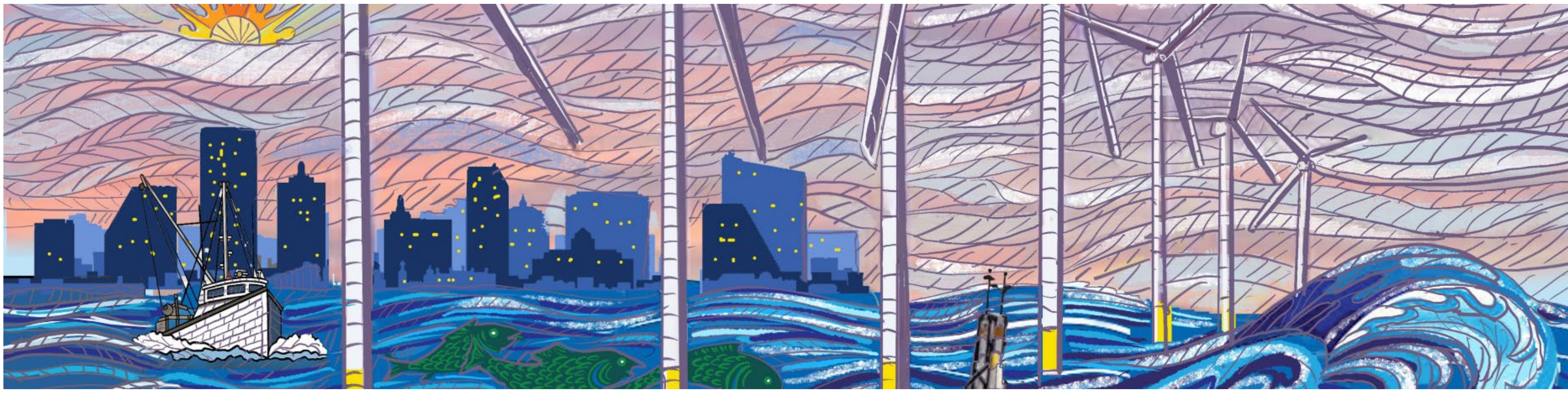

Appendix II-H

Benthic Monitoring Plan

May 2024

MAKING COMPLEX EASY

ATLANTIC SHORES BENTHIC MONITORING PLAN

December 15, 2021

rpsgroup.com

Version	Authored by	Reviewed by	Approved by	Review date
Draft 1	AM,SB,JZ	AM,JR	AM	January 13, 2021
Draft 2	AM,SB,JZ,SD,GD	AM,JZ	AM	November 23, 2021
Draft 3	AM,SB,JZ,SD,GD	AM	AM	December 15, 2021

The purpose of RPS' services will be to inform ASOW and EDR of future potential actions to abide by BOEM guidelines. Information provided by RPS may only be relied upon in the context of RPS' scope of works. ASOW and EDR will necessarily inform itself and make independent decisions, based on its own business needs and on key aspects in relation to the project.

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1 INTRODUCTION AND BACKGROUND

Atlantic Shores Offshore Wind, LLC (Atlantic Shores) is a 50/50 joint venture between EDF-RE Offshore Development, LLC (a wholly owned subsidiary of EDF Renewables, Inc. [EDF Renewables]) and Shell New Energies US LLC (Shell). On behalf of Atlantic Shores, RPS prepared this benthic monitoring plan in support of the submission of the Construction and Operations Plan (COP) to the Bureau of Ocean Energy Management (BOEM) for the development of two offshore wind energy generation projects within the southern portion of Lease Area OCS-A 0499 (the Lease Area).

Atlantic Shores' Lease Area is located on the OCS within the New Jersey Wind Energy Area (NJWEA), which was identified by BOEM as suitable for offshore renewable energy development through a multi-year, public environmental review process. The Projects will be located in an approximately 102,124-acre (413.3-square kilometer [km^2]) Wind Turbine Area (WTA) located in the southern portion of the Lease Area. Project 1 is located in the western 54,175 acres (219.2 km^2) of the WTA, and Project 2 is located in the eastern 31,847 acres (128.9 km^2) of the WTA, with a 16,102-acre (65.2-km^2) Overlap Area that could be used by either Project 1 or Project 2.

In addition to the WTA, the Projects will include two offshore Export Cable Corridors (ECCs) within federal and New Jersey state waters as well as two onshore interconnection cable routes, two onshore substation and/or converter station sites, and a proposed operations and maintenance (O&M) facility in New Jersey.

Atlantic Shores will implement a benthic monitoring plan to measure and assess the disturbance and recovery of marine benthic habitats and communities as a result of construction and operation of Atlantic Shores Offshore Project Area components. The Offshore Project Area includes the WTA and the ECCs. The WTA includes Project 1, Project 2, and the Overlap Area. Offshore Project Area components include the wind turbine generators (WTGs), offshore substations, offshore cable systems, and their associated parts in the WTA. This draft plan will be implemented in support of both Projects. Individual plans for Project 1 and Project 2 will be developed for BOEM review and acceptance prior to construction with each Project's Facility Design Report and/or Fabrication and Installation Report. The monitoring program, focused on seafloor habitat and benthic communities, will be undertaken to measure potential impacts and the recovery of these resources compared to reference areas outside of the areas potentially impacted by construction and operation activities. This monitoring program was developed based on best practices available in scientific literature and employed analyses of preliminary benthic survey information to determine the appropriate sample size for sufficient statistical power (i.e., enough samples to detect significant changes if they were to occur).

Benthic habitat/community monitoring is an active area of research with a wide variety of methods and indices used to detect changes in the environment. Several comprehensive reviews of the topic were used to inform the design of this monitoring plan, including:

- A Bureau of Ocean and Energy Management (BOEM)-funded review of existing monitoring protocols for effects of offshore renewable energy (McCann 2012);
- A BOEM-funded review of site assessment and characterization methods for offshore wind in both the US and Europe (Rein et al. 2013);
- A marine benthic habitat monitoring guidance report developed by the Joint Nature Conservation Committee of the UK (Noble-James et al. 2017);
- A draft guidance document for survey and monitoring of renewable energy deployments on behalf of Scottish Natural Heritage and Marine Scotland (Saunders et al. 2011);
- BOEM's Guidelines for Providing Benthic Habitat Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf (2019); and
- National Marine Fisheries Service (NMFS) Recommendations for Mapping Fish Habitat (2021).

In addition to guidance documents, the design of studies and resulting detection of effects by existing monitoring programs were evaluated for best practices. Analyses of existing programs reviewed include those found in:

- Research papers describing the sampling design and effort needed to detect environmental change based on benthic monitoring case studies (Daan et al. 2009; Franco et al. 2015) and benthic quality indicators (Borja et al. 2000; Borja and Dauer 2008; Van Hoey et al. 2007; Warwick et al. 2010);
- Summaries of environmental impacts of offshore wind farms in the Belgian part of the North Sea (Degraer et al. 2013; Degraer et al. 2017);
- A BOEM-funded study of the benthic monitoring during construction and operation of the Block Island Wind Farm offshore of Rhode Island (HDR, 2017); and
- A comparison of Before-After Gradient (BAG) and Before-After-Control-Impact (BACI) sampling designs (Methratta, 2020).

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 BACI design, or a "beyond BACI" design that incorporates multiple control sites. In past benthic monitoring programs, there has not generally been much agreement on how many control sites should be used, or when or for how long data should be collected (McCann, 2012). It is generally agreed that control sites should 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 encompass all unique habitats and other environmental gradients, such as depth and currents. A consensus in the literature is that 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 (McMann, 2012; Noble-James et al., 2017).

Recent review of BACI studies on fishes as part of offshore wind monitoring noted that BACI studies tended to detect too much variability to find 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 BAG sampling design allows for comparison of metrics over both space and time and can assess the spatial extent of specific impacts. Gradient survey designs have been shown to be more powerful in detecting changes due to disturbances than BACI and simple random block designs (Bailey et al. 2014; Ellis and Schneider, 1997). The BAG design also eliminates the often-difficult task of identifying appropriate control sites. Therefore, BAG designs were used for the designs of surveys described in this Benthic Monitoring Plan.

To quantitatively compare the ecological component of multiple sample stations, various community indices can be calculated. There are dozens of different benthic community indices in use (Warwick et al. 2010), including the AMBI (AZTI's Marine Biotic Index), an index designed to represent the response of European soft-bottom benthic assemblages to changes in environmental quality (Borja et al. 2000), and the Benthic Ecosystem Quality Index (BEQI), which is used in Belgian offshore wind impact monitoring and incorporates the AMBI and further classifies outcomes on a scale between 0 and 1 to allow for rapid assessments of changes in status (bad, poor, moderate, good, high; Coates et al. 2013). No such comprehensive index has yet been developed for benthic communities in US waters. Thus, this monitoring plan focuses on detecting changes in the Shannon-Weiner Diversity Index (symbolized by H') applied to the benthic macroinvertebrate community. This index considers taxonomic richness and the proportion of the community comprised of each unique taxa and is a repeatable measure that is easily obtained from grab sample taxonomic analysis.

To quantitatively compare habitat, a structured, repeatable classification system must be applied. The BOEM (2019) benthic habitat monitoring guidelines suggest benthic habitat data should be classified according to the Coastal and Marine Ecological Classification Standard (CMECS) to the lowest possible taxonomic unit. The CMECS standard is a hierarchical system of classifying ecological units in the marine environment (FGDC, 2012). Benthic species abundance and diversity are combined with percent cover data for the abiotic environment within which they tend to occur to identify substrate and biological components of the benthos that can be monitored for changes post-construction.

In 2021, the NMFS published an updated set of mapping recommendations that modified the original CMECS categories to highlight those most relevant to identifying complex habitat that could be potentially important to fish species as part of Essential Fish Habitat (EFH). For this monitoring plan, the benthic habitats and communities surveyed will be classified following the NMFS-modified CMECS standard (NMFS 2021) which identifies coarse sediment habitats comprised of 5% or more of gravel (grain size > 2 mm) as complex habitat.

The three surveys included in this monitoring plan use benthic grab sampling with associated imagery, towed or ROV video transects of the seafloor, and videos of WTG foundations. These three surveys will focus on indicators to describe potential changes in benthic habitat and recovery of communities post-construction, including benthic macroinvertebrate diversity, CMECS substrate habitat type, and megafauna assemblages of species of interest (i.e., commercial species, invasive species, or ecologically important).

2 ANALYSIS OF EXISTING DATA

Survey and sampling efforts of the Offshore Project Area began in 2019. To date, geological and biological characterization efforts employed a variety of sampling gears, including multibeam echosounder, side scan sonar, transverse gradiometer, subbottom profiler, cultural cores with carbon dating, grab samples, vibracores, Sediment Profile Imaging (SPI) and Plan-View (PV) imagery surveys, underwater video imagery associated with grab samples, and towed underwater video sled transects of the seafloor. The various sampling programs have been conducted across the Offshore Project Area to establish fine-scale resolution of the geophysical properties, habitat composition, and benthic communities (additional details on sampling provided in other portions of the COP). With these data, the Offshore Project Area was categorized into habitat zones based on a modified Folk sediment triangle (Folk, 1954) that correlates with a Coastal and Marine Ecological Classification System (CMECS; FGDC, 2012) substrate type (Figure 1).

To inform the sample size of the grab sample survey, *a priori* power analyses were conducted with simulations based on benthic grab sample data collected in the Offshore Project Area in 2019 and 2020 (see Attachment A). The benthic habitat maps show that sand and gravelly sand made up the overwhelming majority of habitat in the WTA and ECCs. Due to the limited coverage of larger grained habitats and different expected impacts from WTGs and export cables, grab sample data were aggregated into two groups, ECC grabs and WTA grabs, for the power analysis. When conducting a statistical test, power is the probability of correctly rejecting the null hypothesis. A power analysis can estimate the necessary sample size to detect changes in environmental indices at a given power level. It is based on the effect size, statistical test, and chosen levels of power and significance (Antcliffe, 1992). A common power value is 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 threshold is commonly 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).

Effect size, which is the size of the expected or meaningful change to be detected, is expected to vary based on distance from effects (cable or WTG location). For the grab samples, Shannon-Weiner Diversity Index (H') will be the key indicator used to estimate the effect size because it is a relatively sensitive index based on both abundance and evenness of the benthic community. Results from the power analysis (total number of sample stations required for the analysis) were applied within the survey design (Section 3.0) to accurately estimate the number of replicate grab samples, sample stations, and transects needed to detect the selected effect size in the community diversity index at significance levels of 0.05 and power of 0.80. It is also assumed that the power analyses for detecting changes in benthic community diversity will result in enough samples to detect changes in the CMECS classification of the benthic habitat. The video transect survey is a more qualitative study design based on the grab sampling effort and does not have a separate power analysis.

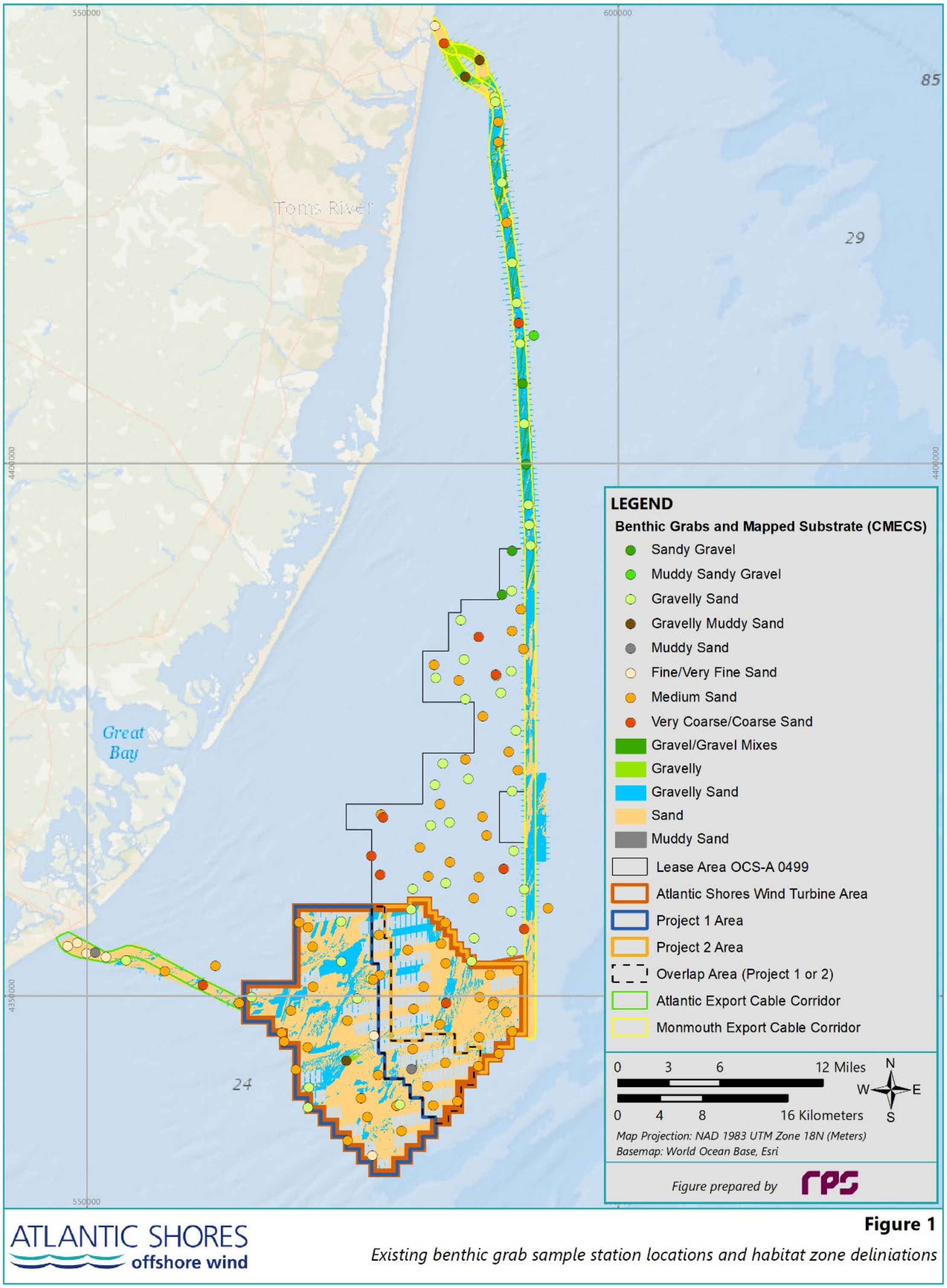

Figure 1

Existing benthic grab sample station locations and habitat zone deliniations

3 METHODOLOGY

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 1 summarizes the methods that have been integrated into the monitoring plan. Further details on these techniques are discussed in the following sections.

Table 1. Summary of sampling methods.

Monitoring System	Focus Area	Purpose
Grab sampler	Seafloor surface and subsurface; benthic macroinvertebrates; and sediment grain size	Identify surface and subsurface organisms and features. Provide specific organism- and grain size-level evidence concerning habitat and community recovery.
Multibeam echosounder	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.
Underwater video	Seafloor surface; benthic habitats; epifaunal/demersal organisms; WTG foundations	Identify gross habitat changes pre- and post-construction as well as during the recovery process. Documents epifaunal abundance/diversity for comparison. Post-construction survey of biofouling communities on WTG foundations.

3.1 Grab Samples

3.1.1 Objectives, Questions, and Hypotheses

The objectives of the grab sample surveys are to investigate the spatial and temporal changes of the benthic macroinvertebrate community and benthic habitat types along a distance gradient from construction-related impacts at WTGs and export cables. The specific research questions driving the study are:

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

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

H_{o1}: The diversity of benthic macroinvertebrates before and after construction does not depend on the distance from effects (i.e., WTGs or export cables).

H_{o2}: The benthic habitat before and after construction does not depend on the distance from effects (i.e., WTGs or export cables).

3.1.2 Survey Design

Based on the results of the power analysis (Section 2 and Attachment A), monitoring a total of 60 stations in the WTA and 66 stations spread across the constructed ECC(s) with triplicate grab samples taken at each station per year is expected to be able to detect a 20% overall difference in benthic macroinvertebrate community diversity pre- and post-construction with 80% power. Classifications of the benthic habitat to CMECS substrate categories based on grain size will also be analyzed for changes along the sampling gradient at each site. The 66 sample stations in the ECC(s) can be distributed at monitoring sites within a single ECC or across both ECCs depending on the final project construction design because the grab sample data from both ECCs were combined during the power analysis. Similarly, the 60 stations in the WTA can be concentrated at monitoring sites within the Project 1 Area, the Project 2 Area, or split between both because grab sample data from both Projects were combined during the power analysis. Individual plans for Project 1 and Project 2 will be developed for BOEM review and acceptance prior to construction with each Project's Facility Design Report and/or Fabrication and Installation Report. The timing of when portions of each project will be constructed may impact where stations can be placed to avoid interference from later construction efforts on existing monitoring sites.

Locations for the impact monitoring sites will be chosen before the first sampling event based on anticipated construction layout and should remain the same throughout the remainder of monitoring unless unforeseen factors interfere with sample locations. The ECC sites will be randomly selected with monitoring transects oriented perpendicular to the direction of the cable. Both the WTG locations and orientation (0-360 degrees) will be randomly selected for the WTA monitoring transects.

A BAG sampling design will be applied by spacing grab sample stations at logarithmic, incremental distances from the impact source (i.e., either the edge of WTG scour protection or export cable) along impact monitoring transects at each site. These distances will be 0 m[1], 15 m, 50 m, 150 m, 400 m, and 1,000 m as shown in Figure 2. Because grab stations are organized in a series of increasing distance from the potential impact source (i.e., in a monitoring transect), detecting a 20% overall difference in benthic diversity refers to the mean change along the whole transect, with greater changes occurring nearer the impact source and little to no change at farther stations.

The farthest grab sample stations are expected to extend well past potential near-field impacts from both WTG and export cable installation. Based on sediment transport modeling, the maximum predicted distance of ≥ 1 mm deposition from the route centerline of export cable installation was 200 m for the Atlantic ECC and 50 m for the Monmouth ECC when not including the Horizontal Directional Drilling pit excavation that would only occur nearshore at the end of the ECC (see Appendix II-J3 of the COP). The BAG sampling design allows for comparison of metrics over both space and time and can assess the spatial extent of specific impacts. Gradient survey designs have been shown to be more powerful in detecting changes due to disturbances than BACI and simple random block designs (Bailey et al. 2014, Ellis and Schneider, 1997). The BAG design also allows for some expected variation in the actual distance sampled from impacts.

Each monitoring transect will contain six stations with three replicate grab samples at each station for a total of 18 grab samples per transect. Ten transects will be located at monitoring sites in the WTA and eleven transects will be distributed at monitoring sites across the ECCs for a total of 378 grabs collected per year (Table 2). Sampling will occur once per year for multiple years as described in Section 4.

[1] Though 0 m is unlikely, the goal of the sampling is to get as close as safely possible to the WTG scour protection or cable.

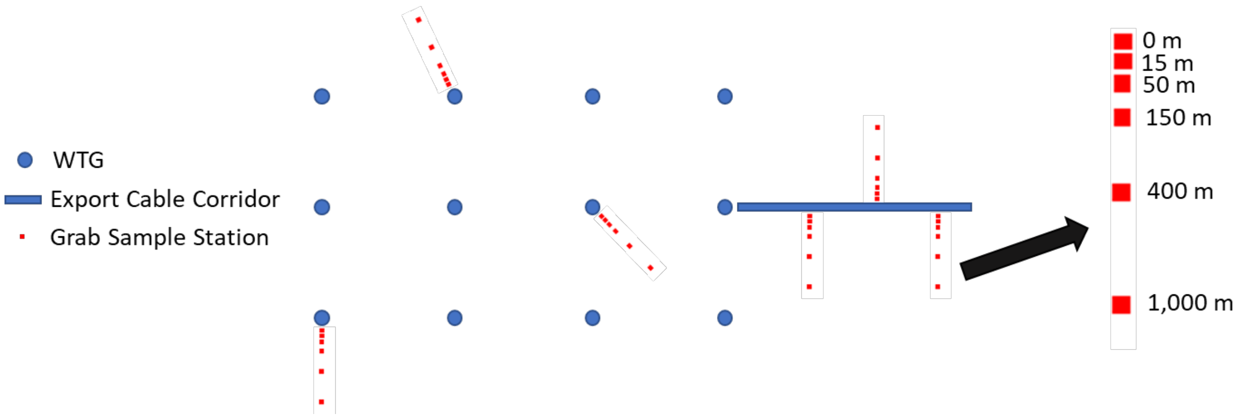

Figure 2. Schematic of benthic grab sampling layout. Each red square represents a station at which three benthic grab samples will be obtained each sampling period.[2]

Table 2. Sample Sizes Required to Detect Modeled Changes in Benthic Community Diversity Based on *a Priori* Power Analyses.

Sample Location	Number in WTA	Number in the ECC or ECCs
Samples per transect (not including replicates) per year	6	6
Samples per transect (Including replicates) per year	18	18
Transects per year	10	11
Samples per survey (including replicates) per year	180	198

3.1.3 Equipment and Operations

An industry standard benthic/sediment grab sampler (e.g., Van Veen, Day, Ponar) will be employed to retrieve sediments from the seabed for analysis. These sampling devices 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.

After the grab samples are collected, they will be processed onboard for standard laboratory sediment grain size analysis and benthic macroinvertebrate identification. Macroinvertebrate samples from a 0.04 m^2 sample area will be passed through a 0.5-millimeter (mm) sieve and fixed in 10% neutral buffered formalin. Rose bengal will 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

[2] Note that this image is not to scale, and WTG sample station locations will be based on the most likely project design at the time of the baseline survey.

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.

Grain size samples will be analyzed with standard methods to produce Wentworth grain size bins for adequate CMECS habitat classification.

3.1.4 Data Analysis

Data analyses for the WTA and ECC samples will be conducted separately due to differences in expected potential impacts from different construction methods. To describe the baseline environment and compare pre- and post- construction conditions, measures of benthic macrofaunal community composition and subsequent calculations of community indices will be made for each sample station along with classification of habitat type according to NMFS-modified CMECS categories (NMFS, 2021; FGDC, 2012).

Changes in the benthic community will be primarily explored using the grab sample data converted into Shannon-Weiner diversity values and analyzed as described in Attachment A with GAMs or GAMMs to assess the null hypothesis (H_{o1}). This approach allows for testing of other covariates such as environmental data (e.g., temperature) for significant relationships. The three replicate grab samples at each station will be analyzed to evaluate within-station variance, then aggregated for hypothesis testing. Other taxonomic parameters (e.g., taxa densities) and ecological parameters (e.g., richness, evenness, diversity, etc.) can be calculated from grab sample data and used to test similar hypotheses with the same approach given that appropriate link functions are used in the model fitting (e.g., negative binomial). The second null hypothesis (H_{o2}) will be assessed by a two-factor ANOVA or a similar approach with adequate post-hoc tests using CMECS habitats derived from grain size as the categorical dependent variable and year and distance from impact as the two factors.

Additional visualization may be provided through multidimensional scaling 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). Permutational ANOVAs (PERMANOVAs) may also be applied to answer specific questions about multivariate responses. Findings will be summarized in a technical report with a supporting series of figures for each monitoring program documenting results from all survey methodologies including comparisons with previous monitoring surveys, other related survey data, and relevant desktop studies.

3.2 Underwater Imagery

3.2.1 Objectives, Questions, and Hypotheses

The objectives of the underwater imagery surveys are to document changes and/or recovery in species occurrence and benthic communities potentially impacted by construction and operation activities around WTG foundations, on WTG foundations/scour protection, and near export cable installations. Numerous studies have documented fish occurring within 200 m of underwater structures with highest densities usually within 50 m of underwater structures, with changes in density often demarcated by a sharp decline with increasing distance from underwater structures (Griffin et al. 2016, Soldal et al., 2002, Lokkeborg et al., 2002, Stanley and Wilson 2000, Valdemarsen, 1979). Additionally, benthic macroinvertebrate distributions in the WTA, especially near WTGs foundations, will likely be influenced by the macroinvertebrate communities that form on WTG foundations as species that settle on turbine foundations have competitive advantages over on-bottom conspecifics (Maar et al., 2009). Finally, visual monitoring of the WTG foundations will allow for the detection of any “stepping stone” effect on invasive species settlement.

The specific research questions driving this study are:

1) Does megafauna species occurrence change from pre- to post- construction around WTG foundations and export cable installations? If so, how?

2) Do the benthic megafauna communities change from pre- to post- construction around WTG foundations and export cable installations? If so, how?

3) Does benthic community composition and distribution change on WTG foundations and scour protection during the survey? If so, how?

From the extant knowledge of ecological responses to offshore wind farm construction and operation, we expect megafauna communities to change near WTGs relative to environmental baseline surveys. We also expect benthic community composition to vary with depth on WTG foundations.

3.2.2 Survey Design

3.2.2.1 Video Transects

Video survey transects will be recorded along the same impact monitoring transects, as the grab samples, with some additional coverage. Video transects will be recorded both perpendicular to (300 m total) and parallel to (100 m total) the export cable or WTG foundation (Figure 3.) for a total of 400 m. One transect extends 250 m from the base of the WTG or offshore cable trench over the same locations where grab sampling occurs. Shorter transects (50 m) will radiate from the WTG and along/across the offshore cable to capture a more complete picture of the area of disturbance. The length of the longest (250 m) transect was chosen because it samples the entire expected gradient of impacts based on the maximum predicted distance of ≥1 mm sediment deposition from export cable installation according to the sediment dispersion modelling (see Appendix II-J3).

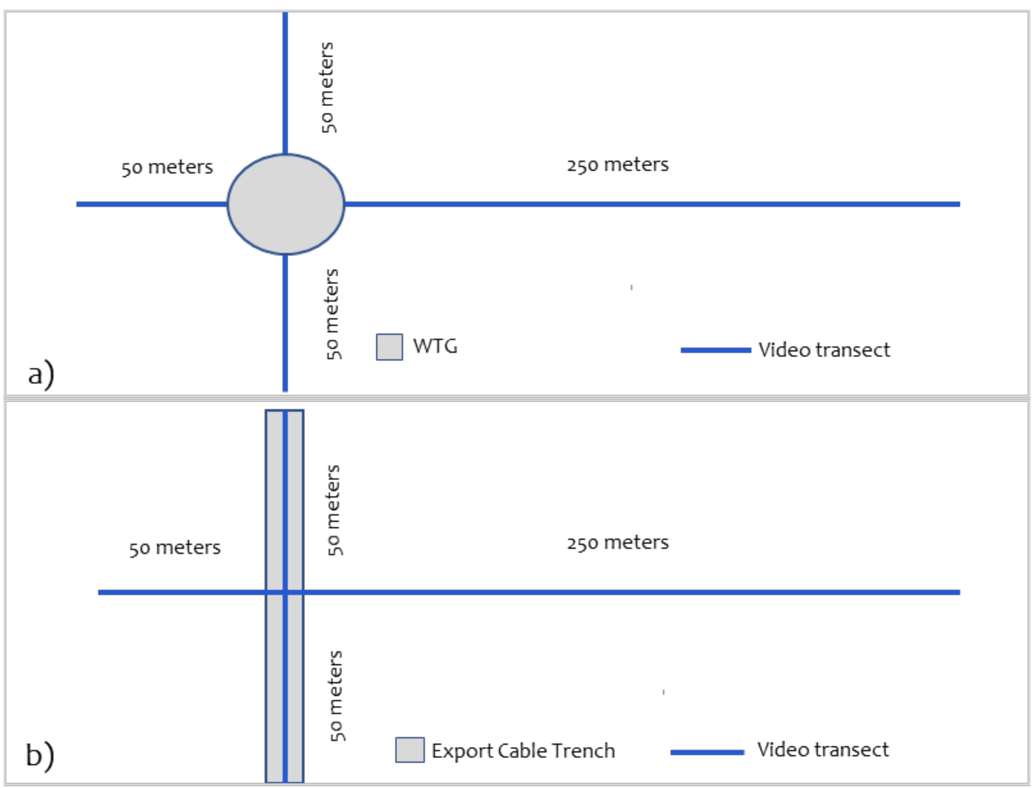

Figure 3. Schematic of epifauna/benthic habitat video survey layout. For WTG (a) and offshore cable (b) stations.

3.2.2.2 WTG Foundation and Scour Protection

Post-construction surveys of the fouling communities on WTG foundations and scour protections will be conducted at the WTGs selected for grab samples and video transects. The north, south, east, and west sides of the WTG will be vertically surveyed using an ROV with calibrated scaling lasers. The foundation survey will begin 0.5 m below the sea surface and extend down to 0.5 m above the seafloor or scour protection. Foundation and scour protection surveys will be focused on documenting sessile epifauna (blue mussels, sponges, anemones, bryozoans, invasive tunicates, etc.), mobile benthic macroinvertebrates (sea urchins, sea stars, crabs, etc.), and macroalgae.

3.2.3 Equipment and Operations

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 and overlaid onto the video feed. For video transects, the transects will run from 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 ECC will be run with a 10 m lead in and lead out distance both parallel and perpendicular to the installed cable. One transect will be run parallel with the cable corridor over the impacted area while the perpendicular transect will record both undisturbed and disturbed area. Video surveys will be conducted using a towed camera sled or ROV with calibrated scaling lasers and an additional dedicated still image camera (Minimum resolution 10 MP per NMFS 2021 guidelines).

The vertical ROV foundation surveys are to be conducted as systematically as local meteorological conditions allow. The ROV will get into position and go straight down from the surface to the scour protection, maintaining a distance of about one meter from the foundation. For surveying the scour protection and immediate benthic area, the ROV will go around the entirety of the scour protection, ad libitum, targeting areas of intertest seen during the survey i.e., dense aggregations of epifauna or flora, invasive species. Further presence of fish species will be documented.

3.2.4 Data Analysis

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.). Findings of statistical analyses will be summarized in a technical report with a supporting series of figures documenting results including comparisons with previous monitoring surveys, other related survey data, and relevant desktop studies.

Underwater video will be used to enumerate larger epifaunal organisms (i.e., megafauna), while high quality still images will be selected for analysis of percent cover to inform quantitative habitat classification. The following observations will be made:

- Characterization of benthic features (three-dimensional surface features and regularity) and habitat types in accordance with the NMFS-modified CMECS standards (NMFS, 2021; FGDC, 2012);
- Quantification and general characterization of benthic megafauna (e.g., crabs, urchins);
- Quantification and general characteristics of visible shellfish (e.g., scallops);
- Changes in invasive species presence or coverage;

- Extent and locations of complex habitat based on hard bottom substrates, epifauna or macroalgae cover, and vegetated habitats; and
- Presence and general characterization of important biogenic habitats (e.g., shells, corals, tube-dwelling anemones, structure-forming polychaetes).

The results of the video survey will provide qualitative information about the potential impacts and recovery of communities and habitat. The data will be explored to answer the stated research questions as best as possible and may include statistical assessment of hypothesis with appropriate tests (ANOVA, GAMs, etc.).

3.3 High-Resolution Multibeam Echosounding

Atlantic Shores will conduct high-resolution multibeam echosounding within the designated monitoring areas. Seabed surface maps to centimeter-level resolution will be created using a multibeam echosounding system to allow detailed comparisons of bottom morphology and detection of minute changes between successive mappings.

Pre- and post-construction video and digital bathymetric maps will be analyzed and compared to describe any potential changes in seabed morphology within the monitoring sites.

4 PROGRAM SCHEDULE

Pre-construction baseline surveys will be conducted at all monitoring sites within a year prior to construction activities to identify and document the natural background conditions at each site. 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 in the region due to frequency of weather prohibitive to sampling. Monitoring surveys may need to occur based on project construction schedules, which is acceptable as long as sampling occurs at roughly the same time from year to year.

Post-construction monitoring surveys are planned to occur within the first year after Project completion to capture short-term recolonization and repeated, in year three and, if necessary, year five after construction 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 the Offshore Project Area, based on species composition and benthic habitat quality at monitoring sites. In prior studies (Coates et al. 2013; 2015) benthic recovery has been observed within a year, so early surveys are useful for observing the start of recovery. The necessity of year 5 post-construction surveys will be assessed for the ECC and WTA survey areas separately and will not be conducted if benthic habitat have recovered or reached a stable climax community.

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.

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Attachment A – Power Analyses

Two a priori power analyses were conducted to determine the number of sample stations required to detect a change in the diversity of benthic macroinvertebrates in two locations, the WTA and ECCs. These project areas were assessed separately due to differences in expected potential impacts. The power analyses were based on BAG-style statistical analyses. There is limited existing literature on how to conduct a power analysis for BAG surveys, so a simulation approach was taken, which created and tested data from distributions of real data after they had been manipulated as expected based on impacts and existing literature.

Distributions of simulated sample diversity were generated based on the center and spread of distributions fitted to real data from 81 grab samples, (ACC: *n*=9, MCC: *n*=20, and WTA: *n*=52) conducted in 2019 and 2020 within the Offshore Project Area. The benthic macroinvertebrate taxonomic data from the grab samples were used to calculate the Shannon-Wiener Diversity index (H') (Equation 1) for each of the 81 grabs samples (Shannon 1948) (Figure A-1). Although a suite of taxonomic parameters (e.g., taxa densities) and ecological parameters (e.g., richness, evenness. Diversity, etc.) can be calculated from grab sample data from the 2019 and 2020 data (Figure A-2), and used to test hypotheses, the Shannon-Weiner Diversity Index was chosen as the key indicator for this survey because it is a measurable feature of the marine environment which is relevant to the integrity and the stability of communities and habitats, and easily obtained from grab sample taxonomic analysis. It also inherently includes components of richness and evenness.

Diversity values from grabs in the Atlantic ECC and Monmouth ECC were pooled together to create a larger sample size because there was no significant difference in the distribution of diversity values between ECC locations (p = 0.20, df =10.88). This combined ECC distribution also allows for the power analysis to be valid for selecting the number of stations required to detect a change in both corridors or either corridor alone depending on final project construction design. In addition, this power analysis is conservative because it uses single grab samples to estimate the number of grab stations needed to fulfill desired power requirements, but proposed sampling will have triplicate grabs at each station combined. These combined data are expected to be less variable than single grab samples and will therefore have more power from an increased signal to noise ratio.

A Shapiro-Wilk test was used to determine if the distribution of diversity observations followed normal distributions in the ECC areas (Shapiro-Wilks, n = 29, p = 0.90), and WTA (Shapiro-Wilks, n = 52, p = 0.41). Fitting a normal distribution to the data for the ECC and WTA (Figure A-3) produced mean and standard deviation estimates that were used to randomly generate samples composing simulation data. Quantile-Quantile plots of normal distribution fits to diversity for the ECC's and WTA showed no unreasonable biases (Figure A-4).

Equation 1:

$$H' = -\sum_{i=1}^{R} p_i \ln(p_i)$$

Where:

p_i is the proportion of individuals belonging to taxa i in the dataset of interest

Interpretation: The greater the H', the greater the richness and evenness.

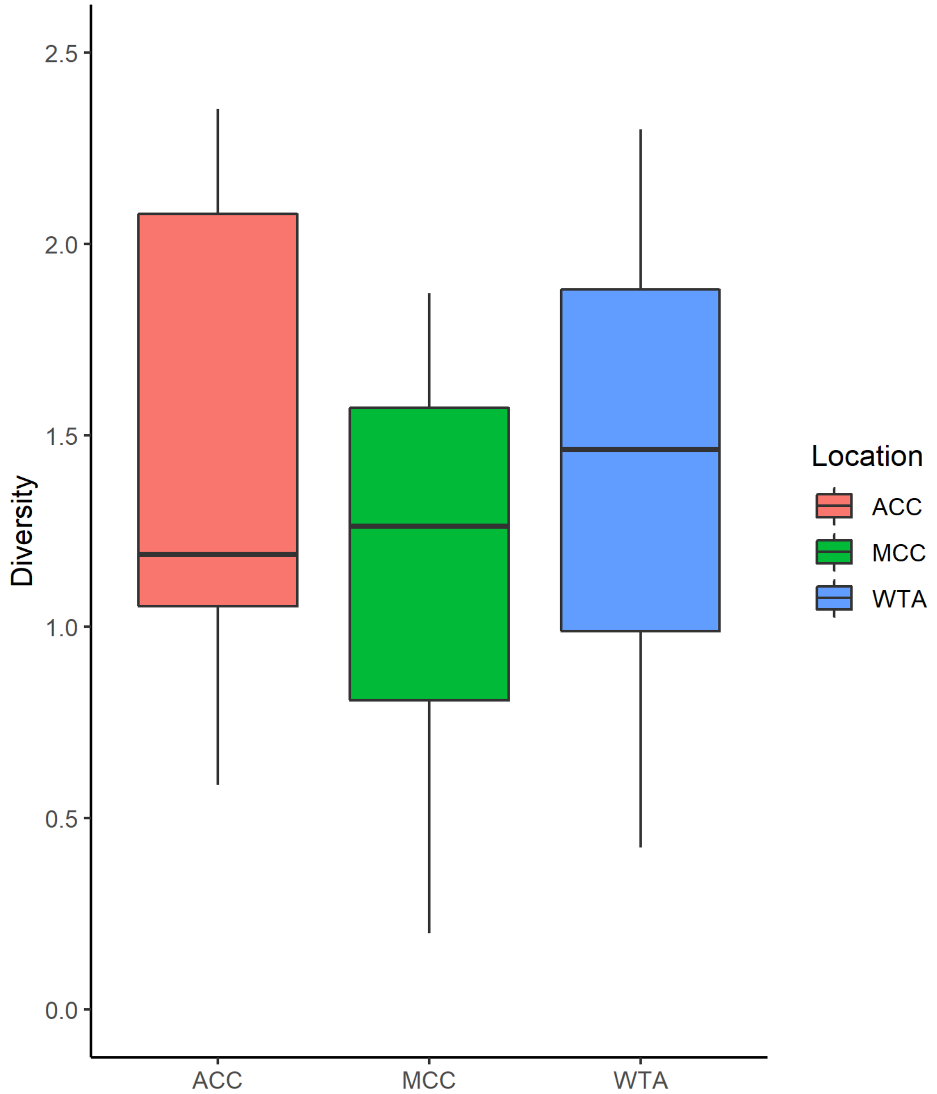

Figure A-1. Boxplots of H' Diversity collected by grab samples within the Atlantic ECC (left), Monmouth ECC (center), and WTA (right) between 2019 and 2020.

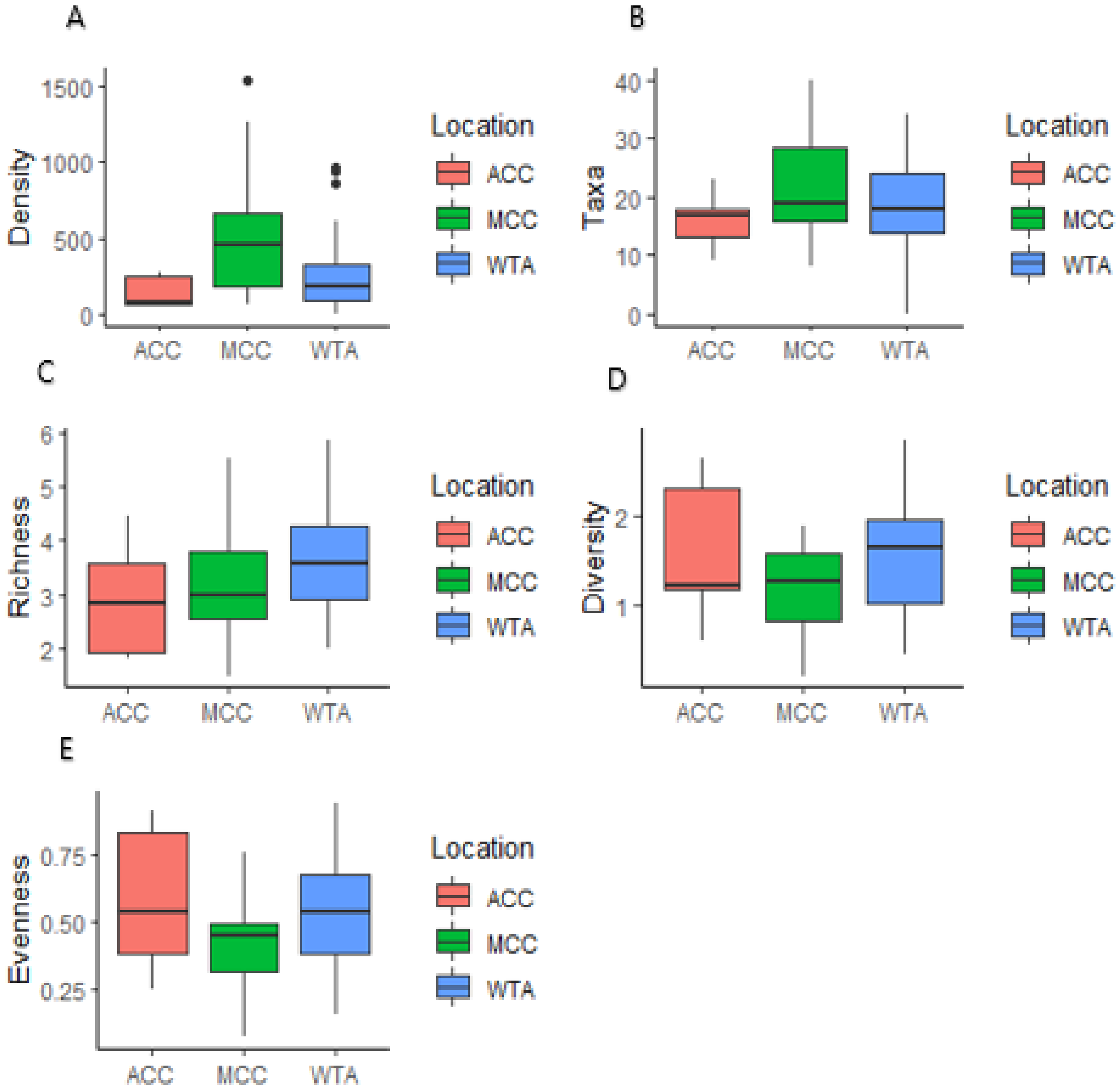

Figure A-2. Boxplots of A) Density, B) Taxa, C) Richness, D) Diversity, and E) Evenness collected by grab samples within the Atlantic ECC (left), Monmouth ECC (center), and WTA (right) between 2019 and 2020.

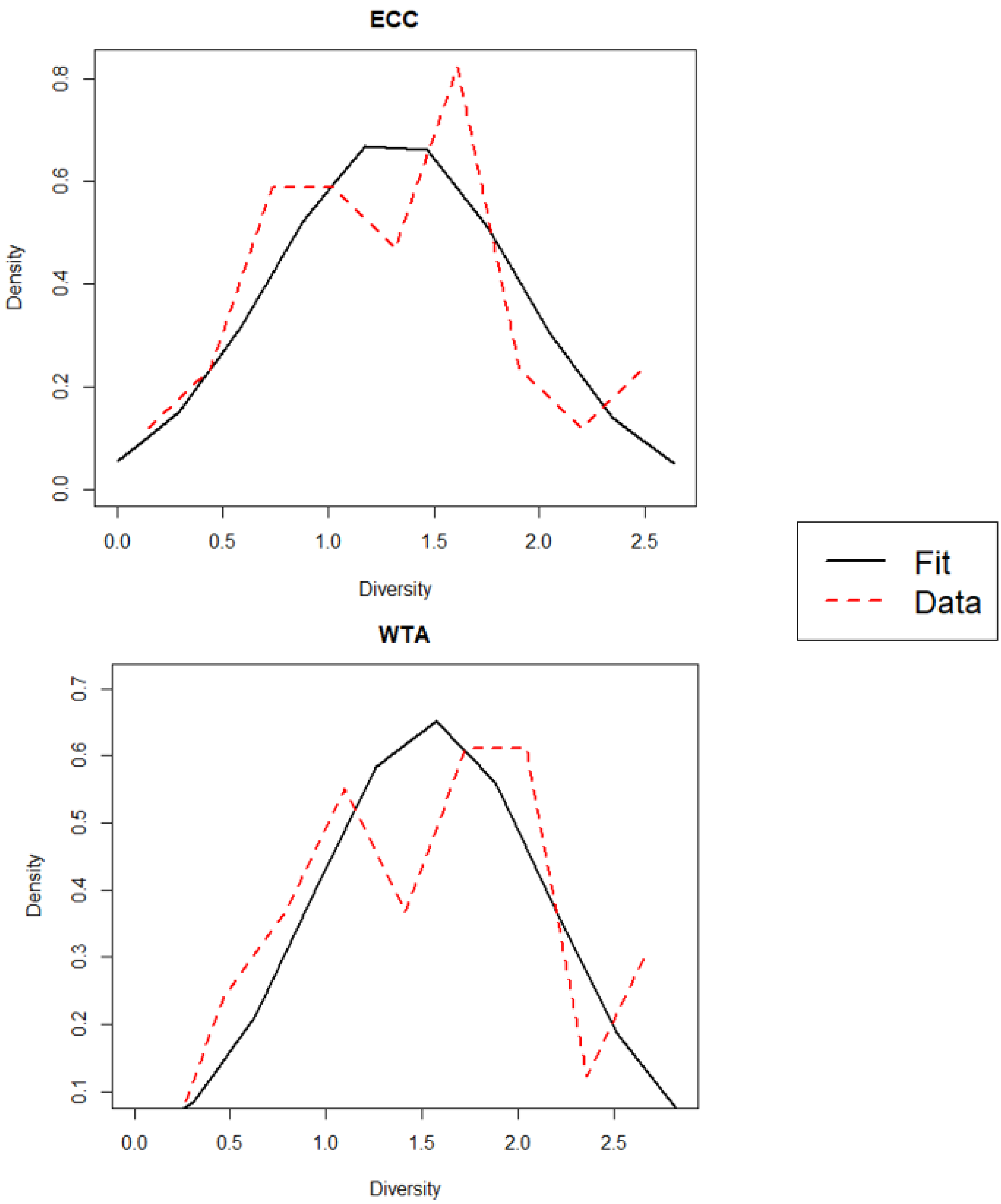

Figure A-3. Normal distributions (black) fitted to H’ Diversity from benthic grab data (red, dashed) collected within the Project Area during 2019 and 2020.

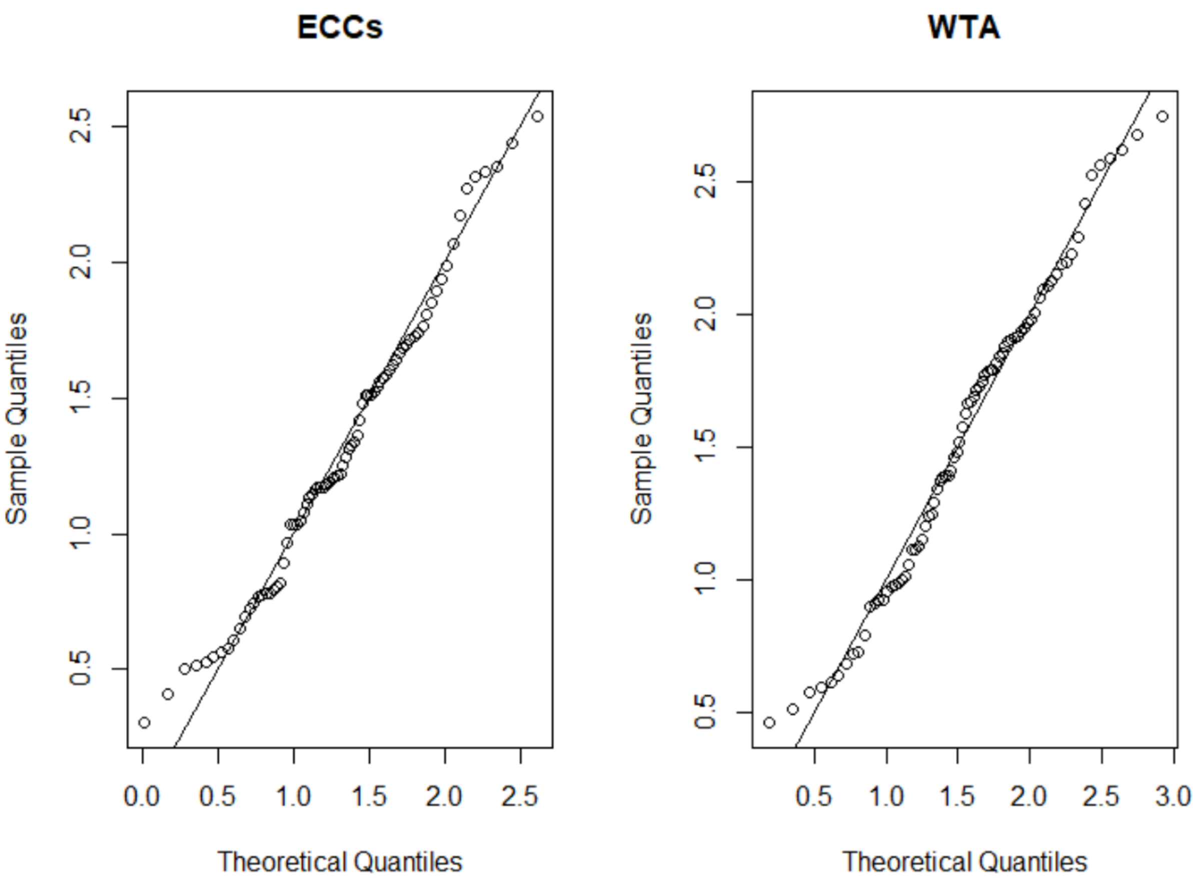

Figure A-4. Quantile-Quantile plots of normal distributions fit to diversity for the ECC's and WTA.

To conduct the power analyses with the correct degrees of freedom, the statistical models used to analyze the data were also chosen a priori, but other models could be fitted after data collection to investigate other questions. A GAM or GAMM with a Gaussian conditional distribution (unless otherwise determined) will be used to assess the null hypothesis for each species because it allows for incorporation of categorical and continuous predictor variables and enables the use of smoothing parameters to deviate from linear relationships and avoids assumptions about a deterministic relationship between predictors and observations (Hastie & Tibshirani 1990). Specifically, the GAM in the simulations allowed for the application of a smoothing spline to the continuous "distance" (from effects) variable in its interaction with a 2-level (i.e., before effects and after effects) categorical predictor, "treatment", while "temperature" and therefore the interaction between temperature and treatment were left linear (Equation 2).

Equation 2:

$$Diversity = treatment + location + temp + treatment: \text{s(distance)} + treatment: temp + \beta_0$$

A.1 ECC Diversity Power Analysis

To test the effect of sample size on power in the ECCs, 19 datasets ranging in size from 24 to 240 samples in multiples of 12 were created for each iteration of a 2,000-iteration simulation. Each set of 12 additional samples contained 1 transect in each treatment (i.e., before effects and after effects) which contained 6 observations spaced at semi-variable distances from effects. The distances were not fully randomized to ensure adequate spatial coverage. Instead, one distance was generated from each of the following normal distributions (Equation 3).

Equation 3:

$$\mathrm{N}(\mu = 0, \sigma^2 = 0), \mathrm{N}(\mu = 15, \sigma^2 = 2), \mathrm{N}(\mu = 50, \sigma^2 = 2), \mathrm{N}(\mu = 150, \sigma^2 = 2), \mathrm{N}(\mu = 400, \sigma^2 = 25),$$

$$N(\mu = 1{,}000, \sigma^2 = 25)$$

The “before effects” treatment diversity data were all selected from the same normal distribution for each ECC (Equation 4) while the “after effects” diversity data were selected from one of four different distributions depending on distance from effects. The “after effects” data at the 400 m and 1,000 m stations were selected from the same distribution as the “before effects” data. The “after effects” data at the 150 m, 50 m, 15 m and 0 m stations were selected from distributions with means reduced by 10%, 20%, 40%, and 50%, respectively (Equation 5 to Equation 8). The decreased diversity near the effects after they occurred assumed a localized mortality effect with neutral changes at farther sampling sites but an increase of the same magnitude near the effects should be equally detectable as well (i.e., two-tailed). A 25% change in community indices has been used before in benthic monitoring studies with power close to 80% for most benthic taxa (Lambert et al. 2017). In this case, changing the mean of the 150 m, 50 m, 15 m and 0 m stations by 10%, 20%, 40%, and 50%, respectively is a mean change of 20% relative to the baseline mean if all stations were combined.

Equation 4:

$$N(\mu = 1.31\,, \sigma^2 = 0.6),$$

Equation 5:

$$N(\mu = 0.9 * 1.31\,, \sigma^2 = 0.6)$$

Equation 6:

$$N(\mu = 0.8 * 1.31\,, \sigma^2 = 0.6)$$

Equation 7:

$$N(\mu = 0.6 * 1.31\,, \sigma^2 = 0.6)$$

Equation 8:

$$N(\mu = 0.5 * 1.31\,, \sigma^2 = 0.6)$$

Bottom temperature was also randomly selected for each tow from a normal distribution (Equation 9). Bottom temperature will be included in the real analyses but was generated from the same distribution for each sample in the simulation to avoid incorrect assumptions.

Equation 9:

$$N(\mu = 20°C\,, \sigma^2 = 2°C\,)$$

Once each dataset was generated, a GAM (Equation 2) was fitted in R using the mgcv package (Wood 2017) with a Gaussian conditional distribution. The p value for the interaction term “treatment(after):distance” was evaluated at an alpha level of 0.05 for significance because it assesses the null hypothesis (Ho1) by determining if the space-diversity relationship was different after construction occurred. This same analysis will be used on the real data after collection. The pass/fail result was recorded for each of the 19 different size datasets and then averaged over 2,000 simulations to determine the power of each sample size. This conservative simulation determined that a sample size of at least 132 stations in the ECC should have 80% power in detecting the simulated changes in diversity (Table A-1)

Table A-1. Estimated power at different sample sizes from 2,000 iterations of a simulation based on ECC diversity data. Bolded values are greater than 80% power.

Total Sample Size (number of stations per two years)	Transects per year	Power
24	2	0.25
36	3	0.32
48	4	0.38
60	5	0.45
72	6	0.52
84	7	0.60
96	8	0.65
108	9	0.70
120	10	0.75
132	**11**	**0.80**
144	**12**	**0.84**
156	**13**	**0.87**
168	**14**	**0.89**
180	**15**	**0.92**
192	**16**	**0.92**
204	**17**	**0.94**
216	**18**	**0.95**
228	**19**	**0.96**
240	**20**	**0.97**

A.2 WTA Diversity Power Analysis

To test the effect of sample size on power in the WTA, 19 datasets ranging in size from 24 to 240 samples in multiples of 12 were created for each iteration of a 2,000-iteration simulation. Each set of 12 additional samples contained 1 transect in each treatment (i.e., before effects and after effects) which contained 6 observations spaced at semi-variable distances from effects. The distances were not fully randomized to ensure adequate spatial coverage. Instead, one distance was generated from each of the following normal distributions (Equation 3).

The “before effects” treatment diversity data were all selected from the same normal distribution for each WTA (Equation 11) while the “after effects” diversity data were selected from one of four different distributions depending on distance from effects. The “after effects” data at the 400 m and 1,000 m stations were selected from the same distribution as the “before effects” data. The “after effects” data at the 150 m, 50 m, 15 m, and 0 m stations were selected from distributions with means reduced by 10%, 20%, 40%, and 50%, respectively (Equation 12 to Equation 15). The decreased diversity near the effects after they occurred assumed a localized mortality effect with neutral changes at farther sampling sites but an increase of the same magnitude near the effects should be equally detectable as well (i.e., two-tailed). A 25% change in community indices has been used before in benthic monitoring studies with power close to 80% for most benthic taxa (Lambert et al. 2017). In this case, changing the mean of the 150 m, 50 m, 15 m and 0 m stations by 10%, 20%, 40%, and 50%, respectively is a mean change of 20% relative to the baseline mean if all stations were combined.

Equation 11:

$$\mathrm{N}(\mu = 1.46\,, \sigma^2 = 0.6),$$

Equation 12:

$$\mathrm{N}(\mu = 0.9 * 1.46\,, \sigma^2 = 0.6)$$

Equation 13:

$$\mathrm{N}(\mu = 0.8 * 1.46\,, \sigma^2 = 0.6)$$

Equation 14:

$$\mathrm{N}(\mu = 0.6 * 1.46\,, \sigma^2 = 0.6)$$

Equation 15:

$$\mathrm{N}(\mu = 0.5 * 1.46\,, \sigma^2 = 0.6)$$

Bottom temperature was also randomly selected for each tow from a normal distribution (Equation 9). Bottom temperature will be included in the real analyses but was generated from the same distribution for the WTA in the simulations to avoid incorrect assumptions.

Once each dataset was generated, a GAM (Equation 2) was fitted in R using the mgcv package (Wood 2017) with a Gaussian conditional distribution. The p value for the interaction term “treatment(after):distance” was evaluated at an alpha level of 0.05 for significance because it assesses the null hypothesis (Ho1) by determining if the space-diversity relationship was different after construction occurred. This same analysis will be used on the real data after collection. The pass/fail result was recorded for each of the 19 different size datasets and then averaged over 2,000 simulations to determine the power of each sample size. This conservative simulation determined that a sample size of at least 120 stations in the WTA should have 80% power in detecting the simulated changes in diversity (Table A-2).

Table A-2. Estimated power at different sample station sizes and effect sizes from 2,000 iterations of a simulation based on WTA diversity data. Bolded values are greater than 80% power.

Total Sample Size (number of stations per two years)	Transects per year	Power
24	2	0.26
36	3	0.35
48	4	0.41
60	5	0.49
72	6	0.58
84	7	0.65
96	8	0.72
108	9	0.77
120	**10**	**0.80**
132	**11**	**0.86**
144	**12**	**0.89**
156	**13**	**0.90**
168	**14**	**0.93**
180	**15**	**0.95**
192	**16**	**0.96**
204	**17**	**0.96**
216	**18**	**0.97**
228	**19**	**0.98**
240	**20**	**0.99**