VINEYARD WIND

Draft
Vineyard Wind South
Construction and Operations Plan

Volume II-A
Appendices

June 28, 2021

Submitted by
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Submitted to
Bureau of Ocean Energy Management
45600 Woodland Road
Sterling, Virginia 20166

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Draft Vineyard Wind South Construction and Operations Plan

Volume II-A Appendices

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Biodiversity Research Institute	Public Archaeology Laboratory, Inc.
Capitol Air Space Group	RPS
Geo SubSea LLC	Saratoga Associates
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Gray & Pape	Wood Thilsted Partners Ltd

June 28, 2021

Appendix II-H

2016-2019 Benthic Reports

1. ESS Group 2016 Benthic Macroinvertebrate Sample Analysis Report
2. Normandeau Associates 2017 Benthic Sample Processing Report
3. CR Environmental 2018 Underwater Video Review
4. CR Environmental June/July 2018 Underwater Video Review
5. RPS/Alpine 2019 Benthic Report
6. RPS 2019 SWDA Benthic Report
7. RPS 2019 OECC Benthic Report
8. CR Environmental 2019 Underwater Video Review

Note: These reports were prepared prior to the June 2021 lease segregation of Lease Area OCS-A 0501 into Lease Area OCS-A 0534 (Vineyard Wind South) and Lease Area OCS-A 0501 (Vineyard Wind 1). These reports therefore refer to the “Vineyard Wind South” development as “501 South” and describe the development as being located within Lease Area OCS-A 0501.

The Vineyard Wind South development is located within the Southern Wind Development Area (SWDA). The footprint of the SWDA includes an overlapping area that was analyzed as part of the Vineyard Wind 1 COP. Additionally, the Offshore Export Cable Corridor (OECC) for Vineyard Wind South is largely the same OECC proposed in the Vineyard Wind 1 COP, though the Vineyard Wind South OECC excludes two options (a New Hampshire Avenue landfall site and a western route through Muskeget Channel) that were included in the Vineyard Wind 1 COP. Accordingly, these reports contain some information from the Vineyard Wind 1 COP that pertains to the overlapping area in the SWDA, as well as some information from the northern portion of Lease Area OCS A-0501 that is not within the boundaries of the SWDA and thus is not relevant for Vineyard Wind South. Likewise, these reports contain some information that is within the Vineyard Wind South OECC, as well as some information from OECC options that were included in the Vineyard Wind 1 OECC but are not included in the Vineyard Wind South OECC and thus are not relevant for Vineyard Wind South. Please refer to the main body of COP Volume II-A for full details on the precise data and limits of the site characterization and supporting information for Vineyard Wind South.

1. ESS Group 2016 Benthic Macroinvertebrate Sample Analysis Report

Benthic Macroinvertebrate Sample Analysis Report

Vineyard Wind Project
Offshore Lease Area OCS-A 0501
Massachusetts

PREPARED FOR:
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Princeton, New Jersey 08540

PREPARED BY:
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Project No. O207-000

January 27, 2017

BENTHIC MACROINVERTEBRATE SAMPLE ANALYSIS REPORT
Vineyard Wind Project
Massachusetts

Prepared For:

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January 27, 2017

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1.0 INTRODUCTION

On behalf of Vineyard Wind, LLC (the Client), ESS Group, Inc. (ESS) analyzed four samples collected from benthic habitats within the Offshore Lease Area OCS-A 0501. Benthic macroinvertebrates were the primary target of the analysis and are defined as organisms greater than 500 microns (μm) in length that either live on or in aquatic sediments, including mollusks, primitive (unsegmented) worms, annelids (segmented worms), crustaceans, and echinoderms.

2.0 METHODS

2.1 Laboratory Analysis

Four benthic grab samples were collected by Geo SubSea LLC on November 10, 2016 using a 0.1 m^2-modified Day grab sampler. All samples originated from Massachusetts waters of Offshore Lease Area OCS-A 0501.

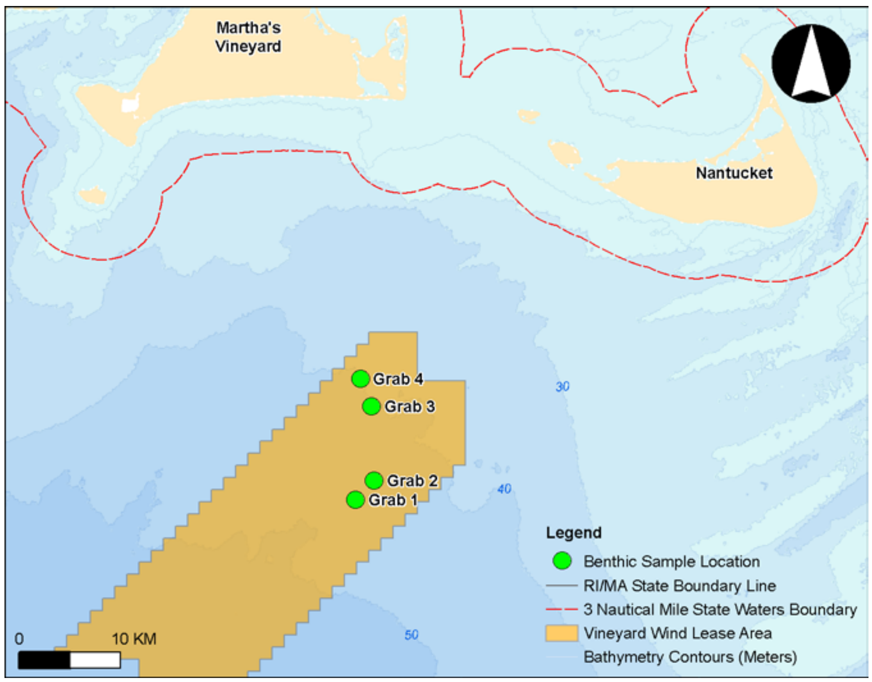

Figure 1. Benthic Grab Sample Locations

The four samples were transferred to ESS on November 11, 2016 and returned to ESS's office in East Providence, Rhode Island for processing. Upon return to the office, each sample was split into two portions: one for grain size analysis and one for benthic analysis. The benthic portion of each sample was passed through a 0.5-mm sieve and fixed in 10% neutral buffered formalin.

Prior to sorting, sample material from each sample was emptied in its entirety into a 0.5-mm mesh sieve. Tap water was gently run over the sieve to rinse away the formalin fixative and any additional fine sediment that was not removed during the initial sieving process. Rinsed samples were preserved in 70% ethanol.

Each benthic sample was sorted to remove benthic organisms from residual debris. Samples were sorted in their entirety under a high-power dissecting microscope (up to 90X magnification)

For quality assurance and control (QA/QC) purposes, a second qualified staff member (quality assurance officer) resorted 10% of the samples (or one, whichever was greater) analyzed by each sorter to ensure organisms were being adequately removed from the samples. The quality assurance officer checked the sorted sample material for remaining organisms and calculated an efficiency rating (E) using the following formula:

$$E = 100 \times \frac{n_a}{n_a + n_b}$$

Where n_a is the number of individuals originally sorted *and* verified as identifiable organisms by the QC checker and n_b is the number of organisms recovered by the QC checker. If the original sorter achieved E < 90% (i.e., less than 90% of the organisms in the sample removed), an additional sample sorted by that analyst was re-examined by the quality assurance officer.

All sorted organisms were subsequently 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. Very small polychaete specimens were mounted in CMC-10 mounting media using methods consistent with those outlined in Epler (2001). Identification of slide-mounted organisms was conducted under a compound microscope with magnification up to 1,000X.

Enumerations of macroinvertebrates identified from each sample were recorded directly in an electronic spreadsheet. Prior to data summary, species abundances for each sample were standardize to number of individuals per square meter, taking into account the sampling equipment dimensions and sub-sampling effort.

2.2 Data Analysis

Measures of benthic macrofaunal diversity, abundance, and community composition were selected to describe existing conditions. The rationale behind selection of each measure follows.

Diversity (Taxa Richness)

Taxa richness is the number of different taxa that are found within a given area or community and is widely accepted as a robust assessment measure of diversity (Magurran 2003). For this study, taxa richness is defined as the total number of unique taxa found in a sample.

Abundance (Macrofaunal Density)

Macrofaunal density is an estimate of the number of individuals per unit area. The density of benthic organisms responds to disturbance as mitigated by the tolerance (or preference) of a given organism to the particular source of disturbance. Density may vary substantially over small areas or short periods of time and should therefore be interpreted cautiously. For this study, macrofaunal density is expressed as the number of organisms per cubic meter.

Community Composition

Community composition is a multivariate measure identifying the different benthic taxa present and respective abundances of each taxon. This descriptive measure uses information regarding the taxa present, providing detail to complement and help interpret summary metrics of diversity and abundance.

3.0 RESULTS

Results of the benthic sample analysis, including taxa richness, density, and community composition are presented in the following sections.

3.1 Taxa Richness

The total number of taxa identified from the samples examined was 32 (Table A). Taxa richness per sample ranged from 6 taxa at Grab 4 to 19 taxa at Grab 1 (Appendix A) with a mean taxa richness of 15 taxa per site (Table A).

Table A. Summary of Key Statistics from the Benthic Sample Analysis

Statistic	Value
Number of Samples	4
Mean Density per Cubic Meter (±1 SD)	118,370 ± 80,581
Mean Taxa Richness (±1 SD)	15 ± 6
Total Number of Taxa	32
Number of Taxa Observed by Taxonomic Group	
Polychaete worms	14
Crustaceans	9
Mollusks	4
Echinoderms	1
Nemertean ribbon worms	3
Nematode roundworms	1
Percent of Total Abundance by Taxonomic Group	
Polychaete worms	47.7%
Crustaceans	23.6%
Mollusks	2.5%
Echinoderms	0.6%
Nemertean ribbon worms	1.8%
Nematode roundworms	23.8%

3.2 Macrofaunal Density

The mean macrofaunal density for the analyzed samples was 118,370 individuals/m^3 (Table A). The highest macrofaunal density (234,409 individuals/m^3) was found at Grab 4, while macrofaunal density was lowest (48,227 individuals/m^3) at Grab 2 (Appendix A). Of the four samples analyzed, three were characterized by densities of 90,000 individuals/m^3 or more.

3.3 Macrofaunal Community Composition

The benthic macrofaunal assemblage documented in the analyzed samples consisted of polychaete worms, crustaceans, mollusks, echinoderms, nematode roundworms, and nemertean ribbon worms. (Appendix A).

The most speciose taxonomic group was polychaete worms, which contributed approximately 45% of the taxa documented in the analyzed samples (Table A).

The taxonomic group with the highest density was polychaete worms, followed by nematode roundworms and crustaceans (Table A).

The most abundant taxa observed were nematode roundworms (Nematoda), the lumbrinerid polychaete *Scoletoma* sp., and a paraonid polychaete (Paraonidae) (Table B). Together, these taxa accounted for more than 50% of all individuals identified in this study.

Table B. Relative Abundance of Taxa Encountered*

Scientific Name	Common Name	Relative Abundance (%)
Nematoda	Nematode roundworm	24
Scoletoma sp.	Lumbrinerid polychaete	19
Paraonidae	Paraonid polychaete	12
Ampelisca sp.	Ampeliscid amphipod	10
Byblis sp.	Ampeliscid amphipod	10

*Includes taxa accounting for at least 10% of total abundance

The most widespread taxa (i.e., observed in the most samples) were the lumbrinerid polychaete *Scoletoma* sp. and the hooded shrimp *Diastylis* sp. which were observed in all four samples (Table C). Other widely distributed taxa included ampeliscid amphipods, immature bivalves, nematode roundworms, ribbon worms, ampharetid bristle worms, bamboo worms, and paranoid worms (all found in three samples).

Table C. Most Widespread Taxa Encountered*

Scientific Name	Common Name	Number of Samples Containing this Taxon
Diastylis sp.	Hooded shrimp	4
Scoletoma sp.	Lumbrinerid worms	4
Ampelisca sp.	Ampeliscid amphipod	3
Bivalvia	Immature bivalves	3
Nematoda	Nematode roundworm	3
Nemertea	Ribbon worms	3
Ampharetidae	Ampharetid bristle worms	3
Clymenella sp.	Bamboo worm	3
Paraonidae	Paraonid worms	3

*Includes taxa observed in at least three samples

3.4 Quality Assurance/Quality Control

QA/QC sorting efficiency checks were conducted on two samples. All QA/QC criteria were met for this project.

Identifications represent the lowest practicable taxonomic level, given the maturity and condition of the organisms encountered, as well as the current state of taxonomic consensus. With the exception of heavily damaged or immature specimens, organisms were successfully identified to family level or better.

3.5 Summary of Results

- Thirty-two marine invertebrate taxa were observed in the 4 samples analyzed for this project.
- Taxa richness averaged 15 per site, and all but one sample contained at least 16 taxa.
- Mean macroinvertebrate density was over 118,000 organisms/m^3.
- The benthic community in the analyzed samples consisted of polychaete worms, bivalve mollusks, nematode roundworms, nemertean ribbon worms, common sand dollars, and crustaceans including amphipods, cumaceans, ostracods, and isopods.
- The most speciose taxonomic group was polychaete worms, which contributed approximately 45% of taxa documented in the analyzed samples
- The most abundant organisms observed were nematode roundworms and the lumbrinerid polychaete *Scoletoma* sp.
- The most widely distributed taxa observed were the lumbrinerid polychaete *Scoletoma* sp. and the hooded shrimp *Diastylis* sp., both of which were observed in all 4 samples.

4.0 REFERENCES

Epler, J.H. 2001. Identification Manual for the Larval Chironomidae (Diptera) of North and South Carolina. Version 1.0.

Magurran, A.E. 2003. Measuring Biological Diversity. Malden, MA: Blackwell Publishing Ltd

Appendix A

Benthic Sample Taxonomy and Enumeration Results

	Organisms/m^3			
	Grab 1	Grab 2	Grab 3	Grab 4
Conversion Factor (multiply by density to find raw sample abundance)	**0.00182**	**0.00141**	**0.00142**	**0.000465**
Taxa				
Crustacea				
Amphipoda				
Ampelisca sp.	6,593	9,220	18,310	
Unidentified Amphipoda			704	
Byblis sp.			3,521	94,624
Cumacea	549			
Diastylis sp.	549			2,151
Harpinia sp.	549		704	
Leptocheirus pinguis		709		
Cumacea				
Unidentified Cumacea			704	
Diastylis sp.		2,128	1,408	
Isopoda				
Cyathura polita			704	
Ostracoda				
Unidentified Ostracoda	549			
Echinodermata				
Echinarachnius parma	549	1,418		
Mollusca				
Bivalvia				
Unidentified Bivalvia	1,648	709	1,408	
Lucinoma sp.	1,648		0	
Periploma papyratium	549			
Tellina sp.			1,408	
Nematoda				
Nematoda	21,978		14,789	118,280
Nemertea				
Cephalothrix sp.		1,418		
Cerebratulus luridus		709		
Unidentified Nemertea	1,099	1,418		4,301
Polychaeta				
Ampharetidae	1,099	709		2,151
Cirratulidae	1,099			
Clymenella sp.	7,692	709	1,408	
Drilonereis longa			1,408	
Exogone sp.	549			
Glycera sp.		1,418	704	
Nephtyidae	1,099			
Nephtys sp.		1,418		
Ninoe nigripes		9,220	19,718	
Paraonidae	23,077	7,801	4,225	
Pholoe minuta		709		
Unidentified Polychaeta	3,297			
Scoletoma sp.	25,824	8,511	18,310	12,903
Sigalionidae			1,408	
Total Density	**100,000**	**48,227**	**90,845**	**234,409**
Taxa Richness	**19**	**16**	**18**	**6**

2. Normandeau Associates 2017 Benthic Sample Processing Report

Benthic Sample Processing Results
Vineyard Wind Cable Route Survey
September 2017

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November 2017
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1.0 Introduction

Normandeau Associates, Inc. (Normandeau), as a subcontractor to Alpine Ocean Seismic Survey, Inc. (Alpine), was contracted to process benthic samples that were collected by Alpine as part of a benthic survey of the Vineyard Wind cable route, located in waters south of Cape Cod, MA. The subsea cable route is located mostly within shallow waters south of Cape Cod, with a concentration of sampling effort in the area between Martha's Vineyard and Nantucket.

Fifty-nine benthic samples were collected using a 0.1 m^2 modified Day Grab. Three subsamples were collected from each grab sample using a 4-inch diameter hand core in the field. Each subsample represented 0.008 m^2. A total of 177 samples (3 core samples from 59 stations) were delivered to Normandeau's Bedford, NH office by Alpine. Normandeau processed one core sample from each station (59 core samples). The other two samples (118 core samples) from each station were washed with fresh water, transferred to 70-80% ethanol, and will be stored for one year from the submittal of the report. These archived samples allow for subsequent additional infaunal data if requested by regulatory agencies.

Normandeau sorted the remaining sample from each station then identified and enumerated individual organisms. Laboratory subsampling was employed on a few occasions to facilitate sorting of certain sample fractions. All organisms were identified to the family level and enumerated, with the following exceptions: nemerteans, nematodes, and sipunculids which were identified to phylum; oligochaetes, turbellarians, and anthozoans which were identified to class; and benthic copepods, ostracods, or other meiofaunal groups were not enumerated. Immature or damaged specimens that were missing the necessary diagnostic features for identification to the target taxonomic level were identified to the lowest practical taxon (above family). To ensure consistency for assessment of the soft-bottom macrofaunal community, any incidental pelagic organisms or fauna attached to hard-substrates were not identified.

This report summarizes processing methods and presents the macroinvertebrate data that were collected from the samples. Laboratory processing methods and data handling procedures are described in Section 2.0. Quality control results for the laboratory sort and taxonomy are provided in Section 3.0. Laboratory processing results are provided in Section 4.0, and macroinvertebrate data are provided in Appendix A.

The contents of this report provide the raw data and a brief data summary as delineated in the project work scope which includes tables presenting the following parameters:

- Number of Samples
- Mean Density per Square Meter (±1 SD) across all samples
- Mean Taxa Richness (±1 SD)
- Total Number of Taxa
- Number of Taxa Observed by Taxonomic Group
- Percent of Total Abundance by Taxonomic Group
- Relative Abundance of Taxa Recovered, and
- Most Common/Widespread Taxa Encountered.

2.0 Methods

2.1 Laboratory Methods

Soft-bottom macroinvertebrate samples from 59 stations were processed by Normandeau's Bedford, NH laboratory following standard processing protocols. Upon arrival at the laboratory, all 177 samples were rinsed with fresh water through a 0.5 mm mesh screen and re-preserved in 70% ethanol to protect specimens from decalcification. Following a subsequent rinsing through a 0.5 mm mesh screen, one randomly selected sub-sample from each station (a total of 59 samples) was elutriated to separate heavy and light materials and those with heterogeneously sized debris or organisms were washed through a series of graduated sieves down to a 0.5 mm mesh to facilitate sorting. Laboratory subsampling was also employed for samples where large quantities of uniform, coarse sand was present. This material was spread evenly in a pan, divided into 36 similar sized quadrants and subsampled by randomly selecting and sorting material from 6 of the 36 quadrants. Specimens were vialed and labeled separately; identifications and counts presented on data sheets were prorated to present an estimate for the entire sample. Macroinvertebrates were sorted from the debris into major taxonomic groups using a dissecting microscope. Organisms removed from each sample were placed in labeled vials with 70% Ethanol. All organisms were identified to the family level and enumerated, except nematodes (identified to phylum) and oligochaete annelids were identified to class. Meiofauna (e.g., benthic copepods, ostracods) were not enumerated.

Normandeau's internal quality control for sorting and taxonomy follows the National Coastal Condition Assessment 2015 Laboratory Operations Manual (Version 2.1 May 2016; USEPA 2016) guidelines. At least the first three samples undertaken by each new macroinvertebrate sorter were re-checked by the Quality Control Supervisor. At the discretion of the Quality Control Supervisor, additional samples could be checked prior to releasing any sorter from training. The first sorted sample for each seasoned sorter was rechecked. Regardless of experience level, a minimum of 10% of each sorter's subsequent samples (one in each batch of 10 samples) was randomly selected and subjected to quality control. Any sorted sample failing quality control resulted in returning to all samples from that batch of 10 for re-checking, with appropriate retraining of the sorter. In addition, 10% of each taxonomists' samples were re-identified. Any work of insufficient quality due to not meeting the National Coastal Condition Assessment guideline resulted in re-checking samples in that batch, returning to earlier program samples possibly affected, and retraining as appropriate.

Identified specimens were logged into the laboratory storage inventory and placed into storage for one-year. Sorted samples were re-preserved in 70% Ethanol and will be held until report acceptance, or for one-year.

2.2 Data Handling and Reduction Methods

Data handling was conducted by Normandeau's Data Center in Bedford, NH. All data were double keypunched using Normandeau's keypunch verification software. Using this software, data are entered electronically into a file that is then keyed a second time to detect data entry errors. When this inspection reveals errors in excess of those acceptable, a full inspection of the data is performed to remove any chance of error in the data, prior to presentation of the data.

Data preparation, reduction, and computation of summary statistics were run in SAS system software (version 9.3). Where laboratory subsampling was employed, estimated total counts were extrapolated for each sample (station and replicate) based on counts from the subsampled fraction of the sample. Macroinvertebrate community structure parameters were calculated based on the biotic abundance estimates (based on subsamples) for each sample. Summary statistics for the macroinvertebrate community included: total abundance, number of species, Shannon diversity index (H′ per sample, log base e), and Pielou's evenness index (J′ per sample) (Magurran 1988). Abundance was reported as counts per 0.008 m^2 core sample and taxonomic group and the overall density across all samples was adjusted to organisms per square meter. The PRIMER 6 package of statistical routines (Clarke & Gorley, 2006) was used to calculate the diversity index Shannon's H′ (loge), and Pielou's evenness value J′. Both H′ and J′ indices are based on the proportional abundances of species (Magurran 1988). Evenness (J′) is entirely a function of proportional abundance; J′ values are unaffected by the number of species in a sample. Values for J' can range between 0 and 1, with J' = 1 when all species in a sample have equal abundances. Diversity (H′) is a function of both proportional abundance and the number of species in the sample. The maximum possible H′ diversity (Hmax) for a given number of species occurs where all species have equal abundances. Any log base can be used to calculate H′; loge is used most commonly (Magurran 1988). H′ values calculated using different log bases are not comparable and must be converted to a common base prior to comparison. J' values are not affected by log base. H′ increases both with increasing numbers of species, and with increasingly even distributions of the total abundance among those species. Thus, H′ values depend on the log base used and on the numbers of taxa per sample, in addition to proportional abundance. H′ can range from 0 (with only one species in a sample) to a typical maximum of around 4.5 (Magurran 1988).

3.0 Quality Control/Quality Assurance Results

Twelve samples were rechecked during the training phase of the sorting, with an additional four samples being resorted and determined to either pass or fail (Table 3-1). Percent sorting efficiency (PSE) must be less than or equal to 90% sorting efficiency (less than 10% difference between sorter and quality control check) and is calculated using the following equation:

$$PSE = \frac{A}{A+B}x100$$

The PSE is the number of organisms recovered by the sorter (A) compared to the combined (total) number of recoveries by the sorter (A) and independent sorter (B). Sample results for PSE were favorable so further checking was not required (Table 3-2).

Table 3-1. Number of samples rechecked for Percent Sorting Efficiency (PSE).

Technician	Training QC	Processing QC	Total
1	3	1	4
2	3	1	4
3	3	2	5
4	1*	0	1
5	1*	0	1
6	1*	0	1
Total	**12**	**4**	**16**

* Seasoned sorter requiring one initial sample checked; Few samples were processed, eliminating the need for additional processing QC's.

Table 3-2. Sample Results for Percent Sorting Efficiency (PSE).

Technician	Processed Sample	% Difference	PSE
1	30C	0%	100.0%
2	19B	3.0%	97.0%
3	28B	1.3%	98.7%
3	39B	1.6%	98.4%

Quality control of taxonomic processing, both identification and enumeration of specimens, was conducted on 10% of the 59 processed samples. Results of this QC comparison are discussed in the following paragraphs. A total of six randomly selected samples were re-identified with PDE (percent disagreement in enumeration) and PTD (percent taxonomic disagreement) for each taxonomist's work.

The first step involved examining the overall counts of individual organisms in each sample using the following equation:

$$PDE = \frac{|n_1 - n_2|}{n_1 + n_2}\ x100$$

The PDE compares the number of organisms, n_1, counted in a sample by the primary taxonomist with the number of organisms, n_2, counted by the internal or external QC taxonomist. The target percent difference for counts below which no additional quality resolution is required is less than or equal to 5%. Comparison of count differences (PDE) for each of the six selected samples required no further examination (Table 3-3).

Table 3-3. Sample Results for Percent Disagreement in Enumeration (PDE).

		Phyla		
QC	Sample	Polychaeta	Mollusca	Arthropoda & Misc
1	10B	0%	0%	4.2%
2	15C	0%	0%	0%
3	27C	0%	0%	0%
4	32B	0%	2.7%	0%
5	49C	0%	0%	0%
6	61C	0%	0%	4.8%

The second step involved examining the accuracy of taxonomic identifications using the following equation:

$$PTD = \left[1 - \frac{comp_{pos}}{N}\right]\ x100$$

The PTD measures the taxonomic precision comparing the number of agreements (positive comparisons, $comp_{pos}$) of the primary taxonomist and internal or external QC taxonomists with N, the total number of organisms in the larger of the two counts. The target percent difference for taxonomic accuracy below which no additional quality resolution is required is less than or equal to 15%. Comparison of differences for each of the six selected samples required no further examination (Table 3-4).

Table 3-4. Sample Results for Percent of Taxonomic Disagreement (PTD).

		Phyla		
QC	Sample	Polychaeta	Mollusca	Arthropoda & Misc
1	10B	4.0%	0%	0%
2	15C	0%	0%	0%
3	27C	0%	0%	0%
4	32B	0%	0%	0%
5	49C	0%	0%	0%
6	61C	0%	0%	0%

4.0 Results

The 59 subsample cores yielded a total of 104 macroinvertebrate families (and higher taxonomic-level organisms including Oligochaeta, Archannelida, Nematoda, and Turbellaria) from nine phyla. Ninety-nine percent of the macroinvertebrates were from four phyla: Arthropoda (contributing 30%), Annelida (27%), Mollusca (25%), and Nematoda (16%; Table 4-1 and Figure 4-1). The other phyla recorded in the samples: Nemertea, Echinodermata, Platyhelminthes, Cnidaria, and Chordata together contributed less than 1 percent to the total abundance.

Arthropoda was represented by the highest number of taxa (n=34) including amphipods, decapods, isopods, and tanaids; followed by Annelida (n=29) including polychaetes and oligochaetes; and Mollusca (n = 28) including gastropods (snails and nudibranchs), chitons, and bivalves. The remaining six phyla were represented by one to five taxa each (Table 4-1).

Arthopods were also the most abundant organisms with a total of 2,474 individuals among all samples, followed by Annelida with 2,235 individuals, Mollusca (2,008 individuals), and Nematoda (1,333 individuals; Table 4-1). Total abundances of Nemertea, Echinodermata, Platyhelminthes, Cnidaria, and Chordata were relatively low ranging from 44 nemerteans to 1 individual chordate.

Overall, the mean abundance was 138 individuals per sample (17,015 organisms per m^2) ranging from two individuals in sample # 43 to 1,588 individuals in sample # 23 (Table 4-2). The two individuals in sample # 43 were one nematode and one polychaete from the family Capitellidae. The relatively high abundance in sample #23 was primarily due to two taxa, caprellid amphipods, Caprellidae (1,146 individuals) and dove snails, Columbellidae (174 individuals; see Appendix Table A). The mean number of taxa among all samples was 15 with a range of 2 in sample #43 to 39 taxa in sample # 7. The mean Shannon diversity index for all samples was 1.80, ranging from 0.63 in sample #16 to 2.73 in sample #21. Pielou's evenness values ranged from 0.34 in sample #23 to 1.00 in sample #33 with an average of 0.73 (Table 4-2). Both of these measures are typically calculated for data analyzed to the species level, so comparisons of these metrics to other survey results should be done with caution.

Among all stations, the most abundant taxon was Nematoda (with total abundance of 1,333 individuals), followed by Caprellidae (1,188 individuals), Tellinidae (518 individuals), and Oligochaetes (480 individuals; Table 4-3).

Table 4-1. Phyla represented in the macroinvertebrate samples collected during the Vineyard Wind cable route survey in September 2017.

Phylum	Number of Taxa[1]	Total abundance (overall number of individuals)	Percentage
Arthropoda	34	2,474	30.43
Annelida	29	2,235	27.49
Mollusca	28	2,008	24.70
Nematoda	1	1,333	16.40
Nemertea	5	44	0.54
Echinodermata	2	16	0.20
Platyhelminthes	1	13	0.16
Cnidaria	3	5	0.06
Chordata	1	1	0.01

[1]Identified to the family-level with the exception of Oligochaeta, Archannelida, Nematoda, and Turbellaria.

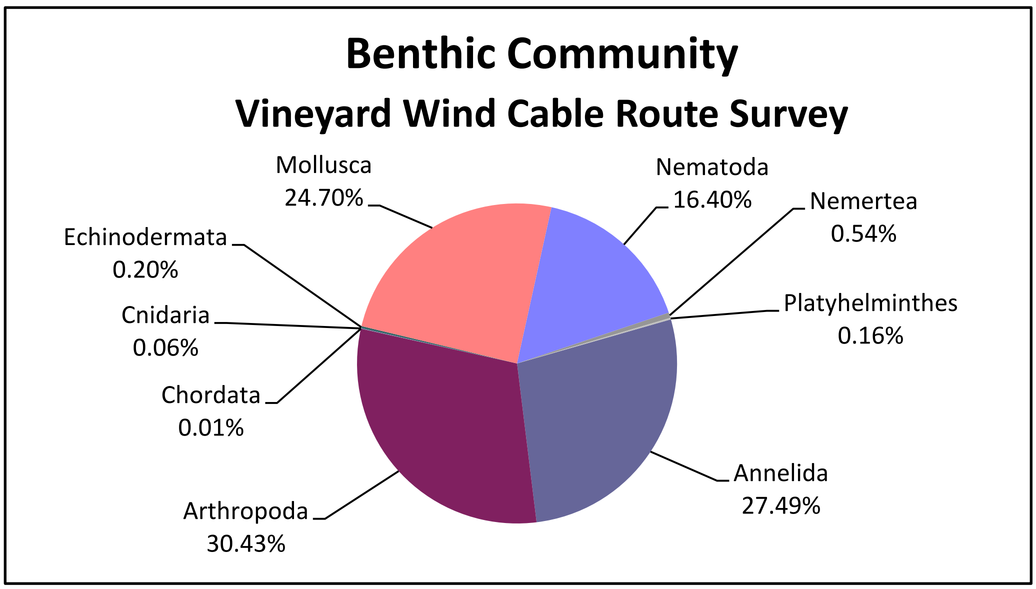

Figure 4-1. Percent contribution to total abundance by phyla in benthic samples collected during the Vineyard Wind cable route survey in September 2017.

Table 4-2. Community parameters for samples collected during the Vineyard Wind cable route survey in September 2017.

Station (Sample ID)	Total Number of Taxa	Total Count (no. per 0.008 m^2)	Diversity (H')	Evenness (J')
1	15	85	2.26	0.84
2	23	136	2.55	0.81
3	20	62	2.32	0.77
4	11	37	1.84	0.77
6	26	612	2.07	0.63
7	39	394	2.54	0.69
8	26	241	1.94	0.60
9	5	18	1.08	0.67
10	19	61	2.52	0.85
11	16	32	2.58	0.93
12	6	10	1.61	0.90
13	12	34	2.07	0.83
14	9	23	1.91	0.87
15	10	20	1.99	0.86
16	4	18	0.63	0.46
17	4	11	1.34	0.97
18	11	183	1.44	0.60
19	19	33	2.69	0.91
20	27	170	2.31	0.70
21	30	157	2.73	0.80
22	4	13	0.79	0.57
23	34	1588	1.19	0.34
24	8	47	1.64	0.79
25	3	8	0.74	0.67
26	20	348	1.56	0.52
27	22	78	2.46	0.79
28	19	77	1.97	0.67
29	15	98	1.56	0.58
30	15	136	1.48	0.55
31	16	148	1.87	0.68
32	12	92	1.07	0.43
33	6	6	1.79	1.00
34	7	31	1.61	0.83
35	9	38	1.46	0.66
36	16	244	1.51	0.54

Table 4-2. Continued.

Station	Total Number of Taxa	Total Count (no. per 0.008 m^2)	Diversity (H')	Evenness (J')
37	19	423	1.29	0.44
38	12	57	1.80	0.72
39	28	401	2.24	0.67
40	10	38	1.97	0.85
43	2	2	0.69	1.00
44	11	38	2.07	0.86
45	11	38	1.85	0.77
46	6	53	1.40	0.78
47	32	323	2.67	0.77
48	4	4	1.39	1.00
49	10	41	1.79	0.78
50	18	89	2.30	0.80
51	11	80	1.65	0.69
52	18	86	2.07	0.72
53	14	97	1.97	0.75
54	15	311	1.37	0.50
55	18	176	2.22	0.77
56	12	21	2.34	0.94
57	12	51	1.94	0.78
58	7	30	1.42	0.73
59	19	343	1.56	0.53
60	11	76	1.58	0.66
61	15	55	2.32	0.86
62	3	7	0.96	0.87
Mean	14.5	137.8	1.80	0.73

Table 4-3. Total macroinvertebrate abundance for samples collected during the Vineyard Wind cable route survey in September 2017.

Phylum	Family	Abundance (total number of individuals per 0.008 m²)
Annelida	Ampharetidae	32
	Archiannelida	135
	Capitellidae	389
	Chaetopteridae	2
	Cirratulidae	208
	Dorvilleidae	22
	Glyceridae	35
	Hesionidae	2
	Lumbrineridae	46
	Magelonidae	34
	Maldanidae	41
	Nephtyidae	82
	Oenonidae	1
	Oligochaeta	480
	Onuphidae	1
	Opheliidae	12
	Orbiniidae	10
	Oweniidae	2
	Paraonidae	76
	Pectinariidae	1
	Phyllodocidae	56
	Pilargidae	3
	Polynoidae	27
	Sabellaridae	54
	Sigalionidae	22
	Sphaerodoridae	2
	Spionidae	170
	Syllidae	175
	Terebellidae	115
Annelida Total		2235

Table 4-3. Continued.

Phylum	Family	Abundance (total number of individuals per 0.008 m²)
Arthropoda	Ampeliscidae	699
	Anthuridae	3
	Aoridae	45
	Argissidae	1
	Bateidae	26
	Bathyporeiidae	14
	Bodotriidae	5
	Callianassidae	3
	Cancridae	3
	Caprellidae	1188
	Corophiidae	11
	Diastylidae	14
	Epialtidae	1
	Haustoriidae	38
	Idoteidae	1
	Inachoididae	2
	Ischyroceridae	22
	Janiridae	29
	Leptocheliidae	1
	Liljeborgiidae	6
	Lysianassidae	11
	Maeridae	8
	Mysidae	5
	Oedicerotidae	13
	Paguridae	81
	Parthenopidae	1
	Photidae	32
	Phoxocephalidae	71
	Pinnotheridae	13
	Stenothoidae	17
	Tanaissuidae	40
	Unciolidae	40
	Upogebiidae	1
	Xanthidae	29
Arthropoda Total		2474

Table 4-3. Continued.

Phylum	Family	Abundance (total number of individuals per 0.008 m²)
Mollusca	Acteocinidae	41
	Arcidae	22
	Astartidae	39
	Busyconidae	1
	Calyptraeidae	367
	Cerithiopsidae	18
	Chaetopleuridae	24
	Columbellidae	387
	Corambidae	6
	Crassatellidae	5
	Lyonsiidae	37
	Mactridae	31
	Mangeliidae	3
	Margaritidae	8
	Muricidae	3
	Myidae	1
	Mytilidae	5
	Nassariidae	18
	Naticidae	8
	Nuculidae	50
	Pandoridae	3
	Pectinidae	2
	Pharidae	18
	Pyramidellidae	380
	Semelidae	1
	Tellinidae	518
	Veneridae	3
	Yoldiidae	9
Mollusca Total		2008

Table 4-3. Continued.

Phylum	Family	Abundance (total number of individuals per 0.008 m^2)
Chordata	Harrimaniidae	1
Cnidaria	Alcyoniidae	1
	Edwardsiidae	1
	Halcampidae	3
Cnidaria Total		5
Echinodermata	Amphiuridae	5
	Echinarachniidae	11
Echinodermata Total		16
Nematoda	Nematoda	1333
Nemertea	Amphiporidae	21
	Carinomidae	7
	Lineidae	6
	Tetrastemmatidae	4
	Tubulanidae	6
Nemertea Total		44
Platyhelminthes	Turbellaria	13

5.0 References

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Appendix A

Macroinvertebrate Data

Appendix Table A. Benthic macroinvertebrate counts (per 0.008 m²) collected during the Vineyard Wind cable route survey; Sept., 2017.

		Station																		
		1	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Annelida	Ampharetidae		1		1		1						2					1	2	2
	Archiannelida		16	3						4	1									
	Capitellidae	11	10		6					1	5		1				2	24		
	Chaetopteridae																			
	Cirratulidae		1			6	108	1		1			3	1				5		14
	Dorvilleidae						14													
	Glyceridae			2			1											1		
	Hesionidae				1		1													
	Lumbrineridae		1										2							4
	Magelonidae										1									
	Maldanidae	1		2	1		1			2									1	
	Nephtyidae			2				2	1	2	1	1	6	2				2	2	
	Oenonidae																			
	Oligochaeta	13	14	1	14	30	31				3							93	1	
	Onuphidae													1						
	Opheliidae																			
	Orbiniidae		1																	
	Oweniidae																			
	Paraonidae		2				45			1	1									
	Pectinariidae				1															
	Phyllodocidae		1			11	6	2											2	1
	Pilargidae			1	1		1													
	Polynoidae					12	2	1												2
	Sabellaridae																			
	Sigalionidae									2						1				
	Sphaerodoridae																			
	Spionidae	19	2			7	19				1			1						2
	Syllidae	1	8	1		7	9	2		3								6		6
	Terebellidae		5	2		1	11			9						1	2	2		

(continued)

Appendix Table A. (Continued)

		Station																		
		1	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Arthropoda	Ampeliscidae										4			1				5	4	1
	Anthuridae								2											
	Aoridae	4				31	2													3
	Argissidae																			
	Bateidae					1	22													1
	Bathyporeiidae			4						2										
	Bodotriidae							3			1		1							
	Callianassidae									1										
	Cancridae							1												
	Caprellidae	8	9	2		1		10											1	
	Corophiidae	1				7														
	Diastylidae			2	2			2	2			1	1						1	
	Epialtidae																			
	Haustoriidae										2	2			2					
	Idoteidae																			1
	Inachoididae																		1	
	Ischyroceridae		1																	
	Janiridae					12	10	2												1
	Leptocheliidae					1														
	Liljeborgiidae							1		2	1				1					
	Lysianassidae	1																		2
	Maeridae						2													2
	Mysidae					1	1													
	Oedicerotidae		1	1	1			2			1	1	2							
	Paguridae			1			1	1											1	2
	Parthenopidae						1													
	Photidae																			8
	Phoxocephalidae			2			6	3		4	4		1	8	1		3			2
	Pinnotheridae									3	3	1	1		1					

(continued)

Appendix Table A. (Continued)

		Station																		
		1	2	3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arthropoda (cont'd)	Stenothoidae							3												
	Tanaissuidae														5	1				
	Unciolidae		1	1			3								1				1	
	Upogebiidae																			
	Xanthidae	2				11	4	1										1		1
Chordata	Harrimaniidae						1													
Cnidaria	Alcyoniidae																			
	Edwardsiidae							1												
	Halcampidae		1																	
Echinodermata	Amphiuridae						1													
	Echinarachniidae																			
Mollusca	Acteocinidae		24																	
	Arcidae	1				5		2												
	Astartidae																			
	Busyconidae						1													
	Calyptraeidae	9				181	6	31											1	59
	Cerithiopsidae		11			3	1	1												
	Chaetopleuridae					2	1													1
	Columbellidae	1	1			14	4	48											1	13
	Corambidae																			
	Crassatellidae			1			1												1	1
	Lyonsiidae			4															1	
	Mactridae																			
	Mangeliidae														1					
	Margaritidae																			
	Muricidae					1														
	Myidae																			
	Mytilidae																			
	Nassariidae														1					

(continued)

Appendix Table A. (Continued)

		Station																		
		1	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Mollusca (cont'd)	Naticidae																			1
	Nuculidae				1	1	2													
	Pandoridae																			
	Pectinidae					1	1													
	Pharidae							1												1
	Pyramidellidae	3	2	3		167		106		2	2			3					1	33
	Semelidae																			1
	Tellinidae		2	1				5	1	1	1	4	2	4	1				7	
	Veneridae																			
	Yoldiidae																			
Nematoda	Nematoda	10	21	26	8	97	68	8	12	17			12	2	6	15	4	43	3	5
Nemertea	Amphiporidae						1			1										
	Carinomidae						1													
	Lineidae							1											1	
	Tetrastemmatidae						1													
	Tubulanidae																			
Platyhelminthes	Turbellaria					1	2			3										

(continued)

Appendix Table A. (Continued)

		Station																			
		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Annelida	Ampharetidae	1		2									1						1	7	
	Archiannelida							1	1											2	1
	Capitellidae					6	160	6	3			27					65	39		6	
	Chaetopteridae											1	1								
	Cirratulidae	4		2			1	4	3			2					1		4		
	Dorvilleidae																				
	Glyceridae			1	3		2	1		1	4	1				6	1			1	
	Hesionidae																				
	Lumbrineridae	2		4			1		1	1		1					1	3		6	
	Magelonidae								12						1						
	Maldanidae						8			1	1		1					3	1	6	
	Nephtyidae				1		4	14	5	3		2				1	3	1	2	3	
	Oenonidae																				
	Oligochaeta	6		12			18	9	1			12	1				4	1	7	14	
	Onuphidae																				
	Opheliidae																				11
	Orbiniidae								1	1								1			
	Oweniidae			1			1														
	Paraonidae																				
	Pectinariidae																				
	Phyllodocidae	1		5				1		1		2	1				1	1		10	
	Pilargidae																				
	Polynoidae	3		1																	
	Sabellaridae	1		2																	
	Sigalionidae																			9	2
	Sphaerodoridae																				
	Spionidae	1	1	89				1	1							2	1	1	1	4	2
	Syllidae	14		12				1				1							2	5	4
	Terebellidae	2		2															2	65	2

(continued)

Appendix Table A. (Continued)

		Station																			
		21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Arthropoda	Ampeliscidae	1					10	1		49	69	59	68			1	100	245			
	Anthuridae													1							
	Aoridae	2																			
	Argissidae																				
	Bateidae	2																			
	Bathyporeiidae								1												
	Bodotriidae																				
	Callianassidae							1	1												
	Cancridae			1																1	
	Caprellidae	6		1146		1		1													
	Corophiidae			2																	
	Diastylidae													1							
	Epialtidae				1																
	Haustoriidae								2					1	5	2		1			
	Idoteidae																				
	Inachoididae			1																	
	Ischyroceridae			20																	
	Janiridae			1																	
	Leptocheliidae																				
	Liljeborgiidae																				
	Lysianassidae	4																			
	Maeridae			4																	
	Mysidae																				
	Oedicerotidae							1													
	Paguridae	4		34						1			1								
	Parthenopidae																				
	Photidae	3		4																	
	Phoxocephalidae	5						2	3						4						
	Pinnotheridae											1		1			2				

(continued)

Appendix Table A. (Continued)

		Station																			
		21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Arthropoda (cont'd)	Stenothoidae	2		10																	
	Tanaissuidae														11						
	Unciolidae	2	1	3							1				1					1	
	Upogebiidae																1				
	Xanthidae			1							1									4	
Chordata	Harrimaniidae																				
Cnidaria	Alcyoniidae								1												
	Edwardsiidae																				
	Halcampidae			1																1	
Echinodermata	Amphiuridae						2		1		1										
	Echinarachniidae																				
Mollusca	Acteocinidae						1			2	2		2					10			
	Arcidae	6																		7	
	Astartidae																				6
	Busyconidae																				
	Calyptraeidae	13		3							3					2				18	
	Cerithiopsidae	1																			
	Chaetopleuridae	1																		18	
	Columbellidae	30		174	6		1	6	1		5										
	Corambidae	1																			
	Crassatellidae																				
	Lyonsiidae						2			2		4						5		16	1
	Mactridae															1					1
	Mangeliidae							1			1										
	Margaritidae			1																6	
	Muricidae																				
	Myidae																				
	Mytilidae			3																	
	Nassariidae						1	3	1	3	3	3	2								

(continued)

Appendix Table A. (Continued)

		Station																			
		21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Mollusca (cont'd)	Naticidae							1												6	
	Nuculidae												1								
	Pandoridae						1												1		
	Pectinidae																				
	Pharidae						3		1	1	2						3	2	1	1	
	Pyramidellidae			1			10			3	1		2	1						6	
	Semelidae																				
	Tellinidae	1		1	10		114	20	37	28	41	24	11	1	8	1	56	104	9	6	
	Veneridae							1										1			
	Yoldiidae											1					1	2			
Nematoda	Nematoda	33	10	39	19	1	7	1			1	7			1	22	2	1	26	171	8
Nemertea	Amphiporidae	4			6													1			
	Carinomidae			2																	
	Lineidae	1			1			1		1											
	Tetrastemmatidae			3																	
	Tubulanidae						1										2	1			
Platyhelminthes	Turbellaria		1																	1	

(continued)

Appendix Table A. (Continued)

		Station																			
		43	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**
Annelida	Ampharetidae					2		1	1										3	3	
	Archiannelida								14	15	21	13	6		4				22	11	
	Capitellidae	1					1		4				1	5		2		2	1		
	Chaetopteridae																				
	Cirratulidae		2			6			5	1		7		5	1	20					
	Dorvilleidae		2									1	1	3					1		
	Glyceridae		2	2			1				1						4				
	Hesionidae																				
	Lumbrineridae							3	1	2	5	1							2	5	
	Magelonidae													20							
	Maldanidae										1	1	1							9	
	Nephtyidae												6	10	3			1	2		
	Oenonidae																			1	
	Oligochaeta		4			1			2	2	1	28	25	37		9		78	7	1	
	Onuphidae																				
	Opheliidae																1				
	Orbiniidae							1	2		1	1								1	
	Oweniidae																				
	Paraonidae								2	2		2	15			4			2		
	Pectinariidae																				
	Phyllodocidae					5			2							1		2			
	Pilargidae																				
	Polynoidae					4									1			1			
	Sabellaridae					50												1			
	Sigalionidae			1	5	1										1					
	Sphaerodoridae												2								
	Spionidae		4			5		1	1				1	2				1			
	Syllidae		10	9	4	20		5	2	2		9	22	6			1	3			
	Terebellidae		1	1		6			1												

(continued)

Appendix Table A. (Continued)

		Station																			
		43	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**
Arthropoda	Ampeliscidae							16	19	11	30					1				4	
	Anthuridae																				
	Aoridae					3															
	Argissidae										1										
	Bateidae																				
	Bathyporeiidae													7							
	Bodotriidae																				
	Callianassidae																				
	Cancridae																				
	Caprellidae										1				1					1	
	Corophiidae					1															
	Diastylidae										1									1	
	Epialtidae																				
	Haustoriidae													16			5				
	Idoteidae																				
	Inachoididae																				
	Ischyroceridae					1															
	Janiridae					2												1			
	Leptocheliidae																				
	Liljeborgiidae														1						
	Lysianassidae					4															
	Maeridae																				
	Mysidae																	3			
	Oedicerotidae											1			2						
	Paguridae					35															
	Parthenopidae																				
	Photidae					5					1							8		3	
	Phoxocephalidae					9			1	5	3	1			2	1				1	
	Pinnotheridae																				

(continued)

Appendix Table A. (Continued)

		Station																			
		43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
Arthropoda (cont'd)	Stenothoidae					2															
	Tanaissuidae												22	1							
	Unciolidae					24															
	Upogebiidae																				
	Xanthidae					1												2			
Chordata	Harrimaniidae																				
Cnidaria	Alcyoniidae																				
	Edwardsiidae																				
	Halcampidae																				
Echinodermata	Amphiuridae																				
	Echinarachniidae									1			5	5							
Mollusca	Acteocinidae																				
	Arcidae					1															
	Astartidae		2	15	15														1		
	Busyconidae																				
	Calyptraeidae					9												32			
	Cerithiopsidae																	1			
	Chaetopleuridae					1															
	Columbellidae		1			71												10			
	Corambidae			1		4															
	Crassatellidae			1																	
	Lyonsiidae													2							
	Mactridae			2	24				1		1			1							
	Mangeliidae																				
	Margaritidae					1															
	Muricidae																	2			
	Myidae						1														
	Mytilidae			1	1																
	Nassariidae								1												

(continued)

Appendix Table A. (Continued)

		Station																			
		43	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**	**61**	**62**
Mollusca (cont'd)	Naticidae																				
	Nuculidae							3	17		8	3				2				10	2
	Pandoridae													1							
	Pectinidae																				
	Pharidae												1		1						
	Pyramidellidae			2		12					1					1	1	17			
	Semelidae																				
	Tellinidae		1			1		1		1			1	2	3	4	2		1		
	Veneridae										1										
	Yoldiidae																			1	4
Nematoda	Nematoda	1	9	3	4	28	1	9	13	38	5	26	202	51	1	5	16	177	34	3	1
Nemertea	Amphiporidae					6									1			1			
	Carinomidae							1			3										
	Lineidae																				
	Tetrastemmatidae																				
	Tubulanidae					2															
Platyhelminthes	Turbellaria											3		2							

3. CR Environmental 2018 Underwater Video Review

CR ENVIRONMENTAL, INC.
Ecological and Oceanographic Consultants

MEMORANDUM

Date: July 12, 2018

To: Jeff Gardner, GEO SUBSEA

From: CR Environmental, Inc., 639 Boxberry Hill Road, East Falmouth, MA 02536

Re: Underwater Video Review Vineyard Wind Project, Proposed Export Cable Corridor, Nantucket Sound and Atlantic Ocean

CR Environmental, Inc. reviewed underwater video collected from 37 transects along the proposed Vineyard Wind corridors within Nantucket Sound and the Atlantic Ocean (Figure 1 - Export Cable Corridor). Video transect review included:

- Identification of the dominant fauna and its relative abundance,
- Bottom habitat classification based on Auster (1998),
- MA CZM modified Barnhardt et al. (1998) bottom type classification.
- The potential for Special, Sensitive or Unique Resources, and
- Presence/absence data for biota observed.

Auster (1998) developed a hierarchical approach for classifying marine bottom habitats in the outer continental shelf of the northwest Atlantic. Sediments are classified along a gradient of grain sizes from mud to boulders. The eight general habitat categories are ranked by Auster (1998) based on their complexity and effectiveness in providing habitat, attachment surfaces and shelter for a variety of marine plants and animals. Those with the *highest rankings are pebble-cobble with sponge, partially buried or dispersed boulders and piled boulders* (Table 1). The various forms these bottom habitats take and the infauna and epifauna associated with the sediments produce a wide diversity of habitat types for fish and associated fauna.

The bottom classifications based on a MACZM modified Barnhardt et al. (1998) sediment classification scheme are: Fine, Fine with Gravel, Fine with Rock, Gravel with Fine, Gravel, Gravel with Rock, Rock with Fine, and Rock.

Massachusetts CZM Special, Sensitive or Unique Resources (SSUs) include resources such as eelgrass beds and hard complex bottom (Figure 1).

RESULTS

Each of the 37 video transects were approximately fifteen minutes in length. Table 2 provides the primary bottom habitat classification observed at each video transect based on Auster (1998) (Table 1). A secondary bottom classification is provided for alternate bottom types observed over at least 25% of the video based on time lapse. Otherwise no secondary bottom class is reported. In addition, Table 2 provides MACZM's modified Barnhardt et al. (1998) sediment classification scheme, the dominant faunal species observed, and identifies transects where Special, Sensitive or Unique Areas (SSUs) may be present. The centroid coordinates for each transect and water depth in meters below mean lower low water (MLLW) at each centroid is also provided.

A list of flora and fauna observed by transect along with summary statistics of species richness by transect and frequency across transects are provided on Table 3.

The primary bottom classification (Auster 1998) for each video transect along the Export Cable Corridor is graphically represented on Figure 2. Figure 3 is a graphical representation of the dominant fauna observed on each transect.

<u>Bottom Habitat Classification Results</u>

- Approximately 67% of transects predominantly along the northern and southern portions of the Export Cable Corridor consisted of low complexity bottom habitats with a primary bottom classification of Flat Sand Mud, Sand Waves, or Biogenic Structures (Figure 2). At these stations, the fewest invertebrate species and only rare observations of fish were recorded. Areas of observed Sand Waves were the least productive of all habitats. Note that the number of transects identified as having sand waves may be underestimated as they were difficult to detect on the underwater video. Project side scan records may more accurately detect their presence.

- Shell Aggregate bottom was observed as the primary or secondary habitat at 10 Transects or 27%.

- Pebble Cobble bottom was observed as a component of the primary or secondary habitat at 9 transects or 24%.

- Higher complexity bottom types included, Pebble Cobble with Sponge observed at T-48, T-52, T-54, and T-55, and Partially Buried or Dispersed Boulders observed at T-49 and T-75. No Piled Boulders or Rock Ledge bottom habitat was observed along the video transects.

- The most productive transects with the highest number of invertebrate species and observations of fish tended to be in areas with large colonies of sulfur sponge and in areas with partially buried or dispersed boulders in the vicinity of Muskeget Channel.

- Three transects with Pebble Cobble with Sponge (sulfur sponge) bottom habitat (T-48, T-52, and T-54), one transect T-75 with dispersed boulders and blue mussels have been flagged as potential Special, Sensitive, or Unique Areas (SSUs) because of their biological communities, vertical relief and energetic stability. The *possible* SSU designation was based on the complexity of bottom habitat and the observation of more abundant biota along these transects.

  Sulfur sponge starts growing on shells and small pebbles that eventually dissolve. Many times these large colonies of sulfur sponge were 3 to 4 feet in height and were not associated with any cobble or boulder bottom appearing to grow right out of the sand. These large colonies were usually found in high current areas and appeared to provide good fish habitat.

- Floating eelgrass strands were observed at five transects (14%), however, no eelgrass SSUs were identified. At T-52, rooted eelgrass was initially recorded. However, upon further observation, the strands were determined to be dead eelgrass that had became embedded in shell or pebbles on the bottom. These observations were also confirmed by the black blade color and the water depths in excess of 30 feet. No eelgrass beds with dense eelgrass growth were observed during the survey.

<u>Biota Results</u>

In addition to the dominant habitats listed in Table 2, the dominant fauna at each transect are listed. Four-eyed amphipods and slipper limpets were the dominant species at 7 transects (19%), and sulfur sponge at 5 transects (14%). The remaining dominant species at 2-3 transects were sedentary polychaetes, knobbed whelk, red beard sponge, four-eyed amphipods, bryozoans, burrowing anemones, and sand dollars. Blue mussel, spider crabs, and plumed worms were dominant at only one transect. Burrowing anemones and sand dollar were dominant in deeper waters at the southern end of the Export Cable Corridor.

Table 3 is a list of invertebrates, fish, and algal species found at each transect, species richness for each transect, and species percent frequency across the 37 transects of the Export Cable Corridor.

- A total of 29 invertebrates, 4 fish, and approximately 4 algal species were observed during the video review.

- Three transects (T-49, T-52, T-54) all within the Muskeget Channel had the greatest species richness (8-9 faunal species)

- Frequencies along the corridor of over 20% were observed for: three invertebrate species: red beard sponge, encrusting bryozoan, and sedentary polychaetes; and the algae: dead man's fingers, *Sargassum*, and branching red algae.

  Red branching algae was observed at 49% of the transects and this general classification represents 4 to 5 different species of bushy red seaweeds 1-2 feet in length and 2 to 3 species of tuft-like algae 3-4 inches in height that were attached to pebble-cobbles and shell.

- Commercial species: Knobbed whelks and their egg cases were the only commercial invertebrate species recorded in significant numbers. Bay scallops, blue mussels, rock crabs, and Jonah crabs were observed in low numbers. Sea scallop shells were noted at a few stations but these are likely associated with shucking outside the harbor entrances. Of the commercial fish species observed: scup, black sea bass, and red hake; only scup were noted at a significant number of transects (19%).

General Observations along the Proposed Export Cable Corridor

- The more complex and species rich habitats, Pebble Cobble with Sponge and areas of Partially Buried Boulders or Dispersed Boulders tend to be found within the higher currents of Muskeget Channel.

- Offshore at the southern end of the proposed Export Cable Corridor there were a variety of species associated with deeper water including sand dollars, burrowing anemones and mysid shrimp.

References

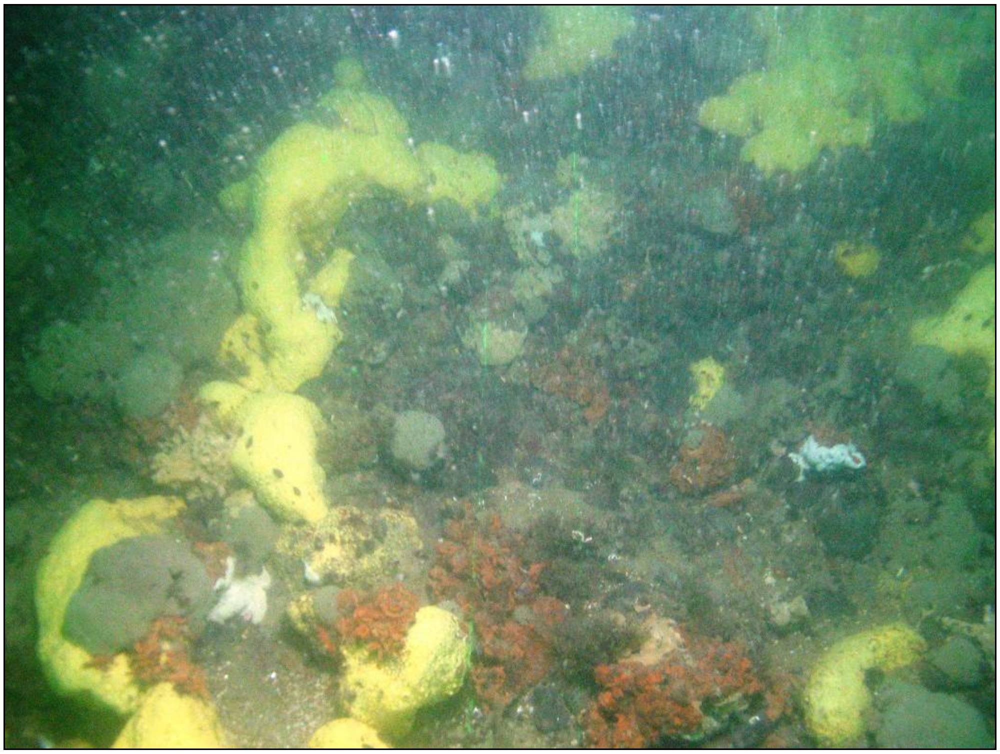
Auster, P.J. 1998. *The conceptual model of the impacts of fishing gear on the integrity of fish habitat.* Conservation Biology V12 (6): 1198-1203.

Barnhardt, W.A., J.T. Kelley, S.M. Dickson, and D.F. Belknap. 1998. *Mapping the Gulf of Maine with Side-Scan Sonar: A New Bottom-Type Classification for Complex Seafloors.* Journal of Coastal Research.14(2): 646-659.

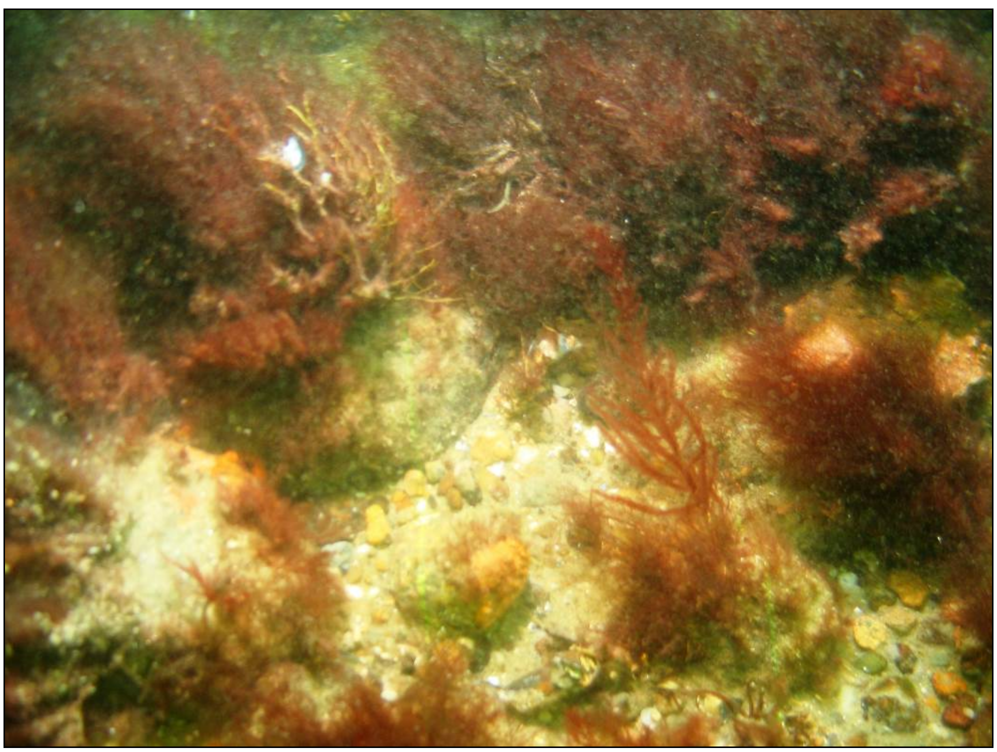
Screen Captures of Bottom Classifications (Auster, 1998) in Areas of Potential SSUs

Transect 48 – The primary bottom classification was pebble cobble with sponge, with some large sulfur sponge (*Cliona celata*) colonies, common sea stars (*Asterias forbesi*), hydroids and abundant attached red and brown algae.

Transect 52 – Flat sand, Mud/Pebble cobble was the primary bottom classification and Pebble cobble with sponge (*Cliona celata*) was the secondary bottom classification. Black sea bass, blue mussels, sand sponge (*Amaroucium* sp.), hermit crabs and hydroids were present.



Transect 54 – The primary bottom classification was Pebble cobble with sponge, and secondary of Flat sand, Mud/Pebble cobble. Present were sulfur sponge, red beard sponge (*Microciona prolifera*), sand sponge, bread crumb sponge (*Holichondria panacea*) black sea bass, and common sea star.



Transect 75 – The primary bottom classification was Flat sand, Mud/ Pebble cobble with a secondary classification of partially buried or dispersed boulders. Present were bread crumb and red beard sponges, bryozoans, hydroids, slipper limpets, hermit crabs, purple sea urchin, and branching red algae.

TABLE 1. Bottom Habitat Classification (Auster, 1998)

Habitat Category	Description	Rationale	Complexity Score
1	Flat sand/mud	Areas with no vertical structure such as depressions, ripples or epifauna	1
2	Sand waves	Troughs provide shelter from current; previous observations indicate that species such as red hake hold position on the downcurrent sides of sand waves and ambush drifting demersal zooplankton and shrimp	2
3	Biogenic structures	Burrows, depressions, cerianthid anemones, hydroid patches; features that are created or used by mobile fauna for shelter	3
4	Shell aggregates	Provide complex interstitial spaces for shelter; also provide a complex, high-contrast background that may confuse visual predators	4
5	Pebble-cobble	Provide small interstitial spaces and may be equivalent in shelter value to shell aggregate, but less ephemeral than shell	5
6	Pebble-cobble with sponge cover	Attached fauna such as sponges provide additional spatial complexity for a wider range of size classes of mobile organisms	10
7	Partially buried or dispersed boulders	Partially buried boulders exhibit high vertical relief; dispersed boulders on cobble pavement provide simple crevices; the shelter value of this type of habitat may be less or greater than previous types based on the size class and behavior of associated species	12
8	Piled boulders	Provide deep interstitial spaces of variable sizes	15

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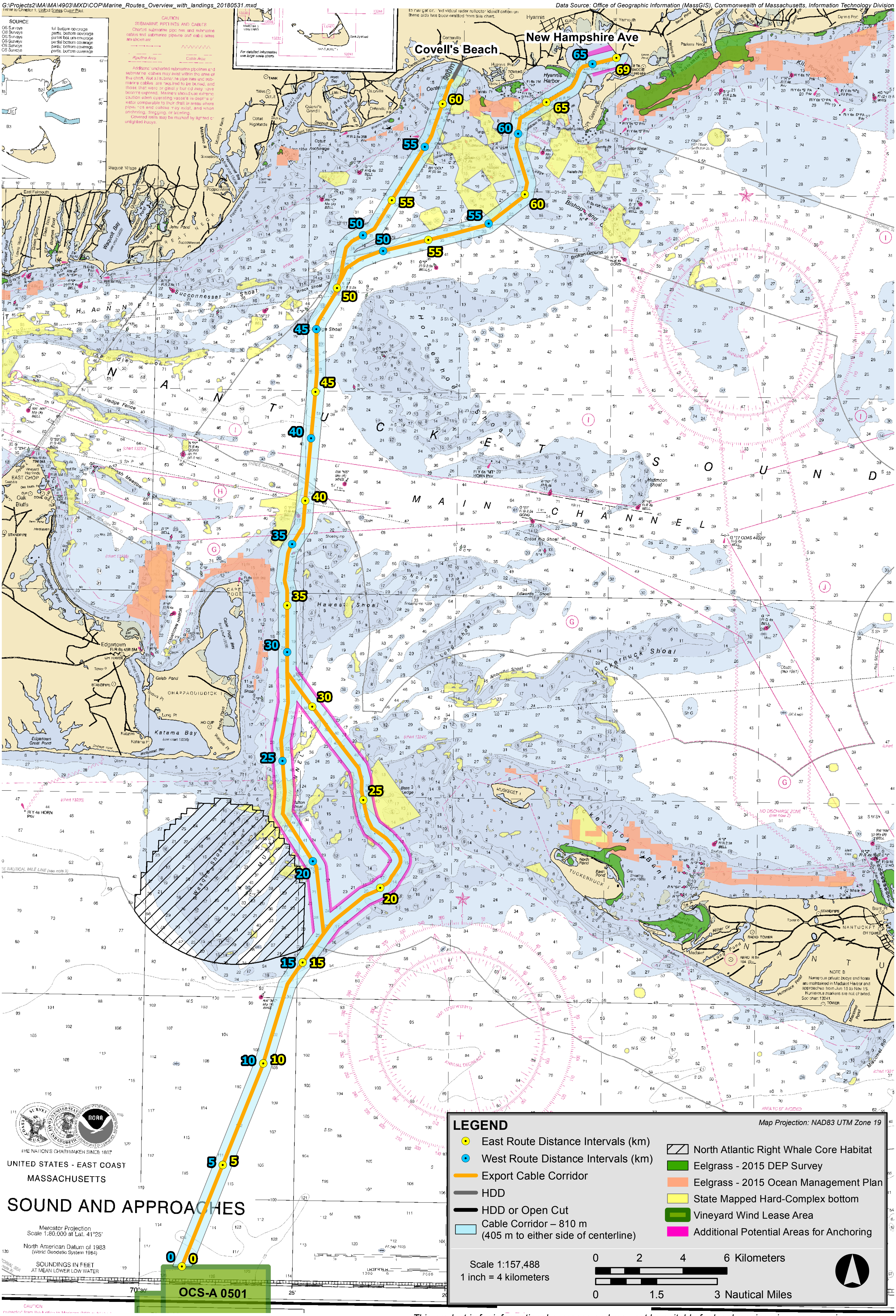
Data Source: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division



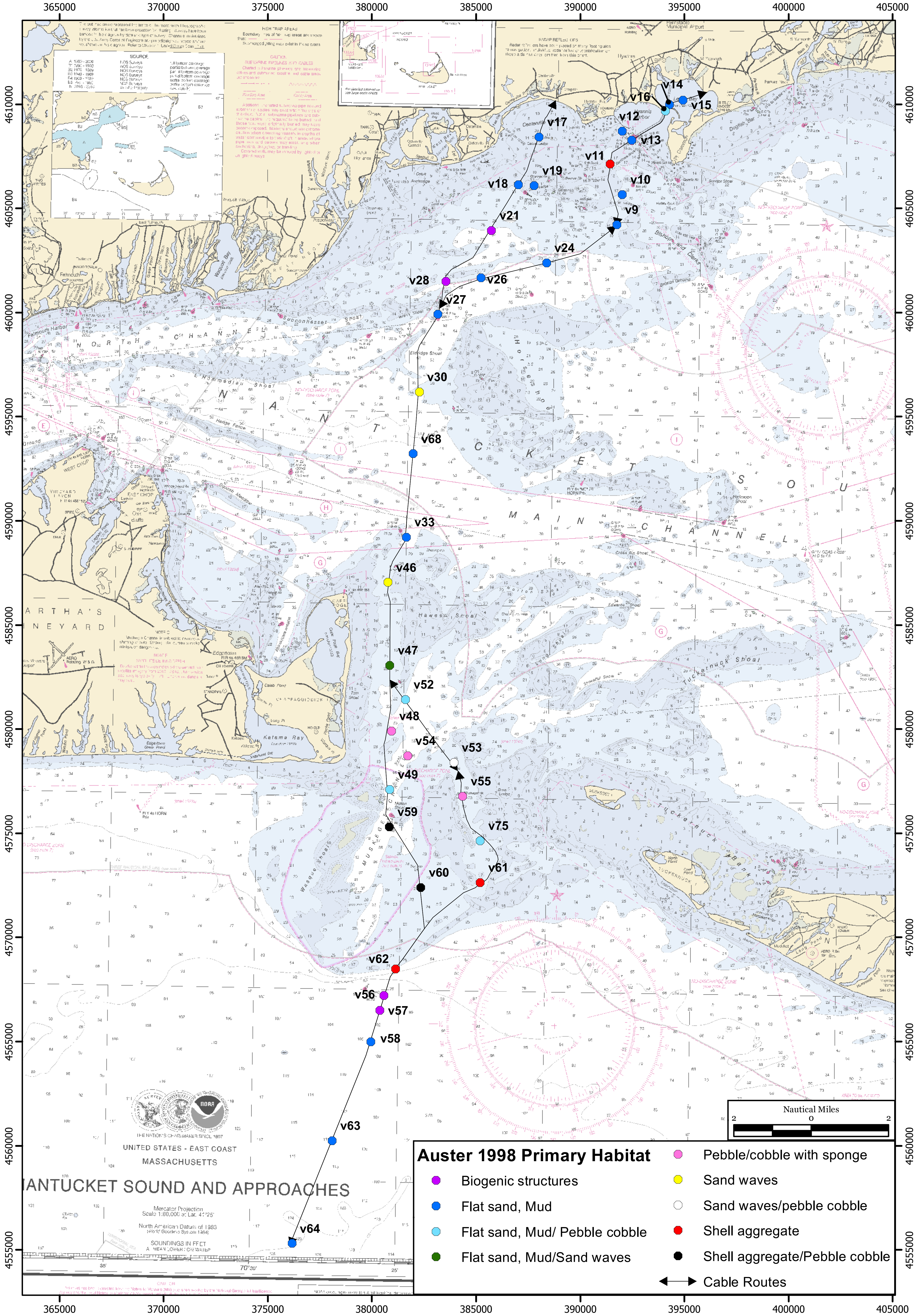
This product is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Vineyard Wind Project

VINEYARD WIND

Figure 1

Export Cable Corridor



Transect Primary Habitat Classification (Auster, 1998) Vineyard Wind Project Nantucket Sound and Atlantic Ocean	N W E S
NOTES: 1) Underwater video data collected September 1-9, 2017. 2) Grid: UTM, Zone 19N, NAD83, metric.	Figure 2

CR
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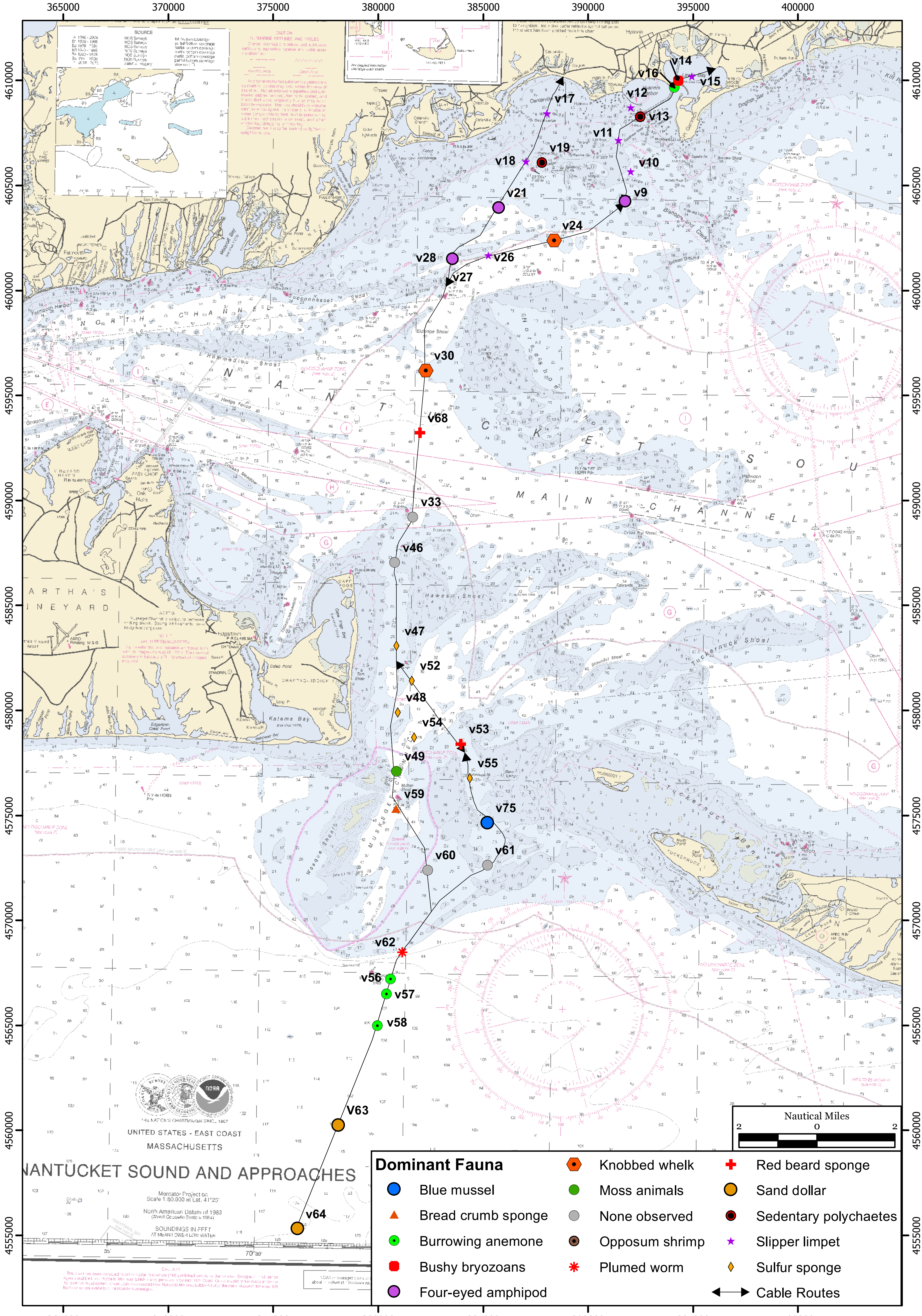

Transect Dominant Species
Vineyard Wind Project
Nantucket Sound and Atlantic Ocean

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NOTES:
1) Underwater video data collected September 1-9, 2017.
2) Grid: UTM, Zone 19N, NAD83, metric.

Figure 3

Transect ID	POINT_X[2]	POINT_Y[2]	Dominant_Fauna		Abundance of Dominant Spp.	Auster (1998) - primary	Auster (1998) -secondary[3]	CZM - Barnhardt et. al (1998)	Eelgrass	SSUs[5]	Depth (m) Below MLLW [2]
9	391766	4604244	Four-eyed amphipod	*Ampelisca sp.*	Rare	Flat sand, Mud		Fine	Absent	Absent	6.49
10	392025	4605680	Slipper limpet	*Crepidula fornicata*	Occasional	Flat sand, Mud	Shell aggregate/ Pebble cobble	Fine	Absent	Absent	7.58
11	391450	4607157	Slipper limpet	*Crepidula fornicata*	Abundant	Shell aggregate		Fine	Absent	Absent	5.54
12	392033	4608726	Slipper limpet	*Crepidula fornicata*	Common	Flat sand, Mud	Shell aggregate	Fine	Absent	Absent	4.48
13	392485	4608287	Sedentary polychaetes[1]	Polychaeta	Occasional	Flat sand, Mud		Fine	Absent	Absent	5.19
14	394296	4610004	Bushy bryozoans	*Bryozoa*	Rare	Flat sand, Mud		Fine	Floating strands	Absent	2.37
15	394948	4610218	Slipper limpet	*Crepidula fornicata*	Occasional	Flat sand, Mud		Fine	Absent	Absent	3
16	394106	4609686	Burrowing anemone	*Cerianthus borealis*	Occasional	Flat sand, Mud/Pebble cobble		Fine with gravel	Absent	Absent	2.63
17	388032	4608443	Slipper limpet	*Crepidula fornicata*	Abundant	Flat sand, Mud	Flat sand, Mud/Shell Aggregate	Fine	Floating strands	Absent	4.78
18	387047	4606148	Slipper limpet	*Crepidula fornicata*	Common	Flat sand, Mud	Flat sand, Mud/Shell Aggregate	Fine	Absent	Absent	4.92
19	387791	4606115	Sedentary polychaetes	*Polychaeta*	Common	Flat sand, Mud	Sand ripples	Fine	Absent	Absent	3.31
21	385748	4603955	Four-eyed amphipod	*Ampelisca sp.*	Common	Biogenic structures		Fine	Absent	Absent	9.54
24	388388	4602405	Knobbed whelk	*Busycon carica*	Occasional	Flat sand, Mud	Sand ripples	Fine	Absent	Absent	8.89
26	385245	4601687	Slipper limpet	*Crepidula fornicata*	Abundant	Flat sand, Mud	Flat sand, Mud/Shell Aggregate	Fine	Absent	Absent	11.78
27	383168	4599929	Spider crab	*Lubinia emarginata*	Rare	Flat sand, Mud	Biogenic structures	Fine	Absent	Absent	15.54
28	383556	4601512	Four-eyed amphipod	*Ampelisca sp.*	Common	Biogenic structures	Flat sand, Mud/Biogenic structures	Fine	Absent	Absent	6.7
30	382278	4596201	Knobbed whelk	*Busycon carica*	Rare	Sand waves[4]	Flat sand, Mud	Fine	Absent	Absent	8.88
33	381657	4589231	None observed			Flat sand, Mud	Sand ripples	Fine	Absent	Absent	9.34
46	380780	4587057	None observed			Sand waves	Flat sand, Mud	Fine	Absent	Absent	7.33
47	380869	4583082	Sulfur sponge	*Cliona celata*	Occasional	Flat sand, Mud/Sand waves	Pebble cobble	Fine with gravel	Absent	Absent	8.6
48	380944	4579925	Sulfur sponge	*Cliona celata*	Abundant	Pebble/cobble with sponge		Gravel with rock	Absent	**Possible**	9.54
49	380872	4577119	Moss animals	*Bryozoa*	Common	Flat sand, Mud/Pebble cobble	Flat sand, Mud/Partially buried or dispersed Boulders	Fine with rock	Absent	Absent	29.8
52	381615	4581435	Sulfur sponge	*Cliona celata*	Abundant	Flat sand, Mud/Pebble cobble	Pebble cobble with sponge	Fine with gravel	Floating strands	**Possible**	12.49
53	383940	4578412	Red beard sponge	*Microciona prolifera*	Occasional	Sand waves/Pebble cobble		Fine with gravel	Floating strands	Absent	11.8
54	381719	4578731	Sulfur sponge	*Cliona celata*	Abundant	Pebble/cobble with sponge	Flat sand, Mud/Pebble/cobble	Fine with gravel	Absent	**Possible**	14.69
55	384360	4576786	Sulfur sponge	*Cliona celata*	Abundant	Pebble/cobble with sponge	Flat sand, Mud/Pebble cobble	Fine with gravel	Absent	Absent	9.98
56	380583	4567222	Burrowing anemone	*Cerianthus borealis*	Occasional	Biogenic structures		Fine	Absent	Absent	29.6
57	380394	4566508	Burrowing anemone	*Cerianthus borealis*	Common	Biogenic structures		Fine	Absent	Absent	30.32
58	379964	4564996	Burrowing anemone	*Cerianthus borealis*	Common	Flat sand, Mud		Fine	Absent	Absent	32.7
59	380844	4575326	Bread crumb sponge	*Halichondria panicea*	Common	Shell aggregate/Pebble cobble		Fine with gravel	Absent	Absent	14.6
60	382351	4572408	None observed			Shell aggregate/Pebble cobble		Fine with gravel	Absent	Absent	9.35
61	385204	4572643	None observed			Shell aggregate		Fine	Absent	Absent	6.76
62	381142	4568488	Plumed worm	*Diopatra cuprea*	Rare	Shell aggregate		Fine	Absent	Absent	12.49
63	378105	4560247	Sand dollar	*Echinoarachnius parma*	Abundant	Flat sand, Mud		Fine	Absent	Absent	33.92
64	376170	4555316	Sand dollar	*Echinoarachnius parma*	Abundant	Flat sand, Mud		Fine	Absent	Absent	37.86
68	381988	4593233	Red beard sponge	*Microciona prolifera*	Rare	Flat sand, Mud		Fine	Absent	Absent	10.04
75	385212	4574654	Blue mussel	*Mytilis edulis*	Common	Flat sand, Mud/Pebble cobble	Partially buried or dispersed Boulders	Fine with gravel	Floating strands	**Possible**	7.12

References:

Auster, P.J. 1998. The conceptual model of the impacts of fishing gear on the integrity of fish habitat. Conservation Biology V12 (6): 1198-1203.

Barnhardt, W.A., J.T. Kelley, S.M. Dickson, and D.F. Belknap. 1998. Mapping the Gulf of Maine with Side-Scan Sonar: A New Bottom-Type Classification for Complex Seafloors. Journal of Coastal Research.14(2): 646-659.

Notes:

1) Sedentary polychaetes = observed worm holes
2) Location coordinates and depth in meters below MLLW are at the centroid of the ~ 15 minute video transects
3) A secondary bottom classification for transects is provided for alternate bottom types observed over at least ~25% of the video based on time lapse. Otherwise none is reported.
4) Sand waves not always able to be detected on video segments refer to side scan record
5) Designation of possible SSUs based on complexity of bottom habitat and the presence of more abundant biota

TRANSECT ID		**T-9**	**T-10**	**T-11**	**T-12**	**T-13**	**T-14**	**T-15**	**T-16**	**T-17**	**T-18**
FAUNA											
PORIFERA											
Bread crumb sponge	*Halichondria panicea*						X				
Red beard sponge[3]	*Microciona prolifera*		X								
Sulfur sponge	*Cliona celata*										
CNIDARIA											
Bell shaped jellyfish											
Burrowing anemone	*Cerianthus borealis*										
Star Coral	*Astrangia poculata*										
Hydroid	Hydrozoa										
CTENOPHORA	Ctenophora										
BRYOZOA											
Bushy bryozoan	Bryozoa						X				
Encrusting bryozoan	*Schizoporella unicornis*		X	X	X	X			X		X
MOLLUSCA											
Bay Scallop	*Argopecten irradians*							X		X	
Blue mussel	*Mytilis edulis*										
Knobbed whelk*[1]	*Busycon carica*		X						X		
Knobbed whelk egg case*	*Busycon carica*		X								
Moon snail	Naticidae										
Slipper limpet	*Crepidula fornicata*		X	X	X		X	X	X		
Threeline Mudsnail	*Ilyanassa trivittata*	X									
ANNELIDA											
Polychaeta											
Lug worm	*Arenicola sp.*						X				X
Plumed worm	*Diopatra cuprea*									X	
Sedentary polychaetes	Polychaeta	X				X					X
ARTHROPODA											
Crustacea											
Barnacle	*Balanus* sp.								X		
Four-eyed amphipod	*Ampelisca sp.*	X									
Hermit crab	*Pagurus sp.*	X						X			X
Jonah crab*	*Cancer borealis*										
Mysid shrimp	Mysids										
Rock crab	*Cancer irroratus*										
Spider crab	*Lubinia emarginata*		X								
Echinoderms											
Common sea star	*Asterias forbesi*										
Sand dollar	*Echinarachnius parma*										
Purple sea urchin	*Arbacia punctulata*										
VERTEBRATA											
Elasmobrachiomorphi											
Little Skate egg case*	*Raja erinacea*										
Little Skate*	*Raja erinacea*									X	
Osteichthyes											
Black sea bass*	*Centropristis striata*										
Red Hake*	*Urophycis chuss*										
Scup*	*Stenotomus chrysops*	X	X								
CHORDATA											
Sand Sponge	*Amaroucium sp.*										
White invasive tunicate	*Didemnum candidum*										
SPECIES RICHNESS FAUNA[2]		5	7	2	2	2	4	3	5	3	4
FLORA											
CHLOROPHYTA											
Dead Man's Fingers	*Codium fragile*		X	X	X	X	X	X	X	X	X
Sea Lettuce	*Ulva lactuca*				X						
PHAEOPHYTA											
Rockweed	*Fucus* sp.					X					X
Sargassum	*Sargassum sp.*		X	X	X	X	X		X	X	
RHODOPHYTA											
Branching red alga	Rhodophyta	X	X	X	X			X	X	X	X
SPECIES RICHNESS FLORA[2]		1	3	3	4	3	2	2	3	3	3
Water depth (m) below MLLW at transect centroid		6.49	7.58	5.54	4.48	5.19	2.37	3	2.63	4.78	4.92

Notes:

1) An * designates species selected for assessment of 'important fish resource areas' an SSU under the Mass. Ocean Management Plan

2) Species Richness = the total number of species observed

3) Species with a frequency across all transects greater than 20% are bolded and shaded

TRANSECT ID	T-19	T-21	T-24	T-26	T-27	T-28	T-30	T-33	T-47	T-48	T-49	T-52	T-53
FAUNA													
PORIFERA													
Bread crumb sponge											X		
Red beard sponge[3]							X				X		X
Sulfur sponge									X	X	X	X	
CNIDARIA													
Bell shaped jellyfish						X		X					
Burrowing anemone						X							
Star Coral													
Hydroid										X	X	X	X
CTENOPHORA								X		X		X	
BRYOZOA													
Bushy bryozoan											X		X
Encrusting bryozoan				X					X	X	X	X	X
MOLLUSCA													
Bay Scallop									X				
Blue mussel												X	
Knobbed whelk*[1]			X				X						
Knobbed whelk egg case*		X											
Moon snail													
Slipper limpet													
Threeline Mudsnail													
ANNELIDA													
Polychaeta													
Lug worm													
Plumed worm													
Sedentary polychaetes	X	X		X	X	X							
ARTHROPODA													
Crustacea													
Barnacle											X		X
Four-eyed amphipod					X								
Hermit crab			X									X	
Jonah crab*													
Mysid shrimp													
Rock crab													X
Spider crab					X								
Echinoderms													
Common sea star										X			
Sand dollar													
Purple sea urchin													
VERTEBRATA													
Elasmobrachiomorphi													
Little Skate egg case*													
Little Skate*					X								
Osteichthyes													
Black sea bass*													
Red Hake*													
Scup*			X		X		X						
CHORDATA													
Sand Sponge											X	X	
White invasive tunicate											X	X	
SPECIES RICHNESS FAUNA[2]	1	2	3	2	6	3	3	2	3	5	9	8	6
FLORA													
CHLOROPHYTA													
Dead Man's Fingers													
Sea Lettuce								X					
PHAEOPHYTA													
Rockweed													
Sargassum								X				X	
RHODOPHYTA													
Branching red alga								X	X	X		X	X
SPECIES RICHNESS FLORA[2]	0	0	0	0	0	0	0	3	1	1	0	2	1
Water depth (m) below MLLV	3.31	9.54	8.89	11.78	15.54	6.7	8.88	9.34	8.6	9.54	29.8	12.49	11.8

TRANSECT ID	T-54	T-55	T-56	T-57	T-58	T-59	T-60	T-61	T-62	T-63	T-64	T-68	T-75	Freqency %
FAUNA														
PORIFERA														
Bread crumb sponge	X					X							X	13.51
Red beard sponge[3]	X	X										X	X	**21.62**
Sulfur sponge	X	X								X				18.92
CNIDARIA														
Bell shaped jellyfish														5.41
Burrowing anemone			X	X										8.11
Star Coral		X												2.70
Hydroid													X	13.51
CTENOPHORA														8.11
BRYOZOA														
Bushy bryozoan	X					X								13.51
Encrusting bryozoan	X												X	**37.84**
MOLLUSCA														
Bay Scallop														8.11
Blue mussel														2.70
Knobbed whelk*[1]					X									13.51
Knobbed whelk egg case*												X		13.51
Moon snail										X egg mass				2.70
Slipper limpet													X	18.92
Threeline Mudsnail			X		X									8.11
ANNELIDA														
Polychaeta														
Lug worm														5.41
Plumed worm									X					5.41
Sedentary polychaetes			X									X		**27.03**
ARTHROPODA														
Crustacea														
Barnacle														8.11
Four-eyed amphipod			X	X	X					X	X			18.92
Hermit crab						X							X	18.92
Jonah crab*				X										2.70
Mysid shrimp					X					X	X			8.11
Rock crab														2.70
Spider crab						X								8.11
Echinoderms														
Common sea star	X	X												8.11
Sand dollar										X	X			5.41
Purple sea urchin													X	2.70
VERTEBRATA														
Elasmobrachiomorphi														
Little Skate egg case*						X				X	X			10.81
Little Skate*														5.41
Osteichthyes														
Black sea bass*	X													2.70
Red Hake*										X				2.70
Scup*						X			X					18.92
CHORDATA														
Sand Sponge	X													8.11
White invasive tunicate	X								X					10.81
SPECIES RICHNESS FAUNA[2]	9	4	4	3	5	6	0	0	3	7	4	3	7	97.2973
FLORA														
CHLOROPHYTA														
Dead Man's Fingers														**24.32**
Sea Lettuce														5.41
PHAEOPHYTA														
Rockweed														5.41
Sargassum								X						**27.03**
RHODOPHYTA														
Branching red alga		X					X	X				X	X	**48.65**
SPECIES RICHNESS FLORA[2]	0	1	0	0	0	0	1	2	0	0	0	1	1	
Water depth (m) below MLLV	14.69	9.98	29.6	30.32	32.7	14.6	9.35	6.76	12.49	33.92	37.86	10.04	7.12	

4. CR Environmental June/July 2018 Underwater Video Review

JUNE/JULY 2018 UNDERWATER VIDEO SURVEY DATA REVIEW

Vineyard Wind Project

Lewis Bay, Centerville Harbor, Nantucket Sound & Atlantic Ocean

Spider crab feeding on a slipper limpet reef

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October 2018

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FIGURES

PLATES of Representative Video Screen Captures of Bottom Habitat and Biota

1.0 INTRODUCTION

CR Environmental, Inc. (CR) reviewed benthic underwater video data collected along the proposed Vineyard Wind Offshore Export Cable Corridor (OECC), and the Eastern Muskeget and New Hampshire Avenue optional corridors within Nantucket Sound and the Atlantic Ocean under contract to GeoSubsea. The proposed OECC runs approximately 78 kilometers from the Atlantic Ocean southeast of Martha's Vineyard north through Nantucket Sound including Muskeget Channel and makes landfall at Covell's Beach, Centerville Harbor. The New Hampshire Avenue Optional Corridor goes through the entrance to Hyannis Harbor and Lewis Bay and makes landfall at New Hampshire Avenue. Water depths were shallowest nearshore ranging from 1 to 7 meters in Centerville Harbor, Lewis Bay and the Hyannis Harbor entrance channel, and deepest 34 to 47 meters offshore southeast of Martha's Vineyard in the Atlantic. Underwater video footage along fifty three transects was collected and initially reviewed by CSA Ocean Sciences, Inc. (CSA) and Epsilon Associates aboard the M/V Theory using a towed video sled from June 24 to July 3, 2018 (CSA, 2018).

2.0 METHODS

A marine biologist from CR reviewed the underwater video footage to further describe and verify bottom habitat types and identify associated biota for each of the transects along the OECC and optional routes. Review methods included freezing frames and collecting screen captures approximately every minute to allow for the confirmation of species identifications and bottom substrate characterization along each transect.

Specifically the underwater video review included the following for each transect:

- Identification of the dominant fauna and its relative abundance,
- Presence/absence data for biota observed and their commercial importance
- Bottom habitat classification based on Auster (1998),
- Massachusetts Coastal Zone Management's (MACZM) modified Barnhardt et al. (1998) bottom sediment classification, and

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- The presence of MACZM Special, Sensitive or Unique Resources (e.g., eelgrass beds, and hard bottom).

Auster (1998) developed a hierarchical approach for classifying marine bottom habitats in the outer continental shelf of the northwest Atlantic. Sediments are classified along a gradient of grain sizes from mud to boulders (Table 1). The eight general habitat categories are ranked by Auster (1998) based on their complexity and effectiveness in providing habitat, attachment surfaces, and shelter for a variety of marine plants and animals. Those with the highest habitat rankings are for *pebble-cobble with sponge*, *partially buried or dispersed boulders*, and *piled boulder* substrates. The various forms these bottom habitats take and the infauna and epifauna associated with the sediments produce a wide diversity of habitat types for fish and associated fauna. Seafloor substrates based on the MACZM modified Barnhardt et al. (1998) sediment classification scheme are: Fine, Fine with Gravel, Fine with Rock, Gravel with Fine, Gravel, Gravel with Rock, Rock with Fine, and Rock. Identification of flora and fauna was made to the lowest taxonomic level possible using references by Weiss (1995), Martinez (1994), Miner (1950), and Bigelow and Schroeder (1953).

3.0 RESULTS

The underwater video transects ranged from approximately ten to thirty minutes in length. Table 2 provides the primary bottom habitat classification based on Auster (1998) observed at each video transect grouped by area. A secondary bottom classification is provided for alternate bottom types observed on ≥10% of the video based on elapsed time. Otherwise no secondary bottom class is reported. In addition, Table 2 provides MACZM's modified Barnhardt et al. (1998) sediment classification scheme, the dominant faunal species observed, and identifies transects where Special, Sensitive or Unique Areas (SSUs) were observed. The centroid coordinates for each transect is also provided.

The primary bottom classification (Auster 1998) for video transects along the proposed OECC and optional corridors is graphically represented on Figure 1. Dominant fauna observed on each transect is graphically represented on Figure 2. Figures 3 and 4, respectively, provide a detail of the substrate and dominant fauna at the nearshore portion of the proposed OECC through

Centerville Harbor landing at Covell's Beach, and the New Hampshire Avenue Option through the entrance to Hyannis Harbor and Lewis Bay.

A list of flora and fauna observed by transect along with summary statistics of species richness by transect and frequency across transects are provided on Table 3.

3.1 Bottom Habitat Classification and Dominant Biota

3.1.1 Nearshore areas - Centerville Harbor (OECC), Lewis Bay and the Hyannis Harbor entrance channel (New Hampshire Avenue Option)

Centerville Harbor Covell's Beach (proposed OECC)

Water depths during the underwater video survey in Centerville Harbor ranged from 3.3 to 6.9 meters. The primary habitats along the OECC in Centerville Harbor were of low complexity and included *flat sand, mud* (6 of 8 transects) and *flat sand, mud / pebble-cobble* (2 of 8 transects). Secondary habitat of *pebble-cobble* (i.e. observed over at least 10% of the elapsed footage) was noted for half of the Centerville Harbor video transects (V-119, -120, -121, and -153) (Table 2, Figure 3). Occasional boulders (*partially buried or dispersed boulder*) were identified as secondary habitat at V-117, -118, and -152 at the shoreward end of the proposed OECC in Centerville Harbor.

Eelgrass a Special, Sensitive or Unique Resource (SSU) was observed at 3 of the 8 transects along the OECC in Centerville Harbor. At transect V-117, a bed with moderate to dense eelgrass was observed (Plate 1), however, only sparse eelgrass strands were observed at V-118 and V-120.

The majority of dominant fauna along transects in Centerville Harbor were rarely observed on the video footage (Table 2, Figure 4). These species included bay scallops, knobbed whelks, spider crabs, and moon snails (Plate 1).

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Dense to moderate macro algae coverage was observed at the majority of the Centerville Harbor transects. The algal cover was predominantly comprised of dead man's fingers, sea lettuce, purple laver, and several species of branching red algae. Gutweed, and rockweed were occasionally observed (Table 3).

Lewis Bay and the Hyannis Harbor Entrance Channel (New Hampshire Avenue Option)

Water depths during the underwater video survey along the New Hampshire Avenue Option ranged from 1 to 6.2 meters. The primary habitat type for all 15 of the underwater video transects in the Hyannis Harbor entrance channel and Lewis Bay was the low complexity *flat sand, mud* bottom (Table 2, Figure 3). A secondary bottom habitat of *pebble-cobble* (i.e. covering at least 10% of a transect) was recorded for the 4 entrance channel transects V-110, -111, -114, and -115; and one Lewis Bay transect, V-103.

No eelgrass was observed along the Hyannis Harbor entrance portion of the optional corridor. Sparse eelgrass, consisting of a few isolated plants was observed at V-109 in Lewis Bay.

Similar to Centerville Harbor, dense to moderate macro algae was observed at the majority of the Lewis Bay video transects. The algal cover was similarly comprised of dead man's fingers, sea lettuce, purple laver, and several species of branching red algae. Gutweed, and rockweed were occasionally observed (Table 3).

The majority of dominant fauna were rarely observed along the transects in Lewis Bay and the Hyannis Harbor entrance channel (Tables 2 and 3, Figure 4). These species included bay scallops, knobbed whelks, spider crabs, and moon snails (Plate 2). The only dominant fauna that was common or abundant was slipper limpets at transects V-103 and V-104 in Lewis Bay, and V-114 in the Hyannis Harbor entrance channel. At V-113, in Lewis Bay a bacterial mat (*Beggiatoa* sp.) was present which can be indicative of anoxic sediment and elevated nutrients.

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3.1.2 Nantucket Sound (OECC)

The Nantucket Sound transects were in water depths of 5.5 to 20 meters. Similar to the harbor video transects, the primary habitat in Nantucket Sound was *flat sand/mud* (Table 2, Figure 2), however, overall there was increased bottom habitat complexity. A *shell aggregate* substrate was observed as the primary habitat type at V-122 and V-148. Secondary habitat of low relief *sand ripples* was observed at V-116, -123, and -124, secondary habitat of *pebble-cobble* was observed at V-146 and -149, and *partially buried or dispersed boulders* at V-122.

Mollusks were the dominant biota in Nantucket Sound including: knobbed whelks, slipper limpets, and mud snails (Tables 2 and 3, Figure 3). At transect V-148, a productive slipper limpet reef with 50-100% coverage was observed. Multiple observations of star coral, spider crabs, knobbed whelks, purple sea urchins, black sea bass, and sea robins were noted at this transect. The spider crabs and knobbed whelks were observed feeding on the slipper limpets (Plate 3).

3.1.3 Muskeget Channel (OECC) and the Eastern Muskeget Option

Water depths in Muskeget Channel during the video survey ranged from 6 to 20 meters. The strong currents of the Muskeget Channel have shaped the bottom habitat. The primary habitat observed on the video transects was *sand waves* often combined with *pebbles-cobble* habitat observed in the troughs. Secondary bottom habitat at 2 of the 11 transects (V-125 and -126) was the higher complexity *partially buried or dispersed boulder* (Table 2, Figure 1).

Rare observations of bread crumb sponge, amphipods, moon snails, tube worms, and plume worms were observed along the OECC and Eastern Muskeget Option (Table 2, Plate 4). Blue mussels were observed within the Muskeget Channel at V-127 west of the OECC (Table 3, Figure 2).

Dominant biota observed included abundant observations of sulfur sponge at V-125, and V-132 on the Eastern Muskeget Option. Other biota associated with the sulfur sponge bottom included

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orange encrusting bryozoans, sand sponge, invasive white tunicate, tube worms, barnacles, sea robins, and black sea bass (Table 3).

3.1.4 Atlantic Ocean southeast of Martha's Vineyard (OECC)

In waters southeast of Martha's Vineyard at depths ranging from 34 to 47 meters the primary habitats along the OECC video transects were the relatively low complexity, *flat sand*, *mud* and *biogenic structure*s. The bottom habitat classification, *biogenic structures,* is characterized by burrows and depressions that are used by mobile fauna for shelter (Table 1, Auster, 1998).

Dominant biota included common sand dollars, sulfur sponge, and burrowing anemones (Plates 5A and 5B). Hermit crabs were the dominant biota at V-136, however, in low numbers. Other biota observed only at these deeper water video transects included solitary hydroids, sea pens, and mysid shrimp. Multiple observations of red hake in burrows, skate, summer flounder, and long-finned squid were also noted.

3.2 General Observations along the Proposed Offshore Export Cable Corridor

3.2.1 Bottom substrate classification

Bottom substrate classification along the cable corridor, based on the MACZM modified Barnhardt classification scheme included 57% fines, 28% fines with gravel, 11% fines with rock, 2 % gravel, and 2% gravel with rock (Table 2). With the exception of a few isolated boulders and areas of gravel bottom, much of the hard bottom encountered during the survey was to limited gravel found within sand wave troughs.

3.2.2 Bottom Habitat and Biota

The video transects with the highest species richness, eight or more invertebrate and fish species, were in the Muskeget Channel at V-127 (10 species), and the Atlantic Ocean, southeast of

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Martha's Vineyard at V-137 (14 species), V-138 (11 species), and V-151 (11 species) (Table 3). The only exceptions were V-122 and V-148 in Nantucket Sound. The lowest species counts, six or fewer, were on the inshore *flat sand, mud* habitat of Centerville Harbor and Lewis Bay, and in the *sand wave* habitat of Muskeget Channel at V-128, -129, -130, and -131.

The most frequently observed biota on all 53 video transects were knobbed whelk (43%), four eyed amphipod (40%), slipper limpet (36%), bay scallop (26%), hermit crabs (26%), and sulfur sponge (21%). A total of 39 invertebrates, 6 fish, and approximately 7 algal species were observed during the video review. Red branching algae was observed at 55% of the transects and this general classification represents 4 to 5 different species of bushy red seaweeds 1-2 feet in length and 2 to 3 species of tuft-like algae 3-4 inches in height that were attached to pebble, cobbles and shell.

3.2.3 Commercial species

Knobbed whelks were the only commercial invertebrate species recorded in significant numbers. Bay scallops, sea scallops, surf clams, blue mussels, rock crabs, blue crabs, and horseshoe crabs were observed in low numbers. Of the commercial fish species observed: scup, black sea bass, skate, and red hake; only red hake and skate were noted at a significant number of transects primarily in the deeper waters southeast of Martha's Vineyard (19%) (Table 3).

3.2.4 Special, Sensitive or Unique Areas

The presence of obvious Special, Sensitive or Unique Areas (SSUs) such as areas of hard/complex bottom or eelgrass beds along the OECC and optional corridors was very limited. Of the 53 video transects, only a small amount of *partially buried or dispersed boulder* habitat was recorded at V-125 and -126 in the Muskeget Channel, at V-122 in Nantucket Sound, and V-117, -118, and -152 in Centerville Harbor. No *piled boulders* or rock ledge bottom habitat was observed along any of the video transects. The moderate to dense eelgrass bed off Covell's Beach at V-117 in Centerville Harbor and areas of isolated rooted plants observed at V-118 and

V-120 in Centerville Harbor, and V-103 in Lewis Bay should be further evaluated to determine the extent of this SSU along the proposed OECC and if needed New Hampshire Avenue optional corridor.

4.0 LIMITATIONS

In the months of June and July, water column visibility in the shallow bays of Cape Cod is often poor due to diatom blooms. The low water column visibility during the 2018 video survey and the presence of dense macro algae nearshore often obscured the bottom, and observations of biota in Lewis Bay and Centerville Harbor may have been underestimated. The ideal time to conduct underwater video surveys in these shallow embayments would be in spring or late fall. Additionally, for segments of the video footage the sled was too high off the bottom to make all but very general biota and bottom habitat observations. The number of transects identified as having sand waves may have been underestimated as they are difficult to detect with underwater video alone due to the camera angle. Project side scan sonar or multibeam backscatter may more accurately detect their presence.

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TABLES

TABLE 1

Bottom Habitat Classification (Auster, 1998)

Habitat Description	**Rationale**	**Complexity Score**
Flat sand, mud	Areas with no vertical structure such as depressions, ripples or epifauna	1
Sand waves	Troughs provide shelter from current; previous observations indicate that species such as red hake hold position on the downcurrent sides of sand waves and ambush drifting demersal zooplankton and shrimp	2
Biogenic structures	Burrows, depressions, cerianthid anemones, hydroid patches; features that are created or used by mobile fauna for shelter	3
Shell aggregates	Provide complex interstitial spaces for shelter; also provide a complex, high-contrast background that may confuse visual predators	4
Pebble-cobble	Provide small interstitial spaces and may be equivalent in shelter value to shell aggregate, but less ephemeral than shell	5
Pebble-cobble with sponge cover	Attached fauna such as sponges provide additional spatial complexity for a wider range of size classes of mobile organisms	10
Partially buried or dispersed boulders	Partially buried boulders exhibit high vertical relief; dispersed boulders on cobble pavement provide simple crevices; the shelter value of this type of habitat may be less or greater than previous types based on the size class and behavior of associated species	12
Piled boulders	Provide deep interstitial spaces of variable sizes	15

TABLE 2
TRANSECT HABITAT CLASSIFICATION, DOMINANT SPECIES, AND SPECIAL, SENSITIVE OR UNIQUE AREAS
VIDEO DATA June 24 - July 3, 2018
VINEYARD WIND PROJECT - NANTUCKET SOUND AND ATLANTIC OCEAN

Video Transect ID	POINT_X[1]	POINT_Y[1]	Dominant_Fauna	Latin Name	Abundance of Dominant Spp.	Auster (1998) - primary	Auster (1998) -secondary[2]	CZM - Barnhardt et. al (1998)	Eelgrass	SSUs[4]
LEWIS BAY [NEW HAMPSHIRE AVENUE OPTION]										
V-101	1297669.609	15125944.842	Bay Scallop	*Aequipecten irradians*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-102	1298201.919	15126109.605	Bay Scallop	*Aequipecten irradians*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-103	1297790.540	15125972.319	Slipper limpet	*Crepidula fornicata*	Common	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
V-104	1297353.192	15125846.904	Slipper limpet	*Crepidula fornicata*	Common	Flat sand, Mud		Fine	Absent	Absent
V-105	1294868.117	15124420.129	Knobbed Whelk	Busycon carica	Rare	Flat sand, Mud		Fine	Absent	Absent
V-106	1294677.254	15124660.158	Bay Scallop	*Aequipecten irradians*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-107	1294445.845	15124781.971	Knobbed Whelk	*Busycon carica*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-108	1294051.616	15124641.095	Slipper limpet	*Crepidula fornicata*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-109	1293818.958	15124349.547	Spider crab	*Lubinia emarginata*	Rare	Flat sand, Mud		Fine	EG (Rare)	Possible
V-112	1296639.041	15124341.762	Knobbed Whelk	*Busycon carica*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-113	1295378.377	15126966.244	Spider crab	*Lubinia emarginata*	Rare	Flat sand, Mud		Fine	Absent	Absent
HYANNIS HARBOR ENTRANCE CHANNEL [NEW HAMPSHIRE AVENUE OPTION]										
V-110	1293663.513	15123881.024	Knobbed Whelk	*Busycon carica*	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
V-111	1293558.679	15123037.523	Knobbed Whelk	*Busycon carica*	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
V-114	1291794.577	15121395.966	Slipper limpet	*Crepidula fornicata*	Abundant	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
V-115	1284904.003	15110384.345	Spider crab	*Lubinia emarginata*	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
CENTERVILLE HARBOR [PROPOSED OECC]										
V-117	1275134.210	15124196.247	Knobbed whelk	*Busycon carica*	Rare	Flat sand, Mud/Pebble-cobble	Dispersed Boulders	Fine with rock	EG (Common)	Yes
V-118	1275452.306	15123976.711	Knobbed whelk	*Busycon carica*	Rare	Flat sand, Mud	Dispersed Boulders	Fine with rock	EG (Rare)	Possible
V-119	1275610.561	15123078.997	Knobbed whelk	*Busycon carica*	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
V-120	1274370.835	15122716.977	Spider crab	Lubinia emarginata	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	EG (Rare)	Possible
V-121	1273735.319	15121125.909	Spider crab	*Lubinia emarginata*	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
V-150	1271852.489	15116107.374	Spider crab	*Lubinia emarginata*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-152	1275113.492	15123924.839	Knobbed whelk	*Busycon carica*	Rare	Flat sand, Mud/Pebble-cobble	Dispersed Boulders	Fine with rock	Absent	Absent
V-153	1275201.376	15123753.536	Northern moon snail	*Lunatia heros*	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
NANTUCKET SOUND [PROPOSED OECC]										
V-116	1279987.961	15101394.422	Threeline Mudsnail	*Ilyanassa trivittata*	Occasional	Flat sand, Mud	Sand Ripples	Fine	Absent	Absent
V-122	1253037.049	15064306.103	Slipper limpet	*Crepidula fornicata*	Common	Flat sand, Mud/Shell Aggregates	Dispersed Boulders	Fine with rock	Absent	Absent
V-123	1249779.636	15042913.535	Knobbed whelk	*Busycon carica*	Common	Flat sand,Mud	Sand Ripples	Fine	Absent	Absent
V-124	1262315.168	15100997.145	Knobbed whelk	*Busycon carica*	Rare	Flat sand, Mud	Sand Ripples	Fine	Absent	Absent
V-146	1253898.044	15074808.233	Knobbed Whelk	*Busycon carica*	Occasional	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent
V-147	1254468.880	15086640.387	Knobbed Whelk	*Busycon carica*	Occasional	Flat sand, Mud	Shell aggregates	Fine	Absent	Absent
V-148	1269193.122	15098303.040	Slipper limpet	*Crepidula fornicata*	Abundant	Shell aggregates		Fine	Absent	Absent
V-149	1267791.878	15108639.220	Hermit crab	*Lunatia heros*	Rare	Flat sand, Mud	Pebble-cobble	Fine with gravel	Absent	Absent

TABLE 2
TRANSECT HABITAT CLASSIFICATION, DOMINANT SPECIES, AND SPECIAL, SENSITIVE OR UNIQUE AREAS
VIDEO DATA June 24 - July 3, 2018
VINEYARD WIND PROJECT - NANTUCKET SOUND AND ATLANTIC OCEAN

Transect ID	POINT_X[1]	POINT_Y[1]	Dominant_Fauna	Latin Name	Abundance of Dominant Spp.	Auster (1998) - primary	Auster (1998) -secondary[2]	CZM - Barnhardt et. al (1998)	Eelgrass	SSUs[5]
MUSKEGET	CHANNEL [PROPOSED OECC]									
V-125	1249908.785	15033083.937	Sulfur sponge	*Cliona celeta*	Abundant	Flat sand, Mud/Shell Aggregates	Pebble-cobble/Dispersed Boulders	Fine with rock	Absent	Absent
V-126	1248871.299	15022268.473	Bread crumb sponge	*Halichodria panicea*	Rare	Pebble-cobble	Dispersed Boulders	Gravel with rock	Absent	Absent
V-127	1248365.801	15006785.021	Blue mussel	*Mytilus edulis*	Common	Sand waves/Pebble-cobble		Fine with gravel	Absent	Absent
V-128	1247896.687	14999759.423	Four-eyed amphipod	*Ampelisca sp.*	Rare	Sand waves[3]	Pebble-cobble	Fine with gravel	Absent	Absent
V-129	1248708.605	14993413.622	Four-eyed amphipod	*Ampelisca sp.*	Rare	Sand waves		Fine	Absent	Absent
V-130	1254440.272	14993764.100	Four-eyed amphipod	*Ampelisca sp.*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-131	1252647.503	15007098.411	Plumed worm	*Diopatra cuprea*	Rare	Flat sand, Mud/Pebble-cobble		Fine with gravel	Absent	Absent
[EASTERN MUSKEGET CHANNEL OPTION]										
V-132	1255338.761	15026684.526	Sulfur sponge	*Cliona celeta*	Abundant	Sand waves/Pebble-cobble		Fine with gravel	Absent	Absent
V-133	1261890.846	15012177.745	Bread crumb sponge	*Halichodria panicea*	Rare	Pebble-cobble		Gravel	Absent	Absent
V-134	1266653.457	15005749.232	Tube worm	*Hydrodes dianthus*	Rare	Sand waves/Pebble-cobble	Flat sand, Mud	Fine	Absent	Absent
V-135	1259706.399	14999114.078	Northern Moon snail	*Lunatia heros*	Rare	Sand waves		Fine	Absent	Absent
ATLANTIC OCEAN SOUTHEAST OF MARTHAS VINEYARD [PROPOSED OECC]										
V-136	1243499.539	14968260.936	Hermit crab	*Pagurus acadianus*	Rare	Flat sand, Mud		Fine	Absent	Absent
V-137	1237426.172	14953150.297	Common sand dollar	*Echinarachnius parma*	Occasional	Flat sand, Mud		Fine	Absent	Absent
V-138	1235714.492	14942804.298	Sulfur sponge	*Cliona*	Occasional	Flat sand, Mud/Biogenic structures		Fine	Absent	Absent
V-139	1211154.149	14918256.940	Common sand dollar	*Echinarachnius parma*	Occasional	Flat sand, Mud		Fine	Absent	Absent
V-140	1261963.685	14918446.274	Sulfur sponge	*Cliona celata*	Occasional	Flat sand,Mud/Biogenic structures		Fine	Absent	Absent
V-141	1238001.002	14919211.989	Common sand dollar	*Echinarachnius parma*	Occasional	Flat sand, Mud		Fine	Absent	Absent
V-142	1251717.183	14897571.855	Common sand dollar	*Echinarachnius parma*	Occasional	Flat sand, Mud/Pebble-cobble		Fine with gravel	Absent	Absent
V-143	1226083.330	14897854.844	Burrowing anemone	*Cerianthus borealis*	Common	Biogenic Structures		Fine	Absent	Absent
V-144	1195563.570	14896825.594	Burrowing anemone	*Cerianthus borealis*	Common	Flat sand, Mud/Biogenic structures		Fine	Absent	Absent
V-145	1227150.600	14873005.838	Sulfur sponge	*Cliona celata*	Common	Flat sand, Mud/Biogenic Structures		Fine	Absent	Absent
V-151	1243903.061	14941115.837	Common sand dollar	*Echinarachnius parma*	Common	Flat sand, Mud/Sand waves		Fine	Absent	Absent

Auster, P.J. 1998. The conceptual model of the impacts of fishing gear on the integrity of fish habitat. Conservation Biology V12 (6): 1198-1203.
Barnhardt, W.A., J.T. Kelley, S.M. Dickson, and D.F. Belknap. 1998. Mapping the Gulf of Maine with Side-Scan Sonar: A New Bottom-Type Classification for Complex Seafloors. Journal of Coastal Research.14(2): 646-659.

Notes:

1) Centroid coordinates for the video transect
2) A secondary bottom classification for transects is provided for alternate bottom types observed over at least ~10% of the video based on time lapse. Otherwise none is reported.
3) Sand waves were not always able to be detected on video segments refer to side scan record
4) Designation of possible SSUs

TABLE 3
SPECIES BY TRANSECT FROM UNDERWATER VIDEO JUNE 24 - JULY 3, 2018
VINEYARD WIND PROJECT - NANTUCKET SOUND AND ATLANTIC OCEAN

TRANSECT ID	**Latin Name**	**V-101**	**V-102**	**V-103**	**V-104**	**V-105**	**V-106**	**V-107**	**V-108**	**V-109**
FAUNA										
PORIFERA										
Bread crumb sponge	*Halichondria panicea*									
Red beard sponge	*Microciona prolifera*									
Sulfur sponge[3]	*Cliona celata*									
CNIDARIA										
Burrowing anemone	*Cerianthus borealis*									
Star Coral	*Astrangia poculata*									
Solitary Hydroid	Hybocodon pendula									
Sea Pens	Pennatulacea									
BRYOZOA										
Bushy bryozoan	Bryozoa									
Encrusting bryozoan	*Schizoporella unicornis*									
MOLLUSCA										
Bay Scallop	*Argopecten irradians*	X	X	X	X	X	X	X		X
Blue mussel	*Mytilis edulis*									
Knobbed whelk*[1]	*Busycon carica*			X	X	X		X		
Long-Finned Squid	*Loligo pealei*									
Northen Moon snail	Lunatia heros									
Sea Scallop	Placopecten magellanicus									
Slipper limpet	*Crepidula fornicata*	X			X	X	X	X	X	X
Surf clam	*Spisula solidissima*									
Threeline Mudsnail	*Ilyanassa trivittata*									
Parchment worm	*Chaetopterus pergamentaceus*									
Plumed worm	*Diopatra cuprea*									X
Tube worm	Hydroides dianthus	X					X			
ARTHROPODA										
Merostomata										
Horshoe Crab	Limulus polyphemus									
Crustacea										
Barnacle	*Balanus* sp.									X
Blue crab	Callinectes sapidus							X		
Four-eyed amphipod	*Ampelisca sp.*									
Green crab	*Carcinus maenas*									
Hermit crab	*Pagurus sp.*									
Lady crab	*Ovalipes occellatus*								X	
Mysid shrimp	Mysids									
Rock crab	*Cancer irroratus*									
Spider crab	*Lubinia emarginata*						X	X		X
Echinoderms										
Common sea star	*Asterias forbesi*									
Norther sea star	*Asterias vulgaris*									
Sand dollar	*Echinarachnius parma*									
Purple sea urchin	*Arbacia punctulata*									
VERTEBRATA										
Elasmobrachiomorphi										
Little Skate*	*Raja erinacea*									
Osteichthyes										
Black sea bass*	*Centropristis striata*									
Red Hake*	*Urophycis chuss*									
Scup*	*Stenotomus chrysops*									
Sea Robin	*Prionotus carolinus*									
Summer Flounder	*Paralichthys dentatus*									
CHORDATA										
Sand Sponge	*Amaroucium sp.*									
White invasive tunicate	*Didemnum candidum*									
SPECIES RICHNESS FAUNA[2]		3	1	2	3	3	4	5	2	5
FLORA										
ALISMATALES										
Zosteraceae										
Eelgrass*	*Zostera marina*									X
CHLOROPHYTA										
Dead Man's Fingers	*Codium fragile*	X	X	X	X	X	X	X	X	X
Gutweed	*Enteromorpha sp.*			X						
Sea Lettuce	*Ulva lactuca*	X		X				X	X	X
PHAEOPHYTA										
Rockweed	*Fucus* sp.	X								
RHODOPHYTA										
Branching red alga	Rhodophyta	X		X		X	X	X	X	X
Purple laver	Porphyra umbilicalis	X		X	X	X	X	X	X	X
SPECIES RICHNESS FLORA2		5	1	5	2	3	3	4	4	4

1) An * designates species selected for assessment of 'important fish resource areas' an SSU under the Mass. Ocean Management Plan
2) Species Richness = the total number of species observed
3) Species with a frequency across all transects greater than 20% are bolded and shaded

TABLE 3
SPECIES BY TRANSECT FROM UNDERWATER VIDEO JUNE 24 - JULY 3, 2018
VINEYARD WIND PROJECT - NANTUCKET SOUND AND ATLANTIC OCEAN

TRANSECT ID	V-110	V-111	V-112	V-113	V-114	V-115	V-116	V-117	V-118	V-119	V-120	V-121
FAUNA												
PORIFERA												
Bread crumb sponge												
Red beard sponge								X		X		
Sulfur sponge[3]								X				
CNIDARIA												
Burrowing anemone							X					
Star Coral												
Solitary Hydroid												
Sea Pens												
BRYOZOA												
Bushy bryozoan												
Encrusting bryozoan												
MOLLUSCA												
Bay Scallop		X	X	X	X						X	
Blue mussel												
Knobbed whelk*[1]	X	X	X	X	X	X	X	X	X	X	X	X
Long-Finned Squid												
Northen Moon snail												
Sea Scallop												
Slipper limpet		X	X	X	X	X					X	
Surf clam												
Threeline Mudsnail							X					
Parchment worm											X	
Plumed worm					X							
Tube worm							X				X	X
ARTHROPODA												
Merostomata												
Horshoe Crab				X	X							
Crustacea												
Barnacle												
Blue crab												
Four-eyed amphipod							X					
Green crab												
Hermit crab				X			X					
Lady crab		X										
Mysid shrimp												
Rock crab												
Spider crab				X		X					X	X
Echinoderms												
Common sea star												
Norther sea star												
Sand dollar												
Purple sea urchin												
VERTEBRATA												
Elasmobrachiomorphi												
Little Skate*												
Osteichthyes												
Black sea bass*												
Red Hake*												
Scup*									X			
Sea Robin							X					
Summer Flounder												
CHORDATA												
Sand Sponge												
White invasive tunicate												
SPECIES RICHNESS FAUNA[2]	1	4	3	6	5	3	7	3	2	2	6	3
FLORA												
ALISMATALES												
Zosteraceae												
Eelgrass*								X	X		X	
CHLOROPHYTA												
Dead Man's Fingers	X	X	X	X	X	X		X	X			X
Gutweed								X				
Sea Lettuce		X		X	X	X		X	X		X	X
PHAEOPHYTA												
Rockweed								X	X			
RHODOPHYTA												
Branching red alga		X	X	X	X	X	X	X	X	X	X	X
Purple laver				X	X						X	X
SPECIES RICHNESS FLORA2	1	3	2	4	4	3	1	5	4	1	3	4

TABLE 3
SPECIES BY TRANSECT FROM UNDERWATER VIDEO JUNE 24 - JULY 3, 2018
VINEYARD WIND PROJECT - NANTUCKET SOUND AND ATLANTIC OCEAN

TRANSECT ID	V-122	V-123	V-124	V-125	V-126	V-127	V-128	V-129	V-130	V-131	V-132	V-133
FAUNA												
PORIFERA												
Bread crumb sponge	X				X	X						X
Red beard sponge	X			X								
Sulfur sponge[3]											X	
CNIDARIA												
Burrowing anemone												
Star Coral						X						X
Solitary Hydroid												
Sea Pens												
BRYOZOA												
Bushy bryozoan												
Encrusting bryozoan	X			X	X	X					X	X
MOLLUSCA												
Bay Scallop												
Blue mussel					X	X						
Knobbed whelk*[1]	X	X	X									
Long-Finned Squid												
Northen Moon snail									X			
Sea Scallop												
Slipper limpet	X			X		X						
Surf clam						X						
Threeline Mudsnail		X										
Parchment worm												
Plumed worm						X				X		
Tube worm				X	X	X					X	X
ARTHROPODA												
Merostomata												
Horshoe Crab												
Crustacea												
Barnacle				X	X						X	
Blue crab												
Four-eyed amphipod		X		X			X	X	X	X	X	
Green crab												
Hermit crab		X		X					X			
Lady crab												
Mysid shrimp												
Rock crab												
Spider crab		X	X									
Echinoderms												
Common sea star												
Norther sea star												
Sand dollar												
Purple sea urchin	X											
VERTEBRATA												
Elasmobrachiomorphi												
Little Skate*												X
Osteichthyes												
Black sea bass*				X		X				X		
Red Hake*												
Scup*												
Sea Robin	X		X		X	X	X			X	X	
Summer Flounder		X						X				
CHORDATA												
Sand Sponge											X	
White invasive tunicate	X				X						X	X
SPECIES RICHNESS FAUNA[2]	8	6	3	8	7	10	2	2	3	4	8	6
FLORA												
ALISMATALES												
Zosteraceae												
Eelgrass*												
CHLOROPHYTA												
Dead Man's Fingers												
Gutweed												
Sea Lettuce												
PHAEOPHYTA												
Rockweed					X							
RHODOPHYTA												
Branching red alga			X		X	X	X				X	X
Purple laver	X											
SPECIES RICHNESS FLORA2	1	0	1	0	2	1	1	0	0	0	1	1

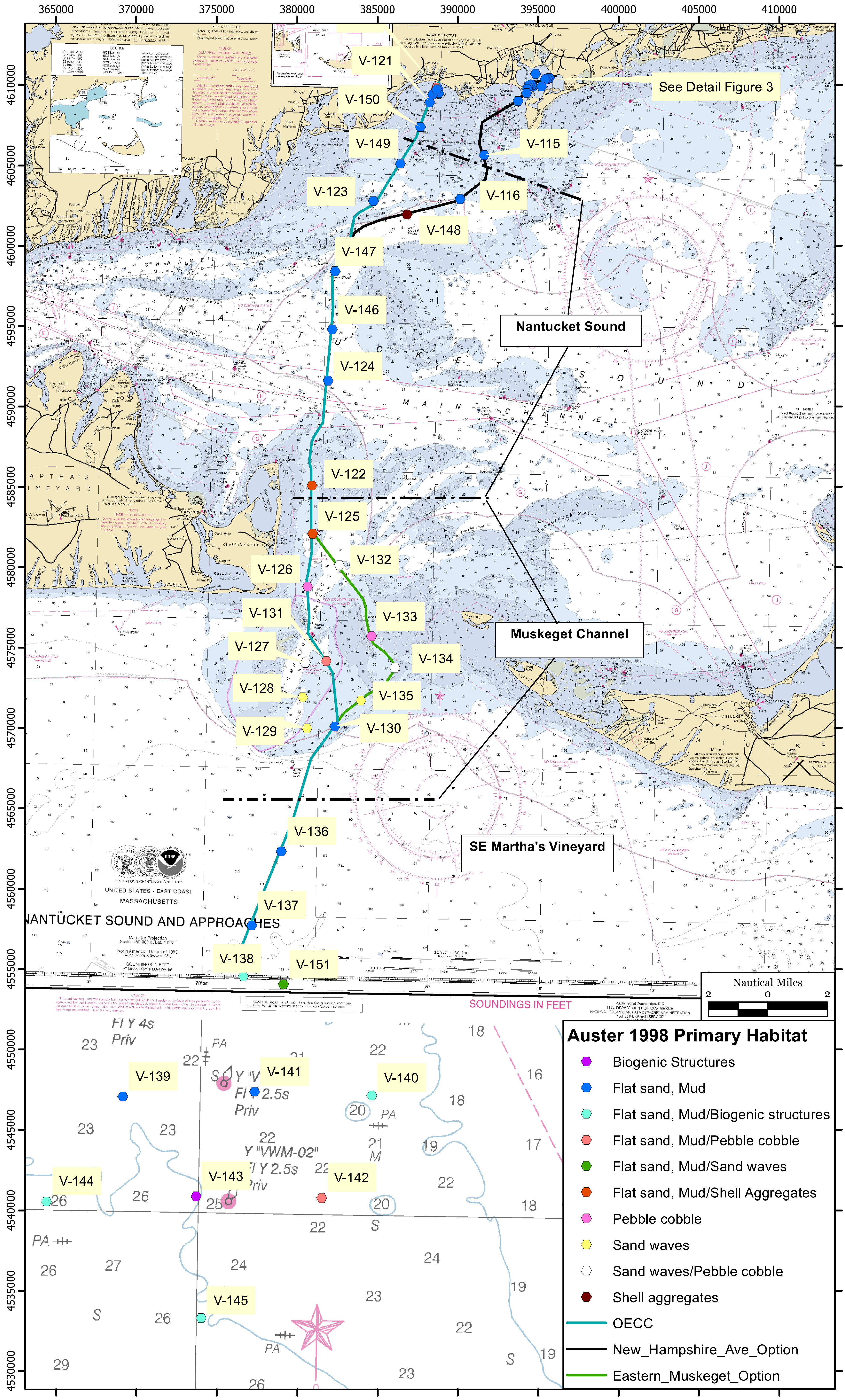
TABLE 3
SPECIES BY TRANSECT FROM UNDERWATER VIDEO JUNE 24 - JULY 3, 2018
VINEYARD WIND PROJECT - NANTUCKET SOUND AND ATLANTIC OCEAN

TRANSECT ID	**V-134**	**V-135**	**V-136**	**V-137**	**V-138**	**V-139**	**V-140**	**V-141**	**V-142**	**V-143**	**V-144**	**V-145**
FAUNA												
PORIFERA												
Bread crumb sponge								X				
Red beard sponge												
Sulfur sponge[3]				X	X		X	X	X	X	X	X
CNIDARIA												
Burrowing anemone			X	X	X	X		X		X	X	X
Star Coral												
Solitary Hydroid						X		X	X	X		x
Sea Pens				X	X		`X	X				
BRYOZOA												
Bushy bryozoan										X		
Encrusting bryozoan	X											
MOLLUSCA												
Bay Scallop												
Blue mussel												
Knobbed whelk*[1]												
Long-Finned Squid			X	X								
Northen Moon snail	X	X	X	X	X			X				
Sea Scallop								X				
Slipper limpet												
Surf clam	X	X										
Threeline Mudsnail				X								
Parchment worm									X			
Plumed worm	X											
Tube worm	X											
ARTHROPODA												
Merostomata												
Horshoe Crab												
Crustacea												
Barnacle	X											
Blue crab												
Four-eyed amphipod	X		X	X	X	X			X	X	X	X
Green crab												
Hermit crab			X	X		X	X	X				X
Lady crab												
Mysid shrimp				X	X							
Rock crab				X	X		X	X				
Spider crab												
Echinoderms												
Common sea star											X	
Norther sea star									X			
Sand dollar			X	X	X	X	X	X	X			
Purple sea urchin												
VERTEBRATA												
Elasmobrachiomorphi												
Little Skate*	X		X	X	X		X		X		X	X
Osteichthyes												
Black sea bass*												
Red Hake*			X	X	X	X	X		X	X	X	X
Scup*												
Sea Robin												
Summer Flounder			X	X	X				X			
CHORDATA												
Sand Sponge												
White invasive tunicate												
SPECIES RICHNESS FAUNA[2]	8	2	9	14	11	6	7	10	9	6	6	7
FLORA												
ALISMATALES												
Zosteraceae												
Eelgrass*												
CHLOROPHYTA												
Dead Man's Fingers												
Gutweed												
Sea Lettuce												
PHAEOPHYTA												
Rockweed												
RHODOPHYTA												
Branching red alga	X	X										
Purple laver	X											
SPECIES RICHNESS FLORA2	2	1	0	0	0	0	0	0	0	0	0	0

TABLE 3
SPECIES BY TRANSECT FROM UNDERWATER VIDEO JUNE 24 - JULY 3, 2018
VINEYARD WIND PROJECT - NANTUCKET SOUND AND ATLANTIC OCEAN

TRANSECT ID	V-146	V-147	V-148	V-149	V-150	V-151	V-152	V-153	Freqency %
FAUNA									
PORIFERA									
Bread crumb sponge									9.43
Red beard sponge									7.55
Sulfur sponge[3]						X			**20.75**
CNIDARIA									
Burrowing anemone						X			18.87
Star Coral			X						5.66
Solitary Hydroid						X			11.32
Sea Pens									7.55
BRYOZOA									
Bushy bryozoan									1.89
Encrusting bryozoan		X		X					16.98
			X						1.89
MOLLUSCA									
Bay Scallop		X							**26.42**
Blue mussel									3.77
Knobbed whelk*[1]	X	X	X				X		**43.40**
Long-Finned Squid						X			5.66
Northen Moon snail								X	15.09
Sea Scallop									1.89
Slipper limpet			X	X			X		**35.85**
Surf clam	X								7.55
Threeline Mudsnail									5.66
Parchment worm									3.77
Plumed worm									9.43
Tube worm	X			X			X	X	**28.30**
ARTHROPODA									
Merostomata									
Horshoe Crab									3.77
Crustacea									
Barnacle				X				X	13.21
Blue crab									1.89
Four-eyed amphipod	X	X		X		X			**39.62**
Green crab								X	1.89
Hermit crab		X		X		X			**26.42**
Lady crab									3.77
Mysid shrimp						X			5.66
Rock crab						X			9.43
Spider crab	X	X	X	X	X				**26.42**
Echinoderms									
Common sea star									1.89
Norther sea star									1.89
Sand dollar						X			15.09
Purple sea urchin			X						3.77
VERTEBRATA									
Elasmobrachiomorphi									
Little Skate*						X			18.87
Osteichthyes									
Black sea bass*			X						7.55
Red Hake*						X			18.87
Scup*									1.89
Sea Robin			X	X					18.87
Summer Flounder									11.32
CHORDATA									
Sand Sponge									1.89
White invasive tunicate							X		9.43
SPECIES RICHNESS FAUNA[2]	5	6	8	8	1	11	4	4	
FLORA									
ALISMATALES									
Zosteraceae									
Eelgrass*									
CHLOROPHYTA									
Dead Man's Fingers					X		X	X	**39.62**
Gutweed							X	X	7.55
Sea Lettuce								X	**26.42**
PHAEOPHYTA									
Rockweed							X	X	11.32
RHODOPHYTA									
Branching red alga				X	X		X		**54.72**
Purple laver				X					**28.30**
SPECIES RICHNESS FLORA2	0	0	0	2	2	0	4	4	

FIGURES

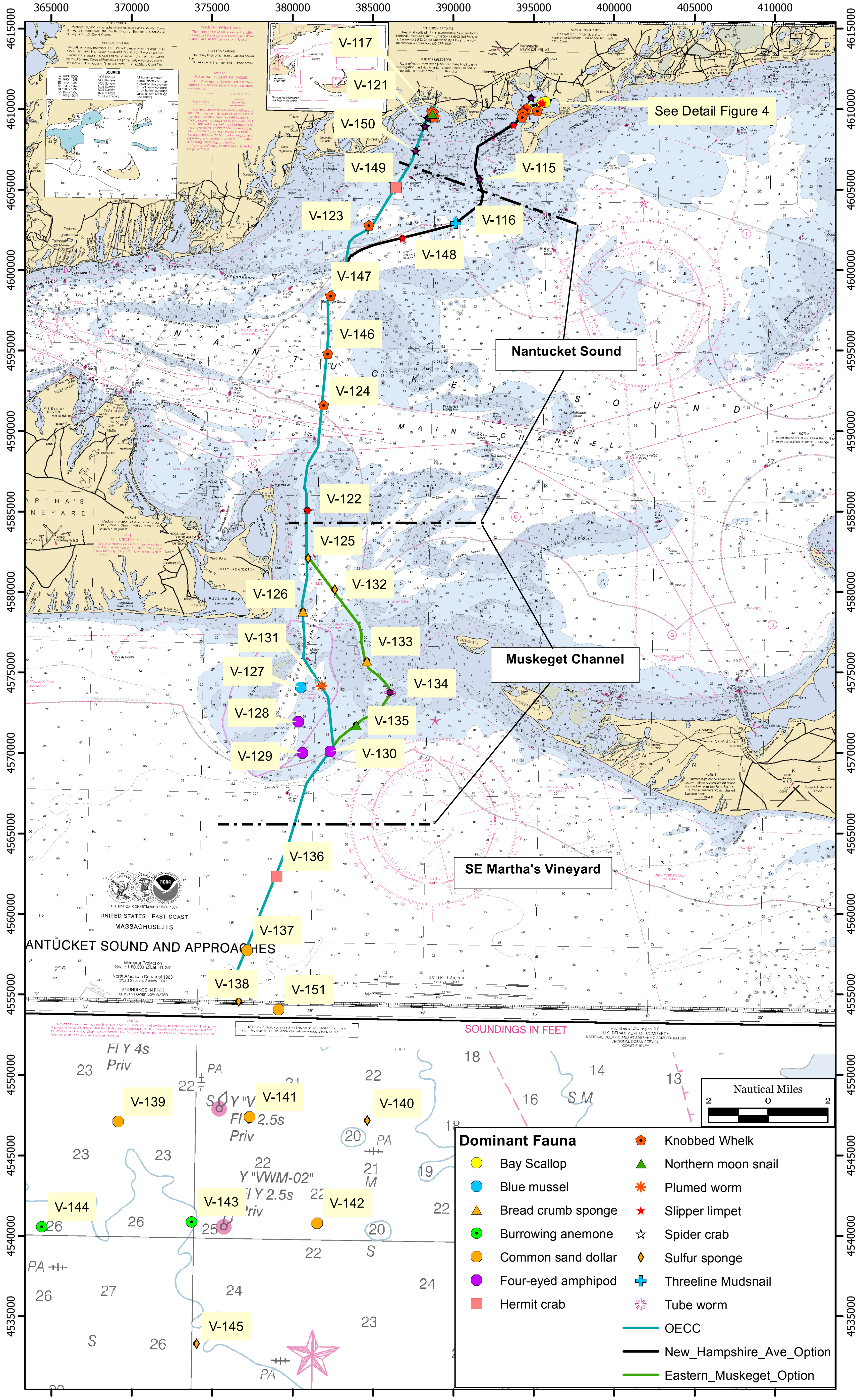


Video Transect Primary Habitat Classification
Vineyard Wind Project

www.crenvironmental.com

NOTES:
1) Underwater video data collected in June and July 2018.
2) Grid: UTM, Zone 19N, NAD83, metric.

Figure 1



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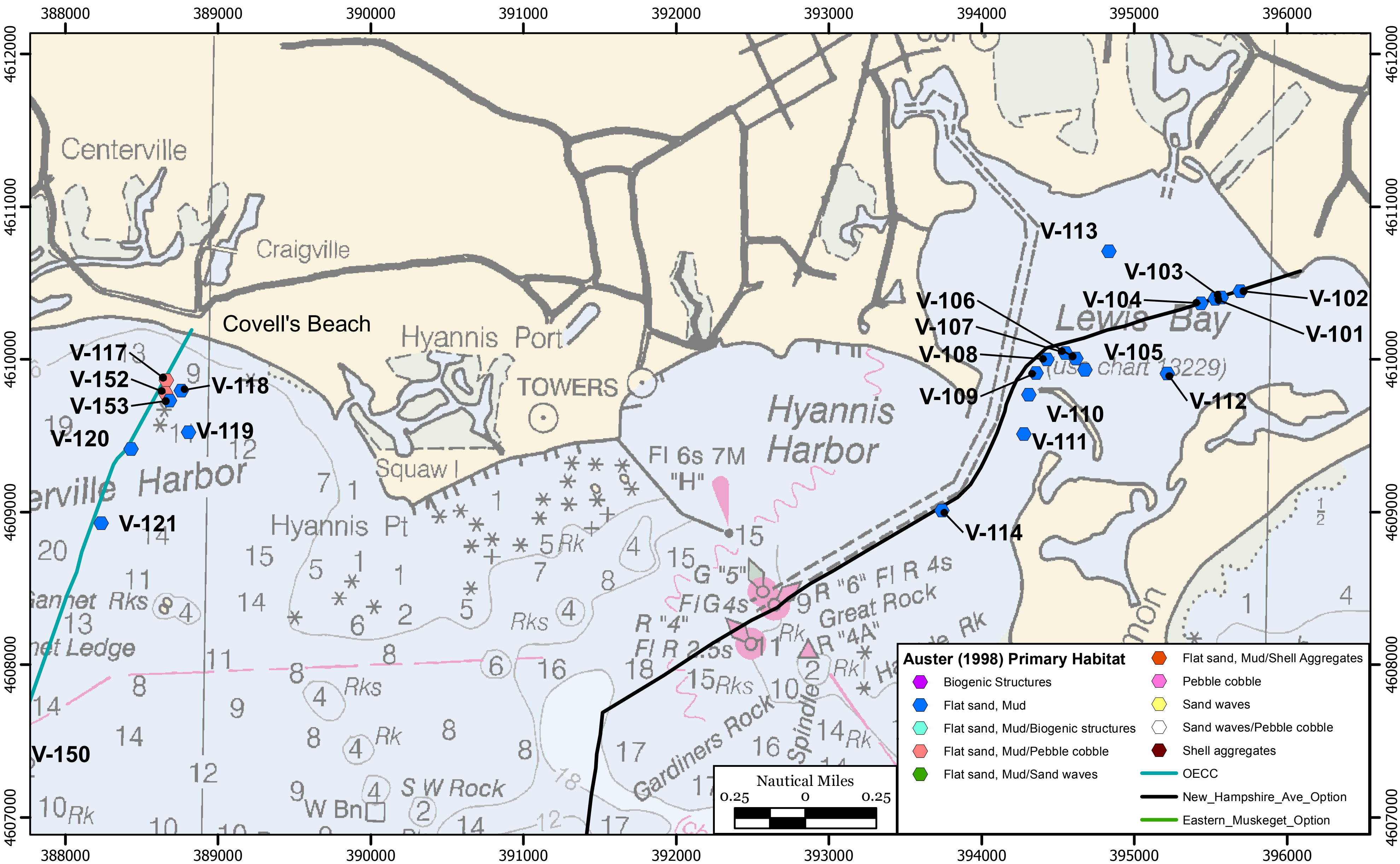
Video Transect Dominant Species
Vineyard Wind Project

NOTES:
1) Underwater video data collected in June and July 2018.
2) Grid: UTM, Zone 19N, NAD83, metric.

Figure 2



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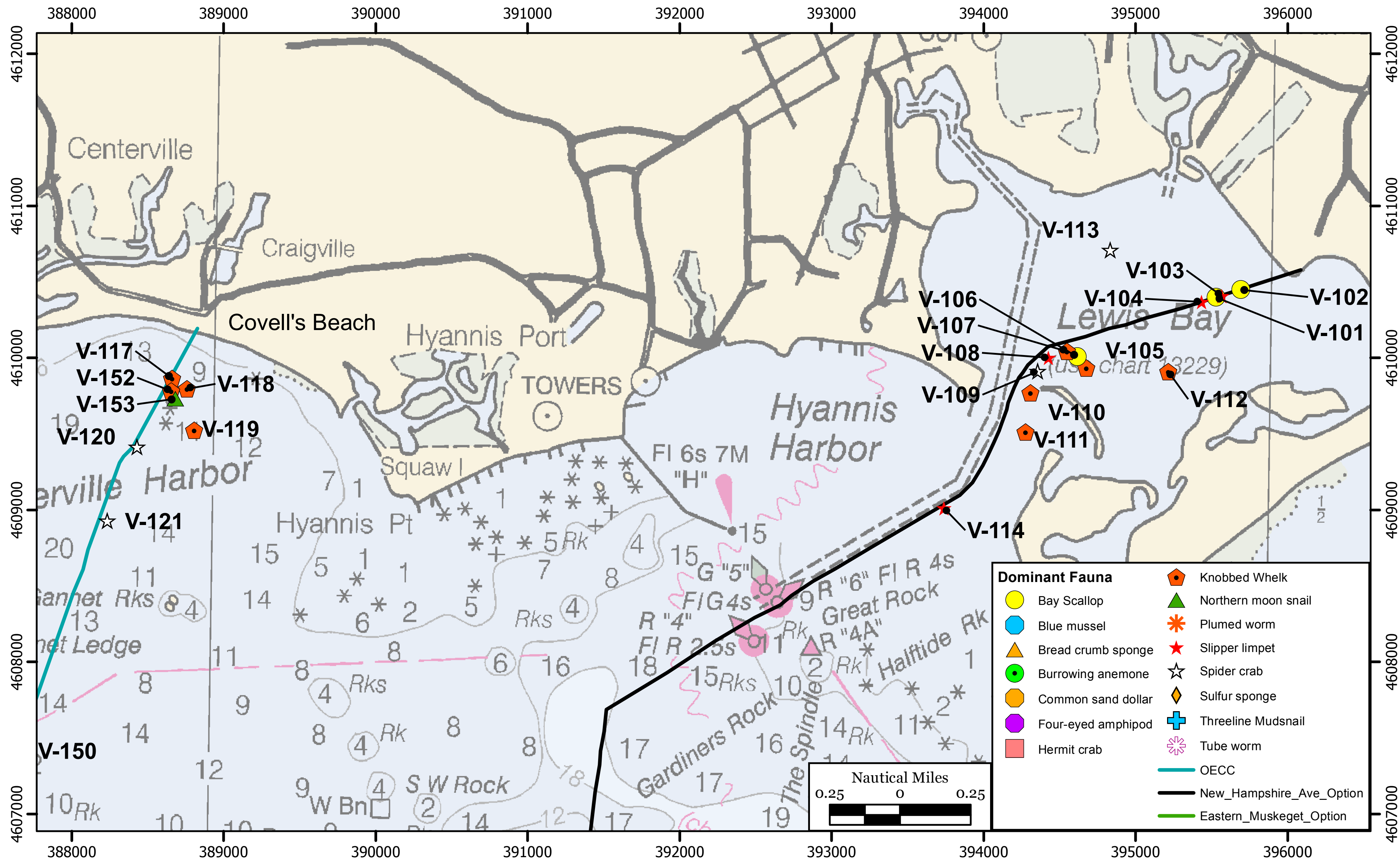
Video Transect Primary Habitat Classification
Centerville Harbor, Hyannis Harbor Entrance and Lewis Bay
Vineyard Wind Project

NOTES:
1) Underwater video data collected in June and July 2018.
2) Grid: UTM, Zone 19N, NAD83, metric.

Figure 3



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Transect Dominant Species
Centerville Harbor, Hyannis Harbor Entrance and Lewis Bay
Vineyard Wind Project

NOTES:
1) Underwater video data collected in June and July 2018.
2) Grid: UTM, Zone 19N, NAD83, metric.

Figure 4

PLATES

V-117 Dense to moderate coverage eelgrass bed in Centerville Harbor

V-120 Knobbed whelk and Dead Man's Fingers (*Codium fragile*)

V-152 Boulder with bushy bryozoan and attached algae

PLATE 1 Representative video screen captures of Bottom Habitat and Biota
CENTERVILLE HARBOR, Hyannis Harbor Entrance Channel

V-104 Bay Scallop in dense branching red algae in Lewis Bay

V-113 Horseshoe crab in Lewis Bay

V-107 Blue crab, scallop shell, branching red algae in Lewis Bay

PLATE 2 Representative video screen captures of Bottom Habitat and Biota
LEWIS BAY (NEW HAMPSHIRE AVENUE OPTION)

V-146 Surf clam in a s*and ripple* bottom

V-148 Spider crab feeding on slipper limpets

V- 123 Summer flounder in Nantucket Sound

PLATE 3 Representative video screen captures of Bottom Habitat and Biota NANTUCKET SOUND

V-127 Blue mussels in a *sand waves/pebble-cobble* bottom (OECC)

V-132 Sulfur sponge, sand sponge, invasive white tunicate (Eastern Option)

V-133 Bread crumb sponge and red tufted algae (Eastern Option)

PLATE 4 R**epresentative video screen captures of Bottom Habitat and Biota**
MUSKEGET CHANNEL

V-136 Long-finned squid at a *flat sand/mud* bottom

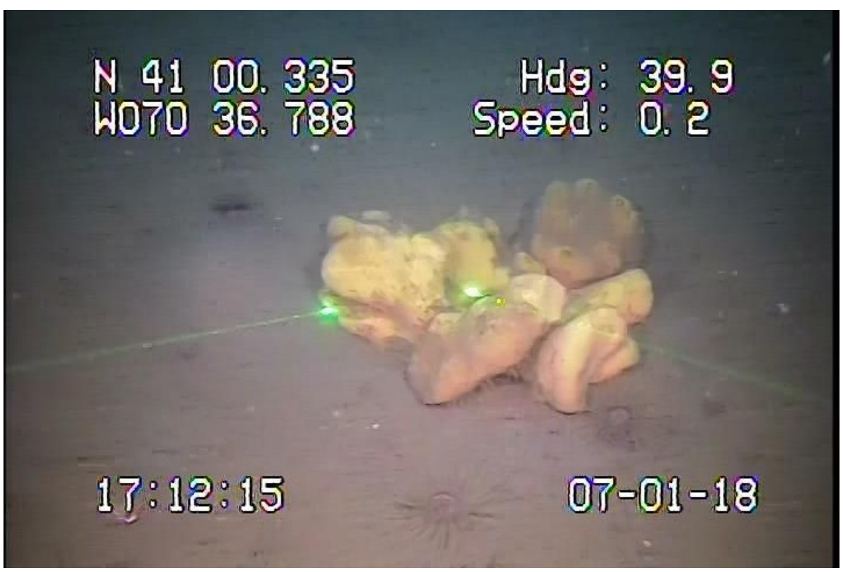
V-136 Little skate on a *flat sand/mud* bottom

V-138 Rock crab, moon snail on a *flat sand/mud* and *biogenic structures* combination bottom habitat

PLATE 5A Representative video screen captures of Bottom Habitat and Biota
ATLANTIC OCEAN SOUTHEAST OF MARTHA'S VINEYARD

V-139 Red hake, and sand dollars

V-139 Burrowing anemones, sand dollars, and hermit crab



V-144 Sulfur sponge, burrowing anemones

PLATE 5B Representative video screen captures of Bottom Habitat and Biota
ATLANTIC OCEAN SOUTHEAST OF MARTHA'S VINEYARD

5. RPS/Alpine 2019 Benthic Report

ALPINE VINEYARD WIND

Lease Area OCS-A 0501 South Benthic Report

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19-P-206028 Alpine Vineyard Wind Lease Areas OCS-A 0501 South Benthic Sampling Report V5

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1 INTRODUCTION

RPS was contracted by Alpine Ocean to collect, process, analyze, and compile benthic data from a towed video sled and grab sampler for two lease areas offshore of Martha's Vineyard, Massachusetts (OCS-A 0501) intended for the construction of offshore wind turbines. The field program focused on environmental data acquisition in the southern portion of Lease OCS-A 0501 (501S). The grab samples and video imagery data conclusions presented here will support interpretation of geophysical data to characterize surficial sediment conditions and classify the benthic habitat in both lease areas according to the Coastal and Marine Ecological Classifications Standards (CMECS; FGDC, 2012) and recent guidance for mapping fish habitat from National Marine Fisheries Service (NMFS, 2020) for inclusion in permitting documentation required by Bureau of Ocean Energy Management (BOEM). This report provides:

- A description of the benthic grab sampling methods, results, and analysis;
- The analysis of benthic grab sampling results using key statistical analyses such as taxa richness, density per cubic meter, community composition, etc.;
- A description and analysis of the video data collected; and
- CMECS classifications of each sample site based on the video, grain size, and benthic community lab results.

2 METHODS

2.1 Field Survey

2.1.1 Towed Camera Sled

Underwater video transects were taken in conjunction with grab samples for visual classification of the seafloor in November and December 2019. The camera sled was equipped with an altimeter to record distance above sea floor, temperature probe, parallel-mounted lasers 7.5 centimeters (cm) apart, and a cable that transmitted real-time viewing of images to the vessel. The video sled was deployed from a side-oriented A-frame by the Alpine Ocean crew and lowered until positioned 0.5-1.5 meters (m) above the seafloor. Distance of camera to the seafloor varied along each transect due to differences in sediment type, vessel speed, swells, and low visibility/high turbidity.

Video transects were recorded in accordance with procedures approved by Alpine and Vineyard Wind and following BOEM's Guidelines for Providing Benthic Habitat Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585 (BOEM, 2019). Vessel speed was usually kept to 1 knot or lower to accommodate the tow sled and never exceeded 3 knots. Direction was given from the video operator to the winch operator to raise and lower the towed camera sled as needed to maintain proximity to the seafloor; however, a combination of difficult weather and the location of the tow sled off the side of the vessel instead of the stern created changes in deck height relative to the seafloor which frequently pulled the towed camera sled out of visible range of the seafloor. While recording, field notes were taken containing sample information (date, time, global positioning satellite [GPS] coordinates, station ID, depth, and video file name) and observations of sediment/seafloor characteristics of note to aid in post-processing of video data. Special notes were made for the beginning and end of the transect as well as any changes in weather or visibility conditions, sediment, or species. During video recording, attention was given to noting if potentially sensitive benthic habitats (e.g., exposed hard bottom, seagrass/kelp/algal beds, coral species) were present, as per BOEM's guidelines (BOEM, 2019). Video transects were roughly 200 m in length.

2.1.2 Grab Sampling

Benthic grab samples were acquired using a Harmon/Day Grab Sampler owned by Alpine Ocean. The standard sampler had been modified to improve penetration and reduce sample disturbance, contamination, and washout during retrieval by the addition of weights, the use of stainless-steel sample doors and bucket, and an extended bucket lip. An ultra-short baseline (USBL) beacon was fixed to the grab sampler to obtain GPS coordinates in conjunction with a pole-mounted USBL system. An attached video camera was intended to be used to collected additional information concerning the area surrounding the grab sample site but high turbidity/low visibility and rapid changes in grab sampler altitude due to weather and side deployment made it difficult to assess bottom type without contact.

Upon retrieval, the grab sampler was examined for sample acceptability. A sample was initially deemed acceptable only if the bucket was more than 50% full, the sample was not over penetrated (i.e., not full to the top), and sample surface structures were undisturbed and even (i.e., not slumped). However, due to the frequency of soft-bottom habitat comprised of mud and silt, RPS was authorized by onboard client representatives to accept over penetrated samples with disturbed surfaces (though discretion was used in cases of severely compromised samples).

If a sample did not fulfil these requirements, the contents were deposited into a clean bucket and another sample attempt was made. All subsequent failed samples (up to three attempts per station) were collected in the same bucket, contents mixed thoroughly, and core and sediment samples collected from the mixture to acquire the sample. If more than three failed sample attempts occurred at one station, sampling moved on to the next station (no more than three fails occurred in any one sampling station). The results of each attempted grab were recorded in field notes.

Once an acceptable sample was obtained, the following steps were taken:

1. A photograph was taken of the sample next to an identification label containing sample identification number.

2. Field notes included descriptions of physical features (depth of penetration, sediment color, texture, surface features) and surface macrofauna; large surface fauna were returned to the water (crabs and a skate were returned at different sites).

3. The grab sample was then divided into an "A" and backup "B" sample based on the bucket design which was accessed via two hinged doors divided by a central support bar. The "A" designation was assigned to the least disturbed side or arbitrarily when samples were of equal quality.

4. A four-inch diameter plexiglass tube was inserted and sediment cores were removed from each side of the grab sampler bucket and placed in sieving buckets.

5. A 100-mL sample was taken from the sediment surrounding the cores on both sides and placed in plastic bags for grain size analysis.

After collection, the "A" sample was then photographed and described more thoroughly (grain size and characteristics at depth) and both samples were then loaded onto a processing table and material washed through a 500-µm sieve using seawater under gentle pressure.

Organisms, shell fragments, and other remaining material was placed into a plastic container using stainless steel forceps as needed. The container was filled no more than two-thirds full of sample and seawater. If the quantity of sample exceeded this volume, it was placed in a second container. The sample was fixed/preserved with 10% buffered formalin solution dyed with Rose Bengal by filling the remaining space within the bottle with solution. Containers were tightly sealed with electrical tape and stored in a cooler at ambient temperature (not frozen or refrigerated). Prior to sieving the next sample, the sieve was cleaned by backwashing with pressurized water. The infaunal samples for OCS-A 0501 South were sent to ESS (Waltham, MA) and the grain size samples were sent to TerraSense (Totowa, NJ) for processing.

2.2 Lab Analysis

2.2.1 Grain Size and TOC Analysis

Grain size samples were analyzed by TerraSense using the American Society for Testing and Materials (ASTM) soil classification system standards D2487 and D2488 (ASTM, 2016a;b).

2.2.2 Benthic Infauna Analysis

The benthic infauna analysis was conducted by ESS according to the following steps:

1. Benthic infaunal samples were catalogued and verified against the Chain of Custody to ensure samples received match those listed in the shipment.

2. Samples were rinsed with freshwater to remove the formalin and transferred to ethanol for sorting and storage.

3. Organisms were identified to the lowest practical taxonomic level (LPTL) and counted by taxonomists using the most appropriate taxonomic references for the region.

4. Prior to performing the infaunal data analysis, the overall dataset was scanned for noninfaunal taxa (i.e., pelagic or planktonic organisms) that were excluded from all analyses; examples include chaetognaths, hyperiid amphipods, and decapod zoea/megalopae.

2.3 Video Data Post-Processing

2.3.1 Objectives

Post-processing and analysis of video transect data were conducted by RPS to provide:

- General characterization of substrate including bottom type, texture, micro-topography, and presence and approximate thickness (absent, light, moderate, or heavy) of sedimentation (“drape”) covering hard substrates;
- Evidence of benthic activity by organisms (burrows, trails, biogenic reefs);
- Identification of epibenthic macroinvertebrates (decapod crustaceans, mollusks including squid mops], echinoderms) and benthic habitat;
- Presence/evidence and general characterization of submerged aquatic vegetation (macroalgae, sea grass);
- Identification of fish and fish habitat (where feasible) as classified by Auster (1998) to provide back compatibility with prior sampling work in the region;
- Identification of organisms to the lowest practical taxonomic level (generally to Order to Family) using standard taxonomic keys for the geographic area;
- Evidence of fishing activity, such as trawl scars, pots, and working nets; and
- Presence of derelict fishing gear, military expended materials, shipwrecks, cultural artifacts, or other marine debris.

All still images from videos were classified according to CMECS (FGDC, 2012), which focuses closely on details of grain size and composition to describe benthic habitats and is being used to define complex and otherwise valuable fish habitats. Auster (1998) classification is also included as it is indicative of overall habitat features that can be important to fish and has been historically used for habitat classification. The BOEM Benthic Habitat Survey guidelines (BOEM, 2019) also require that the developer characterize the benthic community composition which includes documentation of abundance, diversity, percent cover, and community structure. The following were recorded when present and identifiable:

- Characterization and delineation of any submerged aquatic vegetation (seagrass or macro-algae) that occurs within the area of potential adverse effect;
- Characterization and delineation of any hard-bottom gradients of low to high relief such as coral (heads/reefs), rock or clay outcroppings, or other shelter-forming features; and

- Identification of communities of sessile and slow-moving marine invertebrates (clams, quahogs, mussels, polychaete worms, anemones, sponges, echinoderms) that may be within the area of potential adverse effect.

2.3.2 Methods

The video data post-processing methods were developed based on relevant information presented in various peer-reviewed publications and technical guidelines, such as:

- "Northeast Atlantic Marine Biological Analytical Quality Control Scheme (NMBAQC) and Joint Nature Conservation Committee (JNCC): Epibiota remote monitoring from digital imagery: interpretation guidelines (Turner et al., 2016);
- "NMBAQC and JNCC: Epibiota remote monitoring from digital imagery: operational guidelines" (Hitchin et al., 2015).
- "Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects" (Judd, 2011);
- "Mapping European Seabed Habitats (MESH) Seafloor video mapping: collection, analysis, and interpretation of seafloor video footage for the purpose of habitat classification and mapping" (White et al., 2007);
- "Video analysis, experimental design, and database management of submersible-based habitat studies" (Tissot, 2008); and
- "Photographic evaluation of the impacts of bottom fishing on benthic epifauna" (Collie et al., 2000).

Videos were reviewed and analyzed in two separate steps. First, each video was reviewed in its entirety multiple times and any notable seafloor features or epifaunal/benthic/demersal species were recorded. When a feature or species was identified, the reviewer recorded the time, rated video visibility, categorized the bottom based on Auster (1998), and recorded the lowest possible taxon and abundance of organisms greater than ~4 cm in size (equal to roughly half the distance between the laser points). CMECS classification was applied to each individual still image during a later processing step using percent cover information. Most portions of the videos were reviewed multiple times using slower playback speeds and replay functions. After review, the taxonomic details of each macrofaunal observation were investigated and data were recorded at the lowest possible taxonomic level identifiable through the video.

Second, each video was subsampled to produce still images at 5-second intervals. Metadata were recorded for each still image including latitude and longitude, transect, and ID number. The quality of each image was assessed with a categorical scale from 0 to 4. Still images with quality scores of "moderate" (2 or greater) were analyzed with seabed image processing software photoQuad (Trygonis and Sini, 2012). Each image was calibrated using the reference laser points and the area of the visible portion was recorded. Poorly lighted or blurry edges of "passing" images were excluded from analysis.

The abundance of macrofauna was recorded along with presence/absence benthic biotic activity, submerged aquatic vegetation (macroalgae, sea grass), fishing activity, derelict gear, military expended materials, shipwrecks, coral heads/reefs, rock outcroppings, other shelter features, and other marine debris. A score for visibility, Auster (1998) fish habitat characterization, and rugosity (i.e., seafloor roughness or habitat complexity based on visual estimation) were assigned for each image as a whole (see definitions in Table 2).

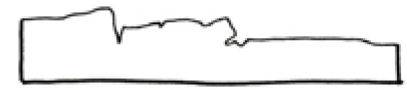
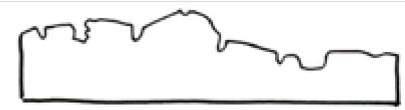
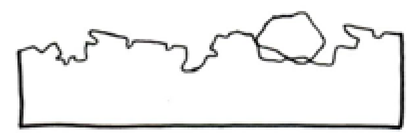
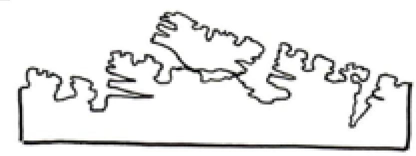
For CMECS classification, fifty points were distributed uniformly across the entire visible portion of each still image using photoQuad. Percent cover data were recorded as the number of points under which different substrate types or features were visible: boulder/cobble, pebble/granule, sand/mud, shells, infaunal structures (e.g., worm or amphipod tubes), burrows (e.g., crab depressions or clam siphon holes), mobile macrofauna, sessile macrofauna, algae, or encrusting organisms. These point counts were multiplied by two to approximate percent cover for the still image and used to assign the appropriate substrate classifications of the habitat to the furthest extent possible according to CMECS standards (FGSC, 2012). Biogenic shell substrate was characterized by the size and percent cover of the biogenic features (Table 1). Other biological elements were recorded (e.g., burrows, infaunal structures, macrofoauna) even though they are not part of the CMECS substrate categories.

Table 1. CMECS biogenic modifier size and percent cover categories.

Biogenic Size	Definition	Biogenic Cover	Definition*
Reef	> 4,096 mm	Trace	< 2%
Rubble	64 – 4,096 mm	Sparse	1 – 30%
Hash	2 – 64 mm	Moderate	30 – 70%
Sand	< 2 mm	Dense	70 – 90%
		Complete	> 90%

* Adapted from FGDC, 2012.

Table 2. Still image data analysis categories for visibility, Auster sediment class, and rugosity.

Visibility Score	Visibility Definition	Auster Category	Auster Definition*	Rugosity Score	Rugosity Definition**
0 – none	obscured or turbid, lasers not visible on seafloor	1 – flat sand/mud	areas with no vertical structure	0 – none	
1 – low	some visibility but still blurry, lasers may or may not be visible	2 – sand waves	troughs and waves in sand	1 – low	
2 – moderate	some features distinguishable, both lasers in view	3 – biogenic structures	burrows, depressions, and other features created or used by mobile fauna for shelter	2 – moderate	
3 – high	most features distinguishable, both lasers in view	4 – shell aggregates	shells create complex interstitial spaces for shelter and high-contrast background	3 – high	
4 - excellent	all features clearly visible, both lasers in view	5 – pebble-cobble	small interstitial spaces, less ephemeral than shell	4 - extreme	
		6 – pebble-cobble with sponge cover	attached fauna increase spatial complexity		
		7 – partially buried or dispersed boulders	partially buried boulders provide high vertical relief while dispersed boulders over cobble provide simple crevices		
		8 – piled boulders	provide deep interstitial spaces of variable sizes		

*Adapted from Auster, 1998. ** Adapted from Turner et al., 2016.

2.4 Benthic Infaunal Data Post-Processing

The benthic infaunal community analysis was based on the laboratory results provided by ESS for the 40 successful grab samples in OCS-A 0501 South. Infaunal community statistics were calculated using species and abundance estimates in each sample, which were reported as count per 0.008 m^2 (area of subsample core). Community composition parameters included: total abundance, number of phyla, number of taxa, Margalef's Richness Index, Shannon Diversity Index, and Pielou's Index of Evenness for each station and within each lease area.

2.4.1 Taxonomic Composition

Taxa composition was assessed to characterize the high-level trends in taxa data. Taxa composition includes the relative proportions of taxonomic groups by number of identifiable taxa and number of individuals, and was used to evaluate dominance of common phyla across all samples. Taxa composition was summarized for individual samples.

2.4.2 Richness, Diversity, and Evenness

Species richness, evenness, and diversity are common ecological parameters used to measure the overall biodiversity of a community or discrete unit. Because some taxa were not identified to the species level, we used abundance data for organisms identified to the LPTL but no further than family, modifying the indices to be taxonomic richness, evenness, and diversity indices. Taxonomic richness is the number of unique species or taxonomic groups represented in an area of interest. In this assessment, taxonomic richness was calculated using Margalef's Richness Index (Formula 1) for each station and lease area to acquire sample and average richness indices.

Formula 1. Margalef's Richness Index (RI).

$$\mathrm{RI} = \frac{(\mathrm{S}-1)}{\ln(\mathrm{n})}$$

Where:

S= the number of unique taxa

n= the total number of individuals in the sample

Interpretation: The higher the index, the greater the richness.

The diversity index for a community considers taxonomic richness and the proportion of each unique taxa. The Shannon Diversity Index (H'; Formula 2) was calculated using the number of each taxa, the proportional abundance of each taxa relative to the total number of individuals, and the sum of the proportions. This index was used to assess diversity of each station and lease area. The diversity index (H') increases with increasing taxonomic richness and evenness.

Formula 2. H'- Shannon Diversity Index.

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

Where:

p_i = the proportion of individuals belonging to the taxa i

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

Evenness of a community refers to the similarity in abundances of different taxa comprising a population or sample. Pielou's Index of Evenness includes H' (Shannon-Weiner Diversity Index) in its calculation.

Formula 2. J'- Pielou's Index of Evenness.

$$J' = \frac{H'}{H_{Max}}$$

Where:

H' = the Shannon- Weiner Diversity Index

H_{Max} = the maximum possible value of H', where each taxon occurs in equal abundances.

$$H_{Max} = \ln(s)$$

Where: s = Number of taxa

Interpretation: J' is constrained between 0 and 1. The greater the value of J', the more evenness in the sample.

3 OCS-A 0501 SOUTH RESULTS

3.1 Video Analysis

The characteristics and locations of the 23 underwater video transects within OCS-A 0501 South are described in Table 3 and shown in Figure 1. Note that four transects collected near the beginning of the survey effort in November 2019 (VT05, VT07, VT08, and VT25_3) used a fiberglass tow sled frame that did not perform well under rough sea conditions. After three attempts at transect VT25_3, the fiberglass frame broke; thus, the same camera was transferred to a heavier metal tow sled frame that provided more stability to the tow system for the remaining transects and that transect was not analyzed in this report because it was not completed.

Table 3. Underwater video transect locations and characteristics in OCS-A 0501 South.

Transect	Date	Recorded Duration (min:sec)	Start Latitude	Start Longitude	End Latitude	End Longitude	Total # Stills	# Analyzed Stills
VT01	12-Dec-2019	10:40	40.899805	-70.643982	40.638867	-70.644450	121	18
VT02	13-Dec-2019	09:26	40.949775	-70.571958	40.949775	-70.568895	112	20
VT03	13-Dec-2019	08:52	40.985128	-70.577737	40.985432	-70.574645	102	33
VT04	12-Dec-2019	09:49	40.976193	-70.650150	40.976420	-70.647145	112	39
VT05	4-Nov-2019	08:22	40.952160	-70.621612	40.952967	-70.619345	92	13
VT06	13-Dec-2019	08:34	40.954183	-70.493593	40.954143	-70.490225	91	33
VT07	4-Nov-2019	14:17	40.934707	-70.641213	40.936673	-70.641215	150	3
VT08	3-Nov-2019	14:53	40.935785	-70.689365	40.936183	-70.689273	166	12
VT09	12-Dec-2019	08:04	40.928763	-70.531435	40.926548	-70.530512	92	32

Transect	Date	Recorded Duration (min:sec)	Start Latitude	Start Longitude	End Latitude	End Longitude	Total # Stills	# Analyzed Stills
VT10	12-Dec-2019	08:51	40.918977	-70.575940	40.920543	-70.573335	103	37
VT11	8-Dec-2019	10:35	40.901282	-70.771778	40.898950	-70.771205	122	40
VT12	12-Dec-2019	08:22	40.901242	-70.590480	40.903597	-70.592352	100	30
VT13	8-Dec-2019	10:48	40.885388	-70.705013	40.883172	-70.706458	120	29
VT14	8-Dec-2019	10:09	40.875468	-70.770185	40.874938	-70.767187	116	37
VT15	12-Dec-2019	10:35	40.870227	-70.640078	40.869065	-70.637275	122	29
VT16	8-Dec-2019	09:47	40.866407	-70.771490	40.867022	-70.768847	121	43
VT17	8-Dec-2019	08:27	40.849055	-70.798527	40.850658	-70.800392	92	26
VT18	8-Dec-2019	12:10	40.833607	-70.682203	40.835863	-70.682227	136	39
VT19	8-Dec-2019	09:51	40.832622	-70.745443	40.834423	-70.747260	109	15
VT20	8-Dec-2019	08:35	40.833700	-70.638287	40.835432	-70.637202	96	39
VT21	8-Dec-2019	10:14	40.791748	-70.701483	40.791748	-70.701007	113	28
VT22	8-Dec-2019	15:16	40.750033	-70.736123	40.751978	-70.735143	156	30
VT25_3*	4-Nov-2019	06:57	40.968617	-70.600275	40.968455	-70.599440	100	0

* Bad video overlay, rough sea conditions, only partial data collected so was not analyzed.

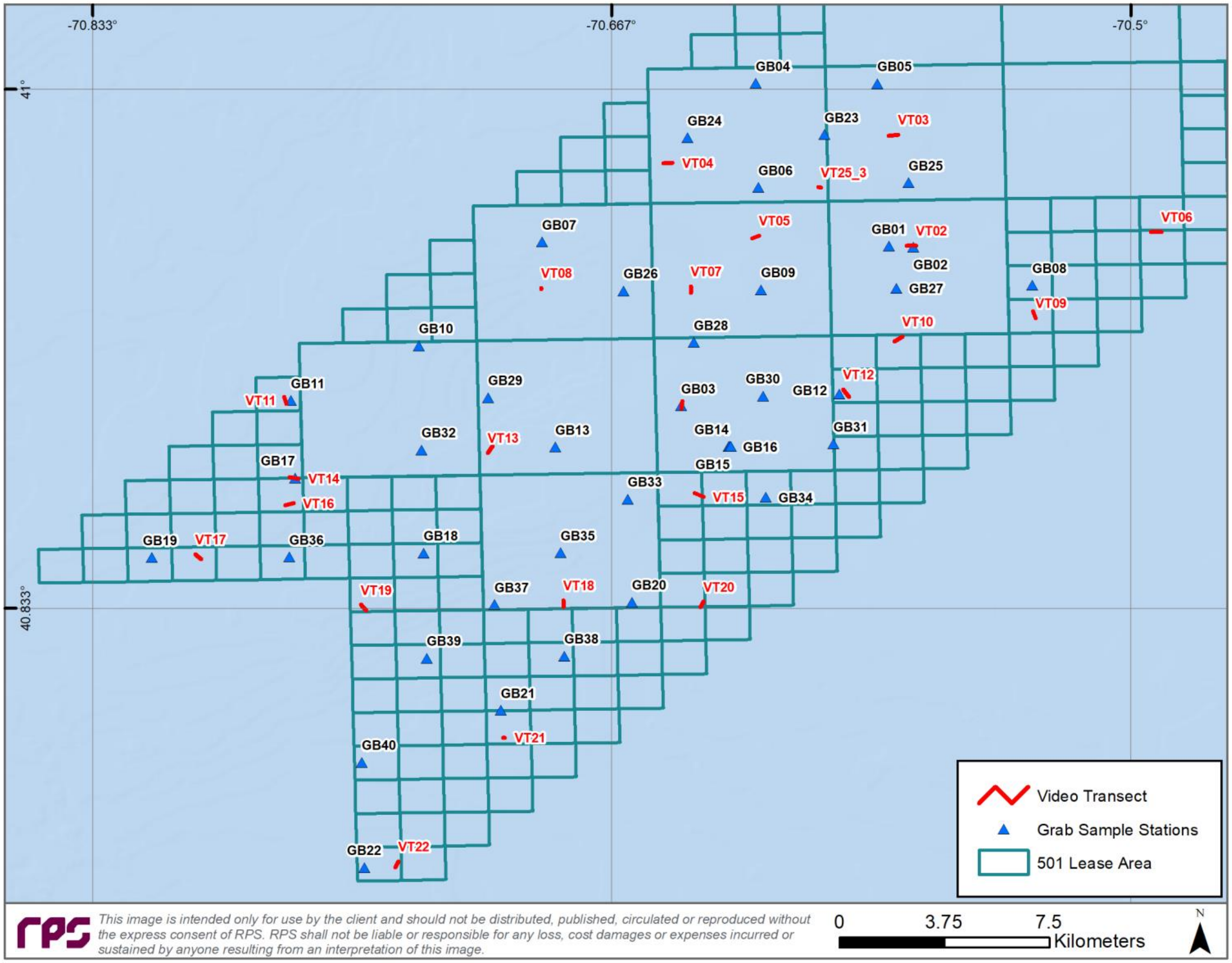


Figure 1. Map of OCS-A 0501 lease area video transects (red) and grab sample sites (blue).

3.1.1 Macrofauna Counts

The presence and abundance of macrofauna > 4 cm were recorded during the video review process (Table 4 and Figure 2). Organisms were identified to the LPTL, usually Order or Family. Seven fish taxa, ten invertebrate taxa, and two kinds of egg cases (skate and moon snail) were observed in the OCS-A 0501 South lease area. A total of 1632 individual macrofauna were counted, 80% of which (1311 individuals) were sea stars (*Asterias* spp.) counted in VT22. Other relatively numerous taxa across transects include hake (*Merluccius* spp.), moon snail (Naticidae), sea sponge (Porifera), and skate (Rajidae). Representative images of some of the macrofauna identified can be seen in Table 5.

Table 4. Macrofauna enumerated during review of the video transects in OCS-A 0501 South (continued on next page).

Common Name	Lowest Taxonomic Grouping	Counts per Transect										
		VT01	VT02	VT03	VT04	VT05	VT06	VT07	VT08	VT09	VT10	VT11
American Lobster	*Homarus americanus*	-	-	-	-	-	-	-	-	-	-	-
Cancer crab	Cancer	-	-	-	-	-	-	-	-	-	-	-
Flounder	Pleuronectiformes	-	-	-	-	-	-	-	-	1	-	1
Fourspot flounder	*Hippoglossina oblonga*	-	-	-	-	-	-	-	-	-	-	-
Hake	Merluccius	1	1	1	3	-	4	1	-	4	1	-
Hermit crab	Pagurus	-	-	-	2	1	1	-	1	-	-	2
Moon snail	Naticidae	1	-	11	9	-	31	-	-	1	-	3
Moon snail egg case	Naticidae egg case	1	-	-	-	1	-	-	-	-	-	-
Northern sea robin	Prionotus	-	-	-	-	-	-	-	1	-	-	-
Ray-finned Fish	Actinopterygii	-	-	1	-	-	-	-	-	-	-	-
Sea scallop	*Placoopecten meagellanicus*	-	-	-	-	-	-	-	-	-	-	4
Sea sponge	Porifera	1	3	4	1	1	6	-	-	2	3	6
Sea urchin	Echinoidea	-	-	-	-	-	-	-	-	-	-	-
Seastar	Asterias	3	2	-	-	-	-	-	-	2	1	-
Shrimp	Decapoda	-	-	-	-	-	-	-	-	-	-	-
Skate	Rajidae	1	2	3	4	2	1	3	1	2	-	2
Skate egg case	Rajidae egg case	-	-	2	-	-	-	-	-	-	-	2
Squid	Cephalopoda	-	-	-	-	-	-	-	-	-	-	-
Unidentified fish	Actinopterygii	-	-	1	-	-	1	-	-	-	-	-
Winter skate	*Leucoraja ocellata*	-	-	-	-	-	-	-	-	-	-	-
Totals	-	8	8	23	19	5	44	4	3	12	5	20

Lowest Taxonomic Grouping	Common Name	Counts per Transect											
		VT12	VT13	VT14	VT15	VT16	VT17	VT18	VT19	VT20	VT21	VT22	Total
American Lobster	*Homarus americanus*	-	-	2	-	-	-	-	-	-	-	-	2
Cancer crab	Cancer	-	-	1	-	-	-	2	-	-	1	10	14
Flounder	Pleuronectiformes	-	-	1	1	-	1	-	3	-	1	29	38
Fourspot flounder	*Hippoglossina oblonga*	-	1	-	-	-	-	-	-	-	-	-	1
Hake	Merluccius	3	2	2	4	1	3	1	-	3	1	3	39
Hermit crab	Pagurus	-	2	3	1	-	1	-	-	1	-	-	15
Moon snail	Naticidae	3	1	-	4	2	-	-	-	-	-	-	66
Moon snail egg case	Naticidae egg case	-	1	-	-	-	1	-	-	-	-	-	4
Northern sea robin	Prionotus	-	-	-	-	-	-	-	-	-	-	-	1
Ray-finned Fish	Actinopterygii	1	-	-	-	-	-	-	-	-	-	-	2
Sea scallop	*Placoopecten meagellanicus*	-	-	-	-	1	-	-	1	1	-	-	7
Sea sponge	Porifera	3	3	-	6	2	1	-	-	1	2	-	45
Sea urchin	Echinoidea	-	-	1	-	-	-	25	-	1	-	-	27
Seastar	Asterias	2	1	1	1	-	-	-	2	-	3	1293	1311
Shrimp	Decapoda	-	1	-	-	-	-	-	-	-	-	-	1
Skate	Rajidae	4	1	2	6	2	3	-	-	2	-	-	41
Skate egg case	Rajidae egg case	-	1	-	-	-	-	-	1	-	-	-	6
Squid	Cephalopoda	-	-	-	2	3	-	-	-	-	-	-	5
Unidentified fish	Actinopterygii	-	-	2	-	-	-	1	-	-	-	-	5
Winter skate	*Leucoraja ocellata*	-	-	2	-	-	-	-	-	-	-	-	2
Total	**-**	**16**	**14**	**17**	**25**	**11**	**10**	**29**	**7**	**9**	**8**	**1335**	**1632**

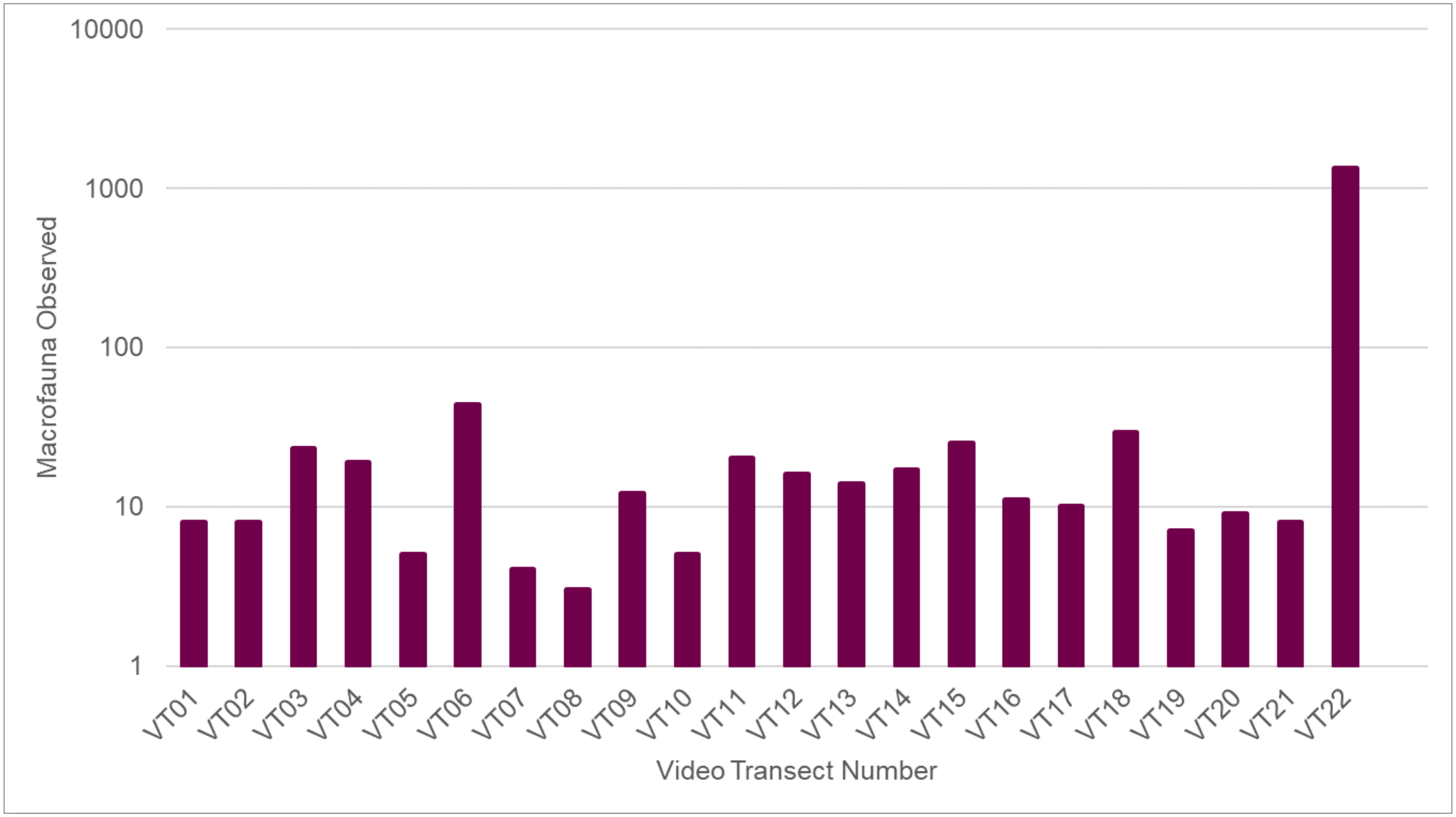
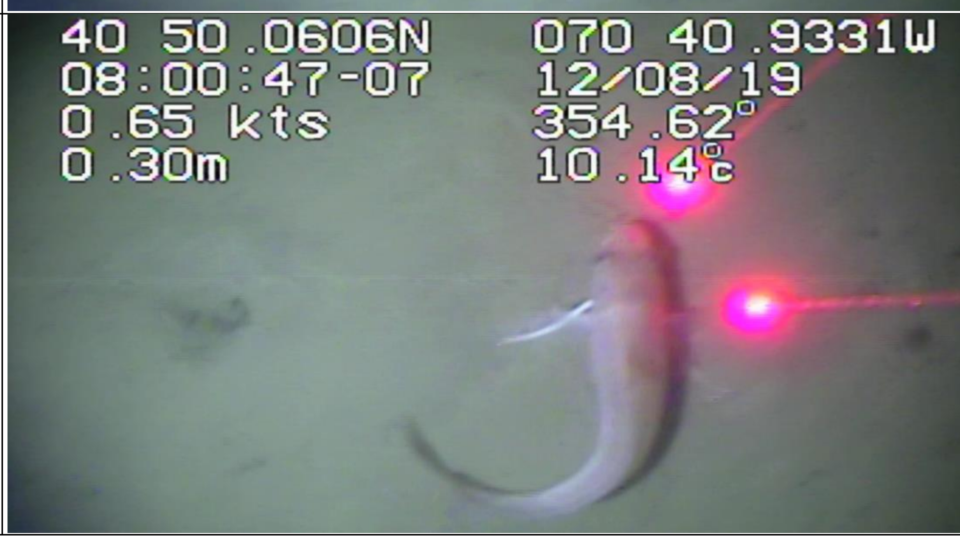


Figure 2. Counts of macrofauna enumerated in OCS-A 0501 South during video review for each transect, identified to lowest practical taxonomic level. Note that Logarithmic scale was used on y-axis to reconcile large range.

Table 5. Representative images of macrofauna observed and identified in transects within OCS-A 0501 South (continued on next two pages).

Sponge (*Porifera* spp.) VT01	
Cancer Crab (*Cancer* spp.) VT14	
Hake (*Merluccius* spp.) VT18	

Skate
(*Leucoraja* spp.)
VT14

Flounder
(Pleuronectiformes)
VT22

American Lobster
(*Homarus americanus*)
VT14

<table>
<tr>
<td>Sea Urchin
(Echinoidea)
VT18</td>
<td>
</td>
</tr>
<tr>
<td>Sea Star
(Asterias spp.)
VT22</td>
<td>
</td>
</tr>
</table>

3.1.2 Percent Cover

The following sections summarize the percent cover data obtained from still images taken throughout the underwater video transects in OCS-A 0501 South (Table 6). CMECS substrate categories were combined to the level detectable via visual analysis. Finer resolution classification into different subgroups requires grain size analysis of samples overlapping the video transect directly, which was done using grain size data in the CMECS classifications in Section 5. For these percent cover estimates, our grain size categories were sand/mud, pebble/granule, and boulder/cobble. Additional categories, included in CMECS as biotic or geoform classes, were included to assess the percent cover of anthropogenic debris and biological elements, such as infaunal structures (e.g., worm tubes, amphipod beds), shells, burrows (> 5 -100 mm width), sessile fauna, and macrofauna. Representative examples of habitat types detected in the still images are presented in Table 7.

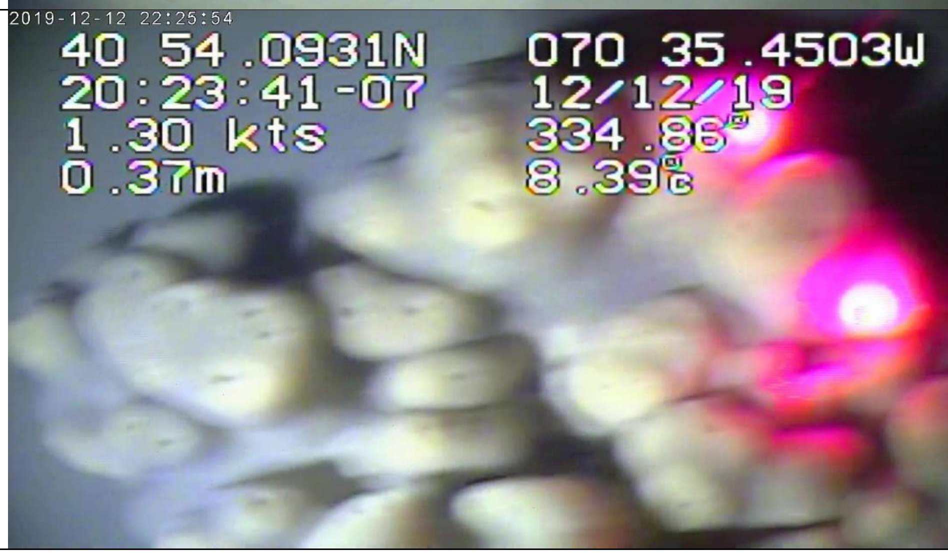
The substrate with the highest percent cover across all transects sampled in OCS-A 0501 South was fine sand/mud. There were no visual observations of boulder, cobble, pebble, or gravel substrates of geologic origin. Of the biological elements, infaunal structures had the highest percent cover and occurred in the most transects. Anthropogenic debris in the form of derelict fishing gear was observed in a single transect, VT14.

Table 6. Area and mean percent cover summarizing point count data across all stills in each of the 22 video transects in OCS-A 0501 South.

Transect	Total Area Analyzed (m^2)	Total # Stills Analyzed	Anthro-pogenic (%)	Biogenic	Geologic		Other Biological Elements				Primary CMECS Substrate Component
				Shells (%)	Gravel (%)	Sand/Mud (%)	Infaunal Structures (%)	Burrows (%)	Sessile (%)	Macrofauna (%)	
VT01	4.24	18	-	-	-	99.1	-	-	0.9	-	Geologic Unconsolidated Fine Sand / Mud
VT02	4.47	20	-	0.2	-	99.8	-	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT03	8.43	33	-	-	-	99.9	0.1	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT04	8.46	39	-	0.1	-	99.8	-	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT05	2.63	13	-	-	-	100.0	-	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT06	6.76	33	-	-	-	100.0	-	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT07	0.22	3	-	-	-	100.0	-	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT08	2.10	12	-	-	-	98.4	1.6	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT09	10.26	32	-	0.1	-	99.7	-	-	-	0.2	Geologic Unconsolidated Fine Sand / Mud
VT10	10.92	37	-	-	-	99.8	0.1	-	0.1	-	Geologic Unconsolidated Fine Sand / Mud
VT11	12.24	40	-	-	-	99.9	-	0.1	-	-	Geologic Unconsolidated Fine Sand / Mud
VT12	7.00	30	-	0.2	-	99.2	-	-	0.5	-	Geologic Unconsolidated Fine Sand / Mud
VT13	9.19	29	-	-	-	99.9	-	0.1	-	-	Geologic Unconsolidated Fine Sand / Mud
VT14	8.37	37	2.4	1.2	-	95.0	0.1	0.3	-	1.0	Geologic Unconsolidated Fine Sand / Mud
VT15	7.42	29	-	-	-	100.0	-	-	-	-	Geologic Unconsolidated Fine Sand / Mud
VT16	14.77	43	-	0.1	-	99.9	-	0.1	-	-	Geologic Unconsolidated Fine Sand / Mud
VT17	7.96	26	-	-	-	99.7	-	0.3	-	-	Geologic Unconsolidated Fine Sand / Mud
VT18	9.69	39	-	-	-	99.0	-	1.0	-	-	Geologic Unconsolidated Fine Sand / Mud
VT19	3.34	15	-	0.8	-	97.7	0.5	0.7	-	0.4	Geologic Unconsolidated Fine Sand / Mud
VT20	9.62	39	-	0.2	-	95.7	3.7	0.1	-	0.4	Geologic Unconsolidated Fine Sand / Mud
VT21	6.05	28	-	0.2	-	89.6	5.9	4.2	-	0.1	Geologic Unconsolidated Fine Sand / Mud
VT22	11.12	30	-	0.2	-	90.6	5.9	0.1	-	3.1	Geologic Unconsolidated Fine Sand / Mud

Table 7. Representative still images of various habitat types observed in 22 video transects in OCS-A 0501 South (continued on next page).

Fine sand/mud (VT11)	
Fine sand/mud with anthropogenic debris (derelict fishing pot with encrusting biota) (VT14)	
Fine sand/mud with shell debris (VT 12)	

Fine sand/mud with burrows (VT19)	
Fine sand/mud with sessile sponge (VT12)	

3.2 Grab Samples

The characteristics and locations of the grab sample stations within the OCS-A 0501 South lease area are described in Table 8 and shown in Figure 1 (in Section 3.1). The sample penetration depth is the depth of the sample within the grab equipment (i.e., the height of collected sediment from the center of the closed sampler to surface of sediment).

Table 8. Grab sample station locations and characteristics in OCS-A 0501 South (continued on next two pages).

Sample	Date	Time (EST)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Sample Penetration Depth
GB01	3-Nov-19	2:10 PM	40.94953	70.57768	53.8	11 cm
GB02	3-Nov-19	1:57 PM	40.94932	70.56974	53.1	10 cm
GB03	4-Nov-19	10:50 AM	40.89828	70.64429	49.5	8 cm

Sample	Date	Time (EST)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Sample Penetration Depth
GB04	3-Nov-19	4:05 PM	41.00187	70.62040	49.4	9 cm
GB05	3-Nov-19	3:34 PM	41.00173	70.58129	50.9	14 cm
GB06	3-Nov-19	4:54 PM	40.96840	70.61960	51.0	12 cm
GB07	4-Nov-19	9:27 AM	40.95088	70.68893	48.0	7 cm
GB08	3-Nov-19	1:27 PM	40.93701	70.53167	52.0	13 cm
GB09	3-Nov-19	6:04 PM	40.93551	70.61873	49.2	>12.5 cm
GB10	4-Nov-19	11:42 PM	40.91754	70.72855	59.2	12 cm
GB11	4-Nov-19	11:29 PM	40.89998	70.76969	56.5	11.5 cm
GB12	4-Nov-19	11:33 AM	40.90212	70.59356	52.8	13 cm
GB13	4-Nov-19	10:03 PM	40.88505	70.68481	56.7	12 cm
GB14	4-Nov-19	1:07 PM	40.88524	70.62909	53.1	14 cm
GB15	4-Nov-19	12:47 PM	40.88524	70.62879	53.5	16 cm
GB16	4-Nov-19	12:20 PM	40.88521	70.62842	57.9	6.5 cm
GB17	4-Nov-19	9:01 PM	40.87514	70.76828	58.1	14 cm
GB18	4-Nov-19	7:21 PM	40.85096	70.72698	57.6	12.5 cm
GB19	4-Nov-19	8:22 PM	40.84955	70.81424	53.5	15 cm
GB20	4-Nov-19	3:11 PM	40.83519	70.66011	58.6	13 cm
GB21	4-Nov-19	4:29 PM	40.80052	70.70225	60.5	13 cm
GB22	4-Nov-19	5:42 PM	40.74996	70.74610	66.5	15.5 cm
GB23	3-Nov-19	3:13 PM	40.98541	70.59835	51.9	12 cm
GB24	3-Nov-19	4:32 PM	40.98440	70.64234	50.2	9.5 cm
GB25	3-Nov-19	2:47 PM	40.96990	70.57137	51.0	10 cm
GB26	4-Nov-19	9:53 AM	40.93517	70.66285	49.4	11 cm
GB27	3-Nov-19	5:30 PM	40.93608	70.57521	51.9	>12.5 cm
GB28	4-Nov-19	10:29 AM	40.91863	70.64026	50.8	11 cm
GB29	4-Nov-19	10:25 PM	40.90093	70.70631	55.4	13.5 cm
GB30	4-Nov-19	11:14 AM	40.90139	70.61795	54.9	8 cm
GB31	4-Nov-19	11:53 AM	40.88602	70.59544	56.9	11 cm
GB32	4-Nov-19	9:32 PM	40.88412	70.72768	54.8	12 cm
GB33	4-Nov-19	2:21 PM	40.86828	70.66146	55.2	11.5 cm
GB34	4-Nov-19	1:33 PM	40.86892	70.61710	56.7	14 cm
GB35	4-Nov-19	2:48 PM	40.85109	70.68299	57.4	12 cm
GB36	4-Nov-19	7:52 PM	40.84974	70.77022	59.3	14 cm

Sample	Date	Time (EST)	Latitude (°N)	Longitude (°W)	Water Depth (m)	Sample Penetration Depth
GB37	4-Nov-19	6:56 PM	40.83445	70.70422	60.2	14 cm
GB38	4-Nov-19	3:36 PM	40.81792	70.68178	60.2	14 cm
GB39	4-Nov-19	6:33 PM	40.81724	70.72601	63.3	15 cm
GB40	4-Nov-19	5:02 PM	40.78373	70.74691	62.7	15 cm

3.2.1 Sediment Analysis

The following section presents grab sample grain size composition results from the TerraSense lab analysis. The grain size data in Section 3.2.1 conform to ASTM D6913, according to contractual agreement. During analysis, it was discovered that the grain sizes reported under this standard do not align exactly with CMECS grain size bins (see Table 9 for comparison). For the sake of applying NMFS (2020) modified CMECS, differences in the threshold for silt or clay (0.0625 mm vs. 0.075 mm) is the only significant factor and may impact classification of muddy sand vs. sand and sandy mud vs. muddy sand in rare instances. To simplify interpretation for CMECS habitat classification in future analyses, requesting CMECS-specific grain size bins from the lab is recommended.

Samples from the 40 grab sample stations in OCS-A 501 South were generally sandy comprised of 15% - 98% sand grains (0.075 mm – 2 mm) with a mean across samples of 73% (Table 10 and Figure 3). Eleven samples contained no CMECS-defined gravel-sized particles (> 2 mm) while 27 samples contained < 1% gravel. Just 2 samples (GB16 and GB24) were comprised of 2.3% gravel-sized particles, with maximum sieve sizes retaining gravel for these samples of 9.53 mm and 19.05 mm, respectively. Fines particles (<0.075 mm) comprised 1 – 84% of samples (mean of 27%), with 5 samples containing more than 50% silt and clay (GB14, GB15, GB22, GB39, and GB40). The fines component may be a slight overestimate because CMECS classifies silt/clay at a smaller scale (< 0.0625 mm) than the lab results (< 0.075 mm).

Table 9. Comparison of ASTM 6913 and CMECS (Wentworth) grain size bins.

Sediment Type	ASTM 6913	CMECS Bin Size
Gravel	> 4.75 mm	2 – < 4,096 mm
Very Coarse Sand	n/a	1 – < 2 mm
Coarse Sand	2 – < 4.75 mm	0.5 – < 1 mm
Medium Sand	0.41 – < 2 mm	0.25 – < 0.5 mm
Fine Sand	0.075 – < 0.41 mm	0.125 – < 0.25 mm
Very Fine Sand	n/a	0.0625 – < 0.125 mm
Silt or Clay	< 0.075 mm	< 0.0625 mm

Table 10. Grain size composition and moisture content from grab samples in OCS-A 0501 South (continued on next page).

Sample	% Grains > 4.75 mm	% Grains 2 – 4.75 mm	% Grains 0.41 – 2 mm	% Grains 0.075 – 0.41 mm	% Grains < 0.075 mm	% Moisture Content
GB01	0	0.1	82.7	15.4	1.8	15.8
GB02	0	0	2.1	65.3	32.6	40.8
GB03	0	0.2	77.0	20.9	1.9	20.1
GB04	0	0.1	6.1	83.7	10.1	36.6
GB05	0	0	1.5	80.4	18.1	35.5
GB06	0	0.1	1.8	84.1	14.0	27.8
GB07	0	0.2	49.9	47.6	2.3	26.0
GB08	0	0.2	9.4	66.8	23.6	41.3
GB09	0	0.1	1.9	78.7	19.3	34.9
GB10	0	0.1	2.2	77.0	20.7	40.5
GB11	0	0	5.2	84.4	10.4	28.2
GB12	0	0.1	12.8	50.7	36.4	44.3
GB13	0	0.1	54.4	44.0	1.5	21.6
GB14	0	0	9.0	13.9	77.1	100.1
GB15	0	0.2	3.1	12.6	84.1	119.8
GB16	0.4	1.9	84	9.8	3.9	19.3
GB17	0	0.1	5.3	82.9	11.7	34.4
GB18	0	0.2	19.7	57.2	22.9	38.7
GB19	0	0.1	5.2	74.1	20.6	37.4
GB20	0	0.1	10.1	54.3	35.5	44.3
GB21	0	0.1	10.9	58.2	30.8	40.5
GB22	0	0	6.0	26.7	67.3	65.4
GB23	0	0.1	5.6	70.9	23.4	38.0
GB24	0.3	2.0	76.8	19.3	1.6	17.4
GB25	0	0	18.5	80.2	1.3	24.1
GB26	0	0.1	2.2	86.0	11.7	30.3
GB27	0	0	7.9	69.8	22.3	28.3
GB28	0	0.1	4.0	73.8	19.1	34.3
GB29	0	0.1	2.4	57.3	40.2	48.9
GB30	0	0.2	64.8	30.3	4.7	21.7
GB31	0	0	1.6	49.2	49.2	60.3
GB32	0	0.1	3.5	54.8	41.6	66.0

Sample	% Grains > 4.75 mm	% Grains 2 – 4.75 mm	% Grains 0.41 – 2 mm	% Grains 0.075 – 0.41 mm	% Grains < 0.075 mm	% Moisture Content
GB33	0	0.1	75.7	22.7	1.5	19.7
GB34	0	0.8	15.9	48.3	35.0	40.7
GB35	0	0	3.2	59.3	37.5	43.8
GB36	0	0.1	3.1	73.7	23.1	38.3
GB37	0	0	8.2	61.5	30.3	44.5
GB38	0	0.1	2.5	48.0	49.4	45.3
GB39	0	0.1	2.1	37.5	60.3	71.9
GB40	0	0	4.6	32.2	63.2	74.1

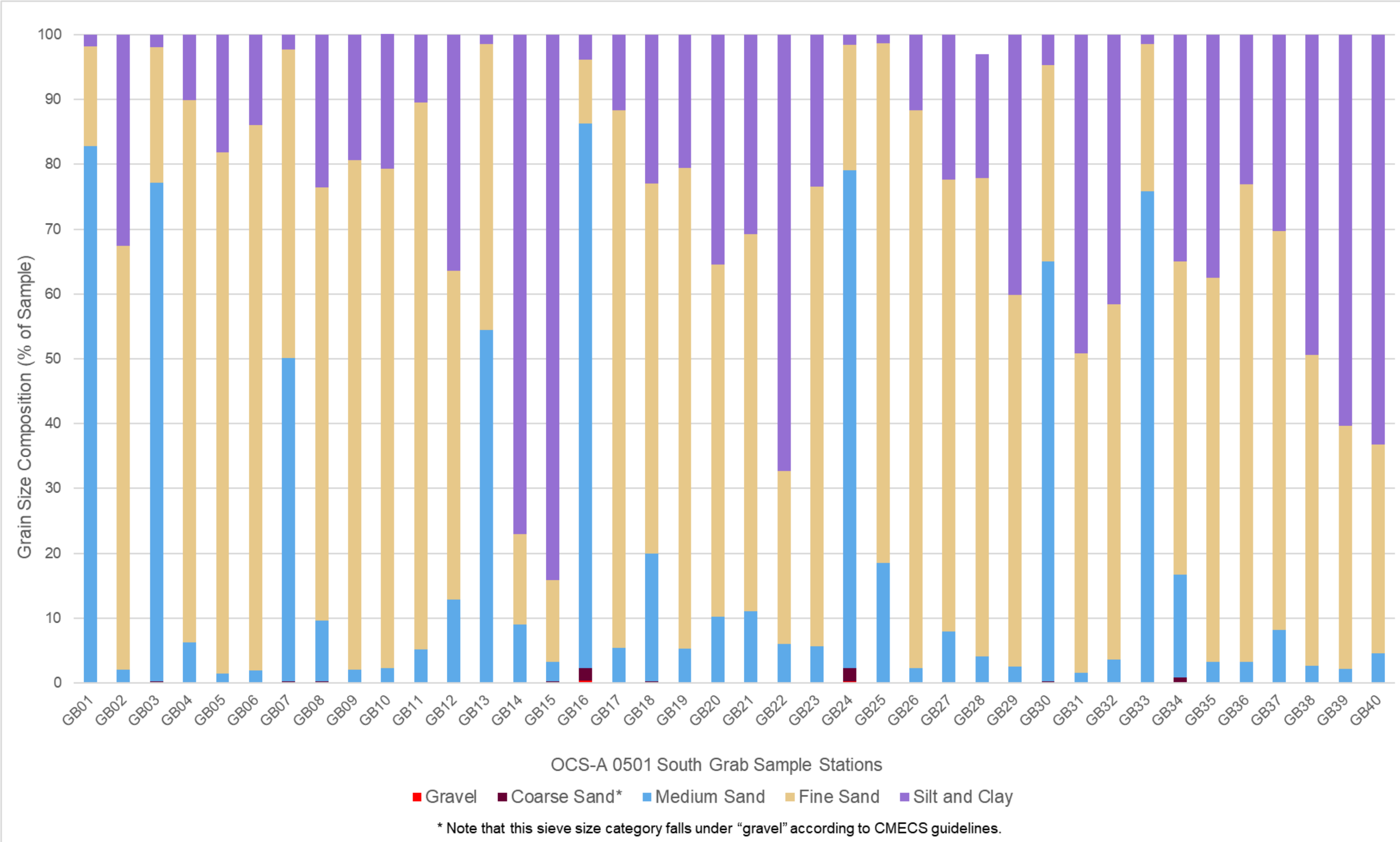


Figure 3. Grain size composition at each grab sample station in OCS-A 0501 South. Note that the size classifications do not exactly match those within the CMECS guidelines, see text for details.

3.2.2 Benthic Community Analysis

3.2.2.1 Taxonomic Composition

Benthic grab samples were collected for infaunal analysis at 40 sites throughout the OCS-A 0501 South lease area (501S-19-GB01 through -GB40). The grab samples yielded a total of 2,641 individual organisms (per all forty 0.008 m^2 core samples) from five (5) unique phyla and 54 families (or LPTL; Table 11). The phyla Arthropoda and Annelida dominated the samples in both abundance and diversity, representing 94% of all organisms and 85% of all unique taxa (Figure 4).

Table 11. Phyla present in the 40 benthic grab samples in OCS-A 0501 South.

Phyla	Abundant Taxonomic Groups (common names)	Density (Abundance per forty 0.008 m^2 samples)	Number of Taxa
Annelida	Polychaete worms	742	20
Arthropoda	Amphipods	1,735	24
Mollusca	Cleft clams, marine bivalve	56	8
Nematoda	Nematode	80	1
Nemertea	Nemertea	28	1
Totals		2,641	54

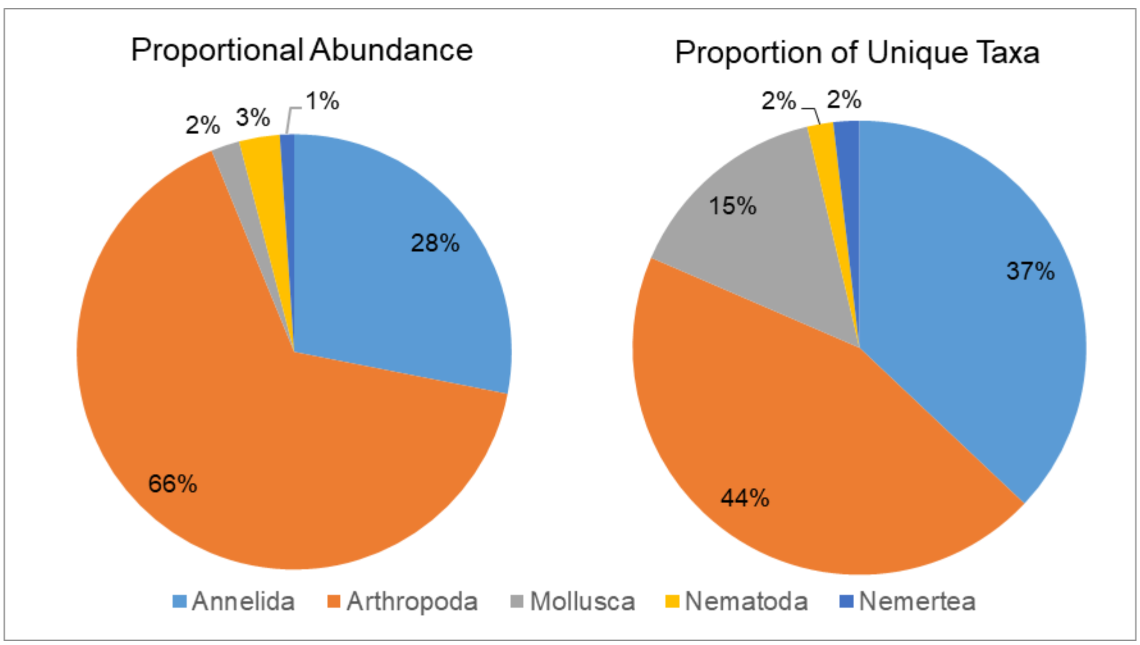


Figure 4. Proportional abundance and proportion of unique taxa (Family or LPTL) for each phylum collected in all benthic grab samples in OCS-A 0501 South. Results presented as percentage of total.

Density across the 40 benthic grab sites ranged from 3 organisms per station at GB13 to 163 at GB05 (Table 12 and Figure 5). Most (118) of the organisms identified in GB05 were amphipods from the Ampeliscidae family. Taxa represented in each sample ranged from 3 families at GB13 to 26 unique families at GB39. Overall, just over half of all organisms identified across the 40 grab samples (51%, or 1,338 organisms/0.32 m^2 [i.e., total sampled area of the 40 grab sites]) were amphipods from a single taxon, the Ampeliscidae family. Abundance of each phyla and taxa are shown in Table 13.

Table 12. Density of each phylum at each station for OCS-A 0501 South (continued on next page).

Station	Annelida	Arthropoda	Mollusca	Nematoda	Nemertea	Density (Abundance per 0.008 m^2)
501S-19-GB01	3	2	0	1	0	6
501S-19-GB02	19	88	2	0	0	109
501S-19-GB03	10	4	0	4	0	18
501S-19-GB04	40	68	1	4	0	113
501S-19-GB05	23	132	5	2	1	163
501S-19-GB06	34	85	2	1	2	124
501S-19-GB07	1	2	1	3	1	8
501S-19-GB08	48	107	1	2	1	159
501S-19-GB09	20	102	0	0	1	123
501S-19-GB10	38	63	6	5	0	112
501S-19-GB11	41	50	3	0	1	95
501S-19-GB12	36	10	0	1	2	49
501S-19-GB13	2	1	0	0	0	3
501S-19-GB14	28	5	7	2	0	42
501S-19-GB15	14	0	0	0	0	14
501S-19-GB16	3	0	0	2	0	5
501S-19-GB17	23	65	0	0	1	89
501S-19-GB18	16	16	5	3	0	40
501S-19-GB19	24	132	0	0	4	160
501S-19-GB20	10	24	1	0	0	35
501S-19-GB21	18	18	2	0	0	38
501S-19-GB22	7	70	0	1	0	78
501S-19-GB23	12	57	0	0	4	73
501S-19-GB24	4	3	0	8	0	15
501S-19-GB25	6	29	0	11	0	46
501S-19-GB26	16	83	0	2	0	101
501S-19-GB27	26	66	6	3	1	102
501S-19-GB28	12	15	0	1	0	28
501S-19-GB29	43	84	1	0	1	129
501S-19-GB30	7	13	0	6	0	26
501S-19-GB31	12	2	1	0	1	16
501S-19-GB32	26	32	1	0	0	59

Station	Annelida	Arthropoda	Mollusca	Nematoda	Nemertea	Density (Abundance per 0.008 m^2)
501S-19-GB33	3	2	0	5	0	10
501S-19-GB34	15	34	3	0	0	52
501S-19-GB35	28	41	3	1	1	74
501S-19-GB36	12	33	2	0	2	49
501S-19-GB37	14	25	0	1	0	40
501S-19-GB38	20	69	3	6	3	101
501S-19-GB39	15	26	0	2	0	43
501S-19-GB40	14	79	0	3	1	97
Totals	**742**	**1735**	**56**	**80**	**28**	**2,641**

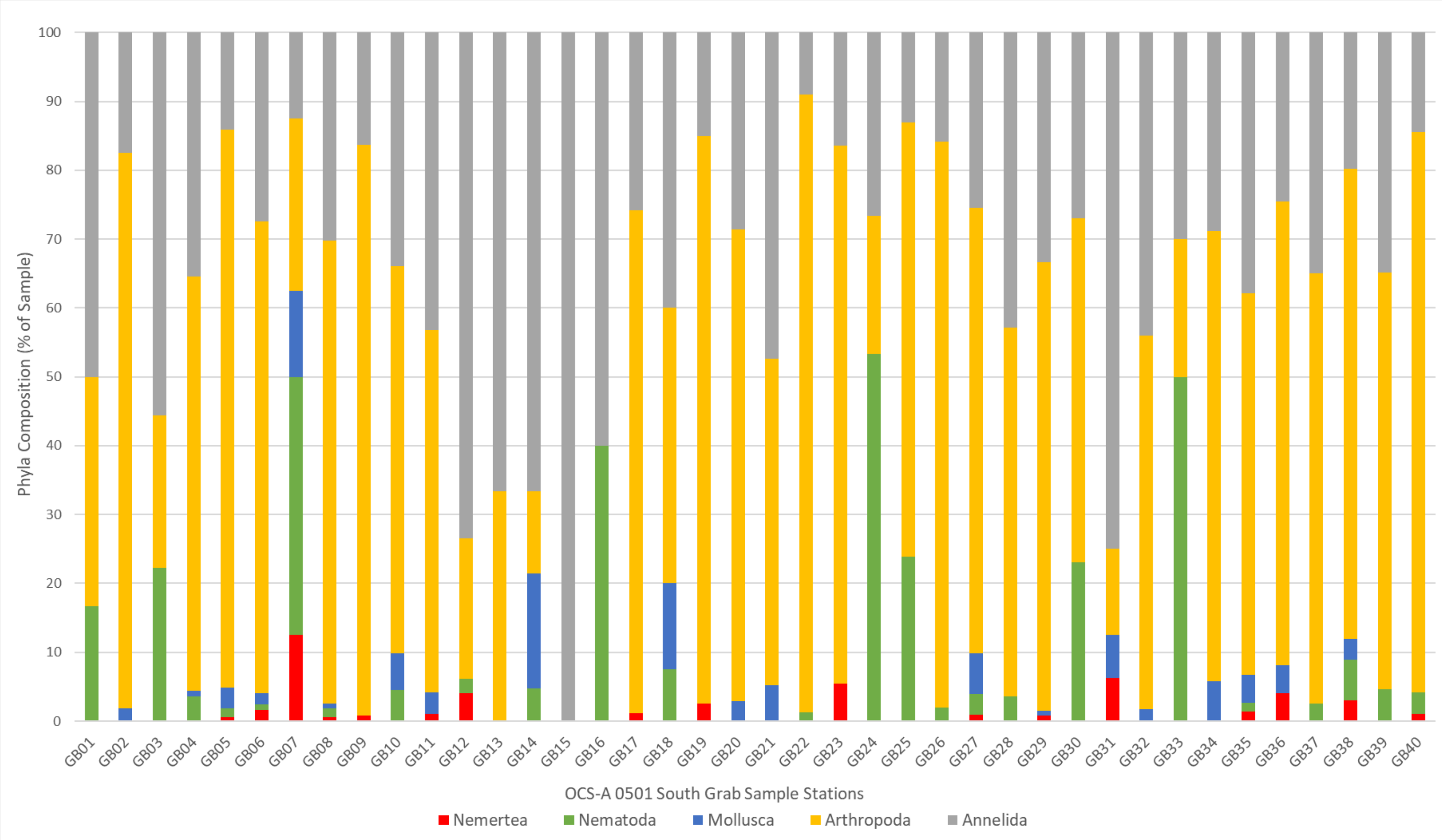


Figure 5. Percent composition of the 40 benthic grab samples in OCS-A 0501 South by phylum.

Table 13. Abundance of each phyla and taxa (family or LPTL) across all 40 samples for OCS-A 0501 South (continued on next page).

Phylum	Family or LPTL	Abundance Across All Samples	Median Abundance per 0.008 m^2	Frequency of Occurrence
Annelida	Lumbrineridae	241	6	37
	Paraonidae	184	5	27
	Maldanidae	75	2	22
	Cirratulidae	33	1	16
	Trichobranchidae	27	1	17
	Scalibregmatidae	24	1	12
	Flabelligeridae	23	1	8
	Oenonidae	21	1	14
	Naididae	18	0	12
	Nephtyidae	18	0	13
	Syllidae	16	0	8
	Opheliidae	15	0	10
	Goniadidae	13	0	7
	Ampharetidae	12	0	11
	Glyceridae	9	0	9
	Sabellidae	7	0	6
	Cossuridae	3	0	3
	Spionidae	2	0	2
	Capitellidae	1	0	1
	Phyllodocidae	1	0	1
Total Annelida		742	1	38
Arthropoda	Ampeliscidae	1338	33	35
	Corophiidae	72	2	19
	Unciolidae	67	2	25
	Hyperiidae	54	1	4
	Leuconidae	38	1	19
	Phoxocephalidae	35	1	22
	Ischyroceridae	31	1	11
	Calanoida (LPTI)	20	0	13
	Lysianassidae	18	0	7
	Diastylidae	11	0	10
	Axiidae	8	0	8
	Cheirocratidae	6	0	5
	Amphipoda (LPTI)	6	0	5
	Gammaridae	5	0	4
	Idoteidae	4	0	3
	Ostracoda (LPTI)	4	0	1

Phylum	Family or LPTL	Abundance Across All Samples	Median Abundance per 0.008 m^2	Frequency of Occurrence
	Pleustidae	4	0	2
	Anthuridae	3	0	3
	Cyclopoida (LPTI)	3	0	3
	Cancridae	2	0	1
	Melitidae	2	0	1
	Photidae	2	0	2
	Brachyura (LPTI)	1	0	1
	Tryphosidae	1	0	1
Total Arthropoda		1,735	7	40
Mollusca	Thyasiridae	21	1	12
	Thraciidae	19	1	10
	Nuculidae	7	1	2
	Bivalvia (LPTL)	3	0	3
	Yoldiidae	3	0	3
	Tellinidae	1	0	1
	Chaetodermatidae	1	0	1
	Pleurobranchaeidae	1	0	1
Total Mollusca		56	0	20
Nematoda	Nematoda (LPTL)	80	3	25
Total Nematoda		80	3	25
Nemertea	Nemertea (LPTL)	28	1	17
Total Nemertea		28	1	17

3.2.2.2 Richness, Diversity, and Evenness

Mean density was 66 organisms per station, averaged across the 40 samples. Taxonomic richness across all grab samples collected in OCS-A 0501 South was 6.7 (Table 14). The richness of organisms collected in each of the benthic grab samples ranged from 0.87 at GB33 to 5.42 at GB39, with an average richness across samples of 2.96. Diversity was higher and evenness lower across all grab samples (2.23 and 0.56, respectively) than the average of individual samples (1.70 and 0.72, respectively). The low evenness in organisms across all stations was a result of the high proportion of organisms from three families, including Ampeliscidae (1,338 organisms), Lumbrineridae (241 organisms), and Paradonidae (184 organisms). Diversity of the 40 grab samples ranged from 1.03 at GB33 to 2.36 at GB39 and evenness ranged from 0.39 at GB19 to 1.00 at GB13. Although evenness was high at GB13, both richness and diversity were low as this sample contained only three organisms from three families (Lumbrineridae, Goniadidae, and Ampeliscidae). Richness, diversity, and evenness are indices that do not have units; however, higher values indicate greater amounts of richness, diversity, or evenness in each sample.

Table 14. Community composition parameters calculated for each grab sample station in OSC-A 0501 South (continued on next page).

Station	Density (Community Abundance per 0.008 m^2)	# of Taxa	Ecological Indices		
			Richness	Diversity	Evenness
GB01	6	4	1.67	1.24	0.90
GB02	109	16	3.20	1.39	0.50
GB03	18	10	3.11	2.12	0.92
GB04	113	18	3.60	1.81	0.63
GB05	163	19	3.53	1.32	0.45
GB06	124	21	4.15	1.70	0.56
GB07	8	6	2.40	1.67	0.93
GB08	159	25	4.73	2.01	0.63
GB09	123	16	3.12	1.36	0.49
GB10	112	20	4.03	2.22	0.74
GB11	95	14	2.85	1.74	0.66
GB12	49	15	3.60	2.27	0.84
GB13	3	3	1.82	1.10	1.00
GB14	42	5	1.52	1.30	0.81
GB15	14	10	2.41	1.76	0.77
GB16	5	4	1.86	1.33	0.96
GB17	89	12	2.45	1.62	0.65
GB18	40	14	3.52	2.20	0.83
GB19	160	17	3.15	1.08	0.38
GB20	38	11	2.75	1.92	0.80
GB21	35	9	2.25	1.34	0.61
GB22	78	11	2.33	1.32	0.55
GB23	73	11	2.30	1.23	0.51

Station	Density (Community Abundance per 0.008 m²)	# of Taxa	Ecological Indices		
			Richness	Diversity	Evenness
GB24	15	5	1.48	1.32	0.82
GB25	46	7	1.57	1.23	0.63
GB26	101	13	2.60	1.65	0.65
GB27	102	21	4.32	2.28	0.75
GB28	28	10	2.70	2.03	0.88
GB29	129	21	4.12	1.84	0.60
GB30	26	9	2.89	1.98	0.90
GB31	16	11	3.07	2.02	0.84
GB32	59	15	3.43	1.97	0.73
GB33	10	3	0.87	1.03	0.94
GB34	52	15	3.54	1.76	0.65
GB35	74	15	3.25	1.99	0.73
GB36	49	15	3.60	1.83	0.68
GB37	40	13	3.25	2.14	0.83
GB38	43	12	2.92	1.81	0.73
GB39	101	26	5.42	2.36	0.73
GB40	97	14	2.84	1.58	0.60
Average	**66**	**13**	**2.96**	**1.70**	**0.72**
Total	**2,641**	**54**	**6.73**	**2.23**	**0.56**

4 CMECS CLASSIFICATIONS

We assigned NMFS (2020) modified CMECS classifications to each grab sample station based on visual inspection of the sample on board the ship, as well as laboratory analysis of grain size. We also assigned a CMECS substrate classification for each still image from the underwater video transects that were analyzed for percent cover.

4.1 CMECS OCS-A 0501 South

Substrate classification results are presented as a hierarchy in Table 15 for grab samples stations in the OCS-A 0501 South lease area. Table 16 shows the images of each grab sample and core after retrieval along with the CMECS classifications for sample. All samples in OCS-A 0501 South were dominated by fine unconsolidated substrate of geologic origin. All samples belonged to the sand, muddy sand, or sandy mud groups. The majority of samples contained small (0.1% - 2.3%) fractions of gravel. The gravel portions of these samples may have been comprised of shell fragments rather than substrate of geologic origin but the grain size analysis did not differentiate between substrate origins and images of the cores are insufficient for determining the composition of the gravel at such a fine scale. Therefore, it is possible that the samples would be more appropriately classified as sand with trace shell hash, muddy sand with trace shell hash, or sandy mud with trace shell hash.

Maps displaying the location and CMECS classification of each individual still image analyzed for the video transects in OCS-A 0501 South are provided in Appendix A, Section 1.

Table 15. CMECS hierarchical classification of substrates collected at each grab sample or video transect within OCS-A 0501 South.

Origin	Class	Subclass	Group	Subgroup	Modifier	Grab Sample

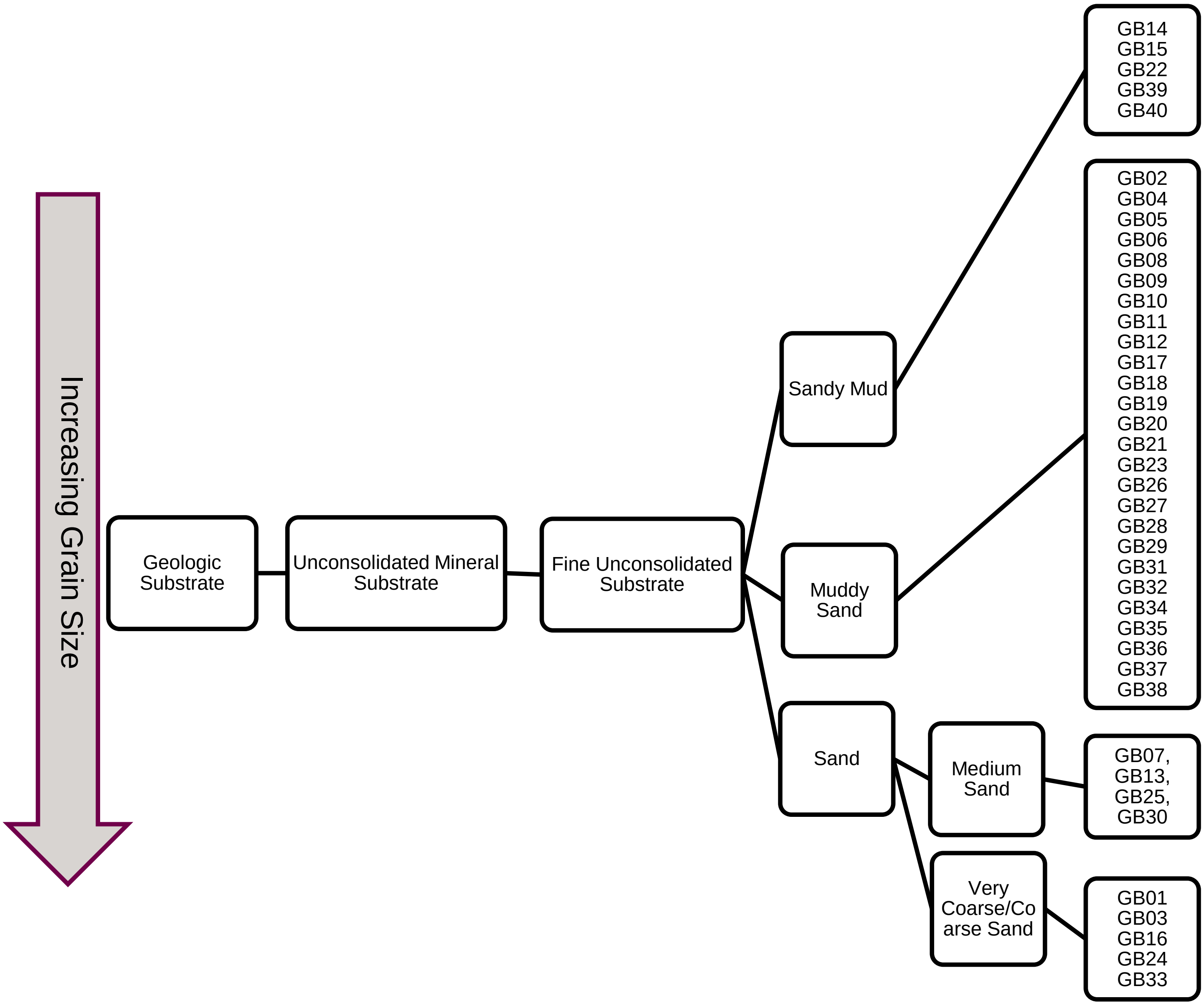
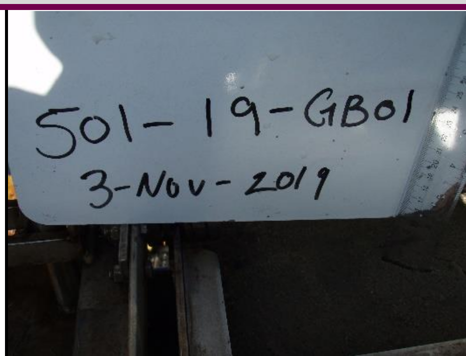
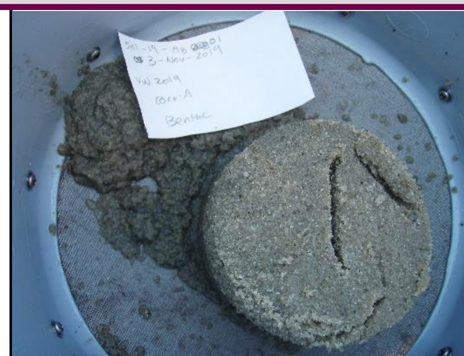
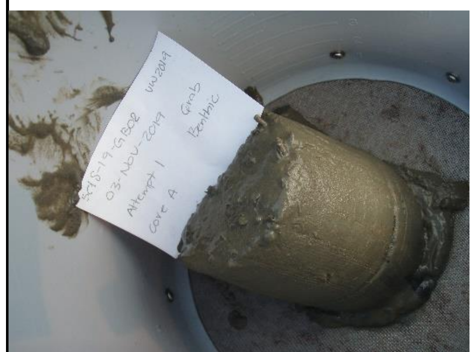
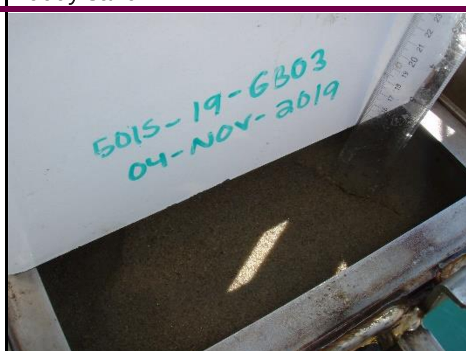
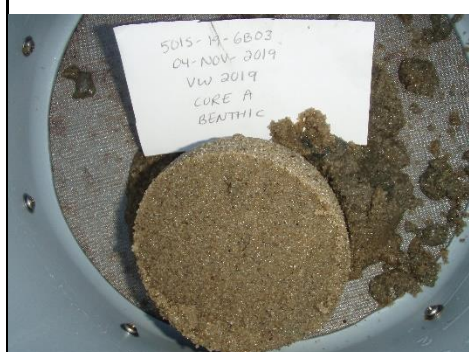
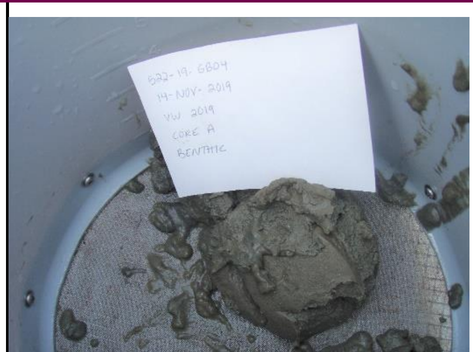
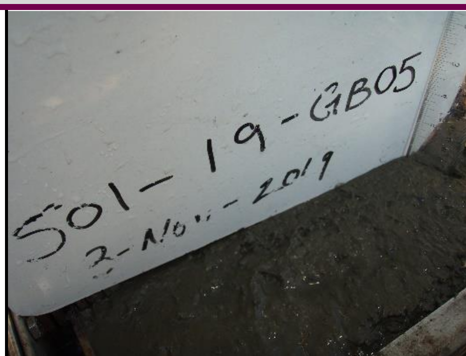
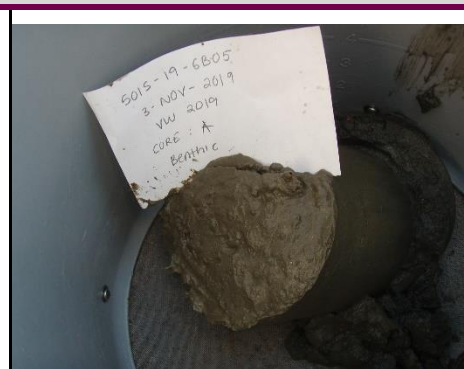
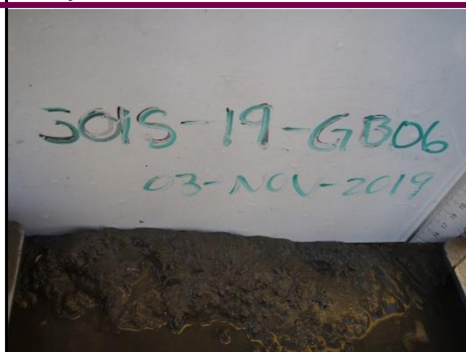
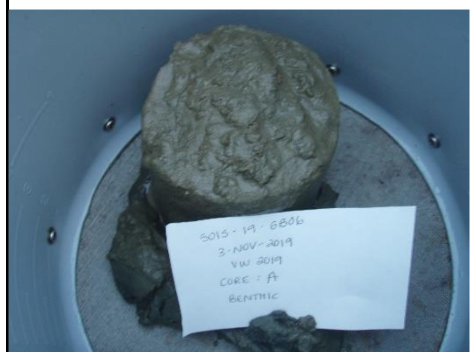
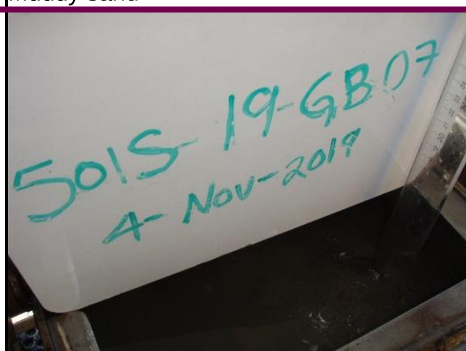


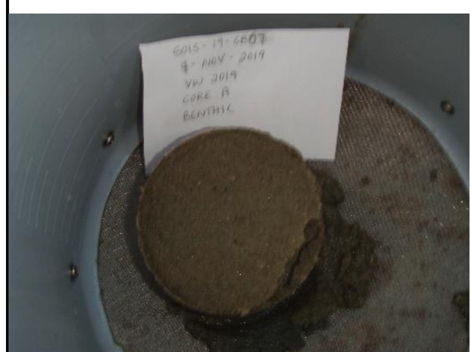
Table 16. Images of grab and subsequent core samples prior to processing from OCS-A 0501 South, along with CMECS classifications (continued on next page).

Station	Grab Sample	Core Sample
GB01	 Very coarse/coarse sand	
GB02	 Muddy sand	
GB03	 Very coarse/coarse sand	
GB04	 Muddy sand	

<table>
<tr><th>Station</th><th>Grab Sample</th><th>Core Sample</th></tr>
<tr><td>GB05</td><td>

Muddy sand</td><td></td></tr>
<tr><td>GB06</td><td>

Muddy sand</td><td></td></tr>
<tr><td>GB07</td><td>

Medium sand</td><td></td></tr>
<tr><td>GB08</td><td>

Muddy sand</td><td></td></tr>
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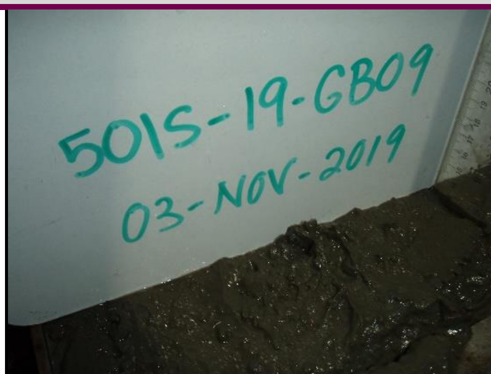
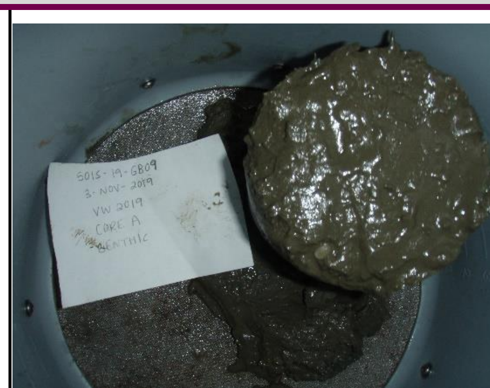
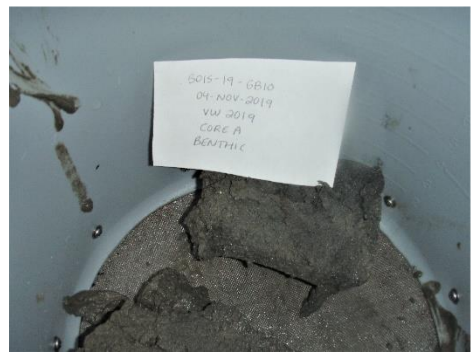
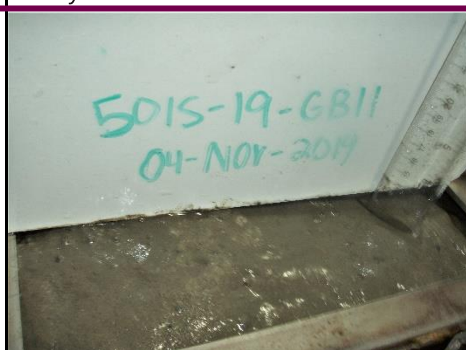
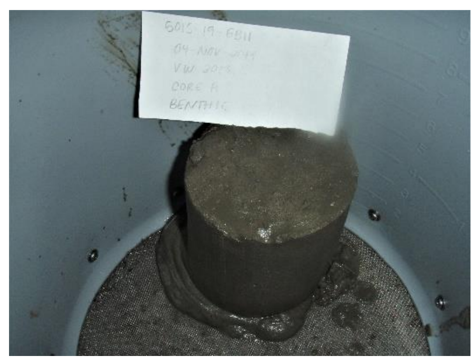
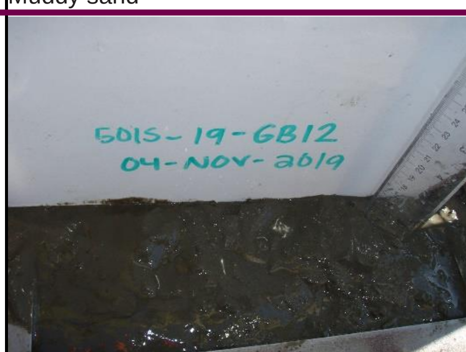
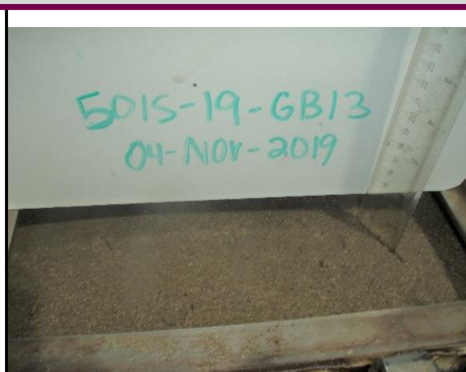
Station	Grab Sample	Core Sample
GB09	 Muddy sand	
GB10	 Muddy sand	
GB11	 Muddy sand	
GB12	 Muddy sand	

<table>
<tr><th>Station</th><th>Grab Sample</th><th>Core Sample</th></tr>
<tr><td>GB13</td><td>

Medium sand</td><td>
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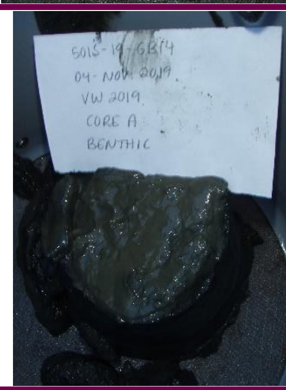
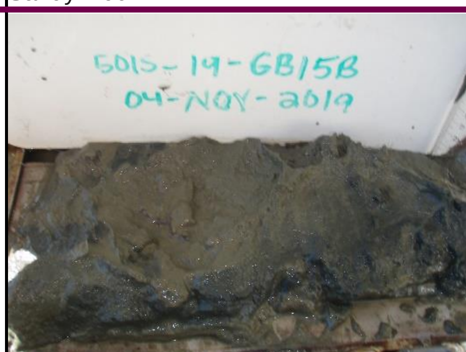
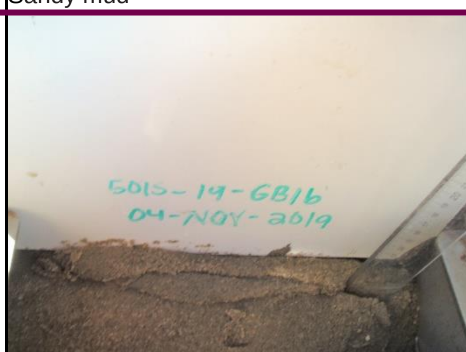
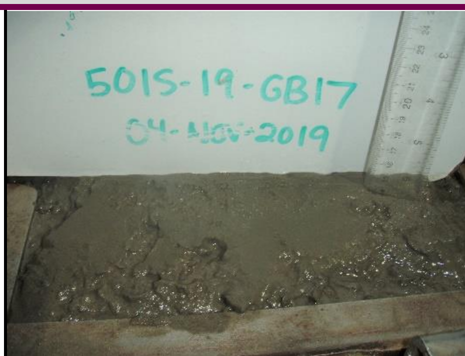
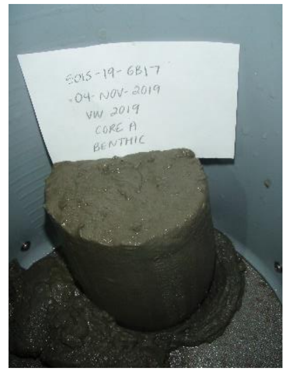
<tr><td>GB14</td><td>

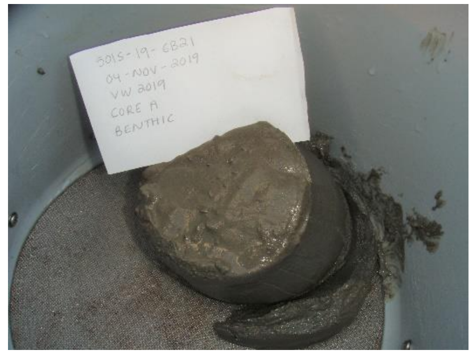
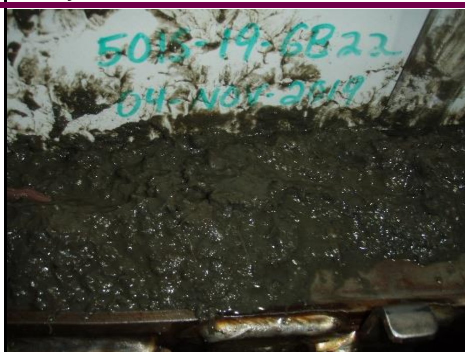
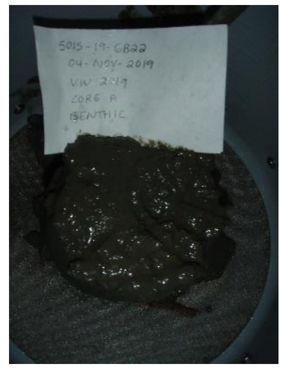
Sandy mud</td><td>
</td></tr>
<tr><td>GB15</td><td>

Sandy mud</td><td></td></tr>
<tr><td>GB16</td><td>

Very coarse/coarse sand</td><td>
</td></tr>
</table>

Station	Grab Sample	Core Sample
GB17	 Muddy sand	
GB18	 Muddy sand	
GB19	 Muddy sand	
GB20	 Muddy sand	

<table>
<tr><th>Station</th><th>Grab Sample</th><th>Core Sample</th></tr>
<tr><td>GB21</td><td>

Muddy sand</td><td>
</td></tr>
<tr><td>GB22</td><td>
Sandy mud</td><td>
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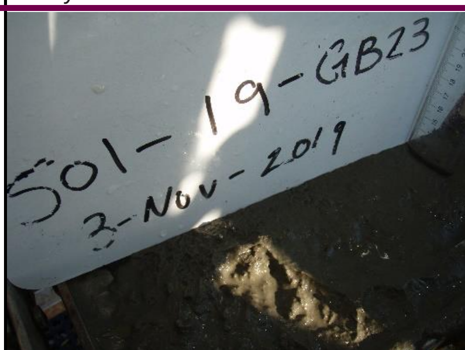
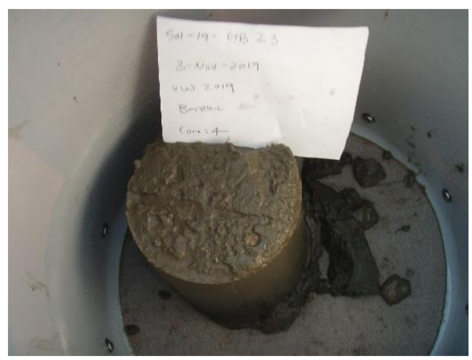
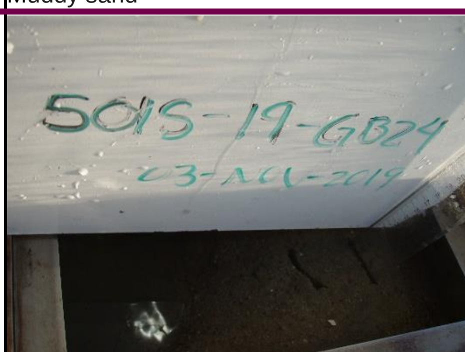
<tr><td>GB23</td><td>

Muddy sand</td><td></td></tr>
<tr><td>GB24</td><td>

Very coarse/coarse sand</td><td>
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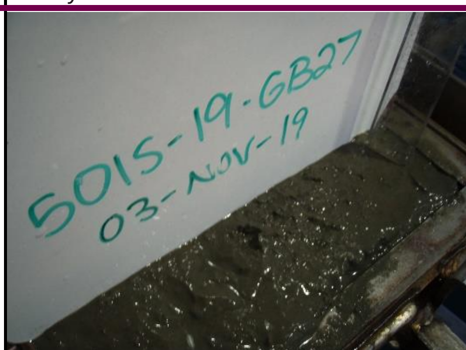
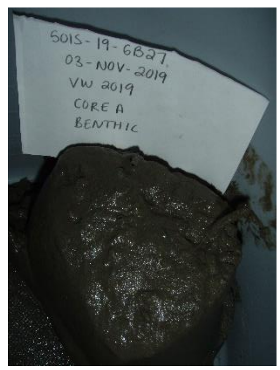
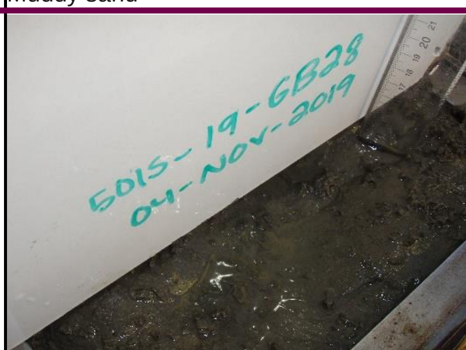
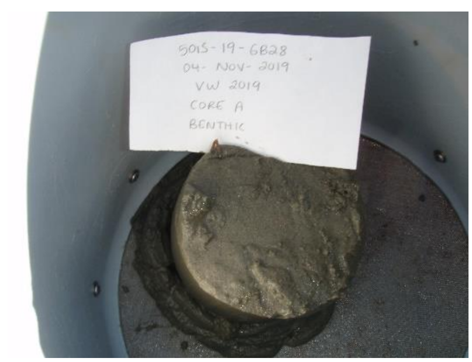
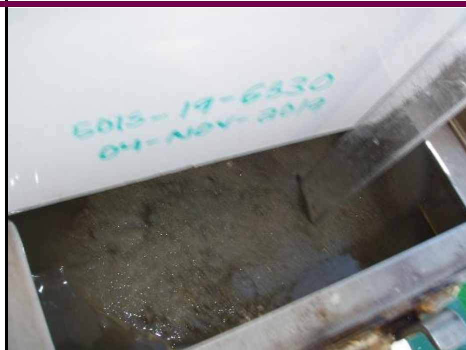
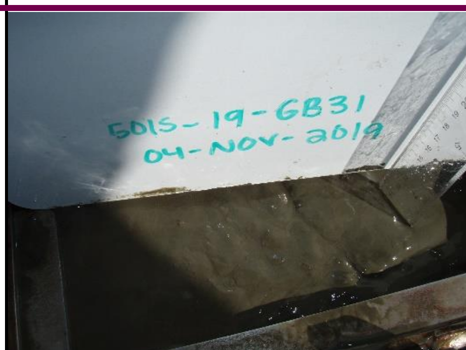
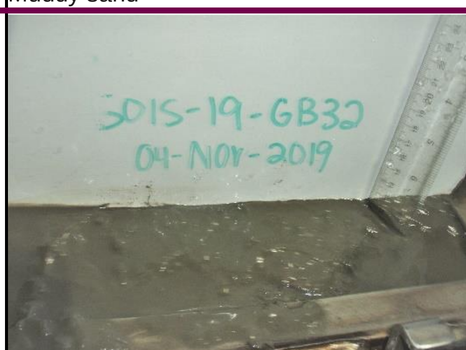
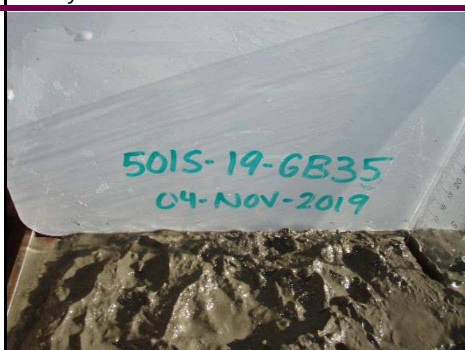
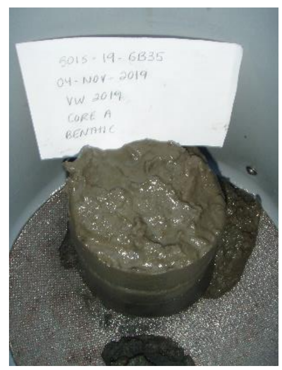
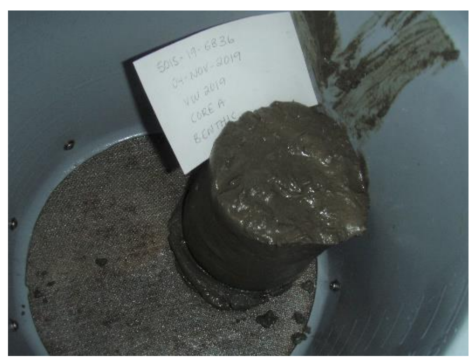
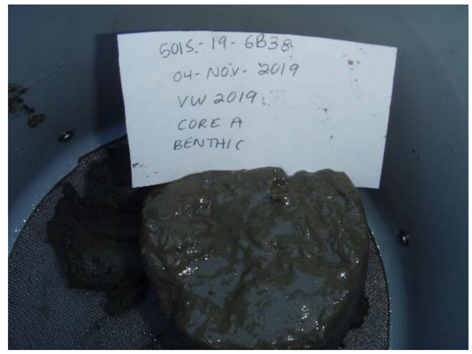
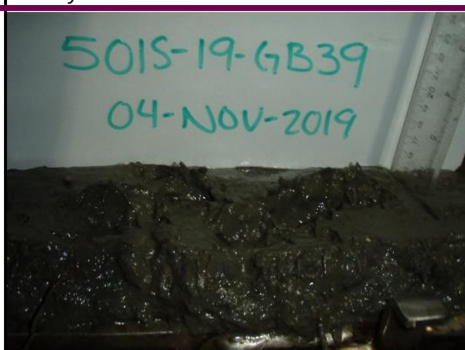
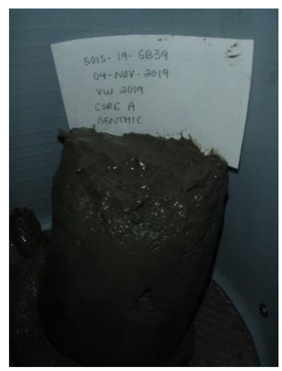
</table>

Station	Grab Sample	Core Sample
GB25	 Medium sand	
GB26	 Muddy sand	
GB27	 Muddy sand	
GB28	 Muddy sand	

Station	Grab Sample	Core Sample
GB29	 Muddy sand	
GB30	 Medium sand	
GB31	 Muddy sand	
GB32	 Muddy sand	

Station	Grab Sample	Core Sample
GB33	 Very coarse/coarse sand	
GB34	 Muddy sand	
GB35	 Muddy sand	
GB36	 Muddy sand	

Station	Grab Sample	Core Sample
GB37	 Muddy sand	
GB38	 Muddy sand	
GB39	 Sandy mud	
GB40	 Sandy mud	

5 SUMMARY

OCS-A 0501 South sampling locations consisted of muddy sand, sand, or sandy mud with no evidence of consolidated substrate. Bottom complexity was low with some evidence of sand ripples to small sand waves. Video revealed that >89.6% of bottom in all transects was comprised of sand/mud with most transects revealing >99% sand/mud. Infaunal structures (seemingly small worm tubes and amphipod structures), burrows, macrofauna, and shells made up most of the remaining surface area. Sea stars were the dominant benthic macrofauna, but were not observed in roughly half of the video transects. Infauna was dominated by the Arthropoda phylum followed by the Annelida phylum. One instance of anthropogenic debris was observed in the form of a derelict fishing pot.

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ALPINE VINEYARD WIND BENTHIC SAMPLING

APPENDIX A – LEASE AREA OCS-A 0501 CMECS MAPS

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Alpine Ocean – Vineyard Wind

19-P-206028 Alpine Vineyard Wind Lease Areas OCS-A 0501 South Benthic Sampling Appendix A

January 18, 2021

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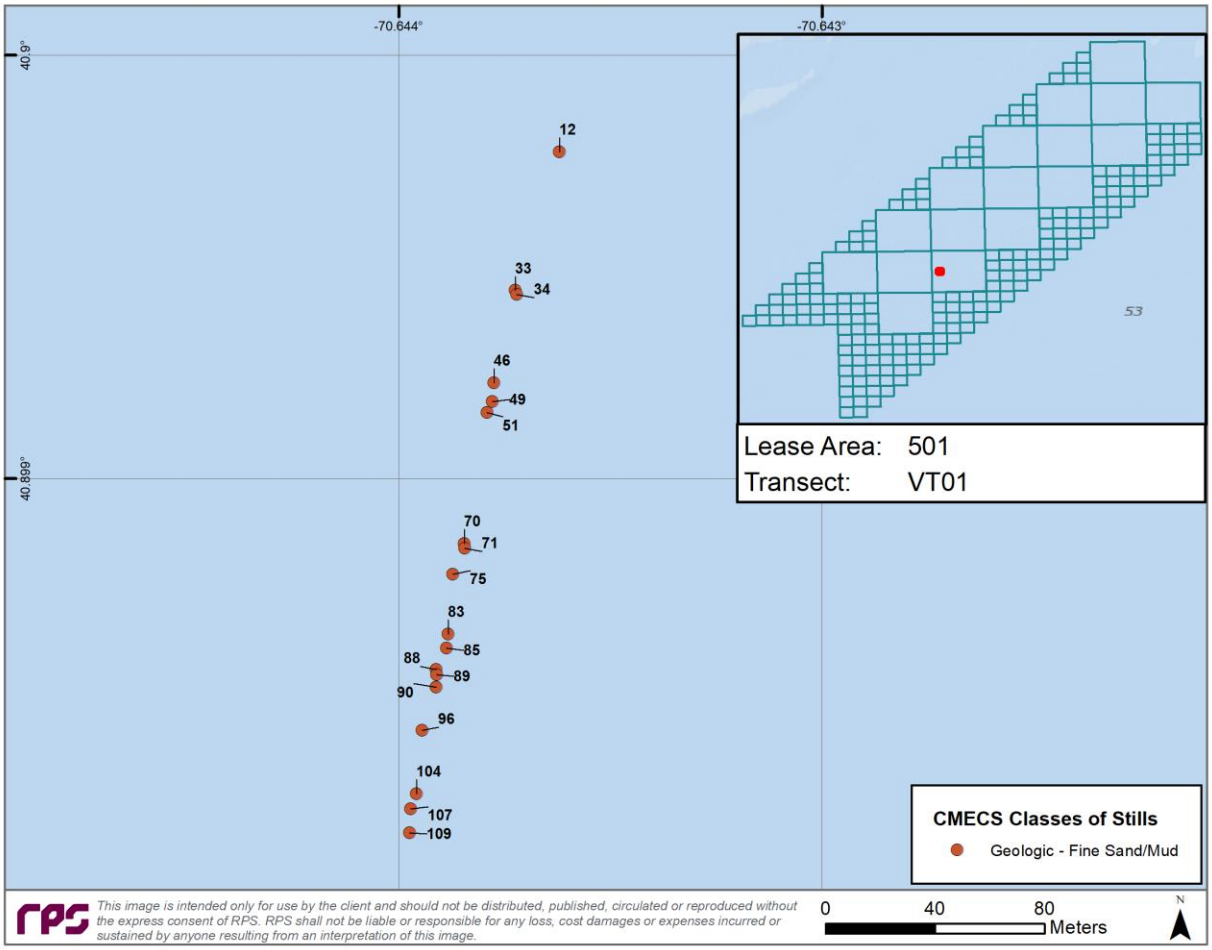
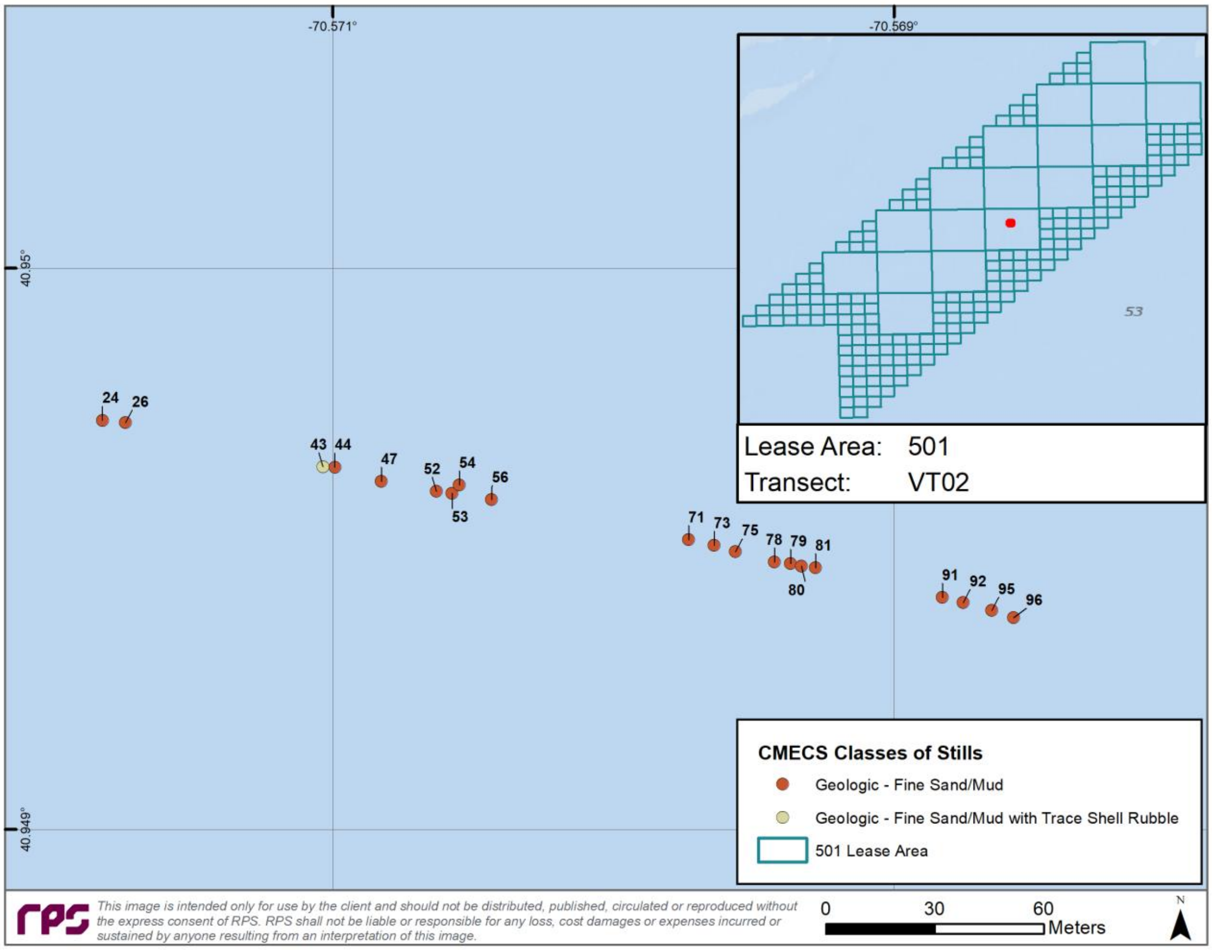


Figure 1 CMECS substrate classification for all viable still images in VT01 (numbers indicate still image ID).



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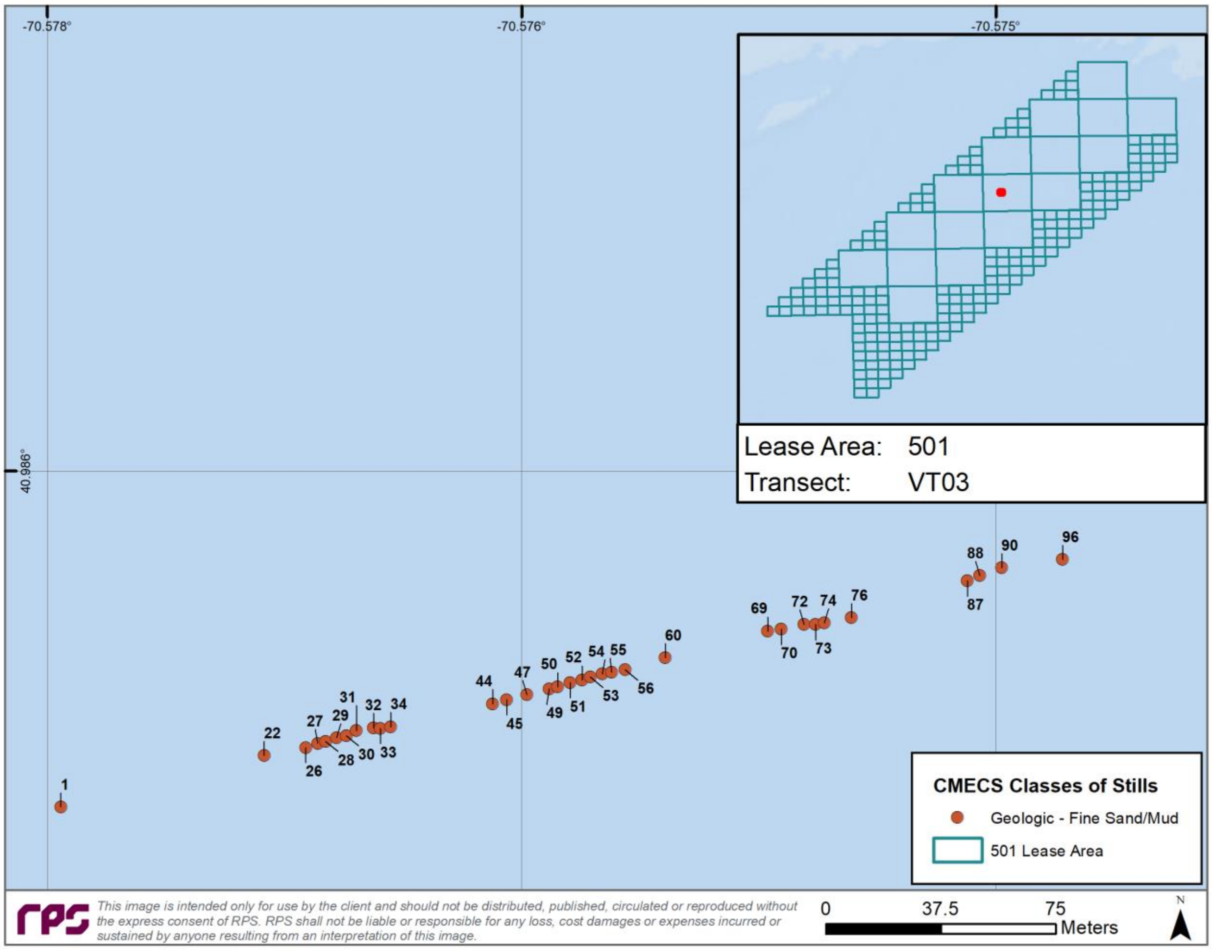

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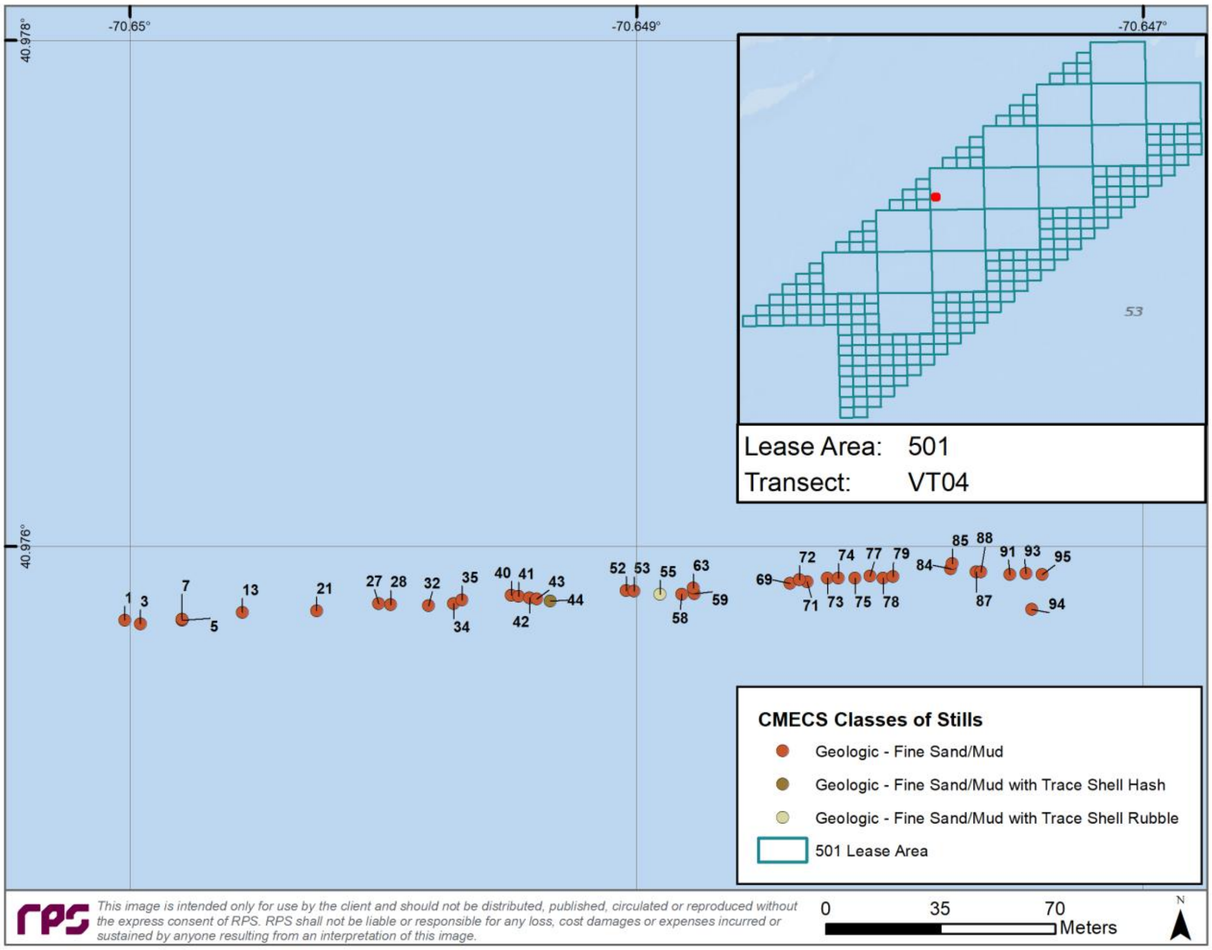

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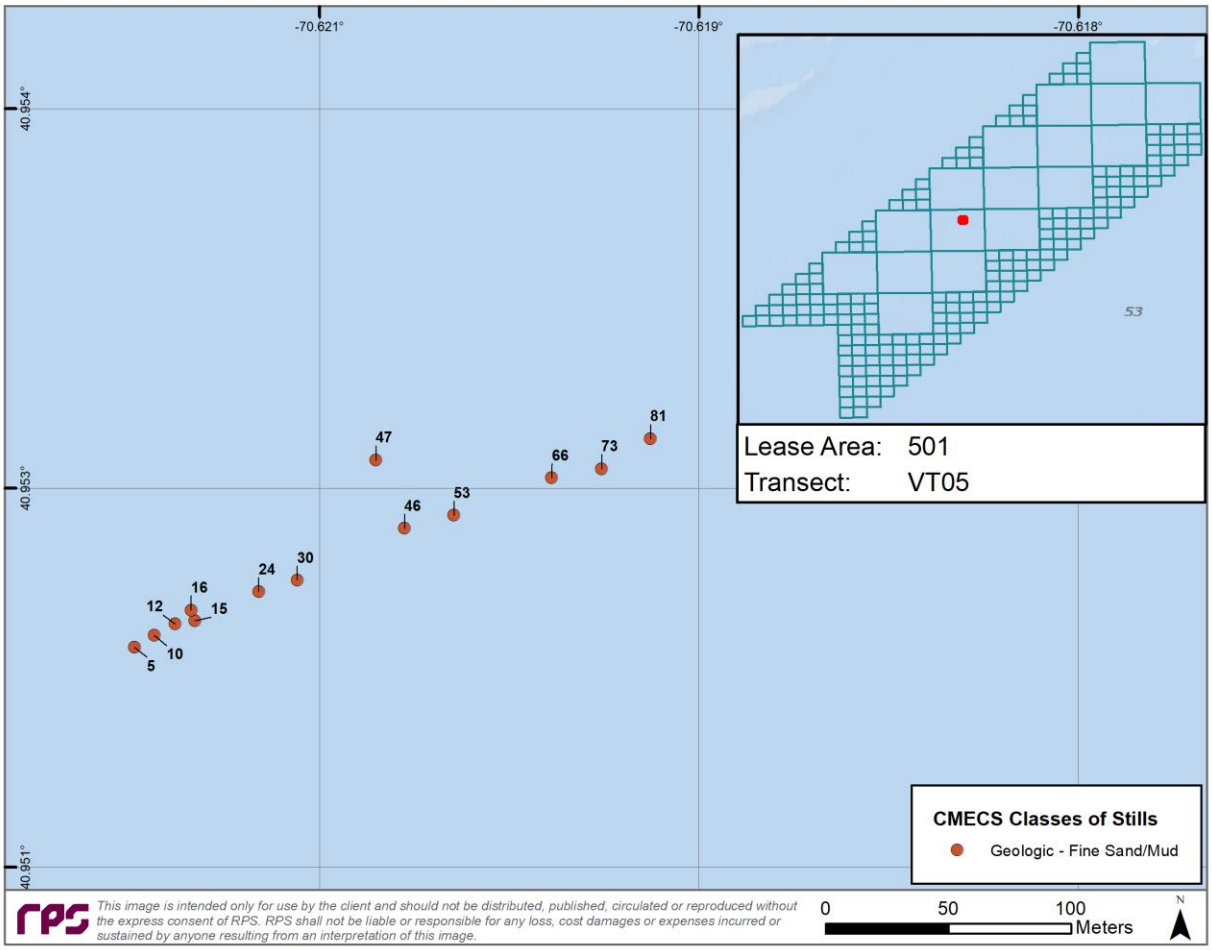

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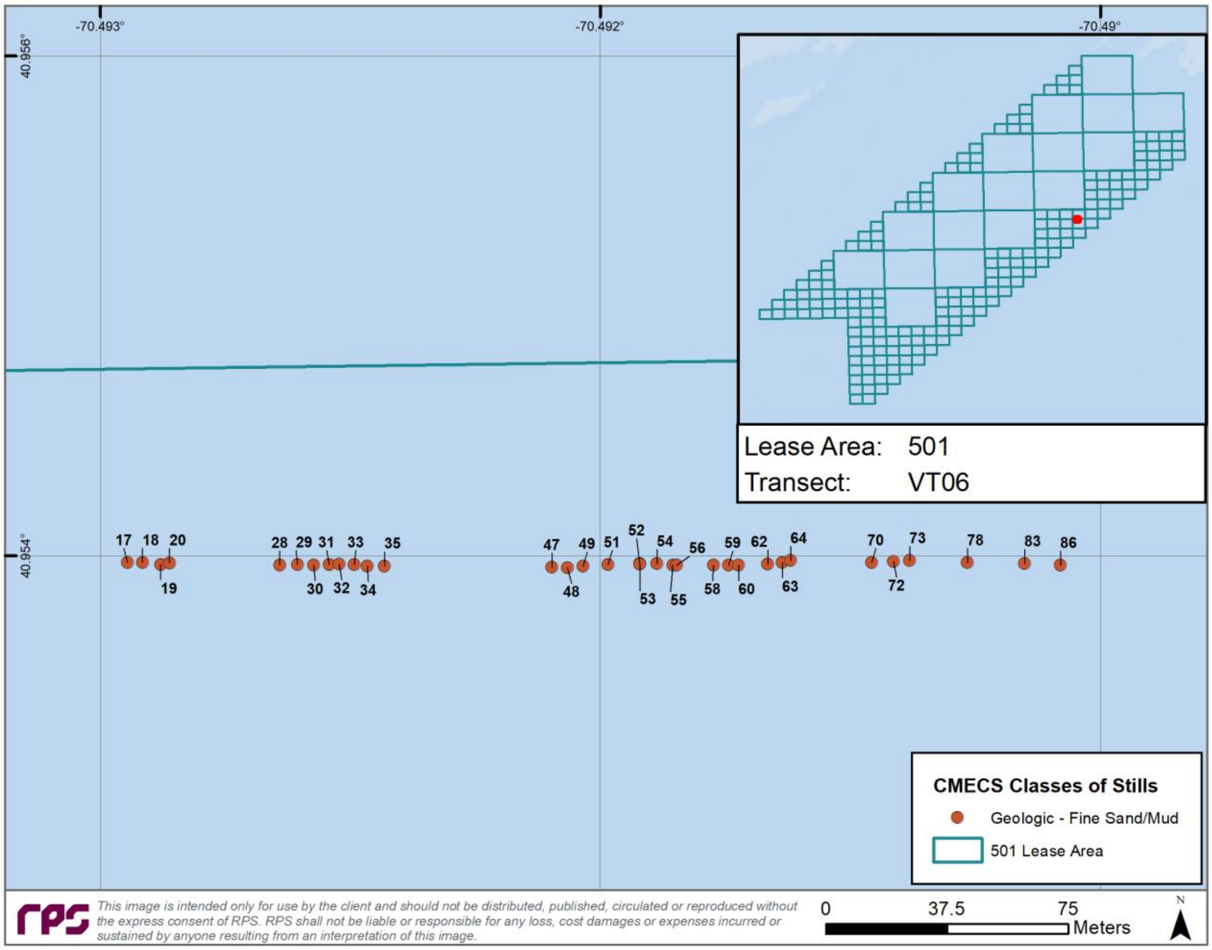

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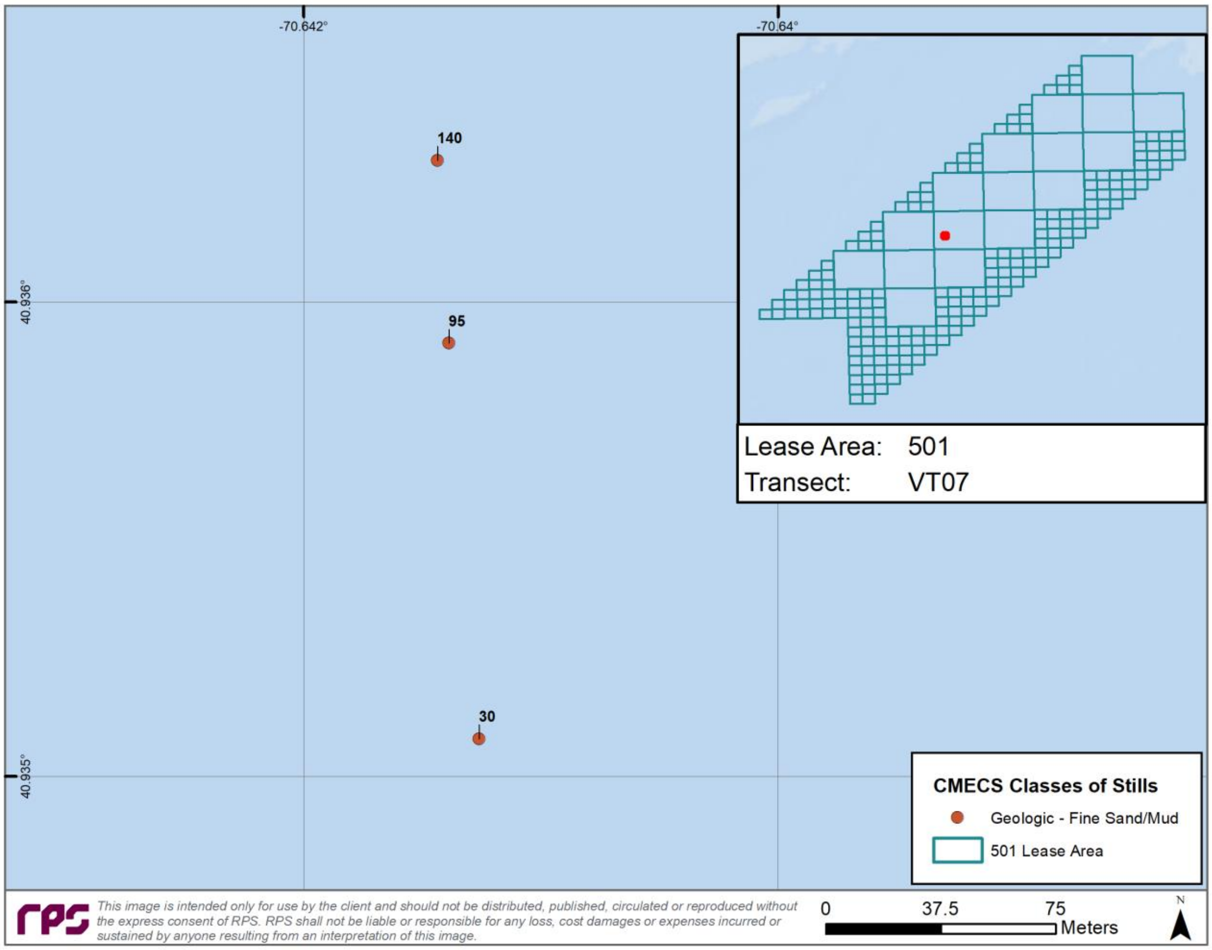

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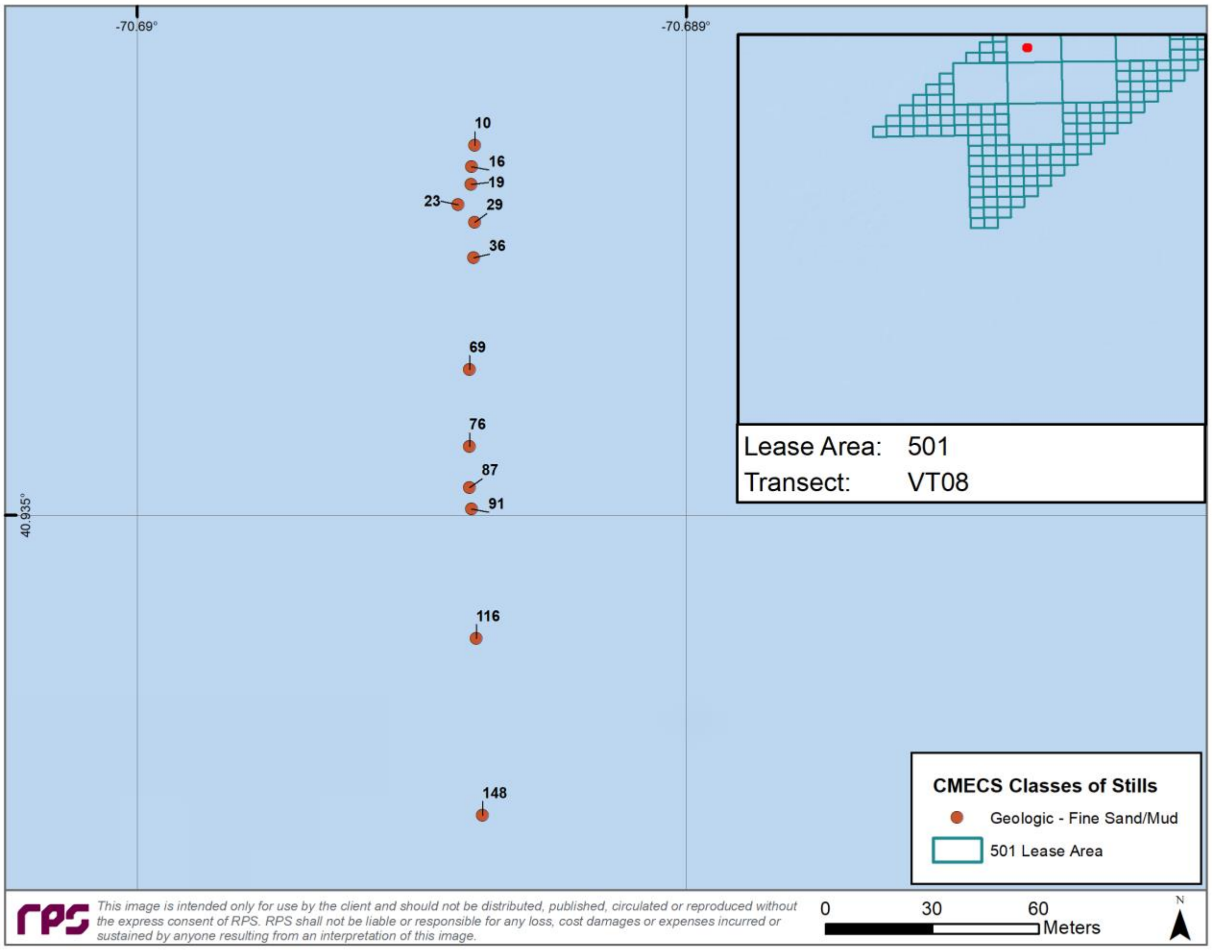

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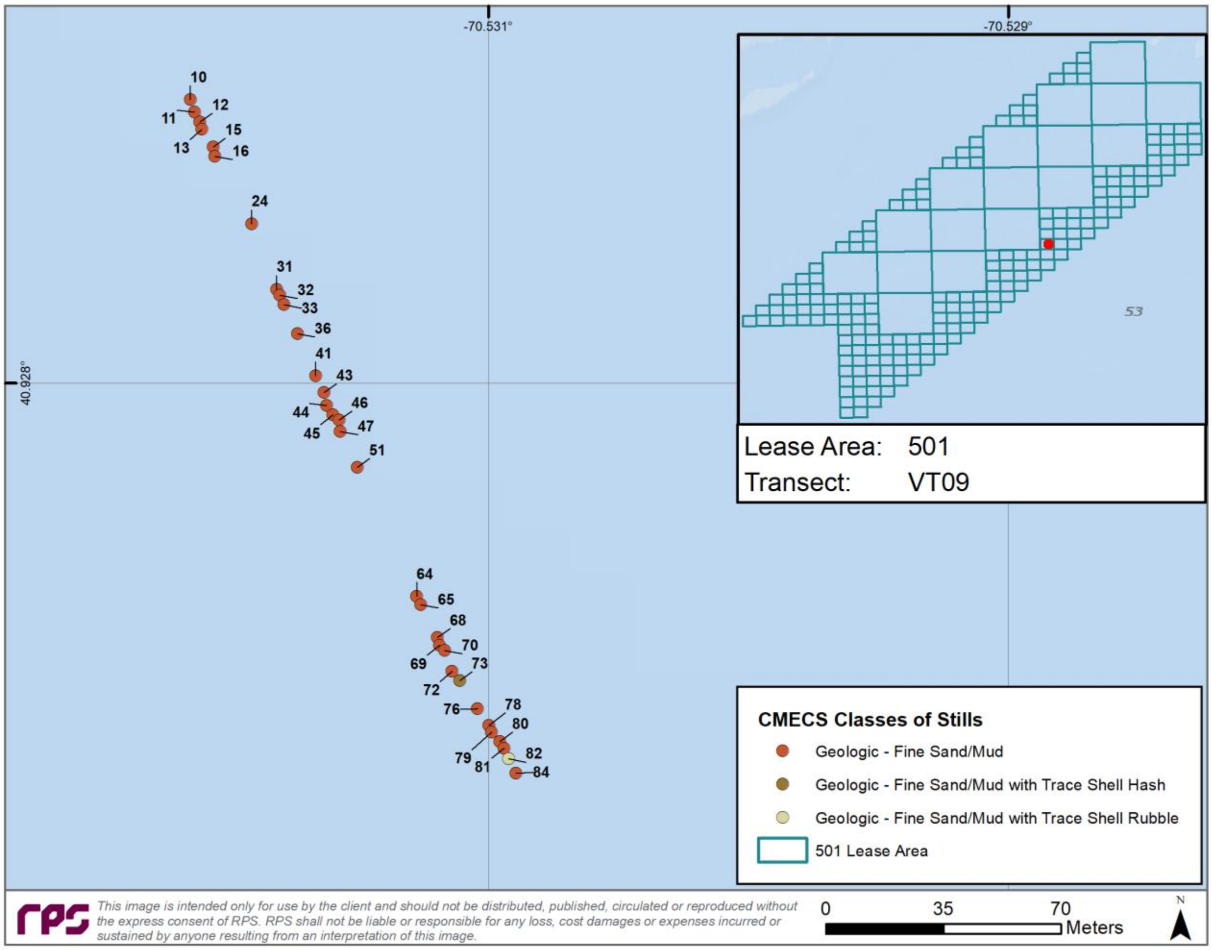

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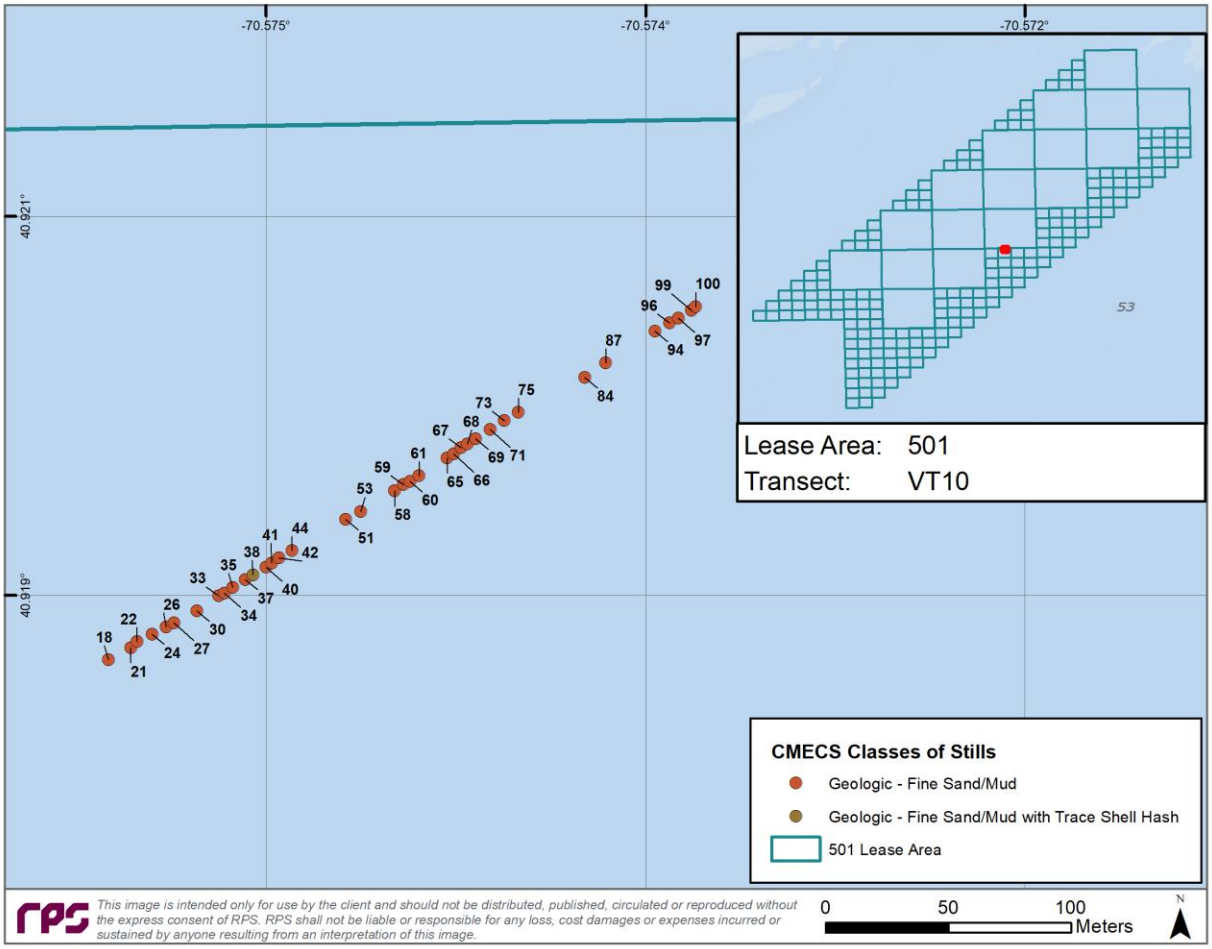

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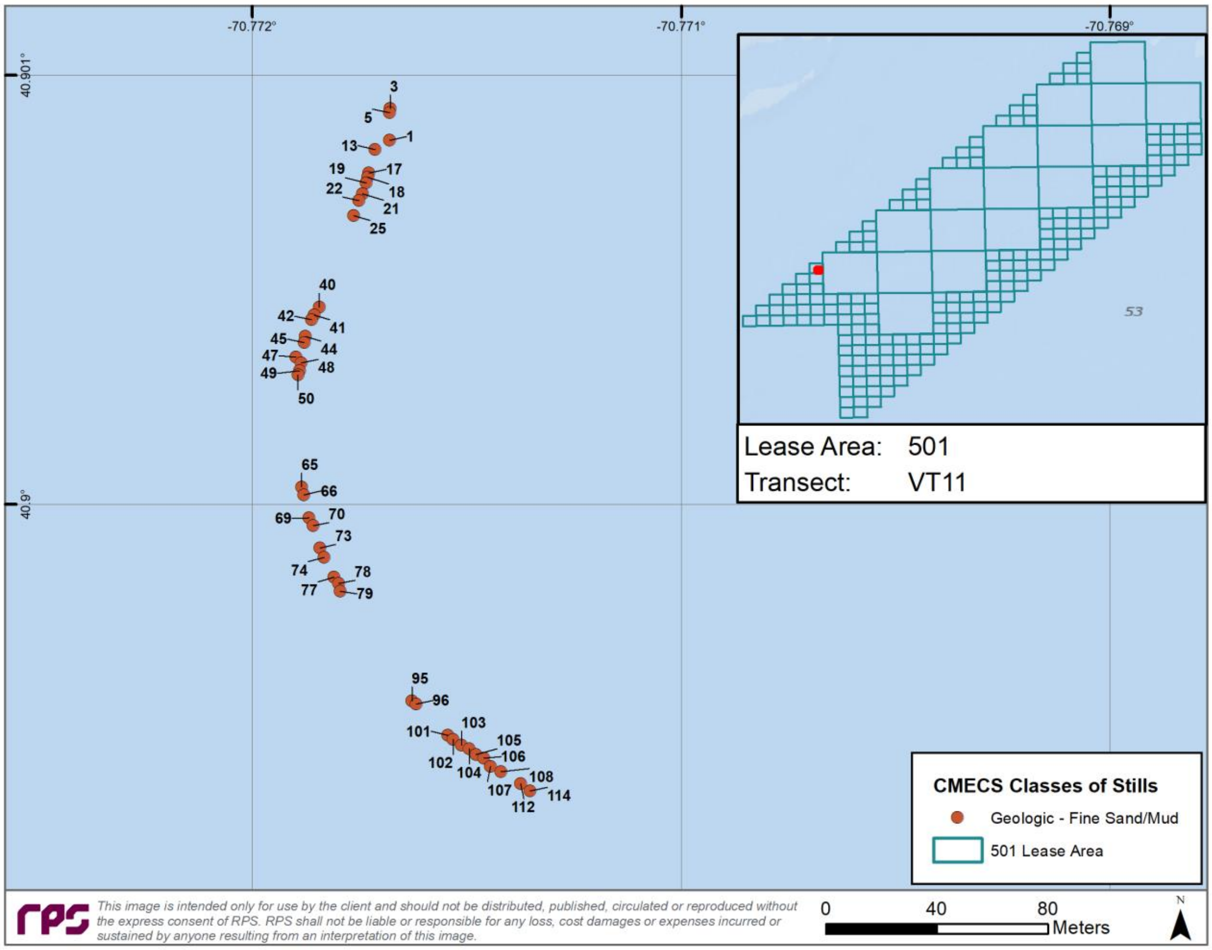

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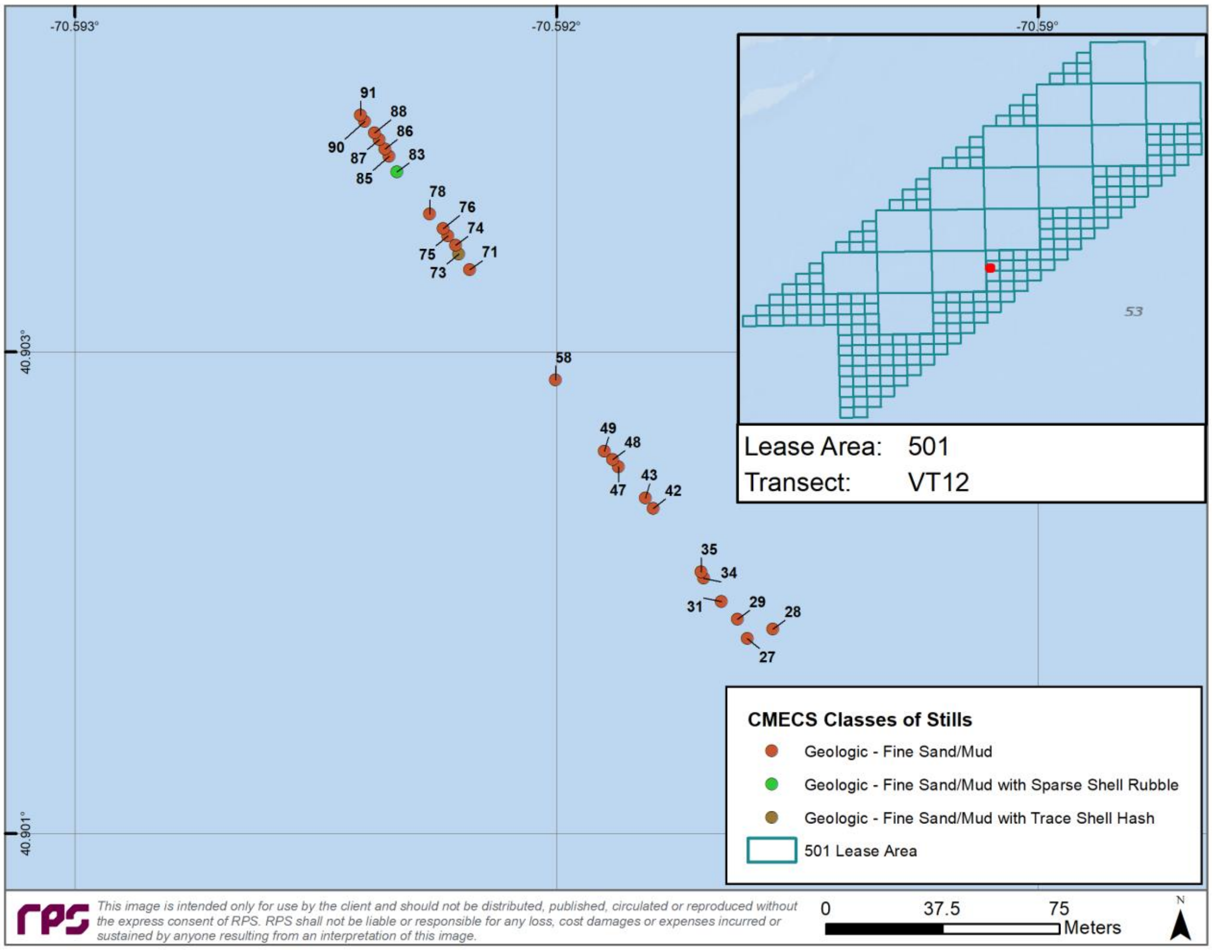

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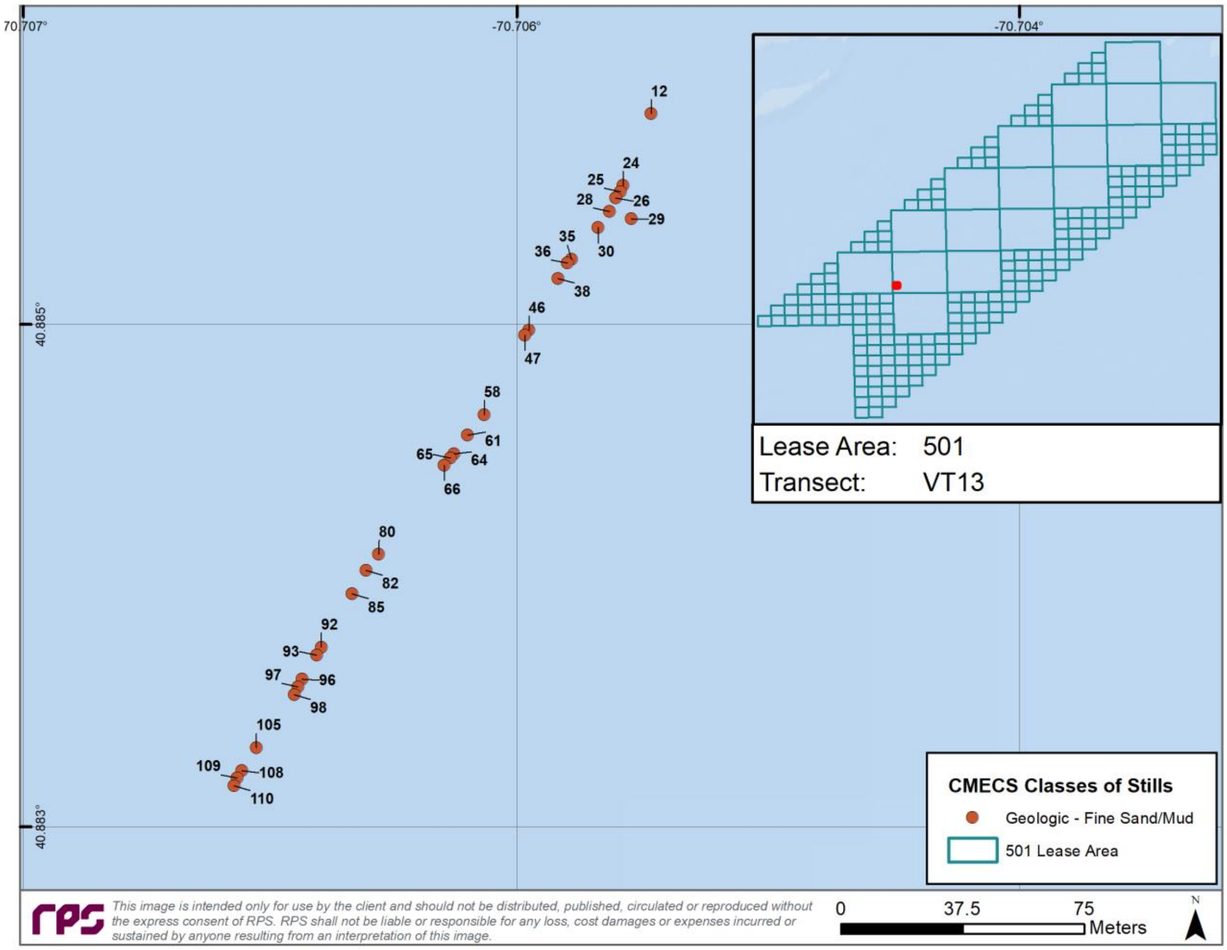

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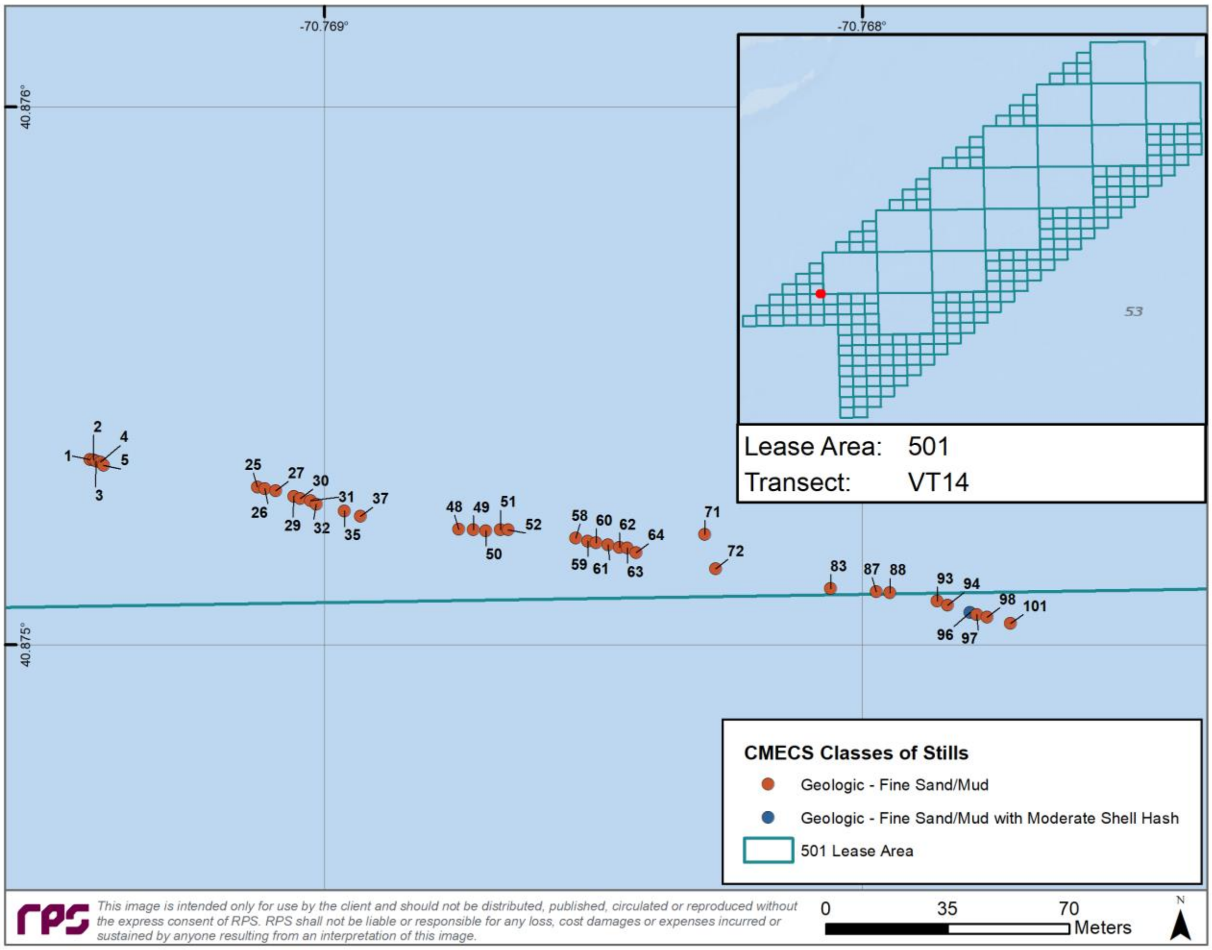

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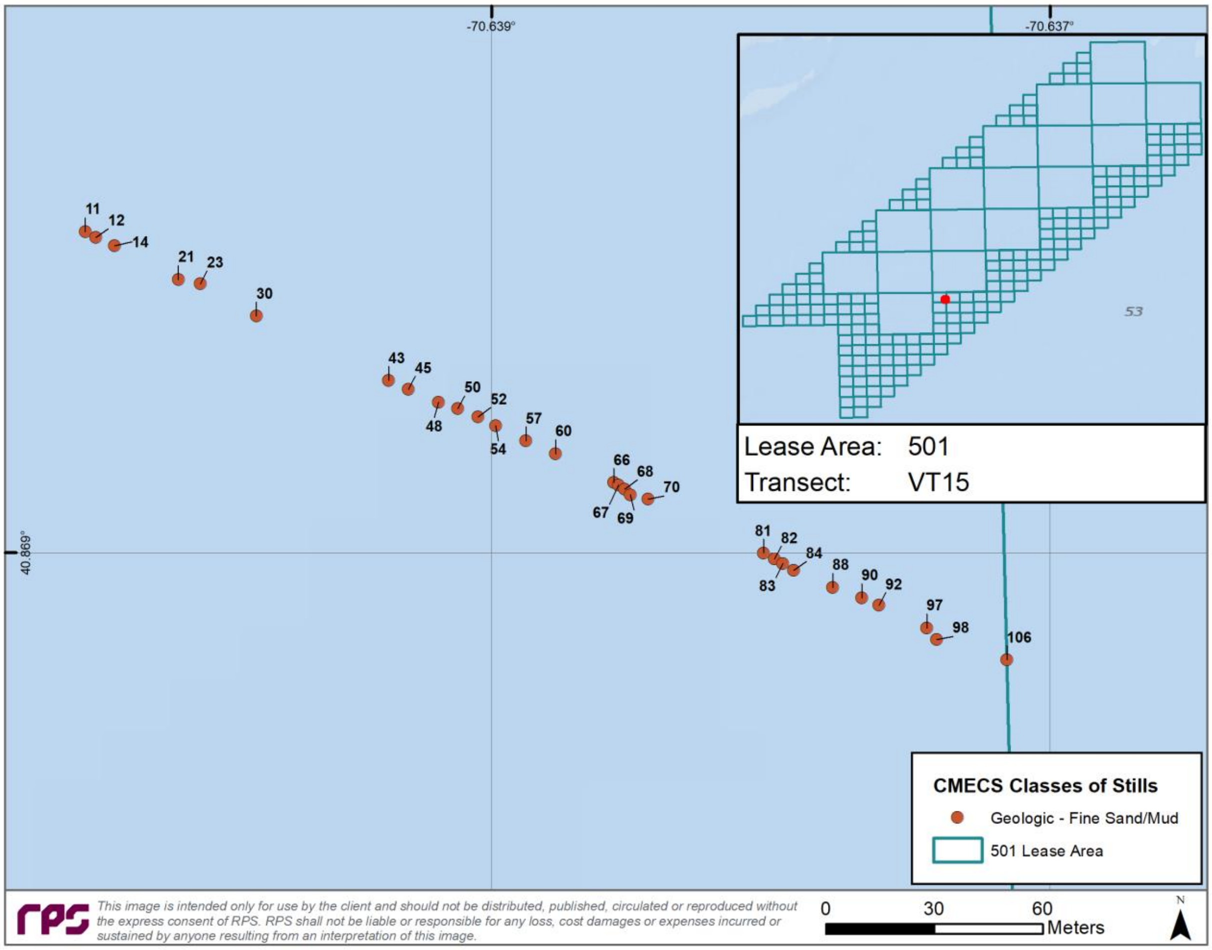

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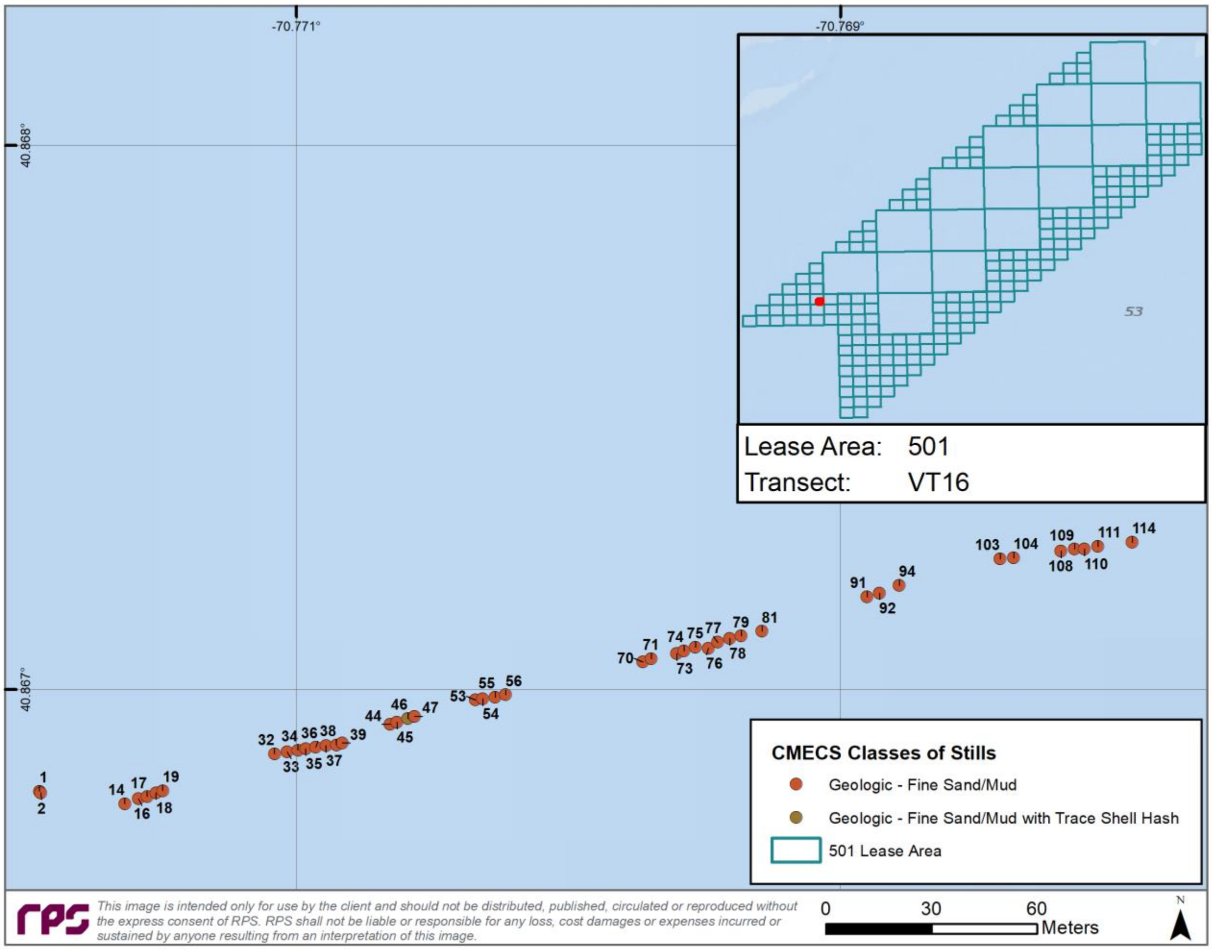

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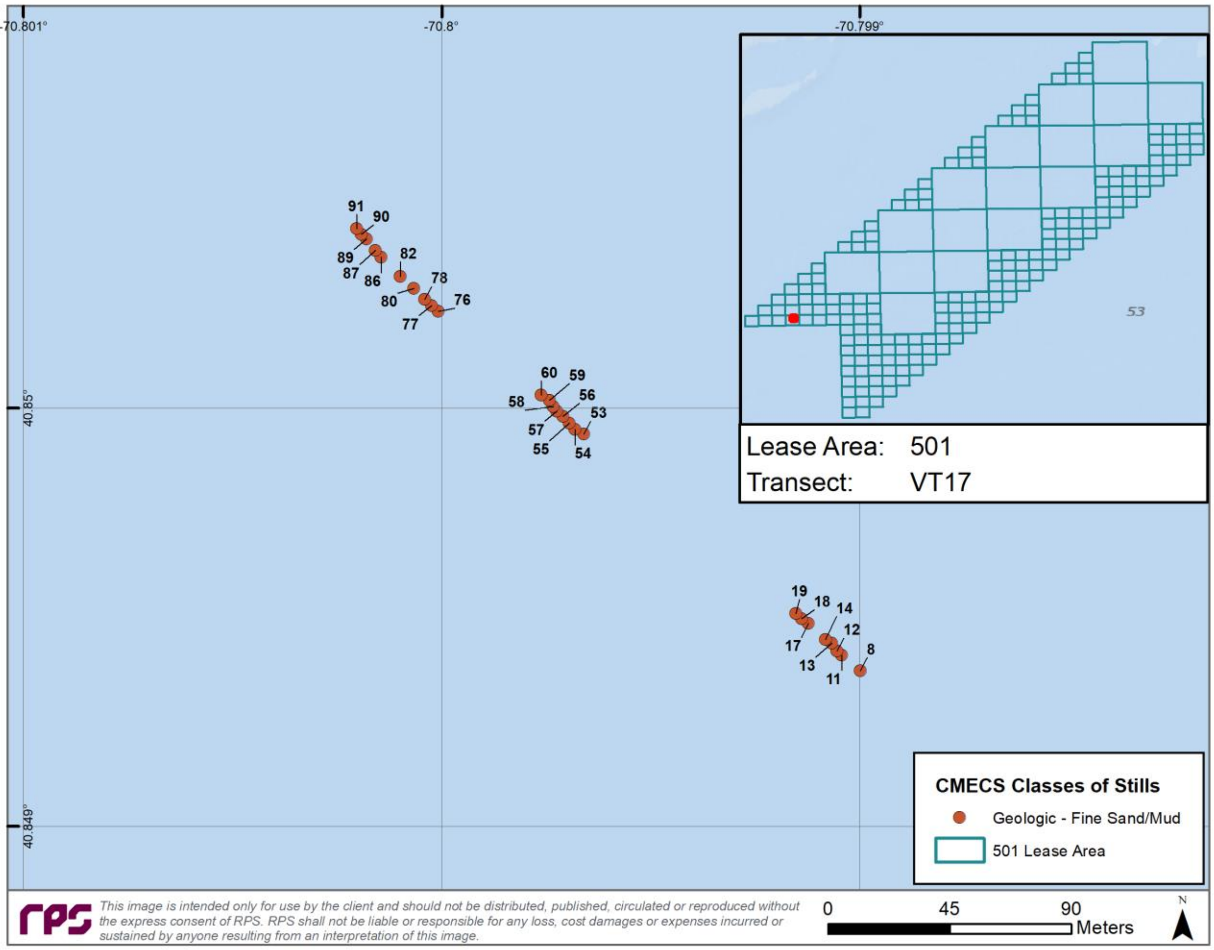
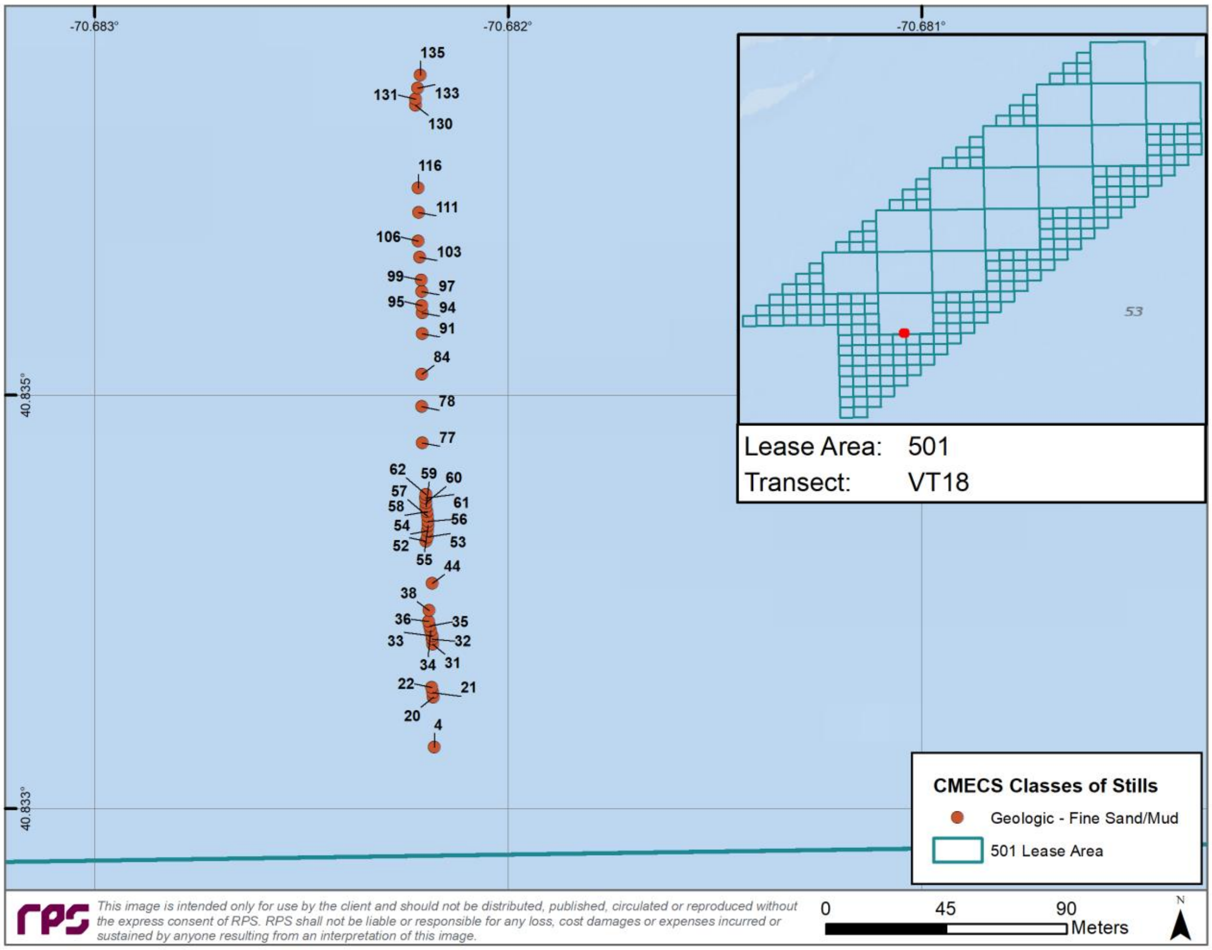


Figure 17 CMECS substrate classification for all viable still images in VT17 (numbers indicate still image ID).



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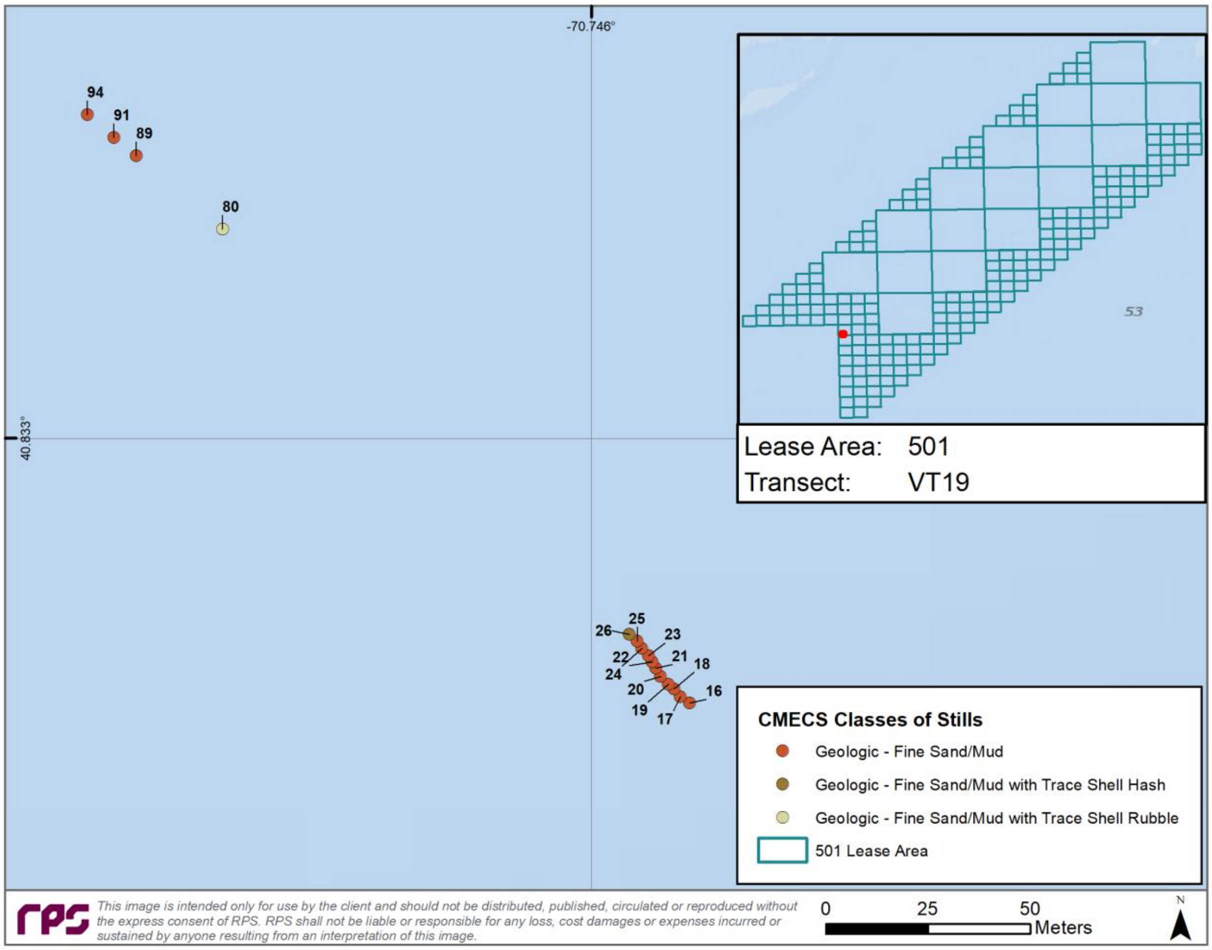

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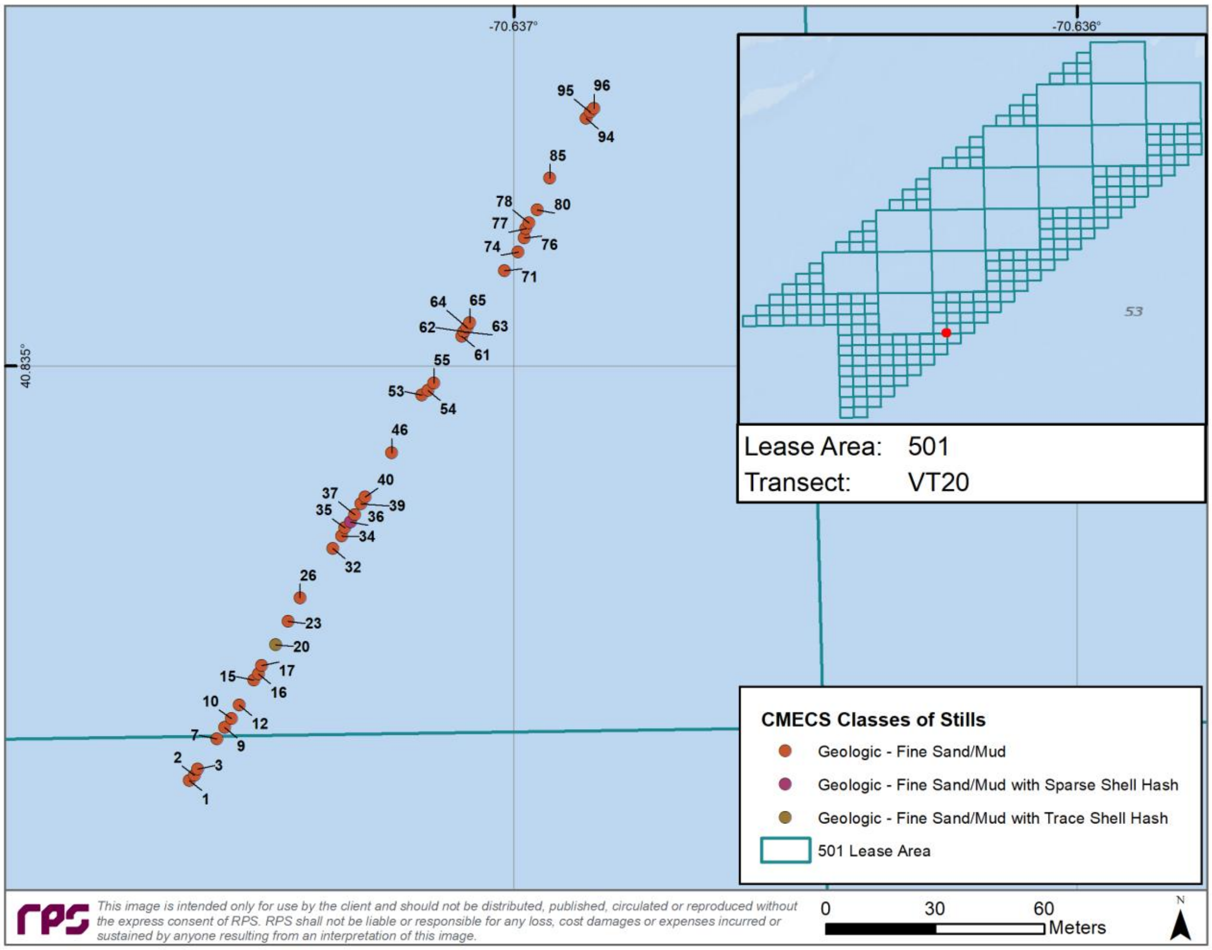

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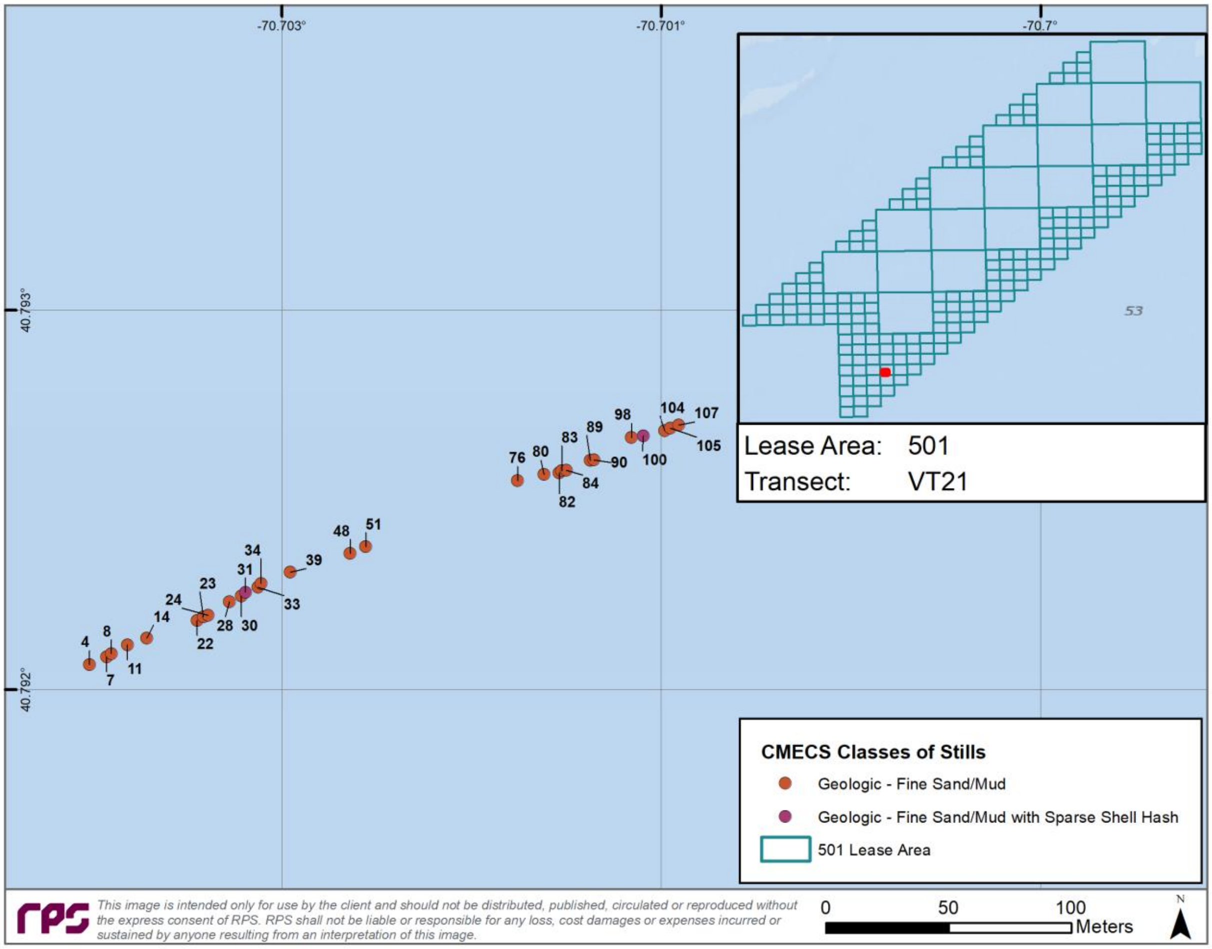

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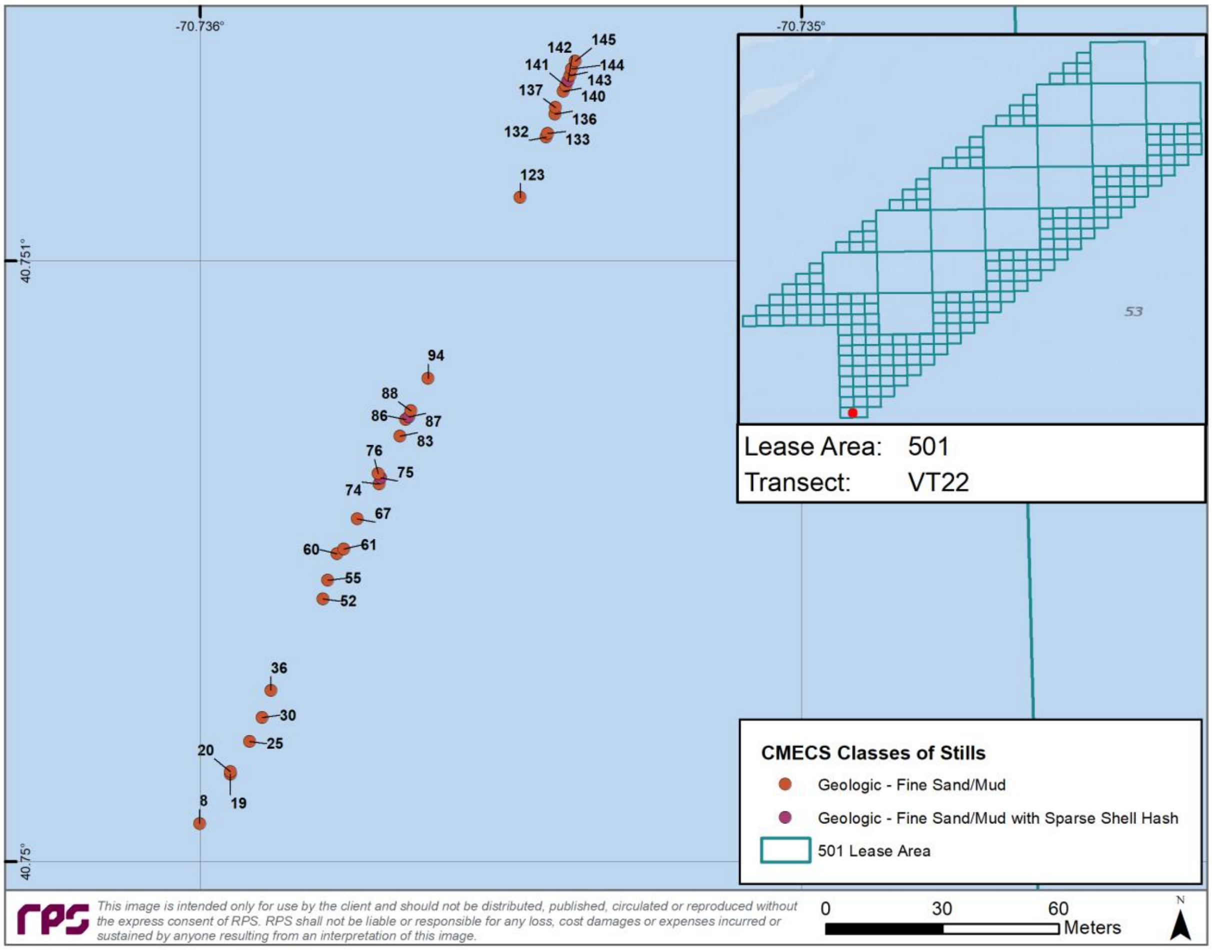

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6. RPS 2019 SWDA Benthic Report

BENTHIC INFAUNAL DATA ANALYSIS

Lease Area OCS-A 0501 South Benthic Report

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Benthic Infaunal Data Analysis

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1 INTRODUCTION

RPS was contracted by Geo SubSea LLC to conduct a statistical analysis of benthic macroinfauna grab sample data from the southern portion of Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0501 known as the Southern Wind Development Area (SWDA), offshore of Martha's Vineyard, Massachusetts. 501 South is intended for the generation of renewable energy from offshore wind in two phases comprised of up to 140 total wind turbine generator (WTG) and electrical service platform (ESP) positions. Samples included in this assessment were collected in the fall of 2016 and summer of 2018 as part of Vineyard Wind's first 800 MW project, Vineyard Wind 1 (also known as 501 North) and in the fall of 2019 as part of 501 South in order to characterize the benthic habitat and infaunal communities throughout the SWDA (Figure 1). Habitat classifications for all samples were completed in accordance with the Coastal and Marine Ecological Classifications Standards (CMECS; FGDC, 2012) and recent guidance for mapping fish habitat from National Marine Fisheries Service (NMFS, 2020).

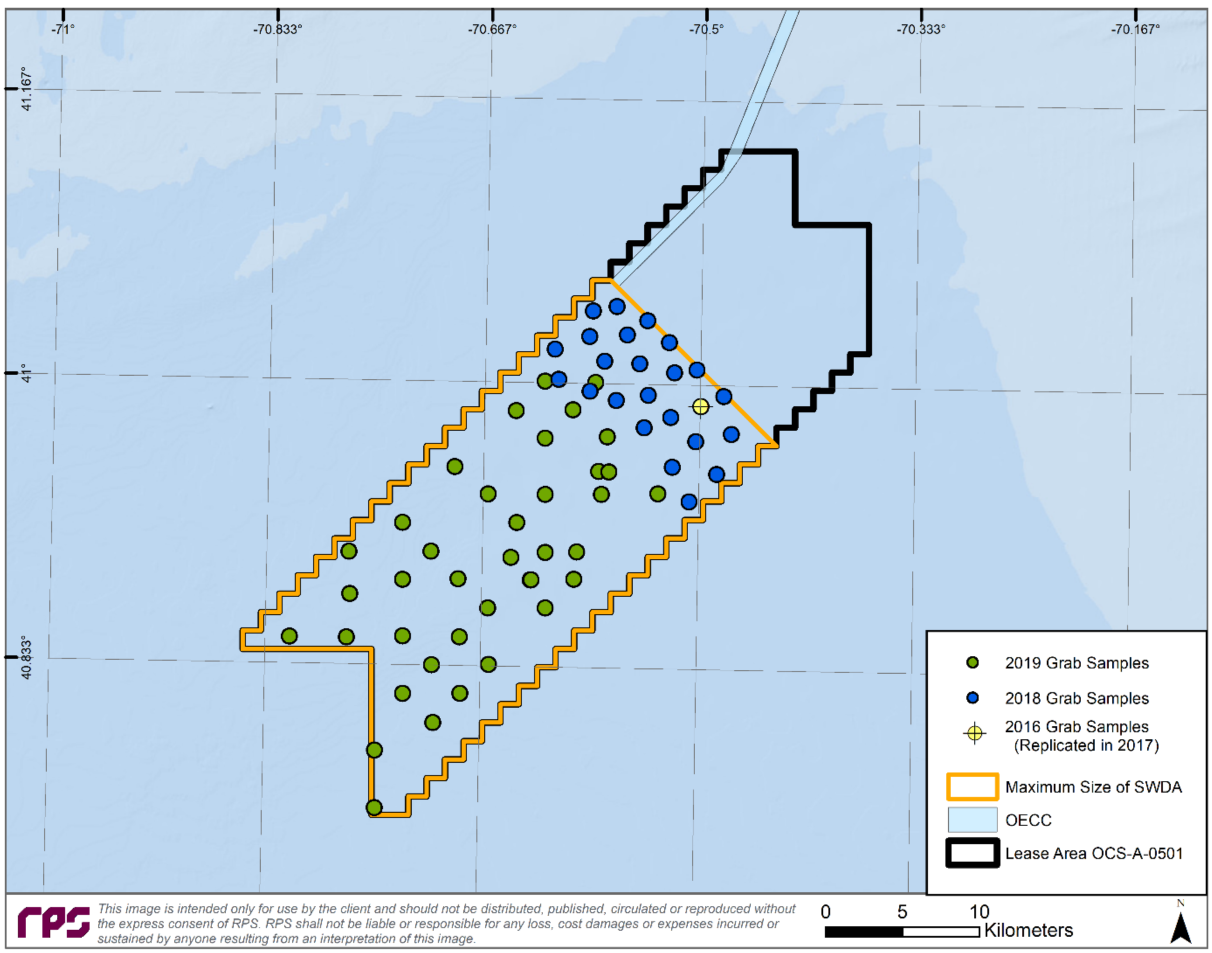

Figure 1. Benthic grab locations in the SWDA. Samples were collected in the fall of 2016 and 2019 and the summer of 2018. The 2016 sample was replicated in 2018 and indicated in the map as an orange point overlaid on a blue point to represent the 2018 sample.

1.1 2016 Field Survey

Benthic macroinfaunal sampling was conducted on November 10, 2016 by Geo Subsea LLC in the Vineyard Wind 1 Wind Development Area (WDA) . Four grab samples at four sites (i.e., no replicates) were collected using a 0.1 m^2 modified Day Grab Sampler. Samples were processed and analyzed by ESS Group, Inc. (ESS; ESS, 2017). However, only one sample from this survey overlapped with the SWDA and was included in these analyses. This location (GB1) was also replicated in the 2018 survey (GB265). Additional information on the 2016 survey can be found in ESS (2017) and RPS (2018).

1.2 2018 Field Survey

Marine benthic habitat sampling was conducted in the OCS-A 0501 lease area by CSA Ocean Sciences, Inc. (CSA) and Alpine Ocean Seismic Survey, Inc. (Alpine) between June 21 and July 5, 2018. Infaunal and grain-size samples were collected at 67 sites in the WDA with a 0.1 m^2 Day Grab Sampler (CSA, 2018). Lab processing and taxonomic identification of all infaunal samples were conducted by EcoAnalysts, Inc. (EcoAnalysts) while grain size samples were analyzed by TerraSense. The abundance of taxa collected and identified in the samples was reported as number of organisms per 0.008 m^2, corresponding to the surface area of the subsample corer used. Of the 67 samples collected in the WDA during the 2018 survey, 24 occurred within the SWDA and were included in these analyses. For the full report on the 2018 survey and data analysis refer to CSA (2018) and RPS (2018).

1.3 2019 Field Survey

Benthic sampling was conducted at 40 stations within the SWDA by Alpine and RPS from November 3-4, 2019. Benthic grab samples were acquired using a 0.1 m^2 Day Grab Sampler owned by Alpine Ocean. Lab processing and taxonomic identification of all infaunal samples was conducted by ESS Group, Inc. As in the 2018 survey, the abundance of taxa collected and identified in the samples was reported as number of organisms per 0.008 m^2, corresponding to the surface area of the subsample plexiglass corer used. Grain size samples were analyzed by TerraSense using the American Society for Testing and Materials (ASTM) soil classification system standards D2487 and D2488 (ASTM, 2017 a;b). For the full survey and benthic data analysis report for the 2019 benthic survey refer to RPS (2020).

2 BENTHIC DATA ANALYSIS METHODS AND RESULTS

2.1 Benthic Infaunal Data Post-Processing

The benthic infaunal community analysis was based on the laboratory results provided by EcoAnalysts (2018) and ESS (2016, 2019) for the 65 grab samples collected in the SWDA. Infaunal community statistics were calculated using species and abundance estimates in each sample, which were reported as count per 0.008 m^2 (area of subsample core). Community composition parameters included: total abundance, number of phyla, number of taxa, Margalef's Richness Index, Shannon Diversity Index, and Pielou's Index of Evenness for each station and within the lease area.

2.1.1 Taxonomic Composition

Taxa composition was assessed to characterize the high-level trends in taxa data. Taxa composition includes the relative proportions of taxonomic groups by number of identifiable taxa and number of individuals, and was used to evaluate dominance of common phyla across all samples. Taxa composition was summarized for individual samples.

2.1.2 Richness, Diversity, and Evenness

Species richness, evenness, and diversity are common ecological parameters used to measure the overall biodiversity of a community or discrete unit. Because some taxa were not identified to the species level, we used abundance data for organisms identified to the LPTL but no further than family. Therefore, this modified the indices to be taxonomic richness, evenness, and diversity indices. Taxonomic richness is the number of unique species or taxonomic groups represented in an area of interest. In this assessment, taxonomic richness was calculated using Margalef's Richness Index (Formula 1) for each station and lease area to acquire sample and average richness indices.

Formula 1. Margalef's Richness Index (RI).

$$\mathrm{RI} = \frac{(\mathrm{S} - 1)}{\ln(\mathrm{n})}$$

Where:

S= the number of unique taxa

n= the total number of individuals in the sample

Interpretation: The higher the index, the greater the richness.

The diversity index for a community further refines taxonomic richness by considering the proportion of each unique taxa. The Shannon Diversity Index (H'; Formula 2) is calculated using the number of each taxa, the proportional abundance of each taxa relative to the total number of individuals, and the sum of the proportions. This index was used to assess diversity of each station and lease area. The diversity index (H') increases with increasing taxonomic richness and evenness.

Formula 2. H'- Shannon Diversity Index.

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

Where:

p_i = the proportion of individuals belonging to the taxa i

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

Evenness of a community refers to the similarity in abundances of different taxa comprising a population or sample. Pielou's Index of Evenness includes H' (Shannon-Weiner Diversity Index) in its calculation.

Formula 3. J'- Pielou's Index of Evenness.

$$J' = \frac{H'}{H_{Max}}$$

Where:

H' = the Shannon- Weiner Diversity Index

H_{Max} = the maximum possible value of H', where each taxon occurs in equal abundances.

$$H_{Max} = \ln(s)$$

Where: s = Number of taxa

Interpretation: J' is constrained between 0 and 1. The greater the value of J', the more evenness in the sample.

2.1.3 Substrate Classification

Sediment samples for grain-size analyses were collected in 2018 and 2019. Grain size samples were analyzed by TerraSense using the American Society for Testing and Materials (ASTM) soil classification system standards D2487 and D2488 (ASTM, 2016a;b). Substrates at each grab site were classified in accordance with the Coastal and Marine Ecological Classifications Standards (CMECS; FGDC, 2012) and recent guidance for mapping fish habitat from National Marine Fisheries Service (NMFS, 2020;Table 1; Table 2; Figure 2). No sediment samples for grain-size analysis were collected in 2016; therefore, substrate classification was determined using field notes and visual assessment of the collected grab sample (Vineyard Wind COP Appendix II-M). Five substrate types were observed in the SWDA and included: Muddy Sand, Fine/Very Fine Sand, Sandy Mud, Medium Sand, and Very Coarse/Coarse Sand; Figure 3).

Table 1. Benthic grab substrate classifications under CMECS/NMFS guidelines.

Substrate Group	Substrate Subgroup	CMECS Bin Size
Muddy Sand	None	**50 to <90% Sand, <5% Gravel**
Sandy Mud	None	**10 to <50% Sand, <5% Gravel**
Sand:		**>90% Sand**
	Very Coarse/Coarse Sand	0.5 – < 2 mm
	Medium Sand	0.25 – < 0.5 mm
	Fine/Very Fine Sand	0.0625 – < 0.25 mm

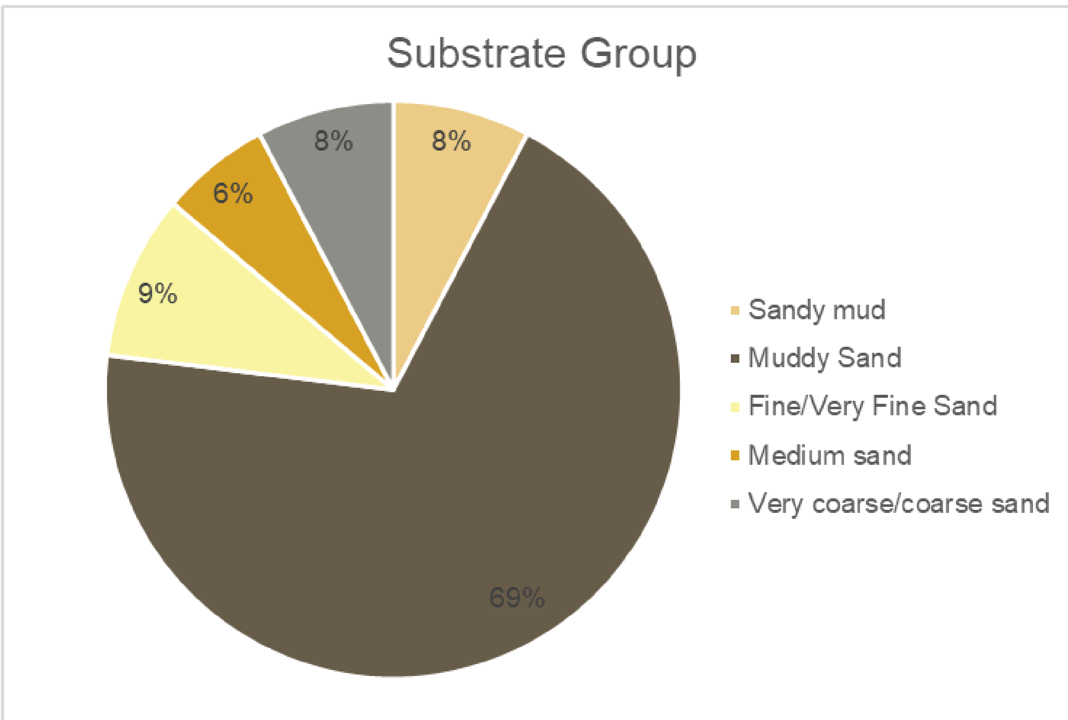

Figure 2. Percent of each substrate group represented in the 65 benthic grab samples located in the SWDA.

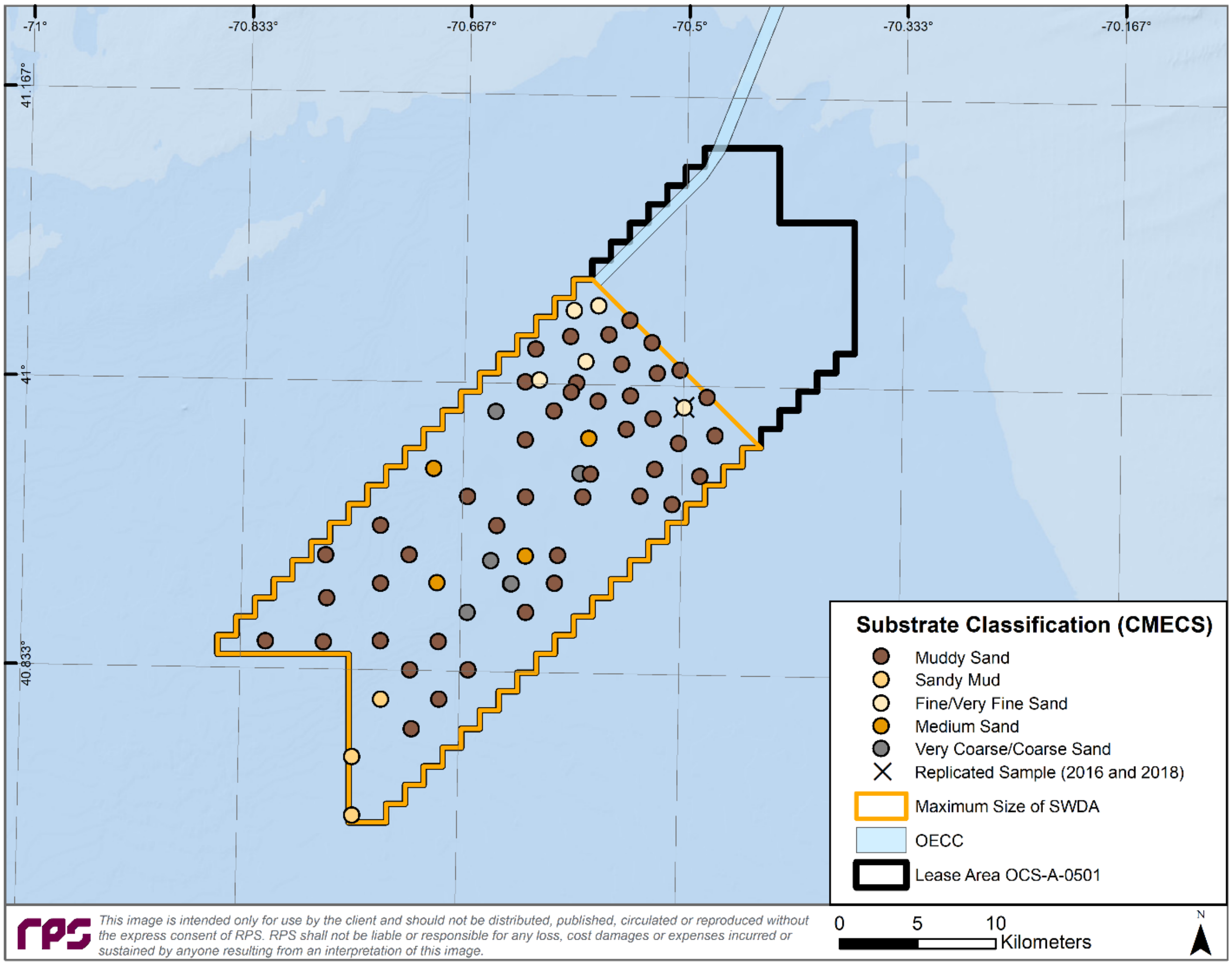

Figure 3. Map of the Southern Wind Development Area with sample points color coded based on substrate type. The station sampled in both 2016 and 2018 is deliniated with a X. The substrate was classified as Fine/Very Fine Sand in both years.

Table 2. Substrate classifications for benthic grab samples collected in the SWDA.

2016		2018		2019	
Site	**Substrate**	**Site**	**Substrate**	**Site**	**Substrate**
16-GB1	Fine/Very Fine Sand	18-GB252	Fine/Very Fine Sand	19-GB01	Very Coarse/Coarse Sand
		18-GB253	Fine/Very Fine Sand	19-GB02	Muddy Sand
		18-GB254	Muddy Sand	19-GB03	Very Coarse/Coarse Sand
		18-GB255	Muddy Sand	19-GB04	Muddy Sand
		18-GB256	Muddy Sand	19-GB05	Muddy Sand
		18-GB257	Muddy Sand	19-GB06	Muddy Sand
		18-GB258	Muddy Sand	19-GB07	Medium sand
		18-GB259	Fine/Very Fine Sand	19-GB08	Muddy Sand
		18-GB260	Muddy Sand	19-GB09	Muddy Sand
		18-GB261	Muddy Sand	19-GB10	Muddy Sand
		18-GB262	Muddy Sand	19-GB11	Muddy Sand
		18-GB264	Muddy Sand	19-GB12	Muddy Sand
		18-GB265	Fine/Very Fine Sand	19-GB13	Medium Sand
		18-GB266	Muddy Sand	19-GB14	Sandy Mud
		18-GB267	Muddy Sand	19-GB15	Sandy Mud
		18-GB268	Muddy Sand	19-GB16	Very Coarse/Coarse Sand
		18-GB269	Fine/Very Fine Sand	19-GB17	Muddy Sand
		18-GB270	Muddy Sand	19-GB18	Muddy Sand
		18-GB271	Muddy Sand	19-GB19	Muddy Sand
		18-GB273	Muddy Sand	19-GB20	Muddy Sand
		18-GB274	Muddy Sand	19-GB21	Muddy Sand
		18-GB275	Muddy Sand	19-GB22	Sandy Mud
		18-GB276	Muddy Sand	19-GB23	Muddy Sand
				19-GB24	Very Coarse/Coarse Sand
				19-GB25	Medium Sand
				19-GB26	Muddy Sand
				19-GB27	Muddy Sand
				19-GB28	Muddy Sand
				19-GB29	Muddy Sand
				19-GB30	Medium Sand
				19-GB31	Muddy Sand
				19-GB32	Muddy Sand
				19-GB33	Very Coarse/Coarse Sand
				19-GB34	Muddy Sand
				19-GB35	Muddy Sand
				19-GB36	Muddy Sand
				19-GB37	Muddy Sand
				19-GB38	Muddy Sand
				19-GB39	Sandy Mud
				19-GB40	Sandy Mud

2.1.4 Results

A single sample collected for Vineyard Wind 1 in the fall of 2016 falls within the SWDA and was included in these analyses. Within the grab sample (16-GB1) there were 85 individual organisms (per 0.008 m^2) from 19 unique taxa and 6 phyla (Table 3). Most of the organisms collected belonged to the phyla Annelida (62%) and Nematoda (21%), while the most unique taxa were from Annelida (42%) and Arthropoda (27%; Figure 4).

In the field survey conducted in the summer of 2018, 24 benthic grab samples were collected in the SWDA (18-GB252 through -GB277) and contained a total of 4,464 individual infaunal organisms (per all 0.008 m^2 core samples) from 68 unique taxa (family or LPTL) and nine plyla (Table 3). Organisms from the phyla Annelida and Arthropoda accounted for 90% of the total abundance and 65% of all unique taxa (Figure 54).

Benthic grab samples were collected for infaunal analysis at 40 sites throughout the SWDA (19-GB01 through -GB40) in the fall of 2019. The grab samples yielded a total of 2,641 individual organisms (per all forty 0.008 m^2 core samples) from five (5) unique phyla and 54 families (or LPTL; Table 3). The phyla Arthropoda and Annelida dominated the samples in both abundance and diversity, representing 94% of all organisms and 85% of all unique taxa (Figure 6).

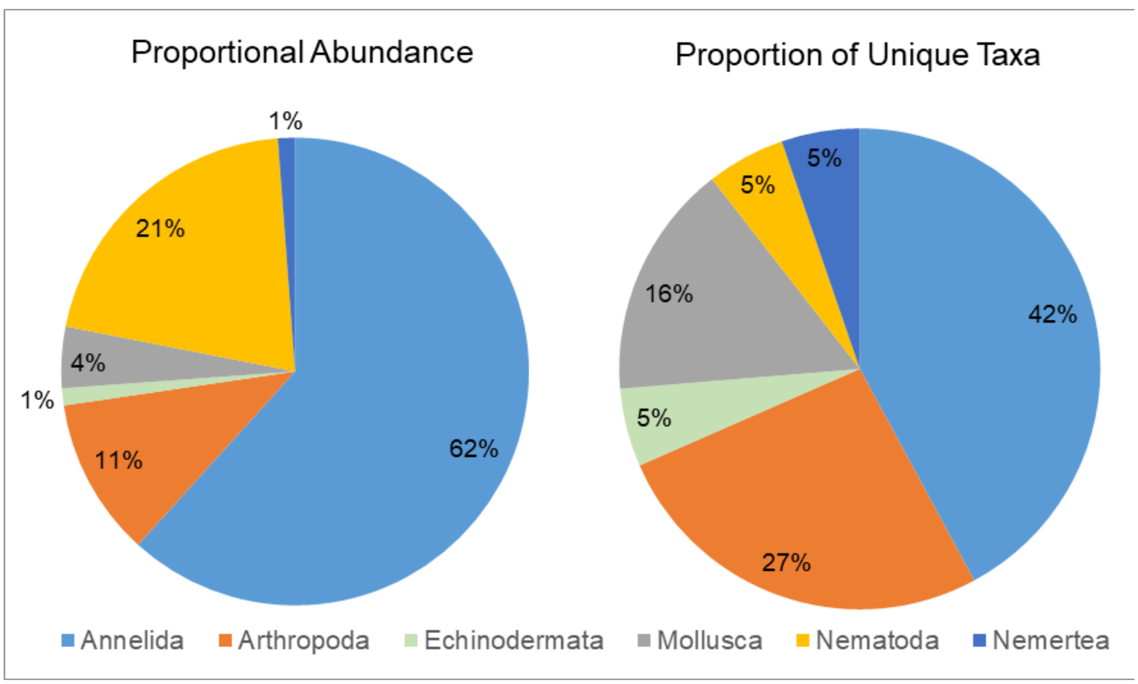

Figure 4. Proportional abundance and proportion of unique taxa (Family or LPTL) for each phylum collected in the benthic grab sample (16-GB1) collected in 2016 in SWDA . Results presented as percentage of total.

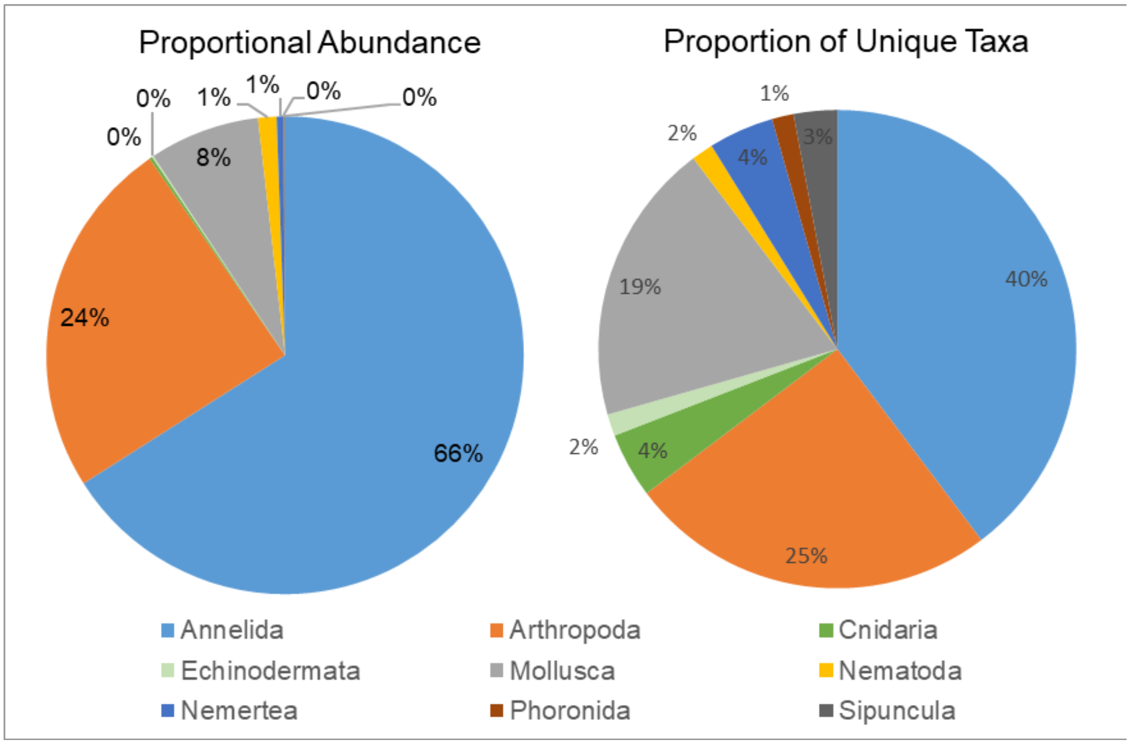

Figure 5. Proportional abundance and proportion of unique taxa (Family or LPTL) for each phylum collected in all (24) benthic grab samples collected in 2018 in SWDA . Results presented as percentage of total.

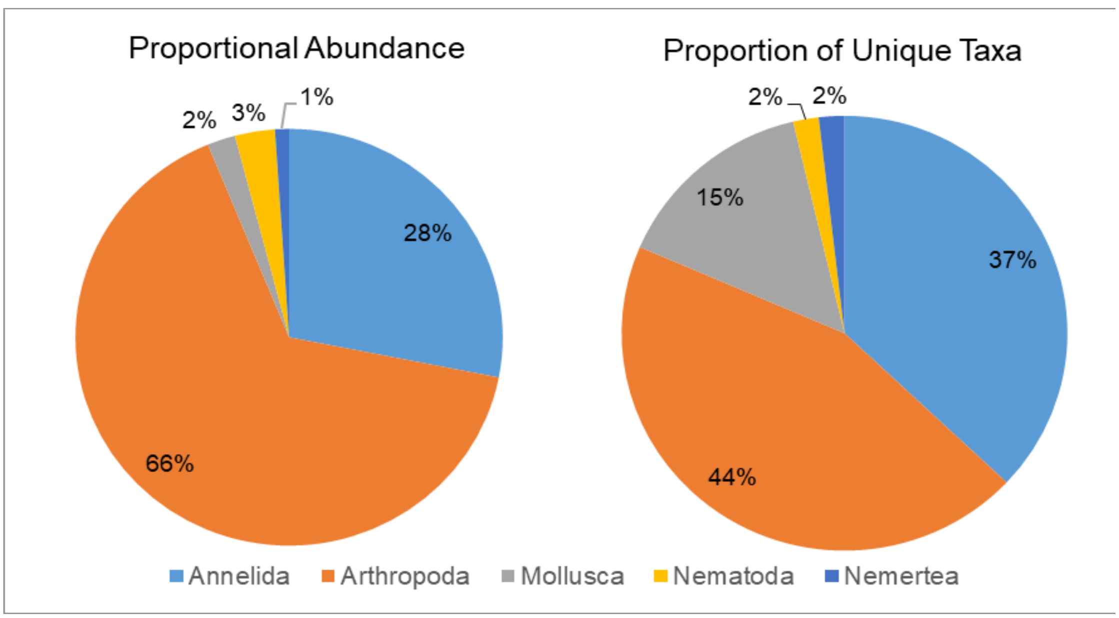

Figure 6. Proportional abundance and proportion of unique taxa (Family or LPTL) for each phylum collected in all (40) benthic grab samples collected in 2019 in SWDA. Results presented as percentage of total.

Table 3. Phyla present in the benthic grab samples collected in the SWDA during the 2016, 2018, and 2019 benthic surveys.

Sample Year	Phyla	Abundant Taxonomic Groups (common names)	Density (Abundance per 0.008 m² samples)	Number of Taxa
2016 1 sample	Annelida	Polychaete worms	52	8
	Arthropoda	Amphipods	9	5
	Echinodermata	Sand dollars	1	1
	Mollusca	Marine clams	4	3
	Nematoda	Nematode worms	18	1
	Nemertea	Ribbon worms	1	1
	Total		85	19
2018 24 samples	Annelida	Polychaete worms	2,946	27
	Arthropoda	Amphipods	1,089	17
	Cnidaria	Sea anemones	9	3
	Echinodermata	Sand dollars	5	1
	Mollusca	Nut clams	334	13
	Nematoda	Nematode worms	56	1
	Nemertea	Ribbon worms	20	3
	Phoronida	Horseshoe worms	1	1
	Sipuncula	Sipunculid worms	4	2
	2018 Total		4,464	68
2019 40 samples	Annelida	Polychaete worms	742	20
	Arthropoda	Amphipods	1,735	24
	Mollusca	Cleft clams, marine bivalve	56	8
	Nematoda	Nematode worms	80	1
	Nemertea	Ribbon worms	28	1
	2019 Total		2,641	54

Samples collected in 2018 averaged higher in abundance, unique taxa, richness, and diversity than those collected in 2019 (Table 4; Figure 7). Sample abundance ranged from 75 to 369 individuals in 2018 and from 3 to 163 individuals in 2019. The number of unique taxa in each sample ranged from 14 to 35 taxa in 2018 and from 3 to 26 taxa in 2019. Richness and diversity ranged from 2.45 to 6.27 and 1.64 to 2.82 in 2018, respectively, and from 0.87 to 5.42 and 1.03 to 2.27 in 2019, respectively. Evenness between sample years was similar and ranged from 0.56 to 0.87 in 2018 and 0.38 to 1.00 in 2019 (Table 5).

Table 4. Summary of community composition parameters calculated for the 2018 and 2019 benthic grab samples collected in the SWDA.

Survey	Avg. Density (Abundance per 0.008 m²)	Avg. # of Taxa	Ecological Indices (Avg.)		
			Richness	Diversity	Evenness
2018	186	24	4.38	2.29	0.73
2019	66	13	2.96	1.70	0.72

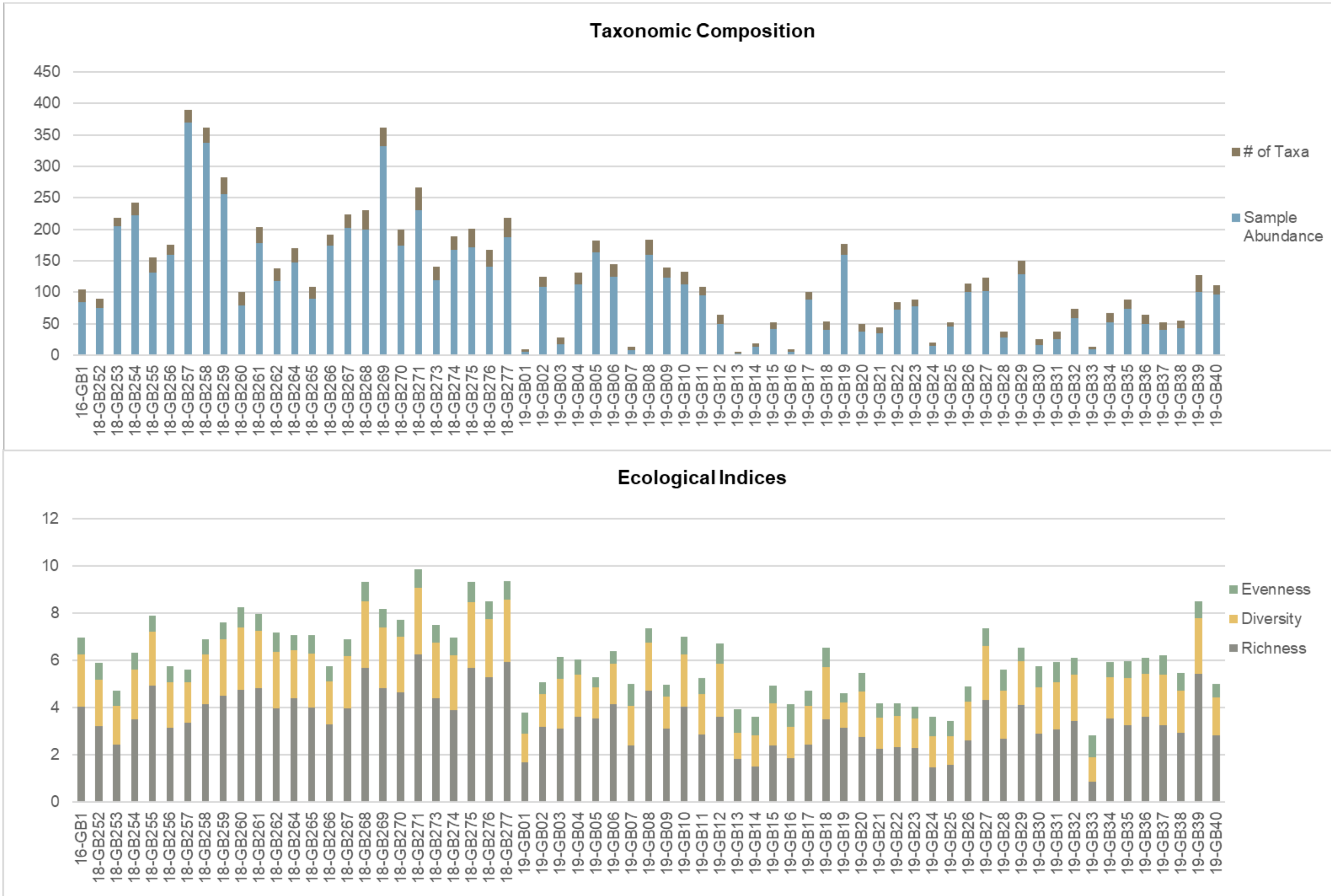

Figure 7. Bar chart representing taxonomic composition (top; # of unique taxa and sample abundance) and ecological indices (bottom; richness, diversity, evenness) for grab sample stations in the SWDA.

Table 5. Community composition parameters calculated for each grab sample station in the SWDA. The first two numbers in the station name indicate year sample was taken (e.g., 16-GB1 represents grab station 1 from the 2016 survey).

Station	Density (Abundance per 0.008 m^2)	# of Taxa	Ecological Indices		
			Richness	Diversity	Evenness
16-GB1	85	19	4.05	2.19	0.74
18-GB252	75	15	3.24	1.95	0.72
18-GB253	205	14	2.45	1.64	0.62
18-GB254	222	20	3.52	2.11	0.7
18-GB255	131	25	4.95	2.26	0.7
18-GB256	159	17	3.16	1.91	0.67
18-GB257	369	21	3.38	1.69	0.56
18-GB258	337	25	4.14	2.1	0.65
18-GB259	256	26	4.52	2.38	0.73
18-GB260	79	21	4.76	2.63	0.86
18-GB261	178	26	4.82	2.42	0.74
18-GB262	118	20	3.98	2.39	0.8
18-GB264	147	23	4.41	2.02	0.65
18-GB265	90	19	4	2.29	0.78
18-GB266	174	18	3.31	1.81	0.63
18-GB267	202	22	3.96	2.23	0.72
18-GB268	199	31	5.69	2.82	0.82
18-GB269	332	29	4.83	2.58	0.77
18-GB270	174	25	4.65	2.35	0.73
18-GB271	231	35	6.27	2.82	0.79
18-GB273	119	22	4.39	2.35	0.76
18-GB274	168	21	3.9	2.32	0.76
18-GB275	171	30	5.67	2.81	0.83
18-GB276	141	27	5.28	2.46	0.75
18-GB277	187	32	5.93	2.65	0.77
19-GB01	6	4	1.67	1.24	0.90
19-GB02	109	16	3.20	1.39	0.50
19-GB03	18	10	3.11	2.12	0.92
19-GB04	113	18	3.60	1.81	0.63
19-GB05	163	19	3.53	1.32	0.45
19-GB06	124	21	4.15	1.70	0.56
19-GB07	8	6	2.40	1.67	0.93
19-GB08	159	25	4.73	2.01	0.63
19-GB09	123	16	3.12	1.36	0.49
19-GB10	112	20	4.03	2.22	0.74
19-GB11	95	14	2.85	1.74	0.66
19-GB12	49	15	3.60	2.27	0.84
19-GB13	3	3	1.82	1.10	1.00
19-GB14	14	5	1.52	1.30	0.81
19-GB15	42	10	2.41	1.76	0.77
19-GB16	5	4	1.86	1.33	0.96
19-GB17	89	12	2.45	1.62	0.65
19-GB18	40	14	3.52	2.20	0.83
19-GB19	160	17	3.15	1.08	0.38
19-GB20	38	11	2.75	1.92	0.80

19-GB21	35	9	2.25	1.34	0.61
19-GB22	73	11	2.33	1.32	0.55
19-GB23	78	11	2.30	1.23	0.51
19-GB24	15	5	1.48	1.32	0.82
19-GB25	46	7	1.57	1.23	0.63
19-GB26	101	13	2.60	1.65	0.65
19-GB27	102	21	4.32	2.28	0.75
19-GB28	28	10	2.70	2.03	0.88
19-GB29	129	21	4.12	1.84	0.60
19-GB30	16	9	2.89	1.98	0.90
19-GB31	26	11	3.07	2.02	0.84
19-GB32	59	15	3.43	1.97	0.73
19-GB33	10	3	0.87	1.03	0.94
19-GB34	52	15	3.54	1.76	0.65
19-GB35	74	15	3.25	1.99	0.73
19-GB36	49	15	3.60	1.83	0.68
19-GB37	40	13	3.25	2.14	0.83
19-GB38	43	12	2.92	1.81	0.73
19-GB39	101	26	5.42	2.36	0.73
19-GB40	97	14	2.84	1.58	0.60

When combining samples from the three surveys, all community composition parameters, other than evenness, were higher in the finer substrates (Muddy Sand, Fine/Very Fine Sand, Sandy Mud) than the coarser substrates (Medium Sand, Very Coarse/Coarse Sand; Table 6).

Table 6. Summary of community composition parameters calculated by CMECS substrate type for benthic grab samples collected in the SWDA.

Survey	Avg. Density (Abundance per 0.008 m^2)	Avg. # of Taxa	Ecological Indices (Avg.)		
			Richness	Diversity	Evenness
Sandy Mud	65	13	2.90	1.66	0.69
Muddy Sand	127	19	3.83	2.02	0.69
Fine/Very Fine Sand	174	20	3.85	2.17	0.73
Medium Sand	18	6	2.17	1.50	0.87
Very Coarse/Coarse Sand	11	5	1.80	1.41	0.91

2.2 Statistical Analyses

2.2.1 Methods

A two-way analysis of variance (ANOVA) following the Type III sums of squares approach in R (Fox and Weisberg, 2019; R Core Team, 2020) was used to test for relationships between sample season, substrate type, and infauna diversity. The Shannon Diversity Index was used to calculate the response variable as it is widely used and an universally accepted ecological index that accounts for both richness and evenness in its estimation. Sample season included two levels, summer and fall. “Fall” samples are defined as those collected from November 2016 and 2019 whereas samples collected from June and July of 2018 are classified as “summer”. Although termed here as “seasons”, these data do not allow for conclusive assessment of seasonal differences due to variation in year and sample location across surveys within the SWDA. The seasonal categorization used here allowed for the sample collected in 2016 to be combined with the 2019 data. Substrate type (based on CMECS) included five levels: Fine/Very Fine Sand, Medium Sand, Muddy Sand, Sandy Mud, and Very Coarse/Coarse Sand. The two null hypotheses tested with the ANOVA included:

$H_0$1: There is no difference in mean diversity for different seasons.

$H_0$2: There is no difference in mean diversity for different substrate types.

Multivariate analyses were conducted in R (Oksanen et al., 2019; R Core Team, 2020) to examine dissimilarity/similarity of stations based on the infaunal assemblages (composition of all species and their abundances). These analyses included nonmetric multidimensional scaling (NMDS), analysis of similarities (ANOSIM), and analysis of similarity percentages (SIMPER; Clarke, 1993). All analyses were built on a Bray-Curtis Similarity Index, using a square-root transformation of the data to ensure all taxa (not just those that dominated samples) would contribute to similarity measures. Differences in the infaunal assemblages between stations were assessed using substrate classification, depth, and sample season.

NMDS was used to compare the distance (difference) between data points and visually evaluate clusters of similarity in the data. Dendrograms present the discrete groupings of samples with similar community structures while NMDS plots present data and groupings spatially, with samples ordinating based on similarity to one another. Samples of high similarity plot in close proximity to one another in NMDS plots.

SIMPER was used to identify the percent dissimilarity between substrate types and taxa that were most responsible for that dissimilarity, i.e., the taxa with the largest difference in mean abundance. ANOSIM was used to help determine if season, depth, or substrate classifications were predictive of the infaunal assemblage clusters. The test statistic (R) calculated in the Global ANOSIM indicates whether samples within classification groups were more similar than samples between groups. R values closer to 1 than 0 and significance levels of p <0.05 indicate that samples within a classification group are more similar to each other than to those in different groups. Specifically, ANOSIM was used to test three null hypotheses:

$H_0$1: Infaunal assemblages do not change within depth classifications.

$H_0$2: Infaunal assemblages do not change within seasons.

$H_0$3: Infaunal assemblages do not change within habitat types.

2.2.2 Results

The two-way ANOVA using Type III sums of squares testing for associations of season and substrate type with infanual diversity found a highly significant ($p < 0.001$) relationship for season, but not for substrate type ($p = 0.15$). These results demonstrated that the mean diversity was significantly higher in the summer season/survey than in the fall season/surveys (Figure 8). The lack of significant interaction between infaunal diversity and substrate indicated high levels of variability between samples (Figure 9).

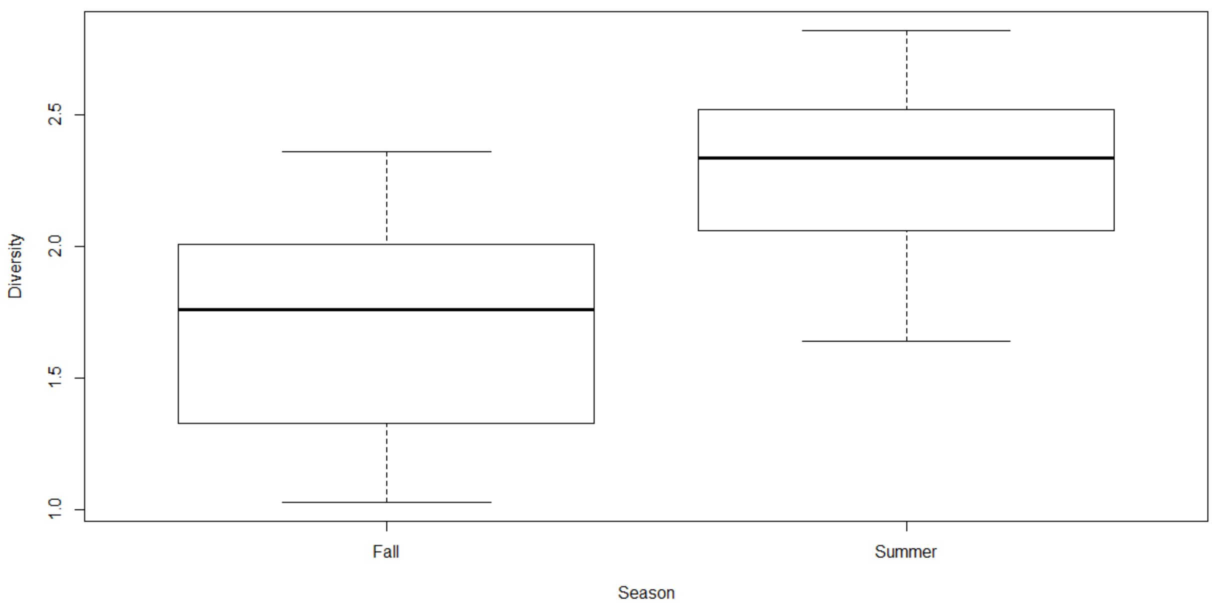

Figure 8. Boxplot presenting the range of diversity values within each season. The bold horizontal line represents the mean value.

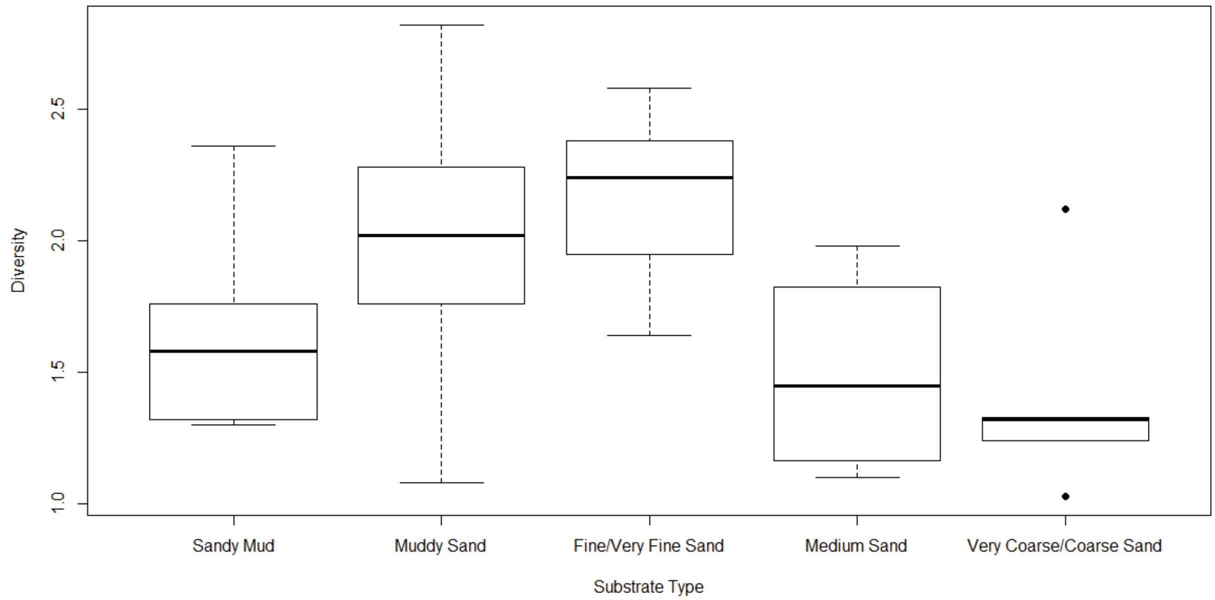

Figure 9. Boxplot presenting the range of diversity values within the CMECS substrate types. The bold horizontal line represents the mean value.

Multivariate analyses distinguished infaunal assemblages in the 65 samples from the 2016, 2018, and 2019 SWDA surveys. Results from the cluster analysis and NMDS based on the Bray-Curtis dissimilarity of infaunal assemblages are presented below in a series of figures including a dendrogram and multiple MDS plots (Figure 10 - Figure 13). Overall, results from the NMDS analysis indicated that the ordination summarized the distance of data points well with a stress value of 0.16. The dendrogram (Figure 10) displays distinct clustering of all samples collected in the summer or 2018 survey, while the fall samples, collected in 2016 and 2019, are dispersed into four distinct clusters.

The NMDS plots were spatially ordinated based on their Bray-Curtis dissimilarity and color-coded based on variables including season, depth, and CMECS substrate type. As displayed in the dendrogram, samples formed distinct clusters based on whether sampling occurred in the summer (2018) or fall (2019 and 2016), however, the wide spread of points within the cluster indicated high variability in infaunal assemblages within each season (Figure 11). The NMDS plot coded by depth showed clusters of shallower sites (right) and deeper sites (left), with higher variability among the deeper sites (Figure 12). The clusters presented in this plot may represent this difference in sampling season in addition to depth, as the summer 2018 survey occurred in the northern, shallower, portion of the WDA, however, as mentioned above, these data are limited in their ability to draw such conclusions due to variation in year and sample location across surveys within the SWDA. Muddy Sand represented most of the samples collected in the SWDA and formed a clear cluster in the NMDS plot coded by substrate type (Figure 13). In general, finer grain size substrates were more similar to one another, forming tighter clusters than the coarse grain sizes, which had higher variability and space between points.

Based on ANOSIM global test results, the null hypothesis that infaunal assemblages do not change within depth classifications was rejected ($R = 0.28$, significance level $p < 0.01$). Although the model showed there was a significant difference between infaunal assemblages at different depths, the low R statistic indicated depth only characterized a small portion of the differences between the infaunal communities at each site. The R value from the ANOSIM of season was 0.37, with a significance level of $p < 0.01$, demonstrating that the overall model was significant; however, infaunal assemblages were only marginally similar within each season, as variability was high within the seasons. The null hypothesis that infaunal assemblages do not change within substrate type was also rejected ($R = 0.58$, significance level $p < 0.01$). The higher R-value indicated that infaunal assemblages are more similar within each substrate type than outside or between the substrate groupings.

The SIMPER analysis was conducted on the substrate factor as the ANOSIM demonstrated significant relationships between the infaunal assemblages within the substrate types. Results from the SIMPER analysis, listed in Table 7, present the percent of dissimilarity between two substrates and the three taxa that contributed the most to that dissimilarity. The substrates with the most dissimilar infaunal assemblages were Very Coarse/Coarse Sand and Fine/Very Fine Sand. Infaunal assemblages in Muddy Sand and Sandy Mud substrates had the highest similarity with Ampeliscidae, Paraonidae, and Maldanidae accounting for 22% of the dissimilarity between substrates. In general, substrates of similar grain size (e.g., Very Coarse/Coarse Sand and Medium Sand) had greater similarities of infaunal assemblages.

Table 7. SIMPER results of the dissimilarity of infaunal compositions between substrate types.

Substrate Type (A)	Substrate Type (B)	Bray-Curtis Dissimilarity	Dissimilar Taxa[1]	% Contribution	Av. Abundance[2] (A)	Av. Abundance[2] (B)
Very Coarse/Coarse Sand	Fine/Very Fine Sand	88%	Polygordiidae	12%	0	5.39
			Lumbrineridae	11%	0.68	5.21
			Paraonidae	8%	0.20	4.25
Fine/Very Fine Sand	Medium Sand	85%	Ampeliscidae	12%	0	5.39
			Paraonidae	10%	0.96	5.21
			Lumbrineridae	8%	0.56	4.25
Very Coarse/Coarse Sand	Muddy Sand	85%	Ampeliscidae	14%	0.77	5.74
			Paraonidae	8%	0.20	3.52
			Lumbrineridae	7%	0.68	3.32
Very Coarse/Coarse Sand	Sandy Mud	82%	Ampeliscidae	15%	0.77	4.25
			Paraonidae	10%	0.20	2.13
			Lumbrineridae	8%	0.68	2.24
Muddy Sand	Medium Sand	77%	Ampeliscidae	13%	5.74	1.80
			Paraonidae	8%	3.52	0.56
			Lumbrineridae	7%	3.32	0.96
Medium Sand	Sandy Mud	76%	Ampeliscidae	16%	1.80	4.25
			Paraonidae	10%	0.56	2.13
			Lumbrineridae	6%	0.96	2.24
Fine/Very Fine Sand	Sandy Mud	73%	Polygordiidae	11%	0	5.39
			Ampeliscidae	8%	4.25	2.39
			Cirratulidae	7%	0.35	3.71
Very Coarse/Coarse Sand	Medium Sand	72%	Nematoda	14%	1.90	1.26
			Ampeliscidae	13%	0.77	1.80
			Scalibregmatidae	8%	0.83	0
Muddy Sand	Fine/Very Fine Sand	62%	Polygordiidae	10%	1.10	5.39
			Ampeliscidae	8%	5.74	2.39
			Paraonidae	6%	3.52	4.25
Muddy Sand	Sandy Mud	62%	Ampeliscidae	12%	5.74	4.25
			Paraonidae	6%	3.52	2.13
			Maldanidae	4%	1.78	0.48

[1] Includes taxa contributing highest percentage to the dissimilarity between substrate types
[2] Average square-root transformed abundance

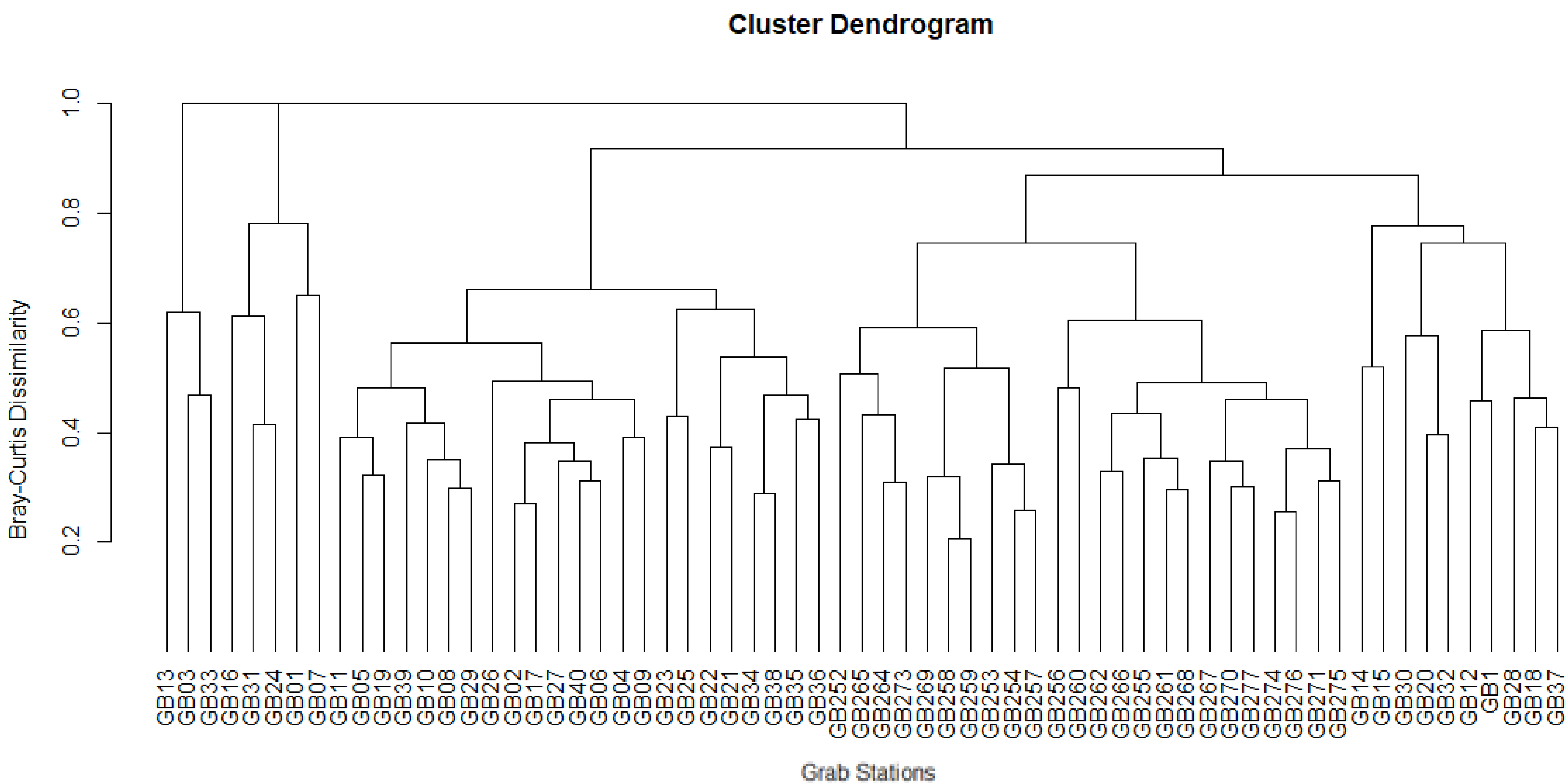

Figure 10. Dendrogram from cluster analysis based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 65 stations sampled in the SWDA. Branches are based on the dissimilarities between those clusters of samples (i.e., samples with lower level clusters are more similar to one another than other samples outside of the cluster), which is labelled on the y-axis. Grab samples labeled GB252-GB277 were collected in the 2018 survey, and sampled labeled GB01-GB40 were sampled in the 2019 survey. The grab sample labeled GB1 was collected in the 2016 survey.

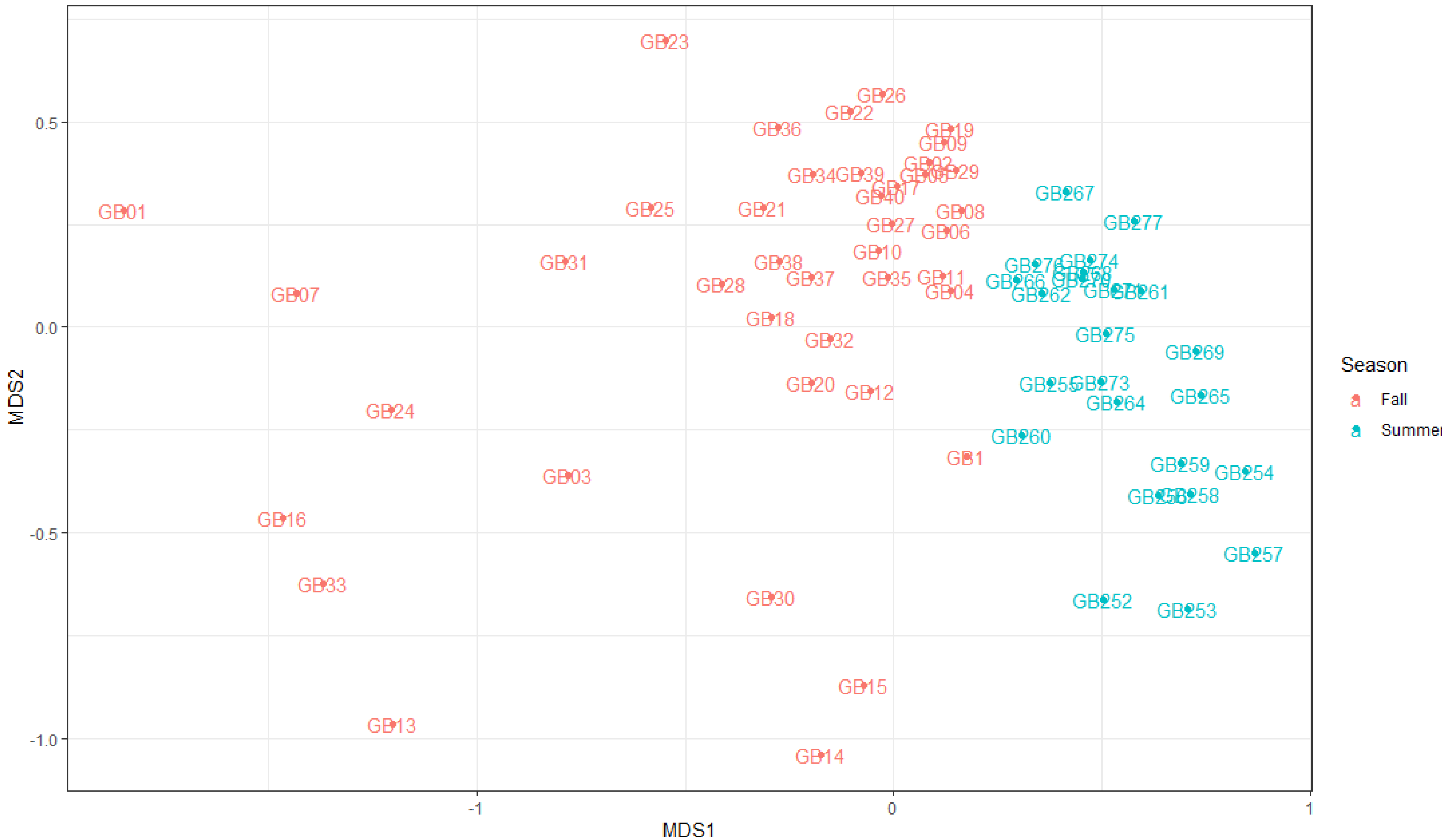

Figure 11. NMDS plot based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 65 stations sampled in the SWDA in the 2016, 2018, and 2019. Each symbol represents a station that is color-coded based on season sampled. Red points represent samples collected in the fall (November 2016 and 2019), while blue points represent those collected in the summer (June/July 2018).

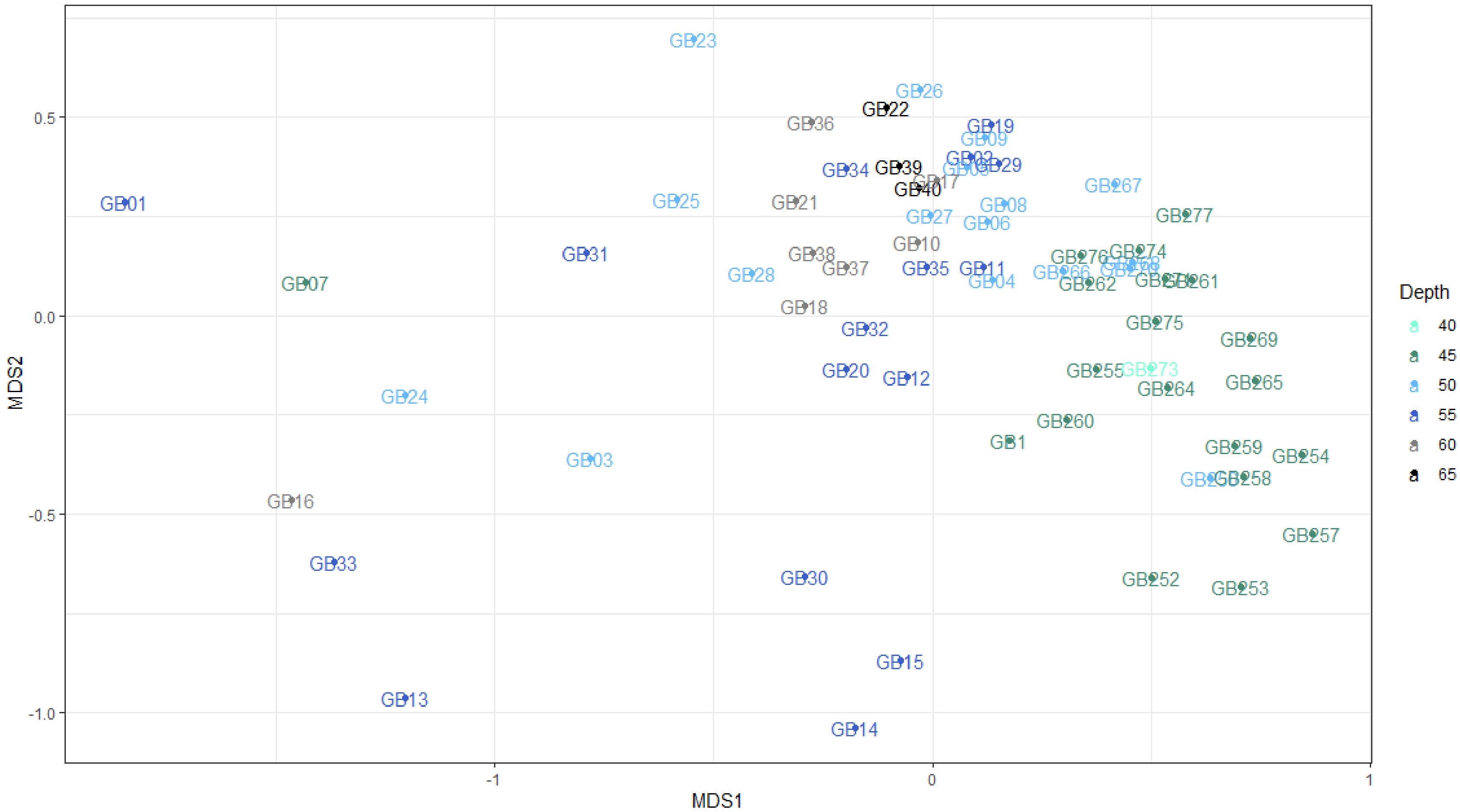

Figure 12. NMDS plot based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 65 stations sampled in the SWDA in the 2016, 2018, and 2019. Each symbol represents a station that is color-coded in a gradient based on depth.

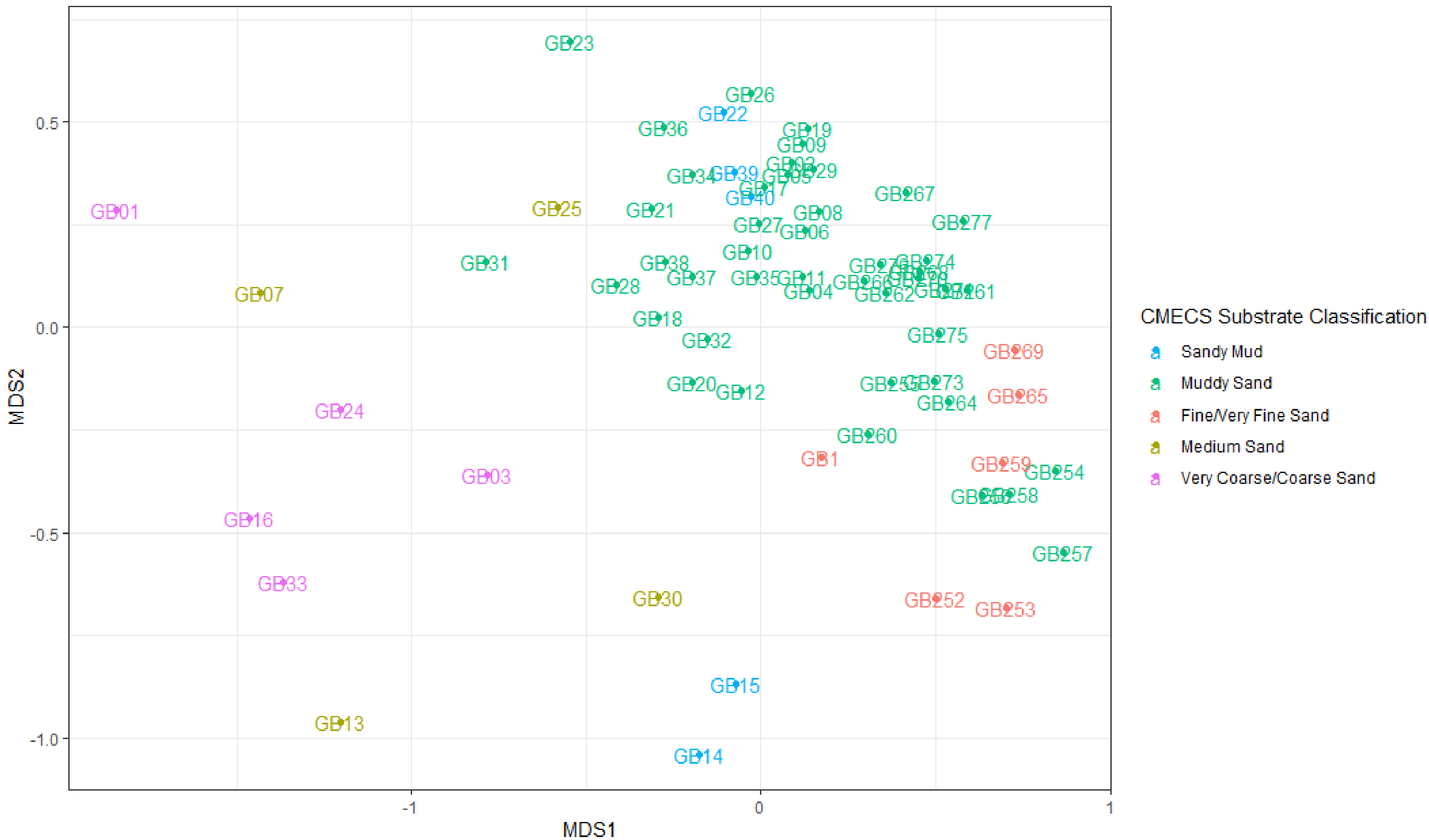

Figure 13. NMDS plot based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 65 stations sampled in the SWDA in the 2016, 2018, and 2019. Each symbol represents a station that is color-coded based on CMECS substrate type. Blue points represent samples in Sandy Mud, green points represent samples in Muddy Sand, red points represent samples in Fine/Very Fine Sand, yellow points represent samples in Medium Sand, and pink points represent samples in Very Coarse/Coarse Sand.

3 DISCUSSION

Across the surveys and benthic grab data included in this analysis, organisms from the phyla Annelida and Arthropoda were consistently dominant in samples throughout the SWDA. Nut clams from the Mollusca phylum were also abundant in 2018 samples, but not in the 2016 sample or 2019 samples. Overall, abundance, number of unique taxa and phyla, richness, and diversity were higher across samples collected in the summer 2018 survey than the fall 2016/2019 surveys. Almost twice as many individual organisms were captured in the 24 samples collected in 2018 than the 40 samples collected in 2019.

Results from the ANOVA and dissimilarity analyses also indicated possible differences in the ecological indices and infaunal assemblages of samples collected in the summer (2018) and fall (2016 and 2019). Many of the ecological indices calculated for samples collected in the summer, other than evenness, were almost double of those from the fall samples. Seasonal differences, related to primary and corresponding secondary production in New England, could explain some of the seasonal trends observed in the data and results. However, the effect of season cannot be conclusively shown by analyses of these data due to changes in season, year, and location within the SWDA over the three years of sampling, as explained below.

Interannual variability could also explain the differences observed within the summer and fall seasons, as summer sampling only occurred in 2018 and fall sampling occurred primarily only in 2019. Interannual variability can be introduced through large-scale climatic events such as storms or shifts in sea temperature, or hydrograhic fronts. Although fall sampling occurred in 2016 and 2019, only one data point from the 2016 survey was included in the dataset; an insufficient number for comparative analyses between the years.

Spatial variability could also contribute to these differences as samples in 2018 were collected in the northern most region of the SWDA, which is closer to shore and in shallower waters. Although statistical results indicate that depth was a poor indicator of infaunal abundance, the variation in depth between the surveys can be observed in the NMDS plot color-coded by depth, which shows loose clustering of the shallow water samples (40-45 m) from the 2018 survey. The NMDS plot also displayed loose clustering of sites at the deepest depths (60-65 m), which may indicate distinct shifts in the infanual assemblages as water depth increases. However, it remains difficult to draw inferences on infaunal assemblages based on depth as it is unclear whether the clustering is an artefact of differences in sample season and year.

Although the diversity scores of infauna collected at each grab site were not significantly different across the substrate types, infaunal assemblages formed several clusters based on the classified substrate. Muddy Sand represented the most samples and formed a loose cluster in the NMDS plot. Although variability was high in the infaunal assemblages within Muddy Sand substrates, these samples were more similar to each other on average than to other samples outside of this group. This is also apparent for samples collected in Fine/Very Fine Sand, which also ordinated in a loose cluster. The coarser substrates, Medium Sand and Very Coarse/Coarse Sand, had the highest variability within the infaunal assemblages, as represented in the wide spread of points in the NMDS plot. This high level of variability may indicate increased heterogenetity within the substrate types that allows for a wider array of taxa.

The SIMPER results found that finer substrates (Muddy Sand, Fine/Very Fine Sand, Sandy Mud) both contained more similar infaunal assemblages within each substrate group and were more similar to each other than the coarse substrates. Infaunal assemblages associated with Muddy Sand were most similar to those within Fine/Very Fine Sand and Sandy Mud and most dissimilar to those associated with Very Coarse/Coarse Sand. Fine/Very Fine Sand and Very Coarse/Coarse Sand had the highest percentage of dissimilarity of any other two substrates. Three families of polychaete worms were most important in distinguishing the infaunal abundances within these substrate types and all occurred in higher abundances on average in Fine/Very Fine Sand than in Very Coarse/Coarse Sand. Although this could describe the natural relationship between infaunal assemblages within these substrates, it should be noted that Fine/Very Fine Sand was only observed in the summer survey in 2018 and at the single site in 2016; whereas Very Coarse/Coarse Sand was only observed in the fall survey in 2019. Therefore, this relationship could be a consequence of the variability between surveys. In general, SIMPER was useful in presenting taxa that contributed the most to the dissimilarity between substrates and highlighted few taxa consistently contributing large percentages to that dissimilarity, including Lumbrineridae, Paraonidae, Ampeliscidae and Polygordiidae. However, SIMPER is sensitive to abundance and highlights the larger-scale variance of individual common taxa, rather than differences in rare or unique taxa.

Overall, these results demonstrated significant interannual, seasonal, and or spatial variability between the summer 2018 and fall 2016/2019 surveys. Higher productivity, richness, and diversity were observed in the infanal assemblages of sampled collected in the summer of 2018, possibly driven by spring production booms and favorable conditions. Additionally, these analyses indicate that infaunal assemblages can be distinguished by substrate type. Muddy Sand substrate represented almost 70% of the total samples collected in 2016, 2018 and 2019, demonstrating largely homogenous habitats within the SWDA. Other substrate types regularly occurred in patches, demonstrating smaller-scale habitat heterogeneity within the SWDA.

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7. RPS 2019 OECC Benthic Report

BENTHIC INFAUNAL DATA ANALYSIS

Lease Area OCS-A 0501 South Offshore Cable Corridor Benthic Report

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OCS-A 0501 South
Benthic Infaunal Data Analysis

May 22, 2020

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1 INTRODUCTION

RPS was contracted by Geo SubSea LLC to conduct a statistical analysis of benthic macroinfauna (referred to as infauna or macroinfauna) grab data sampled along the Offshore Export Cable Corridor (OECC) of 501 South, Vineyard Wind's proposal to develop the southern portion of Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0501 known as the Southern Wind Development Area (SWDA), offshore of Martha's Vineyard, Massachusetts. 501 South is intended for the generation of renewable energy from offshore wind in two phases comprised of up to 140 total wind turbine generator (WTG) and electrical service platform (ESP) positions. Samples included in this assessment were collected in 2017 and 2018 as part of Vineyard Wind's first 800 MW project, Vineyard Wind 1 (also known as 501 North), and in 2019 as part of 501 South in order to characterize the benthic habitat and macroinfaunal communities throughout Offshore Development Area (Figure 1). Habitats at each grab site were classified using field survey notes and the Coastal and Marine Ecological Classifications Standards (CMECS; FGDC 2012) as guidance. The OECC was broken down into four regions or locations, including the nearshore landfall area, the northern OECC, Muskeget channel, and southern OECC (Figure 1).

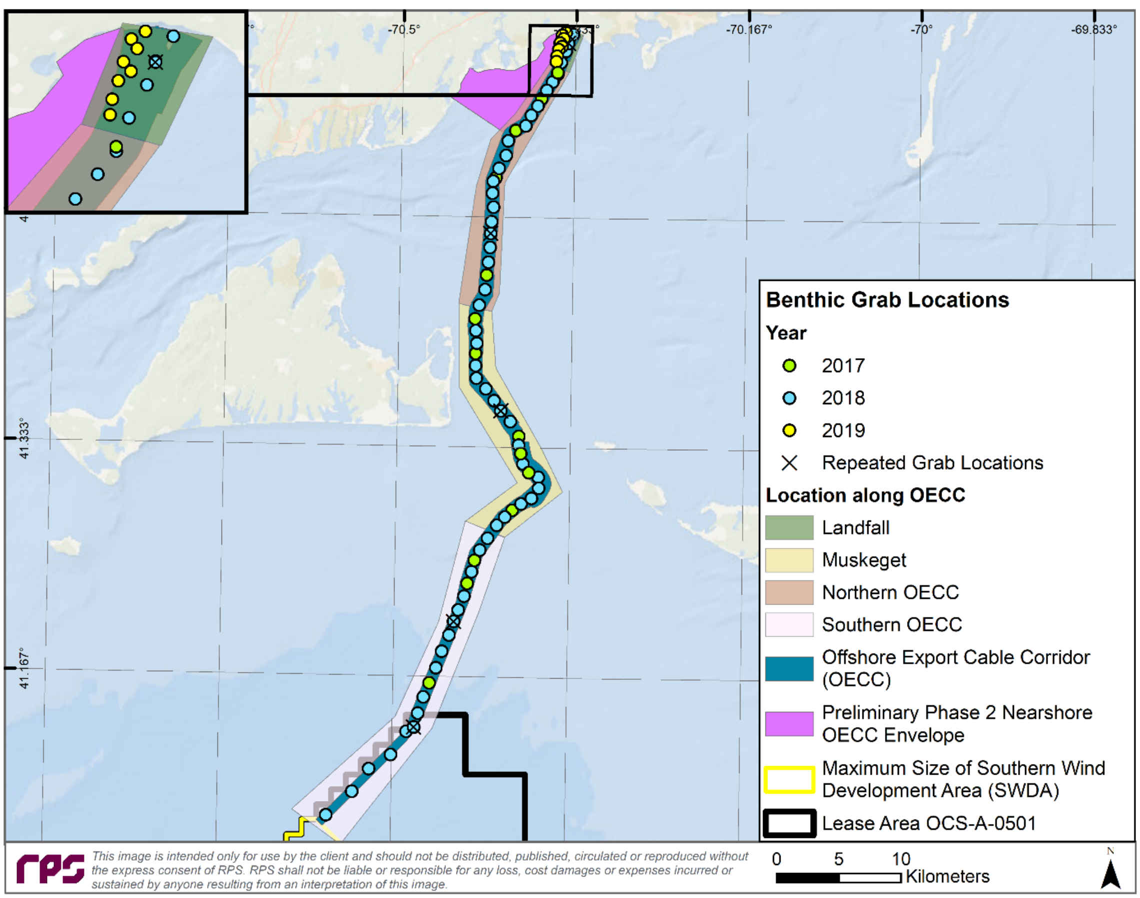

Figure 1. Benthic grab locations along the 501 South Offshore Export Cable Corridor. Samples were collected in 2017, 2018, and 2019. The stations sampled in both 2017 and 2018 are delineated with an X.

1.1 2017 Field Survey

Benthic macroinfaunal sampling was conducted between August 31 and September 4, 2017 by Alpine Ocean Seismic Survey, Inc. (Alpine). Grab samples were collected using a 0.1 m^2 modified Day Grab Sampler and infaunal samples were collected from the grab using a 4-inch diameter handheld core. Samples were processed and analyzed by Normandeau Associates, Inc. (Normandeau 2017). The abundance of taxa collected and identified in the samples was reported as number of organisms per 0.008 m^2, corresponding to the surface area of the subsample corer used. Of the 59 successful grab samples collected during this survey, 16 of the stations are along the currently proposed OECC and included in this analysis. Additional information on the 2017 survey can be found in Normandeau (2017).

1.2 2018 Field Survey

Marine benthic habitat sampling was conducted in the Vineyard Wind I Offshore Development Area by CSA Ocean Sciences, Inc. (CSA) and Alpine Ocean Seismic Survey, Inc. (Alpine) between May 28 and July 5, 2018. Infaunal and grain-size samples were successfully collected at a total of 141 stations (67 sites in the Vineyard Wind I Wind Development Area (WDA) and 74 along the OECC) with a 0.1 m^2 Day Grab Sampler and infaunal samples collected from the grab using a 4-inch diameter handheld core (CSA 2018). Five stations sampled along the OECC in 2017 were replicated in 2018. Lab processing and taxonomic identification of all infaunal samples were conducted by EcoAnalysts, Inc. (EcoAnalysts) while grain size samples were analyzed by TerraSense. The abundance of taxa collected and identified in the samples was reported as number of organisms per 0.008 m^2, corresponding to the surface area of the subsample corer used. Of the 141 samples collected in the Vineyard Wind I Offshore Development Area during the 2018 survey, 50 occurred within the 501 South OECC and were included in these analyses. For the full report on the 2018 survey and data analysis refer to CSA (2018) and RPS (2018).

1.3 2019 Field Survey

Benthic sampling was conducted at 11 stations within the nearshore area of the 501 South OECC by Horizon Geosciences and Seaforth Geosurveys in the summer of 2019. Benthic grab samples were acquired using a Ted Young benthic grab sampler and infaunal subsamples were taken using a 4-inch diameter hand core. Lab processing and taxonomic identification of all infaunal samples were conducted by ESS Group, Inc. As in the 2017 and 2018 surveys, the abundance of taxa collected and identified in the samples was reported as number of organisms per 0.008 m^2, corresponding to the surface area of the subsample plexiglass corer used. Grain size samples were analyzed by TerraSense using the American Society for Testing and Materials (ASTM) soil classification system standards D2487 and D2488 (ASTM 2017 a;b). Of the 11 samples collected in 2019 during the nearshore survey, eight occurred within the currently proposed 501 South OECC and were included in these analyses.

2 BENTHIC DATA ANALYSIS METHODS AND RESULTS

2.1 Benthic Infaunal Data Post-Processing

The benthic macroinfaunal community analysis was based on the laboratory results provided by Normandeau (2017), EcoAnalysts (2018), and ESS Group (2019) for the 74 grab samples collected along the 501 South OECC. Infaunal community statistics were calculated using species and abundance estimates in each sample, which were reported as count per 0.008 m^2 (area of subsample core). Community composition parameters included: total abundance, number of phyla, number of taxa, Margalef's Richness Index, Shannon Diversity Index, and Pielou's Index of Evenness for each station and within the lease area.

2.1.1 Community Composition

Taxonomic data was assessed to characterize the high-level trends in community composition. Community composition includes the relative proportions of taxonomic groups aggregated by the number of identifiable taxa and number of individuals which was used to evaluate dominance of common phyla across all samples. Community composition was also summarized for individual samples.

2.1.2 Richness, Diversity, and Evenness

Species richness, evenness, and diversity are common ecological parameters used to measure the overall biodiversity of a community or discrete unit. Because some taxa were not identified to the species level, we used abundance data for organisms identified to the Lowest Practical Taxonomic Level (LPTL) but no further than family-level. Therefore, this modified the indices to be taxonomic richness, evenness, and diversity indices. In addition, ostracods and copepod taxa were excluded from the analyses as one lab did not include enumeration of these organisms in their infaunal processing. Taxonomic richness is the number of unique species or taxonomic groups represented in an area of interest. In this assessment, taxonomic richness was calculated using Margalef's Richness Index (Formula 1) for each station and lease area to acquire sample and average richness indices.

Formula 1. Margalef's Richness Index (RI).

$$\mathrm{RI} = \frac{\mathrm{S} - 1}{\ln(\mathrm{n})}$$

Where:

S= the number of unique taxa

n= the total number of individuals in the sample

Interpretation: The higher the index, the greater the richness.

The diversity index for a community further refines taxonomic richness by considering the proportion of each unique taxa. The Shannon Diversity Index (H'; Formula 2) is calculated using the number of each taxa, the proportional abundance of each taxa relative to the total number of individuals, and the sum of the proportions. This index was used to assess diversity of each station and lease area. The diversity index (H') increases with increasing taxonomic richness and evenness.

Formula 2. H'- Shannon Diversity Index.

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

Where:

p_i = the proportion of individuals belonging to the taxa i

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

Evenness of a community refers to the similarity in abundances of different taxa comprising a population or sample. Pielou's Index of Evenness includes H' (Shannon-Weiner Diversity Index) in its calculation.

Formula 3. J'- Pielou's Index of Evenness.

$$J' = \frac{H'}{H_{Max}}$$

Where:

H' = the Shannon- Weiner Diversity Index

H_{Max} = the maximum possible value of H', where each taxon occurs in equal abundances.

$$H_{Max} = \ln(s)$$

Where: s = Number of taxa

Interpretation: J' is constrained between 0 and 1. The greater the value of J', the more evenness in the sample.

2.1.3 Habitat Classification

Habitat at each grab site was classified using field survey notes and the Coastal and Marine Ecological Classifications Standards (CMECS; FGDC 2012) as guidance (Table 1; Table 2; Figure 2). Both substrate and biogenic components were noted and combined into a single habitat classification. Five habitat types were observed along the 501 South OECC and included: Silt, Fine Sand 1, Fine Sand 2, Coarse Sand and Gravel; Figure 3). Habitat classifications for eight additional sites (three from 2017 and five from 2018), which were sampled but failed to collect infaunal samples due to improper closure of sampler, were included in Figure 2 and Figure 3. Habitat at all eight sites was classified as Gravel.

Table 1. Habitat classifications used to describe 2017, 2018, and 2019 benthic grab survey stations.

Classification	Description
Fine Sand 1	Fine sand with some shell hash
Fine Sand 2	Plain fine sand
Coarse Sand	Medium to coarse sand with some shell hash
Silt	Silty sand or mud
Gravel	Gravel or large rocks

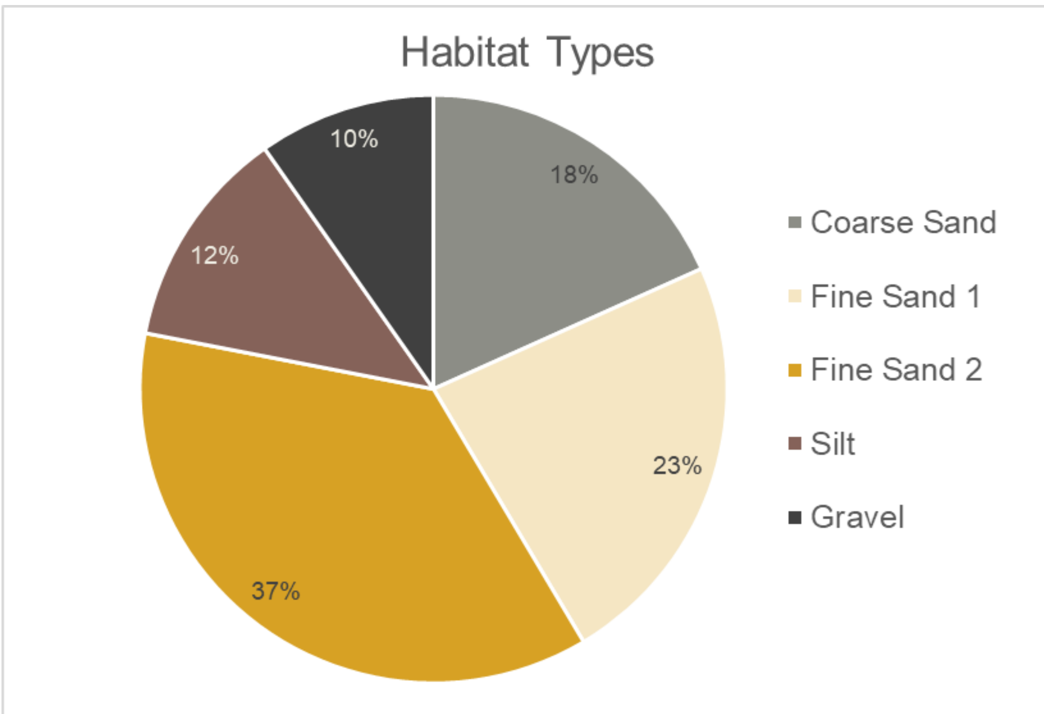

Figure 2. Percent of each habitat type represented in the 82 benthic grab samples located in the 501 South Offshore Export Cable Corridor.

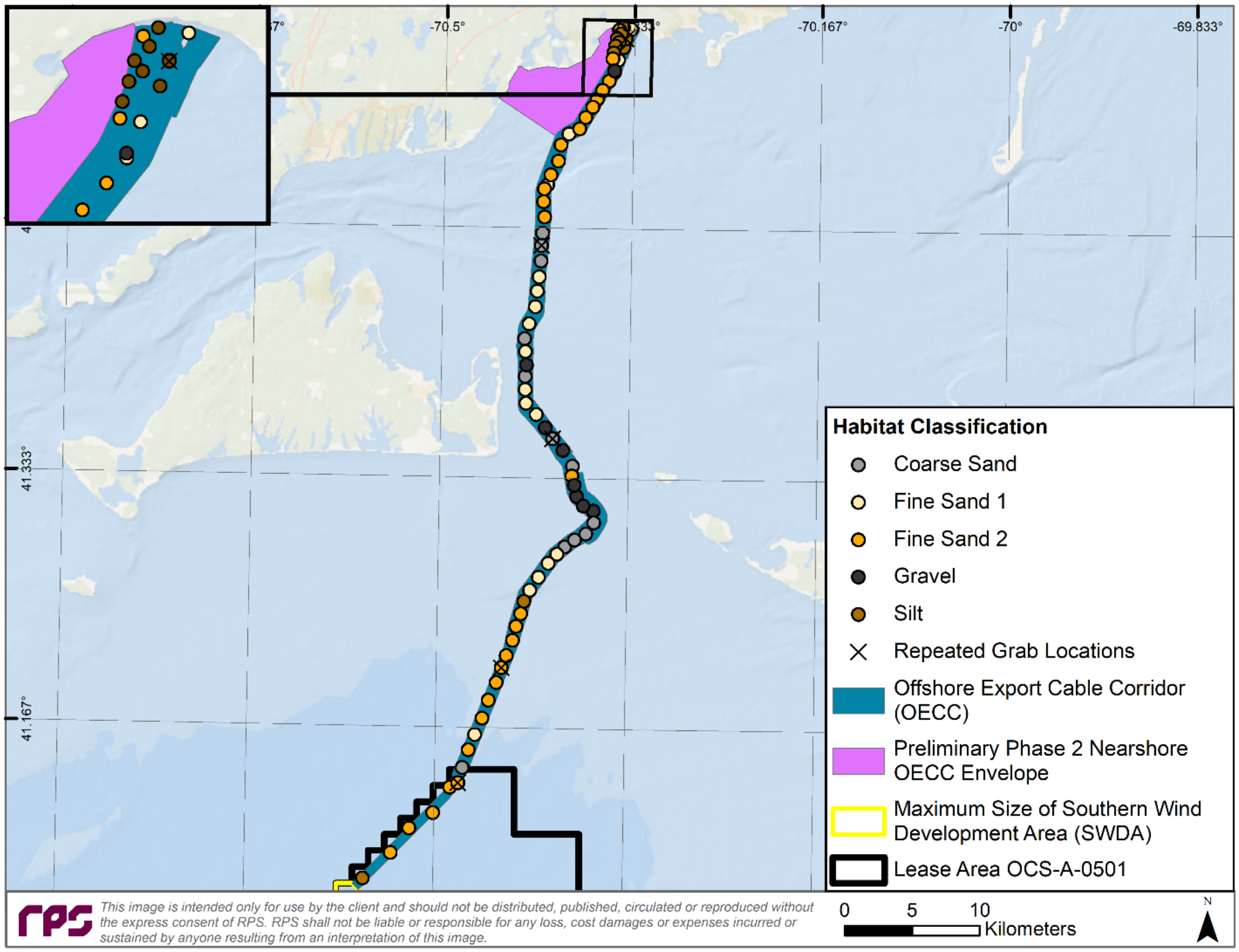

Figure 3. Map of 501 South Offshore Export Cable Corridor with sample points color coded based on habitat type. The stations sampled in both 2017 and 2018 are delineated with an X.

Table 2. Habitat classifications for benthic grab samples collected in the 501 South Offshore Export Cable Corridor.

2017		2018		2019	
Site	**Habitat**	**Site**	**Habitat**	**Site**	**Habitat**
17-GB04	Silt	18-GB04	Silt	19-GB01	Silt
17-GB05	Gravel	18-GB101	Fine Sand 1	19-GB02	Fine Sand 2
17-GB11	Fine Sand 2	18-GB102	Fine Sand 1	19-GB03	Silt
17-GB15	Fine Sand 1	18-GB103	Fine Sand 2	19-GB04	Silt
17-GB17	Fine Sand 1	18-GB104	Fine Sand 2	19-GB05	Silt
17-GB18	Silt	18-GB105	Fine Sand 2	19-GB06	Silt
17-GB19	Fine Sand 1	18-GB106	Fine Sand 2	19-GB09	Silt
17-GB20	Coarse Sand	18-GB107	Fine Sand 2	19-GB11	Fine Sand 2
17-GB22	Coarse Sand	18-GB108	Fine Sand 2		
17-GB40	Coarse Sand	18-GB109	Fine Sand 2		
17-GB41	Gravel	18-GB110	Fine Sand 2		
17-GB42	Gravel	18-GB123	Fine Sand 2		
17-GB46	Coarse Sand	18-GB124	Fine Sand 2		
17-GB49	Fine Sand 2	18-GB125	Fine Sand 2		
17-GB50	Coarse Sand	18-GB126	Coarse Sand		
17-GB51	Fine Sand 1	18-GB127	Coarse Sand		
17-GB58	Coarse Sand	18-GB128	Fine Sand 1		
17-GB61	Coarse Sand	18-GB129	Fine Sand 1		
17-GB62	Silt	18-GB130	Fine Sand 1		
		18-GB131	Fine Sand 1		
		18-GB132	Fine Sand 1		
		18-GB133	Fine Sand 1		
		18-GB134	Gravel		
		18-GB135	Fine Sand 1		
		18-GB136	Fine Sand 1		
		18-GB148	Fine Sand 1		
		18-GB149	Gravel		
		18-GB150	Gravel		
		18-GB151	Fine Sand 2		
		18-GB152	Gravel		
		18-GB153	Gravel		
		18-GB154	Fine Sand 2		
		18-GB155	Coarse Sand		
		18-GB156	Fine Sand 2		
		18-GB157	Coarse Sand		
		18-GB158	Coarse Sand		
		18-GB159	Coarse Sand		
		18-GB160	Fine Sand 1		
		18-GB161	Fine Sand 1		
		18-GB162	Fine Sand 1		
		18-GB163	Fine Sand 1		
		18-GB164	Fine Sand 2		
		18-GB165	Fine Sand 2		
		18-GB166	Fine Sand 2		
		18-GB167	Fine Sand 2		
		18-GB168	Fine Sand 2		
		18-GB18	Coarse Sand		
		18-GB203	Fine Sand 2		
		18-GB206	Fine Sand 2		
		18-GB209	Fine Sand 2		
		18-GB22	Coarse Sand		
		18-GB220	Fine Sand 2		
		18-GB250	Fine Sand 2		
		18-GB50	Fine Sand 2		
		18-GB61	Fine Sand 2		

2.1.4 Results

Within the 16 grab samples collected along the OECC in 2017, there were 892 individual organisms (per all 0.008 m^2 samples) from 66 unique taxa (family or LPTL and 7 phyla (Table 3). Organisms belonging to the phyla Annelida accounted for 40% of all individuals captured in the samples. Organisms from Mollusca (221 organisms), Nematoda (171 organisms), and Arthropoda (140 organisms) were similarly abundant and accounted for 25%, 19%, and 16% of the total abundance, respectively. A similar number of unique taxa represented Annelida (23 unique taxa), Arthropoda (21 unique taxa), and Mollusca (17 unique taxa) phyla, which all accounted for 93% of total unique taxa observed in the samples (Figure 4).

During the field survey conducted in the summer of 2018, 50 benthic grab samples were collected along the OECC (18-GB04 through -GB250) that contained a total of 7,574 individual infaunal organisms (per all 0.008 m^2 core samples) from 104 unique taxa (family or LPTL) and 11 phlyla (Figure 5). Organisms from the phyla Annelida dominated the total abundance of organisms, accounting for 66% of the observed individuals. Unique taxa were primarily from the Annelida (30%), Arthropods (29%), and Mollusca (24%) phyla (Figure 5).

Benthic grab samples were collected for infaunal analysis at eight stations along the OECC (19-GB01 through -GB11) in the summer of 2019. The grab samples yielded a total of 1,151 individual organisms (per all 0.008 m^2 core samples) from five (5) unique phyla and 28 families (or LPTL; Figure 6). Nematode worms dominated the samples in terms of abundance, accounting for 68% of all organisms observed. The Annelida and Mollusca phyla were the most diverse, accounting for 39% and 36% of all unique taxa identified (Figure 6).

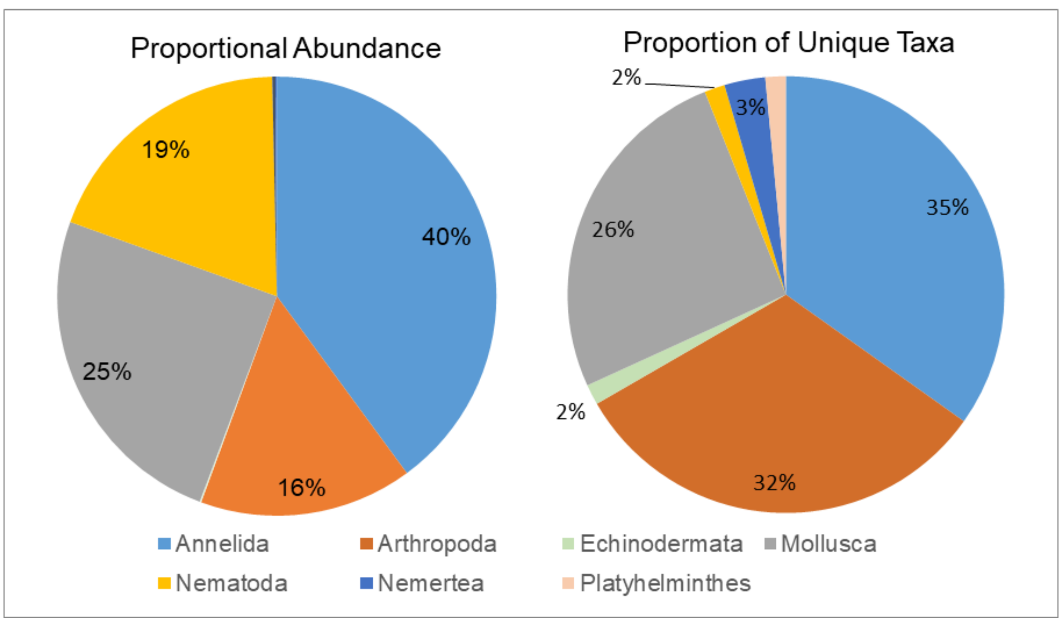

Figure 4. Proportional abundance and proportion of unique taxa (Family or LPTL) for each phylum observed in all (16) benthic grab samples collected in 2017 along the 501 South Offshore Export Cable Corridor. Results presented as percentage of total ≥1%.

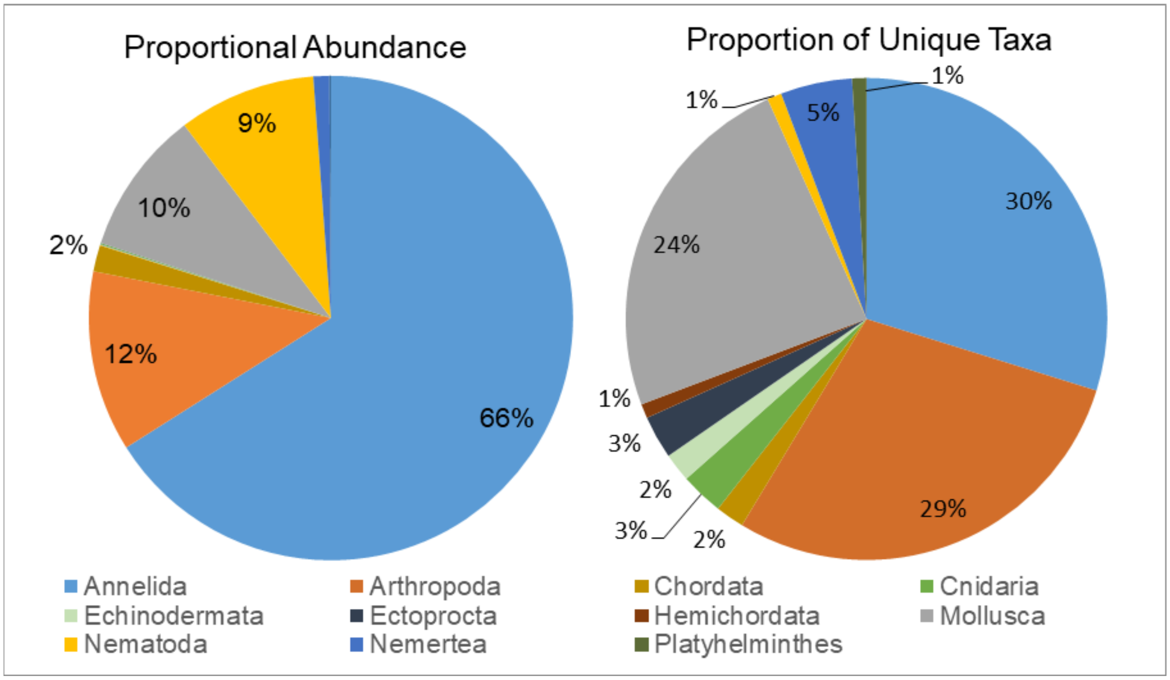

Figure 5. Proportional abundance and proportion of unique taxa (Family or LPTL) for each phylum collected in all (50) benthic grab samples collected in 2018 along the 501 South Offshore Export Cable Corridor. Results presented as percentage of total ≥1%.

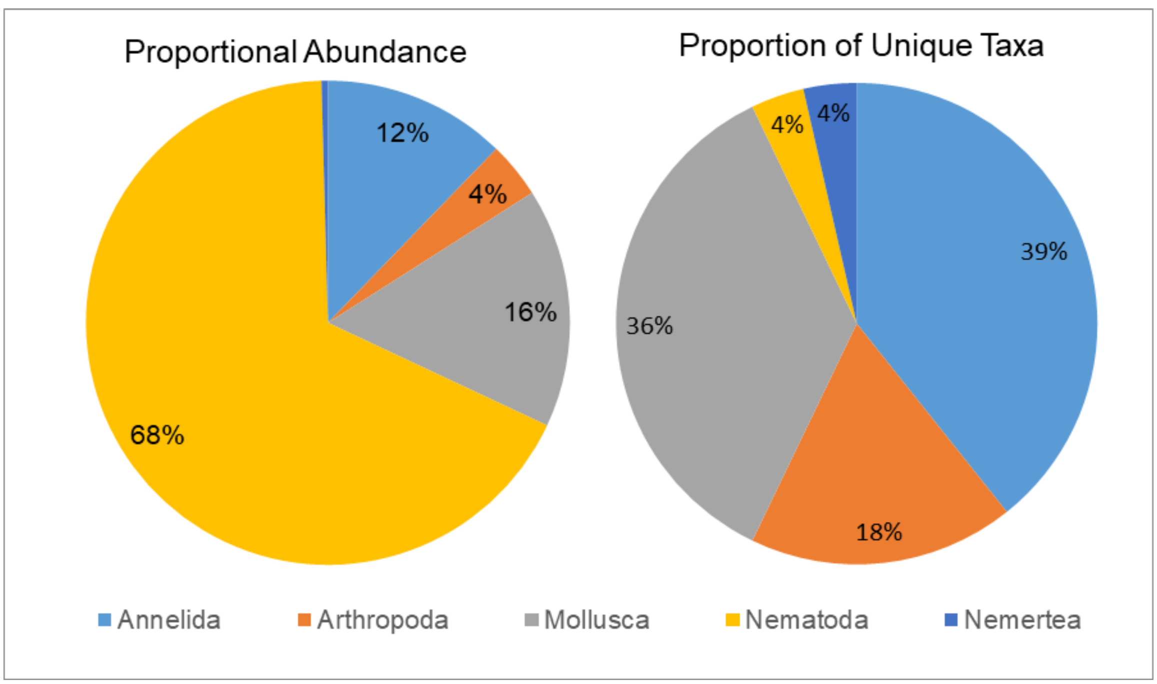

Figure 6. Proportional abundance and proportion of unique taxa (Family or LPTL) for each phylum collected in all (8) benthic grab samples collected in 2019 along the 501 South Offshore Export Cable Corridor. Results presented as percentage of total >1%.

Table 3. Phyla present in the benthic grab samples collected in the 501 South Offshore Export Cable Corridor during the 2017, 2018, and 2019 benthic surveys.

Sample Year and Number	Phyla	Abundant Taxonomic Groups (common names)	Density (Abundance per all 0.008 m^2 samples)	Number of Taxa (Unique family or LPTL)
2017 16 samples	Annelida	Polychaete and oligochaete worms	356	23
	Arthropoda	Amphipods	140	21
	Echinodermata	Sand dollars	1	1
	Mollusca	Sea snails, surf clams, nut clams	221	17
	Nematoda	Nematode worms	171	1
	Nemertea	Ribbon worms	2	2
	Platyhelminthes	Flatworms	1	1
	Total		892	66
2018 50 samples	Annelida	Polychaete worms	5,001	31
	Arthropoda	Amphipods, hooded shrimp	914	30
	Chordata	Tunicates	133	2
	Cnidaria	Sea anemones	3	3
	Echinodermata	Sand dollars, sea cucumbers	3	2
	Ectoprocta	Bryzoans	6	3
	Hemichordata	Acorn worms	1	1
	Mollusca	Nut clams, tellins	729	25
	Nematoda	Nematode worms	696	1
	Nemertea	Ribbon worms	80	5
	Platyhelminthes	Flatworms	8	1
	2018 Total		7,574	104
2019 8 samples	Annelida	Polychaete worms	141	11
	Arthropoda	Barnacles	43	5
	Mollusca	Sea snails, tellins	184	10
	Nematoda	Nematode worms	778	1
	Nemertea	Ribbon worms	5	1
	2019 Total		1,151	28

Samples collected in 2018 had higher average abundance, unique taxa, richness, and diversity than those collected in 2017 and 2019 (Table 4; Figure 7). Sample abundance ranged from 7 to 183 individuals in 2017, 5 to 691 individuals in 2018, and from 2 to 314 individuals in 2019. The number of unique taxa in each sample ranged from 3 to 27 in 2017, 2 to 33 taxa in 2018, and from 2 to 13 taxa in 2019. Richness and diversity ranged from 1.03 to 5.15 and 0.79 to 2.69 in 2017, respectively, and from 0.62 to 5.28 and 0.50 to 2.66 in 2018, and from 0 to 1.41 and 0 to 1.40 in 2019 (Table 5). Evenness between sampled collected in 2017 and 2018 was similar with mean evenness values of 0.79 in 2017 and 0.72 in 2018, while the evenness of samples from 2019 was consistently lower with a mean of 0.53.

Table 4. Summary of community composition parameters calculated for the 2017 (16 samples), 2018 (50 samples), and 2019 (8 samples) benthic grab samples collected in the 501 South Offshore Export Cable Corridor.

Survey	Avg. Density (Abundance per 0.008 m^2)	Avg. # of Taxa (family or LPTL	Ecological Indices (Avg.)		
			Richness	Diversity	Evenness
2017	56	11	2.70	1.80	0.79
2018	151	15	3.00	1.85	0.72
2019	143	7	1.16	0.91	0.53

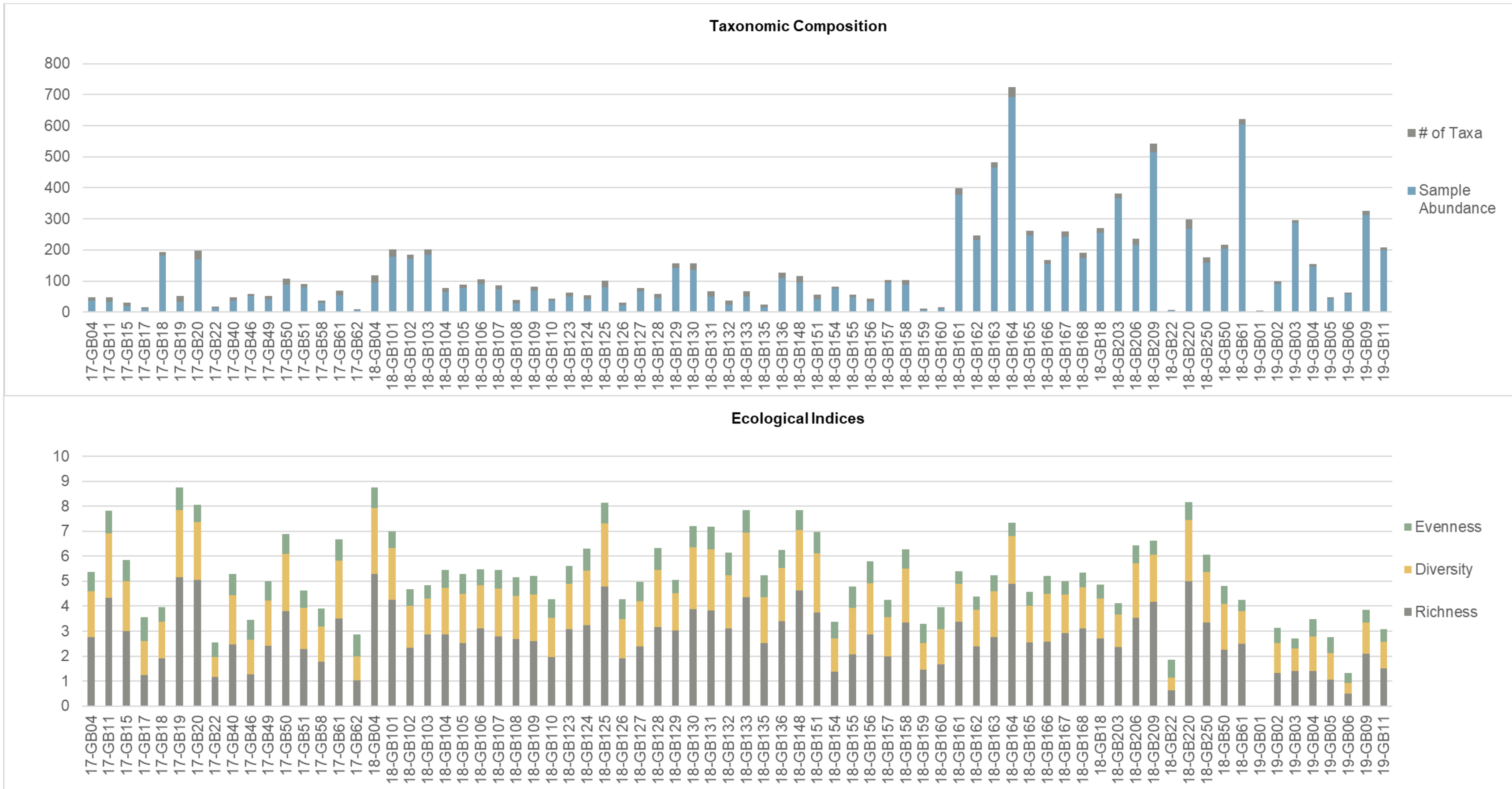

Figure 7. Taxonomic composition (top; # of unique taxa (family or LPTL) and total abundance per sample) and ecological indices (bottom; richness, diversity, and evenness per sample) for grab sample stations along the 501 South Offshore Export Cable Corridor.

Table 5. Community composition parameters calculated for each grab sample station along the 501 South Offshore Export Cable Corridor. The first two numbers in the station name indicate year sample was taken (e.g., 17-GB04 represents grab station 04 from the 2017 survey).

Station	Density (Abundance per 0.008 m^2)	# of Taxa (family or LPTL)	Ecological Indices		
			Richness	Diversity	Evenness
17-GB04	37	11	2.77	1.83	0.77
17-GB11	32	16	4.33	2.58	0.93
17-GB15	20	10	3.00	1.99	0.86
17-GB17	11	4	1.25	1.34	0.97
17-GB18	183	11	1.92	1.44	0.60
17-GB19	33	19	5.15	2.69	0.91
17-GB20	170	27	5.06	2.31	0.70
17-GB22	13	4	1.17	0.79	0.57
17-GB40	38	10	2.47	1.97	0.85
17-GB46	53	6	1.26	1.40	0.78
17-GB49	41	10	2.42	1.79	0.78
17-GB50	89	18	3.79	2.30	0.80
17-GB51	80	11	2.28	1.65	0.69
17-GB58	30	7	1.76	1.42	0.73
17-GB61	55	15	3.49	2.32	0.86
17-GB62	7	3	1.03	0.96	0.87
18-GB04	94	25	5.28	2.66	0.83
18-GB18	255	16	2.71	1.59	0.57
18-GB22	5	2	0.62	0.50	0.72
18-GB50	204	13	2.26	1.83	0.71
18-GB61	605	17	2.50	1.29	0.46
18-GB101	179	23	4.24	2.08	0.66
18-GB102	172	13	2.33	1.69	0.66
18-GB103	185	16	2.87	1.44	0.52
18-GB104	65	13	2.87	1.85	0.72
18-GB105	77	12	2.53	1.96	0.79
18-GB106	91	15	3.10	1.74	0.64
18-GB107	74	13	2.79	1.92	0.75
18-GB108	29	10	2.67	1.73	0.75
18-GB109	70	12	2.59	1.87	0.75
18-GB110	36	8	1.95	1.57	0.76
18-GB123	49	13	3.08	1.82	0.71
18-GB124	41	13	3.23	2.21	0.86
18-GB125	80	22	4.79	2.52	0.82
18-GB126	23	7	1.91	1.57	0.81
18-GB127	67	11	2.38	1.83	0.76
18-GB128	45	13	3.15	2.29	0.89
18-GB129	141	16	3.03	1.48	0.53
18-GB130	136	20	3.87	2.50	0.83
18-GB131	50	16	3.83	2.45	0.88
18-GB132	25	11	3.11	2.13	0.89
18-GB133	49	18	4.37	2.58	0.89
18-GB135	16	8	2.52	1.84	0.88
18-GB136	109	17	3.41	2.11	0.74

Station	Density (Abundance per 0.008 m²)	# of Taxa (family or LPTL)	Ecological Indices		
			Richness	Diversity	Evenness
18-GB148	94	22	4.62	2.44	0.79
18-GB151	42	15	3.75	2.36	0.87
18-GB154	76	7	1.39	1.32	0.68
18-GB155	48	9	2.07	1.86	0.85
18-GB156	33	11	2.86	2.07	0.86
18-GB157	94	10	1.98	1.59	0.69
18-GB158	88	16	3.35	2.14	0.77
18-GB159	8	4	1.44	1.07	0.77
18-GB160	11	5	1.67	1.41	0.88
18-GB161	377	21	3.37	1.52	0.50
18-GB162	232	14	2.39	1.45	0.55
18-GB163	465	18	2.77	1.83	0.63
18-GB164	691	33	4.89	1.91	0.55
18-GB165	246	15	2.54	1.48	0.55
18-GB166	154	14	2.58	1.90	0.72
18-GB167	242	17	2.91	1.54	0.55
18-GB168	175	17	3.10	1.66	0.59
18-GB203	367	15	2.37	1.28	0.47
18-GB206	217	20	3.53	2.19	0.73
18-GB209	515	27	4.16	1.89	0.57
18-GB220	269	29	5.00	2.44	0.73
18-GB250	158	18	3.36	2.01	0.69
19-GB01	2	1	0.00	0.00	NA
19-GB02	91	7	1.33	1.18	0.61
19-GB03	288	9	1.41	0.89	0.40
19-GB04	147	8	1.40	1.40	0.67
19-GB05	43	5	1.06	1.05	0.65
19-GB06	59	3	0.49	0.44	0.40
19-GB09	314	13	2.09	1.27	0.50
19-GB11	200	9	1.51	1.07	0.49

When combining samples from the three surveys, samples collected in Fine Sand 2 habitat had the highest average densities, while samples in Fine Sand 1 had highest average scores for the three ecological indices (Table 6). Although average density was relatively high, samples from silt habitats, most of which were from the nearshore 2019 sampling, had low average values of richness, diversity, and evenness.

Table 6. Summary of community composition parameters calculated by habitat type for benthic grab samples collected in the 501 South Offshore Cable Corridor.

Survey	Avg. Density (Abundance per 0.008 m² sample)	Avg. # of Taxa	Ecological Indices (Avg.)		
			Richness	Diversity	Evenness
Silt	130	7	1.18	0.93	0.58
Fine Sand 1	130	15	3.21	1.96	0.76
Fine Sand 2	164	15	2.99	1.84	0.69
Coarse Sand	65	13	2.26	1.60	0.75

2.2 Statistical Analyses

2.2.1 Methods

One- and two-way analysis of variance (ANOVA) following the Type III sums of squares approach in R (Fox and Weisberg 2019; R Core Team 2020) was used to test for relationships between sample year, habitat type, and infauna diversity. The Shannon Diversity Index was used to calculate the response variable as it is widely used and is a universally accepted ecological index that accounts for both richness and evenness in its estimation. Due to the difference in spatial scales between samples collected in 2017/2018 and 2019, two separate tests were conducted. The first analysis tested whether there was a difference between the infaunal diversity of samples collected in different years and in different habitats. Sample year included two levels, 2017 and 2018. Habitat type included four levels: Silt, Fine Sand 1, Fine Sand 2, and Coarse Sand. The two null hypotheses tested with the two-way ANOVA included:

$H_0$1: There is no difference in mean diversity for different year.

$H_0$2: There is no difference in mean diversity for different habitat types.

As mentioned above, only the landfall region of the OECC was sampled in 2019, therefore, for the second analysis, samples collected within the landfall region were used to test differences in infanual diversity between sampling years. Due to the small sample size (1 sample in 2017 and 4 samples in 2018) and non-significant year effect (described below) between the infaunal diversity of samples collected in 2017 and 2018, they were combined into a single sampling year (2018) for this test. The null hypothesis tested with the one-way ANOVA was:

$H_0$1: There is no difference in mean diversity between years.

Multivariate analyses were conducted in R (Oksanen et al. 2019; R Core Team 2020) to examine dissimilarity/similarity of stations based on the infaunal assemblages (composition of all species and their abundances). These analyses included nonmetric multidimensional scaling (NMDS), analysis of similarities (ANOSIM), and analysis of similarity percentages (SIMPER; Clarke 1993). All analyses were built on a Bray-Curtis Similarity Index, which used square-root transformed data to ensure all taxa (not just those that dominated samples) would contribute to similarity measures. Differences in the infaunal assemblages between stations were assessed using sample year, depth (shallow [<30 m] and deep [>30m]), location, and habitat classification.

NMDS with two dimensions was used to compare the distance (difference) between data points and visually evaluate patterns of similarity in the data. Dendrograms present the discrete groupings of samples with similar community structures while NMDS plots present data and groupings spatially, with samples ordinating based on similarity to one another. Samples of high similarity are plotted in proximity to one another in NMDS plots.

SIMPER was used to identify the percent dissimilarity between location and taxa that were most responsible for dissimilarity (i.e., the taxa with the largest difference in mean abundance). ANOSIM was used to help determine if year, depth (shallow or deep), location, or habitat classifications were predictive of the infaunal assemblage clusters. The test statistic "R" calculated in the Global ANOSIM indicates whether samples within classification groups were more similar than samples between groups. R values closer to 1 than 0 and significance levels of $p < 0.05$ indicate that samples within a classification group are more similar to each other than to those in different groups. Specifically, ANOSIM was used to test four null hypotheses:

$H_0$1: Infaunal assemblages do not change within years.

$H_0$2: Infaunal assemblages do not change within sampled collected in shallow or deep waters.

$H_0$3: Infaunal assemblages do not change within locations.

$H_0$4: Infaunal assemblages do not change within habitat types.

2.2.2 Results

The two-way ANOVA using Type III sums of squares testing for associations of year (2017 and 2018 only) and habitat type with infaunal diversity found that there was no significant difference in mean diversity between years or habitat types (P = 0.73 and P = 0.21, respectively). The lack of significant interaction between infaunal diversity and the two response variables (year and habitat) was likely due to high variability within the dataset (Figure 8) in addition to the difficulties of trying to assess communities based on a metric (e.g. in this case: diversity index).

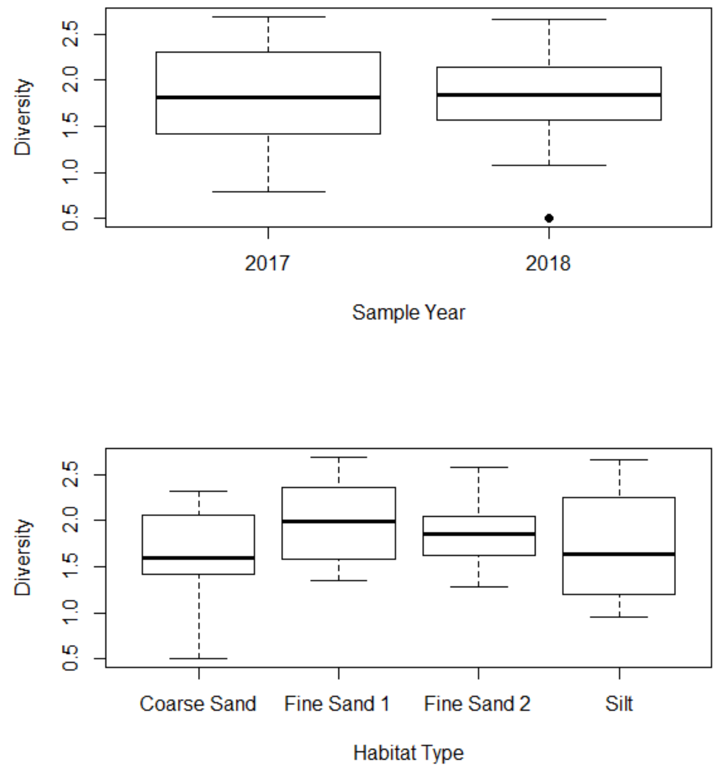

Figure 8. Boxplot presenting the range of diversity values within each sample year (top) and habitat type (bottom) for samples collected in 2017 and 2018. The bold horizontal line represents the median value.

The results for the one-way ANOVA indicated that mean diversity of infaunal samples was significantly different between years (P = 0.003). As can be seen in Figure 9, diversity was higher in landfall samples collected during the 2017 and 2018 surveys than in the 2019 survey.

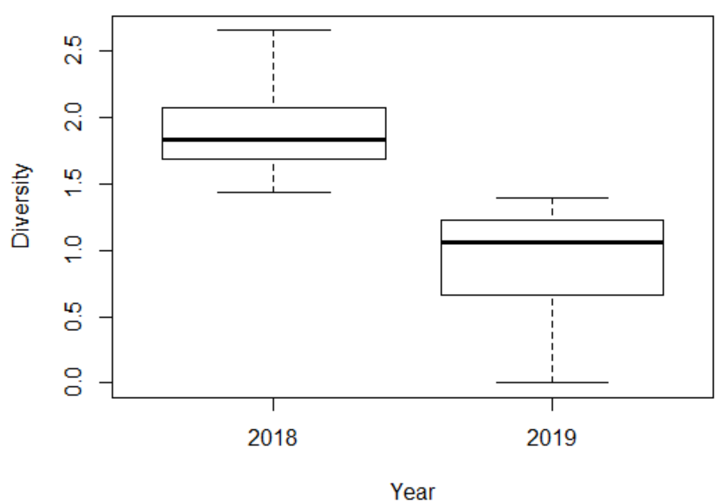

Figure 9. Boxplot presenting the range of diversity values within survey year for samples collected in the landfall area. The bold horizontal line represents the median value.

Multivariate analyses distinguished infaunal assemblages in the 74 samples from the 2017, 2018, and 2019 surveys within the 501 South OECC. Results from the cluster analysis and NMDS based on the Bray-Curtis dissimilarity of infaunal assemblages are presented below in a series of figures including a dendrogram and multiple MDS plots (Figure 10 - Figure 14). Overall, results from the NMDS analysis indicated that ordination summarized the distance of data points only moderately well with a stress value of 0.22. The dendrogram (Figure 10) displays seven higher level clusters, which include a mix of samples from all sample years.

The NMDS plots were spatially ordinated based on their Bray-Curtis dissimilarity and color-coded based on variables including sample year, depth (shallow [<30 m] or deep [>30 m]), location, and habitat type. As observed in the dendrogram (Figure 10), there was no clear clustering across samples collected in different years. As seen in the NMDS plot color-coded by sample year (Figure 11), there is much overlap in grabs from 2017 and 2018, but seven of the eight samples collected in 2019 are ordinated in a loose cluster, indicating increased interannual similarity in grabs collected in 2019 relative to the previous years. The NMDS plot coded by depth showed deeper sites were generally more-similar to each other (ordinated near the bottom of the plot), with higher variability and dissimilarity among sites in the shallower depths (Figure 12). In general, similarity in sample assemblages is greater within sampling locations then they are across sampling locations indicating regional similarity of habitats (Figure 13). Samples collected in the southern OECC produced a clear cluster, indicating that the infaunal assemblage of samples in this area is more homogenous when the NMDS ordination was color-coded based on sample location (Figure 13). Although there is some clustering of samples collected near the landfall, these data are potentially biased because these clustered samples were all collected in 2019 (Figure 11) and therefore the grouping could be a result of missing interannual variability captured at the other sample locations. Samples from the northern OECC region were spread throughout the plot, indicating highest variability in the infaunal assemblages in this region. Loose clustering of samples from the Muskeget channel can also be observed, as they primarily ordinated in a single quadrat of the plot, indicating similarities between infaunal assemblages. As displayed in Figure 14, samples collected in each of the habitat types were spread throughout the ordination plot with comparable inter- and intra-group similarities when the plot was color-coded by habitat type.

The ANOSIM results of the individually analysed categorical variables year, depth (shallow or deep), location, and habitat type all rejected the null hypothesis that infaunal community assemblages do not change within categorical levels (significance value of $p = 0.001$). However, the R statistic for the ANOSIM of year, depth, and habitat type was low (0.10 to 0.26) indicating each variable only weakly accounted for the similarities/differences between the infaunal communities at each site (Table 7). The R statistic for the ANOSIM of location was 0.40, indicating that infaunal assemblages are likely similar within each location group, however variability is high between groupings.

Table 7. Results from the ANOSIM conducted on the four classification groups.

Test Variable	R Statistic	P-Value
Year	0.26	0.001
Depth	0.26	0.001
Location	0.40	0.001
Habitat Type	0.17	0.001

The SIMPER analysis was conducted on the location factor because the ANOSIM demonstrated significant relationships between the infaunal assemblages within this classification. Results from the SIMPER analysis, listed in Table 8, present the percent of dissimilarity between two sampling locations and the three taxa that contributed the most to the dissimilarity. The location pair with the most dissimilar infaunal assemblages was Muskeget and the southern OECC, which were 83% dissimilar. Infaunal assemblages in the northern OECC and the landfall had the lowest dissimilarity (75%) with Nematoda, Capitellidae, and Oligochaeta accounting for 29% of the dissimilarity between assemblages from samples collected in each location. Nematoda consistently accounted for high proportions of the dissimilarity between samples in the different locations and was typically one of the three most influential taxa (Table 8).

Table 8. SIMPER results of the dissimilarity of infaunal assemblages between grab locations and depth categories.

Location (A)	Location (B)	Bray-Curtis Dissimilarity	Dissimilar Taxa[a]	% Contribution	Av. Abundance[b] (A)	Av. Abundance[b] (B)
Muskeget	Southern OECC	83%	Polygordiidae	12%	0.00	7.10
			Oligochaeta	6%	0.95	3.88
			Nematoda	5%	2.99	2.50
Landfall	Southern OECC	81%	Nematoda	12%	7.81	2.50
			Polygordiidae	11%	0.23	7.10
			Oligochaeta	6%	2.06	3.88
Northern OECC	Southern OECC	80%	Polygordiidae	12%	0.49	7.10
			Oligochaeta	6%	1.78	3.88
			Capitellidae	5%	2.71	0.63
Landfall	Muskeget	80%	Nematoda	15%	7.81	2.99
			Capitellidae	7%	2.62	0.00
			Syllidae	6%	1.56	2.31
Northern OECC	Muskeget	77%	Capitellidae	7%	2.71	0.00
			Nematoda	6%	2.28	2.99
			Tellinidae	6%	2.25	0.65
Landfall	Northern OECC	75%	Nematoda	16%	7.81	2.28
			Capitellidae	8%	2.62	2.71
			Oligochaeta	6%	2.06	1.78

[a] Includes taxa contributing highest percentage to the dissimilarity between location
[b] Average square-root transformed abundance

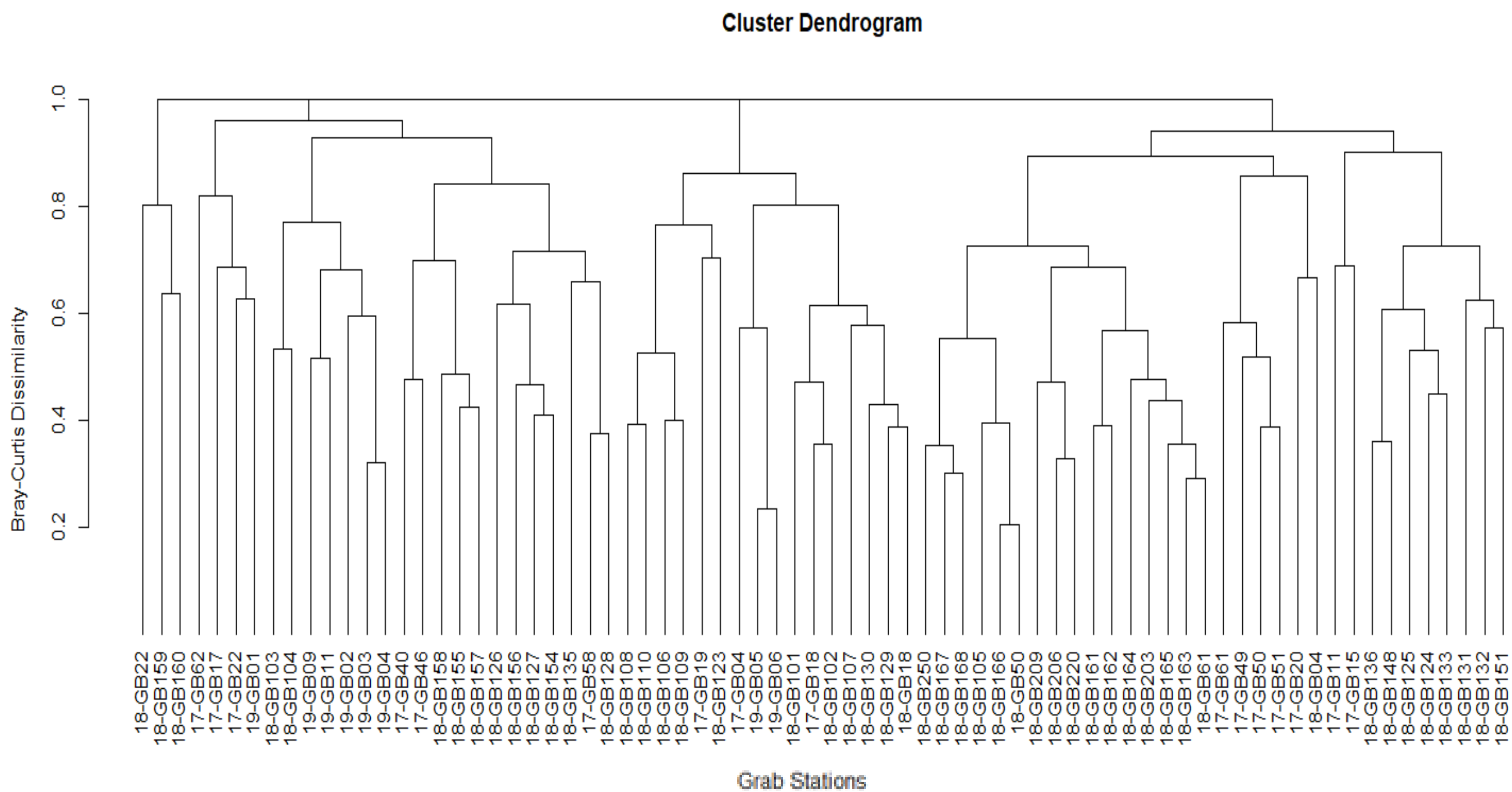

Figure 10. Dendrogram from cluster analysis based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 74 stations sampled in the 501 South Offshore Export Cable Corridor. Branches are based on the dissimilarities between those clusters of samples (i.e., samples with lower level clusters are more similar to one another than other samples outside of the cluster), which is labelled on the y-axis. The number before the grab site (GB) indicates sample year (i.e., 18-GB110 represents grab sample 110 collected in 2018).

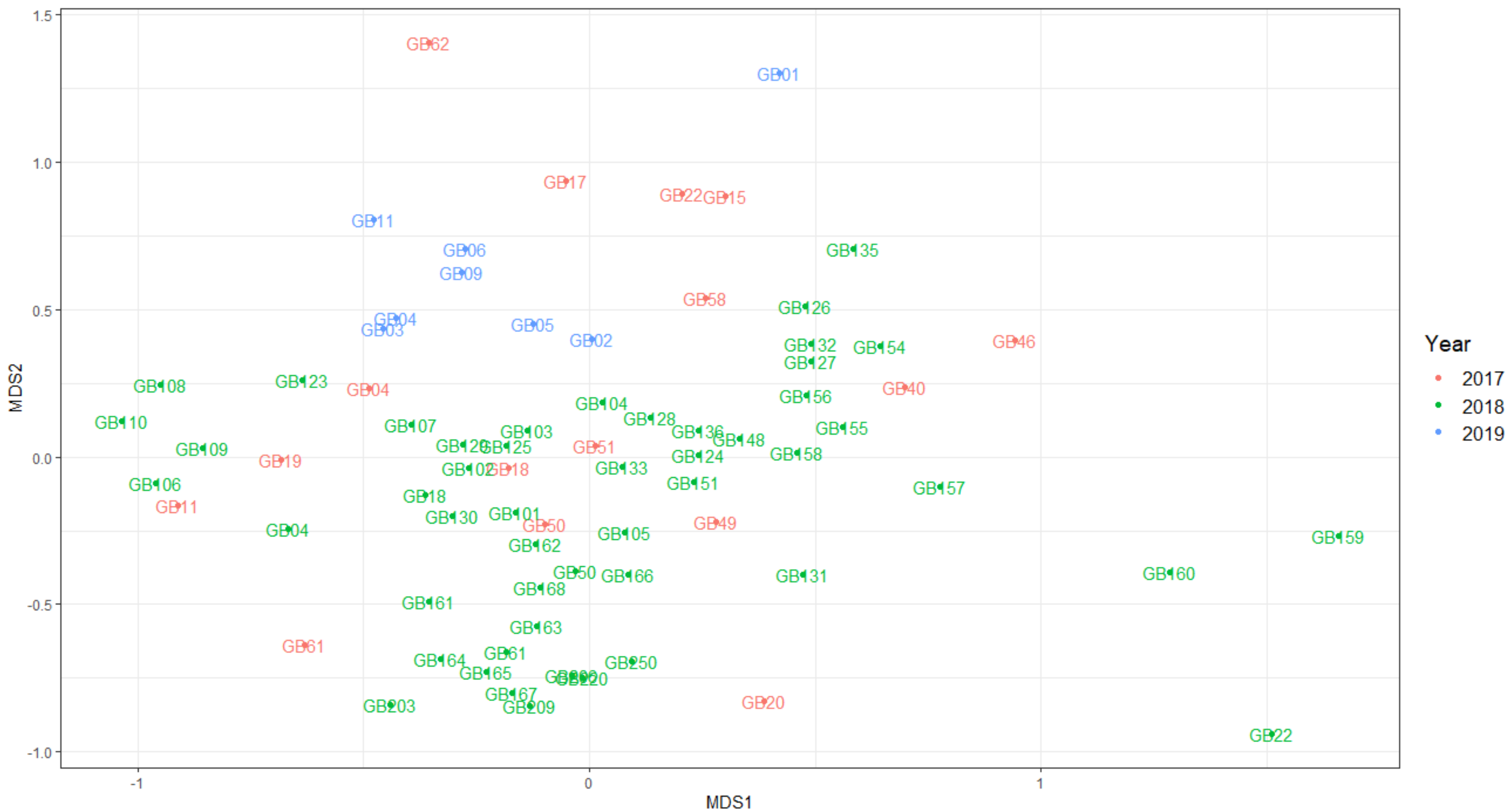

Figure 11. NMDS plot based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 74 stations sampled along the 501 South Offshore Export Cable Corridor in the 2017, 2018, and 2019. Red points represent samples collected in 2017, green points represent samples collected in 2018, and blue points represent samples collected in the 2019.

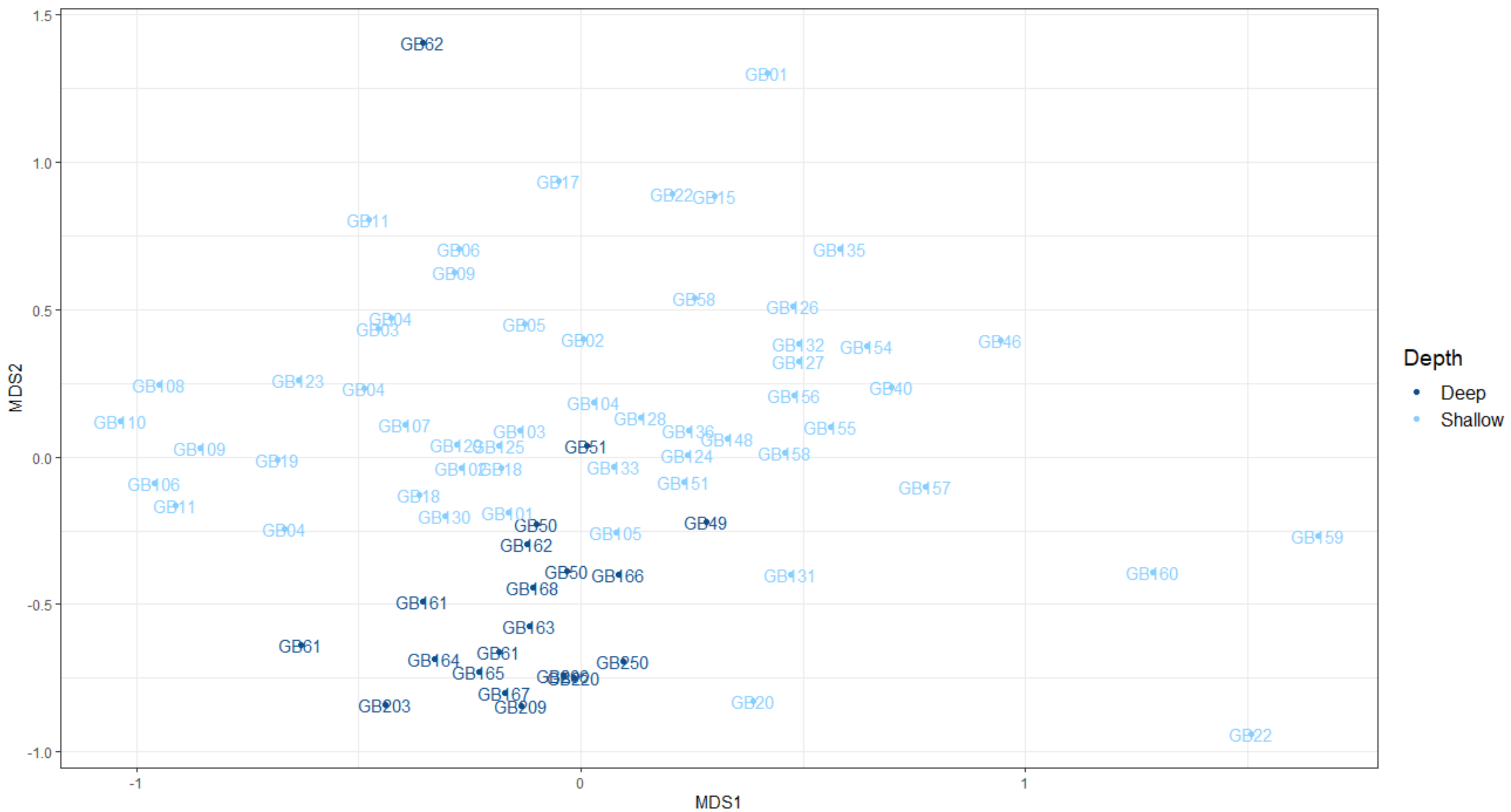

Figure 12. NMDS plot based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 74 stations sampled along the 501 South Offshore Export Cable Corridor in the 2017, 2018, and 2019. Light blue points represent samples located in shallow waters (<30 m depth) and dark blue points represent samples located in deep waters (>30 m depth).

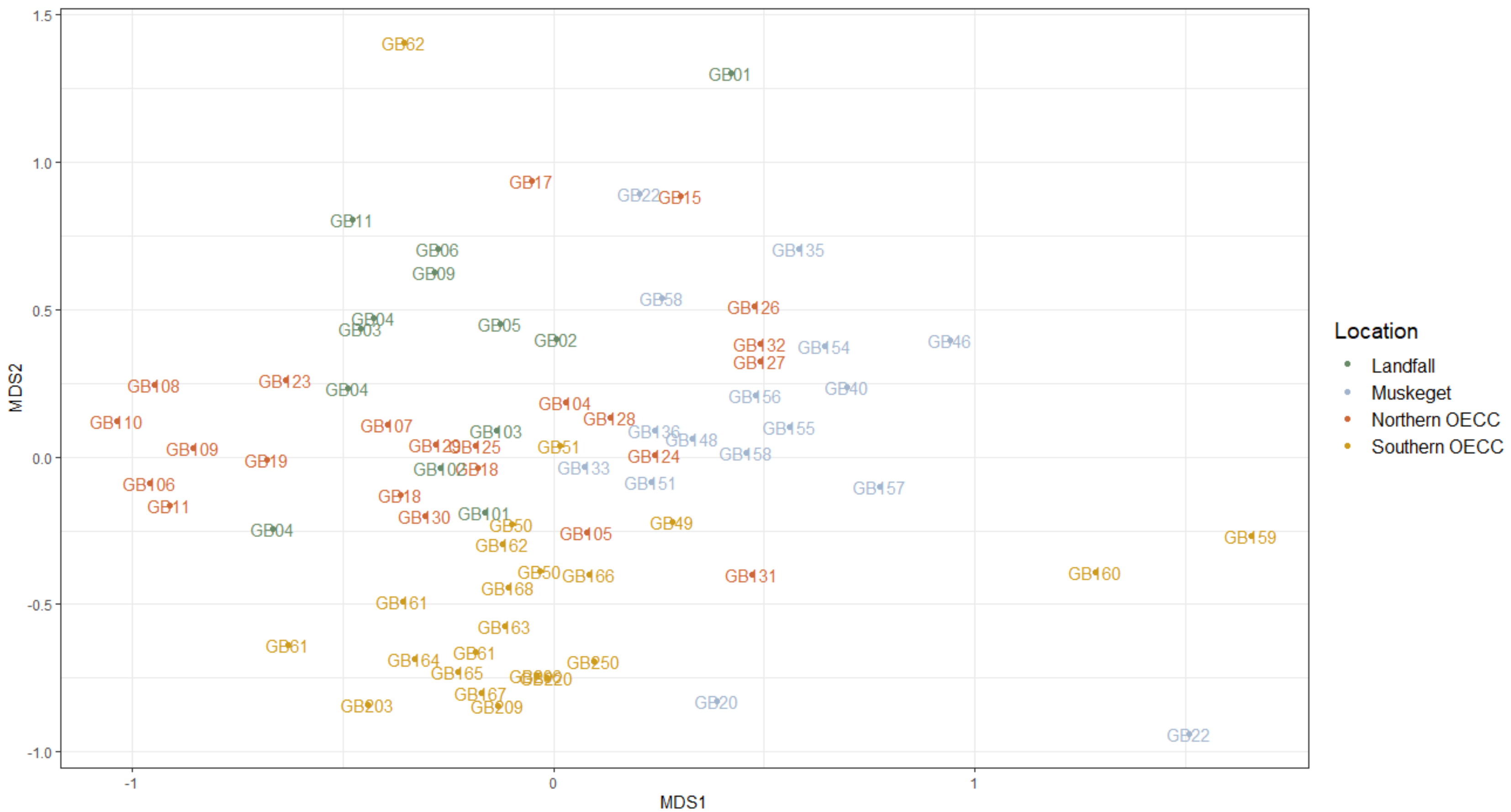

Figure 13. NMDS plot based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 74 stations sampled along the 501 South Offshore Export Cable Corridor in the 2017, 2018, and 2019. Each symbol represents a station that is color-coded based on sample location.

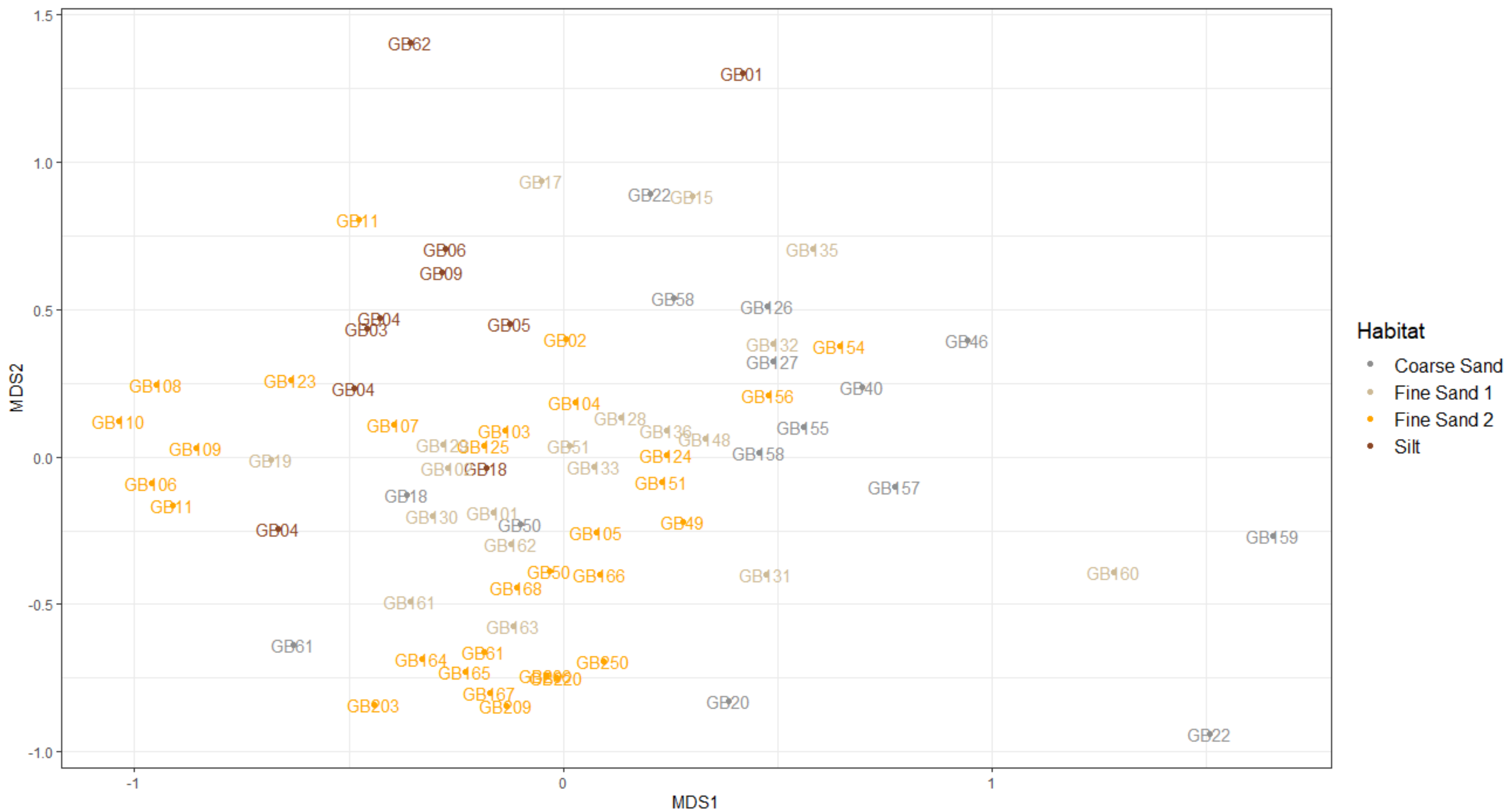

Figure 14. NMDS plot based on Bray-Curtis similarities of square-root transformed infaunal abundances at the 74 stations sampled along the 501 South Offshore Export Cable Corridor in the 2017, 2018, and 2019. Each symbol represents a station that is color-coded based on habitat type.

3 DISCUSSION

Across the three surveys included in this analysis, organisms from the phyla Annelida, Nematoda, and Mollusca were consistently dominant in benthic grab samples throughout the OECC. Polychaete worms were particularly abundant in the samples collected in 2018, accounting for over 60% of the total abundance. Nematode worms dominated the samples in 2019, occurring in all eight samples with 778 nematodes identified. Overall, abundance, number of unique taxa and phyla, richness, and diversity were higher across samples collected in the summer 2018 survey than the 2017 and 2019 surveys.

Results from the ANOVA and dissimilarity analyses also indicated significant differences in the ecological indices and infaunal assemblages of samples collected in the landfall areas during the 2017/2018 and 2019 surveys, with samples collected in 2019 being significantly different from those collected in other years. Alternatively, no significant difference in mean diversity was observed between all samples collected during the 2017 or 2018 surveys. These results may indicate that interannual variability can be distinguished at smaller spatial scales, while these relationships are not apparent when testing across the entire OECC.

Dissimilarities between infaunal sample assemblages could be significantly explained by sediment-based habitat type as found in both the ANOSIM and NMDS ordination. However, the R value for the ANOSIM was small (weak) and no strong clustering based on habitat type is apparent in the NMDS plot, with samples exhibiting comparable inter- and intra-group similarities. The low intra-habitat similarity of infaunal assemblages relative to inter-habitat similarity indicates high variability between sampling sites regardless of habitat. In other words, two samples from the same habitat types were likely to be about equally dissimilar as two samples from different habitat types. In addition, habitat classifications, which were based on CMECS using field notes, are limited in their ability to explain other important habitat features, such as the composition of more complex substrates (e.g., gravel), biogenic materials (e.g., algae, worm tubes, amphipod bed structures), that are also likely important indicators of macroinfaunal community composition.

Spatial variability and offshore conditions could also explain the similarities between infaunal assemblages observed along the OECC. Although ANOSIM results indicated that infaunal assemblages were weakly similar within depth categories (shallow vs deep), the respective NMDS plots show noticeable clustering of the deeper water samples. In addition, plain fine sand (Fine Sand 2) habitat was common in samples from deeper waters, which may indicate increased similarity of infaunal assemblages within these offshore homogenous sand habitats.

Results from the ANOSIM of the variable "sample location" indicated that this classification described differences between infaunal assemblages moderately well, however, there is likely large overlap between the groups. This is apparent in the NMDS plot, which shows a high level of overlap between some location groupings. Samples from the southern OECC formed the tightest cluster, while those from the northern OECC spread across the ordination plot. Samples from Muskeget and the landfall area did not form tight clusters but are primarily ordinated together with increased distance between points. In other words, as expected, it appears that the general sampling location within the OECC can be an indicator of the species present.

The SIMPER results found that in general, samples located closer together were more similar to each other than other locations along OECC. Infaunal assemblages in samples collected in the landfall areas and the northern OECC were the least dissimilar to each other (75%), while assemblages from the landfall area and northern OECC were most dissimilar to those from the southern OECC. This pattern was not observed further offshore as the infaunal assemblages from samples collected in the southern OECC and Muskeget channel were the most dissimilar (83%) of all locations. This dissimilarity could be related to the homogenous vs heterogenous habitats observed in each location as samples from the southern OECC were primarily plain fine sand habitat (Fine Sand 2), while those in Muskeget included both fine sand classifications and coarse sand. The SIMPER was useful in determining taxa that contributed the most to the dissimilarity in infaunal abundances between locations and demonstrated that a few taxa consistently contribute large percentages to that dissimilarity, including Nematoda, Oligochaeta, and Polygordiidae and Capitellidae. However, SIMPER is sensitive to abundance and reflects the larger-scale variability of individual common taxa, rather than differences in rare or unique taxa. In general, the SIMPER results supported that benthic communities change along a gradient moving offshore, with nearshore and offshore sampling detecting different communities as would be expected.

Overall, with the current data available, identifying a single variable, or multiple very strong variables for predicting similarity/dissimilarity between infaunal communities of samples is not possible. There is evidence that samples taken from within the same general location, year, or depth are more likely to be similar within categories than across categories, but there is too much variability or other confounding influences preventing the establishment of strong relationships. Some of these potential influences include interannual, seasonal, and or spatial variability. However, there is support that there is greater similarity between sample community assemblages offshore than in nearshore locations.

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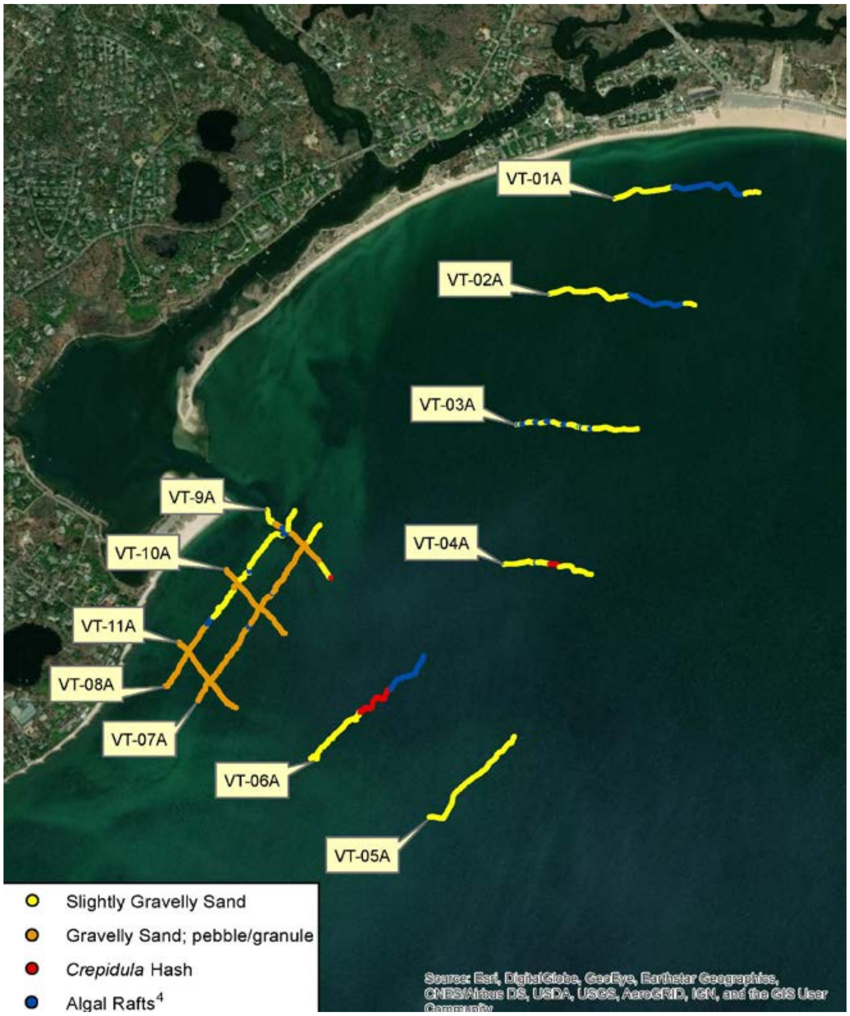
8. CR Environmental 2019 Underwater Video Review

NOVEMBER 2019 UNDERWATER VIDEO SURVEY
Vineyard Wind Project
Barnstable Landing Sites Centerville Harbor
Barnstable, MA



Substrate Classification Barnstable Landing Sites

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January 2020

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1.0 INTRODUCTION

On November 5 and 6, 2019 CR Environmental, Inc. (CR) performed underwater video surveys for Seaforth Geosurveys, Inc. (Seaforth) to document bottom substrate and biota, and identify any potential SSU's at the two proposed Vineyard Wind Barnstable landing sites in Centerville Harbor, Centerville, MA. Underwater video data were collected along 11 video transects, and at 11 sediment grab stations as directed by Seaforth and Geo SubSea LLC.

The collected sediment grabs were provided by Seaforth to ESS Group, Inc. for benthic enumeration and Geotesting Express for grain size analysis. The results of these analyses are discussed elsewhere.

2.0 METHODS

2.1 Vessel and Navigation

Vessel operations were performed from CR's 26-foot custom built aluminum landing craft style vessel, *Lophius.* The vessel has a large enclosed pilothouse, benches for survey equipment, stern mounted davit and hauler, bow mounted A-frame and hydraulic winch. Operations were staged out of the Hyannis Marina in Hyannis Harbor.

Navigation for the surveys was accomplished using a Hemisphere V104 Sub-meter GPS and Heading Sensor that was serially interfaced to a shipboard computer running HYPACK 2015 hydrographic surveying software. This system calculated X and Y positions in the desired grid system (UTM North, Zone 19 (72W-66W), Meters), recorded navigation data, and provided a steering display for the vessel captain.

Progress of the video survey along the proposed transects and grab sampling operations was followed in HYPACK using georeferenced imagery (e.g. orthophotos) as a background file by the vessel captain thus ensuring transect coverage and collection of the grab samples and video at the designated positions.

GPS offsets to the bow mounted A-frame on *Lophius* were input into the HYPACK software. A layback was not entered as the grab sampler and video sled were one to three meters from the A-frame at all time due to the shallow water conditions.

2.2 Underwater Video Methods

2.2.1 Grab video and sediment sampling methods

Grab video and sediment samples were collected at 11 stations (GB-01A through GB-11A) in Centerville Harbor in the vicinity of the proposed landing alignments on November 5, 2019. Proposed sampling locations were provided by Seaforth. CR's Outland Technologies cabled underwater video system and lights were mounted on the grab sampler facing downward and one to two minutes of video footage was recorded prior to collecting each sediment grab. One grab was taken at each station using a Ted Young $0.1m^2$ modified Van Veen grab sampler.

Due rough sea conditions and abundant rafting algae and benthic macroalgae it was often necessary to land the grab sampler on the bottom and wait for the visibility to improve in order to obtain a clearer image of the bottom. Rafting algae at GB-09A required that a second video and grab attempt be made (GB-09B). One or two video screen captures were created for each sediment grab station from the Outland camera footage and notes on visible substrate recorded. Collected sediment grabs were split by subsampling each grab using clean CAB core liner. Seaforth transferred sediment to Geotesting Express for grain size analysis and ESS Group for benthic enumeration.

2.2.2 Video methods along planned transects

Underwater video data were collected on November 6, 2019 along 11 transects with CR's portable towed video sled consisting of a lightweight aluminum frame, Outland Technologies' (OTI) high-definition color video camera, and two wide-angle LED video lights with variable output control. The OTI video camera was cabled to an OTI-1080 HD DVR recorder and high resolution daylight monitor at the surface. As a back-up video system, a GoPro Hero 4+ Black video camera in a Golem Gear deep water housing was mounted below the OTI camera and programmed to record full HD video at 1080P, 30 frames per second, and take 12 megapixel still frames every 10 seconds. Prior to deploying the video sled the OTI camera time was synced to the time on the navigation system. The start time of the video transect for the OTI and GoPro cameras were synced by videotaping the transect number and date on a white board prior to deployment.

The video sled was operated in drift and towed mode. The sled was raised and lowered using the bow mounted A-frame and hydraulic winch on *Lophius*, and the height of the system off the bottom was continually adjusted to achieve the best bottom coverage and video quality. When the video camera was one foot off the bottom, the viewing area of the camera was approximately 1.5 feet x 1.5 feet (18 inches x 18 inches), and the video quality was optimal for bottom sediment characterizations and biota identifications. For scaling purposes, lasers were set 8 inches (20 cm) apart and a calibration check was performed prior to survey operations.

Camera footage was backed up on an external hard drive at the end of the underwater video operation. The video transect data from the OTI camera video footage that displayed time from the GPS was reviewed first. A minimum of every 30 seconds, detailed notes of biota or changes in substrate, actual time, and video screen captures were created by a CR marine biologist. Subsequently, the higher resolution GoPro camera footage was reviewed to confirm species identifications and bottom substrate characterization and to create a series of three representative video screen captures for each transect.

All raw navigation and underwater video data has been furnished to Seaforth. Additionally, 40 to 80 underwater video footage screen captures from the OTI camera, and 15 to 30 screen captures from the Go Pro camera are archived at CR, and can be made available.
Data compiled for each transect includes:

- The CMECS (FGDC-STD, 2012) substrate and biotic components,
- The MA CZM modified Barnhardt et al. (1998) substrate classification,
- Identification of the dominant fauna and its relative abundance,
- Presence/absence data for biota (fauna, seagrass and macroalgae) observed, and
- The presence of MA CZM Special, Sensitive or Unique Resources.

The Coastal and Marine Ecological Classification Standard (CMECS) is a hierarchical arrangement of biogeographic and aquatic setting units and components (water column, geoform, substrate and biotic) that were used to describe ecosystem features within Centerville Harbor in the vicinity of the proposed landing sites (FGDC, 2012).

Also provided are MACZM's modified Barnhardt et al. (1998) substrate classifications (Fine, Fine with Gravel, Fine with Rock, Gravel with Fine, Gravel, Gravel with Rock, Rock with Fine, and Rock); and the observation of any Massachusetts CZM Special, Sensitive or Unique Resources (SSUs) such as, eelgrass beds, hard complex substrate, or commercially important species.

3.0 RESULTS

3.1 Video Sled Transect Results

The underwater video transects as for the two proposed Barnstable landing sites included eight shore parallel transects and three shorter transects perpendicular to the two most westerly transects off Dowses Beach (Figure 1). Table 1 provides the bottom substrate and biotic components observed at each video transect based on the Coastal and Marine Ecological Classification System (CMECS) (FDGC, 2012). Also listed are MACZM's modified Barnhardt et al. (1998) sediment classes, and dominant faunal species observed. Substrate components and areas of algal rafts that partially obscured the substrate are mapped on Figure 1.

A list of flora and fauna observed by transect along with summary statistics of species observations by transect and frequency of observation across transects are provided on Table 2. Plates 1-11 provide screen captures of bottom substrate and biota.

3.1.1 CMECS interpretation from video footage

The CMECS biogeographic setting for the Barnstable landing site was identified as the Virginian ecoregion, the cold temperate Northwest Atlantic province, and the temperate North America realm (Table 4). Water column components were not directly measured within the landing sites marine nearshore subtidal waters however it is estimated that lower water column waters were likely polyhaline. Raw depths on underwater video transects ranged from 2.2 meters (7.2 feet) to 6.3 meters (20.6 feet) at the time of the survey. The geoform component tectonic setting is a passive continental margin and the physiographic setting is an embayment/bay. The main type of unconsolidated bottom substrate geoform encountered was low relief ripples. Visually estimated surficial substrates were primarily of geologic origin and consisted of coarse unconsolidated gravelly sand, and fine unconsolidated slightly gravelly sand. Biogenic substrate was often present in the form of shell mixed with or overlying the sand, and on portions of transects VT-04A, 06A, and 09A formed *Crepidula* hash (Figure 1). Gravelly sand was the predominant substrate component on inshore transects near the entrance to East Bay (VT-11A, 10A, 09A, 08A, and 07A) (Figure 1, Table 1). Finer slightly gravelly sand was observed at the offshore transects (VT-06A, 05A, 04A, and 03A) and the eastern inshore transects off Craigville Beach (VT-02A, and 01A). Most of the gravelly sand bottom was comprised of sand ripples with gravel found in the sand ripple troughs. Only a few isolated cobbles particularly on inshore transects near the entrance to East Bay, and no boulders were observed during the survey operation.

The biotic components consisted of algal rafts of branching red algae, and aquatic vegetation bed subclass benthic macroalgae including *Codium* and *Sargassum*. Rafting algae floated above the seabed at times obscuring the bottom (Figure 1). Co-occurring biotic units included benthic/attached biota: live *Crepidula* that were not substantial reef builders, so the biotic class was assigned to faunal bed/attached *Crepidula*; soft sediment fauna, the tube building plumed worm *Diopatra*; and mobile crustaceans, hermit crabs *Pagurus* spp. on soft sediment. Associated taxa included mobile mollusks *Busycon*, and crustaceans particularly spider crabs *Libinia* that feed on *Crepidula*. Aquatic vascular vegetation, *Zostera marina*, was only observed as bed forming at the very southwestern extDnt of inshore transect, VT-08A (Plate 8). The eelgrass may extend further south or inshore outside the survey area.

A total of 15 invertebrate, two fish, five algal species, and eelgrass were observed. Frequently observed invertebrates (>70%) across transects included knobbed whelks, slipper limpets, plume worms, flat-clawed and long-clawed hermit crabs, and spider crabs. This assemblage of species appeared more abundant along the western inshore transects where the substrate was more complex including a mixture of slightly gravelly sand with ripples, gravelly sand and shell hash or in areas of *Crepidula* hash (e.g. on VT-04A, 06A, 09A). Only two fish were observed during the entire survey, one winter flounder and one northern pipefish most likely due to the late season survey period and lack of hard bottom within the survey area. Dense floating red branching algae (algal rafts) were observed in portions of seven of the 11 transects (Figure 1). In these areas, substrate observations were limited and counts of biota may have been underestimated due to the dense floating algae that obscured the bottom.

The algal cover was comprised of dead man's fingers (*Codium*), sea lettuce (*Ulva*), *Sargassum*, purple laver (*Porphyra*), and branching red algae. Although a few observations of attached branching red algae were noted, the majority of the red algae observed were floating and possibly the invasive species *Heterosiphonia japonica*. Algal blooms of this species were reported at other Cape Cod Beaches in November 2019. Trace eelgrass cover, consisting of a few individual plants were observed at eight of the 11 transects. The only observation of eelgrass with moderate cover was at the start of inshore transect VT-08A.

3.1.2 Commercial species

The dominant mobile mollusk, knobbed whelks *Busycon* were found in low numbers on 91% of transects. Knobbed whelks were the only commercial invertebrate species recorded in significant numbers (Table 2). Single observations of blue crabs and horseshoe crabs were made on two and five of the 11 transects, respectively. No bay scallops were observed during the November 2019 survey, and of the commercial fish species, only one winter flounder was observed.

3.1.3 SSUs

No boulder substrate was encountered during the 2019 video survey and the intermittent observations of slipper limpet hash bottom do not meet the designation of potential Special, Sensitive, or Unique Areas (SSUs) based on the complexity of the bottom habitat and the abundance of biota. Although sparse eelgrass, consisting of isolated rooted plants were observed on multiple transects in Centerville Harbor, only one patch of eelgrass with moderate coverage at the very southwestern end of VT-08A south of Dowses Beach could be designated as an SSU. This *Zostera marina* patch may indicate the edge of a bed that extends to the south or inshore but outside the landing site study area.

3.2 Video Grab Results

The video grab sampling locations are presented on Figure 2, and sample station coordinates on Table 3. One or two video screen captures were created for each of the 11 sediment grab stations at the proposed Centerville Harbor landing sites (Figure 2, Plates GB-1 through GB-3). Basic substrate classifications were obtained despite at times poor visibility due to turbidity and floating algae. Visual estimates of the surficial substrate component were slightly gravelly sand with trace shell hash, ripples; gravelly sand, and gravelly sand with *Crepidula* hash. The dominant substrate was slightly gravelly sand with shell hash. Gravelly sand was observed at GB-09A and 09B along with *Crepidula* hash. Grain size analyses of sediment grabs reported elsewhere by Seaforth indicate that a finer component may be present below the visible sand and shell hash veneer.

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TABLES

TABLE 1
CMECS CLASSIFICATION, DOMINANT SPECIES, AND SPECIAL, SENSITIVE OR UNIQUE AREAS
UNDERWATER VIDEO DATA
VINEYARD WIND - CENTERVILLE HARBOR, BARNSTABLE, MA
November 6, 2019

Video Transect ID	Transect Start_X[1]	Start_Y	Transect End_X	End_Y	Measured Water Depths[5] (ft)	Dominant Fauna	Latin Name	CMECS Substrate Component[2, 6]	CMECS Biotic Component[2]	Biotic Co-occurring and Associated Taxa[6]	CZM - Barnhardt et. al (1998)
CENTERVILLE HARBOR PROPOSED LANDING SITES											
VT-01A	387806.0	4609984.5	388337.0	4610008.5	9.0 to 18.8	Slipper limpet	*Crepidula fornicata*	Slightly gravelly sand with ripples trace *Crepidula* hash	algal rafts[3], benthic macroalgae	sparse attached *Crepidula*; mobile mollusks and crustaceans	Fine
VT-02A	387565.1	4609632.8	388100.1	4609590.8	12.6 to 20.5	Long-clawed hermit crab	*Pagurus longicarpus*	Slightly gravelly sand with ripples co-occurring sparse *Crepidula* hash	algal rafts[3], benthic macroalgae	sparse mobile crustaceans	Fine
VT-03A	387443.8	4609148.5	387890.4	4609133.3	19.6 to 21	Slipper limpet	*Crepidula fornicata*	Slightly gravelly sand with co-occurring moderate *Crepidula* hash	algal rafts[3], benthic macroalgae	sparse attached *Crepidula*; mobile crustaceans	Fine
VT-04A	387397.4	4608630.3	387720.4	4608594.1	17.6 to 20.6	Long-clawed hermit crab	*Pagurus longicarpus*	Slightly gravelly sand/ moderate *Crepidula* hash	algal rafts[3], benthic macroalgae	sparse mobile crustaceans	Fine
VT-05A	387122.0	4607694.9	387434.9	4607993.7	10.6 to 12.0	Spider crab	*Libinia emarginata*	Slightly gravelly sand with ripples, co-occuring *Crepidula* hash	sparse benthic macroalgae	moderate mobile crustaceans	Fine
VT-06A	386683.0	4607913.2	387099.2	4608292.2	8.5 to 19.7	Slipper limpet/ Spider crab	*Crepidula fornicata/ Libinia emarginata*	Slightly gravelly sand with ripples/*Crepidula* hash	algal rafts[3], benthic macroalgae	moderate attached *Crepidula* and mobile crustaceans; sparse mobile mollusks and larger tube building fauna (*Diopatra*)	Fine

TABLE 1
CMECS CLASSIFICATION, DOMINANT SPECIES, AND SPECIAL, SENSITIVE OR UNIQUE AREAS
UNDERWATER VIDEO DATA
VINEYARD WIND - CENTERVILLE HARBOR, BARNSTABLE, MA
November 6, 2019

Video Transect ID	Transect Start_X[1]	Start_Y	Transect End_X	End_Y	Range of Measured Water Depths[5] (ft)	Dominant Fauna	Latin Name	CMECS Substrate Component[2]	CMECS Biotic Component[2]	Co-occurring and Associated Taxa	CZM - Barnhardt et. al (1998)
VT-07A	386267.3	4608124.5	386716.6	4608776.4	7.7	Spider crab	*Libinia emarginata*	Gravelly sand and sparse slightly gravelly sand	patchy sparse algal rafts[3], benthic macroalgae	sparse attached *Crepidula,* mobile mollusks and larger tube building fauna (*Diopatra*); and moderate mobile crustaceans	Fine with gravel
VT-08A	386154.2	4608181.8	386623.4	4608829.4	7.7 to 8.3	Plumed worm	*Diopatra cuprea*	Slightly gravelly sand with ripples/gravelly sand	algal rafts, benthic macroalgae, trace *Zostera marina* [4]	sparse attached *Crepidula,* larger tube building fauna (*Diopatra*); and mobile crustaceans	Fine with gravel
VT-09A	386523.8	4608832.8	386757.3	4608581.3	9.1	Slipper limpet	*Crepidula fornicata*	Gravelly sand/slightly gravelly sand with ripples/*Crepidula* hash	patchy algal rafts[3] , benthic macroalgae	sparse attached *Crepidula,* mobile mollusks; larger tube building fauna (*Diopatra*); and mobile crustaceans	Fine with gravel
VT-10A	386371.9	4608612.5	386588.0	4608374.5	9.2	Spider crab	*Libinia emarginata*	Gravelly sand with ripples sparse shell hash; pebble/granule trace cobble	benthic macroalgae	moderate mobile crustaceans; sparse mobile mollusks and larger tube building fauna (*Diopatra*)	Fine with gravel
VT-11A	386195.5	4608343.2	386407.9	4608099.5	7.2	Spider crab	*Libinia emarginata*	Gravelly sand / slightly gravelly sand; pebble/granule trace cobble	benthic macroalgae	moderate mobile crustaceans and attached *Crepidula* ; sparse barnacles, mobile mollusks and larger tube building fauna (Diopatra)	Fine with gravel

TABLE 1
CMECS CLASSIFICATION, DOMINANT SPECIES, AND SPECIAL, SENSITIVE OR UNIQUE AREAS
UNDERWATER VIDEO DATA
VINEYARD WIND - CENTERVILLE HARBOR, BARNSTABLE, MA
November 6, 2019

References:

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Barnhardt, W.A., J.T. Kelley, S.M. Dickson, and D.F. Belknap. 1998. Mapping the Gulf of Maine with Side-Scan Sonar: A New Bottom-Type Classification for Complex Seafloors. Journal of Coastal Coastal Research 14(2) 646-59.

Notes:

[1] Coordinates for the video transect start and end points in Grid: UTM North, Ellipsoid: WGS-84, Zone: Zone 19 (72W-66W), Distance: Meters

[2] Figure 1 illustrates the major CMECS substate components identified along the video transects

[3] When present dense rafts of red macroalgae floating below the surface of the water often obscured a view of the bottom substrate.The algal rafts were estimated to overlay slightly gravelly sand or gravelly sand substrate.

[4] Possible eelgrass SSU identified at southwestern end of video transect 8 (Figure 1)

[5] Water depths from vessel echosounder - not corrected for tides

[6] CMECS modifiers were used to relay relative frequency within a transect
(number of screen captures in which element was observed / total screen capture observation points, taken ~ every 30 seconds)

- Trace (<1%)
- Sparse (1 to <30%)
- Moderate (30 to 70%)
- Dense (70 to 90%)
- Complete (90 to 100%)

TABLE 2
SPECIES OBSERVATIONS BY TRANSECT
UNDERWATER VIDEO DATA
VINEYARD WIND - CENTERVILLE HARBOR, BARNSTABLE, MA
November 6, 2019

TRANSECT ID	Latin Name	VT-01A	VT-02A	VT-03A	VT-04A	VT-05A	VT-06A	VT-07A	VT-08A	VT-09A	VT-10A	VT-11A	Freqency %
FAUNA													
PORIFERA													
Red beard sponge	*Microciona prolifera*	X (1)						X (2)		X (1)	X (1)	X (2)	45.45
CNIDARIA													
Snail fur	*Hydractinia echinata*		X (1)							X (1)	X (1)		27.27
BRYOZOA													
Bushy bryozoan	Bryozoa		X (1)							X (1)			18.18
MOLLUSCA													
Knobbed whelk*[1]	*Busycon carica*	X (3)	(1eggcase)	X (2)	X (1)		X (3)	X (5)	X (1)	X (4)	X (2)	X (2)	**90.91**
Slipper limpet[6]	*Crepidula fornicata*	X (4)	X (2)	X (9)	X (3)	X (5)	X (18)	X (11)	X (6)	X (10)	X (1)	X (19)	**100.00**
ANNELIDA													
Plumed worm	*Diopatra cuprea*		X (1)	X (2)	X (1)		X (5)	X (10)	X (12)	X (7)	X (8)	X (11)	**81.82**
Tube worm	*Hydroides dianthus*		X (1)							X (1)			18.18
ARTHROPODA													
Merostomata													
Horseshoe Crab	*Limulus polyphemus*	X (1)	X (1)	X (1)	X (1)	X (1)							45.45
Crustacea													
Barnacle	*Balanus* sp.					X (2)		X (2)	X (5)	X (8)	X (6)	X (18)	54.55
Blue crab	*Callinectes sapidus*			X (1)	X (1)								18.18
Flat-Clawed Hermit Crab	*Pagurus pollicaris*	X (1)	X (1)			X (6)	X (5)	X (2)	X (1)	X (2)	X(1)	X (2)	**90.91**
Long-Clawed Hermit Crab	*Pagurus longicarpus*	X (3)	X (10)	X (1)	X (5)	X (5)		X (3)		X (1)	X (2)		**72.73**
Lady crab	*Ovalipes occellatus*									X (1)			9.09
Sand shrimp	*Crangon septemspinosa*								X (4)	X (3)			18.18
Spider crab	*Libinia emarginata*		X (3)		X (4)	X (15)	X (33)	X (52)	X (7)	X (5)	X (22)	X (34)	**81.82**
VERTEBRATA													
Osteichthyes													
Northern pipefish	*Syngnathus fuscus*											X (1)	9.09
Winter flounder	*Pleuronectes americanus*										X (1)		9.09

TABLE 2
SPECIES OBSERVATIONS BY TRANSECT
UNDERWATER VIDEO DATA
VINEYARD WIND - CENTERVILLE HARBOR, BARNSTABLE, MA
November 6, 2019

TRANSECT ID	Latin Name	VT-01A	VT-02A	VT-03A	VT-04A	VT-05A	VT-06A	VT-07A	VT-08A	VT-09A	VT-10A	VT-11A	Freqency %
SPECIES RICHNESS FAUNA[2]		6	10	6	8	6	5	8	7	13	10	8	
FLORA													
ALISMATALES													
Zosteraceae													
Eelgrass*[5]	*Zostera marina*	X (9)[5]	X (6)[5]	X (9)[5]	X (16)[5]		X (7)[5]	X (2)[5]	X (5)[5] bed (1)*		X (2)[5]		**72.73**
CHLOROPHYTA													
Dead Man's Fingers	*Codium fragile*	X (8)	X (2)	X (9)	X (15)	X (1)	X (12)	X (28)	X (28)	X (9)	X (2)	X (17)	**100.00**
Sea Lettuce	*Ulva lactuca*							X (1)		X (1)			18.18
PHAEOPHYTA													
Wire weed	*Sargassum filipendula*	X (3)	X (5)	X (6)	X (5)	X (1)	X (3)	X (6)	X (7)	X (4)	X (2)	X (5)	**100.00**
RHODOPHYTA													
Branching red alga[6]	Rhodophyta	X (28)	X (26)	X (41)	X (28)	X (6)	X (38)	X (55)	X (50)	X (28)	X (13)	X (15)	**100.00**
Purple laver	*Porphyra umbilicalis*		X (1)		X (2)	X (1)	X (3)	X (1)		X (2)		X (3)	63.64
Total # of screen capture observation points		50	45	56	35	27	63	95	82	43	41	56	
SPECIES RICHNESS FLORA[2]		4	5	4	5	4	5	6	4	5	4	4	

1) An * designates species selected for assessment of 'important fish resource areas' an SSU under the Mass. Ocean Management Plan which includes knobbed whelk and eelgrass.

2) Species Richness = the total number of species observed - not normalized for length of transect

3) Species with a frequency across all transects greater than 70% are bolded and shaded

4) X designates presence on a transect; (#) designates the number of individuals observed. Data not normalized for length of transect. For *Crepidula, barnacles* and algae - individuals were too numerous to count

5) Only single strands of eelgrass observed (e.g., Plate 3) - no sign of an eelgrass bed SSU excluding southwestern end of VT-08A (Plate 8).

6) The majority of the branching red algae was rafting above the bottom and may be the invasive *Heterosiphonia japonica*

TABLE 3
VIDEO GRAB STATION COORDINATES
BARNSTABLE LANDING SITES, CENTERVILLE HARBOR, MA
November 2019

STATION ID[1]	X (Eastings)[2]	Y (Northings)	LAT	LONG	TIME	DATE	WATER DEPTH[3]
wb19-gb-01a	388115.51	4610071	41.63452761	70.3433007	11:57:12	11/5/2019	19.4
wb19-gb-02a	387816.11	4609854.79	41.63253864	70.34685385	11:42:27	11/5/2019	11.6
wb19-gb-03a	387932.91	4609588.83	41.63016015	70.34540214	11:21:45	11/5/2019	20.5
wb19-gb-04a	387639.75	4609233.58	41.62691997	70.34885399	10:59:39	11/5/2019	21
wb19-gb-05a	387790.12	4608959.4	41.62447221	70.34699793	10:33:17	11/5/2019	22.5
wb19-gb-06a	387526.59	4608696.75	41.62207001	70.35011122	10:17:15	11/5/2019	22
wb19-gb-07a	386495.79	4608478.91	41.61996245	70.36244012	7:38:43	11/5/2019	9.6
wb19-gb-08a	386912.63	4608458.9	41.61984145	70.35743418	8:33:44	11/5/2019	18
wb19-gb-09a	387389.73	4608185.27	41.61744495	70.35165743	8:48:12	11/5/2019	22.5
wb19-gb-09b	387387.92	4608183.84	41.61743182	70.35167888	9:31:21	11/5/2019	22.5
wb19-gb-10a	386914.58	4607804.49	41.61394894	70.35728721	8:14:18	11/5/2019	11.5
wb19-gb-11a	387334	4607752.79	41.61354271	70.35224482	10:00:10	11/5/2019	12

NOTES:
1) Grid: UTM North, Ellipsoid: WGS-84, Zone: Zone 19 (72W-66W), Distance: Meter
2) Grab attempts are identified by the number at the end of Station ID(1ST attempt="a",2ND attempt="b",3RD attempt="c")
Highlighted cells separate each grab station. See Figure 2 for mapped positions.
3) Water depths are in decimal feet, and are raw, not corrected for tides
4) Navigation Used- Hemisphere Vector V104 Submeter Differential GPS and Hypack Survey Software
5) Grab System- 0.1 m^2 Ted Young Grab Sampler
6) Vessel Used- R/V Lophius 26' Aluminum Workboat

TABLE 4

CMECS CLASSIFICATION OF THE BOTTOM HABITAT PROPOSED CENTERVILLE HARBOR LANDING SITES

Biogeographic Setting

- Realm: Temperate North America
  - Province: Cold Temperate Northwest Atlantic
    - Ecoregion: Virginian

Aquatic Setting

- System: Marine
  - Subsystem: Nearshore
    - Tidal Zone: Subtidal

Water Column Component

- Water Column Layer: Marine Nearshore Lower Water Column
  - Salinity Regime: Polyhaline
    - Temperature Regime: Cool Water

Geoform Component

- Tectonic Setting: Passive Continental Margin
  - Physiographic Setting: Embayment/Bay
    - Geoform Origin: Geologic
    - Level 2 Geoform: Ripples

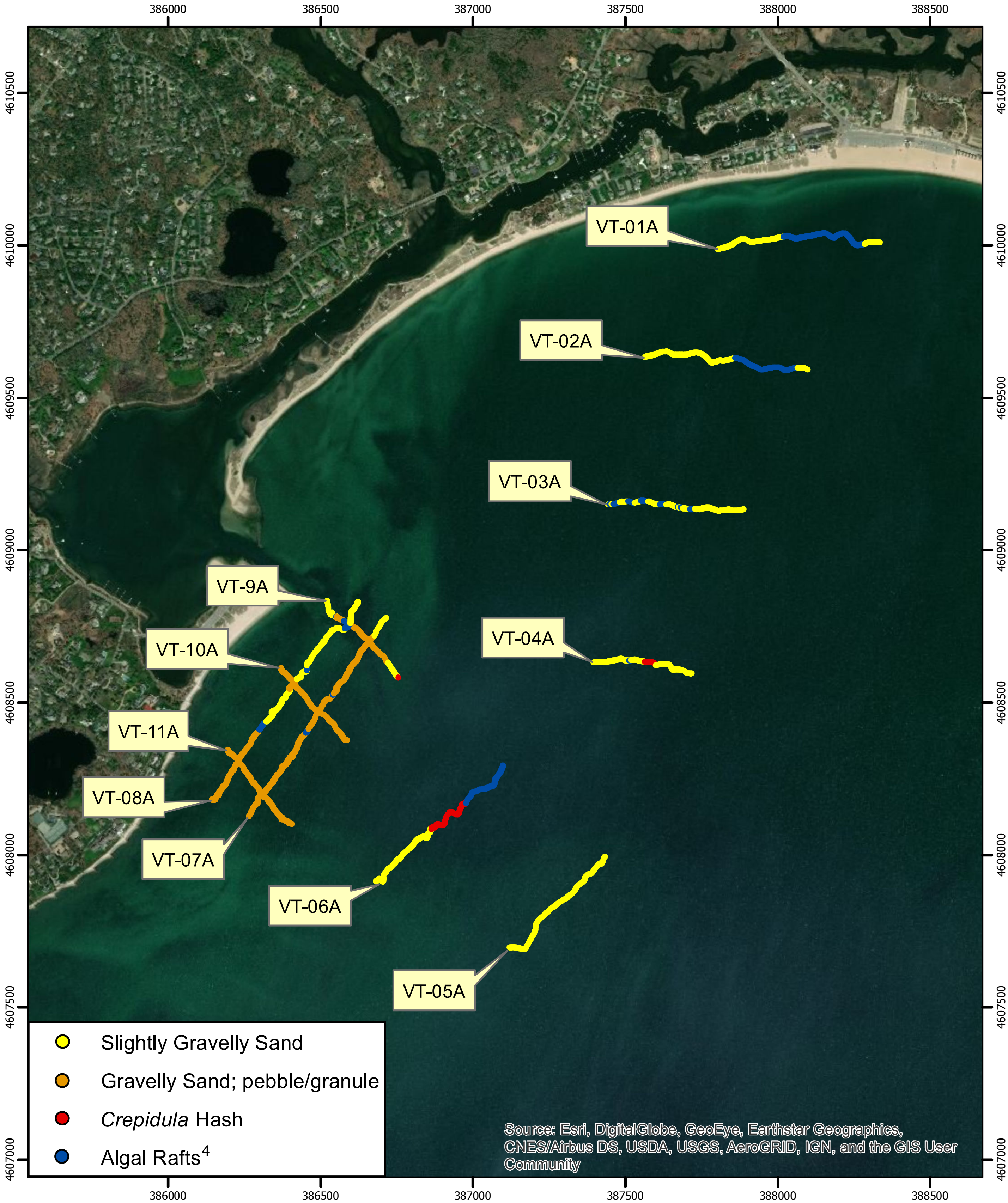
Substrate Component

- Substrate Origin: Geologic Substrate
  - Substrate Class: Unconsolidated Mineral Substrate
    - Substrate Subclass: Coarse Unconsolidated Substrate
      - Substrate Subgroup: Gravelly Sand
    - Substrate Subclass: Fine Unconsolidated Substrate
      - Substrate Group: Slightly Gravelly
        - Substrate Subgroup: Slightly Gravelly Sand
- Substrate Origin: Biogenic Substrate
  - Substrate Class: Shell Substrate
    - Substrate Subclass: Shell Hash
      - Substrate Group: *Crepidula* Hash

Biotic Component

- Biotic Setting: Plantonic Biota
  - Biotic Class: Floating/Suspended Plants and Macroalgae
    - Biotic Subclass: Floating/Suspended Macroalgae
      - Biotic Group: Algal Rafts
- Biotic Setting: Benthic/Attached Biota
  - Biotic Class: Aquatic Vegetation Bed
    - Biotic Subclass: Benthic Macroalgae
      - Co-occuring elements: *Codium and Sargassum* Communities
      - *Zostera marina* Community
  - Biotic Class: Faunal Bed
    - Biotic Subclass: Attached Fauna
      - Co-occurring elements: Attached *Crepidula* and Mobile Mollusks *Busycon;* Soft Sediment Tube Building Fauna *Diopatra* and Associated Taxa: Mobile Crustaceans *Pagurus* and *Lubinia*

FIGURES



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UNDERWATER VIDEO CMECS SUBSTRATE COMPONENTS
Centerville Harbor, Barnstable, Massachusetts

NOTES:
1) Survey conducted November 6, 2019.
2) UTM Zone 19N, NAD 83, Meters
3) Video transects labeled at start of file.
4) Algal rafts obscured substrate - estimated to be over slightly gravelly sand or gravelly sand

Meters
0 200 400

Figure 1

www.crenvironmental.com

SEDIMENT GRAB SAMPLE LOCATIONS
Centerville Harbor
Barnstable, Massachusetts

NOTES:
1) Samples collected November 5, 2019.
2) UTM Zone 19N, NAD 83, Meters

Meters
0 200 400

N W E S

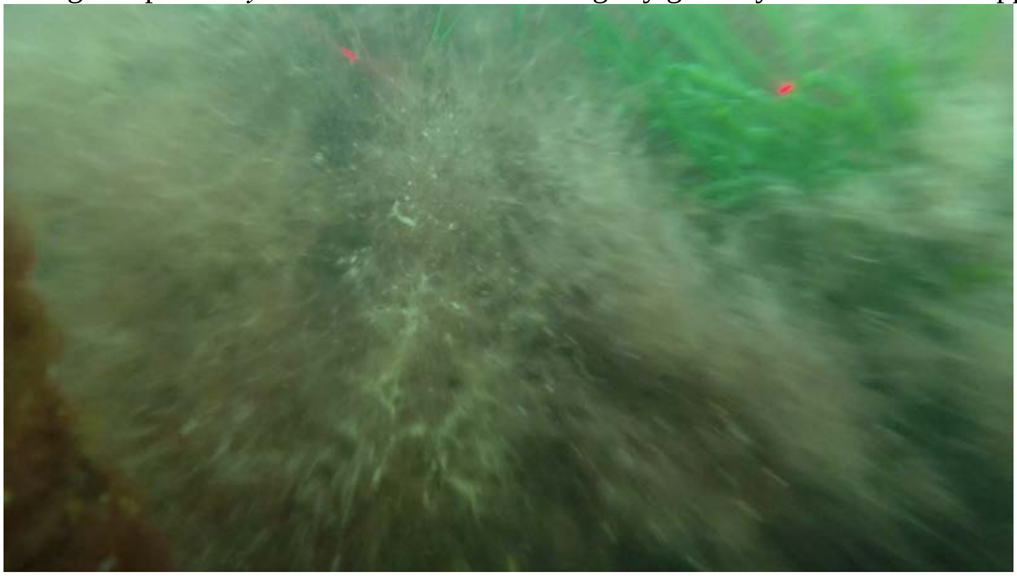
Figure 2

PLATES

PLATES 1-11 UNDERWATER VIDEO SLED TRANSECTS SCREEN CAPTURES

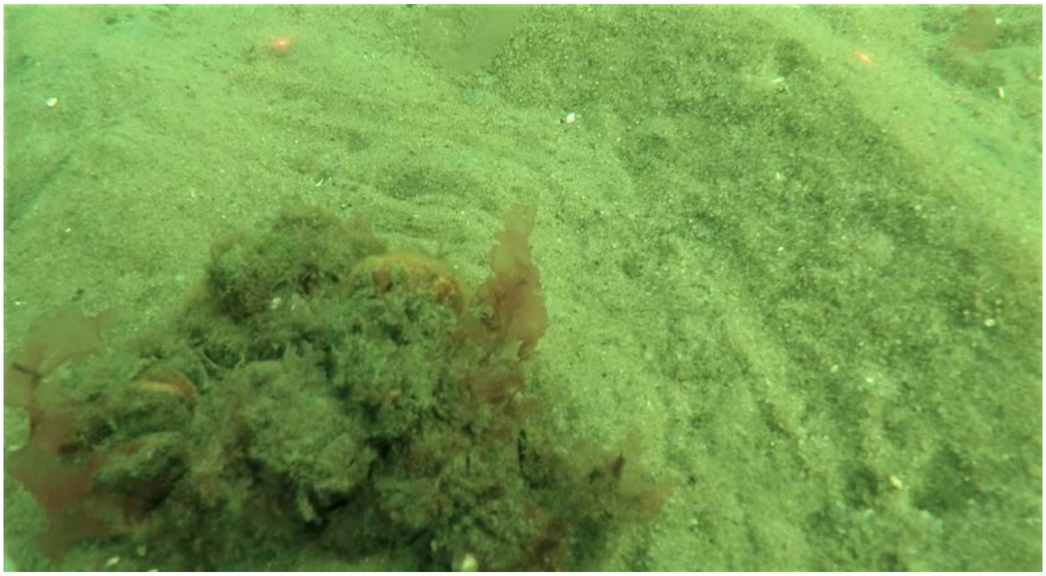
PLATES GB-1-GB-3 VIDEO GRAB SCREEN CAPTURES


Mobile gastropod *Busycon* knobbed whelk on slightly gravelly sand with sand ripples


Dense rafting red algae and benthic macroalgae (*Sargassum, Codium*)


Slightly gravelly sand with trace *Crepidula* shell hash plus attached *Crepidula* and benthic macroalgae *Sargassum*

Plate 1 Video Screen Captures of Substrate and Biota Components at VT-01A



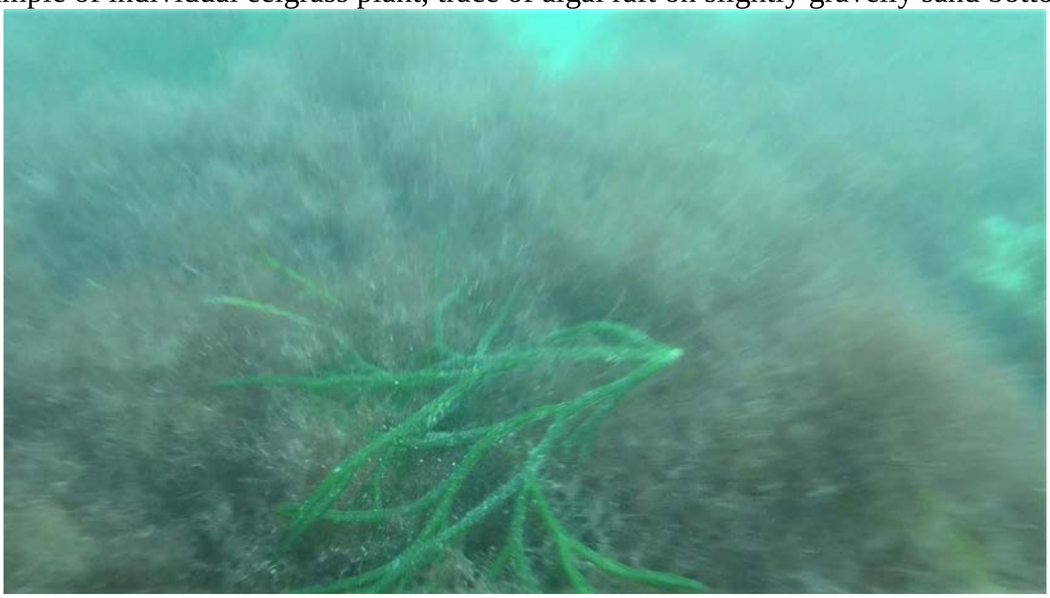
Slightly gravelly sand with trace gravel and shell hash in troughs of sand ripples plus benthic macroalgae (*Porphyra*) on attached *Crepidula*

Mobile crustacean (*Pagarus*) on slightly gravelly sand

Dense rafting red algae and benthic macroalgae (*Sargassum*)

Plate 2 Video Screen Captures of Substrate and Biota Components at VT-02A


Example of individual eelgrass plant, trace of algal raft on slightly gravelly sand bottom


Dense red algal raft and benthic macroalgae (*Codium*)


Slightly gravelly sand bottom with co-occurring *Crepidula* shell hash and trace red algal raft

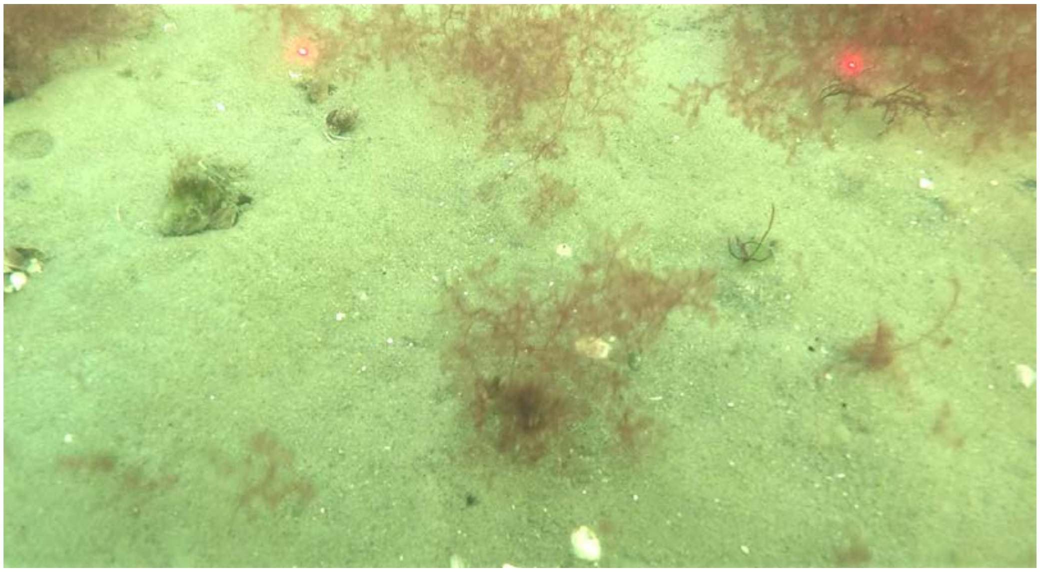
Plate 3 Video Screen Captures of Bottom Substrate and Biota at VT-03A

Slightly gravelly sand ripple bottom and associated mobile crustacean spider crab (*Libinia*)

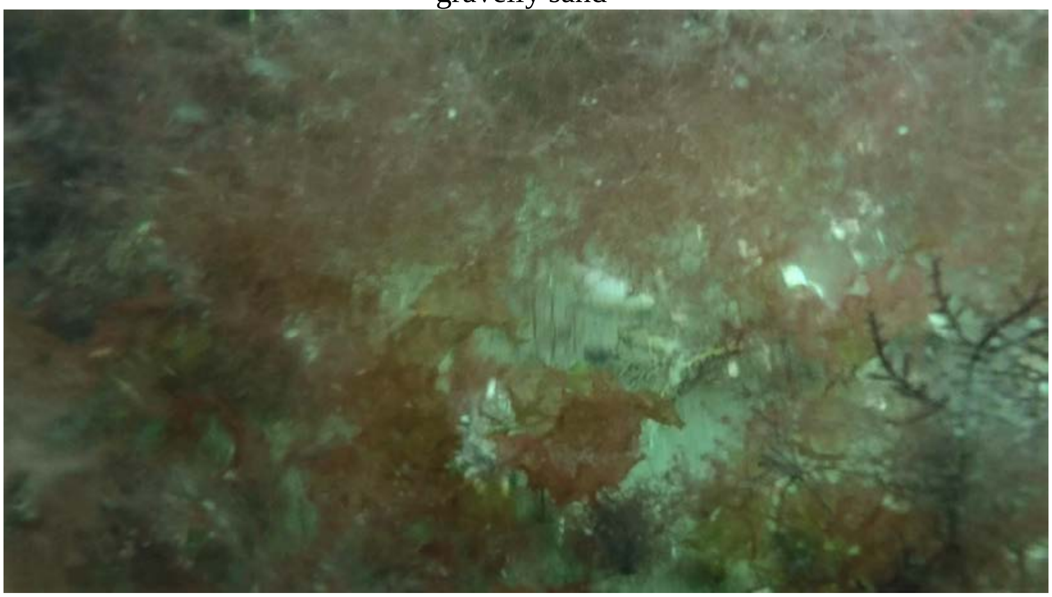
Attached slipper limpets *Crepidula* and *Crepidula* hash on slightly gravelly sand bottom

Dense *Sargassum* benthic macroalgae on slightly gravelly sand bottom

Plate 4. Video Screen Captures of Bottom Substrate and Biota at VT-04A



Patchy branching algal raft and mobile crustacean long-clawed hermit crab (*Pagurus*) on slightly gravelly sand

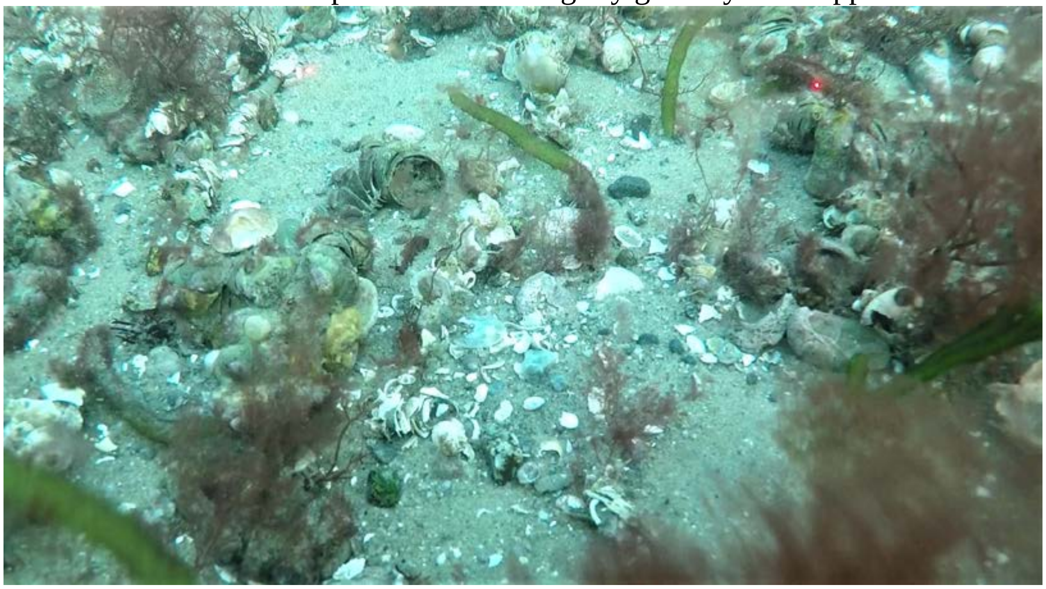


Localized dense branching red algal raft and purple laver (*Porphyra*) and *Sargassum* macroalgae

Mobile crustacean spider crab (*Libinia*) on slightly gravelly sand bottom

Plate 5. Video Screen Captures of Bottom Substrate and Biota at VT-05A

Mobile crustacean spider crab on a slightly gravelly sand ripple bottom

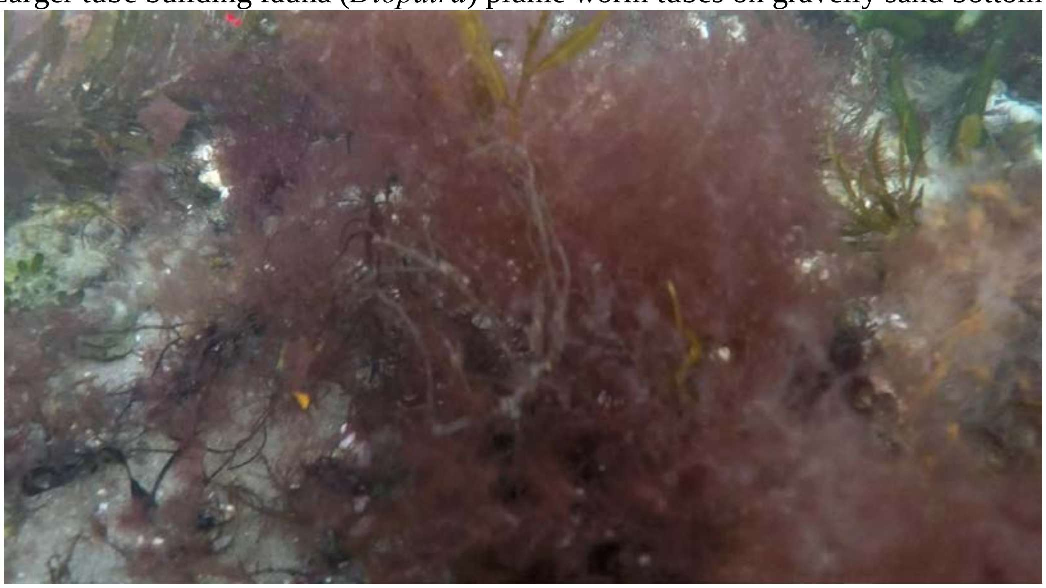


Attached slipper limpets and *Crepidula* hash on gravelly sand bottom

Dense red branching algal raft and benthic macroalgae *Sargassum*

Plate 6. Video Screen Captures of Bottom Substrate and Biota at VT-06A

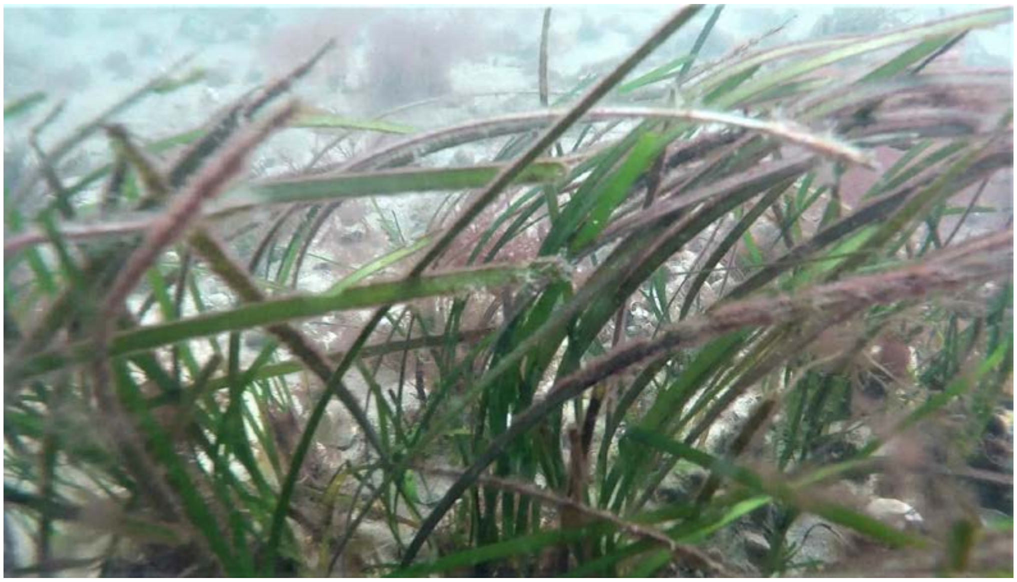
Larger tube building fauna (*Diopatra*) plume worm tubes on gravelly sand bottom



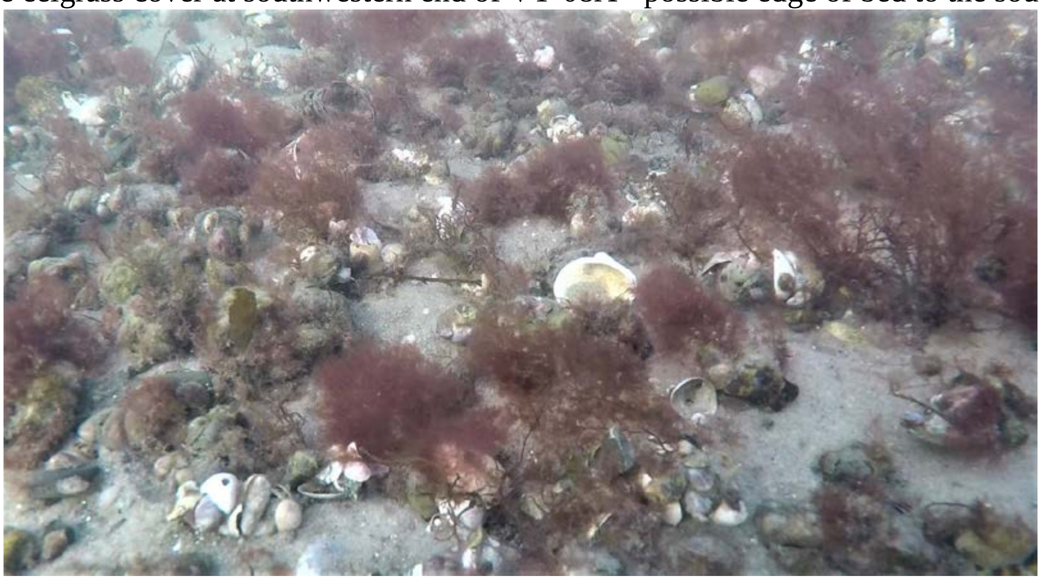
Patchy sparse red branching algal rafts and benthic macroalgae *Sargassum*

Benthic macroalgae dead man fingers (*Codium*) on gravelly sand bottom

Plate 7. Video Screen Captures of Bottom Substrate and Biota at VT-07A



Moderate eelgrass cover at southwestern end of VT-08A - possible edge of bed to the south



Attached slipper limpets *Crepidula* and plumed worm (*Diopatra*) tubes on gravely sand bottom

Benthic macroalgae *Sargassum* on gravelly sand

Plate 8. Video Screen Captures of Bottom Substrate and Biota at VT-08A


Attached slipper limpets (*Crepidula*) and plumed worm (*Diopatra*) tubes, sea lettuce (*Ulva*), *Sargassum*, and red branching macroalgae


Mobile crustacean spider crab (*Libinia*) on a gravelly sand bottom

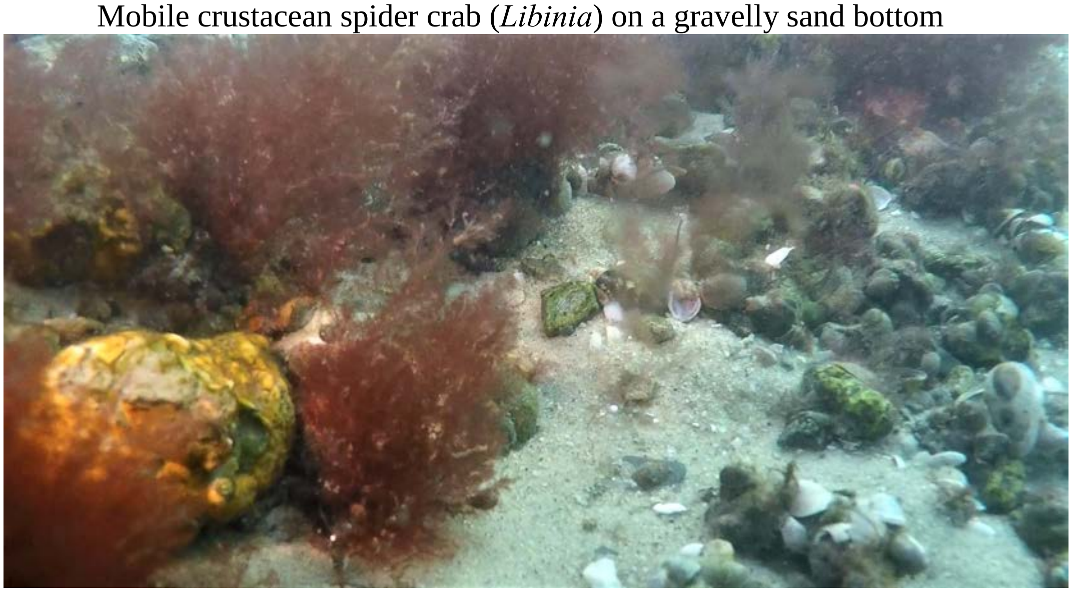

Tube worm, slipper limpets, red branching benthic macroalgae on gravelly sand bottom

Plate 9. Video Screen Captures of Bottom Substrate and Biota at VT-09A

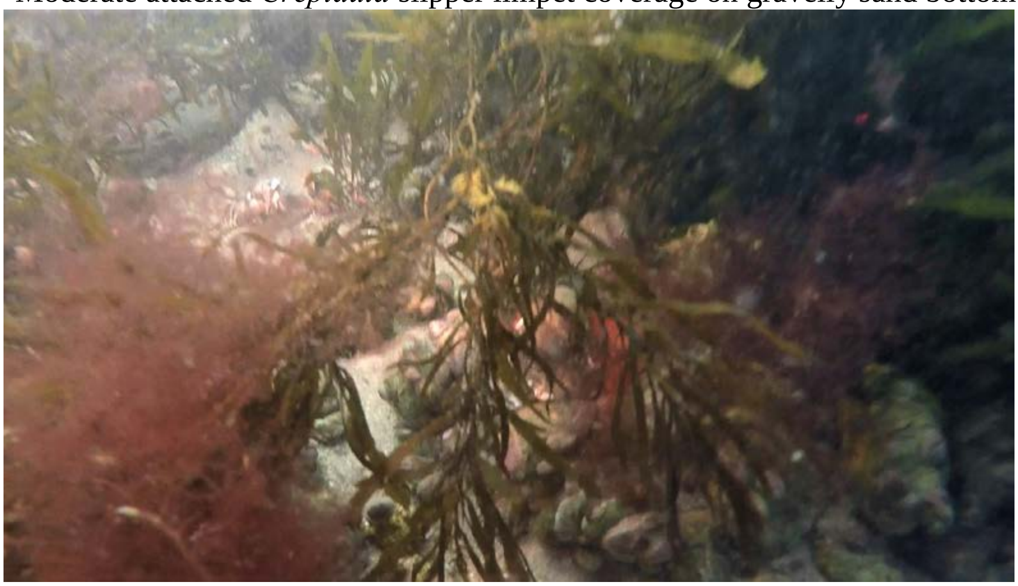
Mobile crustacean flat-clawed hermit (*Pagurus*) with sea fur hydroids and plumed worm (*Diopatra*) tubes on gravelly sand bottom

Mobile gastropod, knobbed whelk, feeding on slipper limpets

Barnacles, plumed worm tubes and red branching benthic macroalgae on gravelly sand

Plate 10. Video Screen Captures of Bottom Substrate and Biota at VT-10A


Moderate attached *Crepidula* slipper limpet coverage on gravelly sand bottom


Benthic macroalgae *Sargassum*, red branching algae over attached *Crepidula* on gravelly sand

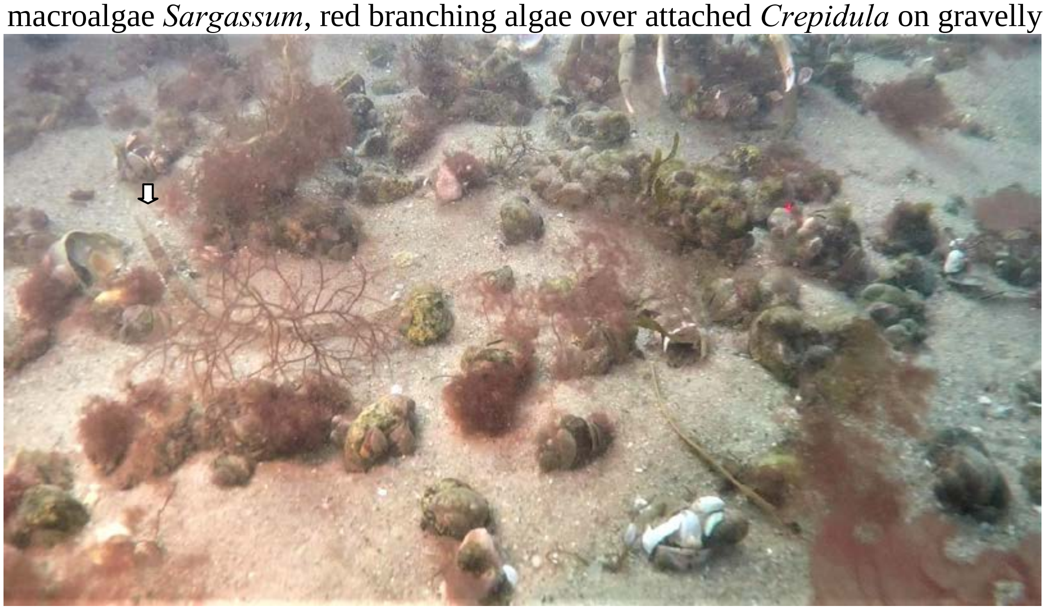

Northern pipefish, and slipper limpets on a gravelly sand bottom

Plate 11. Video Screen Captures of Bottom Substrate and Biota at VT-11A

GB-01A Abundant *Sargassum* macroalgae

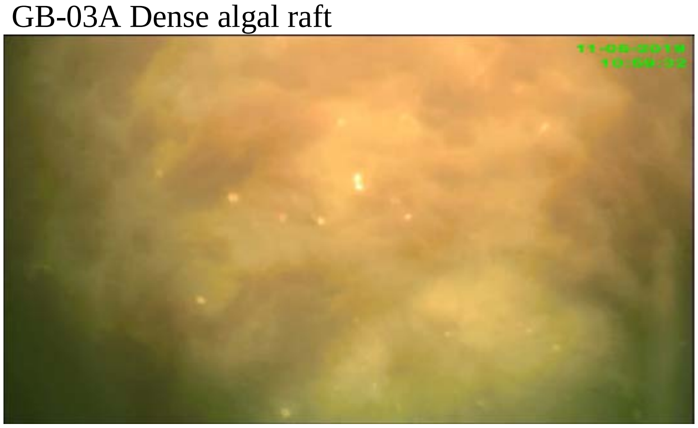
GB-01A Slightly gravelly sand

GB-02A Sand ripples

GB-02A Slightly gravelly sand ripples trace shell hash

GB-03A Dense algal raft

GB-03A Slightly gravelly sand trace shell hash



GB-04A Moderate algal raft over sand

GB-04A Slightly gravelly sand trace shell hash

Plate GB1. Grab Sample Video Screen Captures (reference Figure 2 for video grab station locations)

GB-01A Abundant *Sargassum* macroalgae

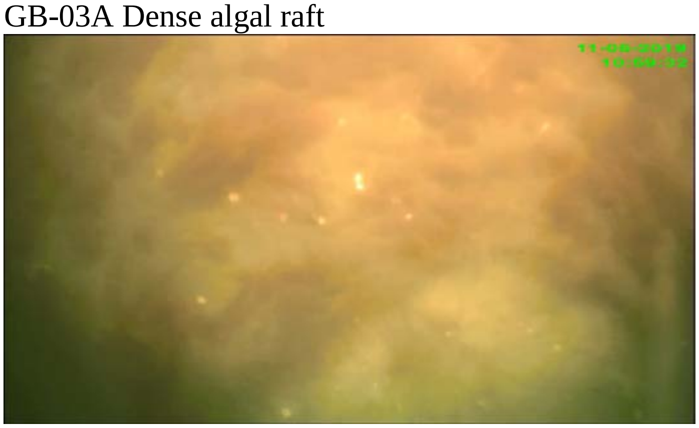
GB-01A Slightly gravelly sand

GB-02A Sand ripples

GB-02A Slightly gravelly sand ripples trace shell hash

GB-03A Dense algal raft

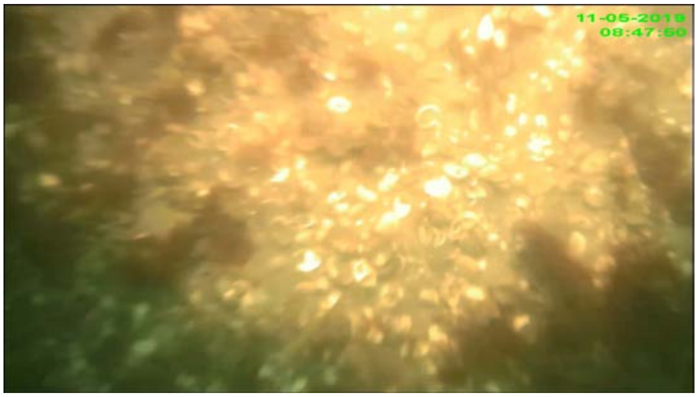
GB-03A Slightly gravelly sand trace shell hash



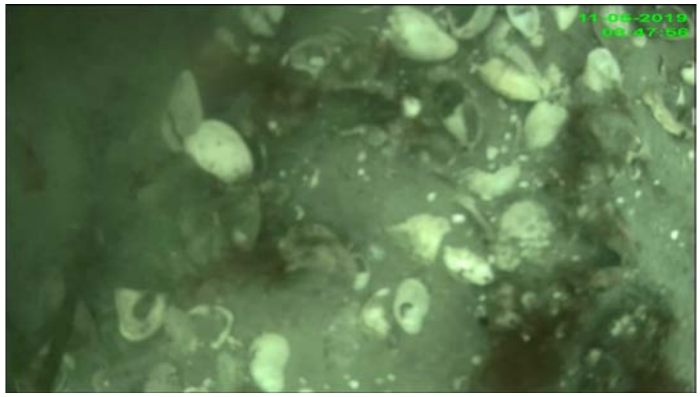
GB-04A Moderate algal raft over sand

GB-04A Slightly gravelly sand trace shell hash

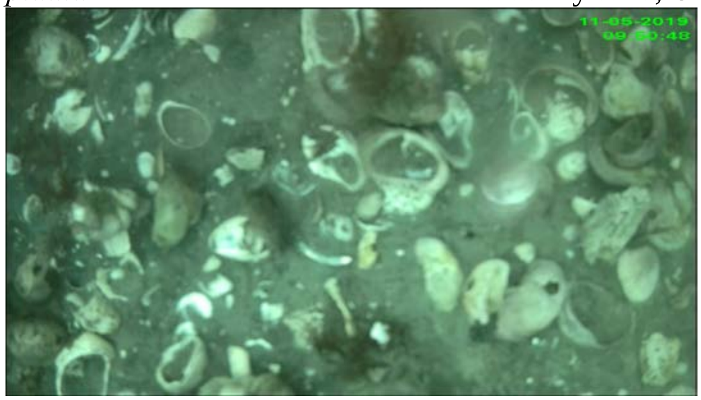
Plate GB1. Grab Sample Video Screen Captures (reference Figure 2 for video grab station locations)



GB-09A Gravelly sand, *Crepidula* hash



GB-09A Gravelly sand, *Crepidula* hash



GB-9B Gravelly sand, *Crepidula* hash

GB-10A Sand ripples, sparse red branching algae

GB-10A Slightly gravelly sand, ripples

GB-11A Sand ripples

GB-11A Slightly gravelly sand, ripples

Plate GB-3. Grab Sample Video Screen Captures (reference Figure 2 for grab station locations)