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Alpine Ocean Seismic Survey Inc. On behalf of Statoil US Wind LLC

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ST18507

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EXECUTIVE SUMMARY

During March and April 2018, Alpine Ocean Seismic Survey, Inc. (Alpine) was contracted by Statoil US Wind LLC (now known as Equinor US Wind LLC) to acquire high resolution geophysical (HRG), environmental and geotechnical survey data in sections of the Commercial Lease of Submerged Lands and Renewable Energy Development on the Outer Continental Shelf (OCS-A 0512). The survey data was required to inform the Site Assessment Plan (SAP) for the deployment of Floating Light Detection and Ranging Buoys and metocean moorings for site resource characterization. The SAP Survey Campaign area is located 22 to 39 kilometers south of Long Island, New York and covered an area of approximately 1380km^2.

The objective of the survey as defined by the scope of work (Statoil, 2017) was to obtain data for:

- Identification of historic properties on or within the seabed
- Identification of seafloor sediment and seafloor morphology
- Identifications of seabed obstructions
- Identification of mobile sand deposits
- Quantify and describe the characteristics of seabed sediments
- Describe the biological nature of the seabed
- Mapping of sand thickness and identification of the unconformity related to the last sea level lowstand
- Identification of shallow paleolandforms that could represent high probability locations (e.g. former river bank areas) where humans would have inhabited when the continental shelf was emergent during the last sea level lowstand
- Identify geological or manmade hazards (e.g. buried objects, shallow gas, lithological heterogeneities, etc.) beneath the seafloor that could affect the mooring systems
- Image the shallow subsurface conditions to support the interpretation and mapping of stratigraphic layering and geologic structure
- Map shallow and deep channel infill
- Map presence of gravel lag
- Describe Unit formation and Stratigraphy

A full geophysical suite consisting of multi-beam bathymetry, side scan sonar, magnetometer, and shallow and medium penetration sub-bottom profiler (high-frequency CHIRP, and single channel sparker) was acquired. The original survey objective was to target up to three Fldar survey locations (Fldar 1 to Fldar 3), however a decision was made by the client to only survey two Fldar sites (Fldar 1 and Fldar 2). Subsequently the current report and the site assessment plan (SAP) will refer to and apply to the two discrete Fldar deployment areas. Four environmental sampling stations (ST18904-ENV1 to ST18904-ENV4) were pre-selected by the client to cover each Fldar location and metocean buoy location. Following review of the geophysical data, one additional station (ST18904-ENV6) was chosen to investigate an area of medium reflectivity to ensure good coverage of all seabed substrate types. These locations are presented in the Location Map and Figure 1.1. The four environmental stations were investigated using a shallow water camera system to acquire seabed imagery and a modified 0.1m^2 Day grab to acquire sediment samples. At each station, three modified 0.1m^2 Day grab samples were collected and described. Two of the samples were acquired for macrofauna and sieved through a 1mm sized mesh, one of the samples (MFA) was later sent for analyses with the other (MFB) retained as a spare. The third sample (CHEM) was acquired for particle size and total organic matter analyses.

Geophysical data described the seabed as generally flat lying with a <1° gradient, and comprised medium to coarse sand with isolated patches of gravelly sand within the survey area. Water depths ranged between 33.0m and 37.8m

NAVD88 across the Flidar 1 survey area and 28.1m and 30.8m NAVD88 across the Flidar 2 survey area. The seabed was essentially flat, and shoaled slightly to the west across the Flidar 1 survey area whilst a broad, shallow depression up to 2m in depth traversed the Flidar 2 survey area from the northwest to southeast.

Environmental camera imagery across the survey area revealed the seabed predominantly comprised slightly gravelly medium sand with occasional shell fragments. Medium reflectivity at Station ST18904-ENV6 indicated areas of sandy gravel with sand ripples. Visible flora and fauna in seabed imagery included: Annelida (including Polychaeta worm tubes), Arthropoda (Amphipoda, Malacostraca, Paguroidea), Chordata (Tunicata), Cnidaria (cf *Hydractinia symbiolongicarpu*, Ceriantharia), Echinodermata (*Echinarachnius parma*, Holothuroidea), Foraminifera, Mollusca (Bivalvia, Cardiidae, Gastropoda, Naticidae, Neogastropoda), Rhodophyta and indeterminate Animalia.

Seabed sampling observations were used to ground truth initial geophysical interpretation and seabed imagery, with results supporting the preliminary findings. The sediment retained in the grab samples reflected the sediment observed in the seabed imagery revealing slightly gravelly fine to medium sand at Stations ENV1, ENV2 and ENV3, slightly gravelly silty sand at Station ENV4 and gravelly sand at Station ENV6. Occasional shells and shell fragments were observed at all stations. Visible fauna in the grab samples included Annelida (Polychaeta), Arthropoda (Paguroidea), Echinodermata (Clypeasteroida), Mollusca (Bivalvia, Veneroidia), Platyhelminthes and Chondrichthyes. No species were identified as listed under the under Endangered Species Act (NOAA, 2018) or any sensitive benthic habitats as defined by BOEM (2013).

Particle size analysis revealed generally uniform sediments at the stations sampled across the survey area. Sediments were moderately well to poorly sorted, dominated by fine to coarse sands according to the Wentworth classification of mean grain size, with low (1.2% to 4.4%) mud and low (0.2% to 1.2%) gravel (≥2mm). The majority of stations were described as slightly gravelly sand under the modified Folk classification. The exception was Station ST1890-ENV6, which was described as gravelly sand. Concentrations of total organic matter (TOM) were generally uniform and ranged from 0.2% to 0.7% while water content ranged between 16.7% and 28.4%.

The macrofaunal community was generally homogenous, and dominated by Arthropoda, representing 49.9% of individuals and 28.3% of taxa. Three individuals were identified as ‘immature’. Univariate statistics highlighted a generally homogenous moderately diverse (H’ 2.38 to 3.75) and evenly distributed (J 0.61 to 0.85) community. There was no evidence of any physical disturbance to the faunal community as a result of any anthropogenic activity in the area.

A single individual of the Ocean Quahog (*Arctica islandica*) was retained within the fauna sample from Station ST18904-ENV3 and the sampled was located within an area designated as an essential fish habitat for this taxon (NOAA, 2018).

Other than the aforementioned, overall, the survey area did not fall in any final or proposed Critical Habitat as defined by the United States Fish and Wildlife Service (USFWS, 2018). Furthermore, no benthic species or protected fish species listed under Endangered Species Act (NOAA, 2018) were observed. Nor was there any evidence from the seabed imagery or sampling of any sensitive habitats within the surveyed area, as defined by BOEM (2013), such as exposed hard bottoms or those covered by ephemeral sand layers, seagrass patches, kelp or other algal beds.

SERVICE WARRANTY

USE OF THIS REPORT

This report has been prepared with due care and diligence and with the skill reasonably expected of a reputable contractor experienced in the types of work carried out under the contract and as such the findings in this report are based on an interpretation of data which is a matter of opinion on which professionals may differ and unless clearly stated is not a recommendation of any course of action.

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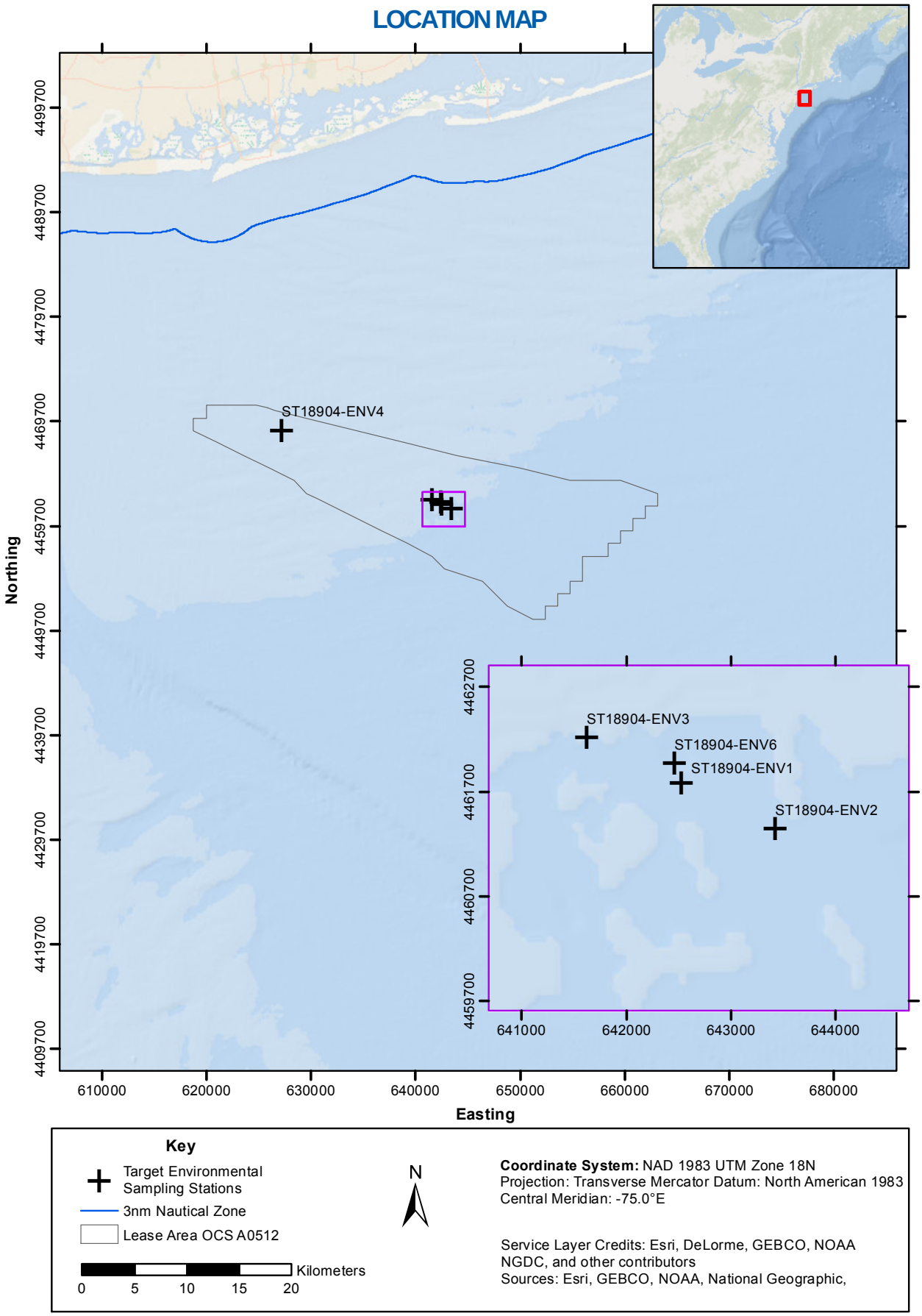
LOCATION MAP
ST18904-ENV4
ST18904-ENV3
ST18904-ENV6
ST18904-ENV1
ST18904-ENV2
Northing
Easting
4499700
4489700
4479700
4469700
4459700
4449700
4439700
4429700
4419700
4409700
610000
620000
630000
640000
650000
660000
670000
680000
4462700
4461700
4460700
4459700
641000
642000
643000
644000
Key
Target Environmental Sampling Stations
3nm Nautical Zone
Lease Area OCS A0512
Kilometers
0 5 10 15 20
N
Coordinate System: NAD 1983 UTM Zone 18N
Projection: Transverse Mercator Datum: North American 1983
Central Meridian: -75.0°E
Service Layer Credits: Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors
Sources: Esri, GEBCO, NOAA, National Geographic,

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GLOSSARY OF TERMS AND ABBREVIATIONS

Benthic	Relating to the seabed
Biogenic	Produced by living organisms
BOEM	Bureau of Ocean Energy Management
Clay	Sediment grains <3.9µm in diameter
CM	Central Meridian
CMECS	Coastal and Marine Ecological Classification Standard
Fines	Sediment grains <63µm in diameter (same as Mud)
FLIDAR	Floating Light Detection and Ranging Buoy
Gravel	Sediment grains >2mm in diameter
HRG	High Resolution Geophysical
Macrofauna	Organisms that are normally larger than the mesh size of the sieve used. In this case 1mm.
MARA	Marine Archaeological Resource Assessment
MBES	Multi-beam Echo Sounder
MDS	Multi Dimensional Scaling
MLLW	Mean Lower Low Water
Mud	Sediment grains <63µm (includes Silt and Clay)
NAD	North American Datum
NOAA	National Oceanic and Atmospheric Administration
PRIMER	A statistical analysis program - Plymouth Routines in Multivariate Research
PSD	Particle Size Distribution
QC	Quality Control
Sand	Sediment grains ≥63µm and <2mm in diameter
SAP	Site Assessment Plan
SD	Standard deviation
Silt	Sediment grains ≥3.9µm and <63µm in diameter
SOW	Scope of Work
SSS	Side Scan Sonar
TOM	Total Organic Matter
UTM	Universal Transverse Mercator

1 INTRODUCTION

1.1 Scope of Work

Gardline Limited completed a geophysical and environmental habitat characterization survey on behalf of Statoil US Wind LLC (now known as Equinor US Wind LLC), across sections of the Commercial Lease of Submerged Lands and Renewable Energy Development on the Outer Continental Shelf (OCS-A 0512). The survey data was required to inform the Site Assessment Plan (SAP) for the deployment of Floating Light Detection and Ranging Buoys and metocean moorings for site resource characterization.. The SAP Survey Campaign area is located 22 to 39 kilometers south of Long Island, New York and covered an area of approximately 328km^2. The location of the survey is presented on the Location Map for reference. Survey operations were undertaken onboard the Gardline research vessel (RV) *Shearwater* between 15-Mar-2018 and 01-Apr-2018.

This report summarizes the results of the habitat characterization survey. The results of the geophysical survey are summarized where relevant in the current report, and reported in full separately (Gardline Limited, 2018).

The objective of the geophysical survey was to undertake a marine archaeological resource assessment (MARA) and a high resolution geophysical (HRG) survey as defined in the scope of work (Statoil, 2017). The purpose of the habitat assessment was to support interpretation of geophysical data to characterize surficial sediment conditions and provide benthic habitat classification. As such the aim of the survey as defined in the SOW was to gather data for:

- Identification of historic properties on or within the seabed
- Identification of seafloor sediment and seafloor morphology
- Identifications of seabed obstructions
- Identification of mobile sand deposits
- Quantify and describe the characteristics of seabed sediments
- Describe the biological nature of the seabed
- Mapping of sand thickness and identification of the unconformity related to the last sea level lowstand.
- Identification of shallow paleolandforms that could represent high probability locations (e.g. former river bank areas) where humans would have inhabited when the continental shelf was emergent during the last sea level lowstand
- Identify geological or manmade hazards (e.g. buried objects, shallow gas, lithological heterogeneities, etc.) beneath the seafloor that could affect the mooring systems.
- Image the shallow subsurface conditions to support the interpretation and mapping of stratigraphic layering and geologic structure.
- Characterize and map sediment structure and bedrock stratigraphy and structure down to 80 meters below the seafloor.
- Map shallow and deep channel infill
- Map presence of gravel lag
- Describe Unit formation and Stratigraphy

The geophysical SoW requirements were achieved by using a multi-beam echo sounder (MBES), side scan sonar (SSS), magnetometer, and shallow and medium penetration sub-bottom profiler (SBP); specifically a pinger and sparker [ultra-high resolution seismic; UHRS]) spread. The environmental survey component utilized a shallow water camera system for seabed imagery acquisition and a 0.1m^2 Day grab to obtain sediment samples across the survey area. The survey area comprised two sites; Flidar 1 and Flidar 2. The Flidar 1 site encompassed the two Metocean moorning locations (Mooring 1 and Mooring 2) and the Flidar 1 location whilst the Flidar 2 site specifically included the Flidar 2 location.

The coordinates for the floating lidar locations are presented in Table 1.1. All positional information in this report is referenced to GRS-1980 Ellipsoid, North American Datum (NAD) 1983. All grid coordinates are projected using Universal Transverse Mercator (UTM) Projection, Grid Zone 18N, Central Meridian (CM) 75° W.

Table 1.1 Coordinates for Floating Lidar Locations

FLIDAR Coordinates	Latitude	Longitude	Easting	Northing
Flidar 1	40º17'39.88" N	73º19'23.02" W	642530	4461784
Metocean mooring 1	40º17'25.27" N	73º18'45.31" W	643430	4461350
Metocean mooring 2	40º17'54.47" N	73º20'00.90" W	641627	4462217
Flidar 2	40º21'36.58" N	73º30'06.02" W	627225	4468810

1.2 Environmental Survey Strategy

A total of four camera and grab stations (ST18904-ENV1 to ST18904-ENV4) were pre-selected by the client to cover each Flidar location and metocean buoy location. Following review of the geophysical data, one additional station (ST18904-ENV6) investigated an area of medium reflectivity to ensure good coverage of all seabed substrate types.

All stations were investigated with a digital still camera system using a 'hover and drift' technique. Seabed sampling was then attempted at the five stations using a 0.1m^2 modified Day Grab. This was to obtain requisite samples for the habitat assessment as well as provide ground-truthing of the geophysical data and visual assessment of seabed habitats based on the seabed imagery. Seabed sampling was successful yielding three acceptable Day grab deployments at each station. One of the samples (designated CHEM) was sub-sampled for particle size distribution (PSD) and total organic matter (TOM) along with a spare. The remaining grab samples, designated MFA and MFB samples, were screened through a 1mm mesh size sieve to provide benthic macrofauna samples and were preserved in buffered formalin. The PSD samples and one of the macrofauna (MFA) samples were sent to their respective analytical laboratories and the results reported in Sections 2.4.1 and 2.5 respectively. A summary of the camera and Day grab sampling positions together with samples acquired at each station is listed in Table 1.2.

Details of the target locations and samples collected at each station are summarized in Table 1.2. Target and actual sampling locations, the latter of which may be slightly offset from the former, are presented in Figure 1.1 and in the surveyor's log sheets in Appendix A. Detailed methods are given in Appendix B.

Table 1.2 Summary of Environmental Sampling Positions and Samples Acquired

Station	Reason for Selection	Target	Water Depth[1]	Easting[2]	Northing[2]	Imagery	Acceptable Day Grab Samples	Samples Acquired			
									Sub-samples		
								Fauna[3]	Total Organic matter	Particle Size	Spare[4]
ST18904-ENV1	Flidar 1	Pre-selected by client	35	642530	4461784	Y	3	2	1	1	1
ST18904-ENV2	Metocean buoy 1	Pre-selected by client	36	643430	4461350	Y	3	2	1	1	1
ST18904-ENV3	Metocean buoy 2	Pre-selected by client	35	641627	4462217	Y	3	2	1	1	1
ST18904-ENV4	Flidar 2	Pre-selected by client	30	627225	4468810	Y	3	2	1	1	1
ST18904-ENV6	Area of medium reflectivity	Pre-selected by client	36	642460	4461973	Y	3	2	1	1	1

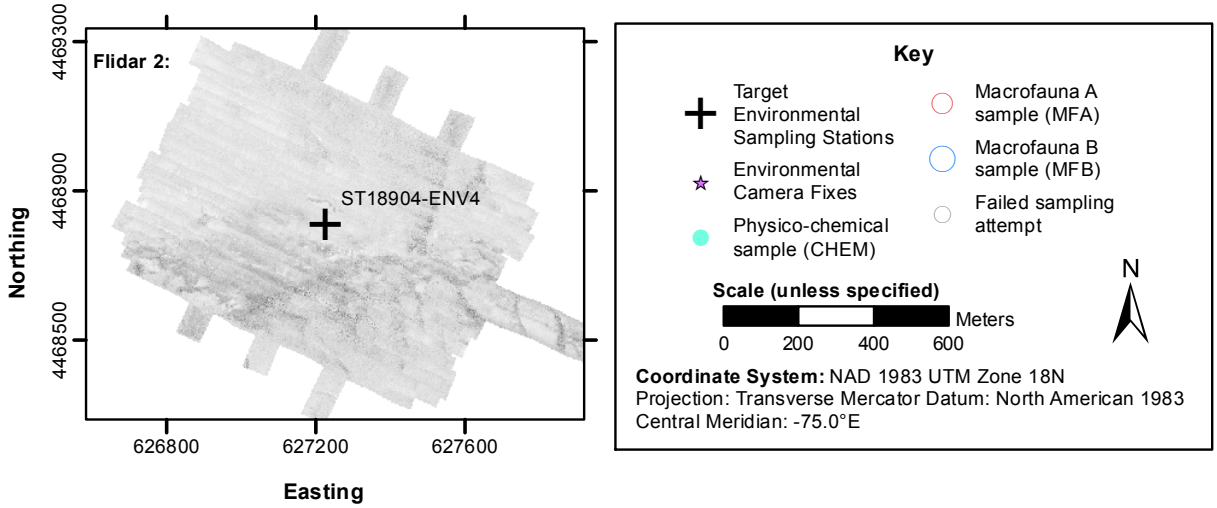
1 Observed depth at time of sampling.

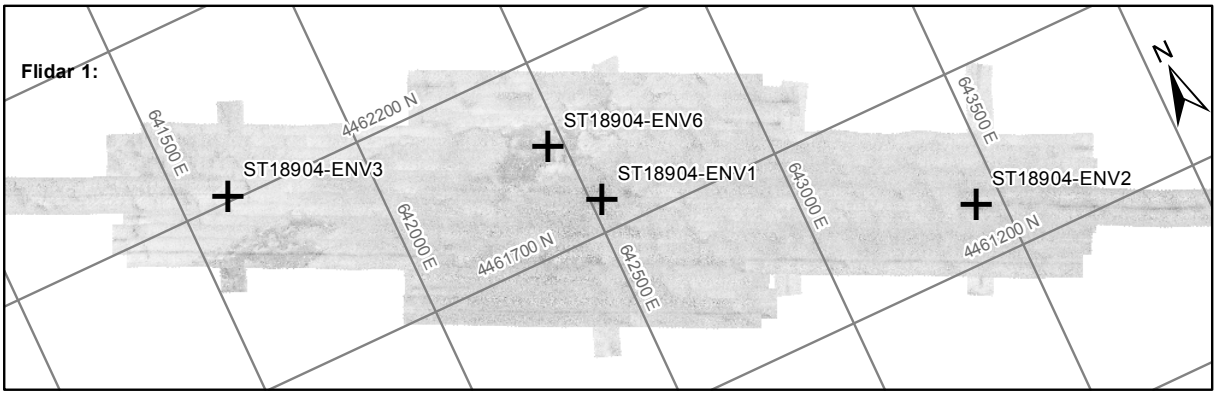
2 Environmental target locations. Actual sampling positions for each individual grab sample are detailed in Appendix A.

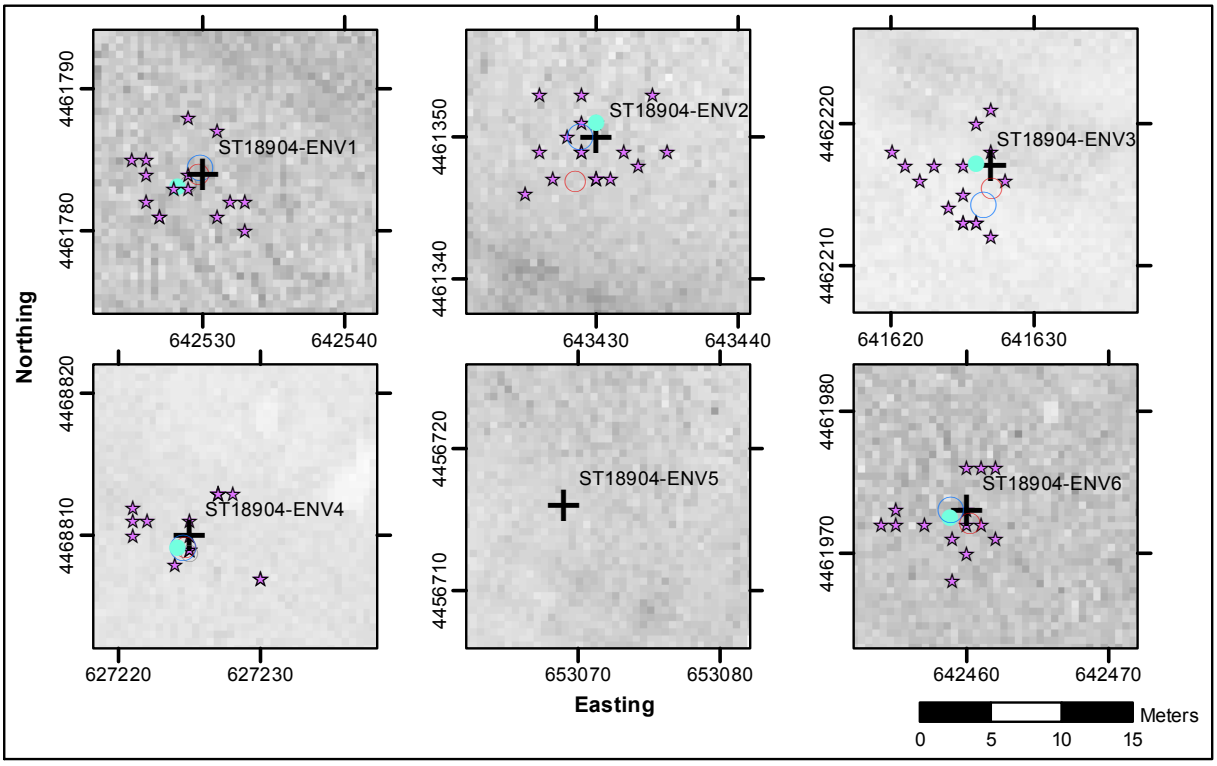
3 One macrofauna sample was sent to be analyzed, one sample kept as a spare at room temperature. Analysis methods are as detailed in Appendix B.

4 One spare sub-sample was stored in a double-lined zip-lock bag and available for analysis of organics and particle size if required. Analysis methods are as detailed in Appendix B.

Figure 1.1 Target and Actual Sampling Locations







2 RESULTS AND DISCUSSION

2.1 Geophysical Survey Summary

2.1.1 Survey Overview

The MARA and HRG surveys for the SAP locations were conducted by the Shearwater. A full geophysical suite consisting of multi-beam echo sounder (MBES), side scan sonar (SSS), magnetometer, and shallow and medium penetration sub-bottom profiler (SBPs; specifically a pinger and sparker [ultra-high resolution seismic; UHRS]) was acquired. After completion of the HRG survey, the RV Shearwater carried out the environmental sampling. A total of five environmental sampling sites were completed during this phase of the project.

2.1.2 Bathymetry and Seabed Features

A color shaded relief of the bathymetry data and SSS mosaics overlain with interpreted seabed features are presented in Figure 2.1 and Figure 2.2. All water depth are reduced to NAVD88.

Flidar 1
Water depths across the Flidar 1 survey area ranged between 33.0m and 37.8m NAVD88. Water depth at the proposed Flidar 1 location (Station ST18904-ENV1) was 36.0m NAVD88, whilst depth at the MetOCean1 and MetOcean 2 locations (Stations ST18904-ENV2 and Stations ST18904-ENV3) were 36.3m and 35.9m NAVD88. The seabed was essentially flat, and shoaled slightly to the west and gradients did not exceed 1°. Low relief bedforms were observed across the survey area.

Seabed sediments were interpreted to comprise sand with occasional shell fragments with areas of higher reflectivity shown to contain a higher proportion of gravel. Two side scan sonar contacts were observed and interpreted as a boulder and an item of linear debris.

Flidar 2
Water depths across the Flidar 2 survey area were slightly shallower than Flidar 1 and ranged between 28.1m and 30.8m NAVD88. Water depth at the proposed Flidar 2 location (Station ST18904-ENV4) was 29.6m NAVD88. A broad, shallow depression up to 2m in depth traversed the survey area from the northwest to southeast with a seabed gradient of <1°.

Seabed sediments were comparable to the Flidar 1 survey area, and comprised sand with occasional shell fragments and isolated patches of gravelly sand. Fourteen side scan sonar contacts were present across the survey area, one of which was interpreted as an item of debris. The remaining thirteen contacts were interpreted as boulders and were situated within areas of gravelly sediments.

No infrastructures were present within both survey areas. Additionally, no seafloor, sub-surface or man-made hazards were observed.

Figure 2.1 Seabed Features with Sonar Mosaic and Color Shaded Relief of Bathymetry – Flidar 1 inclusive of Metocean 1 and Metocean 2

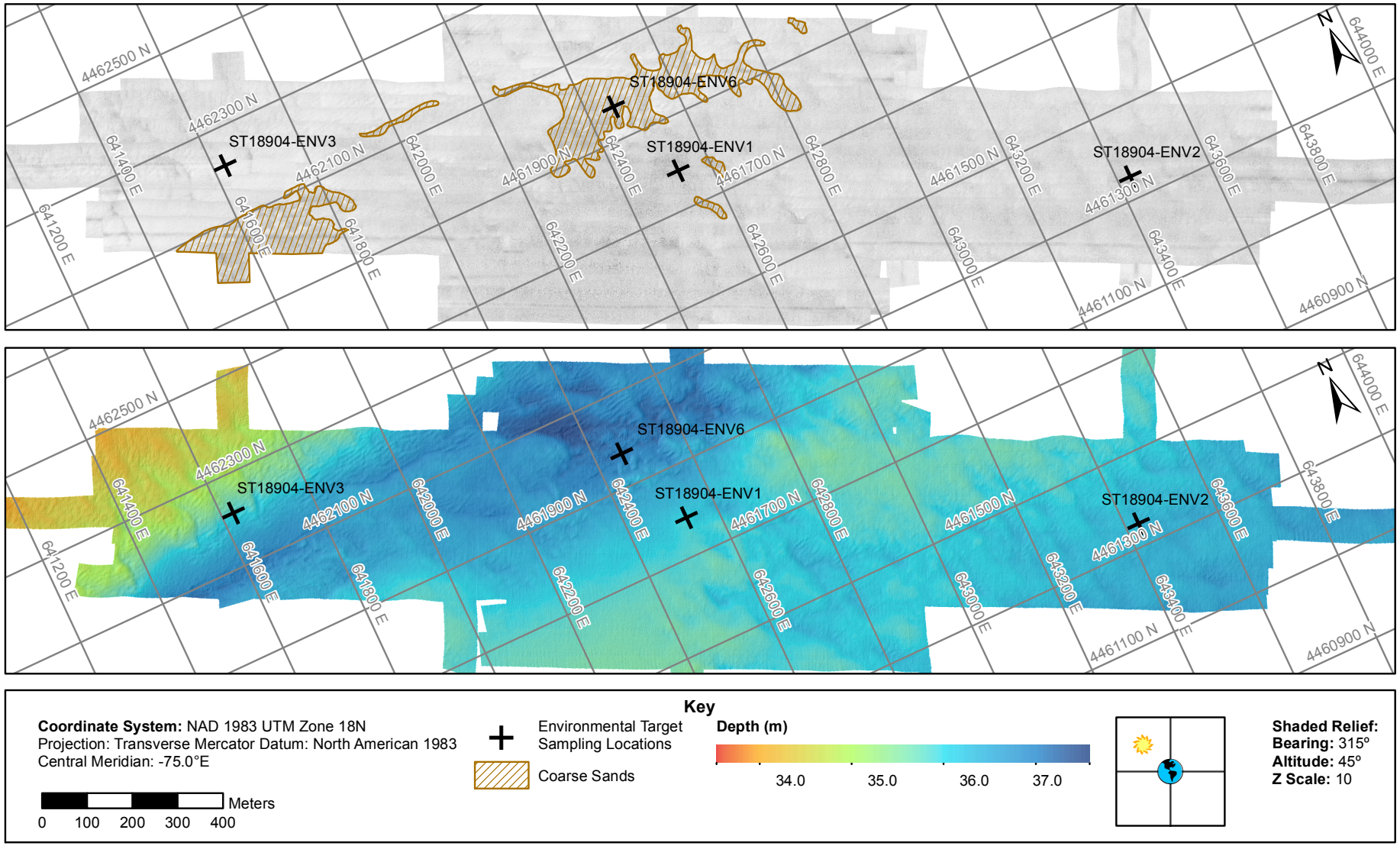
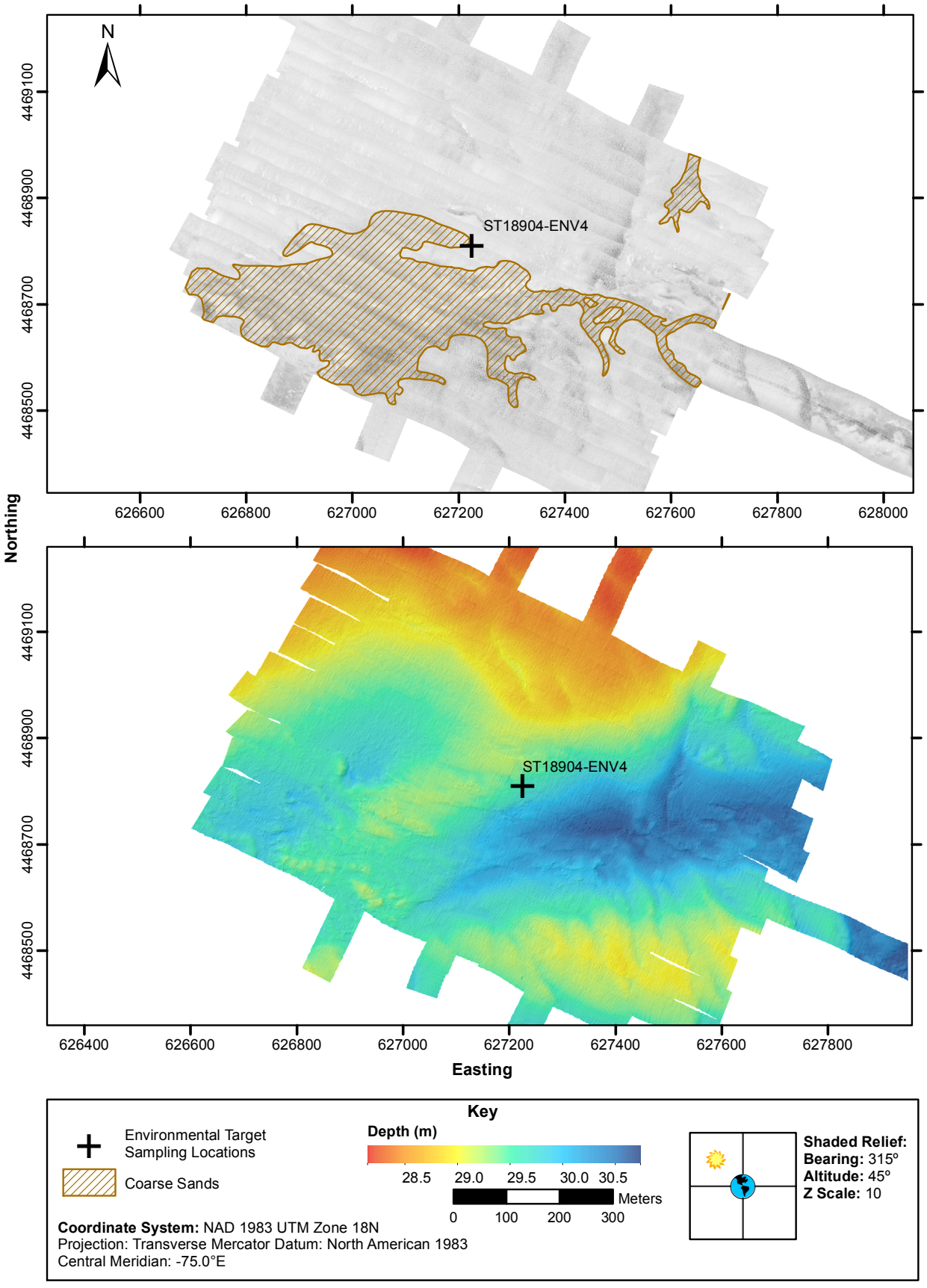


Figure 2.2 Seabed Features with Sonar Mosaic and Color Shaded Relief of Bathymetry – Flidar 2



2.2 Seabed Imagery Observations Summary

Five of the six stations selected for investigation were successfully ground truthed with the digital camera system. Environmental camera imagery across the survey area revealed the seabed predominantly comprised slightly gravelly medium sand with occasional shell fragments. Medium reflectivity at Station ST18904-ENV6 indicated areas of sandy gravel with sand ripples. In all, 80 photographs were taken across the 5 stations. All of the photographs were taken less than 10m from the target location. On average, photographs were taken 3.3m (±1.5 SD) from their target locations. Environmental deck and positioning logs are presented in Appendix A.

The fauna observed included: Annelida (including Polychaeta worm tubes), Arthropoda (Amphipoda, Malacostraca, Paguroidea), Chordata (Tunicata), Cnidaria (cf *Hydractinia symbiolongicarpu*, Ceriantharia), Echinodermata (*Echinarachnius parma*, Holothuroidea), Foraminifera, Mollusca (Bivalvia, Cardiidae, Gastropoda, Naticidae, Neogastropoda), Rhodophyta and indeterminate Animalia.

The survey area did not fall in any final or proposed Critical Habitat as defined by the United States Fish and Wildlife Service (USFWS, 2018). Furthermore, no benthic species or protected fish species listed under the Endangered Species Act (NOAA, 2018) were observed during the current survey. However, special attention should be given to the presence of sensitive benthic habitats as defined by BOEM (2013). These include areas where information suggests the presence of exposed hard bottoms of high, moderate, or low relief; hard bottoms covered by thin, ephemeral sand layers; seagrass patches; or kelp and other algal beds, as well as the presence of Anthozoan species (BOEM, 2013). In the current survey one Anthozoa taxon (Ceriantharia) and one Hydrozoa taxon (*Hydractinia*) were observed. These are not sensitive reef-forming taxa.

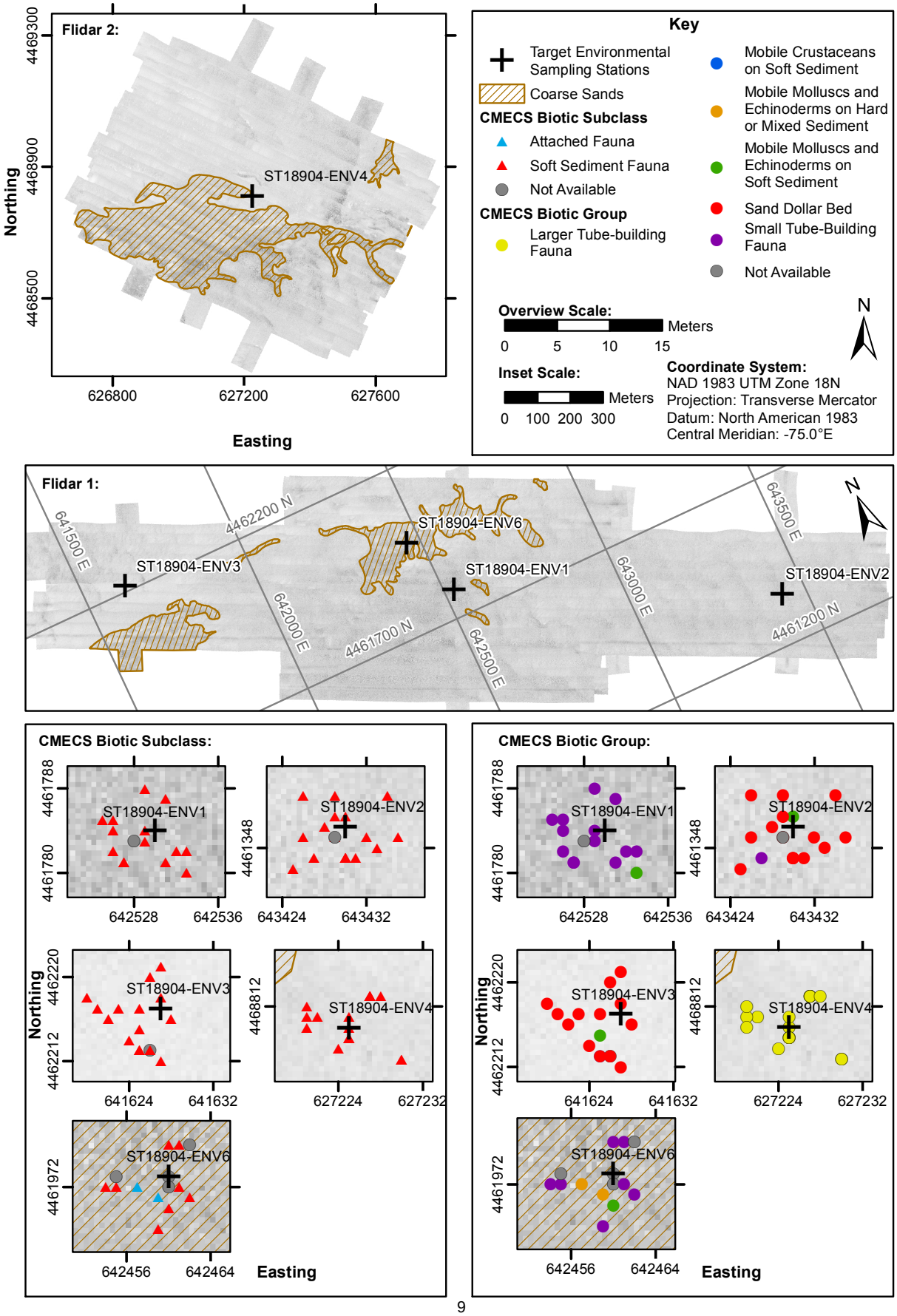
Coastal and Marine Ecological Classification Standard (CMECS) biotic classification of stations based on seabed imagery, presented in Table 2.1 was possible at a lower level at Stations ST18904-ENV2 and ST18904-ENV3, where aggregations of the common sand dollar *Echinarachnius parma* were observed. At these stations the biotic community has been categorized as '*Echinarachnius parma* Bed'.

At Stations ST18904-ENV1 and ST18904-ENV6 small faunal tubes were observed in relatively high densities and therefore these stations were categorized at the biotic group level as 'Small Tube-Building Fauna'. Station ST18904 was categorized as 'Large Tube-Building Fauna'. Figure 2.3 presents the CMECS imagery classification on a fix by fix basis.

Table 2.1 CMECS Biotic Classification From Visual Assessment

Station	Biotic Setting	Biotic Class	Biotic Subclass	Biotic Group	Biotic Community
ST18904-ENV1	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Small Tube-building Fauna	
ST18904-ENV2	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Sand Dollar Bed	*Echinarachnius parma* Bed
ST18904-ENV3	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Sand Dollar Bed	*Echinarachnius parma* Bed
ST18904-ENV4	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Larger Tube-Building Fauna	
ST18904-ENV6	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Small Tube-Building Fauna	

Figure 2.3 CMECS Imagery Classification



2.3 Sediment Sampling Summary

Observations of the sediment were made by the field environmental scientist at the time of sampling. Seabed sampling observations were used to ground truth initial geophysical interpretation and seabed imagery, with results supporting the preliminary findings. A selection of photographs of the recovered samples, together with sample descriptions and positions are given in Appendix D.

Across the 5 sampling stations, 15 grab samples were retained from 17 deployments, using a modified 0.1m^2 steel Day grab. The two failed sampling attempts were due to low sample retention and one occasion of the grab failing to trigger. All samples were taken within 5m of their target location. On average, retained samples were acquired 1.3m (±0.8 SD) from their target location. Environmental deck and positioning logs are presented in Appendix A.

Seabed sampling observations supported the initial geophysical interpretation and seabed imagery, with samples described as consisting of slightly gravelly fine to medium sand at Stations ENV1, ENV2 and ENV3, slightly gravelly silty sand at Station ENV4 and sandy gravel at Station ENV6. Occasional shells and shell fragments were observed at all stations.

Visible fauna within the grab samples included; Annelida (Polychaeta), Arthropoda (Paguroidea), Echinodermata (Clypeasteroida), Mollusca (Bivalvia, Veneroidia), Platyhelminthes and Chondrichthyes (Egg cases). No benthic species or protected fish species listed under the Endangered Species Act (NOAA, 2018) were observed in the grab samples in the current survey.

2.4 Sediment Characteristics

2.4.1 Particle Size Analysis

The results of PSA, determined using wet and dry sieving, are presented in Table 2.2. Full results and histograms illustrating particle size distributions are presented in Appendix E.

The sediments across the survey area were generally homogenous and consistent with the field observations of the recovered sediment samples, seabed imagery observations and geophysical interpretation. Sediments were classified as fine sand or medium sand under the Wentworth classification of mean grain size and were described as moderately well sorted for the majority of stations. The exception was Station ST18904-ENV6 which was classified as poorly sorted coarse sand. The mean particle diameter of sediments showed a degree of variation, ranging from 133.7µm to 831.4 µm at Stations ST18904-ENV4 and ST18904 ENV6.

The sand fraction (≥63µm, <2mm) accounted for the majority of the sample at each station ranging from 75.8% at Station ST18904-ENV6 to 97.9% at Station ST18904-ENV3. The remaining sample comprised gravel (≥2mm) varying between 0.2% at Station ST18904-ENV3 and 23.0% at Station ST18904-ENV6, while percentages of fines (<63µm) ranged between 1.2% and 4.4%. These generally homogenous results resulted in the majority of stations being described as slightly gravelly sand under the modified Folk classification. The exception was Station ST18904-ENV6, comprising gravelly sand due to higher gravel content.

The modified Folk classifications, and therefore CMECS substrate components classification Table 2.3), across all stations ranged from slightly gravelly sand at Stations ST18904-ENV1 to ST18904-ENV4 to gravelly sand at Station ST18904-ENV6.

Overall, the sediment classifications of fine sand to coarse sand (Wentworth) and slightly gravelly sand to gravelly sand (Folk and Ward) were comparable across both Flidar 1 and Flidar 2 survey areas, suggesting overall homogeneity in sediment type, with evidence of subtle natural spatial variation in composition across the survey area. Additionally, the results supported the geophysical interpretation of medium to coarse sands. No evidence of fishing activity such as trawl scars were observed in the seabed imagery. In conclusion, with no evidence of seabed disturbance within the area, the gravelly sediments were considered representative of the wider area and region.

Table 2.2 Sediment Characteristics

Station	Mean Diameter (µm)[1]	Mean Diameter (phi)[1]	Mud %	Sand %	Gravel %	Wentworth Classification of Mean Grain Size	Sorting[1]	Modified Folk Classification	Total Organic Matter (%)	Water Content (%)[2]
ST18904-ENV1	420.4	1.25	1.2	97.6	1.2	Medium Sand	Moderately well	Slightly gravelly sand	0.2	20.8
ST18904-ENV2	337.0	1.57	1.3	97.8	0.9	Medium Sand	Moderately well	Slightly gravelly sand	0.3	23.0
ST18904-ENV3	228.2	2.13	1.9	97.9	0.2	Fine Sand	Moderately well	Slightly gravelly sand	0.4	22.2
ST18904-ENV4	133.7	2.90	4.4	94.7	0.9	Fine Sand	Moderately well	Slightly gravelly sand	0.7	28.4
ST18904-ENV6	831.4	0.27	1.2	75.8	23.0	Coarse Sand	Poor	Gravelly sand	0.2	16.7
Minimum	133.7	0.3	1.2	75.8	0.2	Fine to coarse sand	Poor and moderately well sorted	Slightly gravelly and gravelly sand	0.2	16.7
Maximum	831.4	2.9	4.4	97.9	23.0				0.7	28.4
Mean	390.1	1.6	2.0	92.8	5.2				0.4	22.2
±SD	269.5	1.0	1.4	9.6	9.9				0.2	4.2

1 Statistics calculated using Method of Moments (MoM). Sorting coefficients (MoM standard deviation) have had Folk and Ward (1957) descriptors assigned.

2 Water content as percentage of the dry sample weight.

Table 2.3 CMECS Substrate Component Classification

Station	Substrate Origin	Substrate Class	Substrate Subclass	Substrate Group	Substrate Subgroup
ST18904-ENV1	Geologic Substrate	Unconsolidated Mineral Substrate	Fine Unconsolidated Substrate	Slightly Gravelly	Slightly Gravelly Sand
ST18904-ENV2	Geologic Substrate	Unconsolidated Mineral Substrate	Fine Unconsolidated Substrate	Slightly Gravelly	Slightly Gravelly Sand
ST18904-ENV3	Geologic Substrate	Unconsolidated Mineral Substrate	Fine Unconsolidated Substrate	Slightly Gravelly	Slightly Gravelly Sand
ST18904-ENV4	Geologic Substrate	Unconsolidated Mineral Substrate	Fine Unconsolidated Substrate	Slightly Gravelly	Slightly Gravelly Sand
ST18904-ENV6	Geologic Substrate	Unconsolidated Mineral Substrate	Coarse Unconsolidated Substrate	Gravelly	Gravelly Sand

2.4.2 Organic Matter and Organic Carbon

The results of TOM analysis is presented in Table 2.2. Organic matter in marine sediments is primarily made up of detrital matter and naphthenic materials (carboxylic acids and humic substances with a small proportion of biological biomass). Total organic matter (TOM) concentrations ranged between 0.2% at Stations ST18904-ENV1 and ST18904-ENV6 to 0.7% at Station ST18904-ENV4. Water content, measured as a percentage of the dry sample weight, ranged from 16.7% at Station ST18904-ENV6 to 28.4% at Station ST18904-ENV4.

2.5 Macrofaunal Interpretation of Benthic Grab Samples

2.5.1 Overview

Two 0.1m^2 faunal samples (MFA and MFB) were collected from each station, one of which (MFA) was worked up and the second retained and appropriately stored as a spare. All faunal samples were screened through a 1mm sieve. Before analyzing the data set provided by the laboratory, several taxa were removed as per our stated methods; however all grab sample records, regardless of whether they were included in statistical analyses, are listed in Appendix F. Additional species were observed opportunistically in the digital imagery but were not considered quantitatively in the statistical analysis. Please see Appendix E, Section 2.2, for a discussion of digital imagery.

2.5.2 Summary and Univariate Statistics

In total, 10 faunal samples were collected from five benthic grab sampling stations. A total of 529 individuals representing 60 taxa were recorded across the five stations. Immature specimens accounted for 3 individuals from 3 taxa representing <1% of the total individuals and 5% of the total taxa.

A single individual of the Ocean Quahog (*Arctica islandica*) was retained within the fauna sample from Station ST18904-ENV3 and the sample was located within an area designated as an essential fish habitat for this taxon (NOAA, 2018).

The presence of large numbers of juveniles in the macrobenthos tends to be ephemeral due to high mortality and can temporarily disturb the normal balance of relative abundance amongst species (and consequent measures of diversity). When ranked by abundance no juveniles were within the top ten most abundant species in all sites. A 2STAGE analysis was conducted in PRIMER (v7) to determine whether the presence of ‘immature’ records caused significant variation between the rationalized full and adult (all ‘immature’ removed) data sets. The test showed that the two data sets were *c.*100% similar, indicating that the ‘immature’ records were not expected to introduce any significant variation into the multivariate analyses. For this reason, subsequent analyses were conducted on the full faunal data set, inclusive of ‘immature’ counts.

The full faunal data set was divided into five major taxonomic groups: Annelida (Polychaeta), Arthropoda (Crustacea), Mollusca, Echinodermata and ’Others’. The ‘Other’ category comprised a single taxon of Cnidaria (Anthozoa; Ceriantharia) and three taxa of Nemertea (ribbon worm) across the surveyed area. The proportional and absolute contributions of the major taxonomic groups to the total abundance of individuals and taxa in each station is summarized in Table 2.4.

Table 2.4 Contribution of Gross Taxonomic Groups

Station	Annelida	Arthropoda	Cnidaria	Echinodermata	Mollusca	Nemertea	Total
ST18904-ENV1	29	34	0	1	1	4	69
ST18904-ENV2	14	29	0	0	1	0	44
ST18904-ENV3	20	37	0	5	20	5	87
ST18904-ENV4	86	146	2	0	2	0	236
ST18904-ENV6	70	18	0	0	1	4	93
Number of Individuals	**219**	**264**	**2**	**6**	**25**	**13**	**529**
Number of Taxa	**27**	**17**	**1**	**1**	**11**	**3**	**60**
Percentage (%) of Individuals	**41.4**	**49.9**	**0.4**	**1.1**	**4.7**	**2.5**	**100.0**
Percentage (%) of Taxa	**45.0**	**28.3**	**1.7**	**1.7**	**18.3**	**5.0**	**100.0**

Arthropoda dominated the macrofaunal composition within the survey area, with 264 individuals (49.9% of all individuals) across 17 taxa (28.3% of all taxa) (Table 2.4). Arthropoda dominated the faunal composition in terms of individuals while Polychaeta dominated the faunal composition in terms of taxa at each station. In the full data set only 2 taxa (3% of those enumerated) were found at every station (*Nephtys picta, Byblis serrata*). There were 37 taxa that occurred in only one station (62% of all enumerated taxa), 16 of which were represented by a single individual (27% of all enumerated taxa). Furthermore, 48 taxa (80% of those enumerated) were represented by <10 individuals across all samples.

The results of the species ranking are presented in Table 2.5. The ten most dominant taxa in the full data set comprised; Polychaeta (*Nephtys picta*, *Scoletoma fragilis*, *Scoletoma verrilli*, *Ninoe nigripes*), Crustacea (*Rhepoxynius hudsoni*, *Byblis serrata*, *Unciola irrorata*, *Ampelisca verrilli, Edotia triloba*) and Others (*Carinomella lactea*).

Table 2.5 Species Ranking

Rank		Species/Taxon	Total Rank Score	Fidelity	Total Abundance
Score	Abundance				
1	4	*Nephtys picta*	37	0.74	38
2	2	*Rhepoxynius hudsoni*	31	0.69	52
3	3	*Scoletoma fragilis*	30	0.75	47
4	5	*Byblis serrata*	27	0.77	4727
5	7	*Scoletoma verrilli*	25	0.83	1417
5	8	*Unciola irrorata*	25	1.00	14
7	1	*Ampelisca verrilli*	23	01.15	124
8	6	*Ninoe nigripes*	22	1.47	25
8	9	*Edotia triloba*	22	2.20	11
8	13	*Carinomella lactea*	22	4.40	9

The fidelity of the species ranking can give an indication of the taxonomic distribution, with values close to or ≥ 0.8 and ≤ 1.2 indicating a generally evenly distributed community, while values outside

this range represent a patchier distribution. Three taxa were recorded between the aforementioned range; the polychaete *S. verrilli* and the crustaceans *U. irrorata, A. verrilli.* All remaining top 10 ranked taxa presented values outside this range which indicated a patchy distribution of taxa between stations. There was minor re-ordering of most taxa except *Rhepoxynius hudsoni, S. fragilis, E. triloba* and *C. lactea* when ranked by abundance, and their absence from one or more stations across the survey area were additional indicators of slightly more uneven distribution of these species.

The univariate statistics were indicative of a generally homogenous community structures across the stations in the full data set. All stations were generally evenly distributed and of low dominance, with mean Pielou's evenness values of 0.77 (±0.09 SD) and mean Simpson's dominance indices of 0.19 (±0.07 SD). Mean Shannon-Weiner diversity values for were indicative of a moderately diverse community ($H' \leq 3.75$).

Table 2.6 Faunal Univariate Statistics

Station	n Taxa	n Individuals	Margalef's Richness (d)	Simpson's Dominance (λ)	Pielou's Evenness (J)	Shannon Wiener Diversity (H'_{log2})
ST18904-ENV1	19	69	4.25	0.12	0.85	3.60
ST18904-ENV2	8	44	1.85	0.23	0.79	2.38
ST18904-ENV3	23	87	4.93	0.13	0.83	3.75
ST18904-ENV4	24	236	4.39	0.30	0.61	2.86
ST18904-ENV6	21	93	4.41	0.18	0.76	3.33
Minimum	8	44	1.85	0.12	0.61	2.38
Maximum	25	236	4.93	0.30	0.85	3.75
Mean	19	106	3.97	0.19	0.77	3.18
±SD	6	75	1.21	0.07	0.09	0.56

CMECS Biotic classification of stations based on seabed imagery was mostly confirmed by the dominant macrofauna taxa found at each station, which allowed the classification to the lowest level (Table 2.7). The exceptions were Stations ST18904-ENV1 and ST18904-ENV6, where their Biotic Group changed from 'Small Tube-building Fauna' to 'Diverse Soft Sediment Epifauna' and 'Small Surface-Burrowing Fauna' respectively.

Station ST18904-ENV1 faunal composition comprised sand dollars and mobile mollusk, and was therefore categorized as having a resemblance to a 'Sand Dollar/Sea Pansy/Mobile Mollusk Bed (Large Megafauna). At Station ST18904-ENV4 *Ampelisca* sp. dominated the macrofaunal composition and therefore the biotic community has been categorized as 'Robust *Ampelisca* Bed'. By comparison the macrofauna community at Station ST18904-ENV6 was dominated by Lumbrineridae and therefore categorized at the biotic community level as a 'Lumbrinerid Bed'. The remaining stations were categorized as '*Echinarachnius parma* Bed'.

Table 2.7 CMECS Biotic Classification from Macrofauna

Station	Biotic Setting	Biotic Class	Biotic Subclass	Biotic Group	Biotic Community
ST18904-ENV1	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Diverse Soft Sediment Epifauna	Sand Dollar/ Sea Pansy/ Mobile Mollusk Bed (Large Megafauna)
ST18904-ENV2	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Sand Dollar Bed	*Echinarachnius parma* Bed
ST18904-ENV3	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Sand Dollar Bed	*Echinarachnius parma* Bed
ST18904-ENV4	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Larger Tube-Building Fauna	Robust *Ampelisca* Bed
ST18904-ENV6	Benthic Biota	Faunal Bed	Soft Sediment Fauna	Small Surface-Burrowing Fauna	Lumbrinerid Bed

2.6 Summary of Results

Sediment Characteristics

The geophysical (MBES and SSS) data together with seabed imagery observations indicated that the seabed sediments across the survey area predominantly comprised medium to coarse sand with patches of gravelly sand. Results of the PSD analysis and seabed imagery analysis were consistent with the geophysical interpretation. The modified Folk classification, and therefore CMECS substrate components classification, across all stations ranged between slightly gravelly sand (Stations ST18904-ENV1 and ST18904-ENV4) and gravelly sand (Station ST18904-ENV6).

TOM concentrations and water content were generally homogenous.

Faunal Community

The macrofaunal (infaunal) community was found to be relatively sparse with only 2 taxa (3%) found at every station and 37 taxa (67%) present at only one station. Macrofaunal abundance was also low with 48 taxa (80%) represented by <10 individuals, 16 of which were represented by a single individual (27% of taxa). The analysis of the macrofauna stations revealed a community dominated by Arthropoda (49.9%) followed by Annelida (41.4%) with the remaining Phyla (Cnidaria, Echinodermata, Mollusca and Nemertea) representing ≤5% of the community each. Univariate analysis suggested the survey area was homogenous, with a generally evenly distributed and diverse macrofauna community of low species dominance.

All stations were categorized at the CMECS Biotic Community level as Sand Dollar/Sea Pansy/Mobile Mollusk Bed (Large Megafauna), Echinarachnius parma Bed, Robust Ampelisca Bed and Lumbrinerid Bed.

A single individual of the Ocean Quahog (*Arctica islandica*) was retained within the fauna sample from Station ST18904-ENV3, located within an essential fish habitat for this taxon according to NOAA (2018). Furthermore, two individuals of Anthozoa were observed in the fauna sample from Station ST18904-ENV4. The anthozoan (Ceriantharia) and hydrozoan (*Hydractinia*) are not reef-forming species listed by BOEM (2013) as comprising sensitive habitats.

Other than the aforementioned, overall, the survey area did not fall in any final or proposed Critical Habitat as defined by the United States Fish and Wildlife Service (USFWS, 2018) or National Marine Fisheries Service. Furthermore, no benthic species or protected fish species listed under the Endangered Species Act (NOAA, 2018) were observed in the seabed imagery or the samples acquired and analyzed. Nor was there any evidence from the seabed imagery or sampling of any sensitive habitats within the surveyed area, as defined by BOEM (2013), such as exposed hard bottoms or those covered by ephemeral sand layers, seagrass patches, kelp or other algal beds.

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APPENDICES

APPENDIX A FIELD SAMPLING LOGS

APPENDIX A FIELD SAMPLING LOGS

SEABED IMAGERY LOG SHEET (Deck) **QPRO-0753**

Job No: 11179	**Area:** NJ/NY Bight	**Vessel:** RV *Shearwater*	**Operator:** TSH
Date: from: 31-Mar-2018 to: 31-Mar-2018	**Page:** Page 1 of 2	**Client:** Statoil US Wind LLC	**Scale bar:** 10cm interval laser lines
Project: NY Empire Wind G&G Survey			**Equipment:** Kongsberg 14-208

Sample Number	Station Number	Time on overlay	DVD/ Video No	DVD Chapter	Counter (start & end)	Sediment Description	Comments	TOT FIXES	FIXES Nos
31-Mar-18									
1	ST18904-ENV3	15:07:00	1	3	00:04:00	**Sediment:** Slightly gravelly fine sand with shell fragments. Sediment easily suspended. Occasional sand ripples observed. **Fauna:** Annelida (Polychaeta), Crustacea (Paguroidea), Echinodermata (Clypeasteroida - Sand Dollar), Mollusca (Gastropoda).	Fix number on overlay has extra zero added onto the end. VHS wasn't recording until 15:17	16	1-16
		15:20:00	1		00:17:00				
2	ST18904-ENV6	15:39:00	1	4 & 5	00:17:00	**Sediment:** Coarse sandy gravel, with shells and shell fragments. Sand ripples observed. **Fauna:** Annelida (Polychaeta), Echinodermata (Clypeasteroida - Sand Dollar), Mollusca (Bivalvia).		14	17 - 30
		15:51:00	1		00:29:00				
3	ST18904-ENV1	16:28:00	1	6 & 7	00:28:00	**Sediment:** Slightly gravelly coarse sand with shell fragments. **Fauna:** Annelida **(**Polychaeta), Crustacea (Paguroidea), Echinodermata (Clypeasteroida - Sand Dollar), Mollusca (Bivalvia).		15	31 - 45
		16:41:00	1		00:41:00				
4	ST18904-ENV2	17:03:00	1	8 & 9	00:41:00	**Sediment:** Slightly shelly medium sand. Fine veneer of sediment on surface easily suspended. Sand ripples observed. **Fauna:** Annelida (Polychaeta), Crustacea (Paguroidea), Echinodermata (Clypeasteroida - Sand Dollar).		18	46 - 63
		17:15:00	1		00:53:00				

APPENDIX A FIELD SAMPLING LOGS

SEABED IMAGERY LOG SHEET (Deck)								QPRO-0753
Job No: 11179		**Area:** NJ/NY Bight		**Vessel:** RV *Shearwater*		**Operator:** TSH		
Date: from: 31-Mar-2018 to: 31-Mar-2018		**Page:** Page 2 of 2		**Client:** Statoil US Wind LLC		**Scale bar:** 10cm interval laser lines		
Project: NY Empire Wind G&G Survey						**Equipment:** Kongsberg 14-208		
Sample Number	**Station Number**	**Time on overlay**	**DVD/ Video No**	**DVD Chapter**	**Counter (start & end)**	**Sediment Description**	**Comments**	**TOT FIXES**	**FIXES Nos**
5	ST18904-ENV4	21:10:00	2	1 & 2	00:53:00	**Sediment:** Fine sand with occassional shell fragments. Sediment easily suspended during sampling. **Fauna:** Annelida (Polychaeta tubes).		17	64 - 80
		21:23:00	1		01:06:00				

APPENDIX A FIELD SAMPLING LOGS

Gardline — Seafloor Sampling Positioning Summary

Job No	11179			Vessel	R.V. *Shearwater*						
Client	Statoil US Wind LLC			Vessel Reference Point (VRP)	CoG						
Project Name	NY Empire Wind G&G Survey			Deployment Location	A-frame, starboard side	x	6.946	y	-12.634	z	5.806
Primary Positioning System	QPS QINSy			Actual Coordinates derived fro	Deployment Location						
Geodetic Reference System	Datum	North American Datum (NAD) 1983	Ellipsoid	GRS-1980	Projection	UTM ZONE 18 (75W)		Vertical / Tidal Datum	LAT		

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration	Sample Retention	Retention	Observed Seafloor Depth (m)	Actual coordinates		Target coordinates		Offset from target				Surveyor	Remarks
								Easting	Northing	Easting	Northing	dE	dN	Range	Bearing		
31-Mar-2018	15:09:13	1	ST18904-ENV3			Camera	36	641628	4462216	641627	4462217	-1	1	1	321	TSH	
31-Mar-2018	15:09:41	2	ST18904-ENV3			Camera	36	641625	4462217	641627	4462217	2	0	2	81	TSH	
31-Mar-2018	15:10:39	3	ST18904-ENV3			Camera	36	641625	4462215	641627	4462217	2	2	2	46	TSH	
31-Mar-2018	15:12:13	4	ST18904-ENV3			Camera	36	641625	4462213	641627	4462217	2	4	5	24	TSH	
31-Mar-2018	15:12:56	5	ST18904-ENV3			Camera	36	641626	4462213	641627	4462217	1	4	4	15	TSH	
31-Mar-2018	15:13:10	6	ST18904-ENV3			Camera	36	641625	4462213	641627	4462217	2	4	4	24	TSH	
31-Mar-2018	15:13:48	7	ST18904-ENV3			Camera	36	641626	4462213	641627	4462217	1	4	4	9	TSH	
31-Mar-2018	15:14:23	8	ST18904-ENV3			Camera	36	641624	4462214	641627	4462217	3	3	4	46	TSH	
31-Mar-2018	15:14:37	9	ST18904-ENV3			Camera	36	641627	4462212	641627	4462217	0	5	5	1	TSH	
31-Mar-2018	15:15:56	10	ST18904-ENV3			Camera	36	641622	4462216	641627	4462217	5	1	5	77	TSH	
31-Mar-2018	15:16:04	11	ST18904-ENV3			Camera	36	641621	4462217	641627	4462217	6	0	6	87	TSH	
31-Mar-2018	15:16:49	12	ST18904-ENV3			Camera	36	641623	4462217	641627	4462217	4	0	4	88	TSH	
31-Mar-2018	15:18:10	13	ST18904-ENV3			Camera	36	641620	4462218	641627	4462217	7	-1	7	101	TSH	
31-Mar-2018	15:19:18	14	ST18904-ENV3			Camera	36	641627	4462218	641627	4462217	0	-1	1	190	TSH	
31-Mar-2018	15:20:04	15	ST18904-ENV3			Camera	36	641627	4462221	641627	4462217	0	-4	4	185	TSH	
31-Mar-2018	15:20:48	16	ST18904-ENV3			Camera	36	641626	4462220	641627	4462217	1	-3	3	155	TSH	
31-Mar-2018	15:40:14	17	ST18904-ENV6			Camera	37	642459	4461971	642460	4461973	1	2	2	29	TSH	
31-Mar-2018	15:40:44	18	ST18904-ENV6			Camera	37	642457	4461972	642460	4461973	3	1	3	75	TSH	
31-Mar-2018	15:41:28	19	ST18904-ENV6			Camera	37	642460	4461973	642460	4461973	0	0	0	149	TSH	
31-Mar-2018	15:42:37	20	ST18904-ENV6			Camera	37	642454	4461972	642460	4461973	6	1	6	77	TSH	
31-Mar-2018	15:42:45	21	ST18904-ENV6			Camera	37	642455	4461972	642460	4461973	5	1	5	76	TSH	
31-Mar-2018	15:43:32	22	ST18904-ENV6			Camera	37	642455	4461973	642460	4461973	5	0	5	92	TSH	
31-Mar-2018	15:44:38	23	ST18904-ENV6			Camera	37	642461	4461976	642460	4461973	-1	-3	4	196	TSH	
31-Mar-2018	15:45:17	24	ST18904-ENV6			Camera	37	642460	4461972	642460	4461973	0	1	1	342	TSH	
31-Mar-2018	15:45:44	25	ST18904-ENV6			Camera	37	642462	4461976	642460	4461973	-2	-3	4	221	TSH	
31-Mar-2018	15:46:27	26	ST18904-ENV6			Camera	37	642460	4461976	642460	4461973	0	-3	3	172	TSH	
31-Mar-2018	15:48:09	27	ST18904-ENV6			Camera	37	642459	4461968	642460	4461973	1	5	5	8	TSH	
31-Mar-2018	15:49:07	28	ST18904-ENV6			Camera	37	642460	4461970	642460	4461973	0	3	3	9	TSH	
31-Mar-2018	15:50:03	29	ST18904-ENV6			Camera	37	642461	4461972	642460	4461973	-1	1	1	304	TSH	
31-Mar-2018	15:50:52	30	ST18904-ENV6			Camera	37	642462	4461971	642460	4461973	-2	2	2	320	TSH	
31-Mar-2018	16:28:45	31	ST18904-ENV1			Camera	36	642529	4461784	642530	4461784	1	0	1	71	TSH	
31-Mar-2018	16:29:36	32	ST18904-ENV1			Camera	36	642529	4461783	642530	4461784	1	1	2	54	TSH	
31-Mar-2018	16:30:49	33	ST18904-ENV1			Camera	36	642526	4461784	642530	4461784	4	0	4	83	TSH	
31-Mar-2018	16:31:46	34	ST18904-ENV1			Camera	36	642525	4461785	642530	4461784	5	-1	5	100	TSH	

APPENDIX A FIELD SAMPLING LOGS

Gardline — Seafloor Sampling Positioning Summary

Job No	11179			Vessel	R.V. *Shearwater*						
Client	Statoil US Wind LLC			Vessel Reference Point (VRP)	CoG						
Project Name	NY Empire Wind G&G Survey			Deployment Location	A-frame, starboard side	x	6.946	y	-12.634	z	5.806
Primary Positioning System	QPS QINSy			Actual Coordinates derived fro	Deployment Location						
Geodetic Reference System	Datum	North American Datum (NAD) 1983	Ellipsoid	GRS-1980	Projection	UTM ZONE 18 (75W)		Vertical / Tidal Datum	LAT		

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration	Sample Retention	Retention	Observed Seafloor Depth (m)	Actual coordinates		Target coordinates		Offset from target				Surveyor	Remarks
								Easting	Northing	Easting	Northing	dE	dN	Range	Bearing		
31-Mar-2018	16:32:30	35	ST18904-ENV1			Camera	36	642526	4461785	642530	4461784	4	-1	4	103	TSH	
31-Mar-2018	16:33:39	36	ST18904-ENV1			Camera	36	642531	4461787	642530	4461784	-1	-3	3	196	TSH	
31-Mar-2018	16:34:26	37	ST18904-ENV1			Camera	36	642529	4461788	642530	4461784	1	-4	5	168	TSH	
31-Mar-2018	16:35:34	38	ST18904-ENV1			Camera	36	642533	4461782	642530	4461784	-3	2	3	300	TSH	
31-Mar-2018	16:36:16	39	ST18904-ENV1			Camera	35	642533	4461780	642530	4461784	-3	4	5	326	TSH	
31-Mar-2018	16:37:15	40	ST18904-ENV1			Camera	35	642531	4461781	642530	4461784	-1	3	3	338	TSH	
31-Mar-2018	16:37:57	41	ST18904-ENV1			Camera	35	642532	4461782	642530	4461784	-2	2	2	323	TSH	
31-Mar-2018	16:39:06	42	ST18904-ENV1			Camera	36	642527	4461781	642530	4461784	3	3	4	48	TSH	
31-Mar-2018	16:39:52	43	ST18904-ENV1			Camera	36	642526	4461782	642530	4461784	4	2	4	68	TSH	
31-Mar-2018	16:40:35	44	ST18904-ENV1			Camera	36	642527	4461781	642530	4461784	3	3	4	52	TSH	
31-Mar-2018	16:41:21	45	ST18904-ENV1			Camera	36	642528	4461783	642530	4461784	2	1	2	55	TSH	
31-Mar-2018	17:03:42	46	ST18904-ENV2			Camera	36	643428	4461350	643430	4461350	2	0	2	86	TSH	
31-Mar-2018	17:04:28	47	ST18904-ENV2			Camera	36	643429	4461349	643430	4461350	1	1	1	41	TSH	
31-Mar-2018	17:05:18	48	ST18904-ENV2			Camera	36	643430	4461351	643430	4461350	0	-1	1	163	TSH	
31-Mar-2018	17:06:43	49	ST18904-ENV2			Camera	36	643429	4461353	643430	4461350	1	-3	4	159	TSH	
31-Mar-2018	17:07:54	50	ST18904-ENV2			Camera	36	643426	4461353	643430	4461350	4	-3	5	127	TSH	
31-Mar-2018	17:08:53	51	ST18904-ENV2			Camera	35	643434	4461353	643430	4461350	-4	-3	4	234	TSH	
31-Mar-2018	17:09:35	52	ST18904-ENV2			Camera	36	643432	4461349	643430	4461350	-2	1	2	298	TSH	
31-Mar-2018	17:10:13	53	ST18904-ENV2			Camera	36	643429	4461351	643430	4461350	1	-1	1	123	TSH	
31-Mar-2018	17:10:58	54	ST18904-ENV2			Camera	35	643435	4461349	643430	4461350	-5	1	5	280	TSH	
31-Mar-2018	17:11:17	55	ST18904-ENV2			Camera	35	643433	4461348	643430	4461350	-3	2	4	305	TSH	
31-Mar-2018	17:11:49	56	ST18904-ENV2			Camera	36	643431	4461347	643430	4461350	-1	3	3	349	TSH	
31-Mar-2018	17:12:01	57	ST18904-ENV2			Camera	36	643430	4461347	643430	4461350	0	3	3	352	TSH	
31-Mar-2018	17:12:37	58	ST18904-ENV2			Camera	36	643430	4461347	643430	4461350	0	3	3	3	TSH	
31-Mar-2018	17:12:42	59	ST18904-ENV2			Camera	36	643430	4461347	643430	4461350	0	3	3	7	TSH	
31-Mar-2018	17:13:32	60	ST18904-ENV2			Camera	36	643427	4461347	643430	4461350	3	3	4	47	TSH	
31-Mar-2018	17:14:17	61	ST18904-ENV2			Camera	36	643426	4461349	643430	4461350	4	1	4	75	TSH	
31-Mar-2018	17:14:57	62	ST18904-ENV2			Camera	36	643425	4461346	643430	4461350	5	4	6	54	TSH	
31-Mar-2018	17:15:25	63	ST18904-ENV2			Camera	36	643429	4461349	643430	4461350	1	1	1	40	TSH	
31-Mar-2018	21:11:24	64	ST18904-ENV4			Camera	29	627225	4468809	627225	4468810	0	1	1	357	TSH	
31-Mar-2018	21:12:36	65	ST18904-ENV4			Camera	30	627224	4468808	627225	4468810	1	2	2	17	TSH	
31-Mar-2018	21:13:23	66	ST18904-ENV4			Camera	30	627225	4468810	627225	4468810	0	0	0	306	TSH	
31-Mar-2018	21:13:39	67	ST18904-ENV4			Camera	30	627225	4468809	627225	4468810	0	1	1	358	TSH	
31-Mar-2018	21:14:02	68	ST18904-ENV4			Camera	30	627225	4468809	627225	4468810	0	1	1	0	TSH	

APPENDIX A FIELD SAMPLING LOGS

Gardline — Seafloor Sampling Positioning Summary

Job No	11179			Vessel	R.V. *Shearwater*						
Client	Statoil US Wind LLC			Vessel Reference Point (VRP)	CoG						
Project Name	NY Empire Wind G&G Survey			Deployment Location	A-frame, starboard side	x	6.946	y	-12.634	z	5.806
Primary Positioning System	QPS QINSy			Actual Coordinates derived fro	Deployment Location						
Geodetic Reference System	Datum	North American Datum (NAD) 1983	Ellipsoid	GRS-1980	Projection	UTM ZONE 18 (75W)		Vertical / Tidal Datum	LAT		

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration	Sample Retention	Retention	Observed Seafloor Depth (m)	Actual coordinates		Target coordinates		Offset from target				Surveyor	Remarks
								Easting	Northing	Easting	Northing	dE	dN	Range	Bearing		
31-Mar-2018	21:14:28	69	ST18904-ENV4			Camera	29	627225	4468811	627225	4468810	0	-1	1	215	TSH	
31-Mar-2018	21:15:13	70	ST18904-ENV4			Camera	30	627227	4468813	627225	4468810	-2	-3	4	211	TSH	
31-Mar-2018	21:15:38	71	ST18904-ENV4			Camera	30	627227	4468813	627225	4468810	-2	-3	3	221	TSH	
31-Mar-2018	21:16:07	72	ST18904-ENV4			Camera	30	627227	4468813	627225	4468810	-2	-3	3	213	TSH	
31-Mar-2018	21:16:33	73	ST18904-ENV4			Camera	30	627227	4468813	627225	4468810	-2	-3	3	216	TSH	
31-Mar-2018	21:16:47	74	ST18904-ENV4			Camera	29	627228	4468813	627225	4468810	-3	-3	4	226	TSH	
31-Mar-2018	21:18:04	75	ST18904-ENV4			Camera	30	627230	4468807	627225	4468810	-5	3	5	301	TSH	
31-Mar-2018	21:18:40	76	ST18904-ENV4			Camera	30	627230	4468807	627225	4468810	-5	3	6	307	TSH	
31-Mar-2018	21:20:00	77	ST18904-ENV4			Camera	30	627222	4468811	627225	4468810	3	-1	3	109	TSH	
31-Mar-2018	21:20:34	78	ST18904-ENV4			Camera	30	627221	4468811	627225	4468810	4	-1	4	100	TSH	
31-Mar-2018	21:21:34	79	ST18904-ENV4			Camera	30	627221	4468812	627225	4468810	4	-2	5	112	TSH	
31-Mar-2018	21:22:56	80	ST18904-ENV4			Camera	30	627221	4468810	627225	4468810	4	0	4	87	TSH	

APPENDIX A FIELD SAMPLING LOGS

SEABED SAMPLING LOG SHEET (Deck)							**QPRO-0755**
Job No: 11179		**Area:** NJ/NY Bight		**Vessel:** RV *Shearwater*		**Operator:** TSH	
Date: from: 31-Mar-2018 to: 31-Mar-2018		**Page:** Page 1 of 5		**Client:** Statoil US Wind LLC		**Sieve Size:** 1000µm	
Project: NY Empire Wind G&G Survey						**Equipment:** Day grab	
Sample Number	**Station Number**	**Time**	**Load**	**Retention**	**Sieving Comments**	**Sediment Description**	**Comments**
1	ST18904-ENV2	17:27:37	70%	MFA	1 x 1L	**Sediment:** Light brown fine to medium sand with occasional shell fragments **Fauna:** Annelida (Polychaeta), Crustacea (Paguroidea), Mollusca (Bivalvia)	
2	ST18904-ENV2	17:36:31	80%	CHEM	NA	**Sediment:** Light brown fine to medium sand with occasional shell fragments **Fauna:** Annelida (Polychaeta)	
3	ST18904-ENV2	17:44:58	85%	MFB	1 x 1L	**Sediment:** Light brown fine to medium sand with occasional shell fragments **Fauna:** Annelida (Polychaeta), Crustacea (Paguroidea), Mollusca (Bivalvia)	
4	ST18904-ENV1	18:06:30	85%	MFA	2 x 1L	**Sediment:** Brown slightly gravelly medium sand with occasional shells and shell fragments. Worm tubes visible **Fauna:** Annelida (Polychaeta), Crustacea (Paguroidea), Mollusca (Bivalvia),Platyhelminthes	

APPENDIX A FIELD SAMPLING LOGS

SEABED SAMPLING LOG SHEET (Deck)							**QPRO-0755**
Job No: 11179		**Area:** NJ/NY Bight		**Vessel:** RV *Shearwater*		**Operator:** TSH	
Date: from: 31-Mar-2018 to: 31-Mar-2018		**Page:** Page 2 of 5		**Client:** Statoil US Wind LLC		**Sieve Size:** 1000µm	
Project: NY Empire Wind G&G Survey						**Equipment:** Day grab	
Sample Number	**Station Number**	**Time**	**Load**	**Retention**	**Sieving Comments**	**Sediment Description**	**Comments**
5	ST18904-ENV1	18:11:12	0%	NS	NS	No Sample	Failed to trigger
6	ST18904-ENV1	18:13:40	80%	CHEM	NA	**Sediment:** Brown slightly gravelly medium sand with occasional shells and shell fragments. **Fauna:** Annelida (Polychaeta tubes)	
7	ST18904-ENV1	18:23:43	95%	MFB	1 x 1L	**Sediment:** Brown slightly gravelly medium sand with occasional shells and shell fragments. Worm tubes visible **Fauna:** Annelida (Polychaeta), Mollusca (Bivalvia), Echinodermata (Clypeasteroida), Platyhelminthes	
8	ST18904-ENV6	18:38:05	75%	MFA	2 x 5L	**Sediment:** Dark brown/grey sandy gravel with occasional shell fragments **Fauna:** Annelida (Polychaeta)	

APPENDIX A FIELD SAMPLING LOGS

SEABED SAMPLING LOG SHEET (Deck)							**QPRO-0755**
Job No: 11179		**Area:** NJ/NY Bight		**Vessel:** RV *Shearwater*		**Operator:** TSH	
Date: from: 31-Mar-2018 to: 31-Mar-2018		**Page:** Page 3 of 5		**Client:** Statoil US Wind LLC		**Sieve Size:** 1000µm	
Project: NY Empire Wind G&G Survey						**Equipment:** Day grab	
Sample Number	**Station Number**	**Time**	**Load**	**Retention**	**Sieving Comments**	**Sediment Description**	**Comments**
9	ST18904-ENV6	18:42:33	70%	CHEM	NA	**Sediment:** Dark brown/grey sandy gravel with occasional shell fragments **Fauna:** Annelida (Polychaeta)	
10	ST18904-ENV6	18:50:25	70%	MFB	1 x 5L	**Sediment:** Dark brown/grey sandy gravel with occasional shell fragments **Fauna:** Annelida (Polychaeta)	
11	ST18904-ENV3	19:12:03	70%	MFA	1 x 1L	**Sediment:** Brown fine to medium sand with occasional shell fragments. **Fauna:** Polychaeta, Echinodermata (Clypeasteroida), Crustacea (Paguroidea), Mollusca (Bivalvia), Platyhelminthes.	
12	ST18904-ENV3	19:17:42	70%	CHEM	NA	**Sediment:** Brown fine to medium sand with occasional shell fragments. **Fauna:** No visible fauna.	

APPENDIX A FIELD SAMPLING LOGS

SEABED SAMPLING LOG SHEET (Deck)							**QPRO-0755**
Job No: 11179		**Area:** NJ/NY Bight		**Vessel:** RV *Shearwater*		**Operator:** TSH	
Date: from: 31-Mar-2018 to: 31-Mar-2018		**Page:** Page 4 of 5		**Client:** Statoil US Wind LLC		**Sieve Size:** 1000µm	
Project: NY Empire Wind G&G Survey						**Equipment:** Day grab	
Sample Number	**Station Number**	**Time**	**Load**	**Retention**	**Sieving Comments**	**Sediment Description**	**Comments**
13	ST18904-ENV3	19:25:42	60%	MFB	1 x 1L	**Sediment:** Brown fine to medium sand with occasional shell fragments. **Fauna:** Annelida (Polychaeta), Echinodermata (Clypeasteroida), Crustacea (Paguroidea), Mollusca (Bivalvia, Veneroidia), Platyhelminthes, Egg cases - Chondrichthyes.	
14	ST18904-ENV4	21:31:59	90%	MFA	1 x 1L	**Sediment:** Dark brown/grey slightly gravelly, silty sand with occasional shell fragments. Very slight anoxic smell. **Fauna:** Annelida (Polychaeta), Crustacea (Caridea), Mollusca (Bivalvia),	
15	ST18904-ENV4	21:35:42	55%	MFB	1 x 1L	**Sediment:** Dark brown/grey slightly gravelly, silty sand with occasional shell fragments. Very slight anoxic smell. **Fauna:** Annelida, Polychaeta, Crustacea (Caridea), Mollusca (Bivalvia),	
16	ST18904-ENV4	21:39:55	40%	-	-	No Sample	Insufficient load

APPENDIX A FIELD SAMPLING LOGS

SEABED SAMPLING LOG SHEET (Deck)							QPRO-0755
Job No: 11179			**Area:** NJ/NY Bight			**Vessel:** RV *Shearwater*	**Operator:** TSH
Date: from: 31-Mar-2018 to: 31-Mar-2018			**Page:** Page 5 of 5			**Client:** Statoil US Wind LLC	**Sieve Size:** 1000µm
Project: NY Empire Wind G&G Survey							**Equipment:** Day grab
Sample Number	**Station Number**	**Time**	**Load**	**Retention**	**Sieving Comments**	**Sediment Description**	**Comments**
17	ST18904-ENV4	21:43:20	70%	CHEM	NA	**Sediment:** Dark brown/grey slightly gravelly, silty fine sand with occasional shell fragments. Very slight anoxic smell. **Fauna:** Worm tubes visible	

APPENDIX A FIELD SAMPLING LOGS

Gardline — Seafloor Sampling Positioning Summary

Job No	11179			Vessel	R.V. *Shearwater*						
Client	Statoil US Wind LLC			Vessel Reference Point (VRP)	CoG						
Project Name	NY Empire Wind G&G Survey			Deployment Location	A-frame, starboard side	x	6.946	y	-12.634	z	5.806
Primary Positioning System	QPS QINSy			Actual Coordinates derived from	Deployment Location						
Geodetic Reference System	Datum	North American Datum (NAD) 1983	Ellipsoid	GRS-1980	Projection	UTM ZONE 18 (75W)		Vertical / Tidal Datum	LAT		

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration	Sample Retention	Retention	Observed Seafloor Depth (m)	Actual coordinates		Target coordinates		Offset from target				Surveyor	Remarks
								Easting	Northing	Easting	Northing	dE	dN	Range	Bearing		
31-Mar-2018	17:27:37	1	ST18904-ENV2	70%	MFA	Day Grab	36	643429	4461347	643430	4461350	1	3	3	24	TSH	
31-Mar-2018	17:36:31	2	ST18904-ENV2	80%	CHEM	Day Grab	36	643430	4461351	643430	4461350	0	-1	1	180	TSH	
31-Mar-2018	17:44:58	3	ST18904-ENV2	85%	MFB	Day Grab	35	643429	4461350	643430	4461350	1	0	1	88	TSH	
31-Mar-2018	18:06:30	4	ST18904-ENV1	85%	MFA	Day Grab	35	642530	4461784	642530	4461784	0	0	0	77	TSH	
31-Mar-2018	18:11:12	5	ST18904-ENV1	0%	NS	Day Grab	35	642529	4461783	642530	4461784	1	1	1	52	TSH	No Sample
31-Mar-2018	18:13:40	6	ST18904-ENV1	80%	CHEM	Day Grab	35	642528	4461783	642530	4461784	2	1	2	64	TSH	
31-Mar-2018	18:23:43	7	ST18904-ENV1	95%	MFB	Day Grab	35	642530	4461784	642530	4461784	0	0	0	156	TSH	
31-Mar-2018	18:38:05	8	ST18904-ENV6	75%	MFA	Day Grab	318	642460	4461972	642460	4461973	0	1	1	346	TSH	
31-Mar-2018	18:42:33	9	ST18904-ENV6	70%	CHEM	Day Grab	36	642459	4461973	642460	4461973	1	1	1	66	TSH	
31-Mar-2018	18:50:25	10	ST18904-ENV6	70%	MFB	Day Grab	36	642459	4461973	642460	4461973	1	0	1	91	TSH	
31-Mar-2018	19:12:03	11	ST18904-ENV3	70%	MFA	Day Grab	35	641627	4462215	641627	4462217	0	2	2	357	TSH	
31-Mar-2018	19:17:42	12	ST18904-ENV3	70%	CHEM	Day Grab	35	641626	4462217	641627	4462217	1	0	1	99	TSH	
31-Mar-2018	19:25:42	13	ST18904-ENV3	60%	MFB	Day Grab	35	641626	4462214	641627	4462217	1	3	3	12	TSH	
31-Mar-2018	21:31:59	14	ST18904-ENV4	90%	MFA	Day Grab	30	627225	4468809	627225	4468810	0	1	1	19	TSH	
31-Mar-2018	21:35:42	15	ST18904-ENV4	55%	MFB	Day Grab	30	627225	4468809	627225	4468810	0	1	1	28	TSH	
31-Mar-2018	21:39:55	16	ST18904-ENV4	40%	NS	Day Grab	30	627225	4468809	627225	4468810	0	1	1	0	TSH	No Sample
31-Mar-2018	21:43:23	17	ST18904-ENV4	70%	CHEM	Day Grab	30	627224	4468809	627225	4468810	1	1	1	46	TSH	

APPENDIX B METHODS

B.1 Seabed Sampling

Benthic samples were recovered using a stainless-steel, 0.1m^2 Day grab which had been modified in-house. The modification, shown in Figure B.1 incorporated guides for the cables to prevent them becoming trapped during triggering. The grab carried extra weights to aid penetration on impact and an extended bucket lip to reduce sediment washout. Storm feet and elastic straps were used to reduce the likelihood of the instrument pre-triggering in the water column during deployment.

Figure B.1 Modified Day Grab

Left: The modified 0.1m^2 Day grab.

Above (inset): The modification to the grab incorporated guides for the cables to prevent them from becoming trapped as the grab triggers.

Prior to deployment the vessel's sampling area was pre-cleaned using a powerful deck fire-hose and seawater. The grab was washed thoroughly prior to every station to prevent hydrocarbon cross contamination. A dyneema rope was used to lower the Day grab to the seabed.

Once directly over the target location the grab was lowered to the seabed and then quickly recovered so that the sample could be obtained and the apparatus returned to the pre-deployment position. Positional fixes were captured immediately for each grab sample when the grab reached the sea floor. The precise time that the grab reached the seabed was determined by observations of the tension on the winch cable.

On recovery of a sample, the grab would first be examined for acceptability following strict quality assurance (QA) criteria. In the following cases, a grab sample would be rejected and the instrument returned to the pre-deployment position:

1 Jammed jaws due to a large stone or shell allowing sediment washout;
2 One or both of the bucket doors open on recovery, causing possible surface washout;
3 Half sample obtained where the grab had not struck a flat area of bottom, or not hit true, causing a side or half bite of sediment;
4 Disruption of the sample by obvious shaking or contamination (these can occur when a sample is badly handled or if the grab strikes the side of the vessel during operations);
5 The grab was less than 50% full or totally filled the grab. The latter potentially allowing the sample to overflow the grab or for the surface sediments to come into contact with the lids.
6 Sample was acquired more than 5m from the desired position (as determined by the onboard surveyors, environmentalist and client representative, with consideration of survey objectives);
7 The presence of a hag fish (*Myxine glutinosa*) and/or mucus coagulants.

Brief descriptions of the collected sediments were made at the time of sampling. These were recorded in the environmentalist's log sheets and are presented in Appendix A. A selection of photographs, taken of the sediment samples whilst still in the Day grab, is presented in Appendix D.

Sediment samples collected for physico-chemical analysis (CHEM) were sub-sampled into the relevant containers. All containers were thoroughly washed with the appropriate solvents and labeled externally prior to use. A plastic scoop was used to obtain two sub-samples: one for particle size analysis (PSA) and one as a spare sample. These were placed in double-lined zip-lock bags. All physico-chemical samples were transferred to an onboard freezer for storage at <-18ºC.

Sediment samples collected for faunal analyses (MFA and MFB) were thoroughly washed from the grab into a plastic tray. Once all of the equipment was washed free of sediment, the sediment sample was transferred to a sieving machine where it was broken down using a low powered seawater spray. All materials retained by the 1mm sieve were transferred to a squat jar or bucket by means of a scoop and funnel, making sure that none of the sample was lost or trapped in the mesh. The sample was fixed with a pre-buffered <20% formalin solution of known concentration, then subsequently diluted to a final concentration of approximately 4% formalin. Biological samples were placed in 1 liter polypropylene screw-top squat jars or 5 liter buckets, depending on sample size, and provided with an additional internal waterproof label.

At the end of the survey all of the retained samples were delivered to the relevant laboratories for analysis. All physico-chemical sub-samples were kept frozen, and biological samples stored at room temperature. One physico-chemical sub-sample from each station was then sent frozen, in cool boxes kept cool with ice packs, along with two biological samples, to their respective analytical sub-contractors (see Section B.2). Spares of the physico-chemical sub-sample from each station was stored frozen, and one biological sample from each station stored at room temperature. Spare samples are retained at Alpine's head office for at least six months after which time the client is contacted to advise on appropriate disposal, continued storage or dispatch to a destination of the client's choice.

B.2 Sample Analysis

Sediment and faunal samples were analyzed by the following laboratories / persons:

- PSA, Sediment total organic matter (TOM) were carried out by TerraSence, LLC, Totowa, NJ, USA.
- Benthic macrofaunal identification was undertaken by EcoAnalysts, Inc., Moscow, ID, USA.

The laboratories detailed above meet quality control requirements exacted by Gardline's internal procedures (BS/EN/ISO 9001:2008; BSI, 2008).

B.3 Particle Size Analysis

Sediments from each sample were analyzed by a combination of sieving and laser diffraction.

The results, given in full in Appendix D, and summarized in Section 2.4.1, present the following sample statistics calculated using method of moments (MoM) based on logarithmic grain size (i.e., using the phi scale); mean grain size, sorting (standard deviation), skewness and kurtosis (Krumbein & Pettijohn, 1938). These indices are described below. Mean grain size is also given geometrically (in µm). Size classes, including the mean and mode(s) are named (such as medium sand), according to sediment descriptors given in Table B.1, which are modified from Udden (1914) and Wentworth (1922). Sediment samples are also classified using the Folk triangle classification (presented in Appendix D), which uses the ratio of sand to mud (<63µm, silt and clay) and the percentage of gravel sized-material (>2mm) (Folk, 1954).

1 Mean ($\bar{x}_{\emptyset}$) (First moment) =

$$\sum_{i=1}^{n} f_i M_{i\emptyset}$$

Where f_i = fraction of total weight in each class interval
$M_{i\emptyset}$ = midpoint of each class interval in phi units

2 Standard deviation ($S_{\emptyset}$) (Second moment =

$$\left[\sum_{i=1}^{n} f_i (M_{i\emptyset} - \bar{x}_{\emptyset})\right]^{1/2}$$

The second moment has been used as a measure of the degree of sorting. Sorting statistics are then ascribed physical descriptions (such as moderately sorted), derived from Folk and Ward (1957). Sorting classifications are presented in Table B.2.

3 Skewness ($Sk_{\emptyset}$)(Third moment) =

$$\sum_{i=1}^{n} \frac{f_i (M_{i\emptyset} - \bar{x}_{\emptyset})^3}{S_{\emptyset}^3}$$

The third moment, has been used as a measure of the degree of asymmetry of a frequency or cumulative curve. Positive numbers indicate a fine skewed sediment, while negative numbers indicate a coarse skewed sediment. Skewness classifications are given in Table B.3.

4 Kurtosis ($K_{\emptyset}$) (Fourth moment) =

$$\sum_{i=1}^{n} \frac{f_i(M_{i\emptyset} - \bar{x}_{\emptyset})^4}{S_{\emptyset}^4}$$

The forth moment, has been used as a measure of the 'peakness' of the distribution. When ascribed to statistics calculated by logarithmic MoM, values of <1.7 are considered very platykurtik or flat 'peaked', while values >7.4 are considered very leptokurtic or excessively 'peaked' (Blott, 2010). Kurtosis classifications according to Blott (2010)are given in Table B.4.

Table B.1 Phi and Sieve Aperture with Sediment Descriptions

Aperture in microns	Aperture in Phi Unit	Sediment Description	
<63500 to 50800	<-6 to -5.7	Very Coarse Gravel	GRAVEL
<50800 to 38100	<-5.7 to -5.3		
<38100 to 31800	<-5.3 to -5		
<31800 to 15900	<-5 to -4	Coarse Gravel	
<15900 to 12700	<-4 to -3.7	Medium Gravel	
<12700 to 7900	<-3.7 to -3		
<7900 to 6400	<-3 to -2.7	Fine Gravel	
<6400 to 4000	<-2.7 to -2		
<4000 to 2800	>-2 to -1.5	Very Fine Gravel	
<2800 to 2000	>-1.5 to -1		
<2000 to 1400	>-1 to -0.5	Very Coarse Sand	SAND
<1400 to 1000	>-0.5 to 0		
<1000 to 710	>0 to 0.5	Coarse Sand	
<710 to 500	>0.5 to 1		
<500 to 355	>1 to 1.5	Medium Sand	
<355 to 250	>1.5 to 2		
<250 to 180	>2 to 2.5	Fine Sand	
<180 to 125	>2.5 to 3		
<125 to 90	>3 to 3.5	Very Fine Sand	
<90 to 63	>3.5 to 4		
<63 to 44	>4 to 4.5	Very Coarse Silt	FINES
<44 to 31.5	>4.5 to 5		
<31.5 to 22	>5 to 5.5	Coarse Silt	
<22 to 15.6	>5.5 to 6		
<15.6 to 11	>6 to 6.5	Medium Silt	
<11 to 7.8	>6.5 to 7		
<7.8 to 5.5	>7 to 7.5	Fine Silt	
<5.5 to 3.9	>7.5 to 8		
<3.9 to 2.8	>8 to 8.5	Very Fine Silt	
<2.8 to 2	>8.5 to 9		
<2 to 1.4	>9 to 9.5	Clay	
<1.4 to 1	>9.5 to 10		
<1	>10		

Table B.2 Sorting Classifications for use with Logarithmic Method of Moments

Sorting Coefficient (Graphical Standard Deviation)	Sorting Classifications
0 < 0.35	Very well sorted
0.35 < 0.50	Well sorted
0.50 < 0.71	Moderately well sorted
0.71 < 1.00	Moderately sorted
1.00 < 2.00	Poorly sorted
2.00 < 4.00	Very poorly sorted
4.00	Extremely poorly sorted

Table B.3 Skewness Classification for use with Logarithmic Method of Moments

Skewness Coefficient	Mathematical Skewness	Graphical Skewness
> 1.30	Strongly Positive	Very fine skewed
>0.43 to 1.30	Positive	Fine skewed
>-0.43 to 0.43	Near Symmetrical	Symmetrical
>-1.30 to -0.43	Negative	Coarse skewed
≤-1.30	Strongly Negative	Very coarse skewed

Table B.4 Kurtosis Classification for use with Logarithmic Method of Moments

Kurtosis Coefficient	Kurtosis Classification	Graphical meaning
< 1.70	Very Platykurtic	Flat-peaked; the ends are better sorted than the centre
1.70 to <2.55	Platykurtic	
2.55 to <3.70	Mesokurtic	Normal; bell shaped curve
3.70 to <7.40	Leptokurtic	Curves are excessively peaked; the centre is better sorted than the ends.
≥7.40	Very Leptokurtic	

B.4 Macrofaunal Analysis

B.4.1 Sorting and Identification

In the laboratory, samples were gently washed across a 1mm sieve to remove any sediment fines and preservative. The retained material was sorted by hand to extract all macrofauna. The organisms were identified and counted to produce a species list for each grab sample. The whole sample was processed without sub-sampling.

B.4.2 Data Set Rationalization

The faunal data set was rationalized according to the standard (GGL, 2017) procedure, which is largely based on British Standard ISO16665:2005 (BSI, 2005) and OSPAR (2017) guidelines.

Damaged Specimens

Destructive sampling techniques and sieving may damage delicate benthic organisms. It is, therefore, commonplace for fragmented organisms to be found in faunal samples. The following conditions were applied to the recording of damaged specimens and fragments:

- Fragments that constituted a major component of an individual, that unequivocally represented the presence of an entire organism, and that could be identified to species level, were recorded and included with other counts of that species. Examples include: the heads of polychaetes and crustaceans; the complete mouth structure or central disk of brittle stars; the oral area/feeding tentacles of holothurians.
- Fragments that constituted a significant component of an individual, that unequivocally represented the presence of an entire organism, but that could not be identified to species by virtue of their incompleteness, were recorded to the lowest possible taxonomic level.
- Fragments that did not unequivocally represent the presence of an entire organism were ignored, *e.g. Aphiura* arms, *Echinocardium* shell fragments, etc.

Recorded fragments, therefore, represent discrete observations of individuals that were present at the time of sampling and were included in the analyzed data set.

Treatment of Specific Groups of Organisms
GGL defines macrofauna as organisms that are normally larger that the mesh size of the sieve used to separate them from the sediment (GGL, 2017). Meiofaunal organisms, such as the Ostracoda and Copepoda, which would not be consistently sampled, were not recorded. Due to their generally small size (in fully marine environments), species from the Oligochaeta, Tardigrada and Gnathostomulida were only enumerated when a sieve with a mesh size of 0.5mm or less was used to separate organisms from sediments; otherwise, these organisms were noted to be present, but not enumerated.

Colonial, stoloniferous and encrusting epibenthic species were identified but not enumerated.

With the exception of discrete sea pen (Pennatulacea) colonies, only solitary tunicates and cnidarians were enumerated and included in statistical analyses. Colonial tunicates and cnidarians were identified but not enumerated.

The testate amoeba *Astrorhiza* sp. was the only foram routinely enumerated.

When found, the presence of Porifera (sponges) was recorded, but not identified to lower taxonomic levels, enumerated, or included in statistical analyses.

In accordance with our in-house guidelines the following organisms were not identified to species, but were enumerated and included in the data set for analyses at a higher taxonomic level:
- Nemertea – identified to phylum,
- Platyhelminthes – identified to phylum,
- Phoronida – identified to genus,
- Cephalochordata – identified to subphylum

B.5 Statistical Analyses

B.5.1 Univariate Macrofauna Indices

Univariate community analyses were undertaken using the PRIMER (version 7) software package. Univariate indices seek, by means of a single number, to summarize information about some aspect

of community structure. The two aspects of community structure contributing to the concept of diversity are species richness (a measure related to the total number of species present) and evenness (a measure relating to the pattern of distribution of individuals among the species present).

Diversity indices, as typified by the Shannon-Wiener index, are considered to be a relatively insensitive measure of anthropogenic disturbance. However, benthic ecologists have been able to demonstrate a clear inverse relationship between diversity and total oil concentrations in sediments (e.g. Davies *et al.*, 1984). They are therefore of some practical use for making comparisons between stations and sites.

The following indices were calculated and are presented in the report:

Shannon-Wiener Diversity Index

This is a widely used measure of diversity providing an integrated index of species richness and relative abundance (Clarke & Warwick, 2006). It is basically a measure of the difficulty of predicting the identity of an individual based on overall community composition. The Shannon-Wiener diversity index is expressed as:

$$H' = -\sum_{i=1}^{s} p_i \log_n p_i$$

where H'= Shannon-Wiener Diversity Index
p_i = proportion of the total number of individuals from the i^{th} species.
n = log base value (log base 2 is used during this report; Shannon & Weaver, 1949)

H' integrates the number of species and individual abundance to provide a summary value reflecting the diversity of fauna at a station. This index of diversity is influenced by both species richness (*i.e.* the number of species) and evenness (or equitability) of distribution of individuals between species.

Pielou's Evenness

Evenness (or equitability) is a representation of how uniformly individuals are spread between species in a sample. It is a component of, and calculated using, a theoretical diversity measure (in this instance Shannon-Wiener). Values range from 0 to 1 with high values indicating low dominance and high evenness (*N.B.* the log base that was used to calculate H' must also be used to calculate evenness).

$$J = \frac{H'}{\log_n S}$$

where J= Pielou's Evenness
H'= Shannon-Wiener Diversity index
S = total number of species in a sample

Species Ranking

A measure of the overall dominance pattern in the sampling area may be achieved by ranking the top species per station according to abundance, giving a rank score of ten to the most abundant species, decreasing to one for the tenth most abundant species, and summing these scores for all stations to provide an overall dominance score for each species (Eleftheriou & Basford, 1989). For those species ranked in the top ten, the fidelity of the species ranking can be assessed by comparing the actual rank score with the maximum possible score (thus ten multiplied by number of stations for the top rank,

etc.) for that rank as a proportion; perfect fidelity is equal to one; values lower than 0.8 or higher than 1.2 represent erratic ranking, as in a species with a patchy distribution.

APPENDIX C BACKGROUND INFORMATION

C.1 Sediment Characteristics

Particle size distributions of sediments in the marine environment are to a large extent determined by hydrodynamic energy at the sediment water interface. Strong currents tend to scour the seabed thereby resuspending fine particles and any material associated with them, whilst the finest sediments predominate in areas with the least hydrodynamic energy.

The role of sediment in the transport and retention of chemical pollutants is tied to both particle size and to the amount of particulate organic carbon associated with the sediment. The chemically active fraction of sediment is usually cited as the organic component and the finest size fractions (smaller than 63µm, silt, clay). The sediment, in particular the organic carbon and finer fractions, acts as a sink for many of the persistent compounds, including metals, hydrocarbons and chlorinated compounds. Many of these persistent substances are also inherently bioaccumulative and toxic. The concentrations of many parameters are typically positively correlated with the proportion of fines found in the sediment as a result of fine particles possessing a relatively large surface area. Fine sediment particles are relatively easily resuspended by waves and currents, and may be transported, along with the materials sorbed to them, over large distances, finally being deposited in areas of lower hydrodynamic energy.

Generally speaking, sands and coarser grained materials are often organically deficient. Strong currents have a tendency to resuspend fine materials and their associated organic matter. Therefore, in an environment that is not nutrient enriched due to anthropogenic discharges, both total organic matter and total organic carbon will normally be lowest at sites with coarse-grained sediment, where currents are often strongest.

Sediment particle size and organic content are also critical measurements for the categorization of habitat type since to a large extent they control which organisms are capable of living within sediments. Most benthic infaunal organisms exhibit preferences for sediment with particular grain size characteristics. Many organisms live in tubes or burrows constructed from sediment particles; each organism's ability to do this may be limited by the range of different sized particles available. The distribution and abundance of free-living mobile organisms, i.e. those that do not construct tubes or burrows, are also affected by particle sizes, which influence their ability to move within the sediment. Sand grains of inappropriate sizes may be too big to move or, conversely, too small to be stable.

Feeding guilds are groupings of organisms based upon the feeding strategies they employ (United States Environmental Protection Agency or US EPA, 2008) and, as such, sediment particle size and organic content can greatly affect which species guilds may dominate in any given area. Many deposit feeding organisms, which process sediment through the alimentary tract to obtain nutrition (Gage & Tyler, 1992), are highly selective of the grain sizes that they will ingest, often preferring finer sediments that possess relatively high organic content. Conversely, resuspension of fine particulate matter may clog delicate filtering apparatus used by suspension feeders to obtain their suspended food particles from seawater (Gibson *et al.*, 2005), resulting in their exclusion from muddy sediments. Additionally, the mixtures of particle sizes determine the ease with which water and oxygen move through the sediment. An abundance of fine particles in a stable environment may lead to the formation of substrata with small interstitial spaces through which oxygen diffusion can be restricted. This may lead

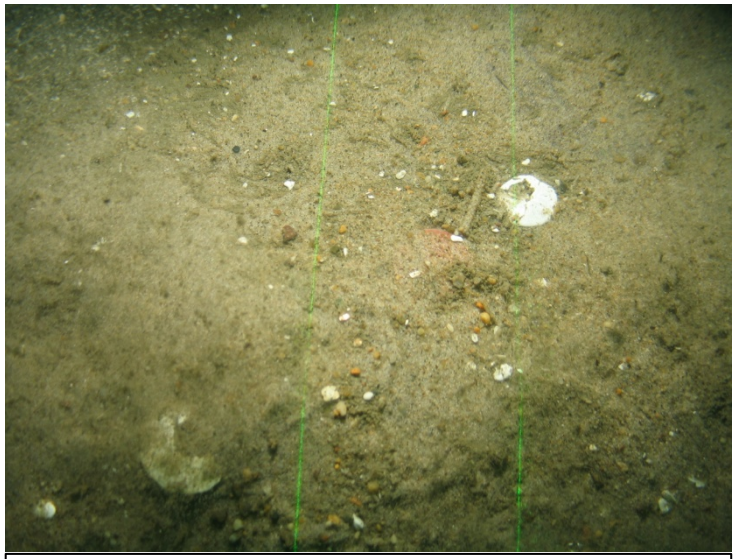
to anoxic conditions within the sediment, which further affects the range of species that may be present. Determination of sediment particle sizes and organic content is therefore of critical importance to the interpretation of benthic environmental survey data.

C.2 Macrofaunal Analyses

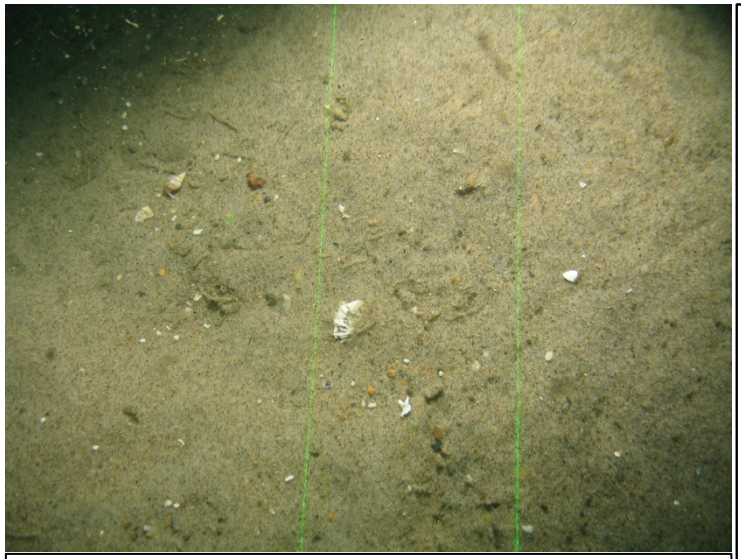
The macrofaunal investigation in this survey is designed to provide a description of the benthic infauna and how it varies across the survey area. Marine benthic invertebrate communities have been shown to be sensitive to environmental change, particularly environmental degradation as a result of anthropogenic contamination (Davies *et al.*, 1984; Warwick & Clarke, 1991). Analysis of faunal data sets may therefore provide insight into any changes resulting from point source pollutants and disturbance.

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 31 **E:** 642529 **N:** 4461784 **Depth:** 36m



Fix: 45 **E:** 642528 **N:** 4461783 **Depth:** 36m

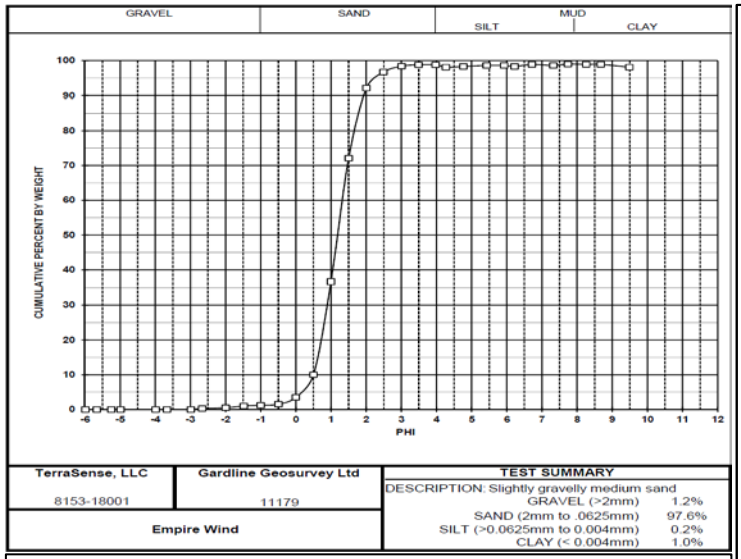
Station: ST18904-ENV1
Sediment Description:
Fix31: Slightly gravelly fine sand with occasional shell fragments

Fix45: Slightly gravelly fine sand with occasional shell fragments

Fauna Description:
Fix31: Annelida (Polychaeta worm tubes) and Echinodermata (*Echinarachnius parma*)

Fix45: Annelida (Polychaeta worm tubes), Arthropoda (Paguroidea) and Mollusca (Neogastropoda)

Fix: 6 **E:** 642528 **N:** 4461783 **Depth:** 35m



Fix: 6 **E:** 642528 **N:** 4461783 **Retention:** PSA

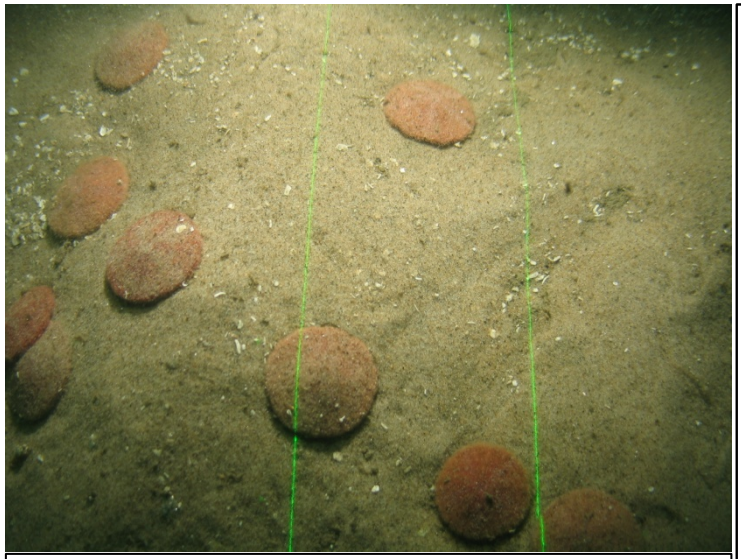
Station: ST18904-ENV1
Sediment Description:
Grab: Slightly gravelly sand with occasional shells and shell fragments

CMECS Substrate Component Subgroup: Slightly gravelly sand

Fauna Description:
Grab: Annelida (Polychaeta worm tubes)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 49 **E:** 643429 **N:** 4461353 **Depth:** 36m



Fix: 56 **E:** 643431 **N:** 4461347 **Depth:** 36m

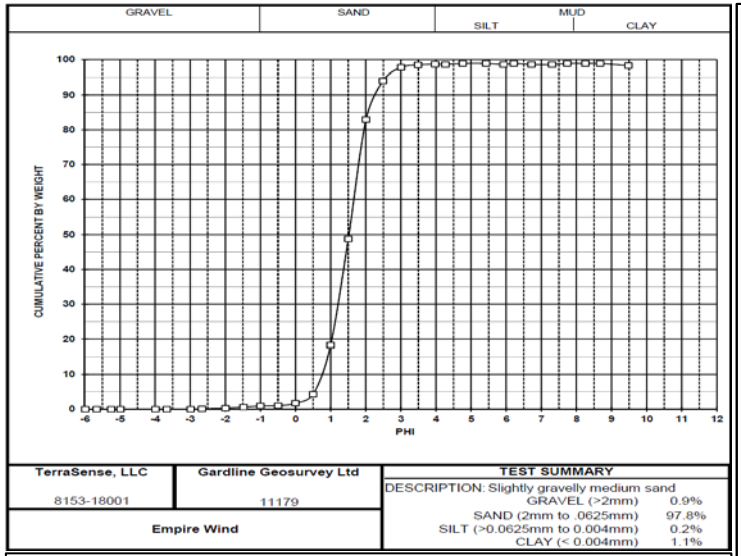
Station: ST18904-ENV2
Sediment Description:
Fix49: Find sand with frequent shell fragments

Fix56: Fine sand with occasional shell fragments

Fauna Description:
Fix49: Echinodermata (*Echinarachnius parma*) and Mollusca (Bivalvia). Faunal burows present

Fix56: Echinodermata (*Echinarachnius parma*)

Fix: 2 **E:** 643430 **N:** 4461351 **Depth:** 36m



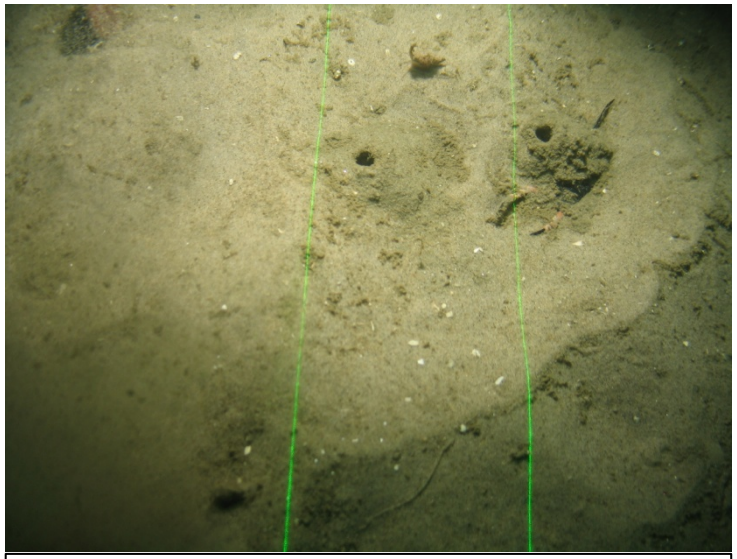
Fix: 2 **E:** 643430 **N:** 4461351 **Retention:** PSA

Station: ST18904-ENV2
Sediment Description:
Grab: Fine to medium sand with occasional shell fragments

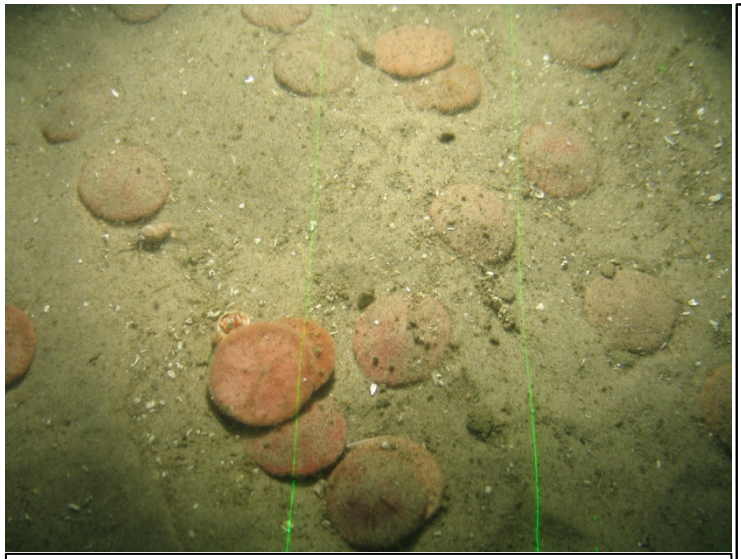
CMECS Substrate Component Subgroup: Slightly gravelly sand

Fauna Description:
Grab: No visible fauna

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 4 **E:** 641625 **N:** 4462213 **Depth:** 36m



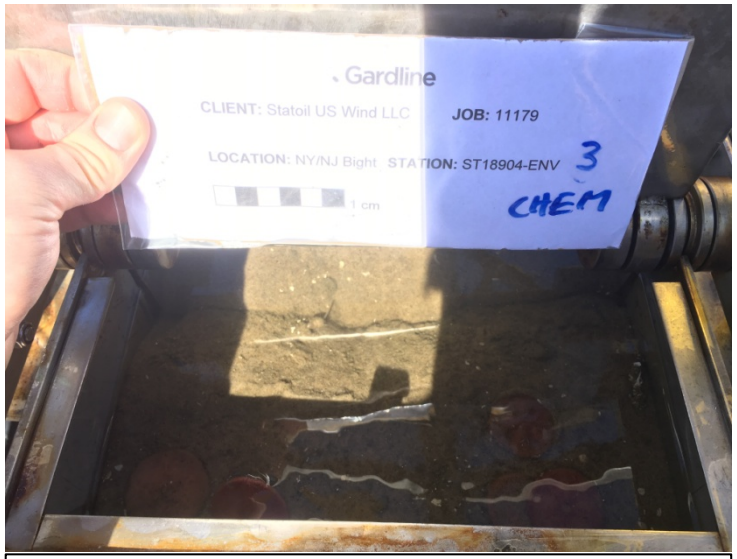
Fix: 9 **E:** 641627 **N:** 4462212 **Depth:** 36m

Station: ST18904-ENV3
Sediment Description:
Fix4: Fine sand with occasional shell fragments

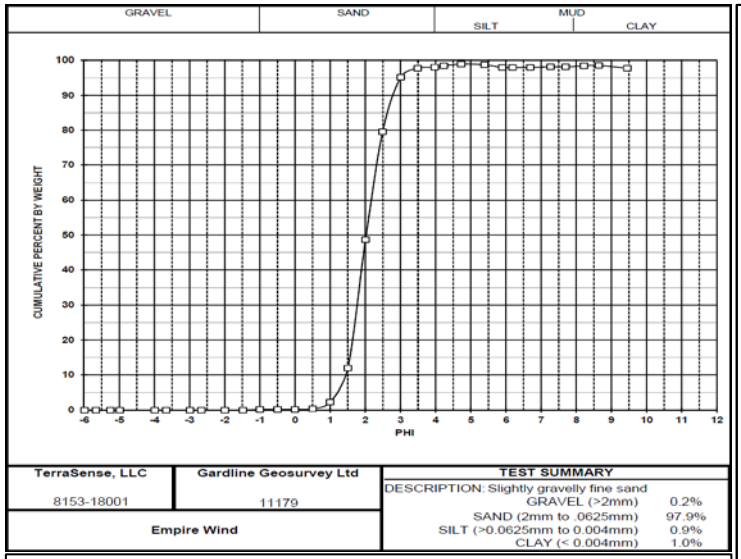
Fix9: Fine sand with occasional shell fragments

Fauna Description:
Fix4: Arthropoda (Malacostraca), Mollusca (Gastropoda, Neogastropoda), Echinodermata (*Echinarachnius parma*). Faunal burrows present

Fix9: Arthropoda (Paguroidea), Echinodermata (*Echinarachnius parma*) and Mollusca (Neogastropoda)



Fix: 12 **E:** 641627 **N:** 4462217 **Depth:** 35m



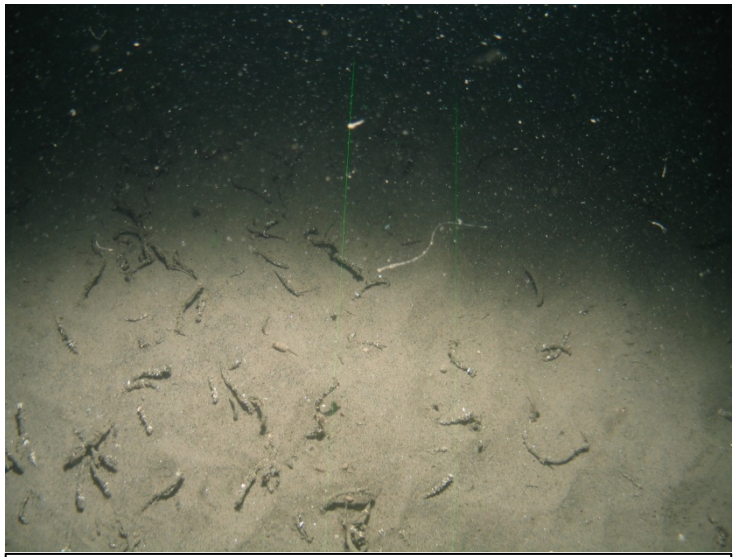
Fix: 12 **E:** 641626 **N:** 4462217 **Retention:** PSA

Station: ST18904-ENV3
Sediment Description:
Grab: Fine to medium sand with occasional shell fragments

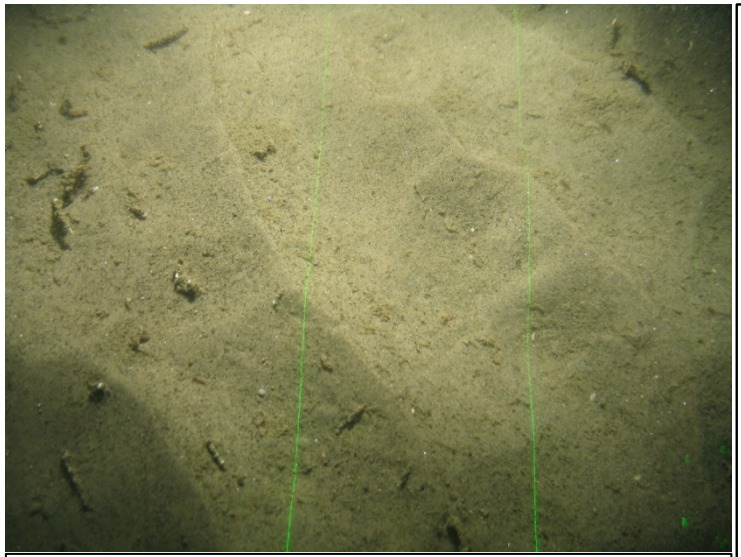
CMECS Substrate Component Subgroup: Slightly gravelly sand

Fauna Description:
Grab: Annelida (Polychaeta worm tubes), Echinodermata (*Echinarachnius parma*)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 67 **E:** 627225 **N:** 4468809 **Depth:** 30m



Fix: 76 **E:** 627230 **N:** 4468807 **Depth:** 30m

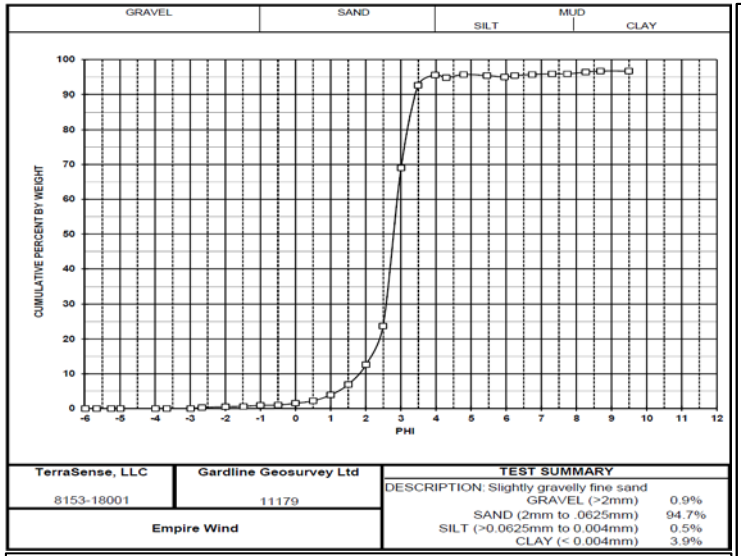
Station: ST18904-ENV4
Sediment Description:
Fix67: Fine sand with rare shell fragments

Fix76: Fine sand with rare shell fragments

Fauna Description:
Fix67: Annelida (Polychaeta worm tubes.) and Mollusca (Neogastropoda)

Fix76: Annelida (Polychaeta worm tubes)

Fix: 17 **E:** 627224 **N:** 4468809 **Depth:** 30m



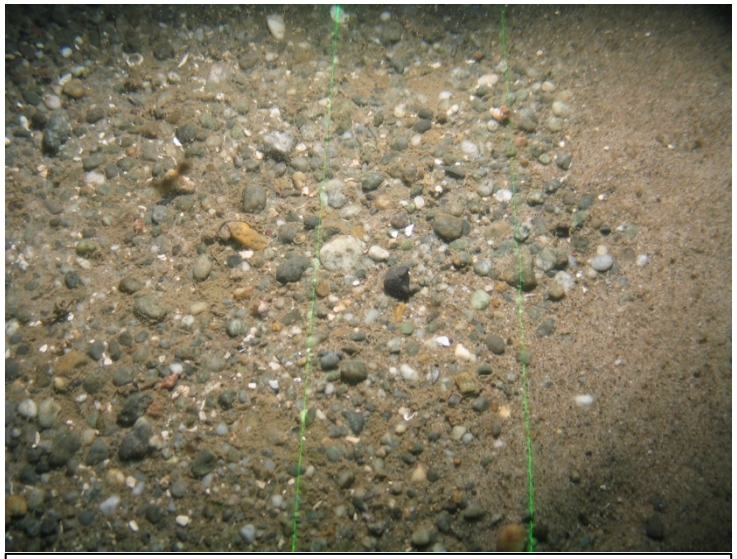
Fix: 17 **E:** 627224 **N:** 4468809 **Retention:** PSA

Station: ST18904-ENV4
Sediment Description:
Grab: Slightly gravelly, silty sand with occasional shell fragments. Very slight anoxic smell

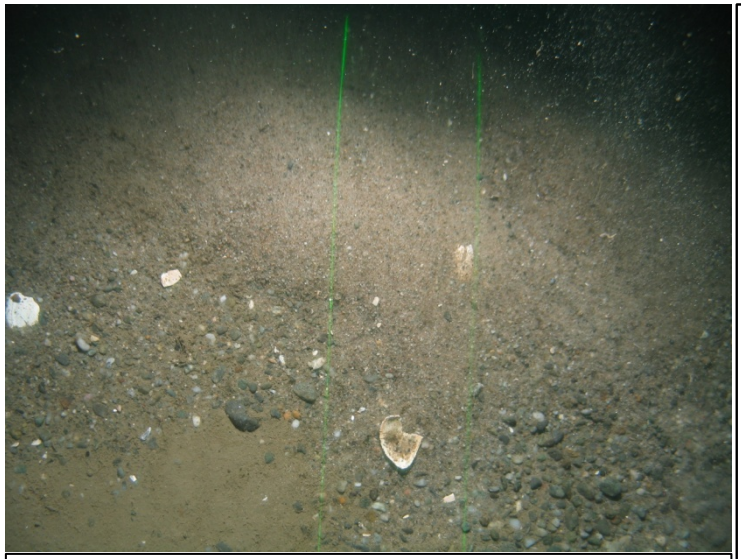
CMECS Substrate Component Subgroup: Slightly gravelly sand

Fauna Description:
Grab: Annelida (Polychaeta worm tubes)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 18 **E:** 642460 **N:** 4461973 **Depth:** 37m



Fix: 23 **E:** 642460 **N:** 4461973 **Depth:** 37m

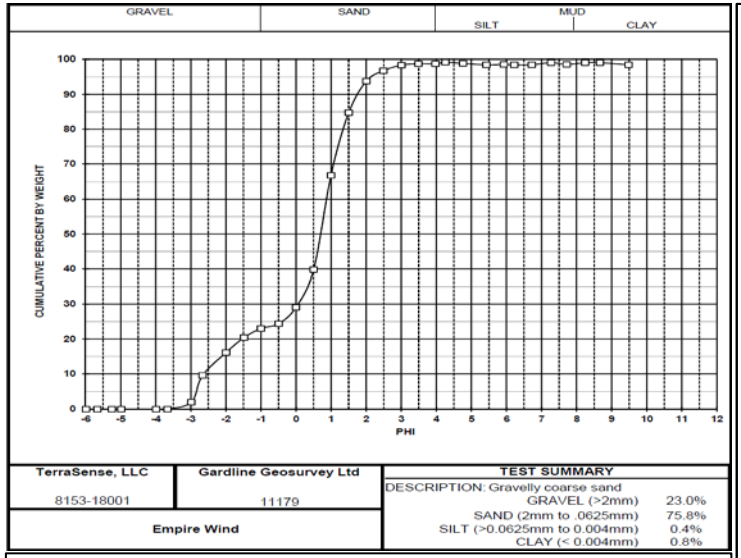
Station: ST18904-ENV6
Sediment Description:
Fix18: Coarse sandy gravel

Fix23: Coarse gravelly sand

Fauna Description:
Fix18: Annelida (Polychaeta worm tubes) and Arthropoda (Paguroidea)

Fix23: Annelida (Polychaeta worm tubes)

Fix: 9 **E:** 642460 **N:** 4461973 **Depth:** 36m



Fix: 9 **E:** 642459 **N:** 4461973 **Retention:** PSA

Station: ST18904-ENV6
Sediment Description:
Grab: Sandy gravel with occasional shell fragments

CMECS Substrate Component Subgroup: Gravelly sand

Fauna Description:
Grab: No visible fauna

APPENDIX E PARTICLE SIZE ANALYSIS

APPENDIX E PARTICLE SIZE ANALYSIS

SAMPLE STATISTICS

SAMPLE IDENTITY: **ENV-1** ANALYST & DATE: , 3/31/2018

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Slightly Gravelly Sand

SEDIMENT NAME: Slightly Very Fine Gravelly Medium Sand

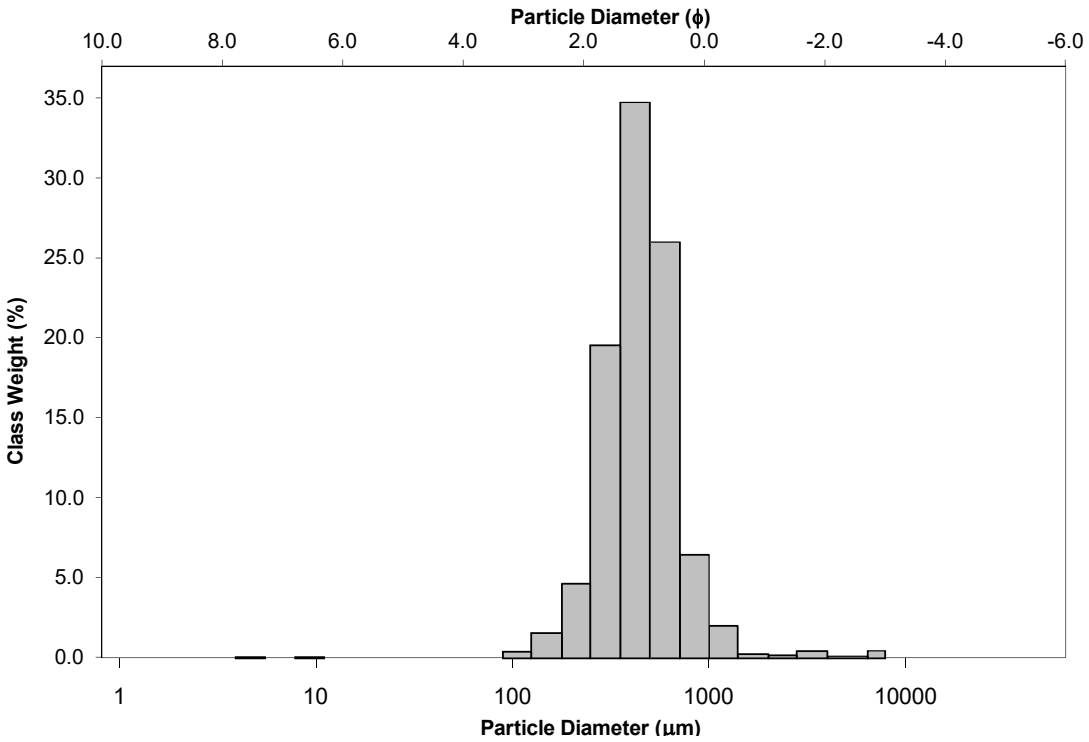
	µm	ϕ
MODE 1:	426.5	1.251
MODE 2:		
MODE 3:		
D_{10}:	258.3	0.494
MEDIAN or D_{50}:	438.7	1.189
D_{90}:	710.0	1.953
(D_{90} / D_{10}):	2.749	3.952
(D_{90} - D_{10}):	451.7	1.459
(D_{75} / D_{25}):	1.737	2.024
(D_{75} - D_{25}):	247.5	0.797

GRAIN SIZE DISTRIBUTION

GRAVEL: 1.2%	COARSE SAND: 33.2%
SAND: 97.6%	MEDIUM SAND: 55.2%
MUD: 1.2%	FINE SAND: 6.5%
	V FINE SAND: 0.4%
V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.0%
COARSE GRAVEL: 0.0%	COARSE SILT: 0.0%
MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 0.1%
FINE GRAVEL: 0.5%	FINE SILT: 0.1%
V FINE GRAVEL: 0.7%	V FINE SILT: 0.0%
V COARSE SAND: 2.3%	CLAY: 1.0%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	523.9	420.4	1.250	435.4	1.199	Medium Sand
SORTING (σ):	519.7	2.153	1.106	1.549	0.631	Moderately Well Sorted
SKEWNESS (Sk):	8.665	-4.086	4.086	-0.024	0.024	Symmetrical
KURTOSIS (K):	97.61	33.88	33.88	1.130	1.130	Leptokurtic

GRAIN SIZE DISTRIBUTION



APPENDIX E PARTICLE SIZE ANALYSIS

SAMPLE STATISTICS

SAMPLE IDENTITY: **ENV-2** ANALYST & DATE: , 3/31/2018

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Slightly Gravelly Sand

SEDIMENT NAME: Slightly Very Fine Gravelly Medium Sand

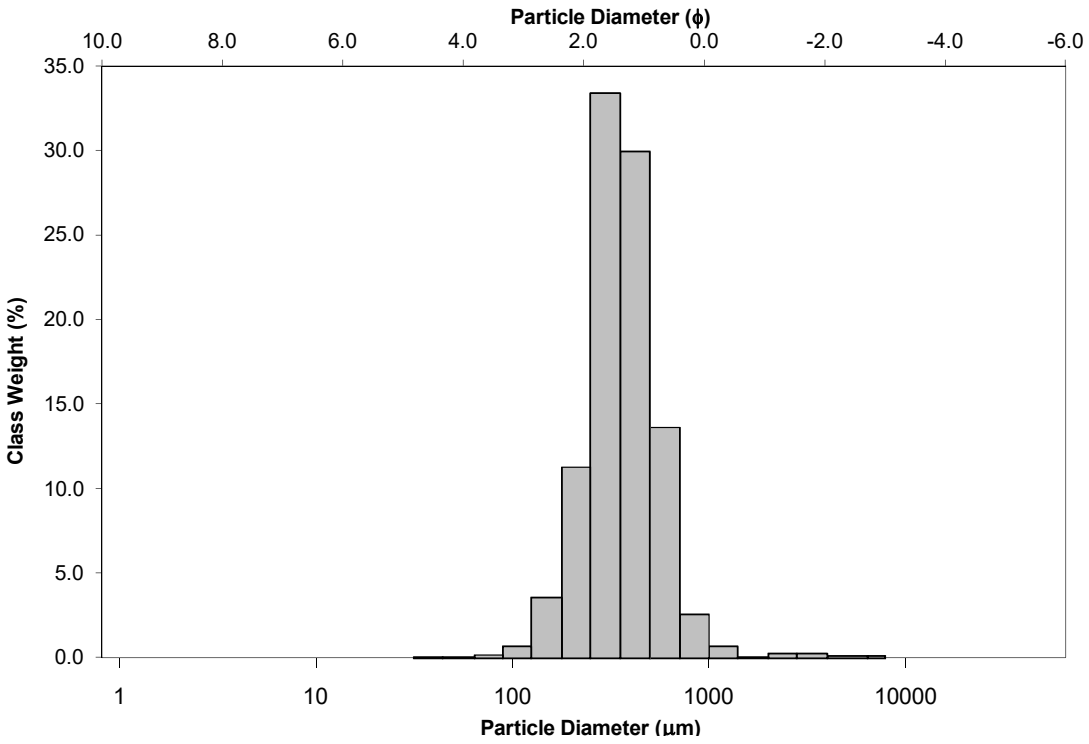
	µm	ϕ
MODE 1:	301.0	1.754
MODE 2:		
MODE 3:		
D_{10}:	200.9	0.700
MEDIAN or D_{50}:	348.7	1.520
D_{90}:	615.5	2.316
(D_{90} / D_{10}):	3.064	3.308
(D_{90} - D_{10}):	414.7	1.615
(D_{75} / D_{25}):	1.716	1.701
(D_{75} - D_{25}):	193.2	0.779

GRAIN SIZE DISTRIBUTION

GRAVEL:	0.9%	COARSE SAND:	16.6%
SAND:	97.8%	MEDIUM SAND:	64.2%
MUD:	1.3%	FINE SAND:	15.2%
		V FINE SAND:	1.0%
V COARSE GRAVEL:	0.0%	V COARSE SILT:	0.2%
COARSE GRAVEL:	0.0%	COARSE SILT:	0.0%
MEDIUM GRAVEL:	0.0%	MEDIUM SILT:	0.0%
FINE GRAVEL:	0.3%	FINE SILT:	0.0%
V FINE GRAVEL:	0.6%	V FINE SILT:	0.0%
V COARSE SAND:	0.8%	CLAY:	1.1%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	415.1	337.0	1.569	354.3	1.497	Medium Sand
SORTING (σ):	400.5	2.108	1.076	1.520	0.604	Moderately Well Sorted
SKEWNESS (Sk):	9.854	-4.077	4.077	0.005	-0.005	Symmetrical
KURTOSIS (K):	132.0	33.72	33.72	1.109	1.109	Mesokurtic

GRAIN SIZE DISTRIBUTION



APPENDIX E PARTICLE SIZE ANALYSIS

SAMPLE STATISTICS

SAMPLE IDENTITY: **ENV-3** ANALYST & DATE: , 3/31/2018

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Slightly Gravelly Sand

SEDIMENT NAME: Slightly Very Fine Gravelly Fine Sand

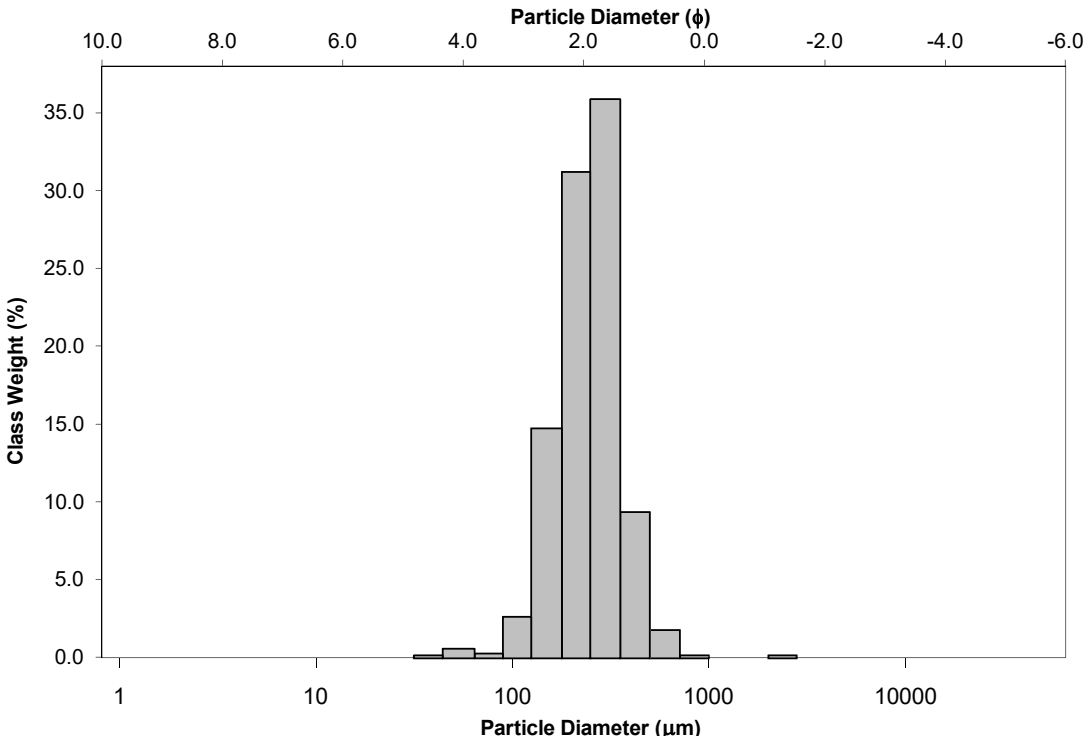
	µm	ϕ
MODE 1:	301.0	1.754
MODE 2:		
MODE 3:		
D_{10}:	139.8	1.403
MEDIAN or D_{50}:	245.5	2.026
D_{90}:	378.2	2.839
(D_{90} / D_{10}):	2.706	2.024
(D_{90} - D_{10}):	238.4	1.436
(D_{75} / D_{25}):	1.668	1.439
(D_{75} - D_{25}):	124.8	0.738

GRAIN SIZE DISTRIBUTION

GRAVEL:	0.2%	COARSE SAND:	2.1%
SAND:	97.9%	MEDIUM SAND:	46.0%
MUD:	1.9%	FINE SAND:	46.6%
		V FINE SAND:	3.3%
V COARSE GRAVEL:	0.0%	V COARSE SILT:	0.9%
COARSE GRAVEL:	0.0%	COARSE SILT:	0.0%
MEDIUM GRAVEL:	0.0%	MEDIUM SILT:	0.0%
FINE GRAVEL:	0.0%	FINE SILT:	0.0%
V FINE GRAVEL:	0.2%	V FINE SILT:	0.0%
V COARSE SAND:	0.0%	CLAY:	1.0%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	262.6	228.2	2.132	237.4	2.075	Fine Sand
SORTING (σ):	140.4	1.918	0.940	1.467	0.553	Moderately Well Sorted
SKEWNESS (Sk):	7.412	-4.742	4.742	-0.092	0.092	Symmetrical
KURTOSIS (K):	109.2	38.41	38.41	1.035	1.035	Mesokurtic

GRAIN SIZE DISTRIBUTION



APPENDIX E PARTICLE SIZE ANALYSIS

SAMPLE STATISTICS

SAMPLE IDENTITY: **ENV-4** ANALYST & DATE: , 3/31/2018

SAMPLE TYPE: Unimodal, Moderately Well Sorted TEXTURAL GROUP: Slightly Gravelly Sand

SEDIMENT NAME: Slightly Fine Gravelly Fine Sand

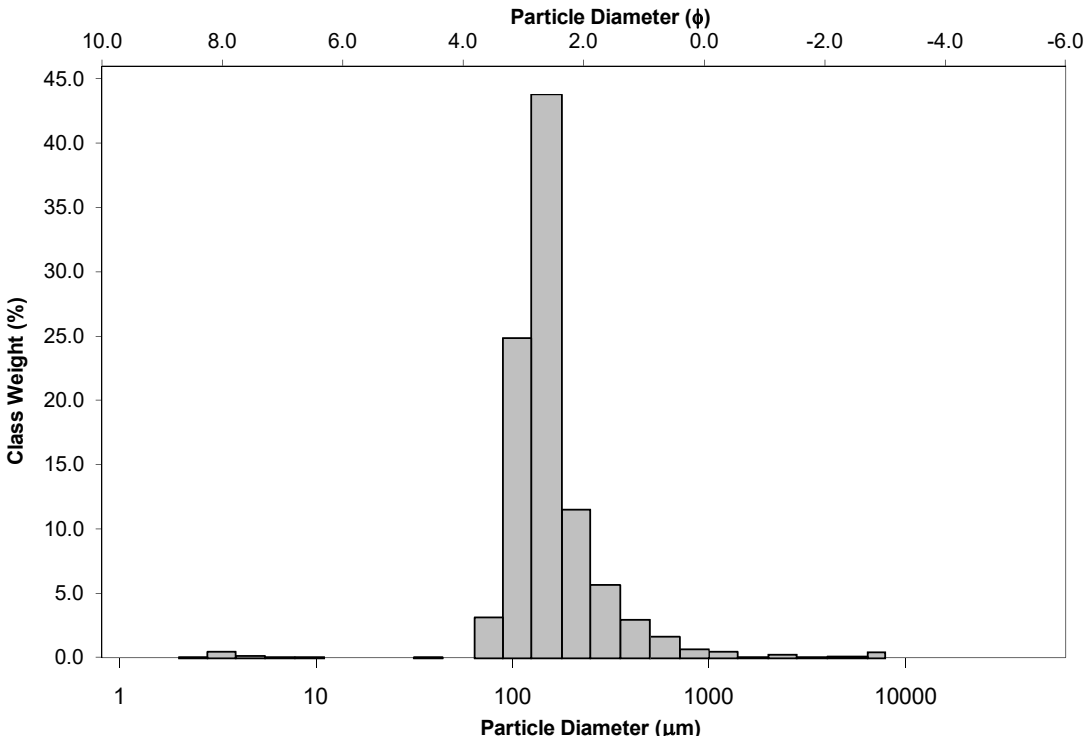
	µm	ϕ
MODE 1:	151.0	2.751
MODE 2:		
MODE 3:		
D_{10}:	92.31	1.776
MEDIAN or D_{50}:	144.3	2.793
D_{90}:	292.0	3.437
(D_{90} / D_{10}):	3.163	1.935
(D_{90} - D_{10}):	199.7	1.661
(D_{75} / D_{25}):	1.546	1.251
(D_{75} - D_{25}):	62.19	0.628

GRAIN SIZE DISTRIBUTION

GRAVEL:	0.9%	COARSE SAND:	2.4%
SAND:	94.7%	MEDIUM SAND:	8.6%
MUD:	4.4%	FINE SAND:	55.5%
		V FINE SAND:	27.6%
V COARSE GRAVEL:	0.0%	V COARSE SILT:	0.1%
COARSE GRAVEL:	0.0%	COARSE SILT:	0.0%
MEDIUM GRAVEL:	0.0%	MEDIUM SILT:	0.1%
FINE GRAVEL:	0.5%	FINE SILT:	0.3%
V FINE GRAVEL:	0.4%	V FINE SILT:	0.6%
V COARSE SAND:	0.6%	CLAY:	3.3%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	216.0	133.7	2.903	148.2	2.754	Fine Sand
SORTING (σ):	489.8	2.908	1.540	1.622	0.697	Moderately Well Sorted
SKEWNESS (Sk):	11.25	-2.418	2.418	0.149	-0.149	Coarse Skewed
KURTOSIS (K):	145.1	13.62	13.62	1.753	1.753	Very Leptokurtic

GRAIN SIZE DISTRIBUTION



APPENDIX E PARTICLE SIZE ANALYSIS

SAMPLE STATISTICS

SAMPLE IDENTITY: **ENV-6**

ANALYST & DATE: , 3/31/2018

SAMPLE TYPE: Bimodal, Poorly Sorted

TEXTURAL GROUP: Gravelly Sand

SEDIMENT NAME: Fine Gravelly Coarse Sand

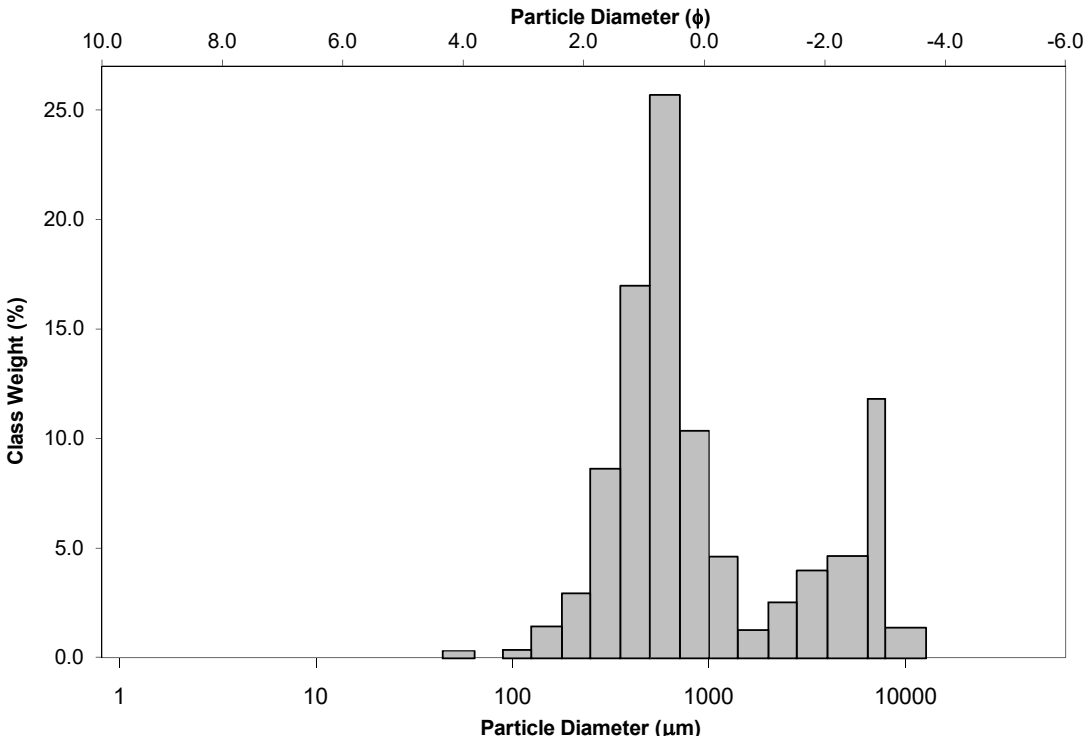
	µm	ϕ
MODE 1:	605.0	0.747
MODE 2:	7150.0	-2.830
MODE 3:		
D_{10}:	288.1	-2.627
MEDIAN or D_{50}:	622.2	0.685
D_{90}:	6176.1	1.796
(D_{90} / D_{10}):	21.44	-0.684
(D_{90} - D_{10}):	5888.1	4.422
(D_{75} / D_{25}):	3.143	-2.901
(D_{75} - D_{25}):	914.4	1.652

GRAIN SIZE DISTRIBUTION

GRAVEL: 23.0%	COARSE SAND: 37.8%
SAND: 75.8%	MEDIUM SAND: 26.8%
MUD: 1.2%	FINE SAND: 4.7%
	V FINE SAND: 0.5%
V COARSE GRAVEL: 0.0%	V COARSE SILT: 0.4%
COARSE GRAVEL: 0.0%	COARSE SILT: 0.0%
MEDIUM GRAVEL: 1.9%	MEDIUM SILT: 0.0%
FINE GRAVEL: 14.2%	FINE SILT: 0.0%
V FINE GRAVEL: 6.9%	V FINE SILT: 0.0%
V COARSE SAND: 6.1%	CLAY: 0.8%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	1742.5	831.4	0.266	964.4	0.052	Coarse Sand
SORTING (σ):	2383.1	3.399	1.765	3.116	1.640	Poorly Sorted
SKEWNESS (Sk):	1.915	-0.513	0.513	0.472	-0.472	Very Coarse Skewed
KURTOSIS (K):	5.674	7.711	7.711	1.255	1.255	Leptokurtic

GRAIN SIZE DISTRIBUTION



APPENDIX F MACROFAUNA ANALYSIS OF BENTHIC GRAB SAMPLES

APPENDIX F BENTHIC GRAB MACROFAUNA ANALYSIS

AphiaID	Phylum	Class	Family	Genus	Species	Taxon	ST18904-ENV1	ST18904-ENV2	ST18904-ENV3	ST18904-ENV4	ST18904-ENV6	Total Individuals	% of Individuals	Number of Stations
129778	Annelida	Polychaeta	Ampharetidae	Ampharete	finmarchica	*Ampharete finmarchica*				3		3	0.6%	1
129155	Annelida	Polychaeta	Ampharetidae	Ampharete		*Ampharete* sp.	2			6		8	1.5%	2
326605	Annelida	Polychaeta	Paraonidae	Aricidea	wassi	*Aricidea (Aricidea) wassi*			3			3	0.6%	1
129430	Animalia	Polychaeta	Paraonidae	Aricidea		*Aricidea sp.*					1	1	0.2%	1
157221	Annelida	Polychaeta	Ampharetidae	Asabellides	oculata	*Asabellides oculata*		1	4			5	**1.0%**	2
919	Annelida	Polychaeta	Cirratulidae			Cirratulidae					4	4	0.8%	1
157357	Annelida	Polychaeta	Oenonidae	Drilonereis	longa	Drilonereis longa				7	1	8	1.5%	2
157358	Annelida	Polychaeta	Oenonidae	Drilonereis	magna	*Drilonereis magna*			1			1	0.2%	1
152232	Annelida	Polychaeta	Maldanidae			*Euclymeninae*					3	3	0.6%	1
157388	Annelida	Polychaeta	Glyceridae	Glycera	americana	*Glycera americana*			2	2	3	7	1.3%	3
129296	Annelida	Polychaeta	Glyceridae	Glycera		*Glycera* sp.	1				1	2	0.4%	2
157407	Annelida	Polychaeta	Goniadidae	Goniadides	carolinae	*Goniadides carolinae*	3				8	11	**2.1%**	2
129418	Annelida	Polychaeta	Orbiniidae	Leitoscoloplos		*Leitoscoloplos* sp.				4		4	0.8%	1
130578	Annelida	Polychaeta	Paraonidae	Levinsenia	gracilis	*Levinsenia gracilis*				2		2	0.4%	1
130228	Annelida	Polychaeta	Lumbrineridae	Lumbrinerides	acuta	*Lumbrinerides acuta*	1					1	0.2%	1
157501	Annelida	Polychaeta	Nephtyidae	Nephtys	picta	*Nephtys picta*	5	13	2	10	8	38	**7.1%**	5
130255	Annelida	Polychaeta	Lumbrineridae	Ninoe	nigripes	*Ninoe nigripes*				25		25	4.7%	1
334234	Annelida	Polychaeta	Oenonidae	Notocirrus	spinifera	*Notocirrus spinifera*				6		6	1.1%	1
129898	Annelida	Polychaeta	Capitellidae	Notomastus	latericeus	*Notomastus latericeus*				1	1	2	0.4%	2
334506	Annelida	Polychaeta	Phyllodocidae	Phyllodoce	groenlandica	*Phyllodoce groenlandica*	1					1	0.2%	1
334512	Annelida	Polychaeta	Phyllodocidae	Phyllodoce	mucosa	*Phyllodoce mucosa*			1			1	0.2%	1
129710	Annelida	Polychaeta	Terebellidae	Polycirrus		*Polycirrus* sp.					1	1	0.2%	1
130261	Annelida	Polychaeta	Lumbrineridae	Scoletoma	fragilis	*Scoletoma fragilis*	2		5	5	35	47	**8.9%**	4
421066	Annelida	Polychaeta	Lumbrineridae	Scoletoma	verrilli	*Scoletoma verrilli*				13	4	17	**3.2%**	2
331978	Annelida	Polychaeta	Sphaerodoridae	Sphaerodoropsis	corrugata	*Sphaerodoropsis corrugata*	3					3	0.6%	1
913	Annelida	Polychaeta	Spionidae			Spionidae	10			1		11	2.1%	2
129595	Annelida	Polychaeta	Sigalionidae	Sthenelais		*Sthenelais* sp.	1		2	1		4	0.8%	3
391588	Arthropoda	Malacostraca	Oedicerotidae	Ameroculodes		*Ameroculodes* sp.					2	2	0.4%	1
158022	Arthropoda	Malacostraca	Ampeliscidae	Ampelisca	vadorum	*Ampelisca vadorum*				4		4	0.8%	1
158023	Arthropoda	Malacostraca	Ampeliscidae	Ampelisca	verrilli	*Ampelisca verrilli*				124		124	23.4%	1
101946	Arthropoda	Malacostraca	Ampeliscidae	Byblis	serrata	*Byblis serrata*	10	14	1	1	1	27	**5.1%**	5
157815	Arthropoda	Malacostraca	Diastylidae	Diastylis	polita	*Diastylis polita*				2		2	0.4%	1
157817	Arthropoda	Malacostraca	Diastylidae	Diastylis	sculpta	*Diastylis sculpta*			1		1	2	0.4%	2
489646	Arthropoda	Malacostraca	Podoceridae	Dyopedos	monacanthus	*Dyopedos monacanthus*				1		1	0.2%	1
157885	Arthropoda	Malacostraca	Idoteidae	Edotia	triloba	*Edotia triloba*	3		3	5		11	**2.1%**	3
102409	Arthropoda	Malacostraca	Ischyroceridae	Ericthonius	rubricornis	*Ericthonius rubricornis*				1		1	0.2%	1
106854	Arthropoda	Malacostraca	Paguridae	Pagurus		*Pagurus* sp.			2		1	3	0.6%	2
102385	Arthropoda	Malacostraca	Isaeidae	Photis	pollex	*Photis pollex*			2			2	0.4%	1
102989	Arthropoda	Malacostraca	Phoxocephalidae	Phoxocephalus	holbolli	*Phoxocephalus holbolli*					10	10	1.9%	1
158137	Arthropoda	Malacostraca	Haustoriidae	Protohaustorius	wigleyi	*Protohaustorius wigleyi*		2				2	0.4%	1
157836	Arthropoda	Malacostraca	Bodotriidae	Pseudoleptocuma	minus	*Pseudoleptocuma minus*		1			1	2	0.4%	2

AphiaID	Phylum	Class	Family	Genus	Species	Taxon	ST18904-ENV1	ST18904-ENV2	ST18904-ENV3	ST18904-ENV4	ST18904-ENV6	Total Individuals	% of Individuals	Number of Stations
549011	Arthropoda	Malacostraca	Phoxocephalidae	Rhepoxynius	hudsoni	*Rhepoxynius hudsoni*	16	8	28			52	**9.8%**	3
157839	Arthropoda	Malacostraca	Tanaissuidae	Tanaissus	psammophilus	*Tanaissus psammophilus*	1	4				5	1.0%	2
158156	Arthropoda	Malacostraca	Aoridae	Unciola	irrorata	*Unciola irrorata*	4			8	2	14	**2.7%**	3
158062	Echinodermata	Echinoidea	Echinarachniidae	Echinarachnius	parma	*Echinarachnius parma*	1		5			6	1.1%	2
420863	Mollusca	Bivalvia	Tellinidae	Angulus	versicolor	*Angulus versicolor*			3			3	0.57%	1
138802	Mollusca	Bivalvia	Arcticidae	Arctica	islandica	*Arctica islandica*			1			1	0.2%	1
140584	Mollusca	Bivalvia	Nuculidae	Ennucula	tenuis	*Ennucula tenuis*			6			6	1.1%	1
933783	Mollusca	Bivalvia	Pharidae	Ensis	directus	*Ensis directus*	1					1	0.2%	1
138154	Mollusca	Bivalvia	Lyonsiidae	Lyonsia		*Lyonsia* sp.			1			1	0.2%	1
156916	Mollusca	Bivalvia	Nuculidae	Nucula	proxima	*Nucula proxima*			6			6	1.1%	1
156963	Mollusca	Bivalvia	Veneridae	Pitar	morrhuanus	Pitar morrhuanus				1		1	0.2%	1
156996	Mollusca	Bivalvia	Mactridae	Spisula	solidissima	*Spisula solidissima*					1	1	0.2%	1
737284	Mollusca	Gastropoda	Nassariidae	Tritia	trivittata	*Tritia trivittata*		1	2			3	0.6%	2
243	Mollusca	Bivalvia	Veneridae			*Veneridae*			1			1	0.2%	1
138672	Mollusca	Bivalvia	Yoldiidae	Yoldia		*Yoldia* sp.				1		1	0.2%	1
1361	Cnidaria	Anthozoa				Ceriantharia				2		2	0.4%	1
146927	Nemertea	Anopla	Carinomidae	Carinomella	lactea	*Carinomella lactea*			5		4	9	**1.7%**	2
122348	Nemertea	Anopla	Lineidae	Cerebratulus		*Cerebratulus* sp.	3					3	0.6%	1
122360	Nemertea	Anopla	Lineidae	Micrura		*Micrura* sp.	1					1	0.2%	1
						individuals	69	44	87	236	93	529	100.0%	
						taxa	19	8	23	25	21	60	60	