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

Essential Fish Habitat Assessment

August 29, 2022

For the National Marine Fisheries Services

U.S. Department of Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs
This report should be cited as:

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### Acronyms and Abbreviations

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<td>µPa</td>
<td>micro-Pascal</td>
</tr>
<tr>
<td>µPa²s</td>
<td>micro Pascal squared second</td>
</tr>
<tr>
<td>µT</td>
<td>micro-Tesla</td>
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<tr>
<td>µV/m</td>
<td>microvolts per meter</td>
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<td>BOEM</td>
<td>Bureau of Ocean Energy Management</td>
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<td>BOEMRE</td>
<td>Bureau of Ocean Energy Management, Regulation, and Enforcement</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
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<td>CFE</td>
<td>Controlled Flow Excavation</td>
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<td>CMECS</td>
<td>Coastal and Marine Ecological Classification Standard</td>
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<td>Construction and Operations Plan</td>
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<td>CPS</td>
<td>cable protection system</td>
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<td>crew transfer vessel</td>
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<td>dB</td>
<td>decibel</td>
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<tr>
<td>dBA</td>
<td>A-weighted decibels</td>
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<td>DP</td>
<td>dynamic positioning</td>
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<td>EFH</td>
<td>Essential Fish Habitat</td>
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<td>EMF</td>
<td>electromagnetic field</td>
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<td>EPM</td>
<td>environmental protection measure</td>
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<td>FGDC</td>
<td>Federal Geographic Data Committee</td>
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<td>FHWG</td>
<td>Fisheries Hydroacoustic Working Group</td>
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<td>FMP</td>
<td>fisheries management plan</td>
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<td>FRMP</td>
<td>Fisheries Research and Monitoring Plan</td>
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<td>HAPC</td>
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<td>HDD</td>
<td>horizontal directional drill</td>
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<td>HRG</td>
<td>high-resolution geophysical</td>
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<td>high voltage alternating current</td>
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<tr>
<td>IPF</td>
<td>impact-producing factor</td>
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<td>kJ</td>
<td>kilojoule</td>
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<tr>
<td>mG</td>
<td>milligauss</td>
</tr>
<tr>
<td>mg/L</td>
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<td>mm</td>
<td>millimeter</td>
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<td>MLLW</td>
<td>mean lower low water</td>
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<td>mV/m</td>
<td>millivolts per meter</td>
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<tr>
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<td>MWA</td>
<td>maximum work area</td>
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<td>National Coastal Condition Assessment</td>
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<td>nm</td>
<td>nautical mile</td>
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<td>National Oceanic and Atmospheric Administration, National Marine Fisheries Service</td>
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<td>O&amp;M</td>
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<td>Acronym</td>
<td>Definition</td>
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<tr>
<td>RI/MA WEA</td>
<td>Rhode Island/Massachusetts Wind Energy Area</td>
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<tr>
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<td>SOV</td>
<td>service operation vessel</td>
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<tr>
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<tr>
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<td>total suspended sediment</td>
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<tr>
<td>TTS</td>
<td>temporary threshold shift</td>
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<tr>
<td>USACE</td>
<td>U.S. Army Corps of Engineers</td>
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<td>USCG</td>
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<td>YOY</td>
<td>young-of-year</td>
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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; and

- **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 Ørsted 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 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 will be EFH consultation will may be conducted for Project decommissioning and it will be determined at that time if an EFH consultation is necessary.
2.0 Proposed Action

The proposed action is the approval of the COP for the RWF and RWEC. 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. 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).

The RWF includes 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, all of which 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. 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 as part of the Proposed Action. Construction of an onshore O&M facility is considered a separate action and is undergoing permitting through the USACE, New York District. Thus, the construction and installation of an O&M facility is not considered as part of this EFH Assessment. Required O&M activities related to WTGs and OSSs are considered as part of this 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 will connect to the grid in Quonset Point in North Kingstown, Rhode Island. The RWEC includes both offshore and onshore segments and a sea-to-shore transition point. The RWEC includes an offshore component located in federal waters (RWEC–OCS) and a component located in Rhode Island State territorial waters (RWEC–RI). The two RWEC circuits will total 83.3 miles in length (23 and 18.6 miles for each RWEC-OCS and RWEC-RI segment per circuit, respectively).

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

Revolution Wind has indicated they are considering WTGs with nameplate capacities of 8 to 12 MW for the project, 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 nameplate capacity. Revolution Wind could select a windfarm design comprising 74 to 100 WTG’s. In this Assessment (Section 5), BOEM is considering the effects of the most extensive design option (100 WTGs and 2 OSSs), because it would result in the most extensive effects on the environment. However, several alternative configurations of the RWF are being considered in the Draft Environmental Impact Statement (DEIS) for the Proposed Action that would result in reduced impacts to EFH. Descriptions and figures of the alternative layout designs are described in Section 6, including brief summaries of how they may reduce impacts to EFH compared with the Proposed Action.

During the construction/installation of offshore and inter-array cables, a combination of seabed preparation (i.e., boulder clearance and sandwave leveling) and cable installation (i.e., jet and/or mechanical plow) methods may be used. The impacts from seabed preparation and cable installation are considered in Section 2.2.2 and reflect the most extensive impacts that are likely to occur from the methods being considered.

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 DEIS, 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 RWEC, RWF 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. 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 electromagnetic field (EMF) effects, and effects resulting from presence of structures]. The RFW and RWEC project areas are shown in Figure 2.1. The RWEC will transition to on-shore and connect to the grid in Quonset Point in North Kingstown, Rhode Island. Additionally, Revolution Wind is evaluating the use of several existing port facilities located in Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Virginia, and Maryland 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.
Figure 2.1. RWF and RWEC Project Components (source: VHB 2022).
Table 2.1. Summary of RWF and RWEC Construction and Installation and Operations and Maintenance by Design Alternative (parameters used in consultation in bold).

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Design Element</th>
<th>Effect Mechanism</th>
<th>Measurement Parameter</th>
<th>Design Alternative</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWF construction and installation</td>
<td>Turbine selection/spacing</td>
<td>Installation disturbance area</td>
<td>WTG size</td>
<td>8 MW - 12 MW</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number of turbines</td>
<td>8 MW - 12 MW</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotor height above mean sea level</td>
<td>8 MW</td>
<td>646 feet (197 meters) at peak 94 feet (29 meters) minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12 MW</td>
<td>873 feet (266 meters) at peak 151 feet (46 meters) minimum</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spacing</td>
<td>8 MW - 12 MW</td>
<td>1.15 linear miles (1.85 km, 1 nautical mile [nm])</td>
</tr>
<tr>
<td>Monopile foundation installation</td>
<td>Habitat alteration, physical disturbance</td>
<td>Number of monopiles</td>
<td>100 WTGs, 2 OSS</td>
<td>3,110 acres (1,259 hectares)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Footprint area total (with scour protection)</td>
<td>100 39-foot (12-meter monopile) Two 15-meter OSS monopiles</td>
<td>480 acres (322 hectares) total for 102 monopiles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Installation method</td>
<td>12-meter WTG monopiles 15-meter OSS monopiles</td>
<td>WTG 4,000 kilojoules (kJ) impact hammer 6,500 strikes/pile 220 minutes/pile installing 2 piles/day OSS 4,000 kilojoules (kJ) impact hammer 11,500 strikes/pile 380 minutes/pile over 1-2 days total</td>
</tr>
<tr>
<td>Vessel Traffic</td>
<td>Noise</td>
<td>Number of vessels</td>
<td>All</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Inter-array cable (IAC) construction and installation</td>
<td>Physical disturbance, turbidity, entrainment</td>
<td>Vessel source level¹</td>
<td>All</td>
<td>150–180 dB re 1 µPa-m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total corridor length</td>
<td>All</td>
<td>155.3 linear miles (249 km/ 139 nm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation method</td>
<td>All</td>
<td>Cable trenching/burial (dredge or jet plow)</td>
<td>4- to 6-feet (1.2- to 1.8-meter) depth</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹Vessel source level includes background noise.
<table>
<thead>
<tr>
<th>Project Component</th>
<th>Design Element</th>
<th>Effect Mechanism</th>
<th>Measurement Parameter</th>
<th>Design Alternative</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term disturbance</td>
<td>All</td>
<td>2,224 acres (900 hectares)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent habitat conversion (exposed cable protection)</td>
<td>All</td>
<td>74.1 acres (30.0 hectares)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total suspended sediments (TSSs)</td>
<td>All</td>
<td>&gt;100 mg/L above background</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area exposed to sediment deposition ≥ 10 mm</td>
<td>All</td>
<td>217 acres (87.8 hectares)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSS-link cable construction and installation</td>
<td>Physical disturbance, turbidity, entrainment</td>
<td>Total corridor length</td>
<td>All</td>
<td>9.3 miles</td>
<td></td>
</tr>
<tr>
<td>Installation method</td>
<td>Cable trenching/burial (dredge 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.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-term disturbance</td>
<td>110 acres (45 hectares)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent habitat conversion (exposed cable protection)</td>
<td>4.4 acres (1.8 hectares)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total suspended sediments (TSSs)</td>
<td>&gt;100 mg/L above background</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area exposed to sediment deposition ≥ 10 mm</td>
<td>8.6 acres (3.5 hectares)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RWF operation</td>
<td>Operational electromagnetic field (EMF) (IAC)</td>
<td>Transmission voltage</td>
<td>8 MW</td>
<td>72 kilovolts (kV) IAC</td>
<td></td>
</tr>
<tr>
<td>12 MW</td>
<td>72 kV IAC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSS Link</td>
<td>275 kV OSS Link</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic field**</td>
<td>All</td>
<td>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</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Component</td>
<td>Design Element</td>
<td>Effect Mechanism</td>
<td>Measurement Parameter</td>
<td>Design Alternative</td>
<td>Effect</td>
</tr>
<tr>
<td>-------------------</td>
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<td>--------</td>
</tr>
<tr>
<td>RWEC</td>
<td>Export cable construction and installation</td>
<td>Construction and installation disturbance area</td>
<td>Total corridor length</td>
<td>All</td>
<td>88 linear miles (142 km, 76 nm) combined total, 48 and 40 linear miles (77 and 64 km, 43 and 34 nm) respectively</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Installation method</td>
<td>All</td>
<td>Cable trenching/burial, 4- to 6-foot (1.2- to 1.8-meter) target depth, dredging used to level seabed and achieve greater burial depth along approximately 21 combined miles of RWEC route. Approximately 190 pull ahead anchoring events required for RWEC installation, totaling 11.6 acres (4.7 hectares) of seabed impacts.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Short-term disturbance area</td>
<td>All</td>
<td>RWEC-OCS 535 acres (217 hectares) RWEC-RI 592 acres (240 hectares)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TSS</td>
<td>All</td>
<td>Maximum concentration &gt;500mg/L, concentrations exceeding 100 mg/L up to 19 hours following disturbance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Area exposed to sediment deposition ≥ 10 mm</td>
<td>All</td>
<td>3,186 acres (1,289 hectares)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Activity duration</td>
<td></td>
<td>8 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Permanent habitat conversion (secondary cable protection)</td>
<td>All</td>
<td>60.6 acres (24.5 hectares)</td>
</tr>
<tr>
<td>Vessel traffic</td>
<td>Number of vessels</td>
<td>All</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vessel source levels¹</td>
<td>All</td>
<td>150-180 dB re 1 µPa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sea-to-shore transition construction and installation</td>
<td>Cofferdam/gravity cell construction and installation/removal*</td>
<td>Cofferdam/Gravity Cell footprint</td>
<td>All</td>
<td>0.084 acres (0.034 hectare) total, 0.042 acre (0.017 hectare)/cofferdam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sheetpile size</td>
<td>All</td>
<td>Z-Type typical</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Piles per day</td>
<td>All</td>
<td>4-6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Component</td>
<td>Design Element</td>
<td>Effect Mechanism</td>
<td>Measurement Parameter</td>
<td>Design Alternative</td>
<td>Effect</td>
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<td>---------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total pile driving days (including</td>
<td>All</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>removal)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction and installation duration</td>
<td>All</td>
<td>12 weeks</td>
<td></td>
</tr>
<tr>
<td>Sea-to-shore transition</td>
<td>No Containment</td>
<td>Dredged HDD exit pit</td>
<td>All</td>
<td>0.042 acre (0.017 hectare)</td>
<td></td>
</tr>
<tr>
<td>Construction and installation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Underwater noise (suction dredging)</td>
<td>All</td>
<td>172-192 dB re 1 µPa-m</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction and installation duration</td>
<td>All</td>
<td>12 weeks</td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td>Operational EMF</td>
<td>Transmission voltage</td>
<td>12 MW</td>
<td>275 kV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Induced magnetic field**</td>
<td>All</td>
<td>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</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Induced electrical field**</td>
<td>All</td>
<td>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</td>
<td></td>
</tr>
</tbody>
</table>

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.
- 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, 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>
<thead>
<tr>
<th>Proposed Action Element</th>
<th>Construction and Installation Milestone</th>
<th>Activity Duration</th>
<th>Anticipated Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWF</td>
<td>Monopile foundation installation</td>
<td>5 months</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td>Inter-array and OSS-link cable installation</td>
<td>5 months</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td>WTG installation</td>
<td>8 months</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td>OSS installation</td>
<td>8 months</td>
<td>2023</td>
</tr>
<tr>
<td>RWEC</td>
<td>Onshore interconnection facility</td>
<td>18 months</td>
<td>2023-2024</td>
</tr>
<tr>
<td></td>
<td>Sea-to-shore transition</td>
<td>12 months</td>
<td>2023-2024</td>
</tr>
<tr>
<td></td>
<td>Offshore cable installation</td>
<td>8 months</td>
<td>2023</td>
</tr>
<tr>
<td></td>
<td>Onshore cable installation</td>
<td>12 months</td>
<td>2023-2024</td>
</tr>
</tbody>
</table>
Figure 2.2 Revolution Wind Farm Indicative Construction Schedule.
2.2.1 Construction and Installation of WTG/OSS Structures and Foundations

RWF would install up to 100 WTGs and two OSSs within the proposed project area. The approximate configuration of these project features is shown in Figure 2.3. 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 RWF. 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 RWF 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 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
Figure 2.3. Locations of WTGs and OSSs (VHB 2022).
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.

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>Number of Vessels</th>
<th>Foundations</th>
<th>OSS</th>
<th>RWEC</th>
<th>IAC</th>
<th>OSS-Link Cable</th>
<th>WTGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jack-up Installation Vessel</td>
<td>1-2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Jack-up Feeder/Supply Vessel</td>
<td>5-9</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crew Transfer Vessel (CTV)</td>
<td>6-8</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Material Barge</td>
<td>3-6</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder Barge</td>
<td>3-6</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tow Tug</td>
<td>2-6</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anchor Handling Tug</td>
<td>2-5</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Support Vessel – Inflatable</td>
<td>1-2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rock Installation Vessel</td>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunkering Vessel</td>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helicopter</td>
<td>1-2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foundation Installation Vessel</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy Transport Vessel</td>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Array Installation Vessel (CLV)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Array Cable Burial</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport Freighter</td>
<td>1</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Operation Vessel (SOV)</td>
<td>2</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pre-Lay Grapnel Run (PLGR)</td>
<td>1</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Survey Vessel</td>
<td>1</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable Lay Vessel (Export)</td>
<td>1</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cable Lay Vessel (Barge)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Export Burial Vessel</td>
<td>1</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support Tug</td>
<td>1</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Table 2.4. Number of Vessels and Vessel Trips Required for Project Construction and Installation, and Typical Operational Speeds, and Draft by Vessel Type.

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>Number of Vessels Used for Construction</th>
<th>Maximum Number of Round Trips (\text{‡} )</th>
<th>Typical Operational Speed (knots)</th>
<th>Approximate Vessel Draft (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchor Handling Tug</td>
<td>7</td>
<td>121</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Array Cable Burial Vessel</td>
<td>1</td>
<td>1</td>
<td>11 (1)(^{\text{a}})</td>
<td>5</td>
</tr>
<tr>
<td>Array Installation (CLV)</td>
<td>1</td>
<td>1</td>
<td>12 (1)(^{\text{a}})</td>
<td>5</td>
</tr>
<tr>
<td>Bunkering Vessel</td>
<td>1</td>
<td>28</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Export Cable Lay Vessel</td>
<td>1</td>
<td>1</td>
<td>12 (1)(^{\text{a}})</td>
<td>5</td>
</tr>
<tr>
<td>Crew Transport Vessel</td>
<td>11</td>
<td>269</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Export Cable Burial Vessel</td>
<td>2</td>
<td>2</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Barge – Towing Tug</td>
<td>6</td>
<td>110</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Barge – Cable Lay</td>
<td>2</td>
<td>2</td>
<td>12 (1)(^{\text{a}})</td>
<td>7</td>
</tr>
<tr>
<td>Barge – Feeder</td>
<td>6</td>
<td>110</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Barge – Material</td>
<td>6</td>
<td>110</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Foundation Installation Vessel</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>13.5</td>
</tr>
<tr>
<td>Foundation Supply Vessel</td>
<td>7</td>
<td>110</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Heavy Transport Vessel</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>6.5</td>
</tr>
<tr>
<td>Jack-up Feeder Vessel</td>
<td>2</td>
<td>45</td>
<td>10</td>
<td>6.5</td>
</tr>
<tr>
<td>Jack-up Installation Vessel</td>
<td>2</td>
<td>7</td>
<td>8</td>
<td>6.5</td>
</tr>
<tr>
<td>Pre-lay Grapnel Run Vessel</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Rock Dumping Vessel</td>
<td>1</td>
<td>28</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Service Operations Vessel</td>
<td>5</td>
<td>16</td>
<td>22</td>
<td>7.5</td>
</tr>
<tr>
<td>Support Vessel - Inflatable</td>
<td>2</td>
<td>n/a</td>
<td>10</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Survey Vessel</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Transport Freighter</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>6.5</td>
</tr>
<tr>
<td>Tug (Support Tug)</td>
<td>4</td>
<td>4</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

\(^{\text{‡}}\) Round trips are trips between the RWF and RWEC corridor and area ports used for project construction.

\(^{\text{a}}\) Speeds shown are general transit speeds and typical speeds during cable installation in parentheses. The majority of cable laying vessels 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 21.1 acres (8.5 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, sandwave (i.e., ripple and mega-ripple) leveling, 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. Large seabed ripples would be leveled using methods similar to those described in Section 2.2.2.2 for transmission cable installation.

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

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

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

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 anticipates that Munitions and Explosives of Concern/Unexploded Ordnance (MEC/UXO) may be encountered within the RWF and along the RWEC route. Avoidance is the preferred approach for MEC/UXO mitigation; however, it is anticipated that there may be instances where confirmed MEC/UXO avoidance is not possible 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. 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 previously designated disposal areas. Relocated devices would either be secured for wet storage or disposal through low noise methods as described for in situ disposal. Revolution Wind has estimated that to 13 UXOs, ranging from 5 to 1,000 pounds in size, could be encountered that cannot be safely relocated. These devices would be detonated in place. The actual number and location of UXOs in the project area is not currently known. However, the areas having the highest probability of device encounters are the central portion of the RWF and along the RWEC corridor in state waters approaching the entrance to Narragansett Bay (Ordtek, Inc. [Ordtek] 2021). Any UXO/MEC detonation would be conducted using a sound attenuation device capable of achieving at least 10 decibels (dB) sound reduction.

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 at RWF 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.

The aforementioned timing constraints would also provide some level of protection for spawning Atlantic cod, which are known to spawn from winter to early spring. Subsequent to COP development, new information has emerged indicating that Atlantic cod spawning occurs within the RWF and vicinity during the months of November and December (BOEM pers. comm. 2021; Inspire Environmental 2020a), indicating the potential for negative effects on Atlantic cod spawning. Moreover, the affected spawning aggregation appears to be a reproductively isolated stock (McBride and Smedbol 2022), and any negative effects could potentially be significant. These findings have influenced the development of a new Habitat Area of Particular Concern (HAPC) designation (see Section 4.2.2) that includes the RWF. See Section 6 for information.
regarding mitigations BOEM could impose to offer further protections to spawning Atlantic cod within the project area.

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 102 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/m³
- 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

Offshore, the RWEC would include two 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 required sandwave leveling, dredging, and boulder clearance. 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).

In areas with dense boulder fields or extensive sand ripples, a displacement plow may be used to remove boulders and flatten the seabed within the cable corridor. 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 clear the corridor of boulders, but not create a deep depression in the seabed. 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 Assessment. If necessary, dredging may be used to achieve the desired burial depths in selected areas. All dredging activities would occur within the general 131 foot (40 meter) wide impact corridor for cable installation activities. Dredged materials would be backfilled into the cable trench to achieve desired burial depths. Where 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.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Construction and Installation Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Lay Cable Surveys</td>
<td>Prior to installation, geophysical surveys would be performed to check for debris and obstructions that may affect cable installation</td>
</tr>
<tr>
<td>Seabed Preparation</td>
<td>Seabed preparation would include required sandwave leveling, boulder clearance and removal of 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.</td>
</tr>
<tr>
<td>Pre-Lay Grapnel Run</td>
<td>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 appropriate licensed disposal ashore.</td>
</tr>
<tr>
<td>Cable Installation</td>
<td>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. Dredging would be used to achieve deeper cable burial depths at selected locations along the RWEC route having high levels of sediment mobility.</td>
</tr>
<tr>
<td>Joint Construction</td>
<td>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.</td>
</tr>
<tr>
<td>Cable Installation Surveys</td>
<td>Cable installation surveys would be required, including pre- and post-installation surveys, to determine the actual cable burial depth. Depending on the instruments selected, type of survey, length of cable, etc. the survey would be completed by equipment mounted to a vessel and/or remote operated vehicle.</td>
</tr>
<tr>
<td>Cable Protection</td>
<td>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).</td>
</tr>
<tr>
<td>Connection to OSS and WTGs</td>
<td>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.</td>
</tr>
</tbody>
</table>

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 would include activities such as sandwave leveling and boulder clearance. Use of high-resolution geophysical (HRG) surveys may be used to identify areas where boulders occur, identify potential areas where micrositing could avoid boulders, or help to determine appropriate clearance methods to relocate boulders. Boulder clearance would occur before construction begins to prepare for trenching and burial operations. A pre-lay grappnel run will also be completed to clear cable routes of possible obstructions (e.g., derelict fishing nets, lobster pots, or rope) prior to installation. Seafloor preparation will occur within a 131-ft (40-m) -wide corridor along submarine cable routes and within a 656-ft (200-m) radius around WTG and OSS foundation locations.

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

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

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

The WTG and OSS foundations will be placed in areas where large boulders or debris may be present. Foundations would be microsited to avoid large-grained complex and complex habitat to the extent practicable. Boulder and debris clearance will occur prior to cable installation and will be completed by a support vessel based on pre-construction surveys.

Dredging would be used on portions of the RWEC route to level sandwaves and achieve deeper cable burial depths in areas having high levels of sediment mobility. Dredging would occur along approximately 16.9 km (10.5 miles) of the RWEC route for each cable, approximately 60 percent occurring in federal waters and the remainder in state waters (RPS 2021). Dredging equipment may include a trailing suction hopper dredger or controlled flow excavation (CFE). Sediments removed during dredging for cable installation would be backfilled within the
excavation area. The impacts associated with these methods would be similar in magnitude. A summary of these methods as described in the COP (VHB 2022) is provided below.

- **Trailing suction hopper dredge**: Used for dredging loose and soft soils such as sand, gravel, silt or clay. One or two suction tubes, equipped with a drag head, are lowered on the seabed, and the drag head is trailed over the bottom to excavate a trench. This method is typically used for sandwave leveling.

- **CFE** is a non-contact methodology. The jetting tool draws in seawater from the sides and then jets this water out at a specified pressure and volume. The tool can be positioned over the sandwaves to level the seabed.

### 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, mechanical plow, and mechanical dredging. 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; however, over time this will backfill to the original seabed level. No permanent seabed impacts are associated with this installation methodology.

**Mechanical Plowing**: Two methods are being considered:
• **Simultaneous lay and bury** involves pulling a 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; however, over time this will restore to the original seabed level. No permanent seabed impacts are associated with this installation methodology.

• **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). Given that the tool is commonly used to target challenging ground conditions (i.e., very hard soils and/or where subsurface boulder risk is high), the disturbed area created by the plow is not expected to recover quickly. The volume of disturbed material is calculated as the cross-sectional area of the trench along its length; the disturbed area also includes the temporary berms created on the seabed. Temporary seabed impacts include the total area of the skids in contact with the seabed, the trench itself, and spoil on the sides of the trench.

### 2.2.2.4 Cable Protection

The WTGs would be linked to the RWE 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

The RWF would use 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. RWF WTGs would be regularly inspected and maintained by service technicians delivered by a dedicated CTV from the O&M facility. Revolution Wind estimates approximately seven routine maintenance trips to and from the RWF each month over the 35-year lifetime of the project. As discussed in Section 5.1.3, vessel anchoring for maintenance would avoid sensitive habitats to avoid significant impacts.

Various vessels would be used periodically for routine O&M and unplanned maintenance activities as needed (VHB 2022). 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.

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Vessel Type</th>
<th>Foundations</th>
<th>OSS</th>
<th>RWEC</th>
<th>IAC</th>
<th>OSS-Link Cable</th>
<th>WTGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine (e.g., annual maintenance, troubleshooting, inspections)</td>
<td>Service Operations Vessel</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Daughter Craft</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Crew Transfer Vessel/Surface Effects Ship</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Helicopter</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Routine (e.g., major components exchange)</td>
<td>Jack-up Vessel</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Cable-lay/Cable Burial Vessel</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Support Barge</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

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 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.

Up to 1,062 linear miles 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 25 days of HRG survey activity per year.

### 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 10,755 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 248 total vessel days (LGL 2022).

Up to 1,062 linear miles of O&M HRG surveys may be conducted in the RWF and RWEC corridor every year for up to 4 years following the completion of Project construction (LGL 2022). 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 would implement a Fisheries Research and Monitoring Plan (FRMP) as part of the proposed action. 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.

2.4.2.1 Benthic Habitat Monitoring

As discussed in the Fisheries Research and Monitoring Plan (FRMP), Revolution Wind is proposing to conduct benthic monitoring to document the disturbance and recovery of marine benthic habitat and communities resulting from the construction and installation of Project components (Revolution Wind and Inspire 2021), including WTG scour protection as well as the inter-array cabling and offshore export cable corridor from the Wind Development Area to shore. The benthic survey would focus on seafloor habitat and benthic communities and make comparisons to areas unaffected by construction and installation of the Project. Surveys would occur based upon the Project construction and installation schedule but would occur at roughly the same time of year in years 1 and 3 and, if necessary, year 5 post-construction and installation. All survey years may not be completed if the benthic community appears to have recovered and all stakeholders agree that monitoring may cease.

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 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 monopile and the RWEC corridor. 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 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 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 RWF, 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. The following 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 RWF 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 RWF, 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

The environmental baseline considers the existing conditions of EFH in the project area and adjacent areas potentially affected by the project. Revolution Wind had detailed surveys of the Maximum Work Area (MWA) for the Project completed by Inspire (2021) to support preparation of the COP (VHB 2022) and the completion of this EFH assessment. The MWA reasonably represents the potential extent of impacts to the benthic habitat components of EFH in and adjacent to the RWF and along the RWEC corridor including the sea-to-shore transition point. 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.

Benthic surveys were conducted using a combination of high-resolution acoustic, video, and photographic imaging methods. High-resolution multibeam echosounders and side-scan sonar surveys were used characterize bathymetric conditions and substrate composition. SPI/PV imaging was used to ground truth the bathymetric data and characterize biogenic features and the presence of habitat forming organisms (Inspire 2021). The benthic habitat characterization was conducted consistent with NOAA (2021) recommendations for mapping fish habitat. The Inspire (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.

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.

3.1 Habitat Types in the RWF and REWC Footprints

Inspire Environmental (2021) identified several benthic habitats, or macrohabitat types in the area of direct effects: 1) sand sheet, 2) sand with mobile gravel, 3) patchy cobbles and boulders on sand, 4)
patchy pebbles on sand with mobile gravel, 5) mollusk bed on mud, and 6) continuous large pebbles and cobbles on sand.

For the purposes of analysis, these various macrohabitat types are consolidated into three groups: 1) complex habitat, 2) large-grained complex habitat, and 3) soft-bottomed. For the benthic habitat, substrate groups are based on sediment grain size and composition, and their associated uses by marine organisms. Habitat conversion impacts resulting from the project are quantified in Section 5 using these three benthic habitat groups. These three benthic habitat types are defined as follows:

- **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)

- **Large-grained complex habitat**: large boulders and bedrock

- **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 provide 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. Inspire Environmental (2021) provides photographic examples of each habitat type. Inspire Environmental (2021) characterized benthic habitat composition within the MWA for the RWF and the RWEC route alternatives using these three habitat categories. The distribution of complex, large-grained complex, and soft bottom benthic habitats within the RWF and RWEC footprints is shown in Figures 3.1 and 3.2, respectively. The surveyed area and proportional distribution of benthic habitat types within these respective footprints are summarized in Table 3.1.
Figure 3.1. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats and CMECS Substrate Classifications within the RWF Project Footprint (Inspire 2021).
Figure 3.2. Distribution of Large-grained Complex, Complex, and Soft Bottom Benthic Habitats and CMECS Substrate Classifications within the RWEC Project Footprint (Inspire 2021).
Table 3.1. Total Survey Acres and Proportional Composition of Benthic Habitat Types in the RWF and RWEC MWAs.

<table>
<thead>
<tr>
<th>Area</th>
<th>Total Survey Acres and Proportional Composition</th>
<th>Large-Grained Complex</th>
<th>Complex</th>
<th>Soft Bottomed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revolution Wind Farm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MWA</td>
<td>Area – acres (hectares)</td>
<td>11,128 (4,503)</td>
<td>17,450 (7,062)</td>
<td>29,563 (11,964)</td>
<td>58,141 (23,529)</td>
</tr>
<tr>
<td></td>
<td>Percentage of Survey Area</td>
<td>19%</td>
<td>30%</td>
<td>51%</td>
<td>100%</td>
</tr>
<tr>
<td>Revolution Wind Export Cable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Outer Continental Shelf</td>
<td>Cable Installation Corridor Area – acres (hectares)</td>
<td>32 (13)</td>
<td>1,617 (654)</td>
<td>3,380 (1,368)</td>
<td>5,029 (2,035)</td>
</tr>
<tr>
<td></td>
<td>Percentage of Survey Area</td>
<td>1%</td>
<td>32%</td>
<td>67%</td>
<td>100%</td>
</tr>
<tr>
<td>Revolution Wind Export Cable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Rhode Island</td>
<td>Cable Installation Corridor² Area – acres (hectares)</td>
<td>177 (72)</td>
<td>817 (331)</td>
<td>4,710 (1,906)</td>
<td>5,704 (2,308)</td>
</tr>
<tr>
<td></td>
<td>Percentage of Survey Area</td>
<td>3%</td>
<td>14%</td>
<td>83%</td>
<td>100%</td>
</tr>
</tbody>
</table>

² Includes the sea-to-shore transition site, which covers approximately 3.1 acres composed entirely of soft-bottomed benthic habitat.

Benthic habitats are periodically exposed to natural and anthropogenic disturbance. Fine sediments in soft bottom benthic habitat are often mobile and can be redistributed during large storm events, leading to shifts in the position of sand ripples and depressions.

Benthic habitats in the RWF and RWEC are also subjected to periodic disturbance by bottom-disturbing commercial fishing methods like bottom trawls, scallop and clam dredges, and lobster pots, which are the dominant gear types used in the project area (VHB 2022). Fisheries using bottom gear in the New England and Mid-Atlantic management regions accounted for total annual revenues over $900 million between 2008 and 2018. 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 RWF 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. Table 3.2 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.

Table 3.2. Percent of Stations by Attached Fauna Coverage Density Category Observed in SPI/PV Imagery by Project Component and Benthic Habitat Type.

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Benthic Habitat Type</th>
<th>Number of SPI/PV Stations in Habitat Type</th>
<th>None</th>
<th>Trace (&lt;1%)</th>
<th>Sparse (1 to &lt;30%)</th>
<th>Moderate (30 to &lt;70%)</th>
<th>Dense (70 to &lt;90%)</th>
<th>Complete (90-100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWF</td>
<td>Large-grained complex</td>
<td>34</td>
<td>12%</td>
<td>18%</td>
<td>21%</td>
<td>24%</td>
<td>15%</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Complex</td>
<td>67</td>
<td>54%</td>
<td>31%</td>
<td>7%</td>
<td>6%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Soft-bottomed</td>
<td>131</td>
<td>92%</td>
<td>7%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>RWEC-OCS</td>
<td>Complex</td>
<td>7</td>
<td>57%</td>
<td>0%</td>
<td>14%</td>
<td>14%</td>
<td>14%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Soft-bottomed</td>
<td>12</td>
<td>92%</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>RWEC-RI</td>
<td>Large-grained complex</td>
<td>1</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Complex</td>
<td>7</td>
<td>29%</td>
<td>0%</td>
<td>43%</td>
<td>14%</td>
<td>0%</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Soft-bottomed</td>
<td>26</td>
<td>85%</td>
<td>4%</td>
<td>8%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

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.

Bedform (i.e., sandwaves, ripples and mega-ripples) and biogenic features (i.e., worm tubes, burrows, and depressions formed by fish and invertebrates) are other features of benthic habitat.
Table 3.3 provides the mapped area of bed form features and extent of benthic habitat categories in each bedform feature. No sandwaves were identified within the RWF and RWEC, but extensive patches of ripples and mega-ripples are present. Ripples are most prevalent within the RWF in complex habitats and in the RWEC-OCS in soft-bottomed habitats, while mega-ripples are prevalent in the RWF and RWEC-OCF in complex habitats primarily and secondarily in large-grained complex (in RWF) and complex (RWEC-OCS). Ripples are present along a limited portion of the RWEC-RI corridor (Inspire 2021).

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

<table>
<thead>
<tr>
<th>Project Element</th>
<th>Bedform Feature</th>
<th>Large-grained complex</th>
<th>Complex</th>
<th>Soft-bottomed</th>
<th>Anthropogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWF</td>
<td>Total mapped area</td>
<td>11,128</td>
<td>17,451</td>
<td>29,563</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Mega-ripples</td>
<td>926</td>
<td>838</td>
<td>6,977</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Ripples</td>
<td>10,864</td>
<td>17,079</td>
<td>25,670</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Linear Depressions</td>
<td>33.1</td>
<td>360</td>
<td>20,142</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Trawl Scars</td>
<td>4.4</td>
<td>429</td>
<td>16,590</td>
<td>0</td>
</tr>
<tr>
<td>RWEC-OCS</td>
<td>Mapped Area</td>
<td>32.3</td>
<td>1,616</td>
<td>3,380</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Mega-ripples</td>
<td>0</td>
<td>142</td>
<td>1,892</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Ripples</td>
<td>0.7</td>
<td>855</td>
<td>1,655</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Linear Depressions</td>
<td>0</td>
<td>124</td>
<td>1,092</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Trawl Scars</td>
<td>0</td>
<td>33.0</td>
<td>816</td>
<td>--</td>
</tr>
<tr>
<td>RWEC-RI</td>
<td>Mapped Area</td>
<td>176.0</td>
<td>816</td>
<td>4,709</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td>Mega-ripples</td>
<td>0</td>
<td>0</td>
<td>1,309</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Ripples</td>
<td>11.0</td>
<td>150</td>
<td>1,980</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Linear Depressions</td>
<td>0</td>
<td>14.9</td>
<td>836</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Trawl Scars</td>
<td>0</td>
<td>629</td>
<td>1,914</td>
<td>0</td>
</tr>
</tbody>
</table>

Biogenic features were recorded throughout the RWF, RWEC-OCS and RWEC-RI in SPI/PV imaging. A total of 285 photographic stations were collected throughout the RWF 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 2021). Table 3.4 provides a summary of the biogenic features observed in SPI/PV imagery for each project component and benthic habitat type.
Table 3.4. Percent of Stations with Biogenic Features Observed in SPI/PV Imagery by Project Component and Benthic Habitat Type.

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Benthic Habitat Type</th>
<th>Number of SPI/PV Stations in Habitat Type</th>
<th>Amphipod Tubes</th>
<th>Burrows</th>
<th>Tracks</th>
<th>Seapens</th>
<th>Other Epifauna‡</th>
<th>Hard Coral (non-reef)</th>
<th>Sea Scallop</th>
<th>Non-native Species¥</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWF</td>
<td>Large-grained complex</td>
<td>34</td>
<td>97%</td>
<td>91%</td>
<td>50%</td>
<td>59%</td>
<td>100%</td>
<td>12%</td>
<td>0%</td>
<td>41%</td>
</tr>
<tr>
<td></td>
<td>Complex</td>
<td>67</td>
<td>84%</td>
<td>97%</td>
<td>52%</td>
<td>34%</td>
<td>100%</td>
<td>0%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Soft-bottomed</td>
<td>131</td>
<td>99%</td>
<td>92%</td>
<td>73%</td>
<td>5%</td>
<td>100%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>RWEC-OCS</td>
<td>Complex</td>
<td>7</td>
<td>71%</td>
<td>100%</td>
<td>14%</td>
<td>14%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Soft-bottomed</td>
<td>12</td>
<td>100%</td>
<td>83%</td>
<td>67%</td>
<td>8%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>RWEC-RI</td>
<td>Large-grained complex</td>
<td>1</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Complex</td>
<td>7</td>
<td>71%</td>
<td>43%</td>
<td>29%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Soft-bottomed</td>
<td>26</td>
<td>88%</td>
<td>85%</td>
<td>92%</td>
<td>0%</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

‡ Other epifauna covers a diverse array of species including barnacles, bryozoans, crabs, corals, sponges, hydroids, sea stars, and other organisms. See Appendix A for detailed list by SPI/PV location.

¥ Possible Botryllloides sp. Observations.
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 RWF 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 3.3 and 3.4, respectively.

Section 4.3.3 of the COP details existing pelagic habitat conditions (i.e., dissolved oxygen; chlorophyll; nutrient content; seasonal variations in algae or bacterial content; upwelling conditions; contaminants in water or sediment; and turbidity or water visibility). The RWF and RWEC are located in temperate waters and, therefore, subjected to highly seasonal variation in temperature, stratification, and productivity. Overall, pelagic habitat quality within the RWF and offshore components of the RWEC is considered fair to good (U.S. Environmental Protection Agency [USEPA] 2015).

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).
Figure 3.3. Surveyed Bathymetry within the RWF Project Footprint and Vicinity (Inspire Environmental 2021).
Figure 3.4. Surveyed Bathymetry within the RWEC Project Footprint and Vicinity (Inspire Environmental 2021).
3.2 Habitat Types by Project Component

The environmental baseline incorporates updated recommendations from NOAA (2021) regarding mapping fish habitat. 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. Table 3.5 provides the area of habitat types mapped within the Maximum Work Area for the RWF and the RWEC.

Table 3.5. Habitat Composition Within the Maximum Work Area by Project Component.

<table>
<thead>
<tr>
<th>Habitat Types</th>
<th>RWF§ (acres)</th>
<th>RWEC-OCS (acres)</th>
<th>RWEC-RI, including the Sea-to-Shore Transition Area (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocky</td>
<td>27,812</td>
<td>1,406</td>
<td>352</td>
</tr>
<tr>
<td>Soft bottom mud</td>
<td>1,509</td>
<td>657</td>
<td>2,226</td>
</tr>
<tr>
<td>Soft bottom sand</td>
<td>29,926</td>
<td>2,965</td>
<td>3,149</td>
</tr>
<tr>
<td>Submerged Aquatic Vegetation (SAV)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tidal Marsh†</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Shell accumulations†</td>
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Source: Inspire 2021
No port facility improvements are proposed as part of the proposed action. No O&M facility development activities are proposed that would impact EFH.

§ Totals are not for the Lease Area, but the Maximum Work Area (Inspire 2021)
† These features are or may be present and observed in SPI/PV imagery but were not mapped by Inspire (2021).

3.2.1 Lease Area

Regional and WEA-specific benthic habitat mapping (Collie and King 2016; Mid-Atlantic Regional Council on the Ocean [MARCO] 2019) provide useful characterization of benthic habitat conditions in the project area. The OCS within and surrounding the project area is characterized by a gradually sloping seabed from the shoreline to the RWF, which is located in waters less than approximately 164 feet (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 RWF footprint. Inspire Environmental (2021) has collected extensive side scan sonar and backscatter data to determine site-specific benthic habitat conditions as part of the EFH analysis.

Sediment profile and plan view images (SPI/PV) were collected at 230 stations within the RWF in July 2019 (Inspire 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. SPI/PV images were analyzed for a suite of variables and were classified using CMECS Substrate and Biotic components.

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

The RWF is 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 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 RWF 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).

### 3.2.2 Offshore/Onshore Export Cable

Similarly, MARCO (2019), BOEM (Guida et al. 2017), and Revolution Wind (Inspire Environmental 2021) have conducted large-scale general benthic habitat mapping along the RWEC corridor (COP Appendix X2). Inspire Environmental (2021) has collected extensive side scan sonar and backscatter data to determine site-specific benthic habitat conditions as part of the EFH analysis.

#### 3.2.2.1 Export Cable Route

The RWEC is broken into two segments, the RWEC-OCS that traverses federal waters and the RWEC-RI, which traverses Rhode Island state waters. Sediment profile and plan view images (SPI/PV) were collected at 19 stations along the RWEC-OCS Study Area, and 34 stations along the RWEC-RI Study Area in July 2019 (Inspire 2021). Presence of attached fauna, bedform features, and proportion of stations with biogenic features present at each of these stations are summarized in Tables 3.2 to 3.4, respectively. Portions of the RWEC-RI corridor are in proximity to shellfish aquaculture lease areas authorized by the RI Department of Environmental Management (RIDEEM). These lease areas are displayed in Figure 3.5. No equivalent information is available for naturally occurring shellfish beds, as RIDEEM does not map or maintain geographic information on these resources.
Figure 3.5. Location of Aquaculture Lease Areas in Proximity to RWEC-RI Corridor.
The RWEC-OCS is located in offshore marine waters, similar to the RWF and water quality is similar to that described above for the RWF. 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 RWF 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).

Similar to the RWF, a uniform current of 1 meter per second (m/s) flowing at right angles to the natural magnetic field occurring within the RWEC could induce a steady-state electrical field on the order of 51.5 microvolts per meter (µV/m). 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.

### 3.2.2.2 Landing Area

A towed video survey along 52 transect lines was conducted near the RWEC-RI landfall at Quonset Point (Inspire 2021). 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 (Inspire 2021). The Benthic Habitat Mapping report is provided as Appendix A of this EFH Assessment.
3.2.2.3 Interior Coast

See Section 3.1.2.1 Export Cable Route.
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.

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<th>Life Stage</th>
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<th>Primary Prey Association</th>
<th>Timing of Occurrence</th>
<th>Exposure to Project Effects by Impact Category</th>
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<th>Atlantic Yellowfin</th>
<th>Sand tiger shark</th>
<th>Smooth dogfish</th>
<th>Spiny dogfish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult (m)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Eggs: S, P, BC/B/E/D
Larvae: S
Juvenile: BS, BC/ES
Adult: BS
Spawning: BS, BC/ES
Plank: P
Pel: P

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<table>
<thead>
<tr>
<th>Skates</th>
<th>Barndoor skate</th>
<th>Juvenile</th>
<th>BS/BC</th>
<th>B/E/D</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Adult</td>
<td>BS/BC</td>
<td>B/E/D</td>
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<tr>
<td>Little Skate</td>
<td>Juvenile</td>
<td>BS/BC</td>
<td>B/E/D</td>
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<td></td>
<td>Adult</td>
<td>BS/BC</td>
<td>B/E/D</td>
<td></td>
</tr>
<tr>
<td>Winter Skate</td>
<td>Juvenile</td>
<td>BS/BC</td>
<td>B/E/D</td>
<td></td>
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<tr>
<td></td>
<td>Adult</td>
<td>BS/BC</td>
<td>B/E/D</td>
<td></td>
</tr>
<tr>
<td>Invertebrates</td>
<td>Atlantic sea scallop</td>
<td>Eggs</td>
<td>BC</td>
<td>Plank</td>
</tr>
<tr>
<td></td>
<td>Larvae</td>
<td>P/BC</td>
<td>Plank</td>
<td></td>
</tr>
<tr>
<td>Ocean quahog</td>
<td>Juvenile</td>
<td>BS</td>
<td>Plank</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>BS</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Shortfin squid</td>
<td>Juvenile</td>
<td>P</td>
<td>Plank</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>P</td>
<td>Pel</td>
<td></td>
</tr>
<tr>
<td>Longfin squid</td>
<td>Eggs</td>
<td>BC</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Juvenile</td>
<td>P</td>
<td>Pel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>P</td>
<td>Pel</td>
<td></td>
</tr>
</tbody>
</table>

**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 4.2.3): 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, while juvenile and adult Atlantic cod are highly mobile, this species demonstrates high fidelity to specific spawning sites and are sensitive to disturbance during spawning (Dean et al. 2022). As such, this life stage is considered sensitive and vulnerable for the purpose of this EFH assessment. BOEM and other researchers have conducted surveys of the RWF and vicinity 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. Spawning cod detections using PAM and hook and line sampling and supporting information sources are presented in Figures 4.1 and 4.2, respectively.
Figure 4.1. Spawning Atlantic Cod Detections Within the RWF and Vicinity Detected Using Fixed and Glider-Based PAM (BOEM pers. comm. 2022).
Figure 4.2.  Locations of Reproductive Spawning Atlantic Cod Captured Within the RWF and Vicinity Using Hook and Line Sampling (Inspire Environmental 2020a).
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 4.3. 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.
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 4.4. 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 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).

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.

Figure 4.4. Southern New England HAPC Designation.
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 heterogeneous 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.

**Sessile Benthic/Epibenthic – Soft Bottom**

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

- 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)

**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-bottomed 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
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-bottomed habitat. Examples include:

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

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-bottomed 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)

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 (eggs, 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.

<table>
<thead>
<tr>
<th>Hearing Group</th>
<th>Description</th>
<th>Examples</th>
<th>Sensitivity to Sound Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hearing specialists</td>
<td>Fish species having a swim bladder that is connected to the inner ear and involved in hearing.</td>
<td>Atlantic herring, black sea bass, gadids</td>
<td>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.</td>
</tr>
<tr>
<td>Hearing generalists</td>
<td>Fish species having a swim bladder that is not involved in hearing. These species are less reliant on hearing and have lower hearing sensitivity.</td>
<td>Bluefish, butterfish, scup, some tunas</td>
<td>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.</td>
</tr>
<tr>
<td>Species without a swim bladder</td>
<td>Fish without swim bladder or hearing associated gas chamber.</td>
<td>Flatfish, monkfish, sharks, rays, some tunas</td>
<td>These fish species are the least sensitive to hearing and barotrauma injury from intense sound exposure.</td>
</tr>
<tr>
<td>Eggs and larvae</td>
<td>The eggs and larvae of fish and invertebrates</td>
<td>Virtually all EFH species except for live bearing sharks</td>
<td>Lack developed hearing organs and gas-filled internal organs. Low sensitivity to noise impacts</td>
</tr>
<tr>
<td>Invertebrates</td>
<td>Shellfish and cephalopods</td>
<td>Longfin squid, Atlantic scallop</td>
<td>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.</td>
</tr>
</tbody>
</table>

#### 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.
**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.

**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.

**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 Adverse Effects

This section provides an analysis of the effects of the proposed project 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 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 physical, chemical, or biological alterations of waters 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 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>
<thead>
<tr>
<th>Project Phase</th>
<th>Impact Producing Factor</th>
<th>Sources</th>
<th>Duration</th>
<th>Analysis Sections</th>
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<tr>
<td>Construction</td>
<td>Construction noise</td>
<td>• Vessel noise</td>
<td>Short-term</td>
<td>5.1.1.1, 5.1.1.3, 5.1.1.4, 5.1.2.1, 5.1.2.3</td>
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<tr>
<td></td>
<td></td>
<td>• Pre-construction HRG surveys</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Pile driving</td>
<td></td>
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<td></td>
<td></td>
<td>• UXO detonation</td>
<td></td>
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<tr>
<td>Crushing, burial,</td>
<td></td>
<td>• Vessel anchoring</td>
<td>Short-term</td>
<td>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</td>
</tr>
<tr>
<td>entainment</td>
<td></td>
<td>• Seabed preparation/boulder relocation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Installation of foundations and scour protection</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Cable installation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Installation of cable protection</td>
<td></td>
<td></td>
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<tr>
<td>Suspended sediment,</td>
<td></td>
<td>• Vessel anchoring</td>
<td>Short-term</td>
<td>5.1.1.1, 5.1.1.2, 5.1.2.1, 5.1.2.2, 5.1.2.4</td>
</tr>
<tr>
<td>sediment deposition</td>
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<td>• Seabed preparation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Cable installation</td>
<td></td>
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<tr>
<td>Habitat disturbance</td>
<td></td>
<td>• Vessel anchoring</td>
<td>Short-term to</td>
<td>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</td>
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<tr>
<td>and conversion</td>
<td></td>
<td>• Seabed preparation/boulder relocation (soft-bottom habitat)</td>
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<tr>
<td></td>
<td></td>
<td>• Installation of foundations and scour protection</td>
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<td></td>
<td></td>
<td>• Cable installation</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• Installation of cable protection</td>
<td></td>
<td></td>
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<tr>
<td>O&amp;M</td>
<td>Habitat disturbance</td>
<td>• Seabed preparation/boulder relocation (complex habitat)</td>
<td>Long-term to</td>
<td>5.1.3.1, 5.1.3.3, 5.1.4.2</td>
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<tr>
<td></td>
<td>and conversion</td>
<td>• Presence of structures</td>
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<td></td>
<td></td>
<td>• Reef effects</td>
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<td></td>
<td></td>
<td>• Hydrodynamic effects</td>
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<tr>
<td>O&amp;M</td>
<td>Operational noise</td>
<td>• O&amp;M and survey vessel noise</td>
<td>Short-term to</td>
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<tr>
<td></td>
<td></td>
<td>• Sound generated by WTG operations</td>
<td>permanent</td>
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<td></td>
<td></td>
<td>• Post-construction HRG surveys</td>
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<tr>
<td>O&amp;M</td>
<td>EMF/substrate heating</td>
<td>• Power transmission (IAC, OSS-link, RWEC)</td>
<td>Permanent</td>
<td>5.1.4.1</td>
</tr>
<tr>
<td>effects</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Bycatch and incidental</td>
<td>• Fisheries and benthic habitat monitoring</td>
<td>Long-term</td>
<td>5.2.2</td>
</tr>
<tr>
<td>take</td>
<td></td>
<td></td>
<td>intermittent</td>
<td></td>
</tr>
</tbody>
</table>
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; Pile Driving and Seabed Preparation/Boulder Relocation/Dredging; 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.
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 102 monopile foundation sites, and 3,162 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 overlap the general anchoring impacts described above, therefore the total extent of impacts from both anchoring activities is estimated at 3,162 acres. The anticipated distribution of anchoring impacts by 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 19.1% large-grained complex, 30.0% complex, and 50.9% 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-bottomed 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-bottomed habitat through existing boulder fields that have persisted since the project was completed (Garinello and Carey 2020). 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.
Table 5.2. Acres and Proportional Distribution of Benthic Habitat Disturbance by Benthic Habitat Type Associated with Vessel Anchoring.

<table>
<thead>
<tr>
<th>Construction Element</th>
<th>Maximum Construction Disturbance Footprint (acres)</th>
<th>Large-Grained Complex</th>
<th>Complex</th>
<th>Soft Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>General construction vessel anchoring*</td>
<td>3,141</td>
<td>19.1%</td>
<td>30.1%</td>
<td>50.7%</td>
</tr>
<tr>
<td>Jack-up vessel anchoring†</td>
<td>21.1</td>
<td>20.0%</td>
<td>30.1%</td>
<td>49.9%</td>
</tr>
</tbody>
</table>

* 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.
† 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.

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 RWF 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.

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 decibels (dB) sound pressure level (SPL) with the loudest sounds reaching 160 dB SPL (Normandeau Associates 2012). As such, auditory masking effects from anthropogenic sound sources that occur in lower frequency ranges is a particular concern. 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). 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 avoidance reaction initiated by the quieter vessel was stronger and more prolonged than the one initiated by 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 found 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 2008). 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
  
  o 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
  
  o 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**

Squid within 6.6 feet [2 meters] of HRG survey equipment may exhibit behavioral responses to particle motion effects for surveys of the RWF 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 RWF 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.

**Effects**

- 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.

**Potential Introduction of Exotic/Invasive Species via Ballast**

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 levelling of sandwaves and 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 project element 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.

<table>
<thead>
<tr>
<th>Construction Element</th>
<th>Maximum Construction Disturbance Footprint (acres)</th>
<th>Large-Grained Complex (%)</th>
<th>Complex (%)</th>
<th>Soft Bottom (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seafloor preparation*</td>
<td>734</td>
<td>18.9%</td>
<td>29.6%</td>
<td>51.5%</td>
</tr>
</tbody>
</table>

* RWF 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.

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.

**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; 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 RWF project 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. 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. 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 RWF project area could 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.

Lethal entrainment impacts could occur during use of the jet plow for the inter-array cable installation and associated dredging used to achieve deeper cable burial depths at selected locations along the RWEC corridor. Entrainment effects may be reduced if Revolution Wind elects to use a mechanical plow for cable installation instead of a jet plow. Ichthyoplankton could be subject to lethal entrainment impacts as part of that project. This includes direct mortality of EFH ichthyoplankton, and ichthyoplankton prey resources for selected EFH species life stages. Modeling results were based on sampling with 0.02-inch (0.505-mm) mesh nets. This estimate likely includes juveniles of EFH species that may or may not be able to avoid the active construction and installation area. EFH species with benthic or epibenthic juveniles that may be exposed to crushing, burial, or entrainment effects during RWF construction and installation include:
Effects on Habitats Used by Benthic or Epibenthic Adult Fish

EFH species with benthic or epibenthic adults that occur within the RWF project area could 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. Benthic invertebrates and other prey organisms targeted by these species 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)
- 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 RWF project 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 project area for the RWF 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. 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 actual number and location of UXOs is not currently known, but the largest devices are most likely to be found within the central portion of the RWF and in state waters on the RWEC corridor at the mouth and outside of Narragansett Bay (Ordtek 2021). Accordingly, these impact determinations apply to UXO detonation for both WTG and OSS foundation and cable installation. 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.

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).

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:

**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.

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 µPa²s
- 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 µPa²s
- Peak injury, recoverable ($L_{pk}$): >207 dB re 1 µPa
- Cumulative injury, recoverable ($L_{E, 24hr}$): 203 dB re 1 µPa²s
- TTS \( (L_{E, 24hr}) \): 186 dB re 1 µPa²s
- Behavioral response \( (L_{rms}) \): 150 dB re 1 µPa

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

- Lethal injury: Unlikely to occur
- Cumulative injury, recoverable \( (L_{E, 48hr}) \): 170 dB re 1 µPa²s
- 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 µPa²s
- Peak injury, recoverable \( (L_{pk}) \): >207 dB re 1 µPa
- Cumulative injury, recoverable \( (L_{E, 24hr}) \): 203 dB re 1 µPa²s
- TTS \( (L_{E, 24hr}) \): >186 dB re 1 µPa²s
- Behavioral response \( (L_{rms}) \): 150 dB re 1 µPa

And for continuous noise sources like vessel engines, dredging, 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 µPa²s
- Peak injury, recoverable \( (L_{pk}) \): >213 dB re 1 µPa
- Cumulative injury, recoverable \( (L_{E, 24hr}) > 216 \text{ dB re } 1 \mu \text{Pa}^2 \text{s} \)
- TTS \( (L_{E, 24hr}) \): much greater than \((>>)186 \text{ dB re } 1 \mu \text{Pa}^2 \text{s}\)
- Behavioral response \( (L_{rms}) \): 150 dB re 1 \mu \text{Pa} \\

And for continuous noise sources like vessel engines, dredging, 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). 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). Jones et al. (2020, 2021) evaluated 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. Other researchers have found evidence of cephalopod sensitivity to continuous low frequency sound exposure comparable to sound sources like vibratory pile driving (Andre et al. 2011).

Based on the available evidence, the following threshold distances are used to evaluate noise effects on EFH for invertebrates:

- 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:
  o Within 6.6 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.

<table>
<thead>
<tr>
<th>Activity†</th>
<th>Number of Sites</th>
<th>Total Days</th>
<th>Noise Exposure Type</th>
<th>Hearing Group</th>
<th>Exposure Threshold*</th>
<th>Range of Threshold Distances (feet)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-meter WTG monopile foundation installation</td>
<td>100</td>
<td>33</td>
<td>Peak injury</td>
<td>Fish–Swim bladder involved in hearing</td>
<td>207</td>
<td>69-371</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish–Swim bladder not involved in hearing</td>
<td>207</td>
<td>69-371</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish–No swim bladder</td>
<td>213</td>
<td>13-59</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Eggs and larvae</td>
<td>207</td>
<td>69-371</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cumulative Injury</td>
<td>Fish–Swim bladder involved in hearing</td>
<td>207</td>
<td>3,848-5,883</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish–Swim bladder not involved in hearing</td>
<td>210</td>
<td>2,470-3,638</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish–No swim bladder</td>
<td>219</td>
<td>604-856</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Eggs and larvae</td>
<td>210</td>
<td>2,470-3,638</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TTS</td>
<td>All fish</td>
<td>186</td>
<td>23,094-43,842</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Behavioral effects</td>
<td>All fish</td>
<td>150</td>
<td>14,403-34,987</td>
</tr>
<tr>
<td>15-meter OSS monopile foundation installation</td>
<td>2</td>
<td>2</td>
<td>Peak injury</td>
<td>Fish–Swim bladder involved in hearing</td>
<td>207</td>
<td>125-299</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish–Swim bladder not involved in hearing</td>
<td>207</td>
<td>125-299</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish–No swim bladder</td>
<td>213</td>
<td>33-62</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Eggs and larvae</td>
<td>207</td>
<td>125-299</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cumulative Injury</td>
<td>Fish–Swim bladder involved in hearing</td>
<td>207</td>
<td>3,885-5,194</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fish–Swim bladder not involved in hearing</td>
<td>210</td>
<td>2,756-3,458</td>
</tr>
</tbody>
</table>
### 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. 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.

Fish eggs and larvae are potentially susceptible to injury and mortality from intense underwater noise. Impact pile driving and UXO detonation are the only construction noise sources likely to produce injury-level effects on eggs and larvae. This level of effect could occur within approximately 2,470 to 3,683 feet and 2,756 to 3,458 feet of WTG and OSS monopile installations, respectively, and within 148 to 1,384 feet of UXO detonations depending on the size of the device. However, the extent and consequences of exposure are likely to vary. 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:
  o Instantaneous injury: Up to approximately 69-371 feet (21-113 meters) of the source
  o Cumulative injury: Up to approximately 6,562-9,357 feet (2,000-2,852 meters) of the source

• TTS and behavioral level:
  o TTS exposure: Up to approximately 23,094-43,842 feet (7,039-13,363 meters) of the source
  o 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 are particularly sensitive to noise and other forms of disturbance during spawning, which can lead to longer-term and more consequential effects. 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 altogether under conditions of intense disturbance (Andersson et al. 2017; Dean et al. 2012; Engås et al. 1996; Meuller-Blenke et al. 2010).

New scientific information indicates that the Atlantic cod that occur within in and around the RWF are a reproductively isolated population. As such, the potential for population level effects from construction-related impact pile driving and other noise sources is an issue of particular concern. Historically, Atlantic cod have been managed in U.S. waters as two units; the Gulf of Maine and the Georges Bank management units. Recently, an Atlantic Cod Stock Structure Working Group (ACSSWG) was formed and identified a number of mismatches between the current management units and biological stock structure and proposed a new biological stock structure that accounts for in-shore and off-shore separation and spawn timing. McBride and Smedbol (2022) summarize several lines of evidence supporting the conclusion that the Atlantic cod found in the southern New England waters of the Mid-Atlantic Bight are one of five reproductively isolated spawning stocks that occur in U.S. waters. The Southern New England stock spawns on and around Cox Ledge, within and in the vicinity of the RWF (Inspire Environmental 2019a, 2019b; BOEM pers comm. 2021). Cod display high spawning site fidelity, meaning that a spawning population will return to the same locations year after year (McBride and Smedbol 2022), and the cod that spawn within the RWF have demonstrated fidelity to this site over 3 consecutive years of monitoring (BOEM pers. comm. 2021). This stock generally spawns twice per year, with spring-spawning peaking in May-June and winter spawning peaking in November-December (McBride and Smedbol 2022), with the latter documented within the RWF (BOEM pers comm. 2021). 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), raising concerns about noise impacts from the Proposed Action. 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 RWF 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 the hearing specialist group would be affected. 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)

- 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)
· Barndoor skate (juvenile, adult)
· Little skate (juvenile, adult)
· Winter skate (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. These organisms are therefore relatively insensitive to intense underwater noise. Popper et al. (2014) were unable to identify useful particle motion thresholds for injury or behavioral-level effects. However, the extent of potential behavioral effects on EFH invertebrate species and invertebrates that provide prey for EFH species can be inferred by comparing noise levels for impulsive noise sources to those evaluated in recent studies (Carroll et al. 2016; Edmonds et al. 2016; Jones et al. 2020, 2021; Hawkins and Popper 2014; Payne et al. 2007). Continuous noise sources like vessel engines are unlikely to produce behavioral effects in invertebrates.

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.

Bivalves, crustaceans, and other benthic invertebrates are far less sensitive to particle motion effects, becoming unresponsive to intense noise sources like impact pile driving within approximately 7 feet (2 meters) of the source. Bivalve EFH species and other benthic invertebrate prey organisms are unlikely to be close enough to HRG survey equipment to detect particle motion 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.

The total spatial extent of impact includes the permanent footprint of the monopiles and scour protection (approximately 3.1 acres and 71 acres [1.25 hectares and 29 hectares], respectively), as well as seabed preparation including up to approximately 31 acres (13 hectares) per monopile. Total area impacted by monopile installation, scour protection and seabed preparation would be approximately 3,174 acres (1,284 hectares). Inspire (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 (2021), it is assumed that of the 102 monopiles to be installed within the RWF; 49 percent would be in Soft Bottom Habitat, 32 percent would be in Complex Habitat, and 19 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 3,172 acres (1,284 hectares) of seabed preparation would occur in Complex and Large-Grained Complex habitat categories mapped within the 82,732-acre Lease Area. Potential crushing, burial, and entrainment impacts could occur throughout the total footprint estimated for each option.

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

<table>
<thead>
<tr>
<th>Monopile Element</th>
<th>Complex Acres (Hectares)</th>
<th>Large-Grained Complex Acres (Hectares)</th>
<th>Soft Bottom Acres (Hectares)</th>
<th>Total Acres (Hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-meter diameter monopile†</td>
<td>1.5 (0.6)</td>
<td>0.1 (0.05)</td>
<td>1.4 (0.6)</td>
<td>3.0 (1.2)</td>
</tr>
<tr>
<td>15-meter diameter monopile†</td>
<td>0.04 (0.02)</td>
<td>0</td>
<td>0.04 (0.02)</td>
<td>0.08 (0.04)</td>
</tr>
<tr>
<td>Scour protection‡</td>
<td>34 (14)</td>
<td>1 (0.4)</td>
<td>36 (15)</td>
<td>71 (29)</td>
</tr>
</tbody>
</table>

† 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 WTG and OSS foundations, respectively, and an estimated 0.71 acre of rock scour protection placed in a circular area around each monopile. Both monopile and scour protection impacts occur within the seafloor preparation footprint and are overlapping impacts.

‡ 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.

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, and either of these methods combined with mechanical dredging at selected locations along the RWEC route where deeper cable depths are required. 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.

The extent of anchoring impacts from cable installation and distribution of impacts by habitat type are summarized Table 5.6.

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

<table>
<thead>
<tr>
<th>Construction Element</th>
<th>Maximum Construction Disturbance Footprint - acres (hectares)</th>
<th>Large-Grained Complex (%)</th>
<th>Complex (%)</th>
<th>Soft Bottom (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pull-ahead anchoring†</td>
<td>16.1 (6.5)</td>
<td>0.0%</td>
<td>21.4%</td>
<td>78.2%</td>
</tr>
<tr>
<td>Sea to shore transition</td>
<td>0.8 (0.3)</td>
<td>0%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

† 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. Values consider the proportional distribution of mapped sediment types along each cable path.

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**

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 RWF 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

See Section 5.5.1 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, Dredging
Impacts from seabed preparation for cable installation, including sandwave levelling 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 the IAC and RWEC are described in Section 5.1.1.4, above.

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 sandwave levelling (including dredging at selected locations), 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. 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). A 20 percent contingency has been included herein to provide a reasonable range for the potential extent of impacts associated with cable installation. Thus, the maximum potential spatial extent of these impacts is approximately 4,141 acres (1,676 hectares).

Sandwave leveling and boulder relocation would be required along portions of the cable route prior to cable installation. While no sandwaves have been identified in the project area, leveling of smaller substrate ripples and mega-ripples may be required in some areas to ensure cable burial to desired depth. Sandwave leveling would impact approximately 2,141 acres (866 hectares) of mapped ripples and 1,309 acres (530 hectares) of mapped mega-ripples. Dredging would be used for seabed preparation in selected areas with high sediment mobility.

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 (e.g., amphipod tubes) in soft-bottomed benthic habitat. These combined effects would reduce habitat suitability within the cable installation footprint for EFH species that associate with soft-bottomed habitat. Sandwaves are naturally dynamic features in soft-bottomed 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-bottomed 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. 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). 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 RWF project 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 5.7. Total Area of Potential Crushing, Burial, or Entrainment during IAC and OSS-link Installation by NOAA Habitat Complexity Category.

<table>
<thead>
<tr>
<th>Cable</th>
<th>Total Length – Linear miles (km)</th>
<th>Estimate</th>
<th>Large-Grained Complex acres (hectares)</th>
<th>Complex acres (hectares)</th>
<th>Soft Bottom acres (hectares)</th>
<th>Total acres (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAC</td>
<td>155.3 (249.9)</td>
<td>Standard</td>
<td>412 (167)</td>
<td>581 (235)</td>
<td>1,231 (498)</td>
<td>2,224 (900)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+20% contingency</td>
<td>494 (200)</td>
<td>698 (282)</td>
<td>1,477 (598)</td>
<td>2,669 (1080)</td>
</tr>
<tr>
<td>OSS-link</td>
<td>9.3 (15.0)</td>
<td>Standard</td>
<td>14 (6)</td>
<td>29 (12)</td>
<td>68 (28)</td>
<td>110 (45)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+20% contingency</td>
<td>16 (7)</td>
<td>35 (14)</td>
<td>82 (33)</td>
<td>132 (53)</td>
</tr>
</tbody>
</table>

Table 5.8 presents the estimated acreage of benthic habitat impacts by NOAA Habitat Complexity Category resulting from RWEC installation, and the estimated acreage plus a 20% contingency. 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. Dredging would be used to achieve deeper burial depths at selected locations along the cable route where pre-construction HRG surveys indicate presence of sediment ripples and potential for cable exposure by sediment mobility. The disturbance corridor would be 131 feet (40 meters) wide for each cable, for a total disturbance corridor of 262 feet (80 meters) along the RWEC route.

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

<table>
<thead>
<tr>
<th>RWEC Route</th>
<th>Total Length – Linear miles (km)</th>
<th>Estimate</th>
<th>Large-Grained Complex acres (hectares)</th>
<th>Complex acres (hectares)</th>
<th>Soft Bottom acres (hectares)</th>
<th>Total acres (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWEC-OCS (RWEC 1 &amp; 2)</td>
<td>37.7 (60.7)</td>
<td>Standard</td>
<td>4 (2)</td>
<td>165 (67)</td>
<td>365 (148)</td>
<td>535 (217)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>+20% contingency</td>
<td>5 (2)</td>
<td>198 (80)</td>
<td>438 (177)</td>
<td>642 (260)</td>
</tr>
<tr>
<td>RWEC-RI (RWEC 1 &amp; 2)</td>
<td>46 (74)</td>
<td>Standard</td>
<td>0 (0)</td>
<td>87 (35)</td>
<td>502 (203)</td>
<td>592 (240)</td>
</tr>
</tbody>
</table>
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 and dredging equipment.

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 and dredging equipment. Additionally, 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.

**Effects on Benthic/Epibenthic and Pelagic Egg and Larval Life Stages of EFH Species**

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. 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. 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 m³ of sea water per hour, or approximately 16,800 m³ 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. For the RWF, 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 used during RWEC installation and at sea-to-shore transition site.

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

- Atlantic cod (eggs, larvae)
- Atlantic herring (eggs, larvae)
Effects on Juveniles of EFH Species in Mobile Benthic/Epibenthic Groups

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

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. Dredging used for RWEC installation could also entrain adult fish within the disturbed area. However, evidence of dredging entrainment effects suggests that the mortality rate would be low (Wenger et al. 2017). 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 the dredging effects 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)
- 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).

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: Sessile Benthic/Epibenthic – Soft Bottom; Mobile Benthic/Epibenthic – Soft Bottom; Summer Flounder HAPC; Prey Species – Benthic.
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.

<table>
<thead>
<tr>
<th>Project Element</th>
<th>Location</th>
<th>Length km (miles)</th>
<th>Area of Sediment Deposition Exceeding – acres (hectares)</th>
<th>Area of Sediment Deposition Exceeding – acres (hectares)</th>
<th>Area of Sediment Deposition Exceeding – acres (hectares)</th>
<th>Maximum Extent of TSS Plumes Exceeding – feet (meters) 100 mg/L</th>
<th>Maximum Extent of TSS Plumes Exceeding – feet (meters) 50 mg/L</th>
<th>Large Grained Complex (%)</th>
<th>Complex (%)</th>
<th>Soft Bottomed (%)</th>
<th>Anthropogenic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inter-array cable*</td>
<td>OCS</td>
<td>155.3 (250)</td>
<td>35,798 (14,487)</td>
<td>22,715 (9,192)</td>
<td>217 (88)</td>
<td>1,209 (369)</td>
<td>932 (284)</td>
<td>18.5%</td>
<td>26.1%</td>
<td>55.3%</td>
<td>0%</td>
</tr>
<tr>
<td>OSS-link cable‡</td>
<td>OCS</td>
<td>9.3 (15)</td>
<td>1,444 (584)</td>
<td>918 (372)</td>
<td>9 (4)</td>
<td>1,209 (369)</td>
<td>932 (284)</td>
<td>12.5%</td>
<td>26.6%</td>
<td>60.9%</td>
<td>0%</td>
</tr>
<tr>
<td>RWEC #1 and #2, seabed preparation†</td>
<td>OCS</td>
<td>16.8 (27)</td>
<td>5,760 (2,331)</td>
<td>2,539 (1,027)</td>
<td>1,078 (436)</td>
<td>4,494 (1,370)</td>
<td>3,067 (935)</td>
<td>0.8%</td>
<td>30.8%</td>
<td>68.5%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>State</td>
<td>3.2 (5)</td>
<td>13,107 (5,304)</td>
<td>6,035 (2,442)</td>
<td>2,066 (836)</td>
<td>6,888 (2,099)</td>
<td>5,838 (1,779)</td>
<td>0.0%</td>
<td>14.7%</td>
<td>85.1%</td>
<td>0.2%</td>
</tr>
<tr>
<td>RWEC #1 and #2, installation‡</td>
<td>OCS</td>
<td>37.3 (60)</td>
<td>5,787 (2,342)</td>
<td>3,681 (1,490)</td>
<td>35 (14)</td>
<td>1,542 (470)</td>
<td>1,476 (450)</td>
<td>0.8%</td>
<td>30.8%</td>
<td>68.5%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>State</td>
<td>46 (74)</td>
<td>8,035 (3,252)</td>
<td>4,672 (1,891)</td>
<td>0 (0)</td>
<td>3,764 (1,147)</td>
<td>2,345 (715)</td>
<td>0.0%</td>
<td>14.7%</td>
<td>85.1%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Sea-to-shore transition†</td>
<td>State</td>
<td>n/a</td>
<td>35 (14)</td>
<td>20 (8)</td>
<td>7 (3)</td>
<td>1,460 (445)</td>
<td>1,312 (400)</td>
<td>0%</td>
<td>0%</td>
<td>100.0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

* 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 seabed preparation impacts acres are the TSS exposure area for dredging used to achieve greater cable burial depth in selected areas having high sediment mobility. 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.
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.

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). On this basis, benthic habitats exposed to measurable burial depths from inter-array cable construction and installation 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)
- Longfin squid (eggs)
- Ocean pout (eggs and larvae)

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)

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

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)

**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 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.
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.

**Effects on Sessile Benthic/Epibenthic Eggs and Larvae of EFH Species**

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 from inter-array cable construction and installation. 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)
- Longfin squid (eggs)
- Ocean pout (eggs and larvae)

**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)

**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)

**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.

**Effects to EFH Species and Habitats**

- **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 – 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 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 RWF 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. Similarly, the number and precise location of potential UXO detonations is not currently known and could be required for cable and/or foundation installation. Therefore, 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 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)

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

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)

Underwater Sound Effects from Sea-to-Shore Transition Construction on Invertebrates

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 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, and the same estimates for each cable segment plus a 20 percent contingency.

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.

<table>
<thead>
<tr>
<th>Cable Route</th>
<th>Estimate</th>
<th>Large-Grained Complex acres (hectares)</th>
<th>Complex acres (hectares)</th>
<th>Soft Bottomed acres (hectares)</th>
<th>Total acres (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAC</td>
<td>Standard</td>
<td>14 (6)</td>
<td>19 (8)</td>
<td>41 (17)</td>
<td>74 (30)</td>
</tr>
<tr>
<td></td>
<td>Standard +20 percent contingency</td>
<td>16 (7)</td>
<td>23 (9)</td>
<td>49 (20)</td>
<td>89 (36)</td>
</tr>
<tr>
<td>OSS-link</td>
<td>Standard</td>
<td>1 (0)</td>
<td>1 (0)</td>
<td>1 (1)</td>
<td>1 (2)</td>
</tr>
<tr>
<td></td>
<td>Standard +20 percent contingency</td>
<td>1 (0)</td>
<td>1 (1)</td>
<td>1 (1)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>RWEC-OCS</td>
<td>Standard</td>
<td>0 (0)</td>
<td>5 (2)</td>
<td>12 (5)</td>
<td>18 (7)</td>
</tr>
<tr>
<td></td>
<td>Standard +20 percent contingency</td>
<td>0 (0)</td>
<td>7 (3)</td>
<td>15 (6)</td>
<td>21 (9)</td>
</tr>
<tr>
<td>RWEC-RI</td>
<td>Standard</td>
<td>0 (0)</td>
<td>6 (3)</td>
<td>39 (16)</td>
<td>46 (19)</td>
</tr>
<tr>
<td></td>
<td>Standard +20 percent contingency</td>
<td>0 (0)</td>
<td>8 (3)</td>
<td>47 (19)</td>
<td>55 (22)</td>
</tr>
</tbody>
</table>
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 and Habitat Complexity Category.

<table>
<thead>
<tr>
<th>Project Feature</th>
<th>Element</th>
<th>Large-Grained Complex Acres (Hectares)</th>
<th>Complex Acres (Hectares)</th>
<th>Soft Bottomed Acres (Hectares)</th>
<th>Total Benthic Acres (Hectares)</th>
<th>Water Column (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 12-meter and two 15-meter Monopile</td>
<td>Monopile Foundation</td>
<td>0.6 (0.2)</td>
<td>1 (0.5)</td>
<td>1.5 (0.6)</td>
<td>3.1 (1.25)</td>
<td>408,211†</td>
</tr>
<tr>
<td></td>
<td>Foundation Protection</td>
<td>14 (6)</td>
<td>21 (8)</td>
<td>36 (15)</td>
<td>71 (29.4)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Seabed Preparation</td>
<td>1,301 (527)</td>
<td>1,871 (757)</td>
<td>0</td>
<td>3,172 (1,284)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1,315.6 (533.2)</strong></td>
<td><strong>1,893 (766)</strong></td>
<td><strong>37.5 (15.6)</strong></td>
<td><strong>3,246.1 (1,314.65)</strong></td>
<td><strong>408,211†</strong></td>
</tr>
<tr>
<td>Cable Standard</td>
<td>Cable Protection</td>
<td>15 (7)</td>
<td>31 (13)</td>
<td>93 (38)</td>
<td>139 (55)</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Boulder Relocation</td>
<td>379 (153)</td>
<td>676 (274)</td>
<td>1,702 (669)</td>
<td>2,757 (1,114)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>394 (160)</strong></td>
<td><strong>707 (287)</strong></td>
<td><strong>1,792 (705)</strong></td>
<td><strong>2,893 (1,169)</strong></td>
<td>n/a</td>
</tr>
<tr>
<td>Cable Standard +20% Contingency</td>
<td>Cable Protection</td>
<td>17 (7)</td>
<td>39 (16)</td>
<td>109 (44)</td>
<td>165 (67)</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Boulder Relocation</td>
<td>455 (184)</td>
<td>811 (328)</td>
<td>2,042 (826)</td>
<td>3,308 (1,339)</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>472 (191)</strong></td>
<td><strong>850 (344)</strong></td>
<td><strong>2,151 (870)</strong></td>
<td><strong>3,473 (1,406)</strong></td>
<td>n/a</td>
</tr>
</tbody>
</table>

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

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 102 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. Seabed preparation and boulder relocation impacts would be distributed by NOAA Habitat Complexity Category as shown in Table 5.11. In total, boulder relocation associated with construction of the WTG and OSS foundations would impact up to 1,301 acres of large-grained complex and 1,871 acres of complex habitat, much of this area overlapping portions of Cox Ledge associated with Atlantic cod spawning and general use by other EFH species that associate with these habitat types. Approximately 1,977 acres of boulder relocation would be required along the RWEC route, a substantial portion of which would occur in the same area.

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. Damage to these
organisms 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-bottomed 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 102 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 100, 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 RWF 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 a decade or more. 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 decades 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 at the RWF 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 vertical hard structure available to biogenic (e.g., bivalve) habitat formation. 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 decade or more, those impacts could be offset over a shorter period of time by beneficial reef effects to other species (see Section 3.6).

The RWF is in the vicinity of, and overlaps Cox Ledge, an area of complex benthic habitat that supports several commercially and recreationally important species. The observations at the BIWF and other European wind farms (Hutchison et al. 2020a; Methratta and Dardick 2019; Guarinello and Carey 2021) 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 102 12-meter diameter monopile foundations would introduce approximately 12,000 to 16,000 m² of new hard surfaces to the water column, respectively, 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)
- 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)
• 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)
• 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

Some of the monopile foundations would be placed in complex or large-grained complex habitat. The WTG (39-foot [12-meter]) and OSS (49-foot [15-meter]) monopiles would displace an estimated 1.5-acres (0.6 hectare) of complex habitat and 0.1 acre (0.05 hectare) of large-grained complex habitat. These 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.

An estimated 34 acres (14 hectares) of complex and 1 acre (0.4 hectare) of large-grained complex benthic habitat would be modified by placement of scour protection around the foundations and the inter-array cable approaches for the 12-meter monopile alternatives.

Approximately 44 acres (18 hectares) of complex and 30 acre (12 hectares) of large-grained complex benthic habitat would be modified by placement of secondary protection to protect exposed segments of inter-array cable. Area estimates for standard +20 percent contingency estimate for disturbance footprint for the inter-array cable would be 68 acres (28 acres) of complex and 45 acres (18 hectares) of large-grained complex benthic habitat would be modified by placement of secondary protection to protect exposed segments of the inter-array cable. Over time, these rock surfaces would become colonized by sessile organisms and would gradually evolve into functional habitat for EFH species.

Approximately 1,903 acres (770 hectares) of complex and 1,269 acres (514 hectares) of large-grained complex benthic habitat would be temporarily impacted by seabed preparation (i.e., boulder relocation) during seabed preparation for installation of the 12-meter monopiles. Some boulders may be relocated to soft bottom benthic habitat, resulting in the conversion of those habitats. Approximately 1,181 acres (478 hectares) of complex and 788 acres (319 hectares) of large-grained complex benthic habitat would be affected by seabed preparation for inter-array cable construction and installation. Area estimates for standard +20 percent contingency estimate for disturbance footprint for seabed preparation (i.e., boulder relocation) along the inter-array
cable network would be 1,383 acres (560 hectares) of complex and 922 acres (373 hectares) of large-grained complex benthic habitat.

The relocation process is likely to injure or kill encrusting organisms and damage biogenic structures that contribute to habitat. Over time, the relocated boulders would be recolonized, 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 a decade or more 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)
- Monkfish (juvenile, adult, spawning)
- Summer flounder (adult)
- Barndoor skate (juvenile, adult)
- Little skate (juvenile, adult)
• Atlantic herring (eggs, spawning)
• Black sea bass (larvae, juvenile, adult)
• Ocean pout (eggs, larvae, spawning)
• Scup (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**

Based on benthic habitat mapping it is estimated that 50 of the 102 monopile foundations would be placed in soft bottom benthic habitat, displacing approximately 1.5 acres (0.6 hectare) of habitat within the WTG (39-foot [12-meter]) and OSS (49-foot [15-meter]) monopile footprints. These impacts would occur within the 82,732-acre Lease Area. 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.

Approximately 36 acres (15 hectares) of soft bottom benthic habitat would be permanently modified by placement of scour protection around the monopiles and the inter-array cable approaches, for the standard estimate. 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.

RWFC 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)
• Witch flounder (juvenile, adult, spawning)
• Scup (juvenile, adult)
• Summer flounder (adult)
• Red hake (juvenile, adult)
• Silver hake (juvenile, adult)
• Windowpane flounder (juvenile, adult, spawning)
• Winter 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:
  o 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:
  o 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.
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 µm/s². 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 µm/s² 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 2021), operational noise effects has not dissuaded hearing specialist species from using these environments. Some degree of habituation to these operational noise and particle motion effects is to be anticipated. Bedjer 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:
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 RWF 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 RWF has the potential to influence hydrodynamic conditions at both local and broader regional scales.

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.

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; 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). Rhode Island Sound and the RWF area are considered to have strong seasonal stratification, with warmer waters and higher salinity leading to strong stratification in the late summer and early fall. Storms and upwelling in the fall result in increased mixing and deterioration of the stratified layers. 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 each monopile 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. These oceanic response changes in current magnitude and wave height have the indirect effect of influencing the bed shear stresses and thereby sediment transport potential, larval transport, and settlement. 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 offshore 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. 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 be biologically significant at population levels, as sea scallop larvae originate both local and distant spawning areas and dispersed throughout the region (Johnson et al. 2021). Localized changes in larval recruitment may not necessarily translate to negative effects on adult biomass, as sea scallops can be prone to localized overcrowding and reduced growth rates in areas with high larval recruitment (Bethoney and Stokesbury 2019).

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, these effects are of potential concern because they 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 “sink,” a condition where a reproductively isolated population is negatively affected by a prolonged reduction in larval survival (Sinclair 1988). This is a particular concern for species like Atlantic cod that return to the same spawning habitats year after year and rely on oceanographic conditions to disperse planktonic eggs to areas that provide favorable habitat conditions for larval and juvenile survival (Dean et al. 2022).
In addition to potential indirect effects to stratification, monopiles can also influence current speed and direction. Monopile wakes have been observed and modeled at the kilometer scale (Cazenave et al. 2016; Vanhellemont and Ruddick 2014). The turbulence of tidal current wakes resulting from the presence of the monopile was found to decrease logarithmically moving away from the monopile (Li et al. 2014). Thus, while impacts to current speed and direction decrease rapidly, there is evidence of hydrodynamic effects out to a kilometer away from a monopile. Turbulence in the water column from the presence of the monopiles structures could lead to localized changes in circulation and stratification patterns, with potential implications for primary and secondary productivity and fish distribution (van Berkel et al. 2020). Because the RWF and surroundings are characterized by strong seasonal stratification (Chen 2018; Lentz 2017), these localized hydrodynamic effects are likely to be limited to within 600 to 1,300 feet down current of each monopile (van Berkel et al. 2020). Localized turbulence and upwelling effects around the monopiles are likely to transport nutrients into the surface layer, potentially increasing primary and secondary productivity. That increased productivity could be partially offset by the formation of abundant colonies of filter feeders on the monopile foundations. While the net impact of these interactions is difficult to predict, they are not likely to result in more than localized effects on the abundance of phyto and zooplankton. The 0.9- to 1.1-nm spacing between monopiles ensures that their respective turbulent zones would not overlap. When considered relative to the broader oceanographic factors that determine primary and secondary productivity, localized changes in plankton distribution are likely to have an insignificant effect on EFH.

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 RWF, not just in the immediate area of the RWF. 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.
Hydrodynamic Effects to Surface and Water Column Habitats used by Pelagic Eggs and Larvae

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, the weight of available evidence supports the conclusion that the cod that spawn on and around Cox Ledge belong to a reproductively isolated spawning stock (McBride and Smedbol 2022). BOEM acknowledges the concern that hydrodynamic impacts could potentially lead to negative population-level effects on this species. 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 RWF 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)

**Hydrodynamic Effects to Water Column Habitats used by Pelagic Juveniles and Adults**

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 RWF area include:
Hydrodynamic Effects to Bottom Habitats used by Benthic-oriented Juveniles and Adults

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 RWF 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)
Hydrodynamic Effects to Bottom Habitats used by EFH Shellfish

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 generally produces lower intensity EMFs than HVDC. 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):
  o Magnetic field: 1,000 mG (observed developmental delay)
  o 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):
  o Magnetic field: > 1,000 mG
  o 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:
  o Finfish: Same thresholds as above.
  o 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):
  o Magnetic field: Detection, unknown; behavioral, 250-1,000 mG (species-specific)
  o 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 at 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.

<table>
<thead>
<tr>
<th>Component</th>
<th>Installation</th>
<th>Total Cable Length – linear miles (km)</th>
<th>Magnetic Field (mG) At Seafloor</th>
<th>Magnetic Field (mG) 3.3 Feet above Seafloor</th>
<th>Electrical Field (mV/m) At Seafloor</th>
<th>Electrical Field (mV/m) 3.3 Feet above Seafloor</th>
<th>Substrate Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAC</td>
<td>Buried to 3.3 feet</td>
<td>139.8 (225)</td>
<td>57</td>
<td>17</td>
<td>2.1</td>
<td>1.3</td>
<td>+10 to +20°C within 0.4 to 0.6 m of cable</td>
</tr>
<tr>
<td></td>
<td>On bed surface</td>
<td>15.5 (25)</td>
<td>522</td>
<td>21</td>
<td>5.4</td>
<td>1.7</td>
<td>Negligible</td>
</tr>
<tr>
<td>OSS-link cable</td>
<td>Buried to 3.3 feet</td>
<td>8.4</td>
<td>147</td>
<td>41</td>
<td>4.4</td>
<td>2.3</td>
<td>+10 to +20°C within 0.4 to 0.6 m of cable</td>
</tr>
<tr>
<td></td>
<td>On bed surface</td>
<td>0.9</td>
<td>1,071</td>
<td>91</td>
<td>13</td>
<td>1.6</td>
<td>Negligible</td>
</tr>
<tr>
<td>RWEC</td>
<td>Buried to 3.3 feet</td>
<td>70.6</td>
<td>147</td>
<td>41</td>
<td>4.4</td>
<td>2.3</td>
<td>+10 to +20°C within 0.4 to 0.6 m of cable</td>
</tr>
<tr>
<td></td>
<td>On bed surface</td>
<td>12.7</td>
<td>1,071</td>
<td>91</td>
<td>13</td>
<td>1.6</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

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 RWF 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 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

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

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 their small 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 60Hz 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 experience 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)

**EMF Effects on Habitats Used by Epibenthic Finfish and Flatfish Species**

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)

**EMF Effects on Demersal Habitats Used by Pelagic Finfish Species**

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 electro sensory 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)
- White shark (neonate/YOY, juvenile)
- Smooth dogfish (neonate, juvenile, adult)
- Spiny dogfish (subadult and adult, male and female)
- Little skate (juvenile, adult)
- Sand tiger shark (neonate/YOY, juvenile)
- Sandbar shark (neonate/YOY, juvenile, adult)
- Winter skate (juvenile, adult)

**EMF and Heat Effects on Benthic Invertebrates**

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. The potential for EMF effects on shellfish EFH and benthic infauna in general is of concern as these species are generally immobile and any exposures to measurable effects would be prolonged. 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 corridor length, this would equate to 977 acres (395 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 155
linear miles (249 km, 135 nm) of exposed cable length. This equates to approximately 75 acres (30 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 concrete mattresses 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)

**EMF Effects on Demersal Habitats Used by Pelagic Finfish Species**
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 seafloor 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 seafloor above buried and exposed cable segments, respectively
- Electrical field: 4.4 to 13 mV/m at seafloor 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)

**EMF Effects on Demersal Habitats Used by Pelagic Invertebrates**

One pelagic EFH invertebrate species, longfin squid, may periodically use demersal habitats at or near 3.3 feet (1 meter) of the seafloor 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 seafloor above buried and exposed cable segments, respectively
- Electrical field: 4.4 to 13 mV/m at seafloor 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)

**EMF and Heat Effects on Benthic Invertebrates**

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 and OSS-link would have permanent effects on complex, large-grained complex, and soft bottom benthic habitats resulting from 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. Cable protection impacts from these project features are summarized in Tables 5.7 and 5.8.

#### Permanent Effects on Complex and Large-Grained Complex Benthic Habitat

The placement of protection for exposed segments of the RWEC and OSS-link would result in the intermediate- to permanent modification of complex and large-grained complex, and soft bottom benthic habitats. Cable protection area and distribution by habitat type would include:

- RWEC-OCS:
  - Complex benthic habitat: Approximately 6 to 7 acres (2 hectares), standard estimate and standard +20 percent contingency, respectively
- Large-grained complex habitat: Approximately 1 acre (0.4 hectare), for both the standard estimate and standard +20 percent contingency

- RWEC-RI:
  - Complex benthic habitat: Approximately 7 to 8 acres (2 to 3 hectares), standard estimate and standard +20 percent contingency, respectively
  - Large-grained complex habitat: Approximately 1 acre (0.4 hectare), for both the standard estimate and standard +20 percent contingency

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.

RWEC and OSS-link installation 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 the additional 15 to 17 acres (6 to 7 hectares) of functional complex (i.e., complex, and large-grained complex) benthic habitat would constitute a beneficial increase in available EFH lasting for at least the remaining 20 years of project life. The cable protection would likely be removed during RWEC decommissioning. The effects of project decommissioning would be addressed under future EFH consultation.

The nearshore terminus of the RWEC overlaps areas of complex habitat that may be within designated HAPC for summer flounder if they support macroalgae or seagrasses. While such areas would be avoided to the extent practicable during construction and installation, any impacts on macroalgae or aquatic vegetation would constitute a long-term adverse effect on HAPC for this 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 resulting from the RWEC:

- 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)
- 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)
Permanent Effects on Soft Bottom Benthic Habitat

The placement of cable protection for exposed segments of the RWEC and OSS-link would result in the permanent conversion of soft bottom benthic habitats to complex benthic habitats. The extent of habitat conversion for the RWEC-OCS would total approximately 13 to 16 acres (5 to 6 hectares), standard estimate and standard +20 percent contingency, respectively. The extent of habitat conversion for the RWEC-RI would total approximately 15 to 17 acres (6 to 7 hectares), standard estimate and standard +20 percent contingency, respectively.

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 overall area of this habitat conversion is 28-33 acres (11-13 hectares) is small relative to the 13,994-acre (5,663-hectare) area of the RWEC right-of-way.

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 EFH for the following species and life stages:

- Ocean pout (juvenile, adult)
- Butterfish (juvenile, adult)
- Witch flounder (juvenile, adult, spawning)
- 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)
- 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 (3,352,996 acres), the continuously moving HRG vessels would distribute those impacts over approximately 10,755 linear miles and 248 days of survey effort. Up to 1,062 linear miles 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 25 days of HRG survey activity per year.

HRG surveys would be conducted concurrent with monopile installation in both the RWF, OSS and IAC. The duration of HRG equipment operation would total approximately 60 days distributed over 2 to 4 months from May to December 2023. 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 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

See Section 5.5.1 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>
<thead>
<tr>
<th>Proposed EPMs to Avoid and Minimize Impacts to be implemented by Revolution Wind</th>
<th>RWF</th>
<th>RWEC</th>
<th>Expected Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>The RWF and RWEC will be sited to avoid and minimize impacts to sensitive habitats (e.g., hard bottom habitats to the extent practicable.)</td>
<td>x</td>
<td>x</td>
<td>Minimizes impacts to sensitive and slow to recover habitats utilized by hard-bottom associated EFH species.</td>
</tr>
<tr>
<td>To the extent feasible, installation of the IACs, OSS-Link Cable and RWEC will be buried using equipment such as subsea cable 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</td>
<td>x</td>
<td>x</td>
<td>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.</td>
</tr>
<tr>
<td>DP vessels will be used for installation of the IACs, OSS-Link Cable, and RWEC to the extent practicable.</td>
<td>x</td>
<td>--</td>
<td>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.</td>
</tr>
<tr>
<td>A plan for vessels will be developed prior to construction and installation to identify no-anchorage areas to avoid documented sensitive resources.</td>
<td>x</td>
<td>x</td>
<td>Avoids adverse effects on benthic EFH from impacts to water quality.</td>
</tr>
<tr>
<td>Accidental spill or release of oils or other hazardous materials will be managed through the Oil Spill Response Plan (OSRP) (OSRP Appendix D).</td>
<td>x</td>
<td>x</td>
<td>Avoids and minimizes adverse effects on benthic and pelagic EFH from impacts to water quality.</td>
</tr>
<tr>
<td>Proposed EPMs to Avoid and Minimize Impacts to be implemented by Revolution Wind</td>
<td>RWF</td>
<td>RWEC</td>
<td>Expected Effects</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>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.</td>
<td>x</td>
<td>--</td>
<td>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.</td>
</tr>
<tr>
<td>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.</td>
<td>x</td>
<td>x</td>
<td>This measure would minimize the impact of waste generated on construction and installation and operations and maintenance related vessels.</td>
</tr>
<tr>
<td>The RWF and RWEC would use HRG surveys and other site characterization methods to identify, avoid, and minimize impacts to complex bottom habitats to the extent practicable.</td>
<td>x</td>
<td>x</td>
<td>Consideration of benthic habitat would reduce impacts to sensitive habitats utilized by benthic EFH species.</td>
</tr>
<tr>
<td>Construction and installation, and operations and maintenance lighting will be limited to the minimum necessary to ensure safety and to comply with applicable regulations.</td>
<td>x</td>
<td>x</td>
<td>This measure would minimize impacts to primarily pelagic EFH and EFH species from artificial lighting.</td>
</tr>
<tr>
<td>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.</td>
<td>x</td>
<td>x</td>
<td>This measure would minimize impacts to benthic EFH and EFH species from EMF.</td>
</tr>
<tr>
<td>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.</td>
<td>x</td>
<td>x</td>
<td>Avoids and minimizes adverse effects on benthic and pelagic EFH from impacts to water quality.</td>
</tr>
<tr>
<td>Exclusion and monitoring zones for marine mammals and sea turtles will be established for impact and vibratory pile driving activities.</td>
<td>x</td>
<td>x</td>
<td>Avoids and minimizes impacts from underwater noise during pile driving.</td>
</tr>
<tr>
<td>Environmental protection measures will be implemented for impact and vibratory pile driving activities. These measures will include seasonal restrictions, soft-start measures, shutdown procedures, marine mammal and sea turtle monitoring protocols, the use of qualified and NOAA approved protected species observers, and Noise Mitigation System (NMS) such as bubble curtains, as appropriate.</td>
<td>x</td>
<td>x</td>
<td>The reduction in sound pressure levels (SPLs) will reduce the area of effects to EFH species and the prey they feed upon.</td>
</tr>
</tbody>
</table>
Proposed EPMs to Avoid and Minimize Impacts to be implemented by Revolution Wind

<table>
<thead>
<tr>
<th>Proposed EPMs</th>
<th>RWF</th>
<th>RWEC</th>
<th>Expected Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>All personnel working offshore will receive training on marine mammal and</td>
<td></td>
<td></td>
<td>Avoids and minimizes adverse effects on marine mammals</td>
</tr>
<tr>
<td>sea turtle awareness and marine debris awareness</td>
<td>x</td>
<td>x</td>
<td>but may reduce potential impacts to EFH from debris also.</td>
</tr>
<tr>
<td>At the landfall location, drilling fluids will be managed within a contained</td>
<td>--</td>
<td>-x</td>
<td>Avoids and minimizes adverse effects on benthic and pelagic</td>
</tr>
<tr>
<td>system to be collected for reuse as necessary. An HDD Contingency Plan will</td>
<td></td>
<td></td>
<td>EFH from impacts to water quality.</td>
</tr>
<tr>
<td>be prepared and implemented to minimize the potential risks associated with</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>release of drilling fluids.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timing restrictions to avoid noise impacts on North Atlantic right whale</td>
<td>x</td>
<td>x</td>
<td>Protective of Atlantic cod.</td>
</tr>
<tr>
<td>would also be protective for the majority of the cod spawning season. This</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>includes the restriction of pile driving to the months of May to December;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no pile driving will occur from January 1st to April 30th.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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 DEIS. Alternative C, also referred to as the Habitat Alternative, is specifically configured to avoid impacts to large-grained complex and complex benthic habitats, with emphasis on habitats potentially used by Atlantic cod for spawning. The remaining alternatives are not explicitly designed to minimize impacts to EFH but would reduce the overall impact footprint to some degree in comparison to the proposed action. These alternatives and the reduction in extent of potential impacts to EFH are summarized in the following sections.

6.2.2.1 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 from the Proposed Action, particularly 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 6.1 and 6.2 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 RWF and vicinity is presented on each figure. Figures 6.3 and 6.4 display the proposed configurations for Alternatives C1 and C2, respectively, overlaid with multibeam backscatter and boulder density data. These configurations avoid the areas of the highest boulder density as well as areas of strong backscatter return in the central portion of the lease area. In terms of differences in impacts to large-grained complex and complex benthic habitat, the two proposed configurations of Alternative C would reduce the total extent of benthic habitat impacts and change the distribution of impacts to large-grained complex and complex benthic habitat compared to the Proposed Action. 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 6.2. 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, the Habitat Alternative would substantively reduce the overall extent of impacts to benthic habitat relative to the Proposed Action and shift the distribution of those impacts towards soft-bottomed habitats. This would reduce the extent of potential adverse impacts to complex habitats used by spawning Atlantic cod.
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.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Maximum Construction Disturbance Footprint (acres)*</th>
<th>Large-Grained Complex (%)</th>
<th>Complex (%)</th>
<th>Soft Bottom (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Action</td>
<td>6,615</td>
<td>7.2%</td>
<td>23.9%</td>
<td>68.9%</td>
</tr>
<tr>
<td>C1</td>
<td>4,440</td>
<td>6.7%</td>
<td>24.4%</td>
<td>68.8%</td>
</tr>
<tr>
<td>C2</td>
<td>4,374</td>
<td>8.1%</td>
<td>24.9%</td>
<td>67.0%</td>
</tr>
</tbody>
</table>

* 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 D and E. IAC impacts for these alternatives are based on the same assumption.

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.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Seafloor Preparation Footprint (acres)*</th>
<th>Monopile Foundations and Scour Protection (acres)†</th>
<th>Large-Grained Complex</th>
<th>Complex</th>
<th>Soft Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Action</td>
<td>734</td>
<td>81.6</td>
<td>19.0%</td>
<td>29.7%</td>
<td>51.3%</td>
</tr>
<tr>
<td>C1</td>
<td>482</td>
<td>53.6</td>
<td>10.7%</td>
<td>21.4%</td>
<td>68.0%</td>
</tr>
<tr>
<td>C2</td>
<td>475</td>
<td>52.8</td>
<td>12.8%</td>
<td>21.4%</td>
<td>65.8%</td>
</tr>
</tbody>
</table>

* 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 under Alternative C1.
Figure 6.2. Proposed RWF WTG Foundation Locations under Alternative C2.
Figure 6.3. Alternative C1 Layout Overlaid with Backscatter and Boulder Density Data. Image courtesy of Orsted.
Figure 6.4. Alternative C2 Layout Overlaid with Backscatter and Boulder Density Data. Image courtesy of Orsted.
6.2.2.2 **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 RWF 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, fewer WTG locations (and probably fewer miles of IAC) than proposed by the lessee would be approved by BOEM. 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 6.5 to 6.11, 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 RWF and vicinity is presented on each figure. In terms of differences in impacts to large-grained complex and complex benthic habitat, the seven proposed configurations of Alternative D would reduce the total extent of benthic habitat impacts to varying degrees relative to the Proposed Action. Alternative D would also change the distribution of impacts by benthic habitat type, but that effect would be limited to the peripheral edges of the RWF outside or at the margins of complex habitats used by spawning Atlantic cod. 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 D 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.
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 Transit Alternative

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Maximum Construction Disturbance Footprint (acres)*</th>
<th>Large-Grained Complex</th>
<th>Complex</th>
<th>Soft Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Action</td>
<td>6,615</td>
<td>7.2%</td>
<td>23.9%</td>
<td>68.9%</td>
</tr>
<tr>
<td>D.1</td>
<td>6,065</td>
<td>7.8%</td>
<td>23.2%</td>
<td>69.0%</td>
</tr>
<tr>
<td>D.2</td>
<td>5,855</td>
<td>7.9%</td>
<td>23.6%</td>
<td>68.4%</td>
</tr>
<tr>
<td>D.3</td>
<td>5,656</td>
<td>7.8%</td>
<td>24.6%</td>
<td>67.6%</td>
</tr>
<tr>
<td>D.1.D.2</td>
<td>5,709</td>
<td>7.9%</td>
<td>22.6%</td>
<td>69.5%</td>
</tr>
<tr>
<td>D.1.D.3</td>
<td>5,972</td>
<td>7.8%</td>
<td>23.6%</td>
<td>68.7%</td>
</tr>
<tr>
<td>D.2.3</td>
<td>5,740</td>
<td>7.9%</td>
<td>24.0%</td>
<td>68.1%</td>
</tr>
<tr>
<td>D.1.D.2.3</td>
<td>5,809</td>
<td>7.9%</td>
<td>23.0%</td>
<td>69.1%</td>
</tr>
</tbody>
</table>

* 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 6.5. 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

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Seafloor Preparation Footprint (acres)*</th>
<th>Monopile Foundations and Scour Protection (acres)†</th>
<th>Large-Grained Complex (%)</th>
<th>Complex (%)</th>
<th>Soft Bottom (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Action</td>
<td>734</td>
<td>81.6</td>
<td>19.0%</td>
<td>29.7%</td>
<td>51.3%</td>
</tr>
<tr>
<td>D.1</td>
<td>684</td>
<td>76.0</td>
<td>20.0%</td>
<td>25.9%</td>
<td>54.1%</td>
</tr>
<tr>
<td>D.2</td>
<td>677</td>
<td>75.2</td>
<td>20.2%</td>
<td>28.4%</td>
<td>51.4%</td>
</tr>
<tr>
<td>D.3</td>
<td>684</td>
<td>76.0</td>
<td>19.7%</td>
<td>31.3%</td>
<td>49.0%</td>
</tr>
<tr>
<td>D.1.D.2</td>
<td>626</td>
<td>69.6</td>
<td>21.4%</td>
<td>24.1%</td>
<td>54.4%</td>
</tr>
<tr>
<td>D.1.D.3</td>
<td>634</td>
<td>70.4</td>
<td>20.9%</td>
<td>27.3%</td>
<td>51.8%</td>
</tr>
<tr>
<td>D.2.3</td>
<td>626</td>
<td>69.6</td>
<td>21.1%</td>
<td>30.1%</td>
<td>48.8%</td>
</tr>
<tr>
<td>D.1.D.2.3</td>
<td>576</td>
<td>64.0</td>
<td>22.5%</td>
<td>25.6%</td>
<td>52.0%</td>
</tr>
</tbody>
</table>

* 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 6.5. Proposed RWF WTG Foundation Locations under Alternative D1.
Figure 6.6. Proposed RWF WTG Foundation Locations under Alternative D2.
Figure 6.7. Proposed RWF WTG Foundation Locations under Alternative D3.
Figure 6.8. Proposed RWF WTG Foundation Locations under Alternative D1+D2.
Figure 6.9. Proposed RWF WTG Foundation Locations under Alternative D1+D3.
Figure 6.10. Proposed RWF WTG Foundation Locations under Alternative D2+D3.
Figure 6.11. Proposed RWF WTG Foundation Locations under Alternative D1+D2+D3.


6.2.2.3 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. Under this alternative, fewer WTG locations (and probably fewer miles of IACs) than proposed by the lessee would be approved. 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 6.12 and 6.13, 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 RWF and vicinity is presented on each figure. In terms of differences in impacts to large-grained complex and complex benthic habitat, the two proposed configurations of Alternative E would reduce the total extent of benthic habitat impacts relative to the Proposed Action. Alternative E would also change the distribution of impacts by benthic habitat type. 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 E 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.

As shown, while Alternative D would substantively reduce the overall extent of the RWF and the associated extent of benthic habitat impacts, that effect would be limited to primarily soft-bottomed habitats on the northern or northwestern portion of the RWF under both alternative configurations. As such, while this alternative would reduce impacts to those EFH species that rely on soft-bottomed habitats, neither configuration would substantively reduce the extent of potential adverse impacts to EFH for species that rely on large-grained complex and complex benthic habitat 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 Viewshed Alternative

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Maximum Construction Disturbance Footprint (acres)*</th>
<th>Large-Grained Complex</th>
<th>Complex</th>
<th>Soft Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Action</td>
<td>6,614</td>
<td>7.2%</td>
<td>23.9%</td>
<td>68.9%</td>
</tr>
<tr>
<td>E1</td>
<td>4,548</td>
<td>4.0%</td>
<td>22.9%</td>
<td>73.1%</td>
</tr>
<tr>
<td>E2</td>
<td>5,332</td>
<td>4.4%</td>
<td>23.0%</td>
<td>72.6%</td>
</tr>
</tbody>
</table>

* 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 6.7. 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 Viewshed Alternative

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Seafloor Preparation Footprint (acres)*</th>
<th>Monopile Foundations and Scour Protection (acres)†</th>
<th>Large-Grained Complex</th>
<th>Complex</th>
<th>Soft Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Action</td>
<td>734</td>
<td>81.6</td>
<td>19.0%</td>
<td>29.7%</td>
<td>51.3%</td>
</tr>
<tr>
<td>E1</td>
<td>475</td>
<td>52.8</td>
<td>22.6%</td>
<td>39.5%</td>
<td>37.9%</td>
</tr>
<tr>
<td>E2</td>
<td>598</td>
<td>66.4</td>
<td>21.7%</td>
<td>34.7%</td>
<td>43.6%</td>
</tr>
</tbody>
</table>

* 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 6.12. Proposed RWF WTG Foundation Locations under Alternative E1.
Figure 6.13. Proposed RWF WTG Foundation Locations under Alternative E2.
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 6.8.

Table 6.8. Relevant Environmental Monitoring for Construction and Installation, and Operations and Maintenance of the RWF and RWEC, as well as the O&M Facility Operations.

<table>
<thead>
<tr>
<th>Proposed Environmental Monitoring to Avoid and Minimize Impacts</th>
<th>RWF</th>
<th>RWEC</th>
<th>Expected Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>x</td>
<td>x</td>
<td>Avoids and minimizes adverse effects on EFH from construction and installation, and operations and maintenance related impacts.</td>
</tr>
<tr>
<td>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.</td>
<td>X</td>
<td>x</td>
<td>Avoids and minimizes adverse effects on EFH from construction and installation, and operations and maintenance related impacts.</td>
</tr>
<tr>
<td>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.</td>
<td>X</td>
<td>x</td>
<td>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.</td>
</tr>
<tr>
<td>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).</td>
<td>X</td>
<td>x</td>
<td>The fisheries and benthic habitat monitoring plan will provide valuable baseline information about the condition and use of habitats within the RWF 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.</td>
</tr>
</tbody>
</table>
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/](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.

PAM will provide valuable information on the use of the RWF 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 RWF 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 RWF and RWEC.

<table>
<thead>
<tr>
<th>Species</th>
<th>Life stage</th>
<th>Habitat Association</th>
<th>IPF Exposure</th>
<th>Impact Determination</th>
<th>Rationale for Determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alewife (Alosa pseudoharengus)¹</td>
<td>Egg, larvae, juvenile</td>
<td>Freshwater</td>
<td>None</td>
<td>No impact</td>
<td>No project elements affecting freshwater habitats</td>
</tr>
<tr>
<td>Blueback herring (Alosa aestivalis)¹</td>
<td>Egg, larvae, juvenile</td>
<td>Freshwater</td>
<td>None</td>
<td>No impact</td>
<td>No project elements affecting freshwater habitats</td>
</tr>
<tr>
<td>American eel (Anguilla rostrata)²</td>
<td>Adult</td>
<td>Freshwater</td>
<td>None</td>
<td>No impact</td>
<td>No project elements affecting freshwater habitats</td>
</tr>
<tr>
<td></td>
<td>Eggs</td>
<td>Sargasso Sea</td>
<td>None</td>
<td>No impact</td>
<td>No suitable habitat within approximately 800 km</td>
</tr>
<tr>
<td>American shad (Alosa sapidissima)¹</td>
<td>Larva</td>
<td>Freshwater</td>
<td>None</td>
<td>No impact</td>
<td>No project elements affecting freshwater habitats</td>
</tr>
<tr>
<td></td>
<td>Egg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Striped bass (Morone saxatilis)³</td>
<td>Larva</td>
<td>Freshwater</td>
<td>None</td>
<td>No impact</td>
<td>No project elements affecting freshwater habitats</td>
</tr>
<tr>
<td></td>
<td>Egg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackfish or tautog (Tautoga onitis)⁵</td>
<td>Juvenile</td>
<td>Nearshore benthic (&lt;1 m to 20 m)</td>
<td>Construction and Installation Noise Hydrodynamic Food Web UXO</td>
<td>Minor, short-term and permanent</td>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Striped bass (Morone saxatilis)³</th>
<th>Juvenile</th>
<th>Estuary</th>
</tr>
</thead>
<tbody>
<tr>
<td>American eel (Anguilla rostrata)</td>
<td>Larvae, juvenile</td>
<td>Pelagic marine, estuary</td>
</tr>
<tr>
<td>Atlantic menhaden (Brevoortia tyrannus)³</td>
<td>Juvenile</td>
<td>Estuary</td>
</tr>
<tr>
<td>Species</td>
<td>Life stage</td>
<td>Habitat Association</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Weakfish or sea trout (Cynoscion regalis)⁹</td>
<td>Egg, larvae, juvenile</td>
<td>Estuary</td>
</tr>
<tr>
<td>Atlantic menhaden (Brevoortia tyrannus)³</td>
<td>Larvae, juvenile</td>
<td>Estuary</td>
</tr>
<tr>
<td>Bay anchovy (Anchoa mitchilli)⁷</td>
<td>Larvae, juvenile</td>
<td>Estuary</td>
</tr>
<tr>
<td>Horseshoe crab (Limulus polyphemus)⁹</td>
<td>Egg</td>
<td>Intertidal sediments</td>
</tr>
<tr>
<td></td>
<td>Larva</td>
<td>Nearshore benthic</td>
</tr>
<tr>
<td>Sand eel (Ammodytes americanus)</td>
<td>Adult, juvenile</td>
<td>Benthic sediments</td>
</tr>
<tr>
<td></td>
<td>Adult, juvenile egg, larva</td>
<td>Pelagic</td>
</tr>
<tr>
<td>Blue crab (Callinectes sapidus)</td>
<td>Adult, juvenile</td>
<td>Benthic</td>
</tr>
<tr>
<td></td>
<td>Larva</td>
<td>Pelagic</td>
</tr>
<tr>
<td>Jonah Crab (Cancer borealis)</td>
<td>Adult, juvenile</td>
<td>Benthic</td>
</tr>
<tr>
<td></td>
<td>Larva</td>
<td>Pelagic</td>
</tr>
<tr>
<td>American Lobster (Homarus americanus)</td>
<td>Adult, juvenile, egg</td>
<td>Benthic</td>
</tr>
<tr>
<td></td>
<td>Larva</td>
<td>Pelagic</td>
</tr>
<tr>
<td>Species</td>
<td>Life stage</td>
<td>Habitat Association</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>---------------------</td>
</tr>
</tbody>
</table>
| 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. |
<table>
<thead>
<tr>
<th>Species</th>
<th>Life stage</th>
<th>Habitat Association</th>
<th>IPF Exposure</th>
<th>Impact Determination</th>
<th>Rationale for Determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern oyster ((Crassostrea virginica))³</td>
<td>Larvae</td>
<td>Nearshore pelagic</td>
<td>Construction and Installation Noise, Crushing, Burial, Entrainment, Elevated TSS/Sedimentation, Habitat Conversion, EMF &amp; Heat, Hydrodynamic, Food Web, UXO</td>
<td>Minor, Short-Term and Permanent</td>
<td>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 &amp; Heat, Hydrodynamic and Food Web Effects could result in localized decrease of larvae.</td>
</tr>
<tr>
<td>Northern Quahog ((Mercenaria mercenaria))⁵</td>
<td>Larvae</td>
<td>Pelagic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Juvenile</td>
<td>Nearshore benthic reefs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>Nearshore benthic reefs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft-shell clam ((Mya arenaria))⁹</td>
<td>Larvae</td>
<td>Nearshore pelagic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Juvenile, adult</td>
<td>Subtidal soft substrate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adult</td>
<td>Subtidal soft substrate</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
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                             | Yes                              |
|                   |             | Larvae     | Pelagic            | Yes                                              | Yes                             | --                             | --                              | No                              | --                              | No                              | Yes                             | Yes                              |
|                   |             | Juvenile   | Benthic complex    | Yes                                              | Yes                             | Yes                            | Yes                             | Yes                              | Yes                              | Yes                              | Yes                              | 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    | --                 | --                                               | --                             | --                             | --                              | --                              | --                              | --                              | --                              |
|                   | Larvae      | Surface    | Yes                | Yes                                              | --                             | --                             | No                              | --                              | --                              | --                              | --                              |
|                   | Juvenile    | Benthic complex | Yes                | 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                              | Yes                              | No                              | Yes                              |
|                   | Adult       | Benthic complex | --                 | --                                               | --                             | --                             | --                              | --                              | --                              | --                              | --                              |
|                   | Spawning    | Benthic complex | --                 | --                                               | --                             | --                             | --                              | --                              | --                              | --                              | --                              |
| 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                              | 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 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                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Larvae     | Pelagic               | Yes                                         | --                                              | --                             | No                                           | No                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Juvenile   | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Adult      | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Spawning   | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             |            |                        |                                              |                                                |                                |                                              |                                                  |                                                |                                                |                                                |                                                  |
|                  | Blueteeth   | Eggs       | Pelagic               | Yes                                         | --                                              | --                             | No                                           | No                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Larvae     | Pelagic               | Yes                                         | --                                              | --                             | No                                           | No                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Juvenile   | Pelagic               | Yes                                         | --                                              | --                             | Yes                                         | No                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Adult      | Pelagic               | Yes                                         | --                                              | --                             | Yes                                         | No                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             |            |                        |                                              |                                                |                                |                                              |                                                  |                                                |                                                |                                                |                                                  |
|                  | Black sea bass | Eggs     | Surface               | --                                          | --                                              | --                             | --                                          | --                                             | No                                             | No                                             | No                                             | No                                             |
|                 |             | Larvae     | Benthic complex       | --                                          | --                                              | --                             | --                                          | --                                             | No                                             | No                                             | No                                             | No                                             |
|                 |             | Juvenile   | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Adult      | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             |            |                        |                                              |                                                |                                |                                              |                                                  |                                                |                                                |                                                |                                                  |
|                  | Butterfish  | Eggs       | Pelagic               | Yes                                         | --                                              | --                             | No                                           | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Larvae     | Pelagic               | Yes                                         | --                                              | --                             | No                                           | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Juvenile   | Pelagic/Pelagic/ Soft bottom | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes |
|                 |             | Adult      | Pelagic/Pelagic/ Soft bottom | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes |
|                 |             |            |                        |                                              |                                                |                                |                                              |                                                  |                                                |                                                |                                                |                                                  |
|                  | Scup        | Eggs       | Pelagic               | Yes                                         | --                                              | --                             | No                                           | No                                             | Yes                                             | No                                             | Yes                                           | No                                             |
|                 |             | Larvae     | Pelagic               | Yes                                         | --                                              | --                             | No                                           | No                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Juvenile   | Soft bottom/Benthic complex | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes |
|                 |             | Adult      | Soft bottom/Benthic complex | Yes | Yes | Yes | Yes | Yes | No | No | Yes | Yes | No | Yes |
|                 |             |            |                        |                                              |                                                |                                |                                              |                                                  |                                                |                                                |                                                |                                                  |
|                  | Ocean pout  | Eggs       | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Juvenile   | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Adult      | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             |            |                        |                                              |                                                |                                |                                              |                                                  |                                                |                                                |                                                |                                                  |
|                  | Atlantic herring | Eggs     | Benthic complex       | --                                          | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Larvae     | Pelagic               | Yes                                         | --                                              | --                             | No                                           | No                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Juvenile   | Pelagic               | Yes                                         | --                                              | --                             | No                                           | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             | Adult      | Pelagic               | Yes                                         | --                                              | --                             | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |
|                 |             |            |                        |                                              |                                                |                                |                                              |                                                  |                                                |                                                |                                                |                                                  |
|                 |             | Spawning   | Benthic complex       | Yes                                         | Yes                                            | Yes                            | Yes                                         | Yes                                             | No                                             | No                                             | Yes                                           | No                                             |

^* Habitats are listed as: Benthic complex, Pelagic, Surface, Soft bottom.
^# Construction and installation-related short-term adverse effect on EFH refers to specific conditions affecting the habitat during the construction and installation phases.

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<p>| EFH Species Group | EFH Species | Life Stage | Habitat Association | Construction and Installation Related Short-Term Adverse Effect on EFH | 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 &amp; 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 | Yes | No | Yes |
|                  |              | Larvae | Pelagic | Yes | -- | Yes | No | 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 |
|                  |              | 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 | -- | No | Yes |
|                  | 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 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 |
| 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 |</p>
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<th>Life Stage</th>
<th>Habitat Association&lt;sup&gt;7&lt;/sup&gt;</th>
<th>Construction and Installation Related Short-Term Adverse Effect on EFH&lt;sup&gt;8&lt;/sup&gt;</th>
<th>Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH&lt;sup&gt;9&lt;/sup&gt;</th>
<th>Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH&lt;sup&gt;9&lt;/sup&gt;</th>
<th>Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH&lt;sup&gt;9&lt;/sup&gt;</th>
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<th>Operations and Maintenance Long-Term or Permanent Adverse Effects on EFH&lt;sup&gt;9&lt;/sup&gt;</th>
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<tr>
<td></td>
<td></td>
<td>Adult</td>
<td>Soft bottom</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td></td>
<td>Shortfin squid</td>
<td>Juvenile</td>
<td>Pelagic</td>
<td>Yes</td>
<td>--</td>
<td>Yes</td>
<td>--</td>
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<tr>
<td></td>
<td></td>
<td>Adult</td>
<td>Pelagic</td>
<td>Yes</td>
<td>--</td>
<td>Yes</td>
<td>--</td>
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<td>Yes</td>
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<td>Longfin squid</td>
<td>Eggs</td>
<td>Benthic complex</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>No</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Juvenile</td>
<td>Pelagic</td>
<td>Yes</td>
<td>--</td>
<td>Yes</td>
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<td>Adult</td>
<td>Pelagic</td>
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<td>No</td>
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</tbody>
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Notes:
\(^\d\) Benthic complex habitat includes complex and large-grained complex benthic habitat.
\(^\d\) ‘Yes’ = adverse effect on habitat suitability; ‘No’ = insignificant effect on habitat suitability; ‘--’ = no life stage EFH exposure to this impact mechanism.
8.2 Conclusions
Over 40 species of finfish and invertebrates with designated EFH occur within the RWF and RWEC project area. 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 6.1.1.1). 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 a decade or more 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.
9.0 References


BOEM. 2019. Movement Patterns of Fish in Southern New England (AT-19-08). Ongoing study project description, Bureau of Ocean Energy Management Environmental Studies Program. Available at:


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