Atlantic Shores Offshore Wind South Project

Essential Fish Habitat Assessment with NOAA Trust Resources

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For the National Marine Fisheries Service

U.S. Department of the Interior

Bureau of Ocean Energy Management
Office of Renewable Energy Programs

BOEM
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Abbreviations

BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
CTV	crew transport vessels
ECC	Export Cable Corridor
EFH	Essential Fish Habitat
EMF	electromagnetic field
HAPC	Habitat Areas of Particular Concern
HDD	horizontal directional drilling
HRG	high-resolution geophysical
HVAC	high voltage alternating current
HVDC	high voltage direct current
L_E	cumulative sound exposure level
L_{pk}	peak sound pressure level
L_{RMS}	sound exposure level, root mean-square
MAFMC	Mid-Atlantic Fishery Management Council
MBES	multibeam echo sounder
MSL	mean sea level
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEFMC	New England Fishery Management Council
NMFS	National Marine Fisheries Service
OCS	Outer Continental Shelf
OEC	offshore export cable
O&M	operation and maintenance
OSS	offshore substation
POIs	points of interconnection
PV	digital plan view video
SCADA	Supervisory Control and Data Acquisition
SEL	sound exposure level
SPL	sound pressure level

SSS	side scan sonar
TSS	total suspended sediment
USACE	U.S. Army Corps of Engineers
USC	United States Code
UXO	unexploded ordnance
WEA	Wind Energy Area
WTA	Wind Turbine Area
WTG	wind turbine generator
YOY	young-of-year

Unit Abbreviations

°C	degrees Celsius
$\mu m/s^2$	micrometers per second squared
µPa	micro Pascal
$\mu Pa^2/Hz/m$	micro Pascal squared per hertz per meter
$\mu Pa^2 s$	micro Pascal squared second
$\mu Pa/sec^2$	micro Pascal per second squared
µT	micro Tesla
µV/m	microvolts per meter
dB	decibels
dB_{peak}	Peak decibels
dB_{RMS}	root mean square decibels
dB_{SEL}	Sound exposure level
Hz	hertz
Hz/m	hertz per meter
kJ	kilojoules
km	kilometers
kV	kilovolts
$L_{E, 24hr}$	Cumulative sound exposure level, 24 hour equivalent
L_{pk}	Peak sound exposure level
m^2	square meters
m^3	cubic meters
m/f	male/female
mG	milligauss
mg/L	milligrams per liter
mm	millimeters

m/s	meters per second
mV/m	millivolts per meter
MW	megawatts
nm	nautical miles
ppt	parts per thousand
yd^3	cubic yards

1. Introduction

The Energy Policy Act of 2005, Public Law No. 109-58, added Section 8(p)(1)(C) to the Outer Continental Shelf Lands Act, which grants the Secretary of the Interior the authority to issue leases, easements, or rights-of-way on the Outer Continental Shelf (OCS) for the purpose of renewable energy development (43 United States Code [USC] § 1337(p)(1)(C)). The Secretary 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) promulgated final regulations implementing this authority at 30 Code of Federal Regulations (CFR) § 585.

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) requires Federal agencies to consult with the Secretary of Commerce, through the National Marine Fisheries Service (NMFS), with respect to "any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect any essential fish habitat identified under this Act," 16 U.S.C. § 1855(b)(2). This process is guided by the requirements of the Essential Fish Habitat (EFH) regulation at 50 CFR 600.905. BOEM would be the lead Federal agency for the consultation, and would coordinate with any other Federal agencies that may be issuing permits or authorizations for this project, as necessary, for one consultation that considers the effects of all relevant Federal actions, including in offshore and inshore coastal environments [e.g., issuance of permits by the U.S. Army Corps of Engineers (USACE)]. Pursuant to the MSA, each Fishery Management Plan (FMP) must identify and describe EFH for the managed fishery, and the statute defines EFH as "those waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity" 16 U.S.C. § 1853(a)(7) and § 1802(10). NOAA's regulations further define EFH adding, "waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle.

The EFH final rule published in the Federal Register on January 17, 2002, defines an adverse effect as: "any impact which reduces the quality and/or quantity of EFH." The rule further states that an adverse effect may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat and other ecosystems components, if such modifications reduce the quality and/or quantity of EFH. The EFH final rule also states that the loss of prey may have an adverse effect on EFH and managed species. As a result, actions that reduce the availability of prey species, either through direct harm or capture, or through adverse impacts to the prey species' habitat may also be considered adverse effects on EFH. Adverse effects to EFH may result from action occurring within EFH or outside EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions.

The Atlantic Shores South Project includes two wind energy facilities: the 1,510-megawatt (MW) Project 1 with up to 136 wind turbine generators (WTGs) and Project 2 with up to 95 WTGs, for a total of up to 200 WTGs for Projects 1 and 2. The capacity for Project 2 has yet to be determined. Atlantic Shores has a goal of 1,327 MW for Project 2, which would align with the interconnection service agreements and interconnection construction service agreements Atlantic Shores intends to execute for both projects with the regional transmission organization (RTO), PJM. All WTGs and associated offshore substations (OSSs) and submarine transmission cable networks connecting the WTGs to the OSS (inter-array cables) and linking the OSSs (inter-link cables) would be located in BOEM Renewable Energy Lease Area OCS-A 0499 (Lease Area), located within the New Jersey Wind Energy Area (WEA).

Consistent with the requirements of 30 CFR 585.620 to 585.638, COP submittal occurs after BOEM grants a lease for the Project and Atlantic Shores completes all studies and surveys defined in their site assessment plan. BOEM's renewable energy development process is described in the following section. Atlantic Shores is working with BOEM to address additional information needs to finalize the COP. This EFH assessment relies on the most current information available for the Project.

BOEM has responsibility as the lead federal agency to initiate an EFH consultation in compliance with the MSA prior to approval, approval with conditions, or disapproval of the COP for the Project. This report describes the Project and presents an assessment of the potential for the proposed construction, operations and maintenance, and conceptual decommissioning of the Project to adversely affect EFH and managed species.

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. Other cooperating agencies include the Bureau of Safety and Environmental Enforcement and USACE. 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 (33 USC § 403) and Section 404 of the Clean Water Act (33 USC § 1344). BOEM will respond to NMFS EFH conservation recommendations under its authority pursuant to OCSLA, while USACE will respond to NMFS EFH conservation recommendations under its authorities pursuant to Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act.

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 EFH consultation would be conducted for Project decommissioning.

2. Proposed Action

The Proposed Action in this EFH assessment entails the construction, operation and maintenance (O&M), and decommissioning of the Atlantic Shores South Project on the OCS offshore of New Jersey (the Project). The Project would be sited 8.7 miles (14 kilometers) from the New Jersey shoreline at its closest point in the Lease Area (OCS-A 0499). The Project includes a maximum of 200 WTGs, 10 OSSs, 547 miles (880 kilometers) of inter-array cables, 37 miles (60 kilometers) of inter-link cables, and 441 miles (710 kilometers) of export cables.

The final design of the Proposed Action is currently in development. Atlantic Shores is considering the following WTG alternatives:

- 200 WTGs mounted on 39- to 49-foot (12- to 15-meter) monopile foundations (Projects 1 and 2)
- 105 WTGs mounted on 39- to 49-foot (12- to 15-meter) monopile foundations (Project 1) and 95 WTGs mounted on 16.4-foot (5-meter) piled jacket foundations (Project 2)

Atlantic Shores is considering the following OSS alternatives for Projects 1 and 2:

- 4 to 10 OSSs mounted on 39- to 49-foot (12- to 15-meter) monopile foundations
- 4 to 10 OSSs mounted on 16.4-foot (5-meter) piled jacket foundations
- 4 to 10 OSSs mounted on suction bucket jacket foundations
- 4 to 5 OSSs mounted on gravity-base structures

Atlantic Shores is considering the following meteorological tower (MET tower) alternatives for Project 1:

- 1 MET tower mounted on a 39- to 49-foot (12- to 15-meter) monopile foundation
- 1 MET tower mounted on a 16.4-foot (5-meter) piled jacket foundation
- 1 MET tower mounted on a suction bucket jacket foundation
- 1 MET tower mounted on a mono-bucket foundation
- 1 MET tower mounted on a gravity-base structure

Atlantic Shores is considering three transmission options for the offshore export cables (OECs):

- High voltage direct current (HVDC) option: Project 1 and Project 2 would each install one HVDC bundle in separate corridors with a closed-loop cooling system
- High voltage alternative current (HVAC) option: Project 1 and Project 2 would each install up to four HVAC cables in separate corridors
- HVDC and HVAC option: one project would install up to four HVAC cables and the other would install one HVDC bundle, in either the same or separate corridors

Atlantic Shores is considering the following cable route alternatives for the export cables:

- Atlantic Landfall Site: S. California Avenue lot located at the eastern end of S. California Avenue, adjacent to the Atlantic City Boardwalk in Atlantic City, New Jersey.
- Monmouth Landfall Site: U.S. Army National Guard Training Center in Sea Girt, New Jersey

Project construction and operational components are summarized in Table 2-1 and described in the following sections.

Table 2-1. Summary of Project 1, Project 2, and OEC construction and O&M effect mechanisms by design Alternative

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Component	Options	Effect Measurement
WTG construction	Turbine selection/ spacing	Installation disturbance area	Pile diameter at base	WTG	Piled jacket	16.4 feet (5.0 meters)
					39.4-foot (12-meter) monopile	39.4 feet (12 meters)
					49-foot (15-meter) monopile	49 feet (15 meters)
			Number of turbines			Up to 200
			Hub height relative to MSL			574 feet (175 meters)
			Spacing			0.6 to 1.0 linear miles (1.1 to 1.9 km)
			Array area			102,124 acres (41,328 hectares)
	Foundation installation	Habitat alteration, physical disturbance	Number of piles	WTG	Monopile	Up to 200 (1 per WTG)
					Piled jacket	Up to 800 (4 per WTG)
				OSS	Small OSS, monopile	10 (1 per OSS)
					Small OSS, piled jacket	40 (4 per OSS)
					Medium OSS, piled jacket	60 (12 per OSS)
					Large OSS, piled jacket	96 (24 per OSS)
			Footprint area total (with scour protection)	WTG	Piled Jacket	140 acres (57 hectares)
					Monopile	261 acres (106 hectares)
				OSS	Piled Jacket (Small)	7 acres (3 hectares)
					Piled Jacket (Medium)	9 acres (4 hectares)
					Piled Jacket (Large)	13 acres (5 hectares)
					Monopile (Small)	13 acres (5 hectares)
					GBS (Medium)	17 acres (7 hectares)
					Suction Bucket Jacket (Medium)	21 acres (8 hectares)
					GBS (Large)	22 acres (9 hectares)
					Suction Bucket Jacket (Small)	26 acres (10 hectares)

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Component	Options	Effect Measurement
					Suction Bucket Jacket (Large)	26 acres (11 hectares)
			Installation method	WTG/OSS	Monopile	4,400 kJ impact hammer, 30 strikes per minute, 7 to 9 hours per pile
					Piled jacket	2,500 kJ impact hammer, 30 strikes per minute, 3 to 4 hours per pile
			Underwater noise (approximate)	WTG/OSS	Piled jacket	SPL up to 213 dB re 1 μPa
					39.4-foot (12-meter) monopile	SPL up to 222 dB re 1 μPa
					49-foot (15-meter) monopile	SPL up to 221 dB re 1 μPa
	Interarray cable construction	Physical disturbance, turbidity, entrainment	Installation method	All		Cable trenching/burial 5- to 6-feet (1.5- to 1.8-meters) depth
			Short-term to long-term disturbance			2,035 acres (824 hectares)
			Long-term habitat conversion (cable protection)			307 acres (124 hectares)
	Construction vessels	Physical disturbance, noise	Number of vessels	WTG/OSS		Up to 42 vessels
				Inter-array cable		Up to 13 vessels
			Anchoring disturbance	All		363 acres (147 hectares)
			Vessel noise	All		SPL 150 to 180 dB re 1 μPa for dynamically positioned vessels (BOEM 2014), SPL 177 to 188 dB re 1 μPa for large shipping vessels (McKenna et al. 2012), duration of construction
WTG operation		Operational EMF (interarray cable)	Transmission voltage	Interarray cable		66 to 150 kV
			Magnetic field			48 to 60 mG
Offshore export cable	Export cable construction	Installation disturbance area	Cable length (OSS to landfall) per cable	Atlantic OEC		25 miles (40 km)
				Monmouth OEC		85 miles (138 km)

Project Component	Design Element	Effect Mechanism	Measurement Parameter	Component	Options	Effect Measurement
			Installation method	All		Cable trenching/burial 5- to 6-feet (1.5- to 1.8-meters) depth
			Short-term to long-term disturbance area	All		1,606 acres (650 hectares)
			Area exposed to sedimentation > 1 mm	Atlantic OEC		164 feet (50 meters) from trench centerline
				Monmouth OEC		656 feet (200 meters) from trench centerline
			Long-term habitat conversion	All		12 acres (5 hectares)
		Vessel traffic	Number of vessels	All		Up to 13 vessels
			Anchoring disturbance	All		266 acres (108 hectares)
			Vessel noise	All		SPL 150 to 180 dB re 1 µPa for dynamically positioned vessels (BOEM 2014), SPL 177 to 188 dB re 1 µPa for large shipping vessels (McKenna et al. 2012) , duration of construction
	Operation and maintenance	Operational EMF (export cable)	Transmission voltage	All	HVAC	230 to 275 kV
					HVDC	320 to 525 kV
			Magnetic field		HVAC	104.7 to 107.8 mG
					HVDC	152.7 to 2,174.5 mG
			Magnetic field (at cable crossing)		HVAC	237.1 to 244.mG
					HVDC	349.2 to 3,305.3 mG

dB = decibel
EMF = electromagnetic field
km = kilometer
kV = kilovolt
mG = milli-Gauss
MSL = mean sea level
OEC = offshore export cable
OSS = offshore substation
SPL = sound pressure level
WTG = wind turbine generator
µPA = micro-Pascal

2.1 Project Area

The Project area comprises the project footprint for the WTGs, MET tower, OSSs, inter-array cables, export cables, O&M facility, port facilities, and all areas affected by the construction and operation of these facilities, which includes coastal habitats in New Jersey, nearshore habitats in New Jersey State waters, and ocean habitats on the OCS offshore of New Jersey. The WTGs, MET tower, OSSs, and inter-array cables would be located in an approximately 102,124-acre (413.3-square kilometer [km^2]) Wind Turbine Area (WTA) located in Lease Area OCS-A 0499 (Figure 2-1). Four locations for the MET tower are currently under consideration (Figure 2-1). Project 1 is located in the western 54,175 acres (219.2 km^2) of the WTA, and Project 2 is located in the eastern 31,847 acres (128.9 km^2) of the WTA with a 16,102-acre (65.2-km2) Overlap Area that could be used by either Project 1 or Project 2 (Figure 2-1).

Two export cable routes are currently being considered (Figure 2-1). The Atlantic Export Cable Corridor (ECC) would depart the WTA along its western boundary and travel northwest to the Atlantic Landfall Site in Atlantic City, New Jersey. The Atlantic ECC is approximately 12 miles (19 kilometers) long, and maximum length of each export cable using the Atlantic ECC would be 25 miles (40 kilometers), including the length of cable within the WTA and contingency for micrositing. The Monmouth ECC would depart the WTA along its eastern boundary and travel north to the Monmouth Landing Site in Sea Girt, New Jersey. The Monmouth ECC is approximately 61 miles (98 kilometers) long, and the maximum length of each export cable using the Monmouth ECC would be 85 miles (138 kilometers), including the length of cable within the lease area and contingency for micrositing. If four export cables are installed in each ECC, the total maximum export cable length would be 441 miles (710 kilometers).

Atlantic Shores has identified five port facilities in that may be used for major construction staging activities for the Proposed Action: New Jersey Wind Port, Paulsboro Marine Terminal, and Repauno Port & Rail Terminal in New Jersey; Portsmouth Marine Terminal in Virginia; and Port of Corpus Christi in Texas. All port facilities being considered to support construction activities are located within industrial waterfront areas with existing marine industrial infrastructure or where such infrastructure is proposed for development within the required timeframe of Atlantic Shores South. Any offshore wind-related construction activities at these port facilities are not project-specific and are therefore not considered components of the Proposed Action.

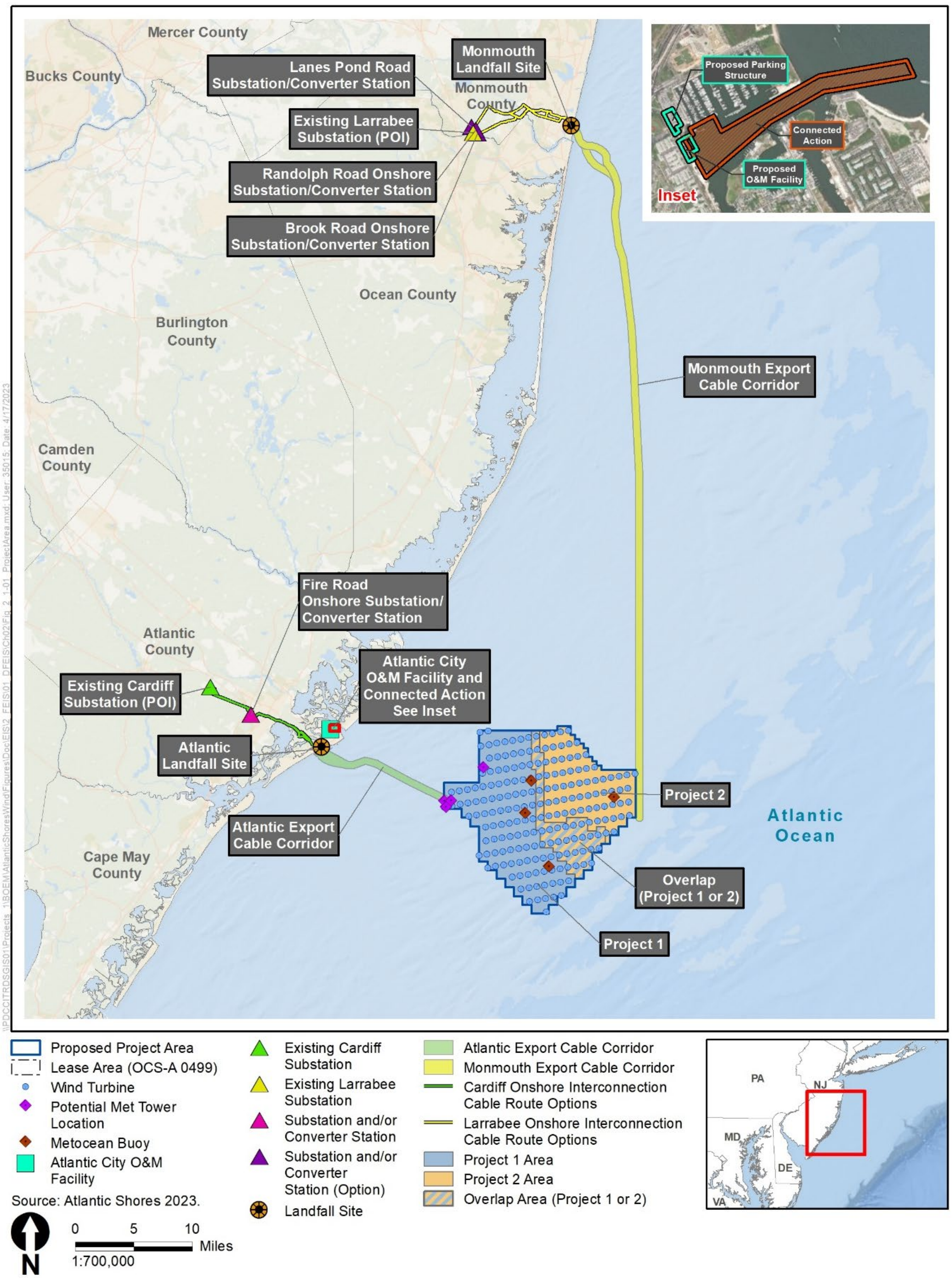


Figure 2-1. Project area overview

2.1.1 Construction and Installation

The construction of the Project would result in short-term and long-term impacts on marine habitats in the nearshore and offshore waters of the mid-Atlantic OCS. Project construction methods and estimated quantities for each design alternative are described in the following section. The short-term and long-term impacts of project construction on the environment are quantified in Section 5.

The total number of construction days for each project component would depend on a number of factors, including environmental conditions, planning, construction and installation logistics. The general installation schedule is provided in Table 2-2. This schedule is approximated based on several assumptions, including the estimated timeframe in which permits are received, anticipated regulatory seasonal restrictions, environmental conditions, planning, and logistics. The installation schedule includes both pile driving and non-pile driving activities.

Table 2-2. Anticipated construction schedule for the Proposed Action

Activity	Duration[a]	Expected Timeframe[b]	Project 1 Start Date	Project 2 Start Date
Onshore Interconnection Cable Installation	9 – 12 months	2024 – 2025	Q1-2024	Q1-2024
Onshore Substation and/or Converter Station Construction	18 – 24 months	2024 – 2026	Q1-2025	Q1-2025
Cofferdam Installation and Removal		2025 – 2026		
Export Cable Installation	6-9 months	2025	Q2-2025	Q3-2025
OSS Installation and Commissioning	5-7 months	2025 – 2027	Q2-2026	Q2-2026
WTG Foundation Installation[c]	10 months	2026 – 2027	Q1-2026	Q1-2026[c]
Inter-Array Cable Installation	14 months	2026 – 2027	Q2-2026	Q3-2026[d]
WTG Installation and Commissioning	17 months	2026 – 2027	Q2-2026	Q1-2027[d]

Notes:
[a] These durations assume continuous foundation structure installation without consideration for seasonal pauses or weather delays; anticipated seasonal pauses are reflected in the expected timeframe.
[b] The expected timeframe is indicative of the most probable duration for each activity; the timeframe could shift and/or extend depending on the start of fabrication, fabrication methods, and installation methods selected.
[c] The expected timeframe depends on the foundation type. If piled foundations are utilized, pile-driving would follow a proposed schedule from May to December to minimize risk to North Atlantic Right Whale. No simultaneous pile driving is proposed.
[d] The expected timeframe is dependent on the completion of the preceding Project 1 activities (i.e., Project 1 inter-array cable installation and WTG installation) and the Project 2 foundation installation schedule.

2.1.2 Installation of WTG/OSS Structures and Foundations

Atlantic Shores would erect 105 to 136 WTGs and 64 to 95 WTGs within the Project 1 and Project 2 proposed work areas, respectively. The Project 1 WTGs would be mounted on 39.4-foot (12-meter) to 49-foot (15-meter) monopile foundations. The Project 2 WTGs would be mounted on 39.4-foot (12-meter) to 49-foot (15-meter) monopile foundations or piled jacket foundations supported by 16.4-foot (5.0-meter) piles.

Atlantic Shores would erect up to 4 large OSSs, 5 medium OSSs, or 10 large OSSs within the Project 1 and Project 2 proposed work areas. The OSSs would connect the inter-array cable network to the OEC transmission lines. Additionally, Atlantic Shores would erect 1 MET tower. The OSSs and MET tower would be supported by monopile foundations, piled jacket foundations, suction bucket jacket foundations, or gravity-base structures. Additionally the MET tower may be supported by a mono-bucket foundation. The monopile and pile jacket foundations would be of the same size described for WTGs. The medium and large suction bucket jacket foundations would be 49 feet (15 meters) in diameter, the medium gravity-based structures would be 263 x 66 feet (80 x 20 meters), and the large gravity-based structures would be 394 x 98 feet (120 x 30 meters).

In addition to the MET tower, up to two temporary meteorological and oceanographic (metocean) buoys may be installed and kept in place during construction to monitor weather and sea state conditions. The metocean buoys are expected to be anchored to the seafloor using a steel chain connected to a steel chain weight on the seafloor. An additional bottom weight associated with a water level sensor may also be connected to the buoys' mooring system. The potential locations for the metocean buoys are shown on Figure 2-1. The buoys will be decommissioned in accordance with 30 CFR Part 585, Subpart I at the end of construction.

As summarized in Table 2-2, above, construction of the Project 1 and Project 2 WTG foundations would occur over a 10-month period beginning in the first quarter of 2026, installation of the Project 1 and Project 2 WTGs would occur over a 17-month period beginning in the second quarter of 2026 for Project 1 and the first quarter of 2027 for Project 2, and construction of the Project 1 and Project 2 offshore substation would occur over an 18- to 24-month period beginning in the first quarter of 2025. During this period, activities would occur 24 hours a day to minimize the overall duration of activities and the associated period of potential impact on marine species.

2.1.2.1 Vessel Activity

Probable vessel classes used to install WTGs and OSSs, with their associated foundations, include bulk carriers, heavy lift vessels, jack-up vessels, jack-up feeders, fall pipe vessels, dredgers, tugboats, barges, service operation vessels, and crew transport vessels (CTVs). Specifically, bulk carriers, heavy lift vessels, and jack-up vessels would be used to install WTG and OSS foundations. Heavy lift vessels would be used to install OSSs. Jack-up vessels assisted by feeder barges or jack-up feeder vessels would be used to install WTGs. Maximum seafloor disturbance per foundation due to anchored or jack-up vessels would be dependent on foundation type and range from 0.0 square feet (0.0 square meters) for gravity-pad tetrahedron base foundations to 58,125 square feet (5,400 square meters) for monopile and mono-bucket foundations (Table 4.2-1, Section 4.2.6, Volume I, Atlantic Shores 2023). Installation of the OSS topsides would require the use of transport vessels and heavy lift or jack-up vessels. The use of heavy lift vessels operating on dynamic positioning would result in no seabed disturbance; jack-up vessels would result in a maximum seabed disturbance of 10,763.9 square feet (1,000 square meters) per OSS foundation; and a heavy lift vessel utilizing anchors would result in a maximum seabed disturbance of 47,361.2 square feet (4,400 square meters) per OSS foundation (Table 4.4-4, Section 4.4.2, Volume I, Atlantic Shores 2023). Fall pipe vessels and dredgers would be used for installation of scour protection. The other vessels would be used to transport construction materials, support construction activities, conduct construction monitoring, and transport construction crews. It is anticipated that up to 15 vessels would be required to install the foundations, up to 11 vessels would be required to install the WTGs, up to 14 vessels would be required to install the OSSs, and 2 vessels would be required to install the scour protection. During construction, Atlantic Shores would receive equipment and materials to be staged and loaded onto installation vessels at one or more existing third-party port facilities.

Anchoring of the vessels used for the installation of the WTGs and OSSs would disturb an estimated 363 acres of seabed during construction of the Proposed Action (Atlantic Shores 2023, Volume I). However, most construction vessels would maintain position using dynamic positioning systems or jack-up features, limiting the use of anchors. Any anchors would be placed within the previously cleared and disturbed area around the foundations.

2.1.2.2 Seabed Preparation/Boulder Relocation/Dredging

For certain foundation types (most commonly gravity foundations), seabed preparation may need to be completed prior to installation of the foundation. The need for seabed preparation will be further assessed during the detailed design stage and will be documented in the FDR/FIR. Seabed preparation can include one or all of the following options: removal of soft, mobile or uneven sediments; level of the seabed without removal of sediment; and/or installation of a stone or aggregate foundation bed, such as a skirt, as an alternative leveling/stabilizing strategy. Seabed preparation, if required, would be completed prior to transport of the foundation to the WTA, as early as one season prior to initiation of foundation installation activities.

Piled and suction bucket foundations are not expected to require seabed preparation unless the seabed is not sufficiently level (e.g., where large sand bedforms are present). Where this occurs, the seabed may need to be prepared prior to pile-driving or suction bucket installation. Seabed preparation could be accomplished using:

- **Trailing suction hopper dredge (TSHD)**: TSHD uses suction pipes to collect sediment in the hopper of the vessel, thus leveling the seabed.
- **Jetting/controlled flow excavation**: This method involves directing columns of water at the seabed to excavate sediments and push them aside.
- **A backhoe/dipper**: A backhoe/dipper is a mechanical method of removing high points on the seabed to level the sediments in preparation for foundation installation.

For gravity foundations, a gravel pad may be installed after completing seabed preparation. The gravel pad is expected to consist of one or more layer(s) of coarse-grained material. The gravel pads may be comprised of a filter layer (i.e., a layer of finer material) and an armor layer (i.e., a layer of coarser material). Installation of the gravel pad typically consists of the following steps:

1. lowering of a steel frame, if needed, to set the boundaries for the gravel pad;
2. leveling the surface of the area within the steel frame;
3. filling the volume inside the steel frame with coarse-grained material;
4. levelling the gravel pad; and
5. compacting the gravel pad and possibly injecting the pad with grout.

Seabed preparation and installation of the gravel pad will likely be performed by a fallpipe vessel using dynamic positioning.

Atlantic Shores has estimated that the volume of seabed that will be disturbed during seabed preparation prior to the installation of the WTG and OSS foundations will range from 0.7 million cubic yards (yd3) (0.5 million cubic meters [m3]) for piled jacket foundations to 1.4 million yd3 (1.1 million m3) for suction bucket foundations. Currently, no specific benthic impact calculations (i.e., acres disturbed) exist for sand wave leveling and seabed debris removal prior to foundation installation. Dredged material will be disposed of within surveyed areas exhibiting sand bedforms, avoiding hard-bottom areas and allowing the volume to be winnowed away by normal currents and tidal actions. Some portion of the dredged sand may also be used for ballast in GBS foundations if those foundations are selected for the Proposed Action. Alternatively, if required, the dredged material could be transported a short distance to an agreed-upon disposal site outside the Lease Area.

2.1.2.3 Piled Foundation Installation

The Projects' monopiles or piled jacket components may be fabricated either in the U.S. or overseas and would be delivered either directly to the WTA or to a marshalling port for final assembly and staging. If storage at a marshalling port is required, equipment such as crawler cranes or self-propelled modular transporters would be used to unload and transport foundations within the marshalling port. Depending on the location of fabrication and any subsequent staging activities, foundation components may be transported to the marshalling port or WTA by heavy transport vessels, ocean-going barges, jack-up feeder vessels, or smaller feeder barges towed by local tugboats.

At the WTA, piled foundations would be installed using one or two jack-up vessels or heavy-lift vessels using dynamic positioning or anchoring. At each foundation location, a crane on the installation vessel would lift the monopile or each piled jacket component from the transportation vessel into a vertical position and lower it to the seabed. Jacket foundations may have either pre-installed piles or post-installed piles. If pre-installed, a template would be used to properly position the piles so they can be driven into the seabed before the jacket arrives at the WTA. The jacket would then be lifted by a vessel crane and set directly onto the installed piles. If post-installed, a vessel crane would lift the jacket foundation and place it on the seabed, after which pin piles would be driven through the jacket's pile sleeves to secure it in place. Mud mats may be used for piled jackets during installation to support the jacket during piling.

Once the monopile or jacket pin pile is lowered to the seabed, the weight of the pile itself will cause the pile to sink a distance into the seabed (but not to target penetration depth). The 39-foot (12-meter) to 49-foot (15-meter) monopile foundations monopiles would be installed using a hydraulic impact hammer with a maximum rated capacity of up to 4,400 kilojoules, which would drive the monopiles up to 263 feet (80 meters) into the seabed. During pile driving, a gripper frame may be used to stabilize the foundation for piling. A vibratory pile driver may also be used at the beginning of pile driving to support embedment of the pile until it is stable enough for pile driving. The installation of one monopile would require approximately 7 to 9 hours of pile driving and up to two monopiles could be installed per vessel spread per day, assuming no time-of-day restrictions. A standard installation scenario assumes that one pile is driven every one to two days such that 200 monopiles piles would be installed over a period of approximately 10 months. The pin piles for piled jacket foundations would be installed using an impact hammer with a maximum rated capacity of 2,500 kilojoules, which would drive the pin piles up to 230 feet (70 meters) into the seabed. The installation of one WTG or small OSS jacket foundation would require approximately one day (three or four pin piles driven per day), assuming 4 hours of pile driving per pile.

Table 2-3. Pile-Driving Schedule (Table G-6, Appendix U, COP Volume II; Atlantic Shores 2023)

Construction Month	Year One		Year Two	
	WTG Monopile 15m diameter MHU4400S (1 pile/day)	OSS Jacket 5m diameter IHCS2500 (4 piles/day)	WTG Monopile 15m diameter MHU4400S (1 pile/day)	OSS Jacket 5m diameter IHCS2500 (4 piles/day)
May	5	0	5	0
June	15	0	15	0
July	15	12	27	0
August	13	12	25	0
September	18	0	18	0
October	20	0	13	0
November	5	0	5	0

Construction Month	Year One		Year Two	
	WTG Monopile 15m diameter MHU4400S (1 pile/day)	OSS Jacket 5m diameter IHCS2500 (4 piles/day)	WTG Monopile 15m diameter MHU4400S (1 pile/day)	OSS Jacket 5m diameter IHCS2500 (4 piles/day)
December	1	0	1	0
Total # of Days	92	24	109	0

While not anticipated, drilling for pile installation may be required if pile driving encounters refusal (e.g., from bedrock or a large boulder). This operation involves placing a rotary drilling unit on top of the pile to drill out material from the internal diameter of the pile so pile driving can continue. Material drilled out of the inner diameter of the pile is expected to be deposited in the vicinity of any scour protection. Fill material may be transferred into the pile after the drilling operation is complete to provide additional stability. The fill material may be sand, grout, or concrete and will be piped or conveyed from the installation or auxiliary vessel into the pile.

Following installation of a monopile, a vessels' crane would lift the transition piece (if used) onto the monopile, and the joint would be secured with grout, bolts, a slip joint, other mechanical joint, or a combination of these methods. If used, grout would be mixed onboard a vessel and pumped into the transition piece above a high-strength rubber grout seal to avoid leakage.

For jacket foundations, once the pin piles are driven to their target depths, the installation vessel would ensure the foundation is level and the piles would be fixed in place with grout. Grout would fill each pile sleeve, and the procedure would be monitored to ensure that grout does not spill over the sleeve. For both monopile and jacket foundations, proper grouting procedures would be used to minimize any overflow.

2.1.2.4 Suction Bucket Foundation Installation

Suction bucket foundations do not require a hammer or drill for installation. Thus, the process of installing a suction bucket foundation is nearly noise-free and the foundation has the potential to be completely removed upon decommissioning. Suction bucket foundation installation can be completed with one or two heavy lift vessels (using anchoring or dynamic positioning) or jack-up vessels. After a crane lifts the suction bucket foundation from the transport vessel and places it on the seabed (or, for certain suction bucket tetrahedron bases, once the foundation is sunk to the seabed after being floated out to the WTA), the weight of the structure will cause partial penetration of the buckets into the seabed.

After the foundation is in place, the tops of each suction bucket are sealed, and pumps are used to remove water from each bucket to create a negative pressure differential that embeds the bucket into the seabed. Atlantic Shores estimates that the total volume of water pumped during installation would range from 1.40 million gallons per bucket for the suction bucket jacket foundation to 11.44 million gallons per bucket for the mono-suction bucket foundation. The flow rate of the pumps would be selected to be low enough to avoid disturbance to the seabed. Pumping could take several hours to several days depending on the size of the suction bucket used. The pump would have a screen installed on the intake in order to protect the pump components. Atlantic Shores anticipates a 20-mesh screen would be reasonable for this application. However, the exact flow rate and screen size are not known at this time and are dependent on the detailed design of the suction bucket foundation should it be selected. Once the foundation is fully embedded, the pumps would be removed. The space inside the suction bucket (between the bucket lid and sediment inside the bucket) may be backfilled with a cement grout, if determined necessary.

The entire installation process for a mono-bucket, including lifting the foundation onto the seabed, self penetration, pumping out water, retrieving the pumps, and grouting the buckets is expected to take less than approximately 7 to 9 hours per foundation. After a mono-bucket foundation is installed, a transition piece (if separate) may be installed by a vessel's crane and secured with bolts, grout, a slip joint, other mechanical joint, or a combination of these methods. The entire installation process for a suction bucket jacket or suction bucket tetrahedron base foundation should be completed within 15 hours.

2.1.2.5 Gravity-Based Structure Installation

Gravity foundations could either be transported to the WTA onboard a large-capacity barge or floated to the WTA using multiple tugboats. If transported to the WTA onboard a large-capacity barge, a heavy lift vessel crane would lift the foundation and place it on the seabed. If floated to the WTA, the foundation may be transported by tugboats directly to the WTA from the supplier's fabrication location or the foundation may first be transported by the supplier on a semisubmersible barge to a sheltered offshore location before being lowered into the water, connected to tugboats, and pulled to the WTA. When the floating foundation arrives at the WTA, the foundation will be lowered to the seabed by increasing ballast. Once the foundation is at its final position on the seabed, the tugboats are disconnected, and the purpose-built installation and transportation aid (if used) is removed.

After the foundation is in place on the seabed, any additional ballast material (if needed) would be pumped into the foundation's interior by a dedicated vessel to provide additional stability. If seawater were used as a ballast material, Atlantic Shores anticipates that a screen would be installed to prevent debris from entering the foundation. Atlantic Shores anticipates a 20-mesh screen would be reasonable for this application. However, the exact flow rate and screen size are not known at this time and are dependent on the detailed design of the suction bucket foundation. For concepts that do not involve quayside installation of the transition piece or WTG, the transition piece and WTG would be installed after the foundation is in place. If a telescoping gravity foundation design is employed, the telescopic portion of the foundation would be jacked up by lifting equipment arranged around the foundation's service platform. After the telescopic portion of the foundation is fully extended and secured, the lifting equipment would be removed from the structure. With a single installation spread, it is anticipated that one gravity foundation would be installed per day.

2.1.2.6 Installation of Scour Protection

Scour protection would most likely be installed around the wind turbine and offshore substation foundations to prevent scouring of seabed material. The locations requiring scour protection, the type of protection selected, and the amount placed around each foundation would be based on a variety of factors, including foundation type and water flow and substrate type (hydrodynamic scour modeling). The need for and selected type(s) of scour protection will be determined by the final design of the foundations and ongoing agency consultations. Descriptions of the scour protection types proposed are:

- Rock placement: up to three layers of rock with increasing rock size in higher layers
- Rock bags: rock-filled filter unit enclosed by polyester mesh
- Grout- or sand-filled bags: bags filled grout or sand
- Concrete mattresses: high-strength concrete blocks cast around a mesh that secures the blocks in a flexible covering
- Ballast-filled mattresses: mattress filled with ballast material (e.g., sand/water/bentonite mixture)

- Frond mattresses: buoyant fronds with similar functionality to natural seaweed densely built into a mattress

Scour protection consisting of freely-laid rock will likely be installed by a fallpipe vessel, which uses a pipe that extends to just above the seafloor to deposit rock contained in the vessel's hopper in a controlled manner. Concrete mattresses, rock bags, grout- or sand-filled bags, and frond mattresses will likely be deployed by a vessel's crane.

Scour protection may occur in any shape and size up to the maximum footprint, including the possibility of no scour protection. The maximum dimensions of scour protection that may be used for different foundation options under the Proposed Action are summarized in Table 2-4. Scour protection for WTG foundations would result in the modification of seabed ranging from 2,749 m2 (0.7 acres) per piled jacket foundation to 5,104 m2 (1.3 acres) per monopile foundation. Scour protection for the MET tower foundation would result in the modification of seabed ranging from 2,749 m^2 (0.7 acres) for a piled jacket foundation to 9,697 m^2 (2.4 acres) for a suction bucket jacket foundation. Scour protection for OSS foundations would result in the modification of seabed ranging from 2,749 m^2 (0.7 acres) per small piled jacket foundation to 24,874 m^2 (6.1 acres) per large suction bucket jacket foundation.

Table 2-4. Foundation Scour Protection Dimensions (COP Volume I; Atlantic Shores 2023)

Project Component	Option	Outer Diameter / Dimensions of Scour Protection	Thickness of Scour Protection	Footprint per Foundation
WTG	Piled Jacket	98.4 ft (30.0 m) per leg	6.6 ft (2.0 m)	2,749 m^2 (0.7 acres)
	Monopile	269.0 ft (82.0 m) per foundation	8.2 ft (2.5 m)	5,104 m^2 1.3 acres)
MET Tower	Piled Jacket	98.4 ft (30.0 m) per leg	6.6 ft (2.0 m)	2,749 m^2 (0.7 acres)
	Monopile	269.0 ft (82.0 m) per foundation	8.2 ft (2.5 m)	5,104 m^2 (1.3 acres)
	Suction Bucket Jacket	334.6 ft x 334.6 ft (102.0 m x 102.0 m) per foundation	6.6 ft (2.0 m)	9,697 m^2 (2.4 acres)
	Mono-Bucket	295.3 ft (90.0 m) per foundation	6.6 ft (2.0 m)	5,400 m^2 (1.3 acres)
	GBS	272.3 ft (83.0 m) per foundation	4.6 ft (1.4 m)	3,035 m^2 (0.7 acres)
OSS	Piled Jacket (Small)	98.4 ft (30.0 m) per leg	6.6 ft (2.0 m)	2,749 m^2 (0.7 acres)
	Monpile (Small)	269.0 ft (82.0 m) per foundation	8.2 ft (2.5 m)	5,104 m^2 (1.3 acres)
	Suction Bucket Jacket (Small)	334.6 ft x 334.6 ft (102.0 m x 102.0 m) per foundation	6.6 ft (2.0 m)	9,697 m^2 (2.4 acres)
	Piled Jacket (Medium)	131.2 ft (40.0 m) per leg	6.6 ft (2.0 m)	6,480 m^2 (1.6 acres)
	Suction Bucket Jacket (Medium)	196.9 ft (60.0 m) per leg	6.6 ft (2.0 m)	15,904 m^2 (3.9 acres)
	GBS (Medium)	393.7 ft x 377.3 ft (120.0 m x 115.0 m) per foundation	5 ft (1.5 m)	10,600 m^2 (2.6 acres)
	Piled Jacket (Large)	147.6 ft (45.0 m) per leg	6.6 ft (2.0 m)	10,210 m^2 (2.5 acres)
	Suction Bucket Jacket (Large)	695.5 ft x 203.4 ft (212.0 m x 62.0 m) per row of	6.6 ft (2.0 m)	24,874 m^2 (6.1 acres)

Project Component	Option	Outer Diameter / Dimensions of Scour Protection	Thickness of Scour Protection	Footprint per Foundation
		four legs		
	GBS (Large)	524.9 ft x 459.3 ft (160.0 m x 140.0 m) per foundation	5 ft (1.5 m)	15,200 m^2 (3.8 acres)

2.1.3 Inter-Array and Offshore/Onshore Cable Installation

The inter-array cables would connect the WTGs into strings and then connect these strings to the OSSs. The inter-array cables would consist of three-stranded core high voltage alternating current (HVAC) cables with a transmission capacity of 66 to 150 kilovolts (kV). The Project 1 and Project 2 inter-array cables would have lengths of 273.5 miles (440 kilometers), each.

The Project may use inter-link cables to connect the OSSs. Inter-link cables would consist of three-stranded core HVAC cables with a transmission capacity of 66 to 275 kV. The Project 1 and Project 2 inter-link cables would have lengths of 18.6 miles (30 kilometers), each.

Up to eight offshore export cables, occupying up to two ECCs, would connect the proposed Project to the onshore electrical grid. The export cables installed within each ECC would typically be separated by approximately 492 ft (150 m), though this separation distance may range from approximately 328 to 820 ft (100 to 250 m), depending on route constraints and water depths. There are three transmission options for the offshore export cables: HVAC transmission, high voltage direct current (HVDC) transmission, and HVAC and HVDC transmission. Under the HVAC option, Project 1 and Project 2 would each install up to four HVAC cables in separate corridors. Under the HVDC option, Project 1 and Project 2 would each install a two-cable HVDC bundle in separate corridors. The HVDC option would use a closed cooling system, which would not require any water withdrawals. Under the HVAC and HVDC option, one project would install up to four HVAC cables and the other would install one HVDC bundle, in either the same or separate corridors. HVAC cables would have a three-stranded core with a transmission capacity of 230 to 275 kV. HVDC cables would have a single core with a transmission capacity of 320 to 525 kV. If four export cables are installed in each ECC (for a total of eight export cables), the total maximum export cable length would be 441 mi (710 km).

The offshore export cables would connect to onshore interconnection cables at the landfall(s). The interconnection cables would consist of either three single-core HVAC cables per circuit, with up to four circuits each for Project 1 and Project 2, or two single-core HVDC cables per circuit, with one circuit per route. The transmission capacity of HVAC interconnection cables would be 230 to 275 kV, and the transmission capacity of HVDC interconnection cables would be 320 to 525 kV.

As summarized in Table 2-2, above, installation of the Project 1 and Project 2 inter-array cables would occur over a 14-month period beginning in the second quarter of 2026 for Project 1 and the third quarter of 2026 for Project 2, installation of the Project 1 and Project 2 export cables would occur over a 6- to 9-month period beginning in the second quarter of 2025 for Project 1 and the third quarter of 2025 for Project 2, and installation of the onshore interconnection cable would occur over a 9- to 12-month period beginning in the first quarter of 2024. During this period, activities would occur 24 hours a day to minimize the overall duration of activities and the associated period of potential impact on marine species.

2.1.3.1 Vessel Activity

Probable vessel classes used to install offshore cables include cable installation vessels, dredgers, anchor handling tug supply vessels, fall pipe vessels, transport and anchor handling tugs, tugboats, barges, and service operation vessels. Cable installation vessels would be used to install and bury submarine cables. Fall pipe vessels would be used for installation of cable protection. The other vessels would be used to transport construction materials and support construction activities. It is anticipated that 7 vessels would be required to install the inter-array cables, and 6 vessels would be required to install the export cables. The maximum area of seafloor disturbance from anchoring during export cable installation is estimated to be 0.55 square miles (1.41 square kilometers) assuming an eight point anchor spread and associated mooring system and the maximum area of seafloor disturbance from jacking-up during cable splicing and HDD at the landfall sites is estimated to be 0.001 square miles (0.0025 square kilometers) (Table 4.5-1, Section 4.5.10.1, Volume I, Atlantic Shore 2021).

The vessels used for the installation of the inter-array and export cables would disturb an estimated 266 acres of seabed during construction of the Proposed Action. However, most construction vessels would maintain position using dynamic positioning systems or jack-up features, limiting the use of anchors. Additionally, while an anchored cable laying vessel may be used in shallow segments of the ECCs, the use of anchored cable laying vessel is not expected in the WTA.

2.1.3.2 Seabed Preparation

Pre-installation activities, including sand bedform clearing, relocation of boulders, UXO (unexploded ordnance) clearance, a pre-lay grapnel run, and a pre-lay survey, would be conducted prior to the installation of offshore cables.

Sand bedform clearing would involve the removal of the tops of some mobile sand bedforms to ensure cables can be installed within stable seabed. Project engineers estimate that up to 20 percent of export cable routes, 20 percent of inter-link cable routes, and 10 percent of inter-array cable routes may require sand bedform clearing; this would amount to sand bedform clearing along 88.3 miles (142 km) of export cables, 54.6 miles (88 km) of inter-array cables, and 7.4 miles (12 km) of inter-link cables. Sand bedform removal is expected to be completed with one or more of the following typical methods:

- **TSHD**: In this dredging method, one or two suction pipes, each equipped with a trailing drag head, descend from the side of the dredging vessel to the seabed. Each drag head is fitted with nozzles that direct high-pressure water at the seabed to loosen seabed material. Because of the lower pressure in the pipe, the loosened material is sucked up and discharged into the vessel's hopper. Once collected, dredged materials can be discharged via the bottom doors of the vessel or a pipe that releases dredged material lower in the water column. The collected material will be disposed of within surveyed areas exhibiting sand bedforms, avoiding hard-bottom areas and allowing the volume to be winnowed away by normal currents and tidal actions. Some portion of the dredged sand may also be used for ballast in GBS foundations if those foundations are selected for the Proposed Action. Alternatively, if required, the removed material could be transported a short distance to an agreed-upon disposal site outside the Project area.
- **Controlled flow excavation**: Controlled flow excavators are equipped with rotating propellers capable of producing high-volume water columns which, when directed at the seabed, rapidly excavate sediments. The tool can be gyroscopically stabilized and deployed either from a crane or A-frame on the cable installation vessel. Controlled flow excavation may also be used for repairs or removal of cables in soft soils such as silt or loose/medium sand.

- **Route clearance plow**: A route clearance plow pushes sand aside, clearing the way for cable installation. Like the use of controlled flow excavation, use of a route clearance plow does not involve collecting sand from the seabed; rather, removed sand is cast aside adjacent to the cable alignments.

In addition to these typical methods, two additional specialty methods may be used in limited areas:

- **Cutterhead dredging**: This type of dredging is like TSHD but is used in hard or rocky seabed conditions. The method employs a cutterhead, which is like a large drill, that breaks up the seabed and loosens it for suction dredging. Given the harder substrate, the rate of production is slower than with a TSHD. Cutterhead dredging is not expected within the WTA but could be required if rocky seabed is encountered along the ECCs.
- **Backhoe dredging**: This type of dredging is more likely to be used in shallow, nearshore areas where only a small amount of material may need to be removed. The backhoe dredging equipment operates in the same way as an onshore backhoe excavator but is mounted on a small barge either with or without stabilizing spud legs. Underwater works are typically monitored using either multibeam or blue-view cameras attached to the vessel. Material extracted in the backhoe may be sidecast or it could be deposited in either a hopper on the barge or on a separate hopper vessel before proper disposal.

Dredging during sand bedform removal prior to cable installation is expected to result in the removal of 7.1 million yd^3 (5.5 million m^3) of material, including 4.2 million yd^3 (3.2 million m^3) along the ECCs, 2.6 million yd^3 (2.0 million m^3) along the inter-array cable corridor, and 0.4 million yd^3 (0.3 million m^3) along the inter-link cable corridor.

Boulder relocation may be required in limited areas along the export cable corridors. Presence of boulders is expected to be minimal, and boulder removal would likely be performed using subsea grab, a method with minimal seabed impact. If more boulders are encountered than expected, a displacement plow may be utilized for boulder removal. If this method is necessary, the plow would be ballasted to only clear boulders, avoiding creation of a deep depression in the seabed.

The export cable route would be surveyed and cleared for UXO prior to cable installation. A study of UXO has been conducted and an associated hazard assessment has been provided to BOEM under confidential cover as part of the COP (see Volume II, Appendix II-A; Atlantic Shores 2023). This study indicated that the likelihood of encountering UXO during construction of the Proposed Action is low. In the event that UXO are observed during construction, Atlantic Shores would implement a mitigation strategy to avoid UXO. At this time, no UXO detonation is planned for the Proposed Action.

A pre-lay grapnel run would be completed approximately two months prior to cable installation to clear final cable alignments of man-made obstructions (e.g., discarded fishing gear). Atlantic Shores expects to make three grapnel runs along each cable alignment. During the pre-lay grapnel run, the seabed would be impacted to a maximum depth of 1.6 feet (0.5 meters).

Pre-lay surveys would be performed along final cable alignments to confirm seabed morphology and bathymetry prior to the start of cable laying operations. These surveys would be performed using a multibeam echosounder.

2.1.3.3 Trenching/Cable Installation

Inter-array and Offshore Export Cables

Once any necessary pre-installation activities are completed, Atlantic Shores would lay and bury the export, inter-link, and inter-array cables. Cable lay and burial may be completed using three common methods:

- Simultaneous lay and burial: Cable is directly guided from the installation vessel through the burial tool and laid into the seabed. Atlantic Shores expects to use this method for installation of export cables
- Post-lay burial: Cable is temporarily laid on the seabed then buried in a subsequent, separate operation. This method leaves the cables unprotected between laying and burial operations, but burial can be completed more quickly, minimizing duration of cable installation impacts, and multiple passes with the burial tool can be completed to reach target burial depth, minimizing the need for cable protection. Atlantic Shores expects to use this method for installation of inter-array and inter-link cables
- Pre-lay trenching: A trench is excavated prior to cable installation, cable is laid into the trench, and the trench is backfilled with spoils from trench excavation. This method would be limited to portions of cable alignments where deeper cable burial is required, or firmer sediments are encountered

Atlantic Shores is considering a variety of tools to perform cable lay and burial operations. Final equipment selection will be based upon seabed conditions, cable properties, laying and burying combinations, burial tool systems, and anticipated performance. Three primary tools are under consideration:

- Jet trenching: Involves injecting pressurized water jets into the seabed, creating a trench. This equipment can be used in soft sediments for either simultaneous lay and burial or post-lay burial techniques
- Plowing/jet plowing: As the plow is dragged along the seabed, a trench to the required burial depth is created and held open. As the plow advances, the cable is placed in the trench and displaced sediment is either mechanically returned to the trench or backfills naturally. This equipment is typically used for simultaneous lay and burial
- Mechanical trenching: This tool cuts a narrow trench into the seabed using a jetting sword or excavation chain, and cable is buried in the trench either simultaneously or subsequently. This equipment is generally used in firmer sediments for simultaneous lay and burial, post-lay burial, and pre-lay trenching techniques

Atlantic Shores anticipates that most of offshore cable installation would use jet trenching equipment or jet plowing. Mechanical trenching is only expected in limited areas. Approximately 80 to 90 percent of offshore cables are expected to require only one pass of the cable installation tool. In the remaining areas, two to four passes may be required to reach target burial depth. Along approximately 5 percent of the export cable corridors, an additional pass may be performed prior to cable installation (i.e., re-pass jetting) to increase the probability of successful cable burial. In shallow portions of the export cable corridor, a fourth tool may be used to perform simultaneous lay and burial: a plow towed by a shallow-water barge with tensioners.

Given the length of the export cables, cable jointing offshore would be required. The end of each cable segment would be held in temporary wet storage on the seabed, which may require temporary cable protection (e.g., concreted mattresses) to be placed over the cable end. Once the cable segments are jointed onboard a jointing vessel, the joints would be buried using either a jet trencher or controlled flow excavation. If sufficient burial is not possible, cable protection would be placed on top of the joint. Depending on the final construction and installation schedule, the ends of the export cables may need to be wet-stored and covered with cable protection until they are pulled into the foundation.

Where cable protection is required, freely-laid rock, if selected as the cable protection type, would be placed using a fallpipe installation method, wherever possible. Alternative rock laying techniques would include placement by vessel crane and side dumping. If concrete mattresses, rock bags, or grout-filled bags are selected for cable protection, they would be deployed using a vessel crane. Half-shell pipes would be installed around the cable on board the cable laying vessel prior to cable installation.

Offshore Export Cable Landfall and Interconnection Cable

The offshore export cables would connect to the onshore interconnection cables at the Monmouth and Atlantic Landfall Sites. As depicted in Figure 2-2 and Figure 2-3, Atlantic Shores has selected two locations for the export cable landfalls:

- Monmouth Landfall Site: U.S. Army National Guard Training Center in Sea Girt, New Jersey
- Atlantic Landfall Site: S. California Avenue lot located at the eastern end of S. California Avenue, adjacent to the Atlantic City Boardwalk in Atlantic City, New Jersey

From the landfall sites, interconnection cables would be installed primarily along existing roadways, utility rights-of-way, and bike paths to the proposed onshore substation or converter station sites. From these sites, the interconnection cables would continue to their points of interconnection (POIs). The existing Larrabee Substation and existing Cardiff Substation are the proposed POIs for the Project.

In the Larrabee Onshore Interconnection Cable Route, the interconnection cables would connect from the Monmouth Landfall site to one of three potential sites for the Larrabee Substation and/or Converter Station and terminate at the Larrabee Substation POI owned by Jersey Central Power & Light (JCP&L). The three potential substation and/or converter station sites, shown on Figure 2-2, are the approximately 16.3-acre (6.6-hectare) Lanes Pond Road Site, located at the southeast intersection of Lanes Pond Road and Miller Road; the approximately 24.6-acre (10-hectare) Randolph Road Site, located east of Lakewood Farmingdale Road and north of Randolph Road; and the approximately 99.4-acre (40.2-hectare) Brook Road Site, located west of Brook Road and south of Randolph Road. All three sites are located in Howell Township, New Jersey (Figure 2-2). The Larrabee Onshore Interconnection Cable Route would be approximately 9.8 to 23.0 miles (15.8 to 37.0 kilometers) and would largely utilize existing linear infrastructure corridors.

In the Cardiff Onshore Interconnection Cable Route, the interconnection cables would connect from the Atlantic Landfall Site to the proposed Cardiff Substation and/or Converter Station at a vacant lot then continue to the Cardiff POI (Figure 2-3 through Figure 2-6). The potential substation and/or converter station site, shown on Figure 2-5, is a vacant lot located in Egg Harbor Township, approximately 20 acres (8 hectares) in size and bordered by Fire Road (County Road 651) to the north and Hingston Avenue to the south. The Cardiff Onshore Interconnection Cable Route intersects three inland waterways, Chelsea Harbor, Beach Thorofare and Great Thorofare (Figure 2-4). The Cardiff Onshore Interconnection Cable Route would be approximately 12.4 to 22.6 miles (20.0 to 36.4 kilometers) and would largely utilize existing linear infrastructure corridors.

Horizontal directional drilling (HDD) will be used to accomplish the offshore-to-onshore transition at the Atlantic Landfall Site, thereby completely avoiding impacts to benthic habitat including any potential areas of SAV. HDD is proposed as the method for the installation of the export cables at the Monmouth Landfall Site. HDD is a trenchless installation method that avoids nearshore and shoreline impacts and allows for deeper cable burial in nearshore environments. Each of the export cables coming ashore will be installed via HDD in separate conduits. Up to six HDD conduits may be installed at each landfall site to accommodate the HVAC and/or HVDC cable options. To support this installation, both onshore and offshore work areas are required. At the Atlantic Landfall Site, the HDD trajectory for each of the cables is expected to be approximately 2,800 ft (853 m) long. At the Monmouth Landfall Site, the HDD trajectory for each of the cables is expected to be approximately 2,800 ft (853 m) long. The estimated average depth of the HDDs is approximately 16 to 131 ft (5 to 40 m) below the seabed. At the offshore HDD entrance/exit location, a shallow area of up to approximately 66 ft by 33 ft (20 m by 10 m) will be excavated. A backhoe dredge may be required to complete excavation of the offshore HDD entrance/exit. A cofferdam may also be used, depending on the results of marine surveys. A temporary offshore platform (i.e., a jack-up barge) may be required to support the HDD drilling rig. If used, Atlantic Shores anticipates the cofferdam for each cable landfall would be 98.4 by 26.2 feet (30 by 8 meters). Each cofferdam would be composed of approximately 109 sheet piles, with a total of 872 sheet piles for all 8 cofferdams combined, that would be installed using a vibratory hammer. Each cofferdam is anticipated to require 8 days to install and 8 days to remove.

In areas where the Projects' onshore transmission cables cross wetlands and inland waterbodies, specialty installation techniques may be implemented. These specialty installation methods would include trenchless techniques that help to avoid direct surface disturbance and hence impact to sensitive areas. These specialty techniques primarily include:

- Horizontal directional drilling: HDD is typically used to cross beneath relatively wide features, such as waterbodies. HDD commonly involves drilling a hole in an arc under the surface feature, then enlarging that hole and pulling either a large PVC or HDPE casing or several smaller PVC or HDPE conduits (in a bundle) back through the bore hole.
- Pipe jacking: In this method, a casing pipe originating in a jacking shaft is driven through the soil by powerful hydraulic jacks to excavate a tunnel that leads to a receiving shaft on the opposite side of the obstacle being avoided on the surface. This method results in a flexible, structural, watertight, and finished conduit for the installation of cables.
- Jack-and-bore: This trenchless crossing technique is used to install a casing beneath the surface feature being avoided. Relative to HDD, jack-and-bore is typically used for shorter crossings (less than approximately 200 ft [61 m]), such as those under streams or highways. A jack-and-bore is performed by excavating a bore pit and a receiving pit, located on opposite sides of the obstacle. Drilling and jacking activities are initiated from the bore pit, while the steel or concrete casing is driven into the receiving pit. As a borehole is drilled, the casing is pushed into the borehole. After the casing is in place, it is cleaned, and then smaller HDPE or PVC conduits are installed inside the casing.

2.1.3.4 Cable Protection

In areas where burial of the cables to the target depth (5 to 6.6 feet [1.5 to 2 meters]) is not feasible, cable protection would be installed on the seabed above the cable as a secondary measure to protect the cables. Cable protection may also be necessary to support the crossing of existing marine infrastructure (e.g., submarine cables or pipelines). Though Atlantic Shores would work to minimize the amount of cable protection required, the Applicant conservatively assumes that up to 10 percent of offshore cables (i.e., 54.6 miles [88 kilometers] of inter-array cables, 3.8 miles [6 kilometers] of inter-link cables, and 44.1 miles [71 kilometers] of export cables) may require cable protection due to insufficient burial depth. Cable protection would extend to a width of up to 41 feet (12.5 meters) and a depth of up to 4.6 feet (1.4 meters). Additionally, cable protection may be required for up to 88 infrastructure crossings. Proposed types of cable protection include the following:

- Rock placement: Up to three layers of rock, with rock size increasing in higher layers
- Concrete mattresses: High-strength concrete blocks cast around mesh that holds the blocks in a flexible covering
- Rock Bags: Rock-filled filter unit enclosed by polyester mesh
- Grout-filled bags: Woven fabric filled with grout
- Half-shell pipes: Composite materials or cast iron that is fixed around a cable

2.1.4 Port Facilities

Atlantic Shores is considering several port facilities in New Jersey, Virginia, and Texas that may be used for major construction staging activities for the Project. Construction ports would be used to support the following functions:

- crew transfers;
- component fabrication and assembly;
- receiving and offloading shipments of Project components;
- storing Project components;
- preparing Project components for installation;
- loading Project components onto installation vessels for delivery to the Project area; and/or
- preparing vessels to tow floating components to the WTA.

A list of U.S. ports considered for temporary use during major construction staging activities is provided in Table 2-5 and depicted on Figure 2-7; it is likely that only some of the ports identified will be used for the Projects' construction. Atlantic Shores may use ports listed in Table 2-5 to support O&M activities such as some crew transfer, bunkering, spare part storage, and load-out of spares to vessels. Further, routine port activities, such as refueling and supply replenishment, may occur at other ports not identified in Table 2-5. While it is anticipated that the identified ports can support the Projects' needs, it is possible that if significant non-routine maintenance is needed for either Project, it could require unplanned use of another U.S. or international port.

Connected Action

Once operational, the Project will be supported by a new O&M facility that Atlantic Shores is proposing to establish in the Atlantic City Inlet Marina (ACIM) in Atlantic City, New Jersey (see Figure 2-8). The O&M facility would be used solely by Atlantic Shores as the primary location for O&M operations including material storage, day-to-day management of inspection and maintenance activities, vehicle parking, marine coordination, vessel docking, and dispatching of technicians. To establish the O&M facility, Atlantic Shores intends to develop a shoreside parcel in the ACIM that was formerly used for vessel docking or other port activities. Construction of the O&M facility is expected to involve the construction of a new building and associated parking structure, installation of new dock facilities, replacement of the existing bulkhead, and maintenance dredging in coordination with the City's dredging of the adjacent basins.

Repair of an existing bulkhead or installation of a new bulkhead and maintenance dredging in coordination with Atlantic City's dredging of the adjacent basins would be conducted regardless of the construction and installation of the Proposed Action. However, the bulkhead and dredging are necessary for the use of the O&M facility included in the Proposed Action. Therefore, the bulkhead repair/installation and dredging activities are considered to be a Connected Action under NEPA. The bulkhead site and dredging activities would be conducted within an approximately 20.6-acre (8.3-hectare) site within the ACIM.

The existing bulkhead in the ACIM is an approximately 250-foot (76-meter) structure consisting of multiple sections, which are made from steel sheet piles, timbers, and concrete. The bulkhead is missing sections, leading it to become unstable and increasing the potential for erosion. Repair and/or replacement of the existing bulkhead is required in order to stabilize the shoreline and prevent additional erosion. Independently of the Proposed Action, Atlantic Shores is pursuing a USACE Nationwide Permit 3/Nationwide Permit 13 to install an approximately 356-feet (109-meter) bulkhead composed of steel or composite vinyl sheet piles. The new bulkhead will be sited externally of the existing bulkhead, as the existing bulkhead will remain in place, unless removal of specific sections is required to safely install the new bulkhead. The installation of the new bulkhead would include installation of 60, 16-inch (0.4-meter) deep sheet piles. Sheet piles would be installed using a vibratory hammer.

The City of Atlantic City obtained a USACE approval (CENAP-OPR-2021-00573-95) and a NJDEP Dredge Permit (No. 0102.20.0001.1 LUP 210001) to perform 10-year maintenance dredging of 13 city waterways, inclusive of the area associated with the proposed O&M facility. Atlantic City's maintenance dredging program targets substantial shoaling that has built up over the last century. The area was historically dredge-maintained during the 1950s and 1980s. The City's maintenance dredging program would reestablish a water depth of 15 feet below the plane of Mean Low Water (MLW) plus 1.0-foot of allowable overdredge and 4:1 slide slopes within the site.

Dredging would be accomplished via hydraulic cutterhead dredge with pipeline or mechanical dredge. The hydraulic cutterhead dredge would be the primary dredge method, with the mechanical dredge utilized to access small marina, canal, or lagoon areas. The hydraulic dredge pipeline would be marked in accordance with U.S. Coast Guard (USCG) regulations and would be sunken, except where submerged aquatic vegetation is encountered, in which case the pipeline would be floated. Dredging associated with the Connected Action would remove approximately 142,823 cubic yards of material, consisting primarily of sand and silt, from an approximately 20.6-acre area of sea bottom. Dredged material would be disposed of at three locations: the Dredged Hole #86 (DH#86) subaqueous borrow pit restoration site (14.0 acres) in Beach Thorofare located in Atlantic City, Atlantic County, New Jersey; the upland Tuckahoe Turf Farm located in Estell Manor, Atlantic County, New Jersey; and the upland Kinsley's Landfill located in Sewell, Mantua Township, Gloucester County, New Jersey. Placement of dredged material into DH #86 is contingent upon execution of a use agreement between Atlantic City and NJDOT-OMR. According to the most current submerged aquatic vegetation (SAV) maps available from NJDEP's Department of Land Use Regulation website[1], the ACIM does not contain any mapped SAV beds.

[1] Available at: https://www.nj.gov/dep/landuse/sav.html

Each maintenance dredging event is anticipated to be approximately twelve weeks in duration, including mobilization/demobilization, dredging, and material placement activities. Two or three maintenance dredging events are anticipated to be conducted over the next ten years, with the initial dredging event proposed to be undertaken starting on or after July 1st, 2022.

Table 2-5. Ports that may be used during construction of the Proposed Action

Port	Location	Description	Staging/Pre-Assembly Activities that May Occur			
			WTG	OSS	Foundation	Offshore Cables
New Jersey Wind Port	Lower Alloways Creek, New Jersey	New Jersey plans to develop the New Jersey Wind Port as a marshaling and manufacturing site for offshore wind projects. Phase 1 of port construction is targeted to start in 2021, and New Jersey anticipates the port will become available in 2023 with a 30-acre (0.12-km2) marshaling area, 25-acre (0.10-km2) manufacturing site, and heavy-lift wharf. Phase 2 of port construction is targeted to start in 2023. As part of Phase 2, more than 160 acres (0.65 km2) of additional marshaling and manufacturing space with additional berths and room for Tier 2 suppliers is expected to become available in 2024-2026 (State of New Jersey 2020).	X Includes full tower assembly	X	X For piled, suction bucket, and gravity foundations	X
Paulsboro Marine Terminal	Paulsboro, New Jersey	The Paulsboro Marine Terminal comprises 200 acres (0.81 km2) on the Delaware River. Its available berth is approximately 850 ft (260 m) in length, with a water depth of approximately 40 ft (12 m) at Mean Low Water (MLW). The port is currently being developed for staging and manufacturing monopiles. The existing 850-foot-long (260-m-long) quayside is currently fully utilized, but an additional 1,500-ft (457-m) quayside is under construction and will have a bearing capacity of 1,500 pounds per square foot (psf) (73 ton/m2). Construction is expected to be completed in 2021 (South Jersey Port Corporation 2020).	X	X For smaller OSS types	X For piled and gravity foundations	X
Repauno Port & Rail Terminal	Greenwich Township, New Jersey	Repauno Port & Rail Terminal (Repauno) is a 1,600-acre (6.47-km2) site along the Delaware River in Greenwich Township, New Jersey. Formerly the site of a DuPont manufacturing facility, the site is currently being redeveloped into a multi-use port facility for energy products, roll-on/roll-off, project cargo, bulk cargo, warehousing, and logistics. The port features a new multi-purpose dock with an approximately 40-ft (12-m) draft capable of handling a wide variety of products.	X	X For smaller OSS types	X For piled and gravity foundations	X
Portsmouth Marine Terminal	Portsmouth, Virginia	Portsmouth Marine Terminal occupies 287 acres (1.2 km2) on the west bank of the Elizabeth River in Portsmouth, Virginia. The terminal is operated by CSX Intermodal Terminals, Inc. and serves both domestic and international freight. It currently handles containers, breakbulk, and roll-on/roll-off cargo. The facilities include approximately 3,540 ft (1,079 m) of wharf and three berths (Virginia Port Authority 2020).	X Includes full tower assembly	X	X For piled, suction, and gravity foundations	X

Port	Location	Description	Staging/Pre-Assembly Activities that May Occur			
			WTG	OSS	Foundation	Offshore Cables
Port of Corpus Christi	Ingleside, Texas	Jackets, topsides, onshore and offshore modules, living quarters, subsea kits, piles, and tendons are fabricated at this 500-acre (2-km2) manufacturing site. The site also houses the world's largest offshore lifter that is 550 ft (167 m) tall and can lift 13,000 tons.		X	X For piled, suction bucket, and gravity foundations	

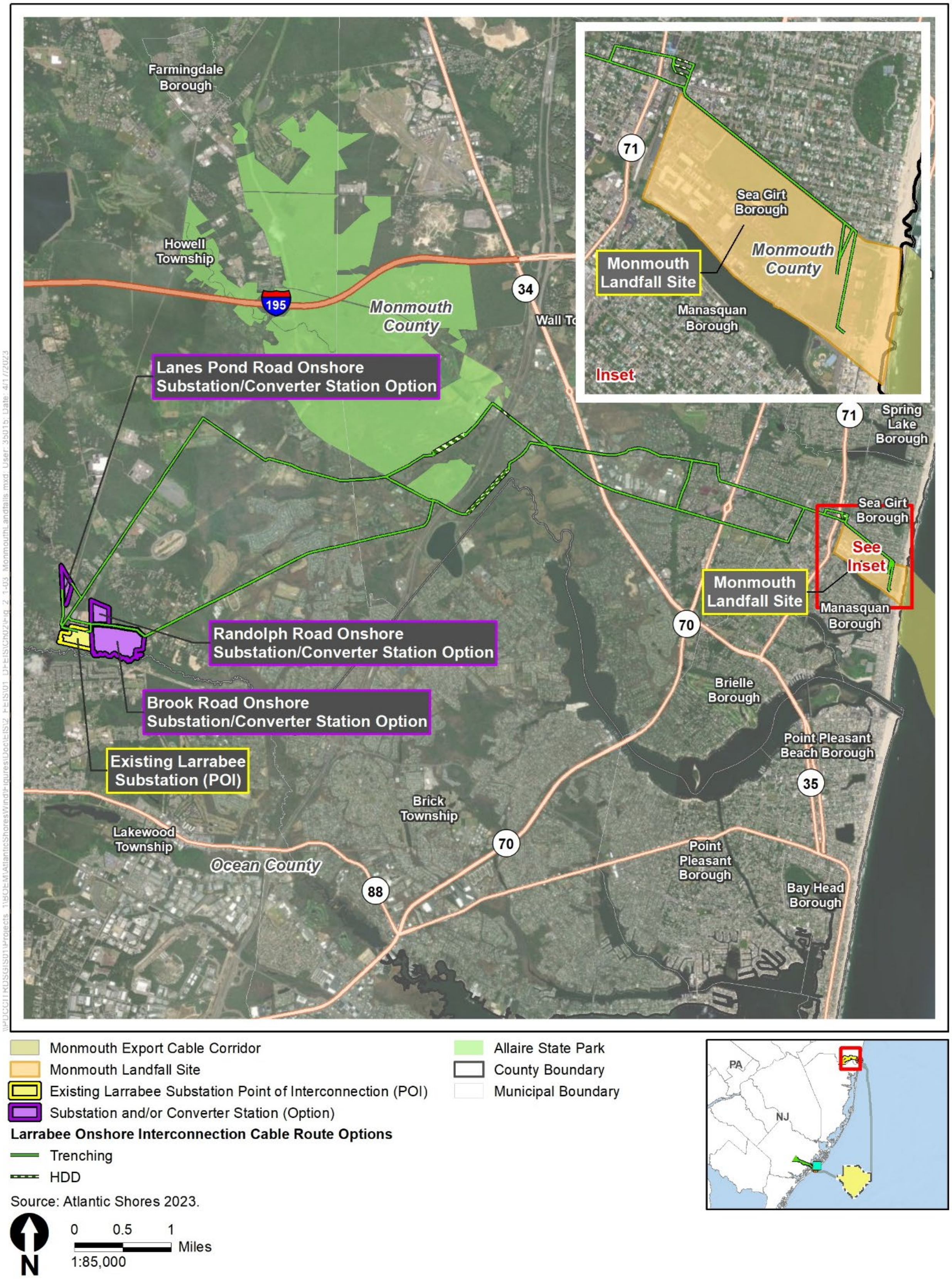


Figure 2-2. Monmouth Landfall Site and onshore cable route to Larrabee Substation

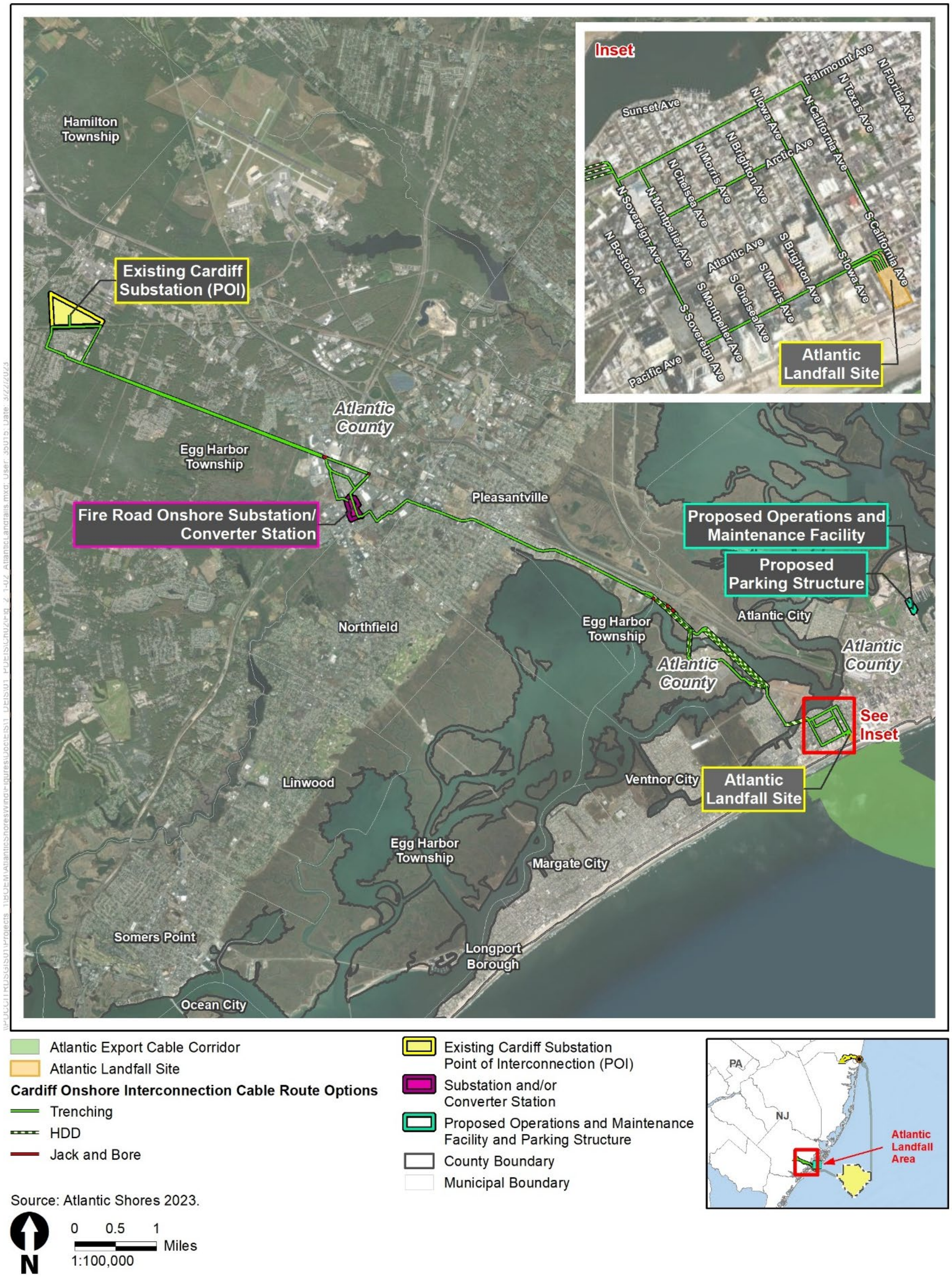


Figure 2-3. Atlantic Landfall Site and onshore interconnection cable routes

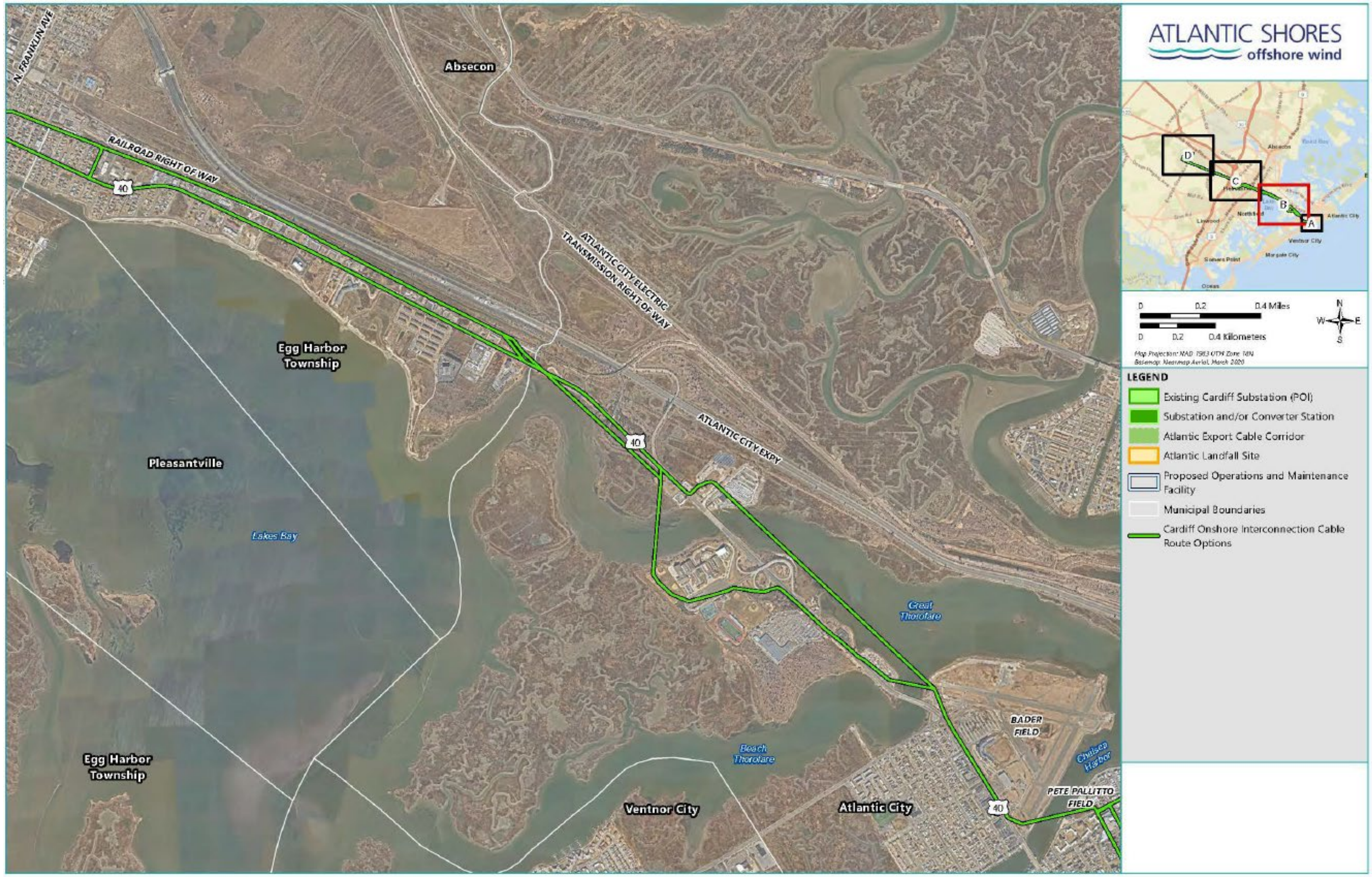


Figure 2-4. Atlantic Landfall Site and onshore interconnection cable routes

Figure 2-5. Atlantic Landfall Site, onshore interconnection cable routes, and onshore substation and/or converter station sites

Figure 2-6. Atlantic Landfall Site, onshore interconnection cable routes, and onshore substation and/or converter station sites

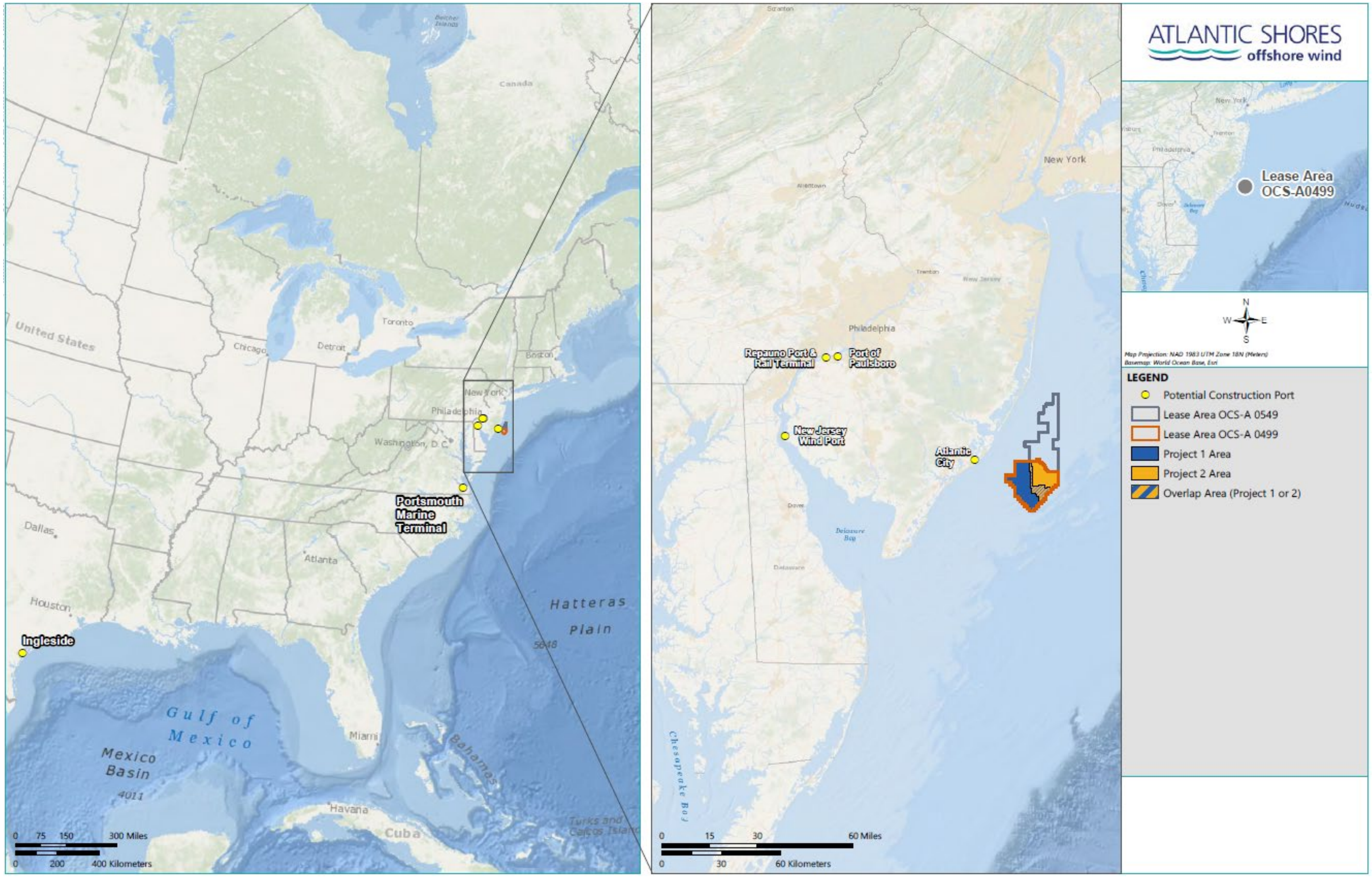


Figure 2-7. Potential construction ports for the Proposed Action

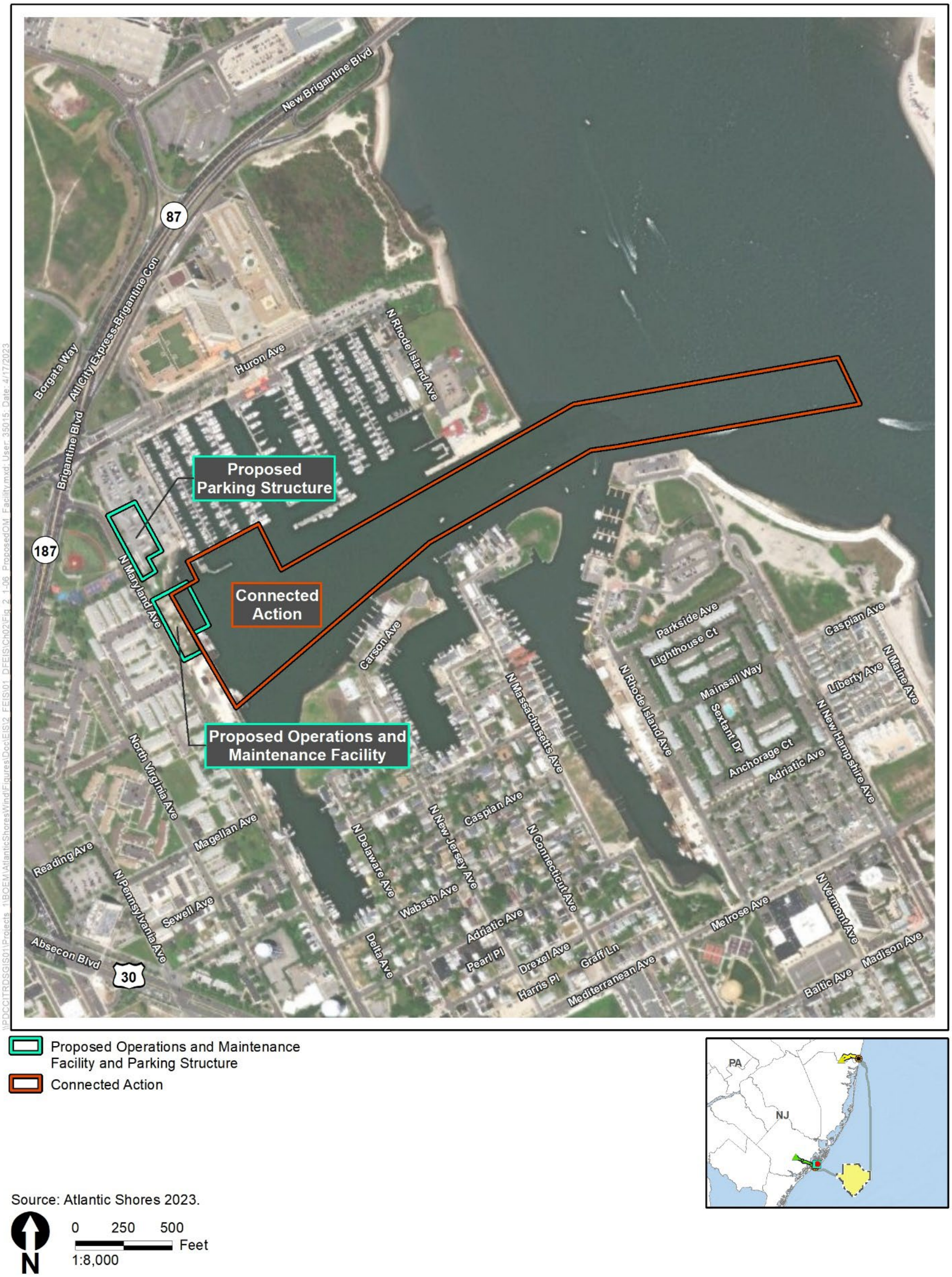


Figure 2-8. Proposed operations and maintenance facility and parking structure

2.1.5 Operations and Maintenance

Project operations and maintenance activities that are pertinent to this assessment are described below. Additional information about Project operation and maintenance requirements is provided in the Project COP (Atlantic Shores 2023, Volume I). The permanent impacts on the environment resulting from the presence of structures, EMF and heat effects from the transmission cables, and the ongoing O&M of the Project are quantified in Section 5, below.

During operation, the WTGs would be remotely monitored through the Supervisory Control and Data Acquisition (SCADA) system, which acts as an interface for a number of sensors and controls throughout the wind farm. The SCADA system allows status and performance to be monitored and for systems to be controlled remotely, where required. The WTGs would be regularly inspected and maintained. Generally, WTG O&M activities would include:

- Inspection of the foundations above and below the waterline at regular intervals to check for corrosion, cracking, and marine growth;
- Regularly scheduled inspections and routine maintenance of the WTG mechanical and electrical components;
- Annual maintenance campaigns for general upkeep (e.g., bolt tensioning, crack and coating inspection, safety equipment inspection, cleaning, high-voltage component service, and blade inspection); and
- Replacement of consumable items (e.g., lubrication, oil changes)

The submarine export cables would be monitored through either a distributed temperature sensing system, a distributed acoustic sensing system, or online partial discharge monitoring. Cable terminations and hang-offs would be inspected and maintained during scheduled maintenance of WTG and OSS foundations. Regular cable surveys would be performed to identify potential issues with scour or burial depth. In the unlikely event of cable exposure, the cable would be reburied or cable protection would be applied. Should unplanned repairs be required, the damaged portion of the cable would be spliced and replaced with a new, working segment. This would require the use of various cable installation equipment, as described for construction activities.

During O&M activities, personnel and equipment would primarily be delivered to the Lease Area by service operation vessels and CTVs. During the O&M phase, 5 to 11 vessels are expected to operate in the Lease Area at a given time. During specialized maintenance or repair activities, a maximum of 22 vessels may be required. Depending on the primary vessel used during O&M, 500 to 2,050 vessel trips to the Lease Area would occur annually, an average of two to six vessel trips per day. Helicopters may be used to support O&M activities, and potentially construction activities, and fixed-wing aircraft may be used to support environmental monitoring and mitigation. All vessels, with the exception of CTVs, are anticipated to travel at speeds of up to 10 knots.

2.2 Project Decommissioning

BOEM’s decommissioning requirements are stated in Section 13, Removal of Property and Restoration of the Leased Area on Termination of Lease, of the December 2018 Lease for OCS-A 0499. Unless otherwise authorized by BOEM, pursuant to the applicable regulations in 30 CFR Part 585, Atlantic Shores would be required to “remove or decommission all facilities, projects, cables, pipelines, and obstructions and clear the seafloor of all obstructions created by activities on leased area, including any project easement(s) within two years following lease termination, whether by expiration, cancellation, contraction, or relinquishment, in accordance with any approved SAP, COP, or approved Decommissioning Application and applicable regulations in 30 CFR Part 585."

When possible, decommissioning would recover valuable recyclable materials, including steel foundation components. The decommissioning process would involve the same types of equipment and procedures used during construction of the Proposed Action, absent pile driving, and would have similar environmental impacts.

In accordance with BOEM requirements, Atlantic Shores would be required to remove and/or decommission all Project infrastructure and clear the seabed of all obstructions when the Project reaches the end of its 30-year designed service life. Before ceasing operation of individual WTGs or the entire Project and prior to decommissioning and removing Project components, Atlantic Shores would consult with BOEM and submit a decommissioning plan for review and approval. Upon receipt of the necessary BOEM approval and any other required permits, Atlantic Shores would implement the decommissioning plan to remove, and recycle, when possible, equipment and associated materials.

The decommissioning process for the WTGs and OSSs, with their associated foundations, is anticipated to generally be the reverse of installation, with Project components transported to an appropriate disposal and/or recycling facility. All foundations and other Project components would need to be removed 15 feet (4.6 meters) below the mudline, unless other methods are deemed suitable through consultation with the regulatory authorities, including BOEM. Submarine export and inter-array cables would be retired in place or removed in accordance with the BOEM-approved decommissioning plan. Atlantic Shores would need to obtain separate and subsequent approval from BOEM to retire any portion of the Project in place. Project components would be decommissioned using a similar suite of vessels.

3. Existing Environment

The existing environment consists of existing EFH conditions in the Project area. To support the characterization of fish and invertebrate resources, Atlantic Shores conducted extensive site-specific surveys, compiled data from publicly available databases, regional surveys, and resource reports, and incorporated relevant peer-reviewed literature.

Site-specific geophysical, geotechnical, and benthic surveys were conducted across the WTA and ECCs between 2019 and 2021 using multibeam echo sounder (MBES), side scan sonar (SSS), SPI camera – plan view video (PV), sediment grab samples, benthic grab samples, benthic towed video, and digital imagery. Site-specific geophysical survey data (multibeam echo sounder, side-scan sonar, and SPI-PV) were used to support the characterization of seabed conditions. Sediment grab samples were analyzed for grain size distribution, total organic carbon, and benthic infauna and were used to ground truth the sediment types observed in digital imagery. Digital imagery was reviewed to aid in identification of key habitat types, macroinvertebrates, and fish.

3.1 Habitat Types by Project Component

The Project Area provides five several distinct habitat types that support managed species or their prey. The acreage of potential temporary and permanent impacts to each of these habitat types is summarized in Table 3-1 below.

Table 3-1. Area of Potential Temporary and Permanent Impacts by Habitat Type

<table>
<tr><th rowspan="3">Habitat Types</th><th colspan="5">Project Component Area [1]</th></tr>
<tr><th rowspan="2">Lease area</th><th colspan="2">Offshore Export Cable: Export cable route</th><th rowspan="2">Onshore Export Cable: Interior coastal</th><th rowspan="2">O&M facility</th></tr>
<tr><th>Monmouth ECC</th><th>Atlantic ECC</th></tr>
<tr><td>Rocky</td><td colspan="3">Based on benthic habitat mapping presented in the EFH Assessment, large-grained, complex habitat (i.e., boulders or large gravel) was not identified in the Offshore Project Area. Additionally, no rocky habitat was identified along the shoreline in the vicinity of the Project.</td><td colspan="2" rowspan="4">Not Applicable to the Onshore Project Area.</td></tr>
<tr><td>Soft bottom [2,3] (ac)</td><td>Temporary: 719 - 851
Permanent: 227 - 306</td><td>Temporary: 517
Permanent: 76</td><td>Temporary: 424
Permanent: 43</td></tr>
<tr><td>Complex [2,4] (ac)</td><td>Temporary: 196 - 240
Permanent: 52 - 74</td><td>Temporary: 815
Permanent: 116</td><td>Temporary: 128
Permanent: 13</td></tr>
<tr><td>Heterogenous Habitat [2,5] (ac)</td><td>Temporary: 111 - 131
Permanent: 34 - 50</td><td>Temporary: < 1
Permanent: < 1</td><td>Temporary: 71
Permanent: 8</td></tr>
<tr><td>Submerged Aquatic Vegetation (SAV) [6]</td><td colspan="5">Based on a review of SAV maps published by the NJDEP in the vicinity of the Project, there are no documented occurrences of SAV in the offshore, nearshore, or coastal areas of the Project (NJDEP 1979).</td></tr>
<tr><td>Tidal Marsh</td><td colspan="3">No tidal marshes were identified in the Offshore Project Area</td><td colspan="2">Tidal marshes were identified along the Cardiff Onshore Interconnection Cable Route; however, impacts will be avoided through the use of HDD or other trenchless cable installation methods. As stated in Appendix II-J2, Section 7.1 of the COP, installation of cable using trenchless methods would result in an avoidance of 51.2 acres of temporary impact to tidal wetlands.</td></tr>
<tr><td>Shellfish reefs and beds (ac) (NJDEP 1963) [6,7]</td><td colspan="4">Based on a review of shellfish bed maps published by the NJDEP, there are not documented occurrences in the Offshore Project Area.</td><td>Permanent – up to 0.4</td></tr>
<tr><td>Shell accumul.</td><td colspan="5" rowspan="2">Shell accumulations and other biogenic features were identified and analyzed during the towed video survey, the report for which can be found in Appendix II-G3. The towed video survey provides results along linear transects, therefore it would inappropriate and inaccurate to extrapolate those results to a given area of seafloor. Please see Appendix II-G3 (Towed Video Report) of the COP or Attachment 3 of Appendix II-J2 (displays results on maps) for additional information.</td></tr>
<tr><td>Other biogenic</td></tr>
<tr><td>Pelagic</td><td colspan="3">The pelagic environment is present throughout the entire Offshore Project Area. The majority of impacts will be associated with the disturbance to the seafloor.</td><td colspan="2">Not Applicable to the Onshore Project Area</td></tr>
<tr><td>Habitat for sensitive life stages [7,8] (ac) (NOAA Fisheries 2021)</td><td>Temporary – 3,206
Permanent – 1,013</td><td>Temporary – 4,068
Permanent – 575</td><td>Temporary – 410
Permanent – 30</td><td colspan="2">Not Applicable to the Onshore Project Area</td></tr>
</table>

Habitat Types	Project Component Area [1]				
	Lease area	Offshore Export Cable: Export cable route		Onshore Export Cable: Interior coastal	O&M facility
		Monmouth ECC	Atlantic ECC		
Habitat Areas of Particular Concern (HAPC) [7,9] (ac) (NOAA Fisheries 2021)	Not Applicable – No HAPC present		Temporary – 6.4 Permanent – 0	Not Applicable to the Onshore Project Area	

Sources:
NJDEP. 1979. Submerged Aquatic Vegetation Distribution – 1979. Available at: https://www.nj.gov/dep/landuse/sav.html.
NJDEP. 1963. Shellfish Map – Little Egg Harbor to Longport. Available at: https://www.nj.gov/dep/landuse/shellfish.html.
NOAA Fisheries. 2021. Essential Fish Habitat Mapper. Available at: https://www.habitat.noaa.gov/apps/efhmapper/.
1. No new port facilities or expansion of existing port facilities are proposed as part of the Project. The offshore-to-onshore transition will be accomplished through HDD or other trenchless measures to avoid nearshore or shoreline impacts; therefore, no impacts to the habitat types above are expected at the landfall sites (see COP Vol I, Section 4.7.1).
2. Benthic sampling was categorized based on NOAA Fisheries' Updated Recommendations for Mapping Fish Habitat (2021). Therefore, data are presented for 'soft bottom habitat' as a whole, rather than separated out as 'soft bottom – sand' and 'soft bottom – mud.' Additionally, to be consistent with guidance from NOAA Fisheries, two categories were added: complex habitat and heterogeneous complex habitat.
3. Soft Bottom Habitat is defined as fine unconsolidated sediments (sands and muddy sand in this study area) that do not exhibit the structural exemptions listed in the heterogeneous complex habitat description (see Attachment 1 to Appendix II-J2 of the COP for additional detail).
4. Complex Habitat is defined as substrates composed of gravelly, gravel sand, or gravel/gravel mixes in accordance with CMECs and complex habitat (see Attachment 1 to Appendix II-J2 of the COP for additional detail).
5. Heterogenous Complex Habitat is defined as areas of interbedded mixes that contain a base of either soft or complex with indecipherable interface between two distinct classes (see Attachment 1 to Appendix II-J2 of the COP for additional detail).
6. Limited geospatial data exists for SAV and shellfish beds. The information presented in the table is based on mapping provided by the NJDEP which date back to the 1960s through 1980s and may not reflect current conditions.
7. Acreages were calculated using proportional percentages of habitat types within each Project component area rather than on a specific locational basis. First, total acres of each habitat type were calculated within each applicable Project component. Next, the acres of each habitat type were divided by the total area in each of the Project components. Lastly these percentages were applied to the temporary and permanent footprint for each installation activity which can be found in COP Vol I, Sections 4.5.10 and 4.11.
8. For the purposes of this table, sensitive life stages were assumed to include the egg and larvae stage. Given that the Project will have the greatest impact on benthic/demersal life stages, only those egg and larvae life stages that are demersal or benthic in nature were quantified in the table. Those species with demersal or benthic egg or larvae stages in the Offshore Project Area include winter flounder (*Pseudopleuronectes americanus*), longfin inshore squid (*Doryteuthis pealeii*), ocean pout (*Zoarces americanus*), and Atlantic sea scallop (*Placopecten magellanicus*).
9. The only HAPC located in the Project Area is in the nearshore area of the Atlantic ECC for sandbar shark (*Carcharhinus plumbeus*).

3.2 WTA

Habitat in the WTA generally consists of unconsolidated deposits of fine to coarse grained sand and is largely dominated by medium sand (0.25 to 0.5 mm) and coarse sand (0.5-1.0 mm), with smaller areas of fine sand (0.125 to 0.25 mm). Regional surficial sediment mapping indicates a fining of predominantly sandy surface sediments to the south across the Lease Area, with increased gravel and gravelly deposits present in the surface sediments in the north and western parts of the Lease Area (Greene et al. 2010). To validate seabed and habitat conditions described in published literature and available data portals, Atlantic Shores initiated site-specific high-resolution geophysical (HRG), geotechnical, and benthic surveys to characterize benthic habitat in the Offshore Project Area. The sediment survey data were characterized in accordance with the Coastal and Marine Ecological Classifications Standards (CMECS), a hierarchical system with classification thresholds based on sediment grain size and the relative percent composition of mud, sand, and gravel-sized components (FGDC 2012). Analysis of grab samples conducted in the WTA demonstrated that medium sand is the most prevalent sediment type, making up 67% and 84% of the Project 1 WTA and Project 2 WTA, respectively (Figure 3-1, Figure 3-2). Under NMFS' Recommendations for Mapping Fish Habitat, medium sand is considered soft bottom habitat. Other soft bottom CMECS-classified sediments identified in the WTA include fine/very fine sand, muddy sand, and very coarse/coarse sand. Some complex habitat was identified in the WTA including habitat classified as gravelly and gravelly sand (Figure 3-1, Figure 3-2). Based on analysis of benthic grab samples, approximately 77,680 acres out of 102,123 acres (76%) of habitat in the WTA was classified by NOAA Habitat Complexity Category. The classified habitat in the WTA included 53,188 acres of soft bottom habitat, 7,985 acres of heterogeneous complex habitat, and 16,506 acres of complex habitat.

The seafloor slope is characterized as gentle throughout the WTA (Figure 3-3). The sediment deposits comprise the bedforms that characterize the seafloor in the WTA, including sandwaves, ripples, mega ripples, depressional areas, and textured seafloor. Ripples were the most prevalent mapped topographic feature in the WTA, comprising the entire surveyed area. Sandwaves and mega ripples were the second most prevalent topographic features mapped in the WTA (Figure 3-4). In addition to soft sediment, hardened structures artificial reefs contribute to the benthic habitat available for marine species. One artificial reef is located proximal to the southwestern corner of the WTA.

The benthic community of the WTA includes infauna and epibenthic organisms such as echinoderms, bivalves, gastropods, polychaetes, oligochaetes, amphipods, crustaceans, and cnidarians (Greene et al. 2010, Guida et al. 2017). Benthic grab samples collected in the WTA were dominated by the phylum Nematoda, which comprised 71% of the abundance, followed by the phyla Arthropoda (amphipods, ostracods), Annelida (polychaetes, oligochaetes), Echinodermata (sand dollars, sea urchins, sea cucumbers), and Mollusca (Atlantic surfclam [Spisula solidissima], ocean quahog [Arctica islandica]) (Figure 3-5). In the Towed Video survey of the WTA, the most common benthic biogenic features observed in the area were sand dollar beds, clam beds, and infaunal structures (e.g., worm tubes) (Atlantic Shores 2023, Volume I). Surveys conducted by NEFSC (Multi-Species Bottom Trawl, Atlantic Surfclam and Ocean Quahog Dredge Survey) and NJDEP (Ocean Stock Assessment Program) identified several crustacean species in the WTA, including American lobster (*Homarus americanus*), Atlantic rock crab (*Cancer irroratus*), and Jonah crab (*Cancer borealis*), as well as several bivalve species with designated EFH, including Atlantic sea scallop (*Placopecten magelanicus*), Atlantic surfclam, and ocean quahog. Living bottoms, such as corals and sponges, could also provide habitat to benthic species. No corals were identified in the WTA during site-specific benthic characterization surveys conducted between 2019 and 2021. Some sponge species were observed in the WTA during towed video surveys.

All waters from the surface to the ocean floor are considered to be pelagic. The entire WTA is in the photic zone (i.e., top 600 ft [200 m]), the top layer of the pelagic environment where sunlight supports photosynthetic phytoplankton (Karleskint et al. 2006). Water depth influences surface and bottom temperatures, light penetration, sediment movement, and other physical and chemical habitat parameters that define EFH. Water depths in the WTA are relatively uniform, ranging from 62 to 121 feet (19 to 37 meters) and gradually increasing with distance from shore (Figure 3-6). The Project area is influenced by the northward flowing Gulf Stream current system and southward flowing cool water from New England. Bottom water temperatures in the New Jersey WEA ranged from 35.6 degrees Fahrenheit (°F) to 73.4 °F (2 to 23 degrees Celsius [°C]) between 2003 and 2016 (Guida et al. 2017). Seasonal water temperature fluctuations in those years were up to 68 °F (20 °C) at the surface and 59 °F (15 °C) at the bottom (Guida et al. 2017).

Oceanic currents, temperature, conductivity, pH, dissolved oxygen, and other features of the water column influence the occurrence and abundance of marine fishes in the WTA. The pelagic environment is particularly important for planktonic eggs and larvae, planktivorous or filter-feeding species/life stages, and migratory pelagic species (NMFS 2017; NEFMC 2017). The water column serves dual functions as EFH: it supports the phytoplankton that sustain marine food webs, and it provides a dispersal mechanism for planktonic larvae of many managed species. Phytoplankton (e.g., diatoms, dinoflagellates) thrive where nutrients and sunlight are abundant, such as along the coast of New Jersey where abundant phytoplankton are sustained by nutrients carried to the well-lit surface waters by upwelling. Phytoplankton are consumed by zooplankton (i.e., tiny animals such as copepods and larval forms of crustaceans, bivalves, and other invertebrates) and ichthyoplankton (fish larvae). The most numerically abundant component of the pelagic fish community in the open waters of the WTA is the ichthyoplankton assemblage. Buoyant eggs and larvae of most marine fishes can remain in the plankton for weeks to months (Walsh et al. 2015). Plankton were prevalent in acoustic surveys in the WTA in 2018, where strong evidence of diel vertical migrations of both plankton and small fish were reported (Battista et al. 2019). The assemblage of species represented in the ichthyoplankton varies seasonally and is strongly influenced by water temperature; patterns of ichthyoplankton assemblages have changed in recent decades, likely in response to climate change (MAMFC 2017; Walsh et al. 2015).

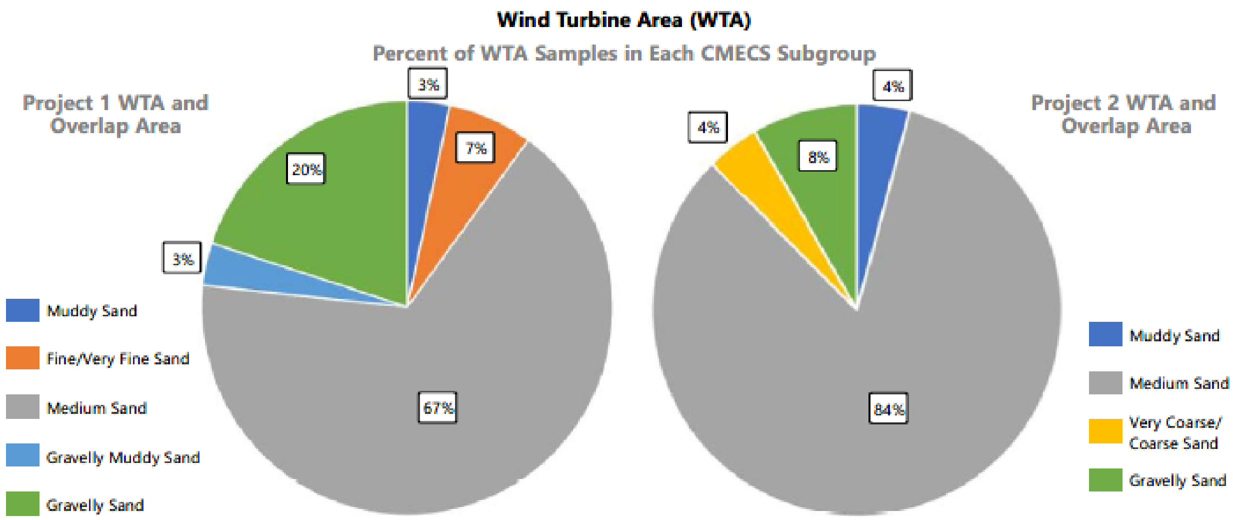


Figure 3-1. Proportion of NMFS CMECS Sediments in the WTA

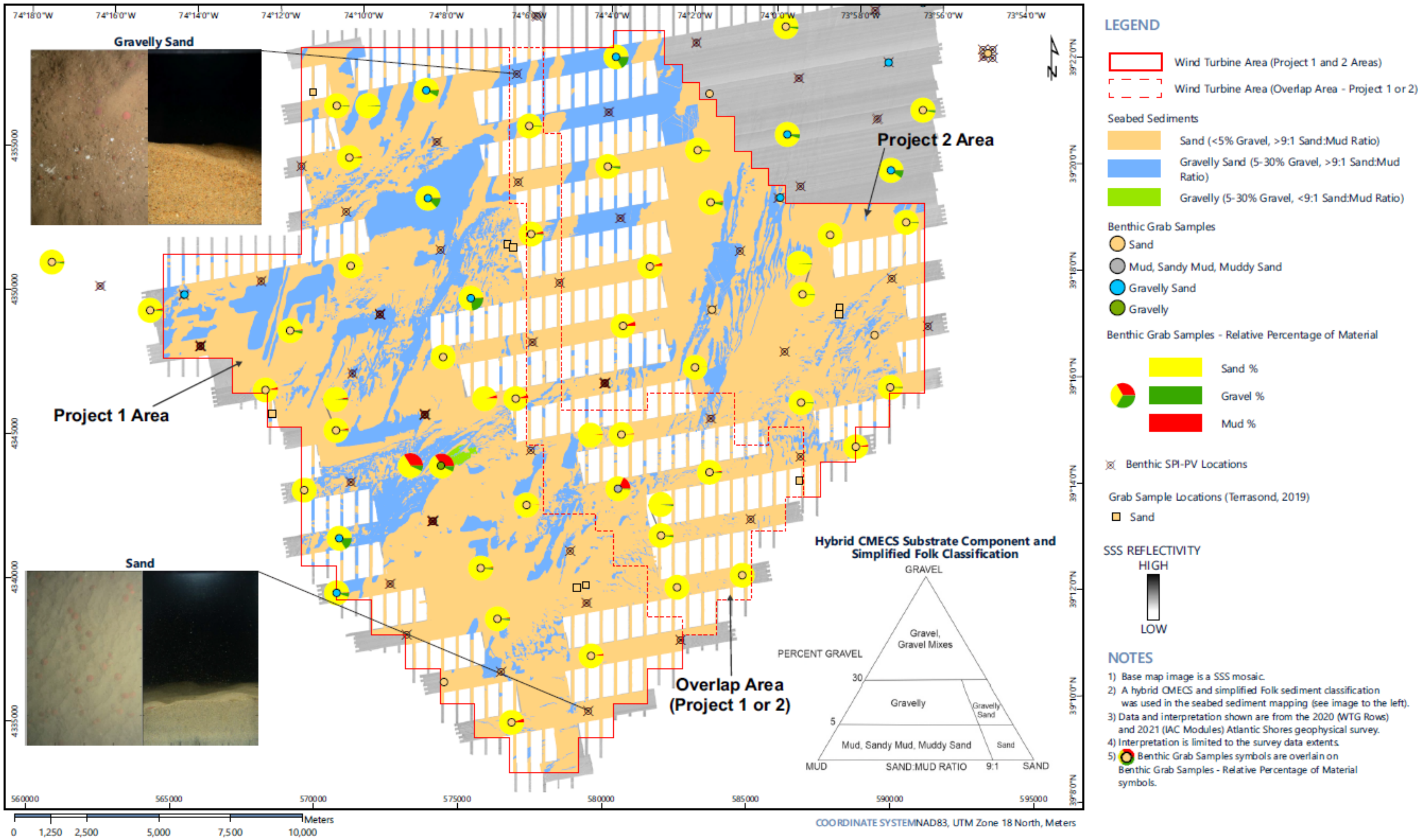


Figure 3-2. Seabed Sediment Composition in the Wind Turbine Area

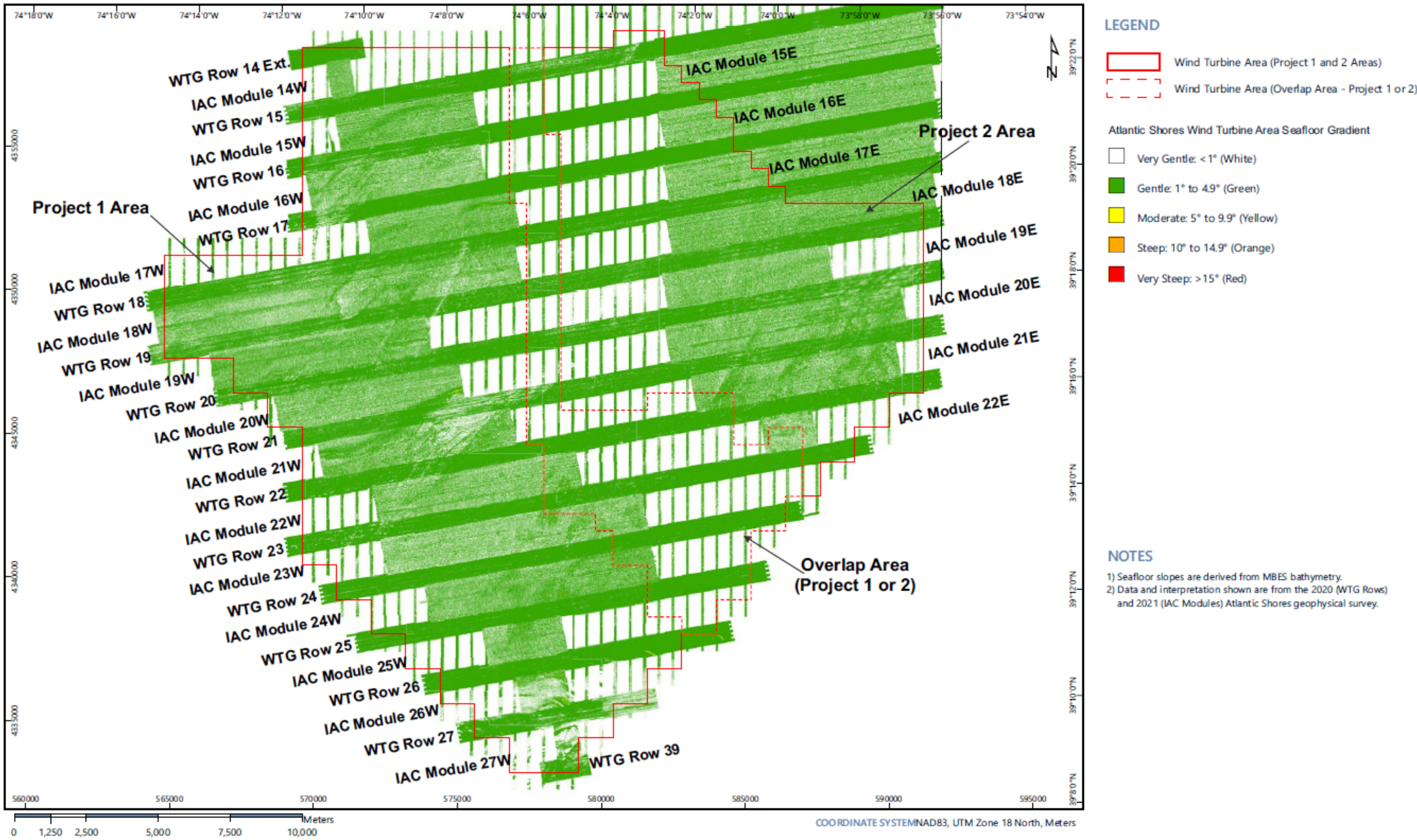


Figure 3-3. Seafloor Gradient in the Wind Turbine Area

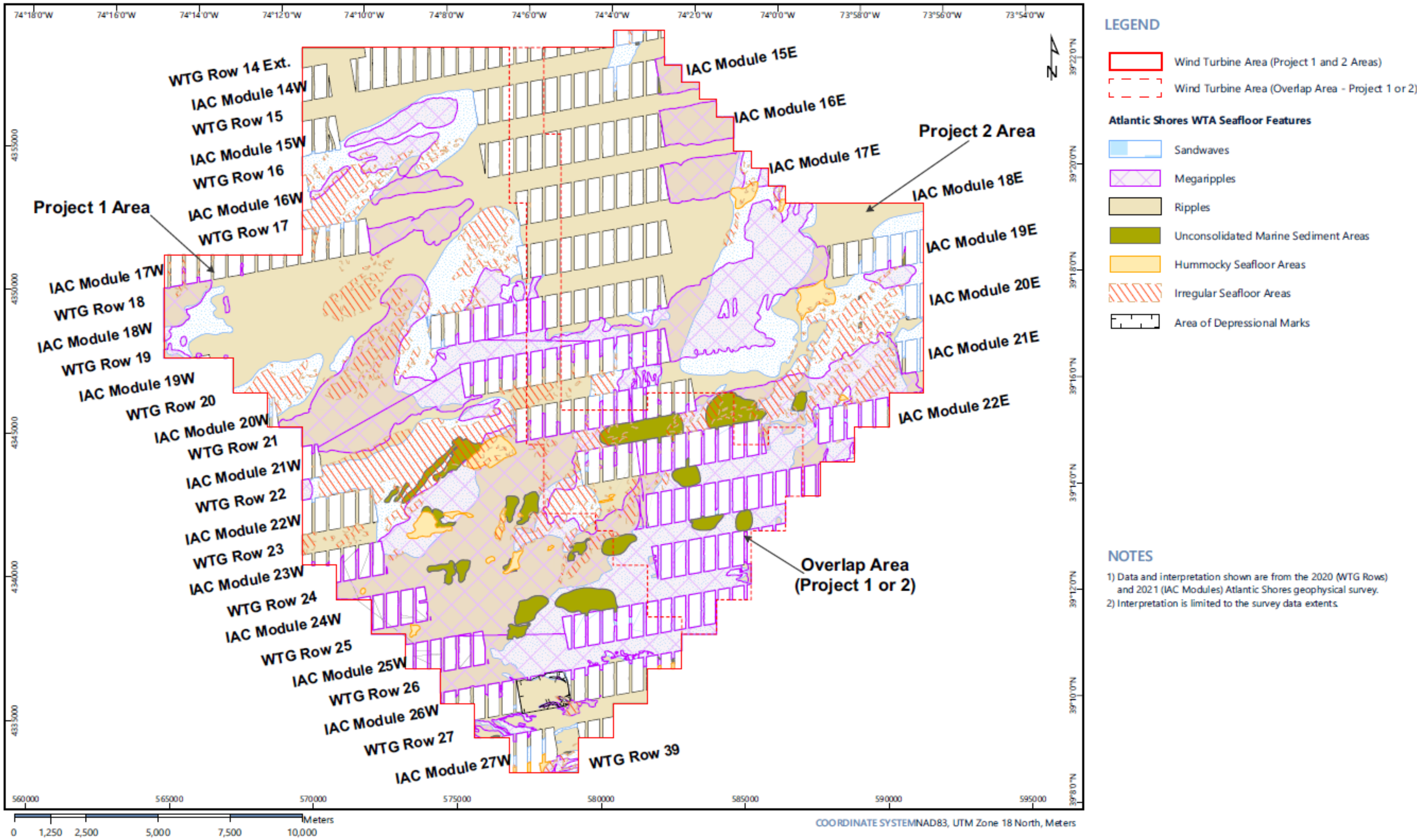


Figure 3-4. Seafloor Sand Bedform Morphology in the Wind Turbine Area

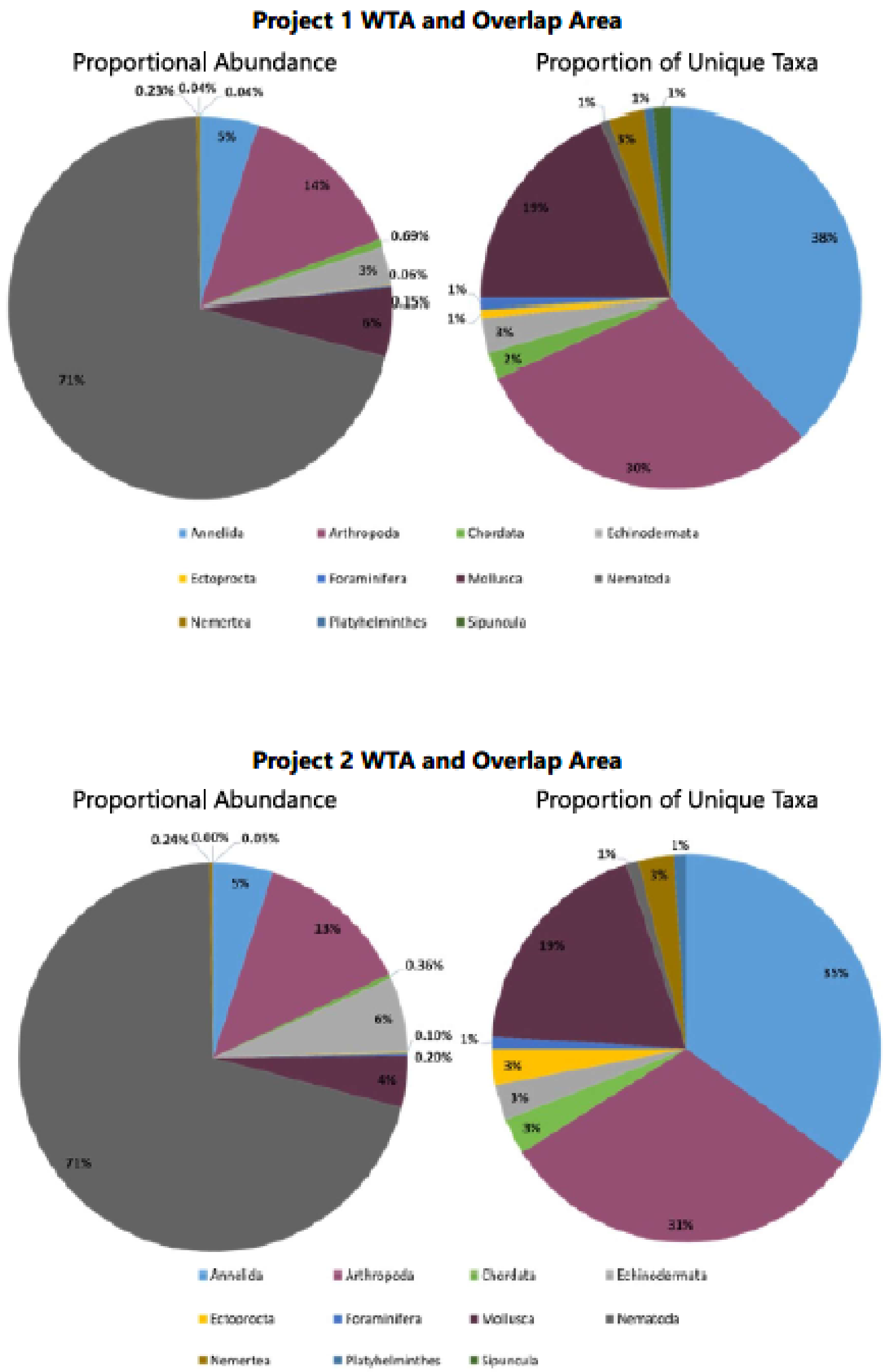


Figure 3-5. Proportional Abundance and Proportion of Unique Taxa Based on Benthic Grabs Conducted in the Wind Turbine Area

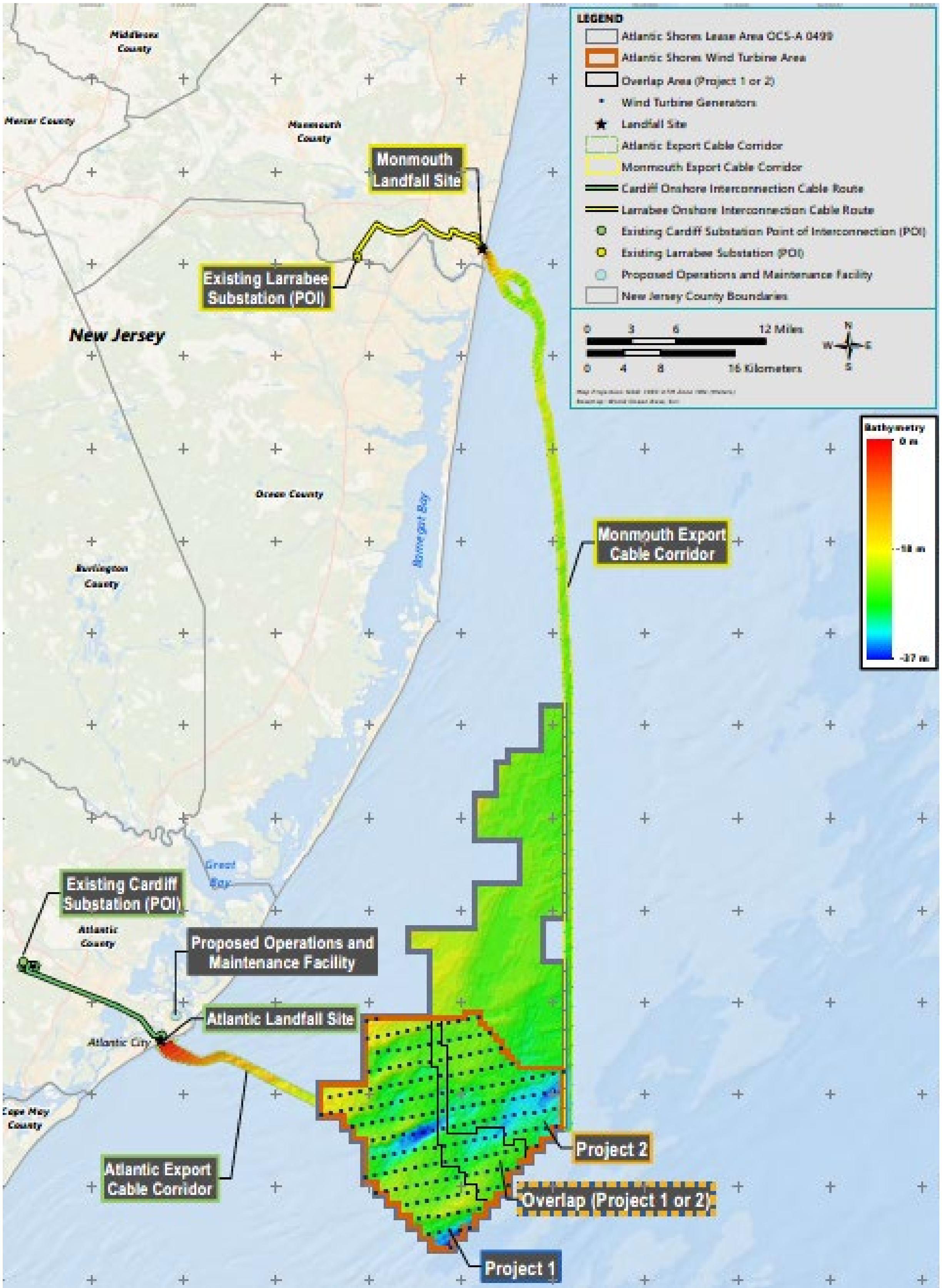


Figure 3-6. Bathymetric Overview of the Project Area

3.3 Offshore/Onshore Export Cable Corridors

3.3.1 Export Cable Corridors

Benthic habitat consists of unconsolidated, fine substrate sediment in the Atlantic ECC and unconsolidated, coarse substrate in the Monmouth ECC. Analysis of the benthic grab samples conducted in the Atlantic ECC observed fine/very fine and medium sand to be the most prevalent sediment types, making up 40% and 30% of the samples collected in the Atlantic ECC, respectively (Figure 3-7, Figure 3-8). By contrast, gravelly sand was the most predominant sediment type in the Monmouth ECC, comprising approximately 48% of the samples collected there (Figure 3-7, Figure 3-9, Figure 3-10). Both fine/very fine and medium sand are considered soft-bottom habitat by NMFS, while gravelly sand is considered complex habitat, containing between 5% and less than 30% gravel content (NMFS 2021). Based on analysis of benthic grab samples, all habitat in the Atlantic and Monmouth OECs was classified by NOAA Habitat Complexity Category. The classified habitat in the Atlantic OECC outside of the WTA includes 4,879 acres of soft bottom habitat, 50 acres of heterogeneous complex habitat, and 552 acres of complex habitat. The classified habitat in the Monmouth OECC outside of the WTA includes 7,935 acres of soft bottom habitat, 10 acres of heterogeneous complex habitat, and 17,735 acres of complex habitat.

Site-specific surveys of the Atlantic ECC characterized the seafloor slope as primarily gentle with moderate, steep, and very steep slopes along the margins of ripple fields and steep to very steep slopes over localized relief features (Figure 3-11). Site-specific surveys also identified ripples, mega ripples, sand waves, textured seafloor (i.e., rugged or uneven texture), and localized areas of relief (Figure 3-12). Ripples were the most prevalent topographic feature in the Atlantic ECC, and mega ripples, sandwaves, and textured seafloor were the second most predominant features. Site-specific surveys of the Monmouth ECC characterized the seafloor slope as primarily gentle with isolated areas of moderate to very steep slopes near the landfall (Figure 3-13, Figure 3-14). Similar to the Atlantic ECC, ripples, mega ripples, and sandwaves were identified in the Monmouth ECC, with ripples being the most dominant topographic feature (Figure 3-15, Figure 3-16). However, unlike the Atlantic ECC, scarps and interbedded surficial sediments (characterized by terraced seafloor with steep slopes) were identified in the nearshore reaches of the Monmouth ECC, near the Monmouth Landfall Site. Features like scarps and interbedded surficial sediments have the potential to add habitat diversity for marine organisms. In addition to soft sediment, hardened structures created by artificial reefs contribute to the benthic habitat available for marine species. Two artificial reefs are located along the outer boundary of the Monmouth ECC.

Benthic grab samples collected in the ECCs were dominated by the phylum Nematoda, which comprised 73% and 41% of the abundance in the Monmouth ECC and Atlantic ECC, respectively (Figure 3-17). Arthropoda (amphipods, ostracods) was the next most abundant phylum in each ECC but was proportionally more abundant in the Atlantic ECC. Other abundant phyla in the ECCs included Mollusca (Atlantic surfclam, ocean quahog) and Annelida (polychaetes, oligochaetes). In the Towed Video survey of the ECCs, the class Gastropoda (snails, whelks) represented 67% of enumerated individuals in the Atlantic ECC, and the class Anthozoa (anemones) represented 72% of enumerated individuals in the Monmouth ECC (Atlantic Shores 2023, Volume II). Surveys conducted by NEFSC and NJDEP identified Atlantic rock crab, blue crab (Callinectes sapidus), and Atlantic surfclam in both ECCs and identified American lobster, Jonah crab, and Atlantic sea scallop in the Monmouth ECC only. Living bottoms, corals and sponges, could also provide habitat to benthic species. No corals were identified in either ECC during site-specific benthic characterization surveys conducted between 2019 and 2021. Some sponge species were observed in the Atlantic ECC and Monmouth ECC during towed video surveys.

The majority of the waters of the ECCs are pelagic, except in shallow waters near landfalls. All of the waters of the ECCs are in the photic zone (i.e., top 600 ft [200 m]), the top layer of the pelagic environment where sunlight supports photosynthetic phytoplankton (Karleskint et al. 2006). Most of the Atlantic ECC is less than 20-m (66-ft) deep, and most of the Monmouth ECC is less than 30-m (98-ft) deep (Figure 3-6). Section 3.1.1 provides a description of the pelagic environment and its importance.

3.3.2 Wetlands

Atlantic Shores conducted wetland and waterbody delineations from 2020-2022 within a study area that encompassed the Cardiff and Larrabee Onshore Project Areas, including the export cable landfall sites, onshore interconnection cable corridors, onshore substations, and POIs. The wetland delineations identified a total of 11.30 acres of estuarine wetlands and 21.52 acres of palustrine wetlands in the Onshore Project Areas (Table 3-2). Estuarine wetlands include all tidal marshes and comprise most of the delineated wetlands. Palustrine wetlands are a diverse class of wetland and includes freshwater marshes, bogs, swamps, and bottomland forests. All delineated wetlands are situated adjacent to roadways and other developed/disturbed areas along the onshore interconnection cable routes (Figure 3-18, Figure 3-19). Wetlands do not occur within the O&M facility Onshore Project Area because of the intensity of previous development and the bulkheaded/filled lands adjacent to the waters of Clam Creek and Delta Basin within the Atlantic City harbor area. There is approximately 0.81 acre of open water mapped by NJDEP within the O&M facility Onshore Project Area, all seaward of the existing bulkhead (Figure 3-20). Additionally, as described in Section 4.1.2, there is submerged aquatic vegetation (SAV) in several inland waterbodies that would be traversed by the Cardiff Onshore Interconnection Cable Route.

Table 3-2. Delineated Wetlands within the Cardiff and Larrabee Onshore Project Areas

Onshore Project Area	Estuarine Wetlands (acres/m^2)	Palustrine Wetlands (acres/m^2)
Cardiff	1.39 / 5,615	0.60 / 2,457
Larrabee	--	1.34 / 5,436
Total	1.39 / 5,615	1.94 / 7,893

The Cardiff Onshore Interconnection Cable Route intersects three inland waterways, Chelsea Harbor, Beach Thorofare and Great Thorofare, which may contain shellfish beds. Information on the distribution of shellfish beds is available through the NJDEP shellfish inventory program, which collects data on the distribution and abundance of shellfish species. NJDEP has published shellfish distribution maps that describe shellfish density by species for hard clams, surfclams, mussels, and oysters (NJDEP 2022). However, the most recent shellfish distribution map that includes the inland waterways along the Cardiff Onshore Interconnection Cable Route was published in 1963. That map identified hard clam habitat throughout each of the inland waterways along the Cardiff Onshore Interconnection Cable Route. The Cardiff Onshore Interconnection Cable Route does not intersect any active shellfish lease areas, and the closest shellfish lease area is located approximately 3.1 miles (5 kilometers) west of the cable route (Figure 3-21).

3.4 Adjacent Habitat

In addition to impacts within Project area limits, nearby habitats may be indirectly impacted by construction activities. Potentially impacted adjacent habitats are defined as habitat areas within a 7-mile buffer around the WTA and a 656-foot buffer around the export cable routes. The WTA and export cable route buffer areas are based on the modeled maximum radial distance traveled by sound at behavioral threshold levels for fish from impact pile driving and the modeled distance that suspended sediments travel to produce reposition depths of 1 mm from cable laying activities.

3.4.1 Artificial Reefs

Locations of adjacent artificial reef habitats were identified from shapefiles obtained from the NJ Bureau of GIS. Artificial reef sites within the Project buffers defined above are considered nearby "Adjacent Habitats" in this analysis. They include the Atlantic City and Great Egg reefs and portions of the Little Egg, Manasquan Inlet, and Axel Carlson reefs (Figure 3-22).

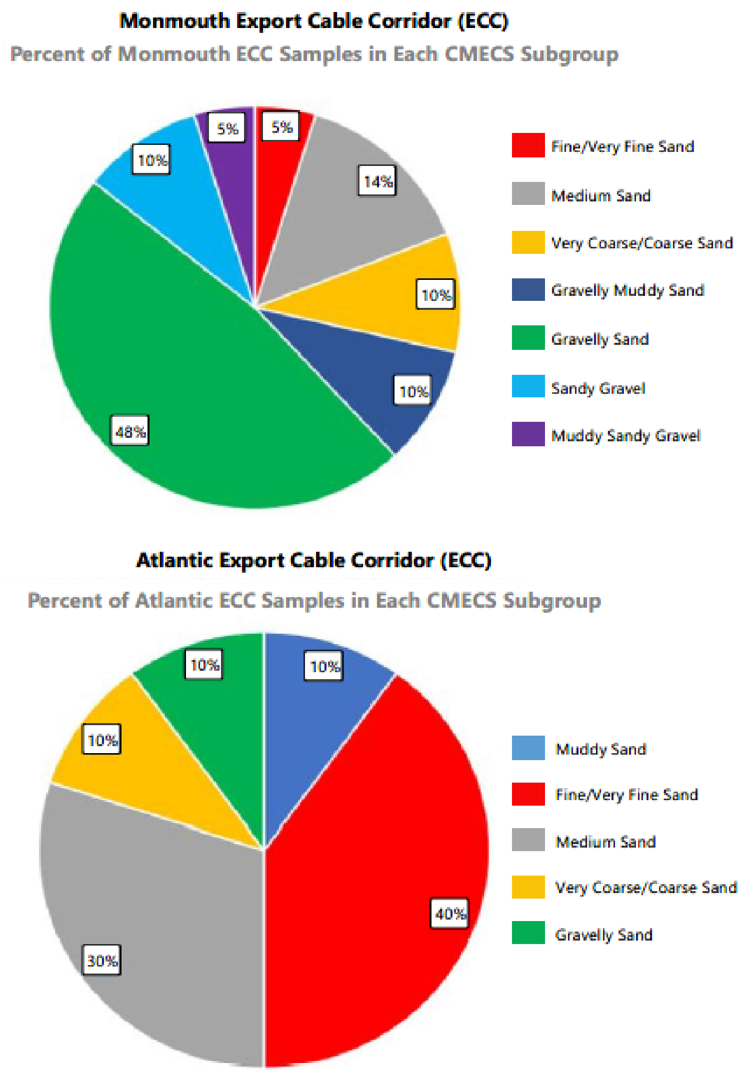


Figure 3-7. Proportion of NMFS CMECS Sediments in the Atlantic ECC and Monmouth ECC

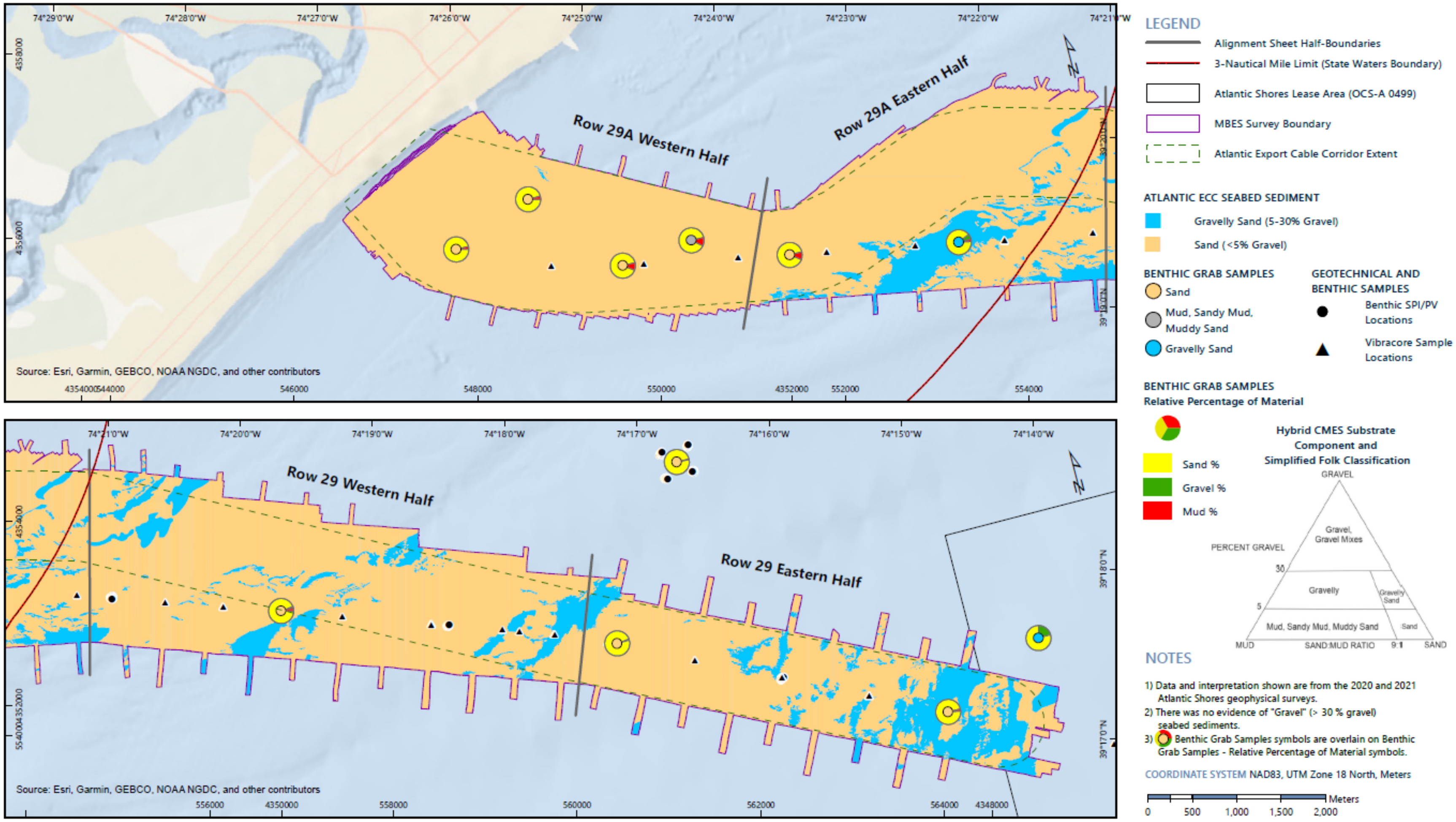


Figure 3-8. Seabed Sediment Composition in the Atlantic Export Cable Corridor

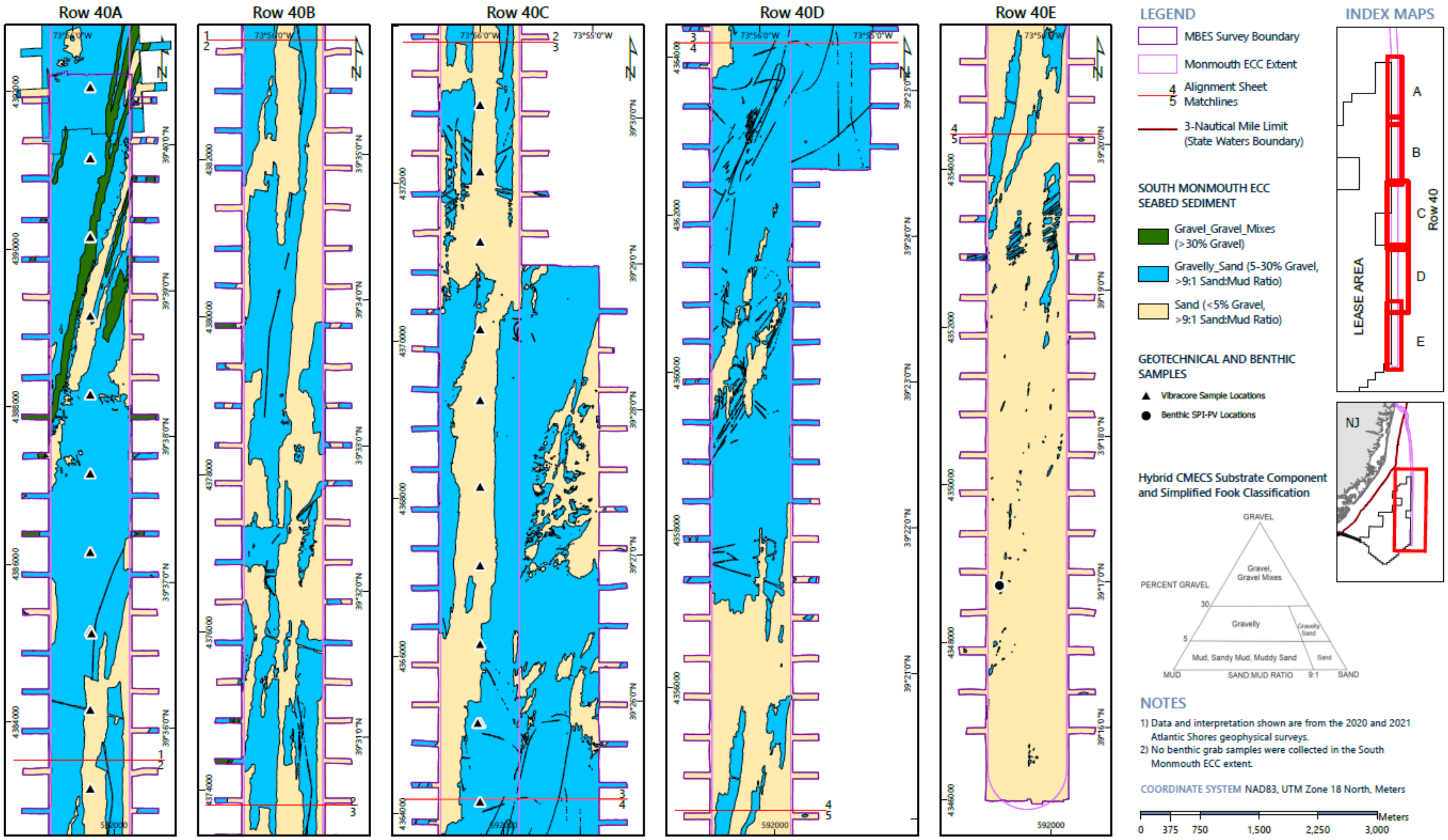


Figure 3-9. Seabed Sediment Composition in the Southern Monmouth Export Cable Corridor

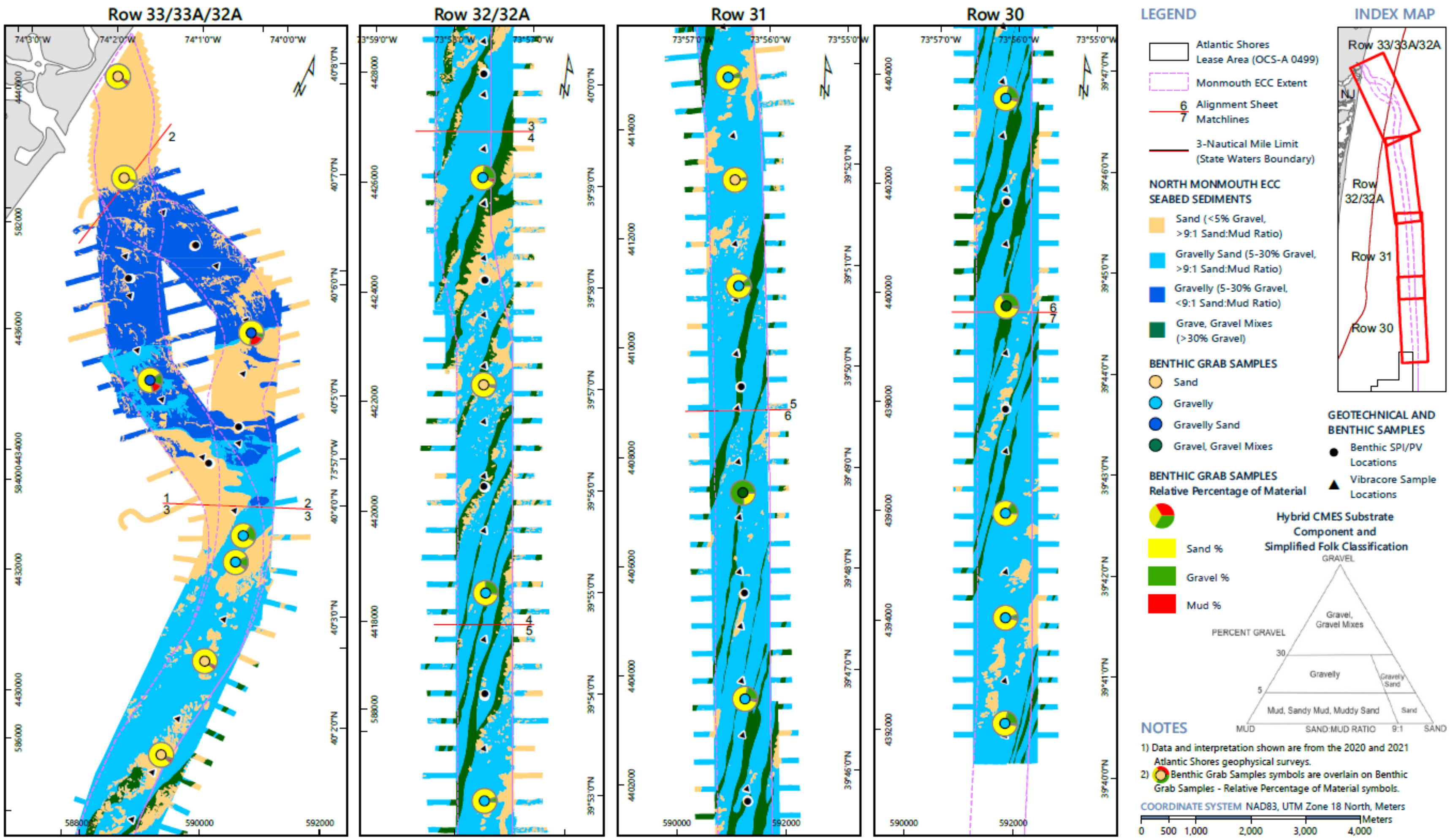


Figure 3-10. Seabed Sediment Composition in the Northern Monmouth Export Cable Corridor

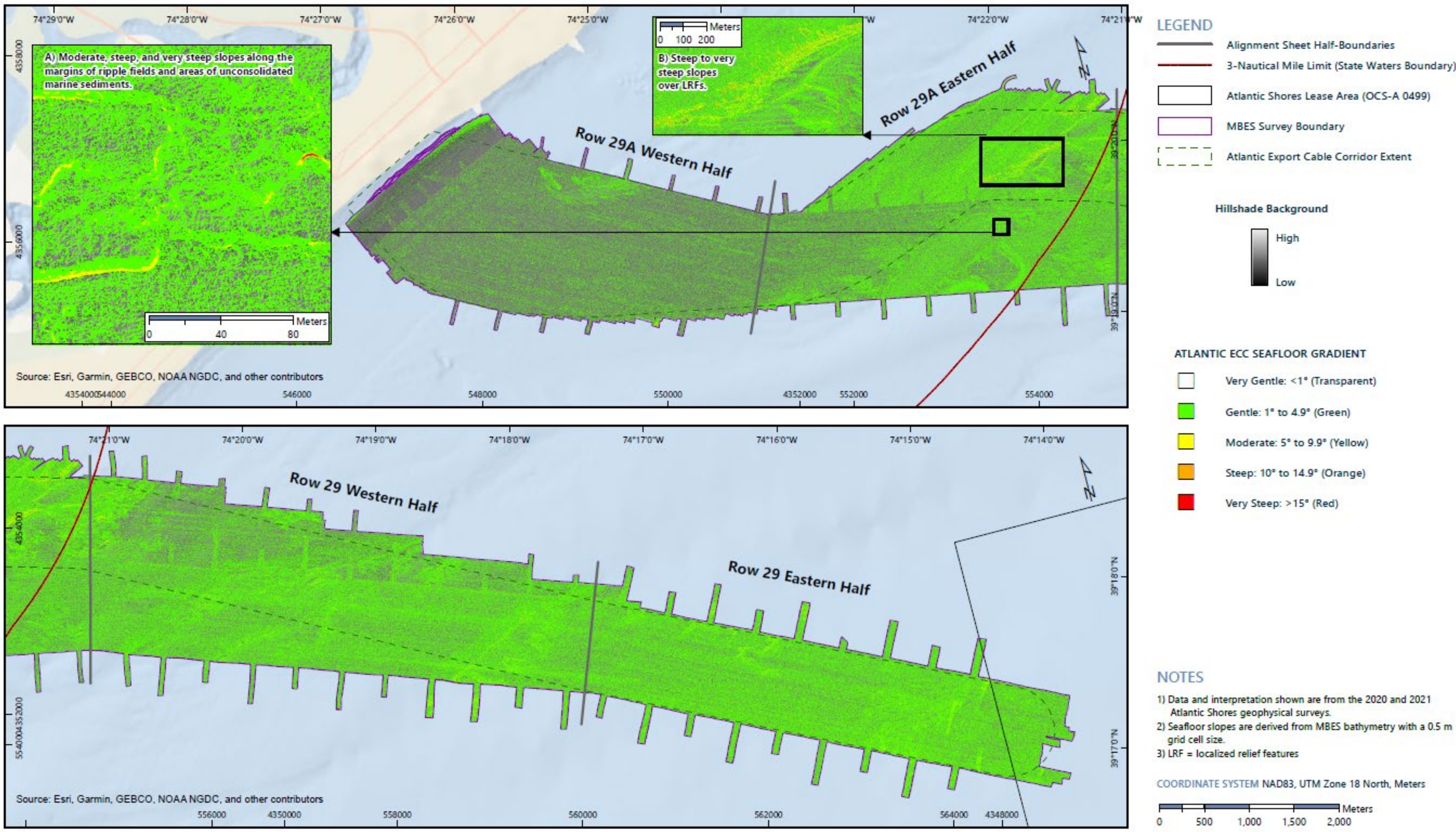


Figure 3-11. Seafloor Gradient in the Atlantic Export Cable Corridor

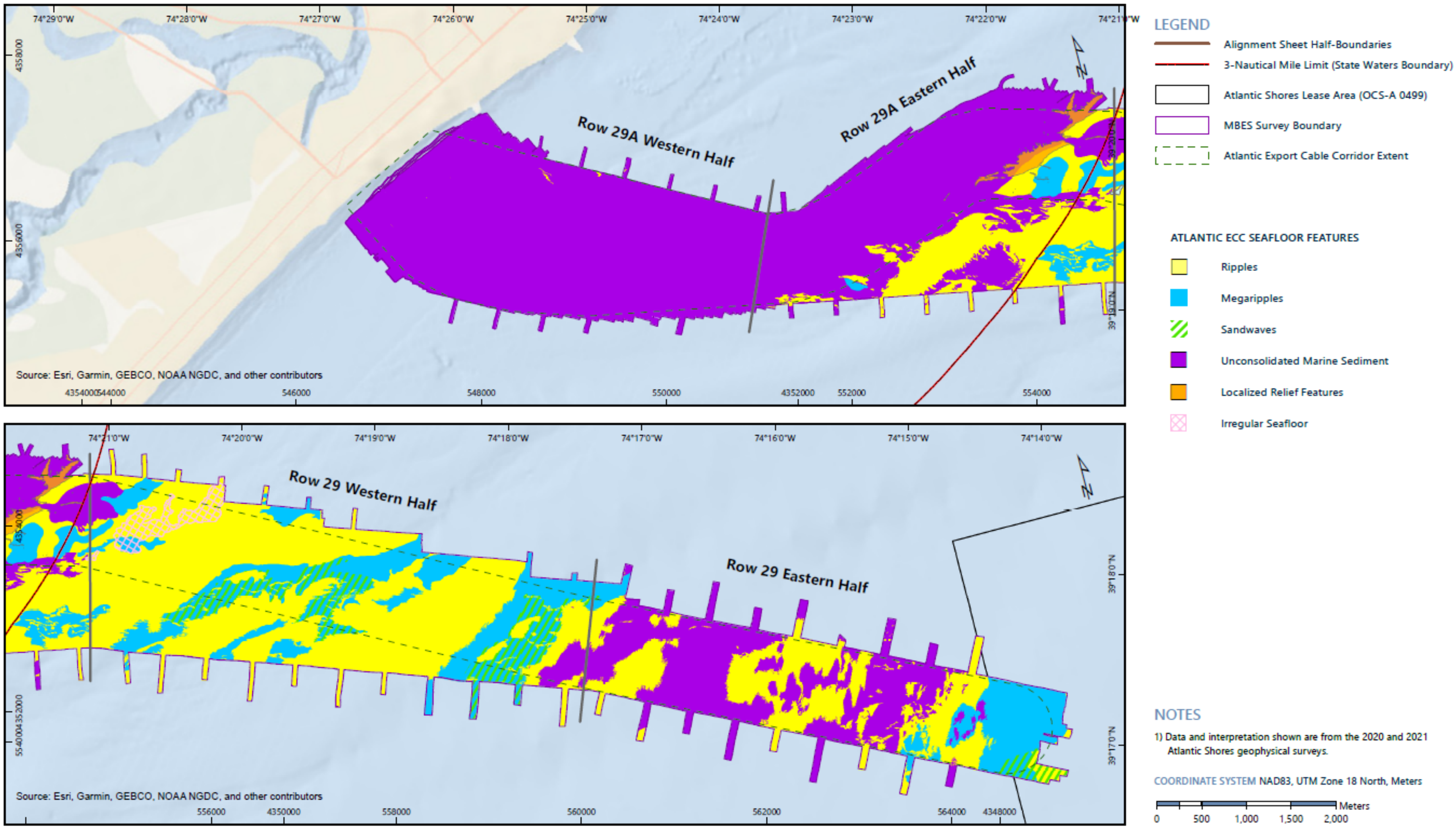


Figure 3-12. Seafloor Morphology in the Atlantic Export Cable Corridor

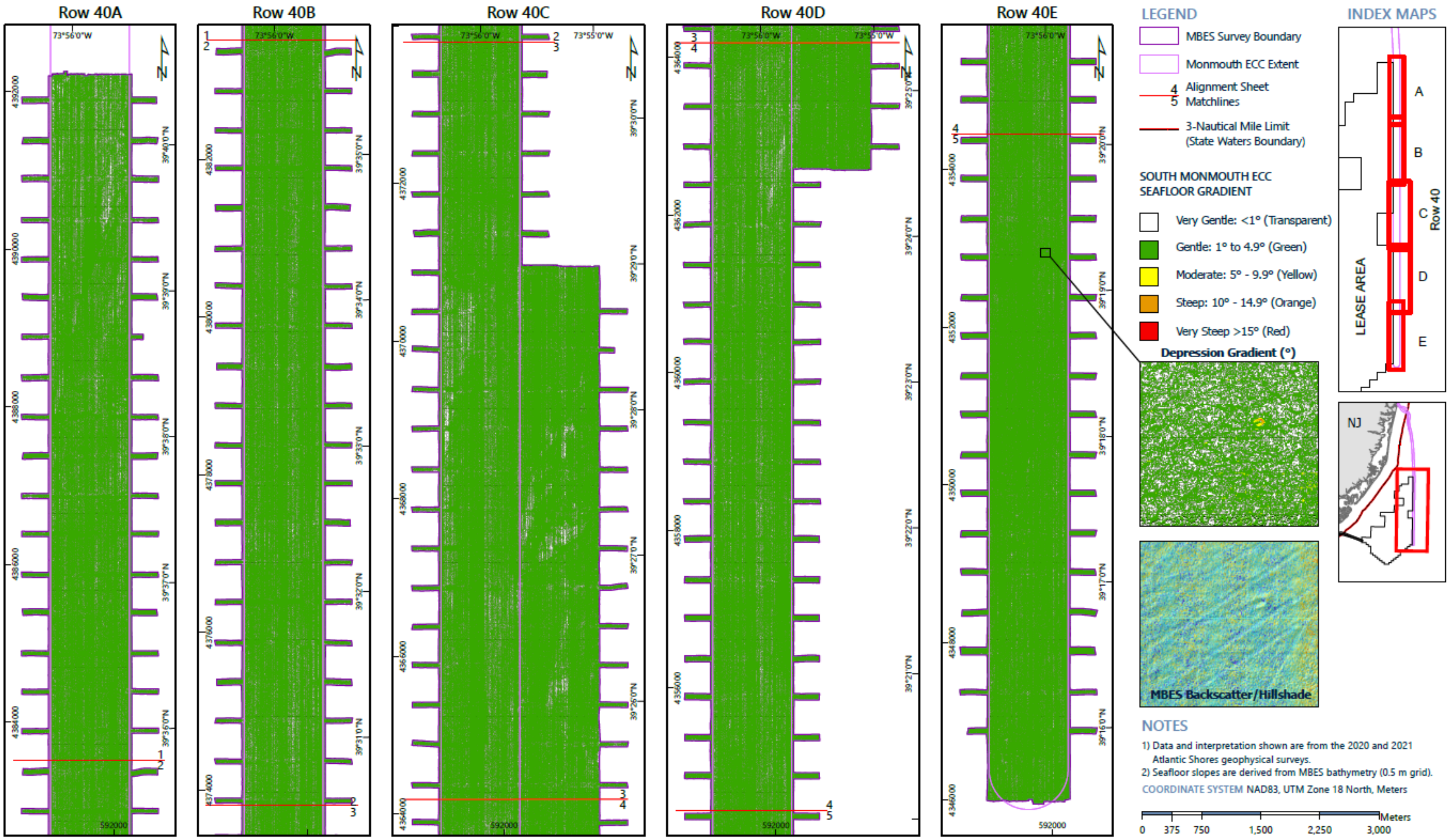


Figure 3-13. Seafloor Gradient in the Southern Monmouth Export Cable Corridor

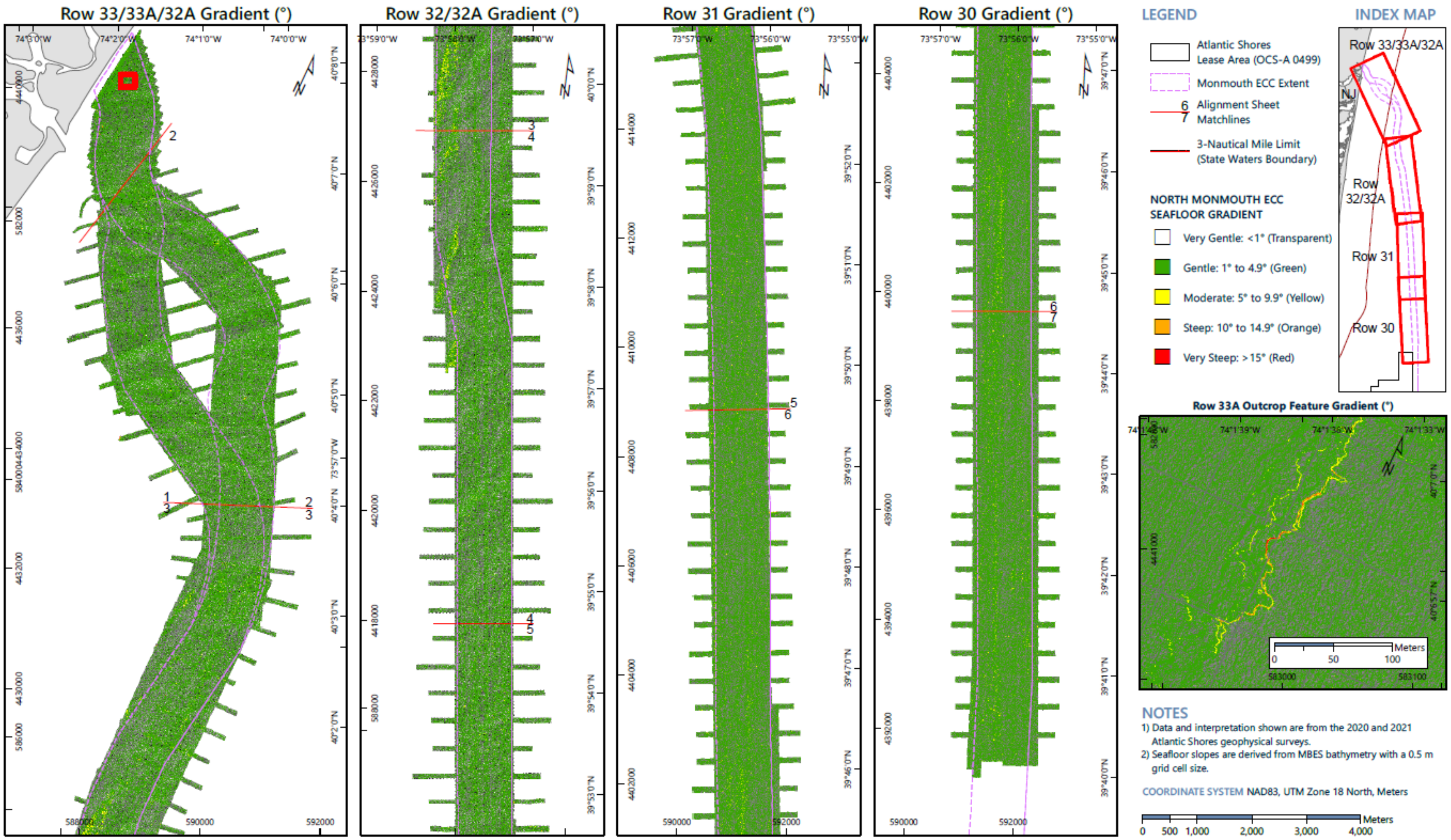


Figure 3-14. Seafloor Gradient in the Northern Monmouth Export Cable Corridor

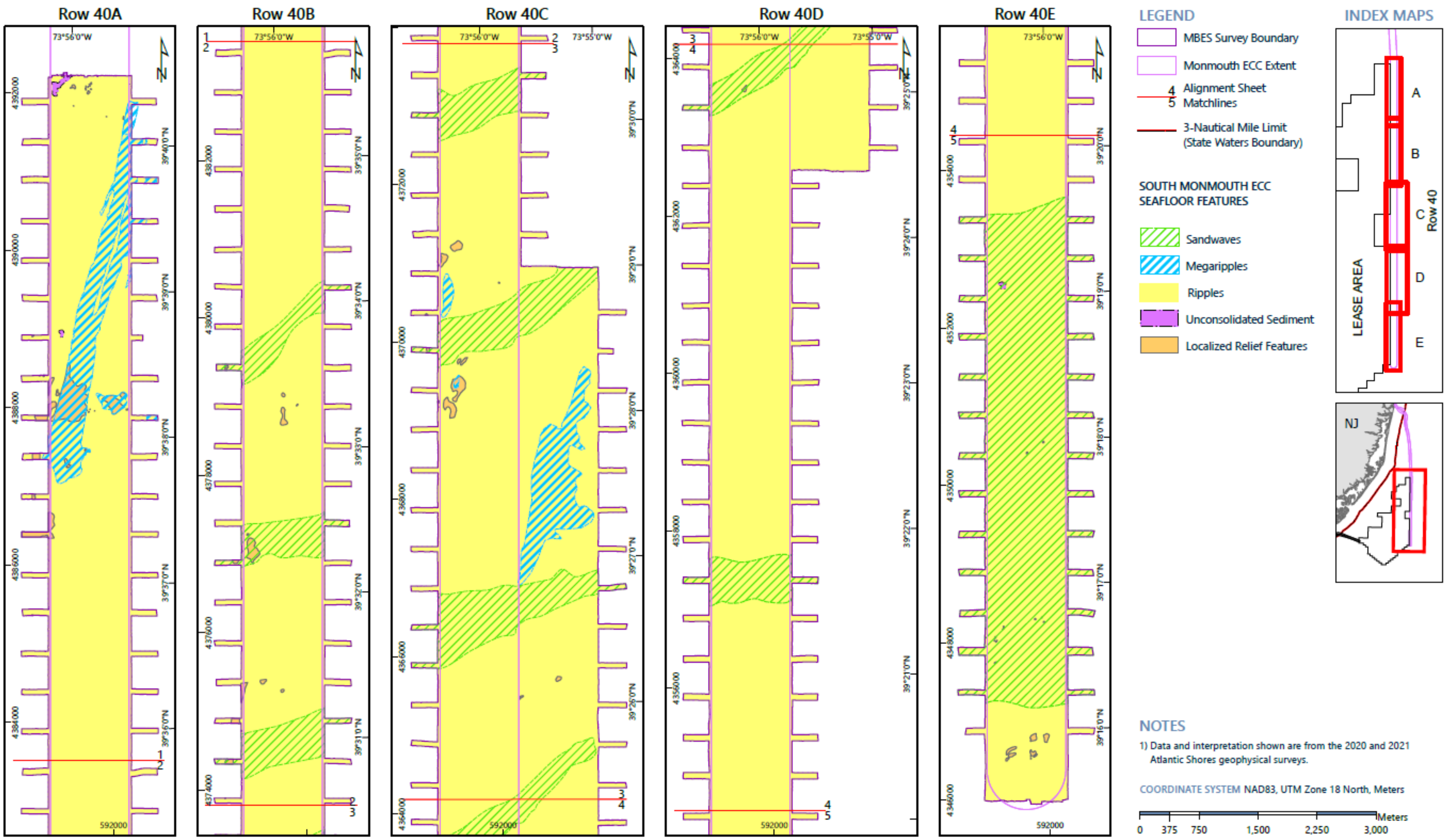


Figure 3-15. Seafloor Morphology in the Southern Monmouth Export Cable Corridor

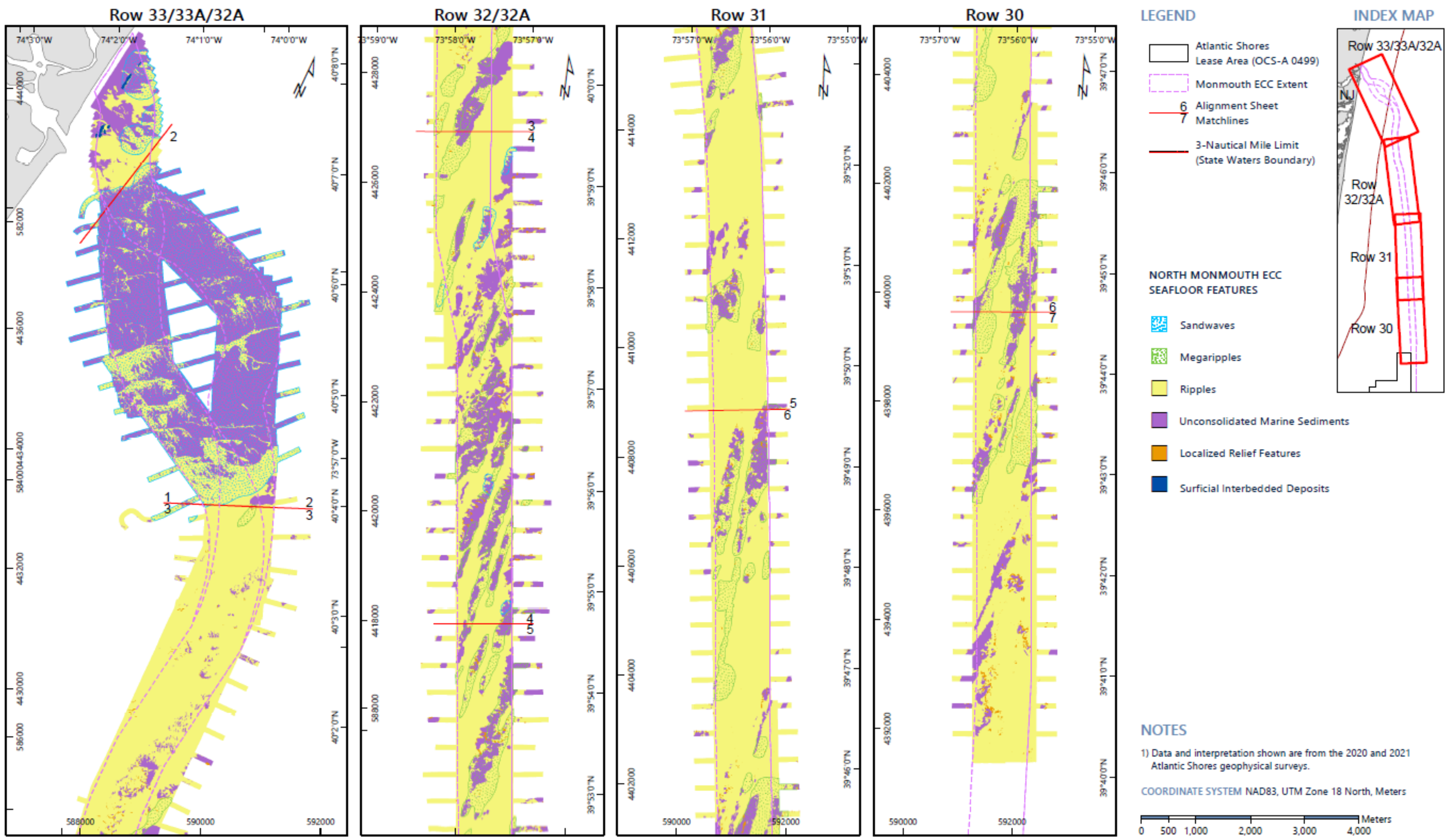


Figure 3-16. Seafloor Morphology in the Northern Monmouth Export Cable Corridor

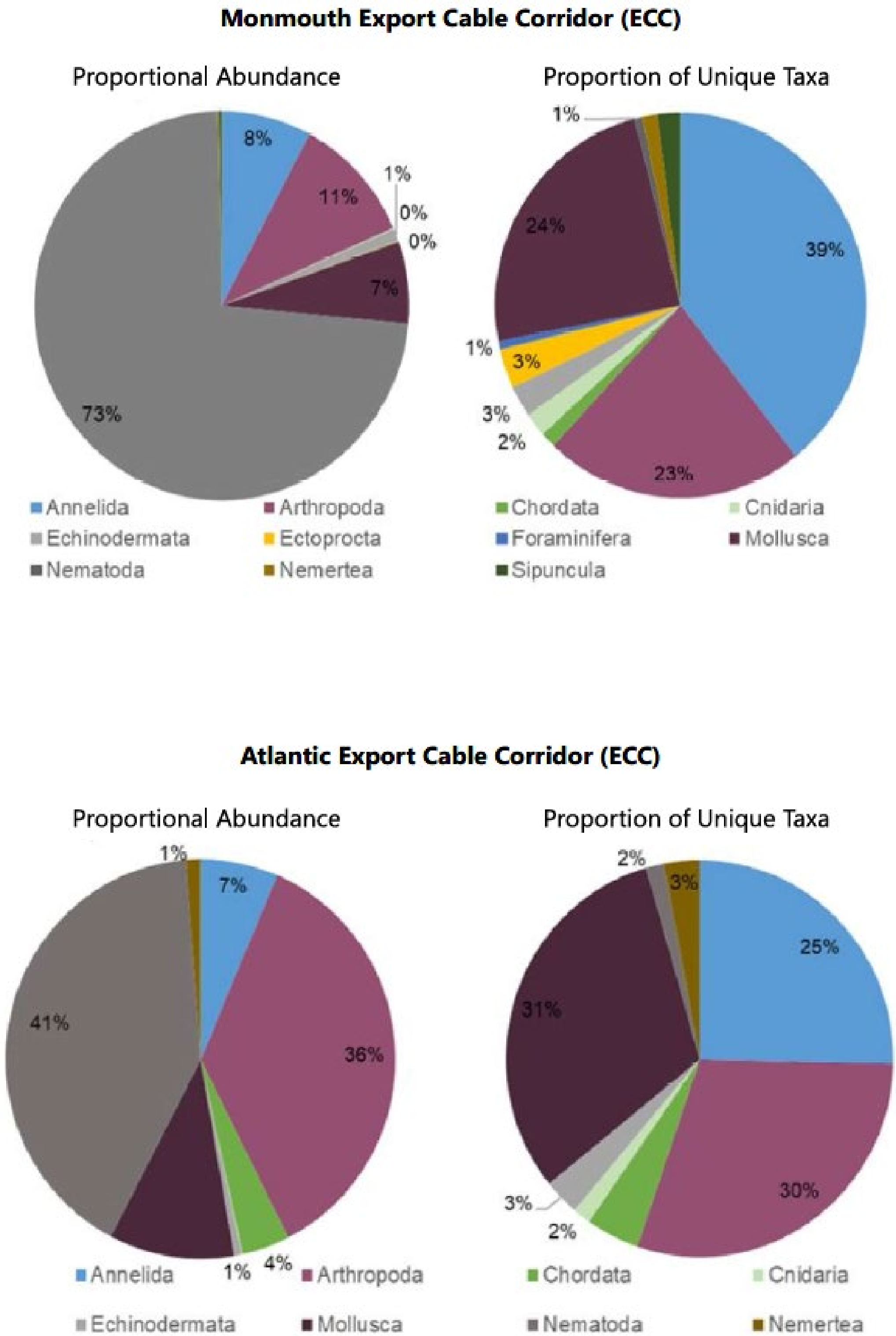


Figure 3-17. Proportional Abundance and Proportion of Unique Taxa Based on Benthic Grabs Conducted in the Atlantic ECC and Monmouth ECC

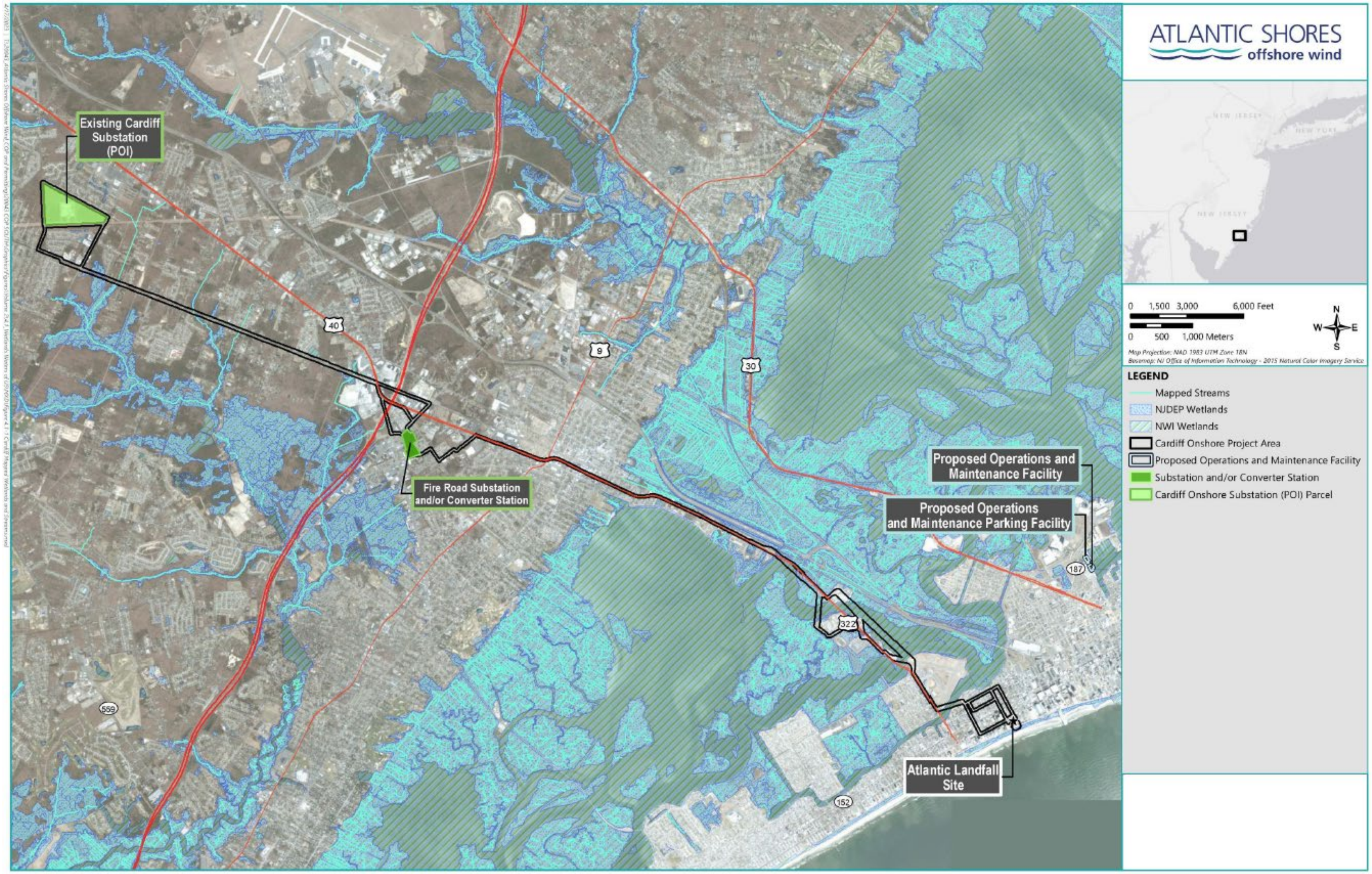


Figure 3-18. Mapped Wetlands and Streams Along the Cardiff onshore Interconnection Cable Route

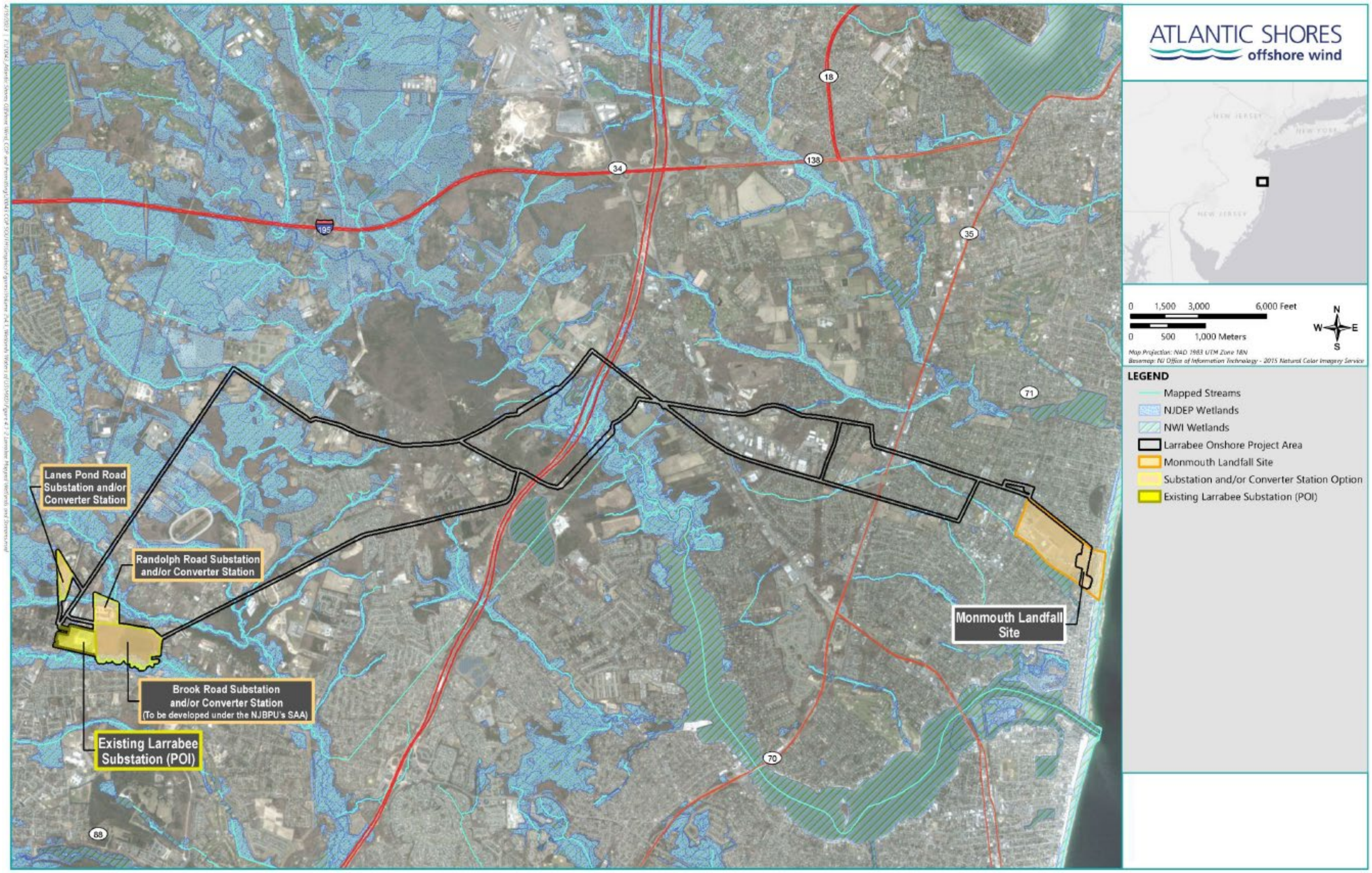


Figure 3-19. Mapped Wetlands and Streams Along the Larrabee Onshore Interconnection Cable Route

Figure 3-20. Mapped Wetlands and Streams within the O&M Onshore Project Area

Figure 3-21. Shellfish Lease Areas Along the Cardiff Onshore Interconnection Cable Route

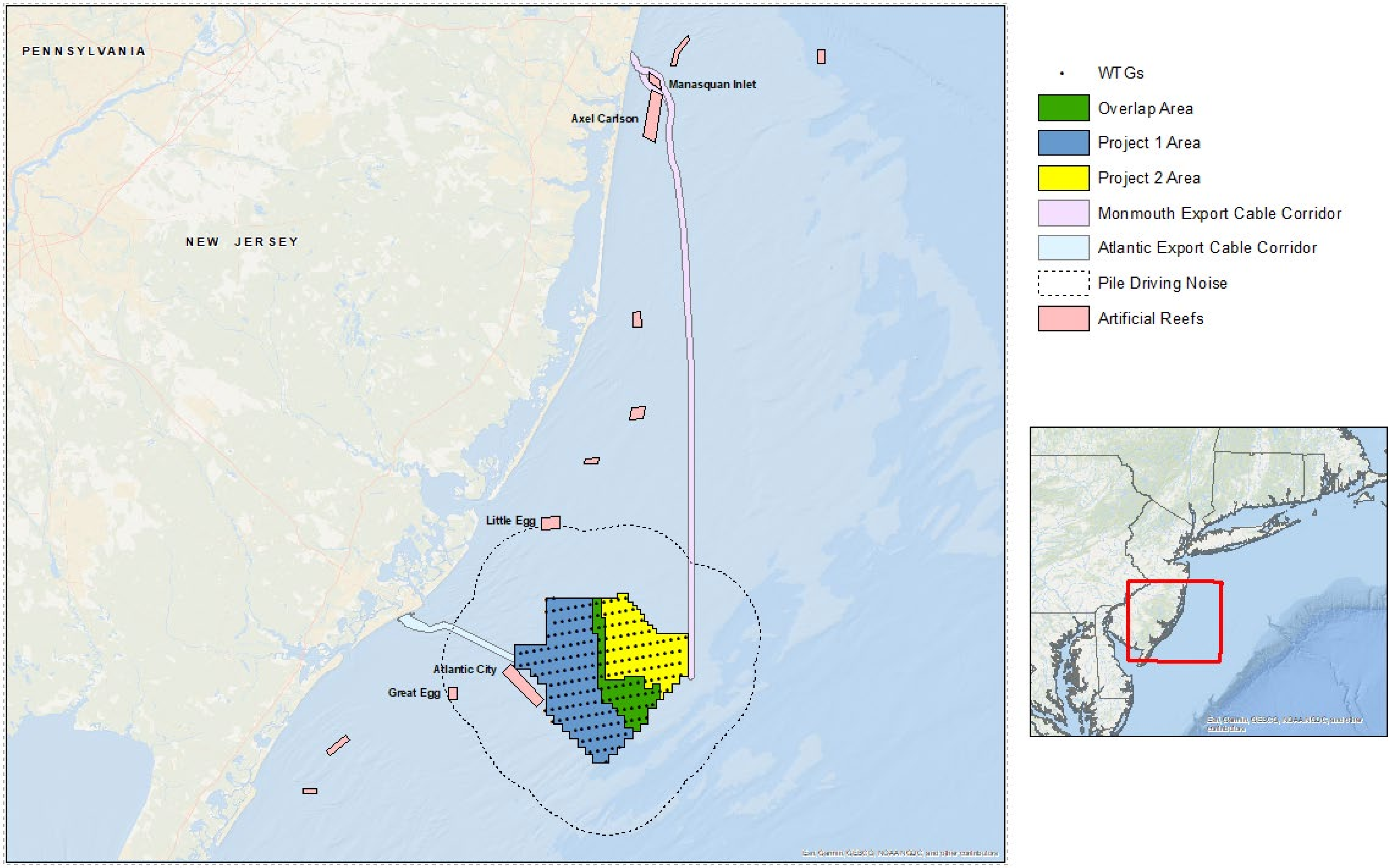


Figure 3-22. Artificial Reefs Adjacent to the Project Area

4. Designated EFH

The Project area includes EFH designations developed by the New England Fishery Management Council (NEFMC), the Mid-Atlantic Fishery Management Council (MAFMC), and NMFS. The site of the Proposed Action lies within the New York Bight, Long Island, and Hudson-Raritan Estuary regions. Species and life stages with EFH in the Project area were identified with the NMFS EFH Mapper (NMFS 2022). Descriptions and habitat designations for EFH-designated species and life stages were primarily developed from NMFS EFH source documents, the Final Omnibus Essential Fish Habitat Amendment 2 (NEFMC 2017), and the Final Amendment 10 to the 2006 Consolidated Atlantic Highly Migratory Species FMP (NMFS 2017). A description of NOAA Trust Resources in the general vicinity of the Project area is provided in Section 7, below.

The Project area includes designated EFH for 40 fish and invertebrate species, with varying species and life stage distribution throughout the Project area. Resources are managed under various FMPs. NEFMC FMPs include Northeast Multispecies; Sea Scallop; Monkfish; Atlantic Herring; Skate, Small-Mesh Multispecies; and Spiny Dogfish. MAFMC FMPs include Summer Flounder, Scup, Black Sea Bass; Mackerel, Squid, Butterfish; Surfclam and Ocean Quahog; and Bluefish. NMFS FMPs include the Highly Migratory Species. Designated EFH occurrence by taxonomic grouping, individual species, and life stage is summarized in for finfish and invertebrates in Table 4-1 and sharks and skates in Table 4-2.

Table 4-1. EFH-Designated Fish and Invertebrate Species within the Project Area

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Gadids													
Atlantic cod *Gadus morhua*	•	•	•	•	•	--	--	--	--	•	•	--	Eggs/Larvae: Pelagic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic region, and in the high-salinity zones of certain bays and estuaries. Adults: Sub-tidal benthic habitats in the Gulf of Maine, south of Cape Cod, and on Georges Bank, between 30 and 160 meters, including high salinity zones in certain bays and estuaries. Structurally complex hard bottom habitats composed of gravel, cobble, and boulder substrates with and without emergent epifauna and macroalgae are essential habitats for adult cod. Adult cod are also found on sandy substrates and frequent deeper slopes of ledges along shore. South of Cape Cod, spawning occurs in nearshore areas and on the continental shelf, usually in depths less than 70 meters.
Haddock *Melanogrammus aeglefinus*	--	--	--	--	--	--	•	•	--	--	--	--	Juveniles: Sub-tidal benthic habitats between 40 and 140 meters in the Gulf of Maine, on Georges Bank and in the Mid-Atlantic region, and as shallow as 20 meters along the coast of Massachusetts, New Hampshire, and Maine. Essential fish habitat for adult haddock occurs on hard sand (particularly smooth patches between rocks), mixed sand and shell, gravelly sand, and gravel. Young-of-the-year juveniles settle on sand and gravel on Georges Bank but are found predominantly on gravel pavement areas within a few months after settlement. As they grow, they disperse over a greater variety of substrate types on the bank. Young-of-the-year haddock do not inhabit shallow, inshore habitats.
Pollock *Pollachius virens*	--	--	--	--	•	--	--	--	--	--	--	--	Larvae: Pelagic inshore and offshore habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic region, including certain bays and estuaries.
Red hake *Urophycis chuss*	•	•	•	•	•	•	•	•	•	•	•	•	Eggs and Larvae: Pelagic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic, and in certain bays and estuaries. Juveniles: Intertidal and sub-tidal benthic habitats throughout the region on mud and sand substrates, to a maximum depth of 80 meters, including certain bays and estuaries. Bottom habitats providing shelter are essential for juvenile red hake, including: mud substrates with biogenic depressions, substrates providing biogenic complexity (e.g., eelgrass, macroalgae, shells, anemone and polychaete tubes), and artificial reefs. Newly settled juveniles occur in depressions on the open seabed. Older juveniles are commonly associated with shelter or structure and often inside live bivalves. Adults: Benthic habitats in the Gulf of Maine and the outer continental shelf and slope in depths of 50 – 750 meters and as shallow as 20 meters in several

	Designated EFH for Species and Life Stages by Project Component												
	Eggs			Larvae			Juvenile			Adult			
EFH Species	**WTA**	**Mon. ECC**	**Atl. ECC**	**WTA**	**Mon. ECC**	**Atl. ECC**	**WTA**	**Mon. ECC**	**Atl. ECC**	**WTA**	**Mon. ECC**	**Atl. ECC**	**EFH Description**
													inshore estuaries and embayments as far south as Chesapeake Bay. Shell beds, soft sediments (mud and sand), and artificial reefs provide essential habitats for adult red hake. They are usually found in depressions in softer sediments or in shell beds and not on open sandy bottom. In the Gulf of Maine, they are much less common on gravel or hard bottom, but they are reported to be abundant on hard bottoms in temperate reef areas of Maryland and northern Virginia.
Silver hake *Merluccius bilinearis*	•	•	•	•	•	•	--	--	--	•	•	--	Eggs and Larvae: Pelagic habitats from the Gulf of Maine to Cape May, New Jersey, including Cape Cod and Massachusetts Bays. Adults: Pelagic and benthic habitats at depths greater than 35 meters in the Gulf of Maine and certain coastal bays and estuaries, between 70 and 400 meters on Georges Bank and the outer continental shelf in the northern portion of the Mid-Atlantic Bight, and in some shallower locations nearer the coast, on sandy substrates. Adult silver hake are often found in bottom depressions or in association with sand waves and shell fragments. They have also been observed at high densities in mud habitats bordering deep boulder reefs, resting on boulder surfaces, and foraging over deep boulder reefs in the southwestern Gulf of Maine. This species makes greater use of the water column (for feeding, at night) than red or white hake.
White hake *Urophycis tenuis*	--	--	--	--	--	--	--	--	--	•	•	--	Adults: Sub-tidal benthic habitats in the Gulf of Maine, including depths greater than 25 meters in certain mixed and high salinity zones portions of several bays and estuaries, between 100 and 400 meters in the outer Gulf of Maine, and between 400 and 900 meters on the outer continental shelf and slope. Essential fish habitat for adult white hake occurs on fine-grained, muddy substrates and in mixed soft and rocky habitats. Spawning takes place in deep water on the continental slope and in Canadian waters.
Flatfish													
Summer flounder *Paralichthys dentatus*	•	•	•	•	•	•	•	•	•	•	•	•	Eggs: North of Cape Hatteras, EFH is the pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ). In general, summer flounder eggs are found between October and May, being most abundant between Cape Cod and Cape Hatteras, with the heaviest concentrations within 9 miles of shore off New Jersey and New York. Eggs abundance is highest at depths of 30 to 360 ft. Larvae: North of Cape Hatteras, EFH is the pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ). Inshore, EFH is all estuaries where summer flounder were identified as being present (rare, common, abundant, or highly abundant) in the ELMR database, in the “mixing” (defined in ELMR as 0.5 to 25.0 ppt) and “seawater” (defined in ELMR as

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													greater than 25 ppt) salinity zones. In general, summer flounder larvae are most abundant nearshore (12-50 miles from shore) at depths between 30 to 230 ft. They are most frequently found in the northern part of the Mid-Atlantic Bight from September to February, and in the southern part from November to May. Juveniles: North of Cape Hatteras, EFH is the demersal waters over the continental shelf (from the coast out to the limits of the EEZ). Inshore, EFH is all estuaries where summer flounder were identified as being present (rare, common, abundant, or highly abundant) in the ELMR database for the “mixing” and “seawater” salinity zones. In general, juveniles use several estuarine habitats as nursery areas, including salt marsh creeks, seagrass beds, mudflats, and open bay areas in water temperatures greater than 37 °F and salinities from 10 to 30 ppt range. Adults: 1) North of Cape Hatteras, EFH is the demersal waters over the continental shelf (from the coast out to the limits of the EEZ). Inshore, EFH is the estuaries where summer flounder were identified as being common, abundant, or highly abundant in the ELMR database for the “mixing” and “seawater” salinity zones. Generally, summer flounder inhabit shallow coastal and estuarine waters during warmer months and move offshore on the outer continental shelf at depths of 500 ft in colder months.
Winter flounder *Pseudopleuronectes americanus*	•	•	•	•	•	--	•	•	--	•	•	--	Eggs: Sub-tidal estuarine and coastal benthic habitats from mean low water to 5 meters from Cape Cod to Absecon Inlet, and as deep as 70 meters on Georges Bank and in the Gulf of Maine, including mixed and high salinity zones in certain bays and estuaries. The eggs are adhesive and deposited in clusters on the bottom. Essential habitats for winter flounder eggs include mud, muddy sand, sand, gravel, macroalgae, and submerged aquatic vegetation. Bottom habitats are unsuitable if exposed to excessive sedimentation. Larvae: Estuarine, coastal, and continental shelf water column habitats from the shoreline to a maximum depth of 70 meters from the Gulf of Maine to Absecon Inlet, and including Georges Bank, including mixed and high salinity zones in certain bays and estuaries. Larvae hatch in nearshore waters and estuaries or are transported shoreward from offshore spawning sites where they metamorphose and settle to the bottom as juveniles. They are initially planktonic but become increasingly less buoyant and occupy the lower water column as they age. Juveniles: Estuarine, coastal, and continental shelf benthic habitats from the Gulf of Maine to Absecon Inlet, and including Georges Bank, and in mixed and high salinity zones in certain bays and estuaries. Essential fish habitat for

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													juvenile winter flounder extends from the intertidal zone to a maximum depth of 60 meters and occurs on a variety of bottom types, such as mud, sand, rocky substrates with attached macroalgae, tidal wetlands, and eelgrass. Young-of-the-year juveniles are found inshore on muddy and sandy sediments in and adjacent to eelgrass and macroalgae, in bottom debris, and in marsh creeks. They settle to the bottom in soft-sediment depositional areas where currents concentrate late-stage larvae and disperse into coarser-grained substrates as they age. Adults: Estuarine, coastal, and continental shelf benthic habitats extending from the intertidal zone to a maximum depth of 70 meters from the Gulf of Maine to Absecon Inlet, and including Georges Bank, and in mixed and high salinity zones in certain bays and estuaries. Essential fish habitat for adult winter flounder occurs on muddy and sandy substrates, and on hard bottom on offshore banks. In inshore spawning areas, essential fish habitat includes a variety of substrates where eggs are deposited on the bottom.
Windowpane flounder *Scophthalmus aquosus*	•	•	•	•	•	•	•	•	•	•	•	•	Eggs/Larvae: Pelagic habitats on the continental shelf from Georges Bank to Cape Hatteras and in mixed and high-salinity zones of coastal bays and estuaries throughout the region. Juveniles: Intertidal and sub-tidal benthic habitats in estuarine, coastal marine, and continental shelf waters from the Gulf of Maine to northern Florida, including mixed and high salinity zones in certain bays and estuaries. Essential fish habitat for juvenile windowpane flounder is found on mud and sand substrates and extends from the intertidal zone to a maximum depth of 60 meters. Young-of-the-year juveniles prefer sand over mud. Adults: Intertidal and sub-tidal benthic habitats in estuarine, coastal marine, and continental shelf waters from the Gulf of Maine to Cape Hatteras, including mixed and high salinity zones in certain bays and estuaries. Essential fish habitat for adult windowpane flounder is found on mud and sand substrates and extends from the intertidal zone to a depth of 70 meters.
Witch flounder *Glyptocephalus cynoglossus*	•	•	•	•	•	--	--	--	--	•	•	•	Eggs and Larvae: Pelagic habitats on the continental shelf throughout the Northeast region. Adults: Sub-tidal benthic habitats between 35 and 400 meters in the Gulf of Maine and as deep as 1500 meters on the outer continental shelf and slope, with mud and muddy sand substrates.
Yellowtail flounder *Limanda ferruginea*	•	•	•	•	•	•	•	•	•	•	•	--	Eggs: Coastal and continental shelf pelagic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic region as far south as the upper Delmarva peninsula, including the high salinity zones of certain bays and estuaries.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													Larvae: Coastal marine and continental shelf pelagic habitats in the Gulf of Maine, and from Georges Bank to Cape Hatteras, including the high salinity zones of certain bays and estuaries. Juveniles: Sub-tidal benthic habitats in coastal waters in the Gulf of Maine and on the continental shelf on Georges Bank and in the Mid-Atlantic, including the high salinity zones of certain bays and estuaries. Essential fish habitat for juvenile yellowtail flounder occurs on sand and muddy sand between 20 and 80 meters. In the Mid-Atlantic, young-of-the-year juveniles settle to the bottom on the continental shelf, primarily at depths of 40-70 meters, on sandy substrates. Adults: Sub-tidal benthic habitats in coastal waters in the Gulf of Maine and on the continental shelf on Georges Bank and in the Mid-Atlantic, including the high salinity zones of certain bays and estuaries. Essential fish habitat for adult yellowtail flounder occurs on sand and sand with mud, shell hash, gravel, and rocks at depths between 25 and 90 meters.
Other Finfish													
Atlantic butterfish *Peprilus triacanthus*	•	•	--	•	•	•	•	•	•	•	•	•	Eggs: EFH is pelagic habitats in inshore estuaries and embayments from Massachusetts Bay to the south shore of Long Island, New York, in Chesapeake Bay, and on the continental shelf and slope, primarily from Georges Bank to Cape Hatteras, North Carolina. EFH for Atlantic butterfish eggs is generally found over bottom depths of 1,500 meters or less where average temperatures in the upper 200 meters of the water column are 6.5-21.5°C. Larvae: EFH is pelagic habitats in inshore estuaries and embayments in Boston harbor, from the south shore of Cape Cod to the Hudson River, and in Delaware and Chesapeake bays, and on the continental shelf from the Great South Channel (western Georges Bank) to Cape Hatteras, North Carolina. EFH for Atlantic butterfish larvae is generally found over bottom depths between 41 and 350 meters where average temperatures in the upper 200 meters of the water column are 8.5-21.5°C. Juveniles: EFH is pelagic habitats in inshore estuaries and embayments from Massachusetts Bay to Pamlico Sound, North Carolina, in inshore waters of the Gulf of Maine and the South Atlantic Bight, and on the inner and outer continental shelf from southern New England to South Carolina. EFH for juvenile Atlantic butterfish is generally found over bottom depths between 10 and 280 meters where bottom water temperatures are between 6.5 and 27°C and salinities are above 5 ppt. Juvenile butterfish feed mainly on planktonic prey.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													Adults: EFH is pelagic habitats in inshore estuaries and embayments from Massachusetts Bay to Pamlico Sound, North Carolina, inshore waters of the Gulf of Maine and the South Atlantic Bight, on Georges Bank, on the inner continental shelf south of Delaware Bay, and on the outer continental shelf from southern New England to South Carolina. EFH for adult Atlantic butterfish is generally found over bottom depths between 10 and 250 meters where bottom water temperatures are between 4.5 and 27.5°C and salinities are above 5 ppt. Spawning probably does not occur at temperatures below 15°C. Adult butterfish feed mainly on planktonic prey, including squids and fishes.
Atlantic mackerel *Scomber scombrus*	•	•	--	•	•	--	•	•	--	•	•	•	Eggs: EFH is pelagic habitats in inshore estuaries and embayments from Great Bay, New Hampshire to the south shore of Long Island, New York, inshore and offshore waters of the Gulf of Maine, and on the continental shelf from Georges Bank to Cape Hatteras, North Carolina (mostly north of 38°N). EFH for Atlantic mackerel eggs is generally found over bottom depths of 100 meters or less with average water temperatures of 6.5-12.5°C in the upper 15 meters of the water column. Larvae: EFH is pelagic habitats in inshore estuaries and embayments from Great Bay, New Hampshire to the south shore of Long Island, New York, inshore waters of the Gulf of Maine, and on the continental shelf from Georges Bank to Cape Hatteras, North Carolina (mostly north of 38°N). EFH for Atlantic mackerel larvae is generally found over bottom depths between 21 and 100 meters with average water temperatures of 5.5-11.5°C in the upper 200 meters of the water column. Juveniles: EFH is pelagic habitats in inshore estuaries and embayments from Passamaquoddy Bay and Penobscot Bay, Maine to the Hudson River, in the Gulf of Maine, and on the continental shelf from Georges Bank to Cape Hatteras, North Carolina. EFH for juvenile Atlantic mackerel is generally found over bottom depths between 10 and 110 meters and in water temperatures of 5 to 20°C. Juvenile Atlantic mackerel feed primarily on small crustaceans, larval fish, and other pelagic organisms. Adults: EFH is pelagic habitats in inshore estuaries and embayments from Passamaquoddy Bay, Maine to the Hudson River, and on the continental shelf from Georges Bank to Cape Hatteras, North Carolina. EFH for adult Atlantic mackerel is generally found over bottom depths less than 170 meters and in water temperatures of 5 to 20°C. Spawning occurs at temperatures above 7°C, with a peak between 9 and 14°C. Adult Atlantic mackerel are opportunistic predators feeding primarily on a wider range and larger individuals of pelagic crustaceans than juveniles, but also on fish and squid.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Atlantic sea herring *Clupea harengus*	--	--	--	--	--	--	•	•	•	•	•	•	Juveniles: Intertidal and sub-tidal pelagic habitats to 300 meters throughout the region, including certain bays and estuaries. One and two-year old juveniles form large schools and make seasonal inshore-offshore migrations. Older juveniles occur in water temperatures of 3 to 15°C in the northern part of their range and as high as 22°C in the Mid-Atlantic. Young juveniles can tolerate low salinities, but older juveniles avoid brackish water. Adults: Sub-tidal pelagic habitats with maximum depths of 300 meters throughout the region, including certain bays and estuaries. Adults make extensive seasonal migrations between summer and fall spawning grounds on Georges Bank and the Gulf of Maine and overwintering areas in southern New England and the Mid-Atlantic region. They seldom migrate beyond a depth of about 100 meters and – unless they are preparing to spawn – usually remain near the surface. They generally avoid water temperatures above 10°C and low salinities. Spawning takes place on the bottom, generally in depths of 5 – 90 meters on a variety of substrates.
Black sea bass *Centropristis striata*	--	--	--	•	•	--	•	•	•	•	•	•	Larvae: North of Cape Hatteras, EFH is pelagic waters over the continental shelf. EFH also is estuaries where black sea bass were identified as common, abundant, or highly abundant in the ELMR database for the "mixing" and "seawater salinity zones. Generally, habitats for larvae are near coastal areas and estuaries between Virginia and New York. When larvae become demersal, they occur on structured inshore habitat such as sponge beds. Juveniles: Offshore, EFH is the demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. Inshore, EFH is the estuaries where black sea bass are identified as being common, abundant, or highly abundant in the ELMR database for the mixing" and "seawater" salinity zones. Juveniles occur in estuaries in summer and spring. Generally, juveniles occur in waters warmer than 43°F with salinities greater than 18 ppt and coastal areas between Virginia and Massachusetts. Juveniles are usually found in association with rough bottom, shellfish and eelgrass beds, man-made structures in sandy shelly areas; offshore clam beds and shell patches may also be used during the wintering. Adults: Offshore, EFH is the demersal waters over the continental shelf, from the Gulf of Maine to Cape Hatteras. Inshore, EFH is the estuaries where adult black sea bass were identified as being common, abundant, or highly abundant in the ELMR database for the "mixing" and seawater" salinity zones. Adults occur in estuaries from May through October. Wintering adults are generally offshore, south of New York to North Carolina. Temperatures above 43°F seem to be the minimum requirements. Structured habitats (natural and man-made), sand and shell are usually the substrate preference.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Bluefish *Pomatomus saltatrix*	•	•	•	•	•	•	•	•	•	•	•	•	Eggs: North of Cape Hatteras, pelagic waters over the continental shelf at mid-shelf depths, from Montauk Point south to Cape Hatteras. Bluefish eggs are generally not collected in estuarine waters and thus there is no EFH designation inshore. Generally, bluefish eggs are collected between April through August in temperatures greater than 64°F (18°C) and normal shelf salinities (> 31 ppt). Larvae: North of Cape Hatteras, pelagic waters over the continental shelf, most commonly above 49 ft (15 m), from Montauk Point south to Cape Hatteras. Bluefish larvae are not generally collected inshore, so there is no EFH designation inshore for larvae. Generally, bluefish larvae are collected April through September in temperatures greater than 64 °F (18°C) in normal shelf salinities (> 30 ppt). Juveniles: 1) North of Cape Hatteras, pelagic waters found over the continental shelf from Nantucket Island south to Cape Hatteras and 2) all major estuaries between Penobscot Bay, Maine and St. Johns River, Florida. Generally, juvenile bluefish occur in North Atlantic estuaries from June through October, Mid-Atlantic estuaries from May through October, and South Atlantic estuaries March through December, within the “mixing” and “seawater” zones. Distribution of juveniles by temperature, salinity, and depth over the continental shelf is undescribed. Adults: 1) North of Cape Hatteras, over the continental shelf (from the coast out to the limits of the EEZ), from Cape Cod Bay south to Cape Hatteras and 2) all major estuaries between Penobscot Bay, Maine and St. Johns River, Florida. Adult bluefish are found in North Atlantic estuaries from June through October, Mid-Atlantic estuaries from April through October, and in South Atlantic estuaries from May through January in the “mixing” and “seawater” zones. Bluefish adults are highly migratory and distribution varies seasonally according to the size of the individuals comprising the schools. Bluefish are generally found in normal shelf salinities (> 25 ppt).
Monkfish *Lophius americanus*	•	•	•	•	•	•	--	--	--	•	•	--	Eggs and Larvae: Pelagic habitats in inshore areas, and on the continental shelf and slope throughout the Northeast region. Monkfish eggs are shed in very large buoyant mucoidal egg “veils.” Monkfish larvae are more abundant in the Mid-Atlantic region and occur over a wide depth range, from the surf zone to depths of 1000 to 1500 meters on the continental slope. Adults: Sub-tidal benthic habitats in depths of 50 to 400 meters in southern New England and Georges Bank, between 20 and 400 meters in the Gulf of Maine, and to a maximum depth of 1000 meters on the continental slope. Essential fish habitat for adult monkfish is composed of hard sand, pebbles, gravel, broken shells, and soft mud. They seem to prefer soft sediments (fine

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													sand and mud) over sand and gravel, and, like juveniles, utilize the edges of rocky areas for feeding.
Ocean pout *Macrozoarces americanus*	•	•	•	--	--	--	--	--	--	•	•	•	Eggs: Hard-bottom habitats in the Gulf of Maine, Georges Bank, and in the Mid-Atlantic Bight, as well as the high-salinity zones in certain estuaries. Eggs are laid in gelatinous masses, generally in sheltered nests, holes, or rocky crevices. Essential fish habitat for ocean pout eggs occurs in depths less than 100 meters on rocky bottom habitats. Adults: Sub-tidal benthic habitats between 20 and 140 meters in the Gulf of Maine, on Georges Bank, in coastal and continental shelf waters north of Cape May, New Jersey, and in the high salinity zones of bays and estuaries north of Cape Cod. Essential fish habitat for adult ocean pout includes mud and sand, particularly in association with structure forming habitat types (i.e., shells, gravel, or boulders). In softer sediments, they burrow tail first and leave a depression on the sediment surface. Ocean pout congregate in rocky areas prior to spawning and frequently occupy nesting holes under rocks or in crevices in depths less than 100 meters.
Scup *Stenotomus chrysops*	--	--	--	--	--	--	•	•	•	•	•	•	Juveniles: 1) Offshore, EFH is the demersal waters over the continental shelf (from the coast out to the limits of the EEZ, from the Gulf of Maine to Cape Hatteras, North Carolina. 2) Inshore, EFH is the estuaries where scup are identified as being common, abundant, or highly abundant in the ELMR database for the “mixing” and “seawater” salinity zones. In general, juvenile scup are found during the summer and spring in estuaries and bays between Virginia and Massachusetts, in association with various sands, mud, mussel and eelgrass bed type substrates and in water temperatures greater than 45 °F and salinities greater than 15 ppt. Adults: 1) Offshore, EFH is the demersal waters over the continental shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina. 2) Inshore, EFH is the estuaries where scup were identified as being common, abundant, or highly abundant in the ELMR database for the “mixing and “seawater” salinity zones. Generally, wintering adults (November through April) are usually offshore, south of New York to North Carolina, in waters above 45 °F.
Highly Migratory Species													
Albacore tuna *Thunnus alalunga*		--	--		--	--		•	--		--	--	Juveniles: Offshore, pelagic habitats of the Atlantic Ocean from the outer edge of the U.S. EEZ through Georges Bank to pelagic habitats south of Cape Cod, and from Cape Cod to Cape Hatteras, North Carolina. EFH also includes offshore pelagic habitats near the outer U.S. EEZ between North Carolina and Florida, and offshore pelagic habitats associated with the Blake Plateau.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Bluefin tuna *Thunnus thynnus*	--	--	--	--	--	--	•	•	•	--	•	--	Juveniles: Coastal and pelagic habitats of the Mid-Atlantic Bight and the Gulf of Maine, between southern Maine and Cape Lookout, from shore (excluding Long Island Sound, Delaware Bay, Chesapeake Bay, and Pamlico Sound) to the continental shelf break. EFH in coastal areas of Cape Cod are located between the Great South Passage and shore. EFH follows the continental shelf from the outer extent of the U.S. EEZ on Georges Bank to Cape Lookout. EFH is associated with certain environmental conditions in the Gulf of Maine (16 to 19°C; 0 to 40 m deep). EFH in other locations associated with temperatures ranging from 4 to 26 °C, often in depths of less than 20 m (but can be found in waters that are 40-100 m in depth in winter). Adults: EFH is offshore and coastal regions of the Gulf of Maine the mid-coast of Maine to Massachusetts; on Georges Bank; offshore pelagic habitats of southern New England; from southern New England to coastal areas between the mouth of Chesapeake Bay and Onslow Bay, North Carolina; from coastal North Carolina south to the outer extent of the U.S. EEZ, inclusive of pelagic habitats of the Blake Plateau, Charleston Bump, and Blake Ridge.
Skipjack tuna *Katsuwonus pelamis*	--	--	--	--	--	--	•	•	•	•	•	•	Juveniles: Offshore pelagic habitats seaward of the continental shelf break between the seaward extent of the U.S. EEZ boundary on Georges Bank (off Massachusetts); coastal and offshore habitats between Massachusetts and South Carolina; localized in areas off Georgia and South Carolina; and from the Blake Plateau through the Florida Straits. In all areas juveniles are found if waters greater than 20 m. Adults: Coastal and offshore habitats between Massachusetts and Cape Lookout, North Carolina and localized areas in the Atlantic off South Carolina and Georgia, and the northern east coast of Florida. EFH in the Atlantic Ocean also located on the Blake Plateau and in the Florida Straits through the Florida Keys.
Yellowfin tuna *Thunnus albacares*	--	--	--	--	--	--	•	•	•	--	--	--	Juveniles: Offshore pelagic habitats are seaward of the continental shelf break between the seaward extent of the U.S. EEZ boundary on Georges Bank and Cape Cod, Massachusetts, and offshore and coastal habitats from Cape Cod to the mid-east coast of Florida and the Blake Plateau. Juveniles are locally distributed in the Florida Straits and off the southwestern edge of the West Florida Shelf. Yellowfish tuna juveniles are also found in the central Gulf of Mexico from the Florida Panhandle to southern Texas. Localized EFH is southeast of Puerto Rico.
Invertebrates													
Atlantic sea scallop *Placopecten*	•	•	--	•	•	--	•	•	--	•	•	--	Eggs: Benthic habitats in inshore areas and on the continental shelf, in the vicinity of adult scallops. Eggs are heavier than seawater and remain on the

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
magellanicus													seafloor until they develop into the first free-swimming larval stage. Larvae: Benthic and water column habitats in inshore and offshore areas throughout the region. Any hard surface can provide an essential habitat for settling pelagic larvae ("spat"), including shells, pebbles, and gravel. They also attach to macroalgae and other benthic organisms such as hydroids. Spat attached to sedentary branching organisms or any hard surface have greater survival rates; spat that settle on shifting sand do not survive. Juveniles: Benthic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic, in depths of 18 to 110 meters. Juveniles (5-12 mm shell height) leave the original substrate on which they settle (see spat, above) and attach themselves by byssal threads to shells, gravel, and small rocks (pebble, cobble), preferring gravel. As they grow older, they lose their byssal attachment. Juvenile scallops are relatively active and swim to escape predation. While swimming, they can be carried long distances by currents. Bottom currents stronger than 10 cm/sec retard feeding and growth. In laboratory studies, maximum survival of juvenile scallops occurred between 1.2 and 15°C and above salinities of 25 ppt. On Georges Bank, age 1 juveniles are less dispersed than older juveniles and adults and are mainly associated with gravel-pebble deposits. Essential habitats for older juvenile scallops are the same as for the adults (gravel and sand). Adults: Benthic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic. Essential habitats for older juvenile and adult sea scallops are found on sand and gravel substrates in depths of 18 to 110 meters, but they are also found in shallower water and as deep as 180 meters in the Gulf of Maine. In the Mid-Atlantic they are found primarily between 45 and 75 meters and on Georges Bank they are more abundant between 60 and 90 meters. They often occur in aggregations called beds which may be sporadic or essentially permanent, depending on how suitable the habitat conditions are (temperature, food availability, and substrate) and whether oceanographic features (fronts, currents) keep larval stages in the vicinity of the spawning population. Bottom currents stronger than 25 cm/sec (half a knot) inhibit feeding. Growth of adult scallops is optimal between 10 and 15°C and they prefer full strength seawater.
Atlantic surf clam *Spisula solidissima*	--	--	--	--	--	--	•	•	•	•	•	•	Juveniles and adults: Throughout the substrate, to a depth of three feet below the water/sediment interface, within federal waters from the eastern edge of Georges Bank and the Gulf of Maine throughout the Atlantic EEZ. Surf clams generally occur from the beach zone to a depth of about 200 feet, but beyond about 125 feet abundance is low.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Ocean quahog *Arctica islandica*	--	--	--	--	--	--	•	--	--	•	•	--	Juveniles and adults: Throughout the substrate, to a depth of three feet below the water/sediment interface, within federal waters from the eastern edge of Georges Bank and the Gulf of Maine throughout the Atlantic EEZ. Distribution in the western Atlantic ranges in depths from 30 feet to about 800 feet. Ocean quahogs are rarely found where bottom water temperatures exceed 60 °F and occur progressively further offshore between Cape Cod and Cape Hatteras.
Longfin inshore squid *Doryteuthis pealeii*	•	•	•	--	--	--	•	•	•	•	•	•	Eggs: Inshore and offshore bottom habitats from Georges Bank to Cape Hatteras, generally where bottom water temperatures are between 10°C and 23°C, salinities are between 30 and 32 ppt, and depth is less than 50 meters. Eggs have also been collected in bottom trawls in deeper water at various places on the continental shelf. Egg masses are demersal and anchored to the substrates on which they are laid. Substrates include a variety of hard bottom types (e.g., shells, boulders), submerged aquatic vegetation, sand, and mud. Pre-recruits: **P**elagic habitats in inshore and offshore continental shelf waters from Georges Bank to South Carolina, in the southwestern Gulf of Maine, and in embayments such as Narragansett Bay, Long Island Sound, and Raritan Bay. Pre-recruits are generally found over bottom depths of 6-160 meters, bottom water temperatures of 8.5-24.5°C, and salinities of 28.5-36.5 ppt. Pre-recruits migrate offshore in the fall where they overwinter in deeper waters along the edge of the shelf. Small individuals feed on planktonic organisms while larger individuals feed on crustaceans and fish. Recruits: Pelagic habitats in inshore and offshore continental shelf waters from Georges Bank to South Carolina, inshore waters of the Gulf of Maine, and in embayments such as Narragansett Bay, Long Island Sound, Raritan Bay, and Delaware Bay. Recruits are generally found over bottom depths of 6-200 meters, bottom water temperatures of 8.5-14°C, and salinities of 24-36.5 ppt. Recruits inhabit the continental shelf and upper continental slope to depths of 400 meters. They migrate offshore in the fall and overwinter in warmer waters along the edge of the shelf. Individuals larger than 12 cm feed on fish and those larger than 16 cm feed on fish and squid. Females deposit eggs in gelatinous capsules which are attached in clusters to rocks, boulders, and aquatic vegetation and on sand or mud bottom, generally in depths less than 50 meters.
Northern shortfin squid *Illex illecebrosus*	--	--	--	--	--	--	•	•	--	--	--	--	Pre-recruits: EFH is pelagic habitats along the outer continental shelf and slope as far south as South Carolina, on Georges Bank, and on the inner continental shelf off New Jersey and southern Maine and New Hampshire. EFH for pre-recruit Northern shortfin squid is generally found over bottom depths between 41 and 400 meters where bottom temperatures are 9.5-

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Eggs			Larvae			Juvenile			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													16.5°C and salinities are 34.5-36.5 ppt. They also inhabit pelagic habitats in the Gulf Stream where water temperatures are above 16°C and migrate onto the shelf as they grow. Pre-recruits make daily vertical migrations, moving up in the water column at night and down in the daytime. They feed primarily on euphausiids at night near the surface. Recruits: EFH is pelagic habitats on the continental shelf and slope from Georges Bank to South Carolina, and in inshore and offshore waters of the Gulf of Maine. EFH for recruit Northern shortfin squid is generally found on the shelf over bottom depths between 41 and 400 meters where bottom temperatures are 4.5-14.5°C and salinities are 34.5-36.5 ppt. They have also been caught in bottom trawls as deep as 2,500 m in waters beyond the edge of the shelf and on Bear Seamount. Recruits make daily vertical migrations, moving up in the water column at night and down in the daytime. They feed primarily on fish and euphausiids and are also cannibalistic (larger females consume smaller males).

Notes:
• = present
-- = not present
EEZ = exclusive economic zone
EFH = essential fish habitat
OCS = outer continental shelf
ppt = parts per thousand
SAV = submerge aquatic vegetation

Table 4-2. EFH-Designated Elasmobranchs within the Project Area

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Neonate/YOY			Juvenile			Subadult			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Skates													
Clearnose skate *Raja eglanteria*	--	--	--	•	•	•	--	--	--	•	•	•	Juveniles: Sub-tidal benthic habitats in coastal and inner continental shelf waters from New Jersey to the St. Johns River in Florida, including the high salinity zones of Chesapeake Bay, Delaware Bay, and certain other bays and estuaries. Essential fish habitat for juvenile clearnose skates occurs from the shoreline to 30 meters, primarily on mud and sand, but also on gravelly and rocky bottom. Adults: Sub-tidal benthic habitats in coastal and inner continental shelf waters from New Jersey to Cape Hatteras as shown on Map 96, including the high salinity zones of Chesapeake Bay, Delaware Bay, and the other bays and estuaries listed in Table 28. Essential fish habitat for adult clearnose skates occurs from the shoreline to 40 meters, primarily on mud and sand, but also on gravelly and rocky bottom.
Little skate *Leucoraja erinacea*	--	--	--	•	•	•	--	--	--	•	•	•	Juveniles**:** Intertidal and sub-tidal benthic habitats in coastal waters of the Gulf of Maine and in the Mid-Atlantic region as far south as Delaware Bay, and on Georges Bank, extending to a maximum depth of 80 meters, and including high salinity zones in certain bays and estuaries. Essential fish habitat for juvenile little skates occurs on sand and gravel substrates, but they are also found on mud. Adults: Intertidal and sub-tidal benthic habitats in coastal waters of the Gulf of Maine and in the Mid-Atlantic region as far south as Delaware Bay, and on Georges Bank, extending to a maximum depth of 100 meters, and including high salinity zones in certain bays and estuaries. Essential fish habitat for adult little skates occurs on sand and gravel substrates, but they are also found on mud.
Winter skate *Leucoraja ocellata*	--	--	--	•	•	•	--	--	--	•	•	•	Juveniles and Adults: Benthic habitats with mud and sand substrates on the outer continental shelf in depths of 80 – 400 meters from approximately 40˚N latitude to Cape Hatteras, North Carolina.
Sharks													
Blue shark *Prionace glauca*	--	--	--	•	•	--	--	--	--	•	•	--	Juveniles and Adults: EFH is localized areas in the Atlantic Ocean in the Gulf of Maine, from Georges Bank to North Carolina, South Carolina, Georgia, and off Florida.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Neonate/YOY			Juvenile			Subadult			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Common thresher *Alopias vulpinus*	•	•	•	•	•	•	•	•	•	•	•	•	Neonates, Juveniles, and Adults: Insufficient data are available to differentiate EFH between the juvenile and adult size classes; therefore, EFH is the same for those life stages. EFH is in the Atlantic Ocean, from Georges Bank (at the offshore extent of the U.S. EEZ boundary) to Cape Lookout, North Carolina, and from Maine to locations offshore of Cape Ann, Massachusetts. EFH occurs with certain habitat associations in nearshore waters of North Carolina, especially in areas with temperatures of 18.2-20.9°C and at depths of 4.6-13.7 meters.
Dusky shark *Carcharhinus obscurus*	•	•	•	•	•	•	--	--	--	•	•	•	Neonate/YOY: EFH in the Atlantic Ocean includes offshore areas of southern New England to Cape Lookout, North Carolina. Specifically, EFH is associated with habitat conditions including temperatures from 18.1 to 22.2 °C, salinities of 25 to 35 ppt and depths at 4.3 to 15.5 m. Seaward extent of EFH for this life stage in the Atlantic is 60 m in depth. Juveniles and adults: Coastal and pelagic waters inshore of the continental shelf break (< 200 meters in depth) along the Atlantic east coast from habitats offshore of southern Cape Cod to Georgia, including the Charleston Bump and adjacent pelagic habitats. Inshore extent for these life stages is the 20-meter bathymetric line, except in habitats of southern New England, where EFH is extended seaward of Martha's Vineyard, Block Island, and Long Island. Pelagic habitats of southern Georges Bank and the adjacent continental shelf break from Nantucket Shoals and the Great South Channel to the eastern boundary of the United States EEZ. Adults are generally found deeper (to 2000 meters) than juveniles, however there is overlap in the habitats utilized by both life stages. Offshore waters of the western and north Gulf of Mexico, at and seaward of the continental shelf break (a buffer is included ~10 nautical miles north of the 200-meter bathymetric line), and in proximity to numerous banks along the continental shelf edge (e.g., Ewing and Sackett Bank). The continental shelf edge habitat from Desoto Canyon west to the Mexican border is important habitat for adult dusky sharks.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Neonate/YOY			Juvenile			Subadult			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Sand tiger shark *Carcharias taurus*	•	•	•	•	•	•	--	--	--	--	--	--	Neonates and juveniles: Neonate EFH ranges from Massachusetts to Florida, specifically the PKD bay system, Sandy Hook, and Narragansett Bays as well as coastal sounds, lower Chesapeake Bay, Delaware Bay (and adjacent coastal areas), Raleigh Bay and habitats surrounding Cape Hatteras. Juveniles EFH includes habitats between Massachusetts and New York (notably the PKD bay system), and between mid-New Jersey and the mid-east coast of Florida. EFH can be described via known habitat associations in the lower Chesapeake Bay and Delaware Bay (and adjacent coastal areas) where temperatures range from 19 to 25 °C, salinities range from 23 to 30 ppt at depths of 2.8-7.0 m in sand and mud areas, and in coastal North Carolina habitats with temperatures from 19 to 27 °C, salinities from 30 to 31 ppt, depths of 8.2-13.7 m, in rocky and mud substrate or in areas surrounding Cape Lookout that contain benthic structure.
Sandbar shark *Carcharhinus plumbeus*	•	•	•	•	•	•	--	--	--	•	•	•	Neonate/YOY: Atlantic coastal areas from Long Island, New York to Cape Lookout, North Carolina, and from Charleston, South Carolina to Amelia Island, Florida. Important neonate/YOY EFH includes: Delaware Bay (Delaware and New Jersey) and Chesapeake Bay (Virginia and Maryland), where the nursery habitat is limited to the southeastern portion of the estuaries (salinity is greater than 20.5 ppt and depth is greater than 5.5 m); Great Bay, New Jersey; and the waters off Cape Hatteras, North Carolina. In all nursery areas between New York and North Carolina, unless otherwise noted, EFH is associated with water temperatures that range from 15 to 30 °C; salinities that vary from 15 to 35 ppt; water depths that range from 0.8 to 23 m; and sand, mud, shell, and rocky sediments/benthic habitat. EFH in the Gulf of Mexico includes localized coastal areas on the Florida panhandle (Indian Pass and St. Andrew Sound, Florida) in water temperatures from 20 to 31°C at salinities from 19 to 39 ppt and depths of 2.1 to 5.2 m in silt/clay habitats. Juvenile**s:** EFH includes coastal portions of the Atlantic Ocean between southern New England (Nantucket Sound, Massachusetts) and Georgia in water temperatures ranging from 20 to 24 °C and depths from 2.4 to 6.4 m. Important nurseries include Delaware Bay, Delaware and New Jersey; Chesapeake Bay, Virginia; Great Bay, New Jersey; and the waters off Cape Hatteras, North Carolina. For all EFH, water temperatures range from 15 to 30°C, salinities range from 15 to 35 ppt, water depth ranges from 0.8 to 23 m, and substrate includes sand, mud, shell, and rocky habitats. EFH in the Gulf of Mexico includes localized

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Neonate/YOY			Juvenile			Subadult			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													areas off Apalachicola Bay, Florida. Adults: EFH in the Atlantic Ocean includes coastal areas from southern New England to the Florida Keys, ranging from inland waters of Delaware Bay and the mouth of Chesapeake Bay to the continental shelf break. EFH in the Gulf of Mexico includes coastal areas between the Florida Keys and Anclote Key, Florida; areas offshore of the Big Bend region; coastal areas of the Florida panhandle and Gulf coast between Apalachicola and the Mississippi River; and habitats surrounding the continental shelf between Louisiana and south Texas. Adults commonly use habitats in the West Florida Shelf, off Cape San Blas, and cool, deep, clear water offshore of Texas and Louisiana.
Shortfin mako shark *Isurus oxyrinchus*	•	•	--	•	•	--	•	•	--	•	•	--	Neonates, Juveniles, and Adults: At this time, available information is insufficient for the identification of EFH by life stage, therefore all life stages are combined in the EFH designation. EFH in the Atlantic Ocean includes pelagic habitats seaward of the continental shelf break between the seaward extent of the U.S. EEZ boundary on Georges Bank (off Massachusetts) to Cape Cod (seaward of the 200m bathymetric line); coastal and offshore habitats between Cape Cod and Cape Lookout, North Carolina; and localized habitats off South Carolina and Georgia. EFH in the Gulf of Mexico is seaward of the 200 m isobaths in the Gulf of Mexico, although in some areas (e.g., northern Gulf of Mexico by the Mississippi delta) EFH extends closer to shore. EFH in the Gulf of Mexico is located along the edge of the continental shelf off Fort Meyers to Key West (southern West Florida Shelf), and also extends from the northern central Gulf of Mexico around Desoto Canyon and the Mississippi Delta to pelagic habitats of the western Gulf of Mexico that are roughly in line with the Texas/Louisiana border.

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Neonate/YOY			Juvenile			Subadult			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
Tiger shark *Galeocerdo cuvieri*	--	--	--	•	•	•	--	--	--	•	•	•	Juveniles and adults: EFH in the Atlantic Ocean extends from offshore pelagic habitats associated with the continental shelf break at the seaward extent of the U.S. EEZ boundary (south of Georges Bank, off Massachusetts) to the Florida Keys, inclusive of offshore portions of the Blake Plateau. EFH in the Gulf of Mexico includes pelagic and coastal habitats between Tampa Bay, Florida Bay and Florida Keys, and the edge of the West Florida Shelf; and an area extending from off eastern Louisiana, Mississippi, and Alabama to offshore pelagic habitats in the central Gulf of Mexico. Grass flats in the Gulf of Mexico are considered feeding areas, and are included as EFH. EFH also includes coastal and pelagic habitats surrounding Puerto Rico (except on the northwest side of the island) and the U.S. Virgin Islands.
White shark *Carcharodon carcharias*	•	•	•	--	•	--	--	--	--	--	•	--	Neonate/YOY: EFH includes inshore waters out to 105 km from Cape Cod, Massachusetts, to an area offshore of Ocean City, New Jersey. Juveniles and adults: Known EFH includes inshore waters to habitats 105 km from shore, in water temperatures ranging from 9 to 28 °C, but more commonly found in water temperatures from 14 to 23 °C from Cape Ann, Massachusetts, including parts of the Gulf of Maine, to Long Island, New York, and from Jacksonville to Cape Canaveral, Florida.
Spiny dogfish *Squalus acanthias*	--	--	--	--	--	--	f	m/f	f	m/f	m/f	m/f	Female Sub-Adults: Pelagic and epibenthic habitats throughout the region. Sub-adult females are found over a wide depth range in full salinity seawater (32-35 ppt) where bottom temperatures range from 7 to 15°C. Sub-adult females are widely distributed throughout the region in the winter and spring when water temperatures are lower, but very few remain in the Mid-Atlantic area in the summer and fall after water temperatures rise above 15°C. Male Sub-Adults: Pelagic and epibenthic habitats, primarily in the Gulf of Maine and on the outer continental shelf from Georges Bank to Cape Hatteras. Sub-adult males are found over a wide depth range in full salinity seawater (32-35 ppt) where bottom temperatures range from 7 to 15°C. Sub-adult males are not as widely distributed over the continental shelf as the females and are generally found in deeper water. They are widely distributed throughout the region in the winter and spring when water temperatures are lower, but very few remain in the Mid-Atlantic area in the summer and fall after water temperatures rise above 15°C. Female Adults: Pelagic and epibenthic habitats throughout the region. Adult females are found over a wide depth range in full salinity seawater (32-35 ppt) where bottom temperatures range from 7 to 15°C. They are

EFH Species	Designated EFH for Species and Life Stages by Project Component												EFH Description
	Neonate/YOY			Juvenile			Subadult			Adult			
	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	WTA	Mon. ECC	Atl. ECC	
													widely distributed throughout the region in the winter and spring when water temperatures are lower, but very few remain in the Mid-Atlantic area in the summer and fall after water temperatures rise above 15°C. Male Adults: Pelagic and epibenthic habitats throughout the region. Adult males are found over a wide depth range in full salinity seawater (32-35 ppt) where bottom temperatures range from 7 to 15°C. They are widely distributed throughout the region in the winter and spring when water temperatures are lower, but very few remain in the Mid-Atlantic area in the summer and fall after water temperatures rise above 15°C.

Notes:
• = present
-- = not present
EEZ = exclusive economic zone
EFH = essential fish habitat
f = female
m = male
OCS = outer continental shelf
ppt = parts per thousand
YOY = young-of-year

4.1.1 Vulnerable Species, Life Stages, and Habitat

Many mobile species are less susceptible to potential project impacts because they can leave or avoid areas of impacts. However, certain EFH species are more susceptible because they are immobile or have limited mobility. Certain habitats are also considered sensitive habitat. The following list summarizes vulnerable species and habitat:

- Winter flounder eggs and larvae, which are demersal and occur in Mid-Atlantic estuaries in late winter through spring
- Sessile or slow-moving benthic/epibenthic invertebrates (bivalve juveniles and adults, squid eggs)
- Skate egg cases
- Ocean pout eggs and larvae
- Tidal saltmarshes, especially those dominated by *Spartina alterniflora* and/or *Spartina patens*.
- SAV, especially beds dominated by *Zostera marina*

4.1.2 Habitat Areas of Particular Concern

Sandbar shark Habitat Areas of Particular Concern (HAPC) extends along the New Jersey coastline from Great Bay to Atlantic City and includes portions of the Atlantic ECC and each of the Atlantic Landfall Sites (Figure 4-1). Further, sandbar shark HAPC occurs in Chelsea Harbor, Beach Thorofare and Great Thorofare, three inland waterways that would be traversed by the Cardiff Onshore Interconnection Cable Route (see Figure 3 8). Sandbar shark HAPC at the mouth of Great Bay constitutes important nursery and pupping grounds. Pregnant female sandbar sharks have the potential to occur in the area between late spring and early summer, when they reportedly give birth and depart shortly after (Merson and Pratt 2007). Sandbar shark neonates and juveniles occupy the nursery grounds to feed in early summer until they migrate to warmer waters in the fall (Rechisky and Wetherbee 2003). The majority of neonate and juvenile sandbar sharks within the Great Bay HAPC have been documented in mid-summer in shallow, near shore-areas including inside Great Bay and in the vicinity of Little Egg Inlet, and not within the Atlantic ECC (Rechisky and Wetherbee 2003; Merson and Pratt 2007). To minimize impacts to sandbar shark habitat, Atlantic Shores would conduct nearshore cable installation activities outside of the anticipated peak period of sandbar shark nursery and pupping activity between June 1st and September 1st (Table 6-1). Additionally, Atlantic Shores would use HDD to route the interconnection cables underneath inland waterways, thereby avoiding cable emplacement impacts on sandbar shark habitat. Impacts of Project activities associated with the installation of the of the Atlantic Export Cable near sandbar shark HAPC are analyzed in Section 5.

Summer flounder HAPC occurs in Chelsea Harbor, Beach Thorofare and Great Thorofare, three inland waterways that would be traversed by the Cardiff Onshore Interconnection Cable Route (see Figure 3-18). Summer flounder HAPC is defined as all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations, within adult and juvenile summer flounder EFH. Juvenile and adult summer flounder commonly inhabit seagrass beds within coastal bays and estuaries. In general, older juveniles and adults inhabit shallow, inshore and estuarine waters during the summer and fall and then move offshore to deeper waters in the winter and spring, although some juveniles will remain in the bays and estuaries for the winter (Packer et al. 1999a). Atlantic Shores would use HDD to route the interconnection cables underneath inland waterways, thereby avoiding impacts on summer flounder habitat. Impacts of Project activities associated with the installation of the Cardiff Onshore Interconnection Cable Route near summer flounder HAPC are analyzed in Section 5.

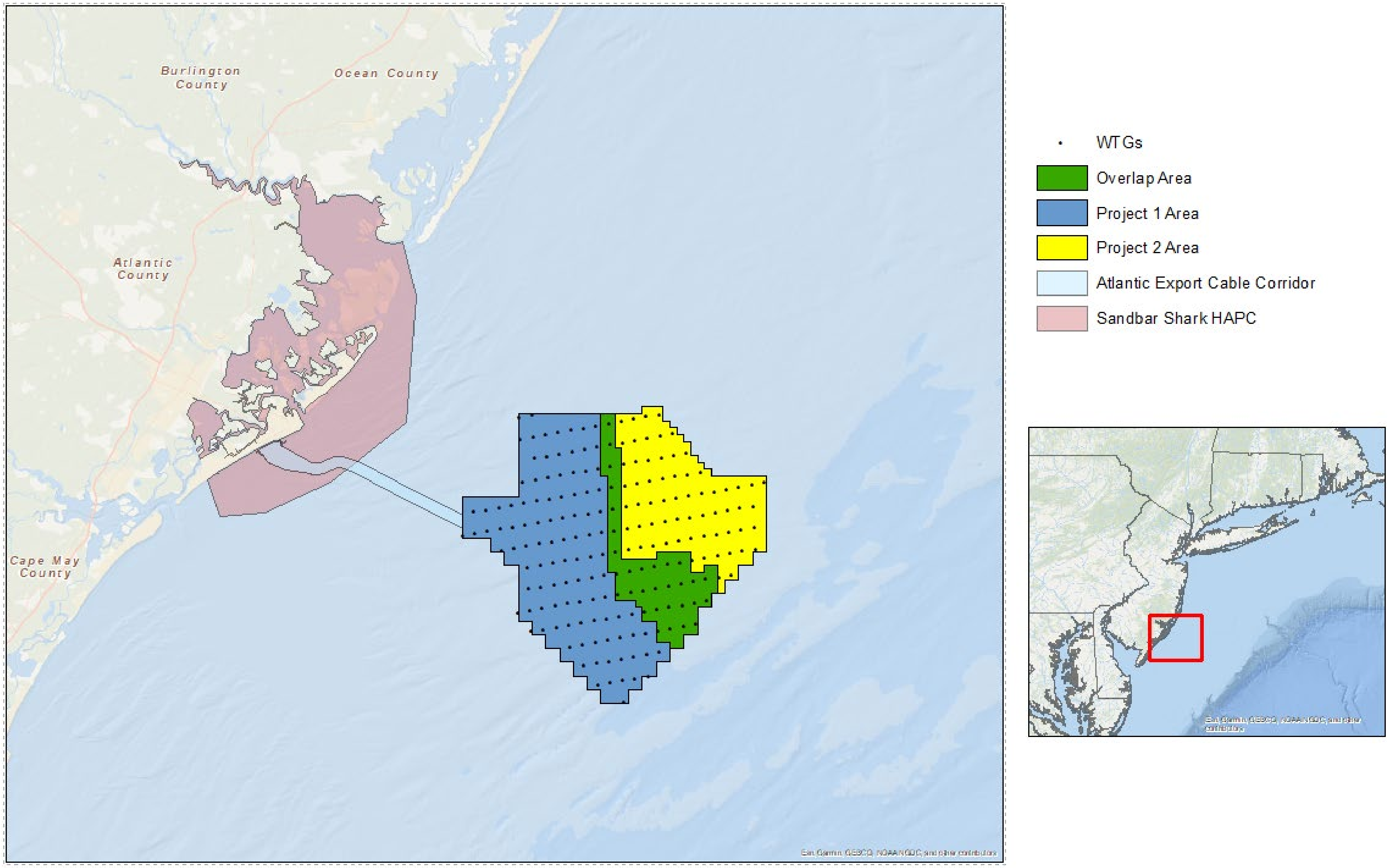


Figure 4-1. Sandbar Shark HAPC Near the Landfall for the Atlantic Export Cable

5. Adverse Effects

This section provides an analysis of the effects of the Proposed Action on designated EFH for managed species and life stages in the Project area defined in Section 2.1. As stated, the Project area is composed of the maximum impact footprints resulting from the WTGs, OSSs, and ECCs. These footprints are defined by the geographic extent of measurable short-term, long-term, and permanent effects from project construction and operation. Potential effects on EFH are evaluated in this section by 1) determining if designated EFH occurs in one or more project footprints, and 2) determining if impact mechanisms are likely to impair the suitability of the affected habitat for the species and life stage 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 ecosystem components. Adverse effects may be short-term (less than 2 years), long-term (2 years to < life of Project), or permanent (life of 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.

5.1 Construction & Operation Activities

Project construction and operation activities would generate short-term, long-term, and permanent direct and indirect effects on EFH through vessel activity, pile driving, seabed preparation, installation of foundations and scour protection, presence of structures, and WTG and transmission cable operations. Effects would include introduction of invasive species, noise, crushing and burial, entrainment, elevated suspended sediments and sediment deposition, habitat loss and conversion, EMF and heat, and hydrodynamic changes. These effects would occur intermittently and at varying locations in the Project area over the construction period. Therefore, the suitability of EFH for managed species may be reduced depending on the nature, duration, and magnitude of each effect. Impacts of Project activities on EFH and EFH species are discussed below.

5.1.1 Installation of WTG/OSS Structures and Foundations

5.1.1.1 Vessel Activity

During installation of the 200 WTGs,4 to 10 OSSs, 1 MET tower, and associated foundations, it is anticipated that up to 15 vessels would be required to install the foundations, up to 11 vessels would be required to install the WTGs, up to 14 vessels would be required to install the OSSs, and 2 vessels would be required to install the scour protection (Atlantic Shores 2023, Volume I). Vessel activity would occur intermittently during the construction period beginning with the start of the Project 1 and Project 2 foundation installation in the first quarter of 2026 and continuing through the completion of the Project 2 WTG installation in the first quarter of 2027 (see Table 2-2, above).

Habitat Disturbance

Certain construction vessels such as jack-up vessels or hotel vessels would require the use of stabilization spuds and anchors during WTG and OSS installation, which would disturb benthic EFH and EFH species that rely on that habitat. These activities would take place within the 102,124-acre WTA. Vessels that use anchors (rather than spud cans) to hold position generally have a greater potential to disturb the seabed and result in crushing or burial impacts and habitat loss or conversion; however, seabed depressions known as "footprints" can remain after the removal of spud cans. The form and duration of these footprints are a factor of the shape of the spud can; type, strength and stratification of sediments; degree of sediment infill during spud can removal; the local hydrodynamic regime; the method of spud can removal; and the penetration depth of the footing (Dier et al. 2004; Hossain and Stainforth 2016). Aside from monopile installation activities, vessels within the Lease Area would primarily use dynamic positioning systems to hold position and would not result in such impacts. In instances when anchoring is required, an anchor midline buoy would be used, where feasible, to minimize seabed disturbance (Table 6-1). Atlantic Shores has estimated that a total of 629 acres of habitat would be disturbed by anchoring of vessels during construction of the Proposed Action, including the installation of the WTGs and OSSs (Atlantic Shores 2023, Volume I), though the breakdown by specific habitat type for that number is not known. To minimize anchoring impacts and reduce impacts to EFH and EFH species, Atlantic Shores would establish a seasonal work window that avoids installation and construction activities during periods when sensitive species and life stages would be present in the Project area, as feasible (Section 6.1.1).Anchor placement and retrieval, anchor chain sweep, and spud placement could cause habitat loss 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. EFH in soft bottom habitats would likely recover in the short-term, but impacts to complex, hard-bottom habitats (e.g., cobble and boulders) could include disturbance of epifaunal communities, which could take much longer to recover. Atlantic Shores will develop an anchoring plan to avoid impacts to sensitive habitats to the maximum extent practicable, including hard bottom and structurally complex habitats, identified through the interpretation of site-specific HRG and benthic assessments (Table 6-1).

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. Benthic/epibenthic communities in soft bottom habitat would be recoverable in the short-term, while benthic/epibenthic communities in complex habitat would be recoverable in the short-term to long-term. Anchor placement and retrieval, anchor chain sweep, and spud placement could cause mobile benthic and pelagic EFH species, as well as benthic and pelagic prey species, to avoid the area of impact, resulting in direct, short-term, localized impacts on these species. Sessile or slow-moving prey species could be crushed or buried as a result of anchoring activities, resulting in indirect short-term effects on pelagic and mobile benthic EFH species and/or life stages that feed on those species.

Direct Effects on EFH and EFH Species

- Short-term loss/conversion of EFH:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic
- Long-term loss/conversion of EFH:
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Prey Species – Benthic/Epibenthic
- Permanent, localized crushing and burial of EFH species:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Prey Species – Benthic/Epibenthic

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

Indirect Effects on EFH and EFH Species

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

Sediment *Suspension/Redeposition*

Some Project vessel activities, such as those associated with anchoring (e.g., anchor placement and retrieval, chain sweep, and/or spud placement), would result in sediment suspension, a concomitant increase in turbidity in the water column, and sedimentation. 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 resulting from a decrease in habitat quality for benthic species and life stages, with small sessile or slow-moving benthic EFH species and life stages experiencing greater impacts from deposition than larger, mobile species or life stages.

Egg and larval life stages are sensitive to suspended sediment and can experience sublethal or lethal effects from as little as 0.4 inch (10 mm) of sediment deposition (Kjelland et al. 2015; Michel et al. 2013; Wilber and Clarke 2001). Subadult life stages of certain species (e.g., winter flounder) are particularly sensitive to sediment deposition and can experience mortality at burial depths less than 0.1 inch (3 mm) (Michel et al. 2013). Adult and juvenile fishes exposed to elevated suspended sediment levels may temporarily cease feeding, abandon cover, and/or experience short-term physiological stress. However, short-term exposure to elevated suspended sediment levels like those anticipated from anchoring are not expected to have adverse effects on filter-feeding bivalves (Wilber and Clarke 2001; Yang et al. 2017). Anchoring is expected to generate lethal sediment deposition levels and elevated suspended sediment levels only in immediate proximity to the anchoring footprint and only for a short duration.

Direct Effects on EFH and EFH Species

- Short-term decrease in quality of EFH resulting from suspended sediments and increased turbidity:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Pelagic
- Short-term, local impacts resulting from sedimentation:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic

Indirect Effects on EFH and EFH Species

- Short-term loss of foraging opportunities:
  - Mobile Epibenthic/Benthic – Soft Bottom

    - Pelagic
- Short-term decrease in quality of EFH in areas adjacent to Project activities:
    - Sessile Benthic/Epibenthic – Soft Bottom
    - Mobile Benthic/Epibenthic – Soft Bottom
    - Prey Species – Benthic

Vessel Noise

Vessel noise may have several effects on fish and invertebrates, including interfering with feeding and breeding, altering schooling behaviors and migration patterns (Buerkle 1973; Schwarz and Greer 1984; Soria et al. 1996; Vabø et al. 2002; Mitson and Knudsen 2003; Ona et al. 2007), masking important environmental auditory cues (Codarin et al. 2009; Radford et al. 2014), and inducing endocrine stress response (Wysocki et al. 2006). Fish communication is mainly in the low-frequency (<1000 hertz [Hz]) range (Ladich and Myrberg 2006; Myrberg and Lugli 2006), so masking is a particular concern because many fish species have unique vocalizations that allow for inter- and intra-species identification and because fish vocalizations are generally not loud, usually ~120 decibels (dB) SPL with the loudest sounds reaching 160 dB SPL (Normandeau 2012). 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 generated by vessels has been observed to cause avoidance behavior in hearing specialist fish species (e.g., Atlantic herring, Atlantic cod) and is likely to cause similar behavior in other hearing specialist species (Vabø et al. 2002; Handegard et al. 2003). For example, analysis of vessel noise related to the Cape Wind Energy Project observed that underwater noise generated by construction vessels at 10 feet (3 meters) was loud enough to cause an avoidance response in fish, but not loud enough to do physical harm (MMS 2008). 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). Pelagic species and life stages and prey species that inhabit the upper water column (e.g., Atlantic butterfish, Atlantic herring, Atlantic mackerel, bluefish, and some highly migratory pelagic species) are the most likely to be impacted by vessel noise, although the behavioral avoidance impacts would be short-term. However, benthic species and life stages inhabiting inshore, shallow waters could also be impacted. Demersal and benthic invertebrates are generally less sensitive to underwater noise compared to fish and are not expected to be impacted by vessel-related noise. Project-related vessel noise would be intermittent and of short duration, so the overall impacts to fish are expected to be short-term. Vessel and pile driving noise effects on specific hearing categories for EFH-designated species are combined and detailed further in Section 5.1.1.2.

Direct Effects on EFH and EFH species

- Short-term, local avoidance responses to vessel noise:
    - Sessile Benthic/Epibenthic – Soft Bottom
    - Mobile Benthic/Epibenthic – Soft Bottom
    - Sessile Benthic/Epibenthic – Complex
    - Mobile Benthic/Epibenthic – Complex
    - Pelagic
    - Prey Species – Benthic/Epibenthic

- Prey Species – Pelagic

Potential Introduction of Exotic/Invasive Species

Non-native (i.e., exotic) species can be accidentally released in the discharge of ballast water and bilge water during vessel activities. Although not all non-native species may survive introduction into a new ecosystem or cause adverse ecological effects, increasing vessel traffic throughout the construction duration of the project would increase the risk of accidental releases of species that may become invasive. Vessels are required to adhere to existing state and federal regulations related to ballast and bilge water discharge, including U.S. Coast Guard ballast discharge regulations (33 CFR 151.2025) and U.S. Environmental Protection Agency National Pollutant Discharge Elimination System Vessel General Permit standards, both of which aim at least in part to prevent the release and movement of invasive species (Table 6-1). Adherence to these regulations would reduce the likelihood of discharge of ballast or bilge water contaminated with invasive species. Although the likelihood of invasive species becoming established due to project-related activities is low, the impacts of invasive species could be strongly adverse, widespread, and permanent if the species were to become established and out-compete native fauna. Indirect impacts could result from competition with invasive species for food or habitat, and/or loss of foraging opportunities if preferred prey is no longer available due to competition with invasive species.

Direct Effects on EFH and EFH Species

- Extremely low likelihood, but potentially long-term and wide-spread impacts to any or all EFH and EFH species:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic

Indirect Effects on EFH and EFH Species

- Extremely low likelihood of competition with invasive species, loss of foraging opportunities:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic

5.1.1.2 Pile Driving

Impact pile driving would be required during the installation of foundations for 200 WTGs, 4 to 10 OSSs, and 1 MET tower foundations. The installation of one monopile would require approximately 7 to 9 hours of pile driving and up to two monopiles could be installed per vessel spread per day, assuming no time-of-day restrictions. The installation of one WTG, MET tower, or small OSS jacket foundation would require approximately one day (three or four pin piles driven per day), assuming 4 hours of pile driving per pile. As summarized in Table 2-2, above, installation of the Project 1 and Project 2 WTG foundations would occur over a period of 10 months beginning in the first quarter of 2026. Installation of the Project 1 and Project 2 OSSs would occur over a period of 5 to 7 months beginning in the second quarter of 2026.

Underwater Sound

Pile driving would generate noise exceeding established thresholds for mortality, permanent or temporary injury, and behavioral effects in fish and invertebrates. Underwater noise would temporarily render the affected habitats unsuitable for EFH species and could temporarily impact prey availability for EFH species. The extent of these stressors would be limited to ensonified areas within the Lease Area and would depend on the noise sensitivity of EFH species, as described below. The assessment of acoustic impacts provided in the following section emphasizes direct acoustic effects on EFH-designated species and their life stages.

Underwater sounds are composed of both pressure and particle motion components and are perceived by fish in different ways. An underwater sound originates from a vibrating source, which causes the particles of the surrounding medium (water) to oscillate, which causes adjacent particles to move and transmit the sound wave. Sound pressure is the variation in hydrostatic pressure caused by the compression and rarefaction of the particles caused by the sound and is measured in terms of decibels (dB) relative to 1 microPascal (µPa). Vibration is a product of particle motion through media including water and sediment substrates (Roberts and Elliott 2017). Vibration is the sum of particle motion waves at a single location (Athanasopoulos and Pelekis 2000).

All fish perceive the particle motion component of sound and have sensory structures in the inner ear that function to detect particle motion (Popper and Hawkins 2018; Nedelec et al. 2016). Particle motion is an important part of a fish's ability to orient itself in its environment and perceive biologically relevant sounds of prey, predators, and other environmental cues (Popper and Hawkins 2018). The sensitivity of receptor systems that perceive particle motion in fish appears to be 10^5 times higher than in crustaceans (Fay and Simmons 1998, as cited in Roberts and Elliot 2017). Limited studies have been conducted on particle motion detection in fish. One of the few studies observed that the European plaice (*Pleuroectes platessa*) is sensitive to water particle velocities of as little as 0.3 µm/s at around 20 Hz (Chapman and Sand 1974, as cited in Hawkins et al. 2021), which is considerably less than the particle velocities of 2,500 µm/s recorded 68 meters from test piles (Hazelwood and Macey 2016, as cited in Hawkins et al. 2021).

Fish with a swim bladder or other air-containing organ can detect the pressure component of sound as the pressure wave causes the compression and vibration of the air-filled swim bladder. The extent to which the pressure component contributes to a fish's ability to hear varies from species to species and is related to the structures in the fish's auditory system, ability to process the signal from the swim bladder, the size of the swim bladder, and its location relative to the inner ear. Sound particle motion and/or vibration is detected by crustaceans and cephalopods (Roberts and Elliott 2017; Breithaupt and Tautz 1990; Packard et al. 1990). In crustaceans, vibrations are detected by hydrodynamic sensory receptors (e.g., hairs and antennae) (Breithaupt and Tautz 1990). Packard et al. (1990) demonstrated clear responses of cephalopods to the particle motion component of sound.

Impacts from sound vary based on the intensity of the noise and the method of sound detection used by the animal. Severe impacts could include physiological reactions, such as ruptured capillaries in fins, hemorrhaging of major organs, or burst swim bladders (Popper et al. 2014), which could cause mortality.

Anthropogenic noise may influence fish behavior by causing auditory masking and alteration of foraging patterns, disruption of communication, and disruption of shoaling or schooling (Herbert-Read et al. 2017; Kunch et al. 2016; Purser and Radford 2011; Radford et al. 2014; Voellmy et al. 2014). The extent of impacts from pile-driving noise depends on the pile size, hammer energy, and local acoustic conditions, as well as the time of year during which it occurs. The impact of noise could be greater if pile driving occurs in spawning habitat during a spawning period, particularly for species that spawn in aggregations, use sound to communicate (e.g., Atlantic cod), or spawn only once during their lifetime (e.g., longfin squid).

Assessment of the potential for underwater noise to injure or disturb a fish or invertebrate requires acoustic thresholds against which received sound levels can be compared. The most conservative available injury thresholds for fish were developed by the Fisheries Hydroacoustic Working Group (2008) and Popper et al. (2014) and are provided in Table 5-1. The current underwater noise thresholds consider effects on fish mainly through sound pressure without taking into consideration the effect of particle motion. Popper et al. (2014) and Popper and Hawkins (2018) suggest that extreme levels of particle motion induced by various impulsive sources may also have the potential to affect fish tissues and that proper attention needs to be paid to particle motion as a stimulus when evaluating the effects of sound on aquatic life. However, thresholds for particle motion exposure are not currently available because of the difficulty of measuring fish sensitivity to this component of sound (Popper et al. 2014; Popper and Hawkins 2018).

Table 5-1. Acoustic Thresholds for Various Effects of Pile Driving

Group	Metric¤	Threshold Level
Injury (Permanent Threshold Shift)†		
Fish Equal or greater than 2g	L_E	187
	L_{pk}	206
Fish less than 2g	L_E	183
	L_{pk}	206
Recoverable Injury*		
Fish without swim bladder	L_E	>216
	L_{pk}	>213
Fish with swim bladder	L_E	203
	L_{pk}	>207
Behavior§		
All fish	L_{rms}	150

¤ L_{pk}: zero-to-peak sound pressure level with units dB re 1 µPa; L_{rms}: root-mean-square sound pressure level with units dB re 1 µPa; $L_{E,24}$: sound exposure level calculated over a 24-hour period in units dB re 1 µPa^{2}s,
*Popper 2014
†Fisheries Hydroacoustic Working Group 2008
§Andersson et al. 2007, Wysocki et al. 2007, Mueller-Blenkle et al. 2010, Purser and Radford 2011

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 their lack of internal air spaces makes them less vulnerable 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, 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) 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. 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 (André et al. 2011). However, Roberts et al. (2015) observed that the blue mussel (*Mytulis edulis*) exhibited behavioral changes in the form of valve closure in response to vibration stimulus at 5 to 410 Hz. Thresholds for behavioral changes were within the range of vibrations measured near anthropogenic activities (e.g., pile driving, blasting). The authors concluded that disruption of valve periodicity in response to vibration is likely to impact the overall fitness of both individuals and mussel beds.

Acoustic impacts on fish and invertebrates from pile driving would vary depending on the ability of the organism to detect sound pressure and whether the air bladder and auditory system are linked, making the species more sensitive to sound impacts (Popper et al. 2014). Fish hearing categories from least sensitive to most sensitive are (1) organisms without swim bladders; (2) fish with swim bladders not involved in hearing; and (3) fish with swim bladders involved in hearing. These categories are shown in Table 2-2.

Table 5-2. Fish and Invertebrates Categorized by Hearing and Susceptibility to Sound Pressure

Category	Description	Examples	Hearing and Susceptibility to Sound
1	Fish without swim bladder or hearing associated gas chamber, invertebrates, fish eggs and larvae	Flatfish, monkfish, sharks, rays, some tunas, cephalopods	Species are less susceptible to barotrauma. Detect particle motion but not sound pressure, but some barotrauma may result from exposure to sound pressure.
2	Fish with swim bladder that does not affect hearing	Bluefish, butterfish, scup, some tunas	Species have a swim bladder, but hearing is not connected to it or other associated gas chamber. Species detect only particle motion but are susceptible to barotrauma.
3	Fish with swim bladder or gas chamber associated with hearing (hearing generalist)	Atlantic herring, black sea bass, gadids.	Hearing connected to swim bladder or other associated gas chamber. Species detect sound pressure as well as particle motion and are most susceptible to barotrauma.

Source: Popper et al. 2014

Acoustic propagation modeling of impact pile-driving activities for the Proposed Action was conducted to determine distances to the established injury and disturbance thresholds for fish (Atlantic Shores 2023, Appendix II-L). Sound fields from a jacket foundation with 5-meter piles driven by an impact hammer with a maximum energy of 2,500 kJ and 12-meter and 15-meter monopiles driven by an impact hammer with a maximum hammer energy of 4,400 kJ were modeled at a shallow location and a deep location in the Lease Area. The modeling assumed that no noise attenuation was used during pile driving. The resulting values represent a radius extending around each pile where potential injurious-level or behavioral effects could occur and are presented in Table 5-3.

Table 5-3. Acoustic Radial Distances ($R_{95\%}$ in km) to Thresholds for Fish During Impact Pile Driving of 5-Meter Jacket Foundations (2,500 kJ Hammer Energy) and 12-Meter and 15-Meter Monopiles (4,400 kJ Hammer Energy) with 0-dB Attenuation

Group	Metric	Threshold Level	Acoustic Radial Distance ($R_{95\%}$ in km) for 5-meter jacket foundation	Acoustic Radial Distance ($R_{95\%}$ in km) for 12-meter monopile	Acoustic Radial Distance ($R_{95\%}$ in km) for 15-meter monopile
Injury (Permanent Threshold Shift)					
Fish Equal or greater than 2g	L_E	187	9.94	8.90	9.46
	L_{pk}	206	0.14	0.44	0.43
Fish less than 2g	L_E	183	11.94	10.51	11.05
	L_{pk}	206	0.14	0.44	0.43
Recoverable Injury					
Fish without swim bladder	L_E	>216	0.88	1.19	1.45
	L_{pk}	>213	0.06	0.20	0.21
Fish with swim bladder	L_E	203	3.82	3.95	4.34
	L_{pk}	>207	0.12	0.41	0.41
Behavior					
All fish	L_{rms}	150	7.98	10.99	11.16

dB re 1 μPa SPLpeak = decibel re 1 micropascal peak sound pressure level; dB re 1 μPa SPLRMS = decibels re 1 micropascal root-mean-square sound pressure level; dB re 1 μPa2s SELcum = decibel re 1 micropascal squared second cumulative sound exposure level; km = kilometers; $R_{95\%}$ = the maximum range at which the sound level was encountered after the 5% farthest such points were excluded

The likelihood of injury from monopile installation depends on proximity to the noise source, intensity of the source, effectiveness of noise-attenuation measures, and duration of noise exposure. Results from the modeling show that the acoustic radial distance for injury from a single strike would range from 0.14 kilometers for a jacket foundation with 5-meter piles to 0.44 kilometers for a 12-meter monopile. The acoustic radial distance for injury from prolonged cumulative exposure (over 24 hours) would range from 10.51 kilometers for a 12-meter monopile to 11.94 kilometers for a jacket foundation with 5-meter piles. The acoustic radial distance for behavioral effects would range from 7.98 kilometers for a jacket foundation with 5-meter piles to 11.16 for a 15-meter monopile. Within this distance, it is likely that some level of behavioral reaction is expected and could include startle responses or migration out of areas exposed to underwater noise (Hastings and Popper 2005). Behavioral disturbance to fish from pile driving noise is therefore considered temporary for the duration of the activity. The ensonified areas over which injurious effects and behavioral effects would occur would overlap between adjacent WTG foundations, but only one foundation would be installed at a given time.

As described in Section 3.4, above, the radial distance for injurious and behavioral effects from pile driving noise would extend to several artificial reefs that are adjacent to the Project area, including the Atlantic City and Great Egg reefs and a portion of the Little Egg reef. Exposure to noise during pile driving may cause injury to fish and invertebrates inhabiting the reefs or may cause reef-dwelling fish and invertebrates to migrate away from the reefs, potentially to less suitable habitat. To mitigate impacts to the extent practicable, the Project would use a noise abatement system consisting of one or more available technologies (e.g., bubble curtains evacuated sleeve systems, encapsulated bubble systems, Helmholtz resonators), and the Project would employ soft starts during impact piling, allowing a gradual increase of hammer blow energy, thus allowing mobile marine life to leave the area (Table 6-1).

Impact pile driving would produce acoustic impacts that would adversely affect EFH for fish and invertebrates across all hearing categories, but the extent of the impacts would vary depending on hearing sensitivity (see Table 5-2) and distance from the pile. EFH species could exhibit physiological and behavioral impacts depending on intensity and duration of the acoustic impact, distance from the sound source, and hearing sensitivity. The noise levels would temporarily make the habitat less suitable and cause individuals to vacate the area of Project activities. Pile driving is anticipated to cause adverse impacts to EFH for both pelagic and demersal life stages; however, this impact would be short-term and EFH is expected to return to pre-pile driving conditions.

Direct Effects on EFH and EFH Species

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

Habitat Conversion

Depending on the types of foundations selected, the installation of foundations for up to 200 WTGs, 4 to 10 OSSs, and 1 MET tower would render approximately 6.6 to 16.4 acres of benthic habitat within the foundation footprint unavailable to EFH species for the entire 30-year life of the project through decommissioning when the foundations are removed; this habitat would include 4.9 to 10.9 acres of soft-bottom habitat, 0.7 to 3.3 acres of heterogeneous complex habitat, and 0.9 to 2.8 acres of complex habitat. The installation of these structures in the Lease Area, where the water depth ranges from 62 to 121 feet (19 to 37 meters) (see Figure 3-5, above), would introduce up to 60 acres of new hard surfaces to the water column extending from the seabed to the water surface. These vertical structures would alter the character of pelagic habitats used by many EFH species and their prey and foraging resources. Over time these new hard surfaces would become colonized by sessile organisms, creating complex habitats that effectively serve as artificial reef.

In addition to the foundation, up to two temporary meteorological and oceanographic (metocean) buoys may be installed and kept in place during construction to monitor weather and sea state conditions. The metocean buoys are expected to be anchored to the seafloor using a steel chain connected to a steel chain weight on the seafloor. The maximum area of seafloor disturbance from each buoy's anchor (including anchor sweep) is anticipated to be approximately 0.005 mi^2 (0.013 km^2), with a maximum depth of disturbance of 3.3 ft (1.0 m).

The artificial 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; Reubens 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 that, overall, abundance of demersal finfish was greater inside of wind farms compared to nearby reference sites; however, an increase in abundance was only observed for a relatively small number of studies. Studies of finfish distributions before and after installation of OWFs demonstrate that some demersal finfish species, including Atlantic cod and black sea bass, spend at least part of their life cycle closely associated with offshore wind structures (Bergström et al. 2013; Reubens et al. 2014; Wilber et al. 2020). Several offshore wind facilities have been observed to attract demersal fish species that are associated with hard substrate and are therefore rare on the surrounding sandy seabed (Van Hal et al. 2017). Effects on pelagic fish species are less clear, however (Floeter et al. 2017; Methratta and Dardick 2019). Increases in fish abundance around offshore structures may be caused by an attraction of individuals without an increase in the local population. Alternatively, the local population may be increased by the addition of suitable habitat that enhances settlement, survival, and/or growth (Schwartzbach et al., 2020). However, beneficial effects of increased habitat suitability for some species could be offset if the colonizable habitats provided by offshore wind energy structures aggregate predators and prey, increasing predation risk, or provide steppingstones for non-native species invasions (Adams et al. 2014; De Mesel et al. 2015; Langlois et al. 2005). While there is concern that non-native species aggregating on offshore structures may pose a threat to native species (Glasby et al. 2007; Adams et al. 2014), this threat has not yet been demonstrated. The net effect of WTG and OSS foundations on pelagic EFH is likely to be neutral to beneficial depending on whether species experience population growth because of the added habitat or are merely attracted to the habitat, with the recognition that beneficial effects could be negated should these structures inadvertently promote the establishment of invasive species on the mid-Atlantic OCS.

Over time, the attractive effects of the structures and complex habitats formed by the maturing reef effect are also expected to alter food web dynamics in ways that are 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, removing particles from the water column that would have otherwise passed by and resulting in reduced turbidity and deeper light penetration. This biofilter effect been observed at the local scale (Reichart et al. 2017) and in the laboratory (Mavraki 2020) but may also manifest at a large scale through the cumulative influence of multiple offshore wind facilities. Soft sediment around turbines may be enriched through the deposition of fecal pellets produced by filter feeders (Maar et al. 2009), thereby facilitating the transfer of pelagic food sources to the benthic community (Slavik et al. 2019). The trophic resources used by suspension feeders could include pelagic eggs or larvae of EFH species, as well as prey resources for ichthyoplankton. 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 WTG and OSS foundations 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 did not detect a significant difference in key food web indicators before and after construction (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, large-scale food web shifts are not expected due to the installation of WTGs and conversion of pelagic habitat to hard surface.

Direct Effects on EFH and EFH Species

- Permanent, adverse effects on EFH and EFH species resulting from decrease in preferred habitat:
  - Sessile Benthic/Epibenthic – Soft Bottom

- Mobile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic
- Long-term, neutral to beneficial effects on EFH and EFH species resulting from increase in preferred habitat:
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Pelagic

Indirect Effects on EFH and EFH Species

- Long-term, adverse effects to EFH and EFH species due to potential increased predation risk associated with aggregation effect:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic

Entrainment

The installation of gravity-based structures would require water withdrawals from surrounding environment if seawater is used a ballast material. Atlantic Shores anticipates that a screen would be installed to prevent debris from entering the foundation. The withdrawal of water through a screen could result in the entrainment of life stages of fish and invertebrates with limited swimming abilities (i.e., eggs and larvae) with assumed 100-percent mortality of entrained individuals. However, because of the limited volume of water that would be withdrawn for ballast, BOEM does not expect population-level impacts on any given species. This is because the rate of egg and larval survival to adulthood for many species is naturally very low (MMS 2009).

Direct Effects on EFH and EFH Species

- Loss of EFH and EFH species due to water intake for eggs, larvae, and small juveniles:
  - Pelagic
  - Prey Species – Pelagic

Indirect Effects on EFH and EFH Species

- Loss of food sources for planktivorous species, including filter-feeding invertebrates:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic

5.1.1.3 Seabed Preparation (including UXO Removal)/Boulder Re-Location/Dredging

Habitat Loss/Conversion

Seabed preparation may be required prior to the installation of WTG, OSS, and MET tower foundations in certain areas depending on the seabed and the foundation type. Non-complex soft-bottom habitat, including small sand waves and depressions in the seabed, is present in the Lease Area and provides EFH for some species in the area (e.g., hakes, flounders). Seabed preparation would remove these habitat features. Seabed preparation activities may include levelling and removal of surface or subsurface debris such as boulder and sand waves, or in-situ UXO disposal. Depending on the foundation types selected, seabed preparation for the installation of 200 WTG foundations and 10 OSS foundations would temporarily disturb an estimated 329.7 to 356.1 acres of benthic habitat, including 250.0 to 266.8 acres of soft-bottom habitat, 32.2 to 39.0 acres of heterogeneous complex habitat, and 47.1 to 53.9 acres of complex habitat. Seabed preparation would disturb an estimated volume of seabed ranging from 0.7 million yd^3 (0.5 million m^3) for piled jacket foundations to 1.4 million yd^3 (1.1 million m^3) for suction bucket foundations. Currently, no specific benthic impact calculations (i.e., acres disturbed) exist for sand wave leveling and seabed debris removal prior to WTG and OSS foundation installation. Seabed preparation would occur over several months prior to the start of installation of the Project 1 and Project 2 foundations in the first quarter of 2026 (see Table 2-2, above).

Benthic habitat would be impacted by boulder relocation during seabed preparation for installation of the WTGs, OSSs, and MET tower. Some boulders may be relocated to non-complex benthic habitat, resulting in the conversion of non-complex to 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 WTG, OSS, and MET tower foundations and scour protection.

The area affected by seabed preparation would be rendered unavailable while the foundations remain in place for EFH species associated with complex, heterogenous complex, and soft bottom benthic habitats during one or more life stages. Seabed preparation would therefore result in a permanent, localized, adverse effect on EFH lasting through the 30-year life span of the Proposed Action.

Direct Effects on EFH and EFH Species

- Permanent, localized, adverse effects to EFH and EFH species/life stages resulting from decreased in preferred habitat for:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Prey Species – Benthic/Epibenthic

Sediment Suspension*/Redeposition*

Seabed preparation activities (e.g., removal of debris or seabed leveling) would result in short-term, localized resuspension and sedimentation of finer grain sediments. Medium to course-grained sediments within the Lease Area are likely to settle to the bottom of the water column quickly, with sand redeposition being short-term and localized. These effects would occur intermittently at varying locations in the project area over the duration of project construction 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. Indirect impacts to EFH could occur as a result of sediment suspension, temporarily decreasing foraging success due to increased turbidity. It would be expected that normal foraging behavior would resume following completion of installation and settlement of suspended sediments.

Low-order (deflagration) or high-order (detonation) in-situ disposal of UXO has the potential to affect benthic resources. UXO disposal has the potential to cause disturbances to the seafloor (sediment suspension and deposition) as well as noise. Impacts are expected to be short term and direct, with the potential to cause injury or mortality to benthic species within the direct vicinity of the disposal activities.

Changes to the Project design and additional impacts that were not considered in the EFH assessment could occur in the unlikely event that UXO are discovered in the project footprint. These changes could include additional micrositing of monopile foundations and cable routes to avoid UXO hazards, and/or the removal and relocation of UXO to other locations on the seabed where avoidance is not practicable. The relocation of project features would result in the same type of short-term construction related and permanent operational impacts as those described in the EFH assessment, but the location, extent, and distribution of those impacts by habitat type may vary. These changes could, in theory, limit the ability to avoid impacts to complex benthic habitat in specific circumstances. The removal and relocation of UXO would result in similar suspended sediment effects from mechanical disturbance of the seabed as those described for project construction in the EFH assessment, but the extent of those impacts would marginally increase as a result of UXO relocation.

Regardless of mitigation strategy, any change in impact area resulting from potential UXO risk avoidance is unknown but is likely to be small relative to the effects of project construction. Those effects would be similar in nature to the short-term crushing and burial effects considered in the EFH assessment and would not alter the effect determination in the EFH assessment for any EFH species. Further coordination with the appropriate federal agencies (e.g., NMFS) would occur as appropriate if UXO mitigation requires action that was not considered in this consultation. Detailed information on UXO are provided in Technical Memorandum: Underwater Acoustic Modeling of Detonation of Unexploded Ordnance (UXO) for Ørsted Wind Farm Construction, US East Coast (Hannay and Zykov 2021).

Direct Effects on EFH and EFH Species

- Short-term, localized, adverse effects to EFH and EFH species/life stages resulting from sediment suspension and deposition would affect the following groups:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic

Underwater Sound (Vessels)

The impacts and direct and indirect effects to EFH and EFH species due to underwater sound from vessels associated with seabed preparation would be similar to those impacts analyzed in Section 5.1.1.1 Vessel Activity.

5.1.1.4 Installation of Scour Protection

Habitat *Loss/Conversion*

Depending on the types of foundations selected, I placement of scour protection (e.g., concrete mattresses) around the WTG, OSS, and MET tower foundations would permanently impact an estimated 202.6 to 277.3 acres of benthic habitat, including 151.2 to 206.6 acres of soft-bottom habitat, 21.0 to 32.8 acres of heterogeneous complex habitat, and 29.1 to 43.6 acres of complex habitat. Approximately 172.2 to 239.3 acres of soft-bottom and heterogeneous habitat would be converted to complex, hard-bottom habitat. The soft-bottom benthic habitats that existed previously in the footprint of the scour protection would no longer be available to EFH species for the entire 30-year life of the project through decommissioning when the foundations and scour protection are removed. Over time, these concrete and natural rock surfaces would become colonized by sessile organisms and would gradually evolve into functional habitat for EFH species. However, the concrete mattresses may take 3 to 12 months to fully cure following placement, during which time the hard substrate would be toxic to eggs, larvae, and invertebrates (Lukens and Selberg 2004). The increase in abundance of hard-bottom habitat and expected artificial reef effect suggests an 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). Further, it is uncertain whether the new hard-bottom habitat would enable population growth of structured-oriented species or would merely attract these species from other locations. Therefore, the addition of complex benthic habitat is expected to provide a neutral to beneficial increase in available EFH lasting for approximately 20 years of Project life, depending on the species-specific responses to this habitat. These features may or may not be removed when the Project is decommissioned, depending on the habitat value they provide.

It is anticipated that mobile life stages would move out of the area to avoid potential impacts. Demersal non-mobile life stages would be impacted due to the placement of scour protection in the immediate area of installation. Most juvenile and adult finfish would actively avoid all construction activities. However, immobile finfish life stages such as demersal eggs and larvae, and sessile organisms could experience mortality as a result of being crushed or buried by the scour protection. EFH-designated species that would likely be impacted by crushing and burial effects of installation of scour protection are similar to those listed in Section 5.1.1.1.

Direct Effects on EFH and EFH Species

- Permanent, adverse effects on EFH and EFH species resulting from decrease in preferred habitat:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic
- Long-term, neutral to beneficial effects on EFH and EFH species resulting from increase in preferred habitat:
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Pelagic

Indirect Effects on EFH and EFH Species

- Permanent, adverse effects to EFH and EFH species due to potential increased predation risk associated with aggregation effect:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic

Sediment Suspension/*Redeposition*

Installation of the scour protection for the WTG, OSS, and MET tower foundations would disrupt approximately 160 acres of primarily soft-bottom benthic habitat. Methods of installation may include side stone dumping, fall pipe, or crane placement. Placement of scour protection may temporarily increase suspended sediments due to resuspension of bottom sediments. These benthic disturbances would increase turbidity and suspend sediment in the water column. Impacts to benthic habitat would occur locally and temporarily at each of the proposed WTG, OSS, and MET tower locations because of the predominately sandy composition of the upper sediments in the Project area. EFH-designated species that would likely be impacted sediment suspension associated with the installation of scour protection are similar to those listed in Section 5.1.1.1.

Direct Effects on EFH and EFH Species

- Short-term, localized decrease in quality of EFH resulting from suspended sediments and increased turbidity:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Pelagic
- Short-term, localized impacts from sedimentation:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic

Indirect Effects on EFH and EFH Species

- Short-term, localized loss of foraging opportunities:
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Pelagic
- Short-term, localized decrease in quality of EFH in areas adjacent to Project activities:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic

5.1.2 Inter-Array and Offshore/Onshore Cable Installation

5.1.2.1 Vessel Activity

It is anticipated that up to 7 construction vessels would be necessary for the installation of the inter-array cables and up to 6 construction vessels would be necessary for the installation of the offshore export cables. Vessels involved in cable installation include main laying vessels, burial vessels, and support vessels. Vessel activity would occur intermittently during the construction period beginning with the start of the Project 1 export cable installation in the second quarter of 2025 and continuing through the completion of the Project 2 inter-array cable installation in the fourth quarter of 2027 (see Table 2-2, above).

Habitat Disturbance

The cable laying vessel would use dynamic positioning and would not require the use of anchors (Table 6-1). Some of the support vessels may require anchoring and/or spudding during the installation of the cables, which may disturb benthic EFH and EFH species associated with that habitat. Vessel anchoring associated with cable emplacement would occur within the Lease Area, along the 25-mile (40-km) Atlantic export cable route, and along the 85-mile (138-km) Monmouth export cable route. Atlantic Shores has estimated that a total of 629 acres of benthic habitat would be disturbed by anchoring of vessels during construction of the Proposed Action, including the installation of the inter-array cables and export cables (Atlantic Shores 2023, Volume I). Impacts of habitat disturbance on EFH from anchoring during array cable installation are expected to be similar to impacts that would occur during installation of the WTG and OSS foundations, as described in Section 5.1.1.1.

Sediment Suspension*/Redeposition*

In general, vessel activities (i.e., anchoring and/or spudding) associated with cable installation would cause short-term impacts to water quality intermittently throughout Project construction. These benthic disturbances would increase turbidity and suspend sediment in the water column. The potential impacts to water quality, and by extension, EFH and EFH-designated species, such as resuspension of sediments, would be short-term and localized. Impacts of sediment suspension on EFH from anchoring during array cable installation are expected to be similar to impacts that would occur during installation of the WTG and OSS foundations, as described in Section 5.1.1.1.

Underwater Noise (*Vessels)*

Impacts of vessel noise on EFH from anchoring during array cable installation are expected to be similar to impacts of vessel noise that would occur during installation of the WTG and OSS foundations, as described in Section 5.1.1.1.

Potential Introduction of Exotic/Invasive Species

Impacts of potential introduction of exotic/invasive species during operation of vessels involved in cable installation are expected to be similar to those of vessels that would be involved in installation of the WTG and OSS foundations, as described in Section 5.1.1.1.

5.1.2.2 Seabed preparation (including UXO removal/Boulder re-location/Dredging

Seabed preparation may be required prior to installation of inter-array and offshore export cables and may include sand bedform clearing, relocation of boulders, a pre-lay grapnel run, and a pre-lay survey. Excavation may be required where debris is buried or partially buried. Seabed preparation would occur intermittently during the construction period beginning with the start of the Project 1 export cable installation in the second quarter of 2025 and continuing through the completion of the Project 2 inter-array cable installation in the fourth quarter of 2027 (see Table 2-2, above).

Habitat Alteration

Seabed preparation is expected to disturb both soft-bottom and complex benthic habitat. Sand bedform clearing would occur along an estimated 88.3 miles (142 km) of export cables, 54.6 miles (88 km) of inter-array cables, and 7.4 miles (12 km) of inter-link cables. Dredging during sand bedform removal prior to cable installation is expected to result in the removal of 7.1 million yd^3 (5.5 million m^3) of material, including 4.2 million yd^3 (3.2 million m^3) along the ECCs, 2.6 million yd^3 (2.0 million m^3) along the inter-array cable corridor, and 0.4 million yd^3 (0.3 million m^3) along the inter-link cable corridor. Non-complex soft-bottom habitat, including small sand waves and depressions in the seabed, is present in the Lease Area and along the ECCs and provides EFH for some species in the area (e.g., hakes, flounders). Sand bedforms that are dredged would likely be redeposited in areas of similar sediment composition, and tidal and wind-forced bottom currents are expected to reform most ripple areas within days to weeks following disturbance. Although some sand ripples may not recover to the same height and width as pre-disturbance, the habitat function is expected to fully recover post-disturbance. Therefore, impacts of sand bedform clearing on EFH and EFH species are expected to be localized and short term, dissipating over time as mobile sand waves fill in the altered seabed profile.

Boulder relocation would potentially alter the composition of both the original and relocated habitat. Over time, the relocated boulders would be recolonized, contributing to the habitat function provided by existing complex benthic habitat of relocated boulders. Boulder clearing would occur along an estimated 44.1 miles (71 km) of cable within the ECCs and would disturb an estimated area of 54 acres (0.22 km^2). Long-term to permanent impacts of artificial structures associated with the Project, as well as affected species are discussed in Section 5.1.3.1.

The areas affected by seabed preparation would be rendered unsuitable for EFH species associated with complex, heterogenous complex, and soft bottom benthic habitats during one or more life stages. Short-term declines in habitat suitability are expected for soft bottom habitat and long-term declines in habitat suitability are expected for complex habitat, which may require several years to recover. Array cables, interconnection cables, and offshore export cable installation would therefore result in a short-term to long-term adverse effect on EFH lasting through surface preparation activities and installation but would be expected to recover shortly after installation.

Direct Effects on EFH and EFH Species

- Short-term loss/conversion of EFH:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Pelagic
  - Prey Species – Benthic/Epibenthic

    - Prey Species – Pelagic
- Long-term loss/conversion of EFH:
    - Sessile Benthic/Epibenthic – Complex
    - Mobile Benthic/Epibenthic – Complex
    - Pelagic
    - Prey Species – Benthic/Epibenthic
    - Prey Species – Pelagic

Indirect Effects on EFH and EFH Species

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

Sediment Suspension*/Redeposition*

Sediment suspension and redeposition would occur as a result of seabed preparation activities. Impacts to EFH species similar to those resulting from seabed preparation for WTG and OSS foundation installation are expected to occur. Sediment consists primarily of sandy surface sediments in the southern part of the Lease Area with increased gravel and gravelly deposits in the northern and western parts of the Lease Area (see Section 3.2), which are likely to settle to the bottom of the water column quickly. Sand re-deposition would be minimal and close in vicinity to the trench centerline, minimizing impacts to demersal fish eggs. Direct impacts to foraging habitat are expected to be localized to the width of the trench and short-term as benthic organisms would recolonize the area.

Direct Effects on EFH and EFH Species

- Short-term decrease in quality of EFH resulting from suspended sediments and increased turbidity:
    - Sessile Benthic/Epibenthic – Soft Bottom
    - Mobile Benthic/Epibenthic – Soft Bottom
    - Prey Species – Pelagic
- Short-term, local impacts resulting from sedimentation:
    - Sessile Benthic/Epibenthic – Soft Bottom
    - Prey Species – Benthic

Indirect Effects on EFH and EFH Species

- Short-term loss of foraging opportunities:
    - Mobile Benthic/Epibenthic – Soft Bottom
    - Pelagic
- Short-term decrease in quality of EFH in areas adjacent to Project activities:
    - Sessile Benthic/Epibenthic – Soft Bottom
    - Mobile Benthic/Epibenthic – Soft Bottom
    - Prey Species – Benthic/Epibenthic

Entrainment

Some types of seabed preparation equipment (e.g., hydraulic dredges) use water withdrawals, which can entrain planktonic larvae of benthic fauna (e.g., larval polychaetes, mollusks, crustaceans) with assumed 100-percent mortality of entrained individuals. Because of the surface-oriented intake, water withdrawal could entrain pelagic eggs and larvae, but would not affect resources on the seafloor. Because of the limited volume of water withdrawn, BOEM does not expect population-level impacts on any given species. This is because the rate of egg and larval survival to adulthood for many species is naturally very low (MMS 2009).

Direct Effects on EFH and EFH Species

- Loss of EFH and EFH species due to water intake for eggs, larvae, and small juveniles:
  - Pelagic
  - Prey Species – Pelagic

Indirect Effects on EFH and EFH Species

- Loss of food sources for planktivorous species, including filter-feeding invertebrates:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic

Underwater *Noise (Vessels)*

The impacts on EFH and EFH species resulting from underwater sound generated by vessels associated with seabed preparation would be similar to those impacts analyzed in Section 5.1.1.1 Vessel Activity.

5.1.2.3 Trenching/Cable Installation

Habitat Loss/Conversion

The maximum total installed length of cables within the WTA would be 621 miles (1,050 km), including 584 miles (990 km) of inter-array cables and 37 miles (60 km) of inter-link cables. Inter-array and inter-link cable installation would be completed primarily using jet trenching or jet plowing. Mechanical trenching is only expected in limited areas. Direct impacts to EFH due to habitat disturbance are expected along the entire length of the inter-array and inter-link cables within the construction corridor. Installation of the inter-array and inter-link cables would result in short-term disturbance of an estimated 698.8 to 862.3 acres of benthic habitat, including 468.6 to 584.0 acres of soft-bottom habitat, 78.5 to 92.1 acres of heterogeneous complex habitat, and 148.6 to 186.2 acres of complex habitat. It is anticipated that pelagic species and motile life stages would avoid construction activities based on typical installation speeds, and direct impacts are not anticipated. Direct impacts to foraging habitat are expected to be localized to the width of the trench and short-term as benthic organisms would recolonize the area. Indirect impacts to EFH could result from sediment suspension, temporarily decreasing foraging success because of increased turbidity. It would be expected that normal foraging behavior would resume following completion of installation and settlement of suspended sediments. Sediment suspension impacts are discussed further below.

The export cables would be placed by the same methods described above for array cables, depending on site conditions. The maximum total cable length would result from the selection of the HVAC transmission option (see Section 2.2.2., above), which would install four cables in each ECC. The maximum total cable length from the Atlantic Landfall Site to the OSSs is 100 miles (160 km), and the maximum total cable length from the Monmouth Landfall Site to the OSSs is 342 miles (550 km). Direct impacts to EFH due to habitat disturbance are expected along the entire length of each ECC. Installation of the export cables would result in short-term disturbance of an estimated 1,955.3 acres of benthic habitat, including 941.1 acres of soft-bottom habitat, 71.2 acres of heterogeneous complex habitat, and 943.1 acres of complex habitat. The impacts of OEC installation are expected to be similar to those of the inter-array cables.

Installation of the inter-array cables and export cables could result in direct impacts, such as crushing and burial of slow-moving or sessile organisms and life stages. The sea-to-shore transition would occur where the onshore and offshore segments of the export cable meet. Cofferdam installation, dredging and sidecast, and vessel anchoring at the sea-to-shore transition could result in crushing and burial effects. Direct mortality of benthic life stages and sessile organisms could also result from fluidizing the sediments along the cable corridors during cable burial. The effects of crushing and burial impacts on EFH resulting from cable installation would vary depending on how benthic and demersal habitats exposed to these impacts are used by EFH-designated species. Benthic and epibenthic life stages would be the primary groups affected, with secondary effects on EFH-designated species and life stages that prey upon benthic and epibenthic organisms. Mobile organisms such as juvenile and adult finfish may be temporarily displaced by cable installation but would be able to avoid mortality related to these activities.

Direct Effects on EFH and EFH Species

  - Short-term loss/conversion of EFH:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic
- Permanent, localized crushing and burial of EFH species:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Prey – Benthic/Epibenthic

Indirect Effects on EFH and EFH Species

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

Sediment Suspension and Redeposition

Cable installation activities would generate localized plumes of suspended sediments and subsequent sediment deposition within the immediate proximity of the trench excavation and reburial. As described in Section 5.1.1.1, above, egg and larval life stages are highly sensitive to sediment deposition, with certain species (e.g., winter flounder) experiencing mortality at burial depths of less than 0.1 inch (3 mm). Atlantic Shores performed sediment transport and deposition modeling for scenarios representative of jet and mechanical trenching at a representative interarray cable location, jet trenching along Branch 1 and Branch 2 of the Monmouth ECC, Branch 1 and Branch 2 of the Atlantic ECC, and excavation at representative HDD pits at both the Monmouth ECC and Atlantic ECC landfall approaches. For each of the scenarios, spatially varying sediment characteristics of the upper 2 meters of the seafloor were developed based on vibracore samples collected in the WTA and along the ECCs by Atlantic Shores. The resulting grain size distributions and percent solids were used in their respective modeling scenarios. In general, the WTA had more coarse sand samples than the ECCs, with patches of fine sediments (clay and silt) scattered throughout the WTA. The ECCs consisted of primarily coarse sediments, also with patches of fine sediments. More fine sediments were present in the Monmouth ECC than in the Atlantic ECC. For the interarray cable scenarios, an individual route that passed through a region of finer sediment (clays and silts) was modeled (Atlantic Shores 2023, Appendix II-J3). Modeling of sediment deposition associated with the Proposed Action estimated that emplacement of the cables with a jet trencher would result in sediment deposition of greater than 1 mm within 110 meters of the inter-array cable trench extending over an area of 148 acres, within 200 meters of the Monmouth Export Cable trench extending over an area of 2,056 acres, and within 50 meters of the Atlantic Export Cable trench extending over an area of 344 acres. Modeling estimated that emplacement of the inter-array cables with a mechanical trencher would result in sediment deposition of greater than 1 mm within 50 meters of the cable trench extending over an area of 104 acres. This indicates that emplacement of the inter-array cables and export cables would expose the most sensitive eggs and larvae to sediment deposition effects over an area of up to 2,548 acres (Atlantic Shores 2023, Appendix II-J3).

The maximum sediment deposition modeled was less than 5 mm for the inter-array cable trench, between 5 to 10 mm for the Atlantic Export Cable trench, and between 10 and 20 mm for the Monmouth Export Cable trench. For all these modeled scenarios, the maximum sediment deposition thickness was predicted to remain within 15 m of each cable route's centerline. Total suspended sediment (TSS) concentrations ≥ 10 mg/L traveled a maximum distance of approximately 2.9 km away from the inter-array centerline, approximately 2.6 km away from the Monmouth Export Cable centerline, and approximately 1.7 km away from the Atlantic Export Cable centerline. Above-ambient TSS concentrations had mainly dissipated within 4 to 6 hours, and fully dissipated in less than 6 hours for the inter-array cable and Atlantic Export Cable model scenarios. Above-ambient TSS concentrations mainly dissipated within 2 to 6 hours, and fully dissipated withing 12 to 25 hours for the Monmouth Export Cable model scenario (Atlantic Shores 2023, Appendix II-J3).

Sediment transport was also modeled for HDD activities near the Monmouth and Atlantic landfalls, assuming the use of an excavator with the introduction of sediment at the surface and no use of cofferdams. Sediment deposition ≥ 1 mm was modeled to extend a maximum distance of 479 m from the Monmouth HDD pit and a maximum distance of 200 m from the Atlantic HDD pit. Total suspended sediment (TSS) concentrations ≥ 10 mg/L traveled a maximum distance of approximately 3.3 km away from the Monmouth Landfall HDD pit, and approximately 1.9 km away from the Atlantic Landfall HDD pit. The tails of the modeled sediment plumes, containing TSS concentrations ≥ 10 mg/L, were transported away from the HDD pits and were short-lived. Sediment concentrations near the HDD pits dissipated within 6 to 12 hours at the Atlantic HDD pit and within 6 to 24 hours at the Monmouth HDD pit (Atlantic Shores 2023, Appendix II-J3).

Juvenile fish are expected to be able to avoid burial effects from sediment deposition and would primarily respond to elevated total suspended sediment (TSS) concentrations in the water column. Modeling of suspended sediments associated with the Proposed Action estimated that emplacement of cables with a jet trencher would generate maximum TSS concentrations exceeding 100 mg/L for longer than 2 hours over an area of 10 acres for the inter-array cables and 326 acres for the Monmouth Export Cable (Atlantic Shores 2023, Appendix II-J3); the aerial extent of these TSS concentrations was not available for the Atlantic Export Cable, but is expected to be small since concentrations exceeding 100 mg/L would only occur within less than 100 meters of that cable. Modeling estimated that emplacement of inter-array cables with a mechanical trencher would generate maximum TSS concentrations exceeding 100 mg/L for longer than 2 hours over an area of 10 acres. 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). This indicates that emplacement of the inter-array cables and export cables would temporarily expose juvenile fish to sediment suspension effects over an area of 336 acres.

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. 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). Modeling of suspended sediments associated with the Proposed Action estimated that emplacement of cables with a jet trencher or mechanical trencher would generate maximum TSS concentrations exceeding 500 mg/L only in immediate proximity to the inter-array and export cable trenches lasting less than 2 hours (Atlantic Shores 2023, Appendix II-J3), suggesting that exposure of adult fish to sediment suspension effects would be over a limited area and short-term. As described in Section 4.1.2, above, sandbar shark HAPC occurs in nearshore waters near the landfall of the Atlantic Export Cable. Sandbar sharks inhabiting the cable corridor during cable emplacement would likely respond to elevated levels of suspended sediment by relocating to surrounding, potentially less suitable habitat during the construction period. Atlantic Shores would minimize impacts on sandbar shark HAPC by avoiding cable emplacement during the period of peak sandbar shark pupping and nursery activity from June 1st through September 1st.

Cable installation could expose adult bivalves to sublethal effects of suspended sediments at TSS concentrations of 1,000 mg/L or higher (Wilber and Clarke 2001). Further, sediment deposition depths between 0.4 and 1.2 inches (10 and 30 mm) could result in sublethal to lethal effects on juvenile and adult bivalves. Modeling of suspended sediments associated with the Proposed Action estimated that emplacement of cables with a jet trencher or mechanical trencher would generate maximum TSS concentrations of 1,000 mg/L only in immediate proximity to the inter-array and export cable trenches and would generate sediment depths of 10 mm over an area of 5 acres for the Monmouth Export Cable and over a areas too small to be modeled at the inter-array cables and Atlantic Export Cable areas (Atlantic Shores 2023, Appendix II-J3). This indicates that emplacement of the inter-array cables and OECs could temporarily expose bivalves to sediment suspension effects over a limited area and for a short-term duration and sediment deposition effects over an area of 5 acres. As noted in Section 4.1.2, the Cardiff Onshore Interconnection Cable Route would traverse inlands waters, including portions of Chelsea Harbor, Great Thorofare, and Beach Thorofare. Atlantic Shores would use HDD to route the interconnection cables under these waterbodies, thereby avoiding generating suspended sediment that could impact bivalves.

As described in Section 3.4, above, the modeled distance of sediment deposition depths of 1 mm from cable laying activities would extend to several artificial reefs that are adjacent to the Monmouth export cable route, including Manasquan Inlet and Axel Carlson reef. Exposure to sediment deposition greater than 1 mm during cable installation may cause mortality in sessile fish and invertebrates (e.g., eggs and larvae) inhabiting the reefs, and suspended sediment may cause mobile fish and invertebrates (e.g., juveniles and adults) to migrate away from the reefs, potentially to less suitable habitat.

Direct Effects on EFH and EFH Species

- Short-term decrease in quality of EFH resulting from suspended sediments and increased turbidity:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Pelagic
- Short-term, local impacts resulting from sedimentation:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic

Indirect Effects on EFH and EFH Species

- Short-term loss of foraging opportunities:
  - Mobile Epibenthic/Benthic – Soft Bottom
  - Pelagic
- 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

Entrainment

In areas where a jet plow is used for cable installation, the surface-oriented intake of the jet plow would potentially entrain pelagic eggs and larvae but would not affect organisms on the seafloor. Because of the limited volume of water withdrawn, BOEM does not expect population-level impacts on any given species.

Direct Effects on EFH and EFH Species

- Loss of EFH and EFH species due to water intake for eggs, larvae, and small juveniles:
  - Pelagic
  - Prey Species – Pelagic

Indirect Effects on EFH and EFH Species

- Loss of food sources for planktivorous species, including filter-feeding invertebrates:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Pelagic

Horizontal Directional Drilling (HDD)

During installation of the estuarine portion of the export cables, impacts to EFH would be minimized, where practicable, by using trenchless installation methods which install the cable beneath overlying sediments without direct physical disturbance (Table 6-1). During HDD, a sediment mix including drilling mud (i.e., bentonite) is used. During drilling, reaming, or pulling events, some drilling mud may be released from the end of the bore hole. Therefore, each HDD would have an exit pit to receive the drilling mud. Bentonite is heavier than water, so it would remain in the exit pit and then be removed through a vacuum or suction dredge. HDD conduits would be drilled for landfall. An HDD entry pit would be required for each cable duct. Trenchless installation (e.g., HDD) has the potential for impact in the event of inadvertent return of drilling fluids, thus causing adverse impacts to water quality through increases in turbidity, as well as hazardous chemical impacts to EFH and EFH-designated species. Best management practices, such as monitoring of the drilling mud volumes, pressures, and pump rates and returns, would be followed to determine if drill mud loss occurs in amounts that signal a possible inadvertent return. Sensitive habitat would be avoided wherever possible, and impacts minimized should the cable need to traverse a unique habitat (e.g., complying with seasonal work windows and other best management practices). As described in Section 4.1.2, above, summer flounder HAPC occurs in inland waterways that would be traversed by the Cardiff Onshore Interconnection Cable Route and may be impacted by cable emplacement. Impacted species would likely relocate to surrounding similar habitat during and immediately following construction. Following construction, the areas of cable burial would be restored to previous elevations and natural succession would proceed.

Underwater Sound

Underwater noise would be generated during the installation of the inter-array cables and export cables, but the types of sound generated along most of the cable corridor would be characterized as continuous, as opposed to percussive (i.e., such as that produced during impact pile driving) and would therefore not cause the same types of impacts as impact pile driving. Impacts of continuous noise would be short-term and would extend only a short distance beyond the emplacement corridor. Continuous noise generated by the cable installation equipment is not likely to result in injury or mortality for finfish in the immediate vicinity of the activity but may cause short-term behavioral changes in a broader area. A cofferdam may also be installed at the landfall sites to support HDD during the installation of the onshore export cables. As noted in Section 2.2.2, the method of installation of the cofferdam is unknown, but the cofferdam would be installed and removed using vibratory pile driving. Vibratory pile driving generates non-impulsive underwater noise with lower source levels than impact pile driving. Noise impacts from non-impulsive noise sources are generally smaller compared to noise impacts from impulsive noise sources, but physiological effects may still occur near the noise source if source levels are sufficiently high and/or if animals are exposed to those levels for a sufficient duration. Underwater sound propagation modeling for vibratory pile driving was conducted for the Proposed Action at the Monmouth and Atlantic cable landing sites and assumed 8 days of installation and 8 days of removal at each of the two sites. In general, vibratory pile driving was estimated to result in peak sound pressure levels of 177 to 195 dB and sound exposure levels of 174.8 to 190.6 dB. Because of the relatively lower exposure levels and short duration, noise generated by vibratory hammers would likely result in smaller noise impacts compared to the impact hammer pile driving described in Section 5.1.1. Following the completion of cable installation, finfish would be expected to return to the impacted areas.

Direct Effects on EFH and EFH Species

- 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
  - Mobile Benthic/Epibenthic – Complex
  - Pelagic
  - Prey Species – Benthic/Epibenthic
  - Prey Species – Pelagic

5.1.2.4 Cable Protection (Concrete Mattresses, etc.)

Cable protection may be required where burial cannot occur, sufficient depth cannot be achieved, or protection is required due to crossing other cables or pipelines. Placement of rocks, concrete mattresses, rock bags, grout-filled bags, and half-shell pipes may be used to protect the cable (see Section 2.2.2.4). Approximately 10% of the cable route may require cable protection (Atlantic Shores 2023, Volume I). Installation of cable protection would cause permanent and localized habitat conversion and short-term and localized sediment suspension and subsequent redeposition that would adversely affect EFH and EFH-designated species.

Habitat Loss/Conversion

Atlantic Shores conservatively assumes that cable protection would be required along 54.6 miles (88 km) of inter-array cables, 3.8 miles (6 km) of inter-link cables, and 44.1 miles (71 km) of export cables. The installation of the inter-array and inter-link cables would permanently disturb an estimated 105.1 to 129.9 acres of benthic habitat, including 70.7 to 88.1 acres of soft-bottom habitat, 11.7 to 13.9 acres of heterogeneous complex habitat, and 22.3 to 27.9 acres complex habitat. Approximately 82.4 to 101.9 acres of soft-bottom and heterogeneous complex habitat would be converted to complex, hard-bottom habitat in the WTA. The installation of the Atlantic and Monmouth export cables would permanently disturb an estimated 255.5 acres of benthic habitat, including 118.6 acres of soft-bottom habitat, 7.7 acres of heterogeneous complex habitat, and 129.2 acres of complex habitat. Approximately 126.3 acres of soft-bottom and heterogeneous complex habitat would be converted to complex, hard-bottom habitat in the export cable corridors. These soft-bottom benthic habitats would no longer be available to EFH species for the entire 30-year life of the project through decommissioning when the foundations and scour protection are removed. Non-complex benthic habitat, including small sand waves and depressions in the seabed, may be present in the Lease Area and along the ECCs and may provide EFH for some species in the area (e.g., hakes, flounders). Conversion or loss of non-complex benthic habitat could influence the local food web by introducing habitat for colonizing organisms. Conversion of soft-bottom habitat to complex, rocky habitat would support a different suite of species and could even aid in dispersal pathways (Adams et al. 2014). While the local food web may shift with the conversion of habitat, large-scale 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 are not anticipated.

As described for the WTG and OSS foundation scour protection Section 5.1.1.4, the natural rock surfaces provided by the cable protection would become colonized by sessile organisms and would gradually develop into functional habitat for EFH species. The increase in hard-bottom habitat provided by these structures and the expected artificial reef effect suggest an expansion of available EFH for species associated with complex benthic habitat. However, it could take a decade or more for the reef effect to develop before fully functional habitat status is achieved. Further, it is uncertain whether the new hard-bottom habitat would enable population growth of structured-oriented species or would merely attract these species from other locations. Therefore, the addition of complex benthic habitat is expected to provide a neutral to beneficial increase in available EFH lasting for approximately 20 years of Project life, depending on the species-specific responses to this habitat. These features may or may not be removed when the Project is decommissioned, depending on the habitat value they provide.

Direct Effects on EFH and EFH species

- Permanent, adverse effects on EFH and EFH species resulting from decrease in preferred benthic habitat:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Prey Species – Benthic/Epibenthic
- Long-term, neutral to beneficial effects on EFH and EFH species resulting from increase in preferred benthic habitat:
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex

Indirect Effects on EFH and EFH species

- Permanent, adverse effects to EFH and EFH species from potential increased predation risk associated with aggregation effect:
  - Sessile Benthic/Epibenthic – Soft Bottom
  - Mobile Benthic/Epibenthic – Soft Bottom
  - Sessile Benthic/Epibenthic – Complex
  - Mobile Benthic/Epibenthic – Complex
  - Prey Species – Benthic/Epibenthic

Sediment Suspension/Redeposition

Installation of cable protection may temporarily cause resuspension of bottom sediments, resulting in increased turbidity and suspended sediment in the water column. Impacts to benthic habitat would occur locally and temporarily within each previously discussed cable corridor. These seabed disturbances could result in short-term suspended sediment and direct mortality of sessile or slow-moving organisms from burial upon sediment deposition. However, the spatial extent of suspended sediment and redeposition levels that would result in impacts on EFH is expected to be smaller than that described for cable emplacement in Section 5.1.2.3. The EFH-designated species that would likely be impacted by suspended sediment from installation of cable protection are similar to those listed in Section 5.1.2.3.

5.1.3 Port Facilities

5.1.3.1 Vessel Traffic

The Connected Action would result in a small increase in vessel traffic during installation of the new bulkhead, during maintenance dredging, and during operations. Vessels that are expected to be used during construction of the Connected Action include one dredge vessel, one tugboat, and one scow. All construction vessels would operate at speeds less than 10 knots, and the dredge vessel would operate at a speed of less than 4 knots.

Habitat Disturbance

During construction of the Connected Action, some vessels may require anchoring and/or spudding, which would disturb benthic EFH and EFH species associated with that habitat. Impacts on seafloor habitats could be long-term if they occur on hard-bottom habitat; however, sediments in the area of the ACIM consist primarily of sand, silt, and clay. Impacts of habitat disturbance on EFH from anchoring associated with the Connected Action are expected to be similar in nature but at a smaller scale compared to impacts that would occur during installation of the WTG and OSS foundations, as described in Section 5.1.1.1.

Sediment Suspension/Redeposition

In general, vessel activities (i.e., anchoring and/or spudding) associated with the Connected Action would cause short-term impacts to water quality intermittently throughout construction and operations. These benthic disturbances would increase turbidity and suspend sediment in the water column. The potential impacts to water quality, and by extension, EFH and EFH-designated species, such as resuspension of sediments, would be short-term and localized. Impacts of sediment suspension on EFH from anchoring associated with the Connected Action are expected to be similar in nature but at a smaller scale compared to impacts that would occur during installation of the WTG and OSS foundations, as described in Section 5.1.1.1.

Underwater Noise (Vessels)

Impacts of vessel noise on EFH from vessels associated with the Connected Action are expected to be similar in nature but at a smaller scale compared to impacts of vessel noise that would occur during installation of the WTG and OSS foundations, as described in Section 5.1.1.1.

5.1.3.2 Pile Driving

Underwater Sound

The Connected Action would require the installation of 60, 16-inch (0.4-meter) deep steel or composite vinyl sheet piles. Sheet piles would be installed using vibratory pile driving. As provided in Section 5.1.2.3, above, vibratory pile driving generates non-impulsive underwater noise with lower source levels than impact pile driving. Noise impacts from non-impulsive noise sources are generally smaller compared to noise impacts from impulsive noise sources, but physiological effects may still occur near the noise source if source levels are sufficiently high and/or if animals are exposed to those levels for a sufficient duration.

Vibratory pile driving would produce acoustic impacts that would adversely affect EFH for fish and invertebrates across all hearing categories, but the extent of the impacts would vary depending on hearing sensitivity (see Table 5-2) and distance from the pile. EFH species could exhibit physiological and behavioral impacts depending on intensity and duration of the acoustic impact, distance from the sound source, and hearing sensitivity. The noise levels would temporarily make the habitat less suitable and cause individuals to vacate the area of Project activities. Pile driving is anticipated to cause adverse impacts to EFH for both pelagic and demersal life stages; however, this impact will be short-term and EFH is expected to return to pre-pile driving conditions.

Direct Effects on EFH and EFH Species

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

5.1.3.3 Dredging and In-Water Construction

Habitat Disturbance

The Connected Action include maintenance dredging in the ACIM to support the use of the O&M facility. The sediments in the ACIM, which consist primarily of sand, silt, and clay, would be dredged to depths of up to 15 below MLW to accommodate the drafts of vessels required to install offshore WTGs. A total of approximately 142,823 cubic yards of sediments would be dredged from a 20.6-acre (8.3-hectare) dredge footprint as part of the connected action. Within the dredge footprint, all benthic organisms would be removed, and the post-dredging surface substrates would consist of unconsolidated sediments.

It is anticipated that pelagic species and mobile life stages will avoid areas where dredging is occurring activities based on typical installation speeds. Direct impacts to foraging habitat are expected to be localized to the immediate area of dredging and short-term, as benthic organisms are expected to recolonize the dredge footprint from surrounding, undisturbed habitat. Dredging could result in crushing and burial effects of benthic finfish and invertebrates with limited mobility. The effects of crushing and burial impacts on EFH resulting from dredging will vary depending on how benthic and demersal habitats exposed to these impacts are used by EFH-designated species. Benthic and epibenthic life stages will be the primary groups affected, with secondary effects on EFH-designated species and life stages that prey upon benthic and epibenthic organisms. Mobile organisms such as juvenile and adult finfish may be temporarily displaced by dredging activities but will be able to avoid direct impacts related to these activities.

Direct Effects on EFH and EFH Species

- Short-term loss/conversion of EFH:
    - Sessile Benthic/Epibenthic – Soft Bottom

    - Mobile Benthic/Epibenthic – Soft Bottom
    - Sessile Benthic/Epibenthic – Complex
    - Pelagic
    - Prey Species – Benthic/Epibenthic
    - Prey Species – Pelagic
- Permanent, localized crushing and burial of EFH species:
    - Sessile Benthic/Epibenthic – Soft Bottom
    - Sessile Benthic/Epibenthic – Complex
    - Prey –Benthic/Epibenthic

Indirect Effects on EFH and EFH Species

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

Sediment Suspension/Redeposition

Dredging and bulkhead replacement activities conducted during construction as part of the Connected Action would result in increased total suspended sediment concentrations and sediment deposition in the ACIM area. Mechanical dredging activities could result in total suspended sediment concentrations of up to 445 milligrams per liter (mg/L) above ambient conditions (NMFS 2021). These total suspended sediment concentrations are below the short-term (1 to 2 days) concentrations shown to have adverse effects on fish, which range from 580 mg/L for the most sensitive species to 1,000 mg/L for more tolerant species (Wilber and Clark 2001). In inshore areas, such as ACIM, sediments are comprised of fine to medium grains, such that disturbed sediments may take longer to settle to the seabed than in areas of sand or coarser-grained sediments. Active swimmers would be able to easily avoid plumes, and passive drifters would only be exposed over short distances (USACE 2015). However, deposition of these sediments could smother benthic organisms, possibly resulting in mortality of benthic organisms and benthic and demersal life stages (e.g., winter flounder eggs and larvae). Sandy or silty habitats, which are abundant in ACIM, are expected to recover fairly quickly from disturbance, although recovery time varies by region, species, and type of disturbance.

Benthic and demersal species in the ACIM area would be potentially exposed to increased contaminant levels directly from exposure to incidental suspended solids from sediment resuspension and deposition and through bioaccumulation in prey species. Sediment suspension may cause hydrophobic organic contaminants and heavy metals to desorb from sediments and become readily available for bioaccumulation, which may impact reproduction, development, osmoregulation, and hormones in various species and life stages. Further, resuspended contaminants may be taken up by filter feeding organisms and may remain elevated in these organisms for several months after dredging activities have been completed. Analysis of sediment grab samples collected from ACIM in 2020 demonstrated that seven out of nineteen samples were above the Residential Direct Contact Soil Remediation Standards for either Benzo(a)pyrene, arsenic, or lead.

Direct Effects on EFH and EFH Species

- Short-term decrease in quality of EFH resulting from suspended sediments and increased turbidity:
    - Sessile Benthic/Epibenthic – Soft Bottom

    - Mobile Benthic/Epibenthic – Soft Bottom
    - Pelagic
- Short-term, local impacts resulting from sedimentation:
    - Sessile Benthic/Epibenthic – Soft Bottom
    - Prey Species – Benthic/Epibenthic

Indirect Effects on EFH and EFH Species

- Short-term loss of foraging opportunities:
    - Mobile Epibenthic/Benthic – Soft Bottom
    - Pelagic
- 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

5.1.4 Operation/Presence of Structures

5.1.4.1 Artificial Substrate (WTG/OSS/Scour Protection)

Habitat Loss/Conversion

Habitat loss and conversion resulting from the presence of WTG, OSS, and MET tower foundations and associated scour protection are discussed in detail in Sections 5.1.1.2 and 5.1.1.4.

5.1.4.2 Underwater Sound

The operation of WTGs under the Proposed Action would produce non-impulsive, low-frequency underwater noise and particle motion effects. Operational noise would occur continuously in the waters immediately surrounding the WTGs over the approximate 30-year lifespan of the Proposed Action from the completion of construction until decommissioning.

Offshore WTGs produce continuous, non-impulsive underwater noise during operation, mostly in lower-frequency bands below 8 kilohertz. Available measurements of operational noise for WTG sizes ranging from 0.2 to 6.15 MW recorded at distances ranging from 14 to 1,000 meters were evaluated in a study by Tougaard et al. (2020). The authors estimated that operational noise from a 6.15-MW WTG, normalized to a distance of 100 meters and a wind speed of 10 m/s, would result in sound pressure levels ranging from 110 to 125 dB re 1 µPa. Applying the practical spreading loss model to a source noise level of 125 dB RMS at 100 meters, noise levels exceeding the behavioral effects threshold of 150 dB RMS for fish (see Table 5-1**)** would be limited to within 5 feet (1.5 meters) of the monopile surface, and a fish belonging to the hearing specialist group would have to remain within 1 foot (0.32 meter) of the pile surface for 24 hours to experience a temporary threshold shift. However, it is important to note that the noise levels generated by the 10-MW WTGs that would be installed under the Proposed Action are expected to be higher than those generated by the 6.2-MW WTGs evaluated in Tougaard et al. (2020). Stöber and Thomsen (2021) attempted to estimate operational noise from larger current-generation, direct-drive WTGs and observed that these designs could generate higher operational noise levels than those reported in earlier research. Overall, operating WTGs would generate noise exceeding injury and behavioral effects thresholds only in the immediate area of the pile surface, such that potentially significant underwater noise effects from the Proposed Action on habitat suitability would be restricted to a small area around each monopile.

Cod and other hearing specialist 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 observations suggest that particle motion effects in the 1- to 6-kHz range could occasionally exceed the lower limit of observed behavioral responses in hearing specialists within these limits. Although behavioral avoidance impacts of operational noise are expected to be limited to the immediate area of the WTGs, operational noise may cause masking of communication and orientation signals in fish over a much larger distance, potentially up to 25 km (Wahlberg and Westerberg 2005).

Collectively, these observations indicate that WTG operations under the Proposed Action 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. Potential adverse effects 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 potential adverse effects over approximately 481 to 504 acres of habitat during the operation of 200 39.4- to 49-foot (12- to 15-meter) monopiles.

Direct Effects on EFH and EFH species

- Permanent, local avoidance responses to operational noise in hearing specialist species:
    - Mobile Benthic/Epibenthic – Soft Bottom
    - Mobile Benthic/Epibenthic – Complex
    - Pelagic
    - Prey Species – Benthic/Epibenthic
    - Prey Species – Pelagic

5.1.4.3 Hydrodynamic Effects

The presence of the WTG, OSS, and MET tower foundations during the operation of the Proposed Action would cause hydrodynamic effects, which may include changes in water flow, changes in vertical mixing and associated primary production, and changes in larval distribution patterns. Based on hydrodynamic modeling studies, the presence of offshore wind arrays would disrupt water flow downstream of the foundations.. While impacts on current speed and direction decrease rapidly around monopiles, there is evidence that monopile wakes can extend out to several kilometers (Cazenave et al. 2016; Li et al. 2014; Vanhellemont and Ruddick 2014). However, other studies observed that substantial disruptions to water flow from monopiles were localized. For instance, Schultze et al. (2020) observed that 6-meter (20-foot) monopiles produced elevated turbulence levels that dissipated to background levels within 300 meters (984 feet) downstream of the monopiles, but that strong turbulence was limited to within 50 to 100 meters (164 to 328 feet) downstream of the monopiles. Miles et al. (2017) observed that water currents returned to background levels 8.3 pile diameters downstream of monopiles, suggesting that flow disruptions would occur 90 to 120 meters (300 to 400 feet) downstream of the monopiles being considered for the Proposed Action. The discrepancies in the spatial extent of flow disruptions among studies are likely related to local conditions, wind farm scale, and sensitivity of the analyses. Under the Proposed Action, the WTGs would be spaced 1.1 to 1.9 km (0.6 to 1.0 nautical miles) apart, which is greater than downstream extent of individual hydrodynamic effects observed in studies at other offshore wind facilities. This suggests that hydrodynamic effects would be localized around each monopile and would not produce additive effects across the entire array. These localized hydrodynamic effects would last over the approximate 30-year lifespan of the Proposed Action from completion of construction through decommissioning.

The presence of the monopiles in the water column can introduce small-scale mixing and turbulence that also results in some loss of stratification (Carpenter et al. 2016; Floeter et al. 2017; Schultze et al. 2020). In strongly stratified locations, the mixing seen at monopiles is often masked by processes forcing toward 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). Modeling of offshore wind installation scenarios in the Massachusetts-Rhode Island wind energy area demonstrated that increased mixing introduced by offshore wind structures resulted in a 1- to 2-meter deepening of the thermocline and a retention of colder water inside the offshore wind area through the summer months (BOEM 2021). 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 strength of stratification associated with the Cold Pool (temperature differences between the surface and the Cold Pool reach 18°F [10°C] [Lentz 2017]) may buffer against the effects of increased mixing. Temperature anomalies created by mixing at each monopile would likely resolve quickly because of strong forcing toward stabilization (Schultze et al. 2020).

In addition to their direct effects on mixing and turbulence in the water column, the presence of the monopiles would generate areas of reduced wind speed known as wind wakes, which may drive upwelling/downwelling dipoles (Broström 2008; Nerge and Lenhart 2010). Large monopiles that will be used for future offshore wind projects may generate wind wakes that extend up to 50 km from the edge of the wind farm (Golbazi et al. 2022). Christiansen et al. (2022) developed a hydrodynamic model to simulate the seasonal cycle of the stratification in consideration of wind farm development in the North Sea and observed that wind wakes caused changes in the vertical and lateral flow that were sufficiently strong to alter the temperature and salinity distribution in areas of wind farm operation. In particular, the authors observed large-scale structural changes in stratification strength, including increased summer stratification.

The foundations for 200 WTGs, 4 to 10 OSSs, and MET tower introduced by the Proposed Action are likely to create individual, localized hydrodynamic effects that could have effects on advection of eggs and larvae and food web productivity. Given their planktonic nature, altered circulation patterns could transport pelagic eggs and larvae out of suitable habitat, leading to reduced survival. BOEM (2021) used Agent-Based Models (ABMs) to evaluate how the introduction of commercial scale offshore wind energy facilities in the Massachusetts-Rhode Island (MA-RI) marine areas may affect local and regional oceanic responses (e.g., currents, temperature stratification) and related egg and larval advection patterns. Three representative species (i.e., sea scallop, silver hake, and summer flounder) were selected to evaluate egg and larval transport patterns. The ABMs included numerous variables that are relevant to dispersal and settlement, including mortality and growth, environmental variables (e.g., temperature, depth, salinity), larval swimming speeds, and vertical migration patterns. The ABMs demonstrated that alterations in circulation patterns related to the presence of offshore wind foundations resulted in a spatial shift in larval settlement density, with some areas experiencing higher settlement density and others experiencing reduced settlement density. Further, the authors observed that, depending on the release characteristics of eggs and larvae, altered current direction and speeds either acted independently and/or collectively to cause the observed shifts. Changes in larval distribution and settlement density can affect regional or local abundances, depending on the species and the size of its population network. Effects on egg and larval survival from altered circulation patterns could be offset by increased primary productivity in the wake of the monopiles. Turbulence downstream 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). These offsetting effects are expected to be highly localized and small relative to the size of the Project area and the natural mortality rate of ichthyoplankton.

Pelagic juvenile and adult fish may experience hydrodynamic effects downstream of the WTG, OSS, and MET tower foundations. These effects may include decreased current speeds and changes to seasonal stratification regimes, which could cause reduced habitat suitability for some EFH species in localized areas. Pelagic juveniles and adults would likely avoid habitat with decreased suitability. Hydrodynamic effects are expected to vary depending on seasonal and tidal hydrodynamic cycles.

5.1.5 Operation/Presence of Inter-Array and Offshore/Onshore Cables

5.1.5.1 Power Transmission (EMF, Heat)

The inter-array cables and export cables would generate intermittent magnetic field effects and substrate heating effects whenever they are under power through the life of the Project. These effects would be present whenever winds speeds are sufficient to turn WTGs. As such, these effects are anticipated to be continuous, with intermittent interruptions during periods of no wind. Atlantic Shores conducted an EMF study to predict EMF levels from operation of the Projects' submarine electrical system which includes a combination of HVDC and HVAC cables (Atlantic Shores 2023, Appendix II-I). Because of cable configuration and shielding, electric fields would not be released into the marine environment from Project cable operation, and therefore were not modeled in Appendix II-I and are not further discussed in this assessment. The EMF study estimated the following peak magnetic fields for the inter-array and export cables under maximum power generation:

- 66 kV HVAC inter-array cable: 48 mG
- 150 kV HVAC inter-array cable: 60 mG
- 230 kV HVAC export cable: 104.7 mG
- 230 kV HVAC export cable (at cable crossing): 237.1 mG
- 275 kV HVAC export cable: 107.8 mG
- 275 kV HVAC export cable (at cable crossing): 244.4 mG
- 320 kV HVDC export cable: 152.7 mG
- 320 kV HVDC export cable (at cable crossing): 349.2 mG
- 525 kV HVDC export cable: 2,174.5 mG
- 525 kV HVDC export cable (at cable crossing): 3,305.3 mG

This section provides a description of the potential effects of these magnetic fields on the following EFH groups:

- Benthic habitats used by EFH finfish species having benthic or epibenthic lifestages
- Benthic habitats used by EFH shark and skate species having benthic or epibenthic life stages
- Benthic and infaunal habitats used by EFH shellfish species, and benthic invertebrate prey organisms for EFH species.

EMF Effects on Habitats Used by Benthic or Epibenthic *Finfish*

Several EFH species of finfish and their prey species use benthic or epibenthic habitats at the seabed during their life cycle that overlap with the inter-array cable and export cable paths, including both buried and exposed cable segments. This includes benthic eggs and larvae that could settle in areas along the inter-array cable and export cable corridors. While there are limited species-specific data on sensitivity of finfish to EMF effects, research on fish sensitivity to magnetic fields suggests that the effects of magnetic fields generated by the inter-array cables and export cables would be insignificant for most cable configurations. For example, Cameron et al. (1985) determined that magnetic fields on the order of 1,000 mG are required to produce observable developmental delay on the eggs of euryhaline Japanese rice fish. Brouard et al. (1996) exposed rainbow trout embryos to electrical fields ranging as high as 5,000 mV/m and observed no evident effects on development or subsequent survival. Similarly, data on magnetic field sensitivity for juvenile and adult fish generally indicate that the minimum magnetic field exposure threshold for behavioral effects exceeds 1,000 mG for most fish species (e.g., Armstrong et al. 2015; Bevelhimer et al. 2013; Orpwood et al. 2015). These exposure thresholds are much higher than the largest potential magnetic field levels that would be generated by HVAC cables and 320 kV HVDC during the operation of the Proposed Action. However, 525 kV HVDC cables would potentially generate magnetic fields of up to 2,174.5 mG along the offshore export cable and up to 3,305.3 mG at cable crossings that would exceed thresholds for developmental and behavioral effects. These observations indicate that the EMF effects of electrified cables during Project operations on benthic EFH of finfish and invertebrates would be insignificant for most cable configurations but may be significant for 525 kV HVDC cables.

EMF *Effects on Habitats Used by Sharks and Skates*

Several shark and skate species have one or more life stages that use demersal or epibenthic habitats overlapping the proposed inter-array cable and export cable corridors. The minimum sensitivity of sharks and rays to magnetic fields is unknown, but some species have exhibited behavioral responses to field strengths ranging from 250 to 1,000 mG (Hutchinson et al. 2018, 2020; Normandeau 2011). This threshold range suggests that some species of sharks and rays may exhibit behavioral effects if they encounter magnetic fields at cable crossings of HVAC cables, at cable crossings of 275 kV HVDC cables, or along the length of 525 kV HVDC cables. However, over most of the length of the inter-array and export cables, except for 525 kV HVDC cables, the generated magnetic fields would fall below the behavioral thresholds. Collectively, the available evidence indicates that EMF effects of the inter-array cables and export cables on EFH used by epibenthic and demersal sharks and skates would be insignificant for most cable configurations but may be significant for 525 kV HVDC cables.

EMF and *Heat Effects on Habitats Used by Benthic Invertebrates*

Several benthic invertebrate species have one or more life stages that use benthic habitats overlapping the proposed inter-array cable and export cable corridors. The potential for EMF and heat effects of cable operation on benthic invertebrates is of particular concern because they are sessile and would be exposed to stressors over prolonged periods. The available evidence on invertebrate sensitivity to EMF suggests that the inter-array cables and export cables could produce sufficient EMF to cause adverse effects on benthic invertebrates, but the specific sensitivity of EFH species likely to occur in the cable path remains unclear. Though well-established magnetic field thresholds for benthic invertebrates are lacking, research suggests that marine species may be more likely to detect magnetic fields from DC cables than AC cables (Normandeau 2011). Studies have demonstrated that marine invertebrates may not be able to detect or respond to magnetic fields produced by AC cables that have a frequency of 60 Hz or less, especially at intensities below 50 mG (Normandeau 2011). Magnetic field strength would drop to approximately 50 mG within 5 feet (1.5 m) of the HVAC export cables (Atlantic Shores 2023, Appendix II-I). Applying this value as a conservative physiological effect threshold over the entire length of the HVAC inter-array and export cables amounts to 1,243 acres of EFH exposed to potentially significant EMF effects on habitat suitability. Additionally, bivalves inhabiting inlands waters (e.g., hard clams) that would be traversed by the Cardiff Onshore Interconnection Cable Route, including portions of Chelsea Harbor, Great Thorofare, and Beach Thorofare, would be exposed to EMF during Project operations. Using the physiological threshold for HVAC cables described above, approximately 1.1 acres of EFH would be exposed to potentially significant EMF effects on habitat suitability within these inland waterbodies. Given that HVDC cables were estimated to produce stronger magnetic fields than HVAC cables, particularly for 525 kV HVDC cables, the operation of HVDC cables would likely result in a larger area of EFH being exposed to potentially significant EMF effects on habitat suitability.

In addition to EMF effects, buried segments of the inter-array cables and OECs 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 the cable. 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 cables and export cables would be buried to a minimum depth of 6 feet (1.8 meters) along approximately 90% of their length, heat effects from buried cable segments on benthic infauna are expected to be minimal and permanent.

5.1.5.2 Cable Protection

Community structure changes resulting from installation of cable protection are discussed in detail in Section 5.1.2.4.

5.2 Project Monitoring Activities

5.2.1 HRG Surveys

High-resolution geophysical (HRG) surveys and geotechnical surveys would be required pre-construction. Survey activities would include use of side scan sonar, multibeam echosounder, magnetometers, gradiometers, sub-bottom profilers, vibracores, cone penetrometer tests, and deep borings within the wind farm area and along the export cable route.

HRG surveys would be conducted prior to construction to verify site conditions. A munitions and explosives of concern survey may also be included in pre-construction HRG survey activities. Pre-construction geotechnical surveys would be performed to inform the final design and engineering of each offshore facility.

5.2.2 Passive Acoustic Monitoring

Atlantic Shores must deploy three moored or autonomous passive acoustic monitoring (PAM) devices to continuously record ambient noise and marine mammals in each of the Project 1 and Project 2 areas before construction, during all construction activities, the remaining calendar year following construction, and for at least 3 calendar years of operation following construction.

PAM systems that may be used for monitoring would either be stationary (e.g., moored) or mobile (e.g., towed autonomous surface vehicle, or AUVs). Moored PAM systems include PAM buoys that would be anchored to the seabed using various types of anchors typically employed in a variety of marine research activities. Typical anchor types include small concrete blocks, steel rings, sandbags, or truck tires filled with cement. PAM systems are typically rigged with a surface float to allow for full retrieval of the buoy, rigging, and anchor system. These mooring systems would temporarily introduce new hard structures to the environment that could become colonized by benthic organisms, including invasive species. Encrusting organisms would be removed from the ecosystem upon removal of the PAM anchoring systems. Placement of the anchors would result in sediment disturbance and a short-term increase in suspended sediment near the anchors and would crush any organisms and habitat underneath the anchors. The effects of the anchors on EFH species and habitats would result in short-term and long-term impacts to EFH and managed species. The movement of autonomous PAM systems and the minimal sound they produce could disturb pelagic EFH and could affect pelagic and benthic managed species through collisions or by affecting behavior (e.g., inducing startle responses), but these impacts are very unlikely. Therefore, it is understood that PAM would not change the effects determination for EFH for any species in the EFH assessment.

5.2.3 Fisheries

5.2.3.1 Demersal Otter Trawl Survey

The demersal otter trawl survey would follow a Before-After-Control-Impact (BACI) design with three strata: an "effects" stratum consisting of sites within 0.9 kilometers (0.5 nautical miles) of WTGs, a "close control" stratum consisting of sites 0.9 to 2.8 kilometers (0.5 to 1.5 nautical miles) from WTGs, and a "far control" stratum consisting of sites 2.8 to 5.6 kilometers (1.5 to 3.0 nautical miles) from WTGs. A total of 9 tows would be collected seasonally within each stratum, resulting in a target sample size of 108 tows per year (36 within the WTA and 72 within the control sites). Trawl surveys are scheduled to occur throughout the year, including a winter survey, a spring survey, a summer survey, and a fall survey. The trawls are designed to capture a representative sample of demersal fish species present in the effects and control sites, emphasizing EFH and other species of commercial and recreational interest. The targeted species will be the "A" priority species from the NEAMAP survey: black sea bass, bluefish, pollock, scup, silver hake, striped bass, summer flounder, weakfish, and winter flounder.

The demersal otter trawl survey would directly affect EFH species and their prey through death of most or all of the trawled individuals. In addition to these direct impacts, bottom-disturbing trawls can alter the composition and complexity of soft-bottom benthic habitats. For example, when trawl gear contacts the seabed it can flatten sand ripples, remove epifaunal organisms and biogenic structures like worm tubes, and expose anaerobic sediments (Nilsson and Rosenberg 2003; Rosenberg et al. 2003). However, impacts to EFH species through capture during the trawl survey are not expected to result in population-level impacts. Trawl surveys are not likely to significantly alter the rate and extent of disturbance of soft-bottom benthic habitat relative to the environmental baseline. BOEM therefore expects that demersal otter trawl surveys would not change the effects determination for EFH for any species in the EFH assessment.

5.2.3.2 Trap survey

The trap survey will follow a Before-After-Gradient (BAG) design with sample sites located at regular distances from WTG or OSS locations. The first trap in a transect will be set as close to the WTG (or planned WTG location for baseline survey) as safely possible with remaining traps set along the transect at nearly logarithmic intervals of about 15 meters (50 feet), 50 meters (164 feet), 150 meters (492 feet), 400 meters (1,312 feet), and 1,100 meters (3,608 feet) from the first trap. Unbaited ventless traps with dimensions of 110.5 x 56 x 38 centimeters (43.5 x 22 x 15 inches) with 3.8-centimeter (1.5-inch) mesh will be deployed with a trawl attached to a groundline to prevent gear loss and protected species entanglement. Twelve transects of six traps will be left to soak for two, one-week (5-7 day) periods in each of four seasons (winter, spring, summer, and fall) for a total of 72 traps sampled eight times per year.

Deployment of traps can damage benthic invertebrates on hard bottom benthic habitat, resulting in long-term effects to community composition and complexity (Tamsett et al. 2010). However, hard bottom benthic habitats within the WTA, including the survey area, are regularly targeted by commercial trap and pot fisheries. This indicates that habitat disturbance from trap and pot placement is routine within the WTA and would continue to occur whether or not the trap survey is implemented. Therefore, the trap survey is not expected to adversely alter the composition and complexity of EFH relative to the environmental baseline. Further, effects of trap deployment are expected to be small relative to those that would result from the construction and operation of the WTGs. BOEM therefore expects that this survey would not change the effects determination for EFH for any species in the EFH assessment.

5.2.3.3 Hydraulic Clam Dredge Survey

The hydraulic clam dredge survey would follow a BACI design with three strata: an “effects” stratum consisting of sites within 0.9 kilometers (0.5 nautical miles) of WTGs, a “close control” stratum consisting of sites 0.9 to 2.8 kilometers (0.5 to 1.5 nautical miles) from WTGs, and a “far control” stratum consisting of sites 2.8 to 5.6 kilometers (1.5 to 3.0 nautical miles) from WTGs. Each stratum (effects and both controls) will be sampled with 16 tows (48 total) once a year in the summer. Sampling will be conducted with a 6-foot (72-inch) dredge that is identical to the dredge used in the NJDEP inventory of New Jersey’s surf clam resources survey (NJDFW 2010).

The towed sampling dredge would cause localized and direct impacts to benthic EFH on both hard- and soft-bottom habitat, potentially resulting in long-term effects on community composition. Soft-bottom impacts would be short-term and expected to recover quickly. Commercial fisheries targeting surf clam and ocean quahog fish intensively with hydraulic clam dredges in the WTA. This indicates that habitat disturbance from hydraulic dredges is routine within the WTA and would continue to occur whether or not the clam dredge survey is implemented. Therefore, the clam dredge survey is not expected to adversely alter the composition and complexity of EFH relative to the environmental baseline. Further, effects of dredge operations during the survey are expected to be small relative to those that would result from the construction and operation of the WTGs. BOEM therefore expects that this survey would not change the effects determination for EFH for any species in the EFH assessment.

5.2.4 Benthic Habitat

5.2.4.1 Benthic Grab Survey

Benthic grab samples will be collected in triplicate at 60 stations in the WTA and 66 stations spread across the constructed ECCs for a total of 378 samples per year. A 0.04-meter^2 benthic grab sampler (e.g., Van Veen, Day, Ponar) will be used to retrieve sediments from the upper 10 to 20 centimeters of the seabed by using lever arms to force two halves of a metal bucket closed after the unit has been lowered to the bottom. The collection of benthic grab samples could impact EFH by crushing benthic organisms, disturbing soft-bottom habitat, and creating a short-term increase in suspended sediment. However, these impacts would be short-term and localized to the area within or immediately surrounding the 0.04-meter^2 footprint of the grab sampler. Therefore, BOEM does not expect that the benthic grab samples would change the effects determination for EFH for any species in the EFH assessment.

5.2.4.2 Video Surveys

Video surveys will be conducted along transects at ten WTGs within the WTA and at eleven positions along the ECCs. Transects will run both perpendicular to (300 meters total) and parallel to (100 meters total) the WTG foundation and export cable for a total of 400 meters per WTG or cable position. For all underwater imagery operations, a vessel equipped with dynamic positioning will hold position as close as safely possible to WTG foundations, thereby avoiding impacts from anchoring. During the video transect, the camera will be lowered to about 1 meter above the bottom and the vessel will maintain speeds at or below 1 knot for the duration of the transect. Additionally, post-construction surveys of the fouling communities on WTG foundations and scour protections will be conducted at the WTGs selected for grab samples and video transects. Video surveys of the fouling communities will be conducted using a towed camera sled or ROV with calibrated scaling lasers and an additional dedicated still image camera. The movement of the camera or ROV through the water, lights produced by the camera or ROV, and sound produced by the ROV, could disturb pelagic EFH and could affect pelagic and benthic species through collisions or by impacting behavior (e.g., inducing startle responses), but these impacts are very unlikely. Therefore, BOEM does not expect that the video surveys would change the effects determination for EFH for any species in the EFH assessment.

5.3 Decommissioning

As described in Section 2.4, above, Atlantic Shores would be required to remove and/or decommission all Project infrastructure and clear the seabed of all obstructions when these facilities reach the end of their 30-year designed service life. Decommissioning activities would involve removing WTG, OSS, and MET tower foundations 15 ft (4.6 m) below the mudline. Inter-array cables, export cables, and associated scour protection would either be removed or retired in place, depending on the habitat value they provide. All Project components that are removed would be transported to an appropriate disposal and/or recycling facility.

Vessels involved in decommissioning would generate underwater noise, which may cause temporary behavioral effects on pelagic EFH species similar to those described in Section 5.1.1.1, above. Vessel noise may result in brief periods of exposure near the surface of the water column but is not expected to cause injury, hearing impairment or long-term masking of biologically relevant cues in fish and invertebrates.

If the cable protection is left in place, hard-bottom habitat would remain along parts of the cable corridors and would continue to support an assemblage of EFH species associated with complex benthic habitat. Removal of the cables would disturb soft-bottom habitat and would cause temporary impacts on EFH species with benthic or epibenthic life stages (e.g., crushing or burial, sediment suspension and deposition) similar to those described for cable emplacement in Section 5.1.2.3, above. Removal of the scour protection would convert hard-bottom habitat to soft-bottom habitat and would likely result in a recolonization by EFH species preferring soft-bottom sand and fine-sediment habitat and the loss of any EFH species associated with complex benthic habitat.

5.4 Cumulative and Synergistic Effects to EFH

In addition to the two existing offshore wind facilities in U.S. waters, there are over 30 offshore wind projects that are planned for construction in the Mid-Atlantic and New England from 2023 through 2030, including the Proposed Action. Collectively, the construction and operation of these facilities would impact EFH and EFH species primarily through seafloor disturbance during cable emplacement, pile driving noise, habitat conversion, hydrodynamic changes, and EMF. The cumulative and synergistic effects of each of these IPFs are discussed in the following paragraphs.

Planned offshore wind development, including the Proposed Action, would place thousands of miles of buried or armored cable along transmission corridors and interarray connections, disturbing more than 184,000 acres of seafloor. Cable emplacement and would disturb, displace, and injure or kill finfish and invertebrates, release sediment into the water column, and cause habitat alterations. As described in Section 5.1.2, above, mobile finfish and invertebrates are likely to move away from cable-laying equipment, but immobile or slow-moving demersal species and life stages (e.g., eggs, larvae) may be injured or killed by the equipment. Some types of equipment that are used to prepare the seabed prior to cable emplacement (e.g., hydraulic dredges) use water withdrawals, which can entrain planktonic eggs and larvae with assumed 100-percent mortality of entrained individuals. Suspended sediment and sediment deposition associated with cable emplacement may cause impacts on EFH and EFH species out to several hundred meters, including behavioral changes in fish and invertebrates and burial of sessile species and life stages. Seabed preparation prior to cable emplacement would cause short-term disturbances of soft-bottom habitat and long-term disturbances of complex habitat, which may require several years to recover.

Planned offshore wind projects, including the Proposed Action, would generate pile driving noise during the installation of up to 2,941 WTG and 66 foundations, which would cause instantaneous behavioral effects and cumulative injurious effects over distances of up to several kilometers from each foundation. The Proposed Action would install foundations for 200 WTGs, 4 to 10 OSSs, and 1 MET tower (up to 211 foundations) from 2026 through 2027, which would overlap with the construction period of several other offshore wind projects. Pile driving noise generated by these projects would temporarily make the surrounding habitat less suitable and cause individuals to vacate the area of project activities. Pile driving is anticipated to cause adverse impacts to EFH for both pelagic and demersal life stages; however, this impact will be short-term, as EFH is expected to return to pre-pile driving conditions.

The primary impacts of the Proposed Action on EFH would result from the presence of structures, including foundations for up to 200 WTGs, 4 to 10 OSSs, and 1 MET tower, 202.6 to 277.3 acres of foundation scour protection, and 360.6 to 385.4 acres of cable protection for the inter-array and export cables. Planned and existing offshore wind activities, including the Proposed Action, would install or continue to operate up to 2,948 WTG and 68 OSS foundations, 4,344 acres of foundation scour protection, and 2,662 acres of cable protection. BOEM anticipates that structures would be added intermittently over an assumed 5-year period and that they would remain until decommissioning of each facility is complete. These structures would be constructed on mostly sandy seafloor and would therefore primarily convert soft-bottom habitat to hard-bottom habitat. The installation of these structure would result in a permanent loss of EFH for epibenthic and benthic finfish and invertebrates that associate with soft-bottom habitat (e.g., clams, flounders, skates). New structures could affect migration patterns of species that prefer complex habitat by providing unique, complex features (relative to the primarily sandy seafloor). This could lead to retention of those species and possibly impact spawning opportunities. Complex habitat and its associated faunal communities are limited in the Mid-Atlantic, and it is possible that additional habitat would facilitate the expansion of these communities. The structures would create an “artificial reef effect,” whereby more sessile and benthic organisms would likely colonize over time (e.g., sponges, algae, mussels, shellfish, sea anemones). Higher densities of invertebrate colonizers would provide a food source and habitat to other invertebrates such as mobile crustaceans. With new foundations being added from additional offshore wind farms, EFH for fishes and invertebrates adapted to complex habitat would increase, but at the expense of EFH for species that are typically associated with soft-bottom habitat. Potential benefits of added complex habitat may be offset if the colonizable habitat provides steppingstones for non-native species. Given the duration over which the monopiles from these projects will remain in the water column (~30 years) and that non-native species have been observed to tolerate higher water temperatures than native species, the presence of these structures may interact synergistically with warming ocean temperatures to promote the establishment of invasive species.

Planned and existing offshore wind activities, including the Proposed Action, would collectively operate up to 2,948 WTG foundations and 68 OSS foundations in the waters of the Mid-Atlantic and New England by 2030. As described in Section 5.1.3.3, above, the presence of these foundations would cause hydrodynamic effects, potentially including changes in water flow, changes in vertical mixing and associated primary production, and changes in larval distribution patterns. NOAA consensus on other projects in the region is that hydrodynamic effects would be limited to within a few hundred meters of the monopiles, such that hydrodynamic effects would be localized around each monopile and are not expected to produce additive effects across offshore wind facilities. These localized hydrodynamic effects would last over the lifespan of each of the projects from completion of construction through decommissioning.

Planned and existing offshore wind activities, including the Proposed Action, would collectively install over 11,000 miles of export and interarray cables in the waters of the Mid-Atlantic and New England. Operation of these cables would increase the presence of EMF in the surrounding waters. EMF strength rapidly decreases with distance from cables and would mostly be confined to within a few meters of cable corridors. As discussed in Section 5.1.4.1, above, EMF levels generated by export and interarray cables are expected to be insufficient to cause impacts on any life stages of finfish. However, because they are sessile and would be exposed to stressors over prolonged periods, benthic invertebrates may be subjected to physiological effects of EMF within 10 meters of cables. In addition to EMF effects, buried segments of the interarray cables and OECs would generate sufficient heat to raise the temperature of the surrounding sediments by as much as 10 to 20 °C above ambient within 1 to 2 feet of the cable. Substrate temperature changes of this magnitude could adversely affect habitat suitability for juvenile and adult life stages of Atlantic surf clam and ocean quahog, as well as other benthic infauna species. Because transmission cables would be buried along most of their length, heat effects from cable operations on benthic infauna are expected to occur over only a small area. EMF impacts on EFH habitat suitability would persist continuously over the operating life of each project.

6. Avoidance, Minimization, and Mitigation

This section describes avoidance and minimization measures, mitigation measures, and environmental monitoring proposed by Atlantic Shores that are intended to avoid, minimize, mitigate, and monitor potential Project impacts on EFH-designated species and EFH during construction, O&M, and decommissioning.

6.1 Avoidance and Minimization Measures

Atlantic Shores has proposed several Protection Measures that are intended to avoid and/or minimize potential Project impacts. Protection Measures that are relevant to EFH-designated species and EFH are summarized by project component in Table 6-1. Atlantic Shores would further evaluate the need for additional avoidance and minimization measures as the Projects progress through development and permitting and in cooperation and coordination with Federal and State jurisdictional agencies and other stakeholders.

Table 6-1. Proposed Avoidance and Minimization Measures Included in the Proposed Action

Protection Measures	Project Component			Expected Effects
	WTGs and OSSs	Inter-array Cables	Export Cables	
Comprehensive benthic habitat surveys (seafloor sampling, imaging, and mapping) have been conducted in coordination with BOEM and NOAA to support identification of sensitive and complex habitat and the development of strategies for minimizing impacts to identify areas to the maximum extent practicable.	X	X	X	Avoid or minimize disturbance of sensitive habitats
Use HDD to avoid or minimize seabed disturbance impacts on benthic habitat at the landfall sites. All HDD activities would be managed by an HDD Contingency Plan for the Inadvertent Releases of Drilling Fluid to ensure the protection of marine and inland surface waters from an accidental release of drilling fluid. All drilling fluids would be collected and recycled upon HDD completion.			X	Avoid or minimize disturbance of benthic habitats. Minimize risk of accidental releases
Bury interarray, inter-link, and export cables to a target depth of 5 to 6.5 feet (1.5 to 2 meters), which would allow the benthic community to recover and recolonize, avoiding direct interaction with benthic invertebrates, and minimize impacts from EMF.		X	X	Minimize EMF and heat effects
Use dynamically positioned vessels and jet plow embedment to the maximum extent practicable to reduce sediment disturbance during cable laying process.		X	X	Minimize habitat disturbance
Operate vessels in compliance with regulatory requirements related to the prevention and control of discharges and accidental spills.	X	X	X	Minimize risk of accidental releases
Manage accidental spills or release of oils or other hazardous materials through the OSRP.	X	X	X	Minimize risk of accidental releases
Use anchor midline buoys on anchored construction vessels, where feasible, to minimize seabed disturbance.	X	X	X	Minimize habitat disturbance
Employ an anchoring plan for areas where anchoring is required to avoid impacts on sensitive habitats, to the maximum extent practicable, including hard bottom and structurally complex habitats, identified through the interpretation of site-specific HRG and benthic assessments.	X	X	X	Avoid disturbance of sensitive habitats
Soft starts and gradual "ramp-up" procedures (i.e., gradually increasing sound output levels) would be employed for activities such as pile driving to allow mobile individuals to vacate the area during noise-generating activities.	X			Minimize impact pile driving effects
During impact pile driving, a noise abatement system consisting of one or more available technologies (e.g., bubble curtains evacuated sleeve systems, encapsulated bubble systems, Helmholtz resonators) would be implemented to decrease the propagation of potentially harmful noise.	X			Minimize impact pile driving effects
Nearshore cable installation activities would be conducted outside of the anticipated peak period of sandbar shark nursery and pupping activity between June 1 and September 1		X	X	Avoid impacts to sandbar HAPC

6.2 Mitigation

Atlantic Shores has not proposed any mitigation to offset potential Project impacts on EFH-designated species and EFH. Atlantic Shores would further evaluate the need for mitigation as the Projects progress through development and permitting and in cooperation and coordination with Federal and State jurisdictional agencies and other stakeholders.

6.3 Alternative Project Designs that Could Avoid/Minimize Impacts

6.3.1 Alternative C – Habitat Impact Minimization/Fisheries Habitat Impact Minimization

Alternative C was developed through the scoping process for the Draft EIS in response to comments received from the Mid-Atlantic Fishery Management Council (MAFMC), New England Fishery Management Council (NEFMC), NMFS, and the Environmental Protection Agency (USEPA). Alternative C includes four sub-alternatives, which would avoid entirely, or in part, two areas of concern (AOCs) identified by NMFS within the Lease Area that have pronounced bottom features and produce valuable habitat. AOC 1 is part of a designated recreational fishing area called "Lobster Hole," and AOC 2 is part of a sand ridge (ridge and swale) complex. The layout and number of WTGs and OSSs would be adjusted to avoid and minimize potential impacts on these identified habitats.

Generally, sand ridge and trough features are physical features that are found throughout the OCS in the mid-Atlantic and provide habitat for various species. Ridge and swale habitat provide complex physical structures that affect the composition and dynamics of ecological communities, with increased structural complexity often leading to greater species diversity, abundance, overall function, and productivity. In the mid-Atlantic sand ridges and troughs are areas of biological significance for migration and spawning of mid-Atlantic fish species, many of which are recreationally targeted in those specific areas. Although the overall artificial reef effect would be decreased by reducing the total number of WTGs in the Lease Area, the biological benefits of preserving natural fish habitat may be beneficial. Each of the sub-alternatives may be individually selected or combined with any or all other alternatives, subject to the combination meeting the purpose and need.

6.3.1.1 Alternative C1 – Lobster Hole Avoidance

Alternative C1 would avoid and minimize the potential impacts on the Lobster Hole (AOC 1), a designated recreational fishing area, by removing up to 16 WTGs, 1 OSS, and associated interarray cables, as shown on Figure 6-1.

Alternative C1 would result in a reduction in the number of foundations and a reduction in the length of interarray cables, such that the impacts associated with the installation and operations of these Project components, as discussed in Section 5, would be reduced. Depending on the types of foundations that are installed, Alternative C1 would result in temporary impacts on 2,904 to 3,078 acres of benthic habitat and permanent impacts on 545 to 643 acres of benthic habitat (Table 10-2). Alternative C1 would result in 2.9 percent and 4.4 percent reductions in the maximum temporary and permanent impacts on benthic habitat compared to the Proposed Action, including 8.8 and 17.1 percent reductions in temporary and permanent impacts on heterogeneous complex habitat.

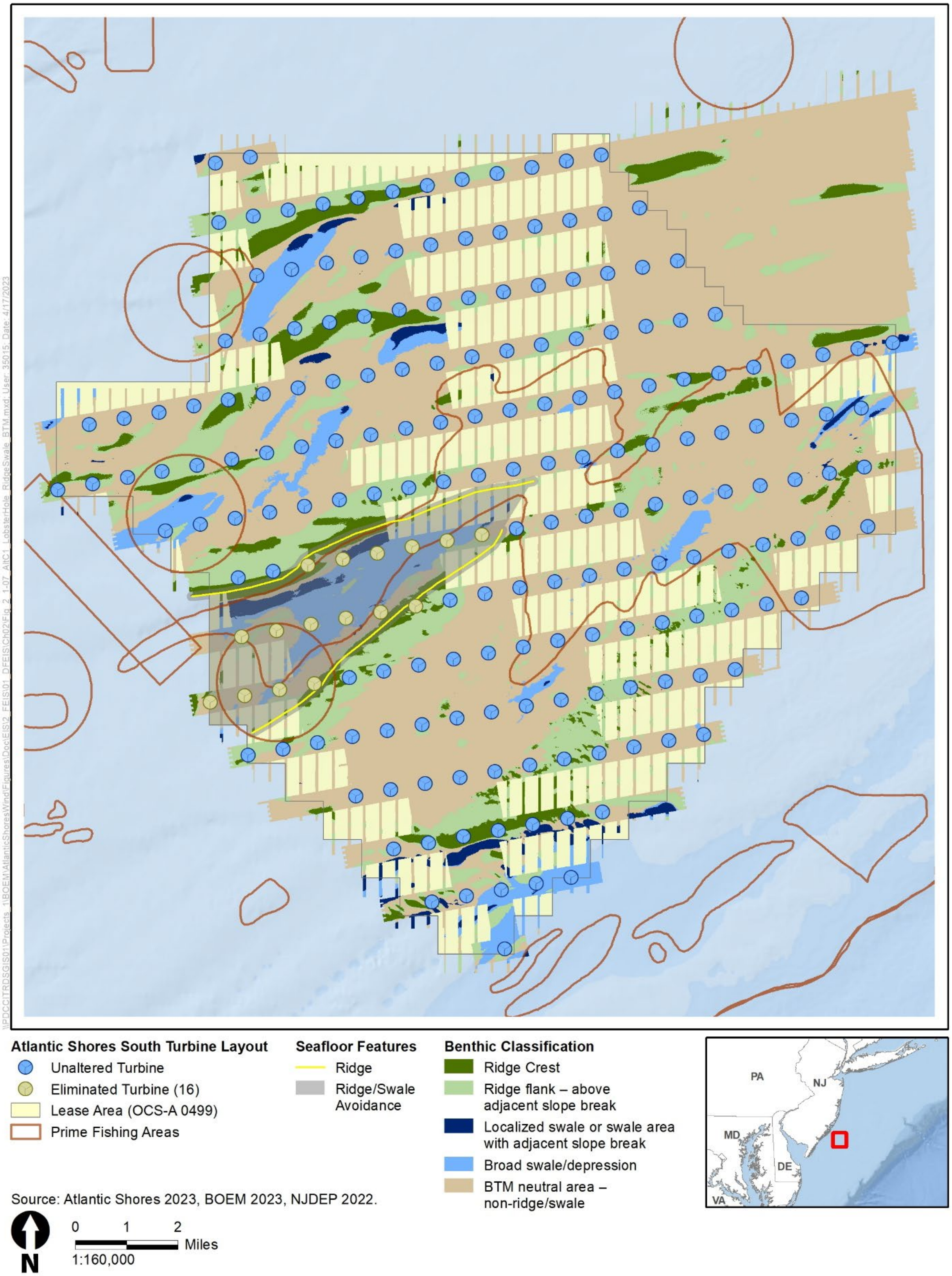


Figure 6-1. Alternative C1 – Lobster Hole Avoidance

6.3.1.2 Alternative C2 – Sand Ridge Complex Avoidance

Alternative C2 would avoid and minimize potential impacts on the sand ridge features in the southern-most portion of the Lease Area (AOC 2) by removing up to 13 WTGs and associated interarray cables within the NMFS-identified sand ridge complex (Figure 6-2).

Alternative C2 would result in a reduction in the number of foundations and a reduction in the length of interarray cables, such that the impacts associated with the installation and operations of these Project components, as discussed in Section 5, would be reduced. Depending on the types of foundations that are installed, Alternative C2 would result in temporary impacts on 2,918 to 3,095 acres of benthic habitat and permanent impacts on 549 to 648 acres of benthic habitat. Alternative C2 would result in 2.4 percent and 3.7 percent reductions in the maximum temporary and permanent impacts on benthic habitat compared to the Proposed Action. Further, Alternative C2 would result in reduced impacts on non-complex soft-bottom habitat, including ripples, which provides EFH for some species in the area (e.g., hakes, flounders).

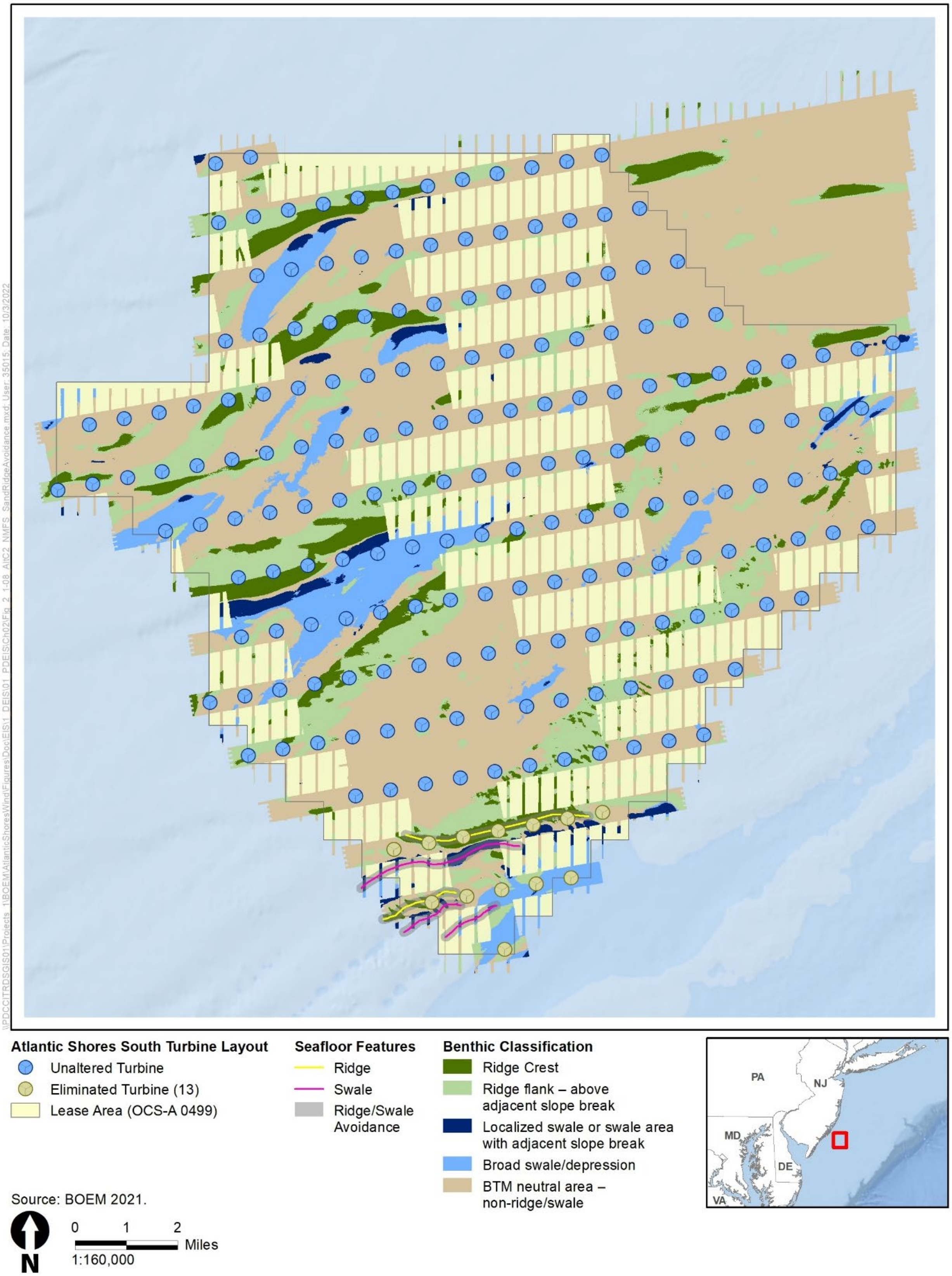


Figure 6-2. Alternative C2 –Sand Ridge Complex Avoidance

6.3.1.3 Alternative C3 – Demarcated Sand Ridge Complex Avoidance

Alternative C3 would remove up to 6 WTGs and associated interarray cables within 1,000 feet (305 meters) of the sand ridge complex area identified by NMFS, but further demarcated using NOAA's Benthic Terrain Modeler and bathymetry data provided by Atlantic Shores (Figure 6-3).

Alternative C3 would result in a reduction in the number of foundations and a reduction in the length of interarray cables, such that the impacts associated with the installation and operations of these Project components, as discussed in Section 5, would be reduced. Depending on the types of foundations that are installed, Alternative C3 would result in temporary impacts on 2,953 to 3,136 acres of benthic habitat and permanent impacts on 561 to 661 acres of benthic habitat (Table 10-4). Alternative C3 would result in 1.1 percent and 1.7 percent reductions in the maximum temporary and permanent impacts on benthic habitat compared to the Proposed Action. Further, Alternative C2 would result in reduced impacts on non-complex soft-bottom habitat, including ripples, which provides EFH for some species in the area.

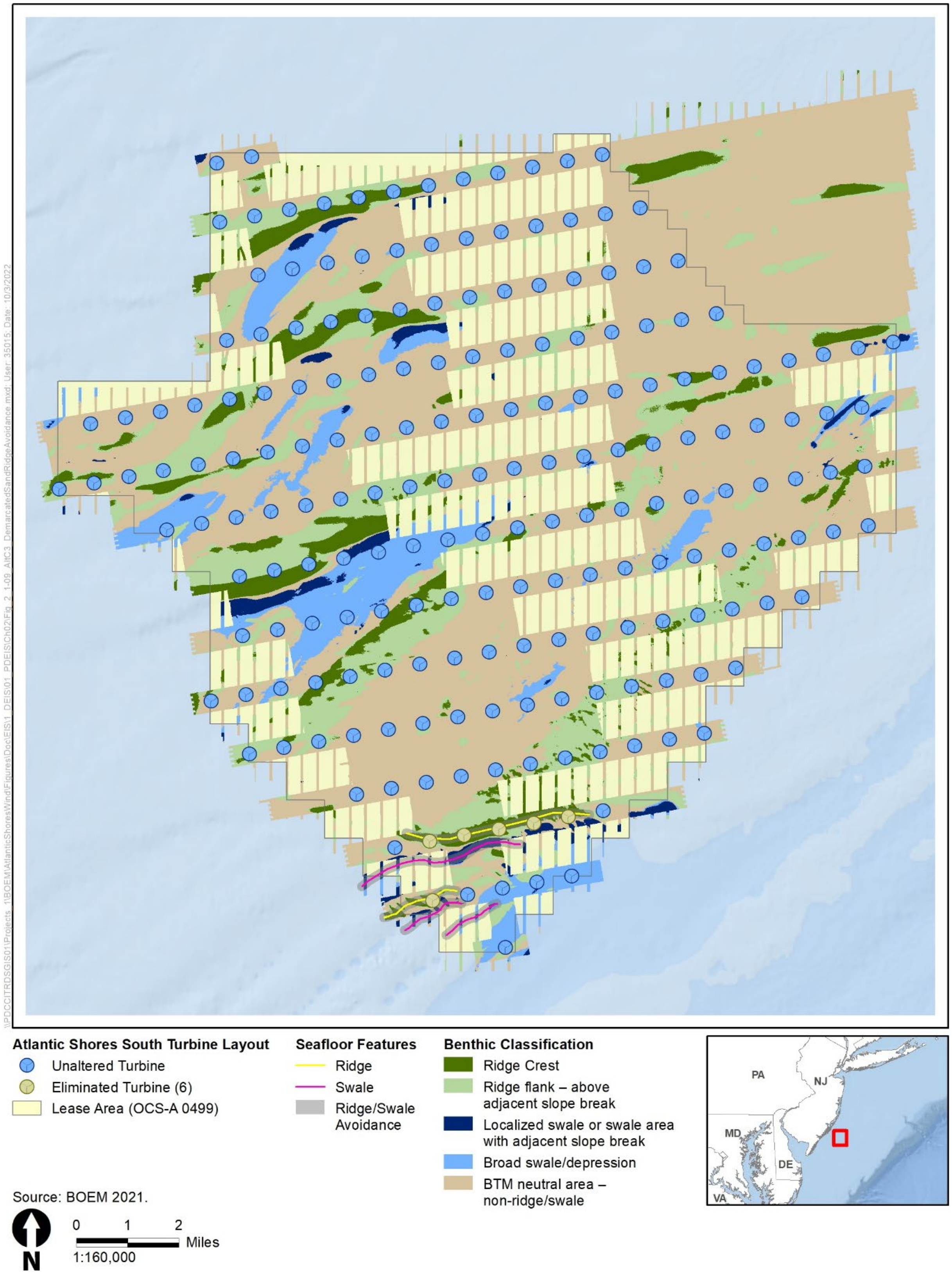


Figure 6-3. Alternative C3 – Demarcated Sand Ridge Complex Avoidance

6.3.1.4 Alternative C4 – Applicant-Proposed Micrositing

Alternative C4 was proposed by Atlantic Shores and would involve the micrositing of 29 WTGs, 1 OSS, and associated interarray cables outside of the 1,000-foot (305-meter) buffer of the ridge and swale features within both AOC 1 and AOC 2. Micrositing would be undertaken to reduce impacts on complex habitat but would not materially change the grid layout (e.g., generally within 500 feet [152 meters] of foundation locations) that is necessary to preserve safe navigation conditions and USCG Search and Rescue missions.

6.3.2 Alternative D – No Surface Occupancy at Select Locations to Reduce Visual Impacts

Alternative D was developed through the scoping process for the Draft EIS in response to public comments concerning the visual impacts of the Atlantic Shores South Project. Under Alternative D, no surface occupancy would occur within defined distances to shore to reduce the visual impacts of the proposed Project. The remaining range of design parameters for Project components and activities to be undertaken for construction and installation, O&M, and conceptual decommissioning would be the same as described in the Proposed Action. Alternative D includes three sub-alternatives where the number of WTGs and turbine heights would be adjusted to reduce visual impacts. Each of the sub-alternatives may be individually selected or combined with any or all other alternatives, subject to the combination meeting the purpose and need.

6.3.2.1 Alternative D1 – No Surface Occupancy Up to 12 Miles (19.3 Kilometers) from Shore: Removal of Up to 21 Turbines

Alternative D1 would result in the exclusion of up to 21 WTG positions in Project 1 within 12 miles (19.3 kilometers) from shore (Figure 6-4). The remaining turbines in Project 1 would be restricted to a maximum hub height of 522 feet (159 meters) AMSL and maximum blade tip height of 932 feet (284 meters) AMSL. The overall exclusion of WTG positions would result in a reduced annual energy production and BOEM is continuing to assess the energy production impact and feasibility of this alternative. The final number of WTG positions considered for exclusion in the Final EIS may be reduced to fewer than 21 to ensure consistency with the 1,510-MW nameplate capacity and annual allowance to awarded to Atlantic Shores by BPU, and any additional offtake agreements that are finalized prior to the Final EIS.

Alternative D1 would result in a reduction in the number of foundations and a reduction in the length of interarray cables, such that the impacts associated with the installation and operations of these Project components, as discussed in Section 5, would be reduced. Depending on the types of foundations that are installed, Alternative D1 would result in temporary impacts on 2,877 to 3,047 acres of benthic habitat and permanent impacts on 534 to 632 acres of benthic habitat (Table 10-5). Alternative D1 would result in 3.9 percent and 6.1 percent reductions in the maximum temporary and permanent impacts on benthic habitat compared to the Proposed Action, including a 7.9 percent reduction in permanent impacts on soft-bottom habitat. Alternative D1 would remove WTG positions from an area that contains non-complex soft-bottom habitat, including ripples, which provides EFH for some species in the area.

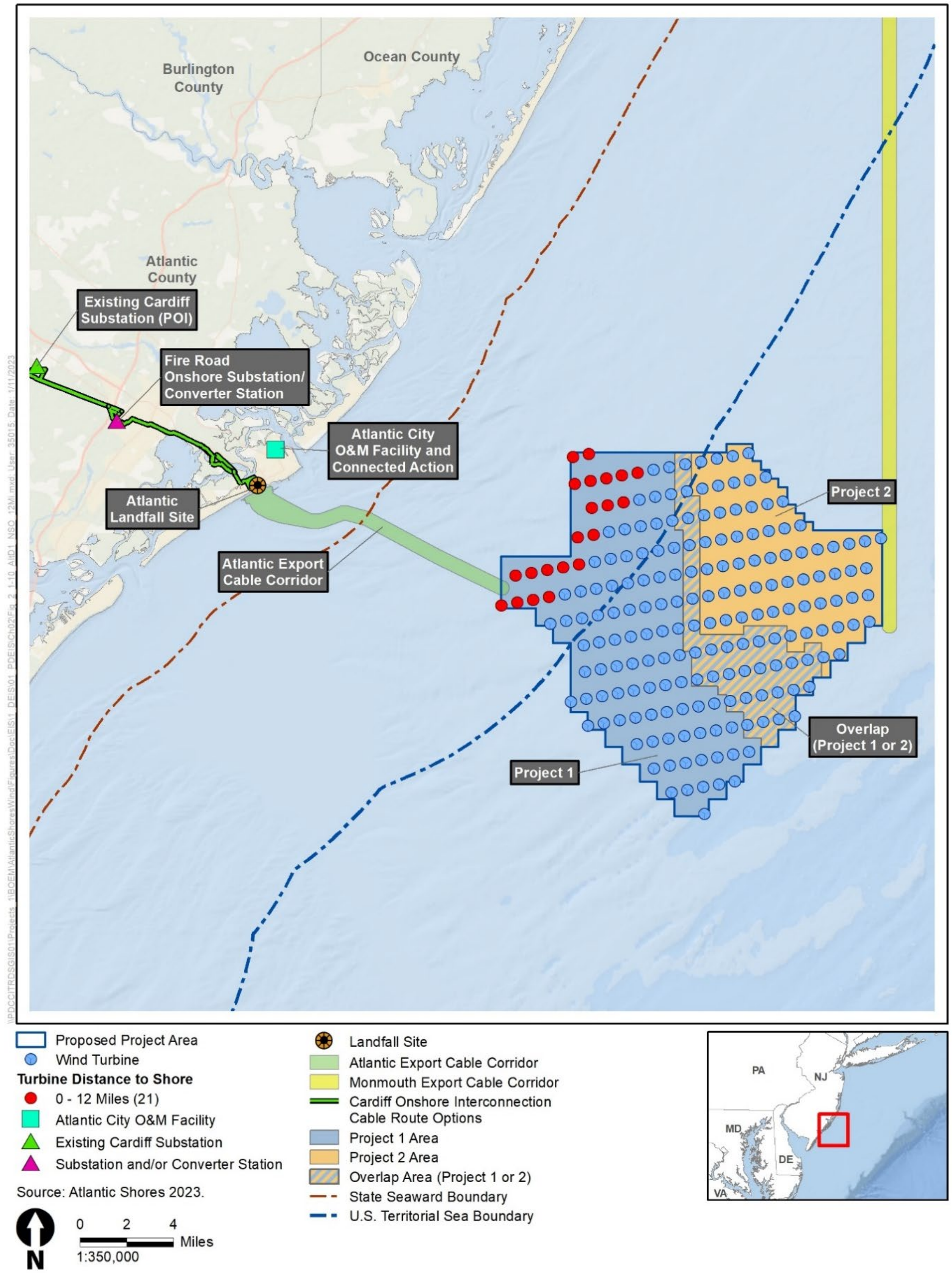


Figure 6-4. Alternative D1 – No Surface Occupancy Up to 12 Miles (19.3 Kilometers) from Shore: Removal of Up to 21 Turbines

6.3.2.2 Alternative D2 – No Surface Occupancy Up to 12.75 Miles (20.5 Kilometers) from Shore: Removal of Up to 31 Turbines

Alternative D2 would result in the exclusion of up to 31 WTG positions in Project 1 that are sited closest to shore (Figure 6-5). The remaining turbines in Project 1 would be restricted to a maximum hub height of 522 feet (159 meters) AMSL and maximum blade tip height of 932 feet (284 meters) AMSL. The overall exclusion of WTG positions would result in reduced annual energy production and BOEM is continuing to assess the energy production impact and feasibility of this alternative. The final number of WTG positions considered for exclusion in the Final EIS may be reduced to fewer than 31 to ensure consistency with the 1,510-MW nameplate capacity and annual allowance awarded to Atlantic Shores by BPU, and any additional offtake agreements that are finalized prior to the Final EIS.

Alternative D2 would result in a reduction in the number of foundations and a reduction in the length of interarray cables, such that the impacts associated with the installation and operations of these Project components, as discussed in Section 5, would be reduced. Depending on the types of foundations that are installed, Alternative D2 would result in temporary impacts on 2,826 to 2,988 acres of benthic habitat and permanent impacts on 516 to 613 acres of benthic habitat (Table 10-6). Alternative D2 would result in 5.8 percent and 8.9 percent reductions in the maximum temporary and permanent impacts on benthic habitat compared to the Proposed Action, including a 10.7 percent reduction in permanent impacts on soft-bottom habitat. Alternative D2 would remove WTG positions from an area that contains non-complex soft-bottom habitat, including ripples, which provides EFH for some species in the area.

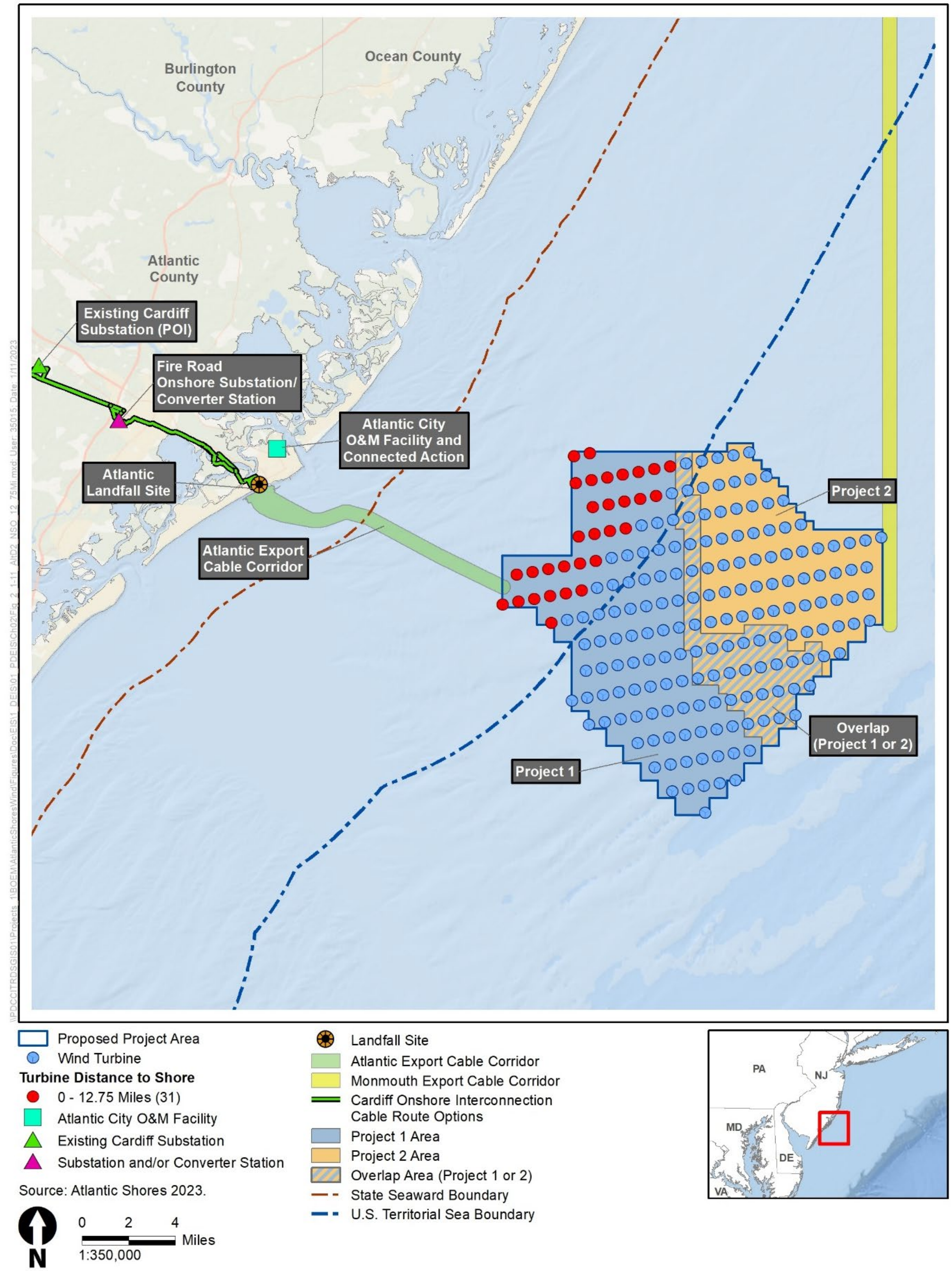


Figure 6-5. Alternative D2 – No Surface Occupancy Up To 12.75 Miles (20.5 Kilometers) from Shore: Removal of Up to 31 Turbines

6.3.2.3 Alternative D3 – No Surface Occupancy Up to 10.8 Miles (17.4 Kilometers) from Shore: Removal of Up to 6 Turbines

Alternative D3 would result in the exclusion of up to 6 WTG positions in Project 1 that are sited closest to shore (Figure 6-6). The remaining turbines in Project 1 would be restricted to a maximum hub height of 522 feet (159 meters) AMSL and maximum blade tip height of 932 feet (284 meters) AMSL.

Alternative D3 would result in a reduction in the number of foundations and a reduction in the length of interarray cables, such that the impacts associated with the installation and operations of these Project components, as discussed in Section 5, would be reduced. Depending on the types of foundations that are installed, Alternative D3 would result in temporary impacts on 2,953 to 3,136 acres of benthic habitat and permanent impacts on 561 to 661 acres of benthic habitat (Table 10-7). Alternative D3 would result in 1.1 percent and 1.7 percent reductions in the maximum temporary and permanent impacts on benthic habitat compared to the Proposed Action. Alternative D3 would remove WTG positions from an area that contains non-complex soft-bottom habitat, including ripples, which provides EFH for some species in the area.

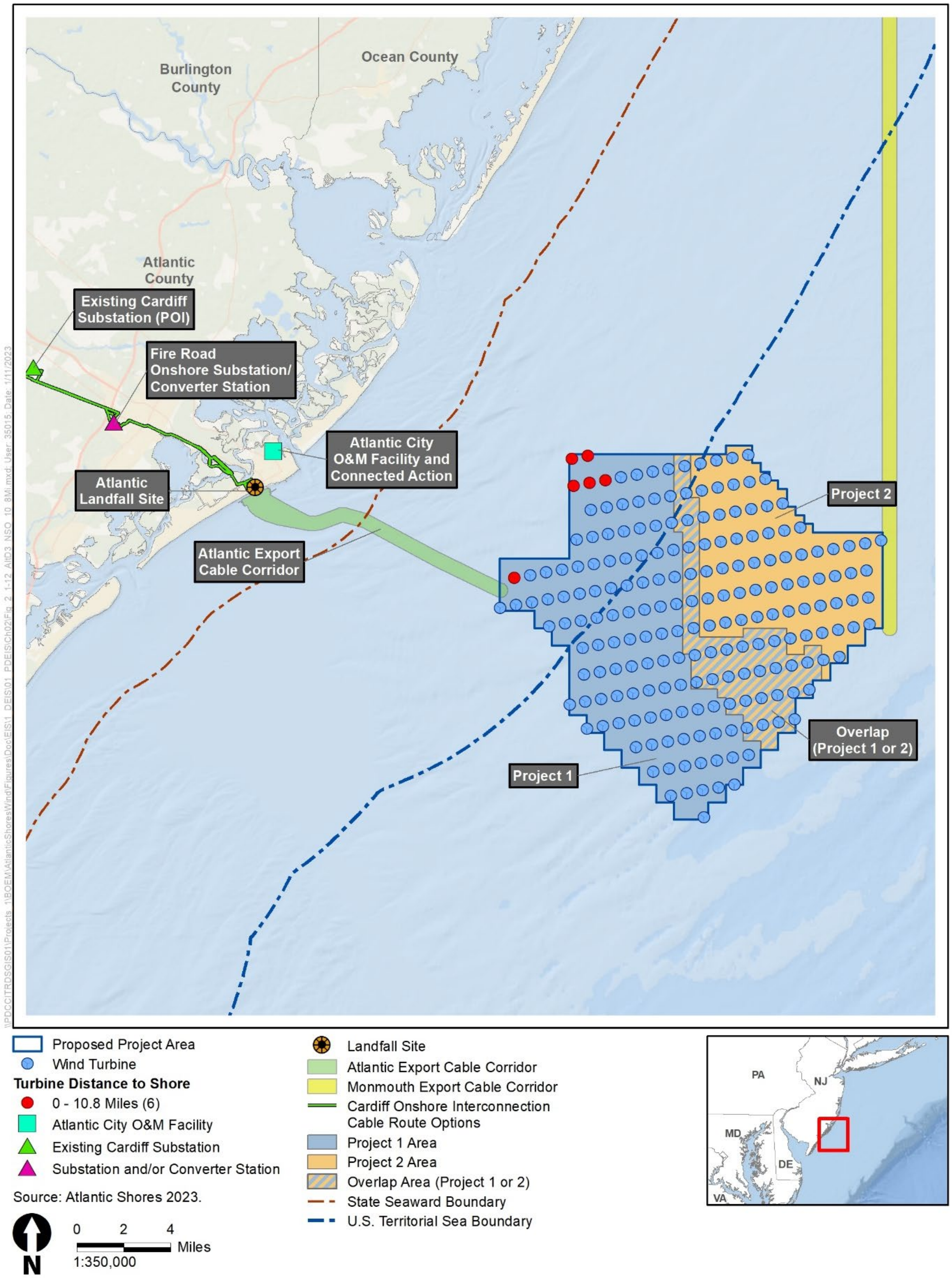


Figure 6-6. Alternative D3 – No Surface Occupancy Up To 10.8 Miles (17.4 Kilometers) from Shore: Removal of Up to 31 Turbines

6.3.3 Alternative E – Wind Turbine Layout Modification to Establish a Setback between Atlantic Shores South and Ocean Wind 1

Alternative E was developed through the scoping process for the Draft EIS in response to comments received from the Responsible Offshore Development Alliance (RODA) concerning the different layouts between the Atlantic Shores South and Ocean Wind 1 projects and the need for a setback between the adjacent areas. Modifications would be made to the wind turbine array layout to create a 0.81-nautical-mile (1,500-meter) to 1.08-nautical-mile (2,000-meter) setback between WTGs in the Atlantic Shores South Lease Area (OCS-A 0499) and the Ocean Wind 1 Lease Area (OCS-A 0498) to reduce impacts on existing ocean uses, such as commercial and recreational fishing and marine (surface and aerial) navigation (7).

This alternative would result in no surface occupancy along the southern boundary of the Atlantic Shores South Lease Area through the exclusion or micrositing of up to 4 to 5 WTG positions. Ocean Wind 1 is currently proposing a layout[2] with a goal of creating a total buffer distance of 0.81 nautical mile (1,500 meters) between WTGs in both projects; however, Ocean Wind 1 would need to modify its wind turbine layout in order to create a total buffer distance greater than 0.81 nautical mile (1,500 meters) This EFH assessment only analyzes the portion of the setback within the Atlantic Shores South Lease Area. A setback would provide a clear visual distinction between the separate projects and provide for sufficient maneuvering space for both surface and aerial (helicopter) navigation.

If the WTG positions were excluded from the setback area, Alternative E would result in a reduction in the number of foundations and a reduction in the length of interarray cables, such that the impacts associated with the installation and operations of these Project components, as discussed in Section 5, would be reduced. Depending on the types of foundations that are installed and if the foundations are excluded from the setback area, Alternative E would potentially result in temporary impacts on 2,960 to 3,143 acres of benthic habitat and permanent impacts on 564 to 663 acres of benthic habitat (Table 10-8). Alternative E would result in 0.9 percent and 1.4 percent reductions in the maximum temporary and permanent impacts on benthic habitat compared to the Proposed Action.

[2] Ocean Wind, LLC and Atlantic Shores Offshore Wind, LLC in coordination with USCG, developed a mutually agreeable scenario for the Ocean Wind 1 and Atlantic Shores South projects, which was documented in a joint letter signed by both developers on July 21, 2022. This scenario is covered in the setback range identified in Alternative E.

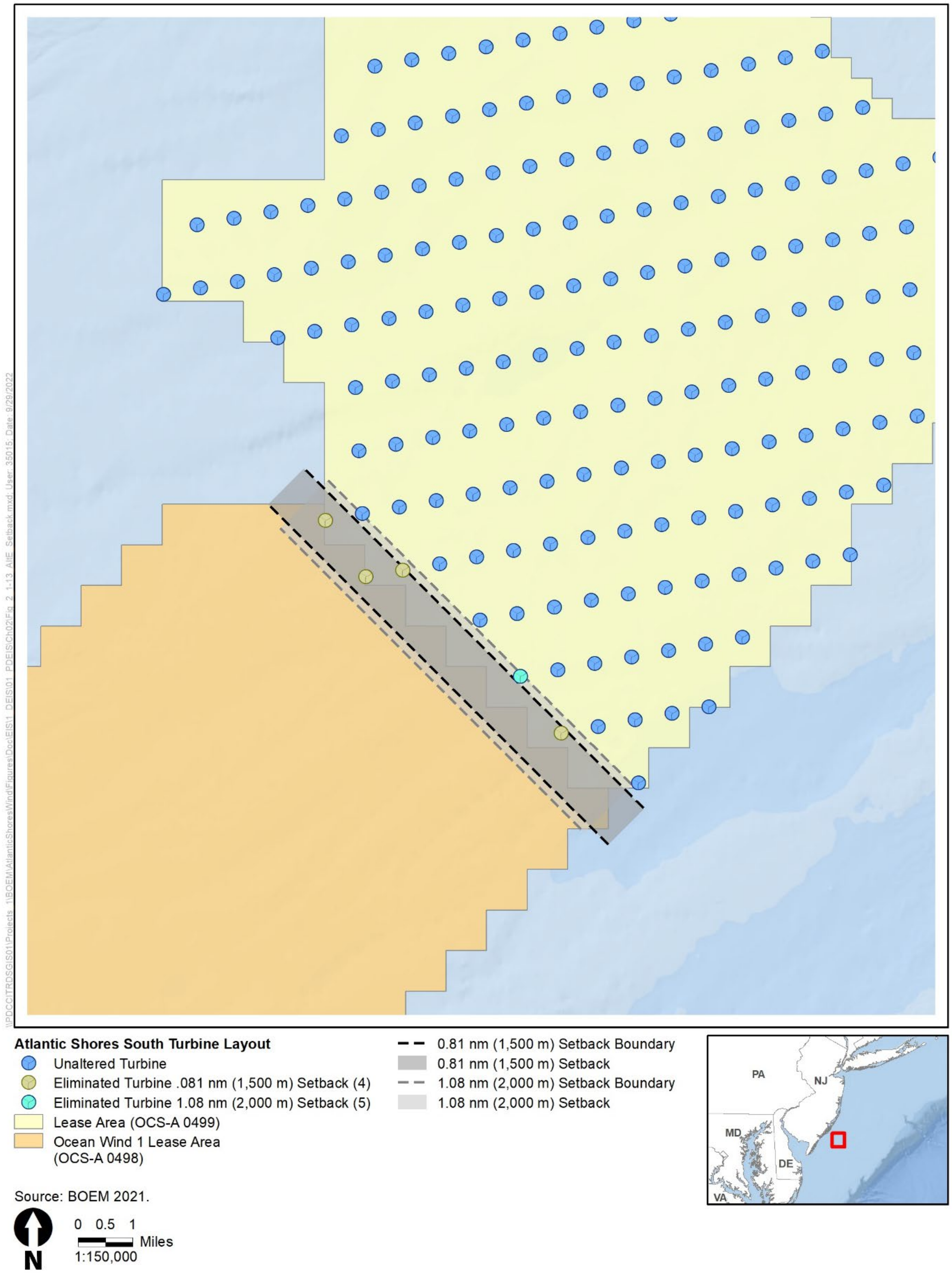


Figure 6-7. Alternative E – Wind Turbine Layout Modification to Establish a Setback between Atlantic Shores South and Ocean Wind 1

6.3.4 Alternative F – Foundation Structures

Alternative F was developed through the scoping process for the Draft EIS in response to comments, as well as options posed in the COP. Alternative F addresses the possibility for one or more foundation types to be utilized for WTGs, OSSs, and the permanent met tower, and includes three sub-alternatives that detail the different foundation structures. Depending on the final OSS design, there would be up to five small OSSs, two medium OSSs, or two large OSSs for Project 1; and up to five small OSSs, three medium OSSs, or two large OSSs for Project 2. The type of OSS foundation used depends on the size of the OSS itself as shown in Table 6-2. For the small OSS, the PDE for each foundation type is identical to the PDE for the WTG foundations. The total foundation footprint, temporary seabed impacts, and combined impacts are all higher for the large OSSs; however, the total temporary seabed disturbance area is slightly higher for the small OSSs. The foundation options for the met tower include all options under consideration for WTG foundations, and the construction methodologies for the met tower are assumed to be the same as those for the WTG foundations. Different foundation types could be used for Project 1 and Project 2 and for different components within each project. The foundation type selected for the WTGs may be different from the foundation type selected for OSSs.

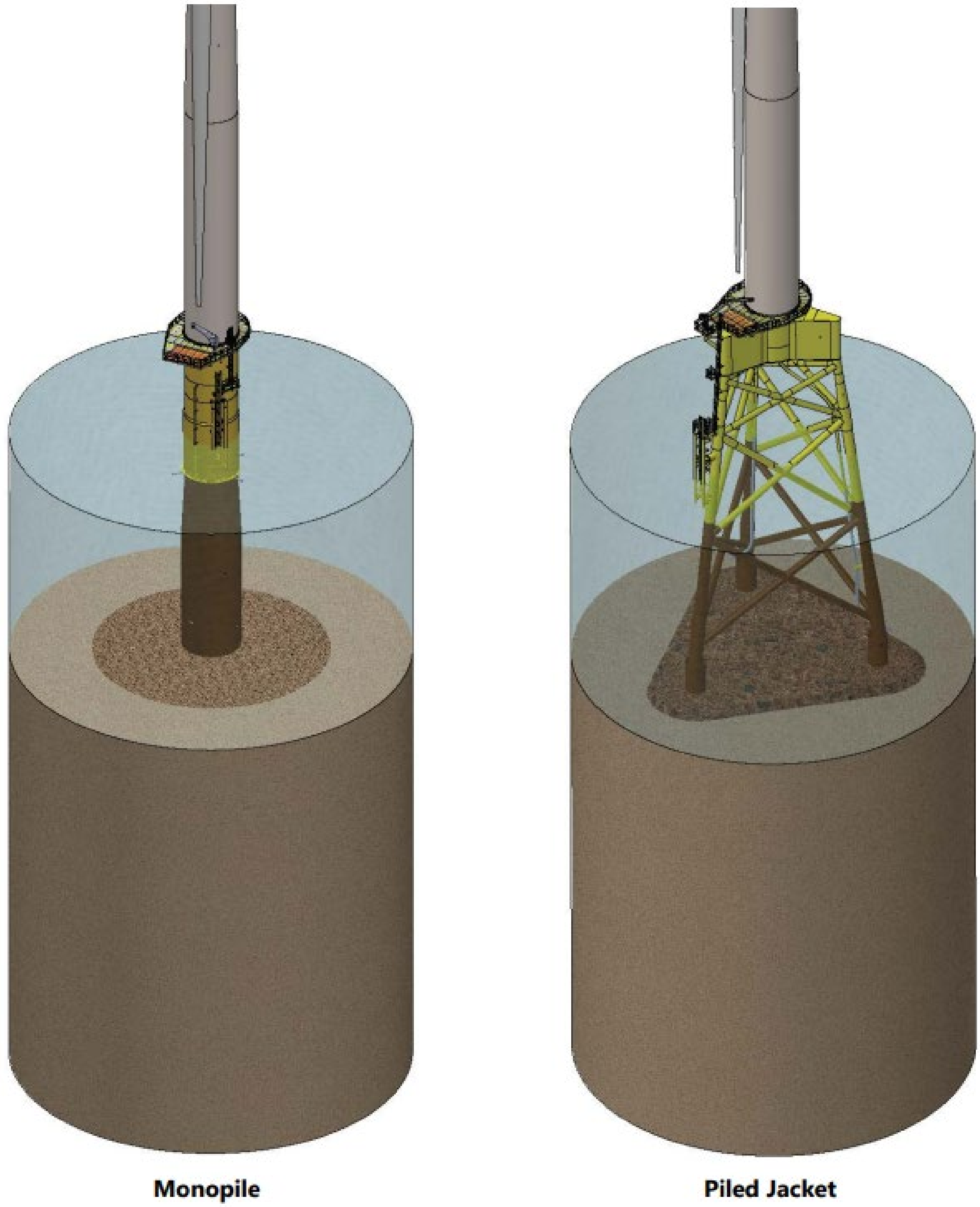
Table 6-2. OSS Foundation Types

Foundation Types		Small OSS	Medium OSS	Large OSS
Piled	Monopile	•	•	•
	Piled Jacket	•	•	•
Suction Bucket	Mono-Bucket	•	•	•
	Suction Bucket Jacket	•	•	•
Gravity	GBS	•	•	•

Source: COP Volume I, Table 4.4-1, Atlantic Shores 2023.
This EFH assessment analyzes the maximum potential impacts on each environmental resource from each type of foundation: piled, suction bucket, and gravity-based at a project level. A representation of the impacts that could occur given the choice of foundation type per project can be found in Table 2-5. The table looks at the maximum extent of how each foundation type used within Project 1, and separately Project 2, could affect a resource. Once combined, the combined configuration of foundations for Project 1 and Project 2 would not exceed 211 (200 turbines, 10 OSSs, and 1 met tower).

6.3.4.1 Alternative F1 – Piled Foundations

Under Alternative F1, the use of the monopile and piled jacket foundation structures (Figure 6-8) for up to 200 WTGs, 1 permanent met tower (Project 1), and either up to 10 small OSSs (monopile or piled jacket), up to 5 medium OSSs (piled jacket), or 4 large OSSs (piled jacket) for Project 1 and Project 2 would be analyzed for the extent of impacts. The installation of piled jacket foundations for each Project component would result in temporary and permanent impacts of 2,989 acres and 509 acres, whereas the installation of monopile foundations would result in temporary and permanent impacts of 3,170 acres and 659 acres (Table 10-9).



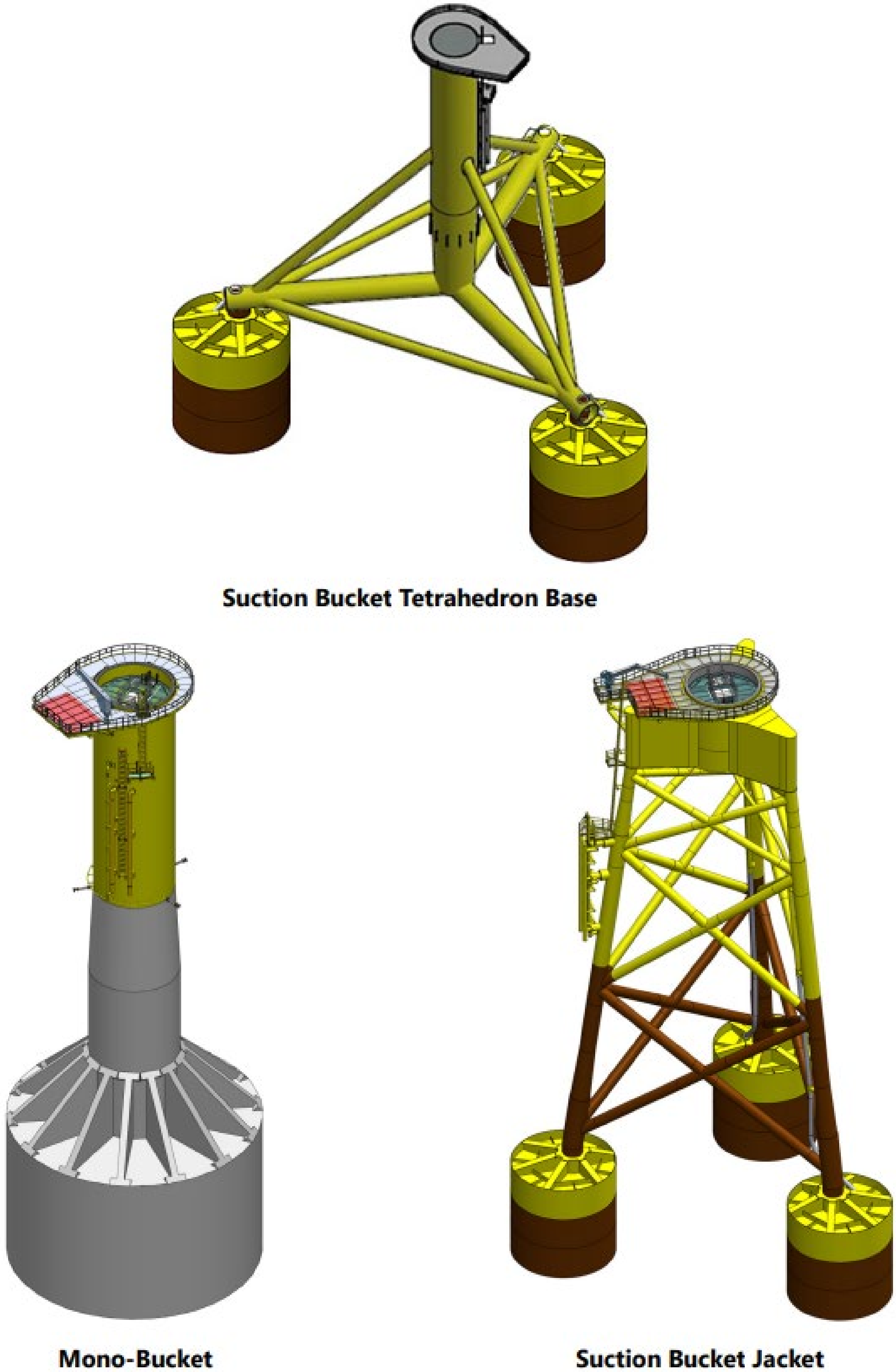
Source: Atlantic Shores 2023, Volume I.

Figure 6-8. Piled Foundations

6.3.4.2 Alternative F2 – Suction Bucket Foundations

Under Alternative F2, the use of mono-bucket, suction bucket jacket, and suction bucket tetrahedron base foundations (Figure 6-9) for up to 200 WTGs, 1 permanent met tower (Project 1), and up to 10 small OSSs (mono-bucket or suction bucket jacket), up to 5 medium OSSs (suction bucket jacket), or up to 4 large OSSs (suction bucket jacket), for Project 1 and Project 2 would be analyzed for the extent of impacts.

The installation of suction bucket jacket or suction bucket tetrahedron foundations and small OSSs would result in the smallest temporary impacts (2,882 acres), whereas the installation of mono-bucket foundations would result in the largest temporary impacts (3,186 acres) (Table 10-10). Conversely, the installation of mono-bucket foundations would result in the smallest permanent impacts (690 acres), whereas the installation of suction bucket jacket foundations and small OSSs would result in the largest permanent impacts (924 acres).



Source: Atlantic Shores 2023, Volume I.

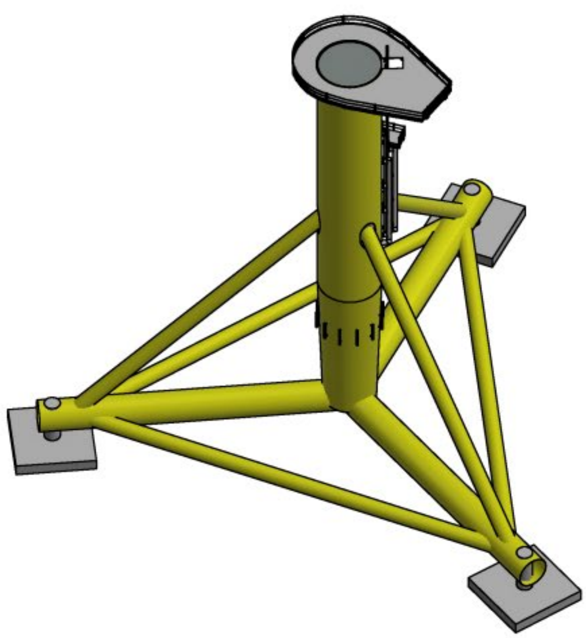
Figure 6-9. Suction Bucket Foundations

6.3.4.3 Alternative F3 – Gravity-Based Foundations

Under Alternative F3, the use of gravity-pad tetrahedron and GBS foundations (Figure 6-10) for up to 200 WTGs, 1 permanent met tower (Project 1), and up to 10 small OSSs, up to 5 medium OSSs, or up to 4 large OSSs for Project 1 and Project 2 would be installed.

The installation of GBS foundations and medium OSSs would result in the smallest temporary impacts (2,779 acres), whereas the installation of gravity-pad tetrahedron foundations and small OSSs would result in the largest temporary impacts (3,062 acres). Conversely, the installation of gravity-pad tetrahedron foundations and medium OSSs would result in the smallest permanent impacts (511 acres), whereas the installation of GBS foundations and small OSSs would result in the largest permanent impacts (666 acres).

Gravity-Base Structures (GBS)



Gravity-Pad Tetrahedron Base

Source: Atlantic Shores 2023, Volume I.

Figure 6-10. Gravity Foundations

6.3.5 Comparison of Alternatives

Relative to the Proposed Action, Alternatives C, D, and E would result in the removal of WTGs and associated inter-array cables from the Lease Area and are expected to provide a reduction in potential adverse impacts on EFH compared to other alternatives, including the Proposed Action. Alternative D2 would remove up to 31 WTGs and associated inter-array cables from the Lease Area to establish a no surface occupancy zone 12.75 miles from shore and would result in the largest reductions in maximum temporary (5.8 percent) and permanent (8.9 percent) impacts on benthic habitat, including a 10.7 percent reduction on permanent impacts on soft-bottom habitat. Alternative C1 would remove up to 16 WTGs, 1 OSS, and associated inter-array cables from the Lease Area to avoid the Lobster Hole fishing area and would result the largest reductions in maximum temporary (8.8 percent) and permanent (17.1 percent) impacts on heterogeneous complex habitat. Alternative E would remove WTGs positions from the Lease Area to establish a setback between Atlantic Shores South and Ocean Wind 1 and would result in a smaller reduction in maximum temporary (0.9 percent) and permanent (1.4 percent) impacts on benthic habitat compared to Alternatives C and D.

Alternative F considers each of the foundation types that were determined to be feasible for the Proposed Action. The installation of GBS foundations would result in the smallest temporary impacts on benthic habitat (2,779 acres), whereas the installation of mono-bucket foundations would result in the largest temporary impacts (3,186 acres). The installation of piled jacket foundations would result in the smallest permanent impacts on benthic habitat (509 acres), whereas the installation of suction bucket jacket foundations would result in the largest permanent impacts (924 acres).

6.4 Environmental Monitoring

Atlantic Shores has proposed the following environmental monitoring efforts that are relevant to EFH-designated species and EFH:

- As described in Section 5.2.1, above, a Fisheries Monitoring Plan would be implemented to monitor baseline environmental conditions relevant to fisheries and how these conditions change during Project construction and operation. Proposed fisheries surveys detailed in the Fisheries Monitoring Plan (see Atlantic Shores 2023, Appendix II-K) include a demersal fish trawl survey, fish trap survey, and clam dredge survey.
- As described in Section 5.2.2, above, a Benthic Monitoring Plan would be implemented to measure and assess the disturbance and recovery of marine benthic habitats and communities because of Project construction and operation. Proposed benthic surveys detailed in the Benthic Monitoring Plan (see Atlantic Shores 2023, Appendix II-H) include a benthic grab survey and a video survey.
- HRG and geotechnical surveys would be required pre-construction. Survey activities would include use of side scan sonar, multibeam echosounder, magnetometers, gradiometers, sub-bottom profilers, vibracores, cone penetrometer tests, and deep borings within the wind farm area and along the export cable route. HRG surveys would be conducted prior to construction to verify site conditions. A munitions and explosives of concern survey may also be included in pre-construction HRG survey activities. Pre-construction geotechnical surveys would be performed to inform the final design and engineering of each offshore facility.
- Atlantic Shores has submitted a Protected Species Management and Equipment Specifications Plan (PSMESP). The PSMESP includes PAM for protected species during pile installation. It is likely that a combination of the following PAM technologies will be employed during pile installation:

- Towed hydrophone arrays that are deployed from a vessel of convenience either locally monitored by an Operator on the vessel or connected to a remote system where data is streamed to a shorebased location for an Operator to monitor;
- Autonomous acoustic recorders (AARs), seafloor mounted acoustic recording devices that record and store data for later analysis Static PAM buoys for activities that are moored in locations that can strategically selected for their operational or biological importance;
- Hydrophone cable systems installed on the seabed; and/or
- Steerable craft like gliders, UAVs or ASVs equipped with hydrophone arrays where data is stored and downloaded periodically and/or streamed to shore selectively.

Towed systems deployed from a vessel and other autonomous systems that will be positioned throughout the monitoring zones where locations will be selected to optimize the acoustic monitoring range of all the systems collectively for all species groups. Mobile systems or systems easy to retrieve and reposition will be selected such that the acoustic monitoring range of the PAM Operators can be adjusted as piling locations change throughout the operation.

6.5 Adaptive Management Plans

Atlantic Shores has not proposed any adaptive management plans.

7. NOAA Trust Resources

Twenty-one species of NOAA Trust Resources have been identified in the Project area. Table 7-1 discusses species and life stages in the Project area and provides impact determination for each species.

The following NOAA Trust Resource species or species groups may use habitat within the Project area:

- Alewife (*Alosa pseudoharengus*)
- American eel (*Anguilla rostrata*)
- American shad (*Alosa sapidissima*)
- Atlantic croaker (*Micropogonias undulatus*)
- Atlantic menhaden (*Brevoortia tyrannus*)
- Blueback herring (*Alosa aestivalis*)
- Blue crab (*Callinectes sapidus*)
- Blue mussel (*Mytilus edulis*)
- Eastern oyster (*Crassostrea virginica*)
- Gulf stream flounder (*Citharichthys arctifrons*)
- Horseshoe crab (*Limulus polyphemus*)
- Northern kingfish (*Menticirrhus saxatilis*)
- Northern sand lance (*Ammodytes dubius*)
- Northern sea robin (*Prionotus carolinus*)
- Smallmouth flounder (*Etropus microstomus*)
- Soft-shelled clams (*Mya arenaria*)
- Spot (*Leiostomus xanthurus*)
- Spotted hake (*Urophycis regia*)
- Striped bass (*Morone saxatilis*)
- Tautog (*Tautoga onitis*)
- Weakfish (*Cynoscion regalis*)

Table 7-1. Impact Determination for NOAA Trust Resources by Species or Species Group

Species	Life Stages within Project Area	Impact Determination	Rationale for Determination
Alewife	Juvenile, Adult	Short-term, long-term, and permanent impacts	Short-term effects (i.e., sediment suspension and deposition, noise, alteration of soft bottom habitat), long-term effects (i.e., alteration of complex habitat) and permanent effect (i.e., entrainment, crushing and burial) would result from Project construction. Behavioral (peak) and injurious (cumulative) effects of pile-driving noise on finfish and invertebrates would have the greatest aerial extent, occurring over estimated areas of 414,280 acres and 410,215 acres, respectively (see Section 5.1.1.2). Effects of suspended sediment and sediment deposition on finfish and invertebrates would occur over estimated areas of up to 336 acres and 2,548 acres, respectively (see Section 5.1.2.3). However, these effects would occur intermittently at various locations within the Project area and not throughout the entire area for the entire duration of construction. Benthic community structure would recovery rapidly, within a few months of the activity. Approximately 575.2 to 672.7 acres of soft-bottom benthic habitat would be permanently displaced or altered by placement of the WTG, OSS, and MET tower foundations, scour protection, and cable protection. Once scour protection is colonized it may provide habitat features for species associated with hard substrates. Operational noise and EMF effects would occur throughout the operational lifespan of the Proposed Action but are below established thresholds for injury effects for fish. Collectively, soft-bottom areas affected by short-term construction related impacts would rapidly return to baseline conditions within minutes to months after the project is completed, whereas construction related impacts on hard-bottom habitats would be long term, requiring years to recover. Permanent habitat alterations would occur in the foundation footprints and in areas where scour and cable protection are required. The area affected is small relative to available habitat in the Project area.
American eel	Larvae, Juvenile, Adult		
American shad	Juvenile, Adult		
Atlantic croaker	All		
Atlantic menhaden	All		
Blueback herring	Juvenile, Adult		
Blue crab	All		
Gulf stream flounder	All		
Horseshoe crab	All		
Northern kingfish	All		
Northern sand lance	All		
Northern sea robin	All		
Smallmouth flounder	All		
Spot	All		
Spotted hake	All		
Striped bass	Juvenile, Adult		
Tautog	All		
Weakfish	All		
Bivalves (blue mussel, eastern oyster, soft-shelled clam)	All	Short-term and permanent impacts	Short-term effects (i.e., sediment suspension and deposition, noise, habitat alteration) and permanent effects (i.e., entrainment, crushing and burial) would occur for bivalves. Cable emplacement would cause effects of suspended sediment on bivalves over a negligible area and effects of sediment deposition on bivalves over an estimated area of 5 acres (see Section 5.1.2.3). Benthic community structure would recovery rapidly, within a few months of the activity. Approximately 572.2 to 672.7 acres of soft-bottom benthic habitat would be permanently displaced or altered by placement of the WTG, OSS, and MET tower foundations, scour protection, and cable protection. The affected area represents a small portion of suitable habitat for these species within the region. Once scour protection is colonized it would provide habitat features for species associated with hard substrates. Operational EMF and thermal effects associated with electrified cables would occur throughout the operational lifespan of the Proposed

Species	Life Stages within Project Area	Impact Determination	Rationale for Determination
			Action. An estimates 1,243 acres of EFH for bivalves would be exposed to potentially significant EMF effects on habitat suitability (see Section 5.1.4.1). The WTA and ECCs have been sited to avoid and minimize overlap of structures with known shellfish habitats in designated EFH. Based on the small area affected relative to the extent of designated EFH in the project area and vicinity, the Project would have a minor effect on habitat for these species. The benthic community structure would adapt and recover rapidly, within a few months of the activity.

8. Conclusions/Determinations

The Proposed Action includes construction, operations and maintenance, and decommissioning of the Project components at the end of the 30-year planned lifespan of the Projects. These activities may have short-term (i.e., less than 2 years), long-term (greater than 2 years but less than the Project lifespan), and permanent (i.e., the Project lifespan) adverse effects on EFH and EFH-designated species in the Project area. There are 39 species of finfish, elasmobranchs, and invertebrates with designated EFH within the area spanning the WTA and ECCs. EFH-designated species with one or more demersal life stage are more likely to experience adverse effects than species with only pelagic life stages, primarily resulting from the permanent conversion of benthic habitat following the installation of the turbine foundations, scour protection, and cable protection.

Project construction is expected to cause short-term, long-term, and permanent adverse effects on the environment that could affect habitat suitability for EFH and EFH-designated species. Short-term adverse effects would include those from construction-related underwater noise, increased turbidity and sedimentation caused by the disturbance of bottom substrates, and construction-related disturbances of soft-bottom habitat. Long-term adverse effects would include those from construction-related disturbance of hard-bottom habitat, which may take several years to recover. Permanent adverse effects on individual fish and invertebrates would result from entrainment, crushing, and burial associated with anchoring, cable emplacement, and seabed preparation. Effects from Project construction would occur intermittently at varying locations in the Project area during the construction period but are not expected to cause permanent impacts to EFH.

Project operations and maintenance are expected to cause permanent adverse effects on EFH for some life stages of EFH-designated species. Permanent adverse effects would include loss of soft-bottom benthic habitat resulting from the presence of WTG foundations, scour and cable protection, operational noise, EMF and heat effects, hydrodynamic changes, and food web changes. Conversion of benthic habitat resulting from the presence of scour and cable protection and conversion of pelagic habitat resulting from the presence of the WTG, OSS, and MET tower foundations may also cause long-term (i.e., greater than 2 years but less than the Project lifespan) neutral to beneficial effects on EFH-designated species that are associated with complex habitat, whether species experience population growth because of the added habitat or are merely attracted to the habitat.

Table 8-1 details short-term, long-term, and permanent adverse effects on habitat suitability by impact mechanism described in Section 5 and overall EFH effect determinations by managed species and life stage. The Proposed Action is expected to adversely affect EFH for a species and life stage if: 1) EFH for the designated species and life stage occurs in the Project area, and 2) one or more of the impact mechanisms described in Section 5 is expected to have an adverse effect on the species and life stage.

Table 8-1. Summary of Effects of the Proposed Action on EFH by Impact Mechanism and EFH Effect Determinations for Managed Species and Life Stages

EFH Species Group	EFH Species	Life Stage	Habitat Association	Short-Term Adverse Effects on EFH				Long-Term and Permanent Adverse Effects on EFH			
				Construction Noise	Crushing and Burial	Entrainment	Water Quality	Habitat Conversion	Operational Noise	EMF & Heat	Hydrodynamic
Gadids	Atlantic cod	Eggs	Surface	Yes	--	--	--	--	No	--	No
		Larvae	Pelagic	Yes	--	Yes	No	--	No	--	No
		Adult	Benthic complex	Yes	Yes	--	Yes	No	Yes	No	No
	Haddock	Juvenile	Benthic complex	Yes	Yes	--	Yes	No	Yes	No	No
	Pollock	Larvae	Pelagic	No	--	Yes	No	--	--	--	--
	Red hake	Eggs	Surface	Yes	--	--	--	--	No	--	No
		Larvae	Surface	Yes	--	--	--	--	No	--	No
		Juvenile	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Silver hake	Eggs	Surface	Yes	--	--	--	--	No	--	No
		Larvae	Surface	Yes	--	--	--	--	No	--	No
		Adult	Benthic complex/non-complex	Yes	Yes	--	Yes	Yes	Yes	No	--
	White hake	Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	Yes
Other finfish	Atlantic butterfish	Eggs	Pelagic	Yes	--	Yes	No	--	No	--	No
		Larvae	Pelagic	Yes	--	Yes	No	--	No	--	No
		Juvenile	Pelagic/benthic non-complex	Yes	Yes	No	Yes	Yes	Yes	No	No
		Adult	Pelagic/benthic non-complex	Yes	Yes	No	Yes	Yes	Yes	No	No
	Atlantic sea herring	Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Black sea bass	Larvae	Benthic complex	Yes	Yes	--	Yes	No	No	No	No
		Juvenile	Benthic complex	Yes	Yes	--	Yes	No	Yes	No	No
		Adult	Benthic complex	Yes	Yes	--	Yes	No	Yes	No	No
	Bluefish	Eggs	Pelagic	Yes	--	Yes	No	--	No	--	No
		Larvae	Pelagic	Yes	--	Yes	No	--	No	--	No
		Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Monkfish	Eggs	Surface	Yes	--	--	--	--	No	--	No
		Larvae	Pelagic	Yes	--	Yes	No	--	No	--	No
		Adult	Benthic complex	Yes	Yes	--	Yes	No	Yes	No	No

EFH Species Group	EFH Species	Life Stage	Habitat Association	Short-Term Adverse Effects on EFH				Long-Term and Permanent Adverse Effects on EFH			
				Construction Noise	Crushing and Burial	Entrainment	Water Quality	Habitat Conversion	Operational Noise	EMF & Heat	Hydrodynamic
Other finfish (cont.)	Ocean pout	Eggs	Benthic complex	Yes	Yes	--	Yes	No	No	No	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Scup	Juvenile	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
Flatfish	Windowpane flounder	Eggs	Surface	Yes	--	--	--	--	No	--	No
		Larvae	Pelagic	Yes	--	Yes	No	--	No	--	No
		Juvenile	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Winter flounder	Eggs	Benthic non-complex	Yes	Yes	--	Yes	Yes	No	No	No
		Larvae	Pelagic/benthic non-complex	Yes	Yes	Yes	Yes	Yes	No	No	No
		Juvenile	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Witch flounder	Eggs	Surface	Yes	--	--	--	--	No	--	No
		Larvae	Surface	Yes	--	--	--	--	No	--	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Yellowtail flounder	Eggs	Surface	Yes	--	--	--	--	No	--	No
		Larvae	Surface	Yes	--	--	--	--	No	--	No
		Juvenile	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Summer flounder	Eggs	Pelagic	Yes	--	Yes	No	--	No	--	No
		Larvae	Pelagic	Yes	--	Yes	No	--	No	--	No
		Juvenile	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
Highly migratory species	Atlantic mackerel	Eggs	Pelagic	Yes	--	Yes	No	--	No	--	No
		Larvae	Pelagic	Yes	--	Yes	No	--	No	--	No
		Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Albacore tuna	Juvenile	Pelagic	No	--	No	Yes	--	--	--	--
	Bluefin tuna	Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	No	--	No	Yes	--	--	--	--
	Skipjack tuna	Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Yellowfin tuna	Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No

EFH Species Group	EFH Species	Life Stage	Habitat Association	Short-Term Adverse Effects on EFH				Long-Term and Permanent Adverse Effects on EFH			
				Construction Noise	Crushing and Burial	Entrainment	Water Quality	Habitat Conversion	Operational Noise	EMF & Heat	Hydrodynamic
Sharks	Blue shark	Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Common thresher	Neonate/YOY	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Subadult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Dusky shark	Neonate/YOY	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Sand tiger shark	Neonate/YOY	Benthic complex/non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Juvenile	Benthic complex/non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Sandbar shark	Neonate/YOY	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Juvenile	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Shortfin mako	Neonate/YOY	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Subadult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	Tiger shark	Juvenile	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
	White shark	Neonate/YOY	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Juvenile	Pelagic	No	--	No	Yes	--	--	--	--
		Adult	Pelagic	No	--	No	Yes	--	--	--	--
	Spiny dogfish	Subadult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	Yes	--	No
Skates	Clearnose skate	Juvenile	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Little Skate	Juvenile	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
	Winter skate	Juvenile	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No
		Adult	Benthic non-complex/complex	Yes	Yes	--	Yes	Yes	Yes	No	No

EFH Species Group	EFH Species	Life Stage	Habitat Association	Short-Term Adverse Effects on EFH				Long-Term and Permanent Adverse Effects on EFH			
				Construction Noise	Crushing and Burial	Entrainment	Water Quality	Habitat Conversion	Operational Noise	EMF & Heat	Hydrodynamic
Invertebrates	Atlantic sea scallop	Eggs	Benthic complex	Yes	Yes	--	Yes	No	No	No	No
		Larvae	Pelagic/benthic complex	Yes	Yes	Yes	Yes	No	No	No	No
		Juvenile	Benthic complex	Yes	Yes	--	Yes	No	No	Yes	No
		Adult	Benthic complex	Yes	Yes	--	Yes	No	No	Yes	No
	Atlantic surf clam	Juvenile	Benthic non-complex	Yes	Yes	--	Yes	Yes	No	Yes	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	No	Yes	No
	Ocean quahog	Juvenile	Benthic non-complex	Yes	Yes	--	Yes	Yes	No	Yes	No
		Adult	Benthic non-complex	Yes	Yes	--	Yes	Yes	No	Yes	No
	Longfin squid	Eggs	Benthic complex	Yes	Yes	--	Yes	No	No	No	No
		Juvenile	Pelagic	Yes	--	No	Yes	--	No	--	No
		Adult	Pelagic	Yes	--	No	Yes	--	No	--	No

Notes:
'Yes' = adverse effect on habitat suitability;
'No' = insignificant effect on habitat suitability;
'--' = no life stage EFH exposure to this impact mechanism.

9. References

Acquafredda, M.P., D.M. Munroe, L.M. Ragone Calvo, and M. De Luca. 2019. The effect of rearing temperature on the survival and growth of early juvenile Atlantic surfclams (*Spisula solidissima*). Aquaculture Reports 13:100176. doi:10.1016/j.aqrep.2018.100176.

Adams, T.P., R.G. Miller, D. Aleynik, and M.T. Burrows. 2014. Offshore marine renewable energy devices as stepping stones across biogeographical boundaries. Journal of Applied Ecology 51:330-338.

André, M., M. Solé, M. Lenoir, M. Durfort, C. Quero, A. Mas, A. Lombarte, M. van der Schaar, M. López-Bejar, M. Morell, S. Zaugg, and L. Houégnigan. 2011. Low-frequency sounds induce acoustic trauma in cephalopods. Frontiers in Ecology and the Environment 9:489-493.

Armstrong, J.D., D.C. Hunter, R.J. Fryer, P. Rycroft, and J.E. Orpwood. 2015. Behavioural Responses of Atlantic Salmon to Mains Frequency Magnetic Fields. Scottish Marine and Freshwater Science 6:9.

Atlantic Shores Offshore Wind, LLC (Atlantic Shores). 2023. Atlantic Shores Offshore Wind: Construction and Operations Plan. Lease Area OCS-A 0499. May. Available: https://www.boem.gov/renewable-energy/state-activities/atlantic-shores-south.

Auster, P.J. and R. Langton. 1999. The effects of fishing on fish habitat. American Fisheries Science Symposium 22:150-187.

Bergström, L., F. Sundqvist, and U. Bergström. 2013. Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community. Marine Ecology Progress Series 485:199-210.

Berthe, C., and D. Lecchini. 2016. Influence of boat noises on escape behaviour of white-spotted eagle ray *Aetobatus ocellatus* at Moorea Island (French Polynesia). Comptes Rendus Biologies 339:99-103.

Bevelhimer, M.S., G.F. Cada, A.M. Fortner, P.E. Schweizer, and K. Riemer. 2013. Behavioral responses of representative freshwater fish species to electromagnetic fields. Transactions of the American Fisheries Society 142:802-813.

Broström, G. 2008. On the influence of large wind farms on the upper ocean circulation. Journal of Marine Systems 74:585-591.

Brouard, D., C. Harvey, D. Goulet, T. Nguyen, R. Champagne, and P. Dubs. 1996. Technical Notes: Evaluation of Potential Effects of Stray Voltage Generated by Alternating Current on Hatchery-Raised Rainbow Trout. The Progressive Fish-culturist 58:47-51.

Buerkle, U. 1973. Detection of trawling noise by Atlantic cod (*Gadus morhua*). PhD Thesis. McGill University, Quebec, Canada.

Bureau of Ocean Energy Management (BOEM). 2019. Guidelines for Providing Benthic Habitat Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585. June 2019. BOEM Office of Renewable Energy Programs, US Department of the Interior. 9 pp.

Bureau of Ocean Energy Management (BOEM). 2021. Hydrodynamic modeling, particle tracking and agent-based modeling of larvae in the U.S. Mid-Atlantic Bight. OCS Study BOEM 2021-049.

Cameron, I.L., K.E. Hunter, and W.D. Winters. 1985. Retardation of embryogenesis by extremely low frequency 60 Hz electromagnetic fields. Physiological Chemistry and Physics and Medical NMR 17:135-138.

Carpenter, J.R., L. Merckelbach, U. Callies, S. Clark, L. Gaslikova, and B. Baschek. 2016. Potential Impacts of Offshore Wind Farms on North Sea Stratification. PLoS ONE 11(8): e0160830. doi: 10.1371/journal.pone.0160830.

Carroll, A.G., R. Przeslawski, A. Duncan, M. Ganning, and B. Bruce. 2016. A critical review of the potential impacts of marine seismic surveys on fish & invertebrates. Marine Pollution Bulletin: 114 (2017):9-24.

Cazenave, P.W., R. Torres, and J.I. Alen. 2016. Unstructured Grid Modelling of Offshore Wind Farm Impacts on Seasonally Stratified Shelf Seas. Progress in Oceanography 145:25-41.

Christiansen, N., U. Daewel, B. Djath, and C. Schrum. 2022. Emergence of large-scale hydrodynamic structures due to atmospheric offshore wind farm wakes. Frontiers in Marine Science. 9. doi: 10.3389/fmars.2022.818501.

Codarin, A., L.E. Wysocki, L. Friedrich, and M. Picciulin. 2009. Effects of ambient and boat noise on hearing and communication in three fish species living in a marine protected area (Miramare, Italy). Marine Pollution Bulletin 58(12):1880-1887.

Collie, J.S., J. Hermsen, P.C. Valentine, and F. Almeida. 2005. Effects of fishing on gravel habitats: assessment and recovery of megafauna on Georges Bank. Pp. 325-343 *In* P.W. Barnes and J.P. Thomas (eds.) Benthic habitats and the effects of fishing. American Fisheries Science Symposium 41, Bethesda, MD.

Degraer, S., D. Carey, J. Coolen, Z. Hutchison, F. Kerckhof, B. Rumes, and J. Vanaverbeke. 2020. Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A Synthesis. Oceanography 33:48-57.

De Mesel, I., F. Kerckhof, A. Norro, B. Rumes, and S. Degraer. 2015. Succession and seasonal dynamics of the epifauna community on offshore wind farm foundations and their role as stepping stones for non-indigenous species. Hydrobiologia 756. doi:10.1007/s10750-014-2157-1.

Dier, A., B. Carroll, and S. Abolfathi. 2004. Guidelines for Jack-up Rigs with Particular Reference to Foundation Integrity. Research Report 289. MSL Engineering Limited for Health and Safety Executive, Suffolk UK. 91 pp.

Edmonds, N.J., C.J. Firmin, D. Goldsmith, R.C. Faulkner, and D.T. Wood. 2016. A review of crustacean sensitivity to high amplitude underwater noise: Data needs for effective risk assessment in relation to UK commercial species. Marine Pollution Bulletin. Available at: http://dx.doi.org/10.1016/j.marpolbul.2016.05.006

Elliot, J., A.A. Khan, L. Ying-Tsong, T. Mason, J.H. Miller, A.E. Newhall, G.R. Potty, and K.J. Vigness-Raposa. 2019. Field Observations during Wind Turbine Operations at the Block Island Wind Farm, Rhode Island. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2019-028. 281pp.

Federal Geographic Data Committee (FGDC). 2012. Coastal and Marine Ecological Classification Standard (CMECS), June 2012. FGDC-STD-018-2012. 353 pp.

Fisheries Hydroacoustic Working Group (FHWG). 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities.

Floeter, J., J.E.E. van Beusekom, D. Auch, U. Callies, J. Carpenter, T. Dudeck, S. Eberle, A. Eckhardt, D. Gloe, K. Hänselmann, M. Hufnagl, S. Janßen, H. Lenhart, K.O. Möller, R.P. North, T. Pohlmann, R. Riethmüller, S. Schulz, S. Spreizenbarth, A. Temming, B. Walter, O. Zielinski, and C. Möllmann. 2017. Pelagic effects of offshore wind farm foundations in the stratified North Sea. Progress in Oceanography 156:154-173.

Folk, R.L. 1954. The distinction between grain size and mineral composition in sedimentary rock nomenclature. Journal of Geology. 62(4):344-359.

Gedamke, J. M. Ferguson, J. Harrison, L. Hatch, L. Henderson, M.B. Porter, B.L. Southall, S.V. Parijs. 2016. Predicting anthropogenic noise contributions to US waters. *In* A. Popper and A. Hawkins (eds) The Effects of Noise on Aquatic Life II. Advances in Experimental Medicine and Biology, vol 875. Springer, New York, NY.

Glasby, T.M., S.D. Connell, M.G. Holloway, and C.L. Hewitt. 2007. Nonindigenous biota on artificial structures: Could habitat creation facilitate biological invasions? Marine Biology 151:887-895.

Golbazi, M., C.L. Archer, and S. Alessandrini. 2022. Surface impacts of large offshore wind farms. Environmental Resource Letters. 17. doi: 064021

Greene J., M. Anderson, D. Morse, C. Shumway, and M. Clark. 2010. The Northwest Atlantic Marine Ecoregional Assessment: Species, Habitats and Ecosystems. Phase One. The Nature Conservancy, Eastern U.S. Division, Boston, MA.

Guida, V., A. Drohan, H. Welch, J. McHenry, D. Johnson, V. Kentner, J. Brink, D. Timmons, and E. Estela-Gomez. 2017. Habitat Mapping and Assessment of Northeast Wind Energy Areas. OCS Study BOEM 2017-088. Sterling, Virginia: U.S. Department of the Interior, Bureau of Ocean Energy Management.

Handegard, N.O., K. Michalsen, and D. Tjøstheim. 2003. Avoidance behaviour in cod (*Gadus morhua*) to a bottom-trawling vessel. Aquatic Living Resources 16(3):265-270.

Harding, J.M., S.E. King, E.N. Powell, and R. Mann. 2008. Decadal Trends in Age Structure and Recruitment Patterns of Ocean Quahogs Arctica Islandica from the Mid-Atlantic Bight in Relation to Water Temperature. Journal of Shellfish Research 27:667-690.

Hastings, M.C., and A.N. Popper. 2005. Effects of sound on fish. Final Report #CA05-0537 Project P476 Noise Thresholds for Endangered Fish. California Department of Transportation, Sacramento, CA.

Hawkins, A.D., and A.N. Popper. 2014. Assessing the impact of underwater sounds on fishes and other forms of marine life. Acoustics Today. Spring 2014. Available at: https://acousticstoday.org/wp-content/uploads/2015/05/Assessing-the-Impact-of-Underwater-Sounds-on-Fishes-and-Other-Forms-of-Marine-Life-Anthony-D.-Hawkins-and-Arthur-N.-Popper.pdf

Hawkins, A.D., R.A. Hazelwood, A.N. Popper, and P.C. Macey. 2021. Substrate vibrations and their potential effects upon fishes and invertebrates. The Journal of the Acoustical Society of America, 149:2782-2790.

Herbert-Read, J.E., L. Kremer, R. Bruintjes, A.N. Radford, and C.C. Loannou. 2017. Anthropogenic noise pollution from pile-driving disrupts the structure and dynamics of fish shoals. Proceedings of the Royal Society B 284:20171627. doi: 10.1098/rspb.2017.1627

Hossain, M.S., and R. Stainforth. 2016. Perforation drilling for easing spudcan-footprint interaction issues. Ocean engineering 113:1:308-318.

Hutchinson, Z.L., P. Sigray, H. He, A.B. Gill, J. King, and C. Gibson. 2018. Electromagnetic Field (EMF) Impacts on Elasmobranch (shark, rays, and skates) and American Lobster Movement and Migration from Direct Current Cables. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2018-003.

Hutchinson, Z.L., A.B. Gill, P. Sigray, H. He, and J.W. King. 2020. Anthropogenic Electromagnetic Fields (EMF) Influence the Behaviour of Bottom-Dwelling Marine Species. Scientific Reports 10:4219. doi:10.1038/s41598-020-60793-x.

Jones, I.T., J.A. Stanley, and T.A. Mooney. 2020. Impulsive pile driving noise elicits alarm responses in squid (*Doryteuthis pealeii*). Marine Pollution Bulletin 150:110792. doi:10.1016/j.marpolbul. 2019.110792.

Karleskint, G., R. Turner, and J.W. Small. 2006. Introduction to Marine Biology – Fourth Edition. Brooks/Cole, Belmont, CA.

Kerckhof, F., B. Rumes, and S. Degraer. 2019. About “mytilisation” and “slimeification”: a decade of succession of the fouling assemblages on wind turbines off the Belgian coast. Pages 73–84 *In* S. Dramer, R. Brabant, B. Rumes, and L Vigin (eds.) Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Marking a Decade of Monitoring, Research, and Innovation. Tethys. Available at: https://tethys.pnnl.gov/publications/environmental-impacts-offshore-wind-farms-belgian-part-north-sea-marking-decade

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.L. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environmental Systems and Decisions 35:334-350.

Kunch, H.P., K.E. McLaughlin, and R. Schmidt. 2016 Aquatic noise pollution: implications for individuals, populations, and ecosystems. Proceedings of the Royal Society B 283: 20160839. doi:10.1098/rspb.2016.0839

Ladich, F., and A.A. Myrberg. 2006. Agonistic behaviour and acoustic communication. *In* F. Ladich, S. P. Collin, P. Moller, and B.G. Kapoor (eds.), Communication in Fishes (pp. 122–148). Science Publishers, Enfield, NH.

Langhamer, O. 2012. Artificial Reef Effect in relation to Offshore Renewable Energy Conversion: State of the Art. The Scientific World Journal. Volume 2012. doi:10.1100/2012/386713.

Langlois, T.J., M.J. Anderson, and R.C. Babcock. 2005. Reef-associated predators influence adjacent soft-sediment communities. Ecology 86:1508-1519.

Lentz, S. J. 2017. Seasonal warming of the Middle Atlantic Bight Cold Pool. Journal of Geophysical Research: Oceans 122(2):941-954.

Li, X., L. Chi, X. Chen, Y. Ren, and S. Lehner. 2014. SAR observation and numerical modeling of tidal current wakes at the East China Sea offshore wind farm. Journal of Geophysical Research: Oceans 119(8):4958-4971.

Long, D. 2006. BGS Detailed Explanation of Seabed Sediment Modified Folk Classification; Technical Report; MESH: Bristol, UK.

Lukens, R.R., and C. Selberg. 2004. Guidelines for Marine Artificial Reef Materials. Second Edition. Atlantic and Gulf States Marine Fisheries Commission. Joint Publication No. 121, January 2004.

Maar, M., K. Bolding, J.K. Petersen, J.L. Hansen, and K. Timmermann. 2009. Local effects of blue mussels around turbine foundations in an ecosystem model of Nysted off-shore wind farm, Denmark. Journal of Sea Research 62:159-174.

Mavraki, N., U. Braeckman, S. Degraer, and J. Vanaverbeke. 2020. Organic matter assimilation by hard substrate fauna in an offshore wind farm area: A pulse-chase study. ICES Journal of Marine Science. fsaa133. doi:10.1093/icesjms/fsaa133.

Merson, R.R., and H.L. Pratt Jr. 2007. Sandbar shark nurseries in New Jersey and New York: Evidence of northern pupping grounds along the United States east coast. Pages 35-43 *In* C.T. McCandless, N.E. Kohler, and H.L. Pratt, Jr. editors. Shark Nursery Grounds of the Gulf of Mexico and the East Coast Waters of the United States. American Fisheries Society Symposium 50, Bethesda, Maryland.

Methratta, E.T., and W.R. Dardick. 2019. Meta-Analysis of Finfish Abundance at Offshore Wind Farms. Reviews in Fisheries Science & Aquaculture 27:242-260.

Michel, J., A.C. Bejarano, C.H. Peterson, and C. Voss 2013. Review of Biological and Biophysical Impacts from Dredging and Handling of Offshore Sand. U.S. Department of the Interior, Bureau of Ocean Energy Management, Herndon, Virginia. OCS Study BOEM 2013-0119. 258 pp.

Miles, J., T. Martin, and L. Goddard. 2017. Current and Wave Effects around Windfarm Monopile Foundations. Coastal Engineering 121:167-178.

Minerals Management Service (MMS). 2008. Cape Wind Energy Project Nantucket Sound Biological Assessment (Appendix G). In Cape Wind Energy Project Final EIS. p. 296.

Minerals Management Service (MMS). 2009. Cape Wind Energy Project Final Environmental Impact Statement. January 2009. U.S. Department of the Interior. OCS Publication No. 2008-040. Accessed: July 11, 2018. Retrieved from: https://www.energy.gov/sites/prod/files/DOE-EIS-0470-Cape_Wind_FEIS_2012.pdf

Mitson, R.B., and H.P. Knudsen. 2003. Causes and effects of underwater noise on fish abundance estimation. Aquatic Living Resources 16(3):255-263.

Myrberg, A.A., and M. Lugli. 2006. Reproductive behavior and acoustical interactions. *In* F. Ladich, S. P. Collin, P. Moller, and B.G. Kapoor (eds.), Communication in Fishes (pp. 149–176). Science Publishers, Enfield, NH.

National Marine Fisheries Service (NMFS). 2017. Amendment 10 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan to Update Essential Fish Habitat Delineations and Life History Descriptions for Atlantic Highly Migratory Species.

National Marine Fisheries Service (NMFS). 2020. Recommendations for Mapping Fish Habitat. NMFS GARFO Habitat Conservation and Ecosystem Services Division. May 2020. 9 pp.

National Marine Fisheries Service (NMFS). 2021. Section 7 Effect Analysis: Turbidity in the Greater Atlantic Region. Available: https://www.fisheries.noaa.gov/new-england-mid-atlantic/ consultations/section-7-effectanalysis-turbidity-greater-atlantic-region.

National Marine Fisheries Service (NMFS). 2022. Essential Fish Habitat Mapper. Available at: https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper.

Nedelec, S.L., J. Campbell, A.N. Radford, S.D. Simpson, and N.D. Merchant. 2016. Particle motion: The missing link in underwater acoustic ecology. Methods in Ecology and Evolution 7:836-842.

Nerge, P., and H. Lenhart. 2010. Wake effects in analyzing coastal and marine changes: Offshore wind farming as a case study. Pp. 68–73 in Zukunft Küste - Coastal Futures Synthesis Report. LOICZ Research & Studies No. 36, GKSS Research Center, Geesthacht, 212 pp.

New England Fishery Management Council (NEFMC). 2017. Final Omnibus Essential Fish Habitat Amendment 2. Volume 2: EFH and HAPC Designation Alternatives and Environmental Impacts.

New Jersey Department of Environmental Protection (NJDEP). 2022. Shellfish maps. Accessed: October 2022. Available at: https://www.nj.gov/dep/landuse/shellfish.html

New Jersey Division of Fish and Wildlife (NJDFW). 2010. Inventory of New Jersey's surf clam (*Spisula solidissima*) resource. 3-IJ-236. 275 pp.

Nilsson, H.C., and R. Rosenberg. 2003. Effects on marine sedimentary habitats of experimental trawling analyzed by sediment profile imagery. Journal of Experimental Marine Biology 285-286:453-463.

Normandeau Associates, Inc. (Normandeau). 2011. Effects of EMFs From Undersea Power Cables on Elasmobranchs and Other Marine Species. A Final Report for the U. S. Department of the Interior, Bureau of Ocean Energy Management, Pacific OCS Region, OCS Study Report No. BOEMRE 2011-09.

Normandeau Associates, Inc. (Normandeau). 2012. Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities. A Workshop Report for the U.S. Department of the Interior, Bureau of Ocean Energy Management. Contract # M11PC00031. 72 pp. plus Appendices.

Ona, E., O.R. Godø, N.O. Handegard, V. Hjellvik, R. Patel, and G. Pedersen. 2007. Silent research vessels are not quiet. Journal of the Acoustical Society of America 121, EL145 (2007). doi:10.1121/1.2710741

Orpwood, J.E., R.J. Fryer, P. Rycroft, and J.D. Armstrong. 2015. Effects of AC Magnetic Fields (MFs) on Swimming Activity in European Eels *Anguilla anguilla*. Scottish Marine and Freshwater Science 6:8.

Payne, J.F., C.A. Andrews, L.L. Fancey, A.L. Cook, and J.R. Christian. 2007. Pilot Study on the Effects of Seismic Air Gun Noise on Lobster (*Homarus americanus*). Canadian Technical Report of Fisheries and Aquatic Sciences No. 2712. Fisheries and Oceans Canada, St. Johns NL Canada.

Peterson, J.K., and T. Malm. 2006. Offshore Windmill Farms: Threats to or Possibilities for the Marine Environment. Ambio 35:75-80.

Popper, A.N., M. Salmon, and K.W. Horch. 2001. Acoustic detection and communication by decapod crustaceans. Journal of Comparative Physiology 187:83–89.

Popper, A.N., and M.C. Hastings. 2009. The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology 75(3):455-489.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, M.B. Halvorsen, S. Lokkeborg, P.H. Rogers, B.L. Southall, D.G. Zeddies, and W.N. Tavolga. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report Prepared by ANSI-Accredited Standards Committee S3/S1 and Registered with ANSI. ASA Press and Springer Press, New York.

Popper, A.N., and A.D. Hawkins. 2018. The importance of particle motion to fishes and invertebrates. The Journal of the Acoustical Society of America. 143.470.

Purser J., and A.N. Radford. 2011 Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (Gasterosteus aculeatus). PLoS ONE 6:e17478. doi:10.1371/journal.pone. 0017478Radford, A.N., E. Kerridge, and S.D. Simpson. 2014. Acoustic communication in a noisy world: can fish compete with anthropogenic noise? Behavioral Ecology 25(5):1022-1030.

Rechisky, E.L., and B.M. Wetherbee. 2003. Short-term movements of juvenile and neonate sandbar sharks, *Carcharhinus plumbeus*, on their nursery grounds in Delaware Bay. Environmental Biology of Fishes 68:113-128.

Reichart, G.J., F. Mienis, G. Duineveld, K. Soetaert, and A. Fillipidi. 2017. Measuring the SHADOW of an Artificial Structure in the North Sea and Its Effect on the Surrounding Soft Bottom Community. Report NIOZ Royal Netherlands Institute for Sea Research and Utrecht University, Netherland. 19 pp.

Reubens, J.T., U. Braeckman, J. Vanaverbeke, C. Van Colen, S. Degraer, and M. Vincx. 2013. Aggregation at windmill artificial reefs: CPUE of Atlantic cod (*Gadus morhua*) and pouting (*Trisopterus luscus*) at different habitats in the Belgian part of the North Sea. Fisheries Research 139:28-34.

Reubens, J.T., S. Degraer, and M. Vincx. 2014. The ecology of benthopelagic fishes at offshore wind farms: A synthesis of 4 years of research. Hydrobiologia 727:121-136.

Roberts, L., S. Cheesman, T. Breithaupt, M. and Elliott. 2015. Sensitivity of the mussel *Mytilus edulis* to substrate-borne vibration in relation to anthropogenically generated noise. Marine Ecology Progress Series 538:185-195.

Roberts, L. and M. Elliott. 2017. Good or bad vibrations? Impacts of anthropogenic vibration on the marine epibenthos. Science of the Total Environment 595:255-268.

Rosenberg, R., H.C. Nilsson, A. Grémare, and J-M. Amouroux. 2003. Effects of demersal trawling on marine sedimentary habitats analyzed by sediment profile imagery. Journal of Experimental Marine Biology and Ecology 285-286:465-477.

Schultze, L.K.P., L.M. Merckelbach, J. Horstmann, S. Raasch, and J.R. Carpenter. 2020. Increased mixing and turbulence in the wake of offshore wind farm foundations. Journal of Geophysical Research – Oceans:125(8). doi:10.1029/2019JC015858

Schwarz, A.L., and G.L. Greer. 1984. Responses of Pacific Herring, *Clupea harengus pallasi*, to some underwater sounds. Canadian Journal of Fisheries and Aquatic Sciences 41(8). doi:10.1139/f84-140.

Schwartzbach, A., J.W. Behrens, and J.C. Svendsen. 2020. Atlantic cod *Gadus morhua* save energy on stone reefs: Implications for the attraction versus production debate in relation to reefs. Marine Ecology Progress Series 635:81-87.

Slavik, K., C. Lemmen, W. Zhang, O. Kerimoglu, K. Klingbeil, and K.W. Wirtz. 2019. The large-scale impact of offshore wind farm structures on pelagic primary productivity in the southern North Sea. Hydrobiologia 845:35-53.

Soria, M., P. Fréon, and F. Gerlotto. 1996. Analysis of vessel influence on spatial behaviour of fish schools using a multi-beam sonar and consequences for biomass estimates by echo-sounder. ICES Journal of Marine Science 53(2):453-458.

Tamsett, A., K.B. Heinonen, P.J. Auster, and J. Linholm. 2010. Dynamics of hard substratum communities inside and outside of a fisheries habitat closed area in Stellwagen Bank National Marine Sanctuary (Gulf of Maine, NW Atlantic). Marine Sanctuaries Conservation Series ONMS-10-05. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 53 pp.

Tougaard, J., L. Hermannsen, and P. T. Madsen. 2020. How loud is the underwater noise from operating offshore wind turbines? Journal of the Acoustical Society of America 148:2885-2892.

U.S. Environmental Protection Agency (USEPA). 1986. Quality Criteria for Water. EPA 440/5-86-001.
U.S. Environmental Protection Agency (USEPA). 2021. Superfund Site: Gowanus Canal Brooklyn, NY Site Home Page. Available: https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0206222.

Vabø, R., K. Olsen, and I. Husea. 2002. The effect of vessel avoidance of wintering Norwegian spring spawning herring. Fisheries Research 58(1):59-77.

Van Hal, R., A.B. Griffioen, and O.A. van Keeken. 2017. Changes in fish communities on a small spatial scale, an effect of increased habitat complexity by an offshore wind farm. Marine Environmental Research 126:26-36.

Vanhellemont, Q., and K. Ruddick. 2014. Turbid wakes associated with offshore wind turbines oberved with Landsat 8. Remote Sensing of the Environment 145:105-115.

Voellmy, I.K., J. Purser, D. Flynn, P. Kennedy, S.D. Simpson, and A.N. Radford. 2014. Acoustic noise reduces foraging success in two sympatric fish species via different mechanisms. Animal Behavior 89:191-198.

Wahlberg, M., and H. Westerberg. 2005. Hearing in fish and their reactions to sounds from offshore wind farms. Marine Ecology Progress Series 288:295-309.

Walsh, H.J., D.E. Richardson, K.E. Marancik, and J.A. Hare. 2015. Long-Term Changes in the Distributions of Larval and Adult Fish in the Northeast U.S. Shelf Ecosystem. PLOS ONE 10:e0137382.

Wentworth, C.K. 1922 A scale of grade and class terms for clastic sediments. Journal of Geology 30:377-392.

Wilber, D.H., and D.G. Clarke. 2001. Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish with Relation to Dredging Activities in Estuaries. North American Journal of Fisheries Management 21: 855-875.

Wilber, D., L. Read, M. Griffin, and D. Carey. 2020. Block Island Wind Farm Demersal Fish Trawl Survey Synthesis Report—Years 1 to 6, October 2012 through September 2018. Technical report prepared for Deepwater Wind, INSPIRE Environmental, Newport, RI, 182 pp.

Wilhelmsson, D., T. Malm, and M.C. Öhman. 2006. The influence of offshore windpower on demersal fish. ICES Journal of Marine Science 63:775-784.

Wysocki, L.E., J.P. Dittami, and F. Ladich. 2006. Ship noise and cortisol secretion in European freshwater fishes. Biological Conservation 128(4):501-508.

Yang, G., L. Song, X. Lu, N. Wang, and Y. Li. 2017. Effect of the exposure to suspended solids on the enzymatic activity in the bivalve *Sinonovacula constricta*. Aquaculture and Fisheries 2:10-17.

10. Appendices

10.1 List of Supporting Documents

10.2 Data Collection and Mapping Methodologies

10.3 List of Supporting Documents

The following documents support this EFH assessment.

- Atlantic Shores Offshore Wind Construction and Operations Plan
- The following documents are COP appendices and may be found at on the BOEM website for Atlantic Shores Offshore Wind: https://www.boem.gov/renewable-energy/state-activities/atlantic-shores-offshore-wind-construction-and-operations-plan
    - Wetland and Stream Delineation Reports, Appendix II-D1 and Appendix II-D2
- The following documents will be transmitted to NMFS via Kiteworks:
    - Benthic Reports (COP Appendices: G1, G2, G3, G4)
    - Benthic Maps (COP Appendix J2)
    - Benthic Monitoring Plan, December 2021
    - Fisheries Monitoring Plan, December 2021
    - GIS Data and Maps
    - Hydroacoustic Modeling Report, April 2023
    - Towed Video Report
- Access to Atlantic Shore’s online benthic mapper and data portal (GAIA) was provided to NMFS staff in January, 2022. Please contact BOEM if new credentials are needed.

10.4 Data Collection and Mapping Methodologies

10.4.1 Benthic Survey Data Collection

Atlantic Shores conducted site-specific benthic surveys across the Lease Area and across a large portion of the ECCs. The surveys were designed to identify the dominant substrates in the Offshore Project Area and to establish a pre-construction baseline and characterizes potentially sensitive or important seafloor areas that may serve as EFH. The benthic survey methods (e.g., recommended equipment, procedures, lab analyses, etc.) were selected to meet federal guidance including the Bureau of Ocean Energy Management (BOEM) 2019 benthic survey guidance and National Marine Fisheries Service (NMFS) 2020 recommendations for mapping essential fish habitat. The survey design met the required sampling density of about 1 sample per 2 km area on average with some sites variably spaced to target apparently different or interesting features/habitats based on geophysical data. The benthic survey included benthic grab sampling and sediment profile imaging and plan view data (SPI/PV) designed to characterize sediment grain size and macroinvertebrate community composition in the Project area. The data collected from the benthic surveys were used to classify the benthic habitat according to the Coastal and Marine Ecological Classifications Standards (CMECS).

In July and September 2020, Fugro USA Marine, Inc. (Fugro) conducted benthic grab sampling at 90 sites in the Lease Area (including 46 sites in the WTA), 21 sites along the Monmouth ECC, and 10 sites along the Atlantic ECC (Figure 10-1). At each site, "GrabCam" video was recorded and Fugro scientists reviewed the video in real-time, described the contents of the grab, and reviewed the video after the survey to make notes for a visual analysis. RPS biologists also reviewed the GrabCam video for confirmation of CMECS classification and to capture representative images for this report. In a separate effort, Integral Consulting Inc. (Integral) collected Sediment Profile and Plan View (SPI/PV) imaging data for 3 replicate samples at 125 sites to obtain high definition still images of the seafloor and the sediment-water interface. Thirty-eight of the SPI/PV sites overlapped with grab sample sites (Figure 10-1).

Benthic grab samples were acquired using a Ted Young-modified double Van Veen grab sampler equipped with a real-time video camera. The dual-bucket (each 0.04 m^2) configured grab sampler with video camera provided sediment samples for physical and chemical sediment characterization, taxonomic identification of benthic macroinvertebrates, estimates of the wet-weight biomass of benthic macrofauna, and real-time high-definition video footage of the seafloor conditions and grab operation at the time of sampling. Each bucket of the dual-bucket grab sampler was processed separately. The first grab bucket was processed for physical and chemical analysis of the sediment (sediment grain size and total organic carbon [TOC]), while the second grab bucket was processed for macroinvertebrate species identification. Sediment grain size samples contained at least 200 mL of substrate collected from the full grab depth, whereas TOC samples contained at least 100 mL of substrate collected from the top two 2 centimeters of the grab. The entirety of the second grab bucket was used for the identification of benthic macroinvertebrates at that station. The contents of the bucket were loaded onto a processing table, material was washed through a 0.5-milimeter sieve, and retained material was fixed/preserved with 10% buffered formalin solution. Containers were tightly sealed with tape and stored in a cooler at ambient temperature (not frozen or refrigerated). Samples were labelled as OCS if located in the Lease Area (Federal Lease Area OCS-A 0499), LAR if located along the Monmouth ECC, or CAR if located along the Atlantic ECC.

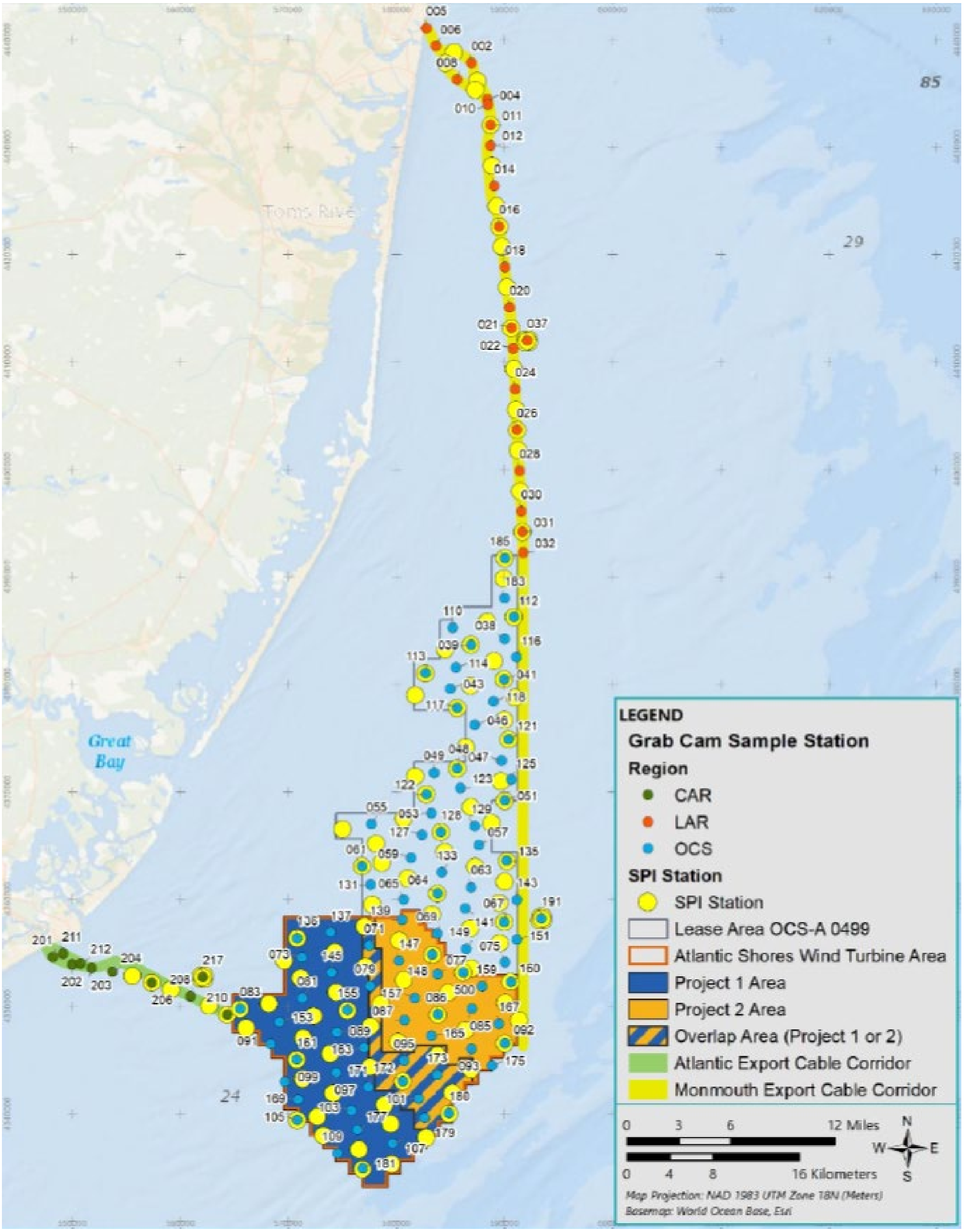


Figure 10-1. Benthic Grab Sample and Overlapping SPI/PV Samples Sites in the Lease Area and ECCs

Based on consultation with BOEM and NMFS regarding subsequent updates to guidelines, Atlantic Shores conducted towed video surveys of the Lease Area and export cable corridors in 2021 to ground-truth the initial grab samples and SPI/PV surveys. The 2021 planned video transect lines were based on results from prior survey campaigns, including acoustic imaging, benthic grab sampling, and SPI/PV sampling. Transect sites were selected to capture features and substrates of interest to fulfill NMFS recommendations for mapping EFH. The goal of these benthic video transects was to provide data on the epifaunal and demersal biological communities and ground truth the previous surveys by targeting transition zones between substrate types in maps based on preliminary geophysical and geotechnical data.

Underwater video transects were taken along with still images for visual classification of the seafloor in June of 2021. The survey was conducted on the research vessel, R/V Shearwater operated by Alpine Ocean Seismic Survey, Inc. between June 4 and June 11, 2021. The camera sled was equipped with parallel-mounted lasers 2.5 centimeters (cm) apart, altimeter, GoPro Hero 9, and a 4K camera with cable that transmitted real-time video to the vessel. During the survey, the video sled was lowered in the water column until positioned 0.5 to 1.0 meters above the seafloor. Video transects approximately 250 m in length were recorded in accordance with procedures following BOEM's Guidelines for Providing Benthic Habitat Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585 (BOEM, 2019). Target vessel speed was 0.5 to 0.8 knots. The sled operator used a remote winch to raise and lower the towed camera sled as needed to maintain proximity to the seafloor. During recording, any potentially sensitive benthic habitats (e.g., exposed hard bottom, seagrass/kelp/algal beds, coral species) were noted, as per BOEM's guidelines (BOEM 2019).

10.4.2 Benthic Habitat Mapping Methodology

10.4.2.1 Data Sources

Mapping products for the EFH assessment were developed by Fugro based on the following data inputs from the various geophysical and geotechnical, and benthic habitat surveys conducted within the Lease Area and ECCs:

- Side scan sonar (SSS) mosaics
- Multibeam echo sounder (MBES) bathymetry
- MBES backscatter data
- Sub-bottom profiler (SBP)
- Grab sample tests (grain size)
- Benthic macrofauna taxonomy results
- SPI-PV
- Video imagery from each grab sample station
- Towed video and still imagery

These acoustic products were processed and interpreted to create polygons of seafloor sediment coverage and morphology over the Project area.

10.4.2.2 Sediment Mapping and CMECS

Seabed sediment interpretation was primarily based on SSS mosaics, benthic grab samples, and SPI-PV data, with MBES bathymetry and backscatter data serving as supplementary datasets. The mapped area of the acoustic-derived sediment polygons was typically 400 m^2 but was as small as 100 m^2 in some areas.

A hybrid scheme of both the simplified version of the Folk (1954, Long 2006) and Coastal and Marine Ecological Classification Standard (CMECS) sediment classification systems was used in the seabed mapping. This classification represents the substrate encountered in the Project area and is well suited to mapping EFH to determine "complex" habitats with improved delineation and relevance over other grain size classifications used in other regions of the Atlantic OCS. Particle size definitions were based on Wentworth (1922). The simplified Folk system and Wentworth particle size system were used, in part, to define ecosystems in accordance with CMECS Substrate Component (CMECS, FDGC 2012). For sand, gravel, and silt, the Folk and Wentworth sediment classification systems agree with the ISO sediment classification standard (sand to gravel particle size boundary = 2 mm, silt to sand particle size boundary = 0.0625 mm), which was adopted for all Atlantic Shores geologic, engineering, and benthic studies.

10.4.2.3 Morphological Benthic Features Interpretation

Seafloor morphology within the Project area was interpreted from SSS mosaics, MBES bathymetry and backscatter, and seafloor slope analyses. Seafloor morphology was classified as the following: sand ridges, sandwave, megaripples, ripples, area of depressional marks, hummocky seafloor, interbedded surficial sediments, irregular seafloor, localized relief features, and scarps.

10.4.2.4 Essential Fish Habitat Classification

Based on guidance from NMFS during EFH consultation in March 2021, the following groupings of CMECS-substrate types were used to develop maps of EFH: soft-bottom habitat, complex habitat, heterogeneous complex habitat, large-grained complex habitat, and benthic features. All seabed sediment feature classes were mapped using ESRI ArcGIS Pro (2.8.2) under the framework outlined in Figure 10-2.

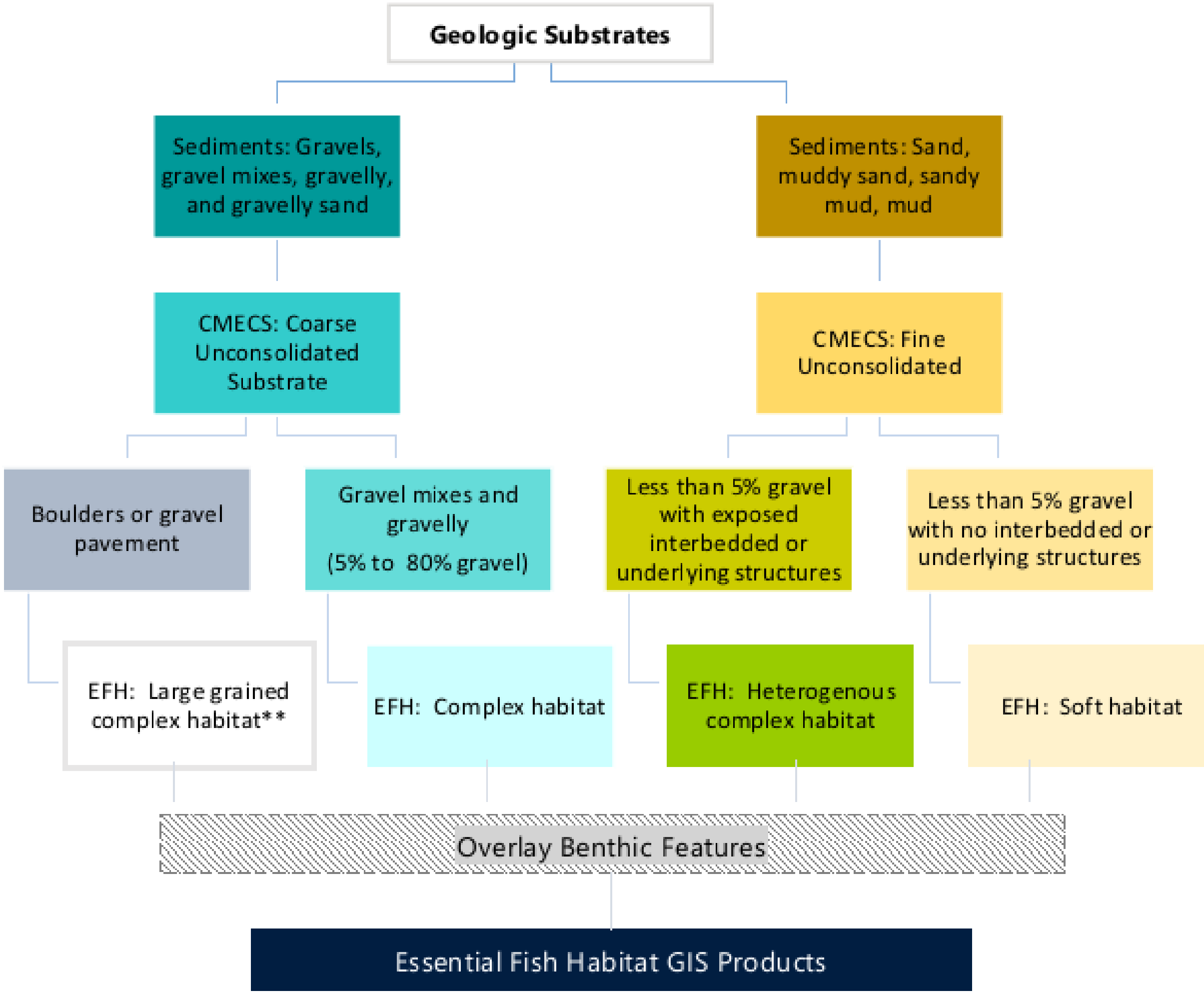


Figure 10-2. EFH Classification Framework Per NMFS Recommendation Letter to BOEM (March 2021)

10.5 Additional EFH Information

10.5.1 Summary of Benthic Habitat Impacts within the Project Area

Table 10-1. Areal Extent of Impacts on Benthic Habitat for Alternative B – Proposed Action

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative B - Proposed Action							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	4.8	0.7	0.9	**6.4**
			Monopile[2]	6.6	0.9	1.1	**8.7**
		Scour Protection	Piled Jacket / Monopile[1]	147.4	20.0	27.8	**195.2**
			Monopile[2]	190.5	24.4	35.4	**250.3**
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	247.9	31.5	46.7	**326.1**
			Monopile[2]	253.8	32.5	48.4	**334.6**
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	**0.0**
			Piled Jacket (Location 2)	0.0	0.0	0.0	**0.0**
			Piled Jacket (Location 3)	0.0	0.0	0.0	**0.0**
			Piled Jacket (Location 4)	0.0	0.0	0.0	**0.0**
			Monopile (Location 1)	0.0	0.0	0.0	**0.0**
			Monopile (Location 2)	0.0	0.0	0.0	**0.0**
			Monopile (Location 3)	0.0	0.0	0.0	**0.0**
			Monopile (Location 4)	0.0	0.0	0.0	**0.0**
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	**0.2**
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	**0.2**
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	**0.2**
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	**0.2**
			Mono-Bucket (Location 1)	0.2	0.0	0.0	**0.2**
			Mono-Bucket (Location 2)	0.2	0.0	0.0	**0.2**
			Mono-Bucket (Location 3)	0.2	0.0	0.0	**0.2**
			Mono-Bucket (Location 4)	0.0	0.2	0.0	**0.2**
			GBS (Location 1)	0.4	0.0	0.2	**0.6**
			GBS (Location 2)	0.6	0.0	0.0	**0.6**
			GBS (Location 3)	0.6	0.0	0.0	**0.6**
			GBS (Location 4)	0.1	0.5	0.0	**0.6**

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	**0.7**
			Piled Jacket (Location 2)	0.7	0.0	0.0	**0.7**
			Piled Jacket (Location 3)	0.7	0.0	0.0	**0.7**
			Piled Jacket (Location 4)	0.2	0.5	0.0	**0.7**
			Monopile (Location 1)	0.8	0.0	0.5	**1.3**
			Monopile (Location 2)	1.3	0.0	0.0	**1.3**
			Monopile (Location 3)	1.2	0.0	0.1	**1.3**
			Monopile (Location 4)	0.4	0.9	0.0	**1.3**
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	**2.4**
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	**2.4**
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	**2.4**
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	**2.4**
			Mono-Bucket (Location 1)	0.8	0.0	0.5	**1.3**
			Mono-Bucket (Location 2)	1.3	0.0	0.0	**1.3**
			Mono-Bucket (Location 3)	1.2	0.0	0.1	**1.3**
			Mono-Bucket (Location 4)	0.5	0.9	0.0	**1.3**
			GBS (Location 1)	0.4	0.0	0.3	**0.7**
			GBS (Location 2)	0.7	0.0	0.0	**0.7**
			GBS (Location 3)	0.7	0.0	0.1	**0.7**
			GBS (Location 4)	0.3	0.5	0.0	**0.7**
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	**1.6**
			Piled Jacket (Location 2)	1.6	0.0	0.0	**1.6**
			Piled Jacket (Location 3)	1.5	0.0	0.1	**1.6**
			Piled Jacket (Location 4)	0.6	1.0	0.0	**1.6**
			Monopile (Location 1)	1.0	0.0	0.7	**1.7**
			Monopile (Location 2)	1.7	0.0	0.0	**1.7**
			Monopile (Location 3)	1.5	0.0	0.2	**1.7**
			Monopile (Location 4)	0.7	1.0	0.0	**1.7**
			Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	**1.1**
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	**1.1**
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	**1.1**

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	**1.1**
			Mono-Bucket (Location 1)	1.0	0.0	0.7	**1.8**
			Mono-Bucket (Location 2)	1.8	0.0	0.0	**1.8**
			Mono-Bucket (Location 3)	1.6	0.0	0.2	**1.8**
			Mono-Bucket (Location 4)	0.7	1.1	0.0	**1.8**
			GBS (Location 1)	0.3	0.0	0.3	**0.6**
			GBS (Location 2)	0.6	0.0	0.0	**0.6**
			GBS (Location 3)	0.6	0.0	0.1	**0.6**
			GBS (Location 4)	0.2	0.4	0.0	**0.6**
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	**0.4**
			Piled Jacket (10 Small)	0.1	0.0	0.1	**0.2**
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	**1.7**
			Piled Jacket (5 Medium)	0.8	0.3	0.3	**1.3**
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	**1.3**
			GBS (5 Medium)	2.4	0.8	0.8	**4.0**
			Piled Jacket (4 Large)	1.2	0.6	0.6	**2.5**
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	**1.4**
			GBS (4 Large)	3.7	1.9	1.5	**7.1**
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	**12.6**
			Piled Jacket (10 Small)	3.7	1.0	2.1	**6.8**
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	**24.0**
			Piled Jacket (5 Medium)	4.9	1.8	1.3	**8.0**
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	**19.6**
			GBS (5 Medium)	8.3	2.9	1.8	**13.1**
			Piled Jacket (4 Large)	5.5	2.8	1.8	**10.1**
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	**24.6**
			GBS (4 Large)	8.5	4.2	2.4	**15.0**

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	**16.9**
			Piled Jacket (10 Small)	8.8	2.5	4.7	**16.0**
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	**10.9**
			Piled Jacket (5 Medium)	10.3	3.5	2.0	**15.9**
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	**11.2**
			GBS (5 Medium)	1.9	0.6	0.4	**3.0**
			Piled Jacket (4 Large)	11.2	5.5	2.9	**19.7**
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	**12.3**
			GBS (4 Large)	2.7	1.3	0.7	**4.7**
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (Small OSS)	87.6	13.3	27.1	**127.9**
			Inter-Array Cables (Medium OSS)	70.2	11.2	21.9	**103.2**
			Inter-Array Cables (Large OSS)	71.2	12.3	21.4	**104.9**
			Inter-Link Cables	0.5	0.6	0.8	**1.9**
	Temporary	Seafloor Disturbance	Inter-Array Cables (Small OSS)	579.8	87.2	179.3	**846.3**
			Inter-Array Cables (Medium OSS)	464.5	73.6	144.7	**682.8**
			Inter-Array Cables (Large OSS)	471.5	80.9	141.7	**694.1**
			Inter-Link Cables	4.2	4.9	6.9	**16.0**
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	**63.9**
			Monmouth	75.8	0.1	115.8	**191.7**
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	**622.7**
			Monmouth	517.2	0.6	814.9	**1,332.7**
Minimum Total Temporary Impacts[3,4]				**1,659.7**	**181.9**	**1,141.8**	**2,983.8**
Maximum Total Temporary Impacts[3,4]				**1,790.1**	**199.4**	**1,183.2**	**3,170.9**
Minimum Total Permanent Impacts[3,4]				**347.3**	**42.8**	**182.1**	**572.2**
Maximum Total Permanent Impacts[3.4]				**418.9**	**52.4**	**201.4**	**672.7**

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-2. Areal Extent of Impacts on Benthic Habitat for Alternative C1

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative C1 - Lobster Hole Area of Concern Avoidance							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	4.6	0.5	0.7	5.8
			Monopile[2]	6.4	0.6	1.0	8.0
		Scour Protection	Piled Jacket / Monopile[1]	140.8	12.7	23.1	176.6
			Monopile[2]	183.8	16.8	30.8	231.3
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	239.2	20.9	40.6	300.7
			Monopile[2]	245.2	21.8	42.0	309.1
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 2)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 3)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 4)	0.0	0.0	0.0	0.0
			Monopile (Location 1)	0.0	0.0	0.0	0.0
			Monopile (Location 2)	0.0	0.0	0.0	0.0
			Monopile (Location 3)	0.0	0.0	0.0	0.0
			Monopile (Location 4)	0.0	0.0	0.0	0.0
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	0.2
			Mono-Bucket (Location 1)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 2)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 3)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 4)	0.0	0.2	0.0	0.2
			GBS (Location 1)	0.4	0.0	0.2	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.0	0.6
			GBS (Location 4)	0.1	0.5	0.0	0.6

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	0.7
			Piled Jacket (Location 2)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 3)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 4)	0.2	0.5	0.0	0.7
			Monopile (Location 1)	0.8	0.0	0.5	1.3
			Monopile (Location 2)	1.3	0.0	0.0	1.3
			Monopile (Location 3)	1.2	0.0	0.1	1.3
			Monopile (Location 4)	0.4	0.9	0.0	1.3
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	2.4
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	2.4
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	2.4
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	2.4
			Mono-Bucket (Location 1)	0.8	0.0	0.5	1.3
			Mono-Bucket (Location 2)	1.3	0.0	0.0	1.3
			Mono-Bucket (Location 3)	1.2	0.0	0.1	1.3
			Mono-Bucket (Location 4)	0.5	0.9	0.0	1.3
			GBS (Location 1)	0.4	0.0	0.3	0.7
			GBS (Location 2)	0.7	0.0	0.0	0.7
			GBS (Location 3)	0.7	0.0	0.1	0.7
			GBS (Location 4)	0.2	0.4	0.0	0.6
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	1.6
			Piled Jacket (Location 2)	1.6	0.0	0.0	1.6
			Piled Jacket (Location 3)	1.5	0.0	0.1	1.6
			Piled Jacket (Location 4)	0.6	1.0	0.0	1.6
			Monopile (Location 1)	1.0	0.0	0.7	1.7
			Monopile (Location 2)	1.7	0.0	0.0	1.7
			Monopile (Location 3)	1.5	0.0	0.2	1.7
			Monopile (Location 4)	0.7	1.0	0.0	1.7

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	1.1
			Mono-Bucket (Location 1)	1.0	0.0	0.7	1.8
			Mono-Bucket (Location 2)	1.8	0.0	0.0	1.8
			Mono-Bucket (Location 3)	1.6	0.0	0.2	1.8
			Mono-Bucket (Location 4)	0.7	1.1	0.0	1.8
			GBS (Location 1)	0.3	0.0	0.3	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.1	0.6
			GBS (Location 4)	0.2	0.4	0.0	0.6
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	0.4
			Piled Jacket (10 Small)	0.1	0.0	0.1	0.2
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	1.7
			Piled Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	1.3
			GBS (5 Medium)	2.4	0.8	0.8	4.0
			Piled Jacket (4 Large)	1.2	0.6	0.6	2.5
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	1.4
			GBS (4 Large)	3.7	1.9	1.5	7.1
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	12.6
			Piled Jacket (10 Small)	3.7	1.0	2.1	6.8
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	24.0
			Piled Jacket (5 Medium)	4.9	1.8	1.3	8.0
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	19.6
			GBS (5 Medium)	8.3	2.9	1.8	13.1
			Piled Jacket (4 Large)	5.5	2.8	1.8	10.1
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	24.6
			GBS (4 Large)	8.5	4.2	2.4	15.0

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	16.9
			Piled Jacket (10 Small)	8.8	2.5	4.7	16.0
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	10.9
			Piled Jacket (5 Medium)	10.3	3.5	2.0	15.9
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	11.2
			GBS (5 Medium)	1.9	0.6	0.4	3.0
			Piled Jacket (4 Large)	11.2	5.5	2.9	19.7
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	12.3
			GBS (4 Large)	2.7	1.3	0.7	4.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (10 Small OSS)	80.6	12.2	24.9	117.7
			Inter-Array Cables (5 Medium OSS)	64.6	10.3	20.1	95.0
			Inter-Array Cables (4 Large OSS)	65.5	11.3	19.7	96.5
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (10 Small OSS)	533.4	80.2	165.0	778.6
			Inter-Array Cables (5 Medium OSS)	427.3	67.7	133.2	628.1
			Inter-Array Cables (4 Large OSS)	433.8	74.4	130.4	638.6
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,613.9	165.3	1,124.1	2,903.7
Maximum Total Temporary Impacts[3,4]				1,735.2	181.8	1,162.5	3,077.7
Minimum Total Permanent Impacts[3,4]				334.9	34.2	175.5	544.7
Maximum Total Permanent Impacts[3,4]				404.9	43.5	194.4	642.7

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-3. Areal Extent of Impacts on Benthic Habitat for Alternative C2

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative C2 – NMFS-Proposed Sand Ridge Complex Avoidance							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	4.3	0.6	0.9	5.8
			Monopile[2]	6.2	0.8	1.1	8.1
		Scour Protection	Piled Jacket / Monopile[1]	133.3	18.4	27.6	179.4
			Monopile[2]	176.5	22.8	35.2	234.5
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	228.8	29.9	46.5	305.2
			Monopile[2]	234.7	30.8	48.2	313.6
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 2)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 3)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 4)	0.0	0.0	0.0	0.0
			Monopile (Location 1)	0.0	0.0	0.0	0.0
			Monopile (Location 2)	0.0	0.0	0.0	0.0
			Monopile (Location 3)	0.0	0.0	0.0	0.0
			Monopile (Location 4)	0.0	0.0	0.0	0.0
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	0.2
			Mono-Bucket (Location 1)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 2)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 3)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 4)	0.0	0.2	0.0	0.2
			GBS (Location 1)	0.4	0.0	0.2	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.0	0.6
			GBS (Location 4)	0.1	0.5	0.0	0.6

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	0.7
			Piled Jacket (Location 2)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 3)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 4)	0.2	0.5	0.0	0.7
			Monopile (Location 1)	0.8	0.0	0.5	1.3
			Monopile (Location 2)	1.3	0.0	0.0	1.3
			Monopile (Location 3)	1.2	0.0	0.1	1.3
			Monopile (Location 4)	0.4	0.9	0.0	1.3
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	2.4
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	2.4
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	2.4
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	2.4
			Mono-Bucket (Location 1)	0.8	0.0	0.5	1.3
			Mono-Bucket (Location 2)	1.3	0.0	0.0	1.3
			Mono-Bucket (Location 3)	1.2	0.0	0.1	1.3
			Mono-Bucket (Location 4)	0.5	0.9	0.0	1.3
			GBS (Location 1)	0.4	0.0	0.3	0.7
			GBS (Location 2)	0.7	0.0	0.0	0.7
			GBS (Location 3)	0.7	0.0	0.1	0.7
			GBS (Location 4)	0.2	0.4	0.0	0.6
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	1.6
			Piled Jacket (Location 2)	1.6	0.0	0.0	1.6
			Piled Jacket (Location 3)	1.5	0.0	0.1	1.6
			Piled Jacket (Location 4)	0.6	1.0	0.0	1.6
			Monopile (Location 1)	1.0	0.0	0.7	1.7
			Monopile (Location 2)	1.7	0.0	0.0	1.7
			Monopile (Location 3)	1.5	0.0	0.2	1.7
			Monopile (Location 4)	0.7	1.0	0.0	1.7

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	1.1
			Mono-Bucket (Location 1)	1.0	0.0	0.7	1.8
			Mono-Bucket (Location 2)	1.8	0.0	0.0	1.8
			Mono-Bucket (Location 3)	1.6	0.0	0.2	1.8
			Mono-Bucket (Location 4)	0.7	1.1	0.0	1.8
			GBS (Location 1)	0.3	0.0	0.3	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.1	0.6
			GBS (Location 4)	0.2	0.4	0.0	0.6
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	0.4
			Piled Jacket (10 Small)	0.1	0.0	0.1	0.2
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	1.7
			Piled Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	1.3
			GBS (5 Medium)	2.4	0.8	0.8	4.0
			Piled Jacket (4 Large)	1.2	0.6	0.6	2.5
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	1.4
			GBS (4 Large)	3.7	1.9	1.5	7.1
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	12.6
			Piled Jacket (10 Small)	3.7	1.0	2.1	6.8
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	24.0
			Piled Jacket (5 Medium)	4.9	1.8	1.3	8.0
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	19.6
			GBS (5 Medium)	8.3	2.9	1.8	13.1
			Piled Jacket (4 Large)	5.5	2.8	1.8	10.1
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	24.6
			GBS (4 Large)	8.5	4.2	2.4	15.0

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	16.9
			Piled Jacket (10 Small)	8.8	2.5	4.7	16.0
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	10.9
			Piled Jacket (5 Medium)	10.3	3.5	2.0	15.9
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	11.2
			GBS (5 Medium)	1.9	0.6	0.4	3.0
			Piled Jacket (4 Large)	11.2	5.5	2.9	19.7
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	12.3
			GBS (4 Large)	2.7	1.3	0.7	4.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (10 Small OSS)	81.9	12.4	25.3	119.6
			Inter-Array Cables (5 Medium OSS)	65.6	10.4	20.5	96.5
			Inter-Array Cables (4 Large OSS)	66.6	11.5	20.0	98.1
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (10 Small OSS)	542.1	81.5	167.7	791.3
			Inter-Array Cables (5 Medium OSS)	434.3	68.8	135.3	638.4
			Inter-Array Cables (4 Large OSS)	440.8	75.6	132.5	649.0
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,610.5	175.4	1,132.2	2,918.4
Maximum Total Temporary Impacts[3,4]				1,733.3	192.0	1,171.4	3,094.9
Minimum Total Permanent Impacts[3,4]				328.3	40.4	180.5	549.2
Maximum Total Permanent Impacts[3,4]				398.7	49.9	199.4	648.0

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-4. Areal Extent of Impacts on Benthic Habitat for Alternative C3

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative C3 – Demarcated Sand Ridge Complex Avoidance							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	4.5	0.7	0.9	6.1
			Monopile[2]	6.4	0.9	1.1	8.4
		Scour Protection	Piled Jacket / Monopile[1]	139.8	20.0	27.8	187.6
			Monopile[2]	183.0	24.4	35.4	242.8
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	238.0	31.5	46.7	316.2
			Monopile[2]	243.9	32.5	48.3	324.7
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 2)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 3)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 4)	0.0	0.0	0.0	0.0
			Monopile (Location 1)	0.0	0.0	0.0	0.0
			Monopile (Location 2)	0.0	0.0	0.0	0.0
			Monopile (Location 3)	0.0	0.0	0.0	0.0
			Monopile (Location 4)	0.0	0.0	0.0	0.0
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	0.2
			Mono-Bucket (Location 1)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 2)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 3)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 4)	0.0	0.2	0.0	0.2
			GBS (Location 1)	0.4	0.0	0.2	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.0	0.6
			GBS (Location 4)	0.1	0.5	0.0	0.6

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	0.7
			Piled Jacket (Location 2)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 3)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 4)	0.2	0.5	0.0	0.7
			Monopile (Location 1)	0.8	0.0	0.5	1.3
			Monopile (Location 2)	1.3	0.0	0.0	1.3
			Monopile (Location 3)	1.2	0.0	0.1	1.3
			Monopile (Location 4)	0.4	0.9	0.0	1.3
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	2.4
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	2.4
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	2.4
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	2.4
			Mono-Bucket (Location 1)	0.8	0.0	0.5	1.3
			Mono-Bucket (Location 2)	1.3	0.0	0.0	1.3
			Mono-Bucket (Location 3)	1.2	0.0	0.1	1.3
			Mono-Bucket (Location 4)	0.5	0.9	0.0	1.3
			GBS (Location 1)	0.4	0.0	0.3	0.7
			GBS (Location 2)	0.7	0.0	0.0	0.7
			GBS (Location 3)	0.7	0.0	0.1	0.7
			GBS (Location 4)	0.2	0.4	0.0	0.6
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	1.6
			Piled Jacket (Location 2)	1.6	0.0	0.0	1.6
			Piled Jacket (Location 3)	1.5	0.0	0.1	1.6
			Piled Jacket (Location 4)	0.6	1.0	0.0	1.6
			Monopile (Location 1)	1.0	0.0	0.7	1.7
			Monopile (Location 2)	1.7	0.0	0.0	1.7
			Monopile (Location 3)	1.5	0.0	0.2	1.7
			Monopile (Location 4)	0.7	1.0	0.0	1.7

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	1.1
			Mono-Bucket (Location 1)	1.0	0.0	0.7	1.8
			Mono-Bucket (Location 2)	1.8	0.0	0.0	1.8
			Mono-Bucket (Location 3)	1.6	0.0	0.2	1.8
			Mono-Bucket (Location 4)	0.7	1.1	0.0	1.8
			GBS (Location 1)	0.3	0.0	0.3	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.1	0.6
			GBS (Location 4)	0.2	0.4	0.0	0.6
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	0.4
			Piled Jacket (10 Small)	0.1	0.0	0.1	0.2
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	1.7
			Piled Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	1.3
			GBS (5 Medium)	2.4	0.8	0.8	4.0
			Piled Jacket (4 Large)	1.2	0.6	0.6	2.5
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	1.4
			GBS (4 Large)	3.7	1.9	1.5	7.1
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	12.6
			Piled Jacket (10 Small)	3.7	1.0	2.1	6.8
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	24.0
			Piled Jacket (5 Medium)	4.9	1.8	1.3	8.0
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	19.6
			GBS (5 Medium)	8.3	2.9	1.8	13.1
			Piled Jacket (4 Large)	5.5	2.8	1.8	10.1
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	24.6
			GBS (4 Large)	8.5	4.2	2.4	15.0

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	16.9
			Piled Jacket (10 Small)	8.8	2.5	4.7	16.0
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	10.9
			Piled Jacket (5 Medium)	10.3	3.5	2.0	15.9
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	11.2
			GBS (5 Medium)	1.9	0.6	0.4	3.0
			Piled Jacket (4 Large)	11.2	5.5	2.9	19.7
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	12.3
			GBS (4 Large)	2.7	1.3	0.7	4.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (10 Small OSS)	85.0	12.9	26.3	124.1
			Inter-Array Cables (5 Medium OSS)	68.1	10.8	21.2	100.1
			Inter-Array Cables (4 Large OSS)	69.0	11.9	20.8	101.8
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (10 Small OSS)	562.4	84.6	174.0	820.9
			Inter-Array Cables (5 Medium OSS)	450.5	71.4	140.4	662.3
			Inter-Array Cables (4 Large OSS)	457.3	78.5	137.5	673.3
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,635.9	179.7	1,137.4	2,953.4
Maximum Total Temporary Impacts[3,4]				1,762.8	196.8	1,177.8	3,135.6
Minimum Total Permanent Impacts[3,4]				337.5	42.4	181.4	561.3
Maximum Total Permanent Impacts[3,4]				408.5	52.0	200.5	661.0

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-5. Areal Extent of Impacts on Benthic Habitat for Alternative D1

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative D1 – No Surface Occupancy Up to 12 Miles from Shores							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	4.0	0.7	0.8	**5.5**
			Monopile[2]	5.8	0.9	1.1	**7.8**
		Scour Protection	Piled Jacket / Monopile[1]	124.4	19.4	25.0	**168.8**
			Monopile[2]	167.6	23.7	32.6	**224.0**
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	218.3	30.2	42.8	**291.3**
			Monopile[2]	224.2	31.1	44.4	**299.8**
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	**0.0**
			Piled Jacket (Location 2)	0.0	0.0	0.0	**0.0**
			Piled Jacket (Location 3)	0.0	0.0	0.0	**0.0**
			Piled Jacket (Location 4)	0.0	0.0	0.0	**0.0**
			Monopile (Location 1)	0.0	0.0	0.0	**0.0**
			Monopile (Location 2)	0.0	0.0	0.0	**0.0**
			Monopile (Location 3)	0.0	0.0	0.0	**0.0**
			Monopile (Location 4)	0.0	0.0	0.0	**0.0**
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	**0.2**
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	**0.2**
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	**0.2**
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	**0.2**
			Mono-Bucket (Location 1)	0.2	0.0	0.0	**0.2**
			Mono-Bucket (Location 2)	0.2	0.0	0.0	**0.2**
			Mono-Bucket (Location 3)	0.2	0.0	0.0	**0.2**
			Mono-Bucket (Location 4)	0.0	0.2	0.0	**0.2**
			GBS (Location 1)	0.4	0.0	0.2	**0.6**
			GBS (Location 2)	0.6	0.0	0.0	**0.6**
			GBS (Location 3)	0.6	0.0	0.0	**0.6**
			GBS (Location 4)	0.1	0.5	0.0	**0.6**

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	**0.7**
			Piled Jacket (Location 2)	0.7	0.0	0.0	**0.7**
			Piled Jacket (Location 3)	0.7	0.0	0.0	**0.7**
			Piled Jacket (Location 4)	0.2	0.5	0.0	**0.7**
			Monopile (Location 1)	0.8	0.0	0.5	**1.3**
			Monopile (Location 2)	1.3	0.0	0.0	**1.3**
			Monopile (Location 3)	1.2	0.0	0.1	**1.3**
			Monopile (Location 4)	0.4	0.9	0.0	**1.3**
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	**2.4**
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	**2.4**
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	**2.4**
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	**2.4**
			Mono-Bucket (Location 1)	0.8	0.0	0.5	**1.3**
			Mono-Bucket (Location 2)	1.3	0.0	0.0	**1.3**
			Mono-Bucket (Location 3)	1.2	0.0	0.1	**1.3**
			Mono-Bucket (Location 4)	0.5	0.9	0.0	**1.3**
			GBS (Location 1)	0.4	0.0	0.3	**0.7**
			GBS (Location 2)	0.7	0.0	0.0	**0.7**
			GBS (Location 3)	0.7	0.0	0.1	**0.7**
			GBS (Location 4)	0.2	0.4	0.0	**0.6**
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	**1.6**
			Piled Jacket (Location 2)	1.6	0.0	0.0	**1.6**
			Piled Jacket (Location 3)	1.5	0.0	0.1	**1.6**
			Piled Jacket (Location 4)	0.6	1.0	0.0	**1.6**
			Monopile (Location 1)	1.0	0.0	0.7	**1.7**
			Monopile (Location 2)	1.7	0.0	0.0	**1.7**
			Monopile (Location 3)	1.5	0.0	0.2	**1.7**
			Monopile (Location 4)	0.7	1.0	0.0	**1.7**

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	**1.1**
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	**1.1**
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	**1.1**
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	**1.1**
			Mono-Bucket (Location 1)	1.0	0.0	0.7	**1.8**
			Mono-Bucket (Location 2)	1.8	0.0	0.0	**1.8**
			Mono-Bucket (Location 3)	1.6	0.0	0.2	**1.8**
			Mono-Bucket (Location 4)	0.7	1.1	0.0	**1.8**
			GBS (Location 1)	0.3	0.0	0.3	**0.6**
			GBS (Location 2)	0.6	0.0	0.0	**0.6**
			GBS (Location 3)	0.6	0.0	0.1	**0.6**
			GBS (Location 4)	0.2	0.4	0.0	**0.6**
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	**0.4**
			Piled Jacket (10 Small)	0.1	0.0	0.1	**0.2**
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	**1.7**
			Piled Jacket (5 Medium)	0.8	0.3	0.3	**1.3**
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	**1.3**
			GBS (5 Medium)	2.4	0.8	0.8	**4.0**
			Piled Jacket (4 Large)	1.2	0.6	0.6	**2.5**
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	**1.4**
			GBS (4 Large)	3.7	1.9	1.5	**7.1**
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	**12.6**
			Piled Jacket (10 Small)	3.7	1.0	2.1	**6.8**
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	**24.0**
			Piled Jacket (5 Medium)	4.9	1.8	1.3	**8.0**
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	**19.6**
			GBS (5 Medium)	8.3	2.9	1.8	**13.1**
			Piled Jacket (4 Large)	5.5	2.8	1.8	**10.1**
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	**24.6**
			GBS (4 Large)	8.5	4.2	2.4	**15.0**

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	**16.9**
			Piled Jacket (10 Small)	8.8	2.5	4.7	**16.0**
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	**10.9**
			Piled Jacket (5 Medium)	10.3	3.5	2.0	**15.9**
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	**11.2**
			GBS (5 Medium)	1.9	0.6	0.4	**3.0**
			Piled Jacket (4 Large)	11.2	5.5	2.9	**19.7**
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	**12.3**
			GBS (4 Large)	2.7	1.3	0.7	**4.7**
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (10 Small OSS)	78.4	11.9	24.2	**114.5**
			Inter-Array Cables (5 Medium OSS)	62.8	10.0	19.6	**92.4**
			Inter-Array Cables (4 Large OSS)	63.7	11.0	19.2	**93.9**
			Inter-Link Cables	0.5	0.6	0.8	**1.9**
	Temporary	Seafloor Disturbance	Inter-Array Cables (10 Small OSS)	518.9	78.0	160.5	**757.5**
			Inter-Array Cables (5 Medium OSS)	415.7	65.8	129.6	**611.1**
			Inter-Array Cables (4 Large OSS)	422.0	72.4	126.8	**621.2**
			Inter-Link Cables	4.2	4.9	6.9	**16.0**
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	**63.9**
			Monmouth	75.8	0.1	115.8	**191.7**
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	**622.7**
			Monmouth	517.2	0.6	814.9	**1,332.7**
Minimum Total Temporary Impacts[3,4]				**1,581.4**	**172.8**	**1,122.7**	**2,877.3**
Maximum Total Temporary Impacts[3,4]				**1,699.6**	**188.9**	**1,160.5**	**3,047.2**
Minimum Total Permanent Impacts[3,4]				**316.2**	**40.9**	**177.0**	**534.1**
Maximum Total Permanent Impacts[3,4]				**385.9**	**50.4**	**195.6**	**631.9**

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-6. Areal Extent of Impacts on Benthic Habitat for Alternative D2

Proposed Project Component			Option	Benthic Habitat Impact (acres) Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative D2 - No Surface Occupancy Up to 12.75 Miles from Shores							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	3.7	0.7	0.6	5.0
			Monopile[2]	5.6	0.8	0.9	7.3
		Scour Protection	Piled Jacket / Monopile[1]	117.3	18.1	20.8	156.2
			Monopile[2]	160.5	22.5	28.5	211.4
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	208.5	28.6	37.3	274.4
			Monopile[2]	214.4	29.5	39.0	282.9
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 2)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 3)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 4)	0.0	0.0	0.0	0.0
			Monopile (Location 1)	0.0	0.0	0.0	0.0
			Monopile (Location 2)	0.0	0.0	0.0	0.0
			Monopile (Location 3)	0.0	0.0	0.0	0.0
			Monopile (Location 4)	0.0	0.0	0.0	0.0
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	0.2
			Mono-Bucket (Location 1)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 2)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 3)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 4)	0.0	0.2	0.0	0.2
			GBS (Location 1)	0.4	0.0	0.2	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.0	0.6
			GBS (Location 4)	0.1	0.5	0.0	0.6

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	0.7
			Piled Jacket (Location 2)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 3)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 4)	0.2	0.5	0.0	0.7
			Monopile (Location 1)	0.8	0.0	0.5	1.3
			Monopile (Location 2)	1.3	0.0	0.0	1.3
			Monopile (Location 3)	1.2	0.0	0.1	1.3
			Monopile (Location 4)	0.4	0.9	0.0	1.3
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	2.4
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	2.4
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	2.4
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	2.4
			Mono-Bucket (Location 1)	0.8	0.0	0.5	1.3
			Mono-Bucket (Location 2)	1.3	0.0	0.0	1.3
			Mono-Bucket (Location 3)	1.2	0.0	0.1	1.3
			Mono-Bucket (Location 4)	0.5	0.9	0.0	1.3
			GBS (Location 1)	0.4	0.0	0.3	0.7
			GBS (Location 2)	0.7	0.0	0.0	0.7
			GBS (Location 3)	0.7	0.0	0.1	0.7
			GBS (Location 4)	0.2	0.4	0.0	0.6
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	1.6
			Piled Jacket (Location 2)	1.6	0.0	0.0	1.6
			Piled Jacket (Location 3)	1.5	0.0	0.1	1.6
			Piled Jacket (Location 4)	0.6	1.0	0.0	1.6
			Monopile (Location 1)	1.0	0.0	0.7	1.7
			Monopile (Location 2)	1.7	0.0	0.0	1.7
			Monopile (Location 3)	1.5	0.0	0.2	1.7
			Monopile (Location 4)	0.7	1.0	0.0	1.7

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	1.1
			Mono-Bucket (Location 1)	1.0	0.0	0.7	1.8
			Mono-Bucket (Location 2)	1.8	0.0	0.0	1.8
			Mono-Bucket (Location 3)	1.6	0.0	0.2	1.8
			Mono-Bucket (Location 4)	0.7	1.1	0.0	1.8
			GBS (Location 1)	0.3	0.0	0.3	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.1	0.6
			GBS (Location 4)	0.2	0.4	0.0	0.6
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	0.4
			Piled Jacket (10 Small)	0.1	0.0	0.1	0.2
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	1.7
			Piled Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	1.3
			GBS (5 Medium)	2.4	0.8	0.8	4.0
			Piled Jacket (4 Large)	1.2	0.6	0.6	2.5
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	1.4
			GBS (4 Large)	3.7	1.9	1.5	7.1
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	12.6
			Piled Jacket (10 Small)	3.7	1.0	2.1	6.8
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	24.0
			Piled Jacket (5 Medium)	4.9	1.8	1.3	8.0
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	19.6
			GBS (5 Medium)	8.3	2.9	1.8	13.1
			Piled Jacket (4 Large)	5.5	2.8	1.8	10.1
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	24.6
			GBS (4 Large)	8.5	4.2	2.4	15.0

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	16.9
			Piled Jacket (10 Small)	8.8	2.5	4.7	16.0
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	10.9
			Piled Jacket (5 Medium)	10.3	3.5	2.0	15.9
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	11.2
			GBS (5 Medium)	1.9	0.6	0.4	3.0
			Piled Jacket (4 Large)	11.2	5.5	2.9	19.7
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	12.3
			GBS (4 Large)	2.7	1.3	0.7	4.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (10 Small OSS)	74.0	11.2	22.9	108.1
			Inter-Array Cables (5 Medium OSS)	59.3	9.4	18.5	87.2
			Inter-Array Cables (4 Large OSS)	60.1	10.4	18.1	88.7
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (10 Small OSS)	489.9	73.7	151.5	715.1
			Inter-Array Cables (5 Medium OSS)	392.5	62.2	122.3	576.9
			Inter-Array Cables (4 Large OSS)	398.4	68.4	119.8	586.5
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,548.4	167.5	1,110.0	2,826.2
Maximum Total Temporary Impacts[3,4]				1,660.8	182.9	1,146.1	2,988.0
Minimum Total Permanent Impacts[3,4]				305.3	39.1	171.5	516.0
Maximum Total Permanent Impacts[3,4]				374.2	48.4	190.0	612.6

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-7. Areal Extent of Impacts on Benthic Habitat for Alternative D3

Proposed Project Component			Option	Benthic Habitat Impact (acres) Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative D3 - No Surface Occupancy Up to 10.8 Miles from Shores							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	4.5	0.7	0.9	6.1
			Monopile[2]	6.4	0.9	1.1	8.4
		Scour Protection	Piled Jacket / Monopile[1]	139.8	20.0	27.8	187.6
			Monopile[2]	183.0	24.4	35.4	242.8
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	237.9	31.5	46.7	316.2
			Monopile[2]	243.8	32.5	48.4	324.7
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 2)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 3)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 4)	0.0	0.0	0.0	0.0
			Monopile (Location 1)	0.0	0.0	0.0	0.0
			Monopile (Location 2)	0.0	0.0	0.0	0.0
			Monopile (Location 3)	0.0	0.0	0.0	0.0
			Monopile (Location 4)	0.0	0.0	0.0	0.0
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	0.2
			Mono-Bucket (Location 1)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 2)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 3)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 4)	0.0	0.2	0.0	0.2
			GBS (Location 1)	0.4	0.0	0.2	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.0	0.6
			GBS (Location 4)	0.1	0.5	0.0	0.6

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	0.7
			Piled Jacket (Location 2)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 3)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 4)	0.2	0.5	0.0	0.7
			Monopile (Location 1)	0.8	0.0	0.5	1.3
			Monopile (Location 2)	1.3	0.0	0.0	1.3
			Monopile (Location 3)	1.2	0.0	0.1	1.3
			Monopile (Location 4)	0.4	0.9	0.0	1.3
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	2.4
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	2.4
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	2.4
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	2.4
			Mono-Bucket (Location 1)	0.8	0.0	0.5	1.3
			Mono-Bucket (Location 2)	1.3	0.0	0.0	1.3
			Mono-Bucket (Location 3)	1.2	0.0	0.1	1.3
			Mono-Bucket (Location 4)	0.5	0.9	0.0	1.3
			GBS (Location 1)	0.4	0.0	0.3	0.7
			GBS (Location 2)	0.7	0.0	0.0	0.7
			GBS (Location 3)	0.7	0.0	0.1	0.7
			GBS (Location 4)	0.2	0.4	0.0	0.6
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	1.6
			Piled Jacket (Location 2)	1.6	0.0	0.0	1.6
			Piled Jacket (Location 3)	1.5	0.0	0.1	1.6
			Piled Jacket (Location 4)	0.6	1.0	0.0	1.6
			Monopile (Location 1)	1.0	0.0	0.7	1.7
			Monopile (Location 2)	1.7	0.0	0.0	1.7
			Monopile (Location 3)	1.5	0.0	0.2	1.7
			Monopile (Location 4)	0.7	1.0	0.0	1.7

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	1.1
			Mono-Bucket (Location 1)	1.0	0.0	0.7	1.8
			Mono-Bucket (Location 2)	1.8	0.0	0.0	1.8
			Mono-Bucket (Location 3)	1.6	0.0	0.2	1.8
			Mono-Bucket (Location 4)	0.7	1.1	0.0	1.8
			GBS (Location 1)	0.3	0.0	0.3	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.1	0.6
			GBS (Location 4)	0.2	0.4	0.0	0.6
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	0.4
			Piled Jacket (10 Small)	0.1	0.0	0.1	0.2
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	1.7
			Piled Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	1.3
			GBS (5 Medium)	2.4	0.8	0.8	4.0
			Piled Jacket (4 Large)	1.2	0.6	0.6	2.5
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	1.4
			GBS (4 Large)	3.7	1.9	1.5	7.1
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	12.6
			Piled Jacket (10 Small)	3.7	1.0	2.1	6.8
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	24.0
			Piled Jacket (5 Medium)	4.9	1.8	1.3	8.0
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	19.6
			GBS (5 Medium)	8.3	2.9	1.8	13.1
			Piled Jacket (4 Large)	5.5	2.8	1.8	10.1
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	24.6
			GBS (4 Large)	8.5	4.2	2.4	15.0

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	16.9
			Piled Jacket (10 Small)	8.8	2.5	4.7	16.0
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	10.9
			Piled Jacket (5 Medium)	10.3	3.5	2.0	15.9
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	11.2
			GBS (5 Medium)	1.9	0.6	0.4	3.0
			Piled Jacket (4 Large)	11.2	5.5	2.9	19.7
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	12.3
			GBS (4 Large)	2.7	1.3	0.7	4.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (10 Small OSS)	85.0	12.9	26.3	124.1
			Inter-Array Cables (5 Medium OSS)	68.1	10.8	21.2	100.1
			Inter-Array Cables (4 Large OSS)	69.0	11.9	20.8	101.8
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (10 Small OSS)	562.4	84.6	174.0	820.9
			Inter-Array Cables (5 Medium OSS)	450.5	71.4	140.4	662.3
			Inter-Array Cables (4 Large OSS)	457.3	78.5	137.5	673.3
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,635.8	179.7	1,137.5	2,953.4
Maximum Total Temporary Impacts[3,4]				1,762.7	196.8	1,177.9	3,135.6
Minimum Total Permanent Impacts[3,4]				337.4	42.4	181.5	561.3
Maximum Total Permanent Impacts[3,4]				408.4	52.0	200.5	661.0

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-8. Areal Extent of Impacts on Benthic Habitat for Alternative E

Proposed Project Component			Option	Benthic Habitat Impact (acres) Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative E – Wind Turbine Layout Modification to Establish a Setback							
Wind Turbine Generators	Permanent	Foundations	Piled Jacket / Monopile[1]	4.6	0.7	0.8	6.2
			Monopile[2]	6.5	0.9	1.1	8.5
		Scour Protection	Piled Jacket / Monopile[1]	142.6	20.0	26.7	189.3
			Monopile[2]	185.8	24.4	34.3	244.5
	Temporary	Seafloor Disturbance	Piled Jacket / Monopile[1]	242.3	31.3	45.5	319.1
			Monopile[2]	248.2	32.2	47.1	327.5
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 2)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 3)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 4)	0.0	0.0	0.0	0.0
			Monopile (Location 1)	0.0	0.0	0.0	0.0
			Monopile (Location 2)	0.0	0.0	0.0	0.0
			Monopile (Location 3)	0.0	0.0	0.0	0.0
			Monopile (Location 4)	0.0	0.0	0.0	0.0
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	0.2
			Mono-Bucket (Location 1)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 2)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 3)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 4)	0.0	0.2	0.0	0.2
			GBS (Location 1)	0.4	0.0	0.2	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.0	0.6
			GBS (Location 4)	0.1	0.5	0.0	0.6

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	0.7
			Piled Jacket (Location 2)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 3)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 4)	0.2	0.5	0.0	0.7
			Monopile (Location 1)	0.8	0.0	0.5	1.3
			Monopile (Location 2)	1.3	0.0	0.0	1.3
			Monopile (Location 3)	1.2	0.0	0.1	1.3
			Monopile (Location 4)	0.4	0.9	0.0	1.3
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	2.4
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	2.4
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	2.4
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	2.4
			Mono-Bucket (Location 1)	0.8	0.0	0.5	1.3
			Mono-Bucket (Location 2)	1.3	0.0	0.0	1.3
			Mono-Bucket (Location 3)	1.2	0.0	0.1	1.3
			Mono-Bucket (Location 4)	0.5	0.9	0.0	1.3
			GBS (Location 1)	0.4	0.0	0.3	0.7
			GBS (Location 2)	0.7	0.0	0.0	0.7
			GBS (Location 3)	0.7	0.0	0.1	0.7
			GBS (Location 4)	0.2	0.4	0.0	0.6
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	1.6
			Piled Jacket (Location 2)	1.6	0.0	0.0	1.6
			Piled Jacket (Location 3)	1.5	0.0	0.1	1.6
			Piled Jacket (Location 4)	0.6	1.0	0.0	1.6
			Monopile (Location 1)	1.0	0.0	0.7	1.7
			Monopile (Location 2)	1.7	0.0	0.0	1.7
			Monopile (Location 3)	1.5	0.0	0.2	1.7
			Monopile (Location 4)	0.7	1.0	0.0	1.7

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Temporary (cont.)	Seafloor Disturbance (cont.)	Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	1.1
			Mono-Bucket (Location 1)	1.0	0.0	0.7	1.8
			Mono-Bucket (Location 2)	1.8	0.0	0.0	1.8
			Mono-Bucket (Location 3)	1.6	0.0	0.2	1.8
			Mono-Bucket (Location 4)	0.7	1.1	0.0	1.8
			GBS (Location 1)	0.3	0.0	0.3	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.1	0.6
			GBS (Location 4)	0.2	0.4	0.0	0.6
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	0.4
			Piled Jacket (10 Small)	0.1	0.0	0.1	0.2
			Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	1.7
			Piled Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	1.3
			GBS (5 Medium)	2.4	0.8	0.8	4.0
			Piled Jacket (4 Large)	1.2	0.6	0.6	2.5
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	1.4
			GBS (4 Large)	3.7	1.9	1.5	7.1
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	12.6
			Piled Jacket (10 Small)	3.7	1.0	2.1	6.8
			Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	24.0
			Piled Jacket (5 Medium)	4.9	1.8	1.3	8.0
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	19.6
			GBS (5 Medium)	8.3	2.9	1.8	13.1
			Piled Jacket (4 Large)	5.5	2.8	1.8	10.1
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	24.6
			GBS (4 Large)	8.5	4.2	2.4	15.0

Proposed Project Component			Option	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations (cont.)	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	16.9
			Piled Jacket (10 Small)	8.8	2.5	4.7	16.0
			Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	10.9
			Piled Jacket (5 Medium)	10.3	3.5	2.0	15.9
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	11.2
			GBS (5 Medium)	1.9	0.6	0.4	3.0
			Piled Jacket (4 Large)	11.2	5.5	2.9	19.7
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	12.3
			GBS (4 Large)	2.7	1.3	0.7	4.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (10 Small OSS)	85.4	12.9	26.4	124.7
			Inter-Array Cables (5 Medium OSS)	68.4	10.9	21.3	100.6
			Inter-Array Cables (4 Large OSS)	69.4	12.0	20.9	102.3
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (10 Small OSS)	565.3	85.0	174.8	825.2
			Inter-Array Cables (5 Medium OSS)	452.9	71.7	141.1	665.7
			Inter-Array Cables (4 Large OSS)	459.7	78.9	138.2	676.8
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum **Total Temporary Impacts**[3,4]				1,642.5	179.8	1,137.0	2,959.7
Maximum Total Temporary Impacts[3,4]				1,770.0	197.0	1,177.5	3,142.7
Minimum Total **Permanent Impacts**[3,4]				340.7	42.5	180.4	563.5
Maximum Total Permanent Impacts[3,4]				411.8	52.1	199.5	663.4

[1] Option assumes that monopile foundations would be installed in the Project 1 area and piled jacket foundations would be installed in the Project 2 area.
[2] Option assumes that monopile foundations would be installed in the Project 1 and Project 2 areas.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-9. Areal Extent of Impacts on Benthic Habitat for Alternative F1

Proposed Project Component			Option[1]	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative F1 – Piled Foundations							
Wind Turbine Generators[2]	Permanent	Foundations	Piled Jacket	3.0	0.4	0.5	3.9
			Monopile	6.6	0.9	1.1	8.7
		Scour Protection	Piled Jacket	102.7	13.4	18.7	134.8
			Monopile	190.5	24.4	35.4	250.3
	Temporary	Seafloor Disturbance	Piled Jacket	240.9	30.6	45.7	317.2
			Monopile	253.8	32.5	48.4	334.6
MET Tower	Permanent	Foundation	Piled Jacket (Location 1)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 2)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 3)	0.0	0.0	0.0	0.0
			Piled Jacket (Location 4)	0.0	0.0	0.0	0.0
			Monopile (Location 1)	0.0	0.0	0.0	0.0
			Monopile (Location 2)	0.0	0.0	0.0	0.0
			Monopile (Location 3)	0.0	0.0	0.0	0.0
			Monopile (Location 4)	0.0	0.0	0.0	0.0
		Scour Protection	Piled Jacket (Location 1)	0.5	0.0	0.2	0.7
			Piled Jacket (Location 2)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 3)	0.7	0.0	0.0	0.7
			Piled Jacket (Location 4)	0.2	0.5	0.0	0.7
			Monopile (Location 1)	0.8	0.0	0.5	1.3
			Monopile (Location 2)	1.3	0.0	0.0	1.3
			Monopile (Location 3)	1.2	0.0	0.1	1.3
			Monopile (Location 4)	0.4	0.9	0.0	1.3
	Temporary	Seafloor Disturbance	Piled Jacket (Location 1)	0.9	0.0	0.7	1.6
			Piled Jacket (Location 2)	1.6	0.0	0.0	1.6
			Piled Jacket (Location 3)	1.5	0.0	0.1	1.6
			Piled Jacket (Location 4)	0.6	1.0	0.0	1.6
			Monopile (Location 1)	1.0	0.0	0.7	1.7
			Monopile (Location 2)	1.7	0.0	0.0	1.7
			Monopile (Location 3)	1.5	0.0	0.2	1.7
			Monopile (Location 4)	0.7	1.0	0.0	1.7

Proposed Project Component			Option[1]	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substations	Permanent	Foundation	Monopile (10 Small)	0.2	0.1	0.1	0.4
			Piled Jacket (10 Small)	0.1	0.0	0.1	0.2
			Piled Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Piled Jacket (4 Large)	1.2	0.6	0.6	2.5
		Scour Protection	Monopile (10 Small)	6.8	2.0	3.9	12.6
			Piled Jacket (10 Small)	3.7	1.0	2.1	6.8
			Piled Jacket (5 Medium)	4.9	1.8	1.3	8.0
			Piled Jacket (4 Large)	5.5	2.8	1.8	10.1
	Temporary	Seafloor Disturbance	Monopile (10 Small)	9.5	2.6	4.9	16.9
			Piled Jacket (10 Small)	8.8	2.5	4.7	16.0
			Piled Jacket (5 Medium)	10.3	3.5	2.0	15.9
			Piled Jacket (4 Large)	11.2	5.5	2.9	19.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (Small)	87.6	13.3	27.1	127.9
			Inter-Array Cables (Medium)	70.2	11.2	21.9	103.2
			Inter-Array Cables (Large)	71.2	12.3	21.4	104.9
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (Small)	579.8	87.2	179.3	846.3
			Inter-Array Cables (Medium)	464.5	73.6	144.7	682.8
			Inter-Array Cables (Large)	471.5	80.9	141.7	694.1
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,661.5	182.9	1,145.3	2,988.8
Maximum Total Temporary Impacts[3,4]				1,781.8	197.4	1,179.0	3,169.9
Minimum Total Permanent Impacts[3,4]				300.9	35.8	172.7	509.4
Maximum Total Permanent Impacts[3,4]				411.8	48.8	198.2	658.7

[1] Each option assumes that a single foundation type will be used for each project component.
[2] Alternative assumes that 200 WTG foundations would be installed in the Lease Area.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-10. Areal Extent of Impacts on Benthic Habitat for Alternative F2

Proposed Project Component			Option[1]	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative F2 - Suction Bucket Foundations							
Wind Turbine Generators[2]	Permanent	Foundations	Mono-Bucket	36.1	4.8	6.3	47.2
			Suction Bucket Jacket	26.5	3.5	4.6	34.7
			Suction Bucket Tetrahedron	22.7	3.0	3.9	29.6
		Scour Protection	Mono-Bucket	201.3	25.6	37.8	264.8
			Suction Bucket Jacket	361.0	46.1	68.2	475.3
			Suction Bucket Tetrahedron	299.0	38.2	56.3	393.4
	Temporary	Seafloor Disturbance	Mono-Bucket	264.8	33.7	50.6	349.2
			Suction Bucket Jacket	163.3	20.5	31.4	215.2
			Suction Bucket Tetrahedron	163.2	20.8	31.2	215.3
MET Tower	Permanent	Foundation	Mono-Bucket (Location 1)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 2)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 3)	0.2	0.0	0.0	0.2
			Mono-Bucket (Location 4)	0.0	0.2	0.0	0.2
			Suction Bucket Jacket (Location 1)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 2)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 3)	0.2	0.0	0.0	0.2
			Suction Bucket Jacket (Location 4)	0.0	0.2	0.0	0.2
			Suction Bucket Tetrahedron (Location 1)	0.1	0.0	0.0	0.1
			Suction Bucket Tetrahedron (Location 2)	0.1	0.0	0.0	0.1
			Suction Bucket Tetrahedron (Location 3)	0.1	0.0	0.0	0.1
			Suction Bucket Tetrahedron (Location 4)	0.0	0.1	0.0	0.1
		Scour Protection	Mono-Bucket (Location 1)	0.8	0.0	0.5	1.3
			Mono-Bucket (Location 2)	1.3	0.0	0.0	1.3
			Mono-Bucket (Location 3)	1.2	0.0	0.1	1.3
			Mono-Bucket (Location 4)	0.5	0.9	0.0	1.3
			Suction Bucket Jacket (Location 1)	1.4	0.0	1.0	2.4
			Suction Bucket Jacket (Location 2)	2.4	0.0	0.0	2.4
			Suction Bucket Jacket (Location 3)	2.2	0.0	0.2	2.4
			Suction Bucket Jacket (Location 4)	0.9	1.5	0.0	2.4

Proposed Project Component			Option[1]	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
MET Tower (cont.)	Permanent (cont.)	Scour Protection (cont.)	Suction Bucket Tetrahedron (Location 1)	1.2	0.0	0.8	2.0
			Suction Bucket Tetrahedron (Location 2)	2.0	0.0	0.0	2.0
			Suction Bucket Tetrahedron (Location 3)	1.8	0.0	0.1	2.0
			Suction Bucket Tetrahedron (Location 4)	0.7	1.3	0.0	2.0
	Temporary	Seafloor Disturbance	Mono-Bucket (Location 1)	1.0	0.0	0.7	1.8
			Mono-Bucket (Location 2)	1.8	0.0	0.0	1.8
			Mono-Bucket (Location 3)	1.6	0.0	0.2	1.8
			Mono-Bucket (Location 4)	0.7	1.1	0.0	1.8
			Suction Bucket Jacket (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Jacket (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Jacket (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Jacket (Location 4)	0.4	0.6	0.0	1.1
			Suction Bucket Tetrahedron (Location 1)	0.7	0.0	0.4	1.1
			Suction Bucket Tetrahedron (Location 2)	1.1	0.0	0.0	1.1
			Suction Bucket Tetrahedron (Location 3)	1.0	0.0	0.1	1.1
			Suction Bucket Tetrahedron (Location 4)	0.4	0.6	0.0	1.1
Offshore Substations	Permanent	Foundation	Suction Bucket Jacket (10 Small)	1.0	0.3	0.5	1.7
			Suction Bucket Jacket (5 Medium)	0.8	0.3	0.3	1.3
			Suction Bucket Jacket (4 Large)	0.7	0.3	0.3	1.4
			Mono-Bucket (10 Small)	1.3	0.3	0.7	2.4
		Scour Protection	Suction Bucket Jacket (10 Small)	13.1	3.7	7.1	24.0
			Suction Bucket Jacket (5 Medium)	12.5	4.3	2.9	19.6
			Suction Bucket Jacket (4 Large)	13.6	6.9	4.1	24.6
			Mono-Bucket (10 Small)	7.2	2.1	4.1	13.3
	Temporary	Seafloor Disturbance	Suction Bucket Jacket (10 Small)	6.2	1.6	3.1	10.9
			Suction Bucket Jacket (5 Medium)	7.3	2.6	1.2	11.2
			Suction Bucket Jacket (4 Large)	7.0	3.5	1.8	12.3
			Mono-Bucket (10 Small)	9.9	2.6	5.1	17.6

Proposed Project Component			Option[1]	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (Small)	87.6	13.3	27.1	127.9
			Inter-Array Cables (Medium)	70.2	11.2	21.9	103.2
			Inter-Array Cables (Large)	71.2	12.3	21.4	104.9
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (Small)	579.8	87.2	179.3	846.3
			Inter-Array Cables (Medium)	464.5	73.6	144.7	682.8
			Inter-Array Cables (Large)	471.5	80.9	141.7	694.1
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,580.7	172.8	1,127.2	2,881.6
Maximum Total Temporary Impacts[3,4]				1,801.6	200.7	1,185.7	3,186.3
Minimum Total Permanent Impacts[3,4]				441.0	54.4	199.8	695.2
Maximum Total Permanent Impacts[3,4]				609.9	75.1	238.6	923.6

[1] Each option assumes that a single foundation type will be used for each project component.

[2] Alternative assumes that 200 WTG foundations would be installed in the Lease Area.

[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.

[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum

Table 10-11. Areal Extent of Impacts on Benthic Habitat for Alternative F3

Proposed Project Component			Option[1]	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Alternative F3 - Gravity-Based Foundations							
Wind Turbine Generators[2]	Permanent	Foundations	Gravity-Pad Tetrahedron	13.6	1.8	2.4	17.8
			GBS	88.8	11.6	16.0	116.5
		Scour Protection	Gravity-Pad Tetrahedron	87.3	11.4	16.0	114.7
			GBS	113.2	14.2	21.4	148.9
	Temporary	Seafloor Disturbance	Gravity-Pad Tetrahedron	180.1	22.8	34.1	237.1
			GBS	92.1	11.8	17.5	121.4
MET Tower	Permanent	Foundation	Gravity Pad Tetrahedron (Location 1)	0.1	0.0	0.0	0.1
			Gravity Pad Tetrahedron (Location 2)	0.1	0.0	0.0	0.1
			Gravity Pad Tetrahedron (Location 3)	0.1	0.0	0.0	0.1
			Gravity Pad Tetrahedron (Location 4)	0.0	0.1	0.0	0.1
			GBS (Location 1)	0.4	0.0	0.2	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.0	0.6
			GBS (Location 4)	0.1	0.5	0.0	0.6
		Scour Protection	Gravity Pad Tetrahedron (Location 1)	0.4	0.0	0.2	0.6
			Gravity Pad Tetrahedron (Location 2)	0.6	0.0	0.0	0.6
			Gravity Pad Tetrahedron (Location 3)	0.6	0.0	0.0	0.6
			Gravity Pad Tetrahedron (Location 4)	0.1	0.4	0.0	0.6
			GBS (Location 1)	0.4	0.0	0.3	0.7
			GBS (Location 2)	0.7	0.0	0.0	0.7
			GBS (Location 3)	0.7	0.0	0.1	0.7
			GBS (Location 4)	0.3	0.5	0.0	0.7
	Temporary	Seafloor Disturbance	Gravity Pad Tetrahedron (Location 1)	0.7	0.0	0.5	1.2
			Gravity Pad Tetrahedron (Location 2)	1.2	0.0	0.0	1.2
			Gravity Pad Tetrahedron (Location 3)	1.1	0.0	0.1	1.2
			Gravity Pad Tetrahedron (Location 4)	0.4	0.7	0.0	1.2
			GBS (Location 1)	0.3	0.0	0.3	0.6
			GBS (Location 2)	0.6	0.0	0.0	0.6
			GBS (Location 3)	0.6	0.0	0.1	0.6
			GBS (Location 4)	0.2	0.4	0.0	0.6

Proposed Project Component			Option[1]	Benthic Habitat Impact (acres)			
				Soft Bottom	Heterogeneous Complex	Complex	Total
Offshore Substation	Permanent	Foundation	GBS (10 Small)	3.2	0.9	1.8	5.9
			GBS (5 Medium)	2.4	0.8	0.8	4.0
			GBS (4 Large)	3.7	1.9	1.5	7.1
		Scour Protection	GBS (10 Small)	4.0	1.2	2.3	7.5
			GBS (5 Medium)	8.3	2.9	1.8	13.1
			GBS (4 Large)	8.5	4.2	2.4	15.0
	Temporary	Seafloor Disturbance	GBS (10 Small)	3.4	0.9	1.8	6.1
			GBS (5 Medium)	1.9	0.6	0.4	3.0
			GBS (4 Large)	2.7	1.3	0.7	4.7
Inter-Array and Inter-Link Cables	Permanent	Cable Protection	Inter-Array Cables (Small)	87.6	13.3	27.1	127.9
			Inter-Array Cables (Medium)	70.2	11.2	21.9	103.2
			Inter-Array Cables (Large)	71.2	12.3	21.4	104.9
			Inter-Link Cables	0.5	0.6	0.8	1.9
	Temporary	Seafloor Disturbance	Inter-Array Cables (Small)	579.8	87.2	179.3	846.3
			Inter-Array Cables (Medium)	464.5	73.6	144.7	682.8
			Inter-Array Cables (Large)	471.5	80.9	141.7	694.1
			Inter-Link Cables	4.2	4.9	6.9	16.0
Offshore Export Cables	Permanent	Cable Protection	Atlantic	42.9	7.6	13.4	63.9
			Monmouth	75.8	0.1	115.8	191.7
	Temporary	Seafloor Disturbance	Atlantic	423.8	70.6	128.2	622.7
			Monmouth	517.2	0.6	814.9	1,332.7
Minimum Total Temporary Impacts[3,4]				1,504.0	162.1	1,112.6	2,779.0
Maximum Total Temporary Impacts[3,4]				1,709.8	187.8	1,165.7	3,062.0
Minimum Total Permanent Impacts[3,4]				301.5	36.3	173.1	510.9
Maximum Total Permanent Impacts[3,4]				416.8	49.5	199.2	665.5

[1] Each option assumes that a single foundation type will be used for each project component.
[2] Alternative assumes that 200 WTG foundations would be installed in the Lease Area.
[3] Minimum and maximum total impacts reflect the combination of options producing the minimum and maximum impacts across project components.
[4] Color shading denotes which options were included in the total impacts as follows: orange = minimum only, blue = maximum only, grey = minimum and maximum