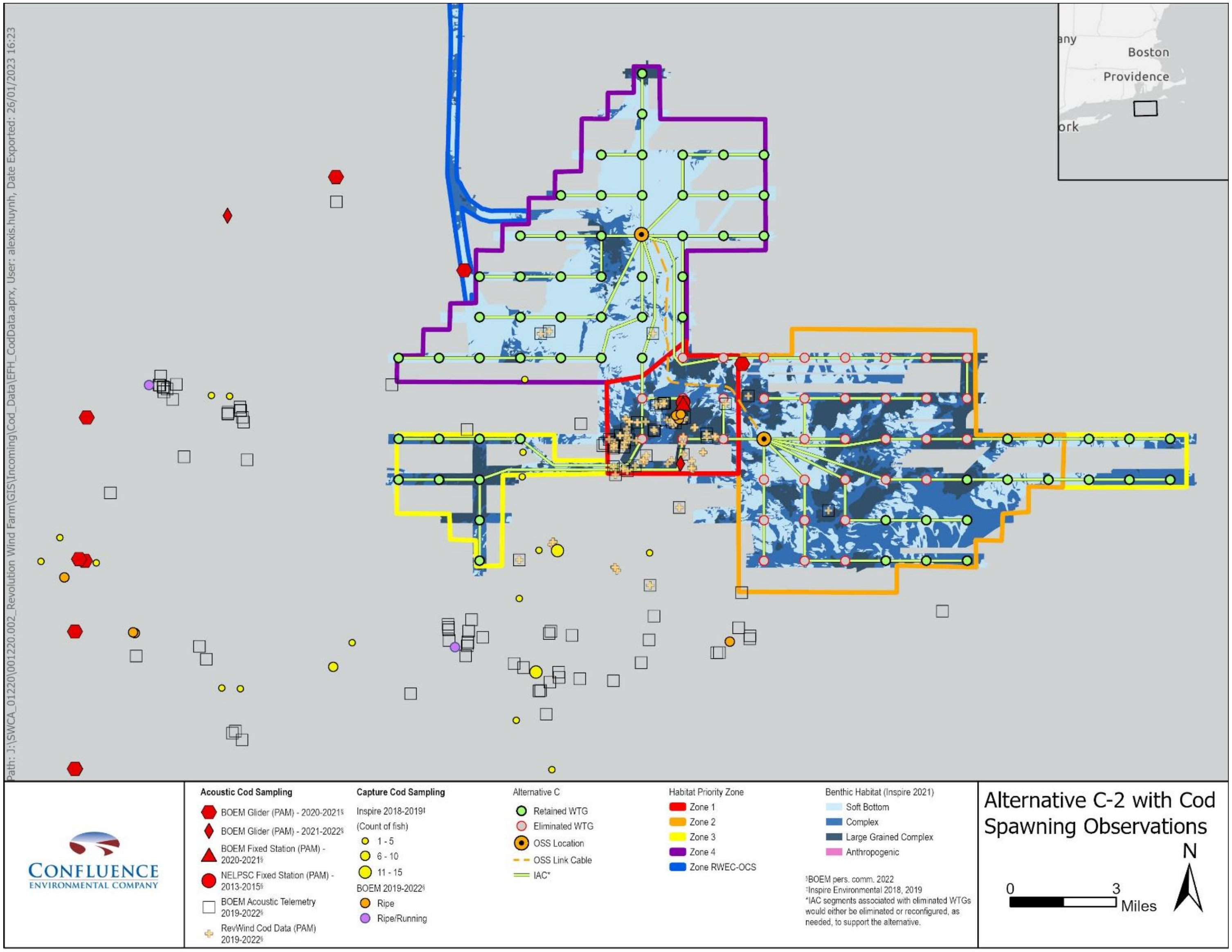

Figure 6.3. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative C2.

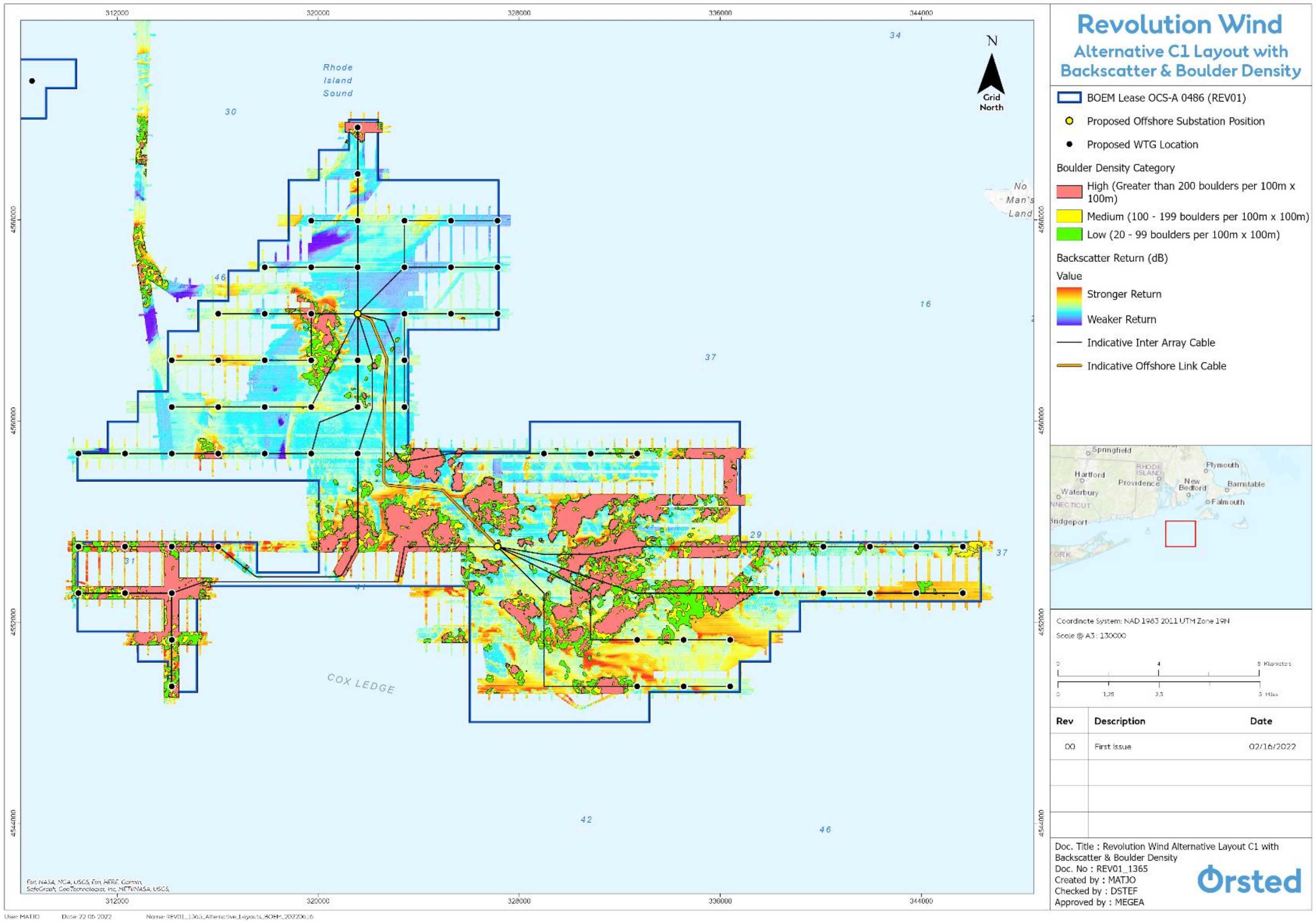

Figure 6.4. Alternative C1 Layout Overlaid with Backscatter and Boulder Density Data. Image courtesy of Orsted.

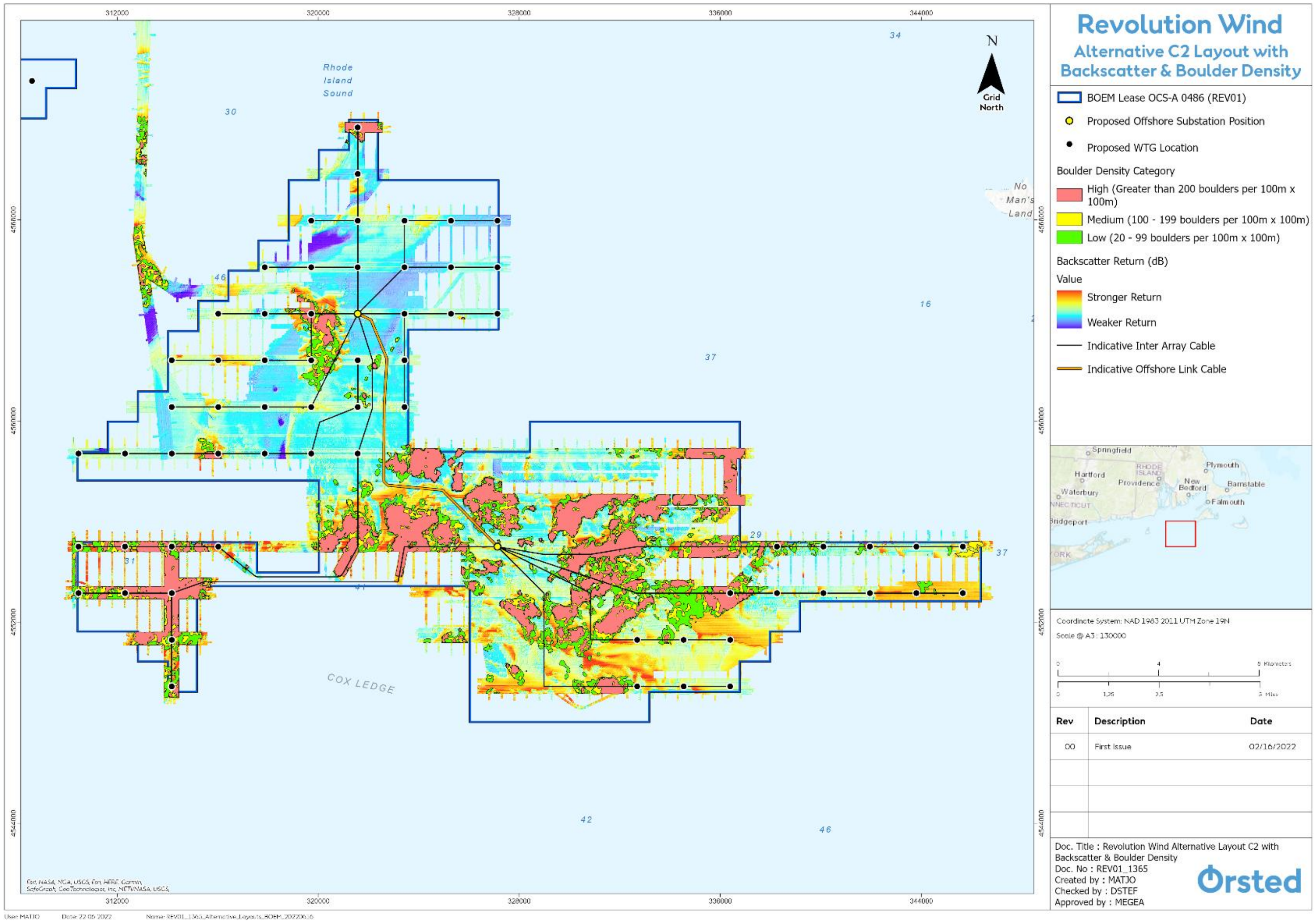

Figure 6.5. Alternative C2 Layout Overlaid with Backscatter and Boulder Density Data. Image courtesy of Orsted.

6.2.2.3 Alternative D – Transit Alternative

Alternative D (No Surface Occupancy in One or More Outermost Portions of the Project Area Alternative), hereafter referred to as the Transit Alternative, would eliminate selected blocks of WTG foundations from the Lease Area to reduce navigation risks and potential conflicts with other competing uses of the offshore environment. Seven alternative configurations were developed in collaboration with stakeholders. Under this alternative, BOEM could select one, all, or a combination of the following three alternatives to Alternative D. Seven alternative configurations are being considered:

- **Alternative D1:** Removal of up to seven WTGs and associated IAC segments.
- **Alternative D2:** Removal of up to eight WTGs and associated IAC segments.
- **Alternative D3:** Removal of up to seven WTGs and associated IAC segments.
- **Alternative D1+D2:** Removal of up to 15 WTGs and associated IAC segments.
- **Alternative D1+D3:** Removal of up to 14 WTGs and associated IAC segments.
- **Alternative D2+D3:** Removal of up to 15 WTGs and the associated IAC segments.
- **Alternative D1+D2+D3:** Removal of up to 22 WTGs and associated IAC segments.

The proposed WTG locations that would be eliminated under the above configurations are presented in Figures 6.6 to 6.12, respectively. Each figure displays benthic habitat composition at the removed and retained WTG foundation locations. The general distribution of observed Atlantic cod spawning activity in the Lease Area and vicinity is presented on each figure. The projected extent of construction-related and long-term habitat alteration impacts to benthic habitat from the IAC and the distribution of those impacts under Alterative D compared to those resulting from the Proposed Action are presented in Table 6.6. The comparable extent of habitat impacts from the construction and long-term presence of the WTG and OSS foundations and associated scour protection are presented by benthic habitat type in Table 6.7.

In terms of differences in impacts to large-grained complex and complex benthic habitat, the seven proposed configurations of Alternative D would increase the total extent of benthic habitat impacts to varying degrees relative to the Proposed Action. All Alternative D configurations would increase the extent of habitat impacts in RWF zone 1 and in the center of RWF zone 2, thereby increasing the potential adverse impacts on complex habitats used by spawning Atlantic cod relative to the Proposed Action.

Table 6.6. 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 under the Proposed Action and Proposed Configurations for the Transit Alternative

Alternative	Maximum Construction Disturbance Footprint (acres)*	Large-Grained Complex	Complex	Soft Bottom
Proposed Action	4,291	6.7%	25.9%	67.4%
D.1	4,885	15.2%	25.0%	59.7%
D.2	4,845	15.7%	26.1%	58.2%
D.3	4,885	15.3%	28.4%	56.3%
D.1.2	4,562	16.0%	23.7%	60.3%
D.1.D.3	4,603	15.6%	26.0%	58.3%
D.2.3	4,562	16.1%	27.3%	56.7%
D.1.2.3	4,280	16.5%	24.7%	58.8%

* Estimated maximum extent of seafloor disturbance, accounting for overlapping impacts occurring at different points in time. IAC configurations for Alternatives C through E have not been developed. Therefore, the benthic habitat impacts presented for Alternative C are based on a hypothetical configuration that underestimates the likely extent and distribution of benthic habitat impacts and are presented here for comparison to impacts from Alternatives C and E. IAC impacts for these alternatives are based on the same assumption.

Table 6.7. Acres of Benthic Habitat Disturbance from Wind Turbine Generator and Offshore Substation Foundation Installation and Proportional Distribution of Impacts by Habitat Type for the Proposed Action and Proposed Configurations of the Transit Alternative

Alternative	Seafloor Preparation Footprint (acres)*	Monopile Foundations and Scour Protection (acres)†	Large-Grained Complex (%)	Complex (%)	Soft Bottom (%)
Proposed Action	583	64.7	5.4%	30.5%	64.1%
D.1	684	75.8	20.0%	25.9%	54.1%
D.2	677	75.0	20.2%	28.4%	51.4%
D.3	684	75.8	19.7%	31.3%	49.0%
D.1.2	626	69.5	21.4%	24.1%	54.4%
D.1.D.3	634	70.3	20.9%	27.3%	51.8%
D.2.3	626	69.5	21.1%	30.1%	48.8%
D.1.2.3	576	63.9	22.5%	25.6%	52.0%

* 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. Monopile and scour protection impacts all 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.

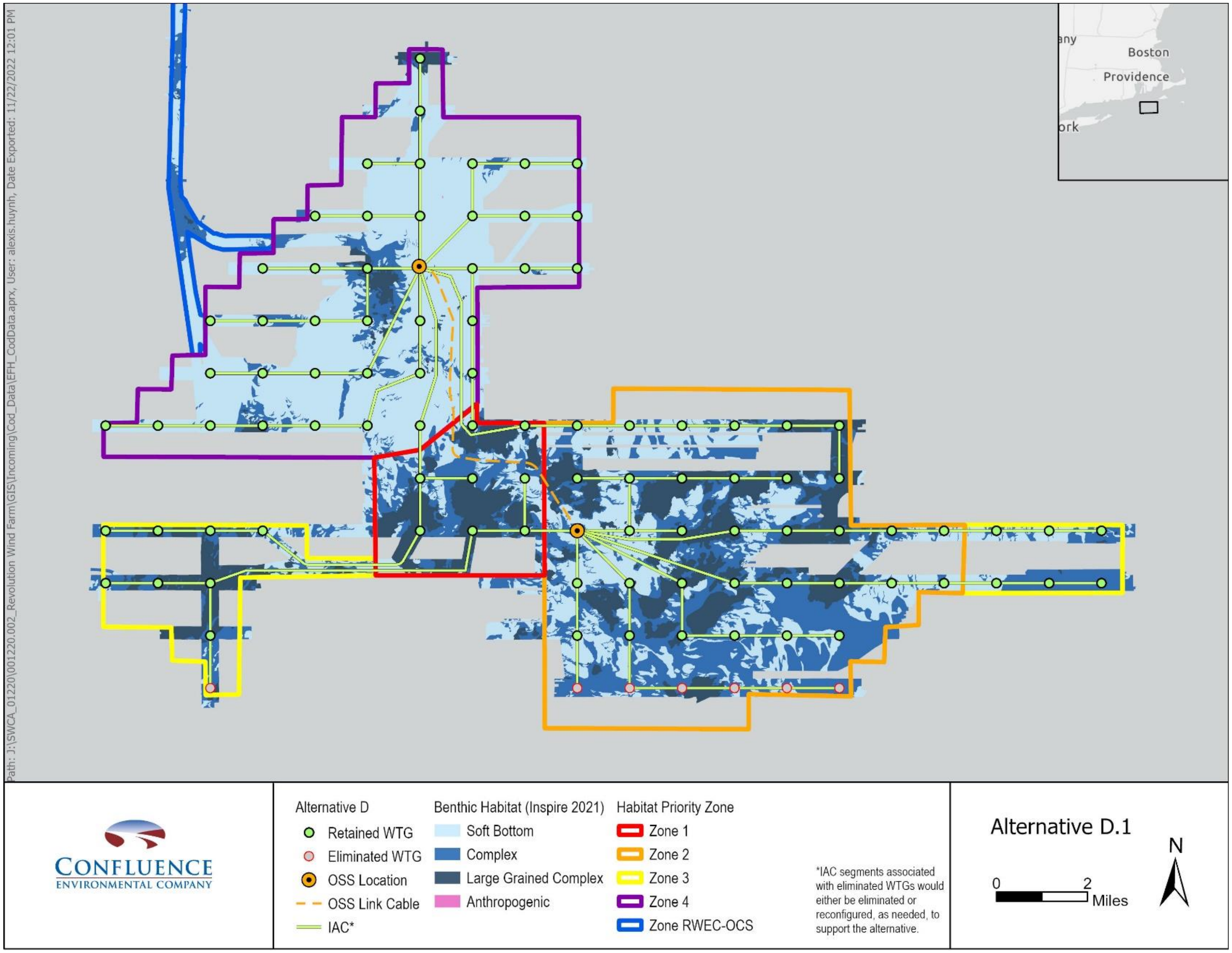

Figure 6.6. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative D1.

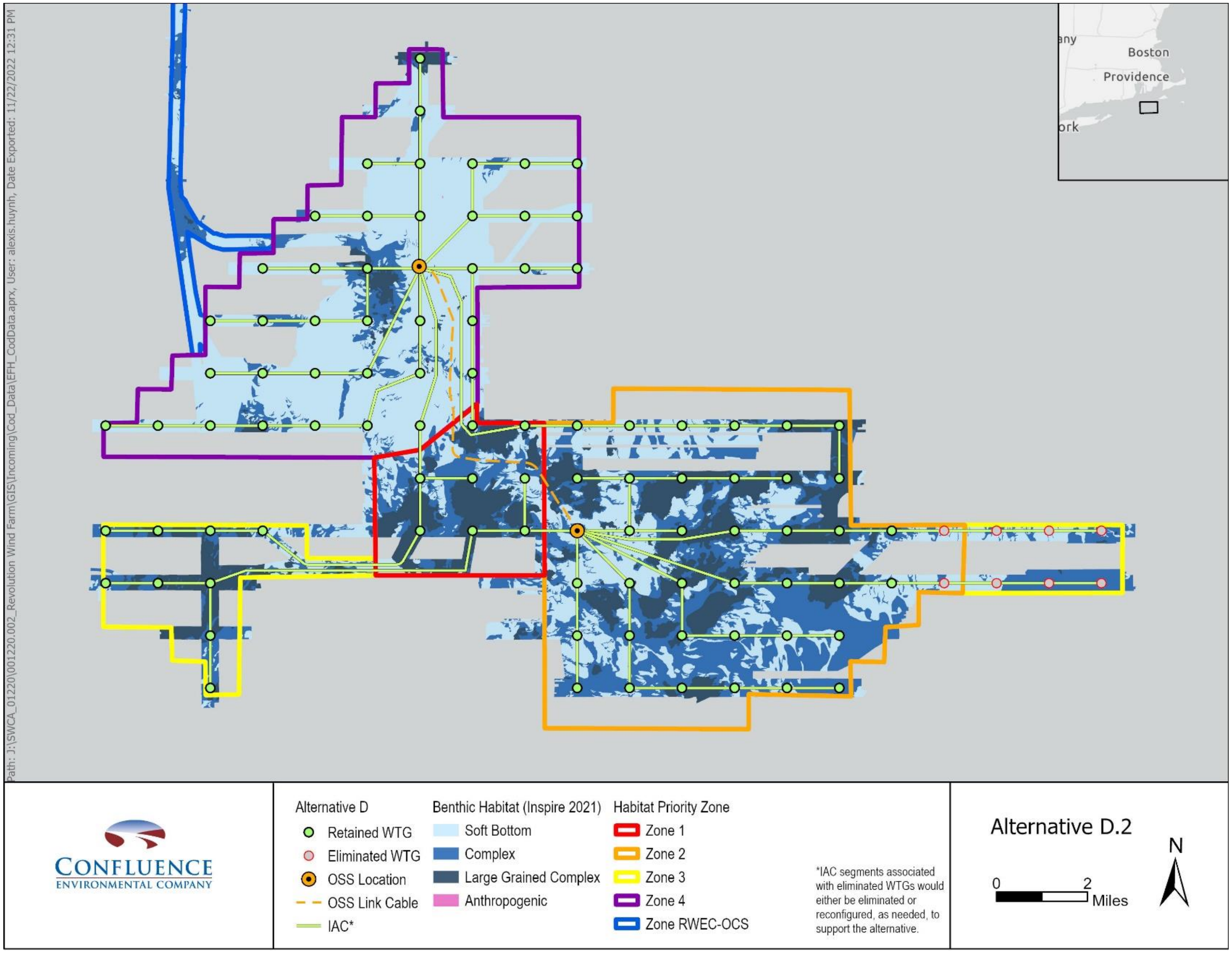

Figure 6.7. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative D2.

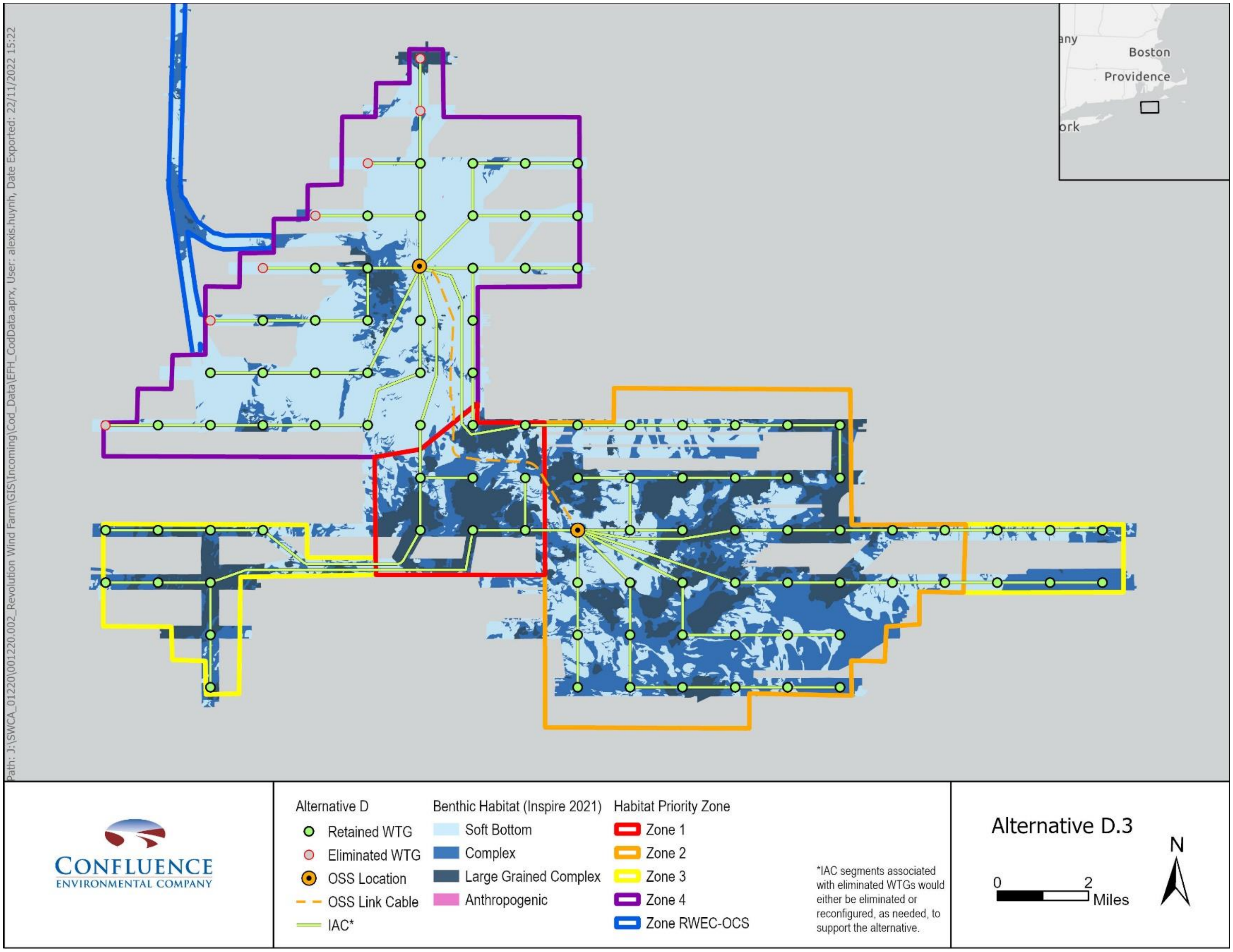

Figure 6.8. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative D3.

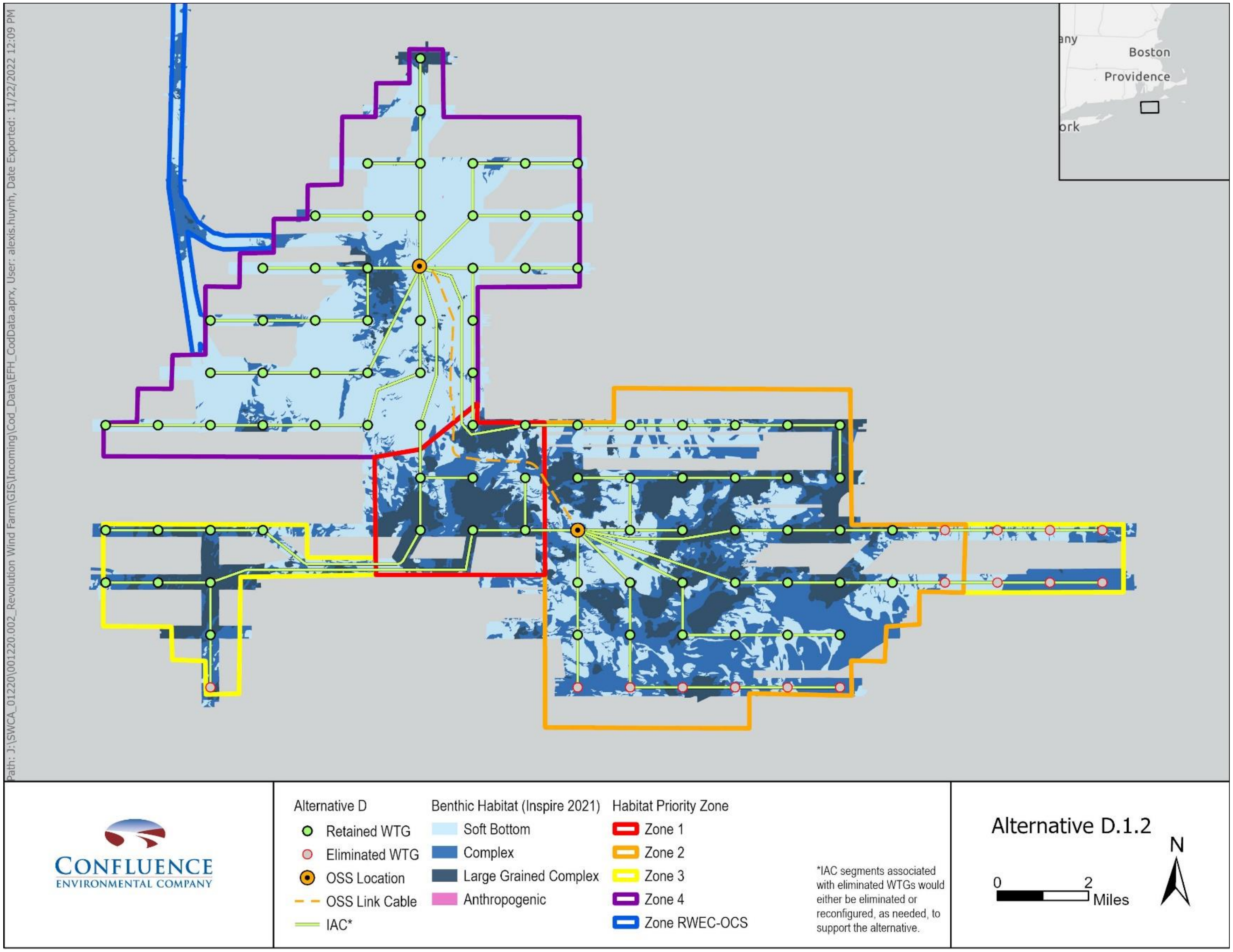

Figure 6.9. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative D1+D2.

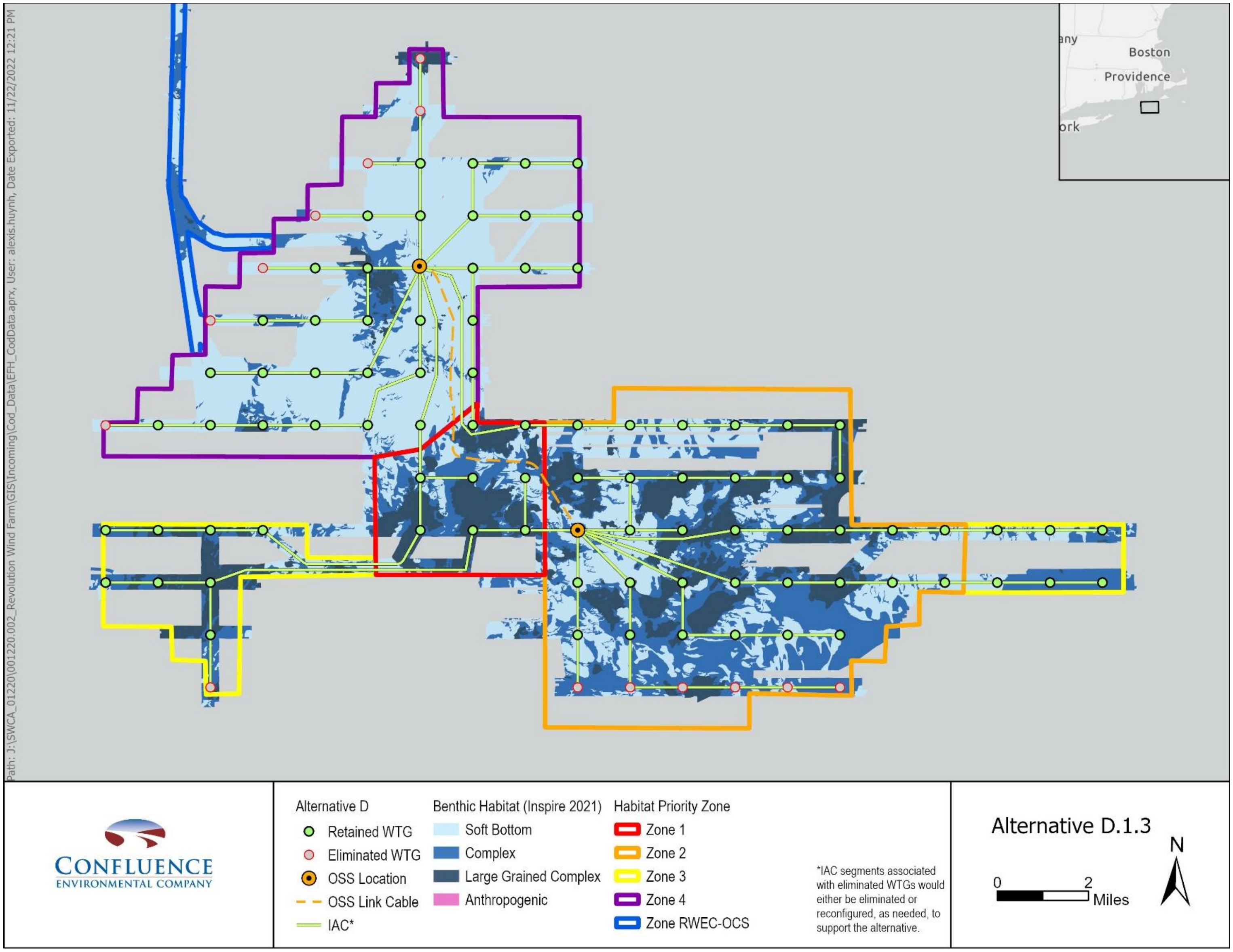

Figure 6.10. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative D1+D3.

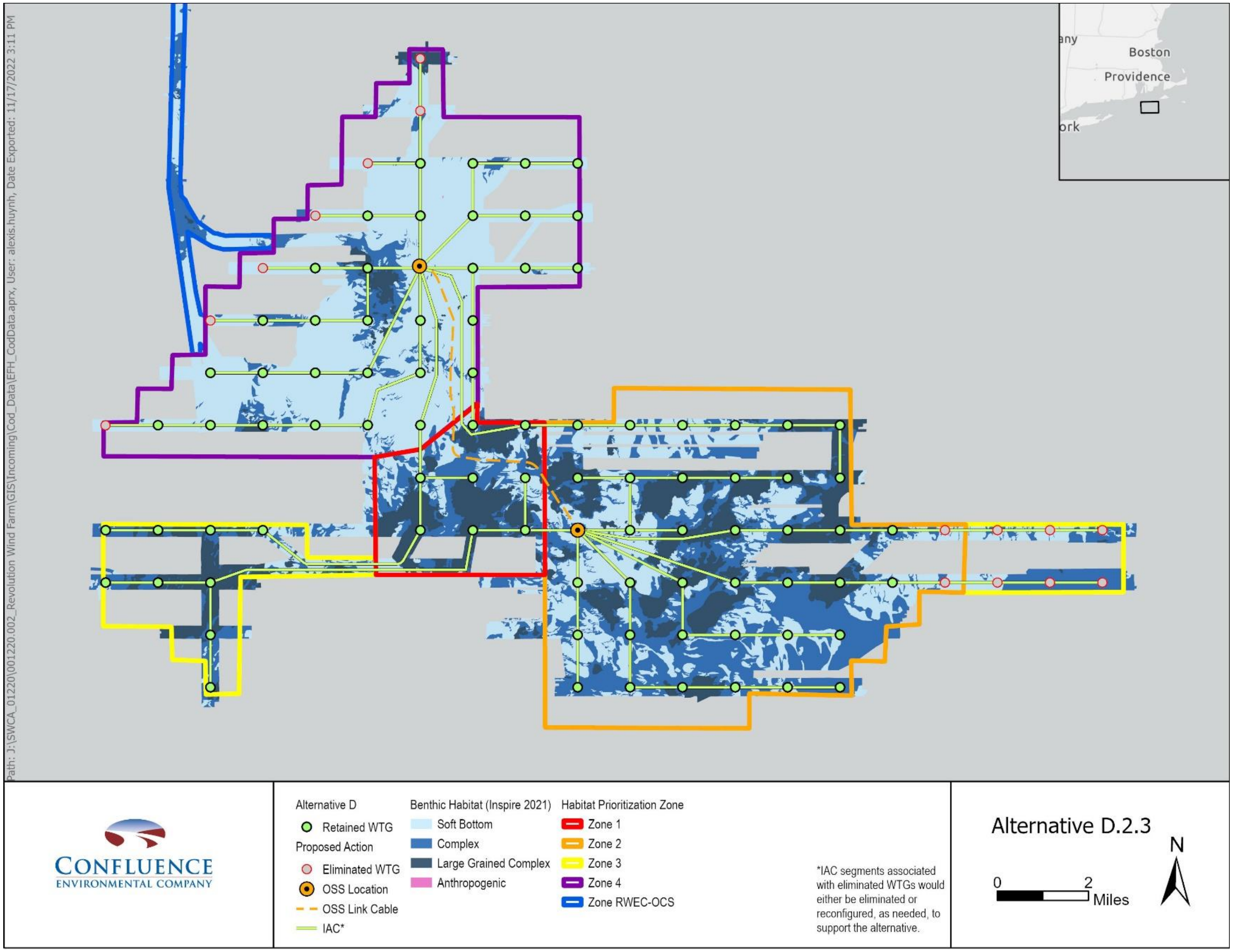

Figure 6.11. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative D2+D3.

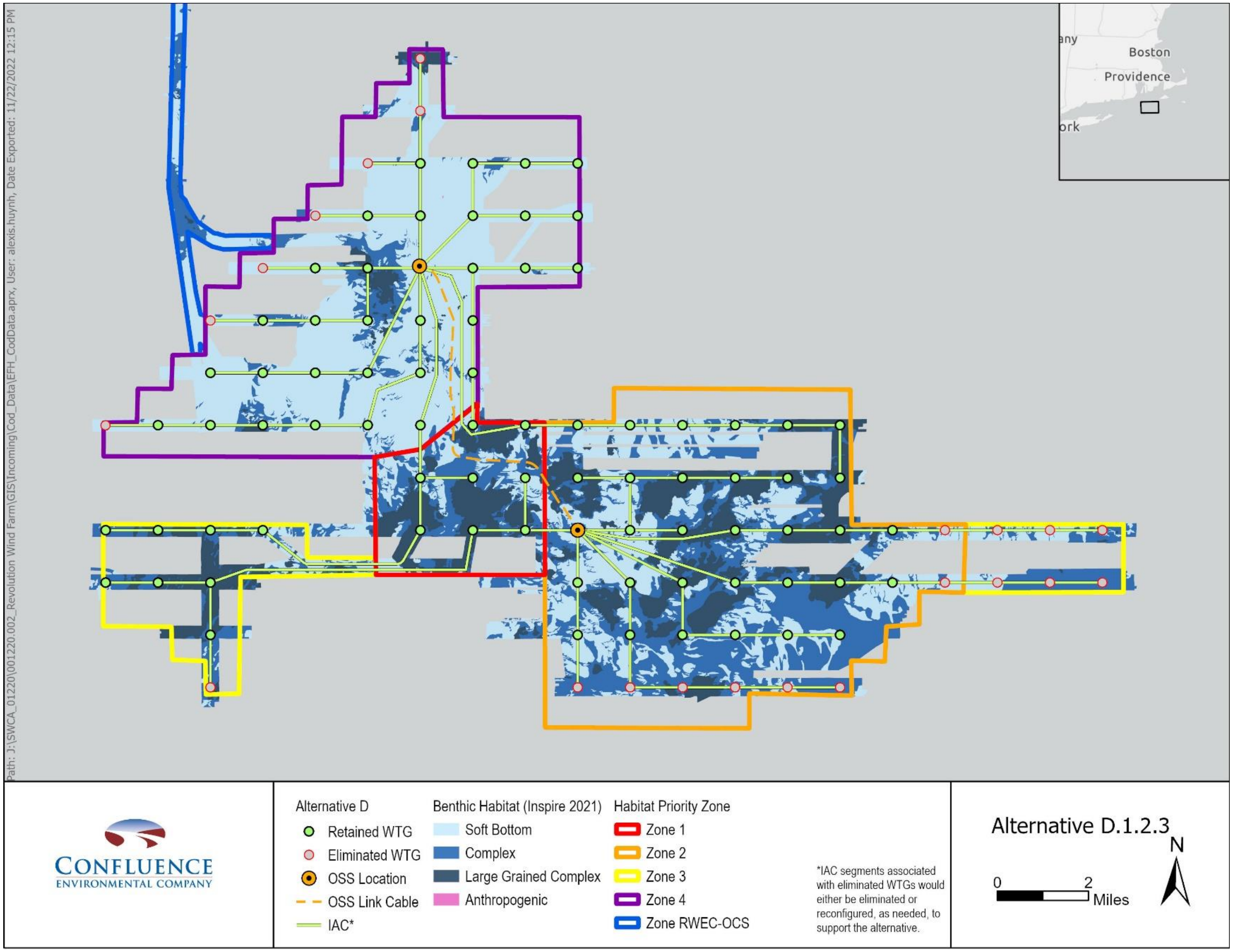

Figure 6.12. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative D1+D2+D3.

6.2.2.4 Alternative E – Viewshed Alternative

Alternative E (Reduction of Surface Occupancy to Reduce Impacts to Culturally Significant Resources Alternative), hereafter referred to as the Viewshed Alternative, would reduce the visual impacts on culturally important resources on Martha's Vineyard and other National Historic Landmarks in Rhode Island and Massachusetts. BOEM could select one of the following alternative configurations:

- **Alternative E1:** This configuration would remove 36 WTG locations and associated IAC segments to reduce visual impacts to culturally important viewsheds and resources on Martha's Vineyard. Under this alternative, up to 64 WTG positions would be approved.

- **Alternative E2:** This configuration would remove 19 WTG locations and associated IAC segments to reduce visual impacts to culturally important viewsheds and resources. Under this alternative, up to 81 WTG positions would be approved.

The proposed WTG locations that would be eliminated under the above configurations are presented in Figures 6.13 and 6.14, respectively. Each figure displays benthic habitat composition at the removed and retained WTG foundation locations. The projected extent of construction-related and long-term habitat alteration impacts to benthic habitat from anchoring and cable installation and the distribution of those impacts under Alterative E compared to those resulting from the Proposed Action are presented in Table 6.8. The comparable extent of habitat impacts from the construction and long-term presence of the WTG and OSS foundations and scour and cable protection are presented by benthic habitat type in Table 6.9.

As shown, the two proposed configurations of Alternative E would reduce the overall RWF footprint and total extent of benthic habitat impacts relative to the Proposed Action. However, the reduction in impacts would be limited to primarily soft bottom habitats in RWF zone 4 under both alternative configurations. Both configurations would increase the total impact acreage in complex and large-grained complex habitats and the proportional distribution of impacts in those habitat types. Alternative E2 would develop all 8 available WTG foundation locations in RWF zone 1 and all 30 locations in RWF zone 2, producing the maximum extent of benthic habitat impacts in these habitat zones. As such, while this alternative would reduce impacts to those EFH species that rely on soft bottom habitats, both configurations would increase the extent of potential adverse impacts to EFH for species that rely on large-grained complex and complex benthic habitat compared to the Proposed Action.

Table 6.8. 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 under the Proposed Action and Proposed Configurations for the Viewshed Alternative

Alternative	Maximum Construction Disturbance Footprint (acres)*	Large-Grained Complex	Complex	Soft Bottom
Proposed Action	4,291	6.7%	25.9%	67.4%
E1	4,572	16.3%	33.0%	50.7%
E2	5,365	16.5%	30.6%	52.9%

* Estimated maximum extent of seafloor disturbance, accounting for overlapping impacts occurring at different points in time. IAC configurations for Alternatives C through E have not been developed. Therefore, the benthic habitat impacts presented for Alternative C are based on a hypothetical configuration that underestimates the likely extent and distribution of benthic habitat impacts and are presented here for comparison to impacts from Alternatives C and D.

Table 6.9. Acres of Benthic Habitat Disturbance from Wind Turbine Generator and Offshore Substation Foundation Installation and Proportional Distribution of Impacts by Habitat Type for the Proposed Action and Proposed Configurations of the Viewshed Alternative.

Alternative	Seafloor Preparation Footprint (acres)*	Monopile Foundations and Scour Protection (acres)†	Large-Grained Complex	Complex	Soft Bottom
Proposed Action	583	64.7	5.4%	30.5%	64.1%
E1	475	52.7	22.5%	39.5%	38.0%
E2	598	66.3	21.6%	34.6%	43.7%

* 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.

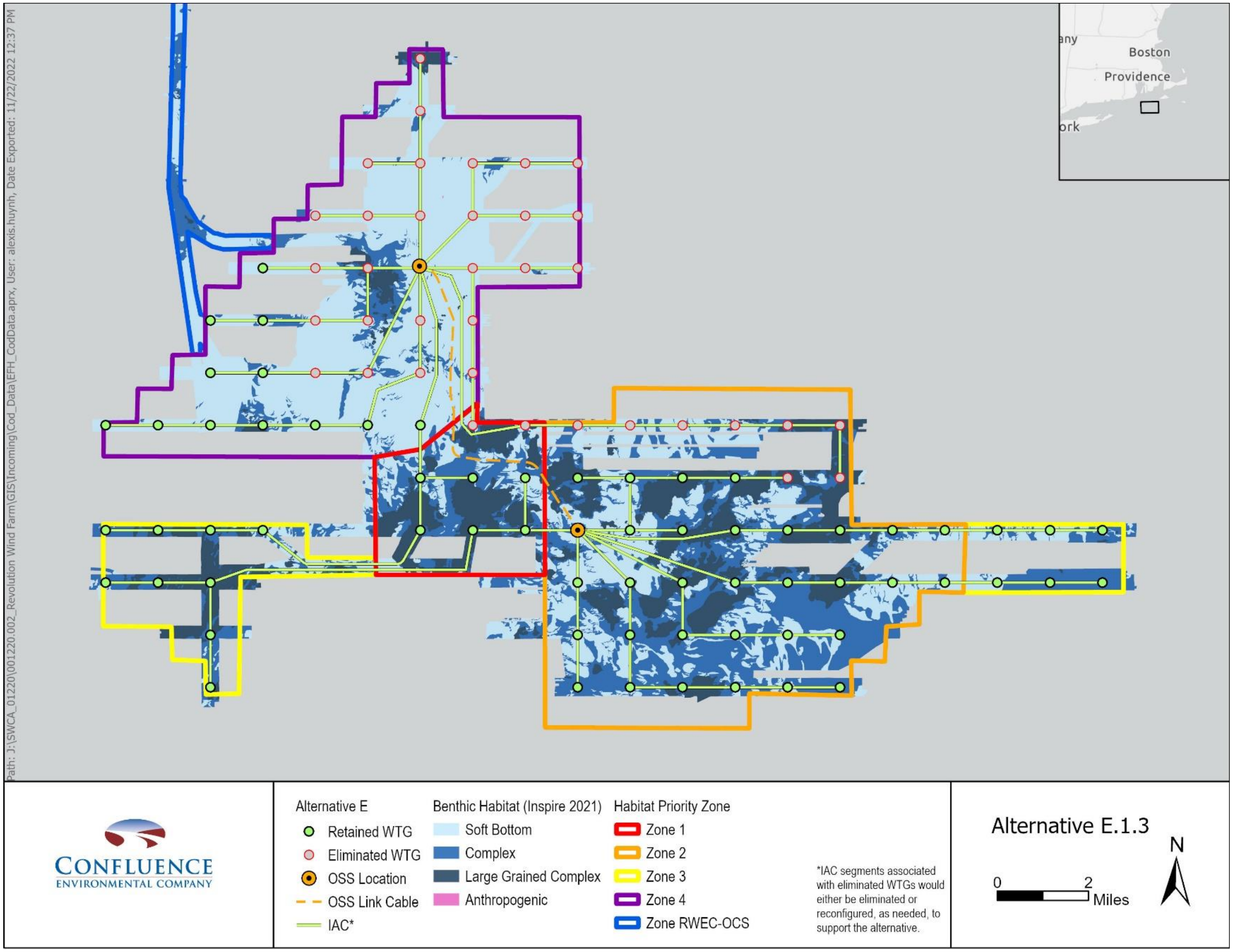

Figure 6.13. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative E1.

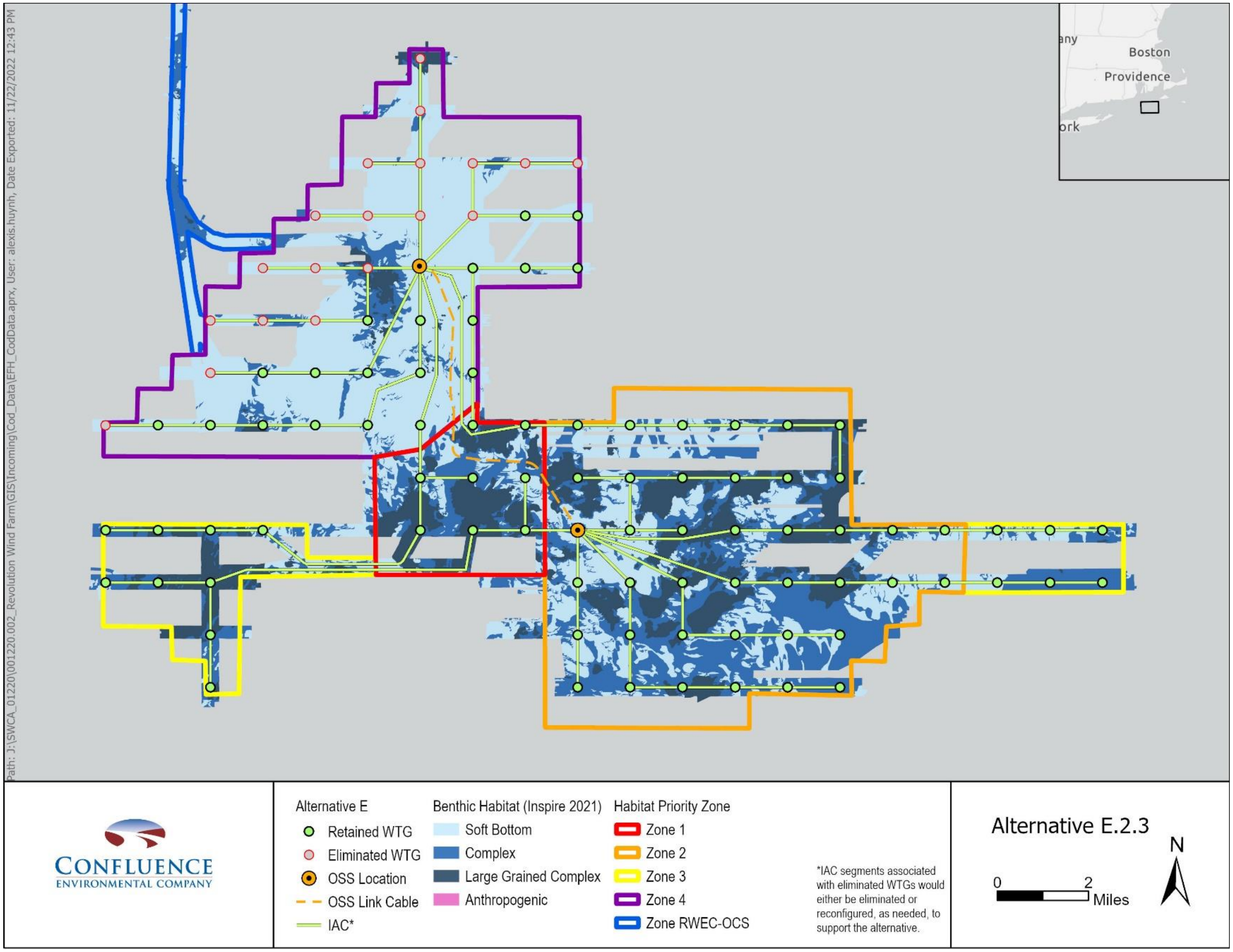

Figure 6.14. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative E2.

6.2.2.5 Alternative F – FEIS Alternative

No specific WTG configurations have been proposed for Alternative F. Alternative F would be implemented using one of the configurations described for Alternatives C-G and would employ the same WTG and OSS foundation designs as the Proposed Action. As such, the construction and operational impacts would be similar to those described for the Proposed Action, varying in extent consistent with the alternative configurations described below. For example, if Alternative C were combined with Alternative F, even fewer WTGs would be cited in habitats that may support cod spawning (e.g., complex and large-grained complex). This may reduce potential effects to this species and their reproduction. Similar reduction of potential impacts to cod and cod spawning may be realized if Alternative F were combined with Alternative G, which also focuses removal of WTGs in complex and large-grained complex habitats in the southern portion of the lease area. As there is no specific layout for Alternative F, the reduction of potential impacts to benthic habitat types cannot be quantified. However, if combined with Alternatives C or G there would be 8 to 9 fewer WTGs installed and fewer corresponding acres of benthic habitat disturbed through construction.

6.2.2.6 Alternative G- FEIS Alternative Configurations

FEIS Alternative G considers three alternative configurations designed to reduce impacts to visual resources and benthic habitat. Alternative G comprises the installation of 65 WTGs in the 79 WTG locations considered in the Proposed Action, 2 OSSs, indicative layouts for the IAC and OSS-link cables, and the RWEC. The WTGs would have a nameplate capacity of 8-12 MW. This flexibility in design could allow for further refinement for visual resources impact reduction on Martha's Vineyard and Rhode Island, and/or avoidance and minimization of habitat impacts in RWF zone 1.

- **Alternative layout G1:** Relocates 2 WTGs from RWF zone 1 to RWF zone 4 to reduce impacts to EFH. Under this alternative, 65 WTGs installed in the positions identified in layout G1, would be approved.

- **Alternative layout G2:** Relocates 2 WTGs from RWF zone 4 to reduce culturally important viewshed impacts. Under this alternative, 65 WTGs installed in the positions identified in layout G2 would be approved.

- **Alternative layout G3:** Similar to Alternative G2, relocates 2 WTGs from RWF zone 4 to reduce culturally important viewshed impacts. Under this alternative, 65 WTGs installed in the positions identified in layout G2 would be approved.

Each configuration retains 14 "spare" WTG locations to allow for flexibility during installation.

The 65 WTG locations under three proposed Alternative G configurations are presented in Figures 6.15, 6.16, and 6.17, respectively. Each figure displays the proposed, removed, and potential spare WTG locations by Lease Area habitat zone, and the distribution of observed Atlantic cod spawning activity in the Lease Area and vicinity.

The three proposed configurations of Alternative G would reduce the total extent of benthic habitat impacts relative to the Proposed Action. Alternative G would also change the distribution of impacts by benthic habitat type. The projected extent of construction-related and long-term habitat alteration from vessel anchoring and cable installation and the distribution of those impacts under Alterative G compared to those resulting from the Proposed Action are presented in Table 6.10. The comparable extent of habitat impacts from the construction and long-term presence of the WTG and OSS foundations and scour and cable protection are presented by benthic habitat type in Table 6.11.

As shown, Alternative G1 would remove 3 of the potential 7 and 1 of the potential 26 WTG foundations from habitat zones RWF 1 and RWF 2, respectively. Alternatives G2 and G3 are configured similarly and would each remove 1 potential WTG foundation from zone RWF 1 and 1 from zone RWF 2. As shown in Tables 6.10 and 6.11, respectively, the three configurations of Alternative G would reduce the seabed disturbance footprint from cable installation and vessel anchoring by over 470 acres and foundation installation by approximately 100 acres relative to the Proposed Action. Long-term to permanent habitat alteration from the presence of monopile foundations and scour protection would be reduced by approximately 18 acres. The proportion of foundation installation impacts in large-grained complex habitat would decrease from 5.4% under the Proposed Action to 1.1% to 1.2% under Alternative G (Table 6.11). The impacts to large-grained complex, complex, and soft bottom habitats from cable installation and WTG/OSS foundation installation are broadly similar between each configuration. However, Alternative G1 would result in slightly less extensive impacts to large-grained complex and complex habitats (1.1% and 29.1%, respectively) from WTG/OSS foundation installation than Alternatives G2 and G3 (1.2% and 32.1%). The bulk of this difference would result from the removal of 3 WTG foundations from zone RWF 1 under Alternative G1 versus 1 under Alternatives G2 and G3.

If implemented as shown, the three configurations of Alternative G would reduce the project footprint in zones RWF 1 and 2 relative to the Proposed Action. Alternative G1 would avoid and minimize overlap with areas documented to support Atlantic cod spawning in zone RWF 1 to a greater extent than Alternatives G2 and G3. All three alternative configurations would substantially reduce seabed impacts in large-grained complex and complex habitats in zone RWF 2 relative to the Proposed Action.

Table 6.10. 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 under the Proposed Action and Proposed Configurations for the Viewshed Alternative

Alternative	Maximum Construction Disturbance Footprint (acres)*	Large-Grained Complex	Complex	Soft Bottom	Uncategorized‡
Proposed Action	4,291	6.7%	25.9%	67.4%	--
G1	3,812	5.1%	29.0%	65.4%	0.5%
G2	3,803	5.2%	29.1%	65.3%	0.5%
G3	3.803	5.2%	29.0%	65.3%	0.5%

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

‡ IAC routing for FEIS Alternative G configurations includes portions of the MWA that have not been mapped for benthic habitat composition. These areas are classified as uncategorized.

Table 6.11. Acres of Benthic Habitat Disturbance from Wind Turbine Generator and Offshore Substation Foundation Installation and Proportional Distribution of Impacts by Habitat Type for the Proposed Action and Proposed Configurations of the Viewshed Alternative.

Alternative	Seafloor Preparation Footprint (acres)*	Monopile Foundations and Scour Protection (acres)†	Large-Grained Complex	Complex	Soft Bottom
Proposed Action	583	64.7	5.4%	30.5%	64.1%
G1	483	53.5	1.1%	29.1%	69.7%
G2	483	53.5	1.2%	32.1%	66.7%
G3	483	53.5	1.2%	32.1%	66.7%

* 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.

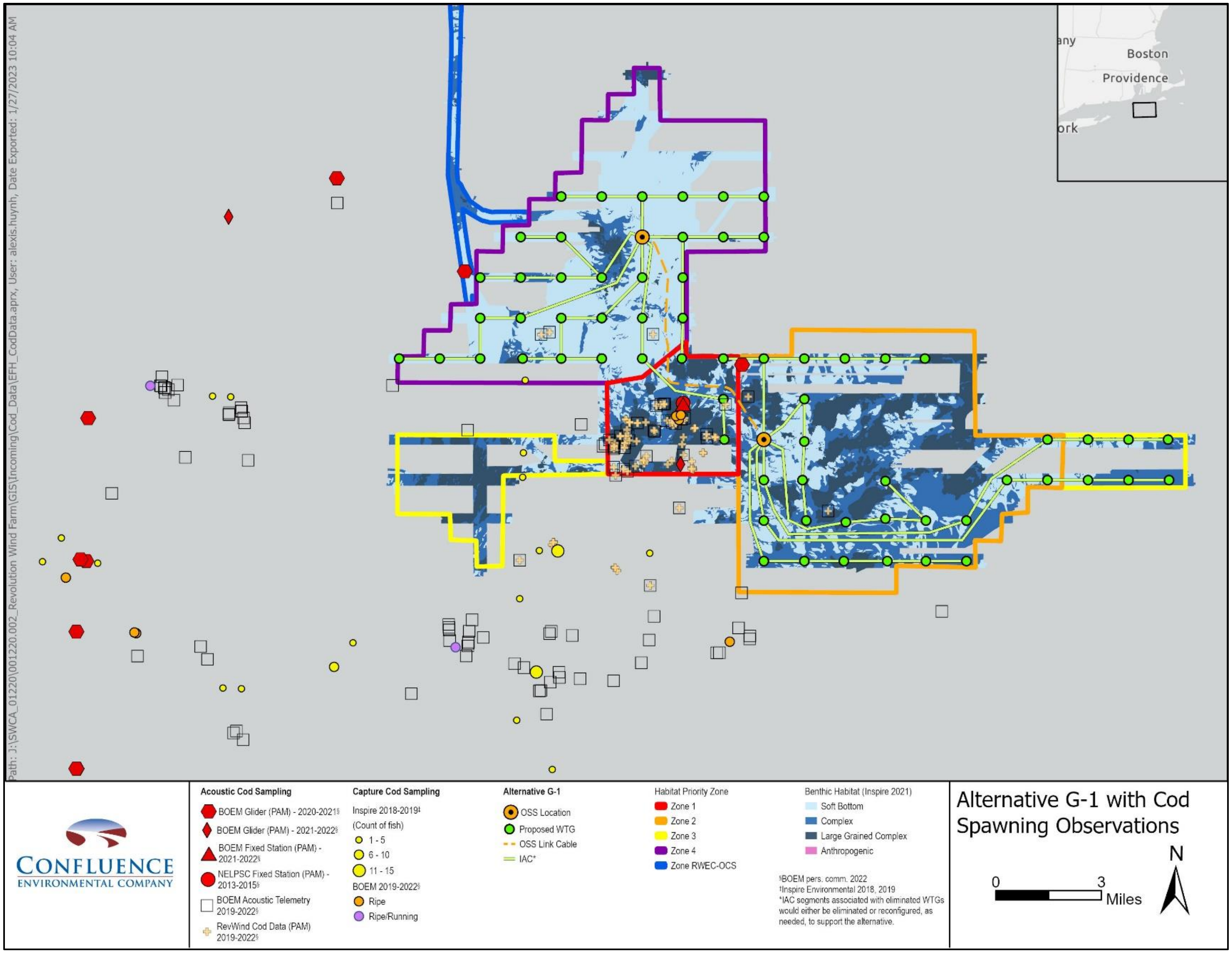

Figure 6.15. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative G1.

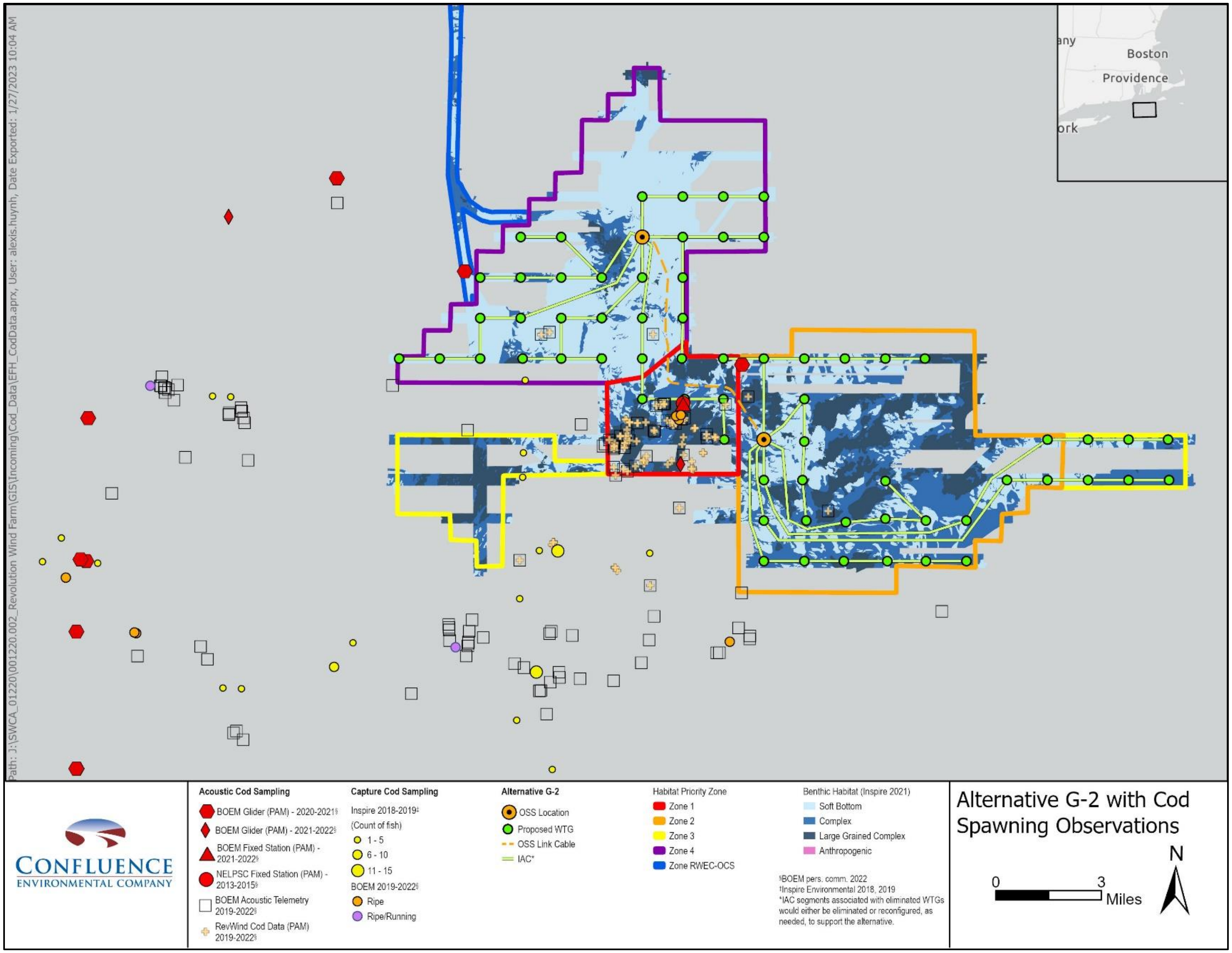

Figure 6.16. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative G2.

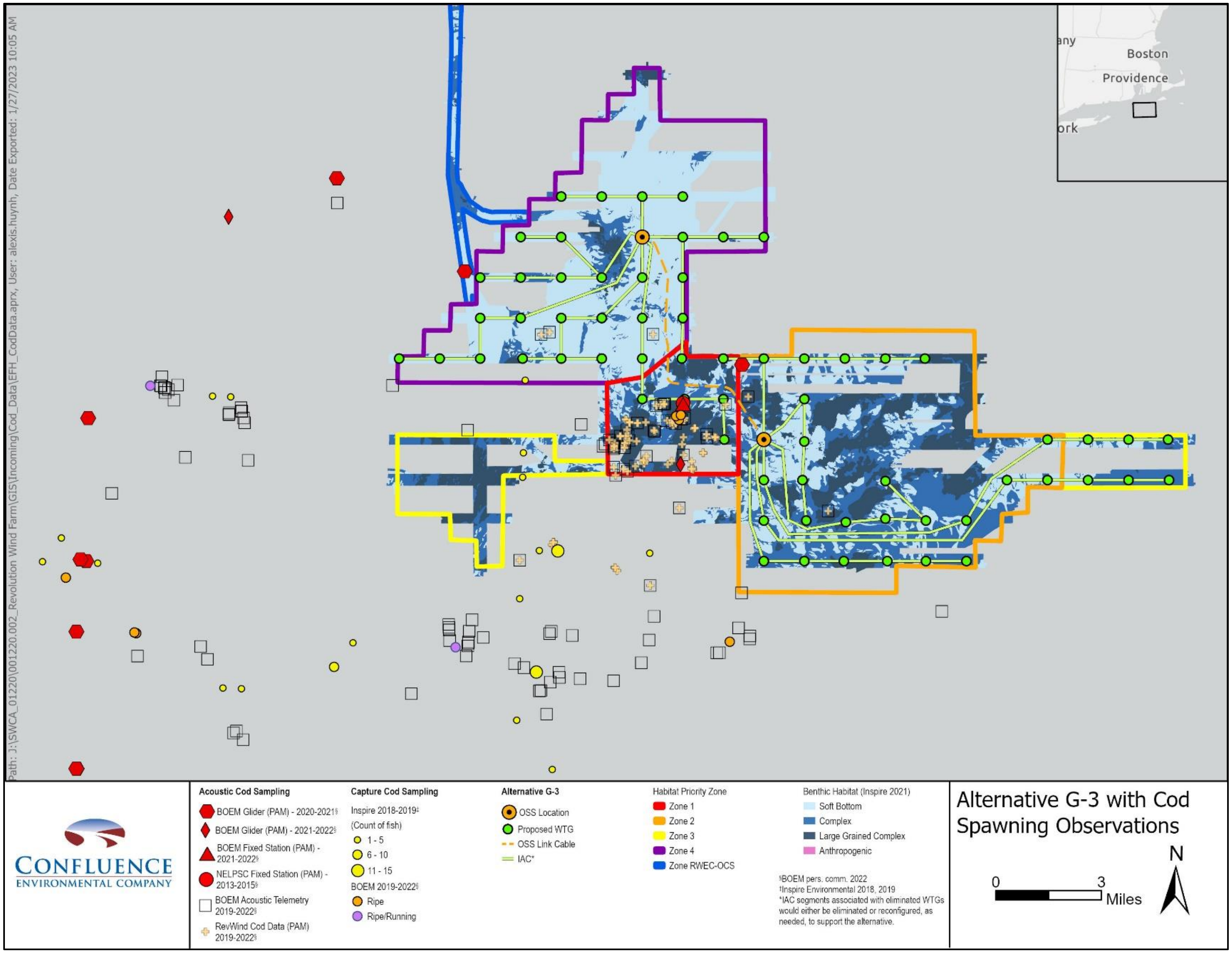

Figure 6.17. Proposed RWF WTG Foundation Locations and IAC Configuration under Alternative G3.

6.3 Environmental Monitoring

Relevant environmental monitoring to avoid, minimize and/or mitigate potential impacts to EFH, and supporting rationale are summarized by project component in Table 6.12.

Table 6.12. Relevant Environmental Monitoring for Construction and Installation, and Operations and Maintenance of the RWF and RWEC, as well as the O&M Facility Operations.

Proposed Environmental Monitoring to Avoid and Minimize Impacts	RWF	RWEC	Expected Effects
Revolution Wind is committed to collaborative science with the commercial and recreational fishing industries pre-, during, and post-construction and installation. Fisheries 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. A Fisheries and Benthic Monitoring Plan is included as Appendix Y to the RWF COP	x	x	Avoids and minimizes adverse effects on EFH from construction and installation, and operations and maintenance related impacts.
A pre-construction and installation submerged aquatic vegetation (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.	X	x	Avoids and minimizes adverse effects on EFH from construction and installation, and operations and maintenance related impacts.
Data-sharing: Revolution Wind has agreed to share fisheries monitoring data with regulatory agencies and interested stakeholders upon request. Data sharing will occur on an annual cycle, which may be unique to each survey, and all data will be subject to rigorous quality assurance and quality control criterion prior to dissemination.	X	x	Physical and biological habitat data collected by Revolution Wind will be available to support increased understanding of EFH on the mid-Atlantic OCS. This information may be used to inform future management and conservation of EFH resources.
Fisheries and benthic monitoring plan. Revolution Wind has developed a fisheries and benthic habitat monitoring plan (dated October 2021) that has been prepared in accordance with recommendations set forth in Guidelines for Providing Information on Fisheries for Renewable Energy Development on the Atlantic Outer Continental Shelf (BOEM 2019).	X	x	The fisheries and benthic habitat monitoring plan will provide valuable baseline information about the condition and use of habitats within the Lease Area and RWEC project footprints. This information will support assessment of ecological impacts from project construction and installation, and operations and maintenance, and inform future management of EFH on the Mid-Atlantic OCS.

Proposed Environmental Monitoring to Avoid and Minimize Impacts	RWF	RWEC	Expected Effects
BOEM is recommending implementation of 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 postconstruction monitoring needs. The underwater acoustic monitoring must follow standardized measurement and processing methods and visualization metrics developed by the Atlantic Deepwater Ecosystem Observatory Network (ADEON) for the U.S. Mid- and South Atlantic OCS (see https://adeon.unh.edu/). At least two buoys must be independently deployed within or bordering the Lease Area or one or more buoys must be deployed in coordination with other acoustic monitoring efforts in the RI and MA Lease Areas.	X		PAM will provide valuable information on the use of the Lease Area by Atlantic cod and potentially other EFH species that use vocalizations to communicate. This information will inform understanding of the effects of RWF construction and operation on sensitive species and habitats.

6.4 Adaptive Management Plans

No adaptive management plans have been developed as part of the Revolution Wind project.

7.0 NOAA Trust Resources

NOAA trust resources are living marine resources that include commercial and recreational fishery resources (marine fish and shellfish and their habitats); anadromous fish (fish that spawn in freshwater and then migrate to the sea); endangered and threatened marine species and their habitats; marine mammals, sea turtles and their habitats; marshes, mangroves, seagrass beds, coral reefs, and other coastal habitats; and resources associated with National Marine Sanctuaries and National Estuarine Research Reserves.

NOAA has identified a subset of trust resources that are subject to interagency coordination and management under the Fish and Wildlife Coordination Act (16 U.S.C. 661-667e as amended). Sixteen species of NOAA trust resources have been identified as occurring within the general vicinity of the Lease Area and RWEC and could be exposed to impacts resulting from the construction and installation, operations and maintenance, and decommissioning of the Project. These species and their potential exposure to project impacts are summarized in Table 7.1.

Table 7.1. Impacts to NOAA Trust Resources that May Occur within the Vicinity of the Lease Area and RWEC Corridor.

Species	Life stage	Habitat Association	IPF Exposure	Impact Determination	Rationale for Determination
Alewife (*Alosa pseudoharengus*)[1]	Egg, larvae, juvenile	Freshwater	None	No impact	No project elements affecting freshwater habitats
Blueback herring (*Alosa aestivalis*)[1]	Egg, larvae, juvenile	Freshwater	None	No impact	No project elements affecting freshwater habitats
American eel (*Anguilla rostrata*)[2]	Adult	Freshwater	None	No impact	No project elements affecting freshwater habitats
	Eggs	Sargasso Sea	None	No impact	No suitable habitat within approximately 800 km
American shad (*Alosa sapidissima*)[1]	Larva Egg	Freshwater	None	No impact	No project elements affecting freshwater habitats
Striped bass (*Morone saxatilis*)[4]	Larva Egg	Freshwater	None	No impact	No project elements affecting freshwater habitats
Blackfish or tautog (*Tautoga onitis*)[5]	Juvenile	Nearshore benthic (<1 m to 20 m)	Construction and Installation Noise Hydrodynamic Food Web UXO	Minor, short-term and permanent	Noise disturbance from construction and installation noise and UXO detonation would reduce habitat suitability in the short-term, during construction and installation. Operations and maintenance noise would be below established behavioral and injury thresholds for fish. Hydrodynamic effects for pelagic marine oriented fish and life-stages could result in local decrease of eggs and larvae but is unlikely to impact the reproductive success of affected species as a whole. Hydrodynamic effects could affect food-web dynamics but would be localized and not result in large-scale shifts.
Striped bass (*Morone saxatilis*)	Juvenile	Estuary			
American eel (*Anguilla rostrata*)	Larvae, juvenile	Pelagic marine, estuary			
Atlantic menhaden (*Brevoortia tyrannus*)[3]	Juvenile	Estuary			

Species	Life stage	Habitat Association	IPF Exposure	Impact Determination	Rationale for Determination
Weakfish or sea trout (*Cynoscion regalis*)[6]	Egg, larvae, juvenile	Estuary			
Atlantic menhaden (*Brevoortia tyrannus*)[3]	Larvae, juvenile	Estuary			
Bay anchovy (*Anchoa mitchilli*)[7]	Larvae, juvenile	Estuary			
Horseshoe crab (*Limulus polyphemus*)[8]	Egg	Intertidal sediments			
	Larva	Nearshore benthic			
Sand eel (*Ammodytes americanus*)	Adult, juvenile	Benthic sediments			
	Adult, juvenile egg, larva	Pelagic			
Blue crab (*Callinectes sapidus*)	Adult, juvenile	Benthic			
	Larva	Pelagic			
Jonah Crab (*Cancer borealis*)	Adult, juvenile	Benthic			
	Larva	Pelagic			
American Lobster (*Homarus americanus*)	Adult, juvenile, egg	Benthic			
	Larva	Pelagic			

Species	Life stage	Habitat Association	IPF Exposure	Impact Determination	Rationale for Determination
Blue mussel (*Mytilus edulis*)[3]	Larvae	Pelagic	Construction and Installation Noise Operational Noise Crushing, Burial, Entrainment Elevated TSS/Sedimentation Habitat Conversion EMF & Heat Hydrodynamic Food Web UXO	Minor, Short-Term and Permanent	Construction and installation noise and UXO detonation would reduce habitat suitability in the short-term and could have lethal effects to individuals (depending upon location). Operations and maintenance Noise would be permanent but is not expected to have measurable impacts. Crushing, Burial and Entrainment and elevated TSS/Sedimentation would result in both minor short-term impacts and potentially lethal impacts to individuals, but species would be expected to recover and recolonize rapidly. Habitat Conversion, EMF & Heat, Hydrodynamic and Food Web Effects could result in localized decrease of larvae.
	Juvenile, adult	Benthic hard substrate; intertidal built environment	Crushing, Burial, Entrainment Elevated TSS/Sedimentation EMF & Heat Hydrodynamic	Minor, Short-Term and Permanent	Crushing, Burial and Entrainment and elevated TSS/Sedimentation would result in both minor short-term impacts and potentially lethal impacts to individuals, but species would be expected to recover and recolonize rapidly. Habitat Conversion, EMF & Heat, Hydrodynamic and Food Web Effects could result in localized decrease of juveniles and adults.

Species	Life stage	Habitat Association	IPF Exposure	Impact Determination	Rationale for Determination
Eastern oyster (*Crassostrea virginica*)[3]	Larvae	Nearshore pelagic	Construction and Installation Noise Crushing, Burial, Entrainment Elevated TSS/Sedimentation Habitat Conversion EMF & Heat Hydrodynamic Food Web UXO	Minor, Short-Term and Permanent	Construction and installation noise and UXO detonation would reduce habitat suitability in the short-term and could have lethal effects to individuals (depending upon location). Crushing, Burial and Entrainment and elevated TSS/Sedimentation would result in both minor short-term impacts and potentially lethal impacts to individuals, but species would be expected to recover and recolonize rapidly. Habitat Conversion, EMF & Heat, Hydrodynamic and Food Web Effects could result in localized decrease of larvae.
	Adult Juvenile	Nearshore benthic reefs			
Northern Quahog (*Mercenaria mercenaria*)[9]	Larvae	Pelagic			
	Juvenile, adult	Subtidal soft substrate			
Soft-shell clam (*Mya arenaria*)[10]	Larvae	Nearshore pelagic			
	Juvenile, adult	Subtidal soft substrate			

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8.0 Determinations and Conclusions

The following sections provide the effect determinations for EFH based on the analysis presented above.

8.1 Determinations

EFH effect determinations are summarized by species and life stage in Table 8.1. This table details designated EFH in the project area, short-term, long-term, and permanent impacts on habitat suitability by construction and installation, and operations and maintenance related impacts detailed in Section 5, and EFH effect determinations by managed species and life stage. If one or more of the construction and installation or operations and maintenance related impacts presented in Section 5 affects EFH, the project **will adversely affect** EFH for those managed species and life stages affected. The project **will not adversely affect** EFH if 1) EFH for the designated species or life stage does not occur in the project area, or 2) the effects of construction and installation, and operations and maintenance related impacts on habitat suitability for the affected life stage is insignificant.

As indicated, the Proposed Action will result in adverse impacts to EFH for the majority of EFH species that occur in the project area and vicinity. However, it is important to recognize that those impacts represent a small percentage of the habitat available within the Lease Area and RWEC corridors. While the habitat zones are arbitrary, expressing the impacts of the Proposed Action as a proportion of zone acreage provides a useful basis for placing those into context.

For example, within RWF zone 1, the highest priority area for impact avoidance and minimization, the combined cable and foundation installation footprint represents approximately 5 percent of total zone area (Table 3.7). Over 60 percent of estimated impact acreage is from cable installation in soft bottom habitat and would be short-term in duration. Similarly, in RWF zone 2, combined cable and foundation installation impacts represent 3 percent of total zone area, approximately half of which would be short-term impacts in soft bottomed habitat (Table 3.8). In total, long-term to permanent impacts resulting from the presence of structures and disturbance of large-grained complex and complex habitats during construction would constitute less than 3 percent of available habitat in the Lease Area.

Cable installation impacts in the RWEC corridor would constitute approximately 11 percent of combined RWEC-OCS and RWEC-RI zone area (Tables 3.12 and 3.13). Over 70 percent of impacts would be short-term effects on soft bottom habitat from cable installation. Long-term to permanent impacts on complex and large-grained complex habitats would constitute less than 3 percent of combined zone area but approximately 10 percent of the combined zone acreage of both habitat types. While the habitats adjacent to the cable corridor have not been mapped, it is reasonable to assume that complex and large grained complex habitats are present in adjacent areas, and those habitats would be unaffected by the project. Underwater noise impacts from impact and vibratory pile driving would result in temporary to short-term effects on EFH species and habitats outside of the Lease Area and RWEC corridor during project construction. Direct effects to those species and habitats would cease once the activity is completed. BOEM expects that indirect effects on prey resources would also be short-term in duration, recovering fully within weeks to months after construction is complete. As such, long-term to permanent impacts from RWEC installation and presence of cable protection are likely to constitute a small proportion of available habitat for EFH species occurring in the project area and vicinity.

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Table 8.1. Summary of Project Effects on EFH by Impact Mechanism and EFH Effect Determinations for Managed Species by Managed Species and Life Stages.

EFH Species Group	EFH Species	Life Stage	Habitat Association§	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Construction and Installation Noise	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Habitat Conversion	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Water Quality	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Artificial Substrate	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Operational Noise	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: EMF & Heat	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Hydrodynamic	EFH Effect Determination (will adversely affect EFH?)
Gadids	Atlantic cod	Eggs	Surface	Yes	Yes	--	--	No	--	No	Yes
		Larvae	Pelagic	Yes	Yes	Yes	--	No	No	No	Yes
		Juvenile	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Benthic complex/ soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Haddock	Eggs	Surface	--	--	--	--	--	--	--	No
		Larvae	Surface	Yes	Yes	--	--	No	--	No	Yes
		Juvenile	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Pollock	Juvenile	Benthic complex/ soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Benthic complex	--	--	--	--	--	--	--	No
		Spawning	Benthic complex	--	--	--	--	--	--	--	No
	Red hake	Eggs	Surface	Yes	--	--	--	No	--	No	Yes
		Larvae	Surface	Yes	--	--	--	No	--	No	Yes
		Juvenile	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft Bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Soft Bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Silver hake	Eggs	Surface	Yes	--	--	--	No	--	No	Yes
		Larvae	Surface	Yes	--	--	--	No	--	No	Yes
		Juvenile	Benthic complex/ soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Benthic complex/ soft bottom	--	--	--	--	--	--	--	No
		Spawning	Benthic complex/ soft bottom	--	--	--	--	--	--	--	No
	White hake	Larvae	Surface	Yes	--	--	--	No	--	No	Yes
		Juvenile	Benthic complex/ soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom	--	--	--	--	--	--	--	No
		Spawning	Soft bottom	--	--	--	--	--	--	--	No

EFH Species Group	EFH Species	Life Stage	Habitat Association§	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Construction and Installation Noise	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Habitat Conversion	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Water Quality	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Artificial Substrate	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Operational Noise	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: EMF & Heat	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Hydrodynamic	EFH Effect Determination (will adversely affect EFH?)
Other finfish	Monkfish	Eggs	Surface	Yes	--	--	--	No	--	No	Yes
		Larvae	Pelagic	Yes	--	Yes	--	No	No	No	Yes
		Juvenile	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Bluefish	Eggs	Pelagic	Yes	--	--	--	No	No	No	Yes
		Larvae	Pelagic	Yes	--	--	--	No	No	No	Yes
		Juvenile	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Adult	Pelagic	Yes	--	--	--	Yes	No	No	Yes
	Black sea bass	Eggs	Surface	--	--	--	--	--	--	--	No
		Larvae	Benthic complex	--	--	--	--	--	--	--	No
		Juvenile	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Butterfish	Eggs	Pelagic	Yes	--	--	--	No	Yes	No	Yes
		Larvae	Pelagic	Yes	--	--	--	No	Yes	No	Yes
		Juvenile	Pelagic/ Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Pelagic/ Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Scup	Eggs	Pelagic	Yes	--	--	--	No	No	No	Yes
		Larvae	Pelagic	Yes	--	Yes	--	No	No	No	Yes
		Juvenile	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Ocean pout	Eggs	Benthic complex	Yes	Yes	Yes	Yes	No	Yes	No	Yes
		Juvenile	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Atlantic herring	Eggs	Benthic complex	--	Yes	Yes	Yes	No	Yes	No	Yes
		Larvae	Pelagic	Yes	--	--	--	No	No	No	Yes
		Juvenile	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Adult	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Spawning	Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

EFH Species Group	EFH Species	Life Stage	Habitat Association§	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Construction and Installation Noise	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Habitat Conversion	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Water Quality	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Artificial Substrate	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Operational Noise	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: EMF & Heat	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Hydrodynamic	EFH Effect Determination (will adversely affect EFH?)
Flatfish	Windowpane flounder	Eggs	Surface	Yes	--	--	--	No	--	No	Yes
		Larvae	Pelagic	Yes	--	Yes	--	No	Yes	No	Yes
		Juvenile	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Winter flounder	Eggs	Soft bottom	Yes	Yes	Yes	Yes	--	--	--	Yes
		Larvae	Pelagic/ Soft bottom	Yes	Yes	Yes	Yes	--	--	--	Yes
		Juvenile	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Witch flounder	Eggs	Surface	Yes	--	--	--	No	--	No	Yes
		Larvae	Surface	Yes	--	--	--	No	--	No	Yes
		Juvenile	Soft bottom	--	--	--	--	--	--	--	No
		Adult	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Yellowtail flounder	Eggs	Surface	Yes	--	--	--	No	--	No	Yes
		Larvae	Surface	Yes	--	--	--	No	--	No	Yes
		Juvenile	Soft bottomed	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottomed	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Spawning	Soft bottomed	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Summer flounder	Eggs	Pelagic	Yes	--	--	--	No	Yes	No	Yes
		Larvae	Pelagic	Yes	--	Yes	--	No	Yes	No	Yes
		Juvenile	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

EFH Species Group	EFH Species	Life Stage	Habitat Association§	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Construction and Installation Noise	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Habitat Conversion	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Water Quality	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Artificial Substrate	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Operational Noise	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: EMF & Heat	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Hydrodynamic	EFH Effect Determination (will adversely affect EFH?)
Highly Migratory Species	Atlantic mackerel	Eggs	Pelagic	Yes	--	--	--	No	--	--	Yes
		Larvae	Pelagic	Yes	--	--	--	No	--	--	Yes
		Juvenile	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Adult	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Spawning	Pelagic	Yes	--	--	--	Yes	No	No	Yes
	Albacore tuna	Juvenile	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Adult	Pelagic	Yes	--	--	--	Yes	No	No	Yes
	Atlantic bluefin	Juvenile	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Adult	Pelagic	Yes	--	--	--	Yes	No	No	Yes
	Atlantic skipjack	Juvenile	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Adult	Pelagic	Yes	--	--	--	Yes	No	No	Yes
	Atlantic yellowfin	Juvenile	Pelagic	Yes	--	--	--	Yes	No	No	Yes
		Adult	Pelagic	Yes	--	--	--	Yes	No	No	Yes
Sharks	Sand tiger shark	Neonate/YOY	Benthic complex/ soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Juvenile	Benthic complex/ soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Sandbar shark	Neonate/YOY	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Juvenile	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Smooth dogfish	Neonate	Pelagic	Yes	--	Yes	--	Yes	Yes	No	Yes
		Juvenile	Pelagic	Yes	--	Yes	--	Yes	Yes	No	Yes
		Adult	Pelagic	Yes	--	Yes	--	Yes	Yes	No	Yes
	Spiny dogfish	Sub-Adult (f)	Pelagic	Yes	--	Yes	--	Yes	Yes	No	Yes
		Sub-Adult (m)	Pelagic	Yes	--	Yes	--	Yes	Yes	No	Yes
		Adult (f)	Pelagic	Yes	--	Yes	--	Yes	Yes	No	Yes
		Adult (m)	Pelagic	Yes	--	Yes	--	Yes	Yes	No	Yes
Skates	Barndoor skate	Juvenile	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Little Skate	Juvenile	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Winter skate	Juvenile	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
		Adult	Soft bottom/ Benthic complex	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

EFH Species Group	EFH Species	Life Stage	Habitat Association§	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Construction and Installation Noise	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Habitat Conversion	Construction and Installation Related Short-Term Adverse Effect on EFH‡: Water Quality	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Artificial Substrate	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Operational Noise	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: EMF & Heat	Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH‡: Hydrodynamic	EFH Effect Determination (will adversely affect EFH?)
Invertebrates	Atlantic sea scallop	Eggs	Benthic complex	Yes	Yes	Yes	Yes	No	Yes	No	Yes
		Larvae	Pelagic/ Benthic complex	Yes	Yes	Yes	Yes	No	Yes	No	Yes
		Juvenile	Benthic complex	Yes	Yes	Yes	Yes	No	Yes	No	Yes
	Atlantic sea scallop	Adult	Benthic complex	Yes	Yes	Yes	Yes	No	Yes	No	Yes
		Spawning	Benthic complex	Yes	Yes	Yes	Yes	No	Yes	No	Yes
	Atlantic surf clam	Juvenile	Soft bottom	Yes	Yes	Yes	Yes	No	Yes	No	Yes
		Adult	Soft bottom	Yes	Yes	Yes	Yes	No	Yes	No	Yes
	Ocean quahog	Juvenile	Soft bottom	Yes	Yes	Yes	Yes	No	Yes	No	Yes
		Adult	Soft bottom	Yes	Yes	Yes	Yes	No	Yes	No	Yes
	Shortfin squid	Juvenile	Pelagic	Yes	--	Yes	--	No	Yes	No	Yes
		Adult	Pelagic	Yes	--	Yes	--	No	Yes	No	Yes
	Longfin squid	Eggs	Benthic complex	Yes	Yes	Yes	Yes	No	Yes	No	Yes
		Juvenile	Pelagic	Yes	--	Yes	--	No	No	No	Yes
		Adult	Pelagic	Yes	--	Yes	--	No	No	No	Yes

Notes:

§ Benthic complex habitat includes complex and large-grained complex benthic habitat.

‡ 'Yes' = adverse effect on habitat suitability; 'No' = insignificant effect on habitat suitability; '--' = no life stage EFH exposure to this impact mechanism.

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8.2 Conclusions

Over 40 species of finfish and invertebrates with designated EFH occur within the Lease Area and RWEC corridor. As stated in Section 4, juvenile inshore cod HAPC has been delineated in the RWEC-RI corridor (Figure 4.1). Summer flounder HAPC has not been mapped, but includes all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes (i.e., SAV). The proposed action, described in Section 2, includes construction and installation, operations and maintenance, and decommissioning of the project components. Project decommissioning would occur at the end of the 35-year planned lifetime of the project and would be subject to separate EFH consultation at that time. Effects of project activities on EFH are analyzed in Section 5. Project effects on EFH are then summarized by impact mechanism, species, and life stage in Table 8.1, which details designated EFH in the project area, short-term, long-term, and permanent impacts on habitat suitability by impact mechanism, and EFH effect determinations by managed species and life stage.

Impacts associated with construction and installation activities, such as pile driving and jet-plowing, are likely to be greater than those associated with operations and maintenance, such as sound produced by operational turbines. EFH species with one or more demersal life stage are more likely to be subjected to long-term or permanent adverse impacts than species with only pelagic life stages, primarily due to the installation of the turbine foundations and scour and cable protection measures, and the concomitant alteration and conversion of benthic habitat.

Project construction and installation would result in short-term adverse effects on the environment that could affect habitat suitability for managed species. Short-term adverse effects include construction and installation-related underwater noise impacts; crushing, burial, and entrainment effects; and disturbance of bottom substrates resulting in increased turbidity and sedimentation. These effects would occur intermittently at varying locations in the project area over the duration of project construction and installation but are not expected to cause permanent effects on EFH quality. Depending on the nature, extent, and severity of each effect, this may temporarily reduce the suitability of EFH for managed species, which would result in short-term adverse effects on EFH for those species. For example, underwater noise from pile-driving could temporarily render the affected habitats unsuitable as EFH for multiple life stages of Atlantic cod and longfin squid (see Section 5.1.1.4). However, EPMs such as sound attenuation and soft start procedures could minimize such acoustic impacts. Additional project EPMs are described in Table 6.1.

The operation and maintenance of the RWF, RWEC, and O&M facility would result in intermediate to long-term/permanent adverse effects on EFH for some life stages of EFH species. Long-term adverse effects are those that would last over the approximately 35-year lifespan of project, so would be effectively permanent. These impacts include alteration of water column and benthic habitats, operational noise, EMF and heat effects, hydrodynamic effects, and food web effects. Monopile foundations, scour protection and cable protection would alter habitat.

Benthic habitat areas mapped within the Lease Area include 17,945 acres (7,062 hectares) of complex, 11,128 acres (4,503 hectares) of large-grained complex, and 29,563 acres (23,529 hectares) of soft bottom benthic habitat (Table 3.1). Foundation piles would displace approximately 1.54 acres (0.61 hectare) of complex, 0.1 acres (0.05 hectare) of large-grained complex and 1.44 acres (0.62 hectare) of soft bottom benthic habitat within the footprint of the 100 12-meter WTG monopiles and two 15-meter OSS monopiles. An additional estimated 34 acres (14 hectares) of complex, 1 acre (0.4 hectare) of large-grained complex, and 36 acres (15 hectares) of soft bottom benthic habitat would be modified by placement of scour protection around the foundations and inter-array cable approaches. Approximately 44 acres (18 hectares) of complex and 30 acres (12 hectares) of large-grained complex benthic habitat would be modified by placement of secondary cable protection along approximately 10 percent of the inter-array cables anticipated to be surface-laid. The potential increase in abundance of epibenthic and demersal fishes resulting from the reef effect may offset some impacts to EFH of those species over the life of the wind farm, although it may take several years for the reef effect to fully develop. Analyses of habitat impacts are found in Section 5. The implementation of EPMs (Table 6.1) would likely result in the avoidance and minimization of some of the intermediate to long-term (permanent) project impacts to EFH described above.

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Appendix A - Benthic Habitat Mapping Report

Benthic Habitat Mapping to Support Essential Fish Habitat Consultation Revolution Wind Offshore Wind Farm

Prepared for:

Revolution Wind | Powered by Ørsted & Eversource

Revolution Wind, LLC

Submitted by:

INSPIRE ENVIRONMENTAL

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December 2021

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LIST OF ACRONYMS

BOEM	Bureau of Ocean Energy Management
CMECS	Coastal and Marine Ecological Classification Standard
COP	Construction and Operations Plan
EFH	Essential fish habitat
FGDC	Federal Geographic Data Committee
Fugro	Fugro USA Marine, Inc.
GIS	Geographic Information System
HAPC	Habitat Area of Particular Concern
HDD	Horizontal directional drilling
IAC	Inter-Array Cable
INSPIRE	INSPIRE Environmental, LLC
kya	thousand years ago
MBES	Multibeam echosounder
mmu	Minimum mapping unit
NOAA	National Oceanic and Atmospheric Administration
NOAA Habitat	NOAA National Marine Fisheries Greater Atlantic Regional Fisheries Office Habitat Conservation and Ecosystem Services Division
OCS	Outer continental shelf
OSS	Offshore Substation
PV	Plan View
RIMA WEA	Rhode Island Massachusetts Wind Energy Area
RWEC	Revolution Wind Farm Export Cable
RWEC–RI	Revolution Wind Farm Export Cable in Rhode Island state waters
RWEC–OCS	Revolution Wind Farm Export Cable traversing federal waters
RWF	Revolution Wind Farm
SAV	Submerged aquatic vegetation
SPI	Sediment Profile Imaging
SSS	Side-scan sonar
TOY	Time of year
YOY	Young-of-the-year

GLOSSARY

Revolution Wind & Environmental Permitting: Key Terms & Abbreviations

Term	Definition
Benthic Habitat Classification	Benthic habitat classifications with a minimum mapping unit of 2,000 m^2, prepared by INSPIRE
Boulder picks	Isolated boulders, outside boulder field; Boulders >= 50 cm (0.5 m) identified from geophysical data
Coastal and Marine Ecological Classification System (CMECS)	Federal habitat classification standard recommended by BOEM for benthic assessments and applied here using NOAA Habitat's recommended modifications (NOAA Habitat 2021)
EFH Crosswalk	The process of reviewing species with mapped EFH in the Project Area and comparing their habitat preferences with the mapped benthic habitat types described in Sections 3.1 & 3.2 to identify where EFH for those species is likely to be found
Facies	Bodies of sediment that are recognizably distinct from adjacent sediments that resulted from different depositional environments.
Foundation	The bases to which the WTGs and OSS are installed on the seabed. Monopile is the selected foundation type for the WTGs and OSSs.
Hard bottom	Stable cobbles and boulders found predominantly within Glacial Moraine A & B habitats and within Boulder Fields.
horizontal directional drilling (HDD)	Landfall of RWEC will be completed via HDD. HDD is a subsurface installation technique that will create an underground conduit through which the RWEC will be installed through the intertidal zone. The HDD methodology avoids impacts to the beach and nearshore environment.
Minimum mapping unit (mmu)	The smallest size areal seabed or habitat polygon to be mapped as a discrete entity
Modifiers	Additional descriptive terms used to provide further characterization of benthic habitat types; terms consistent with CMECS are used where feasible
NOAA Complexity Category	Indicates habitat complexity using categories of complexity as defined by NOAA Habitat for the purposes of EFH consultation. These categories include: soft bottom, complex, heterogeneous complex, and large-grained complex (large boulders). For purposes of the EFH consultation, complex habitats include submerged aquatic vegetation (SAV) and sediments with >5% gravel of any size (pebbles to boulders; CMECS Substrate of Rock, Groups of Gravelly, Gravel Mixes, and Gravels). Heterogenous complex is used for habitats with a combination of soft bottom and complex features (NOAA Habitat 2021).
Project Area	Inclusive of the areas Revolution Wind surveyed for siting the RWF in the Lease Area, the RWEC–OCS Study Area, and the RWEC–RI Study Area.

Term	Definition
Revolution Wind Farm (RWF)	Located in federal waters off the coast of Rhode Island, within the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS) #OCS-A 0486 (Lease Area). The RWF will consist of up to 100 WTGs, inter-array cables (IAC), up to two offshore substations (OSSs), and an OSS-Link Cable.
Revolution Export Cable (RWEC)	The export cable system from the RWF to the mainland electric grid interconnection includes segments in federal waters (RWEC–OCS) and segments in state waters (RWEC–RI).
Revolution Export Cable – Outer Continental Shelf (RWEC–OCS)	The submarine segment of the export cable system located on the OCS from the RWF to the 3-nautical mile (3.5-mile; 5.6-km) state boundary.
Revolution Export Cable – RI State Waters (RWEC–RI)	The submarine segment of the export cable system located within the state waters of Rhode Island to the landfall location at Quonset Point.
RWEC–OCS Study Area	The area Revolution Wind surveyed for siting the RWEC–OCS in federal waters
RWEC–RI Study Area	The area Revolution Wind surveyed for siting the RWEC–RI in state waters

EXECUTIVE SUMMARY

Revolution Wind, LLC, a 50/50 joint venture between Orsted North America Inc. and Eversource Investment LLC proposes to construct and operate the Revolution Wind Farm Project. The Project will be comprised of both offshore and onshore components, which are described in detail in Section 3 of the Construction and Operations Plan. The Revolution Wind Farm will be located in federal waters on the Outer Continental Shelf in the designated Bureau of Ocean Energy Management Renewable Energy Lease Area OCS-A 0486 and will consist of up to 100 Wind Turbine Generators connected by a network of Inter-Array Cables and up to two Offshore Substations connected by an OSS-Link Cable. The Revolution Wind Farm Export Cable will consist of up two submarine export cables generally co-located within a single corridor traversing federal waters and Rhode Island state waters to a landfall location at Quonset Point in North Kingstown, Rhode Island. Revolution Wind is committed to an indicative layout scenario with foundations sited in a uniform east-west/north-south grid with 1.15 by 1.15-mi (1 by 1-nm; 1.85 by 1.85-km) spacing that aligns with other proposed adjacent offshore wind projects in the Rhode Island - Massachusetts Wind Energy Area and the Massachusetts Wind Energy Area. To support this agreed upon spacing, a diamond shaped micro-siting allowance is provided for each foundation location.

The purpose of this report and associated data is to provide detailed information about the physical and biological characteristics and spatial composition of benthic habitats found within the Project Area (the Revolution Wind Farm and within the corridor studied for siting of the Revolution Wind Farm Export Cable collectively). These data are intended to serve as foundation data for an evaluation of benthic habitat types that may be impacted by the Project and, subsequently, the demersal species with essential fish habitat designated in the Project Area that may be impacted by Project-related disturbances to these seafloor habitats. These results will be used to support the essential fish habitat consultation requested by the Bureau of Ocean Energy Management and performed by the National Oceanic and Atmospheric Administration National Marine Fisheries Greater Atlantic Regional Fisheries Office Habitat Conservation and Ecosystem Services Division (NOAA Habitat).

Revolution Wind has collected extensive geophysical and ground-truth data to support the mapping and characterization of habitats within the Project Area. The geophysical data used to support benthic habitat mapping not only meet the recommended resolution specified in BOEM's Geophysical, Geotechnical, and Geohazard Guidelines and NOAA Habitat's recommendations, but these data were collected with state-of-the-art equipment and are provided at the highest resolution possible. The benthic habitat data provided here should be viewed as the most accurate representation of the seafloor possible using the high-resolution geophysical and ground-truth data collected. In addition to mapping benthic habitats within the Project Area, INSPIRE Environmental has prepared a crosswalk of the delineated benthic habitat types to essential fish habitat for species and life stages of demersal taxa with designated essential fish habitat in the Project Area.

Seven primary benthic habitat types were mapped within the Project Area: Glacial Moraine A, Glacial Moraine B, Mixed-Size Gravel in Muddy Sand, Coarse Sediment, Sand and Muddy Sand, Mud and Sandy Mud, and Bedrock. When habitats were updated with modifiers, a total of twenty-four habitat types were mapped within the Project Area including mobile habitats characterized by ripples, discrete habitat areas with low or medium density boulder fields, and inshore habitats characterized by shell substrate or submerged aquatic vegetation.

Sand and mobile sand and coarse sediment habitats were the most prevalent habitats mapped within the Revolution Wind Farm. Clear spatial patterns in habitat composition were evident at the Revolution Wind Farm with the northern portion primarily composed of sands and muds and the central and southern portions composed of a mix of these habitats and habitats of glacial origin composed of a complex patchwork of variable sediment types and gravels, particularly boulders. Specifically, the northern portion of the Revolution Wind Farm was primarily composed of Sand and Muddy Sand with smaller areas of Mud and Sandy Mud, Coarse Sediment, and Glacial Moraine A and B habitats, and the central and southern portions of the Revolution Wind Farm were primarily composed of a mix of Sand and Muddy Sand, Coarse Sediment, Glacial Moraine A habitats, with smaller areas of Glacial Moraine B habitats. The spatial distribution of Glacial Moraine A and B habitats, as well as boulder fields, correspond well with the previously published locations of the Ronkonkoma Moraine.

The corridor studied for siting of the Revolution Wind Farm Export Cable was primarily composed of dynamic sands offshore and depositional muds within Narragansett Bay in Rhode Island State Waters. Exceptions were an area south of the Jamestown Bridge composed of living and dead shell substrate over muddy sediments and near the Revolution Wind Farm where an area of Mixed-Size Gravel in Muddy Sand with low and medium density boulder fields was mapped; this location was proximal to the modeled location of the Harbor Hill Moraine. In addition, small discrete areas of Coarse Sediment, Bedrock, Glacial Moraine A, and Glacial Moraine B habitats were present in both federal and state waters, and were mostly mapped on the edges of the studied corridor. One submerged aquatic vegetation bed was mapped near the shoreline east of the proposed landfall location.

NOAA Habitat recently provided updated habitat mapping recommendations, which request that the maximum potential acres that may be impacted by the Project be inventoried in terms of the NOAA Habitat Complexity Categories outlined in these recommendations. To provide an impact assessment of the Project Area in terms of NOAA Habitat Complexity Categories, the benthic habitats delineated by Revolution Wind and detailed here have been crosswalked to the NOAA Habitat Complexity Categories. This crosswalk was used to calculate acres of each habitat category that may be impacted by Project activities. For purposes of the essential fish habitat consultation, NOAA has defined complex habitats as submerged aquatic vegetation, shell substrate, and sediments with >5% gravel of any size.

The majority of the habitats mapped within the Revolution Wind Farm were crosswalked to the soft bottom category, approximately 20% crosswalked to the large grained complex category, and over one-quarter crosswalked to the complex category. The foundations are generally sited across the habitats present at the RWF approximately proportional to their spatial prevalence and distribution. The majority of the micro-siting diamonds within the Revolution Wind Farm (64 of 102) are located wholly within dynamic sand, mud, and mobile coarse sediments expected to recover relatively quickly from impacts related to installation of the foundations. In contrast, habitats characterized by boulder fields and diverse complex glacial moraine habitats overlap with fewer than one-third of the micro-siting diamonds. Potential impacts to habitats crosswalked to large grain complex and complex categories are likely to be minimized through layout refinement and micro-siting of foundation positions and cables. Revolution Wind will micro-site foundations within the micro-siting diamonds on a case-by-case basis to avoid significant seabed hazards such as surface and subsurface boulders and to avoid and minimize impacts to complex habitat types to the extent feasible and in consideration of other siting constraints.

Permanent and temporary impacts related to the Revolution Wind Export Cable are anticipated to occur mostly in soft bottom habitats; specifically, 66% of habitats mapped within federal waters and 85% of those mapped within Rhode Island state waters were crosswalked to the soft bottom category. The cables are sited approximately proportional to their spatial prevalence and distribution within the areas surveyed. Revolution Wind will avoid and minimize impacts to complex habitats with siting of the RWEC–OCS and RWEC–RI to the extent feasible and in consideration of other siting constraints. Revolution Wind will also utilize an horizonal directional drilling cable installation methodology, which will avoid direct impacts to documented submerged aquatic vegetation and juvenile cod Habitat Area of Particular Concern near the Project's landfall location. In addition, Revolution Wind will avoid construction in state waters during the peak SAV growing season (i.e., July 1 to September), which will further minimize potential effects due to increased turbidity and sediment deposition associated with cable installation and excavation of the HDD exit pits.

A complete crosswalk of delineated benthic habitat types to essential fish habitat for all demersal species/life stages with designated essential fish habitat in the Project Area provides detailed information to facilitate review of potential impacts to each species/life stage. Primary benthic habitat types were used for the crosswalk with additional columns for boulders, shell substrate, and submerged aquatic vegetation; habitats with modifiers were not used for the crosswalk because the level of detail supporting essential fish habitat designations is rarely available at a level that matches the detail provided by modifiers. In total, 25 benthic/demersal species and 54 life stages with designated essential fish habitat within the Project Area have been crosswalked to mapped benthic habitats: 40 life stages to Glacial Moraine A and B habitats, 35 to Mixed-Size Gravel in Muddy Sand habitats, 47 to Coarse Sediment habitats, 45 to Sand and Muddy Sand habitats, 36 to Mud and Sandy Mud habitats; and 22 to boulders, 14 to SAV habitats, and nine to Shell Substrate within any habitat type. While construction and operation activities may affect essential fish habitat for demersal/benthic life stages, these impacts are also anticipated to be temporary and minor as they will disturb a small portion of available essential fish habitat in the area. Species with a preference for sandy habitats, such as Atlantic surfclam and ocean quahog, are more likely to experience long-term impacts to their habitats from the conversion of sand habitat into hard bottom habitat with the addition of materials used for cable and scour protection, where needed. Additionally, sessile species or species with benthic eggs such as Atlantic sea scallop, ocean pout, and winter flounder that have limited or no mobility and increased sensitivity to turbidity are likely to be injured, displaced, or experience mortality from these activities. Revolution Wind has proposed a number of environmental protection measures, including time of year restrictions, to minimize and mitigate impacts to these species.

1.0 INTRODUCTION

1.1 Revolution Wind Project Overview and Layout

Revolution Wind, LLC (Revolution Wind), a 50/50 joint venture between Orsted North America Inc. (Orsted NA) and Eversource Investment LLC (Eversource), proposes to construct and operate the Revolution Wind Farm Project (hereinafter referred to as the Project). The wind farm portion of the Project will be located in federal waters on the Outer Continental Shelf (OCS) in the designated Bureau of Ocean Energy Management (BOEM) Renewable Energy Lease Area OCS-A 0486 (Lease Area) (Figure 1-1). The Project consists of the Revolution Wind Farm (RWF), located within the Lease Area, and the Revolution Wind Farm Export Cable (RWEC), traversing federal waters (RWEC–OCS) and Rhode Island state waters (RWEC–RI) (Figure 1-1) to a landfall location at Quonset Point in North Kingstown, Rhode Island (Figure 1-2). The Project will be comprised of both offshore and onshore components, which are described in detail in Section 3 of the Construction and Operations Plan (COP) (Revolution Wind, LLC 2021a). The offshore components are most relevant to the benthic habitat mapping assessment provided here and include (Figure 1-3):

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

This report provides a detailed assessment of benthic habitats that have been mapped from geophysical and benthic ground-truth data within the Project Area. The Project Area is inclusive of the areas Revolution Wind surveyed for siting the RWF in the Lease Area, the RWEC–OCS Study Area, and the RWEC–RI Study Area. The RWEC–OCS Study Area is defined as the area Revolution Wind surveyed for siting the RWEC–OCS in federal waters; and the RWEC–RI Study Area is defined as the area Revolution Wind surveyed for siting the RWEC–RI in state waters. The RWEC–OCS Study Area ranges in width from approximately 10,500 ft (3,200 m) at its widest point to approximately 1,360 ft (415 m) at its narrowest. The RWEC–RI Study Area ranges in width from approximately 10,500 ft (3,200 m) at its widest point to approximately 1,300 ft (396 m) at its narrowest. Ultimately, the RWEC route will be sited within these broader Study Areas and direct impacts will be limited to an approximate 131-foot (40-meter) -wide disturbance corridor centered on each cable.

1.2 Benthic Habitat Mapping Assessment Purpose and Objectives

The purpose of this report and associated data is to provide detailed information about the physical and biological characteristics and spatial composition of benthic habitats found within the Project Area. Revolution Wind has collected extensive geophysical data (Revolution Wind, LLC 2021b) and ground-truth data (Attachments A and B) to support the mapping and characterization of habitats within the Project Area. In addition to mapping benthic habitats within the Study Area, INSPIRE has prepared a crosswalk of the delineated benthic habitat types to EFH for species and life stages of demersal taxa with designated EFH in the Project Area (Attachment C).

This report and data are provided to support the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Greater Atlantic Regional Fisheries Office Habitat Conservation and Ecosystem Services Division (NOAA Habitat) in conducting a thorough and complete essential fish habitat (EFH) consultation for the Project. NOAA Habitat developed recommendations for mapping benthic habitats to facilitate EFH consultations (May 2020) in conjunction with BOEM, and BOEM released the recommendations as a supplement to the BOEM Benthic Survey Guidelines (2019). NOAA Habitat recently (March 2021) provided a new version of these habitat mapping recommendations (NOAA Habitat 2021). The updated NOAA Habitat Complexity Categories outlined in these new recommendations have been used to inform discussion of potential Project impacts to benthic habitats.

The geophysical data used to support benthic habitat mapping not only meet the recommended resolution specified in BOEM's Geophysical, Geotechnical, and Geohazard Guidelines (BOEM 2020a) and NOAA Habitat's recommendations (NOAA Habitat 2021), but these data were collected with state-of-the-art equipment and are provided at the highest resolution possible. INSPIRE used these geophysical and ground-truth data to further delineate and refine geological seabed interpretations prepared for the Revolution Wind Marine Site Investigation Report (Revolution Wind LLC 2021b) into a detailed benthic habitat map for the Project Area. The benthic habitat data provided here should be viewed as the most accurate representation of the seafloor possible using the high-resolution geophysical and ground-truth data collected.

Acreage of benthic habitat that may be impacted by construction and installation of each component of the Project (e.g., foundations, cables) are provided in Section 4.0. Formal EFH consultation for the Project is anticipated to be initiated in Summer 2022.

2.0 INPUT DATA AND APPROACH

Multiple sources of geophysical and ground-truth data were used as input data sources for mapping benthic habitats within the Project Area. Brief summaries of these data sources and details pertinent to their use in the habitat mapping process are described here. Full details of geophysical and ground-truth data collection, processing, and analysis are provided in the Marine Site Investigation Report (Revolution Wind, LLC 2021b) and benthic assessment report (Revolution Wind, LLC 2021c) appended to the Revolution Wind COP (Revolution Wind, LLC 2021a).

2.1 Input Data

2.1.1 Geophysical Data

To support Revolution Wind Site Investigations, Fugro USA Marine, Inc. (Fugro) conducted high-resolution multibeam echosounder (MBES) and side-scan sonar (SSS) surveys within the Project Area (Revolution Wind, LLC 2021b). MBES and SSS are collected using different instruments deployed from the same survey vessel (Figure 2-1). The MBES is mounted to the vessel and provides the highest degree of positional accuracy; the MBES can be optimized for either bathymetric or backscatter data, but not for both. The geophysical surveys conducted for offshore wind development are designed to support engineering and construction design and, therefore, the MBES was optimized for bathymetric data, and backscatter data were collected as an ancillary data product.

Bathymetric data were derived from the MBES and processed to a resolution of 50 cm (Revolution Wind, LLC 2021b). Bathymetric data provide information on depth and seafloor topography (Figures 2-2 and 2-3). Bathymetric data were used to create a model of seafloor slope for the Project Area with a cell size of 3 m (Figures 2-4 and 2-5).

Backscatter data were derived from the MBES and processed to a resolution of 25 cm (Revolution Wind, LLC 2021b). Backscatter data are based on the strength of the acoustic return to the instrument and provide information on seafloor sediment composition and texture and are best interpreted in concert with hill-shaded bathymetry (Figures 2-6 and 2-7). Backscatter returns are relative (see below) and referred to in terms of low, medium, and high reflectance rather than absolute decibel values. Nominally, softer, fine-grained sediments absorb more of the acoustic signal and a weaker signal is returned to the MBES. Although backscatter data provide valuable information about sediment grain size, decibel values reflect not only sediment grain size, but also compaction, water content, and texture (Lurton and Lamarche 2015). For example, sand that is hard-packed and sand that has prominent ripples may have higher acoustic returns than sediments of similar grain size that do not exhibit compaction or ripples.

Backscatter decibel values are also influenced by water temperature and salinity, sensor settings, seafloor rugosity, and MBES operating frequency, among others (Lurton and Lamarche 2015; Brown et al. 2019). Differences in backscatter decibel values can also occur when data have been collected over a very large survey area under dynamic conditions, with different instruments, and in different years. This scenario is common and does not nullify the data; methods to optimize processing (as appropriate to the sensors) and to display the data optimal for interpretation are well developed (Lurton and Lamarche 2015; Schimel et al. 2018). Backscatter data products vary based on processing (Lucieer et al. 2017) and data display procedures. Mapping of seafloor composition and habitats, while greatly aided by backscatter data, rarely relies solely on these data (see Table 1 in Brown et al. 2011). The manner in which the suite of data collected were used for habitat delineations is described further in Section 2.2.

SSS data were generated from a towed instrument (Figure 2-1) and, thus, have a lower positional accuracy than MBES data. However, because the SSS is closer to the seafloor with a lower angle of incidence, the resolution, signal to noise ratio, and intensity contrast of SSS images are higher than those of MBES backscatter images (Lurton and Jackson 2008). The processed SSS images provide the highest resolution data on sediment textures and objects on the seafloor (boulders, debris) (Figure 2-8). Thermoclines and haline variations affect the acoustic signal and result in data artifacts, presenting as sinuous rippling of alternating low and high returns that cannot be removed from the data; they are visible when viewed at very close range. SSS data were processed to a resolution of 10 cm; this resolution permits detection of boulders but does not permit the reliable detection of individual cobbles (6.4 cm to 25.6 cm). Although individual small boulders and cobbles cannot be detected in 10-cm resolution SSS, SSS textures and patterns can indicate the presence or absence of higher densities of these features.

An artificial intelligence algorithm paired with a manual review step was used to aggregate boulders into boulder fields where they were present in low (20 – 99 per 10,000 m^2), medium (100 – 199 per 10,000 m^2) and high (>199 per 10,000 m^2) densities. (Revolution Wind, LLC 2021b). These density values were set by the Revolution Wind Site Investigations team; boulder fields are defined as a geoform by the federal Coastal and Ecological Marine Classification Standard (CMECS; FGDC 2012), however no density values are provided. Isolated individual boulders greater than or equal to 50 cm (0.5 m) in diameter outside the boulder fields were identified from the MBES and SSS data using automatic and manual detection methods to generate a “boulder pick” data set to accompany the boulder field dataset (Figure 2-9). In addition to individual boulders, other solitary objects (known as “contacts” in geophysical survey terminology), such as various types of debris were identified in this manner. A combination of these geophysical data was used to detect large- and small-scale bedforms, such as mega-ripples and ripples (*sensu* BOEM 2020a) (Figure 2-10).

2.1.2 Ground-Truth Data

Sediment profile and plan view images (SPI/PV; Figure 2-11) were collected at 240 stations within the RWF (Figure 2-12), 19 stations along the RWEC–OCS Study Area, and 34 stations along the RWEC–RI Study Area in July 2019 (Figure 2-13). Stations sampled with the RWF include eight stations surveyed to support the benthic assessment for the South Fork Wind Farm. Summarized data results are presented in Attachment A. SPI/PV images were used to ground-truth sediment types, bedform dynamics, presence of sensitive habitats and taxa, and to characterize benthic biological communities. SPI/PV images were analyzed for a suite of variables (Table 2-1) and were classified using CMECS Substrate and Biotic components (Tables 2-2, 2-3, and 2-4). CMECS Substrate Group/Subgroup was particularly useful as ground-truth data for purposes of delineating seafloor sediments and benthic habitats (Figure 2-14). CMECS Biotic Subclasses and Groups and notations of sessile and mobile epifauna present (Figure 2-15) were used to provide detail about the biological communities observed within each mapped habitat type. Detailed descriptions of each variable analyzed and full data analysis results can be found in the COP Benthic Assessment (Revolution Wind, LLC 2021c).

A towed video survey along 52 transect lines was conducted near the RWEC–RI landfall at Quonset Point (Figure 2-16). This survey focused on nearshore regions around the landfall where there was a higher probability of submerged aquatic vegetation (SAV) presence. Survey planning and analysis followed protocols as outlined in federal agency protocols (Colarusso and Verkade 2016) and in the RI Coastal Resources Management Council's regulations in the Coastal Resources Management Program, or "Red Book", (650-RICR-20-00-1 et seq.). Video transect data were analyzed to identify the presence or absence of SAV in each video file. Additional parameters were analyzed where SAV was present including SAV bed extent and general sediment type, in accordance with federal agency protocols (Colarusso and Verkade 2016).

Table 2-1. SPI/PV Ground-truth Parameters with Corresponding BOEM COP Requirements and Guidelines (BOEM 2019, 2020b; NOAA Habitat 2021)

BOEM COP Guidelines and *NOAA† Recommendations*	Parameters Derived from PV Images	Parameters Derived from SPI Images
Classification of CMECS sediment type Grain size analysis	CMECS Substrate Group CMECS Substrate Subgroup Gravel measurements	CMECS Substrate Subgroup Sediment type (based on grain size major mode)
Identification of distinct horizons in subsurface sediment	None	Sediment type (based on grain size major mode) Apparent Redox Potential Discontinuity (aRPD)*
Delineate hard bottom substrates	CMECS Substrate Group CMECS Substrate Subgroup	Sediment type (based on grain size major mode)
Identification of bedforms Characterization of physical hydrodynamic properties	Bedform type	Boundary roughness
Identification of rock outcrops and boulders Characterization and delineation of any hard bottom gradients of low to high relief such as coral (heads/reefs), rock or clay outcroppings, or other shelter-forming features	CMECS Substrate Group CMECS Substrate Subgroup Gravel measurements	None
Characterization of benthic habitat attributes	Gravel measurements Sediment Descriptor* Macrohabitat	aRPD* Prism penetration depth Sediment oxygen demand and proxies (methane, *Beggiatoa*)
Classification to CMECS Biotic Component to lowest taxonomic unit practicable	CMECS Dominant Biotic Subclass CMECS Co-occurring Biotic Subclass	None
Characterization of benthic community composition (identify and confirm benthic species (flora and fauna) that inhabit the area) Identification of communities of sessile and slow-moving marine invertebrates (clams, quahogs,	CMECS Dominant Biotic Subclass CMECS Co-occurring Biotic Subclass Epifauna* Sensitive taxa Attached Flora/Fauna Percent Cover* Burrows/Tubes/Tracks	Epifauna* Sensitive taxa Tubes/Voids Successional Stage*

BOEM COP Guidelines and *NOAA*† *Recommendations*	Parameters Derived from PV Images	Parameters Derived from SPI Images
mussels, polychaetes, anemones, sponges, echinoderms) *Identification of potentially sensitive seafloor habitat* *Identification of important biogenic habitats:* • *Hard bottom substrates with epifauna* • *Hard bottom substrates with macroalgae* • *Submerged aquatic vegetation (seagrass)* • *Long-lived and habitat forming taxa (e.g. emergent fauna)*	Macrohabitat	

† NOAA Habitat Recommendations are indicated by use of italicized characters and support BOEM Guidelines with further detail.

* Indicates variable that is a CMECS modifier. CMECS Modifiers provide additional detail to further characterize habitat components using a consistent set of definitions.

Table 2-2. CMECS Classification Levels Used in Analysis and Classifications for the Revolution Wind SPI/PV Survey in the RWF

CMECS Term	Scale of Classification	Classifications
Substrate Component		
Substrate Origin	Site	Geologic Substrate
Substrate Class	SPI/PV	Unconsolidated Mineral Substrate
+Substrate Subclass	SPI/PV	**Fine Unconsolidated Substrate**; Coarse Unconsolidated Substrate
+Substrate Group	PV	**Sand or finer;** Slightly Gravelly; Gravelly; Gravel Mixes; Gravel
+Substrate Subgroup	SPI/PV	Very Fine Sand; Fine Sand; Medium Sand; Coarse Sand; Slightly Gravelly Sand; Gravelly Sand; Sandy Gravel; Granule, Cobble
Biotic Component		
Biotic Setting	SPI/PV	Benthic/Attached Biota
Biotic Class	SPI/PV	Faunal Bed
Biotic Subclass	SPI/PV	**Soft Sediment Fauna**; Attached Fauna; Inferred Fauna
+Biotic Group	SPI/PV	**Larger Tube-Building Fauna; Larger Deep-Burrowing Fauna**; Small Tube-Building Fauna; Small Surface-Burrowing Fauna; Attached Hydroids; Mobile Crustaceans on Hard or Mixed Substrates; Diverse Colonizers; Barnacles

+ Indicates variability within the surveyed area at this level of the hierarchy.

Bold text indicates an overwhelming dominant classification across the surveyed area.

Table 2-3. CMECS Classification Levels Used in Analysis and Classifications for the Revolution Wind SPI/PV Survey in the RWEC–OCS Study Area

CMECS Term	Scale of Classification	Classifications
	Substrate Component	
Substrate Origin	Site	Geologic Substrate
Substrate Class	SPI/PV	Unconsolidated Mineral Substrate
+Substrate Subclass	SPI/PV	Fine Unconsolidated Substrate; Coarse Unconsolidated Substrate
+Substrate Group	PV	Sand or finer; Slightly Gravelly; Gravel Mixes; Gravel
+Substrate Subgroup	SPI/PV	Very Fine Sand; Fine Sand; Medium Sand; Coarse Sand; Slightly Gravelly Sand; Sandy Gravel; Pebble, Cobble
	Biotic Component	
Biotic Setting	SPI/PV	Benthic/Attached Biota
Biotic Class	SPI/PV	Faunal Bed
Biotic Subclass	SPI/PV	**Soft Sediment Fauna**; Attached Fauna; Inferred Fauna
+Biotic Group	SPI/PV	Larger Tube-Building Fauna; Larger Deep-Burrowing Fauna; **Small Tube-Building Fauna**; Attached Hydroids; Barnacles

+ Indicates variability within the surveyed area at this level of the hierarchy.
Bold text indicates an overwhelming dominant classification across the surveyed area.

Table 2-4. CMECS Classification Levels Used in Analysis and Classifications for the Revolution Wind SPI/PV Survey in the RWEC–RI Study Area

CMECS Term	Scale of Classification	Classifications
	Substrate Component	
Substrate Origin	Site	Geologic Substrate
+Substrate Class	SPI/PV	**Unconsolidated Mineral Substrate;** Shell Substrate
+Substrate Subclass	SPI/PV	**Fine Unconsolidated Substrate**; Shell Reef Substrate; Shell Hash
+Substrate Group	PV	Sand or finer; Slightly Gravelly
+Substrate Subgroup	SPI	**Very Fine Sand**; Fine Sand; Medium Sand; Coarse Sand; Slightly Gravelly Sand; Shell Hash; Crepidula Reef Substrate
	Biotic Component	
Biotic Setting	SPI/PV	Benthic/Attached Biota
+Biotic Class	SPI/PV	**Faunal Bed;** Aquatic Vegetation Bed
+Biotic Subclass	SPI/PV	**Soft Sediment Fauna**; Attached Fauna; Inferred Fauna; Benthic Macroalgae
+Biotic Group	SPI/PV	**Larger Deep-Burrowing Fauna;** Larger Tube-Building Fauna; Small Tube-Building Fauna; Tracks and Trails; Attached Hydroids; Attached Sponges; Mussel Bed; Sessile Gastropods; Tunneling Megafauna; Filamentous Algal Bed

+ Indicates variability within the surveyed area at this level of the hierarchy.

Bold text indicates an overwhelming dominant classification across the surveyed area.

2.2 Habitat Mapping Approach

Geophysical and ground-truth data were reviewed in an iterative process to delineate benthic habitats. MBES data, viewed as backscatter draped over a hillshaded bathymetric relief model, was used at a “zoomed out” scale (~1:10,000) to identify large-scale facies – areas of sedimentary characteristics (reflectance, bedform, slope) distinct from those adjacent (Figure 2-17). These initial delineations were further refined at “zoomed in” scales (~1:2,000 or finer) using the MBES data in combination with SSS, boulder picks, and ground-truth data (Figure 2-17). Delineations must be of a size appropriate both to the resolution of the data and to the subject of interpretation. For these purposes, a minimum mapping unit (mmu) is defined as “the smallest size areal entity to be mapped as a discrete entity” (Lillesand et al. 2015). Minimum mapping units, the resolution of the geophysical data, and the use the CMECS Substrate Component meet agency recommendations (NOAA Habitat 2021).

2.2.1 Geological Seabed Characterization

Revolution Wind developed information on the geological seabed to characterize the geological provenance and stratigraphic conditions of the seafloor inclusive of surface and subsurface features. Methods used to collect this information included MBES bathymetry and backscatter, SSS, sub-bottom profile, magnetometer, and seismic profile data, along with vibracores. For the purposes of defining geological seabed types present at the sediment surface, the Folk classification (Folk 1954) was used, which aligns with CMECS Substrate classifications (Figure 2-18). Seabed types present within the Project Area based solely on this scheme are Mud and Sandy Mud, Sand and Muddy Sand, Coarse Sediment, and Mixed Sediment. In addition, areas of the seabed of unconsolidated and consolidated glacial drift deposits were mapped as Glacial Moraine and exposed bedrock was mapped as such. Anthropogenic features, such as dredged material and debris from the former Jamestown Bridge were also mapped as such. The geological seabed characterization map was developed using a minimum mapping unit of 4,000 m^2.

2.2.2 Delineation of Benthic Habitat Types

Geological characterizations of seabed conditions are not strictly equivalent to benthic habitats as experienced by benthic biological communities and demersal fish. To map these habitats for the purposes of assessing the potential impacts of the Project on these biotic communities, INSPIRE refined the seabed interpretations to map benthic habitats with a minimum mapping unit of 2,000 m^2 within the Project Area. Multibeam 50-cm resolution bathymetry, 25-cm resolution backscatter, and 10-cm SSS data were examined along with boulder picks and SPI/PV data (Figure 2-19) to delineate new habitat polygons and to refine the seabed classifications for the purposes of evaluating benthic habitats (Figures 2-20 and 2-21).

Specifically, modifiers were used to provide additional descriptive information about the benthic habitats found within the Project Area; CMECS modifiers and Geoform or Substrate terms were used to the extent practicable. These modifiers include features of the seafloor that are relevant to the biota that utilize these habitats and describe the value of the habitats for these biota beyond what is provided in the geological seabed mapping. Modifiers are related to features that describe the mobility, stability, and complexity of the benthic habitats mapped. Where bedforms indicating frequent physical disturbance of the seafloor were observed, the “Mobile” modifier was used. Boulder fields mapped by Fugro were used to refine habitat boundaries and applied as modifiers, except where they overlapped with glacial habitats, as these habitats are all characterized by high densities of boulders. Shell substrate (living or non-living shells) and SAV both provide unique habitats for certain species of benthic invertebrates and demersal fish; modifiers have been applied for both.

Mixed Sediment is a broadly defined category used for the geological seabed interpretation (Figure 2-18). As defined, Mixed Sediment could include Muddy Sand with a small gravel component or a gravel pavement with a thin deposition of mud. In the process of refining seabed interpretations into well-characterized benthic habitats, those areas mapped as Mixed Sediments were examined closely and a more descriptive name (Mixed-Size Gravel in Muddy Sand) was applied.

Glacial moraine habitats do not fit neatly into the Folk or CMECS classification schemes (Figure 2-18) and modifiers were not applied to these habitats as they were to those described above. Glacial moraines are complex and heterogeneous environments with characteristic surface and subsurface features that relate to their glacial origin. The surface benthic habitats associated with glacial moraines often provide valuable habitat for sessile and mobile benthic invertebrates and for demersal fish. Glacial moraine habitats are presented as two types (A and B), in order to distinguish unconsolidated glacial moraine deposits (A) from consolidated moraine habitats that have high structural complexity and structural permanence (B).

All habitats and their distributions within the Project Area are described in more detail in Section 3.0. For the purposes of aiding interpretation and presentation of data in ground-truth tables, individual benthic habitat types with modifiers have been grouped and color-coded to consolidate types of related habitats that are present in very small areas (Table 2-5). In addition to the habitat data present on maps in this report, the geospatial data contain separate attributes to record several other features of each habitat polygon: type of bedforms observed, area, presence of scattered boulders and debris, and refinements of Coarse Sediment habitats. In addition to the natural bedforms defined in the BOEM Geophysical Survey Guidelines (2020a): mega-ripples = 5 - 60 m wavelength and 0.5 - 1.5 m height; ripples = <5 m wavelength and <0.5 m height; other bedforms such as linear depressions and trawl marks were noted where present. The presence of isolated boulders and debris identified by Fugro in the geophysical analysis (boulder picks and debris contacts) were noted as “scattered boulders and debris” in the habitat data. Additionally, further characterizations of Coarse Sediment habitat polygons were recorded as “coarse sediment refinements” to provide additional detail on the nature of coarse sediment (e.g., gravelly sand or sandy gravel) where it could be reliably determined from ground-truth and geophysical data. These refinements were only applied to polygons in which ground-truth SPI/PV stations were located. These data are available in the interactive Popup map, which was made available to BOEM and NOAA Habitat.

2.3 Benthic Habitat to EFH Crosswalk

Essential fish habitat (EFH) is implemented through the Magnuson-Stevens Fishery Conservation and Management Act. In the Mid-Atlantic and northeastern United States, the New England and Mid-Atlantic Fishery Management Councils (Councils) work with NOAA Fisheries to identify and describe EFH in published fisheries management plans. To evaluate the potential impacts to EFH for individual species/life stages resulting from activities that directly impact benthic habitats, it is important to identify which benthic habitat types fit the descriptions of habitat use for each EFH species/life stage. Therefore, a crosswalk between benthic habitat types and EFH was conducted. For the purposes of this analysis, a crosswalk is defined as the process of reviewing species with mapped EFH in the Project Area and comparing their habitat preferences with the mapped benthic habitat types described in Sections 3.1 and 3.2 to identify where EFH for those species are likely to be found. Primary benthic habitat types were used for the crosswalk with additional columns for boulders, shell substrate, and SAV (Attachment C); habitats with modifiers were not used for the crosswalk because the level of detail supporting EFH designations is rarely available at a level that matches the detail provided by modifiers. The crosswalk includes all three offshore components of the Project Area: the RWF, the RWEC–OCS Study Area, and the RWEC–RI Study Area.

EFH maps, data, and text descriptions were downloaded from the NOAA Habitat Conservation EFH Mapper, an online mapping application (NOAA Fisheries 2021a). Additional EFH source information was gathered from the Northeast Fisheries Science Center's series of "EFH source documents" that contain a compilation of available information on the distribution, abundance, and habitat requirements for each species managed by the Councils (NOAA Fisheries 2021b). EFH is defined by temperature, salinity, pH, physical structure, biotic structure, depth, and currents. While all these habitat variables are important to consider in the greater context of fisheries management, the focus for this report was to create a crosswalk among individual species EFH and mapped benthic habitats. The crosswalk focused on the mapped variables of physical structure, biotic structure, and depth. In addition, only demersal species and life stages were crosswalked for this report.

EFH data for all Council-managed species were queried using GIS software to determine where each species' EFH overlaps with the Project Area. Available EFH source information was then reviewed to determine habitat requirements for each demersal species/life stage. These requirements were then crosswalked to each of the Project Area habitats based on detailed characterizations and spatial distributions (See Sections 3.1 and 3.2) to determine if the substrate, biotic structure, and depth requirements for each species/ life stage were likely to be found within a given mapped benthic habitat type.

2.4 Calculating Potential Project Impacts to Benthic Habitats

NOAA Habitat recently provided updated habitat mapping recommendations (March 2021), which requests that the maximum potential acres that may be impacted by the Project be inventoried in terms of the NOAA Habitat Complexity Categories outlined in these recommendations. These habitat complexity categories were defined by NOAA Habitat for the purposes of EFH consultation. The NOAA Habitat Complexity Categories include soft bottom, complex, heterogeneous complex, and large-grained complex (large boulders). For purposes of the EFH consultation, NOAA has defined complex habitats as SAV and sediments with >5% cover of gravel of any size (CMECS Substrate Class Rock, CMECS Substrate Groups of Gravelly, Gravel Mixes, and Gravels, as well as Shell Substrate CMECS classifications). Heterogenous complex is used for habitats with a combination of soft bottom and complex features. To provide an impact assessment of the Study Area in terms of NOAA Habitat Complexity Categories, the benthic habitats delineated by Revolution Wind and detailed here have been crosswalked to the NOAA Habitat Complexity Categories. This crosswalk was used to calculate acres of each habitat category that may be impacted by Project activities.

Project activities with the potential to impact the seafloor during construction include installation of foundations for up to 100 WTGs and 2 OSSs, connected by a network of up to 250 km of IACs plus an OSS-Link Cable that will be a maximum of 15 km in length, and up to two export cables generally co-located within a single corridor up to 67 km long. During Operations & Maintenance, disturbance to the seafloor could result from the presence of infrastructure and temporarily anchored maintenance vessels. Over the life of the Project, the placement of foundations and scour protection will alter the seabed and associated habitat by replacing the existing seabed and habitat with hard structures that create a reefing effect, which results in colonization by assemblages of both sessile and mobile animals. Decommissioning activities will have similar impacts to the seafloor as construction.

Project activities, design parameters, and associated potential impacts through seafloor disturbance are presented in detail in the Volume I, Section 3 of the COP (Revolution Wind, LLC 2021a). Specific Project components evaluated for seafloor disturbance include:

- RWF:
    - Foundations (see Figure 2-22):
        - Up to 100 WTG monopile foundations, each with a 12-m diameter
        - 2 OSS foundations, each with a 15-m diameter
        - Scour Protection and Cable Protection System (CPS) stabilization for IACs associated with each foundation (extending in a ring around the foundation up to 30 m from the foundation center point in each direction (24-m ring around each WTG, 22.5-m ring around each OSS, the CPS stabilization would extend an additional 12 m from the edge of the scour protection and would be 12 m wide. The number of IACs per foundation will vary)
        - Seafloor preparation area for each foundation inclusive of planned permanent structures; 200-m radius from the center point of each foundation
    - IACs:

    - Cable protection, where needed, 12-m width across cable centerline
    - Cable installation and seafloor preparation corridor, inclusive of sand wave level and boulder clearance where needed, 40-m width across cable centerline (inclusive of area where cable protection may be placed)
    - Cable burial trials may also be performed; these trials would occur within the 40-m wide cable installation and seafloor preparation corridor
    - Support activities, such as anchoring or use of barges, may be needed to support installation. If anchoring (or a pull ahead anchor) is necessary during cable installation it will occur within the area surveyed and mapped to support the Project.

- RWEC–OCS:
  - Export cable, 2 cables generally co-located within a single corridor up to 30 km long, but typically spaced greater than 164 ft (50 m) apart where practical
    - Cable protection, where needed, 12-m width across each cable centerline
    - Cable installation and seafloor preparation area, inclusive of sand wave level and boulder clearance where needed, 40-m width across each cable centerline (inclusive of area where cable protection may be placed)
    - Additional preparation area for installation of up to 2 omega joints (one per cable), each up to 250m in length, within a 205-m wide corridor (165-m in addition to the standard 40-m corridor)
    - Cable burial trials within the RWEC–OCS Study Area; up to 5 trial locations (a maximum of 10 for the entire RWEC, division between federal and state waters is not yet determined and an even split is assumed), each up to 250m in length, within a 40-m wide corridor
    - Support activities, such as anchoring or use of barges, may be needed to support installation. If anchoring (or a pull ahead anchor) is necessary during cable installation it will occur within the area surveyed and mapped to support the Project.
- RWEC–RI:
  - Export cable, 2 cables generally co-located within a single corridor up to 37 km long, but typically spaced greater than 164 ft (50 m) apart where practical
    - Cable protection, where needed, 12-m width across each cable centerline
    - Cable installation and seafloor preparation area, inclusive of sand wave level and boulder clearance where needed, 40-m width across each cable centerline (inclusive of area where cable protection may be placed)

    - Additional preparation area for installation of up to 2 omega joints (one per cable), each up to 250 m in length, within a 205-m wide corridor (165-m in addition to the standard 40-m corridor)
    - Cable burial trials within the RWEC–OCS Study Area; up to 5 trial locations (a maximum of 10 for the entire RWEC, division between federal and state waters is not yet determined and an even split is assumed), each up to 250 m in length, within a 40-m wide corridor
    - Support activities, such as anchoring or use of barges, may be needed to support installation. If anchoring (or a pull ahead anchor) is necessary during cable installation it will occur within the area surveyed and mapped to support the Project.
- Landfall HDD
    - Up to two HDD exit pits, each extending over approximate 0.4 acres, , including grading from the seafloor surface to the base of the pit
    - Support activities, such as anchoring or use of barges, may be needed to support installation. If anchoring (or a pull ahead anchor) is necessary during cable installation it will occur within the area surveyed and mapped to support the Project.

Table 2-5. Color-coded key to Benthic Habitat Types with Modifiers and Related Groupings for Ground-truth Tables and Plot

Habitat Type	Color	Grouped Color	Grouped Habitat Type
Glacial Moraine B Glacial Moraine A			Glacial Moraine
Mixed-Size Gravel in Muddy Sand with Medium Density Boulder Field Mixed-Size Gravel in Muddy Sand with Low Density Boulder Field			Mixed-Size Gravel in Muddy Sand with Boulder Field
Mixed-Size Gravel in Muddy Sand			not grouped
Coarse Sediment with Medium Density Boulder Field Coarse Sediment with Low Density Boulder Field Coarse Sediment - Mobile with Medium Density Boulder Field Coarse Sediment - Mobile with Low Density Boulder Field			Coarse Sediment with Boulder Field
Coarse Sediment - Mobile			not grouped
Coarse Sediment			not grouped
Sand and Muddy Sand with Medium Density Boulder Field Sand and Muddy Sand with Low Density Boulder Field Sand and Muddy Sand - Mobile with Medium Density Boulder Field Sand and Muddy Sand - Mobile with Low Density Boulder Field			Sand and Muddy Sand with Boulder Field
Sand and Muddy Sand - Mobile			not grouped
Sand and Muddy Sand - Delta			not grouped
Sand and Muddy Sand			not grouped
Mud and Sandy Mud with Low Density Boulder Field			not grouped
Mud and Sandy Mud with Shell Substrate			not grouped
Mud and Sandy Mud with SAV			not grouped
Mud and Sandy Mud - Mobile Mud and Sandy Mud			Mud and Sandy Mud
Bedrock			not grouped
Anthropogenic			not grouped

Individual benthic habitat types with modifiers have been grouped and color-coded to consolidate types of relative habitats that are present in very small amounts within the respective project areas (RWF, RWEC–RI, or RWEC–OCS); grouped colors are also used in statistical plots and ground-truth tables.

3.0 RESULTS

3.1 Benthic Habitat Types

Seven primary benthic habitat types were mapped within the Project Area: Glacial Moraine A, Glacial Moraine B, Mixed-Size Gravel in Muddy Sand, Coarse Sediment, Sand and Muddy Sand, Mud and Sandy Mud, and Bedrock. When habitats were updated with modifiers, a total of 24 habitat types were mapped within the Project Area (15 within the RWF, 15 within the RWEC–OCS Study Area, and 16 within the RWEC–RI Study Area). In addition, Anthropogenic Features were mapped in several locations near the proposed landfall location, near the Jamestown Bridge, and in one small discrete area in the RWF. Overall descriptions of each habitat type as observed across the Project Area are provided below and descriptions of spatial distribution within the RWF, the RWEC–OCS Study Area, and the RWEC–RI, respectively, are provided in Section 3.2. Spatial distributions and characteristics of the benthic habitat types are summarized in Table 3-1 for the RWF, in Table 3-3 for the RWEC–OCS Study Area, and Table 3-5 for the RWEC–RI Study Area. CMECS Substrate and Biotic component classifications derived from SPI/PV ground-truth data at stations located within the various benthic habitats are presented in Table 3-2 for the RWF, Table 3-4 for the RWEC–OCS Study Area, and in Table 3-6 for the RWEC–RI Study Area. The color key presented in Table 2-5 is utilized in all of these tables. A range of substrate and biotic communities were present within each benthic habitat category as expected, given the differences in observation scale between geophysical data and ground-truth point samples (Tables 3-2, 3-4, and 3-6). Full data results by station are provided in Attachment A.

3.1.1 Glacial Habitats: Bedrock, Moraine A & B, & Mixed-Size Gravel in Muddy Sand

Many of the habitats within the Project Area have their origin in the region’s glacial history. Glaciation results in characteristic geologic remnants indicate how glaciers sculpted the landscape and seascape. Four of the primary benthic habitat types mapped for the present assessment are direct remnants of glaciation that remain present at the seafloor surface. These habitat types are Bedrock, Glacial Moraine A, Glacial Moraine B, and Mixed-Size Gravel in Muddy Sand.

In offshore federal waters at and near the Project Area, moraine deposits related to various glacial events have been recognized. Glacial moraines are complex landforms associated with deposition of sediment carried by glaciers during advance and retreat. Typically, they consist of unstratified drift (till or diamicton) but may have a complex structure with stratified drift interbedded with till and abundant erratic boulders (Bennet and Glasser 2009). Till is characteristically composed of a poorly sorted mix of pebbles, cobbles and/or boulders within a fine-grained matrix of silt and clay. Till has a wide range of origins including supraglacial and subglacial that affect the nature of the deposits (Bennet and Glasser 2009). It displays distinctive patterns in geophysical data with a wide range of geotechnical properties depending upon the processes that formed it (O´Cofaigh et al. 2007). In southern New England, the glacial moraine landform has a topographic pattern where higher topographic areas can be formed by coarser grained sediment (e.g., cobbles and boulders) derived from patches of basal till deposited when the ice advanced across the moraine prior to retreat (Oldale and O'Hara 1984). Deposits on the surface of glacial moraine landforms can be a mix of till, stratified drift, and reworked sediments derived from the glacial deposits and subsequent marine transgression. Subsurface expressions of glaciation are present in the Project Area and are reviewed in detail in the Marine Site Investigation Report (Revolution Wind, LLC 2021b); only the surface expression of these geologic features represent benthic habitats and are of relevance to the assessment presented here.

It is generally accepted that Cox Ledge, located near the RWF, represents part of a terminal, or end, moraine of Late Wisconsinan glaciation, a complex structure of glacial-tectonic origin that may have heterogeneous patterns of seabed types (Oldale and O'Hara 1984). This terminal moraine complex is known as the Ronkonkoma Moraine and dates to 23,000 thousand years ago (kya), and another end moraine complex, the Harbor Hill Moraine, dating to ~18,000 kya is located northwest of the RWF and intersects the RWEC–OCS Study Area (Revolution Wind, LLC 2021b). Benthic habitats related to both of these moraines were mapped in offshore waters, with Glacial Moraines A and B mapped in the RWF coincident and proximal to the modeled location of the Ronkonkoma Moraine and Mixed-Size Gravel in Muddy Sand mapped proximal to the modeled location of the Harbor Hill Moraine (Figure 3-1). The physical and biological characteristics of each of these habitats is discussed below.

In state waters, Narragansett Bay and Rhode Island Sound were once both glacial lakes and Narragansett Bay is a drowned river valley that was shaped by actions of the Laurentide ice sheet during the last glacial period (~18,000 years ago). Channels cut by the ice are evident in the channels of the West and East Passages of the Bay on either side of Conanicut Island. Deglaciation and modern geological action have continued to influence the seafloor and benthic habitats found within Narragansett Bay and Rhode Island Sound. Within Rhode Island state waters, moraine and bedrock features were generally present as discrete surface outcroppings and reefs.

Glacial Moraine A, Glacial Moraine B, and Bedrock all have distinct geophysical signatures (Figure 3-2). Due to the presence of very coarse and poorly sorted sediment, the seabed of these habitat types generally exhibits high reflectance in backscatter data, and SSS data reveal distinct characteristics of each glacial habitat. Bedrock habitats consist of exposed outcroppings of bedrock, either present as solitary outcrops or in groupings of large bedrock outcrops (Figure 3-2). Glacial Moraine habitats, on the other hand, are complex habitat classification categories composed of consolidated and unconsolidated geologic debris directly deposited by glacial movement (rather than reworking from meltwaters or transgressive seas) and are limited in distribution along the outer continental shelf near New England.

A distinction was made between Glacial Moraine A and Glacial Moraine B habitats to distinguish between areas of unconsolidated geological debris (A) and consolidated geological debris (B). The surface of Glacial Moraine B deposits appeared poorly sorted and dense with very high boulder densities resulting in greater structural complexity and permanence. By comparison, the surfaces of Glacial Moraine A units have been reworked with sand and gravel deposits resulting in less structural complexity and permanence. More specifically, Glacial Moraine B habitats are characterized by marked topographic relief, highly consolidated cobble and boulder features that commonly lack loose / mobile cover sediments (Figure 3-2), and, in locations further offshore, evidence of topographic striations oriented NNW-SSE. In contrast, densities of boulders are generally lower and distribution of cobbles and boulders is more dispersed and patchy within Glacial Moraine A habitats (Figures 3-2 and 3-3). The seabed of Glacial Moraine A habitats is typically irregular and contains loose mobile sediments near/at the boulders, which can also display morphological features (ripples) (Figure 3-3). Generally, however, boulders appear chaotic with no apparent structural pattern (Figure 3-3). Because medium to high density boulder fields are typically a characteristic of both of these moraine habitats, boulder field modifiers were not applied to Glacial Moraine A and B habitat types.

Sediments sampled with SPI/PV within Glacial Moraine A and B habitat types include sand, mixed sand and gravel, small gravel, and areas with medium to high densities of cobbles and boulders (Tables 3-2 and 3-6). Ripples were also present within these habitats, with a higher percentage of habitat polygons containing ripples in the offshore waters, where glacial moraine habitats were larger than in state waters (Tables 3-1 and 3-5). Although the density of cobbles and boulders was generally high in areas designated as Glacial Moraine A, the areas of high density are rarely continuous; rather, distribution of cobbles and boulders is patchy; therefore, a high degree of heterogeneity was observed among ground-truth sampling within Glacial Moraine A and B habitat types (Tables 3-2 and 3-5). The 34 ground-truth stations sampled within Glacial Moraine A and B habitats in the RWF capture the range and heterogeneity of sediment types and biota found within these habitats (Table 3-2). Notably, the highest percent cover of Attached Fauna was Complete (90-100%) and a range of sessile and mobile epifauna were observed, including the sensitive taxa of the northern star coral (Table 3-2).

Glacial Moraine A habitats were prevalent, representing 19% of the mapped area of the RWF (Table 3-1), and Glacial Moraine B habitat type was limited in distribution in the RWF (0.2%; Table 3-1). Glacial Moraine A and B habitats were also limited in distribution in the RWEC–OCS Study Area (0.6% for Glacial Moraine A and 0.04% for Glacial Moraine B; Table 3-3) and in the RWEC–RI Study Area (1.5% for Glacial Moraine A and 0.9% for Glacial Moraine B; Table 3-5). Within Rhode Island state waters, these moraine habitats were generally present as discrete surface outcroppings and reefs. No ground-truth SPI/PV stations were sampled in Glacial Moraine A habitats and only one was sampled in Glacial Moraine B habitats (Table 3-6). At that one station, the CMECS Substrate Subgroup was Slightly Gravelly Sand and a mix of CMECS Biotic Subclasses Soft Sediment Fauna and Attached Fauna (barnacles, sponges) were observed (Table 3-4).

The Mixed-Size Gravel in Muddy Sand habitat is a unique habitat composed of gravels ranging from pebbles to boulders embedded in a muddy sand matrix (Table 3-4; Figure 3-4). The seafloor of this habitat type exhibited generally medium-high to high reflectance values in backscatter data and a mix of reflectance and textures in SSS data, with occasional ripples and linear depressions (Table 3-3; Figure 3-4). Three SPI/PV ground-truth stations were sampled within Mixed-Size Gravel in Muddy Sand habitats, all Substrate Subgroups included high percent cover of gravel components and supported Attached Fauna with a maximum coverage of Dense (70 – 90%) (Table 3-4). In addition, one very small (~0.01 acres) area of Mixed-Sized Gravel in Muddy Sand habitat was identified from aerial imagery along the shoreline west of the landfall location in Quonset Point.

3.1.2 Coarse Sediment Habitats

Coarse Sediment habitat types encompass sands with varying degrees of gravel. The Coarse Sediment – Mobile habitat type describes these sand and gravel habitats where the seafloor is subjected to small, but frequent currents and storm events and is common on the outer continental shelf. The seafloor within these habitats is characterized by distinct and regular ripples visible in the SSS data (Figure 3-5). The seafloor of these Coarse Sediment habitat types exhibited generally medium to high reflectance values in backscatter and SSS data (Figure 3-6). The Coarse Sediment – Mobile habitat type was prevalent at the RWF, representing 21% of the mapped area of the RWF (Table 3-1). Coarse Sediment and Coarse Sediment – Mobile habitats were prevalent within the RWEC–OCS Study Area representing a combined ~21% of the mapped area (12% Mobile, 9.3% Coarse Sediment; Table 3-3). Coarse Sediment habitats within the RWEC–RI Study Area were limited in distribution (<3%, Table 3-5) and were generally discrete in size, often present as depressions on the seafloor surrounded by sand (Figure 3-7); depressions were most evident in bathymetric data and the coarser nature of the sediment was evident in backscatter data. Coarse Sediment habitats with Low or Medium Density Boulder Field were limited in distribution throughout the Project Area (<6% at RWF, <2% in RWEC–OCS, <0.1% in RWEC–RI; Tables 3-1, 3-3, and 3-5). Examples of Low and Medium Density Boulder Fields are provided in Figure 3-8. In a number of cases in the offshore waters of the Project Area, ground-truth data supported a refinement of coarse sediment to Gravelly Sand (Figure 3-9) and, in fewer instances, Sandy Gravel (Figure 3-10).

Coarse Sediment habitats were well sampled by SPI/PV in the RWF with a total of 61 stations sampled (40 in Coarse Sediment – Mobile; 18 in Coarse Sediment with Boulder Fields, and three in Coarse Sediment; Table 3-2). These stations were categorized by a range of sandy and gravelly sediments with variable cover of gravel (as expected per definition, see Section 2.2) and support a variety of sessile and mobile epifauna (Table 3-2). The maximum percent cover of Attached Fauna ranged from Sparse in Coarse Sediment – Mobile habitats to Moderate and Dense in Coarse Sediment with Boulder Fields and Coarse Sediment habitats (Table 3-2). Four ground-truth SPI/PV stations sampled Coarse Sediment habitats along the RWEC, two each in the RWEC–OCS and RWEC–RI Study Areas, respectively (Tables 3-4 and 3-6). These stations were characterized by the CMECS Substrate Subgroups Fine Sand, Coarse Sand, and Slightly Gravely Sand, as well as a mix of CMECS Biotic Subclasses Soft Sediment Fauna and Inferred Fauna (tracks and trails of mobile epifauna) (Tables 3-4 and 3-6). Taxa were generally comprised of amphipods (infauna; Attachment A), and mobile crustaceans and mollusks (epifauna; Tables 3-2, 3-4, and 3-6; Figure 2-15).

3.1.3 Sand and Muddy Sand Habitats

The Sand and Muddy Sand habitat types consist of sand that has been subjected to a wide range of oceanic processes. These habitat types are very common on the outer continental shelf and were widespread at the RWF, in the RWEC–OCS Study Area, and in the RWEC–RI Study Area (Tables 3-1, 3-3, and 3-5). The Muddy Sand included in this category has a high sand to mud ratio, ranging from an 8:2 sand to mud ratio to 100% sand (Figure 2-18). The seafloor of these habitats exhibited a range of values in backscatter and SSS data reflectance but were predominantly low to medium (Figures 3-6 and 3-11). The Sand and Muddy Sand – Mobile habitat type describes these sandy habitats where the seafloor is subjected to small but frequent currents and storm events where ripples and/or mega-ripples are prevalent (Figure 3-5).

Sand and Muddy Sand habitats comprise close to half of the area mapped at the RWF (38% Sand and Muddy Sand, 10% - Mobile, and <3% with Boulder Fields; Table 3-1), the majority of the area mapped with the RWEC–OCS Study Area (37% - Mobile, 17% Sand and Muddy Sand, and <5% with Boulder Fields; Table 3-3), and approximately 40% of the area mapped within the RWEC–RI Study Area (23% - Mobile, 15% Sand and Muddy-Sand, and <1% with Boulder Fields; Table 3-5). In addition, sandy habitats within the RWEC–RI Study Area also included a small delta near the shoreline at Quonset Point (Table 3-5).

Sand and Muddy Sand habitats were well sampled by SPI/PV in the Project Area (131 stations RWF, 8 stations RWEC–OCS, 13 stations RWEC–RI; Tables 3-2, 3-4, and 3-6).

The sediments within these habitats were generally composed of Fine and Medium Sands, with fewer ground-truth stations classified as Very Fine, Coarse, or Slightly Gravelly Sand, and four stations classified as Gravelly Sand and one as Sandy Gravel (Attachment A; Tables 3-2, 3-4, and 3-6). The CMECS Biotic Subclasses of Soft Sediment Fauna was the predominant Biotic Subclass within the Sand and Muddy Sand habitats and Benthic Macroalgae was the predominant Subclass at one station in Narragansett Bay; Attached Fauna and Inferred Fauna (epifaunal tracks and trails) were also observed as co-occurring Subclasses (Attachment A; Tables 3-2, 3-4, and 3-6). Soft Sediment Taxa were generally comprised of large and small burrowing taxa, large and small tube-building taxa, amphipods (infauna; Attachment A), and mobile crustaceans and mollusks epifauna; Tables 3-2, 3-4, and 3-6; Figure 2-15).

3.1.4 Mud and Sandy Mud Habitats

The Mud and Sandy Mud habitat types consist of relatively featureless mud and sand, except where described by modifiers for boulder fields, shell substrate, and SAV. The sand to silt/clay ratio within these habitat types is expected to be less than 8:2 (Figure 2-18). The seafloor of these habitats exhibited predominantly low backscatter and SSS data reflectance (Figure 3-11) indicating that the surface is less dense and the sediments more fine-grained compared to other habitat types. Mud and Sandy Mud habitat was limited at the RWF (2.5%; Table 3-1), relatively prevalent within the RWEC–OCS Study Area (~13%; Table 3-3), and represented the majority of the seafloor mapped within the RWEC–RI Study Area (44% Mud and Sandy Mud, 11% with

Shell Substrate, <1% with Boulder Fields, <1% with SAV; Table 3-5). Backscatter values were higher and of medium reflectance in one area in Narragansett Bay where Shell Substrate was evident in ground-truth data and was used as a modifier to these habitats (11% of RWEC–RI; Tables 3-5 and 3-6; Figure 3-12). These Shell Substrates were composed of both living and dead mollusks (Table 3-6; Figures 2-14I, 2-15C, and 2-15D) namely blue mussels and Crepidula. These habitats also support mobile mollusks and crustaceans (Table 3-6). A very small area of Mud and Sandy Mud with SAV habitat was observed and mapped near the shoreline at Quonset Point in Narragansett Bay based on aerial imagery and ground-truth video data (0.2 acres Table 3-5; Figure 3-13). Trawl marks related to fishing activity were also observed within many of the Mud and Sandy Mud habitats mapped (Tables 3-1, 3-3, and 3-5; see Figure 3-10 for an example).

Mud and Sandy Mud Habitats were well-sampled with six SPI/PV ground-truth stations sampled at the RWF, four within the RWEC–OCS Study Area, and 13 in the RWEC–RI Study Area (Tables 3-2, 3-4, and 3-6). Five stations were sampled within Mud and Sandy Mud with Shell Substrate habitats within the RWEC–RI Study Area (Table 3-6). The sediments within these habitats were generally composed of very fine sands and silt/clay (Attachment A; Tables 3-2, 3-4, and 3-6). The CMECS Biotic Subclasses of Soft Sediment Fauna and Inferred Fauna were observed within Mud and Sandy Mud habitats (Tables 3-2, 3-4, and 3-6). Of these, Soft Sediment Fauna were observed most frequently, with Inferred Fauna (epifaunal tracks and trails) generally observed as the co-occurring Subclass (Attachment A). Soft Sediment Taxa were generally comprised of large and small burrowing taxa, large and small tube-building taxa, amphipods, and mobile crustaceans and mollusks (Attachment A; Tables 3-2, 3-4, and 3-6; Figure 2-15). In the Mud and Sandy Mud with Shell Substrate habitats, CMECS Substrate Subgroups included Crepidula Reef Substrate and Shell Hash and the Biotic Subclasses included Soft Sediment Fauna, Inferred Fauna, and Attached Fauna (Table 3-6). Sessile and mobile epifauna characteristic of these habitats were observed, namely blue mussels, barnacles, Crepidula, and mobile crustaceans and mollusks (Table 3-6; Figures 2-15C and 2-15D).

3.1.5 Anthropogenic Features

Distinct features of anthropogenic origin were mapped on the seafloor within the RWF and in RWEC–RI Study Area (Tables 3-1 and 3-5). These features may provide some habitat value but are considered separately from the primary habitats evaluated. A small area (0.6 acres; Table 3-1) of debris that appeared to be shipping containers and contents was identified in the SSS data within the RWF. A series of structural objects and debris associated with the demolition of the old Jamestown Bridge were identified in geophysical data (Figure 3-14). A number of shoreline-related structures such as boat ramps and revetment walls along the shoreline in Quonset Point were identified in aerial imagery. Two areas of dredged material were also identified, one near the landfall location and one just south of the Jamestown Bridge. These areas within RWEC–RI total 26 acres, 0.5% of the area mapped (Table 3-5).

3.2 Benthic Habitat Distributions

Distributions of benthic habitat types in the Project Area are related to a combination of ancient and modern geological events in the region. The geophysical and benthic survey data collected by Revolution Wind have refined the understanding of the distribution of the habitats within the Project Area. While seven primary benthic habitat types were mapped, 24 with modifiers, not all types were present in each portion of the Project Area. In addition, a few anthropogenic features were also mapped within the RWF (shipping container and contents) and the RWEC–RI Study Area (dredged material, demolition debris, revetment walls). Habitat composition and characteristics and corresponding ground-truth data within the RWF Study Area in Rhode Island Sound are provided in Tables 3-1 and 3-2. Habitat composition and characteristics, and corresponding ground-truth data within the RWF, RWEC–OCS Study Area, and RWEC–RI Study Area are provided in Tables 3-1 through 3-6.

3.2.1 Revolution Wind Farm

A total of 59,247 acres were mapped at the RWF. All primary habitats, with the exceptions of Bedrock and Mixed-Size Gravel in Muddy Sand, were mapped at the RWF (Table 3-1; Figure 3-15). The northern portion of the RWF was primarily composed of Sand and Muddy Sand with smaller areas of Mud and Sandy Mud, Coarse Sediment, and Glacial Moraine A and B habitats (Figure 3-15). The central and southern portions of the RWF were primarily composed of a mix of Sand and Muddy Sand, Coarse Sediment, Glacial Moraine A habitats, with smaller areas of Glacial Moraine B habitats (Figure 3-15). Seafloor areas dominated by sands and muds in the northern portion of the RWF generally had lower slope compared to those in the central and southern portion of the RWF dominated by Coarse Sediment and Glacial Moraine A and B habitats (Figure 2-4).

When habitats with modifiers are considered, Sand and Muddy Sand was the most prevalent habitat type mapped at the RWF (22,477 acres, 38%), followed by Coarse Sediment – Mobile (12,310 acres, 21%), Glacial Moraine A (11,395 acres, 19%), and Sand and Muddy Sand – Mobile (6,084 acres, 10%) (Table 3-1; Figure 3-16). High density boulder fields aligned with Glacial Moraine A and B habitats and proximal areas of the seafloor (Figure 3-17). Coarse Sediment with Low or Medium Density Boulder Fields were present on the edges of Glacial Moraine habitats primarily the southern portion of the RWF, with more areas of Medium Density Boulder Fields present in the southwestern compared to southeastern section of the RWF (Figure 3-17). The spatial distribution of Glacial Moraine A and B habitats, as well as boulder fields, correspond well with the previously published locations of the Ronkonkoma Moraine (Figure 3-1).

A total of 240 ground-truth SPI/PV stations were sampled at the RWF (Table 3-2) and were distributed relatively evenly across the area mapped. Generally, CMECS Substrate Subgroups defined by >30% gravel composition (Sandy Gravel, Granule, and Cobble) corresponded with Glacial Moraine habitats, while those with <30% gravel (Gravelly Sand, Slightly Gravelly Sand) and coarser sands (Coarse Sand) predominated in Coarse Sediment habitats (Table 3-2; Figure 3-18). Fine and Medium Sands generally were observed within the Sand and Muddy Sand habitats and Very Fine Sand was recorded in the Mud and Sandy Mud habitats (Table 3-2; Figure 3-18). Although all habitat types were dominated by Soft Sediment Fauna (Attachment A), a few patterns are evident at the Biotic Group classification level (Figure 3-19). These communities in sand and mud habitats were characterized by Larger Deep-Burrowing Fauna, Larger and Small Tube-Building Fauna (Figure 3-19), in addition mobile epifauna, such as sand dollars, mobile crustaceans and mollusks, and sea scallops were also observed (Table 3-2). These soft sediment communities were also documented within Coarse Sediment and Glacial Moraine A habitats, in addition multiple stations were characterized by Biotic Groups of sessile taxa, such as Barnacles, Attached Hydroids, and Diverse Colonizers (Figure 3-19). In addition, the presence/absence of the sea pen *Halipteris finmarchia* was recorded in SPI/PV analysis, as the presence of this emergent taxa may be relevant to demersal species (Revolution Wind, LLC 2021c). Sea pens are known to create structural complexity on the seafloor when present in dense aggregations or “fields”, provide food and shelter resources to invertebrates and demersal fish, and some species are sensitive to suspended sediment and human activities such as trawling (Downie et al. 2021). Sea pens observed at RWF were not observed in these densities; they were sparse in distribution with one to a few visible in the SPI/PV images where observed (Figure 3-20; Revolution Wind, LLC 2021c). There was a high degree of spatial correlation between presence of these taxa and Glacial Moraine A habitats, as well as some records outside but proximal to these habitats (Figure 3-20).

Table 3-1. Composition & Characteristics of Mapped Benthic Habitat Types at the RWF

Revolution Wind Farm ***(~59,247 acres mapped)***	**Presence in RWF**		**Bedforms** *Type Present in Given Percentage of Habitats*			
	Area (acres)	**Percentage**	**Mega-ripples**	**Ripples**	**Linear Depression**	**Trawl marks**
Glacial Moraine B	102	0.2%	0%	57%	0%	0%
Glacial Moraine A	11,395	19%	8.1%	98%	0.5%	0.04%
Coarse Sediment with Medium Density Boulder Field	107	0.2%	0%	100%	0%	0%
Coarse Sediment with Low Density Boulder Field	168	0.3%	0%	93%	0%	0%
Coarse Sediment - Mobile with High Density Boulder Field	1	0.002%	0%	100%	0%	0%
Coarse Sediment - Mobile with Medium Density Boulder Field	511	0.9%	0%	100%	0.6%	0.0%
Coarse Sediment - Mobile with Low Density Boulder Field	2,663	4.5%	0%	100%	0.1%	0.9%
Coarse Sediment - Mobile	12,310	21%	3.3%	99.9%	1.2%	3.3%
Coarse Sediment	555	0.9%	5.5%	82%	0%	0.8%
Sand and Muddy Sand with Medium Density Boulder Field	270	0.5%	16%	67%	7.1%	0%
Sand and Muddy Sand with Low Density Boulder Field	954	1.6%	22%	83%	20%	0%
Sand and Muddy Sand - Mobile with Medium Density Boulder Field	16	0.03%	97%	100%	0%	0%
Sand and Muddy Sand - Mobile with Low Density Boulder Field	125	0.2%	94%	100%	0%	0%
Sand and Muddy Sand - Mobile	6,084	10%	91%	100%	49%	0%
Sand and Muddy Sand	22,477	38%	8.2%	89%	77%	68%
Mud and Sandy Mud	1,509	2.5%	0%	0%	0%	94%
Anthropogenic	0.6	0.001%	0%	100%	0%	0%

Table 3-2. Characteristics of Mapped Benthic Habitat Types as Informed by SPI/PV Ground-truth Data at the RWF

Revolution Wind Farm *(~59,247 acres mapped)*		**Glacial Moraine**	**Coarse Sediment with Boulder Field**	**Coarse Sediment - Mobile**	**Coarse Sediment**	**Sand and Muddy Sand with Boulder Field**	**Sand and Muddy Sand - Mobile**	**Sand and Muddy Sand**	**Mud and Sandy Mud**
SPI/PV Ground-truth Values	Number of SPI/PV stations	35	18	40	3	6	20	110	8
	CMECS Substrate Subgroups Observed in Ground-truth Data[1]	Cobble, Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Medium Sand, Fine Sand	Sandy Gravel, Granule, Gravelly Sand, Slightly Gravelly Sand, Medium Sand	Sandy Gravel, Granule, Gravelly Sand, Slightly Gravelly Sand, Coarse Sand, Medium Sand, Fine Sand	Sandy Gravel	Gravelly Sand, Slightly Gravelly Sand, Medium Sand, Fine Sand	Gravelly Sand, Coarse Sand, Medium Sand, Fine Sand	Sandy Gravel, Slightly Gravelly Sand, Muddy Sand, Coarse Sand, Medium Sand, Fine Sand, Very Fine Sand	Sand, Muddy Sand, Fine Sand, Very Fine Sand
	CMECS Biotic Subclasses Observed in Ground-truth Data	Attached Fauna, Inferred Fauna, Soft Sediment Fauna	Attached Fauna, Inferred Fauna, Soft Sediment Fauna	Attached Fauna, Inferred Fauna, Soft Sediment Fauna	Attached Fauna, Soft Sediment Fauna	Attached Fauna, Inferred Fauna, Soft Sediment Fauna	Attached Fauna, Inferred Fauna, Soft Sediment Fauna	Attached Fauna, Inferred Fauna, Soft Sediment Fauna	Inferred Fauna, Soft Sediment Fauna
	Maximum Percent Cover of Attached Fauna Observed in Ground-truth Data	Complete (90-100%)	Moderate (30 to < 70%)	Sparse (1 to <30%)	Dense (70 to <90%)	Sparse (1 to <30%)	Sparse (1 to <30%)	Trace (<1%)	None
	Sessile Epifauna Observed in Ground-truth Data	Anemone, Attached Tubes, Barnacle(s), Bryozoan, Colonial Tunicate(s), Hydroids, Northern Star Coral, Polymastia Sponge, Sponges, Tubes, Tunicate(s)	Attached Tubes, Barnacle(s), Bryozoan, Colonial Tunicate(s), Hydroids, Sponge(s), Tunicate(s)	Barnacle(s), Bryozoan, Ceriantхid, Colonial Tunicate, Corymorpha, Hydroid(s), Tunicate(s)	Anemone, Barnacle(s), Bryozoan, Cerianthid, Colonial Tunicate, Hydroids	Barnacles, Colonial Tunicate(s), Hydroids, Tunicates	Barnacles, Bryozoan, Cerianthid, Corymorpha, Hydroids, Tunicate(s)	Barnacle(s), Bryozoan, Cerianthid, Corymorpha, Hydroid(s), Tunicate(s)	None
	Mobile Epifauna Observed in Ground-truth Data	Crab(s), Gastropod(s), Moon Snail, Nudibranchs, Paguroid(s), Sea Star(s), Shrimp	Gastropod(s), Paguroid(s), Sea Scallop, Sea Star, Shrimp	Gastropod, Isopod, Moon Snail, Paguroid(s), Sea Star(s), Shrimp	Crab(s), Nudibranchs, Shrimp	Crab, Paguroid, Sand Dollar, Shrimp	Gastropod(s), Nudibranch, Paguroid, Shrimp	Crab(s), Gastropod(s), Isopod(s), Jonah Crab, Nudibranch, Paguroid(s), Sand Dollar, Sea Scallop, Sea Star(s), Shrimp	Crab, Nudibranch, Sea Star(s), Shrimp

Notes:
1 Substrate Subgroup determined from combined SPI/PV analysis.

3.2.2 RWEC–OCS Study Area

A total of 5,029 acres were mapped in the RWEC–OCS Study Area. All primary habitats, with the exceptions of Bedrock, were mapped in the RWEC–OCS Study Area (Table 3-3; Figure 3-21). The northern portion of the RWEC–OCS Study Area was primarily composed of interspersed Sand and Muddy Sand and Coarse Sediment habitats, with a small area of Mud and Sandy Mud habitats (Figure 3-21). Near the RWF the seafloor was composed of primarily Mud and Sandy Mud habitats (Figure 3-21), coincident with a deeper channel (Figure 2-3); and, on the other side of the channel, a region dominated by Mixed-Size Gravel in Muddy Sand habitat (Figure 3-21), spatially coincident with the previously mapped Harbor Hill Moraine (Figure 3-1). Seafloor slopes were generally low throughout the RWEC–OCS Study Area (Figure 2-5).

When habitats with modifiers are considered, Sand and Muddy Sand - Mobile was the most prevalent habitat type mapped in the RWEC–OCS Study Area (1,876 acres, 37%), followed by Sand and Muddy Sand (847 acres, 17%), Mud and Sandy Mud (647 acres, 13%), and Coarse Sediment – Mobile (579 acres, 12%) (Table 3-3; Figure 3-22). Medium and high-density boulder fields aligned with Glacial Moraine A and B and Mixed-Size Gravel in Muddy Sand habitats and proximal areas of the seafloor (Figure 3-23). Smaller discrete areas of medium and low boulder fields overlapped with Coarse Sediment and Sand and Muddy Sand habitats in offshore federal waters in Rhode Island Sound (Figure 3-23).

A total of 19 ground-truth SPI/PV stations were sampled in the RWEC–OCS Study Area (Table 3-4) and were distributed evenly across the area mapped. CMECS Substrate Subgroups defined by >30% gravel composition (Sandy Gravel, Pebble, and Cobble) corresponded with Mixed-Size Gravel in Muddy Sand habitats, and those with <5% gravel (Slightly Gravelly Sand) and coarser sands (Coarse Sand) predominated in Coarse Sediment habitats (Table 3-4; Figure 3-24). Very Fine to Coarse Sands were observed within the Sand and Muddy Sand habitats and Very Fine Sand was recorded in the Mud and Sandy Mud habitats (Table 3-2; Figure 3-24). Attached Fauna were the dominant Subclass in Mixed-Size Gravel in Muddy Sand habitats (Attachment A), with Biotic Groups of Attached Hydroids and Barnacles (Figure 3-25); additional sessile taxa, namely anemones and sponges, were also observed in these habitats (Table 3-4). All other habitat types were dominated by Soft Sediment Fauna (Attachment A), classified at the Biotic Group classification level by Larger Deep-Burrowing Fauna, Larger and Small Tube-Building Fauna (Figure 3-25), in addition, mobile epifauna, such as sand dollars, mobile crustaceans and mollusks, and sea stars were observed (Table 3-4).

Table 3-3. Composition & Characteristics of Mapped Benthic Habitat Types within the RWEC–OCS Study Area

Revolution Wind Export Cable - Outer Continental Shelf ***(~5,029 acres mapped)***	**Presence in RWEC–OCS Study Area**		**Bedforms** *Type Present in Given Percentage of Habitats*			
	Area (acres)	**Percentage**	**Mega-ripples**	**Ripples**	**Linear Depression**	**Trawl marks**
Glacial Moraine B	2.3	0.04%	0%	0%	0%	0%
Glacial Moraine A	30	0.6%	0%	2.2%	0%	0%
Mixed-Size Gravel in Muddy Sand with Medium Density Boulder Field	181	3.6%	0%	53%	33%	0%
Mixed-Size Gravel in Muddy Sand with Low Density Boulder Field	74	1.5%	0%	0%	0%	0%
Coarse Sediment with Low Density Boulder Field	14	0.3%	0%	78%	29%	0%
Coarse Sediment - Mobile with Medium Density Boulder Field	33	0.7%	0%	100%	0%	0%
Coarse Sediment - Mobile with Low Density Boulder Field	24	0.5%	0%	100%	13%	0%
Coarse Sediment - Mobile	579	12%	0%	100%	1.0%	5.7%
Coarse Sediment	469	9.3%	23%	1.8%	0.9%	0%
Sand and Muddy Sand with Medium Density Boulder Field	76	1.5%	45%	58%	58%	0%
Sand and Muddy Sand with Low Density Boulder Field	166	3.3%	0%	36%	1.8%	0%
Sand and Muddy Sand - Mobile	1,876	37%	100%	80%	51%	0.5%
Sand and Muddy Sand	847	17%	0.7%	17%	16%	28%
Mud and Sandy Mud - Mobile	10	0.2%	100%	100%	0%	0%
Mud and Sandy Mud	647	13%	0%	0%	0%	88%

Table 3-4. Characteristics of Mapped Benthic Habitat Types as Informed by SPI/PV Ground-truth Data within the RWEC–OCS Study Area

Revolution Wind Export Cable - Outer Continental Shelf ***(~5,029 acres mapped)***		**Mixed-Size Gravel in Muddy Sand with Boulder Field**	**Coarse Sediment**	**Sand and Muddy Sand with Boulder Field**	**Sand and Muddy Sand - Mobile**	**Sand and Muddy Sand**	**Mud and Sandy Mud**
SPI/PV Ground-truth Values	Number of SPI/PV stations	3	2	2	5	3	4
	CMECS Substrate Subgroups Observed in Ground-truth Data[1]	Cobble, Sandy Gravel, Pebble	Slightly Gravelly Sand, Coarse Sand	Slightly Gravelly Sand	Slightly Gravelly Sand, Medium Sand, Fine Sand	Slightly Gravelly Sand, Coarse Sand, Very Fine Sand	Very Fine Sand
	CMECS Biotic Subclasses Observed in Ground-truth Data	Attached Fauna, Soft Sediment Fauna	Soft Sediment Fauna	Inferred Fauna, Soft Sediment Fauna	Attached Fauna, Inferred Fauna, Soft Sediment Fauna	Inferred Fauna, Soft Sediment Fauna	Inferred Fauna, Soft Sediment Fauna
	Maximum Percent Cover of Attached Fauna Observed in Ground-truth Data	Dense (70 to < 90%)	None	None	Trace (<1%)	None	None
	Sessile Epifauna Observed in Ground-truth Data	Anemone, Barnacle(s), Hydroids, Sponges	None	None	Hydroids, Tunicates	Tunicate(s)	Corymorpha
	Mobile Epifauna Observed in Ground-truth Data	Crab, Paguroid, Sea Star, Shrimp	Gastropod, Paguroid, Sand Dollar	Shrimp	Paguroid(s), Sand Dollar, Shrimp	Crab, Sea Star(s)	Sea Star(s), Shrimp

Notes:
1 Substrate Subgroup determined from combined SPI/PV analysis.

3.2.3 RWEC–RI Study Area

A total of 5,729 acres were mapped in the RWEC–RI Study Area. All seven primary habitats were mapped in the RWEC–RI Study Area (Table 3-5; Figure 3-21). The habitats mapped within the RWEC–RI Study Area offshore in Rhode Island Sound were primarily dynamic sands and muds typical of offshore environments in Southern New England (Figure 3-21). The benthic habitats mapped within the RWEC–RI Study Area in Narragansett Bay, from the West Passage to Quonset Point, were primarily depositional muds and sandy mud (Figure 3-21). Mud and Sandy Mud habitats comprised more than half of the area mapped within the RWEC–RI Study Area (Table 3-5; Figure 3-21). Sand and Muddy Sand habitats were located on the northwestern side of Conanicut Island north of the Jamestown Bridge and near the mouth of the Bay at Brenton Reef where Coarse Sediment habitats were interspersed within the sand matrix, as well as near the state waters line (Figure 3-21).

When habitats with modifiers are considered, Mud and Sandy Mud was the most prevalent habitat type in the RWEC–RI Study Area (2,510 acres, 4%), followed by Sand and Muddy Sand – Mobile (1,322 acres, 23%), Sand and Muddy Sand (877 acres, 15%), and Mud and Sandy Mud with Shell Substrate (620 acres, 11%) (Table 3-3; Figures 3-22). Sand and Muddy Sand – Mobile was mapped at the mouth of the Bay, whereas Sand and Muddy Sand habitats in the West Passage were not assigned the Mobile modifier because ripples did not dominate the habitat features, although there was some evidence of ripples in these habitats (Table 3-6; Figure 3-12). Smaller areas with distinct characteristics were captured with modifiers as well. Additional habitats mapped within the RWEC–RI Study Area were small areas of Coarse Sediment, Glacial Moraine A and B, Bedrock, and non-moraine habitats with Low or Medium Density Boulder Fields interspersed within the predominant sand and mud habitats (Table 3-3; Figure 3-22). A Sand and Muddy Sand – Delta was evident in aerial imagery along the shoreline at Quonset Point west of the landfall, as were areas of Coarse Sediment – Mobile and a very small area of Mixed-Sized Gravel in Muddy Sand (Figure 3-26). Mud and Sandy Mud with SAV was mapped to the east of the proposed landfall location (Figure 3-26). Anthropogenic features were mapped near the Jamestown Bridge (Figure 3-14) and near the shoreline at Quonset Point (Figure 3-26). Boulder fields were generally associated with areas of coarse sediment and bedrock, particularly offshore in the region of Brenton Reef and at the edges of the RWEC–RI Study Area near Conanicut and Dutch Islands within the West Passage of Narragansett Bay (Figure 3-23). Discrete areas of Sand and Muddy Sand and Mud and Sandy Mud with Low Density Boulder Fields were mapped near the Glacial Moraine habitats on the edges of Conanicut and Dutch Islands (Figures 3-22 and 3-23).

A total of 34 SPI/PV ground-truth stations were sampled within the RWEC–RI Study Area (Table 3-6) and were distributed evenly across the area mapped. All Mud and Sandy Mud habitats were characterized by the CMECS Substrate Group of Very Fine Sand, except in habitats modified with Shell Substrate, where Shell Hash was recorded and at Station 450 where Crepidula Reef Substrate was observed (Figure 3-24). The sediment type measured with SPI below the surface shells was silt/clay (Attachment A; Figure 2-14I). Ground-truth samples in Sand and Muddy Sand and Coarse Sediment habitat types were characterized by a range of sands, from Fine Sand to Slightly Gravelly Sand, with Fine Sand recorded most frequently (Table 3-6; Figure 3-24). The Substrate Subgroup of Slightly Gravelly Sand was observed in Glacial Moraine B habitat (Table 3-6; Figure 3-24).

The depositional Mud and Sandy Mud habitats that dominated the portion of the RWEC–RI Study Area in Narragansett Bay support a combination of small and large tube-building and burrowing infauna, as well as mobile epifauna (mollusks and crustaceans) (Table 3-6; Figure 3-25). Most habitat types were dominated by Soft Sediment Fauna, with Attached Fauna dominating in Glacial Moraine B and Mud and Sandy Mud with Shell Substrate habitats (Attachment A; Table 3-6). Benthic Macroalgae was the dominant Subclass at one Sand and Muddy Sand station (Attachment A), and additional patterns were evident at the Biotic Group classification level (Figure 3-25). Small and Larger Tube-Building Fauna were the predominant Biotic Group observed in the sand and mud habitats furthest offshore (Figure 3-25). Biotic Groups of Larger Deep-Burrowing Fauna were prevalent across the sand and mud habitats at the mouth of the Bay and within the West Passage, except in the section of Mud and Sandy Mud with Shell Substrate habitats where Sessile Gastropods, Mussel Bed, Attached Hydroids, and Small Tube-Building Fauna were the predominant Biotic Groups (Attachment A; Figure 3-25). Attached Sponges were observed at Station 452 (north of the Jamestown Bridge) coincident with Glacial Moraine B habitats (Attachment A; Figure 3-25). Other Biotic Groups observed within sand and mud habitats included Tunneling Megafauna, Small and Larger Tube-Building Fauna and Tracks and Trails related to mobile epifauna (Attachment A; Figure 3-25). The benthic habitats and their characterizing sediments and benthic biological communities as mapped for this Revolution Wind assessment within Narragansett Bay generally agree with recent biotopes mapped from a SPI survey conducted throughout Narragansett Bay (Shumchenia and King 2019).

Offshore dynamic sand and mud habitats provide a mix of mobile sands and depositional muddy environments that support a combination of small and large tube-building and burrowing infauna, as well as mobile epifauna (mollusks and crustaceans) (Table 3-6; Figure 3-25). Small and Larger Tube-building Fauna were the predominant Biotic Group observed in the sand and mud habitats furthest offshore (Figure 3-25). Larger Deep-Burrowing Fauna were the predominant group in the Sand and Muddy Sand – Mobile habitats at Brenton Reef where a mix of sandy and coarse sediment habitats were observed (Figure 3-25). Small Tube-Building Fauna were also the predominant Biotic Group in Sand and Muddy Sand near Brenton Reef and within Coarse Sediment - Mobile habitats (Attachment A; Figure 3-25)

Table 3-5. Composition & Characteristics of Mapped Benthic Habitat Types within the RWEC–RI Study Area

Revolution Wind Export Cable - Rhode Island ***(~5,729 acres mapped)***	**Presence in RWEC–RI Study Area**		**Bedforms** *Type Present in Given Percentage of Habitats*			
	Area (acres)	**Percentage**	**Mega-ripples**	**Ripples**	**Linear Depression**	**Trawl marks**
Glacial Moraine B	50	0.9%	0%	3.0%	0%	0%
Glacial Moraine A	88	1.5%	0%	1.7%	0%	0%
Mixed-Size Gravel in Muddy Sand	0.01	0.0001%	0%	0%	0%	0%
Coarse Sediment with Medium Density Boulder Field	0.6	0.01%	0%	100%	0%	0%
Coarse Sediment with Low Density Boulder Field	0.5	0.01%	0%	54%	0%	0%
Coarse Sediment - Mobile	149	2.6%	0%	99%	10%	0%
Sand and Muddy Sand with Medium Density Boulder Field	5.1	0.09%	0%	0%	0%	0%
Sand and Muddy Sand with Low Density Boulder Field	22	0.4%	0%	8.1%	0%	0%
Sand and Muddy Sand - Mobile	1,322	23%	99%	100%	63%	0%
Sand and Muddy Sand - Delta	0.3	0.01%	0%	0%	0%	0%
Sand and Muddy Sand	877	15%	0%	75%	0.4%	3.6%
Mud and Sandy Mud with Low Density Boulder Field	19	0.3%	0%	0%	0%	45%
Mud and Sandy Mud with Shell Substrate	620	11%	0%	0%	0%	100%
Mud and Sandy Mud with SAV	0.2	0.003%	0%	0%	0%	0%
Mud and Sandy Mud	2,510	44%	0%	0%	0%	75%
Bedrock	38	0.7%	0%	21%	0%	0%
Anthropogenic	26	0.5%	0%	0%	0%	0%

Table 3-6. Characteristics of Mapped Benthic Habitat Types as Informed by SPI/PV Ground-truth Data within the RWEC–RI Study Area

Revolution Wind Export Cable - Rhode Island ***(~5,729 acres mapped)***		**Glacial Moraine**	**Coarse Sediment - Mobile**	**Sand and Muddy Sand - Mobile**	**Sand and Muddy Sand**	**Mud and Sandy Mud with Shell Substrate**	**Mud and Sandy Mud**
SPI/PV Ground-truth Values	Number of SPI/PV stations	1	2	10	3	5	13
	CMECS Substrate Subgroups Observed in Ground-truth Data[1]	Slightly Gravelly Sand	Coarse Sand, Fine Sand	Coarse Sand, Fine Sand, Very Fine Sand	Slightly Gravelly Sand, Medium Sand, Fine Sand	Crepidula Reef Substrate, Shell Hash	Very Fine Sand
	CMECS Biotic Subclasses Observed in Ground-truth Data	Attached Fauna, Soft Sediment Fauna	Inferred Fauna, Soft Sediment Fauna	Inferred Fauna, Soft Sediment Fauna	Benthic Macroalgae, Soft Sediment Fauna	Attached Fauna, Soft Sediment Fauna	Attached Fauna, Inferred Fauna, Soft Sediment Fauna
	Maximum Percent Cover of Attached Fauna Observed in Ground-truth Data	Sparse (1 to <30%)	None	None	Moderate (30 to < 70%)	Complete (90-100%)	Sparse (1 to <30%)
	Sessile Epifauna Observed in Ground-truth Data	Barnacles, Sponge(s)	None	None	Sponge(s)	Barnacles, Crepidula, Hydroids, Mussels, Sponges	Barnacles, Hydroids
	Mobile Epifauna Observed in Ground-truth Data	Gastropod(s)	Gastropod(s), Paguroid(s)	Gastropod(s), Moon Snail, Paguroid(s), Shrimp	Gastropod, Whelk	Crab, Gastropod, Jonah Crab	Crab(s), Gastropod(s), Paguroid(s), Shrimp

Notes:
1 Substrate Subgroup determined from combined SPI/PV analysis.

3.3 Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories

The NOAA Habitat Complexity Categories were defined by NOAA Habitat for the purposes of EFH consultation (NOAA Habitat 2021). The NOAA Habitat Complexity Categories include soft bottom, complex, heterogeneous complex, and large grained complex (large boulders). For purposes of the EFH consultation, NOAA has defined complex habitats as SAV, shell substrate, and sediments with >5% gravel of any size (pebbles to boulders; CMECS Substrate of Rock, Groups of Gravelly, Gravel Mixes, and Gravels) (NOAA Habitat 2021). Heterogenous complex is used for habitats with a combination of soft bottom and complex features (NOAA Habitat 2021). A crosswalk between benthic habitat types with modifiers mapped within the Study Area and NOAA Habitat Complexity Categories is provided in Table 3-7. The three benthic habitat types of Bedrock, Glacial Moraine A, and Glacial Moraine B were crosswalked to the “large grained complex” category and twelve benthic habitat types were crosswalked to the “complex” category, based on having >5% gravel or on the presence of Shell Substrate or SAV or on the presence of boulder fields. In addition, on request from NOAA Habitat, sand and mud habitats with boulder fields that were previously crosswalked to the “heterogeneous complex” category, were crosswalked to “complex.” Sand and mud habitats were crosswalked to the “soft bottom” category.

Approximately half of the RWF was categorized as soft bottom, approximately 20% categorized as large grained complex, and over one-quarter categorized as complex (Figure 3-27). Habitats crosswalked to the large grained complex category were found in the central and southern portions of the RWF (Figure 3-27) where Glacial Moraine A and B habitats were mapped (Figure 3-16). Habitats crosswalked to the complex category were located predominantly in the southeast portion of the RWF and in discrete areas in the central and northern portions of the RWF (Figure 3-27). Habitats crosswalked to soft bottom habitats were generally found in central and northern portions of the RWF and in discrete areas in the southeast portion of the RWF (Figure 3-27). Boulder fields were found coincident with and proximal to Glacial Moraine A and B habitats. A high incidence of low density boulder fields was mapped in the central and southeast portions of the RWF in habitats crosswalked to the complex category; scattered boulders were also present and dispersed in soft bottom habitats in the northern portion of the RWF (Figure 3-27).

The RWEC–OCS Study Area was primarily categorized as soft bottom, just over a quarter was categorized as complex, and a small portion was categorized as large grained complex (Figure 3-28). Habitats crosswalked to the complex category proximal to the RWF were Mixed-Size Gravel in Muddy Sand (Figure 3-22), a relatively stable matrix of pebbles and cobbles with boulder fields of varying density that support attached fauna (Figure 3-4). The remainder of the habitats within the RWEC–OCS Study Area crosswalked to the complex category were comprised of Coarse Sediment and Coarse Sediment–Mobile habitats interspersed with Sand and Muddy Sand–Mobile habitats (Figure 3-22), often mobile gravelly sands within linear depressions (Figure 3-7).

Approximately 80% of the RWEC–RI Study Area was classified as soft bottom, approximately 15% was classified as complex, and a small portion was categorized as large grained complex (Figure 3-28). Habitats crosswalked to the large grained complex category were small outcroppings of Glacial Moraine A and B and Bedrock found along the edges of the RWEC–RI Study Area near Breton Reef and within the West Passage of Narragansett Bay (Figure 3-22). One large section of seafloor within the southern portion of the West Passage of Narragansett Bay was crosswalked to the complex category (Figure 3-28) due to the presence of Mud and Sandy Mud with Shell Substrate habitat (Figure 3-22), composed of living and dead shells on top of a mud matrix (Figure 3-12). SAV near the landfall at Quonset Point (Figure 3-13) was also crosswalked to the complex category.

Table 3-7. Crosswalk of Benthic Habitat Types with Modifiers Mapped at the Project to NOAA Habitat Complexity Categories

Benthic Habitat Type with Modifiers	Color	Complex Color	NOAA Habitat Complexity Category
Anthropogenic			Anthropogenic
Bedrock			Large Grained Complex
Glacial Moraine B			Large Grained Complex
Glacial Moraine A			Large Grained Complex
Mixed-Size Gravel in Muddy Sand with Medium Density Boulder Field			Complex
Mixed-Size Gravel in Muddy Sand with Low Density Boulder Field			Complex
Mixed-Size Gravel in Muddy Sand			Complex
Coarse Sediment (- Mobile) with Medium Density Boulder Field			Complex
Coarse Sediment (- Mobile) with Low Density Boulder Field			Complex
Coarse Sediment – Mobile			Complex
Coarse Sediment			Complex
Sand and Muddy Sand (- Mobile) with Medium Density Boulder Field			Complex
Sand and Muddy Sand (- Mobile) with Low Density Boulder Field			Complex
Sand and Muddy Sand – Mobile			Soft Bottom
Sand and Muddy Sand – Delta			Soft Bottom
Sand and Muddy Sand			Soft Bottom
Mud and Sandy Mud with Low Density Boulder Field			Complex
Mud and Sandy Mud with Shell Substrate			Complex
Mud and Sandy Mud with SAV			Complex
Mud and Sandy Mud – Mobile			Soft Bottom
Mud and Sandy Mud			Soft Bottom

3.4 EFH Crosswalk to Benthic Habitats

The results of the full EFH benthic habitat crosswalk are presented in Attachment C. All species are presented in the table with an EFH presence determination for each project study area and primary benthic habitat type. Gray cells in the table indicate that NOAA-mapped EFH does not overlap with the specified project area and dashed cells indicate that even though the NOAA mapped EFH does overlap with that project area, the species/ life stage is not anticipated to utilize the given habitat type as EFH. There were various levels of EFH information available to support the crosswalk depending on the species. Some species have more explicitly identified preferred and essential substrates, while others, such as ocean quahog and spiny dogfish, have limited information. For species with limited information, or broader substrate preferences, a conservative approach was taken when crosswalking EFH to specific habitats. For example, scup adults are associated with soft, sandy bottoms; mixed sand; and mud; but prefer soft bottoms near structure. Habitats with scattered boulders or SAV are much more likely to have sand near structure than other primary benthic habitat types, and thus may have a “higher value” for these species than others. However, because sandy bottom is found in portions of all the primary habitats within the Study Area, adult scup EFH has been crosswalked to all mapped habitat types (Attachment C).

In total, 25 benthic/demersal species and 54 life stages with designated essential fish habitat within the Project Area have been crosswalked to mapped benthic habitats: 40 life stages to Glacial Moraine A and B habitats, 35 to Mixed-Size Gravel in Muddy Sand habitats, 47 to Coarse Sediment habitats, 45 to Sand and Muddy Sand habitats, 36 to Mud and Sandy Mud habitats; and 22 to boulders, 14 to SAV habitats, and nine to Shell Substrate regardless of underlying substrate. A list of ten priority species and their specific habitat preferences are highlighted and discussed in Section 4.4.

4.0 DISCUSSION

A complete summary of anticipated impacts to the seafloor is provided in Table 4-1, along with associated information related to the Project Design Envelope and related assumptions; additional information can be found in the COP (Revolution Wind, LLLC 2021a). Per NOAA Habitat recommendations (NOAA Habitat 2021), proportional representation of benthic habitats within each potential area of impact have been summarized by the NOAA Habitat Complexity Category to which they have been crosswalked. These proportional representations of benthic habitats have been calculated across the entire potential area of impact for each project component footprint (see Section 2.4 for details). Importantly, these calculated values and proportions are conservative estimates; the actual total anticipated areas of impact in acres along with Project Design Envelope context are provided in Table 4-1. For example, 23% of the foundation seafloor preparation area is a conservative estimate for anticipated boulder clearance at foundation locations based on worst case boulder densities at the foundation locations and this value, along with anticipated use of jack-up vessels, has been utilized to calculate a realistic estimate of the total area within the seafloor preparation footprints that may be directly, but temporarily, impacted by the Project (Table 4-1). Certain impacts may be more likely to occur in particular habitat types; for example, boulder clearance is more likely to be needed in habitats that have been crosswalked to the NOAA Habitat “complex” category. Where differential impacts are anticipated, these have also been noted in Table 4-1.

With few exceptions, the composition of benthic habitats crosswalked to NOAA Habitat Complexity Categories included in potential permanent and temporary impact footprints (Table 4-1) was similar to the composition documented within the given project component area (RWF: Figure 3-27; RWEC: Figure 3-28). These results indicate that significantly altered layouts would do little to measurably shift the overall composition of benthic habitats impacted by the Project. However, Revolution Wind has, and will continue to, micro-site foundations within the micro-siting allowances that support the agreed upon regional uniform east-west/north-south grid with 1.15 by 1.15-mi (1 by 1-nm; 1.85 by 1.85-km) spacing on a case-by-case basis to avoid significant seabed hazards such as surface and subsurface boulders and to avoid and minimize impacts to complex habitat types to the extent feasible and in consideration of other siting constraints.

Table 4-1. Maximum Potential Impacts to Benthic Habitats by NOAA Habitat Complexity Category from Proposed Project Design and Associated Assumptions and Information from the COP related to Areas of Anticipated Impact*

* The current indicative GIS layout was used to determine the distribution of benthic habitat types crosswalked to NOAA Complexity Categories within the total maximum footprint of each Project element. This may result in different total numbers from those presented in the COP, for example the current indicative IAC network is 224.5 km in GIS; the project design envelope presented in the COP allows for an approximately 12% increase on this value for a total of 250 km, this approach allows for some changes to the length of the IAC as Revolution Wind further refines its design and construction plans. The total allowable values presented in the COP have been used to calculate the values presented in the "Total Area of Anticipated Impacts to the Seafloor" column.

Revolution Wind Offshore Wind Farm Project Design Envelope			Unit of Measure	Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *				Total Area of Anticipated Impacts to the Seafloor
				Large Grained Complex	Complex	Soft Bottom	Total	
WTG & OSS Foundations	PERMANENT	Foundations	acres	0.62	0.89	1.57	3.08	**up to 3.08 acres**
			%	20%	29%	51%	100%	**up to 100%**
		Associated Assumptions and Context Estimates are based on 0.03 acre for each 12-m diameter monopile WTG foundation and 0.04 acre for each 15-m diameter monopile OSS foundation, resulting in totals of 3 acres for all 100 WTGs, 0.08 acres for the 2 OSSs, and 3.08 acres inclusive of all 100 WTG and 2 OSS foundations. This area may be disturbed by seabed preparation activities before being permanently impacted by the physical structure of the foundations. **Anticipated Activities or Structures that would cause Impact** Physical structure - WTG and OSS vertical hard substrate Minimal seafloor preparation required (e.g., boulder clearance and/or seafloor leveling) Impacts to habitats categorized as large grained complex and complex habitats will likely be minimized through layout refinement and micro-siting.						

<table>
<tr><th colspan="3" rowspan="2">Revolution Wind Offshore Wind Farm Project Design Envelope</th><th rowspan="2">Unit of Measure</th><th colspan="4">Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *</th><th rowspan="2">Total Area of Anticipated Impacts to the Seafloor</th></tr>
<tr><th>Large Grained Complex</th><th>Complex</th><th>Soft Bottom</th><th>Total</th></tr>
<tr><td rowspan="3">WTG & OSS Foundations</td><td rowspan="3">PERMANENT</td><td rowspan="2">Maximum Scour Protection & Cable Protection System (CPS) Stabilization for IACs and OSS-Link Cable</td><td>acres</td><td>14.96</td><td>22.62</td><td>37.86</td><td>75.4</td><td>up to 75.4 acres</td></tr>
<tr><td>%</td><td>20%</td><td>30%</td><td>50%</td><td>100%</td><td>up to 100%</td></tr>
<tr><td colspan="7">Associated Assumptions and Context
Scour protection and Cable Protection System (CPS) stabilization for IACs associated with each foundation.

The maximum extent of scour protection for each WTG foundation would be in a ring around the foundation up to 24 m in each direction (22.5 m for OSS foundations), covering 0.67 acres per WTG foundation and 0.66 acres for each OSS foundation; the CPS stabilization would extend an additional 12 m from the edge of the scour protection and would be 12 m wide. The number of IACs per WTG foundation will vary and there will be more IACs at each OSS than at each WTG; each IAC CPS stabilization would be 0.04 acres. The maximum total scour protection (68.3 acres) + CPS stabilization (7.1 acres) across the 102 foundations would be 75.4 acres.

This area may be disturbed by seabed preparation activities before being permanently impacted by physical structures.

Anticipated Activities or Structures that would cause Impact
Physical structure - foundation, scour protection and CPS stabilization, specific type of material to be selected at final design

Minimal seafloor preparation required (e.g., boulder clearance and/or seafloor leveling)

Impacts to habitats categorized as large grained complex and complex will likely be minimized through layout refinement and micro-siting.</td></tr>
<tr><td rowspan="3">WTG & OSS Foundations</td><td rowspan="3">PERMANENT</td><td rowspan="2">Total - Foundations + Maximum Scour Protection & CPS Stabilization for IACs and OSS-Link Cable</td><td>acres</td><td>15.6</td><td>23.5</td><td>39.4</td><td>78.5</td><td>up to 78.5 acres</td></tr>
<tr><td>%</td><td>20%</td><td>30%</td><td>50%</td><td>100%</td><td>up to 100%</td></tr>
<tr><td colspan="7">Associated Assumptions and Context

Estimates are based on 0.7 acre per monopile foundation for foundations + scour protection (30 m radius from the foundation center point), with CPS stabilization for IACs resulting in additional permanent impacts where needed. The maximum total area that may be permanently impacted by foundations, scour protection and CPS stabilization totals 78.5 acres.

Anticipated Activities or Structures that would cause Impact
Physical structure - foundation, scour protection and CPS stabilization, specific type of material to be selected at final design

Minimal seafloor preparation required (e.g., boulder clearance and/or seafloor leveling)

Impacts to habitats categorized as large grained complex and complex will likely be minimized through layout refinement and micro-siting.</td></tr>
</table>

<table>
<tr><th colspan="3" rowspan="2">Revolution Wind Offshore Wind Farm Project Design Envelope</th><th rowspan="2">Unit of Measure</th><th colspan="4">Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *</th><th rowspan="2">Total Area of Anticipated Impacts to the Seafloor</th></tr>
<tr><th>Large Grained Complex</th><th>Complex</th><th>Soft Bottom</th><th>Total</th></tr>
<tr><td rowspan="3">WTG & OSS Foundations</td><td rowspan="3">TEMPORARY</td><td rowspan="2">Seafloor Disturbance around Permanent Structures</td><td>acres</td><td>591.0</td><td>928.7</td><td>1574.0</td><td>3,093.7</td><td>up to 755.5 acres</td></tr>
<tr><td>%</td><td>19%</td><td>30%</td><td>51%</td><td>100%</td><td>up to 24.4%</td></tr>
<tr><td colspan="7">Associated Assumptions and Context
Represents wide area around permanent features in which temporary disturbance is anticipated, up to a 200-m radius from foundation center point. This 200-m radius equates to 31.1 acres per foundation; the area of seafloor preparation only that surrounds the maximum permanent footprint of the foundation, scour protection, and CPS stabilization varies based on the number of cables pulled into each foundation, each is approximately between 30 and 30.4 acres. The total area for all 102 foundations is 3,093.7 acres.

Approximately 23% of the 31.1-acre area (7.2 acres per foundation) may be disturbed during boulder clearance. This is a conservative estimate based on worst case boulder densities at foundation locations. Across 102 foundation locations, the total maximum acres would be 734.4 acres.

The total area of seabed disturbance per jack-up will be approximately 724.4 sq m (0.18 acre). Based on assumption of using a jack-up at each of up to 102 foundations (18.36 acres) and using a second jack-up at up to 15% of the foundations (2.75 acres), up to 21.1 acres of seabed disturbance will occur from jack-up activity during WTG installation. Jack-up activities will occur within the 200-m radius surrounding each foundation location.

Therefore, the total anticipated maximum area of seafloor disturbance is estimated to be 755.5 acres (734.4 + 21.1), which is 24.4% of the total 3,093.7-acre seafloor preparation area around the permanent structures.

Anticipated Activities or Structures that would cause Impact
Boulder clearance activities; Jack-up barges/spud cans to support installation activities

Boulder clearance will occur where boulders are present and cannot be avoided with micro-siting; these impacts are more likely to occur in habitats categorized as large grained complex and complex.</td></tr>
<tr><td rowspan="3">WTG & OSS Foundations</td><td colspan="2" rowspan="2">TOTAL
Permanent + Temporary
400-m diameter (200-m radius) circle around center point of foundations</td><td>acres</td><td>606.6</td><td>952.2</td><td>1613.4</td><td>3,172.2</td><td>up to 834.0 acres</td></tr>
<tr><td>%</td><td>19%</td><td>30%</td><td>51%</td><td>100%</td><td>up to 26.3%</td></tr>
<tr><td colspan="8">Associated Assumptions and Context
Represents wide area in which permanent features will be installed and in which temporary disturbance is anticipated. Up to a 200-m radius from foundation center point for WTG and OSS foundations. This 200-m radius equates to 31.1 acres per foundation, a total of 3,172.2 acres across all 102 foundations.

The total area anticipated to be impacted is 834.0 acres, equal to the maximum potential permanent impact (78.5 acres) and the maximum total temporary impact (755.5 acres), which represents 26.3% of the total 3,172.2 acres.

Anticipated Activities or Structures that would cause Impact
See above rows for details on each foundation component</td></tr>
</table>

Revolution Wind Offshore Wind Farm Project Design Envelope			Unit of Measure	Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *				Total Area of Anticipated Impacts to the Seafloor
				Large Grained Complex	Complex	Soft Bottom	Total	
Inter-Array Cables & OSS-Link Cable	**PERMANENT**	**Cable Protection Inter-Array Cables**	**acres**	121.9	177.4	365.8	665.1	**up to 74.1 acres**
			%	18%	27%	55%	100%	**up to 10%**
		Cable Protection OSS-Link Cable	**acres**	0.0	8.3	29.5	37.8	**up to 4.4 acres**
			%	0%	22%	78%	100%	**up to 10%**

Associated Assumptions and Context
Up to 265 km of cable are anticipated to connect foundations; up to 250 km for the IACs and up to 15 km for the OSS-Link Cable.

Up to 26.5 km (25 km for the IAC, 1.5 km for the OSS-Link Cable) may require cable protection. Cable protection will measure up to 39 ft (12 m) wide. Therefore, an area of up to 78.5 acres (74.1 acres for the IAC and 4.4 acres for the OSS-Link Cable) may require cable protection; no cable crossings are anticipated that would require additional cable protection.

Anticipated Activities or Structures that would cause Impact
Physical structure - concrete mattresses, frond mattresses, rock bags, and/or rock berms; specific cable protection material will be selected at final design

Cable protection will be used where burial cannot occur, sufficient burial depth cannot be achieved due to seabed conditions or to avoid risk of interaction with external hazards. These locations may occur in areas of complex habitats, where siting in these habitats cannot be avoided.

Revolution Wind Offshore Wind Farm Project Design Envelope			Unit of Measure	Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *				Total Area of Anticipated Impacts to the Seafloor
				Large Grained Complex	Complex	Soft Bottom	Total	
Inter-Array Cables & OSS-Link Cable	TEMPORARY	**Cable Installation & Seafloor Preparation Inter-Array Cables**	**acres**	407.4	589.9	1215.6	2,213	**up to 2,471 acres**
			%	18%	27%	55%	100%	**< 100%**
		Cable Installation & Seafloor Preparation OSS-Link Cable	**acres**	0.0	27.0	99.3	126.3	**up to 148 acres**
			%	0%	21%	79%	100%	**< 100%**

Associated Assumptions and Context

Represents 40-m wide corridor for the IAC network (up to 250 km) and OSS-Link Cable (up to 15 km) in which seafloor preparation and installation activities are anticipated; these corridors encompass a total of approximately 2,619 acres (2,471 acres for the IAC, 148 acres for the OSS-Link Cable). Seafloor preparation activities will not extend beyond the 40-m installation and preparation corridor. Additional cable burial trials may be performed; these trials would occur within the 40-m cable installation and seafloor preparation corridor.

Up to 80% of the IAC network, 200 km, and 60 % of the OSS-Link Cable, 9 km, may require boulder clearance. Up to 10% of the IAC network, 25 km, and 10% of the OSS-Link Cable, 1.5 km, may require sand wave leveling. The maximum area that may be temporarily disturbed by these activities would be 2,065.8 acres for boulder clearance (1,976.8 acres for the IAC, 89.0 acres for the OSS-Link) and 261.9 acres for sand wave leveling (247.1 acres for the IAC, 14.8 acres for the OSS-Link).

In addition to seafloor preparation activities, temporary disturbance related to installation of the cable is anticipated along the entire length of the IAC network and OSS-Link Cable.

The area of the full seafloor preparation and installation corridor represents a conservative assumption for maximum temporary seafloor disturbance, as noted above these areas total approximately **2,619 acres**.

Anticipated Activities or Structures that would cause Impact

Cable laying activities will involve boulder clearance, sand wave leveling, and pre-lay grapnel runs to locate and clear remaining obstructions prior to cable installation; cable laying installation activities may involve use of jet-plow, mechanical plowing, or mechanical cutters. Controlled flow excavation and a trailing suction hopper dredger may be used for sand wave leveling or remedial burial.

Dynamic Positioning (DP) vessels will generally be used for cable burial activities. If anchoring (or a pull ahead anchor) is necessary during cable installation it will occur within the area surveyed and mapped to support the Project.

Boulder clearance will occur where boulders are present and cannot be avoided with micro-siting; these impacts are more likely to occur in complex habitats. Sand wave leveling is most likely to occur in soft bottom habitats.

Revolution Wind Offshore Wind Farm Project Design Envelope			Unit of Measure	Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *				Total Area of Anticipated Impacts to the Seafloor
				Large Grained Complex	Complex	Soft Bottom	Total	
RWEC	PERMANENT	**Cable Protection RWEC–OCS**	**acres**	1.5	53.5	108.7	163.7	**up to 17.8 acres**
			%	1%	33%	66%	100%	**up to 10%**
		Cable Protection RWEC–RI	**acres**	0.0	30.6	176.6	207.2	**up to 42.7 acres**
			%	0%	15%	85%	100%	**up to 19%**

Associated Assumptions and Context
The RWEC is anticipated to include up to 134 km of cable, comprised of up to two export cables co-located within a single corridor up to 67 km in length (up to 30 km in federal waters RWEC–OCS and 37 km in state waters RWEC–RI).

Up to 10% of the up to 60-km RWEC–OCS, 6 km, and up to 10% of the up to 74-km long RWEC–RI, 7.4 km, may require cable protection. Cable protection will measure up to 39 ft (12 m) wide. Therefore, a total area of up to 39.7 acres (17.8 acres for the RWEC–OCS; 21.9 acres for the RWEC–RI) may require cable protection.

Up to 14 crossings of existing submarine assets (e.g., existing submarine cables) along the RWEC–RI (7 per cable) are anticipated and will require protection. It is assumed up to 1,640 ft (500 m) of cable protection will be required per crossing, for a total of 1.48 acres per crossing. A total of up to 21.9 acres of additional cable protection may be needed for these crossings. Cable protection for cable crossing plus the assumed 10% needed for the remainder of the RWEC–RI would result in a maximum of 42.7 acres of cable protection for the RWEC–RI.

If cable protection were needed across the entire up to 60-km RWEC–OCS, 177.9 acres would be needed; therefore 17.8 acres represents 10%; for the up to 74-km long RWEC–RI, 219.4 acres would be needed, therefore 42.7 acres represents 19%. For the entire 134-km long RWEC a total of 397.3 acres would be needed; therefore, 60.5 acres (17.8 acres for the RWEC–OCS, 42.7 acres for the RWEC–RI,) represents 15% of the entire RWEC.

Anticipated Activities or Structures that would cause Impact
Physical structure - concrete mattresses, frond mattresses, rock bags, and/or rock berms; specific cable protection material will be selected at final design

Cable protection will be used where burial cannot occur, sufficient burial depth cannot be achieved due to seabed conditions or to avoid risk of interaction with external hazards. These locations may occur in areas of complex habitats, where siting through these habitats cannot be avoided. Cable protection will also be used where cable crossings occur.

Revolution Wind Offshore Wind Farm Project Design Envelope			Unit of Measure	Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *				Total Area of Anticipated Impacts to the Seafloor
				Large Grained Complex	Complex	Soft Bottom	Total	
RWEC	TEMPORARY	**Cable Installation & Seafloor Preparation RWEC–OCS**	**acres**	5.0	179.0	361.0	545.0	**up to 625.9 acres**
			%	1%	33%	66%	100%	**< 100%**
		Cable Installation & Seafloor Preparation RWEC–RI	**acres**	0.0	101.8	588.0	689.8	**up to 764.2 acres**
			%	0%	15%	85%	100%	**< 100%**

Associated Assumptions and Context
Represents 40-m wide corridor for the RWEC (up to 134 km) in which seafloor preparation and installation activities are anticipated; this corridor encompasses a total of 1,324.5 acres (593.1 acres for the RWEC–OCS and 731.4 acres for the RWEC–RI). Seafloor preparation activities will not extend beyond the 40-m installation and preparation corridor. Additional cable burial trials may occur outside of this particular 40-m cable disturbance corridor; these trials will occur within the area surveyed and mapped and will occur within a 40-m corridor. Up to 10 trials over a 250-m length each may be conducted for the RWEC; at present, the division of these trials between the RWEC–OCS and the RWEC–RI is unknown and an even split (5 per) is assumed for these calculations. These trials would add an additional maximum area of seafloor preparation of approximately 24.7 acres (12.36 acres for the RWEC–OCS and 12.36 acres for the RWEC–RI). Further, four omega joints will be required for the RWEC, two will be required per cable, one each along the RWEC–OCS and along the RWEC–RI; these will be buried and will require a seafloor preparation corridor that is 250-m long and 205-m in width, 165-m in addition to the standard 40-m width. These 4 omega joints will add an additional maximum area of seafloor preparation of 40.8 (20.4 acres for the RWEC–OCS and 20.4 acres for the RWEC–RI). Therefore, the total maximum area of seafloor disturbance would be approximately 1,390 acres (1324.5 acres for the 40-m seafloor preparation and installation corridor, 24.7 acres for cable burial trials, and 40.8 acres for omega joints), 625.9 acres associated with the RWEC–OCS and 764.2 acres associated with the RWEC–RI.

Up to 40% of the RWEC–OCS, 24 km, and 70% of the RWEC–RI, 51.8 km, may require boulder clearance. Up to 45% of the RWEC–OCS, 27 km, and 7% of the RWEC–RI, 5.2 km, may require sand wave leveling. The maximum area that may be temporarily disturbed by these activities would be 749.2 acres for boulder clearance (237.2 acres for the RWEC–OCS, 512.0 acres for the RWEC–RI) and 318.1 acres for sand wave leveling (266.9 acres for the RWEC–OCS, 51.2 acres for the RWEC–RI). As noted above, an additional 24.7 acres along the RWEC may be disturbed through cable burial trials and an additional 40.8 acres may be disturbed by additional seafloor preparation activity for omega joints.

In addition to seafloor preparation activities, temporary disturbance related to installation of the cable is anticipated along the entire length of the RWEC.

The area of the full seafloor preparation and installation corridor, plus the maximum area that may be disturbed for cable burial trials and the omega joints, represents a conservative assumption for maximum temporary seafloor disturbance, as noted above these areas total approximately 1,390 acres.

Anticipated Activities or Structures that would cause Impact
Cable laying activities will involve boulder clearance, sand wave leveling, and pre-lay grapnel runs to locate and clear remaining obstructions prior to cable installation; cable laying installation activities may involve use of jet-plow, mechanical plowing, or mechanical cutters. Controlled flow excavation and a trailing suction hopper dredger may be used for sand wave leveling or remedial burial.

Dynamic Positioning (DP) vessels will generally be used for cable burial activities. If anchoring (or a pull ahead anchor) is necessary during cable installation it will occur within the area surveyed and mapped to support the Project.

Boulder clearance will occur where boulders are present and cannot be avoided with micro-siting; these impacts are more likely to occur in complex habitats. Sand wave leveling is most likely to occur in soft bottom habitats.

<table>
<tr><th colspan="3" rowspan="2">Revolution Wind Offshore Wind Farm Project Design Envelope</th><th rowspan="2">Unit of Measure</th><th colspan="4">Acres of Maximum Potential Impact to Benthic Habitats Crosswalked to NOAA Habitat Complexity Categories Calculated from Current Indicative GIS Layout *</th><th rowspan="2">Total Area of Anticipated Impacts to the Seafloor</th></tr>
<tr><th>Large Grained Complex</th><th>Complex</th><th>Soft Bottom</th><th>Total</th></tr>
<tr><td rowspan="3">Landfall HDD</td><td rowspan="3">TEMPORARY</td><td rowspan="2">HDD Exit Pits</td><td>acres</td><td>0</td><td>0</td><td>0.8</td><td>0.8</td><td>up to 0.8 acres</td></tr>
<tr><td>%</td><td>0%</td><td>0%</td><td>100%</td><td>100%</td><td>< 100%</td></tr>
<tr><td colspan="7">Associated Assumptions and Context
Excavation of up to two HDD exit pits, each covering a seafloor area of approximately 0.4 acres, including grading from the seafloor surface to the base of the pit, will temporarily impact up to 0.8 acres.

Cofferdams, measuring up to 50 m x 10 m, may be required to keep the excavation free of debris and from silting back in. These areas are contained within those assessed for seafloor disturbance from the exit pits.

Anticipated Activities or Structures that would cause Impact
Support activities, such as anchoring or use of barges, may be needed to support installation. If anchoring (or a pull ahead anchor) is necessary during cable installation it will occur within the area surveyed and mapped to support the Project.

Exit pits will be backfilled post-construction.

Most temporary impacts related to the HDD exit pits and associated support activities will occur in soft bottom habitats. The HDD cable installation methodology will avoid direct impacts to documented SAV and juvenile cod HAPC near the Project’s landfall location. In addition, Revolution Wind will avoid construction in state waters during the peak SAV growing season (i.e., July 1 to September), which will further minimize potential effects due to increased turbidity and sediment deposition associated with cable installation and excavation of the HDD exit pits.</td></tr>
</table>

4.1 Project Impacts to Benthic Habitats within the RWF

Revolution Wind is committed to an indicative layout scenario with WTG and OSS foundations sited in a uniform east-west/north-south grid with 1.15 by 1.15-mi (1 by 1-nm; 1.85 by 1.85-km) spacing that aligns with other proposed adjacent offshore wind projects in the RI-MA WEA and MA WEA. To support this agreed upon spacing, a diamond shaped micro-siting allowance is provided for each foundation location (102 total, 100 WTGs, 2 OSSs) (Figure 1-3). The center point of each of these diamonds represents the default position of each foundation. Revolution Wind will micro-site foundations within the micro-siting diamonds on a case-by-case basis to avoid significant seabed hazards such as surface and subsurface boulders and to avoid and minimize impacts to complex habitat types to the extent feasible and in consideration of other siting constraints. Scour protection and CPS stabilization for IACs associated with each foundation will be used as required for engineering purposes.

The WTG and OSS foundations are generally sited across the habitats present at the RWF approximately proportional to their spatial prevalence and distribution (roughly 50% soft bottom, 30% complex, 20% large grained complex) (Table 4-1; Figure 4-1). Anticipated impacts calculated for the IAC network and OSS-Link Cable were skewed toward soft bottom habitats in higher proportions than their distribution with the RWF, 55 – 79 % compared to ~ 50 % spatial distribution (Table 4-1). Potential impacts to habitats crosswalked to large grain complex and complex NOAA Habitat Complexity categories are likely to be minimized through layout refinement and micro-siting of foundation positions and cables.

The majority of the micro-siting diamonds within the RWF (64 of 102) are located wholly within dynamic sand, mud, and mobile coarse sediments expected to recover relatively quickly from impacts related to installation of the foundations (Figure 4-2). A portion of another 15 micro-siting diamonds overlap with dynamic sand, mud, and mobile coarse sediment habitats. In contrast, habitats characterized by boulder fields and diverse complex glacial moraine habitats overlap with fewer than one-third of the micro-siting diamonds (Figure 4-2). Two micro-siting diamonds are located wholly in sand, mud, or coarse sediment habitats coincident with low or medium density boulder fields and 29 micro-siting diamonds partially coincide with these habitats (Figure 4-2). Five micro-siting diamonds are located wholly within Glacial Moraine A habitats and none within Glacial Moraine B habitats (Figure 4-2). Twenty-seven micro-siting diamonds partially overlap with Glacial Moraine A habitats and four with Glacial Moraine B habitats (Figure 4-2). There are over 70 micro-siting diamonds that do not overlap at all with boulder fields or Glacial Moraine A and B habitats.

4.2 Project Impacts to Benthic Habitats within the RWEC

Permanent and temporary impacts related to the RWEC are anticipated to occur mostly in soft bottom habitats; specifically, 66% of the RWEC–OCS and 85% of the RWEC–RI 40-m corridor in which cable preparation and installation activities are planned is represented by benthic habitats crosswalked to the soft bottom category (Table 4-1). The cables are sited approximately proportional to their spatial prevalence and distribution (Figure 3-28). Temporary impacts related to the HDD exit pits and support area would be primarily contained within habitats crosswalked to the soft bottom category (Table 4-1). With a few exceptions, the RWEC is generally composed of soft bottom sand and mud habitats (Figure 3-21), with few areas of scattered boulders (Figure 3-22).

The areas of complex habitat nearest to the RWF (Mixed-Size Gravel in Muddy Sand) and in the West Passage of Narragansett Bay (Mud and Sandy Mud with Shell Substrate) are notable in that they span the width of the RWEC–OCS and RWEC–RI Study Areas (Figure 3-28). Therefore, impacts to these habitats cannot be altered by micro-siting the cable routes within the RWEC–RI Study Area. Revolution Wind will avoid and minimize impacts to complex habitats with siting of the RWEC–OCS and RWEC–RI to the extent feasible and in consideration of other siting constraints.

4.2.1 Impacts to Shell Substrate Habitats

A large area of Mud and Sandy Mud habitat south of the Jamestown Bridge was characterized by a seafloor surface of Shell Substrate and comprised approximately 620 acres and 11% of the habitats mapped within the RWEC–RI Study Area (Table 3-5; Figures 3-12 and 3-22). The shells in these habitats included both live and dead shells (Figures 2-14I, 2-15C, and 2-15D). Live blue mussels, such as those observed with patchy cover on the seafloor at Station 448 (Figure 2-15C) provide filtration ecosystem services. Shells and shell hash are included in the EFH designations of several priority species in the region, such as black sea bass and ocean pout (for more detail on demersal fish species habitat utilization see Section 4.4). The Mud and Sandy Mud with Shell Substrate habitat extends across nearly the entire width of an approximately 14,000-ft (4,267-m) section of the RWEC–RI Study Area south of the Jamestown Bridge (Figure 3-22). Therefore, impacts to these habitats cannot be avoided by micro-siting the cable routes within the RWEC–RI Study Area. However, Shell Substrate and live mussels and/or gastropods are likely to reestablish the Mud and Sandy Mud with Shell Substrate after the cables have been installed. Shells and shell hash are generated where bivalves are living and blue mussels and gastropods rapidly recolonize suitable habitat. The cable will be buried with trenching or jet plows which will leave some shell material on the surface. The surface environment is expected to return to pre-construction conditions through the same processes that created the habitat. Should cable protection be needed along these stretches of the RWEC, a permanent benefit may result as the converted habitat may provide useful substrate for mussel attachment or other epifauna.

4.2.2 Impacts to Submerged Aquatic Vegetation

SAV beds, dominated by *Zostera marina*, represent unique habitats throughout the shallow coastal waters of Narragansett Bay and their distribution is periodically mapped across the Bay using aerial imagery and field verification by the URI Environmental Data Center (URI Environmental Data Center and RIGIS). SAV extent varies over time and these aquatic plants experience peak growth during late summer months. SAV are found in mud and muddy sand sediments, and a single Mud and Sandy Mud with SAV habitat was mapped within the area east of the landfall location. SAV habitats are defined by NOAA as complex habitats (NOAA Habitat 2021) and are widely known to provide important ecosystem services related to water clarity and nutrient cycling, and provide habitat for invertebrates and demersal fish, particularly juveniles. Mud and Sandy Mud with SAV habitats comprising 0.2 acres were mapped within the RWEC–RI Study Area in Narragansett Bay.

The western edge of the SAV habitat mapped at Compass Rose Beach is approximately 845 feet (257 m) east of the center point of nearest proposed HDD exit pit work area. SAV beds are found in shallow coastal areas throughout the Bay, including along the western shores of Conanicut and Dutch Islands, proximal to the RWEC–RI route. The nearest SAV bed within the West Passage is approximately 142 ft (43 m) from the edge of the RWEC–RI Study Area and 1,150 ft (350 m) from the indicative RWEC–RI route, on the western side of Dutch Island. At a distance of 1,150 ft (350 m), SAV habitat near the indicative cable route is 115 ft (35 m) beyond the projected impact distance for deposition and is within the projected impact distance for elevated turbidity (RPS 2021). The SAV bed mapped at the landfall location during the 2020 video survey is 105 ft (32 m) beyond the projected impact distance for deposition and is within the projected impact distance for elevated turbidity (RPS 2021). Turbidity levels elevated above background concentrations are not predicted to persist for more than 70.2 hrs and most of the affected area is expected to return to ambient levels within 6 hrs (RPS 2021); thereby minimizing potential negative impacts to SAV. Revolution Wind will utilize an HDD cable installation methodology to avoid documented SAV near the Project's landfall location. In addition, Revolution Wind will avoid construction in state waters during the peak SAV growing season (i.e., July 1 to September), which will further minimize potential effects due to increased turbidity and sediment deposition associated with cable installation and excavation of the HDD exit pits.

4.3 Impacts to Glacial Habitats

Bedrock, Glacial Moraine A and B, and Mixed-Size Gravel in Muddy Sand habitats, as well as nearby Low or Medium Density Boulder Fields coincident with sand and mud habitats, provide structure that supports attached fauna such as hydroids and sponges and, in shallower photic waters (West Passage of Narragansett Bay), flora such as benthic macroalgae, as well as demersal fish, such as black sea bass and tautog, that utilize hard bottom substrates and structure (for more detail on demersal fish species habitat utilization see Section 4.4). A distinction was made between Glacial Moraine A and Glacial Moraine B habitats to distinguish between areas of unconsolidated geological debris (A) and consolidated geological debris (B). The surface of Glacial Moraine B deposits appeared poorly sorted and dense with very high boulder densities resulting in greater structural complexity and permanence. By comparison, the surface of Glacial Moraine A units was reworked with sand and gravel deposits resulting in less structural complexity and permanence.

Glacial Moraine A habitats are prevalent in the central and southern portions of the RWF, coincident with the Ronkonkoma Moraine (Figures 3-1 and 3-15). Glacial Moraine A habitats comprise the total area of five micro-siting diamonds and part of the area of another 27; these habitats are not found within 70 of the 102 micro-siting diamonds at RWF. Glacial Moraine B habitats were more limited in distribution within the RWF (Figure 3-15) and do not comprise the total habitat composition of any micro-siting diamond; however, Glacial Moraine B habitats are present within four micro-siting diamonds, and were not found within the remaining 98 micro-siting diamonds. Low and Medium Density Boulder Fields coincident with sand and mud or coarse sediment habitats were generally present proximal to Glacial Moraine A habitat (Figure 3-15). Two micro-siting diamonds are located wholly in sand, mud, or coarse sediment habitats coincident with low or medium density boulder fields, 29 micro-siting diamonds partially coincide with these habitats; a total of 71 micro-siting diamonds did not overlap with these habitats. Revolution Wind will micro-site foundations within the micro-siting diamond on a case-by-case basis to avoid significant seabed hazards such as surface and subsurface boulders and to avoid and minimize impacts to complex glacial habitat types to the extent feasible and in consideration of other siting constraints.

Both Glacial Moraine A and B habitats were limited in their distribution along the RWEC and are found mostly on the edges of the RWEC–OCS and RWEC–RI Study Areas (Figure 3-21). Mixed-Size Gravel in Muddy Sand habitats was present across most of the width of the RWEC–OCS Study Area near the RWF (Figure 3-21). Also, as described in Section 1.1, the RWEC–OCS and RWEC–RI Study Areas represent broad areas evaluated by Revolution Wind for siting of the export cables in federal and state waters, respectively. Revolution Wind will avoid and minimize impacts to glacial habitats with siting of the RWEC–OCS and RWEC–RI to the extent feasible and in consideration of other siting constraints.

4.4 Project Impacts to Benthic EFH for Priority Species

Species with demersal/benthic life stages are more vulnerable to project impacts than species with pelagic life stages. Specifically, demersal/benthic life stages are vulnerable to impacts from project activities that permanently or temporarily disturb the seafloor and/or result in temporary sediment suspension and deposition, such as seafloor preparation, impact pile driving and/or vibratory pile driving/foundation installation, cable installation, and vessel anchoring (detailed impacts to EFH are outlined in Section 3.1 of the Essential Fish Habitat Technical Report, Appendix L of the Revolution Wind Construction and Operations Plan (Revolution Wind, LLC. 2021d). While construction and operation activities may affect EFH for demersal/benthic life stages, these impacts are also anticipated to be temporary (except as noted below) and minor as they will disturb a small portion of available EFH in the area. Species with a preference for sandy habitats, such as Atlantic surfclam and ocean quahog, are more likely to experience long-term impacts to their habitats from the conversion of sand habitat into hard bottom habitat with the addition of materials used for cable and scour protection, where needed. Additionally, sessile species or species with benthic eggs such as Atlantic sea scallop, ocean pout, and winter flounder that have limited or no mobility and increased sensitivity to turbidity are likely to be injured, displaced, or experience mortality from these activities. Many of the potential impacts from these Project activities will be mitigated with procedures outlined in Section 4.5 Proposed Environmental Protection Measures.

In total, 25 benthic/demersal species and 54 life stages with designated essential fish habitat within the Project Area have been crosswalked to mapped benthic habitats: 40 life stages to

Glacial Moraine A and B habitats, 35 to Mixed-Size Gravel in Muddy Sand habitats, 47 to Coarse Sediment habitats, 45 to Sand and Muddy Sand habitats, 36 to Mud and Sandy Mud habitats; and 22 to boulders, 14 to SAV habitats, and nine to Shell Substrate within any habitat type. A list of ten priority species and their specific habitat preferences are highlighted and discussed in more detail below. Only impact producing factors related to physical habitat disturbance (i.e., habitat conversion, seafloor disturbance and suspended sediment deposition) are considered here. Due to the conservative approach used in crosswalking species EFH to benthic habitat types and, in a number of cases, the limited information on species' sediment preferences, it should be kept in mind that there are likely much smaller areas within each mapped habitat type that may be more valuable for each species/life stage than others. Because of the conservative crosswalk approach utilized, impacts to a given habitat may not necessarily affect all species with EFH crosswalked to that habitat type.

Atlantic Cod

EFH for both juvenile and adult cod consists of hard bottom habitats, with juveniles preferring cobble substrates, and adults preferring structurally complex hard bottom habitats composed of gravel, cobble, and boulder substrates (Lough 2004). Cobble habitats are essential for the survival of juvenile cod in that they may assist with avoiding predation by older year classes (Gotceitas and Brown 1993) and recent studies suggest that rocky, hard bottom habitats may be important for reproduction (DeCelles et al. 2017; Siceloff and Howell 2012). An active Atlantic cod winter spawning ground has been identified in a broad geographical area that includes Cox Ledge and surrounding locations (Zemeckis et al. 2014b; Dean et al., 2020). Adult and juvenile cod EFH is likely to occur within the Glacial Moraine (A&B), Mixed-Size Gravel in Muddy Sand, and Coarse Sediment habitats within the Revolution Wind project areas, primarily found in large patches in the southern portion of the RWF and smaller patches in the northern portion of the RWF and RWEC–OCS and RWEC–RI Study Areas. In addition, the RWEC–RI Study Area crosses a Habitat Area of Particular Concern (HAPC) for juvenile cod which includes vegetated and structurally complex rocky-bottom habitats at depths under 66 feet (20m) that likely to be found in the Glacial Moraine, Mixed-size Gravel in Muddy Sand, and SAV habitats (Figure 4-3) that provide juvenile cod with protection from predation and support a wide variety of prey items (NEFMC 2017).

As mentioned above, cod are expected to experience some impacts to their habitat from project activities that permanently or temporarily disturb the seafloor. In southern New England, cod spawn primarily from December through May (Dean et al., 2020; Langan et al., 2020), so they could be more susceptible to a disturbance to their preferred spawning habitats during that time. Given the availability of similar surrounding habitat, Project activities are not expected to result in long term adverse impacts to spawning habitat or adult or juvenile EFH; conversely, the use of gravel, boulders, and/or concrete mats for cable or scour protection will create new hard substrate. This substrate is expected to be initially colonized by barnacles, tube-forming species, hydroids, and other fouling species found on existing hard bottom habitat in the region, which may ultimately provide additional preferred cod habitat (Reubens et al. 2013). Impacts to juvenile cod HAPC from nearshore project activities will be avoided by use of HDD for cable landfall, thus avoiding direct impacts to nearshore habitats (Figure 4-3). In addition, most temporary impacts related to the HDD exit pits and associated support activities will occur in soft bottom habitats not preferred by cod.

Atlantic Sea Scallop

Atlantic sea scallops are likely to be found throughout the Project area and were collected in the majority of NEFSC seasonal trawls from 2003 to 2016 in the Rhode Island Massachusetts Wind Energy Area (RIMA WEA) (Guida et al. 2017). Due to their benthic existence and limited mobility, scallops have been identified as a species of concern for habitat disturbance in the RIMA WEA by Guida et al. (2017).

Atlantic sea scallop eggs likely remain on the seafloor as they develop into free-swimming larvae, which settle to the seafloor (as “spat”) before metamorphosing into juveniles (Hart and Chute 2004). Hard surfaces are essential for the survival of the spat, including sedentary branching plants or animals, shells, small pebbles, or adult scallops (Stokesbury and Himmelman 1995). Because of these associations with the seafloor, egg and larval scallop EFH is likely to be found in Glacial Moraine (A&B), Mixed-Size Gravel in Muddy Sand, Coarse Sediment, and Sand and Muddy Sand habitats within the RWF, RWEC–OCS, and RWEC–RI Study Areas, although larvae are less likely to be found on mobile bottom habitats. Similarly, juvenile scallops are primarily found on gravel, shells, and silt (Thouzeau et al. 1991; Parsons et al. 1992), or attached to branching bryozoans, hydroids or algae (Stokesbury and Himmelman 1995), and adult scallops are generally found on firm sand, gravel, shells and rock (MacKenzie et al. 1978; Langton and Robinson 1990; Thouzeau et al. 1991; Stewart and Arnold 1994). EFH for juvenile and adult scallops is also likely to be found in Glacial Moraine (A&B), Mixed-Size Gravel in Muddy Sand, Coarse Sediment, and Sand and Muddy Sand habitats within the RWF, RWEC–OCS, and RWEC–RI Study Areas.

All life stages of scallops may experience temporary direct impacts from the construction and operation of the project. Seafloor preparation may cause injury, displacement, or mortality to scallops of all life stages. These impacts are expected to be temporary as the direct impacts will cease after seafloor preparation is completed in an area, and minor as they will disturb a small portion of available EFH in the area. Scallops will be able to recolonize most areas once construction is complete.

Atlantic Surfclam and Ocean Quahog

Atlantic surfclams are found in medium to coarse sand and gravel substrates and can also be found in fine or silty sand, but not in mud (Dames and Moore, Inc. 1993; MacKenzie et al. 1985; Cargnelli et al. 1999b). They are most abundant in water depths between 26 and 217 ft (8 and 66 m) beyond the surf zone (Fay et al. 1983). EFH for adult surfclams is likely to be found in the Glacial Moraine (A&B), Mixed-Size Gravel in Muddy Sand, Coarse Sediment, and Sand and

Muddy Sand habitats within the RWEC–OCS Study Area, and for juveniles and adults within the same habitats in the RWEC–RI Study Area.

Ocean quahogs are generally distributed just below the sediment surface in medium to fine grain sand, sandy mud, silty sand, and fine to medium grained sand primarily at depths between 82 and 200 ft (25 and 61 m) (Cargnelli et al. 1999c; Merrill and Ropes 1969; Serchuk et al. 1982). Mapped EFH for adult and juvenile ocean quahogs only intersects with the Project area in the RWF and EFH occurs within all habitats in the RWF area that contain sand or mud, including Glacial Moraine (A&B), Coarse Sediment, Sand and Muddy Sand, and Mud and Sandy Mud habitats.

Atlantic surfclam and ocean quahog are likely to be similarly impacted from project activities. Due to their lack of mobility, it is possible that seafloor preparation could cause injury, displacement, or mortality to these species. Shellfish will be able to recolonize most areas once construction is complete, however they may experience small amounts of permanent habitat loss in areas around the WTGs where scour protection is needed and sections of the array and substation interconnection and export cables where cable protection may be required as they will not be able to colonize the new structured habitat. Detailed impacts to benthic and shellfish resources are discussed in Revolution Wind COP Section 4.3.2.2 (Revolution Wind, LLC 2021a).

Black Sea Bass

Black sea bass juveniles and adults are well documented as having strong associations with structured habitats, including natural and artificial reefs, shellfish beds, shell hash, vegetated bottom, cobble, gravel, and boulder habitats (Drohan et al. 2007). Within the Project area, existing structure consists primarily of boulders and cobbles and the attached epifauna that grows on them. These habitat features are found within the RWF, RWEC–OCS, and RWEC–RI Study Areas in the Glacial Moraine (A&B), Mixed-Size Gravel in Muddy Sand, and Coarse Sediment habitats, as well as in any habitat with boulders, shell substrate, or SAV. Both juveniles and adults have shown strong site fidelity (Able and Hales 1997; Briggs 1979) so may be vulnerable to disruptions to structured habitats.

Black sea bass may experience temporary impacts to their habitat from project activities that permanently or temporarily disturb the seafloor or result in temporary sediment suspension and deposition. Long term adverse impacts to both adult and juvenile EFH are expected to be minor as the species is expected to recolonize the area post construction. Beneficial impacts are expected with the creation of additional structured habitats from WTGs and conversion of sandy and gravelly sediments into structured hard bottom habitat as was demonstrated at the Block Island Wind Farm where a dramatic increase in black sea bass occurred post-construction (HDR 2020)

Little Skate and Winter Skate

Little skate and winter skate are discussed together for the purposes of this report as they share similar habitat requirements, are frequently co-occurring (McEachran and Musick 1975), and are expected to experience similar impacts from Project activities. Both species are expected to occur throughout the Project area and were dominant species during the winter and spring NEFSC Trawl Surveys within the RIMA WEA between 2003 and 2016 (with little skate being dominant in both cold and warm seasons) (Guida et al. 2017).

Little skate and winter skate juveniles and adults are found throughout southern New England on sandy or gravelly substrate but have also been found on mud (Bigelow and Schroeder 1953; McEachran and Musick 1975; Langton et al. 1995; Tyler 1971). These species are likely to be associated with all habitats within the RWF, RWEC–OCS, and RWEC–RI as all habitats have some component with sand, gravel, or mud.

Given the broad distribution of these species throughout all Project areas, there are likely to be temporary and permanent impacts to their preferred habitats. These species may be temporarily displaced by seafloor disturbing activities but are anticipated to recolonize most areas once construction is complete. However, they may experience permanent habitat loss in areas that are converted from sandy and gravelly sediments to hard bottom habitats around the WTGs and sections of the inter-array and export cables where scour and cable protection may be required. Loss of habitat due to conversion to hard bottom is not expected to have a significant impact on these species due the large amount of alternate suitable habitat available.

Longfin Squid

Little information is available on egg habitat locations for longfin squid (Jacobson 2005); however, egg mops are often found attached to cobbles and boulders on sandy or muddy bottoms or attached to aquatic vegetation (Arnold et al. 1974; Griswold and Prezioso 1981; Summers 1983). Due to the limited information available on suitable egg habitat, it is assumed that egg mops could be present on any substrates within adult spawning habitat and EFH for longfin squid eggs has been mapped to all project habitats. Specifically, EFH for eggs may be found during the spawning months of May to August (Summers 1971; Macy 1980) within the RWF, RWEC–OCS and RWEC–RI Study Areas. Depending on timing, longfin squid egg mops could experience injury, displacement, or mortality from construction and cable laying activities in their immediate vicinity, but most impacts are expected to be minimal as only a small amount of available spawning habitat will be disturbed. Furthermore, as described in the proposed environmental protection measures laid out in Section 4.5, Revolution Wind is coordinating with NOAA Fisheries and RIDEM to develop time of year (TOY) restrictions that would restrict cable laying activities and result in reduced likelihood of impacts to spawning squid.

Ocean Pout

Ocean pout eggs are demersal and laid in gelatinous masses, generally in sheltered nests, holes, or rocky crevices within hard bottom habitats (NEFMC 2017). These essential habitats are expected within the Glacial Moraine (A&B), Mixed-Size Gravel in Muddy Sand, and Coarse Sediment habitats within the Project area, specifically where found in large patches throughout the RWF and in smaller sections of the RWEC–OCS and RWEC–RI Study Areas.

Juvenile and adult ocean pout occur on a wide variety of substrates, including shells, rocks, algae, soft sediments, sand, and gravel (NEFMC 2017). Rocky shelter is shown to be especially important for spawning adults in the autumn when they lay their eggs (Smith 1898). EFH for juveniles and adults is expected to occur within all habitat types in the Project area, specifically throughout the RWF and RWEC–OCS. Essential adult habitats may also be found in deeper (> 66 ft (20 m)) portions of the RWEC–RI cable routes (Figure 2-3).

All life stages of ocean pout may experience temporary impacts from the construction, operations and maintenance, and decommissioning phases of the Project. Eggs are particularly vulnerable to impacts due to their inability to vacate the Project area during construction. These impacts are expected to be temporary as the direct impacts will cease after seafloor preparation is completed, and minor as they will disturb a small portion of available EFH in the area. Ocean pout are expected to recolonize the area once construction is complete and may experience permanent beneficial impacts from the creation of additional preferred habitats for eggs, juveniles, and spawning adults from the conversion of sandy and gravelly sediments into structured hard bottom habitat.

Winter Flounder

Winter flounder egg clusters stick to the substrates on which they are laid, which include mud, muddy sand, gravel, macroalgae and submerged aquatic vegetation (NEFMC 2017). Essential habitats for winter flounder eggs, young-of-the-year (YOY) juveniles, and spawning adults are likely to be found in waters less than 16.4 ft (5 m) in depth (NEFMC 2017) in Mixed-Size Gravel in Muddy Sand, Coarse Sediment, Sand and Muddy Sand, or Mud and Sandy Mud habitats, as well as any benthic substrate with SAV. Eggs and spawning adults are most likely to be found in these habitats from January through June (Massie 1998). Non-spawning winter flounder adults and older juveniles are found in continental shelf benthic habitats and deeper coastal waters than eggs and YOY (Phelan 1992; NEFMC 2017), therefore juveniles and non-spawning adults are likely to utilize these habitats within all Project areas, however EFH for eggs and spawning adults is only expected within habitats less than 16.4 ft (5 m) of water, occurring in approximately 1.6 mi (2.6 km) of the RWEC–RI Study Area.

Impacts from project activities related to installation of the RWEC–RI may temporarily directly affect winter flounder eggs, YOY, and spawning adults. Eggs could be entrained within the jet plow or experience increased mortality due to sediment suspension (Berry et al. 2011), however as there will be very little project activity in shallow (< 16.4 ft) inshore areas, the impact to spawning habitat is expected to be minimal. These impacts are expected to be minor as they will disturb a small portion of available EFH in the area and temporary because the substrates within the RWEC–RI are expected to remain fundamentally the same as pre-existing conditions and would therefore allow for continued use by spawning winter flounder, YOY, and eggs.

Juveniles and adult flounder are also likely to be temporarily displaced by seafloor disturbing activities. Flounder are expected to recolonize most areas once construction is complete, however similar to other species that utilize sandy habitats, they may experience permanent habitat loss in areas that are converted from sandy and gravelly sediments to hard bottom habitats around the WTGs and sections of the inter-array and export cables where scour and cable protection may be required. Loss of habitat due to conversion to hard bottom is not expected to have a significant impact on these species due to the large area of alternate suitable habitat available. In addition to mitigation measures laid out in Section 4.5 Revolution Wind has coordinated with RIDEM and NOAA Fisheries regarding TOY restrictions in state waters. Based on the coordination conducted to-date, in general, offshore site preparation 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*).

4.5 Proposed Environmental Protection Measures

Revolution Wind will implement the following environmental protection measures to reduce potential impacts on benthic resources and shellfish. These measures are based on protocols and procedures successfully implemented for similar offshore projects.

- The RWF and RWEC will be sited to avoid and minimize impacts to sensitive habitats (e.g., hard bottom habitats) to the extent practicable.
- To the extent feasible, installation of the IACs, OSS-Link Cable and RWEC will be buried using equipment such subsea cable trenchers such as jet trenchers or mechanical cutting trenchers, simultaneous lay and burial using a cable plow, or jet plow. The feasibility of cable burial equipment will be determined based on an assessment of seabed conditions and the 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 ft (1.2 to 1.8 m) below seabed. The target burial depth will be determined based on an assessment of seabed conditions, seabed mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a site-specific Cable Burial Risk Assessment.
- Dynamic positioning vessels will be used for installation of the IACs, OSS-Link Cable, and RWEC to the extent practicable.
- A plan for vessels will be developed prior to construction to identify no-anchorage areas to avoid documented sensitive resources.
- Revolution Wind is committed to collaborative science with the commercial and recreational fishing industries pre-, during, and post-construction. Fisheries 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.

- 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.
- Revolution Wind is coordinating with RIDEM and NOAA Fisheries regarding time of year restrictions for cable laying activities in RI State Waters and will comply with such restrictions.

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Benthic Habitat Mapping to Support Essential Fish Habitat Consultation
Revolution Wind Offshore Wind Farm

FIGURES

Prepared for:

Revolution Wind | Powered by Ørsted & Eversource

Revolution Wind, LLC

Submitted by:

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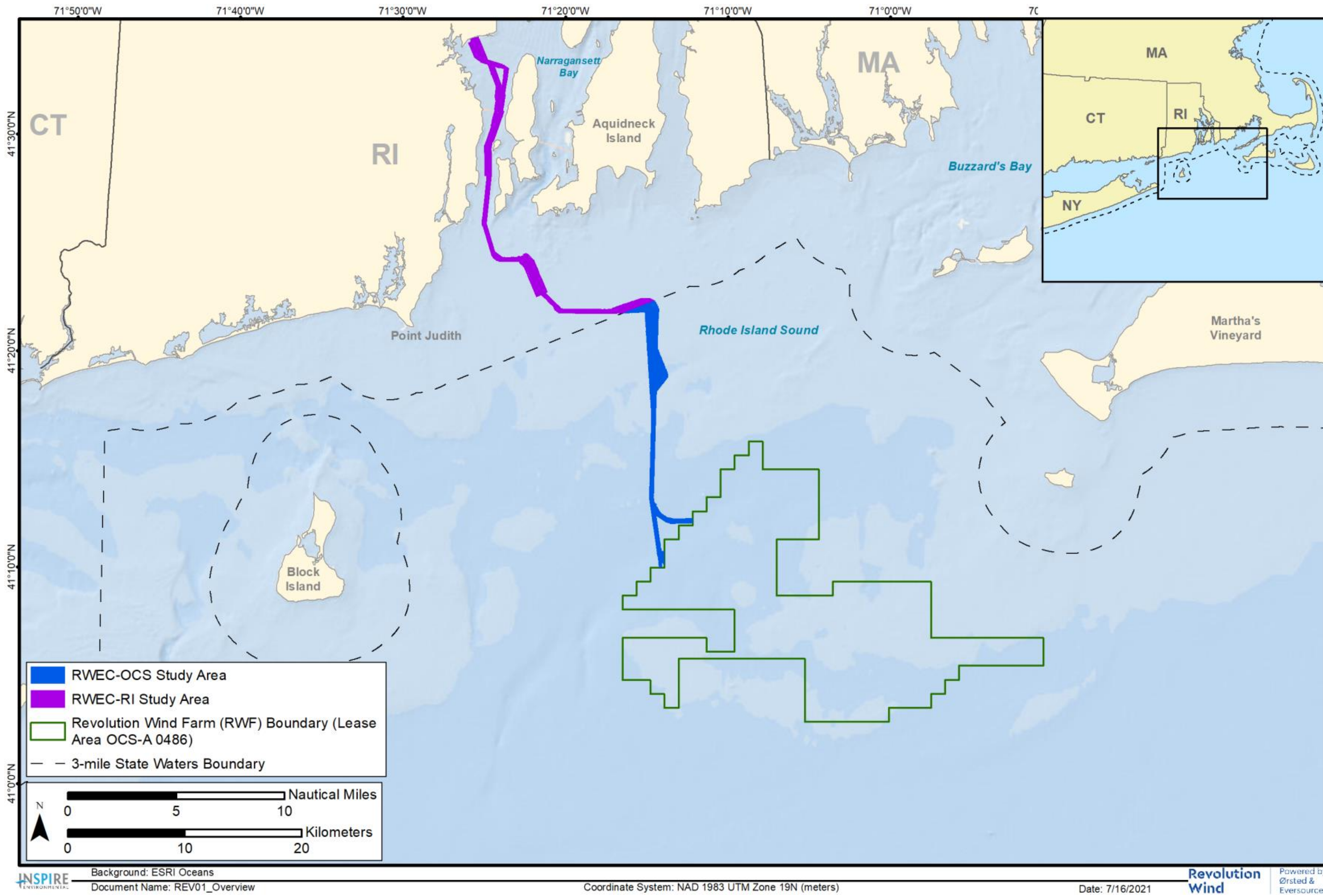


Figure 1-1. **Location of the planned Revolution Wind Farm (RWF) and Export Cable Corridor (RWEC) on the outer continental shelf in federal waters (RWEC-OCS) and within Rhode Island state waters (RWEC-RI)**

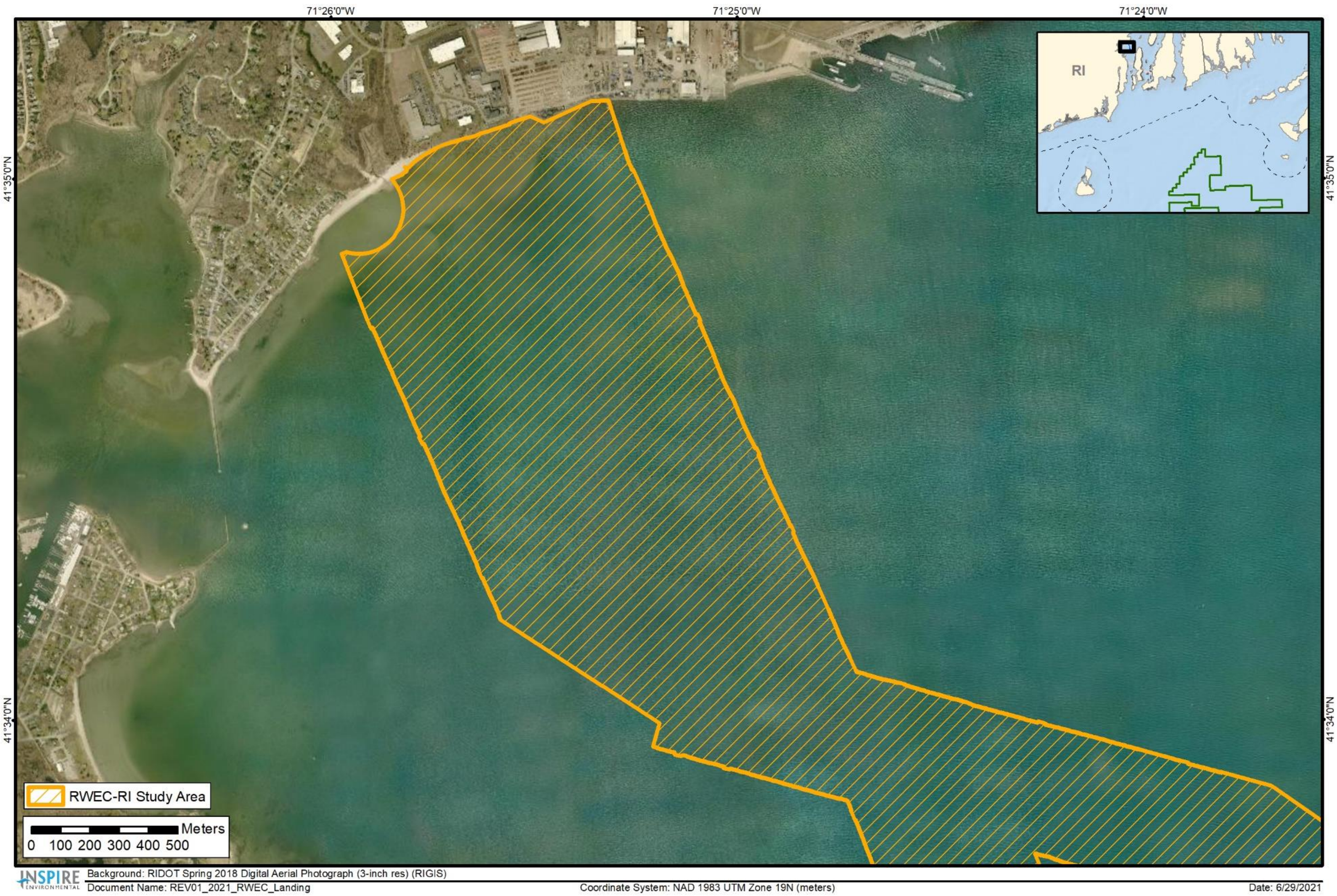


Figure 1-2. Potential landfall of the RWEC at Quonset Point in North Kingstown, RI, including the RWEC-RI Study Area

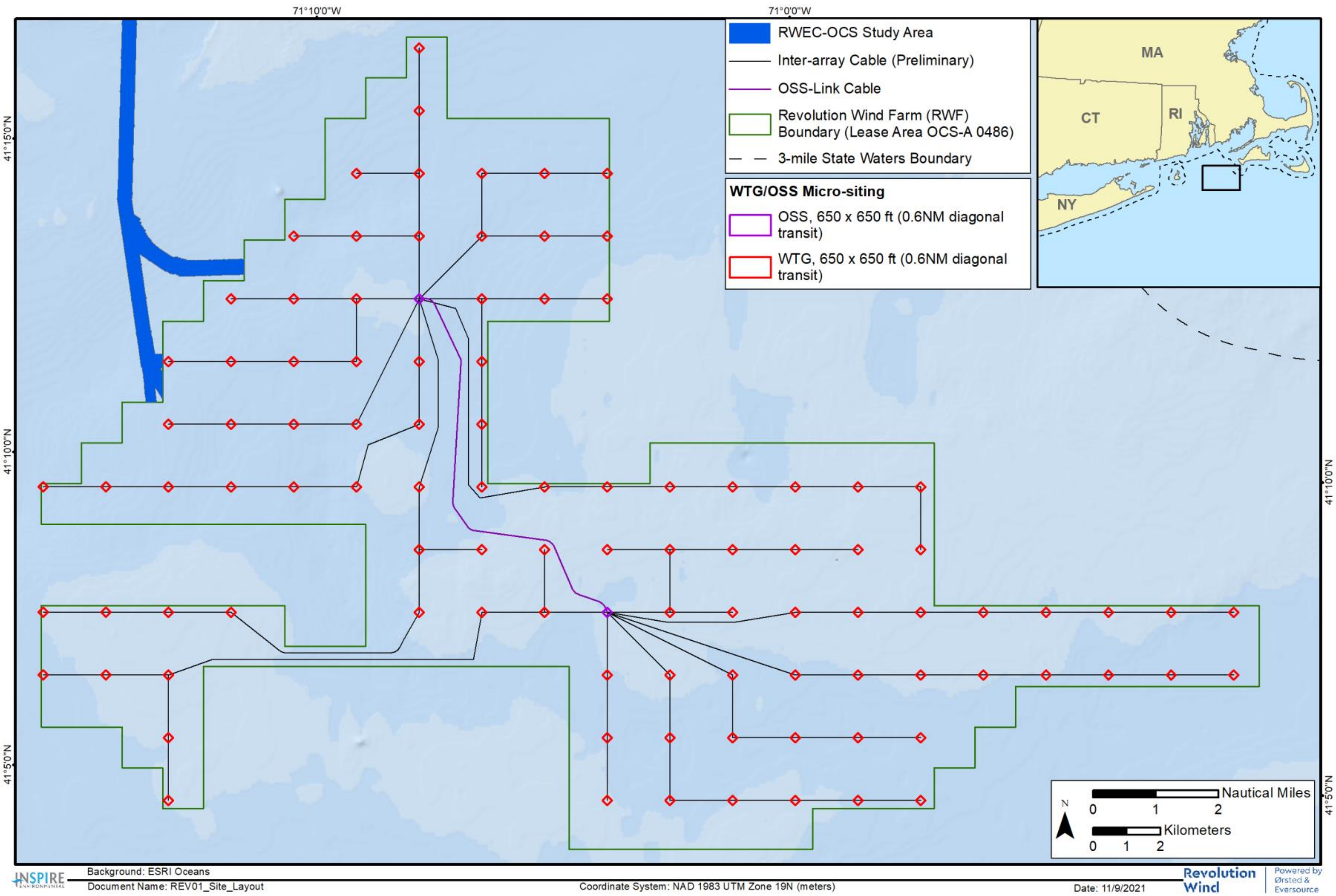


Figure 1-3. **Revolution Wind Farm proposed layout of up to 100 wind turbine generators (WTGs), 2 offshore substations (OSSs), inter-array cables (IACs), and the OSS-Link Cable. Micro-siting allowance limits related to navigation transit constraints are depicted as diamonds. At this time, IAC routes between foundations are preliminary and are shown as straight lines; specific indicative IAC routes will be shared once available.**

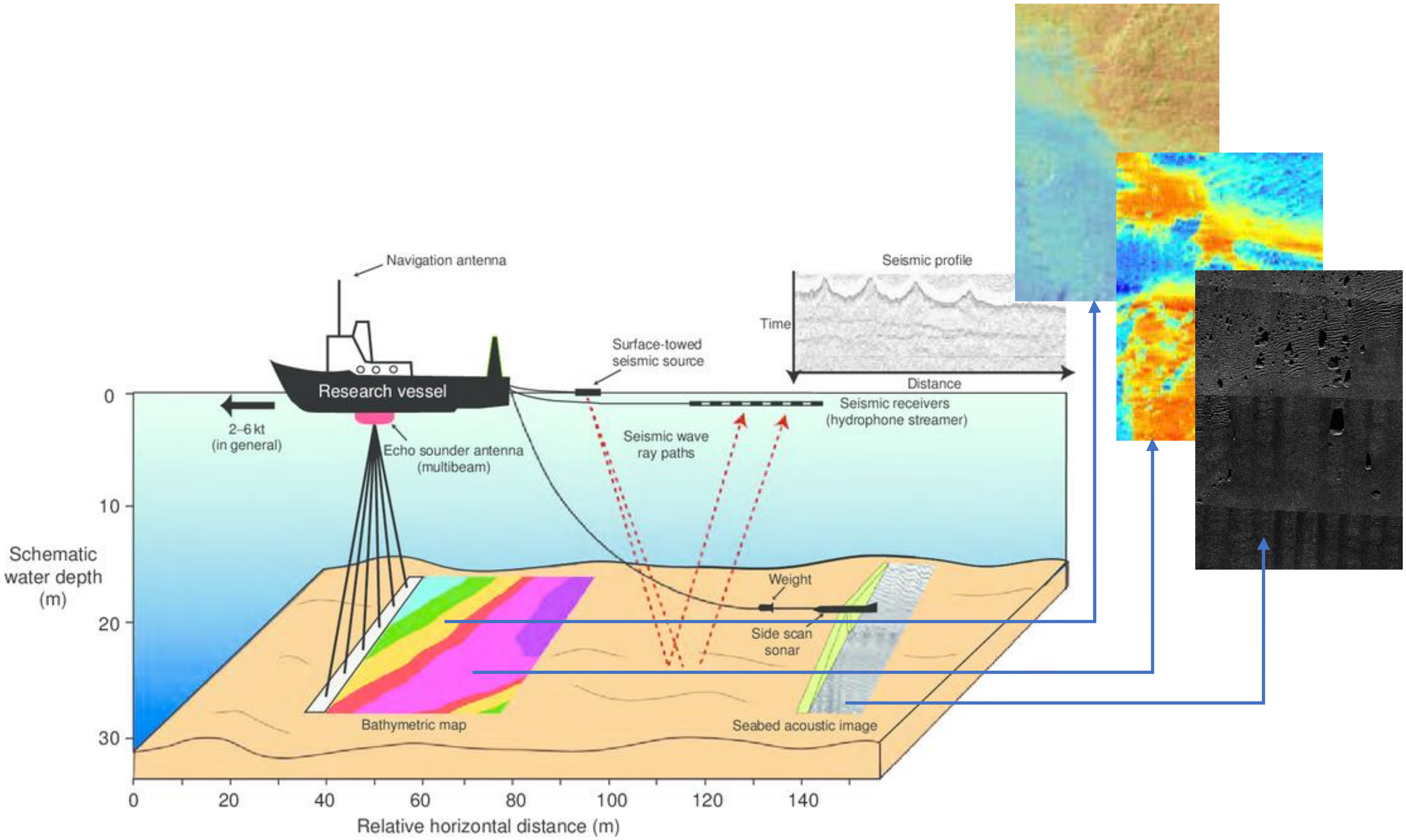


Figure 2-1. Schematic depicting a standard acoustic survey vessel set-up and data collection (after Garel et al. 2009)

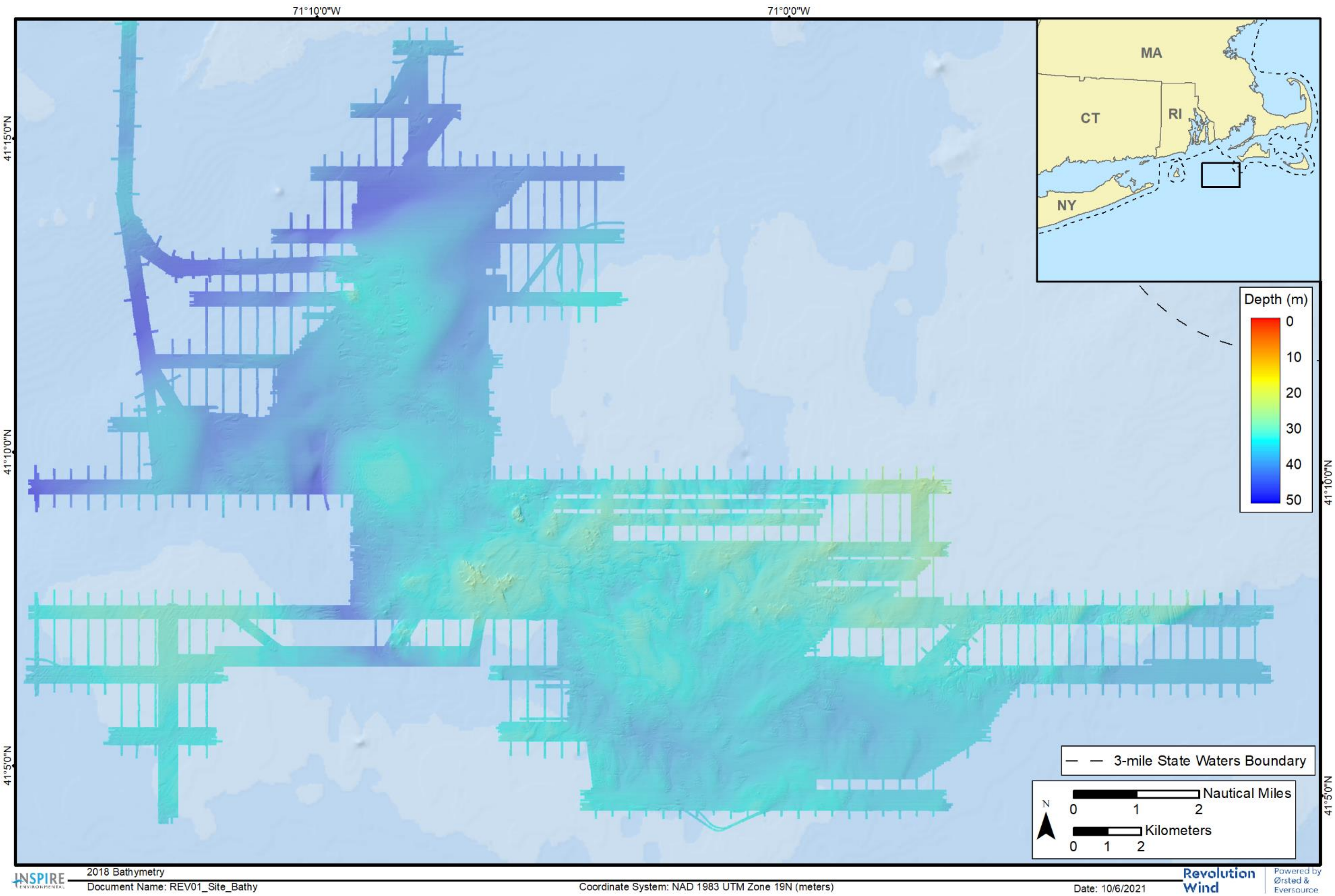


Figure 2-2. Bathymetric data at the RWF

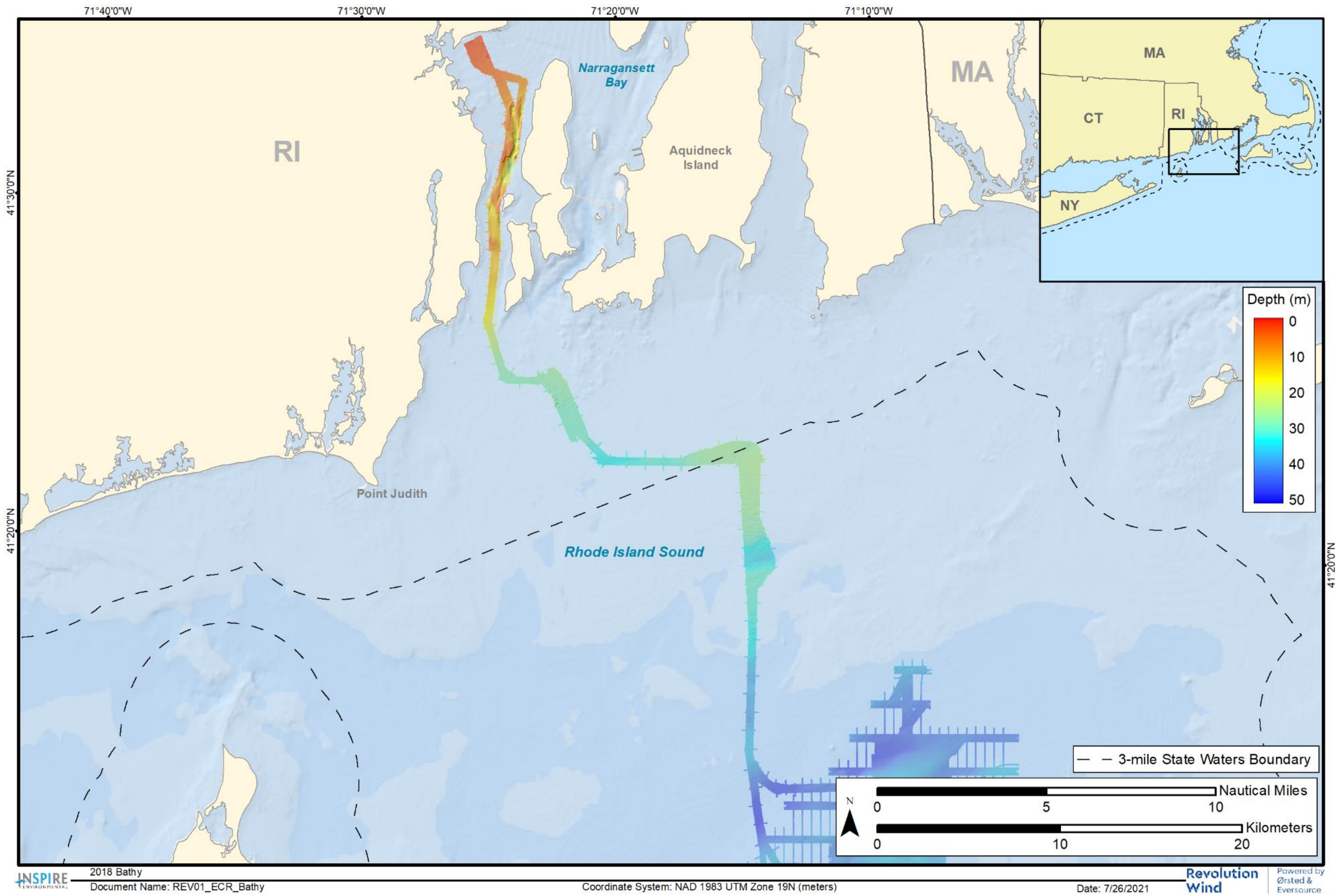


Figure 2-3. Bathymetric data along the RWEC

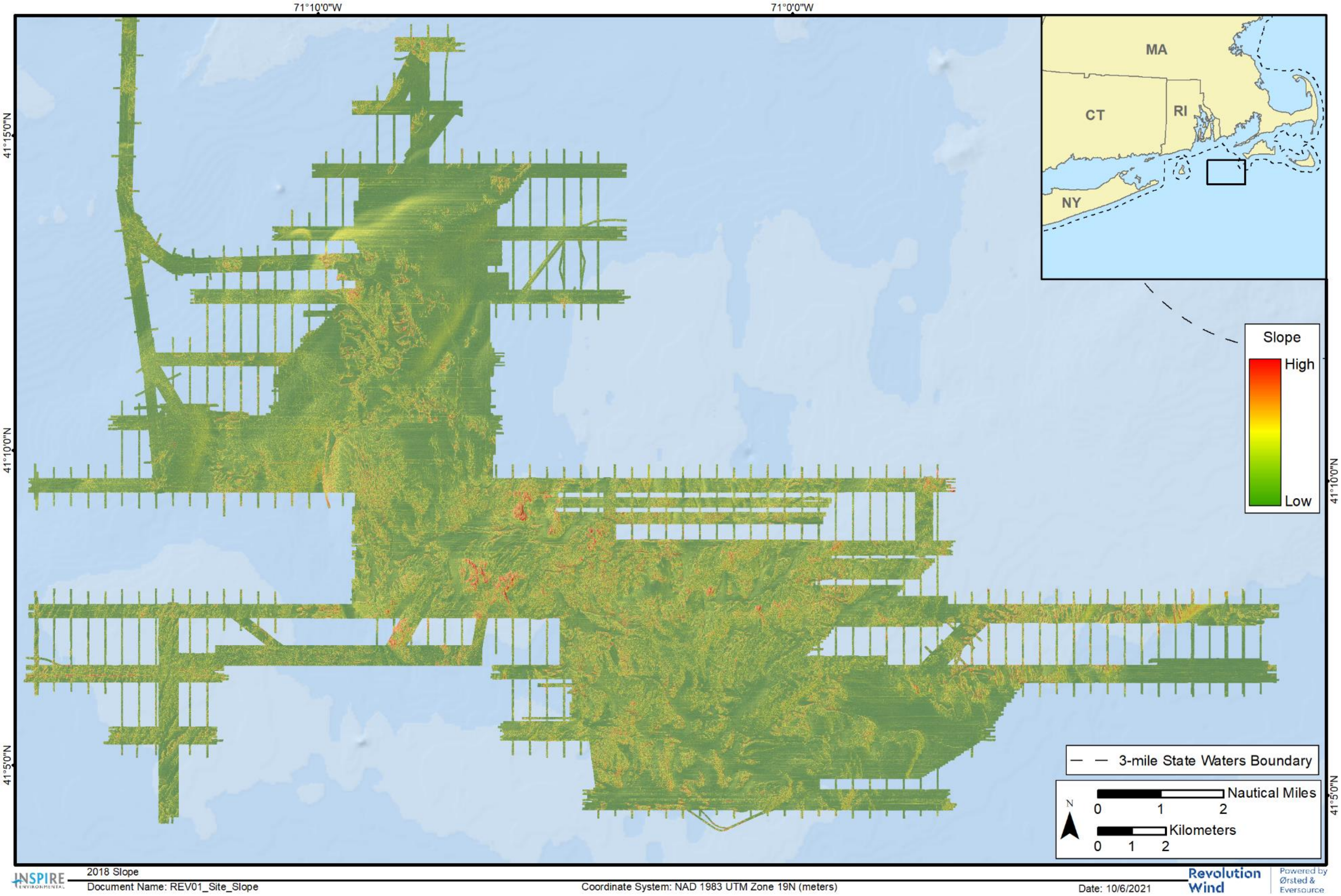


Figure 2-4. Model of seafloor slope at the RWF

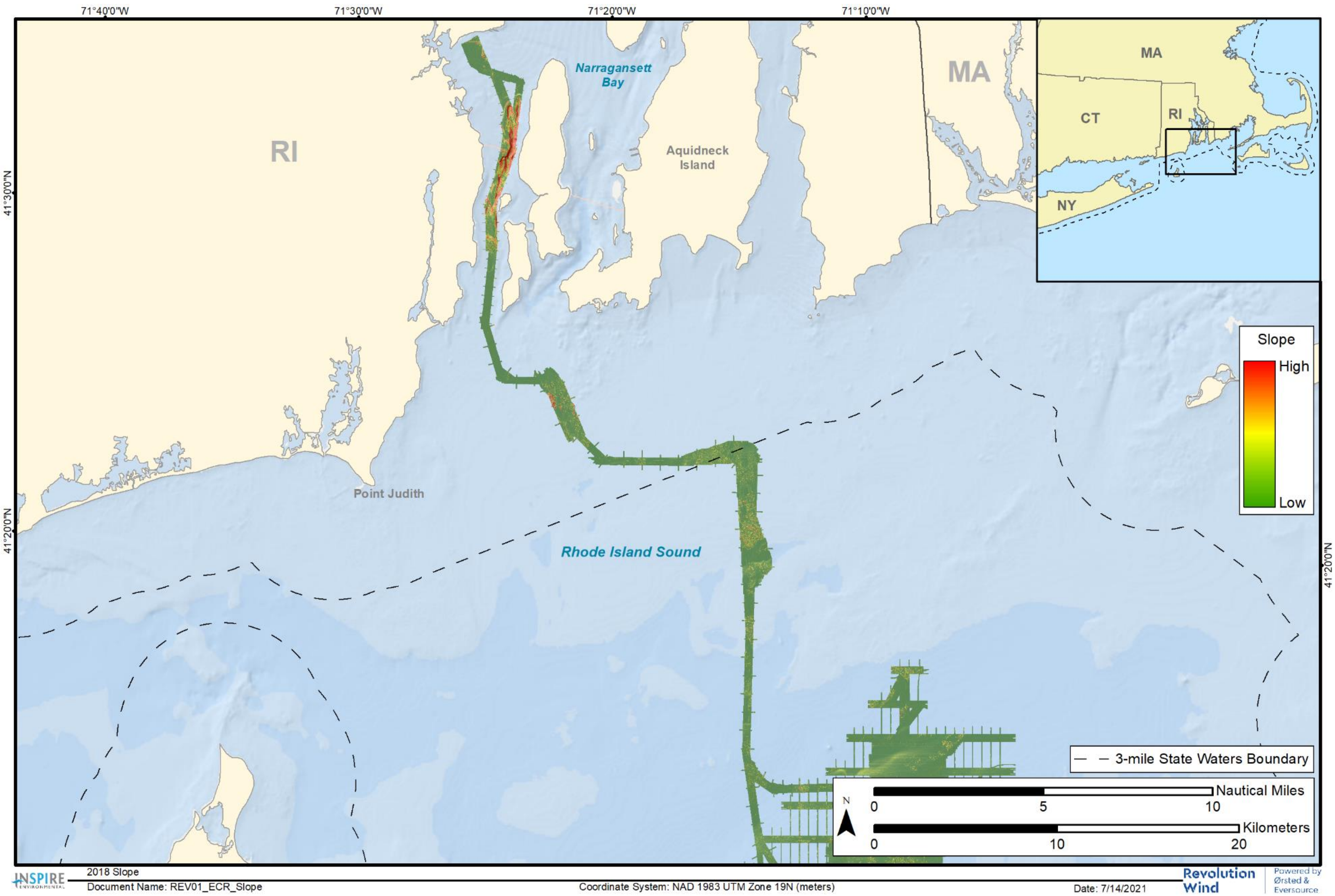


Figure 2-5. Model of seafloor slope along the RWEC

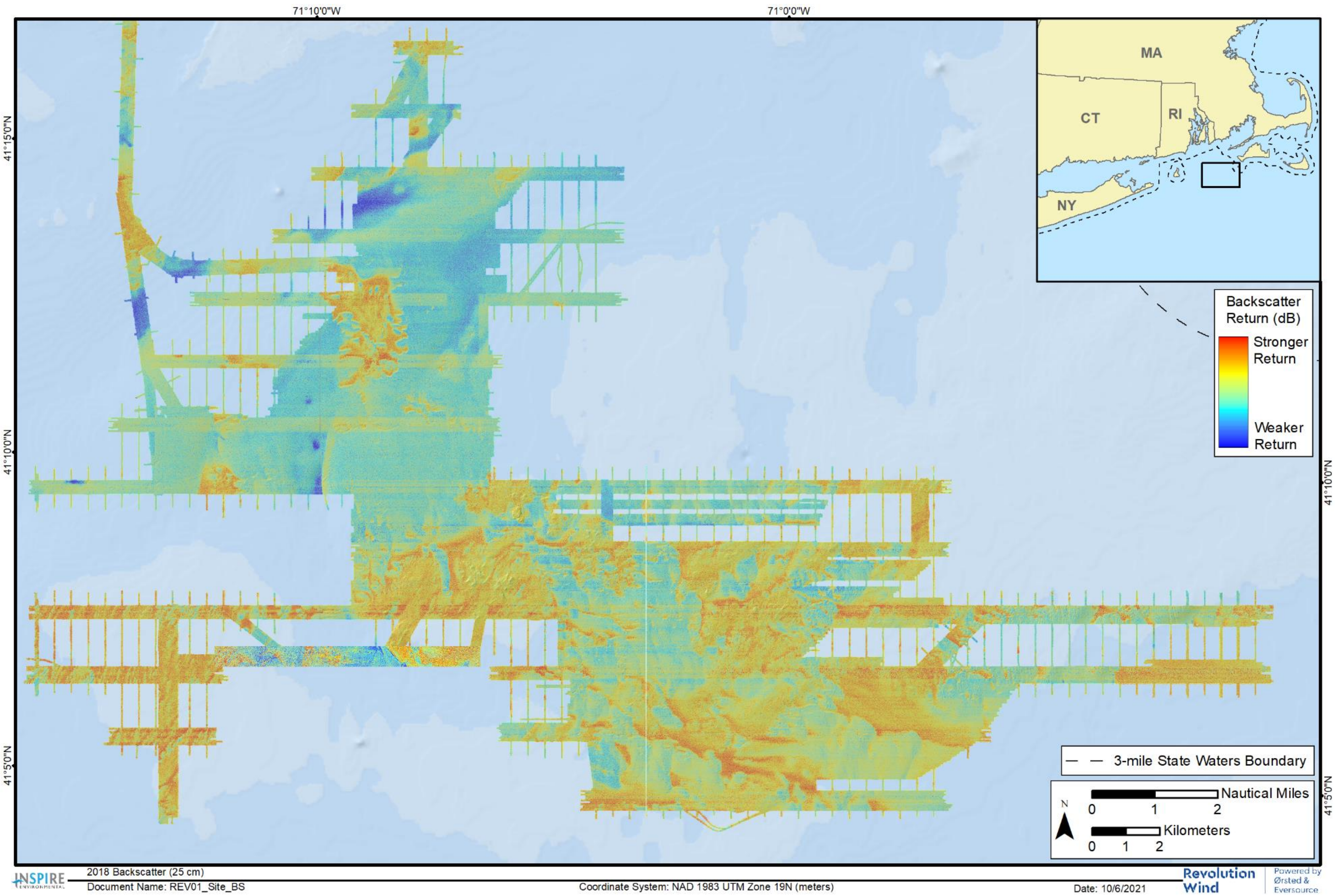


Figure 2-6. Backscatter data over hillshaded bathymetry at the RWF

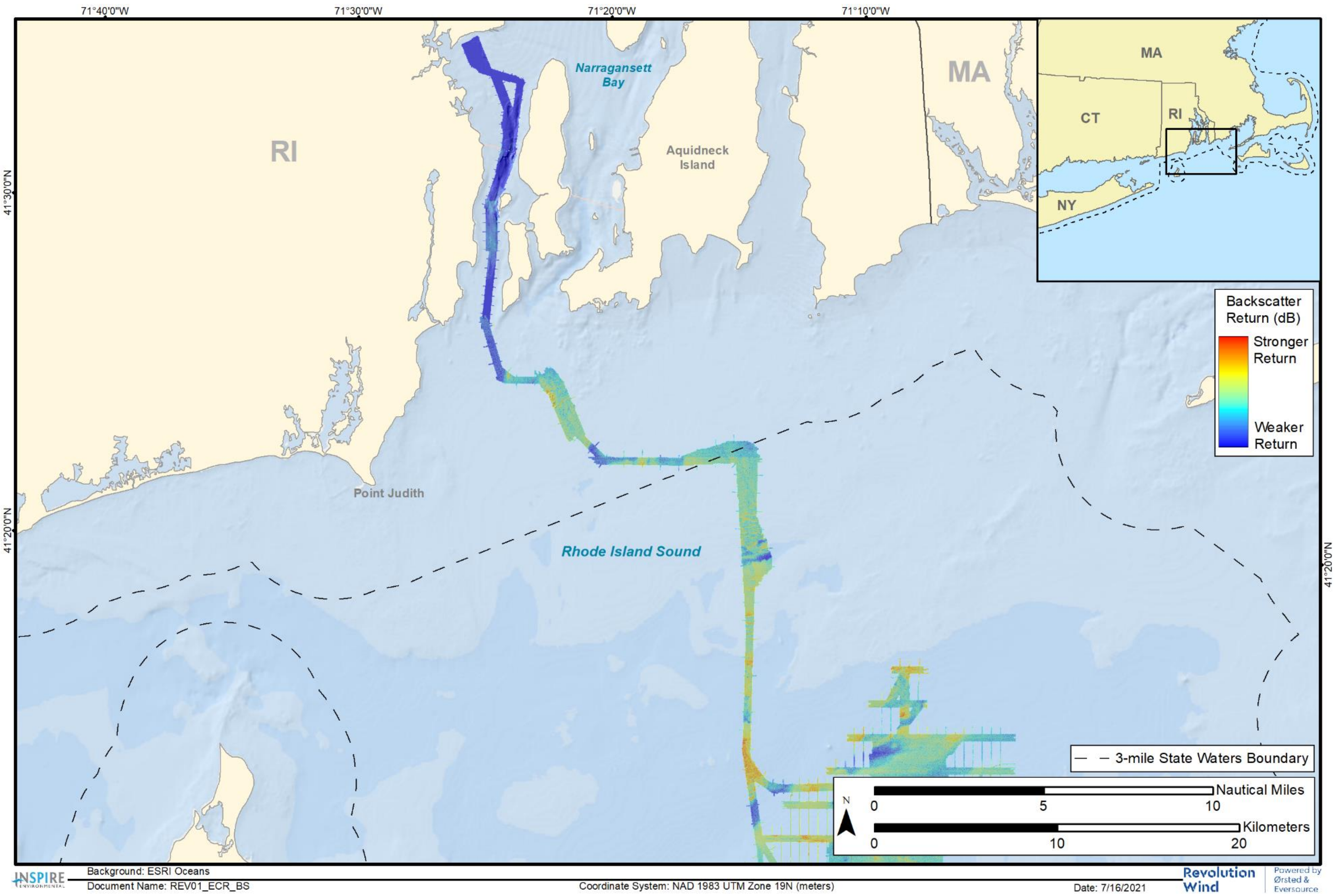


Figure 2-7. Backscatter data over hillshaded bathymetry along the RWEC

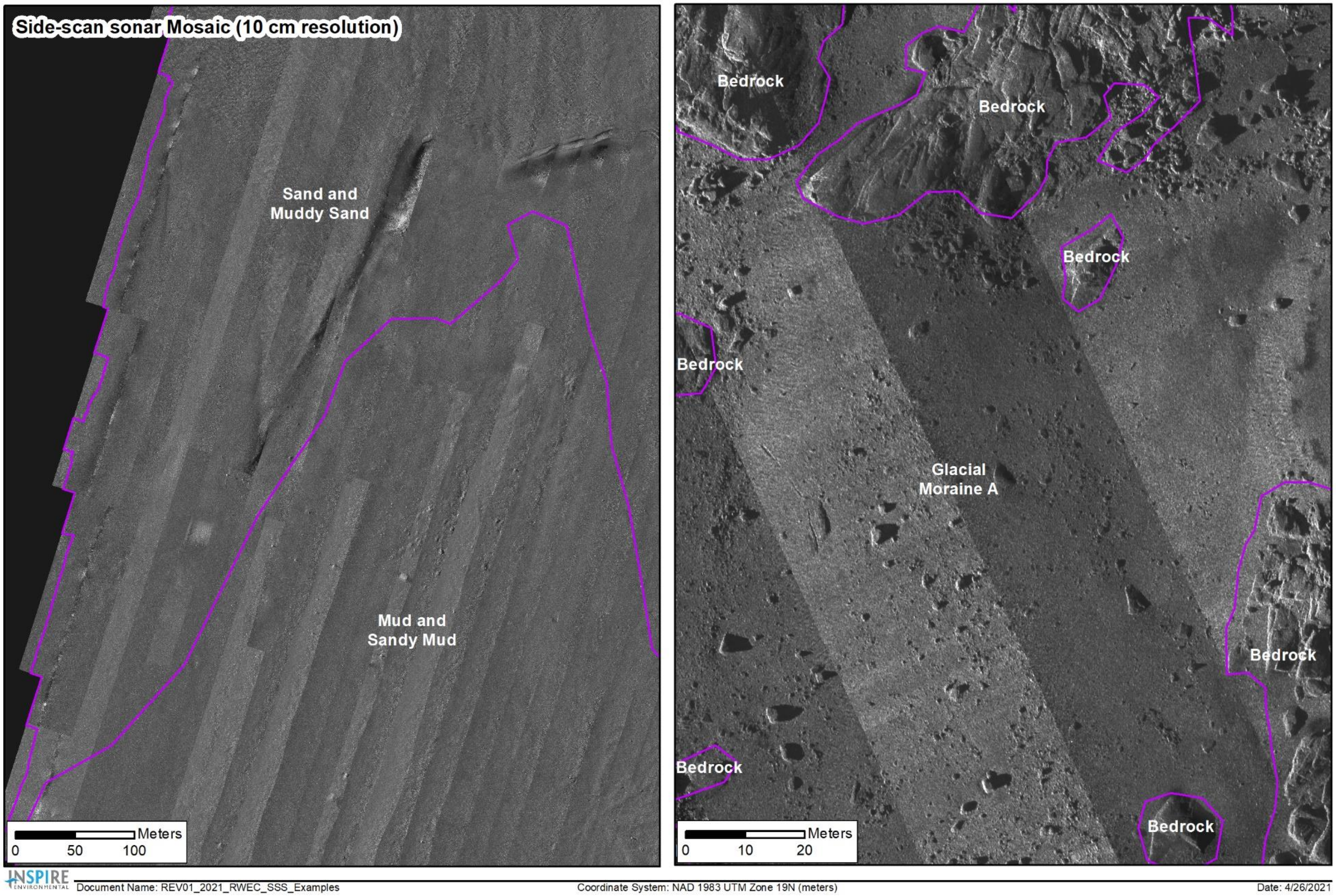


Figure 2-8. Examples of side-scan sonar data showing soft benthic habitats of sand and mud (left) and heterogeneous and complex hard bottom habitats of glacial origin, namely bedrock and moraine (right)

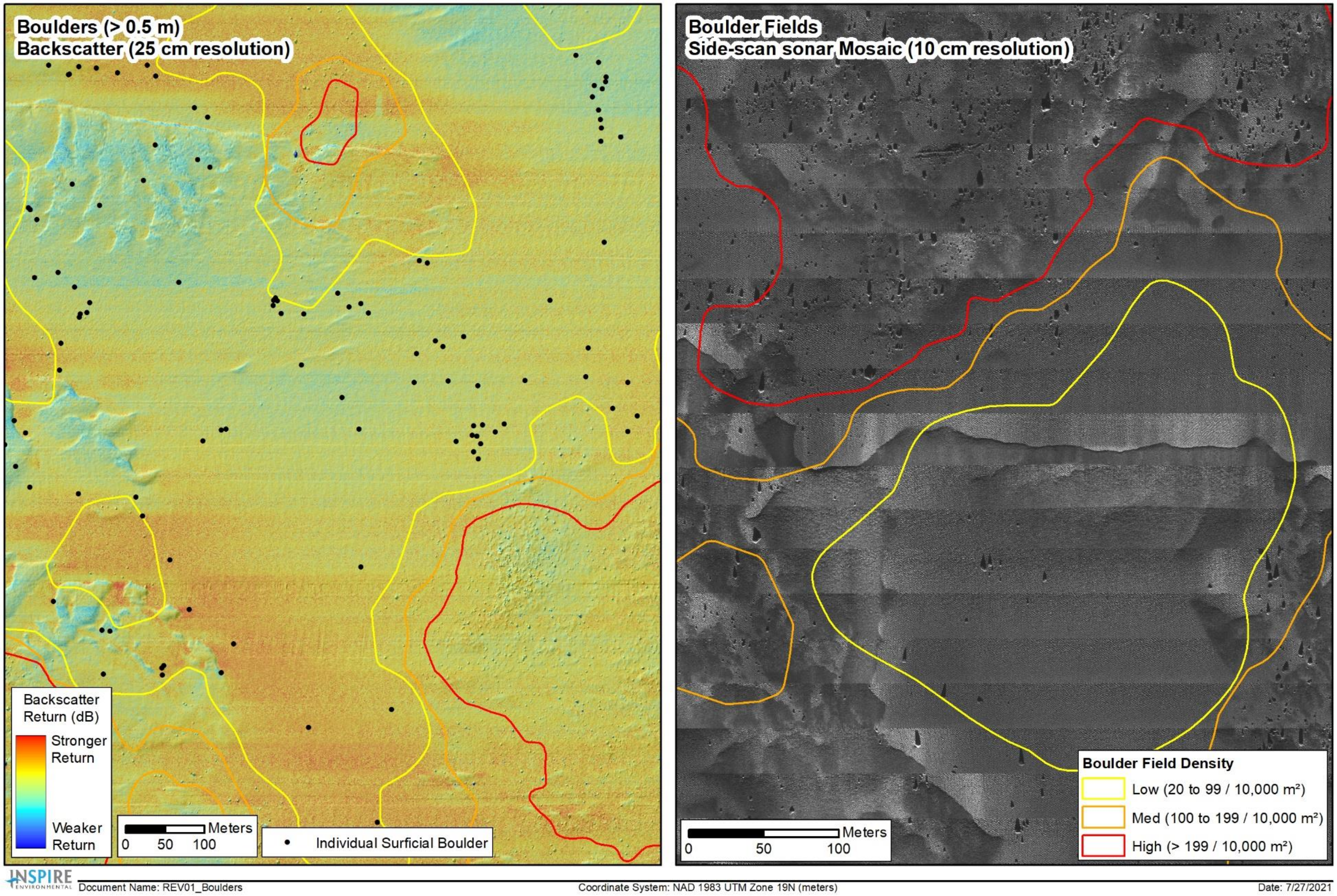


Figure 2-9. Boulder fields and surficial boulders (>0.5 m) individually identified ("picked") from the geophysical data on hillshaded bathymetric data (left) and on side-scan sonar data (right); two different locations are used as examples here. Note that boulders were aggregated into the boulder fields where present in densities >20 boulders per 10,000 m^2 and were not individually identified.

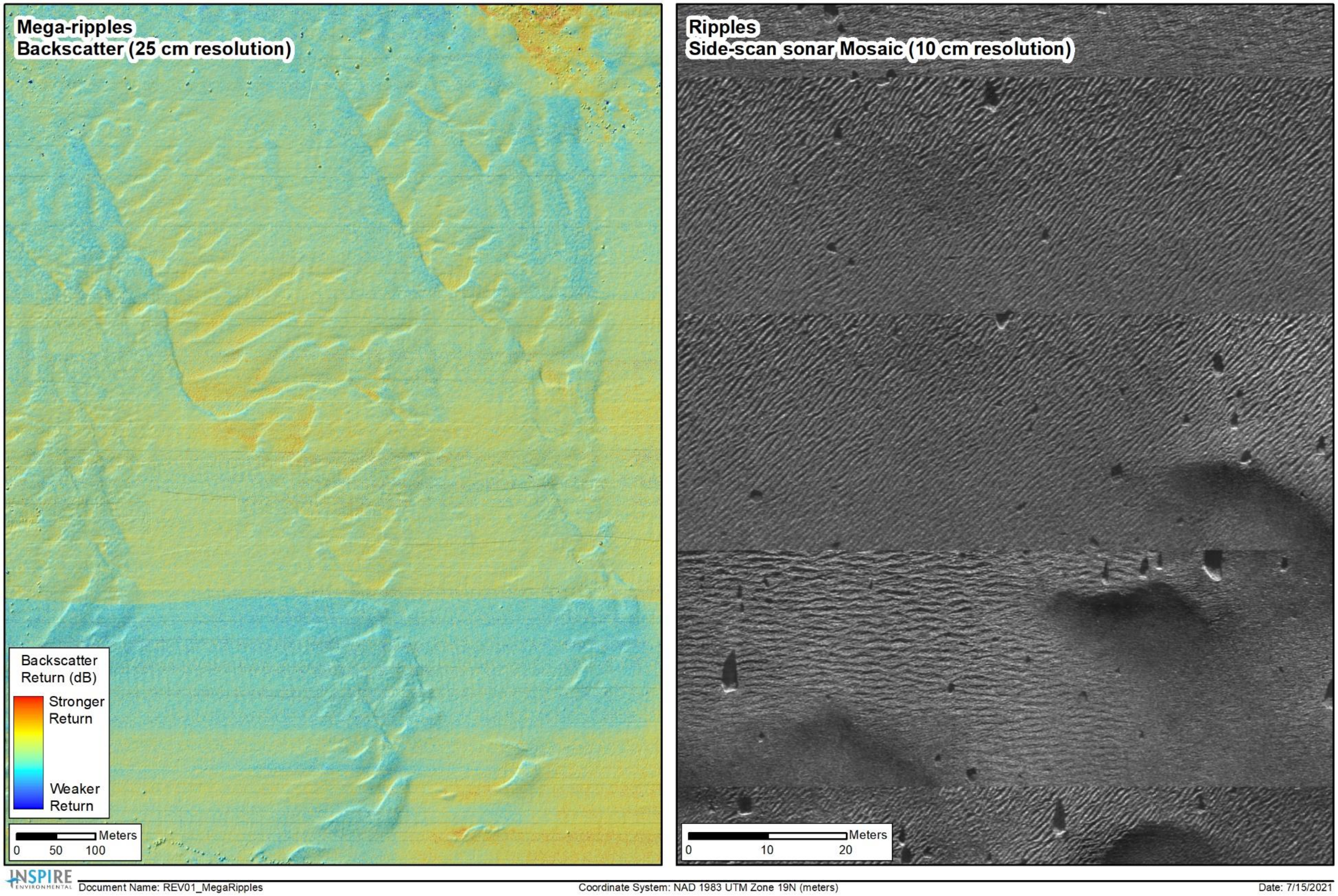
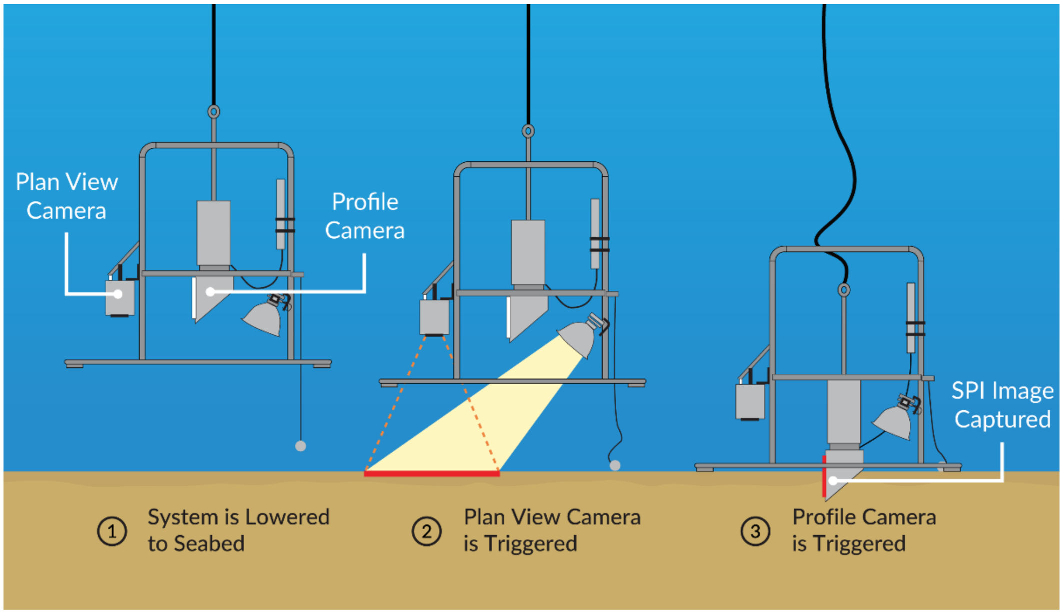


Figure 2-10. Mega-ripples visible in backscatter data over hillshaded bathymetry (left) and small-scale ripples visible in SSS data (right); two different locations are used as examples here



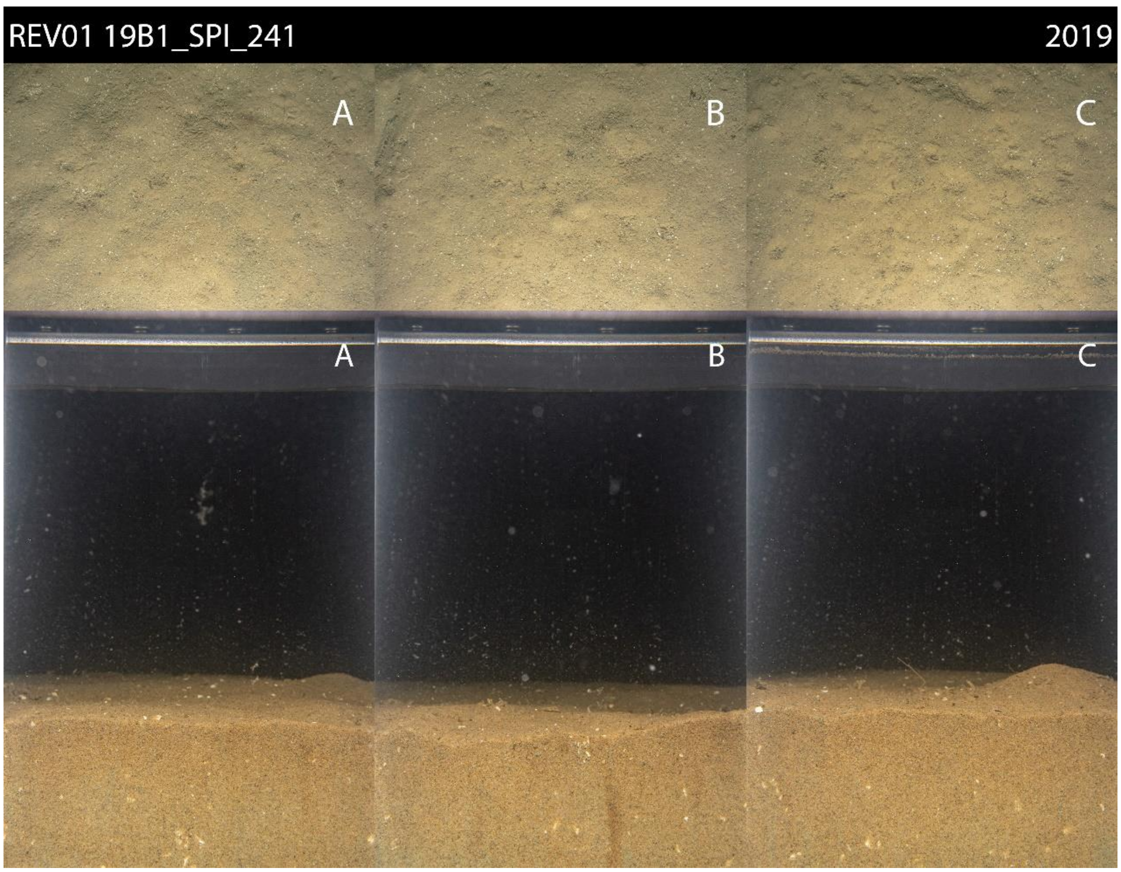


Figure 2-11. Schematic diagram of the operation of the sediment profile and plan view (SPI/PV) camera imaging system; the PV camera images an area of ~1 m^2 and the SPI camera images a profile of the sediment column that is 14.5 cm across and up to ~21 cm high. Three replicate images are analyzed at each station and a composite of these three paired replicate PV images (top) and SPI images (bottom) is prepared for use in reporting products.

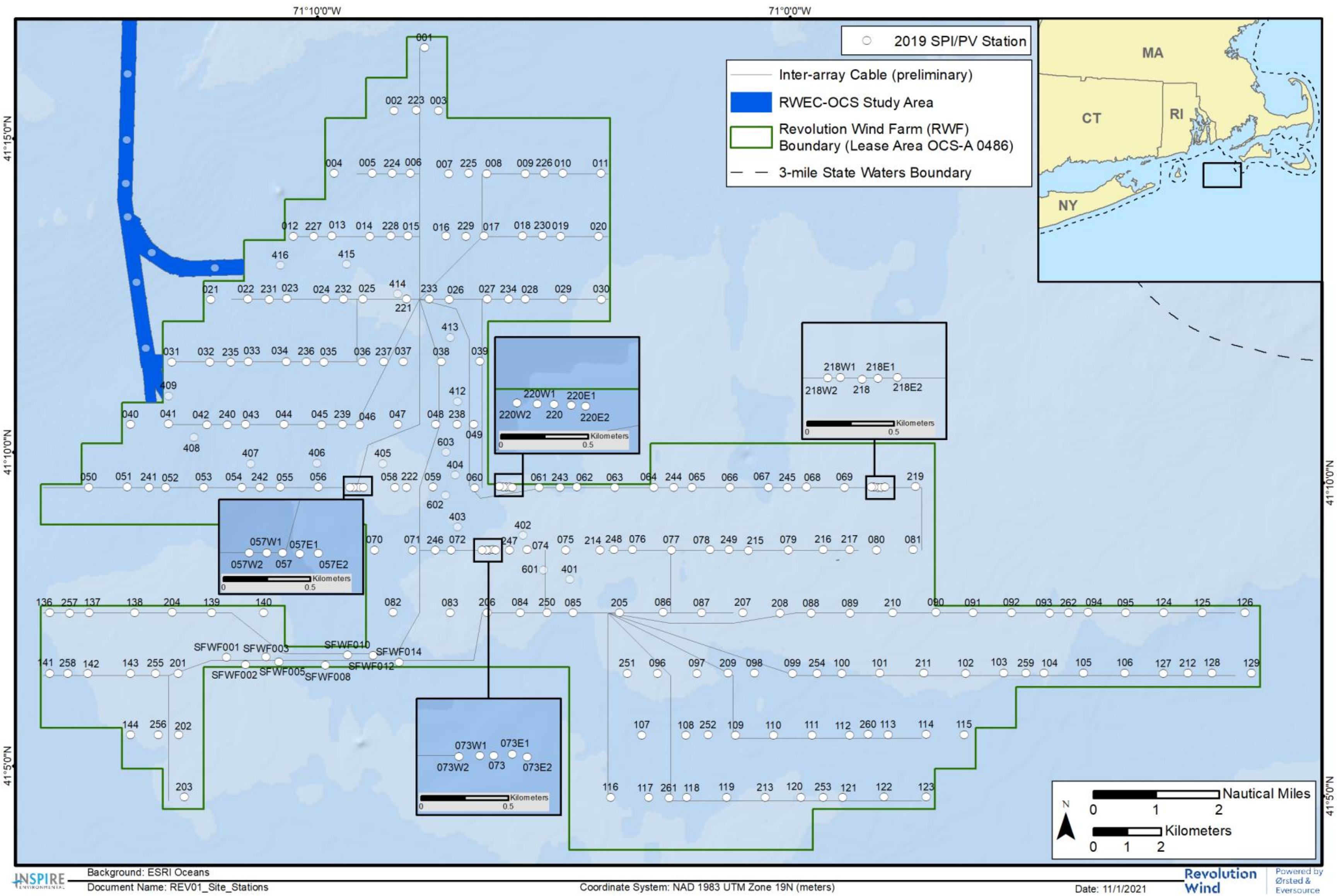


Figure 2-12. Locations sampled with sediment profile and plan view imaging (SPI/PV) used in ground-truthing geophysical data and habitat type interpretations at the RWF

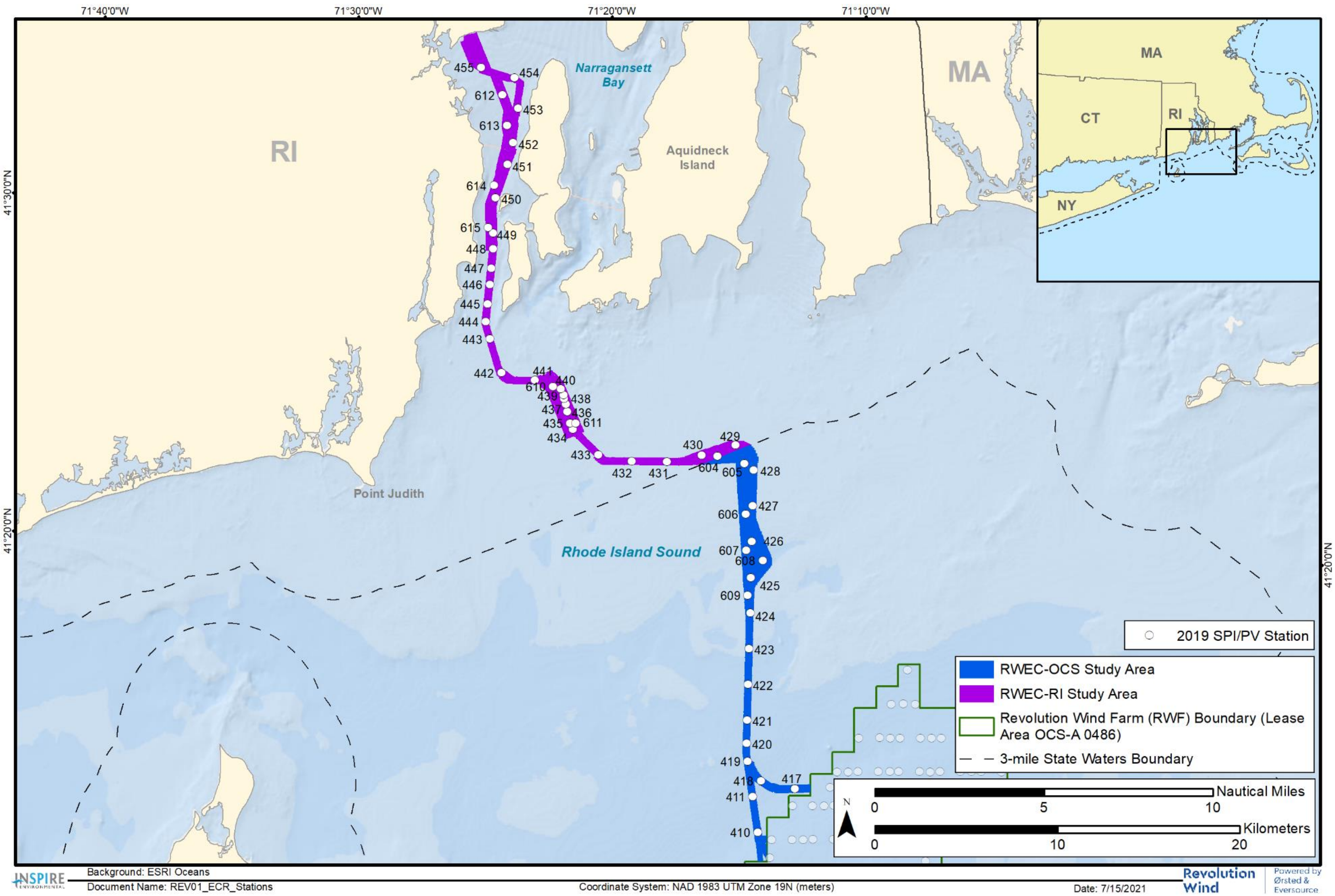


Figure 2-13. Locations sampled with SPI/PV used in ground-truthing geophysical data and habitat type interpretations along the RWEC

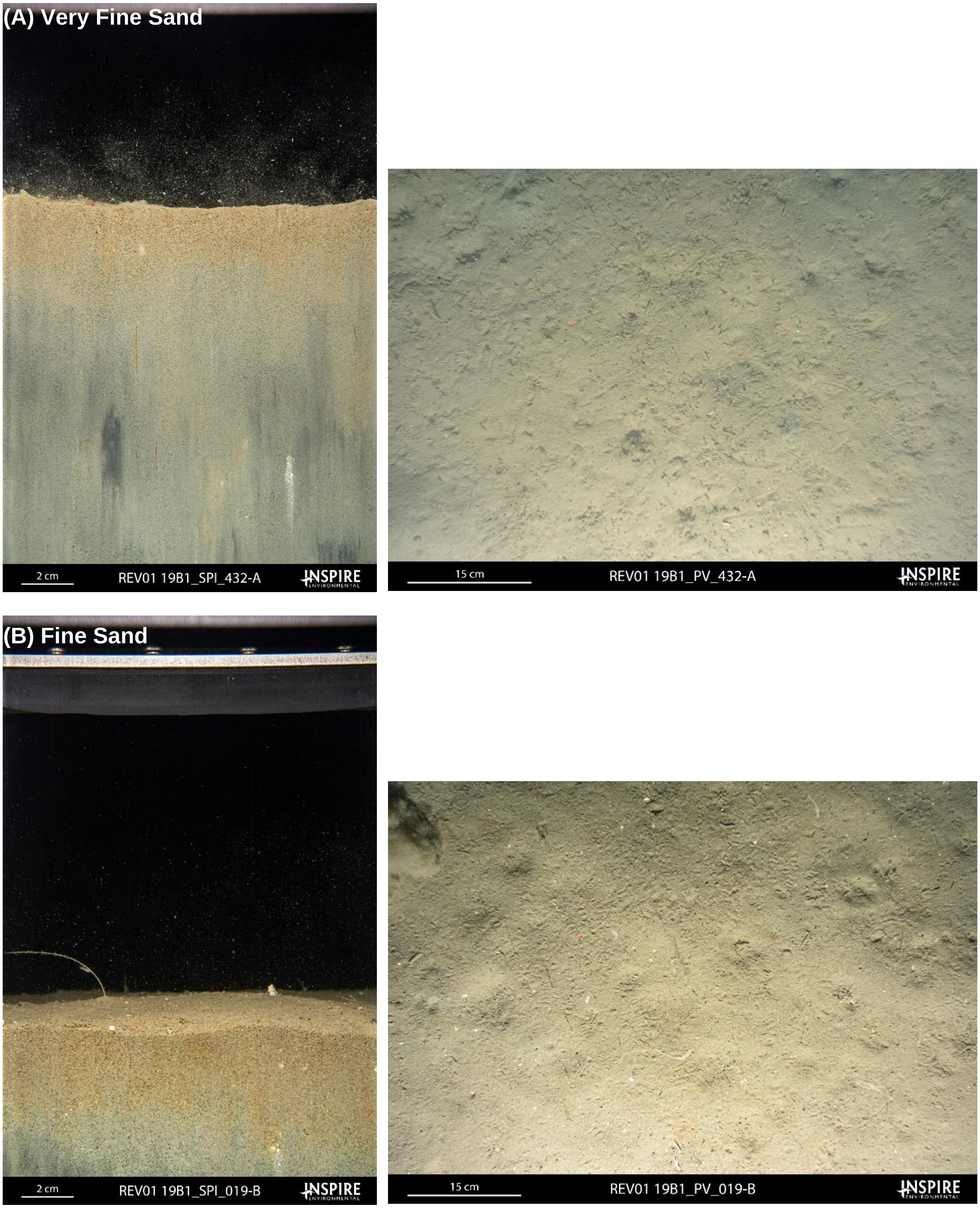


Figure 2-14. Representative SPI and PV images depicting the range of CMECS Substrate Subgroups across the Project Area: (A) Very Fine Sand; (B) Fine Sand; (C) Medium Sand; (D) Very Coarse Sand; (E) Gravelly Sand; (F) Sandy Gravel; (G) Pebble; (H) Cobble; and (I) Shell Substrate

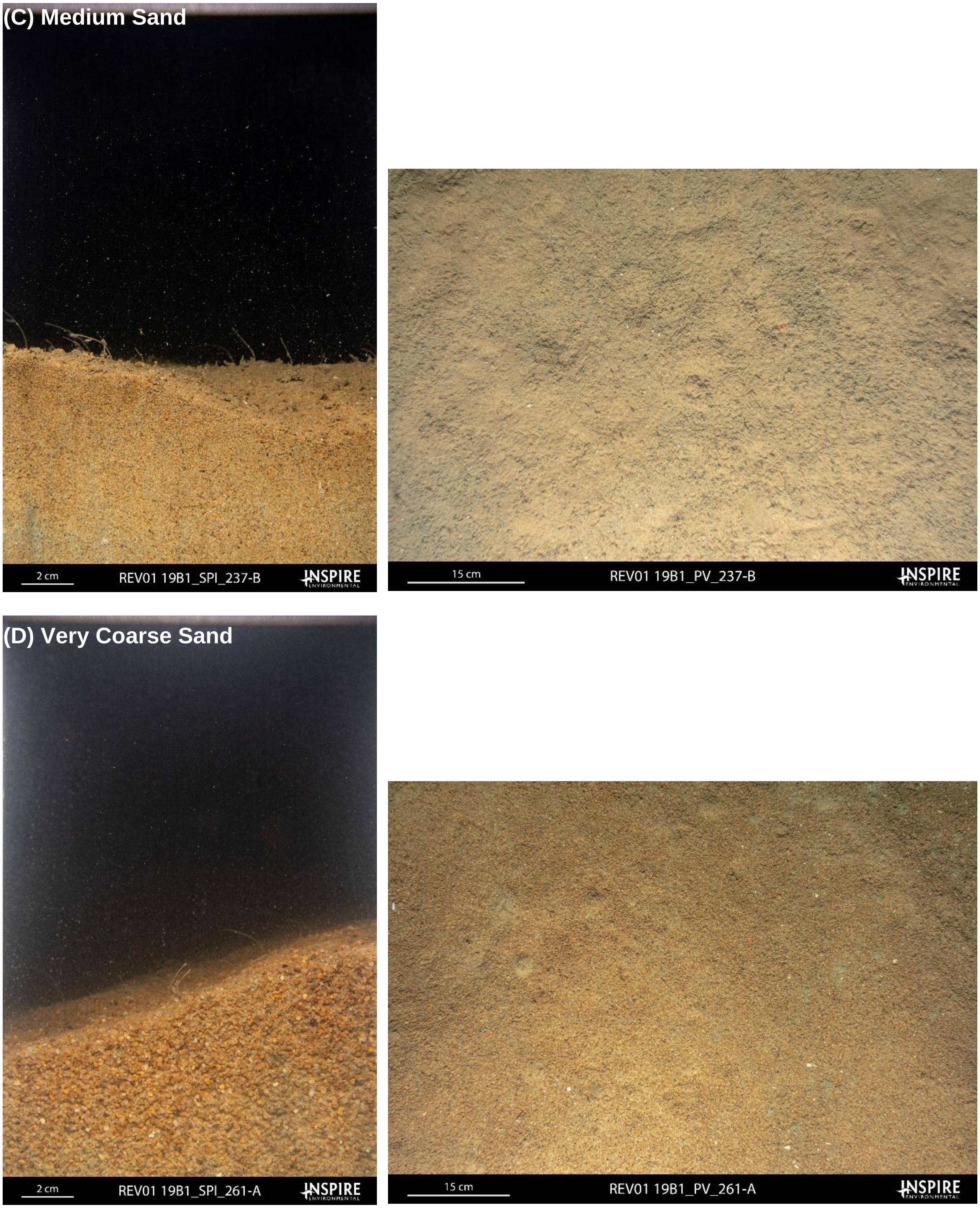
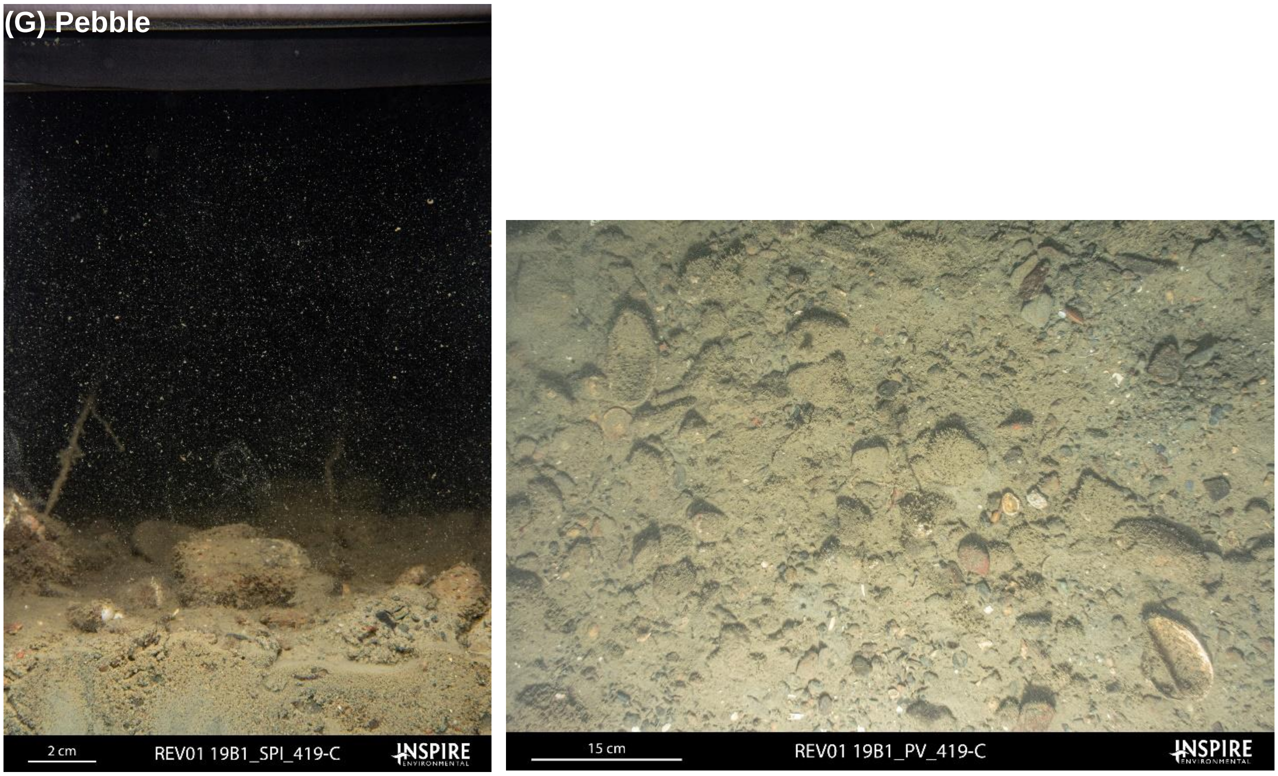


Figure 2-14. continued Representative SPI and PV images depicting the range of CMECS Substrate Subgroups across the Project Area: (A) Very Fine Sand; (B) Fine Sand; (C) Medium Sand; (D) Very Coarse Sand; (E) Gravelly Sand; (F) Sandy Gravel; (G) Pebble; (H) Cobble; and (I) Shell Substrate

Figure 2-14. continued Representative SPI and PV images depicting the range of CMECS Substrate Subgroups across the Project Area: (A) Very Fine Sand; (B) Fine Sand; (C) Medium Sand; (D) Very Coarse Sand; (E) Gravelly Sand; (F) Sandy Gravel; (G) Pebble; (H) Cobble; and (I) Shell Substrate



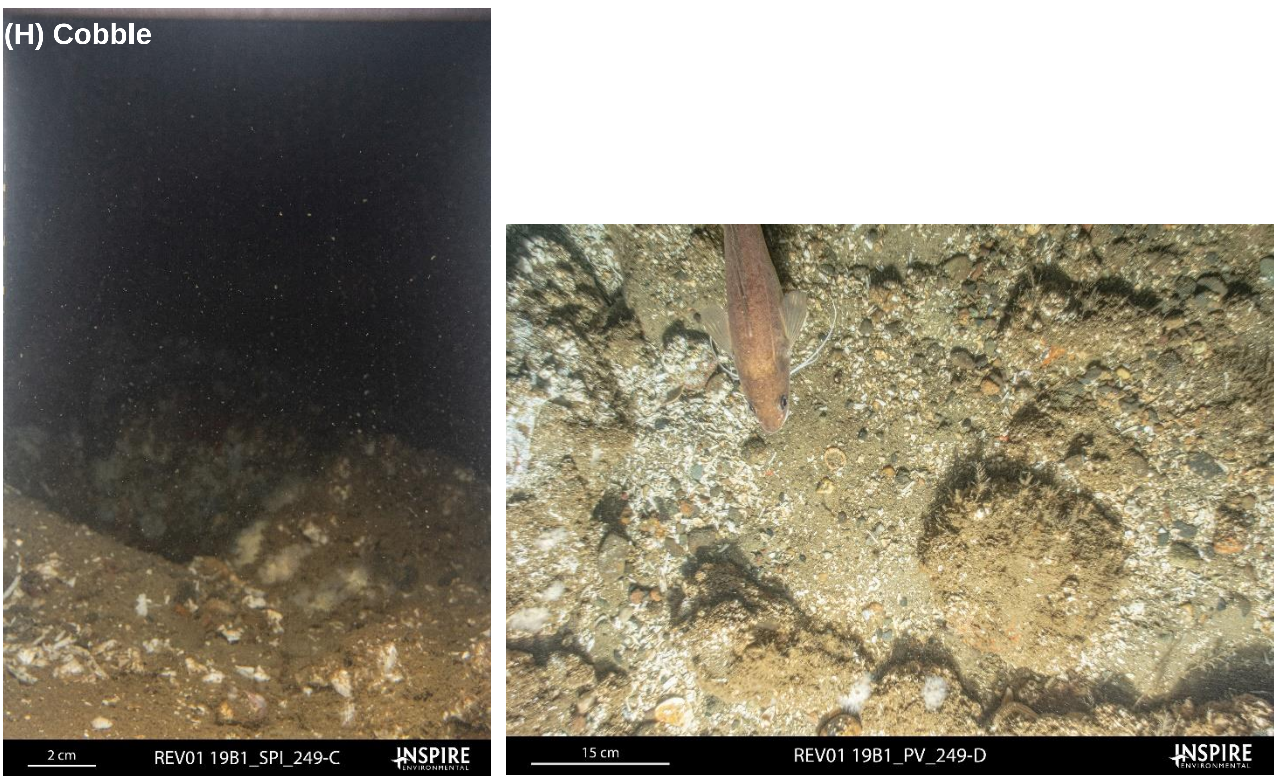


Figure 2-14. continued Representative SPI and PV images depicting the range of CMECS Substrate Subgroups across the Project Area: (A) Very Fine Sand; (B) Fine Sand; (C) Medium Sand; (D) Very Coarse Sand; (E) Gravelly Sand; (F) Sandy Gravel; (G) Pebble; (H) Cobble; and (I) Shell Substrate

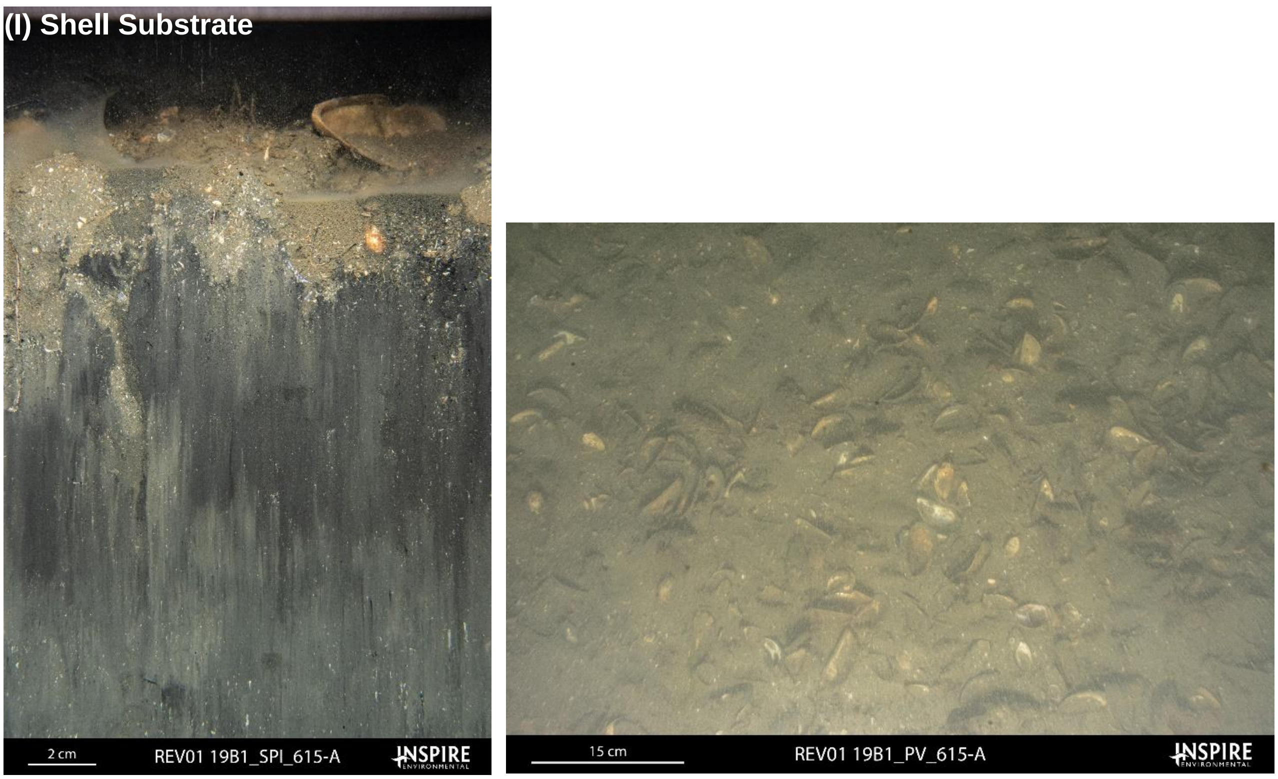
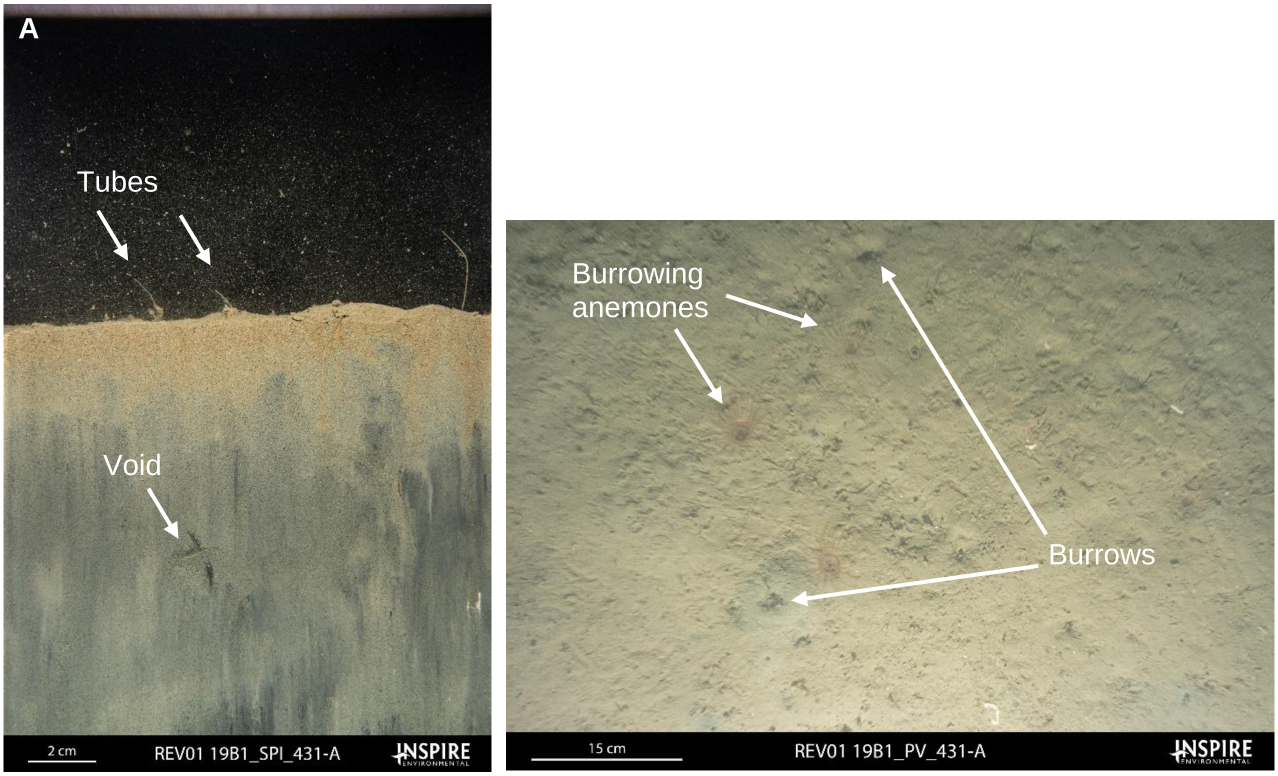
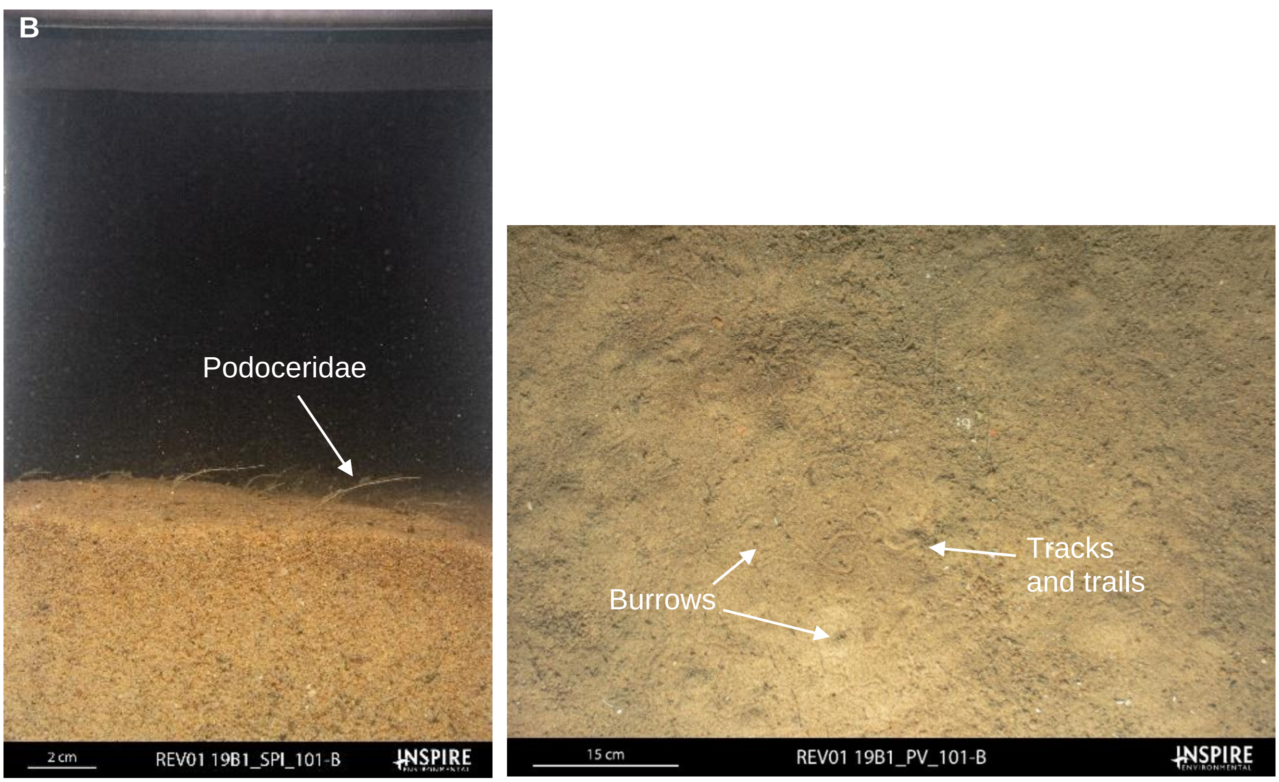


Figure 2-14. continued Representative SPI and PV images depicting the range of CMECS Substrate Subgroups across the Project Area: (A) Very Fine Sand; (B) Fine Sand; (C) Medium Sand; (D) Very Coarse Sand; (E) Gravelly Sand; (F) Sandy Gravel; (G) Pebble; (H) Cobble; and (I) Shell Substrate

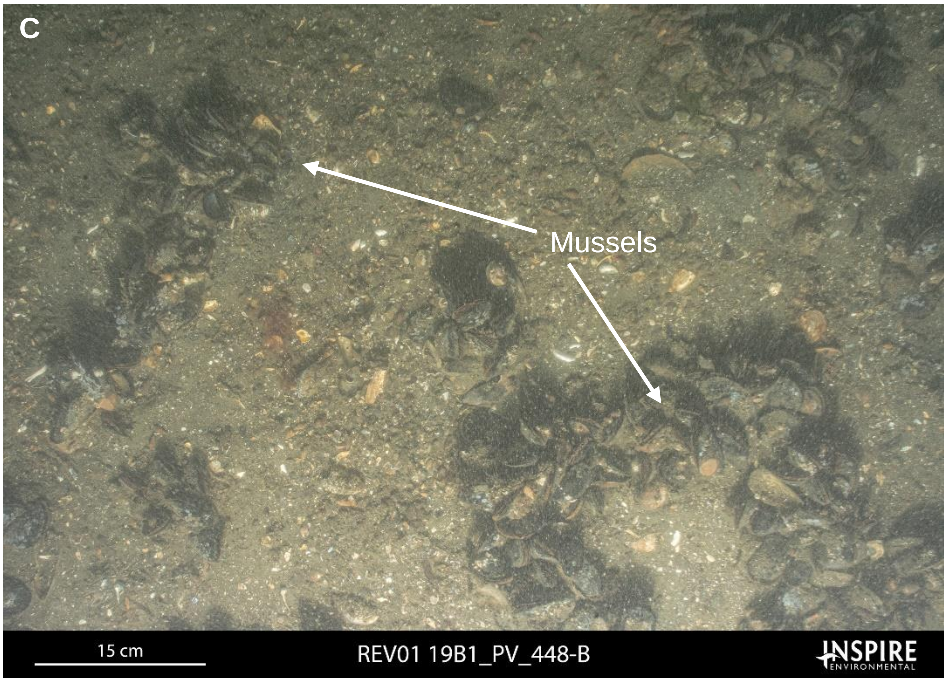


(A) infaunal tubes, burrows, and voids, as well as burrowing anemones (*Ceriantheids*) on very fine sand

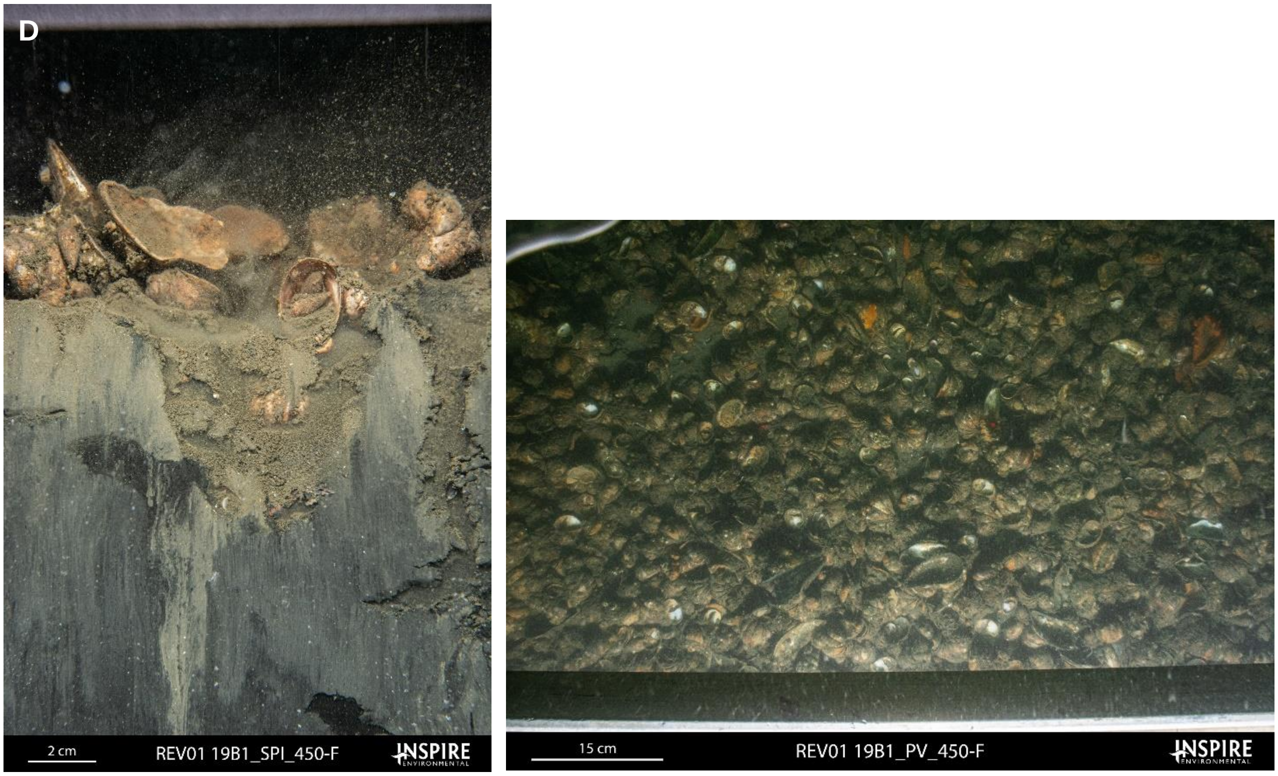


(B) tracks, trails, burrows, and Podoceridae amphipods on medium sand

Figure 2-15. Representative SPI and PV images depicting infaunal and epifaunal communities

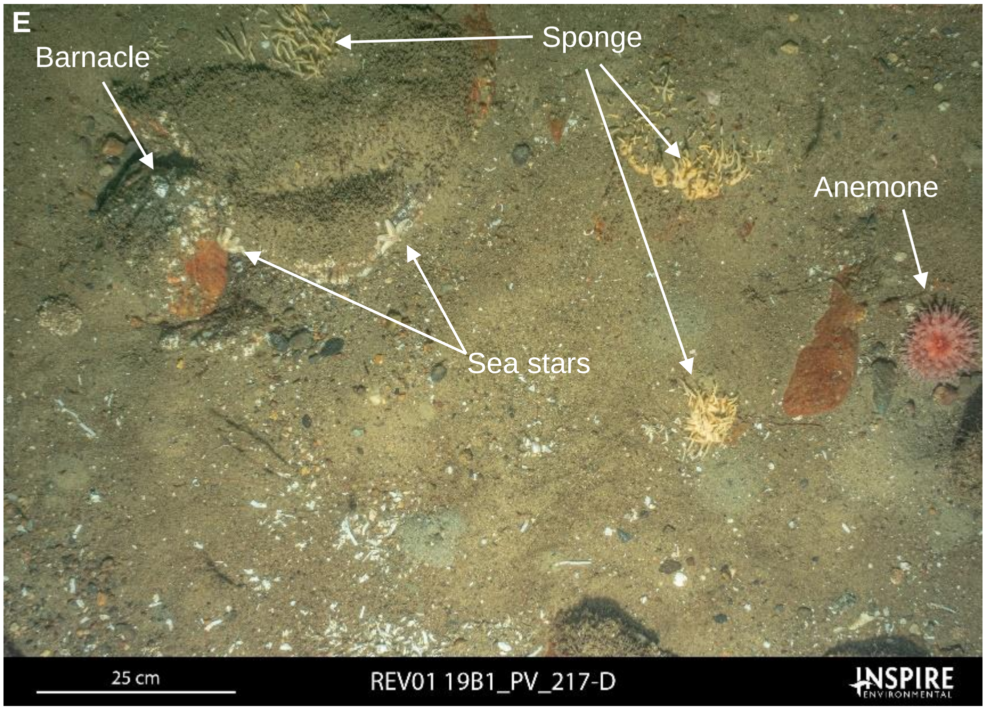


(C) blue mussels on shell hash and silt/clay

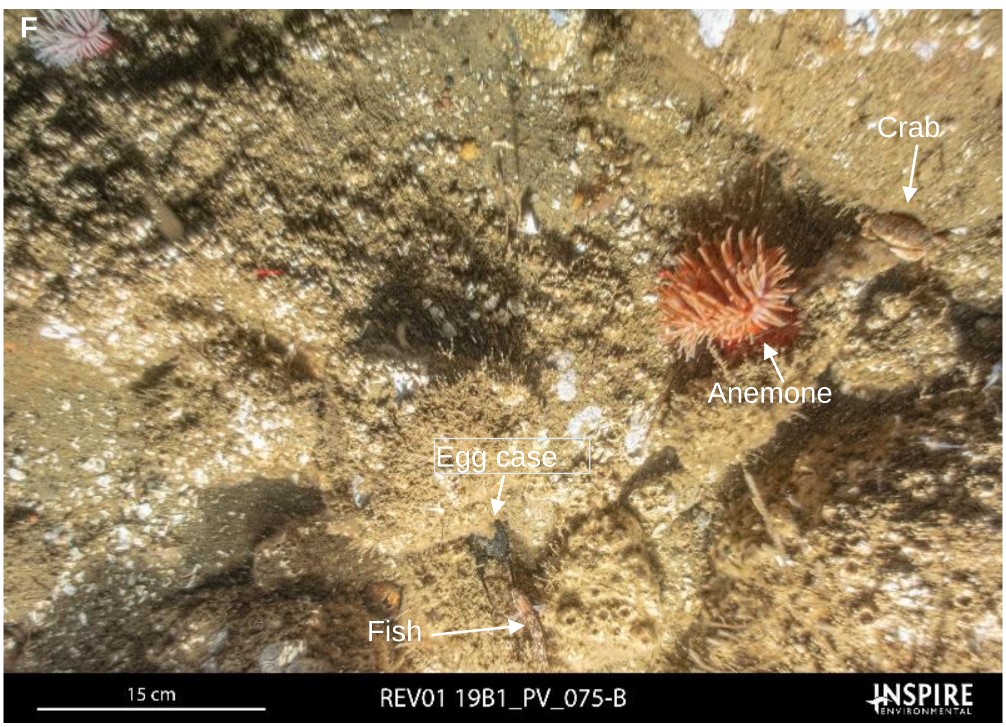


(D) *Crepidula* gastropods forming a reef substrate

Figure 2-15. continued Representative SPI and PV images depicting infaunal and epifaunal communities



(E) sea stars, barnacles, sponges, and an anemone on patchy cobbles and boulders on sand



(F) anemones, sponges, bryozoa, sea pens, and barnacles were observed, in addition to a small fish, a skate egg case, and crabs on boulders

Figure 2-15. continued Representative SPI and PV images depicting infaunal and epifaunal communities

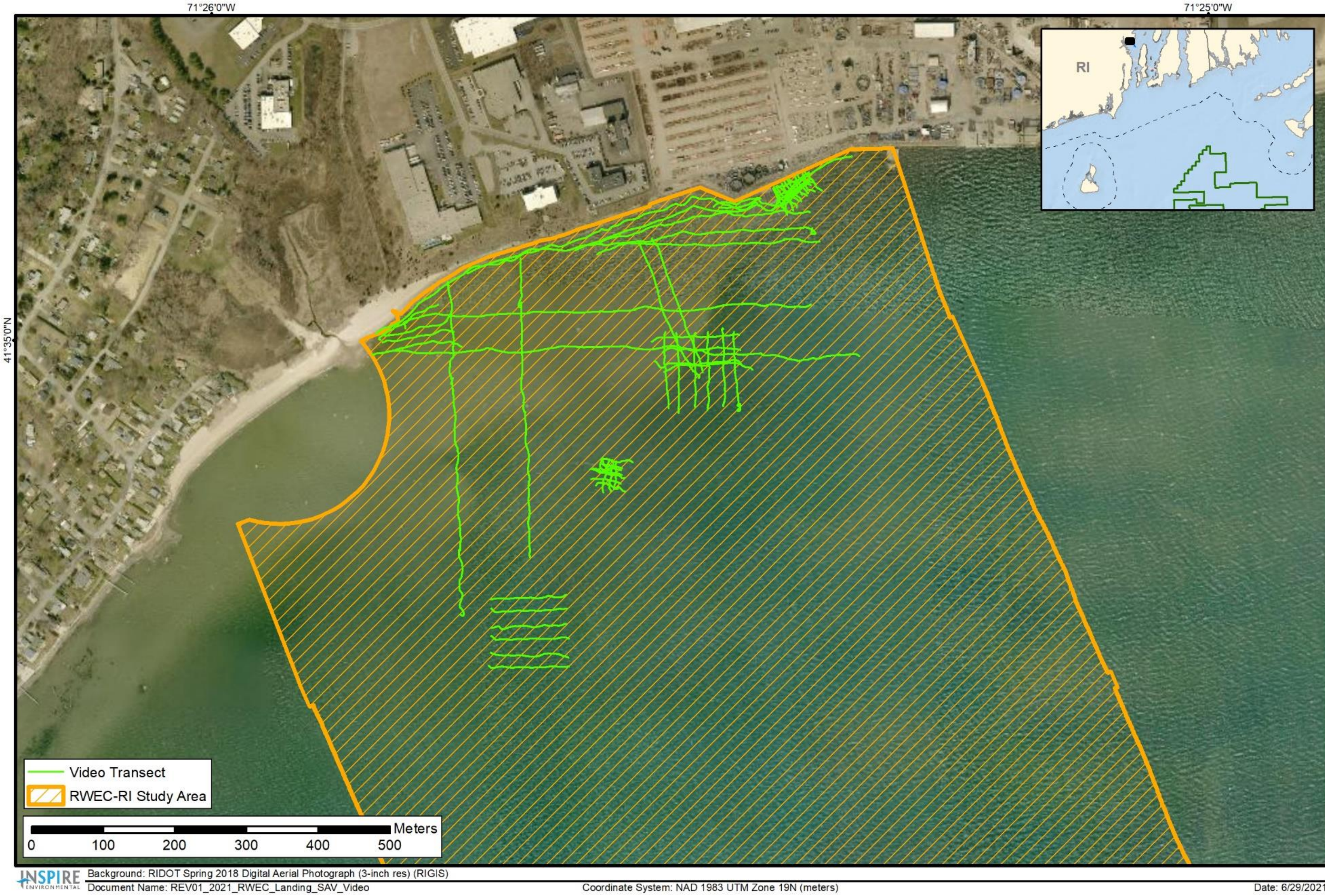


Figure 2-16. Locations of video transects surveyed for presence of submerged aquatic vegetation (SAV) in the vicinity of the potential landfall at Quonset Point

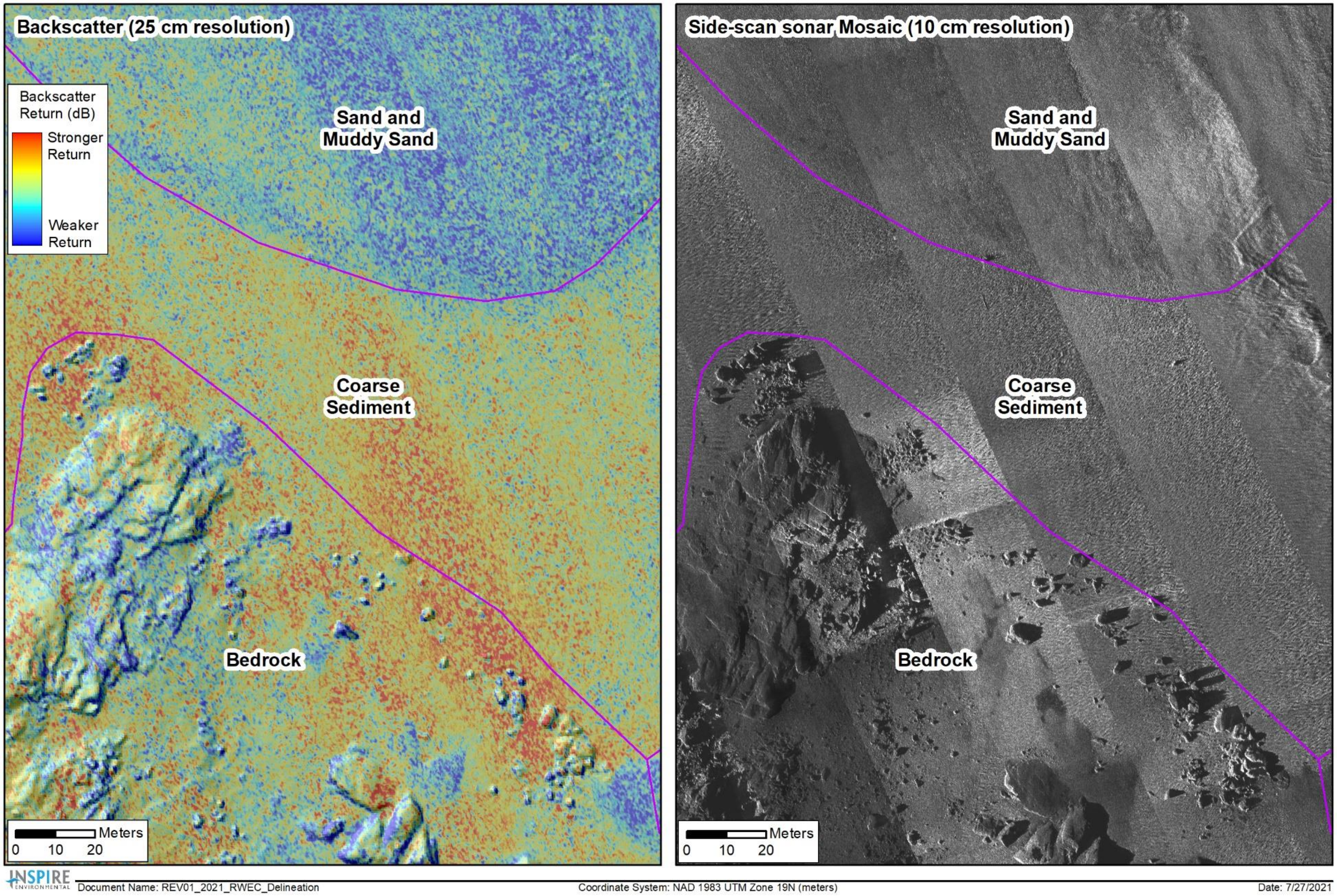


Figure 2-17. Example of delineation process, using MBES to delineate large scale facies (left) and SSS to refine seabed delineations (right)

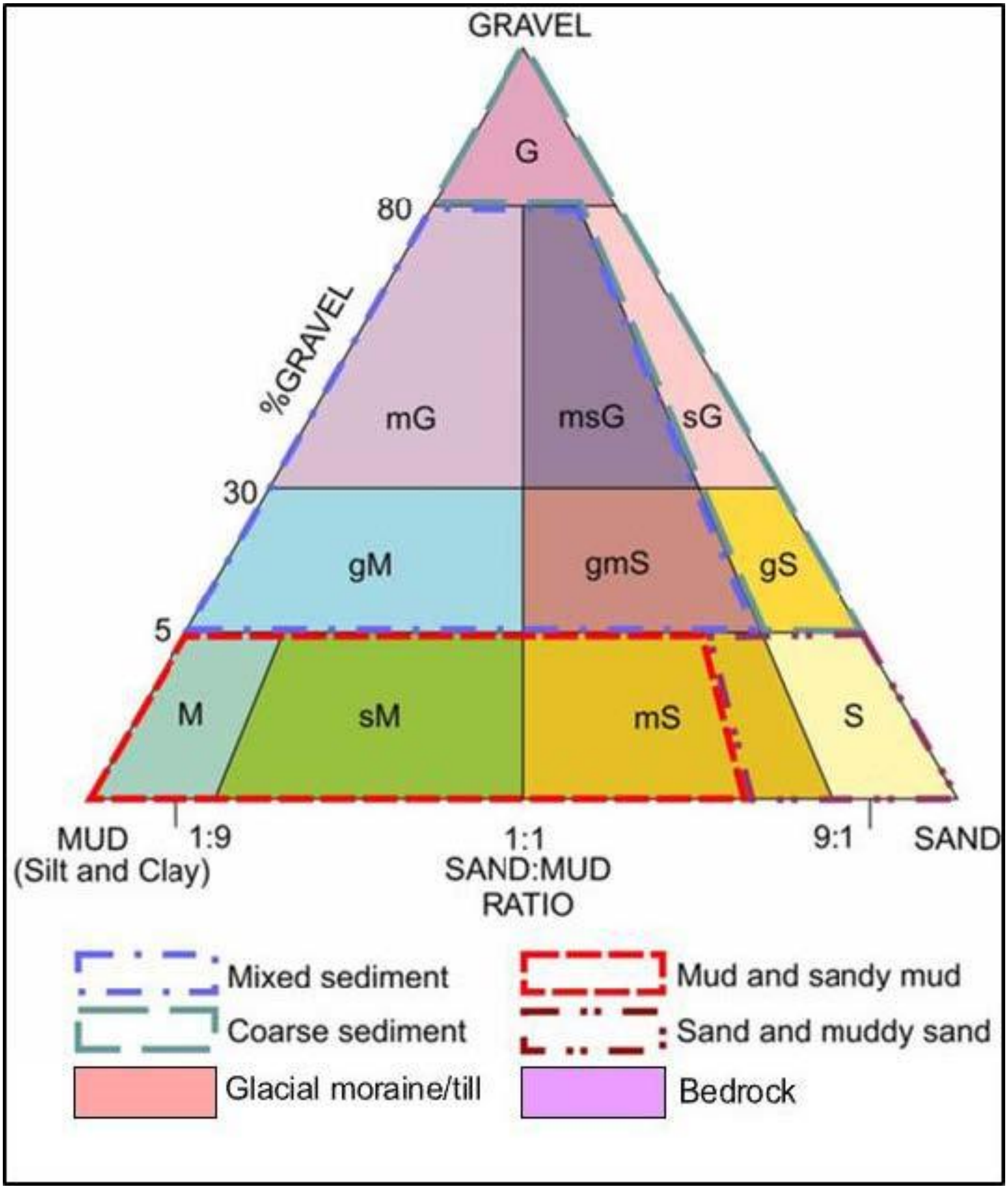


Figure 2-18. CMECS ternary diagram with Revolution Wind's geological seabed interpretation categories

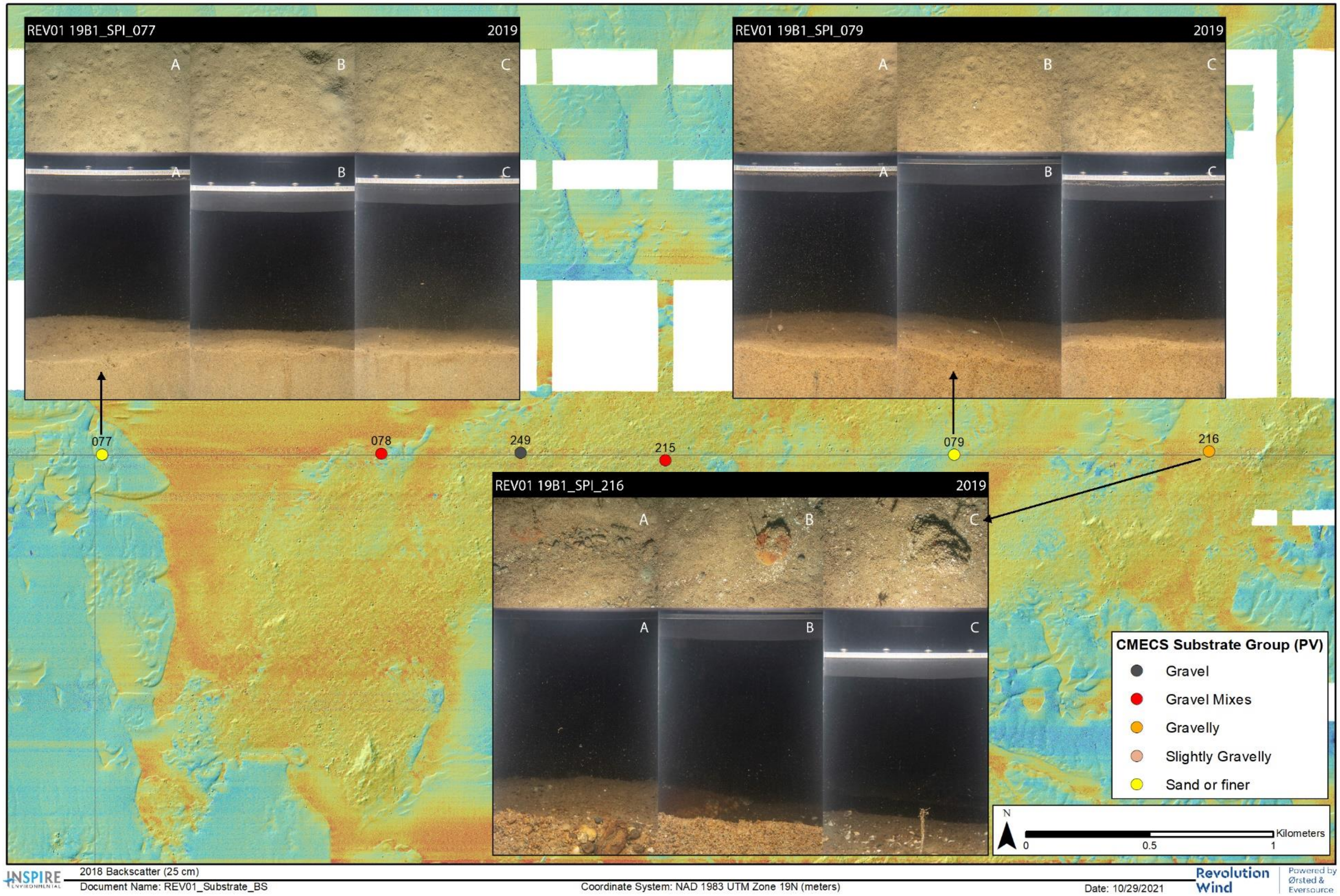


Figure 2-19. Ground-truth PV data for CMECS Substrate Group on backscatter data over hillshaded bathymetry; inset images for Stations 077, 079, and 216 show three paired replicate PV images (top) and SPI images (bottom)

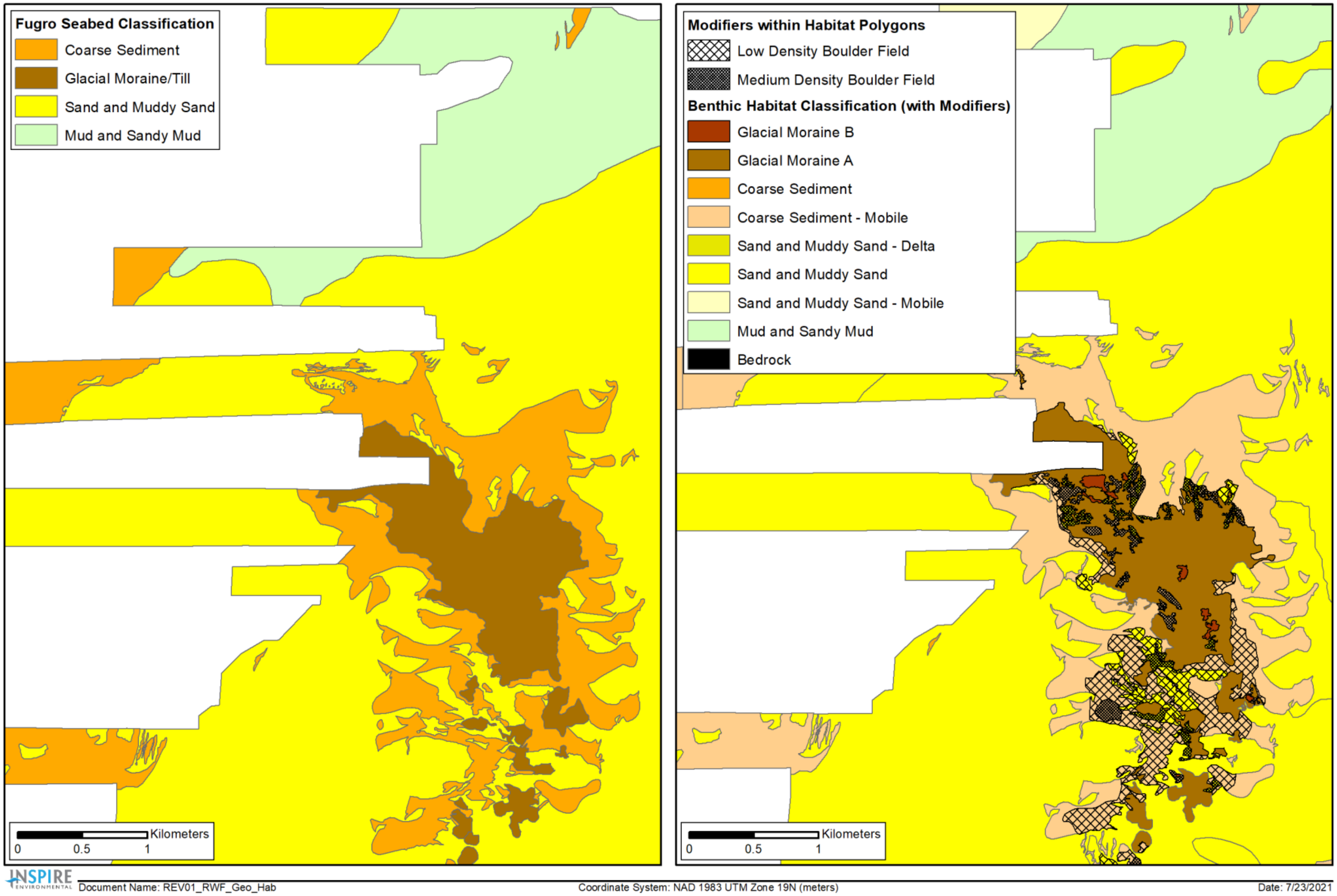


Figure 2-20. Geological seabed interpretations refined to benthic habitat types with modifiers for purposes of assessing potential impacts to essential fish habitat; example from the RWF

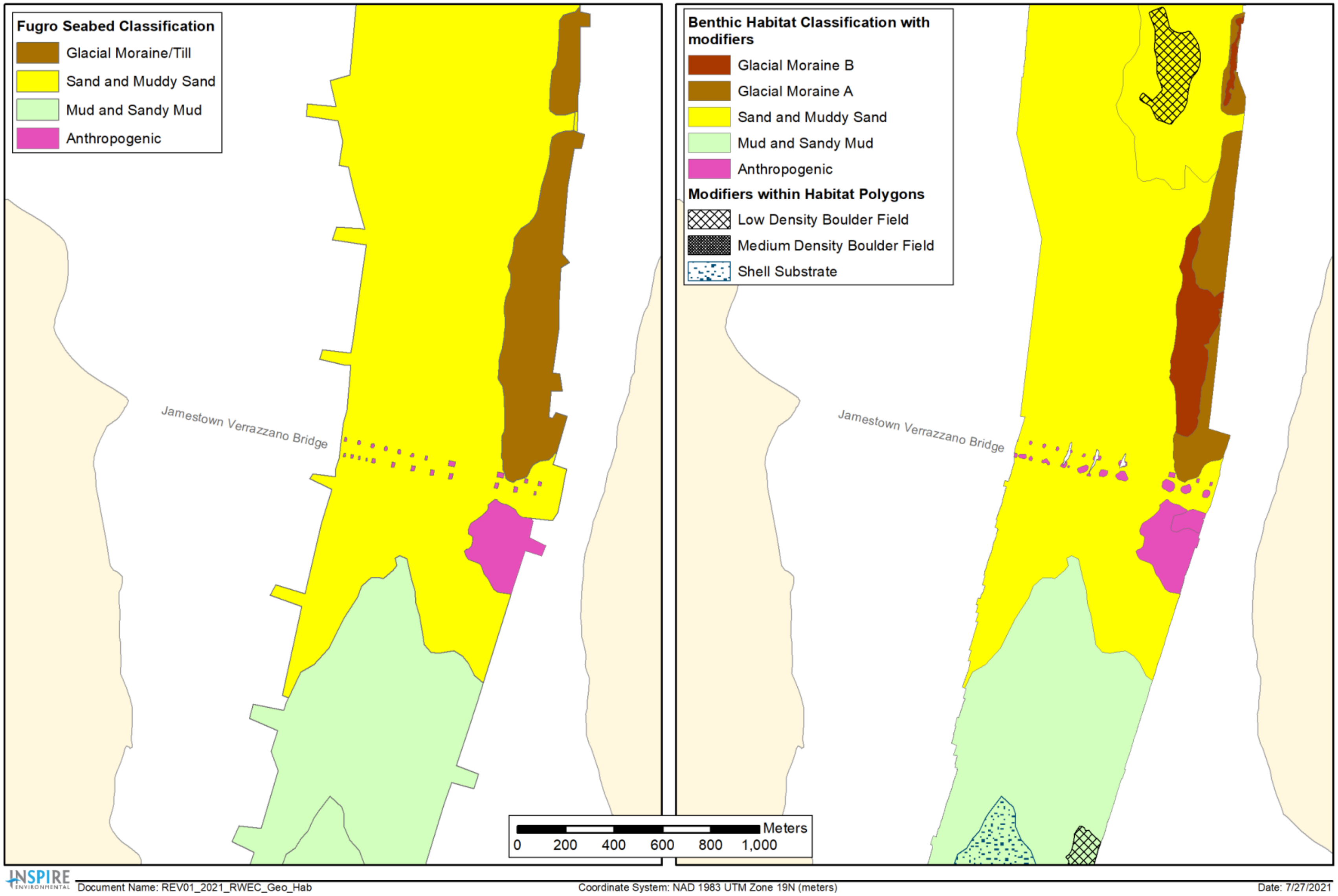


Figure 2-21. Geological seabed interpretations refined to benthic habitat types with modifiers for purposes of assessing potential impacts to essential fish habitat; example from the RWEC-RI

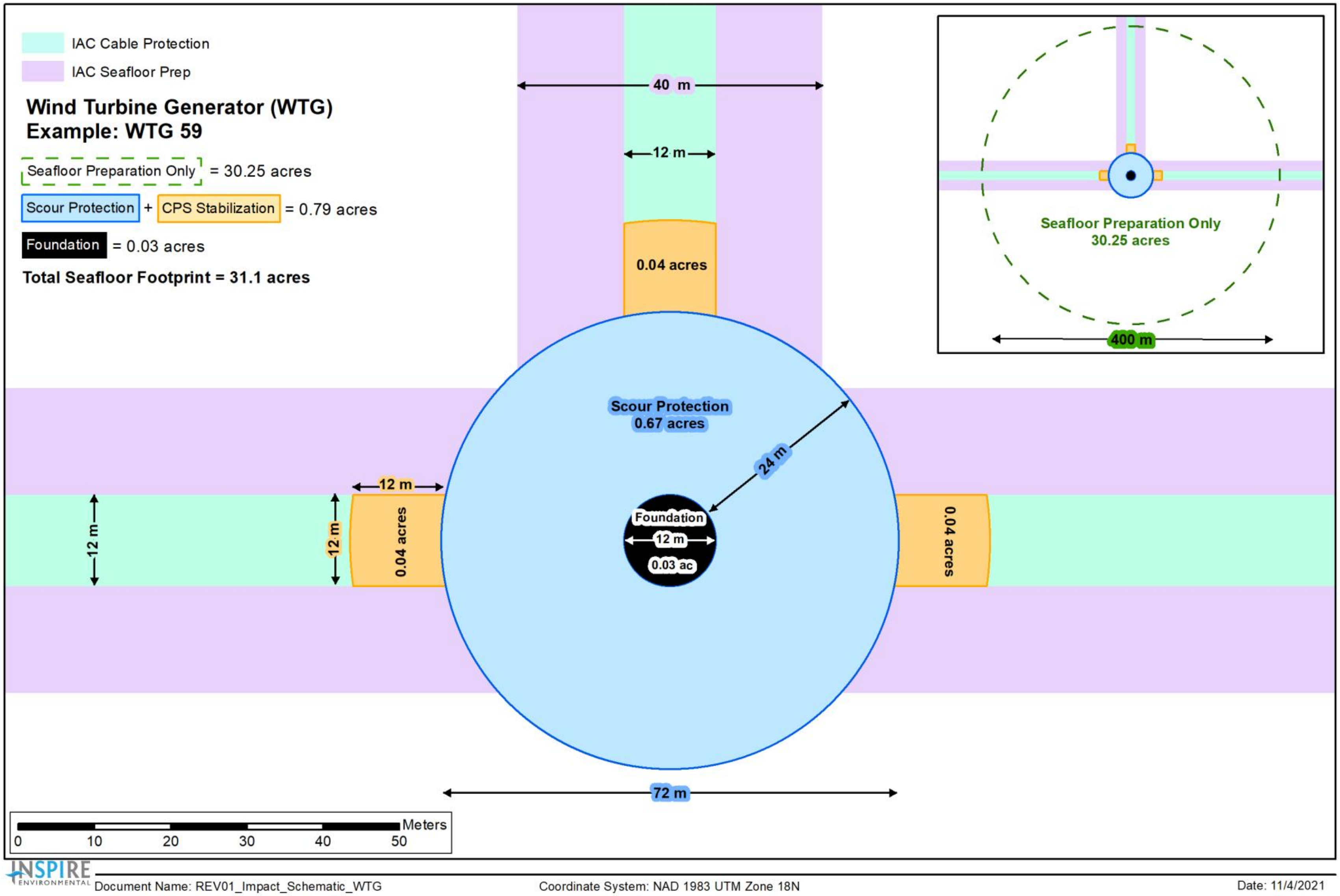


Figure 2-22. Schematic of WTG monopile foundation footprint

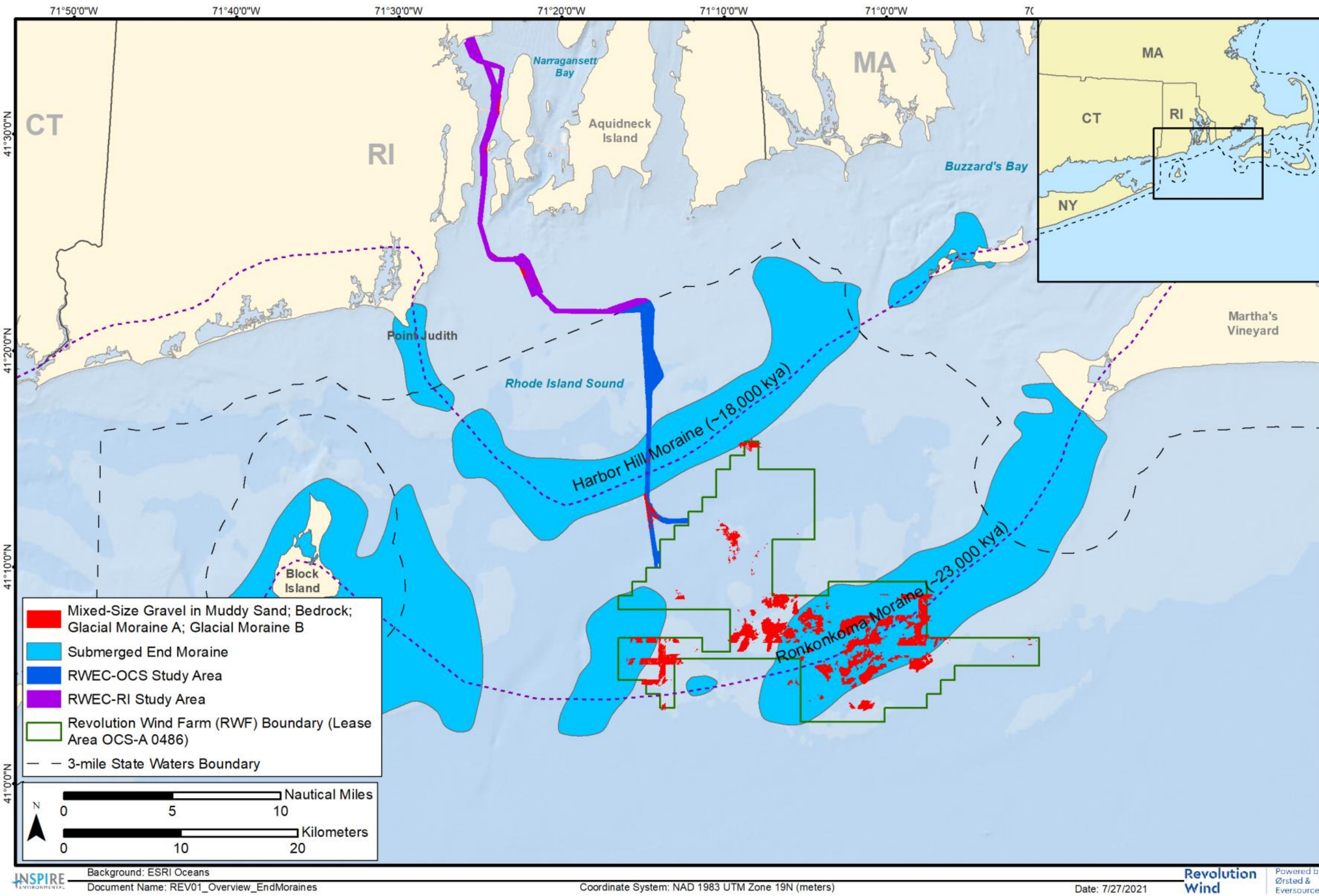


Figure 3-1. **Modeled locations of the Ronkonkoma and Harbor Hill end moraine complexes (Revolution Wind, LLC 2021b) and the mapped locations of glacial habitats (Bedrock, Glacial Moraine A and B, and Mixed-Size Gravel in Muddy Sand)**

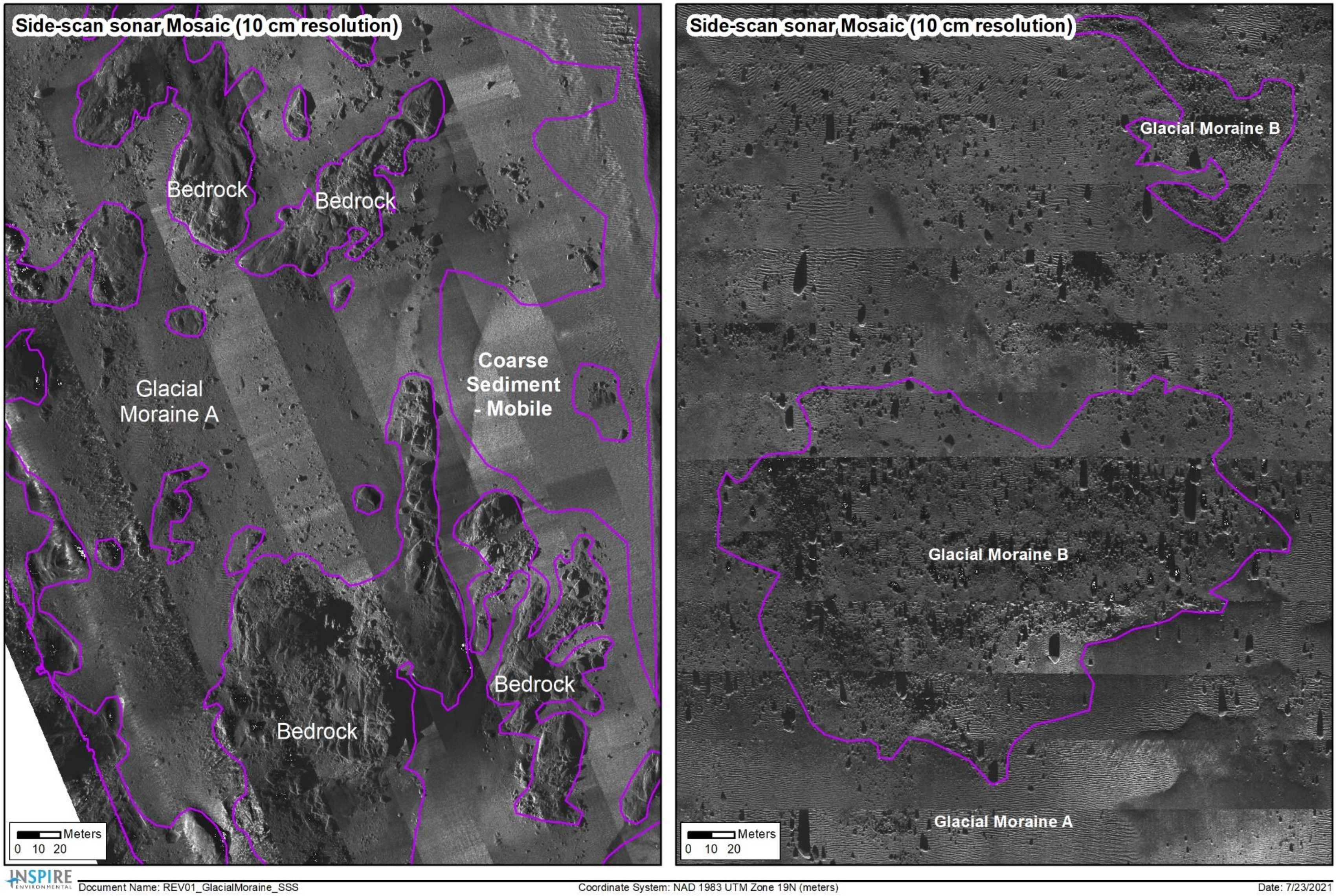


Figure 3-2. Glacial Moraine B, Glacial Moraine A and Bedrock as detected in geophysical data

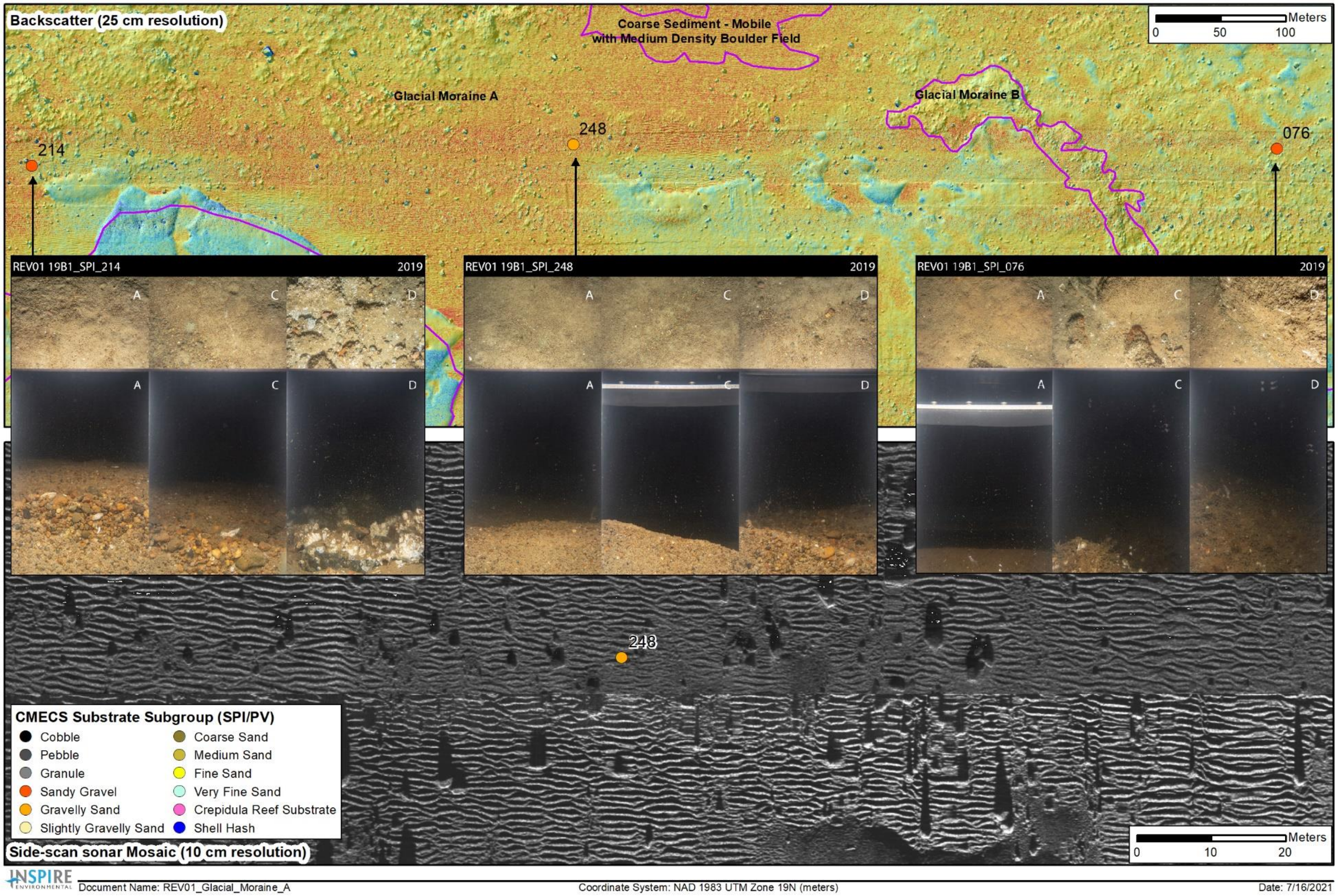


Figure 3-3. Glacial Moraine A habitat as detected in backscatter data over hillshaded bathymetry (top), side-scan sonar (bottom), and ground-truth data; inset images for Stations 214, 248, and 076 show three paired replicate PV images (top) and SPI images (bottom)

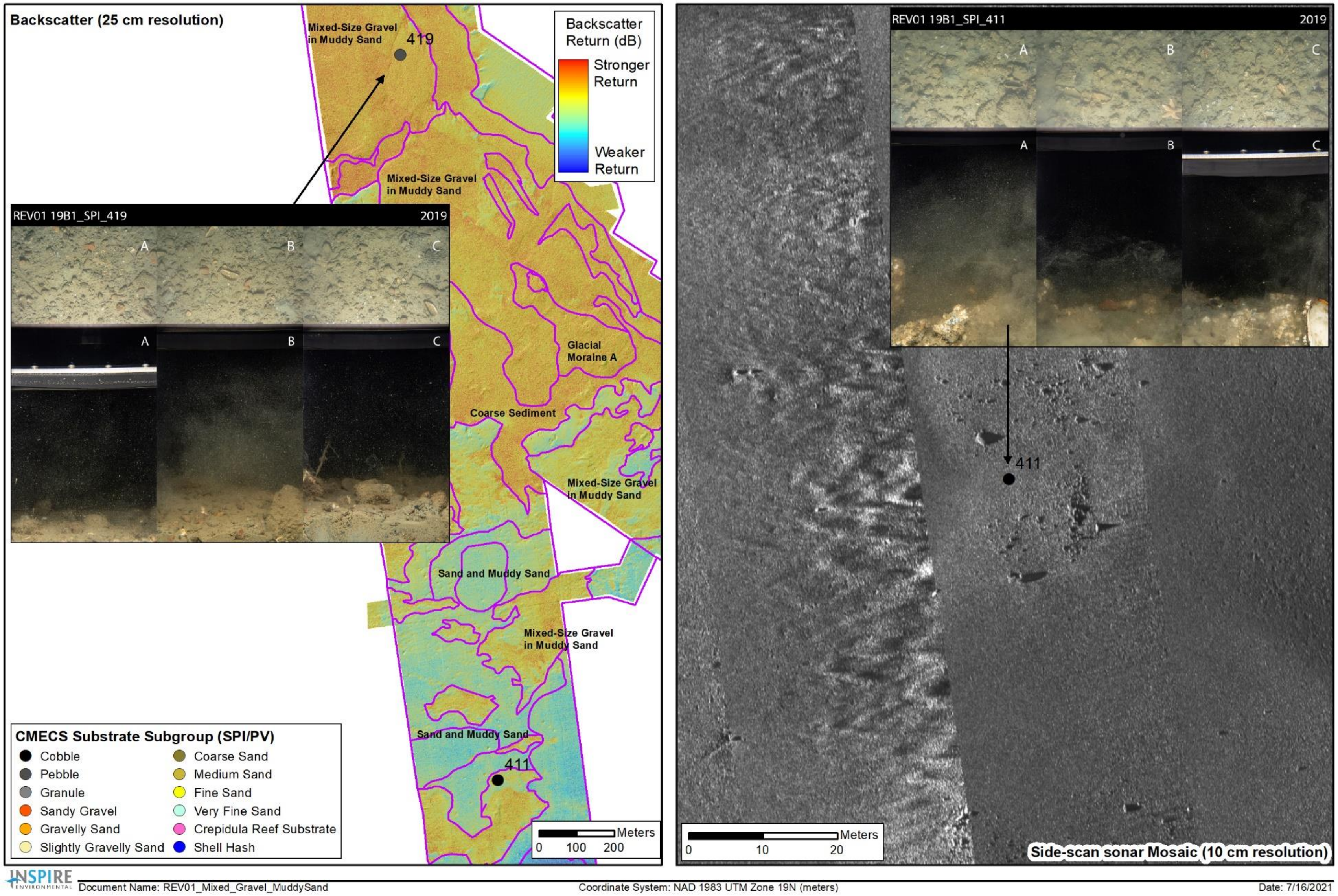


Figure 3-4. Mixed-Size Gravel in Muddy Sand habitat as detected in backscatter data over hillshaded bathymetry (left), side-scan sonar (right), and ground-truth data; inset images for Stations 419 and 411 show three paired replicate PV images (top) and SPI images (bottom)

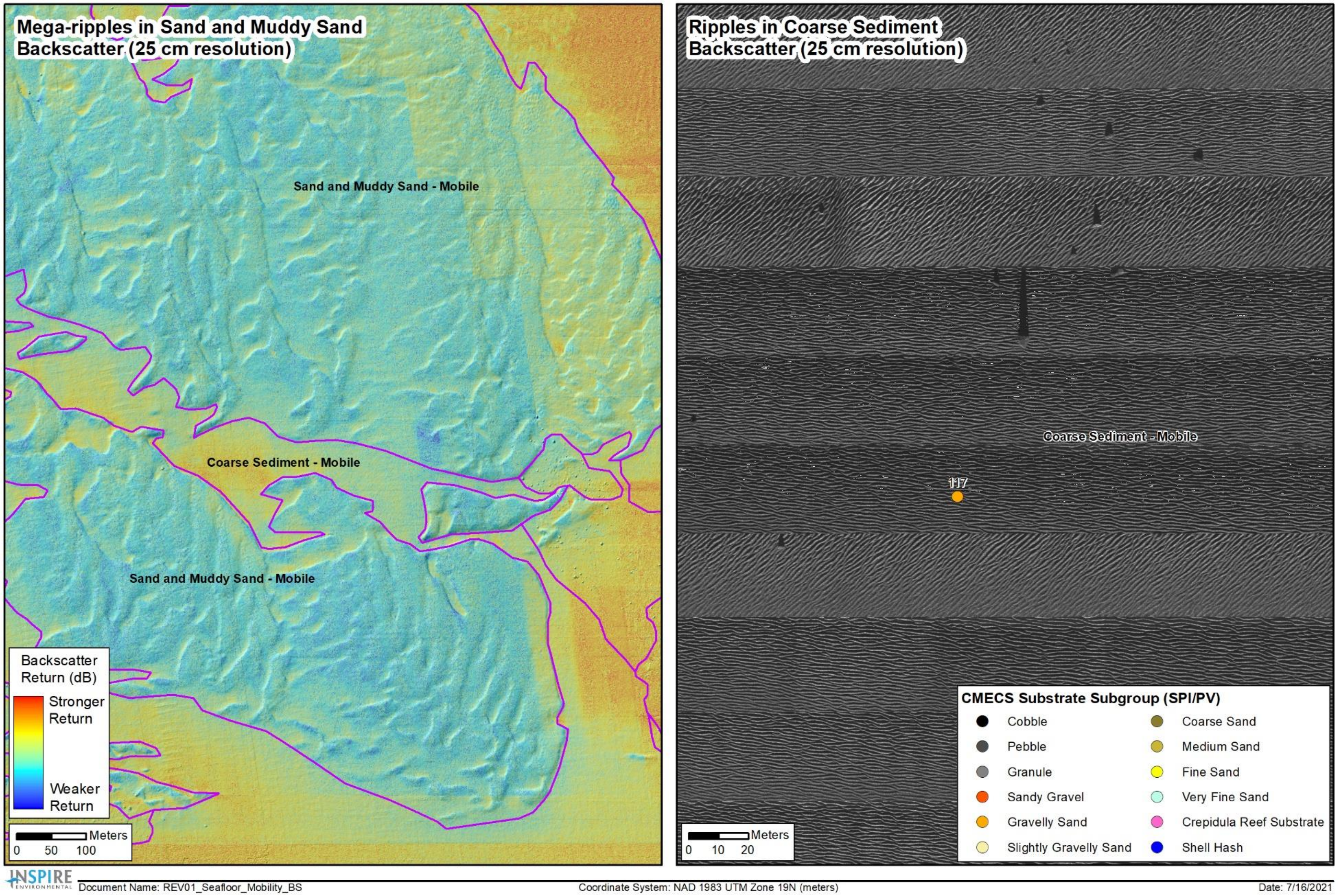


Figure 3-5. **Mobility of the seafloor evident in geophysical data: mega-ripples detected in backscatter and bathymetric relief in Sand and Muddy Sand (left); and ripples detected in Coarse Sediment - Gravelly Sand in geophysical data (right); two different locations are used as examples here. The modifier of "- Mobile" is applied to these habitats where seafloor features, including mega-ripples and/or ripples, are observed.**

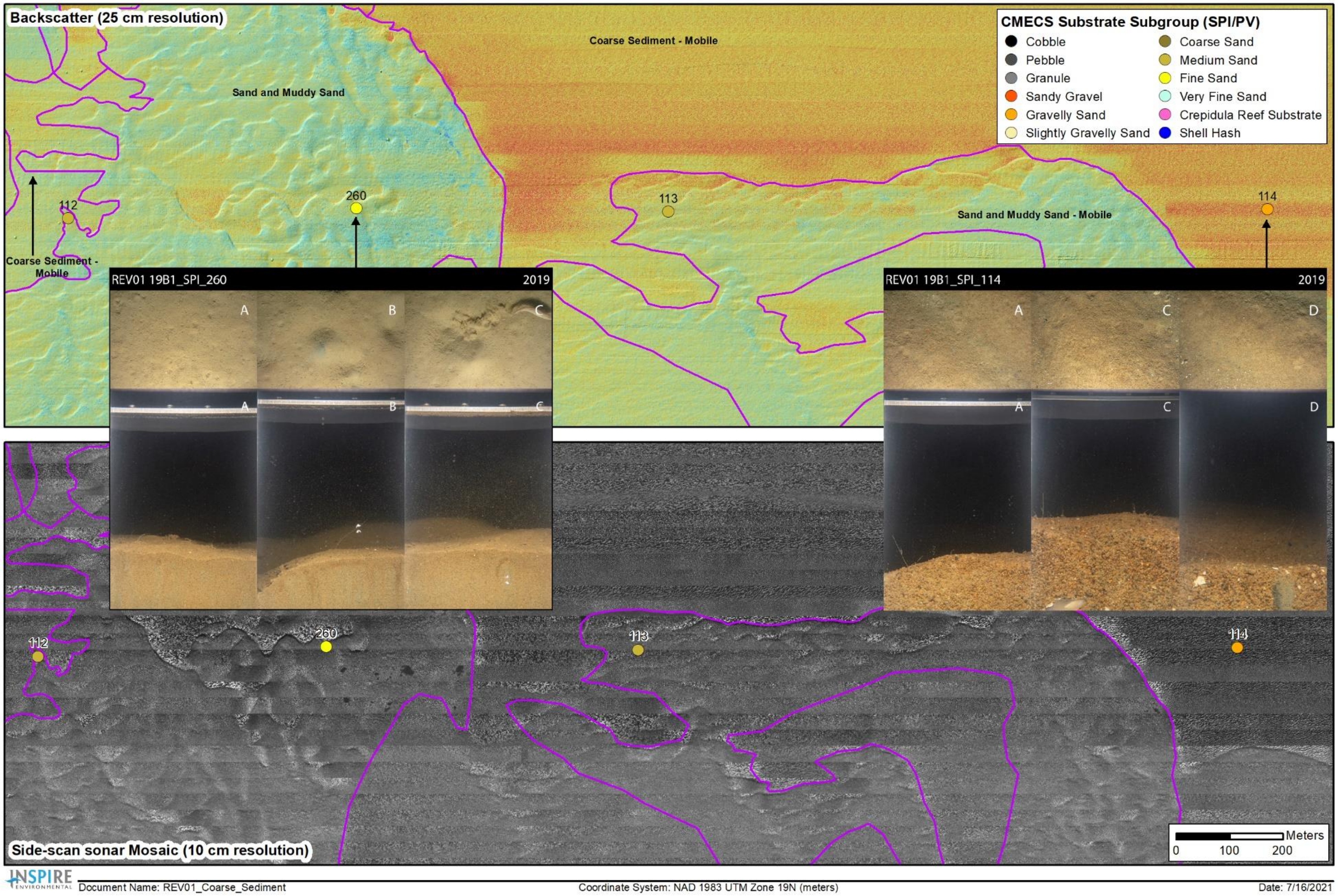


Figure 3-6. Coarse Sediment habitat and Sand and Muddy Sand habitat as detected in backscatter data over hillshaded bathymetry (top), side-scan sonar (bottom), and ground-truth data; inset images for Stations 260 and 114 show three paired replicate PV images (top) and SPI images (bottom)

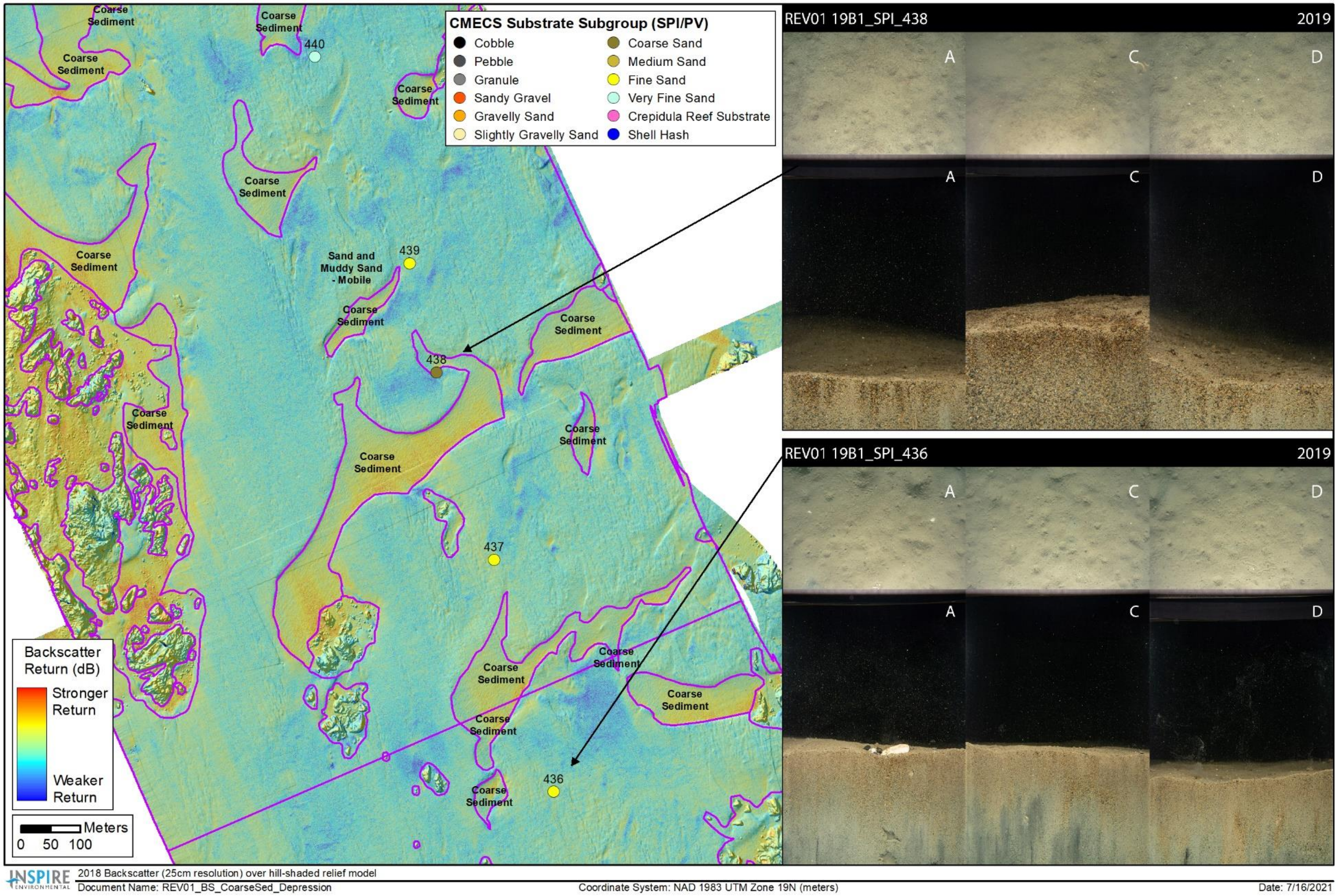


Figure 3-7. Coarse Sediment in depressions in the seafloor detected in geophysical data, surrounded by Sand and Muddy Sand detected in geophysical and ground-truth data

Figure 3-8. Low density (20 to 99 boulders / 10,000 m^2) (left) and medium density (100 to 199 boulders / 10,000 m^2) (right) boulder fields identified from geophysical data and included as a habitat type modifier for mud, sand, and coarse sediment habitat types where present

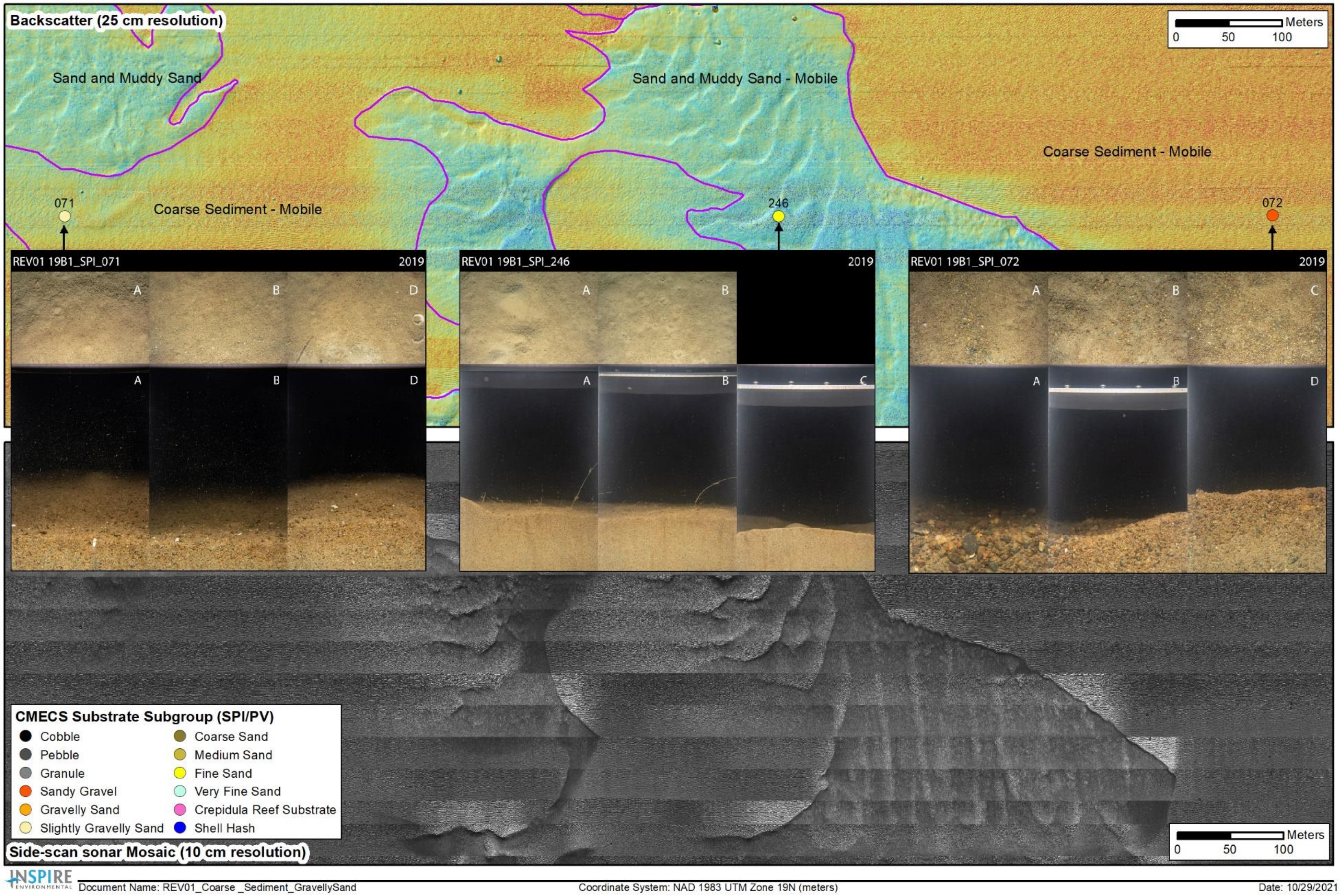


Figure 3-9. Coarse Sediment - Mobile as detected in backscatter data over hillshaded bathymetry (top) and in side-scan sonar data (bottom) and refined as mobile Gravelly Sand based on ground-truth data; inset images for Stations 071, 072, and 246 show three paired replicate PV images (top) and SPI images (bottom)

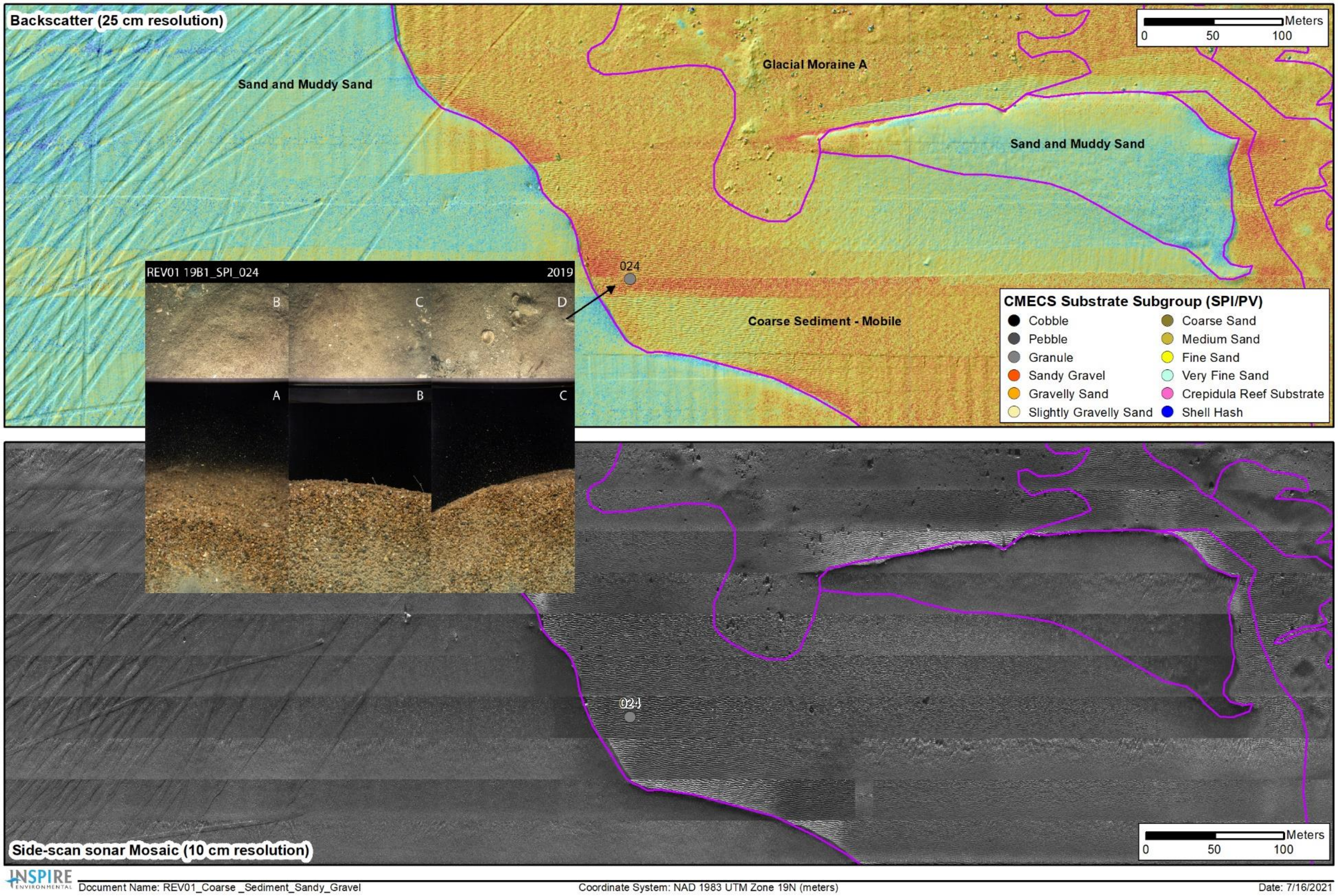


Figure 3-10. Coarse Sediment - Mobile as detected in backscatter data over hillshaded bathymetry (top) and in side-scan sonar data (bottom) and refined as mobile Sandy Gravel based on ground-truth data; inset images for Station 024 show three paired replicate PV images (top) and SPI images (bottom). Note - linear marks visible on the seafloor in the Sand and Muddy Sandy habitat to the left are from trawling activity.

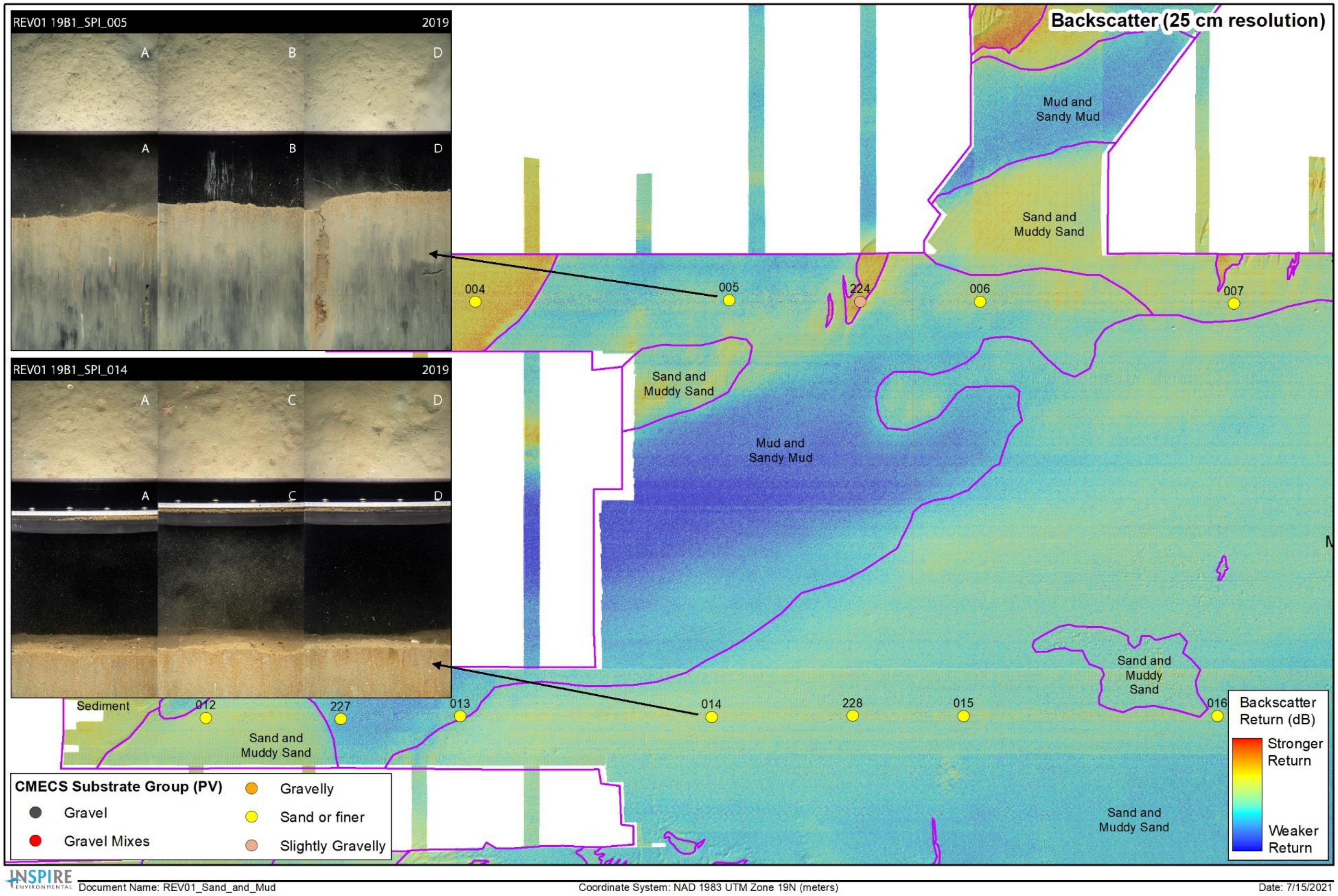


Figure 3-11. Sand and Muddy Sand and Mud and Sandy Mud habitat as detected in backscatter data over hillshaded bathymetry and ground-truth data; inset images for Stations 005 and 014 show three paired replicate PV images (top) and SPI images (bottom)

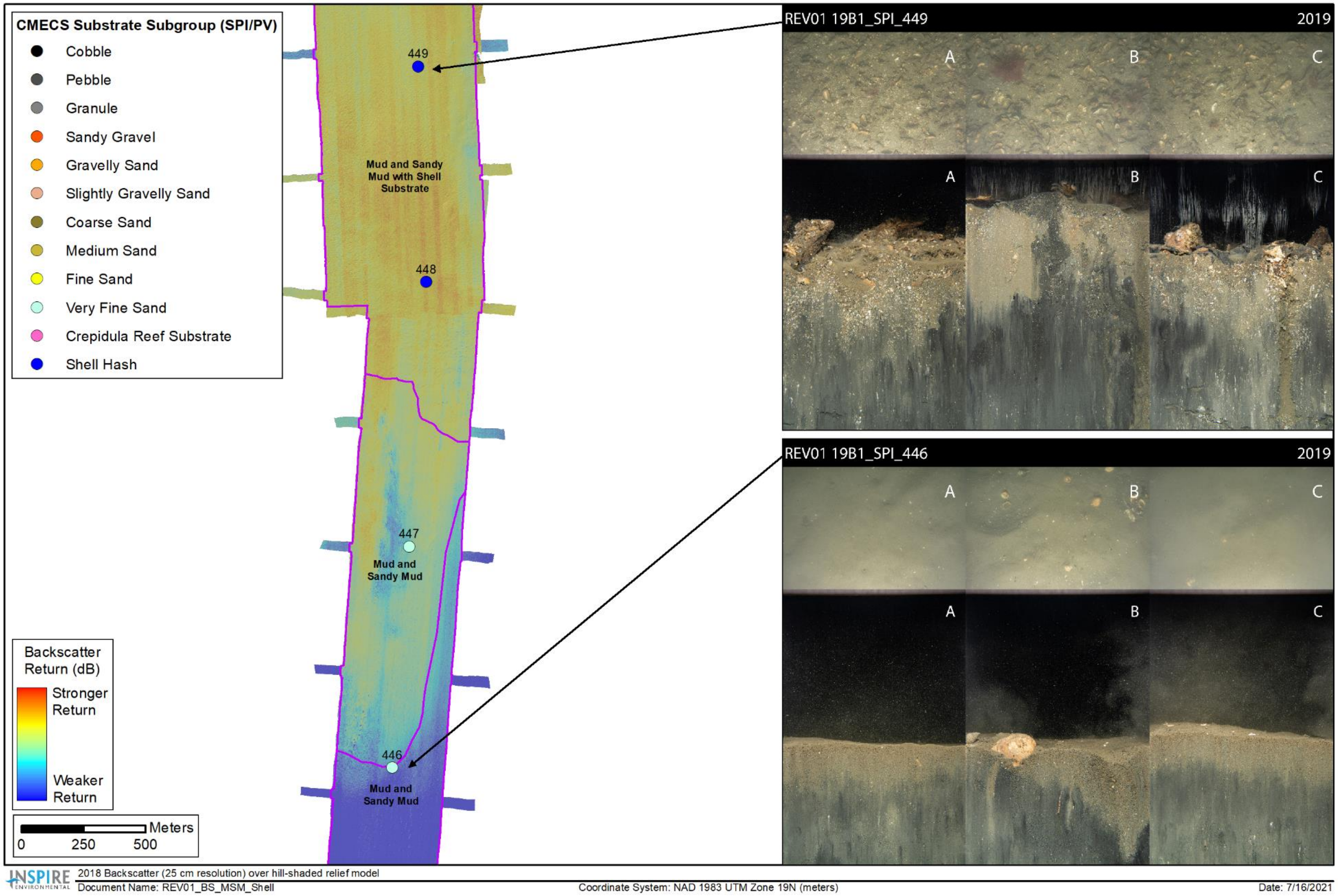


Figure 3-12. Mud and Sandy Mud and Mud and Sandy Mud with Shell Substrate as detected in geophysical and ground-truth data; inset images for Stations 446 and 449 show three paired replicate PV images (top) and SPI images (bottom)

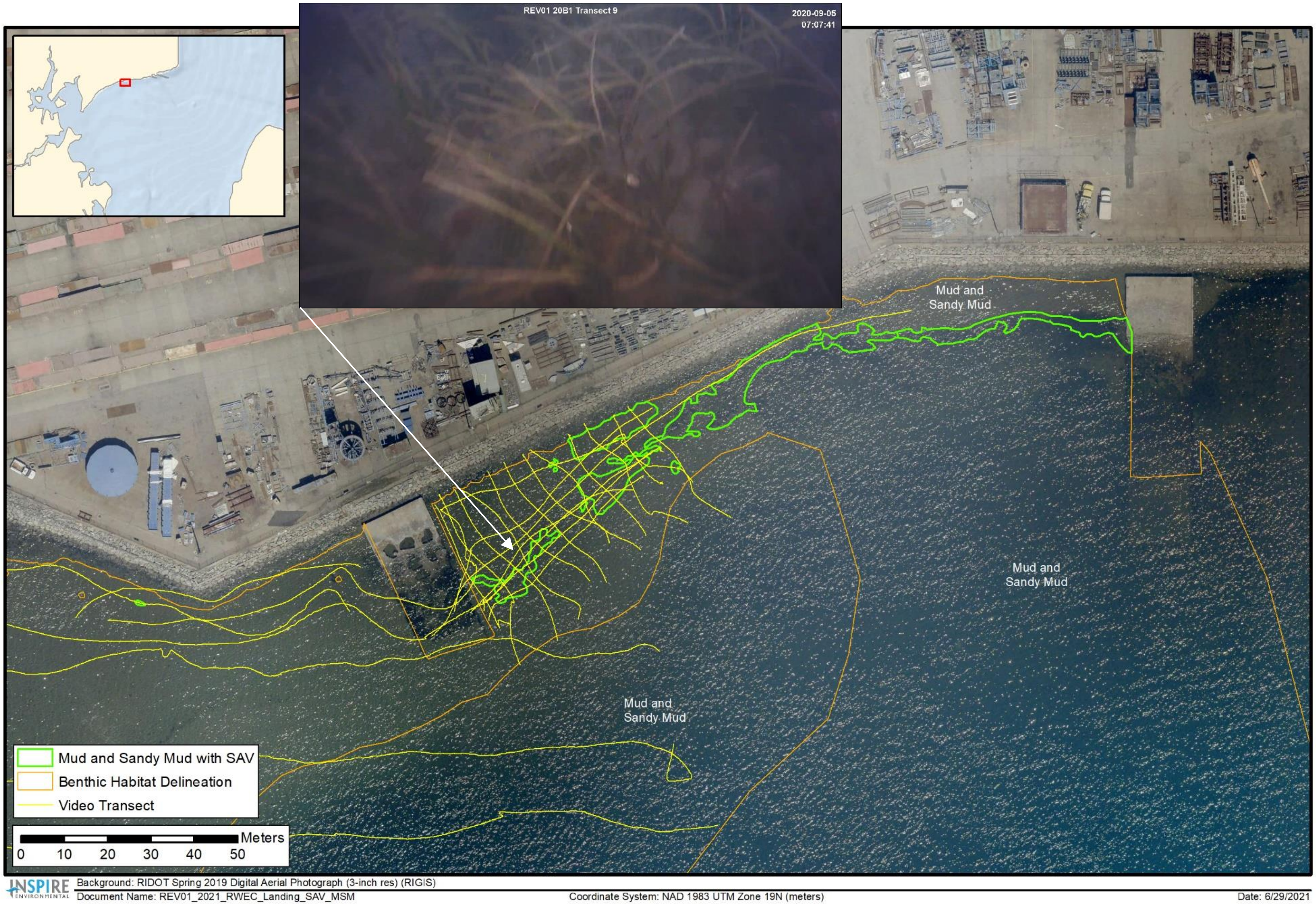


Figure 3-13. Mud and Sandy Mud with submerged aquatic vegetation (SAV) habitat detected in aerial imagery and underwater video footage

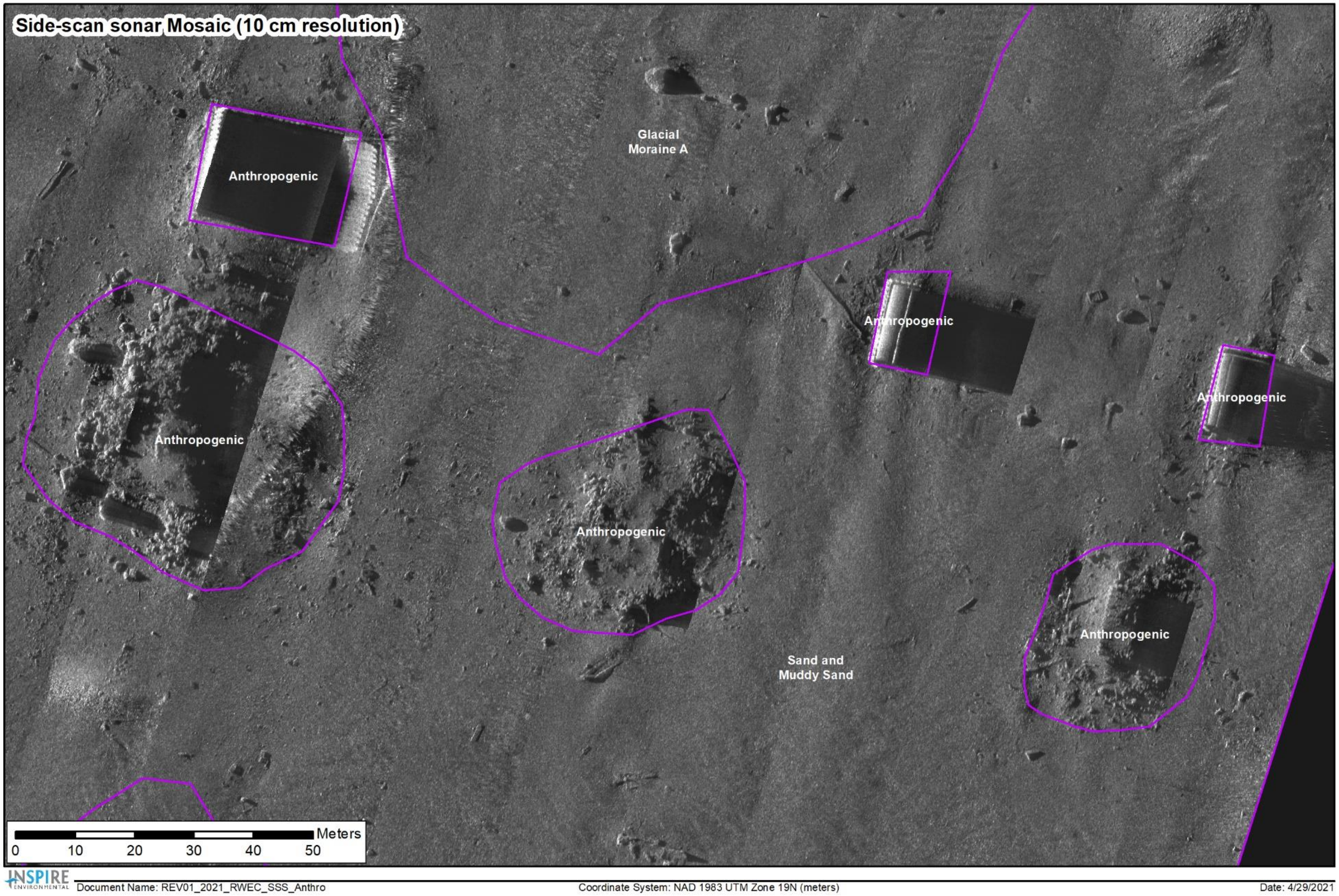


Figure 3-14. Anthropogenic features, such as debris related to the demolition of the old Jamestown Bridge, as detected in SSS data

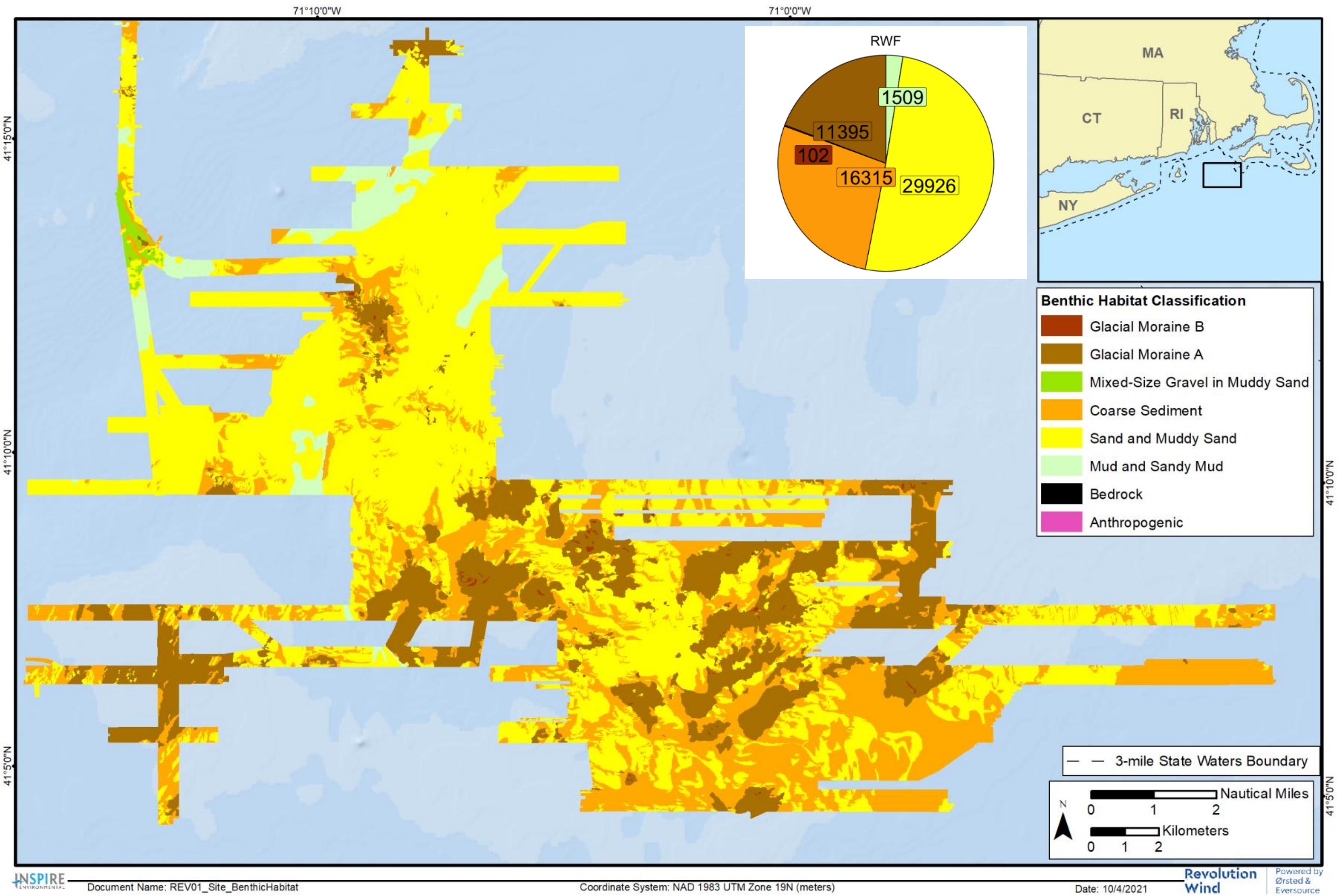


Figure 3-15. Benthic habitat types mapped at the RWF and pie chart of habitat composition with total acres presented as values

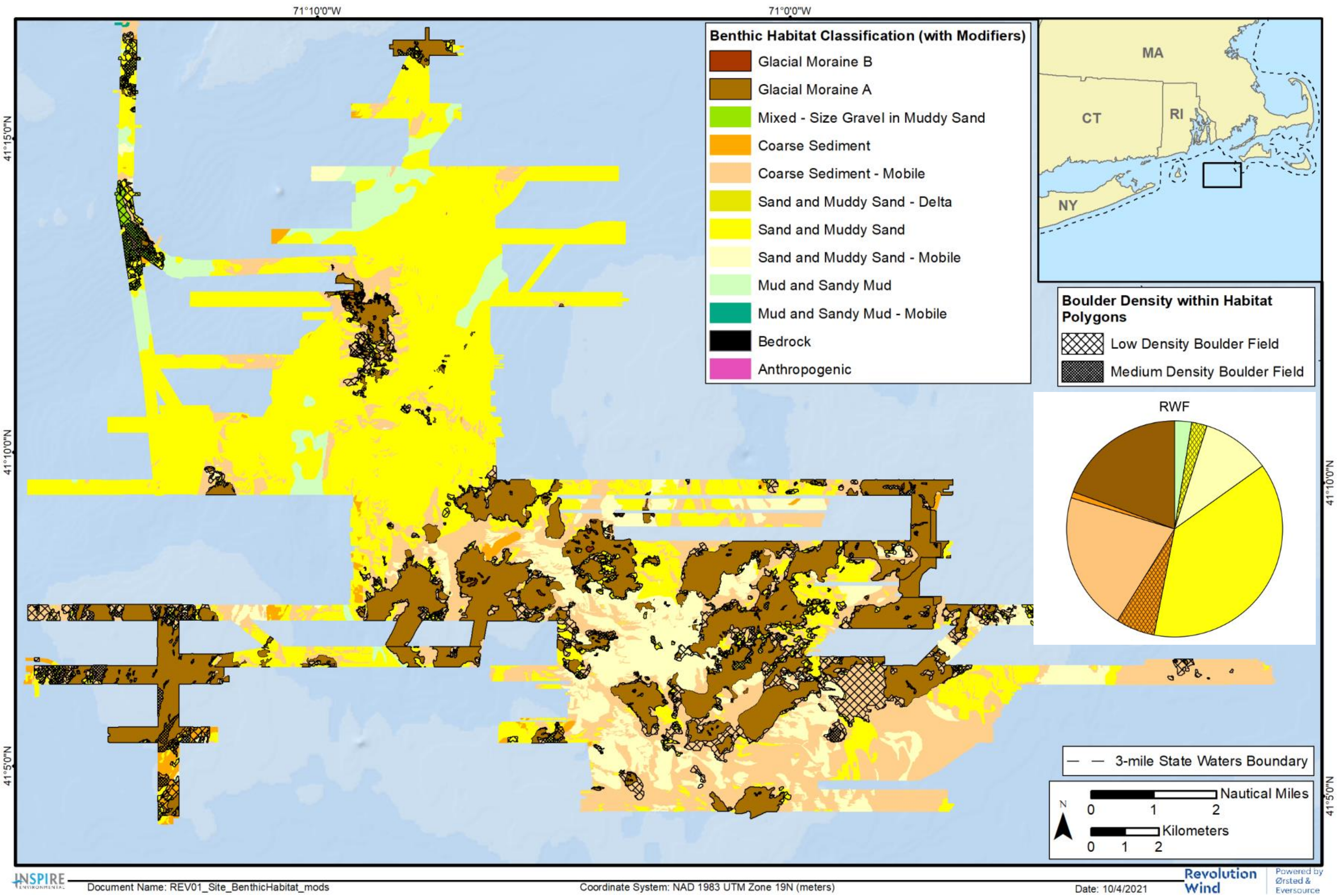


Figure 3-16. Benthic habitat types with modifiers mapped at the RWF and pie chart of habitat composition

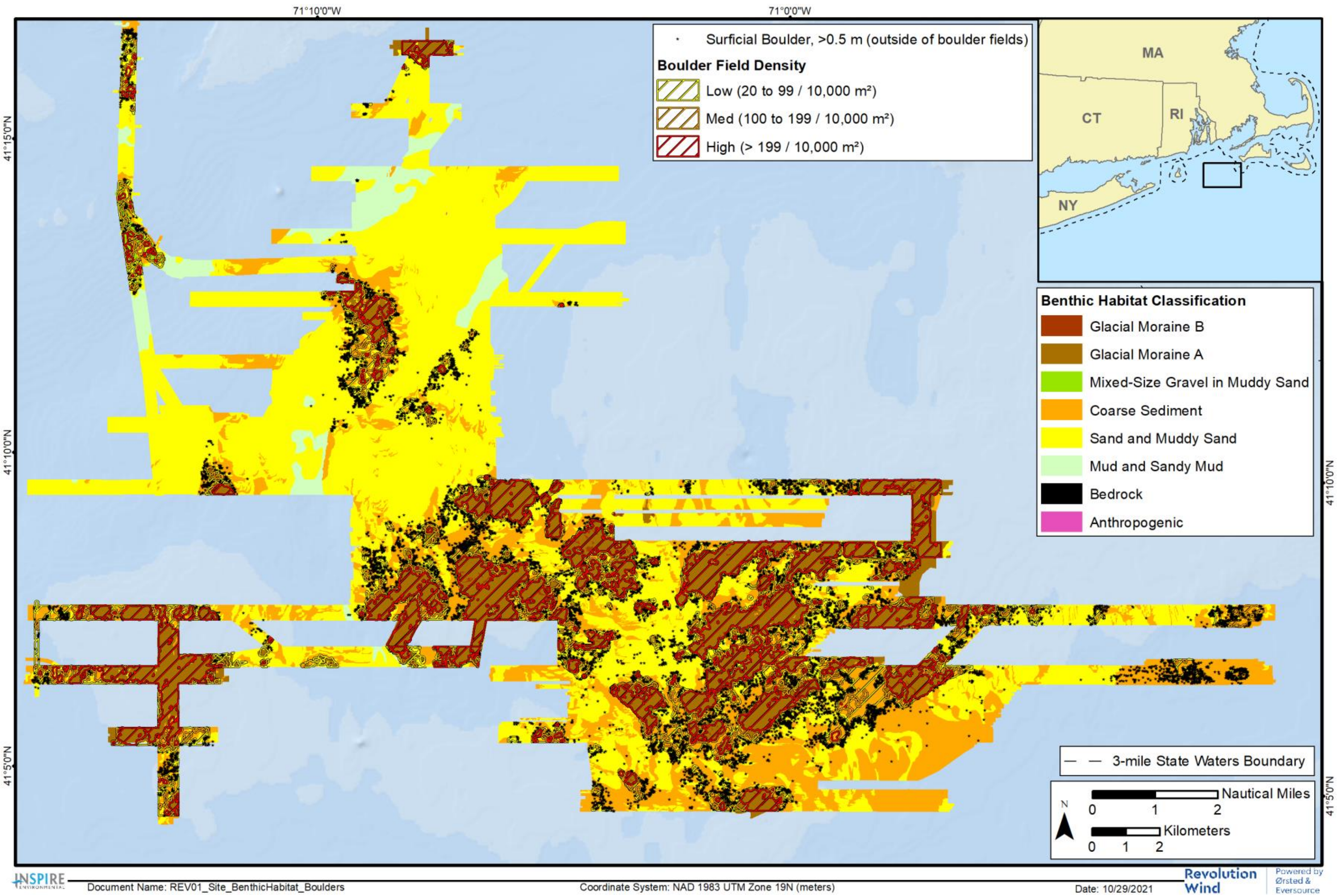


Figure 3-17. Benthic habitat types, boulder fields, and individual large boulders (>0.5 m) mapped at the RWF

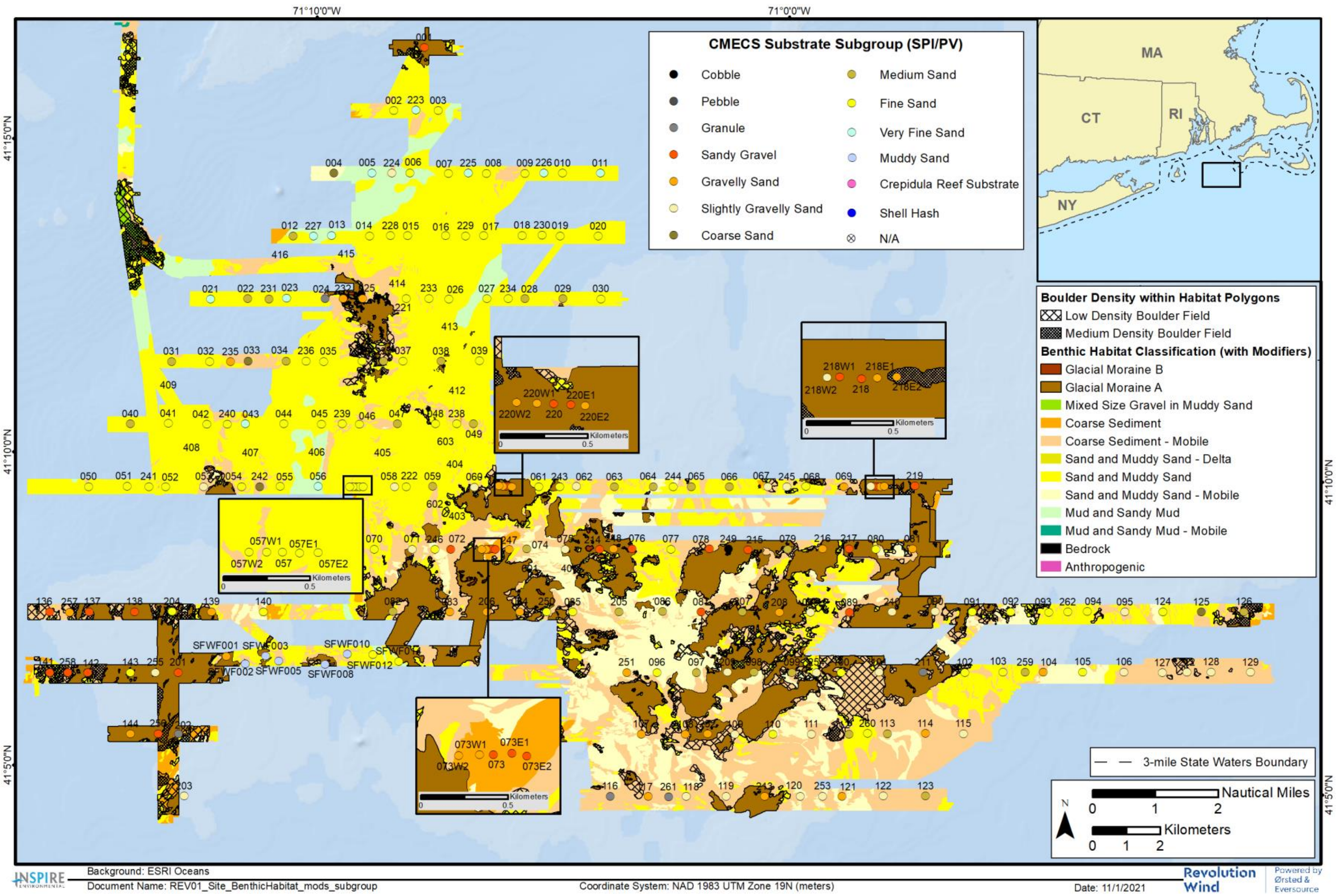


Figure 3-18. Benthic habitat types with modifiers and ground-truth CMECS Substrate Subgroup at the RWF

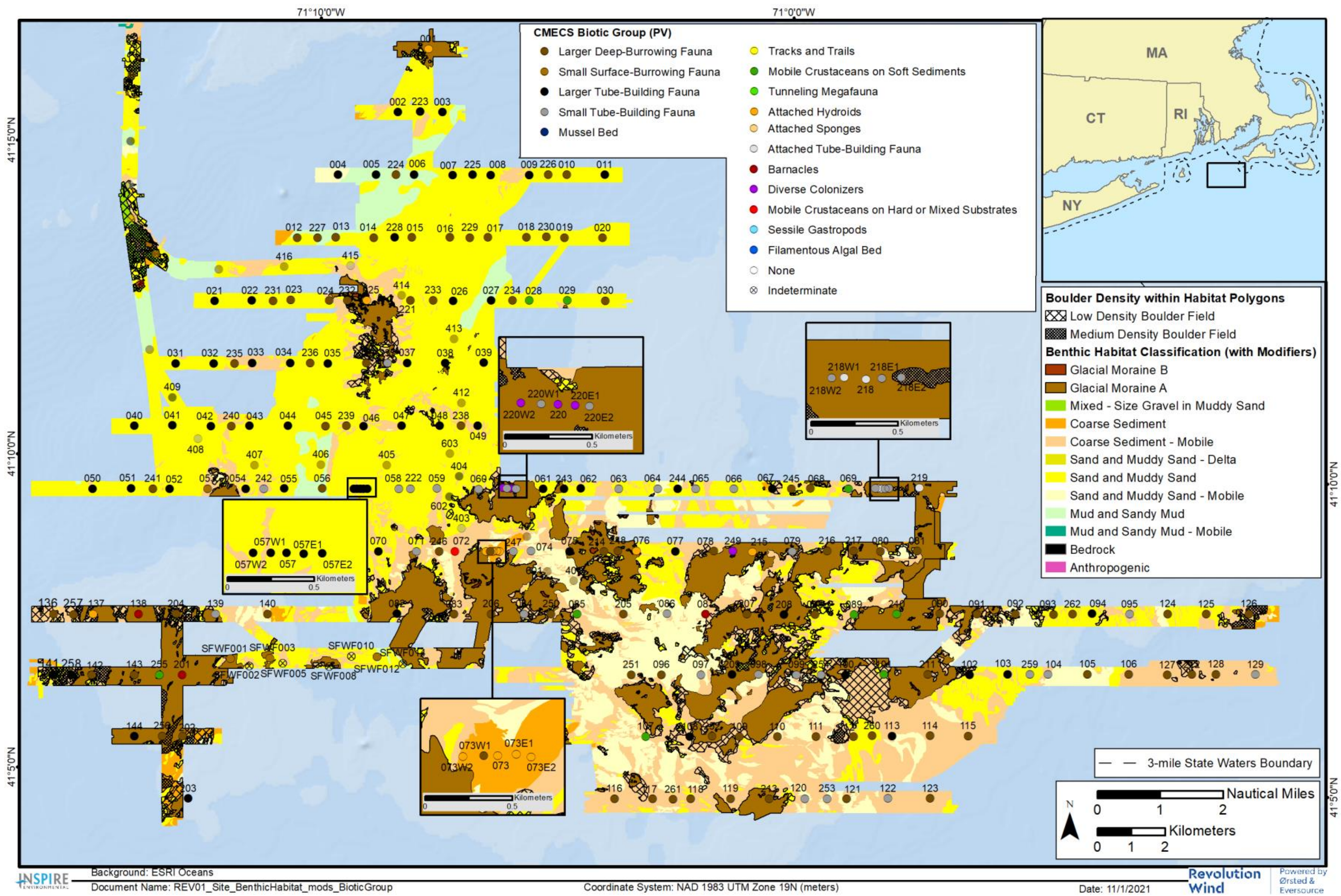


Figure 3-19. Benthic habitat types with modifiers and ground-truth CMECS Biotic Group at the RWF

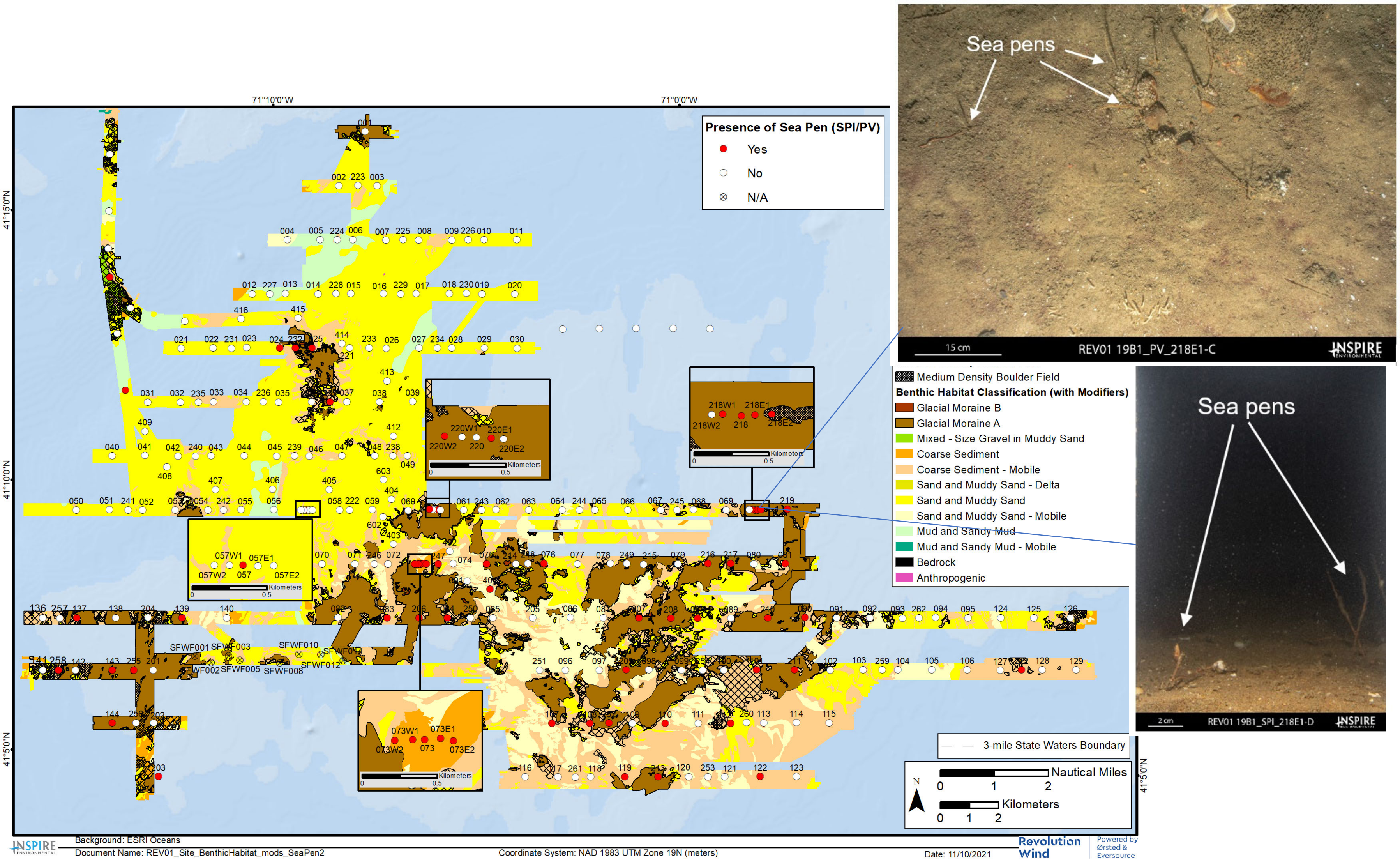


Figure 3-20. Benthic habitat types with modifiers and the distribution of the sea pen *Halipteris finmarchia*

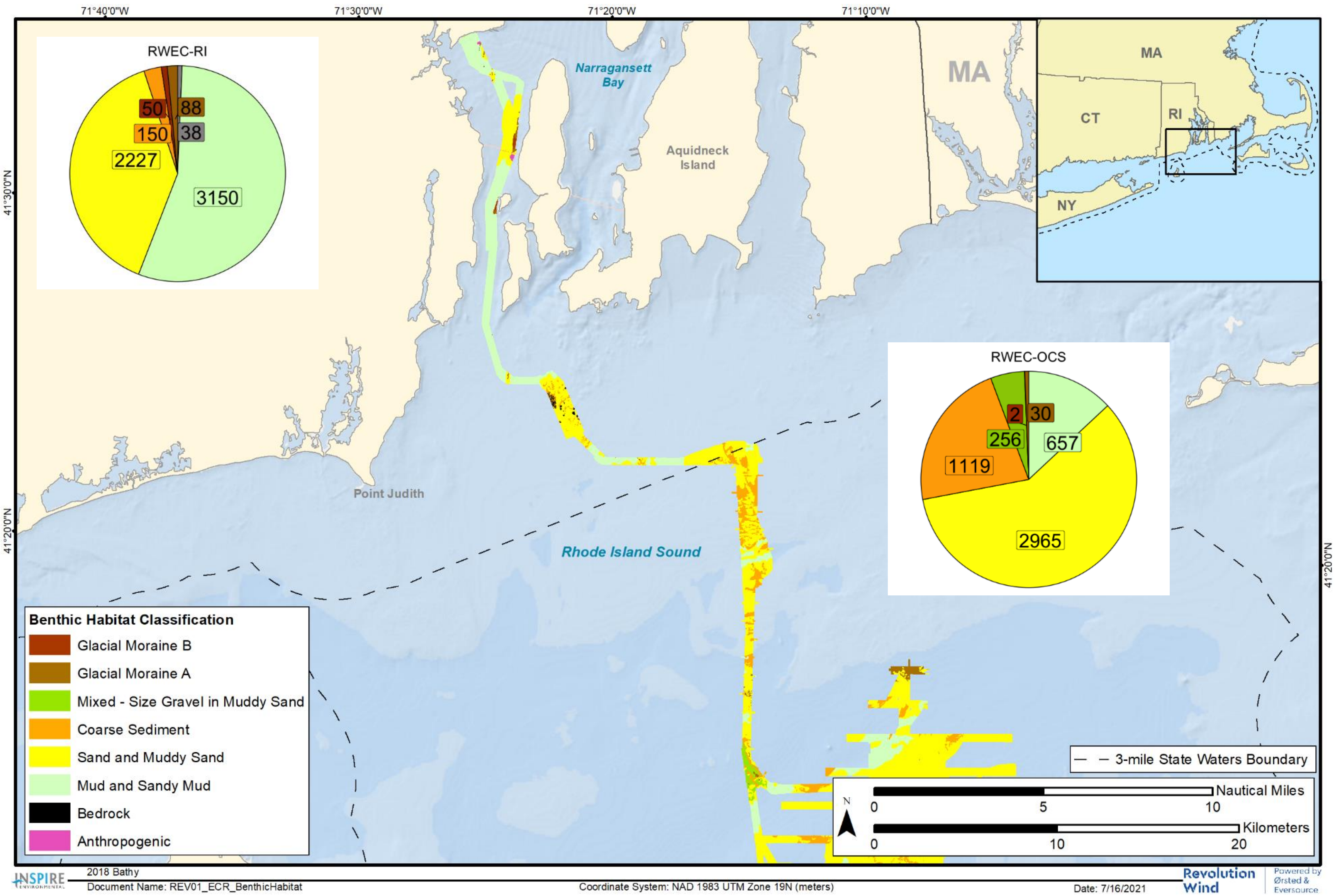


Figure 3-21. Benthic habitat types mapped along the RWEC and pie charts of habitat composition with total acres presented as values

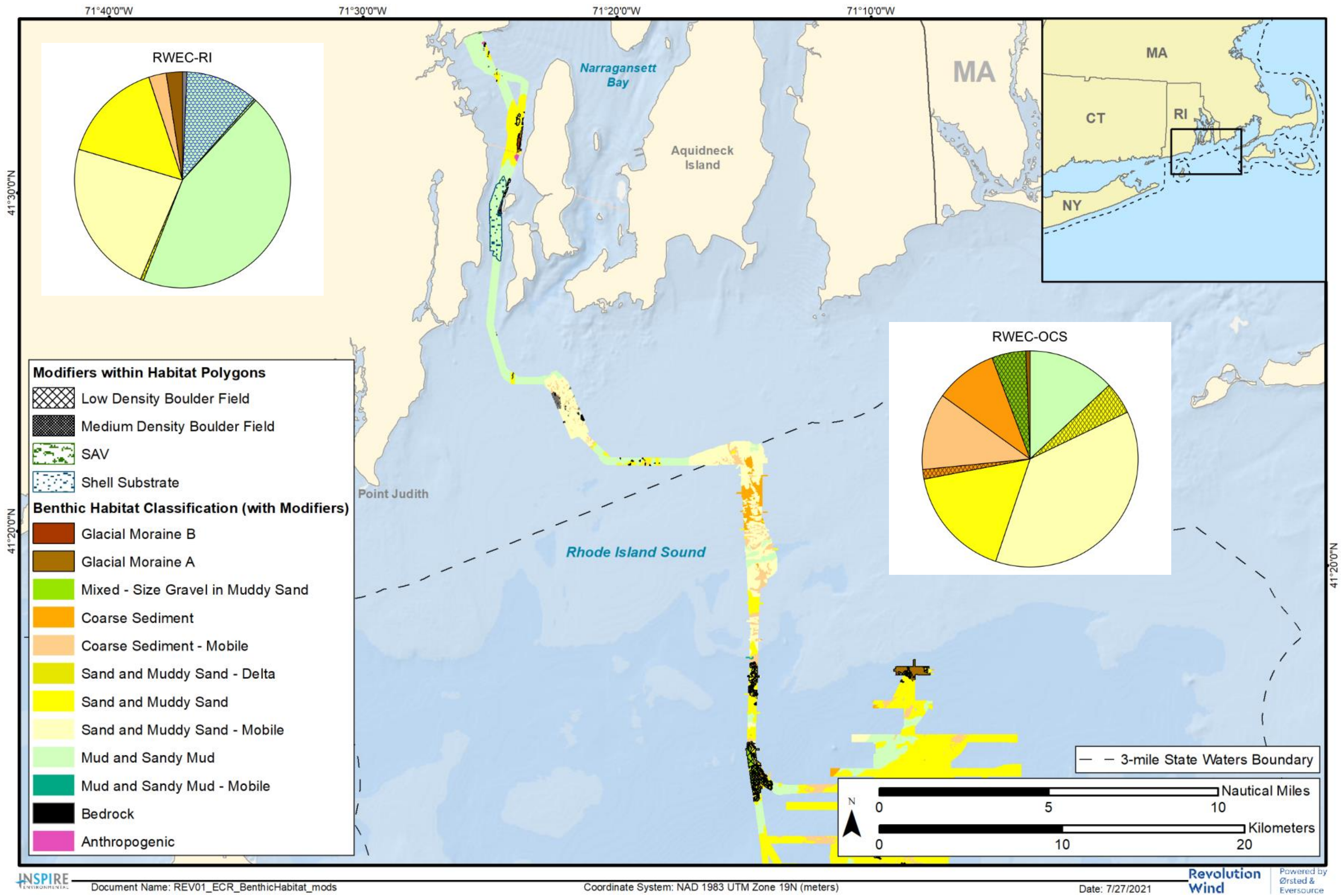


Figure 3-22. Benthic habitat types with modifiers mapped along the RWEC and pie charts of habitat composition

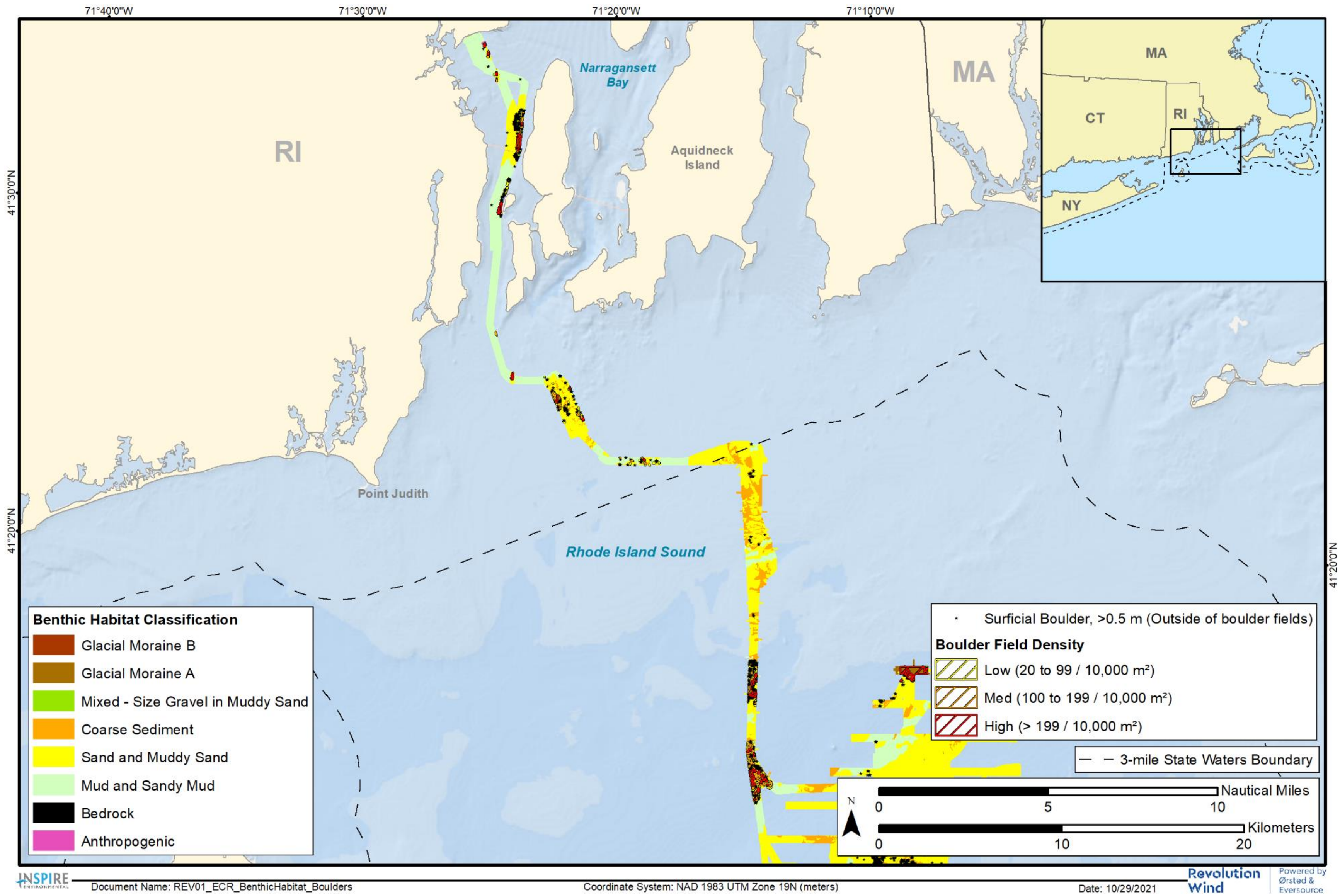


Figure 3-23. Benthic habitat types, boulder fields, and individual large boulders (>0.5 m) mapped along the RWEC

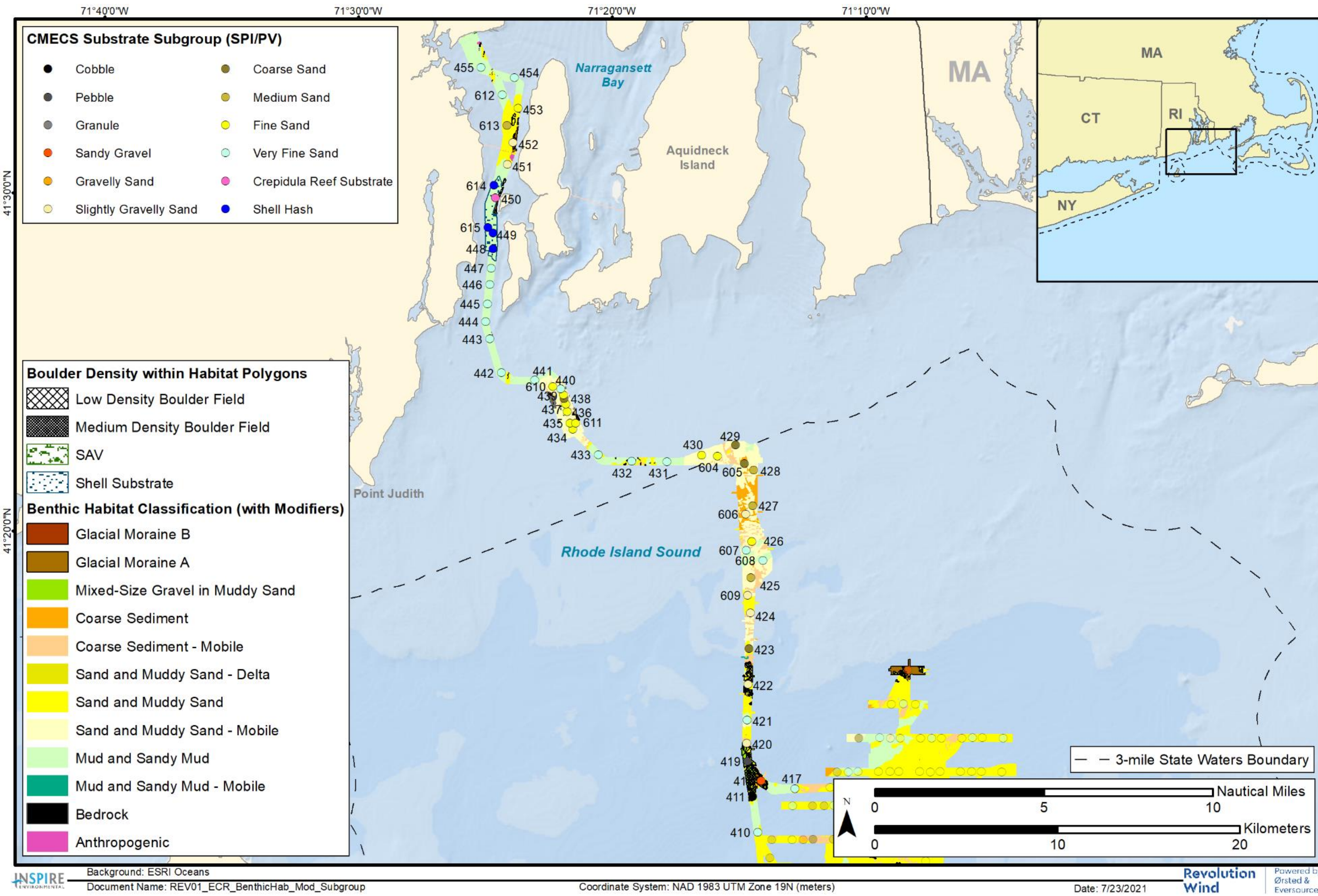


Figure 3-24. Benthic habitat types with modifiers and ground-truth CMECS Substrate Subgroup along the RWEC

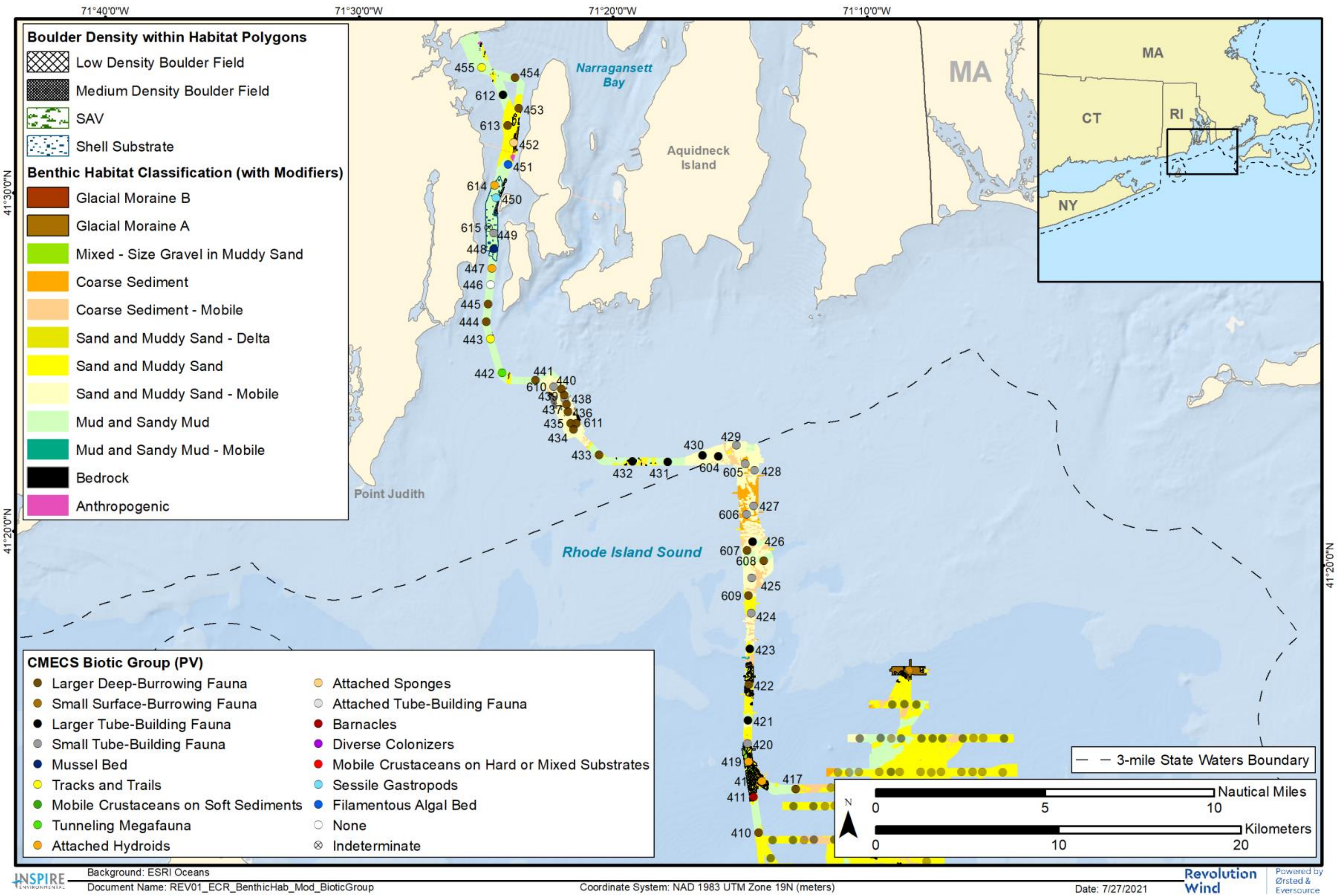


Figure 3-25. Benthic habitat types with modifiers and ground-truth CMECS Biotic Group along the RWEC

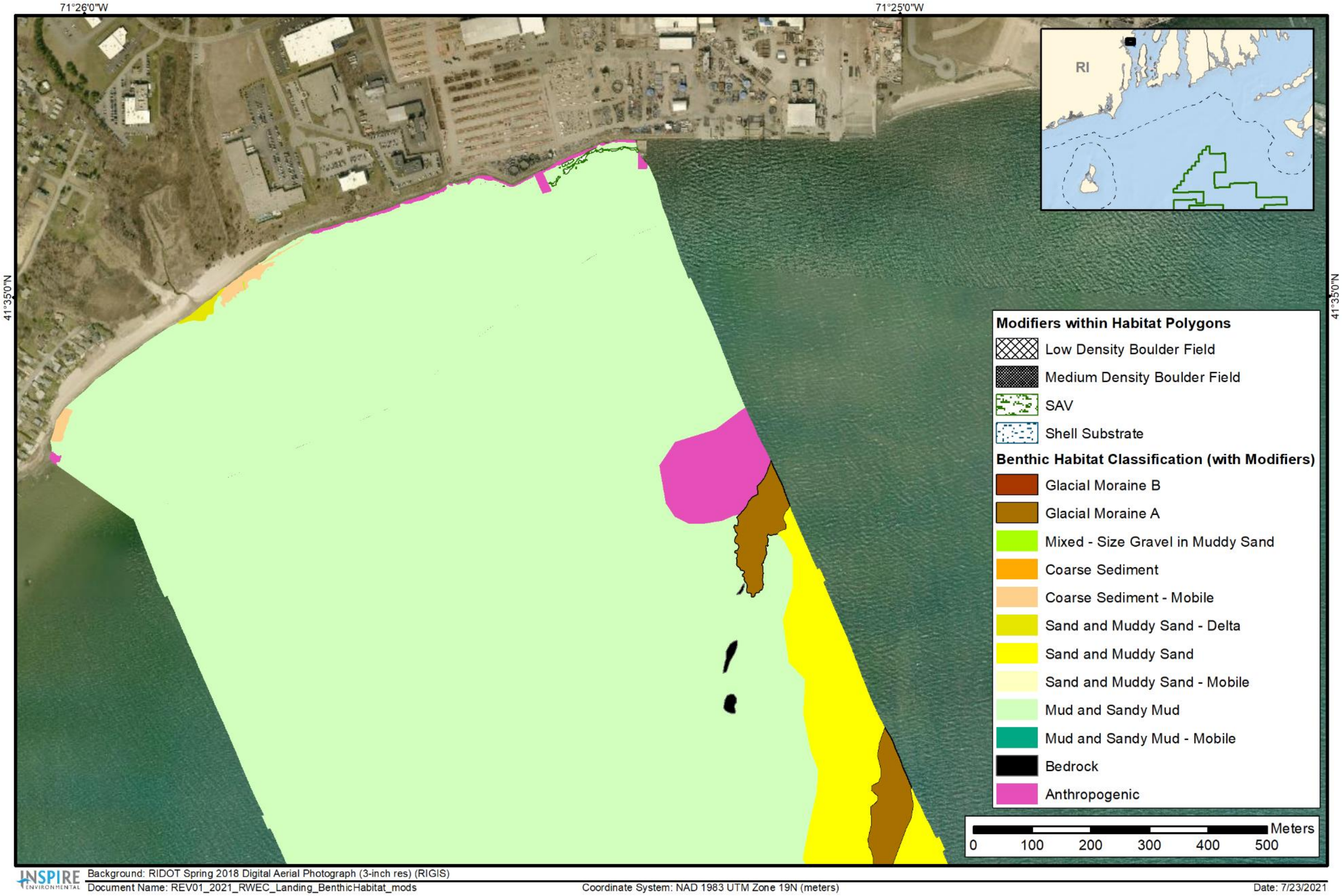


Figure 3-26. Benthic habitat types with modifiers along the RWEC-RI at the Quonset Point landfall

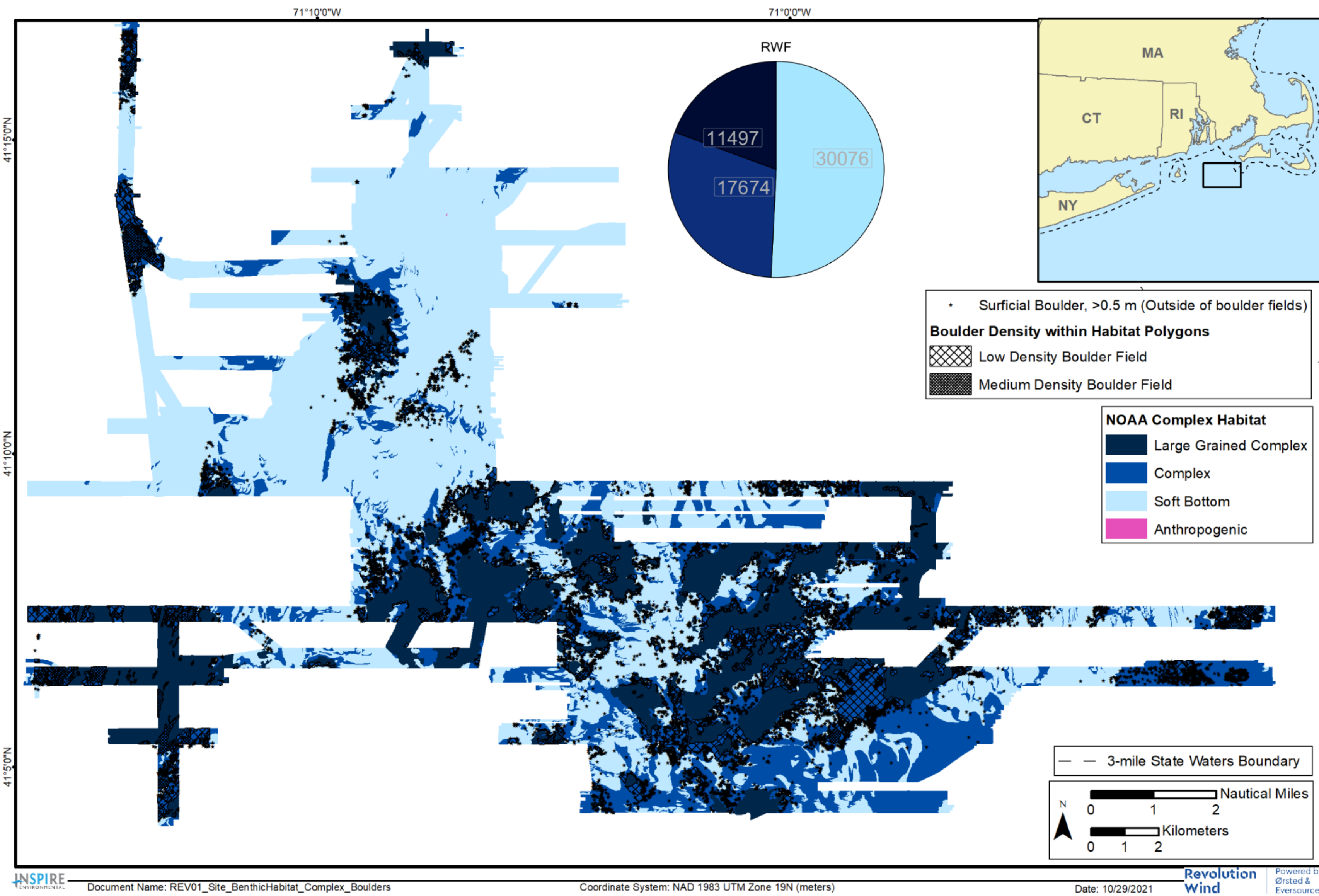


Figure 3-27. Benthic habitats categorized by NOAA Complexity Category, along with boulder fields and individual boulder picks, at the RWF, along with a pie chart of NOAA Complexity Category composition with total acres presented as values

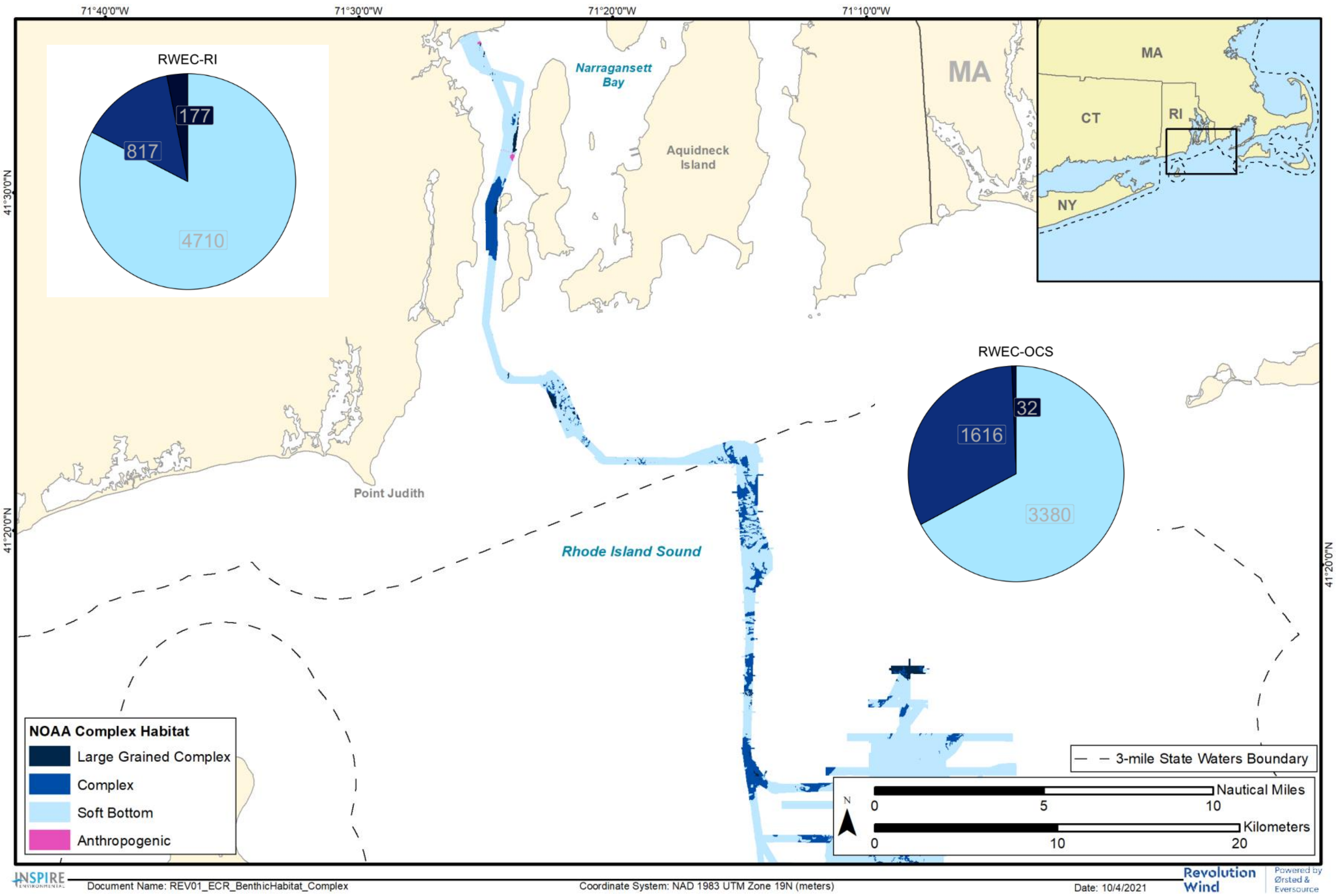


Figure 3-28. Benthic habitats categorized by NOAA Complexity Category along the RWEC, along with pie charts of NOAA Complexity Category composition with total acres presented as values for the RWEC-OCS and RWEC-RI, respectively

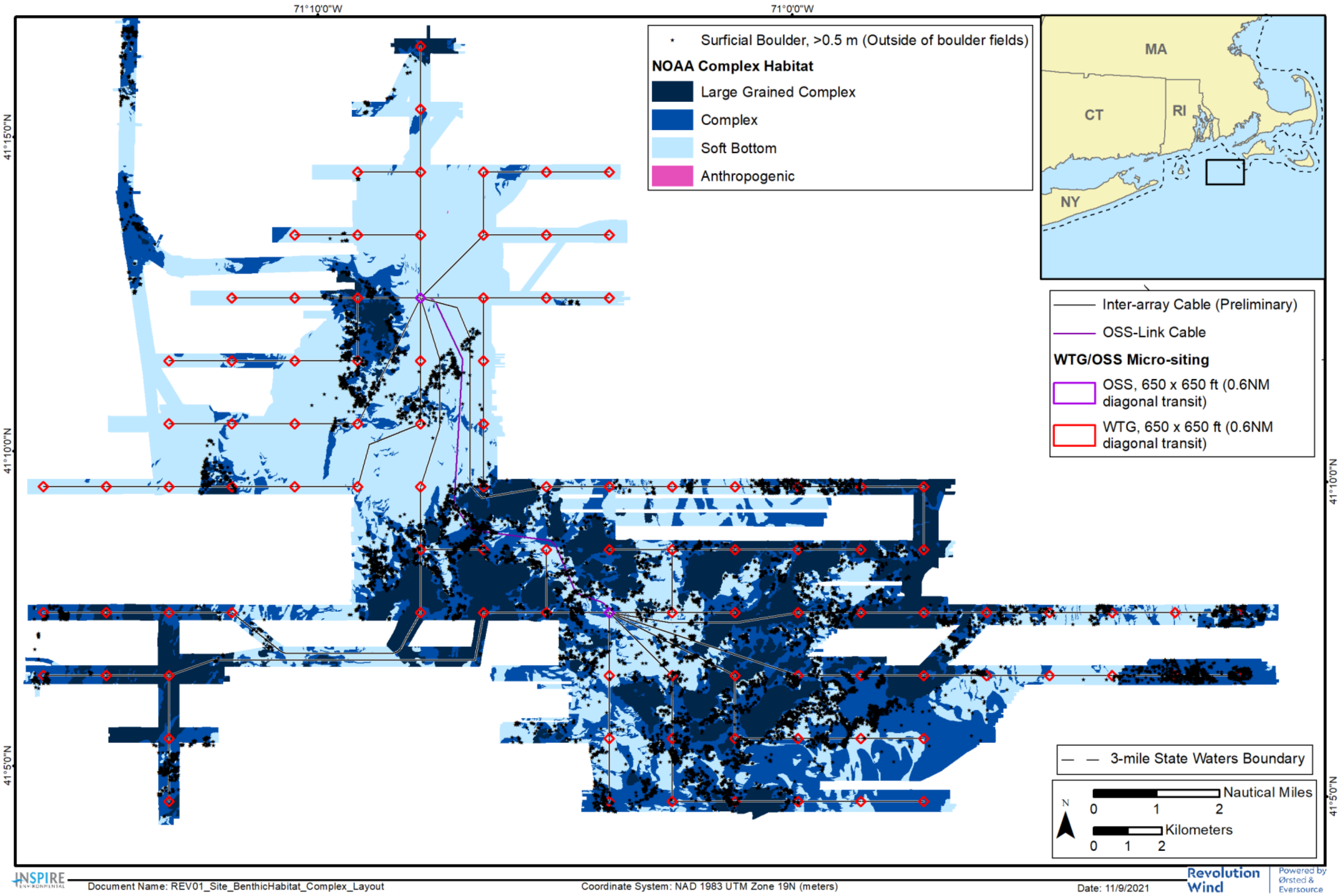


Figure 4-1. Benthic habitats categorized by NOAA Complexity Category at the RWF, current indicative layout showing the micro-siting allowance for each foundation, preliminary IAC routes, and the OSS-Link Cable

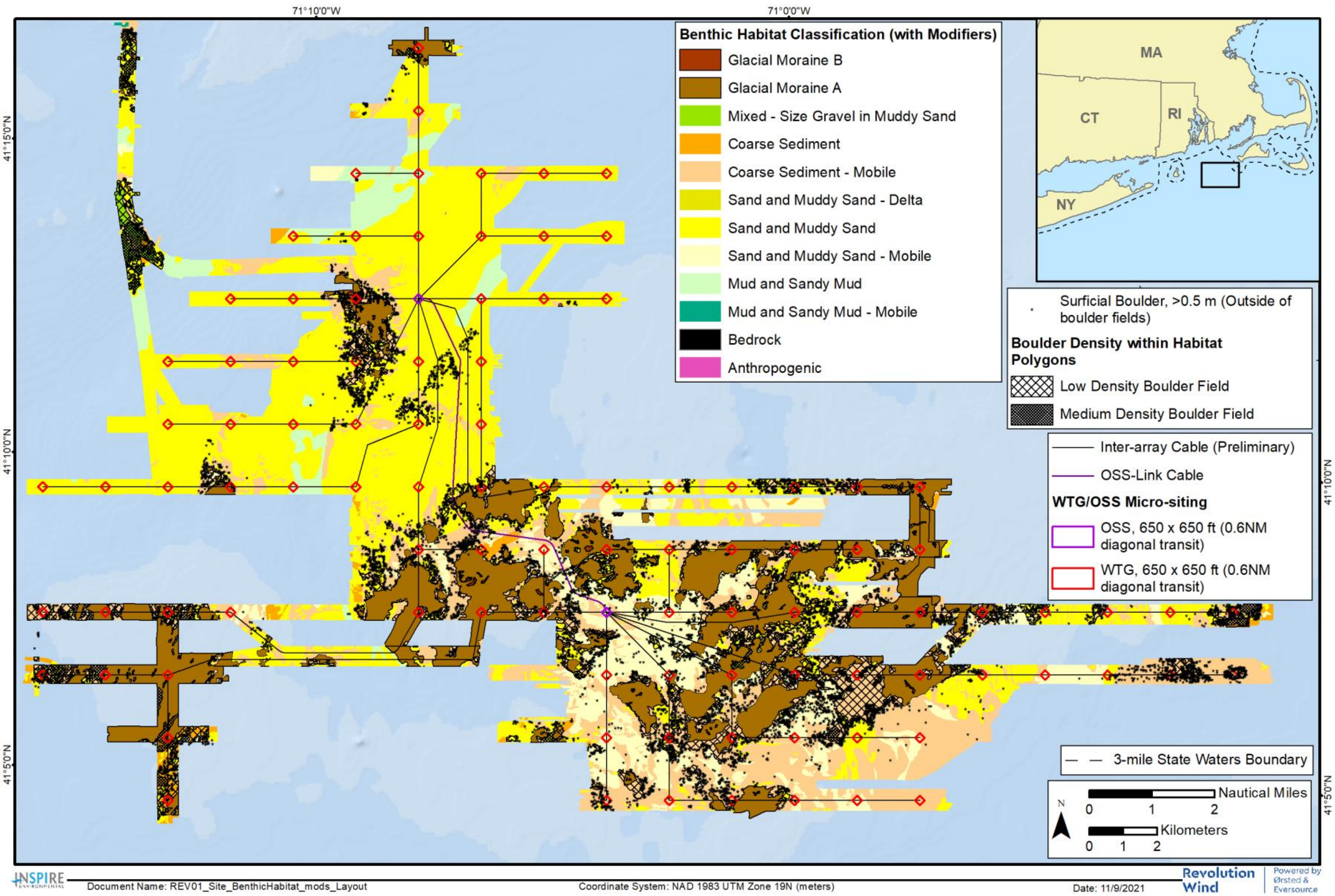


Figure 4-2. Benthic habitat types with modifiers, along with individual boulder picks, at the RWF, current indicative layout showing the micro-siting allowance for each foundation, preliminary IAC routes, and the OSS-Link Cable

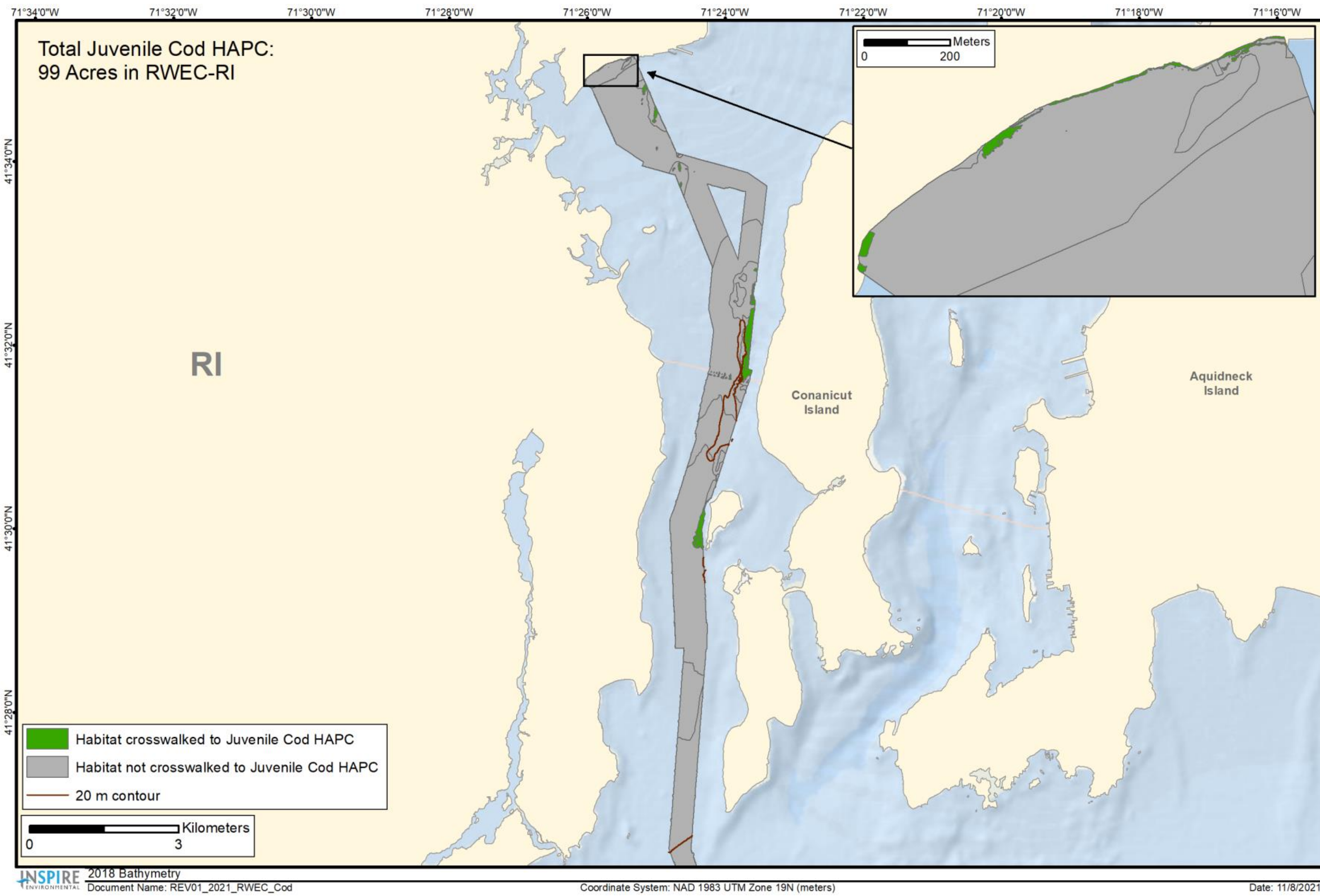


Figure 4-3. Benthic habitats crosswalked to designated juvenile Atlantic cod Habitat Area of Particular Concern (HAPC)

Benthic Habitat Mapping to Support Essential Fish Habitat Consultation Revolution Wind Offshore Wind Farm

ATTACHMENTS

Prepared for:

Revolution Wind, LLC

Submitted by:

INSPIRE Environmental
Newport, Rhode Island 02840

December 2021

Attachment A – Benthic SPI/PV Ground-Truth Data Analysis Results

Notes:

Ground-Truth results include data from stations surveyed in the Revolution Wind Farm and Export Cables, as well as eight stations surveyed to support the benthic assessment for the South Fork Wind Farm.

IND=Indeterminate

N/A=Not Applicable

1 Successional Stage: “on” indicates one Stage is found on top of another Stage (i.e., 1 on 3); “->” indicates one Stage is progressing to another Stage (i.e., 2 -> 3).

2 Variable determined from combined SPI and PV analysis

Area	Station ID	Water Depth (m)	PV Replicate (n)	Mapped Habitat Type	PV Macrohabitat (# of reps)	PV CMECS Substrate Group	SPI/PV CMECS Substrate Subgroup	PV Max Gravel Measurement (mm)	PV Boulder Presence	PV Bedforms (# of reps)	PV Mean Bedform Wavelength (cm)	PV Biological Debris	PV CMECS Biotic Subclass	PV CMECS Co-occurring Biotic Subclasses	PV CMECS Biotic Group	PV CMECS Co-occurring Biotic Group	PV Maximum Attached Fauna Percent Cover	PV Burrow Presence	PV Tracks Presence	PV Fish Presence/Type
RWF	001	37.7	3	Glacial Moraine A	Continuous Large Pebbles and Cobbles on Sand (3)	Gravel Mixes	Sandy Gravel	35.77	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Barnacles	Sparse (1 to <30%)	No	Yes	None
RWF	002	41.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	003	42.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	004	42.3	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	005	44.5	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	006	44.4	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	007	42.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	008	42.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	009	41.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	010	42.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWF	011	42.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	Silver Hake
RWF	012	42.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWF	013	43.8	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Tracks and Trails	None	Yes	Yes	None

Area	Station ID	Water Depth (m)	PV Replicate (n)	Mapped Habitat Type	PV Macrohabitat (# of reps)	PV CMECS Substrate Group	SPI/PV CMECS Substrate Subgroup	PV Max Gravel Measurement (mm)	PV Boulder Presence	PV Bedforms (# of reps)	PV Mean Bedform Wavelength (cm)	PV Biological Debris	PV CMECS Biotic Subclass	PV CMECS Co-occurring Biotic Subclasses	PV CMECS Biotic Group	PV CMECS Co-occurring Biotic Group	PV Maximum Attached Fauna Percent Cover	PV Burrow Presence	PV Tracks Presence	PV Fish Presence/Type
RWF	014	40.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	015	37.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	016	38.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	017	41.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	018	41.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	019	38.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	020	37.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	021	44.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Starfish Bed	None	Yes	Yes	None
RWF	022	42.4	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	023	43.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWF	024	37.3	3	Coarse Sediment - Mobile	Patchy Cobbles & Boulders on Sand (1), Sand with Mobile Gravel (2)	Gravel	Granule	2.23	Yes	Ripples (2)	IND	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Attached Hydroids	Trace (<1%)	Yes	No	None
RWF	025	34.2	3	Sand and Muddy Sand with Medium Density Boulder Field	Patchy Cobbles & Boulders on Sand (3)	Gravelly	Gravelly Sand	33.09	Yes	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Attached Hydroids	Varies	Sparse (1 to <30%)	No	Yes	None
RWF	026	37.0	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	027	40.4	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None

Area	Station ID	Water Depth (m)	PV Replicate (n)	Mapped Habitat Type	PV Macrohabitat (# of reps)	PV CMECS Substrate Group	SPI/PV CMECS Substrate Subgroup	PV Max Gravel Measurement (mm)	PV Boulder Presence	PV Bedforms (# of reps)	PV Mean Bedform Wavelength (cm)	PV Biological Debris	PV CMECS Biotic Subclass	PV CMECS Co-occurring Biotic Subclasses	PV CMECS Biotic Group	PV CMECS Co-occurring Biotic Group	PV Maximum Attached Fauna Percent Cover	PV Burrow Presence	PV Tracks Presence	PV Fish Presence/Type
RWF	028	37.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Mobile Crustaceans on Soft Sediments	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	029	35.3	3	Sand and Muddy Sand	Patchy Cobbles on Sand (1), Sand Sheet (2)	Sand or finer	Medium Sand	44.17	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Mobile Crustaceans on Soft Sediments	Varies	Trace (<1%)	No	Yes	None
RWF	030	34.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWF	031	42.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	032	40.4	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	033	39.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	No	None
RWF	034	39.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	035	38.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	036	36.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	Hake
RWF	037	35.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	038	38.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	039	39.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	040	37.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	No	None
RWF	041	36.3	2	Sand and Muddy Sand	Sand Sheet (2)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	042	39.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None

Area	Station ID	Water Depth (m)	PV Replicate (n)	Mapped Habitat Type	PV Macrohabitat (# of reps)	PV CMECS Substrate Group	SPI/PV CMECS Substrate Subgroup	PV Max Gravel Measurement (mm)	PV Boulder Presence	PV Bedforms (# of reps)	PV Mean Bedform Wavelength (cm)	PV Biological Debris	PV CMECS Biotic Subclass	PV CMECS Co-occurring Biotic Subclasses	PV CMECS Biotic Group	PV CMECS Co-occurring Biotic Group	PV Maximum Attached Fauna Percent Cover	PV Burrow Presence	PV Tracks Presence	PV Fish Presence/Type
RWF	043	41.0	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	044	39.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	045	39.1	2	Sand and Muddy Sand	Sand Sheet (2)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	No	None
RWF	046	37.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	Trace (<1%)	Yes	Yes	Red Hake
RWF	047	36.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Tunicate Bed	None	Yes	Yes	None
RWF	048	37.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	049	36.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	050	43.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Tracks and Trails	None	Yes	Yes	Silver Hake
RWF	051	40.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	None	Larger Tube-Building Fauna	None	None	No	No	None
RWF	052	37.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	053	39.6	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	8.07	No	None	N/A	None	Soft Sediment Fauna	None	Small Surface-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	No	None
RWF	054	38.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	055	38.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	No	No	None
RWF	056	45.1	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	Yes	Hake

Area	Station ID	Water Depth (m)	PV Replicate (n)	Mapped Habitat Type	PV Macrohabitat (# of reps)	PV CMECS Substrate Group	SPI/PV CMECS Substrate Subgroup	PV Max Gravel Measurement (mm)	PV Boulder Presence	PV Bedforms (# of reps)	PV Mean Bedform Wavelength (cm)	PV Biological Debris	PV CMECS Biotic Subclass	PV CMECS Co-occurring Biotic Subclasses	PV CMECS Biotic Group	PV CMECS Co-occurring Biotic Group	PV Maximum Attached Fauna Percent Cover	PV Burrow Presence	PV Tracks Presence	PV Fish Presence/Type
RWF	057	35.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	No	None
RWF	057E1	35.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Tunicate Bed	None	No	No	None
RWF	057E2	34.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Tunicate Bed	None	No	No	None
RWF	057W1	36.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragments, Shell Hash, Unidentified Object	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Tunicate Bed	None	No	Yes	None
RWF	057W2	38.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Tunicate Bed	None	No	No	None
RWF	058	33.2	3	Sand and Muddy Sand	Sand Sheet (3)	Slightly Gravelly	Slightly Gravelly Sand	2.63	No	None	N/A	Large Shell Fragment(s), Shell Hash, Sand Dollar Test	Soft Sediment Fauna	None	Small Tube-Building Fauna	None	None	No	No	None
RWF	059	35.0	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Small Tube-Building Fauna	Larger Tube-Building Fauna	None	No	No	None
RWF	060	36.2	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (2), Sand with Mobile Gravel (1)	Slightly Gravelly	Slightly Gravelly Sand	17.41	No	Ripples (3)	90.10	None	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	Yes	None
RWF	061	34.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Tunicate Bed	None	Yes	Yes	None
RWF	062	35.2	3	Sand and Muddy Sand	Sand Sheet (1), Sand with Mobile Gravel (2)	Slightly Gravelly	Slightly Gravelly Sand	4.75	No	None	N/A	Shell Hash	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	No	None
RWF	063	33.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Small Tube-Building Fauna	None	None	No	No	None
RWF	064	34.1	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	No	No	None

Area	Station ID	Water Depth (m)	PV Replicate (n)	Mapped Habitat Type	PV Macrohabitat (# of reps)	PV CMECS Substrate Group	SPI/PV CMECS Substrate Subgroup	PV Max Gravel Measurement (mm)	PV Boulder Presence	PV Bedforms (# of reps)	PV Mean Bedform Wavelength (cm)	PV Biological Debris	PV CMECS Biotic Subclass	PV CMECS Co-occurring Biotic Subclasses	PV CMECS Biotic Group	PV CMECS Co-occurring Biotic Group	PV Maximum Attached Fauna Percent Cover	PV Burrow Presence	PV Tracks Presence	PV Fish Presence/Type
RWF	065	33.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	066	34.1	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	No	None
RWF	067	35.8	3	Sand and Muddy Sand with Low Density Boulder Field	Sand Sheet (1), Sand with Mobile Gravel (2)	Slightly Gravelly	Slightly Gravelly Sand	8.10	No	None	N/A	Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	068	34.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	069	32.5	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	10.70	No	Ripples (2)	52.58	Small Shell Fragment(s)	Soft Sediment Fauna	None	Mobile Crustaceans on Soft Sediments	None	Trace (<1%)	Yes	No	None
RWF	070	38.3	3	Sand and Muddy Sand	Sand Sheet (2), Sand with Mobile Gravel (1)	Sand or finer	Fine Sand	6.61	No	None	N/A	Shell Hash	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	071	36.4	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	3.46	No	None	N/A	Large Shell Fragments, Seagrass Detritus, Shell Hash	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	None	None	Yes	Yes	None
RWF	072	35.2	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravel Mixes	Sandy Gravel	4.39	No	Ripples (1)	48.75	None	Attached Fauna	None	Mobile Crustaceans on Hard or Mixed Substrates	None	Trace (<1%)	Yes	No	None
RWF	073	33.1	3	Coarse Sediment	Coarse Pebbles on Sand (1), Continuous Large Pebbles and Cobbles on Sand (2)	Gravel Mixes	Sandy Gravel	39.86	No	None	N/A	None	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Barnacles	Dense (70 to < 90%)	Yes	No	None
RWF	073E1	32.9	3	Coarse Sediment	Continuous Large Pebbles and Cobbles on Sand (3)	Gravel Mixes	Sandy Gravel	19.64	No	None	N/A	None	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Barnacles	Moderate (30 to < 70%)	Yes	No	None
RWF	073E2	32.4	3	Coarse Sediment	Continuous Large Pebbles and Cobbles on Sand (3)	Gravel Mixes	Sandy Gravel	21.75	No	None	N/A	None	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Barnacles	Moderate (30 to < 70%)	Yes	Yes	None

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RWF	073W1	33.2	3	Sand and Muddy Sand - Mobile	Patchy Cobbles on Sand (2), Sand with Mobile Gravel (1)	Gravelly	Gravelly Sand	138.09	Yes	None	N/A	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Sparse (1 to <30%)	Yes	Yes	None
RWF	073W2	33.7	3	Sand and Muddy Sand - Mobile	Patchy Cobbles & Boulders on Sand (2), Patchy Cobbles on Sand (1)	Gravelly	Gravelly Sand	48.73	Yes	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Attached Hydroids	Barnacles	Sparse (1 to <30%)	Yes	Yes	Pout
RWF	074	32.7	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	2.12	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	075	32.9	3	Glacial Moraine A	Continuous Large Cobbles and Boulders on Sand (1), Patchy Cobbles on Sand (1), Sand Sheet (1)	Slightly Gravelly	Slightly Gravelly Sand	302.55	Yes	None	N/A	None	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Varies	Complete (90-100%)	Yes	Yes	None
RWF	076	33.3	3	Glacial Moraine A	IND (1), Patchy Cobbles & Boulders on Sand (2)	Gravel Mixes	Sandy Gravel	580.21	Yes	None	N/A	None	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Varies	Moderate (30 to < 70%)	Yes	No	None
RWF	077	33.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	078	31.7	3	Sand and Muddy Sand	Patchy Pebbles on Sand with Mobile Gravel (2), Sand Sheet (1)	Gravel Mixes	Sandy Gravel	4.67	No	Ripples (2)	51.09	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	Yes	None
RWF	079	32.5	3	Coarse Sediment - Mobile with Low Density Boulder Field	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	080	31.3	3	Glacial Moraine A	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	081	30.7	3	Coarse Sediment - Mobile	Patchy Cobbles on Sand (2), Sand with Mobile Gravel (1)	Gravelly	Gravelly Sand	5.12	No	None	N/A	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	None	Trace (<1%)	Yes	Yes	None
RWF	082	37.0	3	Sand and Muddy Sand	Sand Sheet (2), Sand with Mobile Gravel (1)	Sand or finer	Medium Sand	9.67	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	083	33.8	3	Coarse Sediment - Mobile	Patchy Pebbles on Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	9.99	No	Ripples (2)	61.28	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Sparse (1 to <30%)	Yes	No	None

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RWF	084	32.9	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Cobbles & Boulders on Sand (1), Patchy Cobbles on Sand (2)	Gravelly	Gravelly Sand	35.26	Yes	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Barnacles	Moderate (30 to < 70%)	Yes	Yes	None
RWF	085	35.0	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Mobile Crustaceans on Soft Sediments	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	086	33.9	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Sand Dollar Test(s)	Soft Sediment Fauna	None	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	No	None
RWF	087	33.8	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (3)	Gravel Mixes	Sandy Gravel	8.20	No	Ripples (1)	57.77	Small Shell Fragment(s)	Attached Fauna	None	Barnacles	None	Trace (<1%)	Yes	No	Pout, Red Hake
RWF	088	32.8	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Boulders on Sand (1), Patchy Pebbles on Sand (1), Sand Sheet (1)	Slightly Gravelly	Slightly Gravelly Sand	315.35	Yes	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Sparse (1 to <30%)	Yes	Yes	None
RWF	089	32.1	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravel Mixes	Sandy Gravel	2.93	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Mobile Crustaceans on Soft Sediments	Larger Deep-Burrowing Fauna	None	Yes	No	Fourspot Flounder
RWF	090	32.3	3	Coarse Sediment - Mobile with Low Density Boulder Field	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	2.76	No	Ripples (2)	IND	Large Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWF	091	32.7	3	Sand and Muddy Sand - Mobile with Low Density Boulder Field	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	092	33.4	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	093	33.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	094	33.4	3	Sand and Muddy Sand	Sand Sheet (2), Sand with Mobile Gravel (1)	Sand or finer	Fine Sand	7.86	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None

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RWF	095	32.8	3	Coarse Sediment - Mobile	Sand Sheet (1), Sand with Mobile Gravel (2)	Slightly Gravelly	Slightly Gravelly Sand	2.62	No	Ripples (3)	63.23	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Varies	Trace (<1%)	Yes	Yes	None
RWF	096	33.7	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	097	34.5	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	098	35.9	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	099	35.2	3	Sand and Muddy Sand - Mobile with Low Density Boulder Field	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	100	35.5	3	Sand and Muddy Sand	Sand Sheet (2), Sand with Mobile Gravel (1)	Sand or finer	Fine Sand	2.24	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	101	34.6	3	Coarse Sediment - Mobile with Low Density Boulder Field	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	3.29	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Mobile Crustaceans on Soft Sediments	None	None	Yes	Yes	None
RWF	102	34.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Sand Dollar Test(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	Hake, Silver Hake
RWF	103	34.9	3	Sand and Muddy Sand	Sand Sheet (2), Sand with Mobile Gravel (1)	Sand or finer	Fine Sand	2.68	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWF	104	34.8	3	Sand and Muddy Sand - Mobile	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	3.24	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Varies	Trace (<1%)	Yes	No	None
RWF	105	37.1	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	106	37.7	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	3.27	No	Ripples (3)	59.03	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None

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RWF	107	38.3	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	2.74	No	Ripples (3)	68.66	None	Soft Sediment Fauna	None	Mobile Crustaceans on Soft Sediments	None	None	Yes	No	None
RWF	108	37.5	3	Coarse Sediment - Mobile	Patchy Cobbles on Sand (1), Sand with Mobile Gravel (2)	Gravelly	Gravelly Sand	3.15	No	None	N/A	None	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	None	Trace (<1%)	Yes	No	None
RWF	109	36.4	3	Coarse Sediment - Mobile with Low Density Boulder Field	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	3.36	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	Yes	None
RWF	110	36.0	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	111	37.3	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	5.04	No	Ripples (2)	71.39	Large Shell Fragment(s), Shell Hash	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	None	None	Yes	Yes	None
RWF	112	37.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	Hake
RWF	113	37.3	3	Sand and Muddy Sand - Mobile	Sand Sheet (2), Sand with Mobile Gravel (1)	Sand or finer	Medium Sand	2.20	No	None	N/A	Sand Dollar Test(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	114	36.9	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	3.01	No	Ripples (3)	71.63	Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	115	36.2	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	3.96	No	Ripples (1)	64.12	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	No	None
RWF	116	34.9	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravel	Granule	2.41	No	Ripples (1)	IND	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Hard or Mixed Substrates	Trace (<1%)	Yes	No	None
RWF	117	35.0	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	2.47	No	None	N/A	Skate Egg Case	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	118	36.1	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	4.92	No	Ripples (1)	63.87	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Varies	None	Yes	No	None
RWF	119	35.6	3	Coarse Sediment - Mobile	Patchy Pebbles on Sand with Mobile Gravel (1), Sand with Mobile Gravel (2)	Slightly Gravelly	Slightly Gravelly Sand	5.12	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	Yes	None

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RWF	120	34.9	3	Coarse Sediment - Mobile	Sand Sheet (2), Sand with Mobile Gravel (1)	Slightly Gravelly	Slightly Gravelly Sand	3.66	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	121	35.0	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	4.74	No	Ripples (3)	65.35	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	No	None
RWF	122	36.3	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	2.97	No	None	N/A	Moon Snail Egg Case, Sand Dollar Test, Shell Hash	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	123	35.6	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	Ripples (3)	33.05	Shell Hash	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	124	32.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	125	34.5	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWF	126	37.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	Ripples (1)	7.62	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Varies	None	Yes	No	None
RWF	127	37.7	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	3.12	No	Ripples (3)	70.15	Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	None	None	Yes	No	None
RWF	128	37.6	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	2.49	No	Ripples (2)	IND	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	129	37.8	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	7.48	No	Ripples (1)	78.06	Large Shell Fragment(s)	Soft Sediment Fauna	None	Small Tube-Building Fauna	Varies	None	Yes	No	Hake
RWF	136	34.2	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (3)	Gravel Mixes	Sandy Gravel	7.49	No	Ripples (3)	34.62	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Attached Hydroids	Trace (<1%)	Yes	No	None
RWF	137	32.7	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (3)	Gravel Mixes	Sandy Gravel	9.92	No	Ripples (1)	67.43	None	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Barnacles	Trace (<1%)	No	No	None

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RWF	138	31.8	3	Glacial Moraine A	Continuous Large Cobbles and Boulders on Sand (1), IND (1), Patchy Cobbles & Boulders on Sand (1)	Gravel	Sandy Gravel	66.29	Yes	None	N/A	Large Shell Fragment(s), Shell Hash	Attached Fauna	Soft Sediment Fauna	Barnacles	Attached Hydroids	Complete (90-100%)	No	No	None
RWF	139	31.6	3	Glacial Moraine A	Patchy Cobbles on Sand (2), Patchy Pebbles on Sand with Mobile Gravel (1)	Gravelly	Gravelly Sand	37.78	No	Ripples (1)	67.96	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Barnacles	Trace (<1%)	Yes	No	None
RWF	140	33.2	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	141	36.4	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (1), Sand with Mobile Gravel (2)	Gravel Mixes	Sandy Gravel	9.94	No	Ripples (3)	40.55	None	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	Trace (<1%)	Yes	No	None
RWF	142	34.7	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Boulders on Sand (1), Patchy Pebbles on Sand with Mobile Gravel (2)	Gravel Mixes	Sandy Gravel	2.88	Yes	Ripples (3)	49.32	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	Sparse (1 to <30%)	Yes	No	None
RWF	143	33.2	3	Sand and Muddy Sand with Medium Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (1), Sand Sheet (2)	Sand or finer	Fine Sand	2.08	No	Ripples (1)	53.79	Skate Egg Case	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	Yes	None
RWF	144	34.6	3	Glacial Moraine A	Patchy Pebbles on Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	5.90	No	Ripples (3)	IND	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Barnacles	Trace (<1%)	Yes	No	None
RWF	201	32.5	3	Glacial Moraine A	Continuous Large Cobbles and Boulders on Sand (1), Patchy Cobbles & Boulders on Sand (2)	Gravel Mixes	Sandy Gravel	355.11	Yes	None	N/A	Small Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Barnacles	Attached Hydroids	Complete (90-100%)	Yes	Yes	None
RWF	202	35.0	3	Coarse Sediment with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (1), Sand with Mobile Gravel (2)	Gravel	Granule	2.90	No	Ripples (3)	75.21	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	None	Trace (<1%)	Yes	No	None
RWF	204	31.6	3	Sand and Muddy Sand with Low Density Boulder Field	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None

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RWF	205	34.1	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	206	32.8	3	Glacial Moraine A	Patchy Boulders on Sand (1), Sand with Mobile Gravel (2)	Gravelly	Gravelly Sand	3.96	Yes	Ripples (1)	IND	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Attached Hydroids	Sparse (1 to <30%)	Yes	Yes	None
RWF	207	33.1	3	Glacial Moraine A	Sand Sheet (3)	Sand or finer	Medium Sand	2.36	No	None	N/A	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	Trace (<1%)	Yes	Yes	None
RWF	208	32.7	3	Glacial Moraine A	Patchy Boulders on Sand (2), Patchy Cobbles on Sand (1)	Gravelly	Gravelly Sand	679.66	Yes	None	N/A	None	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Varies	Moderate (30 to < 70%)	Yes	No	None
RWF	209	35.4	3	Glacial Moraine A	Patchy Cobbles on Sand (2), Patchy Pebbles on Sand (1)	Slightly Gravelly	Slightly Gravelly Sand	117.94	No	None	N/A	None	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	Sparse (1 to <30%)	Yes	No	None
RWF	210	30.9	3	Glacial Moraine A	Patchy Cobbles on Sand (1), Sand Sheet (1), Sand with Mobile Gravel (1)	Slightly Gravelly	Slightly Gravelly Sand	2.89	No	Ripples (1)	IND	None	Soft Sediment Fauna	Attached Fauna	Mobile Crustaceans on Soft Sediments	Varies	Trace (<1%)	Yes	No	Silver Hake
RWF	211	33.9	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (2), Sand with Mobile Gravel (1)	Gravel	Granule	3.36	No	None	N/A	Moon Snail Egg Case, Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Trace (<1%)	Yes	No	None
RWF	212	37.7	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	11.14	No	Ripples (3)	IND	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	Hake
RWF	213	34.4	3	Glacial Moraine A	Patchy Cobbles on Sand (2), Sand with Mobile Gravel (1)	Gravelly	Gravelly Sand	92.73	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Sparse (1 to <30%)	Yes	Yes	None
RWF	214	33.2	3	Glacial Moraine A	Continuous Large Cobbles and Boulders on Sand (1), Patchy Pebbles on Sand with Mobile Gravel (1), Sand with Mobile Gravel (1)	Gravel Mixes	Sandy Gravel	337.24	Yes	Ripples (2)	73.82	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Attached Hydroids	Dense (70 to < 90%)	Yes	No	None
RWF	215	31.4	3	Glacial Moraine A	Patchy Cobbles & Boulders on Sand (2), Patchy Pebbles on Sand with Mobile Gravel (1)	Gravel Mixes	Sandy Gravel	92.59	Yes	None	N/A	Barnacle Hash	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Barnacles	Moderate (30 to < 70%)	Yes	Yes	None

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RWF	216	30.8	3	Glacial Moraine A	Patchy Boulders on Sand (2), Patchy Pebbles on Sand (1)	Gravelly	Gravelly Sand	28.50	Yes	None	N/A	Barnacle Hash, Shell Hash	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Sparse (1 to <30%)	Yes	No	None
RWF	217	31.5	3	Glacial Moraine A	Patchy Cobbles & Boulders on Sand (1), Patchy Pebbles on Sand (1), Patchy Pebbles on Sand with Mobile Gravel (1)	Gravel Mixes	Sandy Gravel	165.70	Yes	Ripples (1)	41.67	Barnacle Hash	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Moderate (30 to < 70%)	Yes	No	None
RWF	218	29.2	3	Glacial Moraine A	Patchy Cobbles & Boulders on Sand (3)	Gravel Mixes	Sandy Gravel	89.34	Yes	None	N/A	None	Attached Fauna	Soft Sediment Fauna	Attached Tube-Building Fauna	Barnacles	Moderate (30 to < 70%)	Yes	Yes	None
RWF	218E1	29.0	3	Glacial Moraine A	Patchy Cobbles & Boulders on Sand (3)	Gravelly	Gravelly Sand	60.23	Yes	None	N/A	None	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Attached Tube-Building Fauna	Complete (90-100%)	Yes	No	None
RWF	218E2	28.8	3	Coarse Sediment - Mobile with Medium Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	7.00	No	Ripples (3)	41.22	None	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	Trace (<1%)	Yes	No	None
RWF	218W1	29.7	3	Glacial Moraine A	Patchy Boulders on Sand (1), Patchy Cobbles & Boulders on Sand (1), Patchy Cobbles on Sand (1)	Gravel Mixes	Sandy Gravel	398.10	Yes	None	N/A	Spent Squid Eggs	Attached Fauna	Soft Sediment Fauna	Attached Tube-Building Fauna	Varies	Moderate (30 to < 70%)	Yes	Yes	None
RWF	218W2	29.9	3	Glacial Moraine A	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	7.92	No	Ripples (2)	56.06	None	Soft Sediment Fauna	None	Small Tube-Building Fauna	None	None	Yes	No	None
RWF	219	28.3	3	Glacial Moraine A	IND (1), Patchy Cobbles & Boulders on Sand (2)	Gravel Mixes	Sandy Gravel	308.89	Yes	None	N/A	Barnacle Hash	Attached Fauna	Soft Sediment Fauna	Attached Tube-Building Fauna	Varies	Dense (70 to < 90%)	Yes	Yes	None
RWF	220	34.8	3	Glacial Moraine A	Patchy Boulders on Sand (1), Patchy Cobbles & Boulders on Sand (1), Patchy Cobbles on Sand (1)	Gravel Mixes	Sandy Gravel	54.41	Yes	None	N/A	Barnacle Hash, Small Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Diverse Colonizers	Larger Deep-Burrowing Fauna	Dense (70 to < 90%)	Yes	Yes	None

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RWF	220E1	34.7	3	Glacial Moraine A	Patchy Cobbles & Boulders on Sand (3)	Gravel Mixes	Sandy Gravel	231.39	Yes	None	N/A	Barnacle Hash, Large Shell Fragment(s), Skate Egg Sack	Attached Fauna	Soft Sediment Fauna	Diverse Colonizers	Larger Deep-Burrowing Fauna	Dense (70 to < 90%)	Yes	No	None
RWF	220E2	34.7	3	Glacial Moraine A	Patchy Cobbles & Boulders on Sand (2), Sand with Mobile Gravel (1)	Gravelly	Gravelly Sand	156.45	Yes	Ripples (1)	52.66	Barnacle Hash	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Varies	Moderate (30 to < 70%)	Yes	No	None
RWF	220W1	35.0	3	Glacial Moraine A	Patchy Boulders on Sand (1), Patchy Cobbles on Sand (1), Patchy Pebbles on Sand with Mobile Gravel (1)	Gravelly	Gravelly Sand	735.37	Yes	None	N/A	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Varies	Sparse (1 to <30%)	Yes	Yes	None
RWF	220W2	34.8	3	Glacial Moraine A	Patchy Cobbles & Boulders on Sand (3)	Gravelly	Gravelly Sand	130.53	Yes	None	N/A	Small Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Diverse Colonizers	Larger Deep-Burrowing Fauna	Moderate (30 to < 70%)	Yes	Yes	None
RWF	221	34.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	No	None
RWF	222	33.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	None	Small Tube-Building Fauna	None	None	Yes	No	None
RWF	223	42.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	224	44.7	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	2.62	No	None	N/A	Large Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	225	42.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	226	42.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	227	46.0	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Tracks and Trails	None	Yes	Yes	Silver Hake
RWF	228	38.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	229	39.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	230	40.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None

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RWF	231	42.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	Red Hake
RWF	232	35.3	3	Coarse Sediment - Mobile with Medium Density Boulder Field	Continuous Large Pebbles and Cobbles on Sand (1), Patchy Pebbles on Sand with Mobile Gravel (2)	Gravelly	Gravelly Sand	223.13	Yes	None	N/A	Barnacle Hash, Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Moderate (30 to < 70%)	Yes	No	None
RWF	233	36.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Varies	None	Yes	No	None
RWF	234	38.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	235	40.0	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	2.10	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	None	None	Yes	No	None
RWF	236	39.4	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Tracks and Trails	None	Yes	Yes	None
RWF	237	36.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	238	36.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	239	38.7	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragment(s), Shell Hash	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	Sparse (1 to <30%)	Yes	Yes	None
RWF	240	41.4	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	No	None
RWF	241	38.0	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	No	None
RWF	242	38.4	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	None	N/A	Moon Snail Egg Case	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	243	36.4	3	Glacial Moraine A	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	244	33.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None

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RWF	245	34.6	3	Sand and Muddy Sand	Patchy Cobbles on Sand (1), Sand Sheet (1), Sand with Mobile Gravel (1)	Slightly Gravelly	Slightly Gravelly Sand	106.30	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	Yes	None
RWF	246	35.4	2	Sand and Muddy Sand - Mobile	Sand Sheet (2)	Sand or finer	Fine Sand	IND	No	None	N/A	Moon Snail Egg Case	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	247	33.0	3	Coarse Sediment - Mobile	Patchy Pebbles on Sand with Mobile Gravel (2), Sand with Mobile Gravel (1)	Gravelly	Gravelly Sand	22.16	No	Ripples (3)	38.45	None	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	None	Trace (<1%)	Yes	Yes	None
RWF	248	33.5	3	Glacial Moraine A	Patchy Pebbles on Sand with Mobile Gravel (1), Sand with Mobile Gravel (2)	Gravelly	Gravelly Sand	13.58	No	Ripples (1)	IND	Moon Snail Egg Case	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	None	Trace (<1%)	Yes	No	None
RWF	249	31.7	3	Glacial Moraine A	Continuous Large Cobbles and Boulders on Sand (3)	Gravel	Cobble	174.91	Yes	None	N/A	Shell Hash	Attached Fauna	None	Diverse Colonizers	Attached Hydroids	Dense (70 to < 90%)	No	No	Red Hake
RWF	250	34.5	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	251	34.8	3	Coarse Sediment - Mobile	Sand Sheet (1), Sand with Mobile Gravel (2)	Gravelly	Gravelly Sand	5.43	No	Ripples (1)	62.86	Shell Hash	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	252	36.0	3	Glacial Moraine A	Patchy Cobbles on Sand (2), Patchy Pebbles on Sand (1)	Gravelly	Gravelly Sand	163.69	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Varies	Sparse (1 to <30%)	Yes	Yes	None
RWF	253	34.2	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	2.78	No	None	N/A	Large Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	254	35.6	3	Sand and Muddy Sand	Sand Sheet (1), Sand with Mobile Gravel (2)	Slightly Gravelly	Slightly Gravelly Sand	2.41	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	Trace (<1%)	Yes	No	None
RWF	255	32.6	3	Glacial Moraine A	Sand Sheet (1), Sand with Mobile Gravel (2)	Slightly Gravelly	Slightly Gravelly Sand	6.47	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Mobile Crustaceans on Soft Sediments	Tracks and Trails	None	Yes	Yes	None
RWF	256	34.5	3	Glacial Moraine A	Patchy Pebbles on Sand with Mobile Gravel (2), Sand with Mobile Gravel (1)	Gravel Mixes	Sandy Gravel	16.49	No	Ripples (3)	66.36	None	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	None	Trace (<1%)	Yes	Yes	None

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RWF	257	33.6	3	Coarse Sediment - Mobile with Low Density Boulder Field	Sand with Mobile Gravel (3)	Gravelly	Gravelly Sand	4.76	No	Ripples (1)	72.31	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	258	35.4	3	Coarse Sediment - Mobile with Low Density Boulder Field	Patchy Pebbles on Sand with Mobile Gravel (2), Sand with Mobile Gravel (1)	Gravel Mixes	Sandy Gravel	17.81	No	Ripples (2)	32.81	Moon Snail Egg Case	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Small Tube-Building Fauna	Trace (<1%)	Yes	Yes	None
RWF	259	34.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	260	37.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	No	Hake
RWF	261	36.0	3	Coarse Sediment - Mobile	Sand with Mobile Gravel (3)	Gravel	Granule	2.18	No	Ripples (1)	IND	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	None	None	Yes	No	None
RWF	262	33.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None
RWF	401	33.9	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	Hake
RWF	402	33.6	3	Coarse Sediment - Mobile	Patchy Pebbles on Sand (2), Sand with Mobile Gravel (1)	Slightly Gravelly	Slightly Gravelly Sand	31.99	No	None	N/A	Shell Hash	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	Trace (<1%)	Yes	Yes	None
RWF	403	35.3	3	Sand and Muddy Sand	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	2.73	No	None	N/A	Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	404	36.0	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Large Shell Fragment(s), Shell Hash	Soft Sediment Fauna	Attached Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	Trace (<1%)	Yes	Yes	None
RWF	405	33.4	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	No	None
RWF	406	41.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	407	38.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None

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RWF	408	38.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Large Shell Fragment(s), Shell Hash	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	Trace (<1%)	Yes	Yes	None
RWF	409	38.0	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Small Tube-Building Fauna	None	Yes	No	None
RWEC-OCS	410	45.6	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-OCS	411	44.9	3	Mixed-Size Gravel in Muddy Sand with Medium Density Boulder Field	Continuous Large Pebbles and Cobbles on Sand (3)	Gravel	Cobble	82.12	No	None	N/A	Large Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Barnacles	Attached Hydroids	Dense (70 to < 90%)	Yes	No	None
RWF	412	37.7	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	No	None
RWF	413	39.9	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	Yes	None
RWF	414	34.5	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	Yes	None
RWF	415	35.8	3	Coarse Sediment - Mobile	Patchy Pebbles on Sand (2), Sand Sheet (1)	Slightly Gravelly	Slightly Gravelly Sand	31.86	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWF	416	42.8	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-OCS	417	46.1	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-OCS	418	43.3	3	Mixed-Size Gravel in Muddy Sand with Medium Density Boulder Field	Continuous Large Cobbles and Boulders on Sand (1), Continuous Large Pebbles and Cobbles on Sand (2)	Gravel Mixes	Sandy Gravel	100.87	Yes	None	N/A	Large Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	Varies	Moderate (30 to < 70%)	Yes	No	Red Hake
RWEC-OCS	419	37.2	3	Mixed-Size Gravel in Muddy Sand with Low Density Boulder Field	Continuous Large Pebbles and Cobbles on Sand (3)	Gravel	Pebble	81.56	No	None	N/A	Large Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Attached Hydroids	None	Sparse (1 to <30%)	Yes	No	None

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RWEC-OCS	420	37.2	3	Sand and Muddy Sand with Low Density Boulder Field	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	19.29	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	None	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	No	None
RWEC-OCS	421	40.4	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWEC-OCS	422	38.8	3	Sand and Muddy Sand with Medium Density Boulder Field	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	12.94	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWEC-OCS	423	34.4	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	Ripples (3)	69.01	Shell Hash	Soft Sediment Fauna	None	Larger Tube-Building Fauna	Small Tube-Building Fauna	None	No	No	None
RWEC-OCS	424	32.6	3	Sand and Muddy Sand	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	7.84	No	Ripples (3)	59.96	Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	None	Small Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	No	None
RWEC-OCS	425	31.6	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Large Shell Fragment(s), Shell Hash	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Larger Tube-Building Fauna	Trace (<1%)	Yes	No	None
RWEC-OCS	426	31.5	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	None	None	Yes	Yes	None
RWEC-OCS	427	27.6	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	Ripples (1)	IND	Moon Snail Egg Case	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-OCS	428	26.7	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	None	None	No	Yes	None
RWEC-RI	429	27.5	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	None	N/A	Moon Snail Egg Case, Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	None	None	No	Yes	None
RWEC-RI	430	28.2	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Varies	None	Yes	Yes	None
RWEC-RI	431	32.4	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWEC-RI	432	34.1	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWEC-RI	433	33.7	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Small Tube-Building Fauna	None	Yes	Yes	None

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RWEC-RI	434	31.0	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-RI	435	31.1	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-RI	436	31.1	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-RI	437	30.5	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-RI	438	30.1	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	None	None	Yes	Yes	None
RWEC-RI	439	29.9	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWEC-RI	440	29.4	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	Moon Snail Egg Case	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Tracks and Trails	None	Yes	Yes	None
RWEC-RI	441	29.8	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Tunneling Megafauna	None	Yes	Yes	None
RWEC-RI	442	29.4	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Tunneling Megafauna	Tracks and Trails	None	Yes	Yes	None
RWEC-RI	443	23.5	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	Ripples (3)	11.93	None	Soft Sediment Fauna	Inferred Fauna	Tracks and Trails	Varies	None	Yes	Yes	None
RWEC-RI	444	19.9	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	Ripples (3)	IND	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	None	None	Yes	Yes	None
RWEC-RI	445	17.6	2	Mud and Sandy Mud	Sand Sheet (2)	Sand or finer	Very Fine Sand	IND	No	Ripples (1)	IND	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Larger Deep-Burrowing Fauna	None	Trace (<1%)	Yes	Yes	None
RWEC-RI	446	14.7	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	None	None	None	No	Yes	Northern Sea Robin
RWEC-RI	447	15.0	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	Large Shell Fragment(s)	Soft Sediment Fauna	Attached Fauna	Attached Hydroids	None	Sparse (1 to <30%)	Yes	Yes	None
RWEC-RI	448	10.9	3	Mud and Sandy Mud with Shell Substrate	Mollusk Bed (or Shells) on Mud (3)	Shell Substrate	Shell Hash	IND	No	None	N/A	Large Mussel Shell Fragments	Soft Sediment Fauna	Attached Fauna	Mussel Bed	Varies	Moderate (30 to < 70%)	Yes	No	None

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RWEC-RI	449	13.8	3	Mud and Sandy Mud with Shell Substrate	Mollusk Bed (or Shells) on Mud (3)	Shell Substrate	Shell Hash	IND	No	None	N/A	Large Mussel Shell Fragments	Soft Sediment Fauna	Attached Fauna	Small Tube-Building Fauna	Filamentous Algal Bed	Sparse (1 to <30%)	No	No	None
RWEC-RI	450	11.0	3	Mud and Sandy Mud with Shell Substrate	Mollusk Bed (or Shells) on Mud (3)	Shell Substrate	Crepidula Reef Substrate	IND	No	None	N/A	Large Shell Fragment(s)	Attached Fauna	None	Sessile Gastropods	Attached Hydroids	Complete (90-100%)	No	No	None
RWEC-RI	451	25.5	3	Sand and Muddy Sand	IND (1), Patchy Cobbles on Sand (2)	Slightly Gravelly	Slightly Gravelly Sand	IND	No	None	N/A	Large Shell Fragment(s)	Benthic Macroalgae	Soft Sediment Fauna	Filamentous Algal Bed	Attached Sponges	Moderate (30 to < 70%)	IND	Yes	None
RWEC-RI	452	21.5	3	Glacial Moraine B	Patchy Cobbles on Sand (2), Patchy Pebbles on Sand (1)	Slightly Gravelly	Slightly Gravelly Sand	114.61	No	None	N/A	Large Shell Fragment(s), Small Shell Fragment(s)	Attached Fauna	Soft Sediment Fauna	Attached Sponges	None	Sparse (1 to <30%)	No	Yes	None
RWEC-RI	453	13.6	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Benthic Macroalgae	Larger Deep-Burrowing Fauna	Filamentous Algal Bed	Sparse (1 to <30%)	Yes	No	None
RWEC-RI	454	8.6	2	Mud and Sandy Mud	Sand Sheet (2)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	None	None	Yes	Yes	None
RWEC-RI	455	5.2	1	Mud and Sandy Mud	Sand Sheet (1)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Tracks and Trails	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	601	33.0	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWF	602	36.0	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Larger Deep-Burrowing Fauna	None	Yes	Yes	None
RWF	603	36.3	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-RI	604	27.8	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	Small Shell Fragment(s)	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	None	None	No	Yes	None
RWEC-OCS	605	27.3	3	Coarse Sediment	Sand Sheet (3)	Sand or finer	Coarse Sand	IND	No	Ripples (1)	IND	Large Shell Fragment(s), Shell Hash	Soft Sediment Fauna	None	Small Tube-Building Fauna	None	None	Yes	No	None
RWEC-OCS	606	28.6	3	Coarse Sediment	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	7.49	No	Ripples (3)	68.36	Shell Hash	Soft Sediment Fauna	None	Small Tube-Building Fauna	None	None	Yes	No	None
RWEC-OCS	607	34.7	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Varies	None	Yes	Yes	None
RWEC-OCS	608	36.1	3	Mud and Sandy Mud	Sand Sheet (3)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Mobile Crustaceans on Soft Sediments	None	Yes	Yes	None

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RWEC-OCS	609	31.6	3	Sand and Muddy Sand - Mobile	Sand with Mobile Gravel (3)	Slightly Gravelly	Slightly Gravelly Sand	2.36	No	Ripples (3)	38.80	Shell Hash, Small Shell Fragment(s)	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	Varies	None	Yes	No	None
RWEC-RI	610	29.5	3	Coarse Sediment - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Small Tube-Building Fauna	Tracks and Trails	None	Yes	Yes	None
RWEC-RI	611	30.8	3	Sand and Muddy Sand - Mobile	Sand Sheet (3)	Sand or finer	Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Deep-Burrowing Fauna	Larger Tube-Building Fauna	None	Yes	Yes	None
RWEC-RI	612	8.9	2	Mud and Sandy Mud	Sand Sheet (2)	Sand or finer	Very Fine Sand	IND	No	None	N/A	None	Soft Sediment Fauna	Inferred Fauna	Larger Tube-Building Fauna	Tracks and Trails	None	Yes	Yes	None
RWEC-RI	613	9.2	3	Sand and Muddy Sand	Sand Sheet (3)	Sand or finer	Medium Sand	IND	No	None	N/A	Shell Hash	Soft Sediment Fauna	None	Larger Deep-Burrowing Fauna	IND	None	Yes	IND	None
RWEC-RI	614	11.2	3	Mud and Sandy Mud with Shell Substrate	Mollusk Bed (or Shells) on Mud (3)	Shell Substrate	Shell Hash	IND	No	None	N/A	Large Shell Fragment(s), Shell Hash	Attached Fauna	None	Attached Hydroids	None	Sparse (1 to <30%)	No	No	None
RWEC-RI	615	14.2	3	Mud and Sandy Mud with Shell Substrate	Mollusk Bed (or Shells) on Mud (3)	Shell Substrate	Shell Hash	IND	No	None	N/A	Large Mussel Shell Fragments	Attached Fauna	None	IND	None	Sparse (1 to <30%)	No	No	None

Area	Station ID	SPI Replicate (n)	SPI Sediment Type (# of reps)	SPI Mean Prism Penetration Depth (cm)	SPI Mean Boundary Roughness (cm)	SPI Mean aRPD Depth (cm)	SPI Sediment Oxygen Demand Level	SPI Successional Stage (by replicate)[1]			SPI/PV Sensitive Taxa Type[2]	SPI/PV Species of Concern[2]	SPI/PV Presence of Tubes[2]	SPI/PV Amphipod Presence/Type[2]	SPI/PV Sea Pen Presence[2]	SPI/PV Other Epifauna Present[2]	SPI/PV Possible Non-Native *Botrylloides sp.*[2]
RWF	001	3	Pebble over finer sediment (1), Very fine sand (2)	3.6	1.2	IND	Low	2	IND	IND	None	None	No	None	No	Barnacles, Bryozoan, Hydroids, Sea Star	No
RWF	002	3	Fine sand (2), Fine sand over very fine sand (1)	12.3	0.8	4.77	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Hydroid, Shrimp, Unidentified Organism	No
RWF	003	3	Fine sand (3)	12.8	0.7	3.93	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Caprellidae, Podoceridae	No	None	No
RWF	004	3	Coarse sand (3)	5.3	2.1	IND	Low	2	2	IND	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	005	3	Very fine sand (3)	14.4	1.4	4.30	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	006	3	Fine sand over very fine sand (3)	12.7	0.8	4.80	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	007	3	Fine sand (3)	10.1	1.4	4.82	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	008	3	Fine sand (3)	9.8	1.5	6.35	Low	2	2 -> 3	3	None	None	Yes	Podoceridae	No	Hydroids, Nudibranch, Paguroid(s), Shrimp	No
RWF	009	3	Fine sand (3)	6.0	0.9	4.46	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	010	3	Fine sand over very fine sand (3)	13.8	0.8	5.73	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	None	No
RWF	011	3	Very fine sand (3)	16.8	0.7	4.15	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Ampeliscid, Caprellidae, Podoceridae	No	None	No
RWF	012	3	Medium sand (2), Medium sand over finer sediment (1)	6.8	1.1	4.15	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid, Shrimp	No
RWF	013	3	Very fine sand (3)	18.9	1.3	3.62	Medium	3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	None	No

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RWF	014	3	Fine sand (3)	4.7	0.5	IND	Low	2 on 3	IND	IND	None	None	Yes	Podoceridae	No	Sea Star(s)	No
RWF	015	3	Fine sand (3)	4.5	0.7	4.18	Low	2	2	2	None	None	Yes	None	No	Sea Star, Shrimp	No
RWF	016	3	Fine sand (3)	4.2	1.0	IND	Low	2	2	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	None	No
RWF	017	3	Fine sand over very fine sand (3)	16.7	0.6	5.38	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Caprellidae, Podoceridae	No	Shrimp	No
RWF	018	3	Fine sand over very fine sand (3)	17.1	1.0	5.52	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	None	No
RWF	019	3	Fine sand (3)	5.0	0.9	3.21	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	020	3	Fine sand (3)	4.9	0.9	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	None	No
RWF	021	3	Very fine sand (3)	14.0	1.1	3.27	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	None	No	Sea Star(s)	No
RWF	022	3	Medium sand (3)	5.2	1.2	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	None	No	Crab, Sea Star(s), Shrimp	No
RWF	023	3	Very fine sand (3)	16.1	0.5	1.92	Low	2 -> 3	2 -> 3	1 on 3	None	None	Yes	None	No	Sea Star(s)	No
RWF	024	3	Granule (2), Granule over sand (1)	9.3	2.3	IND	None	2	IND	IND	None	None	No	Podoceridae	Yes	Barnacles, Hydroids	No
RWF	025	3	Coarse sand (2), Medium sand (1)	3.0	0.7	IND	None	2	IND	IND	None	None	No	Caprellidae, Podoceridae	Yes	Barnacles, Colonial Tunicate(s), Crab, Hydroids, Shrimp	Yes
RWF	026	3	Fine sand (3)	4.4	0.8	3.11	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	027	3	Fine sand over very fine sand (3)	9.0	1.2	3.90	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	Crab, Nudibranch	No

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RWF	028	3	Medium sand over finer sediment (3)	5.7	0.7	4.03	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	029	3	Coarse sand over finer sediment (1), Medium sand (2)	4.7	1.5	IND	Low	2	2	IND	None	None	No	Caprellidae, Podoceridae	No	Crab(s), Hydroids, Shrimp	No
RWF	030	3	Fine sand (3)	4.5	0.5	4.06	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Crab, Shrimp	No
RWF	031	3	Medium sand (3)	5.0	0.9	IND	Low	2	2 -> 3	IND	None	None	Yes	None	No	Sea Star(s)	No
RWF	032	3	Fine sand (3)	4.3	0.9	3.23	Low	2	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Sea Star(s), Shrimp	No
RWF	033	3	Coarse sand over finer sediment (3)	7.1	2.7	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Crab, Shrimp, Tunicate(s)	No
RWF	034	3	Fine sand (1), Medium sand (2)	5.7	1.9	1.75	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	035	3	Fine sand (3)	5.8	1.9	2.94	Low	2 -> 3	2 -> 3	IND	None	None	Yes	Ampeliscid, Podoceridae	No	Isopod, Shrimp	No
RWF	036	3	Fine sand (3)	5.4	1.0	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Shrimp, Tunicates	No
RWF	037	3	Fine sand (3)	4.0	1.4	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid, Shrimp	No
RWF	038	3	Medium sand (3)	4.9	1.3	2.68	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	039	3	Fine sand (2), Fine sand over very fine sand (1)	4.6	0.8	2.49	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	040	3	Medium sand (3)	6.1	0.8	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid, Shrimp	No
RWF	041	3	Fine sand (3)	5.7	1.1	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	Sea Star, Tunicates	No
RWF	042	3	Fine sand (2), Fine sand over very fine sand (1)	5.5	0.8	2.29	Low	2	2 -> 3	2 on 3	None	None	Yes	Ampeliscid, Podoceridae	No	None	No

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RWF	043	3	Very fine sand (2), Very fine sand over silt/clay (1)	11.3	0.7	1.13	Medium	2	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	Shrimp	No
RWF	044	3	Fine sand (3)	6.0	1.5	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	Isopod, Shrimp	No
RWF	045	3	Fine sand (3)	6.4	0.7	2.10	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	046	3	Fine sand (2), Fine sand over very fine sand (1)	9.1	1.8	3.17	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Hydroids, Tunicates	No
RWF	047	3	Medium sand (3)	6.1	1.2	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	048	3	Fine sand (3)	4.8	0.5	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	None	No
RWF	049	3	Medium sand (3)	4.6	1.0	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	050	3	Fine sand (2), Fine sand over silt/clay (1)	7.7	1.2	2.28	Low	2 -> 3	2 -> 3	2 on 3	None	None	Yes	Ampeliscid	No	Nudibranch, Sea Star(s)	No
RWF	051	3	Fine sand (3)	5.8	0.8	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	052	3	Fine sand (3)	6.4	1.3	IND	Low	2 -> 3	2 on 3	IND	None	None	Yes	Podoceridae	No	None	No
RWF	053	3	Sand over very coarse sand (2), Very coarse sand over sand (1)	8.5	3.3	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	054	3	Fine sand (3)	6.2	1.0	IND	Low	2	2 -> 3	2 on 3	None	None	Yes	Ampeliscid, Podoceridae	No	Corymorpha, Crab, Paguroid, Shrimp, Tunicates	No
RWF	055	3	Fine sand (3)	6.2	2.1	7.47	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Shrimp, Tunicates	No
RWF	056	3	Very fine sand over silt/clay (3)	14.0	0.5	2.19	Medium	2	2	3	None	None	Yes	Podoceridae	No	Sea Star(s)	No

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RWF	057	3	Fine sand (3)	5.0	1.1	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	Yes	Corymorpha, Gastropod, Hydroids, Shrimp, Tunicates	No
RWF	057E1	3	Fine sand (3)	5.0	0.9	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Crab, Paguroid, Tunicates	No
RWF	057E2	3	Fine sand (3)	6.2	0.6	IND	Low	2	2	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Paguroid, Shrimp, Tunicates	No
RWF	057W1	3	Fine sand (3)	5.1	0.7	IND	Low	1	1	1	None	None	Yes	Podoceridae	No	Paguroid, Shrimp, Tunicates	No
RWF	057W2	3	Fine sand (3)	4.2	0.8	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Crab, Paguroid, Tunicates	No
RWF	058	3	Coarse sand over finer sediment (3)	6.0	1.7	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Ceriantid, Gastropod, Paguroid, Tunicates	No
RWF	059	3	Medium sand (3)	5.8	1.5	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Paguroid, Sand Dollar	No
RWF	060	3	Medium sand (1), Very coarse sand (1), Very coarse sand over sand (1)	7.1	1.7	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Hydroids, Shrimp	No
RWF	061	3	Fine sand (3)	4.9	0.7	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Crab, Shrimp, Tunicates	No
RWF	062	3	Fine sand over silt/clay (1), Fine sand over very fine sand (1), Very fine sand (1)	8.4	0.7	2.46	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	063	3	Medium sand (3)	6.5	1.7	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Corymorpha, Gastropod, Sand Dollar, Shrimp, Tunicates	No
RWF	064	3	Medium sand (3)	6.7	1.4	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Gastropod, Paguroid, Shrimp, Tunicate(s)	No

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RWF	065	3	Medium sand (3)	5.4	1.4	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Gastropod, Shrimp, Tunicates	No
RWF	066	3	Medium sand (3)	5.2	1.3	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Gastropod, Isopod, Shrimp, Tunicates	No
RWF	067	3	Fine sand over silt/clay (2), Medium sand over finer sediment (1)	13.7	0.7	2.77	Medium	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	068	3	Fine sand (3)	5.3	0.8	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Hydroid, Paguroid, Shrimp, Tunicates	No
RWF	069	3	Finer sediment over pebble (1), Granule over sand (1), Very coarse sand over sand over pebble (1)	4.5	1.8	IND	Low	1	2	2 -> 3	None	None	Yes	Podoceridae	No	Barnacle, Hydroid(s), Shrimp, Tunicate(s)	No
RWF	070	3	Fine sand (3)	4.6	2.1	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Crab, Tunicate(s)	No
RWF	071	3	Coarse sand over finer sediment (2), Medium sand (1)	3.6	0.8	IND	Low	2	2 -> 3	IND	None	None	Yes	Podoceridae	No	Gastropod, Shrimp, Unidentified Crustacean	No
RWF	072	3	Pebble over finer sediment (2), Very coarse sand over sand (1)	5.6	1.6	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Paguroid(s)	No
RWF	073	3	Fine sand (1), Indeterminate (2)	1.0	0.8	IND	Low	IND	IND	IND	None	None	No	None	Yes	Barnacle(s), Bryozoan, Colonial Tunicate, Crab(s), Hydroids	Yes
RWF	073E1	3	Fine sand (1), Indeterminate (2)	0.1	1.1	IND	Low	IND	IND	IND	None	None	No	None	Yes	Anemone, Barnacle(s), Bryozoan, Hydroids, Shrimp	No
RWF	073E2	3	Indeterminate (3)	0.1	1.8	IND	IND	IND	IND	IND	None	None	No	Podoceridae	Yes	Barnacle(s), Ceriantihid, Colonial Tunicate, Crab, Hydroids, Nudibranchs, Shrimp	Yes

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RWF	073W1	3	Fine sand (3)	1.0	0.9	IND	Low	2 -> 3	2 -> 3	IND	None	None	Yes	Podoceridae	Yes	Barnacles, Bryozoan, Hydroids	No
RWF	073W2	3	Fine sand (1), Indeterminate (1), Medium sand (1)	1.7	0.9	IND	Low	2 -> 3	2 -> 3	IND	None	None	Yes	Podoceridae	Yes	Barnacles, Hydroids, Shrimp	No
RWF	074	3	Medium sand over finer sediment (3)	6.7	1.6	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	075	3	Fine sand (2), Indeterminate (1)	3.6	1.1	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	Yes	Anemone, Barnacles, Crabs, Hydroids, Shrimp, Sponges, Tunicates	No
RWF	076	3	Indeterminate (3)	0.0	IND	IND	IND	IND	IND	IND	None	None	Yes	Podoceridae	Yes	Barnacles, Bryozoan, Colonial Tunicate(s), Hydroids, Shrimp, Tunicates	Yes
RWF	077	3	Fine sand (3)	4.0	1.0	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Gastropod, Tunicates	No
RWF	078	3	Fine sand (1), Sand over granule (2)	5.0	1.4	IND	Low	2 -> 3	2 -> 3	IND	None	None	Yes	Podoceridae	No	Barnacles, Hydroids, Tunicates	No
RWF	079	3	Medium sand over finer sediment (3)	4.0	1.2	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Gastropod, Tunicates	No
RWF	080	3	Fine sand (3)	5.4	0.9	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	081	3	Coarse sand (3)	2.0	2.6	IND	Low	IND	IND	IND	None	None	Yes	Caprellidae, Podoceridae	Yes	Barnacles, Bryozoan, Hydroids, Shrimp	No
RWF	082	3	Medium sand (3)	5.2	1.1	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	083	3	Coarse sand (1), Pebble over finer sediment (1), Very coarse sand over sand (1)	3.6	1.5	IND	Low	2 -> 3	IND	IND	None	None	No	Podoceridae	Yes	Barnacles, Bryozoan, Hydroids, Paguroid, Shrimp	No

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RWF	084	3	Fine sand (2), Indeterminate (1)	1.8	1.7	IND	Low	2 -> 3	2 -> 3	IND	None	None	Yes	Podoceridae	Yes	Barnacle(s), Bryozoan, Colonial Tunicate(s), Hydroids, Shrimp, Sponge	Yes
RWF	085	3	Fine sand (3)	5.5	1.0	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	086	3	Medium sand (1), Medium sand over finer sediment (2)	5.4	1.0	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha	No
RWF	087	3	Granule over sand (2), Sand over granule (1)	5.9	1.7	3.06	Low	2	2 -> 3	IND	None	None	Yes	Podoceridae	No	Barnacles, Hydroids, Paguroid(s), Shrimp	No
RWF	088	3	Medium sand (2), Medium sand over finer sediment (1)	6.9	1.8	7.00	Low	2 -> 3	2 -> 3	2 on 3	None	None	Yes	Podoceridae	Yes	Barnacles, Colonial Tunicate, Gastropod(s), Hydroids, Paguroid, Shrimp	Yes
RWF	089	3	Granule over sand (1), Very coarse sand over sand (2)	7.9	4.1	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	No	Podoceridae	No	Paguroid	No
RWF	090	3	Coarse sand over finer sediment (2), Medium sand (1)	5.9	1.6	IND	Low	2 -> 3	2 -> 3	IND	None	None	Yes	Podoceridae	Yes	Gastropod, Tunicates	No
RWF	091	3	Fine sand (3)	5.0	1.0	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid, Tunicates	No
RWF	092	3	Fine sand (3)	4.8	0.5	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Gastropod, Tunicate(s)	No
RWF	093	3	Fine sand (3)	5.3	0.7	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Tunicate(s)	No
RWF	094	3	Fine sand (3)	5.2	1.9	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Tunicates	No

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RWF	095	3	Finer sediment over coarse sand (1), Medium sand (1), Medium sand over finer sediment (1)	7.0	1.2	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	Barnacles, Paguroid, Shrimp, Tunicates	No
RWF	096	3	Fine sand (3)	5.2	1.0	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Tunicate(s)	No
RWF	097	3	Medium sand (3)	6.2	1.4	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	098	3	Medium sand (3)	7.7	1.1	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Tunicate(s)	No
RWF	099	3	Medium sand (3)	5.8	1.2	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Sand Dollar, Shrimp, Tunicates	No
RWF	100	3	Coarse sand over finer sediment (1), Fine sand (2)	5.6	1.5	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	101	3	Finer sediment over coarse sand (2), Medium sand (1)	5.7	2.6	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	Yes	Shrimp, Tunicate(s)	No
RWF	102	3	Fine sand (3)	4.3	1.2	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Shrimp	No
RWF	103	3	Fine sand (3)	5.1	1.6	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	104	3	Coarse sand over finer sediment (1), Very coarse sand over sand (2)	5.2	1.5	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Barnacles, Hydroids, Tunicates	No
RWF	105	3	Fine sand (3)	6.3	0.9	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Cerianthid, Tunicates	No
RWF	106	3	Coarse sand (1), Coarse sand over finer sediment (1), Very coarse sand over sand (1)	5.9	2.3	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	No	None	No

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RWF	107	3	Coarse sand (1), Sand over very coarse sand (1), Very coarse sand (1)	8.0	2.2	IND	Low	2	2 -> 3	IND	None	None	No	Podoceridae	Yes	Cerianthid, Shrimp	No
RWF	108	3	Coarse sand (2), Coarse sand over finer sediment (1)	5.8	3.0	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	Yes	Barnacles, Colonial Tunicate, Gastropod	Yes
RWF	109	3	Coarse sand over finer sediment (3)	5.9	3.4	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	110	3	Fine sand (3)	5.6	0.7	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	Yes	Tunicates	No
RWF	111	3	Coarse sand over finer sediment (3)	7.3	1.8	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Barnacles, Shrimp, Tunicate(s)	No
RWF	112	3	Medium sand (3)	5.8	1.3	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Caprellidae, Podoceridae	Yes	Bryozoan, Shrimp, Tunicate(s)	No
RWF	113	3	Medium sand (3)	5.3	1.2	IND	Low	2	2	2	None	None	Yes	Caprellidae, Podoceridae	No	Shrimp, Tunicates	No
RWF	114	3	Very coarse sand (3)	5.1	1.8	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Gastropod, Shrimp	No
RWF	115	3	Coarse sand (2), Very coarse sand over sand (1)	6.9	2.0	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	116	3	Very coarse sand (1), Very coarse sand over sand (2)	7.3	1.4	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Barnacles, Corymorpha	No
RWF	117	3	Very coarse sand (3)	6.7	3.2	IND	None	2	2	2	None	None	Yes	Podoceridae	No	None	No
RWF	118	3	Coarse sand over finer sediment (3)	6.3	2.1	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	119	3	Coarse sand (1), Very coarse sand over sand (2)	6.3	2.0	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Shrimp, Tunicates	No

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RWF	120	3	Coarse sand over finer sediment (2), Medium sand (1)	6.3	2.1	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	None	No
RWF	121	3	Coarse sand over finer sediment (1), Medium sand (1), Very coarse sand over sand (1)	6.2	1.0	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Barnacles, Paguroid, Tunicates	No
RWF	122	3	Coarse sand over finer sediment (2), Medium sand (1)	4.6	0.8	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Paguroids, Tunicates	No
RWF	123	3	Medium sand (3)	5.3	2.8	IND	Low	2	2	2	None	None	No	Podoceridae	No	Tunicates	No
RWF	124	3	Fine sand (3)	5.6	0.7	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Gastropods, Paguroid, Tunicate(s)	No
RWF	125	3	Coarse sand over finer sediment (2), Medium sand (1)	6.1	1.2	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	126	3	Coarse sand over finer sediment (1), Medium sand (2)	5.9	1.7	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	127	3	Coarse sand (2), Very coarse sand (1)	2.7	1.2	IND	None	2	2	2	None	None	No	Podoceridae	No	None	No
RWF	128	3	Very coarse sand over sand (3)	8.1	2.4	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	None	No
RWF	129	3	Very coarse sand (1), Very coarse sand over sand (2)	5.9	3.3	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	None	No
RWF	136	3	Granule over sand (1), Pebble over finer sediment (1), Very coarse sand over sand (1)	4.9	3.0	IND	Low	2	2	2	None	None	Yes	None	No	Barnacles, Hydroids, Shrimp	No
RWF	137	3	Pebble over finer sediment (2), Very coarse sand over sand (1)	6.9	3.6	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacle(s), Hydroids, Shrimp	No

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RWF	138	3	Indeterminate (2), Very coarse sand over sand (1)	1.5	2.1	IND	None	2	IND	IND	None	None	Yes	None	No	Anemone, Barnacle(s), Hydroids, Sea Star, Shrimp, Sponges	No
RWF	139	3	Coarse sand (1), Very coarse sand over sand (2)	2.8	1.5	IND	Low	2	2	2	None	None	Yes	None	Yes	Barnacles, Gastropod, Hydroids	No
RWF	140	3	Fine sand (3)	4.9	1.1	IND	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Nudibranch, Tunicates	No
RWF	141	3	Pebble over finer sediment (2), Very coarse sand over sand (1)	4.0	2.5	IND	Low	2	2	2 -> 3	None	Sea Scallop	Yes	Podoceridae	No	Barnacles, Hydroids, Sea Scallop, Shrimp	No
RWF	142	3	Pebble over finer sediment (1), Very coarse sand (2)	6.0	1.2	IND	None	2	2	1 -> 2	None	None	Yes	Podoceridae	No	Barnacles, Hydroids, Shrimp, Sponges, Tunicates, Unidentified Organism	No
RWF	143	3	Coarse sand (1), Fine sand (2)	3.7	1.5	IND	Low	2	2	IND	None	None	Yes	Podoceridae	Yes	Barnacles, Hydroids, Shrimp	No
RWF	144	3	Coarse sand (1), Pebble over finer sediment (1), Very coarse sand (1)	2.6	3.0	IND	None	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Hydroids	No
RWF	201	3	Indeterminate (3)	0.0	IND	IND	IND	IND	IND	IND	None	None	Yes	None	No	Barnacle(s), Colonial Tunicate, Hydroids, Sea Star, Shrimp	Yes
RWF	202	3	Granule (2), Granule over sand (1)	6.5	1.0	IND	None	2	2	2	None	None	Yes	Podoceridae	No	Barnacles	No
RWF	204	3	Fine sand (3)	5.7	1.3	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	None	No

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RWF	205	3	Medium sand over finer sediment (3)	5.7	1.3	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	206	3	Very coarse sand over sand (3)	4.8	2.0	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	Yes	Barnacles, Colonial Tunicate(s), Hydroids	Yes
RWF	207	3	Medium sand (3)	1.8	1.5	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Tunicates	No
RWF	208	3	Fine sand (1), Medium sand (2)	2.1	1.3	IND	Low	2	2	IND	Non-Reef Building Hard Coral	None	Yes	Podoceridae	Yes	Barnacles, Hydroids, Northern Star Coral, Polymastia Sponge, Sea Star(s), Tunicates	No
RWF	209	3	Indeterminate (1), Medium sand (2)	1.6	1.1	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Shrimp	No
RWF	210	3	Coarse sand over finer sediment (1), Very coarse sand over sand (2)	4.2	1.1	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Gastropods, Paguroid	No
RWF	211	3	Very coarse sand (2), Very coarse sand over sand (1)	2.5	2.3	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Hydroids, Paguroid	No
RWF	212	3	Coarse sand (1), Coarse sand over finer sediment (2)	6.9	1.6	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Paguroid	No
RWF	213	3	Coarse sand over finer sediment (3)	2.5	2.9	IND	Low	2	2	IND	None	None	Yes	Podoceridae	Yes	Barnacles	No
RWF	214	3	Indeterminate (1), Pebble over finer sediment (2)	3.4	1.3	IND	None	IND	IND	IND	None	None	Yes	Podoceridae	No	Barnacles, Colonial Tunicate, Crabs, Hydroids, Shrimp	Yes
RWF	215	3	Fine sand (2), Indeterminate (1)	1.0	0.8	IND	Low	2	IND	IND	Non-Reef Building Hard Coral	None	Yes	Podoceridae	No	Anemone, Barnacles, Colonial Tunicate, Hydroids, Moon Snail, Northern Star Coral, Paguroid, Polymastia Sponge, Sea Star	Yes

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RWF	216	3	Indeterminate (1), Very coarse sand (2)	1.7	2.3	IND	Low	1	2	IND	None	None	Yes	None	Yes	Barnacles, Colonial Tunicate(s), Gastropods, Hydroids, Sea Star, Sponges	Yes
RWF	217	3	Coarse sand (1), Indeterminate (2)	0.3	0.5	IND	Low	2	IND	IND	None	None	Yes	Podoceridae	Yes	Anemone, Barnacles, Colonial Tunicate, Crab(s), Hydroids, Polymastia Sponge, Sea Star, Sponges	Yes
RWF	218	3	Fine sand (1), Indeterminate (2)	0.1	0.9	IND	Low	IND	IND	IND	None	None	Yes	None	Yes	Barnacles, Hydroids, Polymastia Sponge, Shrimp, Sponges	No
RWF	218E1	3	Fine sand (1), Indeterminate (2)	0.1	1.0	IND	Low	2	IND	IND	None	None	Yes	None	Yes	Barnacles, Colonial Tunicate, Gastropod, Hydroids, Polymastia Sponge, Sea Star, Sponges, Unidentified Organism	Yes
RWF	218E2	3	Medium sand (1), Very coarse sand over sand (2)	2.8	1.3	IND	Low	2	2	2	None	None	Yes	Caprellidae, Podoceridae	Yes	Barnacles, Hydroids	No
RWF	218W1	3	Indeterminate (2), Medium sand (1)	0.1	0.9	IND	Low	2	IND	IND	None	None	Yes	None	Yes	Barnacles, Colonial Tunicate, Polymastia Sponge, Sea Star(s), Shrimp, Sponges	Yes
RWF	218W2	3	Coarse sand (1), Coarse sand over finer sediment (1), Very coarse sand over sand (1)	4.3	1.5	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Nudibranchs, Tunicates	No
RWF	219	3	Indeterminate (2), Very coarse sand (1)	1.7	0.7	IND	Low	2	IND	IND	Non-Reef Building Hard Coral	None	Yes	None	Yes	Barnacles(s), Hydroids, Northern Star Coral, Shrimp, Sponges	No
RWF	220	3	Indeterminate (2), Pebble over finer sediment (1)	0.6	2.2	IND	Low	IND	IND	IND	None	None	Yes	Podoceridae	No	Barnacle(s), Colonial Tunicate, Hydroids, Sea Star, Shrimp, Sponges	Yes

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RWF	220E1	3	Fine sand (1), Indeterminate (2)	0.1	0.5	IND	Low	IND	IND	IND	None	None	Yes	None	Yes	Barnacle(s), Crab, Hydroids, Shrimp, Sponges	No
RWF	220E2	3	Indeterminate (2), Very coarse sand over sand (1)	1.5	1.7	IND	Low	2	IND	IND	None	None	Yes	Podoceridae	No	Barnacles, Colonial Tunicate, Hydroids, Shrimp, Sponges, Tunicate	Yes
RWF	220W1	3	Coarse sand (1), Indeterminate (1), Medium sand (1)	2.5	2.4	IND	Low	2	2	IND	None	None	Yes	Podoceridae	No	Barnacles, Hydroids, Paguroid(s)	No
RWF	220W2	2	Indeterminate (2)	0.0	IND	IND	IND	2	IND	-	None	None	Yes	Podoceridae	Yes	Barnacles, Colonial Tunicate, Hydroids, Sponges, Tunicates	Yes
RWF	221	3	Fine sand (3)	4.8	1.0	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	222	3	Fine sand (3)	5.5	0.8	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	223	3	Very fine sand (3)	11.8	1.1	3.47	Low	2 -> 3	2 on 3	2 on 3	None	None	Yes	Ampeliscid	No	None	No
RWF	224	3	Very coarse sand (3)	7.1	2.1	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	None	No
RWF	225	3	Very fine sand (3)	8.8	0.9	3.24	Low	2 -> 3	2 -> 3	2 on 3	None	None	Yes	Ampeliscid, Podoceridae	No	Shrimp	No
RWF	226	3	Very fine sand (3)	11.7	1.7	4.32	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Ampeliscid, Podoceridae	No	Shrimp	No
RWF	227	3	Very fine sand (3)	18.3	1.1	1.73	Medium	1 on 3	1 on 3	2 on 3	None	None	Yes	Podoceridae	No	Sea Star(s)	No
RWF	228	3	Fine sand (3)	4.6	0.9	2.77	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Paguroids, Sea Star, Shrimp	No
RWF	229	3	Fine sand (3)	5.0	1.0	2.54	Low	2	2	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Shrimp	No
RWF	230	3	Fine sand over very fine sand (3)	9.1	0.7	3.16	Medium	2 -> 3	2 -> 3	2 -> 3	None	Sea Scallop	Yes	Ampeliscid, Podoceridae	No	Sea Scallop, Shrimp	No

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RWF	231	3	Medium sand over finer sediment (3)	5.2	1.2	3.21	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Crab, Sea Star, Shrimp	No
RWF	232	3	Indeterminate (1), Medium sand (2)	1.6	1.8	IND	Low	2	2	IND	None	Sea Scallop	Yes	Podoceridae	Yes	Barnacles, Hydroids, Scallop, Sea Star	No
RWF	233	3	Fine sand (3)	4.2	0.6	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Jonah Crab, Shrimp	No
RWF	234	3	Fine sand (1), Fine sand over very fine sand (1)	7.6	1.4	4.03	Medium	2	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Shrimp	No
RWF	235	3	Very coarse sand (3)	6.8	1.1	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Sea Star(s)	No
RWF	236	3	Fine sand (3)	7.0	1.0	1.59	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid, Shrimp	No
RWF	237	3	Medium sand (3)	5.8	2.4	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Shrimp, Tunicate(s)	No
RWF	238	3	Fine sand (2), Fine sand over silt/clay (1)	5.3	1.1	3.00	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	239	3	Fine sand (2), Medium sand (1)	3.9	1.6	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Hydroids, Shrimp, Tunicates	No
RWF	240	3	Fine sand (3)	5.9	1.1	2.33	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	241	3	Fine sand (3)	5.7	0.7	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Jonah Crab, Tunicates	No
RWF	242	3	Coarse sand (1), Coarse sand over finer sediment (2)	6.0	0.8	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Paguroid, Shrimp, Tunicates, Unidentified Organism	No
RWF	243	3	Fine sand (1), Fine sand over silt/clay (2)	7.6	1.2	2.06	High	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	244	3	Fine sand (3)	5.3	1.2	2.29	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Tunicates	No

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RWF	245	3	Fine sand (3)	4.3	0.5	1.87	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Barnacle(s), Shrimp, Tunicates	No
RWF	246	3	Fine sand (3)	5.3	1.2	IND	Low	2	2	2	None	None	Yes	Ampeliscid, Caprellidae, Podoceridae	No	Tunicates	No
RWF	247	3	Very coarse sand (1), Very coarse sand over sand (2)	4.5	1.9	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Hydroids, Shrimp	No
RWF	248	3	Very coarse sand (1), Very coarse sand over sand (2)	3.6	2.6	IND	Low	2	2	IND	None	None	Yes	Podoceridae	No	Barnacles, Hydroids, Paguroid(s)	No
RWF	249	3	Indeterminate (3)	0.0	IND	IND	IND	IND	IND	IND	Non-Reef Building Hard Coral	None	Yes	None	No	Barnacle(s), Colonial Tunicate, Hydroids, Northern Star Coral, Sea Star(s)	Yes
RWF	250	3	Fine sand (3)	8.2	0.9	8.08	Low	2	2	2	None	None	Yes	Podoceridae	No	Paguroid, Shrimp, Tunicate(s)	No
RWF	251	3	Fine sand (1), Very coarse sand over sand (2)	7.4	3.1	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp, Tunicate(s)	No
RWF	252	3	Coarse sand (2), Medium sand (1)	4.4	1.3	IND	Low	2	2	2	None	None	Yes	Podoceridae	Yes	Barnacles, Colonial Tunicate, Hydroids, Shrimp	Yes
RWF	253	3	Coarse sand (3)	8.2	1.9	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Moon Snail, Tunicates	No
RWF	254	3	Coarse sand (3)	5.0	3.9	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Barnacles, Shrimp, Tunicate(s)	No
RWF	255	3	Coarse sand (1), Medium sand (2)	5.1	1.1	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	Yes	Tunicates	No
RWF	256	3	Very coarse sand (2), Very coarse sand over sand (1)	8.4	1.3	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Barnacles, Hydroids	No

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RWF	257	3	Very coarse sand (2), Very coarse sand over sand (1)	5.7	3.6	IND	Low	1	1	2	None	None	Yes	Podoceridae	No	Shrimp	No
RWF	258	3	Coarse sand (1), Pebble over finer sediment (1), Very coarse sand (1)	5.0	1.3	IND	Low	2	2	2	None	Sea Scallop	Yes	Caprellidae, Podoceridae	Yes	Barnacles, Sea Scallop, Shrimp	No
RWF	259	3	Medium sand (3)	7.4	0.7	IND	Low	2	2	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Paguroid, Tunicates	No
RWF	260	3	Fine sand (3)	5.1	1.9	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	261	3	Very coarse sand (3)	8.4	3.8	IND	Low	2	2	2 -> 3	None	None	No	Podoceridae	No	Tunicates	No
RWF	262	3	Fine sand (3)	5.4	0.8	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Shrimp, Tunicates	No
RWF	401	3	Fine sand (3)	4.0	1.3	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	Yes	Tunicates	No
RWF	402	3	Indeterminate (1), Medium sand (2)	1.1	2.0	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Barnacles, Gastropod, Hydroids, Shrimp, Tunicates	No
RWF	403	3	Coarse sand (3)	6.6	1.1	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Hydroids, Shrimp, Tunicate(s)	No
RWF	404	3	Fine sand over silt/clay (1), Medium sand over finer sediment (2)	15.4	2.0	2.87	High	2	2 -> 3	2 on 3	None	None	Yes	Podoceridae	No	Barnacles, Gastropod, Shrimp, Tunicates	No
RWF	405	3	Medium sand (3)	4.9	1.2	IND	Low	2	2	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	406	3	Very fine sand (3)	5.3	1.2	2.94	Medium	2 -> 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Paguroid, Tunicates, Unidentified Organism	No
RWF	407	3	Fine sand (3)	4.3	0.7	IND	Low	2	2	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Isopods, Tunicate(s)	No

Area	Station ID	SPI Replicate (n)	SPI Sediment Type (# of reps)	SPI Mean Prism Penetration Depth (cm)	SPI Mean Boundary Roughness (cm)	SPI Mean aRPD Depth (cm)	SPI Sediment Oxygen Demand Level	SPI Successional Stage (by replicate)[1]			SPI/PV Sensitive Taxa Type[2]	SPI/PV Species of Concern[2]	SPI/PV Presence of Tubes[2]	SPI/PV Amphipod Presence/Type[2]	SPI/PV Sea Pen Presence[2]	SPI/PV Other Epifauna Present[2]	SPI/PV Possible Non-Native *Botrylloides sp.*[2]
RWF	408	3	Medium sand (3)	4.1	0.6	IND	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Hydroids, Tunicates	No
RWF	409	3	Medium sand (3)	4.7	0.7	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Sea Star(s)	No
RWEC-OCS	410	3	Very fine sand (3)	12.7	0.8	3.72	Medium	2 on 3	2 on 3	2 on 3	None	None	Yes	None	Yes	Sea Star(s)	No
RWEC-OCS	411	3	Indeterminate (3)	0.0	IND	IND	IND	IND	IND	IND	None	None	No	None	No	Barnacle(s), Crab, Hydroids, Sea Star, Shrimp, Sponges	No
RWF	412	3	Fine sand (2), Fine sand over very fine sand (1)	5.1	1.4	2.32	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	413	3	Fine sand (1), Fine sand over very fine sand (1)	4.5	2.8	3.47	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid, Tunicates	No
RWF	414	3	Medium sand (3)	5.0	1.1	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	415	3	Indeterminate (1), Medium sand (2)	0.2	0.9	IND	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid, Shrimp, Tunicates	No
RWF	416	3	Fine sand (3)	4.7	2.0	3.07	Low	2 -> 3	2 -> 3	2 on 3	None	None	Yes	Podoceridae	No	Shrimp, Unidentified Organism	No
RWEC-OCS	417	3	Very fine sand (3)	13.6	0.7	2.59	Medium	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Sea Star(s)	No
RWEC-OCS	418	3	Indeterminate (1), Silt/clay (2)	1.6	2.3	IND	Low	IND	IND	IND	None	None	Yes	None	No	Anemone, Barnacles, Crab, Hydroids, Sea Star	No
RWEC-OCS	419	3	Indeterminate (1), Silt/clay (1), Very fine sand (1)	0.9	1.1	IND	Low	IND	IND	IND	None	None	No	None	Yes	Barnacles, Crab, Hydroids, Paguroid, Shrimp	No

Area	Station ID	SPI Replicate (n)	SPI Sediment Type (# of reps)	SPI Mean Prism Penetration Depth (cm)	SPI Mean Boundary Roughness (cm)	SPI Mean aRPD Depth (cm)	SPI Sediment Oxygen Demand Level	SPI Successional Stage (by replicate)[1]			SPI/PV Sensitive Taxa Type[2]	SPI/PV Species of Concern[2]	SPI/PV Presence of Tubes[2]	SPI/PV Amphipod Presence/Type[2]	SPI/PV Sea Pen Presence[2]	SPI/PV Other Epifauna Present[2]	SPI/PV Possible Non-Native *Botrylloides sp.*[2]
RWEC-OCS	420	3	Fine sand (2), Medium sand over finer sediment (1)	4.1	1.5	IND	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Shrimp	No
RWEC-OCS	421	3	Very fine sand over silt/clay (3)	14.8	1.4	2.35	Medium	2 -> 3	2 on 3	2 on 3	None	None	Yes	Ampeliscid, Podoceridae	No	Sea Star, Shrimp	No
RWEC-OCS	422	3	Fine sand (3)	5.0	0.7	2.76	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid	No	Shrimp	No
RWEC-OCS	423	3	Coarse sand (3)	5.2	2.2	IND	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Crab	No
RWEC-OCS	424	3	Coarse sand (3)	7.8	3.1	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Tunicates	No
RWEC-OCS	425	3	Coarse sand (1), Medium sand (2)	5.3	1.6	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Hydroids, Sand Dollar, Shrimp, Tunicates	No
RWEC-OCS	426	3	Fine sand (2), Medium sand over finer sediment (1)	4.7	1.5	IND	Low	2	2	2	None	None	Yes	Ampeliscid, Podoceridae	No	Sand Dollar, Tunicates	No
RWEC-OCS	427	3	Medium sand (3)	4.4	0.6	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Paguroid, Tunicates	No
RWEC-OCS	428	3	Coarse sand over finer sediment (1), Medium sand (2)	4.9	1.2	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Paguroid(s), Shrimp	No
RWEC-RI	429	3	Coarse sand over finer sediment (3)	5.4	0.8	IND	Low	2	2	2 -> 3	None	None	Yes	Unidentified	No	Shrimp	No
RWEC-RI	430	3	Fine sand (3)	4.6	0.4	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	None	No	None	No
RWEC-RI	431	3	Very fine sand (3)	13.4	0.6	1.80	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Ampeliscid, Podoceridae	No	None	No
RWEC-RI	432	3	Very fine sand (3)	13.8	1.5	2.08	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Ampeliscid, Podoceridae	No	None	No
RWEC-RI	433	3	Very fine sand over silt/clay (3)	14.7	1.1	1.63	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Crab	No

Area	Station ID	SPI Replicate (n)	SPI Sediment Type (# of reps)	SPI Mean Prism Penetration Depth (cm)	SPI Mean Boundary Roughness (cm)	SPI Mean aRPD Depth (cm)	SPI Sediment Oxygen Demand Level	SPI Successional Stage (by replicate)[1]			SPI/PV Sensitive Taxa Type[2]	SPI/PV Species of Concern[2]	SPI/PV Presence of Tubes[2]	SPI/PV Amphipod Presence/Type[2]	SPI/PV Sea Pen Presence[2]	SPI/PV Other Epifauna Present[2]	SPI/PV Possible Non-Native *Botrylloides sp.*[2]
RWEC-RI	434	3	Fine sand (3)	5.8	0.9	1.97	Low	2	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid	No	Paguroid	No
RWEC-RI	435	3	Fine sand (3)	6.0	1.3	2.51	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Ampeliscid, Podoceridae	No	Moon Snail, Paguroid	No
RWEC-RI	436	3	Fine sand over very fine sand (3)	8.2	1.0	2.95	Low	2 -> 3	2 -> 3	3	None	None	Yes	None	No	Gastropods, Paguroid, Unidentified Organism	No
RWEC-RI	437	3	Fine sand over very fine sand (3)	9.1	1.9	3.16	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Gastropod(s)	No
RWEC-RI	438	3	Coarse sand (1), Coarse sand over finer sediment (2)	5.3	1.3	IND	Low	2	2	2	None	None	Yes	Podoceridae	No	Gastropod(s), Paguroid(s)	No
RWEC-RI	439	3	Fine sand over very fine sand (1), Finer sediment over coarse sand (2)	7.3	1.6	2.92	Low	2	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Gastropod(s), Moon Snail, Paguroid(s)	No
RWEC-RI	440	3	Fine sand over very fine sand (1), Very fine sand over silt/clay (2)	18.0	1.2	2.00	Medium	1 on 3	1 on 3	1 on 3	None	None	Yes	None	No	Gastropod, Paguroid, Unidentified Organism	No
RWEC-RI	441	3	Very fine sand (3)	16.7	1.1	2.30	Low	2 -> 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	None	No
RWEC-RI	442	3	Very fine sand over silt/clay (3)	14.7	2.5	1.77	Low	2 -> 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Crab(s)	No
RWEC-RI	443	3	Very fine sand (3)	10.0	1.5	1.99	Low	1 on 3	1 on 3	1 on 3	None	None	Yes	None	No	Gastropod(s), Paguroid(s)	No
RWEC-RI	444	3	Very fine sand (3)	10.8	0.7	2.26	Medium	2 -> 3	1 on 3	2 on 3	None	None	Yes	unidentified	No	Paguroid(s), Shrimp	No
RWEC-RI	445	3	Very fine sand (3)	8.4	1.1	1.84	Medium	2	2	2	None	None	Yes	Podoceridae	No	Barnacles, Gastropod(s), Paguroid(s)	No
RWEC-RI	446	3	Medium sand over finer sediment (1), Very fine sand over silt/clay (2)	9.5	0.9	1.52	Medium	2 -> 3	1 on 3	2 on 3	None	None	Yes	None	No	Crab, Gastropod, Paguroid(s)	No
RWEC-RI	447	3	Very fine sand over silt/clay (3)	9.3	0.8	1.22	Medium	2	2	1 on 3	None	None	Yes	None	No	Barnacles, Hydroids, Paguroid(s)	No
RWEC-RI	448	3	Silt/clay (3)	8.2	1.2	0.98	Medium	2 -> 3	IND	IND	None	None	Yes	None	No	Barnacles, Gastropod, Hydroids, Mussels	No

Area	Station ID	SPI Replicate (n)	SPI Sediment Type (# of reps)	SPI Mean Prism Penetration Depth (cm)	SPI Mean Boundary Roughness (cm)	SPI Mean aRPD Depth (cm)	SPI Sediment Oxygen Demand Level	SPI Successional Stage (by replicate)[1]			SPI/PV Sensitive Taxa Type[2]	SPI/PV Species of Concern[2]	SPI/PV Presence of Tubes[2]	SPI/PV Amphipod Presence/Type[2]	SPI/PV Sea Pen Presence[2]	SPI/PV Other Epifauna Present[2]	SPI/PV Possible Non-Native *Botrylloides sp.*[2]
RWEC-RI	449	3	Silt/clay (3)	15.1	1.5	0.98	Medium	3	3	3	None	None	Yes	None	No	Crab, Hydroids	No
RWEC-RI	450	3	Silt/clay (3)	11.8	3.3	IND	Medium	IND	IND	IND	None	None	No	None	No	Barnacles, Crepidula, Hydroids, Sponges	No
RWEC-RI	451	3	Very fine sand over silt/clay (3)	11.6	1.3	1.06	Medium	1	2 -> 3	3	None	None	Yes	None	No	Gastropod, Sponge(s), Whelk	No
RWEC-RI	452	3	Fine sand (2), Fine sand over silt/clay (1)	3.1	0.9	0.02	Medium	1	1	1	None	None	No	None	No	Barnacles, Barnacles, Gastropod(s), Sponge(s)	No
RWEC-RI	453	3	Fine sand (3)	1.9	0.9	1.10	Low	1	IND	IND	None	None	No	None	No	None	No
RWEC-RI	454	3	Very fine sand over silt/clay (3)	13.3	1.0	1.96	Low	2 -> 3	2 on 3	2 on 3	None	None	No	None	No	None	No
RWEC-RI	455	3	Silt/clay (1), Very fine sand (2)	8.9	1.3	2.20	Medium	2	2 -> 3	2 on 3	None	None	Yes	None	No	None	No
RWF	601	3	Medium sand (3)	5.7	0.6	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Corymorpha, Gastropod(s), Tunicates	No
RWF	602	3	Medium sand (3)	6.1	1.5	6.66	Low	2 -> 3	2 -> 3	2 on 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWF	603	3	Fine sand (3)	4.2	0.7	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWEC-RI	604	3	Fine sand (3)	4.6	1.0	IND	Low	2	2	2	None	None	Yes	Ampeliscid	No	Gastropod(s)	No
RWEC-OCS	605	3	Coarse sand (3)	5.5	1.4	IND	None	2 -> 3	IND	IND	None	None	Yes	Podoceridae	No	Gastropod, Paguroid	No
RWEC-OCS	606	3	Very coarse sand (2), Very coarse sand over sand (1)	3.4	2.1	IND	None	2	2	IND	None	None	Yes	Podoceridae	No	Gastropod, Sand Dollar	No
RWEC-OCS	607	3	Very fine sand (3)	13.0	1.0	3.08	Low	2 -> 3	2 -> 3	3	None	None	Yes	Caprellidae, Podoceridae	No	Corymorpha, Shrimp	No
RWEC-OCS	608	3	Very fine sand (3)	13.4	0.5	2.88	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	Podoceridae	No	Shrimp	No

Area	Station ID	SPI Replicate (n)	SPI Sediment Type (# of reps)	SPI Mean Prism Penetration Depth (cm)	SPI Mean Boundary Roughness (cm)	SPI Mean aRPD Depth (cm)	SPI Sediment Oxygen Demand Level	SPI Successional Stage (by replicate)[1]			SPI/PV Sensitive Taxa Type[2]	SPI/PV Species of Concern[2]	SPI/PV Presence of Tubes[2]	SPI/PV Amphipod Presence/Type[2]	SPI/PV Sea Pen Presence[2]	SPI/PV Other Epifauna Present[2]	SPI/PV Possible Non-Native *Botrylloides sp.*[2]
RWEC-OCS	609	3	Medium sand (3)	5.8	1.2	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Tunicates	No
RWEC-RI	610	3	Fine sand (3)	5.1	1.7	IND	Low	2 -> 3	2 -> 3	2 -> 3	None	None	Yes	Podoceridae	No	Paguroid(s)	No
RWEC-RI	611	3	Fine sand (3)	5.3	1.6	4.62	Low	2 -> 3	2 -> 3	IND	None	None	Yes	Ampeliscid, Podoceridae	No	Gastropods, Paguroid	No
RWEC-RI	612	3	Very fine sand (3)	11.7	1.1	2.10	Low	2 on 3	2 on 3	2 on 3	None	None	Yes	None	No	None	No
RWEC-RI	613	3	Medium sand (3)	2.2	1.3	IND	None	IND	IND	IND	None	None	No	None	No	None	No
RWEC-RI	614	3	Silt/clay (3)	9.4	0.7	2.18	High	3	3	IND	None	None	No	None	No	Hydroids, Sponges	No
RWEC-RI	615	3	Silt/clay (3)	15.7	1.5	1.55	High	3	2 on 3	2 on 3	None	None	Yes	None	No	Hydroids, Jonah Crab	No

Area	Station ID	Water Depth (m)	PV Replicate Count (n)	Mapped Habitat Type	PV Macrohabitat	PV CMECS Substrate Group/Subgroup (by replicate)			PV Boulder Presence	PV Bedforms (by replicate)			PV Dominant CMECS Biotic Subclass	PV Dominant CMECS Co-occurring Biotic Subclass	PV Dominant CMECS Biotic Group	PV Dominant CMECS Co-occurring Biotic Group	PV Maximum Attached Fauna Percent Cover	PV Burrow Presence	PV Tubes Presence	PV Tracks Presence	PV Flora Present	PV Fish Present	SPI Replicate Count (n)	SPI Mean Prism Penetration Depth (cm)
RWF	SFWF001	33.8	3	Glacial Moraine A	Sand with Mobile Gravel	Gravelly Sand	Gravelly Sand	Slightly Gravelly Sand	No	Ripples	Ripples	Ripples	Soft Sediment Fauna	Attached Fauna (1)	Small Surface-Burrowing Fauna	Attached Hydroids	Sparse (1 to <30%)	Yes	No	Yes	None	None	3	2.5
RWF	SFWF002	34.2	3	Sand and Muddy Sand	Sand Sheet	Muddy Sand	Muddy Sand	Muddy Sand	No	Mounds/ hummocks on low relief topography	Mounds/ hummocks on low relief topography	Irregular short period ripples	Soft Sediment Fauna	None	IND	None	None	No	No	Yes	None	None	3	6.7
RWF	SFWF003	35.7	3	Sand and Muddy Sand	Sand Sheet	Muddy Sand	Muddy Sand	Muddy Sand	No	Irregular short period ripples	Irregular short period ripples	Irregular short period ripples	Soft Sediment Fauna	None	Small Surface-Burrowing Fauna	None	None	Yes	No	Yes	None	None	3	4.1
RWF	SFWF005	36.5	3	Sand and Muddy Sand	Sand Sheet	Muddy Sand	Muddy Sand	Muddy Sand	No	Irregular short period ripples	Irregular short period ripples	Irregular short period ripples	Soft Sediment Fauna	None	IND	None	None	No	No	Yes	None	None	3	3.4
RWF	SFWF008	37.4	3	Sand and Muddy Sand	Sand Sheet	Muddy Sand	Muddy Sand	Muddy Sand	No	Irregular short period ripples	Irregular short period ripples	Irregular short period ripples	Soft Sediment Fauna	None	IND	None	None	No	No	No	None	None	3	4.0
RWF	SFWF010	38.8	3	Sand and Muddy Sand	Sand Sheet	Muddy Sand	Muddy Sand	Muddy Sand	No	Mounds/ hummocks on low relief topography	Mounds/ hummocks on low relief topography	IND	Soft Sediment Fauna	None	IND	None	None	No	No	No	None	None	3	5.6
RWF	SFWF012	40.3	3	Mud and Sandy Mud	Sand Sheet	Muddy Sand	Sand	Sand	No	IND	IND	IND	Soft Sediment Fauna	None	Small Surface-Burrowing Fauna	None	None	Yes	No	No	None	None	3	5.9
RWF	SFWF014	40.3	3	Mud and Sandy Mud	Sand Sheet	Sand	Sand	Sand	No	Mounds/ hummocks on low relief topography	Mounds/ hummocks on low relief topography	Mounds/ hummocks on low relief topography	Soft Sediment Fauna	None	IND	None	None	No	No	No	None	None	3	6.4

Area	Station ID	Water Depth (m)	PV Replicate Count (n)	SPI Mean Boundary Roughness (cm)	SPI Sediment Type (by replicate)			SPI Mean aRPD Depth (cm)	SPI Sediment Oxygen Demand Level	SPI Low Dissolved Oxygen Presence	SPI Methane Presence	SPI Successional Stage (by replicate)[1]			SPI Non-Native Taxa Present	SPI Sensitive Taxa Present	SPI/PV Infauna Present[2]	SPI/PV Epifauna Present[2]
RWF	SFWF001	33.8	3	3.4	Coarse sand	Pebble	Very coarse sand	IND	Low	No	No	IND	IND	IND	No	No	None	Hydroids
RWF	SFWF002	34.2	3	2.3	Medium sand	Medium sand	Medium sand	IND	Low	No	No	2			No	No	Tubes	None
RWF	SFWF003	35.7	3	1.8	Fine sand	Fine sand	Fine sand	0.8	Low	No	No	2			No	No	Tubes	None
RWF	SFWF005	36.5	3	0.9	Fine sand	Fine sand	Fine sand	1.1	Low	No	No	2			No	No	Tubes	None
RWF	SFWF008	37.4	3	2.1	Fine sand	Fine sand	Fine sand	1.3	Low	No	No	2			No	No	None	None
RWF	SFWF010	38.8	3	1.5	Medium sand	Medium sand	Medium sand	IND	Low	No	No	2			No	No	Tubes	None
RWF	SFWF012	40.3	3	0.8	Silt/clay & Silt/clay over sand	Very fine sand over silt/clay	Very fine sand over silt/clay	1.1	Medium	No	Yes	2			No	No	Polychaete(s), Tubes	None
RWF	SFWF014	40.3	3	0.9	Silt/clay & Silt/clay over sand	Very fine sand	Very fine sand	1.2	Medium	No	No	2			No	No	None	None

Attachment B – SAV Ground-Truth Data Analysis Results

Notes:

SAV=Submerged Aquatic Vegetation

Survey ID	Transect ID	Date	Time	Transect	SAV Period	SAV Present?	SAV Description	SAV Percent Cover	X_UTM19N_m	Y_UTM19N_m	Lat_WGS84_N	Lon_WGS84_W
REV01_20B1	T01	9/4/2020	7:37:31	Start	-	No	None	None	298009.25	4606488.28	41.58456262	-71.42319762
REV01_20B1	T01	9/4/2020	8:24:01	End	-	No	None	None	297390.76	4606378.72	41.58342011	-71.43057406
REV01_20B1	T02	9/4/2020	8:26:01	Start	-	No	None	None	297394.37	4606369.67	41.58333956	-71.43052765
REV01_20B1	T02	9/4/2020	9:00:25	End	-	No	None	None	297995.56	4606400.45	41.58376871	-71.42333212
REV01_20B1	T03	9/4/2020	9:21:05	Start	-	No	None	None	297388.7	4606350.27	41.58316352	-71.43058905
REV01_20B1	T03	9/4/2020	9:57:30	End	-	No	None	None	298060.41	4606328.47	41.58313739	-71.4225306
REV01_20B1	T04	9/4/2020	10:16:15	Start	-	No	None	None	297496.8	4605982.27	41.57987922	-71.42916919
REV01_20B1	T04	9/4/2020	10:47:57	End	-	No	None	None	297491.38	4606446.44	41.584055	-71.42939085
REV01_20B1	T05	9/4/2020	11:01:09	Start	-	No	None	None	297992.97	4606576.67	41.58535395	-71.42342251
REV01_20B1	T05	9/4/2020	11:01:24	-	Start	Yes	Shoots	Sparse (1 to 10%)	297992.83	4606578.95	41.58537439	-71.42342498
REV01_20B1	T05	9/4/2020	11:01:25	-	End	Yes	Shoots	Sparse (1 to 10%)	297992.8	4606579.07	41.58537548	-71.42342538
REV01_20B1	T05	9/4/2020	11:01:29	-	Start	Yes	Patches	Sparse (1 to 10%)	297992.36	4606579.34	41.58537777	-71.42343078
REV01_20B1	T05	9/4/2020	11:02:23	-	End	Yes	Patches	Sparse (1 to 10%)	297981.73	4606574.28	41.58532954	-71.42355642
REV01_20B1	T05	9/4/2020	11:02:40	-	Start	Yes	Continuous	High (> 50%)	297976.35	4606572.87	41.58531552	-71.42362044
REV01_20B1	T05	9/4/2020	11:10:22	-	End	Yes	Continuous	High (> 50%)	297879.43	4606543.82	41.58502957	-71.4247724
REV01_20B1	T05	9/4/2020	11:29:00	End	-	No	None	None	297520.48	4606458.86	41.58417414	-71.42904627
REV01_20B1	T06	9/4/2020	12:17:32	Start	-	No	None	None	297595.01	4606060.26	41.5806059	-71.42801844
REV01_20B1	T06	9/4/2020	12:41:02	End	-	No	None	None	297593.96	4606475.2	41.58433981	-71.42817102
REV01_20B1	T07	9/5/2020	6:26:13	Start	-	No	None	None	297992.96	4606566.51	41.58526247	-71.42341922
REV01_20B1	T07	9/5/2020	6:26:25	-	Start	Yes	Patches	Sparse (1 to 10%)	297990.5	4606566.58	41.5852625	-71.42344876
REV01_20B1	T07	9/5/2020	6:26:26	-	End	Yes	Patches	Sparse (1 to 10%)	297990.26	4606566.58	41.58526241	-71.42345165
REV01_20B1	T07	9/5/2020	6:26:38	-	Start	Yes	Patches	Low (11 to 25%)	297988.08	4606566.28	41.58525915	-71.42347769
REV01_20B1	T07	9/5/2020	6:26:41	-	End	Yes	Patches	Low (11 to 25%)	297987.32	4606566.12	41.58525759	-71.42348678
REV01_20B1	T07	9/5/2020	6:27:04	-	Start	Yes	Patches	Moderate (26 to 50%)	297982.17	4606563.9	41.58523628	-71.42354776
REV01_20B1	T07	9/5/2020	6:29:08	-	End	Yes	Patches	Moderate (26 to 50%)	297960.2	4606542.1	41.58503457	-71.42380371
REV01_20B1	T07	9/5/2020	6:35:28	-	Start	Yes	Patches	Sparse (1 to 10%)	297851.68	4606538.83	41.58497768	-71.4251034
REV01_20B1	T07	9/5/2020	6:35:29	-	End	Yes	Patches	Sparse (1 to 10%)	297851.44	4606538.92	41.58497847	-71.42510624
REV01_20B1	T07	9/5/2020	6:46:30	End	-	No	None	None	297670.41	4606486.13	41.58445753	-71.42725835
REV01_20B1	T08	9/5/2020	6:54:20	Start	Start	Yes	Patches	Sparse (1 to 10%)	298000.84	4606575.36	41.58534412	-71.42332781
REV01_20B1	T08	9/5/2020	6:54:47	-	End	Yes	Patches	Sparse (1 to 10%)	298000.41	4606575.98	41.58534957	-71.42333314
REV01_20B1	T08	9/5/2020	6:55:04	-	Start	Yes	Patches	Low (11 to 25%)	297997.05	4606573.76	41.58532882	-71.42337263
REV01_20B1	T08	9/5/2020	6:55:54	-	End	Yes	Patches	Low (11 to 25%)	297987.22	4606567.71	41.58527183	-71.4234885
REV01_20B1	T08	9/5/2020	6:56:13	-	Start	Yes	Patches	Moderate (26 to 50%)	297983.32	4606564.21	41.58523936	-71.42353398
REV01_20B1	T08	9/5/2020	6:58:11	-	End	Yes	Patches	Moderate (26 to 50%)	297959.54	4606542.7	41.58503974	-71.42381183
REV01_20B1	T08	9/5/2020	6:58:26	End	-	No	None	None	297956.58	4606539.94	41.58501419	-71.42384636
REV01_20B1	T09	9/5/2020	7:03:18	Start	-	No	None	None	297948.73	4606535.86	41.58497553	-71.42393907
REV01_20B1	T09	9/5/2020	7:04:20	-	Start	Yes	Patches	Low (11 to 25%)	297958.04	4606548.89	41.5850951	-71.42383191
REV01_20B1	T09	9/5/2020	7:06:38	-	End	Yes	Patches	Low (11 to 25%)	297986.58	4606572.75	41.58531703	-71.42349788
REV01_20B1	T09	9/5/2020	7:06:54	-	Start	Yes	Continuous	Moderate (26 to 50%)	297990.57	4606575.92	41.58534662	-71.42345108
REV01_20B1	T09	9/5/2020	7:10:20	-	End	Yes	Continuous	Moderate (26 to 50%)	298055.51	4606605.24	41.58562689	-71.42268253
REV01_20B1	T09	9/5/2020	7:10:24	End	-	No	None	None	298056.7	4606605.42	41.58562875	-71.42266828
REV01_20B1	T10	9/5/2020	7:15:49	Start	-	No	None	None	297952.97	4606542.81	41.58503914	-71.42389062
REV01_20B1	T10	9/5/2020	7:16:17	-	Start	Yes	Patches	Sparse (1 to 10%)	297955.96	4606551.35	41.58511674	-71.42385765
REV01_20B1	T10	9/5/2020	7:19:39	-	End	Yes	Patches	Sparse (1 to 10%)	297998.64	4606584.86	41.58542908	-71.4233573

Survey ID	Transect ID	Date	Time	Transect	SAV Period	SAV Present?	SAV Description	SAV Percent Cover	X_UTM19N_m	Y_UTM19N_m	Lat_WGS84_N	Lon_WGS84_W
REV01_20B1	T10	9/5/2020	7:19:40	End	-	Yes	Patches	Sparse (1 to 10%)	297998.85	4606585	41.58543038	-71.42335489
REV01_20B1	T11	9/5/2020	7:24:57	Start	-	No	None	None	297959.18	4606540.78	41.58502238	-71.42381553
REV01_20B1	T11	9/5/2020	7:25:21	-	Start	Yes	Continuous	Moderate (26 to 50%)	297960.43	4606542.43	41.58503759	-71.4238011
REV01_20B1	T11	9/5/2020	7:25:59	-	End	Yes	Continuous	Moderate (26 to 50%)	297968	4606548.96	41.58509822	-71.42371252
REV01_20B1	T11	9/5/2020	7:26:20	-	Start	Yes	Patches	Sparse (1 to 10%)	297971.9	4606551.72	41.58512408	-71.42366675
REV01_20B1	T11	9/5/2020	7:27:08	-	End	Yes	Patches	Sparse (1 to 10%)	297980.17	4606558.79	41.58518983	-71.42356992
REV01_20B1	T11	9/5/2020	7:27:33	-	Start	Yes	Patches	Low (11 to 25%)	297984.38	4606562.56	41.58522483	-71.42352072
REV01_20B1	T11	9/5/2020	7:27:56	-	End	Yes	Patches	Low (11 to 25%)	297988.11	4606566.66	41.58526261	-71.42347738
REV01_20B1	T11	9/5/2020	7:28:04	-	Start	Yes	Patches	Sparse (1 to 10%)	297989.8	4606568.22	41.58527709	-71.42345767
REV01_20B1	T11	9/5/2020	7:28:29	-	End	Yes	Patches	Sparse (1 to 10%)	297995.8	4606572.9	41.58532068	-71.42338731
REV01_20B1	T11	9/5/2020	7:28:30	End	-	No	None	None	297996.03	4606573.05	41.58532216	-71.42338467
REV01_20B1	T12	9/5/2020	7:32:48	Start	-	No	None	None	297961.17	4606540.35	41.58501903	-71.4237915
REV01_20B1	T12	9/5/2020	7:34:25	-	Start	Yes	Patches	Sparse (1 to 10%)	297977.95	4606553.7	41.58514344	-71.42359479
REV01_20B1	T12	9/5/2020	7:35:25	-	End	Yes	Patches	Sparse (1 to 10%)	297989.36	4606564.75	41.58524571	-71.42346179
REV01_20B1	T12	9/5/2020	7:35:51	End	-	No	None	None	297995.47	4606568.88	41.5852845	-71.42338994
REV01_20B1	T13	9/5/2020	7:43:42	Start	Start	Yes	Shoots	Sparse (1 to 10%)	297962.39	4606536.17	41.58498173	-71.42377546
REV01_20B1	T13	9/5/2020	7:44:21	-	End	Yes	Shoots	Sparse (1 to 10%)	297959.66	4606541.85	41.58503212	-71.42381005
REV01_20B1	T13	9/5/2020	7:45:40	End	-	No	None	None	297948.68	4606564.13	41.58522992	-71.42394915
REV01_20B1	T14	9/5/2020	7:49:17	Start	-	No	None	None	297975.14	4606535.89	41.58498246	-71.4236225
REV01_20B1	T14	9/5/2020	7:50:07	-	Start	Yes	Continuous	High (> 50%)	297968.42	4606547.42	41.5850845	-71.42370694
REV01_20B1	T14	9/5/2020	7:50:39	-	End	Yes	Continuous	High (> 50%)	297963.14	4606552.43	41.58512821	-71.42377193
REV01_20B1	T14	9/5/2020	7:51:51	End	-	No	None	None	297953.17	4606567.67	41.58526292	-71.4238966
REV01_20B1	T15	9/5/2020	7:53:56	Start	-	No	None	None	297980.84	4606548.91	41.58510103	-71.42355863
REV01_20B1	T15	9/5/2020	7:54:31	-	Start	Yes	Continuous	High (> 50%)	297971.93	4606554.6	41.58515002	-71.42366729
REV01_20B1	T15	9/5/2020	7:54:46	-	End	Yes	Continuous	High (> 50%)	297968.27	4606558.25	41.58518188	-71.42371241
REV01_20B1	T15	9/5/2020	7:55:41	End	-	No	None	None	297961.49	4606570.5	41.58529045	-71.42379778
REV01_20B1	T16	9/5/2020	7:58:10	Start	-	No	None	None	297988.49	4606554.61	41.58515431	-71.42346885
REV01_20B1	T16	9/5/2020	7:59:04	-	Start	Yes	Patches	Low (11 to 25%)	297980.94	4606560.83	41.58520836	-71.42356138
REV01_20B1	T16	9/5/2020	7:59:20	-	End	Yes	Patches	Low (11 to 25%)	297977.03	4606563.67	41.58523294	-71.42360919
REV01_20B1	T16	9/5/2020	8:00:18	End	-	No	None	None	297969.12	4606575.37	41.58533616	-71.42370803
REV01_20B1	T17	9/5/2020	8:02:38	Start	-	No	None	None	297994.28	4606560.03	41.58520449	-71.42340119
REV01_20B1	T17	9/5/2020	8:03:04	-	Start	Yes	Patches	Low (11 to 25%)	297989.27	4606565.43	41.58525183	-71.42346317
REV01_20B1	T17	9/5/2020	8:03:28	-	End	Yes	Patches	Low (11 to 25%)	297985.06	4606569.43	41.58528682	-71.42351496
REV01_20B1	T17	9/5/2020	8:03:55	-	Start	Yes	Patches	Sparse (1 to 10%)	297981.6	4606574.81	41.5853343	-71.42355816
REV01_20B1	T17	9/5/2020	8:04:09	-	End	Yes	Patches	Sparse (1 to 10%)	297980.68	4606577.5	41.58535825	-71.42357009
REV01_20B1	T17	9/5/2020	8:04:23	End	-	No	None	None	297979.8	4606579.67	41.5853776	-71.42358138
REV01_20B1	T18	9/5/2020	8:06:55	Start	-	No	None	None	298005.91	4606570.57	41.58530234	-71.42326542
REV01_20B1	T18	9/5/2020	8:07:47	-	Start	Yes	Patches	High (> 50%)	297993.53	4606576.13	41.5853492	-71.42341567
REV01_20B1	T18	9/5/2020	8:07:51	-	End	Yes	Patches	High (> 50%)	297993.01	4606577.11	41.5853579	-71.42342222
REV01_20B1	T18	9/5/2020	8:08:05	-	Start	Yes	Patches	Sparse (1 to 10%)	297991.72	4606580.5	41.58538805	-71.42343881
REV01_20B1	T18	9/5/2020	8:08:19	-	End	Yes	Patches	Sparse (1 to 10%)	297990.44	4606583.18	41.58541184	-71.42345512
REV01_20B1	T18	9/5/2020	8:08:24	End	-	No	None	None	297990.28	4606583.69	41.58541643	-71.42345715
REV01_20B1	T19	9/5/2020	8:16:06	Start	-	No	None	None	297965.43	4606532.15	41.58494633	-71.42373771
REV01_20B1	T19	9/5/2020	8:16:57	-	Start	Yes	Patches	High (> 50%)	297965.1	4606543.63	41.58504955	-71.42374545

Survey ID	Transect ID	Date	Time	Transect	SAV Period	SAV Present?	SAV Description	SAV Percent Cover	X_UTM19N_m	Y_UTM19N_m	Lat_WGS84_N	Lon_WGS84_W
REV01_20B1	T19	9/5/2020	8:17:19	-	End	Yes	Patches	High (> 50%)	297960.76	4606549.01	41.58509686	-71.42379937
REV01_20B1	T19	9/5/2020	8:18:24	End	-	No	None	None	297949.54	4606566.62	41.5852525	-71.42393968
REV01_20B1	T20	9/5/2020	8:20:17	Start	-	No	None	None	297981.31	4606539.82	41.58501935	-71.42354987
REV01_20B1	T20	9/5/2020	8:21:08	-	Start	Yes	Patches	Moderate (26 to 50%)	297969.15	4606550.53	41.5851127	-71.42369922
REV01_20B1	T20	9/5/2020	8:21:30	-	End	Yes	Patches	Moderate (26 to 50%)	297966.93	4606555.56	41.58515735	-71.42372758
REV01_20B1	T20	9/5/2020	8:22:42	End	-	No	None	None	297954.9	4606567.42	41.58526103	-71.42387572
REV01_20B1	T21	9/5/2020	8:24:35	Start	-	No	None	None	297985.8	4606549.25	41.58510536	-71.42349925
REV01_20B1	T21	9/5/2020	8:25:01	-	Start	Yes	Patches	Sparse (1 to 10%)	297979.35	4606554.83	41.58515395	-71.42357843
REV01_20B1	T21	9/5/2020	8:25:04	-	End	Yes	Patches	Sparse (1 to 10%)	297978.57	4606555.62	41.58516083	-71.4235881
REV01_20B1	T21	9/5/2020	8:25:18	-	Start	Yes	Patches	High (> 50%)	297975.66	4606559.01	41.58519064	-71.42362412
REV01_20B1	T21	9/5/2020	8:25:25	-	End	Yes	Patches	High (> 50%)	297974.21	4606560.55	41.58520416	-71.42364201
REV01_20B1	T21	9/5/2020	8:25:33	-	Start	Yes	Patches	Sparse (1 to 10%)	297972.25	4606562.46	41.58522078	-71.42366613
REV01_20B1	T21	9/5/2020	8:25:34	-	End	Yes	Patches	Sparse (1 to 10%)	297971.99	4606562.71	41.585223	-71.42366929
REV01_20B1	T21	9/5/2020	8:26:16	End	-	No	None	None	297964.74	4606573.63	41.58531944	-71.42375994
REV01_20B1	T22	9/5/2020	8:28:09	Start	-	No	None	None	297992.83	4606554.63	41.58515555	-71.42341683
REV01_20B1	T22	9/5/2020	8:28:40	-	Start	Yes	Patches	Low (11 to 25%)	297984.54	4606560.38	41.58520518	-71.42351816
REV01_20B1	T22	9/5/2020	8:29:37	-	End	Yes	Patches	Low (11 to 25%)	297978.03	4606571.84	41.58530672	-71.42360002
REV01_20B1	T22	9/5/2020	8:29:47	-	Start	Yes	Patches	High (> 50%)	297975.47	4606573.28	41.58531899	-71.42363119
REV01_20B1	T22	9/5/2020	8:29:49	-	End	Yes	Patches	High (> 50%)	297974.73	4606573.72	41.58532274	-71.42364021
REV01_20B1	T22	9/5/2020	8:30:03	End	-	No	None	None	297970.83	4606576.37	41.58534564	-71.42368778
REV01_20B1	T23	9/5/2020	8:32:14	Start	-	No	None	None	298001.97	4606560.56	41.58521119	-71.42330927
REV01_20B1	T23	9/5/2020	8:33:10	-	Start	Yes	Patches	Sparse (1 to 10%)	297992.98	4606572	41.58531187	-71.42342083
REV01_20B1	T23	9/5/2020	8:33:12	-	End	Yes	Patches	Sparse (1 to 10%)	297992.9	4606572.26	41.58531425	-71.42342197
REV01_20B1	T23	9/5/2020	8:33:22	-	Start	Yes	Patches	Low (11 to 25%)	297990.78	4606574.4	41.58533292	-71.42344799
REV01_20B1	T23	9/5/2020	8:33:24	-	End	Yes	Patches	Low (11 to 25%)	297990.25	4606574.77	41.58533611	-71.42345452
REV01_20B1	T23	9/5/2020	8:33:48	-	Start	Yes	Patches	Sparse (1 to 10%)	297984.53	4606579.73	41.58537937	-71.42352478
REV01_20B1	T23	9/5/2020	8:33:50	-	End	Yes	Patches	Sparse (1 to 10%)	297984.25	4606580.38	41.58538514	-71.42352827
REV01_20B1	T23	9/5/2020	8:33:56	End	-	No	None	None	297983.69	4606581.61	41.58539604	-71.42353539
REV01_20B1	T24	9/5/2020	8:36:23	Start	Start	Yes	Shoots	Sparse (1 to 10%)	298008.4	4606565.21	41.5852547	-71.42323379
REV01_20B1	T24	9/5/2020	8:36:25	-	End	Yes	Shoots	Sparse (1 to 10%)	298008.19	4606565.56	41.58525778	-71.4232364
REV01_20B1	T24	9/5/2020	8:37:07	-	Start	Yes	Continuous	Moderate (26 to 50%)	298004.23	4606573.98	41.58533258	-71.42328664
REV01_20B1	T24	9/5/2020	8:37:11	-	End	Yes	Continuous	Moderate (26 to 50%)	298003.2	4606575.37	41.58534483	-71.42329946
REV01_20B1	T24	9/5/2020	8:37:17	-	Start	Yes	Patches	Sparse (1 to 10%)	298001.94	4606576.5	41.58535466	-71.42331492
REV01_20B1	T24	9/5/2020	8:37:42	-	End	Yes	Patches	Sparse (1 to 10%)	297996.73	4606581.75	41.58540063	-71.42337921
REV01_20B1	T24	9/5/2020	8:38:02	End	-	No	None	None	297993.68	4606585.57	41.58543424	-71.42341701
REV01_20B1	T25	9/5/2020	8:47:24	Start	-	No	None	None	297705.29	4606495.97	41.58455496	-71.42684354
REV01_20B1	T25	9/5/2020	8:55:44	-	Start	Yes	Patches	Sparse (1 to 10%)	297867.12	4606530.6	41.58490747	-71.42491549
REV01_20B1	T25	9/5/2020	8:55:46	-	End	Yes	Patches	Sparse (1 to 10%)	297867.74	4606530.84	41.58490987	-71.42490822
REV01_20B1	T25	9/5/2020	8:56:30	-	Start	Yes	Shoots	Sparse (1 to 10%)	297882.58	4606532.78	41.58493103	-71.42473095
REV01_20B1	T25	9/5/2020	8:56:32	-	End	Yes	Shoots	Sparse (1 to 10%)	297883	4606532.84	41.58493174	-71.42472589
REV01_20B1	T25	9/5/2020	9:03:30	End	-	No	None	None	297997.38	4606530.5	41.58493952	-71.4233541
REV01_20B1	T26	9/5/2020	9:09:05	Start	-	No	None	None	297991.4	4606508.54	41.58474042	-71.42341846
REV01_20B1	T26	9/5/2020	9:22:12	End	-	No	None	None	297703.32	4606481.61	41.5844252	-71.42686235
REV01_20B1	T27	9/5/2020	9:32:51	Start	-	No	None	None	297868	4606543.99	41.58502825	-71.42490943

Survey ID	Transect ID	Date	Time	Transect	SAV Period	SAV Present?	SAV Description	SAV Percent Cover	X_UTM19N_m	Y_UTM19N_m	Lat_WGS84_N	Lon_WGS84_W
REV01_20B1	T27	9/5/2020	9:36:30	End	-	No	None	None	297929.91	4606551.03	41.58510725	-71.42416981
REV01_20B1	T28	9/5/2020	9:38:12	Start	-	No	None	None	297926.37	4606543.37	41.58503746	-71.42420966
REV01_20B1	T28	9/5/2020	9:41:14	End	-	No	None	None	297873.56	4606539.91	41.58499296	-71.42484147
REV01_20B1	T29	9/5/2020	10:04:56	Start	-	No	None	None	297732.09	4606191.13	41.58181838	-71.42641954
REV01_20B1	T29	9/5/2020	10:07:28	End	-	No	None	None	297700.48	4606194.49	41.58184059	-71.42679956
REV01_20B1	T30	9/5/2020	10:09:10	Start	-	No	None	None	297726.73	4606180.04	41.58171722	-71.42648011
REV01_20B1	T30	9/5/2020	10:09:35	-	Start	Yes	Shoots	Sparse (1 to 10%)	297721.3	4606182.34	41.58173654	-71.42654596
REV01_20B1	T30	9/5/2020	10:09:37	-	End	Yes	Shoots	Sparse (1 to 10%)	297720.86	4606182.45	41.5817374	-71.42655124
REV01_20B1	T30	9/5/2020	10:11:12	End	-	No	None	None	297700.19	4606187.09	41.58177398	-71.42680053
REV01_20B1	T31	9/5/2020	10:13:00	Start	-	No	None	None	297724.53	4606177.93	41.58169772	-71.42650569
REV01_20B1	T31	9/5/2020	10:14:19	End	-	No	None	None	297697.87	4606180.56	41.58171461	-71.42682613
REV01_20B1	T32	9/5/2020	10:17:54	Start	-	No	None	None	297689.09	4606180.93	41.5817157	-71.42693153
REV01_20B1	T32	9/5/2020	10:19:58	End	-	No	None	None	297724.86	4606168.63	41.58161409	-71.4264986
REV01_20B1	T33	9/5/2020	10:22:43	Start	-	No	None	None	297693.79	4606176.72	41.58167901	-71.42687378
REV01_20B1	T33	9/5/2020	10:24:41	End	-	No	None	None	297724.79	4606171.71	41.58164174	-71.42650054
REV01_20B1	T34	9/5/2020	10:30:17	Start	-	No	None	None	297688.24	4606167.07	41.58159075	-71.42693701
REV01_20B1	T34	9/5/2020	10:32:23	End	-	No	None	None	297723.45	4606159.7	41.58153335	-71.42651261
REV01_20B1	T35	9/5/2020	10:35:19	Start	-	No	None	None	297727.73	4606148.47	41.58143336	-71.42645747
REV01_20B1	T35	9/5/2020	10:37:37	End	-	No	None	None	297694.04	4606161.26	41.58153994	-71.42686563
REV01_20B1	T36	9/5/2020	10:45:54	Start	-	No	None	None	297699.43	4606157.34	41.58150606	-71.42679967
REV01_20B1	T36	9/5/2020	10:51:48	End	-	No	None	None	297708.92	4606193.08	41.58183002	-71.42669794
REV01_20B1	T37	9/5/2020	10:55:20	Start	-	No	None	None	297710.54	4606149.23	41.58143583	-71.42666377
REV01_20B1	T37	9/5/2020	10:58:38	End	-	No	None	None	297713.4	4606192.1	41.58182236	-71.42664394
REV01_20B1	T38	9/5/2020	11:01:09	Start	-	No	None	None	297715.18	4606152.48	41.58146626	-71.42660918
REV01_20B1	T38	9/5/2020	11:03:48	End	-	No	None	None	297718.56	4606187.83	41.58178524	-71.42658059
REV01_20B1	T39	9/14/2020	6:20:18	Start	-	No	None	None	297891.63	4606262.24	41.58249872	-71.42453137
REV01_20B1	T39	9/14/2020	6:28:17	End	-	No	None	None	297888.36	4606365.58	41.58342785	-71.42460533
REV01_20B1	T40	9/14/2020	6:29:24	Start	-	No	None	None	297872.79	4606371.31	41.58347548	-71.42479392
REV01_20B1	T40	9/14/2020	6:34:53	End	-	No	None	None	297870.41	4606262.71	41.58249754	-71.42478585
REV01_20B1	T41	9/14/2020	6:36:31	Start	-	No	None	None	297848.94	4606260.66	41.58247364	-71.42504252
REV01_20B1	T41	9/14/2020	6:44:16	End	-	No	None	None	297851.7	4606367.03	41.58343163	-71.42504527
REV01_20B1	T42	9/14/2020	6:45:48	Start	-	No	None	None	297833.9	4606365.39	41.58341236	-71.42525808
REV01_20B1	T42	9/14/2020	6:50:36	End	-	No	None	None	297831.27	4606262.77	41.58248819	-71.42525504
REV01_20B1	T43	9/14/2020	6:52:19	Start	-	No	None	None	297808.15	4606256.72	41.58242789	-71.42553003
REV01_20B1	T43	9/14/2020	6:58:25	End	-	No	None	None	297807.99	4606366.48	41.58341558	-71.42556899
REV01_20B1	T44	9/14/2020	6:59:49	Start	-	No	None	None	297791.75	4606366.5	41.58341172	-71.42576361
REV01_20B1	T44	9/14/2020	7:05:10	End	-	No	None	None	297794.14	4606262.77	41.58247883	-71.42570002
REV01_20B1	T45	9/14/2020	7:10:53	Start	-	No	None	None	297838.15	4606304.76	41.58286776	-71.42518667
REV01_20B1	T45	9/14/2020	7:20:49	End	-	No	None	None	297758.67	4606496.84	41.58457625	-71.42620401
REV01_20B1	T46	9/14/2020	7:22:14	Start	-	No	None	None	297778.1	4606497.73	41.58458914	-71.42597149
REV01_20B1	T46	9/14/2020	7:31:23	End	-	No	None	None	297843.4	4606311.96	41.58293389	-71.42512622
REV01_20B1	T47	9/14/2020	7:38:58	Start	-	No	None	None	297640.22	4606004.54	41.58011598	-71.42745775
REV01_20B1	T47	9/14/2020	7:44:19	End	-	No	None	None	297539.3	4606003.17	41.5800781	-71.42866685
REV01_20B1	T48	9/14/2020	7:45:02	Start	-	No	None	None	297539.73	4605989.29	41.57995325	-71.42865701

Survey ID	Transect ID	Date	Time	Transect	SAV Period	SAV Present?	SAV Description	SAV Percent Cover	X_UTM19N_m	Y_UTM19N_m	Lat_WGS84_N	Lon_WGS84_W
REV01_20B1	T48	9/14/2020	7:50:46	End	-	No	None	None	297643.97	4605987.22	41.57996102	-71.42740698
REV01_20B1	T49	9/14/2020	7:51:46	Start	-	No	None	None	297638.47	4605964.78	41.57975772	-71.42746535
REV01_20B1	T49	9/14/2020	7:57:03	End	-	No	None	None	297539.29	4605963.38	41.57972002	-71.42865365
REV01_20B1	T50	9/14/2020	7:58:35	Start	-	No	None	None	297539.79	4605950.53	41.57960448	-71.42864325
REV01_20B1	T50	9/14/2020	8:04:24	End	-	No	None	None	297643.59	4605946.28	41.5795925	-71.42739774
REV01_20B1	T51	9/14/2020	8:08:04	Start	-	No	None	None	297644.34	4605918.93	41.5793466	-71.4273795
REV01_20B1	T51	9/14/2020	8:13:53	End	-	No	None	None	297539.26	4605927.04	41.57939296	-71.42864174
REV01_20B1	T52	9/14/2020	8:15:30	Start	-	No	None	None	297534.82	4605909.11	41.57923047	-71.42868889
REV01_20B1	T52	9/14/2020	8:21:27	End	-	No	None	None	297643.78	4605906.53	41.57923485	-71.42738203
REV01_20B1	T53	9/14/2020	8:32:28	Start	-	No	None	None	297430.35	4606388.48	41.58351797	-71.43010283
REV01_20B1	T53	9/14/2020	8:36:07	End	-	No	None	None	297476.8	4606415.69	41.58377457	-71.42955525
REV01_20B1	T54	9/14/2020	8:37:03	Start	-	No	None	None	297493.33	4606401.79	41.58365372	-71.42935242
REV01_20B1	T54	9/14/2020	8:42:20	End	-	No	None	None	297402.74	4606374.95	41.58338918	-71.43042915
REV01_20B1	T55	9/14/2020	8:43:34	Start	-	No	None	None	297400.61	4606366.35	41.58331129	-71.43045176
REV01_20B1	T55	9/14/2020	8:48:52	End	-	No	None	None	297496.96	4606377.31	41.58343435	-71.42930063
REV01_20B1	T56	9/14/2020	9:24:10	Start	-	No	None	None	297507.09	4606356.51	41.58324968	-71.42917223
REV01_20B1	T56	9/14/2020	9:29:22	End	-	No	None	None	297413.13	4606354.03	41.58320353	-71.43029755
REV01_20B1	T57	9/14/2020	9:44:07	Start	-	No	None	None	297783.95	4606361.05	41.58336062	-71.42585532
REV01_20B1	T57	9/14/2020	9:49:18	End	-	No	None	None	297891.75	4606362.37	41.58339984	-71.4245636
REV01_20B1	T58	9/14/2020	9:50:19	Start	-	No	None	None	297890.79	4606341.76	41.58321413	-71.42456817
REV01_20B1	T58	9/14/2020	9:55:27	End	-	No	None	None	297789.38	4606341.95	41.58319012	-71.42578375
REV01_20B1	T59	9/14/2020	9:56:33	Start	-	No	None	None	297782	4606322.64	41.58301447	-71.42586566
REV01_20B1	T59	9/14/2020	10:02:57	End	-	No	None	None	297893.41	4606321.5	41.58303242	-71.42452998
REV01_20B1	T60	9/14/2020	10:16:35	Start	-	No	None	None	297900.08	4606317.93	41.58300197	-71.42444877
REV01_20B1	T60	9/14/2020	10:21:55	End	-	No	None	None	297790.85	4606313.94	41.58293847	-71.42575675

Attachment C – Benthic Species & Life Stages with EFH in the Project Area Crosswalked to Mapped Benthic Habitat Types

Notes:

• Mapped EFH overlaps with the given project component and given habitat falls within the species life stage EFH definition.

- Mapped EFH overlaps with the given project component but the given habitat does not fall within the species life stage EFH definition.

☐ Mapped EFH does not overlap with the given project component.

1 Species life stage unlikely to utilize mobile habitats.

2 Species life stage may be present on any given project habitat type with the presence of boulders, SAV, or shell substrate.

HAPC= Habitat Area of Particular Concern

References: Atlantic Wolffish BRT 2009; Brodziak 2005; Cargnelli et al. 1999a, 1999b, 1999c; Chang et al. 1999a, 1999b; Drohan et al. 2007; Hart and Chute 2004; Jacobson 2005; Lock and Packer 2004; Lough 2004; NEFMC 2017; NOAA Fisheries 2017; Packer at al. 1999, 2003a, 2003b; Pereira et al. 1999; Steihlik 2007; Steimle et al. 1999a, 1999b, 1999c, 1999d

Species Name	Benthic Life Stage	Revolution Wind Habitat Types														Distinct habitat features that serve as EFH regardless of underlying substrate[2]		
		Glacial Moraine (A&B)			Mixed-Size Gravel in Muddy Sand		Coarse Sediment			Sand and Muddy Sand			Mud and Sandy Mud					
		RWF	RWEC-OCS	RWEC-RI	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	Boulders	Shell Substrate (RWEC-RI)	SAV (RWEC-RI)
New England Finfish Species																		
Atlantic cod	Juveniles	●	●	●	●	●	●	●	●	-	-	-	-	-	-	●	-	●
	Adults	●	●	●	●	●	●	●	●	-	-	-	-	-	-	●		
Atlantic wolffish	Eggs	●					●			-			-			●		
	Larvae	●					●[1]			-			-			●		
	Juveniles	●					●			●			●			●		
	Adults	●					●			●			-			●		
Haddock	Juveniles	●					●			-			-			●		
Monkfish	Juveniles	-					●			●			●			●		
	Adults	-					●			●			●			●		
Ocean pout	Eggs	●	●	●	●	●	●	●	●	-	-	-	-	-	-	●	-	-
	Juveniles	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-
	Adults	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-
Pollock	Juveniles	●	●	●	●	●	-	-	-	-	-	-	-	-	-	●	-	●
Red hake	Juveniles	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	●	●
	Adults	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-
Silver hake	Juveniles	-	-	-	-	-	-	-	-	●	●		●	●		-	●	-
White hake	Juveniles	-	-	-	-	-	-	-	-	●	●	●	●	●	●	-	-	●
Windowpane flounder	Juveniles	-	-	-	-	-	-	-	-	●	●	●	●	●	●	-	-	-
	Adults	-	-	-	-	-	-	-	-	●	●	●	●	●	●	-	-	-
Winter flounder	Eggs			-		●			●[1]			●[1]			●[1]	-	-	●
	Juveniles	-	-	-	●	●	●	●	●	●	●	●	●	●	●	-	-	●
	Adults	-	-	-	●	●	●	●	●	●	●	●	●	●	●	-	-	●
Yellowtail flounder	Juveniles	-	-	-	-	-	●	●	●	●	●	●	-	-	-	-		
	Adults	-	-	-	-	-	●	●	●	●	●	●	-	-	-	-		

Species Name	Benthic Life Stage	Revolution Wind Habitat Types														Distinct habitat features that serve as EFH regardless of underlying substrate[2]		
		Glacial Moraine (A&B)			Mixed-Size Gravel in Muddy Sand		Coarse Sediment			Sand and Muddy Sand			Mud and Sandy Mud					
		RWF	RWEC-OCS	RWEC-RI	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	Boulders	Shell Substrate (RWEC-RI)	SAV (RWEC-RI)
Mid-Atlantic Finfish species																		
Black sea bass	Juveniles	●	●	●	●	●	●	●	●	-	-	-	-	-	-	●	●	●
	Adults	●	●	●	●	●	●	●	●	-	-	-	-	-	-	●	●	●
Scup	Juveniles	-	-	-	-	●	●	●	●	●	●	●	●	●	●	●	●	●
	Adults	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Summer flounder	Juveniles	-	-	-	-	-	-	-	-	●	●	●	●	●	●	-	-	HAPC
	Adults	-	-	-	-	-	-	-	-	●	●	●	●	●	●	-	-	HAPC
Sharks																		
Sand tiger shark	Neonate/YOY	-	-	●	●	●	-	●	●	-	-	●	-	-	●	●	-	-
	Juvenile	-	-	●	●	●	-	●	●	-	-	●	-	-	●	●	-	-
Sandbar shark	Juvenile	-	-	●	●	●	-	●	●	-	-	●	-	-	●	●	●	-
	Adult	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
Smooth dogfish	Neonate	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
	Juvenile	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
	Adult	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
Spiny dogfish	Sub-Adults (female)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
	Sub-Adults (male)	●					●			●			●			-		
	Adults (female)	●	●		●		●	●		●	●		●	●		-		
	Adults (male)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
Skates																		
Little skate	Juveniles	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
	Adults	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
Winter skate	Juveniles	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-
	Adults	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	-	-

Species Name	Benthic Life Stage	Revolution Wind Habitat Types														Distinct habitat features that serve as EFH regardless of underlying substrate[2]		
		Glacial Moraine (A&B)			Mixed-Size Gravel in Muddy Sand		Coarse Sediment			Sand and Muddy Sand			Mud and Sandy Mud					
		RWF	RWEC-OCS	RWEC-RI	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	RWF	RWEC-OCS	RWEC-RI	**Boulders**	**Shell Substrate (RWEC-RI)**	**SAV (RWEC-RI)**
Invertebrates																		
Atlantic sea scallop	Eggs	●	●	●	●	●	●	●	●	●	●	●	-	-	-	-	-	-
	Larvae	●	●	●	●	●	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	-	-	-	-	-	-
	Juveniles	●	●	●	●	●	●	●	●	●	●	●	-	-	-	-	-	-
	Adults	●	●	●	●	●	●	●	●	●	●	●	-	-	-	-	-	-
Atlantic surfclam	Juveniles			●		●			●			●			-	-	-	-
	Adults		●	●		●		●	●		●	●		-	-	-	-	-
Longfin squid	Eggs	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	-	●
Ocean quahog	Juveniles	●					●			●			●			-		
	Adults	●					●			●			●			-		

• Mapped EFH overlaps with the given project component and given habitat falls within the species life stage EFH definition.
- Mapped EFH overlaps with the given project component but the given habitat does not fall within the species life stage EFH definition.
☐ Mapped EFH does not overlap with the given project component.

[1] Species life stage unlikely to utilize mobile habitats.
[2] Species life stage may be present on any given project habitat type with the presence of boulders, SAV, or shell substrate.
HAPC= Habitat Area of Particular Concern

References: Atlantic Wolffish BRT 2009; Brodziak 2005; Cargnelli et al. 1999a, 1999b, 1999c; Chang et al. 1999a, 1999b; Drohan et al. 2007; Hart and Chute 2004; Jacobson 2005; Lock and Packer 2004; Lough 2004; NEFMC 2017; NOAA Fisheries 2017; Packer at al. 1999, 2003a, 2003b; Pereira et al. 1999; Steihlik 2007; Steimle et al. 1999a, 1999b, 1999c, 1999d