New England Wind
Benthic Habitat Monitoring Plan

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Revision Summary				
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New England Wind

Benthic Habitat Monitoring Plan

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Prepared by:

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

BENTHIC HABITAT MONITORING PLAN

1.0 Introduction and Background

1.1 Overview

New England Wind is the proposal to develop offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0534 along with associated offshore and onshore cabling, onshore substations, and onshore operations and maintenance (O&M) facilities. Lease Area OCS-A 0534 is within the Massachusetts Wind Energy Area identified by BOEM, following a public process and environmental review, as suitable for wind energy development. Park City Wind LLC, a wholly owned subsidiary of Avangrid Renewables LLC, is the Proponent of New England Wind.

New England Wind will be developed in two Phases with a maximum of 130 wind turbine generator (WTG) and electrical service platform (ESP) positions. New England Wind will occupy all of Lease Area OCS-A 0534 and potentially a portion of Lease Area OCS-A 0501 in the event that Vineyard Wind 1 does not develop “spare” or extra positions included in Lease Area OCS-A 0501 and Vineyard Wind 1 assigns those positions to Lease Area OCS-A 0534.[1] Phase 1, which includes Park City Wind, will be developed immediately southwest of Vineyard Wind 1. Phase 2, which includes Commonwealth Wind, will be developed immediately southwest of Phase 1 and will occupy the remainder of the Lease Area. The WTGs and ESP(s) in the Lease Area will be oriented in fixed east-to-west rows and north-to-south columns with one nautical mile (1.85 km) spacing between positions. Figure 1-1 provides an overview of New England Wind.

Five offshore export cables—two cables for Phase 1 and up to three cables for Phase 2 will transmit electricity from the Lease Area to shore.[2] Unless technical, logistical, grid interconnection, or other unforeseen issues arise, all five New England Wind offshore export cables will be installed within a shared Offshore Export Cable Corridor (OECC) that will travel from the northwestern corner of the Lease Area and then head northward along the eastern side of Muskeget Channel toward landfall sites in the Town of Barnstable (see Figure 1-1).[3] The OECC for New England Wind is largely the same OECC proposed in the approved Vineyard Wind 1 Construction and Operations Plan (COP), but it has been widened to the west along the entire corridor and to the east in portions of Muskeget Channel. The two Vineyard Wind

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1 The BHMP uses “Lease Area” to refer to Lease Area OCS-A 0534 and any portion of Lease Area OCS-A 0501 assigned to Lease Area OSC-A 0534.

2 While the COP allows for four or five offshore export cables in the OECC, based on current capacity for New England Wind, five cables would be required.

3 As described further in Section 4.1.3 of COP Volume I, the Proponent has identified two variations of the Phase 2 OECC in the event that technical, logistical, grid interconnection, or other unforeseen issues arise during the COP review and engineering processes that preclude one or more Phase 2 offshore export cables from being installed within all or a portion of the OECC.

1 offshore export cables will also be installed within the New England Wind OECC. To avoid cable crossings, the Phase 1 cables are expected to be located to the west of the Vineyard Wind 1 cables and, subsequently, the Phase 2 cables are expected to be installed to the west of the Phase 1 cables.

Each Phase of New England Wind will connect independently to an onshore transmission system located in the Town of Barnstable.[4] Phase 1 will make landfall at either the Craigville Public Beach Landfall Site or the Covell's Beach Landfall Site in the Town of Barnstable. Phase 2 will make landfall at the Dowses Beach Landfall Site and/or Wianno Avenue Landfall Site in Barnstable. See Figure 1-1 for more detail.

The Proponent is committed to developing an appropriate benthic habitat monitoring plan (BHMP) for New England Wind in consultation with federal and state agencies. The Proponent has developed a single BHMP for both phases of New England Wind. The New England Wind BHMP is based upon the approved Vineyard Wind 1 BHMP and will replicate the Vineyard Wind 1 BHMP to the greatest extent practicable, including sharing the same six habitat zones, sampling effort, sampling equipment types, sample station design, control sites, and timing.

The BHMP focuses on seafloor habitat and benthic communities to measure potential impacts and the recovery of these resources compared to control sites located outside of the areas potentially impacted by construction activities. As described further in Section 2.0, the survey design includes collection of bathymetric data, video data, and benthic grab sample data.

[4] One or more Phase 2 offshore export cables may deliver power to a second grid interconnection point if technical, logistical, grid interconnection, or other unforeseen issues arise. Under this scenario, Phase 2 could include one onshore transmission system in Barnstable and/or an onshore transmission system(s) in proximity to the second grid interconnection point (see Section 4.1.4 of COP Volume I).

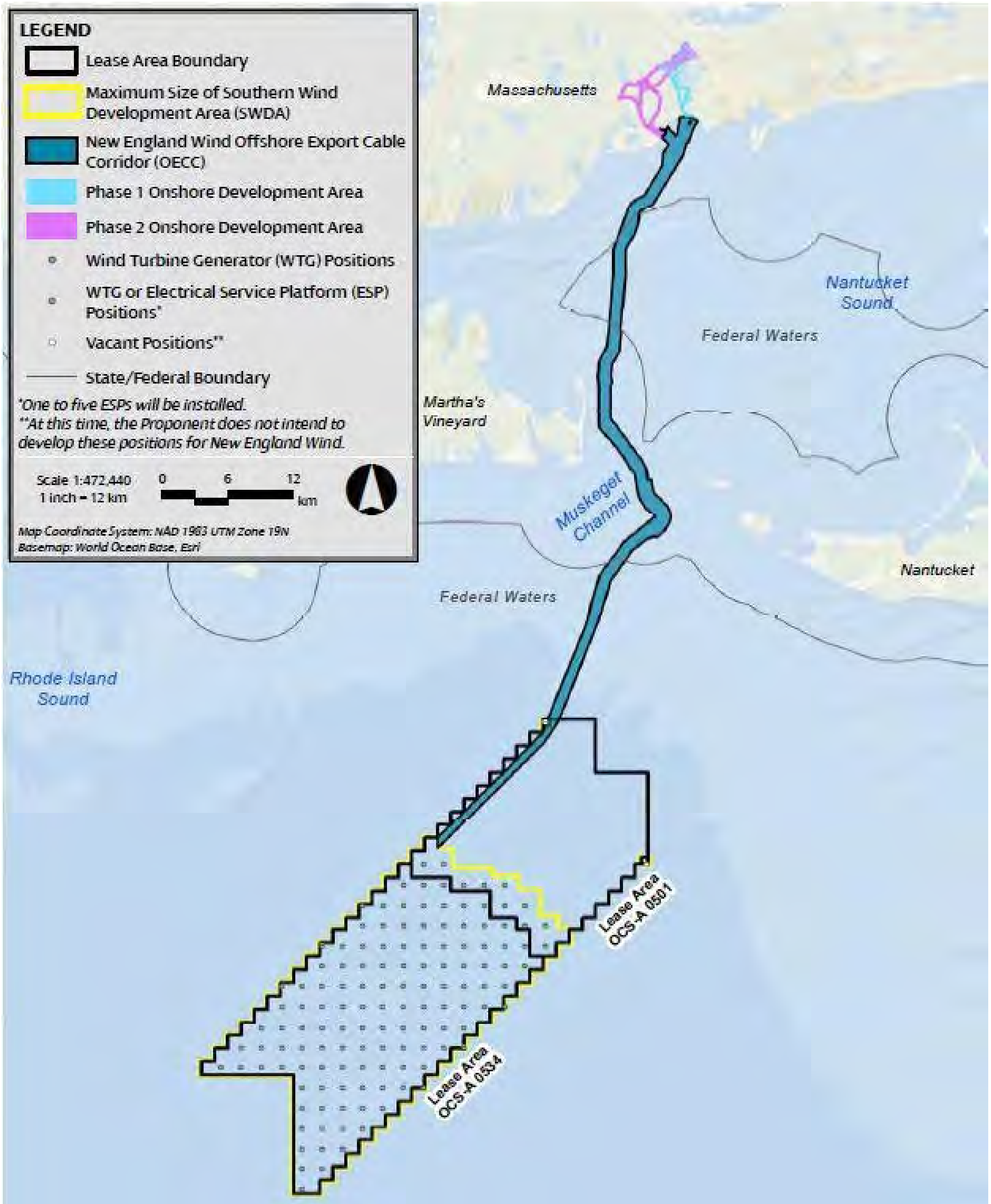

Figure 1-1 New England Wind Overview

1.2 Monitoring Background

The BHMP was developed based on best practices available in the literature along with an analysis of existing benthic survey information to determine the sample size needed for sufficient statistical power (Borja et al. 2000; Van Hoey et al. 2007; Borja and Dauer 2008; Daan et al. 2009; Degraer et al. 2013; Degraer et al. 2017; Franco et al. 2015; HDR 2017; Hutchison et al. 2020). The following guidelines and reviews were used to inform the design of the benthic habitat monitoring plan, including:

- *Developing Environmental Protocols and Modeling Tools to Support Ocean Renewable Energy and Stewardship*—a BOEM-funded review of existing monitoring protocols for effects of offshore renewable energy (McCann 2012);
- *Offshore Wind Energy Development Site Assessment and Characterization: Evaluation of the Current Status and European Experience*—a BOEM-funded review of site assessment and characterization methods for offshore wind in both the US and Europe (Rein et al. 2013);
- *Monitoring Guidance for Marine Benthic Habitats*—a marine benthic habitat monitoring guidance report developed by the Joint Nature Conservation Committee of the UK (Noble- James et al. 2017);
- *Guidance on Survey and Monitoring in Relation to Marine Renewables Deployments in Scotland* (Saunders et al. 2011);
- BOEM's *Guidelines for Providing Benthic Habitat Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf* (BOEM 2019); and
- National Marine Fisheries Service (NMFS) *Recommendations for Mapping Fish Habitat* (NMFS 2021).

A lack of a "one-size-fits-all" approach is apparent in the literature, so appropriate monitoring protocols must be developed on a case-by-case basis (McCann 2012). Despite the multitude of options for benthic habitat assessment and monitoring (Warwick et al. 2010), some generally- accepted guidelines exist. First, standardized protocols are important for comparison over time and between projects within an area, to obtain a fuller picture of cumulative impacts on the environment. Many monitoring studies apply a Before-After-Control-Impact (BACI) design, or a Beyond BACI design that incorporates multiple control sites. It is generally recommended that control sites be placed where similar environmental conditions (substrate type, hydrodynamics, other anthropogenic impacts) to those at the impact sites also occur (McMann 2012). Sampling stations should also encompass all unique habitats and other environmental gradients, such as depth and currents. At least three replicate samples should be taken at each sampling station to evaluate small-scale variability, increase the likelihood that sparsely distributed taxa will be captured and accounted for, and obtain a more representative sample of the site (McCann 2012; Noble-James et al. 2017).

A recent review of BACI studies on fishes, as part of offshore wind monitoring, noted that the large degree of variability in the data makes it difficult to detect significant patterns and presented the importance of incorporating distance as a monitoring factor, but also noted that BACI designs may be more appropriate for less-mobile organisms (Methratta 2020). A Before-After Gradient (BAG) sampling design allows for comparison of species indices over both space and time and determines the spatial extent of a particular impact, which is useful for future planning of similar projects. Gradient survey designs have been shown to be more powerful in detecting changes due to disturbances than BACI and simple random block designs (Elliott 1997; Bailey et al. 2014); however, BACI designs analyzed with Analysis of Variance (ANOVA) tests are widespread in environmental monitoring literature (Underwood and Chapman 2013). The New England Wind BHMP utilizes a combination BAG/BACI survey design to allow for agile analysis of data.

To quantitatively compare habitat, a structured, repeatable classification system must also be applied. The BOEM benthic habitat monitoring guidelines (BOEM 2019), suggest benthic habitat data should be classified according to the Coastal and Marine Ecological Classification Standard (CMECS) to the lowest taxonomic unit possible. The CMECS standard is a hierarchical system of classifying ecological units in the marine environment (FGDC 2012). Basic benthic community indices (species abundance, richness, diversity) are combined with knowledge of the abiotic environment within which they tend to occur (water column and substrate features) to identify substrate and biological components of the benthos that can be monitored for changes post-construction. For this monitoring plan, the benthic habitats and communities surveyed will be classified under the CMECS standard, with unique biotopes defined where possible.

1.3 Habitat Zones

Extensive survey work has been conducted to characterize the geological and biological conditions within the Development Area (which includes the Lease Area and OECC), including multibeam, side scan sonar, magnetometer, grab samples, vibracores, and underwater video imagery. The Development Area was categorized into six major habitat zones (one habitat zone in the Lease Area and five habitat zones in the OECC), which were defined by primary seabed characteristics including surficial sediment types/geology, seafloor features, and general benthic conditions (Table 1-1 and Figure 1-2). As described further in Section 2.0, the proposed study design is based on habitat zonation informed by geological zones and the benthic grab sample and underwater video collected in the Lease Area and along the OECC.

While the Proponent intends to install all Phase 2 offshore export cables within this OECC, the Proponent has identified two variations of the OECC that may be employed for Phase 2: the Western Muskeget Variant (which passes along the western side of Muskeget Channel) and the South Coast Variant (which connects to a potential second grid interconnection point). These variations are necessary to provide the Proponent with commercial flexibility should technical, logistical, grid interconnection, or other unforeseen issues arise during the COP review and engineering processes. The Western Muskeget Variant includes two habitat zones (Zone 2 and Zone 5), which are the same two zones found on the eastern side of Muskeget Channel within the OECC (Figure 1-3). If the Western Muskeget Variant is used for Phase 2, sample transects within these two zones could be placed in either the main OECC or the Western Muskeget Variant. In the unlikely event the South Coast Variant is used for Phase 2, benthic habitat monitoring would follow the same BHMP developed for the OECC and would be carried out within the six habitat zones of the South Coast Variant (Table 1-2 and Figure 1-4).

Table 1-1 Summary of Habitat Zones within the OECC and Lease Area that will be Sampled by the Benthic Habitat Monitoring Plan

Development Area and Habitat Zone	Habitat Type
OECC – 1	Flat sand-mud habitat, deeper water offshore (>20 m), along the OECC segment nearest the Lease Area.
OECC – 2	Sand and gravel with patches of coarse materials with some small sand waves/ mega ripples along the OECC between Martha's Vineyard and Nantucket. Depths range between 6 – 30 m.
OECC – 3	Mainly featureless sandy bottom with some patches of dense shell hash and high ripples/sand waves. Waters from 10 – 20 m along the OECC in Nantucket Sound.
OECC – 4	Flat, featureless sand with some silty areas. Shallow water depths from 1 – 10 m along the OECC nearest shore.
OECC – 5	High relief bottom topography with abundance of coarser material and hard bottom areas, high currents, and water depths between 6 – 15 m along the OECC in the middle of Muskeget Channel.
Lease Area – 1	Soft bottom containing sand and mud with some benthic features present, especially in the center of Lease Area. Deeper water (43 – 62 m) with depth increasing towards the south-southwestern portion of the Lease Area.

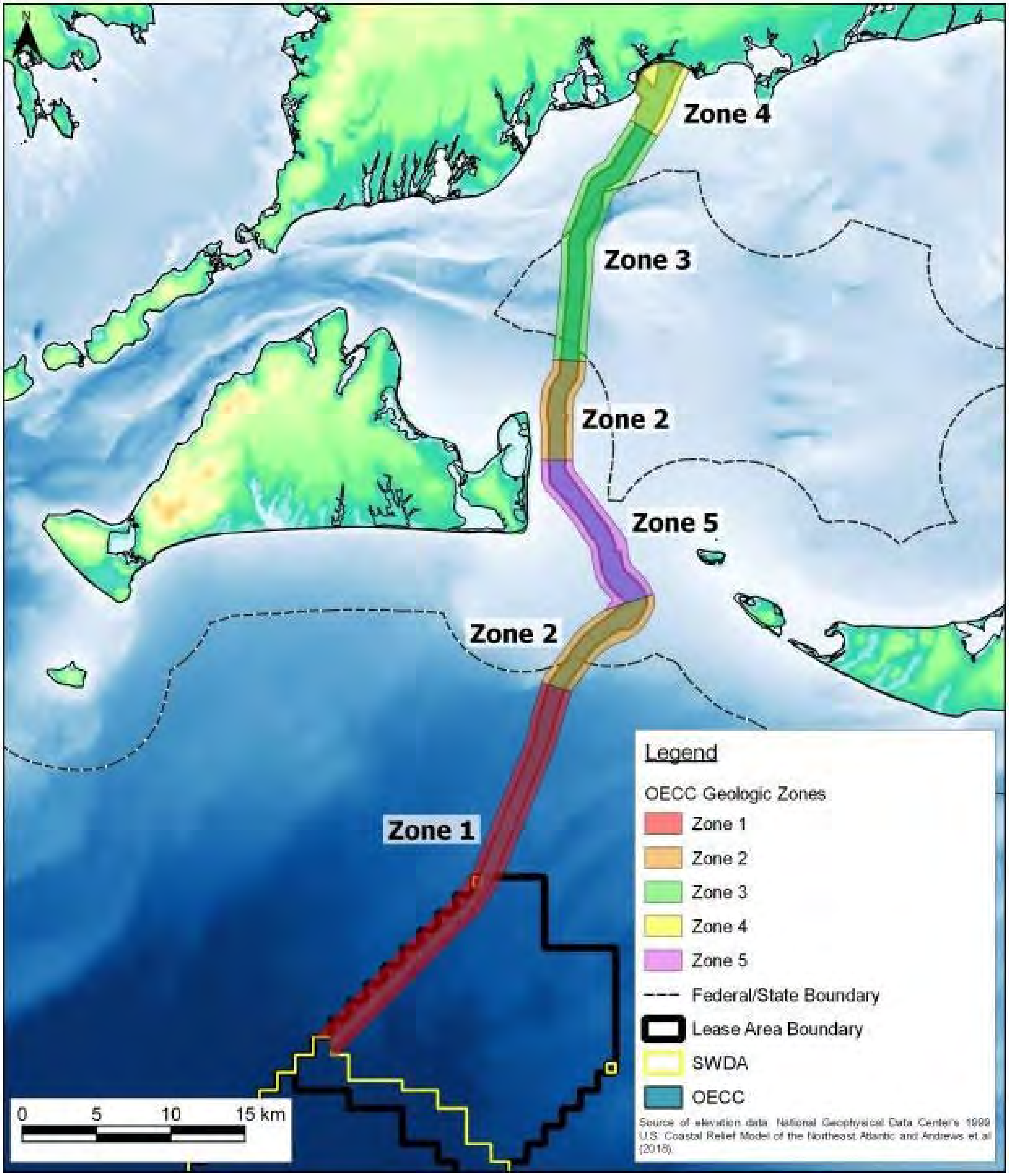

Figure 1-2 Primary habitats within the Lease Area and along the OECC

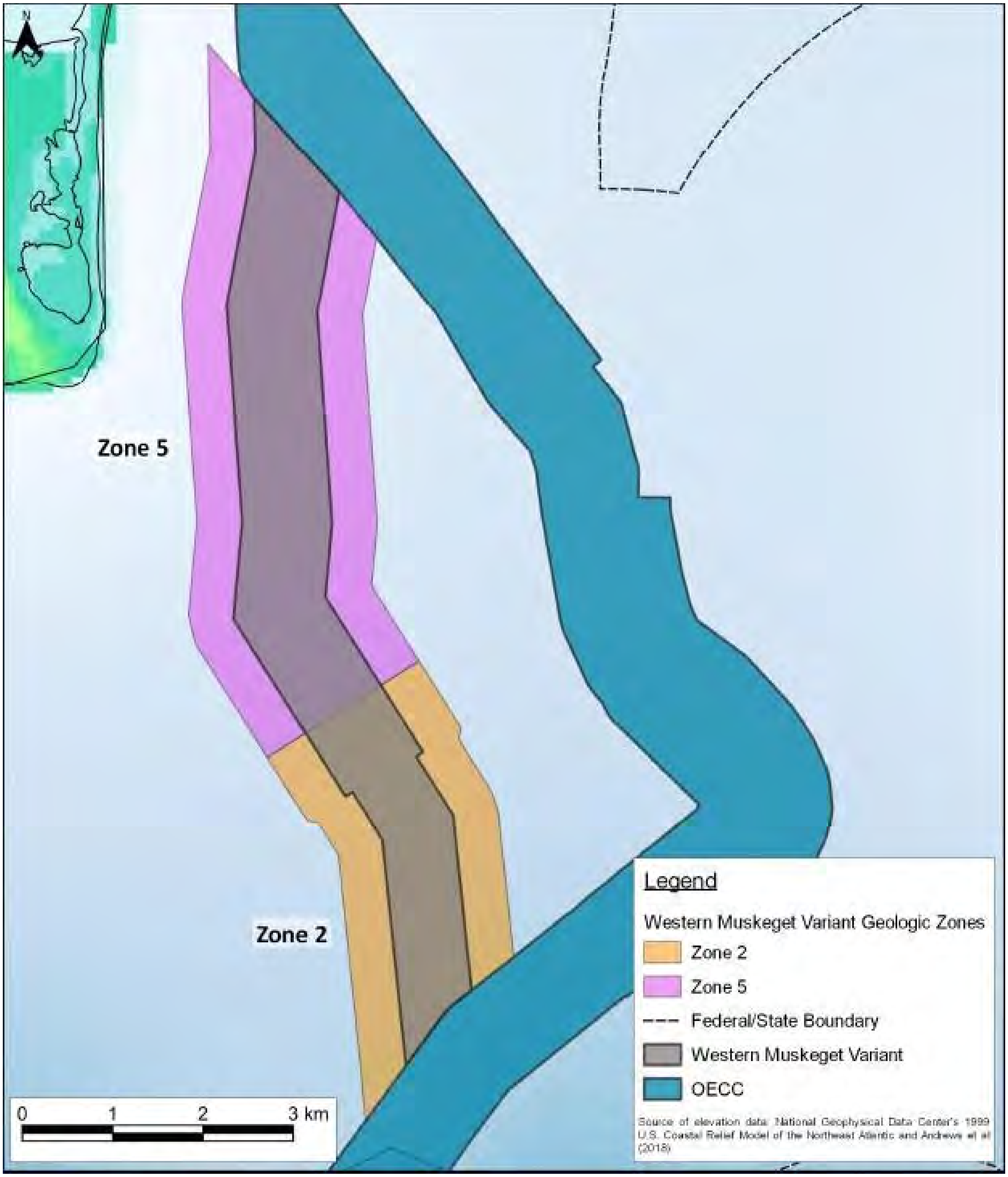

Figure 1-3 Primary habitats within the Phase 2 OECC Western Muskeget Variant

Table 1-2 Summary of Habitat Zones within the South Coast Variant that will be sampled by the Benthic Habitat Monitoring Plan

Development Area and Habitat Zone	Habitat Type
SCV – A	Soft bottom close to shore interspersed with patches containing ripples, coarse sediment, and boulders. Depths range from 18 – 26 m.
SCV – B	Flat, soft sediments containing sand and mud with one isolated boulder mound. Depths ranging from 25 – 38 m.
SCV – C	Mostly soft sediments with occasional ripples containing coarse sediment in transition zone from deeper water up onto Southwest Shoal. Isolated boulders and patchy boulder fields are also present in areas. Depths range from 29 – 37 m.
SCV – D	Complex seafloor containing boulder piles, boulder fields, and sand ripples on Southwest Shoal. Small patches of soft sediment are present on the eastern portion of this zone. Depths range from 16 – 34 m.
SCV – E	Mixture of soft and coarse sediments with boulders and widespread ripples with water depths of 23 – 36 m.
SCV – F	Soft sandy and muddy sediments in deeper water (34 – 41 m) south of Martha’s Vineyard. Ripples and occasional isolated boulders are present.

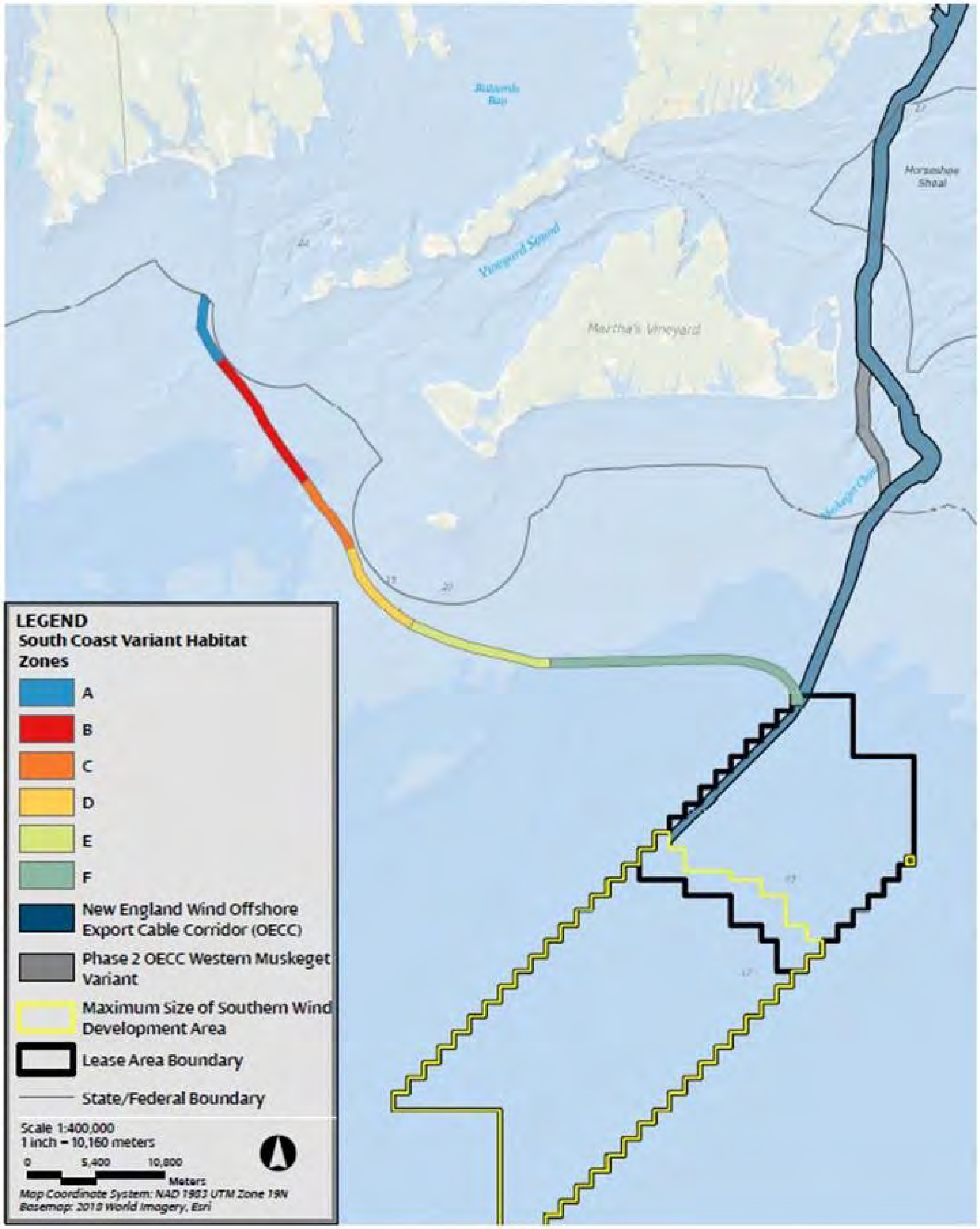

Figure 1-4 Primary habitats within the Phase 2 OECC South Coast Variant

2.0 Proposed Benthic Habitat Monitoring Plan

2.1 Objectives, Questions, and Hypotheses

Grab Sample Grain Size and Macroinvertebrate Analysis

The objectives of the grab sample surveys are to investigate the spatial and temporal changes of the benthic macroinvertebrate community and benthic habitat types from construction-related activities in the Lease Area and OECC. The specific research questions driving the study are:

1. Does the benthic macroinvertebrate community change after construction? If so, how?
2. Does the benthic habitat change after construction? If so, how?

From the data collected by this survey, the following primary null hypotheses will be tested:

- H_{01}: There will be no difference in benthic community metrics (e.g., abundance, diversity, or other indicator) or grain size distribution (e.g., CMECS classification) between impact and control areas before and after construction.

- H_{02}: There will be no difference in benthic community metrics or grain size distribution along a gradient of distance from potential impact sources (i.e., WTGs or OECCs) before and after construction.

2.1.1 Underwater Imagery Epifauna Percent Cover Analysis

The objectives of the video surveys are to further augment benthic characterization of hard-bottom substrates that cannot be surveyed by grab sampling; to capture the presence of epifaunal communities; and to document changes and/or recovery of epifaunal and benthic communities potentially impacted by construction-related activities in the Lease Area and OECC. The specific research questions driving the study are:

1. Does the percent cover of epifaunal species change after construction? If so, how?
2. Does the presence or abundance of epifaunal species change after construction? If so, how?

From the data collected by this survey, the following primary null hypotheses will be tested:

- H_{01}: There will be no difference in epifaunal community metrics (e.g., species occurrence, abundance, percent cover) between impact and control monitoring areas before and after construction.

- H_{02}: There will be no difference in epifaunal community metrics along a gradient of distance from potential impact sources (i.e., WTGs or OECCs) before and after construction.

2.1.2 Bathymetric Analysis

The objective of the bathymetric analysis is to assess and monitor bottom morphology, micro-relief, and potential future remnant seabed scarring within each of the monitoring sites and stations. The bathymetric analysis is a qualitative assessment that relies on seabed surface maps and backscatter data that allows comparisons of bottom morphology and informs changes in sediment composition, substrate variations, and benthic features ("bedforms") at each successive mapping.

2.2 Statistical Analysis of Prior Data

Survey and sampling efforts of the Development Area began in 2016. To date, various sampling programs have been conducted across the Development Area to establish fine-scale resolution of the geophysical properties, habitat composition, and benthic communities (see Appendix II-H 2016-2020 Benthic Reports of COP Volume II-A). Statistical analysis of the Vineyard Wind 1 benthic habitat data was conducted to inform the New England Wind BHMP. An *a priori* power analysis was conducted with G*Power software using benthic grab sample data collected in the Vineyard Wind 1 Offshore Development Area. A power analysis estimates the necessary sample size to detect changes in environmental indices at a particular power level. It is based on the effect size, tests to be run, and the specified level of power and significance (Antcliffe 1992). The level of power is commonly defined as 0.80, which represents an 80% chance of detecting an effect where one exists, or a 20% chance of failing to reject the null hypothesis when it is false (Type II error). The significance is usually set to 0.05, which represents a 5% chance of detecting an effect where one does not exist, or incorrectly rejecting the null hypothesis when it is true (Type I error) (Cohen 1988; Antcliffe 1992; Noble- James et al. 2017).

The power analysis for the current study was based on a three-factor analysis of variance (ANOVA) to test three null hypotheses, as described above in Section 2.1 for the grab sample analysis. Effect size, which is the expected or meaningful change to be detected, was estimated based on the variability in infaunal community diversity from benthic grab samples. Diversity (Shannon- Wiener) was used as the effect size indicator because it is a relatively sensitive index based on both abundance and evenness of an infaunal community and it is a measurable feature of the marine environment that is relevant to the integrity and the stability of communities and habitats (McCann 2012). A 25% change in the benthic community diversity index was simulated in the data to calculate effect size and input into G*Power 3.1 (Faul et al. 2009) to determine required sample sizes. A 25% change in community indices has been used before in benthic monitoring studies and has been found to be detected with power close to 80% for most benthic taxa (Lambert et al. 2017).

Results from (total number of sample stations required for the analysis) were applied within the survey design (Section 2.3) to illustrate the number of replicate grab samples, sample stations, and transects needed to detect a 25% percent change in community diversity indices at significance levels of 0.05 and power of 0.80 (Table 2-1). These same stations were then used for the underwater imagery and bathymetry monitoring analyses (Section 3.0).

Table 2-1 Sample Sizes Required to Detect 25% Percent Changes in Benthic Community Diversity, Based on *A Priori* Power Analysis Results of Vineyard Wind 1

Needed to detect:	25% change in diversity
Total sample size (G*Power output)	73
# sample stations per transect	7 (4 impact, 3 control)
# transects per habitat zone (73 stations / 7 stations per transect / 6 habitat zones rounded to nearest integer)	2
# stations per habitat zone (7 stations x 2 transects)	14
Total # grab samples for each survey, across all 6 habitat zones (6 habitat zones x 14 stations x 3 replicate samples)	252

2.3 Survey Design

The Proponent will apply a combination BAG/BACI sampling design to incorporate elements of each sampling strategy and allow for a more rigorous assessment of impacts and recovery. Following a BAG/BACI design, sample stations will be placed at regular distances from the impact source (either WTG scour protection or offshore export cable) along impact monitoring transects, while sample stations placed > 1 km outside impact monitoring areas will serve as controls. Based on the sediment dispersion modeling report (see Appendix III-A of COP Vol III), the maximum distance of appreciable settlement of suspended sediments from cable installation is 150 m. Thus, designating control stations >1 km outside of the Lease Area is considered well outside of the expected area of benthic impacts.

Using a combination BAG/BACI design, sampling would occur at two randomly placed benthic monitoring transects within the one habitat zone of the Lease Area and within each of the five habitat zones in the OECC along the easternmost New England Wind Phase 1 cable. The number of transects is based on the results of the power analysis, which suggests that two transects in each habitat zone (12 transects total), each with seven sampling stations, are required to detect a 25% difference in benthic community diversity pre- and post-construction (i.e., before and after impact), between impact and control monitoring areas, and between stations at different distances from the impact source, with sufficient statistical power.

The OECC transects will be placed along the easternmost New England Wind Phase 1 cable in order to avoid confounding results from installation of other New England Wind offshore export cables, which will be installed to the west of the easternmost New England Wind Phase 1 cable (Figure 2-1). At each site, video and multibeam echo sounder (i.e., bathymetry) surveys will be performed in a “t” pattern, with the long axis oriented perpendicular to the easternmost offshore export cable and the short axis oriented parallel to the cable alignment. The transects will extend 150 meters (m) (492 feet [ft])[5] to the east and 50 m (164 ft) to the north, west, and south. The length of the longest (150 m) transect was chosen because it samples the entire expected gradient of impacts based on the maximum predicted distance of ≥1 millimeter (mm) sediment deposition from export cable installation according to the sediment dispersion modeling (see Appendix III-A of COP Vol III). Four grab stations, with three replicate grab samples collected at each station, will be sampled along a gradient extending east from the impact source (either scour protection or offshore export cable). Stations will be positioned within the impact area immediately adjacent to the impact source (0 m) and at distances of 50 m (164 ft), 100 m (328 ft), and 150 m (492 ft), with three replicate benthic grab samples collected at each sample station (Figure 2-1 and Figure 2-2). Including three replicated grab samples at each station increases understanding of small-scale variability, improves the precision of the mean indices analyzed for each sample station in the ANOVA, and increases capture of organisms that are rare or patchily distributed while also reducing the effects of random variation at the station (Gotelli and Ellison 2004; Noble-James et al. 2017). Replicated grab samples will be processed separately to analyze variation within the station and then averaged for each sample station.

Underwater video imagery will be captured along 300 m (984 ft) of each impact monitoring transect, both perpendicular and parallel to the cable or WTG foundation (Figure 2-1 and Figure 2-2). Three control stations, each comprising 100 m (328 ft) of video footage and one benthic grab sample station (and three replicate grabs), will be placed ≥ 1 km from the nearest impact grab station along the OECC. A minimum of 1 km will be maintained between control and impact grab stations where geography allows within the bounds of a habitat zone, based on the distance at which differences in community indices observed in a gradient sampling design around an oil platform leveled off (Ellis and Schneider 1997). For the Lease Area, control stations will be placed outside of the Lease Area boundary in the control survey area designated in the Fisheries Monitoring Plan (Figure 2-3). Control areas will be selected to have similar physical and environmental characteristics to detect natural environmental shifts that may occur unrelated to New England Wind activities.

This sampling design of four sample stations along each of 12 impact monitoring transects (two transects in each of the six habitat types), with three replicate grab samples per station, yields 144 grab samples in monitoring areas. In the control areas, there will be an additional 108 grab samples (three control stations a distance away from each transect, with three replicate grab samples per station, for 12 impact monitoring areas), for a total of 252 grab samples for each annual survey (144 grabs in impact monitoring areas and 108 grabs in control areas). This configuration is designed to document the benthic variability in and around the zone of potential disturbance from cables or scour protection installation and allow for comparison between samples at different distances from the impact source. Additionally, 3,600 m (11,811 ft) of video survey will be collected along the impact monitoring transects (300 m of video per

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5 In the unlikely event the South Coast Variant is used for Phase 2, Sampling transects will extend up to 250 m (820 ft) from the direct impact location (i.e., the cable trench). This distance is slightly longer than used for the OECC and is based on sediment transport modeling completed for the South Coast Variant, which predicted deposition above 1 mm thickness would occur at a maximum distance of 200 m (656 ft) of the route centerline.

each of the 12 impact monitoring transects) and 3,600 m (11,811 ft) of video survey will be collected along the control area transects (300 m [984 ft] of video per the 12 control area monitoring transects), for a total of 7,200 m (23,622 ft) of video collected per survey.

Collected grab sample and video data will be used to monitor the following parameters (as recommended by McCann 2012):

- Changes in the infaunal density, diversity, and community structure (benthic grabs);
- Changes in the infaunal biomass (benthic grabs);
- Changes to the seafloor morphology and structure (multi-beam echo sounder);
- Changes in median grain size (benthic grab and underwater video); and
- Changes in abundance, diversity, and cover of epibenthic species, with focus on important species and those colonizing hard structures (i.e., reef effects; underwater video).

A schematic of the infauna benthic grab sampling layout and the epifauna/benthic habitat video survey layout are shown for the OECC and the Lease Area (Figure 2-1 and 2-2, respectively). The expected potential impact area covers approximately 150 m out from the base of the WTG scour protection or offshore export cable. Each red square represents a sample station at which three replicate benthic grab samples will be obtained. Control stations will be placed 1 km away for all OECC transects, with Lease Area control stations placed outside the Lease Area boundary within the nearest fisheries monitoring plan control area (Figures 2-1 and 2-3). There will be three sets of one grab sample and 100 meters of video collected at sample locations around each control station.

For the video survey layout, one transect extends 150 m out from the offshore export cable trench (Figure 2-1) or base of the WTG scour protection (Figure 2-2) over the same locations where grab sampling occurs. Shorter transects (50 m) will radiate from the WTG and along/ across the offshore export cable to capture a more complete picture of the area of disturbance.

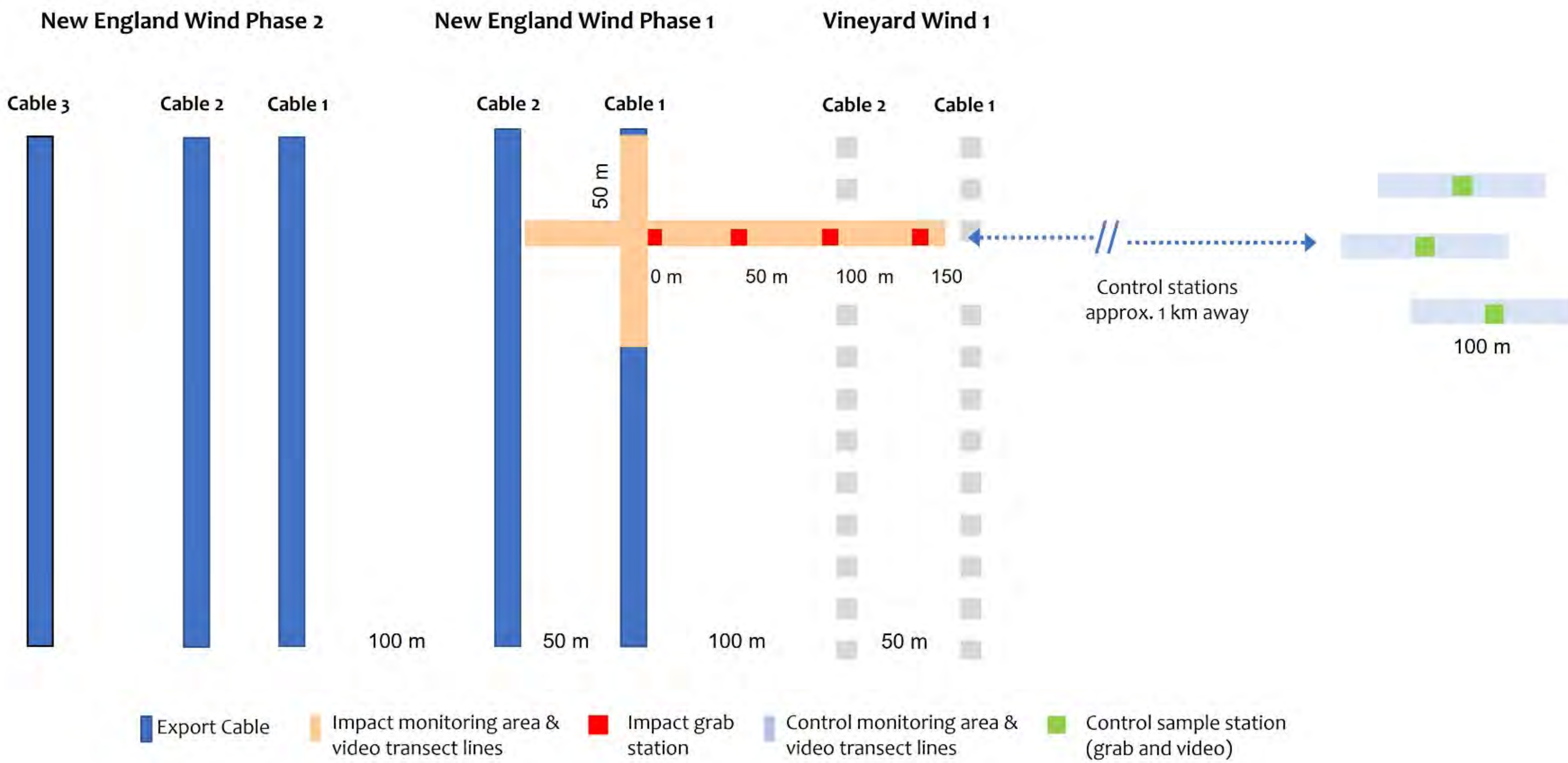

Figure 2-1 Proposed Benthic Habitat Monitoring Sampling along the OECC

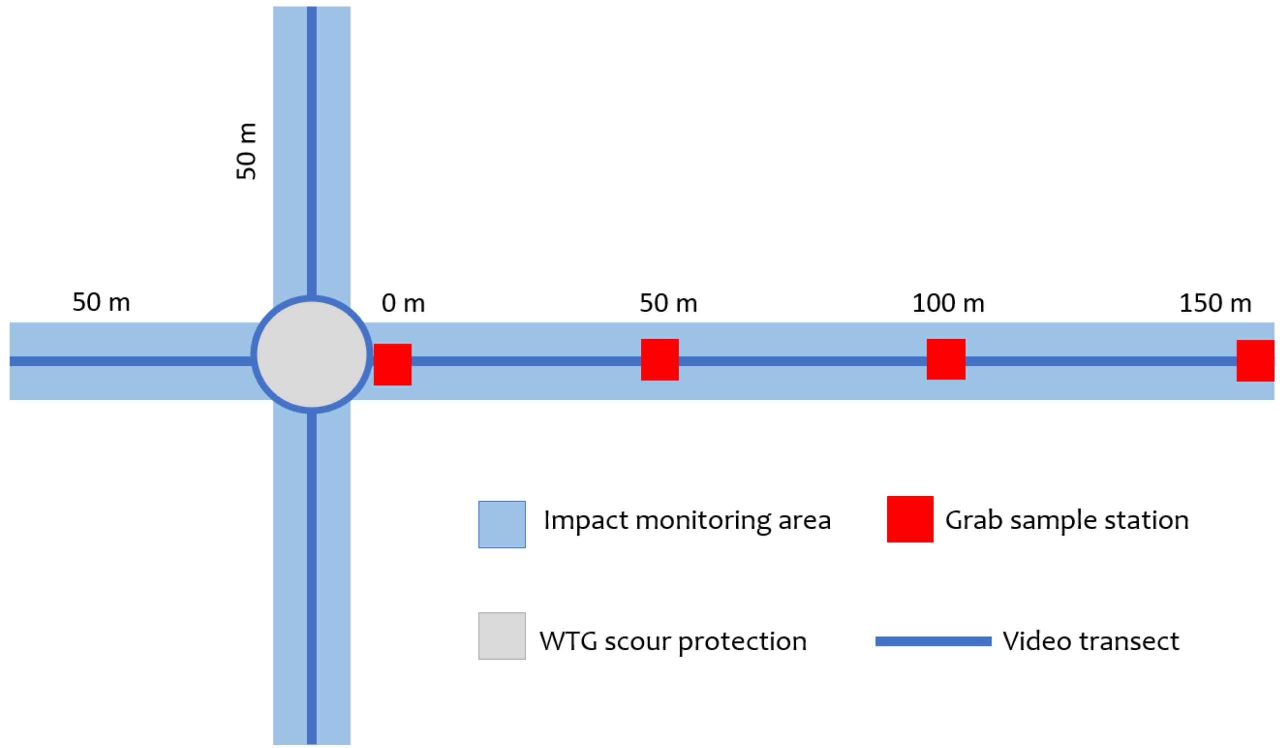

Figure 2-2 Proposed Benthic Habitat Monitoring Sampling within the Lease Area (Note: control sites not shown)

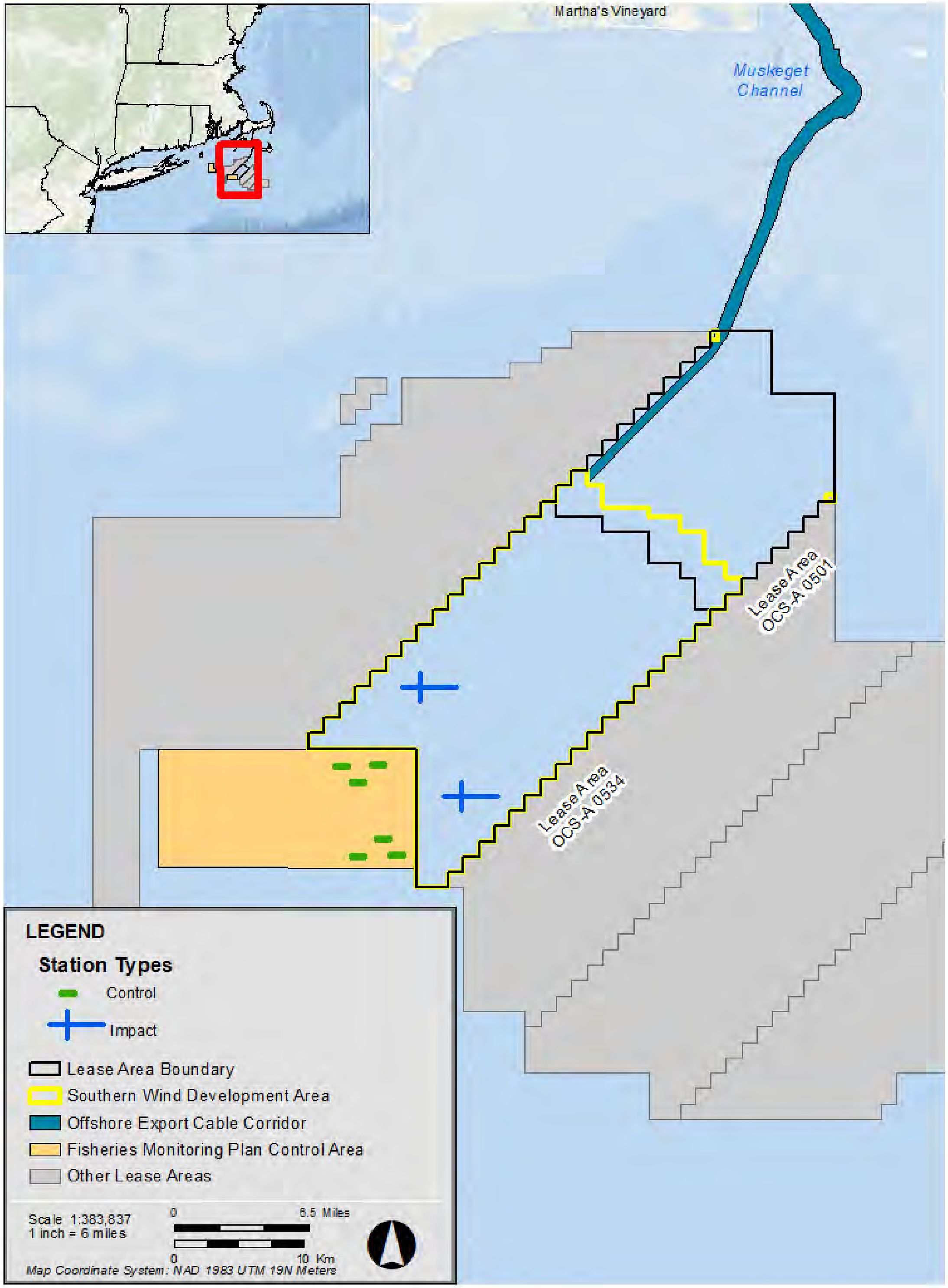

Figure 2-3 New England Wind Lease Area with representative control and impact monitoring stations shown.

3.0 Monitoring Equipment and Methods

Pre- and post-construction monitoring surveys will be conducted using the same gear, methods, and monitoring areas to maximize comparability and determine differences in survey results before and after construction. Table 3-1 summarizes the methods that have been integrated into the monitoring plan. Further details on these techniques are discussed in the following sections. It is important to note that the exact monitoring locations and number of samples collected may vary slightly depending on the substrate and oceanographic conditions in each of the monitoring and control areas.

Table 3-1 Summary of Methods Proposed for the Benthic Habitat Monitoring Plan

Monitoring System	Focus Area	Purpose
Grab sampler	Surface and subsurface; epifaunal, infaunal organisms, and structures, grain size	Identify surface and subsurface organisms and features. Provides specific organism-level evidence concerning habitat recovery.
Underwater video	Surface; benthic habitats, epifaunal organisms	Identify gross habitat changes pre- and post- as well as during the recovery process. Documents epifaunal activity for comparison between mappings.
Multibeam bathymetry	Surface; seafloor morphology	Pre- and post- changes in bottom morphology and micro-relief, changes in the seabed scar over time. Data can show the detailed topographic differences in the seafloor between successive mappings.

3.1 Benthic Grab Sampling and Analysis

Following BOEM guidelines, an industry standard benthic/sediment grab sampler such as a 0.04 m^2 Ted Young-modified Van Veen grab will be used to retrieve sediments from the seabed for analysis (BOEM 2019). The selected equipment will ultimately depend on the type of sediment and seabed surface at each site wherein a Power, Hamon, Day or Ponar grab samplers can be used as alternative sediment grab sampling devices. These sampling devices will recover material from the seabed by using lever arms to force two halves of a metal bucket closed after the unit has been lowered to the bottom. Material from the upper 10 to 20 centimeters (cm) of the seabed is then raised to the deck of the vessel for photographs and subsampling.

Two or more subsamples of the same specified volume (to the extent possible) will be removed from the grab for sieving and lab analysis. Subsample volumes will be documented in a field logsheet along with other sediment and benthic descriptors. This information supports estimates of species abundance values and ensures all data and results are comparable.

After the grab samples are collected, they will be processed onboard, passed through a 0.5-mm sieve and fixed in 10% neutral buffered formalin. Rose bengal can be added in the field or in the lab. Once delivered to the lab and prior to being sorted, the sample material will be emptied in its entirety into a 0.5-mm mesh sieve for a second time. Tap water will then be gently run over the sieve to rinse away the formalin fixative and any additional fine sediment that is not removed during the initial sieving process. Rinsed samples will be preserved in 70% ethanol. Each sample will then be sorted to remove benthic organisms from residual debris. Samples will be sorted under a high-power dissecting microscope (up to 90X magnification). All sorted organisms will then be identified by a qualified taxonomist to the lowest practicable taxonomic level using a dissecting microscope with magnification up to 90X and readily available taxonomic keys. Identification of slide-mounted organisms will be conducted under a compound microscope with magnification up to 1,000X. Enumerations of macroinvertebrates will be made and species abundances from each sample will be standardized to number of individuals per square meter, considering the sampling equipment dimensions and sub-sampling effort. The wet weight biomass of the organisms in each sample will be collected.

To describe existing conditions and compare pre- and post- construction conditions, measures of benthic macrofaunal diversity, abundance, and community composition will be made for each sampling site and characterized under the CMECS standard (FGDC 2012) following NMFS recommendations (NMFS 2021). Changes in the benthic community will be explored by converting grab sample data into Shannon-Weiner diversity values and analyzed using a three-factor ANOVA. Additional visualization will be provided through multidimensional scaling (MDS) plots of Bray-Curtis dissimilarity to compare species composition between sites. Analysis of similarities (ANOSIM) and analysis of similarity percentages (SIMPER) can provide more quantitative assessment of multidimensional similarity of benthic communities between groupings (e.g., control vs impact sites). ANOSIM tests will be run using community indices and biomass as a metric. Permutational ANOVAs (PERMANOVAs) may also be applied to answer specific questions about multivariate responses. Other statistical methods such as Generalized Additive Models (GAM) or Generalized Additive Mixed Models (GAMM) may be explored.

3.2 High Resolution Multibeam Bathymetry and Video Survey

The Proponent will conduct high-resolution multibeam bathymetry and video surveillance within the designated monitoring and control areas. For all underwater imagery operations, a vessel equipped with dynamic positioning will hold position as close as safely possible to WTG foundations. An ultra-short baseline system will be used to record the position of a beacon attached to the sled or ROV and overlaid onto the video feed. For video transects, the transects will run from the scour protection around the foundation out to the specified distance. The camera will be lowered to about 1 m above the bottom and the vessel will maintain speeds at or below 1 knot for the duration of the transect. Transects in the OECC will be run with a 10 m lead in and lead out distance both parallel and perpendicular to the installed cable. Video surveys will be conducted using a towed camera sled or ROV and an additional dedicated still image camera with a minimum resolution of 10 megapixels per NMFS guidelines (NMFS 2021).

Along the same video transects, seabed surface maps to centimeter level resolution will be created using a multibeam depth sounding system to allow detailed comparisons of bottom morphology and detection of minute changes between successive mappings.

Pre- and post-construction video and digital terrain maps will be analyzed and compared to assess seabed morphology within the monitoring sites. The entire underwater video will be viewed to count larger epibenthic organisms, while high quality still frames will be randomly selected for analysis of smaller organisms and the percent cover of different substrate types (Sheehan et al. 2010). The following observations will be made:

- Locations, presence, and general characterization of the substrate (three-dimensional surface features and regularity) in accordance with the CMECS standards (FGDC 2012);
- Quantification and general characterization of epibenthic invertebrates (e.g., lobster and crabs), including attached epibenthos (e.g., anemones, sea pens, sponges, etc.);
- Quantification and general characteristics of shellfish (e.g., clams, scallops);
- Changes in invasive species coverage;
- Evidence of burrowing activity; and
- Presence and general characterization of benthic and nektonic habitats observed.

Results will be documented in the form of high-resolution digital terrain model (DTM) surfaces of the seabed created from the multi-beam and difference maps between mappings. Processing and interpretation of the MBES results will help identify and delineate seafloor morphology, substrate types, and benthic features (“bedforms”). Backscatter intensity (reflectivity), measured in decibels, will inform on seafloor types with low decibels correlated to fine-grained, soft bottom sediments and high decibels correlated to coarse, hard bottom sediments.

All videos will be reviewed to record presence and density (abundance per transect length) of benthic organisms and other notable features. Still images will be recorded at discrete intervals for quantifying seafloor coverage (substrate, organisms, etc.). The results of the video survey will provide qualitative information about potential changes in communities and habitat in the impact area. The data will be explored to answer the stated research questions to the extent possible and will include statistical assessment of hypotheses with appropriate tests (ANOVA, GAMs, etc.). Findings will be summarized in a technical report with a supporting series of charts/figures for each monitoring program documenting results from all survey methodologies performed and will include comparisons with previous monitoring surveys, other related survey data, and relevant desktop studies.

4.0 Program Logistics

4.1 Schedule

Based upon the preliminary construction schedule for New England Wind Phase 1 and Phase 2, it is currently expected that benthic habitat monitoring sampling would occur in 2026 (pre- construction), 2027 or 2028 (Year 1), 2029 or 2030 (Year 3), and possibly 2031 or 2032 (Year 5). Note that schedules could shift based on the actual construction schedule. Since New England Wind shares an OECC with Vineyard Wind 1, pre-construction sampling in 2026 allows for three years between Vineyard Wind 1 offshore export cable installation (occurring in 2022-2023) and pre-construction sampling, eliminating interruption and minimizing potential impacts by Vineyard Wind 1 cable installation in the same OECC.

Pre-construction baseline surveys will be conducted in all monitoring and control areas prior to construction activities to identify and document the natural background conditions at each site, with increased attention on any hard bottom habitats that are in the direct path of the planned cable. February through April has been noted as an ideal time to survey the benthos as it is before the main recruitment period for pelagic larvae (Judd 2011); however, this timing is extremely difficult for offshore work, and several studies have noted a continuity in benthic community indices between seasons in nearby Block Island Sound (see studies cited within HDR 2017). Thus, monitoring surveys may occur at the most logical time based on staggered project construction schedules, with the intent of conducting them at roughly the same time from year to year.

Post-construction monitoring surveys are planned to occur, as soon as feasible, after construction activities for Phase 1 have been completed. This schedule is put forth to capture short-term recolonization, and to repeat for multiple years after impact to establish whether benthic community metrics and habitats have recovered to states similar to what they were before impact. These surveys will assess recovery progression of the various habitats that overlap with the Development Area, species composition, and benthic habitat quality at monitoring sites. Monitoring will occur in years 1, 3, and, if necessary, year 5 post-construction. If recovery is not observed within three years for the portion of the OECC located in state waters, the Proponent and the Massachusetts Department of Environmental Protection (MassDEP) will confer regarding potential additional monitoring. Should additional monitoring be required, the sample sizes for the macrofaunal community analysis would be based on a power analysis of existing data, and the recovery thresholds would vary based on the statistical tests utilized.

4.2 Benthic Habitat Recovery Assessment

The presence of WTG foundations, the associated scour protection, and cable protection may result in both negative and/or beneficial effects on benthic community composition and sediment profiles. Species and life stages that inhabit hard bottom habitats may see positive effects as a higher diversity of organisms will be attracted to habitat that had previously been soft bottom. Habitat conversion is expected to cause a shift in species assemblages towards those found in rocky reef/rock outcrop habitat; this is known as the “reef effect” (Wilhelmsson et al. 2006; Reubens et al. 2013). Infaunal and epifaunal species that are associated with soft substrate may experience negative effects through habitat displacement, competition, or attraction of larger concentrations of predatory species (Ambrose and Anderson 1990; Schröder et al. 2006). Maar et al. (2009) observed a decreased macrofaunal biomass at a local scale around a turbine foundation in Denmark and related this to the enhanced abundance and, therefore, predatory pressure of shore crabs.

Based on data collected from successive post-construction surveys, benthic habitat recovery will be evaluated using on the following indicators:

1. Benthic Grab Sampling and Underwater Imagery

    - Species composition, richness, diversity, and biomass
    - Grain size distribution
    - Percent cover of epifauna and substate types

2. High Resolution Multibeam Echosounder

    - Sediment disturbance and recovery

Table 4-1 describes the analytical parameters to assess recovery and Table 4-2 describes the analytical approach to evaluate the degree of benthic community recovery, and thus determine the need for further monitoring. The decision for future monitoring and mitigation strategies will be based on discussions between the Proponent and an interagency review committee.

Table 4-1 Benthic Habitat Recovery Parameters

Method	Recovery Target
Numerical Classification: Cluster Analysis, Multidimensional Scaling (MDS) and Analysis of Similarities (ANOSIM)	Post-construction: Stations (50 m, 100 m, 150 m and 1,000 m)* should exhibit the same level** of similarity in community metrics (diversity, richness, biomass, etc.) to control stations and to the same stations pre-construction. No significant difference is found between ANOSIM results.
Analysis of Variance (ANOVA or non-parametric equivalent), Pair T-tests of means	No significant** changes in total abundance or Shannon-Weiner diversity pre- and post- construction within transect points 50 m, 100 m, 150 m, and 1000 m from scour protection or cable installation area
Sediment Classification	No significant** changes in median grain size and CMECS classification pre- and post- construction within transect points 50 m, 100 m, 150 m, and 1,000 m from scour protection

* 0 m from scour protection is likely to exhibit spillover effects of novel hard bottom colonization and therefore is likely to experience reef effects. Thus, should be exempted from recovery but still compared to see if impacts of introduced hard bottom substrate provides negative or positive changes in abundance, diversity, and species richness.

* * Levels of significance will be determined based on discussions with agencies after pre-construction monitoring data has been evaluated.

Table 4-2 Benthic Community Recovery Evaluation Criteria

Analytical Tool	Recovered	Improving	Not Recovered
Numerical Classification (similarity analysis) & ANOSIM: Benthic Community Structure (abundance & species composition)	Post-construction impact stations cluster with pre-construction impact stations and/or post-construction control station; no significant* differences (ANOSIM). Instances where significant difference is attributed to a post-construction increase in biomass will be considered acceptable.	Post-Construction impact stations do not cluster with pre-construction stations; significant differences between pre- and post-construction but not between post-construction and control stations (ANOSIM)	Post-Construction impact stations do not cluster with pre-construction stations nor do the pre- & post-construction stations cluster with the control stations; significant differences (ANOSIM)
ANOVA - Total Abundance - Species Richness - Diversity - Median grain size - Indicator Species (Paired T-tests or Kruskal-Wallace methods)	No significant interaction term OR impact stations exhibit the same pattern as control stations. Instances where there is a significant interaction due to a post-construction increase in community indices are considered acceptable.	Significant interaction term at the impact stations, but a similar trend is detected at the control stations	Significant interaction term with dissimilar trends at the impact and control stations OR Significant differences between means for impact and control areas (the entire zones)
Sediment Size Classes and CMECS Classification (Paired T-tests or one way ANOVA methods)	No significant differences in median grain sizes of impact stations and/or pre-construction/control stations; No differences in CMECS classifications (ex. Medium Sand, Sandy Muddy Gravel) or percent cover of epifaunal organisms between impact stations and pre-construction and/or control	Significant differences in median grain size or percent cover of epifauna at of impact stations and pre-construction stations but similar trend to control; Impact stations and control stations are within the same Major Classification of CMECS designation (Sand, Gravel Mixes, Gravelly Substrate, Gravel, Silt, Shell) and percent cover of epifauna	Significant differences in median grain size and percent cover of epifauna with dissimilar trends at the impact and control stations; Impact stations and controls are no longer within the same Major CMECS Classifications

* Levels of significance will be determined based on discussions with agencies after pre-construction monitoring data has been evaluated.

4.3 Reporting and Data Sharing Plan

Program updates will be shared with the appropriate federal and state agencies, throughout the monitoring study, in the form of processed reports and data made available for regional use. Monitoring reports will include:

- Methods employed to conduct the monitoring study;
- Summary of monitoring results;
- Analysis and summary of habitat recovery; and
- A list of planned monitoring activities to be conducted at the next survey interval.

All raw data will be stored initially in secured network storage in multiple locations and kept for the life of New England Wind. A written report containing detailed methodology, environment conditions, operational parameters, summarized data, analysis, and interpretation will be prepared after completion of each survey. Reports will include analysis of data within and between years. These reports will be publicly available online. Data and metadata dissemination will occur in accordance with best practices, as tools and methods for offshore wind data sharing are currently under development by various stakeholder groups.

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