South Fork Wind Benthic Habitat Mapping to Support Essential Fish Habitat Consultation

Prepared for:

South Fork Wind | Powered by Ørsted & Eversource

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BOEM	Bureau of Ocean Energy Management
CMECS	Coastal and Marine Ecological Classification Standard
COP	Construction and Operation Plan
DWSF	Deepwater Wind South Fork, LLC
EFH	Essential fish habitat
FGDC	Federal Geographic Data Committee
FMP	Fisheries management plan
Fugro	Fugro USA Marine, Inc.
HDD	horizontal direction drill
IAC	Inter-Array Cable
INSPIRE	INSPIRE Environmental, LLC
MBES	Multibeam echosounder
mmu	Minimum mapping unit
NOAA	National Oceanic and Atmospheric Administration
NOAA Habitat	NOAA National Marine Fisheries Greater Atlantic Regional Fisheries Office Habitat Conservation and Ecosystem Services Division
MWA	SFW Maximum Work Area
OCS	Outer Continental Shelf
OSS	Offshore Sub-station
PV	Plan View
SFEC	South Fork Export Cable
SFEC – NYS	South Fork Export Cable – New York State
SFEC – OCS	South Fork Export Cable – Outer Continental Shelf
SFW	South Fork Wind
SFWF	South Fork Wind Farm
SPI	Sediment Profile Imaging
SSS	Side-scan sonar
WTG	Wind Turbine Generator

EXECUTIVE SUMMARY

Deepwater Wind South Fork, LLC has submitted a Construction and Operations Plan to support the siting and development of South Fork Wind Farm and South Fork Export Cable, collectively the Project. The South Fork Wind Farm is an offshore energy project proposed within the Bureau of Ocean Energy Management Renewable Energy Lease Area OCS-A 0517 to deliver energy to Long Island, New York. The Project will consist of up to 15 wind turbine generators, an offshore substation, and an alternating current electric cable that will connect the South Fork Wind Farm to the existing mainland electric grid in East Hampton, New York. Deepwater Wind South Fork has committed to an indicative layout scenario with wind turbine generator and offshore substation foundations sited in a grid with approximately 1.15 mile (1.9 km, 1.0 nm) by 1.15 mile (1.9 km, 1.0 nm) spacing that aligns with other proposed adjacent offshore wind projects in the Rhode Island/Massachusetts Wind Energy Area.

Positioning of foundations for the wind turbine generators and offshore substation, as well as Inter-array Cables is constrained and complicated by the heterogeneous composition of the seabed (e.g. boulders, hard bottom) and other potential constraints, including cultural and archeological resources in the South Fork Wind Farm Maximum Work Area. Layout of the Project may be refined based on further consultation with agencies and stakeholders, ongoing offshore geophysical and geotechnical surveys, and detailed engineering and design. As such, Deepwater Wind South Fork requires flexibility to micro-site foundations. In accordance with 30 CFR § 585.634(c)(6), micro-siting of foundations can occur up to 152.5 m (500-feet) from the locations identified in the indicative layout scenario shown in the Construction and Operation Plan.

Deepwater Wind South Fork has collected extensive data to support the characterization of habitats within the South Fork Wind Farm and along the South Fork Export Cable route. These data were used to conduct detailed benthic habitat mapping and a crosswalk of delineated benthic habitat types to essential fish habitat. Habitats were described in terms of complexity, sediment composition, heterogeneity, bedforms, and observed/anticipated infaunal and epifaunal communities. The detailed mapping and characterization of benthic habitat types within the Project Area greatly improves the collective knowledge base about seafloor environments on Cox Ledge and the outer continental shelf between Cox Ledge and Long Island. Six benthic habitat types were mapped in the Project Area:

1) Glacial Moraine;
2) Coarse Sediment - 30 to 80% Cobble/Boulder;
3) Coarse Sediment - 5 to 30% Cobble/Boulder;
4) Coarse Sediment - <5% Cobble/Boulder;
5) Sand and Muddy Sand; and
6) Mud and Sandy Mud.

All six benthic habitat types were observed within the buffered area of potential effect in the South Fork Wind Farm and along the South Fork Export Cable where benthic habitat types were mapped (~9,203 acres). Nearly half of the area was Sand and Muddy Sand, approximately 30% was Coarse Sediment - <5% Cobble/Boulder, and approximately 20% was Glacial Moraine; Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - 30 to 80% Cobble/Boulder, and Mud and Sandy Mud each occupied less than 1% of the mapped South Fork Wind Farm. All three Coarse Sediment habitat types and Sand and Muddy Sand were found within the ~8,530 acres mapped along the portion of the South Fork Export Cable in federal waters. Nearly half of the area was Sand and Muddy Sand, approximately 37% was Coarse Sediment - <5% Cobble/Boulder, and Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - 30 to 80% Cobble/Boulder, and Mud and Sandy Mud each occupied less than 10% of the area mapped along the portion of the South Fork Export Cable in federal waters. With the exception of Glacial Moraine, all benthic habitats were found within the 1,119 acres of the area mapped along the portion of the South Fork Export Cable in New York state waters. The entirety of the preferred route to Beach Lane was composed of Sand and Muddy Sand. The alternate route to Hither Hills included all Coarse Sediment habitat types, Sand and Muddy Sand, and Mud and Sandy Mud.

Given the uncertainty of the exact locations of impacts to the seafloor, an extremely conservative approach, for purposes of EFH consultation, was used to estimate the maximum potential total area and composition of habitats that may be impacted by the Project. Although the same component design parameters (e.g., width of cable protection) as those presented in the Construction and Operation Plan were used to determine acres of impact, the maximum design scenario approach used for this report assumed Project activities would occur over the entirety of the area possible. An additional contingency was also added to acres of impact calculated for cable routes as those will be further refined based on ongoing offshore geophysical and geotechnical surveys and detailed engineering and design. In reality, only a fraction of these areas will ultimately be impacted by Project activities. Given this conservative approach, the maximum potentially impacted acres presented in this report will differ from those footprints presented in the Construction and Operation Plan. The footprint estimates presented in the Construction and Operation Plan are intended to represent the total actual acres of seafloor (agnostic to habitat type) that will be impacted by each project component. ***The acres presented in this benthic habitat mapping report are conservative maximum design scenario estimates developed for EFH review to describe potential impacts by habitat type and therefore, should not be considered representative of the total acres that may be impacted by the Project.***

The potential exists for all six mapped benthic habitat types to be permanently and/or temporarily impacted by the Project, with over half of the impacts to the non-complex habitats of Sand and Muddy Sand (57% permanent, 56% temporary), and Mud and Sandy Mud (1% permanent, 1% temporary). The remaining 43-44% intersects complex habitats with the majority of impacts affecting Coarse Sediment - <5% Cobble/Boulder (34% permanent, 30% temporary), followed by Glacial Moraine (5% permanent, 9% temporary), Coarse Sediment - 5 to 30%

Cobble/Boulder (2% permanent, 3% temporary), and Coarse Sediment - 30 to 80% Cobble/Boulder (1% permanent, 1% temporary). With few exceptions, the benthic habitat composition of permanent and temporary impacts was similar to the habitat composition documented within the given project component area, indicating that altered layouts would do little to measurable shift the overall composition of benthic habitats impacted by the Project.

The proposed project design for the South Fork Wind Farm avoids areas with high densities of boulders to the extent practicable while maintaining the indicative 1 x 1 nm layout scenario. The majority of the foundations are sited within areas of Sand and Muddy Sand combined with Coarse Sediment - <5% Cobble/Boulder and very low boulder density. The high-resolution acoustic data, particularly side-scan sonar, provided along with detailed habitat delineations and descriptions makes it possible to assess potential impacts to specific habitat features (e.g., boulders, bedforms). The proposed project design for the Inter-array Cables and South Fork Export Cable is already indicative of a number of siting decisions, including consideration of constraints related to seafloor composition. Based on the available data and engineering assessment to date, it appears all the proposed project design locations and preferred routes are appropriate for installation.

The crosswalk of the delineated benthic habitat types to essential fish habitat for all demersal species/life stages with designated essential fish habitat in the Project Area provides detailed information to facilitate review of potential impacts to each species/life stage. In total, 25 benthic/demersal species and 54 life stages with designated essential fish habitat within the Project Area have been crosswalked to mapped benthic habitats:

1) 44 to Glacial Moraine habitats;
2) 48 to Coarse Sediment - 30-80% and 5-30% Cobble/Boulder;
3) 47 to Coarse Sediment - < 5% Cobble/Boulder;
4) 45 to Sand and Muddy Sand; and
5) 34 to Mud and Sandy Mud.

Species with demersal/ benthic life stages are most vulnerable to permanent project impacts. Species with designated essential fish habitat that includes sandy habitats are more likely to experience these long-term impacts from the conversion of sand habitat into hard bottom habitat associated with cable armoring and scour protection. While other construction impacts are expected to have effects on essential fish habitat for demersal/benthic life stages, they are also anticipated to be temporary. Due to the conservative approach used in crosswalking species to benthic habitat types and, in a number of cases, the limited information on species' sediment preferences, it should be kept in mind that there are likely much smaller areas within each mapped habitat type that may be more valuable for each species/life stage than others. Because of the conservative crosswalk approach utilized, impacts to a given habitat may not necessarily affect all species with designated essential fish habitat crosswalked to that habitat type.

1.0 INTRODUCTION

1.1 South Fork Wind Project Overview and Layout

Deepwater Wind South Fork, LLC (DWSF) has submitted a Construction and Operations Plan (COP; DWSF 2020) to support the siting and development of South Fork Wind Farm (SFWF), and South Fork Export Cable (SFEC), collectively the Project. The SFWF is an offshore energy project proposed within the Bureau of Ocean Energy Management (BOEM) Renewable Energy Lease Area OCS-A 0517, proximal to Cox Ledge, (Figure 1-1) to deliver energy to Long Island, New York. DWSF will be responsible for the construction, operations and maintenance (O&M), and decommissioning of the Project, which consists of the following components:

- South Fork Wind Farm: includes up to 15 wind turbine generators (WTGs, turbines) with a nameplate capacity of 6 to 12 megawatts (MW) per turbine, submarine cables between the WTGs (Inter-array Cables, IAC), and an offshore substation (OSS), all of which will be located within federal waters on the OCS, specifically in BOEM Renewable Energy Lease Area OCS-A 0517 (Lease Area), approximately 19 miles (30.6 kilometers [km], 16.6 nautical miles [nm]) southeast of Block Island, Rhode Island, and 35 miles (56.3 km, 30.4 nm) east of Montauk Point, New York. The SFWF also includes an O&M facility that will be located onshore at either Montauk in East Hampton, New York or Quonset Point in North Kingstown, Rhode Island.
- South Fork Export Cable (SFEC): an alternating current electric cable that will connect the SFWF to the existing mainland electric grid in East Hampton, New York. The SFEC includes both offshore and onshore segments.
    - SFEC – OCS: the submarine segment of the export cable buried beneath the seabed within federal waters on the OCS from the OSS to the boundary of New York State territorial waters. SFEC installation method for offshore cable (installed via mechanical cutter, mechanical plow, and/or jet-plow to achieve the target burial depth of 4 to 6 feet (1.22 to 1.83 meters [m]).
    - SFEC – New York State (NYS): the submarine segment of the export cable buried beneath the seabed within state territorial waters from the boundary of New York State waters to a sea-to-shore transition vault located in the Town of East Hampton on Long Island, Suffolk County, New York. The SFEC – NYS includes the sea-to-shore transition. SFEC installation method for sea-to-shore transition (a conduit installed by horizontal directional drilling [HDD] under the beach and intertidal water; may also include a temporary cofferdam located offshore beyond the intertidal zone).
    - SFEC – Onshore: the terrestrial underground segment of the export cable from the sea-to-shore transition vault to the interconnection facility where the SFEC will interconnect with the Long Island Power Authority electric transmission and distribution system East Hampton. The SFEC – Onshore includes the SFEC – Interconnection Facility.

DWSF has committed to an indicative layout scenario with WTG and OSS foundations sited in a grid with approximately 1.15 mile (1.9 km, 1.0 nm) by 1.15 mile (1.9 km, 1.0 nm) spacing that aligns with other proposed adjacent offshore wind projects in the Rhode Island/Massachusetts Wind Energy Area (Figures 1-2). The proposed location of the SFEC – OCS and SFEC – NYS are shown in detail in Figure 1-3, including two landing sites, a preferred landing at Beach Lane and an alternate at Hither Hills.

The proposed Maximum Work Area (MWA) shown on Figure 1-2 is the designated area where installation and supporting activities having seabed disturbance (e.g., anchoring) will occur. The MWA has an approximate buffer of at least 631 m (2,070 feet) around the outer edge of the SFW foundations layout for increased work space. While the MWA includes limited areas outside the boundary of the Lease Area, all foundations and associated scour protection will be installed inside the Lease Area (Figure 1-2).

Positioning of foundations for WTG and OSS, as well as Inter-array Cables is constrained and complicated by the heterogeneous composition of the seabed (e.g. boulders, hard bottom) and other potential constraints, including cultural and archeological resources in the MWA. Layout of the Project may be refined based on further consultation with agencies and stakeholders, ongoing offshore geophysical and geotechnical surveys, and detailed engineering and design. As such, DWSF requires flexibility to micro-site foundations. In accordance with 30 CFR § 585.634(c)(6), micro-siting of foundations can occur up to 152.5 m (500-feet) from the locations identified in the indicative layout scenario shown in the COP.

For purposes of this assessment, the "proposed project design" includes siting the proposed foundation locations as described in the indicative layout scenario on an exact 1 x 1 nm grid, along with currently proposed IAC and SFEC preferred routes. Two alternate WTG positions (16A, 17A), also located on the 1 x 1 nm layout (Figure 1-2), are included in the project design envelope as described in the COP (see COP Table 3.0-1, DWSF 2020). The two alternate WTG positions will only be used if one of the primary proposed project design sites cannot be used.

The proposed project design for the foundations includes the foundation footprint (5.5 m (18 ft) radius), conservative limits of scour protection (34 m (112 ft) radius), and conservative limits of seafloor disturbance for other associated activities (200 m (656 ft) radius). Additionally, a conservative layout envelope that accounts for micro-siting flexibility encompasses the area where components of the project (permanent disturbance) and activities (temporary disturbance) may occur is included for illustrative purposes (Figure 1-2).

1.2 Habitat Mapping Assessment Purpose and Objectives

The purpose of this report and associated data is to provide information on benthic habitat characteristics and spatial composition of sufficient resolution, quality, and detail (per NOAA Habitat 2020) to support the NOAA National Marine Fisheries Greater Atlantic Regional Fisheries Office Habitat Conservation and Ecosystem Services Division (NOAA Habitat) in conducting a thorough and complete essential fish habitat (EFH) consultation for the Project. The NOAA Habitat's recommendations for mapping benthic habitats to facilitate EFH consultations (May 2020) were developed in conjunction with BOEM and BOEM has released the recommendations as a supplement to the BOEM Benthic Survey Guidelines (2019).

DWSF has collected extensive data to support the characterization of habitats within the SFWF and along the SFEC route. INSPIRE Environmental (INSPIRE) has used these data to conduct detailed benthic habitat mapping and a crosswalk of the delineated benthic habitat types to EFH, as well as calculate the maximum total area of each benthic habitat type that may potentially be permanently and/or temporarily impacted by the Project. A list of key terms used in this report is provided in Table 1-1.

The objectives of this habitat mapping assessment report are to:

1. Use high-resolution acoustic and ground-truth data to delineate geological seabed types for the Project Area, and further refine these to delineate and characterize benthic habitats within a buffered area of potential effect for the Project;

2. Identify complex benthic habitats and describe these habitats in terms of sediment composition, heterogeneity, bedforms, and observed/anticipated infaunal and epifaunal communities (per NOAA Habitat 2020 definitions);

3. Provide results of the crosswalk between mapped benthic habitat types and demersal EFH; and

4. Use a conservative, maximum design scenario (*sensu* BOEM 2018) to calculate the maximum total area of each benthic habitat type that may be permanently or temporarily impacted by each component of the Project.

Given the uncertainty of the exact locations of impact to the seafloor, an extremely conservative approach, for purposes of EFH consultation, was used to estimate the maximum potential total area and composition of habitats that may be impacted by the Project. Although the same component design parameters (e.g., width of cable protection) as those presented in the COP were used to determine acres of impact, the maximum design scenario approach used for this report assumed Project activities would occur over the entirety of the area possible. An additional contingency was also added to acres of impact calculated for cable routes as those will be further refined based on ongoing offshore geophysical and geotechnical surveys and detailed engineering and design. In reality, only a fraction of these areas will ultimately be impacted by Project activities. Given this conservative approach, the maximum potentially impacted acres presented in this report will differ from those footprints presented in the COP. The footprint estimates presented in the COP are intended to represent the total actual acres of seafloor (agnostic to habitat type) that will be impacted by each project component. ***The acres presented in this benthic habitat mapping report are conservative maximum design scenario estimates developed for EFH review to describe potential impacts by habitat type and therefore, should not be considered representative of the total acres that may be impacted by the Project.***

Table 1-1. Key Project Terms and Abbreviations

Term	Definition
Proposed project design	Proposed foundation locations sited on exact 1 x 1 nm layout, along with currently proposed IAC and SFEC preferred routes
Boulder picks	Boulders >= 50 cm (0.5 m) identified from 10-cm resolution side-scan sonar data
Crosswalk	The process of reviewing species with mapped EFH in the Project Area and comparing their habitat preferences with the mapped benthic habitat types described in Section 3.1 & 3.2 to identify where EFH for those species is likely to be found
Deepwater Wind South Fork, LLC (DWSF)	Owner and future operator of the Project, the Project Applicant. A wholly-owned indirect subsidiary of North East Offshore, LLC, a joint venture between Ørsted and Eversource
Facies	Bodies of sediment that are recognizably distinct from adjacent sediments that resulted from different depositional environments.
Foundation	The bases to which the WTGs and OSS are installed on the seabed. Monopile is the selected foundation type for the project.
Fugro Seabed Sediment Classification	Geological seabed classifications with a minimum mapping unit of 4,000 m^2, prepared by Fugro
Hard bottom	Stable cobbles and boulders found predominantly within Glacial Moraine and Coarse Sediment-30-80% Cobble/Boulder habitats, and in sparse or trace amounts in all other habitat types.
horizontal direction drill (HDD)	Subsurface installation technique that will create an underground conduit through which the SFEC – Offshore will come ashore and join the SFEC – Onshore within a transition vault (i.e., the sea-to-shore transition). HDD avoids impacts to the beach and near shore environment.
INSPIRE Benthic Habitat Classification	Benthic habitat classifications with a minimum mapping unit of 2,000 m^2, prepared by INSPIRE
Inter-Array Cables (IAC)	Submarine cables interconnecting the WTGs and OSS

Term	Definition
Maximum Work Area (MWA)	SFW proposed Maximum Work Area includes all areas were temporary disturbance to the seafloor may occur; this area extends beyond the Lease Area
Minimum mapping unit (mmu)	The smallest size areal seabed or habitat polygon to be mapped as a discrete entity
Offshore Substation (OSS)	Collects electric energy generated by the WTG through the IAC for transmission through the SFEC. Mounted on dedicated monopile foundation
Project Area	The area encompassing the SFWF, SFEC – OCS, SFEC – NYS, and Onshore Facilities
Sea-to-Shore Transition	Connects the SFEC – NYS to the SFEC – Onshore. Comprised of the onshore transition vault where the offshore cable and the onshore cable will be spliced together and the underground conduit that leads from onshore transition vault to the exit point of the HDD.
South Fork Wind (SFW) Lease Area	BOEM-designated Renewable Energy Lease Area OCS-A 0517
South Fork Wind Project (the Project)	Term includes the Project holistically, including offshore and onshore components
South Fork Export Cable (SFEC)	Comprised of an alternating current (AC) electric cable that will connect the SFWF to the existing mainland electric grid in East Hampton, New York. The SFEC includes both the SFEC – Offshore and SFEC – Onshore.
South Fork Export Cable – Outer Continental Shelf (SFEC – OCS)	The submarine segment of the export cable buried beneath the seabed within federal waters on the OCS from the OSS to the boundary of New York State territorial waters.
South Fork Export Cable – NY State Waters (SFEC – NYS)	The submarine segment of the export cable buried beneath the seabed within state territorial waters from the boundary of New York State territorial waters to a sea-to-shore transition vault located in the town of East Hampton on Long Island, Suffolk County, New York.
Wind Turbine Generators (WTGs)	Electricity-generating wind turbine made of a tower, nacelle, rotor, and blades.

2.0 INPUT DATA AND APPROACH

Multiple sources of acoustic and ground-truth data were used as input data sources for mapping benthic habitats at the SFWF and SFEC. Brief summaries of these data sources and details pertinent to their use in the habitat mapping process are described here. Full details of acoustic and ground-truth data collection, processing, and analysis are provided in geophysical and benthic assessment reports appended to the SFW COP (DWSF 2020).

2.1 Input Data

2.1.1 Acoustic Data

Fugro USA Marine, Inc. (Fugro) conducted high-resolution multibeam echosounder (MBES), side-scan sonar (SSS), and shallow sub-bottom seismic surveys within the Project Area (30-meter spaced primary lines and 500-meter tie lines, Chart-1_SFWF_Post_Plot_ArchE, Fugro 2018). MBES, SSS, and seismic data are collected using different instruments deployed from the same survey vessel (Figure 2-1). The MBES is mounted to the vessel and provides the highest degree of positional accuracy. Bathymetric data were derived from the MBES and processed to a resolution of 25 cm in the SFWF and along the SFEC. Bathymetric data provide information on depth and seafloor topography (Figures 2-2, 2-3) and were used to create a model of seafloor slope for the project with a cell size of 50 cm (Figures 2-4, 2-5). Backscatter data were derived from the MBES and processed to a resolution of 50 cm in the SFWF and along the SFEC. Backscatter data are based on the strength of the acoustic return to the instrument and provide information on seafloor sediment composition and texture (Figures 2-6, 2-7). Nominally softer, fine-grained sediments absorb more of the signal and a weaker signal is returned to the MBES; backscatter returns are relative and referred to in terms of low, medium, and high reflectance rather than absolute decibel values. SSS data were generated from a towed instrument and, thus, have a lower positional accuracy than MBES data. However, because the SSS is closer to the seafloor, it provides the highest resolution data on sediment textures and objects on the seafloor (boulders, debris) (Figure 2-8). SSS data were processed to a resolution of 10 cm for the SFWF and SFEC; this resolution permits detection of boulders but does not permit the reliable detection of individual cobbles (6.4 cm to 25.6 cm). Boulders greater than or equal to 50 cm (0.5 m) were identified from the MBES and SSS data using automatic and manual detection methods to generate a “boulder pick” data set (Figures 2-9, 2-10). A combination of these acoustic data was used to detect large and small scale bedforms, namely mega-ripples and ripples (*sensu* BOEM 2015) (Figures 2-11, 2-12).

2.1.2 Ground-Truth Data

Sediment profile and plan view images (SPI/PV) were collected at 161 stations in November 2017 (141 stations) and November 2018 (20 stations). A total of 98 stations were collected within the SFWF, 60 stations along the SFEC, and 3 stations within a potential reference area east of the SFWF. Four of these stations are outside the footprint of geophysical data (stations 201, C-03, C-04, and C-05) and have been excluded from maps, tables, and summarized data results (Attachment A). During the 2017 survey, supplemental grab samples were collected at 16 stations and analyzed for grain size composition (Fugro 2018).

SPI/PV images were used to ground-truth sediment types, bedform dynamics, presence of sensitive habitats and taxa, and to characterize benthic biological communities. SPI/PV images were analyzed for a suite of variables (Table 2-1) and were classified using the Coastal and Marine Ecological Classification Standard (CMECS; FGDC 2012) Substrate and Biotic components (Table 2-2). CMECS Substrate Group/Subgroup was particularly useful as ground-truth data for purposes of delineating seafloor sediments and benthic habitats (Figure 2-13). CMECS Biotic Subclasses and notations of sessile and mobile epifauna present (Figure 2-14) were used to provide detail about the biological communities observed within each mapped habitat type. Detailed descriptions of each variable were analyzed and full data analysis results can be found in the SPI/PV Geophysical and Benthic Assessment reports (INSPIRE 2019a, 2019b).

2.2 Habitat Mapping Approach

Acoustic and ground-truth data were reviewed in an iterative process to delineate benthic habitats. MBES data, viewed as backscatter draped over a hill-shaded bathymetric relief model, was used at a “zoomed out” scale (~1:10,000) to identify large scale facies, areas of sedimentary characteristics (reflectance, bedform, slope) distinct from those adjacent (Figure 2-15). These initial delineations are further refined at “zoomed in” scales (~1:2,000 or finer) using SSS, boulder picks, and ground-truth data (Figure 2-16). Delineations must be of a size appropriate both to the resolution of the data and to the subject of interpretation. For these purposes, a minimum mapping unit (mmu) is defined. An mmu is defined as “the smallest size areal entity to be mapped as a discrete entity” (Lillesand et al. 2015). Application of this concept to seafloor mapping is demonstrated visually in Figure 2-17.

2.2.1 Geological Seabed Characterization

Ørsted developed information on the geological seabed to characterize the geological provenance and stratigraphic conditions of the seafloor inclusive of surface and subsurface features. Methods used to collect this information included MBES bathymetry and backscatter, SSS, sub-bottom profile, magnetometer, and seismic profile data, along with vibracores, piezocone penetration tests, and grab samples. Fugro performed the geophysical analyses and delineated the seabed classification polygons. Detailed descriptions of methodologies and related interpretative results are available in Appendices H1-H4 of the SFW COP (DWSF 2020). For the purposes of defining geological seabed types, the Folk classification was used, which aligns with CMECS Substrate classifications (Figure 2-18). Seabed types present at SFWF and SFEC based solely on this scheme are Mud and Sandy Mud, Sandy and Muddy Sand, and Coarse Sediment (i.e., >5 – 80% gravel on a sand matrix). High boulder density based on the boulder picks dataset was used as a hallmark surface expression of glacial moraines; subsurface features were also considered in delineating Glacial Moraine / Glacial Till geological seabed types. The geological seabed characterization map was developed using a minimum mapping unit of 4,000 m^2.

2.2.2 Delineation of Benthic Habitat Types

Geological characterizations of seabed conditions are not strictly equivalent to benthic habitats as experienced by benthic biological communities and demersal fish. In order to map these habitats for the purposes of assessing the potential impacts of the Project on these biotic communities, INSPIRE refined the seabed interpretations to map benthic habitats with a minimum mapping unit of 2,000 m^2 within a buffered area of potential effect within the SFWF and along the SFEC. Multibeam 25-cm resolution bathymetry, 25-cm (SFWF) and 50-cm (SFEC) resolution backscatter, and 10 cm SSS data were examined along with boulder picks and SPI/PV data (Figure 2-19) in order to delineate new habitat polygons and to refine the Fugro seabed classifications. For example, surface expression of areas of Coarse Sediment and Sand and Muddy Sand were identified within geological seabed units of Glacial Moraine / Glacial Till and were reclassified as such (Figure 2-20).

Additionally, the geological seabed classification of Coarse Sediment was refined into three benthic habitat types. As defined by the geological classification scheme (Figure 2-18), Coarse Sediment encompasses a broad range of habitats composed of variable mixtures and arrangements of gravel and sand, including gravelly sand composed mostly of small mobile granules and pebbles and sandy gravel with patchy distributions of larger cobbles and boulders. From the EFH perspective, these environments are very different. Therefore, Coarse Sediment was divided into three types based on total percent cover of cobbles and boulders observed in SSS data within each delineated Coarse Sediment habitat polygon: <5 %, 5-30%, and 30-80%. Data were viewed at scales from 1:2,000 up to 1:500 in completing these refinements. Where cobble/boulder cover levels was spatially distinct within an examined polygon, it was split and categorized accordingly. Visual estimates of percent cover were made and where cover was in the range of thresholds between categories, the higher cover category was conservatively selected (e.g., 30-80% selected over 5-30%).

Further characteristics were noted for each habitat polygon to capture spatial complexity and the variety of bedforms observed. To identify where variability in habitat composition was present below the mmu, habitat polygons were flagged as “heterogeneous.” The definition for this term provided in the NOAA Habitat Recommendations (May 2020) was adapted for use: if an area larger than 100 m^2 of a different habitat type was observed, the habitat polygon was identified as heterogeneous (Figure 2-21). Bedforms (mega-ripples, ripples, etc.) observed were also noted for each habitat polygon. Bedform definitions were based on those in the BOEM Geophysical Survey Guidelines (2015): mega-ripples = 5 - 60 m wavelength and 0.5 - 1.5 m height; ripples = <5 m wavelength and <0.5 m height.

2.3 Benthic Habitat to EFH Crosswalk

Essential fish habitat (EFH) is implemented through the Magnuson-Stevens Fishery Conservation and Management Act. In the northeastern United States, the New England and Mid-Atlantic Fishery Management Councils (Councils) work with NOAA Fisheries to identify and describe EFH in published fisheries management plans (FMPs). In order to evaluate the potential impacts to EFH for individual species/life stages resulting from activities that directly impact benthic habitats, it is important to identify which benthic habitat types fit the descriptions of habitat use for each EFH species/life stage. Therefore, a crosswalk between benthic habitat types and EFH was conducted. For purposes of this analysis, a crosswalk is defined as the process of reviewing species with mapped EFH in the Project Area and comparing their habitat preferences with the mapped benthic habitat types described in Section 3.1 & 3.2 to identify where EFH for those species is likely to be found.

EFH maps, data, and text descriptions were downloaded from the NOAA Habitat Conservation EFH Mapper, an online mapping application (NOAA Fisheries 2020a). Additional EFH source information was gathered from the Northeast Fisheries Science Center's series of "EFH source documents" that contain a compilation of available information on the distribution, abundance, and habitat requirements for each species managed by the councils (NOAA Fisheries 2020b). EFHs are defined by temperature, salinity, pH, physical structure, biotic structure, depth, and currents. While all these habitat variables are important to consider in the greater context of fisheries management, the focus of this report was to create a crosswalk among individual species EFH and mapped benthic habitats. The crosswalk focused on the mapped variables of physical structure, biotic structure, and depth. In addition, only demersal species and life stages were mapped for this report.

EFH data for all Council-managed species were queried using GIS software to determine where each species' EFH overlaps with the SFWF, SFEC – OCS, and SFEC – NYS. Available EFH source information was then reviewed to determine habitat requirements for each demersal species/life stage. These requirements were then crosswalked to each of the project area habitats based on detailed characterizations and spatial distributions (See Sections 3-1 and 3-2) to determine if the substrate, biotic structure, and depth requirements for each species/ life stage were likely to be found within a given mapped benthic habitat type. Many EFH source documents refer to "hard bottom" habitats; for purposes of this analysis, the term "hard bottom" means stable cobbles and boulders.

2.4 Project Impacts to Benthic Habitats

2.4.1 Seafloor Disturbance Impact Producing Factors

The Project activities with the potential to adversely affect the seafloor during construction include installation of foundations for up to 15 WTGs and one OSS, the installation of IAC, and SFEC. During Operations & Maintenance, disturbance to the seafloor could result from the presence of infrastructure and temporarily anchored maintenance vessels. Over the life of the Project, the placement of foundations and scour protection will alter the seabed and associated habitat by replacing the existing seabed and habitat with hard structures that create a reefing effect that results in colonization by assemblages of both sessile and mobile animals. Decommissioning activities will have similar impacts to the seafloor as construction.

SFWF and SFEC activities and associated potential impacts through seafloor disturbance are presented in detail in the COP (DWSF 2020). Specifically,

- SFWF and SFEC activities that could result in potential impacts by seafloor disturbances were presented in Table 4.0-1 and are further described in Section 4.1.1 of the COP.
- SFWF design parameters are discussed in Section 3.1.2 of the COP. The extent of anticipated seabed disturbance during the construction and O&M phases are presented in Table 3.1-1 and repeated in Table 4.1-2 of the COP.
- SFEC design parameters are discussed in Section 3.2.2 of the COP. The extent of anticipated seabed disturbance during the construction and O&M phases are presented in Table 3.2-2 and repeated in Table 4.1-3 of the COP.

2.4.2 Calculating Potential Impacts to Benthic Habitats

Given the uncertainty of the exact locations of impact to the seafloor, an extremely conservative approach, for purposes of EFH consultation, was used to estimate the maximum potential total area and composition of habitats that may be impacted by the Project. Although the same component design parameters (e.g., width of cable protection) as those presented in the COP were used to determine acres of impact, the maximum design scenario approach used for this report assumed Project activities would occur over the entirety of the area possible.

Specifically, design parameters and specifications for each component detailed in COP Sections 3.1.2 (SFWF) and 3.2.2 (SFEC) (DWSF 2020) were used to determine values to use in calculating areas of potential impact to each mapped benthic habitat type for each Project components (e.g., 5.5 m radius of monopile foundation, 12 m wide cable protection for the IAC). However, the assumptions used in summarizing the maximum areas of potential impact to each habitat type differed from those in the COP. For example, it is predicted that up to 10% of the IAC will require cable protection and in the COP this measure is applied to the total maximum area that may be impacted. However, because the precise locations of that 10% will not be known until after construction is complete and because habitats vary within the Project Area, the calculations presented here assume that cable protection will be needed along 100% of the IAC in order to capture the maximum total area of each benthic habitat type that may be permanently or temporarily impacted by cable protection along the IAC.

For convenience, the specific measurements used for each of the following footprint impact areas are provided below and also in the tables that present results of these calculations (Attachment B):

1) Foundations: the foundation (0.02 acres, 5.5 m radius), maximum scour protection (0.87 acres, 28.5 m radius around foundation), and seafloor disturbance area for each foundation (30.14 acres, 166 m radius around maximum scour protection);
2) Inter-array Cables: the trench (7.5 m wide strip along length of each segment, which varies), cable protection (12 m wide strip inclusive of trench width), and boulder relocation area for each IAC segment (14 m wide strip extending out from the cable protection on each side);

3) SFEC – OCS: the trench (7.5 m wide strip, or 12.5 m wide strip for segments where boulder relocation is anticipated, along length of each segment, which varies) and cable protection for each SFEC – OCS segment (6.1 m wide strip within trench width), and boulder relocation for those segments of the SFEC – OCS where boulder relocation is anticipated (16.95 m wide strip extending out from the cable protection on each side) ; and

4) SFEC – NYS: the trench (7.5 m wide strip along length of each segment, which varies), cofferdam sediment excavation area (0.04 acres, rectangular area 4..6 x 22.9 m), and cofferdam-HDD anchoring area for each SFEC – NYS route (within surveyed area, up to 1000 m from cofferdam).

Cumulative areas for each disturbance footprint type were calculated for the proposed project design scenario (e.g., total of all maximum scour protection that may be used for all 15 WTGs plus OSS). The maximum total areas of permanent and temporary impacts to each habitat type were also calculated for the proposed project design components listed below. Ongoing offshore geophysical and geotechnical surveys are being conducted to improve surface and subsurface data in order to make optimal detailed engineering and design decisions. While the current IAC and SFEC routes are sited based on previously collected high-resolution data and consideration of engineering, archaeological, and habitat constraints (among others), these routes may be adjusted between the present and construction. Therefore, the total values summarize for permanent and temporary impacts to benthic habitats from IAC and SFEC components have been increased by 20% as a contingency.

1) SFWF: Foundations

2) SFWF: Inter-array Cables (with 20% contingency added)

3) SFEC – OCS: Export Cable (with 20% contingency added)

4) SFEC – NYS preferred route to Beach Lane: Export Cable and HDD/Cofferdam (with 20% contingency added)

Footprint impact areas were also calculated for the two alternate WTG locations, related hypothetical IAC segments, and the alternate SFEC route to Hither Hills. However, these were excluded from total summary calculations.

In reality, only a fraction of the total areas calculated will ultimately be impacted by Project activities. Given this conservative approach, the maximum potentially impacted acres presented in this report will differ from those footprints presented in the COP. The footprint estimates presented in the COP are intended to represent the total actual acres of seafloor (agnostic to habitat type) that will be impacted by each project component. ***The acres presented in this benthic habitat mapping report are conservative maximum design scenario estimates developed for EFH review to describe potential impacts by habitat type and therefore, should not be considered representative of the total acres that may be impacted by the Project.***

Table 2-1. SPI/PV Survey Parameters with Corresponding BOEM COP Requirements and Guidelines (BOEM 2015, 2019; NOAA Habitat 2020)

BOEM COP Guidelines and *NOAA† Recommendations*	Parameters Derived from PV Images	Parameters Derived from SPI Images
Classification of CMECS sediment type Grain size analysis	CMECS Substrate Group CMECS Substrate Subgroup Gravel measurements	Sediment type (based on grain size major mode)
Identification of distinct horizons in subsurface sediment	None	Sediment type (based on grain size major mode) Apparent Redox Potential Discontinuity (aRPD)*
Delineate hard bottom substrates	CMECS Substrate Group CMECS Substrate Subgroup Gravel measurements	Sediment type (based on grain size major mode)
Identification of bedforms Characterization of physical hydrodynamic properties	Bedform type Sediment Descriptor (e.g., mobile or non-mobile)*	Boundary roughness
Identification of rock outcrops and boulders Characterization and delineation of any hard bottom gradients of low to high relief such as coral (heads/reefs), rock or clay outcroppings, or other shelter-forming features	CMECS Substrate Group CMECS Substrate Subgroup Gravel measurements	None
Characterization of benthic habitat attributes	Gravel measurements Sediment Descriptor* Habitat type	aRPD* Prism penetration depth Sediment oxygen demand and proxies (methane, *Beggiatoa*)
Classification to CMECS Biotic Component to lowest taxonomic unit practicable	CMECS Dominant Biotic Subclass CMECS Co-occurring Biotic Subclass	None
Characterization of benthic community composition (identify and confirm benthic species (flora and fauna) that inhabit the area) Identification of communities of sessile and slow-moving marine invertebrates (clams, quahogs, mussels, polychaetes, anemones, sponges, echinoderms)	CMECS Dominant Biotic Subclass CMECS Co-occurring Biotic Subclass Epifauna* Sensitive taxa Attached Flora/Fauna Percent Cover* Burrows/Tubes/Tracks	Epifauna* Sensitive taxa Tubes/Voids Successional Stage*

BOEM COP Guidelines and *NOAA*† *Recommendations*	**Parameters Derived from PV Images**	**Parameters Derived from SPI Images**
Identification of potentially sensitive seafloor habitat *Identification of important biogenic habitats:* • *Hard bottom substrates with epifauna* • *Hard bottom substrates with macroalgae* • *Submerged aquatic vegetation (seagrass)* • *Long-lived and habitat forming taxa (e.g. emergent fauna)*	Habitat type	

† NOAA Recommendations are indicated by use of italicized characters and support BOEM Guidelines with further detail.

* Indicates variable that is a CMECS modifier. CMECS Modifiers provide additional detail to further characterize habitat components using a consistent set of definitions.

Table 2-2. CMECS Classification Levels Used in Analysis and Classifications for the SFW SPI/PV Survey

CMECS Term	Scale of Classification	Classifications
Substrate Component		
Substrate Origin	Site	Geologic Substrate
Substrate Class	SPI/PV	Unconsolidated Mineral Substrate
+Substrate Subclass	SPI/PV	Fine Unconsolidated Substrate; Coarse Unconsolidated Substrate
+Substrate Group	PV	Sandy Mud; Muddy Sand; Sand; Slightly Gravelly; Gravelly Sand; Sandy Gravel; Boulder
+Substrate Subgroup	SPI	Silt-Clay; Very Fine Sand; Fine Sand; Medium Sand; Coarse Sand; Very Coarse Sand; Granule; Pebble; Cobble
Biotic Component		
Biotic Setting	SPI/PV	Benthic/Attached Biota
Biotic Class	SPI/PV	Faunal Bed
+Biotic Subclass	SPI/PV	**Soft Sediment Fauna**; Attached Fauna; Inferred Fauna
+Biotic Group	SPI/PV	**Small Surface-Burrowing Fauna**; Attached Hydroids; Barnacles; Diverse Colonizers; Egg Masses; Pennatulid Bed; Sand Dollar Bed

\+ Indicates variability within the surveyed area at this level of the hierarchy
Bold text indicates an overwhelming dominant classification across the surveyed area

3.0 RESULTS

3.1 Benthic Habitat Types

Six benthic habitat types were mapped in the Project Area: Glacial Moraine, Coarse Sediment - 30 to 80% Cobble/Boulder, Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - <5% Cobble/Boulder, Sand and Muddy Sand, and Mud and Sandy Mud. Overall descriptions of each habitat type as observed across the Project Area are provided below and descriptions of spatial distribution within the SFWF, along the SFEC – OCS and the SFEC – NYS routes are provided in Section 3.2. Spatial distributions and characteristics of the all benthic habitat types are summarized in Table 3-1. Each of the six benthic habitat categories mapped were also crosswalked to CMECS Substrate and Biotic component classifications using SPI/PV ground-truth data (Table 3-1; full data results by station in Attachment A, full results by replicate in Appendix N1 of the COP [INSPIRE 2019b]). A range of substrate and biotic communities were present within each benthic habitat category, as expected given the difference in observation scale between acoustic data and ground-truth point samples (Table 3-1).

3.1.1 Glacial Moraine

The Glacial Moraine habitat type (Figures 3-1, 3-2) is a complex seabed and habitat classification category composed of consolidated and unconsolidated geologic debris directly deposited by glacial movement (rather than reworking from meltwaters or transgressive seas) and is limited in distribution along the outer continental shelf near New England. Due to the presence of very coarse and poorly sorted sediment, the seabed of this habitat generally exhibits high reflectance in backscatter data. Sediments include sand, small mobile gravel, and areas with high density of cobbles and boulders; small patchy areas of ripples are also present. Although the density of cobbles and boulders is generally high in areas designated as Glacial Moraine, the areas of high density are rarely continuous; rather, distribution of cobbles and boulders is very patchy and not well captured by point sampling approaches (SPI/PV stations); therefore, a high degree of heterogeneity was observed among ground-truth sampling with few capturing features diagnostic of Glacial Moraine (cobbles, boulder, attached fauna) (Figures 3-1, 3-2).

The CMECS Substrate Groups/Subgroups observed at ground-truth stations within this habitat type were Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Sand, and Muddy Sand (Table 3-1). The CMECS Biotic Subclasses of Soft Sediment Fauna and Attached Fauna were both observed (Table 3-1), with Attached Fauna dominating patches of stable gravel. Small washed gravel substrates were present and subject to frequent hydrodynamics preventing the establishment of attached fauna. Biotic communities were characterized by small to large burrowing and tube-building fauna with successional stages up to Stage 2 (Attachment A). Bivalves such as the ocean quahog and sea scallop are also expected in this habitat category (Section 4.3.2 of the COP, DWSF 2020). Mobile epifauna such as sand dollars, crabs, lobsters, shrimp, gastropods, squid, and sea stars and sessile epifauna such as bryozoa, hydroids, barnacles, sea pens, sponges, and non-reef building hard corals were observed and/or are expected to occur within this habitat type (Table 3-1; Attachment A). Overall, attached fauna percent cover is expected to be low to high and proportional to stable gravel cover and aggregation; the highest observed cover was Moderate (30 to <70%; Table 3-1).

3.1.2 Coarse Sediment

The Coarse Sediment geological habitat type (Figure 3-3) consists of sand and gravel that has been subjected to small, but frequent currents and storm events and is common on the outer continental shelf. The seafloor of this habitat type exhibits a full range of reflectance, but is predominantly high, indicating that the sediment is more dense and coarser than observed in the sand and mud categories. The sediment is composed of sandy gravel and gravelly sand, with variable distribution and cover of cobbles and boulders. Differing ranges of cobble/boulder percent cover are represented as 3 habitat types within the seabed type of Coarse Sediment: <5%, 5-30%, and 30-80% (Figure 3-4).

The majority of the Coarse Sediment geological seabed type mapped within the Project Area had <5% cover of cobbles and boulders. In nearly all cases, no or trace (<1% cover) cobbles or boulders were detected and dense, well-developed ripples were observed in a majority of these habitat polygons (INSPIRE 2020; Table 3-1; Figure 3-3). The CMECS Substrate Groups/Subgroups observed within the Coarse Sediment - <5% Cobble/Boulder habitat type were Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Sand, and Muddy Sand (Table 3-1). The CMECS Biotic Subclasses of Soft Sediment Fauna and Attached Fauna were both observed (Table 3-1), with Attached Fauna dominating patches of stable gravel. Small washed gravel substrates are present and subject to frequent hydrodynamics preventing the establishment of attached fauna. Biotic communities are characterized by small to large burrowing and tube-building fauna with successional stages up to Stage 2 and by sand dollar beds (Attachment A). Bivalves such as the ocean quahog and sea scallop are also expected in this habitat category (Section 4.3.2 of the COP, DWSF 2020). Mobile epifauna such as sand dollars, crabs, lobsters, shrimp, gastropods, and sea stars and sessile epifauna such as bryozoa, hydroids, barnacles, sea pens, and sponges were observed and/or are expected to occur within this habitat type (Table 3-1; Attachment A). Overall, attached fauna percent cover is expected to be low to high and proportional to stable gravel cover and aggregation; the highest observed cover was Sparse (1 to <30%; Table 3-1). Only two SPI/PV stations overlapped the Coarse Sediment habitat types with >5% cover of cobble/boulder; at these SFWF-OCS stations, the CMECS Substrate Group observed was Sand, the Biotic Subclass was Soft Sediment and no epifauna were observed (Table 3-1; Attachment A).

3.1.3 Sand and Muddy Sand

The Sand and Muddy Sand habitat type (Figure 3-5) consists of sand that has been subjected a wide range of oceanic processes and is very common on the outer continental shelf. The muddy sand included in this category has a high sand to mud ratio, ranging from an 8:2 sand to mud ratio to 100% sand (Figure 2-18). The seafloor of this habitat exhibits a full range of backscatter reflectance, but is predominantly low. The areas with high backscatter reflectance usually occur in the trough of mega-ripples (Figure 2-11), which were observed only within this habitat type (Table 3-1). Small scale ripples were also present in portions of this habitat type (Table 3-1).

The CMECS Substrate Groups/Subgroups observed at ground-truth stations within this habitat type were Boulder, Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Sand, and Muddy Sand (Table 3-1). The Boulder Substrate type was observed at station 7 where the SPI/PV frame landed on an isolated boulder (Attachment A); trace presence of boulders was observed and is expected within this habitat type (Table 3-1). The CMECS Biotic Subclasses of Soft Sediment Fauna and Attached Fauna were both observed (Table 3-1) and Soft Sediment Fauna was observed to dominate the Sand and Muddy Sand habitat type with communities characterized by small to large burrowing and tube-building fauna with successional stages up to Stage 2 and by sand dollar beds (Attachment A). Bivalves such as the ocean quahog and sea scallop are also expected in this habitat category (Section 4.3.2 of the COP, DWSF 2020). Mobile epifauna such as sand dollars, crabs, shrimp, gastropods, and sea stars were observed and/or are expected to occur within this habitat type. Sessile epifauna were observed and/or are expected to occur in low densities where isolated cobbles and boulders are found (Table 3-1, Attachment A).

3.1.4 Mud and Sandy Mud

The Mud and Sandy Mud habitat type (Figure 3-6) consists of relatively featureless mud and sand. The sediment is composed of mud, sandy mud, and muddy sand and ranges from 100% mud to an 8:2 sand to mud ratio (Figure 2-18). The muddy sand included in this category has a low sand to mud ratio. These sediments are less dense and less coarse than all other habitat types observed, as exhibited by low to medium backscatter reflectance.

CMECS Substrate Groups/Subgroups observed at ground-truth stations within this habitat type were Sand and Muddy Sand (Table 3-1). The CMECS Biotic Subclass of Soft Sediment dominated the Mud and Sandy Mud habitat type with communities characterized by small to large burrowing and tube-building fauna with successional stages up to Stage 3 equilibrium deep burrowing taxa (Table 3-1, Attachment A). Mobile epifauna such as crabs, gastropods, and sea stars were observed and/or are expected within this habitat type (Table 3-1, Attachment A).

Table 3-1. Composition & Characteristics of Mapped Benthic Habitat Types

		Glacial Moraine	Coarse Sediment - 30-80% Cobble/Boulder	Coarse Sediment - 5-30% Cobble/Boulder	Coarse Sediment - <5% Cobble/Boulder	Sand and Muddy Sand	Mud and Sandy Mud
South Fork Wind Farm ***(~9,203 acres mapped)***							
Presence in Project Area	Area (km^2)	7.73	0.01	0.28	11.23	17.68	0.31
	Area (acres)	1910.13	2.21	69.05	2775.53	4368.54	77.82
	Percentage of Project Area	20.75%	0.02%	0.75%	30.16%	47.47%	0.85%
Boulder Density	Boulder (>0.5 m) Density per km^2 - Range	0.38 - 19.88	2.24 - 2.24	0.26 - 2.53	0 - 6.15	0 - 2.9	0 - 0
	Boulder (>0.5 m) Density per km^2 - Mean +/- Std Dev	3.84 +/- 3.79	-	1.14 +/- 0.99	0.22 +/- 0.79	0.17 +/- 0.37	0 +/- 0
	Boulder (>0.5 m) Density per acre - Range	1.55 - 80.45	9.05 - 9.05	1.06 - 10.25	0 - 24.87	0 - 11.74	0 - 0.01
	Boulder (>0.5 m) Density per acre - Mean +/- Std Dev	15.56 +/- 15.33	-	4.6 +/- 4.02	0.91 +/- 3.19	0.67 +/- 1.49	0.01 +/- 0.01
Heterogeneity	Percentage of Habitat Polygon Area that is Heterogeneous (per NOAA definition)	100.0%	0%	0%	40.15%	67.9%	0%

		Glacial Moraine	Coarse Sediment - 30-80% Cobble/Boulder	Coarse Sediment - 5-30% Cobble/Boulder	Coarse Sediment - <5% Cobble/Boulder	Sand and Muddy Sand	Mud and Sandy Mud
Bedforms Type Present in Given Percentage of Habitats	Mega-ripples	0%	0%	0%	0%	82.6%	0%
	Ripples	99.8%	100.0%	100.0%	99.9%	67.2%	0%
	Linear Depression	0%	0%	0%	0%	0%	0%
	Trawl marks	0%	0%	0%	0%	0%	0%
SPI/PV Ground-truth Values	Number of SPI/PV stations	27	0	0	24	38	4
	CMECS Substrate Groups/Subgroups Observed in Ground-truth Data	Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Sand, Muddy Sand	-	-	Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Sand, Muddy Sand	Boulder, Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Sand, Muddy Sand	Sand, Muddy Sand
	CMECS Biotic Subclasses Observed in Ground-truth Data	Attached Fauna, Soft Sediment Fauna	-	-	Attached Fauna, Soft Sediment Fauna	Attached Fauna, Soft Sediment Fauna	Soft Sediment Fauna
	Maximum Percent Cover of Attached Fauna Observed in Ground-truth Data	Moderate (30 to <70%)	-	-	Sparse (1 to <30%)	Moderate (30 to <70%)	None
	Sessile Epifauna Observed in Ground-truth Data	Barnacles, Bryozoans, Coralline Algae, Grazed Barnacles, Hydroids, Sea Pens, Sponges	-	-	Barnacles, Hydroids, Sea Pens	Anemone, Barnacles, Hydroids, Sea Pens	None
	Mobile Epifauna Observed in Ground-truth Data	Sand Dollar, Sea Star, Shrimp	-	-	Hermit Crab, Sand Dollar, Sea Scallop, Shrimp	Hermit Crab	Shrimp

		Glacial Moraine	Coarse Sediment - 30-80% Cobble/Boulder	Coarse Sediment - 5-30% Cobble/Boulder	Coarse Sediment - <5% Cobble/Boulder	Sand and Muddy Sand	Mud and Sandy Mud
South Fork Export Cable - Outer Continental Shelf ***(~8,530 acres mapped)***							
Presence in Project Area	Area (km^2)	0	3.02	2.02	12.68	16.80	0
	Area (acres)	0	746.73	498.22	3133.98	4151.37	0
	Percentage of Project Area	0%	8.8%	5.8%	36.7%	48.7%	0%
Boulder Density	Boulder (>0.5 m) Density per km^2 - Range	-	0.39 - 4.29	0.19 - 0.78	0 - 0.75	0 - 4.87	-
	Boulder (>0.5 m) Density per km^2 - Mean +/- Std Dev	-	1.62 +/- 1.13	0.46 +/- 0.18	0.03 +/- 0.1	0.33 +/- 0.6	-
	Boulder (>0.5 m) Density per acre - Range	-	1.56 - 17.35	0.75 - 3.17	0 - 3.05	0 - 19.71	-
	Boulder (>0.5 m) Density per acre - Mean +/- Std Dev	-	6.55 +/- 4.57	1.88 +/- 0.74	0.11 +/- 0.41	1.34 +/- 2.43	-
Heterogeneity	Percentage of Habitat Polygon Area that is Heterogeneous (per NOAA definition)	-	94.9%	61.1%	28.8%	27.2%	-

		Glacial Moraine	Coarse Sediment - 30-80% Cobble/Boulder	Coarse Sediment - 5-30% Cobble/Boulder	Coarse Sediment - <5% Cobble/Boulder	Sand and Muddy Sand	Mud and Sandy Mud
Bedforms Type Present in Given Percentage of Habitats	Mega-ripples	-	0%	0%	0%	21.1%	-
	Ripples	-	100.0%	95.6%	90.7%	31.0%	-
	Linear Depression	-	0%	0%	0%	0%	-
	Trawl marks	-	0.0%	0.0%	14.18%	19.10%	-
SPI/PV Ground-truth Values	Number of SPI/PV stations	-	1	1	23	28	-
	CMECS Substrate Groups/Subgroups Observed in Ground-truth Data	-	Sand	Indeterminate	Sandy Gravel, Gravelly Sand, Slightly Gravelly Sand, Sand, Muddy Sand	Slightly Gravelly Sand, Sand, Muddy Sand	-
	CMECS Biotic Subclasses Observed in Ground-truth Data	-	Soft Sediment Fauna	Indeterminate	Attached Fauna, Soft Sediment Fauna	Attached Fauna, Soft Sediment Fauna	-
	Maximum Percent Cover of Attached Fauna Observed in Ground-truth Data	-	None	None	Sparse (1 to <30%)	None	-
	Sessile Epifauna Observed in Ground-truth Data	-	None	None	Anemone, Barnacles, Hydroids, Sea Pens, Slipper Shells	Slipper Shell	-
	Mobile Epifauna Observed in Ground-truth Data	-	None	None	Hermit Crab, Sand Dollar, Sea Scallop, Shrimp	Gastropod, Hermit Crab, Sea Star, Sand Dollars, Shrimp	-

		Glacial Moraine	Coarse Sediment - 30-80% Cobble/Boulder	Coarse Sediment - 5-30% Cobble/Boulder	Coarse Sediment - <5% Cobble/Boulder	Sand and Muddy Sand	Mud and Sandy Mud
South Fork Export Cable - New York State ***(~1,119 acres mapped)***							
Presence in Project Area	Area (km^2)	0.00	0.10	0.003	0.14	3.68	0.60
	Area (acres)	0.00	24.61	0.74	34.81	910.00	148.45
	Percentage of Project Area	0%	2.20%	0.07%	3.11%	81.35%	13.27%
Boulder Density	Boulder (>0.5 m) Density per km^2 - Range	-	3.5 - 20.26	0 - 0.51	0 - 1.24	0 - 0.42	0.02 - 0.02
	Boulder (>0.5 m) Density per km^2 - Mean +/- Std Dev	-	10.39 +/- 7.77	0.25 +/- 0.36	0.25 +/- 0.55	0.14 +/- 0.18	-
	Boulder (>0.5 m) Density per acre - Range	-	14.17 - 81.99	0 - 2.06	0 - 5.02	0 - 1.69	0.07 - 0.07
	Boulder (>0.5 m) Density per acre - Mean +/- Std Dev	-	42.05 +/- 31.43	1.03 +/- 1.46	1.02 +/- 2.24	0.57 +/- 0.71	-
Heterogeneity	Percentage of Habitat Polygon Area that is Heterogeneous (per NOAA definition)	-	0%	0%	0%	0%	0%

		Glacial Moraine	Coarse Sediment - 30-80% Cobble/Boulder	Coarse Sediment - 5-30% Cobble/Boulder	Coarse Sediment - <5% Cobble/Boulder	Sand and Muddy Sand	Mud and Sandy Mud
Bedforms Type Present in Given Percentage of Habitats	Mega-ripples	-	0%	0%	0%	0%	0%
	Ripples	-	0%	0%	0%	0%	0%
	Linear Depression	-	0%	0%	7.3%	0%	0%
	Trawl marks	-	0%	0%	0%	0%	0%
SPI/PV Ground-truth Values	Number of SPI/PV stations	-	0	0	1	5	0
	CMECS Substrate Groups/Subgroups Observed in Ground-truth Data	-	-	-	Slightly Gravelly Sand	Sand, Muddy Sand	-
	CMECS Biotic Subclasses Observed in Ground-truth Data	-	-	-	Soft Sediment Fauna	Soft Sediment Fauna	-
	Maximum Percent Cover of Attached Fauna Observed in Ground-truth Data	-	-	-	None	None	-
	Sessile Epifauna Observed in Ground-truth Data	-	-	-	None	None	-
	Mobile Epifauna Observed in Ground-truth Data	-	-	-	None	Sand Dollar	-

3.2 Benthic Habitat Distributions

Distributions of benthic habitat types in the Project Area are related to a combination of glacial and modern geological events in the region. The geophysical and benthic survey data collected by DWSF have refined the understanding of the distribution of glacial moraine deposits, glacio-fluvial deposits, and Holocene transgressive marine deposits within the Project Area. It is clear from high-resolution data that within the Project Area, Ronkonkoma terminal moraine deposits are overlain by glacio-fluvial deposits and marine deposits (Fugro 2018, Figure 3-7). This interpretation follows the regional framework established by O'Hara and Oldale (1980) and expanded by Stone and Borns (1986) and Uchupi et al. (2001). O'Hara and Oldale (1980) and subsequent authors recognized that within the broad distribution of the end moraine identified on Cox Ledge, there were deep channels cut into the glacial moraine by meltwaters and subsequent reworking and deposition as the glaciers retreated and transgressive seas flooded the area. As a result of the higher spatial density of seismic and sub-bottom data collection, we now know that these processes have left patches of exposed glacial moraine across the surface of Cox Ledge interspersed with more modern marine sand deposits (Figures 3-7, 3-8). The terminal moraine is formed from dense to very dense sand and gravel with abundant boulders and cobbles (Fugro 2018). The terminal moraine complex has been interpreted to include a 'moraine flank' that is a transition from the bouldery moraine to the glacial outwash plain to the west (Figure 3-8). In this area, dense glacial outwash sands thicken from < 1 m to 2.5 m and contain boulders. The glacial outwash plain has very few boulders and thickens to the west except for a rocky outcrop of bouldery moraine off the South Fork of Long Island (Figure 3-8).

While six benthic habitat types were mapped, not all were present in each portion of the Project Area. Habitat composition, characteristics, and corresponding ground-truth data within the SFWF, SFEC – OCS, and SFEC – NYS are provided in Table 3-1.

3.2.1 South Fork Wind Farm

All six benthic habitat types were observed within the portion of SFWF mapped for benthic habitat types (~9,203 acres; Table 3-1; Figure 3-9). Nearly half of the area was Sand and Muddy Sand, approximately 30% was Coarse Sediment - <5% Cobble/Boulder, and approximately 20% was Glacial Moraine; Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - 30 to 80% Cobble/Boulder, and Mud and Sandy Mud each occupied less than 1% of the mapped SFWF (Table 3-1; Figure 3-9). Within the SFWF, the Glacial Moraine habitat generally corresponds spatially to regional geological maps of moraine deposits (Figure 3-7), although portions are categorized as Coarse Sediment (predominantly <5% Cobble/Boulder) and Sand and Muddy Sand (Figures 3-7, 3-9). Coarse Sediment (predominantly <5% Cobble/Boulder) and Sand and Muddy Sand characterize the benthic habitats found within Holocene marine deposits and Quaternary fluvial-estuarine deposits (Figures 3-7, 3-9).

Areas of very high boulder density within the SFWF correspond to Glacial Moraine habitats (Figure 3-10). As expected, boulder density decreased along the gradient of habitat types from Glacial Moraine thru Coarse Sediments to Sand and Mud (Table 3-1; Figure 3-10). Variability in boulder density also decreased along the same gradient of habitats (Table 3-1; Figure 3-10), indicating the patchy nature of boulder distributions within moraine deposits on Cox Ledge. The spatial complexity of habitat composition within the SFWF is further illustrated when heterogeneity of habitat polygons is examined (Figure 3-11). Glacial Moraines by definition are heterogenous and heterogeneity was also documented across ~40% of Coarse Sediment - <5% Cobble/Boulder and ~68% of Sand and Muddy Sand habitats (Table 3-1). Mega-ripples and ripples were common bedforms observed within the SFWF. Mega-ripples were documented only in Sand and Muddy Sand habitats and were recorded across ~83% of these habitats. Ripples were present in ~67% of Sand and Muddy Sand habitats and were nearly ubiquitous in all other habitats, with the exception of Mud and Sandy Mud (Table 3-1). The CMECS Substrate Group/Subgroup, Biotic Subclass, and epifauna presence ground-truth data observed within the SFWF for each habitat type follow the descriptions as provided in Section 3.1 (Table 3-1; Figures 3-12, 3-13).

3.2.2 South Fork Export Cable – Outer Continental Shelf

All three Coarse Sediment habitat types and Sand and Muddy Sand were found within the ~8,530 acres of the SFEC – OCS area mapped (Table 3-1; Figure 3-14). Nearly half of the area was Sand and Muddy Sand, approximately 37% was Coarse Sediment - <5% Cobble/Boulder, and Coarse Sediment - 5 to 30% Cobble/Boulder, and Coarse Sediment - 30 to 80% Cobble/Boulder each occupied less than 10% of the mapped SFEC – OCS area (Table 3-1; Figure 3-14). The SFEC is located within the glacial outwash plain and crosses several north-south trending paleo-drainages along the eastern and western margins of Block Island. These drainage channels are interpreted as forming during the marine transgression (unlike the Pleistocene channels in the SFWF) and some have been filled with coarse sand and some with finer sediment. The SFEC crosses the moraine flank deposits as it approaches the SFWF (Fugro 2018; Figure 3-8). This moraine flank corresponds with a spatially complex mosaic of habitats, including large areas of Coarse Sediment - 30 to 80% Cobble/Boulder and Coarse Sediment - 5 to 30% Cobble/Boulder and a moderately high density of boulder picks (Figure 3-15). A smaller discrete area of moderate boulder density occurs southeast of the tip of Long Island, where the SFEC – OCS is routed around a rocky outcrop of bouldery moraine and small patches of Coarse Sediment - 30 to 80% Cobble/Boulder and Coarse Sediment - 5 to 30% Cobble/Boulder habitats were documented (Figures 3-14, 3-15). The remainder of the SFEC – OCS is composed of mobile Sandy and Muddy Sand and Coarse Sediment - <5% Cobble/Boulder (Figure 3-14), corresponding to several fluvial, marine, and glacial drift deposits (Figure 3-8).

Most habitats identified as heterogenous were located within the moraine flank near the SFWF, and a few discrete areas of heterogenous habitats were observed along other portions of the SFEC – OCS (Figure 3-16). Accordingly, heterogeneity presence was highest in the Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - 30 to 80% Cobble/Boulder habitat types that were predominantly found within the moraine flank region; Coarse Sediment - <5% Cobble/Boulder and Sand and Muddy Sand each exhibited just under 30% heterogeneity (Table 3-1). Mega-ripples were documented only in Sand and Muddy Sand habitats and were recorded across ~21% of these habitats. Ripples were present in ~31% of Sand and Muddy Sand habitats and were nearly ubiquitous in all other habitats (Table 3-1). Trawl marks were observed in both Sandy and Muddy Sand and Coarse Sediment - <5% Cobble/Boulder habitat types (Figure 3-17), respectively across ~19% and ~15% of their distribution and were located along the stretch of the SFEC – OCS between the bouldery moraine outcrop and the moraine flank (Table 3-1; INSPIRE 2020). The CMECS Substrate Group/Subgroup, Biotic Subclass, and epifauna presence ground-truth data observed along the SFEC – OCS for each habitat type follow the descriptions as provided in Section 3.1 (Table 3-1; Figures 3-18, 3-19).

3.2.3 South Fork Export Cable – NY State Waters

With the exception of Glacial Moraine, all benthic habitats were found within the 1,119 acres of the SFEC – NYS area mapped (Table 3-1; Figure 3-14). The entirety of the preferred route to Beach Lane was composed of Sand and Muddy Sand. These habitats were homogeneous (Figure 3-16), no bedforms were observed, and only two boulders were identified from the SSS data (INSPIRE 2020). Ground-truth data include the CMECS Substrate Group/Subgroup of Sand and the Biotic Subclass of Soft Sediment Taxa, sand dollars were also observed (table 3-1; Figures 3-18, 3-19; Attachment A).

The alternate route to Hither Hills included all Coarse Sediment habitat types, Sand and Muddy Sand, and Mud and Sandy Mud (Figure 3-14). Several small habitat polygons of Coarse Sediment - 30 to 80% Cobble/Boulder with very high densities of boulders were documented within the area closest to shore (Figure 3-14). These habitats were located within a larger Sand and Muddy Sand habitat and just offshore of a larger area of Mud and Sandy Mud; a few very small areas of Coarse Sediment - 5 to 30% were also observed in this region (Figure 3-14). While the mosaic of habitat nearshore was complex, none of these polygons or those offshore were identified as heterogeneous (Table 3-1; Figure 3-16). Due to depth restrictions, no ground-truth samples were collected in this nearshore area (Table 3-1; Figures 3-18, 3-19). Two small linear depressions of Coarse Sediment - <5% Cobble/Boulder were documented just shoreward of the 3-nm state waters boundary (Table 3-1; INSPIRE 2020). The Coarse Sediment - <5% Cobble/Boulder habitats observed along the Hither Hills route had a CMECS Substrate Group/Subgroup of Slightly Gravelly Sand (Table 3-1; Figures 3-18). The Soft Sediment Biotic Subclass was observed in both these habitats and in the Sand and Muddy Sand habitats, and, similar to Sand and Muddy Sand habitats at Beach Lane, sand dollars were also observed (Table 3-1; Figure 3-19; INSPIRE 2020).

3.3 Project Impacts to Benthic Habitats

Given the uncertainty of the exact locations of impact to the seafloor, an extremely conservative approach, for purposes of EFH consultation, was used to estimate the maximum potential total area and composition of habitats that may be impacted by the Project. Although the same component design parameters (e.g., width of cable protection) as those presented in the COP were used to determine acres of impact, the maximum design scenario approach used for this report assumed Project activities would occur over the entirety of the area possible. An additional contingency was also added to acres of impact calculated for cable routes as those will be further refined based on ongoing offshore geophysical and geotechnical surveys and detailed engineering and design. In reality, only a fraction of these areas will ultimately be impacted by Project activities. Given this conservative approach, the maximum potentially impacted acres presented in this report will differ from those footprints presented in the COP. The footprint estimates presented in the COP are intended to represent the total actual acres of seafloor (agnostic to habitat type) that will be impacted by each project component. ***The acres presented in this benthic habitat mapping report are conservative maximum design scenario estimates developed for EFH review to describe potential impacts by habitat type and therefore, should not be considered representative of the total acres that may be impacted by the Project.***

Considered collectively, the maximum total area that may be permanently altered by all proposed project design components is 306.02 acres and that may be temporarily impacted by project activities is 1,730.34 acres (Table 3-2). The potential exists for all six mapped benthic habitat types to be permanently and/or temporarily impacted by the Project, with over half of the impacts to the non-complex habitats of Sand and Muddy Sand (57% permanent, 56% temporary), and Mud and Sandy Mud (1% permanent, 1% temporary). The remaining 43-44% intersects complex habitats with the majority of impacts affecting Coarse Sediment - <5% Cobble/Boulder (34% permanent, 30% temporary), followed by Glacial Moraine (5% permanent, 9% temporary), Coarse Sediment - 5 to 30% Cobble/Boulder (2% permanent, 3% temporary), and Coarse Sediment - 30 to 80% Cobble/Boulder (1% permanent, 1% temporary) (Table 3-2).

Maximum areas of potential impact to each of the six mapped benthic habitat types from Project components and activities anticipated to permanently and temporarily disturb the seafloor are presented for the proposed project design layout and routes (foundations, IAC segments, SFEC – OCS segments, the preferred SFEC – NYS route), as well as for alternate locations and routes in Attachment B.

Table 3-2. Maximum Potential Permanent & Temporary Impacts to Benthic Habitats from Proposed Project Design*

South Fork Wind Proposed Project Design		Unit of Measure	Glacial Moraine	Coarse Sediment - 30-80% Cobble/Boulder	Coarse Sediment - 5-30% Cobble/Boulder	Coarse Sediment - <5% Cobble/Boulder	Sand and Muddy Sand	Mud and Sandy Mud	Total
Foundations	PERMANENT Foundations + Maximum Scour Protection	acres	3.09	0	0.00	3.93	7.08	0.20	14.30
		%	22%	0%	0%	27%	50%	1%	100%
	TEMPORARY Seafloor Disturbance	acres	112.82	0	0.36	123.44	231.66	13.93	482.20
		%	23%	0%	0.1%	26%	48%	3%	100%
Inter-array Cables (with 20% contingency)	PERMANENT Cable Protection	acres	13.27	0	0	33.93	63.66	1.61	112.46
		%	12%	0%	0%	30%	57%	1%	100%
	TEMPORARY Trenches + Boulder Relocation	acres	39.64	0	0	99.51	188.85	4.58	332.58
		%	12%	0%	0%	30%	57%	1%	100%
SFEC-OCS (with 20% contingency)	PERMANENT Cable Protection	acres	-	3.63	6.85	65.31	93.47	-	169.27
		%	-	2%	4%	39%	55%	-	100%
	TEMPORARY Trenches + Boulder Relocation	acres	-	24.26	46.00	300.97	247.41	-	618.63
		%	-	4%	7%	49%	40%	-	100%
SFEC-NYS Beach Lane (with 20% contingency)	PERMANENT Cable Protection	acres	-	-	-	-	9.99	-	9.99
		%	-	-	-	-	100%	-	100%
	TEMPORARY Trenches + Cofferdam	acres	-	-	-	-	296.92	-	296.92
		%	-	-	-	-	100%	-	100%
All Project Design Components	**PERMANENT**	acres	**16.36**	**3.63**	**6.85**	**103.17**	**174.20**	**1.81**	**306.02**
		%	**5%**	**1%**	**2%**	**34%**	**57%**	**1%**	**100%**
	TEMPORARY	acres	**152.46**	**24.26**	**46.36**	**523.91**	**964.84**	**18.51**	**1730.34**
		%	**9%**	**1%**	**3%**	**30%**	**56%**	**1%**	**100%**

** The acres presented in this benthic habitat mapping report are conservative maximum design scenario estimates developed for EFH review to describe potential impacts by habitat type; therefore, they should not be used to represent the total acres that may be impacted by the Project.*

Foundations

Foundation impact footprints inclusive of all anticipated scour protection, and seafloor disturbance intersect all mapped benthic habitat types, except Coarse Sediment - 30 to 80% Cobble/Boulder (Table 3-2; Figure 3-20). Foundation footprints would permanently impact habitats of Glacial Moraine, Coarse Sediment - <5% Cobble/Boulder, and Sand and Muddy Sand, with each foundation footprint altering a total area of 0.02 acres (Attachment B). In almost all cases, this footprint was located within one habitat type; at WTG-5 the area was split between Sand and Muddy Sand and Coarse Sediment - <5% Cobble/Boulder habitats (Attachment B). Similarly, maximum scour protection footprints would permanently impact habitats of Glacial Moraine, Coarse Sediment - <5% Cobble/Boulder, and Sandy and Muddy Sand, with each scour protection footprint altering a total area of 0.87 acres (Attachment B). The maximum total area that may be permanently altered collectively by the foundations and scour protection is 14.30 acres, over half of which was classified as the non-complex habitats of Sand and Muddy Sand (50%) or Mud and Sandy Mud (1%) (Table 3-2; Figure 3-21). The remaining 49% intersects the complex habitats of Coarse Sediment - <5% Cobble/Boulder (27%) and Glacial Moraine (22%) (Table 3-2; Figure 3-21). Temporary seafloor disturbance activities associated with the foundations will potentially impact a similar composition of habitats (Table 3-2; Figure 3-21). The composition of benthic habitats that may be impacted by foundation activities (Figure 3-21) is very similar to that observed within the area mapped in the SFWF (Figure 3-9).

Inter-array Cables

IAC impact footprints inclusive of all potential trenching, cable protection, and boulder relocation intersect four of the benthic habitat types mapped within the SFWF: Glacial Moraine, Coarse Sediment - <5% Cobble/Boulder, Sand and Muddy Sand, and Mud and Sandy Mud (Table 3-2; Figure 3-20). IAC segment footprints would permanently impact these four habitat types through the use of cable protection over a maximum potential area of 112.46 acres including contingency (Table 3-2). More than half of this area is composed of non-complex Sand and Muddy Sand (57%) or Mud and Sandy Mud (1%), the remaining 42% intersects the complex habitats of Coarse Sediment - <5% Cobble/Boulder (30%) and Glacial Moraine (12%) (Table 3-2; Figure 3-22). Because the cable protection impact footprints are inclusive of the area of seafloor that would temporarily be disturbed during trenching operations, the composition of habitats potentially impacted is approximately the same, adding to a total area of 70.30 acres including contingency (Attachment B). Temporary seafloor disturbance activities associated with the IAC will potentially impact a nearly identical composition of habitats (Table 3-2; Figure 3-22). The portion of Sand and Muddy Sand potentially impacted by IAC activities is higher than the portion of this benthic habitat mapped in the SFWF and that of Glacial Moraine is lower; except for these differences, the composition of habitats potentially impacted by IAC activities is similar to those mapped in the SFWF (Figures 3-9, 3-22).

SFEC-OCS

SFEC-OCS impact footprints inclusive of all potential trenching, cable protection, and boulder relocation intersect all four of the benthic habitat types mapped along the SFEC-OCS: Coarse Sediment - 30 to 80%, Cobble/Boulder, Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - <5% Cobble/Boulder, and Sand and Muddy Sand (Table 3-2; Figure 3-23). The SFEC-OCS was evaluated by segments denoted by KPs; KPs mark kilometers between the landfall and the OSS, with KP 0 indicating land fall and KP 100 the OSS (Figure 3-23). SFEC-OCS segment footprints would permanently impact these four habitat types through the use of cable protection over a maximum potential area of 169.27 acres including contingency (Table 3-2). Over half of this area is composed of non-complex Sand and Muddy Sand (55%), the remaining 45% intersects the complex habitats of Coarse Sediment - <5% Cobble/Boulder (39%), Coarse Sediment - 5 to 30% Cobble/Boulder (4%), and Coarse Sediment - 30 to 80% (2%) (Table 3-2; Figure 3-24). The cable protection impact footprints overlap and extend beyond the potential temporary impact footprints of the cable trench, a total area of 271.26 acres including contingency, and the composition of habitats potentially impacted is approximately the same (Attachment B). Temporary seafloor disturbance associated with boulder relocation is only anticipated along two segments of the SFEC-OCS (KP80 - KP100, KP29 - KP52) and the total potential area impacted is 347.37 acres, over half of which is composed of Coarse Sediment - <5% Cobble/Boulder (54%), and the remaining is composed of Sand and Muddy Sand (32%), Coarse Sediment - 5 to 30% Cobble/Boulder (9%), and Coarse Sediment - 30 to 80% (5%) (Attachment B; Figure 3-24). The composition of benthic habitats that may be permanently impacted by SFEC-OCS activities (Figure 3-24) is very similar to that observed within the area mapped (Figure 3-14). The portion of Coarse Sediment - <5% Cobble/Boulder that may be temporarily impacted by SFEC-OCS activities is higher than the portion of this benthic habitat mapped in the SFEC-OCS area and that of Sand and Muddy Sand is lower; except for these differences, the composition of habitats that may be temporarily impacted by SFEC-OCS activities is similar to those mapped in the SFEC-OCS area (Figures 3-14, 3-24).

SFEC-NYS Beach Lane

The SFEC-NYS preferred route to Beach Lane (KP0 – KP6) is composed entirely of the Sand and Muddy Sand habitat (Figures 3-23, 3-25). Therefore, 100% of all permanent impacts from cable protection (9.99 acres with contingency) and temporary impacts (296.92 acres with contingency) from the trench (12.28 acres with contingency), and sediment excavation (0.05 acres with contingency) and anchoring (284.59 acres with contingency) related to the cofferdam would impact Sand and Muddy Sand habitats (Table 3-2; Figures 3-23, 3-25).

Alternate Locations & Routes

Foundation impact footprints inclusive of all anticipated scour protection, and seafloor disturbance for the two alternate WTG locations are composed almost entirely of Glacial Moraine, with 11% of the temporary disturbance footprint for WTG-16A consisting of other habitat types (Attachment B; Figure 3-20). At this time, design and engineering routes to these locations have not been determined; therefore, hypothetical routes were assessed (Figure 3-20). These routes transverse a mixture of habitats, composed of Glacial Moraine (20 - 25%), Coarse Sediment - <5% Cobble/Boulder (36 - 55%), and Sand and Muddy Sand (21 - 45%) (Attachment B; Figure 3-20).

The SFEC-OCS portion of the alternate SFEC route to Hither Hills intersects predominantly Sand and Muddy Sand and discrete areas of Coarse Sediment - <5% Cobble/Boulder and Coarse Sediment - 5 to 30% Cobble/Boulder (Figure 3-23). Potential permanent impacts related to the cable protection (6.34 acres) and temporary impacts related to the trench (7.79 acres) along the SFEC-OCS route to Hither Hill are expected to predominantly impact Sand and Muddy Sand (56%) and Coarse Sediment - <5% Cobble/Boulder (44%) and a very small area of Coarse Sediment - 5 to 30% Cobble/Boulder (0.1%) (Attachment B). The SFEC-NYS route is composed mostly of Sand and Muddy Sand, until the nearshore sea-to-shore transition area, where Mud and Sandy Mud is found shoreward of Sand and Muddy Sand with small areas of Coarse Sediment - 30 to 80% Cobble/Boulder and Coarse Sediment - 5 to 30% Cobble Boulder (Figure 3-26). Potential permanent impacts related to cable protection (8.08 acres) and temporary impacts from the trench (9.94 acres), and sediment excavation (0.04 acres) and anchoring (304.32 acres with contingency) related to the cofferdam are expected to predominantly impact the non-complex habitats of Sand and Muddy Sand and Muddy Sand with small areas of impact to the all three Coarse Sediment habitat types (Attachment B; Figures 3-23, 3-26).

3.4 Project Impacts to Benthic EFH for Priority Species

The results of the full EFH benthic habitat crosswalk are presented in Attachment C. All species are presented in the table with presence of EFH by habitat type and specific project area indicated. There were various levels of EFH information available to support the crosswalk depending on the species. Some species, such as winter flounder, have more explicitly identified preferred and essential substrates, while others, such as ocean quahog and spiny dogfish, have limited information. For species with limited information, or broader substrate preferences, a conservative approach was taken when crosswalking EFH to specific habitats. For example, scup adults are associated with soft, sandy bottoms; mixed sand; and mud; but prefer soft bottoms near structure. The Coarse Sediment and Glacial Moraine habitats are much more likely to have sand near structure (i.e., boulder) than other project habitats, and thus may have a “higher value” for these species than others. However, because sandy bottom is found in portions of all habitats within the Project Area, the conservative crosswalk maps adult scup to all mapped habitat types (Attachment C).

In total, 25 benthic/demersal species and 54 life stages with designated EFH within the Project Area have been crosswalked to mapped benthic habitats. A total of 44 species/life stages have been crosswalked to Glacial Moraine habitats, 48 to Coarse Sediment - 30-80% and 5-30% Cobble/Boulder, 47 to Coarse Sediment - < 5% Cobble/Boulder, 45 to Sand and Muddy Sand, and 34 to Mud and Sandy Mud. The majority of life stages with mapped EFH in the project area were crosswalked to the Coarse Sediment habitats due to the variability of sediments found in that category. Many species/life stages have preferences for sand, rock or gravel, all of which may be found in the Coarse Sediment habitats. In addition, 13 species and 28 life stages were crosswalked to all mapped benthic habitat types. These species generally have broad sediment preferences or, as is the case of most of the demersal shark species, very limited information is available on their sediment preferences, if any. A list of nine priority species are discussed in more detail in Section 4.2.

4.0 DISCUSSION

The detailed mapping and characterization of benthic habitat types within the Project Area greatly improves the collective knowledge base about seafloor environments on Cox Ledge and the outer continental shelf between Cox Ledge and Long Island. The glacial history of this region is rich and varied (Figures 3-7, 3-8), as are the characteristics of benthic habitats, particularly those associated with morainal features. There are multiple types of moraines (terminal, end) and morainal features (flank, channels) and the surface expression of these habitats at the scale at which demersal fish utilize them varies. For example, boulder density is highly varied through the habitats found at the SFWF, with very high boulder density occurring in only a few areas (Figure 4-1). For regional context, it is important to note that even within these areas of high boulder density at SFWF, on Cox Ledge, the patchy distribution of Glacial Moraine habitat and of cobbles and boulders is markedly different from the continuous cobble/boulder fields found at the glacial moraine located on Southeast Ledge near the Block Island Wind Farm (Figure 4-2).

Further, the habitat mapping assessment presented here provides the spatial information necessary to estimate the potential impacts of the Project to each of the six benthic habitat types mapped: Glacial Moraine, Coarse Sediment - 30 to 80% Cobble/Boulder, Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - <5% Cobble/Boulder, Sand and Muddy Sand, and Mud and Sandy Mud (Table 3-2; Attachment B). The crosswalk of the delineated benthic habitat types to EFH for all demersal species/life stages with designated EFH in the Project Area provides detailed information to facilitate review of potential impacts to each species/life stage (Attachment C).

4.1 Project Impacts to Benthic Habitats

Siting, engineering, and design criteria and considerations should also be understood when evaluating the potential impact footprint areas. For example, required engineering criteria considered for the final SFW layout include:

- WTG size and number
- Seabed soil and sub-bottom characteristics must align with foundation design requirements
- Seabed surface characteristics must align with constructability requirements, including:
  - Areas clear of boulders where foundations can be installed, and installation vessels can anchor or jack-up
  - Areas accessible to cable lay operations, where Inter-array Cables can be installed to and from the foundation.

The proposed project design for the SFW foundations, IAC, and SFEC (Figures 1-1, 1-2) is already indicative of a number of siting decisions, including consideration of constraints related to seafloor composition. For example, the SFEC route has been diverted in two places to avoid bouldery moraine - from the west the SFEC was diverted to the south around a patch of moraine and at the eastern terminus the cable route transits moraine flank deposits through a series of broad bends to minimize contact with boulders (Figure 3-8, 3-23). The proposed project design for the SFWF avoids areas with high densities of boulders to the extent practicable while maintaining the indicative 1 x 1 nm layout scenario (Figure 4-1). Based on the available data and engineering assessment to date, it appears all the proposed project design locations and preferred routes are appropriate for installation.

The Project design envelope approach detailed in the COP (DWSF 2020) paired with the maximum design scenario approach utilized provide extremely conservative estimates for the maximum total area of each benthic habitat type that may be permanently or temporarily impacted by each component of the Project. With few exceptions, the benthic habitat composition of permanent and temporary impacts was similar to the habitat composition documented within the given project component area (SFWF: Figures 3-9, 3-21,3-22; SFEC: Figures 3-14, 3-24). These results indicate that altered layouts would do little to measurably shift the overall composition of benthic habitats impacted by the Project.

The foundation locations in the indicative 1 x 1 nm scenario are presumed to be where the foundations will be installed provided that ongoing detailed engineering and design assessments continue to support constructability. Adherence to these locations as closely as possible is important for maintaining the 1 x 1 nm grid layout. Use of conservative estimates for the maximum extent of scour protection and seafloor disturbance associated with each foundation footprint provides a maximum design scenario for seafloor impacts from all foundations.

The majority of the foundations are sited within areas of Sand and Muddy Sand combined with Coarse Sediment - <5% Cobble/Boulder (Figure 3-9) and very low boulder density (Figure 4-1; for example, WTG-2, Figure 4-3). A heterogeneous mix of benthic habitats are within the proposed project design footprint for several foundations (Figure 3-9; for example, WTG-1, Figure 4-4). The high-resolution acoustic data, particularly side-scan sonar, provided along with detailed habitat delineations and descriptions makes it possible to assess potential impacts to specific habitat features (e.g., boulders, bedforms). For example, on close examination of the SSS data it is clear that the foundation and maximum potential scour protection footprints of WTG-9 overlap a portion of Glacial Moraine habitat that has very low boulder density compared to nearby areas of the same habitat polygon (Figure 4-5). The permanent impact footprint of WTG-5 is the only foundation sited near high boulder density habitats (Figure 4-1), and upon close examination it is clear that the majority of the maximum permanent impact footprint is within low boulder density Sand and Muddy Sand and Coarse Sediment - <5% Cobble/Boulder habitats (Figure 4-6).

Due to the conservative design parameters detailed in the COP (Sections 3.1.2, 3.2.2, DWSF 2020), the maximum design scenario approach, and the 20% contingency added to total area calculations, the estimated total acreage of benthic habitats potentially permanently and temporarily impacted by the IAC and the SFEC represent the maximum design scenario. For example, calculations of maximum potential areas of impact assume the cable protection will be placed on all portions of the IAC and SFEC, however, it is estimated that approximately only 10% of the IAC, 5 % of the SFEC-OCS, and 2% of the SFEC-NYS will need cable protection, in addition to where protection will be needed on IAC approach to the foundations (see COP Tables 3.1-4 and 3.2-3 for assumptions; DWSF 2020). While it cannot be predicted precisely where the engineering need for cable protection will occur, the likelihood of use is highest in areas of high complexity and boulder density. Therefore, IAC segments that traverse Glacial Moraine habitats and SFEC-OCS segments that pass through Coarse Sediment - 30 to 80% Cobble/Boulder and Coarse Sediment - 5 to 30% Cobble/Boulder are more likely to require cable protection (Figures 3-20, 3-22). In areas where cable protection is not required, there will not be permanent impacts. Similarly, these same habitat types are the most likely to require boulder relocation, which has been assumed for the entire IAC, up to ~ 50% of the SFEC-OCS, and none of the SFEC-NYS (see COP Tables 3.1-4 and 3.2-3 for assumptions; DWSF 2020).

An extremely conservative approach was used to calculate the maximum potential total area and composition of habitats that may be impacted by the Project for purposes of EFH consultation. In reality, only a fraction of these areas will ultimately be impacted by Project activities. Given this conservative approach, the maximum potentially impacted acres presented in this report will differ from those footprints presented in the COP. The footprint estimates presented in the COP are intended to represent the total actual acres of seafloor (agnostic to habitat type) that will be impacted by each project component. ***The acres presented in this benthic habitat mapping report are conservative maximum design scenario estimates developed for EFH review to describe potential impacts by habitat type and therefore, should not be considered representative of the total acres that may be impacted by the Project.***

4.2 Project Impacts to Benthic EFH for Priority Species

Species with demersal/ benthic life stages are most vulnerable to permanent project impacts. Species with EFH that includes sandy habitats are more likely to experience these long-term impacts from the conversion of sand habitat into hard bottom habitat associated with cable armoring and scour protection. While other construction impacts are expected to have effects on EFH for demersal/benthic life stages, they are also anticipated to be temporary.

A list of nine priority species were vetted with NOAA Habitat and are highlighted and discussed in more detail below. Only impact producing factors related to physical seafloor disturbance and suspended sediment deposition are considered here. Due to the conservative approach used in crosswalking species to benthic habitat types and, in a number of cases, the limited information on species' sediment preferences, it should be kept in mind that there are likely much smaller areas within each mapped habitat type that may be more valuable for each species/life stage than others. Because of the conservative crosswalk approach utilized, impacts to a given habitat may not necessarily affect all species with EFH crosswalked to that habitat type.

Atlantic Cod

EFH for both juvenile and adult cod consists of hard bottom habitats, with juveniles preferring cobble substrates, and adults preferring structurally complex hard bottom habitats composed of gravel, cobble, and boulder substrates (Lough 2004). Cobble habitats are essential for the survival of juvenile cod in that they may assist with avoiding predation by older year classes (Gotceitas and Brown 1993) and recent studies suggest that rocky, hard bottom habitats may be important for reproduction (DeCelles et al. 2017). Adult and juvenile cod EFH is likely to occur within the Glacial Moraine and Coarse Sediment habitats within the Project Area (Attachment C), specifically in large patches throughout the SFWF and SFEC – OCS route (Figure 3-7, 3-12). Adult EFH may also be found in small sections of Coarse Sediment - <5% Cobble/Boulder within the alternate SFEC – NYS route to Hither Hills. Cod may therefore be expected to experience short term impacts to their habitat from project activities that permanently and temporarily disturb the seafloor and result in temporary sediment suspension and deposition (detailed impacts to EFH discussed in Tables 10-13 of Appendix O of the COP [INSPIRE 2019c]). Long term adverse impacts to both adult and juvenile EFH are not expected; conversely, beneficial impacts may be seen with the creation of additional preferred habitats from the conversion of sandy and gravelly sediments into hard bottom habitat. Potential negative effects to essential cod habitat will be mitigated with hard bottom mapping and avoidance strategies (see Section 4.3).

Atlantic Sea Scallop

Atlantic sea scallop eggs likely remain on the seafloor as they develop into free-swimming larvae, which settle to the seafloor (as “spat”) before metamorphosing into juveniles (Hart and Chute 2004). Hard surfaces are essential for the survival of the spat, including sedentary branching plants or animals, shells, small pebbles, or adult scallops (Stokesbury and Himmelman 1995). Because of these associations with the seafloor, egg and larval scallop EFH has been mapped to Glacial Moraine, all 3 Coarse Sediment habitats, and Sand and Muddy Sand habitats within the Project Area. Similarly, juvenile scallops are primarily found on gravel, shells and silt (Thouzeau et al. 1991; Parsons et al. 1992), or attached to branching bryozoans, hydroids or algae (Stokesbury and Himmelman 1995), and adult scallops are generally found on firm sand, gravel, shells and rock (MacKenzie et al. 1978; Langton and Robinson 1990; Thouzeau et al. 1991a; Stewart and Arnold 1994). Juvenile and adult scallops have also been mapped to the Glacial Moraine, all 3 Coarse Sediment habitats, and Sand and Muddy Sand habitats within the project area. These habitats are found throughout the SFWF, SFEC – OCS and along both the preferred SFEC – NYS route to Beach Lane and the alternate to Hither Hills.

All life stages of scallops may experience temporary direct impacts from the construction, O&M, and decommissioning phases of the project (detailed impacts to EFH discussed in Tables 10-13 of Appendix O of the COP [INSPIRE 2019c]). Activities that will cause seafloor disturbance include the construction, installation, and decommissioning of WTG foundations, the OSS, inter array cables, and export cable. Seafloor preparation may cause injury, displacement, or mortality to scallops of all life stages. These impacts are expected to be temporary as the direct impacts will cease after seafloor preparation is completed in an area, and minor as they will disturb a small portion of available EFH in the area. Scallops will be able to recolonize most areas once construction is complete. Adults and juveniles may experience some small amount of permanent habitat loss in areas around the WTGs where scour protection is needed, and sections of the IAC and SFEC where protective armoring is required as these life stages may not colonize the new structured habitat.

Black Sea Bass

Black sea bass juveniles and adults are well documented as having strong associations with structured habitats, including natural and artificial reefs, shellfish beds, shell hash, vegetated bottom, cobble, gravel, and boulder habitats (Drohan et al. 2007). Within the Project Area, existing structure consists primarily of boulders and cobbles and the attached epifauna that grows on them. These habitat features are found within the Glacial Moraine and Coarse Sediment habitats, particularly in those with 5-30% and 30-80 % Cobble/Boulder. Both juveniles and adults have shown strong site fidelity (Able and Hales 1997, Briggs 1979) so may be vulnerable to disruptions to structured habitats.

Black sea bass may experience temporary impacts to their habitat from project activities that permanently and temporarily disturb the seafloor and result in temporary sediment suspension and deposition (detailed impacts to EFH discussed in Tables 10-13 of Appendix O of the COP [INSPIRE 2019c]). Long term adverse impacts to both adult and juvenile EFH are expected to be minor as the species is expected to recolonize the area post construction. Beneficial impacts may be seen with the creation of additional preferred habitats from the conversion of sandy and gravelly sediments into structured hard bottom habitat. Potential negative effects from disruption to complex habitats will be mitigated with hard bottom mapping and avoidance strategies (see Section 4.3).

Little and Winter Skate

Little and winter skate will be discussed together for the purposes of this report as they share similar habitat requirements, are frequently co-occurring (McEachran and Musick 1975), and are expected to experience similar impacts from SFW project activities. Little and winter skate juveniles and adults are found throughout southern New England on sandy or gravelly substrate but have also been found on mud (Bigelow and Schroeder 1953; McEachran and Musick 1975; Langton et al. 1995; Tyler 1971). These species have been mapped to all habitats within the South Fork Wind project area as all habitats have some component with sand, gravel, or mud.

Given the broad distribution of these species throughout the Project Area, there are likely to be temporary and permanent impacts to their preferred habitats. These species may be temporarily displaced by seafloor preparation activities that disrupt the benthos such as installation and decommissioning of WTG foundations, the OSS, inter-array cables, and export cable (detailed impacts to EFH discussed in Tables 10-13 of Appendix O of the COP [INSPIRE 2019c]). Skates will be able to recolonize most areas once construction is complete, however they may experience permanent habitat loss in areas that are converted from sandy and gravelly sediments to hard bottom habitats around the WTGs where scour protection is needed, and sections of the inter-array and export cables where protective armoring may be required. Loss of habitat due to conversion to hard bottom is not expected to have a significant impact on these species due the large amount of alternate suitable habitat available.

Longfin Squid

Little information is available on egg habitat locations for longfin squid (Jacobson 2005), however egg mops are often found attached to cobbles and boulders on sandy or muddy bottoms or attached to aquatic vegetation (Arnold et al. 1974; Griswold and Prezioso, 1981; Summers 1983). Due to the limited information available on suitable egg habitat, it is assumed that egg mops could be present on any substrates within adult spawning habitat and has been mapped to all project habitats within the bounds of mapped EFH for longfin squid eggs. Specifically, EFH for eggs may be found during the spawning months of May to August (Summers 1971; Macy 1980) within the SFEC – OCS and both SFEC – NYS cable routes.

Longfin squid egg mops may be temporarily adversely affected by activities that will cause seafloor disturbance and suspended sediments including the installation and decommissioning of the OSS and export cable (detailed impacts to EFH discussed in Tables 12-13 of Appendix O of the COP [INSPIRE 2019c]). Cable laying activities may cause injury, displacement, or mortality to egg mops, but most impacts are expected to be temporary as the direct impacts will cease after cable laying has been completed and minimal as only a small amount of available habitat will be disturbed.

Ocean Pout

Ocean pout eggs are demersal, laid in gelatinous masses, generally in sheltered nests, holes, or rocky crevices within hard bottom habitats (NEFMC 2017). These essential habitats are expected within the Glacial Moraine, Coarse Sediment 30-80% Cobble/Boulder, and Coarse Sediment 5-30% Cobble/Boulder habitats within the Project Area, specifically where found in large patches throughout the SFWF and SFEC – OCS route, as well as in small sections of the alternate SFEC – NYS route to Hither Hills (Figures 3-9, 3-14).

Juvenile and adult ocean pout occur on a wide variety of substrates, including shells, rocks, algae, soft sediments, sand, and gravel (NEFMC 2017). Rocky shelter is shown to be especially important for spawning adults in the autumn where they will lay their eggs (Smith 1898). EFH for juveniles and adults is expected to occur within all habitat types in the Project Area, specifically throughout the SFWF and SFEC – OCS route. Essential adult habitats may also be found in deeper (> 20 m) portions of the SFEC – NYS cable routes (Figure 2-3).

All life stages of ocean pout may experience temporary direct impacts from the construction, O&M, and decommissioning phases of the project (detailed impacts to EFH discussed in Tables 10-13 of Appendix O of the COP [INSPIRE 2019c]). Activities that will cause seafloor disturbance include the construction, installation, and decommissioning of WTG foundations, the OSS, inter-array cables, and export cable. Seafloor preparation may cause injury, displacement, or mortality to ocean pout of all life stages, eggs being particularly vulnerable to impacts due to their inability to vacate during construction. These impacts are expected to be temporary as the direct impacts will cease after seafloor preparation is completed, and minor as they will disturb a small portion of available EFH in the area. Ocean pout are expected to recolonize the area once construction is complete and may experience permanent beneficial impacts from the creation of additional preferred habitats for eggs, juveniles, and spawning adults from the conversion of sandy and gravelly sediments into structured hard bottom habitat. Potential negative affects to essential ocean pout habitat will be mitigated with hard bottom mapping and avoidance strategies (see Section 4.3).

Windowpane Flounder

Windowpane flounder juveniles and adults primarily utilize sand substrates off southern New England and may also be found on mud (NEFMC 2017; Langton et al. 1994). Portions of sandy habitat can be found within all habitat categories within the Project Area including Glacial Moraine and all 3 Coarse Sediment habitats, however portions of hard, structured bottom within those areas may be less suitable for this species. Windowpane EFH is expected throughout the SFWF, SFEC – OCS and SFEC – NYS routes, therefore juveniles and adult flounder are likely to be temporarily displaced by seafloor preparation activities that disrupt the benthos such as installation, and decommissioning of WTG foundations, the OSS, inter-array cables, and export cable (detailed impacts to EFH discussed in Tables 10-13 of Appendix O of the COP [INSPIRE 2019c]). Flounder are expected to be able to recolonize most areas once construction is complete, however they may experience permanent habitat loss in areas that are converted from sandy and gravelly sediments to hard bottom habitats around the WTGs where scour protection is needed, and sections of the inter-array and export cables where protective armoring may be required. Loss of habitat due to conversion to hard bottom is not expected to have a significant impact on these species due to the large area of alternate suitable habitat available.

Yellowtail Flounder

Sand, sandy mud, and gravel sediments are essential to benthic yellowtail flounder life stages (juveniles and adults) for feeding and growth (Bowering and Brodie 1991; Scott 1982; NEFMC 2017). Yellowtail flounder juveniles and adults utilize shallow (5 m) coastal water and are most frequently found between 20 and 50 m (Wigley and Gabriel 1991; Johnson et al. 1999). Given their habitat requirements, EFH for yellowtail flounder juveniles and adults is likely to be found in portions of all habitats within the Project Area as all habitats have some component with sand, gravel, or mud, however portions of hard, structured bottom within the Coarse Sediment and Glacial Moraine habitats may be less suitable for this species. Yellowtail juvenile EFH has been mapped within the SFWF, SFEC – OCS and adult EFH has been mapped to all project areas including the SFWF, SFEC – OCS, SFEC – NYS preferred route to Beach Lane and alternate to Hither Hills (Attachment C). Yellowtail flounder juveniles and adults are expected to experience similar impacts as discussed for windowpane flounder juveniles and adults in these areas.

4.3 Minimization/ Mitigation of Potential Impacts to Benthic Habitats & EFH

DWSF proposes the following mitigation measures to ensure that impacts to benthic habitat designated as EFH and to EFH-designated species/life stages are minimal. Only those measures directly related to potential impacts to benthic habitats are included here. Additional minimization/mitigation measures proposed for EFH and EFH-designated species can be found in Section 4.3.3.3 and Appendix O of the SFW COP (INSPIRE 2019c).

In Sections 4.3.2.3 (Benthic) and 4.3.3.3 (EFH) of the SFW COP, DWSF proposed the following environmental protection measures to reduce potential impacts to benthic resources and essential fish habitat:

- The Project will minimize impacts to important habitats for finfish species.
- The Project will minimize impacts to harder and rockier bottom habitats to the extent practicable.
- Use of monopiles with associated scour protection will minimize impacts to benthic habitat, compared to other foundation types.
- Installation of the Inter-array Cable and SFEC – Offshore will occur using equipment such as mechanical cutter, mechanical plow, and/or jet plow. Compared to open cut dredging, this method will minimize long-term impacts to the benthic habitat.
- The Inter-array Cable and SFEC – Offshore will be buried to a target depth of 4 to 6 feet (1.2 to 1.8 m).
- Use of dynamic positioning vessels for cable installation for the Inter-array Cable and SFEC – Offshore will minimize impacts to finfish and EFH resources, as compared to use of a vessel relying on multiple-anchors.
- The SFEC sea-to-shore transition will be installed using horizontal direction drill (HDD) to avoid impacts to the dunes, beach, and near-shore zone, including finfish and EFH resources.
- Siting of the SFW and SFEC – Offshore were informed by site-specific benthic habitat assessments and Atlantic cod spawning surveys.
- A plan for vessels will be developed prior to construction to identify no-anchor areas inside the MWA to protect sensitive areas or other areas to be avoided.

Further mitigation measure details are proposed in Appendix O (EFH) of the SFW COP (INSPIRE 2019c), specific to benthic habitats are:

Hard Bottom Habitat Mapping and Avoidance - Vessel operators will be provided with maps of sensitive hard bottom habitat in the SFWF and SFEC, as well as a proposed anchoring plan that will minimize impacts on the hard bottom habitat to the greatest extent practicable. These plans will be provided for all anchoring activity, including construction, maintenance, and decommissioning.

Intake Screens on Pump Intakes - All jet-plow or self-propelled mechanical plow water intakes will be covered with a mesh screen or screening device to minimize potential for impingement or entrainment of fish species. A qualified biologist will verify that the screens are in place at the beginning of each jet-plow or self-propelled mechanical plow work period and examine them for impinged fish species whenever the screens are cleaned or the hydroplow is raised out of the water during the cable laying.

DWSF has recently established plans for benthic monitoring, documented within the SFW Fisheries Research and Monitoring Plan (DWSF and INSPIRE 2020).

Benthic habitat monitoring - The SFW benthic survey will be conducted not more than six months prior to construction and again after construction to determine the spatial scale of potential impacts on benthic habitats and biological communities within the proposed SFWF and along the SFEC, and to examine potential impacts on scallops along the SFEC. A SPI/PV survey will be conducted within the Project Area. This survey will characterize the geological (sediment size and type) and benthic (animal habitat) characteristics of the areas with potential effects from construction and operations. SPI and PV will be used to provide an integrated, multi-dimensional view of the benthic and geological condition of seafloor sediments and characterize benthic habitats as a baseline not more than six months before construction and not more than six months after operation has begun, providing neither period is during the winter. The SPI and PV cameras collect high-resolution imagery over several meters of the seafloor (plan view) as well as the sediment–water interface (profile) in the shallow seabed. SPI/PV surveys have been conducted within the SFWF and along the SFEC to provide detailed assessment of benthic habitat for EFH consultation (DWSF 2020). A Before After Gradient survey will be conducted at SFW using fixed stations to assess the spatial scale and extent of wind farm effects on benthic habitat.

5.0 CONCLUSIONS

The primary conclusions of this benthic habitat mapping assessment to support EFH consultations are:

1. Six benthic habitat types were mapped: Glacial Moraine, Coarse Sediment - 30 to 80% Cobble/Boulder, Coarse Sediment - 5 to 30% Cobble/Boulder, Coarse Sediment - <5% Cobble/Boulder, Sand and Muddy Sand, and Mud and Sandy Mud.
    a. All six were documented in the SFWF.
    b. All but Glacial Moraine and Mud and Sandy Mud were documented along the SFEC-OCS route.
    c. Only Sand and Muddy Sand was documented along the preferred SFEC-NYS route to Beach Lane. The alternate route to Hither Hills included all Coarse Sediment habitat types, Sand and Muddy Sand, and Mud and Sandy Mud.
2. The conservative maximum design scenario approach utilized to estimate the estimate the maximum potential total area and composition of habitats that may be impacted by the Project is appropriate for providing values for the purposes of EFH consultation. These estimates differ from the footprints presented in the COP, which are intended to represent the total actual acres of seafloor (agnostic to habitat type) that will be impacted by each project component. Therefore, the acres presented in this benthic habitat mapping report should not be considered representative of the total acres that may be impacted by the Project.
3. The potential exists for all six mapped benthic habitat types to be permanently and/or temporarily impacted by the Project.
    a. Over half of the impacts to the non-complex habitats of Sand and Muddy Sand (57% permanent, 56% temporary), and Mud and Sandy Mud (1% permanent, 1% temporary).
    b. The remaining 43-44% intersects complex habitats with the majority of impacts affecting Coarse Sediment - <5% Cobble/Boulder (34% permanent, 30% temporary), followed by Glacial Moraine (5% permanent, 9% temporary), Coarse Sediment - 5 to 30% Cobble/Boulder (2% permanent, 3% temporary), and Coarse Sediment - 30 to 80% Cobble/Boulder (1% permanent, 1% temporary).
4. With few exceptions, the benthic habitat composition of permanent and temporary impacts was similar to the habitat composition documented within the given project component area, indicating that altered layouts would do little to measurable shift the overall composition of benthic habitats impacted by the Project.

5. The proposed project design for the SFWF avoids areas with high densities of boulders to the extent practicable while maintaining the indicative 1 x 1 nm layout scenario. The proposed project design for the IAC and SFEC is already indicative of a number of siting decisions, including consideration of constraints related to seafloor composition.

6. Based on the available data and engineering assessment to date, it appears all the proposed project design locations and preferred routes are appropriate for installation.

7. The high-resolution acoustic data, particularly side-scan sonar, provided along with detailed habitat delineations and descriptions makes it possible to assess potential impacts to specific habitat features (e.g., boulders, bedforms).

8. A complete crosswalk of delineated benthic habitat types to EFH for all demersal species/life stage with designated EFH in the Project Area provides detailed information to facilitate review of potential impacts to each species/life stage. In total, 25 benthic/demersal species and 54 life stages with designated EFH within the Project Area have been crosswalked to mapped benthic habitats:

    a. 44 to Glacial Moraine habitats;

    b. 48 to Coarse Sediment - 30-80% and 5-30% Cobble/Boulder;

    c. 47 to Coarse Sediment - < 5% Cobble/Boulder;

    d. 45 to Sand and Muddy Sand; and

    e. 34 to Mud and Sandy Mud.

9. Species with demersal/ benthic life stages are most vulnerable to permanent project impacts. Species with EFH that includes sandy habitats are more likely to experience these long-term impacts from the conversion of sand habitat into hard bottom habitat associated with cable armoring and scour protection. While other construction impacts are expected to have effects on EFH for demersal/benthic life stages, they are also anticipated to be temporary.

10. Due to the conservative approach used in crosswalking species to benthic habitat types and, in a number of cases, the limited information on species' sediment preferences, it should be kept in mind that there are likely much smaller areas within each mapped habitat type that may be more valuable for each species/life stage than others. Because of the conservative crosswalk approach utilized, impacts to a given habitat may not necessarily affect all species with EFH crosswalked to that habitat type.

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