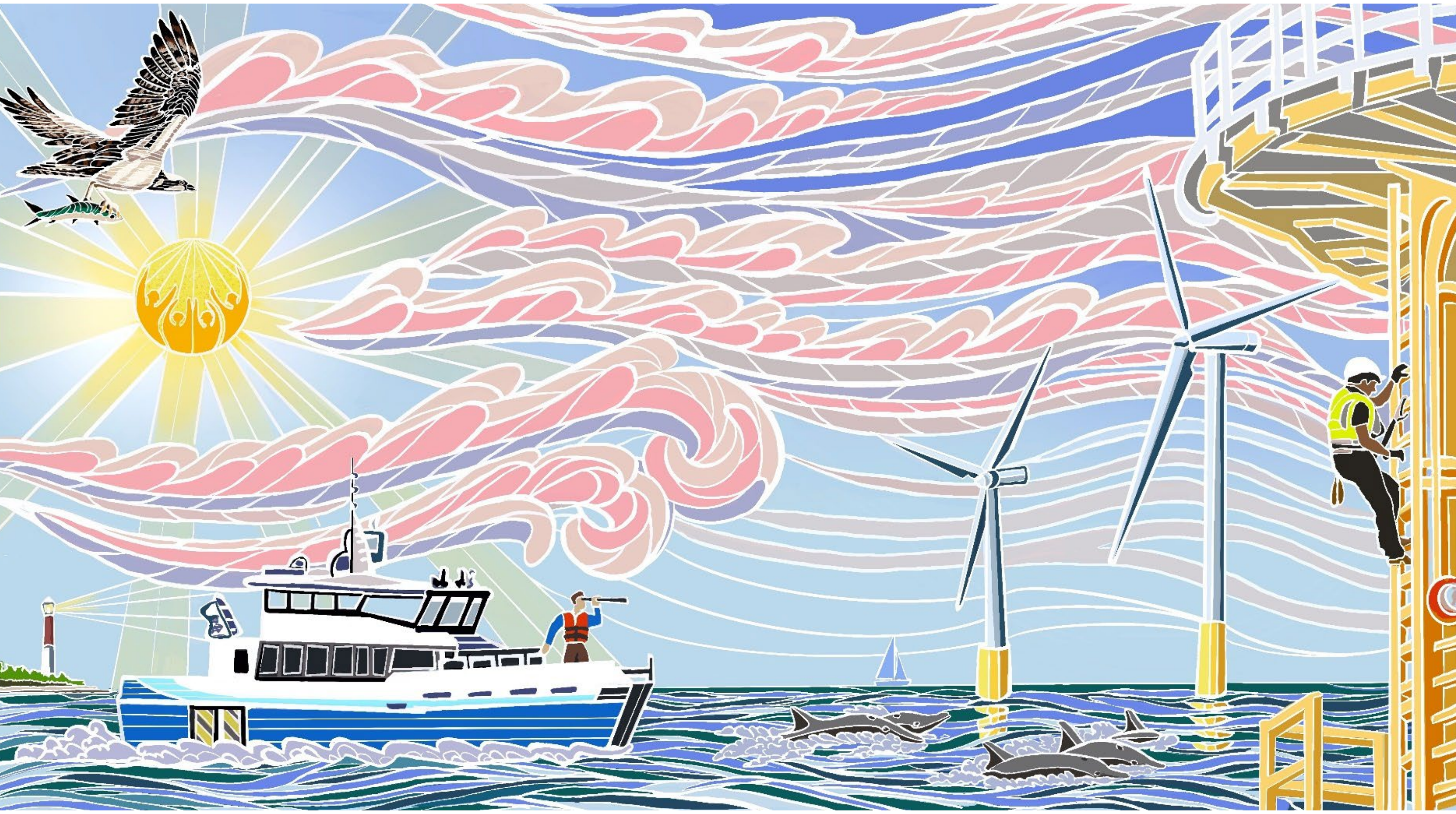


Appendix II-J1

Essential Fish Habitat (EFH) Technical Report

March 2024

Note: Atlantic Shores has updated the Project Design Envelope to include the following landfall sites: Monmouth Landfall Site, Asbury Landfall Site, Kingsley Landfall Site, Lemon Creek Landfall Site, Wolfe's Pond Landfall Site, and Fort Hamilton Landfall Site. The information included in this report demonstrates the completeness of Atlantic Shores' multi-year development efforts and should be considered representative for the Project. For additional information regarding the layout of the Project, please refer to COP Volume I Project Information, Sections 1.0 Introduction and 4.7 Landfall Sites, as well as Figure 1.1-2 Project Overview.

Essential Fish Habitat Technical Report

Atlantic Shores Offshore Wind North

Prepared for:

Atlantic Shores Offshore Wind, LLC
1 Dock 72 Way
7th Floor
Brooklyn, NY 11205
www.atlanticshoreswind.com

Prepared by:

Environmental Design & Research,
Landscape Architecture, Engineering & Environmental Services, D.P.C.
217 Montgomery Street, Suite 1000
Syracuse, New York 13202
P: 315.471.0688
F: 315.471.1061
www.edrdpc.com

March 2024

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

LIST OF ACRONYMS

AC	Alternating Current
BOEM	Bureau of Ocean Energy Management
CMECS	Coastal and Marine Ecological Classifications Standards
COP	Construction and Operation Plan
dB	Decibels
DC	Direct Current
DP	Dynamically Positioned
ECC	Export Cable Corridor
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EMF	Electromagnetic Field
FMP	Fishery Management Plan
GARFO	Greater Atlantic Regional Fisheries Office
GBS	Gravity-Based Structure
HAPC	Habitat Area of Particular Concern
HDD	Horizontal Directional Drilling
HRG	High Resolution Geophysical

HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
kV	Kilovolts
MAFMC	Mid-Atlantic Fishery Management Council
MARACOOS	Mid-Atlantic Regional Association Coastal Ocean Observing System
MARMAP	Marine Resources Monitoring, Assessment and Prediction
MEC	Munitions and Explosives of Concern
MW	Megawatt
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NJDEP OSAP	New Jersey Department of Environmental Protection Ocean Stock Assessment Program
NMFS	National Marine Fisheries Service
NOAA	National Ocean and Atmospheric Administration
O&M	Operations and Maintenance
OSRP	Oil Spill Response Plan
OSS	Offshore Substation
PDE	Project Design Envelope
PK	Peak Sound Level
POI	Point of Interconnection
PTS	Permanent Threshold
SEL	Sound Exposure Level
spl	Sound Pressure Level
TSS	Total Suspended Sediments
TTS	Temporary Threshold Shift
USCG	United States Coast Guard
WTG	Wind Turbine Generator

1.0 INTRODUCTION

Atlantic Shores Offshore Wind, LLC (Atlantic Shores) is a 50/50 joint venture between EDF-RE Offshore Development, LLC (an indirect wholly owned subsidiary of EDF Renewables, Inc. [EDF Renewables]) and Shell New Energies US, LLC (Shell). Atlantic Shores is submitting this Construction and Operations Plan (COP) to the Bureau of Ocean Energy Management (BOEM) for the development of an offshore wind energy generation project within Lease Area OCS-A 0549 (the Lease Area).

The Atlantic Shores North Project (Project) will be located in the approximately 81,129-acre (328.3-square kilometer) Lease Area (Figure 1). In addition to the Lease Area, the Project will include two offshore export cable corridors (ECCs), the Monmouth ECC and the Northern ECC, within federal and New Jersey state waters as well as multiple Northern ECC Branches which make landfall in New Jersey and New York. The Lease Area, ECCs, and ECC Branches combined, make up the Offshore Project Area which is depicted on Figure 1.

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), passed in 1976 and amended in 1996, requires that an EFH consultation be conducted for any activity that may adversely affect important habitats of federally managed marine and anadromous species. BOEM, as the lead federal agency for the Project, has the responsibility to initiate an EFH consultation prior to approving the Project. This EFH Technical Report is prepared as an appendix to Atlantic Shores' COP at the request of BOEM to provide information needed to begin their consultation with National Oceanic and Atmospheric Administration (NOAA) Fisheries regarding EFH and EFH species.

Atlantic Shores conducted high resolution geophysical (HRG) and geotechnical surveys from 2019 to 2022 in the Lease Area, Monmouth ECC, and Northern ECC (Figure 1), including benthic grab samples, sediment profile imaging (SPI) camera – plan view video (PV) surveys, video transect surveys, and ecological classification of benthic habitats which provide data to inform this EFH Technical Report. Data from these surveys, as well as additional publicly available desktop data were used in this assessment to evaluate EFH in the Offshore Project Area.

2.0 DESCRIPTION OF PROPOSED ACTION

2.1 Project Overview

The Atlantic Shores offshore wind energy generation Project will be located in Lease Area OCS-A 0549, which is approximately 81,129 acres (328.3 square kilometers) (Figure 1). In addition to the Lease Area, the Project will include two offshore ECCs within federal and New Jersey state waters as well as six onshore interconnection cable routes, and five onshore substation and/or converter station sites. Figure 1 provides an overview of the Offshore Project Area.

At its closest point, the Project is approximately 8 miles (12.8 kilometers) from the New Jersey shoreline. Within the Lease Area, the Project will include:

- a maximum of up to 157 wind turbine generators (WTGs)
- up to eight offshore substations (OSSs)
- up to one permanent meteorological (met) tower, to be installed during construction
- up to two temporary meteorological and oceanographic (metocean) buoys.

The Project includes three options for WTG, OSS, and meteorological tower (met tower) foundations: piled, suction bucket, or gravity foundations.

The Project WTGs and OSSs will be connected by a system of 66 kilovolt (kV) to 150 kV high voltage alternating current (HVAC) inter-array cables. OSSs within the Lease Area may be connected to each other by 66 kV to 275 kV HVAC inter-link cables.

The Lease Area layout is designed to maximize offshore renewable wind energy production while minimizing effects on existing marine uses. The structures will be aligned in a uniform grid with multiple lines of orientation allowing straight transit corridors through the Lease Area. The primary east-northeast to west-southwest transit corridors through the Lease Area were selected to align with the predominant flow of vessel traffic; accordingly, WTGs will be placed along east-northeast to west-southwest rows spaced 1.0 nautical mile (1.9 kilometers) apart to allow for two-way vessel movement. The proposed grid also facilitates north to south transit by positioning WTGs along rows in an approximately north to south direction spaced 0.6 nautical miles (1.1 kilometers) apart (Figure 1). The WTG grid will also create diagonal corridors of 0.54 nautical mile (1.0 kilometers) running approximately northwest to southeast as well as diagonal corridors of 0.49 nautical miles (0.9 kilometers) running approximately north-northeast to south-southwest. The OSS positions will be located along the same east-northeast to west-southwest rows as the WTGs, preserving all of the primary east-northeast transit corridors and the majority of the secondary transit corridors (see Volume 1, Section 3.1 of the COP).

Energy from the Project's OSSs will be delivered to shore via 230 kV to 525 kV HVAC and/or high voltage direct current (HVDC) export cables. A total of up to eight export cables will be installed. The export cables will traverse federal and state waters to deliver energy from the OSSs to landfall sites in New Jersey and New York. The approximately 68-mile (109-kilometer) Monmouth ECC travels from the eastern corner of the Lease Area, along the eastern edge of the Lease Area to the Monmouth Landfall Site in Sea Girt, New Jersey. The Northern ECC extends between approximately 86 miles (138 kilometer) and 90 miles (146 kilometers), depending on the Landfall Site, north from the Lease Area to landfall sites in New York and/or New Jersey.

At the Landfall Sites in both New Jersey and New York, horizontal directional drilling (HDD) will be employed to support each export cables' offshore-to-onshore transition. The HDD landfall technique has been selected both to ensure stable cable burial along the coast and to avoid nearshore and shoreline impacts. From each landfall site, new 230 kV to 275 kV HVAC and/or 320 kV to 525 kV HVDC onshore interconnection cables will travel underground primarily along existing roadways and/or utility rights-of-way (ROW) to new onshore substation and/or converter station sites.

2.2 Project Design and Construction Activities

2.2.1 Project Design Envelope Overview

Atlantic Shores is requesting BOEM's review and authorization of the Project in accordance with BOEM's (2018) Project Design Envelope (PDE) guidance. The Project's PDE includes a reasonable range of designs for proposed Project components (e.g., foundations, WTGs, export cables, onshore elements) and installation techniques (e.g., use of anchored, jack-up, or dynamic positioning vessels). Identifying a range of design parameters and installation methods allows BOEM to analyze the maximum effects that could occur from the Project while providing Atlantic Shores with the flexibility to optimize the Project within the approved PDE during later stages of the development process. The PDE will enable Atlantic Shores to employ the best available technology, which often outpaces the permitting process, to maximize renewable energy production, minimize adverse environmental effects, address stakeholder concerns, and minimize cost to ratepayers.

The offshore components of the Project's PDE include the following elements (see Volume I, Section 4.0 of the COP for additional details):

- A maximum of up to 157 WTGs, each with a maximum rotor diameter of approximately 968 feet (295 meters), will be installed on three main foundation types (piled, suction bucket, and gravity foundations).
- Up to 8 small OSSs, up to four medium OSSs, or up to three large OSSs will serve as common collection points for power from the WTGs and also serve as the origin for the export cables that deliver power to shore.
- Up to 466 miles (750 kilometers) of HVAC inter-array cables will connect strings of WTGs to a shared OSS.
- Up to 62 miles (100 kilometers) of HVAC inter-link cables may be used to connect OSSs to each other.
- Up to eight total HVAC and/or HVDC export cables will be installed in two offshore ECCs, the Monmouth ECC and the Northern ECC, that are each approximately 3,300 feet (1,000 meters) wide.

The length per cable in the Monmouth ECC will be 68 miles (104 kilometers) and for the Northern ECC is between 66 and 90 miles (106 and 146 kilometers), respectively.

- Up to one permanent met tower and up to two temporary meteorological and metocean buoys may be installed within the Lease Area.

2.2.2 Project Construction Process and Schedule

The anticipated Project construction schedule is shown in Table 1.

Table 1. Project Schedule

Activity	Duration[a]	Expected Timeframe[b]
Onshore Interconnection Cable Installation	9 - 12 months	2025 – 2026
Onshore Substation and/or Converter Station Construction	18 - 24 months	2025 – 2027
Export Cable Installation	6-9 months	2026
OSS Installation and Commissioning	5-7 months	2026 – 2027
WTG Foundation Installation[c]	10 months	2027 – 2028
Inter-Array Cable Installation	14 months	2027 – 2028
WTG Installation and Commissioning	17 months	2027 – 2028

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 will follow a proposed schedule from May to December to minimize risk to North Atlantic Right Whale. No simultaneous pile driving is proposed.

Construction of the offshore facilities is expected to begin with installation of the export cables and the WTG and OSS foundations (including scour protection). Once the OSS foundations are installed, the topsides can be installed and commissioned, and the inter-link cables (if used) can be installed. At each WTG position, after the foundation is installed, the associated inter-array cables and WTGs can be installed (if WTGs are not installed onto gravity-base structure [GBS] foundations at port). Given the number of WTG and OSS positions, there is expected to be considerable overlap in various equipment installation periods. Installation of the Project's offshore facilities may occur over a period of up to 2 years to accommodate weather and/or seasonal work restrictions.

HRG and geotechnical surveys will be conducted to verify site conditions prior to offshore construction and HRG surveys will be conducted post-construction to ensure proper installation of the components of each Project. HRG survey equipment may include side-scan sonar, multibeam echo-sounder, magnetometers, gradiometers, and sub-bottom profilers. Based on the results of a munitions and explosives of concern (MEC) studies (see Volume II, Appendix II-A5 and II-A6 of the COP) and based on final facility siting and engineering design, Atlantic Shores may also elect to include a MEC study as part of the Project's pre-construction HRG survey campaign. Geotechnical surveys to inform the final design and engineering of the offshore facilities may include vibracores, cone penetrometer tests, and deep borings. Geotechnical surveys will only be performed in areas that are surveyed and cleared for cultural resources.

2.2.3 Wind Turbine Generator Foundations

The WTG foundations will provide a robust, stable, and level base for the WTG towers. The Project includes three categories of WTG foundations that may be affixed to the seabed using piles, suction buckets, or gravity:

1. **Piled foundations**: monopiles or piled jackets
2. **Suction bucket foundations**: mono-buckets, suction bucket jackets, or suction bucket tetrahedron bases
3. **Gravity foundations**: GBS or gravity-pad tetrahedron bases.

Foundations, particularly gravity foundations, may require some seabed preparation. Seabed preparation involves removing the uppermost sediment layer to establish a level surface, remove any surficial sediments that are too weak to support the planned structure, and enable full contact between the foundation base and the seafloor. This is necessary to ensure that the foundation remains vertical and its weight is uniformly distributed. For gravity foundations it may take three to four days to prepare the seabed prior to installation. Piled and suction bucket foundations are not expected to require seabed preparation unless the seabed is not sufficiently level (i.e., 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[1], jetting/controlled flow excavation, or backhoe/dipper. 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). Seabed preparation and installation of the gravel pad will likely be performed by a dynamically-positioned (DP) fallpipe vessel.

Scour protection may be installed at the base of each foundation to protect it from sediment transport/erosion caused by water currents. The PDE includes six types of scour protection: rock placement, rock bags, grout or sand-filled bags, concrete mattresses, ballast-filled mattresses, and frond mattresses. 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 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. The need for and selected type(s) of scour protection will be determined by the final design of the foundations and ongoing agency consultations.

[1] Atlantic Shores does not anticipate the removal of dredged material.

2.2.4 *Offshore Substation Foundations*

The Project will include one or more OSSs that serve as common collection points for power from the WTGs and also serve as the origin for the export cables that deliver power to shore. Similar to the WTG foundations, the Project includes three categories of OSS foundations that may be affixed to the seabed using piles, suction buckets, or gravity. The type of OSS foundation used depends on the size of the OSS itself. These foundation types are similar to those under consideration for the WTGs, although tetrahedron base foundations are not included in the OSS foundation PDE. OSS foundations (particularly gravity foundations), may require seabed preparation (i.e., removing the uppermost sediment layer beneath the foundation). Gravity foundations are also expected to require gravity pads. Scour protection may be installed at the base of each OSS foundation to protect it from sediment transport/erosion caused by water currents. The different types of scour protection that could be placed around OSS foundations are the same as for WTG foundations.

2.2.5 *Offshore Cables*

The Project will include offshore export, inter-array, and possibly inter-link cables (the "offshore cables"). The export cables will deliver electricity from the Project OSSs to the landfall sites. The inter-array cables will connect strings of WTGs to and OSS and interlink cables could be used to connect OSSs to each other.

2.2.5.1 ***Export Cables***

The PDE for export cables includes transmission options, which are based upon the use of HVAC and/or HVDC offshore export cables. As previously stated, the Project will include a total of up to eight export cables; however, the number of cables within each ECC is dependent on the types and configuration of cables selected. Atlantic Shores is including these options to provide technical flexibility for ongoing detailed offshore and onshore engineering processes, to account for varying interconnection capacity at each POI, and to provide commercial optionality.

- Monmouth ECC: The Project may install up to five export cables (four HVAC cables and one HVDC cable, or four HVDC cables).
- Northern ECC (from the Lease Area to Asbury Branch): Up to five cables will be used in one of three configurations: (1) four HVAC export cables and one HVDC export cable; (2) three HVAC export cables and two HVDC cables; or (3) four HVDC export cables.
- Northern ECC Branches: The Asbury Branch will have the capacity to contain either four HVAC or two HVDC export cables. The rest of the branches will have the capacity of between one and two HVDC export cables.

The export cable design will include a monitoring system, such as a distributed temperature system (DTS), distributed acoustic sensing (DAS) system, or online partial discharge (OLPD) monitoring, to continuously assess the status of offshore cables and detect anomalous conditions, insufficient or excess cable depth, or potential cable damage. The target burial depth of the export cables will be 5 to 6.6 feet (1.5 to 2 meters).

The export cables will be installed within the Monmouth ECC and/or the Northern ECC (Figure 1). The width of each ECC corresponds to marine survey corridors. The width of the Monmouth ECC (to the landfall) and Northern ECC trunk corresponds to the width of the marine survey corridors and ranges up to 3,300 feet (1 km), while the width of the Northern ECC branches range from 394 feet to 1,969 feet (120 meters to 600 meters). The width of each ECC is needed to accommodate the planned export cables, as well as the associated cable installation vessel activities, and allows for avoidance of resources such as shipwrecks and sensitive habitats. Variations in width at the landfall sites are needed to accommodate the construction vessel activities necessary to support the landfall of each export cable via HDD.

A minimum separation distance of approximately 328 feet (100 meters) is planned between the export cables installed within each ECC. The cables will typically be separated by at least 328 feet (100 meters) and will be dependent on route constraints and water depths. This separation distance, which provides flexibility for routing and installation as well as for future cable repairs (if needed), may be adjusted pending ongoing evaluation and site conditions. The distance between the Northern ECC, from the boundary of the Lease Area to the furthest potential landfall location, is approximately 90 miles (146 kilometers). The ECC from the Lease Area boundary to the Monmouth Landfall Site is approximately 67 miles (108 kilometers).

2.2.5.2 Inter-Array and Inter-Link Cables

The electrically distinct inter-array cables and inter-link cables (if used) for the Project will be installed within surveyed corridors in the Lease Area where full archaeological and geological assessments will have been completed. Atlantic Shores will engineer potential inter-array and inter-link cable layouts based on the results of surveys conducted in 2022. Atlantic Shores anticipates that up to 466 miles (750 kilometers) of inter-array cables and up to approximately 62 miles (100 kilometers) of inter-link cables may be needed.

2.2.5.3 Pre-Installation and Offshore Cable Installation

Activities that will be conducted prior to cable installation include sand bedform clearing (including dredging activities), relocation of boulders, a pre-lay grapnel run, and a pre-lay survey. Detailed cable pre-installation and installation methods are described in more detail in Volume I, Section 4.5.4 of the COP.

Three common methods may be used to lay and bury the export cables, inter-array cables, and/or inter-link cables: simultaneous lay and burial, post-lay burial, and pre-lay trenching. Atlantic Shores is evaluating available cable installation tools to select techniques that are appropriate for the site and that maximize the likelihood of achieving the target cable burial depth of 5 to 6.6 feet (1.5 to 2 meters). The selection of equipment best suited for the task is an iterative process that involves reviewing seabed conditions, cable properties, laying and burying combinations, burial tool systems, and anticipated performance. The three primary cable installation tools proposed are: jet trenching, plowing/jet plowing, and mechanical trenching.

Cable installation is anticipated to create a trench with a maximum depth of approximately 10 feet (3 meters) and a maximum width of up to approximately 3.3 feet (1 meter). The burial depth may be deeper in specific locations such as Federal channels that are dredged to ensure that the cables maintain a sufficient depth of cover. In addition to the direct trench impact, the installation tool's two skids or tracks (each approximately 6.6 feet [2 meters] wide) could result in surficial seabed disturbance on either side of the cable trench. An anchored cable laying vessel may be used in shallow portions of the ECCs; no anchoring is expected to be required to support cable installation in the Lease Area (see Volume I, Section 4.5.4 of the COP).

Most of the export, inter-array, and inter-link cables are expected to be installed using jet trenching (either simultaneous lay and burial or post-lay burial) or jet plowing, with limited areas of mechanical trenching. It is estimated that 80-90% of the offshore cables could be installed with a single pass of the cable installation tool. However, in limited areas expected to be more challenging for cable burial (along up to 10-20% of the export, inter-array, and inter-link cable routes), an additional one to three passes of the cable installation tool may be required to further lower the cable to its target burial depth.

During export cable installation, an additional pass of the cable installation tool prior to installing the cable (known as pre-pass jetting) may be performed along up to 5% of the cable alignments to loosen sediments and increase the probability of successful burial. Geophysical and geotechnical surveys will confirm the most likely locations where pre-pass jetting may be performed for the offshore cables. Finally, for export cable installation in shallow water, a shallow-water barge with tensioners to tow a plow may be used for simultaneous lay-and-bury.

To install an inter-array cable, a cable-laying vessel will first pull the end of an inter-array cable into a WTG or OSS foundation, then lay the cable along the route to the next WTG, where the second cable end will be pulled into the WTG or OSS foundation. The vessel will repeat the process until all WTGs in a string are connected to a single OSS. If post-lay burial is used, a cable burial vessel will then progress along the laid strings of inter-array cables, burying them to target depth. If simultaneous lay and burial is used, the cables will be installed to the target depth in a single operation. If inter-link cables are included in the final design of the Project, the same process will apply to inter-link cables, except these cables will connect OSSs to one another rather than to strings of WTGs.

2.2.5.4 Export Cable Jointing

Given the length of the export cables, Atlantic Shores expects that they will be installed in one or more segments and that cable jointing offshore will be required. For either HVAC and/or HVDC export cables, joints will be installed approximately every 25 miles (40 kilometers). Field joints may also be required at each end to facilitate the pill-in and tie-in processes.

After the installation of each export cable segment and prior to jointing, the end of the cable segment will be left on the seabed and held in temporary wet storage. In this case, temporary cable protection (e.g., concrete mattresses) may be placed over the cable end to avoid damage prior to splicing. The cable jointing process can take multiple days. After a joint is complete, the vessel lowers the joint to the seabed and the joint will be buried. If the joint is not too wide, it could be buried with a jet trencher; alternatively, controlled flow excavation could be used to cover the joint. If burial is not possible or practical due to sediment conditions, cable protection could be placed on top of the joint.

2.2.5.5 *Offshore Cable Protection*

Cable protection may be necessary if sufficient burial depth cannot be achieved (i.e., due to sediment properties or a cable joint). Cable protection may also be required to support the crossing of existing marine infrastructure such as submarine cables or pipelines. While Atlantic Shores will work to minimize the amount of cable protection required, it is conservatively assumed that up to 10% of the export cables, inter-array cables, and inter-link cables may require cable protection where sufficient burial depth is not achieved. Atlantic Shores is considering the use of five types of cable protection: rock placement, concrete mattresses, rock bags, grout-filled bags, and half-shell pipes (see Volume 1, Section 4.5.7 of the COP).

One or more of these types of cable protection may be used. Cable protection consisting of freely-laid rock can be installed by a fallpipe vessel, a vessel's crane, or side dumping from a vessel. If freely laid rock is used, the fallpipe installation method, which is the most accurate technique, will be used wherever possible. Concrete mattresses, rock bags, and grout-filled bags will likely be deployed by a vessel's crane. Half-shell pipes are expected to be installed around the cable onboard the cable laying vessel prior to installing the cable.

2.2.6 Landfall Site Construction Activities

The offshore-to-onshore transition is proposed to be accomplished using HDD, a trenchless installation method that will avoid nearshore impacts as well as impacts directly along the shoreline. HDD, in comparison to trenching, also results in a deeper burial depth for cables in the nearshore environment, facilitating sufficient burial over the life of the Project and decreasing the likelihood that cables will become exposed over time.

Each of the export cables coming ashore will be installed via HDD with each cable contained within a separate conduit. Up to six HDD conduits may be installed at each landfall site to accommodate the HVAC and/or HVDC cables. To support HDD activities, Atlantic Shores will establish an onshore staging area at each landfall site. The HDDs will either be initiated or exit landward of the beach to avoid impacts to the beach. The estimated average depth of the HDDs is approximately 16 to 131 feet (5 to 40 meters) below the seabed.

HDD at each landfall site requires the excavation of an entrance pit and exit pit. At the offshore HDD entrance/exit location, a shallow area of up to approximately 66 feet by 33 feet (20 meters by 10 meters) will be excavated. A backhoe dredge may be required to complete the excavation and a cofferdam (or similar method) of approximately the same size as the excavated pit may be utilized. The need for a cofferdam (or similar) will depend on the results of marine surveys conducted near the landfall sites, the depth of burial, and the direction of HDD. A temporary offshore platform (e.g., jack-up barge) may be needed to support the HDD drilling rig.

2.2.7 Summary of Maximum Design Scenario and Seafloor Disturbance

The maximum offshore build-out of the Project is defined as installation of up to 157 WTGs, eight small OSSs, one permanent met tower, two temporary metocean buoys, up to 8 offshore export cables (with a maximum total length of 424 mi [682.3 km]), 466 mi (750 km) of inter-array cables, and 62.1 mi (100 km) of inter-link cables, along with associated scour and cable protection. The maximum area of total permanent and temporary seabed disturbance in the Lease Area and ECCs from construction of the Project's maximum PDE is provided in Table 2. See Volume I, Section 4.11 of the COP for additional details related to the basis of calculation.

Table 2. Maximum Total Seabed Disturbance

Installation Activity	Maximum Area of Seafloor Disturbance		
	Permanent Disturbance	Additional Temporary Disturbance	Total[1]
WTG Foundation Installation (Including Scour Protection)[2]	0.63 mi^2 (1.63 km^2; 403 ac)	0.43 mi^2 (1.11 km^2 275 ac)	1.06 mi^2 (2.75 km^2; 678 ac)
WTG Installation and Commissioning	N/A	0.09 mi^2 (0.23 km^2; 58 ac)	0.09 mi^2 (0.23 km^2; 58 ac)
OSS Foundation Installation (Including Scour Protection), Topside Installation, and Commissioning[3]	0.03 mi^2 (0.07 km^2; 19 ac)	0.04 mi^2 (0.10 km^2; 26 ac)	0.06 mi^2 (0.16 km^2; 38 ac)
Inter-Array Cable Installation (Including Cable Protection)[4]	0.41 mi^2 (1.06 km^2; 262 ac)	2.49 mi^2 (6.45 km^2; 1,594 ac)	2.9 mi^2 (7.51 km^2; 1,856 ac)
Inter-Link Cable Installation (Including Cable Protection)[4]	0.06 mi^2 (0.16 km^2; 38 ac)	0.42 mi^2 (1.09 km^2; 269 ac)	0.48 mi^2 (1.24 km^2; 307)
Temporary Met Ocean Buoy Installation[5]	N/A	0.01 mi^2 (0.03 km^2, 6 ac)	0.01 mi^2 (0.03 km^2; 6 ac)
Export Cable in Lease Area			
Monmouth ECC	0.04 mi^2 (0.11 km^2; 26 ac)	0.22 mi^2 (.57 km^2; 141 ac)	0.29 mi^2 (0.76 km^2; 186 ac)
Northern ECC[6]	0.05 mi^2 (0.13 km^2; 32 ac)	0.30 mi^2 (.78 km^2; 192 ac)	0.36 mi^2 (0.93 km^2; 230 ac)
Max. Total Seabed Disturbance in the Lease Area	**1.38 mi^2 (3.58 km^2; 883 ac)**	**4.00 mi^2 (10.36 km^2; 2,560 ac)**	**5.38 mi^2 (13.93 km^2; 3,443 ac)**
Max. Total Seabed Disturbance in the ECCs[7]	**0.75 mi^2 (1.95 km^2; 480 ac)**	**5.21 mi^2 (13.50 km^2; 3,334 ac)**	**5.96 mi^2 (15.44 km^2; 3,814 ac)**
Monmouth ECC	0.35 mi^2 (0.90 km^2; 224 ac)	2.21 mi^2 (5.73 km^2; 1,414 ac)	2.56 mi^2 (6.63 km^2; 1,638 ac)
Northern ECC[6]	0.40 mi^2 (1.04 km^2; 256 ac)	3.00 mi^2 (7.76 km^2; 1,920 ac)	3.40 mi^2 (8.80 km^2; 2,195 ac)

[1] For WTG, OSS, and met tower foundations, the foundation type with the maximum footprint is not the same as the type with the maximum area of additional seabed disturbance. Thus, the sum of the maximum area of permanent disturbance and additional temporary disturbance does not equal the total seabed disturbance.

[2] Impacts calculations in the Lease Area include impacts from seabed preparation activities, which may include dredging operations. A total area of 111,987.6 square feet (10,404.0 square meters) per foundation may be required for seabed preparation activities. Assuming the use of 157 wind turbine foundations, the total area of seabed preparation that would be required totals approximately 17.5 million square feet (1.6 million square meters). The total volume of material anticipated for seabed preparation is approximately 1.1 million cubic yards (861,634 cubic meters).

[3] Total impact calculations within the Lease Area include seabed preparation activities, which may include dredging operations, around the OSS foundations. A total area of 369,676 square feet (34,344 square meters) around each OSS foundation may be subject to seabed preparation. Assuming the use of three large OSS foundations, a total area of 1.1 million square feet (103,032 square meters) may be

required for seabed preparation activities. The total volume of material anticipated for seabed preparation is approximately 135,000 cubic yards (103,214 cubic meters).

[4] Total impact calculations in the Lease Area account for dredging activities along the inter-array and interlink cables. Along the inter-array and inter-link cables, dredging activities would total approximately 0.67 square miles (1.73 square kilometers) and 0.18 square miles (0.46 square kilometers), respectively. These activities will result in a total of approximately 2.2 million (1.7 million cubic meters) cubic yards and 588,600 cubic yards (450,000 cubic meters) of dredged material from inter-array and inter-link cable installation, respectively.

[5] There is sufficient conservatism in the total estimates of permanent and temporary seafloor disturbance from WTG foundation installation to account for the impacts from the met tower's installation.

[6] Impacts associated with the Northern ECC include four export cables extending to the Asbury Branch and three extending to the New York Landfall Sites.

[7] Impact values within the ECC includes impacts from dredging activities. Along the Monmouth and Northern ECC, dredging activities would total approximately 0.96 square miles (2.48 square kilometers) and 1.19 square miles (3.08 square kilometers), respectively. These activities will result in a total of approximately 3.2 million cubic yards (2.4 million cubic meters) and 4.0 million cubic yards (3.0 million cubic meters) of dredged material for the Monmouth and Northern ECC, respectively.

2.3 Offshore Operations and Maintenance and Inspections

2.3.1 Foundations and Scour Protection

WTG, OSS, and met tower foundations will be inspected both above and underwater at regular intervals to check their condition including checking for corrosion, cracking, and marine growth. Scheduled maintenance of foundations will also include safety inspections and testing, coating touch up, preventative maintenance of cranes, electrical equipment, and auxiliary equipment, and removal of marine growth.

Unscheduled maintenance will be conducted for minor component repair/replacement if damage to a foundation occurs (e.g., due to an accidental event or conditions that exceed the foundation design loads). Corrective actions will be taken if any issues with scour protection are discovered.

2.3.2 Offshore Cables

The offshore cables will be continuously monitored using either a DTS, a DAS system, and/or OLPD monitoring. The inter-array cables and inter-link cables (if used) may also use a monitoring system. In addition, cable surveys will be performed at regular intervals to identify any issues associated with potential scour and depth of burial. Annual surveys will be performed for the first few years of operation, and provided no abnormal conditions are detected during those initial surveys, less frequent surveys will continue for the life of the Project. Cable terminations and hang-offs will be inspected and maintained during scheduled maintenance of foundations, OSS, or WTGs.

In the unlikely event that a cable becomes exposed, the issue will be addressed by reburying the cable and/or applying cable protection. If a cable repair is required, it is expected that the damaged segment of the cable would be recovered from the seafloor. If required, a new section of cable would be spliced into the existing cable onboard a vessel within a controlled environment. After the new segment of cable was rejoined to the existing cable, the repaired cable would be lowered to the seafloor and reburied. The planned cable spacing is sufficient to allow for a cable repair to occur within each ECC. Vessels supporting these procedures will typically be of the same type as those used during construction.

2.3.3 *Offshore Substations*

Power generated by the WTGs will be transmitted to the OSSs via 66 kV to 150 kV inter-array cables, which will connect to switchgear, transformers, and converter equipment (if HVDC) located within the OSS topsides. These transformers will increase the voltage level to the export cable voltage (230 kV to 525 kV). From the OSSs, the export cables will transmit electricity to shore.

Seawater may be used in a once-through (open loop) system to provide cooling for equipment on an offshore HVDC OSS. The need for seawater cooling will only apply to the HVDC offshore substations. HVAC OSSs will be air cooled per industry standard. Seawater intake for HVDC equipment cooling would typically be supplied by one or more seawater pumps submerged below sea level in pump caissons attached to the OSS foundation structure (either electric submersible pumps or shaft-driven pumps). Seawater entering the bottom of the pump caisson would pass through an appropriately sized inlet port and screen to prevent impingement (through-screen intake water superficial velocity less than 0.5 ft/s). This seawater would be pumped to the offshore substation topsides where it would typically pass through a coarse seawater strainer (to protect the downstream heat exchangers from particles and debris). The seawater would then typically be treated with hypochlorite to prevent biofouling of the heat exchange equipment. This treatment can be achieved either by dosing the seawater with a concentrated sodium hypochlorite liquid or by using a seawater electrolyzer to generate hypochlorite in-situ by passing an electric current through a small portion of the seawater flow (in a controlled electrolyzer cell) which is then blended with the inlet seawater. Treatment is applied to maintain an active residual chorine concentration at the end of the discharge pipe of between 0.5 and 0.8 parts per million (ppm). This treated seawater would then pass through one or more heat exchangers to provide the removal of heat from the closed-loop circulation system (typically consisting of deionized water), thus cooling the closed circulation system water so that it can in turn recycle to cool the offshore substation's electrical equipment. This seawater, after picking up the rejected heat from the topsides equipment, would be discharged to the water column via one or more dedicated caissons attached to the OSS foundation structure.

2.4 Decommissioning

Atlantic Shores will follow the decommissioning requirements stated in Section 13, "Removal of Property and Restoration of the Leased Area on Termination of Lease," of the original Lease Agreement for Lease Area OCS-A 0499. Pursuant to the applicable regulations in 30 CFR §585.902, and unless otherwise authorized by BOEM under 30 CFR §585.909, Atlantic Shores will be required to remove or decommission all facilities, projects, cables, pipelines, and obstructions and clear the seabed of all obstructions created by activities on the leased area, including any Project easements(s). Removal or decommissioning activities must be completed within two years after lease termination (whether by expiration, cancellation, contraction, or relinquishment) in accordance with an approved Site Assessment Plan (SAP), Construction and Operations Plan (COP), or approved Decommissioning Application and applicable regulations in 30 CFR Part 585. Per 30 CFR §585.910(a), all offshore facilities must be removed to 15 feet (ft) (4.5 meters [m]) below the mudline, unless otherwise authorized by BOEM.

Atlantic Shores will submit a Decommissioning Application to BOEM prior to decommissioning any Project facilities. BOEM's process for reviewing and approving this plan will include consultations with municipal, State, and Federal agencies, other stakeholders, and the public.

3.0 AFFECTED ENVIRONMENT

3.1 Pelagic Habitat

The Offshore Project Area is located in the Mid-Atlantic Bight, a region known for diverse species assemblages, with fish and shellfish species of commercial and recreational importance (BOEM, 2012). The Offshore Project Area, which includes the nearshore areas at the landfall sites, contains estuarine, tidal, nearshore, and offshore habitat, with water depths ranging from 66 to 98 feet (20 to 30 meters) in the Lease Area, approximately 0 to 98 feet (0 to 30 meters) in the Monmouth ECC, and approximately 0 to 95 feet (0 to 29 meters) in the Northern ECC and Northern ECC Branches. Based on data collected at the New Jersey Wind Energy Area between 2003 and 2016, the median salinity of water in the Offshore Project Area is 32.2 parts per thousand and ranges from 29.4 to 34.4 parts per thousand (BOEM, 2017). Within the New Jersey Wind Energy Area, which includes the Lease Area, water temperature fluctuates seasonally, with variation of temperature as high as 68 °F (20 °C) at the surface and 59 °F (15 °C) at the seabed (BOEM, 2017). Such fluctuations are a primary factor in finfish distribution in the Offshore Project Area (Geo-Marine, 2010). Many species of finfish present in the Offshore Project Area migrate seasonally, spending the spring and summer in nearshore or estuarine environments to breed and spawn, then migrating offshore in the fall and winter for warmer water temperatures.

A key feature of the Mid-Atlantic Bight is the Cold Pool. The Cold Pool is an oceanographic phenomenon referring to a bottom-trapped, cold, nutrient-rich pool that extends from Cape Cod, Massachusetts to Cape Hatteras, North Carolina, located over the mid- and outer-shelf of the Mid-Atlantic Bight (Chen, 2018; Ganim, 2019). The formation of the Cold Pool is driven by seasonal patterns in solar heating and wind (Ganim, 2019) and is not spatially uniform (Lentz, 2017). It forms at the start of spring when wind mixing is reduced, and surface heat fluxes increase, causing the water column to become stratified (Ganim, 2019; Lentz, 2017). Freshwater runoff in the spring can further intensify stratification (Castelao et al., 2010). The Cold Pool, located along the seafloor, is isolated from warming surface waters by the seasonal thermocline and creates habitat conditions that provide thermal refuge to colder water species in the Mid-Atlantic Bight ecosystem (Lentz, 2017). Recruitment and settlement of several cold water species, such as yellowtail flounder (*Pleuronectes ferruginea*) and red hake (*Urophycis chuss*), has been linked to the presence of the Cold Pool (Chen, 2018; Lentz, 2017; Sullivan et al., 2005; Miller et al., 2016). This feature also provides temporary habitat for some northern species, like haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*Gadus morhua*), which thrive in colder temperatures (Steves et al., 1999; Kohut and Brodie, 2019). Cold pool waters are also nutrient-enriched and when upwelled toward the surface, can drive phytoplankton growth and high concentrations of particulate organic matter in the water column (Voynova et al., 2013).

The timing of the formation and breakdown of the Cold Pool, as well as its spatial extent, varies significantly each year but generally develops annually between spring and fall (Chen and Curchitser, 2020). The Cold Pool dissipates in the fall due to enhanced vertical mixing from an increase in the frequency of strong wind events and the cooling of surface temperatures (Ganim, 2019). The breakdown of the stratified Cold Pool is known to influence the timing of migration for fish species like winter flounder (*Pseudopleuronectes americanus*), summer flounder (*Paralichthys dentatus*), black sea bass (*Centropristis striata*), and Atlantic butterfish (*Peprilus triacanthus*) (Kohut and Brodie, 2019). Additionally, temporal changes in the breakdown of the Cold Pool have been linked to increased mortality in Atlantic surfclams and altered timing of spawning for ocean quahog (Narvaez et al., 2015; Toupoint et al., 2012). Many of the species dependent on the Mid-Atlantic Cold Pool (e.g., yellowtail flounder, winter flounder, summer flounder, black sea bass, etc.) have EFH designated in the Offshore Project Area.

3.2 Benthic Habitat

Topographic features and sediment composition influences the distribution of finfish and invertebrate species, particularly benthic and demersal species, by the type of habitat they provide. The Offshore Project Area is located on the shelf of the Mid-Atlantic Bight. The shelf of the Mid-Atlantic Bight is characterized by valleys, channels, shoal massifs, scarps, and swales (Stevenson et al. 2004; BOEM 2012). Though these topographic features exist within the Mid-Atlantic Bight, most of the Offshore Project Area is topographically flat, characterized by smaller features such as ripples, mega ripples, sand bedforms, and sand ridges (Steimle and Zetlin 2000; Stevenson et al. 2004; BOEM 2012). Much of the Offshore Project Area and continental shelf of the Mid-Atlantic Bight is characterized by soft sediment, including course, medium, and fine sands (The Nature Conservancy 2015).

In addition to soft sediment, hardened structures created by features such as artificial reefs contribute to the benthic habitat available for marine species. These features, which are also identified as prime fishing areas, represent areas of hard substrate projecting above the seabed that attract benthic resources and fish species in areas where reef habitat is sparse like the Mid-Atlantic Bight (Ross et al. 2015). There are three artificial reefs located at the boundaries of the Offshore Project Area including one artificial reef located at the northwestern tip of the Lease Area (Garden State North Reef) and two located at the outer boundary of the Monmouth ECC (Manasquan Inlet Reef and Axel Carlson Reef; depicted in Figure 2 along with prime fishing areas). Project components will be sited and designed to avoid these features to the greatest extent practicable and Atlantic Shores will work with NJDEP regarding the avoidance and minimization of effects to any artificial reef from Project activities.

Shellfish beds are another hardened structure along the seafloor that contribute to benthic habitat of the Project Area. These areas provide opportunities for foraging as well as shelter to EFH species. Historic locations of shellfish beds have been mapped by the NJDEP[2] (see Figures 3, and 4a through 4b). Additionally, while historical maps of shellfish areas were largely unavailable from the NYSDEC, areas of hard clams were obtained in the vicinity of the Offshore Project Area (see Figure 4a) (C. Sandrow, NYSDEC 2022 personal communication). According to these maps, the majority of documented shellfish beds within the Offshore Project Area are located in small segments in the nearshore region of the Lemon Creek and Wolfe's Pond Branches. These beds primarily consist of soft clams, surf clams, blue mussel, and hard clam. Hard clams were also identified within lower reaches of the Manasquan River, which may be crossed by the Larrabee Onshore Interconnection Route. While these maps identify shellfish beds within the nearshore and coastal portions of the Project, it is important to note that many of these maps are over 40 years old and it is likely that conditions have changed. The Applicant collected data on the presence of shellfish beds during benthic assessment surveys in order to understand where these features are located within the Project Area. Results

[2] Similar maps were not available for New York waters.

of the benthic studies are provided in Sections 3.2.1 through 3.2.3. Additional information on the results of that study can be found in Appendix II-G of the COP.

Atlantic Shores has completed site-specific HRG, geotechnical, and benthic surveys in accordance with BOEM's 2019 guidelines for benthic habitat surveying (BOEM, 2019). Such surveys included side-scan sonar, backscatter, benthic grab, and SPI camera –PV conducted over several seasons. Following consultations with NOAA Fisheries and BOEM regarding updates to surveying guidelines, Atlantic Shores completed a towed video survey which served to ground-truth initial surveying results. Additional information on the rationale, methodology, and adequacy of surveying efforts can be found in Appendices II-A1 and II-G of the COP. The results of these surveying efforts provide Atlantic Shores with an increased understanding of the types of benthic habitat and organisms present in the Offshore Project Area that may be of importance to EFH species.

On behalf of Atlantic Shores, Fugro worked collaboratively to both collect site-specific HRG survey data as well as compile data from other Atlantic Shores' consultants to support the classification and interpretation of habitat areas from the multiple survey campaigns across the Offshore Project Area. From these efforts, Fugro created morphology and habitat shapefiles as well as detailed maps for the Offshore Project Area which are included in Attachment 3 to this EFH Technical Report and in Volume II, Appendix II-A1 of the COP. Fugro used data processed from side-scan sonar with other geophysical survey equipment (e.g., multibeam echosounder bathymetry and backscatter data, sub-bottom profiler), as described in the NMFS *Updated Recommendations for Mapping Fish Habitat* (NMFS, 2021), to delineate seafloor trends, patterns, and textures. Habitat mapping also incorporated the results of grab sample, SPI/PV, and towed video surveys. Additional details on mapping methodology and data analysis can be found in Attachment 2 to this EFH Technical Report. These data were then used to determine the presence and location of benthic features (e.g., ripples, mega ripples, sandwaves, scarps) and to delineate habitat types (soft bottom, complex, heterogenous complex, and large grained complex) in the Offshore Project Area.

Soft bottom and complex habitat were also characterized in accordance with the Coastal and Marine Ecological Classifications Standards (CMECS). CMECS is 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). In the CMECS classification system, grain size and composition is used to describe benthic habitats and define complex and potentially valuable fish habitats. Results of the CMECS classifications are illustrated in Figures 5 and 6 of this assessment. According to NMFS, sediment containing at least 5% gravel content is considered complex habitat, while sediment containing less than 5% is considered soft bottom habitat (see Attachment 2 for additional information). Areas identified as heterogenous complex habitats represent the transitional space between soft and complex sediment. Areas where benthic features and surficial sand coverage intersected were also classified as heterogenous complex habitat. Large-grained complex habitat apply to large boulders. In addition to benthic features and habitat classification, biotic components that contribute to the benthic habitat (e.g., tube-dwelling organisms, sand dollar beds) were identified through SPI-PV and towed video surveys. Maps of benthic features, soft bottom habitat, complex habitat, heterogenous habitat, large-grained complex habitat, and biotic habitat components can be found in Attachments 3 and 4 to this EFH Technical Report.

A summary of the areal extent of delineated habitat types based on results from the site-specific surveys is provided in Tables 3 and 4 for the Lease Area, Monmouth ECC, Northern ECC, and Northern ECC Branches. Key observations and characteristics from these surveys are also summarized for each component of the Offshore Project Area.

Table 3. Area of Habitat Types in the Offshore Project Area

Habitat Type	Lease Area	Monmouth ECC	Northern ECC[1]
Soft-Bottom	84.1 mi^2 (217.8 km^2)	12.4 mi^2 (32.1 km^2)	13.7 mi^2 (35.5 km^2)
Heterogenous	7.1 mi^2 (18.4 km^2)	<0.1 mi^2 (<0.3 km^2)	1.3 mi^2 (3.4 km^2)
Complex	24.6 mi^2 (63.7 km^2)	27.4 mi^2 (71.0 km^2)	28.4 mi^2 (73.6 km^2)
Large grained complex	---	---	2.3 mi^2 (6.0 km^2)

[1] Data presented for the Northern ECC represents conductions within the main "trunk", which spans from the Lease Area, to Asbury, New Jersey, Staten Island, New York, and/or Brooklyn, New York.

Table 4. Area of Habitat Types in the Northern ECC Branches

Habitat Type	Asbury	Wolfe's Pond	Lemon Creek	Fort Hamilton
Soft-Bottom	0.7 mi^2 (1.8 km^2)	1.5 mi^2 (3.9 km^2)	2.3 mi^2 (6.0 km^2)	0.3 mi^2 (0.8 km^2)
Heterogenous	0.1 mi^2 (0.3 km^2)	0.1 mi^2 (0.3 km^2)	0.1 mi^2 (0.3 km^2)	0.1 mi^2 (0.3 km^2)
Complex	3.1 mi^2 (8.0 km^2)	0.4 mi^2 (1.0 km^2)	0.5 mi^2 (1.3 km^2)	0.6 mi^2 (1.6 km^2)
Large grained complex	0.3 mi^2 (0.8 km^2)	<0.1 mi^2 (<0.3 km^2)	<0.1 mi^2 (<0.3 km^2)	<0.1 mi^2 (<0.3 km^2)

3.2.1 *The Lease Area*

Using side-scan sonar, bathymetry, backscatter, seafloor slope analyses, and SPI-PV surveys, Atlantic Shores identified the following topographic features in the Lease Area: sand ridges, sandwaves, ripples, mega ripples, unconsolidated marine sediment (i.e., flat accumulations of muddy to sandy sediments with no discernable bedforms), seabed scars, irregular seafloor, and features of localized relief. Ripples were the most prevalent, mapped topographic feature in the Lease Area, comprising the majority of the surveyed area. In addition to ripples, sandwaves were present throughout much of the Lease Area, and trend in a northeast – southwest direction. Rugged or uneven seafloor (i.e., irregular seafloor) and localized relief features (i.e., raised accumulations of mixed sediment) were observed in the central, northeast, and northwest portions of the Lease Area. These features add texture to the existing smooth seafloor. Additional information on these topographic features, including maps, can be found in Attachments 3 and 4 to this EFH Technical Report and in Volume II, Appendix II-A1 of the COP.

As shown in Table , the Lease Area consists of both soft bottom and complex habitat (Figure 7). According to NMFS, soft bottom habitat is characterized as sediment containing less than 5% gravel content. Sediment containing at least 5% gravel content or greater is characterized as complex habitat. Of the grab samples collected in the Lease Area, approximately 50% of samples are categorized as soft bottom habitat, while the other 50% contribute to complex habitat. The grab samples collected in the Lease Area that contribute to soft bottom habitat include medium sand (approximately 33% of samples), very coarse/coarse sand (approximately 12% of samples), and gravelly sand (approximately 5% of samples). The remaining samples collected in the Lease Area consist of sediment types that contribute to complex habitat. Gravelly sand is the most prevalent sediment type in the Lease Area that contributes to complex habitat, making up 42% of grab samples in the Lease Area. Gravelly sand consists of a gravel content between 5 and less than 30%. The remaining samples that contain sediment that contributes to complex habitat includes sandy gravel (approximately 7% of samples) and muddy sandy gravel (approximately 2% of samples), both of which consist of a gravel content between 30% and less than 80%.

In addition to soft bottom and complex habitat, heterogenous habitat was identified in the Lease Area (Table 3 and Figure 7). Heterogenous complex habitat within the Lease Area exists within areas of interbedded sediment mixes with an indecipherable interface between two distinct classes. The areas of heterogenous complex habitat in the Lease Area represent a transitional space between soft and complex habitat types. In addition to sediment type, the presence of irregular seafloor, seafloor scars, and localized relief features contributed to the classification of heterogenous complex habitat.

Common biotic features observed in the Lease Area through towed video and SPI-PV surveys that contribute to benthic habitat in the Lease Area include burrowing anemones, sand dollars, decorator worms, and *Astarte* clams (see Attachments 3 and 4 to this EFH Technical Report and Volume II, Appendix II-G of the COP). No invasive tunicate or solitary hard coral species were identified in the Lease Area during benthic site characterization surveys (see Volume II, Appendix II-G of the COP).

3.2.2 *Monmouth ECC*

The Monmouth ECC contains similar topographic features to the Lease Area, including a significant presence of ripples and sand waves. Similar to the Lease Area, localized relief features were observed throughout the Monmouth ECC. Similar to the Lease Area, mega ripples were identified in the Monmouth ECC, primarily throughout the central portion. Additionally, 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. Seabed scars were another feature observed in the Monmouth ECC, which appeared to be reflective of commercial fishing and vessel anchoring activities. Additional information on these topographic features, including maps, can be found in Attachments 3 and 4 to this EFH Technical Report and in Volume II, Appendix II-A1 of the COP.

The Monmouth ECC differs from the lease Area as the majority of the area consists of complex habitat as defined by NMFS (2021) (Table 3 and Figure 7). Data collected from benthic grabs showed gravelly sand to be the most predominant sediment type, comprising approximately 42% of the samples collected in the ECC (Figures 5 and 6). According to the *NMFS Updated Recommendations for Mapping Fish Habitat* (2021), gravelly sand contains between 5% and less than 30% gravel content. Additional sediment types classified as complex habitat per NMFS' recommendations in the Monmouth ECC include sandy gravel (approximately 12% of samples), gravelly muddy sand (approximately 9% of samples), and muddy sandy gravel (approximately 3% of samples). Both sandy gravel and muddy sandy gravel consist of 30% to less than 80% of gravel, while gravelly muddy sand and gravelly sand consists of 5% to less than 30% gravel content. No grab samples collected in the Monmouth ECC contained gravel content greater than 80%. NEFSC (2021) reports that surficial sediment of the continental shelf of the Mid-Atlantic Bight is dominated by gravels and sands. Therefore, the surficial sediment conditions documented in site-specific surveys for the Monmouth ECC are consistent with those reported by Northeast Fisheries Science Center (NEFSC) (2021) for the larger Mid-Atlantic Bight region. The remaining portions of the Monmouth ECC largely consist of soft bottom habitat like sand. Data collected from grab samples show that soft bottom habitat consists of medium sand (approximately 18% of grab samples), very coarse/coarse sand (approximately 12% of grab samples), and fine/very fine sediment (approximately 3% of grab samples).

Limited areas of heterogenous habitat were identified in the Monmouth ECC, primarily in small areas around the Monmouth Landfall Site (Figure 7). Heterogenous habitat in these areas are characterized by the intersection of surficial sediment and exposed underlying strata. This type of habitat has the potential to influence fish behavior and habitat use.

In addition to sediment type and morphological features, biotic features identified in the Monmouth ECC that contribute to the benthic habitat included Astarte clams, Atlantic sea scallops (*Placopecten magellanicus*), blue mussels (*Mytilus edulis*), sand dollars, slipper shells, sponges, decorator worms, tunicates, burrowing anemones, worm tubes, and encrusting and bushy plant-like organisms (see Attachments 3 and 4 to this EFH Technical Report and Volume II, Appendix II-G of the COP). No invasive tunicate or solitary hard coral species were identified in the Monmouth ECC during benthic site characterization surveys (see Volume II, Appendix II-G of the COP).

3.2.3 *Northern ECC*[3]

Consistent with the Lease Area and Monmouth ECC, the main "trunk" of the Northern ECC as well as the Northern ECC Branches, are predominately covered by sand ripples. Other morphological features in the main "trunk" of the Northern ECC and Branches include sand waves, localized relief features (i.e., raised accumulations of sandy sediments), patches of irregular seafloor (e.g., rugged or uneven texture and undulating seafloor), heavily scarred areas generally aligned with fishing gears and anchoring activities, and surficial interbedded sediment associated with scarps. Two morphological features that are present in the main "trunk" and Asbury Branch but were not observed along the remaining Northern ECC Branches that extend to Staten Island and Brooklyn, New York, are sand waves and sand ridges. Debris and boulder fields were also identified in discrete areas within the main "trunk" and Asbury Branch of the Northern ECC. Additionally, one feature observed in the main "trunk" of the Northern ECC and the five Northern ECC branches leading to Staten Island and Brooklyn, New York that was not observed in the Asbury Branch was

[3] Atlantic Shores has updated the Project Design Envelope to include the following branches/landfall sites along the Northern ECC: Asbury Landfall Site, Kingsley Landfall Site, Lemon Creek Landfall Site, Wolfe's Pond Landfall Site, and Fort Hamilton Landfall Site. Several locations of benthic habitat sampling are no longer located within the Northern ECC Branches; however, are included in benthic habitat analyses presented in this Report and attachements as they are considered to be representative for the Project. For additional information regarding the layout of the Project, please refer to COP Volume I Project Information, Sections 1.0 Introduction and 4.7 Landfall Sites, as well as Figure 1.1-2 Project Overview.

unconsolidated sediment (i.e., flat accumulations of muddy to sandy sediments with no discernable bedforms).

The Northern ECC contains a more diverse composition of habitat than the Lease Area and Monmouth ECC (Tables 3 and 4). Data collected from benthic grabs showed medium sand to be the most predominant sediment type, comprising approximately 26% of the samples collected in the Northern ECC (including all branches). According to the *NMFS Updated Recommendations for Mapping Fish Habitat* (2021), medium sand is classified as soft bottom habitat. Additional sediments classified as soft bottom habitat in the Northern ECC (including all branches) include muddy sand (approximately 12% of samples), fine/very fine sand (approximately 9% of samples), sandy mud (approximately 6% of samples), and very coarse sand (approximately 3% of samples). The remaining approximately 44% of samples were classified as complex habitat per *NMFS Updated Recommendations for Mapping Fish Habitat* (2021), which include sediments with a gravel content greater than 5%. Of these 44% of samples classified as complex habitat, approximately 17% contain a gravel content between 5% to less than 30% (approximately 14% gravelly sand and approximately 3% gravelly muddy sand), approximately 24% contain a gravel content between 30% and less than 80% (approximately 16% sandy gravel and approximately 8% muddy sandy gravel), and approximately 3% contain a gravel content greater than 80% (pebble/granule).

Small areas of heterogenous habitat were identified in the main "trunk" of the Northern ECC and each of the Northern ECC Branches. Heterogenous complex habitat was defined as areas of interbedded sediment mixed with an indecipherable interface between two distinct class. Other features such as irregular seafloor, seafloor scars, and localized relief features indicate transitions zones and contribute to areas categorized as heterogenous complex.

In addition to morphological features and sediment type, biotic features identified in the Northern ECC and Branches include that contribute to benthic habitat include Astarte clams, Atlantic sea scallops, razor clams, sea pens, northern star coral, solitary hydroids, Actinarian anemones, ocean quahog, surf clams, burrowing anemones, worm tubes, northern star coral, invasive tunicates, and encrusting and bushy plant-like organisms (see Attachments 3 and 4 to this EFH Technical Report and Volume II, Appendix II-G of the COP).

4.0 ESSENTIAL FISH HABITAT DESIGNATIONS

The Sustainable Fisheries Act defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" and requires that the regional fishery management councils, through Fishery Management Plans (FMPs), "describe and identify EFH" for the improved management of that fishery. EFH is typically assigned by egg, larvae, juvenile, and adult life stages and designated as habitat for waters or substrates. NOAA Fisheries further defines the terms associated with EFH (50 CFR § 600.10) as:

- Waters – Aquatic areas and their associated physical, chemical, and biological properties that are used by fish and, where appropriate, may include aquatic areas historically used by fish;
- Substrate – Sediments, hard bottoms, structures underlying the waters, and associated biological communities;
- Necessary – The habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and,
- Spawning, breeding, feeding, or growth to maturity – Stages representing a species' full life cycle.

EFH data were downloaded from the NOAA Fisheries Essential Fish Habitat Data Inventory for the Essential Fish Habitat Mapper, an online mapping application (NOAA, 2021a). The data were then queried using GIS software to obtain results for EFH designations in the Lease Area, Monmouth ECC, Northern ECC, and Northern ECC Branches. Within these areas that comprise the Offshore Project Area, a total of 38 fish and five invertebrate species have designated EFH for various life stages. Table 5a summarizes the life stages of each species that has designated EFH within the Lease Area, Monmouth ECC, and Northern ECC, while Table 5b summarizes EFH designations within the Northern ECC Branches, as defined by NOAA's EFH Mapper. Detailed EFH definitions and life history descriptions for designated species and life stages are included in Attachment 1.

In addition to designated species and life stages, NOAA Fisheries also defines habitat areas of particular concern (HAPC) as a subset of EFH for areas that exhibit one or more of the following traits: rare, stressed by development, provides important ecological functions for Federally managed species, or is especially vulnerable to anthropogenic degradation. There is one HAPC located within the Offshore Project Area, HAPC for summer flounder. This area of HAPC occurs in Raritan and Lower New York Bay along the following Northern ECC Branches: Wolfe Pond, Lemon Creek, and Fort Hamilton (Figure 8). Though summer flounder HAPC is identified in these areas, NOAA Fisheries classifies HAPC for summer flounder as areas containing submerged aquatic vegetation (SAV). According to seagrass data mapped by NOAA, which compiles data from multiple state and local sources, and the NJDEP, there are no known areas of SAV along the Northern ECC Branches (NOAA 2020a). The closest known areas of SAV to the Project are depicted in Figure 9. No areas of SAV, as mapped by NOAA, were identified along the Northern ECC in New York waters. HAPC for summer flounder 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. The HAPC definition also states that if native species of submerged aquatic vegetation (SAV) are eliminated then exotic species should be protected because of functional value, however, all efforts should be made to restore native species (MAFMC, 2016). The closest known area of SAV to the Offshore Project Area is approximately 3.5 miles south of the Monmouth Landfall Site, within Barnegat Bay.

One additional area of HAPC in the vicinity of the Offshore Project Area is for sandbar shark (*Carcharhinus plumbeus*) around the area of Great Bay; an area that has been designated as pupping and nursey grounds for sandbar sharks (Figure 8). Though this HAPC is located approximately 8 miles west of the Offshore Project Area, vessels transiting to and from existing O&M infrastructure in Atlantic County, New Jersey would cross these areas. However, it should be noted that vessel traffic is common off the coast of Atlantic County, including within Absecon Channel which contains mapped HAPC and is located adjacent to existing O&M infrastructure that may be used for the Project. Vessel traffic from the Project is not expected to significantly increase existing vessel traffic off the coast of Atlantic County, New Jersey, therefore impacts to sandbar HAPC are not expected and not discussed further in this report.

Table 5a. EFH Designation for Species in the Offshore Project Area[1]

Species and Life Stages	Eggs			Larvae/ Neonate			Juvenile			Adult		
	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC
New England Finfish Species												
Atlantic Cod (*Gadus morhua*)		X	X	X	X	X				X	X	X
Atlantic Herring (*Clupea harengus*)							X	X	X	X	X	X
Clearnose Skate (*Raja eglanteria*)							X	X	X	X	X	X
Haddock (*Melanogrammus aeglefinus*)							X	X	X			
Little Skate (*Leucoraja erinacea*)							X	X	X	X	X	X
Monkfish (*Lophius americanus*)	X	X	X	X	X	X				X	X	X
Ocean Pout (*Macrozoarces americanus*)	X	X	X							X	X	X
Pollock (*Pollachius virens*)					X	X						
Red Hake (*Urophycis chuss*)	X	X	X	X	X	X	X	X	X	X	X	X
Silver Hake (*Merluccius bilinearis*)	X	X	X	X	X	X				X	X	X
White Hake (*Urophycis tenuis*)										X	X	X
Windowpane Flounder (*Scophthalmus aquosus*)	X	X	X	X	X	X	X	X	X	X	X	X
Winter Flounder (*Pseudopleuronectes americanus*)	X	X	X	X	X	X	X	X	X	X	X	X

Species and Life Stages	Eggs			Larvae/ Neonate			Juvenile			Adult		
	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC
Winter Skate (*Leucoraja ocellate*)							X	X	X	X	X	X
Witch Flounder (*Glyptocephalus cynoglossus*)	X	X	X	X	X	X				X	X	X
Yellowtail Flounder (*Limanda ferruginea*)	X	X	X	X	X	X	X	X	X	X	X	X
Mid-Atlantic Finfish Species												
Atlantic Butterfish (*Peprilus triacanthus*)	X	X	X	X	X	X	X	X	X	X	X	X
Atlantic Mackerel (*Scomber scombrus*)	X	X	X	X	X	X	X	X	X	X	X	X
Black Sea Bass (*Centropristis striata*)				X	X	X	X	X	X	X	X	X
Bluefish (*Pomatomus saltatrix*)	X	X	X	X	X	X	X	X	X	X	X	X
Scup (*Stenotomus chrysops*)							X	X	X	X	X	X
Spiny Dogfish[3] (*Squalus acanthias*)										X	X	X
Summer Flounder (*Paralichthys dentatus*)	X	X	X	X	X	X	X	X	X	X	X	X
New England Invertebrate Species												
Atlantic Sea Scallop *(Placopecten magellanicus)*	X	X	X	X	X	X	X	X	X	X	X	X
Mid-Atlantic Invertebrate Species												
Atlantic Surfclam (*Spisula solidissima*)							X	X	X	X	X	X
Longfin Inshore Squid (*Doryteuthis pealeii*)	X	X	X				X	X	X	X	X	X

Species and Life Stages	Eggs			Larvae/ Neonate			Juvenile			Adult		
	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC
Northern Shortfin Squid (*Illex illecebrosus*)							X	X	X			
Ocean Quahog (*Arctica islandica*)										X	X	X
Highly Migratory Species												
Tunas												
Albacore Tuna (*Thunnus alalunga*)							X	X	X			
Bluefin Tuna (*Thunnus thynnus*)							X	X	X		X	X
Skipjack Tuna (*Katsuwonus pelamis*)							X	X	X	X	X	X
Yellowfin Tuna (*Thunnus albacares*)							X	X	X			
Sharks												
Blue Shark (*Prionace glauca*)								X			X	
Common Thresher Shark (*Alopias vulpinus*)				X	X	X	X	X	X	X	X	X
Dusky Shark (*Carcharhinus obscurus*)				X	X	X	X	X	X	X	X	X
Sand Tiger Shark (*Carcharias taurus*)				X	X	X	X	X	X			
Sandbar Shark (*Carcharhinus plumbeus*)				X	X	X	X	X	X	X	X	X
Shortfin Mako Shark (*Isurus oxyrinchus*)				X	X	X	X	X	X	X	X	X
Smoothhound Shark Complex (Atlantic Stock) (*Mustelus canis*)				X	X	X	X	X	X	X	X	X

Species and Life Stages	Eggs			Larvae/ Neonate			Juvenile			Adult		
	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC	Lease	M.ECC	N.ECC
Tiger Shark (*Galeocerdo cuvieri*)							X	X	X	X	X	X
White Shark (*Carcharodon carcharias*)				X	X	X		X	X		X	X
South Atlantic Finfish Species												
King Mackerel (*Scomberomorus cavalla*)	X	X	X	X	X	X	X	X	X	X	X	X
Spanish Mackerel (*Scomberomorus maculatus*)	X	X	X	X	X	X	X	X	X	X	X	X

[1] For the purpose of this analysis, the Offshore Project Area is separated into three parts: Lease Area, Monmouth ECC, and Northern ECC.

[2] M.ECC- Monmouth ECC; N.ECC – Northern ECC

[3] Spiny dogfish EFH can be further broken down by sub-male and sub-female life stages. These life stages refer to smaller adults that are not full grown. These stages have a different spatial distribution than full-grown adults. Spiny dogfish sub-female and sub-male EFH can be found in the Lease Area, Monmouth ECC, and Northern ECC.

[4] Based on consultations with NOAA, EFH for king and Spanish mackerel occurs in the Mid-Atlantic Bight, and therefore was added to the analysis; however, based on a review of available data, EFH for these species does not exist in the Offshore Project Area.

Table 5b. EFH Designation for Species in the Northern ECC Branches[1]

Species and Life Stages	Eggs				Larvae/Neonate				Juvenile				Adult			
	A	W	L	F	A	W	L	F	A	W	L	F	A	W	L	F
New England Finfish Species																
Atlantic Cod (*Gadus morhua*)	X	X	X	X	X	X	X	X					X			
Atlantic Herring (*Clupea harengus*)						X	X	X	X	X	X	X	X	X	X	X
Clearnose Skate (*Raja eglanteria*)									X	X	X	X	X	X	X	X
Little Skate (*Leucoraja erinacea*)									X	X	X	X	X	X	X	X
Monkfish (*Lophius americanus*)	X	X	X	X	X	X	X	X								
Ocean Pout (*Macrozoarces americanus*)	X	X	X	X									X	X	X	X
Red Hake (*Urophycis chuss*)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Silver Hake (*Merluccius bilinearis*)	X	X	X	X	X	X	X	X					X	X	X	X
Windowpane Flounder (*Scophthalmus aquosus*)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Winter Flounder (*Pseudopleuronectes americanus*)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Winter Skate (*Leucoraja ocellate*)									X	X	X	X	X	X	X	X
Witch Flounder (*Glyptocephalus cynoglossus*)	X					X	X	X								
Yellowtail Flounder (*Limanda ferruginea*)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mid-Atlantic Finfish Species																
Atlantic Butterfish	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Species and Life Stages	Eggs				Larvae/Neonate				Juvenile				Adult			
	A	W	L	F	A	W	L	F	A	W	L	F	A	W	L	F
(*Peprilus triacanthus*)																
Atlantic Mackerel (*Scomber scombrus*)	X	X	X	X		X	X	X		X	X	X	X	X	X	X
Black Sea Bass (*Centropristis striata*)					X				X	X	X	X	X	X	X	X
Bluefish (*Pomatomus saltatrix*)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Scup (*Stenotomus chrysops*)		X	X	X		X	X	X	X	X	X	X	X	X	X	X
Spiny Dogfish (*Squalus acanthias*)[3]													X	X	X	X
Summer Flounder (*Paralichthys dentatus*)	X				X	X	X	X	X	X	X	X	X	X	X	X
New England Invertebrate Species																
Atlantic Sea Scallop *(Placopecten magellanicus)*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mid-Atlantic Invertebrate Species																
Atlantic Surfclam (*Spisula solidissima*)									X				X			
Longfin Inshore Squid (*Doryteuthis pealeii*)	X	X	X	X					X	X	X	X	X	X	X	X
Ocean Quahog (*Arctica islandica*)													X	X	X	X
Highly Migratory Species																
Tuna																
Bluefin Tuna (*Thunnus thynnus*)									X				X			
Skipjack Tuna (*Katsuwonus pelamis*)									X				X	X	X	X
Sharks																
Common Thresher Shark (*Alopias vulpinus*)					X	X	X	X	X	X	X	X	X	X	X	X

Species and Life Stages	Eggs				Larvae/Neonate				Juvenile				Adult			
	A	W	L	F	A	W	L	F	A	W	L	F	A	W	L	F
Dusky Shark (*Carcharhinus obscurus*)					X	X	X	X	X				X			
Sand Tiger Shark (*Carcharias taurus*)					X	X	X	X	X	X	X	X				
Sandbar Shark (*Carcharhinus plumbeus*)					X				X	X	X	X	X	X	X	X
Shortfin Mako Shark (*Isurus oxyrinchus*)					X				X				X			
Smoothhound Shark Complex (Atlantic Stock) (*Mustelus canis*)					X	X	X	X	X	X	X	X	X	X	X	X
Tiger Shark (*Galeocerdo cuvieri*)									X				X			
White Shark (*Carcharodon carcharias*)					X				X	X	X	X	X	X	X	X

[1] The Northern ECC is broken into six potential branches: A – Asbury; W – Wolfe Pond; L – Lemon Creek; F – Fort Hamilton.

[2] The Asbury Branch contains two landfall options, however due to their close proximity, the routes to both landfalls are collectively referred and analyzed under the Asbury Branch.

[3] Spiny dogfish EFH can be further broken down by sub-male and sub-female life stages. These life stages refer to smaller adults that are not full grown. These stages have a different spatial distribution than full-grown adults. Spiny dogfish sub-female EFH is mapped within all Northern ECC Branches. No sub-male EFH is located in the Northern ECC Branches.

5.0 DESCRIPTION OF OTHER NOAA TRUST RESOURCES

At the request of NOAA, a summary of the preferred habitat and potential occurrence of other NOAA-trust resources in the Offshore Project Area is included in Table 6. The species evaluated in these sections are based on a list provided during a virtual meeting held on May 20, 2020 between NOAA Fisheries Greater Atlantic Regional Fisheries Office (GARFO) and Atlantic Shores (NOAA, 2020b).

Table 6. Other NOAA Trust Resources Habitat and Potential Occurrence in the Offshore Project Area

Species	Description of Preferred Habitat	Potential Occurrence in Offshore Project Area[1]
	Finfish	
River Herring (Alewife and Blueback Herring) (*Alosa pseudoharengus* and *Alosa aestivalis*)	Adults utilize offshore waters between 184 to 361 feet (56 and 110 meters) for most of their lives but migrate to freshwater environments to spawn every four to five years (NOAA, 2021b; ASMFC, 2021).	Potential occurrence of adults and some juveniles is likely throughout the Offshore Project Area. Occurrence of eggs and larvae is not expected given the absence of freshwater habitat in the Offshore Project Area.
American Eel (*Anguilla rostrata*)	Larvae utilize the water column of the continental shelf to passively drift, where they mature into glass eels (ASMFC, 2017). Glass eels mature into elvers and migrate to freshwater habitat or coastal rivers and estuaries. Upstream migration can continue as elvers mature into yellow eels. As yellow eels mature into silver eels, they migrate downstream, returning to the marine environment (ASMFC, 2017). While in marine environments, silver eels have been observed throughout the water column from 49 to 1,312 feet (15 to 400 meters) (ASMFC, 2012).	Potential occurrence of larval eels is likely throughout the Offshore Project Area between February and April (Brust, 2006). Potential occurrence for silver eels is likely throughout the Offshore Project Area when traveling between freshwater and offshore marine environments.
American Shad (*Alosa sapidissima*)	Adults utilize coastal riverine habitat in the spring with sand, silt, muck, gravel, or boulder substrates for spawning, productive coastal waters in the summer, and offshore waters in the winter (ASFMC, 2021). Juveniles utilize the mouths of natal rivers for the first year, then emigrate to the ocean (ASFMC, 2021).	Potential occurrence throughout the Offshore Project Area, primarily during summer, fall and winter. Occurrence of American shad is not anticipated during spring as they typically utilize coastal riverine habitat which is not present in the Offshore Project Area.
Atlantic Menhaden (*Brevoortia tyrannus*)	Larvae and juveniles utilize estuarine waters (ASMFC, 2021). Adults utilize productive coastal waters for feeding opportunities between spring and fall, and offshore waters (20 to 30 miles [32 to 48 kilometers]) for spawning in fall and winter (ASMFC, 2021).	Potential occurrence throughout the Offshore Project Area is likely between spring and early fall.

Species	Description of Preferred Habitat	Potential Occurrence in Offshore Project Area[1]
Striped bass (*Morone saxatilis*)	Adults largely utilize open ocean and coastal waters along rocky shores and sandy beaches. In the ocean, striped bass migrate northward in the summer and south in the winter (VIMS, 2021). In spring, adults migrate inshore to freshwater to spawn (URI, 2021). Larvae and juveniles utilize inland portions of sounds and estuaries (ASMFC, 2021).	Potential occurrence throughout the Offshore Project Area for adults, likely during spring, fall, and winter. Occurrence of larvae and juveniles could be present in the nearshore reaches of the Northern ECC Branches that are located in Raritan Bay.
Tautog (*Tautoga onitis*)	Adults utilize structures like wrecks, reefs, rocks, and shellfish beds at depths up to 120 feet (37 meters) (ASMFC, 2021). Juveniles utilize vegetated estuaries or inshore areas (ASMFC, 2021).	Potential occurrence in Offshore Project Area, likely around shipwrecks, a majority of which are located along the outer boundaries of the Offshore Project Area, and the three artificial reefs, located outside the Lease Area and the Monmouth ECC.
Weakfish (*Cynoscion regalis*)	Adults utilize offshore environments in the winter, and nearshore bays, sounds, and estuaries in the spring for spawning (ASMFC, 2021). While inshore, adults and juveniles can be found along the periphery of eelgrass beds (ASMFC, 2021).	Potential occurrence throughout the Offshore Project Area for adults during winter. Occurrence of adult weakfish during spring is possible along the nearshore reaches of the Northern ECC Branches in Raritan Bay. Occurrence of juvenile weakfish are not anticipated due to the absence of eelgrass beds in the Offshore Project Area.
Invertebrates		
Blue Crab *(Callinectes sapidus*)	Utilizes grasses and oyster reefs, ranging from shallow brackish water to deeper, saltier water (NOAA, 2021b). Blue crab larvae are free-floating and enter the ocean via currents (CBP, 2021)	Potential occurrence in the nearshore areas of the ECCs; however, there are no documented underwater grasses in the Offshore Project Area.
Blue Mussel (*Mytilus edulis*)	Utilizes intertidal shallow waters attached to rocks, pilings, shells, or other solid objects (URI, 2021). Blue mussel larvae drift through water column for one to two months before settling.	Potential occurrence in Offshore Project Area, particularly in nearshore regions of the Monmouth and Northern ECCs, or around artificial reefs, shipwrecks and other hard structures/ substrates.
Eastern Oyster (*Crassostrea virginica*)	Utilizes brackish and salty waters between 8 to 35 feet (2.4 to 10.6 meters)) deep, often concentrated in beds and forming dense reefs (CBP, 2021). Eggs and larvae are free-swimming, and adults are sessile (CBP, 2021)	Potential occurrence in the nearshore reaches of the Monmouth and Northern ECCs. Occurrence of eastern oyster is not expected in the Lease Area due to depth thresholds.
Horseshoe Crab (*Limulus polyphemus*)	Utilizes inshore sandy substrates during spring spawning, then migrates to deeper estuarine and continental shelf habitats during fall (ASMFC, 2015). Juveniles can be found nearshore for the first two years of their life (ASMFC, 2021).	Potential occurrence throughout the Offshore Project Area.
Soft-Shell Clam (*Mya arenaria*)	Utilizes sandy or muddy substrate in bays and estuaries (URI, 2021).	Potential occurrence in the nearshore reaches of the Northern ECC Branches within Raritan and lower New York Bays.

[1] Occurrence in the Offshore Project Area is based on NEFSC and NJDEP OSAP trawl results and known habitat requirements.

6.0 ESSENTIAL FISH HABITAT SUMMARY BY LIFE STAGE AND HABITAT

The extent that EFH and EFH-designated species may be affected by Project construction, installation, O&M, and decommissioning activities is based in part on the habitat type and life stage of the organism at the time of various Project activities. The following sections categorize species into groups by presence near the seafloor (benthic/demersal) or in the water column (pelagic) as well as life stage (egg, larvae, juvenile, adult) to assist in evaluating effects. A summary of the species and life stages with the greatest potential to be affected by Project activities is presented in Section 6.5; these species and their EFH are the focus of the more detailed assessment of potential Project effects to EFH and EFH species presented in Section 7.0.

6.1 Early Pelagic Life Stages

Table 7a summarizes early (eggs and larvae) pelagic life stages of species that have designated EFH within the Lease Area, Monmouth ECC, and Northern ECC, as defined by NOAA's EFH Mapper database. Table 7b summarizes early pelagic life stages of species that have designated EFH within the Northern ECC branches. These tables also indicate the percentage of mapped EFH within each of these portions of the Offshore Project Area.

Table 7a. Early Pelagic Life Stages of Species with Designated EFH Mapped in the Offshore Project Area

Species with Early Pelagic Life Stages	Eggs			Larvae/Neonate		
	Percent Mapped EFH within Areas			Percent Mapped EFH within Areas		
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC
Finfish						
Atlantic Butterfish	34%	30%	60%	26%	31%	32%
Atlantic Cod	---	12%	44%	72%	54%	75%
Atlantic Mackerel	47%	35%	60%	<1%	12%	28%
Black Sea Bass	---	---	---	64%	38%	48%
Bluefish	38%	19%	44%	72%	50%	75%
Monkfish	75%	81%	91%	75%	81%	91%
Pollock	---	---	---	---	25%	16%
Red Hake	100%	100%	100%	100%	100%	100%
Silver Hake	98%	92%	100%	98%	92%	100%
Summer Flounder	38%	19%	32%	64%	42%	48%
Windowpane Flounder	72%	54%	75%	64%	54%	75%
Winter Flounder[1]	N/A	N/A	N/A	89%	88%	100%
Witch Flounder	47%	19%	32%	47%	19%	27%
Yellowtail Flounder	47%	31%	60%	47%	35%	60%
Highly Migratory Species – Sharks						
Common Thresher Shark[2]	---	---	---	100%	100%	100%
Dusky Shark[2]	---	---	---	100%	100%	100%
Shortfin Mako Shark[2]	---	---	---	59%	61%	74%
White Shark[2]	---	---	---	100%	98%	94%

N/A – This life stage is benthic/demersal; therefore, percentage of mapped EFH habitat is presented in Table 9a.

[1] Winter flounder larvae are initially pelagic and then settle to the bottom where they metamorphose to juveniles.

[2] These sharks have neonate life stages designated in the Offshore Project Area; however, neonate sharks are considered more similar to the juvenile life stage than the larval life stages for this analysis.

Table 7b. Early Pelagic Life Stages of Species with Designated EFH Mapped in the Northern ECC Branches[1]

Species with Early Pelagic Life Stages	Eggs Percent Mapped EFH within Areas				Larvae/Neonate Percent Mapped EFH within Areas			
	A[2]	W	L	F	A[2]	W	L	F
Finfish								
Atlantic Butterfish	100%	31%	22%	31%	---	72%	80%	61%
Atlantic Cod	100%	33%	24%	31%	100%	33%	24%	32%
Atlantic herring	---	---	---	---	---	72%	80%	61%
Atlantic Mackerel	100%	31%	22%	31%	---	59%	60%	58%
Black Sea Bass	---	---	---	---	100%	---	---	---
Bluefish	100%	31%	22%	31%	100%	31%	22%	31%
Monkfish	100%	34%	24%	54%	100%	34%	24%	54%
Red Hake	100%	100%	100%	100%	100%	100%	100%	100%
Scup	---	59%	60%	58%	---	59%	60%	58%
Silver Hake	100%	89%	67%	100%	100%	89%	67%	100%
Summer Flounder	100%	---	---	---	100%	72%	80%	61%
Windowpane Flounder	100%	100%	100%	92%	100%	100%	100%	92%
Winter Flounder[3]	N/A	N/A	N/A	N/A	100%	100%	100%	100%
Witch Flounder	100%	---	---	---	---	33%	24%	31%
Yellowtail Flounder	100%	33%	24%	32%	100%	33%	24%	32%
Highly Migratory Species – Sharks								
Common Thresher Shark[4]	---	---	---	---	99%	35%	25%	50%
Dusky Shark[4]	---	---	---	---	99%	16%	12%	21%
Shortfin Mako Shark[4]	---	---	---	---	27%	---	---	---
White Shark[4]	---	---	---	---	85%	---	---	---

N/A – This life stage is benthic/demersal; therefore, percentage of mapped EFH habitat is presented in Table 9b.
[1] The Northern ECC is broken into six potential branches: A – Asbury; W – Wolfe Pond; L – Lemon Creek; F – Fort Hamilton.
[2] The Asbury Branch contains two landfall options, however due to their close proximity, the routes to both landfalls are collectively referred and analyzed under the Asbury Branch.
[3] Winter flounder larvae are initially pelagic and then settle to the bottom where they metamorphose to juveniles.
[4] These sharks have neonate life stages designated in the Offshore Project Area; however, neonate sharks are considered more similar to the juvenile life stage than the larval life stages for this analysis.

6.2 Late Pelagic Life Stages

Table 8a summarizes late (juvenile and adult) pelagic life stages of species that have designated EFH within the Lease Area, Monmouth ECC, and Northern ECC, as defined by NOAA's EFH Mapper database. Table 8b summarizes late pelagic life stages of species that have designated EFH within the Northern ECC branches. These tables also indicate the percentage of mapped EFH within each of these portions of the Offshore Project Area.

Table 8a. Late Pelagic Life Stages of Species with Designated EFH Mapped in the Offshore Project Area

Species with Late Pelagic Life Stages	Juveniles			Adults		
	Percent Mapped EFH within Areas			Percent Mapped EFH within Areas		
	Lease Area	M.ECC	N.ECC	Lease Area	M.ECC	N.ECC
Finfish						
Atlantic Butterfish	100%	100%	100%	98%	92%	100%
Atlantic Herring	100%	100%	100%	100%	100%	100%
Atlantic Mackerel	66%	58%	41%	91%	58%	68%
Bluefish	47%	54%	75%	75%	81%	91%
Silver Hake[1]	---	---	---	26%	73%	91%
Spiny Dogfish	---	---	---	100%	100%	100%
Invertebrates						
Longfin Inshore Squid	100%	100%	100%	98%	92%	100%
Northern Shortfin Squid	89%	88%	72%	---	---	---
Highly Migratory Species - Tunas						
Albacore Tuna	4%	45%	51%	---	---	---
Bluefin Tuna	99%	100%	96%	---	27%	47%
Skipjack Tuna	98%	92%	93%	100%	100%	100%
Yellowfin Tuna	100%	61%	38%	---	---	---
Highly Migratory Species - Sharks						
Blue Shark	---	7%	---	---	7%	---
Common Thresher Shark	100%	100%	100%	100%	100%	100%
Dusky Shark	98%	92%	94%	98%	92%	94%
Shortfin Mako Shark	59%	61%	74%	59%	61%	74%
Tiger Shark	100%	100%	92%	100%	100%	92%
White Shark	---	43%	66%	---	43%	66%

[1] Silver hake adult EFH is defined as pelagic and benthic habitats.

Table 8b. Late Pelagic Life Stages of Species with Designated EFH Mapped in the Northern ECC Branches[1]

Species with Late Pelagic Life Stages	Juvenile				Adult			
	Percent Mapped EFH within Areas				Percent Mapped EFH within Areas			
	A[2]	W	L	F	A[2]	W	L	F
Finfish								
Atlantic Butterfish	100%	31%	22%	100%	100%	31%	22%	89%
Atlantic Herring	100%	100%	100%	100%	100%	100%	100%	100%
Atlantic Mackerel	---	59%	60%	58%	100%	90%	83%	89%
Bluefish	100%	100%	100%	100%	100%	100%	100%	100%
Silver Hake*	---	---	---	---	100%	33%	24%	31%
Spiny Dogfish	---	---	---	---	100%	33%	24%	31%

Species with Late Pelagic Life Stages	Juvenile Percent Mapped EFH within Areas				Adult Percent Mapped EFH within Areas			
	A[2]	W	L	F	A[2]	W	L	F
Invertebrates								
Longfin Inshore Squid	100%	33%	24%	31%	100%	33%	24%	31%
Highly Migratory Species - Tunas								
Bluefin Tuna	100%	---	---	---	100%	---	---	---
Skipjack Tuna	28%	---	---	---	100%	28%	20%	36%
Highly Migratory Species - Sharks								
Common Thresher Shark	99%	35%	25%	50%	99%	35%	25%	50%
Dusky Shark	28%	---	---	---	28%	---	---	---
Shortfin Mako Shark	27%	---	---	---	27%	---	---	---
Tiger Shark	100%	---	---	---	100%	---	---	---
White Shark	100%	23%	17%	31%	100%	23%	17%	31%

[1] The Northern ECC is broken into six potential branches: A – Asbury; W – Wolfe Pond; L – Lemon Creek; F – Fort Hamilton.
[2] The Asbury Branch contains two landfall options, however due to their close proximity, the routes to both landfalls are collectively referred and analyzed under the Asbury Branch.

6.3 Early Benthic or Demersal Life Stages

Table 9a summarizes early (eggs and larvae) benthic or demersal life stages that have designated EFH within the Lease Area, Monmouth ECC, and Northern ECC, as defined by NOAA's EFH Mapper database. Table 9b summarizes early benthic or demersal life stages that have designated EFH within the Northern ECC branches. These tables also indicate the percentage of field-mapped benthic habitat delineations (soft bottom and complex and/or heterogenous complex) applicable to each species that are within designated EFH for these portions of the Offshore Project Area. A description of the preferred habitat for each species or life stage is also included. The detailed benthic habitat maps that support this summary are included as Attachments 3 and 4 to this EFH Technical Report.

The dominant habitat type in the Lease Area is soft bottom habitat while the dominant habitat type in the Monmouth and Northern ECCs is complex habitat (Tables 3 and 4). As shown in Tables 9a and 9b, only three species have benthic or demersal early life stages with EFH that prefer or utilize soft bottom habitat. These include winter flounder eggs and larvae, Atlantic sea scallop eggs, and longfin inshore squid eggs. For the portions of the Offshore Project Area that consist of complex or heterogenous complex bottom habitat (Tables 3 and 4), four species have early life stages with EFH that potentially utilize this habitat type including ocean pout eggs, winter flounder eggs and larvae, Atlantic sea scallop eggs and larvae, and longfin inshore squid eggs (Tables 9a and 9b). Winter flounder eggs and larvae, Atlantic sea scallop eggs, and longfin inshore squid eggs can also be found on soft bottom habitats. The complex habitat in the Offshore Project Area consists mainly of gravelly sand and sandy gravel which can be found in the Lease Area, Monmouth ECC, and Northern ECC. Large-grained sediment (equal to or greater than 80% gravel), which contributes to complex habitat, occurs in the Northern ECC (Table 3). Although sand tiger shark and sandbar shark have neonate life stages designated in the Offshore Project Area that utilize both sandy, muddy, and rocky habitats, neonate sharks are considered more similar to the juvenile life stage than the larval life stage in terms of mobility and capability of avoiding Project activities and are evaluated in Section 6.4.

Table 9a. Percentage of Field-Mapped NMFS Habitat Categories within Designated EFH for Early Benthic/Demersal Life Stages in the Offshore Project Area

Species with Early Benthic Life Stages	Eggs: Percent Field-Mapped Habitat Categories within Designated EFH			Larvae/Neonate: Percent Field-Mapped Habitat Categories within Designated EFH			Description of Preferred Habitat
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC	
Finfish							
Ocean Pout[1]							Eggs: Hard bottom habitats – sheltered nests, holes, and crevices.
Complex[2] and/or Heterogenous	24%	69%	65%	---	---	---	
Winter Flounder[3]							Eggs: Bottom habitats with substrate of mud, muddy sand, sand, gravel, macroalgae, and submerged aquatic vegetation. Larvae: Pelagic and bottom (demersal) waters.
Soft bottom	< 1%	2%	1%	59%	21%	28%	
Complex[2] and/or Heterogenous	< 1%	5%	5%	22%	67%	65%	
Invertebrates							
Atlantic Sea Scallop							Eggs and Larvae: Eggs can be deposited on unspecified benthic habitats. Hard surfaces for pelagic larvae to settle, including shells, pebbles, and gravel. Larvae also attach to macroalgae and other benthic organisms such as hydroids.
Soft bottom	66%	29%	28%	N/A	N/A	N/A	
Complex[2] and/or Heterogenous	25%	66%	65%	25%	66%	65%	
Longfin Inshore Squid							Eggs: Egg masses or "mops" are laid on a variety of substrates, including hard bottom (shells, lobster pots, fish traps, boulders, and rocks), SAV (e.g., *Fucus*), sand, and mud
Soft bottom	22%	16%	27%	---	---	---	
Complex[2] and/or Heterogenous	12%	58%	64%	---	---	---	
Highly Migratory Species – Sharks[4]							
Sand Tiger Shark							Neonate: Rocky, sand and mud substrate or in areas surrounding Cape Lookout that contain benthic structure
Soft bottom	---	---	---	58%	20%	30%	
Complex[2] and/or Heterogenous	---	---	---	22%	61%	67%	
Sandbar Shark							Neonate: Sand, mud, shell, and rocky sediments/benthic habitats. All life stages tend to swim, associate, and feed near the bottom.
Soft bottom	---	---	---	66%	22%	16%	
Complex[2] and/or Heterogenous	---	---	---	25%	60%	37%	

Species with Early Benthic Life Stages	Eggs			Larvae/Neonate			Description of Preferred Habitat
	Percent Field-Mapped Habitat Categories within Designated EFH			Percent Field-Mapped Habitat Categories within Designated EFH			
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC	
Smoothhound Shark Complex (Atlantic Stock)							Neonate: Near or on the bottom.
Soft bottom	---	---	---	66%	31%	30%	
Complex[2] and/or Heterogenous	---	---	---	25%	69%	71%	

N/A – The habitat type is not utilized by this life stage.

[1] Percentage of mapped soft bottom habitat not reported since this species prefers hard bottom habitat.

[2] Includes complex and large grained complex habitats.

[3] Winter flounder larvae are initially pelagic and then settle to the bottom where they metamorphose to juveniles.

[4] Sand tiger shark, sandbar shark, and smoothhound shark have neonate life stages designated in the Offshore Project Area; however, neonate sharks are considered more similar to the juvenile life stage than the larval life stages for this analysis.

Table 9b. Percentage of Field-Mapped NMFS Habitat Categories within Designated EFH for Early Benthic/Demersal Life Stages in the Northern ECC Branches[1]

Species with Early Benthic Life Stages	Eggs: Percent Field-Mapped Habitat Categories within Designated EFH				Larvae: Percent Field-Mapped Habitat Categories within Designated EFH				Description of Preferred Habitat
	A[2]	W	L	F	A[2]	W	L	F	
Finfish									
Ocean Pout[3]									Eggs: Hard bottom habitats – sheltered nests, holes, and crevices.
Complex[4] and/or Heterogenous	81%	11%	8%	18%	---	---	---	---	
Winter Flounder[5]									Eggs: Bottom habitats with substrate of mud, muddy sand, sand, gravel, macroalgae, and submerged aquatic vegetation. Larvae: Pelagic and bottom waters.
Soft bottom	11%	75%	81%	32%	17%	75%	81%	32%	
Complex[4] and/or Heterogenous	60%	25%	19%	68%	81%	25%	19%	68%	
Invertebrates									
Atlantic Sea Scallop									Eggs and Larvae: Eggs can be deposited on unspecified benthic habitats. Hard surfaces for pelagic larvae to settle, including shells, pebbles, and gravel. Larvae also attach to macroalgae and other benthic organisms such as hydroids.
Soft bottom	17%	24%	17%	14%	N/A	N/A	N/A	N/A	
Complex[4] and/or Heterogenous	81%	11%	8%	18%	81%	11%	8%	18%	
Longfin Inshore Squid									Eggs: Egg masses or "mops" are laid on a variety of substrates, including hard bottom (shells, lobster pots, fish traps, boulders, and rocks), SAV (e.g., *Fucus*), sand, and mud
Soft bottom	17%	75%	81%	32%	---	---	---	---	
Complex[4] and/or Heterogenous	81%	25%	19%	68%	---	---	---	---	
Highly Migratory Species – Sharks[6]									
Sand Tiger Shark									Neonate: Rocky, sand and mud substrate or in areas surrounding Cape Lookout that contain benthic structure
Soft bottom	---	---	---	---	16%	18%	13%	15%	
Complex[4] and/or Heterogenous	---	---	---	---	81%	10%	7%	25%	
Sandbar Shark									Neonate: Sand, mud, shell, and rocky sediments/benthic habitats. All life stages tend to swim, associate, and feed near the bottom.
Soft bottom	---	---	---	---	17%	---	---	---	
Complex[4] and/or Heterogenous	---	---	---	---	81%	---	---	---	
Smoothhound Shark Complex (Atlantic Stock)									Neonate: Near or on the bottom.
Soft bottom	---	---	---	---	17%	67%	68%	32%	

Species with Early Benthic Life Stages	Eggs Percent Field-Mapped Habitat Categories within Designated EFH				Larvae Percent Field-Mapped Habitat Categories within Designated EFH				Description of Preferred Habitat
	A[2]	W	L	F	A[2]	W	L	F	
Complex[2] and/or Heterogenous	---	---	---	---	81%	24%	19%	68%	

N/A – The habitat type is not utilized by this life stage.
[1] The Northern ECC is broken into six potential branches: A – Asbury; W – Wolfe Pond; L – Lemon Creek; F – Fort Hamilton.
[2] The Asbury Branch contains two landfall options, however due to their close proximity, the routes to both landfalls are collectively referred and analyzed under the Asbury Branch.
[3] Percentage of mapped soft bottom habitat not reported since this species prefers hard bottom habitat.
[4] Includes complex and large grained complex habitats
[5] Winter flounder larvae are initially pelagic and then settle to the bottom where they metamorphose to juveniles.
[6] Sand tiger shark, sandbar shark, and smoothhound shark have neonate life stages designated in the Offshore Project Area; however, neonate sharks are considered more similar to the juvenile life stage than the larval life stages for this analysis.

6.4 Late Benthic or Demersal Life Stages

Table 10a summarizes late (juvenile and adult) benthic or demersal life stages that have designated EFH within the Lease Area, Monmouth ECC, and Northern ECC, as defined by NOAA's EFH Mapper database. Table 10b summarizes late benthic or demersal life stages that have designated EFH within the Northern ECC branches. These tables also indicate the percentage of field-mapped benthic habitat delineations (soft bottom and complex and/or heterogenous complex) applicable to each species that are within designated EFH for these portions of the Offshore Project Area. A description of the preferred habitat for each species or life stage is also included. The detailed benthic habitat maps that support this summary are included as Attachments 3 and 4 to this EFH Technical Report.

The dominant habitat type in the Lease Area is soft bottom habitat while the dominant habitat type in the Monmouth and Northern ECCs is complex habitat (Tables 3 and 4). As shown in Tables 10a and 10b, only three species have more sensitive sessile benthic later life stages with EFH that prefer soft bottom habitat. These include Atlantic surfclam juveniles and adults, and ocean quahog adults. The remaining species are mobile benthic or demersal later life stages that can temporarily leave the area during Project activities. Approximately 21 species have mobile benthic or demersal later life stages with EFH in the Offshore Project Area that prefer or utilize soft bottom habitat and approximately 18 species have mobile benthic or demersal later life stages that utilize complex habitats (hard bottom, rocky, or gravel substrates) (Tables 10a and 10b); however, these species are not limited to complex habitats and also utilize soft bottom habitat. The complex habitat in the Offshore Project Area consists mainly of gravelly sand and sandy gravel which can be found in the Lease Area, Monmouth ECC, and Northern ECC. Large-grained sediment (equal to or greater than 80% gravel) occurs in the Northern ECC (Table 3).

Table 10a. Percentage of Field-Mapped NMFS Habitat Categories within Designated EFH for Late Benthic/Demersal Life Stages in the Offshore Project Area

Species with Late Benthic Life Stages	Juveniles: Percent Field-Mapped Habitat Categories within Designated EFH			Adults: Percent Field-Mapped Habitat Categories within Designated EFH			Description of Preferred Habitat
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC	
Finfish							
Atlantic Cod							Adults: Bottom habitats with a substrate of cobble, gravel, or boulders. Also found on sandy substrates.
Soft bottom	---	---	---	4%	14%	15%	
Complex[3] and/or Heterogenous	---	---	---	21%	37%	35%	
Black Sea Bass							Juveniles: 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. Adult: Structured habitats (natural and man-made), sand and shell are usually the substrate preference.
Soft bottom	5%	9%	20%	65%	24%	28%	
Complex[3] and/or Heterogenous	4%	47%	55%	24%	69%	65%	
Haddock							Juveniles: Young-of-the-year juveniles settle on sand and gravel but are found predominantly on gravel pavement areas. As they grow, they disperse over a greater variety of substrate types.
Soft bottom	40%	23%	12%	---	---	---	
Complex[3] and/or Heterogenous	14%	39%	22%	---	---	---	
Monkfish							Adults: Bottom habitats with substrates of hard sand, pebble, gravel, broken shells, and soft mud.
Soft bottom	---	---	---	< 1%	< 1%	4%	
Complex[3] and/or Heterogenous	---	---	---	< 1%	17%	12%	
Ocean Pout							Adults: Mud and sand, particularly in association with structure forming habitat types; i.e. shells, gravel, or boulders.
Soft bottom	---	---	---	65%	24%	28%	
Complex[3] and/or Heterogenous	---	---	---	24%	69%	65%	

Species with Late Benthic Life Stages	Juveniles: Percent Field-Mapped Habitat Categories within Designated EFH			Adults: Percent Field-Mapped Habitat Categories within Designated EFH			Description of Preferred Habitat
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC	
Red Hake							Juveniles: Intertidal and sub-tidal benthic habitats on mud and sand substrates. Bottom habitats providing shelter, 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: Shell beds, soft sediments (mud and sand), and artificial reefs. Usually found in depressions in softer sediments or in shell beds and not on open sandy bottom.
Soft bottom	66%	31%	28%	45%	22%	23%	
Complex[3] and/or Heterogenous	25%	69%	65%	21%	42%	52%	
Scup							Juveniles: Various sands, mud, mussel and eelgrass bed type substrates Adults: Demersal waters in estuaries
Soft bottom	43%	23%	28%	66%	29%	28%	
Complex[3] and/or Heterogenous	17%	67%	65%	25%	66%	65%	
Silver Hake[1]							Adult: Bottom depressions or in association with sandwaves 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.
Soft bottom	---	---	---	17%	16%	27%	
Complex[3] and/or Heterogenous	---	---	---	9%	58%	64%	
Spiny Dogfish							Adults: Pelagic and epibenthic habitats throughout the region
Soft bottom	---	---	---	%	31%	28%	
Complex[3] and/or Heterogenous	---	---	---	%	68%	65%	

Species with Late Benthic Life Stages	Juveniles: Percent Field-Mapped Habitat Categories within Designated EFH			Adults: Percent Field-Mapped Habitat Categories within Designated EFH			Description of Preferred Habitat
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC	
Summer Flounder[2]							Juveniles: Prefer sandy substrates. Also salt marsh creeks, seagrass beds, mudflats, and open bay areas. Adults: Prefer sandy substrates. Also shallow coastal and estuarine waters during warmer months and move offshore on the outer continental shelf at depths of 500 feet (152 meters) in colder months.
Soft bottom	5%	9%	20%	66%	31%	28%	
White Hake							Adult: Fine-grained, muddy substrates and in mixed soft and rocky habitats.
Soft bottom	---	---	---	18%	14%	7%	
Complex[3] and/or Heterogenous	---	---	---	9%	12%	9%	
Windowpane Flounder[2]							Adults and Juveniles: Bottom habitats with a substrate of mud or sand.
Soft bottom	65%	24%	28%	66%	31%	28%	
Winter Flounder							Juveniles: Variety of bottom types such as mud, sand, rocky substrates with attached macroalgae, tidal wetlands, and eelgrass. YOY juveniles found inshore on muddy and sandy sediments in and adjacent to eelgrass and macroalgae, in bottom debris, and in marsh creeks. They tend to settle to the bottom in soft-sediment depositional areas and disperse into coarser-grained substrates as they get older. Adults: Muddy and sandy substrates, and on hard bottom on offshore banks.
Soft bottom	59%	21%	28%	59%	21%	28%	
Complex[3] and/or Heterogenous	22%	67%	65%	22%	67%	65%	
Witch Flounder[2]							Adult: Mud and muddy sand substrates
Soft bottom	---	---	---	23%	12%	5%	
Yellowtail Flounder							Juveniles: Sand and muddy sand.
Soft bottom	40%	24%	28%	66%	31%	28%	

Species with Late Benthic Life Stages	Juveniles – Percent Field-Mapped Habitat Categories within Designated EFH			Adults – Percent Field-Mapped Habitat Categories within Designated EFH			Description of Preferred Habitat
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC	
Complex[3] and/or Heterogenous	N/A	N/A	N/A	25%	69%	65%	Adults: Sand and sand with mud, shell hash, gravel, and rocks.
Skates							
Clearnose Skate							Juveniles and Adults: Mud and sand, but also on gravelly and rocky bottom.
Soft bottom	65%	19%	23%	65%	24%	28%	
Complex[3] and/or Heterogenous	24%	59%	54%	24%	69%	65%	
Little Skate							Juveniles and Adults: Bottom habitats with a sandy or gravelly substrate or mud.
Soft bottom	66%	31%	28%	5%	5%	15%	
Complex[3] and/or Heterogenous	25%	69%	65%	4%	37%	22%	
Winter Skate							Juveniles and Adults: Bottom habitats with a substrate of sand and gravel or mud.
Soft bottom	66%	31%	28%	26%	23%	27%	
Complex[3] and/or Heterogenous	25%	69%	65%	13%	57%	64%	
Invertebrates							
Atlantic Sea Scallop							Juveniles: Bottom habitats with a substrate of shells, gravel, and small rocks (pebble, cobble), preferring gravel. Adults: Bottom habitats with sand and gravel substrates.
Soft bottom	66%	29%	28%	66%	29%	28%	
Complex[3] and/or Heterogenous	25%	66%	65%	25%	66%	65%	
Atlantic Surfclam[2]							Juveniles and Adults: Prefers well-sorted medium and fine sandy substrates.
Soft bottom	66%	29%	26%	66%	29%	26%	
Ocean Quahog[2]							Juveniles and Adults: Prefers medium to fine sandy bottom.
Soft bottom	---	---	---	1%	8%	7%	

Species with Late Benthic Life Stages	Juveniles: Percent Field-Mapped Habitat Categories within Designated EFH			Adults: Percent Field-Mapped Habitat Categories within Designated EFH			Description of Preferred Habitat
	Lease Area	M. ECC	N. ECC	Lease Area	M. ECC	N. ECC	
Highly Migratory Species – Sharks							
Sand Tiger Shark							Juveniles: Sand, mud, and rocky substrates. Coastal and shallow bays; generally near bottom.
Soft bottom	58%	20%	30%	---	---	---	
Complex[3] and/or Heterogenous	22%	61%	67%	---	---	---	
Sandbar Shark							Juveniles and Adults: Sand, mud, shell, and rocky sediments/benthic habitat.
Soft bottom	66%	31%	30%	66%	31%	30%	
Complex[3] and/or Heterogenous	25%	69%	71%	25%	69%	71%	
Smoothhound Shark Complex (Atlantic Stock)							Juveniles and Adults: Near or on the bottom.
Soft bottom	66%	31%	30%	66%	31%	30%	
Complex[3] and/or Heterogenous	25%	69%	71%	25%	69%	71%	

N/A – The habitat type is not utilized by the life stage.

[1] Silver hake adult EFH is defined as pelagic and benthic habitats.

[2] Percentage of mapped complex habitat is not reported since the later life stages of this species prefers hard bottom habitat.

[3] Includes complex and large grained habitat.

Table 10b. Percentage of Field-Mapped NMFS Habitat Categories within Designated EFH for Late Benthic/Demersal Life Stages in the Northern ECC Branches[1]

Species with Early Benthic Life Stages	Juvenile: Percent Field-Mapped Habitat Categories within Designated EFH				Adult: Percent Field-Mapped Habitat Categories within Designated EFH				Description of Preferred Habitat
	A[2]	W	L	F	A[2]	W	L	F	
Finfish									
Atlantic Cod									Adults: Bottom habitats with a substrate of cobble, gravel, or boulders. Also found on sandy substrates.
Soft Bottom	---	---	---	---	17%	---	---	---	
Complex and/or Heterogenous	---	---	---	---	81%	---	---	---	
Black Sea Bass									Juveniles: 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. Adult: Structured habitats (natural and man-made), sand and shell are usually the substrate preference.
Soft Bottom	17%	24%	17%	14%	81%	25%	18%	21%	
Complex and/or Heterogenous	81%	11%	8%	18%	17%	11%	8%	34%	
Ocean Pout									Adults: Mud and sand, particularly in association with structure forming habitat types; i.e. shells, gravel, or boulders.
Soft Bottom	---	---	---	---	17%	24%	17%	14%	
Complex and/or Heterogenous	---	---	---	---	81%	11%	8%	18%	
Red Hake									Juveniles: Intertidal and sub-tidal benthic habitats on mud and sand substrates. Bottom habitats providing shelter, including mud substrates with biogenic depressions, substrates providing biogenic complexity (e.g., eelgrass,
Soft Bottom	17%	75%	81%	32%	17%	75%	81%	32%	

Species with Early Benthic Life Stages	Juvenile: Percent Field-Mapped Habitat Categories within Designated EFH				Adult: Percent Field-Mapped Habitat Categories within Designated EFH				Description of Preferred Habitat
	A[2]	W	L	F	A[2]	W	L	F	
Complex and/or Heterogenous	81%	25%	19%	68%	81%	25%	19%	60%	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: Shell beds, soft sediments (mud and sand), and artificial reefs. Usually found in depressions in softer sediments or in shell beds and not on open sandy bottom.
Scup									Juveniles: Various sands, mud, mussel and eelgrass bed type substrates Adults: Demersal waters in estuaries
Soft Bottom	17%	70%	65%	32%	17%	70%	65%	32%	
Complex and/or Heterogenous	81%	24%	19%	68%	81%	24%	19%	68%	
Silver Hake									Adult: Bottom depressions or in association with sandwaves 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.
Soft bottom	---	---	---	---	17%	24%	17%	14%	
Complex and/or Heterogenous	---	---	---	---	81%	11%	8%	18%	
Spiny Dogfish									Adults: Pelagic and epibenthic habitats throughout the region
Soft Bottom	---	---	---	---	17%	24%	17%	14%	
Complex and/or Heterogenous	---	---	---	---	82%	11%	8%	18%	
Summer Flounder[3]									

Species with Early Benthic Life Stages	Juvenile: Percent Field-Mapped Habitat Categories within Designated EFH				Adult: Percent Field-Mapped Habitat Categories within Designated EFH				Description of Preferred Habitat
	A[2]	W	L	F	A[2]	W	L	F	
Soft Bottom	17%	75%	81%	32%	17%	75%	81%	32%	Juveniles: Prefer sandy substrates. Also salt marsh creeks, seagrass beds, mudflats, and open bay areas. Adults: Prefer sandy substrates. Also shallow coastal and estuarine waters during warmer months and move offshore on the outer continental shelf at depths of 500 feet (152 meters) in colder months.
Windowpane Flounder[3]									Adults and Juveniles: Bottom habitats with a substrate of mud or sand.
Soft Bottom	17%	75%	81%	32%	17%	75%	81%	32%	
Winter Flounder[4]									Juveniles: Variety of bottom types such as mud, sand, rocky substrates with attached macroalgae, tidal wetlands, and eelgrass. YOY juveniles found inshore on muddy and sandy sediments in and adjacent to eelgrass and macroalgae, in bottom debris, and in marsh creeks. They tend to settle to the bottom in soft-sediment depositional areas and disperse into coarser-grained substrates as they get older. Adults: Muddy and sandy substrates, and on hard bottom on offshore banks.
Soft Bottom	17%	75%	81%	32%	17%	75%	81%	32%	
Complex and/or Heterogenous	81%	25%	19%	68%	81%	25%	19%	68%	
Yellowtail Flounder									Juveniles: Sand and muddy sand.
Soft Bottom	17%	67%	51%	32%	17%	24%	17%	14%	

Species with Early Benthic Life Stages	Juvenile: Percent Field-Mapped Habitat Categories within Designated EFH				Adult: Percent Field-Mapped Habitat Categories within Designated EFH				Description of Preferred Habitat
	A[2]	W	L	F	A[2]	W	L	F	
Complex and/or Heterogenous	N/A	N/A	N/A	N/A	81%	11%	8%	18%	Adults: Sand and sand with mud, shell hash, gravel, and rocks.
Skates									
Clearnose Skate									Juveniles and Adults: Mud and sand, but also on gravelly and rocky bottom.
Soft Bottom	17%	75%	81%	32%	17%	75%	81%	32%	
Complex and/or Heterogenous	81%	25%	19%	60%	81%	25%	19%	60%	
Little Skate									Juveniles and Adults: Bottom habitats with a sandy or gravelly substrate or mud.
Soft Bottom	17%	75%	81%	32%	17%	75%	81%	32%	
Complex and/or Heterogenous	81%	25%	19%	68%	81%	24%	18%	60%	
Winter Skate									Juveniles and Adults: Bottom habitats with a substrate of sand and gravel or mud.
Soft Bottom	17%	75%	81%	32%	17%	75%	81%	32%	
Complex and/or Heterogenous	81%	25%	19%	68%	81%	25%	19%	68%	
Invertebrates									
Atlantic Sea Scallop									Juveniles: Bottom habitats with a substrate of shells, gravel, and small rocks (pebble, cobble), preferring gravel. Adults: Bottom habitats with sand and gravel substrates.
Soft Bottom	17%	24%	17%	14%	17%	24%	17%	14%	
Complex and/or Heterogenous	81%	11%	8%	18%	81%	11%	8%	18%	
Atlantic Surfclam[3]									Juveniles and Adults: Prefers well-sorted medium and fine sandy substrates.
Soft Bottom	17%	---	---	---	17%	---	---	---	
Ocean Quahog[3]									

Species with Early Benthic Life Stages	Juvenile – Percent Field-Mapped Habitat Categories within Designated EFH				Adult – Percent Field-Mapped Habitat Categories within Designated EFH				Description of Preferred Habitat
	A[2]	W	L	F	A[2]	W	L	F	
Soft Bottom	---	---	---	---	17%	24%	17%	14%	Adults: Prefers medium to fine sandy bottom.
Highly Migratory Species – Sharks									
Sand Tiger Shark					---	---	---	---	Juveniles: Sand, mud, and rocky substrates. Coastal and shallow bays; generally near bottom.
Soft Bottom	16%	18%	13%	15%	---	---	---	---	
Complex and/or Heterogenous	81%	10%	7%	25%	---	---	---	---	
Sandbar Shark									Juveniles and Adults: Sand, mud, shell, and rocky sediments/benthic habitat.
Soft Bottom	17%	13%	10%	13%	17%	25%	18%	17%	
Complex and/or Heterogenous	81%	4%	3%	8%	81%	17%	12%	32%	
Smoothhound Shark Complex (Atlantic Stock)									Juveniles and Adults: Near or on the bottom.
Soft Bottom	17%	67%	68%	32%	17%	67%	68%	32%	
Complex and/or Heterogenous	81%	24%	19%	68%	81%	24%	19%	68%	

N/A – The habitat type is not utilized by the life stage.
[1] The Northern ECC is broken into six potential branches: A – Asbury; W – Wolfe Pond; L – Lemon Creek; F – Fort Hamilton.
[2] The Asbury Branch contains two landfall options, however due to their close proximity, the routes to both landfalls are collectively referred and analyzed under the Asbury Branch.
[3] Percentage of mapped complex habitat is not reported since the later life stages of this species prefers soft bottom habitat.
[4] Winter flounder larvae are initially pelagic and then settle to the bottom where they metamorphose to juveniles.

6.5 Summary of Effects to EFH Life Stages and Habitat Types

As demonstrated in Tables 7a, 7b, 8a, and 8b, many of the species with designated EFH in the Offshore Project Area have a completely pelagic lifestyle and most species have pelagic early life histories (Tables 7a and 7b) and are not dependent on benthic habitat. These species are expected to experience negligible impacts to their EFH as the pelagic zone will not be directly affected by most Project activities. Given their mobile nature, pelagic juvenile and adult life stages (Tables 8a and 8b) should largely avoid the areas affected by Project disturbance and are expected to return shortly after activities cease in a given location.

For most Project activities, early life stages of EFH species that are benthic or demersally oriented (Tables 9a and 9b) or later life stages of benthic-oriented sessile species (Tables 10a and 10b) are subject to the greatest potential effects (injury or mortality) from temporary disturbance to their EFH. Mobile benthic or demersal later life stages of EFH species (Tables 10a and 10b) may also experience temporary effects to EFH; however, impacts to individual species are expected to be less than those for eggs and larvae since these older life stages are mobile and can temporarily leave the area during Project activities.

As stated in Section 3.0, the Offshore Project Area consists primarily of sands and gravels and includes seabed features (e.g., ripples and mega ripples) indicative of a dynamic system where species are adapted to periodic disturbances. Only three species (winter flounder eggs and larvae, Atlantic sea scallop eggs, and longfin inshore squid eggs) have sensitive benthic or demersal early life stages (Table 9a and 9b) and two species (Atlantic surfclam juveniles and adults and ocean quahog adults) have sensitive sessile benthic later life stages (Tables 10a and 10b) with EFH that prefer soft bottom habitat. The remaining species that prefer soft bottom habitat are mobile benthic or demersal later life stages (Tables 10a and 10b) and can temporarily leave the area during Project activities. As described further in Section 7.0, the EFH and EFH species in these dynamic areas are adapted to periodic disturbances (Guida et al., 2017) similar to those associated with Project activities and tend to recover quickly from disturbances.

EFH and EFH-designated species that rely on sensitive habitat areas such as hard bottom habitats, could experience longer-term effects from Project activities; however, as stated in Section 3.0, most of the complex habitat in the Offshore Project Area consists of gravelly sand and only contains small areas of large-grained complex habitat. In addition, only four species (ocean pout eggs, winter flounder eggs and larvae, Atlantic sea scallop eggs and larvae, and longfin inshore squid eggs) have the most sensitive early life stages with EFH that utilize complex habitats (Tables 9a and 9b). Of these species, winter flounder eggs and larvae, Atlantic sea scallop eggs and larvae, and longfin inshore squid eggs may also be found in soft bottom habitat. The remaining species that may utilize complex habitat are mobile benthic or demersal later life stages (Tables 10a and 10b) that can temporarily leave the area during Project activities.

Section 7.0 provides a complete assessment of potential Project effects on these EFH and EFH-designated species in the Offshore Project Area.

7.0 ASSESSMENT OF POTENTIAL EFFECTS

Effects to EFH and EFH species from Project construction, operation and decommissioning activities are expected to be temporary, localized and not result in population effects. This section addresses potential species effects – direct and indirect - of each Project phase on EFH and EFH-designated species in the Offshore Project Area. These effects include:

- Temporary disturbance or displacement of habitat for marine resources;
- Direct mortality or injury to marine species;
- Habitat conversion and creation;
- Disturbance or injury of marine species through Project-related noise;
- Direct or indirect effects on marine species through Project-related EMFs; and
- Direct or indirect effects on marine species through Project-related lighting.

The following sections discuss each of these effects as they relate to construction, operation, and decommissioning based on the maximum PDE for the offshore build-out of the Project as defined in Section 2.2.7, including the use of piled foundations to support the assessment of underwater noise. The Project activity and characteristics (e.g., timing, duration, extent, intensity) of each potential effect on EFH and/or EFH species as well as the environmental measures Atlantic Shores will implement during each Project phase to avoid, minimize, and/or mitigate effects to the maximum extent practicable are addressed in Sections 7.1 through 7.7. A complete summary of environmental protection measures is also provided in Section 8.0.

7.1 Temporary Direct Habitat Loss and Disturbance

This section focuses on the temporary direct disturbances to EFH and EFH species that will primarily occur during the construction phase. Section 7.4, Habitat Conversion and Creation, addresses permanent seafloor disturbance from the footprints of foundations, scour protection, and offshore cable protection that will result in habitat conversion of primarily sandy substrate to hard substrate. The O&M phase is expected to have significantly lower seafloor disturbance than Project construction. During O&M, Project components will be monitored as described in Volume I, Section 5.0 of the COP. If portions of buried offshore cables require maintenance, the sediment cover may need to be removed temporarily for inspection and possible replacement of a portion of the cable. These activities would temporarily disturb the seafloor but would be short-term and extremely localized. The decommissioning phase is expected to have similar, but less seafloor disturbance than Project construction.

Seafloor-disturbing activities during construction of the WTG and OSS foundations include jack-up vessel positioning and anchoring, seabed preparation, foundation placement, and scour protection installation. Seabed preparation may be required for gravity-based foundations or in areas with large sand bedforms. Seafloor-disturbing activities during installation of the offshore cables include anchoring, pre-installation activities (e.g., sand bedform removal, boulder relocation, and pre-lay grapnel run), offshore cable installation, cable protection installation, where needed, and excavation of the offshore HDD pit. Detailed methodologies for conducting these activities are described in Volume I, Section 4.0 of the COP.

The maximum area of seabed disturbance associated with these activities in the Offshore Project Area is summarized in Table 2. A summary of the number of square miles of each NMFS habitat type that may be disturbed during various project activities in the Lease Area and ECCs is provided in Table 11. Based on the range of activities in the Project lifecycle associated with the maximum case PDE, the total area of temporary seafloor disturbance (not including the area of the seafloor that will be permanently occupied by structures or cables [Section 7.4]) in the Lease Area is approximately 4.0 square miles (10.4 square kilometers), with 73% of impacts occurring to soft bottom habitat, 21% to complex habitat, and 6% to heterogenous habitat. The Northern and Monmouth ECC from the landfall to the Lease Area boundary will result in a total temporary impact of approximately 2.2 square miles (5.7 square kilometers) and 3.0 square miles (7.8 square kilometers) respectively. The Monmouth and Northern ECCs have a greater presence of complex habitat compared to the Lease Area. Though complex habitat is present in the Offshore Project Area and is expected to be temporarily and permanently disturbed by installation activities, the majority of such habitat consists of gravelly and gravelly mixes which is consistent with other areas of the Mid-Atlantic Bight. Within the Monmouth ECC, 69% of impacts will occur to complex habitat, 31% will occur to soft bottom habitat, and less than 1% will occur to heterogenous complex habitat. Temporary impacts within the Northern ECC consist of a similar breakdown as that of the Monmouth ECC. Within the Northern ECC, 60% of temporary impacts will occur to complex habitat, 31% will occur to soft bottom habitat, 5% will occur to large-grained habitat, and 3% will occur to heterogenous complex habitat. These estimated areas of temporary disturbance are small relative to the total area of available surrounding habitat in the Lease Area and ECCs.

In addition to impacts in the offshore environment, the Fresh Kills/Goethals Onshore Interconnection Route will traverse areas of tidal wetland habitat around the New York City Department of Sanitation landfill that is dominated by *Phragmites* species. Tidal wetlands can provide habitat for invertebrate and fish species, particularly in the juvenile stage, however, it should be noted that given the close proximity between the tidal wetlands and the landfill, such habitat may not be suitable for all species (NYSDEC, 2021). Though tidal wetlands exist along the Fresh Kills/Goethals Onshore Interconnection Route, impacts will be avoided through the use of HDD. The use of HDD allows Atlantic Shores to avoid approximately 2.5 acres of impacts to tidal wetlands. Atlantic Shores will also implement an Inadvertent Return Plan to minimize potential impacts from HDD activities (See Volume II, Section 4.1 of the COP for more detail on wetland habitat). There are no mapped tidal wetlands within the Offshore Project Area, including at the landfall sites (see Figure 10).

Table 11. Estimated Temporary and Permanent Disturbance to NMFS Habitat Types[1]

Installation Activity	Temporary Impact (square miles)				Permanent Impact (square miles)			
	Soft	Heterogenous	Complex	Large Grained	Soft	Heterogenous	Complex	Large Grained
Impacts within the Lease Area								
WTG Foundation Installation (including scour protection)	0.312 (199.79 ac)	0.027 (16.99 ac)	0.091 (58.41 ac)	---	0.457 (292.72 ac)	0.039 (24.90 ac)	0.134 (85.58 ac)	---
WTG Installation and Commissioning	0.065 (41.82 ac)	0.006 (3.56 ac)	0.019 (12.23 ac)	---	---	---	---	---
OSS Foundation Installation (Including Scour Protection), Topside Installation, and Commissioning	0.029 (18.59 ac)	0.002 (1.58 ac)	0.008 (5.43 ac)	---	0.022 (13.94 ac)	0.002 (1.19 ac)	0.006 (4.08 ac)	---
Inter-Array Cable Installation (Including Cable Protection)	1.808 (1,156.95 ac)	0.154 (98.39 ac)	0.529 (338.26 ac)	---	0.298 (190.50 ac)	0.025 (16.20 ac)	0.087 (55.70 ac)	---
Inter-Link Cable Installation (Including Cable Protection)	0.305 (195.15 ac)	0.026 (16.60 ac)	0.089 (57.06 ac)	---	0.044 (27.88 ac)	0.004 (2.37 ac)	0.013 (8.15 ac)	---
Metocean Buoy Installation	0.007 (4.65 ac)	0.001 (0.40 ac)	0.002 (1.36 ac)	---	---	---	---	---
Export Cable in Lease Area								
Monmouth ECC	0.160 (102.22 ac)	0.014 (8.69 ac)	0.047 (29.89 ac)	---	0.029 (18.59 ac)	0.002 (1.58 ac)	0.008 (5.43 ac)	---
Northern ECC[2]	0.218 (139.39 ac)	0.019 (11.86 ac)	0.064 (40.75 ac)	---	0.036 (23.23 ac)	0.003 (1.97 ac)	0.011 (6.79 ac)	---
Subtotal – Lease Area	**2.904 (1,858.55 ac)**	**0.247 (158.06 ac)**	**0.849 (543.39 ac)**	---	**0.886 (655.86 ac)**	**0.075 (48.21 ac)**	**0.259 (165.73 ac)**	**---**

Installation Activity	Temporary Impact (square miles)				Permanent Impact (square miles)			
	Soft	Heterogenous	Complex	Large Grained	Soft	Heterogenous	Complex	Large Grained
Impacts within the ECCs								
Monmouth ECC to Lease Area	0.680 (434.93 ac)	0.001 (0.55 ac)	1.530 (978.92 ac)	---	0.108 (68.88 ac)	<0.001 (0.09 ac)	0.242 (155.03 ac)	---
Northern ECC to Lease Area[2]	0.933 (597.02 ac)	0.101 (64.89 ac)	1.811 (1,159.01 ac)	0.155 (99.07 ac)	0.124 (79.60 ac)	0.014 (8.65 ac)	0.241 (154.54 ac)	0.021 (13.21 ac)

[1] Impacts to NMFS habitat types were calculated using proportional percentages of sediment types within each Project component area rather than on a specific locational basis. First, total acres of each habitat type were calculated within the Lease Area, Monmouth ECC, and Northern ECC. Next, the acres of each habitat type were divided by the total surveyed area in each Project component area to yield a percent of each habitat type in each Project component area. Lastly, these percentages were applied to the temporary and permanent footprint of each installation activity.

[2] Disturbance values for the Northern ECC include four export cables extending to the Asbury branch and three extending to the New York Landfall sites.

Given the dynamic nature of sediment processes in the Offshore Project Area, Project seabed disturbing activities are expected to create only temporary and localized alterations to the seafloor habitat. The benthic community associated with the soft bottom habitat that dominates the Offshore Project Area is expected to rapidly recover following construction (Brooks et al., 2004; Guarinello et al., 2017; Guida et al., 2017). A review of studies of the recovery and recolonization along the U.S. East Coast by Brooks et al. (2004) reported that recovery of benthic assemblages to background levels following dredging disturbance can range from three months to two and a half years with recovery time dependent on site-specific taxa, type of sediment disturbance, and environmental conditions. Fine grain sediments typically recover to pre-disturbance conditions more quickly, in a matter of months, than sand and gravel sediments which may take 2-3 years to recover (Wilber and Clarke 2007). BOEM (2021) reported that benthic assemblages subjected to physical disturbance in soft sediment communities typically recover in 6 to 18 months through dispersal from adjacent areas, assuming the affected area is not disturbed during the recolonization period. The Project will be isolated within the Offshore Project Area, which is a relatively small area compared to the surrounding environment. Additionally, disturbances from the Project will primarily occur during the construction phase, therefore the frequency of disturbance to the benthic habitat would be relatively low. Therefore, Project-related seabed disturbance is unlikely to result in long-term adverse effects on EFH or displacement of EFH species because these habitats have persisted through natural and anthropogenic disturbances (e.g., dredging, vessel traffic and fishing activities) and the EFH and EFH species in these dynamic areas are adapted to disturbances similar to those associated with Project activities. For these reasons, Project-related impacts from the installation and maintenance of structures and cables to the benthic community, which supports benthic and demersally oriented finfish species and their EFH, are expected to be temporary and localized.

For those locations in the Offshore Project Area identified by site-specific surveys as complex habitat, the installation and maintenance of new structures, cables, and associated vessel anchoring and jacking activities could result in longer-term effects to EFH because complex habitats are reported to have longer recovery times than areas with soft sediment (HDR 2020). The frequency, severity, and spatial extent of the disturbance are important factors in how benthic recovery may occur. There may be lower species resistance in areas that are not adapted to severe disturbances at frequent intervals (Watling and Norse 1998); however, the Project represents a one-time disturbance that is limited in its spatial extent. Freese et al. (1999) conducted a single trawl pass in an area of hard-bottom habitat in Alaska that had recently experienced no or minimal trawling activity. Immediate changes to habitat and the benthic community consisted of boulder displacement and removal and damage of large epifaunal invertebrates, sponges, and anthozoans; however, there were not significant impacts to mobile invertebrate densities and individuals were not obviously damaged (Freese et al. 1999). As provided in Table 11, the total temporary impact to complex habitat from installation activities for the Project is estimated to be approximately 0.85 and 3.34 square miles (2.2 and 8.65 square kilometers) in the Lease Area and ECCs, respectively. The total temporary impact for the Project to heterogenous habitat is estimated to be approximately 0.25 and 0.10 square miles (0.65 and 0.26 square kilometers) in the Lease Area and ECCs, respectively. The total temporary impact for the Project to large-grained complex habitat is estimated to be approximately 0 and 0.16 square miles (0 and 0.41 square kilometers) in the Lease Area and ECCs, respectively. Complex habitat in the Offshore Project Area consists mainly of gravelly sand, sandy gravel, and gravelly muddy sand, all of which are common in the region (NEFSC, 2021). Complex habitat mapped in the Offshore Project Area also consists of small areas of large-grained sediment (equal to or greater than 80% gravel) within the Northern ECC. Mapped complex habitat in the Offshore Project Area is displayed in Attachments 3 and 4 to this EFH Technical Report and in Volume II, Appendix II-A1 of the COP. Additionally, Section 6 of this Report provides context regarding the percentage of mapped complex habitat in designated EFH. All Project activities will occur in previously surveyed areas. Atlantic Shores has selected installation tools and methods that minimize disturbance to bottom habitats, including complex habitats, to the maximum extent practicable. In addition, the Offshore Project Area does not contain any salt marshes, mud flats, coral reefs, or significant areas of submerged aquatic vegetation such as eel grass, which are considered sensitive habitat for EFH species. Atlantic Shores will further reduce impacts to hard bottom and structurally complex habitats, identified by site-specific surveys as complex habitat, through the use of anchor midline buoys and by following an anchoring plan designed to avoid impacts to these identified complex habitats to the maximum extent practicable.

NOAA Fisheries has also identified areas of summer flounder HAPC along the northeastern coastline. This identified area overlaps with portions of the following NECC branches: Wolfe Pond (approximately 11 miles [17.7 kilometers] of the cable route), Lemon Creek (approximately 12 miles [19.3 kilometers] of the route), and Fort Hamilton (approximately 8 [12.8 kilometers] miles of the route) (Figure 8). Though summer flounder HAPC is identified by NOAA Fisheries along the Northern ECC routes, as stated in Section 4.0, NOAA Fisheries defines summer flounder HAPC 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. According to available mapping from NOAA, which compiles data from state and local sources, and available mapping from the NJDEP, no known areas of SAV exist along the Northern ECC Branches (NOAA, 2020a). The closest known area of SAV exists approximately 3.5 miles south of the Monmouth ECC. If summer flounder habitat containing SAV is identified in the nearshore reaches of the Offshore Project Area, Atlantic Shores will coordinate with BOEM and NOAA Fisheries to avoid and minimize potential effects from Project activities.

Most species with designated EFH in the Offshore Project Area have pelagic early life histories (eggs and larvae) (Section 6.0, Tables 7a and 7b) and are not dependent on benthic habitat. Therefore, modification and/or disturbance of the seafloor, including temporary sediment suspension and deposition will not substantially impact these species or life stages. There may be some temporary impacts on the use of specific areas by these species during construction resulting from increased sediment suspension in the lower water column; however, as discussed further in Section 7.2, any sediment plume generated during Project construction is expected to be small, localized, and temporary. In addition, given their mobile nature, pelagic juvenile and adult life stages (Section 6.0, Tables 8a and 8b) should largely avoid these areas during the period of disturbance. During this time, these species will be able to forage in nearby areas and are expected to return soon after sediment disturbing activities are complete.

Sessile benthic species (e.g., Atlantic surfclam juveniles and adults and ocean quahog adults [Section 6.0, Tables 10a and 10b]) or species with early life stages (eggs and larvae) that are dependent on benthic habitat (e.g., ocean pout eggs, winter flounder eggs and larvae, Atlantic sea scallop eggs and larvae, and longfin inshore squid eggs [Section 6.0, Tables 9a and 9b]) will be more susceptible to injury or mortality from seabed disturbing Project activities. Mortality of these species will most likely be limited to the direct footprint of the disturbance. These species will also be more susceptible to temporary increases in sediment suspension and deposition; however, as discussed further in Section 7.2, any sediment plume generated during Project construction is expected to be small, localized, and temporary. Any injury of mortality to these species and life stages is not expected to result in population level effects given the surrounding available habitat that will not be disturbed. The extent of impacts on the early life stages of these EFH species will also be dependent on the time of year that Project activities occur, as early life stages will only be present for short periods during specific times of year depending on the species. Therefore, the potential exposure of the most vulnerable early life stages to seabed disturbance will be limited to only their seasonal presence in the Offshore Project Area.

Mobile juvenile and adult life stages (including the neonate stage of sand tiger shark, sandbar shark, and smoothhound shark) of benthic and demersal EFH species (Section 6.0, Tables 10a and 10b) are less likely to experience injury or mortality during seafloor disturbing activities because they are expected to temporarily leave the immediate area during these activities. By moving away from Project-related activities, mobile finfish would be able to avoid direct mortality and injury; however, they may be temporarily displaced from a portion of available habitat in the Offshore Project Area. During this time, these species will be able to forage in nearby areas and are expected to return soon after sediment disturbing activities are complete. The extent of impacts to individual older life stages of EFH species is also affected by the time of year that Project activities occur. Many species within the Offshore Project Area migrate seasonally, such as black sea bass, scup, monkfish, and spiny dogfish and use benthic habitat for only a portion of their life stage. Therefore, the potential exposure of these species to seabed disturbance will be limited to their seasonal presence in the Offshore Project Area.

Based on documented cases of habitat recolonization and recovery after significant disturbances involving benthic communities like those found in the Offshore Project Area, and the assumption that the surrounding available habitat will not be disturbed, seafloor-disturbing Project activities are not expected to result in long-term population-level effects to the resident benthic organisms and communities that support EFH and EFH species. An estimate of 4.0 and 4.1 square miles of temporary disturbance is expected to occur from installation activities in the Lease Area and ECCs, respectively. These areas of disturbance are fairly small compared to the entire Offshore Project Area, comprising 1.9% and 1.9%, respectively, of the Offshore Project Area, and overall surrounding habitat. Although localized mortality of some benthic invertebrates is anticipated in the Offshore Project Area, impacts are not expected to be significant at the population level and would not measurably alter the environmental baseline as similarly concluded in BOEM (2021).

Environmental protection measures, such as using HDD techniques to avoid seabed disturbance impacts at the landfall sites, burying offshore cables to a target depth of 5 to 6.6 feet (1.5 to 2 meters), using installation tools that minimize seabed disturbance to the maximum extent practicable, and using anchor midline buoys and an anchoring plan, where feasible, will avoid and further minimize impacts to EFH and EFH-designated species as described in detail in Section 8.0.

7.2 Water Quality

7.2.1 Suspended Sediment and Deposition

Various sediment-disturbing Project activities conducted during construction, O&M, and decommissioning have the potential to suspend sediments into the water column resulting in the transport and deposition of these sediments on the seafloor. As described in Volume II, Section 2.1 of the COP, sediments disturbed during Project activities are not expected to contain hazardous contaminants. Therefore, during all Project phases, EFH and EFH species will primarily be affected by the short-term, localized, and temporary physical suspension of sediments and resulting deposition.

The primary construction activities that will result in elevated suspended sediment concentrations and deposition include seabed foundation preparation, sand bedform removal, inter-array and offshore export cable installation, and excavation at the offshore HDD pit. In order to determine the extent of suspended sediment and deposition produced by construction activities, a Sediment Transport Modeling study was conducted (see Volume II, Appendix II-J2 of the COP). This study examined the extent and duration of elevated total suspended solids (TSS) concentrations and sediment deposition as a result of seabed preparation for WTG and OSS foundation installation, sand wave clearance in the Lease Area and along the ECCs, inter-array, and, offshore export cable installation, and HDD activities at the Monmouth and Northern ECC Landfall Sites[4]. Results of the study represent a maximum case scenario by modeling facility components and activities that would result in the greatest impact including, but not limited to, the use of a TSHD for seabed preparation activities, use of a suction bucket jacket for all foundations (both WTG and OSS), and the presence of three large OSS structures. A summary of these findings is provided in the following sections.

Suspended Sediment Concentration Predictions

Model simulation results of above-ambient TSS concentrations stemming from seabed preparation for WTG and OSS foundation installation; sand wave clearance; cable installation for the inter-array cable, Monmouth ECC, and Northern ECC; and HDD activities remained relatively close to the area where seabed preparation and installation activities would take place, were constrained to the bottom of the water column, and were relatively short-lived. Table 12 summarizes the extent and duration of suspended sediment concentrations resulting from seabed preparation for WTG and OSS foundation installation, sand wave clearance, cable installation, and HDD activities. Two TSS concentration thresholds are provided in Table 12 milligram per liter (mg/L) and 100 mg/L. A threshold of ≥10 mg/L is cited in literature as within the range of ambient TSS concentration conditions of the Mid-Atlantic Bight (Balthis et al., 2009). A threshold of ≥100 mg/L has been cited in literature as a level at which larval fish and mobile benthic organisms exhibit signs of sensitivity (Auld and Schubel, 1978; Turner and Miller, 1991, Wilber and Clarke, 2001; Anderson and Mackas, 1986).

[4] For modeling purposes, the Sediment Transport Report selected one route along the Northern ECC. The route selected uses the South Beach Branch due to the length of the route and the complex hydrodynamic conditions that exist along the route. This branch is no longer under consideration for this Project, but remains representative of the conditions in the areas of the New York landfall sites.

Simulations of seabed preparation for WTG and OSS foundation installation and sand wave clearance using a trailing suction hopper dredge, and several possible inter-array cable or offshore export cable installation methods using either jet trenching installation parameters (for inter-array cable and export cable installation) or mechanical trenching installation parameters (for inter-array cable installation only) predicted above-ambient TSS of ≥10 mg/L stayed relatively close to the representative foundation locations and route centerline. This is due to sediments being introduced to the water column close to the seabed. TSS concentrations of ≥10 mg/L traveled a maximum distance of approximately 0.7 miles (1.1 kilometers) from the representative WTG foundation site, up to approximately 1.6 miles (2.6 kilometers) from representative OSS foundation sites, and 2.4 miles (3.9 kilometers), 2.0 miles (3.2 kilometers), and 2.8 miles (4.5 kilometers) from the sand wave clearing route for the inter-array cables, Monmouth ECC, and Northern ECC, respectively. TSS concentrations of ≥10 mg/L traveled a maximum distance of approximately 1.7 miles (2.7 kilometers), 1.6 miles (2.6 kilometers), and 1.5 miles (2.4 kilometers) for inter-array, Monmouth ECC, and Northern ECC cable installation, respectively (Table 12). For the landfall approach scenarios, use of an excavator was assumed, and sediment was introduced at the surface. This resulted in a maximum distance for the predicted above-ambient TSS concentrations ≥10 mg/L of approximately 2.1 miles (3.3 kilometers) and 1.1 miles (1.9 kilometers) for the Monmouth and Northern ECC HDD pits, respectively (Table 12).

For the model scenario of seabed preparation for the representative WTG foundation location, above-ambient TSS concentrations were predicted to substantially dissipate within 4 hours, with full dissipation occurring in less than 5 hours. Modeling scenarios for seabed preparation for OSS foundations predicted above-ambient TSS concentrations to substantially dissipate within 7 to 10 hours, with full dissipation occurring between 9 to 12 hours. Sand wave clearing model scenarios for the inter-array cable, Monmouth ECC, and Northern ECC predicted above-ambient TSS concentrations to substantially dissipate within 4 to 6 hours, with full dissipation in less than 15 hours. For the inter-array cable installation model scenario, above-ambient TSS concentrations substantially dissipated within 4 to 6 hours and fully dissipated in 9 or less hours. For the Monmouth and Northern ECC installation model scenarios, above-ambient TSS concentrations substantially dissipated within 2 to 6 hours but required between 12 and 18 hours to fully dissipate, likely due to the relatively longer route (i.e., larger volume of suspended sediment), route orientation in relation to currents, and more frequent occurrence of fine sediment. For the landfall approach scenarios, the tails of the plumes, with concentrations of ≥10 mg/L, were transported away from the source and were short-lived, while concentrations around the HDD pits dissipated within approximately 6 to 12 hours for the Monmouth HDD pit and 6 to 10 hours for the Northern HDD pit. The larger areas of TSS concentrations above thresholds and the longer time for the plume to diminish to ambient conditions for the Monmouth HDD pit may be attributed to sediments being released in deeper water, the higher fraction of fine sediments taking longer to settle, and slightly stronger currents transporting the sediments parallel with the shore.

Table 12. Suspended Sediment Modeling Results from Seabed Preparation for Foundations, Cable Installation and HDD Activities

Scenario	Maximum Duration of TSS >10 mg/L (hrs)	Maximum Extent of TSS ≥10 mg/L	Maximum Duration of TSS >100 mg/L (hrs)	Maximum Extent of TSS ≥100 mg/L
Seafloor Preparation for Foundations				
Representative WTG Seabed Foundation Preparation[1]	4.9	0.7 mi (1.11 km)	4.4	0.7mi (1.05 km)
Large OSS Seabed Foundation Preparation – 1[1,2]	11.9	1.5 mi (2.4 km)	7.6	1.4 mi (2.3 km)
Large OSS Seabed Foundation Preparation – 2[1,2]	12.1	1.5 mi (2.4 km)	9.1	1.4 mi (2.3 km)
Large OSS Seabed Foundation Preparation – 3[1,2]	8.9	1.6 mi (2.6 km)	7.2	1.4 mi (2.2 km)
Sand Wave Clearance				
Representative IAC – Sand Wave Clearance	14.3	2.4 mi (3.9 km)	8.3	2.0 mi (3.2 km)
Representative Sand Wave Clearance, Monmouth ECC	12.5	2.0 mi (3.2 km)	7.0	1.3 mi (2.1 km)
Representative Northern ECC– Sand Wave Clearance	8.7	2.8 mi (4.5 km)	7.0	0.8 mi (1.3 km)
Offshore Cable Installation				
Inter-array Cable - Jet Trencher	8.0	1.4 mi (2.2 km)	2.5	0.5 mi (0.8 km)
Inter-array Cable - Mechanical Trencher	8.7	1.7 mi (2.7 km)	3.8	0.4 mi (0.6 km)
Monmouth Export Cable - Jet Trencher	12.8	1.6 mi (2.6 km)	6.0	0.9 mi (1.5 km)
Northern Export Cable - Jet Trencher	17.7	1.5 mi (2.4 km)	3.0	0.3 mi (0.4 km)
HDD Activities at Landfall Site				
Monmouth Landfall Representative HDD Pit Excavator	12.3	2.1 mi (3.3 km)	11	0.3 mi (0.4 km)

Northern Landfall Representative HDD Pit Excavator	10.3	1.1 mi (1.9 km)	10.2	0.1 (0.18 km)

[1] A suction bucket jacket foundation, which represents the maximum disturbance of all foundation types under consideration, was used to model impacts from seafloor preparation for WTG and OSS installation.
[2] The modeling assumed three large OSS structures for the Project.

These model predictions agree with modeling results conducted for similar projects in similar sediment conditions (BOEM, 2021; Elliot et al., 2017; West Point Partners, LLC 2013; ASA, 2008). Actual suspended sediment concentrations and sediment transport during installation may be even lower given that environmental monitoring surveys conducted during installation of the Block Island Wind Farm submarine cable found that suspended sediment levels measured during jet plow installation were up to 100 times lower than those predicted by the modeling (Elliot et al., 2017).

Elevated suspended sediment concentrations have the potential to influence feeding and foraging behavior, respiratory functionality, and survival of finfish species; however, impacts vary by species and life stage (Wilber and Clark 2001). Historically, studies on the impacts of suspended sediments on marine organisms have heavily focused on sediment concentrations. More recent studies have shown that exposure duration is also an important influencing factor (Wilber and Clark, 2001). Wilber and Clark (2001) compiled numerous studies which examined the impacts of suspended sediment concentration and exposure duration. A majority of the studies observed lethal impacts at high sediment concentrations and long exposure durations. One study conducted by Auld and Schubel (1978) showed a 13% mortality rate in American shad larvae when exposed to suspended sediment concentration of 100 mg/L for a duration of 4 days (Wilber and Clark, 2001). Another study conducted by Sherk et al. (1974) showed a 10% mortality in Atlantic silverside juveniles and adults when exposed to sediment concentrations of 580 mg/L for 1 day (Wilber and Clark 2001).

Effects from elevated suspended sediment concentrations on benthic invertebrates, including some EFH species or prey of EFH species can include abrasion, respiration interference, feeding disruption, excretion disruption, reduced growth rate, and in some cases, mortality (Johnson, 2018; Wilber and Clarke, 2001; Kjelland et al., 2015; Roberts and Elliott 2017; Roberts et al. 2016). A typical adult bivalve response to elevated suspended sediment reported by Wilber and Clarke (2001) is a reduction in net pumping rate and rejecting excess filtered material. Johnson (2018) reports that adult bivalves are relatively tolerant of TSS but could still exhibit reduced growth and survival rates; however, very high TSS concentrations would be required to induce mortality. Wilber and Clarke (2001) reported that adult bivalves exposed to TSS levels below 100,000 mg/L for shorter than 5 days did not experience mortality. For mobile invertebrate species, impacts from short-term turbidity plumes are mediated by leaving the area, expelling filtered sediments, or reducing filtration rates (NYSERDA 2017; Bergstrom et al. 2013; Clarke and Wilber 2000), thereby reducing the extent of or avoiding lethal impacts.

Results from the Sediment Transport Modeling report showed that suspended sediment concentrations greater than 100 mg/L are only anticipated to last up to 5 hours for seabed preparation activities for the representative WTG foundation, approximately 9 hours for seabed preparation activities for representative OSS foundation locations, approximately 8 hours for sand wave clearing activities, approximately 11 hours for HDD activities and approximately 6 hours for cable installation, both of which are significantly less than the multiple-day studies compiled by Wilber and Clark (2001). Additionally, concentrations greater than 100 mg/L are expected to be localized, extending up to a maximum distance of 0.7 mile (1.1 km) from the representative WTG foundation location, 1.4 miles (2.3 kilometers) from representative OSS foundation locations, 2.0 miles (3.2 kilometers) from sand wave clearing routes, 0.9 mile (1.5 kilometers) from cable centerlines, and 0.3 mile (0.4 kilometer) from HDD activities. Therefore, while effects could occur to sessile and less mobile individuals and early life stages of EFH species in the immediate vicinity of the seabed preparation, cable installation, and HDD activities, these effects are expected to be short-term and not result in high levels of mortality.

Effects to finfish EFH species are dependent on the time of year of that these activities occur, as species presence differs seasonally. Demersal and pelagic egg and larval stages of EFH fish species potentially present in the Offshore Project Area (Tables 7a, 7b, 9a, and 9b) will be most sensitive to the increased suspended sediment concentrations. Juvenile and adult EFH life stages (Tables 8a, 8b, 10a, and 10b) will likely temporarily avoid the disturbed area which could have a temporary displacement effect; however, these species are expected to return after the activities cease in a given location. Potential impacts to finfish and benthic invertebrate EFH species would be short-term and localized since sediment-disturbing Project activities are expected to only reach high TSS concentrations for a limited time and the sediment plume is expected to be limited to the relative proximity of the activity. In addition, as described in Section 6.0 and 7.1, much of the habitat in the Offshore Project Area is indicative of a dynamic system and the species that live in the mobile sandy habitat areas are adapted to survive periodic natural disturbances similar to what they would experience from sediment-disturbing Project activities. Furthermore, the area affected by increased suspended sediment is expected to be small compared to the surrounding habitat. Therefore, population-level effects to EFH and EFH species are not anticipated.

Sediment Deposition Predictions

Installation and maintenance of structures and cables will also result in the transport of sediment that will subsequently deposit over time as sediment particles settle through the water column to the seabed. Sediment deposition levels were modeled, as part of the Sediment Transport Modeling study, for seabed preparation activities for WTG and OSS foundations, sand wave clearing activities, the offshore installation of inter-array cables, the Monmouth ECC, Northern ECC, and HDD activities at the Monmouth and Northern ECC Landfall Sites.

Table 13 summarizes the areal extent and maximum distance of sediment deposition due to seabed preparation activities, cable installation, HDD activities, and sandwave clearance. Two depositional thresholds are provided in the table below, 0.04 inch (1 millimeter) and 0.4 inch (10 millimeters). A threshold of 0.04 inch (1 millimeter) is cited in literature as the level at which burial and mortality occurs in demersal eggs (Berry et al., 2011). A threshold of 0.4 inch (10 millimeters) is cited in literature as the level at which sessile benthic invertebrates exhibit signs of sensitivity (Essink, 1999).

Table 13. Deposition Modeling Results from Seabed Preparation for Foundations, Cable Installation and HDD Activities

Scenario	Area of Deposition 0.04 in (≥1 mm)[1]	Maximum Extent of Deposition ≥0.04 in (1 mm)[1]	Area of Deposition ≥0.4 in (10 mm)[2]	Maximum Extent of Deposition ≥0.4 in (10 mm)[2]
Seafloor Preparation for Foundations				
Representative WTG Seabed Foundation Preparation[3]	0.2 mi^2 (0.6 km^2)	2,821 ft (860 m)	0.04 mi^2 (0.1 km^2)	1,214 ft (370 m)
Large OSS Seabed Foundation Preparation – 1[3,4]	1.0 mi^2 (2.6 km^2)	6,890 ft (2,100 m)	0.2 mi^2 (0.4 km^2)	2,493 ft (760 m)
Large OSS Seabed Foundation Preparation – 2[3,4]	1.0 mi^2 (2.7 km^2)	7,152 ft (2,180 m)	0.2 mi^2 (0.5 km^2)	3,182 ft (970 m)
Large OSS Seabed Foundation Preparation – 3[3,4]	1.1 mi^2 (2.8 km^2)	6,660 ft (2,030 m)	0.2 mi^2 (0.5 km^2)	2,690 ft (820 m)
Sand Wave Clearing				
Representative IAC – Sand Wave Clearance	1.4 mi^2 (3.5 km^2)	4,002 ft (1,220 m)	0.3 mi^2 (0.8 km^2)	492 ft (150 m)
Representative Sand Wave Clearance, Monmouth ECC	2.0 mi^2 (5.2 km^2)	2,821 ft (860 m)	0.9 mi^2 (2.3 km^2)	558 ft (170 m)
Representative Northern ECC– Sand Wave Clearance	2.0 mi^2 (5.2 km^2)	1,903 ft (580 m)	1.1 mi^2 (2.9 km^2)	656 ft (200 m)
Offshore Cable Installation				
Inter-array Cable Jet Trencher[3]	0.01 mi^2 (<0.01 km^2)	164 ft (50 m)	N/A	N/A
Inter-array Cable Mechanical Trencher	N/A[5]	N/A[5]	N/A[5]	N/A[5]
Monmouth Export Cable - Jet Trencher	3.21 mi^2 (8.32 km^2)	656 ft (200 m)	0.01 mi^2 (0.02 km^2)	98 ft (30 m)
Northern Export Cable - Jet Trencher	1.71 mi^2 (4.45 km^2)	295 ft (90 m)	N/A[6]	N/A[6]
HDD Activities at Landfall Site				

Scenario	Area of Deposition 0.04 in (≥1 mm)[1]	Maximum Extent of Deposition ≥0.04 in (1 mm)[1]	Area of Deposition ≥0.4 in (10 mm)[2]	Maximum Extent of Deposition ≥0.4 in (10 mm)[2]
Monmouth Landfall Representative HDD Pit Excavator	0.03 mi^2 (0.09 km^2)	1,572 ft (479 m)	<0.01 mi^2 (0.01 km^2)	335 ft (102 m)
Northern Landfall Representative HDD Pit Excavator	<0.01 mi^2 (0.01 km^2)	479 ft (146 m)	<0.01 mi^2 (<0.01 km^2)	230 ft (70 m)

[1] A depositional threshold of 0.04 inch (1 millimeter) was used in the Sediment Transport Modeling report as it is the burial and mortality threshold for demersal eggs (Berry et al 2011).
[2] Sensitivity in sessile benthic organisms has been observed 0.4 inch (10 millimeter) (Essink, 1999).
[3] A suction bucket jacket foundation, which represents the maximum disturbance of all foundation types under consideration, was used to model impacts from seafloor preparation for WTG and OSS installation.
[4] The modeling assumed three large OSS structures for the Project.
[5] Installation of inter-array cables resulted in deposition less than 0.04 inch (1 millimeter) for both jet and mechanical trenching.
[6] Installation of the Northern ECC resulted in a deposition less than 0.4 inch (10 millimeter).

Project-induced sediment deposition has the potential to bury demersal eggs and larvae of EFH species (Tables 9a and 9b) that are within the zone of deposition. Thresholds for lethal burial depths are species-dependent, with sessile organisms being most sensitive (Essink, 1999). According to Berry et al. (2011), deposition of ≥0.04 inch (1 millimeter) can result in delayed hatching or mortality of demersal eggs (e.g., Atlantic herring, winter flounder, longfin inshore squid). According to Essink (1999), sessile organisms such as oysters and mussels can survive in sediment deposition of 0.4 to 0.8 inches (10 to 20 millimeters), while other macrozoobenthos can survive in deposition of 8.0 to 11.8 inches (200 to 300 millimeters). One study, conducted by Colden and Lipcius (2015), showed deposition-caused mortality occurring in eastern oysters only when over 90% of the individual was covered in sediment.

Results from the Sediment Transport Modeling report show that deposition greater than 0.04 inch (1 millimeter) (e.g., the threshold of burial for demersal eggs) will occupy a maximum area of 0.2 square miles (0.6 square kilometers) around the representative WTG foundation location, 1.1 square miles (2.8 square kilometers) around the representative OSS foundation locations, 3.21 square miles (8.32 square kilometers) for cable installation, and 0.03 square miles (0.09 square kilometer) for HDD activities. Based on the modeling results, the area of deposition of ≥ 0.04 inch (1 millimeter) will be minimal compared to the surrounding available habitat and limited to the cable corridor.

Sediment deposition could result in delayed hatching or mortality of non-mobile benthic organisms (e.g., Atlantic surfclams, ocean quahogs) or non-mobile finfish life stages (e.g., demersal eggs and larvae); however impacts will be restricted to the vicinity of cable installation and HDD activities. In addition, only four species with demersal or benthic eggs or larvae have designated EFH in small portions of the Offshore Project Area (Tables 9a and 9b) and these early life stages are only present for short periods of time throughout the year further reducing the likelihood of impacts. Therefore, sediment disturbing Project activities are not expected to result in population-level effects to EFH species. Although sessile juvenile and adult EFH life stages (e.g., Atlantic surfclam, ocean quahog) could experience localized increases in physical abrasion, burial, or limited mortality, mobile older life stages (Tables 8a, 8b, 10a, and 10b) are expected to temporarily vacate the area during these activities and return shortly after sediment conditions return to ambient conditions, a phenomenon that has commonly been observed following dredging activities and other physical disturbance of seafloor conditions (Brooks et al., 2004; BOEM, 2021; Guida et al., 2017).

Potential impacts from offshore spills, discharges, and accidental releases are considered to have a low likelihood of occurrence. Atlantic Shores will implement measures to minimize the potential for accidental releases and discharges, including drilling fluid release and frac-outs during HDD installation at the landfall sites. These measures include the development of an Oil Spill Response Plan (OSRP) and HDD Contingency Plan.

The degree of suspended sediment and deposition will be significantly lower during O&M activities than during Project construction. Some sediment suspension and deposition may occur from maintenance of structures and cables if repairs are required, but impacts are expected to be short-term and temporary due to the sandy seafloor composition seafloor and shallow sediments in the Offshore Project Area. Decommissioning of structures and cables is expected to have similar limited impacts as those described for construction. During all Project phases, DP vessels and jet plow embedment will be used to the maximum extent practicable to reduce sediment disturbance during cable laying processes.

7.2.2 Offshore Substation Operation

As discussed in Section 2.3.3, if the Project uses an HVDC OSS, seawater may be used in a once-through cooling system to provide cooling to the HVDC OSS. To cool the HVDC OSS, seawater is brought into the unit via a subsurface intake, pumped through the system to absorb the excess heat, and discharged back into the environment with an elevated temperature. The seawater may be filtered to remove small particulates and disinfected with hypochlorite to prevent biofouling.

Atlantic Shores performed a water quality assessment to investigate the hydraulic zone of influence (HZI) created during water intake operations, and using the USEPA-approved CORMIX model, computational effluent discharge modeling was conducted to predict the magnitude, and extent of the effluent plumes above background values and in association with the potential dilution that would result. From these analyses, the dilution of the thermal plume and residual chlorine concentrations from a representative large OSS location were predicted (see Appendix W to the COP).

These studies accounted for seasonality, the influence of ambient current velocities, and variable flow rates from two, 2100 MW and 1400 MW, potential OSS cooling water systems. To bound the potential environmental and design conditions associated with the OSSs, 24 effluent discharge configurations were evaluated using design configurations associated with a 2,100 MW and 1,400 MW HVDC systems. To be conservative, the largest temperature differential was evaluated for both the 1,400 MW and 2,100 MW HVDC's, while the influence of flow rate was evaluated using the 2,100 MW HVDC as an upper bound and the 1,400 MW HVDC as a lower bound.

The discharge modeling showed that plume dynamics and dilution factors were primarily affected by the total volume of the release, seasonality of the release, and the associated current speeds. All simulated cases met the water quality standards for both the excess temperature threshold of 5.4°F (3°C) temperature excess and the residual chorine threshold of 0.5 mg/L of residual chlorine concentration at the regulatory distance threshold of 328 feet (100 meters) from the discharge point. In fact, the thermal discharge water quality standard was generally met within 32.8 feet (10 meters) or less of the discharge point, but two simulated cases reached up to 105 feet (32 meters) from the discharge point before dropping below the thresholds. The residual chorine water quality standard was generally met within 3.3 feet (1 meter) or less from the discharge point, but two simulated cases reached up to 17.7 and 19 feet (5.4 and 5.8 meters) from the discharge point before dropping below the thresholds.

As each simulated plume was discharged into the ambient environment, the thermal plumes experienced rapid mixing and were sufficiently diluted as they traveled downstream from the discharge point. Higher rates of discharge predicted faster mixing in close proximity (<3.3 feet [1 meter]) with the discharge pipe, which was observed with the 2,100 MW HVDC scenarios. Contrarily, the 1,400 MW HVDC scenarios showed similar, but slightly less mixing within the same <3.3 feet (1 meter) distance. Seasonality differences were observed in the plume simulations, mostly due to stratification effects within the water column, where the most stratified season (summer) showed the lowest potential for mixing. The least stratified environment (winter) predicted the most potential for mixing in general. Current speeds also affected the plume dynamics. In general, higher current speeds exhibited the plume traveling further downstream before meeting the water quality standards, but also predicted the smallest lateral plume radius. In summary, the plume behavior and dilution is highly dependent on the environmental conditions present at the discharge location and the operational conditions that initialize the discharged plume. However, based on the model input parameters, the predicted dilution would be sufficient to minimize potential water quality impacts outside of 328 feet (100 meters) for all scenarios considered (see Appendix W of the COP for the full results of the OSS discharge modeling).

These model predictions indicate that impacts from the OSS discharge to finfish with designated EFH are expected to be minimal given the highly localized extent of the thermal and residual chorine discharge plume. In addition, impacts to EFH will also be minimal given the dynamic nature of the plume and the dilution that occurs within a maximum distance of 328 feet (100 meters) for all modeled scenarios. The final design, configuration, and operation of the cooling water system and discharge will be permitted as part of an individual NPDES permit with the U.S. Environmental Protection Agency (EPA).

7.3 Impingement or Entrainment of Fish Larvae

Construction and operation of the Project could result in the impingement and/or entrainment of pelagic fish eggs and larvae. During the construction phase of the Project, cable installation activities such as vessel operation, jet plow operation, jet trenching operations and/or dredging operations could result in the impingement and/entrainment of pelagic eggs and larvae. Once the Project is operational, entrainment and/or impingement of fish larvae and eggs could occur through operation of the OSSs if the Project uses an HVDC OSS. Based on the location of the Offshore Project Area, EFH species with pelagic egg and larval stages that could be susceptible to entrainment and impingement impacts include, but are not limited to pollock (*Pollachius virens*), bluefish (*Pomatomus saltatrix*), Atlantic mackerel (*Scomber scombrus*), and Atlantic butterfish (Walsh et al. 2015, Berrien and Sibunka 1999). Potential entrainment and impingement impacts to the egg and larval stages of EFH designated species are discussed in the following sections.

7.3.1 Cable Installation

Project installation operations requiring the use of water, such as standard vessel operations, jet plow, jet trenching, or dredging activities, will likely result in the impingement and/or entrainment of pelagic planktonic species. During the construction, operation, and decommissioning phases, direct mortality of pelagic planktonic species is expected as a result of entrainment and impingement during water withdrawals for vessel operation, jet plowing, and dredging activities. Entrainment of planktonic species typically results in high levels of mortality due to temperature changes and injury as organisms travel through piping systems (USDOE, 2009). With respect to jet plowing activities, injury to entrained organisms can occur when water is injected into sediments as high pressure, resulting in mortality. However, such occurrence will be limited to periods of vessel operation and jet plowing.

Assuming an installation rate between 150 meters and 300 meters (492 feet and 984 feet) per hour for export, inter-array, and interlink cable installation using jet plowing, and a water withdrawal rate between 400 cubic meters and 1,400 cubic meters (14,125 and 49,441 cubic feet) per hour for jet plow activities, water withdrawal volumes are expected to range from approximately 5,230 to 9,150 million liters (1,381 to 2,417 million gallons) from jet plowing activities for the Project. Additional water withdrawal may be required for sandwave clearance using a hydraulic dredge. Sandwave clearing activities may require up to two passes with a hydraulic dredge, one which serves as the initial clearing pass and the other which serves as a clean-up pass. Though the exact locations of sandwave clearance will be determined closer to construction, a conservative estimate for the initial clearing path of 20% of the export and interlink cable lengths, and 10% for inter-array cable lengths was used to calculate total water withdrawal. Additionally, a conservative estimate of 10% of the export and interlink cable lengths and 5% for inter-array cable lengths was used to calculate total water withdrawal during the clean-up pass for sandwave clearing. Assuming an installation rate between 105 meters and 240 meters (344 feet and 788 feet) per hour for export, inter-array, and interlink cable and a water withdrawal rate between 10,000 cubic meters and 30,000 cubic meters (353,147 cubic feet and 1,059,400 cubic feet) per hour, water withdrawal volumes are expected to range from approximately 30,200 to 39,650 million liters (7,977 to 10,474 million gallons) from initial sandwave clearing activities using a hydraulic dredge for the Project. Assuming an installation rate for a clean-up pass for sandwave clearing between 210 meters and 450 meters (689 feet and 1,476 feet) per hour for export, inter-array and interlink cable, and a water withdrawal rate between 10,000 cubic meters and 30,000 cubic meters (353,147 cubic feet and 1,059,400 cubic feet) per hour, water withdrawal volumes are expected to range from approximately 7,550 to 10,600 million liters (1,994 to 2,800 million gallons).

Mortality of ichthyoplankton is considered likely due to water withdrawal activities; however, many species that inhabit the Offshore Project Area produce millions of eggs per year (e.g., Atlantic herring, Atlantic cod, haddock, winter flounder) which allows the species to persist in the presence of natural and anthropogenic-related effects (NOAA, 2021b; Adams, 1980). Additionally, cable installation activities requiring water withdrawal will be limited in time and space. As a result, water withdrawal activities are not expected to cause population-level impacts to ichthyoplankton.

7.3.2 Offshore Substation Operation

As discussed in Section 2.3.3, if the Project uses an HVDC OSS, seawater may be used in a once-through cooling system to provide cooling to the HVDC OSS. Operation of an HVDC OSS will require continuous water withdrawal with a maximum water withdrawal rate from OSS operation of approximately 8.8 million gallons per day (mgd). Similar to cable installation, water withdrawal from operation of the OSS could result in the entrainment and/or impingement of pelagic fish eggs and larvae.

The intake of water from the HVDC OSS would create a hydraulic zone of influence (HZI). The HZI is the portion of the waterbody that is hydraulically influenced by the withdrawal of ambient water by the intake system. Beyond the HZI, the ambient currents dominate flow (Golder Associates, 2008). In order to estimate the HZI of the HVDC OSS intake withdrawal, and thus the localized area within which eggs and larvae could be susceptible to entrainment or impingement, Atlantic Shores performed calculations to estimate the HZI (see Appendix W of the COP).

The HZI for the HVDC OSS was calculated using the expected maximum and minimum operational intake flow rates during both the 5th- and 95th-percentile current speeds exhibited in the study area. Under all calculated conditions, the maximum HZI is predicted to be 0.38 feet (0.116 meters) from the intake location and the minimum HZI is predicted to be 0.003 feet (0.001 meters) from the intake location. It should be noted that during operation, the HZI will vary with changing current speeds and intake rates. As the intake velocities increase and the ambient current speeds decrease, a larger HZI would form. Conversely, with higher current speeds and lower intake velocities, the HZI would decrease in size.

These predictions indicate that the HZI for the HVDC OSS will be highly localized and is not expected to extend beyond 0.38 feet (0.116 meters) under maximum calculated conditions. Only eggs and larvae that enter this highly localized HZI would be susceptible to entrainment and impingement. In addition, many species with designated EFH that inhabit the Offshore Project Area produce millions of eggs per year (e.g., Atlantic herring, Atlantic cod, haddock, winter flounder) which allows the species to persist in the presence of natural and anthropogenic-related effects (NOAA, 2021b; Adams, 1980). Therefore, entrainment and impingement impacts from the HVDC OSS are not expected to result in substantial impacts to eggs or larvae of EFH -designated species. In addition, impingement impacts will be further minimized through an intake design that utilizes an appropriately sized inlet port and screens to prevent impingement and a through-screen intake water velocity of less than 0.5 feet/second (see Section 2.3.3). Entrainment impacts will be mitigated by minimizing and managing the water use required for OSS cooling to the greatest extent practicable.

7.4 Habitat Conversion and Creation

This section addresses permanent seafloor disturbance from the footprints of foundations, scour protection, and offshore cable protection that will result in habitat conversion of primarily sandy substrate to hard substrate. Within the Offshore Project Area, the presence of foundations, cable protection, and scour protection may result in habitat conversion/creation, increased food availability, localized hydrodynamic alterations, and species attraction.

The presence of foundations and scour protection will result in localized habitat conversion of any sandy, soft bottom habitat to a coarser, complex habitat. The maximum estimated total area of permanent seafloor disturbance in the Lease Area, using the foundation type with the maximum footprint, is approximately 1.38 square miles (3.58 square kilometers) (Table 2), which represents approximately 1.1% of the 127 square mile (328 square kilometers) Lease Area. The maximum estimated total permanent seafloor disturbance in the Monmouth and Northern ECCs from the placement of cable protection, excluding the portion of the ECCs located in the Lease Area, is approximately 0.35 square miles (0.9 square kilometers) and 0.40 square miles (1.04 square kilometers), which represents 0.80% of the total area of the ECCs (Table 2)[5]. This permanent habitat conversion of predominantly sandy and gravelly benthic habitat to hard structure habitat will be localized and restricted to the foundation, cable protection, and scour protection footprints (ICF, 2020).

Even though the presence of foundations, cable and scour protection will eliminate a small percentage of sandy and gravelly habitat in the Offshore Project Area, the Project is expected to produce ecological benefits by creating new, diverse habitat for structure-oriented species. In two different wind farms, the Block Island Wind Farm off the coast of Rhode Island and the Horns Rev Wind Farm in the North Sea, abundance within soft-bottom communities largely remained the same between pre- and post-construction (ICF, 2020). At the Block Island Wind Farm, abundance of small invertebrates (e.g., nematodes and polychaetes) in existing soft-bottom benthic communities increased after construction around some WTGs. The presence of structures can also increase the presence of fouling and colonial communities such as corals. A study conducted by Schweitzer and Stevens (2019) showed that biogenic structural communities like artificial reefs facilitated the growth of sea whips (*Leptogorgia virgulate*), which ultimately led to higher abundances of fish. The increase in smaller invertebrate species can lead to the attraction of predators with EFH in the Offshore Project Area (e.g., larger invertebrates, fish) due to increased prey availability (ICF, 2020; HDR, 2018).

Structure-oriented species with EFH in the Offshore Project Area or identified as NOAA Trust Resources include black sea bass, ocean pout, adult silver hake, juvenile red hake, longfin squid egg mops, tautog, blue mussel, and eastern oyster. Foundations can create a “reef effect”, providing ecological benefits and habitat diversity in the Mid-Atlantic Bight. Introduction of hard structures such as foundations and scour protection provide shelter and feeding opportunities as well as spawning and nursery grounds in an area that is largely comprised of sandy and gravelly habitat with small topographic features (e.g., ripples) (ICF, 2020). Leonhard et al. (2011) studied fish assemblages one year before and eight years after the construction of the Horns Rev Wind Farm in the North Sea and observed an increase in species diversity close to WTGs, specifically in reef fishes (Leonhard et al., 2011). This increase in fish diversity may be attributed to the diversification of feeding opportunities by newly established epibenthic invertebrates (Leonhard et al.,

[5] The total area within each ECC accounts for a single route option. For example, as the Monmouth ECC approaches the landfall site, the route could take one of two route options. For the purposes of this analysis, the total area within the ECCs only accounts for one of the two route options. The same approach was applied to the Northern ECC, with analyses only accounting for one of the potential branch options. For this analysis, the Fort Hamilton Northern ECC branch was used.

2011). A visual transect study of two windfarms in the Baltic Sea observed higher fish abundance in the vicinity of the turbines, and at individual turbines when compared with the surrounding environment, indicating that turbine foundations may function as combined artificial reefs and fish aggregation devices for small demersal and semi-pelagic fish (Wilhelmsson et al., 2006). The same study observed the retreat of some species to the monopile foundation upon the introduction of disturbance, which could indicate that turbines provide a source of refuge (Wilhelmsson et al., 2006). Similarly, Reubens et al. (2011) reported that wind turbines can have an aggregating effect for fish populations. In the Belgian part of the North Sea, pouting densities were highly enhanced near the windmill artificial reef at Thorntonbank. Pouting demonstrated a preference for hard substrate prey species that were recorded in high densities at the wind turbine studied. However, it is unclear whether the windmill artificial reef increased local pouting productivity or simply attract and concentrate the species (Reubens et al. 2011).

The presence of foundations and scour protection have the potential to provide supporting habitat for structure-oriented species that seasonally migrate from nearshore to offshore environments, a common phenomenon for species off the coast of New Jersey and within the Offshore Project Area (Steimle and Zetlin, 2000; Causon and Gill, 2018). Structure-oriented species that participate in seasonal migrations and have EFH in the Offshore Project Area or are identified as NOAA Trust Resources include, black seabass, ocean pout, silver hake, and tautog. Impacts of these structures in the offshore environment and the subsequent impact to structure-oriented species has already been documented around the Block Island Wind Farm, where studies conducted showed an increase in catch per unit effort of black sea bass and Atlantic cod following turbine installation (Wilber et al. 2022). Studies on black sea bass have shown that the species primarily occurs within less than 3.3 feet (1 meter) of hard bottom substrata and can occur near newly introduced structures with little overgrowth (Stevens et al. 2019). Structures may also attract highly migratory species. However, limited evidence of this behavior in operating windfarms has been documented (ICF, 2020). Studies have shown aggregations of highly migratory species, around oil platforms and artificial reefs. One study in the North Sea examined the presence of porbeagle sharks at an oil platform and found a minimum of 20 individuals aggregating around the structure at one time (Haugen and Papastamatiou, 2019). In the U.S., a study off the coast of North Carolina found a high presence of transient predator density, mainly sand tiger shark and sandbar shark, around artificial reefs compared to natural reefs (Paxton et al., 2020). Similar aggregations of highly migratory species could occur at structures within the Offshore Project Area. Though foundations and cable protection could be utilized by migratory species for food and shelter, migration is largely driven by water temperatures and seasonality rather than the availability of resources (BOEM, 2020). Therefore, any use of structures by migratory species is expected to be temporary, and the overall presence of foundations and cable protection is not expected to hinder migration patterns (BOEM, 2020).

Some studies have shown that the addition of foundations, cable, and scour protection may play a role in facilitating the establishment of non-indigenous species. The new hard-bottom habitat could act as stepping stones for these species and allow them to expand into new areas from which they were previously excluded. At the Block Island Wind Farm the non-indigenous invasive tunicate (*Didemnum vexillum*) has been observed, which was already common to the region (Hutchison et al. 2020). In the Belgian part of the North Sea, non-indigenous species that were already present in the southern North Sea colonized parts of the turbine foundations (De Mesel et al. 2015). Vertical zonation was apparent on the foundations, with both indigenous and non-indigenous species present; competition with indigenous species may be excluded depending on the zone (De Mesel et al. 2015). However, though these structures could act as stepping stones between habitats for non-indigenous species, it is unlikely that this phenomena would result in population-level impacts to native species, which would be dominated by species inhabiting soft sediments (BOEM, 2021a).

The presence of WTGs and other foundation structures in the Lease Area may affect currents and water movement within the Lease Area; however, effects are expected to be highly localized at the foundations. As water moving along a current approaches a foundation, it changes and accelerates around a structure, creating turbulence (ICF, 2020). This phenomenon is known as the wake effect (ICF, 2020). The magnitude of wake effect depends on the diameter of foundation structures, volume of impervious surface in the water column and seafloor, and current speed (ICF, 2020; English et al., 2017). Wake effect from monopile foundations has been observed approximately 600 feet (200 meters) downcurrent of the structures (English et al., 2017). During peak tidal movements, turbulent wakes have been observed as far as 1,312 feet (400 meters) from the monopile (English et al., 2017). These localized wake effects could influence larval settlement, primary productivity, and feeding efficiency of predators (ICF 2020; English et al. 2017; Vanhellemont and Ruddick 2014). However, changes in turbulence around the foundations could also result in increased food availability for plankton-consuming species with EFH in the Offshore Project Area like filter-feeding invertebrates (e.g., Atlantic sea scallop, Atlantic surfclam, ocean quahog) as well as larval and juvenile fish species (e.g., Atlantic cod, haddock, monkfish, scup, windowpane) (Andersson, 2011; ICF, 2020). Increases in food availability could result in fish and invertebrate aggregation. Increased turbulence also has the potential to reduce visibility around the turbine, which may reduce feeding efficiency of predators, thereby indirectly affecting the risk of predation on prey species (English et al., 2017; Vanhellemont and Ruddick, 2014).

In addition to changes in currents, it is important to understand how the placement of WTGs may affect Cold Pool processes, specifically with regards to ocean mixing, and EFH species in the Offshore Project Area. The formation and the nutrient fluxes of the Cold Pool are important to fish and their movement in the Mid-Atlantic Bight. The breakdown of the stratified Cold Pool is known to influence the timing of migration for EFH species such as winter flounder, summer flounder, black sea bass, and Atlantic butterfish (Kohut and Brodie, 2019). Additionally, temporal changes in the breakdown of the Cold Pool have been linked to mortality in Atlantic surfclam and changes in spawning timing for ocean quahog, both of which have EFH in the Offshore Project Area (Narvaez et al., 2015; Toupoint et al., 2012). Modeling studies, considering varying sizes of wind projects and technology, have indicated that wind turbines may cause atmospheric disturbances to near-surface winds that influence ocean mixing (Afsharian and Taylor, 2019). The extent of changes to ocean mixing at local and regional, or mesoscale, scales is not well known and can vary widely in magnitude as local mixing is dependent on atmospheric forcing, daily heating and cooling, wind, changes in temperature and humidity associated with mesoscale weather, and other processes (Paskyabi et al., 2015). Measuring and predicting any possible effects to ocean mixing is highly dependent on the characteristics of the wind project (e.g., spacing between turbines, size of turbines) and the local and regional atmospheric and oceanographic conditions (Moum and Smyth, 2019), including conditions of fish and fisheries in the local and regional areas.

Conditions and observations at local and regional scales are necessary to understand if effects to mixing may occur from the Project and if so, whether those effects may influence the Cold Pool dynamics. Drawing early conclusions from European or modeling studies have inherent differences, as the Mid-Atlantic Bight has weaker tidal currents and more intense stratification than the North Sea and is different from other western boundary currents or mesoscale circulation features in European waters. It has been suggested that slower ocean velocities in the southern Mid-Atlantic Bight would result in significantly less mixing than has been found in Europe (Carpenter et al., 2016). European studies are more representative of Mid-Atlantic Bight conditions during weaker stratification. Therefore, it is not likely that structure-induced mixing would be sufficient to overcome intense summer stratification to influence the Cold Pool and cause broader ocean mixing (Miles et al., 2020). As a result, substantial effects to the Cold Pool and ocean mixing from the presence of Project WTGs is not expected. However, considering the seasonal, annual, and longer scale changes in the Cold Pool and Mid-Atlantic Bight, Atlantic Shores is supportive of contributing to regional collaborative science to study and monitor the Cold Pool and its influence on benthic invertebrates, fish and fisheries.

In 2019, Atlantic Shores, in collaboration with Rutgers University and Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS), deployed a metocean buoy to contribute to the study of the Mid-Atlantic Cold Pool. This buoy contains sensors at the atmospheric-boundary layer and ocean floor that allow for continuous measurements of the Cold Pool, as well as support regional oceanographic and atmospheric modeling efforts. The data collected by this buoy is publicly accessible and can be accessed through the MARACOOS data portal *at https://ioos.noaa.gov/regions/maracoos*. Once operational, the Project will also represent a living laboratory as it provides abundant opportunities for direct ocean and ecological observations, such as the anticipated beneficial effects of introducing structure to a sandy/gravelly sea floor that lacks significant areas of topographic relief.

As stated, the presence of foundations and cable and scour protection could create a range of positive effects to EFH and species with designated EFH in the Offshore Project Area during the O&M phase of the Project. Most of these effects will be permanent throughout the life of the Project and mostly beneficial. Foundations and cable and scour protection are expected to produce ecologically beneficial effects that could outweigh the risk of introducing hard structure to a small area of the sandy/gravelly habitat found in the Mid-Atlantic Bight. Once the Project is decommissioned, the local environmental and ecological features of the area are expected to revert back to pre-construction conditions. Potential effects from decommissioning include the loss of Project-related hard structures, which are expected to be colonized at the time of decommissioning. Reef or structure-oriented species will be displaced during decommissioning as the foundations and scour protection are removed.

7.5 Noise

This section addresses underwater sound that may be generated during activities conducted in the Offshore Project Area, including impulsive pile driving and other noise sources (e.g., HRG surveys, vessels, cable installation, vibratory pile driving, operational WTGs, operational offshore cables, and decommissioning) and assesses the potential effects noise generated from these activities may have on EFH-designated species. Noise, defined as unwanted sound, is detected by fish and invertebrates as particle motion, with some fish additionally sensing pressure. Noise generated during Project construction, O&M, and decommissioning has the potential to result in physiological stress and behavioral changes, as well as limited mortality or injury in finfish and pelagic invertebrates when the noise is present. As described in the following sections, effects to finfish and pelagic invertebrates from underwater noise will be limited to radial distances from the source where sound levels are above regulatory thresholds. Pile driving noise during construction (if a piled foundation type is chosen or an HDD conductor barrel is used) would be mitigated through the use of noise abatement systems such as bubble curtains and hydro-dampeners and noise mitigating measures such as soft starts and ramp up procedures.

Fish and invertebrates are sensitive to particle motion and some fish are additionally sensitive to pressure. Particle motion is described by displacement, velocity, and acceleration. Because the ears of fish function as inertial accelerometers, all fish are sensitive to particle motion. In contrast, sensitivity to sound pressure and frequency in fish is functionally correlated to the presence or absence of gas-filled chambers, such as the swim bladder (Wiernicki et al. 2020). Sensing pressure extends hearing to higher frequencies (Ladich and Popper, 2004, Braun and Grande, 2008). The presence of a swim bladder, or other gas-filled cavity, makes fish more susceptible to injury from anthropogenic sound as these loud, often impulsive, noises can cause swim bladders to vibrate with enough force to cause damage to tissues and organs around the bladder (Halvorsen et al., 2011, Casper et al., 2012). Many invertebrates and crustaceans lack swim bladders and are therefore less sensitive to sound. However, some aquatic invertebrates, including all cephalopod species, have statocysts which are a complex sensory organ comprised of a fluid-filled chamber containing sensitive hairs and one or more statocysts. Cephalopods can detect particle motion using these statocysts, but do not have gas-filled cavities associated with these sensory structures and lack the ability to detect pressure; therefore, cephalopods are also less susceptible to injury from anthropogenic sound compared to fish with a swim bladder (Budelmann et al. 1992).

The most sensitive fish species are those with swim bladders connected or close to the inner ear. These species can acquire both recoverable and mortal injuries at lower sound levels than other species (Thomsen et al. 2006, Popper et al. 2014). EFH-designated species and other NOAA trust resource species that may be present in the Lease Area and are considered high-sensitivity fish species (Popper et al. 2014) due to swim bladder involvement in hearing, include Atlantic cod, Atlantic herring, silver hake, white hake, alewife, blueback herring, American eel, American shad, Atlantic menhaden, and weakfish.

Some fish found in the Lease Area have swim bladders not involved in hearing (e.g., Atlantic sturgeon, Atlantic butterfish, Atlantic mackerel, black sea bass, bluefish, haddock, monkfish, ocean pout, red hake, scup, bluefin tuna, yellowfin tuna, striped bass, tautog). Their detection of sound is mediated primarily through particle motion, and these species have relatively low susceptibility to anthropogenic sound-induced effects (Popper et al. 2014). The least sound-sensitive fish species are those that have no swim bladder, including elasmobranchs (i.e., sharks and rays) and flatfish such as summer flounder.

Research suggests that cephalopods may be sensitive to low frequency sound sources, and sound exposure may cause physical damage to statocysts (André et al. 2011; Mooney et al. 2010; Solé et al. 2013, 2017). More recently, studies have specifically examined the impacts of sound sources from offshore wind energy development on cephalopods. Solé et al. (2022) exposed cuttlefish adults and eggs in a laboratory setting pile-driving and drilling noise, with maximum levels of 170 dB re 1 µPa2 and 167 dB re 1 µPa2, respectively. Adults experienced damage to their statocyst sensory epithelia but did not exhibit any behavioral reactions; the larvae statocysts were damaged similarly to the adults . There was an increase in larvae mortality and a decrease in egg hatching success with increasing sound levels, but exposed larva and hatchlings born of exposed eggs presented normal size, healthy appearance, and normal behavior. Researchers determined these effects were acute in the very vicinity of the sound source where they have the potential to affect cephalopod populations and offspring (Solé et al. 2022).

Laboratory studies on the impacts of pile driving noise in the cephalopod species longfin inshore squid have been conducted using sound recordings from Block Island Wind Farm construction. The studies found exposure to pile driving noise may elicit alarm responses and changes in feeding behavior leading to a reduced capacity to hunt. However, alarm responses rapidly decreased within the first minute of noise exposure suggesting the squid developed an increased tolerance to the noise over time and may have behaviorally habituated (Jones et al. 2020; Jones et al. 2021). In a separate study on longfin inshore squid, Cones et al. (2022) found that pile driving noise disrupts fine-scale movements in the short-term, indicating that wind farm construction may minimally impact the species' energetics. Jones et al. (2023) found that pile driving noise had no significant effects on occurrence rates of agonistic behaviors, mate guarding, mating, and egg laying. Further, longfin inshore squid have a relatively short lifespan, around one year, and individuals engaging in these reproductive behaviors are both highly motivated to reproduce despite environmental stressors (i.e., pile driving noise) and are nearing the end of their lifespan. Therefore, it is anticipated that Project-related noise would not significantly affect longfin inshore squid and other cephalopod species. Additionally, individuals in the wild may be able to escape Project-related noise by temporarily leaving the area.

Impact (impulsive) pile driving may occur if piled foundation types (monopile and jackets) are chosen as the foundation type for the Project. Impulsive sounds are discontinuous, high intensity sounds that are extremely short in duration (with a rapid onset and decay) but may be repetitive. There are also other noise sources associated with offshore Project construction, O&M, and decommissioning that are primarily non-impulsive in nature. Non-impulsive sounds are continuous sounds that remain constant and relatively stable over time (e.g., vessel sounds, WTG operational noise, vibratory pile driving noise).

To assess the potential effects from impact pile driving to finfish and pelagic invertebrates (specifically pelagic cephalopods), if piled foundations or an HDD conductor barrel are used, and vibratory pile driving, if a cofferdam or casing pipe is used, Atlantic Shores conducted quantitative acoustic modeling and compared the results against impulsive acoustic thresholds. For other sound sources from the Project, Atlantic Shores provides a qualitative assessment of potential impacts to finfish and invertebrates in relation to the relevant acoustic thresholds. These other sound sources were not quantitatively modeled because the potential acoustic impact of these sound sources is expected to be much less than impulsive pile driving.

Injury and behavioral response exposure criteria for impulsive and non-impulsive sounds are based on relevant regulatory-defined thresholds and best available science for fish (NOAA, 2005; Andersson et al., 2007; Wysocki et al., 2007; FHWG, 2008; Mueller-Blenkle et al., 2010; Purser and Radford, 2011) and are described in detail in Volume II, Appendix II-L of the COP. Table 14 provides regulatory approved acoustic thresholds to evaluate the potential for finfish to experience injury and behavioral response from impulsive sounds. Because few data are available regarding particle motion sensitivity in fish (Popper and Fay, 2011; Popper et al., 2014), the thresholds for acoustic sensitivity are based on sound pressure only (FHWG, 2008; Stadler and Woodbury, 2009). The thresholds that are currently used by NOAA Fisheries GARFO and BOEM to assess potential impacts to fish exposed to pile driving sounds are based on criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG, 2008; Stadler and Woodbury, 2009). Table 14 also presents threshold levels suggested by Popper et al. (2014) for injury and temporary threshold shift (TTS) for impulsive sounds, which are based on the presence, and role, of a swim bladder, as well as the behavioral thresholds as defined by GARFO (2020). Additionally, although literature on the hearing capabilities of cephalopods is limited, research shows them to be most vulnerable to particle motion (Mooney, Samson, and Zacarias 2016) and they are therefore expected to have hearing thresholds most similar to fish without swim bladders, but that can detect particle motion.

Table 14. Interim Fish Injury and Behavioral Acoustic Thresholds Currently used by NOAA Fisheries GARFO and BOEM for Impulsive Pile Driving

Fish Group	Injury		TTS	Behavioral Threshold
	SEL[1] (unweighted)	Lpk[1] (unweighted)	SEL[1] (unweighted)	Lpk1 (unweighted)
Fish without a swim bladder (particle motion detection)[2]	> 216	> 213	≫ 186	–
Fish with swim bladder not involved in hearing (particle motion detection)[2]	203	> 207	> 186	—
Fish with swim bladder involved in hearing (primarily sound pressure detection)[2]	203	> 207	186	—
Fish weighing ≥2 grams[3]	187	206	—	150
Fish weighing <2 grams[3]	183	206	—	150

Source: BOEM 2022

[1] Threshold units: SEL in dB re 1 µPa2·s; Lpk in dB re 1 µPa

[2] Popper et al. (2014)

[3] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (2008).

Impulsive underwater noise generated from Project activities has the potential to cause mortality or injury (e.g., ruptured gas bladders, damage to auditory processes) mainly to the finfish identified above that have swim bladders connected or close to the inner ear (Casper et al., 2012; Popper and Hastings, 2009; Riefolo et al,. 2016). Exposure to intense anthropogenic sound levels can also cause an increase in the hearing thresholds of fishes, resulting in less sensitive (i.e., poorer) hearing abilities. This change in hearing threshold may be temporary (i.e., TTS) or permanent (i.e., permanent threshold [PTS]). In addition, underwater noise may elicit a behavioral response in finfish and pelagic invertebrates, such as avoidance, changes in feeding, breeding, schooling, migration behavior, or masking of environmental auditory cues (Buerkle, 1973; Mitson and Knudsen, 2003; Olsen et al., 1983; Ona et al,. 2007; Sarà et al., 2007; Schwarz and Greer, 1984; Soria et al., 1996; Vabø et al., 2002). Behavioral responses in fish differ depending on species and life stage, with younger, less mobile age classes being the most vulnerable (Gedamke et al., 2016; Popper and Hastings, 2009).

The effects of impulsive sound on fish eggs and larvae have been studied in the context of offshore pile driving. Bolle et al. (2012) investigated the risk of mortality in common sole larvae by exposing them to impulsive stimuli in an acoustically well-controlled study. Even at the highest exposure level tested, at a sound exposure level (SEL) of 206 decibels (dB) re 1 μPa2·s (corresponding to 100 strikes at a distance of 100 meters) no statistically significant differences in mortality were found between exposure and control groups. Popper et al. (2014) published exposure guidelines for fish eggs and larvae, which are based on pile driving data. The guidelines proposed a precautionary threshold for mortality of fish eggs and larvae of >207 dB re 1 μPa PK, which they note is likely conservative. As no thresholds exist for pelagic invertebrates, fish eggs and larvae thresholds are used as a proxy for these species.

There are very few studies on the effect of non-impulsive sound sources on fish and pelagic cephalopods and no data exist for eggs and larvae (Popper et al. 2014). Acoustic thresholds for fish used to qualitatively evaluate impacts from non-impulsive sounds are provided in Table 15.

Table 15. Interim Fish Injury and Behavioral Acoustic Thresholds Currently Recommended by BOEM for Non-impulsive Sources

Fish Group	Non-Impulsive Signals	
	Injury	TTS
	Lpk[1](unweighted)	Lpk[1] (unweighted)
Fish without a swim bladder (particle motion detection)[2]	—	—
Fish with swim bladder not involved in hearing (particle motion detection)[2]	—	—
Fish with swim bladder involved in hearing (primarily sound pressure detection)[2]	170 (for 48 hours)	158 (for 12 hours)
Fish weighing ≥2 grams[3]	—	—
Fish weighing <2 grams[3]	—	—

Source: BOEM 2022
[1] Threshold units: SEL in dB re 1 μPa2·s; Lpk in dB re 1 μPa
[2] Popper et al. (2014)
[3] NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (2008).

7.5.1 Impact Pile Driving Noise

Atlantic Shores conducted site-specific acoustic propagation modeling assuming the maximum PDE to assess the potential risks to marine organisms, including fish, from pile driving noise during construction of foundations and HDD support structures (i.e., HDD conductor barrel) (Volume II, Appendix II-L of the COP). The model evaluated distances to NMFS thresholds based on a range of operational conditions (e.g., foundation type, hammer type, pile-driving schedule) as well as levels of potential noise attenuation (ranging from 0 to 15 dB) that could potentially be achieved through the application of industry standard noise abatement systems (NAS). For the exposure assessment conducted for foundation installation, the 10 dB attenuation level was conservatively chosen as the minimum sound reduction achievable with the application of a single NAS. The acoustic modeling maximum radial distances to regulatory thresholds results are provided in summary below (Table 16 and Table 17) and in detail in Volume II, Appendix II-L of the COP.

Table 16. Maximum Radial Distance (in kilometers) to the 95th Percentile of the Thresholds for Fish due to Impact Pile Driving of One 15 meter monopile foundation with a 3,015 kJ Hammer at Varying Levels of Sound Attenuation for the Shallow Model Site

Fish Group	Metric	Threshold	Distance from Pile to Threshold (km)			
Attenuation Level			0 dB	6 dB	10 dB	15 dB
Fish without a swim bladder (particle motion detection)[1]	Injury (L_{PK})	213	0.785	0.350	0.250	0.150
	Injury (L_E)	216	1.250	0.685	0.300	0.150
	TTS (L_E)	186	9.635	7.285	5.885	4.385
Fish with swim bladder not involved in hearing (particle motion detection) [1]	Injury (L_{PK})	207	1.200	0.785	0.550	0.250
	Injury (L_E)	203	3.835	2.385	1.685	1.050
	TTS (L_E)	186	9.635	7.285	5.885	4.385
Fish with swim bladder involved in hearing (primarily sound pressure detection) [1]	Injury (L_{PK})	207	1.200	0.785	0.550	0.250
	Injury (L_E)	203	3.835	2.385	1.685	1.050
	TTS (L_E)	186	9.635	7.285	5.885	4.385
Fish weighing ≥2 grams[2,3,4]	Injury (L_{PK})	206	1.300	0.850	0.600	0.300
	Injury (L_E)	187	9.185	6.885	5.585	4.085
	Behaviour (L_P)	150	13.245	9.850	8.135	6.385
Fish weighing <2 grams[2,3,4]	Injury (L_{PK})	206	1.300	0.850	0.600	0.300
	Injury (L_E)	183	11.170	8.350	6.885	5.270
	Behaviour (L_P)	150	13.245	9.850	8.135	6.385

All thresholds are unweighted.
L_{PK} – peak sound pressure (dB re 1 µPa).
L_E – sound exposure level (dB re 1 µPa^2·s).
L_p – root mean square sound pressure (dB re 1 µPa).
TTS – temporary, recoverable hearing effects.

1. Popper et al. (2014).
2. NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).
3. Stadler and Woodbury (2009)
4. Andersson et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011), Wysocki et al. (2007)

Table 17. Maximum Radial Distance (in kilometers) to the 95th Percentile of the Thresholds for Fish due to Impact Pile Driving of One 15 meter monopile foundation with a 3,015 kJ Hammer at Varying Levels of Sound Attenuation for the Deep Model Site

Fish Group	Metric	Threshold	Distance from Pile to Threshold (km)			
Attenuation Level			**0 dB**	**6 dB**	**10 dB**	**15 dB**
Fish without a swim bladder (particle motion detection)[1]	Injury (L_{PK})	213	0.650	0.300	0.200	0.100
	Injury (L_E)	216	1.435	0.500	0.250	0.150
	TTS (L_E)	186	18.280	12.035	9.070	6.500
Fish with swim bladder not involved in hearing (particle motion detection) [1]	Injury (L_{PK})	207	1.400	0.650	0.400	0.200
	Injury (L_E)	203	5.635	3.300	2.050	1.035
	TTS (L_E)	186	18.280	12.035	9.070	6.500
Fish with swim bladder involved in hearing (primarily sound pressure detection) [1]	Injury (L_{PK})	207	1.400	0.650	0.400	0.200
	Injury (L_E)	203	5.635	3.300	2.050	1.035
	TTS (L_E)	186	18.280	12.035	9.070	6.500
Fish weighing ≥2 grams[2,3,4]	Injury (L_{PK})	206	1.450	0.750	0.450	0.250
	Injury (L_E)	187	16.865	11.170	8.435	6.050
	Behaviour (L_P)	150	27.245	18.640	13.935	9.950
Fish weighing <2 grams[2,3,4]	Injury (L_{PK})	206	1.450	0.750	0.450	0.250
	Injury (L_E)	183	22.095	14.500	11.170	7.900
	Behaviour (L_P)	150	27.245	18.640	13.935	9.950

All thresholds are unweighted.
L_{PK} – peak sound pressure (dB re 1 μPa).
L_E – sound exposure level (dB re 1 μPa^2·s).
L_p – root mean square sound pressure (dB re 1 μPa).
TTS – temporary, recoverable hearing effects.

1. Popper et al. (2014).
2. NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).
3. Stadler and Woodbury (2009)
4. Andersson et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011), Wysocki et al. (2007)

Exposure assessments were also conducted for impact pile driving activities associated with HDD support structures. Impact pile driving activities that would support the HDD installation of the export cables include the installation of an HDD conductor barrel. Table 18 provides the acoustic modeling maximum radial distances to regulatory thresholds results. Additional details are provided in Volume II, Appendix II-L of the COP.

Table 18. Maximum Radial Distance (in meters) to the 95th Percentile of the Thresholds for Fish due to the Impact Pile Driving for the Installation or Removal of the HDD Conductor Barrel at the Representative Landfall Sites in Monmouth, NJ and Wolfe's Pond, NY Using a 18 kJ Hammer with No Sound Attenuation.

Fish Group	Metric	Threshold	Distance (m) at Landfall Locations	
			Monmouth, NJ	Wolfe's Pond, NY
Fish without a swim bladder (particle motion detection)[1]	Injury (L_{PK})	213	16	11
	Injury (L_E)	216	51	26
	TTS (L_E)	186	850	300
Fish with swim bladder not involved in hearing (particle motion detection)[1]	Injury (L_{PK})	207	25	11
	Injury (L_E)	203	167	76
	TTS (L_E)	186	850	300
Fish with swim bladder involved in hearing (primarily sound pressure detection)[1]	Injury (L_{PK})	207	25	11
	Injury (L_E)	203	167	76
	TTS (L_E)	186	850	300
Fish weighing ≥2 grams[2,3,4]	Injury (L_{PK})	206	25	11
	Injury (L_E)	187	800	300
	Behaviour (L_P)	150	630	250
Fish weighing <2 grams[2,3,4]	Injury (L_{PK})	206	25	11
	Injury (L_E)	183	910	385
	Behaviour (L_P)	150	630	250

L_{PK} – peak sound pressure (dB re 1 µPa).
L_E – sound exposure level (dB re 1 µPa^2·s).
L_p – root mean square sound pressure (dB re 1 µPa).
TTS – temporary, recoverable hearing effects.

1. Popper et al. (2014).
2. NMFS recommended criteria adopted from the Fisheries Hydroacoustic Working Group (FHWG 2008).
3. Stadler and Woodbury (2009)
4. Andersson et al. (2007), Mueller-Blenkle et al. (2010), Purser and Radford (2011), Wysocki et al. (2007)

Based on the regulatory-defined thresholds for fish and the corresponding exposure ranges, and the intermittent nature of the sound source, effects on EFH-designated finfish and invertebrates from pile driving noise are expected to be localized and short-term. Therefore, the risk of noise-related impacts from pile driving is expected to be low. For pile driving of foundations in the Lease Area, the most sensitive species will likely only be present in the Lease Area between fall and winter. By spring, all high-sensitive species discussed above, except for Atlantic cod, are expected to migrate inshore or southward, to spawn (NOAA, 2021b; ASMFC, 2021; Geo-Marine, 2010). Additionally, installation of the HDD conductor barrel will only occur for a short duration, and distances to potential injurious effects will be concentrated within the area of the landfall site, therefore impacts during these pile driving activities is expected to be low.

Atlantic Shores is implementing measures to avoid Project-related impacts to finfish and invertebrates. In addition to continuing existing marine programs to study important habitats, key noise mitigation and monitoring strategies that will be implemented throughout all phases of the Project include equipment operating procedures to protect or prevent finfish and invertebrate species from harmful underwater sound levels generated by pile driving. For example, noise abatement systems that reduce the likelihood for exposure to threshold sound levels arising from pile driving for marine mammals will also benefit other marine fauna, including finfish. Soft starts will be implemented for activities such as impact pile driving. Standard soft-start procedures are a "ramp-up" procedure whereby the sound source level is increased gradually before full use of power. In combination, these impact mitigation strategies are expected to minimize impacts to fish and invertebrates.

7.5.2 Vibratory Pile Driving

Non-impulsive vibratory pile driving may be used in support of HDD installation of the export cables if construction of a cofferdam or casing pipe is necessary. Use of a cofferdam would require the installation of sheet piles which would result in the generation of underwater noise. Modeling of cofferdam installation was conducted for two representative locations, one along the Monmouth ECC and the other along the Northern ECC (Appendix II-L). Results of the modeling show that within 164 feet (50 meters) of the cofferdam site , fish with swim bladders that are involved in hearing could experience injury or TTS. Other fish groups could experience behavioral impacts within the 164 feet (50 meters) of the cofferdam site, but are not expected to receive injury or hearing impairment from the construction of the cofferdam.

Installation of a casing pipe is also considered to facilitate HDD installation activities of the export cables. Installation of a casing pipe would also require non-impulsive vibratory pile driving. Modeling of this installation was conducted for two representative locations, one near Monmouth, New Jersey and another in Wolfe's Pond, New York. The results of the modeling show that injury to fishes with swimbladders would only occur within approximately 52 feet (16 meters) of the landfall site, while temporary, recoverable impacts may occur up to approximately 249 feet (76 meters) from the landfall site. The remaining fish groups may experience behavioral impacts, but the extent of those impacts is only anticipated to extend approximately 820 feet (250 meters) from the landfall site. Additional information on noise modeling for casing pipe installation is provided in Volume II, Appendix II-L of the COP.

Noise impacts from decommissioning are expected to be equal to or less than those predicted for construction. Based on the modeling results, noise impacts are expected to occur relatively close to the cofferdam or casing pipe installation sites. Given the localized extent of impacts and the mobile nature of fish, impacts to fish from cofferdam or casing pipe installation or decommissioning is expected to be minimal and localized.

7.5.3 Other Noise Sources

There are several other potential anthropogenic sound sources associated with offshore Project construction, O&M, and decommissioning. These sources were not quantitatively modeled because the potential acoustic effects of these sound sources are expected to be much less than the impact pile driving sound source associated with hammer-installed foundations. A qualitative assessment of possible effects to finfish and pelagic invertebrates from other noise sources generated by Project activities, including HRG surveys, vessels, cable installation, vibratory pile driving (if needed), operational WTGs, operational offshore cables, and decommissioning is summarized in this section.

As detailed in Volume I, Sections 4.5.3 and 4.5.9 of the COP, HRG surveys may be conducted to support pre-construction site clearance activities as well as post construction facilities surveys. The HRG survey equipment used for this type of survey work would be the same or similar to the equipment deployed during Atlantic Shores' 2019-2022 site characterization surveys including multibeam echosounders, side scan sonars, sub-bottom profilers, and high-resolution seismic equipment. Of this equipment, sub-bottom profilers and high-resolution seismic equipment emit acoustic signals vertically downwards into the water column, some of which will penetrate the seabed. Studies of stronger HRG survey equipment (not being deployed by Atlantic Shores, e.g., seismic airguns), have shown mortality is very unlikely; however, behavioral responses have been observed in fish exposed to airgun sound levels exceeding 147–151 sound pressure level (SPL) (Fewtrell and McCauley, 2012) and some HRG active acoustic sound sources can produce these sound levels within tens of to a few hundred meters of the source (Halvorsen and Heaney, 2018). In the Biological Assessment for data collection activities on the Atlantic OCS, Baker and Howson (2021) found that mobile HRG sound sources are not likely to result in PTS for fish. Based on the variable responses observed in studies used to establish threshold levels of sound for impulsive sources (Table 14), finfish would be expected to either vacate the survey area, experience short-term TTS and/or masking of biologically relevant sounds, show no visible effects, or be completely unaffected. Given the results of these studies, the mobile and intermittent nature of HRG surveys, the short-term and infrequent nature of surveying small areas of the seafloor relative to the overall area, and the likelihood that finfish will move away from the sound source, noise from HRG surveys is not expected to pose a risk to EFH-designated finfish or pelagic invertebrates.

Vessel noise includes non-impulsive sounds that arise from vessel engines, propellers, and thrusters. Sound levels emitted from vessels depend on the vessel's operational state (e.g., idling, in transit) and are strongly weather dependent. Zykov et al. (2013) and McPherson et al. (2019) report a maximum broadband source level of 192 dB re 1 μPa for numerous vessels with varying propulsion power. The characteristics of these noises are described in more detail in Volume II, Appendix II-L of the COP. Noise from Project vessels is likely to be similar in frequency characteristics and sound levels to existing commercial vessel traffic in the region. Given the rapid attenuation of underwater vibrations with increasing distance from a sound source (Morley et al. 2014), it is unlikely that these stimuli will cause more than short-term behavioral effects (e.g., flight or retraction) or physiological (e.g., stress) responses. Overall, impacts to EFH-designated finfish and pelagic invertebrates from vessel noise are expected to be short-term and localized and are not anticipated to pose a risk to these resources.

Noise impacts from cable installation activities (e.g., from sand bedform removal [if needed], jet trenching, plowing/jet plowing, mechanical trenching, dredging) are expected to be minimal, with most activities generating noise impacts similar to those described for vessel noise. A detailed modeling and measurement study conducted for construction activities associated with cable installations concluded that underwater sound generated by cable laying vessels was similar to that of other vessels already operating in the area and no significant acoustic impacts were identified (JASCO 2006). A review of studies published by the U.S. Army Corps of Engineers examined noise impacts from dredging operations on a variety of species, including fish, and found that based on available literature, dredging induced sounds were not considered to pose significant risk of direct injury or mortality to juvenile or adult fish (Suedel et al., 2019). Therefore, noise associated with cable laying activities is not expected to pose a risk to EFH-designated finfish or pelagic invertebrates.

Non-impulsive, vibratory pile driving could be an additional source of noise generated during construction of the WTGs. Vibratory pile driving may be used for a short period at the beginning of pile driving or to install the entire pile, depending on sediment conditions (see Volume I, Section 4.2.1 of the COP). Compared to noise generated from impulsive pile driving, vibratory pile installation typically produces lower amplitude sounds in the marine environment (Rausche and Beim, 2012). Received peak sound pressure levels (PK) and SEL near impact pile driving can exceed 200 dB, while studies of vibratory pile driving measured source levels ranging from 177 to 195 dB PK and 174.8 to 190.6 dB SEL (Hart Crowser, Illingworth and Rodkin, 2009; Houghton et al., 2010). Suction bucket installation, which is also a non-impulsive pile installation method, is expected to result in lower peak pressure levels than impact pile driving. Exposure to vibratory hammer and suction bucket installation noise is unlikely to induce injury in EFH-designated fish or pelagic invertebrates because of its lower peak pressure levels and its relatively short duration.

During Project operation, WTGs will generate non-impulsive sound in the nacelle that will be transmitted down the WTG tower to the foundation and then radiated into the water. Underwater sound levels generated by an operational WTG are related to the WTG's power and wind speed, with increased wind speeds creating increased underwater sound (Wahlberg and Westerberg, 2005). Under normal conditions, the sound level that results from WTG operation is of low intensity (Madsen et al., 2006), with energy concentrated at low frequencies (below a few kilohertz) (Tougaard et al., 2008). At high wind speeds, Wahlberg and Westerberg (2005) estimated permanent avoidance by fish would only occur within a range of 13 feet (4 meters) to 820 feet (250 meters) of a turbine. These findings were dependent on the number and size of windmills, wind speed, background noise level, hearing abilities of the fish, bathymetry, and seabed characteristics (Wahlberg and Westerberg, 2005).

Pangerc et al. (2016) recorded SPL measurements at approximately 164 feet (50 meters) from two individual 3.6 megawatt (MW) monopile wind turbines over a 21-day operating period. The sound pressure level increased with wind speed up to an average value of 128 dB re 1 μPa at a wind speed of about 10 meters per second, and then showed a general decrease. Additional studies conducted during operation of the Block Island Wind Farm measured sound levels below 120 dB SPL at wind speeds less than 13 meters per second (HDR, 2019). These sound levels are expected to be similar to those reported for cable laying/trenching, and are well below existing non-impulsive acoustic thresholds for injury or behavioral response in fish (Table 15). Overall, current literature indicates sound generated from the operation of wind farms is of minor significance for fish (Wahlberg and Westerberg, 2005; Stenberg et al., 2015). Therefore, the effects of WTG noise on finfish, while long-term, are not expected to be substantial and will not cause population-level effects.

HVAC offshore cables are expected to produce non-impulsive low-frequency tonal vibration sound in the water. HVDC cables do not produce a similar tonal sound because the current is not alternating. Low level tonal sound from an existing 138 kV transmission line buried up to 4 feet (1 meter) was measured in Trincomali Channel, offshore Vancouver Island, British Columbia during a quiet period of recording. The SPL at approximately 328 feet (100 meters) from the cable was below 80 dB. Assuming cylindrical spreading of sound, the source level of the submarine cable was approximately 100 dB SPL (JASCO, 2006). Anticipated SPL arising from the vibration of alternating current (AC) cables during operation are significantly lower than SPL that may occur during cable installation (Meißner et al., 2006) and may be undetectable in the ambient soundscape of the Lease Area. Based on these studies, no effects to EFH-designated finfish or pelagic invertebrates are expected from low-frequency tonal vibration sound emitted during cable operation.

Sounds associated with decommissioning are reasonably assumed to be similar to, or less than, those produced during either the construction or O&M phases of the Project. The methods used to decommission and remove the Project's foundations will depend on the type of foundation (see Volume I, Section 6.2.3 of the COP); therefore, the level and duration of sounds emitted during decommissioning will depend on the type (e.g., gravity versus piled foundation), size, and location of the foundation. Piled foundations, if used, will be cut below the mudline, likely using underwater acetylene cutting torches, mechanical cutting, and/or a high-pressure water jet. Mechanical cutting tools and high-pressure water jetting will generate non-impulsive broadband sound (Topham and McMillan 2017). Regardless of the foundation type used, removal and transport of Project components (e.g., foundations, WTGs, OSSs, etc.), will require the use of vessels, which will also generate non-impulsive sound. Potential impacts to finfish and pelagic invertebrates, including EFH species, from sound generated during decommissioning activities are expected to be similar or less than those produced during the construction or O&M phases of the Project.

The risks of noise-related impacts from other sound sources to EFH-designated finfish and invertebrates due to noise exposure and associated behavioral responses are expected to be very low. The mitigation measures that will be implemented for both marine mammals and sea turtles such as noise abatement systems and soft starts, are expected to minimize any sound-related impacts during all phases of the Project.

7.6 Electromagnetic Fields

This section addresses electromagnetic fields (EMF) generated during operation of the Project and the localized effects on EFH species and other NOAA trust resource species. EMFs are invisible areas of electric and magnetic energy that occur both naturally and anthropogenically in the marine environment. Atlantic Shores conducted an EMF study to predict EMF levels from operation of the Project's submarine electrical system which includes a combination of HVDC and HVAC cables and OSSs (see Volume II, Appendix II-I of the COP). The modeling results show that EMF levels are predicted to decrease exponentially with increasing distance from the cables and are therefore expected to cause minimal risk to EFH species.

EFH species equipped with specialized sensory organs (e.g. elasmobranchs with ampullary receptors) or chemical or mechanical receptors (e.g., select invertebrates) may be able to detect electric fields generated in a marine environment (Normandeau et al. 2011). Studies have shown that the purpose of electrical field detection in invertebrates and fish is for prey and predator detection and also navigation (CSA Ocean Sciences Inc. and Exponent 2019; Normandeau et al. 2011). However, due to cable configuration and shielding, electric fields will not be released into the marine environment from Project cable operation, and therefore were not modeled in Volume II, Appendix II-I of the COP and are not further discussed in this section.

Magnetic fields will, however, be generated by the offshore cable system, which includes HVAC and HVDC export cables, HVAC interlink cables, and HVAC inter-array cables. Multiple theories have been proposed for finfish and invertebrate detection of magnetic fields. The most supported theory proposes the use of a magnetite-based system which involves the presence of magnetic crystals (magnetite) that can detect differences in magnetic fields (CSA Ocean Sciences, Inc. and Exponent 2019; Normandeau et al. 2011). Researchers believe magnetosensitive fish and invertebrate species use magnetic fields for orientation, migration, and navigation (Normandeau et al. 2011). Additionally, finfish species may also use magnetic field detection to locate food, habitat, and spawning grounds (CSA Ocean Sciences, Inc. and Exponent 2019). Magnetosensitivity has been observed in elasmobranchs and select bony fish, including the following species with EFH in the Offshore Project Area: clearnose skate, little skate, winter skate, spiny dogfish, yellowfin tuna, blue shark, common thresher shark, dusky shark, sand tiger shark, sandbar shark, shortfin mako shark, smooth dogfish, tiger shark, and white shark (CSA Ocean Science Inc. and Exponent 2019). Based on available literature, magnetosensitivity in invertebrates has been identified in three phyla including Mollusca (e.g. snails and bivalves), Echinodermata (e.g. sea urchins), and Arthropoda (e.g. lobsters) (Normandeau et al. 2011); however, the identification of specific magnetosensitive invertebrate species is lacking. Other finfish and invertebrate species with EFH in the Offshore Project Area (e.g. flounders, mackerels, scup, bluefish, black sea bass) likely lack the physiological components necessary to detect electric and magnetic fields and therefore are not expected to be adversely affected by EMF outputs from Project HVAC and HVDC export cables, HVAC inter-link cables, and HVAC inter-array cables.

Well-established magnetic field thresholds are lacking for finfish and invertebrates; however, research suggests that marine species may be more likely to detect magnetic fields from direct current (DC) sources than AC sources (Normandeau et al. 2011). Magnetic fields generated from HVAC and HVDC export cables and HVAC inter-link and inter-array cables used for the Project will be minimized by cable burial (between approximately 5 to 6.6 feet [1.5 to 2 meters]) and armoring (see Volume 1, Section 4.5.1 of the COP), which will minimize potential impacts to demersal and pelagic species. Table 18 summarizes the modeled peak magnetic field production anticipated for Project HVAC and HVDC export cables and HVAC inter-array cables under maximum power generation scenarios for cable crossing and normal conditions. Model results also showed that magnetic fields produced by HVAC and HVDC export cables and HVAC inter-array cables decrease exponentially with increasing horizontal and vertical distance (see Volume II, Appendix II-I of the COP).

Table 18. Peak Magnetic Fields Modeled under Maximum Power Generation for the Atlantic Shores Export and Inter-Array Cables

Cable Type	Peak Magnetic Field (mG) for Maximum Modeled Case
HVAC[1]	
Export Cable	107.82
Export Cable (at cable crossing)	244.42
Inter-array Cable	60.07
HVDC	
Export Cable	152.68
Export Cable (at cable crossing)	349.22

[1] HVAC inter-link cables are part of the larger OSS electrical system, and were not analyzed as isolated, individual cables. However, due to the configuration of the inter-link cables, they are expected to operate in a similar fashion as either HVAC export cables or the inter-array cables.

Biologically significant impacts to EFH species have not been documented for EMF generated from AC cables (BOEM, 2020). Multiple studies provide evidence that fish and invertebrate species are unlikely to detect high frequency fields (e.g. 60 Hz) produced by AC cables (CSA Ocean Sciences Inc. and Exponent 2019; Normandeau et al. 2011). Laboratory studies examining frequency impacts from an AC source on skates found decreasing sensitivity as frequencies incrementally increased above 1 hertz (CSA Ocean Sciences Inc. and Exponent 2019). Researchers also believe that marine species with magnetite-based systems may not be able to detect magnetic fields below 50 milligauss from a high frequency (e.g. 50 or 60 hertz) AC source (Normandeau et al. 2011). Modeling of Atlantic Shores' HVAC export and inter-array cables, which will operate at 60 hertz, predict magnetic fields ranging from 60.07 to 244.42 milligaus at the cable centerline. However, the field is predicted to drop to approximately 50 milligauss between 5.4 and 8.4 feet (1.6 to 2.6 meters) in horizontal distance from the HVAC export cables and between 1.7 and 2.8 feet (0.52 to 0.85 meter) in horizontal distance from the inter-array cables. Additionally, magnetic field strength will drop to approximately 50 milligauss between 3.0 and 5.0 feet (0.91 and 1.5 meters) in vertical distance from HVAC export cables and 0.61 feet (0.19 meter) in vertical distance from inter-array cables. Since the HVAC export and inter-array cables will operate at 60 hertz, and the magnetic fields are predicted to drop to approximately 50 milligauss at a maximum horizontal distance of 8.4 feet (2.6 meters) and a maximum vertical distance of 5.0 feet (1.5 meters), it can reasonably be assumed that magnetic fields produced by Project HVAC offshore cables will result in minimal impacts to EFH-designated species in the Offshore Project Area.

It is likely that EFH-designated species potentially present in the immediate vicinity of the HVAC export and HVAC inter-array cables, where modeled magnetic levels are larger than 50 milligauss, may not experience effects. Studies on bamboo sharks, a small shark in the same family as dogfish (Scyliorhinidae), observed no impacts to behavior when exposed to magnetic field strengths of 14,300 milligauss from a 50 hertz AC source (CSA Ocean Sciences Inc. and Exponent 2019). Additional studies conducted on Atlantic salmon and American eel in the presence of a 950 milligauss magnetic field from a 50 hertz AC power source showed no impact on swimming behavior (CSA Ocean Sciences Inc. and Exponent 2019). Results of these studies provide evidence that magnetosensitive species may not be able to detect magnetic fields above 50 milligauss emitted from a high frequency AC source. Since magnetosensitive species have shown minimal effects in the presence of high magnetic field strengths emitted from high frequency AC sources, it can reasonably be assumed that other species in the Offshore Project Area which lack the physiological components to detect magnetic fields would not experience adverse impacts from magnetic fields produced by AC cable operation.

As previously stated, studies have shown finfish and invertebrates to be more sensitive to magnetic fields produced by DC cables than AC cables (Normandeau et al. 2011). Though thresholds have not been established for marine species in the presence of magnetic fields from a DC source, studies have aimed to determine potential impacts from such sources. Hutchison et al. (2018) examined behavioral impacts in little skates when exposed to a magnetic field of 655 milligauss from a DC cable. Results of this field study showed changes in behavior such as altered travel pattens and increased travel speed; however, the cable did not represent a barrier for crossing. Additional field studies observed migrating European eels (*Anguilla anguilla*) across a DC cable. While slower swimming speeds were observed when crossing the DC cable, the cable did not create a barrier to crossing or present any permanent obstacles to migrating adult eels or elvers (Normandeau et al. 2011). Woodruff et al. (2013) studied responses in the non-mangetosensitive Atlantic halibut (*Hippoglossus hippoglossus*) to graduated magnetic field strengths from a DC source ranging from 2,700 to 12,300 milligauss and found no significant changes in behavior. . Klimley et al. (2017) studied the effects of the Trans Bay Cable, an HVDC transmission line in California, on adult green sturgeon (*Acipenser medirostris*) and found that increases in the magnetic field did not impact the migration or travels of green sturgeon as they were able to successfully travel to spawning grounds. Given that the magnetic fields used in many of these studies far exceed the modeled magnetic fields from HVDC export cables for the Project (Table 18) and the results of those studies did not result in substantial effects to the subject species, impacts from the Project's HVDC export cables are not expected to adversely affect fish behavior in the Offshore Project Area.

Studies have also been conducted for benthic invertebrates to determine potential effects on behavior and movement from a DC source. Hutchison et al. (2018) conducted a field study which used enclosures situated over an existing DC cable to examine American lobster response in the presence of a maximum magnetic field of 653 milligauss DC. Results of the field study showed that though subtle changes in behavior (e.g. exploration activity) and differences in spatial distribution (e.g. use of enclosure space, proximity to seabed) were observed, the magnetic field did not present a barrier to movement. Laboratory studies have also been conducted on marine invertebrates to determine potential effects of magnetic fields produced by a DC source on invertebrate behavior and movement. Studies conducted by Woodruff et al. (2012 and 2013) examined responses of Dungeness crab and American lobster in the presence of high DC magnetic fields and observed no statistically significant difference in behavior (e.g. feeding) or spatial use (e.g. distribution in tanks). Woodruff et al. (2012) examined behavioral changes such as antennular flicking and feeding in Dungeness crabs when exposed to 30,000 milligauss DC. Results of the study showed no statistically significant differences between controlled (i.e. no DC field exposure) and experimental trials (i.e. 30,000 milligauss DC exposure). Woodruff et al. (2013) continued their study in 2012 and examined spatial distribution (e.g. location in tanks with respect to EMF source) and activity levels (e.g. time spent buried or active) of Dungeness crabs when exposed to 10,000 milligauss DC and found no statistical significance with respect to magnetic field strength. Woodruff et al. (2013) also studied changes in spatial use and behavior in American lobster when exposed to a maximum EMF level of 11,000 milligauss DC. Unlike the results of the Hutchison et al. (2018) field study, results from Woodruff et al. (2013) laboratory studies showed no correlation between EMF levels and spatial use (e.g. location in tank, time spent under shelter or buried) and behavior in American lobsters (e.g. activity levels). The magnetic DC fields used in the Hutchison et al. (2018) and Woodruff et al (2012 and 2013) studies are significantly greater than the modeled magnetic field levels expected to be generated by HVDC export cables for the Project. Although some effects to the spatial distribution of American lobster were observed in the field studies conducted by Hutchison et al. (2018), the presence of the cable did not represent a barrier to crossing meaning effects to orientation, navigation, and homing would be unlikely.

Of the studies reviewed regarding effects of EMF on invertebrate and fish species, exposure did not result in substantial impacts to behavior. Demersal and benthic-oriented species that live on or close to the bottom have the greatest likelihood of encountering EMF from the Project. Pelagic species that swim higher in the water column have a lower likelihood of encountering Project-generated EMF given the modeling results which showed an exponential decrease in magnetic fields with increasing vertical distance from the export or inter-array cable. CSA Ocean Sciences, Inc. and Exponent (2019) concluded that finfish species that are exposed to EMF from buried power cables may experience a behavioral effect during the time of exposure; however, most exposures would be short in duration (minutes, not hours) and the area affected would be small compared to surrounding available habitat for fish. Given the localized spatial extent of expected EMF emissions from the Project and proposed mitigation measures, EMFs associated with Project operation are not expected to pose a risk to EFH species. Therefore, although magnetic fields would be present as long as the Project is in operation, impacts from EMFs generated by Project offshore cables on EFH species would be highly localized and would likely be biologically insignificant, a conclusion also reached by BOEM (2020).

7.7 Lighting

Artificial light can attract or deter certain finfish and invertebrates. Reactions to artificial light are considered highly species-dependent. The amount of artificial Project lighting that would penetrate the sea surface is expected to be minimal and not likely to cause adverse effects to finfish or invertebrates, including EFH-designated species.

During construction, O&M, and decommissioning, vessels working or transiting during periods of darkness and fog will utilize navigational and deck lighting. During O&M, regardless of the foundation type selected, all WTG and OSS foundations will contain marine navigational lighting and marking in accordance with U.S. Coast Guard (USCG) and BOEM guidance. In addition to any required marine navigational lighting, some outdoor lighting on the OSS structures will be necessary for maintenance at night, which would be illuminated only when the OSS is manned.

Artificial light has the potential to cause behavioral reactions in finfish or pelagic invertebrates such as attraction or avoidance in a highly localized area. Artificial light could also disrupt diel vertical migration patterns in some fish and potentially increase the risk of predation or disrupt predator/prey interactions (Orr, 2013; BOEM, 2020). Artificial light generated from Project vessels used during construction, O&M, and decommissioning would be more intense from downward directed deck lighting compared to navigational lights. However, potential impacts from vessel lights will be transient and will only occur in a limited and localized area relative to surrounding unlit areas. Therefore, no substantial impacts to finfish or pelagic invertebrates with designated EFH are expected from vessel and deck lighting. The navigation lighting on the WTG and OSS structures during O&M is also not expected to substantially impact EFH-designated finfish or pelagic invertebrates since it is not downward-focused and the amount of light penetrating the sea surface is expected to be minimal (BOEM, 2020).

8.0 SUMMARY OF PROPOSED ENVIRONMENTAL PROTECTION MEASURES

The following provides a summary of proposed environmental protection measures that Atlantic Shores will implement to avoid and minimize impacts to EFH and EFH-designated species within the Offshore Project Area. Additional measures will be evaluated further in cooperation and coordination with Federal and state jurisdictional agencies and other stakeholders as the Project continues to progress through development and permitting.

- Comprehensive benthic habitat surveys (seafloor sampling, imaging, and mapping) have been designed and conducted in consultation with BOEM and NOAA to support the identification of sensitive and complex habitats and the development of strategies for minimizing impacts to identified areas to the maximum extent practicable.
- HDD will be used to avoid seabed disturbance impacts to benthic habitat at the landfall sites. All HDD activities will 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 will be collected and recycled upon HDD completion.
- Inter-array, inter-link, and export cables will be buried to a target depth of 1.5 to 2 meters (5 to 6.6. feet) which will allow the benthic community to recover and recolonize, avoid direct interaction with finfish and benthic invertebrates, and minimize effects from EMF.
- DP vessels and jet plow embedment will be used to the maximum extent practicable to reduce sediment disturbance during cable laying processes.
- Vessels will operate in compliance with regulatory requirements related to the prevention and control of discharges and accidental spills.
- Accidental spill or release of oils or other hazardous materials will be managed through the OSRP (Volume I, Appendix I-C of the COP).
- Anchor midline buoys will be used on anchored construction vessels, where feasible, to minimize seabed disturbance.
- An anchoring plan will be employed for areas where anchoring is required 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.
- Soft starts and gradual "ramp-up" procedures (i.e., gradually increase sound output levels) will be employed for activities such as pile driving to allow mobile individuals to vacate the area during noise-generating activities.

- 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) will be implemented to decrease the propagation of potentially harmful noise.
- A fisheries monitoring plan will be implemented to monitor baseline environmental conditions relevant to fisheries and how these conditions may change throughout Project construction and operation. Proposed fisheries surveys detailed in the Fisheries Monitoring Plan (see Volume II, Appendix II-K of the COP) include a demersal fish trawl survey, fish pot survey, and clam dredge survey.
- A benthic habitat monitoring plan will be implemented to measure and assess the disturbance and recovery of marine benthic habitats and communities as a result of Project construction and operation (see Volume II, Appendix II-H of the COP).
- During operation of an HVDC OSS, impingement impacts will be minimized through an intake design that utilizes an appropriately sized inlet port and screens to prevent impingement and a through-screen intake water velocity of less than 0.5 feet/second. Entrainment impacts will be mitigated by minimizing and managing the water use required for OSS cooling to the greatest extent practicable.
- Coordination and consultation will occur throughout the filing of the NPDES permitting associated with an HVDC OSS to ensure impacts are minimized and reduced to the greatest extent practicable.

9.0 CONCLUSION

Most of the anticipated Project-related effects on EFH and EFH-designated species are expected to be localized and reversible as natural processes are expected to return temporarily disturbed areas to pre-construction conditions. The permanent impacts from the presence of structures and cables will only occur within a small area compared to the available surrounding undisturbed habitat. The introduction of structures to the Offshore Project Area are expected to be ecologically beneficial to structure-oriented species over the life of the Project. The maximum total seabed disturbance in the Lease Area (temporary and permanent) is 5.38 square miles (13.93 square kilometers) which represents approximately 4.2% of the 127-square mile (329-square kilometer) Lease Area. The maximum total seabed disturbance in the ECCs (temporary and permanent), excluding the portion of the ECCs located in the Lease Area, is 5.96 square miles (15.44 square kilometers), which represents approximately 6.2% of the total ECC area.

Within the Lease Area, the majority of the temporary and permanent habitat disturbance will occur to soft bottom habitat; however, in the Monmouth and Northern ECC, the majority of temporary and permanent habitat disturbance will occur to complex habitat. Though complex habitat is present in the Offshore Project Area and is expected to be temporarily and permanently disturbed by installation activities, the majority of such habitat consists of gravelly and gravelly mixes which is consistent with other areas of the Mid-Atlantic Bight. These areas of temporary and permanent habitat disturbance are small compared to the available undisturbed surrounding habitat in the Offshore Project Area. Where impacts are unavoidable, Atlantic Shores has selected installation tools and methods that minimize disturbance to bottom habitats, including complex and sensitive habitats, to the maximum extent practicable.

As demonstrated in Tables 7a through 8b, many of the species with designated EFH in the Offshore Project Area have a completely pelagic lifestyle and most species have pelagic early life histories (Tables 7a and 7b) and are not dependent on benthic habitat. These species are expected to experience negligible impacts to their EFH as the pelagic zone will not be directly affected by most Project activities. Given their mobile nature, pelagic juvenile and adult life stages (Tables 8a and 8b) should largely avoid the areas affected by Project disturbance and are expected to return shortly after activities cease in a given location.

Project-related effects to EFH-designated species are expected to primarily occur to sensitive benthic early life stages and later sessile life stages. As described in Section 6.0, only four EFH-designated species have EFH for benthic early life stages in the Offshore Project Area (ocean pout eggs, winter flounder eggs and larvae, Atlantic sea scallop eggs and larvae, and longfin inshore squid eggs) (Tables 9a and 9b). Additionally, only two EFH-designated species have sessile benthic later life stages in the Offshore Project Area (Atlantic surfclam juveniles and adults and ocean quahog adults) (Tables 10a and 10b). Tables 9a through 10b show that these species have EFH designated in only a portion of each of the components of the Offshore Project Area. The remaining benthic or demersal species are mobile later life stages (Tables 10a and 10b) and can temporarily leave the area during Project activities. In addition, as stated in Sections 7.2.2 and 7.3.2, impacts to egg and larval stages of EFH-designated species from the intake and discharge at a potential HVDC OSS are expected to be minimal. Therefore, overall Project impacts to EFH and EFH-designated species are not expected to be biologically significant.

10.0 REFERENCES

Adams PB. 1980. Life history patterns in marine fishes and their consequences for management. NOAA – Fisheries Bulletin. 78(1).

Afsharian, S., Taylor, P.A. 2019: *On the potential impact of Lake Erie wind farms on water temperatures and mixed-layer depths: Some preliminary 1-D modeling using COHERENS*. J. of Geophy. Res.: Oceans, 124, 1736–1749.

Anderson, EP, Mackas, DL. 1986. *Lethal and sublethal effects of a molybdenum mine tailing on marine zooplankton: mortality, respiration, feeding and swimming behavior in Calanus marshallae, Metridia pacifica and Euphausia pacifica*. Mar Environ Res. 19(2):131-155.

Andersson MH. 2011. *Offshore wind farms – ecological effects of noise and habitat alteration on fish*. Stockholm University, Department of Zoology. ISBN 978-91-7447-172-4.

Andersson MH, Dock-Åkerman E, Ubral-Hedenberg R, Öhman MC, Sigray P. 2007. *Swimming behavior of roach (Rutilus rutilus) and three-spined stickleback (Gasterosteus aculeatus) in response to wind power noise and single-tone frequencies*. Ambio. 36(8):636-638.

André M, Solé M, Lenoir M, Durfort M, Quero C, Mas A, Lombarte A, van der Schaar M, López-Bejar M, Morell M, Zaugg S, and Houégnigan L. 2011. Low-frequency sounds induce acoustic trauma in cephalopods. Frontiers in Ecology and the Environment, 9(9), 489-493. https://doi.org/10.1890/100124.

Applied Science Associates, Inc (ASA). 2008. *Results from Modeling of Sediment Dispersion during Installation of the Proposed Bayonne Energy Center Submarine Cable*. Narragansett (RI): ASA Project 2007-025. http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=28172.

Atlantic States Marine Fisheries Commission (ASMFC). 2012. *Atlantic States Marine Fisheries Commission American Eel Benchmark Stock Assessment (Report No. 12-01).* Available at: http://www.asmfc.org/uploads/file/americanEelBenchmarkStockAssessmentReport_May2012.pdf (Accessed February 2021).

ASMFC. 2015. Horseshoe Crab (Limulus polyphemus). Available at: http://www.asmfc.org/uploads/file/5dfd4c1aHorsehoeCrab.pdf (Accessed November 2020).

ASMFC. 2017. *2017 American Eel Stock Assessment Update*. Available at: https://www.asmfc.org/uploads/file/59fb5847AmericanEelStockAssessmentUpdate_Oct2017.pdf (Accessed February 2021).

Atlantic States Marine Fisheries Commission (ASMFC). 2021. *Fisheries Management*. Available at: http://www.asmfc.org/fisheries-management/program-overview (Accessed January 2021).

Auld AH, Schubel JR. 1978. Effects of suspended sediment on fish eggs and larvae: a laboratory assessment. Estuarine and Coastal Marine Science 6:153–164.

Baker, K and Howson, U. 2021. Data Collection and Site Survey Activities for Renewable Energy on the Atlantic Outer Continental Shelf Biological Assessment. U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. Published October 2018, Revised February 2021. https://www.boem.gov/sites/default/files/documents/renewable-energy/OREP-Data-Collection-BA-Final.pdf.

Balthis WL, Hyland JL, Fulton MH, Wirth EF, Kiddon JA, Macauley J. 2009. Ecological Condition of Coastal Ocean Waters Along the U.S. Mid-Atlantic Bight: 2006. NOAA Technical Memorandum NOS NCCOS 109, NOAA National Ocean Service: Charleston (SC); 29412-9110.Bergstrom L, F Sundqvist, and U Bergstrom. 2013. *Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community*. Marine Ecology Progress Series. 485: 199-210.

Berrien P, and Subunka J. 1999. Distribution Patterns of Fish Eggs in the U.S. Northeast Continental Shelf Ecosystem, 1977-1987. NOAA Technical Report NMFS 145.

Berry WJ, Rubinstein NI, Hinchey EK, Klein-MacPhee G, Clarke DG (2011). *Assessment of Dredging-Induced Sedimentation Effects on Winter Flounder (Pseudopleuronectes americanus) Hatching Success: Results of Laboratory Investigations, Proceedings of the Western Dredging Association Technical Conference and Texas A&M Dredging Seminar*, Nashville, Tennessee, June 5-8, 2011.

Bolle LJ, de Jong CAF, Bierman SM, van Beek PJ, van Keeken OA, Wessels PW, van Damme CJ, Winter HV, de Haan D, Dekeling RPA. 2012. *Common sole larvae survive high levels of pile-driving sound in controlled exposure experiments.* PLoS ONE. 7:e33052.

Braun CB, Grande T. 2008. *Evolution of Peripheral Mechanisms for the Enhancement of Sound Reception*. In: Webb JF, Fay RR, Popper AN, editors. Fish Bioacoustics. NY, USA: Springer. p. 99-144.

Brooks RA, Bell SS, Purdy CN, Sulak KJ. 2004. *The benthic community of offshore sand banks: a literature synopsis of the benthic fauna resources in potential MMS OCS sand mining areas. Gainesville (FL): USGS Florida Integrated Science Center, Center for Aquatic Resource Studies*. USGS Scientific Investigation Report No. 2004-5198.

Brust J. 2006. Species Profile: American Eel. NJDEP Marine Issue. Vol 19, No. 3. Available at: https://www.state.nj.us/dep/fgw/pdf/2006/digmar20-27.pdf (Accessed March 2021).

Budelmann, BU. 1992. Reprinted from: Webster DB, Popper AN, R. R. Fay RR, editors. The Evolutionary Biology of Hearing. Springer New York. pp. 141-155.

Buerkle U. 1973. *Gill-net catches of cod (Gadus morhua L.) in relation to trawling noise.* Marine Behaviour and Physiology. 2:277-281.

Bureau of Ocean Energy Management (BOEM). 2012. *Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New Jersey, Delaware, Maryland, and Virginia- Final Environmental Assessment*. OCS EIS/EA BOEM 2012-003

BOEM. 2017. *Habitat mapping and assessment of northeast wind energy areas*. Available at: https://tethys.pnnl.gov/publications/habitat-mapping-assessment-northeast-wind-energy-areas (Accessed February 2021).

BOEM. 2018. Draft Guidance Regarding the Use of a Project Design Envelope in a Construction and Operations Plan. Available at: https://www.boem.gov/sites/default/files/renewable-energy-program/Draft-Design-Envelope-Guidance.pdf (Accessed March 2021).

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. Published June 2019. Available at: https://www.boem.gov/sites/default/files/renewable-energy-program/Regulatory-Information/BOEM-Renewable-Benthic-Habitat-Guidelines.pdf.

BOEM. 2020. *Vineyard Wind 1 Offshore Wind Energy Project Supplement to the Draft Environmental Impact Statement.* Sterling (VA): BOEM; OCS EIS/EA BOEM 2020-025.

BOEM. 2021. *South Fork Wind Farm and South Fork Export Cable Project Draft Environmental Impact Statement.* Sterling (VA): BOEM; OCS EIS/EA BOEM 2020-057.

BOEM. 2022. Draft BOEM Nationwide Recommendations for Impact Pile Driving Sound Exposure Modeling and Sound Field Measurement for Offshore Wind Construction and Operation Plans. Available at: https://www.boem.gov/renewable-energy/draft-boem-2022-0057.

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. e0160830.

Casper BM, Popper AN, Matthews F, Carlson TJ, Halvorsen MB. 2012. *Recovery of barotrauma injuries in Chinook salmon, Oncorhynchus tshawytscha from exposure to pile driving sound*. PLoS ONE. 7(6):e39593.

Castelao, R., S. Glenn, and O. Schofield. 2010: *Temperature, salinity, and density variability in the central Middle Atlantic Bight*. Journal of Geophysical Research: Oceans, 115. C10005.

Causon PD, Gill AB. 2018. *Linking Ecosystem Services with Epibenthic Biodiversity Change Following Installation of Offshore Wind Farms.* Environmental Science and Policy. 89: 340-347.

Chen Z. 2018. *Dynamics and Spatio-Temporal Variability of the Mid-Atlantic Bight Cold Pool.* Doctoral dissertation. New Brunswick (NJ). Rutgers University

Chen, Z., and E. N. Curchitser. 2020: *Interannual Variability of the Mid-Atlantic Bight Cold Pool*. J. Geophys. Res. Oceans, 125. https://doi.org/10.1029/2020JC016445

Chesapeake Bay Program (CBP). 2021. *Field Guide*. Available at: https://www.chesapeakebay.net/discover/field-guide (Accessed January 2021).
Colden A, Lipcius R. 2015. Lethal and Sublethal Effects of Sediment Burial on the Eastern Oyster, Crassostrea virginica. Marine Ecology Progress Series 527: 105-117. DOI: 10.3354/meps11244.

Clarke, D. G., and Wilber, D. H. (2000). "Assessment of potential impacts of dredging operations due to sediment resuspension," DOER Technical Notes Collection (ERDC TN-DOER-E9), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes. army,mil/el/dots/doer.

Cones SF, Jézéquel Y, Ferguson S, Aoki N, and Mooney TA. 2022. Pile driving noise induces transient gait disruptions in the longfin squid (Doryteuthis pealeii). Frontiers in Marine Science, 9. https://doi.org/10.3389/fmars.2022.1070290.

CSA Ocean Sciences Inc. and Exponent. 2019. *Evaluation of Potential EMF Effects on Fish Species of Commercial or Recreational Fishing Importance in Southern New England*. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Sterling, VA. OCS Study BOEM 2019-049. 59 pp.

De Mesel I, Kerckhof F, Norro A, Rumes B, and Degraer S. 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(1), 37-50. https://doi.org/10.1007/s10750-014-2157-1.

Elliott J, Smith K, Gallien DR, and Khan A. 2017. *Observing Cable Laying and Particle Settlement During the Construction of the Block Island Wind Farm*. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2017-027. 225 pp.

English PA et al. 2017. *Improving Efficiencies of National Environmental Policy Act Documentation for Offshore Wind Facilities Case Studies Report*. Norfolk (VA): Fugro Marine GeoServices Inc. and Fugro GB Marine Ltd. OCS Study, BOEM 20147-026.

Essink K. 1999. Ecological effects of dumping of dredged sediments; options for management. Journal of Coastal Conservation 5: 69-80. DOI:10.1007/BF02802741.

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

Fewtrell JL, McCauley RD. 2012. *Impact of air gun noise on the behaviour of marine fish and squid*. Marine Pollution Bulletin. 64(5):984-993.

Fisheries Hydroacoustic Working Group (FHWG). 2008. *Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities*. 12 Jun 2008 ed.

Freese L, Auster P, Heifetz J, Wing B. 1999. Effects of trawling on seafloor habitat and associated invertebrate taxa in the Gulf of Alaska. Marine Ecology Progress Series, 182, 119-126. DOI:10.3354/meps182119.

Ganim J. Cold Pool. 2019. *MARACOOS*. Newark (DE): Mid-Atlantic Regional Association Coastal Ocean Observing System. https://www.integratedecosystemassessment.noaa.gov/regions/northeast/components/cold-pool/ (Accessed November 2020).

[GARFO] Greater Atlantic Regional Fisheries Office. 2020. GARFO Acoustics Tool: Analyzing the effects of pile driving on ESA-listed species in the Greater Atlantic Region. https://www.fisheries.noaa.gov/new-england-mid-atlantic/consultations/section-7-consultation-technical-guidance-greater-atlantic.

Geo-Marine Inc. 2010. *NJDEP Ocean/Wind Power Ecological Baseline Studies Final Report - Volume IV: Fish and Fisheries Studies*. Plano (TX). https://www.nj.gov/dep/dsr/ocean-wind/.

Gedamke J, Harrison J, Hatch LT, Angliss RP, Barlow JP, Berchok CL, Caldow C, Castellote M, Cholewiak DM, DeAngelis ML et al. 2016. *Ocean noise strategy roadmap*. Washington, DC: National Oceanic and Atmospheric Administration.

Golder Associates Inc., 2008. Source water and cooling water data and impingement mortality and entrainment characterization for Monroe power plant. July 2008. Prepared for Detroit Edison Company. Project 063-9564. 444 pp. Gong, D., Kohut, J.T. and Glenn, S.M., 2010. Seasonal climatology of wind-driven circulation on the New Jersey Shelf. Journal of Geophysical Research: Oceans, 115(C4).

Guarinello M, Carey D, Read LB. 2017. *Year 1 Report for 2016 Summer Post-Construction Surveys to Characterize Potential Impacts and Response of Hard Bottom Habitats to Anchor Placement at the Block Island Wind Farm (BIWF)*. INSPIRE Environmental prepared for Deepwater Wind Block Island LLC. May.

Guida, V., A. Drohan, H. Welch, J. McHenry, D. Johnson, V. Kentner, J. Brink, D. Timmons, E. Estela-Gomez. 2017. *Habitat Mapping and Assessment of Northeast Wind Energy Areas. Sterling, VA: US Department of the Interior, Bureau of Ocean Energy Management*. OCS Study BOEM 2017-088. 312 p.

Halvorsen MB, Casper BM, Woodley CM, Carlson TJ, Popper AN. 2011. *Predicting and mitigating hydroacoustic impacts on fish from pile installations*. Project 25–28. National Cooperative Highway Research Program Research Results Digest. 363:2011.

Halvorsen MB, Heaney KD. 2018. *Propagation characteristics of high-resolution geophysical surveys: open water testing*. Prepared by CSA Ocean Sciences Inc. for U.S. Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2018-052.

Hart Crowser IPE, Illingworth and Rodkin, Inc. 2009. *Acoustic Monitoring and In-site Exposures of Juvenile Coho Salmon to Pile Driving Noise at the Port of Anchorage Marine Terminal Redevelopment Project, Knik Arm, Anchorage, Alaska*. Report by Hart Crowser, Inc./Pentec Environmental and Illingworth and Rodkin, Inc. for URS Corporation for US Department of Transportation, Maritime Administration; Port of Anchorage; and Integrated Concepts and Research Corporation

Haugen JB, Papastamatiou Y. 2019. *Observation of a porbeagle shark Lamna nasus aggregation at a North Sea oil platform*. Journal of Fish Biology. DOI: 10.1111/jfb.14149.

HDR. 2018. *Field Observations during Wind Turbine Foundation Installation 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 2018-029.

HDR. 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.

HDR. 2020. Seafloor Disturbance and Recovery Monitoring at the Block Island Wind Farm, Rhode Island – Summary Report. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2020-019.

Houghton J, Starkes J, Stutes J, Havey M, Reyff JA, Erikson D. 2010. *Acoustic monitoring of in situ exposures of juvenile coho salmon to pile driving noise at the port of Anchorage Marine Terminal redevelopment project, Knik Arm, Alaska*. Paper presented at: Alaska Marine Sciences Symposium, Anchorage.

Hutchison ZL, Sigray P, He H, Gill AB, King J, and Gibson C. 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.

Hutchison ZL, Bartley ML, DeGraer S, English P, Khan A, Livermore J, Rumes B, and King JW. 2020. Offshore Wind Energy and Benthic Habitat Changes: Lessons from Block Island Wind Farm. Oceanography, 33(4), 58-69. https://doi.org/10.5670/oceanog.2020.406.

ICF Incorporated, L.L.C. (ICF). 2020. *Comparison of Environmental Effects from Different Offshore Wind Turbine Foundations*. Prepared for: U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Sterling (VA). OCS Study BOEM 2020-041.

JASCO Research Ltd. 2006. *Vancouver Island Transmission Reinforcement Project: Atmospheric and Underwater Acoustics Assessment Report*. Prepared for British Columbia Transmission Corporation 49 pp.

Johnson A. 2018. *The Effects of Turbidity and Suspended Sediments on ESA-Listed Species from Projects Occurring in the Greater Atlantic Region*. Greater Atlantic Region Policy Series 18-02. NOAA Fisheries Greater Atlantic Regional Fisheries Office. Available at: www.greateratlantic. fisheries.noaa.gov/policyseries/. Accessed February 28, 2019.

Jones IT, Peyla JF, Clark H, Song Z, Stanley JA, and Mooney TA. 2021. Changes in feeding behavior of longfin squid (Doryteuthis pealeii) during laboratory exposure to pile driving noise. Marine Environmental Research, 165, 105250. https://doi.org/10.1016/j.marenvres.2020.105250.

Jones IT, Schumm M, Stanley JA, Hanlon RT, and Mooney TA. 2023. Longfin squid reproductive behaviours and spawning withstand wind farm pile driving noise. ICES Journal of Marine Science, 2023, 1-10. https://doi.org/10.1093/icesjms/fsad117

Jones IT, Stanley JA, Mooney TA. 2020. Impulsive pile driving noise elicits alarm responses in squid (Doryteuthis pealeii). Marine Pollution Bulletin, 150, 110792. https://doi.org/10.1016/j.marpolbul.2019.110792.

Kjelland ME, Woodley CM, Swannack TM, Smith DL. 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. DOI 10.1007/s10669-015-9557-2.

Klimley AP, Wyman MT, Kavet R. 2017. Chinook salmon and green sturgeon migrate through San Francisco Estuary despite large distortions in the local magnetic field produced by bridges. PLoS ONE, 12(6): e0169031. https://doi.org/10.1371/journal.pone.0169031.

Kohut J, Brodie J. 2019. *White Paper-Partners in Science Workshop: Offshore Wind and the Mid-Atlantic Cold Pool*. New Brunswick (NJ): Rutgers, The State University of New Jersey; Hosted July 17, 2019. https://rucool.marine.rutgers.edu/wp-content/uploads/2020/10/PartnersWorkshop_WhitePaper_Final.pdf (Accessed December 2020).

Ladich F, Popper AN. 2004. *Parallel evolution in fish hearing organs*. In: Manley GA, Popper AN, Fay RR, editors. Evolution of the Vertebrate Auditory System NY, USA: Springer-Verlag. p. 98-127.

Lentz SJ. 2017. *Seasonal warming of the Middle Atlantic Bight Cold Pool*. Journal of Geophysical Research: Oceans, 122: 941-954.

Leonhard SB, Stenberg C, StØttrup J. 2011. *Effect of the Horns Rev 1 Offshore Wind Farm on Fish Communities Follow-up Seven Years after Construction*. DTU Aqua Report No 246-2011.

Madsen PT, Wahlberg M, Tougaard J, Lucke K, Tyack PL. 2006. *Wind turbine underwater noise and marine mammals: Implications of current knowledge and data needs*. Mar Ecol Prog Ser. 309:279-295.

MAFMC. 2016. Regional Use of the Habitat Area of Particular Concern (HAPC) Designation. Available at: https://www.mafmc.org/habitat (Accessed February 2021).

McPherson CR, Quijano JE, Weirathmueller MJ, Hiltz KR, Lucke K. 2019. *Browse to North-West-Shelf Noise Modelling Study: Assessing Marine Fauna Sound Exposures*. Technical report by JASCO Applied Sciences for Jacobs

Meißner K, Schabelon H, Bellebaum J, Sordyl H. 2006. *Impacts of submarine cables on the marine environment: A literature review*. Report by the Institute of Applied Ecology Ltd for the Federal Agency of Nature Conservation, Germany.

Miles, T., Murphy, S., Kohut, J., Borsetti, S., and Munroe, D., 2020. *Could federal wind farms influence continental shelf oceanography and alter associated ecological processes? A literature review*. Science Center for Marine Fisheries, Rutgers University. Available from https://scemfis.org/wp-content/uploads/2021/01/ColdPoolReview.pdf. (February 2021)

Miller TJ, Hare JA, Alade LA. 2016. *A state-space approach to incorporating environmental effects on recruitment in an age-structured assessment model with an application to southern New England yellowtail flounder*. Canadian Journal of Fisheries and Aquatic Sciences, 76(9): 1528-1540.

Mitson RB, Knudsen HP. 2003. *Causes and effects of underwater noise on fish abundance estimation*. Aquat Living Resour. 16(3):255-263.

Mooney TA, Hanlon RT, Christensen-Dalsgaard J, Madsen PT, Ketten DR, and Nachtigall PE. 2010. Sound detection by the longfin squid (Loligo pealeii) studied with auditory evoked potentials: sensitivity to low-frequency particle motion and not pressure. The Journal of Experimental Biology 213, 3748-3759. https://doi.org/10.1242/jeb.048348.

Mooney, TA, Samson JE, and Zacarias S. 2016. Loudness-dependent behavioral responses and habituation to sound by the longfin squid (Doryteuthis pealeii). Journal of Comparative Physiology A, 202(7):489-501. DOI:10.1007/s00359-016-1092-1.

Morley EL, Jones G, Radford AN. 2014. *The importance of invertebrates when considering the impacts of anthropogenic noise.* Proceedings of the Royal Society of London Series B. 281(1776).

Moum JN, Smyth WD. 2019. Upper Ocean Mixing. Encyclopedia of Ocean Sciences (3rd Edition). 1: 71-79.

Mueller-Blenkle C, McGregor PK, Gill AB, Andersson MH, Metcalfe J, Bendall V, Sigray P, Wood DT, Thomsen F. 2010. *Effects of Pile-driving Noise on the Behaviour of Marine Fis*h. COWRIE Ref: Fish 06-08; Cefas Ref: C3371.

Narvaez, D. A., D. M. Munroe, E. E. Hofmann, J. M. Klinck, and E. N. Powell, 2015: Long-term dynamics in Atlantic surfclam (Spisula solidissima) populations: the role of bottom water temperature. Journal of Marine Systems, 141, 136-148.

NMFS. 2021. *Updated Recommendations for Mapping Fish Habitat*. Gloucester (MA): NMFS GARFO Habitat Conservation and Ecosystem Services Division.

NOAA. 2005. *Notice of Public Scoping and Intent to Prepare an Environmental Impact Statement*. Federal Register. 70(7):1871-1875.

NOAA 2020a. Seagrasses [GIS dataset]. Available at: https://data.noaa.gov/dataset/dataset/seagrasses. Accessed January 27, 2023.

NOAA. 2020b. *Personal Communication*. Meeting between NOAA and EDR personnel. May 21, 2020.

NOAA. 2021a. *Essential Fish (EFH) Habitat Mapper*. Accessed September 24, 2018. https://www.habitat.noaa.gov/protection/efh/efhmapper/.

NOAA. 2021b. *Species Directory*. Available at: https://www.fisheries.noaa.gov/species-directory (Accessed February 2021).

New York State Department of Environmental Conservation (NYSDEC). 2021. Tidal Wetland Habitat. Available at: https://www.dec.ny.gov/lands/87643.html. Accessed January 2023.

New York State Energy Research and Development Authority (NYSERDA). 2017. New York State Offshore Wind Master Plan: Fish and Fisheries Study Final Report: 202 pages.

Normandeau, Exponent, Tricas T, and A. Gill. 2011. *Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species.* U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

Northeast Fisheries Science Center (NEFSC). 2021. Ecology of the Northeast US Continental Shelf – Physical Setting and Habitat. Available at: https://apps-nefsc.fisheries.noaa.gov/nefsc/ecosystem-ecology/physical.html. Accessed December 2021.

Olsen K, Agnell J, Pettersen F, Løvik A. 1983. *Observed fish reactions to a surveying vessel with special reference to herring, cod, capelin and polar cod.* FAO Fisheries Reports. 300:131-138.

Ona E, Godø OR, Handegard NO, Hjellvik V, Patel R, Pedersen G. 2007. *Silent research vessels are not quiet*. J Acoust Soc Am. 121(4):EL145-EL150.

Orr TL, Herz SM, Oakley DL. 2013. *Evaluation of Lighting Schemes for Offshore Wind Facilities and Impacts to Local Environments*. OCS Study. BOEM 2013-0116.

Pangerc T, Theobald PD, Wang LS, Robinson SP, Lepper PA. 2016. *Measurement and characterization of radiated underwater sound from a 3.6 MW monopile wind turbine*. J Acoust Soc Am. 140(4):2913-2922.

Paskyabi, M. B., 2015: Offshore Wind Farm Wake Effect on Stratification and Coastal Upwelling. Energy Procedia, 80, 131-140.

Paxton AB, Newton EA, Adler AM, Van Hoeck RV, Iversen ES, Taylor J, Peterson CH, Silliman BR. 2020. *Artificial habitats host elevated densities of large reef-associated predators*. PLoS ONE 15(9). https://doi.org/10.1371/journal.

Popper AN, Fay RR. 2011. *Rethinking sound detection by fishes*. Hear Res. 273(1):25-36.

Popper AN, Hastings MC. 2009. *The effects of human-generated sound on fish*. Integr Zool. 4(1):43-52.

Popper AN, Hawkins AD, Fay RR, Mann DA, Bartol S, Carlson TJ, Coombs S, Ellison WT, Gentry RL, Halvorsen MB et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles*: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. ASA Press and Springer.

Purser J, Radford AN. 2011. *Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks* (Gasterosteus aculeatus). PLoS ONE. 6(2):e17478.

Rausche F, Beim J. 2012. *Analyzing and Interpreting Dynamic Measurements Taken During Vibratory Pile Driving*. Paper presented at: International Conference on Testing and Design Methods for Deep Foundations. Kanazawa, Japan.

Reubens J, Degraer S. 2011. Aggregation and feeding behaviour of pouting (Trisopterus luscus) at wind turbines in the Belgian part of the North Sea. Fisheries Research 108(1):223-227. DOI:10.1016/j.fishres.2010.11.025

Riefolo L, Lanfredi C, Azzellino A, Tomasicchio GR, Felice DA, Penchev V, Vicinanza D. 2016. *Offshore wind turbines: an overview of the effects on the marine environment.* Paper presented at: 26th International Ocean and Polar Engineering Conference. International Society of Offshore and Polar Engineers; Rhodes, Greece.

Roberts, L., H. R. Harding, I. Voellmy, R. Bruintjes, S. D. Simpson, A.N. Radford, T. Breithaupt, and M. Elliott. 2016. Exposure of benthic invertebrates to sediment vibration: From laboratory experiments to outdoor simulated pile-driving. Proceedings of Meetings on Acoustics: Fourth International Conference on the Effects of Noise on Aquatic Life. 27: 1-10.

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.

Ross SW, Rhode M, Viada ST, Mather R. 2015. Fish species associated with shipwreck and natural hard-bottom habitats from the middle to outer continental shelf of the Middle Atlantic Bight near Norfolk Canyon. NOAA National Marine Fisheries Service. [accessed 14 October 2022] https://spo.nmfs.noaa.gov/sites/default/files/ross.pdf.

Sarà G, Dean JM, D'Amato D, Buscaino G, Oliveri A, Genovese S, Ferro S, Buffa G, Lo Martire M, Mazzola S. 2007. *Effect of boat noise on the behaviour of bluefin tuna Thunnus thynnus in the Mediterranean Sea.* Mar Ecol Prog Ser. 331:243-253.

Schwarz AL, Greer GL. 1984. *Responses of Pacific Herring, Clupea harengus pallasi, to Some Underwater Sounds*. Can J Fish Aquat Sci. 41(8):1183-1192.

Schweitzer, CC and Stevens, BG. 2019. The relationship between fish abundance and benthic community structure on artificial reefs in the Mid-Atlantic Bight, and the importance of sea whip corals Leptogorgia virgulate. PeerJ 7:e7277. https://doi.org/10.7717/peerj.7277.

Sherk JA, O'Connor JM, Neumann DA, Prince RD, Wood KV. 1974. Effects of suspended and deposited sediments on estuarine organisms. Phase II. University of Maryland Natural Resources Institute, Reference 74-20.

Solé M, Lenoir M, Durfort M, López-Bejar M, Lombarte A, van der Schaar M, and André M. 2013. Does exposure to noise from human activities compromise sensory information from cephalopod statocysts? Deep Sea Research Part II: Topical Studies in Oceanography, 95, 160-181. https://doi.org/10.1016/j.dsr2.2012.10.006.

Solé M, Sigray P, Lenoir M, van der Schaar M, Lalander E, and André M. 2017. Offshore exposure experiments on cuttlefish indicate received sound pressure and particle motion levels associated with acoustic trauma. Scientific Reports, 7, 45899. https://doi.org/10.1038/srep45899.

Solé M, De Vreese S, Fortuño JM, van der Schaar M, Sánchez AM, and André M. 2022. Commercial cuttlefish exposed to noise from offshore windmill construction show short-range acoustic trauma. Environmental Pollution, 312(1), 119853. https://doi.org/10.1016/j.envpol.2022.119853.

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. https://doi.org/10.1006/jmsc.1996.0064.

Stadler JH, Woodbury DP. 2009. *Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria*. Paper presented at: Inter-Noise 2009: Innovations in Practical Noise Control. Ottawa, Canada.

Steimle FW, Zetlin C. 2000. *Reef Habitats in the Middle Atlantic Bight: Abundance, Distribution, Associated Biological Communities, and Fishery Resource Use*. Marine Fisheries Review. 62(2).

Stenberg C, Støttrup JG, van Deurs M, Berg CW, Dinesen GE, Mosegaard H, Grome TM, Leonhard SB. 2015. *Long-term effects of an offshore wind farm in the North Sea on fish communities.* Mar Ecol Prog Ser. 528:257-265.

Stevens BG, Schweitzer C, Price A. 2019. Hab in the MAB: Characterizing Black Sea Bass Habitat in the Mid-Atlantic Bight. Final Report to the Atlantic Coastal Fish Habitat Partnership.

Stevenson, D. (2004). Characterization of the fishing practices and marine benthic ecosystems of the northeast U.S. shelf, and an evaluation of the potential effects of fishing on essential fish habitat. NOAA technical memorandum NMFS-NE ; 181.

Steves BP, Cowen RK, Malchoff MH. 1999. *Settlement and Nursery Habitats for Demersal Fishes on the Continental Shelf of the New York Bight*. Fish. Bull. 98:167–188.

Suedel BC, McQueen AD, Wilkens JL, and Fields MP. 2019. Evaluating Effects of Dredging-Induced Underwater Sound on Aquatic Species: A Literature Review. ERDC/EL TR-19-18. Available at: https://erdc-library.erdc.dren.mil/jspui/handle/11681/34245. Accessed March 2023.

Sullivan MC, Cowen RK, Steves BP. 2005. *Evidence for atmosphere-ocean forcing of yellowtail flounder (Limanda ferruginea) recruitment in the Middle Atlantic Bight*. Fisheries Oceanography, 14(5):386-399.

The Nature Conservancy. 2015. Northwest Atlantic Marine Ecosystem Assessment- Soft Sediments (Chapter 3) [dataset]. Arlington (VA): Conservation Gateway; [accessed 2020 December 16]. http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reports data/marine/data/Pages/default.aspx.

Thomsen F, Lüdemann K, Kafemann R, Piper W. 2006. *Effects of offshore wind farm noise on marine mammals and fish*. Hamburg, Germany: Report by Biola for COWRIE Ltd.

Topham E, McMillan D. 2017. *Sustainable decommissioning of an offshore wind farm*. Renewable Energy. 102:470-480.

Tougaard J, Madsen PT, Wahlberg M. 2008. *Underwater noise from construction and operation of offshore wind farms*. Bioacoustics. 17(1-3):143-146.

Toupoint, N., L. Gilmore-Solomon, F. Bourque, B. Myrand, F. Pernet, F. Olivier, and R. Tremblay, 2012: Match/mismatch between the Mytilus edulis larval supply and seston quality: effect on recruitment. Ecology, 93, 1922-1934.

Turner, EJ. Miller, DC. 1991. *Behavior and growth of Mercenaria during simulated storm events*. Mar Biol. 111:55-64.

University of Rhode Island (URI). 2021. *Habitat Restoration: Species Gallery.* Available at: https://www.edc.uri.edu/restoration/html/gallery/seagrass.htm (Accessed February 2021).

U.S. Department of Energy, Minerals Management Service (USDOE). (2009). Final Environmental Impact Statement for the Proposed Cape Wind Energy Project, Nantucket Sound, Massachusetts (Adopted), DOE/EIS-0470. Retrieved from https://www.boem.gov/Cape-Wind-FEIS/.

Vabø R, Olsen K, Huse I. 2002. *The effect of vessel avoidance of wintering Norwegian spring spawning herring*. Fish Res. 58(1):59-77.

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

Virginia Institute of Marine Sciences (VIMS). 2021. Life History of Striped Sea Bass. Available at: https://www.vims.edu/research/departments/fisheries/programs/striped_bass_assessment_program/life_history/index.php (Accessed March 2021).

Voynova, Y. G., M. J. Oliver, and J. H. Sharp. 2013: *Wind to zooplankton: Ecosystem-wide influence of seasonal wind-driven upwelling in and around the Delaware Bay.* J. Geophys. Res. Oceans, 118, 6437-6450. doi:10.1002/2013JC008793.

Wahlberg M, Westerberg H. 2005. *Hearing in fish and their reactions to sounds from offshore wind farms*. Mar Ecol Prog Ser. 288:295-309.

Walsh HJ, Richardson DE, Marancik KE, and Hare JA. 2015. Long-Term Changes in the Distributions of Larval and Adult Fish in the Northeast U.S. Shelf Ecosystem. PLoS ONE, 10(9): e0137382. DOI:10.1371/journal.pone.0137382.

Watling, L and Norse, EA. 1998. Disturbance of the Seabed by Mobile Fishing Gear: A Comparison to Forest Clearcutting. Conservation Biology, 12(6), 1180-1197. https://doi.org/10.1046/j.1523-1739.1998.0120061180.x.

West Point Partners, LLC. 2013. *Application to the United States Army Corps of Engineers (New York District) for a Department of the Army Individual Permit. Volume 1 of 2.* Fairfield (CT): West Point Partners, LLC. http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BC191AEEA-9CFF-4D39-9654-E21B59A3629A%7D.

Wiernicki CJ, Liang D, Bailey H, and Secor DH. 2020. The Effect of Swim Bladder Presence and Morphology on Sound Frequency Detection for Fishes. Reviews in Fisheries Science and Aquaculture, 28(4), 459-477. https://doi.org/10.1080/23308249.2020.1762536.

Wilber, DH and Clarke, DG. 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: 4, 855-875. https://doi.org/10.1007/s10669-015-9557-2.

Wilber, DH and Clarke, DG. 2007. Defining and assessing benthic recovery following dredging and dredged material disposal. Presentation from the 2007 WODCON XVIII Conference in Lake Buena Vista, FL.

Wilber DH, Brown L, Griffin M, DeCelles GR, and Carey DA. 2022. Demersal fish and invertebrate catches relative to construction and operation of North America's first offshore wind farm. ICES Journal of Marine Science, 2022, 0, 1–15. DOI:10.1093/icesjms/fsac051.

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

Woodruff DL, Schultz IR, Marshall KE, Ward JA, Cullinan VI. 2012. *Effects of Electromagnetic Fields on Fish and Invertebrates, Task 2.1.3: Effects on Aquatic Organisms Fiscal Year 2011 Progress Report*. Prepared for U.S. Department of Energy. Richland, Washington: Pacific Northwest National Laboratory.

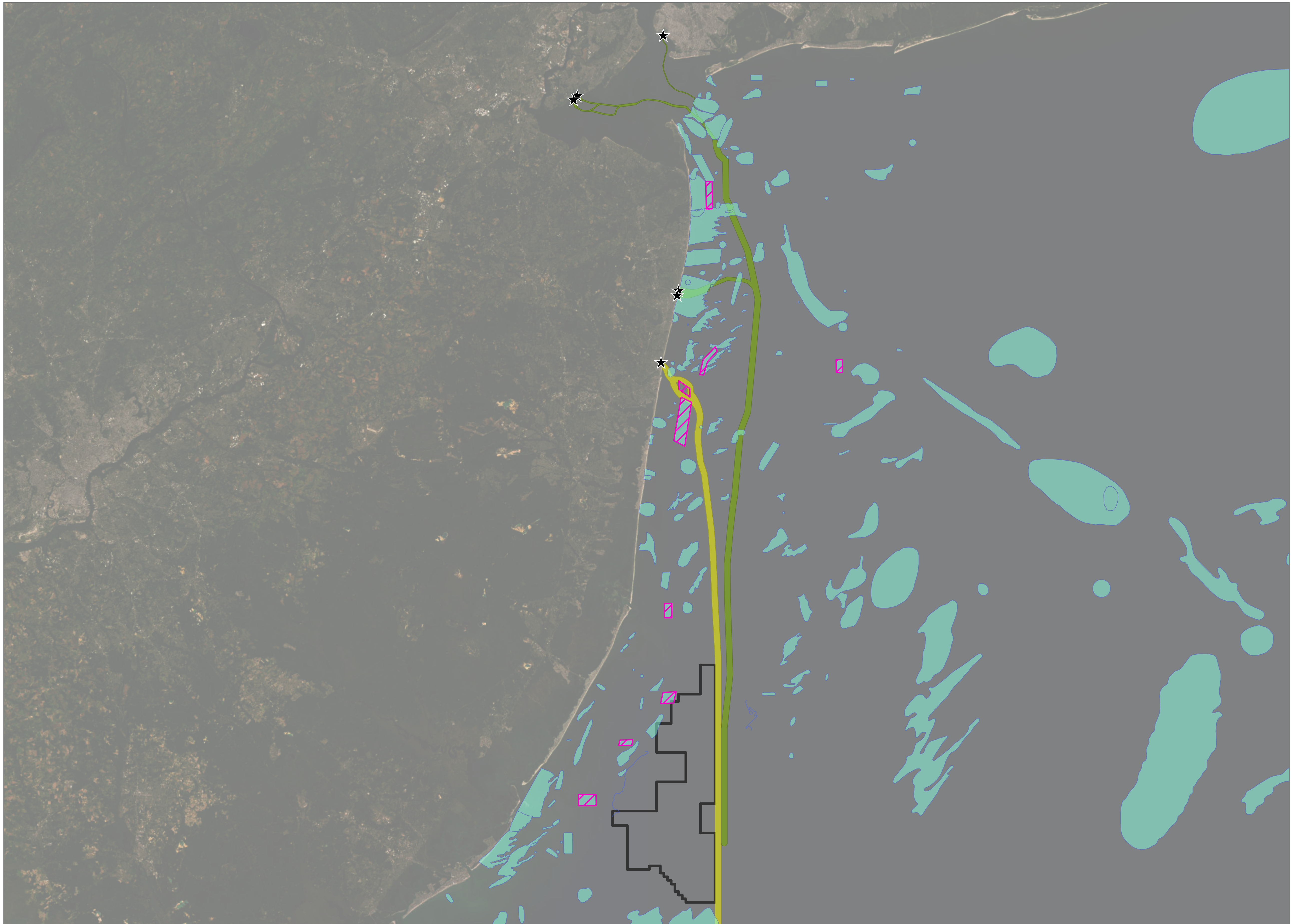
Woodruff DL, Schultz IR, Marshall KE, Ward JA, Cullinan VI. 2013. *Effects of Electromagnetic Fields on Fish and Invertebrates, Task 2.1.3: Effects on Aquatic Organisms, Fiscal Year 2012 Progress Report*. PNNL-22154. Prepared for U.S. Department of Energy. Richland, Washington: Pacific Northwest National Laboratory.

Wysocki LE, Amoser S, Ladich F. 2007. *Diversity in ambient noise in European freshwater habitats: Noise levels, spectral profiles, and impact on fishes*. J Acoust Soc Am. 121(5):2559-2566.

Zykov MM, Bailey L, Deveau TJ, Racca RG. 2013. *South Stream Pipeline – Russian Sector – Underwater Sound Analysis*. Technical report by JASCO Applied Sciences for South Stream Transport B.V.

Figures

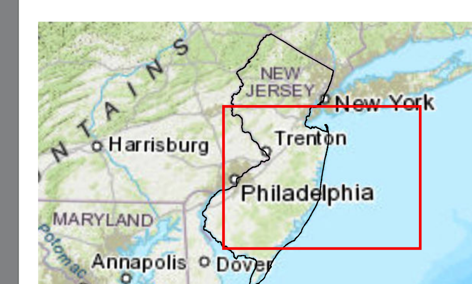
Figure 2. Artificial Reef and Prime Fishing Areas



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

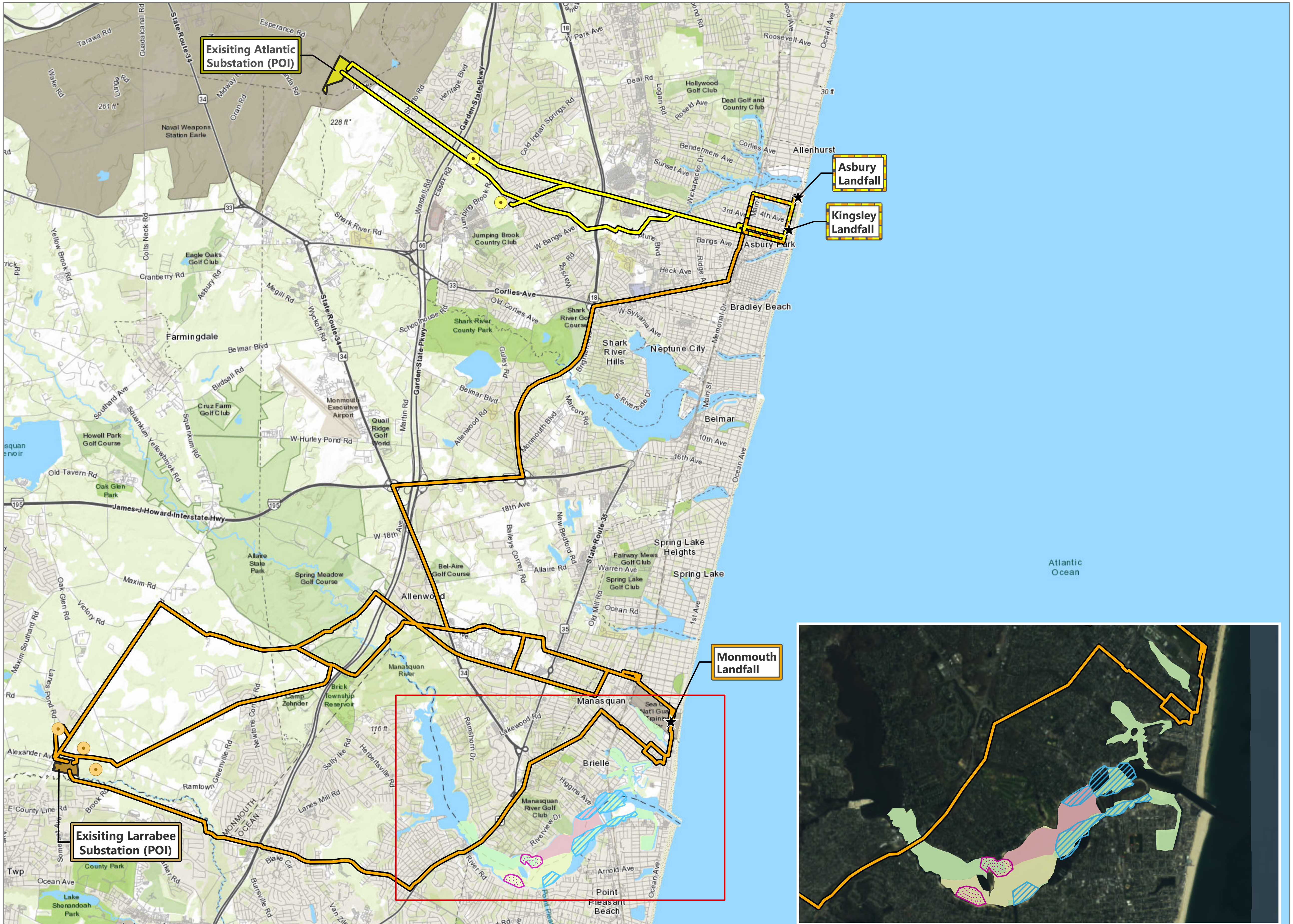
Prime Fishing Area
Artificial Reef Site
Potential Landfall
Monmouth Export Cable Corridor (ECC)
Northern Export Cable Corridor (ECC)
Atlantic Shores Lease Area OCS-A-0549



0 5 10
Miles

Prepared September 21, 2023
Basemap: ESRI ArcGIS Online "World Imagery" map service.

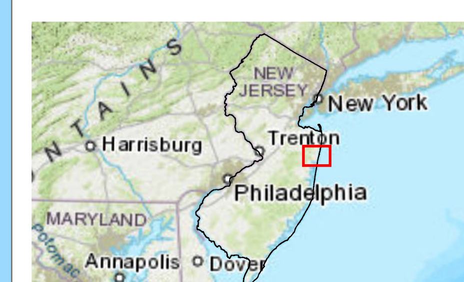
Figure 3. New Jersey Project Vicinity Historic Shellfish Locations



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- ★ Potential Landfall
- Potential Atlantic Substation and/or Converter Station
- Potential Larrabee Substation and/or Converter Station
- Larrabee Onshore Interconnection Route Option
- Atlantic Onshore Interconnection Route Option
- Atlantic and/or Larrabee Onshore Interconnection Route Option
- Potential Atlantic Point of Interconnection (POI)
- Potential Larrabee Point of Interconnection (POI)
- Mussels
- Soft Clams
- Hard Clams- High
- Hard Clams - Moderate
- Hard Clams - Ocurrence



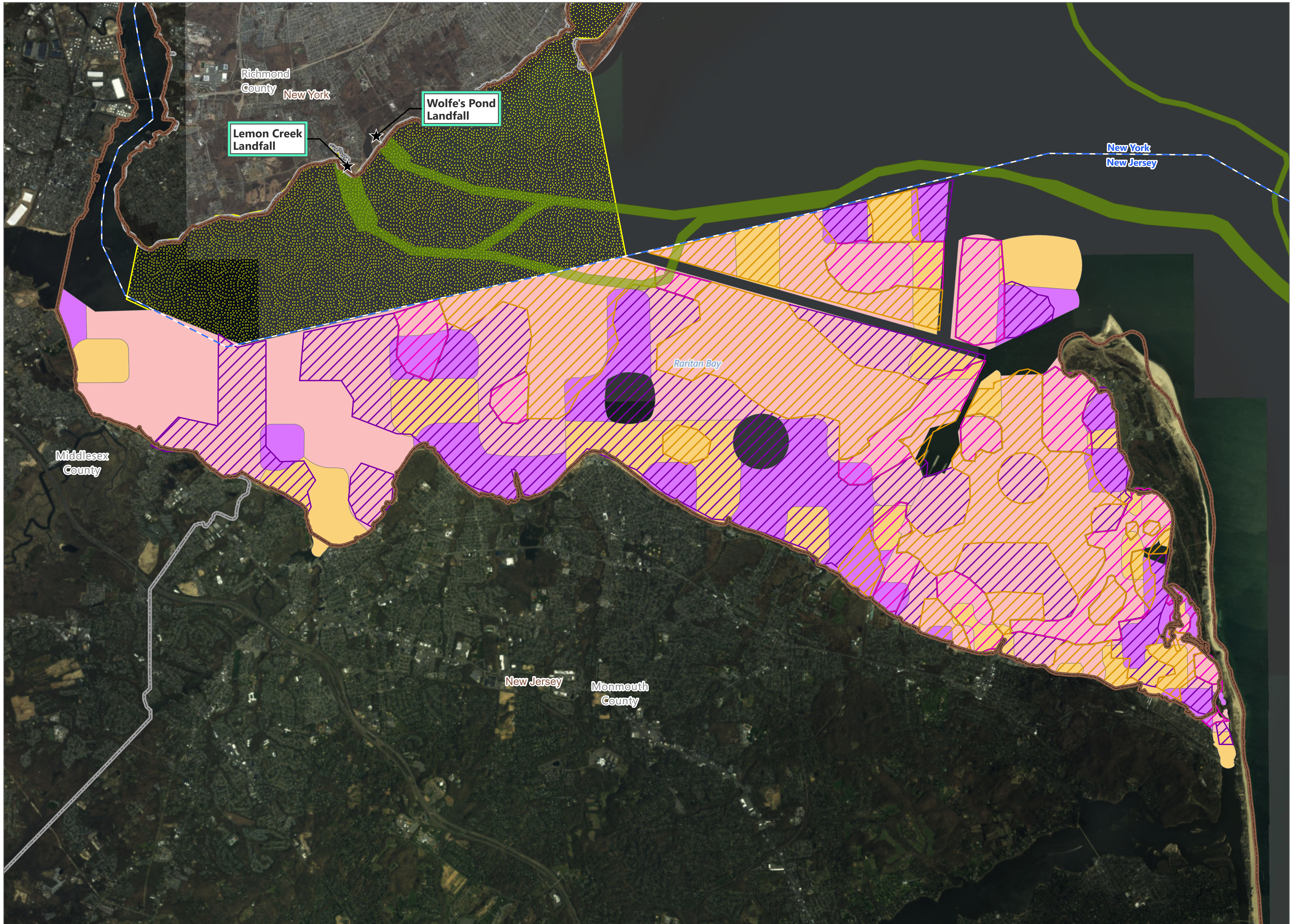
0 1 2
Miles

Prepared September 21, 2023
Basemap: ESRI "World Topo Map" map service.

ATLANTIC SHORES offshore wind

EDR

Figure 4a. Hard Clam Occurrence within Raritan Bay



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

★ Potential Landfall
Federal And State Water Boundary
Hard Clam Occurence
2014 - High
2014 - Moderate
2014 - Occurence
1983 - High
1983 - Moderate
1983 - Occurrence
NYSDEC Productive Hard Clam Area
Northern Export Cable Corridor (ECC)

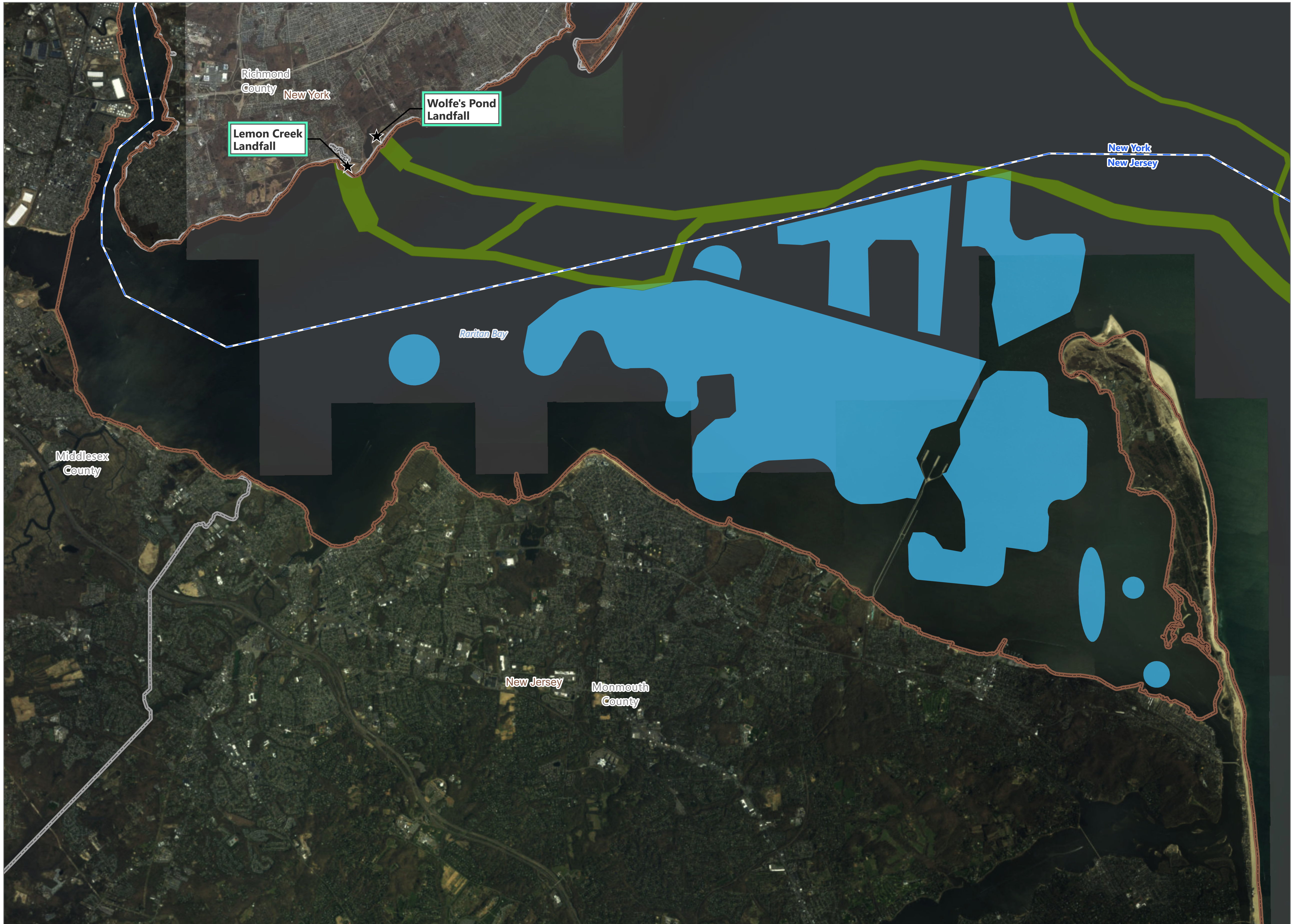
0 1 2
Miles

Prepared September 21, 2023
Basemap: Basemap: NJ Office of GIS "2020" Natural Color imagery and ESRI "World Imagery" map service.

ATLANTIC SHORES offshore wind

EDR

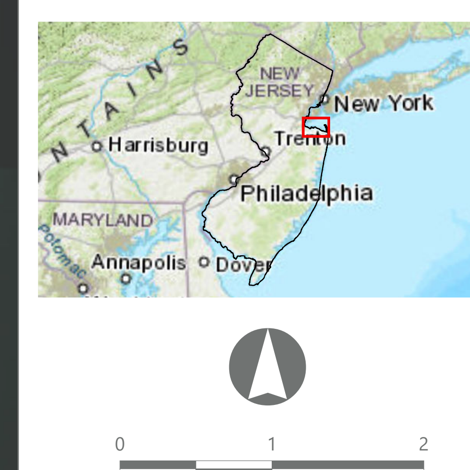
Figure 4b. Mussel Occurrence within Raritan Bay



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- ★ Potential Landfall
- Federal and State Water Boundary
- 2014 Blue Mussels
- Northern Export Cable Corridor (ECC)



Prepared September 21, 2023

Basemap: NJ Office of GIS "2020" Natural Color imagery and ESRI "World Imagery" map service.

ATLANTIC SHORES offshore wind

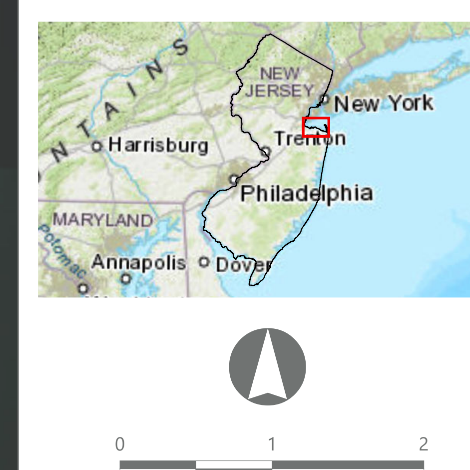
EDR

Figure 4c. Oyster Bed Occurrence within Raritan Bay

Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- ★ Potential Landfall
- Federal and State Water Boundary
- 1983 Oysters
- Northern Export Cable Corridor (ECC)



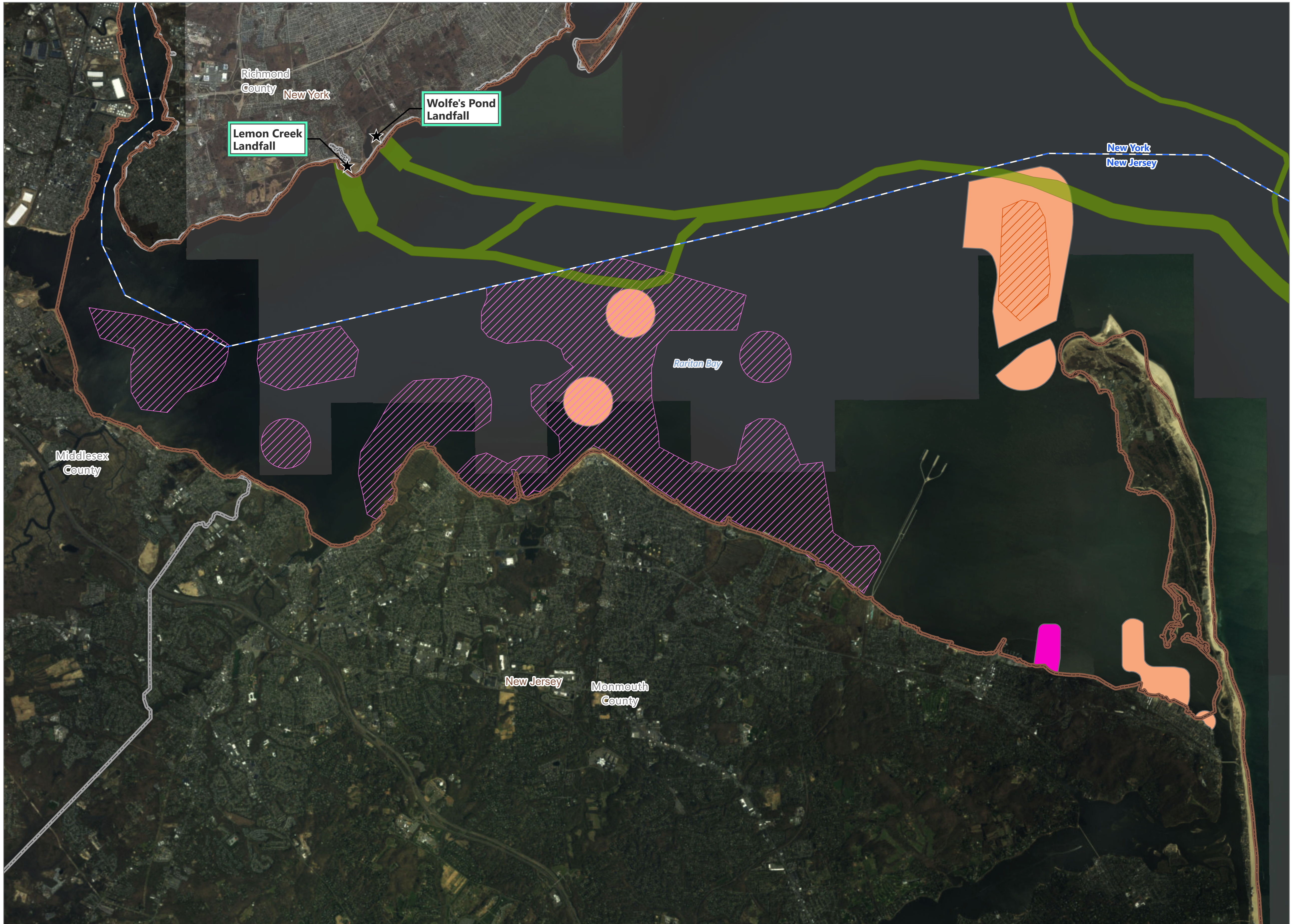
Prepared September 21, 2023

Basemap: Basemap: NJ Office of GIS "2020" Natural Color imagery and ESRI "World Imagery" map service.

ATLANTIC SHORES offshore wind

EDR

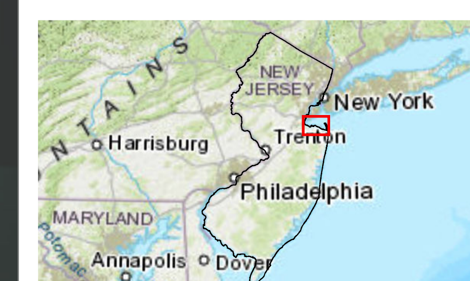
Figure 4d. Soft and Surf Clam Occurrence within Raritan Bay



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

Potential Landfall
Federal and State Water Boundary
2014 Soft Clams
2014 Surf Clams
1983 Soft Clams
1983 Surf Clams
Northern Export Cable Corridor (ECC)



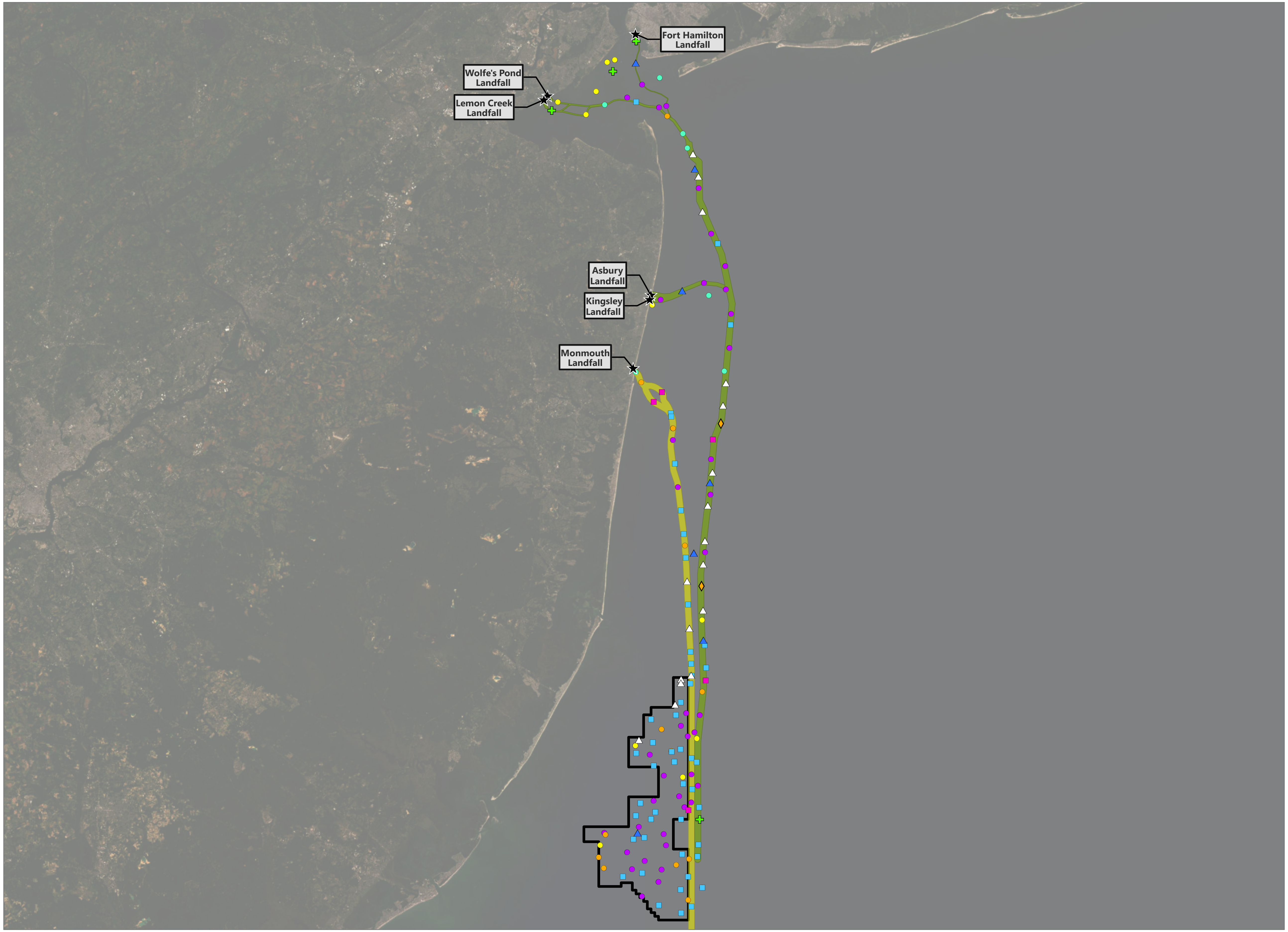
0 1 2
Miles

Prepared September 21, 2023
Basemap: Basemap: NJ Office of GIS "2020" Natural Color imagery and ESRI "World Imagery" map service.

ATLANTIC SHORES offshore wind

EDR

Figure 5. NMFS CMECS Classifications



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

Grab Sample Site
- Sandy Mud

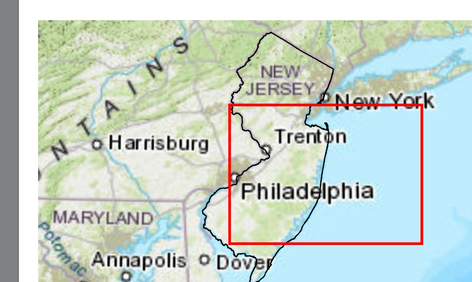
Sands (<5% gravel)
- Fine/Very Fine Sand
- Medium Sand
- Muddy Sand
- Very Coarse/Coarse Sand

Gravelly (5 - <30% gavel)
- Gravelly Muddy Sand
- Gravelly Sand

Gravel Mixes (30 to <80% gravel)
- Sandy Gravel
- Muddy Sandy Gravel

Gravels (≥80% gravel)
- Gravel (Pebble/Granule)

- Potential Landfall
- Monmouth Export Cable Corridor (ECC)
- Northern Export Cable Corridor (ECC)
- Atlantic Shores Lease Area OCS-A 0549



0 5 10
Miles

Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Imagery" map service.

ATLANTIC SHORES offshore wind

EDR

Figure 6. Proportion of NMFS CMECS Sediments in the Lease Area, Monmouth ECC and Northern ECC

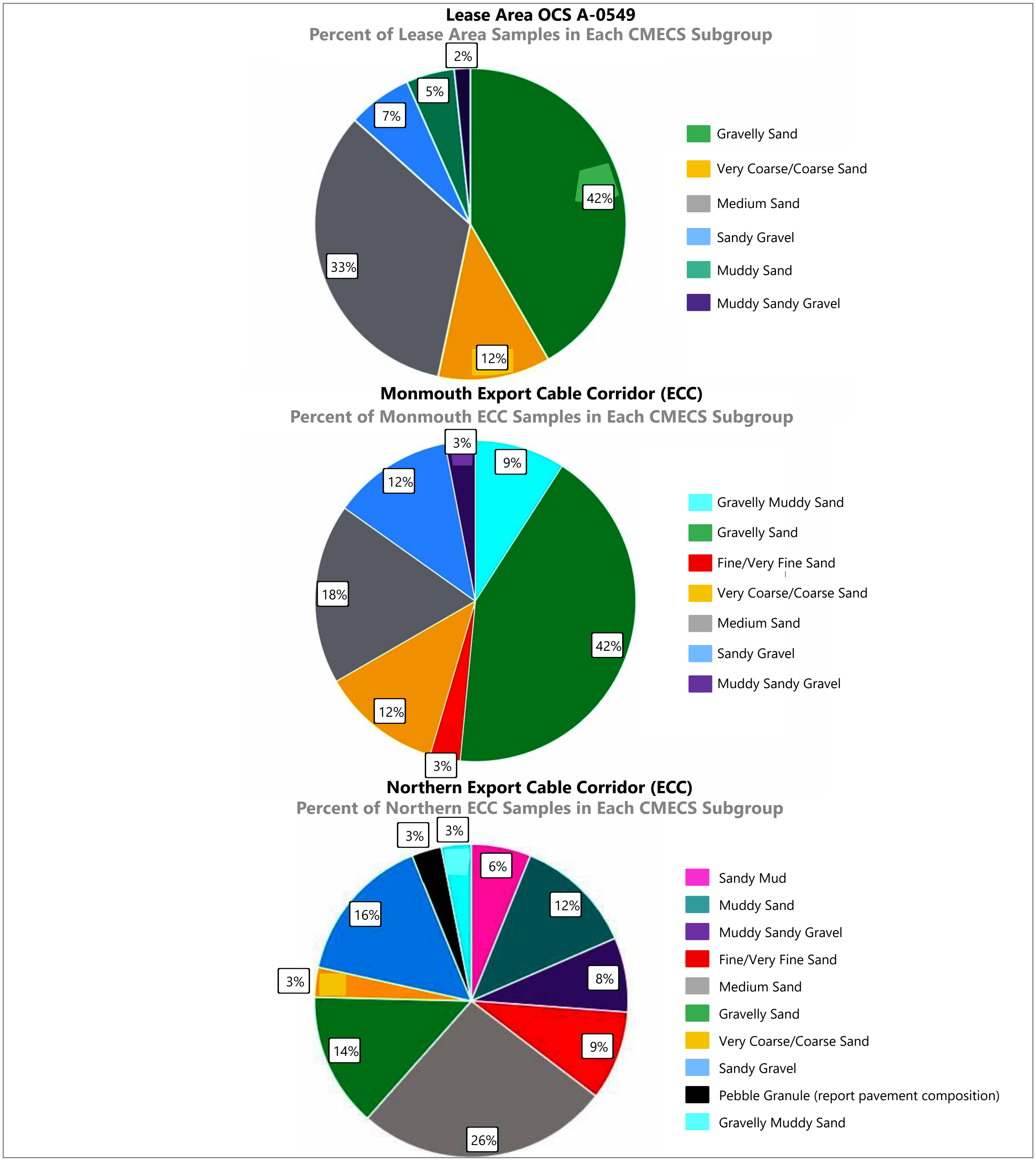
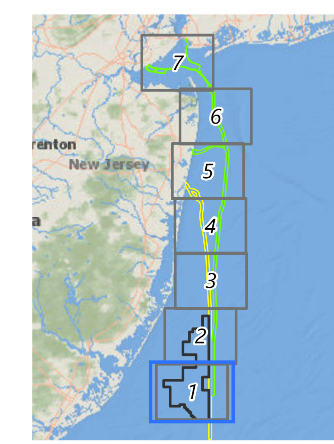


Figure 7. Habitat Types in Offshore Project Area

Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

Soft Bottom
Heterogeneous Complex
Complex
Wind Turbine Generators
Monmouth Export Cable Corridor (ECC)
Northern Export Cable Corridor (ECC)
Atlantic Shores Lease Area OCS-A 0549



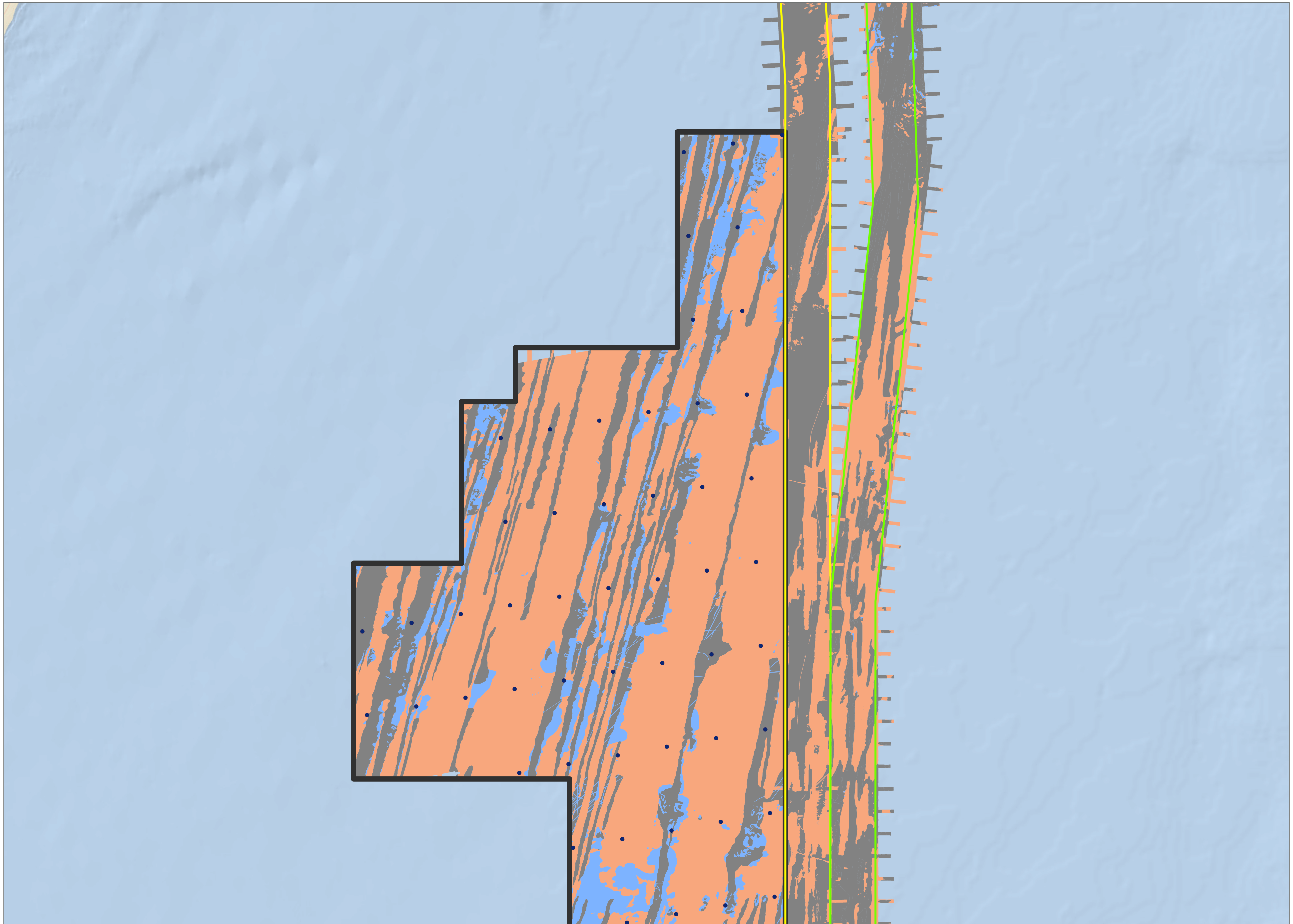
0 1 2
Miles

Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Ocean Basemap" map service.

ATLANTIC SHORES offshore wind

EDR

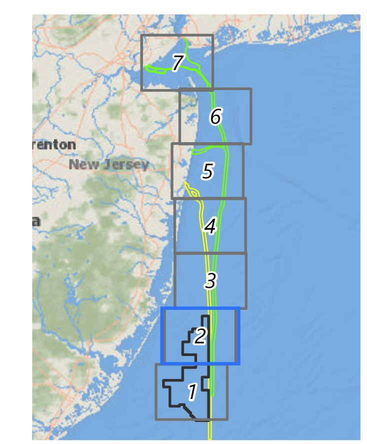
Figure 7. Habitat Types in Offshore Project Area

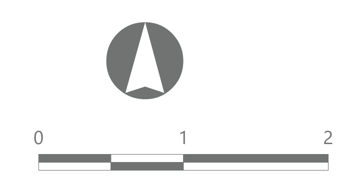


Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- Soft Bottom
- Heterogeneous Complex
- Complex
- Wind Turbine Generators
- Monmouth Export Cable Corridor (ECC)
- Northern Export Cable Corridor (ECC)
- Atlantic Shores Lease Area OCS-A 0549





Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Ocean Basemap" map service.

ATLANTIC SHORES offshore wind

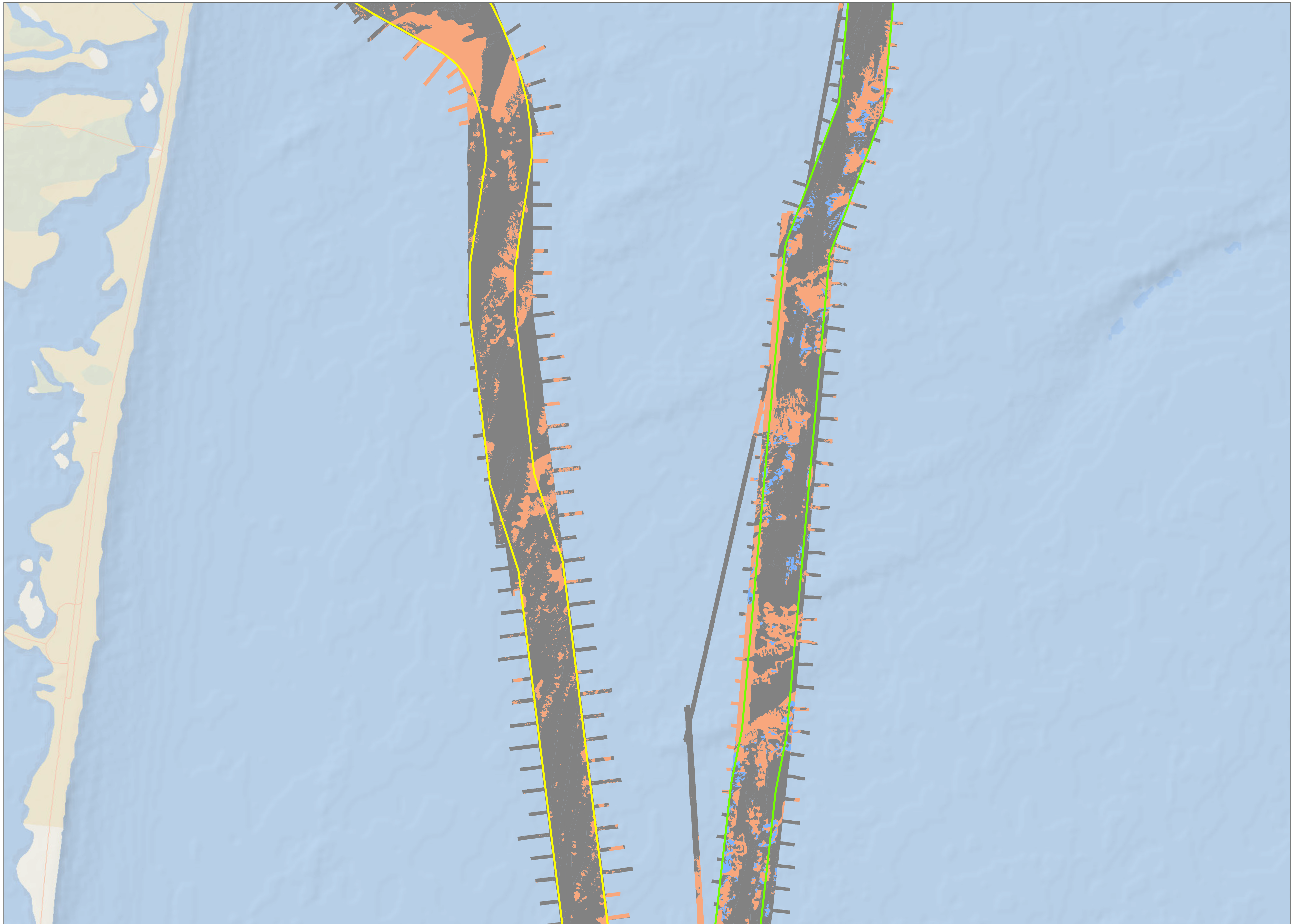
EDR

Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Ocean Basemap" map service.

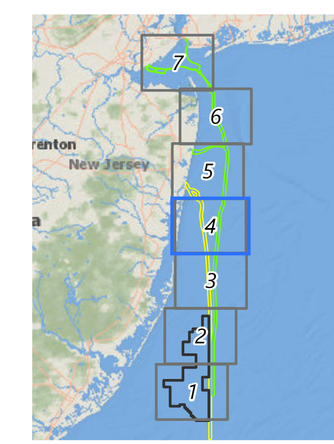
Figure 7. Habitat Types in Offshore Project Area

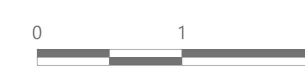


Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- Soft Bottom
- Heterogeneous Complex
- Complex
- Monmouth Export Cable Corridor (ECC)
- Northern Export Cable Corridor (ECC)



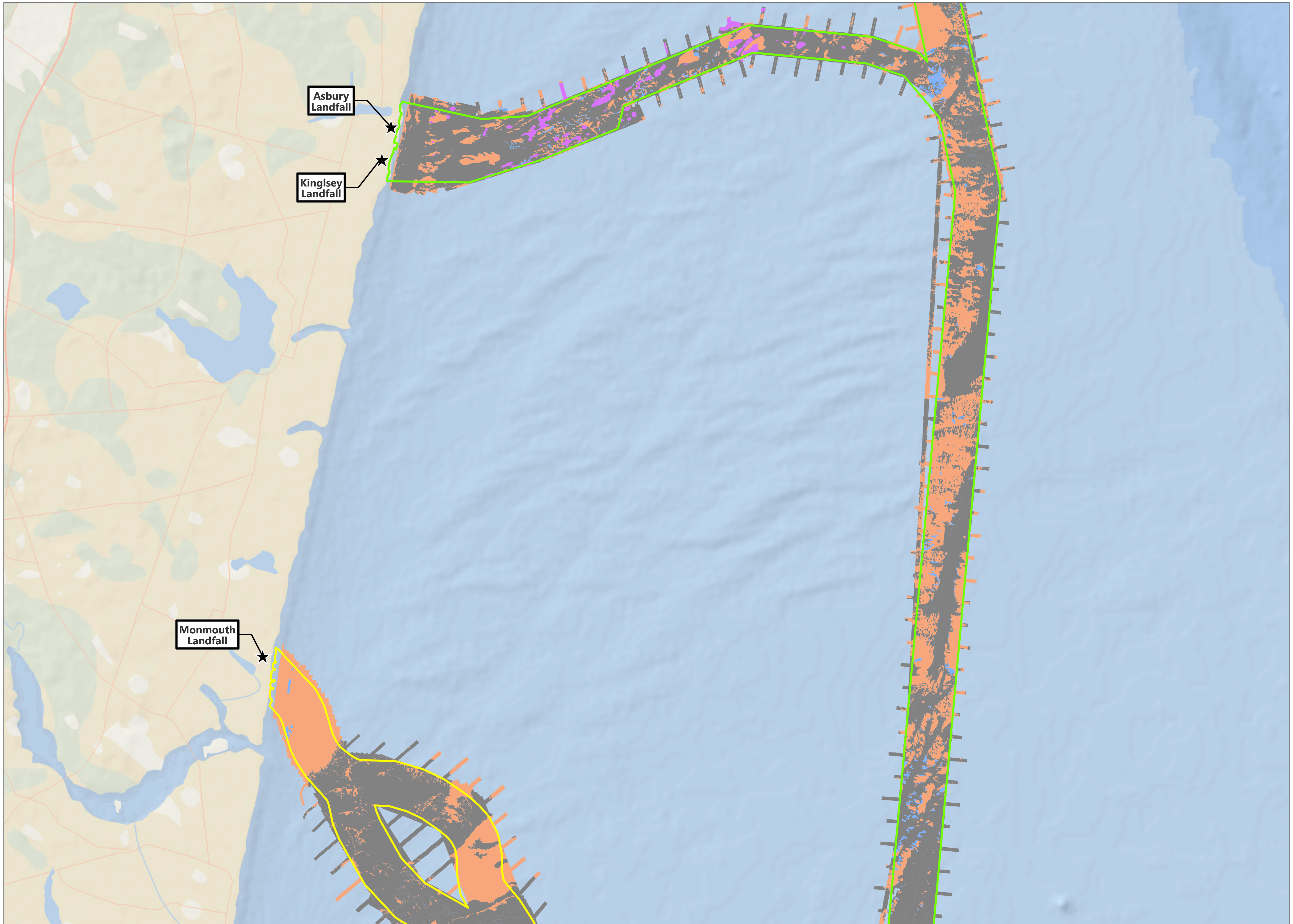


Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Ocean Basemap" map service.

ATLANTIC SHORES offshore wind

EDR

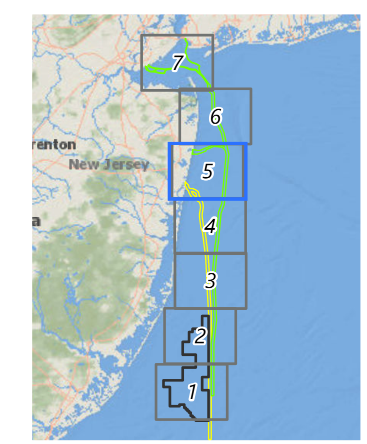
Figure 7. Habitat Types in Offshore Project Area



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

Soft Bottom
Heterogeneous Complex
Complex Large Grain
Complex
Potential Landfall
Monmouth Export Cable Corridor (ECC)
Northern Export Cable Corridor (ECC)



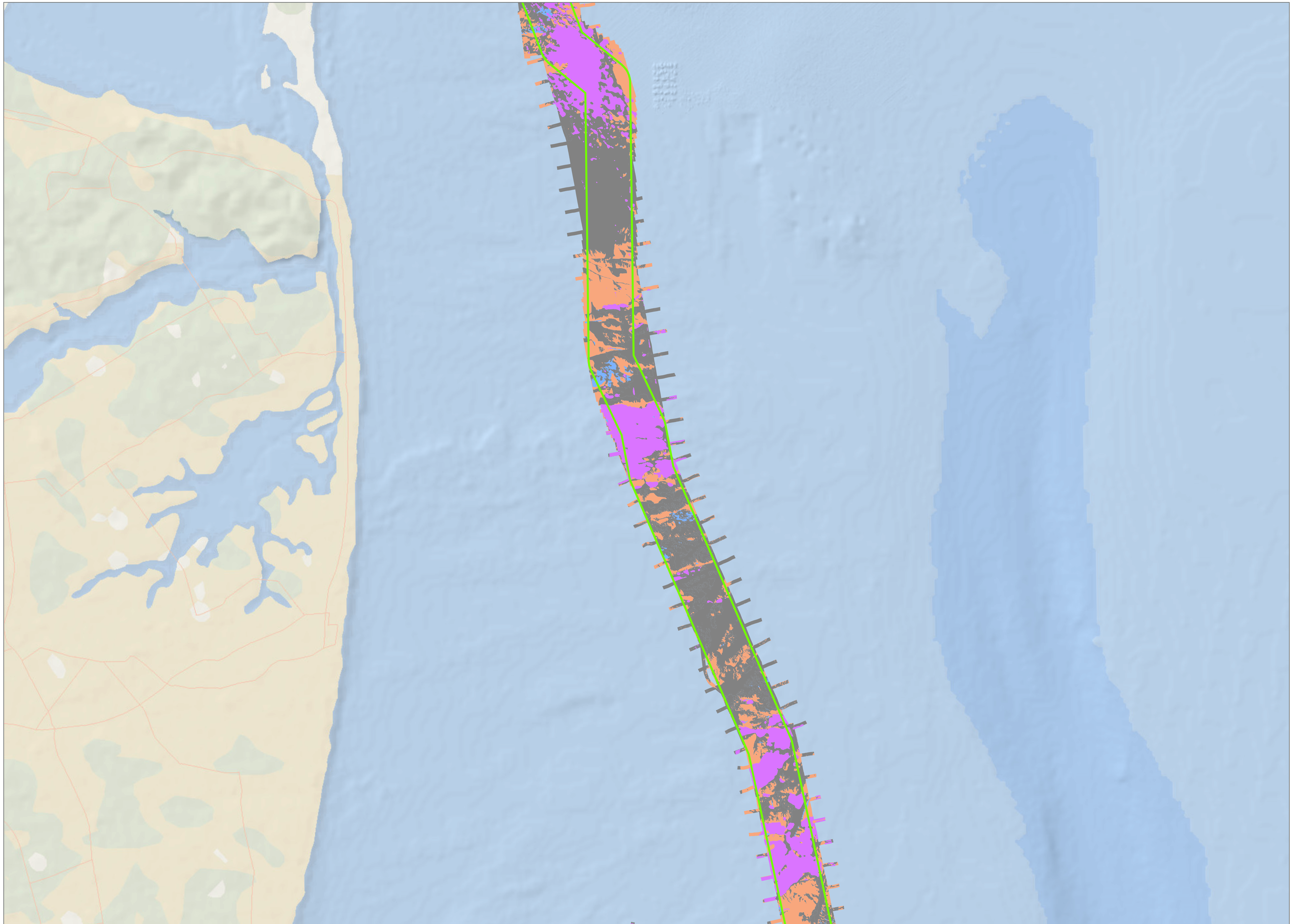
0 1 2
Miles

Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Ocean Basemap" map service.

ATLANTIC SHORES offshore wind

EDR

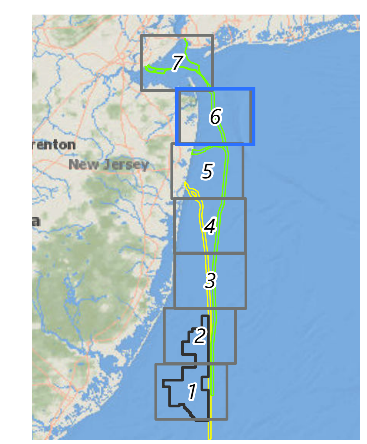
Figure 7. Habitat Types in Offshore Project Area



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

Soft Bottom
Heterogeneous Complex
Complex Large Grain
Complex
Northern Export Cable Corridor (ECC)



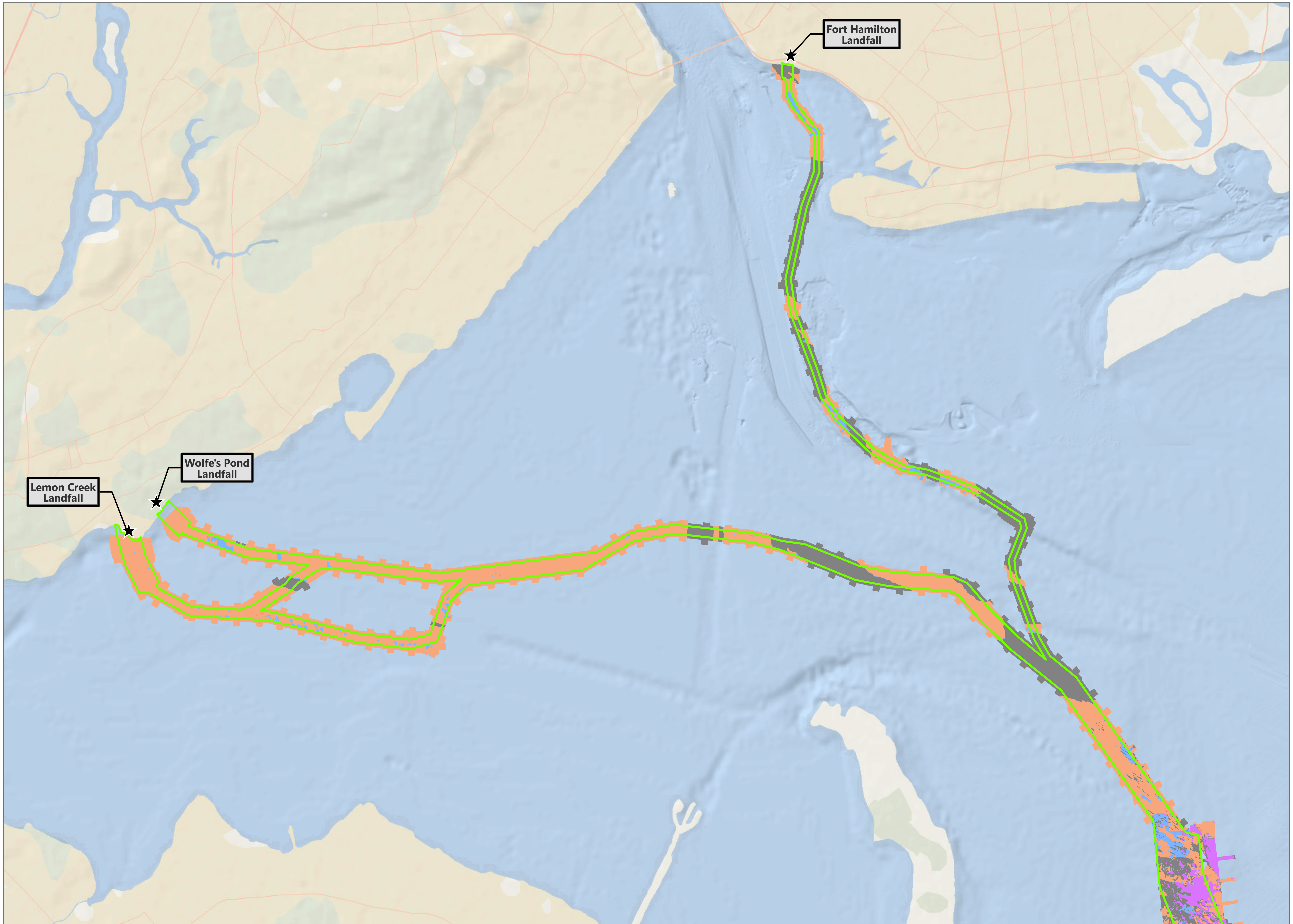
0 1 2
Miles

Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Ocean Basemap" map service.

ATLANTIC SHORES offshore wind

EDR

Figure 7. Habitat Types in Offshore Project Area



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

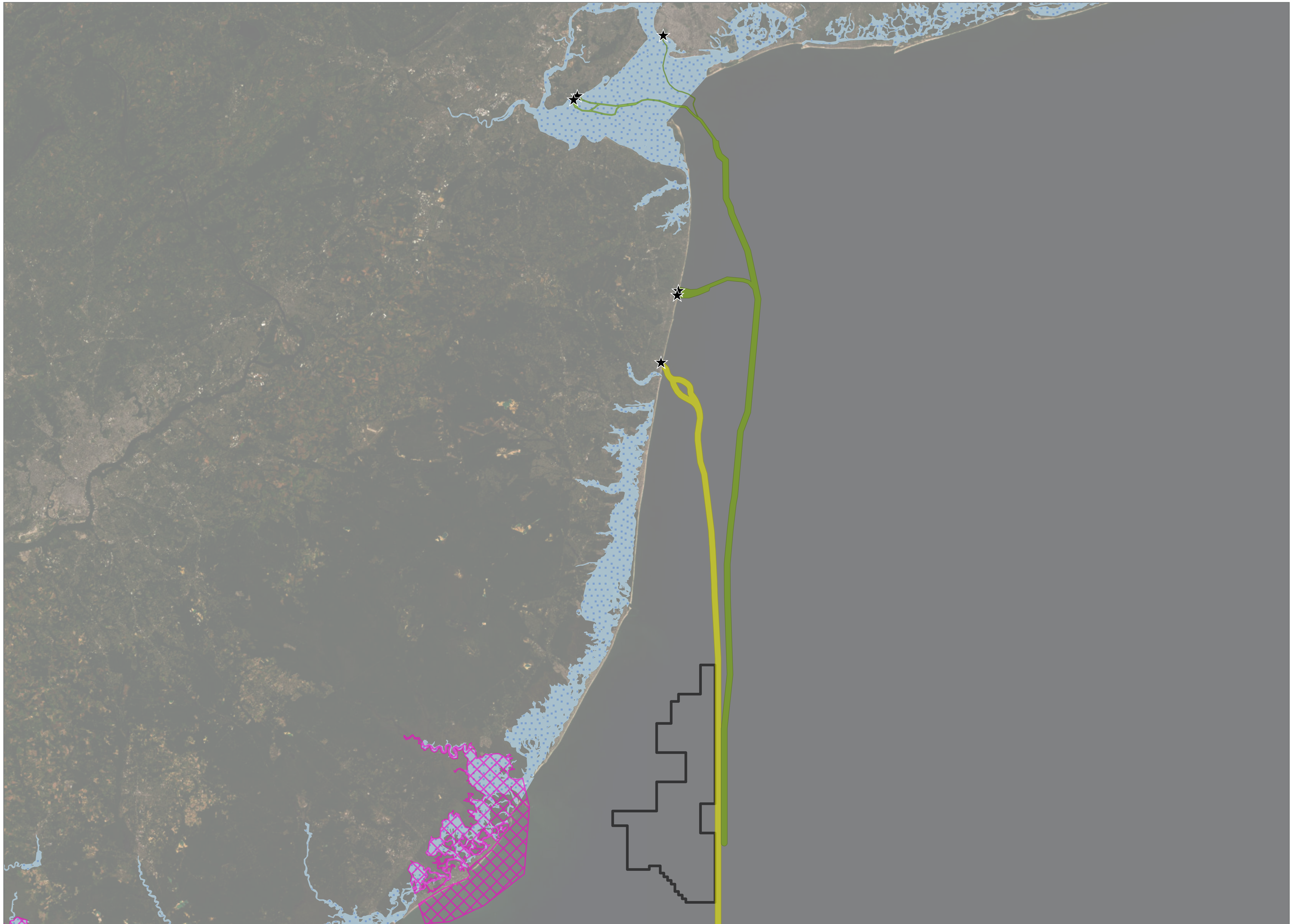
- Soft Bottom
- Heterogeneous Complex
- Complex Large Grain
- Complex
- ★ Potential Landfall
- Northern Export Cable Corridor (ECC)

Prepared September 21, 2023
Basemap: Esri ArcGIS Online "World Ocean Basemap" map service.

ATLANTIC SHORES offshore wind

EDR

Figure 8. Potential Habitat Area of Particular Concern for Summer Flounder and Sandbar Shark

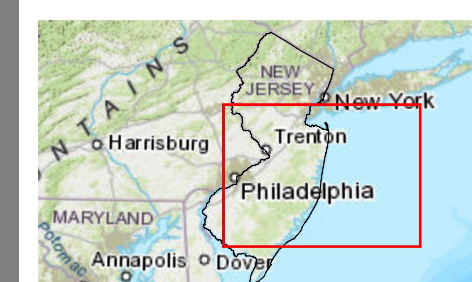


Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- Potential Summer Flounder Habitat Area of Particular Concern (HAPC)
- Sandbar Shark Habitat Area of Particular Concern (HAPC)
- Potential Landfall
- Monmouth Export Cable Corridor (ECC)
- Northern Export Cable Corridor (ECC)
- Atlantic Shores Lease Area OCS-A-0549

Map Note: Due to the dynamic nature of submerged aquatic vegetation and the differences in local mapping, the detailed region-wide mapping of this HAPC is not available. HAPC will only be present in areas verified to contain SAV. According to seagrass data mapped by NOAA, which compiles data from multiple state and local sources, there is no known areas of SAV along the Northern ECC Branches.



0 5 10
Miles

Prepared September 21, 2023
Basemap: ESRI ArcGIS Online "World Imagery" map service.

ATLANTIC SHORES offshore wind

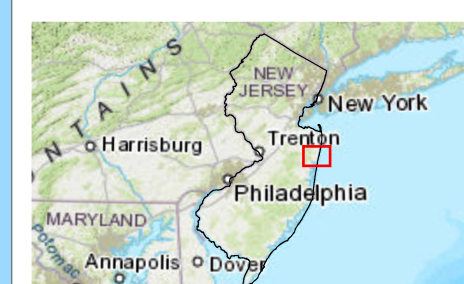
EDR

Figure 9. New Jersey Project Vicinity Submerged Aquatic Vegetation

Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- ★ Potential Landfall
- Potential Atlantic Substation and/or Converter Station
- Potential Larrabee Substation and/or Converter Station
- Larrabee Onshore Interconnection Route Option
- Atlantic Onshore Interconnection Route Option
- Atlantic and/or Larrabee Onshore Interconnection Route Option
- Potential Atlantic Point of Interconnection (POI)
- Potential Larrabee Point of Interconnection (POI)
- NJDEP Previously Documented Location of Submerged Aquatic Vegetation (SAV)



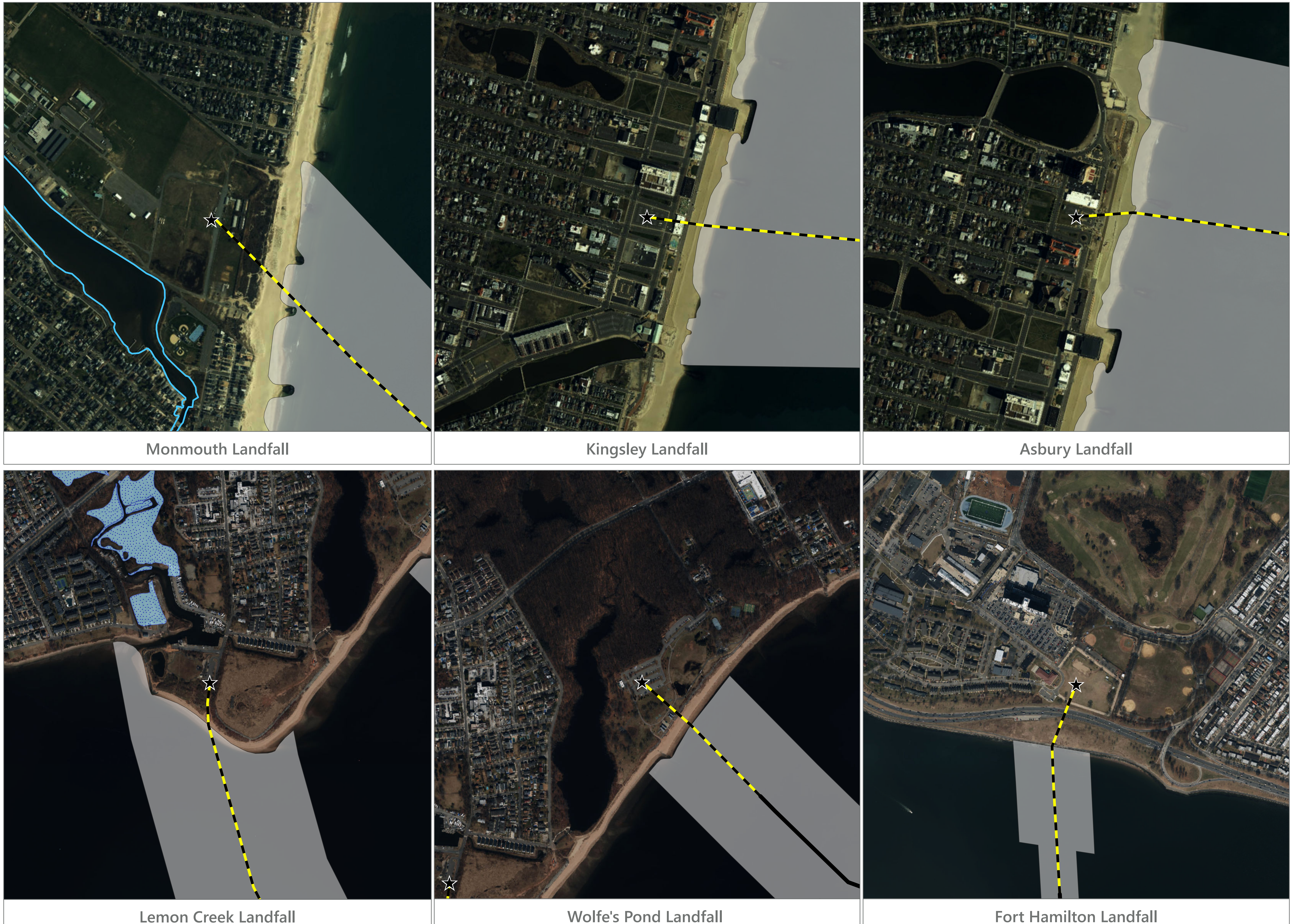
0 1 2
Miles

Prepared September 21, 2023
Basemap: ESRI "World Topo Map" map service.

ATLANTIC SHORES offshore wind

EDR

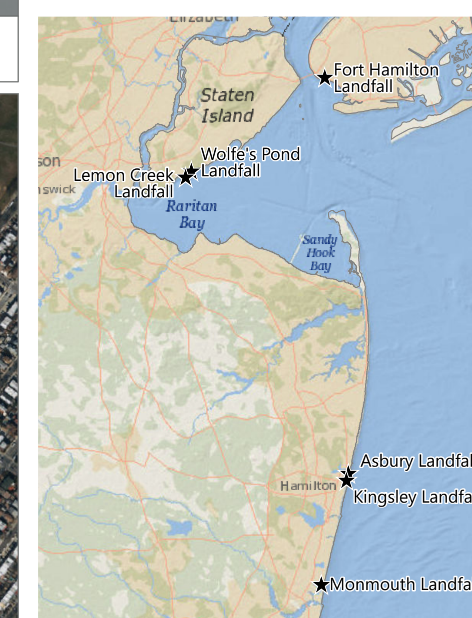
Figure 10. Tidal Wetlands at Landfall Locations



Atlantic Shores North Offshore Wind COP and Permitting

Essential Fish Habitat Technical Report

- ★ Potential Landfall
- NJDEP Tidelands Claim Line
- HDD Submarine Export Cable
- Export Cable Corridor (ECC)
- NJDEP Tidal Wetlands NJDEP Tidal Wetlands
- NYSDEC Tidal Wetlands



0 500 1,000
Feet

Prepared September 21, 2023
Basemap: NJ Office of GIS "2020" Natural Color Imagery and NYSDOP "2022" orthoimagery map service.

ATLANTIC SHORES offshore wind

EDR

Attachment 1

Description of EFH Species and Life Stages

1.0 INTRODUCTION

Essential Fish Habitat (EFH) for a variety of species was identified within the Lease Area OCS-A 0549 (the Lease Area), Monmouth Export Cable Corridor (ECC), Northern ECC, and Northern ECC Branches[1] (collectively referred to as the Offshore Project Area). Essential Fish Habitat is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" and requires that the regional fishery management councils, through Fishery Management Plans (FMPs), "describe and identify EFH" for the improved management of that fishery. EFH is typically assigned by egg, larvae, juvenile, and adult life stages and designated as habitat for waters or substrates. NOAA Fisheries further defines the terms associated with EFH (50 CFR § 600.10) as:

- Waters – Aquatic areas and their associated physical, chemical, and biological properties that are used by fish and, where appropriate, may include aquatic areas historically used by fish;
- Substrate – Sediments, hard bottoms, structures underlying the waters, and associated biological communities;
- Necessary – The habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and,
- Spawning, breeding, feeding, or growth to maturity – Stages representing a species' full life cycle.

The following sections describe the life stages of EFH-designated species in the Offshore Project Area. EFH definitions were obtained from the EFH Mapper webpage (NOAA, 2021) that provides links to the appropriate FMP for each species. Although Atlantic Shores recognizes that EFH is based on the habitat that supports species and life stages and not the actual presence of those life stages and species, for context on the actual presence of EFH species in the Offshore Project Area, Atlantic Shores included additional information, where available, on species abundance and seasonal presence. Some of the primary sources used for additional species information include EFH source documents, fishery management plans, federal and state trawl surveys[2], and other available literature.

---

[1] There are six branches associated with the Northern ECC: Asbury, Wolfe Pond, Lemon Creek, Fort Hamilton, Midland, and South Beach.

[2] Data from federal and state trawl surveys within the Offshore Project Area were compiled for surveys conducted between 2008 and 2021. Locations of these surveys overlap with the Lease Area, Monmouth ECC, and Northern ECC; none of the survey locations overlap with the Northern ECC Branches. Therefore, results from trawl surveys in the Offshore Project Area are reflective of conditions within the Lease Area, Monmouth ECC, and Northern ECC only.

2.0 NEW ENGLAND FISHERY MANAGEMENT COUNCIL FINFISH SPECIES

EFH for species managed under FMPs developed by the New England Fishery Management Council (NEFMC) are covered under the Omnibus Essential Fish Habitat Amendment 2 (NEFMC, 2017). Sixteen NEMFC finfish species, including skates, have designated EFH in the Offshore Project Area.

2.1 Atlantic Cod

Eggs: EFH is designated for Atlantic cod (*Gadus morhua*) eggs throughout the entirety of the Asbury Northern ECC Branch, the northern portion of the Monmouth ECC and Northern ECC, and the southern portions of the remaining Northern ECC Branches (Wolfe Pond, Lemon Creek, Fort Hamilton, South Beach, and Midland). No EFH is designated in the Lease Area. EFH is defined as the pelagic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic region, as shown on Map 38 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017) and in high salinity zones of the bays and estuaries listed in Table 19 of NEFMC (2017). According to NEFSC's Marine Resources Monitoring, Assessment and Prediction (MARMAP) program, Atlantic cod eggs can be found year round from the Gulf of Maine to Cape Hatteras, with higher abundance in spring and lowest densities in late-summer (NOAA, 1999a). The highest densities of Atlantic cod eggs have been observed in the Gulf of Maine compared to waters off the New England coast (NOAA, 1999a).

Larvae: EFH is designated for Atlantic cod larvae throughout the entirety of the Asbury Northern ECC Branch, the northern and western portions of the Lease Area, along central and northern portions of the Monmouth ECC and Northern ECC, and southern portions of the remaining Northern ECC Branches. EFH is defined as the pelagic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic region, as shown on Map 39 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), and in the high salinity zones of the bays and estuaries listed in Table 19 of NEFMC (2017). According to MARMAP Icthyoplankton surveys that spanned from the Gulf of Maine to Cape Hatteras, larvae were abundant year-round throughout the surveyed region. Off the coast of New Jersey, larvae were most abundant in spring and least abundant in late-summer and fall (NOAA, 1999a).

Adults: EFH is designated for Atlantic cod adults in the southeastern part of the Lease Area, and in the Asbury Northern ECC Branch, and along portions of the Monmouth ECC and most of the Northern ECC. No EFH is designated in the remaining Northern ECC branches. EFH includes sub-tidal benthic habitats in the Gulf of Maine, south of Cape Cod, and on Georges Bank, between 30 and 160 meters (98 to 525 feet) as shown on Map 41 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including high-salinity zones in the bays and estuaries listed in Table 19 of (NEFMC, 2017). 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 (230 feet) (NEFMC, 2017). Guida et al. (2017) examined

NEFSC seasonal trawl surveys throughout the entire New Jersey Wind Energy Area from 2003 to 2016 which did not result in any catch of Atlantic cod. During federal and state trawl surveys, Atlantic cod were collected year-round in the Offshore Project Area.

2.2 Atlantic Herring

Larvae: EFH is designated for Atlantic herring (*Clupea harengus*) eggs in the northern portions of the following Northern ECC Branches: Wolfe Pond, Lemon Creek, Fort Hamilton, Midland, and South Beach. No EFH is designated for Atlantic herring eggs in the Lease Area, Monmouth ECC, Northern ECC, or Asbury Northern ECC Branch. EFH includes inshore and offshore benthic habitats in the Gulf of Maine and on Georges Bank and Nantucket Shoals in depths of 5 – 90 meters on coarse sand, pebbles, cobbles, and boulders and/or macroalgae at the locations shown in Map 98. Eggs adhere to the bottom, often in areas with strong bottom currents, forming egg "beds" that may be many layers deep (NEMFC, 2017).

Juveniles: EFH is designated for Atlantic herring juveniles throughout the entire Offshore Project Area. EFH is defined as intertidal and sub-tidal pelagic habitats to 300 meters (984 feet) throughout the region, as shown on Map 100 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the bays and estuaries listed in Table 30 of (NEFMC, 2017). One and two-year old juveniles form large schools and make limited seasonal inshore-offshore migrations. Older juveniles are usually found in water temperatures of 3 to 15 °C (37.4 to 59 °F) in the northern part of their range and as high as 22 °C (71 °F) in the Mid-Atlantic. Young-of-the-year juveniles can tolerate low salinities, but older juveniles avoid brackish water (NEFMC, 2017). According to MARMAP survey results, the majority of juvenile Atlantic herring are caught between depths of 30 to 90 meters (98 to 295 feet) in spring, 15 to 135 meters (49 to 443 feet) in summer, and 30 to 60 meters (98 to 197 feet) in fall and winter (NOAA, 1999b). On the inner shelf off the coast of New Jersey the lowest abundance of juvenile Atlantic herring occurs in the summer and fall. The highest abundance of juveniles occurs in the spring (NOAA, 1999b).

Adults: EFH is designated for Atlantic herring adults throughout the entire Offshore Project Area. EFH is defined as sub-tidal pelagic habitats with maximum depths of 300 meters (984 feet) throughout the region, as shown on Map 100 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the bays and estuaries listed in Table 30 of NEFMC (2017). 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 (328 feet) and – unless they are preparing to spawn – usually remain near the surface. They typically avoid water temperatures above 10 °C (50 °F) and low salinities. Spawning takes place on the bottom, generally in depths of 5 to 90 meters (16 to 295 feet) on a variety of substrates (NEFMC, 2017); however, since eggs are not designated as EFH in the Offshore Project Area, spawning is also not expected to occur in the Offshore Project Area. Adult and juvenile Atlantic herring have similar geographic ranges and seasonal distributions (NOAA, 1999b). During federal and state trawl surveys, Atlantic herring were collected year-round in the Offshore Project Area.

2.3 Clearnose Skate

Juveniles: EFH is designated for juvenile clearnose skate (*Raja eglanteria*) throughout the entire Northern ECC Branches, and the majority of the Lease Area, Monmouth ECC and Northern ECC. EFH is defined as sub-tidal benthic habitats in coastal and inner continental shelf waters from New Jersey to the St. Johns River in Florida as shown on Table 28 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of Chesapeake Bay, Delaware Bay, and the other bays and estuaries listed in Table 28 of NEFMC (2017). EFH for juvenile clearnose skates occurs from the shoreline to 30 meters (98 feet), primarily on mud and sand, but also on gravelly and rocky bottom (NEFMC, 2017).

Adults: EFH is designated for adult clearnose skate throughout the entire Northern ECC and Northern ECC Branches, and throughout the majority of the Lease Area and Monmouth ECC. EFH is defined as sub-tidal benthic habitats in coastal and inner continental shelf waters from New Jersey to Cape Hatteras as shown on Map 96 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of Chesapeake Bay, Delaware Bay, and the other bays and estuaries listed in Table 28 of NEFMC (2017). EFH for adult clearnose skates occurs from the shoreline to 40 meters (131 feet), primarily on mud and sand, but also on gravelly and rocky bottom (NEFMC, 2017). Adult clearnose skates migrate seasonally between inshore and offshore environments. In the winter, adults will concentrate offshore on the continental shelf out to a depth up to 200 meters (656 feet) and inshore during the spring and summer (NOAA, 2003a). During federal and state trawls, clearnose skates were collected year-round in the Offshore Project Area.

2.4 Haddock

Juveniles: EFH is designated for juvenile haddock (*Melanogrammus aeglefinus*) in the eastern half of the Lease Area and the southern portions of the Monmouth and Northern ECCs. No EFH is designated in the Northern ECC Branches. EFH is defined as sub-tidal benthic habitats between 40 and 140 meters (131 to 459 feet) in the Gulf of Maine, on Georges Bank and in the Mid-Atlantic region, and as shallow as 20 meters (66 feet) along the coast of Massachusetts, New Hampshire, and Maine, as shown on Map 46 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017). 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 (NEFMC, 2017). Haddock are known to range from West Greenland to Cape Hatteras with most species distribution typically concentrated around the Gulf of Maine and Georges Bank (NOAA, 1999s). Haddock were collected year-round in federal and state trawl surveys in the Offshore Project Area.

2.5 Little Skate

Juveniles: EFH is designated for juvenile little skate (*Leucoraja erinacea*) throughout the entire Offshore Project Area. EFH is defined as 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 (262 feet), as shown on Map 90 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), and including high salinity zones in the bays and estuaries listed in Table 28 of NEFMC (2017). EFH for juvenile little skates occurs on sand and gravel substrates, but they are also found on mud (NEFMC, 2017). Juvenile little skates migrate seasonally between inshore and offshore environments. In winter, juveniles can be found offshore out to the 200 meters (656 foot) depth contour from Georges Bank to Cape Hatteras (NOAA, 2003b). In the spring, juveniles can be found inshore throughout the Mid-Atlantic Bight (NOAA, 2003b).

Adults: EFH is designated for adult little skate throughout the Northern ECC Branches, in a few small areas in the northern portion of the Lease Area, and in northern and central portions of the Monmouth and Northern ECCs. EFH is defined as 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 (328 feet), as shown on Map 91 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), and including high salinity zones in the bays and estuaries listed in Table 28 of NEFMC (2017). EFH for adult little skates occurs on sand and gravel substrates, but they are also found on mud (NEFMC, 2017). Seasonal migration between inshore environments in the spring and offshore environments in the fall and winter have been observed in adult little skate (NOAA, 2003b). According to the NJDEP Environmental Baseline Study, which examined species composition along the New Jersey coastline, little skate were among the ten most dominant species collected during NJDEP OSAP surveys collected from 2003 to 2008 from Barnegat Bay to Hereford Inlet (Geo-Marine, 2010). During federal and state trawl surveys, little skates were collected year-round in the Offshore Project Area.

2.6 Monkfish

Eggs/Larvae: EFH is designated for monkfish (*Lophius americanus*) eggs/larvae throughout the entire Asbury Northern ECC Branch, the majority of the Lease Area except for the southeastern portion, the majority of the Monmouth and Northern ECCs, and the southern portions of the remaining Northern ECC Branches. EFH is defined as pelagic habitats in inshore areas, and on the continental shelf and slope throughout the Northeast region, as shown on Map 82 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017). 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 1,000 to 1,500 meters (3280 to 4921 feet) on the continental slope (NEFMC, 2017). Based on NEFSC MARMAP Icthyoplankton surveys, monkfish eggs and larvae have been collected between Cape Cod and Cape Hatteras (NOAA, 1999c). Peak monkfish larvae abundance occurs between May and July off the coast of New Jersey in offshore environments (NOAA, 1999c). Monkfish larvae are seldom present in inshore environments (NOAA, 1999c).

Adults: EFH is designated for monkfish adults in a very small area in the northern and southern portions of the Lease Area, and in small central portions of the Monmouth and Northern ECCs.

No EFH is designated in the Northern ECC Branches. EFH is defined as sub-tidal benthic habitats in depths of 50 to 400 meters (164 to 1,312 feet) in southern New England and Georges Bank, between 20 and 400 meters (66 to 1312 feet) in the Gulf of Maine, and to a maximum depth of 1,000 meters (328 feet) on the continental slope, as shown on Map 84 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017). EFH for adult monkfish is composed of hard sand, pebbles, gravel, broken shells, and soft mud. They seem to prefer soft sediments (fine sand and mud) over sand and gravel, and, like juveniles, utilize the edges of rocky areas for feeding (NEFMC, 2017). Monkfish migrate between inshore and offshore environments based on water temperatures (Geo-Marine, 2010). Based on NEFSC bottom trawl data from 1963 to 1997, adult monkfish can occur year-round off the coast of New Jersey (NOAA, 1999c). Their presence has also been documented by NJDEP OSAP trawl surveys off the coast of New Jersey from 2003 to 2008 as reported in the NJDEP Baseline Study (Geo-Marine, 2010). Monkfish distribution along the Mid-Atlantic Bight has been linked to food availability (Wood, 1982 as referenced in NOAA, 1999c). Monkfish distribution has been associated with the presence of silver hake (*Merluccius bilinearis*), spiny dogfish (*Squalus acanthias*), and red hake, all of which have been documented by state and federal trawls in the Offshore Project Area (Colvocoresses and Musick, 1984 as referenced in NOAA, 1999c). During more recent federal trawl surveys, monkfish were collected in small quantities in the Offshore Project Area; however, no monkfish were collected within the Offshore Project Area during state trawl surveys.

2.7 Ocean Pout

<u>Eggs</u>: EFH is designated for ocean pout (*Macrozoarces americanus*) throughout the entirety of the Northern ECC and Asbury Northern ECC Branch, the majority of the Lease Area (with the exception of the very most southern portion), the majority of the Monmouth ECC, and the southern portions of the remaining Northern ECC Branches. EFH is defined as hard bottom habitats on Georges Bank, in the Gulf of Maine, and in the Mid-Atlantic Bight as shown on Map 48 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), as well as the high salinity zones of the bays and estuaries listed in Table 20 of NEFMC (2017). Eggs are laid in gelatinous masses, generally in sheltered nests, holes, or rocky crevices. EFH for ocean pout eggs occurs in depths less than 100 meters (328 feet) on rocky bottom habitats (NEFMC, 2017).

<u>Adults</u>: EFH is designated for ocean pout adults throughout the entirety of the Northern ECC and Asbury Northern ECC Branch, the majority of the Lease Area (with the exception of the very most southern portion), the majority of the Monmouth ECC, and the southern portions of the remaining Northern ECC Branches. EFH is defined as sub-tidal benthic habitats between 20 and 140 meters (65 to 459 feet) 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 several bays and estuaries north of Cape Cod as shown on Map 50 and Table 20 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017). EFH for adult ocean pout includes mud and sand, particularly in association with structure forming habitat types (e.g., 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 (328 feet) (NEFMC, 2017). Based on NMFS trawl surveys conducted between 1968 and 1967, ocean pout inhabit inshore environments off the coast of New Jersey in the spring, and offshore environments in the fall and winter (NOAA, 1999d). The same trawling data indicated low adult abundance in the summer in both inshore and offshore environments off the coast of New Jersey (NOAA, 1999d). During federal and state trawl surveys, ocean pout were collected year-round in the Offshore Project Area.

2.8 Pollock

Larvae: EFH is designated for pollock (*Pollachius virens*) larvae along northern and central portions of the Monmouth ECC, and a central portion of the Northern ECC. No EFH is designated in the Lease Area or Northern ECC Branches. EFH is defined as pelagic inshore and offshore habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic region, as shown on Map 52 of the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the bays and estuaries listed in Table 21 of NEFMC (2017). Based on MARMAP icthyoplankton surveys conducted between 1977 and 1987, pollock larvae have been collected off the coast of New Jersey from February to May in both inshore and offshore environments (NOAA, 1999e).

2.9 Red Hake

EFH is designated for red hake (*Urophycis chuss*) eggs/larvae/juveniles throughout the entire Offshore Project Area.

Eggs/Larvae: EFH is defined as pelagic habitats in the Gulf of Maine, on Georges Bank, and in the MidAtlantic, as shown on Map 77 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), and in the bays and estuaries listed in Table 27 of NEFMC (2017). Red hake egg distribution is seasonally dependent. In the winter, eggs are typically located on the edge of the continental shelf throughout the Mid-Atlantic Bight (NOAA, 1999f). During warmer months, eggs can be found across the entire continental shelf (NOAA, 1999f). Based on ichthyoplankton surveys conducted between 1978 and 1987, eggs were most prevalent off the coast of New Jersey between May and October (NOAA, 1999f). Ichthyoplankton surveys conducted between 1982 and 1987 found evidence of larval red hake off the coast of New Jersey between the months of July and November (NOAA, 1999f).

Juveniles: EFH is defined as intertidal and sub-tidal benthic habitats throughout the region on mud and sand substrates, to a maximum depth of 80 meters (262 feet), as shown on Map 77 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the bays and estuaries listed in Table 27 of NEFMC (2017). Bottom habitats providing shelter are essential for juvenile red hake. These habitats include 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 (e.g., rocks, shells, sponges) and often inside live bivalves (NEFMC, 2017; Geo-Marine, 2010). Based on NMFS seasonal trawl surveys conducted between

1964 and 1997, juvenile red hake are present year-round off the coast of New Jersey, with the greatest nearshore abundance occurring in the spring and the greatest offshore abundance occurring in the fall (NOAA, 1999f).

Adults: EFH is designated for red hake adults throughout the Northern ECC Branches and the majority of the Lease Area, and Monmouth and Northern ECCs. EFH is defined as benthic habitats in the Gulf of Maine and the outer continental shelf and slope in depths of 50 to 750 meters (164 to 2461 feet) as shown on Map 78 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), and as shallow as 20 meters (66 feet) in a number of inshore estuaries and embayments as shown in Table 27 of NEFMC (2017), 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 (NEFMC, 2017). Adult red hake exhibit similar seasonal distribution as juveniles within the Mid-Atlantic Bight, inhabiting inshore waters in the spring and summer, and offshore waters in the fall and spring (NOAA, 1999f). Presence within the Offshore Project Area could be attributed to the presence of soft sediment, which is preferred habitat for adult red hake (Geo-Marine, 2010). During federal and state trawls, red hake were collected year-round in the Offshore Project Area.

2.10 Silver Hake

Eggs/Larvae: EFH is designated for silver hake (*Merluccius bilinearis*) eggs/larvae throughout the entire Northern ECC and following Northern ECC Branches: Asbury, South Beach, Midland, and Fort Hamilton. Additionally, EFH is designated within the majority of the Lease Area, Monmouth ECC, and the Lemon Creek and Wolfe's Pond Northern ECC Branches. EFH is defined as pelagic habitats from the Gulf of Maine to Cape May, New Jersey, including Cape Cod and Massachusetts Bays as shown on Map 74 and Table 26 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017). Within the Mid-Atlantic Bight, egg abundance for silver hake is higher in inshore and continental shelf waters. In winter and fall, eggs are typically found in smaller numbers in deep waters within the Mid-Atlantic Bight (NOAA, 2004). Based on MARMAP ichthyoplankton surveys conducted between 1977 and 1987, silver hake larvae are abundant in depths from 60 to 130 meters (197 to 427 feet) between Georges Bank and Virginia during May and June (NOAA, 2004). Peak larvae abundance occurs in the summer months, typically between July and September. The lowest abundance of silver hake typically occurs during winter (NOAA, 2004).

Adults: EFH is designated for silver hake adults throughout the Asbury Northern ECC Branch, the northern portion of the Lease Area, Monmouth and Northern ECCs, and in the southern portions of the remaining Northern ECC Branches. EFH is defined as pelagic and benthic habitats at depths greater than 35 meters (115 feet) in the Gulf of Maine and the coastal bays and estuaries listed in Table 26 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), between 70 and 400 meters (230 to 1,312 feet) 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 as shown on Map 76 of NEFMC (2017). Adult silver hake are often found in bottom depressions or in association with sandwaves 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 (*Urophycis tenuis*) (NEFMC, 2017). During NEFSC bottom trawls conducted between 1963 to 2002, adult silver hake were observed throughout the shelf of the Mid-Atlantic Bight at depths ranging from 11 to 400 meters (36 to 1,312 feet) (NOAA, 2004). During federal and state trawl surveys, silver hake were collected year-round in the Offshore Project Area.

2.11 White Hake

<u>Adults</u>: EFH is designated for white hake (*Urophycis tenuis*) adults in the northern portion and a small southern portion of the Lease Area, and in the southern portion of the Monmouth and Northern ECCs. No EFH is designated in the Northern ECC Branches. EFH is defined as sub-tidal benthic habitats in the Gulf of Maine, including depths greater than 25 meters (82 feet) in certain mixed and high salinity zones portions of a number of bays and estuaries as shown, in Table 22 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), between 100 and 400 meters (328 to 1,312 feet) in the outer gulf, and between 400 and 900 meters (1,312 to 2,953 feet) on the outer continental shelf and slope (see Map 58 of NEFMC (2017)). EFH 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 (NEFMC, 2017). During NEFSC bottom trawl surveys conducted between 1963 and 1996, adult white hake were most abundant between depths of 50 to 325 meters (1,066 feet) (NOAA, 1999g). During federal trawl surveys, which are only conducted in the spring and fall, white hake were collected in the Offshore Project Area. No white hake were collected in the Offshore Project Area during state trawl surveys.

2.12 Windowpane Flounder

<u>Eggs/Larvae</u>: EFH is designated for windowpane flounder (*Scophthalmus aquosus*) eggs throughout the entirety of the following Northern ECC branches: Asbury, South Beach, Lemon Creek, Wolfe's Pond, and Midland. Additionally, EFH for windowpane flounder eggs is designated throughout the majority of the Monmouth ECC, Northern ECC, and Fort Hamilton Northern ECC Branch, and in the northern and western portions of the Lease Area. Designated EFH for windowpane flounder larvae within the Offshore Project Area largely mirrors that of windowpane eggs, with the exception of the Lease Area, which contains a smaller area of EFH in the northern and western portions. EFH for windowpane flounder eggs and larvae is defined as 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 as shown on Map 59, Map 60, and Table 23 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017). During MARMAP ichthyoplankton surveys, conducted between 1978 and 1987, eggs were typically found at depths less than 40 meters (131 feet) from Georges Bank to Cape Hatteras (NOAA, 1999h). Off the coast of New Jersey,

eggs were present in MARMAP ichthyoplankton surveys between the months of March and November, with peak abundance occurring in April, May June, and October (NOAA, 1999h).

Juveniles: EFH is designated for windowpane flounder juveniles throughout the entire of the Northern ECC and Branches, and the majority of the Lease Area and Monmouth ECC. EFH is defined as intertidal and sub-tidal benthic habitats in estuarine, coastal marine, and continental shelf waters from the Gulf of Maine to northern Florida, as shown on Map 61 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including mixed and high salinity zones in the bays and estuaries listed in Table 23 of NEFMC (2017). EFH for juvenile windowpane flounder is found on mud and sand substrates and extends from the intertidal zone to a maximum depth of 60 meters (197 feet). Young-of-the-year juveniles prefer sand over mud (NEFMC, 2017). In the Mid-Atlantic Bight, juvenile windowpane are typically found nearshore, in water depths less than 40 meters (131 feet) (NOAA, 1999h). Therefore, given that depths within the Offshore Project Area range from 0 to 30 meters (0 to 98 feet), juvenile windowpane could inhabit the Offshore Project Area.

Adults: EFH is designated for windowpane flounder adults throughout the entire Offshore Project Area. EFH is defined as intertidal and sub-tidal benthic habitats in estuarine, coastal marine, and continental shelf waters from the Gulf of Maine to Cape Hatteras, as shown on Map 62 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including mixed and high salinity zones in the bays and estuaries listed in Table 23 of NEFMC (2017). EFH for adult windowpane flounder is found on mud and sand substrates and extends from the intertidal zone to a maximum depth of 70 meters (230 feet) (NEFMC, 2017). Adult windowpane are typically found at depths less than 75 meters (246 feet) in the spring and less than 50 meters (164 feet) in the fall (NOAA, 1999h). Based on federal and state trawl surveys, windowpane flounder were collected year-round in the Offshore Project Area.

2.13 Winter Flounder

Eggs: EFH is designated for winter flounder (*Pseudopleuronectes americanus*) eggs throughout the following Northern ECC Branches: South Beach, Lemon Creek, Wolfe’s Pond, Midland, and Fort Hamilton. EFH is also designated in small western portions of the Lease Area, northern extent of the Monmouth ECC, northern portion of the Northern ECC, and eastern portion of the Asbury Northern ECC Branch. EFH is defined as sub-tidal estuarine and coastal benthic habitats from mean low water to 5 meters (16 feet) from Cape Cod to Absecon Inlet (39° 22’ N), and as deep as 70 meters (230 feet) on Georges Bank and in the Gulf of Maine as shown on Map 63 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including mixed and high salinity zones in the bays and estuaries listed in Table 24 of NEFMC (2017). 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 which can reduce hatching success (NEFMC, 2017).

Larvae: EFH is designated for winter flounder larvae throughout the entirety of the Northern ECC and the Northern ECC Branches, and the majority of the Lease Area and the Monmouth ECC. EFH is defined as estuarine, coastal, and continental shelf water column habitats from the shoreline to a maximum depth of 70 meters (230 feet) from the Gulf of Maine to Absecon Inlet (39° 22′ N), and including Georges Bank, as shown on Map 65 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including mixed and high salinity zones in the bays and estuaries listed in Table 24 of NEFMC (2017). 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 get older (NEFMC, 2017). Winter flounder larvae have been documented in New Jersey estuaries and rivers including the Manasquan River located 0.6 miles (.97 kilometers) south of the Monmouth Landfall Site (NOAA, 1999i).

Juveniles: EFH is designated for winter flounder juveniles throughout the entirety of the Northern ECC and Northern ECC branches, and the majority of the Lease Area and Monmouth ECC. EFH is defined as estuarine, coastal, and continental shelf benthic habitats from the Gulf of Maine to Absecon Inlet (39° 22′ N), and including Georges Bank, as shown on Map 64, and in mixed and high salinity zones in the bays and estuaries listed in Table 24 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017). EFH for juvenile winter flounder extends from the intertidal zone (mean high water) to a maximum depth of 60 meters (197 feet) 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 tend to settle to the bottom in soft-sediment depositional areas where currents concentrate late-stage larvae and disperse into coarser-grained substrates as they get older (NEFMC, 2017). Juvenile flounder are common in the inshore waters of New Jersey, according to NMFS trawl surveys conducted between 1964 and 1997, with the highest presence occurring in fall and spring (NOAA, 1999i).

Adults: EFH is designated for winter flounder adults throughout the entirety of the Northern ECC and Northern ECC Branches, and the majority of the Lease Area and Monmouth ECC. EFH is defined as estuarine, coastal, and continental shelf benthic habitats extending from the intertidal zone (mean high water) to a maximum depth of 70 meters (230 feet) from the Gulf of Maine to Absecon Inlet (39° 22′ N), and including Georges Bank, as shown on Map 65 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), and in mixed and high salinity zones in the bays and estuaries listed in Table 24 of NEFMC (2017). EFH for adult winter flounder occurs on muddy and sandy substrates, and on hard bottom on offshore banks. In inshore spawning areas, EFH includes a variety of substrates where eggs are deposited on the bottom (see eggs) (NEFMC, 2017). Off the coast of New Jersey, winter flounder have been observed in protected bays and coastal ponds (NOAA, 1999i). During federal and state trawl surveys, winter flounder were collected year-round in the Offshore Project Area.

2.14 Winter Skate

Juveniles: EFH is designated for winter skate (*Leucoraja ocellate*) juveniles throughout the entire Offshore Project Area. EFH is defined as sub-tidal benthic habitats in coastal waters from eastern

Maine to Delaware Bay and on the continental shelf in southern New England and the Mid-Atlantic region, and on Georges Bank, from the shoreline to a maximum depth of 90 meters (295 feet), as shown on Map 92 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of the bays and estuaries listed in Table 28 of NEFMC (2017). EFH for juvenile winter skates occurs on sand and gravel substrates, but they are also found on mud (NEFMC, 2017). In winter, winter skates are found from Georges Bank to Cape Hatteras, out to the 200-meter (656-foot) depth contour (NOAA, 2003c). In the spring, winter skates can be found in nearshore environments in the Mid-Atlantic Bight (NOAA, 2003c). Based on NEFSC bottom trawl surveys conducted between 1964 and 2002, the highest concentrations of juvenile winter skate off the coast of New Jersey occurs in spring, while the lowest occurs in the summer (NOAA, 2003c).

<u>Adults</u>: EFH is designated for winter skate adults throughout the entire Northern ECC Branches, the majority of the Northern ECC and Monmouth ECC, and in the northern and smaller southern portion of the Lease Area. . EFH is defined as sub-tidal benthic habitats in coastal waters in the southwestern Gulf of Maine, in coastal and continental shelf waters in southern New England and the Mid-Atlantic region, and on Georges Bank, from the shoreline to a maximum depth of 80 meters (262 feet), as shown on Map 93 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of the bays and estuaries listed in Table 28 of NEFMC (2017). EFH for adult winter skates occurs on sand and gravel substrates, but they are also found on mud (NEFMC, 2017). Similar seasonal distribution has been observed in adult winter skate as juvenile winter skate, with higher abundance in nearshore environments in the spring and offshore in the winter (NOAA, 2003c). Winter skates were collected year-round during state and federal trawl surveys in the Offshore Project Area.

2.15 Witch Flounder

<u>Eggs/Larvae</u>: EFH is designated for witch flounder (*Glyptocephalus cynoglossus*) eggs throughout the entire Asbury Northern ECC Branch, the western portion of the Lease Area, and in central portions of the Monmouth and Northern ECCs. No EFH for witch flounder eggs is designated in the remaining Northern ECC Branches. EFH is designated for witch flounder larvae in the western portion of the Lease Area, central portion of the Monmouth ECC, northern portion of the Northern ECC, and southern portions of the Northern ECC Branches except for the Asbury Branch. No EFH for witch flounder larvae is designated within the Asbury Northern ECC Branch. EFH is defined as pelagic habitats on the continental shelf throughout the Northeast region, as shown on Map 66 and Map 67 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017). Based on MARMAP ichthyoplankton surveys, eggs have been collected from Nova Scotia to Cape Hatteras, with eggs appearing sooner in the Mid-Atlantic Bight than in the New England Region. Witch flounder eggs have been collected from a wide range of depths spanning from 10 to 1,250 meters (32 to 4,101 feet), depending on the season, with most catches occurring between 30 and 150 meters (98 to 492 feet). Most larvae have been collected between 10 and 210 meters (33 to 689 feet).

<u>Adults</u>: EFH is designated for witch flounder adults in the southwestern portion of the Lease Area and northern portions of the Monmouth and Northern ECCs. No EFH is designated for adult witch

flounder in the Northern ECC Branches. EFH is defined as sub-tidal benthic habitats between 35 and 400 meters (115 to 1,312 feet) in the Gulf of Maine and as deep as 1,500 meters (4,921 feet) on the outer continental shelf and slope, with mud and muddy sand substrates, as shown on Map 69 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017). Witch flounder can typically be found along the outer continental shelf in the winter and throughout the shelf in spring (NOAA, 1999j). Witch flounder were collected in state and federal trawl surveys in the Offshore Project Area during the fall and spring (NOAA, 1999j).

2.16 Yellowtail Flounder

Eggs: EFH is designated for yellowtail flounder (*Limanda ferruginea*) eggs throughout the entire Asbury Northern ECC Branch, western portion of the Lease Area, northern portions of the Monmouth and Northern ECCs, and the southern portions of the remaining Northern ECC Branches. EFH is defined as 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, as shown on Map 70 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of the bays and estuaries listed in Table 25 of NEFMC (2017). Yellowtail flounder eggs begin to appear off the coast of New Jersey between March and April on the continental shelf, typically within water depths of 30 to 90 meters (98 to 295 feet) (NOAA, 1999k).

Larvae: EFH is designated for yellowtail flounder larvae throughout the entire Asbury Northern ECC Branch, western portion of the Lease Area, northern portions of the Monmouth and Northern ECCs, and the southern portions of the remaining Northern ECC Branches. EFH is defined as coastal marine and continental shelf pelagic habitats in the Gulf of Maine, and from Georges Bank to Cape Hatteras, as shown on Map 71 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of the bays and estuaries listed in Table 25 of NEFMC (2017). Yellowtail larvae begin to appear on the continental shelf in April in waters of the New York Bight, south to the Delmarva peninsula (NOAA, 1999k). A majority of yellowtail flounder larvae can be found in water depths ranging from 10 to 90 meters (33 to 295 feet) (NOAA, 1999k). According to MARMAP Ichthyoplankton surveys conducted between April and October, 1977 to 1987, larvae are largely present off the coast of New Jersey between May and July (NOAA, 1999k).

Juveniles: EFH is designated for yellowtail flounder juveniles throughout the following Northern ECC Branches: Asbury, South Beach, Midland, and Fort Hamilton. EFH for juvenile yellowtail flounder is also designated throughout the majority of the Monmouth ECC, Northern ECC, and Lemon Creek and Wolfe's Pond Northern ECC Branches, and within the northeastern and southwest portions of the Lease Area. EFH is defined as 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 as shown on Map 72 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of the bays and estuaries listed in Table 25 of NEFMC (2017). EFH for juvenile yellowtail flounder occurs on sand and muddy sand between 20 and 80 meters (66 to 262 feet). In the Mid-Atlantic, young-of-the-year juveniles settle to the bottom on the continental shelf, primarily at depths of 40 to 70 meters (131 to 230 feet), on sandy substrates (NEFMC, 2017).

During spring and fall NEFSC bottom trawl surveys conducted off the coast of New Jersey between 1968 and 1987, yellowtail flounder juveniles were found at depths ranging from 5 to 75 meters (16 to 246 feet). According to NMFS year-round trawl surveys between 1968 and 1997, juvenile yellowtail flounder were most prevalent in nearshore waters off the coast of New Jersey in the spring and offshore in the fall (NOAA, 1999k).

Adults: EFH is designated for yellowtail flounder adults throughout the entire Monmouth ECC, Northern ECC, and Asbury Northern ECC Branch. EFH is also designated within the majority of the Lease Area and the southern portions of the remaining Northern ECC Branches. EFH is defined as 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 as shown on Map 73 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), including the high salinity zones of the bays and estuaries listed in Table 25 of NEFMC (2017). EFH for adult yellowtail flounder occurs on sand and sand with mud, shell hash, gravel, and rocks at depths between 25 and 90 meters (82 to 295 feet) (NEFMC, 2017). Adult yellowtail flounder are frequently found at depths less than 100 meters (328 feet), which could include areas of the Offshore Project Area which ranges in depth from 0 to 30 meters (0 to 98 feet) (NOAA, 1999k). During federal trawl surveys, which are only conducted in spring and fall, yellowtail flounder were collected in the Offshore Project Area; however, no yellowtail flounder were collected during state trawl surveys.

3.0 MID-ATLANTIC FISHERY MANAGEMENT COUNCIL FINFISH SPECIES

EFH for finfish species managed by the Mid-Atlantic Fishery Management Council (MAFMC) are covered under the following FMPs: Amendment 11 to the Atlantic Mackerel, Squid, and Butterfish FMP (MAFMC, 2011); Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass FMP (MAFMC, 1998a); Amendment 1 to the Bluefish FMP (MAFMC and ASMFC, 1998); and Amendment 3 to the Spiny Dogfish FMP (MAFMC, 2014). Seven MAFMC finfish species have designated EFH in the Offshore Project Area.

3.1 Atlantic Butterfish

Eggs: EFH is designated for Atlantic butterfish (*Peprilus triacanthus*) eggs throughout the entire Asbury Northern ECC Branch, northern portion of the Lease Area, northern and central portions of the Monmouth and Northern ECCs, and southern portions of the remaining Northern ECC Branches. EFH is defined as 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 (4,921 feet) or less where average temperatures in the upper 200 meters (656 feet) of the water column are 6.5 – 21.5 °C (43.7 – 70.7 °F) (MAFMC, 2011). During MARMAP ichthyoplankton surveys conducted between 1978 to 1987, Atlantic butterfish were collected in nearshore and offshore environments between May and August off the coast of New Jersey (NOAA, 1999l).

Larvae: EFH is designated for Atlantic butterfish larvae in the northern portion of the Lease Area, along portions of the Monmouth and Northern ECCs, and in the northern portions of the Northern ECC Branches except for Asbury. No EFH for Atlantic butterfish larvae is designated in the Asbury Northern ECC Branch. EFH is defined as 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 (135 to 1,148 feet) where average temperatures in the upper 200 meters (656 feet) of the water column are 8.5-21.5 °C (47.3 – 70.7 °F) (MAFMC, 2011). Atlantic butterfish larvae have been observed in Great Bay in New Jersey, located approximately 18 kilometers (11 miles) west of the Lease Area and approximately 72 kilometers (45 miles) south of the nearest landfall site (Monmouth Landfall Site) (NOAA, 1999l). Atlantic butterfish larvae have been collected in MARMAP ichthyoplankton surveys from 1977 to 1987 off the coast of New Jersey between July and September (NOAA, 1999l).

Juveniles: EFH is designated for Atlantic butterfish juveniles throughout the entire Lease Area and Monmouth and Northern ECCs, and throughout the Asbury and Fort Hamilton Northern ECC Branches and along the southern portions of the remaining Northern ECC Branches. EFH is defined as 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 (32 to 919 feet) where bottom water temperatures are between 6.5 and 27 °C (43.7 and 80.6 °F) and salinities are above 5 parts per thousand. Juvenile butterfish feed mainly on planktonic prey (MAFMC, 2011). Juvenile Atlantic butterfish undergo seasonal migrations. In the Mid-Atlantic Bight, juveniles spend winters along the outer continental shelf and summers inshore (NOAA, 1999l). According to NEFSC bottom trawl surveys conducted between 1963 and 1997, juvenile Atlantic butterfish can be found off the coast of New Jersey year-round; however, the largest abundance of juveniles typically occurs in the fall (NOAA, 1999l).

Adults: EFH is designated for Atlantic butterfish adults throughout the entire Northern ECC, Asbury and Fort Hamilton Northern ECC Branches, throughout the majority of the Lease Area and Monmouth ECC, and along the southern portions of the remaining Northern ECC Branches. EFH for adult Atlantic butterfish is also designated in the southern portions of the remaining Northern ECC Branches. EFH is defined as 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 (33 to 820 feet) where bottom water temperatures are between 4.5 and 27.5 °C (40.1 and 81.5 °F) and salinities are above 5 parts per thousand. Spawning probably does not occur at temperatures below 15 °C (59 °F). Adult butterfish feed mainly on planktonic prey, including squids and fishes (MAFMC, 2011). Similar to juveniles, adult Atlantic butterfish undergo seasonal migration within the Mid-Atlantic Bight, spending winters along the outer edge and spring in inshore reaches (NOAA, 1999l). During federal and state trawl surveys, Atlantic butterfish were caught year-round in the Offshore Project Area.

3.2 Atlantic Mackerel

Eggs: EFH is designated for Atlantic mackerel (*Scomber scombrus*) eggs throughout the entire Asbury Northern ECC Branch, in western portions of the Lease Area, along the northern portions of the Monmouth and Northern ECCs, and the southern portions of the remaining Northern ECC Branches. EFH is defined as 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 (328 feet) or less with average water temperatures of 6.5 12.5 °C (43.7 – 54.5 °F) in the upper 15 meters (49 feet) of the water column (MAFMC, 2011). During MARMAP ichthyoplankton surveys conducted between April and August from 1977 to 1987, eggs were caught most frequently in April and May off the coast of New Jersey (NOAA, 1999m).

Larvae: EFH is designated for Atlantic mackerel larvae in an extremely small area in the southeastern portion of the Lease Area, along northern portions of the Monmouth and Northern ECCs, and in the southern portions of the Northern ECC Branches except for the Asbury Branch. No EFH for Atlantic mackerel larvae is designated in the Asbury Northern ECC Branch. EFH is defined as 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 (69 to 328 feet) with average water temperatures of 5.5-11.5 °C (41.9 – 52.7 °F) in the upper 200 meters (656 feet) of the water column (MAFMC, 2011). During MARMAP ichthyoplankton surveys conducted between May and August from 1977 to 1987, larvae were caught most frequently in May and June off the coast of New Jersey (NOAA, 1999m).

Juveniles: EFH is designated for Atlantic mackerel juveniles in the southern portion of the Lease Area, portions of the Monmouth and Northern ECCs, and northern portions of the Northern ECC Branches except for the Asbury Branch. No EFH for Atlantic mackerel juveniles is designated in the Asbury Northern ECC Branch. EFH is defined as 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 (361 feet) and in water temperatures of 5 to 20 °C (41 to 68 °F). Juvenile Atlantic mackerel feed primarily on small crustaceans, larval fish, and other pelagic organisms (MAFMC, 2011). During NEFSC bottom trawl surveys conducted between 1963 and 1987, juvenile Atlantic mackerel were frequently caught off the coast of New Jersey, with the largest catch numbers occurring in spring surveys compared to fall surveys (NOAA, 1999m).

Adults: EFH is designated for Atlantic mackerel adults throughout the entire Asbury Northern ECC Branch, majority of the Lease Area, majority of the Northern ECC and remaining Northern ECC Branches, and along the southern and northern portions of the Monmouth ECC. EFH is defined as 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 (558 feet) and in water temperatures of 5 to 20 °C (41 to 68 °F). Spawning occurs at temperatures above 7 °C (44.6 °F), with a peak between 9 and 14 °C (48.2 and 57.2 °F). Adult Atlantic mackerel are opportunistic predators that feed on a wide range of larger pelagic crustaceans, as compared to juveniles, as well as fish and squid (MAFMC, 2011). During federal and state trawls, Atlantic mackerel were collected in the Offshore Project Area during fall, winter, and spring. No Atlantic mackerel were collected in the Offshore Project Area during summer surveys.

3.3 Black Sea Bass

Larvae: EFH is designated for black sea bass (*Centropristis striata*) larvae throughout the entire Asbury Northern ECC Branch, the northeastern and southwestern portions of the Lease Area, and along portions of the Monmouth and Northern ECCs. No EFH is designated for the remaining Northern ECC Branches. North of Cape Hatteras, EFH is defined as the pelagic waters found over the continental shelf (from the coast out to the limits of the Exclusive Economic Zone [EEZ]), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all ranked ten-minute squares of the area where black sea bass larvae are collected in the MARMAP survey. EFH also is estuaries where black sea bass were identified as common, abundant, or highly abundant in the NOAA's Estuarine Living Marine Resources Program (ELMR) database for the "mixing" and "seawater” salinity zones. Generally, the habitats for the transforming (to juveniles) larvae are near the coastal areas and into marine parts of estuaries between Virginia and New York. When larvae become demersal, they are generally found on structured inshore habitat such as sponge beds (MAFMC, 1998a). During MARMAP ichthyoplankton surveys conducted between 1977 and 1987, larvae were collected off the coast of New Jersey from July to October (NOAA, 1999n).

Juveniles: EFH is designated for black sea bass juveniles throughout the entire Asbury Northern ECC Branch, the majority of the Monmouth and Northern ECCs, northwestern and southwestern portions of the Lease Area, and the southern portion of the remaining Northern ECC Branches. Offshore, EFH is defined as 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, in the highest 90% of all the ranked squares of the area where juvenile black sea bass are collected in the NEFSC trawl survey. 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 are found in the estuaries in the summer and spring. Generally, juvenile black sea bass are found in waters warmer than 43 °F (6.1 °C) with salinities greater than 18 parts per thousand

and coastal areas between Virginia and Massachusetts, but winter offshore from New Jersey and south. Juvenile black sea bass 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 (MAFMC, 1998a). Juvenile black sea bass undergo seasonal migrations, traveling between the outer continental shelf in the winter and inshore environments in the spring (NOAA, 1999n). During NEFSC bottom trawl surveys conducted between 1963 and 1987, the abundance of juvenile black sea bass off the coast of New Jersey was highest in inshore environments in the fall and offshore in the winter (NOAA, 1999n). During spring and summer surveys, most black sea bass were caught south of New Jersey (NOAA, 1999n).

Adults: EFH is designated for black sea bass adults throughout the entire Northern ECC and Asbury Northern ECC Branch, the majority of the Lease Area, majority of the Monmouth ECC, and the southern portions of the remaining Northern ECC Branches. Offshore, EFH is defined as 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, in the highest 90% of all the ranked ten-minute squares of the area where adult black sea bass are collected in the NEFSC trawl survey. 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. Black sea bass are generally found in estuaries from May through October. Wintering adults (November through April) are generally offshore, south of New York to North Carolina. Temperatures above 43 °F (6.1 °C) seem to be the minimum requirements. Structured habitats (natural and man-made), sand, and shell are usually the substrate preference (MAFMC, 1998a). During state and federal trawl surveys, black sea bass were largely collected in the Offshore Project Area during spring, summer, and fall. Only one individual was collected during winter trawl surveys.

3.4 Bluefish

Eggs: EFH is designated for bluefish (*Pomatomus saltatrix*) eggs throughout the entire Asbury Northern ECC Branch, and in southwestern portions of the Lease Area, portions of the Monmouth ECC, Northern ECC, and the southern portions of the remaining Northern ECC Branches. North of Cape Hatteras, EFH is defined as pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ) at mid-shelf depths, from Montauk Point, NY south to Cape Hatteras in the highest 90% of the area where bluefish eggs were collected in the MARMAP surveys. 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 parts per thousand) (MAFMC and ASMFC, 1998). Water temperature in the Offshore Project Area reaches a high of 68 °F (20 °C) at the surface and 59 °F (15 °C) at the seabed. Given the water temperatures in the Offshore Project Area, bluefish eggs could be present in the Offshore Project Area. If bluefish eggs are present in the Offshore Project Area, they would occur between May and August, with the highest abundance occurring in July (MAFMC and ASMFC, 1998)

Larvae: EFH is designated for bluefish larvae throughout the entire Asbury Northern ECC Branch, majority of the Lease Area, majority of the Monmouth and Northern ECCs, and the southern portions of the remaining Northern ECC Branches. North of Cape Hatteras, EFH is defined as pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ) most commonly above 49 feet (15 meters), from Montauk Point, New York south to Cape Hatteras, in the highest 90% of the area where bluefish larvae were collected during the MARMAP surveys. EFH is also defined as the "slope sea" and Gulf Stream between latitudes 29° 00 N and 40° 00 N. 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 parts per thousand) (MAFMC and ASMFC, 1998). Off the coast of New Jersey, peak larval abundance occurs in June (MAFMC and ASMFC 1998). Within the Mid-Atlantic Bight, MARMAP sampling between 1977 and 1987 found that the majority of larvae were collected at sea surface temperatures between 62 and 79 °F (16.6 and 26.1°C) over depths of 30 to 70 meters (98 to 230 feet) (MAFMC and ASMFC, 1998). Given that the sea surface temperatures can reach a high of 68 °F (20 °C) in the Offshore Project Area, and depths within the Offshore Project can reach up to 37 meters (121 feet), the Offshore Project Area could provide habitat to bluefish larvae.

Juveniles: EFH is designated for bluefish juveniles throughout the entire Northern ECC Branches, the western half of the Lease Area, and the majority of the Monmouth ECC and most of the Northern ECC. North of Cape Hatteras, EFH is defined as pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ) from Nantucket Island, Massachusetts south to Cape Hatteras, in the highest 90% of the area where juvenile bluefish are collected in the NEFSC trawl survey. EFH is also defined as the "slope sea" and Gulf Stream between latitudes 29° 00 N and 40° 00 N and 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 (MAFMC and ASMFC, 1998). Within the Mid-Atlantic Bight, abundance of juvenile bluefish is greatest between Rhode Island and New Jersey (MAFMC and ASMFC, 1998).

Adults: EFH is designated for bluefish adults throughout the entire Northern ECC Branches, and the majority of the Lease Area, Monmouth ECC, and Northern ECC. North of Cape Hatteras, over the continental shelf (from the coast out to the limits of the EEZ), from Cape Cod Bay, Massachusetts south to Cape Hatteras, EFH is defined as the highest 90% of the area where adult bluefish were collected in the NEFSC trawl survey. EFH is also defined as 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 and according to the size of the individuals comprising the schools. Bluefish are generally found in normal shelf salinities (>

25 parts per thousand) (MAFMC and ASMFC, 1998). During federal and state trawl surveys, bluefish were collected in the Offshore Project Area during spring, summer, and fall. No bluefish were collected during winter trawl surveys.

3.5 Scup

Eggs: EFH is designated for scup (*Stenotomus chrysops*) eggs in a majority of the following Northern ECC Branches: South Beach, Lemon Creek, Wolfe's Pond, Midland, and Fort Hamilton. No EFH for scup eggs is designated within the Lease Area, Monmouth ECC, Northern ECC, or Asbury Northern ECC Branches. EFH for scup eggs consists of estuaries where scup eggs were identified as common, abundant, or highly abundant in the ELMR database for the "mixing" and "seawater" salinity zones (MAFMC, 1998a). Typically scup eggs are found between May and August from southern New England to coastal Virginia in water ranging from 55°F to 73°F and salinities greater than 15 ppt (MAFMC, 1998a). Based on MARMAP surveys, eggs are most commonly collected in water depths less than 164 feet (50 meters) (NOAA 1999o).

Larvae: EFH is designated for scup larvae in a majority of the following Northern ECC Branches: South Beach, Lemon Creek, Wolfe's Pond, Midland, and Fort Hamilton. No EFH for scup larvae is designated within the Lease Area, Monmouth ECC, Northern ECC, or Asbury Northern ECC Branches. EFH for larval scup are estuaries where scup are identified as common, abundant, or highly abundant in the ELMR database for "mixing" and "seawater" salinity zones (MAFMC, 1998a). Generally, scup larvae are most abundant nearshore between May and September, in waters between 55°F to 73°F and salinities greater than 15 ppt (MAFMC, 1998a). Based on MARMAP surveys, juvenile scup abundance is highest in waters around 17°C and less than 164 feet (50 meters) (NOAA 1999o).

Juveniles: EFH is designated for scup juveniles throughout the following Northern ECC Branches: Asbury, South Beach, Midland, and Fort Hamilton. EFH was also designated for scup juveniles throughout the entire Northern ECC, majority of the Monmouth ECC and remaining Northern ECC Branches, and the eastern portion of the Lease Area. Offshore, EFH is defined as 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, in the highest 90% of all the ranked ten-minute squares of the area where juvenile scup are collected in the NEFSC trawl survey. 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 (7.2 °C) and salinities greater than 15 parts per thousand (MAFMC, 1998a). According to data collected during NEFSC bottom trawl surveys, conducted between 1963 and 1966, juvenile scup abundance is greatest in inshore reaches of New Jersey waters in the fall and offshore reaches in the spring (NOAA, 1999o).

Adults: EFH is designated for scup adults throughout the entire Lease Area, Northern ECC, and the Asbury, Fort Hamilton, Midland, and South Beach Northern ECC Branches. EFH is also designated for adult scup along the majority of the Monmouth ECC and remaining Northern ECC Branches. Offshore, EFH is defined as 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, in the highest 90% of all the ranked ten-minute squares of the area where adult scup are collected in the NEFSC trawl survey. 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 (7.2 °C) (MAFMC, 1998a). Adult scup commonly inhabit the Mid-Atlantic Bight, where they migrate from offshore winter habitat to coastal waters (NOAA, 1999o). During federal and state trawl surveys, scup were collected in the Offshore Project Area in spring, summer, and fall. No scup were collected during winter trawl surveys.

3.6 Spiny Dogfish

Adults: EFH is designated for both sub-adult and adult spiny dog fish (*Squalus acanthias*). EFH for spiny dogfish is mapped separately for male and female. EFH is designated for sub-adult males in the northeastern portion of the Lease Area, and in a small southern portion of the Monmouth and Northern ECC. EFH is designated for sub-adult females throughout the entire Lease Area, Monmouth ECC, Northern ECC, and Asbury Northern ECC Branch. EFH for sub-adult females is also present in the southern portion of the remaining Northern ECC branches. EFH for male sub-adults is defined as 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 (MAFMC, 2014). EFH for female sub-adults is defined as 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 (MAFMC, 2014).

EFH for adult spiny dogfish is also mapped separately for males and females. EFH for adult males is designated throughout the entire Northern ECC and Asbury Northern ECC Branch, the majority of the Lease Area and Monmouth ECC, and in the southern portion of the remaining Northern ECC Branches. EFH for adult female spiny dogfish is designated throughout the entire Lease Area, Northern ECC, and Asbury Northern ECC Branch. EFH is also designated for adult female spiny dogfish throughout the majority of the Monmouth ECC and the southern portions of the remaining Northern ECC Branches. EFH for spiny dogfish adults is defined as pelagic and epibenthic habitats throughout the region. Adults are found over a wide depth range in full salinity seawater (32-35 parts per thousand) where bottom temperatures range from 7 to 15 °C (44.6 to 59 °F). 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 (59 °F) (MAFMC, 2014). During federal and state trawls, spiny dogfish were collected year-round in the Offshore Project Area.

3.7 Summer Flounder

Eggs: EFH is designated for summer flounder (*Paralichthys dentatus*) eggs throughout the entire Asbury Northern ECC Branch, within the southwestern portion of the Lease Area, and along a portion of the Monmouth and Northern ECCs. No EFH is designated for the remaining Northern ECC Branches. North of Cape Hatteras, EFH is defined as the pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of the all the ranked ten-minute squares for the area where summer flounder eggs are collected in the MARMAP survey. 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 (14.5 kilometers) of shore off New Jersey and New York. Eggs are most commonly collected at depths of 9 to 109 meters (30 to 360 feet) (MAFMC, 1998a).

Larvae: EFH is designated for summer flounder larvae throughout the entire Asbury Northern ECC Branch, within the southwestern and northeastern portions of the Lease Area, along portions of the Monmouth and Northern ECCs, and in the northern portions of the remaining Northern ECC Branches. North of Cape Hatteras, EFH is defined as the pelagic waters found over the continental shelf (from the coast out to the limits of the EEZ), from the Gulf of Maine to Cape Hatteras, North Carolina, in the highest 90% of all the ranked ten-minute squares for the area where summer flounder larvae are collected in the MARMAP survey. Inshore, EFH is all the 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 parts per thousand) and "seawater" (defined in ELMR as greater than 25 parts per thousand) salinity zones. In general, summer flounder larvae are most abundant nearshore (12-50 miles or 19-80 kilometers from shore) at depths between 9 to 70 meters (30 to 230 feet). 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 (MAFMC, 1998a).

Juveniles: EFH is designated for summer flounder juveniles throughout the Northern ECC Branches, within small northern and southern portions of the Lease Area, and along the majority of the Monmouth and Northern ECCs. North of Cape Hatteras, EFH is defined as 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, in the highest 90% of all the ranked ten-minute squares for the area where juvenile summer flounder are collected in the NEFSC trawl survey. Inshore, EFH is all of the 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 (2.7 °C) and salinities from 10 to 30 parts per thousand range (MAFMC, 1998a). Juvenile summer flounder have been observed in Great Bay which is located 42 miles (68 kilometers) south of the Monmouth Landfall Site, and 11 miles (18 kilometers) northwest of the Lease Area (NOAA, 1999p).

Adults: EFH is designated for summer flounder adults throughout the entire Offshore Project Area, with the exception of the Monmouth ECC, which has a small portion lacking EFH for adult summer flounder. North of Cape Hatteras, EFH is defined as 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, in the highest 90% of all the ranked ten-minute squares for the area where adult summer flounder are collected in the NEFSC trawl survey. 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 feet (152 meters) in colder months (MAFMC, 1998a). Adult summer flounder exhibit strong seasonal migration between inshore and offshore environments (NOAA, 1999p). Adult summer flounder spend warmer months in coastal and estuarine waters, and colder months offshore (NOAA, 1999p). Tagging studies have shown that during winter, summer flounder can be found offshore of New Jersey at water depths of 30 to 183 meters (98 to 600 feet) (NOAA, 1999p). Additionally, through tagging studies off the coast of New Jersey and New York, homing behavior was observed in adult summer flounder meaning adults will return to the same inshore environment every spring and summer (NOAA, 1999p). During federal and state trawls, summer flounder were collected in the Offshore Project Area during spring, summer, and fall. Summer flounder were not largely collected during winter trawl surveys, with the exception of two individuals one of which was collected in the Lease Area and the other in the Northern ECC.

Habitat of Particular Concern (HAPC): There is one HAPC located within the Offshore Project Area, HAPC for summer flounder. This area of HAPC occurs in Raritan and Lower New York Bay along the following Northern ECC Branches: Wolfe Pond, Lemon Creek, Fort Hamilton, Midland, and South Beach. Though summer flounder HAPC is identified in these areas, NOAA Fisheries classifies HAPC for summer flounder as areas containing submerged aquatic vegetation (SAV). According to seagrass data mapped by NOAA, which compiles data from multiple state and local sources, there is no known areas of SAV along the Northern ECC Branches (NOAA 2022). 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. The HAPC definition also states that if native species of submerged aquatic vegetation (SAV) are eliminated then exotic species should be protected because of functional value, however, all efforts should be made to restore native species (MAFMC, 2016). The closest known area of SAV to the Offshore Project Area is approximately 3.5 miles south of the Monmouth Landfall Site, within Barnegat Bay.

4.0 NEW ENGLAND FISHERY MANAGEMENT COUNCIL INVERTEBRATE SPECIES

One NEFMC-managed invertebrate species has EFH in the Offshore Project Area, the Atlantic sea scallop (*Placopecten magellanicus*). This species is covered under the Omnibus Essential Fish Habitat Amendment 2 (NEFMC, 2017) and managed under Amendment 14 to the Atlantic Sea Scallop FMP.

4.1 Atlantic Sea Scallop

EFH is designated for Atlantic sea scallop (*Placopecten magellanicus*) eggs/larvae/juveniles/adults throughout the entire Northern ECC and Asbury Northern ECC Branch. EFH is also designated within the majority of the Lease Area and Monmouth ECC, and in the southern portions of the remaining Northern ECC Branches.

Eggs: EFH is defined as benthic habitats in inshore areas and on the continental shelf as shown on Map 97 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), in the vicinity of adult scallops. Eggs are heavier than seawater and remain on the seafloor until they develop into the first free-swimming larval stage (NEFMC, 2017).

Larvae: EFH is defined as benthic and water column habitats in inshore and offshore areas throughout the region, as shown on Map 97 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017). 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 (NEFMC, 2017).

Juveniles: EFH is defined as benthic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic, as shown on Map 97 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017), in depths of 18 to 110 meters (59 to 361 feet). Juveniles (5-12 millimeter shell height) leave the original substrate on which they settle (see larvae, 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 centimeters per second retard feeding and growth. In laboratory studies, maximum survival of juvenile scallops occurred between 1.2 and 15 °C (34.2 and 59 °F) and above salinities of 25 parts per thousand. 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) (NEFMC, 2017).

Adults: EFH is defined as benthic habitats in the Gulf of Maine, on Georges Bank, and in the Mid-Atlantic, as shown on Map 97 in the Final Omnibus EFH Amendment 2 (NEFMC, 2017). Essential habitats for older juvenile and adult sea scallops are found on sand and gravel substrates in depths of 18 to 110 meters (59 to 361 feet), but they are also found in shallower water and as deep as

180 meters (591 feet) in the Gulf of Maine. In the Mid-Atlantic they are found primarily between 45 and 75 meters (148 to 246 feet) and on Georges Bank they are more abundant between 60 and 90 meters (197 to 295 feet). 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 (50 and 59 °F) and they prefer full strength seawater (NEFMC, 2017). During federal trawl, federal dredge, and state trawl surveys, Atlantic sea scallops were collected in the Offshore Project Area during spring, summer, and fall. No Atlantic sea scallops were collected during winter surveys.

5.0 MID-ATLANTIC FISHERY MANAGEMENT COUNCIL INVERTEBRATE SPECIES

EFH for invertebrate species managed by the MAFMC are covered under the following FMPs: Amendment 12 to the Atlantic Surfclam and Ocean Quahog FMP (MAFMC, 1998b) and Amendment 11 to the Atlantic Mackerel, Squid, and Butterfish FMP (MAFMC, 2011). Four MAFMC invertebrate species have designated EFH in the Offshore Project Area.

5.1 Atlantic Surfclam

Juveniles/Adults: EFH is designated for juvenile and adult Atlantic surfclam (*Spisula solidissima*) throughout the entire Lease Area and the Asbury Northern ECC Branch, and along the majority of the Monmouth and Northern ECCs. No EFH is designated for the remaining Northern ECC Branches. EFH is defined as occurring throughout the substrate, to a depth of three feet (0.9 meters) below the water/sediment interface, within federal waters from the eastern edge of Georges Bank and the Gulf of Maine throughout the Atlantic EEZ, in areas that encompass the top 90% of all the ranked ten-minute squares for the area where surfclams were caught in the NEFSC surfclam and ocean quahog dredge surveys. Surfclams generally occur from the beach zone to a depth of about 200 feet (61 meters), but beyond about 125 feet (38 meters) abundance is low (MAFMC, 1998b). Atlantic surfclam can be found on well-sorted, medium and fine sandy sediment (NOAA, 1999r). During federal trawl, federal dredge, and state trawl survey, Atlantic surfclam were collected year-round in the Offshore Project Area.

5.2 Longfin Inshore Squid

Eggs: EFH is designated for longfin inshore squid (*Doryteuthis pealeii*) eggs throughout the Northern ECC Branches, in the northern portion of the Lease Area, and the majority of the Monmouth and Northern ECCs. EFH is defined for *Doryteuthis pealeii* eggs as inshore and offshore bottom habitats from Georges Bank southward to Cape Hatteras, generally where bottom water temperatures are between 10 °C and 23 °C (50 and 73.4 °F), salinities are between 30 and 32 parts per thousand, and depth is less than 50 meters (164 feet). *Doryteuthis pealeii* eggs have also been collected in bottom trawls in deeper water at various places on the continental shelf. Like most loliginid squids, *D. pealeii* egg masses or "mops" are demersal and anchored to the substrates on which they are laid, which include a variety of hard bottom types (e.g., shells, lobster pots, piers, fish traps, boulders, and rocks), submerged aquatic vegetation (e.g., Fucus sp.), sand, and mud (MAFMC, 2011).

Juveniles (Pre-recruits): EFH is designated for longfin inshore squid juveniles throughout the entire Lease Area, Monmouth ECC, Northern ECC, and in the Asbury Northern ECC Branch. EFH for longfin inshore squid juveniles is also designated in the southern portions of the remaining Northern ECC Branches. EFH is defined as pelagic 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. EFH for recruit longfin inshore squid is generally found over bottom depths between 6 and 160 meters (20 to 525 feet) where bottom water temperatures are 8.5-24.5 °C (47.3 – 76.1 °F) and salinities are 28.5-36.5 parts per thousand. Pre-recruits migrate offshore in the fall where they overwinter in deeper waters along the edge of the shelf. They make daily vertical migrations, moving up in the water column at night and down in the daytime. Small immature individuals feed on planktonic organisms while larger individuals feed on crustaceans and small fish (MAFMC, 2011). During NEFSC bottom trawls conducted between 1969 and 2003, as reported in the NOAA EFH Source Document, pre-recruits were generally found offshore, concentrated around the 200-meter (656-foot) depth contour during winter months (NOAA, 2005a). During summer, pre-recruits can generally be found within the 50-meter (164-foot) depth contour off the coast of New Jersey (NOAA, 2005a).

Adults (Recruits): EFH is designated for longfin inshore squid adults throughout the Northern ECC and Asbury Northern ECC Branch, within the majority of the Lease Area and the Monmouth ECC, and in the southern portions of the remaining Northern ECC Branches. EFH is defined as pelagic habitats in inshore and offshore continental shelf waters from Georges Bank to South Carolina, in inshore waters of the Gulf of Maine, and in embayments such as Narragansett Bay, Long Island Sound, Raritan Bay, and Delaware Bay. EFH for recruit longfin inshore squid is generally found over bottom depths between 6 and 200 meters (20 to 656 feet) where bottom water temperatures are 8.5-14 °C (47.3 – 57.2 °F) and salinities are 24-36.5 parts per thousand. Recruits inhabit the continental shelf and upper continental slope to depths of 400 meters (1,312 feet). They migrate offshore in the fall and overwinter in warmer waters along the edge of the shelf. Like the pre-recruits, they make daily vertical migrations. Individuals larger than 12 centimeters feed on fish and those larger than 16 centimeters 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 (164 feet) (MAFMC, 2011). Data from NEFSC bottom trawl surveys conducted between 1981 and 2003 show similar seasonal distribution for pre-recruits and recruits (NOAA, 2005a). During winter months, recruits can be found along the edge of the continental shelf, concentrated around the 200-meter isobath (NOAA, 2005a). During summer, recruits can generally be found within the 50-meter (164 foot) isobath off the coast of

New Jersey (NOAA, 2005a). During federal and state trawl surveys, longfin squid were collected year-round in the Offshore Project Area.

5.3 Northern Shortfin Squid

Juveniles (Pre-recruits): EFH is designated for northern shortfin squid (*Illex illecebrosus*) juveniles throughout the majority of the Lease Area, Monmouth ECC, and Northern ECC. No EFH is designated for the Northern ECC Branches. EFH is defined as 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 (135 to 1,312 feet) where bottom temperatures are 9.5-16.5 °C (49.1 – 61.7 °F) and salinities are 34.5-36.5 parts per thousand. They also inhabit pelagic habitats in the Gulf Stream where water temperatures are above 16 °C (60.8 °F) 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 (MAFMC, 2011). During federal and state trawl surveys, northern shortfin squid were collected in the Offshore Project Area during spring, summer, and fall. No northern shortfin squid were collected during winter surveys.

5.4 Ocean Quahog

Adults: EFH is designated for ocean quahog (*Arctica islandica*) adults throughout the entire Asbury Northern ECC Branch, in a small, southern portion of the Lease Area and Monmouth ECC, along the northern portion of the Northern ECC, and in the southern portions of the remaining Northern ECC Branches. EFH is defined as occurring throughout the substrate, to a depth of 3 feet (0.9 meters) below the water/sediment interface, within federal waters from the eastern edge of Georges Bank and the Gulf of Maine throughout the Atlantic EEZ, in areas that encompass the top 90% of all the ranked ten-minute squares for the area where ocean quahogs were caught in the NEFSC surfclam and ocean quahog dredge surveys. Distribution in the western Atlantic ranges in depths from 30 feet to about 800 feet (9 to 244 meters) (MAFMC, 1998b), typically on sandy sediment of medium to fine grain size (NOAA, 1999q). Ocean quahogs are rarely found where bottom water temperatures exceed 60 °F (15.5 °C) and occur progressively further offshore between Cape Cod and Cape Hatteras (MAFMC, 1998b). During federal trawl and dredge surveys ocean quahog were collected throughout the Offshore Project during spring and summer. No ocean quahogs were collected during fall and winter federal surveys. Additionally, no ocean quahogs were collected during state trawl surveys.

6.0 HIGHLY MIGRATORY SPECIES

EFH for highly migratory species are managed by NOAA's Highly Migratory Species Division under Amendment 10 to the Consolidated Atlantic Highly Migratory Species FMP (NOAA, 2017). Four highly migratory tuna species and eight highly migratory shark species have designated EFH in the Offshore Project Area.

6.1 Tunas

6.1.1 Albacore Tuna

Juveniles: EFH is designated for albacore tuna (*Thunnus alalunga*) juveniles in a small northern portion of the Lease Area, and along portions of the Monmouth and Northern ECCs. No EFH for albacore tuna juveniles is designated for the Northern ECC Branches. Offshore, EFH is defined as 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 (NOAA, 2017). The central Atlantic provides wintering habitat for juvenile albacore tuna. In the summer, juveniles migrate to productive waters in the northeast Atlantic for feeding opportunities (NOAA, 2017).

6.1.2 Bluefin Tuna

Juveniles: EFH is designated for bluefin tuna (*Thunnus thynnus*) juveniles throughout the entire Monmouth ECC, and Asbury Northern ECC Branch. EFH for juvenile bluefin tuna is also designated throughout the majority of the Lease Area and along the majority of the Northern ECC. No EFH is designated within the remaining Northern ECC Branches. EFH is defined as 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 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 (60.8 to 66.2 °F); 0 to 40 meters or 0 to 131 feet deep). EFH in other locations associated with temperatures ranging from 4 to 26 °C (39.2 to 78.8 °F), often in depths of less than 20 meters (66 feet) (but can be found in waters that are 40-100 meters or 131 to 328 feet in depth in winter) (NOAA, 2017). Tagging studies have shown that summer distribution of juvenile bluefin tuna includes coastal areas, the Gulf Stream margin, and the continental shelf break between the Gulf of Maine and Cape Hatteras. In the fall, juveniles have been observed migrating south along the continental shelf break to the South Atlantic Bight and northern Bahamas. Winter and spring distributions of juvenile bluefin tuna were dependent on the Gulf Stream position (NOAA, 2017).

Adults: EFH is designated for bluefin tuna adults throughout the entire Asbury Northern ECC Branch, and along the northern portions of the Monmouth and Northern ECCs. No EFH for adult bluefin tuna is designated for the Lease Area or the remaining Northern ECC Branches. EFH is defined as 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 (NOAA, 2017). Bluefin tuna can be found in waters overlying the continental shelf and slope of the Mid-Atlantic Bight between June and March (NOAA, 2017). No bluefin tuna were collected during state or federal trawl surveys.

6.1.3 Skipjack Tuna

Juveniles: EFH is designated for skipjack tuna (*Katsuwonus pelamis*) juveniles throughout the majority of the Lease Area, Monmouth ECC, Northern ECC, and along the eastern portion of the Asbury Northern ECC Branch. No EFH is designated for skipjack tuna juveniles in the remaining Northern ECC Branches. EFH is defined as 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 in waters greater than 20 meters (66 feet) (NOAA, 2017).

Adults: EFH is designated for skipjack tuna adults throughout the entire Lease Area, Monmouth ECC, Northern ECC, and in the Asbury Northern ECC Branch. EFH is also designated in the southern portions of the remaining Northern ECC Branches. EFH is defined as 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 (NOAA, 2017). Optimum temperature for skipjack tuna is 80 °F (27 °C), with a range from 68 to 88 °F (20 to 31 °C) (NOAA, 2017). Other studies state preferred temperature ranges from 58 to 86 °F (14.4 to 20 °C) (Geo-Marine, 2010). No skipjack tuna were collected during state or federal trawl surveys.

6.1.4 Yellowfin Tuna

Juveniles: EFH is designated for yellowfin tuna (*Thunnus albacares*) juveniles throughout the entire Lease Area, and along the southern portions of the Monmouth and Northern ECCs. No EFH is designated for the Northern ECC Branches. EFH is defined as offshore pelagic habitats 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 (NOAA, 2017). No yellowfin tuna were collected during state or federal trawl surveys.

6.2 Sharks

6.2.1 Blue Shark

Juveniles/Adults: EFH is designated for blue shark (*Prionace glauca*) juveniles/adults in the southern tip of the Monmouth ECC. No EFH is designated for juvenile or adult blue shark in the Lease Area, Northern ECC, or Northern ECC Branches. EFH is defined as localized areas in the

Atlantic Ocean in the Gulf of Maine, from Georges Bank to North Carolina, South Carolina, Georgia, and off Florida (NOAA, 2017). Studies have shown that blue shark movement can be seasonally dependent, with restricted movements over the continental shelf occurring in the summer, and offshore movement occurring in the fall (Howey 2010 and Campana et al., 2011 as cited in NOAA, 2017). Movement of blue shark in the water column can vary, with depths ranging from the sea surface to 600 meters (1,969 feet) (Geo-Marine, 2010). Though the species is oceanic, blue sharks can be found close to shore at night (Geo-marine, 2010). Blue sharks are typically found in waters with temperatures ranging from 44.6 to 60.8 °F (7 to 16 °C) but can tolerate waters as warm as 69.8 °F (21 °C)(Geo-Marine, 2010). Since temperatures within the Offshore Project Area are within the thermal range of blue shark, the species could be present in the vicinity of the Project. No blue sharks were collected during state and federal trawl surveys.

6.2.2 Common Thresher Shark

<u>All (Neonate/Young of Year [YOY], Juveniles, and Adults)</u>: EFH is designated for common thresher shark (*Alopias vulpinus*) neonates/YOY/juveniles/adults throughout the entire Lease Area, Monmouth ECC, Northern ECC, and Asbury Northern ECC Branch, and in the southern portions of the remaining Northern ECC Branches. Currently, insufficient data is available to differentiate EFH between the juvenile and adult size classes; therefore, EFH is the same for those life stages. EFH is located 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 (NOAA, 2017). EFH occurs with certain habitat associations in nearshore waters of North Carolina, especially in areas with temperatures from 18.2 to 20.9 °C (64.8 to 69.6 °F) and at depths from 4.6 to 13.7 meters (15 to 45 feet) (McCandless et al. 2002 as reported in NOAA, 2017). Common thresher sharks are typically found within 40 to 75 miles (64 to 121 kilometers) of land (Geo-Marine, 2010). Juvenile common threshers inhabit coastal bays and nearshore waters while adults commonly inhabit waters over the continental shelf (Geo-Marine, 2010). During federal trawl surveys a total of three common thresher sharks were collected in the Lease Area, all of which occurred in the fall. No common thresher sharks were collected in the ECCs and none were collected during state trawl surveys.

6.2.3 Dusky Shark

<u>Neonate/YOY</u>: EFH is designated for dusky shark (*Carcharhinus obscurus*) neonates/YOY throughout the entire Lease Area, Monmouth ECC, Northern ECC, and Asbury Northern ECC Branch. EFH is also designated in the southern portions of the remaining Northern ECC Branches. 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 (64.6 to 72 °F), salinities of 25 to 35 parts per thousand and depths at 4.3 to 15.5 meters (14 to 51 feet). Seaward extent of EFH for this life stage in the Atlantic is 60 meters (197 feet) in depth (NOAA, 2017). Major nursey areas have been identified in coastal waters from Massachusetts to North Carolina, where dusky shark give birth from April to May (Geo-Marine, 2010). During federal trawl surveys a total of two dusky sharks were collected in the Lease Area,

all of which occurred in the spring. No dusky sharks were collected in the ECCs and none were collected during state trawl surveys.

Juveniles/Adults: EFH is designated for dusky shark juveniles/adults throughout the majority of the Lease Area, Monmouth ECC, Northern ECC, and in the eastern portion of the Asbury Northern ECC Branch. No EFH is designated for dusky shark juveniles/adults in the remaining Northern ECC Branches. EFH is defined as coastal and pelagic waters inshore of the continental shelf break (< 200 meters or 656 feet 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 (66 foot) bathymetric line. Adults are generally found deeper (to 2,000 meters or 6,562 feet) than juveniles, however there is overlap in the habitats utilized by both life stages (NOAA, 2017). Dusky shark have a large distributional range spanning from inshore waters to the outer reaches of the continental shelf (NOAA, 2017). The species also undergoes a seasonal migration, traveling north in the summer and south in the fall in search of warmer waters (Geo-Marine, 2010). During federal trawl surveys, dusky shark were collected in small quantities in the Lease Area. No dusky sharks were collected in the Monmouth or Northern ECCs.

6.2.4 Sand Tiger Shark

Neonate/Juveniles: EFH is designated for sand tiger shark (*Carcharias taurus*) neonates/juveniles throughout the entire Asbury Northern ECC Branch, and throughout the majority of the Lease Area, Monmouth ECC, Northern ECC, and in the southern portions of the remaining Northern ECC Branches. 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. Juvenile 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 (66.2 to 77 °F), salinities range from 23 to 30 parts per thousand at depths of 2.8-7.0 meters (9 to 23 feet) in sand and mud areas, and in coastal North Carolina habitats with temperatures from 19 to 27 °C (66.2 to 80.6 °F), salinities from 30 to 31 parts per thousand, depths of 8.2-13.7 meters (27 to 45 feet), in rocky and mud substrate or in areas surrounding Cape Lookout that contain benthic structure (NOAA, 2017). Based on numerous tagging programs, juvenile sand tiger sharks are known to occur from Maine to the Delaware Bay during summer, then migrate south during winter (NOAA, 2017). During federal trawl surveys, two sand tiger sharks were collected, one in the Lease Area and one in the Monmouth ECC. Both individuals were collected during spring surveys. No sand tiger sharks were collected in the Northern ECC or in state trawl surveys.

6.2.5 Sandbar Shark

Neonate/YOY: EFH is designated for sandbar shark (*Carcharhinus plumbeus*) neonates/YOY throughout the Asbury Northern ECC Branch and within the majority of the Lease Area, Monmouth ECC, and Northern ECC. No EFH is designated for the remaining Northern ECC Branches. EFH is defined as 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 parts per thousand and depth is greater than 5.5 meters or 18 feet); 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 (59 to 86 °F); salinities that vary from 15 to 35 parts per thousand; water depths that range from 0.8 to 23 meters (2.6 to 75 feet); and sand, mud, shell, and rocky sediments/benthic habitat (NOAA, 2017). The closest nursery habitat of importance to the Offshore Project Area, as identified by NOAA Fisheries, is in Great Bay, New Jersey which is located approximately 11 miles (18 kilometers) west of the Lease Area.

Juveniles: EFH is designated for sandbar shark juveniles throughout the entire Lease Area, Monmouth and Northern ECCs, and the Asbury Northern ECC Branch. EFH is also designated in the southern portions of the remaining Northern ECC Branches. EFH is defined as coastal portions of the Atlantic Ocean between southern New England (Nantucket Sound, Massachusetts) and Georgia in water temperatures ranging from 20 to 24 °C (68 to 75.2 °F) and depths from 2.4 to 6.4 meters (7.9 to 21 feet). 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 (59 to 86 °F), salinities range from 15 to 35 parts per thousand, water depth ranges from 0.8 to 23 meters (2.6 to 75 feet), and substrate includes sand, mud, shell, and rocky habitats (NOAA, 2017).

Adults: EFH is designated for sandbar shark adults throughout the entire Lease Area, Monmouth and Northern ECCs, and the Asbury Northern ECC Branch. EFH is also designated in the southern portions of the remaining Northern ECC Branches. EFH in the Atlantic Ocean is defined as 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 (NOAA, 2017). Sandbar sharks are a bottom-dwelling species that are commonly found at depths between 20 to 55 meters (66 to 180 feet) (NOAA, 2017). Comparatively, water depths within the Offshore Project Area range from 0 to 30 meters (0 to 98 feet). Given the depth ranges present in the Offshore Project Area, and the presence of important nursery grounds in the vicinity of the Project, sandbar sharks could be present in the Offshore Project Area. During federal trawl surveys, three sandbar sharks were collected, all of which occurred in the Lease Area during the spring and fall. No sandbar sharks were collected in the ECCs or during state trawl surveys.

HAPC: HAPC for sandbar shark constitutes important nursery and pupping grounds which have been identified in shallow areas and at the mouth of Great Bay, New Jersey, in lower and middle Delaware Bay, Delaware, lower Chesapeake Bay, Maryland, and offshore of the Outer Banks of North Carolina in water temperatures ranging from 15 to 30 °C; salinities at least from 15 to 35 ppt; water depth ranging from 0.8 to 23 meters; and in sand and mud habitats (NOAA, 2017). The closest HAPC for sandbar shark to the Offshore Project Area is located at the mouth of Great Bay, New Jersey which is approximately 10 miles (16.1 km) from closest point of the Offshore Project Area. Therefore the Project will not affect HAPC for sandbar shark.

6.2.6 Shortfin Mako Shark

All: EFH is designated for all life stages of the shortfin mako shark (*Isurus oxyrinchus*) in the southeastern portion of the Lease Area, along the majority of the Monmouth ECC and most of the Northern ECC, and in the eastern portion of the Asbury Northern ECC Branch. No EFH is designated for the remaining Northern ECC Branches. 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 is defined as 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 200-meter or 656-foot bathymetric line); coastal and offshore habitats between Cape Cod and Cape Lookout, North Carolina; and localized habitats off South Carolina and Georgia (NOAA, 2017). Shortfin mako sharks are typically found in warm-temperate to tropical waters around the world, but rarely in waters less than 60.8 °F (16 °C) (Geo-Marine, 2010). Based on data collected in the Offshore Project Area, waters off the coast of New Jersey fluctuate seasonally, but have reached 68 °F (20 °C) at the surface and 59 °F (15 °C) at the seafloor. Water temperatures in the Offshore Project Area are within the suitable temperature range for shortfin mako. No shortfin mako sharks were collected in the Offshore Project Area during federal and state trawl surveys.

6.2.7 Smoothhound Shark Complex (Atlantic Stock)

All: EFH is designated for all life stages of the smoothhound shark complex (Atlantic Stock) (*Mustelus canis*) throughout the entire Lease Area, Monmouth ECC, Northern ECC, and following Northern ECC Branches: Asbury, South Beach, Midland, and Fort Hamilton. EFH is also designated throughout the majority of the Lemon Creek and Wolfe's Pond Northern ECC Branches. At this time, available information is insufficient for the identification of EFH for life stages of this stock, therefore all life stages are combined in the EFH designation. Smoothhound shark EFH identified in the Atlantic is exclusively for smooth dogfish. EFH in Atlantic coastal areas ranges from Cape Cod Bay, Massachusetts to South Carolina, inclusive of inshore bays and estuaries (e.g., Pamlico Sound, Core Sound, Delaware Bay, Long Island Sound, Narragansett Bay, etc.). EFH also includes continental shelf habitats between southern New Jersey and Cape Hatteras, North Carolina (NOAA, 2017). Smooth dogfish seasonally migrate inshore in the spring and summer, and offshore in the fall and winter, and can be found at depths of up to 200 meters (656 feet). Telemetry studies have shown the use of estuaries by smooth dogfish within New Jersey. Estuaries and marsh creeks serve as critical nursery habitat to YOY (NMFS, 2010). During federal and state trawl surveys, smooth dogfish were collected in the Offshore Project Area during the spring, summer, and fall. No smooth dogfish were collected during winter surveys.

6.2.8 Tiger Shark

Juveniles/Adults: EFH is designated for tiger shark (*Galeocerdo cuvieri*) juveniles/adults throughout the entire Lease Area, Monmouth ECC, and Asbury Northern ECC Branch, as well as throughout the majority of the Northern ECC. No EFH is designated for the remaining Northern ECC Branches. 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 (NOAA, 2017). Tiger sharks can be found along the continental shelf, estuaries, harbors, and inlets at depths ranging from surface water to 350 meters (1,148 feet) (Geo-Marine, 2010). Given the wide-range distribution of tiger sharks, the species could be present in the Offshore Project Area. During federal trawl surveys, two tiger sharks were collected with one occurring in the Lease Area and the other in the Monmouth ECC. Both collections occurred during fall surveys. No tiger sharks were collected in the Northern ECC or during state trawl surveys.

6.2.9 White Shark

Neonate: EFH is designated for white shark (*Carcharodon carcharias*) neonates throughout the entire Lease Area, and the majority of the Monmouth ECC, Northern ECC, and the Asbury Northern ECC Branch. No EFH is designated within the remaining Northern ECC Branches. EFH is defined as inshore waters out to 105 kilometers (65 miles) from Cape Cod, Massachusetts, to an area offshore of Ocean City, New Jersey (NOAA, 2017).

Juveniles/Adults: EFH is designated for white shark juveniles/adults throughout the entire Asbury Northern ECC Branch, along the northern portions of the Monmouth ECC and Northern ECC, and the southern portions of the remaining Northern ECC Branches. No EFH is designated for the Lease Area. Known EFH is defined as inshore waters to habitats 105 kilometers (65 miles) from shore, in water temperatures ranging from 9 to 28 °C (48.2 to 82.4 °F), but more commonly found in water temperatures from 14 to 23 °C (57.2 to 73.4 °F) from Cape Ann, Massachusetts, including parts of the Gulf of Maine, to Long Island, New York, and from Jacksonville to Cape Canaveral, Florida (NOAA, 2017). The Mid-Atlantic Bight is known for having the highest occurrence of white shark when compared to other areas in their habitat range (NOAA, 2017). Within the Mid-Atlantic Bight, white sharks have been spotted from April through December along the continental shelf (NOAA, 2017; Geo-Marine, 2010). No white sharks were collected during federal or state trawl surveys conducted in the Offshore Project Area.

REFERENCES:

Geo-Marine Inc. 2010. *NJDEP Ocean/Wind Power Ecological Baseline Studies Finalfgeoz Report - Volume IV: Fish and Fisheries Studies*. Plano (TX). https://www.nj.gov/dep/dsr/ocean-wind/.

Guida, V., A. Drohan, H. Welch, J. McHenry, D. Johnson, V. Kentner, J. Brink, D. Timmons, E. Estela-Gomez. 2017. *Habitat Mapping and Assessment of Northeast Wind Energy Areas. Sterling, VA: US Department of the Interior, Bureau of Ocean Energy Management*. OCS Study BOEM 2017-088. 312

Mid-Atlantic Fishery Management Council (MAFMC). 1998a. *Amendment 12 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan*. MAFMC and the ASMFC in cooperation with NMFS, NEFSC, and SAFMC.

MAFMC. 1998b. *Amendment 12 to the Atlantic Surfclam and Ocean Quahog Fishery Management Plan*. Dover (DE): MAFMC incorporation with NMFS.

MAFMC and Atlantic States Marine Fisheries Commission (ASMFC). 1998. *Amendment 1 to the Bluefish Fishery Management Plan*. Dover (DE): MAFMC and ASMFC in cooperation with NMFS.

MAFMC. 2011. *Amendment 11 to the Atlantic Mackerel, Squid, and Butterfish (MSB) Fishery Management Plan (FMP)*. Dover (DE): MAFMC in cooperation with NMFS.

MAFMC. 2014. *Amendment 3 to the Spiny Dogfish Fishery Management Plan*. Dover (DE): MAFMC in cooperation with NMFS.

MAFMC. 2016. Regional Use of the Habitat Area of Particular Concern (HAPC) Designation. Available at: https://www.mafmc.org/habitat (Accessed February 2021).

National Marine Fisheries Service (NMFS). 2010. Final Amendment 3 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Sustainable Fisheries, Highly Migratory Species Management Division, Silver Spring, MD.

National Oceanic and Atmospheric Administration (NOAA). 1999a. *Essential Fish Habitat Source Document: Atlantic Cod, Gadus morhua, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-124.

NOAA. 1999b. *Essential Fish Habitat Source Document: Atlantic Herring, Clupea harengus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-126.

NOAA. 1999c. *Essential Fish Habitat Source Document: Goosefish, Lophius americanus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-127.

NOAA. 1999d. *Essential Fish Habitat Source Document: Ocean Pout, Macrozoarces americanus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-129.

NOAA. 1999e. *Essential Fish Habitat Source Document: Pollock, Pollachius virens, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-131.

NOAA. 1999f. *Essential Fish Habitat Source Document: Red Hake, Urophycis chuss, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-133.

NOAA. 1999g. *Essential Fish Habitat Source Document: White Hake, Urophycis tenuis, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-136.

NOAA. 1999h. *Essential Fish Habitat Source Document: Windowpane, Scophthalmus aquosus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-137.

NOAA. 1999i. *Essential Fish Habitat Source Document: Winter Flounder, Pseudopleuronecte samericanus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-138.

NOAA. 1999j. *Essential Fish Habitat Source Document: Witch Flounder, Glyptocephalus cynoglossus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-139.

NOAA. 1999k. *Essential Fish Habitat Source Document: Yellowtail Flounder, Limanda ferruginea, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-140.

NOAA. 1999l. *Essential Fish Habitat Source Document: Butterfish, Peprilus triacanthus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-145.

NOAA. 1999m. *Essential Fish Habitat Source Document: Atlantic Mackerel, Scomber scombrus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-141.

NOAA. 1999n. *Essential Fish Habitat Source Document: Black Sea Bass, Centropristis striata, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-143.

NOAA. 1999o. *Essential Fish Habitat Source Document: Scup, Stenotomus chrysops, Life History and Habitat Characteristics.* NOAA Technical Memorandum NMFS – NE-149.

NOAA. 1999p. *Essential Fish Habitat Source Document: Summer Flounder, Paralichthys dentatus, Life History and Habitat Characteristics.* NOAA Technical Memorandum NMFS – NE-151.

NOAA. 1999q. *Essential Fish Habitat Source Document: Ocean Quahog, Arctica islandica, Life History and Habitat Characteristic*s. NOAA Technical Memorandum NMFS – NE-148.

NOAA. 1999r. *Essential Fish Habitat Source Document: Atlantic Surfclam, Spisula solidissima, Life History and Habitat Characteristics.* NOAA Technical Memorandum NMFS – NE-142.

NOAA. 1999s. *Essential Fish Habitat Source Document: Haddock, Melanogrammus aeglefinus, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS-NE-128.

NOAA. 2003a. *Essential Fish Habitat Source Document: Clearnose Skate, Raja eglanteria, Life History and Habitat Characteristics.* NOAA Technical Memorandum NMFS-NE-174.

NOAA. 2003b. *Essential Fish Habitat Source Document: Winter Skate, Leucoraja ocellata, Life History and Habitat Characteristics.* NOAA Technical Memorandum NMFS-NE-179.

NOAA. 2003c. *Essential Fish Habitat Source Document: Little Skate, Leucoraja erinacea, Life History and Habitat Characteristics.* NOAA Technical Memorandum NMFS-NE-175.

NOAA. 2004. *Essential Fish Habitat Source Document: Silver Hake, Merluccius bilinearis, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-186.

NOAA. 2005a. *Essential Fish Habitat Source Document: Longfin Inshore Squid, Loligo pealeii, Life History and Habitat Characteristics*. NOAA Technical Memorandum NMFS – NE-193.

NOAA. 2017. *Final Amendment 10 to the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan: Essential Fish Habitat and Environmental Assessment.* Office of Sustainable Fisheries Atlantic Highly Migratory Species Management Division.

NOAA. 2021. *Essential Fish (EFH) Habitat Mapper*. Accessed September 24, 2018. https://www.habitat.noaa.gov/protection/efh/efhmapper/.

NEFMC. 2017. *Omnibus Essential Fish Habitat Amendment 2. Volume 2: EFH and HAPC Designation Alternatives and Environmental Impacts*. Newburyport (MA): NEMFC in cooperation with NMFS.

NOAA 2022. Seagrasses [GIS dataset]. NOAA Office for Costal Management. Available at: https://www.fisheries.noaa.gov/inport/item/56960/.

Attachment 2

Benthic and Essential Fish Habitat Mapping Methodology

Note: Atlantic Shores has updated the Project Design Envelope to include the following landfall sites: Monmouth Landfall Site, Asbury Landfall Site, Kingsley Landfall Site, Lemon Creek Landfall Site, Wolfe's Pond Landfall Site, and Fort Hamilton Landfall Site. The information included in this report demonstrates the completeness of Atlantic Shores' multi-year development efforts and should be considered representative for the Project. For additional information regarding the layout of the Project, please refer to COP Volume I Project Information, Sections 1.0 Introduction and 4.7 Landfall Sites, as well as Figure 1.1-2 Project Overview.

Benthic and Essential Fish Habitat Mapping Methodology

Atlantic Shores Offshore Wind 2021 – 2022 Geophysical Survey | Lease Area OCS-A 0549, North and South Monmouth ECC, Northern ECC Trunk, and the NJ and NY Landfall Approaches

02.22030006-0549-ECC 01 | February 23, 2023

Final

Atlantic Shores Offshore Wind, LLC

Document Control

Document Information

Project Title	Atlantic Shores Offshore Wind 2021 – 2022 Geophysical Survey
Document Title	Benthic and Essential Fish Habitat Mapping Methodology
Fugro Project No.	02.22030006
Fugro Document No.	02.22030006-0549-ECC
Issue Number	01
Issue Status	Final

Client Information

Client	Atlantic Shores Offshore Wind, LLC
Client Address	1 Dock 72 Way, Floor 7, Brooklyn, NY, 11205
Client Contacts	Deanne Hargrave, Eric Swanson, and Craig Scherschel

Document History

Issue	Date	Status	Comments on Content	Prepared By	Checked By	Approved By
00	03 Feb 2023	For Review	Awaiting client comments	DK, KD	DK	DD
01	23 Feb 2023	Final	Comments addressed	DK, KD	DK	DD

Project Team

Initials	Name	Role
DD	Daniel Doolittle	Environmental Service Line Manager – Americas (Benthic Project Manager)
DK	Darron Kriegel	Project Environmental Manager
KD	Katie Duncan	Project Environmental Scientist
KR	Kathryn Rovang	Senior Geoscientist/GIS Analyst (GIS Liaison)
AJ	Alan Jacquez	Project Geoscientist
MK	Matthew Kratochvil	Staff Geoscientist
AM	Audrey McBee	Project Geoscientist/GIS Analyst
VF	Victoria Fortiz	Senior Geoscientist and Interpretation Technical Lead
SV	Steve Varnell	Principal Geoscientist and Interpretation and Reporting Manager

Contents

Figures in the Main Text

Tables in the Main Text

1. Introduction and Purpose

This document describes Fugro's approach and methodology to developing Benthic and Essential Fish Habitat (EFH) mapping products which inform future consultations with the National Marine Fisheries Service (NMFS) and the Bureau of Ocean Energy Management (BOEM). The data within also supports the completion of Atlantic Shores Offshore Wind's (ASOW) Construction and Operations Plan (COP) for its developments within the ASOW Lease Area OCS-A 0549 and associated export cable corridors (ECC), which include North and South Monmouth ECCs, and the Northern ECC Trunk and two potential landfalls in New Jersey and New York.

Fugro conducted several integrated Benthic Habitat Survey campaigns, including, July to September 2020, and May 2022 to June 2022, as components of its high-resolution geophysical (HRG) and geotechnical investigations within the 0549 Lease Area and along the Export Cable Corridors, including the individual landfalls. These benthic habitat surveys consisted of sediment grab sample stations (with laboratory analysis of grain size, total organic carbon, and macrofaunal taxonomy), real-time seafloor video also collected from each grab, and Sediment Profile and Plan View (SPI-PV) imaging stations. Towed video transects were accomplished later in August of 2022 and are reported on in a separate study.

The interpretative steps taken to arrive at Fugro's Benthic and EFH mapping, and GIS products are outlined below. These products are shared with ASOW and its various contractors for additional interpretative and reporting products for inclusion to the COP. Per BOEM (2019) guidance and NMFS (2021) requests for benthic information, mapped habitats are assigned Coastal Marine Ecological Classification Standard (CMECS) groupings. Benthic plates, charts, and this memo are presented in Appendix E of the Fugro Marine Site Investigation Report (MSIR) for each study area.

2. Methodology and Interpretation Workflow

An overview of the methodology and interpretation steps taken to produce Fugro's spatial mapping of Benthic and Essential Fish Habitat is presented below. Additional information can be found in the Fugro (2021a, 2021b, 2022, 2023a, 2023b, 2023c) MSIR documents.

2.1 Data Sources and Seafloor Interpretation Workflow

All benthic habitat and EFH mapping products have included the following acoustic, imaging, and sampling data inputs from the various Geophysical, Geotechnical, and Benthic Habitat surveys conducted within each survey area:

- Side Scan Sonar (SSS) Mosaics
  - 0.25 m cell-size resolution
  - SSS raster reclassification results are calibrated (adjusted) to the ground truth data.
  - Original SSS (600 kHz) are also used in integration/interpretation.
- Multibeam Echo Sounder (MBES) Bathymetry (400 kHz)
  - 0.5 m cell-size resolution
  - Used in integration/ interpretation
- MBES Backscatter Data
  - 0.25 m cell-size resolution
  - Used in integration/ interpretation
- Sub-bottom Profiler (SBP)
- Grab Sample Analysis (Grain size)
- Benthic Macrofauna Taxonomy Results
- Sediment Profile and Plan View Imagery (SPI-PV)
- Video imagery from each Grab Sample Station (GrabCam)
- Seafloor Video and Still Imagery (towed video transects) were conducted as separate surveys after the initial data review/integration of the above data has occurred.

Acoustic data products were processed and interpreted by Fugro to create polygons of seafloor sediment coverage over the ASOW study areas. The resulting polygons were developed with a blending of automated and manual processes.

Seabed sediment interpretation, and polygon delineation, were primarily based on SSS, benthic grab samples, and SPI-PV data. MBES backscatter and bathymetry were used as supplementary datasets. Polygon delineation followed several steps, outlined below:

1) An automapping procedure was applied to 600 kHz SSS reflectivity data to capture changes in seafloor characteristics.

2) SSS reflectivity raster layers with 1 m resolution for each survey row were applied focal statistics within ArcGIS Pro 3.0.3. Focal statistics is a smoothing operation which calculates the mean value of each cell based on the cells within 5 m.

3) The results were reclassified into up to four distinct classes with unique integer values, based on manual analysis to determine classes. Manual analysis assessed relative changes in SSS reflectivity governed by changes in seafloor characteristics, i.e., sediment texture or seafloor morphology.

4) These reclassified SSS reflectivity raster layers were then converted into polygons for training data for an Artificial Intelligence model. The Artificial Intelligence model was trained to export four general classes predetermined from our training data.

5) After receiving lab results for benthic grab sample data, these classes were compared to benthic grab sample and SPI-PV data and were consolidated and assigned appropriate sediment classifications codes.

6) The four classes for NECCNY were consolidated to reflect the five sediment classes present in the study area due to lab results being received after initial interpretation had commenced. Manual review and occasional editing of polygons were necessary after integration with all available geophysical and ground truth data.

An example of this process is described in Figure 2.1 below and in more detail within the Fugro MSIR Reports (2021a, 2021b, 2022, 2023a, 2023b, 2023c).

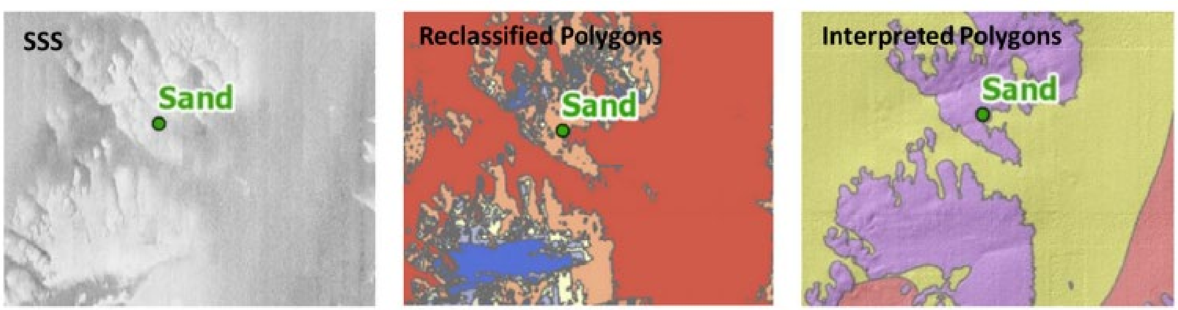


Figure 2.1: Seafloor sediment interpretation, SSS input data (Step 1), reclassification (Step 4), and mapping examples (Step 6) of interpretation workflow

Benthic habitat data were collected throughout the project areas and incorporated into Fugro's Interpretation and Reporting products, as well as to ground truth the acoustic interpretations. Benthic survey data types and quantities used to support the benthic survey goals are summarized in Table 2.1 below. This summary incorporates only benthic data collected within the survey areas covered in this report.

Table 2.1: Atlantic Shores Benthic Surveys, Data Types, and Total Quantities Collected from Lease Area 0549, NMECC, SMECC, NECCT, NECCNJ, and NECCNY.

Survey Contractor	Survey Dates	Benthic Grab Samples	Seafloor Videos	SPI PV Image Pairs
TerraSond	Sept. – Oct. 2019	7	0	0
Fugro	July – Sept. 2020	69	69	94
RPS	June 2021	0	52	0
Fugro	May – June 2022	66	66	252
RPS	August 2022	0	105	0
Totals		142	292	346

2.1.1 Minimum Mapping Unit

The automapping procedure described above has resulted in a flexible level of detail concerning defining a minimum mapping unit for each polygon. Nominally the minimum mapping unit is 400 m^2 but can increase to 100 m^2 in some areas. The value is considered to strike a fair balance between accuracy, usability, and ability to correlate with various resolutions of horizontal (e.g., MBES and SSS) and vertical acoustic data sets (e.g., sub-bottom profiler).

2.2 Sediment Mapping Procedure

A hybrid sediment classification scheme is used for this project. It consists of elements from both Folk (1954, modified by Long, 2006) and the Coastal and Marine Ecological Classification Standard (CMECS) sediment classification systems. This Hybrid-CMECS classification represents the sedimentary conditions encountered within the Mid-Atlantic offshore area and is well suited to mapping benthic habitats to determine ecologically significant “complex” habitats (per NMFS, 2021) with improved delineation and relevance over other grain size classifications used in other regions of the Atlantic OCS (e.g., modified Folk per Long, 2006) for grain size classification. Particle size definitions within the CMECS system are based on those of Wentworth (1922).

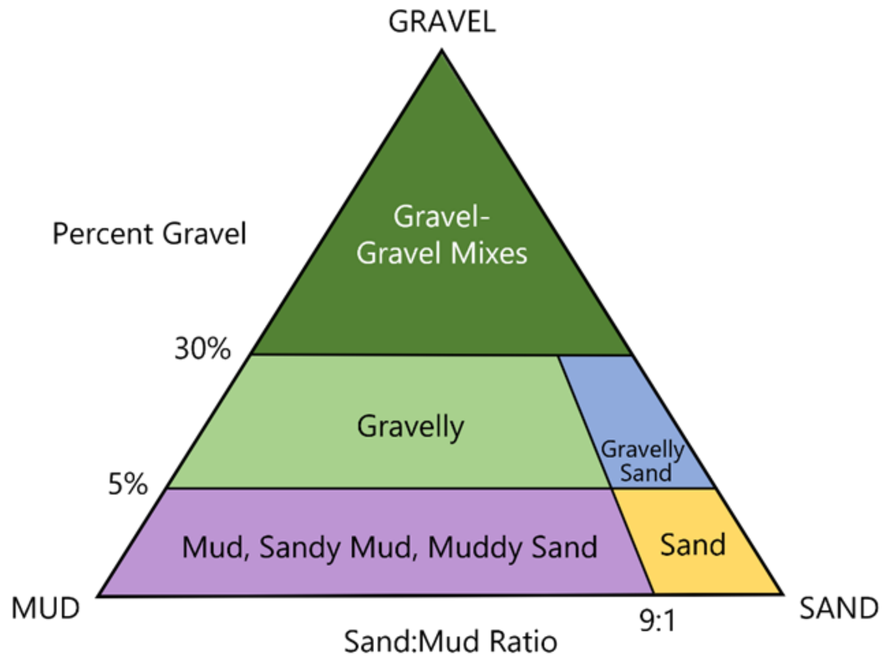


Figure 2.2: Hybrid CMECS Substrate and Simplified-Folk Sediment Classification System in use by Atlantic Shores Offshore Wind

Sediment groupings in the CMECS/Modified Folk system (Figure 2.2) consist of five main categories that encompass the following sediment types and percentage mixtures. Key features of the CMECS/Modified Folk system include its congruency with the CMECS system and has been specifically delineated to better reflect those sediments found in the mid-Atlantic environments:

1. **Mud, Sandy Mud, Muddy Sand** - the ratio of Sand:Mud is less than 9:1 and the sediments contain less than 5 percent gravel.
2. **Sand** - the ratio of Sand:Mud is greater than or equal to 9:1 and the sediments contain less than 5 percent gravel.
3. **Gravelly** - the ratio of Sand:Mud is less than 9:1 and these sediments contain a gravel percentage between 5 and less than 30.
4. **Gravelly Sand** - the ratio of Sand:Mud is greater than or equal to 9:1 and these sediments contain a gravel percentage between 5 and less than 30.
5. **Gravel-Gravel Mixes** - These sediments have Gravel percentages greater than or equal to 30, with no further demarcation made for remaining Sand:Mud ratio.

The simplified Folk system and Wentworth particle size system are used, in part, to define ecosystems following 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 has been adopted for all Atlantic Shores geologic, engineering, and benthic studies. The differences between the classification systems can be seen in Figure 2.3 below.

<table>
<tr><th rowspan="2">Particle Sizes (mm)</th><th colspan="3">Classification System</th></tr>
<tr><th>USCS</th><th>Wentworth</th><th>BS/EN ISO</th></tr>
<tr><td>4026</td><td rowspan="3">Boulders</td><td rowspan="4">Boulders</td><td rowspan="5">Boulders</td></tr>
<tr><td>630</td></tr>
<tr><td>300</td></tr>
<tr><td>256</td><td rowspan="3">Cobbles</td></tr>
<tr><td>200</td><td rowspan="2">Cobbles</td></tr>
<tr><td>75</td><td rowspan="3">Cobbles</td></tr>
<tr><td>64</td><td rowspan="3">Gravel</td><td rowspan="5">Gravel</td></tr>
<tr><td>63</td></tr>
<tr><td>4.75</td><td rowspan="3">Gravel</td></tr>
<tr><td>4</td><td rowspan="3">Sand</td></tr>
<tr><td>2</td></tr>
<tr><td>0.075</td><td rowspan="2">Sand</td><td rowspan="2">Sand</td></tr>
<tr><td>0.0625</td><td rowspan="3">Silt</td></tr>
<tr><td>0.0039</td><td>Silt</td><td rowspan="2">Silt</td></tr>
<tr><td>0.002</td><td rowspan="2">Clay</td></tr>
<tr><td>0</td><td>Clay</td><td>Clay</td></tr>
</table>

Figure 2.3: Overview of commonly-used grain size classification systems. The CMECS and Modified Folk Systems are used by Atlantic Shores for Benthic Mapping and are based on the Wentworth System

2.3 Interpreted Sediment Distribution

The sediment CMECS substrates (Group and Subgroups, modified per ASOW's Hybrid/CMECS Folk Sediment Classification System) types identified across the survey area and interpreted are "Mud, Sandy Mud, Muddy Sand," "Sand," "Gravelly," "Gravelly Sand," and "Gravel-Gravel Mixes." Results of the interpreted sediment distribution are summarized in Table 2.2 below, by study area.

Table 2.2: Surficial sediments and substrates mapped within the Atlantic Shores Offshore Wind study areas.

Project Area	Surficial Sediments and Substrates					
	Mud, Sandy Mud, Muddy Sand	Sand	Gravelly Sand	Gravelly	Gravel Gravel Mixes	Boulder/Debris, Boulder Field
Lease Area OCS-A 0549	NA	Yes	Yes	Yes	NA	NA
North Monmouth (NMEEC)	NA	Yes	Yes	Yes	Yes	NA
South Monmouth (SMECC)	NA	Yes	Yes	NA	Yes	NA
Northern ECC Trunk (NECCT)	Yes	Yes	Yes	Yes	Yes	Yes
Northern ECC New York Landfalls (NECCNY)	Yes	Yes	Yes	Yes	NA	NA
Northern ECC New Jersey Landfall (NECCNJ)	NA	Yes	Yes	Yes	Yes	Yes

2.4 Morphological Benthic Features Interpretation

Seafloor morphology was interpreted from side scan sonar mosaics, bathymetry, backscatter, and seafloor slope analyses. Seabed conditions within the entire project area are characterized as the following: ridge and swale (sand ridges), sand waves, megaripples, and ripples, boulders/ debris and boulder/debris fields, hardground, seabed scars, localized relief features, unconsolidated marine sediment, irregular seafloor, and surficial interbedded deposits and associated scarps.

The sections below provide an overview of Benthic Features seen across the whole study area, or within areas of interest, as noted.

2.4.1 Ridge and Swale (Sand Ridges)

Regionwide, the continental shelf generally has a gentle slope that extends from the New Jersey coastline eastward. The continental shelf across the project area is characterized by ridge-and-swale topography with a northeasterly trend (Fugro, 2020). These ridges are postulated to be shoreface deposits abandoned as the shoreline transgressed during the last sea level rise.

These features are found in the 0549 Lease Area, North and South MECC, and the NECCNJ landfall approach. Within the 0549 Lease Area, sand ridges exhibit relief of over 5 m and widths of approximately 500 to 7,500 m, trending northeast-to-southwest, and extending up to 17.5 km. Throughout all other applicable areas, sand ridges cross through with vertical relief of over 4 m and widths of 500 to 1,000 m. These ridges may extend for distances of up to 25 km and are postulated to be shoreface deposits abandoned as the shoreline transgressed during the last sea level rise. These features are present at a regional scale and should be considered as contributing to the overall morphology of the total project site and area. Various-sized sand waves, megaripples, and ripples are often superimposed (overprinted) on the underlying large-scale ridges and swales.

2.4.2 Sand Waves, Megaripples, and Ripples

Sand waves, megaripples, and ripples represent migrating depositional features that form as sediments are transported and redeposited by bottom currents. Interpretation of bedforms uses BOEM's (2020) classification based on wavelength and height, as shown in Table 2.3 where height and wavelength differed in class, weight was given to the wavelength.

Table 2.3: BOEM bedform classification guidance (2020).

Name	Wavelength (meters)	Height (meters)
Sand wave	Greater than 60	Greater than 1.5
Megaripples	Between 5 and 60	Between 0.5 and 1.5
Ripple	Less than 5	Less than 0.5

Sand waves are migrating depositional features, generally understood to form from sediments that are transported and redeposited by bottom currents (Wynn and Stow, 2002). These features have a height greater than 1.5 m from trough to peak with wavelengths greater than 60 m from peak to peak (Table 2.3). Sand waves were observed in the 0549 Lease Area, North and South MECC, the NECCT, and the NECCNJ landfall approach. Within the 0549 Lease Area, the sand waves can be up to 2.5 m high (trough-to-peak) and exhibit a wavelength (peak-to-peak) ranging from approximately 60 to 1500 m, trending northeast-to-southwest. Sand waves within the North MECC can be up to 4 m high and display a wavelength ranging from approximately 60 to 140 m. Two types of sand waves are observed in the South MECC: larger and smaller sand waves. The larger trend between west-to-east and southwest-to-northeast may be related to the regional sand ridges. They can be up to 2 m high and display an average wavelength around 4 km; however, the spacing between crests ranges from approximately 1.5 to 8 km. The smaller are predominantly located in the southern part of the SMECC and are somewhat transitional features, as their wave heights are typically 0.5 to 1 m. These smaller sand waves span an area between 1.5 to 2.5 km long. In the North ECC Trunk, sand waves can be up to 4 m high with wavelengths ranging from approximately 60 to 180 m. Sand waves in the NECCNJ landfall approach range up to 1.2 m high and exhibit a wavelength of approximately 60 to 1000 m.

Megaripples may represent migrating depositional features, generally understood to form from sediments that are transported and redeposited by bottom currents and other hydrodynamic forcings. Megaripple crests generally trend northwest to southeast. This feature is present in all survey areas. The most prominent megaripples that most closely conform to BOEM criteria occur in the southwestern portion of the 0549 Lease Area. However, megaripple-like features, which meet the BOEM wavelength criteria, but do not meet the height criteria, were found across the 0549 Lease Area. In the North Monmouth ECC, megaripples are up to 0.6 m high with wavelengths ranging from approximately 20 to 50 m and slopes up to 13°. The current activity level of the megaripples within the NMECC could not be determined based on the available datasets. Megaripples are present in two areas of the South Monmouth ECC. The first area is in the northern part of the SMECC along the shoreward side of a relative bathymetric high. Towards the center of the ECC, they are in an area of irregular bathymetry. In both areas, their crests trend roughly east-west, are up to 0.4 m high and have wavelengths of 20 to 40 m. In the NECCT, megaripples are between 0.3 to 1.5 m high with wavelengths ranging from approximately 5 to 60 m. Throughout the NECCNY landfall approaches, megaripples height was approximately 0.6 m tall, with crest-to-crest wavelengths ranging from 7 to 55 m and slopes up to 13°. Megaripples in the NECCNJ landfall approach have a mapped height of about 0.3 m, and their wavelengths range from approximately 20 to 50 m.

Ripples are characterized by their high SSS reflectivity and MBES backscatter intensity and are typically in bathymetric lows. Ripples actively change orientation, may be planed off during storm events, and readily reform. They are not anticipated to present a significant hazard to cables due to their small height. Ripples were present in all survey areas.

Each of these features is mapped within most or all project areas which indicates the potential for mobile seafloor sediments.

2.4.3 Boulders/Debris and Boulder/Debris Fields

These features are recognized as a substrate but have been shown on charts as benthic features to not occlude the above sediment substrates. Boulders/debris are clasts greater than 30 cm in diameter and may be of glacial or anthropogenic origin. The general study area, and surrounding region, have been subjected to ocean dumping of dredged materials (Ocean Disposal Database, 2022) and aggregations of anthropogenic debris (e.g., harbor dredged sediments, construction materials, bricks, asphalt, artificial reef materials, etc.) are known to exist on the seafloor within the survey area. Without optical confirmation, it’s difficult to distinguish between a bolder of glacial/morainal origin or of anthropogenic sources and the terms are used interchangeably. As boulder/debris picking was performed, areas of boulders that met or exceeded the agreed-upon threshold of ten boulders within a 100m square area were included in polygons. As mentioned above, these polygons are designated as boulder fields.

Within the NECCT and NECCNJ study areas, individual boulders/debris are interpreted to occur at the edges of mapped boulder/debris fields. High- and low-density boulder/debris fields are mapped within discrete sections of the NECCT route (see Fugro MSIR, Appendix E 2023a, Charts E1 through E12). These NECCT boulder/debris fields range in size from about 2.5 square meters to 2.1 square kilometers.

Individual boulders and boulder debris fields in the NECCNJ range in size from about 290 to 132,367 m^2. Within the NECCNY study area, boulders and rocks have been charted by NOAA (Fugro, 2023b) yet have not been interpreted along any of the various approach routes.

2.4.4 Seabed Scars

Commercial fishing activities, using bottom tending gear are the likely sources of these features. Scar morphologies are generally aligned with fishing gears such as bottom trawls, paired scallop dredges, clam dredges, and or scars from anchoring activities by a wide range of vessels.

Seabed scars have been observed in the 0549 Lease Area, North and South MECC, NECCT, and NECCNJ and NECCNY landfall approaches. They are observed as isolated scars or areas of multiple overlapping scars. Seabed scars all share similar morphologies throughout the study areas. Scar geometries, measured from MBES data, range in width from approximately 1 to 9 m and measured depths range from 2 cm to 30 cm.

2.4.5 Unconsolidated Marine Sediment

Unconsolidated marine sediment areas are relatively flat accumulations of muddy to sandy sediments with no discernible bedforms and are characterized by relatively featureless seabed and low to medium SSS reflectivity and MBES backscatter intensity. Unconsolidated marine sediments have an overall smooth, featureless shape and are generally found along areas of locally high bathymetric relief.

Within the study area, unconsolidated marine sediments were found in the NECCT and NECCNY landfall approaches. In the NECCT, unconsolidated marine sediments were observed in the northern nearshore areas, and around kilometer point 82. The NECCNY landfall approaches have a significant amount of unconsolidated marine sediment that lies in channel dredge areas, and high amounts of mud, muddy sand, and sandy mud also lead to areas of smooth featureless sediment.

2.4.6 Surficial Interbedded Deposits and Associated Scarps

Surficial interbedded deposits are areas of localized terraced, Holocene-aged, deposits. The features have a low, homogeneous backscatter return with bands of higher returns along scarp edges. The sub-bottom data suggest relatively weak internal reflectors that truncate at the seafloor along the scarp slopes. These features have the potential to present relatively consolidated fine-grained estuarine deposits that have resisted erosion. The interbedded sediment can also be mapped from the SBP data.

Surficial interbedded deposits were observed in the North MECC, NECCT, and NECCNJ and NECCNY landfall approaches, while scarps were only observed in the North MECC and NECCNJ. In the North MECC, these features were characterized as relatively cohesive sediments, with relief up from 0.3 to 1.0 m and a terraced pattern with steep slopes up to 27° along the edges in the MBES. The scarps found in the nearshore region of the NMECC vary in horizontal extent from 16 to 335 m and have a general NNE linear trend largely parallel to the shoreface. These features tend to be on the east/southeast facing steeper outer edges of the surficial interbedded sediments. Within the NECCT, the densest concentrations of interbedded sediments occur at Shrewsbury Rocks (see Fugro MSIR, Appendix E 2023a, Charts E1 through E12). In the NECCNJ landfall approach, surficial interbedded deposits exhibit a wide range of submarine heights above the seafloor ranging from 0.1 to 1 m and have a terraced pattern ending at a localized crest. Scarps associated with surficial interbedded deposits extend laterally for about 80 to 3000 m in length. The relatively lower-angle scarps are generally oriented east to west but have a northerly trend within the nearshore area.

2.4.7 Irregular Seafloor

Irregular seafloor features exhibit a rugged or uneven texture and undulating seafloor as compared to the smooth or rippled seafloor features interpreted elsewhere in the study area. They may be relict features from prior erosional events and not indicative of active/modern sediment transport. The SSS data in the irregular seafloor areas are characterized by patchy high and low SSS reflectivity, consistent with interpretations of highly variable seafloor sediments. Areas of irregular seafloor appear in the MBES bathymetry and SSS data to have a fractal/ chaotic/disorderly texture. The features are distributed throughout the study area.

Within the study area, irregular seafloor was found within the 0549 Lease Area, the NECCT, and both NECCNJ and NECCNY landfall approaches. Within the 0549 Lease Area, imagery from benthic SPI-PV locations in rough and irregular seafloor areas also shows a higher amount of shell hash as compared to the rest of the project areas (Integral, 2020). Irregular seafloor has a fractal texture identified in MBES bathymetric products. In various locations along the NECCT small modules of irregular seafloor link together to form larger linear trends. Irregular Seafloor is evenly distributed throughout the NECCNJ landfall approach. Throughout the NECCNY landfall approaches, areas of irregular seafloor have exposures ranging from 0.1 to 0.4 m and a fractal texture identified in MBES bathymetric products. Irregular seafloor areas tend to be concentrated far from shore.

2.4.8 Localized Relief Features (LRFs)

Localized Relief Features are interpreted as raised accumulations of sandy sediments. The features are characterized by low MBES backscatter intensity and a rugose seafloor texture visible on SSS and seafloor photography and video data. LRFs also generally display well-defined raised margins and appear to better preserve seafloor scars compared to the surrounding seafloor, potentially due to their being more cohesive and resistant to hydrodynamic transport. In some occurrences, LRFs may be comprised of concentrations of tube-building infauna, as evidenced by GrabCam data and SPI-PV imagery, and a sediment-organism relationship may exist that binds the sediments. Video footage at OCS-A 0549 sample locations shows these features have structure and relief above the seafloor, providing some ecosystem services to demersal fish species, such as the northern sea robin (*Prionotus carolinus*) which has been seen feeding and resting in these LRFs (Figure 2.4).

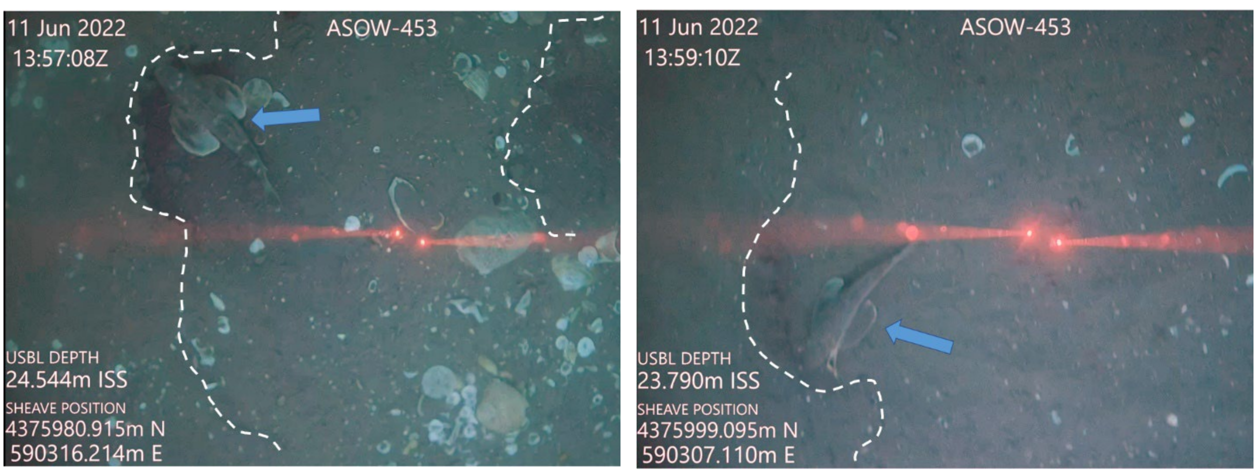


Figure 2.4: LRF edges outlined in white dashes, sea robin (blue arrows) shown feeding on edges of the LRF (left) and resting in the base of the LRF (right) at the Lease Area (OCS-A 0549) benthic grab station OCS-A BG-453

Feature relief (as interpreted from the acoustic data) ranges from 0.1 to 2.3 m, with maximum seafloor slopes of 22°. Optical resolution within the SPI-PV and GrabCam datasets is greater and LRF relief can be more subtle, on the order of centimeters. LRF edges have a fractal/disorderly edge pattern leading to the overall rough seafloor texture. This pattern may be the inherent result of sediment accumulation, or it may be the result of bio-erosion from fish feeding activity.

LRFs are present in all survey areas. In the 0549 Lease Area, the localized relief features are present in the central, northeast, and northwest portions of the 0549 Lease Area in a northeast-to-southwest direction (Fugro, 2022, Figure 4.7a, Charts 5A-5E). These features are raised accumulations of mixed sediments and are characterized by variable MBES backscatter intensity and a raised rugose seafloor that has been interpreted to be resistant to erosion. Similar features are observed in the Monmouth ECCs, however, their distribution in the 0549 Lease Area is more widespread with a northeast-to-southwest trend. The difference in spatial occurrence may be due to seasonal variability across the multiple survey campaigns. Localized relief features also generally display well-defined raised margins and appear to better preserve seafloor scars compared to the surrounding seafloor (Fugro, 2022, Figure 4.7a). Seafloor slopes in these areas are typically 3 to 7.5 degrees but can be up to 10 degrees on some features.

The LRF features are not acoustically prominent in the Northern ECC New Jersey landfall approach and occur in local areas less than about 10,000 m^2, with feature relief (as interpreted from the acoustic data) ranges from 0.1 to 0.3 m and maximum seafloor slopes of 8°. In the Northern ECC New York landfall approaches study area, LRF interpretations represent erosional features that have locally high relief around areas of dredging activity (dredge borrows and trenches). The rugose texture is most likely the result of mixed sediments around areas of erosion. Feature relief ranges from 0.2 to 2.3 m, with slopes between 11° and 22°. In the NECCT, feature relief ranges from 0.1 to 1 m with an average of 6.5° and a max seafloor slope of 20°. Localized relief features edges have a fractal pattern leading to the overall rough texture. Localized relief features are not promenade NECCT and occur in local concentrations no larger than 0.01 km^2. In both North and South Monmouth Feature relief ranges from 0.1 to 0.4 m, with slopes up to 16°.

LRFs may represent concentrations of biogenic substrates, as evidenced SPI-PV imagery, and video footage at sample locations. That ground truth data shows these features have regular geometric structure and some slight vertical relief above the seafloor. The LRF structures may provide habitat for a variety of organisms, however, more imagery and direct samples of these structures are needed to verify this interpretation and understand any potential habitat implications.

3. Essential Fish Habitat Classification

Essential fish habitat (EFH) mapping guidance, per NMFS (2021), recommended that the following groupings of the CMECS-substrate types are condensed into the following groups:

1) *soft bottom habitats;*
2) *complex habitats;*
3) *heterogeneous complex habitats;*
4) *large-grained complex habitats; and*
5) *benthic features (representing morphologies that overlie or overprint the above habitats).*

As part of Fugro's deliverables for this task, the following criteria were used to develop Charts and GIS products according to NMFS (2021) guidance to support consultations around Essential Fish Habitat distribution in the ECCs and Lease Area OCS-A 0459.

3.1 Soft Bottom Habitat

Geologic substrates with less than 5 % gravel (Mud, Sandy Mud, Muddy Sand, and Sand) are considered fine unconsolidated sediments per CMECS but under the NMFS EFH recommendations are not considered complex habitat. "Soft" habitat characterizes fine unconsolidated sediments (sand and muddy sand in this study area) that do not exhibit the structural exemptions listed in the heterogeneous complex habitat description.

3.2 Complex Habitat

Substrates with greater than 5 % and less than 80 % gravels (as Gravelly, Gravelly Sand, or Gravel/Gravel Mixes) are considered coarse sediments by CMECS and complex habitat under EFH recommendations.

3.3 Heterogenous Complex Habitats

Habitat and surficial sediments classified as "heterogenous complex" exist within areas of interbedded sediment mixes that contain a base of either sand (or "soft" per NMFS, 2021 guidance) or "complex habitats" (NMFS, 2021) with an indecipherable interface between two distinct classes. These heterogeneous complex areas appear to make up the transitional space between soft and complex sediment. Other morphological, or benthic, features such as irregular seafloor, seafloor scars, and LRFs were mapped as complex or heterogenous complex as they pertain to NMFS (2021). These areas are indicative of variable benthic habitats or transition zones.

3.4 Large Grained Complex Habitat

This category of complex habitat is largely characterized by boulders or other anthropogenic sourced clasts (debris) that exceed 30 cm in diameter and appear to provide some vertical relief from the seafloor. The general study area, and the surrounding region, have been subjected to ocean dumping of dredged materials (Ocean Disposal Database, 2022) and aggregations of anthropogenic debris (e.g., harbor dredged sediments, construction materials, bricks, asphalt, artificial reef materials, etc.) are known to exist on the seafloor within the survey area. Without optical confirmation, it’s difficult to distinguish between a bolder of glacial/morainal origin or of anthropogenic sources and the terms are used interchangeably. Boulders/debris often also are suitable habitats for encrusting organisms as well as protective cover for other mobile fish and some crustacean species.

3.5 EFH Benthic Features

Benthic features include seabed sediment bodies and morphologies such as ripples, megaripples, and sand waves (per NMFS, 2021). Fugro has also included other morphological features that have the potential to provide topographical structure on the seafloor that may influence fish behavior or utilization over their various life-history stages. See Table 3.1 for a full list of these habitat and morphological benthic features.

NMFS (2021) recommendations suggest using existing substrate and morphology geometries delineated by geophysical interpretations that were visually verified by benthic imagery and ground truth data to classify the layers and intersections with EFH designations. Within ESRI ArcGIS Pro (3.3.0), all seabed sediment feature classes were mapped utilizing the framework outlined in Figure 3.1 below.

The process shown in Figure 3.1 can be described following the general order presented below:

a. Interpret surficial sediment polygons to classify habitat complexity based on grain size. By the CMECS definition, coarse unconsolidated substrate (gravels, gravel mixes, gravelly, or gravelly sand) contain greater than 5 % but less than 80 % gravel. Surficial sediment coverages interpreted to be comprised of between 5 % to 80 % gravel in this project were reinterpreted into complex sediments layers per project area. Areas of complex substrate outweigh benthic features that impact fine unconsolidated sediments.

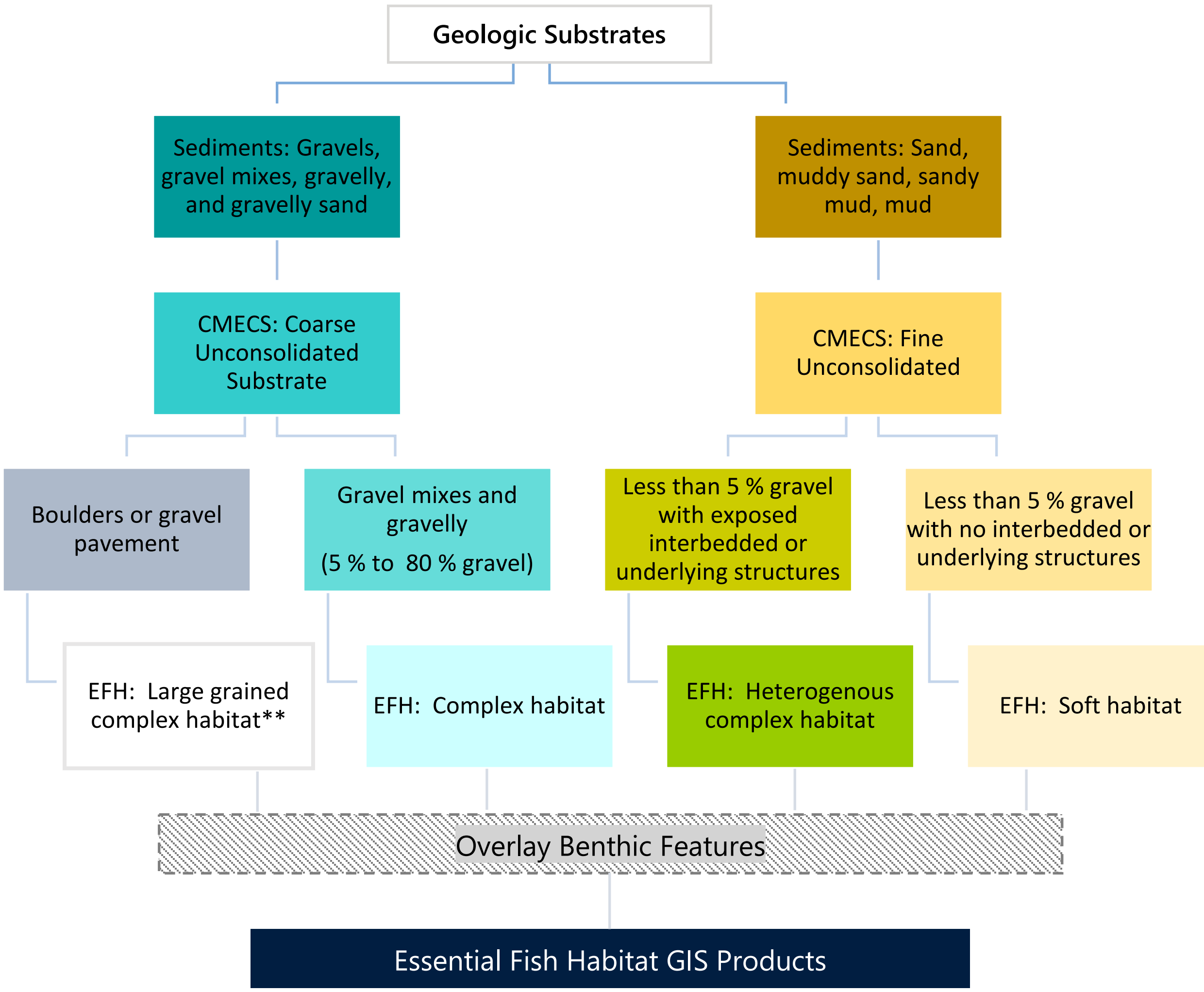


Figure 3.1: Essential Fish Habitat classification framework per NMFS (2021) recommendations

b. Interpret substrates with > 80 % gravel cover or boulders that meet/exceed the threshold criteria of > 10 boulders per 100 m^2 to be mapped as Boulder Fields. These areas would then be mapped as Large Grained Complex Habitats.

c. Evaluate the area of overlap between sand substrate and interbedded or erosional morphologic and benthic features in ArcGIS Pro 3.3.0. Within the workspace, areas of irregular seafloor or interbedded surficial sediment and sand feature classes were input into the intersection tool. The overlap of benthic features with the surficial sediments was indicative of heterogeneous sediment coverage at the surface. Although the surficial sediment body was predominately covered in an eroding layer of sand, the geophysical SBP shows shallow burial of transgressive channel units and interbedded layers near or at the surface. The outcome of the benthic features and surficial sand coverage intersection was classified as heterogeneous complex. Seabed scaring through complex habitat was interpreted as heterogeneous complex as a transition between the surrounding complex sediment and the softer sediment deposited in the center of seabed scars.

d. The remaining surficial sand coverage areas in this project were classified as soft sediments.

These outputs were then converted into Charts (at 1:10,000 scale). On all Charts, the top panel will display the SSS mosaic, the middle panel will display the CMECS Substrates, and the lower panel will show the resulting EFH habitat groupings (Soft, Complex, Heterogenous Complex, Large-Grained Complex, and overlain Benthic Features).

Essential Fish Habitat substrate and benthic feature shapefiles used in the creation of Fugro Charts and Plates/Figures are detailed in Table 3.1.

Table 3.1: EFH Substrates and benthic features found in the study area.

Layer	OCS 0549	NMECC	SMECC	NECCT	NECCNJ	NECCNY
EFH Substrates						
Soft	X	X	X	X	X	X
Complex	X	X	X	X	X	X
Heterogeneous Complex	X	X		X	X	X
Large-Grained Complex				X	X	
EFH Benthic Features						
Ridge and Swale (Sand Ridges)	X	X	X	X	X	
Sand Waves	X	X	X	X	X	
Mega Ripples	X	X	X	X	X	X
Ripples	X	X	X	X	X	X
Boulders/Debris, Boulder/Debris Fields				X	X	
Seabed Scars	X	X	X	X	X	
Unconsolidated Marine Sediment	X			X		X
Surficial Interbedded Deposits and Associated Scarps		X		X	X	X
Irregular Seafloor	X			X	X	X
Localized Relief Features (LRFs)	X	X	X	X	X	X

4. Summary of Results

4.1 Lease Area OCS-A 0549

The CMECS surficial sediments of the Lease Area (OCS-A 0549) are comprised of the Substrate Groups "Sand," "Gravel-Gravel Mixes" and the Substrate Subgroup "Gravelly Sand," with several notable morphological and benthic features distributed across the study area. Fugro's 2022 MSIR Volume 1, Appendix E, Charts F1A-F1E shows the distribution of all CMECS substrates mapped in the 0549 Lease Area. The CMECS Substrate Group "Sand" makes up nearly 79 % of the mapped area. There were twenty-nine (29) grab stations across the 0549 Lease Area that indicated gravelly sand as the predominate CMECS sediment class. The most abundant taxon is *Tanaissus psammophilus* (Isopoda), followed by the *Ampelisca vadorum* (Amphipod). Sediment Profile and Plan View Images that were classified as "Sand" number 85 image pairs. The CMECS Biotic Group and Co-Occurring Biotic Groups that occur across most "Sand" substrates are "Sand Dollar Bed" (36 % occurrence), "Larger Tube Building Fauna" (15 % occurrence), and "Mobile Crustaceans on Soft Sediments" (15 % occurrence).

"Gravelly Sand" was the next most abundant CMECS Substrate Subgroup across the 0549 Lease Area, making up 16.1 % of the mapped area. There were 23 grain size samples and 21 infauna grab samples collected across the 0549 Lease Area that were classified as "Gravelly Sand". Here, the most abundant taxon is *Tanaissus psammophilus* (Isopoda) followed by *Unciola irrorata* (Amphipod). Twenty (20) SPI-PV image pairs were classified as "Gravelly Sand". The CMECS Biotic Group and Co-Occurring Biotic Groups that occur across the majority of Gravelly Sand subgroup are "Soft Sediment Fauna" (44 % occurrence), "Attached Fauna" (27 % occurrence) and "Sand Dollar Bed" (7 % occurrence).

Mapped concentrations of CMECS Substrate Group "Gravel-Gravel Mixes" made up 5.4 % of the study area. Seven (7) grain-size samples were collected, and three (3) infauna grab samples were collected in this category. The most abundant taxon is *Ampelisca vadorum* (Amphipod) followed by Oligochaeta. Twenty-one (21) SPI-PV image pairs were classified as "Gravel-Gravel Mixes". The CMECS Biotic Group and Co-Occurring Biotic Groups that occur across "Gravel-Gravel Mixes" substrates are "Attached Fauna" (43 % occurrence), "Soft Sediment Fauna" (29 % occurrence), and "Inferred Fauna" (11 % occurrence).

Of the mapped Benthic Features (or morphologies), only the areas of irregular seafloor characterized by erosional features that have exposed underlying transgressive channel units were noted to have a potential impact on fish behavior and life history stages/use. The underlying beds partially exposed at the surface could influence the overall substrate properties. Therefore, any areas of sand that intersect irregular seafloor are classified as heterogenous complex habitat (Fugro, 2022, Appendix E, Charts G2A though G2E). The remaining sand areas are classified as soft habitat. All areas of gravelly sand and gravelly substrate are classified as complex habitat.

4.2 North Monmouth ECC

Substrates in Northern Monmouth ECC are characterized as sand gravelly sand, gravelly, and gravels or gravel mixes, with several mapped morphological and benthic features present. The most prevalent CMECS substrate along the North Monmouth ECC is "Gravelly Sand" (59 %), followed by "Sand" (18 %), and then "Gravelly" (12 %, Plates 5 and 6), and "Gravel-Gravel Mixes" (11 %; Fugro, 2021a, Appendix E, Plates 7 and 8). The distribution of the various mapped substrates is shown in Fugro, 2021a, Appendix E, Plates 2, 4, 6, and 8.

Ground truth of these substrates and their distributions across the area was provided SPI-PV, grab, and towed video data. A total of 20 sediment grab, 17 SPI-PV, and 37 video transect sampling stations were established along the NMECC. At each SPI-PV station, a total of 6 images (3 SPI and 3 PV) were analyzed, for a total of 102 images. Additionally, five (5) stations were placed outside the corridor to serve as control areas for future baseline studies. All sampling locations are shown on Fugro, 2021a, Appendix E, Charts E1 through E7.

The most numerous CMECS biotic groups and subgroups that occur across the NMECC "Sand" substrates, as documented by analysis of the SPI-PV imagery, include "Larger Tube-building Fauna" (21 % occurrence), "Mobile Crustaceans on Soft Sediments" (~ 17 % occurrence), and "Sand Dollar Beds" (~ 17 % occurrence). See Fugro, 2021a, Appendix E, Plate 1 for additional details on benthic community statistics for infauna related to this substrate.

Within the "Gravelly Sand" substrate subgroup, also the most predominant type across the area, the top CMECS biotic groups and subgroups found to occur on this substrate are: "Sand Dollar Beds" (28 % occurrence), "Mobile Crustaceans on Soft Sediment" (16 % occurrence), "Tracks and Trails" (16 % occurrence), and "Larger Tube-Building Fauna" (16 % occurrence). See Fugro, 2021a, Appendix E, Plate 3 for additional details on benthic community statistics for infauna related to this substrate type.

"Gravelly" substrates, comprising 12 % of the NMECC, were seen in the northernmost part of the study area (Plate 6 and Charts E1 and E2) and at one Control Area station. Only two grab samples were collected in these sediments, and the SPI-PV sample was collected at the Control Station outside the survey area. CMECS biotic group and subgroups, based primarily on the SPI-PV imagery, were not visualized for the one control station (Fugro, 2021a, Appendix E, Plate 5, SPG-37-E), but were reported as "Larger Tube-Building Fauna" as the CMECS biotic Group, with Mobile Crustaceans on Soft Sediments as the co-occurring biotic group. See Fugro, 2021a, Appendix E, Plates 5 and 6 for additional details.

Within the “Gravel-Gravel Mixes” substrates, comprising only 11 % of the NMECC, the top CMECS biotic groups and subgroups found to occur on this substrate are “Mobile Crustaceans on Soft Sediments” (38 % occurrence), “Larger Tube-Building Fauna” (19 % occurrence), and “Sand Dollar Bed” (9 % occurrence). See Fugro, 2021a, Appendix E, Plate 7 for additional details on benthic community statistics for infauna related to this substrate.

A meiofauna analysis was not specifically undertaken on any benthic survey. Meiofauna organisms (i.e., nematodes) that were retained on the 0.5 mm sieve were enumerated in the 2020 survey and excluded during the 2022 survey.

In the “Sand” substrates, the most dominant infauna taxon was the tube-building amphipod, *Pseudunciola obliquua* (Fugro, 2021a, Appendix E, Plate 1). In the “Gravelly Sand” substrate subgroup, the most dominant infauna taxon was the tube-building amphipod, *Unciola irrorata* (Fugro, 2021a, Appendix E, Plate 3). The most abundant infauna taxa in “Gravelly” substrates were the bivalve mollusk *Nucula proxima*, followed by the amphipod *Unciola irrorata* (Fugro, 2021a, Appendix E, Plate 5). Lastly, the most abundant benthic infaunal communities found in the “Gravel-Gravel Mixes” substrates were Oligochaete and Polychaete worms (*Pisione remota*).

Of the mapped morphologies (benthic features) across the NMECC area that may impact fish behavior or habitat usage, there are numerous instances of Localized Relief Features and patches of Interbedded Surficial Sediments and associated Scarps. The LRFs have a slight vertical relief and have potential to serve as refugia for some species. The LRFs are highlighted as their own Benthic Feature to avoid being overlooked with the “complex habitat” classification. The remaining “Sand” areas were classified as soft habitat, and all areas of “Gravelly Sand”, “Gravelly”, and “Gravel-Gravel Mixes” were classified as complex habitat. Heterogenous Complex areas were also noted in the NMECC study area, primarily associated with the benthic feature Interbedded Surficial Sediments.

4.3 South Monmouth ECC

Substrates (CMECS) in South Monmouth ECC are characterized as being comprised of sand, gravelly sand, and gravel or gravel mixes with several mapped morphological and benthic features. Areas of “Sand” substrate were classified as soft habitat. “Gravelly Sand,” “Gravel-Gravel Mixes” were classified as complex habitat (per NMFS, 2021 guidance). “Gravelly Sand” is the most abundant substrate type in the South Monmouth ECC area, followed by “Sand,” and “Gravel-Gravel Mixes” are sparsely present in the northern portion of the study area (Fugro, 2021b, Appendix E, Chart E1). The distribution of the various substrates is shown on Charts E1 through E5 in Fugro MSIR Volume 4 Appendix E (2021b).

Ground truth of these substrates and their distributions across the area was provided SPI-PV, grab, and towed video data. A total of three sediment grabs, one SPI-PV image pair, and five video transect sampling stations were established along the SMECC. At each SPI-PV station, a total of six images (three SPI and three PV) were analyzed. Additionally, five (5) stations were placed outside the corridor to serve as control areas for future baseline studies. All sampling locations are shown on Charts E1 through E5 in the South Monmouth MSIR report (Fugro, 2021b). Additional ground truth stations are established on the western and northern perimeter of the SMECC and serve to add additional interpretative ground truth data when the South Monmouth ECC study area is reviewed in conjunction with the 0549 Lease Area (Fugro, 2022).

Benthic features recognized in the South Monmouth area are comprised of LRFs, sand waves, megaripples, and ripples. The largest (by area) LRFs are found predominately in the northern portion of the study area, with sparse coverage to the southern area of smaller and isolated mapped features. The predominant benthic features across the study area are ripples, with discreet bands of sand waves crossing the area (also following a southwesterly to northeasterly trend). See Charts E1 through E5 contained in Appendix E of Fugro's report (2021b) for more details on the distribution of the mapped benthic features and morphologies.

4.4 North ECC Trunk

The Hybrid CMECS/Simplified Folk surficial sediments of the NECCT study area are comprised of the Substrate Groups "Mud, Sandy Mud, Muddy Sand", "Sand," "Gravelly," and "Gravel-Gravel Mixes," and the Substrate Subgroup "Gravelly Sand," with several morphological and benthic features distributed across the study area. Boulders and boulder fields are included in the "Gravel-Gravel Mixes" CMECS group. The distribution of the various substrates is shown in Charts E1 through E12, and Plates 2, 4, 6, 8, and 10. Fugro MSIR, Appendix E (2023a).

The CMECS Substrate Group "Mud, Sandy Mud, Muddy Sand" makes up 0.02 % of the mapped area. There were two (2) grab stations across the NECCT area that were classified as "Mud, Sandy Mud, Muddy Sand" per CMECS, with infauna samples being collected at both stations (Fugro, 2023a, Appendix E, Plates 1 and 2). In these two grab samples, the most abundant benthic community taxon sampled in the sediment grabs was the Polychaeta *Polygordius jouinae*, followed by *Oligochaeta* (Annelida) worms, and *Tanaissus psammophilus* (Tanaidacea). Sediment Profile and Plan View Images that were classified as "Mud, Sandy Mud, Muddy Sand" number 11 image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Mud, Sandy Mud, Muddy Sand" station. The most common Biotic Groups and Co-Occurring Biotic Groups in Mud, Sandy Mud, Muddy Sand" are "Mobile Mollusks on Soft Sediments" (32 % occurrence), "Sand Dollar Bed" (18 % occurrence), and "Burrowing Anemones" (18 % occurrence).

The CMECS Substrate Group "Sand" makes up 36 % of the mapped area. Thirteen (13) grab stations across the NECCT area were classified as "Sand" per CMECS, with infauna samples being collected at all stations (Fugro 2023a, Appendix E, Plates 3 and 4). In those grab samples, the most abundant benthic community taxon sampled in the sediment grabs was the Polychaeta

Polygordius jouinae, followed by nearly an equal abundance of Oligochaeta (Annelida) worms, with the third most abundant being *Pseudunciola obliquua* (Amphipod). Sediment Profile and Plan View Images that were classified as "Sand" number 166 image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Sand" station. The most common Biotic Groups and Co-Occurring Biotic Groups in "Sand" are "Sand Dollar Bed" (38 % occurrence), "Mobile Mollusks on Soft Sediments" (22 % occurrence), and "Mobile Crustaceans on Soft Sediments" (10 % occurrence).

The CMECS Substrate Group "Gravelly" makes up a small percentage of the NECCT mapped area (3.4 %). There were six (6) grab stations across the NECCT area that were classified as "Gravelly" per CMECS (Fugro, 2023a, Appendix E, Plates 5 and 6). The most abundant benthic community was Polychaeta *Polygordius jouinae*, followed by *Oligochaeta* (Annelida) worms, and *Tanaissus psammophilus* (Tanaidacea). Sediment Profile and Plan View Images that were classified as "Gravelly" number four (4) image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Gravelly" station. There were three found Biotic Groups and Co-Occurring Biotic Groups in "Gravelly," which are "Burrowing Anemones" (60 % occurrence), "Mobile Crustaceans on Soft Sediments" (20 % occurrence), and "Mobile Mollusks on Hard or Mixed Substrates" (20 % occurrence).

The CMECS Substrate Subgroup "Gravelly Sand" is the most common substrate throughout the NECCT study area. It covers 37.9 % of the mapped NECCT area. There were two (2) grab stations across the NECCT area that were classified as "Gravelly Sand" per CMECS (Fugro, 2023a, Appendix E, Plates 7 and 8). The most abundant benthic community was *Oligochaeta* (Annelida) worms, followed by *Pseudunciola obliquua* (Amphipod), and *Tanaissus psammophilus* (Tanaidacea). Sediment Profile and Plan View Images that were classified as "Gravelly Sand" number 49 image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Gravelly Sand" station. The most common Biotic Groups and Co-Occurring Biotic Groups in "Gravelly Sand" are "Sand Dollar Bed" (28 % occurrence), "Mobile Crustaceans on Hard or Mixed Substrates" (25 % occurrence), and "Mobile Mollusks on Hard or Mixed Substrates" (14 % occurrence).

The CMECS Substrate Group "Gravely-Gravel Mixes" make up 22.7 % of the NECCT mapped area. There were 15 grab sample stations within the NECCT area that were classified as "Gravel-Gravel Mixes" per CMECS (Fugro, 2023a, Appendix E, Plates 9 and 10). The most abundant benthic community taxon sampled was Polychaeta *Polygordius jouinae*, followed by *Oligochaeta* (Annelida) worms, and *Spio setosa* (Polychaeta). Sediment Profile and Plan View Images that were classified as "Gravel-Gravel Mixes" number 49 image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Gravel-Gravel Mixes" station. The distribution of Biotic Group and Co-occurring Biotic Groups on Gravel-Gravel Mixes was "Mobile Crustaceans on Hard or Mixed Substrates" (39 % occurrence), "Larger Tube-Building Fauna" (15 % occurrence), and "Sand Dollar Bed" (14 % occurrence).

Of the mapped morphologies (benthic features) across the NECCT area that may impact fish behavior or habitat usage, there are numerous instances of Localized Relief Features and patches of irregular seafloor, heavily scarred areas, and surficial interbedded sediments and associated scarps. The LRFs have a slight vertical relief and have potential to serve as refugia for some species. The LRFs are highlighted as their own Benthic Feature to avoid being overlooked with the "complex habitat" classification. The remaining "Sand" areas were classified as soft habitat (28 % of the mapped area), and all areas of "Gravelly Sands", "Gravelly", and "Gravel Mixes" were classified as complex habitat, covering 61 % of the mapped area. Heterogenous Complex areas comprised 6 % the NECCT study area, as well as 5 % was mapped as Large Grained Complex.

4.5 North ECC New Jersey Landfall

The CMECS surficial sediments of the NECCNJ study area are comprised of the Substrate Groups "Sand," "Gravelly," and "Gravel-Gravel Mixes," and the Substrate Subgroup "Gravelly Sand," with several notable morphological and benthic features distributed across the study area. Distribution of the various substrates is shown on Chart E1 in the Fugro MSIR, Appendix E (2023c).

Starting from the finest grain fraction to the coarsest, the following CMECS groups are acoustically interpreted to exist in the NECCNJ survey area. The CMECS group "Mud, Sandy Mud, Muddy Sand" is not interpreted to be present in the survey area.

The CMECS Substrate Group "Sand" makes up 23 % of the mapped area. There were four (4) grab stations across the NECCNJ area that were classified as "Sand" per CMECS (Fugro, 2023c, Appendix E, Plates 1 and 2). In those grab samples, the most abundant benthic community taxon sampled in the sediment grabs was the amphipod *Pseudunciola obliquua*, followed by nearly equal abundances of *Oligochaeta* (Annelida) worms, and sand dollars *Echinarachnius parma* (Echinoidea). Sediment Profile and Plan View Images that were classified as "Sand" number 30 image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Sand" station. The most common Biotic Groups and Co-Occurring Biotic Groups in sands are "Sand Dollar Bed" (27 % occurrence), "Mobile Mollusks on Soft Sediments" (20 % occurrence), and "Larger Tube-Building Fauna" (16 % occurrence).

The CMECS Substrate group "Gravelly" makes up 42 % of the mapped NECCNJ area. No grab samples or SPI-PV stations were classified to this substrate subgroup type in the NECCNJ corridor (Fugro, 2023c, Appendix E, Plates 3 and 4).

The CMECS Substrate Subgroup "Gravelly Sand" makes up 26 % of the mapped NECCNJ area. No grab samples or SPI-PV stations were classified to this substrate subgroup type in the

NECCNJ corridor. Three SPI-PV stations from the nearby Control Site were classified as “Gravelly Sand” (Fugro, 2023c, Appendix E, Plates 5 and 6).

The CMECS Substrate Group “Gravel-Gravel Mixes” make up ~ 9 % of the mapped area. One (1) grab station within the NECCNJ area was classified as “Gravel-Gravel Mixes” per CMECS (Fugro, 2023c, Appendix E, Plates 7 and 8). In the one grab sample, the most abundant benthic community taxon sampled was *Oligochaeta* (Annelida) worms, followed by the Polychaetes *Paradoneis lyra* and *Parapionosyllis longicirrata*. A single SPI-PV image pair was collected in this Substrate Group as part of a transect collected along the width of the NECCNJ corridor. The transects were collected as single drops along a line, so only 1 SPI-PV pair per drop was collected. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from the PV image collected in this Substrate Group. The distribution of Biotic Group and Co-occurring Biotic Groups on Gravel-Gravel Mixes was “Attached Anemones” (50 % occurrence) and “Mobile Mollusks on Hard or Mixed Substrates” (50 % occurrence).

Of the mapped morphologies (benthic features) across the NECCNJ area that may impact fish behavior or habitat usage, there are numerous instances of Localized Relief Features and patches of Surficial Interbedded Sediments and associated Scarps. The LRFs have a slight vertical relief and have potential to serve as refugia for some species. The LRFs are highlighted as their own Benthic Feature to avoid being overlooked with the “complex habitat” classification. The remaining “Sand” areas were classified as soft habitat, and all areas of “Gravelly Sands”, “Gravelly”, and “Gravel Mixes” were classified as complex habitat. Heterogenous Complex areas were also noted in the NECCNJ study area, as well as Large Grained Complex.

4.6 North ECC New York Landfalls

The CMECS surficial sediments of the NECCNY study area are comprised of the Substrate Groups “Mud, Sandy Mud, Muddy Sand”, “Sand,” and “Gravelly,” and the Substrate Subgroup “Gravelly Sand,” with several notable morphological and benthic features distributed across the study area. Fugro, 2023b, Appendix E, Chart E1 show the distribution of all CMECS substrates mapped in the study area.

The CMECS Substrate Group “Mud, Sandy Mud, Muddy Sand” makes up 16 % of the mapped area. There were seven (7) grab stations across the NECCNY area that were classified as “Mud, Sandy Mud, Muddy Sand” per CMECS (Fugro, 2023b, Appendix E, Plates 1 and 2). Infauna samples were collected at five (5) of the seven (7) grabs. In these five grab samples, the most abundant benthic community taxon sampled in the sediment grabs was the Polychaeta *Mediomastus ambiseta*, followed by *Oligochaeta* (Annelida) worms, and *Streblospio benedicti* (polychaeta). Sediment Profile and Plan View Images that were classified as “Mud, Sandy Mud, Muddy Sand” number 16 image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each “Mud, Sandy Mud, Muddy Sand” station. The most common Biotic Groups and Co-Occurring Biotic Groups in Mud, Sandy Mud, Muddy Sand" are "Larger Tube-Building Fauna" (32 % occurrence), "Tracks and Trails" (21 % occurrence), and "Mobile Crustaceans on Soft Sediments" (16 % occurrence).

The CMECS Substrate Group "Sand" makes up 58 % of the mapped area. There were seven (7) grab stations across the NECCNY area that were classified as "Sand" per CMECS (Fugro, 2023b, Appendix E, Plate 3 and 4). Infauna samples were collected at four (4) of the seven (7) grabs. In these grab samples, the most abundant benthic community taxon sampled in the sediment grabs was *Streblospio benedicti* (polychaeta), followed by *Oligochaeta* (Annelida) worms and *Mediomastus ambiseta* (polychaeta) (Fugro, 2023b, Appendix E, Plate 3). Sediment Profile and Plan View Images that were classified as "Sand" number 39 image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Sand" station. The most common Biotic Groups and Co-Occurring Biotic Groups in sands are "Mobile Crustaceans on Soft Sediments" (21 % occurrence), "Tracks and Trails" (21 % occurrence), and "Larger Tube-Building Fauna" (19 % occurrence).

The CMECS Substrate group "Gravelly" makes up 0.3 % of the mapped NECCNY area. One grab sample was collected across the NECCNY area that was classified as "Gravelly" (Fugro, 2023b, Appendix E, Plate 5 and 6). The most abundant benthic community taxon sampled in the sediment grab was Oligochaeta (Annelida) followed by *Tharyx* sp. (polychaeta) and *Neanthes arenaceodentata* (polychaeta). No SPI-PV stations were classified to this substrate subgroup type in the NECCNY corridor.

The CMECS Substrate Subgroup "Gravelly Sand" makes up 25 % of the mapped NECCNY area (Fugro, 2023b, Appendix E, Plate 7 and 8). No grab sample was collected in this substrate subgroup type in the NECCNY corridor. Sediment Profile and Plan View Images were classified as "Gravelly Sand" number three image pairs. CMECS Biotic Group and Co-Occurring Biotic Groups are derived primarily from PV images at each "Gravelly Sand" station. The most common Biotic Groups and Co-Occurring Biotic Groups are "Mussel Bed" (40 % occurrence), "Attached Hydroids" (40 % occurrence), and "Tracks and Trails" (20 % occurrence).

Of the mapped morphologies (benthic features) across the NECCNY area that may impact fish behavior or habitat usage, there are numerous instances of Localized Relief Features and patches of Surficial Interbedded Sediments and associated Scarps. The LRFs have a slight vertical relief and have potential to serve as refugia for some species. The LRFs are highlighted as their own Benthic Feature to avoid being overlooked with the "complex habitat" classification. The remaining "Sand" areas were classified as soft habitat, and all areas of "Gravelly Sands", "Gravelly", and were classified as complex habitat. Heterogenous Complex areas were also noted in the NECCNY study area.

5. References and Related Reports

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.

Bureau of Ocean Energy Management (BOEM). (2020). *Guidelines for Providing Geophysical, Geotechnical, and Geohazard Information,* Pursuant to 30 CFR Part 585.

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

Fugro. (2020). *Atlantic Shores Offshore Wind Farm Geoscience-Focused Desktop Study* (Fugro Document No. 02.2003-0003). Fugro USA Marine, Inc.

Fugro. (2021a). *Marine Site Investigation Report Volume 3: North Monmouth Export Cable Corridor* (Fugro Document No. 02.2003-0003-MSIR-NM-ECC). Fugro USA Marine, Inc.

Fugro. (2021b). *Marine Site Investigation Report Volume 4: South Monmouth Export Cable Corridor* (Fugro Document No. 02.2103-0011-MSIR-SM-ECC). Fugro USA Marine, Inc.

Fugro. (2022). *Marine Site Investigation Report Volume 1: Lease Area OCS-A 0549, Atlantic Shores Offshore Wind High-Resolution Geophysical Survey* (Fugro Document No. 02.2103-0011-MSIR-LA-0549). Fugro USA Marine, Inc.

Fugro. (2023a). *Marine Site Investigation Report Volume 2: Northern Export Cable Corridor Trunk* (Fugro Document No. 02.22030006 -MSIR-0549-ECC 01). Fugro USA Marine, Inc.

Fugro. (2023b). *Marine Site Investigation Report Volume 3: Northern Export Cable Corridor New York Landfall Approaches* (Fugro Document No. 02.2203-0006-MSIR-NECCNY 01). Fugro USA Marine, Inc.

Fugro. (2023c). *Marine Site Investigation Report Volume 4: Northern Export Cable Corridor New Jersey Landfall Approaches* (Fugro Document No. 02.2203-0006-MSIR-NECCNJ 01). Fugro USA Marine, Inc.

Integral. (2020). *Sediment Profile and Plan View Imaging Survey of the Atlantic Shores Offshore Wind Project Areas*. Integral Consulting, Inc.

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

National Marine Fisheries Service (NMFS). (2021). Recommendations for Mapping Fish Habitat. NMFS GARFO Habitat Conservation and Ecosystem Services Division. March 2021. 22 pp.

Ocean Disposal Database. (2022). Environmental Laboratory, U.S. Army Engineer Research and Development Center. Retrieved (January 2023) from http://odd.el.erdc.dren.mil/.

RPS. (2021). *Atlantic Shores Offshore Wind Project: Towed Video Report V1*. RPS Group, Inc. 38 pp.

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

Wynn, R.B., and Stow, D.A.V. (2002). Classification and Characterization of Deep-Water Sediment Waves. *Marine Geology*. 192, 7-22.