Hornsea Project Four

Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report

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02	75-77	Table 13	*Amphiura filiformis* and *Sabellaria spinulosa* added to table of Valued Ecological Receptors

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Glossary

Term	Definition
Annelida	Phylum consisting of ringed or segmented worms, including earthworms, lugworms, ragworms and leeches.
Bathymetry	The depth of water in an ocean, sea or lake.
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment.
Biotope	A region of habitat associated with a particular ecological community.
Bray-Curtis Similarity	Statistic that compares fauna samples in terms of abundance and number of taxa
Drop Down Video (DDV)	A survey method in which imagery of habitat is collected, used predominantly to survey marine environments.
Development Consent Order (DCO)	An order made under the Planning Act 2008 granting development consent for one or more Nationally Significant Infrastructure Projects (NSIPs).
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement.
Echinodermata	A phylum of marine invertebrates of radial symmetry including starfish, brittle stars, crinoids and sea cucumbers.
EUNiS habitat classification	A pan-European system which facilitates the harmonised description and classification of all types of habitat, through the use of criteria for habitat identification.
Gas Chromatography (GC)	Mainly used in analytical chemistry to separate and analyse compounds that can be vaporised without decomposition.
Geophysical	Relating to the physics of the earth.
Holocene	The Holocene is the current geological epoch. It began approximately 11,650 calibrated years before present, after the last glacial period, which concluded with the Holocene glacial retreat. The Holocene and the preceding Pleistocene together form the Quaternary period.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Hydrocarbon	A compound consisting of both Hydrogen and Carbon.
Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.
Macro	Large scale.
Magnetometer	A device which measure's magnetism; the direction, strength or relative change of a magnetic field.
Megafauna	Large animals of a particular region, habitat or geological period.
Megaripples	An extensive undulation of the surface of a sandy beach or seabed, typically tens of meters from crest to crest and tens of centimetres in height.

Term	Definition
Mini-hamon grab	Comprises of a stainless-steel box shaped sampling scoop mounted in a triangular frame, ideal for sampling seabed sediment's, as well as sampling for benthic macrofauna.
Mollusca	Phylum of invertebrates which have a soft unsegmented body, commonly protected by a calcareous shell.
Multi-Dimensional Scaling (MDS)	A statistical manipulation used to identify groups of distinct fauna (communities).
Multivariate	Involving two or more variable quantities.
Order Limits	The limits within which Hornsea Four (the 'authorised project') may be carried out.
Orsted Hornsea Project Four Ltd	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
SACFOR	An abundance scale used for both littoral and sublittoral taxa from 1990 onwards.
Side Scan Sonar (SSS)	Side-imaging sonar used to create an image of the seafloor.
Single-beam and multi-beam echo sounders (SBES and MBES)	A type of sonar which transmits soundwaves, using the time taken between emission and return to establish a depth. This can be done using singular or multiple beams.
Subtidal	The region of shallow waters which are below the level of low tide.
Taxon	A grouping of the fauna, may be a species or, if different species are indistinguishable, it may be based on a higher taxonomic group such as the genus or family.
Topography	The arrangement of natural and artificial physical features of an area.
Total Organic Carbon (TOC)	The total amount of carbon found within an organic compound.
Univariate	The use of one variate or variable quantity.

Acronyms

Acronym	Definition
AGDS	Acoustic Ground Discrimination System
BAC	Background Assessment Concentrations
BAP	Biodiversity Action Plan
BC	Background Concentrations
BGS	British Geological Survey
DCO	Development Consent Order
DDV	Drop Down Video
DECC	Department of Energy and Climate Change
DTI	Department of Trade and Industry
EAOL	East Anglia Offshore Windfarm
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ES	Environmental Statement
EUNIS	European Nature Information System
FOCI	Feature of Conservation Importance
GC	Gas Chromatography

Acronym	Definition
GIS	Geographical Information Systems
IECS	Institute of Estuarine and Coastal Studies
ISQG	Canadian Interim Sediment Quality Guideline
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LOD	Limit of Detection
MBES	Multi-beam echo sounders
MCZ	Marine Conservation Zone
MDS	Multi-dimensional Scaling
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MNCR	Marine Nature Conservation Review
MPA	Marine Protected Area
NERC	Natural Environment Research Council
NNR	National Nature Reserve
NSIP	Nationally Significant Infrastructure Project
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PAH	Polycyclic Aromatic Hydrocarbons
PEIR	Preliminary Environmental Information Report
PINS	Planning Inspectorate
PSA	Particle Size Analysis
PSD	Particle Size Distribution
REC	Regional Environmental Characterisation
ROFI	Region of Freshwater Influence
SAC	Special Area of Conservation
SBES	Single-beam Echo Sounders
SBP	Sub-bottom Profiler
SEA	Strategic Environmental Assessment
SNS	Southern North Sea
SPA	Special Protected Area
SSS	Side Scan Sonar
SSSI	Sites of Special Scientific Interest
THC	Total Hydrocarbon
TOC	Total Organic Carbon
UCM	Unresolved Complex Mixture
VER	Valued Ecological Receptors
ZoC	Zonal Characterisation

Units

Unit	Definition
C	Celsius
g	Gram
km	Kilometre
km^2	Square kilometre
m	Metre
m^2	Square metre
ppm	Parts per million
µg	Microgram

1 Introduction

1.1 Project Background

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter the 'Applicant') is proposing to develop the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 69 km offshore the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone (please see **Volume A1, Chapter 1: Introduction** for further details on the Hornsea Zone). Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network. The location of Hornsea Four is illustrated on **Figure 1**. The Order Limits combines the search areas for the offshore infrastructure.

1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 846 km^2 at the Scoping phase of project development. In the spirit of keeping with Hornsea Four's approach to Proportionate Environmental Impact Assessment (EIA), the project has due consideration to the size and location (within the existing AfL area) of the final project that is being taken forward to Development Consent Order (DCO) application. This consideration is captured internally as the "Developable Area Process", which includes Physical, Biological and Human constraints in refining the developable area, balancing consenting and commercial considerations with technical feasibility for construction.

1.1.1.3 The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the array area taken forward at the point of DCO application. (see **Figure 1**). Hornsea Four adopted a major site reduction from the array area presented at Scoping (846 km^2) to the Preliminary Environmental Information Report (PEIR) boundary (600 km^2), with a further reduction adopted for the Environmental Statement (ES) and DCO application (468 km^2) due to the results of the PEIR, technical considerations and stakeholder feedback. The evolution of the Hornsea Four Order Limits is detailed in **Volume A1, Chapter 3: Site Selection and Consideration of Alternatives** and **Volume A4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure**.

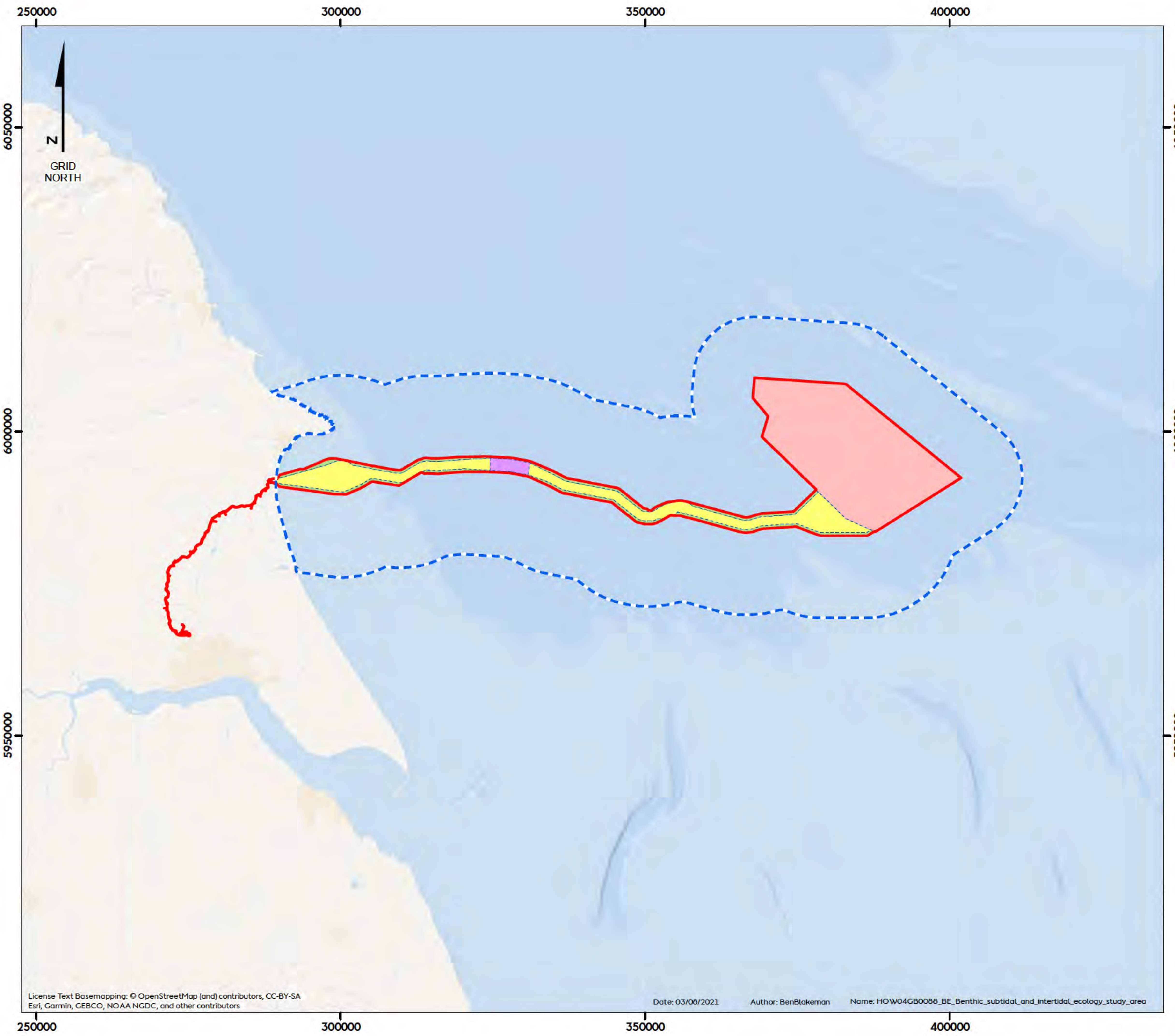
1.1.1.4 GoBe Consultants Ltd. (GoBe) was commissioned by the Applicant to undertake a subtidal and intertidal benthic ecology characterisation study of the Hornsea Four site and surrounding area. The characterisation of the existing subtidal and intertidal environment has been derived using data from a number of sources, including existing scientific studies of the regional area, benthic surveys undertaken within the former Hornsea Zone and other offshore wind farms within the vicinity and site-specific characterisation surveys undertaken for Hornsea Four.

1.1.1.5 This report has been produced following a review of the relevant parts of the Scoping Opinion provided by the Planning Inspectorate (PINS) the feedback provided by stakeholders in response to the Section 42 consultation process, informed by the publication of the PEIR, and subsequent discussions with the Evidence Plan Technical Panel.

1.2 Aims and Objectives

1.2.1.1 The aim of this study is to provide an up-to-date characterisation of the benthic subtidal and intertidal ecological resources within the Hornsea Four Order Limits (which incorporates the intertidal and offshore components of Hornsea Four) and the surrounding area.

1.2.1.2 Using existing data, including benthic subtidal grab data from former Hornsea Zone, other Hornsea projects and Dogger Bank A and B Offshore Wind Farms (Dogger Bank A & B), together with publicly available information, new data collected specifically for Hornsea Four and benthic habitat modelling, the objective was to develop a robust baseline description of the subtidal benthic and intertidal resources within the Hornsea Four Order Limits and surrounding area. The location of the Hornsea Four Order Limits is presented in **Figure 1**.



Hornsea Four

Figure 1

Benthic subtidal and intertidal ecology study area

- Order Limits
- Array Area
- HVAC Booster Station Works Area
- Offshore Temporary Works Area
- Offshore Export Cable Corridor
- Study Area (14km from ECC and 10km from Array Area)

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:600,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
----	First Issue	17/06/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Benthic subtidal and intertidal ecology study area
Document no: HOW04GB0088
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2 Methodology

2.1 Benthic Subtidal and Intertidal Ecology Study Area

2.1.1.1 For the purposes of this report, the Hornsea Four benthic subtidal and intertidal study areas (**Figure 1**) have been defined by the following:

- The Hornsea Four Order Limits is defined as the Hornsea Four array area (hereafter array area) along with the Hornsea Four offshore ECC (hereafter offshore ECC), where the landfall area lies along the Holderness coast between Bridlington and Skipsea;
- The Hornsea Four benthic subtidal ecology study area is defined by a 10 km buffer surrounding the array area, and a 14 km buffer around the offshore ECC, to represent the tidal ellipse distance, in order to incorporate the maximum distance sediments may travel in one tidal cycle (for further explanation see **Volume A2, Chapter 1: Marine Geology, Oceanography and Physical Processes**); and
- The Hornsea Four benthic intertidal ecology study area is defined by the intertidal habitats up to the Mean High-Water Spring (MHWS) mark within the Hornsea Four Order Limits.

2.1.1.2 Habitats landward of MHWS have been considered in the onshore ecology assessment (see **Volume A3, Chapter 3: Ecology and Nature Conservation**).

3 Desktop Review

3.1 Introduction

3.1.1.1 A detailed desktop review has been carried out to establish the baseline information available on benthic subtidal and intertidal resources within the Hornsea Four study area (as shown in **Figure 1**) and the wider region Southern North Sea (SNS) area surrounding Hornsea Four, for contextualisation.

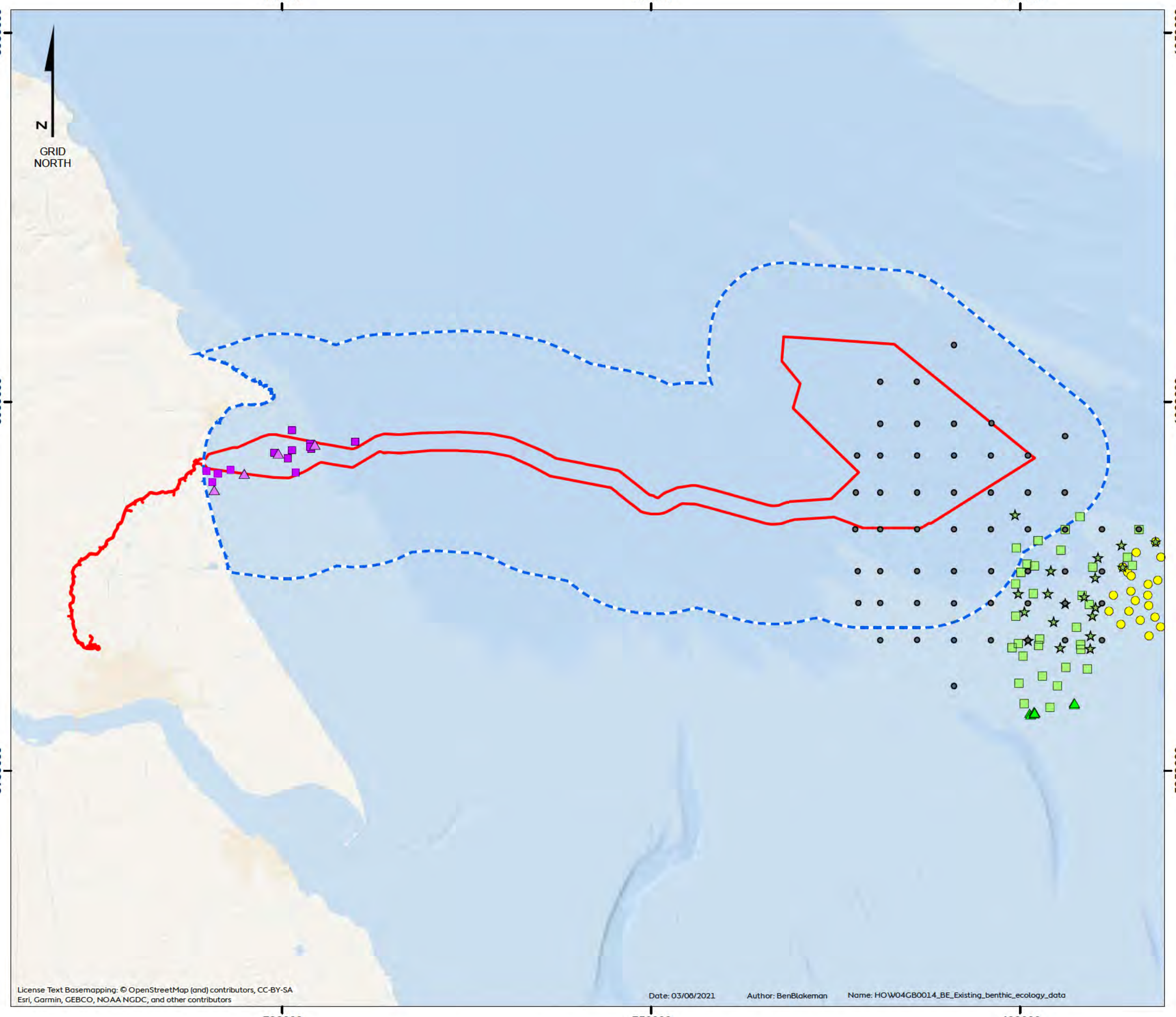
3.2 Data Sources

3.2.1.1 Non-site specific benthic ecological data to support the baseline characterisation of the Hornsea Four study area were utilised from the sources listed in **Table 1** below. **Figure 2** presents the spatial distribution of benthic sampling locations that coincide with the Hornsea Four array area and offshore ECC, used to inform this desktop review characterisation. Fully comprehensive site-specific data has been collected across the Hornsea Four Order Limits, as presented in **Section 4**.

Table 1: Key sources of pre-existing benthic subtidal ecology data.

Source	Summary	Coverage of Hornsea Four
Hornsea Zonal Characterisation (ZoC) Survey (2010)	Drop down video (DDV) and grab sampling gear were deployed across the former Hornsea Zone in a regular grid pattern applying a 5 km x 5 km spacing to optimise sampling of the full range of habitats within the former Hornsea zone. An	Stratified random sampling across the Hornsea Four array area.

Source	Summary	Coverage of Hornsea Four
	epibenthic beam trawl was also deployed at 11 stations within the Hornsea Four array area.	
Hornsea Project One Offshore Wind Farm (Hornsea Project One) Array Survey (2010 - 2011)	An infill survey was undertaken at the Hornsea Project One array area deploying DDV and grab sampling gear. Epibenthic beam trawls were also deployed at a number of stations.	There is overlap between the Hornsea Project One survey area and the Hornsea Four array area, furthermore the data provides some regional context with regards to benthic habitat distribution.
Hornsea Project Two Offshore Wind Farm (Hornsea Project Two) Array Survey (2012)	DDV and grab sampling gear were deployed across the Hornsea Project Two zone with an epibenthic beam trawl also deployed at a number of stations.	The survey targeted Hornsea Project Two although five sampling stations were located on the periphery of the Hornsea Four array area and additional data providing more regional context.
Dogger Bank A & B ES (Forewind, 2013)	The Dogger Bank A & B ES, submitted as part of the DCO application, presented an analysis of geophysical Acoustic Ground Discrimination System (AGDS) data ground-truthed with benthic grab samples and DDV to characterise the offshore array and ECC to a landfall location on the Holderness coast.	The inshore area of the Dogger Bank A & B offshore ECC coincides with the Hornsea Four offshore ECC for approximately 16 km from the landfall.
Humber Regional Environmental Characterisation (REC) (Tappin et al. 2012)	Regional characterisation of wider Humber area including geophysical data, grab, epifaunal beam trawl and DDV ground truthing.	No overlap with Hornsea Four array area or offshore ECC. Closest sampling locations are located just beyond the southern boundary of the Hornsea Four array area. Dataset provides a regional context for site-specific information.
Technical reports for Strategic Environmental Assessment (SEA) Areas 2 and 3 (Department of Trade and Industry (DTI), 2001a; DTI, 2001b);	Description of survey data published in the SEA for Area 2 (Northern North Sea) and Area 3 (Southern North Sea).	Broadscale data with regional coverage.
UKSeaMap (2018)	European Nature Information System (EUNIS) Level 4 model, detailing biological zone and substrate.	Complete coverage up to MHWS.
Spatial Models of Seabed Sediment Composition (Stephens et al. 2015)	Sediment model detailing multiple different sediment classifications, including Folk and EUNIS substrate.	Complete coverage up to 0 m depth (unspecified what datum this refers to in Cefas publication)



Hornsea Four

Figure 2

The location of Hornsea Four with key sources of existing benthic subtidal ecology data

Order Limits

Study Area (14km from ECC and 10km from Array Area)

Former Hornsea Zone and Hornsea Project One Array Survey (2010 to 2011)

Creyke Beck beam trawl location

Creyke Beck Grab and DDV sampling location

Hornsea Project Two Array Sampling Survey

Grab and DDV sample location

Grab, DDV and beam trawl sample location

DDV sample location

Grab sample Location

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

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Existing benthic ecology data coverage
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3.2.1.2 The following sections summarise what is currently known of the existing benthic subtidal and intertidal habitats and communities, based on a review of pre-existing data sets described in **Table 1**.

3.3 Subtidal Habitats

3.3.1.1 Former Hornsea Zone and Hornsea Project One pre-existing data collected within the Hornsea Four array area (**Figure 2**) indicated that subtidal habitats were predominately characterised by infralittoral muddy sand with areas of circalittoral fine sand at the northern and south east periphery. Further analysis of the data was undertaken and predicted the component biotopes associated with the habitats to comprise SS.SSa.IMuSa.FfabMag (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand) and SS.SSa.CFiSa.EpusOborApri (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand).

3.3.1.2 Other surveys conducted in the region such as the North Sea SEA surveys (Department of Energy and Climate Change (DECC), 2016) and the Humber REC (Tappin et al. 2011) recorded large areas of similar well-sorted medium or fine sands within the wider Southern North Sea area.

3.3.1.3 Current full coverage sediment maps of the Hornsea Four area are provided by British Geological Survey (BGS) seabed sediment, the Cefas 2015 and 2019 sediment models and the Joint Nature Conservation Committee's (JNCC) UKSeaMap 2018 (published in 2019). These projects predict habitats within the North Sea, based on known environmental characteristics cross-checked with extant survey data. Using this data, GoBe developed a seabed sediment model (**Section 7.2**). The central and offshore sections of the offshore ECC is predicted to comprise of the same habitat type that covers the majority of the array area; deep circalittoral sand (A5.27). Although, this is the habitat predicted across the array area, in reality, Hornsea Zone site specific surveys indicate that the habitats recorded are more representative of EUNIS level four habitat infralittoral muddy sand (A5.24). It is anticipated that the habitat types along the offshore section of the ECC will be similar to those known to be present within the array area.

3.3.1.4 The benthic subtidal habitats along the nearshore sections of the offshore ECC are more heterogeneous with more coarse and mixed sediments predicted. The predicted EUNIS habitat types are deep circalittoral coarse sediment (A5.15), circalittoral coarse sediments (A5.14), deep circalittoral mixed sediments (A5.45) and infralittoral coarse sediments (A5.13). Close to shore the seabed habitats were predicted by the GoBe habitat model (**Section 7**) to exhibit a greater proportion of fine sediment comprising circalittoral fine sand (A5.25), circalittoral muddy sand (A5.26) and infralittoral fine sand (A5.23) or infralittoral muddy sand (A5.24).

3.3.1.5 The Dogger Bank A & B offshore ECC partially overlaps with the Hornsea Four offshore ECC for approximately 16 km from the landfall location. Habitat mapping conducted for Forewind's Dogger Bank A & B reported that the inshore area of the Dogger Bank A & B ECC, where it overlaps with the Hornsea Four offshore ECC, broadly corroborates the predicted broadscale habitats identified from UKSeaMap which is characterised by a heterogeneous distribution of sedimentary habitats ranging from sand and mixed sediments to muddy sand sediments. Where the Dogger Bank A & B cable route and offshore ECC overlap furthest offshore, the dominant biotopes identified were *Mysella* *bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment (SS.SMx.CMx.MysThyMx) and *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand (SS.SSa.CFiSa.EpusOborApri). Within approximately 8 km from shore, the Dogger Bank A & B cable route was characterised by the biotopes *Mytilus edulis* beds on sublittoral sediment (SS.SBR.SMus.MytSS) and *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat).

3.4 Intertidal Habitats

3.4.1.1 The Hornsea Four landfall area lies along the Holderness coast between Bridlington and Skipsea. Site-specific surveys were commissioned by Forewind in 2011 to characterise the landfall location associated with the Dogger Bank A & B electrical infrastructure (Forewind, 2013). These surveys found the landfall area to be characterised by long, clean sandy beaches, with cliffs at the upper shore. The intertidal biotopes were characterised by barren littoral sand (LS.LSa.MoSa.BarSa) with small areas of coarse sediment (LS.LCS) on the upper shore. These habitat types and biotopes are ubiquitous in the area and are anticipated to be the dominant biotope type within the wider Hornsea Four offshore ECC (Forewind, 2013; IECS, 2019). The JNCC reported highly mobile sediments subject to high degrees of drying between tides to be typical of the wider region (Connor et al. 2004).

4 Site-Specific Data Collection

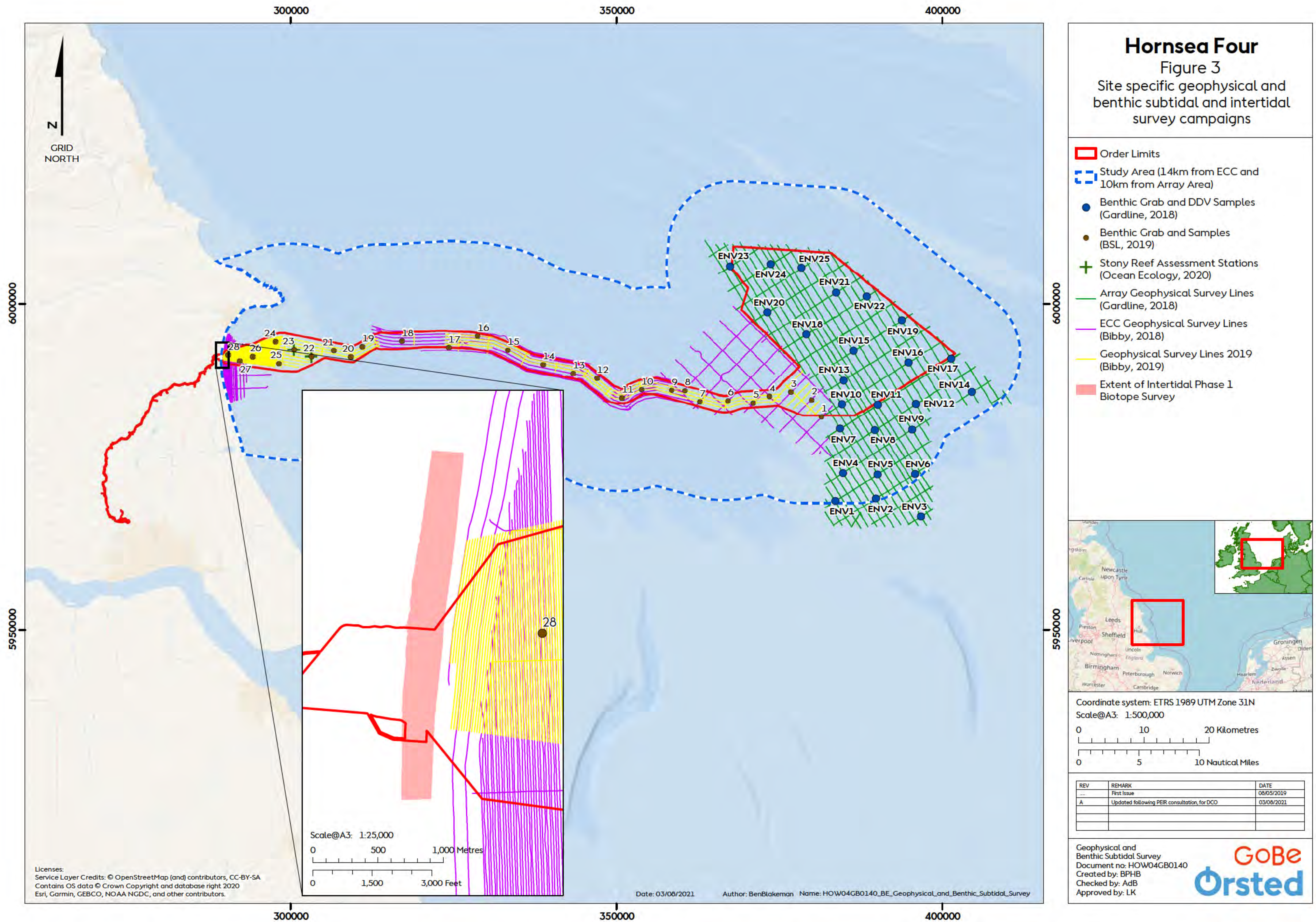
4.1.1.1 Site-specific baseline characterisation surveys were conducted within the Hornsea Four Order Limits in 2018 and 2019. Details of the site-specific surveys are presented in Table 2 and Figure 3.

4.1.1.2 The detailed methods and analyses for the Hornsea Four site-specific surveys are appended to this report.

Table 2: Hornsea Four site-specific benthic subtidal and intertidal survey data.

Title	Summary	Coverage of Hornsea Four
Hornsea Four Geophysical Survey, 2018 **Appendix A (Array) and B (ECC)**	Geophysical survey using single-beam and multi-beam echo sounders (SBES and MBES), side scan sonar (SSS), magnetometer and a sub-bottom profiler (SBP).	Array area and partial coverage of offshore ECC (Figure 3).
Hornsea Four Array Area Benthic Survey, 2018 **Appendix A**	A total of 664 images were collected across 21 benthic sample locations. Benthic sediment grab samples were collected with 0.1 m^2 mini-hamon grab at all 21 locations. All benthic grab samples were subject to infaunal species analysis, particle size analysis (PSA) and contaminants analysis.	Array area (Figure 3).
Hornsea Four Intertidal Survey, 2019 **Appendix C**	Phase I walkover survey carried out landward to mean low water springs (MLWS). Phase I survey data including description of biotope distribution and the extent of sub-features.	Coverage of Hornsea Four intertidal zone from Bridlington to Skipsea. (Figure 12).

Title	Summary	Coverage of Hornsea Four
Hornsea Four Offshore ECC Geophysical Survey, 2019 Appendix E	Geophysical survey carried out to complete the 2018 coverage of offshore ECC using SBES and MBES, SSS, magnetometer and SBP.	Partial coverage of the offshore ECC to complete data gaps in 2018 data (Figure 3).
Hornsea Four ECC Benthic Subtidal Survey, 2019 Appendix D	Benthic DDV and benthic sediment grab sample campaign at 28 locations, with 0.1 m^2 mini-hamon grab. All benthic grab samples were subject to infaunal species analysis, PSA and contaminants analysis. Two stations within the offshore ECC (ECC_22 and ECC_23) were subject to further DDV survey work to investigate the presence and extent of potential Annex I stony reef.	Representative coverage across the offshore ECC (Figure 3).


Hornsea Four
Figure 3
Site specific geophysical and benthic subtidal and intertidal survey campaigns
Order Limits
Study Area (14km from ECC and 10km from Array Area)
Benthic Grab and DDV Samples (Gardline, 2018)
Benthic Grab and Samples (BSL, 2019)
Stony Reef Assessment Stations (Ocean Ecology, 2020)
Array Geophysical Survey Lines (Gardline, 2018)
ECC Geophysical Survey Lines (Bibby, 2018)
Geophysical Survey Lines 2019 (Bibby, 2019)
Extent of Intertidal Phase 1 Biotope Survey
GRID NORTH
N
300000
350000
400000
6000000
5950000
ENV1 ENV2 ENV3 ENV4 ENV5 ENV6 ENV7 ENV8 ENV9 ENV10 ENV11 ENV12 ENV13 ENV14 ENV15 ENV16 ENV17 ENV18 ENV19 ENV20 ENV21 ENV22 ENV23 ENV24 ENV25
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0 5 10 Nautical Miles
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5 Site-Specific Benthic Subtidal Ecology Results

5.1 Introduction

5.1.1.1 This section provides a detailed analysis and description of the results from site-specific surveys undertaken within the Hornsea Four benthic subtidal ecology study area. The full survey reports including detailed methodologies and results are included as **Appendix A**, **B**, **D** and **E** to this report.

5.2 Geophysical Results

5.2.1 Bathymetry

5.2.1.1 Within the array area, water depths varied from 25 m Lowest Astronomical Tide (LAT) in an area of sand waves in the south of the array and 61 m LAT in the north of the array. Seabed gradients were generally <1° deepening to the north, with steeper gradients found locally on the slopes of the numerous sand waves and megaripples, which were the dominant topographic features.

5.2.1.2 Seabed levels in the offshore section of the offshore ECC were around 46.2 m below LAT in the northern and southernmost survey lines, reaching a maximum depth of 51.5 m below LAT. Seabed levels in the funnel area of the offshore ECC (adjacent to the array) commence between 44.7 m and 48.7 m below LAT and generally range from 30.8 m below LAT on the crest of a sand wave, to 54.0 m below LAT in the north-west extents of this portion of the surveyed area.

5.2.1.3 Within the nearshore section of the offshore ECC, seabed levels generally range from 0.4 m above LAT in the most inshore section to 11.9 m below LAT in the southern section. Seabed levels deepen from around LAT to 8.5 m in the initial section of the offshore ECC at an average gradient of around 0.7°. As the survey lines space out further, seabed levels generally range from 2.1 m below LAT (in the southern portion of this area) to 11.5 m below LAT in the southern portion of this area, with the deepest seabed levels in the south-eastern area.

5.2.2 Seabed Features

5.2.2.1 Sand megaripples were the most frequently observed bedform recorded, while sand waves were also common. Megaripples had wavelengths of up to 15 m and, where sand waves occur, were often superimposed upon them. The prevalence of these flow driven bedforms suggested sand was the predominant seabed sediment, a conclusion supported by the interpreted SSS mosaic data with reference to the results of PSA analysis. In areas where sand waves are absent, the sand was relatively uniform. The observed variation in sediment grain size occurred around the sand waves themselves, with finer sands observed on the stoss side of the sand waves and more coarse sand and gravel content occurring in the troughs between sand waves.

5.2.2.2 Numerous objects were present on the seabed throughout the array area, identified on both SSS and bathymetry data. The majority of these were thought to be boulders, although some were likely to be debris associated with commercial fishing. Due to the mobile nature of the seabed, it can be assumed that there may be further boulders present in the shallow subsurface across the array area.

5.2.2.3 Across the offshore ECC, seabed sediments generally comprised Holocene sands, although areas of exposed till were found within the inshore survey extent. The offshore portion of the ECC was recorded as being more mobile with mega-ripples up to 0.5 m high, oriented ENE-WSW or NE-SW with wavelengths of 1.5 – 25 m. Some seabed scars were also noted along the central portion of the offshore ECC.

5.2.2.4 Seabed sediments were interpreted to comprise a veneer of gravelly sands overlying glacial till and relic mega-ripples up to 0.5 m high at the inshore extent of the ECC. The inshore section of the ECC also encompassed a boulder field with densities ranging from 0.9 to 1.8 boulders per 100 m^2. Maximum boulder sizes were approximately 3.0 x 1.8 x 0.5 m (L x W x H).

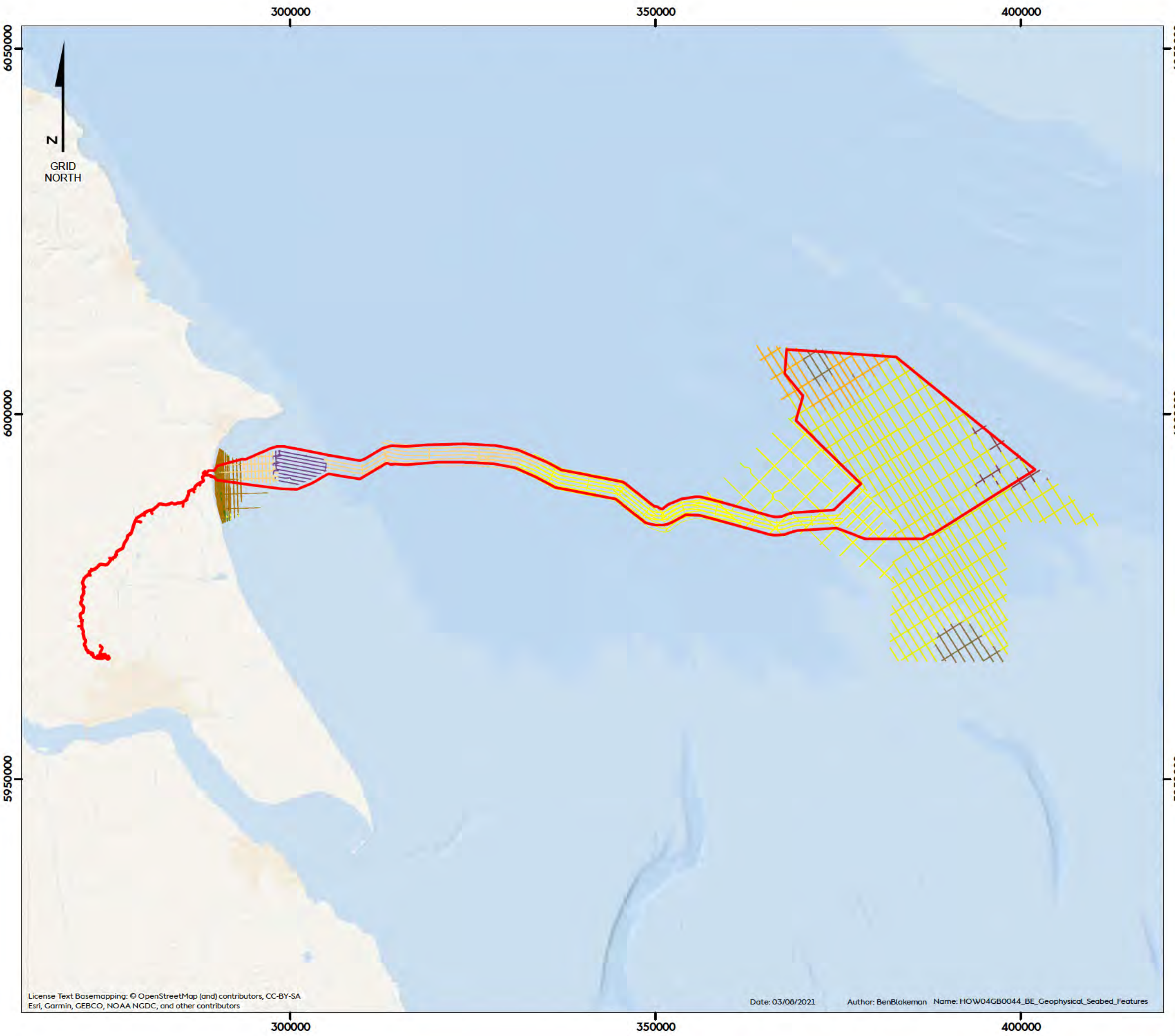
5.2.2.5 Smithic Bank is a sandbank feature formed by a supply of sediment which arrives into Bridlington Bay having been brought around Flamborough Head by currents that flow north to south (Williams, 2018). The sandbank feature does not form a qualifying feature of any Special Area of Conservation (SAC), Special Protection Area (SPA) or Ramsar site. Further detail on this sandbank feature is presented within the **Annex 1.1: Marine Processes Technical Report**.

5.2.2.6 The full geophysical results are presented in **Appendix A, B** and **E**. The seabed sediment features identified during the geophysical survey campaigns are presented in **Figure 4.**

Hornsea Four

Figure 4

Hornsea Four geophysical seabed sediment features



Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0044_BE_Geophysical_Seabed_Features

Order Limits

Seabed Features (Gardline, 2019; BibbyHydro Map 2019)

- Fine sand
- Fine to coarse sand
- Medium to coarse sand
- Fine sand with gravel
- Exposed till layer
- Gravelly sand
- Sand
- Sand with patches of gravelly sand
- Sandy gravel w. boulders
- Sandy till

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
—	First Issue	08/05/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Geophysical and Benthic Subtidal Survey
Document no: HOW04GB0044
Created by: BPHB
Checked by: AdB
Approved by: LK

5.3 Physical Sediment Characteristics

5.3.1 Particle Size Distribution (PSD)

5.3.1.1 The PSD data (expressed as percentage distribution by weight) of the surface sediments from the 47 stations within the Hornsea Four offshore ECC and array area have been summarised in **Table 3** and include the percentage composition of the silt and clay (<0.063 mm), sand (0.063 mm to <2 mm) and gravel (≥ 2 mm) at each station.

Table 3: Summary of surface PSD.

Station	Mean Sediment (mm)	Mean Sediment (Phi (φ))	Sorting	Skewness	Kurtosis	Fines (%)	Sands (%)	Gravel (%)	Folk Classification
ECC_01	0.19	2.38	1.04	0.34	2.42	8.31	91.62	0.07	Sand
ECC_02	0.21	2.23	1.02	0.18	1.76	5.8	94.05	0.15	Sand
ECC_03	0.17	2.54	0.95	0.36	2.6	8.83	91.09	0.09	Sand
ECC_04	0.09	3.52	1.84	0.68	2.3	21.38	78.51	0.11	Muddy sand
ECC_05	0.15	2.71	1.2	0.47	2.99	15.48	84.44	0.09	Muddy sand
ECC_06	0.16	2.66	1.02	0.39	2.8	10.43	89.39	0.18	Muddy sand
ECC_07	0.1	3.28	1.65	0.68	2.86	17.36	82.55	0.09	Muddy sand
ECC_08	0.17	2.59	0.98	0.37	2.69	9.34	90.49	0.17	Sand
ECC_09	0.18	2.49	0.82	0.26	1.88	5.41	94.33	0.26	Sand
ECC_10	0.17	2.53	0.82	0.29	2.27	6.51	93.35	0.14	Sand
ECC_11	0.1	3.29	1.69	0.66	2.51	18.19	81.68	0.13	Muddy sand
ECC_12	0.2	2.36	1	0.3	2.41	8.33	91.03	0.64	Sand
ECC_13	0.19	2.36	0.94	0.33	2.34	7.86	92.03	0.11	Sand
ECC_14	0.25	2	0.67	0.07	1.13	4.37	95.17	0.46	Sand
ECC_15	0.28	1.82	0.96	-0.08	1.25	4.18	93.77	2.06	Slightly gravelly sand
ECC_16	0.29	1.8	0.98	-0.15	1.33	3.63	94.08	2.29	Slightly gravelly sand
ECC_17	0.13	2.94	3.58	0.17	0.7	35.43	51.31	13.26	Gravelly muddy sand
ECC_18	0.14	2.82	4.44	-0.01	0.6	46.91	23.02	30.08	Muddy gravel
ECC_19	1.72	-0.78	4.17	0.27	0.81	15.36	33.67	50.97	Muddy sandy gravel
ECC_20	0.46	1.11	4.48	0.57	0.55	36.75	14.82	48.44	Muddy gravel
ECC_21	0.26	1.93	3.56	0.08	1.22	24.83	55.87	19.3	Gravelly muddy sand
ECC_23*	3.09	-1.63	2.63	0.37	0.6	1.07	39.86	59.07	Sandy gravel
ECC_24	0.21	2.25	0.56	0	0.94	0	99.96	0.04	Sand
ECC_25	0.28	1.85	0.84	-0.07	0.95	0	99.72	0.28	Sand
ECC_26	0.19	2.38	0.54	0	0.98	0	99.92	0.08	Sand
ECC_27	0.19	2.36	0.49	0.01	0.99	0	99.86	0.14	Sand
ENV1	3.56	1.49	0.51	0.01	1.78	0.00	100.00	0.00	Medium sand
ENV2	5.81	0.78	0.85	0.05	3.90	3.56	95.82	0.62	Coarse sand
ENV4	3.13	1.67	1.07	1.78	8.57	0.00	93.12	6.88	Medium sand
ENV5	4.20	1.25	0.76	0.61	9.02	0.61	98.69	0.70	Medium sand
ENV6	3.72	1.43	0.96	1.09	7.47	1.00	94.92	4.09	Medium sand
ENV8	2.98	1.75	0.73	1.84	9.90	0.00	95.71	4.29	Medium sand
ENV9	2.88	1.79	1.28	1.51	6.30	0.00	89.91	10.09	Medium sand
ENV10	2.78	1.85	0.90	2.04	10.86	0.00	94.63	5.37	Medium sand
ENV11	2.84	1.82	0.76	2.00	11.00	0.00	95.21	4.79	Medium sand
ENV14	2.45	2.03	1.00	1.92	9.63	0.00	93.66	6.34	Fine sand
ENV15	3.28	1.61	0.98	1.41	7.40	0.00	95.34	4.66	Medium sand
ENV16	4.46	1.17	1.82	0.50	4.11	9.08	83.50	7.43	Medium sand
ENV17	4.64	1.11	3.24	0.02	2.45	23.77	60.98	15.25	Medium sand
ENV18	5.88	0.77	0.66	0.76	2.72	0.00	100.00	0.00	Coarse sand
ENV19	3.80	1.40	2.98	-0.31	3.53	15.37	70.90	13.73	Medium sand
ENV20	3.94	1.34	0.86	1.39	8.14	0.00	97.35	2.65	Medium sand
ENV21	4.37	1.19	1.33	1.49	6.28	0.00	93.01	6.99	Medium sand
ENV22	4.64	1.11	0.96	1.71	8.93	0.00	95.99	4.01	Medium sand
ENV23	5.20	0.94	0.73	1.65	10.21	0.00	98.53	1.47	Coarse sand
ENV24	5.54	0.85	1.32	0.03	5.34	7.66	89.66	2.68	Coarse sand
ENV25	5.87	0.77	1.09	-1.21	8.15	4.06	95.43	0.51	Coarse sand

Station	Mean Sediment (mm)	Mean Sediment (Phi (φ))	Sorting	Skewness	Kurtosis	Fines (%)	Sands (%)	Gravel (%)	Folk Classification
Mean	*2.03*	*1.79*	*1.44*	*0.57*	*4.03*	*8.10*	*84.85*	*7.05*	
Standard Deviation (SD)	*2.06*	*0.95*	*1.08*	*0.73*	*3.32*	*10.94*	*20.82*	*13.53*	
Coefficient of Variation (CV) (%)	*101.4*	*53.5*	*75.2*	*127.1*	*82.3*	*135.0*	*24.5*	*192.0*	

5.3.1.2 The sand fraction (≥63 µm to <2 mm) dominated the sediment composition at all stations across the array area and contributed to between 61% of the total sediment composition at Station ENV17 to 100% of the total sediment composition at Stations ENV1 and ENV18. This resulted in the majority of stations across the Hornsea Four array area being classified as sand under the Folk classification (Folk, 1954) (**Figure 5**). Stations ENV2 and ENV25 were classified as slightly gravelly sand under the Folk classification due to the proportion of gravel sized particles (≥2 mm) which accounted for c.4% of the total sediment at both these stations. Stations ENV16 and ENV24 were classified as gravelly sand due to the higher percentage contribution of gravel (c.9% and c.8% respectively) at these stations whilst Station ENV9 presented a relatively higher percentage of fine sediment (<63 µm; 10%) and classified as muddy sand. Sediments at Stations ENV17 and ENV19 were described as gravelly due to the highest percentages of gravels (c.24% and c.15%, respectively) and fines (c.15% and c.14% respectively) content observed across the Hornsea Four array area.

5.3.1.3 Sediment sorting across the array area ranged from very poorly sorted to moderately well sorted. A Spearman's rank correlation (**Appendix A**) conducted on the data revealed a statistically significant negative correlation between the sorting co-efficient and the percentage sand contribution (Spearman's r= 0.82, p<0.01) across the Hornsea Four array area. This corresponded to a general trend within the data of samples with high sand components being well sorted whilst more mixed sediments were generally considered less well sorted.

5.3.1.4 Across the offshore ECC, the mean sediment fraction ranged from 0.087 mm at ECC_04 to 3.089 mm at ECC_23, demonstrating the variability in the proportions of silts, sands and gravels. According to the Folk classification the dominant sediment types throughout the offshore ECC were 'muddy sand' and 'sand'.

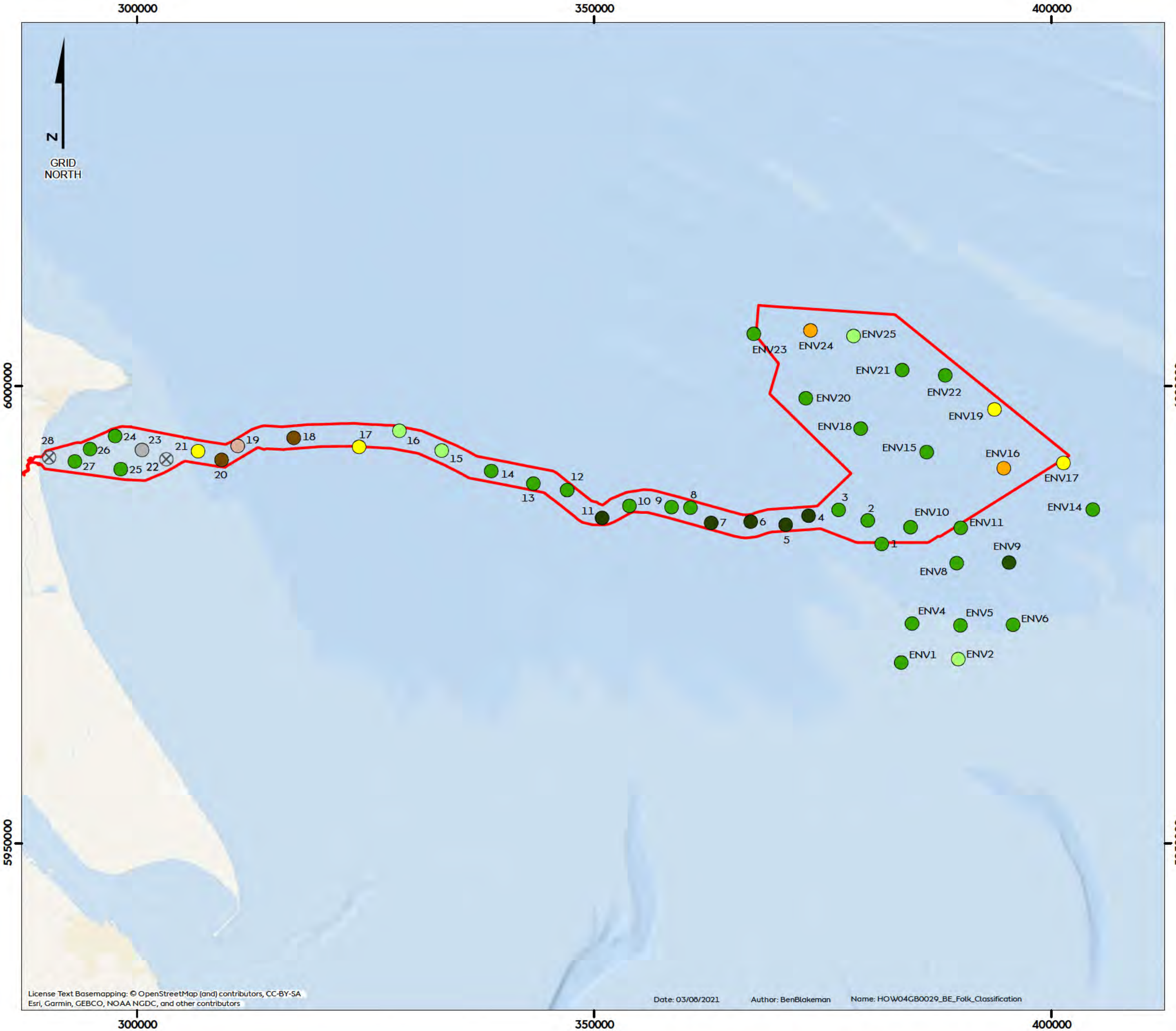
5.3.1.5 Sediments closest to landfall were comprised almost entirely of sand, while those between 10 km and 30 km offshore were more mixed with varying additional proportions of silt and clay (15 – 46%) and gravel (13 – 50%), with Stations ECC_17 and ECC_21 being described as gravelly muddy sand, Station ECC_18 and ECC_20 as muddy gravel and Station ECC_19 as muddy sandy gravel. Beyond 30 km from the shore the sand fractions became dominant again with sediments comprising almost no gravel fraction and generally proportions of silt and clay less than 10%, although silt and clay accounted for 18% and 21% of the sample volume at stations ECC_11 and ECC_4 respectively. Sediment sorting across the offshore ECC ranged from extremely poorly sorted to well sorted.

5.3.1.6 The Folk classification for all samples collected across the benthic subtidal ecology study area are plotted in **Figure 5**. Full results and histograms illustrating the particle size distribution at each sampled station are presented in **Appendix A** and **Appendix D**.

Hornsea Four

Figure 5

Modified folk sediment classification map



Order Limits

Folk Classification

- Muddy Sand
- Sand
- Slightly Gravelly Sand
- Gravelly Muddy Sand
- Gravelly Sand
- Muddy gravel
- Muddy Sandy Gravel
- Sandy Gravel
- No Sample

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:400,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
—	First Issue	08/05/2019
A	Updated following PEIR consultation, for DCO	03/08/2021

Modified folk sediment classification map
Document no: HOW04GB0029
Created by: BPHB
Checked by: AdB
Approved by: LK

Multivariate Analysis of PSD Data

5.3.1.7 The PSD results presented above provide an overview of the sediment character across Hornsea Four. More detailed analysis of the PSD data has been carried out using multivariate analysis techniques within the PRIMER v7 software package (Clarke and Warwick 1994).

5.3.1.8 **Figure 6** presents a group average sorting dendrogram based upon Euclidean distances and illustrates the similarities and differences in sediment character between stations. A Euclidean distance of 25 was applied to the SIMPROF analysis in order to prevent over-differentiation of the data set and to group the sediment particle size at a level relevant to the baseline survey objectives. This manipulation of the data resulted in the identification of four main sediment groups or 'clusters' as labelled 'A' to 'D' in **Figure 6**.

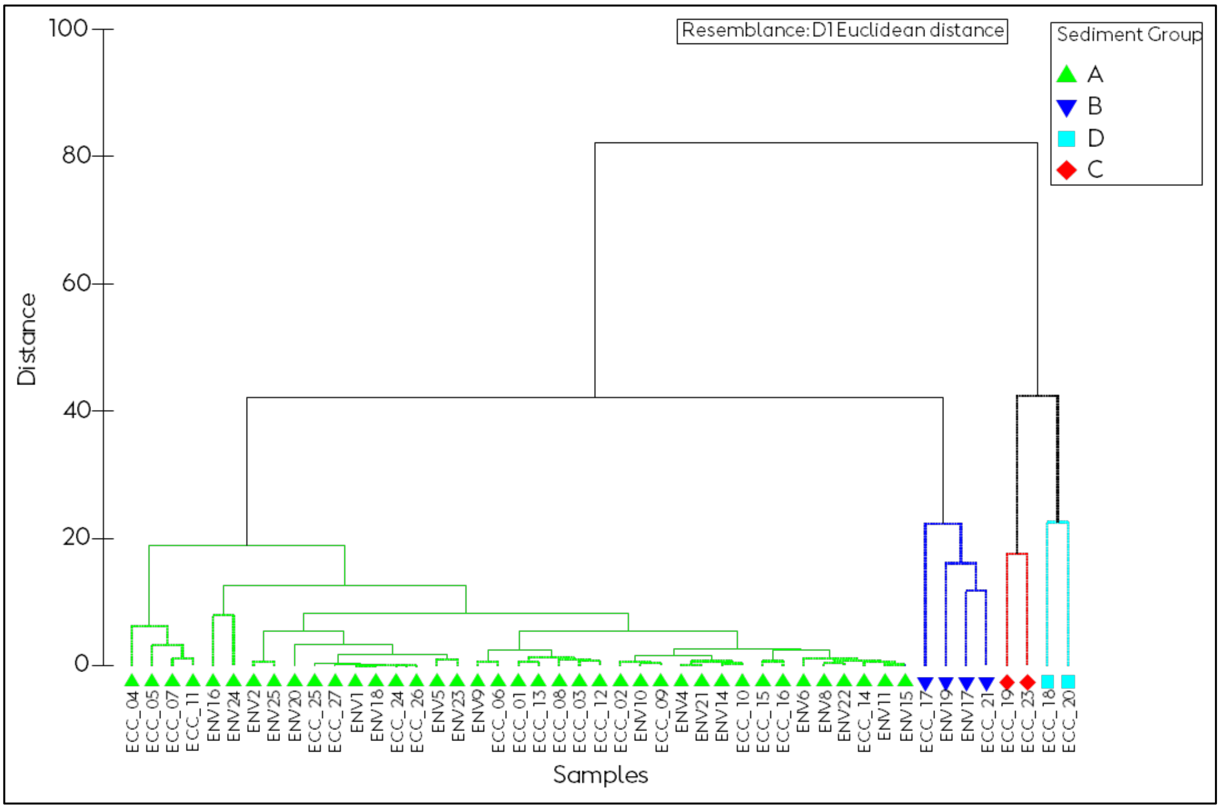


Figure 6: Group average dendrogram of PSD data, based on Euclidean Distance.

5.3.1.9 Group A includes 39 of the 47 stations and comprises sediments characterised by large proportions of sand (78.5% to 100%). Group B consists of four stations which are set apart by smaller proportions of sand (mean c. 60%), with the remainder of the fraction made up of fines (silt and clay) and gravel, each contributing an average of c. 22% and c.18% respectively to the sample volume. Groups C and D represent mixed sediments. Group C has smaller proportions of fines (<10% on average), and moderate proportions of gravel and sand (55% and 37% on average respectively), while Group D represents sediments with smaller proportions of sand (c. 20% on average) and equal proportions of fines and gravel (c40%). The mean proportions of silt and clay, sand and gravel analysed within each group are outlined in **Table 4** together with the Folk scale classifications that were captured within each group.

Table 4: Mean proportions of silt and clay, sand and gravel within each of the sediment groups identified using multivariate analysis techniques.

Sediment Group	Mean % Silt & Clay	Mean % Sand	Mean % Gravel	Folk Scale Classifications
Group A	5.87	93.3	0.86	Sand (S)
Group B	22.3	59.8	17.9	Gravelly muddy Sand (gmS)
Group C	8.22	36.8	55	Muddy sandy gravel (msG)
Group D	41.8	18.49	39.3	Muddy gravel (mG)

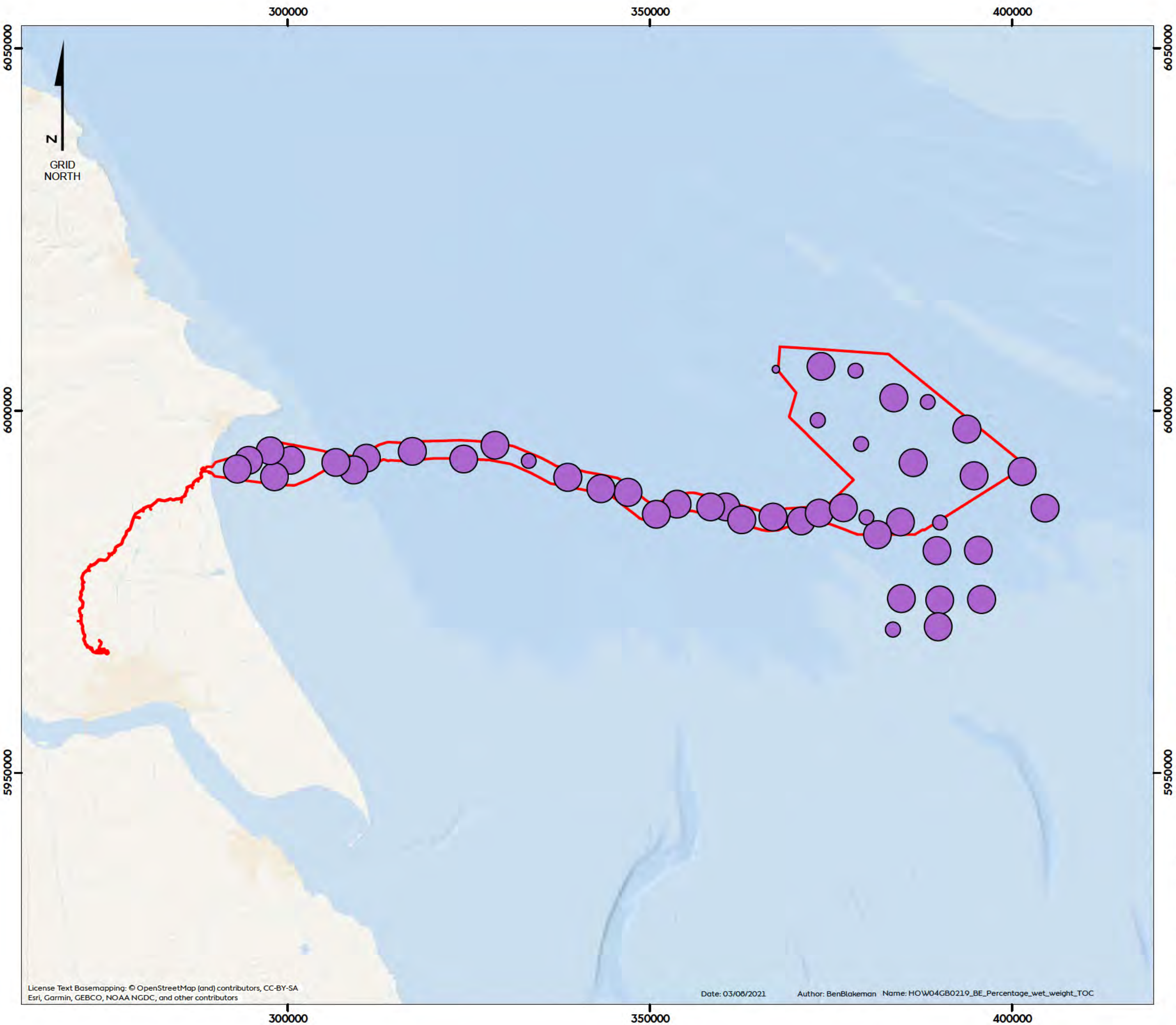
5.3.2 Total Organic Carbon (TOC)

3.3.1.1 Terrestrially derived carbon from run-off and fluvial systems, combined with primary production from sources such as phytoplankton blooms, contribute to the TOC levels recorded in marine sediments. TOC represents the proportion of organic detritus present. Organic detritus is metabolised by heterotrophic bacteria but is also consumed directly by a wide range of marine invertebrates (UK MPA 2001), it is therefore an important source of food for benthic fauna (Snelgrove and Butman 1994). Although unlikely in open coast environment such as the offshore ECC, an over-abundance of TOC (also termed organic enrichment) may lead to community changes and a reduction in diversity by favouring detritivore groups or those tolerant of low oxygen levels (as increased oxygen demand can be brought about by elevated bacterial respiration).

3.3.1.2 The results of the sediment TOC at the 47 stations sampled are presented in Table 5. TOC levels were low (ranging between 0.05% at ENV23 and 1.12% at ECC_19) and reflect an organically deprived environment throughout the offshore ECC. Figure 7 presents the results in a geographical context within the Hornsea Four Order Limits. When comparing this figure with the sediment Folk Classification data (Figure 7), it can be seen that the higher TOC values generally corresponded to those stations with greater proportions of silt and clay (although these stations also had the greatest proportions of gravel). As would be expected the lower concentrations were generally found at stations dominated by sand. This relationship has been demonstrated using the RELATE routine which explored the correlation of TOC with the proportion of sand, the results show a reasonably strong (negative) Spearman's Rank correlation between these two sediment parameters of 0.638, which is significant (0.1%).

Table 5: TOC recorded at stations across Hornsea Four.

Station	Total Organic Carbon (% wet weight)	Station	Total Organic Carbon (% wet weight)
ECC_01	0.13	ENV1	0.09
ECC_02	0.09	ENV2	0.11
ECC_03	0.12	ENV4	0.17
ECC_04	0.14	ENV5	0.15
ECC_05	0.16	ENV6	0.12
ECC_06	0.15	ENV8	0.13
ECC_07	0.16	ENV9	0.29
ECC_08	0.18	ENV10	0.15
ECC_09	0.18	ENV11	0.1
ECC_10	0.17	ENV14	0.13
ECC_11	0.14	ENV15	0.11
ECC_12	0.11	ENV16	0.16
ECC_13	0.11	ENV17	0.19
ECC_14	0.29	ENV18	0.06
ECC_15	0.09	ENV19	0.19
ECC_16	0.17	ENV20	0.08
ECC_17	0.15	ENV21	0.12
ECC_18	0.49	ENV22	0.09
ECC_19	1.12	ENV23	0.05
ECC_20	0.96	ENV24	0.11
ECC_21	0.88	ENV25	0.07
ECC_23	0.22	***Mean***	**0.28**
ECC_24	0.15		
ECC_25	0.16		
ECC_26	0.13	***SD***	**0.05**
ECC_27	0.12		



Hornsea Four

Figure 7
TOC recorded from stations across Hornsea Four (% wet weight)

Order Limits

Total Organic Carbon (% w/w)

- 0 - 0.05
- 0.05 - 0.1
- 0.1 - 1.2

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	03/08/2021

TOC % wet weight across Hornsea Four
Document no: HOW04GB0219
Created by: BPHB
Checked by: AdB
Approved by: LK

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5.4 Sediment Contamination

5.4.1.1 The following section provides a summary of the sediment contaminant analyses undertaken across the Hornsea Four Order Limits, with the full detailed results and methods presented in **Appendix A** (array area) and **Appendix D** (offshore ECC).

5.4.2 Contaminant Analysis

5.4.2.1 Total hydrocarbon (THC) concentrations (comprising total n-alkanes, pristane, phytane, unresolved complex mixture (UCM) and polycyclic aromatic hydrocarbons (PAH)) ranged from 1.6 µg g^{-1} at Station ENV23 to 8.6 µg g^{-1} at Station ENV17, with a mean value of 4.7 µg g^{-1} (±1.8 SD) across the array area. Gas Chromatography (GC) traces across the array area were generally indicative of background levels of hydrocarbons in areas of historic oil and gas exploration and suggested a mixture of petrogenic and pyrogenic sources.

5.4.2.2 It has previously been shown that benthic macrofauna suffer adverse effects when THC concentrations are in excess of 50 µg g^{-1} (UKOOA 2001; Kjeilen-Eilertsen et al. 2004; UKOOA 2005) and as such, this value represents the threshold above which hydrocarbons are expected to have a 'significant environmental impact'. Kingston (1992) also previously reported that benthic macrofauna suffer adverse effects, namely reduced diversity, when THC is in excess of 50 µg g^{-1} to 60 µg g^{-1}, and that specific sensitive species may be impacted at levels greater than 10 µg g^{-1}. Mair et al. (1987) observed a notable increase in the dominance of opportunistic species at THC levels in excess of 291.4 µg g^{-1}. The THC concentrations recorded across the array were well below these threshold values. Therefore, the faunal community was not expected to be influenced by THC concentrations.

5.4.2.3 THC was variable across the offshore ECC, where values ranged from 2.8 µg g^{-1} at ECC_12 to 61.4 µg g^{-1} at ECC_20. THC levels above the UKOOA (2001) 95th percentile of 11.39 mg/kg for THC in the southern North Sea were found at five stations (ECC_18 to ECC_21, and ECC_08). The higher THC levels observed at stations ECC_18 to ECC_21 are consistent with the elevated TOC at those stations.

5.4.2.4 Concentrations of the US Environmental Protection Agency (EPA) 16 PAHs were compared to the Convention for the Protection of the Marine Environment of the North-East Atlantic's (OSPAR's) background concentrations (BC) and background assessment concentrations (BACs; OSPAR 2005). Comparison to BCs and BACs requires normalisation to 2.5% TOC (OSPAR 2005). Eight US EPA 16 PAHs (Naphthalene, Phenanthrene, Anthracene, Flouranthene, Pyrene, Benzo[a]anthracene, Chrysene and Benzo[a]pyrene) were above their respective BC values at all stations sampled across the array area where values were greater than the limit of detection (LOD) whilst a further two US EPA 16 PAHs (Indeno[123,cd]pyrene and Benzo[ghi]perylene) were above their respective BC values at the majority of stations where values were greater than the LOD. These patterns indicated that concentrations of US EPA PAHs were not representative of a 'pristine' environment, as described by OSPAR (2005), which could be expected considering the extent of oil and gas activities within the wider area. Information derived from molecular weight PAH indices on the origin of US EPA 16 PAHs presented a mix of pyrolytic and petrogenic inputs from the range of indices calculated.

5.4.2.5 Across the offshore ECC, total PAH data were also normalised to the 2.5% TOC content of the sediment at each station to enable comparison of results with the OSPAR BACs. The mean PAH calculated from the data at all stations exceeded the OSPAR BAC threshold. The normalised PAH data displayed a similar spatial pattern to the non-normalised data which showed elevated concentrations at stations ECC-18 to ECC_21. Station ECC_27 (the station closest to the shore) had a comparatively high normalised PAH value of 1.887 µg g^{-1}. It is suggested that the low TOC levels and relatively small proportions of silt and clay at all stations may have led to an exaggeration of the normalised total PAH values when compared to the BAC (OSPAR 2014).

5.4.2.6 Metals concentrations varied across the Hornsea Four array area with generally higher concentrations presented at Stations ENV16 and ENV17 and lower concentrations at Stations ENV1 and ENV23. All metals concentrations were within the Cefas Action Level 1 (AL1), apart from four stations which exceeded this level for Arsenic, which indicated that toxicological impacts on the biota were unlikely across the array area. The Canadian Interim Sediment Quality Guideline (ISQG) was exceeded for arsenic at 11 stations, these levels were not exceeded for other metals (cadmium, chromium, copper, lead, nickel and zinc).

5.4.2.7 Across the offshore ECC metal concentrations were generally low, except for arsenic, which exceeded the Cefas AL1 at 14 stations. The ISQG level for lead was exceeded at two stations, while that for nickel was very slightly exceeded at one station. Metals data across the offshore ECC were normalised (to 52 parts per million (ppm) lithium) to enable comparison of results with OSPAR BCs and BACs (OSPAR 2014). With the exception of cadmium (Cd) and Cromium (Cr) the mean of all other normalised metal concentrations exceeded the BAC levels. However, it is suggested that these exceedances are most likely to be attributable to the relatively low lithium concentrations that were found throughout the offshore ECC. Furthermore, the normalisation procedure using pivot values could not be used for several of the metals as their measured concentrations were below the pivot values (the results of the metal normalisation process have not been applied to the data obtained across the array area as the comparison to Cefas action levels were more insightful). As discussed above, metals were generally present at low concentrations. Therefore, despite the apparent exceedances of the BACs by numerous metal analytes, metal concentrations are considered to be at background levels.

5.5 Benthic Subtidal Ecology

5.5.1.1 A single 0.1 m^2 faunal sample was collected from each of the 49 stations across the Hornsea Four Order Limits and screened through a 1 mm mesh sieve prior to enumeration and biomass analysis. The full comprehensive benthic characterisation reports for the Hornsea Four array area and offshore ECC can be found in **Appendix A** and **Appendix D**, respectively. The following section provides a summary of these findings.

5.5.2 Description of the Benthic Subtidal Fauna

5.5.2.1 Across the array area, a total of 2,678 individuals representing 163 taxa were recorded from the 21 macrofaunal samples acquired. The macrofaunal community was found to be relatively sparse with 54 taxa appearing at a single station and 34 of those taxa represented by a single individual.

5.5.2.2 Review of the abundance data set revealed that benthic subtidal communities across the array area were generally dominated by Annelida, Mollusca and Echinodermata, all of which contributed c.30% of the total individuals identified. The Mollusca group was dominated by the bivalve *Abra* which contributed 60% of total Mollusc individuals whilst the Echinodermata group was dominated by the brittle star *A. filiformis*, which contributed 72% of the total Echinoderm individuals. The Annelid group was not dominated by a single taxon rather the group was represented by a diverse range of taxa. Review of the biomass data revealed an equally variable data set which was dominated by single large specimens of Arthropoda, Mollusca and Echinodermata particularly at stations which recorded biomass values >3 g.

5.5.2.3 Overall, the univariate indices indicated a generally diverse and evenly distributed community with a lack of notable dominance structure, across the array area. Examination of the taxonomic data at each station, highlighted the most abundant taxa, *Abra* and *Amphiura filiformis* to be responsible for much of the variation.

5.5.2.4 Across the offshore ECC, a total of 2,813 individuals representing 259 taxa were recorded from the 26 macrofaunal samples acquired, with a mean number of 26 taxa and 108 individuals per station. Collectively, the faunal assemblages were comprised of 102 Annelida species, 51 Arthropoda, 40 Mollusca, 12 Echinodermata, whilst all other phyla accounted for the remaining seven taxa or 2% of individuals. Colonial epifauna (which were not quantified) were represented by 47 taxa.

5.5.2.5 Review of the abundance data set revealed that taxa belonging to the phylum Annelida dominated the benthic communities both in terms of organism abundance and number of taxa. Arthropoda accounted for c.25% of the total taxa and number of individuals, while mollusca accounted for 19% of each. Echinoderms and miscellaneous phyla collectively contributed less than 10% to these community attributes.

5.5.2.6 The univariate indices were generally lowest within approximately 18 km of landfall. Taxonomic diversity peaked at station ECC_17, which is situated 20 km off the coast, but beyond that to the east of the offshore ECC, diversity was broadly similar. Both the total number of individual organisms and total number of taxa were also found to peak in the coastal zone between 18 km and 35 km from landfall. Within 18 km and 35 km from landfall the seabed was characterised by mixed sediments that comprised an additional gravel component (as well as significant silt and clay fractions). The greater stability and broader range of ecological niches offered by these mixed substrates are likely to be the main factors driving the elevated univariate indices. The higher numbers of individual organisms are partly driven by the high abundance of polychaetes including *Sabellaria spinulosa* and *Melinna elisabethae*, as well as Lumbrineridae polychaetes, at some sample locations.

Multivariate Analysis of Community Composition

5.5.2.7 The application of multivariate analyses enables subtler trends within the data set to be identified. Multivariate analyses were performed on the combined array area and offshore ECC rationalised abundance data sets using PRIMER v7.

5.5.2.8 **Figure 8A** presents a group average sorting dendrogram (based on Bray-Curtis similarity of square-root transformed data) and **Figure 8B** presents the corresponding multi-dimensional scaling (MDS) ordination, presented in two-dimensional format, for the benthic infauna recorded across the Hornsea Four benthic subtidal ecology study area. The 2D stress of the MDS ordination is low (0.2) indicating that the two-dimensional representation provides a useful interpretation of the interrelationships that occur between the communities sampled at the different survey stations.

5.5.2.9 The similarity between infauna recorded from each of the sampling sites was low. Figure 8A demonstrates that samples acquired from across the Hornsea Four benthic subtidal ecology study area were representative of a total of seven infaunal groups at the 24% similarity level.

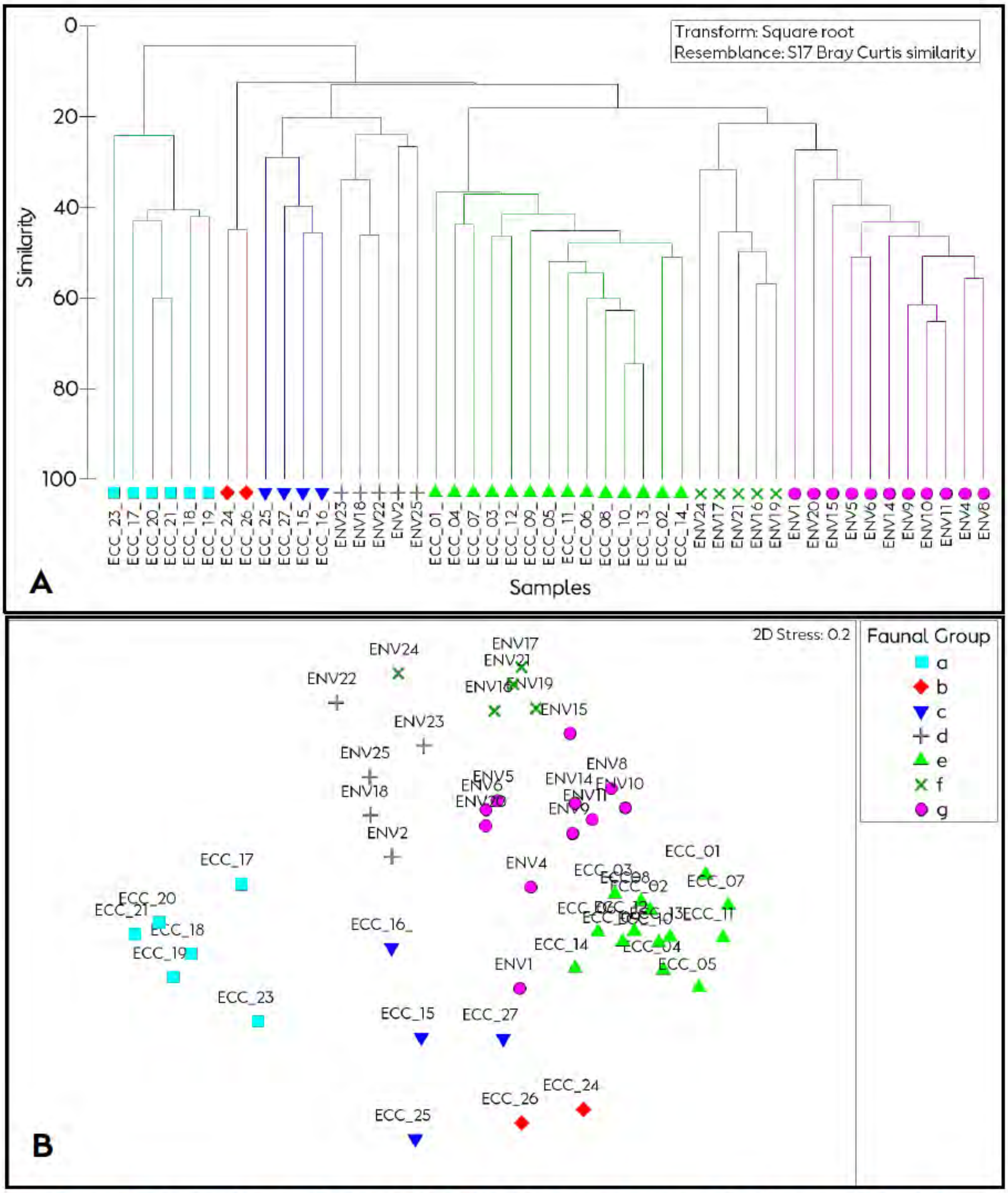


Figure 8: Multivariate analysis outputs. Plot A is a group average dendrogram of benthic community data, based on Bray-Curtis similarity. Plot B is a MDS plot representing the similarities in benthic fauna between sample stations.

5.5.2.10 SIMPER analysis has been used to determine the main contributing species within each of the seven infaunal groups identified, as discussed below.

5.5.2.11 Group E was the most commonly occurring group identified within the Hornsea Four benthic subtidal ecology study area and encompassed 14 stations within the offshore portion of the ECC. The SIMPER routine returned a community similarity of 44% between the Group E sampling stations, which although is the highest similarity compared to the other groups identified within the Hornsea Four benthic subtidal ecology study area (which range between 29% and 65%), this value is moderately low when considering absolute community similarity. The bivalve *Fabulina fabula* was the most commonly occurring species accounting for c.15% of the group's similarity, closely followed by the amphipod *Bathyporeia tenuipes* and the polychaetes *Spiophanes bombyx* and *Magelona johnstoni*; all these species favour sand or muddy sand substrates.

5.5.2.12 Group G was the second most frequently sampled group, with data derived from 11 stations within the southern portion of the array area and surrounding study area. The groups similarity was 41% and the bivalve *Abra* accounted for c.22% of the community similarity within the group. *Bathyporeia tenuipes*, the polychaete worm *Amphictene auricoma* and *Amphiura filiformis* were also characteristic of this group.

5.5.2.13 Group A was characteristic of six stations located within the portion of the offshore ECC that had a greater gravel content within the sediments. The polychaete worms *Sabellaria spinulosa, Lumbrineris cingulate* and the saltwater clam *Hiatella arctica* accounted for c.35% of the community similarity sampled within the group. The overall group similarity was 34%. This group was also the most diverse reflecting the increased complexity of the habitat types found at these stations.

5.5.2.14 Group D had a community similarity of 29% and was located at five stations dotted across the array area. The polychaete worms *Ophelia borealis, Spiophanes bombyx, Scoloplos armiger* and the pea urchin *Echinocyamus pusillus* accounted for c.55% of the contribution to similarity within this group.

5.5.2.15 Group F was also found at five stations which were located at various locations across the array and surrounding study area. This group was also characterised by polychaete worms, including *Pholoe* sp., *Scalibregma inflatum* and *Lagis koreni* and the burrowing mud shrimp *Callianassa subterranea,* which reflected the muddier sands located at these stations. This group had a community similarity of 42%.

5.5.2.16 Group C was the second least commonly occurring group identified across the Hornsea Four benthic subtidal ecology study area. This group was located at four stations across the inshore and mid-portion of the ECC. The groups similarity was 35% and the bivalve *Fabulina fabula* accounted for c.15% of the community similarity within the group, closely followed by the *Bathyporeia tenuipes, Spiophanes bombyx* and *Magelona johnstoni.*

5.5.2.17 Group B was the least diverse group and the least commonly occurring, accounting for only two stations within the nearshore ECC. The community similarity was 45%. The amphipod *Bathyporeia elegans* and the bivalve *Tellimya ferruginosa* were characteristic of this group accounting for c.63% of the community similarity.

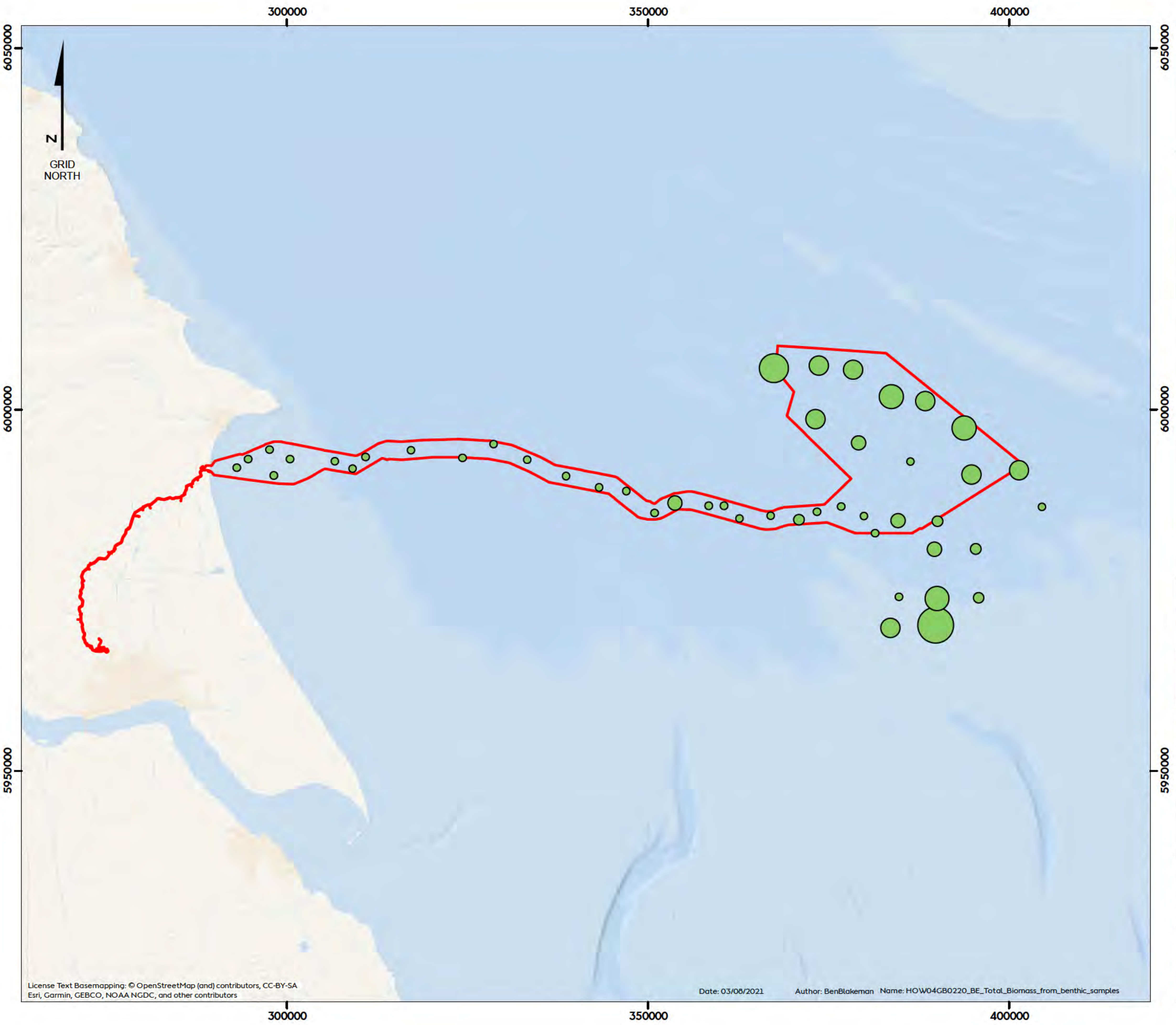
5.5.2.18 It is well documented that sediment granulometry is an important factor in determining the structure of benthic communities (Rhoads, 1974; Ellingsen, 2002). A comparison of the geographical distribution of PSD Groups (determined using SIMPROF analysis) in **Figure 5** and the descriptions presented above demonstrates some correlation. The relationship between the sediment character and benthic communities is further explored in the following section and within the respective characterisation reports (**Appendix A** and **D**).

Faunal Biomass

5.5.2.19 The Ash Free Dry Weight (AFDW) for each major phylum sampled has been manipulated using a phylum specific conversion factor (Riccardi and Bourget 1998) to ensure that the data is as representative as possible.

5.5.2.20 The detailed faunal biomass data is available in the respective characterisation reports (**Appendix A** and **D**). A summary of the total biomass measured at each station has been plotted spatially in **Figure 9**. This plot shows that there is no obvious geographical trend in the total biomass throughout the offshore ECC, but within the array area, biomass appears to increase towards the eastern extent of the Order Limits and outside the Order Limits to the south.

5.5.2.21 The percentage composition of the biomass by each phyla has been plotted spatially in **Figure 10**. With regards to the main contributing phyla, Echinodermata generally contribute the greatest proportions to biomass at stations in the eastern half of the Hornsea Four offshore ECC, at two stations at the very western extent, closest to landfall and in the central array area stations. At the remaining stations Molluscs and / or Annelida generally contribute most significantly to the total biomass, with Mollusca most commonly dominant, although Annelida account for greater proportions at a few stations in the southern array area and occasionally within the offshore ECC. The sum of 'other phyla' contribute approximately 50 % at two stations in the eastern extent of the offshore ECC.



Hornsea Four

Figure 9

Total biomass recorded from benthic samples at each station across Hornsea Four

Order Limits

Total Ash-Free Dry Weight (g)

0 - 1
1 - 2
2 - 5
5 - 10
10 - 20
20 - 40
40 - 60

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:500,000
0 10 20 Kilometres
0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	03/08/2021

Total biomass across Hornsea Four
Document no: HOW04GB0220
Created by: BPHB
Checked by: AdB
Approved by: LK

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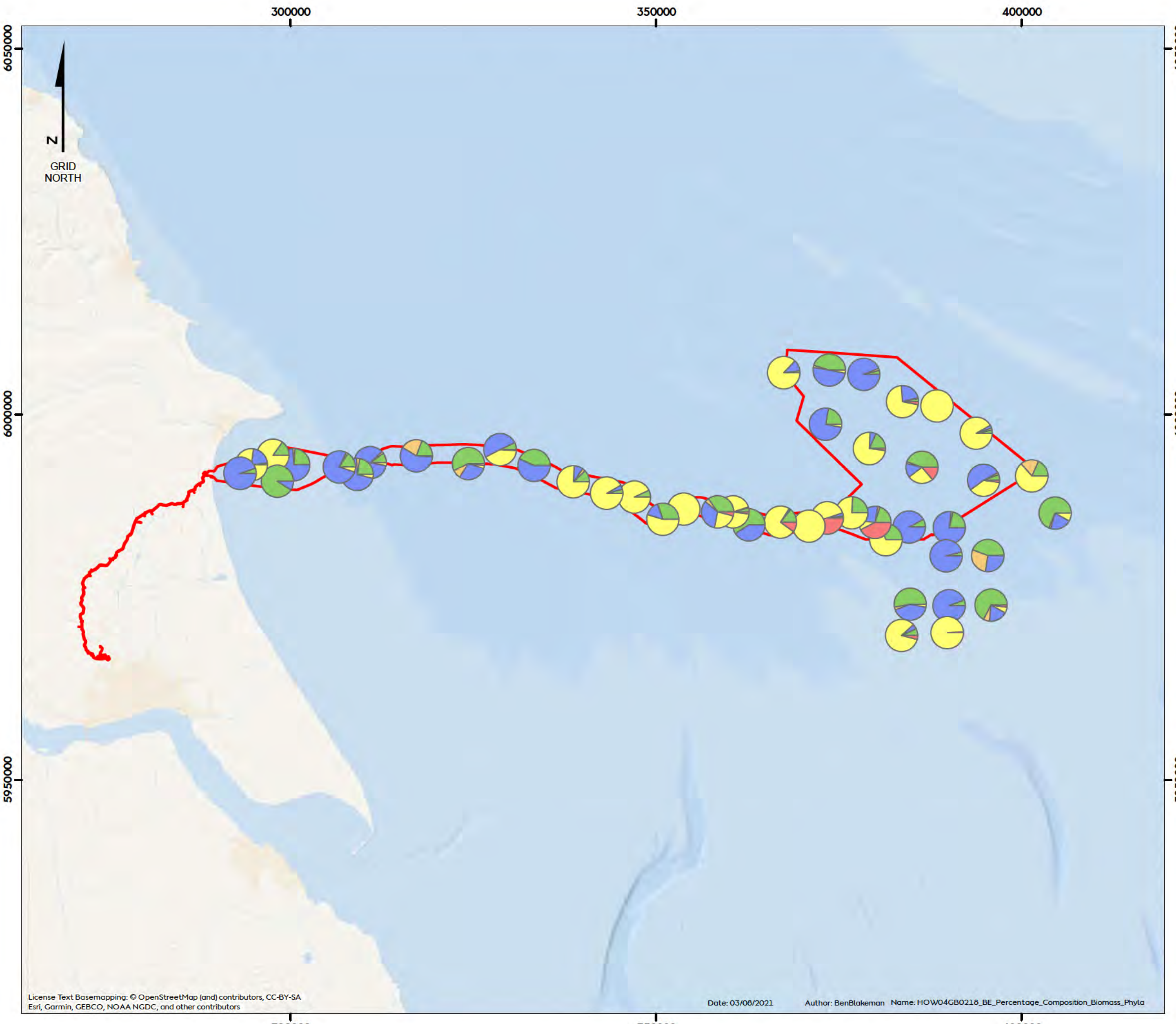

Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0218_BE_Percentage_Composition_Biomass_Phyla

Hornsea Four

Figure 10

Percentage composition of biomass by each phyla across Hornsea Four

Order Limits

% Biomass per Phyla

- Annelida
- Arthropoda
- Mollusca
- Echinodermata
- Other

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:500,000

0 10 20 Kilometres
0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	03/08/2021

Percentage Biomass Phyla across Hornsea Four
Document no: HOW04GB0218
Created by: BPHB
Checked by: AdB
Approved by: LK

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The Relationship between Sediment Character and Benthic Fauna

5.5.2.22 The relationship between the community structure of the benthic macrofauna and the proportions of silt and clay, sand and gravel at each respective station has been explored using the RELATE routine in PRIMER v6, which provides a means of testing for correlations in the environmental data. The results of the analysis demonstrate a reasonably strong Spearmans Rank correlation of 0.498 which is significant (0.1%).

5.5.2.23 In order to establish which aspects of the sediment granulometry account for the correlation observed, further analysis using the BIOENV routine was carried out. It revealed that the best individual correlation between the multivariate faunal data and the PSD data was the proportion of gravel in the sediments, but the best overall correlation observed was associated with the combined proportions of silt, clay and gravel. Both correlations were moderate (0.556 and 0.529 respectively).

5.5.2.24 A multitude of other environmental parameters can also influence benthic community assemblages, although on open coasts such as is being considered within the offshore ECC, sediment granulometry and depth are likely to be the main influencing factors. As such, the correlation between depth and the community assemblages was explored but found to be weak (0.293).

5.5.3 Seabed Imagery Results

5.5.3.1 Seabed images were collected at a total of 49 co-located camera and grab sample locations within the Hornsea Four benthic subtidal ecology study area (**Figure 3**). A selection of seabed photographs and detailed descriptions are presented in **Appendix A** (array area) and **Appendix D** (offshore ECC).

5.5.3.2 Seabed imagery and video footage corroborated the findings of the PSD and faunal sample data, indicating a relatively heterogenous benthos across Hornsea Four benthic subtidal ecology study area, which ranged from muddy sand to sandy gravel.

5.5.3.3 Across the array area, visible fauna observed within the seabed imagery was generally sparse and included: Annelida (*Ditrupa*, *Echiura*, Polychaeta, Serpulidae, Terebellidae), Arthropoda (Brachyura, Paguridae), Chordata (Actinopterygii including, Ammodytidae, Callionymidae, Pleuronectiformes, Triglidae, Scorpaeniformes, Scyliorhinidae), Cnidaria (Actiniaria, *Alcyonium digitatum*, *Ceriantharia* sp., *Urticina* sp., Hydrozoa), Echinodermata (Asteroidea including, *Asterias rubens*, *Astropectin irregularis* Ophiuoridea), Mollusca (Bivalvia, Naticidae, Scaphopoda, Sepiolidae). Small burrows and faunal tubes were observed across the array area, particularly where finer sediment was observed.

5.5.3.4 Across the offshore ECC, as could be expected given the variability in the substrate and water depth between stations, the conspicuous fauna recorded was also variable. Epifauna that were observed included hydroids, bryozoans, anthozoans and echinoderms (both echinoids and asteroids). Free swimming megafauna were limited to demersal teleosts (bony fish) including pleuronectiforms and dragonets. Evidence of burrowing macrofauna was also present throughout much of the offshore ECC.

Sea Pen and Burrowing Megafauna Communities Assessment

5.5.3.5 Burrows were observed at 19 stations within the seabed imagery obtained within the array area and at 18 stations across the offshore portion of the ECC, however, sea pens (*Pennatulacea*) were not observed within any of the seabed imagery data acquired. The observed sediment type across the array area was not consistent with the fine mud described as typical for the 'sea pen and burrowing megafauna communities' habitat, as defined by (OSPAR 2010). However, as a precaution, the densities of burrows at all stations were analysed and their abundance categorised using the JNCC's Marine Nature Conservation Review (MNCR) SACFOR classification to assess the suitability of the stations to be classified as a 'sea pen and burrowing megafauna communities' habitat.

5.5.3.6 The JNCC (2014) clarification report acknowledges the inherent difficulties of identifying species from burrow type alone using ever evolving identification guides, such as the cited ICES (2011) guide. Subsequently, the overall density of burrows themselves was assessed instead, in order to consider whether their density was a 'prominent' feature of the sediment surface and potentially indicative of a sub-surface complex gallery burrow system. Therefore, areas with burrows with densities considered 'frequent' or more under the SACFOR scale were considered likely to constitute a 'sea pen and burrowing megafauna communities' habitat. However, as recommended in the JNCC report (2014), any such interpretation of the density of burrows should be treated with a degree of caution, particularly without formal observation and identification of the taxa present. The average burrow densities were calculated for each station using the total area covered by the photographs as calculated from laser scale lines (average image swathe x camera transect length). The results of this assessment for the array area are presented in **Appendix A**. The images obtained across the offshore ECC are presented in **Appendix D**.

5.5.3.7 Burrow density revealed a SACFOR score of 'rare' at all stations across the Hornsea Four benthic subtidal ecology study area except at Stations ENV1, ENV11 and ENV19 within the array area, where densities ranged from 'rare' to 'occasional' at Stations ENV11 and ENV19 and 'rare' to 'frequent' at ENV1. The area of the seabed covered by the camera transect at all stations exceeded the required 25 m^2 as set out in the OSPAR (2010) definition of the 'sea pen and burrowing megafauna communities. Therefore, of all the burrows observed within the seabed imagery across the whole of the array area, only the burrow abundances at Station ENV1 (located at the most southerly station, which lies outside the array), with a SACFOR score encompassing 'frequent', could be considered to present some similarity to a 'sea pen and burrowing megafauna community' habitat as defined by OSPAR (2010). However, it should be noted that this habitat is widespread across the central North Sea, around the south and west coasts of Norway and around the north of the British Isles (OSPAR 2010).

Stony Reef Assessment

5.5.3.8 Two stations within the inshore portion of the offshore ECC (stations ECC_22 and ECC_23) were located within an area of seabed classified by the biotope *Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment (SS.SMX.CMx.FluHyd / A5.444) and as 'Sandy gravel with boulders' as identified by the geophysical seabed interpretation (Bibby HydroMap, 2019). The analysis of DDV data collected at these stations revealed the presence of coarse sediments with boulders and cobbles also visible.

The data also revealed a high percentage of finer matrix surrounding the coarser sediments. The quality of the offshore ECC characterisation survey data did not allow for a robust assessment of stony reef to be undertaken, therefore an additional DDV study at these locations was commissioned (Ocean Ecology Limited 2020), the full details of which are presented within Appendix D8 (Hornsea Project Four Offshore Wind Farm, Annex I Habitat Assessment Survey 2020) of **Volume A5, Annex 2.1: Benthic and Intertidal Ecology Technical Report** and summarised below.

5.5.3.9 The potential Annex I habitat assessment survey at stations ECC_22 and ECC_23 followed robust analyses against the various Annex I stony reef qualifying criteria (composition, elevation and extent), the results were then overlain on the most recent acoustic survey data (MBES and SSS) available for the areas of interest which allowed for manual delineation of the areas deemed to qualify as potential Annex I stony reef habitat. A total of 4,381.8 m^2 and 173.1 m^2 of 'low' resemblance Annex I stony reef was determined to occur surrounding Stations ECC_22 (**Appendix D1**, **Figure 6**) and ECC_23 (**Appendix D1**, **Figure 7**), respectively.

5.5.3.10 The patches of stony reef habitat recorded during this survey were scored as 'low' resemblance, as per the qualifying criteria set out in regulatory guidance on assessing stony reef habitats (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not be considered to contribute to the National Site Network unless there is strong justification. Given that none of these reefs are designated features of any sites within the National Site Network or any other marine protected areas (MPA) and that 'low' was generally scored against each of the qualifying criteria for the majority of seabed images in each area, it is unlikely that any impacts associated with the installation of the proposed Hornsea Four offshore export cables will be of any significance in the context of the National Site Network.

5.5.3.11 Based on these results, the area of 'Sandy gravel with boulders' encompassing stations ECC_22 and ECC_23 is expected to comprise a patchy mosaic of stony substrate surrounded by gravels and coarse sands. Further review of the SSS mosaic from this area highlighted the presence of a number of north-south aligned ribbons of rippled sands and gravelly sand, although much of the area was expected to be 'sandy gravel with boulders'.

5.5.4 Habitat Classification

5.5.4.1 Habitat classification is used to identify different habitats and biotopes based on the biotic and abiotic features of the seabed. Habitat and biotope classification were conducted on the available survey data across Hornsea Four Order Limits, adhering to protocols set out within EUNIS.

5.5.4.2 The EUNIS classification hierarchy to biotopes (to a maximum level 5) across the Hornsea Four Order Limits was mainly based on depth, sediment type and species composition. A more detailed explanation of the EUNIS classification process across the Hornsea Four

Order Limits are presented within the corresponding characterisation reports for the array area and offshore ECC, **Appendix A** and **Appendix C**, respectively and detailed below.

5.5.4.3 Sample locations across the array area were categorised within eleven EUNIS categories and ranged between level 4 and level 5 depending on the level of confidence to which the data could be classified. The EUNIS habitat codes (and corresponding JNCC 04.05 biotope code) identified are presented in **Table 6** and **Figure 11**.

Table 6: Biotopes found across the array area (Gardline 2019; GoBe 2020).

EUNIS Code	Biotope Name	JNCC 04.05 Code
A5.14	Circalittoral coarse sediment	SS.SCS.CCS
A5.233	*Nephtys cirrosa* and Bathyporeia spp. in infralittoral sand	SS.SSa.IFiSa.NcirBat
A5.242	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	SS.SSa.IMuSa.FfabMag
A5.25	Circalittoral fine sand	SS.SSa.CFiSa
A5.251	*Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	SS.SSa.CFiSa.EpusOborApri
A5.252	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	SS.SSa.CFiSa.ApriBatPo
A5.261	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	SS.SSa.CMuSa.AalbNuc
A5.43	Infralittoral mixed sediment	SS.SMx.Imx
A5.44	Circalittoral mixed sediment	SS.SMx.CMx
A5.443	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	SS.SMx.CMx.MysThyMx
A5.444	*Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment	SS.SMX.CMx.FluHyd

5.5.4.4 EUNIS habitat code A5.25 corresponds to clean fine sands in depths of over 20 m and was noted at Station ENV21. Station ENV16 was classified as EUNIS code A5.44 which corresponds to circalittoral mixed sediments generally below 20 m, whilst station ENV24 was classified as EUNIS code A5.14 which corresponds to circalittoral coarse sediments. Station ECC_28 was classified by the habitat code A5.43, which corresponds to Infralittoral mixed sediment. It was not possible to further classify these stations to EUNIS habitat level 5 due to the lack of biological community level information from the ground-truthing investigations.

5.5.4.5 When considering the epifauna identified within the seabed imagery and the faunal communities identified during the macrofaunal analysis, it was possible to classify all remaining stations to EUNIS level 5. EUNIS habitat code A5.233 is derived from A5.23 (infralittoral fine sand) and corresponds to *Nepthys cirrosa* and *Bathyporeia* spp. in infralittoral sand, this biotope was only found at one station outside the array area. The EUNIS habitat codes A5.251 and A5.252, which are both derived from A5.25, relate to *Echinocyamus pusillus*, *Opheliea borealis* and *Abra prismatica* in circalittoral fine sand and *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand, respectively and were located within the array area. EUNIS code A5.261 is derived from A5.26 (circalittoral muddy sand) and corresponds to *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment. EUNIS habitat code A5.443 is derived from A5.44 (circalittoral mixed sediments) and corresponds to *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediments.

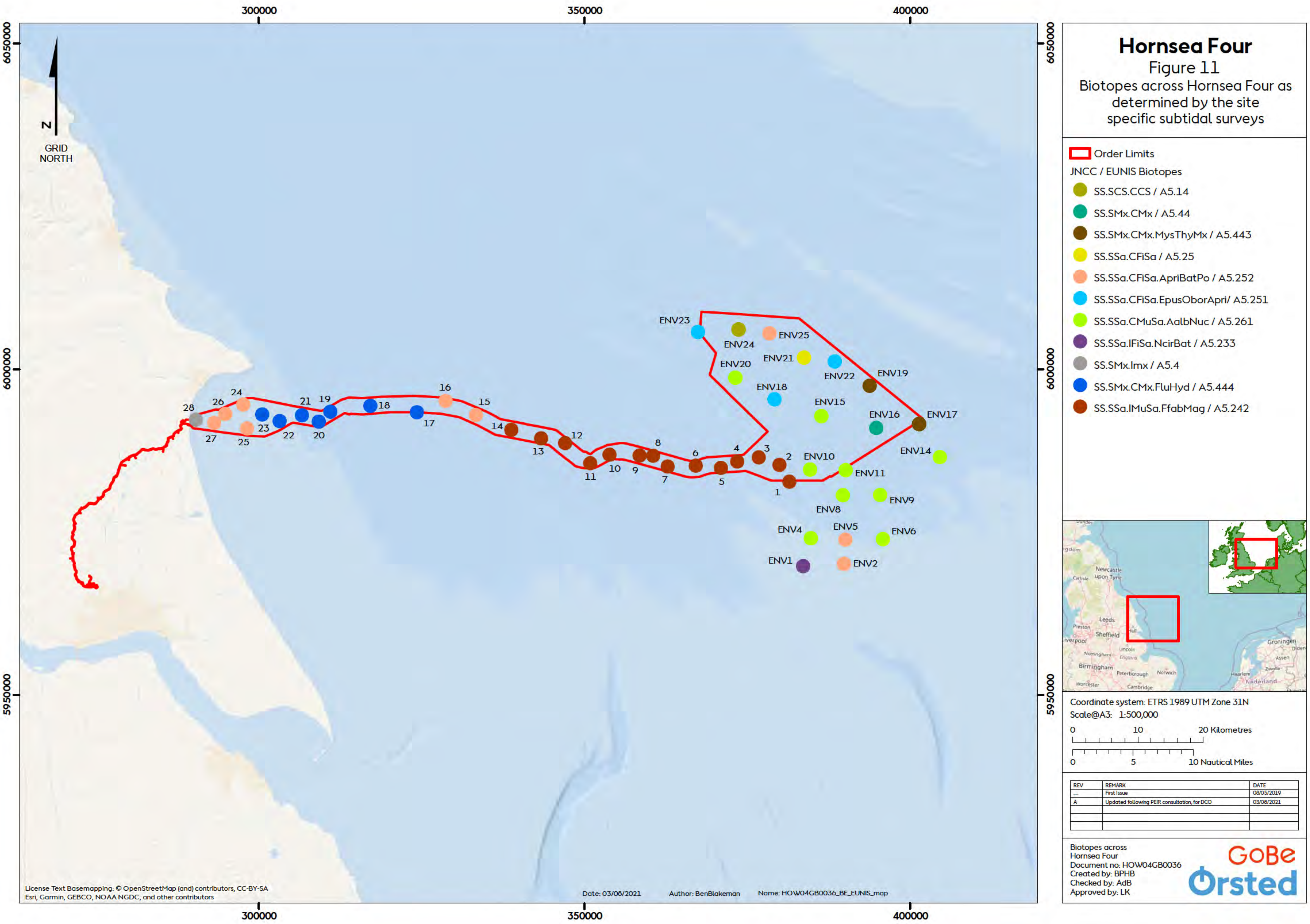
5.5.4.6 Sediment characteristics at Stations ENV17 and ENV19 were similar to those described in the EUNIS code A5.443. In addition, macrofaunal communities at these stations were dominated by the brittle star *A. filiformis*. It was noted in the habitat classification for A5.443 that this brittle star species is known to be abundant at some previous sites where this classification has been used (EEA, 2018). *A. filiformis* was also dominant at Station ENV21, however due to the sediment characteristics and the remaining macrofaunal community it was not possible to characterise this station further than EUNIS level 4. The EUNIS classification A5.251 has been used to classify Stations ENV4, ENV6 to ENV15 and ENV20. These stations all presented similar sediment profiles of sand with varying small quantities of fine material and were all dominated by the bivalve mollusc *Abra alba*. Due to the high abundance of *A. filiformis* at stations ENV16, ENV17, ENV19 and ENV21 the biotope A5.351, '*Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud', will also be taken through to the ecological impact assessment and is presented within the table of valued ecological receptors (VERs) (**Table 13**).

5.5.4.7 A5.242, '*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand' dominated the offshore portion of the ECC. The main characterising taxa *Fabulina fabula* and *Magellona* spp were found in sediments at all fourteen stations that were sampled within the habitat type, while *Bathyporeia spp.* amphipods were captured at all but two stations.

5.5.4.8 The sediments across stations allocated to EUNIS habitat code A5.444 were heterogenous with varying proportions of silt and clay, sand and gravel, with stations ECC_17 and ECC_23 being additionally characterised by the presence of cobbles and boulders. However, collectively the sediment types mostly resembled circalittoral mixed sediments. Given the heterogeneity of the sediments, the infaunal communities were also variable, with this group reflecting the most diverse faunal group. Despite the infaunal variability of these stations, the dominant infauna included the polychaete worms *Sabellaria spinulosa*, *Lumbrineris cingulate* and the saltwater clam *Hiatella arctica* (as detailed in **Section 5.5.2.13**). Analysis of the epifaunal assemblages revealed that characteristic taxa were broadly similar and ultimately informed the habitat type assignment. At stations ECC_19 and ECC_20, *Sabellaria spinulosa* individuals were recorded at relatively high densities (102 and 109 individuals were sampled, respectively), whilst the evidence suggests that these stations don't represent reef habitat, this species has been added to the table of VERs on account of its ecological importance (**Table 13**).

5.5.4.9 The two major characterising epifaunal species within A5.444 '*Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment' communities were frequently observed in the benthic imaging. Other characterising epifaunal species that were recorded included the soft coral *Alcyonium digitatum*, the barnacle *Balanus crenatus*, robust bryozoans *Alcyonidium diaphanum* and *Vesicularia spinosa* as well as the tube worm polychaetes *Sabella pavonia* and *Lanice conchilega*.

5.5.4.10 Overall, the wide range of observed EUNIS classifications supported the conclusion that the habitats across Hornsea Four Order Limits varied in accordance with the heterogenous sandy sediments encountered. The varying gravel and fines components and their effects on the faunal community were noted on final EUNIS classifications.



Hornsea Four
Figure 11
Biotopes across Hornsea Four as determined by the site specific subtidal surveys
Order Limits
JNCC / EUNIS Biotopes
SS.SCS.CCS / A5.14
SS.SMx.CMx / A5.44
SS.SMx.CMx.MysThyMx / A5.443
SS.SSa.CFiSa / A5.25
SS.SSa.CFiSa.ApriBatPo / A5.252
SS.SSa.CFiSa.EpusOborApri/ A5.251
SS.SSa.CMuSa.AalbNuc / A5.261
SS.SSa.IFiSa.NcirBat / A5.233
SS.SMx.Imx / A5.4
SS.SMx.CMx.FluHyd / A5.444
SS.SSa.IMuSa.FfabMag / A5.242
GRID NORTH
N
300000
350000
400000
6050000
6000000
5950000
ENV23
ENV24
ENV25
ENV21
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Name: HOW04GB0036_BE_EUNIS_map

6 Site-Specific Intertidal Ecology Results

6.1 Introduction

6.1.1.1 This section provides a detailed description of the results from the site-specific intertidal survey undertaken within the Hornsea Four intertidal ecology study area by The Institute of Estuarine and Coastal Studies (IECS) in March 2019 (IECS 2019). The full report including detailed methodologies and results is included as **Appendix C** to this report.

6.1.1.2 Five transects were surveyed across the Hornsea Four intertidal ecology study area (**Figure 12**). At each transect, periodic assessments of biotopes were carried out at the high-, mid-, and low-shore. Using a 1 mm sieve, a dig-over was also performed on an area 30 cm^2 to a depth of 15 cm to assess fauna and surface features along with boundaries of any biotopes. Digital geo-referenced photographs were also taken of characteristic biotopes, habitats and noteworthy features.

6.2 Phase I Results

6.2.1 Site Description

6.2.1.1 **Figure 12** presents the biotopes and noted features of interest recorded during the Phase I walkover survey along the Holderness Coast between Bridlington and Skipsea. As demonstrated by this figure, the biotope that characterised the intertidal was coarse littoral sand (LS.LSa.MoSa.Bar.Sa), which is typical of clean sands in areas of high hydrodynamic energy, common along this section of coastline. A full description of each transect is detailed below.

Transect area 1 (T1)

6.2.1.2 The upper and lower shore were characterised by coarse littoral barren sand (LS.LSa.MoSa.Bar.Sa) (**Plate 1 & 3**), with cobbles and pebbles found at mid-shore on top of the coarse sand (**Plate 2**).

6.2.1.3 No animals were found in the dig-over. Other features to note were large boulders, identified as anthropogenic in nature, (most probably old sea defences) with attached algal species (*Ulva, Porphyra* and *Fucoids* predominantly *Fucus vesiculosus*). *Semibalanus balanoides, Mytilus edulis, Littorina saxatilis* and *Patella vulgata* were also present on the boulder features. Pools at the base of the boulders were caused by scouring and not natural features.

Plate 1 & 2: Coarse Littoral Sand on upper shore T1 Site location number (left). Coarse littoral sand with cobbles and pebbles on top, T1 mid-shore (right). Figure 3 within Appendix C of Volume A5, Annex 2.1 Appendix C Intertidal Foreshore Survey Report identifies a map of the transect location. Photographs collected 22nd of March 2019 during the Phase I habitat survey.

Plate 3 & 4: Coarse Littoral Sand T1, lower-shore (left). Sparse *Lanice* tubes. T2 (right). Figure 3 within Appendix C of Volume A5, Annex 2.1 Appendix C Intertidal Foreshore Survey Report identifies a map of the transect location. Photographs collected 22nd of March 2019 during the Phase I habitat survey.

Transect area 2 (T2)

6.2.1.4 As with T1, T2 was characterised at the upper and lower shore by coarse littoral barren sand (LS.LSa.MoSa.Bar.Sa), with cobbles and pebbles found at mid-shore on top of the coarse sand. No animals were found in the dig-over, however it was noted that an area of sparse *Lanice* tubes (Plate 4) were observed at this location. Other features to note were, again, large anthropogenic boulders, with attached algal and faunal species, *Ulva, Porphyra* and Fucoids.

Transect area 3 (T3)

6.2.1.5 T3 is again characterised at the upper and lower shore by coarse littoral barren sand (LS.LSa.MoSa.Bar.Sa), with cobbles and pebbles found at mid-shore on top of the coarse sand. From the dig-over, no animals were present in the mid and lower shore sieves, however at the upper shore dig location, a single *Talitrus* was found. This would be a species associated with a strand line biotope which we could have expected to find at high shore. However, no significant strand line features were identified during this survey. Freshwater runoff was noted along this section and sea defences with pools were noted.

Transect area 4 (T4)

6.2.1.6 T4 was characterised by coarse littoral sand at the upper, mid and low shore points along the full section (LS.LSa.MoSa.Bar.Sa). Sea defences with ephemeral scoured pools at the base were present again and it was also noted that an area of coarse sand over hard clay was present (Plate 5). No animals were found in the dig-overs at high and mid shore with a single *Lanice conchilega* found at lowshore.

Plate 5: Coarse sand over hard clay. Figure 3 within Appendix C of Volume A5, Annex 2.1 Appendix C Intertidal Foreshore Survey Report identifies a map of the transect location. Photographs collected 22nd of March 2019 during the Phase I habitat survey.

Transect area 5 (T5)

6.2.1.7 T5 was characterised by coarse littoral sand at the upper, mid and low shore points along the full section (LS.LSa.MoSa.Bar.Sa). An area of very sparse *Lanice* tubes, was also observed at this location. No animals were found in the dig-overs.

Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0045_BE_Phase_1_Biotope_Survey

Hornsea Four

Figure 12

Phase I biotope map of the intertidal Hornsea Four landfall area, showing the designated intertidal biotopes

Order Limits

Biotope Areas

- LSaMoSaBarSa (Coarse sand over laying mud)
- LSaMoSaBarSa (Coarse sand with pebbles and cobbles)
- LSaMoSaBarSa (Coarse sand)
- LSaMoSaBarSa (Fresh water run off)
- LSaMoSaBarSa (Rocks with pools)

Coordinate system: British National Grid
Scale@A3: 1:5,500

0 100 200 Metres

0 500 1,000 Feet

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Phase 1
Biotope Survey
Document no: HOWGB0045
Created by: BPHB
Checked by: AdB
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GoBe
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7 Habitat Mapping

7.1 Context

7.1.1.1 To address the data gaps identified at PEIR (when there was incomplete site-specific survey data), a full coverage model of marine benthic subtidal habitats was developed by GoBe Consultants Ltd. across the Hornsea Four benthic subtidal ecology study area (as agreed through the evidence plan process). The model collates available physical and biological point data across the area of interest to help understand the occurrence of potential biotopes over a wider study area and, as such, has been retained to support the application and the assessment of impacts on the subtidal benthic ecology.

7.1.1.2 The model uses survey data from across the region, including site-specific Hornsea Four data (Gardline 2019; GoBe 2020). The model improves the benthic subtidal ecology baseline understanding across the whole area, including the offshore ECC and array area, both of which have benthic site-specific sampling to inform the model. The area modelled in the ES is defined by the Hornsea Four benthic subtidal ecology study area, as described in **Section 2.1**.

7.1.1.3 In regional / strategic studies, undertaken in research or by government, as well as a few cases by industry, biotope communities have been mapped through more extensive models that are justified by the scale of the project, e.g. Biomor 5 / HabMap (Robinson et al. 2009), Humber REC (Tappin et al. 2011) and East Anglia Offshore Windfarm (EAOL 2012). These projects (the latter two of which were developed by the author of this report) have been further developed to inform the Hornsea Four benthic subtidal model developed by GoBe.

7.1.1.4 Biotopes depend on a range of environmental preferences, some of which are well established, e.g. sediment, and others which are experimental, e.g. temperature. By examining the relationship biotopes have with these parameters, the Hornsea Four benthic subtidal model has been developed to predict the 'suitability' of each biotope to a range of environmental conditions, therefore giving the 'likelihood' of its occurrence. The method ensures stakeholder understanding and yet still allows for a robust methodology and clear communication of data standards through confidence levels.

7.1.1.5 The Hornsea Four benthic subtidal model has been developed using a three-tiered process (as detailed in the following sections):

- Seabed sediment model;
- EUNIS Level 4 model; and
- Biotope model.

7.2 Seabed Sediment Model

7.2.1 Existing Models

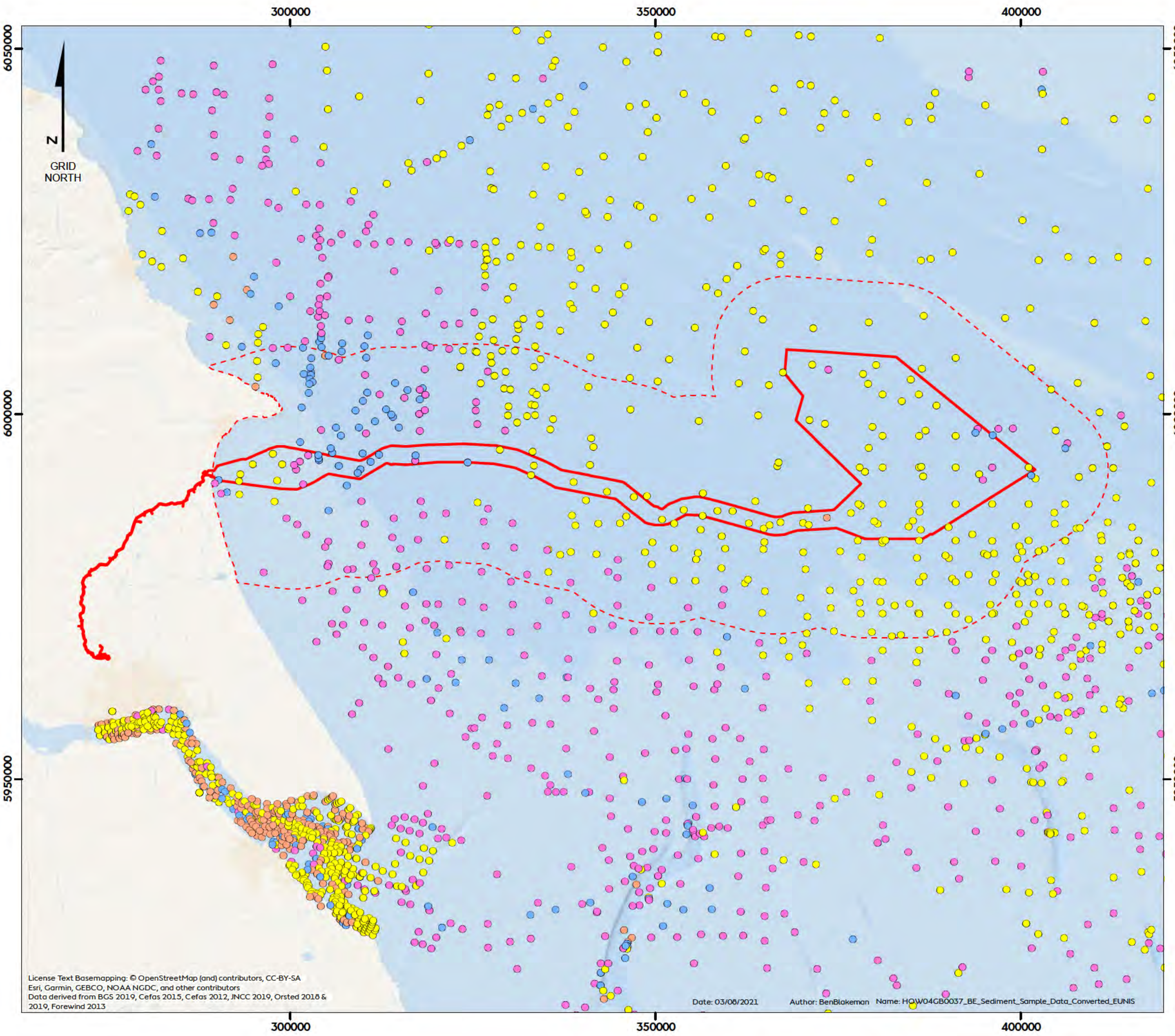
7.2.1.1 Current full coverage sediment maps of the Hornsea Four area are provided by BGS seabed sediment, the Cefas 2015 and 2019 sediment models and JNCC's UKSeaMap 2018 (published in 2019). Whilst these do not have the density of ground truthing stations that have become available since, including Hornsea Project One, Hornsea Project Two, Hornsea Four and Dogger Bank A & B surveys, as well as the Cefas Southern North Sea Synthesis Study (Cefas 2012), they do provide a baseline from which to develop a project-specific sediment model, as described in this section.

7.2.1.2 Of the three sediment maps described above, those from BGS and UKSeaMap 2018 were developed using PSA at sample points. The Cefas models incorporate additional environmental forcings from the physical environment that may impact on sediment location, e.g. current speed and wave velocity. Therefore, the Cefas models are considered the most up to date existing sediment maps in the area on which to base the development of the Hornsea Four sediment model.

7.2.1.3 The Cefas sediment models provide sediment in a range of classification systems, including the 11 standard Folk categories (e.g. gravelly Sand, sandy Mud); as well as the more broadscale four European Nature Information System (EUNIS) substrate types of i) coarse sediment, ii) mixed sediment, iii) sand (sand and muddy sand) and iv) mud (mud and sandy mud) (Connor et al. 2006). These are related to the percentage gravel, sand and mud as shown in **Figure 13**. As biotopes are known to inhabit a range of different sediment types, they are therefore classified with more broadscale descriptions, as adopted in the Marine Classification for Britain and Ireland (JNCC 2004; version 04.05) and EUNIS biotope classifications. Therefore, the main output of the Hornsea Four sediment model was to produce a EUNIS substrate model.

7.2.1.4 As the Cefas models were predicted through a complex array of parameters and rules, and as the source data was not made available, it was not possible to amend the predictions using recent Hornsea / Dogger Bank A & B survey PSA data. However, by simply interpolating all PSA data (from BGS and Hornsea / Dogger Bank A & B surveys), the detail of the Cefas model and consideration of other physical parameters effecting sediment distribution would be lost. Therefore, through the evidence plan process, it was agreed that an acceptable approach for the purposes of PEIR, and subsequently the ES, would be to manually modify the boundaries of the Cefas sediment model using the most recent site specific survey data and supported by other older PSA data). As a result, the EUNIS substrate map has been produced directly from the Cefas model and survey point EUNIS values (as opposed to developing a Folk sediment map first).

7.2.1.5 Whilst the Cefas 2019 model has been reported to improve the accuracy of the 2015 model (Mitchel et al. 2019), GoBe have tested the difference between each in the vicinity of Hornsea Four. Point validation data were combined from BGS, the Cefas Southern North Sea Synthesis Study 2012, Hornsea Four, other historic Hornsea surveys and Dogger Bank A & B surveys as shown in **Figure 13** and **Figure 14**. The EUNIS substrate categories in **Figure 16** were assigned from PSA values using an in-house Excel macro, which is governed by the categorisation shown in **Figure 15**. (Note this EUNIS categorisation, as also used in the Cefas models, differs slightly from the REC studies).



Hornsea Four

Figure 13

All Sediment Sample Data Sourced: Uniformly Converted to EUNIS Substrate

Order Limits
Benthic Study Area
GoBe Calculated EUNIS Substrate
Coarse
Mixed
Mud
Sand

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:500,000

0 10 20 Kilometres
0 5 10 Nautical Miles

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Sediment Sample Data
EUNIS Substrate
Document no: HOW04GB0037
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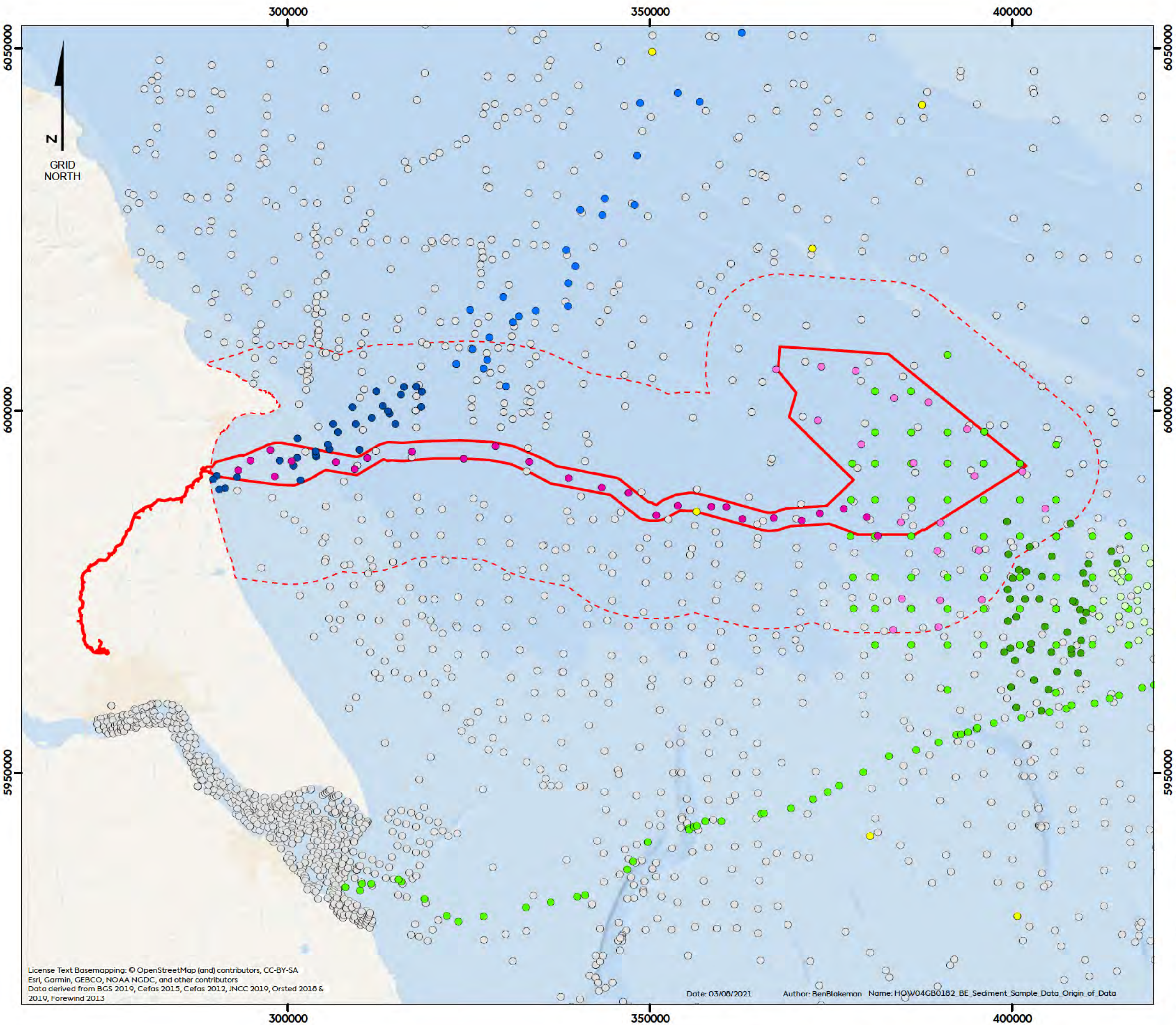
Checked by: RM
Approved by: LK



Hornsea Four

Figure 14

All Sediment Sample Data
Sourced: Origin of Data

- Order Limits
- Benthic Study Area

All OWF and BGS Sediment Samples

- H4 ECC (2018)
- H4 Array (2018)
- HP2 Array (2012)
- H Zonal (2011)
- H1 Array (2010)
- Creyke Nearshore Tranch A (2012)
- Creyke Offshore Tranch A (2012)
- Creyke and Dogger Bank Tranch B (2012)
- Creyke and Dogger Bank Tranch C (2012)
- Cefas (2009 to 2011)
- BGS UK (Various Years)

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
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Sediment Sample Data
Origin of Data
Document no: HOW04GB0182
Created by: BPHB
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Approved by: LK

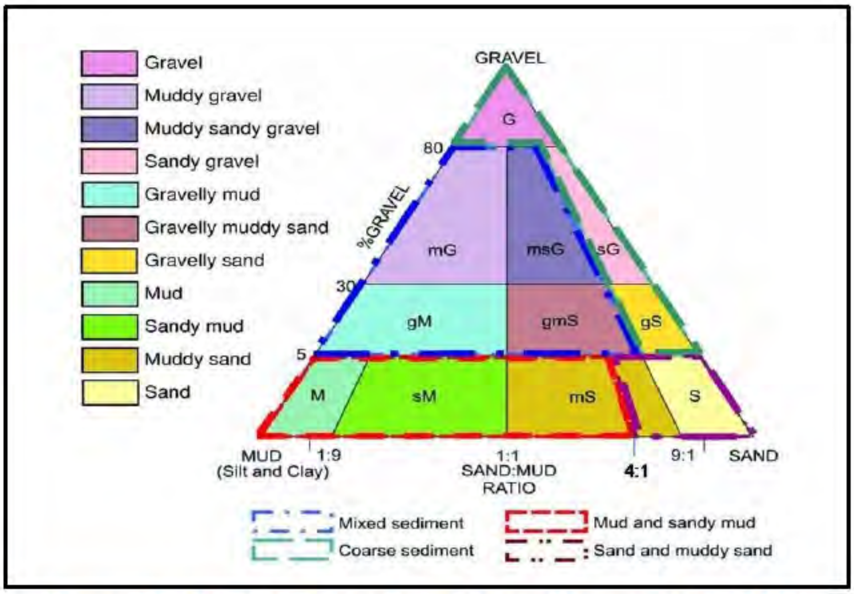


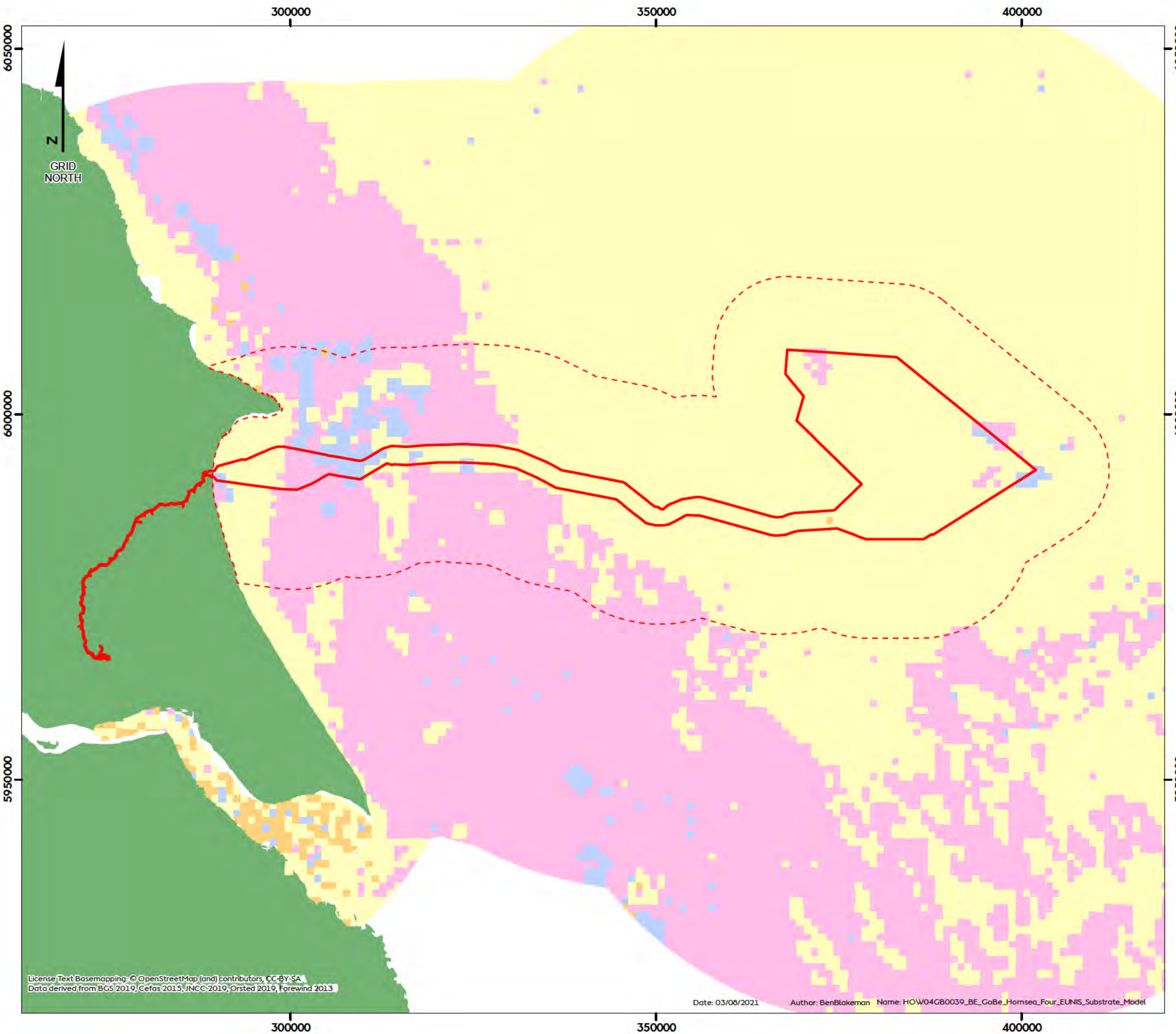
Figure 15: Modified Folk sediment trigon (Connor et al. 2006).

7.2.1.6 The Cefas 2015 model was found to agree with the EUNIS substrate of approximately 2000 PSA points, compared to ~1500 for the Cefas 2019 model. This improved accuracy in the older model was particularly evident in viewing the Hornsea Four array area which has good coverage of PSA points and clear disagreement with a significant section of the array. Therefore, the Cefas 2015 model was used as the basis for the Hornsea Four sediment model.

7.2.2 Application of Recent Survey Data to Model

7.2.2.1 The Hornsea Four site-specific survey data formed the priority data sets in amending the Cefas 2015 model boundaries, overriding any nearby older data. The site-specific data, whilst categorised into four broadscale substrates, was also validated to ensure the same substrate groups / rules had been applied from Connor et al. (2006). Further to the uniform categorisation of PSA data as detailed above, the geophysical line substrate groupings were compared to the point data and whilst these agreed mostly, the substrate type for a few areas were amended to fit the recent point survey data.

7.2.2.2 Therefore, boundaries of EUNIS substrate were manually defined in Geographical Information Systems (GIS) using a gridded approach, using survey data to amend the overall Cefas 2015 model, with results shown in Figure 16. Whilst the Hornsea Four Order Limits is characterised predominantly with sand and muddy sand, there is a large area of coarse sediment with pockets of mixed sediments in the nearshore to midway section of the cable, as well as small patches close to the coast and in the northern and eastern parts of the array area.



Hornsea Four

Figure 16

Hornsea Four EUNIS substrate model

Order Limits

Benthic Study Area

GoBe Hornsea Four EUNIS Substrate Model

- Coarse
- Mixed
- Mud
- Sand

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
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EUNIS Substrate Model

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Approved by: LK

7.3 Level 4 EUNIS Physical Habitat Model

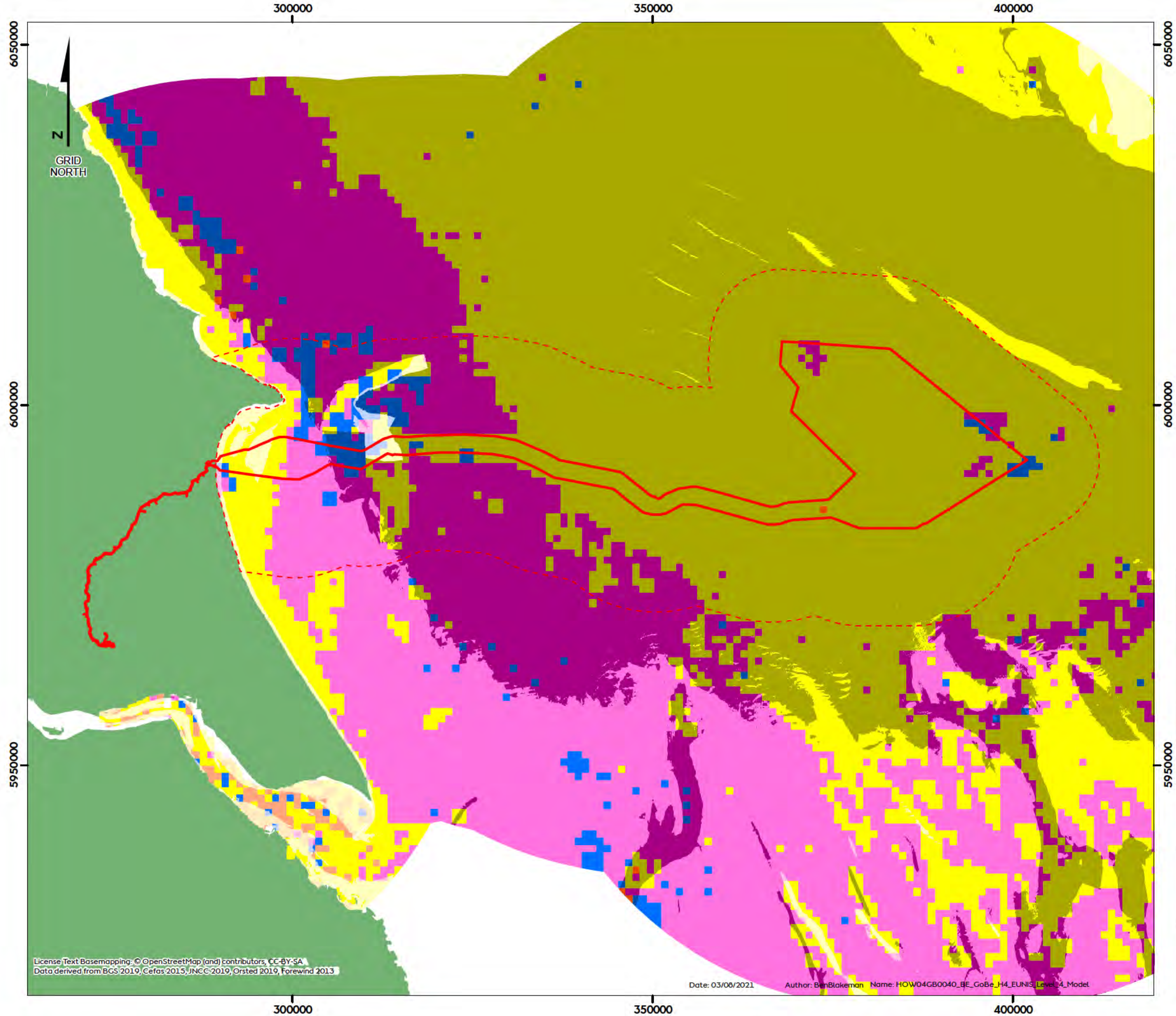
7.3.1.1 The full EUNIS habitat classification scheme provides a hierarchal structure with increasing level of detail to describe habitats. At level 4, habitats are described by marine / terrestrial, biological zone and sediment type. Biological zone considers i) the upper and lower limit in depth of the intertidal zone, ii) the 1% light attenuation depth limit and iii) depth of the wavebase.

7.3.1.2 The Hornsea Four EUNIS Level 4 model was developed in ArcGIS using a union (combination) between the UKSeaMap 2018 biological zones and Hornsea Four sediment model (detailed above). As shown in **Figure 17**, the majority of the offshore seabed is Deep Circalittoral (i.e. beyond the reach of light at the seabed but still impacted by wave motion). Nearer the shore (<25 km), the area varies between Infralittoral, Shallow Circalittoral and Deep Circalittoral.

Hornsea Four

Figure 17

Hornsea Four EUNIS Level Four model



- Order Limits
- Benthic Study Area

GoBe Hornsea Four EUNIS Level 4 Model

- Infralittoral Mud and Sandy Mud
- Shallow Circalittoral Mud and Sandy Mud
- Deep Circalittoral Mud and Sandy Mud
- Infralittoral Sand and Muddy Sand
- Shallow Circalittoral Sand and Muddy Sand
- Deep Circalittoral Sand and Muddy Sand
- Infralittoral Mixed Sediments
- Shallow Circalittoral Mixed Sediments
- Deep Circalittoral Mixed Sediments
- Infralittoral Coarse Sediments
- Shallow Circalittoral Coarse Sediments
- Deep Circalittoral Coarse Sediments

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

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EUNIS Level 4 Model

Document no: HOW04GB0040

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7.4 Biotope Model

7.4.1.1 The development of the biotope maps followed three tasks (as detailed below):

- Definition of point biotope dataset;
- Development of broadscale environmental 'predictor' layers; and
- Development of biotope model controls and likelihood outputs.

7.4.2 Point Biotope Dataset

7.4.2.1 Point biotope data was compiled from Hornsea Four surveys, other historic Hornsea surveys and Dogger Bank A & B surveys (where available on the Marine Data Exchange). Starting with a total list of 28 biotopes, these then underwent a screening process to reduce the list from all surveys, whilst keeping all biotopes from the Hornsea Four site-specific surveys as a baseline throughout (i.e. no site-specific biotopes were screened out other than physical biotopes, see below).

7.4.2.2 Firstly, all physical 'biotopes' were removed, e.g. SS.SCS.CCS, Circalittoral coarse sediment. These data were already accounted for in the GoBe substrate model.

7.4.2.3 Secondly, if a biotope was a combination of two or three different biotope codes, then it was relabelled to the first occurring biotope. This ensured that the biotopes predicted were as distinct as possible. Note that none of the site-specific biotopes were combined codes.

7.4.2.4 Thirdly, a review of spatial coverage was carried out to determine whether points were relevant to Hornsea Four, in tandem with review of the substrate and whether this was relevance to the Hornsea Four. This informed the removal of a number of biotopes as follows:

- Dogger Bank A & B array area – remaining points removed as biological zone / substrate not relevant and further away than all other points;
- Dogger Bank A & B cable corridor (to Teesside) – remaining points removed as biological zone / substrate not relevant;
- Hornsea Project One and Hornsea Project Two arrays and the former Hornsea zone - remaining points removed as whilst biological zone / substrate relevant, it is not found in Hornsea Four array area which is adjacent and therefore it is unlikely to be present; and
- Hornsea Project One ECC (nearshore or midway) – remaining points removed as biological zone / substrate not relevant.

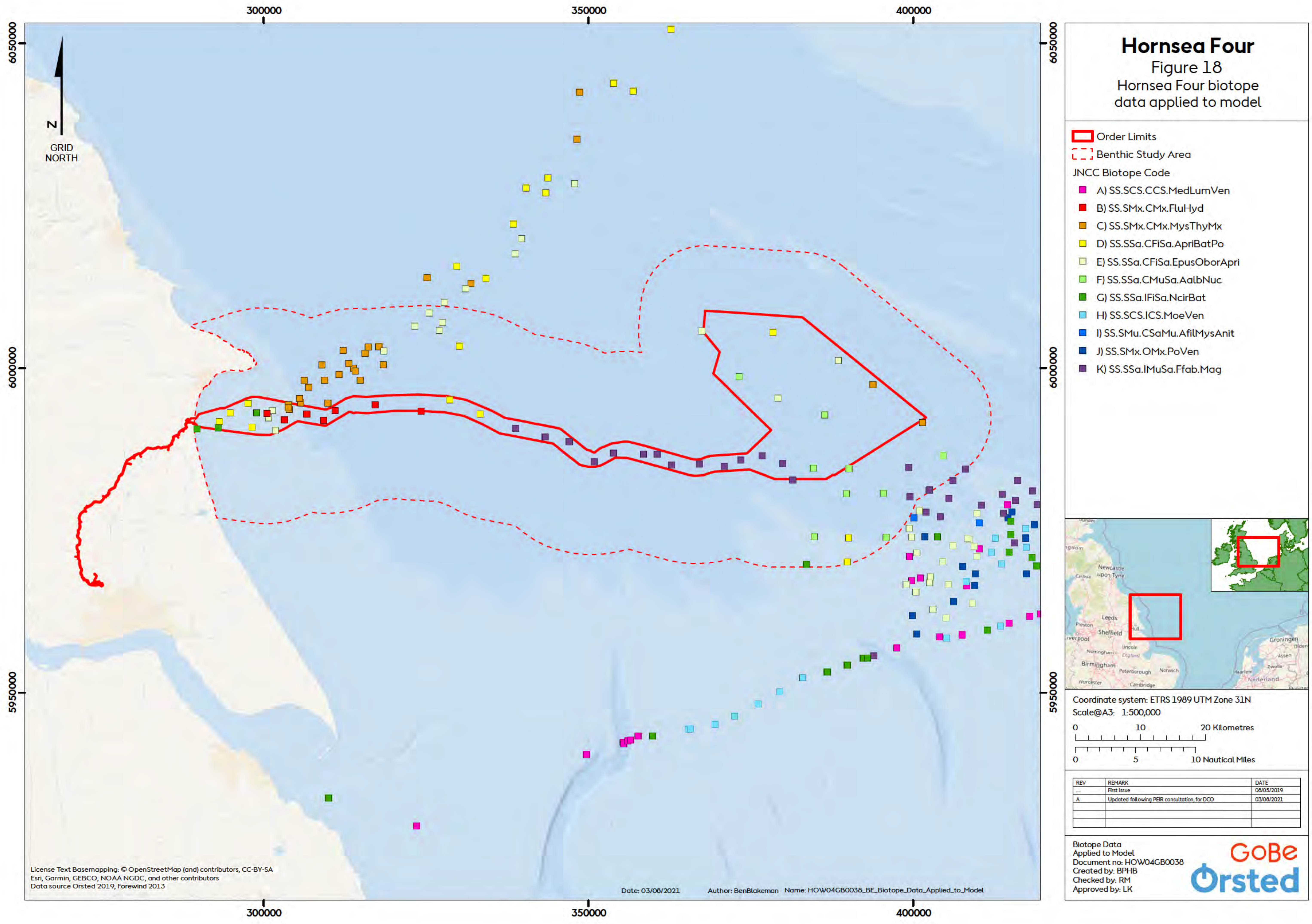
7.4.2.5 Fourthly, the data were screened to remove any biotopes outside of the Hornsea Four habitat modelling area that were identified in less than three samples, therefore only leaving those that were better represented at more than three survey locations.

7.4.2.6 Lastly, if any remaining biotopes inside the habitat modelling area occurred in less than three locations and were sampled during surveys more than seven years ago (pre-2013), then these were excluded.

7.4.2.7 **Table 7** and **Figure 18** include biotopes that exist in some of the areas listed above because they are also found in the Hornsea Four benthic subtidal ecology study area. Any occurrence of each of these 11 biotopes in any area is used to inform the environmental preferences.

Table 7: Biotopes selected to model.

ID	JNCC 04.05	EUNIS name	Coverage	Duplicates	Hornsea Four site-specific survey
A	SS.SCS.CCS.MedLumVen	*Mediomastus fragilis, Lumbrineris spp.* and venerid bivalves in circalittoral coarse sand or gravel	Hornsea Project Two array areas and Hornsea Project One and Two ECCs		No
B	SS.SMx.CMx.FluHyd	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment	Hornsea Project One ECC near- to mid-shore		Yes
C	SS.SMx.CMx.MysThyMx	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	Hornsea Four array area, Hornsea Project One, Hornsea Project Two and Hornsea Three array areas; and Dogger Bank A & B ECC		Yes
D	SS.SSa.CFiSa.ApriBatPo	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	South of Hornsea Four array area; and Dogger Bank A & B ECC		Yes
E	SS.SSa.CFiSa.EpusOborApri	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Hornsea Four array area, Hornsea Project One and Hornsea Project Two array areas; Dogger Bank A & B ECC (near to mid-shore).	Yes	Yes
F	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa in* circalittoral muddy sand or slightly mixed sediment	Hornsea Four array area and south of the array area		Yes
G	SS.SSa.IFiSa.NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	South of Hornsea Four array area, Hornsea Four ECC (nearshore), Hornsea Project One and Hornsea Project Two ECCs and array areas		Yes
H	SS.SCS.ICS.MoeVen	*Moerella* spp. with venerid bivalves in infralittoral gravelly sand	Hornsea Project One and Hornsea Project Two array areas and mid- to far-shore ECCs		No
I	SS.SMu.CSaMu.AfilMysAnit	*Amphiura filiformis, Mysella bidentate* and *Abra nitida* in circalittoral sandy mud	Hornsea Project One array area		No
J	SS.SMx.OMx.PoVen	Polychaete-rich deep *Venus* community in offshore mixed sediments	Hornsea Project One and Hornsea Project Two array areas and far-shore ECCs; and wider Hornsea Zone		No
K	SS.SSa.IMuSa.Ffab.Mag	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand	Hornsea Project Four mid- to far-shore ECC, Hornsea Project One and Hornsea Project Two array areas and far-shore ECC; and Dogger Bank A & B far-shore ECC		Yes


Hornsea Four
Figure 18
Hornsea Four biotope data applied to model
Order Limits
Benthic Study Area
JNCC Biotope Code
A) SS.SCS.CCS.MedLumVen
B) SS.SMx.CMx.FluHyd
C) SS.SMx.CMx.MysThyMx
D) SS.SSa.CFiSa.ApriBatPo
E) SS.SSa.CFiSa.EpusOborApri
F) SS.SSa.CMuSa.AalbNuc
G) SS.SSa.IFiSa.NcirBat
H) SS.SCS.ICS.MoeVen
I) SS.SMu.CSaMu.AfilMysAnit
J) SS.SMx.OMx.PoVen
K) SS.SSa.IMuSa.Ffab.Mag
GRID NORTH
N
300000
350000
400000
6050000
6000000
5950000
Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:500,000
0 10 20 Kilometres
0 5 10 Nautical Miles
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Biotope Data
Applied to Model
Document no: HOW04GB0038
Created by: BPHB
Checked by: RM
Approved by: LK
License Text Basemapping: © OpenStreetMap (and) contributors, CC-BY-SA
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
Data source Orsted 2019, Forewind 2013
Date: 03/08/2021
Author: BenBlakeman
Name: HOW04GB0038_BE_Biotope_Data_Applied_to_Model

7.4.3 Environmental Predictor Layers

7.4.3.1 In addition to sediment type, other variables may also have an impact on biotope distribution, including seabed energy, tidal range, light attenuation, wavebase, water body type (e.g. region of freshwater influence), seabed temperature and salinity. Data were sourced from The Met Office 2019 and UKSeaMap 2018, as shown in **Table 8**.

Table 8: Environmental full coverage data sourced to inform the model.

Environmental Layer	Source Organisation and Year	Origin of Data
Seabed sediment	Cefas 2015	Input data predominantly sourced from BGS which was collected 1968-1984 in study area.
EUNIS Level 4 (energy and biological zone)	JNCC 2019	UKSeaMap 2018 (various different physical models, too many data input to list here)
Seabed temperature	The Met Office 2019	Reanalysis predicted model data for February (winter) and August (summer) 2016
Sea surface temperature	The Met Office 2019	Reanalysis predicted model data for February (winter) and August (summer) 2016
Seabed salinity	The Met Office 2019	Reanalysis predicted model data for February (winter) and August (summer) 2016
Surface salinity	The Met Office 2019	Reanalysis predicted model data for February (winter) and August (summer) 2016

7.4.3.2 Some of the data required processing beyond the standard GIS (transformation, gridded etc.) to calculate or determine the layer values. This included the seabed salinity which required Excel formula to extract the depth layer at seabed from which to extract the value (seabed temperature did not require this).

7.4.3.3 Also, the water body layer required processing of data. The water body type was determined using the criteria used in UKSeaMap 2006 (Connor et al. 2006), which provided a spatial layer on water bodies but has since not applied this to UKSeaMap 2018. The UKSeaMap criteria required the temperature and salinity data to be processed to assess value ranges over the water column depth; these were used to assign categories of water body type.

7.4.3.4 The resulting list of data layers used directly by the model is shown in **Table 9** with a summary of processing required and categories assigned. Note salinity data was excluded as a stand-alone predictor layers as the water body types considered the salinity values. Temperature data was only included for the seabed in summer (August) as the winter data did not show significant correlation.

Table 9: Final environmental predictor layers to inform the model.

Environmental Layer	Unique Data Processing	Categories within Hornsea Four
EUNIS seabed substrate	PSA point data from Hornsea, Dogger Bank A & B array areas/ECCs, Cefas Southern North Sea Synthesis Study and BGS, uniformly converted to EUNIS substrate. Geophysical line data from Hornsea Four 2018 and 2019 surveys, substrate names modified using PSA data in some areas. Cefas 2015 sediment model boundaries modified manually using PSA and geophysical line data.	Sand and Muddy Sand Mud and Sandy Mud Mixed Sediments Coarse Sediments
Biological zones	No processing	Infralittoral (intertidal) Shallow Circalittoral (to depth of 1% light attenuation) Deep Circalittoral (to limit of wavebase)
Energy at the seabed	No processing	Low Moderate High
Summer water body	Surface to seabed temperature difference calculated to assign whether well-mixed, frontal or stratified Maximum salinity used to assign whether estuarine, Region of Freshwater Influence (ROFI), shelf or oceanic. Categories combined to give overall water body type.	Estuarine / ROFI / Shelf / Oceanic and Well Mixed / Frontal / Stratified
Seabed temperature August 2016	None	0.5 Celsius (C) categories

7.4.3.5 All predictor layers were transformed to WGS84 UTM31N projection, to a shapefile polygon, cleaned where necessary, attribute fields minimised to required information only (value and source) and then combined into a single shapefile polygon layer. This was based on a grid of 1 km but boundaries between original data categories were kept in the model by use of the intersect tool.

7.4.4 Biotope and PSA Data Inputs

7.4.4.1 The combined GIS layer, containing all predictor layers, was further matched to record all cells / segments that contained a model biotope (one of the 11 biotopes listed above) and its associated survey EUNIS substrate. The resulting model combined (union-ed) layer therefore contained both the Hornsea Four habitat modelling area as well as discrete model cells that contained biotope / PSA point data (which is required by the model format).

7.4.5 Extracting and Amending Preferences

7.4.5.1 An Excel macro model was developed by GoBe in-house to process the unioned model layer attribute table to determine the environmental preferences at each biotope; and predict likelihood of the biotope's coverage across Hornsea Four.

7.4.5.2 For each model cell / segment, a set of environmental preferences were extracted automatically for each biotope group of points. These were then modified manually through expert judgement. For any biotope where there were more than five points used to inform the preferences, singular outlier categories were removed. E.g. if biotope X has 10 points on moderate energy and one on high energy, then the high energy is removed from the preferences. Numerical ranges remained as automatically extracted (i.e. seabed temperature), but the lower limit rounded down to the nearest 0.5°C and upper limit rounded up.

7.4.5.3 The final list of model environmental preferences is shown in **Table 10**.

Table 10: Environmental preferences.

Group	Sea Bottom Temperature °C	Summer Water Body	Energy	Biological Zone	Substrate
A	15.0 – 16.5	Well Mixed shelf	High energy Moderate energy	Deep circalittoral Shallow circalittoral	Mixed Sediments Coarse Sediments Sand and Muddy Sand
B	14.0 - 16.0	Well Mixed Shelf	Moderate energy	Deep circalittoral Shallow circalittoral Infralittoral	Mixed Sediments Coarse Sediments
C	10.0 – 16.0	Well Mixed Shelf Frontal Shelf Stratified Shelf	Moderate energy Low energy	Deep circalittoral Shallow circalittoral Infralittoral	Coarse Sediments Mixed Sediments Sand and Muddy Sand
D	–10.0 – 16.5	Well Mixed Shelf Frontal Shelf Stratified Shelf	High energy Moderate energy Low energy	Shallow circalittoral Deep circalittoral Infralittoral	Coarse Sediments Sand and Muddy Sand
E	–11 – 16.5	Well Mixed Shelf Frontal Shelf Stratified Shelf	High energy Moderate energy Low energy	Deep circalittoral Shallow circalittoral	Mixed Sediments Coarse Sediments Sand and Muddy Sand
F	11 – 16.5	Well Mixed Shelf Frontal Shelf	Moderate energy Low energy	Deep circalittoral	Sand and Muddy Sand
G	15 – 17.5	Well Mixed Region of freshwater Influence Well Mixed Shelf	High energy Moderate energy Low energy	Deep circalittoral Shallow circalittoral Infralittoral	Coarse Sediments Mixed Sediments Sand and Muddy Sand
H	15 – 16.5	Well Mixed Shelf	High energy Moderate energy	Deep circalittoral Shallow circalittoral	Coarse Sediments Mixed Sediments Sand and Muddy Sand
I	15.5 – 16.0	Well Mixed Shelf	Moderate energy	Deep circalittoral	Coarse Sediments Sand and Muddy Sand
J	15.0 – 16.5	Well Mixed Shelf Frontal Shelf	Moderate energy Low energy	Deep circalittoral Shallow circalittoral	Coarse Sediments Mixed Sediments Sand and Muddy Sand
K	15.0 – 16.5	Well Mixed Shelf	Moderate energy	Deep circalittoral	Coarse Sediments

Group	Sea Bottom Temperature °C	Summer Water Body	Energy	Biological Zone	Substrate
		Frontal Shelf	Low energy	Shallow circalittoral	Mixed Sediments Sand and Muddy Sand

7.4.6 Prediction Criteria

7.4.6.1 A second macro was developed to then process the biotope preferences. The likelihood for each biotope was calculated through a scoring mechanism where each cell is assigned a score of one for each environmental layer that fits the required criteria for that biotope. Therefore, if three environmental variables are within the required range for that biotope, it would receive a summed overall score of three. However, as sediment type is essential for the biotope prediction, where sediment type is not suitable for a specific biotope the score was forced to zero.

7.4.6.2 A separate predictive model for each biotope was therefore produced showing these scores which represent the 'likelihood' of that biotope occurring. These are shown in **Figure 19**.

7.4.6.3 It should be noted that there will always be a greater degree of uncertainty where there is no survey data. In some cases, it may be coincidental that a certain environmental preference is found for a biotope and there is in fact no correlation, though this is reduced by sample size. Also, there are rarely any hard boundaries between biotopes and transition between is normally more varied / 'fuzzy'.

7.4.7 Model Interpretation

7.4.7.1 The predictive habitat model enables us to develop a better understanding of the benthic subtidal ecology baseline where ground-truth data was not collected, based on the suitability of likely biotopes that were modelled through a well-developed three-tiered process: creation of a seabed sediment model, a EUNIS Level 4 model and a biotope model.

7.4.7.2 **Figure 19**, **Figure 20**, **Figure 21**, and **Figure 22** reveal that the five biotopes that are predicted to occur across Hornsea Four benthic subtidal ecology study area show varying degrees of modelled coverage. The differences are explained by each of the faunal groups' preferences for different environmental conditions within each of the five modelled layers:

- Substrate type;
- Biological zone;
- Energy;
- Sea bottom temperature; and
- Water body type.

7.4.7.3 In general terms, the greater the coverage of a particular biotope the less defined is a given faunal group's affinity with a particular habitat.

7.4.7.4 The model output demonstrate that the biotopes are present in four distinct groups, with the biotopes A, G, H and I are predicted across the southern section of the offshore ECC and array area. These all prefer warmer waters in the south, though biotope I is restricted to deep circalittoral so not present close to the shore.

7.4.7.5 Owing to their broad range preferences across most model parameters, biotopes C, D, E, J and K cover the majority of the area with minor differences resulting from e.g. substrate preference.

7.4.7.6 Biotope B is unique in being predominantly found towards the west of the study area, with a preference for mixed and coarse sediments, and moderate energy.

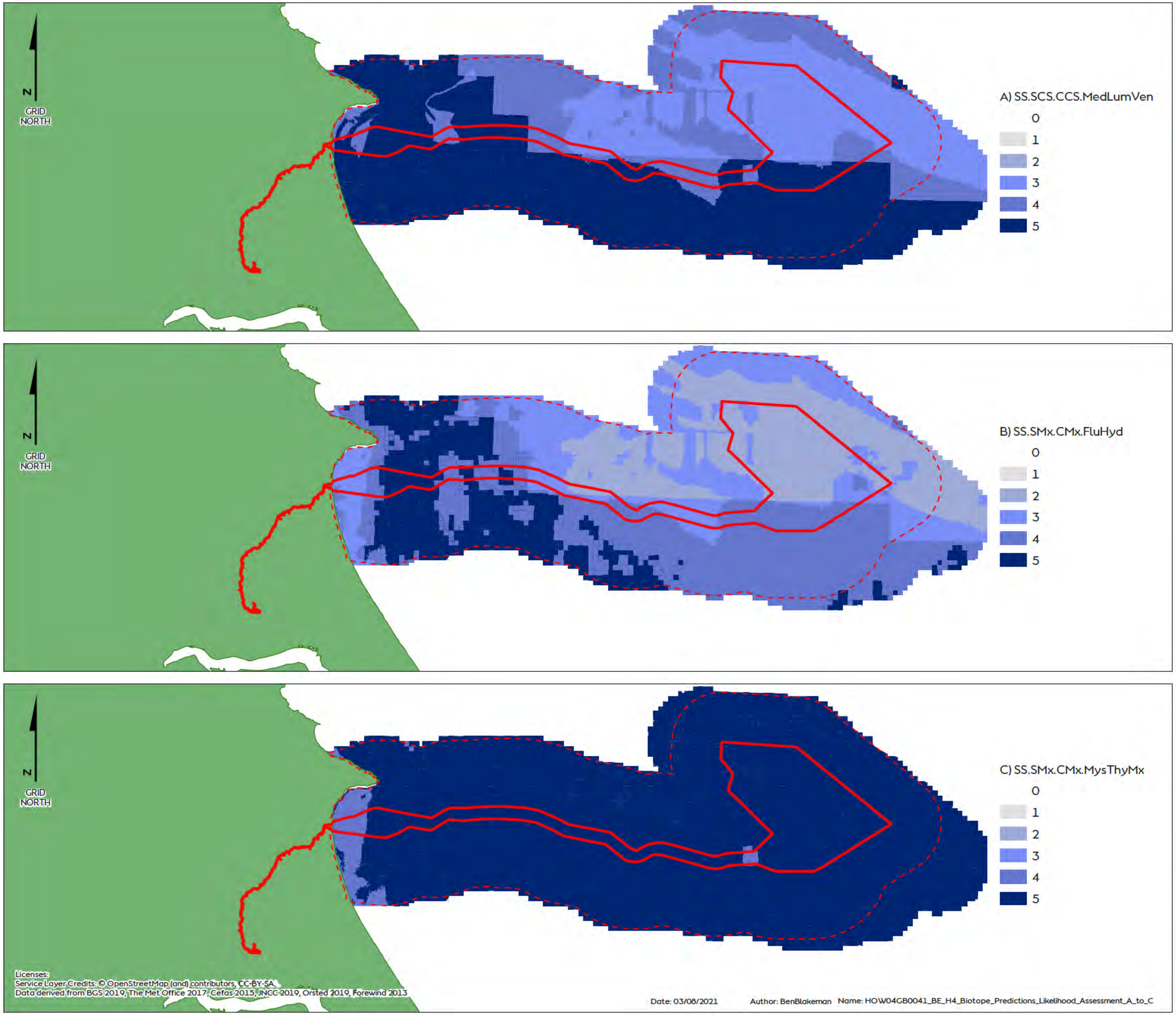
7.4.7.7 Lastly, biotope F is unique in being predominantly found towards the east of the study area, in deeper waters or the circalittoral zone on sand and muddy sand.

7.4.7.8 The habitat model therefore reveals that each of the biotopes had differing but also overlapping habitat requirements in some instances, which is likely to be reflective of the homogeneity of ecological conditions across some of the site, particularly in the offshore section of Hornsea Four benthic subtidal ecology study area.

Hornsea Four

Figure 19

Hornsea Four biotope predictions: likelihood assessment (1 of 4)



Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0041_BE_H4_Biotope_Predictions_Likelihood_Assessment_A_to_C

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

REV	REMARK	DATE
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H4 Biotope Predictions:
Likelihood Assessment
Document no: HOW04GB0041
Created by: BPHB
Checked by: AdB
Approved by: LK

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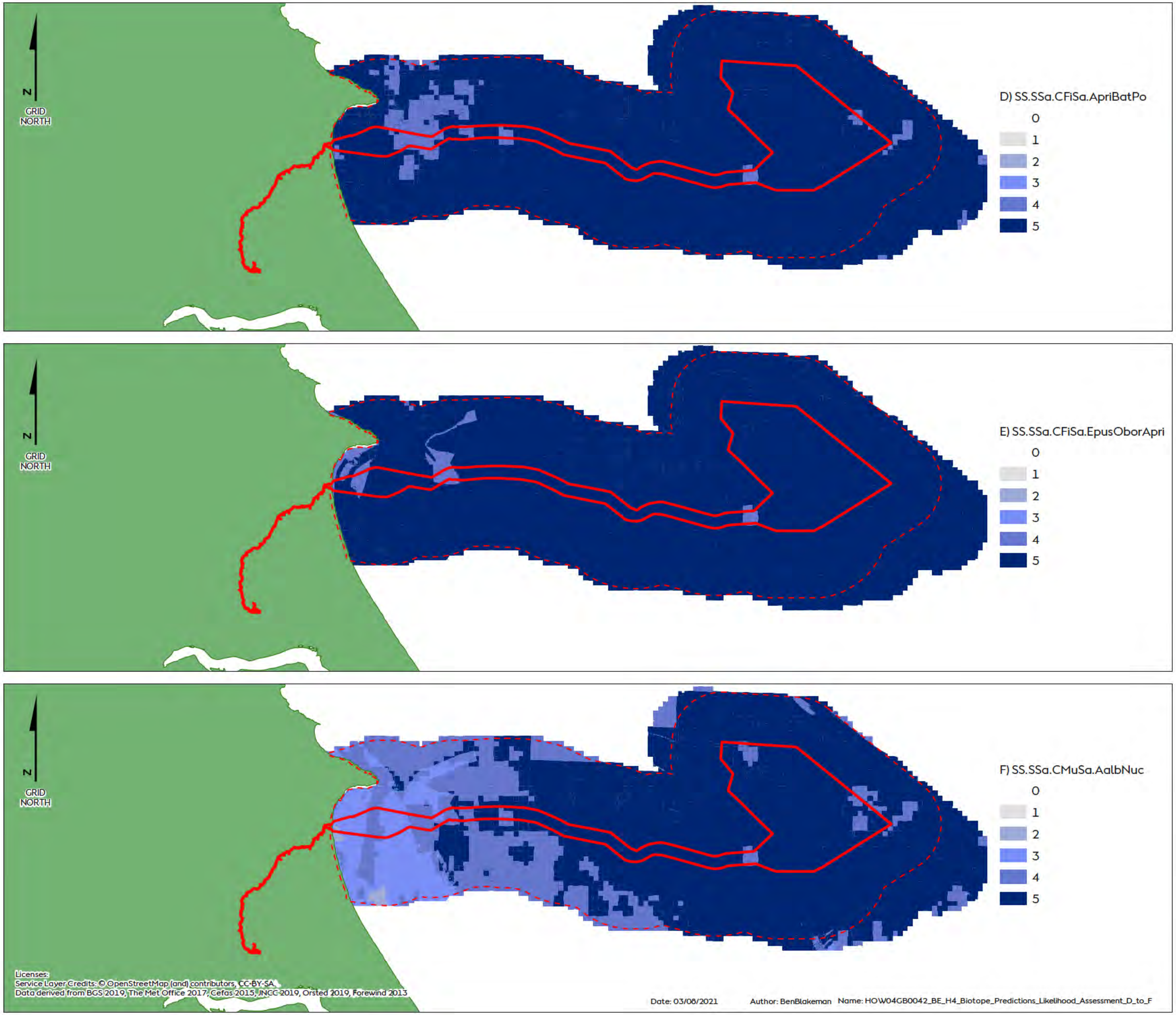
Hornsea Four

Figure 20

Hornsea Four biotope predictions: likelihood assessment (2 of 4)

Order Limits

Benthic Study Area



Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

REV	REMARK	DATE
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H4 Biotope Predictions: Likelihood Assessment

Document no: HOW04GB0042

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Checked by: AdB

Approved by: LK

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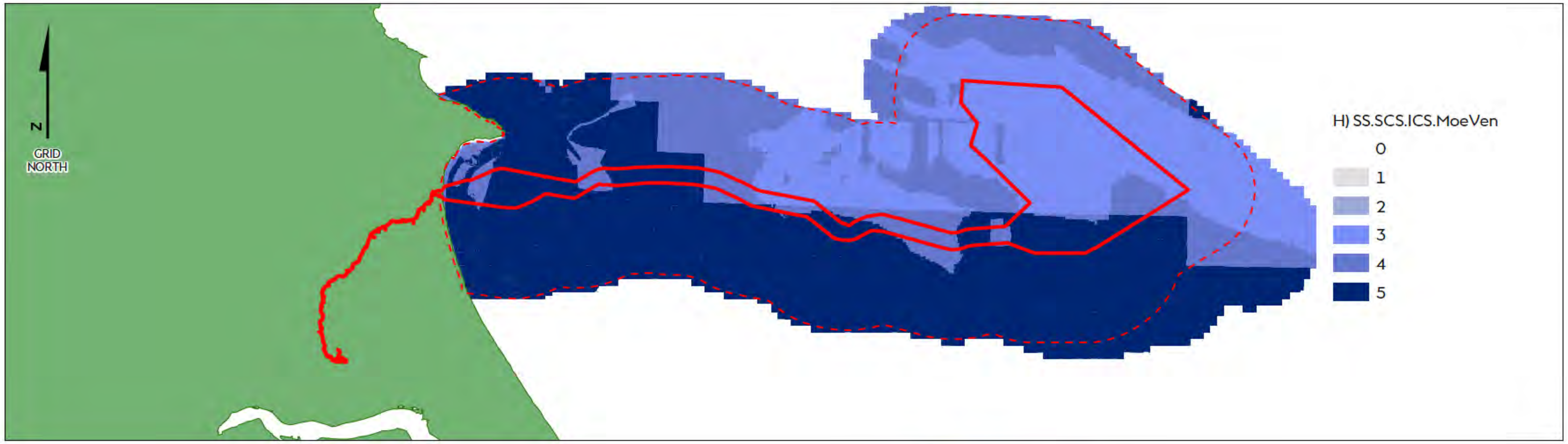

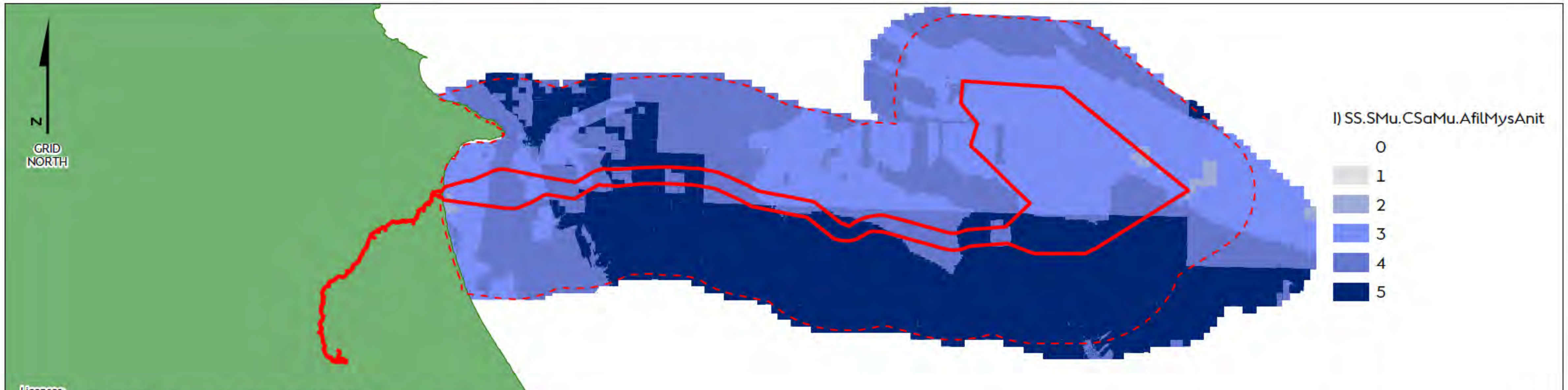

Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0183_BE_H4_Biotope_Predictions_Likelihood_Assessment_G_to_I

Hornsea Four

Figure 21

Hornsea Four biotope predictions: likelihood assessment (3 of 4)

Order Limits

Benthic Study Area

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

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H4 Biotope Predictions: Likelihood Assessment
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Hornsea Four

Figure 22

Hornsea Four biotope predictions: likelihood assessment (4 of 4)

Order Limits

Benthic Study Area

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:750,000

0 10 20 Kilometres

0 10 20 Nautical Miles

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H4 Biotope Predictions:
Likelihood Assessment
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Data derived from BGS 2019, The Met Office 2017, Cefas 2015, JNCC 2019, Orsted 2019, Forewind 2013

Date: 03/08/2021 Author: BenBlakeman Name: HOW04GB0184_BE_H4_Biotope_Predictions_Likelihood_Assessment_J_to_K

8 Nature Conservation

8.1 Features of Conservation Interest

8.1.1.1 Although individuals of the tube building worm *Sabellaria spinulosa* were identified within the benthic grab samples at five stations within the offshore ECC (ECC_17 to ECC_21), the only aggregation observed in the DDV footage was a small patch encrusting a pebble that would not itself be classified as a potential Annex I reef. Detailed review of the SSS and multibeam bathymetry datasets acquired within the Hornsea Four Order Limits (Gardline 2019; Bibby HydroMap 2019) found no evidence of the distinctive signatures which would be typically associated with the presence of biogenic reefs.

8.1.1.2 Stations closest to landfall (in water depth less than 20 m) were characterised by mobile clean sand substrates. These substrates are a sediment depository known as the sandbank feature Smithic Bank and are formed by a supply of sediment which arrives into Bridlington Bay having been brought around Flamborough Head by currents that flow north to south (Williams 2018). The sandbank feature does not form a qualifying feature of any SAC, SPA, Ramsar site or Marine Conservation Zone (MCZ). The Flamborough Head SAC N2k Standard data form states its representativity is grade D i.e. no need to establish conservation objectives or conservation measures. This is reflected in the conservation objectives for the Flamborough Head SAC – which does not include subtidal sandbanks as a qualifying feature. In terms of benthic ecology, communities found on sandbank crests are predominantly those typical of mobile sediment environments and tend to have low diversity. Troughs or areas between banks generally contain more stable gravelly sediments and support diverse infaunal and epifaunal communities. Here sediment movement is reduced and therefore the areas support an abundance of attached bryozoans, hydroids and sea anemones. The benthic and epifaunal communities typical of such features fall into the category of sublittoral sands and gravels that have been identified across the site.

8.1.1.3 As detailed in **paragraphs 5.5.3.8** *et seq.,* four discrete patches of stony reef habitat were recorded as present across a portion of the offshore ECC, although were scored as 'low' resemblance to Annex I stony reef, as per the qualifying criteria set out in regulatory guidance (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not be considered as contributing to the National Site Network unless there is strong justification. Based on these results and evidence from geophysical studies across the site (Bibby Hydro Map 2019), the area of 'Sandy gravel with boulders' encompassing stations ECC_22 and ECC_23 is expected to comprise a patchy mosaic of stony substrate surrounded by gravels and coarse sands, rather than extensive areas of unbroken stony reef. This habitat is typical of the wider region and has been recorded within several other development projects in the region including Dogger Bank A & B (Forewind 2013) and the Tolmount to Easington Pipeline (Premier Oil 2018).

8.1.1.4 As discussed previously in **paragraphs 5.5.3.5** *et seq.*, burrows were observed in the sediments throughout the Hornsea Four benthic subtidal ecology study area however, no sea pens were observed in any of the seabed imagery acquired. Application of the SACFOR abundance scale revealed scores that ranged from 'rare' to 'occasional' at Stations ENV11 and ENV19 and 'rare' to 'frequent' at Station ENV1 (which is located outside Hornsea Four Order Limits). At all other stations, SACFOR densities were not sufficient to be classified as showing similarities to a 'sea pen and burrowing megafauna communities' habitat as listed under the OSPAR (2010) list of threatened and/or declining species and habitats.

8.1.1.5 Visible fauna in seabed imagery included an individual specimen of a sand eel (*Ammodytidae*). Members of the *Ammodytes* genus (specifically *Ammodytes marinus* and *Ammodytes tobianus*) are listed as a priority species under UK Post 2010 Biodiversity Framework (JNCC and Defra 2012) and listed under the NERC Act (2006).

8.1.1.6 Within the full macrofaunal data set the presence of three juvenile ocean quahog (*Arctica islandica)*, a species of conservation importance, were recorded. A single individual was identified at Stations ENV6, ENV15 and ENV25 respectively. The identification of *A. islandica* within the fauna data set corroborates the presence of *A. islandica* individuals tentatively identified from the sieved grab samples. *A. islandica* is a long-lived species with a slow growth rate and is listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR 2008), as well as being listed under the MCZ guidance as a species feature of conservation importance (FOCI) (Natural England and JNCC 2010). Additionally, a single lesser sandeel (*Ammodytes tobianus*) was identified at Station ENV2 with a biomass of 1.8 g. *A. tobianus* is a species which is listed under Section 41 of the NERC Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as a conservation priority in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra 2012). Further consideration of sandeel is presented within **Volume A2, Chapter 3: Fish and Shellfish Ecology**.

8.1.1.7 Other than those discussed above, there was no evidence of any other potential Annex I habitats (Habitats Directive 92/43/ECC, 1992), species or other habitats listed as FOCI (Natural England and JNCC 2010). No other species or habitats listed under Section 41 of the NERC Act (2006). No additional species or habitats listed on the OSPAR (2008) list of threatened and/or declining species and habitats were recovered in the samples. No species on the International Union for Conservation of Nature (IUCN) Global Red List of threatened species (IUCN 2018).

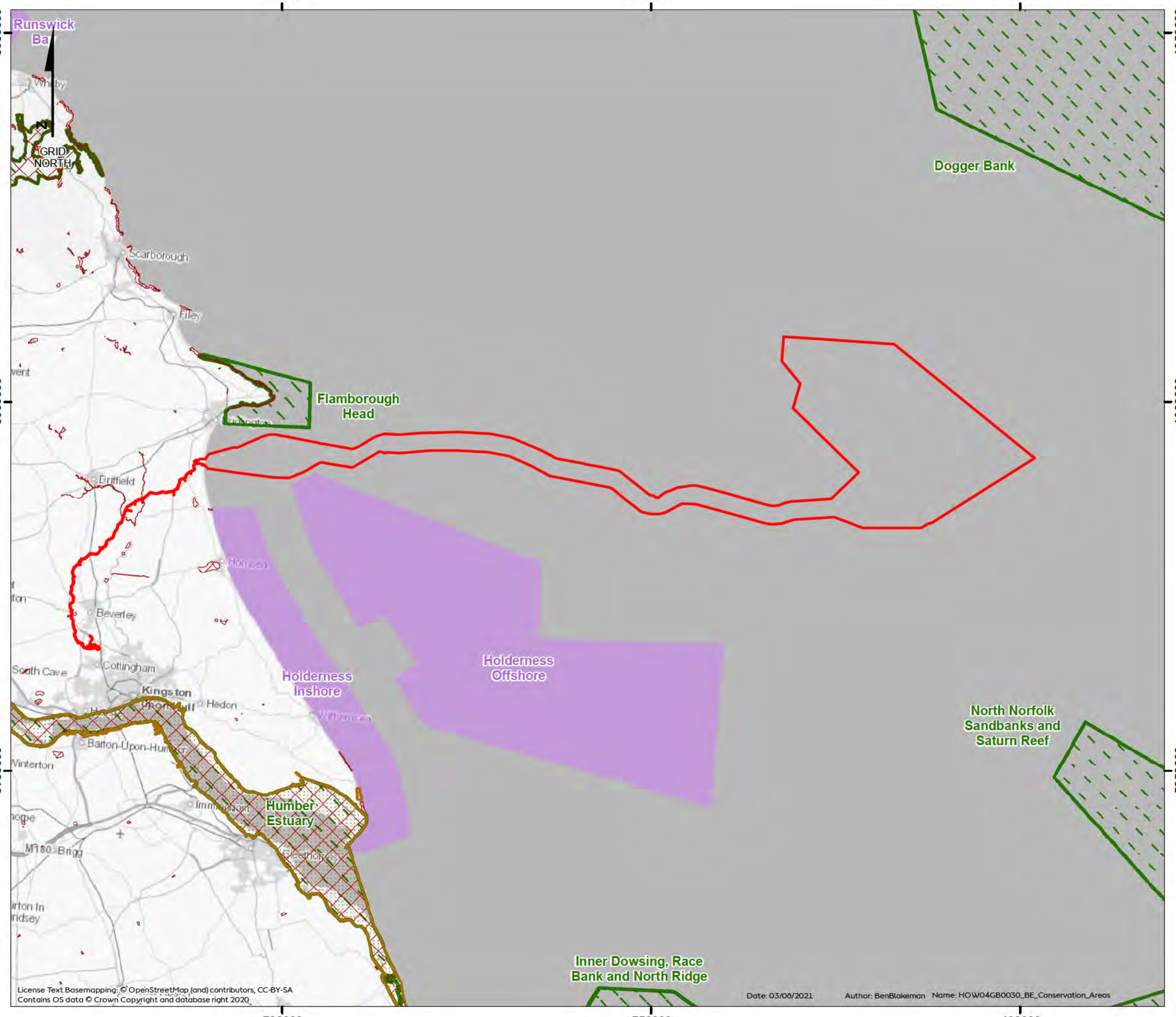
8.2 Protected Areas

8.2.1.1 The marine nature conservation designations which fall within the vicinity but out with of Hornsea Four comprise designations within the National Site Network (i.e. SACs and SPAs) and national designations (i.e. MCZs and Sites of Special Scientific Interest (SSSIs)). All designated sites were specifically routed around through the Hornsea Four route planning and site selection process. This section looks at those sites that have cited qualifying features that relate to seabed habitats and benthic ecology.

8.2.1.2 There are several other designated sites in proximity to Hornsea Four, as presented in **Figure 23**. Details of the designations, including the qualifying features relative to benthic subtidal and intertidal ecology and distance from the development area are presented in **Table 11**. A more detailed description of each site is given within this Section.

Table 11: National and international conservation designations within the vicinity but out with of Hornsea Four.

Site and Status	Qualifying features	Distance from Hornsea Four
Flamborough Head SAC	Annex I habitats: • Reefs • Vegetated sea cliffs of the Atlantic and Baltic Coasts • Submerged or partially submerged sea caves	>1 km distance from the nearshore section of the offshore ECC
Holderness Inshore MCZ	• Intertidal sand and muddy sand • Moderate energy circalittoral rock • High energy circalittoral rock • Subtidal coarse sediment • Subtidal mixed sediments • Subtidal sand • Subtidal mud • Spurn head (subtidal geological feature)	<5 km distance from the nearshore section of the offshore ECC
Holderness Offshore MCZ	• North Sea Glacial Tunnel valleys • Subtidal coarse sediment • Subtidal sand Subtidal mixed sediments • Ocean Quahog (*Arctica islandica*)	<1 km distance from the nearshore section of the offshore ECC
Flamborough Head SSSI	• Supralittoral rock	~4 km distance from the nearshore section of the offshore ECC
Humber Estuary SSSI	• Littoral sediment • Supralittoral sediment	>44 km distance from the offshore ECC



Hornsea Four

Figure 23

Hornsea Four in relation to national and international conservation areas that have seabed habitat features and benthic ecology interest

- Order Limits
- Marine Conservation Zones
- Special Area of Conservation
- Sites of Special Scientific Interest
- Ramsar

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:500,000

0 10 20 Kilometres

0 5 10 Nautical Miles

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Conservation Areas in relation to Hornsea Four

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8.2.2 Flamborough Head SAC

8.2.2.1 Flamborough Head was selected for the presence of species associated with the chalk and for the site's location at the southern limit of distribution of several northern species. It lies close to the biogeographic boundary between two North Sea waterbodies and encompasses a large area of hard and soft chalk on the east coast of England. The site covers around 14% of UK and 9% of European coastal chalk exposure, represents the most northern outcrop of chalk in the UK, and includes bedrock and boulder reefs which extend further into deeper water than at other subtidal chalk sites in the UK, giving one of the most extensive areas of sublittoral chalk in Europe. The clarity of the relatively unpolluted sea water and the hard nature of the chalk have enabled kelp *Laminaria hyperborea* forests to become established in the shallow sublittoral. The reefs to the north support a different range of species from those on the slightly softer and more sheltered south side of the headland. The site supports an unusual range of marine species and includes rich animal communities and some species that are at the southern limit of their North Sea distribution e.g. the northern alga *Ptilota plumose* (JNCC n.d. [a]).

8.2.3 Holderness Inshore MCZ

8.2.3.1 The seabed in this site is made up of rock, sand, mud and sediment. The mosaic of habitats within the site supports a diverse range of organisms including red algae, sponges and other encrusting fauna. The site also supports fish species such as European eel, dab and wrasse, as well as commercially significant crustaceans such as edible and velvet swimming crabs and lobster.

8.2.3.2 Partly above the water, the sandy beaches of intertidal sand and muddy sand are uncovered at low tide. These sandy shores may appear devoid of marine life, but are in fact home to many species, buried in the damp sand. On all but the most barren sandy shores, there will be different kinds of worms just beneath the surface. The strandline of seaweed and other debris left behind at the top of the shore by the falling tide is also home to creatures including shrimp-like sandhoppers. Muddier sands support bivalves (with their paired, hinged shells), including the common cockle, and sea snails like the laver spire shell.

8.2.3.3 The site also protects a geological feature, Spurn Head, which is in the south of the MCZ. This is a unique example of an active spit system, extending across the mouth of the Humber Estuary (DEFRA 2016).

8.2.4 Holderness Offshore MCZ

8.2.4.1 The Holderness Offshore seabed is predominantly composed of sediment habitats ranging from subtidal sand to subtidal coarse sediments and contains part of a glacial tunnel valley. The varied nature of the seabed means it supports a wide range of animals, both on and in the sediment, such as worms, bivalves, starfish and crustaceans. The site is also a spawning and nursery ground for a number of fish species including lemon sole, plaice and European sprat (DEFRA 2018).

8.2.5 Flamborough Head SSSI

8.2.5.1 The Flamborough Head SSSI is designated for notified features including aggregations of breeding birds and coastal geology features. Intertidal features are included within the broad habitats, which incorporate supralittoral rock.

8.2.6 Humber Estuary SSSI

8.2.6.1 The Humber Estuary SSSI is designated for broad habitats which include coastal habitats including littoral sediment and supralittoral sediment. Notified benthic and intertidal features include invertebrate assemblage, moderately exposed sandy shores (with polychaetes and bivalves), sheltered muddy shores (including estuarine muds), saltmarsh and wave exposed sandy shores.

9 Valued Ecological Receptors (VERs)

9.1.1.1 The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2016). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g. Annex I habitats under the Habitats Directive, OSPAR, Biodiversity Action Plan (BAP) habitats and species, habitats/species of principal importance listed under the Natural Environment and Rural Communities (NERC) Act 2006 and habitats/species listed as features of MCZs). However, only a very small proportion of marine habitats and species are afforded protection under the existing legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species. For example, some features may not have a specific conservation value in themselves but may be functionally linked to a feature of high conservation value.

9.1.1.2 Table 12 details the criteria applied to determining the ecological value of VERs within the geographic frame of reference applicable to the Hornsea Four benthic ecology study area.

Table 12: Criteria used to inform the valuation of ecological receptors in the Hornsea Four benthic and intertidal ecology study area (derived from guidance published by CIEEM (2016).

VER Value	VER Criteria used to define value
International	Internationally designated sites, or species designated under international law (i.e. Annex II species listed as features of SACs).
National	Nationally designated sites (SSSIs and NNRs (National Nature Reserve)); Species protected under national law; Annex I habitats not within an SAC boundary; UK BAP priority habitats and species that have nationally important populations within the Hornsea Four benthic ecology study area, particularly in the context of species/habitat that may be rare or threatened in the UK; and Habitats and species that are listed as conservation priorities in regional plans including MCZs and the Southern North Sea Marine Protected Area (MPA).
Regional	UK BAP priority habitats that have regionally important populations within the Hornsea Four benthic ecology study area (i.e. are locally widespread and/or abundant);

VER Value	VER Criteria used to define value
	Habitats or species that provide important prey items for other species of conservation or commercial value.
Local	Local designations; Habitats and species which are not protected under conservation legislation form a key component of the benthic ecology within the Hornsea Four benthic ecology study area.

9.1.1.3 **Table 13** presents the VERs, their conservation status and importance within the Hornsea Four benthic subtidal and intertidal ecology study area and the justification and regional importance of each receptor.

9.1.1.4 For the purposes of conducting the EIA, the biotopes present across the Hornsea Four benthic subtidal and intertidal ecology study area have been grouped into broad habitat/community types. Habitats with similar physical, biological characteristics (including species complement and richness/diversity) have been grouped together. Consideration was also given to the inherent sensitivities of different habitats in assigning the groupings presented in **Table 13**, such that habitats and species with similar vulnerability and recoverability, often because of similar broad sediment types and species complements, were grouped together.

9.1.1.5 Habitats and species of nature conservation interest have also been considered as VERs. The overall value of each VER was determined to an international, national, regional or local value and the justification presented. VERs will be used to assess impacts associated with the construction, operation and decommissioning of Hornsea Four on benthic and intertidal ecology.

Table 13: Valued ecological receptors (VERs) within the Hornsea Four benthic and intertidal ecology study area.

VER	Representative biotope	Protection status	Conservation interest	Distribution within Hornsea Four benthic and intertidal ecology study area	Importance within Hornsea Four benthic and intertidal ecology study area and justification
Coarse and mixed sediments with moderate to high infaunal diversity and scour tolerant epibenthic communities	MysThyMx, FluHyd, MedLumVen, MoeVen, PoVen	None	UK BAP priority habitat	This habitat is found within the array area and within the area of coarse sediments within the nearer shore portion of the ECC. Modelling predicted the presence across much of the study area, but predominantly to the south and inshore portion of the ECC.	Regional – although this habitat is representative of a nationally important marine habitat, the Southern North Sea is not a key geographic area.
Sandy sediments with low infaunal diversity and sparse epibenthic communities	ApriBatPo; EpusOborApri; NcirBat, FfabMag	None	UK BAP priority habitat	This habitat is likely to be located across much of the Hornsea Four Order Limits, FfabMag found within found within the offshore portion of the ECC, ApriBatPo found throughout the whole Hornsea Four Order Limits and NcirBat in the southern offshore area. Modelling predicted the presence of these habitat across much of the Hornsea Four benthic subtidal ecology study area.	Regional – UK BAP with regional distribution from outer Humber to Thames region.
Fine muddy sands with moderate species diversity, characterised by bivalves in areas of moderate to high wave exposure	AalbNuc	None	UK BAP priority habitat	This habitat was found widely spread across the array area. Modelling predicted this habitat across much of the Hornsea Four benthic subtidal ecology study area.	Regional - although this habitat is representative of a nationally important marine habitat, the Southern North Sea is not a key geographic area.
Brittlestar dominated communities in deep muddy sands	AfilMysAnit	None	UK BAP priority habitat	Brittle stars (*A. filiformis*) were found in high abundances at four stations within the Hornsea Four array. This habitat was located in the Hornsea Project One array area. Modelling predicted this habitat across the southern portion of the study area, largely outside the Hornsea Four Order Limits.	Regional – although this habitat is representative of a nationally important marine habitat, the Southern North Sea is not a key geographic area.
Sea pen and burrowing megafauna communities	SS.SMu.CFiMu.SpnMeg	None	OSPAR List of Threatened and/or Declining Species and Habitats (Region II – North	Rare habitat located across the array area. Frequent habitat located outside the array area at the most southerly sample station.	National - however, it should be noted that this habitat is widespread across the central North Sea, around the south and west coasts of Norway and around the north of the British Isles (OSPAR, 2010).

VER	Representative biotope	Protection status	Conservation interest	Distribution within Hornsea Four benthic and intertidal ecology study area	Importance within Hornsea Four benthic and intertidal ecology study area and justification
			Sea, Region III – Celtic Sea)		
Coarse littoral barren sand	LS.LSa.MoSa.BarSa	None	n/a	Across the whole intertidal ecology study area.	Local – Habitat is not protected under any conservation legislation and are found widespread around much of the UK.
Ocean quahog *Arctica islandica*	N/A	None	OSPAR List of threatened and/or declining species for the Greater North Sea (OSPAR Region II). FOCI under the Nature Conservation part (Part 5) of the Marine and Coastal Access Act (MCAA) 2009	Three individuals were found within the array area.	National – UK BAP with nationally important populations close to the Hornsea Four benthic subtidal ecology study area. Ocean quahogs are found all around and offshore from, British and Irish coasts, particularly the Southern North Sea and the English Channel
The Ross worm *Sabellaria spinulosa*	N/A	None	When in reef form: OSPAR List of threatened and/or declining species for the Greater North Sea (OSPAR Region II). FOCI under the Nature Conservation part (Part 5) of the MCAA 2009. UK BAP priority habitat	*Sabellaria spinulosa* individuals were recorded across the ECC at 6 stations but in relatively high abundances at stations ECC 18 and ECC 20. However, all evidence suggests that these stations do not represent reef habitat.	None (as there is no evidence of reef habitat).

VER	Representative biotope	Protection status	Conservation interest	Distribution within Hornsea Four benthic and intertidal ecology study area	Importance within Hornsea Four benthic and intertidal ecology study area and justification
Annex I habitat features of Flamborough Head SAC					
Subtidal chalk reefs	N/A	Annex I Habitats Directive	Annex I 'Reefs' within an SAC. UK BAP priority habitat.	The SAC does not overlap with Hornsea Four Order Limits. However, indirect impacts using a 10 km tidal excursion have been screened into the assessment on a precautionary basis. The 10 km tidal excursion from the offshore ECC overlaps with the SAC.	International – part of European designated sites (Flamborough Head SAC).
Submerged or partially submerged sea caves	N/A	Annex I Habitats Directive	Annex I within an SAC. UK BAP priority habitat.	The SAC does not overlap with Hornsea Four Order Limits. However, indirect impacts using a 10 km tidal excursion have been screened into the assessment on a precautionary basis. The 10 km tidal excursion from the offshore ECC overlaps with the SAC.	International – part of European designated sites (Flamborough Head SAC).

10 Conclusions

10.1.1.1 This technical report has satisfied the aims and the objectives of the study by providing a comprehensive characterisation in terms of the benthic subtidal and intertidal habitats, surficial sediments and seabed features across the Hornsea Four benthic subtidal and intertidal ecology study area. This data has been used to inform the EIA and ES to accompany the development application.

10.1.1.2 The benthic biotopes recorded are typical of the wider region and were characterised by seven habitat types. These largely conform to the JNCC Habitat Classifications (JNCC 2015) and the equivalent EUNIS habitat classification codes (EEA 2017), as follows:

- SS.SSa.IFiSa.NcirBat (A5.233) *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand;
- SS.SSa.IMuSa.FfabMag (A5.242) *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand;
- SS.SSa.CFiSa.EpusOborApri (A5.251) *Echinocyamus pusillus, Ophelia borealis* and *Abra prismatica* in circalittoral fine sand;
- SS.SSa.CFiSa.ApriBatPo (A5.252) *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand;
- SS.SSa.CMuSa.AalbNuc (A5.261) *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment;
- SS.SMx.CMx.MysThyMx (A5.443) *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment; and
- SS.SMX.CMx.FluHyd (A5.444) *Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment.

10.1.1.3 The biotope that characterised the intertidal area during the Phase I walkover survey along the Holderness Coast between Bridlington and Skipsea was 'coarse littoral sand' (LS.LSa.MoSa.Bar.Sa), which is typical of clean sands in areas of high hydrodynamic energy, as seen along this portion of coastline.

10.1.1.4 The predictive habitat model enabled a better understanding of the benthic subtidal ecology baseline, based on the suitability of likely biotopes that were modelled through a well-developed three-tiered process: creation of a seabed sediment model, a EUNIS Level 4 model and a biotope model.

10.1.1.5 Although individuals of *Sabellaria spinulosa* were identified within the benthic grab samples at five stations across the offshore ECC, these were not recorded in numbers that would constitute reef (Gubbay 2007) and the only aggregation observed in the DDV footage was a small patch encrusting a pebble that would not itself be classified an Annex I reef. Detailed review of the SSS and multibeam bathymetry datasets found no evidence of the distinctive signatures which would be typically associated with the presence of biogenic reefs.

10.1.1.6 Four discrete patches of stony reef habitat were recorded as present across a portion of the offshore ECC, although were scored as 'low' resemblance to Annex I stony reef, as per the qualifying criteria set out in regulatory guidance (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*When determining* *whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not be considered as contributing to the National Site Network unless there is strong justification. Based on these results and evidence from geophysical studies across the site (Bibby Hydro Map 2019), the area of 'Sandy gravel with boulders' encompassing stations ECC_22 and ECC_23 is expected to comprise a patchy mosaic of stony substrate surrounded by gravels and coarse sands, rather than extensive areas of unbroken stony reef. This habitat is typical of the wider region and has been recorded within several other development projects in the region including Dogger Bank A & B (Forewind 2013) and the Tolmount to Easington Pipeline (Premier Oil 2018).

10.1.1.7 Infaunal burrows were observed in the sediments throughout the Hornsea Four benthic subtidal Order Limits however, no sea pens were observed in any of the seabed imagery acquired. Application of the SACFOR abundance scale revealed scores that ranged from 'rare' to 'occasional' at two stations in the array and 'rare' to 'frequent' at one station located outside the Hornsea Four Order Limits. At all other stations, SACFOR densities were not sufficient to be classified as showing similarities to a 'sea pen and burrowing megafauna communities' habitat as listed under the OSPAR (2010) list of threatened and/or declining species and habitats. However, it should be noted that this habitat is widespread across the central North Sea, around the south and west coasts of Norway and around the north of the British Isles (OSPAR 2010).

10.1.1.8 Visible fauna in seabed imagery included an individual specimen of a sand eel (*Ammodytidae*). Members of the *Ammodytes* genus (specifically *Ammodytes marinus* and *Ammodytes tobianus*) are listed as a priority species under UK Post 2010 Biodiversity Framework (JNCC and Defra 2012) and listed under the NERC Act (2006).

10.1.1.9 Within the full macrofaunal data set the presence of three juvenile ocean quahog (*Arctica islandica)*, a species of conservation importance, were recorded. *A. islandica* is listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR 2008), as well as being listed under the MCZ guidance as a species FOCI (Natural England and JNCC, 2010). Additionally, a single lesser sandeel (*Ammodytes tobianus*) was identified. *A. tobianus* is a species which is listed under Section 41 of the NERC Act (2006) that were deemed to require action in the UK BAP and continue to be regarded as a conservation priority in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra 2012).

10.1.1.10 Evidence acquired during the benthic characterisation did not reveal the presence of any other potential Annex I habitats (as defined under the Council Directive 92/43/EEC) or other protected habitats/species within the Hornsea Four benthic subtidal ecology study area.

11 Final Recommendation

11.1.1.1 No benthic ecology constraints to development have been identified as a result of this characterisation of benthic resources across the Hornsea Four benthic subtidal and intertidal ecology study area, although this is subject to a detailed assessment within the

ES (**Volume A2, Chapter 2: Benthic and Intertidal Ecology**). Furthermore, as detailed within **Volume A4, Annex 5.2 Commitments Register**, a geophysical survey will be undertaken during pre-construction site investigations which in turn will inform engineering work and any micro-siting that might be required to avoid protected features.

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Appendix A: Hornsea Four Offshore Wind Farm Array Area, Habitat Classification Report (Gardline 2019)

Survey Report for
Ørsted Wind Power A/S

Project:
Hornsea 4 Offshore Wind Farm

Description:
Habitat Classification Report

Survey Date:
Survey: 14-Sep-2018 to 18-Sep-2018
Environmental: 14-Sep-2018 to 18-Sep-2018

Project Number:
11210

Client Reference:
Lot 6 GP1a Array Area

Report Status:
Final

REPORT AUTHORISATION AND DISTRIBUTION

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	Surveying	R Grice
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Distribution

No of copies 1

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For attention of

Russell Venning / Elizabeth Dewing Andrews

EXECUTIVE SUMMARY

During September 2018, Gardline completed an environmental habitat classification survey on behalf of Ørsted Wind Power AS (Ørsted) across the Hornsea Project Four Offshore Wind Farm (HOW4) location. The proposed HOW4 survey area was located within the Southern North Sea (SNS) across United Kingdom Continental Shelf (UKCS) Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2 and 48/3. Survey operations, which were combined with a geophysical survey, were undertaken onboard the Gardline Motor Vessel (MV) *Ocean Endeavour* between the 16-Aug-2018 and 18-Sep-2018, with all environmental survey work conducted between 14-Sep-2018 and 18-Sep-2018.

The overall aim of the habitat classification survey, as defined by the SOW (Ørsted, 2017) was to ground truth the seabed sediment classification derived from the geophysical data and to provide benthic ecology information to support the consenting process. Additionally, the survey area was monitored for the following protected habitats and species:

- Habitats, such as *Sabellaria spinulosa* reefs or pockmarks containing methane-derived authigenic carbonate (MDAC), listed under Annex I of the Habitats Directive (1992), as implemented by the Conservation of Offshore Marine Habitats and Species Regulations (2017);
- Habitat and/or species listed as features of conservation importance (FOCI) and broadscale habitats, defined in relation to the Marine Conservation Zones (MCZ) network (Natural England and Joint Nature Conservation Committee, 2010) as required under the Marine and Coastal Access Act (Marine and Coastal Access Act, 2009);
- Priority habitats or species in England, listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra, 2012); and
- Species or habitats on the OSPAR (2008) list of threatened and/or declining species and habitats; and
- Species on the IUCN Global Red List of threatened species (IUCN, 2018)

A total of 21 co-located camera and grab stations were pre-selected at the Gardline office and confirmed by the client prior to environmental survey work commencing. All target locations were investigated as intended with a drop-down camera and sampled with 0.1m^2 grab with samples acquired for faunal and physico-chemical analyses. At each station, one sample was sub-sampled for analysis of particle size, hydrocarbons, metals and organics and was frozen prior to analysis. A second sample was screened through a 1mm mesh sieve to provide benthic faunal sample which was preserved in buffered formalin.

Natural water depths ranged from 25m lowest astronomical tide (LAT) in the south of the HOW4 survey area to 61m LAT in the north of the HOW4 survey area. Sand megaripples were the most frequently observed bedform across the HOW4 survey area while sand waves were also common. The megaripples had wavelengths of up to 15m and, where sand waves occur, were often superimposed upon them. The prevalence of these flow driven bedforms suggested that sand was the predominant seabed sediment, a conclusion which was supported by the interpretations from seabed imagery and grab samples as well as the interpreted side scan sonar mosaic data with reference to the results of the PSA analysis.

Seabed imagery and video footage supported the initial interpretation by geophysical data of seabed sediments. Sediments were interpreted to predominantly comprise sands and ranged between gravely sand and muddy sand.

Visible fauna observed within the seabed imagery was generally sparse and included: Annelida (*Ditrupa*, *Echiura*, Polychaeta, Serpulidae, Terebellidae), Arthropoda (Brachyura, Paguridae), Chordata (Actinopterygii, Ammodytidae, Callionymidae, Pleuronectiformes, Triglidae, Scorpaeniformes, Scyliorhinidae), Cnidaria (Actiniaria, *Alcyonium digitatum*, *Ceriantharia* sp., *Urticina* sp., Hydrozoa), Echinodermata (Asteroidea including, *Asterias rubens*, *Astropectin irregularis* Ophiuoridea), Mollusca (Bivalvia, Naticidae, Scaphopoda, Sepiolidae). Small burrows and faunal tubes were observed across the HOW4 survey area, particularly where finer sediment was observed.

Although no sea pens (Pennatulacea) were observed within the seabed imagery, the presence of burrows within the imagery meant that an assessment for 'sea pen and burrowing megafauna communities' habitats, as defined by OSPAR (2010) was conducted. The assessment referred to the Marine Nature Conservation (MNCR) SACFOR abundance scale (JNCC, 2013b) and was conducted on the burrow density data. Burrow density was considered 'rare' at all stations with the exception of Stations ENV11 and ENV19 which ranged from 'rare' to 'occasional' and Station ENV1 which ranged between 'rare' and 'frequent'. Therefore, burrow densities at station ENV1, which encompassed the 'common' score presented some similarity to a 'sea pen and burrowing megafauna community' as listed under the OSPAR (2008) list of threatened and/or declining species and habitats. Despite the classification as a threatened and/or declining habitat (OSPAR, 2008), this habitat is widespread in the North Sea (OSPAR, 2010).

A single individual sand eel (Ammodytidae) was observed within a seabed sample obtained at Station ENV2. Additionally, the presence of Ammodytidae was noted within the seabed imagery. The lesser sand eel (*Ammodytes tobianus*) and Raitt's sand eel (*Ammodytes marinus*) are species, listed under the NERC Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra, 2012).

Shells, possibly belonging to the ocean quahog (*Arcitca islandica*) were present in sediment samples recovered from Stations ENV24 and ENV25. *A. islandica* is a species listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008). In addition, *A. islandica* is species listed as a FOCI, defined in relation to the Marine Conservation Zones (MCZ) network (Natural England and Joint Nature Conservation Committee, 2010); however this species is commonly found within this area of the North Sea (Oil and Gas U.K., 2010).

Other than those mentioned above, there was no further evidence within the seabed imagery of any Annex I habitats (1992), species or habitats listed as FOCI (Natural England and Joint Nature Conservation Committee, 2010) or species or habitats listed under the NERC Act (2006). No additional species or habitats listed on the OSPAR (2008) list of threatened and/or declining species and habitats and no species on the IUCN Global Red List of threatened species (IUCN, 2018).

Particle size analysis (PSA) generally supported the initial interpretation of the geophysical survey data and observations made on the seabed imagery and grab samples. Mean particle diameter at stations across the HOW4 survey area varied between 245µm at Station ENV14 and 648µm at ENV 17 whilst the Wentworth classification of the mean grain size (Folk & Ward, 1957) generally presented as medium to coarse sand across the HOW4 survey area. The **sand** (≥63µm to <2mm) fraction of the sediment comprised the majority of all samples across the survey area and presented a range of modified folk classification ranging from muddy sand to gravelly sand, all of which were sand dominated classifications.

Concentrations of total organic carbon (TOC) across the HOW4 survey area ranged from between 0.05% at Station ENV23 and 0.29% at Station ENV9. TOC is known to vary depending on sediment particle size, as such, the variation observed within the TOC values were not unexpected due to the variation in gravel and fines content observed within the particle size data.

Results of the chemical analyses revealed that hydrocarbon concentrations across the majority of the HOW4 survey area were within the expected UKOOA (2001) background concentrations. Some elevation in total hydrocarbon (THC) concentrations was noted nearby existing infrastructure which was expected. Gas chromatography traces at all stations presented a consistent pattern of low level low molecular weight (LMW) and low level high molecular weight (HMW) resolved n-alkanes with minimal unresolved complex mixture (UCM) in the LMW range of the chromatogram. GC traces were typical of background levels of hydrocarbon inputs in areas of historical oil and gas exploration such as the North Sea (McDougall, 2000). Hydrocarbons in the weight range nC_{24} to nC_{36} commonly originate from terrestrial plant sources (Harborne, 1999), or may represent the residue of highly weathered and biodegraded petrogenic material including hydrocarbons from natural seeps, shipping discharges and oil and gas exploration and extraction (Bouloubassi *et al*., 2001).

Total 2-6 ring polycyclic aromatic hydrocarbons (PAH) ranged between 0.013µg g^{-1} at Station ENV18 and 0.248µg g^{-1} at Station ENV17. The 2-3 ring naphthalene, phenanthrene and dibenzothiophene (NPD) concentrations recorded values between 0.007µg g^{-1} and 0.097µg g^{-1}. Total PAH and NPD PAH values, once normalised to 1% TOC, were well below the Effects Range Low (ERL) and the Effects Range Median (ERM) values (Long *et al*., 1995) indicating that toxic effects to fauna were unlikely. In addition, PAH concentrations were below the apparent effect threshold (AET;Buchman, 2008) further suggesting that adverse biological impacts would be unlikely. Information derived from molecular weight PAH indices on the origin of US EPA 16 PAHs presented a mix of pyrolytic and petrogenc inputs from the range of indices calculated. These conclusions were consistent with the wide area surveyed and the range of sandy sediment types observed within the HOW4 survey area.

Concentrations of metals were generally higher at Stations ENV16 and ENV17 and lower at Stations ENV1 and ENV23. However, all metals concentrations, when compared to Buchman (2008) AETs, were below their respective AETs indicating that toxicological impacts on the fauna were unlikely.

Concentrations of the organotin monobutyltin (MBT) was recorded as 1ng g^{-1} at Stations ENV10, ENV14, ENV15, ENV17, ENV19, ENV21 and ENV25. All other values for MBT, dibutyltin (DBT) and tributyltin (TBT) were below their respective LODs across the HOW4 survey area, suggesting that no toxicological effects could be expected.

A total of 2,678 individuals representing 163 taxa were recorded from the 21 macrofaunal samples collected across the HOW4 survey area. A total of 54 taxa were endemic to a single station, with 34 of those taxa represented by a single individual suggesting a relatively sparse macrofaunal community.

Across the HOW4 survey area the adult faunal community was generally dominated by a combination of Mollusca (n=755), Annelida (Polychaeta; n=723) and Echinodermata (n=710) contributing 30%, 28% and 28% of the total adult individuals observed, respectively. The Mollusca group was dominated by the bivalve *Abra* which contributed 18% of total individuals within the adult data set whilst the Echinodermata group was dominated by the brittle star *Amphiura filiformis* which contributed 20% of the total individuals observed across the HOW4 survey area. In contrast, the Polychaeta group contributed 38% of the total taxa present across the survey area suggesting a relatively more even faunal distribution than the other two dominant taxa groups.

Variation in the total individual abundance of adult fauna across the HOW4 survey area, which ranged from 46 individuals at Station ENV18 to 322 individuals at Station ENV19, attributed to localised variations in abundance values of the bivalve *Abra* and the brittle star *A. filiformis*.

Biomass data were equally variable and tended to be dominated by single large specimens of Arthropoda, Mollusca and Echinodermata particularly at stations which recorded a total biomass greater than 3g.

Within the Macrofaunal data set, a total of three juveniles of the ocean quahog *A. islandica* were recorded across three of the twenty-one stations. The presence of shells possibly belonging to *A. islandica* (Ocean Quahog) individuals were also observed within the grab samples at Stations ENV24 and ENV25. *A. islandica* is on the OSPAR (2008) list of threatened and/or declining species and habitats, as well as being listed under the Marine Conservation Zone (MCZ) guidance as a species feature of conservation importance and priority marine feature (Natural England and Joint Nature Conservation Committee, 2010; Marine Scotland Act, 2010; Marine and Coastal Access Act, 2009). Additionally, a single lesser sand eel (*A. tobianus*) was identified at Station ENV2 with a biomass of 1.805g. *A. tobianus* is a species which is listed under Section 41 of the NERC Act (2006).

Faunal data, in conjunction with physico-chemical data, enabled some of the observed habitats to be resolved to levels 4 and 5 EUNIS classifications. The EUNIS habitat codes identified across the survey area were: A5.14, A5.233, A5.25, A5.251, A5.252, A5.261, A5.44 and A5.443. Sediment characteristics at Stations ENV 17 and EV19 were similar to those described in the EUNIS code A5.443. In addition, macrofaunal communities at these stations were dominated by the brittle star *A. filiformis*. It was noted in the habitat classification for A5.443 that this brittle star species is known to be abundant at some previous sites where this classification has been used (EEA, 2018). The EUNIS classification A5.251 has been used to classify Stations ENV4, ENV6 to ENV15 and ENV20. These stations all presented similar sediment profiles of sand with varying small quantities of fine material and were all dominated by the bivalve mollusc *Abra*.

Overall, the EUNIS classifications support the conclusion that the habitat across the HOW4 survey area varied in accordance with the heterogenous sandy sediments encountered. The varying gravel and fines components and their effects on the faunal community were noted as an influence on final EUNIS classifications.

Report volumes are as follows:

Report	Job No.
Hornsea 4 Offshore Wind Farm GP1A Survey Acquisition Report	11210.1
Hornsea 4 Offshore Wind Farm GP1A Survey Processing and Interpretation Report	11210.2
Hornsea 4 Offshore Wind Farm Habitat Classification Report	11210.3

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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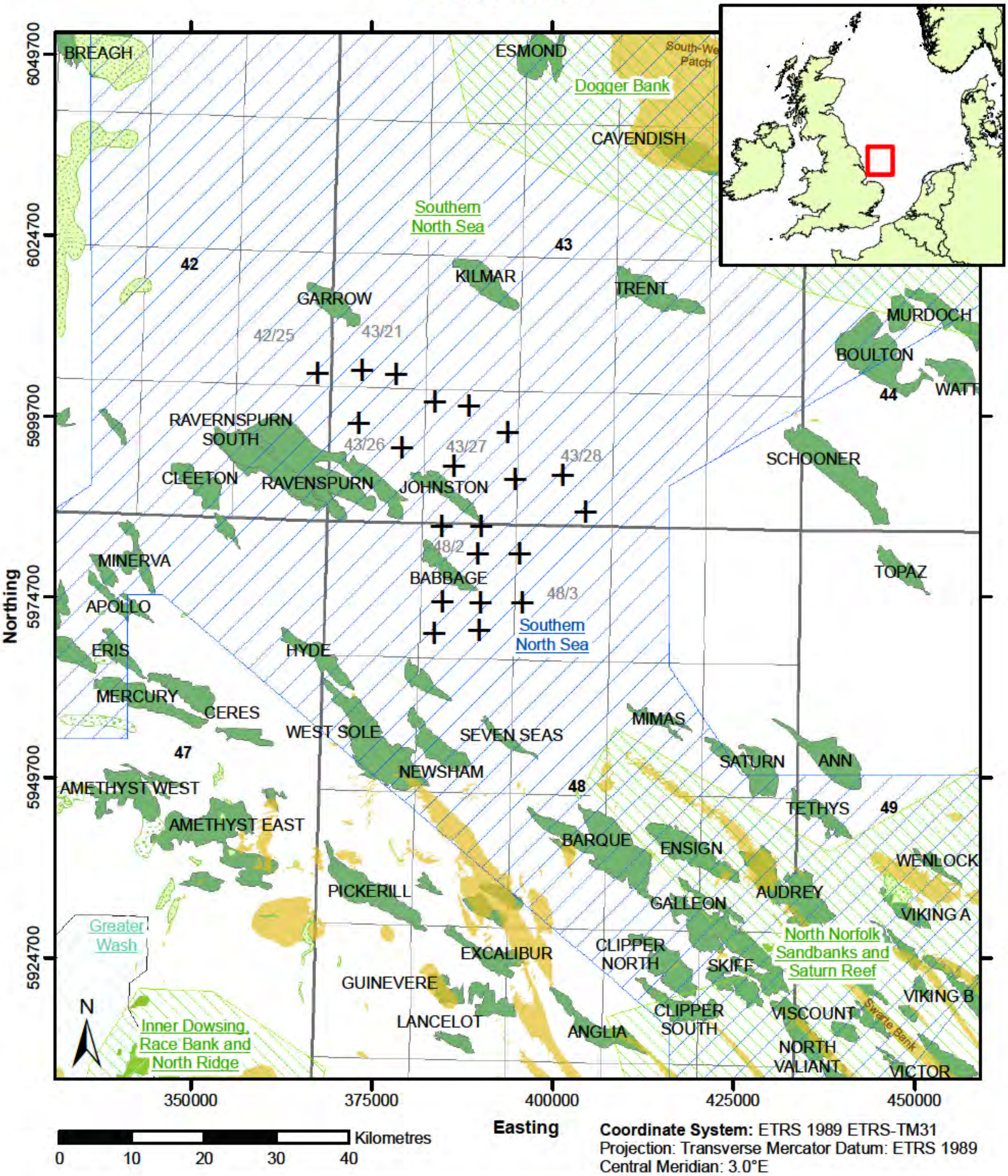
LOCATION MAP



Coordinate System: ETRS 1989 ETRS-TM31
Projection: Transverse Mercator Datum: ETRS 1989
Central Meridian: 3.0°E

Key

- Environmental Target Stations
- Areas of potential Annex 1 sandbank habitat (Areas of sandy sediments (according to the BGS) In water depth 20m <LAT, (Johnston, *et al.*, 2002)
- Gas Field (UKOGD, 2018)

Offshore Marine Protected Areas (JNCC, 2018)

- Special Areas of Conservation (SAC)
- Special Protected Areas (SPA)
- cSAC/ Sites of Community Importance (SCI)

Potential Reefs (JNCC, 2013)

- Bedrock
- Stony
- Biogenic

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GLOSSARY OF TERMS AND ABBREVIATIONS

AET	Apparent Effects Threshold
Aliphatic	An organic compound having open-chain structure (see Alkane)
Alkane	Any of a series of open-chain, saturated hydrocarbons C_nH_{2n+2} (*e.g.* methane, ethane)
Aqua Regia	A mixture of nitric and hydrofluoric acids
BAC	Background Assessment Criteria
BC	Background Concentration(s)
Benthic	Relating to the seabed
Biogenic	Produced by living organisms
BSI	British Standards Institute
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CHEM	Physico-Chemical Sample
Clay	Sediment grains <3.9µm in diameter
CM	Central Meridian
CPI	Carbon Preference Index
CPT	Cone Penetrometer Testing
CRM	Certified Reference Material
DBT	Dibutyltin
DCM	Dichloromethane
DDC	Drop Down Camera System
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential Global Positioning Service
EEA	European Environment Agency
ERL	Effects Range Low
ERM	Effects Range Medium
ETRS	European Terrestrial Reference System
EUNIS	European Union Nature Identification System
Fines	Sediment grains <63µm in diameter (same as Mud)
FOCI	Feature of Conservational Interest
GC	Gas Chromatography
GC-FID	Gas Chromatography Flame Ionisation Detection
GC-MS	Gas Chromatography Mass Spectrometry
Gravel	Sediment grains >2mm in diameter
HDD	Portable Hard Disk Drive
HMW	High Molecular Weight
HOW4	Hornsea Project Four Offshore Wind Farm
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
IDA	Industrial Denatured Alcohol
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature and Conservation Committee
LAT	Lowest Astronomical Tide
LMW	Low Molecular Weight
LOD	Limit of Detection
Macrofauna	Organisms that are normally larger than the mesh size of the sieve used. In this case 1mm.
MBES	Multi-beam Echo Sounder
MBT	Monobutyltin
MCZ	Marine Conservation Zone
MF	Macrofauna Sample
MNCR	Marine Nature Conservation Review
Mud	Sediment grains <63µm (includes Silt and Clay)
MV	Motor Vessel
NDIR	Non-dispersive infrared
NERC	Natural Environment and Rural Communities
NMBAQC	National Marine Biological Association Quality Control
NPD	Naphthalenes, phenanthrenes and dibenzothiophenes
OGA	Oil and Gas Authority
Ørsted	Ørsted Wind Power AS
MV	Motor Vessel
OSPAR	Oslo and Paris convention
PAH	Polycyclic aromatic hydrocarbon(s)
Petrogenic	Relating to unburned petroleum products
Ph	Phytane
Pr	Pristane
PRIMER	A statistical analysis program - Plymouth Routines in Multivariate Research
PSA/PSD	Particle Size Analysis/ Particle Size Distribution
Pyrogenic	Produced under conditions involving intense heat (see pyrolytic)
Pyrolytic	Produced under conditions involving intense heat (see pyrogenic)
QC	Quality Control
SAC	Special Area of Conservation
SACFOR	JNCC (2013b) density scale classification: Superabundant, abundant, common, frequent, occasional and rare
Sand	Sediment grains >63µm and <2mm in diameter
SBES	Single Beam Echo Sounder
SBP	Sub Bottom Profiler
SCI	Site of Community Importance
SEI	Significant Environmental Impact
SD	Standard Deviation
Silt	Sediment grains >3.9µm and <63µm in diameter
SNS	Southern North Sea
Sorting	Measure of the range of grain sizes in a sediment sample
SOW	Scope of Work
SSS	Sidescan Sonar
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
TBT	Tributyltin
UCM	Unresolved Complex Mixture
UHRS	Ultra-High resolution seismic
UKAS	United Kingdom Accreditation Service
UKCS	United Kingdom Continental Shelf
UKOGD	United Kingdom Oil and Gas Data (formerly UKDEAL)
USBL	Ultra Short Base Line
UTM	Universal Transverse Mercator

1 PROJECT SUMMARY

1.1 Scope of Work

During September 2018, Gardline completed an environmental habitat classification survey on behalf of Ørsted Wind Power A/S (Ørsted) across the Hornsea Project Four Offshore Wind Farm (HOW4) location located within the southern North Sea (SNS) across United Kingdom Continental Shelf (UKCS) Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2 and 48/3. This survey was coupled with a geophysical survey across the HOW4 area which was conducted between 16-Aug-2018 and 18-Sep-2018. The geophysical survey comprised a seabed and sub-seabed survey of the Hornsea 4 Offshore Wind Farm, whilst the habitat classification survey comprised the collection of seabed imagery and seabed sediment samples across the HOW4 survey area. The geophysical survey report is available as a separate report (Gardline, 2018a) and summarised where relevant in the current report. Environmental survey operations were undertaken onboard the Gardline motor vessel (MV) *Ocean Endeavour* between the 14-Sep-2018 and 18-Sep-2018.

The aim of the geophysical survey as defined by the scope of work (SOW; Ørsted, 2017) was to provide information to aid in the turbine foundation concept and positioning; fulfil archaeological and ecological consenting requirements; plan geotechnical investigations and to confirm that the geotechnical works will avoid UXO, shallow hazards and sensitive biological resources. The objectives of the survey were to:

- Provide accurate bathymetry
- Provide seabed sediment classification
- Map seabed morphology
- Create a shallow seismic stratigraphic and structural model (<70m below seabed)
- Provide information on ferromagnetic objects
- Provide information on archaeological features
- Provide information on geo-hazards

The overall aim of the habitat classification survey, as defined by the SOW (Ørsted, 2017) was to ground truth the seabed sediment classification derived from the geophysical data and to provide benthic ecology information to support the consenting process. Additionally, the survey area was monitored for the following protected habitats and species:

- Habitats, such as *Sabellaria spinulosa* reefs or pockmarks containing methane-derived authigenic carbonate (MDAC), listed under Annex I of the Habitats Directive (1992), as implemented by the Conservation of Offshore Marine Habitats and Species Regulations (2017);
- Habitat and/or species listed as features of conservation importance (FOCI) and broadscale habitats, defined in relation to the Marine Conservation Zones (MCZ) network (Natural England and Joint Nature Conservation Committee, 2010) as required under the Marine and Coastal Access Act (Marine and Coastal Access Act, 2009);
- Priority habitats or species in England, listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra, 2012); and
- Species or habitats on the OSPAR (2008) list of threatened and/or declining species and habitats; and
- Species on the IUCN Global Red List of threatened species (IUCN, 2018)

The geophysical SOW requirements were achieved by using a single- and multi-beam echo sounder (SBES and MBES), side scan sonar (SSS), magnetometer, and a sub-bottom profiler (SBP); specifically, a pinger and sparker (ultra-high resolution seismic; UHRS) spread. The environmental survey component utilised a shallow water camera system for seabed imagery acquisition and a 0.1m^2 Hamon grab to obtain seabed sediment samples across the survey area.

All positional information in the current is referenced to GRS 1980 Ellipsoid, European Terrestrial Reference System (ETRS) 1989. All grid coordinates are projected using Universal Transverse Mercator (UTM) Projection, Grid Zone 31 N, Central Meridian (CM) 3° East.

1.2 Environmental Survey Strategy

In total 21 co-located camera and grab stations were pre-selected at the Gardline office and confirmed by the client prior to environmental survey work commencing. These stations were systematically selected in a grid pattern to cover the entirety of the HOW4 survey area. Individual stations were then moved within this in order to target the range of different sediment types and depths observed from the SSS and bathymetry data obtained during the geophysical swing of the survey.

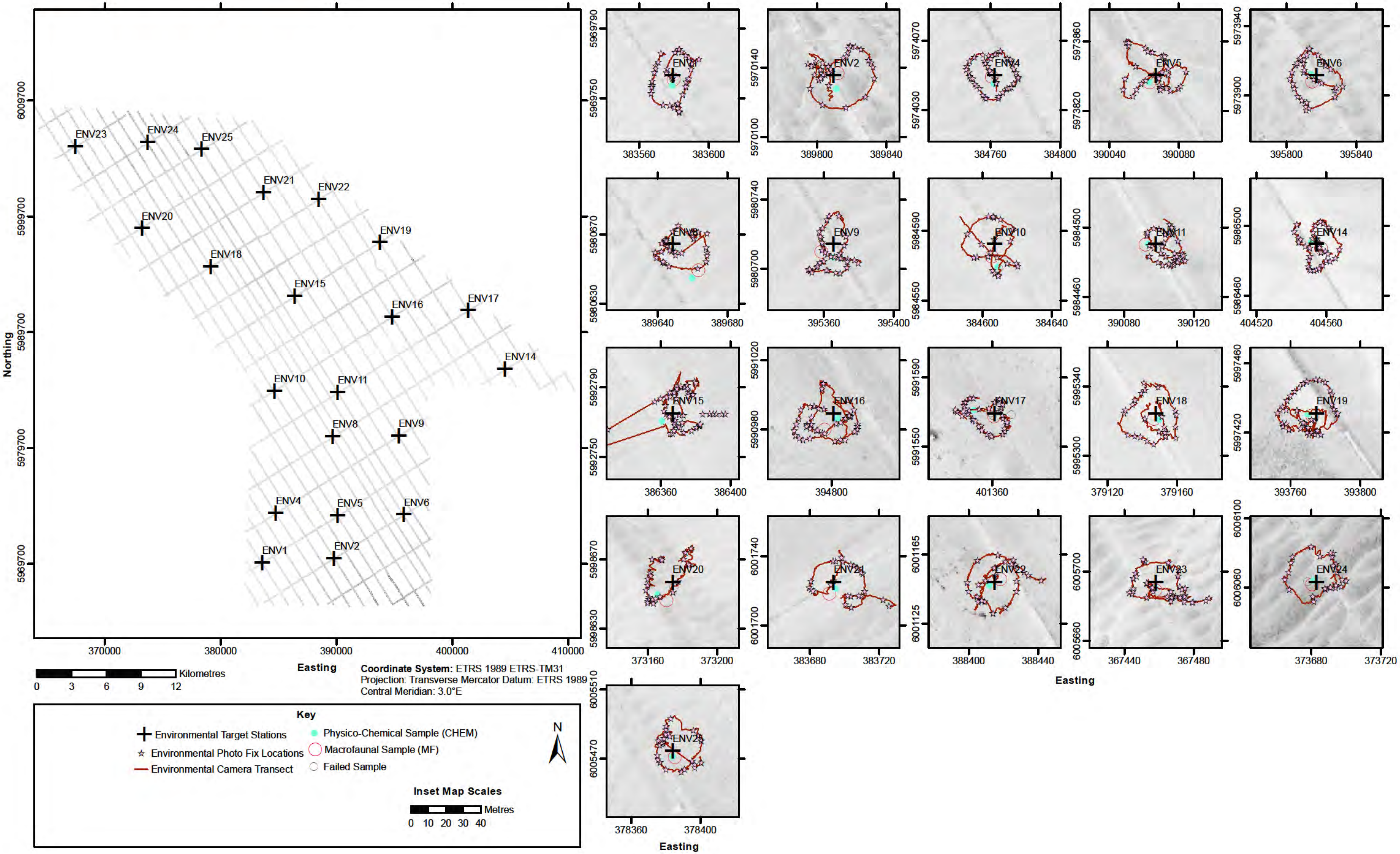
All target locations were investigated with a drop-down shallow-water camera systemin order to provide ground truthing prior to sampling with a 0.1m^2 Mini-Hamon grab, with samples acquired for faunal and physico-chemical analyses. At all stations, two sediment samples were collected; one sample (designated CHEM) was sub-sampled for analysis of particle size (PSA), hydrocarbons, metals and organics and was frozen until analysed. The second grab sample designated macrofauna (MF) was screened onboard through a 1mm mesh sieve to provide benthic faunal samples which were preserved in buffered formalin. The PSA, organics, hydrocarbons and metals samples along with the MF sample were sent to their respective analytical laboratories for analysis. Details of the target locations and samples collected at each station are summarised in Table 1.1, together with the selection rationale and details of samples acquired at each station.
Target and actual locations, the latter of which might be slightly offset from the former, are presented in Figure 1.1, and in the Surveyor's log sheets in Appendix A.

Table 1.1 Summary of Environmental Sampling Positions and Samples Acquired

Station	Target Rationale	Depth (m LAT)[1]	Easting[2]	Northing[2]	Camera	Acceptable Grab Sample	Grab Samples Acquired[3]				
								Sub Samples			
							Fauna	Particle Size	Metals	Hydrocarbons	Spare[4]
ENV1	Lower reflectivity sand waves	35	383579	5969763	Y	2	1	1	1	1	2
ENV2	Variable reflectivity Sand waves	33	389810	5970135	Y	2	1	1	1	1	2
ENV4	Lower reflectivity sand waves	36	384762	5974050	Y	2	1	1	1	1	2
ENV5	Lower reflectivity sand waves	38	390067	5973840	Y	2	1	1	1	1	2
ENV6	Lower reflectivity sand waves	38	395817	5973911	Y	2	1	1	1	1	2
ENV8	Lower reflectivity sand waves	41	389649	5980664	Y	2	1	1	1	1	2
ENV9	Lower reflectivity sand waves	43	395365	5980714	Y	2	1	1	1	1	2
ENV10	Lower reflectivity seabed	43	384607	5984582	Y	2	1	1	1	1	2
ENV11	Lower reflectivity seabed	42	390098	5984490	Y	2	1	1	1	1	2
ENV14	Lower reflectivity seabed	42	404555	5986490	Y	2	1	1	1	1	2
ENV15	Lower reflectivity seabed	51	386367	5992775	Y	2	1	1	1	1	2
ENV16	Area of variable moderate reflectivity	48	394801	5990989	Y	2	1	1	1	1	2
ENV17	Area of variable moderate reflectivity	50	401361	5991569	Y	2	1	1	1	1	2
ENV18	Boundary	46	379148	5995324	Y	2	1	1	1	1	2
ENV19	Area of variable moderate reflectivity	57	393775	5997431	Y	2	1	1	1	1	2
ENV20	Lower reflectivity sand waves	47	373174	5998657	Y	2	1	1	1	1	2
ENV21	Lower reflectivity sand waves	60	383694	6001725	Y	2	1	1	1	1	2
ENV22	Area of variable moderate reflectivity	59	388415	6001149	Y	2	1	1	1	1	2
ENV23	Variable reflectivity sand waves	58	367458	6005694	Y	2	1	1	1	1	2
ENV24	Variable reflectivity sand waves	56	373683	6006063	Y	2	1	1	1	1	2
ENV25	Lower reflectivity sand waves	58	378384	6005474	Y	2	1	1	1	1	2

1 CHEM sample depth corrected to lowest astronomical tide (LAT)
2 Environmental target locations. Actual sampling positions for each individual grab sample are detailed in Appendix A.
3 One macrofaunal samples (MF) hand sieved through 1mm and one physico-chemistry sample (CHEM).
4 One spare sub-sample was stored in a double lined zip lock bag and available for analysis of PSA or Metals analysis and one spare sub-sample was stored in a 250ml aluminium tin and available for hydrocarbons analysis.

Figure 1.1 Target and Actual Sampling Locations



1.3 Background Habitat Information

1.3.1 Overview

This section presents an overview of the habitats and faunal communities which could occur within UK waters in the vicinity of the HOW4 survey area.

The entire extent of the HOW4 survey area is located within the SNS candidate Special Area of Conservation (cSAC) (JNCC, 2017b). The SNS cSAC covers an area of 36 951 km^2 and has been identified as an area of importance for harbour porpoise (*Phocoena phocoena*). (JNCC, 2017a)

1.3.2 Biogenic Reefs – *Sabellaria spinulosa*

In the SNS, frequent observations of biogenic reefs created by the Ross worm *Sabellaria spinulosa* have been noted. Biogenic reefs formed by the tube-dwelling *S. spinulosa* (Graham *et al*., 2001), are listed under Annex I of the Habitats Directive (1992). Areas of *S. spinulosa* reefs consist of thousands of fragile sand-tubes made by ross worms (polychaetes). In favourable conditions *S. spinulosa* tubes form dense aggregations which have consolidated to create solid structures rising above the surrounding seabed. Individual clumps of *S. spinulosa* tubes can regularly form and disintegrate; however overall reef structures can persist for several years (OSPAR, 2013). The structural complexity provided by *S. spinulosa* reefs often enables the development of a faunal community of numerous small epifauna species typically comprising calcareous tubeworms, pycnogonids, hermit crabs, amphipods, hydroids, bryozoans, sponges and ascidians (Connor *et al*., 2004).

1.3.3 Sea Pen and Burrowing Megafauna Communities

A 'sea pen and burrowing megafauna communities' habitat is defined by OSPAR (2010) as plains of fine mud, extending over an area of at least 25m^2 and at water depths ranging from 15m to 200m or more. These areas are defined as being heavily bioturbated by burrowing megafauna including *Nephrops norvegicus*, *Calocaris macandreae* or *Callianassa subterranea*, with burrows and mounds typically forming a prominent feature of the sediment surface, and which may include conspicuous populations of sea pen (Pennatulacea), typically *Virgularia mirabilis* and *Pennatula phosphorea*. To put this into context: despite its classification as a threatened and/or declining habitat (OSPAR, 2008) in the North Sea, around the south and west coasts of Norway and around the north of the British Isles this habitat is widespread throughout these areas (OSPAR, 2010).

1.3.4 Sand Eel Spawning

Sand eels are small eel-like fish which swim in large shoals. Of the five species of sand eels inhabiting the North Sea, *Ammodytes marinus* is the most abundant and comprises 90% of sand eel fishery catches (ICES, 1997).

As with other sand eel species *A. maurinus* has a close association with sandy substrates into which they burrow. It is common for sand eels to prefer sandy sediments to those comprised predominately of gravel or silt (Pinto *et al*., 1984). Spawning is suggested to occur between November and February (Coull *et al*., 1998; Ellis *et al*., 2010; 2012) where sand eels will spawn on the seabed and the eggs attach themselves to grains of sand (Hassel *et al*., 2002). Physical disturbance to sand eel habitats may occur during pipeline installation, potentially resulting in increased mortality, although it is expected that the population would recover following installation.

1.4 Published Background Physico-Chemical Data

Reference, where possible, has also been made to suitable published background data for marine sediments from the North-East Atlantic and North Sea such as UKOOA (2001) and OSPAR (2005), along with toxicity information including effects range low and effects range median (Long *et al.*, 1995) and the apparent effects thresholds (AETs) as detailed by Buchman (2008). Background information is also provided in Appendix C.

Oil and Gas UK (formerly UKOOA) commissioned an analysis of seabed environmental surveys carried out on behalf of UK North Sea offshore oil operators. The purpose of these surveys was to monitor the seabed in the vicinity of offshore operations with the aim of detecting environmental impact. The analysis was completed in three phases. Phase 1 consisted of the compilation of an inventory of surveys carried out in the UK sector. This initially summarised the results of 472 environmental surveys carried out between 1975 and 1998 by environmental monitoring contractors, government agencies and universities. Background contaminant levels were recorded in three different sectors of the North Sea, and the presence of oil installation clusters situated successively further north allowed the region to be separated into northern (north of latitude 60°N), central (between latitudes 55°N and 60°N) and southern (south of latitude 55°N) sectors. Phase 2 involved the production of database files containing detailed biological, chemical and location data. Phase 3 examined the extent of contamination from offshore exploration and production activities and impacts on the biota and attempted to determine any large-scale trends over wider geographical areas. This final phase was completed in April 2001. Care was taken to record the database in a format that ensures the contaminant concentrations measured by different analytical methods are kept separate. UKOOA (2001) background reference concentrations were averaged from stations >5km from the nearest platform in each of the three sections of the North Sea, with hydrocarbon concentrations determined by gas chromatography (GC) and metal concentrations as given by sodium fusion or similar extraction methods. Mean data and 95th percentiles are available; the latter representing the threshold, which 95% of stations recorded a concentration below. Comparison and reference are made throughout this report to findings from the published report (UKOOA, 2001) with reference to the UKOOA defined SNS sector.

OSPAR (2005) has published a set of background concentrations (BC), which represent the concentrations of certain hazardous substances that would be expected in the North-East Atlantic if certain industrial developments had not happened. OSPAR has also described 'background assessment criteria' (BACs), a set of statistical tools that enable testing of whether mean observed concentrations (*i.e.*, collected during a seabed survey) can be considered to be near background concentrations. Comparison to OSPAR (2005) data required normalisation of the hydrocarbon concentrations to 2.5% total organic carbon (TOC).

The best estimates of the potential toxicity of polyaromatic hydrocarbons (PAHs) in marine sediments are ERL and ERM concentrations for total low molecular weight (2- to 3-ring, LMW), total high molecular weight (4- to 6-ring, HMW) and total 2-6 ring PAHs (Neff, 2004) as given by Long *et al.* (1995) gives ERL concentrations for. These concentrations are not actual thresholds of toxicity but delineate concentration ranges with associated probabilities of toxicity. More information on the ERL and ERM for PAHs can be found in Appendix Section C.2. Comparison to ERL and ERM (Long *et al.*, 1995) data required normalisation of the PAH concentrations to 1% TOC. Long *et al.* (1995) also define ERL and ERM values for selected metals.

Buchman's (2008) AETs were obtained by establishing relationships between the sediment metal concentrations and benthic community toxicological impacts and correspond to the highest concentrations at which no toxicological effects were observed.

1.5 Existing Infrastructure

The position and status of wells (subsea infrastructure) within 5km of any of the target locations within the HOW04 survey area were obtained from UK Oil and Gas Data (2017) and Cogea Srl (2018) and are listed in Table 1.2 and Table 1.3 and presented in Figure 1.2. A total of 37 wells were recorded within 5km of any of the target stations in the HOW04 survey area of which 3 were situated within 1km of a target station. Similarly, a total of 11 pipelines were recorded within 5km of the proposed location.

Table 1.2 Details of Historical Wells

Infrastructure	Easting	Northing	Flow Class	Intent	Completion Date	Distance and Direction from nearest Station Target
48/02- 1	383007	5969599	GS	Exploration	29-Nov-84	595m WSW of ENV1
43/26b- 9	378774	5994766	DH	Exploration	12-Sep-91	672m SW of ENV18
43/28- 2	404358	5987245	DH	Exploration	19-Apr-93	781m NNW of ENV14
48/02c- 5	382193	5970601	GW	Exploration	21-May-08	1620m WNW of ENV1
48/03- 1	396272	5971771	GS	Exploration	26-Aug-68	2188m SSE of ENV6
43/27- 2	384301	5986877	GW	Exploration	13-Oct-90	2315m N of ENV10
43/28a- 3	395653	5998919	DH	Exploration	06-Apr-96	2396m NE of ENV19
43/26b- 10	370900	5997466	GW	Exploration	01-Jun-98	2567m WSW of ENV20
43/27a- 5	388366	5986620	D	Development	30-Sep-07	2745m NW of ENV11
43/27a- 5Z	388366	5986620	GPW	Development	17-Nov-07	2745m NW of ENV11
43/27a- 4	388339	5986620	D	Development	08-Aug-05	2762m NW of ENV11
43/27a- 4Z	388339	5986620	GPW	Development	19-Sep-05	2762m NW of ENV11
48/02b- 3	390947	5976524	GW	Exploration	11-Jul-97	2824m NNE of ENV5
43/27- 1	384390	5989949	GW	Exploration	09-Apr-90	3449m SW of ENV15
48/02a-B5	383267	5981088	NA	Development	23-Jan-13	3743m SSW of ENV10
48/02a-B5Y	383267	5981088	NA	NA	06-May-13	3743m SSW of ENV10
48/02a-B5Z	383267	5981088	NA	NA	13-Mar-13	3743m SSW of ENV10
48/02a-B2	383268	5981086	JW	Development	17-Jul-09	3744m SSW of ENV10
48/02a-B2Z	383268	5981086	SATD	Development	10-Feb-10	3744m SSW of ENV10
48/02a- 4	383265	5981086	GW	Appraisal	20-Sep-06	3745m SSW of ENV10
48/02a-B1	383267	5981084	GPW	Development	06-Feb-10	3746m SSW of ENV10
48/02a-B4	383263	5981084	NA	Development	28-Nov-12	3747m SSW of ENV10
48/02a-B3	383265	5981083	GPW	Development	01-Feb-10	3748m SSW of ENV10
43/27- 3	391406	5993008	DH	Exploration	03-Dec-91	3950m WNW of ENV16
48/02- 2	386334	5978431	GW	Exploration	14-Jan-89	3997m SW of ENV8
43/26a- 8	381169	5991557	GW	Appraisal	06-Aug-91	4275m SSE of ENV18
43/27-J1	382630	5990303	GPW	Development	09-May-94	4480m WSW of ENV15
43/27-J2	382632	5990300	GPW	Development	29-Apr-94	4480m WSW of ENV15
43/27-J3	382628	5990306	GPW	Development	22-Oct-96	4480m WSW of ENV15
43/27-J3Y	382628	5990306	GPW	Development	06-Jan-97	4480m WSW of ENV15
43/27-J3Z	382628	5990306	GPW	Development	03-Nov-96	4480m WSW of ENV15
43/27-J4	382626	5990310	NA	NA	07-May-13	4480m WSW of ENV15
43/21- 1	369946	6009606	DH	Exploration	25-Mar-70	4636m NNE of ENV23
48/03- 4	399989	5979341	GS	Exploration	17-Jul-88	4823m ESE of ENV9
43/28- 1	406085	5992783	GS	Exploration	16-Dec-91	4877m ENE of ENV17
43/21- 3	379412	6010314	DH	Exploration	18-Aug-94	4947m NNE of ENV25
43/26- 5	377311	5990729	GW	Appraisal	30-Mar-86	4949m SSW of ENV18

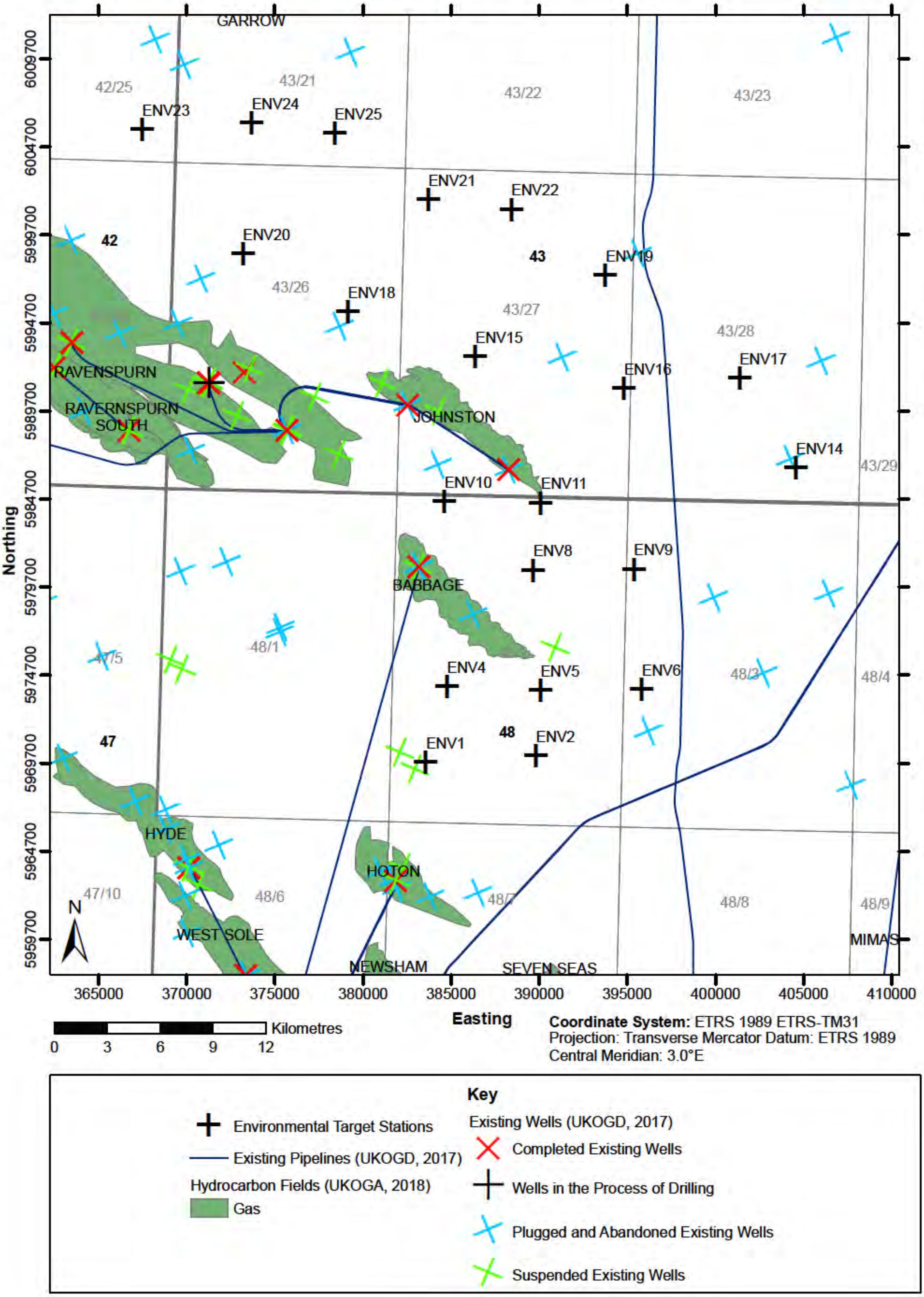
GPW = Gas Producing Well, GS = Gas Shows, JW = Junked Well, D = Drilling, DH = Dry Hole, GW = Gas Well, SATD = Suspended above Total Depth, NA = information unavailable

<1km from nearest station	1-2km from nearest station	2-3km from nearest station	3-4km from nearest station	>4km from nearest station

Table 1.3 Details of Existing Pipelines and Cables

Infrastructure	Status	Type
Babbage Export	Active	Gas
Johnston J5 Export	Active	Gas
Johnston J5 Methanol	Active	Methanol
Johnston Methanol	Active	Methanol
JFE Production	Active	Gas
Shearwater to Bacton	Active	Gas
Theddlethorpe to Murdoch MD MEOH Line	Active	Methanol
Johnston Export	Active	Gas
Johnston Umbilical	Active	Chemical
JFE Umbilical	Active	Chemical
Theddlethorpe to Murdoch MD	Active	Gas

Figure 1.2 Local Subsea Infrastructure Features



2 RESULTS AND DISCUSSION

2.1 Geophysical Survey Summary

2.1.1 Survey Overview

Gardline acquired shallow geophysical data across the HOW4 survey area. The survey utilised single-beam and multi-beam echo sounders (SBES and MBES), SSS, magnetometer, sub-bottom profiler, piston corer and cone penetrometer testing (CPT) unit.

2.1.2 Bathymetry

Water depths varied from 25m LAT in an area of sand waves in the south of the survey area to 61m LAT in the north of the survey area. Seabed gradients were generally <1° deepening to the north, with steeper gradients found locally on the slopes of the numerous sand waves and megaripples, which were the dominant topographic features within the survey area.

2.1.3 Seabed Features

Across the HOW 4 survey area, seabed sediment and morphological interpretations were produced by integrating the PSA results from the environmental grabs with the side scan sonar mosaics and bathymetry data set.

Sand megaripples were the most frequently observed bedform across the survey area, while sand waves were also common. The megaripples had wavelengths of up to 15m and, where sand waves occur, were often superimposed upon them. The prevalence of these flow driven bedforms suggested that sand was the predominant seabed sediment, a conclusion which was supported by the interpreted side scan sonar mosaic data with reference to the results of the PSA analysis. PSA results showed that the sediments covering the entire site were predominantly sand, with some variation in coarseness and some isolated areas with increased gravel content. In areas where the sand waves are absent the sand was relatively uniform. The observed variation in sediment grain size occurred around the sand waves themselves, with finer sands observed on the stoss side of the sand waves and more coarse sand and gravel content occurring in the troughs between the sand waves.

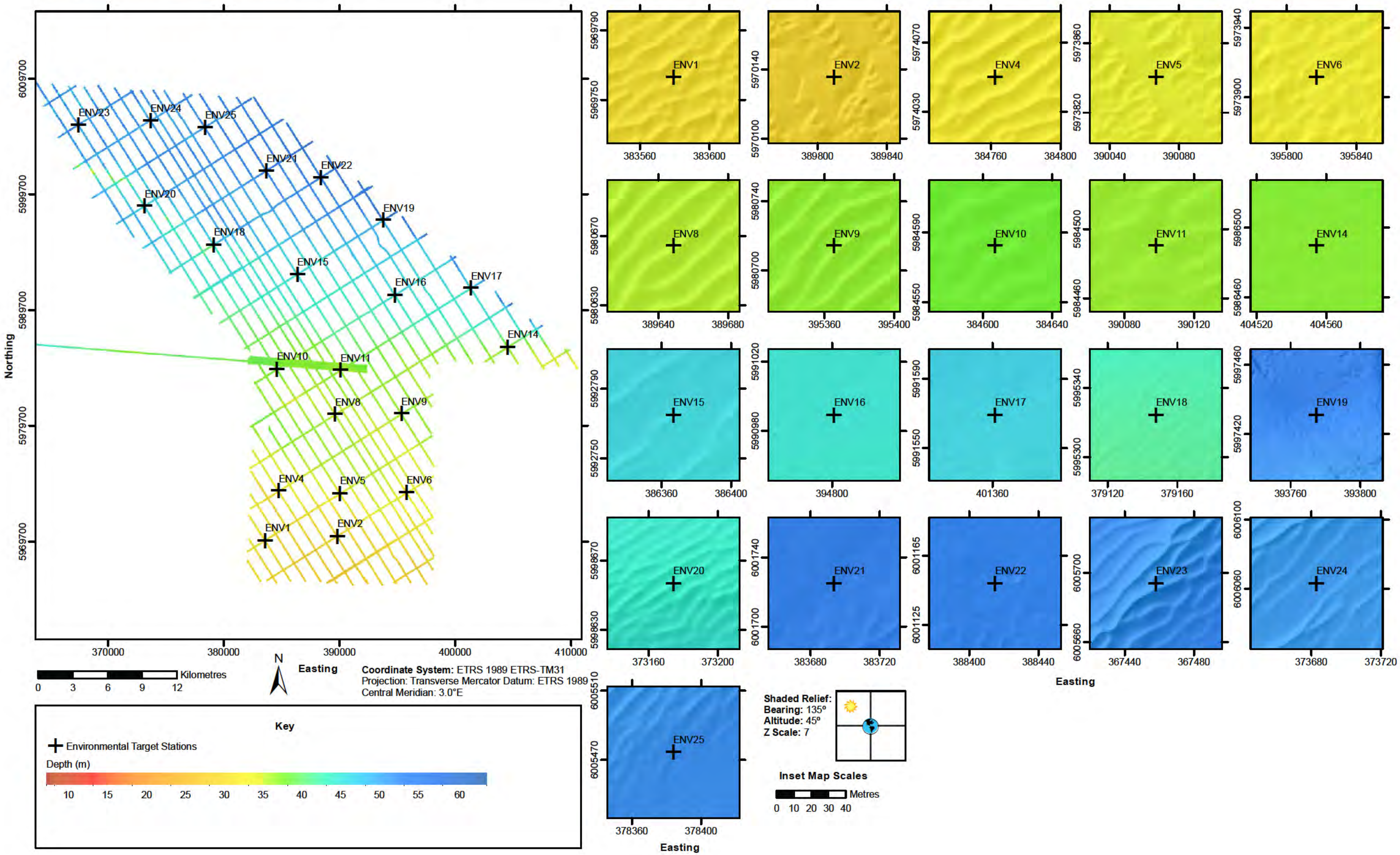
Numerous objects were present at seabed throughout the HOW4 survey area as identified on both SSS and bathymetry data. The majority of these were thought to be boulders (as defined by the USCS) although some were likely to be debris associated with the fishing activity in the area. Due to the mobile nature of the seabed, it can be assumed that there may be further boulders present in the shallow subsurface across the HOW4 survey area. Additionally, numerous static fishing pots were identified on the SSS data, generally concentrated in the southern and eastern areas where sand waves and megraipples were common. Two wrecks were also identified within the survey area.

Within the sonar data, fishing activity was noted to be common across the HOW4 site with trawling marks particularly prevalent. Trawl scars were common in the central belt of the survey area where sand waves and megaripples were absent. It should be noted that these bedforms indicated mobile sediments across the majority of the site. Therefore, any evidence of recent trawling activity may not be preserved in the form of seafloor scars, or may be ephemeral within these regions. Accordingly, it was not possible to fully quantify the extent of fishing activity across the survey area given both the mobility of sediments and the sonar data coverage acquired.

A total of five pipelines pass through the HOW4 survey area. Of these, the Shearwater to Bacton Gas line (PL1570) was the most notable. This pipeline was orientated north/south through the east of the survey area and was identified on all geophysical data. Numerous exploration, prospecting and production well locations were noted across the HOW4 survey area. These related to the

Johnston, Babbage and Ravernspurn South fields. The majority of these locations were suspended or abandoned and also fall outside the extents of the acquired geophysical data set. Wells 48/02-1 and 48/03-1 were identified on the magnetometer data set and both occurred within the extent of the acquired data set. Well 48/02a-B4 was located at the western edge of the survey area and the associated rig infrastructure prevented the completion of the northern section of survey line M08 leaving a data gap for all systems. Wells 43/27-1 and 43/27-J1 fall outside the data extents however their associated gas pipelines and umbilicals were identified on the sub bottom profiler and magnetometer data.

Figure 2.1 Colour Shaded Relief of Bathymetry



2.2 Seabed Imagery Observations

Seabed imagery and video footage revealed a range of sediment types across the HOW4 survey area from gravely sand to muddy sand. Coarse sediments were visibly present at four Stations (ENV2, ENV5, ENV24, and ENV25) were described as gravely sand.

Visible fauna observed within the seabed imagery was generally sparse and included: Annelida (*Ditrupa*, *Echiura*, Polychaeta, Serpulidae, Terebellidae), Arthropoda (Brachyura, Paguridae), Chordata (Actinopterygii including, Ammodytidae, Callionymidae, Pleuronectiformes, Triglidae, Scorpaeniformes, Scyliorhinidae), Cnidaria (Actiniaria, *Alcyonium digitatum*, *Ceriantharia* sp., *Urticina* sp., Hydrozoa), Echinodermata (Asteroidea including, *Asterias rubens*, *Astropectin irregularis* Ophiuoridea), Mollusca (Bivalvia, Naticidae, Scaphopoda, Sepiolidae). Small burrows and faunal tubes were observed across the HOW4 survey area, particularly where finer sediment was observed.

2.2.1 Sea Pen and Burrowing Megafauna Communities Assessment

Burrows were observed at 19 stations within the seabed imagery, however, sea pens (Pennatulacea) were not observed within any of the seabed imagery data acquired across the HOW4 survey area. The observed sediment type across the HOW4 survey area was not consistent with the fine mud described as typical for the ‘sea pen and burrowing megafauna communities’ habitat, as defined by (OSPAR, 2010). However, as a precaution, the densities of burrows at all stations were analysed and their abundance categorised using the JNCC’s MNCR SACFOR classification (Appendix B.4) to assess the suitability of the stations to be classified as a ‘sea pen and burrowing megafauna communities’ habitat.

The JNCC (2014) clarification report acknowledges the inherent difficulties of identifying species from burrow type alone using ever evolving identification guides, such as the cited ICES (2011) guide. Subsequently, the overall density of burrows themselves was assessed instead, in order to consider whether their density was a ‘prominent’ feature of the sediment surface and potentially indicative of a sub-surface complex gallery burrow system. Therefore, areas with burrows and, if observed, sea pen species with densities considered ‘frequent’ or more under the SACFOR scale were considered likely to constitute a ‘sea pen and burrowing megafauna communities’ habitat. However, as recommended in the JNCC report (2014), any such interpretation of the density of burrows should be treated with a degree of caution, particularly without formal observation and identification of the taxa present. The average burrow densities were calculated for each station using the total area covered by the photographs as calculated from laser scale lines (average image swathe x camera transect length). The results of this assessment are summarised in Table 2.1 and full methodology on how the assessment for a 'sea pen and burrowing megafauna communities' habitat was conducted is presented in Appendix B.4.1.

Burrow density revealed a SACFOR score of ‘rare’ at all stations except Stations ENV1, ENV11 and ENV19, where densities ranged from ‘rare’ to 'occasional’ at Stations ENV11 and ENV19 and ‘rare’ to ‘frequent’ at ENV1. The area of the seabed covered by the camera transect at all stations exceeded the required 25m^2 as set out in the OSPAR (2010) definition of the ‘sea pen and burrowing megafauna communities. Therefore of all the burrows observed within the seabed imagery across the whole of the HOW4 survey area, only the burrow abundances at Station ENV1, with a SACFOR score encompassing 'frequent', could be considered to present some similarity to a 'sea pen and burrowing megafauna community' habitat as defined by OSPAR (2010). However, it should be noted that this habitat is widespread across the central North Sea, around the south and west coasts of Norway and around the north of the British Isles (OSPAR, 2010).

Table 2.1 Total Sea Pens and Faunal Burrows Qualification

Stations	Number of Images Assessed	Estimated Total Area Investigated (m^2)[1]	Burrows			
			Quantity	Size Range (diameter in cm)	Density (Burrows m^2)	SACFOR Range[2]
ENV1	34	95	17	0.2 to 4.1	0.179	R to F
ENV2	35	146	0	0.0 to 0.0	0.000	-
ENV4	45	87	32	0.2 to 0.7	0.367	R
ENV5	33	124	5	0.2 to 0.5	0.040	R
ENV6	33	106	6	0.2 to 0.5	0.057	R
ENV8	32	140	34	0.3 to 0.5	0.243	R
ENV9	40	113	53	0.2 to 0.6	0.470	R
ENV10	22	138	3	0.2 to 0.5	0.022	R
ENV11	39	108	45	0.2 to 1.8	0.416	R to O
ENV14	35	141	50	0.2 to 0.6	0.355	R
ENV15	49	243	145	0.2 to 0.9	0.596	R
ENV16	40	1444	56	0.2 to 0.5	0.039	R
ENV17	39	119	106	0.2 to 0.7	0.892	R
ENV18	24	159	0	0.0 to 0.0	0.000	-
ENV19	40	249	256	0.3 to 1.2	1.030	R to O
ENV20	23	169	12	0.3 to 0.4	0.071	R
ENV21	24	116	90	0.2 to 0.5	0.777	R
ENV22	26	166	74	0.2 to 0.7	0.446	R
ENV23	38	184	56	0.2 to 0.6	0.304	R
ENV24	24	136	7	0.2 to 0.4	0.051	R
ENV25	24	156	2	0.3 to 0.3	0.013	R

1 Total area of seabed photographed for station calculated using laser line scaling.

2 SACFOR classification scale S=Superabundant, A=Abundant, C=Common, F=Frequent, O=Occasional and R=Rare. Classification based on minimum and maximum estimated size of seabed and burrows and the respective mean density at each station and transect.

2.2.2 Other Species of Conservation Interest

Visible fauna in seabed imagery included an individual specimen of a sand eel (*Ammodytidae*). Members of the *Ammodytes* genus (specifically *Ammodytes marinus* and *Ammodytes tobianus*) are listed as a priority species under UK Post 2010 Biodiversity Framework (JNCC and Defra, 2012) and listed under the NERC Act (2006).

Other than those mentioned above, within the seabed imagery, there was no evidence of any other Annex I habitats (1992), no species or habitats listed as FOCI (Natural England and Joint Nature Conservation Committee, 2010). No species or habitats listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act (2006). No additional species or habitats listed on the OSPAR (2008) list of threatened and/or declining species and habitats were recovered in the samples. Finally, no species on the IUCN Global Red List of threatened species (IUCN, 2018).

2.3 Sediment Sampling Observations

Seabed sampling observations were used to ground truth the initial geophysical interpretation and seabed imagery, with results supporting the preliminary findings. Across the HOW4 survey area seabed samples were described as sand and silty sand with the exception of Station ENV19 which was described as silty sand with gravel. Shell fragments were regularly observed throughout the seabed sediment samples. Furthermore, sediment samples acquired at Stations ENV4, ENV10 and ENV19 presented layers of anoxic sediment. A selection of photographs of the recovered samples, together with sample descriptions and positions are presented in Appendix D.

Observed fauna in the seabed samples was generally sparse and included: Annelida (Polychaeta), Arthropoda (Brachyura, Isopoda, Upogebiidae), Echinodermata (Asteroidea, Echinoidea, Ophiuroidea), Mollusca (possible *Arctica islandica* shell, Bivalvia, Scaphopoda), Chordata (Ammodytidae).

Shells, possibly belonging to the ocean quahog (*A. islandica*) were present in sediment samples recovered from Stations ENV24 and ENV25. *A. islandica* is a species listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008). In addition, *A. islandica* is species listed as a FOCI, defined in relation to the Marine Conservation Zones (MCZ) network (Natural England and Joint Nature Conservation Committee, 2010); however this species is commonly found within this area of the North Sea (Oil and Gas U.K., 2010).

A single individual of a sand eel (Ammodytidae) was observed within a seabed sample obtained at Station ENV2. The lesser sand eel (*A. tobianus*) and Raitt's sand eel (*A. marinus*) are species, listed under the NERC Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra, 2012). It should be noted that the example observed at Station ENV2 was not identified to species level.

Other than those mentioned above, there was no further evidence from sediment sampling of any Annex I habitats (1992), no species or habitats listed as features of conservation importance (Natural England and Joint Nature Conservation Committee, 2010). No species or habitats listed under the NERC Act (2006). No additional species or habitats listed on the OSPAR (2008) list of threatened and/or declining species and habitats were recovered in the samples. Finally, no species on the IUCN Global Red List of threatened species (IUCN, 2018) were present.

2.4 Sediment Characteristics

2.4.1 Particle Size Analysis

The results of the PSA determined using wet and dry sieving, are presented in Table 2.2. The modified Folk classification and the broadscale sediment classification used in the EUNIS classification is plotted against the sonar data and presented in Figure 2.2. Full results and histograms illustrating the particle size distribution at each sampled station are presented in Appendix G.

The PSA results were generally heterogenous in nature and supported observations of the recovered sediment samples and seabed imagery. Mean particle diameter at stations across the HOW4 survey area varied between 245µm at Station ENV14 and 648µm at ENV 17 with an overall mean diameter of 414µm (±117 SD). The Wentworth classification of the mean grain size (Folk & Ward, 1957) generally presented as medium to coarse sand across the HOW4 survey area with the exception of Station ENV14 which presented as fine sand.

The sand fraction (≥63µm to <2mm) dominated the sediment composition at all stations and contributed between 61% of the total sediment composition at Station ENV17 to 100% of the total sediment composition at Stations ENV1 and ENV18. This resulted in the majority of the stations across the HOW4 survey area being classified as sand under the modified Folk classification (Folk, 1954). Stations ENV2 and ENV25 were classified as slightly gravelly sand under the modified Folk classification (Fo k, 1954) due to the proportion of gravel sized particles (≥2mm) which accounted for *c.*4% of the total sediment at both these stations. Under modified Folk (Folk, 1954), Stations ENV16 and ENV24 were classified as gravelly sand due to the higher percentage contribution of gravel (*c.*9% and *c.*8% respectively) at these stations whilst Station ENV9 presented a relatively higher percentage of fine sediment (<63µm; 10%) and classified as muddy sand under the modified Folk classification.

Lastly, sediments at Stations ENV17 and ENV19 were described as gravelly muddy sand under the modified Folk classification (Folk, 1954) due to the highest percentages of gravels (*c.*24% and *c.*15%, respectively) and fines (*c.*15% and *c.*14% respectively) content observed across the HOW4 survey area. Stations ENV17 and ENV19 targeted an area of moderate reflectivity as indicated by the SSS data (Figure 1.1).

Sediment sorting ranged from very poorly sorted to moderately well sorted across the HOW4 survey area. A Spearman's rank correlation (Appendix H) conducted on the data revealed a statistically significant negative correlation between the sorting co-efficient and the percentage sand contribution (Spearman's $r= 0.82$, $p<0.01$) across the HOW4 survey area. This corresponded to a general trend within the data of samples with high sand components being well sorted whilst more mixed sediments were generally considered less well sorted.

2.4.2 Organic Carbon

The results of the TOC analysis are presented in Table 2.2. TOC is measured as a percentage of the total weight and represents the carbon constituent of the organic matter.

Across the HOW4 survey area, TOC concentrations were considered low and varied. TOC ranged between 0.05% at Station ENV23 to 0.29% at Station ENV9 with a mean value of 0.13% (±0.05 SD). In general, for continental shelf sediments there is a close relationship between the organic carbon content and the surface area of the mineral matrix (Mayer, 1994). As such, the variation observed within the TOC values were not unexpected due to the variation of sediment types observed within the particle size data. This was further corroborated by a statistically significant positive correlation between TOC and percentage fines across the HOW4 survey area (Spearman's $r=0.81$; $p<0.01$; Appendix H).

Table 2.2 Sediment Characteristics

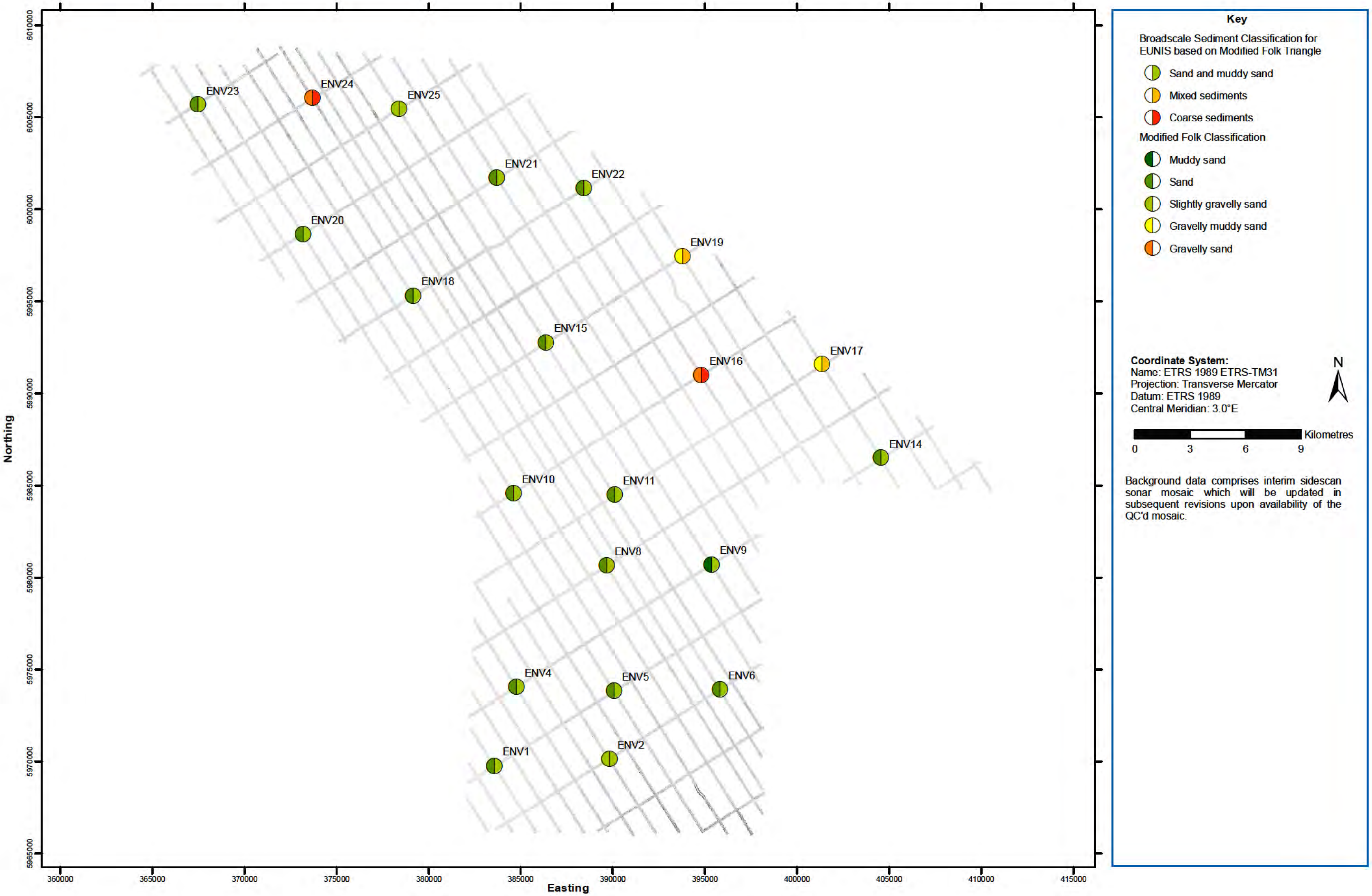
Station	Mean Diameter (µm)	Mean Diameter (phi)	Fines %	Sand %	Gravel %	Wentworth Classification of Mean Grain Size	Sorting[1]	Modified Folk Classification	Broadscale Habitat Classification Based on Modified Folk Classification[2]	Total Organic Carbon %
ENV1	356	1.5	0.0	100.0	0.0	Medium sand	Moderately well	Sand	Sand and muddy sand	0.09
ENV2	584	0.8	0.6	95.8	3.6	Coarse sand	Moderate	Slightly gravelly sand	Sand and muddy sand	0.11
ENV4	308	1.7	6.9	93.1	0.0	Medium sand	Moderate	Sand	Sand and muddy sand	0.17
ENV5	424	1.2	0.7	98.7	0.6	Medium sand	Moderately well	Sand	Sand and muddy sand	0.15
ENV6	374	1.4	4.1	94.9	1.0	Medium sand	Moderate	Sand	Sand and muddy sand	0.12
ENV8	296	1.8	4.3	95.7	0.0	Medium sand	Moderately well	Sand	Sand and muddy sand	0.13
ENV9	282	1.8	10.1	89.9	0.0	Medium sand	Poor	Muddy sand	Sand and muddy sand	0.29
ENV10	272	1.9	5.4	94.6	0.0	Medium sand	Moderate	Sand	Sand and muddy sand	0.15
ENV11	279	1.8	4.8	95.2	0.0	Medium sand	Moderately well	Sand	Sand and muddy sand	0.10
ENV14	245	2.0	6.3	93.7	0.0	Fine sand	Moderate	Sand	Sand and muddy sand	0.13
ENV15	329	1.6	4.7	95.3	0.0	Medium sand	Moderate	Sand	Sand and muddy sand	0.11
ENV16	440	1.2	7.4	83.5	9.1	Medium sand	Poor	Gravelly sand	Coarse sediments	0.16
ENV17	648	0.6	15.3	61.0	23.8	Coarse sand	Very poor	Gravelly muddy sand	Mixed sediments	0.19
ENV18	561	0.8	0.0	100.0	0.0	Coarse sand	Moderately well	Sand	Sand and muddy sand	0.06
ENV19	444	1.2	13.7	70.9	15.4	Medium sand	Very poor	Gravelly muddy sand	Mixed sediments	0.19
ENV20	388	1.4	2.6	97.4	0.0	Medium sand	Moderate	Sand	Sand and muddy sand	0.08
ENV21	416	1.3	7.0	93.0	0.0	Medium sand	Poor	Sand	Sand and muddy sand	0.12
ENV22	452	1.2	4.0	96.0	0.0	Medium sand	Moderate	Sand	Sand and muddy sand	0.09
ENV23	506	1.0	1.5	98.5	0.0	Coarse sand	Moderately well	Sand	Sand and muddy sand	0.05
ENV24	527	0.9	2.7	89.7	7.7	Coarse sand	Poor	Gravelly sand	Coarse sediments	0.11
ENV25	560	0.8	0.5	95.4	4.1	Coarse sand	Moderate	Slightly gravelly sand	Sand and muddy sand	0.07
This Study **Minimum**	245	0.6	0.0	61.0	0.0	Fine to Coarse sand	Very Poor to Moderately well	Muddy sand to Gravely Sand	Sand and muddy sand to Coarse Sediments	0.05
Maximum	648	2.0	15.3	100.0	23.8					0.29
Mean	414	1.3	4.9	92.0	3.1					0.13
±SD	117	0.4	4.2	9.6	6.2					0.05

Sediments were not treated to remove carbonates prior to particle size analyses.

1 Sorting according to Folk and Ward (1957)

2 Calculated using the modified Folk triangle classification (Appendix B)

Figure 2.2 Modified folk and Broadscale Sediment Classifications Map



2.5 Hydrocarbon Concentrations

2.5.1 Total Hydrocarbons and Alkanes

A summary of results of the hydrocarbon analysis is presented in Table 2.3. Total hydrocarbon (THC) concentrations (comprising total n-alkanes, pristane, phytane, unresolved complex mixture (UCM) and polycyclic aromatic hydrocarbons (PAH)) ranged from 1.6µg g^{-1} at Station ENV23 to 8.6µg g^{-1} at Station ENV17, with a mean value of 4.7µg g^{-1} (±1.8 SD) across the HOW4 survey area. There was a statistically significant positive correlation ($p<0.01$) between THC and percentage fines across the HOW4 survey area ($r=0.76$; Appendix H). To put these results into context, UKOOA (2001) recorded a mean THC concentration of 4.3µg g^{-1} (measured by GC) for stations over 5km from existing infrastructure in the SNS (latitudes below 55°N) sampled between 1975 and 1995. Across the HOW4 survey area, THC values at seven stations exceeded the 95th percentile of 11.39µg g^{-1} and were situated with 5km of the nearest existing infrastructure. THC concentrations across the HOW4 survey area could be considered broadly consistent with background values for this region of the North Sea.

It has previously been shown that benthic macrofauna suffer adverse effects when THC concentrations are in excess of 50µg g^{-1} (UKOOA, 2001; Kjeilen-Eilertsen *et al.*, 2004; UKOOA, 2005) and as such, this value represents the threshold above which hydrocarbons are expected to have a 'significant environmental impact' (SEI). Kingston (1992) also previously reported that benthic macrofauna suffer adverse effects, namely reduced diversity, when THC is in excess of 50µg g^{-1} to 60µg g^{-1}, and that specific sensitive species may be impacted at levels greater than 10µg g^{-1}. Mair *et al.* (1987) observed a notable increase in the dominance of opportunistic species at THC levels in excess of 291.4µg g^{-1}. The THC concentrations recorded in the current survey were well below all published threshold values. Therefore, the faunal community was not expected to be influenced by THC concentrations; this is further explored in Section .

The UCM is composed of a mixture of hydrocarbons including cycloalkanes, which remain after substantial weathering and biodegradation of mostly petrogenic inputs to the sediment (McDougall, 2000). The UCM accounted for 94% to 99% of the THC at all stations across the HOW4 survey area, indicating that the majority of hydrocarbons at all stations were well weathered.

Although THC concentrations provide an indication of the total oil in the sediment at each station, it does not give an indication of the source. Further understanding of the distribution of hydrocarbons can therefore be gained through analysis of GC chromatograms (Appendix I), which can provide an indication of the origin of hydrocarbons in marine sediments and offer an illustration of the extent to which they are weathered. These chromatograms take the form of plots of signal strength against eluting time. Peaks in the chromatograms correspond to individual n-a kanes and other compounds, with carbon numbers increasing with eluting time. The area beneath the trace constitutes the unresolved complex mixture (UCM) of hydrocarbons that could not be resolved by GC, which remain after substantial weathering and biodegradation of mostly petrogenic inputs to the sediment (McDougall, 2000).

The chromatograms generally presented a similar pattern of low-level LMW and low-level HMW resolved n-alkanes with minimal UCM in the LMW range of the chromatogram. Chromatograms at all stations presented a general peak between nC_{20} and nC_{22}, around nC_{25}, and between nC_{29} to nC_{33}. Chromatograms with low level, HMW resolved n-alkanes and UCM, peaking from nC_{24} to nC_{36} are typical of background levels of hydrocarbons inputs in areas of historic oil and gas explorations such as the North Sea (McDougall, 2000).

Hydrocarbons in the molecular weight range nC_{24} to nC_{36} commonly originate from terrestrial plant sources (Harborne, 1999), or may present the residue of highly weathered and biodegraded petrogenic material including hydrocarbons from natural seeps, shipping discharges and oil and gas exploration and extraction (Bouloubassi *et al.*, 2001). The peak within the chromatograms noted at nC_{25} was given a tentative ID by the third party laboratory conducting the analysis as having 9,19-Cyclocholest-24-en-3-ol, 14-methyl-, (3.beta.-, 5.alpha.-) and 1-Hexyl-2-nitrocyclohexane present. However, nC_{25} may co-elute with these compounds, and therefore this interpretation should be treated with caution.

Further insight into the origin of hydrocarbons in marine sediments may be gained by measuring concentrations of individual a kanes. Concentrations of n-alkanes from nC_{10} to nC_{37}, pristane and phytane are summarised in Table 2.3 with individual n-alkane concentrations presented in Table 2.4 and their distributions at each station are presented as bar charts in Appendix I.

Across the survey area, total n-alkane concentrations (nC_{10} to nC_{37}) were relatively uniform varying between 0.030µg g^{-1} at Station ENV18 to 0.283µg g^{-1} at Station ENV17 with a mean value of 0.128µg g^{-1} (±0.068 SD). To put these results into context, UKOOA (2001) recorded a mean n-alkane concentration of 0.33µg g^{-1} for stations (n=152) over 5km from existing infrastructure in the SNS. As all stations within the current survey recorded levels lower than this mean value, n-alkane values across the survey area can therefore be considered representative of background conditions.

Across the survey area, the concentrations of nC_{10} to nC_{20} LMW n-alkanes ranged from 0.011µg g^{-1} at Station ENV18 to 0.116µg g^{-1} at Station ENV2 with a mean value of 0.041g g^{-1} (±0.025 SD). LMW n-alkanes contributed between 24% and 44% of total n-alkanes suggesting an input from petrogenic hydrocarbon sources across all stations. The total n-alkane bar charts (Appendix I) generally presented bimodal peaks, with the weathered peaks consistent with historic diesel inputs (Wang & Fingas, 2005). Examination of the distribution within the LMW range highlighted a higher contribution from the odd number nC_{15} and nC_{17} alkanes. Marine organisms (phyto- and zooplankton) have a preference for the synthesis of odd numbered short chain n-alkanes, being the most abundant in phytoplankton at nC_{15}, nC_{17}, nC_{19} and nC_{21} (McDougall, 2000). Microbial degradation was therefore one likely low-level hydrocarbon source at each station.

An exception to the general trend was observed at Station ENV24, where a higher contribution of the even number nC_{14}, nC_{16} and nC_{18} alkanes over the odd nC_{15} and nC_{17} was present. This distribution was generally indicative of a petrogenic source hydrocarbon. However, Station ENV24 recorded a THC concentration below the UKOOA mean (2001), along with a UCM trend indicative of very well weathered hydrocarbons. Therefore, any petrogenic inputs at Station ENV24 were likely to be historical and could be considered typical for this area of the North Sea. Within the HMW range, the n-alkanes were predominantly odd-numbered peaking at nC_{25}, nC_{27}, nC_{29} and nC_{31} which suggested the presence of biogenic alkanes most likely derived from diffuse higher terrestrial plant waxes.

The ratio of odd to even numbered n-alkanes within the HMW range (nC_{26} to nC_{30}), commonly referred to as the carbon preference index (CPI), can provide further insight into the origin of n-alkanes within marine sediments. Marine sediments containing a high level of biogenically derived (odd carbon number) n-alkanes are known to have CPI values ≥2, with values ≥4.0 suggesting a virtual absence of petrogenic hydrocarbons (McDougall, 2000). CPI values close to 0 indicate a predominance of petrogenic hydrocarbons. Within the current survey, all stations had CPI values ≥2, apart from Station ENV1 which returned a value of 1.9 and was located within 1km of existing infrastructure. Generally, CPI values recorded across the HOW4 survey area suggested a mixture of alkanes from both petrogenic and biogenic sources. In addition, Stations ENV8, ENV17, ENV19 and ENV22 had a CPI value >4 suggesting an absence of petrogenic hydrocarbons at these stations.

The isoprenoid phytane, which is rarely produced biogenically, was present at all stations within the exception of Stations ENV18, ENV20 and ENV23 within the HOW4 survey area. Recorded phytane values at all stations were ≤0.01µg g^{-1} other than at Station ENV2 where the phytane concentration was 0.039µg g^{-1}. Pristane, an isoprenoid often associated with biogenic sources, was recorded at all stations with concentrations ranging between 0.005µg g^{-1} at Station ENV23 and 0.048µg g^{-1} at Station ENV2. The concentrations of these isoprenoids reflected the generally low n-alkane concentrations and further supported the biogenic and petrogenic mixed origin of hydrocarbons present across the survey area.

Table 2.3 Summary of Sediment Hydrocarbon Analyses

Station		GC-FID									GC-MS		
		THC	UCM	n-alkanes			CPI[1]	Isoprenoids			NPD[2]	Total PAH	NPD/4-6 Ring
				nC_{10-20}	nC_{21-37}	nC_{10-37}		Pristane (Pr)	Phytane (Ph)	Pr/Ph Ratio			
ENV1		3.3	3.1	0.037	0.077	0.114	1.9	0.013	0.005	2.7	0.015	0.036	0.68
ENV2		5.5	5.2	0.116	0.148	0.264	2.0	0.048	0.039	1.2	0.036	0.082	0.78
ENV4		6.9	6.6	0.071	0.092	0.163	3.2	0.032	0.008	4.2	0.060	0.142	0.74
ENV5		3.8	3.6	0.043	0.104	0.147	2.0	0.020	0.009	2.3	0.019	0.058	0.48
ENV6		3.7	3.6	0.029	0.051	0.080	2.8	0.016	0.003	4.8	0.021	0.052	0.69
ENV8		4.0	3.9	0.034	0.072	0.106	4.6	0.014	0.002	6.0	0.027	0.075	0.56
ENV9		6.0	5.8	0.058	0.105	0.163	2.6	0.024	0.006	3.9	0.050	0.125	0.67
ENV10		7.5	7.3	0.047	0.115	0.162	3.8	0.029	0.005	6.3	0.056	0.159	0.55
ENV11		5.3	5.1	0.026	0.076	0.103	3.3	0.011	0.002	6.0	0.020	0.065	0.46
ENV14		3.7	3.6	0.024	0.069	0.093	2.1	0.010	0.002	4.3	0.020	0.058	0.54
ENV15		5.9	5.7	0.048	0.134	0.182	2.7	0.016	0.002	6.5	0.050	0.145	0.53
ENV16		5.4	5.2	0.045	0.120	0.165	3.3	0.019	0.003	7.2	0.056	0.149	0.60
ENV17		8.6	8.3	0.079	0.204	0.283	4.1	0.024	0.003	7.2	0.097	0.248	0.64
ENV18		2.7	2.7	0.011	0.019	0.030	NC	0.006	NC	NC	0.007	0.013	1.11
ENV19		6.3	6.1	0.046	0.149	0.195	4.2	0.012	0.002	5.6	0.058	0.159	0.57
ENV20		3.3	3.2	0.016	0.025	0.041	NC	0.006	0.001	5.1	0.014	0.037	0.58
ENV21		5.0	4.9	0.029	0.069	0.099	3.9	0.010	0.002	5.2	0.036	0.100	0.56
ENV22		3.8	3.7	0.023	0.051	0.074	5.2	0.006	NC	NC	0.027	0.083	0.48
ENV23		1.6	1.6	0.012	0.035	0.047	NC	0.005	NC	NC	0.010	0.019	1.09
ENV24		3.3	3.2	0.043	0.054	0.097	3.3	0.022	0.010	2.2	0.051	0.103	0.98
ENV25		2.5	2.4	0.024	0.052	0.076	2.1	0.007	0.003	2.1	0.015	0.039	0.66
This Study	Minimum	1.6	1.6	0.011	0.019	0.030	1.9	0.005	0.001	1.2	0.007	0.013	0.46
	Maximum	8.6	8.3	0.116	0.204	0.283	5.2	0.048	0.039	7.2	0.097	0.248	1.11
	Mean	4.7	4.5	0.041	0.087	0.128	3.2	0.017	0.006	3.9	0.035	0.093	0.66
	±SD	1.8	1.7	0.025	0.046	0.068	1.0	0.011	0.009	2.4	0.023	0.059	0.19

Unless indicated, concentrations expressed as $\mu g\ g^{-1}$ dry sediment

1 Calculated using $2(nC_{27} + nC_{29})/nC_{26} + 2(nC_{28}) + nC_{30}$ (Farrington & Tripp, 1977).

2 Naphthalenes, phenanthrenes and dibenzothiophenes (total).

NC due to one or more values below the LOD

Table 2.4 n-Alkane Concentrations

Station	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25
nC_{10}	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC_{11}	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC_{12}	<1	2.8	2.4	<1	<1	2.1	1.8	<1	<1	<1	1.4	<1	5.0	<1	2.6	2.0	2.0	<1	<1	<1	<1
nC_{13}	4.0	5.3	4.8	<1	<1	3.5	<1	<1	<1	<1	4.0	1.9	6.9	<1	4.9	1.1	2.0	1.7	<1	<1	1.2
nC_{14}	3.1	11.8	6.9	4.3	2.8	1.8	4.9	4.8	2.5	1.9	3.7	4.1	7.5	1.0	4.0	1.0	2.2	2.4	<1	4.6	2.0
nC_{15}	5.3	18.7	13.5	6.7	6.6	5.1	11.3	10.9	4.3	4.9	7.8	7.4	13.3	1.4	7.3	2.6	4.9	3.3	1.2	6.0	2.2
nC_{16}	5.1	19.0	10.0	6.8	4.3	4.1	8.5	7.5	3.9	3.8	7.1	7.7	12.5	1.5	6.5	2.5	4.1	2.9	1.6	8.0	4.2
nC_{17}	9.3	22.0	14.2	8.1	7.1	8.3	13.1	11.6	6.5	6.2	9.1	10.0	15.5	4.2	9.0	3.7	6.1	5.6	4.2	8.2	5.7
nC_{18}	4.1	14.4	9.2	7.7	3.7	4.2	8.3	5.5	3.8	3.3	6.1	6.6	9.1	1.5	6.2	1.5	4.0	3.4	1.7	9.1	3.6
nC_{19}	3.4	11.0	5.8	4.6	1.9	2.9	5.8	3.8	3.2	2.4	4.7	4.2	5.1	1.1	3.2	1.6	2.4	2.1	1.7	3.8	2.6
nC_{20}	2.9	10.8	3.9	5.3	2.5	2.1	4.4	2.9	2.3	1.6	3.6	2.9	3.8	<1	2.4	<1	1.8	1.2	1.4	2.9	2.3
nC_{21}	5.1	15.3	8.3	7.7	6.5	6.0	8.5	11.3	6.0	4.4	8.1	7.7	11.0	<1	5.5	2.3	2.9	3.1	2.1	4.7	3.2
nC_{22}	2.1	11.8	3.2	6.3	2.8	2.8	5.8	5.1	2.5	2.0	4.9	2.8	5.3	<1	2.4	<1	<1	<1	1.4	1.2	2.4
nC_{23}	3.3	18.1	5.8	9.8	3.5	4.5	8.6	7.4	5.1	4.8	8.9	7.1	13.1	1.3	4.2	1.4	2.4	2.5	2.6	4.4	4.1
nC_{24}	2.8	13.0	3.2	8.8	4.2	3.1	5.7	7.7	3.5	2.1	5.9	6.5	9.4	1.2	4.3	<1	2.6	2.3	2.0	3.6	4.8
nC_{25}	26.9	17.1	18.6	25.1	7.5	18.2	14.2	7.4	8.5	8.4	16.2	12.0	13.8	2.7	31.0	1.1	3.4	6.8	10.1	7.2	3.7
nC_{26}	3.8	12.8	5.0	7.7	3.5	2.7	6.6	5.7	3.7	3.0	6.5	5.4	7.9	<1	3.6	<1	3.7	1.3	2.2	2.7	3.3
nC_{27}	6.6	14.5	9.9	11.4	6.6	6.7	12.5	17.7	11.5	6.0	15.5	14.3	23.6	2.9	14.7	2.0	7.5	6.9	2.4	6.5	4.5
nC_{28}	2.3	7.7	3.8	4.9	2.3	1.7	5.0	5.4	2.7	4.5	9.2	6.4	8.2	1.5	5.9	2.2	3.0	1.6	<1	2.6	2.3
nC_{29}	4.1	16.9	14.5	8.1	8.3	10.7	14.1	18.9	12.8	9.4	22.4	22.4	38.9	3.8	27.4	5.3	19.0	10.7	4.0	9.6	7.0
nC_{30}	2.9	3.4	2.5	1.7	2.4	1.5	4.2	2.5	5.5	2.9	2.8	4.4	6.4	2.5	4.9	1.6	4.0	2.2	1.3	1.9	3.3
nC_{31}	4.9	4.1	6.5	4.2	2.3	5.0	6.9	11.0	3.8	6.1	15.5	15.5	35.0	1.7	20.5	2.0	8.7	6.8	4.0	6.1	4.6
nC_{32}	2.0	2.2	2.1	1.2	<1	2.1	2.3	1.4	1.5	1.4	4.5	1.2	2.2	<1	2.9	<1	2.9	1.1	<1	<1	<1
nC_{33}	2.4	3.0	1.8	1.5	<1	1.2	2.1	4.0	1.5	2.8	3.8	4.6	10.4	<1	5.5	<1	1.7	1.1	<1	1.6	1.6
nC_{34}	4.3	3.2	2.0	1.4	<1	1.8	2.9	2.7	3.2	3.0	2.6	3.6	4.5	1.8	8.8	2.8	3.5	1.3	1.7	2.0	1.2
nC_{35}	1.5	2.9	1.8	1.5	1.1	2.3	3.8	5.9	1.5	3.3	3.5	3.4	8.1	<1	3.4	2.5	2.0	2.0	<1	<1	2.3
nC_{36}	1.1	2.3	1.2	2.2	<1	1.8	<1	1.1	2.7	3.0	3.8	3.1	4.1	<1	2.7	2.0	1.7	1.3	1.5	<1	2.4
nC_{37}	1.2	<1	1.7	<1	<1	<1	1.1	<1	<1	1.6	<1	<1	2.4	<1	1.2	<1	<1	<1	<1	<1	1.3
Total	114.4	264.1	162.6	147.0	80.1	106.2	162.7	162.3	102.6	92.8	181.9	165.3	283.2	30.1	195.1	41.4	98.6	73.6	47.2	96.8	75.8

Concentrations expressed as ng g^{-1} dry weight sediment.
<1 indicates concentrations below LOD

2.5.2 Polycyclic Aromatic Hydrocarbons

A summary of the total 2-6 ring PAH and total NPD (2-3 ring, naphthalene, phenanthrene and dibenzothiophene) concentrations are presented in Table 2.3, with a breakdown of the individual PAHs and their alkyl derivatives presented in Table 2.5. PAH bar charts, showing the proportion of parent compounds and alkylated homologues for each molecular weight class of PAH at each station are presented in Appendix J.

Total PAH concentrations ranged from 0.013µg g^{-1} at Station ENV18 to 0.248µg g^{-1} at Station ENV17 with a mean value of 0.093µg g^{-1} (0.059 SD), while NPD concentrations recorded values between 0.007µg g^{-1} and 0.097µg g^{-1} and accounted for between 31% and 53% of total PAHs values.

Further information on the source(s) of PAH in the sediment may be obtained from a study on their alkyl homologue distributions. According to Wang and Fingas (2005), pyrogenic PAHs are predominantly unalkylated, whereas petrogenic PAHs display a greater degree of alkylation. The PAH bar charts in Appendix I generally presented a mixture of alkylated LMW (2-3 ring) PAHs and parent compounds within the (4-6 ring) HMW range with a dominance of the latter. This dominance was reflected in the NPD: 4-6 ring ratio in which all stations, with the exception of Stations ENV18 and ENV23, recorded a ratio of <1, which indicated that the PAHs were predominantly higher in molecular weight. Aromatics with 2-3 rings are produced at low temperatures within hydrocarbon reservoirs and both the parent compounds and their alkyl derivatives are formed in equal concentrations. Parent compounds are generally more water soluble then their alkyl derivatives and are therefore easily lost through dilution, evaporation and bacterial degradation (Page *et al.,* 1999). Overall these results suggested a mixture of petrogenic and pyrogenic inputs. Pyrogenic inputs can include atmospheric fallout and river discharges (McDougall, 2000; Neff, 1979) while petrogenic PAHs in the area are likely to be sourced from anthropogenic activities such as shipping and oil and gas exploration.

The best estimates of the potential toxicity in marine sediments are the ERL and the ERM values. Comparison to the ERL and ERM (Long *et al.*, 1995) data required the normalisation of the PAH concentrations to 1% TOC (Appendix C.2), with normalised values reported as 4.022µg g^{-1} and 44.792µg g^{-1}, respectively. Concentrations below the ERL represent a range in which toxic effects would rarely be observed, whilst concentrations ≥ERL but ≤ERM represent a range within which effects could frequently be expected. Total PAH and NPD PAH concentrations, normalised to 1% TOC, were well below their representative ERL at all stations therefore indicating that toxic effects of PAH were unlikely.

The AETs (Buchman, 2008) represents the concentration above which adverse biological impacts would be expected by that biological indicator due to the exposure to that contaminant alone. Total 2-3 ring LMW and 4-6 ring HMW PAH concentrations were below their respective AETs (1.2µg g^{-1} and 7.9µg g^{-1}) at all stations which suggested that overall adverse biological impacts would be extremely unlikely.

Concentrations of total PAHs and NPD PAHs were noted to be positively correlated with percentages of fine sediment (Spearman's r=0.80 and r=0.76, p<0.01 Appendix H), across the HOW4 survey area, suggesting that PAH distribution was related to natural variations in sediment composition across the survey area.

2.5.3 US EPA16 PAHs

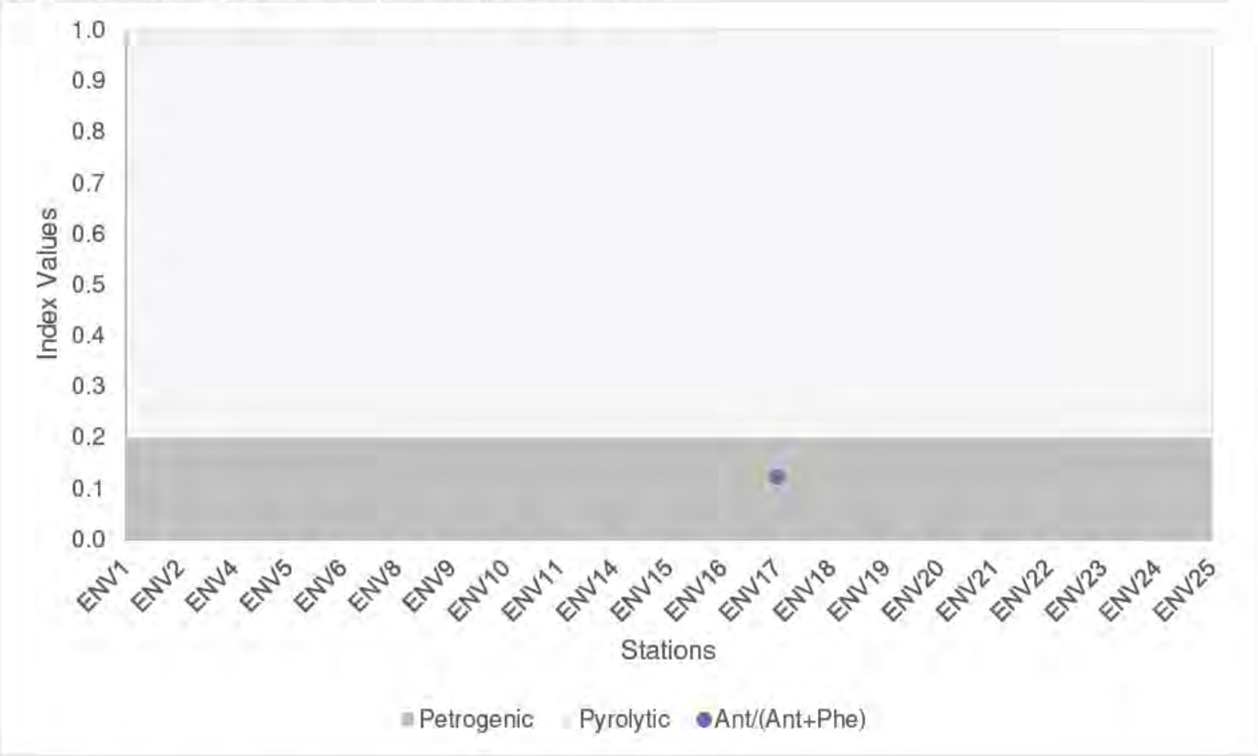
Concentrations of the US EPA 16 PAHs were compared to Long *et al.*'s ERL and ERM (1995), Buchman's AETs (2008) and OSPAR's background concentrations (BC) and background assessment concentrations (BACs; OSPAR, 2005). Comparison to the ERL and ERM requires normalisation of the data to 1% TOC (Long *et al.*, 1995), while comparison to BCs and BACs requires normalisation to 2.5% TOC (OSPAR, 2005), all of which is presented in Appendix I.

All US EPA 16 PAH concentrations were below their respective AETs, and ERL and ERMs (Buchman, 2008; Long *et al.*, 1995), indicating that there was no evidence of these individual concentrations having an ecotoxicological effect on the fauna. Eight US EPA 16 PAHs (Naphthalene, Phenanthrene, Anthracene, Flouranthene, Pyrene, Benzo[a]anthracene, Chrysene and Benzo[a]pyrene) were above their respective BC values at all stations where values were greater than the limit of detection (LOD) whilst a further two US EPA 16 PAHs (Indeno[123,cd]pyrene and Benzo[ghi]perylene) were above their respective BC values at the majority of stations where values were greater than the LOD. These patterns indicated that concentrations of US EPA PAHs were not representative of a 'pristine' environment, as described by OSPAR (2005), which could be expected considering the extent of oil and gas activities within the wider area.

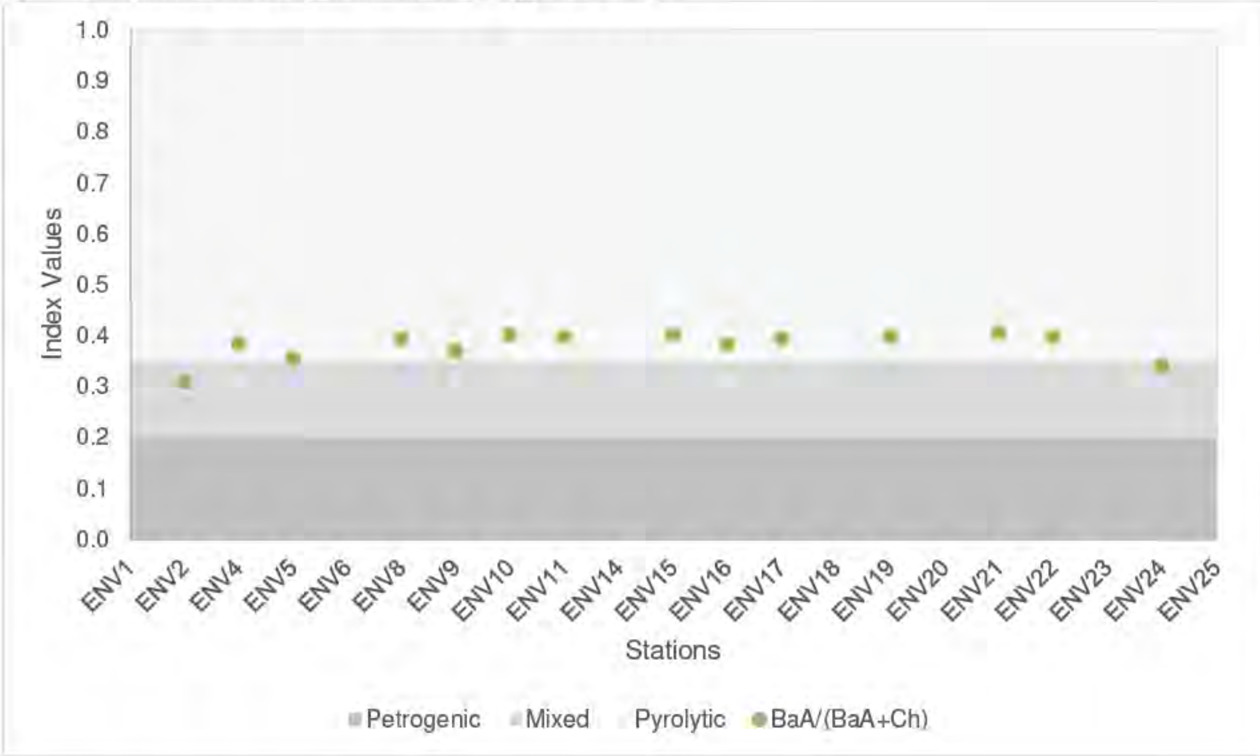
Further information on the origin of the PAHs can be derived from the molecular weight indices as presented in Figure 2.3. Calculated ratios of the 202 and 276 indices identified these US EPA 16 PAHs to be of petrogenic origin whilst the 228 indices predominantly showed a pyrolytic origin with the exception of Stations ENV2 and ENV24 which showed a mixed origin of both pyrolytic and petrogenic origin. Due to most values being below the LOD, calculations of the 178 indices were generally not possible. The only station where a value was recorded, Station ENV17, presented US EPA 16 PAHs to be of a petrogenic origin. Overall, these indices suggested a mix of petrogenic and pyrolytic sources which is corroborated by the conclusions drawn from the other hydrocarbon analyses.

Figure 2.3 PAH Molecular Weight Indices

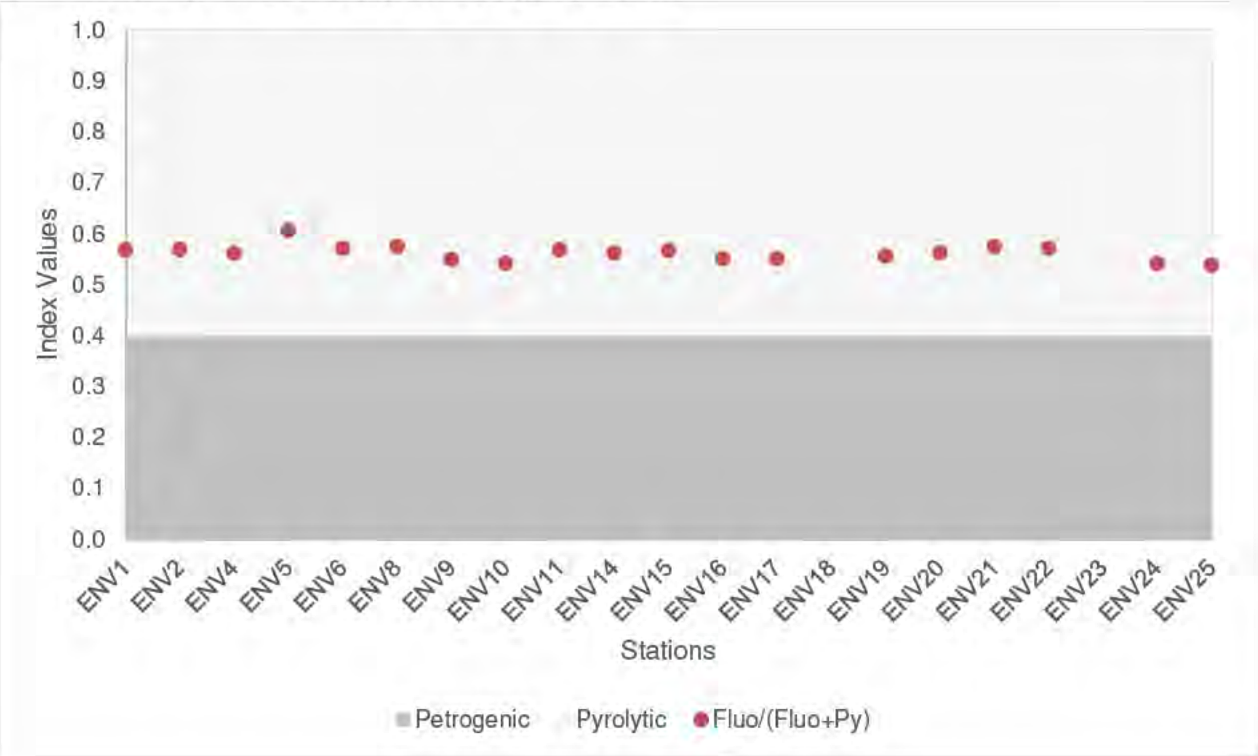
a) Calculated Ratio of 178 Molecular Weights PAH Index



c) Calculated Ratio of 228 Molecular Weight PAH Index



b) Calculated Ratio of 202 Molecular Weight PAH Index



d) Calculated Ratio of 276 Molecular Weight PAH Index

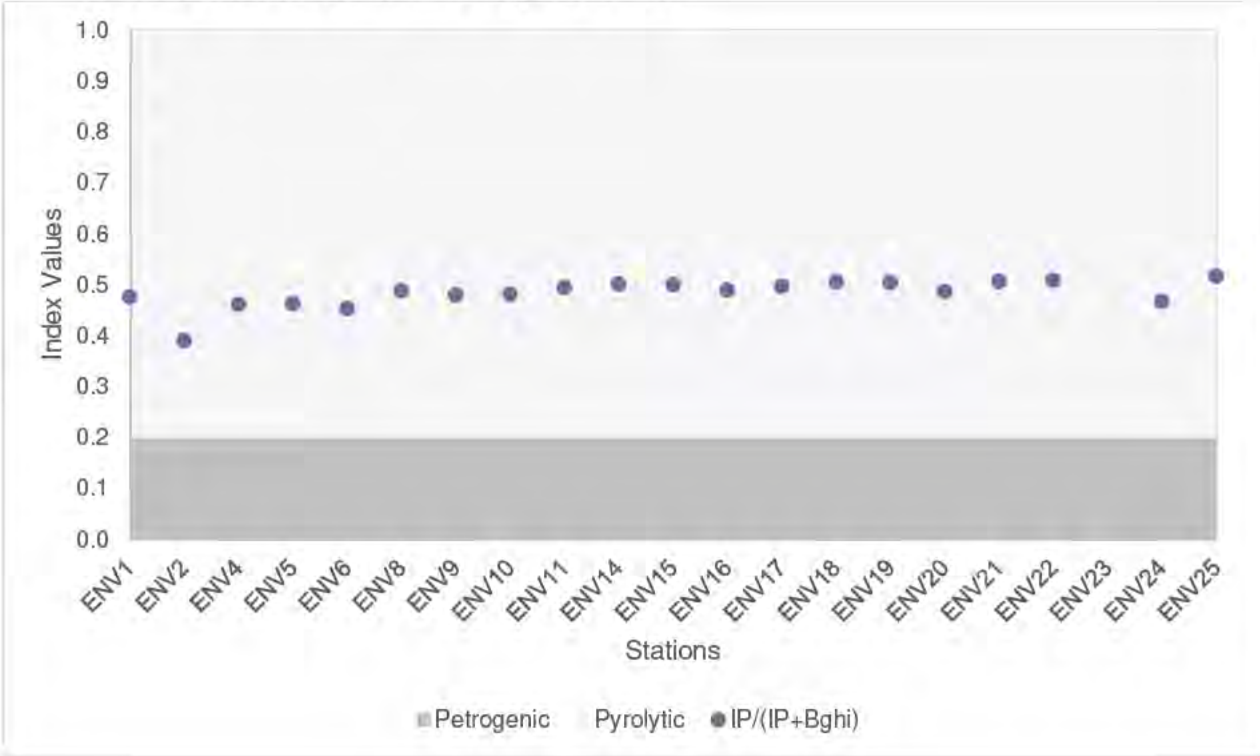


Table 2.5 PAH Concentrations

Station	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25
Naphthalene (128)	<1	<1	2	<1	<1	1	2	2	<1	<1	2	2	5	<1	2	<1	2	1	<1	1	<1
C1 128	2	4	7	2	3	4	6	6	3	3	7	8	16	1	8	2	5	4	2	5	3
C2 128	2	5	9	2	3	5	7	7	3	3	8	8	16	2	9	2	6	4	2	9	3
C3 128	2	6	8	3	4	4	7	9	3	3	8	9	13	2	9	2	5	4	2	9	3
C4 128	2	4	5	2	2	2	4	5	2	2	4	4	6	<1	4	1	2	2	<1	3	1
Total 128	8	19	32	9	12	16	26	29	11	12	28	31	56	5	32	9	21	16	6	28	9
Phenanthrene/Anthracene (178)	1	3	5	2	2	2	4	4	2	2	4	5	9	<1	5	1	3	2	1	6	2
C1 178	2	4	7	3	3	3	6	6	3	2	6	6	10	1	6	2	4	3	1	7	2
C2 178	2	4	8	3	3	4	6	8	3	3	7	7	12	1	7	2	5	4	1	6	2
C3 178	1	3	4	2	2	3	4	5	1	1	4	3	5	<1	5	<1	2	2	<1	3	1
Total 178	7	14	24	10	10	11	20	23	9	8	21	21	36	2	23	5	14	11	4	23	6
Dibenzothiophene (184)	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
C1 184	<1	<1	2	<1	<1	<1	1	1	<1	<1	<1	1	2	<1	1	<1	<1	<1	<1	<1	<1
C2 184	<1	2	2	<1	<1	<1	2	1	<1	<1	1	1	2	<1	1	<1	1	<1	<1	<1	<1
C3 184	<1	1	2	<1	<1	<1	1	1	<1	<1	<1	1	2	<1	1	<1	<1	<1	<1	<1	<1
Total 184	NC	3	5	NC	NC	NC	4	4	NC	NC	1	4	5	NC	3	NC	1	NC	NC	NC	NC
Fluoranthene/Pyrene (202)	3	6	10	6	4	5	8	10	5	4	9	9	14	<1	10	2	7	6	<1	4	2
C1 202	2	4	7	3	2	3	6	6	3	3	5	6	9	<1	6	2	4	3	1	4	2
C2 202	2	5	7	3	3	3	6	7	3	3	6	6	10	<1	6	2	4	3	1	5	2
C3 202	1	4	5	2	2	2	4	6	2	2	4	5	7	<1	5	1	3	2	1	4	1
Total 202	8	18	28	15	11	13	24	29	12	11	24	25	40	NC	26	7	17	14	3	17	7
Benzanthracene/Chrysene (228)	1	4	6	4	2	3	5	7	3	1	6	6	10	<1	6	1	4	4	<1	3	1
C1 228	1	3	4	2	2	2	4	6	2	2	4	5	8	<1	5	1	3	3	<1	3	1
C2 228	<1	3	4	2	2	2	3	6	2	2	4	4	6	<1	4	1	2	2	<1	3	1
Total 228	3	9	14	8	5	7	12	18	7	5	14	15	23	NC	15	4	10	9	NC	10	4
Benzfluoranthrenes/Benzpyrenes (252)	3	6	13	6	4	9	13	17	8	7	17	17	29	<1	19	3	13	11	<1	6	3
C1 252	2	4	7	3	3	4	6	10	4	4	9	9	14	2	9	3	6	5	2	4	2
C2 252	1	3	5	2	2	3	4	7	2	2	6	6	8	1	7	2	4	3	1	4	2
Total 252	6	13	24	11	9	16	24	34	15	13	33	31	52	3	35	7	22	20	3	14	7
Anthanthrenes/Idenopyrene/ Benzperylene (276)	3	4	9	3	4	6	9	13	6	6	14	14	23	2	16	4	10	9	1	6	4
C1 276	<1	<1	3	<1	1	2	2	3	2	1	4	3	6	<1	3	<1	2	2	<1	1	<1
C2 276	1	3	5	2	2	3	4	7	2	2	6	6	8	1	7	2	4	3	1	4	2
Total 276	4	7	16	6	7	11	16	22	10	9	24	22	37	3	26	5	15	14	2	11	6
Total NPD[1]	15	36	60	19	21	27	50	56	20	20	50	56	97	7	58	14	36	27	10	51	15
Total 2 to 6 ring PAH	36	82	142	58	52	75	125	159	65	58	145	149	248	13	159	37	100	83	19	103	39

Concentrations expressed as ng g^{-1} dry weight sediment
1 napthalenes, phenanthrenes and dibenzothiophenes
Cells in grey highlight where concentrations were below the LOD
NC = Not Calculable due to all values being below the LOD

Table 2.6 US EPA PAH Sediment Concentrations

Station	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	OSPAR (2005)	PSPAR (2005) BAC	Long et al (1995) ERL
Naphthalene	<1	<1	2	<1	<1	1	2	2	<1	<1	2	2	5	<1	2	<1	2	1	<1	1	<1	5	8	160
Acenaphthylene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	44
Acenaphthene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	16
Fluorene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	19
Phenanthrene	1	3	5	2	2	2	4	4	2	2	4	5	8	<1	5	1	3	2	1	6	2	17	32	240
Dibenzothiophene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	NA	NA	NA
Anthracene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	3	5	85
Fluoranthene	2	3	5	4	2	3	5	5	3	2	5	5	8	<1	5	1	4	3	<1	2	1	20	39	600
Pyrene	1	2	4	2	2	2	4	4	2	2	4	4	6	<1	4	1	3	2	<1	2	1	13	24	665
Benzo[a]anthracene	<1	1	2	1	<1	1	2	3	1	<1	3	2	4	<1	2	<1	2	1	<1	1	<1	9	16	261
Chrysene	1	3	3	2	2	2	3	4	2	1	4	4	6	<1	4	1	3	2	<1	2	1	11	20	384
Benzo[b]fluoranthene	2	3	5	3	2	3	5	6	3	3	7	6	10	<1	7	2	5	4	<1	3	2	NA	NA	NA
Benzo[k]fluoranthene	<1	<1	2	<1	<1	1	2	3	1	1	2	3	5	<1	2	<1	2	2	<1	<1	<1	NA	NA	NA
Benzo[a]pyrene	<1	1	2	1	<1	2	3	3	2	1	3	3	5	<1	3	<1	2	2	<1	1	<1	15	30	430
Indeno[123,cd]pyrene	1	2	4	2	2	3	5	6	3	3	7	6	11	1	7	2	5	5	<1	3	2	50	103	NA
Dibenzo[a,h]anthracene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	1	2	<1	1	<1	<1	<1	<1	<1	<1	NA	NA	63
Benzo[ghi]perylene	2	2	5	2	2	3	5	7	3	3	7	6	11	1	7	2	5	4	1	3	2	45	80	NA

Concentrations expressed as ng g^{-1} dry weight sediment
Cells highlighted in red correspond to concentrations above the BC when normalised to 2.5% TOC (OSPAR, 2005; see Appendix I)
Cells in grey highlight where concentrations were below the LOD

2.6 Metal Concentrations

Concentrations of arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), nickel (Ni), tin (Sn), vanadium (V) and zinc (Zn) were determined by ICP-MS following Aqua Regia acid extraction. Due to its volatility mercury (Hg) was extracted using Aqua Regia following digestion of the organic material on the sediment with hydrogen peroxide and subsequently analysed by ICP-MS The analytical methods are detailed in Appendix B.8. Results of the sediment metal analyses are presented in Table 2.7.

Metals concentrations varied across the HOW4 survey area. Generally higher metal concentrations were observed at Stations ENV16 and ENV17 and lower metal concentrations were observed at Stations ENV1 and ENV23. The exceptions were Cd and Ni which presented the highest concentrations at Station ENV2 and Cu which presented the highest concentrations at Station ENV24. Concentrations of Sn were below the LOD at fourteen stations. According to a Dixon's outlier test (Appendix H), concentrations of Cr ($r=0.49$, $p<0.05$) at Station ENV17, V ($r=0.45$, $p<0.05$) at Station ENV16 and Cu ($r=0.69$, $p<0.01$) at Station ENV24 were identified as statistically significant high outliers within the data set and corroborated the variable nature of the metals concentrations across the HOW4 survey area.

Results of the Spearman's rank correlation (Appendix H) illustrated significant correlations between five metals and percentage sand as well as six metals with percentage gravel. These patterns suggest that metal concentrations were linked to the sediment minerology and that the heterogeneous sand and sandy gravel sediments observed across the HOW4 survey area could be impacting on heavy metals retention within the sediments.

Metals data were directly compared to Buchman (2008) AETs. All metals were below their respective AETs at all stations indicating that toxicological impacts on the biota were unlikely.

2.7 Organotins

Concentrations of the organotins, Monobutyltin, Dibutyltin and Tributyltin (DBT, TBT and MBT) were analysed at all stations across the HOW4 survey area. The LODs for MBT, DBT and TBT were <1ng g^{-1} across the HOW4 survey area.

Values of MBT were below the LOD at all stations except for Stations ENV10, ENV 14, ENV15, ENV17, ENV19, ENV21 and ENV25 where a value of 1ng g^{-1} was recorded. Values were below the limit of detection for DBT and TBT across the HOW4 survey area.

Table 2.7 Sediment Metal Concentrations

Station		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury1	Nickel	Tin	Vanadium	Zinc
ENV1		5.9	0.05	5.8	5.9	3.8	0.02	2.9	<0.5	13.6	11.3
ENV2		21.0	0.11	8.7	7.2	6.3	0.01	7.9	<0.5	31.7	21.0
ENV4		4.4	0.06	8.1	7.1	5.1	0.01	4.2	<0.5	16.1	15.1
ENV5		15.8	0.06	6.3	5.6	5.4	0.01	3.6	<0.5	23.1	21.7
ENV6		10.9	0.06	6.9	6.1	5.1	0.01	3.5	<0.5	21.4	16.8
ENV8		4.3	0.05	7.7	5.7	5.2	0.05	4.0	0.5	16.0	16.9
ENV9		5.3	0.08	8.9	6.5	5.8	0.04	5.2	0.5	19.3	20.9
ENV10		4.2	0.07	7.9	7.2	5.7	0.03	4.0	0.5	15.7	18.5
ENV11		5.0	0.05	7.8	5.9	4.7	0.02	3.5	0.5	15.6	15.7
ENV14		4.2	0.08	7.3	6.2	5.2	0.03	3.8	<0.5	16.0	15.2
ENV15		7.2	0.07	9.5	6.2	7.2	0.03	4.1	<0.5	26.5	19.5
ENV16		31.8	0.06	10.0	7.3	12.2	0.03	6.0	<0.5	55.3	22.4
ENV17		24.2	0.05	13.5	6.5	10.8	0.05	8.0	0.6	50.3	24.8
ENV18		13.7	0.06	6.4	6.2	6.8	0.02	5.2	<0.5	24.9	23.1
ENV19		6.8	0.08	9.1	7.2	7.4	0.03	4.6	0.5	22.9	22.1
ENV20		4.9	0.06	6.1	6.9	4.1	0.01	3.1	<0.5	16.5	13.7
ENV21		7.5	0.05	10.0	6.2	7.6	0.02	4.3	<0.5	26.7	17.7
ENV22		15.3	0.06	9.7	6.2	9.6	0.02	4.3	<0.5	37.6	22.4
ENV23		6.1	<0.04	6.6	5.0	3.7	0.02	3.3	<0.5	20.5	10.8
ENV24		20.0	0.09	9.1	10.8	8.5	<0.01	6.5	0.5	33.2	22.1
ENV25		18.5	0.09	7.1	7.4	8.0	0.02	4.9	<0.5	32.4	18.3
This Study	Minimum	4.2	<0.04	5.8	5.0	3.7	<0.01	2.9	<0.5	13.6	10.8
	Maximum	31.8	0.11	13.5	10.8	12.2	0.05	8.0	0.6	55.3	24.8
	Mean	11.3	NC	8.2	6.6	6.6	NC	4.6	NC	25.5	18.6
	±SD	8.0	NC	1.8	1.2	2.3	NC	1.4	NC	11.3	3.9

Unless specified, concentrations determined by Aqua Regia digest followed by analysis by ICP-MS.

1 Concentrations determined following Aqua Regia acid digest preceded by digestion of organic matter with hydrogen peroxide.

NC Not calculated due to one or more of the values below the LOD

2.8 Macrofaunal Interpretation

2.8.1 Overview

A single $0.1m^2$ faunal sample was collected from each station and screened through a 1mm mesh sieve prior to enumeration and biomass analysis which was conducted by a third-party laboratory. Full details of the analysis methods used by the laboratory can be found in Appendix B. Before analysing the dataset provided by the laboratory, several taxa were removed as per our stated methods (Appendix B.10); however all records, regardless of whether they were included in statistical analyses, are listed in Appendix J.

2.8.2 Summary and Univariate Statistics

A total of 2,678 individuals representing 163 taxa were recorded from the 21 macrofaunal samples collected across the HOW4 survey area. Of these, juveniles accounted for 126 individuals from 9 taxa (Aphroditidae, Decapoda, *Acanthocardia*, *Arctica islandica, Mya*, Asteroidea, Ophiuroidea, Spatangoida and *Echinocardium*); representing 4.7% of the total number of individuals and 5.5% of the total number of taxa recorded. Total biomass for all samples across the HOW4 survey area equated to 200.094g with juvenile biomass totalling 2.057g and accounted for 1.0% of the total biomass recorded.

Of the 163 total taxa recorded throughout the full data set, none were observed at all stations within the survey area. A total of 54 taxa (c.33%) were present at a single station, with 34 taxa (21%) represented by a single individual. It is generally accepted that ecological communities which are frequently subjected to local disturbance or contamination events will be dominated by a limited number of tolerant taxa, which will be represented in high individual abundances (Clarke & Warwick, 2006). The relatively high numbers of single and low abundance species recorded in this survey could suggest a reasonably diverse community that has been subjected to relatively little disturbance or contamination

Juveniles, although a valid part of the community, are ephemeral in their nature due to high levels of mortality and usually have little impact on faunal communities. To determine whether the presence of juveniles caused a significant variation between the rationalised full and rationalised adult only (with all the juveniles removed) data sets, a RELATE analysis was conducted in PRIMER (v7). The result of the RELATE analysis revealed that the two data sets were 98% similar which indicated that there was no significant differences between the two data sets. Additionally, OSPAR (2017b) recommend that, should juveniles appear among the top ten most dominant taxa in a data set, statistical analyses of the faunal community should be conducted both without and with juveniles to illustrate their influence on the faunal community. A single juvenile taxon (Spatangoida) appeared within the top ten most dominant taxa in the data set, however the discussion of the faunal community analysis will be made using the adult only data set to avoid skewing the results with the abundant but largely ephemeral juvenile taxa.

Three juvenile ocean quahog, (*A. islandica)*, a species of conservation importance, were recorded within the data set, with single individuals identified at Stations ENV6, ENV15 and ENV25respoectively with a total biomass of $7.200*10^{-3}$g. The identification of *A. islandica* within the fauna data set corroborates the presence of *A. islandica* individuals tentatively identified from the sieved grab samples. *A. islandica* is a long-lived species with a slow growth rate and is listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008), as well as listed under the Marine Conservation Zone (MCZ) guidance as a species FOCI (Natural England and Joint

Nature Conservation Committee, 2010). Their presence is indicative of the general suitability of the sandy sediments within the area for *A. islandica*; it is commonly found within this area of the North Sea (Oil and Gas U.K., 2010; NBN atlas, 2018) with populations of 40-80 year old specimens observed, with a substantial proportion over a 100 years old (OSPAR, 2009b).

A single lesser sand eel (*Ammodytes tobianus*) was identified at Station ENV2 with a biomass of 1.805g. *A. tobianus* is a species of sand eel which lives in the water column above sandy sediments from the shore line to 200m depth. It is a species which is listed under Section 41 of the NERC Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as a conservation priority in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra, 2012).

Initially, the adult data set was divided into five major taxonomic groups: Annelida (Polychaeta), Arthropoda (Crustacea), Mollusca, Echinodermata and 'Others'. The 'Other' group comprised four taxa of Cnidaria (*Cerianthus lloydii,* Actinaria*, Edwardsiidae*, *Edwardsia claparedii*), and a single taxon of each of the following; Fominifera (Astrorhiza), Hemichordata (Enteropneusta), Nemertea, Phoronida (*Phoronis*) and Platyhelminthes. The absolute and proportional contributions of these five taxonomic groups to the overall community structure is summarised in Table 2.8 whilst biomass values, as well as proportional contribution by gross taxonomic groups, are presented in Table 2.9. The contributions of the five taxonomic groups toward individual and taxa totals are illustrated as stacked bar charts in Figure 2.4 whilst the contribution of gross taxonomic groups to total biomass within each sample is presented in Figure 2.5.

Across the HOW4 survey area the adult faunal community was generally dominated by a combination of Annelida (Polychaeta; n=723), Mollusca (n=755) and Echinodermata (n=710) contributing 28%, 30% and 28% of the total adult individuals observed, respectively. At individual stations, gross taxonomic group dominance was variable with Annelida dominating at five stations and ranging from 35% to 60% of the total species at each station. Mollusca dominated at eight stations and ranged between 40% and 75% of the total species at each station whilst Echinodermata dominated at six stations ranging from 31% to 70% of the total species at a station. Two Stations (ENV2 and ENV24) were dominated by Arthropoda with contributions of 47% and 56% respectively.

Biomass data were equally variable and tended to be dominated by single large specimens of Arthropoda, Mollusca and Echinodermata particularly at stations which recorded a total biomass greater than 3g.

Mollusca (n=755) were the most abundant taxonomic group in the adult data set contributing 30% of total individuals and 23% of total taxa observed across the survey area. The bivalve mollusc *Abra* (n=458) was the most dominant species within the Mollusca group, contributing 60% of total individuals and 18% of total individuals within the data set. The Mollusca group (47.095g) had the second highest weight in the adult biomass data set accounting for 24% of total biomass across the survey area. Upon review of the data, a single razor clam (*Ensis ensis*) observed at Station ENV5 weighing 13.470g contributed 29% of the total biomass within the group. Additionally, biomass values in this group generally comprised single large individuals >1g.

Echinodermata (n=710) was the joint second most abundant taxonomic group accounting for 28% of all recorded individuals and 6% of total taxa observed across the survey area. As with the Mollusca group, a single taxon, *Amphiura filiformis* (n=508), was responsible for the dominance for 72% of the total Echinodermata abundance and 20% of the total abundance overall. Within the data set individual large specimens of the sea potato *Echinocardium cordatum* were responsible for 86% of the total

Echinodermata biomass and 68% of the total recorded biomass across the HOW4 survey area. The high percentage contribution of this species to the overall total biomass could be due to the size of the organism and/or weight of its protective calcite skeleton.

Annelida (Polychaeta; n= 723), although the joint second most abundant taxonomic group contributing 28% of individuals, this group contributed the highest number of taxa representing 38% of the total taxa observed across the HOW4 survey area. The higher number of taxa present within the Annelida group suggested that this group was more evenly distributed than the other two dominant groups within the data set. Annelida contributed 6% of the total biomass recorded across the HOW4 survey area, which, given the contribution of Annelida to total individuals and total taxa numbers, again suggested a more evenly distributed community with many small individual Annelids rather than single large organisms dominating the data set.

In contrast, Arthropoda only contr buted 11% of individuals and 27% of taxa. The “Other” group included taxa that were intentionally grouped to phylum and represented a lower contribution of individuals (3%), but a slightly higher contribution towards total taxa (6%). Arthropoda contributed 11% towards the total biomass value whilst the 'Others' group contributed 1%.

There was apparent variation in the total individual abundance of adult fauna across the HOW4 survey area which ranged from 46 individuals at Station ENV18 to 322 individuals at Station ENV19. Upon review of the raw data, the variation identified within the faunal community appeared to be due to localised variations in abundance values of the bivalve *Abra* and the brittle star *A. filiformis*.

Table 2.8 Contribution of Gross Taxonomic Groups – Adult Data Set

Group	Individuals		Taxa	
	Abundance	Proportional Contribution %	Abundance	Proportional Contribution %
Annelida (Polychaeta)	723	28	58	38
Arthropoda	284	11	41	27
Mollusca	755	30	36	23
Echinodermata	710	28	10	6
Others	80	3	9	6
Total	**2552**	**100**	**154**	**100**

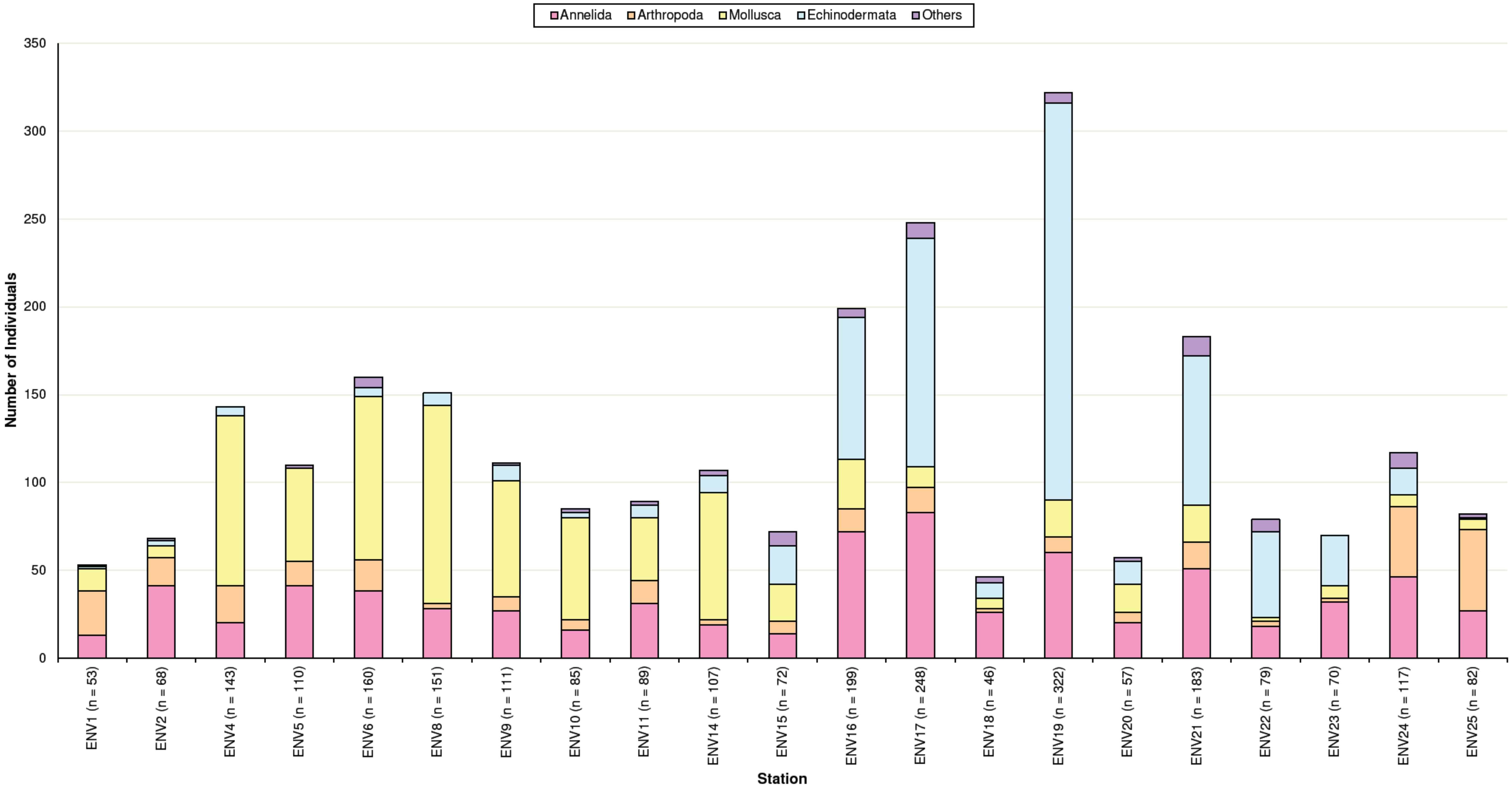
Table 2.9 Contribution of Biomass to Gross Taxonomic Groups – Adult Data Set

Sample	Sample Biomass (g)					Subtotal
	Annelida	Arthropoda	Mollusca	Echinodermata	Other	
ENV1	0.416	0.030	0.271	4.882	0.228	5.827
ENV2	0.608	0.014	0.272	54.655	0.005	55.555
ENV4	0.416	0.023	0.324	0.008	0.000	0.771
ENV5	0.906	0.012	13.709	0.000	0.007	14.634
ENV6	0.775	0.063	0.210	0.037	0.019	1.104
ENV8	0.178	0.018	4.731	0.022	0.000	4.950
ENV9	0.508	0.323	0.310	0.009	0.000	1.149
ENV10	0.278	0.014	3.313	0.019	0.014	3.638
ENV11	0.267	0.027	0.986	0.008	0.001	1.290
ENV14	0.395	0.011	0.120	0.045	0.005	0.576
ENV15	0.210	0.009	0.066	0.116	0.065	0.465
ENV16	0.366	0.144	3.181	2.370	0.111	6.172
ENV17	0.979	1.016	0.028	3.496	0.018	5.536
ENV18	0.375	0.004	0.134	0.762	0.053	1.327
ENV19	0.631	0.400	0.489	17.471	0.117	19.107
ENV20	1.249	0.017	4.272	0.146	0.074	5.758
ENV21	0.499	0.093	3.309	10.375	0.473	14.748
ENV22	0.125	0.006	0.002	9.228	0.007	9.369
ENV23	0.713	0.008	3.919	30.899	0.000	35.539
ENV24	2.530	0.087	2.756	0.093	0.033	5.498
ENV25	0.205	0.100	4.693	0.002	0.025	5.025
Total	**12.628**	**2.419**	**47.095**	**134.641**	**1.254**	**198.037**
Proportional Contribution	**6.4**	**1.2**	**23.8**	**68.0**	**0.6**	**100.0**

Cells highlighted grey where no biomass observed

Figure 2.4 Contributions of Gross Taxonomic Groups – Adult Fauna Data

a) Individuals



b) Taxa

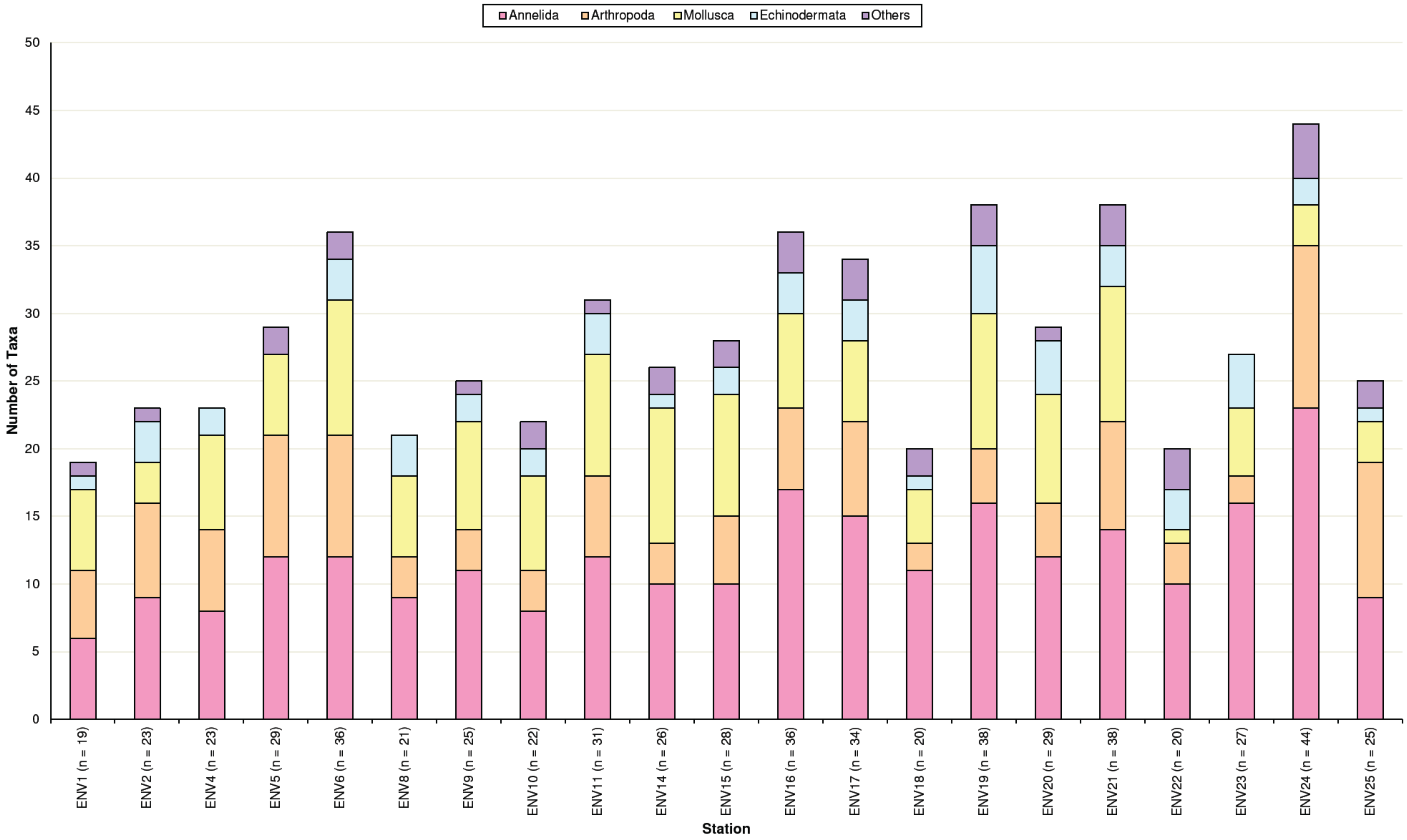
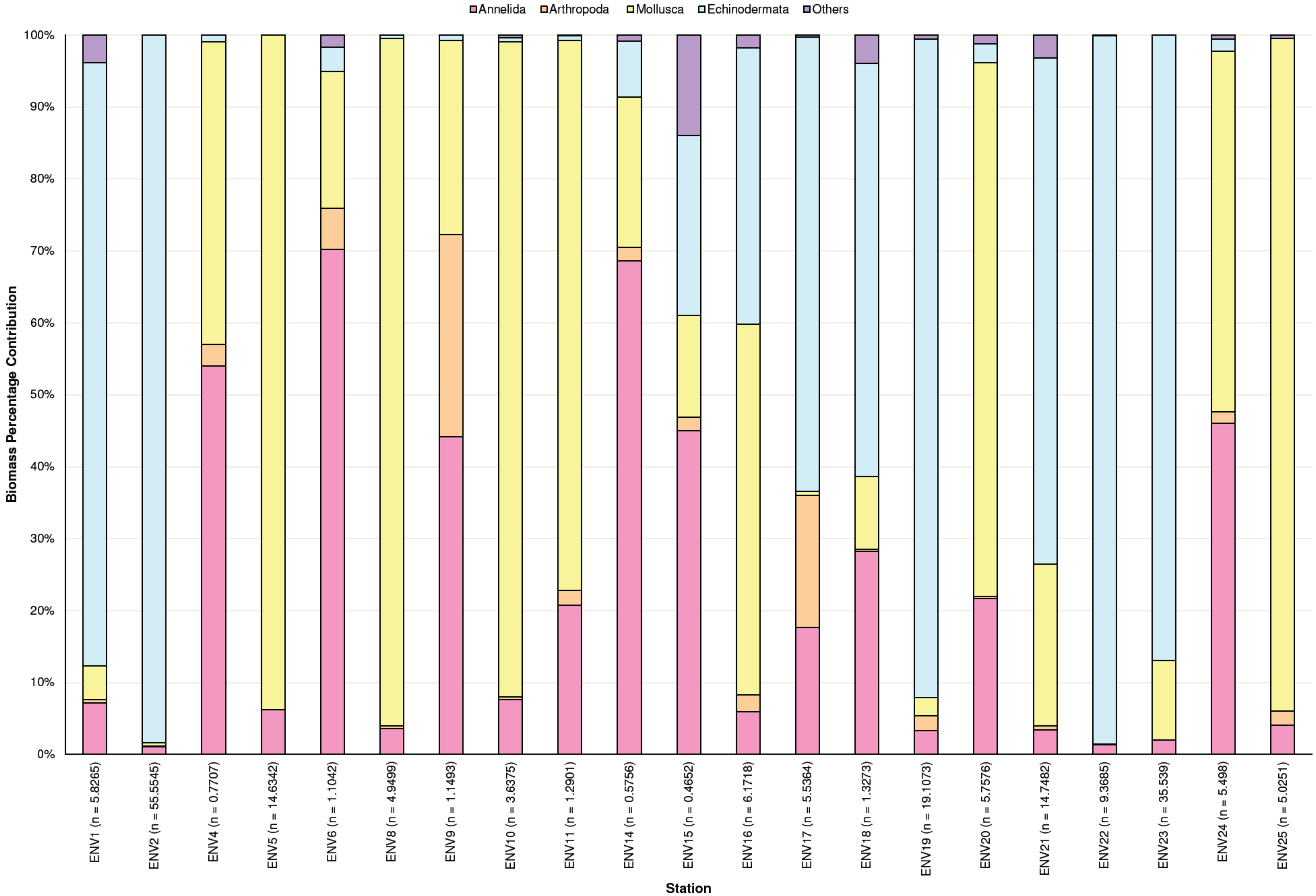

Annelida
Arthropoda
Mollusca
Echinodermata
Others
Number of Taxa
0
5
10
15
20
25
30
35
40
45
50
ENV1 (n = 19)
ENV2 (n = 23)
ENV4 (n = 23)
ENV5 (n = 29)
ENV6 (n = 36)
ENV8 (n = 21)
ENV9 (n = 25)
ENV10 (n = 22)
ENV11 (n = 31)
ENV14 (n = 26)
ENV15 (n = 28)
ENV16 (n = 36)
ENV17 (n = 34)
ENV18 (n = 20)
ENV19 (n = 38)
ENV20 (n = 29)
ENV21 (n = 38)
ENV22 (n = 20)
ENV23 (n = 27)
ENV24 (n = 44)
ENV25 (n = 25)
Station

Figure 2.5 Percentage Biomass Contribution to Gross Taxonomic Groups - Adult Fauna Data



Species ranking provides additional information on the dominance structure of the faunal community within the HOW4 survey area and is presented by adult only abundance in Table 2.10 and by adult only biomass in Table 2.11. Of the top ten most dominant taxa within the adult abundance data set; two were Mollusca (*Abra* and *Fabulina fabula*), two were Echinodermata (*Amphiura filiformis* and *Amphiuridae*), five were Annelida (*Spiophanes bombyx, Lagis koreni, Scoloplos armiger, Amphictene auricoma and Nephtys cirrosa*), and one from the 'Others' group (Nemertea). Of the top ten most dominant taxa within the adult only biomass data set two were Echinodermata (*Amphiura filiformis*, and *Echinocardium cordatum*), seven were Annelida (*Nephtys cirrosa*, *Lagis koreni*, *Sigalion mathildae*, *Sthenelais limicola*, *Scalibregma inflatum, Scoloplos armiger* and *Nephtys caeca*), and one Mollusca (*Dosinia lupinus*). Four taxa (*Amphiura filiformis, Lagis koreni, Scoloplos armiger* and *Nephtys cirrosa)* were present in the top ten of both the species ranking by abundance and the species ranking by biomass.

The echinoderm *A. filiformis* was the second most abundant species as well as the highestranking species in terms of biomass across the HOW4 survey area. It is described as favouring finer or muddy sediments (Daan & Mulder, 2002b) and can tolerate some smothering and hypoxia as its arms bioturbate the sediment, protruding out into the water column and allowing an influx of oxygen (Vopel *et al*., 2003). It should be noted that abundances varied across the survey area and abundances were higher at stations that had a greater fines component of the sediment. *A. filiformis* is highly sensitive to synthetic chemicals and hydrocarbons (Eggleton *et al*., 2007b).

The annelid *S. bombyx* was ranked third with the abundance ranking in the adult data set. It is reportedly tolerant to both smothering (Hiscock *et al*., 2004) and substratum loss (Desprez, 2000; van Dalfsen *et al*., 2000). Consequently, this polychaete may be found over a range of sediment types (Moulaert *et al*., 2007). Indeed, *S. bombyx* was observed to be the most frequently distributed species in the entire North Sea in a pooled data set of the North Sea Benthos Survey and the Ministry of Agriculture, Fisheries and Food cruises (Heip & Craeymeersch, 1995). Rees (1983) reported *S. bombyx* to be a short-lived annelid with high reproductive potential and thus enabled this polychaete to dominate conditions which had high physical disturbance from wave and tidal action. Consequently, this polychaete may be found over a range of conditions and substratum types (Moulaert *et al*., 2007). This species is reportedly intolerant of hydrocarbon and nutrient enrichment (Shillabeer & Tapp, 1990; Olsgard & Gray, 1995).

The mollusc *F. fabula* was ranked fourth in the adult abundance ranking and is a species which feeds using an inhalant siphon that protrudes above the sediment surface. This mollusc is intolerant to any form of smothering or dramatic increase in sedimentation (Hiscock *et al*., 2002). The mollusc *F. fabula* is found at depths of up to 100m in fine and medium sands (Van Hoey *et al*., 2004). This species is also highly intolerant of other forms of physical disturbance, organic enrichment and hydrocarbons (Hiscock *et al*., 2004). Its presence in abundance is therefore a potential indicator of undisturbed 'clean' sediments.

N. cirrosa has shown a capacity to manage with the impact of smothering as it does not rely on well maintained and structurally stable burrow. However, this species has been shown to be unable to tolerate physical disturbance (Tuck *et al*., 1998). Desroy *et al*. (2002) showed *N. cirrosa* to favour sandy rather than muddy sediments in the SNS, although there may be some degree of flexibility. *N. cirrosa* is a typical species from the south western North Sea (Rees *et al*., 2007), inhabiting a wide variety of sediment types, from littoral sands and muddy sands to sublittoral cobbles, gravel, coarse sands and muds.

The fidelity of the species ranking can give an indication of the taxonomic distribution, with values of ≥0.8 and <1.2 indicating a generally evenly distribution community, while values outside this range representing a patchier distribution. Within the adult data set a single taxon (*Amphictene auricoma*) presented fidelity scores within this range which indicated that their dominance was relatively stable across the HOW4 survey area. Fidelity scores for all other species suggested that there was a dominance structure within individual communities which could be expected given the large area surveyed and the range of sediment types observed across the HOW4 survey area.

The species ranking presented a reordering of the taxa when ranked purely by abundance, indicating an uneven distribution of these species and a heterogenous faunal community. This was expected given the geographical range and variation in the sand and gravel composition.

Table 2.10 Species Ranking by Abundance – Adult Fauna Data

Rank		Species/Taxon	Total Rank Score	Fidelity	Total Abundance
Score	Abundance				
1	2	*Abra*	124	0.59	458
2	1	*Amphiura filiformis*	111	0.59	508
3	8	*Spiophanes bombyx*	89	0.53	59
4	5	*Fabulina fabula*	76	0.52	72
5	10	*Lagis koreni*	71	0.56	46
6	13	*Scoloplos armiger*	68	0.65	43
7	3	Amphiuridae	66	0.79	96
8	10	*Amphictene auricoma*	64	1.02	46
8	14	Nemertea	64	1.52	36
10	12	*Nephtys cirrosa*	62	2.95	44
Species which were in top ten abundance rank but not top ten rank score					
14	4	*Scalibregma inflatum*	49	NC	88
15	6	*Echinocyamus pusillus*	47	NC	70
17	7	*Pholoe*	45	NC	60
11	9	*Ophelia borealis*	61	NC	54

Cells are coloured to indicate the gross taxonomic division. Annelida, Echinodermata, Mollusca and Others.

Table 2.11 Species Ranking by Biomass – Adult Fauna Data

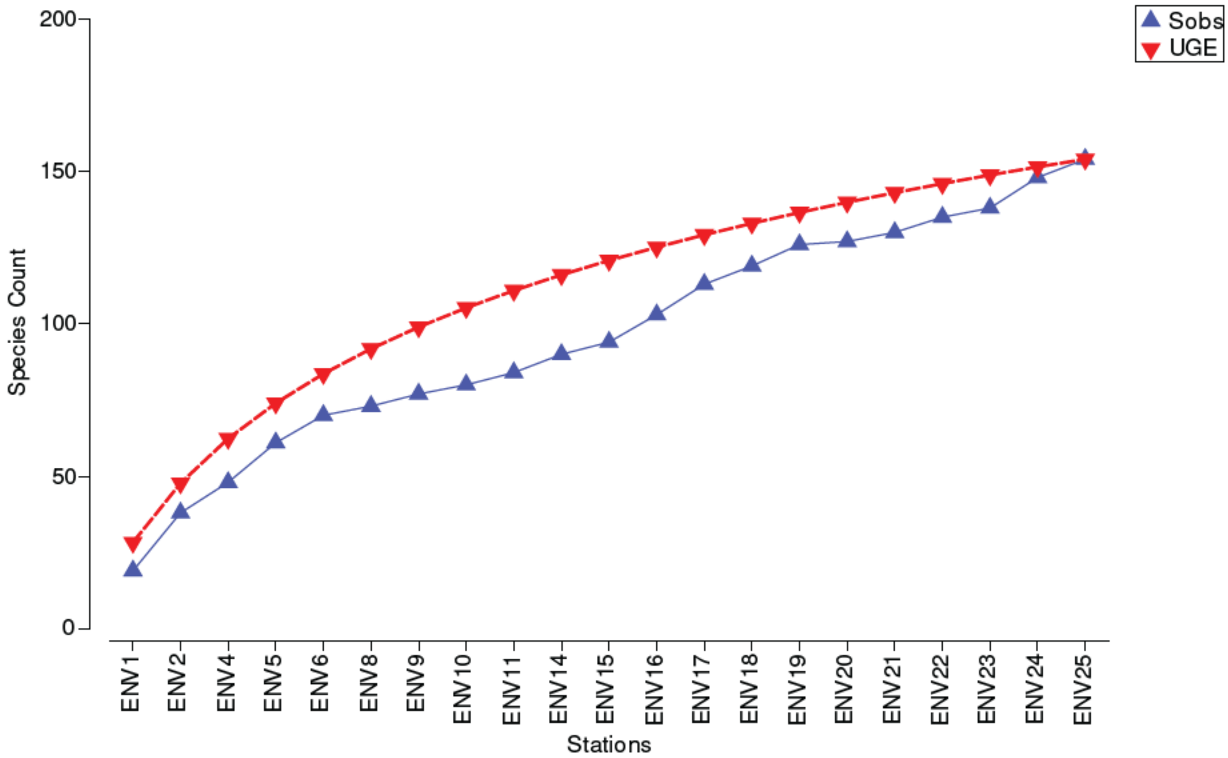
Rank		Species/Taxon	Total Rank Score	Fidelity	Total Biomass
Score	Biomass				
1	5	*Amphiura filiformis*	79	0.38	6.93
2	1	*Echinocardium cordatum*	60	0.32	115.33
3	17	*Nephtys cirrosa*	59	0.35	0.99
4	20	*Lagis koreni*	46	0.31	0.72
5	2	*Dosinia lupinus*	40	0.32	14.80
6	14	*Sigalion mathildae*	39	0.37	1.02
7	27	*Sthenelais limicola*	37	0.44	0.43
8	16	*Scalibregma inflatum*	36	0.57	1.00
9	23	*Scoloplos armiger*	35	0.83	0.59
10	6	*Nephtys caeca*	34	1.62	3.65
Species which were in top ten biomass rank but not top ten rank score					
36	3	*Ensis ensis*	10	NC	13.47
21	4	*Echinocardium*	19	NC	8.0532
18	7	*Chamelea striatula*	22	NC	3.5616
14	8	*Dosinia*	28	NC	3.4885
40	9	*Gari fervensis*	9	NC	3.332
36	10	*Mactra stultorum*	10	NC	3.2345

Cells are coloured to indicate the gross taxonomic division. Annelida, Echinodermata and Mollusca.

A species accumulation plot for the full data set is presented in Figure 2.6. The plot presents the increasing total number of different taxa observed as stations are successfully pooled. Two lines are plotted; the first (plotted in blue) adds the new taxa to those already recorded in station order (often referred to as the Sobs curve). The second curve (plotted in red) is smooth, as it is an average output based on the samples being added in random order 999 times (often referred to as a UGE curve; Ugland *et al.*, 2003)

The Sobs curve was below the UGE curve for all stations with the exception of Station ENV25, indicating that fewer species were elicited at these stations than would be expected. Significant changes in the slope of the Sobs curve compared to the UGE curve can be an indication of differences in the community composition. A steeper Sobs curve when compared to the UGE curve indicates a higher recruitment of new taxa than average for the HOW4 survey area. The Sobs curve rises steeply from Station ENV1 and therefore suggested a change in community with the additions of new taxa present at Stations ENV2 to ENV6, before levelling out between Stations ENV8 and ENV15. Additionally, the Sobs curve can be seen to increase between Stations ENV16 to ENV19 and with the addition of Station ENV24. The Sobs and UGE curves continue to rise with the addition of the last sample which indicated that further sampling would be required to fully characterise the benthic macrofaunal community within the HOW4 survey area.

Figure 2.6 Accumulation Plot – Adult Fauna Data



The adult only data set was analysed to provide the total number of individuals and taxa, the Shannon-Wiener diversity index (H') was calculated using logarithm base 2 (Shannon & Weaver, 1949), Simpson's dominance (λ), Pielou's evenness (J) and Margalef's index (d). Increasing values of the Shannon-Wiener diversity index corresponds to increasing diversity of the community. Values for the Simpson's dominance index and Pielou's evenness both range from 0 to 1, with 1 indicating a dominated community for the former and an even community for the latter. Margalef's index (d) takes account of the number of species present for a given number of individuals. Detailed information on methods for univariate statistics is presented in Appendix B.11.2.

The univariate statistics for the adult only data set are presented per station (0.1m^2) in Table 2.12. Shannon-Wiener diversity values ranged from 2.07 at Station ENV8 to 4.91 at Station ENV24 and indicated that species diversity varied across the HOW4 survey area. Pielou's evenness suggested a relatively even community with values between 0.48 at Station ENV8 and 0.93 at Station ENV20, while Simpson's dominance values ranged between 0.05 at Station ENV20 to 0.48 at Station ENV8. These values generally indicated low species dominance across the majority of the survey area with the possible exception of Station ENV8.

Both Pielou's evenness and Simpson's dominance values observed at Station ENV 8 suggested that one or a few species were creating a relatively uneven community at the Station. Upon review of the raw adult data set it was revealed to be due to the higher abundance of the bivalve mollusc *Abra* which accounted for 68% of the total individuals recorded at this station.

Overall, the pooled station univariate statistics indicated a generally diverse and evenly distributed community with a lack of notable dominance structure. Examination of the taxonomic data at each station, highlighted the most abundant taxa, *Abra* and *Amphiura filiformis* to be responsible for much of the variation.

Table 2.12 Faunal Univariate Statistics – Adult Fauna Data

Station		n Taxa	n Individuals	Margalef's Richness (*d*)	Simpson's Dominance (λ)	Pielou's Evenness (*J*)	Shannon Wiener Diversity (H'log^2)
ENV1		19	53	4.53	0.09	0.89	3.78
ENV2		23	68	5.21	0.11	0.83	3.74
ENV4		23	143	4.43	0.32	0.62	2.83
ENV5		29	110	5.96	0.20	0.72	3.50
ENV6		36	160	6.90	0.15	0.74	3.83
ENV8		21	151	3.99	0.48	0.47	2.07
ENV9		25	111	5.10	0.15	0.76	3.53
ENV10		22	85	4.73	0.25	0.69	3.10
ENV11		31	89	6.68	0.08	0.85	4.24
ENV14		26	107	5.35	0.23	0.70	3.27
ENV15		28	72	6.31	0.09	0.86	4.13
ENV16		36	199	6.61	0.14	0.75	3.88
ENV17		34	248	5.99	0.31	0.56	2.83
ENV18		20	46	4.96	0.10	0.89	3.85
ENV19		38	322	6.41	0.33	0.54	2.83
ENV20		29	57	6.93	0.05	0.93	4.54
ENV21		38	183	7.10	0.21	0.70	3.65
ENV22		20	79	4.35	0.24	0.69	2.97
ENV23		27	70	6.12	0.10	0.85	4.03
ENV24		44	117	9.03	0.06	0.88	4.78
ENV25		25	82	5.45	0.17	0.76	3.54
This Study	Minimum	19	46	3.99	0.05	0.47	2.07
	Maximum	44	322	9.03	0.48	0.93	4.78
	Mean	28	122	5.82	0.18	0.75	3.57
	±SD	7	70	1.20	0.11	0.13	0.64

2.8.3 Multivariate Analyses

In comparison to univariate statistics, multivariate analyses enable subtler trends within the adult only data set to be identified. Multivariate analyses were performed on the rationalised abundance and rationalised biomass adult only data sets using PRIMER v7 (Plymouth Marine Laboratories). Prior to undertaking analyses, the adult only abundance data set was subjected to square-root transformation whilst the adult only biomass data set was subjected to a fourth-root transformation. Both transformations were conducted in order to down-weight the influence of the more numerically dominant species in the abundance data and down-weight the heavier species in the biomass data set. These transformations also helped to ensure that the intermediate and sparse values contributed to the multivariate pattern. Two Bray-Curtis similarity matrix was produced based on the transformed adult only abundance data and the transformed adult only biomass data on the, from which CLUSTER routines, SIMPROF routines (using 999 permutations, 95% significance level), and nMDS routines were performed.

A SIMPROF permutation test was conducted in conjunction with CLUSTER analysis for both the abundance and biomass adult only data sets and the results were visualised on two dendrograms. Red lines on the dendrogram join statistically indistinguishable stations together, while black lines join stations which are different from one another. Due to the permutative nature of the SIMPROF test, only three or more stations joined together by the red lines may be considered as a true cluster while two joined stations are considered a closely associated pair. The Bray-Curtis similarity dendrograms and nMDS ordination for the adult only abundance data set are presented in Figure 2.7 whilst the Bray-Curtis dendrogram and nMDS plot for the adult only biomass data set are presented in Figure 2.8.

The CLUSTER analysis and dendrogram of showed variation in the adult only abundance data set (Figure 2.7a). The CLUSTER analysis presented three distinct broadscale groups (group A, group B and group C). Broad group A (SIMPROF a; Stations ENV25, ENV2, ENV18, ENV22, ENV20 and ENV23) was separated from all the other stations at a similarity of 20.0%. A single outlier and a cluster (SIMPROF b; ENV24 and SIMPROF c; ENV21, ENV17, ENV16 and ENV19) comprised broad group B and was separated from broad group C at a Bray-Curtis similarity of 20.4%. Broad group C consisted of an outlier, two pairs and a cluster (SIMPROF d; ENV1, SIMPROF e; ENV14 and ENV15, SIMPROF f; ENV9, ENV10, ENV11, ENV14 and ENV8; SIMPROF g; ENV5 and ENV6). Within broad group B, the outlying Station ENV24 (SIMPROF d) was separated from SIMPROF c at a Bray-Curtis similarity of 33.8%. Within broad group C the outlier Station ENV1 (SIMPROF d) was separated from the remaining stations within the broad group at a similarity of 28.0%.

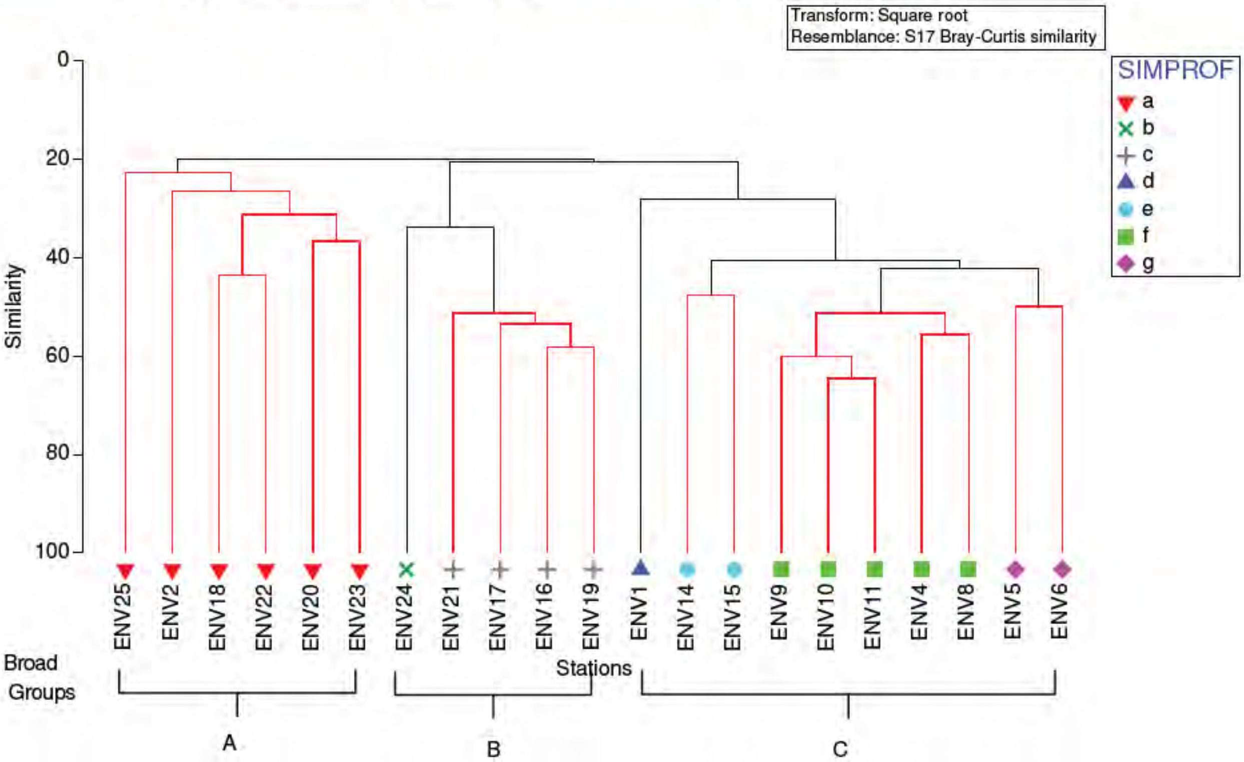
The CLUSTER analysis and dendrogram of the adult only biomass data (Figure 2.8a) identified two broad groups separated at a nominal Bray-Curtis similarity of 19.7%. A cluster of seven stations (SIMPROF a; ENV8, ENV14, ENV4, ENV9, ENV15, ENV10 and ENV11) was separated from a cluster of three stations (SIMPROF b; ENV5, ENV1 and ENV6) within broad group A at a Bray-Curtis similarity of 28.7%. Within broad group B, a cluster of seven stations (SIMPROF c; ENV16, ENV17, ENV19, ENV21, ENV23, ENV20 and ENV24) were separated from a cluster of four stations (SIMPROF d; ENV25, ENV2, ENV18, ENV22) at a Bray-Curtis similarity of 21.2%.

The patterns observed within both the adult only abundance data set and the adult only biomass data set were corroborated in the nMDS plots (Figure 2.7b and Figure 2.8b). With stress factors of 0.12 and 0.18 respectively both nMDS plots can be considered a useful representation of rank (dis)similarities and the overall patterns observed in the data.

Examination of the raw adult only abundance data in conjunction with a SIMPER analysis indicated that a range of species contributed to the observed dissimilarity between stations and broad groups of stations. Within the adult only abundance data set, broad group A was separated from groups B and C due to the absence or relatively lower abundances of the bivalve *Abra* and the brittle star *A. filiformis* and the relatively higher abundance of the pea urchin (*Echinocyamus pusillus*) within group A. Broadscale groups B and C were separated due to relatively higher abundances of *A. fuliformis* and the relatively lower abundances of *Abra*. Within broad group B, Station ENV24 was considered an outlier due to relatively lower abundance of *A. filiformis*. The outlier station observed within broad group C (ENV1) was separated from the remaining stations within broad group C due to the relatively lower abundance of *Abra* compared to the other stations within the group. All remaining stations within broad group C presented relatively higher abundances of the arthropod *Bathyporeia elegans*. Comparison of the rationalised adult only biomass data with a SIMPER analysis suggested that the two broadscale groups identified were due to the absence of *E. cordatum and Dosina lupinus* and the absence or relatively lower weights of *A. filiformis*.

Figure 2.7 Multivariate Analysis of Faunal Data – Adult Fauna Data by Stations

a) Bray-Curtis Similarity Dendrogram



b) MDS Ordination

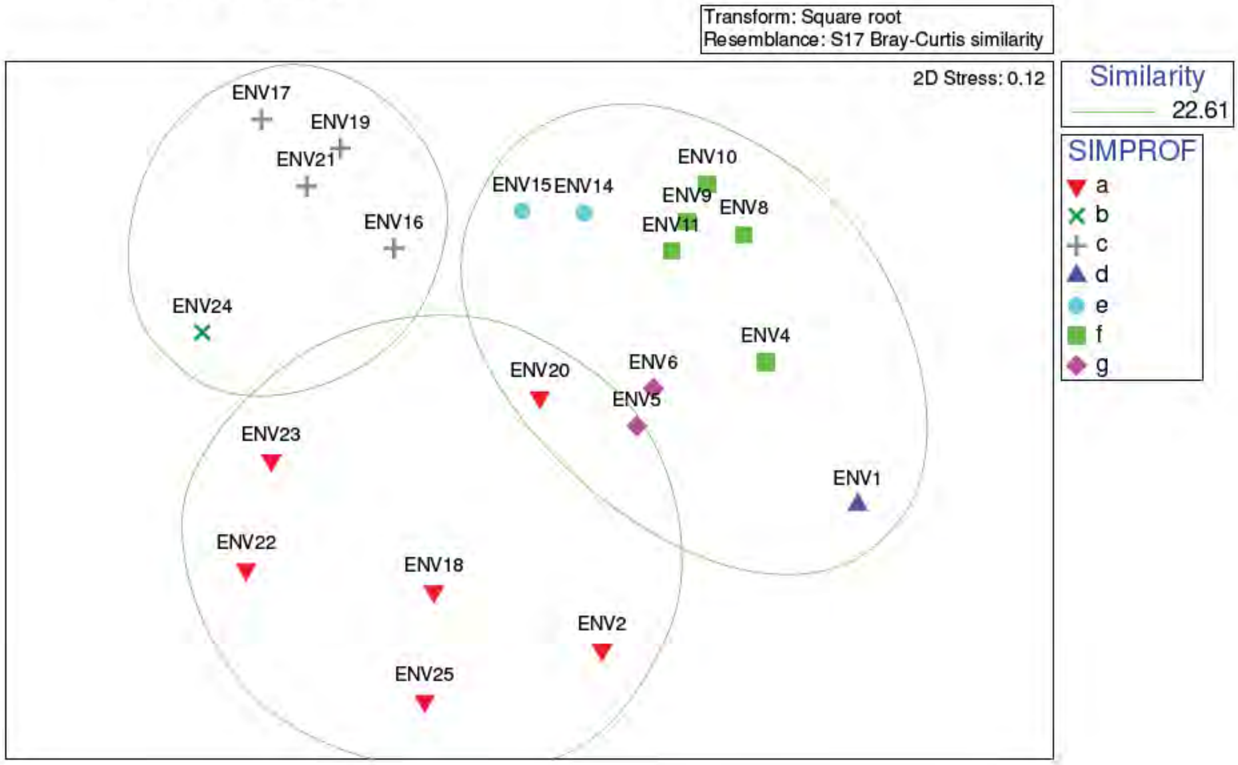
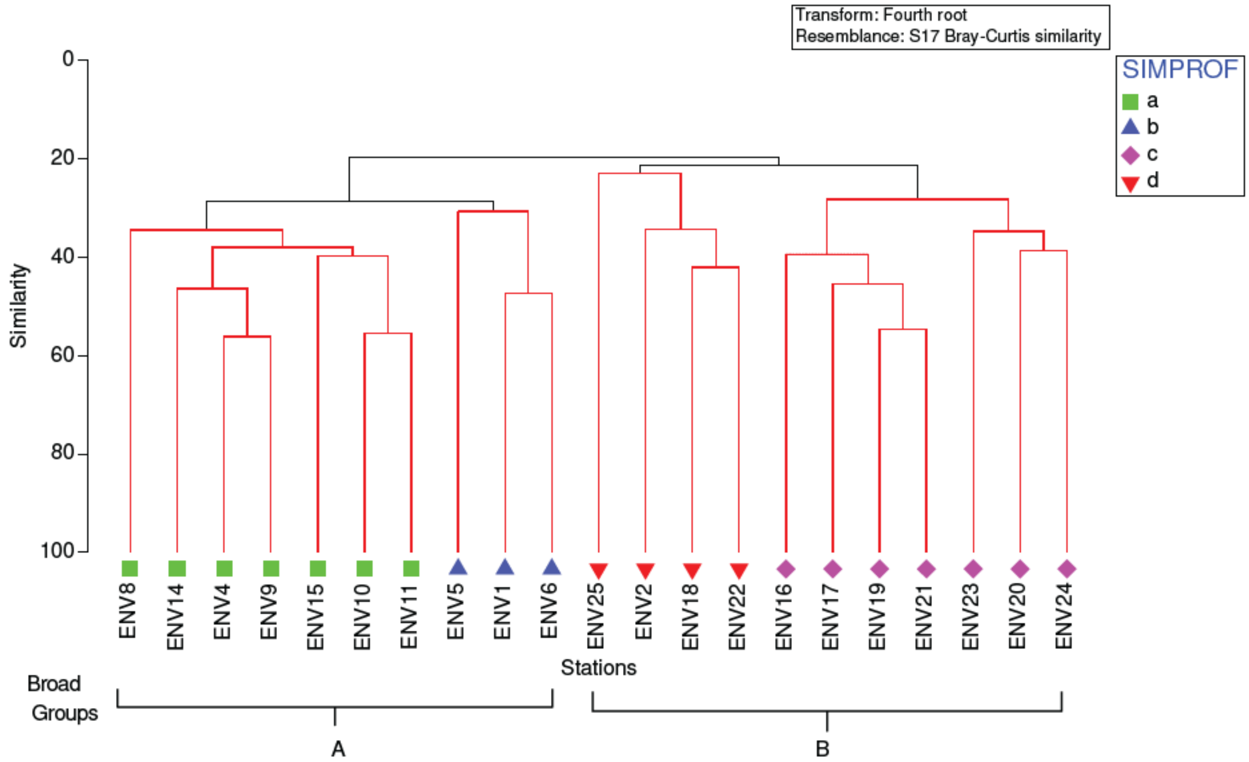
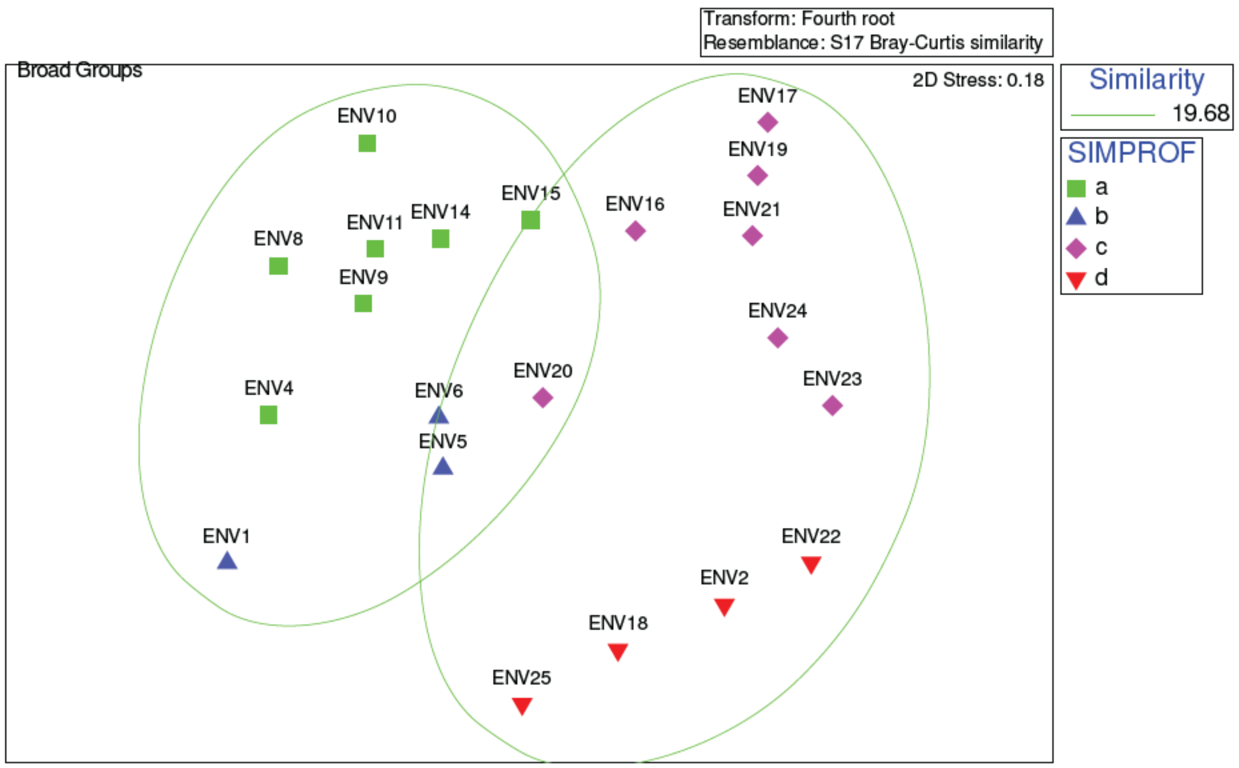


Figure 2.8 Multivariate Analysis of Faunal Biomass Data

a) Bray-Curtis Similarity Dendrogram



b) MDS Ordination



2.9 EUNIS Habitat Classification

Habitat classification is used to identify different habitats and biotopes based on the biotic and abiotic features of the seabed. Habitat and biotope classification were conducted on the available survey data, adhering to protocols within the European Union Nature Identification System (EUNIS). The system was developed between 1996 and 2001 by the European Environment Agency (EEA) in collaboration with European experts. Table 2.13 gives examples of the five EUNIS levels used to describe the marine environments.

Table 2.13 Example EUNIS Habitat Classification Levels

Level	Detail Covered (EUNIS code)
1. Environment	Marine (A)
2. Broad habitats	Sublittoral Sediment (A5)
3. Main habitats	Sublittoral biogenic reefs on sediment (A5.6)
4. Biotope complexes	Polychaete worm reefs (A5.61)
5. Biotopes	*Sabellaria spinulosa* on stable circalittoral mixed sediment (A5.611)

Development of the EUNIS classification comes from both a top-down and a bottom-up approach. Top-down classification differentiates between rock and sediment habitats, and between those habitats on the shore (intertidal) and those in the subtidal or offshore (deep) area. These high-level divisions can be further subdivided based on different types of sediment (e.g. gravel, mud), different degrees of wave exposure on rocky coasts (exposed, sheltered) and varying depth bands below the low water mark (e.g. shallow water where light penetrates, deeper water with little light). Such broad-scale differences in habitat character are readily understood by non-specialists and provide classification types that are easily mapped. However, they also have ecological relevance as they reflect major changes in habitat character upon which species distribution depends (Connor *et al.*, 2004).

Bottom-up classification differentiates between places with different species communities. Relative species composition, diversity and abundance vary from place to place and are dependent both on environmental characteristics and upon interactions between species. Surveyed sites with similar environmental characteristics, such as sediment type and depth, show certain levels of similarity in their species communities.

The EUNIS classification hierarchy to biotopes (level 5) was mainly based on depth, sediment type and species composition. Results of the EUNIS habitat classification based on PSA, seabed imagery and macrofaunal data are summarised in Table 2.14. A more detailed summary of the key parameters used for EUNIS classification are tabulated in Appendix K.

All habitats observed related to the EUNIS level 1 category marine habitats (EUNIS habitat type code A) and level 2 category sublittoral sediment (EUNIS habitat type code A5), corresponding to sediment habitats in the sublittoral near shore zone extending up to 200m depth. Sublittoral sediments can range from boulders and cobbles, through pebbles and shingle, coarse sands, sands, fine sands, muds and mixed sediments (EEA, 2017). EUNIS level 3 habitat classification was determined based on PSA results and seabed imagery observations of the sediment composition. EUNIS levels 4 and 5 were determined taking into account the habitat type descriptions on both the EUNIS website and associated documentation (Davies *et al.*, 2004; EEA, 2017) together with the epifauna observed in seabed imagery and species identified during macrofaunal analysis.

Stations across the HOW4 survey area were categorised within eight EUNIS categories and ranged between level 4 and level 5 depending on the level of confidence to which the data could be classified. The EUNIS habitat codes identified across the HOW4 survey area were: A5.14, A5.233, A5.25, A5.251, A5.252, A5.261, A5.44 and A5.443.

EUNIS habitat code A5.25 corresponds to clean fine sands in depths of over 20m and was noted at Station ENV21. Station ENV16 was classified as EUNIS code A5.44 which corresponds to circalittoral mixed sediments generally below 20m, whilst Station ENV24 was classified as EUNIS code A5.14 which corresponds to circalittoral coarse sediments. It was not possible to further classify these stations to EUNIS habitat level 5.

When considering the epifauna identified within the seabed imagery and the faunal communities identified during the macrofaunal analysis, it was possible to classify all remaining stations to EUNIS level 5. EUNIS habitat code A5.233 is derived from A5.23 (infralittoral fine sand) and corresponds to *Nepthys cirrosa* and *Bathyporeia* spp. in infralittoral sand whilst EUNIS habitat code A5.25 relates to circalittoral fine sand. The EUNIS habitat codes A5.251 and A5.252, which are both derived from A5.25, relate to *Echinocyamus pusillus*, *Opheliea borealis* and *Abra prismatica* in circalittoral fine sand and *Abra prismatica*, *Bathyporeia elefans* and polychaetes in circalittoral fine sand, respectively. EUNIS code A5.261 is derived from A5.26 (circalittoral muddy sand) and corresponds to *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment. Finally, EUNIS habitat code A5.443 is derived from A5.44 (circalittoral mixed sediments) and corresponds to *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediments.

Sediment characteristics at Stations ENV17 and ENV19 were similar to those described in the EUNIS code A5.443. In addition, macrofaunal communities at these stations were dominated by the brittle star *A. filiformis*. It was noted in the habitat classification for A5.443 that this brittle star species is known to be abundant at some previous sites where this classification has been used (EEA, 2018). *A. filiformis* was also dominant at Station ENV21, however due to the sediment characteristics and the remaining macrofaunal community it was not possible to characterise this station further than EUNIS level 4. The EUNIS classification A5.251 has been used to classify Stations ENV4, ENV6 to ENV15 and ENV20. These stations all presented similar sediment profiles of sand with varying small quantities of fine material and were all dominated by the bivalve mollusc *Abra.*

Overall, the wide range of observed EUNIS classifications supported the conclusion that the habitat across the HOW4 survey area varied in accordance with the heterogenous sandy sediments encountered. The varying gravel and fines components and their effects on the faunal community were noted on final EUNIS classifications.

Table 2.14 EUNIS Habitat Classification

Station	Depth[1] (m LAT)	Modified Folk Classification	EUNIS habitat Classification[2]	
			Habitat Type	Code
ENV1	35	Sand	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	A5.233
ENV2	33	Slightly gravelly sand	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	A5.252
ENV4	37	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV5	38	Sand	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	A5.252
ENV6	39	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV8	41	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV9	43	Muddy sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV10	43	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV11	42	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV14	42	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV15	52	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV16	47	Gravelly sand	Circalittoral mixed sediment	A5.44
ENV17	50	Gravelly muddy sand	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	A5.443
ENV18	47	Sand	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	A5.251
ENV19	57	Gravelly muddy sand	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	A5.443
ENV20	47	Sand	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261
ENV21	61	Sand	Circalittoral fine sand	A5.25
ENV22	59	Sand	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	A5.251
ENV23	58	Sand	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	A5.251
ENV24	56	Gravelly Sand	Circalittoral coarse sediment	A5.14
ENV25	58	Sand	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	A5.252

2 Observed depth at time of sampling corrected to LAT
3 Calculated using the modified Folk triangle classification (Appendix B)

3 CONCLUSION

Imagery Assessment

Across the HOW4 survey area seabed sediments, supported by seabed imagery and seabed sediment sampling, were interpreted to predominantly comprise sand with varying amounts of gravel and fine sediment. Depending on the contributions of fines and gravel content to the sediment composition, sediments across the HOW4 survey area range from gravelly sand to muddy sand.

Benthic fauna observed within the seabed imagery was generally sparse. Burrows were observed throughout the HOW4 survey area however, no sea pens were observed in any of the seabed imagery acquired. Application of the SACFOR abundance scale revealed scores that ranged from 'rare' to 'occasional' at Stations ENV11 and ENV19 and 'rare' to 'frequent' at Station ENV1. At all other stations, SACFOR densities were not sufficient to be classified as showing similarities to a 'sea pen and burrowing megafauna communities' habitat as listed under the OSPAR (2010) list of threatened and/or declining species and habitats.

The presence of possible *A. islandica* shells were noted in sediment samples recovered from Stations ENV24 and ENV25. *A. islandica* is listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008) and is a species listed as a FOCI, defined in relation to the Marine Conservation Zones (MCZ) network (Natural England and Joint Nature Conservation Committee, 2010). However, *A. islandica* is a species commonly found within this area of the North Sea (Oil and Gas U.K., 2010). Additionally, a single individual of a sand eel (Ammodytidae) was observed within a seabed sample obtained at Station ENV2. The lesser sand eel (*A. tobianus*) and Raitt's sand eel (*A. marinus*) are species, listed under the NERC Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as conservation priorities in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra, 2012).

Other than those mentioned above, within the seabed imagery and seabed grab samples, there was no further evidence of any Annex I habitats (1992), species or habitats listed as FOCI (Natural England and Joint Nature Conservation Committee, 2010) or species or habitats listed under the NERC Act (2006). Furthermore, no additional species or habitats listed on the OSPAR (2008) list of threatened and/or declining species and habitats and no species on the IUCN Global Red List of threatened species (IUCN, 2018) were observed from the imagery data.

Sediment Characteristics

Particle size analysis generally supported the initial interpretation made from the seabed imagery and seabed sediment samples. The sand fraction (≥63µm to <2mm) dominant the PSA and ranged between 61% and 100% of sediment composition. Therefore, the majority of stations presented a modified Folk classification of sand. This classification varied where gravels (≥2mm) and fines (<63µm) accounted for a greater proportion of the sediment. Where this was the case, sediments were described as muddy sand, slightly gravely sand, gravely sand and gravely muddy sand on the modified Folk classification.

Results of the chemical analyses revealed that the majority of hydrocarbons observed within the HOW4 survey area were within expected background concentrations with some elevation present close to existing infrastructure which was as expected. GC traces across the HOW4 survey area were generally indicative of background levels of hydrocarbons in areas of historic oil and gas exploration and suggested a mixture of petrogenic and pyrogenic sources. All hydrocarbons were below thresholds likely to exert an effect on the faunal community.Total PAH concentrations ranged between 0.013µg g-1 at Station ENV18 to 0.248µg g-1 at Station ENV17 whilst NPD concentrations ranged between 0.007µg g-1 and 0.097µg g-1. Both total PAHs and NPDs, once normalised to 1% TOC, were well below the ERL and the ERM values (Long *et al*., 1995) indicating that toxic effects to fauna were unlikely. Information derived from molecular weight PAH indices on the origin of US EPA 16 PAHs presented a mix of pyrolytic and petrogenic inputs from the range of indices calculated consistent with the wide area surveyed as part of the HOW4 survey.

Metals concentrations varied across the HOW4 survey area with generally higher concentrations presenting at Stations ENV16 and ENV17 and lower concentrations at Stations ENV1 and ENV23. All metals concentrations were below their respective AETs (Buchman, 2008) which indicated that toxicological impacts on the biota were unlikely across the HOW4 survey area.

Values of the organotin MBT were below the LOD at all stations with the exception of Stations ENV10, ENV 14, ENV15, ENV17, ENV19, ENV21 and ENV25 where a value of 1ng g^{-1} was recorded. Values were below the limit of detection for DBT and TBT across the HOW4 survey area.

Faunal Community
Across the survey area, a total of 2,678 individuals representing 163 taxa were recorded from the 21 macrofaunal samples acquired. The macrofaunal community was found to be relatively sparse with 54 taxa appearing at a single station and 34 of those taxa represented by a single individual.

Review of the adult only abundance data set revealed that benthic communities across the HOW4 survey area were generally dominated by Annelida, Mollusca and Echinodermata all of which contributed *c.*30% of the total individuals identified. The Mollusca group was dominated by the bivalve *Abra* which contributed 60% of total Mollusc individuals whilst the Echinodermata group was dominated by the brittle star *A. filiformis*, which contributed 72% of the total Echinoderm individuals. The Annelid group was not dominated by a single taxon rather the group was represented by a diverse range of taxa. Review of the adult only biomass data revealed an equally variable data set which was dominated by single large specimens of Arthropoda, Mollusca and Echinodermata particularly at stations which recorded biomass values >3g.

Within the full macrofaunal data set the presence of three juvenile ocean quahog (*A. islandica)*, a species of conservation importance, were recorded. A single individual was identified at Stations ENV6, ENV15 and ENV25 respectively. The identification of *A. islandica* within the fauna data set corroborates the presence of *A. islandica* individuals tentatively identified from the sieved grab samples. *A. islandica* is a long-lived species with a slow growth rate and is listed on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008), as well as listed under the Marine Conservation Zone (MCZ) guidance as a species feature of conservation importance (FOCI) (Natural England and Joint Nature Conservation Committee, 2010). Additionally, a single lesser sand eel (*Ammodytes tobianus*) was identified at Station ENV2 with a biomass of 1.805g. *A. tobianus* is a species which is listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act (2006) that were deemed to require action in the UK Biodiversity Action Plan and continue to be regarded as a conservation priority in the subsequent UK Post-2010 Biodiversity Framework (JNCC and Defra, 2012).

Faunal data, in conjunction with physico-chemical data, enabled some of the observed habitats to be resolved to levels 4 and 5 EUNIS classifications. The sediment profile at Stations ENV17 and ENV19 presented a proportion of fines that allowed these stations to be classified as mixed sediments. Additionally, these stations were dominated by the brittle star *A.filiformis* and were therefore classified as EUNIS code A5.443. Stations ENV4, ENV6 to ENV15 and ENV20 presented sand dominated sediments with varying quantities of fine material. These stations were dominated by the bivalve *Abra* and were classified as EUNIS habitat A5.261.

Overall, the EUNIS habitat and biotope classification at each station further highlighted the habitat heterogeneity associated with variation in water depth and sediment type within the HOW4 survey area.

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APPENDICES

APPENDIX A FIELD SAMPLING LOGS

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

SEABED IMAGERY LOG SHEET (Deck) QPRO-0753

Job No: 11210	Area: UKCS Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2, 48/3	Scale:	95mm Laser lines
Project: Hornsea 4 Offshore Wind Farm Lot 6		Equipment:	Kongsberg 14-208 Shallow water Camera System
Client: Ørsted		Vessel:	M.V. *Ocean Endeavour*

Station Number	Date	Time on Overlay Start	Time on Overlay Finish	Media Location			Sediment Description	Fauna Description	Operator(s)	No. of Photos	First Fix No.	Last Fix No.	Comments
				VHS No.	DVD No. & Chapter	HDD File Name(s)							
ENV23	14-Sep-18	20:17:00	20:33:27			2018-09-14_20-17-00_ENV23	Rippled sand with patches of shells	Arthropoda (Paguridae), Echinodermata (*Asterias rubens*, *Astropecten irregularis*), Chordata (Pleuronectiformes), Cnidaria (Actinaria)	KS	38	1	38	
ENV20	15-Sep-18	03:38:12	03:53:45			2018-09-15_03-38-12_ENV20	Rippled sand with ocasional shell fragments	Echinodermata (*A. irregularis*), Chordata (Pleuronectiformes).	GD	23	39	61	Wrong date recorded on overlay
ENV24	15-Sep-18	05:35:15	05:50:24			2018-09-15_05-35-15_ENV24	Rippled sand with ocasional shell fragments	Echinodermata (*A. irregularis*), Chordata (Pleuronectiformes)	GD	24	62	85	
ENV25	15-Sep-18	07:16:07	07:31:25			2018-09-15_07-16-07_ENV25	Rippled sand with ocasional shell fragments	Echinodermata (*A. irregularis*), Arthropoda (Brachyura)	GD	24	86	110	Temporary loss of connection to USBL beacon, break of 3 minutes. Fix with no photo - fix 93
ENV21	15-Sep-18	08:54 37	09:08:26			2018-09-15_08-54-37 ENV21	Rippled sand with ocasional shell fragments	Echinodermata, (*A. rubens*), Chordata (Actinopterygii)	GD	24	111	134	
ENV22	15-Sep-18	10:24:17	10:38:10			2018-09-15_10-24-17 ENV22	Silty sand overlying harder substrate, ocasional shell fragments present	Echinodermata (Echinoidea), Chordata (Callionymidae, Scorpaeniformes, Pleuronectiformes, Scyliorhinidae), Cnidaria (Actiniaria, *Alcyonium digitatum*)	GD	26	135	160	
ENV19	15-Sep-18	12:08 35	12:25:21			2018-09-15_12-08-35 ENV19	Silty sand overlying harder substrate	Echinodermata (*A. rubens*, Ophiuroidea), Chordata (Callionymidae, Pleuronectiformes), Cnidaria (Actinaria, *A. digitatum*)	KS	40	161	200	
ENV16	15-Sep-18	14:05:19	14:23:23			2018-09-15_14-05-19 ENV16	Silty sand with shell fragments. Burrows were present	Echinodermata, (*A. rubens*), Chordata (Pleuronectiformes)	KS	40	201	240	
ENV17	15-Sep-18	15:49 20	16:03:59			2018-09-15_15-49-20 ENV17	Rippled silty sand with shell fragments and gravel. Burrows were present	Echinodermata (*A. irregularis*, Ophiuroidea), Chordata (Gadidae, Pleuronectiformes), Cnidaria (*A. digitatum*)	KS	39	241	279	1 knot tide
ENV14	15-Sep-18	17:05 55	18:13:47			2018-09-15_17-05-55 ENV14	Rippled silty sand with occassional shell fragments. Burrows were present	Echinodermata, (*A. rubens*, *A. irregularis*), Chordata (Pleuronectiformes)	KS	35	280	314	Flash not working during deck test
ENV15	15-Sep-18	20:37:16	20:44:59			2018-09-15_20-37-16 ENV15			KS	8	315	322	Positional Error - all fixes

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

SEABED IMAGERY LOG SHEET (Deck) QPRO-0753

Job No: 11210	Area: UKCS Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2, 48/3	Scale:	95mm Laser lines
Project: Hornsea 4 Offshore Wind Farm Lot 6		Equipment:	Kongsberg 14-208 Shallow water Camera System
Client: Ørsted		Vessel:	M.V. *Ocean Endeavour*

Station Number	Date	Time on Overlay Start	Time on Overlay Finish	Media Location: VHS No.	Media Location: DVD No. & Chapter	Media Location: HDD File Name(s)	Sediment Description	Fauna Description	Operator(s)	No. of Photos	First Fix No.	Last Fix No.	Comments
ENV15	15-Sep-18	21:01:04	21:06:58			2018-09-15_21-01-04 ENV15	Sand with shell fragments	Echinodermata, (*A. rubens*, *A. irregularis*, Ophiuroidea), Chordata (Gadidae, Pleuronectiformes)	KS	14	323	337	Communication error with USBL beacon. Jumped fix 337
ENV15	15-Sep-18	21:57:08	21:59:53			2018-09-15_21-57-08 ENV15	Sand with shell fragments	Echinodermata, (*A. rubens*, *A. irregularis*, Ophiuroidea), Chordata (Gadidae, Pleuronectiformes)	KS	9	338	347	Communication error with USBL beacon. Fix with no photo - fix 343
ENV15	15-Sep-18	22:25 37	22:32:59			2018-09-15_22-25-37 ENV15	Sand with shell fragments	Echinodermata, (*A. rubens*, *A. irregularis*, Ophiuroidea), Chordata (Gadidae, Pleuronectiformes)	KS	26	348	373	
ENV18	15-Sep-18	23:40 51	23:55:05			2018-09-15_23-40-51 ENV18	Sand	Echinodermata (*A. rubens*, *A. irregularis*, Ophiuroidea), Chordata (Pleuronectiformes)	GD	24	374	397	
ENV10	16-Sep-18	01:48 29	02:01:57			2018-09-16_01-48-29 ENV10	Sand	Echinodermata (*A. irregularis*, Ophiuroidea), Chordata (Pleuronectiformes)	GD	22	398	419	
ENV11	16-Sep-18	19:42:13	19:55:37			2018-09-16_19-42-12_ENV11	Rippled sand with occasional shell fragments	Arthropoda (Brachyura), Echinodermata (*A. rubens*, *A. irregularis*), Chordata (Pleuronectiformes), Cnidaria (Actinaria)	KS	39	420	458	
ENV8	16-Sep-18	20:50 30	20:55:39			2018-09-16_20-50-29_ENV8	Sand with shell fragments	Echinodermata (*A. irregularis*, Ophiuroidea), Chordata (Pleuronectiformes)	KS	12	459	470	Communication error with USBL beacon
ENV8	16-Sep-18	20:57:49	21:07:02			2018-09-16_20-57-49_ENV8	Sand with shell fragments	Echinodermata (*A. irregularis*, Ophiuroidea), Chordata (Pleuronectiformes)	KS	20	471	490	
ENV9	16-Sep-18	22:11:15	22:27:22			2018-09-16_22-11-15_ENV9	Rippled sand with occasional shell fragments	Echinodermata (*A. rubens*, *A. irregularis*), Chordata (Gadidae, Pleuronectiformes)	KS	40	491	530	Overlay says ENV8
ENV6	16-Sep-18	23:46 23	23:59:59			2018-09-16_23-44-44_ENV6	Rippled sand with shell fragments	Echinodermata (*A. irregularis*), Chordata (Pleuronectiformes)	GD	33	531	563	Wrong date on overlay. Poor visibility due to current
ENV5	17-Sep-18	01:16:05	01:31:17			2018-09-17_01-16-06_ENV5	Rippled silty sand with shell fragments	Arthropoda (Decapoda), Echinodermata (*A. rubens*, *A. irregularis*), Chordata (Pleuronectiformes)	GD	33	564	596	
ENV2	17-Sep-18	02:33:02	02:46:15			2018-09-17_02-33-01_ENV2	Rippled silty sand with shell fragments	Arthropoda (Brachyura), Echinodermata (Ophiuroidea), Chordata (Pleuronectiformes)	GD	35	597	631	
ENV4	17-Sep-18	03:58 24	04:12:50			2018-09-17_03-58-24_ENV4	Rippled silty sand with shell fragments	Arthropoda (Decapoda), Echinodermata (*A. rubens*, *A. irregularis*, Ophiuroidea), Chordata (Pleuronectiformes)	GD	45	632	676	

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

SEABED IMAGERY LOG SHEET (Deck)														QPRO-0753
Job No:	11210			Area: UKCS Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2, 48/3					Scale:	95mm Laser lines				
Project:	Hornsea 4 Offshore Wind Farm Lot 6								Equipment:	Kongsberg 14-208 Shallow water Camera System				
Client:	Ørsted								Vessel:	M.V. *Ocean Endeavour*				
Station Number	Date	Time on Overlay Start	Time on Overlay Finish	Media Location			Sediment Description	Fauna Description	Operator(s)	No. of Photos	First Fix No.	Last Fix No.	Comments	
				VHS No.	DVD No. & Chapter	HDD File Name(s)								
ENV1	17-Sep-18	05:16 57	05:31:41			2018-09-17_05-16-58_ENV1	Rippled silty sand with shell fragments	Echinodermata (*A. rubens*, Ophiuroidea), Chordata (Plueronectiformes)	GD	34	677	710		

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*					
Client	Ørsted			Vessel Reference Point (VRP)	CoG					
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon					
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)		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		
14-Sep-2018	20:17:11	1	ENV23			Camera	54	367488	6005685	367458	6005694	31	-9	32	287		(Corr'd Nav, Kongsberg 14208, img#1) (B) (T.A)
14-Sep-2018	20:17:54	2	ENV23			Camera	54	367487	6005683	367458	6005694	29	-11	31	290		(Corr'd Nav, Kongsberg 14208, img#2) (B) (T.A)
14-Sep-2018	20:18:27	3	ENV23			Camera	54	367479	6005683	367458	6005694	21	-11	24	298		(Corr'd Nav, Kongsberg 14208, img#3) (B) (T.A)
14-Sep-2018	20:18:36	4	ENV23			Camera	54	367479	6005682	367458	6005694	21	-12	24	299		(Corr'd Nav, Kongsberg 14208, img#4) (B) (T.A)
14-Sep-2018	20:18:56	5	ENV23			Camera	54	367474	6005683	367458	6005694	16	-11	20	304		(Corr'd Nav, Kongsberg 14208, img#5) (B) (T.A)
14-Sep-2018	20:19:19	6	ENV23			Camera	53	367469	6005686	367458	6005694	11	-8	14	306		(Corr'd Nav, Kongsberg 14208, img#6) (B) (T.A)
14-Sep-2018	20:20:07	7	ENV23			Camera	54	367453	6005685	367458	6005694	-5	-9	10	30		(Corr'd Nav, Kongsberg 14208, img#7) (B) (T.A)
14-Sep-2018	20:20:53	8	ENV23			Camera	54	367443	6005688	367458	6005694	-15	-6	16	68		(Corr'd Nav, Kongsberg 14208, img#8) (B) (T.A)
14-Sep-2018	20:21:17	9	ENV23			Camera	54	367444	6005687	367458	6005694	-14	-7	15	64		(Corr'd Nav, Kongsberg 14208, img#9) (B) (T.A)
14-Sep-2018	20:21:30	10	ENV23			Camera	54	367445	6005689	367458	6005694	-13	-5	14	69		(Corr'd Nav, Kongsberg 14208, img#10) (B) (T.A)
14-Sep-2018	20:21:46	11	ENV23			Camera	54	367445	6005690	367458	6005694	-13	-4	13	74		(Corr'd Nav, Kongsberg 14208, img#11) (B) (T.A)
14-Sep-2018	20:22:19	12	ENV23			Camera	54	367445	6005696	367458	6005694	-13	2	13	100		(Corr'd Nav, Kongsberg 14208, img#12) (B) (T.A)
14-Sep-2018	20:22:26	13	ENV23			Camera	54	367445	6005696	367458	6005694	-13	2	13	100		(Corr'd Nav, Kongsberg 14208, img#13) (B) (T.A)
14-Sep-2018	20:22:42	14	ENV23			Camera	54	367446	6005699	367458	6005694	-12	5	13	114		(Corr'd Nav, Kongsberg 14208, img#14) (B) (T.A)
14-Sep-2018	20:22:58	15	ENV23			Camera	54	367447	6005697	367458	6005694	-11	3	12	107		(Corr'd Nav, Kongsberg 14208, img#15) (B) (T.A)
14-Sep-2018	20:23:29	16	ENV23			Camera	53	367452	6005706	367458	6005694	-6	12	13	152		(Corr'd Nav, Kongsberg 14208, img#16) (B) (T.A)
14-Sep-2018	20:23:38	17	ENV23			Camera	53	367451	6005707	367458	6005694	-7	13	15	151		(Corr'd Nav, Kongsberg 14208, img#17) (B) (T.A)
14-Sep-2018	20:24:17	18	ENV23			Camera	53	367465	6005705	367458	6005694	7	11	13	212		(Corr'd Nav, Kongsberg 14208, img#18) (B) (T.A)
14-Sep-2018	20:24:55	19	ENV23			Camera	53	367471	6005701	367458	6005694	13	7	15	243		(Corr'd Nav, Kongsberg 14208, img#19) (B) (T.A)
14-Sep-2018	20:25:16	20	ENV23			Camera	54	367471	6005698	367458	6005694	13	4	13	254		(Corr'd Nav, Kongsberg 14208, img#20) (B) (T.A)
14-Sep-2018	20:25:50	21	ENV23			Camera	53	367472	6005691	367458	6005694	14	-3	14	281		(Corr'd Nav, Kongsberg 14208, img#21) (B) (T.A)
14-Sep-2018	20:25:59	22	ENV23			Camera	54	367473	6005690	367458	6005694	15	-4	16	284		(Corr'd Nav, Kongsberg 14208, img#22) (B) (T.A)
14-Sep-2018	20:26:08	23	ENV23			Camera	54	367475	6005690	367458	6005694	17	-4	17	282		(Corr'd Nav, Kongsberg 14208, img#23) (B) (T.A)
14-Sep-2018	20:26:46	24	ENV23			Camera	54	367475	6005686	367458	6005694	17	-7	18	294		(Corr'd Nav, Kongsberg 14208, img#24) (B) (T.A)
14-Sep-2018	20:27:01	25	ENV23			Camera	54	367475	6005685	367458	6005694	17	-9	19	298		(Corr'd Nav, Kongsberg 14208, img#25) (B) (T.A)
14-Sep-2018	20:27:43	26	ENV23			Camera	54	367474	6005686	367458	6005694	16	-8	18	297		(Corr'd Nav, Kongsberg 14208, img#26) (B) (T.A)
14-Sep-2018	20:27:52	27	ENV23			Camera	54	367472	6005685	367458	6005694	14	-9	17	302		(Corr'd Nav, Kongsberg 14208, img#27) (B) (T.A)
14-Sep-2018	20:28:07	28	ENV23			Camera	47	367468	6005686	367458	6005694	10	-8	13	309		(Corr'd Nav, Kongsberg 14208, img#28) (B) (T.A)
14-Sep-2018	20:28:13	29	ENV23			Camera	53	367467	6005686	367458	6005694	9	-8	12	312		(Corr'd Nav, Kongsberg 14208, img#29) (B) (T.A)
14-Sep-2018	20:28:22	30	ENV23			Camera	53	367465	6005686	367458	6005694	7	-8	11	321		(Corr'd Nav, Kongsberg 14208, img#30) (B) (T.A)
14-Sep-2018	20:30:13	31	ENV23			Camera	53	367456	6005689	367458	6005694	-1	-5	5	16		(Corr'd Nav, Kongsberg 14208, img#31) (B) (T.A)
14-Sep-2018	20:30:56	32	ENV23			Camera	53	367455	6005691	367458	6005694	-2	-3	4	37		(Corr'd Nav, Kongsberg 14208, img#32) (B) (T.A)
14-Sep-2018	20:31:12	33	ENV23			Camera	53	367456	6005691	367458	6005694	-2	-3	3	34		(Corr'd Nav, Kongsberg 14208, img#33) (B) (T.A)
14-Sep-2018	20:31:47	34	ENV23			Camera	53	367453	6005693	367458	6005694	-5	-1	5	83		(Corr'd Nav, Kongsberg 14208, img#34) (B) (T.A)
14-Sep-2018	20:32:02	35	ENV23			Camera	53	367453	6005694	367458	6005694	-5	0	5	86		(Corr'd Nav, Kongsberg 14208, img#35) (B) (T.A)
14-Sep-2018	20:32:43	36	ENV23			Camera	53	367467	6005689	367458	6005694	9	-5	10	302		(Corr'd Nav, Kongsberg 14208, img#36) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*		
Client	Ørsted			Vessel Reference Point (VRP)	CoG		
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x 6.701	y 21.939 z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon		
Geodetic Reference System	Datum WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)	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		
14-Sep-2018	20:33:04	37	ENV23			Camera	54	367467	6005685	367458	6005694	9	-9	13	315		(Corr'd Nav, Kongsberg 14208, img#37) (B) (T.A)
14-Sep-2018	20:33:16	38	ENV23			Camera	54	367467	6005683	367458	6005694	9	-11	14	321		(Corr'd Nav, Kongsberg 14208, img#38) (B) (T.A)
15-Sep-2018	03:38:42	39	ENV20			Camera	46	373168	5998670	373174	5998657	-7	14	15	154		(Corr'd Nav, Kongsberg 14208, img#39) (B) (T.A)
15-Sep-2018	03:39:25	40	ENV20			Camera	46	373168	5998669	373174	5998657	-6	13	14	154		(Corr'd Nav, Kongsberg 14208, img#40) (B) (T.A)
15-Sep-2018	03:39:56	41	ENV20			Camera	46	373163	5998670	373174	5998657	-12	13	18	139		(Corr'd Nav, Kongsberg 14208, img#41) (B) (T.A)
15-Sep-2018	03:40:39	42	ENV20			Camera	46	373162	5998662	373174	5998657	-13	5	14	113		(Corr'd Nav, Kongsberg 14208, img#42) (B) (T.A)
15-Sep-2018	03:40:50	43	ENV20			Camera	46	373162	5998660	373174	5998657	-13	4	13	107		(Corr'd Nav, Kongsberg 14208, img#43) (B) (T.A)
15-Sep-2018	03:41:28	44	ENV20			Camera	46	373160	5998659	373174	5998657	-14	2	14	97		(Corr'd Nav, Kongsberg 14208, img#44) (B) (T.A)
15-Sep-2018	03:42:02	45	ENV20			Camera	46	373160	5998655	373174	5998657	-14	-2	14	83		(Corr'd Nav, Kongsberg 14208, img#45) (B) (T.A)
15-Sep-2018	03:42:29	46	ENV20			Camera	46	373159	5998652	373174	5998657	-15	-4	16	74		(Corr'd Nav, Kongsberg 14208, img#46) (B) (T.A)
15-Sep-2018	03:43:05	47	ENV20			Camera	46	373161	5998648	373174	5998657	-14	-8	16	58		(Corr'd Nav, Kongsberg 14208, img#47) (B) (T.A)
15-Sep-2018	03:43:29	48	ENV20			Camera	46	373161	5998647	373174	5998657	-13	-10	17	54		(Corr'd Nav, Kongsberg 14208, img#48) (B) (T.A)
15-Sep-2018	03:43:44	49	ENV20			Camera	47	373160	5998646	373174	5998657	-14	-11	18	53		(Corr'd Nav, Kongsberg 14208, img#49) (B) (T.A)
15-Sep-2018	03:44:07	50	ENV20			Camera	46	373160	5998645	373174	5998657	-14	-12	19	50		(Corr'd Nav, Kongsberg 14208, img#50) (B) (T.A)
15-Sep-2018	03:44:53	51	ENV20			Camera	46	373163	5998645	373174	5998657	-11	-12	16	42		(Corr'd Nav, Kongsberg 14208, img#51) (B) (T.A)
15-Sep-2018	03:45:21	52	ENV20			Camera	46	373163	5998647	373174	5998657	-12	-10	15	49		(Corr'd Nav, Kongsberg 14208, img#52) (B) (T.A)
15-Sep-2018	03:45:49	53	ENV20			Camera	46	373163	5998647	373174	5998657	-12	-10	15	50		(Corr'd Nav, Kongsberg 14208, img#53) (B) (T.A)
15-Sep-2018	03:46:44	54	ENV20			Camera	46	373165	5998647	373174	5998657	-10	-10	14	45		(Corr'd Nav, Kongsberg 14208, img#54) (B) (T.A)
15-Sep-2018	03:47:17	55	ENV20			Camera	46	373167	5998649	373174	5998657	-7	-8	11	41		(Corr'd Nav, Kongsberg 14208, img#55) (B) (T.A)
15-Sep-2018	03:48:02	56	ENV20			Camera	46	373175	5998651	373174	5998657	0	-6	6	357		(Corr'd Nav, Kongsberg 14208, img#56) (B) (T.A)
15-Sep-2018	03:48:51	57	ENV20			Camera	46	373177	5998657	373174	5998657	3	0	3	264		(Corr'd Nav, Kongsberg 14208, img#57) (B) (T.A)
15-Sep-2018	03:50:12	58	ENV20			Camera	46	373184	5998667	373174	5998657	9	10	14	223		(Corr'd Nav, Kongsberg 14208, img#58) (B) (T.A)
15-Sep-2018	03:51:54	59	ENV20			Camera	46	373185	5998676	373174	5998657	11	20	22	208		(Corr'd Nav, Kongsberg 14208, img#59) (B) (T.A)
15-Sep-2018	03:52:32	60	ENV20			Camera	46	373182	5998674	373174	5998657	7	17	19	203		(Corr'd Nav, Kongsberg 14208, img#60) (B) (T.A)
15-Sep-2018	03:53:36	61	ENV20			Camera	46	373181	5998670	373174	5998657	6	13	15	205		(Corr'd Nav, Kongsberg 14208, img#61) (B) (T.A)
15-Sep-2018	05:35:44	62	ENV24			Camera	54	373694	6006060	373683	6006063	11	-3	12	286		(Corr'd Nav, Kongsberg 14208, img#62) (B) (T.A)
15-Sep-2018	05:36:12	63	ENV24			Camera	52	373698	6006061	373683	6006063	15	-2	15	280		(Corr'd Nav, Kongsberg 14208, img#63) (B) (T.A)
15-Sep-2018	05:36:44	64	ENV24			Camera	53	373700	6006064	373683	6006063	17	1	17	267		(Corr'd Nav, Kongsberg 14208, img#64) (B) (T.A)
15-Sep-2018	05:37:00	65	ENV24			Camera	53	373698	6006064	373683	6006063	15	1	15	265		(Corr'd Nav, Kongsberg 14208, img#65) (B) (T.A)
15-Sep-2018	05:37:34	66	ENV24			Camera	53	373695	6006069	373683	6006063	12	6	14	245		(Corr'd Nav, Kongsberg 14208, img#66) (B) (T.A)
15-Sep-2018	05:38:04	67	ENV24			Camera	54	373694	6006074	373683	6006063	11	11	16	227		(Corr'd Nav, Kongsberg 14208, img#67) (B) (T.A)
15-Sep-2018	05:38:27	68	ENV24			Camera	54	373693	6006073	373683	6006063	10	10	14	226		(Corr'd Nav, Kongsberg 14208, img#68) (B) (T.A)
15-Sep-2018	05:39:53	69	ENV24			Camera	54	373692	6006078	373683	6006063	9	15	17	212		(Corr'd Nav, Kongsberg 14208, img#69) (B) (T.A)
15-Sep-2018	05:40:09	70	ENV24			Camera	54	373693	6006080	373683	6006063	10	17	20	210		(Corr'd Nav, Kongsberg 14208, img#70) (B) (T.A)
15-Sep-2018	05:40:23	71	ENV24			Camera	54	373691	6006080	373683	6006063	8	17	19	206		(Corr'd Nav, Kongsberg 14208, img#71) (B) (T.A)
15-Sep-2018	05:40:43	72	ENV24			Camera	54	373685	6006078	373683	6006063	2	15	15	189		(Corr'd Nav, Kongsberg 14208, img#72) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210		Vessel	M.V *Ocean Endeavour*				
Client	Ørsted		Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6		Deployment Location	Starboard Crane	x 6.701	y 21.939	z 2.932	
Primary Positioning System	Starpack_Port		Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)		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		
15-Sep-2018	05:41:34	73	ENV24			Camera	53	373680	6006084	373683	6006063	-3	20	21	172		(Corr'd Nav, Kongsberg 14208, img#73) (B) (T.A)
15-Sep-2018	05:42:42	74	ENV24			Camera	54	373670	6006078	373683	6006063	-13	15	20	137		(Corr'd Nav, Kongsberg 14208, img#74) (B) (T.A)
15-Sep-2018	05:42:57	75	ENV24			Camera	54	373669	6006074	373683	6006063	-14	11	18	128		(Corr'd Nav, Kongsberg 14208, img#75) (B) (T.A)
15-Sep-2018	05:43:34	76	ENV24			Camera	53	373667	6006069	373683	6006063	-16	6	17	110		(Corr'd Nav, Kongsberg 14208, img#76) (B) (T.A)
15-Sep-2018	05:44:08	77	ENV24			Camera	54	373665	6006065	373683	6006063	-18	2	18	96		(Corr'd Nav, Kongsberg 14208, img#77) (B) (T.A)
15-Sep-2018	05:44:40	78	ENV24			Camera	54	373668	6006059	373683	6006063	-15	-4	16	74		(Corr'd Nav, Kongsberg 14208, img#78) (B) (T.A)
15-Sep-2018	05:46:24	79	ENV24			Camera	53	373682	6006052	373683	6006063	-1	-11	11	6		(Corr'd Nav, Kongsberg 14208, img#79) (B) (T.A)
15-Sep-2018	05:46:56	80	ENV24			Camera	54	373681	6006055	373683	6006063	-2	-8	8	13		(Corr'd Nav, Kongsberg 14208, img#80) (B) (T.A)
15-Sep-2018	05:48:07	81	ENV24			Camera	53	373688	6006059	373683	6006063	5	-4	7	307		(Corr'd Nav, Kongsberg 14208, img#81) (B) (T.A)
15-Sep-2018	05:48:21	82	ENV24			Camera	54	373688	6006060	373683	6006063	5	-3	6	304		(Corr'd Nav, Kongsberg 14208, img#82) (B) (T.A)
15-Sep-2018	05:48:46	83	ENV24			Camera	53	373691	6006060	373683	6006063	8	-3	8	291		(Corr'd Nav, Kongsberg 14208, img#83) (B) (T.A)
15-Sep-2018	05:48:57	84	ENV24			Camera	54	373691	6006060	373683	6006063	8	-3	9	289		(Corr'd Nav, Kongsberg 14208, img#84) (B) (T.A)
15-Sep-2018	05:49:46	85	ENV24			Camera	53	373694	6006062	373683	6006063	11	-2	11	278		(Corr'd Nav, Kongsberg 14208, img#85) (B) (T.A)
15-Sep-2018	07:16:24	86	ENV25			Camera	54	378400	6005468	378384	6005474	16	-7	18	292		(Corr'd Nav, Kongsberg 14208, img#86) (B) (T.A)
15-Sep-2018	07:16:39	87	ENV25			Camera	54	378397	6005465	378384	6005474	13	-9	16	307		(Corr'd Nav, Kongsberg 14208, img#87) (B) (T.A)
15-Sep-2018	07:17:19	88	ENV25			Camera	53	378397	6005467	378384	6005474	13	-8	15	301		(Corr'd Nav, Kongsberg 14208, img#88) (B) (T.A)
15-Sep-2018	07:21:10	89	ENV25			Camera	53	378379	6005479	378384	6005474	-5	5	7	134		(Corr'd Nav, Kongsberg 14208, img#89) (B) (T.A)
15-Sep-2018	07:21:43	90	ENV25			Camera	53	378378	6005479	378384	6005474	-6	5	7	131		(Corr'd Nav, Kongsberg 14208, img#90) (B) (T.A)
15-Sep-2018	07:22:06	91	ENV25			Camera	54	378378	6005479	378384	6005474	-6	4	8	124		(Corr'd Nav, Kongsberg 14208, img#91) (B) (T.A)
15-Sep-2018	07:22:42	92	ENV25			Camera	54	378379	6005482	378384	6005474	-5	7	9	146		(Corr'd Nav, Kongsberg 14208, img#92) (B) (T.A)
15-Sep-2018	07:23:14	93	ENV25			Camera	53	378380	6005487	378384	6005474	-4	13	13	163		fix with no photo
15-Sep-2018	07:23:25	94	ENV25			Camera	53	378380	6005489	378384	6005474	-4	15	15	166		(Corr'd Nav, Kongsberg 14208, img#94) (B) (T.A)
15-Sep-2018	07:24:02	95	ENV25			Camera	52	378383	6005493	378384	6005474	-1	19	19	177		(Corr'd Nav, Kongsberg 14208, img#95) (B) (T.A)
15-Sep-2018	07:24:47	96	ENV25			Camera	54	378396	6005487	378384	6005474	12	12	17	224		(Corr'd Nav, Kongsberg 14208, img#96) (B) (T.A)
15-Sep-2018	07:25:01	97	ENV25			Camera	54	378399	6005484	378384	6005474	15	9	17	238		(Corr'd Nav, Kongsberg 14208, img#97) (B) (T.A)
15-Sep-2018	07:25:17	98	ENV25			Camera	54	378401	6005481	378384	6005474	17	6	18	249		(Corr'd Nav, Kongsberg 14208, img#98) (B) (T.A)
15-Sep-2018	07:26:18	99	ENV25			Camera	53	378395	6005469	378384	6005474	11	-6	12	296		(Corr'd Nav, Kongsberg 14208, img#99) (B) (T.A)
15-Sep-2018	07:26:40	100	ENV25			Camera	53	378391	6005464	378384	6005474	7	-10	12	326		(Corr'd Nav, Kongsberg 14208, img#100) (B) (T.A)
15-Sep-2018	07:27:06	101	ENV25			Camera	55	378389	6005463	378384	6005474	5	-12	13	337		(Corr'd Nav, Kongsberg 14208, img#101) (B) (T.A)
15-Sep-2018	07:27:34	102	ENV25			Camera	54	378380	6005464	378384	6005474	-4	-10	11	21		(Corr'd Nav, Kongsberg 14208, img#102) (B) (T.A)
15-Sep-2018	07:28:18	103	ENV25			Camera	54	378377	6005468	378384	6005474	-7	-6	9	48		(Corr'd Nav, Kongsberg 14208, img#103) (B) (T.A)
15-Sep-2018	07:28:36	104	ENV25			Camera	54	378376	6005470	378384	6005474	-8	-5	10	61		(Corr'd Nav, Kongsberg 14208, img#104) (B) (T.A)
15-Sep-2018	07:28:55	105	ENV25			Camera	54	378375	6005472	378384	6005474	-9	-2	9	77		(Corr'd Nav, Kongsberg 14208, img#105) (B) (T.A)
15-Sep-2018	07:29:21	106	ENV25			Camera	54	378377	6005478	378384	6005474	-7	4	8	117		(Corr'd Nav, Kongsberg 14208, img#106) (B) (T.A)
15-Sep-2018	07:29:44	107	ENV25			Camera	54	378376	6005481	378384	6005474	-8	6	10	127		(Corr'd Nav, Kongsberg 14208, img#107) (B) (T.A)
15-Sep-2018	07:30:08	108	ENV25			Camera	53	378380	6005484	378384	6005474	-4	10	11	159		(Corr'd Nav, Kongsberg 14208, img#108) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*						
Client	Ørsted			Vessel Reference Point (VRP)	CoG						
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z	2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon						
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)		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		
15-Sep-2018	07:30:23	109	ENV25			Camera	53	378382	6005485	378384	6005474	-2	10	11	168		(Corr'd Nav, Kongsberg 14208, img#109) (B) (T.A)
15-Sep-2018	07:31:09	110	ENV25			Camera	54	378382	6005483	378384	6005474	-2	9	9	170		(Corr'd Nav, Kongsberg 14208, img#110) (B) (T.A)
15-Sep-2018	08:54:49	111	ENV21			Camera	56	383726	6001711	383694	6001725	32	-14	35	293		(Corr'd Nav, Kongsberg 14208, img#111) (B) (T.A)
15-Sep-2018	08:56:20	112	ENV21			Camera	57	383722	6001715	383694	6001725	29	-10	30	289		(Corr'd Nav, Kongsberg 14208, img#112) (B) (T.A)
15-Sep-2018	08:57:02	113	ENV21			Camera	57	383710	6001717	383694	6001725	16	-8	18	296		(Corr'd Nav, Kongsberg 14208, img#113) (B) (T.A)
15-Sep-2018	08:57:10	114	ENV21			Camera	57	383708	6001717	383694	6001725	15	-8	17	298		(Corr'd Nav, Kongsberg 14208, img#114) (B) (T.A)
15-Sep-2018	08:57:31	115	ENV21			Camera	57	383704	6001717	383694	6001725	10	-8	13	309		(Corr'd Nav, Kongsberg 14208, img#115) (B) (T.A)
15-Sep-2018	08:57:59	116	ENV21			Camera	57	383702	6001717	383694	6001725	8	-8	11	313		(Corr'd Nav, Kongsberg 14208, img#116) (B) (T.A)
15-Sep-2018	08:59:12	117	ENV21			Camera	56	383701	6001712	383694	6001725	7	-13	15	331		(Corr'd Nav, Kongsberg 14208, img#117) (B) (T.A)
15-Sep-2018	08:59:44	118	ENV21			Camera	56	383704	6001711	383694	6001725	10	-14	18	325		(Corr'd Nav, Kongsberg 14208, img#118) (B) (T.A)
15-Sep-2018	09:00:43	119	ENV21			Camera	57	383712	6001720	383694	6001725	18	-5	19	286		(Corr'd Nav, Kongsberg 14208, img#119) (B) (T.A)
15-Sep-2018	09:01:26	120	ENV21			Camera	57	383711	6001730	383694	6001725	17	5	18	254		(Corr'd Nav, Kongsberg 14208, img#120) (B) (T.A)
15-Sep-2018	09:01:40	121	ENV21			Camera	57	383710	6001731	383694	6001725	16	6	17	251		(Corr'd Nav, Kongsberg 14208, img#121) (B) (T.A)
15-Sep-2018	09:02:02	122	ENV21			Camera	57	383708	6001733	383694	6001725	14	8	16	239		(Corr'd Nav, Kongsberg 14208, img#122) (B) (T.A)
15-Sep-2018	09:02:22	123	ENV21			Camera	57	383706	6001734	383694	6001725	12	9	15	231		(Corr'd Nav, Kongsberg 14208, img#123) (B) (T.A)
15-Sep-2018	09:02:34	124	ENV21			Camera	57	383704	6001735	383694	6001725	10	10	14	224		(Corr'd Nav, Kongsberg 14208, img#124) (B) (T.A)
15-Sep-2018	09:02:55	125	ENV21			Camera	57	383699	6001737	383694	6001725	5	12	13	205		(Corr'd Nav, Kongsberg 14208, img#125) (B) (T.A)
15-Sep-2018	09:03:18	126	ENV21			Camera	57	383695	6001737	383694	6001725	1	12	12	186		(Corr'd Nav, Kongsberg 14208, img#126) (B) (T.A)
15-Sep-2018	09:03:30	127	ENV21			Camera	57	383694	6001737	383694	6001725	0	12	12	179		(Corr'd Nav, Kongsberg 14208, img#127) (B) (T.A)
15-Sep-2018	09:05:18	128	ENV21			Camera	57	383681	6001726	383694	6001725	-13	1	13	93		(Corr'd Nav, Kongsberg 14208, img#128) (B) (T.A)
15-Sep-2018	09:05:30	129	ENV21			Camera	57	383680	6001722	383694	6001725	-14	-3	14	77		(Corr'd Nav, Kongsberg 14208, img#129) (B) (T.A)
15-Sep-2018	09:05:45	130	ENV21			Camera	57	383681	6001721	383694	6001725	-13	-4	13	72		(Corr'd Nav, Kongsberg 14208, img#130) (B) (T.A)
15-Sep-2018	09:05:55	131	ENV21			Camera	56	383682	6001720	383694	6001725	-12	-5	13	67		(Corr'd Nav, Kongsberg 14208, img#131) (B) (T.A)
15-Sep-2018	09:06:53	132	ENV21			Camera	57	383692	6001724	383694	6001725	-2	-1	2	48		(Corr'd Nav, Kongsberg 14208, img#132) (B) (T.A)
15-Sep-2018	09:07:04	133	ENV21			Camera	57	383694	6001726	383694	6001725	0	1	1	190		(Corr'd Nav, Kongsberg 14208, img#133) (B) (T.A)
15-Sep-2018	09:07:39	134	ENV21			Camera	57	383698	6001739	383694	6001725	5	14	15	198		(Corr'd Nav, Kongsberg 14208, img#134) (B) (T.A)
15-Sep-2018	10:24:21	135	ENV22			Camera	56	388442	6001150	388415	6001149	27	1	27	267		(Corr'd Nav, Kongsberg 14208, img#135) (B) (T.A)
15-Sep-2018	10:25:12	136	ENV22			Camera	56	388434	6001153	388415	6001149	20	4	20	258		(Corr'd Nav, Kongsberg 14208, img#136) (B) (T.A)
15-Sep-2018	10:25:30	137	ENV22			Camera	56	388432	6001155	388415	6001149	17	6	18	250		(Corr'd Nav, Kongsberg 14208, img#137) (B) (T.A)
15-Sep-2018	10:25:49	138	ENV22			Camera	56	388427	6001159	388415	6001149	12	10	16	230		(Corr'd Nav, Kongsberg 14208, img#138) (B) (T.A)
15-Sep-2018	10:26:04	139	ENV22			Camera	56	388426	6001162	388415	6001149	11	13	17	220		(Corr'd Nav, Kongsberg 14208, img#139) (B) (T.A)
15-Sep-2018	10:26:35	140	ENV22			Camera	56	388417	6001165	388415	6001149	2	16	16	187		(Corr'd Nav, Kongsberg 14208, img#140) (B) (T.A)
15-Sep-2018	10:27:39	141	ENV22			Camera	56	388405	6001162	388415	6001149	-10	13	16	142		(Corr'd Nav, Kongsberg 14208, img#141) (B) (T.A)
15-Sep-2018	10:28:49	142	ENV22			Camera	56	388399	6001149	388415	6001149	-16	0	16	89		(Corr'd Nav, Kongsberg 14208, img#142) (B) (T.A)
15-Sep-2018	10:28:58	143	ENV22			Camera	56	388400	6001144	388415	6001149	-15	-5	16	71		(Corr'd Nav, Kongsberg 14208, img#143) (B) (T.A)
15-Sep-2018	10:29:19	144	ENV22			Camera	56	388405	6001141	388415	6001149	-10	-8	13	51		(Corr'd Nav, Kongsberg 14208, img#144) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210		Vessel	M.V *Ocean Endeavour*				
Client	Ørsted		Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6		Deployment Location	Starboard Crane	x 6.701	y 21.939	z 2.932	
Primary Positioning System	Starpack_Port		Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)		Vertical / Tidal Datum	LAT	

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration	Sample Retention	Retention	Observed Seafloor Depth (m)	Actual coordinates Easting	Actual coordinates Northing	Target coordinates Easting	Target coordinates Northing	Offset from target dE	Offset from target dN	Offset from target Range	Offset from target Bearing	Surveyor	Remarks
15-Sep-2018	10:29:51	145	ENV22			Camera	55	388409	6001138	388415	6001149	-6	-11	12	27		(Corr'd Nav, Kongsberg 14208, img#145) (B) (T.A)
15-Sep-2018	10:30:09	146	ENV22			Camera	56	388414	6001131	388415	6001149	-1	-18	18	3		(Corr'd Nav, Kongsberg 14208, img#146) (B) (T.A)
15-Sep-2018	10:30:54	147	ENV22			Camera	56	388421	6001134	388415	6001149	6	-15	16	337		(Corr'd Nav, Kongsberg 14208, img#147) (B) (T.A)
15-Sep-2018	10:31:42	148	ENV22			Camera	56	388428	6001144	388415	6001149	13	-5	14	293		(Corr'd Nav, Kongsberg 14208, img#148) (B) (T.A)
15-Sep-2018	10:31:57	149	ENV22			Camera	56	388427	6001150	388415	6001149	13	1	13	267		(Corr'd Nav, Kongsberg 14208, img#149) (B) (T.A)
15-Sep-2018	10:32:20	150	ENV22			Camera	56	388426	6001158	388415	6001149	11	9	15	231		(Corr'd Nav, Kongsberg 14208, img#150) (B) (T.A)
15-Sep-2018	10:32:33	151	ENV22			Camera	56	388425	6001160	388415	6001149	10	11	14	223		(Corr'd Nav, Kongsberg 14208, img#151) (B) (T.A)
15-Sep-2018	10:32:54	152	ENV22			Camera	56	388421	6001161	388415	6001149	6	12	13	208		(Corr'd Nav, Kongsberg 14208, img#152) (B) (T.A)
15-Sep-2018	10:33:21	153	ENV22			Camera	56	388416	6001158	388415	6001149	1	9	9	184		(Corr'd Nav, Kongsberg 14208, img#153) (B) (T.A)
15-Sep-2018	10:33:28	154	ENV22			Camera	56	388415	6001157	388415	6001149	0	8	8	179		(Corr'd Nav, Kongsberg 14208, img#154) (B) (T.A)
15-Sep-2018	10:34:23	155	ENV22			Camera	56	388410	6001150	388415	6001149	-5	1	5	100		(Corr'd Nav, Kongsberg 14208, img#156) (B) (T.A)
15-Sep-2018	10:35:23	156	ENV22			Camera	56	388406	6001138	388415	6001149	-9	-11	15	39		(Corr'd Nav, Kongsberg 14208, img#157) (B) (T.A)
15-Sep-2018	10:36:15	157	ENV22			Camera	56	388407	6001139	388415	6001149	-8	-10	13	37		(Corr'd Nav, Kongsberg 14208, img#158) (B) (T.A)
15-Sep-2018	10:36:30	158	ENV22			Camera	56	388408	6001139	388415	6001149	-7	-10	13	35		(Corr'd Nav, Kongsberg 14208, img#159) (B) (T.A)
15-Sep-2018	10:37:14	159	ENV22			Camera	55	388406	6001148	388415	6001149	-9	-1	9	82		(Corr'd Nav, Kongsberg 14208, img#160) (B) (T.A)
15-Sep-2018	10:38:05	160	ENV22			Camera	55	388415	6001153	388415	6001149	0	4	4	184		(Corr'd Nav, Kongsberg 14208, img#161) (B) (T.A)
15-Sep-2018	12:09:44	161	ENV19			Camera	55	393764	5997433	393775	5997431	-11	2	11	100		(Corr'd Nav, Kongsberg 14208, img#162) (B) (T.A)
15-Sep-2018	12:10:25	162	ENV19			Camera	55	393756	5997435	393775	5997431	-19	4	20	101		(Corr'd Nav, Kongsberg 14208, img#163) (B) (T.A)
15-Sep-2018	12:10:43	163	ENV19			Camera	55	393758	5997433	393775	5997431	-17	2	17	97		(Corr'd Nav, Kongsberg 14208, img#164) (B) (T.A)
15-Sep-2018	12:11:39	164	ENV19			Camera	54	393766	5997427	393775	5997431	-9	-4	10	65		(Corr'd Nav, Kongsberg 14208, img#165) (B) (T.A)
15-Sep-2018	12:11:51	165	ENV19			Camera	54	393768	5997424	393775	5997431	-7	-7	9	44		(Corr'd Nav, Kongsberg 14208, img#166) (B) (T.A)
15-Sep-2018	12:12:11	166	ENV19			Camera	54	393768	5997426	393775	5997431	-7	-6	9	50		(Corr'd Nav, Kongsberg 14208, img#167) (B) (T.A)
15-Sep-2018	12:12:36	167	ENV19			Camera	54	393768	5997426	393775	5997431	-7	-5	9	55		(Corr'd Nav, Kongsberg 14208, img#168) (B) (T.A)
15-Sep-2018	12:13:16	168	ENV19			Camera	54	393772	5997428	393775	5997431	-2	-3	4	36		(Corr'd Nav, Kongsberg 14208, img#169) (B) (T.A)
15-Sep-2018	12:13:42	169	ENV19			Camera	54	393775	5997427	393775	5997431	0	-4	4	6		(Corr'd Nav, Kongsberg 14208, img#170) (B) (T.A)
15-Sep-2018	12:14:12	170	ENV19			Camera	54	393772	5997420	393775	5997431	-3	-11	11	13		(Corr'd Nav, Kongsberg 14208, img#171) (B) (T.A)
15-Sep-2018	12:14:33	171	ENV19			Camera	54	393771	5997419	393775	5997431	-4	-12	13	19		(Corr'd Nav, Kongsberg 14208, img#172) (B) (T.A)
15-Sep-2018	12:14:41	172	ENV19			Camera	54	393770	5997421	393775	5997431	-5	-11	12	25		(Corr'd Nav, Kongsberg 14208, img#173) (B) (T.A)
15-Sep-2018	12:15:20	173	ENV19			Camera	54	393775	5997419	393775	5997431	0	-12	12	2		(Corr'd Nav, Kongsberg 14208, img#174) (B) (T.A)
15-Sep-2018	12:15:31	174	ENV19			Camera	54	393778	5997419	393775	5997431	3	-12	12	347		(Corr'd Nav, Kongsberg 14208, img#175) (B) (T.A)
15-Sep-2018	12:16:20	175	ENV19			Camera	55	393787	5997431	393775	5997431	12	0	12	271		(Corr'd Nav, Kongsberg 14208, img#176) (B) (T.A)
15-Sep-2018	12:16:26	176	ENV19			Camera	55	393787	5997431	393775	5997431	13	0	12	269		(Corr'd Nav, Kongsberg 14208, img#177) (B) (T.A)
15-Sep-2018	12:16:42	177	ENV19			Camera	55	393785	5997434	393775	5997431	10	3	11	255		(Corr'd Nav, Kongsberg 14208, img#178) (B) (T.A)
15-Sep-2018	12:17:10	178	ENV19			Camera	55	393784	5997437	393775	5997431	9	5	11	240		(Corr'd Nav, Kongsberg 14208, img#179) (B) (T.A)
15-Sep-2018	12:17:49	179	ENV19			Camera	56	393784	5997442	393775	5997431	9	11	15	219		(Corr'd Nav, Kongsberg 14208, img#180) (B) (T.A)
15-Sep-2018	12:18:01	180	ENV19			Camera	55	393783	5997444	393775	5997431	8	13	16	212		(Corr'd Nav, Kongsberg 14208, img#181) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*						
Client	Ørsted			Vessel Reference Point (VRP)	CoG						
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z	2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon						
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)		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		
15-Sep-2018	12:18:37	181	ENV19			Camera	55	393780	5997449	393775	5997431	5	18	19	196		(Corr'd Nav, Kongsberg 14208, img#182) (B) (T.A)
15-Sep-2018	12:18:59	182	ENV19			Camera	56	393777	5997451	393775	5997431	2	19	20	186		(Corr'd Nav, Kongsberg 14208, img#183) (B) (T.A)
15-Sep-2018	12:19:09	183	ENV19			Camera	56	393775	5997451	393775	5997431	0	20	20	180		(Corr'd Nav, Kongsberg 14208, img#184) (B) (T.A)
15-Sep-2018	12:19:33	184	ENV19			Camera	56	393770	5997450	393775	5997431	-5	18	19	164		(Corr'd Nav, Kongsberg 14208, img#185) (B) (T.A)
15-Sep-2018	12:19:44	185	ENV19			Camera	56	393768	5997449	393775	5997431	-7	18	19	157		(Corr'd Nav, Kongsberg 14208, img#186) (B) (T.A)
15-Sep-2018	12:19:55	186	ENV19			Camera	56	393765	5997446	393775	5997431	-10	15	18	147		(Corr'd Nav, Kongsberg 14208, img#187) (B) (T.A)
15-Sep-2018	12:20:10	187	ENV19			Camera	56	393763	5997444	393775	5997431	-12	13	18	136		(Corr'd Nav, Kongsberg 14208, img#188) (B) (T.A)
15-Sep-2018	12:20:23	188	ENV19			Camera	55	393760	5997441	393775	5997431	-15	10	18	125		(Corr'd Nav, Kongsberg 14208, img#189) (B) (T.A)
15-Sep-2018	12:20:35	189	ENV19			Camera	55	393758	5997439	393775	5997431	-17	8	18	114		(Corr'd Nav, Kongsberg 14208, img#190) (B) (T.A)
15-Sep-2018	12:20:53	190	ENV19			Camera	55	393756	5997435	393775	5997431	-19	4	20	102		(Corr'd Nav, Kongsberg 14208, img#191) (B) (T.A)
15-Sep-2018	12:21:05	191	ENV19			Camera	55	393754	5997434	393775	5997431	-21	2	21	97		(Corr'd Nav, Kongsberg 14208, img#192) (B) (T.A)
15-Sep-2018	12:21:48	192	ENV19			Camera	55	393753	5997432	393775	5997431	-22	0	22	91		(Corr'd Nav, Kongsberg 14208, img#193) (B) (T.A)
15-Sep-2018	12:22:24	193	ENV19			Camera	54	393756	5997425	393775	5997431	-19	-6	20	73		(Corr'd Nav, Kongsberg 14208, img#194) (B) (T.A)
15-Sep-2018	12:22:36	194	ENV19			Camera	54	393756	5997424	393775	5997431	-19	-7	20	69		(Corr'd Nav, Kongsberg 14208, img#195) (B) (T.A)
15-Sep-2018	12:23:05	195	ENV19			Camera	54	393760	5997422	393775	5997431	-15	-9	18	59		(Corr'd Nav, Kongsberg 14208, img#196) (B) (T.A)
15-Sep-2018	12:23:12	196	ENV19			Camera	54	393758	5997426	393775	5997431	-17	-6	18	72		(Corr'd Nav, Kongsberg 14208, img#197) (B) (T.A)
15-Sep-2018	12:23:52	197	ENV19			Camera	54	393766	5997423	393775	5997431	-9	-9	12	46		(Corr'd Nav, Kongsberg 14208, img#198) (B) (T.A)
15-Sep-2018	12:24:14	198	ENV19			Camera	54	393771	5997423	393775	5997431	-4	-8	9	29		(Corr'd Nav, Kongsberg 14208, img#199) (B) (T.A)
15-Sep-2018	12:24:42	199	ENV19			Camera	54	393775	5997421	393775	5997431	0	-10	10	357		(Corr'd Nav, Kongsberg 14208, img#200) (B) (T.A)
15-Sep-2018	12:24:54	200	ENV19			Camera	54	393776	5997421	393775	5997431	1	-10	10	355		(Corr'd Nav, Kongsberg 14208, img#201) (B) (T.A)
15-Sep-2018	14:05:33	201	ENV16			Camera	46	394796	5990992	394801	5990989	-6	3	6	116		(Corr'd Nav, Kongsberg 14208, img#202) (B) (T.A)
15-Sep-2018	14:05:48	202	ENV16			Camera	46	394790	5990994	394801	5990989	-11	4	12	112		(Corr'd Nav, Kongsberg 14208, img#203) (B) (T.A)
15-Sep-2018	14:06:07	203	ENV16			Camera	46	394788	5990993	394801	5990989	-13	4	14	107		(Corr'd Nav, Kongsberg 14208, img#204) (B) (T.A)
15-Sep-2018	14:07:15	204	ENV16			Camera	46	394782	5990992	394801	5990989	-19	3	19	98		(Corr'd Nav, Kongsberg 14208, img#205) (B) (T.A)
15-Sep-2018	14:07:40	205	ENV16			Camera	46	394781	5990987	394801	5990989	-20	-3	20	82		(Corr'd Nav, Kongsberg 14208, img#206) (B) (T.A)
15-Sep-2018	14:08:01	206	ENV16			Camera	46	394780	5990984	394801	5990989	-21	-6	22	75		(Corr'd Nav, Kongsberg 14208, img#207) (B) (T.A)
15-Sep-2018	14:08:23	207	ENV16			Camera	46	394779	5990980	394801	5990989	-23	-10	25	66		(Corr'd Nav, Kongsberg 14208, img#208) (B) (T.A)
15-Sep-2018	14:08:38	208	ENV16			Camera	46	394779	5990977	394801	5990989	-22	-13	25	60		(Corr'd Nav, Kongsberg 14208, img#209) (B) (T.A)
15-Sep-2018	14:08:53	209	ENV16			Camera	46	394782	5990975	394801	5990989	-20	-14	24	54		(Corr'd Nav, Kongsberg 14208, img#210) (B) (T.A)
15-Sep-2018	14:09:23	210	ENV16			Camera	46	394784	5990974	394801	5990989	-17	-15	23	49		(Corr'd Nav, Kongsberg 14208, img#211) (B) (T.A)
15-Sep-2018	14:09:39	211	ENV16			Camera	46	394788	5990975	394801	5990989	-13	-14	19	44		(Corr'd Nav, Kongsberg 14208, img#212) (B) (T.A)
15-Sep-2018	14:10:25	212	ENV16			Camera	47	394802	5990974	394801	5990989	1	-16	16	357		(Corr'd Nav, Kongsberg 14208, img#213) (B) (T.A)
15-Sep-2018	14:10:58	213	ENV16			Camera	46	394805	5990975	394801	5990989	4	-15	16	344		(Corr'd Nav, Kongsberg 14208, img#214) (B) (T.A)
15-Sep-2018	14:11:10	214	ENV16			Camera	46	394808	5990974	394801	5990989	7	-15	17	336		(Corr'd Nav, Kongsberg 14208, img#215) (B) (T.A)
15-Sep-2018	14:11:55	215	ENV16			Camera	46	394808	5990987	394801	5990989	7	-3	8	291		(Corr'd Nav, Kongsberg 14208, img#216) (B) (T.A)
15-Sep-2018	14:12:05	216	ENV16			Camera	46	394811	5990988	394801	5990989	10	-1	10	278		(Corr'd Nav, Kongsberg 14208, img#217) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*			
Client	Ørsted			Vessel Reference Point (VRP)	CoG			
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x 6.701	y 21.939	z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon			
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)	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		
15-Sep-2018	14:12:20	217	ENV16			Camera	46	394811	5990988	394801	5990989	10	-2	10	280		(Corr'd Nav, Kongsberg 14208, img#218) (B) (T.A)
15-Sep-2018	14:12:29	218	ENV16			Camera	46	394810	5990988	394801	5990989	9	-1	9	276		(Corr'd Nav, Kongsberg 14208, img#219) (B) (T.A)
15-Sep-2018	14:13:26	219	ENV16			Camera	46	394795	5991007	394801	5990989	-6	17	18	162		(Corr'd Nav, Kongsberg 14208, img#220) (B) (T.A)
15-Sep-2018	14:14:23	220	ENV16			Camera	47	394795	5991004	394801	5990989	-6	14	16	156		(Corr'd Nav, Kongsberg 14208, img#221) (B) (T.A)
15-Sep-2018	14:15:02	221	ENV16			Camera	46	394793	5990992	394801	5990989	-9	3	9	108		(Corr'd Nav, Kongsberg 14208, img#222) (B) (T.A)
15-Sep-2018	14:15:28	222	ENV16			Camera	46	394789	5990987	394801	5990989	-13	-2	13	80		(Corr'd Nav, Kongsberg 14208, img#223) (B) (T.A)
15-Sep-2018	14:15:49	223	ENV16			Camera	46	394788	5990983	394801	5990989	-13	-6	14	64		(Corr'd Nav, Kongsberg 14208, img#224) (B) (T.A)
15-Sep-2018	14:16:06	224	ENV16			Camera	46	394786	5990983	394801	5990989	-15	-6	16	67		(Corr'd Nav, Kongsberg 14208, img#225) (B) (T.A)
15-Sep-2018	14:16:18	225	ENV16			Camera	46	394786	5990982	394801	5990989	-15	-7	17	65		(Corr'd Nav, Kongsberg 14208, img#226) (B) (T.A)
15-Sep-2018	14:16:26	226	ENV16			Camera	46	394786	5990982	394801	5990989	-15	-7	17	64		(Corr'd Nav, Kongsberg 14208, img#227) (B) (T.A)
15-Sep-2018	14:16:38	227	ENV16			Camera	46	394788	5990981	394801	5990989	-13	-9	16	58		(Corr'd Nav, Kongsberg 14208, img#228) (B) (T.A)
15-Sep-2018	14:16:53	228	ENV16			Camera	46	394791	5990980	394801	5990989	-10	-9	14	46		(Corr'd Nav, Kongsberg 14208, img#229) (B) (T.A)
15-Sep-2018	14:17:00	229	ENV16			Camera	46	394792	5990980	394801	5990989	-9	-10	13	43		(Corr'd Nav, Kongsberg 14208, img#230) (B) (T.A)
15-Sep-2018	14:17:17	230	ENV16			Camera	46	394795	5990979	394801	5990989	-6	-11	13	30		(Corr'd Nav, Kongsberg 14208, img#231) (B) (T.A)
15-Sep-2018	14:17:30	231	ENV16			Camera	46	394796	5990978	394801	5990989	-5	-11	12	23		(Corr'd Nav, Kongsberg 14208, img#232) (B) (T.A)
15-Sep-2018	14:18:16	232	ENV16			Camera	46	394803	5990984	394801	5990989	2	-6	6	344		(Corr'd Nav, Kongsberg 14208, img#233) (B) (T.A)
15-Sep-2018	14:18:41	233	ENV16			Camera	46	394805	5990984	394801	5990989	4	-5	7	319		(Corr'd Nav, Kongsberg 14208, img#234) (B) (T.A)
15-Sep-2018	14:20:35	234	ENV16			Camera	46	394810	5990997	394801	5990989	8	8	11	228		(Corr'd Nav, Kongsberg 14208, img#235) (B) (T.A)
15-Sep-2018	14:21:25	235	ENV16			Camera	47	394813	5990992	394801	5990989	12	2	12	260		(Corr'd Nav, Kongsberg 14208, img#236) (B) (T.A)
15-Sep-2018	14:22:00	236	ENV16			Camera	46	394815	5990984	394801	5990989	14	-6	15	293		(Corr'd Nav, Kongsberg 14208, img#237) (B) (T.A)
15-Sep-2018	14:22:09	237	ENV16			Camera	46	394815	5990982	394801	5990989	14	-7	16	298		(Corr'd Nav, Kongsberg 14208, img#238) (B) (T.A)
15-Sep-2018	14:22:21	238	ENV16			Camera	46	394815	5990981	394801	5990989	14	-9	17	303		(Corr'd Nav, Kongsberg 14208, img#239) (B) (T.A)
15-Sep-2018	14:22:32	239	ENV16			Camera	46	394814	5990979	394801	5990989	13	-10	16	309		(Corr'd Nav, Kongsberg 14208, img#240) (B) (T.A)
15-Sep-2018	14:22:40	240	ENV16			Camera	46	394813	5990979	394801	5990989	12	-10	16	311		(Corr'd Nav, Kongsberg 14208, img#241) (B) (T.A)
15-Sep-2018	15:49:35	241	ENV17			Camera	49	401349	5991578	401361	5991569	-12	9	15	127		(Corr'd Nav, Kongsberg 14208, img#242) (B) (T.A)
15-Sep-2018	15:49:55	242	ENV17			Camera	49	401347	5991578	401361	5991569	-14	9	17	122		(Corr'd Nav, Kongsberg 14208, img#243) (B) (T.A)
15-Sep-2018	15:50:12	243	ENV17			Camera	49	401345	5991576	401361	5991569	-17	7	18	112		(Corr'd Nav, Kongsberg 14208, img#244) (B) (T.A)
15-Sep-2018	15:50:22	244	ENV17			Camera	49	401345	5991576	401361	5991569	-17	6	18	111		(Corr'd Nav, Kongsberg 14208, img#245) (B) (T.A)
15-Sep-2018	15:50:50	245	ENV17			Camera	49	401344	5991574	401361	5991569	-18	5	18	105		(Corr'd Nav, Kongsberg 14208, img#246) (B) (T.A)
15-Sep-2018	15:51:04	246	ENV17			Camera	49	401344	5991573	401361	5991569	-17	4	18	101		(Corr'd Nav, Kongsberg 14208, img#247) (B) (T.A)
15-Sep-2018	15:51:37	247	ENV17			Camera	49	401346	5991570	401361	5991569	-16	1	16	92		(Corr'd Nav, Kongsberg 14208, img#248) (B) (T.A)
15-Sep-2018	15:51:46	248	ENV17			Camera	49	401346	5991569	401361	5991569	-15	0	15	90		(Corr'd Nav, Kongsberg 14208, img#249) (B) (T.A)
15-Sep-2018	15:52:09	249	ENV17			Camera	49	401349	5991566	401361	5991569	-13	-3	13	76		(Corr'd Nav, Kongsberg 14208, img#250) (B) (T.A)
15-Sep-2018	15:52:17	250	ENV17			Camera	49	401349	5991566	401361	5991569	-12	-3	13	75		(Corr'd Nav, Kongsberg 14208, img#251) (B) (T.A)
15-Sep-2018	15:52:27	251	ENV17			Camera	48	401350	5991565	401361	5991569	-11	-4	12	69		(Corr'd Nav, Kongsberg 14208, img#252) (B) (T.A)
15-Sep-2018	15:52:43	252	ENV17			Camera	48	401354	5991562	401361	5991569	-8	-7	10	48		(Corr'd Nav, Kongsberg 14208, img#253) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*		
Client	Ørsted			Vessel Reference Point (VRP)	CoG		
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x 6.701	y 21.939, z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon		
Geodetic Reference System	Datum: WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)	Vertical / Tidal Datum	LAT

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration	Sample Retention	Retention	Observed Seafloor Depth (m)	Actual coordinates Easting	Actual coordinates Northing	Target coordinates Easting	Target coordinates Northing	Offset from target dE	dN	Range	Bearing	Surveyor	Remarks
15-Sep-2018	15:52:55	253	ENV17			Camera	48	401353	5991562	401361	5991569	-9	-8	12	50		(Corr'd Nav, Kongsberg 14208, img#254) (B) (T.A)
15-Sep-2018	15:53:13	254	ENV17			Camera	48	401354	5991560	401361	5991569	-7	-10	12	37		(Corr'd Nav, Kongsberg 14208, img#255) (B) (T.A)
15-Sep-2018	15:54:02	255	ENV17			Camera	48	401357	5991558	401361	5991569	-4	-12	12	20		(Corr'd Nav, Kongsberg 14208, img#256) (B) (T.A)
15-Sep-2018	15:54:15	256	ENV17			Camera	48	401359	5991557	401361	5991569	-2	-12	13	11		(Corr'd Nav, Kongsberg 14208, img#257) (B) (T.A)
15-Sep-2018	15:54:35	257	ENV17			Camera	48	401360	5991556	401361	5991569	-2	-13	13	7		(Corr'd Nav, Kongsberg 14208, img#258) (B) (T.A)
15-Sep-2018	15:55:32	258	ENV17			Camera	49	401366	5991558	401361	5991569	5	-12	13	338		(Corr'd Nav, Kongsberg 14208, img#259) (B) (T.A)
15-Sep-2018	15:55:49	259	ENV17			Camera	49	401367	5991559	401361	5991569	6	-10	12	330		(Corr'd Nav, Kongsberg 14208, img#260) (B) (T.A)
15-Sep-2018	15:56:18	260	ENV17			Camera	49	401367	5991561	401361	5991569	6	-8	10	326		(Corr'd Nav, Kongsberg 14208, img#261) (B) (T.A)
15-Sep-2018	15:57:12	261	ENV17			Camera	49	401369	5991563	401361	5991569	7	-6	9	311		(Corr'd Nav, Kongsberg 14208, img#262) (B) (T.A)
15-Sep-2018	15:57:24	262	ENV17			Camera	49	401369	5991564	401361	5991569	7	-5	9	304		(Corr'd Nav, Kongsberg 14208, img#263) (B) (T.A)
15-Sep-2018	15:58:07	263	ENV17			Camera	49	401366	5991567	401361	5991569	5	-3	6	298		(Corr'd Nav, Kongsberg 14208, img#264) (B) (T.A)
15-Sep-2018	15:58:29	264	ENV17			Camera	49	401366	5991568	401361	5991569	5	-1	5	282		(Corr'd Nav, Kongsberg 14208, img#265) (B) (T.A)
15-Sep-2018	15:58:59	265	ENV17			Camera	49	401364	5991571	401361	5991569	3	1	3	246		(Corr'd Nav, Kongsberg 14208, img#266) (B) (T.A)
15-Sep-2018	15:59:11	266	ENV17			Camera	49	401365	5991572	401361	5991569	3	2	4	236		(Corr'd Nav, Kongsberg 14208, img#267) (B) (T.A)
15-Sep-2018	15:59:21	267	ENV17			Camera	49	401365	5991573	401361	5991569	4	4	5	228		(Corr'd Nav, Kongsberg 14208, img#268) (B) (T.A)
15-Sep-2018	15:59:35	268	ENV17			Camera	49	401366	5991575	401361	5991569	5	5	7	221		(Corr'd Nav, Kongsberg 14208, img#269) (B) (T.A)
15-Sep-2018	16:00:02	269	ENV17			Camera	49	401364	5991577	401361	5991569	3	8	9	201		(Corr'd Nav, Kongsberg 14208, img#270) (B) (T.A)
15-Sep-2018	16:00:33	270	ENV17			Camera	49	401362	5991576	401361	5991569	0	7	7	181		(Corr'd Nav, Kongsberg 14208, img#271) (B) (T.A)
15-Sep-2018	16:00:53	271	ENV17			Camera	49	401358	5991573	401361	5991569	-3	3	5	135		(Corr'd Nav, Kongsberg 14208, img#272) (B) (T.A)
15-Sep-2018	16:01:23	272	ENV17			Camera	49	401353	5991572	401361	5991569	-9	3	9	107		(Corr'd Nav, Kongsberg 14208, img#273) (B) (T.A)
15-Sep-2018	16:01:44	273	ENV17			Camera	49	401347	5991571	401361	5991569	-15	2	15	98		(Corr'd Nav, Kongsberg 14208, img#274) (B) (T.A)
15-Sep-2018	16:01:54	274	ENV17			Camera	49	401345	5991571	401361	5991569	-17	2	17	97		(Corr'd Nav, Kongsberg 14208, img#275) (B) (T.A)
15-Sep-2018	16:02:05	275	ENV17			Camera	49	401344	5991571	401361	5991569	-18	1	18	94		(Corr'd Nav, Kongsberg 14208, img#276) (B) (T.A)
15-Sep-2018	16:02:26	276	ENV17			Camera	49	401340	5991570	401361	5991569	-22	1	22	93		(Corr'd Nav, Kongsberg 14208, img#277) (B) (T.A)
15-Sep-2018	16:02:36	277	ENV17			Camera	49	401339	5991571	401361	5991569	-22	2	22	94		(Corr'd Nav, Kongsberg 14208, img#278) (B) (T.A)
15-Sep-2018	16:03:06	278	ENV17			Camera	49	401339	5991572	401361	5991569	-23	2	23	96		(Corr'd Nav, Kongsberg 14208, img#279) (B) (T.A)
15-Sep-2018	16:03:43	279	ENV17			Camera	49	401343	5991568	401361	5991569	-19	-1	19	87		(Corr'd Nav, Kongsberg 14208, img#280) (B) (T.A)
15-Sep-2018	17:59:19	280	ENV14			Camera	40	404544	5986501	404555	5986490	-11	12	16	137		(Corr'd Nav, Kongsberg 14208, img#281) (B) (T.A)
15-Sep-2018	18:00:05	281	ENV14			Camera	39	404542	5986497	404555	5986490	-13	8	15	122		(Corr'd Nav, Kongsberg 14208, img#282) (B) (T.A)
15-Sep-2018	18:00:45	282	ENV14			Camera	40	404544	5986494	404555	5986490	-10	4	11	112		(Corr'd Nav, Kongsberg 14208, img#283) (B) (T.A)
15-Sep-2018	18:00:57	283	ENV14			Camera	40	404546	5986493	404555	5986490	-9	3	9	110		(Corr'd Nav, Kongsberg 14208, img#284) (B) (T.A)
15-Sep-2018	18:01:08	284	ENV14			Camera	40	404545	5986491	404555	5986490	-10	2	10	100		(Corr'd Nav, Kongsberg 14208, img#285) (B) (T.A)
15-Sep-2018	18:01:23	285	ENV14			Camera	40	404548	5986489	404555	5986490	-6	-1	6	84		(Corr'd Nav, Kongsberg 14208, img#286) (B) (T.A)
15-Sep-2018	18:01:40	286	ENV14			Camera	40	404551	5986488	404555	5986490	-4	-2	4	64		(Corr'd Nav, Kongsberg 14208, img#287) (B) (T.A)
15-Sep-2018	18:02:05	287	ENV14			Camera	40	404551	5986483	404555	5986490	-4	-7	7	28		(Corr'd Nav, Kongsberg 14208, img#288) (B) (T.A)
15-Sep-2018	18:02:17	288	ENV14			Camera	40	404550	5986481	404555	5986490	-4	-8	9	26		(Corr'd Nav, Kongsberg 14208, img#289) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*					
Client	Ørsted			Vessel Reference Point (VRP)	CoG					
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon					
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80		Projection	UTM ZONE 31 N (3° E)		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		
15-Sep-2018	18:02:50	289	ENV14			Camera	40	404550	5986477	404555	5986490	-4	-12	13	19		(Corr'd Nav, Kongsberg 14208, img#290) (B) (T.A)
15-Sep-2018	18:03:09	290	ENV14			Camera	40	404551	5986476	404555	5986490	-4	-14	14	15		(Corr'd Nav, Kongsberg 14208, img#291) (B) (T.A)
15-Sep-2018	18:03:21	291	ENV14			Camera	40	404552	5986475	404555	5986490	-3	-14	15	12		(Corr'd Nav, Kongsberg 14208, img#292) (B) (T.A)
15-Sep-2018	18:03:41	292	ENV14			Camera	40	404554	5986475	404555	5986490	-1	-15	15	4		(Corr'd Nav, Kongsberg 14208, img#293) (B) (T.A)
15-Sep-2018	18:03:49	293	ENV14			Camera	40	404555	5986476	404555	5986490	1	-14	14	358		(Corr'd Nav, Kongsberg 14208, img#294) (B) (T.A)
15-Sep-2018	18:04:01	294	ENV14			Camera	40	404556	5986476	404555	5986490	2	-13	13	352		(Corr'd Nav, Kongsberg 14208, img#295) (B) (T.A)
15-Sep-2018	18:04:32	295	ENV14			Camera	40	404558	5986478	404555	5986490	4	-12	12	342		(Corr'd Nav, Kongsberg 14208, img#296) (B) (T.A)
15-Sep-2018	18:05:07	296	ENV14			Camera	39	404560	5986481	404555	5986490	6	-9	11	327		(Corr'd Nav, Kongsberg 14208, img#297) (B) (T.A)
15-Sep-2018	18:05:43	297	ENV14			Camera	40	404563	5986480	404555	5986490	8	-9	12	319		(Corr'd Nav, Kongsberg 14208, img#298) (B) (T.A)
15-Sep-2018	18:06:18	298	ENV14			Camera	40	404566	5986482	404555	5986490	11	-7	13	303		(Corr'd Nav, Kongsberg 14208, img#299) (B) (T.A)
15-Sep-2018	18:06:44	299	ENV14			Camera	40	404568	5986487	404555	5986490	14	-3	14	281		(Corr'd Nav, Kongsberg 14208, img#300) (B) (T.A)
15-Sep-2018	18:07:51	300	ENV14			Camera	40	404562	5986499	404555	5986490	8	9	12	222		(Corr'd Nav, Kongsberg 14208, img#301) (B) (T.A)
15-Sep-2018	18:08:05	301	ENV14			Camera	39	404562	5986500	404555	5986490	7	10	13	216		(Corr'd Nav, Kongsberg 14208, img#302) (B) (T.A)
15-Sep-2018	18:08:54	302	ENV14			Camera	40	404559	5986502	404555	5986490	4	13	13	198		(Corr'd Nav, Kongsberg 14208, img#303) (B) (T.A)
15-Sep-2018	18:09:37	303	ENV14			Camera	39	404557	5986503	404555	5986490	2	14	14	190		(Corr'd Nav, Kongsberg 14208, img#304) (B) (T.A)
15-Sep-2018	18:09:57	304	ENV14			Camera	39	404554	5986501	404555	5986490	0	11	11	179		(Corr'd Nav, Kongsberg 14208, img#305) (B) (T.A)
15-Sep-2018	18:10:47	305	ENV14			Camera	40	404553	5986497	404555	5986490	-1	7	7	169		(Corr'd Nav, Kongsberg 14208, img#306) (B) (T.A)
15-Sep-2018	18:11:10	306	ENV14			Camera	39	404552	5986493	404555	5986490	-2	4	4	151		(Corr'd Nav, Kongsberg 14208, img#307) (B) (T.A)
15-Sep-2018	18:11:24	307	ENV14			Camera	40	404555	5986493	404555	5986490	0	4	4	183		(Corr'd Nav, Kongsberg 14208, img#308) (B) (T.A)
15-Sep-2018	18:11:32	308	ENV14			Camera	40	404555	5986493	404555	5986490	0	3	3	186		(Corr'd Nav, Kongsberg 14208, img#309) (B) (T.A)
15-Sep-2018	18:11:55	309	ENV14			Camera	39	404557	5986491	404555	5986490	2	1	2	243		(Corr'd Nav, Kongsberg 14208, img#310) (B) (T.A)
15-Sep-2018	18:12:12	310	ENV14			Camera	40	404557	5986490	404555	5986490	2	0	2	266		(Corr'd Nav, Kongsberg 14208, img#311) (B) (T.A)
15-Sep-2018	18:12:19	311	ENV14			Camera	40	404556	5986488	404555	5986490	2	-1	2	304		(Corr'd Nav, Kongsberg 14208, img#312) (B) (T.A)
15-Sep-2018	18:12:41	312	ENV14			Camera	40	404557	5986486	404555	5986490	3	-4	5	326		(Corr'd Nav, Kongsberg 14208, img#313) (B) (T.A)
15-Sep-2018	18:12:52	313	ENV14			Camera	40	404560	5986486	404555	5986490	5	-3	6	303		(Corr'd Nav, Kongsberg 14208, img#314) (B) (T.A)
15-Sep-2018	18:13:22	314	ENV14			Camera	40	404561	5986485	404555	5986490	7	-5	8	306		(Corr'd Nav, Kongsberg 14208, img#315) (B) (T.A)
15-Sep-2018	20:40:55	315	ENV15			Camera	48	386373	5992774	386367	5992775	6	-1	6	279		(Raw Nav, Kongsberg 14208, img#316) (B) (T.A)
15-Sep-2018	20:41:58	316	ENV15			Camera	48	386384	5992775	386367	5992775	17	0	17	270		(Raw Nav, Kongsberg 14208, img#317) (B) (T.A)
15-Sep-2018	20:42:19	317	ENV15			Camera	48	386388	5992775	386367	5992775	21	0	21	270		(Raw Nav, Kongsberg 14208, img#318) (B) (T.A)
15-Sep-2018	20:42:32	318	ENV15			Camera	48	386390	5992775	386367	5992775	23	0	23	270		(Raw Nav, Kongsberg 14208, img#319) (B) (T.A)
15-Sep-2018	20:42:48	319	ENV15			Camera	48	386392	5992775	386367	5992775	25	0	25	270		(Raw Nav, Kongsberg 14208, img#320) (B) (T.A)
15-Sep-2018	20:43:04	320	ENV15			Camera	48	386395	5992775	386367	5992775	28	0	28	270		(Raw Nav, Kongsberg 14208, img#321) (B) (T.A)
15-Sep-2018	20:43:16	321	ENV15			Camera	48	386397	5992775	386367	5992775	30	0	30	270		(Raw Nav, Kongsberg 14208, img#322) (B) (T.A)
15-Sep-2018	20:44:39	322	ENV15			Camera	48	386411	5992776	386367	5992775	44	1	44	269		(Raw Nav, Kongsberg 14208, img#323) (B) (T.A)
15-Sep-2018	20:59:59	323	ENV15			Camera	47	386370	5992774	386367	5992775	4	-1	4	279		(Corr'd Nav, Kongsberg 14208, img#1) (B) (T.A)
15-Sep-2018	21:01:17	324	ENV15			Camera	48	386369	5992784	386367	5992775	2	9	9	195		(Corr'd Nav, Kongsberg 14208, img#2) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210		Vessel	M.V *Ocean Endeavour*				
Client	Ørsted		Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6		Deployment Location	Starboard Crane	x 6.701	y 21.939	z 2.932	
Primary Positioning System	Starpack_Port		Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)		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		
15-Sep-2018	21:01:55	325	ENV15			Camera	48	386368	5992787	386367	5992775	1	12	12	186		(Corr'd Nav, Kongsberg 14208, img#3) (B) (T.A)
15-Sep-2018	21:02:10	326	ENV15			Camera	48	386368	5992788	386367	5992775	1	13	13	184		(Corr'd Nav, Kongsberg 14208, img#4) (B) (T.A)
15-Sep-2018	21:02:26	327	ENV15			Camera	47	386369	5992788	386367	5992775	2	13	13	189		(Corr'd Nav, Kongsberg 14208, img#5) (B) (T.A)
15-Sep-2018	21:02:52	328	ENV15			Camera	48	386372	5992790	386367	5992775	5	15	16	197		(Corr'd Nav, Kongsberg 14208, img#6) (B) (T.A)
15-Sep-2018	21:03:12	329	ENV15			Camera	49	386369	5992791	386367	5992775	3	16	16	189		(Corr'd Nav, Kongsberg 14208, img#7) (B) (T.A)
15-Sep-2018	21:03:30	330	ENV15			Camera	48	386365	5992787	386367	5992775	-2	12	12	172		(Corr'd Nav, Kongsberg 14208, img#8) (B) (T.A)
15-Sep-2018	21:03:44	331	ENV15			Camera	48	386360	5992784	386367	5992775	-7	9	11	142		(Corr'd Nav, Kongsberg 14208, img#9) (B) (T.A)
15-Sep-2018	21:03:52	332	ENV15			Camera	47	386357	5992782	386367	5992775	-10	7	12	125		(Corr'd Nav, Kongsberg 14208, img#10) (B) (T.A)
15-Sep-2018	21:05:03	333	ENV15			Camera	47	386330	5992766	386367	5992775	-37	-9	38	76		(Corr'd Nav, Kongsberg 14208, img#11) (B) (T.A)
15-Sep-2018	21:05:19	334	ENV15			Camera	47	386323	5992762	386367	5992775	-43	-13	45	73		(Corr'd Nav, Kongsberg 14208, img#12) (B) (T.A)
15-Sep-2018	21:05:34	335	ENV15			Camera	47	386318	5992759	386367	5992775	-49	-16	51	72		(Corr'd Nav, Kongsberg 14208, img#13) (B) (T.A)
15-Sep-2018	21:06:04	336	ENV15			Camera	48	386306	5992752	386367	5992775	-60	-23	65	69		(Corr'd Nav, Kongsberg 14208, img#14) (B) (T.A)
15-Sep-2018	21:57:27	338	ENV15			Camera	47	386366	5992763	386367	5992775	-1	-12	12	6		(Corr'd Nav, Kongsberg 14208, img#1) (B) (T.A)
15-Sep-2018	21:57:39	339	ENV15			Camera	48	386367	5992764	386367	5992775	0	-11	11	360		(Corr'd Nav, Kongsberg 14208, img#2) (B) (T.A)
15-Sep-2018	21:57:50	340	ENV15			Camera	48	386367	5992765	386367	5992775	1	-10	10	356		(Corr'd Nav, Kongsberg 14208, img#3) (B) (T.A)
15-Sep-2018	21:58:10	341	ENV15			Camera	48	386373	5992764	386367	5992775	6	-11	12	329		(Corr'd Nav, Kongsberg 14208, img#4) (B) (T.A)
15-Sep-2018	21:58:24	342	ENV15			Camera	47	386378	5992765	386367	5992775	11	-10	15	312		(Corr'd Nav, Kongsberg 14208, img#5) (B) (T.A)
15-Sep-2018	21:58:33	343	ENV15			Camera	47	386380	5992767	386367	5992775	14	-8	16	300		fix with no photo
15-Sep-2018	21:58:44	344	ENV15			Camera	47	386382	5992768	386367	5992775	15	-7	17	295		(Corr'd Nav, Kongsberg 14208, img#7) (B) (T.A)
15-Sep-2018	21:58:54	345	ENV15			Camera	47	386382	5992768	386367	5992775	16	-7	17	294		(Corr'd Nav, Kongsberg 14208, img#8) (B) (T.A)
15-Sep-2018	21:59:14	346	ENV15			Camera	47	386382	5992769	386367	5992775	16	-6	17	292		(Corr'd Nav, Kongsberg 14208, img#9) (B) (T.A)
15-Sep-2018	21:59:42	347	ENV15			Camera	48	386383	5992769	386367	5992775	16	-6	17	291		(Corr'd Nav, Kongsberg 14208, img#10) (B) (T.A)
15-Sep-2018	22:25:50	348	ENV15			Camera	48	386372	5992770	386367	5992775	6	-5	8	312		(Corr'd Nav, Kongsberg 14208, img#11) (B) (T.A)
15-Sep-2018	22:26:04	349	ENV15			Camera	48	386371	5992767	386367	5992775	4	-8	9	331		(Corr'd Nav, Kongsberg 14208, img#12) (B) (T.A)
15-Sep-2018	22:26:19	350	ENV15			Camera	48	386370	5992767	386367	5992775	3	-8	8	337		(Corr'd Nav, Kongsberg 14208, img#13) (B) (T.A)
15-Sep-2018	22:26:33	351	ENV15			Camera	48	386369	5992768	386367	5992775	2	-7	7	343		(Corr'd Nav, Kongsberg 14208, img#14) (B) (T.A)
15-Sep-2018	22:26:49	352	ENV15			Camera	48	386368	5992768	386367	5992775	1	-7	7	348		(Corr'd Nav, Kongsberg 14208, img#15) (B) (T.A)
15-Sep-2018	22:26:58	353	ENV15			Camera	48	386368	5992770	386367	5992775	1	-5	5	350		(Corr'd Nav, Kongsberg 14208, img#16) (B) (T.A)
15-Sep-2018	22:27:09	354	ENV15			Camera	48	386368	5992771	386367	5992775	1	-4	4	338		(Corr'd Nav, Kongsberg 14208, img#17) (B) (T.A)
15-Sep-2018	22:27:26	355	ENV15			Camera	48	386367	5992773	386367	5992775	0	-2	2	359		(Corr'd Nav, Kongsberg 14208, img#18) (B) (T.A)
15-Sep-2018	22:27:39	356	ENV15			Camera	48	386365	5992773	386367	5992775	-2	-2	2	49		(Corr'd Nav, Kongsberg 14208, img#19) (B) (T.A)
15-Sep-2018	22:27:55	357	ENV15			Camera	48	386363	5992775	386367	5992775	-4	0	4	87		(Corr'd Nav, Kongsberg 14208, img#20) (B) (T.A)
15-Sep-2018	22:28:12	358	ENV15			Camera	48	386362	5992777	386367	5992775	-5	2	5	110		(Corr'd Nav, Kongsberg 14208, img#21) (B) (T.A)
15-Sep-2018	22:28:19	359	ENV15			Camera	48	386363	5992780	386367	5992775	-4	5	6	138		(Corr'd Nav, Kongsberg 14208, img#22) (B) (T.A)
15-Sep-2018	22:29:22	360	ENV15			Camera	48	386364	5992785	386367	5992775	-3	10	10	162		(Corr'd Nav, Kongsberg 14208, img#23) (B) (T.A)
15-Sep-2018	22:29:32	361	ENV15			Camera	48	386365	5992785	386367	5992775	-1	10	10	172		(Corr'd Nav, Kongsberg 14208, img#24) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*		
Client	Ørsted			Vessel Reference Point (VRP)	CoG		
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x 6.701	y 21.939 z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon		
Geodetic Reference System	Datum WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)	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		
15-Sep-2018	22:29:43	362	ENV15			Camera	48	386368	5992787	386367	5992775	1	12	12	185		(Corr'd Nav, Kongsberg 14208, img#25) (B) (T.A)
15-Sep-2018	22:29:53	363	ENV15			Camera	47	386369	5992789	386367	5992775	3	14	14	190		(Corr'd Nav, Kongsberg 14208, img#26) (B) (T.A)
15-Sep-2018	22:30:04	364	ENV15			Camera	47	386371	5992791	386367	5992775	5	16	17	197		(Corr'd Nav, Kongsberg 14208, img#27) (B) (T.A)
15-Sep-2018	22:30:26	365	ENV15			Camera	47	386374	5992790	386367	5992775	7	16	17	205		(Corr'd Nav, Kongsberg 14208, img#28) (B) (T.A)
15-Sep-2018	22:30:35	366	ENV15			Camera	47	386375	5992791	386367	5992775	8	16	18	207		(Corr'd Nav, Kongsberg 14208, img#29) (B) (T.A)
15-Sep-2018	22:30:49	367	ENV15			Camera	47	386380	5992794	386367	5992775	13	19	23	214		(Corr'd Nav, Kongsberg 14208, img#30) (B) (T.A)
15-Sep-2018	22:31:13	368	ENV15			Camera	48	386380	5992793	386367	5992775	13	18	22	217		(Corr'd Nav, Kongsberg 14208, img#31) (B) (T.A)
15-Sep-2018	22:31:55	369	ENV15			Camera	48	386377	5992787	386367	5992775	10	12	16	219		(Corr'd Nav, Kongsberg 14208, img#32) (B) (T.A)
15-Sep-2018	22:32:03	370	ENV15			Camera	48	386376	5992786	386367	5992775	9	11	15	220		(Corr'd Nav, Kongsberg 14208, img#33) (B) (T.A)
15-Sep-2018	22:32:11	371	ENV15			Camera	48	386378	5992786	386367	5992775	12	11	16	227		(Corr'd Nav, Kongsberg 14208, img#34) (B) (T.A)
15-Sep-2018	22:32:25	372	ENV15			Camera	48	386376	5992785	386367	5992775	9	10	14	220		(Corr'd Nav, Kongsberg 14208, img#35) (B) (T.A)
15-Sep-2018	22:32:33	373	ENV15			Camera	48	386375	5992789	386367	5992775	9	14	17	211		(Corr'd Nav, Kongsberg 14208, img#36) (B) (T.A)
15-Sep-2018	23:42:43	374	ENV18			Camera	44	379151	5995323	379148	5995324	4	-2	4	294		(Corr'd Nav, Kongsberg 14208, img#37) (B) (T.A)
15-Sep-2018	23:42:59	375	ENV18			Camera	44	379153	5995317	379148	5995324	5	-7	9	326		(Corr'd Nav, Kongsberg 14208, img#38) (B) (T.A)
15-Sep-2018	23:43:10	376	ENV18			Camera	44	379154	5995314	379148	5995324	6	-11	12	330		(Corr'd Nav, Kongsberg 14208, img#39) (B) (T.A)
15-Sep-2018	23:44:13	377	ENV18			Camera	44	379153	5995311	379148	5995324	6	-13	14	336		(Corr'd Nav, Kongsberg 14208, img#40) (B) (T.A)
15-Sep-2018	23:44:38	378	ENV18			Camera	44	379147	5995307	379148	5995324	-1	-18	18	4		(Corr'd Nav, Kongsberg 14208, img#41) (B) (T.A)
15-Sep-2018	23:45:07	379	ENV18			Camera	44	379143	5995309	379148	5995324	-5	-16	16	18		(Corr'd Nav, Kongsberg 14208, img#42) (B) (T.A)
15-Sep-2018	23:45:21	380	ENV18			Camera	44	379139	5995311	379148	5995324	-9	-13	16	33		(Corr'd Nav, Kongsberg 14208, img#43) (B) (T.A)
15-Sep-2018	23:45:35	381	ENV18			Camera	44	379136	5995312	379148	5995324	-12	-13	18	43		(Corr'd Nav, Kongsberg 14208, img#44) (B) (T.A)
15-Sep-2018	23:45:51	382	ENV18			Camera	44	379132	5995312	379148	5995324	-16	-12	20	53		(Corr'd Nav, Kongsberg 14208, img#45) (B) (T.A)
15-Sep-2018	23:46:39	383	ENV18			Camera	43	379129	5995325	379148	5995324	-18	0	18	91		(Corr'd Nav, Kongsberg 14208, img#46) (B) (T.A)
15-Sep-2018	23:46:47	384	ENV18			Camera	43	379130	5995327	379148	5995324	-17	2	18	97		(Corr'd Nav, Kongsberg 14208, img#47) (B) (T.A)
15-Sep-2018	23:46:59	385	ENV18			Camera	43	379134	5995330	379148	5995324	-13	5	14	112		(Corr'd Nav, Kongsberg 14208, img#48) (B) (T.A)
15-Sep-2018	23:47:16	386	ENV18			Camera	44	379136	5995332	379148	5995324	-12	8	14	123		(Corr'd Nav, Kongsberg 14208, img#49) (B) (T.A)
15-Sep-2018	23:47:48	387	ENV18			Camera	44	379139	5995336	379148	5995324	-8	12	14	145		(Corr'd Nav, Kongsberg 14208, img#50) (B) (T.A)
15-Sep-2018	23:48:09	388	ENV18			Camera	43	379141	5995338	379148	5995324	-6	14	15	155		(Corr'd Nav, Kongsberg 14208, img#51) (B) (T.A)
15-Sep-2018	23:48:27	389	ENV18			Camera	43	379141	5995342	379148	5995324	-7	18	19	159		(Corr'd Nav, Kongsberg 14208, img#52) (B) (T.A)
15-Sep-2018	23:48:58	390	ENV18			Camera	43	379149	5995340	379148	5995324	1	16	16	185		(Corr'd Nav, Kongsberg 14208, img#53) (B) (T.A)
15-Sep-2018	23:50:14	391	ENV18			Camera	44	379159	5995326	379148	5995324	11	2	12	262		(Corr'd Nav, Kongsberg 14208, img#54) (B) (T.A)
15-Sep-2018	23:50:29	392	ENV18			Camera	44	379159	5995324	379148	5995324	12	-1	12	273		(Corr'd Nav, Kongsberg 14208, img#55) (B) (T.A)
15-Sep-2018	23:51:06	393	ENV18			Camera	44	379159	5995317	379148	5995324	11	-7	14	303		(Corr'd Nav, Kongsberg 14208, img#56) (B) (T.A)
15-Sep-2018	23:51:24	394	ENV18			Camera	44	379159	5995311	379148	5995324	12	-14	18	320		(Corr'd Nav, Kongsberg 14208, img#57) (B) (T.A)
15-Sep-2018	23:52:32	395	ENV18			Camera	43	379153	5995314	379148	5995324	5	-11	12	334		(Corr'd Nav, Kongsberg 14208, img#58) (B) (T.A)
15-Sep-2018	23:52:49	396	ENV18			Camera	43	379150	5995314	379148	5995324	2	-10	10	350		(Corr'd Nav, Kongsberg 14208, img#59) (B) (T.A)
15-Sep-2018	23:53:45	397	ENV18			Camera	43	379141	5995321	379148	5995324	-6	-3	7	65		(Corr'd Nav, Kongsberg 14208, img#60) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*					
Client	Ørsted			Vessel Reference Point (VRP)	CoG					
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon					
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)	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		
16-Sep-2018	01:49:20	398	ENV10			Camera	40	384607	5984586	384607	5984582	0	3	3	177		(Corr'd Nav, Kongsberg 14208, img#61) (B) (T.A)
16-Sep-2018	01:49:45	399	ENV10			Camera	40	384605	5984578	384607	5984582	-2	-4	5	27		(Corr'd Nav, Kongsberg 14208, img#62) (B) (T.A)
16-Sep-2018	01:50:42	400	ENV10			Camera	40	384606	5984568	384607	5984582	-1	-15	15	5		(Corr'd Nav, Kongsberg 14208, img#63) (B) (T.A)
16-Sep-2018	01:50:52	401	ENV10			Camera	40	384607	5984566	384607	5984582	0	-16	16	359		(Corr'd Nav, Kongsberg 14208, img#64) (B) (T.A)
16-Sep-2018	01:51:34	402	ENV10			Camera	40	384609	5984565	384607	5984582	2	-17	17	353		(Corr'd Nav, Kongsberg 14208, img#65) (B) (T.A)
16-Sep-2018	01:52:08	403	ENV10			Camera	40	384609	5984565	384607	5984582	2	-18	18	353		(Corr'd Nav, Kongsberg 14208, img#66) (B) (T.A)
16-Sep-2018	01:53:11	404	ENV10			Camera	39	384616	5984585	384607	5984582	9	2	9	254		(Corr'd Nav, Kongsberg 14208, img#67) (B) (T.A)
16-Sep-2018	01:53:57	405	ENV10			Camera	39	384618	5984592	384607	5984582	11	9	14	229		(Corr'd Nav, Kongsberg 14208, img#68) (B) (T.A)
16-Sep-2018	01:54:55	406	ENV10			Camera	39	384610	5984597	384607	5984582	3	15	15	193		(Corr'd Nav, Kongsberg 14208, img#69) (B) (T.A)
16-Sep-2018	01:55:12	407	ENV10			Camera	40	384607	5984598	384607	5984582	0	16	16	179		(Corr'd Nav, Kongsberg 14208, img#70) (B) (T.A)
16-Sep-2018	01:55:25	408	ENV10			Camera	40	384607	5984599	384607	5984582	0	17	17	179		(Corr'd Nav, Kongsberg 14208, img#71) (B) (T.A)
16-Sep-2018	01:55:35	409	ENV10			Camera	40	384606	5984599	384607	5984582	-1	16	16	177		(Corr'd Nav, Kongsberg 14208, img#72) (B) (T.A)
16-Sep-2018	01:55:55	410	ENV10			Camera	40	384604	5984599	384607	5984582	-3	17	17	168		(Corr'd Nav, Kongsberg 14208, img#73) (B) (T.A)
16-Sep-2018	01:56:52	411	ENV10			Camera	40	384591	5984589	384607	5984582	-16	6	17	112		(Corr'd Nav, Kongsberg 14208, img#74) (B) (T.A)
16-Sep-2018	01:58:08	412	ENV10			Camera	40	384595	5984575	384607	5984582	-12	-7	14	58		(Corr'd Nav, Kongsberg 14208, img#75) (B) (T.A)
16-Sep-2018	01:58:26	413	ENV10			Camera	40	384597	5984576	384607	5984582	-10	-7	12	56		(Corr'd Nav, Kongsberg 14208, img#76) (B) (T.A)
16-Sep-2018	01:58:51	414	ENV10			Camera	40	384603	5984576	384607	5984582	-4	-7	8	30		(Corr'd Nav, Kongsberg 14208, img#77) (B) (T.A)
16-Sep-2018	02:00:01	415	ENV10			Camera	40	384620	5984572	384607	5984582	13	-11	16	310		(Corr'd Nav, Kongsberg 14208, img#78) (B) (T.A)
16-Sep-2018	02:00:20	416	ENV10			Camera	40	384620	5984570	384607	5984582	13	-12	18	312		(Corr'd Nav, Kongsberg 14208, img#79) (B) (T.A)
16-Sep-2018	02:00:59	417	ENV10			Camera	39	384614	5984572	384607	5984582	7	-11	13	326		(Corr'd Nav, Kongsberg 14208, img#80) (B) (T.A)
16-Sep-2018	02:01:14	418	ENV10			Camera	40	384608	5984575	384607	5984582	1	-7	7	349		(Corr'd Nav, Kongsberg 14208, img#81) (B) (T.A)
16-Sep-2018	02:01:34	419	ENV10			Camera	39	384600	5984583	384607	5984582	-7	1	7	95		(Corr'd Nav, Kongsberg 14208, img#82) (B) (T.A)
16-Sep-2018	19:42:42	420	ENV11			Camera	39	390106	5984502	390098	5984490	8	12	14	214		(Corr'd Nav, Kongsberg 14208, img#83) (B) (T.A)
16-Sep-2018	19:42:50	421	ENV11			Camera	39	390107	5984501	390098	5984490	9	11	14	220		(Corr'd Nav, Kongsberg 14208, img#84) (B) (T.A)
16-Sep-2018	19:42:57	422	ENV11			Camera	39	390107	5984500	390098	5984490	9	10	14	223		(Corr'd Nav, Kongsberg 14208, img#85) (B) (T.A)
16-Sep-2018	19:43:11	423	ENV11			Camera	39	390108	5984498	390098	5984490	10	8	13	232		(Corr'd Nav, Kongsberg 14208, img#86) (B) (T.A)
16-Sep-2018	19:43:31	424	ENV11			Camera	39	390111	5984492	390098	5984490	13	2	13	260		(Corr'd Nav, Kongsberg 14208, img#87) (B) (T.A)
16-Sep-2018	19:44:16	425	ENV11			Camera	39	390111	5984485	390098	5984490	13	-6	14	293		(Corr'd Nav, Kongsberg 14208, img#88) (B) (T.A)
16-Sep-2018	19:44:49	426	ENV11			Camera	38	390113	5984485	390098	5984490	15	-5	16	288		(Corr'd Nav, Kongsberg 14208, img#89) (B) (T.A)
16-Sep-2018	19:45:03	427	ENV11			Camera	39	390114	5984484	390098	5984490	16	-6	17	292		(Corr'd Nav, Kongsberg 14208, img#90) (B) (T.A)
16-Sep-2018	19:45:14	428	ENV11			Camera	38	390114	5984482	390098	5984490	16	-9	18	298		(Corr'd Nav, Kongsberg 14208, img#91) (B) (T.A)
16-Sep-2018	19:45:23	429	ENV11			Camera	38	390115	5984481	390098	5984490	17	-9	19	298		(Corr'd Nav, Kongsberg 14208, img#92) (B) (T.A)
16-Sep-2018	19:46:18	430	ENV11			Camera	39	390111	5984481	390098	5984490	13	-10	16	308		(Corr'd Nav, Kongsberg 14208, img#93) (B) (T.A)
16-Sep-2018	19:46:29	431	ENV11			Camera	39	390109	5984481	390098	5984490	11	-9	14	310		(Corr'd Nav, Kongsberg 14208, img#94) (B) (T.A)
16-Sep-2018	19:46:50	432	ENV11			Camera	39	390109	5984482	390098	5984490	11	-8	13	309		(Corr'd Nav, Kongsberg 14208, img#95) (B) (T.A)
16-Sep-2018	19:46:58	433	ENV11			Camera	39	390109	5984483	390098	5984490	11	-7	13	303		(Corr'd Nav, Kongsberg 14208, img#96) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*				
Client	Ørsted			Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939
						z	2.932		
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)	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		
16-Sep-2018	19:47:15	434	ENV11			Camera	39	390104	5984484	390098	5984490	6	-7	9	319		(Corr'd Nav, Kongsberg 14208, img#97) (B) (T.A)
16-Sep-2018	19:47:25	435	ENV11			Camera	39	390101	5984486	390098	5984490	3	-5	6	327		(Corr'd Nav, Kongsberg 14208, img#98) (B) (T.A)
16-Sep-2018	19:47:44	436	ENV11			Camera	39	390097	5984489	390098	5984490	-1	-2	2	33		(Corr'd Nav, Kongsberg 14208, img#99) (B) (T.A)
16-Sep-2018	19:47:57	437	ENV11			Camera	39	390094	5984490	390098	5984490	-4	0	4	90		(Corr'd Nav, Kongsberg 14208, img#100) (B) (T.A)
16-Sep-2018	19:48:29	438	ENV11			Camera	38	390093	5984496	390098	5984490	-5	6	8	137		(Corr'd Nav, Kongsberg 14208, img#101) (B) (T.A)
16-Sep-2018	19:48:36	439	ENV11			Camera	38	390093	5984497	390098	5984490	-5	7	8	144		(Corr'd Nav, Kongsberg 14208, img#102) (B) (T.A)
16-Sep-2018	19:48:47	440	ENV11			Camera	38	390093	5984498	390098	5984490	-5	7	9	148		(Corr'd Nav, Kongsberg 14208, img#103) (B) (T.A)
16-Sep-2018	19:49:21	441	ENV11			Camera	39	390097	5984500	390098	5984490	-1	10	10	173		(Corr'd Nav, Kongsberg 14208, img#104) (B) (T.A)
16-Sep-2018	19:49:38	442	ENV11			Camera	38	390100	5984499	390098	5984490	2	9	9	192		(Corr'd Nav, Kongsberg 14208, img#105) (B) (T.A)
16-Sep-2018	19:49:57	443	ENV11			Camera	39	390104	5984496	390098	5984490	6	6	8	221		(Corr'd Nav, Kongsberg 14208, img#106) (B) (T.A)
16-Sep-2018	19:50:06	444	ENV11			Camera	39	390106	5984497	390098	5984490	8	7	11	227		(Corr'd Nav, Kongsberg 14208, img#107) (B) (T.A)
16-Sep-2018	19:50:19	445	ENV11			Camera	38	390108	5984497	390098	5984490	10	6	12	237		(Corr'd Nav, Kongsberg 14208, img#108) (B) (T.A)
16-Sep-2018	19:50:39	446	ENV11			Camera	38	390108	5984497	390098	5984490	10	6	12	236		(Corr'd Nav, Kongsberg 14208, img#109) (B) (T.A)
16-Sep-2018	19:51:14	447	ENV11			Camera	39	390103	5984492	390098	5984490	5	1	5	253		(Corr'd Nav, Kongsberg 14208, img#110) (B) (T.A)
16-Sep-2018	19:51:49	448	ENV11			Camera	38	390102	5984489	390098	5984490	4	-1	4	284		(Corr'd Nav, Kongsberg 14208, img#111) (B) (T.A)
16-Sep-2018	19:52:38	449	ENV11			Camera	39	390109	5984485	390098	5984490	11	-5	12	293		(Corr'd Nav, Kongsberg 14208, img#112) (B) (T.A)
16-Sep-2018	19:52:52	450	ENV11			Camera	39	390110	5984484	390098	5984490	12	-7	14	298		(Corr'd Nav, Kongsberg 14208, img#113) (B) (T.A)
16-Sep-2018	19:53:01	451	ENV11			Camera	38	390111	5984482	390098	5984490	13	-8	16	303		(Corr'd Nav, Kongsberg 14208, img#114) (B) (T.A)
16-Sep-2018	19:53:12	452	ENV11			Camera	39	390111	5984480	390098	5984490	13	-10	16	308		(Corr'd Nav, Kongsberg 14208, img#115) (B) (T.A)
16-Sep-2018	19:53:28	453	ENV11			Camera	38	390108	5984479	390098	5984490	10	-11	15	318		(Corr'd Nav, Kongsberg 14208, img#116) (B) (T.A)
16-Sep-2018	19:54:06	454	ENV11			Camera	39	390106	5984479	390098	5984490	8	-12	14	324		(Corr'd Nav, Kongsberg 14208, img#117) (B) (T.A)
16-Sep-2018	19:54:32	455	ENV11			Camera	39	390106	5984479	390098	5984490	8	-11	13	325		(Corr'd Nav, Kongsberg 14208, img#118) (B) (T.A)
16-Sep-2018	19:54:45	456	ENV11			Camera	39	390102	5984479	390098	5984490	4	-12	12	341		(Corr'd Nav, Kongsberg 14208, img#119) (B) (T.A)
16-Sep-2018	19:54:59	457	ENV11			Camera	39	390099	5984480	390098	5984490	1	-10	10	352		(Corr'd Nav, Kongsberg 14208, img#120) (B) (T.A)
16-Sep-2018	19:55:19	458	ENV11			Camera	38	390094	5984484	390098	5984490	-4	-6	7	31		(Corr'd Nav, Kongsberg 14208, img#121) (B) (T.A)
16-Sep-2018	20:50:42	459	ENV8			Camera	37	389668	5980671	389649	5980664	20	7	21	251		(Corr'd Nav, Kongsberg 14208, img#122) (B) (T.A)
16-Sep-2018	20:50:54	460	ENV8			Camera	38	389654	5980660	389649	5980664	5	-5	7	311		(Corr'd Nav, Kongsberg 14208, img#123) (B) (T.A)
16-Sep-2018	20:51:12	461	ENV8			Camera	38	389650	5980659	389649	5980664	2	-6	6	341		(Corr'd Nav, Kongsberg 14208, img#124) (B) (T.A)
16-Sep-2018	20:51:27	462	ENV8			Camera	38	389650	5980661	389649	5980664	2	-4	4	337		(Corr'd Nav, Kongsberg 14208, img#125) (B) (T.A)
16-Sep-2018	20:51:39	463	ENV8			Camera	38	389648	5980661	389649	5980664	-1	-3	4	9		(Corr'd Nav, Kongsberg 14208, img#126) (B) (T.A)
16-Sep-2018	20:51:46	464	ENV8			Camera	38	389647	5980661	389649	5980664	-1	-3	3	27		(Corr'd Nav, Kongsberg 14208, img#127) (B) (T.A)
16-Sep-2018	20:52:30	465	ENV8			Camera	38	389642	5980665	389649	5980664	-6	1	6	100		(Corr'd Nav, Kongsberg 14208, img#128) (B) (T.A)
16-Sep-2018	20:53:12	466	ENV8			Camera	37	389644	5980667	389649	5980664	-4	2	5	120		(Corr'd Nav, Kongsberg 14208, img#129) (B) (T.A)
16-Sep-2018	20:53:29	467	ENV8			Camera	37	389644	5980667	389649	5980664	-4	3	5	125		(Corr'd Nav, Kongsberg 14208, img#130) (B) (T.A)
16-Sep-2018	20:53:52	468	ENV8			Camera	37	389645	5980667	389649	5980664	-3	3	5	133		(Corr'd Nav, Kongsberg 14208, img#131) (B) (T.A)
16-Sep-2018	20:54:25	469	ENV8			Camera	38	389649	5980672	389649	5980664	0	8	8	182		(Corr'd Nav, Kongsberg 14208, img#132) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*						
Client	Ørsted			Vessel Reference Point (VRP)	CoG						
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z	2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon						
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)		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		
16-Sep-2018	20:54:52	470	ENV8			Camera	38	389652	5980676	389649	5980664	3	11	12	196		(Corr'd Nav, Kongsberg 14208, img#133) (B) (T.A)
16-Sep-2018	20:58:06	471	ENV8			Camera	38	389661	5980668	389649	5980664	12	4	13	254		(Corr'd Nav, Kongsberg 14208, img#134) (B) (T.A)
16-Sep-2018	20:58:48	472	ENV8			Camera	38	389660	5980670	389649	5980664	12	6	13	245		(Corr'd Nav, Kongsberg 14208, img#135) (B) (T.A)
16-Sep-2018	20:59:06	473	ENV8			Camera	38	389659	5980671	389649	5980664	11	7	13	237		(Corr'd Nav, Kongsberg 14208, img#136) (B) (T.A)
16-Sep-2018	20:59:17	474	ENV8			Camera	37	389659	5980672	389649	5980664	10	7	12	234		(Corr'd Nav, Kongsberg 14208, img#137) (B) (T.A)
16-Sep-2018	21:00:05	475	ENV8			Camera	37	389663	5980672	389649	5980664	15	7	16	243		(Corr'd Nav, Kongsberg 14208, img#138) (B) (T.A)
16-Sep-2018	21:00:37	476	ENV8			Camera	38	389668	5980663	389649	5980664	19	-1	19	274		(Corr'd Nav, Kongsberg 14208, img#139) (B) (T.A)
16-Sep-2018	21:00:51	477	ENV8			Camera	37	389668	5980660	389649	5980664	20	-4	20	282		(Corr'd Nav, Kongsberg 14208, img#140) (B) (T.A)
16-Sep-2018	21:01:03	478	ENV8			Camera	38	389668	5980658	389649	5980664	20	-6	21	287		(Corr'd Nav, Kongsberg 14208, img#141) (B) (T.A)
16-Sep-2018	21:01:20	479	ENV8			Camera	38	389668	5980655	389649	5980664	19	-10	22	296		(Corr'd Nav, Kongsberg 14208, img#142) (B) (T.A)
16-Sep-2018	21:02:00	480	ENV8			Camera	38	389663	5980651	389649	5980664	15	-13	20	313		(Corr'd Nav, Kongsberg 14208, img#143) (B) (T.A)
16-Sep-2018	21:03:17	481	ENV8			Camera	38	389646	5980652	389649	5980664	-2	-12	12	10		(Corr'd Nav, Kongsberg 14208, img#144) (B) (T.A)
16-Sep-2018	21:03:40	482	ENV8			Camera	38	389644	5980654	389649	5980664	-5	-10	11	25		(Corr'd Nav, Kongsberg 14208, img#145) (B) (T.A)
16-Sep-2018	21:03:49	483	ENV8			Camera	38	389643	5980655	389649	5980664	-6	-10	11	30		(Corr'd Nav, Kongsberg 14208, img#146) (B) (T.A)
16-Sep-2018	21:03:58	484	ENV8			Camera	38	389643	5980655	389649	5980664	-5	-9	11	30		(Corr'd Nav, Kongsberg 14208, img#147) (B) (T.A)
16-Sep-2018	21:04:49	485	ENV8			Camera	38	389639	5980657	389649	5980664	-9	-7	12	51		(Corr'd Nav, Kongsberg 14208, img#148) (B) (T.A)
16-Sep-2018	21:05:35	486	ENV8			Camera	37	389639	5980660	389649	5980664	-10	-4	11	67		(Corr'd Nav, Kongsberg 14208, img#149) (B) (T.A)
16-Sep-2018	21:05:53	487	ENV8			Camera	37	389642	5980661	389649	5980664	-6	-4	7	60		(Corr'd Nav, Kongsberg 14208, img#150) (B) (T.A)
16-Sep-2018	21:06:26	488	ENV8			Camera	38	389646	5980664	389649	5980664	-3	0	3	86		(Corr'd Nav, Kongsberg 14208, img#151) (B) (T.A)
16-Sep-2018	21:06:39	489	ENV8			Camera	38	389646	5980665	389649	5980664	-3	1	3	113		(Corr'd Nav, Kongsberg 14208, img#152) (B) (T.A)
16-Sep-2018	21:06:49	490	ENV8			Camera	38	389645	5980667	389649	5980664	-4	2	4	124		(Corr'd Nav, Kongsberg 14208, img#153) (B) (T.A)
16-Sep-2018	22:11:29	491	ENV9			Camera	40	395380	5980704	395365	5980714	14	-10	18	305		(Corr'd Nav, Kongsberg 14208, img#154) (B) (T.A)
16-Sep-2018	22:12:03	492	ENV9			Camera	40	395377	5980706	395365	5980714	12	-9	15	306		(Corr'd Nav, Kongsberg 14208, img#155) (B) (T.A)
16-Sep-2018	22:12:21	493	ENV9			Camera	40	395374	5980706	395365	5980714	8	-8	11	315		(Corr'd Nav, Kongsberg 14208, img#156) (B) (T.A)
16-Sep-2018	22:12:42	494	ENV9			Camera	40	395371	5980707	395365	5980714	5	-7	9	326		(Corr'd Nav, Kongsberg 14208, img#157) (B) (T.A)
16-Sep-2018	22:12:56	495	ENV9			Camera	40	395368	5980707	395365	5980714	2	-7	8	342		(Corr'd Nav, Kongsberg 14208, img#158) (B) (T.A)
16-Sep-2018	22:13:08	496	ENV9			Camera	40	395366	5980708	395365	5980714	1	-7	7	355		(Corr'd Nav, Kongsberg 14208, img#159) (B) (T.A)
16-Sep-2018	22:13:23	497	ENV9			Camera	40	395364	5980708	395365	5980714	-1	-6	7	11		(Corr'd Nav, Kongsberg 14208, img#160) (B) (T.A)
16-Sep-2018	22:13:33	498	ENV9			Camera	40	395362	5980709	395365	5980714	-3	-5	6	33		(Corr'd Nav, Kongsberg 14208, img#161) (B) (T.A)
16-Sep-2018	22:13:58	499	ENV9			Camera	40	395361	5980710	395365	5980714	-5	-4	6	49		(Corr'd Nav, Kongsberg 14208, img#162) (B) (T.A)
16-Sep-2018	22:14:26	500	ENV9			Camera	40	395359	5980711	395365	5980714	-6	-3	7	66		(Corr'd Nav, Kongsberg 14208, img#163) (B) (T.A)
16-Sep-2018	22:14:50	501	ENV9			Camera	40	395360	5980715	395365	5980714	-6	1	6	97		(Corr'd Nav, Kongsberg 14208, img#164) (B) (T.A)
16-Sep-2018	22:14:58	502	ENV9			Camera	40	395359	5980716	395365	5980714	-7	2	7	103		(Corr'd Nav, Kongsberg 14208, img#165) (B) (T.A)
16-Sep-2018	22:15:23	503	ENV9			Camera	40	395358	5980718	395365	5980714	-7	4	8	120		(Corr'd Nav, Kongsberg 14208, img#166) (B) (T.A)
16-Sep-2018	22:15:41	504	ENV9			Camera	40	395358	5980719	395365	5980714	-8	5	9	123		(Corr'd Nav, Kongsberg 14208, img#167) (B) (T.A)
16-Sep-2018	22:16:03	505	ENV9			Camera	40	395357	5980722	395365	5980714	-8	8	11	134		(Corr'd Nav, Kongsberg 14208, img#168) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210	Vessel	M.V *Ocean Endeavour*
Client	Ørsted	Vessel Reference Point (VRP)	CoG
Project Name	Hornsea 4 Offshore Wind Farm Lot 6	Deployment Location	Starboard Crane; x 6.701; y 21.939; z 2.932
Primary Positioning System	Starpack_Port	Actual Coordinates derived from	Beacon
Geodetic Reference System	Datum WGS84 - ETRS89; Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E); 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		
16-Sep-2018	22:16:48	506	ENV9			Camera	40	395359	5980724	395365	5980714	-6	10	12	148		(Corr'd Nav, Kongsberg 14208, img#169) (B) (T.A)
16-Sep-2018	22:17:16	507	ENV9			Camera	40	395362	5980729	395365	5980714	-4	15	15	166		(Corr'd Nav, Kongsberg 14208, img#170) (B) (T.A)
16-Sep-2018	22:17:34	508	ENV9			Camera	39	395363	5980731	395365	5980714	-2	17	17	172		(Corr'd Nav, Kongsberg 14208, img#171) (B) (T.A)
16-Sep-2018	22:18:39	509	ENV9			Camera	40	395369	5980731	395365	5980714	3	17	17	191		(Corr'd Nav, Kongsberg 14208, img#172) (B) (T.A)
16-Sep-2018	22:19:58	510	ENV9			Camera	40	395371	5980721	395365	5980714	6	6	9	223		(Corr'd Nav, Kongsberg 14208, img#173) (B) (T.A)
16-Sep-2018	22:20:10	511	ENV9			Camera	39	395373	5980719	395365	5980714	7	5	9	236		(Corr'd Nav, Kongsberg 14208, img#174) (B) (T.A)
16-Sep-2018	22:20:35	512	ENV9			Camera	40	395372	5980714	395365	5980714	6	0	6	270		(Corr'd Nav, Kongsberg 14208, img#175) (B) (T.A)
16-Sep-2018	22:21:07	513	ENV9			Camera	40	395369	5980710	395365	5980714	4	-5	6	319		(Corr'd Nav, Kongsberg 14208, img#176) (B) (T.A)
16-Sep-2018	22:21:24	514	ENV9			Camera	39	395369	5980708	395365	5980714	3	-6	7	331		(Corr'd Nav, Kongsberg 14208, img#177) (B) (T.A)
16-Sep-2018	22:21:40	515	ENV9			Camera	40	395370	5980707	395365	5980714	4	-7	9	331		(Corr'd Nav, Kongsberg 14208, img#178) (B) (T.A)
16-Sep-2018	22:22:01	516	ENV9			Camera	40	395373	5980705	395365	5980714	8	-10	12	320		(Corr'd Nav, Kongsberg 14208, img#179) (B) (T.A)
16-Sep-2018	22:22:17	517	ENV9			Camera	40	395373	5980701	395365	5980714	8	-13	15	329		(Corr'd Nav, Kongsberg 14208, img#180) (B) (T.A)
16-Sep-2018	22:22:58	518	ENV9			Camera	40	395369	5980698	395365	5980714	4	-16	17	347		(Corr'd Nav, Kongsberg 14208, img#181) (B) (T.A)
16-Sep-2018	22:23:18	519	ENV9			Camera	40	395367	5980698	395365	5980714	1	-16	16	355		(Corr'd Nav, Kongsberg 14208, img#182) (B) (T.A)
16-Sep-2018	22:24:01	520	ENV9			Camera	40	395362	5980700	395365	5980714	-3	-14	15	12		(Corr'd Nav, Kongsberg 14208, img#183) (B) (T.A)
16-Sep-2018	22:24:12	521	ENV9			Camera	40	395362	5980700	395365	5980714	-4	-14	15	15		(Corr'd Nav, Kongsberg 14208, img#184) (B) (T.A)
16-Sep-2018	22:24:59	522	ENV9			Camera	40	395352	5980699	395365	5980714	-13	-15	20	42		(Corr'd Nav, Kongsberg 14208, img#185) (B) (T.A)
16-Sep-2018	22:25:06	523	ENV9			Camera	40	395352	5980699	395365	5980714	-13	-15	20	42		(Corr'd Nav, Kongsberg 14208, img#186) (B) (T.A)
16-Sep-2018	22:25:19	524	ENV9			Camera	39	395351	5980700	395365	5980714	-14	-14	20	45		(Corr'd Nav, Kongsberg 14208, img#187) (B) (T.A)
16-Sep-2018	22:25:34	525	ENV9			Camera	39	395352	5980700	395365	5980714	-14	-14	20	44		(Corr'd Nav, Kongsberg 14208, img#188) (B) (T.A)
16-Sep-2018	22:25:54	526	ENV9			Camera	39	395353	5980699	395365	5980714	-12	-16	20	38		(Corr'd Nav, Kongsberg 14208, img#189) (B) (T.A)
16-Sep-2018	22:26:15	527	ENV9			Camera	39	395356	5980702	395365	5980714	-9	-13	16	37		(Corr'd Nav, Kongsberg 14208, img#190) (B) (T.A)
16-Sep-2018	22:26:32	528	ENV9			Camera	40	395356	5980702	395365	5980714	-9	-12	15	37		(Corr'd Nav, Kongsberg 14208, img#191) (B) (T.A)
16-Sep-2018	22:26:47	529	ENV9			Camera	40	395358	5980704	395365	5980714	-8	-10	13	38		(Corr'd Nav, Kongsberg 14208, img#192) (B) (T.A)
16-Sep-2018	22:27:07	530	ENV9			Camera	40	395360	5980705	395365	5980714	-5	-9	11	30		(Corr'd Nav, Kongsberg 14208, img#193) (B) (T.A)
16-Sep-2018	23:45:03	531	ENV6			Camera	36	395828	5973903	395817	5973911	11	-8	14	307		(Corr'd Nav, Kongsberg 14208, img#194) (B) (T.A)
16-Sep-2018	23:45:32	532	ENV6			Camera	36	395829	5973905	395817	5973911	12	-7	13	300		(Corr'd Nav, Kongsberg 14208, img#195) (B) (T.A)
16-Sep-2018	23:46:25	533	ENV6			Camera	36	395821	5973907	395817	5973911	3	-4	5	320		(Corr'd Nav, Kongsberg 14208, img#196) (B) (T.A)
16-Sep-2018	23:46:38	534	ENV6			Camera	36	395818	5973909	395817	5973911	1	-3	3	349		(Corr'd Nav, Kongsberg 14208, img#197) (B) (T.A)
16-Sep-2018	23:46:53	535	ENV6			Camera	36	395816	5973909	395817	5973911	-1	-2	2	34		(Corr'd Nav, Kongsberg 14208, img#198) (B) (T.A)
16-Sep-2018	23:47:09	536	ENV6			Camera	36	395813	5973911	395817	5973911	-4	0	4	90		(Corr'd Nav, Kongsberg 14208, img#199) (B) (T.A)
16-Sep-2018	23:47:32	537	ENV6			Camera	36	395810	5973914	395817	5973911	-7	2	7	107		(Corr'd Nav, Kongsberg 14208, img#200) (B) (T.A)
16-Sep-2018	23:47:45	538	ENV6			Camera	36	395811	5973915	395817	5973911	-7	3	7	117		(Corr'd Nav, Kongsberg 14208, img#201) (B) (T.A)
16-Sep-2018	23:48:16	539	ENV6			Camera	36	395810	5973919	395817	5973911	-7	7	10	135		(Corr'd Nav, Kongsberg 14208, img#202) (B) (T.A)
16-Sep-2018	23:48:40	540	ENV6			Camera	36	395810	5973921	395817	5973911	-7	9	12	144		(Corr'd Nav, Kongsberg 14208, img#203) (B) (T.A)
16-Sep-2018	23:49:02	541	ENV6			Camera	36	395812	5973924	395817	5973911	-5	12	13	156		(Corr'd Nav, Kongsberg 14208, img#204) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*					
Client	Ørsted			Vessel Reference Point (VRP)	CoG					
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon					
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)		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		
16-Sep-2018	23:49:31	542	ENV6			Camera	35	395814	5973927	395817	5973911	-4	15	16	167		(Corr'd Nav, Kongsberg 14208, img#205) (B) (T.A)
16-Sep-2018	23:49:57	543	ENV6			Camera	35	395813	5973927	395817	5973911	-4	16	16	167		(Corr'd Nav, Kongsberg 14208, img#206) (B) (T.A)
16-Sep-2018	23:51:11	544	ENV6			Camera	36	395818	5973923	395817	5973911	1	12	12	186		(Corr'd Nav, Kongsberg 14208, img#207) (B) (T.A)
16-Sep-2018	23:51:38	545	ENV6			Camera	36	395821	5973920	395817	5973911	4	8	9	204		(Corr'd Nav, Kongsberg 14208, img#208) (B) (T.A)
16-Sep-2018	23:51:48	546	ENV6			Camera	36	395822	5973917	395817	5973911	5	6	8	222		(Corr'd Nav, Kongsberg 14208, img#209) (B) (T.A)
16-Sep-2018	23:52:01	547	ENV6			Camera	36	395826	5973915	395817	5973911	8	4	9	244		(Corr'd Nav, Kongsberg 14208, img#210) (B) (T.A)
16-Sep-2018	23:52:58	548	ENV6			Camera	36	395832	5973905	395817	5973911	15	-6	16	292		(Corr'd Nav, Kongsberg 14208, img#211) (B) (T.A)
16-Sep-2018	23:53:21	549	ENV6			Camera	36	395828	5973899	395817	5973911	11	-12	16	318		(Corr'd Nav, Kongsberg 14208, img#212) (B) (T.A)
16-Sep-2018	23:54:17	550	ENV6			Camera	36	395813	5973893	395817	5973911	-4	-19	19	12		(Corr'd Nav, Kongsberg 14208, img#213) (B) (T.A)
16-Sep-2018	23:54:27	551	ENV6			Camera	36	395812	5973892	395817	5973911	-6	-20	20	16		(Corr'd Nav, Kongsberg 14208, img#214) (B) (T.A)
16-Sep-2018	23:55:39	552	ENV6			Camera	36	395811	5973894	395817	5973911	-6	-18	19	18		(Corr'd Nav, Kongsberg 14208, img#215) (B) (T.A)
16-Sep-2018	23:56:01	553	ENV6			Camera	36	395812	5973896	395817	5973911	-5	-15	16	19		(Corr'd Nav, Kongsberg 14208, img#216) (B) (T.A)
16-Sep-2018	23:56:21	554	ENV6			Camera	36	395809	5973897	395817	5973911	-8	-14	16	30		(Corr'd Nav, Kongsberg 14208, img#217) (B) (T.A)
16-Sep-2018	23:56:40	555	ENV6			Camera	36	395807	5973899	395817	5973911	-10	-12	16	41		(Corr'd Nav, Kongsberg 14208, img#218) (B) (T.A)
16-Sep-2018	23:57:10	556	ENV6			Camera	36	395805	5973904	395817	5973911	-12	-7	14	59		(Corr'd Nav, Kongsberg 14208, img#219) (B) (T.A)
16-Sep-2018	23:57:25	557	ENV6			Camera	36	395804	5973907	395817	5973911	-13	-4	14	71		(Corr'd Nav, Kongsberg 14208, img#220) (B) (T.A)
16-Sep-2018	23:57:40	558	ENV6			Camera	36	395802	5973910	395817	5973911	-15	-2	15	83		(Corr'd Nav, Kongsberg 14208, img#221) (B) (T.A)
16-Sep-2018	23:58:04	559	ENV6			Camera	36	395804	5973914	395817	5973911	-14	2	14	99		(Corr'd Nav, Kongsberg 14208, img#222) (B) (T.A)
16-Sep-2018	23:58:41	560	ENV6			Camera	36	395806	5973917	395817	5973911	-12	6	13	118		(Corr'd Nav, Kongsberg 14208, img#223) (B) (T.A)
16-Sep-2018	23:58:50	561	ENV6			Camera	36	395807	5973919	395817	5973911	-11	7	13	125		(Corr'd Nav, Kongsberg 14208, img#224) (B) (T.A)
16-Sep-2018	23:59:03	562	ENV6			Camera	36	395808	5973921	395817	5973911	-9	10	13	136		(Corr'd Nav, Kongsberg 14208, img#225) (B) (T.A)
16-Sep-2018	23:59:14	563	ENV6			Camera	36	395808	5973922	395817	5973911	-9	11	14	139		(Corr'd Nav, Kongsberg 14208, img#226) (B) (T.A)
17-Sep-2018	01:16:26	564	ENV5			Camera	35	390073	5973834	390067	5973840	6	-6	9	317		(Corr'd Nav, Kongsberg 14208, img#227) (B) (T.A)
17-Sep-2018	01:17:13	565	ENV5			Camera	36	390074	5973841	390067	5973840	7	1	7	266		(Corr'd Nav, Kongsberg 14208, img#228) (B) (T.A)
17-Sep-2018	01:17:32	566	ENV5			Camera	36	390068	5973840	390067	5973840	1	0	1	268		(Corr'd Nav, Kongsberg 14208, img#229) (B) (T.A)
17-Sep-2018	01:18:15	567	ENV5			Camera	36	390055	5973846	390067	5973840	-12	5	13	115		(Corr'd Nav, Kongsberg 14208, img#230) (B) (T.A)
17-Sep-2018	01:19:48	568	ENV5			Camera	36	390051	5973858	390067	5973840	-16	17	23	138		(Corr'd Nav, Kongsberg 14208, img#231) (B) (T.A)
17-Sep-2018	01:20:00	569	ENV5			Camera	36	390050	5973860	390067	5973840	-17	19	26	139		(Corr'd Nav, Kongsberg 14208, img#232) (B) (T.A)
17-Sep-2018	01:20:20	570	ENV5			Camera	36	390051	5973860	390067	5973840	-16	19	25	141		(Corr'd Nav, Kongsberg 14208, img#233) (B) (T.A)
17-Sep-2018	01:21:10	571	ENV5			Camera	36	390061	5973857	390067	5973840	-6	16	17	160		(Corr'd Nav, Kongsberg 14208, img#234) (B) (T.A)
17-Sep-2018	01:21:26	572	ENV5			Camera	36	390062	5973854	390067	5973840	-4	14	15	163		(Corr'd Nav, Kongsberg 14208, img#235) (B) (T.A)
17-Sep-2018	01:21:48	573	ENV5			Camera	36	390065	5973854	390067	5973840	-2	14	14	172		(Corr'd Nav, Kongsberg 14208, img#236) (B) (T.A)
17-Sep-2018	01:22:19	574	ENV5			Camera	36	390070	5973852	390067	5973840	4	12	12	197		(Corr'd Nav, Kongsberg 14208, img#237) (B) (T.A)
17-Sep-2018	01:22:35	575	ENV5			Camera	36	390071	5973852	390067	5973840	4	12	13	201		(Corr'd Nav, Kongsberg 14208, img#238) (B) (T.A)
17-Sep-2018	01:22:59	576	ENV5			Camera	36	390072	5973852	390067	5973840	5	11	13	204		(Corr'd Nav, Kongsberg 14208, img#239) (B) (T.A)
17-Sep-2018	01:23:13	577	ENV5			Camera	36	390072	5973849	390067	5973840	5	8	10	212		(Corr'd Nav, Kongsberg 14208, img#240) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210				Vessel	M.V *Ocean Endeavour*				
Client	Ørsted				Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6				Deployment Location	Starboard Crane	x	6.701	y	21.939	z	2.932
Primary Positioning System	Starpack_Port				Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)	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		
17-Sep-2018	01:23:30	578	ENV5			Camera	36	390070	5973842	390067	5973840	4	2	4	241		(Corr'd Nav, Kongsberg 14208, img#241) (B) (T.A)
17-Sep-2018	01:23:46	579	ENV5			Camera	36	390068	5973839	390067	5973840	2	-1	2	309		(Corr'd Nav, Kongsberg 14208, img#242) (B) (T.A)
17-Sep-2018	01:24:11	580	ENV5			Camera	36	390069	5973835	390067	5973840	2	-5	6	337		(Corr'd Nav, Kongsberg 14208, img#243) (B) (T.A)
17-Sep-2018	01:24:21	581	ENV5			Camera	36	390069	5973834	390067	5973840	3	-6	7	338		(Corr'd Nav, Kongsberg 14208, img#244) (B) (T.A)
17-Sep-2018	01:24:31	582	ENV5			Camera	36	390069	5973833	390067	5973840	3	-8	8	342		(Corr'd Nav, Kongsberg 14208, img#245) (B) (T.A)
17-Sep-2018	01:24:43	583	ENV5			Camera	35	390069	5973832	390067	5973840	3	-8	9	341		(Corr'd Nav, Kongsberg 14208, img#246) (B) (T.A)
17-Sep-2018	01:25:14	584	ENV5			Camera	36	390073	5973833	390067	5973840	6	-7	9	319		(Corr'd Nav, Kongsberg 14208, img#247) (B) (T.A)
17-Sep-2018	01:25:27	585	ENV5			Camera	36	390075	5973832	390067	5973840	9	-9	12	315		(Corr'd Nav, Kongsberg 14208, img#248) (B) (T.A)
17-Sep-2018	01:26:17	586	ENV5			Camera	35	390080	5973833	390067	5973840	13	-7	15	299		(Corr'd Nav, Kongsberg 14208, img#249) (B) (T.A)
17-Sep-2018	01:26:27	587	ENV5			Camera	35	390081	5973835	390067	5973840	14	-6	15	292		(Corr'd Nav, Kongsberg 14208, img#250) (B) (T.A)
17-Sep-2018	01:26:57	588	ENV5			Camera	36	390084	5973843	390067	5973840	17	2	17	262		(Corr'd Nav, Kongsberg 14208, img#251) (B) (T.A)
17-Sep-2018	01:27:40	589	ENV5			Camera	34	390074	5973845	390067	5973840	7	4	8	239		(Corr'd Nav, Kongsberg 14208, img#252) (B) (T.A)
17-Sep-2018	01:28:06	590	ENV5			Camera	36	390065	5973841	390067	5973840	-1	1	1	116		(Corr'd Nav, Kongsberg 14208, img#253) (B) (T.A)
17-Sep-2018	01:28:17	591	ENV5			Camera	36	390061	5973838	390067	5973840	-6	-3	6	65		(Corr'd Nav, Kongsberg 14208, img#254) (B) (T.A)
17-Sep-2018	01:28:33	592	ENV5			Camera	36	390058	5973836	390067	5973840	-8	-4	9	62		(Corr'd Nav, Kongsberg 14208, img#255) (B) (T.A)
17-Sep-2018	01:28:46	593	ENV5			Camera	36	390055	5973833	390067	5973840	-11	-8	14	55		(Corr'd Nav, Kongsberg 14208, img#256) (B) (T.A)
17-Sep-2018	01:29:07	594	ENV5			Camera	36	390053	5973829	390067	5973840	-13	-12	18	48		(Corr'd Nav, Kongsberg 14208, img#257) (B) (T.A)
17-Sep-2018	01:30:21	595	ENV5			Camera	35	390048	5973833	390067	5973840	-19	-8	20	67		(Corr'd Nav, Kongsberg 14208, img#258) (B) (T.A)
17-Sep-2018	01:31:13	596	ENV5			Camera	35	390049	5973839	390067	5973840	-18	-2	18	85		(Corr'd Nav, Kongsberg 14208, img#259) (B) (T.A)
17-Sep-2018	02:33:22	597	ENV2			Camera	31	389807	5970130	389810	5970135	-3	-5	6	26		(Corr'd Nav, Kongsberg 14208, img#260) (B) (T.A)
17-Sep-2018	02:33:59	598	ENV2			Camera	31	389803	5970143	389810	5970135	-6	8	10	141		(Corr'd Nav, Kongsberg 14208, img#261) (B) (T.A)
17-Sep-2018	02:35:21	599	ENV2			Camera	31	389800	5970144	389810	5970135	-10	9	13	132		(Corr'd Nav, Kongsberg 14208, img#262) (B) (T.A)
17-Sep-2018	02:35:51	600	ENV2			Camera	31	389799	5970136	389810	5970135	-11	1	11	93		(Corr'd Nav, Kongsberg 14208, img#263) (B) (T.A)
17-Sep-2018	02:36:15	601	ENV2			Camera	31	389796	5970128	389810	5970135	-13	-7	15	62		(Corr'd Nav, Kongsberg 14208, img#264) (B) (T.A)
17-Sep-2018	02:36:50	602	ENV2			Camera	31	389803	5970119	389810	5970135	-6	-17	18	21		(Corr'd Nav, Kongsberg 14208, img#265) (B) (T.A)
17-Sep-2018	02:37:23	603	ENV2			Camera	31	389817	5970117	389810	5970135	7	-18	20	338		(Corr'd Nav, Kongsberg 14208, img#266) (B) (T.A)
17-Sep-2018	02:37:54	604	ENV2			Camera	31	389828	5970123	389810	5970135	18	-12	22	303		(Corr'd Nav, Kongsberg 14208, img#267) (B) (T.A)
17-Sep-2018	02:38:22	605	ENV2			Camera	31	389833	5970134	389810	5970135	24	-2	24	274		(Corr'd Nav, Kongsberg 14208, img#268) (B) (T.A)
17-Sep-2018	02:38:36	606	ENV2			Camera	32	389832	5970141	389810	5970135	23	5	23	257		(Corr'd Nav, Kongsberg 14208, img#269) (B) (T.A)
17-Sep-2018	02:38:47	607	ENV2			Camera	32	389831	5970143	389810	5970135	21	8	23	251		(Corr'd Nav, Kongsberg 14208, img#270) (B) (T.A)
17-Sep-2018	02:38:56	608	ENV2			Camera	32	389830	5970145	389810	5970135	20	9	22	246		(Corr'd Nav, Kongsberg 14208, img#271) (B) (T.A)
17-Sep-2018	02:39:16	609	ENV2			Camera	31	389826	5970151	389810	5970135	16	15	22	226		(Corr'd Nav, Kongsberg 14208, img#272) (B) (T.A)
17-Sep-2018	02:39:33	610	ENV2			Camera	31	389822	5970152	389810	5970135	13	17	21	217		(Corr'd Nav, Kongsberg 14208, img#273) (B) (T.A)
17-Sep-2018	02:39:45	611	ENV2			Camera	31	389819	5970153	389810	5970135	10	17	20	209		(Corr'd Nav, Kongsberg 14208, img#274) (B) (T.A)
17-Sep-2018	02:40:00	612	ENV2			Camera	31	389819	5970153	389810	5970135	10	17	20	210		(Corr'd Nav, Kongsberg 14208, img#275) (B) (T.A)
17-Sep-2018	02:40:15	613	ENV2			Camera	31	389818	5970151	389810	5970135	9	16	18	209		(Corr'd Nav, Kongsberg 14208, img#276) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*				
Client	Ørsted			Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x 6.701	y 21.939	z 2.932	
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80		Projection	UTM ZONE 31 N (3° E)	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		
17-Sep-2018	02:40:33	614	ENV2			Camera	30	389818	5970149	389810	5970135	8	13	16	212		(Corr'd Nav, Kongsberg 14208, img#277) (B) (T.A)
17-Sep-2018	02:40:45	615	ENV2			Camera	31	389817	5970147	389810	5970135	8	11	14	214		(Corr'd Nav, Kongsberg 14208, img#278) (B) (T.A)
17-Sep-2018	02:41:06	616	ENV2			Camera	31	389815	5970146	389810	5970135	6	10	12	209		(Corr'd Nav, Kongsberg 14208, img#279) (B) (T.A)
17-Sep-2018	02:41:59	617	ENV2			Camera	31	389807	5970141	389810	5970135	-3	6	6	154		(Corr'd Nav, Kongsberg 14208, img#280) (B) (T.A)
17-Sep-2018	02:42:05	618	ENV2			Camera	31	389807	5970141	389810	5970135	-3	5	6	152		(Corr'd Nav, Kongsberg 14208, img#281) (B) (T.A)
17-Sep-2018	02:42:25	619	ENV2			Camera	31	389808	5970139	389810	5970135	-1	4	4	159		(Corr'd Nav, Kongsberg 14208, img#282) (B) (T.A)
17-Sep-2018	02:42:39	620	ENV2			Camera	30	389809	5970138	389810	5970135	-1	2	3	163		(Corr'd Nav, Kongsberg 14208, img#283) (B) (T.A)
17-Sep-2018	02:43:00	621	ENV2			Camera	31	389807	5970137	389810	5970135	-3	2	3	124		(Corr'd Nav, Kongsberg 14208, img#284) (B) (T.A)
17-Sep-2018	02:43:12	622	ENV2			Camera	31	389805	5970136	389810	5970135	-5	1	5	99		(Corr'd Nav, Kongsberg 14208, img#285) (B) (T.A)
17-Sep-2018	02:43:35	623	ENV2			Camera	31	389803	5970139	389810	5970135	-7	3	8	114		(Corr'd Nav, Kongsberg 14208, img#286) (B) (T.A)
17-Sep-2018	02:44:01	624	ENV2			Camera	31	389798	5970142	389810	5970135	-11	6	13	118		(Corr'd Nav, Kongsberg 14208, img#287) (B) (T.A)
17-Sep-2018	02:44:19	625	ENV2			Camera	31	389795	5970142	389810	5970135	-15	7	16	115		(Corr'd Nav, Kongsberg 14208, img#288) (B) (T.A)
17-Sep-2018	02:44:45	626	ENV2			Camera	31	389797	5970141	389810	5970135	-13	6	14	114		(Corr'd Nav, Kongsberg 14208, img#289) (B) (T.A)
17-Sep-2018	02:45:04	627	ENV2			Camera	31	389802	5970139	389810	5970135	-8	4	8	116		(Corr'd Nav, Kongsberg 14208, img#290) (B) (T.A)
17-Sep-2018	02:45:22	628	ENV2			Camera	31	389804	5970136	389810	5970135	-6	1	6	96		(Corr'd Nav, Kongsberg 14208, img#291) (B) (T.A)
17-Sep-2018	02:45:33	629	ENV2			Camera	31	389803	5970135	389810	5970135	-7	-1	7	83		(Corr'd Nav, Kongsberg 14208, img#292) (B) (T.A)
17-Sep-2018	02:45:46	630	ENV2			Camera	31	389801	5970133	389810	5970135	-8	-2	9	73		(Corr'd Nav, Kongsberg 14208, img#293) (B) (T.A)
17-Sep-2018	02:46:03	631	ENV2			Camera	31	389802	5970134	389810	5970135	-7	-1	7	79		(Corr'd Nav, Kongsberg 14208, img#294) (B) (T.A)
17-Sep-2018	03:58:39	632	ENV4			Camera	35	384756	5974062	384762	5974050	-7	12	14	151		(Corr'd Nav, Kongsberg 14208, img#295) (B) (T.A)
17-Sep-2018	03:59:47	633	ENV4			Camera	35	384751	5974061	384762	5974050	-12	11	16	133		(Corr'd Nav, Kongsberg 14208, img#296) (B) (T.A)
17-Sep-2018	04:00:09	634	ENV4			Camera	35	384748	5974058	384762	5974050	-15	9	17	121		(Corr'd Nav, Kongsberg 14208, img#297) (B) (T.A)
17-Sep-2018	04:00:28	635	ENV4			Camera	35	384747	5974055	384762	5974050	-16	5	17	109		(Corr'd Nav, Kongsberg 14208, img#298) (B) (T.A)
17-Sep-2018	04:00:39	636	ENV4			Camera	35	384746	5974054	384762	5974050	-16	4	17	103		(Corr'd Nav, Kongsberg 14208, img#299) (B) (T.A)
17-Sep-2018	04:01:07	637	ENV4			Camera	35	384748	5974052	384762	5974050	-15	2	15	98		(Corr'd Nav, Kongsberg 14208, img#300) (B) (T.A)
17-Sep-2018	04:01:21	638	ENV4			Camera	35	384748	5974050	384762	5974050	-14	0	14	89		(Corr'd Nav, Kongsberg 14208, img#301) (B) (T.A)
17-Sep-2018	04:01:32	639	ENV4			Camera	35	384749	5974049	384762	5974050	-14	-1	14	85		(Corr'd Nav, Kongsberg 14208, img#302) (B) (T.A)
17-Sep-2018	04:01:44	640	ENV4			Camera	35	384750	5974048	384762	5974050	-13	-2	13	82		(Corr'd Nav, Kongsberg 14208, img#303) (B) (T.A)
17-Sep-2018	04:02:07	641	ENV4			Camera	35	384751	5974045	384762	5974050	-11	-5	12	67		(Corr'd Nav, Kongsberg 14208, img#304) (B) (T.A)
17-Sep-2018	04:02:17	642	ENV4			Camera	35	384752	5974044	384762	5974050	-10	-6	12	61		(Corr'd Nav, Kongsberg 14208, img#305) (B) (T.A)
17-Sep-2018	04:02:29	643	ENV4			Camera	35	384754	5974043	384762	5974050	-8	-7	11	49		(Corr'd Nav, Kongsberg 14208, img#306) (B) (T.A)
17-Sep-2018	04:02:49	644	ENV4			Camera	35	384756	5974039	384762	5974050	-7	-11	13	31		(Corr'd Nav, Kongsberg 14208, img#307) (B) (T.A)
17-Sep-2018	04:03:06	645	ENV4			Camera	35	384757	5974038	384762	5974050	-6	-12	14	24		(Corr'd Nav, Kongsberg 14208, img#308) (B) (T.A)
17-Sep-2018	04:03:20	646	ENV4			Camera	35	384757	5974037	384762	5974050	-5	-13	14	21		(Corr'd Nav, Kongsberg 14208, img#309) (B) (T.A)
17-Sep-2018	04:04:14	647	ENV4			Camera	35	384765	5974037	384762	5974050	2	-13	13	351		(Corr'd Nav, Kongsberg 14208, img#310) (B) (T.A)
17-Sep-2018	04:04:26	648	ENV4			Camera	35	384765	5974038	384762	5974050	2	-12	12	349		(Corr'd Nav, Kongsberg 14208, img#311) (B) (T.A)
17-Sep-2018	04:04:57	649	ENV4			Camera	35	384767	5974040	384762	5974050	5	-10	11	334		(Corr'd Nav, Kongsberg 14208, img#312) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*					
Client	Ørsted			Vessel Reference Point (VRP)	CoG					
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon					
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid GRS 80	Projection	UTM ZONE 31 N (3° E)		Vertical / Tidal Datum	LAT		

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration	Sample Retention	Retention	Observed Seafloor Depth (m)	Actual coordinates Easting	Actual coordinates Northing	Target coordinates Easting	Target coordinates Northing	Offset from target dE	Offset from target dN	Offset from target Range	Offset from target Bearing	Surveyor	Remarks
17-Sep-2018	04:05:17	650	ENV4			Camera	35	384769	5974042	384762	5974050	7	-7	10	317		(Corr'd Nav, Kongsberg 14208, img#313) (B) (T.A)
17-Sep-2018	04:05:24	651	ENV4			Camera	35	384770	5974043	384762	5974050	7	-7	10	314		(Corr'd Nav, Kongsberg 14208, img#314) (B) (T.A)
17-Sep-2018	04:05:42	652	ENV4			Camera	35	384771	5974043	384762	5974050	9	-7	11	309		(Corr'd Nav, Kongsberg 14208, img#315) (B) (T.A)
17-Sep-2018	04:05:59	653	ENV4			Camera	35	384772	5974043	384762	5974050	10	-7	12	304		(Corr'd Nav, Kongsberg 14208, img#316) (B) (T.A)
17-Sep-2018	04:06:18	654	ENV4			Camera	35	384774	5974046	384762	5974050	11	-4	12	291		(Corr'd Nav, Kongsberg 14208, img#317) (B) (T.A)
17-Sep-2018	04:06:30	655	ENV4			Camera	35	384776	5974048	384762	5974050	14	-2	14	277		(Corr'd Nav, Kongsberg 14208, img#318) (B) (T.A)
17-Sep-2018	04:06:44	656	ENV4			Camera	35	384776	5974049	384762	5974050	14	-1	14	273		(Corr'd Nav, Kongsberg 14208, img#319) (B) (T.A)
17-Sep-2018	04:07:01	657	ENV4			Camera	35	384775	5974052	384762	5974050	12	2	13	262		(Corr'd Nav, Kongsberg 14208, img#320) (B) (T.A)
17-Sep-2018	04:07:16	658	ENV4			Camera	34	384773	5974054	384762	5974050	11	4	12	250		(Corr'd Nav, Kongsberg 14208, img#321) (B) (T.A)
17-Sep-2018	04:07:41	659	ENV4			Camera	35	384773	5974057	384762	5974050	10	7	12	237		(Corr'd Nav, Kongsberg 14208, img#322) (B) (T.A)
17-Sep-2018	04:07:48	660	ENV4			Camera	35	384772	5974058	384762	5974050	10	8	12	231		(Corr'd Nav, Kongsberg 14208, img#323) (B) (T.A)
17-Sep-2018	04:08:05	661	ENV4			Camera	35	384772	5974060	384762	5974050	9	10	13	223		(Corr'd Nav, Kongsberg 14208, img#324) (B) (T.A)
17-Sep-2018	04:08:30	662	ENV4			Camera	34	384770	5974060	384762	5974050	7	10	13	216		(Corr'd Nav, Kongsberg 14208, img#325) (B) (T.A)
17-Sep-2018	04:08:59	663	ENV4			Camera	35	384766	5974064	384762	5974050	3	14	15	194		(Corr'd Nav, Kongsberg 14208, img#326) (B) (T.A)
17-Sep-2018	04:09:28	664	ENV4			Camera	35	384764	5974063	384762	5974050	1	13	13	186		(Corr'd Nav, Kongsberg 14208, img#327) (B) (T.A)
17-Sep-2018	04:09:44	665	ENV4			Camera	35	384763	5974062	384762	5974050	0	13	12	182		(Corr'd Nav, Kongsberg 14208, img#328) (B) (T.A)
17-Sep-2018	04:10:00	666	ENV4			Camera	34	384759	5974061	384762	5974050	-3	12	12	164		(Corr'd Nav, Kongsberg 14208, img#329) (B) (T.A)
17-Sep-2018	04:10:12	667	ENV4			Camera	35	384760	5974060	384762	5974050	-2	10	10	167		(Corr'd Nav, Kongsberg 14208, img#330) (B) (T.A)
17-Sep-2018	04:10:30	668	ENV4			Camera	35	384757	5974058	384762	5974050	-6	9	10	146		(Corr'd Nav, Kongsberg 14208, img#331) (B) (T.A)
17-Sep-2018	04:10:41	669	ENV4			Camera	35	384757	5974057	384762	5974050	-5	7	9	145		(Corr'd Nav, Kongsberg 14208, img#332) (B) (T.A)
17-Sep-2018	04:10:52	670	ENV4			Camera	35	384758	5974055	384762	5974050	-4	6	7	144		(Corr'd Nav, Kongsberg 14208, img#333) (B) (T.A)
17-Sep-2018	04:11:04	671	ENV4			Camera	35	384759	5974053	384762	5974050	-3	3	5	137		(Corr'd Nav, Kongsberg 14208, img#334) (B) (T.A)
17-Sep-2018	04:11:13	672	ENV4			Camera	35	384760	5974053	384762	5974050	-3	3	4	138		(Corr'd Nav, Kongsberg 14208, img#335) (B) (T.A)
17-Sep-2018	04:11:46	673	ENV4			Camera	35	384761	5974051	384762	5974050	-2	1	2	130		(Corr'd Nav, Kongsberg 14208, img#336) (B) (T.A)
17-Sep-2018	04:12:05	674	ENV4			Camera	35	384763	5974048	384762	5974050	0	-2	2	353		(Corr'd Nav, Kongsberg 14208, img#337) (B) (T.A)
17-Sep-2018	04:12:16	675	ENV4			Camera	35	384763	5974046	384762	5974050	1	-4	4	347		(Corr'd Nav, Kongsberg 14208, img#338) (B) (T.A)
17-Sep-2018	04:12:23	676	ENV4			Camera	35	384763	5974046	384762	5974050	1	-4	4	350		(Corr'd Nav, Kongsberg 14208, img#339) (B) (T.A)
17-Sep-2018	05:17:26	677	ENV1			Camera	33	383573	5969776	383579	5969763	-7	13	15	153		(Corr'd Nav, Kongsberg 14208, img#340) (B) (T.A)
17-Sep-2018	05:18:09	678	ENV1			Camera	33	383571	5969771	383579	5969763	-8	8	11	135		(Corr'd Nav, Kongsberg 14208, img#341) (B) (T.A)
17-Sep-2018	05:18:26	679	ENV1			Camera	33	383569	5969769	383579	5969763	-10	6	11	122		(Corr'd Nav, Kongsberg 14208, img#342) (B) (T.A)
17-Sep-2018	05:18:37	680	ENV1			Camera	33	383569	5969767	383579	5969763	-10	4	11	113		(Corr'd Nav, Kongsberg 14208, img#343) (B) (T.A)
17-Sep-2018	05:18:47	681	ENV1			Camera	33	383569	5969765	383579	5969763	-10	2	11	100		(Corr'd Nav, Kongsberg 14208, img#344) (B) (T.A)
17-Sep-2018	05:19:07	682	ENV1			Camera	33	383568	5969760	383579	5969763	-12	-3	12	76		(Corr'd Nav, Kongsberg 14208, img#345) (B) (T.A)
17-Sep-2018	05:19:31	683	ENV1			Camera	33	383568	5969758	383579	5969763	-12	-5	13	65		(Corr'd Nav, Kongsberg 14208, img#346) (B) (T.A)
17-Sep-2018	05:19:43	684	ENV1			Camera	33	383567	5969757	383579	5969763	-12	-6	13	62		(Corr'd Nav, Kongsberg 14208, img#347) (B) (T.A)
17-Sep-2018	05:20:01	685	ENV1			Camera	33	383567	5969753	383579	5969763	-12	-10	16	51		(Corr'd Nav, Kongsberg 14208, img#348) (B) (T.A)

Gardline

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V *Ocean Endeavour*			
Client	Ørsted			Vessel Reference Point (VRP)	CoG			
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x 6.701	y 21.939	z 2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon			
Geodetic Reference System	Datum WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31 N (3° E)	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		
17-Sep-2018	05:21:05	686	ENV1			Camera	33	383574	5969746	383579	5969763	-5	-17	18	18		(Corr'd Nav, Kongsberg 14208, img#349) (B) (T.A)
17-Sep-2018	05:21:21	687	ENV1			Camera	33	383578	5969746	383579	5969763	-1	-17	17	5		(Corr'd Nav, Kongsberg 14208, img#350) (B) (T.A)
17-Sep-2018	05:21:34	688	ENV1			Camera	33	383580	5969745	383579	5969763	1	-18	18	357		(Corr'd Nav, Kongsberg 14208, img#351) (B) (T.A)
17-Sep-2018	05:22:03	689	ENV1			Camera	33	383583	5969742	383579	5969763	4	-21	21	350		(Corr'd Nav, Kongsberg 14208, img#352) (B) (T.A)
17-Sep-2018	05:22:16	690	ENV1			Camera	33	383583	5969742	383579	5969763	4	-21	21	349		(Corr'd Nav, Kongsberg 14208, img#353) (B) (T.A)
17-Sep-2018	05:23:01	691	ENV1			Camera	33	383582	5969747	383579	5969763	3	-16	17	349		(Corr'd Nav, Kongsberg 14208, img#354) (B) (T.A)
17-Sep-2018	05:23:08	692	ENV1			Camera	33	383582	5969747	383579	5969763	3	-16	16	349		(Corr'd Nav, Kongsberg 14208, img#355) (B) (T.A)
17-Sep-2018	05:23:50	693	ENV1			Camera	33	383585	5969752	383579	5969763	6	-11	12	331		(Corr'd Nav, Kongsberg 14208, img#356) (B) (T.A)
17-Sep-2018	05:24:25	694	ENV1			Camera	33	383587	5969757	383579	5969763	8	-6	10	310		(Corr'd Nav, Kongsberg 14208, img#357) (B) (T.A)
17-Sep-2018	05:24:55	695	ENV1			Camera	33	383587	5969759	383579	5969763	8	-3	9	294		(Corr'd Nav, Kongsberg 14208, img#358) (B) (T.A)
17-Sep-2018	05:25:10	696	ENV1			Camera	33	383588	5969761	383579	5969763	9	-2	9	281		(Corr'd Nav, Kongsberg 14208, img#359) (B) (T.A)
17-Sep-2018	05:25:54	697	ENV1			Camera	33	383590	5969767	383579	5969763	11	4	11	249		(Corr'd Nav, Kongsberg 14208, img#360) (B) (T.A)
17-Sep-2018	05:26:22	698	ENV1			Camera	33	383590	5969770	383579	5969763	11	7	13	238		(Corr'd Nav, Kongsberg 14208, img#361) (B) (T.A)
17-Sep-2018	05:26:59	699	ENV1			Camera	33	383594	5969773	383579	5969763	15	10	18	238		(Corr'd Nav, Kongsberg 14208, img#362) (B) (T.A)
17-Sep-2018	05:27:32	700	ENV1			Camera	33	383589	5969774	383579	5969763	9	11	14	221		(Corr'd Nav, Kongsberg 14208, img#363) (B) (T.A)
17-Sep-2018	05:27:44	701	ENV1			Camera	32	383587	5969775	383579	5969763	8	12	14	213		(Corr'd Nav, Kongsberg 14208, img#364) (B) (T.A)
17-Sep-2018	05:28:15	702	ENV1			Camera	33	383584	5969777	383579	5969763	5	14	15	200		(Corr'd Nav, Kongsberg 14208, img#365) (B) (T.A)
17-Sep-2018	05:28:30	703	ENV1			Camera	33	383583	5969778	383579	5969763	4	16	16	194		(Corr'd Nav, Kongsberg 14208, img#366) (B) (T.A)
17-Sep-2018	05:29:17	704	ENV1			Camera	33	383581	5969777	383579	5969763	2	14	14	188		(Corr'd Nav, Kongsberg 14208, img#367) (B) (T.A)
17-Sep-2018	05:29:23	705	ENV1			Camera	33	383581	5969777	383579	5969763	2	14	14	187		(Corr'd Nav, Kongsberg 14208, img#368) (B) (T.A)
17-Sep-2018	05:30:33	706	ENV1			Camera	33	383576	5969767	383579	5969763	-3	4	5	146		(Corr'd Nav, Kongsberg 14208, img#369) (B) (T.A)
17-Sep-2018	05:30:50	707	ENV1			Camera	33	383576	5969765	383579	5969763	-4	2	4	121		(Corr'd Nav, Kongsberg 14208, img#370) (B) (T.A)
17-Sep-2018	05:30:57	708	ENV1			Camera	33	383576	5969764	383579	5969763	-3	1	4	112		(Corr'd Nav, Kongsberg 14208, img#371) (B) (T.A)
17-Sep-2018	05:31:25	709	ENV1			Camera	33	383579	5969763	383579	5969763	0	0	0	68		(Corr'd Nav, Kongsberg 14208, img#372) (B) (T.A)
17-Sep-2018	05:31:33	710	ENV1			Camera	33	383579	5969762	383579	5969763	0	-1	1	360		(Corr'd Nav, Kongsberg 14208, img#373) (B) (T.A)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

SEABED SAMPLING LOG SHEET (Deck)										QPRO-0755
Job No:	11210	Area: UKCS Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2, 48/3						Sieve Size:	1.0mm	
Project:	Hornsea 4 Offshore Wind Farm Lot 6							Equipment:	Mini-Hamon Grab	
Client:	Ørsted							Vessel:	M.V. *Ocean Endeavour*	
Sample Number	Station Number	Date	Time	Penetration	Sample Retention	Sample Receptacle	Sediment Description	Fauna Description	Operator(s)	Comments
1	ENV23	14-Sep-2018	20:55	70%	MF	1 x 1L pot	Brown sand with shells	Annelida (Polychaeta), Echinodermata (Echinoidea), Mollusca (Bivalvia)	KS	
2	ENV23	14-Sep-2018	21:06	70%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Brown sand with shells	Echinodermata (Echinoidea)	KS	
3	ENV20	15-Sep-2018	04:04	NS	No Sample				GD	Grab triggered in water column
4	ENV20	15-Sep-2018	04:12	70%	MF	1 x 1L pot	Sand with shell fragments	Annelida (Polychaeta), Mollusca (Bivalvia), Echinodermata (Ophiuroidea)	GD	
5	ENV20	15-Sep-2018	04:24	80%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Sand with shell fragments	No visible fauna	GD	
6	ENV24	15-Sep-2018	06:01	NS	No Sample				GD	Grab did not trigger
7	ENV24	15-Sep-2018	06:09	70%	MF	1 X 1L pot	Sand and shell fragments	Annelida (Polychaeta)	GD	
8	ENV24	15-Sep-2018	06:20	80%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Sand and shell fragments	Mollusca (Possible *Arctica islandica* shell)	GD	
9	ENV25	15-Sep-2018	07:46	80%	MF	1x1L pot	Sand	No visible fauna	GD	
10	ENV25	15-Sep-2018	07:58	90%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Sand	Mollusca (Possible *A. islandica* shell)	GD	
11	ENV21	15-Sep-2018	09:21	90%	MF	1 x 5L Bucket	Grey sand with no obvious layer or odour	Mollusca (Bivalvia, Scaphopoda), Echinodermata (Echinoidea, Ophiuroidea)	GD	
12	ENV21	15-Sep-2018	09:33	70%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Grey sand with no obvious layer or odour	No visible fauna	GD	
13	ENV22	15-Sep-2018	10:50	95%	MF	1 x 1L pot	Sand	Echinodermata (Echinoidea)	GD	
14	ENV22	15-Sep-2018	11:02	50%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Sand	Annelida (Polychaeta), Echinodermata (Echinoidea)	GD	
15	ENV19	15-Sep-2018	12:38	90%	MF	1 x 1L pot	Silty sand with shell fragments	Annelida (Polychaete), Arthropoda, Echinodermata (Ophiuroidea)	KS	
16	ENV19	15-Sep-2018	12:49	80%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty sand with gravel and shell fragments. Anoxic layer at <5cm grey sediment, with slight odour	Annelida (Polychaeta), Echinodermata (Echinoidea, Ophiuroidea)	KS	
17	ENV16	15-Sep-2018	14:35	60%	MF	1 x 5L Bucket	Brown sand, with frequent shell fragments	Echinodermata, Mollusca (Bivalvia)	KS	

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

SEABED SAMPLING LOG SHEET (Deck)										QPRO-0755
Job No:	11210	Area: UKCS Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2, 48/3						Sieve Size:	1.0mm	
Project:	Hornsea 4 Offshore Wind Farm Lot 6							Equipment:	Mini-Hamon Grab	
Client:	Ørsted							Vessel:	M.V. *Ocean Endeavour*	
Sample Number	Station Number	Date	Time	Penetration	Sample Retention	Sample Receptacle	Sediment Description	Fauna Description	Operator(s)	Comments
18	ENV16	15-Sep-2018	14:44	40%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Brown sand, with frequent shell fragments	No visible fauna	KS	
19	ENV17	15-Sep-2018	16:18	20%	No Sample		Muddy sand and shells		KS	Low sample retention
20	ENV17	15-Sep-2018	16:26	40%	MF	1 x 1L pot	Muddy sand and shells	Arthropoda (Upogebiidae)	KS	
21	ENV17	15-Sep-2018	16:35	20%	No Sample				KS	Grab did not trigger
22	ENV17	15-Sep-2018	16:40	40%	No Sample				KS	Cobble in jaws
23	ENV17	15-Sep-2018	16:49	40%	No Sample				KS	Cobble in jaws
24	ENV17	15-Sep-2018	16:58	20%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Muddy sand and shells	No visible fauna	KS	Client accepted low sample penetration
25	ENV14	15-Sep-2018	18:23	40%	MF	1 x 1L pot	Silty brown sand	Annelida (Polychaeta), Echinodermata (Echinoidea)	KS	
26	ENV14	15-Sep-2018	18:32	40%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty brown sand	No visible fauna	KS	
27	ENV15	15-Sep-2018	21:28	70%	MF	1 x 1L pot	Silty brown sand	Annelida (Polychaeta)	KS	
28	ENV15	15-Sep-2018	21:27	50%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty brown sand.	Echinodermata (Asteroidea)	KS	
29	ENV18	16-Sep-2018	00:05	90%	MF	1 x 1L pot	Brown sand, occasional shell fragments	Annelida (Polychaeta)	GD	
30	ENV18	16-Sep-2018	00:15	90%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Brown sand, occasional shell fragments	Mollusca (Bivalvia)	GD	
31	ENV10	16-Sep-2018	18:40	40%	MF	1 x 1L pot	Silty sand with occasional shell fragments	Annelida (Polychaeta), Mollusca (Bivalvia)	KS	
32	ENV10	16-Sep-2018	18:49	NS	No Sample	NS			KS	Grab did not trigger
33	ENV10	16-Sep-2018	18:54	40%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty sand with occasional shell fragments. Anoxic layer at >3cm grey sediment, with a mild odour	No visible fauna	KS	
34	ENV11	16-Sep-2018	20:05	50%	MF	1 x 1L pot	Silty sand with occasional shell fragments	Annelida (Polychaeta)	KS	
35	ENV11	16-Sep-2018	20:13	50%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty sand with occasional shell fragments	No visible fauna	KS	
36	ENV8	16-Sep-2018	21:16	50%	MF	1 x 1L pot	Silty sand with occasional shell fragments	Arthropoda (Isopoda)	KS	
37	ENV8	16-Sep-2018	21:24	40%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty sand with occasional shell fragments	No visible fauna	KS	

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

SEABED SAMPLING LOG SHEET (Deck)										QPRO-0755
Job No:	11210	Area: UKCS Blocks 42/25, 43/21, 43/26, 43/27, 43/28, 48/2, 48/3						Sieve Size:	1.0mm	
Project:	Hornsea 4 Offshore Wind Farm Lot 6							Equipment:	Mini-Hamon Grab	
Client:	Ørsted							Vessel:	M.V. *Ocean Endeavour*	
Sample Number	Station Number	Date	Time	Penetration	Sample Retention	Sample Receptacle	Sediment Description	Fauna Description	Operator(s)	Comments
38	ENV9	16-Sep-2018	22:37	50%	MF	1 x 1L pot	Sand with silt and shell fragments	Annelida (Polychaeta), Arthropoda (Brachyura)	KS	
39	ENV9	16-Sep-2018	22:45	40%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Sand with silt and shell fragments	No visible fauna	KS	
40	ENV6	17-Sep-2018	00:09	60%	MF	1 x 1L pot	Silty sand with occasional shell fragments	Mollusca (Scaphopoda)	GD	
41	ENV6	17-Sep-2018	00:18	70%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty sand with occasional shell fragments	No visible fauna	GD	
42	ENV5	17-Sep-2018	01:41	70%	MF	1 x 1L pot	Sand with occasional shell fragments	Annelida (Polychaeta), Mollusca (Bivalvia)	GD	
43	ENV5	17-Sep-2018	01:50	80%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty sand with occasional shell fragments	Mollusca (Bivalvia)	GD	
44	ENV2	17-Sep-2018	02:55	90%	MF	1 x 5L Bucket	Sand and shell fragments	Chordata (Ammodytidae)	GD	
45	ENV2	17-Sep-2018	03:04	95%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Sand and shell fragments	Chordata (Ammodytidae)	GD	
46	ENV4	17-Sep-2018	04:21	60%	MF	1 x 1L pot	Silty sand. Anoxic layer present at >3cm witth no obvious odour	Annelida (Polychaeta)	GD	
47	ENV4	17-Sep-2018	04:30	60%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Silty sand. Anoxic layer present at > 3cm with no obvious odour	Echinodermata (Echinoidea)	GD	
48	ENV1	17-Sep-2018	05:40	100%	MF	1 x 1L pot	Sand with shell fragments	Anneldia (Polychaeta), Echinodermata (damaged Echinoidea)	GD	
49	ENV1	17-Sep-2018	05:48	90%	CHEM	1x HA Tin, 1x HB Tin,1x Metals bag, 1x PSA bag,1x SPR bag	Sand with shell fragments	No visible fauna	GD	

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Gardline — Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V. *Ocean Endeavour*				
Client	Ørsted			Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z	2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31N (3° E)	Vertical / Tidal Datum	LAT	

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration (%)	Sample Retention	Retention	Observed Seafloor Depth	Actual coordinates		Target coordinates		Offset from target				Surveyor	Remarks
								Easting	Northing	Easting	Northing	dE	dN	Range	Bearing		
14-Sep-2018	20:55	1	ENV23	70	MFA	Hamon Grab	58	367458	6005689	367458	6005694	0	5	5	183	BL	
14-Sep-2018	21:06	2	ENV23	70	CHEM	Hamon Grab	58	367458	6005691	367458	6005694	0	3	3	186	BL	
15-Sep-2018	04:04	3	ENV20	-	NS	Hamon Grab	47	373175	5998654	373174	5998657	-1	3	3	166	AR	Grab triggered in the water column.
15-Sep-2018	04:12	4	ENV20	70	MFA	Hamon Grab	47	373171	5998646	373174	5998657	4	10	11	199	AR	
15-Sep-2018	04:24	5	ENV20	80	CHEM	Hamon Grab	47	373166	5998650	373174	5998657	9	7	11	230	AR	
15-Sep-2018	06:01	6	ENV24	-	NS	Hamon Grab	56	373678	6006063	373683	6006063	5	0	5	274	AR	Grab did not trigger.
15-Sep-2018	06:09	7	ENV24	70	MFA	Hamon Grab	56	373681	6006062	373683	6006063	2	1	3	236	AR	
15-Sep-2018	06:20	8	ENV24	80	CHEM	Hamon Grab	56	373682	6006064	373683	6006063	1	-1	2	299	AR	
15-Sep-2018	07:46	9	ENV25	80	MFA	Hamon Grab	58	378385	6005471	378384	6005474	-1	4	4	162	AR	
15-Sep-2018	07:58	10	ENV25	90	CHEM	Hamon Grab	58	378384	6005471	378384	6005474	0	3	3	182	AR	
15-Sep-2018	09:21	11	ENV21	90	MFA	Hamon Grab	61	383691	6001718	383694	6001725	2	7	7	199	AR	
15-Sep-2018	09:33	12	ENV21	70	CHEM	Hamon Grab	60	383695	6001721	383694	6001725	-1	4	4	164	AR	
15-Sep-2018	10:50	13	ENV22	95	MFA	Hamon Grab	59	388418	6001151	388415	6001149	-3	-2	4	61	AR	
15-Sep-2018	11:02	14	ENV22	50	CHEM	Hamon Grab	59	388412	6001147	388415	6001149	3	2	3	243	AR	
15-Sep-2018	12:38	15	ENV19	90	MFA	Hamon Grab	57	393773	5997430	393775	5997431	2	1	2	245	BL	
15-Sep-2018	12:49	16	ENV19	80	CHEM	Hamon Grab	57	393770	5997431	393775	5997431	5	0	5	264	BL	
15-Sep-2018	14:35	17	ENV16	60	MFA	Hamon Grab	47	394796	5990980	394801	5990989	5	9	11	210	BL	
15-Sep-2018	14:44	18	ENV16	40	CHEM	Hamon Grab	48	394803	5990987	394801	5990989	-2	3	3	138	BL	
15-Sep-2018	16:18	19	ENV17	-	NS	Hamon Grab	49	401368	5991562	401361	5991570	-7	8	10	138	BL	Low sample retention.
15-Sep-2018	16:26	20	ENV17	40	MFA	Hamon Grab	50	401361	5991568	401361	5991570	0	2	2	196	BL	
15-Sep-2018	16:35	21	ENV17	-	NS	Hamon Grab	50	401359	5991570	401361	5991570	2	0	2	287	BL	Grab did not trigger.
15-Sep-2018	16:40	22	ENV17	-	NS	Hamon Grab	50	401360	5991568	401361	5991570	1	1	1	226	BL	Cobble in jaws
15-Sep-2018	16:49	23	ENV17	-	NS	Hamon Grab	50	401371	5991569	401361	5991570	-9	1	10	93	BL	Cobble in jaws
15-Sep-2018	16:58	24	ENV17	20	CHEM	Hamon Grab	50	401350	5991572	401361	5991570	12	-2	12	281	BL	Onboard client accepted lower sample penetration
15-Sep-2018	18:23	25	ENV14	40	MFA	Hamon Grab	42	404557	5986488	404555	5986490	-3	2	3	124	BL	
15-Sep-2018	18:32	26	ENV14	40	CHEM	Hamon Grab	42	404552	5986491	404555	5986490	3	-2	3	304	BL	
15-Sep-2018	21:18	27	ENV15	40	MFA	Hamon Grab	52	386365	5992770	386367	5992775	2	5	6	197	BL	
15-Sep-2018	21:27	28	ENV15	50	CHEM	Hamon Grab	51	386361	5992771	386367	5992775	6	4	7	235	BL	
16-Sep-2018	00:05	29	ENV18	90	MFA	Hamon Grab	47	379146	5995321	379148	5995324	1	3	3	201	AR	
16-Sep-2018	00:15	30	ENV18	90	CHEM	Hamon Grab	46	379150	5995321	379148	5995324	-2	3	4	151	AR	
16-Sep-2018	18:40	31	ENV10	40	MFA	Hamon Grab	43	384605	5984576	384607	5984582	2	7	7	193	BL	
16-Sep-2018	18:49	32	ENV10	-	NS	Hamon Grab	43	384610	5984569	384607	5984582	-2	13	14	170	BL	Grab did not trigger.
16-Sep-2018	18:54	33	ENV10	40	CHEM	Hamon Grab	43	384609	5984570	384607	5984582	-2	13	13	173	BL	
16-Sep-2018	20:05	34	ENV11	50	MFA	Hamon Grab	42	390092	5984490	390098	5984490	6	0	6	271	BL	
16-Sep-2018	20:13	35	ENV11	50	CHEM	Hamon Grab	42	390094	5984491	390098	5984490	5	-1	5	278	BL	
16-Sep-2018	21:16	36	ENV8	40	MFA	Hamon Grab	41	389663	5980650	389649	5980664	-15	15	21	135	BL	

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Seafloor Sampling Positioning Summary

Job No	11210			Vessel	M.V. *Ocean Endeavour*				
Client	Ørsted			Vessel Reference Point (VRP)	CoG				
Project Name	Hornsea 4 Offshore Wind Farm Lot 6			Deployment Location	Starboard Crane	x	6.701	y	21.939	z	2.932
Primary Positioning System	Starpack_Port			Actual Coordinates derived from	Beacon				
Geodetic Reference System	Datum	WGS84 - ETRS89	Ellipsoid	GRS 80	Projection	UTM ZONE 31N (3° E)	Vertical / Tidal Datum	LAT	

Date	Time (UTC/GMT)	Fix number	Stn No	Penetration (%)	Sample Retention	Retention	Observed Seafloor Depth	Actual coordinates		Target coordinates		Offset from target				Surveyor	Remarks
								Easting	Northing	Easting	Northing	dE	dN	Range	Bearing		
16-Sep-2018	21:24	37	ENV8	40	CHEM	Hamon Grab	41	389660	5980645	389649	5980664	-11	15	22	150	BL	
16-Sep-2018	22:37	38	ENV9	60	MFA	Hamon Grab	43	395359	5980710	395365	5980714	7	4	8	240	BL	
16-Sep-2018	22:45	39	ENV9	40	CHEM	Hamon Grab	43	395365	5980707	395365	5980714	0	7	7	181	BL	
17-Sep-2018	00:09	40	ENV6	60	MFA	Hamon Grab	39	395815	5973908	395817	5973911	2	3	4	213	AR	
17-Sep-2018	00:18	41	ENV6	70	CHEM	Hamon Grab	38	395814	5973912	395817	5973911	3	-1	3	287	AR	
17-Sep-2018	01:41	42	ENV5	70	MFA	Hamon Grab	38	390063	5973836	390067	5973840	4	4	5	223	AR	
17-Sep-2018	01:50	43	ENV5	80	CHEM	Hamon Grab	38	390063	5973837	390067	5973840	4	4	5	229	AR	
17-Sep-2018	02:55	44	ENV2	90	MFA	Hamon Grab	33	389812	5970137	389810	5970135	-2	-1	3	60	AR	
17-Sep-2018	03:04	45	ENV2	95	CHEM	Hamon Grab	33	389811	5970128	389810	5970135	-2	7	8	167	AR	
17-Sep-2018	04:21	46	ENV4	60	MFA	Hamon Grab	37	384761	5974049	384762	5974050	2	1	2	248	AR	
17-Sep-2018	04:30	47	ENV4	60	CHEM	Hamon Grab	36	384762	5974045	384762	5974050	0	4	5	185	AR	
17-Sep-2018	05:40	48	ENV1	95	MFA	Hamon Grab	35	383580	5969761	383579	5969763	-1	2	2	165	AR	
17-Sep-2018	05:48	49	ENV1	90	CHEM	Hamon Grab	35	383579	5969757	383579	5969763	0	6	6	184	AR	

APPENDIX B METHODS

B.1 Seabed Imagery

Environmental seabed images were taken by means of a digital stills shallow water camera system with a dedicated strobe and video lamp, mounted within a stainless-steel frame. A ultra-short baseline (USBL) positioning beacon was attached to the camera frame.

Footage was viewed in real time via an umbilical, assisting in the control of the digital stills camera. This allowed for shot selection, in the event that the system recorded a sediment change or feature at the seafloor.

A minimum of 22 seabed photographs were taken at each station using a hover and drift technique at appropriate intervals. This technique allowed the frame to move progressively along the seabed as the vessel traversed the work area on its thrusters or drifted. The images were captured remotely using the surface control unit and stored on the camera's internal memory card. Video footage was overlaid with time, position, and depth, and recorded directly onto hard drive (HDD). On completion, photographs were downloaded onto a PC via a USB download cable and copied onto external portable HDDs. All HDDs were labelled with the relevant job details, write-protected and stored.

A total of 664 images were taken across 21 stations. A selection of seabed photographs is presented in Appendix D, whilst environmental deck and positioning logs are contained in Appendix A.

Main instrumental and acquisition details are as follows:

Table B.1 Camera Equipment Specifications

Equipment	Stills Camera System
Manufacturer	Kongsberg/Simrad.
Model	OE14-208
Lens	f 7.2 – 28.8 (35mm format equivalent to 38 – 140mm) 4x optical zoom and automatic or manual focus control
Pixels	5.0 M
Video Resolution	PAL 625 Line / 50 Hz PAL
Image Resolution (pixels)	2592 x 1944
Field of View	48.4° horizontal (β) by 29.9° vertical (α)
Video Overlay	Sea and Sun Telemetry Control
Trigger	Remote from deck
Height Control	USBL Beacon and Video footage
Lighting	1 fixed forward facing strobe, 1 fixed LED lamp
Scale bar	Green line lasers with 95mm separation between lines

Table unit definitions: PAL = phase alternating line

B.2 Benthic Sampling

Benthic samples were recovered using a $0.1m^2$ Mini-Hamon grab, specifically designed for this type of environmental sampling.

Mini-Hamon grab sampling operational procedures were as follows:

The vessel's sampling area was pre-cleaned using a powerful deck fire-hose and seawater. The Mini-Hamon grab was thoroughly washed down using Pentane prior to deployment at every station to prevent hydrocarbon cross contamination. A 180m-length of 18mm, dry-core, galvanised-steel cable was used to lower the Mini-Hamon grab to the seabed.

All containers were thoroughly washed with appropriate solvents and labelled externally prior to use. Biology samples were placed in 1-litre polypropylene, screw-top, squat jars / 5-litre buckets and provided with an additional internal waterproof label. Hydrocarbon samples were placed in 250ml, tinned-steel containers, whilst the remaining samples (metals and particle size) were placed in double-lined zip-lock bags.

Communication between the deck, bridge crew and the surveyors were conducted by means of VHF radio. When directly over the sampling station the grab was winched to the seabed and quickly recovered so that the sample could be obtained, and the apparatus returned to the pre-deployment position.

Positional fixes were taken for each grab sample immediately following the grab reaching the sea floor. The precise time that the grab reached the seabed was determined by observations of the tension on the winch cable. The vessel offset of grab deployment was used to represent the position of the sampler.

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 surface sediment washout;
2. Grab not fully closed upon 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 sample represents less than 40% of the grab's total capacity;
6. Sample is an unacceptable distance from the desired position (as determined by the on-board surveyors);
7. The presence of a "Hag Fish" and/or mucus coagulants;
8. Loss of finer sediment fractions of the sediment is suspected;
9. Depth of sediment is less that 5cm, unless the sediment is very hard and/or coarse and it is clear that better samples cannot be obtained.

Grab samples deemed acceptable for physico-chemical analyses were photographed and described prior to sub-sampling. Grab samples for macrofaunal analyses were only photographed if there were organisms or other objects of interest clearly visible on the sediment surface.

Two sediment samples, one for hydrocarbon determination (HC) the other to act as a spare, were scooped using a stainless-steel spoon into 250ml tins that had been previously washed with pentane to remove any organic contaminants. Three further sub-samples of approximately 500g comprising one each for metals determination (M), particle size distribution (PSD) analysis and a spare were taken using a plastic scoop and placed into plastic zip-lock bags. All physico-chemical samples were stored at less than -18°C prior to analysis.

One grab sample from each station was collected for infaunal macroinvertebrate identification. For each faunal sample the entire contents of a single grab were washed into a clean plastic tray using seawater and then transferred to a 1.0mm sieve. Finer sediment fractions were washed from the sample using an auto-sieve, which sprayed a low powered seawater jet onto the underside of the sieve. The residual sieve contents were transferred to uniquely labelled sample jars using a scoop and/or funnel, making sure that none of the sample was lost or trapped in the sieve mesh. Sieved samples were immediately fixed with a known concentration of formaldehyde solution (‘formalin’, less than 20%). The formalin in the sample pots was subsequently diluted to a concentration of approximately 4%.

Across the 21 sampling stations, 42 single grab samples were retained from 50 deployments, with all retained samples taken within 22m of their target location. On average, retained samples were acquired 5.9m (±4.5 SD) from their target location. Environmental deck and positioning logs are presented in Appendix A.

B.3 Imagery Processing

Seabed images were assessed using the Gardline developed imagery analysis program (CountEM). The program allows for individual fauna to be tagged and a sediment description to be assigned to each image. The software allows features to be selected within an image to provide an accurate figure of percentage coverage of each individual element (*e.g.* cobbles and boulders, sponges) based upon the proportion of pixels. CountEM can also measure the area of seabed and observed features primarily in pixels, though can be converted to millimetres (mm) given a reference scale within the image, such as using two laser lines with a known separation.

Following quality control (QC), data were exported into an excel file used to summarise seabed imagery observations and to allow for further analysis as applicable. A reference collection of ID is retained and available for the project and presented in Appendix E.

B.4 Habitat Analysis

B.4.1 Sea Pen and Burrowing Megafauna Communities

Clarifications on the identification of OSPAR description of the habitat were summarised in a report by the JNCC (2014) to improve the definition and correct identification of this habitat. These clarifications suggest that burrowed areas of mud should be deemed to be a ‘sea pen and burrowing megafauna communities’ habitat regardless of the presence of sea pens, if multiple sightings of burrows and/or mounds attributable to the relevant species are observed. Furthermore, although the habitat occurs predominantly in fine mud sediments, examples of the habitat have been identified in areas of sandy muds where there is clear evidence of the relevant biological assemblages (burrowing megafauna and in some examples, sea pens). Consequently, habitats can be classed as ‘sea pen and burrowing megafauna communities’ regardless of the grain size composition of the sediment (JNCC, 2014). The report (JNCC, 2014) also recommends that the definition should extend further than the habitat classification biotope 'Sea-pens and burrowing megafauna in circalittoral fine mud' (Connor *et al.*, 2004) since additional biotopes are also considered to be associated with the habitat.

The clarifications (JNCC, 2014) advocate utilising seabed video imagery and/or photographs to confirm the presence of burrows and/or mounds, and sea pens where present. Whilst from seabed grab samples, identification would confirm associated fauna and PSA data a fine mud/sandy mud habitat. The density classifications as laid out by the Marine Nature Conservation Review (MNCR) SACFOR scale (JNCC, 2013b) should be used to quantify these defining features (see Table B.2). The report specifies that multiple sightings of burrows and/or mounds attributable to relevant species together with sea pens, if present, should be classified as at least 'frequent' for their size on the SACFOR scale in order to be considered a 'sea pen and burrowing megafauna communities' habitat. The JNCC (2014) clarification report acknowledges the inherent difficulties of identifying species from burrow type alone. Subsequently, the overall density of burrows themselves will be assessed instead, in order to consider whether their density was a 'prominent' feature of the sediment surface and potentially indicative of a sub-surface complex gallery burrow system.

Table B.2 SACFOR Abundance Scale

Density	Size of Individuals			
	<1cm	1-3cm	3-15cm	>15cm
≥10000 m^{-2}	S	S	S	S
≥1000 m^{-2} to <10000 m^{-2}	A	S	S	S
≥100 m^{-2} to <1000 m^{-2}	C	A	S	S
≥10 m^{-2} to <100 m^{-2}	F	C	A	S
≥1 m^{-2} to <10 m^{-2}	O	F	C	A
≥0.1 to <1 m^{-2}	R	O	F	C
≥0.01 m^{-2} to <0.1 m^{-2}	R	R	O	F
≥0.001 m^{-2} to <0.01 m^{-2}	R	R	R	O
<0.001 m^{-2}	R	R	R	R

S= Superabundant, A = Abundant, C = Common, F = Frequent, O = Occasional and R = Rare. Table amended from: JNCC (2013b).
For sedentary species attached to the substratum, percentage cover should be used in preference to the density scale whenever possible.

B.5 Particle Size Analysis

Particle size analysis (PSA) was conducted by Thomson Ecology in accordance with NMBAQC methods for diamictons (Mason, 2016).

No dispersants were used, and the sediment was not treated to remove carbonates or organic matter prior to analysis. The range of sieve sizes, together with their Wentworth classifications (Wentworth, 1922), is given in Table B.3.

The results, given in Appendix D and summarised in Section 2.4.1, present particle size distributions in terms of mean phi, fraction percentages (*i.e.*, gravel, sand and fines), sorting (mixture of sediment sizes) and skewness (weighting of sediment fractions above and below the mean sediment size) and kurtosis (degree of peakedness) (Folk & Ward, 1957). These indices are described below:

1 Graphic Mean - a measure of average particle size in phi units (-log2(diamm), Fo k & Ward, 1957).

$$M_z = \frac{\emptyset 16 + \emptyset 84 + \emptyset 50}{3}$$

where M_z = The graphic mean particle size in phi
ø = the phi size of the nth percentile of the sample

2 Sorting – the inclusive graphic standard deviation of the sample is a measure of the degree of sorting. Sorting classifications are presented in Table B.4.

$$\sigma_1 = \frac{\emptyset 84 - \emptyset 16}{4} + \frac{\emptyset 95 - \emptyset 5}{6.6}$$

where σ_1 = the inclusive graphic standard deviation

3 Inclusive Graphic Skewness – the degree of asymmetry of a frequency or cumulative curve, Skewness classification are presented in Table B.5.

$$S = \frac{\emptyset 16 + \emptyset 84 - 2(\emptyset 50)}{2(\emptyset 84 - \emptyset 16)} + \frac{\emptyset 5 + \emptyset 95 - 2(\emptyset 50)}{2(\emptyset 95 - \emptyset 5)}$$

where S = the skewness of the sample

4 Graphic Kurtosis – The degree of peakdness or departure from a ‘normal’ frequency or cumulative curve. Kurtosis classifications are presented in Table B.6.

$$K = \frac{\emptyset 95 - \emptyset 5}{2.44(\emptyset 75 - \emptyset 25)}$$

where K= Kurtosis

The sediment samples were additionally classified using the modified Folk triangle classification (Folk, 1954). as well as the associated broadscale sediment classifications (McBreen *et al.*, 2011) to aid

EUNIS classifications (presented in Figure B.1), which uses the sand:mud ratio and the percentage of gravel.

Table B.3 Phi and Sieve Aperture with Wentworth Classifications

Aperture in microns	Aperture in Phi Unit	Sediment Description	
≥16000	≤-4	Pebble	GRAVEL
<16000 to 11200	>-4 to -3.5		
<11200 to 8000	>-3.5 to -3		
<8000 to 5600	>-3 to -2.5		
<5600 to 4000	>-2.5 to -2		
<4000 to 2800	>-2 to -1.5	Granule	
<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	Coarse Silt	FINES
<44 to 31.5	>4.5 to 5		
<31.5 to 22	>5 to 5.5	Medium Silt	
<22 to 15.6	>5.5 to 6		
<15.6 to 11	>6 to 6.5	Fine Silt	
<11 to 7.8	>6.5 to 7		
<7.8 to 5.5	>7 to 7.5	Very Fine Silt	
<5.5 to 3.9	>7.5 to 8		
<3.9 to 2.8	>8 to 8.5	Clay	
<2.8 to 2	>8.5 to 9		
<2 to 1.4	>9 to 9.5		
<1.4 to 1	>9.5 to 10		
<1	>10		

Table B.4 Sorting Classifications

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

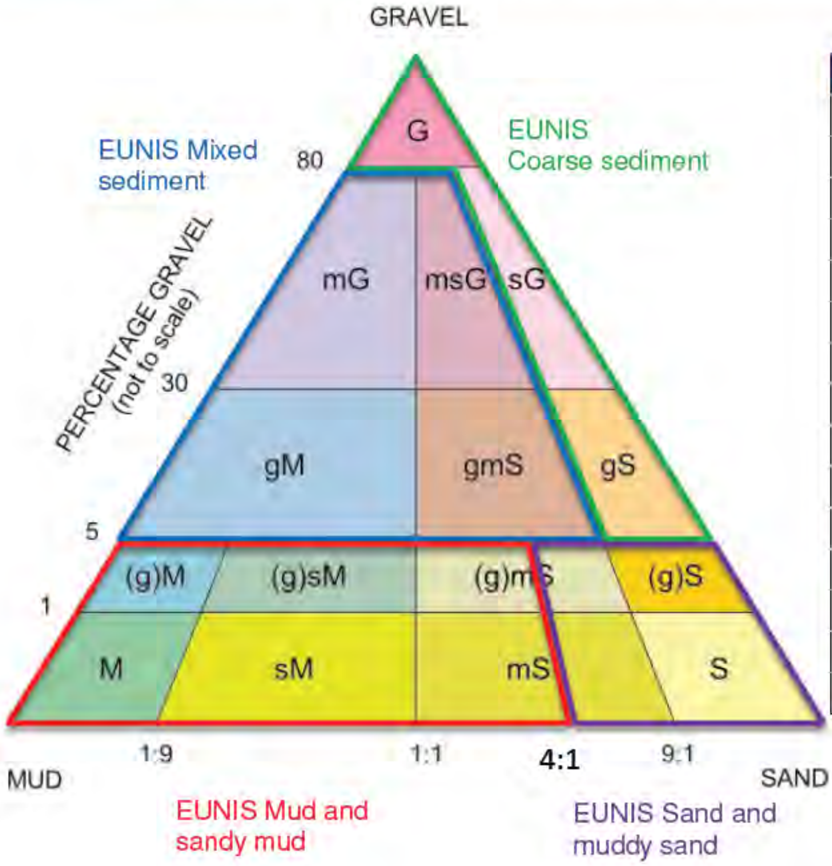
Table B.5 Skewness Classification

Skewness Coefficient	Mathematical Skewness	Graphical Skewness
1.00 > 0.30	Strongly Positive	Strongly fine skewed
0.30 > 0.10	Positive	Fine skewed
0.10 > -0.10	Near Symmetrical	Symmetrical
-0.10 > -0.30	Negative	Coarse skewed
-0.30 > -1.00	Strongly Negative	Strongly coarse skewed

Table B.6 Kurtosis Classification

Kurtosis Coefficient	Kurtosis Classification	Graphical meaning
≤ 0.67	Very Platykurtic	Flat-peaked; the ends are better sorted than the centre
0.67 < 0.90	Platykurtic	
0.90 < 1.11	Mesokurtic	Normal; bell shaped curve
1.11 < 1.50	Leptokurtic	Curves are excessively peaked; the centre is better sorted than the ends
1.50 < 3.00	Very Leptokurtic	
≥ 3.00	Extremely Leptokurtic	

Figure B.1 Modified Folk Triangle with Associated Broadscale Sediment classifications for EUNIS



Code	Modified Folk Classification
G	Gravel
mG	Muddy gravel
msG	Muddy sandy gravel
sG	Sandy gravel
gM	Gravelly mud
gmS	Gravelly muddy sand
gS	Gravelly sand
(g)M	Slightly gravelly mud
(g)sM	Slightly gravelly sandy mud
(g)mS	Slightly gravelly muddy sand
(g)S	Slightly gravelly sand
M	Mud
sM	Sandy mud
mS	Muddy sand
S	Sand

B.6 Total Organic Carbon

A 0.25g aliquot of air dried and ground (particle size <118µm) sample was mixed with 10ml of analytical grade sulphurous acid and allowed to effervesce at 40°C for fourteen hours in order to remove any inorganic carbon. The digested sample was then heated to 105°C until any remaining acid had evaporated, and the sample had dried. The dried residue was then analysed for carbon content using an Eltra induction furnace, fitted with a non-dispersive infrared (NDIR) cell. In this instrument the sample was combusted at 1600°C in an oxygen atmosphere, the combustion gases pass through the NDIR cell which measures the carbon dioxide (CO_2) concentration. The total quantity of carbon liberated is calculated and reported as a percentage of the original mass of sample.

The method is calibrated every day and incorporates a three-point calibration (including blank) using matrix matched standards sourced from traceable material. The calibration range extends to 4.0%. Any samples that are over-range are re-extracted with reduced sample weight and re-analysed. The method is statistically controlled using both process and instrument quality control samples. Both are sourced independently from the solutions used to calibrate the method. Instrument and process blank solutions are also run at regular intervals (with each batch) to monitor potential sources of contamination.

The results are expressed as % w/w of a dry sample and will not include volatile organic carbons, the majority of which are lost during digestion and drying. The upper range limit of this technique has not been investigated, whilst the lower limit is dependent on the sensitivity of the furnace and the sample weight taken. In practice, the limit of detection (LOD) is 0.02% of sample weight. The standard used was OAS Acetanilide.

B.7 Hydrocarbons

B.7.1 Extraction Procedures

A 15g sub-sample of the sample was treated with 15ml of methanol and 60ml of dichloromethane (DCM) and mixed on a magnetic stirring plate for one hour (wet vortex extraction). The solvent extract was then chemically dried, water partitioned and then reduced to approximately 1ml using a Kuderna Danish evaporator with micro Snyder. The clean -up stage utilised 1g of activated silica gel along with DCM and pentane, which removes polar organics. One third of the column was made up with the DCM/Silica slurry and then the column was eluted with 9ml of DCM and 3ml of pentane. The 1ml of DCM extract was then eluted through the column with a further 1ml of DCM and 2ml of Pentane giving a final extract of 4ml (DCM:pentane). The samples were then subjected to a further copper clean up stage to remove any sulphur.

A separate sub-sample was taken for analysis of moisture content by drying at 120ºC for 8 hours. The moisture content was later used to convert the hydrocarbon concentrations from wet weight to dry weight.

B.7.2 Analysis by Gas Chromatography

An aliquot of the extract was then taken and analysed for total hydrocarbons and individual n-alkanes by large volume injection GC-FID and one taken to be analysed for PAH, DBT and alkylated isomer concentrations by GC-MS selected ion monitoring as specified in DTI (1992).

Appropriate column and GC conditions were used to provide sufficient chromatographic separation of all analytes and required sensitivity. GC chromatograms are presented in Appendix H.

B.7.3 Quality Control Samples

All samples have surrogates and internal standards (heptamethylnonane (A), 1-chlorooctadecane (B) and squalane (C)) added prior to commencement of extraction. Decanoic acid and eicosanoic Acid were added to the sample post extraction but prior to the clean-up stage. These are reverse surrogates to measure the clean-up. The method was statistically controlled using both process and instrument quality control samples. Both were sourced independently from the solutions used to calibrate the method. Three instrument blanks of 50:50 pentane:DCM were run initially and one after the continuing calibration check (CCC) before any samples. Two method blanks and an in-house prepared reference material were analysed with each batch and process blank solutions were also run at regular intervals (with each batch) to monitor potential sources of contamination.

B.7.4 Calibration and Calculation

Two calibration check standards are measured by GC-FID before and after each batch. The first CCC is a florida mix used to calibrate the individual alkane method and determine retention times and areas for the nC_{10} – nC_{40} alkane groups. The second CCC is a diesel/mineral oil mix which provides the odd alkane group retention times from nC_{11} – nC_{27}, pristane and phytane. The second CCC is used to calibrate the total petroleum hydrocarbons area.

Concentrations of total hydrocarbons from the extract analysed by GC-FID were quantified by comparison with the chromatographic envelopes from the mixed diesel/mineral oil calibration standards. The concentration in the sample was then calculated against the squalene surrogate. The chromatographically resolved individual n-alkane peaks nC_{10}-nC_{37} were quantified using the florida mix standard.

The GC/MS is calibrated initially at four concentrations to confirm linearity of each target compound across the working range. With each batch a calibration check standard is measured before and after each batch and the concentration calculated from the slope of the four-point initial calibration. The CCC is used to calibrate the method and samples are quantified using the CCC response factors.

Concentrations of PAH from the extract analysed by GC-MS were determined by referencing individual quantified mass peak areas for each target compound to the appropriate internal standard quantified mass peak area and the relative response factor calculated from the applicable CCC standard.

The analysis detection limits were 1ng g^{-1} for PAHs, 1ng g^{-1} for individual n-alkanes and 100ng g^{-1} for THC.

B.8 Metals

B.8.1 Aqua Regia Extractions for ICP-MS Determination

Approximately 0.25g of the air dried and ground (<118µm) sediment was weighed and transferred to a beaker. 10ml hydrogen peroxide (30% v/v) was added and the covered sample left to stand for 30 minutes in a fume cupboard. Samples were placed on the hotplate for one hour to aid digestion after the addition of 10ml concentrated nitric acid. The sample was then filtered through a Whatman 542 filter paper into a clean 100ml standard flask. The utensils were thoroughly rinsed on to the filter paper, which was then itself rinsed into the flask. The filter funnel was then also rinsed into the flask. The flask was then made up to volume, before being mixed well. The filtrate was analysed by ICP-MS.

B.8.2 Mercury Extraction

Approximately 0.25g of the air dried and ground (<118µm) sediment was weighed and transferred to a beaker. 10ml hydrogen peroxide (30% v/v) was added and the covered sample left to stand for 30 minutes in a fume cupboard. Samples were placed on the hotplate for one hour to aid digestion after the addition of 10ml concentrated nitric acid. The sample was then filtered through a Whatman 542 filter paper into a clean 100ml standard flask. The utensils were thoroughly rinsed on to the filter paper, which was then itself rinsed into the flask. The filter funnel was then also rinsed into the flask. The flask was then made up to volume, before being mixed well. The filtrate was analysed by ICP-MS.

B.8.3 Inductively Coupled Plasma – Mass Spectrometry (ICP-MS)

Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Nickel (Ni), Lead (Pb) and Zinc (Zn) were determined by ICP-MS. The spectrometer was calibrated using seven different concentrations of matrix-matched standards made from dilutions of 10g l^{-1} spectroscopic standard solution. Target analyte concentrations were measured by direct comparison to the internal standard with the nearest mass ionisation properties, to take into account changes in plasma conditions as a result of matrix differences between standards and samples. Detection limits and the atomic mass units of the various elements analysed are presented in Table B.7.

Table B.7 ICP Detection Limits, Elemental Emission Wavelengths and Atomic Masses

Analysis	ICP-MS	Aqua Regia Extraction LOD (µg g^{-1})
Element	Atomic Mass Units	
As	75	0.5
Cd	111	0.1
Cr	52	2
Cu	65	2
Ni	60	2
Pb	208	1.5
Zn	66	3

Element	Atomic mass Units	Hydrogen Peroxide/ Nitric Digest LOD (µg g^{-1})
Hg	202	0.06

B.8.4 Quality Control

Quality control consists of running full method blanks together with one in-house reference material or certified reference material (CRM) where required, and one duplicate sample per batch of twenty samples. Instrument performance is monitored by the use of instrument blanks, continuing calibration checks and independent calibration checks.

Instrument and process blank solutions are also run at regular intervals (with each batch) to monitor potential sources of contamination.

B.9 Organotins

Organotins were extracted into an acidified solvent, derivatised with sodium tetraborate and further solvent extracted into hexane. The samples were cleaned up by solid phase extraction and the analysis was carried out by GC-MS or OES.

B.10 Macrofaunal Analysis

B.10.1 Sorting and Identification

In the laboratory, samples were gently washed across a 1mm mesh sieve to remove any sediment fines and preservatives. 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. Sample residues were checked by a second individual to provide a degree of quality control.

B.10.2 Data Set Rationalisation

The faunal data set was rationalised according to the standard Gardline (2018b) procedure, which is largely based on British Standard ISO16665:2005 (BSI, 2005) and OSPAR (2017a) guidelines. A summary of these methods follows.

Juveniles
The inclusion of juvenile organisms in data sets is a contentious issue, as is the definition of a juvenile. Only when the following conditions were satisfied was an organism recorded as a juvenile:

- Organisms that were too small or immature to be identified to species were identified to the lowest possible taxonomic level and recorded as juveniles.
- The organism was in a pre-adult life stage *e.g.* megalopa, praniza, etc.
- For large-bodied (>4cm) species of echinoderm and bivalve, the organism was less than 10% of the maximum body size reported in the literature.

In accordance with ISO16665:2005 guidelines, juveniles are recorded separately in the faunal list in 0. Juveniles were included in the analysed data set at the lowest achievable taxonomic level. In the first instance, statistical analyses were performed after counts of juveniles of known species had been combined with adult records of that same species. In accordance with OSPAR (OSPAR, 2017a), if one or more of the juvenile taxa, or species that included juvenile records, were among the ten most dominant, then a RELATE analysis was carried out to compare the data sets with and without juveniles to determine if discussion of both sets separately is required. If the two data sets are found to be at least 95% similar, then the juveniles are included in the data set for all further multivariate analyses and discussion. Alternatively, the multivariate analyses are additionally performed following exclusion of all juvenile records in order to illustrate their influence.

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 analysed data set.

Treatment of Specific Groups of Organisms
Gardline defines macrofauna as organisms that are normally larger that the mesh size of the sieve used to separate them from the sediment (Gardline, 2018b). 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.

Planktonic organisms, such as the Chaetognatha and Mysidacea were not recorded. The presence of nektonic species, such as fish and Cephalopoda, was recorded, but they were 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,
- Hemichordata – identified to phylum

B.10.3 Biomass

To determine biomass animals identified in the course of benthic analyses were weighed. To derive a fresh weight using a non-destructive method, animals were blotted dry before weighing as animals had been stored in 70% industrial denatured alcohol (IDA)

The balance was checked to ensure that it was level and then calibrated prior to biomass. All specimens were removed from the petri-dish, pot or vial and placed onto a dry piece of tissue paper. A microscope was used, where necessary, to check that all the specimens had been removed from the vial for weighing. Animals were blotted gently to remove excess surface alcohol, with care taken to avoid damage.

A weighing boat was placed onto the balance and the balance was tared to discount the weight of the weighing boat. The blotted specimens were then placed in the weighing boat, on the balance. The standard procedure for operation of the balance, as outlined in the manual, was followed *e.g.* closing the doors to stop air currents and excess evaporation and using the stability indicator feature on balance.

The weight was then recorded when the balance settles. The mass was recorded in grams, down to four decimal places. Where the weight was less than 0.0001g, it would be recorded as 0.0001g. Faunal fragments are combined with 'headed' fauna and weighed. Attached parasites (e.g. Sacculina) were weighed with hosts.

B.11 Statistical Analyses

B.11.1 Hydrocarbon Indices

In order to aid the determination of hydrocarbon sources and levels of weathering of recorded hydrocarbons, a number of indices (largely based on n-alkanes) have been developed (Tran *et al.*, 1995). The following indices were calculated from raw data using Microsoft Excel:

Carbon Preference Index (CPI)
The ratio of odd to even numbered alkanes, commonly referred to as the CPI, may provide further insight into the origin of alkanes in marine sediments. Opinions differ as to which is the most

informative chain length over which to calculate CPI. Douglas and Eglinton (1966) suggest that the nC_{20} to nC_{36} range is most informative, whilst Farrington and Tripp (1977) suggest CPI calculated using nC_{27} to nC_{33} alkanes is most informative. The basic premise of most CPI calculations is that land-based vegetation predominantly produces alkanes with odd carbon numbers (*i.e.*, nC_{29}), whereas there is no such tendency in alkanes of anthropogenic or marine origin. Therefore, the sum of odd numbered alkanes divided by the sum of even numbered alkanes decreases with increasing petrogenic contamination. Sleeter *et al.*, (1980) suggest that the tendency for land-based vegetation to predominantly produce alkanes with odd carbon numbers is most prevalent in the nC_{27} to nC_{33} range.

The carbon preference index of Farrington and Tripp (1977), which is used more often than any other in the literature, is calculated as follows:

$$CPI = \frac{2(nC_{27} + nC_{29})}{nC_{26} + 2(nC_{28}) + nC_{30}}$$

CPI values close to unity suggest that sediments are contaminated with petrogenic material; whereas values of 4 and above suggest a dominance of biogenic material and a virtual absence of petrogenics.

Pristane/Phytane Ratio

Pristane and phytane are both biogenic and petrogenic but their relative abundance may vary greatly. Pristane is primarily biogenic and most commonly originates from the decomposition of a phytol side-chain of chlorophyll (Muniz *et al*., 2004). Elevated concentrations of pristane in sediments can be indicative of high levels of microbial degradation. Phytane is rarely produced biogenically but is a common component of crude oil (Steinhauer & Boehm, 1992); it is generally absent or found in only small quantities in marine sediments. Concentrations of pristane and phytane, and their ratio to each other have, therefore, been used as an indicator of petrogenic contamination (Berthou & Friocourt, 1981). In samples that are contaminated by petroleum products the concentrations of pristane and phytane are usually nearly equal (pristane/phytane ratio close to unity) (McDougall, 2000).

Molecular weight PAH Indices

Information regarding the possible petrogenic or pyrogenic sources of PAHs in the environment can be derived from the ratio of PAH compounds of the same molecular weight (Fisner *et al*., 2013). Fisner et al. (2013) states that the identification of possible sources can be made according to the ratios that are commonly used in studies related to sediment analysis, such as: anthracene/anthracene + phenanthrene $(Ant/(Ant + Phe))$, where values >0.10 indicate the dominance of pyrogenic sources; fluoranthene/fluoranthene + pyrene $(Fluo/(Fluo + Py))$, where values <0.40 indicate the dominance of petrogenic, and >0.50 the dominance of pyrolytic input; benz[a]anthracene/benzo[a]anthracene + chrysene $(BaA/(BaA + Ch))$, where values <0.20 indicate the dominance of petrogenic inputs, 0.20 to 0.35 a mixture of inputs and >0.35 the dominance of pyrolytic inputs; and indeno[1,2,3-cd]pyrene/ indeno[1,2,3-cd]pyrene + benzo[g,h,i]perylene $(IP/IP + Bghi)$) where values 0.50 the dominance of pyrolytic sources . (Yunker & Macdonald, 2003; Yunker *et al*., 2002).

B.11.2 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 summarise 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 (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:

Margalef's Richness Index
Species richness is sometimes given simply as the number of species in a sample, but this is of course very dependent upon sample size. Alternatively, Margalef's index (d) may be used as this takes account of the number of species present for a given number of individuals. Margalef's Richness index is calculated as follows:

$$d = \frac{(S-1)}{\ln N}$$

where d = Margalef's Richness
S = total number of species
N = total number of individuals

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.

Simpson's Dominance Index
Simpson's is a dominance index derived from the probability of picking two individuals from a community at random that are from the same species. Therefore, Simpson's dominance index values with be large when a community is dominated by one or a few species but lower when the community is diverse. Simpson's dominance index was calculated as follows:

$$\lambda = \sum p_i{}^2$$

where λ = Simpson's Dominance Index
p_i = proportion of the total number of individuals from the i^{th} species

Simpson's dominance index ranges from 0 to 1 with values typically reflecting the abundances of the most common species in the samples.

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 Accumulation Curves

Species accumulation curves show the increasing total number of different taxa observed as samples are successively pooled. Two versions are plotted in this report; the first (plotted in green) simply takes the samples in their label order, this is often referred to as the "species observed" (Sobs) curve. The second curve (plotted in blue) is smooth as it is an averaged output based on the samples being added in random order 999 times. This is referred to as the UGE (Ugland, Gray, Ellingsen) curve after Ugland et al. (2003).

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.

B.11.3 Multivariate Analyses

In addition to univariate analyses, the data were subjected to multivariate analysis using a number of different methods available within the PRIMER package (Clarke & Warwick, 2006). By considering the full data matrix as a whole and comparing each station with every other, multivariate analyses are able to highlight subtle trends in data sets that are commonly not identified when using univariate techniques. Multivariate techniques are not restricted to use with faunal data sets and if treated appropriately may also be used to compare complex physico-chemical data sets. Multivariate analyses were computed from resemblance or similarity matrices. In the case of faunal abundance data these were constructed using the Bray-Curtis measure of similarity following transformation of the data to down-weight the influence of highly abundant or dominant species. For the purposes of this survey, both square-root and fourth-root transformations were utilised. According to Clarke and Warwick (2006), square root transformation allows the intermediately abundant species to contribute to the similarity, while a fourth root takes account of the rarer species. .

Cluster Analysis and SIMPROF

Cluster analysis groups samples according to their similarity *i.e.*, samples within a group are more similar to each other than they are to samples in other groups. Clustering was by a hierarchical agglomerative method using group average sorting, and the results are presented as a dendrogram. Using PRIMER v7 it is possible to perform a SIMPROF (similarity profile) test at the same time as the cluster analysis to determine whether groups of samples are statistically indistinguishable or whether they contain identifiable structure. SIMPROF is an a priori test designed to identify groups of samples from unstructured data sets. The test employs a permutation-based analysis to determine whether groups of samples below each successive node of a dendrogram possess identifiable internal structure. If the result of a test at a particular node is not significant there is no identifiable structure within the samples below the node and they might therefore be considered to be a uniform group. A significant result indicates that samples within a group (below a particular node in the dendrogram) contain some structure and therefore may not be considered uniform. The analysis therefore identifies groups of samples that are each highly self-similar and also that are distinguishable from each other.

Ordination Analyses using non-Metric Multidimensional Scaling

Non-metric multidimensional scaling (nMDS or MDS) is a type of ordination method which creates a 2- or 3-dimensional ‘map’ of the samples (or stations) from the similarity matrix. The configuration of the samples on the ‘map’ is a reflection of their similarity, with distances between samples being representative of their dissimilarity.

It is normal for there to be some distortion (stress) between actual similarity values (in the resemblance matrix) and distance between samples on the ordination plot; perfect solutions are very rarely achieved when dealing with complex data sets. In order to achieve the lowest possible stress PRIMER adopts an iterative approach to ordination, constructing the plot by successively refining the positions of samples until the lowest stress is achieved. In reality, the lowest possible stress is not always achieved since data points may become trapped in local minima. It is therefore necessary to re-run the analyses multiple times to ensure that the lowest achievable stress is found. The ordination analysis results reported were the product of a minimum of 25 restarts. In instances where the lowest achieved stress was found for <5 (20%) of the restarts the ordination was repeated with 100 restarts to ensure that a lower stress result could not be found.

The scale and orientation of MDS ordinations are arbitrary so no axes are drawn on the plots. Stress values increase with sample size, and usually also with increasingly severe transformation of the initial data set (due to the increasing influence of rarer species on the outcome of analyses). The stress value may be used as an indication of the usefulness of plots, with a general guide being as follows (Clarke & Warwick, 2006):

<0.05	Almost perfect representation of rank similarities
0.05 to <0.1	Good representation
0.1 to <0.2	Still useful
0.2 to <0.3	Should be treated with caution
>0.3	Little better than random points

SIMPER

Where differences between groups of samples are found, SIMPER may be used to interpret which species, or environmental variables, are principally responsible for the differences between the groups and which are most responsible for the similarities within groups. The SIMPER analysis decomposes differences between all pairs of samples, one from each identified group, into their contributions from each species or variable, and ranks them in decreasing order of their contribution to overall dissimilarity.

RELATE

The RELATE test of PRIMER calculates the rank similarity of two specified data matrices, so, for instance, may be used to provide an indication of the effect of the removal of a subset of taxa (*e.g.*, juveniles) on the structure of the data set overall.

B.11.4 Spearman's Rank Correlation

Spearman's Rank Correlation Co-efficient is a non-parametric correlation analysis that may be used to test for relationships between environmental variables. Significant relationships indicate that environmental variables vary similarly. Large numbers of significant correlations might suggest the presence of an environmental gradient, that in the absence of obvious natural changes in the environment (such a depth gradient), may be attributable to point source pollution or some other form of anthropogenic interference. A matrix of Spearman's rank correlation coefficients, comparing many of the environmental variables, was calculated using Microsoft Excel and is presented in Appendix H.

B.11.5 Dixon's and Grubb's test for Outliers

Within the data set of environmental variables, one or more values may differ considerably from the majority of the rest. In order to identify such values for investigation as to whether they are deviant results or indicative of a notable trend at seabed, Dixon's Q-test for outliers may be used for data sets of five to 25 samples, assuming a normal distribution, while Grubb's test may be used for data sets containing >25samples. Both tests assume a normal distribution.

The Dixon's Q-test is performed by taking the difference of the highest (or lowest) value and the value nearest to it and dividing this by the range of the data for that variable. The Grubb's test (also called the extreme studentised deviate) compare each value with the mean and the standard deviation for the variable.

The results of the Dixon's / Grubb's test for both high and low outliers was calculated using Microsoft Excel and is presented in Appendix H.

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 categorisation 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 Sediment Hydrocarbons

The principal sources of hydrocarbons in the marine environment are anthropogenic (McDougall, 2000). However, contamination of the marine environment with crude oils is not a recent phenomenon, nor solely attributable to anthropogenic activities (Douglas *et al.*, 1981). Three general processes can add hydrocarbons to marine environments: biosynthetic, geochemical and anthropogenic (McDougall, 2000).

Oil is a complex mixture of hydrocarbons and other organic compounds. Hydrocarbons are the principal component of oil, usually contributing >75% of the constituents (Laflamme & Hites, 1978). Petroleum hydrocarbons can be divided into the following broad classes according to their structure: saturates (alkanes, isoalkanes and cycloalkanes), olefins (alkenes), aromatics (benzene, toluene, ethylbenzene and xylenes, or BTEX, and polycyclic aromatic hydrocarbons), asphaltenes, polar compounds and resins (Leahy & Colwell, 1990; Wang & Fingas, 2005).

Due to the complex and variable composition of oil in marine sediments, quantification of total hydrocarbons, groups of hydrocarbons and individual hydrocarbons is required to allow identification of the source of oil within the sediments, be it anthropogenic, biogenic or geochemical. The OSPAR (2017a) guidelines for monitoring the environmental impact of offshore oil and gas activities recommend the following analyses to be conducted for environmental surveys (including baseline surveys): total hydrocarbon (THC) concentration, unresolved complex mixture (UCM) concentration, individual and total n-alkane concentrations, pristane and phytane concentrations; individual and total 2-6 ring polycyclic aromatic hydrocarbon (PAH) concentrations, and those of their respective alkyl derivatives.

Total Hydrocarbon Concentration

THC concentration gives an indication of the total hydrocarbon present within a sediment sample; it does not give an indication of the source of contamination. The definition of THC is wholly dependent on the analytical process utilised to quantify it. In this case, THC is equivalent to total n-alkane (nC_{10} to nC_{37}), pristane, phytane, UCM and total PAH (all PAHs including alkylated derivatives) concentrations.

Unresolved Complex Mixture

The UCM consists of a large variety of branched alicyclic hydrocarbons, which are not resolved by conventional capillary gas chromatography (GC) columns and appear as a 'hump' in GC chromatograms (Bouloubassi *et al.*, 2001). These compounds remain after substantial weathering and biodegradation of petrogenic inputs has taken place, with the 'hump' becoming a more predominant feature as resolvable n-alkanes are selectively transformed by weathering. Abundant UCM is ascribed to either degraded or weathered oil residues, and therefore its occurrence in environmental samples is an indicator of oil pollution (Bouloubassi *et al.*, 2001). Notably, a UCM between nC_{20} and nC_{34}, centred on nC_{29} is typical of North Sea sediments, and is generally considered as 'North Sea Background'.

N-alkanes

Alkanes are the simplest aliphatic compounds, containing only carbon and hydrogen held together by single bonds and not containing a ring; they have the general formula C_nH_{2n+2} (Lyons & Plisga, 2005). The n-alkanes are continuous, straight chain alkanes, while branched-chain alkanes are known as isoalkanes or isoprenoids (Lyons & Plisga, 2005). The only isoprenoids quantified in this survey are pristane and phytane, which are isomers of nC_{18} and nC_{19}. These compounds are substantially less susceptible to weathering than their straight chain equivalents and are therefore of use when investigating the degree of weathering of a sample (Tran *et al.*, 1995).

Although generally less harmful to many living organisms than aromatic hydrocarbons, analysis of the aliphatic component (n-alkanes, pristane and phytane) can still provide valuable information to aid in the determination of hydrocarbon sources (Tran *et al.*, 1995). N-alkanes can be derived from a variety of origins, both anthropogenic and natural; it is therefore necessary to distinguish which of these are present, or indeed predominate, in a given environment (Tran *et al.*, 1995). There is a wide range of methods available for this purpose, but those undertaken in this report include: quantification of individual n-a kane concentrations, interpretation of GC chromatograms, the carbon preference index (CPI; Farrington & Tripp, 1977) and the pristane:phytane ratio (Berthou & Friocourt, 1981).

Polycyclic Aromatic Hydrocarbons

PAHs and their alkyl derivatives are almost ubiquitous in marine environments (Laflamme & Hites, 1978). Natural sources of PAHs include forest fires (Youngblood & Blumer, 1975), synthesis by plants (Neff, 1979) and oil seeps (Page *et al.*, 1998). However, the largest sources of PAHs are associated with anthropogenic activities, particularly fossil fuel combustion (Neff, 2004; Laflamme & Hites, 1978). Pyrogenic PAHs may be transported long distances through the atmosphere before finally being deposited. Even after deposition, PAHs may undergo further transport, *e.g.* in urban runoff and rivers, before ultimately being deposited in marine sediments, where they sorb to organic matter and sediment particles.

Concentrations of PAHs in marine sediments vary by many orders of magnitude, ranging from less than 1ng g^{-1} in deep-water oceanic sediments up to a few mg g^{-1} in highly contaminated harbours and coastal sediments (Neff, 2004). In enclosed waters subjected to oil exploration and production activity, PAH concentrations tend to be somewhat higher than in the open ocean. Generally speaking, the greatest PAH concentrations are found in coastal sediments. Barring the presence of point sources of hydrocarbon contamination, total PAH concentrations in marine sediments normally decrease with distance from major human population centres (Larsen *et al.*, 1986).

The occurrence and concentration of PAHs in the environment is of concern since many possess mutagenic, carcinogenic and toxic properties (McDougall, 2000; Neff, 2004). Many PAHs are readily bioaccumulated through the food web and higher weight aromatics in particular are persistent. The rate at which PAHs degrade is affected by many factors; in the marine environment photooxidation and biodegradation are considered to be the two most important processes of degradation (Neff, 2004). Therefore, PAHs are likely to be most persistent in cold, high latitude deep-waters where sediments receive little or no light. ESGOSS (1994) estimate the half-lives of 2-ring aromatics to be generally less than 100 days whilst heavier weight 5- and 6-ring aromatics may possess half lives in excess of 10,000 days.

Although found in most marine sediments, petrogenic aromatics are normally less abundant than the pyrogenic, HMW aromatics (Bence *et al.*, 1996). Elevated concentrations of LMW, more volatile, 2 and 3 ring PAHs (naphthalenes, phenanthrenes and dibenzothiophenes; NPD) may often be related to the presence of point sources of hydrocarbon input, including oil spills, natural seeps, drilling activity and produced water outfalls (Neff, 2004). A major source of NPD PAHs is the use of oil-based muds during drilling operations and the subsequent discharge of these cuttings on the seabed (Breuer *et al.*, 2004). Pyrogenic PAHs tend to be more widespread, but generally in relatively low concentrations.

The concentrations at which individual PAHs produce toxic effects vary widely (Long *et al.*, 1995) and are dependent on their type and bioavailability. Values for the toxicity of individual aromatics may be misleading since individual PAHs are rarely found in isolation. The best estimates of the potential toxicity of PAHs in marine sediments are ERL and ERM concentrations for total LMW, total HMW and total PAHs (Neff, 2004). Long *et al.* (1995) gives ERL concentrations for LMW and HMW PAHs of 0.55µg g^{-1} and 1.70µg g^{-1}, respectively. ERM concentrations are 3.16 and 9.60µg g^{-1} for LMW and HMW PAHs, respectively. The ERL and ERM concentrations for total PAH concentration in sediments are 4.022µg g^{-1} and 44.792µg g^{-1}, respectively. These concentrations are not actual thresholds of toxicity but delineate concentration ranges with associated probabilities of toxicity. The ERL is the tenth percentile in the PAH effects data provided by Long *et al.* (1995), while the ERM is the median, or 50th percentile. Concentrations below the ERL concentration therefore represent a range in which effects would rarely be observed; concentrations equal to or above the ERL concentration, but below the ERM concentration, represent a range in which effects would occasionally occur and concentrations equalling or exceeding the ERM concentration represent a range within which effects could frequently be expected.

The US EPA identified 16 priority low and higher molecular weight PAHs. Nine of these were selected by OSPAR as the focus for their studies and are the 4 to 6 ring compounds of particular importance due to their toxic nature even at very low concentrations. OSPAR CEMP EAC benchmark concentrations (OSPAR, 2009a) have been developed for the nine OSPAR priority PAHs plus naphthalene and dibenzothiophenes (DBT).

Information on the source of PAHs in sediments may be obtained from a study of the alkyl homologues (*e.g.* methyl, ethyl etc. substitution) and parent compound distributions and concentrations. Sediments contaminated with petrogenic material normally contain a predominance of alkylated PAHs, particularly within the LMW range, whereas pyrogenic PAHs comprise mostly HMW unalkylated parent compounds.

C.3 Sediment Metal Concentrations

Metals are generally persistent and at elevated concentrations most are toxic to varying degrees. Many metals such as copper, zinc and chromium are readily bioaccumulated meaning that they are absorbed and stored in organisms over time leading to potential high concentrations capable of causing lethal and sub-lethal toxic effects in benthic organisms even when found in apparently low concentrations in sediment. Metal concentrations in uncontaminated marine sediments generally exceed those found in overlying seawater by three to five orders of magnitude (Bryan & Langston, 1992), since the buffering effects of saline water cause many metals to be rapidly precipitated. Furthermore, dissolved metals are readily scavenged from the water column by organic coatings and iron and manganese coatings found on the surface of fine sediment particles. Consequently, fresh waters that are metal enriched by terrestrial runoff tend to deposit much of their metal load in estuarine or near coastal sediments. Ecological impacts attributable to anthropogenic metal contamination in non-coastal marine environments are often somewhat limited in geographical range close to the point of their origin (Rygg, 1985).

Several metals are found in high concentrations in drilling muds and produced water. Some of these metals are added intentionally to drilling muds as metal salts or organo-metallic compounds whilst others are present as trace impurities in major mud ingredients, particularly barite and clay. Those metals most characteristic of contamination of the sediment with drilling muds or cuttings are barium, chromium, lead and zinc (Neff, 2005), but this may vary depending upon the specific constituents of the muds. By far the most abundant metal in most drilling muds is barium, found in the form of barite ($BaSO_4$). In exceptional cases, fine-grained marine sediments may naturally contain in excess of 1000µg g^{-1} barium, but this figure may be greatly enhanced by contamination of sediments with drilling muds containing up to 450mg g^{-1} barium (Neff, 2005). Due to its low solubility and the fact that it is not toxic in its sulphate form (Gerrard *et al.*, 1999), elevated barium concentrations are rarely of toxicological concern. However, monitoring sediment barium concentrations can provide information regarding the extent to which drill cuttings have been transported from their point of origin.

When considering the results of the sediment metal determinations it should be borne in mind that speciation (the particular forms, or species, of any given metal that exist in a sample), sediment granulometry and partitioning of metals between water and sediment phases all affect bioavailability and therefore toxicity. Even if a metal is present at above normal concentrations, it does not necessarily follow that the metal will produce ecologically deleterious effects, particularly if it is present in an insoluble or relatively low toxicity form. Historically, a wide range of different extraction techniques have been employed that were intended to provide an estimate of the concentrations of metals in marine sediments that may be available to the biota. One of the most commonly used methods of modelling metal bioavailability is extraction of oxic (surficial) sediments with weak acids (*e.g.* 1M nitric acid) since most anthropogenic metal contaminants show a much higher affinity to fine particulate matter than the coarse fraction by the presence of organic matter and clay minerals. These techniques have been shown to produce results that correlate closely with metal burdens in the tissues of benthic organisms (Luoma & Davis, 1983; Bryan & Langston, 1992). However, the extent to which a particular method of extracting metals from sediments reflects their bioavailability is still not well understood, and the debate regarding which methods may be most appropriate is ongoing.

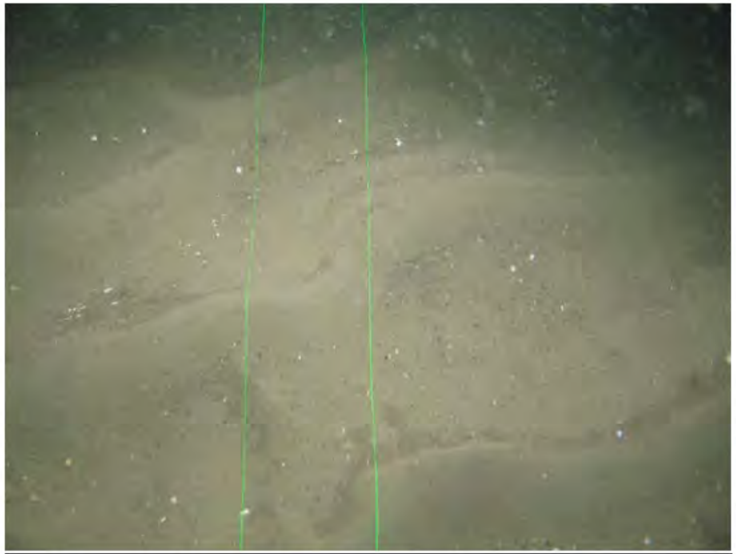
Total sediment metal concentrations have historically been the preferred measurement for offshore surveys. Whilst these provide little information regarding concentrations of metals that may be bioavailable, since they involve total dissolution of the sediment, they are however useful for comparisons between surveys and will give an indication of whether or not sediments are contaminated. There is a growing body of data that provides broad figures for the total concentrations of many metals likely to be found in uncontaminated marine sediments (see OSPAR, 2005). Baseline figures may therefore be compared to these data in order to assess whether sediments in an area may have been anthropogenically contaminated prior to any works being carried out. Where elevated concentrations of metals are found, results may be compared to existing sediment metal toxicity data in order to assess whether particular metals may be exerting a toxicological effect on benthic communities (see Buchman, 2008).

C.4 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: 685 **E:** 383567 **N:** 5969753 **Depth:** 33m

Fix: 702 **E:** 383584 **N:** 5969777 **Depth:** 33m

Station: ENV1
Sediment Description:
Fix685: Rippled sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix702: Rippled sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix685: No visible fauna.

Fix702: No visible fauna.

Fix: 48 **E:** 383580 **N:** 5969761 **Depth:** 35m

Fix: 48 **E:** 383580 **N:** 5969761 **Retention:** MF

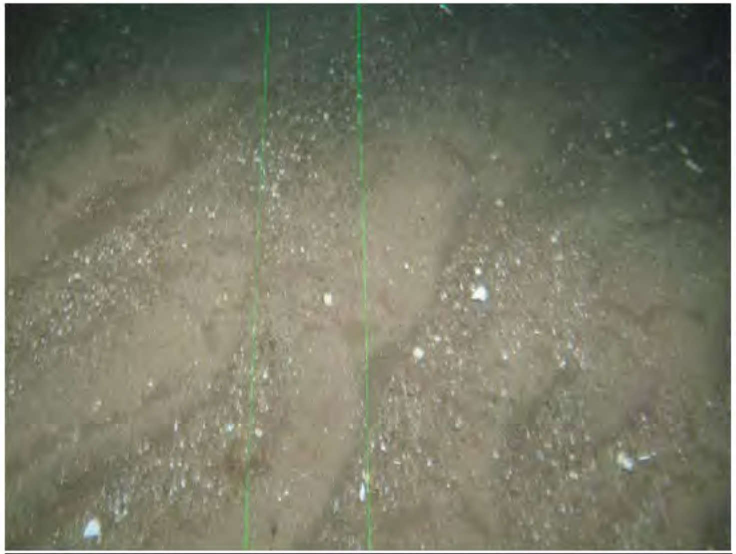
Station: ENV1
Sediment Description:
Grab: Sand with shell fragments.

Sieve: Shell fragments.

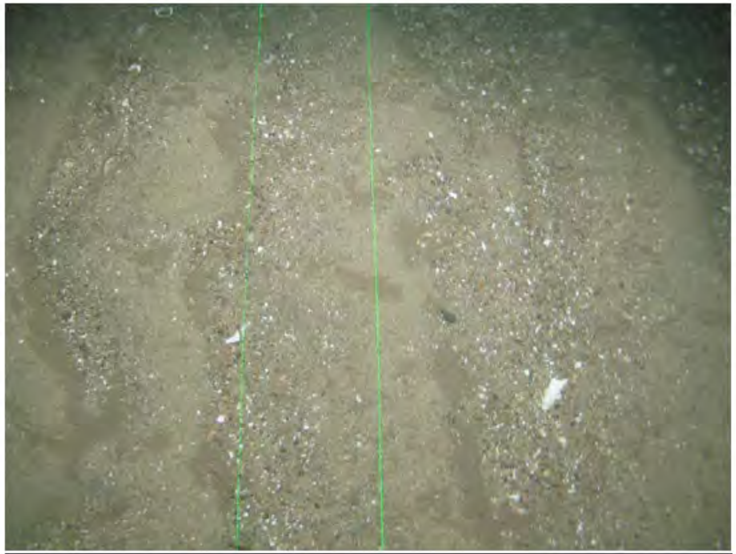
Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta), Echinodermata (*Spatangoida* sp.)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 601 **E:** 389796 **N:** 5970128 **Depth:** 31m



Fix: 625 **E:** 389795 **N:** 5970142 **Depth:** 31m

Station: ENV2
Sediment Description:
Fix601: Rippled gravely sand with shell fragments.
Broadscale EUNIS Classification: A5.1

Fix625: Rippled gravely sand with shell fragments.
Broadscale EUNIS Classification: A5.1

Fauna Description:
Fix601: Cnidaria (Hydrozoa)

Fix625: No visible fauna.

Fix: 44 **E:** 389812 **N:** 5970137 **Depth:** 33m

Fix: 44 **E:** 389812 **N:** 5970137 **Retention:** MF

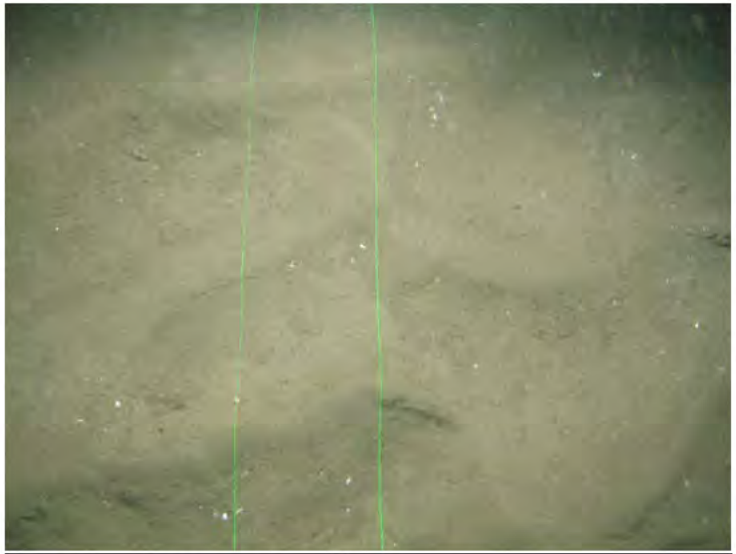
Station: ENV2
Sediment Description:
Grab: Sand with shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: Chordata (Ammodytidae)

Sieve: Echinodermata (*Spatangoida* sp.)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 640 **E:** 384750 **N:** 5974048 **Depth:** 35m

Fix: 672 **E:** 384760 **N:** 5974053 **Depth:** 35m

Station: ENV4
Sediment Description:
Fix640: Rippled sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix672: Rippled muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix640: No visible fauna.

Fix672: Chordata (Pleuronectiformes sp. B), Fauna burrows present

Fix: 46 **E:** 384761 **N:** 5974049 **Depth:** 37m

Fix: 46 **E:** 384761 **N:** 5974049 **Retention:** MF

Station: ENV4
Sediment Description:
Grab: Silty sand.

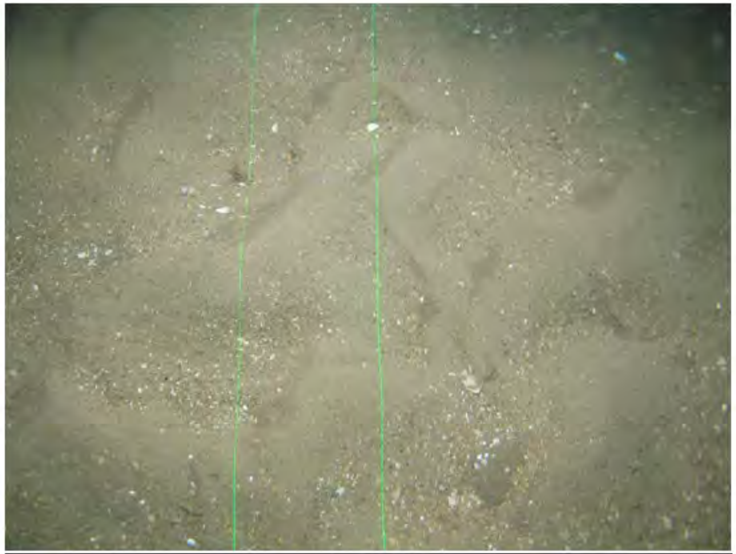
Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta), Mollusca (Bivalvia)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 574 **E:** 390070 **N:** 5973852 **Depth:** 36m



Fix: 588 **E:** 390084 **N:** 5973843 **Depth:** 36m

Station: ENV5
Sediment Description:
Fix574: Rippled gravely muddy sand with shell fragments.
Broadscale EUNIS Classification: A5.4

Fix588: Rippled gravely sand with shell fragments.
Broadscale EUNIS Classification: A5.1

Fauna Description:
Fix574: Arthropoda (Caridea), Cnidaria (Hydrozoa), Fauna burrows present

Fix588: Mollusca (Naticidae), Cnidaria (Hydrozoa)

Fix: 42 **E:** 390063 **N:** 5973836 **Depth:** 38m

Fix: 42 **E:** 390063 **N:** 5973836 **Retention:** MF

Station: ENV5
Sediment Description:
Grab: Sand with occasional shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta), Mollusca (*Ensis* sp.)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 539 **E:** 395810 **N:** 5973919 **Depth:** 36m

Fix: 558 **E:** 395802 **N:** 5973910 **Depth:** 36m

Station: ENV6
Sediment Description:
Fix539: Sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix558: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix539: No visible fauna.

Fix558: Chordata (Pleuronectiformes sp. A), Fauna burrows present

Fix: 40 **E:** 395815 **N:** 5973908 **Depth:** 39m

Fix: 40 **E:** 395815 **N:** 5973908 **Retention:** MF

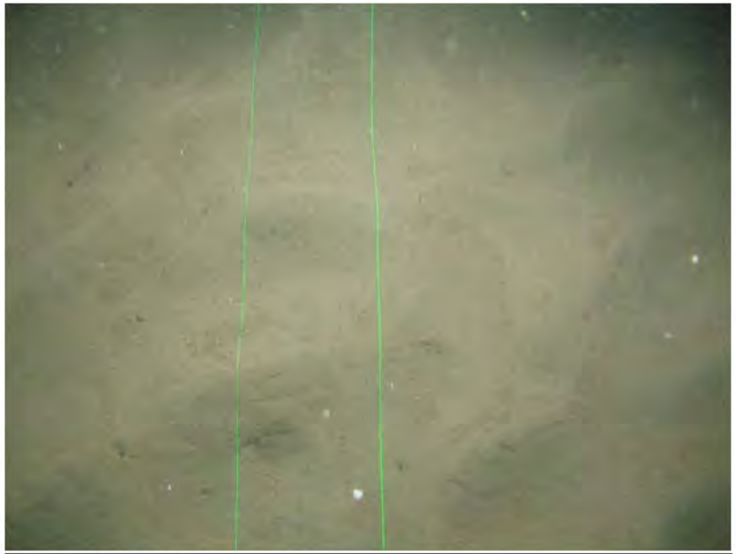
Station: ENV6
Sediment Description:
Grab: Silty sand with occasional shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Mollusca (Scaphopoda)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 460 **E:** 389654 **N:** 5980660 **Depth:** 38m

Fix: 484 **E:** 389643 **N:** 5980655 **Depth:** 38m

Station: ENV8
Sediment Description:
Fix460: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix484: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix460: Fauna burrows present.

Fix484: Fauna burrows present.

Fix: 36 **E:** 389663 **N:** 5980650 **Depth:** 41m

Fix: 36 **E:** 389663 **N:** 5980650 **Retention:** MF

Station: ENV8
Sediment Description:
Grab: Silty sand with occasional shell fragments.

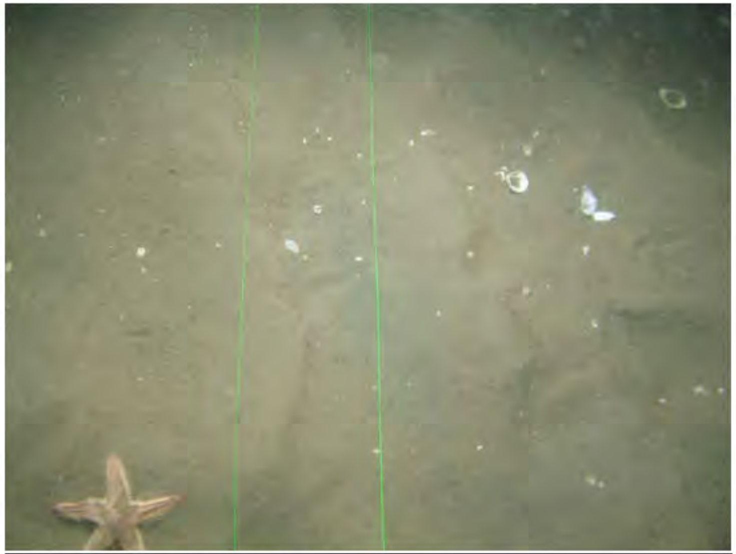
Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: No visible fauna.

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 496 **E:** 395366 **N:** 5980708 **Depth:** 40m



Fix: 515 **E:** 395370 **N:** 5980707 **Depth:** 40m

Station: ENV9
Sediment Description:
Fix496: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix515: Sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix496: Fauna burrows present.

Fix515: Echinodermata (*Astropecten irregularis*)

Fix: 39 **E:** 395365 **N:** 5980707 **Depth:** 43m

Fix: 39 **E:** 395365 **N:** 5980707 **Retention:** MF

Station: ENV9
Sediment Description:
Grab: Sand with silt and shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Arthropoda Megolopa

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 400 **E:** 384606 **N:** 5984568 **Depth:** 40m

Fix: 416 **E:** 384620 **N:** 5984570 **Depth:** 40m

Station: ENV10
Sediment Description:
Fix400: Sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix416: Sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix400: No visible fauna.

Fix416: No visible fauna.

Fix: 31 **E:** 384605 **N:** 5984576 **Depth:** 43m

Fix: 31 **E:** 384605 **N:** 5984576 **Retention:** MF

Station: ENV10
Sediment Description:
Grab: Silty sand with occasional shell fragments.

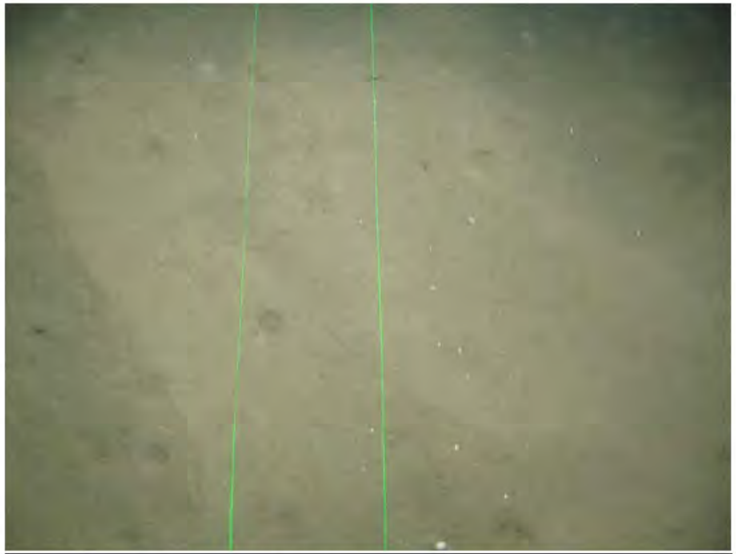
Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 421 **E:** 390107 **N:** 5984501 **Depth:** 39m



Fix: 445 **E:** 390108 **N:** 5984497 **Depth:** 38m

Station: ENV11
Sediment Description:
Fix421: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix445: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix421: Chordata (Actinopterygii indeterminate), Fauna burrows present

Fix445: Fauna burrows present.

Fix: 34 **E:** 390092 **N:** 5984490 **Depth:** 42m

Fix: 34 **E:** 390092 **N:** 5984490 **Retention:** MF

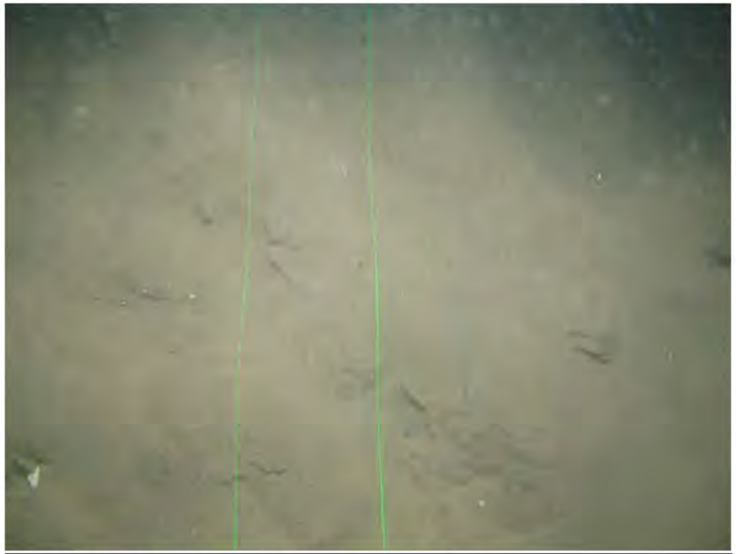
Station: ENV11
Sediment Description:
Grab: Silty sand with occasional shell fragments.

Sieve: Shell fragments.

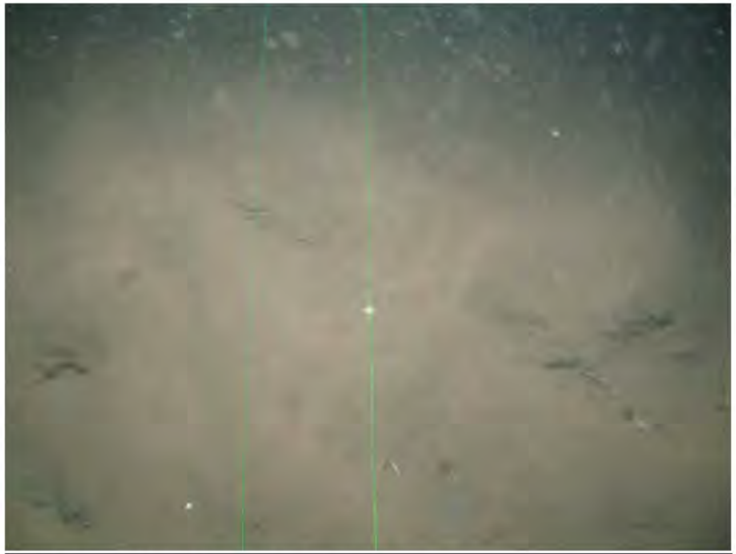
Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 290 **E:** 404551 **N:** 5986476 **Depth:** 40m



Fix: 307 **E:** 404555 **N:** 5986493 **Depth:** 40m

Station: ENV14
Sediment Description:
Fix290: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix307: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix290: Fauna burrows present.

Fix307: No visible fauna.

Fix: 25 **E:** 404557 **N:** 5986488 **Depth:** 42m

Fix: 25 **E:** 404557 **N:** 5986488 **Retention:** MF

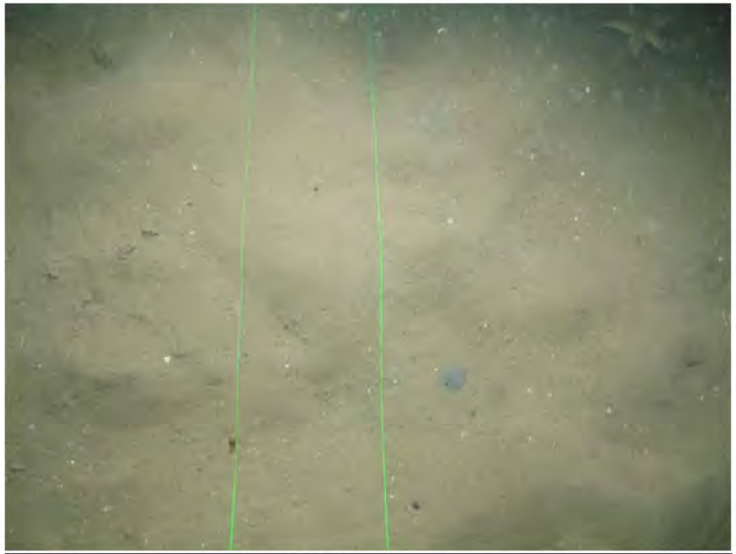
Station: ENV14
Sediment Description:
Grab: Silty brown sand.

Sieve: Shell fragments.

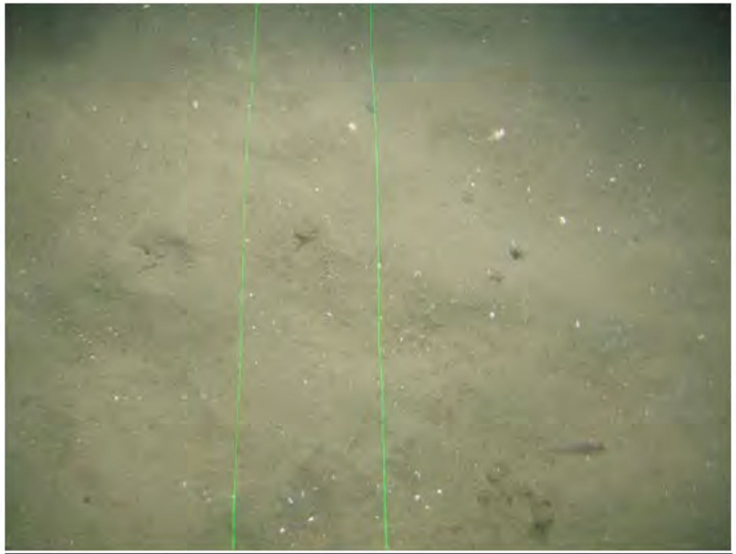
Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta), Echinodermata (*Echinocardium* sp.)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 326 **E:** 386368 **N:** 5992788 **Depth:** 48m



Fix: 362 **E:** 386368 **N:** 5992787 **Depth:** 48m

Station: ENV15
Sediment Description:
Fix326: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix362: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix326: Echinodermata (*Astropecten irregularis*), Fauna burrows present

Fix362: Chordata (Actinopterygii indeterminate), Fauna burrows present

Fix: 27 **E:** 386365 **N:** 5992770 **Depth:** 52m

Fix: 27 **E:** 386365 **N:** 5992770 **Retention:** MF

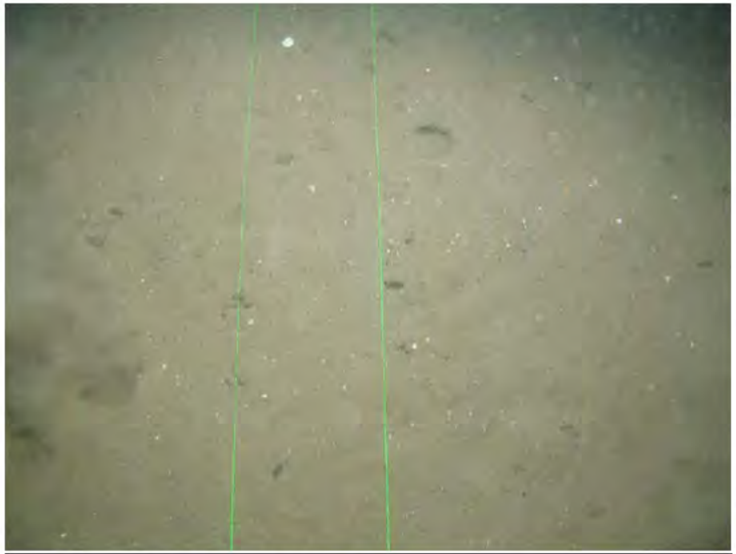
Station: ENV15
Sediment Description:
Grab: Silty brown sand.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta), Mollusca (Bivalvia)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 212 **E:** 394802 **N:** 5990974 **Depth:** 47m

Fix: 231 **E:** 394796 **N:** 5990978 **Depth:** 46m

Station: ENV16
Sediment Description:
Fix212: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix231: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix212: Fauna burrows present.

Fix231: Fauna burrows present.

Fix: 17 **E:** 394796 **N:** 5990980 **Depth:** 47m

Fix: 17 **E:** 367451 **N:** 5990980 **Retention:** MF

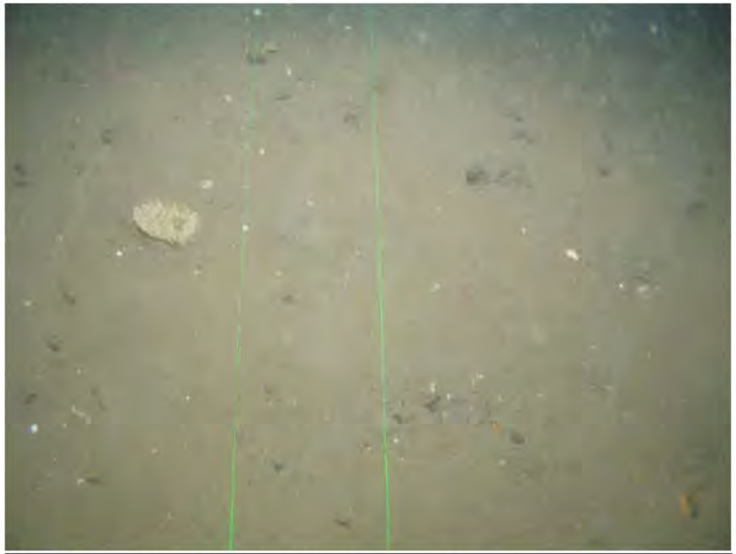
Station: ENV16
Sediment Description:
Grab: Brown sand with shell fragments.

Sieve: Shells and shell fragments.

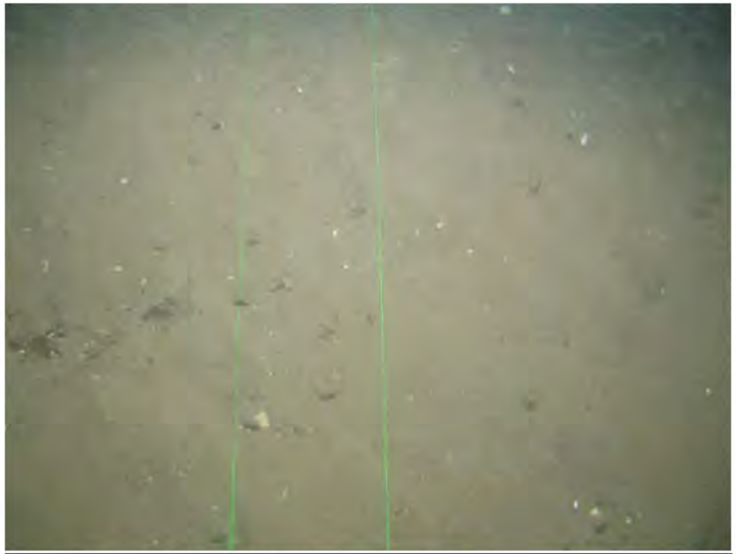
Fauna Description:
Grab: No visible fauna.

Sieve: Mollusca (Bivalvia), Echinodermata (*Echinocardium* sp.)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 251 **E:** 401350 **N:** 5991565 **Depth:** 48m



Fix: 271 **E:** 401358 **N:** 5991573 **Depth:** 49m

Station: ENV17
Sediment Description:
Fix251: Muddy sand with scattered shell fragments and pebbles.
Broadscale EUNIS Classification: A5.2

Fix271: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix251: Fauna burrows present.

Fix271: Fauna burrows present.

Fix: 20 **E:** 401361 **N:** 5991568 **Depth:** 50m

Fix: 20 **E:** 401361 **N:** 5991568 **Retention:** MF

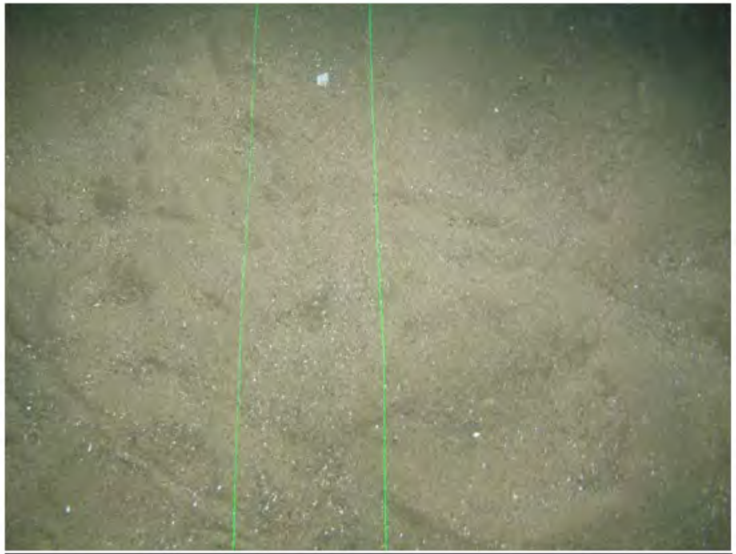
Station: ENV17
Sediment Description:
Grab: Muddy sand and shells.

Sieve: Shells and shell fragments.

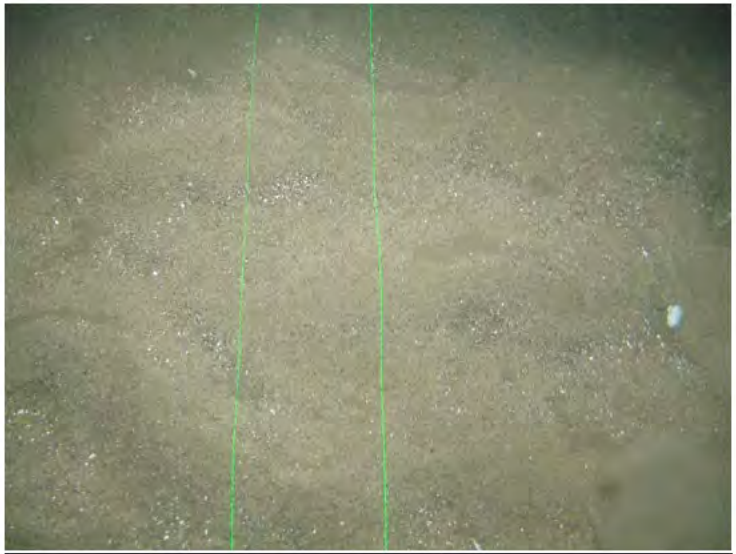
Fauna Description:
Grab: No visible fauna.

Sieve: Arthropoda (Upogebiidae), Echinodermata (Ophiuroidea)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 385 **E:** 379134 **N:** 5995330 **Depth:** 43m



Fix: 396 **E:** 379150 **N:** 5995314 **Depth:** 43m

Station: ENV18
Sediment Description:
Fix385: Gravelly sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix396: Gravelly sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix385: No visible fauna.

Fix396: No visible fauna.

Fix: 29 **E:** 379146 **N:** 5995321 **Depth:** 47m

Fix: 29 **E:** 379146 **N:** 5995321 **Retention:** MF

Station: ENV18
Sediment Description:
Grab: Sand with shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 172 **E:** 393770 **N:** 5997421 **Depth:** 54m

Fix: 200 **E:** 393776 **N:** 5997421 **Depth:** 54m

Station: ENV19
Sediment Description:
Fix172: Gravely muddy sand with shell fragments and pebbles.
Broadscale EUNIS Classification: A5.2

Fix200: Muddy sand with scattered shell fragments and pebbles.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix172: Chordata (Pleuronectiformes sp. B), Cnidaria (*Alcyonium digitatum*), Fauna burrows present

Fix200: Fauna burrows present.

Fix: 15 **E:** 393777 **N:** 5997430 **Depth:** 57m

Fix: 15 **E:** 393777 **N:** 5997430 **Retention:** MF

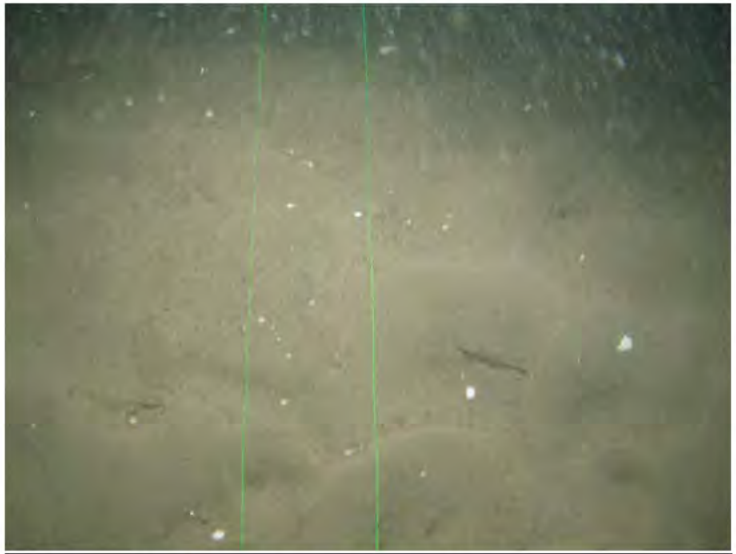
Station: ENV19
Sediment Description:
Grab: Silty sand with shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polychaete), Arthropoda, Echinodermata (*Echinocardium* sp., Ophiuroidea)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 44 **E:** 373160 **N:** 5998659 **Depth:** 46m

Fix: 61 **E:** 373181 **N:** 5998670 **Depth:** 46m

Station: ENV20
Sediment Description:
Fix44: Sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix61: Sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix44: No visible fauna.

Fix61: No visible fauna.

Fix: 4 **E:** 373171 **N:** 5998646 **Depth:** 47m

Fix: 4 **E:** 373171 **N:** 5998646 **Retention:** MF

Station: ENV20
Sediment Description:
Grab: Sand with shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta), Mollusca (Bivalvia), Echinodermata (Ophiuroidea)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 121 **E:** 383710 **N:** 6001731 **Depth:** 57m

Fix: 131 **E:** 383682 **N:** 6001720 **Depth:** 56m

Station: ENV21
Sediment Description:
Fix121: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix131: Muddy sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix121: Fauna burrows present.

Fix131: Fauna burrows present.

Fix: 11 **E:** 383691 **N:** 6001718 **Depth:** 61m

Fix: 11 **E:** 383691 **N:** 6001718 **Retention:** MF

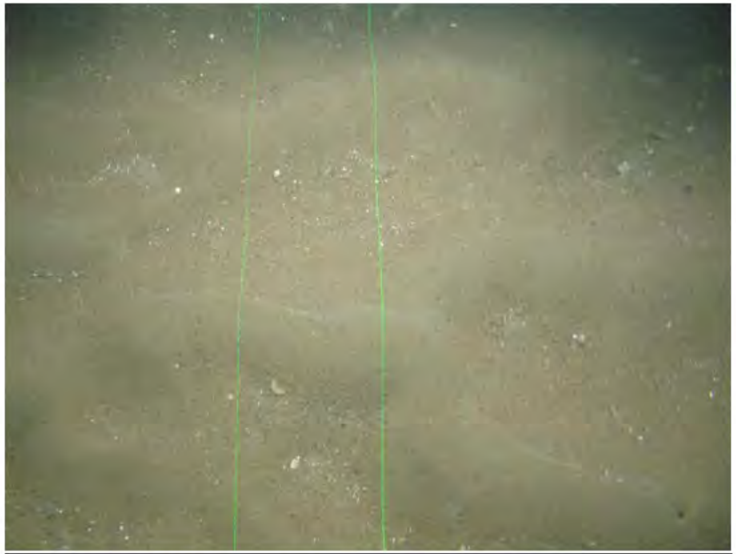
Station: ENV21
Sediment Description:
Grab: Grey sand.

Sieve: Shell fragments.

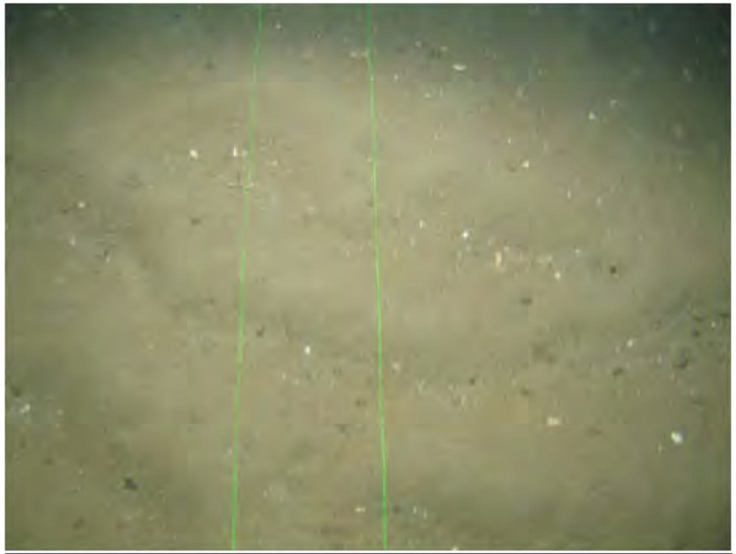
Fauna Description:
Grab: No visible fauna.

Sieve: Mollusca (Bivalvia, Scaphopoda), Echinodermata (*Echinocardium* sp., Ophiuroidea)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 136 **E:** 388434 **N:** 6001153 **Depth:** 56m



Fix: 152 **E:** 388421 **N:** 6001161 **Depth:** 56m

Station: ENV22
Sediment Description:
Fix136: Rippled sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix152: Sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix136: Fauna burrows present.

Fix152: Fauna burrows present.

Fix: 13 **E:** 388418 **N:** 6001151 **Depth:** 59m

Fix: 13 **E:** 388418 **N:** 6001151 **Retention:** MF

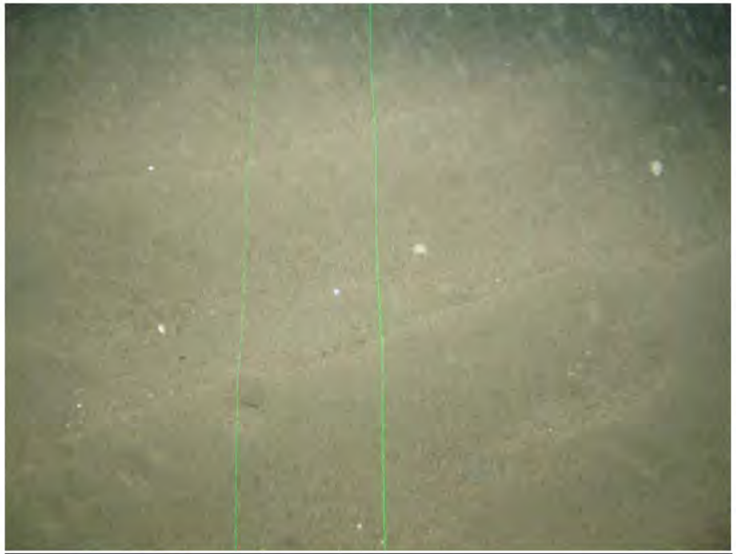
Station: ENV22
Sediment Description:
Grab: Sand.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Echinodermata (*Echinocardium* sp.)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 12 **E:** 367445 **N:** 6005696 **Depth:** 54m

Fix: 36 **E:** 367467 **N:** 6005689 **Depth:** 53m

Station: ENV23
Sediment Description:
Fix12: Rippled sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fix36: Rippled sand with scattered shell fragments.
Broadscale EUNIS Classification: A5.2

Fauna Description:
Fix12: Fauna burrows present.

Fix36: Echinodermata (*Astropecten irregularis*)

Fix: 1 **E:** 367458 **N:** 6005689 **Depth:** 58m

Fix: 1 **E:** 367458 **N:** 6005689 **Retention:** MF

Station: ENV23
Sediment Description:
Grab: Brown sand with shells.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta), Mollusca (Bivalvia), Echinodermata (*Echinocardium* sp.)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

Fix: 73 **E:** 373680 **N:** 6006084 **Depth:** 53m

Fix: 84 **E:** 373691 **N:** 6006060 **Depth:** 54m

Station: ENV24
Sediment Description:
Fix73: Rippled gravely sand with shell fragments.
Broadscale EUNIS Classification: A5.1

Fix84: Rippled gravely sand with shell fragments.
Broadscale EUNIS Classification: A5.1

Fauna Description:
Fix73: No visible fauna.

Fix84: Annelida (Serpulidae), Cnidaria (Hydrozoa)

Fix: 7 **E:** 373681 **N:** 6006062 **Depth:** 56m

Fix: 7 **E:** 373681 **N:** 6006062 **Retention:** MF

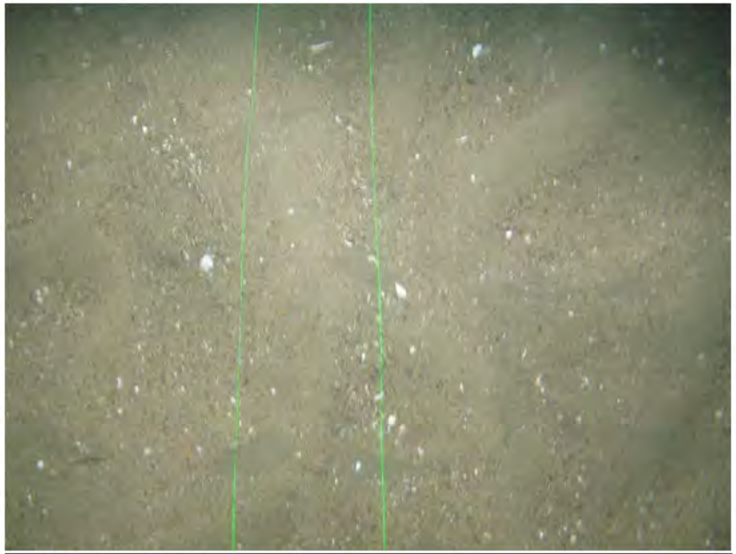
Station: ENV24
Sediment Description:
Grab: Sand and shell fragments.

Sieve: Shell fragments.

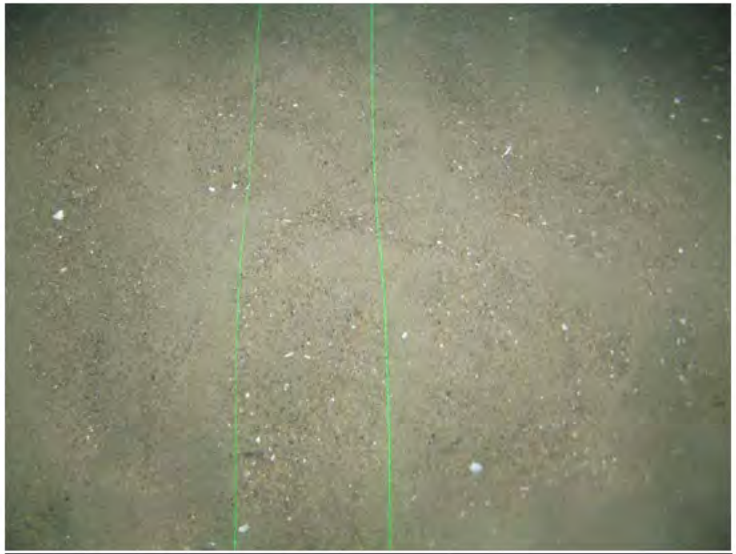
Fauna Description:
Grab: No visible fauna.

Sieve: Annelida (Polycheta)

APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS



Fix: 91 **E:** 378378 **N:** 6005479 **Depth:** 54m



Fix: 109 **E:** 378382 **N:** 6005485 **Depth:** 53m

Station: ENV25
Sediment Description:
Fix91: Rippled gravely sand with shell fragments.
Broadscale EUNIS Classification: A5.1

Fix109: Rippled gravely sand with shell fragments.
Broadscale EUNIS Classification: A5.1

Fauna Description:
Fix91: No visible fauna.

Fix109: No visible fauna.

Fix: 9 **E:** 378385 **N:** 6005471 **Depth:** 58m

Fix: 9 **E:** 378385 **N:** 6005471 **Retention:** MF

Station: ENV25
Sediment Description:
Grab: Sand with shell fragments.

Sieve: Shell fragments.

Fauna Description:
Grab: No visible fauna.

Sieve: No visible fauna.

APPENDIX E FAUNAL CATALOGUE

APPENDIX E FAUNAL CATALOGUE


1. Animalia - indeterminate A


2. Animalia - indeterminate C


3. Annelida - *Ditrupa* sp.


4. Annelida - *Lanice conchilega*


5. Annelida - Polychaeta tube A


6. Annelida - Polychaeta tube B


7. Annelida - Serpulidae


8. Annelida - Terebellidae

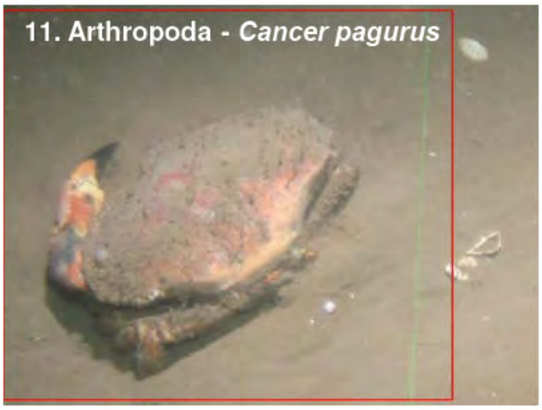
APPENDIX E FAUNAL CATALOGUE


9. Arthropoda – Brachyura sp. A

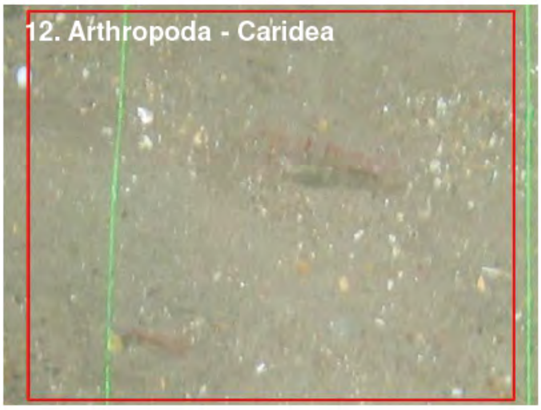

13. Arthropoda - Paguridae


10. Arthropoda - Brachyura sp. B


14. Chordata - Actinopterygii indeterminate


11. Arthropoda - *Cancer pagurus*


15. Chordata - Actinopterygii sp. A


12. Arthropoda - Caridea

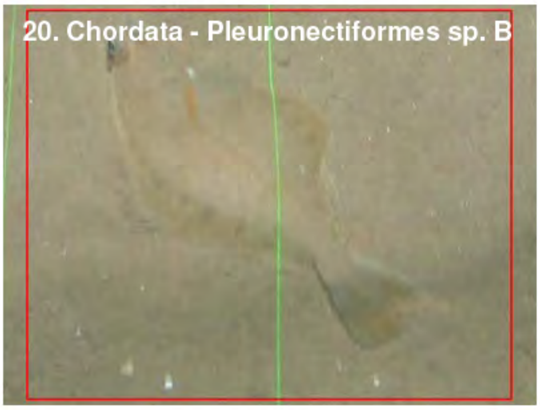

16. Chordata - Actinopterygii sp. B

APPENDIX E FAUNAL CATALOGUE


17. Chordata - Ammodytidae


18. Chordata - Callionymidae


19. Chordata - Pleuronectiformes sp. A


20. Chordata - Pleuronectiformes sp. B


21. Chordata - Scorpaniformes


22. Chordata - Squaliformes


23. Chordata - Triglidae


24. Cnidaria - Actiniaria

APPENDIX E FAUNAL CATALOGUE


25. Cnidaria - *Alcyonium digitatum*

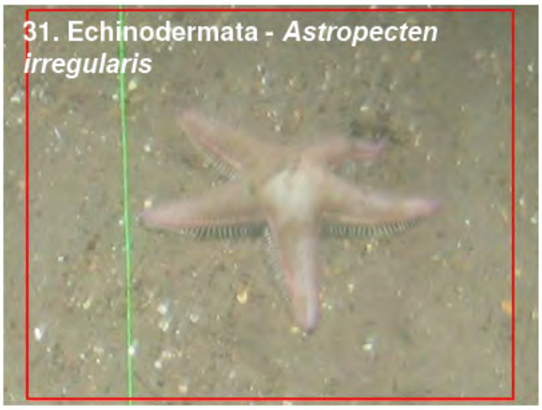

26. Cnidaria – *Ceriantharia* sp.


27. Cnidaria - Hydrozoa


28. Cnidaria - *Urticina* sp. A


29. Echinodermata - *Asterias rubens*


30. Echinodermata - Asteroidea (juv.)


31. Echinodermata - *Astropecten irregularis*


32. Echinodermata - Ophiuroidea sp. A

APPENDIX E FAUNAL CATALOGUE

APPENDIX F FAUNAL OBSERVATION SUMMARY

APPENDIX F FAUNAL OBSERVATION SUMMARY

Table F.1 Semi-Quantitative Faunal Summary

Station		Phylum - Taxon																			
		Animalia - indeterminate A	Animalia - indeterminate C	Annelida - *Ditrupa* sp.	Annelida - *Lanice conchilega*	Annelida - Polychaeta tube A	Annelida - Polychaeta tube B	Annelida - Serpulidae	Annelida - Terebellidae	Arthropoda - Brachyura sp. A	Arthropoda - Brachyura sp. B	Arthropoda - *Cancer pagurus*	Arthropoda - Caridea	Arthropoda - Paguridae	Burrow	Chordata - Actinopterygii indeterminate	Chordata - Actinopterygii sp. A	Chordata - Actinopterygii sp. B	Chordata - Ammodytidae	Chordata - Callionymidae	Chordata - Pleuronectiformes sp. A
ENV1	Number of Images			1											17	1					2
	% Images			3%											N/A	3%					6%
ENV2	Number of Images				1	1													1		3
	% Images				3%	3%													N/A		9%
ENV4	Number of Images			1		1				1					32						
	% Images			2%		2%				2%					N/A						
ENV5	Number of Images									1			1		5	3					
	% Images									3%			3%		N/A	9%					
ENV6	Number of Images														6	2					3
	% Images														N/A	6%					9%
ENV8	Number of Images														34	2					
	% Images														N/A	6%					
ENV9	Number of Images					1									53	2					
	% Images					3%									N/A	5%					
ENV10	Number of Images						1								3	1					
	% Images						5%								N/A	5%					
ENV11	Number of Images	1										1			45	2					1
	% Images	3%										3%			N/A	5%					3%
ENV14	Number of Images					1			1						50						1
	% Images					3%			3%						N/A						3%
ENV15	Number of Images					1	1		1				2		145	4	1				1
	% Images					2%	2%		2%				4%		N/A	8%	2%				2%
ENV16	Number of Images														56	1					
	% Images														N/A	3%					
ENV17	Number of Images														106	1					
	% Images														N/A	3%					
ENV18	Number of Images															2					
	% Images															8%					
ENV19	Number of Images					1		2							256	2				1	
	% Images					3%		5%							N/A	5%				3%	
ENV20	Number of Images														12						
	% Images														N/A						
ENV21	Number of Images														90	2					
	% Images														N/A	8%					
ENV22	Number of Images						1								74	3		1		1	
	% Images						4%								N/A	12%		4%		4%	
ENV23	Number of Images		1			2		1			1			1	56	3				1	
	% Images		3%			5%		3%			3%			3%	N/A	8%				3%	
ENV24	Number of Images						1	2							7						
	% Images						4%	8%							N/A						
ENV25	Number of Images														2	1					
	% Images														N/A	4%					

Protected species and burrows for habitat assessments

NA = not applicable as individuals were enumerated within each image

APPENDIX F FAUNAL OBSERVATION SUMMARY

Table F.1 Semi-Quantitative Faunal Summary

Station		Phylum - Taxon																		
		Chordata - Pleuronectiformes sp. B	Chordata - Scorpaniformes	Chordata - Squaliformes	Chordata - Triglidae	Cnidaria - Actiniaria	Cnidaria - *Alcyonium digitatum*	Cnidaria - *Cerianthria* sp.	Cnidaria - Hydrozoa	Cnidaria - *Urticina* sp. A	Echinodermata - *Asterias rubens*	Echinodermata - Asteroidea (juv.)	Echinodermata - *Astropecten irregularis*	Echinodermata - Ophiuroidea sp. A	Echinodermata - Ophiuroidea sp. B	Faunal turf	Mollusca - Bivalvia	Mollusca - Naticidae	Mollusca - Scaphopoda	Mollusca - Sepiolidae
ENV1	Number of Images	1							4		1			1						
	% Images	3%							12%		3%			3%						
ENV2	Number of Images	1							1					8						
	% Images	3%							3%					23%						
ENV4	Number of Images	7							8		2			2						
	% Images	16%							18%		4%			4%						
ENV5	Number of Images	2							3		1		3					1	4	
	% Images	6%							9%		3%		9%					3%	12%	
ENV6	Number of Images	4											2				1		1	
	% Images	12%											6%				3%		3%	
ENV8	Number of Images												1			2				
	% Images												3%			6%				
ENV9	Number of Images	2							3				5							
	% Images	5%							8%				13%							
ENV10	Number of Images	1											4	1						
	% Images	5%											18%	5%						
ENV11	Number of Images	1									4		1							
	% Images	3%									10%		3%							
ENV14	Number of Images										1		3	1						
	% Images										3%		9%	3%						
ENV15	Number of Images	2			1				1		2		8	2						1
	% Images	4%			2%				2%		4%		16%	4%						2%
ENV16	Number of Images	1									1									
	% Images	3%									3%									
ENV17	Number of Images						3		1		3			1						
	% Images						8%		3%		8%			3%						
ENV18	Number of Images												2	1						
	% Images												8%	4%						
ENV19	Number of Images	1				1	16		2		2			2	5	1				
	% Images	3%				3%	40%		5%		5%			5%	13%	3%				
ENV20	Number of Images								1				1							
	% Images								4%				4%							
ENV21	Number of Images																			
	% Images																			
ENV22	Number of Images		1	1					1	1						1				
	% Images		4%	4%					4%	4%						4%				
ENV23	Number of Images	1						1			1		5	1		2	1			
	% Images	3%						3%			3%		13%	3%		5%	3%			
ENV24	Number of Images		1						5		2	1	1			1	1			
	% Images		4%						21%		8%	4%	4%			4%	4%			
ENV25	Number of Images												1							
	% Images												4%							

Protected species and burrows for habitat assessments

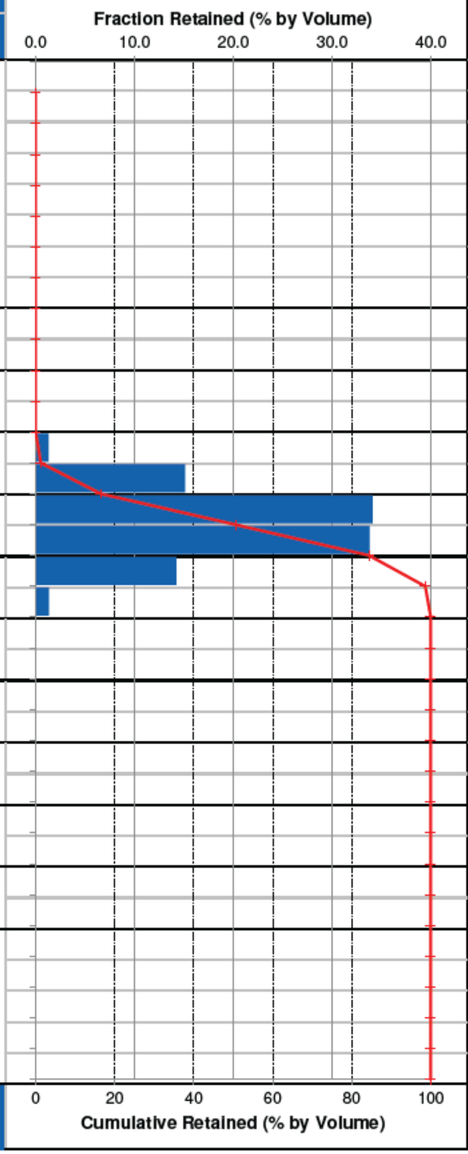
NA = not applicable as individuals were enumerated within each image

APPENDIX G PARTICLE SIZE ANALYSIS

APPENDIX G PARTICLE SIZE ANALYSIS

ENV1

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	1.3	1.3	Coarse sand
500.0	1.0	15.1	16.5	
353.6	1.5	34.1	50.6	Medium sand
250.0	2.0	33.8	84.4	
176.8	2.5	14.3	98.6	Fine sand
125.0	3.0	1.4	100.0	
83.4	3.5	0.0	100.0	Very fine sand
62.5	4.0	0.0	100.0	
44.2	4.5	0.0	100.0	Coarse silt
31.3	5.0	0.0	100.0	
22.1	5.5	0.0	100.0	Medium silt
15.6	6.0	0.0	100.0	
11.0	6.5	0.0	100.0	Fine silt
7.8	7.0	0.0	100.0	
5.5	7.5	0.0	100.0	Very fine silt
3.9	8.0	0.0	100.0	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



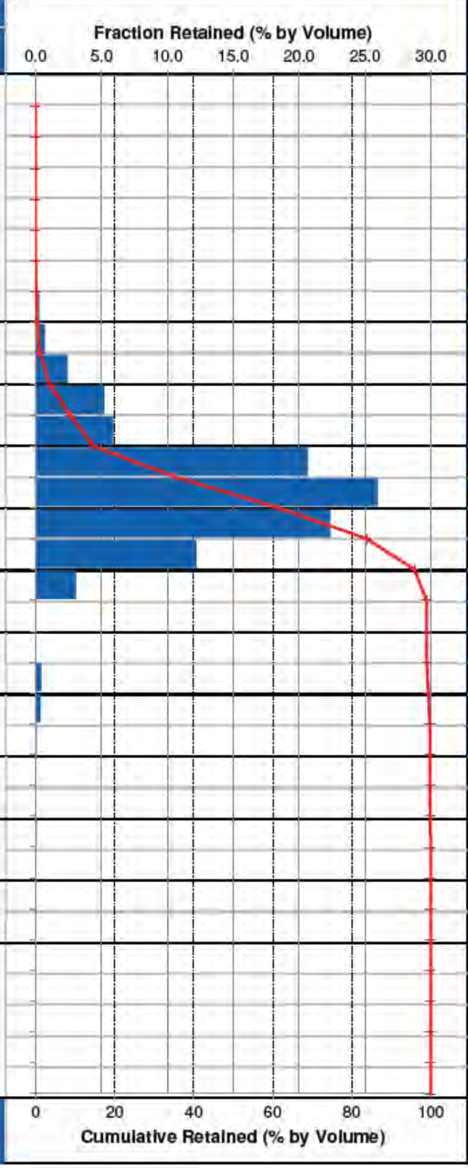
Method of Moments			
Geometric	Mean (µm)	355 22	Wentworth:
Logarithmic	Mean (Phi)	1.49	Medium sand
	Sorting	0 50	Well
	Skewness	0 02	Symmetrical
	Kurtosis	2 59	Mesokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	355 93	Wentworth:
Logarithmic	Mean (Phi)	1.49	Medium sand
	Sorting	0 52	Moderately well
	Skewness	0 00	Symmetrical
	Kurtosis	0 97	Mesokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.49	355 59	Medium sand
1st Local Maxima (Mode)	1 50	353.55	Medium sand
2nd Local Maxima	-	-	-
3rd Local Maxima	-	-	-

Classification		Composition	
Modified Folk	Sand	Fines	0.00%
EUNIS Folk	Sand and muddy sand	Sand	100.00%
Distribution	Unimodal	Gravel	0.00%

APPENDIX G PARTICLE SIZE ANALYSIS

ENV2

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.1	0.1	
4000.0	-2.0	0.3	0.4	
2800.0	-1.5	0.7	1.1	Granule
2000.0	-1.0	2.4	3.6	
1400.0	-0.5	5.2	8.8	Very coarse sand
1000.0	0.0	5.9	14.7	
707.0	0.5	20.7	35.3	Coarse sand
500.0	1.0	26.0	61.3	
353.6	1.5	22.4	83.7	Medium sand
250.0	2.0	12.2	95.9	
176.8	2.5	3.1	98.9	Fine sand
125.0	3.0	0.0	99.0	
83.4	3.5	0.0	99.0	Very fine sand
62.5	4.0	0.4	99.4	
44.2	4.5	0.4	99.8	Coarse silt
31.3	5.0	0.1	99.8	
22.1	5.5	0.0	99.8	Medium silt
15.6	6.0	0.1	99.9	
11.0	6.5	0.1	100.0	Fine silt
7.8	7.0	0.0	100.0	
5.5	7.5	0.0	100.0	Very fine silt
3.9	8.0	0.0	100.0	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	

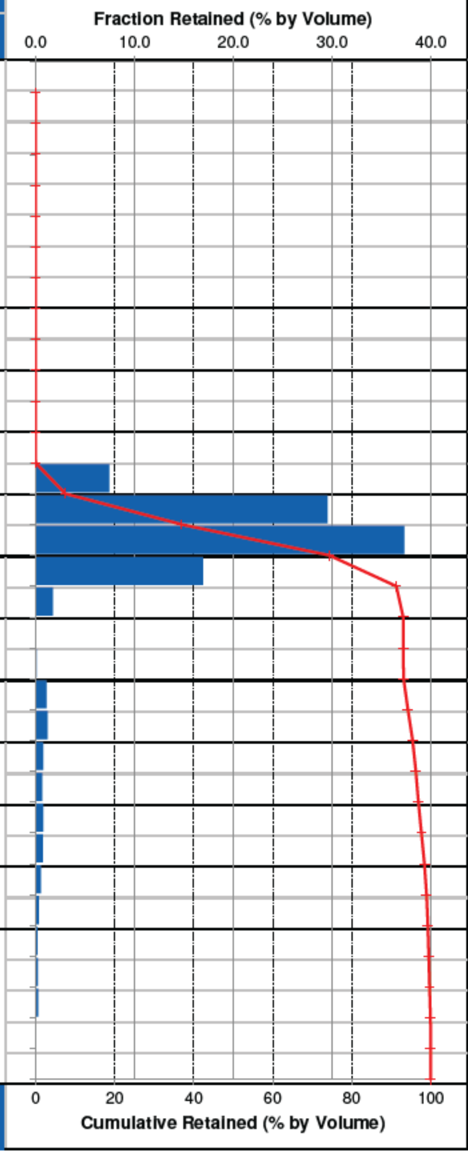


Method of Moments			
Geometric	Mean (µm)	595.67	Wentworth:
Logarithmic	Mean (Phi)	0.75	Coarse sand
	Sorting	0.90	Moderately
	Skewness	0.20	Symmetrical
	Kurtosis	6.71	Leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	584.08	Wentworth:
Logarithmic	Mean (Phi)	0.78	Coarse sand
	Sorting	0.80	Moderate
	Skewness	-0.09	Symmetrical
	Kurtosis	1.10	Mesokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	0.78	581.48	Coarse sand
1st Local Maxima (Mode)	1.00	500.00	Coarse sand
2nd Local Maxima	-	-	-
3rd Local Maxima	-	-	-

Classification		Composition	
Modified Folk	Slightly gravelly sand	Fines	0.60%
EUNIS Folk	Sand and muddy sand	Sand	95.80%
Distribution	Unimodal	Gravel	3.60%

APPENDIX G PARTICLE SIZE ANALYSIS

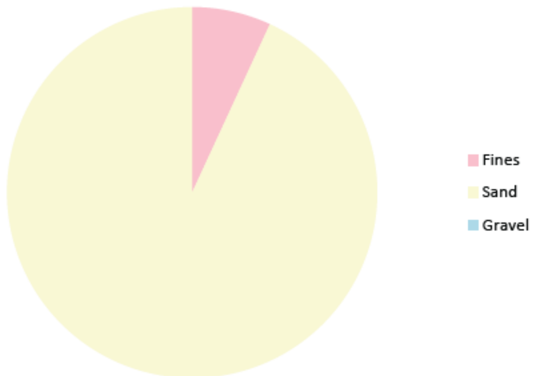
ENV4				
Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	0.0	0.0	Coarse sand
500.0	1.0	7.5	7.5	
353.6	1.5	29.5	37.0	Medium sand
250.0	2.0	37.3	74.3	
176.8	2.5	16.9	91.3	Fine sand
125.0	3.0	1.7	93.0	
83.4	3.5	0.0	93.0	Very fine sand
62.5	4.0	0.1	93.1	
44.2	4.5	1.1	94.2	Coarse silt
31.3	5.0	1.2	95.4	
22.1	5.5	0.8	96.2	Medium silt
15.6	6.0	0.7	96.9	
11.0	6.5	0.8	97.7	Fine silt
7.8	7.0	0.7	98.4	
5.5	7.5	0.5	98.9	Very fine silt
3.9	8.0	0.3	99.2	
2.8	8.5	0.2	99.5	Clay
2.0	9.0	0.2	99.7	
1.4	9.5	0.2	99.9	
1.0	10.0	0.1	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	263.75	Wentworth:
Logarithmic	Mean (Phi)	1 92	Medium sand
	Sorting	1 25	Poor
	Skewness	3 24	Very fine
	Kurtosis	14 88	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	307 59	Wentworth:
Logarithmic	Mean (Phi)	1.70	Medium sand
	Sorting	0 89	Moderate
	Skewness	0 32	Very fine
	Kurtosis	2 26	Very leptokurtic

Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.67	313.43	Medium sand
1st Local Maxima (Mode)	2 00	250.00	Medium sand
2nd Local Maxima	5.00	31 25	Coarse silt
3rd Local Maxima	-	-	-

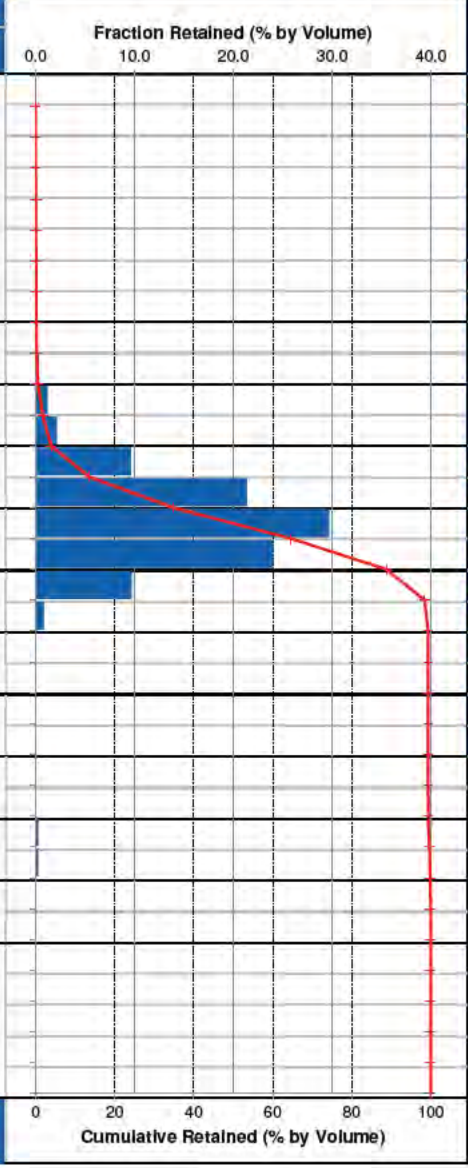
Classification		Composition	
Modified Folk	Sand	Fines	6.90%
EUNIS Folk	Sand and muddy sand	Sand	93.10%
Distribution	Bimodal	Gravel	0.00%



APPENDIX G PARTICLE SIZE ANALYSIS

ENV5

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.1	0.1	
11200.0	-3.5	0.0	0.1	
8000.0	-3.0	0.0	0.1	
5600.0	-2.5	0.0	0.1	
4000.0	-2.0	0.0	0.2	
2800.0	-1.5	0.1	0.3	Granule
2000.0	-1.0	0.3	0.6	
1400.0	-0.5	1.2	1.8	Very coarse sand
1000.0	0.0	2.1	3.9	
707.0	0.5	9.7	13.6	Coarse sand
500.0	1.0	21.4	35.0	
353.6	1.5	29.7	64.7	Medium sand
250.0	2.0	24.0	88.7	
176.8	2.5	9.7	98.5	Fine sand
125.0	3.0	0.8	99.3	
83.4	3.5	0.0	99.3	Very fine sand
62.5	4.0	0.0	99.3	
44.2	4.5	0.0	99.3	Coarse silt
31.3	5.0	0.0	99.3	
22.1	5.5	0.0	99.3	Medium silt
15.6	6.0	0.1	99.4	
11.0	6.5	0.3	99.6	Fine silt
7.8	7.0	0.2	99.9	
5.5	7.5	0.1	100.0	Very fine silt
3.9	8.0	0.0	100.0	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



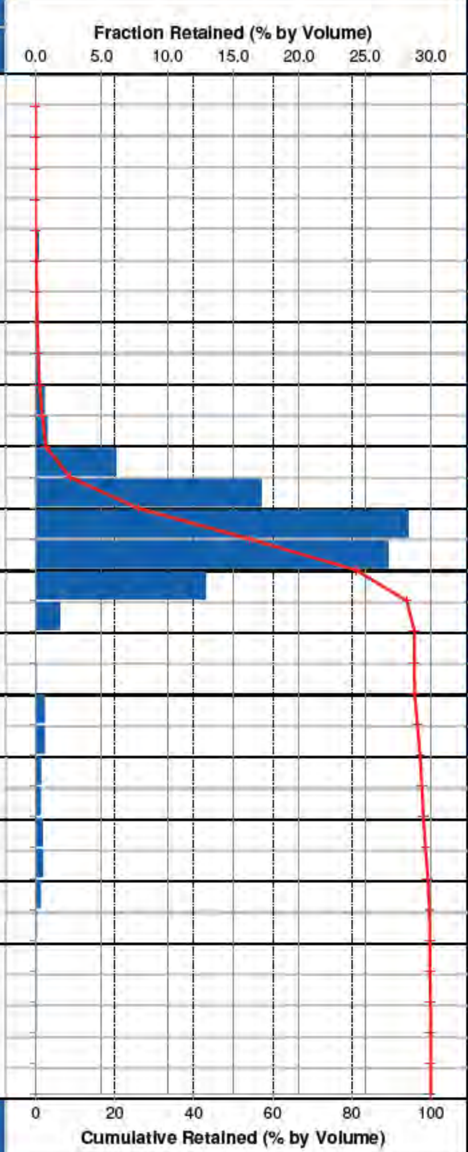
Method of Moments			
Geometric	Mean (µm)	423.82	Wentworth:
Logarithmic	Mean (Phi)	1.24	Medium sand
	Sorting	0.84	Moderately
	Skewness	1.26	Fine
	Kurtosis	17.07	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	424.29	Wentworth:
Logarithmic	Mean (Phi)	1.24	Medium sand
	Sorting	0.68	Moderately well
	Skewness	-0.05	Symmetrical
	Kurtosis	0.98	Mesokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.25	419.62	Medium sand
1st Local Maxima (Mode)	1.50	353.55	Medium sand
2nd Local Maxima	-	-	-
3rd Local Maxima	-	-	-

Classification		Composition	
Modified Folk	Sand	Fines	0.70%
EUNIS Folk	Sand and muddy sand	Sand	98.70%
Distribution	Unimodal	Gravel	0.60%

APPENDIX G PARTICLE SIZE ANALYSIS

ENV6

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.2	0.2	
5600.0	-2.5	0.1	0.3	
4000.0	-2.0	0.1	0.4	
2800.0	-1.5	0.2	0.6	Granule
2000.0	-1.0	0.4	1.0	
1400.0	-0.5	0.7	1.7	Very coarse sand
1000.0	0.0	0.9	2.6	
707.0	0.5	6.1	8.7	Coarse sand
500.0	1.0	17.2	25.9	
353.6	1.5	28.3	54.2	Medium sand
250.0	2.0	26.8	81.0	
176.8	2.5	13.0	94.0	Fine sand
125.0	3.0	1.9	95.8	
83.4	3.5	0.0	95.8	Very fine sand
62.5	4.0	0.1	95.9	
44.2	4.5	0.7	96.6	Coarse silt
31.3	5.0	0.7	97.3	
22.1	5.5	0.4	97.7	Medium silt
15.6	6.0	0.4	98.1	
11.0	6.5	0.5	98.7	Fine silt
7.8	7.0	0.6	99.3	
5.5	7.5	0.4	99.7	Very fine silt
3.9	8.0	0.1	99.8	
2.8	8.5	0.1	99.8	Clay
2.0	9.0	0.1	99.9	
1.4	9.5	0.1	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	

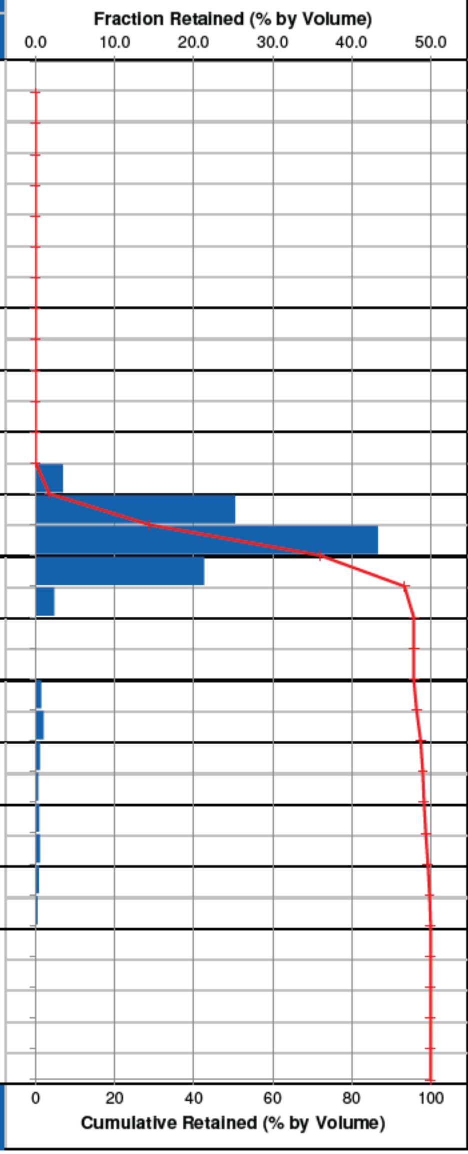


Method of Moments				
Geometric	Mean (µm)	347.63	Wentworth:	
Logarithmic	Mean (Phi)	1.52	Medium sand	
	Sorting	1.17	Poor	
	Skewness	2.16	Very fine	
	Kurtosis	13.78	Very leptokurtic	
Graphic Folk and Ward				
Geometric	Mean (µm)	374.28	Wentworth:	
Logarithmic	Mean (Phi)	1.42	Medium sand	
	Sorting	0.74	Moderate	
	Skewness	0.02	Symmetrical	
	Kurtosis	1.16	Leptokurtic	
Other Statistics	Phi (ϕ)	µm	Wentworth:	
Median (D50)	1.43	372.22	Medium sand	
1st Local Maxima (Mode)	1.50	353.55	Medium sand	
2nd Local Maxima	-	-	-	
3rd Local Maxima	-	-	-	

Classification		Composition	
Modified Folk	Sand	Fines	4.10%
EUNIS Folk	Sand and muddy sand	Sand	94.90%
Distribution	Unimodal	Gravel	1.00%

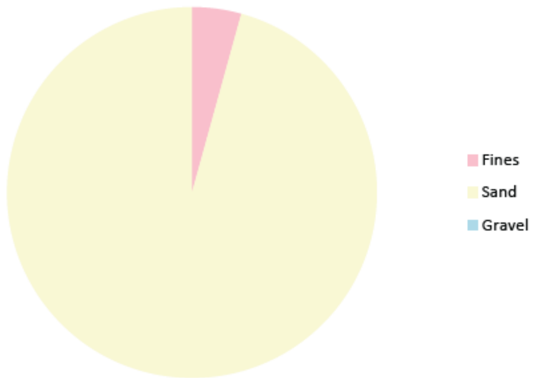
APPENDIX G PARTICLE SIZE ANALYSIS

ENV8				
Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	0.0	0.0	Coarse sand
500.0	1.0	3.4	3.4	
353.6	1.5	25.3	28.7	Medium sand
250.0	2.0	43.3	72.0	
176.8	2.5	21.3	93.3	Fine sand
125.0	3.0	2.4	95.7	
83.4	3.5	0.0	95.7	Very fine sand
62.5	4.0	0.0	95.7	
44.2	4.5	0.7	96.4	Coarse silt
31.3	5.0	1.0	97.4	
22.1	5.5	0.5	98.0	Medium silt
15.6	6.0	0.3	98.3	
11.0	6.5	0.5	98.7	Fine silt
7.8	7.0	0.5	99.3	
5.5	7.5	0.4	99.7	Very fine silt
3.9	8.0	0.3	100.0	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	270.14	Wentworth:
Logarithmic	Mean (Phi)	1 89	Medium sand
	Sorting	0 93	Moderately
	Skewness	3 55	Very fine
	Kurtosis	18.65	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	295 51	Wentworth:
Logarithmic	Mean (Phi)	1.76	Medium sand
	Sorting	0 53	Moderately well
	Skewness	0.13	Fine
	Kurtosis	1.16	Leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.75	298.13	Medium sand
1st Local Maxima (Mode)	2 00	250.00	Medium sand
2nd Local Maxima	5.00	31 25	Coarse silt
3rd Local Maxima	-	-	-

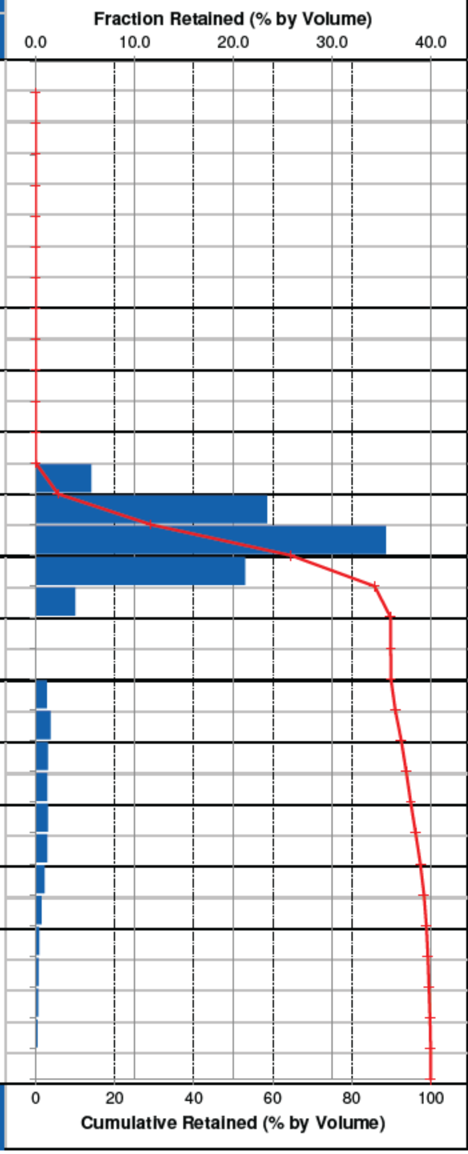
Classification		Composition	
Modified Folk	Sand	Fines	4.30%
EUNIS Folk	Sand and muddy sand	Sand	95.70%
Distribution	Bimodal	Gravel	0.00%



APPENDIX G PARTICLE SIZE ANALYSIS

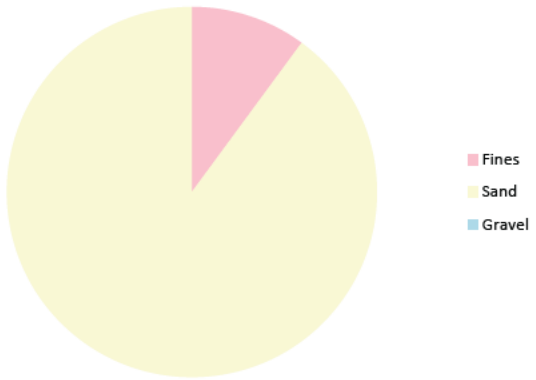
ENV9

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	0.0	0.0	Coarse sand
500.0	1.0	5.6	5.7	
353.6	1.5	23.4	29.1	Medium sand
250.0	2.0	35.5	64.6	
176.8	2.5	21.2	85.8	Fine sand
125.0	3.0	4.0	89.8	
83.4	3.5	0.0	89.9	Very fine sand
62.5	4.0	0.0	89.9	
44.2	4.5	1.1	91.0	Coarse silt
31.3	5.0	1.5	92.6	
22.1	5.5	1.2	93.8	Medium silt
15.6	6.0	1.1	94.9	
11.0	6.5	1.2	96.2	Fine silt
7.8	7.0	1.2	97.4	
5.5	7.5	0.9	98.3	Very fine silt
3.9	8.0	0.6	98.9	
2.8	8.5	0.4	99.3	Clay
2.0	9.0	0.3	99.5	
1.4	9.5	0.3	99.8	
1.0	10.0	0.2	100.0	
<1	>10	0.0	100.0	



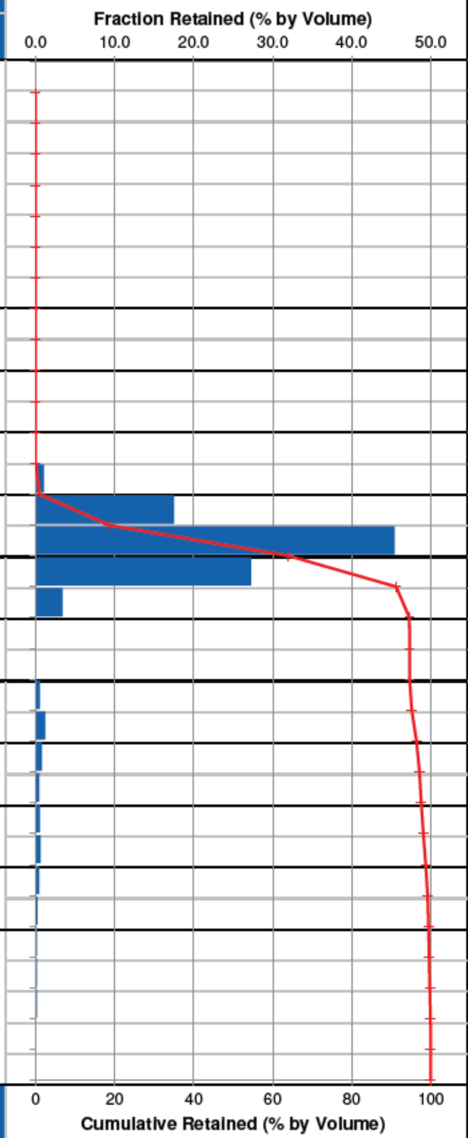
Method of Moments			
Geometric	Mean (µm)	222 51	Wentworth:
Logarithmic	Mean (Phi)	2.17	Fine sand
	Sorting	1.48	Poor
	Skewness	2.64	Very fine
	Kurtosis	10.11	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	282 37	Wentworth:
Logarithmic	Mean (Phi)	1 82	Medium sand
	Sorting	1 08	Poor
	Skewness	0 37	Very fine
	Kurtosis	2 50	Very leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.79	288 25	Medium sand
1st Local Maxima (Mode)	2 00	250.00	Medium sand
2nd Local Maxima	5.00	31 25	Coarse silt
3rd Local Maxima	6.50	11 05	Fine silt

Classification		Composition	
Modified Folk	Muddy sand	Fines	10.10%
EUNIS Folk	Sand and muddy sand	Sand	89.90%
Distribution	Multimodal	Gravel	0.00%



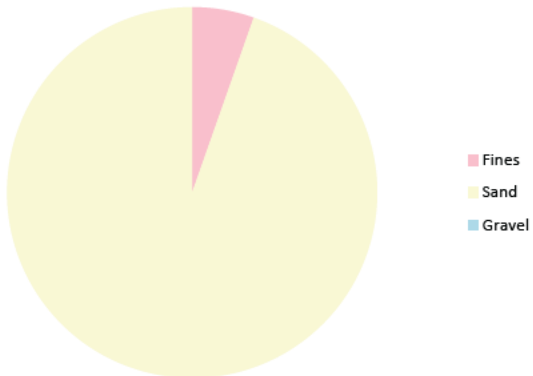
APPENDIX G PARTICLE SIZE ANALYSIS

ENV10				
Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	0.0	0.0	Coarse sand
500.0	1.0	1.0	1.0	
353.6	1.5	17.5	18.6	Medium sand
250.0	2.0	45.4	64.0	
176.8	2.5	27.2	91.2	Fine sand
125.0	3.0	3.4	94.6	
83.4	3.5	0.0	94.6	Very fine sand
62.5	4.0	0.0	94.6	
44.2	4.5	0.5	95.2	Coarse silt
31.3	5.0	1.2	96.4	
22.1	5.5	0.8	97.2	Medium silt
15.6	6.0	0.4	97.6	
11.0	6.5	0.5	98.1	Fine silt
7.8	7.0	0.6	98.7	
5.5	7.5	0.5	99.2	Very fine silt
3.9	8.0	0.3	99.5	
2.8	8.5	0.1	99.6	Clay
2.0	9.0	0.1	99.7	
1.4	9.5	0.2	99.9	
1.0	10.0	0.1	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	241 30	Wentworth:
Logarithmic	Mean (Phi)	2 05	Fine sand
	Sorting	1 07	Poor
	Skewness	3.75	Very fine
	Kurtosis	19.63	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	271.64	Wentworth:
Logarithmic	Mean (Phi)	1 88	Medium sand
	Sorting	0.72	Moderate
	Skewness	0 33	Very fine
	Kurtosis	2 09	Very leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.85	278.13	Medium sand
1st Local Maxima (Mode)	2 00	250.00	Medium sand
2nd Local Maxima	5.00	31 25	Coarse silt
3rd Local Maxima	-	-	-

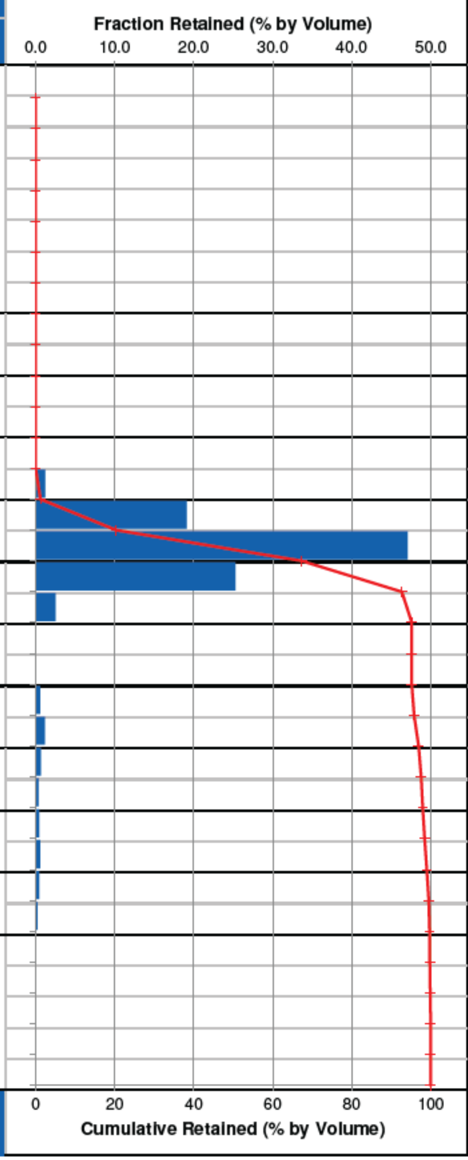
Classification		Composition	
Modified Folk	Sand	Fines	5.40%
EUNIS Folk	Sand and muddy sand	Sand	94.60%
Distribution	Bimodal	Gravel	0.00%



APPENDIX G PARTICLE SIZE ANALYSIS

ENV11

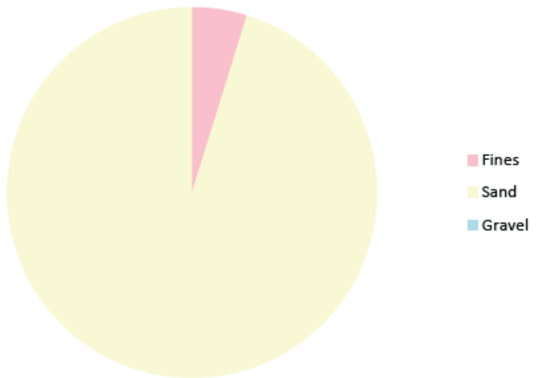
Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	0.0	0.0	Coarse sand
500.0	1.0	1.2	1.2	
353.6	1.5	19.1	20.3	Medium sand
250.0	2.0	47.1	67.4	
176.8	2.5	25.3	92.7	Fine sand
125.0	3.0	2.5	95.2	
83.4	3.5	0.0	95.2	Very fine sand
62.5	4.0	0.0	95.2	
44.2	4.5	0.6	95.8	Coarse silt
31.3	5.0	1.2	96.9	
22.1	5.5	0.7	97.6	Medium silt
15.6	6.0	0.4	98.0	
11.0	6.5	0.5	98.4	Fine silt
7.8	7.0	0.6	99.0	
5.5	7.5	0.5	99.5	Very fine silt
3.9	8.0	0.2	99.7	
2.8	8.5	0.1	99.8	Clay
2.0	9.0	0.1	99.9	
1.4	9.5	0.1	99.9	
1.0	10.0	0.1	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	251 56	Wentworth:
Logarithmic	Mean (Phi)	1 99	Medium sand
	Sorting	0 99	Moderately
	Skewness	3 83	Very fine
	Kurtosis	20.73	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	278.71	Wentworth:
Logarithmic	Mean (Phi)	1 84	Medium sand
	Sorting	0 52	Moderately well
	Skewness	0.16	Fine
	Kurtosis	1 27	Leptokurtic

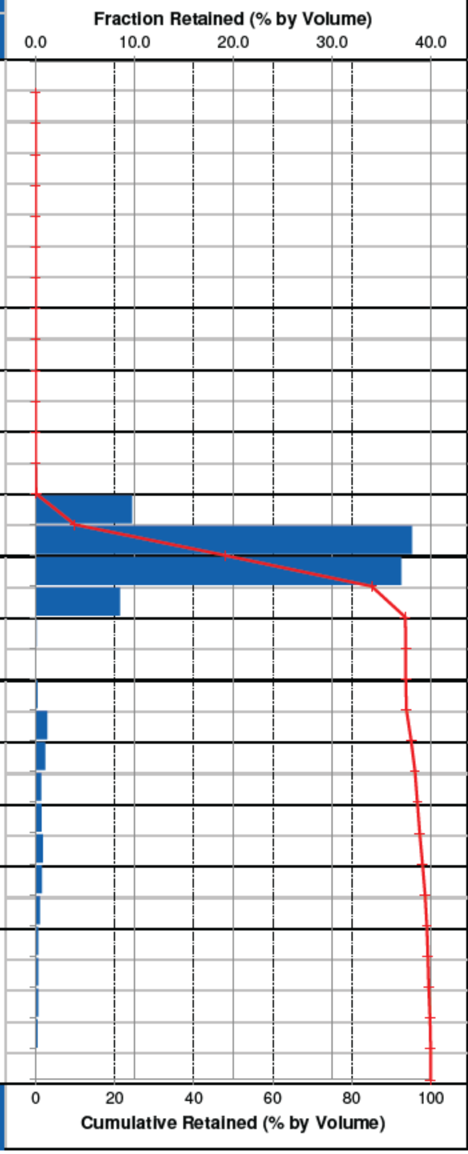
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.82	284.19	Medium sand
1st Local Maxima (Mode)	2 00	250.00	Medium sand
2nd Local Maxima	5.00	31 25	Coarse silt
3rd Local Maxima	-	-	-

Classification		Composition	
Modified Folk	Sand	Fines	4.80%
EUNIS Folk	Sand and muddy sand	Sand	95.20%
Distribution	Bimodal	Gravel	0.00%



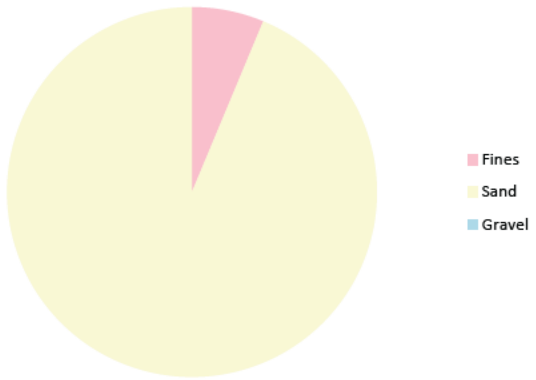
APPENDIX G PARTICLE SIZE ANALYSIS

ENV14				
Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	0.0	0.0	Coarse sand
500.0	1.0	0.1	0.1	
353.6	1.5	9.8	9.9	Medium sand
250.0	2.0	38.1	48.0	
176.8	2.5	37.0	85.0	Fine sand
125.0	3.0	8.5	93.6	
83.4	3.5	0.1	93.7	Very fine sand
62.5	4.0	0.0	93.7	
44.2	4.5	0.2	93.8	Coarse silt
31.3	5.0	1.2	95.0	
22.1	5.5	1.0	96.0	Medium silt
15.6	6.0	0.6	96.6	
11.0	6.5	0.6	97.2	Fine silt
7.8	7.0	0.7	97.9	
5.5	7.5	0.6	98.6	Very fine silt
3.9	8.0	0.4	99.0	
2.8	8.5	0.3	99.3	Clay
2.0	9.0	0.3	99.5	
1.4	9.5	0.3	99.8	
1.0	10.0	0.2	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	207.79	Wentworth:
Logarithmic	Mean (Phi)	2 27	Fine sand
	Sorting	1 21	Poor
	Skewness	3 54	Very fine
	Kurtosis	16 95	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	244.69	Wentworth:
Logarithmic	Mean (Phi)	2 03	Fine sand
	Sorting	0.79	Moderate
	Skewness	0 30	Fine
	Kurtosis	2 30	Very leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	2.03	245 38	Fine sand
1st Local Maxima (Mode)	2 00	250.00	Medium sand
2nd Local Maxima	5.00	31 25	Coarse silt
3rd Local Maxima	-	-	-

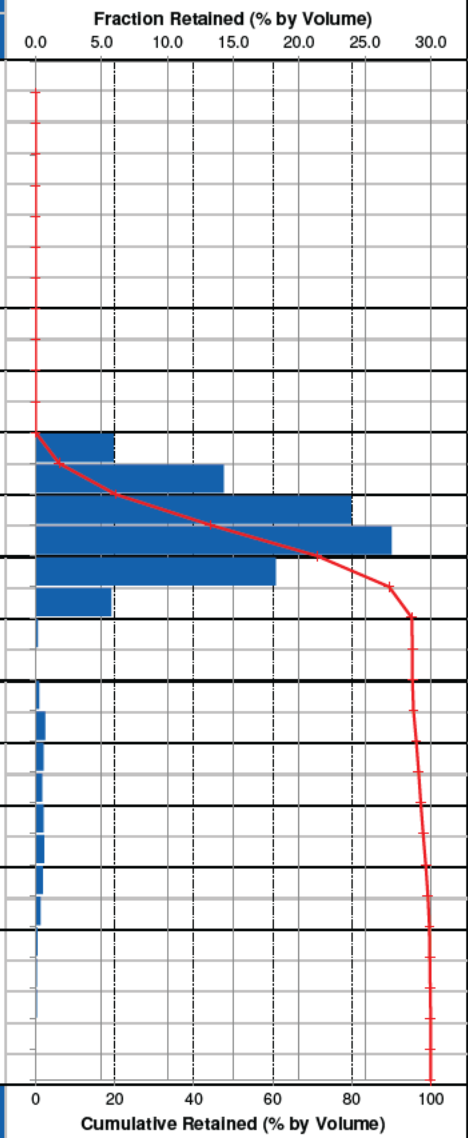
Classification		Composition	
Modified Folk	Sand	Fines	6.30%
EUNIS Folk	Sand and muddy sand	Sand	93.70%
Distribution	Bimodal	Gravel	0.00%



APPENDIX G PARTICLE SIZE ANALYSIS

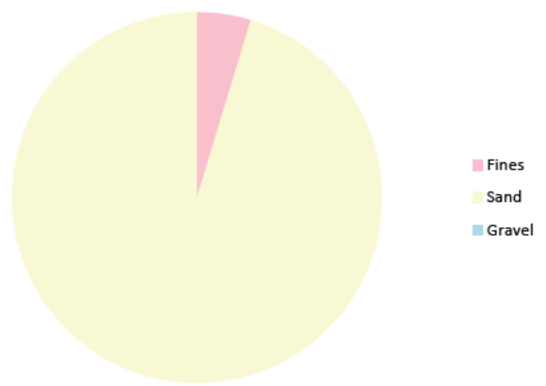
ENV15

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	5.9	5.9	Coarse sand
500.0	1.0	14.3	20.2	
353.6	1.5	24.0	44.2	Medium sand
250.0	2.0	27.0	71.2	
176.8	2.5	18.2	89.4	Fine sand
125.0	3.0	5.7	95.2	
83.4	3.5	0.2	95.3	Very fine sand
62.5	4.0	0.0	95.3	
44.2	4.5	0.3	95.6	Coarse silt
31.3	5.0	0.7	96.3	
22.1	5.5	0.6	97.0	Medium silt
15.6	6.0	0.5	97.5	
11.0	6.5	0.6	98.1	Fine silt
7.8	7.0	0.7	98.7	
5.5	7.5	0.5	99.3	Very fine silt
3.9	8.0	0.4	99.6	
2.8	8.5	0.1	99.8	Clay
2.0	9.0	0.1	99.9	
1.4	9.5	0.1	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



Method of Moments				
Geometric	Mean (µm)	295.73	Wentworth:	
Logarithmic	Mean (Phi)	1.76	Medium sand	
	Sorting	1 20	Poor	
	Skewness	2 80	Very fine	
	Kurtosis	13.76	Very leptokurtic	
Graphic Folk and Ward				
Geometric	Mean (µm)	329 00	Wentworth:	
Logarithmic	Mean (Phi)	1.60	Medium sand	
	Sorting	0.76	Moderate	
	Skewness	0 03	Symmetrical	
	Kurtosis	1 05	Mesokurtic	
Other Statistics	Phi (ϕ)	µm	Wentworth:	
Median (D50)	1.61	328 08	Medium sand	
1st Local Maxima (Mode)	2 00	250.00	Medium sand	
2nd Local Maxima	-	-	-	
3rd Local Maxima	-	-	-	

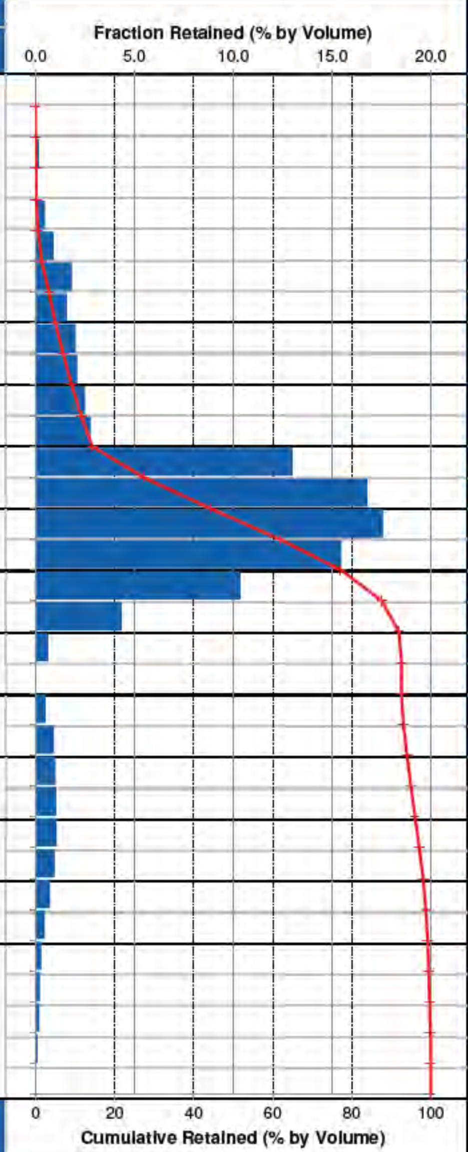
Classification		Composition	
Modified Folk	Sand	Fines	4.70%
EUNIS Folk	Sand and muddy sand	Sand	95.30%
Distribution	Unimodal	Gravel	0.00%



APPENDIX G PARTICLE SIZE ANALYSIS

ENV16

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.2	0.2	
16000.0	-4.0	0.0	0.2	
11200.0	-3.5	0.5	0.6	
8000.0	-3.0	0.9	1.5	
5600.0	-2.5	1.8	3.4	
4000.0	-2.0	1.6	4.9	
2800.0	-1.5	2.0	7.0	Granule
2000.0	-1.0	2.1	9.1	
1400.0	-0.5	2.5	11.6	Very coarse sand
1000.0	0.0	2.8	14.4	
707.0	0.5	13.0	27.4	Coarse sand
500.0	1.0	16.8	44.1	
353.6	1.5	17.6	61.7	Medium sand
250.0	2.0	15.5	77.2	
176.8	2.5	10.4	87.6	Fine sand
125.0	3.0	4.4	91.9	
83.4	3.5	0.6	92.6	Very fine sand
62.5	4.0	0.0	92.6	
44.2	4.5	0.5	93.1	Coarse silt
31.3	5.0	0.9	94.0	
22.1	5.5	1.0	95.0	Medium silt
15.6	6.0	1.0	96.0	
11.0	6.5	1.1	97.1	Fine silt
7.8	7.0	1.0	98.1	
5.5	7.5	0.7	98.8	Very fine silt
3.9	8.0	0.5	99.2	
2.8	8.5	0.3	99.5	Clay
2.0	9.0	0.2	99.7	
1.4	9.5	0.2	99.9	
1.0	10.0	0.1	100.0	
<1	>10	0.0	100.0	



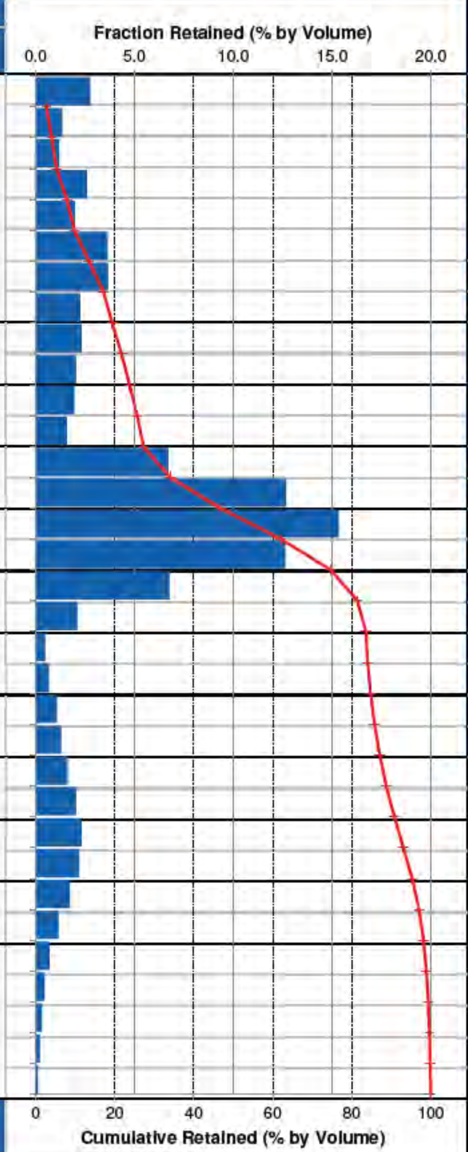
Method of Moments			
Geometric	Mean (µm)	417 84	Wentworth:
Logarithmic	Mean (Phi)	1 26	Medium sand
	Sorting	1 93	Poor
	Skewness	0 91	Fine
	Kurtosis	6 20	Leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	439.60	Wentworth:
Logarithmic	Mean (Phi)	1.19	Medium sand
	Sorting	1.70	Poor
	Skewness	0 09	Symmetrical
	Kurtosis	2 02	Very leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.17	445 54	Medium sand
1st Local Maxima (Mode)	1 50	353.55	Medium sand
2nd Local Maxima	-2.50	5656 85	Pebble
3rd Local Maxima	6.50	11 05	Fine silt

Classification		Composition	
Modified Folk	Gravelly sand	Fines	7.40%
EUNIS Folk	Coarse sediments	Sand	83.50%
Distribution	Multimodal	Gravel	9.10%

APPENDIX G PARTICLE SIZE ANALYSIS

ENV17

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	2.8	2.8	Pebble
31500.0	-5.0	1.3	4.1	
22400.0	-4.5	1.2	5.3	
16000.0	-4.0	2.6	7.9	
11200.0	-3.5	2.0	9.9	
8000.0	-3.0	3.6	13.5	
5600.0	-2.5	3.7	17.2	
4000.0	-2.0	2.2	19.4	
2800.0	-1.5	2.3	21.7	Granule
2000.0	-1.0	2.0	23.8	
1400.0	-0.5	1.9	25.7	Very coarse sand
1000.0	0.0	1.6	27.3	
707.0	0.5	6.7	34.0	Coarse sand
500.0	1.0	12.7	46.7	
353.6	1.5	15.4	62.1	Medium sand
250.0	2.0	12.6	74.7	
176.8	2.5	6.8	81.5	Fine sand
125.0	3.0	2.1	83.6	
83.4	3.5	0.5	84.1	Very fine sand
62.5	4.0	0.7	84.7	
44.2	4.5	1.1	85.8	Coarse silt
31.3	5.0	1.3	87.1	
22.1	5.5	1.6	88.7	Medium silt
15.6	6.0	2.0	90.8	
11.0	6.5	2.3	93.1	Fine silt
7.8	7.0	2.2	95.3	
5.5	7.5	1.7	97.0	Very fine silt
3.9	8.0	1.2	98.2	
2.8	8.5	0.7	98.9	Clay
2.0	9.0	0.4	99.4	
1.4	9.5	0.3	99.7	
1.0	10.0	0.2	99.9	
<1	>10	0.1	100.0	



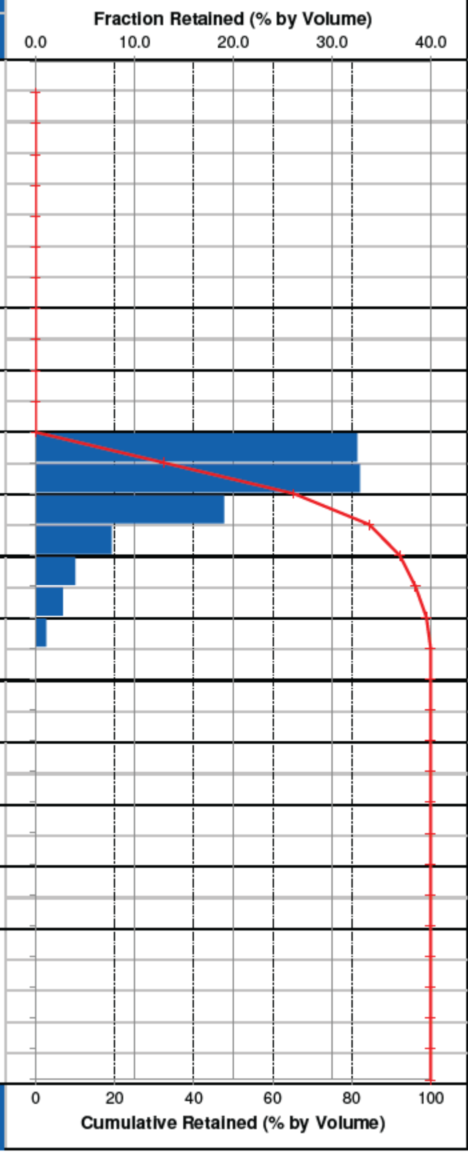
Method of Moments			
Geometric	Mean (µm)	524.45	Wentworth:
Logarithmic	Mean (Phi)	0.93	Coarse sand
	Sorting	3.20	Very poor
	Skewness	0.16	Symmetrical
	Kurtosis	3.15	Mesokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	647.86	Wentworth:
Logarithmic	Mean (Phi)	0.63	Coarse sand
	Sorting	3.27	Very poor
	Skewness	-0.11	Coarse
	Kurtosis	1.75	Very leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.11	464.25	Medium sand
1st Local Maxima (Mode)	1.50	353.55	Medium sand
2nd Local Maxima	-2.50	5656.85	Pebble
3rd Local Maxima	-5.50	45254.83	Pebble

Classification		Composition	
Modified Folk	Gravelly muddy sand	Fines	15.30%
EUNIS Folk	Mixed sediments	Sand	61.00%
Distribution	Multimodal	Gravel	23.80%

APPENDIX G PARTICLE SIZE ANALYSIS

ENV18

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	32.6	32.6	Coarse sand
500.0	1.0	32.8	65.4	
353.6	1.5	19.1	84.5	Medium sand
250.0	2.0	7.7	92.1	
176.8	2.5	4.0	96.1	Fine sand
125.0	3.0	2.8	98.9	
83.4	3.5	1.1	100.0	Very fine sand
62.5	4.0	0.0	100.0	
44.2	4.5	0.0	100.0	Coarse silt
31.3	5.0	0.0	100.0	
22.1	5.5	0.0	100.0	Medium silt
15.6	6.0	0.0	100.0	
11.0	6.5	0.0	100.0	Fine silt
7.8	7.0	0.0	100.0	
5.5	7.5	0.0	100.0	Very fine silt
3.9	8.0	0.0	100.0	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



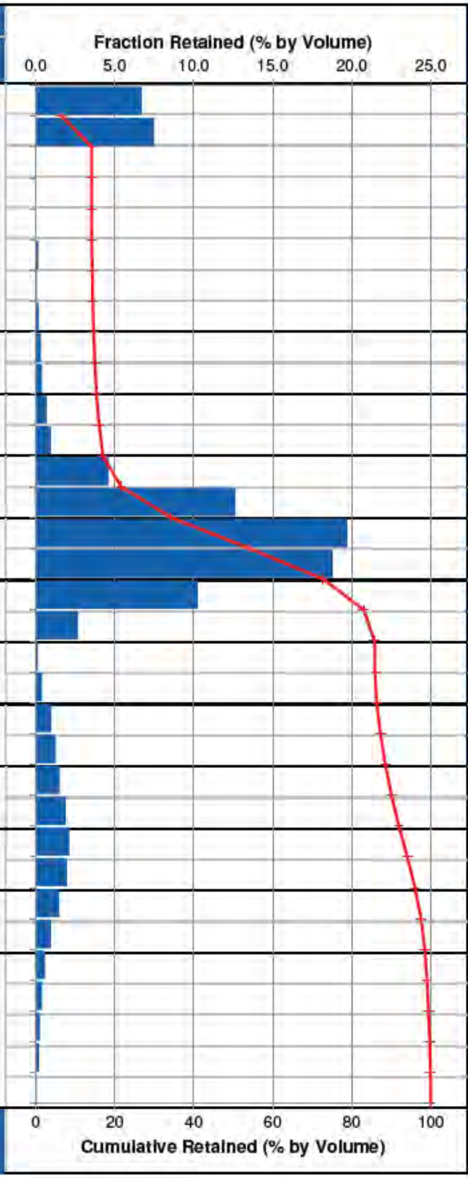
Method of Moments			
Geometric	Mean (µm)	535.10	Wentworth:
Logarithmic	Mean (Phi)	0 90	Coarse sand
	Sorting	0.67	Moderately well
	Skewness	1 25	Fine
	Kurtosis	4 36	Leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	561 32	Wentworth:
Logarithmic	Mean (Phi)	0 83	Coarse sand
	Sorting	0.66	Moderately well
	Skewness	0 28	Fine
	Kurtosis	1 08	Mesokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	0.77	588.17	Coarse sand
1st Local Maxima (Mode)	1 00	500.00	Coarse sand
2nd Local Maxima	-	-	-
3rd Local Maxima	-	-	-

Classification		Composition	
Modified Folk	Sand	Fines	0.00%
EUNIS Folk	Sand and muddy sand	Sand	100.00%
Distribution	Unimodal	Gravel	0.00%

APPENDIX G PARTICLE SIZE ANALYSIS

ENV19

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	6.7	6.7	Pebble
31500.0	-5.0	7.5	14.2	
22400.0	-4.5	0.0	14.2	
16000.0	-4.0	0.0	14.2	
11200.0	-3.5	0.0	14.2	
8000.0	-3.0	0.2	14.4	
5600.0	-2.5	0.1	14.5	
4000.0	-2.0	0.2	14.7	
2800.0	-1.5	0.3	15.0	Granule
2000.0	-1.0	0.4	15.4	
1400.0	-0.5	0.7	16.1	Very coarse sand
1000.0	0.0	1.0	17.0	
707.0	0.5	4.6	21.7	Coarse sand
500.0	1.0	12.7	34.3	
353.6	1.5	19.7	54.0	Medium sand
250.0	2.0	18.8	72.8	
176.8	2.5	10.3	83.1	Fine sand
125.0	3.0	2.7	85.7	
83.4	3.5	0.1	85.9	Very fine sand
62.5	4.0	0.4	86.3	
44.2	4.5	1.0	87.2	Coarse silt
31.3	5.0	1.3	88.5	
22.1	5.5	1.5	90.0	Medium silt
15.6	6.0	1.9	91.9	
11.0	6.5	2.1	94.0	Fine silt
7.8	7.0	2.0	96.0	
5.5	7.5	1.5	97.5	Very fine silt
3.9	8.0	1.0	98.5	
2.8	8.5	0.6	99.1	Clay
2.0	9.0	0.4	99.5	
1.4	9.5	0.3	99.7	
1.0	10.0	0.2	99.9	
<1	>10	0.1	100.0	



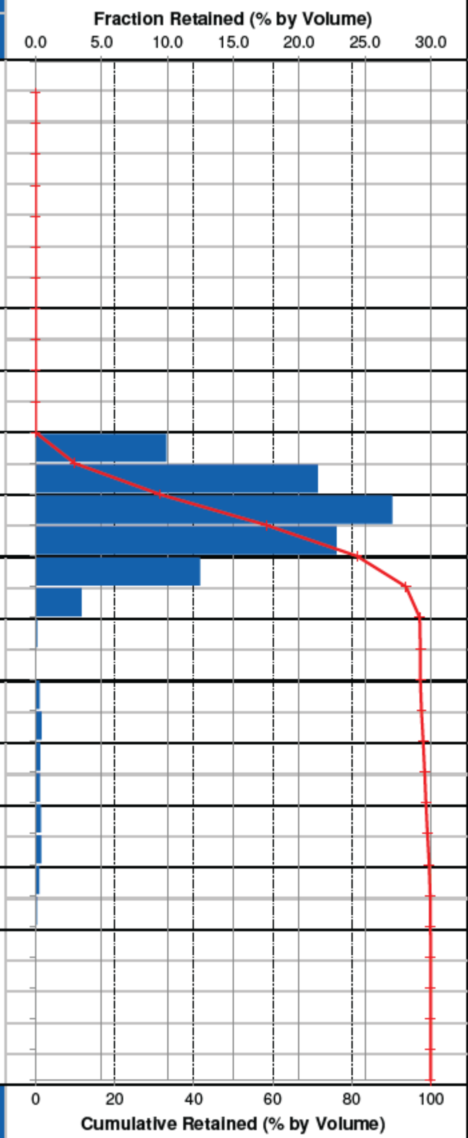
Method of Moments			
Geometric	Mean (µm)	476.70	Wentworth:
Logarithmic	Mean (Phi)	1.07	Medium sand
	Sorting	3.28	Very poor
	Skewness	-0.45	Coarse
	Kurtosis	3.62	Mesokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	443.58	Wentworth:
Logarithmic	Mean (Phi)	1.17	Medium sand
	Sorting	2.68	Very poor
	Skewness	-0.17	Coarse
	Kurtosis	3.44	Extremely leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.40	379.55	Medium sand
1st Local Maxima (Mode)	1.50	353.55	Medium sand
2nd Local Maxima	-5.00	32000.00	Pebble
3rd Local Maxima	6.50	11.05	Fine silt

Classification		Composition	
Modified Folk	Gravelly muddy sand	Fines	13.70%
EUNIS Folk	Mixed sediments	Sand	70.90%
Distribution	Multimodal	Gravel	15.40%

APPENDIX G PARTICLE SIZE ANALYSIS

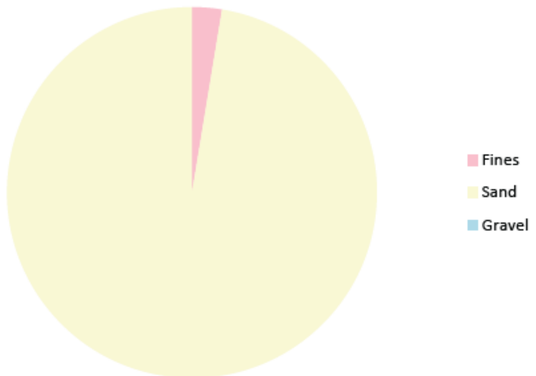
ENV20

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	9.9	9.9	Coarse sand
500.0	1.0	21.4	31.3	
353.6	1.5	27.1	58.4	Medium sand
250.0	2.0	22.8	81.3	
176.8	2.5	12.5	93.8	Fine sand
125.0	3.0	3.5	97.2	
83.4	3.5	0.1	97.3	Very fine sand
62.5	4.0	0.0	97.4	
44.2	4.5	0.3	97.6	Coarse silt
31.3	5.0	0.4	98.1	
22.1	5.5	0.4	98.5	Medium silt
15.6	6.0	0.3	98.8	
11.0	6.5	0.4	99.2	Fine silt
7.8	7.0	0.4	99.6	
5.5	7.5	0.3	99.9	Very fine silt
3.9	8.0	0.1	99.9	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	363.64	Wentworth:
Logarithmic	Mean (Phi)	1.46	Medium sand
	Sorting	0 98	Moderately
	Skewness	2.71	Very fine
	Kurtosis	15 29	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	388 22	Wentworth:
Logarithmic	Mean (Phi)	1 37	Medium sand
	Sorting	0.73	Moderate
	Skewness	0 07	Symmetrical
	Kurtosis	0 98	Mesokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.34	393 84	Medium sand
1st Local Maxima (Mode)	1 50	353.55	Medium sand
2nd Local Maxima	-	-	-
3rd Local Maxima	-	-	-

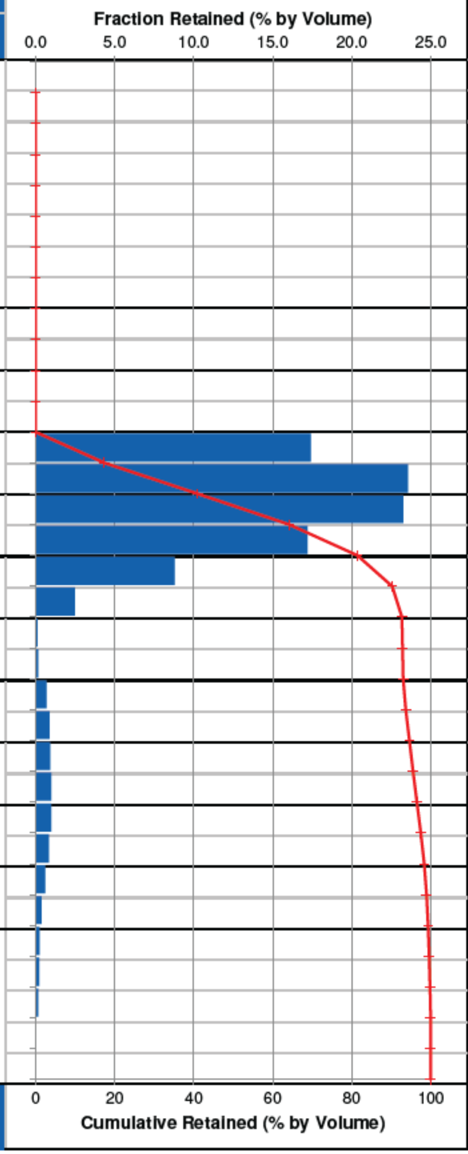
Classification		Composition	
Modified Folk	Sand	Fines	2.60%
EUNIS Folk	Sand and muddy sand	Sand	97.40%
Distribution	Unimodal	Gravel	0.00%



APPENDIX G PARTICLE SIZE ANALYSIS

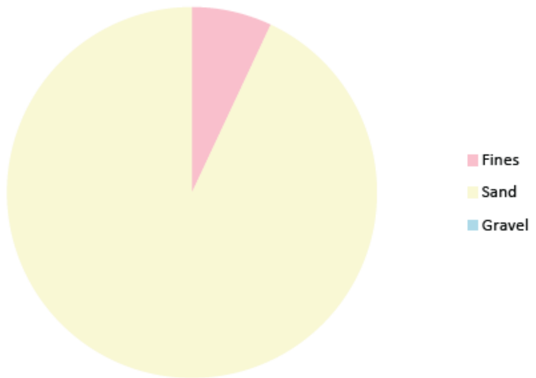
ENV21

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	17.4	17.4	Coarse sand
500.0	1.0	23.6	41.0	
353.6	1.5	23.3	64.2	Medium sand
250.0	2.0	17.2	81.4	
176.8	2.5	8.8	90.2	Fine sand
125.0	3.0	2.5	92.7	
83.4	3.5	0.1	92.8	Very fine sand
62.5	4.0	0.2	93.0	
44.2	4.5	0.7	93.7	Coarse silt
31.3	5.0	0.9	94.6	
22.1	5.5	0.9	95.5	Medium silt
15.6	6.0	1.0	96.5	
11.0	6.5	1.0	97.5	Fine silt
7.8	7.0	0.9	98.3	
5.5	7.5	0.6	99.0	Very fine silt
3.9	8.0	0.4	99.3	
2.8	8.5	0.3	99.6	Clay
2.0	9.0	0.2	99.8	
1.4	9.5	0.2	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



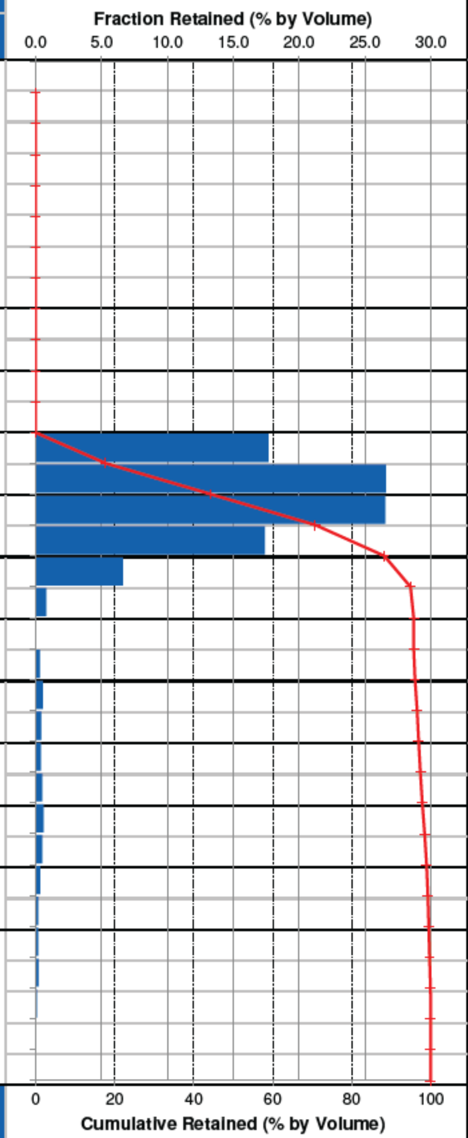
Method of Moments			
Geometric	Mean (µm)	349.41	Wentworth:
Logarithmic	Mean (Phi)	1 52	Medium sand
	Sorting	1.47	Poor
	Skewness	2.61	Very fine
	Kurtosis	10.74	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	415.75	Wentworth:
Logarithmic	Mean (Phi)	1 27	Medium sand
	Sorting	1.19	Poor
	Skewness	0 36	Very fine
	Kurtosis	1 81	Very leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.19	437 09	Medium sand
1st Local Maxima (Mode)	1 00	500.00	Coarse sand
2nd Local Maxima	-	-	-
3rd Local Maxima	-	-	-

Classification		Composition	
Modified Folk	Sand	Fines	7.00%
EUNIS Folk	Sand and muddy sand	Sand	93.00%
Distribution	Unimodal	Gravel	0.00%



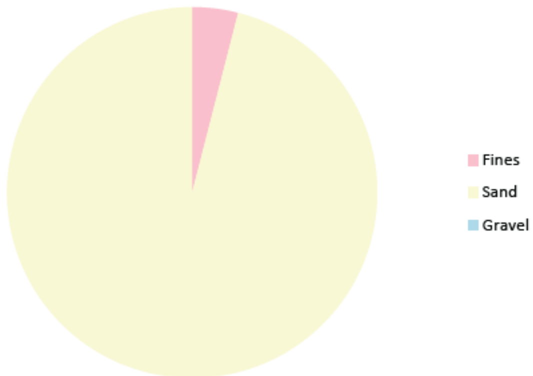
APPENDIX G PARTICLE SIZE ANALYSIS

ENV22				
Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	17.7	17.7	Coarse sand
500.0	1.0	26.6	44.3	
353.6	1.5	26.5	70.8	Medium sand
250.0	2.0	17.4	88.2	
176.8	2.5	6.6	94.9	Fine sand
125.0	3.0	0.8	95.7	
83.4	3.5	0.0	95.7	Very fine sand
62.5	4.0	0.3	96.0	
44.2	4.5	0.5	96.5	Coarse silt
31.3	5.0	0.4	97.0	
22.1	5.5	0.4	97.3	Medium silt
15.6	6.0	0.5	97.9	
11.0	6.5	0.6	98.4	Fine silt
7.8	7.0	0.5	99.0	
5.5	7.5	0.3	99.3	Very fine silt
3.9	8.0	0.2	99.5	
2.8	8.5	0.2	99.7	Clay
2.0	9.0	0.2	99.9	
1.4	9.5	0.1	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	403.00	Wentworth:
Logarithmic	Mean (Phi)	1.31	Medium sand
	Sorting	1.20	Poor
	Skewness	3.28	Very fine
	Kurtosis	16.84	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	451.85	Wentworth:
Logarithmic	Mean (Phi)	1.15	Medium sand
	Sorting	0.73	Moderate
	Skewness	0.14	Fine
	Kurtosis	1.02	Mesokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	1.11	464.06	Medium sand
1st Local Maxima (Mode)	1.00	500.00	Coarse sand
2nd Local Maxima	-	-	-
3rd Local Maxima	-	-	-

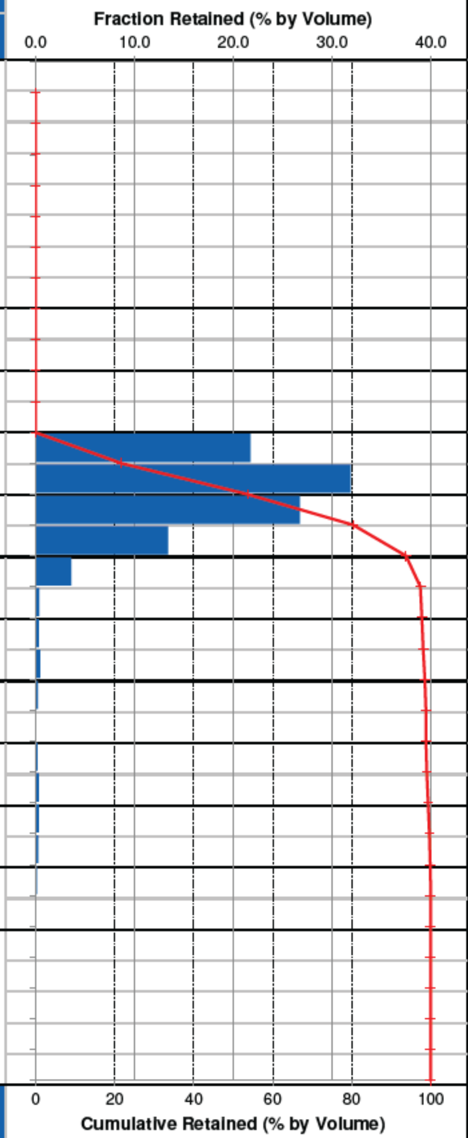
Classification		Composition	
Modified Folk	Sand	Fines	4.00%
EUNIS Folk	Sand and muddy sand	Sand	96.00%
Distribution	Unimodal	Gravel	0.00%



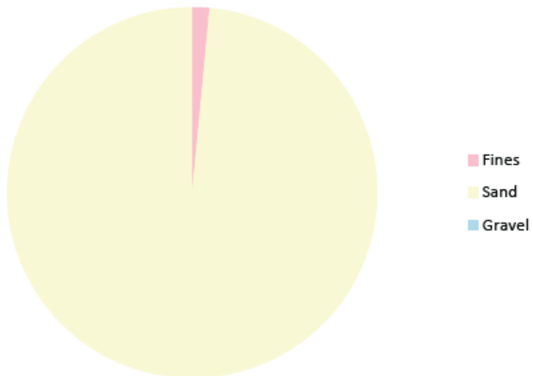
APPENDIX G PARTICLE SIZE ANALYSIS

ENV23

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.0	0.0	Pebble
31500.0	-5.0	0.0	0.0	
22400.0	-4.5	0.0	0.0	
16000.0	-4.0	0.0	0.0	
11200.0	-3.5	0.0	0.0	
8000.0	-3.0	0.0	0.0	
5600.0	-2.5	0.0	0.0	
4000.0	-2.0	0.0	0.0	
2800.0	-1.5	0.0	0.0	Granule
2000.0	-1.0	0.0	0.0	
1400.0	-0.5	0.0	0.0	Very coarse sand
1000.0	0.0	0.0	0.0	
707.0	0.5	21.7	21.7	Coarse sand
500.0	1.0	31.9	53.6	
353.6	1.5	26.7	80.4	Medium sand
250.0	2.0	13.4	93.8	
176.8	2.5	3.6	97.3	Fine sand
125.0	3.0	0.4	97.7	
83.4	3.5	0.3	98.1	Very fine sand
62.5	4.0	0.5	98.5	
44.2	4.5	0.2	98.8	Coarse silt
31.3	5.0	0.0	98.8	
22.1	5.5	0.2	99.0	Medium silt
15.6	6.0	0.3	99.3	
11.0	6.5	0.3	99.6	Fine silt
7.8	7.0	0.3	99.9	
5.5	7.5	0.1	100.0	Very fine silt
3.9	8.0	0.0	100.0	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



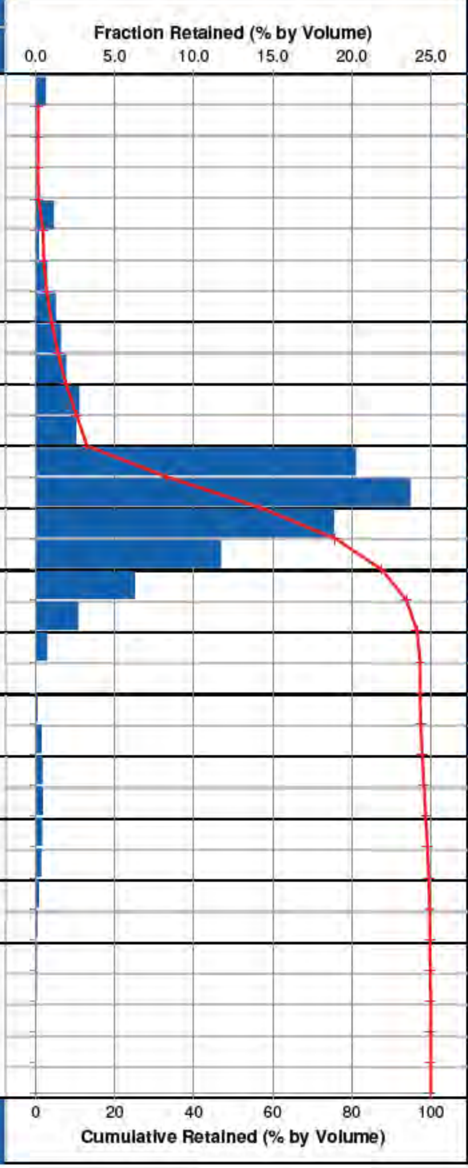
Method of Moments				
Geometric	Mean (µm)	477.15	Wentworth:	
Logarithmic	Mean (Phi)	1 07	Medium sand	
	Sorting	0 84	Moderately	
	Skewness	3.16	Very fine	
	Kurtosis	19.42	Very leptokurtic	
Graphic Folk and Ward				
Geometric	Mean (µm)	506.11	Wentworth:	
Logarithmic	Mean (Phi)	0 98	Coarse sand	
	Sorting	0.63	Moderately well	
	Skewness	0.14	Fine	
	Kurtosis	0 99	Mesokurtic	
Other Statistics	Phi (ϕ)	µm	Wentworth:	
Median (D50)	0.94	520 03	Coarse sand	
1st Local Maxima (Mode)	1 00	500.00	Coarse sand	
2nd Local Maxima	-	-	-	
3rd Local Maxima	-	-	-	
Classification			Composition	
Modified Folk	Sand		Fines	1.50%
EUNIS Folk	Sand and muddy sand		Sand	98.50%
Distribution	Unimodal		Gravel	0.00%



APPENDIX G PARTICLE SIZE ANALYSIS

ENV24

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	0.7	0.7	Pebble
31500.0	-5.0	0.0	0.7	
22400.0	-4.5	0.0	0.7	
16000.0	-4.0	0.1	0.7	
11200.0	-3.5	1.2	1.9	
8000.0	-3.0	0.2	2.1	
5600.0	-2.5	0.7	2.8	
4000.0	-2.0	1.3	4.1	
2800.0	-1.5	1.6	5.7	Granule
2000.0	-1.0	1.9	7.7	
1400.0	-0.5	2.8	10.4	Very coarse sand
1000.0	0.0	2.6	13.0	
707.0	0.5	20.3	33.2	Coarse sand
500.0	1.0	23.7	57.0	
353.6	1.5	18.9	75.9	Medium sand
250.0	2.0	11.7	87.6	
176.8	2.5	6.3	93.8	Fine sand
125.0	3.0	2.7	96.6	
83.4	3.5	0.7	97.3	Very fine sand
62.5	4.0	0.0	97.3	
44.2	4.5	0.1	97.5	Coarse silt
31.3	5.0	0.4	97.8	
22.1	5.5	0.4	98.3	Medium silt
15.6	6.0	0.5	98.7	
11.0	6.5	0.4	99.1	Fine silt
7.8	7.0	0.4	99.5	
5.5	7.5	0.2	99.7	Very fine silt
3.9	8.0	0.1	99.8	
2.8	8.5	0.1	99.9	Clay
2.0	9.0	0.1	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



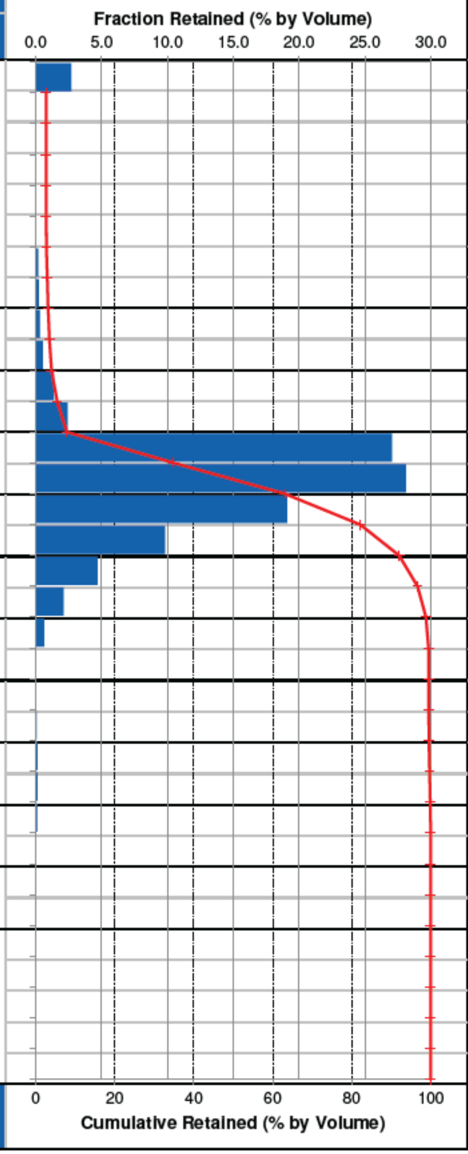
Method of Moments			
Geometric	Mean (µm)	553.51	Wentworth:
Logarithmic	Mean (Phi)	0.85	Coarse sand
	Sorting	1.53	Poor
	Skewness	0.08	Symmetrical
	Kurtosis	9.13	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	526.69	Wentworth:
Logarithmic	Mean (Phi)	0.92	Coarse sand
	Sorting	1.12	Poor
	Skewness	-0.02	Symmetrical
	Kurtosis	1.54	Very leptokurtic
Other Statistics	**Phi (ϕ)**	**µm**	**Wentworth:**
Median (D50)	0.85	553.58	Coarse sand
1st Local Maxima (Mode)	1.00	500.00	Coarse sand
2nd Local Maxima	-0.50	1414.21	Very coarse sand
3rd Local Maxima	-3.50	11313.71	Pebble

Classification		Composition	
Modified Folk	Gravelly sand	Fines	2.70%
EUNIS Folk	Coarse sediments	Sand	89.70%
Distribution	Multimodal	Gravel	7.70%

APPENDIX G PARTICLE SIZE ANALYSIS

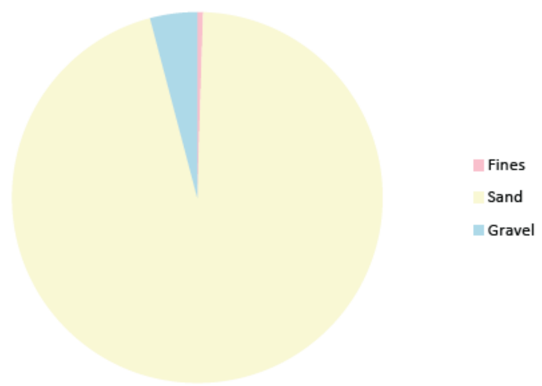
ENV25

Aperature (µm)	Aperature (Phi)	Percentage Fraction	Cumulative Percentage	Sediment Description
45000.0	-5.5	2.7	2.7	Pebble
31500.0	-5.0	0.0	2.7	
22400.0	-4.5	0.0	2.7	
16000.0	-4.0	0.0	2.7	
11200.0	-3.5	0.0	2.7	
8000.0	-3.0	0.0	2.7	
5600.0	-2.5	0.2	2.9	
4000.0	-2.0	0.2	3.2	
2800.0	-1.5	0.3	3.5	Granule
2000.0	-1.0	0.6	4.1	
1400.0	-0.5	1.4	5.4	Very coarse sand
1000.0	0.0	2.4	7.9	
707.0	0.5	27.0	34.9	Coarse sand
500.0	1.0	28.1	63.0	
353.6	1.5	19.1	82.2	Medium sand
250.0	2.0	9.8	92.0	
176.8	2.5	4.7	96.7	Fine sand
125.0	3.0	2.1	98.8	
83.4	3.5	0.7	99.5	Very fine sand
62.5	4.0	0.0	99.5	
44.2	4.5	0.0	99.5	Coarse silt
31.3	5.0	0.1	99.6	
22.1	5.5	0.2	99.7	Medium silt
15.6	6.0	0.1	99.9	
11.0	6.5	0.1	100.0	Fine silt
7.8	7.0	0.0	100.0	
5.5	7.5	0.0	100.0	Very fine silt
3.9	8.0	0.0	100.0	
2.8	8.5	0.0	100.0	Clay
2.0	9.0	0.0	100.0	
1.4	9.5	0.0	100.0	
1.0	10.0	0.0	100.0	
<1	>10	0.0	100.0	



Method of Moments			
Geometric	Mean (µm)	612 07	Wentworth:
Logarithmic	Mean (Phi)	0.71	Coarse sand
	Sorting	1 36	Poor
	Skewness	-2 52	Very coarse
	Kurtosis	15 07	Very leptokurtic
Graphic Folk and Ward			
Geometric	Mean (µm)	559.64	Wentworth:
Logarithmic	Mean (Phi)	0 84	Coarse sand
	Sorting	0 81	Moderate
	Skewness	0 09	Symmetrical
	Kurtosis	1 23	Leptokurtic
Other Statistics	Phi (ϕ)	µm	Wentworth:
Median (D50)	0.77	587.18	Coarse sand
1st Local Maxima (Mode)	1 00	500.00	Coarse sand
2nd Local Maxima	-5.50	45254 83	Pebble
3rd Local Maxima	-	-	-

Classification		Composition	
Modified Folk	Slightly gravelly sand	Fines	0.50%
EUNIS Folk	Sand and muddy sand	Sand	95.40%
Distribution	Bimodal	Gravel	4.10%



APPENDIX H SPEARMAN'S RANK CORRELATIONS

APPENDIX H SPEARMAN'S RANK CORRELATIONS

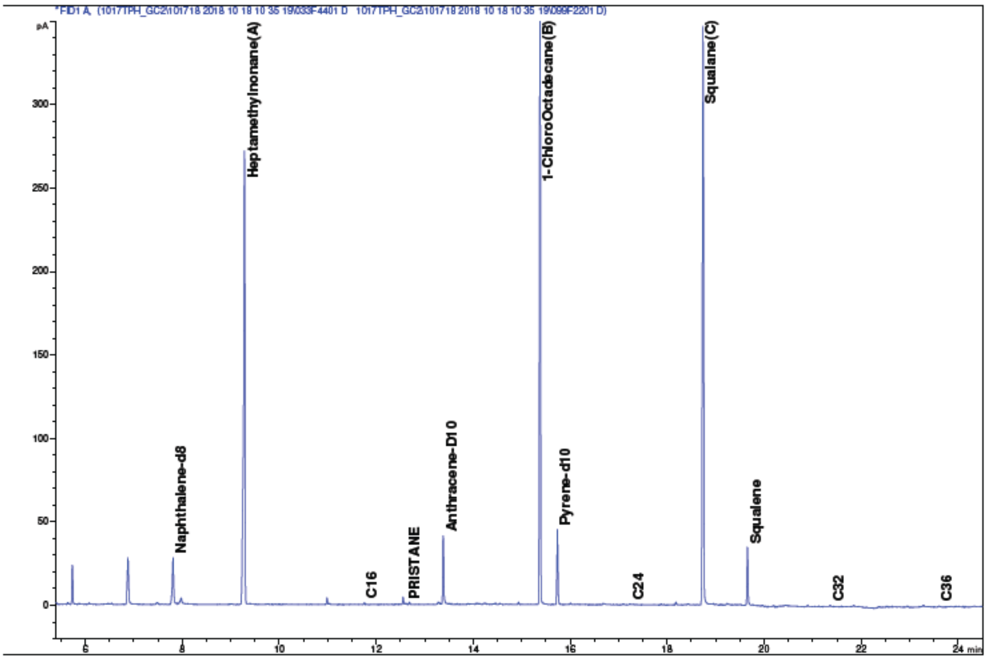
Stations	Depth (m LAT)	Mean Diameter (µm)	Fines %	Sand %	Gravel %	Sorting Value	Total Organic Carbon %	Arsenic	Chromium	Copper	Lead	Nickel	Vanadium	Zinc	THC	nC10-20	nC10-37	Pristane (Pr)	NPD	Total PAH
Dixon's test for high outliers (n=14 to 25)	0.10	0.24	0.35	0.08	0.62	0.57	0.45	0.39	0.49	0.69	0.32	0.32	0.45	0.22	0.29	0.45	0.37	0.45	0.46	0.42
Dixon's test for low outliers (n=14 to 25)	0.14	0.11	0.05	0.60	0.00	0.01	0.14	0.01	0.12	0.30	0.07	0.11	0.09	0.25	0.20	0.09	0.10	0.04	0.13	0.15
ENV1	35	356	0.0	100.0	0.0	0.52	0.09	5.9	5.8	5.9	3.8	2.9	13.6	11.3	3.2	0.037	0.114	0.013	0.015	0.036
ENV2	33	584	0.6	95.8	3.6	0.80	0.11	21	8.7	7.2	6.3	7.9	31.7	21.0	5.5	0.116	0.264	0.048	0.036	0.082
ENV4	36	308	6.9	93.1	0.0	0.89	0.17	4.4	8.1	7.1	5.1	4.2	16.1	15.1	6.9	0.071	0.163	0.032	0.060	0.142
ENV5	38	424	0.7	98.7	0.6	0.68	0.15	15.8	6.3	5.6	5.4	3.6	23.1	21.7	3.8	0.043	0.147	0.020	0.019	0.058
ENV6	38	374	4.1	94.9	1.0	0.74	0.12	10.9	6.9	6.1	5.1	3.5	21.4	16.8	3.7	0.029	0.080	0.016	0.021	0.052
ENV8	41	296	4.3	95.7	0.0	0.53	0.13	4.3	7.7	5.7	5.2	4.0	16.0	16.9	4.0	0.034	0.106	0.014	0.027	0.075
ENV9	43	282	10.1	89.9	0.0	1.08	0.29	5.3	8.9	6.5	5.8	5.2	19.3	20.9	6.0	0.058	0.163	0.024	0.050	0.125
ENV10	43	272	5.4	94.6	0.0	0.72	0.15	4.2	7.9	7.2	5.7	4.0	15.7	18.5	7.5	0.047	0.162	0.029	0.056	0.159
ENV11	42	279	4.8	95.2	0.0	0.52	0.10	5.0	7.8	5.9	4.7	3.5	15.6	15.7	5.3	0.026	0.103	0.011	0.020	0.065
ENV14	42	245	6.3	93.7	0.0	0.79	0.13	4.2	7.3	6.2	5.2	3.8	16.0	15.2	3.7	0.024	0.093	0.010	0.020	0.058
ENV15	51	329	4.7	95.3	0.0	0.76	0.11	7.2	9.5	6.2	7.2	4.1	26.5	19.5	5.9	0.048	0.182	0.016	0.050	0.145
ENV16	48	440	7.4	83.5	9.1	1.70	0.16	31.8	10	7.3	12.2	6.0	55.3	22.4	5.4	0.045	0.165	0.019	0.056	0.149
ENV17	50	648	15.3	61.0	23.8	3.27	0.19	24.2	13.5	6.5	10.8	8.0	50.3	24.8	8.6	0.079	0.283	0.023	0.097	0.248
ENV18	46	561	0.0	100.0	0.0	0.66	0.06	13.7	6.4	6.2	6.8	5.2	24.9	23.1	2.7	0.011	0.030	0.006	0.007	0.013
ENV19	57	444	13.7	70.9	15.4	2.68	0.19	6.8	9.1	7.2	7.4	4.6	22.9	22.1	6.3	0.046	0.195	0.012	0.058	0.159
ENV20	47	388	2.7	97.4	0.0	0.73	0.08	4.9	6.1	6.9	4.1	3.1	16.5	13.7	3.3	0.016	0.041	0.006	0.014	0.037
ENV21	60	416	7.0	93.0	0.0	1.19	0.12	7.5	10	6.2	7.6	4.3	26.7	17.7	5.0	0.029	0.099	0.010	0.036	0.100
ENV22	59	452	4.0	96.0	0.0	0.73	0.09	15.3	9.7	6.2	9.6	4.3	37.6	22.4	3.8	0.023	0.074	0.006	0.027	0.083
ENV23	58	506	1.5	98.5	0.0	0.63	0.05	6.1	6.6	5.0	3.7	3.3	20.5	10.8	1.6	0.012	0.047	0.005	0.010	0.019
ENV24	56	527	2.7	89.7	7.7	1.12	0.11	20	9.1	10.8	8.5	6.5	33.2	22.1	3.3	0.043	0.097	0.022	0.051	0.103
ENV25	58	560	0.5	95.4	4.1	0.81	0.07	18.5	7.1	7.4	8.0	4.9	32.4	18.3	2.5	0.024	0.076	0.007	0.015	0.039
Depth (m LAT)		0.38	0.19	-0.26	0.14	0.36	-0.22	0.28	0.46	0.24	0.55	0.27	0.54	0.29	-0.14	-0.34	-0.26	-0.50	0.06	0.18
Mean Diameter (µm)			-0.32	0.08	0.61	0.32	-0.29	0.83	0.17	0.28	0.51	0.56	0.77	0.54	-0.23	-0.06	-0.05	-0.14	-0.05	-0.10
Fines %				-0.87	0.17	0.62	0.81	-0.15	0.71	0.23	0.32	0.29	0.06	0.20	0.76	0.49	0.55	0.35	0.76	0.80
Sand %					-0.48	-0.82	-0.73	-0.11	-0.75	-0.55	-0.51	-0.53	-0.28	-0.32	-0.64	-0.53	-0.53	-0.45	-0.82	-0.80
Gravel %						0.63	0.32	0.73	0.35	0.52	0.57	0.57	0.63	0.56	0.19	0.36	0.41	0.32	0.41	0.35
Sorting Value							0.57	0.43	0.71	0.70	0.68	0.71	0.61	0.46	0.46	0.50	0.47	0.36	0.68	0.65
Total Organic Carbon %								-0.07	0.49	0.24	0.26	0.34	0.01	0.30	0.81	0.75	0.74	0.70	0.78	0.76
Arsenic									0.37	0.31	0.69	0.63	0.90	0.68	-0.06	0.15	0.17	0.11	0.12	0.10
Chromium										0.44	0.77	0.69	0.60	0.57	0.65	0.52	0.55	0.36	0.80	0.84
Copper											0.58	0.66	0.44	0.40	0.29	0.37	0.28	0.36	0.53	0.51
Lead												0.84	0.85	0.86	0.30	0.27	0.30	0.17	0.50	0.57
Nickel													0.74	0.80	0.38	0.46	0.42	0.39	0.56	0.53
Vanadium														0.74	0.04	0.12	0.13	0.04	0.27	0.29
Zinc															0.34	0.30	0.33	0.24	0.42	0.47
THC																0.84	0.84	0.73	0.88	0.89
nC10-20																	0.94	0.92	0.82	0.76
nC10-37																		0.78	0.78	0.76
Pristane (Pr)																			0.73	0.65
NPD																				0.96
Total PAH																				

Critical Values Outliers Test
p < 0.01 if value >= 0.524
p < 0.05 if value >= 0.44

Critical Values Spearmans Test
p < 0.01 if value >= 0.556
p < 0.05 if value >= 0.438

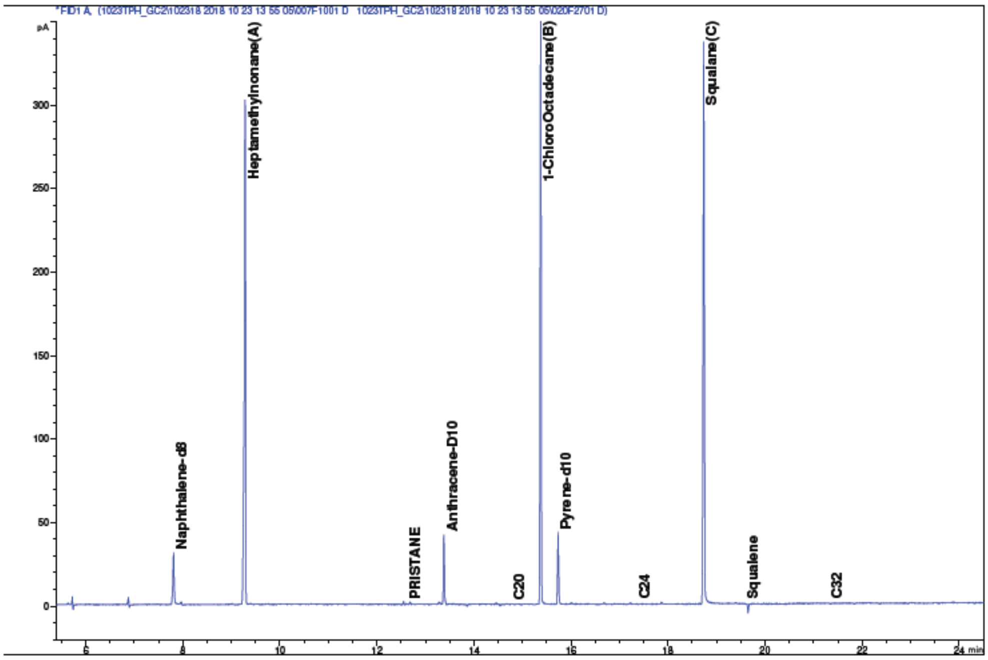
APPENDIX I HYDROCARBON ANALYSIS

APPENDIX I HYDROCARBON ANALYSIS



Blank for Batch 1

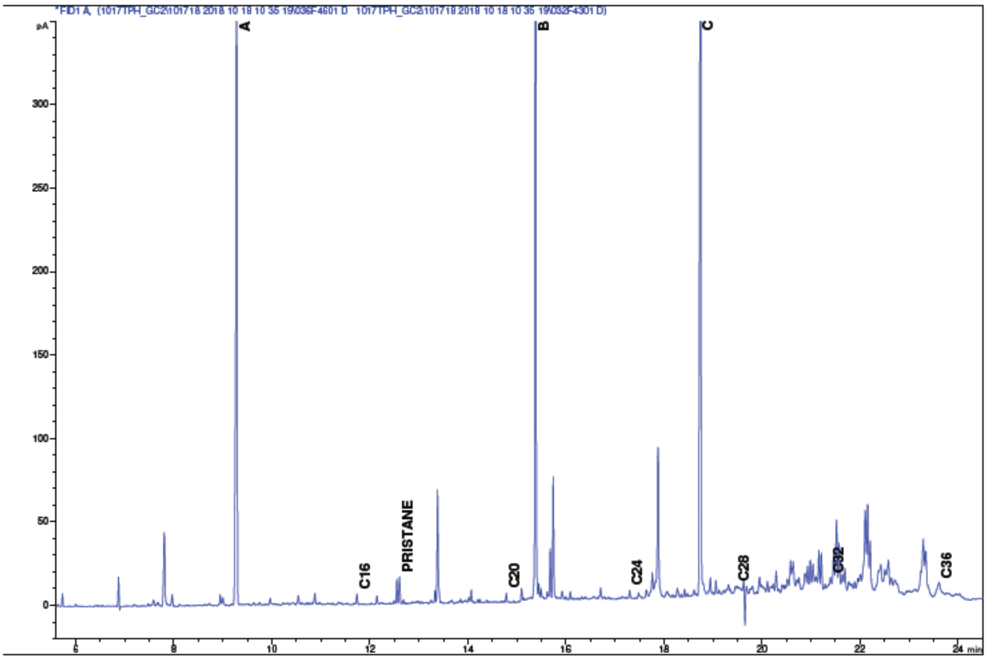
(ENV1 to ENV15)



Blank for Batch 2

(ENV16 to ENV25)

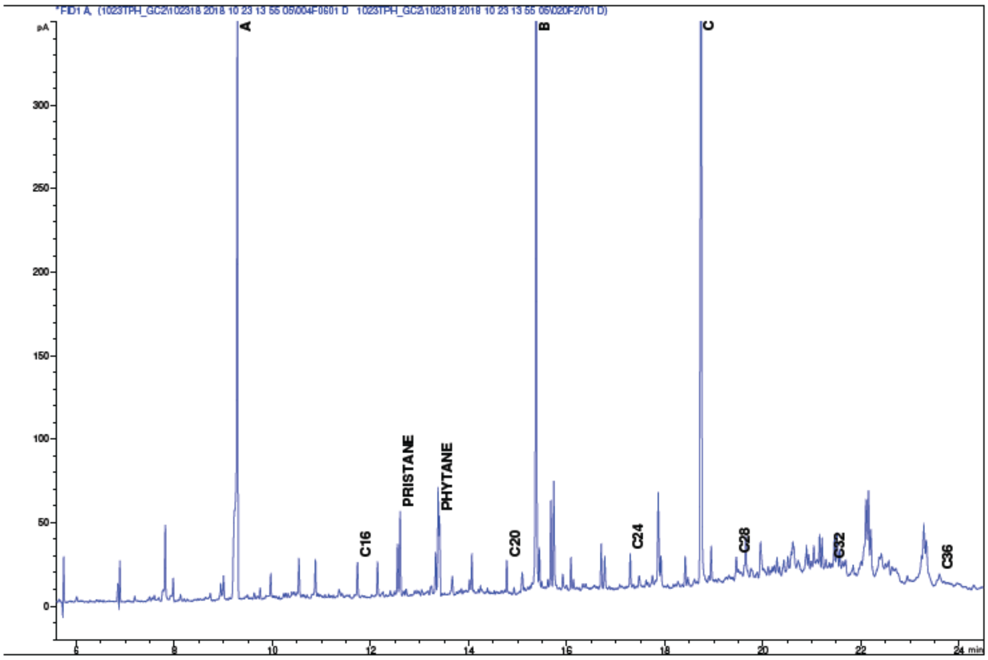
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV1

THC: 3.248µg g^{-1}

n-Alkanes: 0.114µg g^{-1}

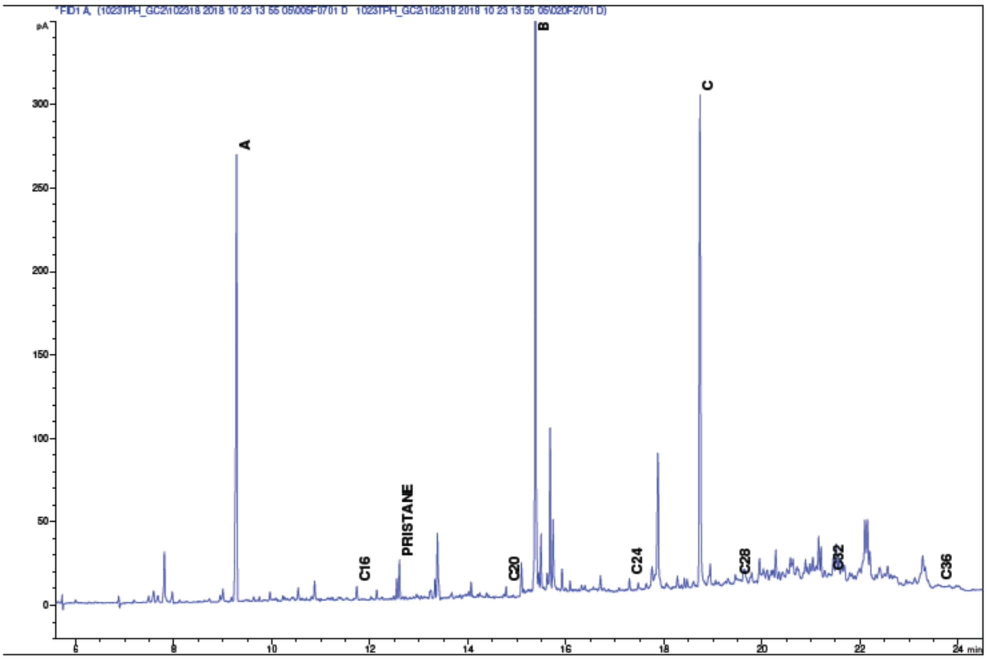


11210 ENV2

THC: 5.547µg g^{-1}

n-Alkanes: 0.264µg g^{-1}

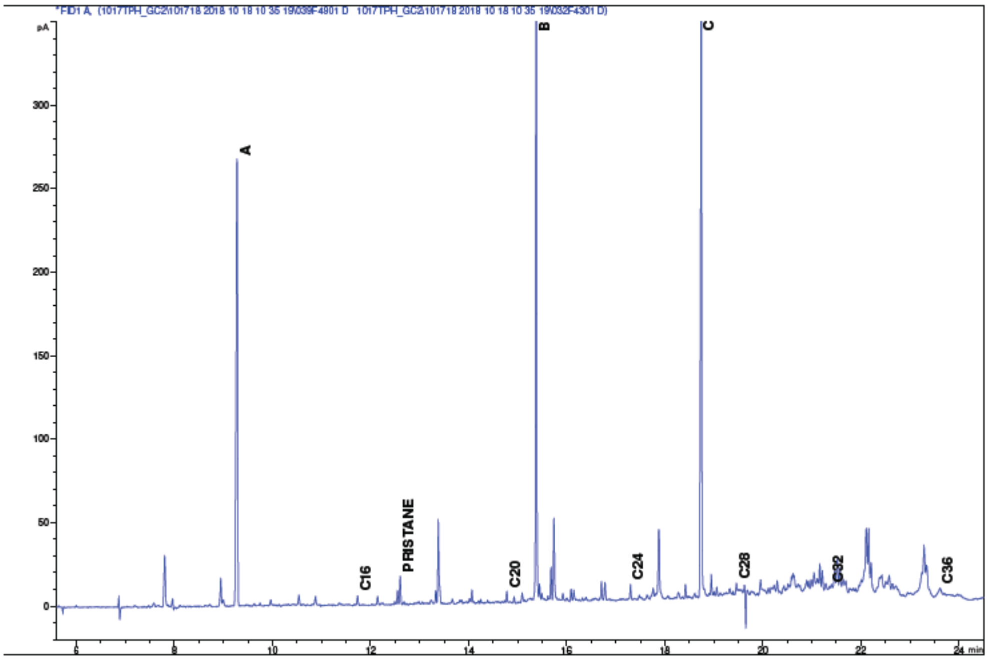
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV4

THC: 6.884µg g^{-1}

n-Alkanes: 0.220µg g^{-1}

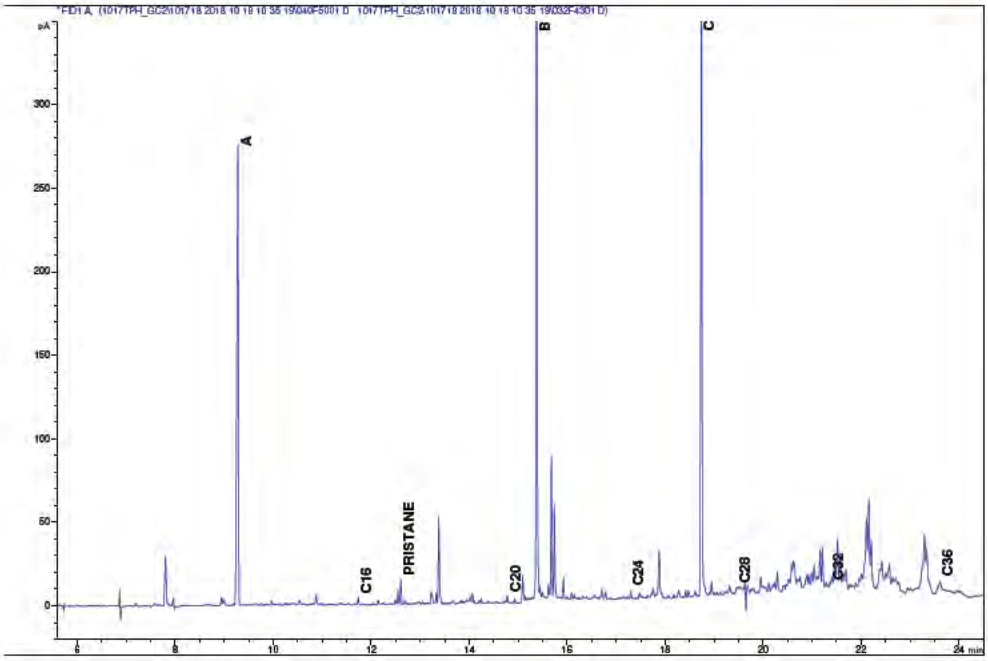


11210 ENV5

THC: 3.820µg g^{-1}

n-Alkanes: 0.147µg g^{-1}

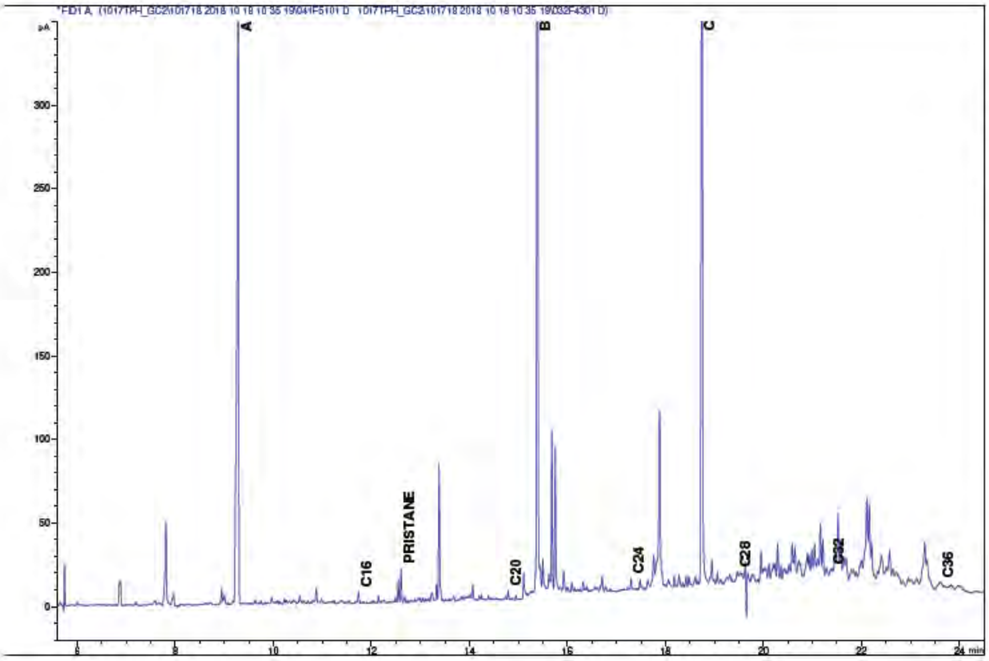
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV6

THC: 3.742µg g^{-1}

n-Alkanes: 0.080µg g^{-1}

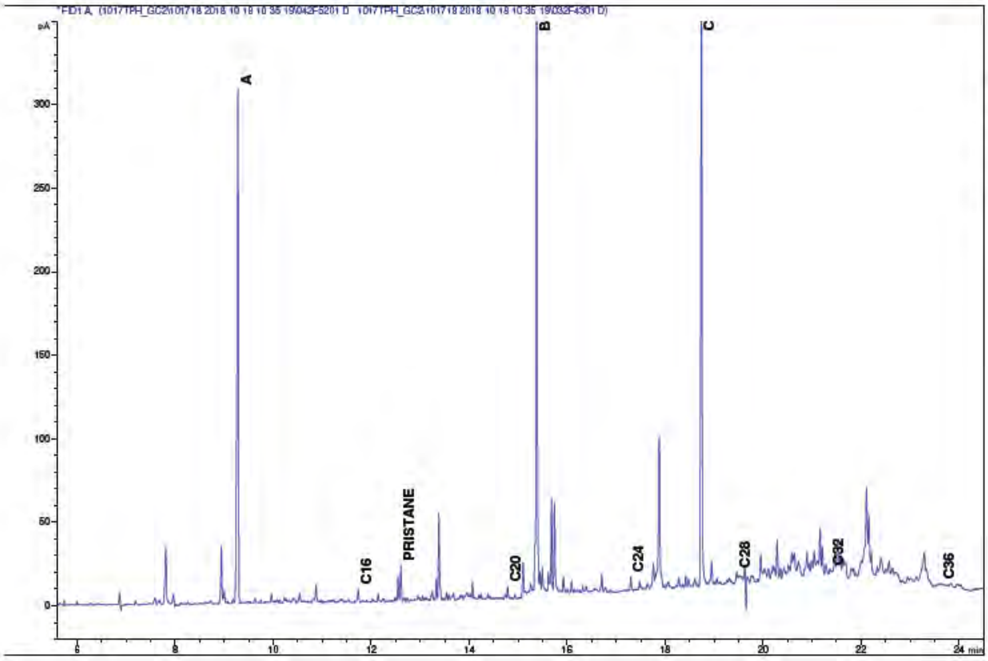


11210 ENV8

THC: 4.035µg g^{-1}

n-Alkanes: 0.106µg g^{-1}

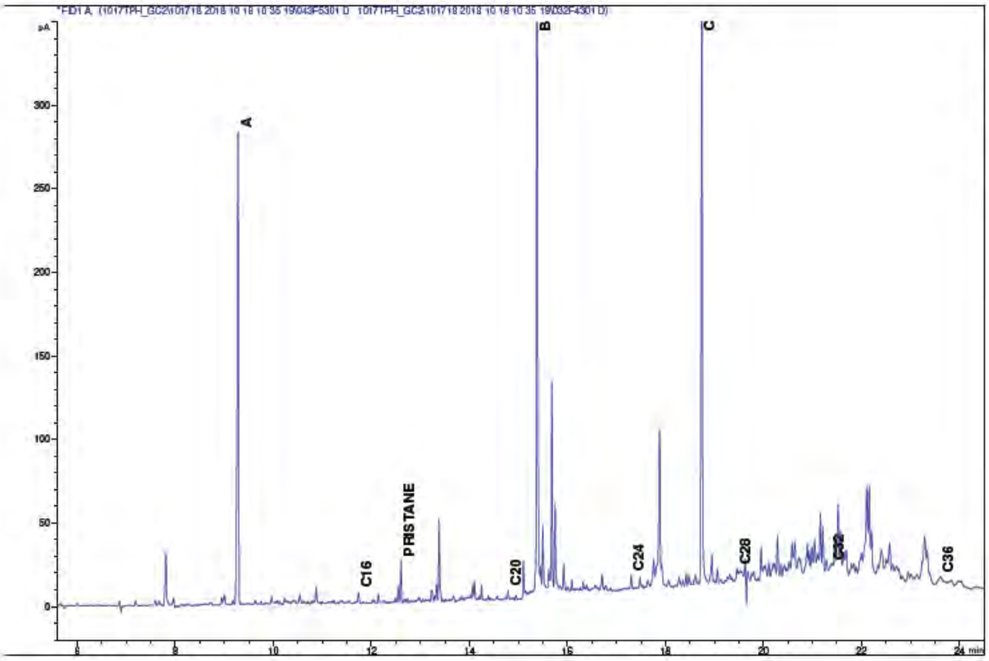
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV9

THC: 6.035µg g^{-1}

n-Alkanes: 0.163µg g^{-1}

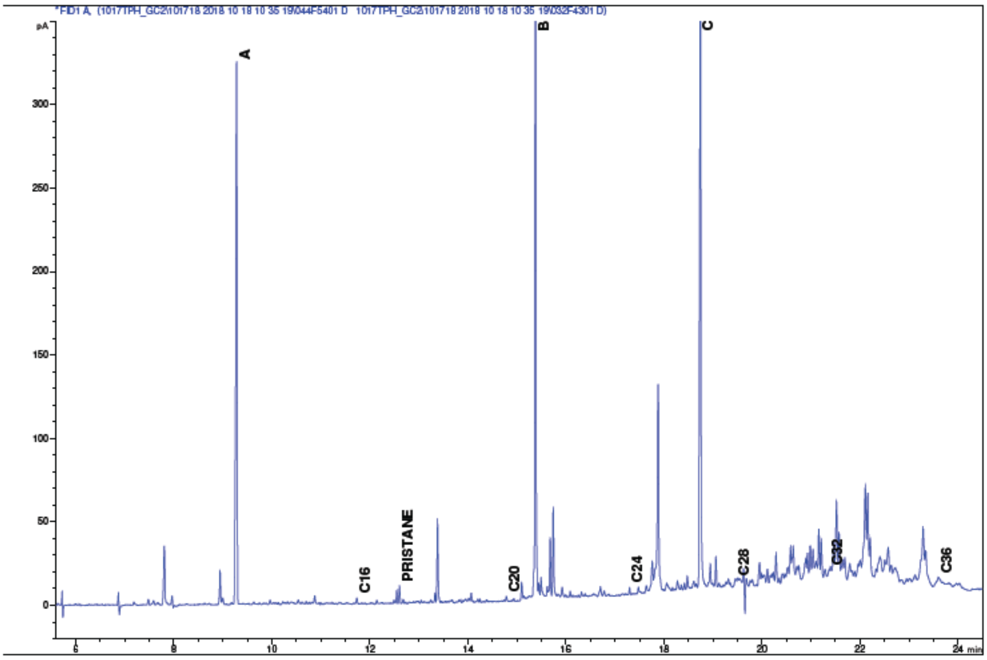


11210 ENV10

THC: 7.525µg g^{-1}

n-Alkanes: 0.162µg g^{-1}

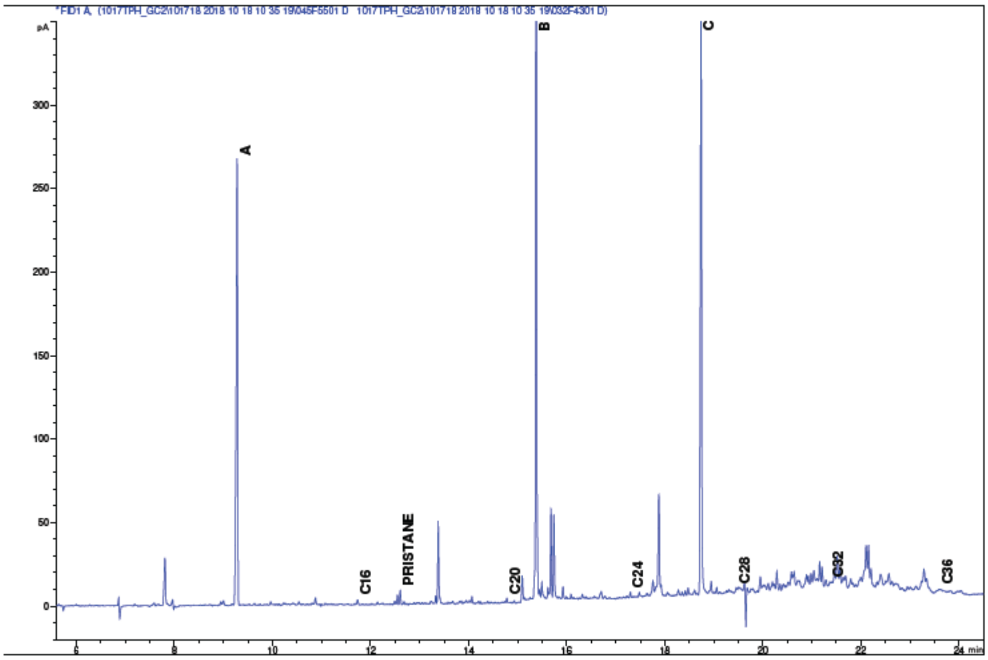
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV11

THC: 5.251µg g^{-1}

n-Alkanes: 0.103µg g^{-1}

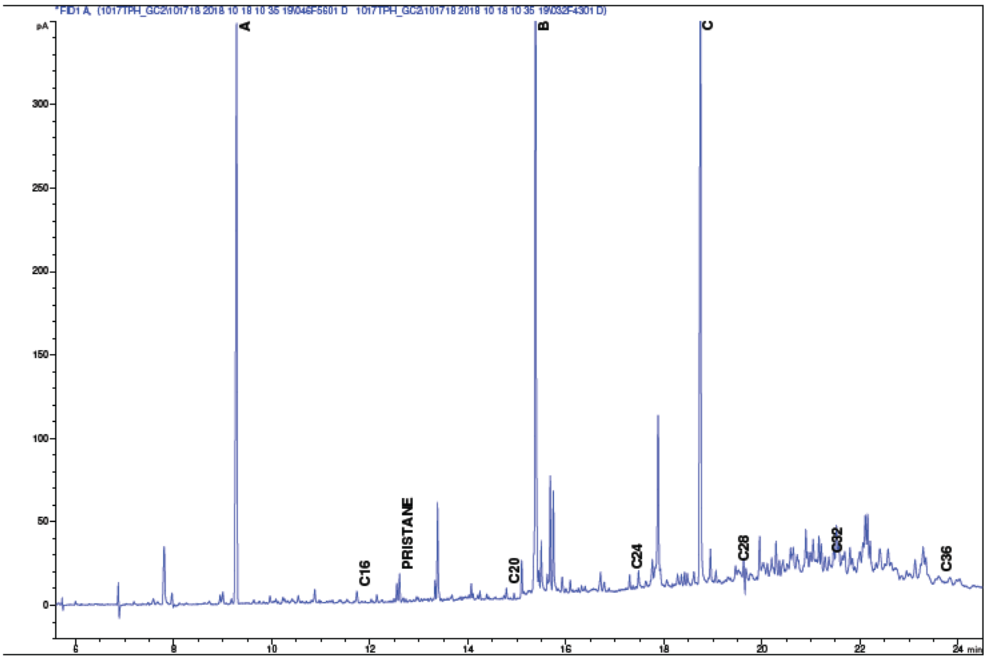


11210 ENV14

THC: 3.698µg g^{-1}

n-Alkanes: 0.093µg g^{-1}

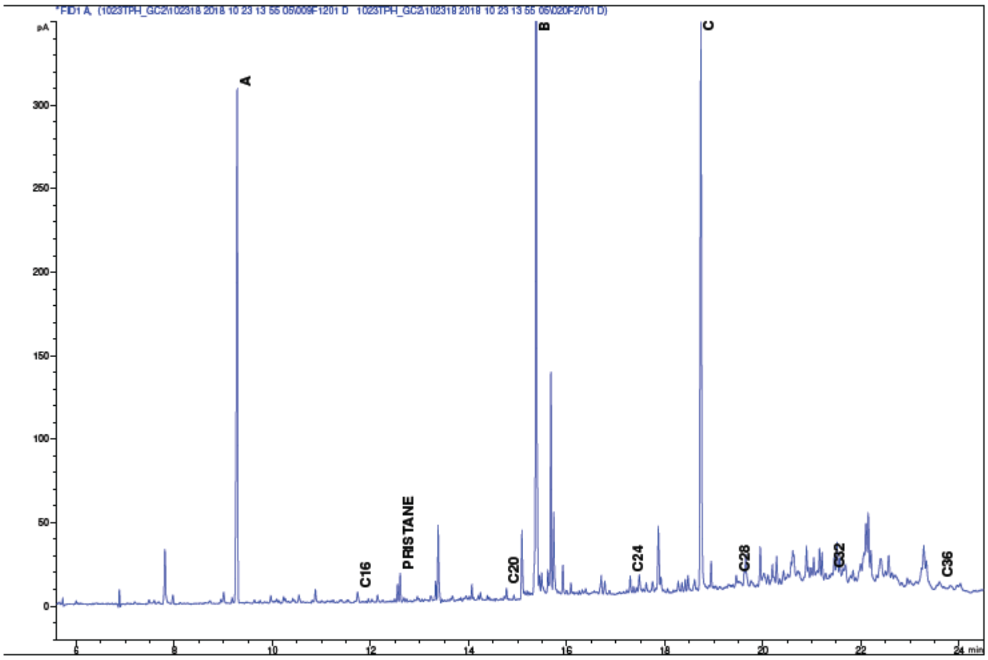
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV15

THC: 5.886µg g^{-1}

n-Alkanes: 0.182µg g^{-1}

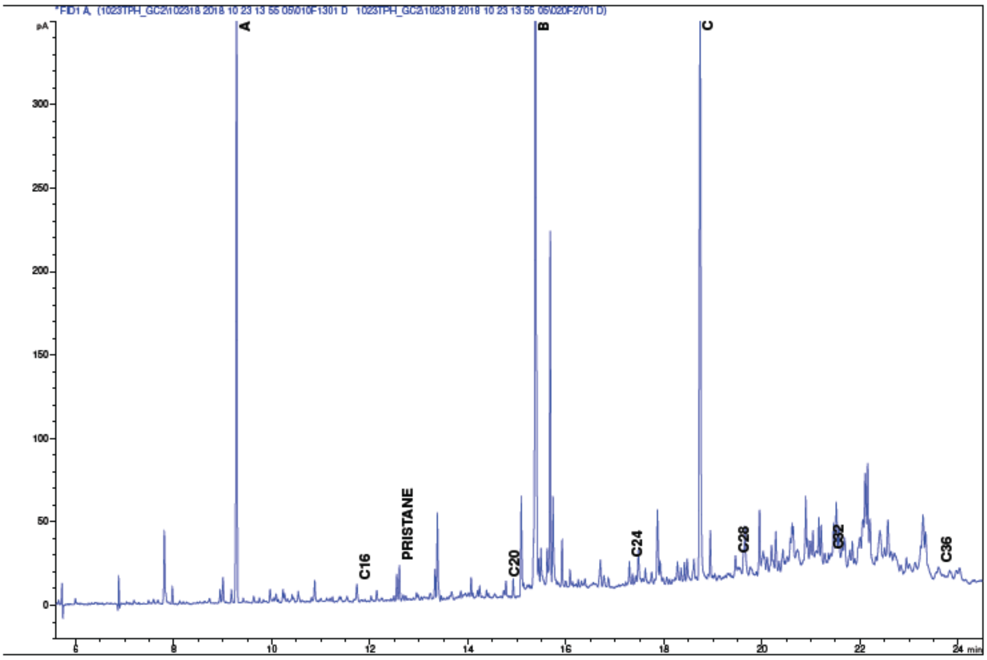


11210 ENV16

THC: 5.372µg g^{-1}

n-Alkanes: 0.165µg g^{-1}

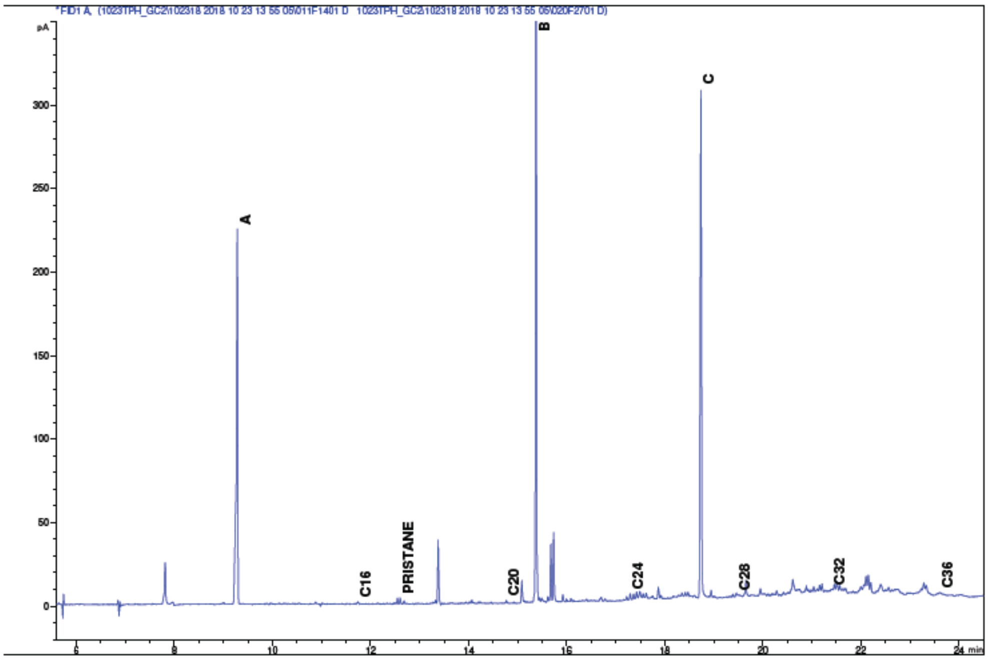
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV17

THC: 8.584µg g^{-1}

n-Alkanes: 0.283µg g^{-1}

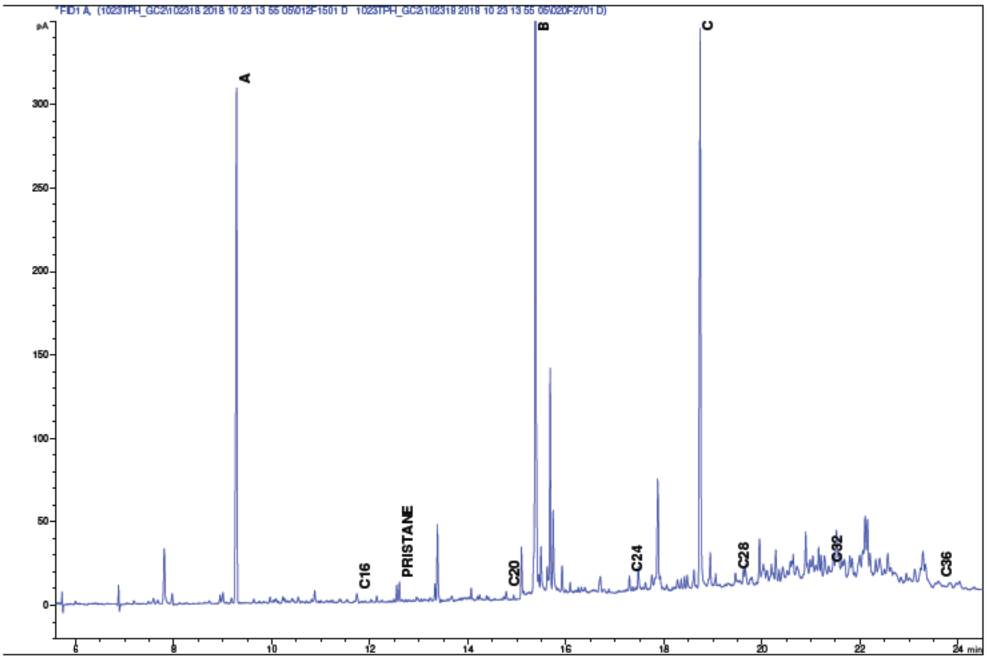


11210 ENV18

THC: 2.696µg g^{-1}

n-Alkanes: 0.030µg g^{-1}

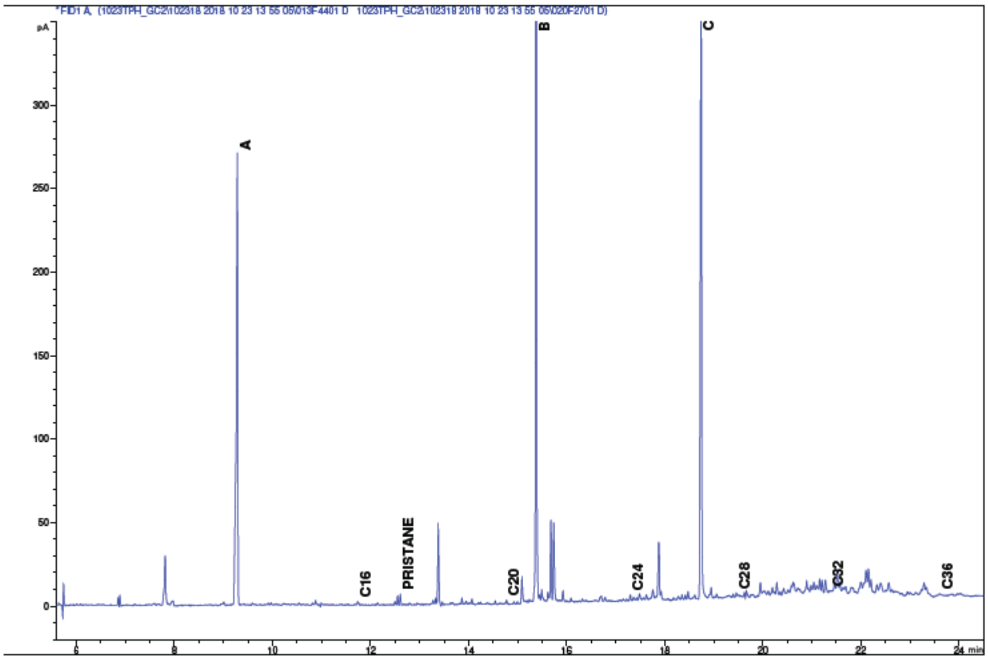
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV19

THC: 6.286µg g^{-1}

n-Alkanes: 0.195µg g^{-1}

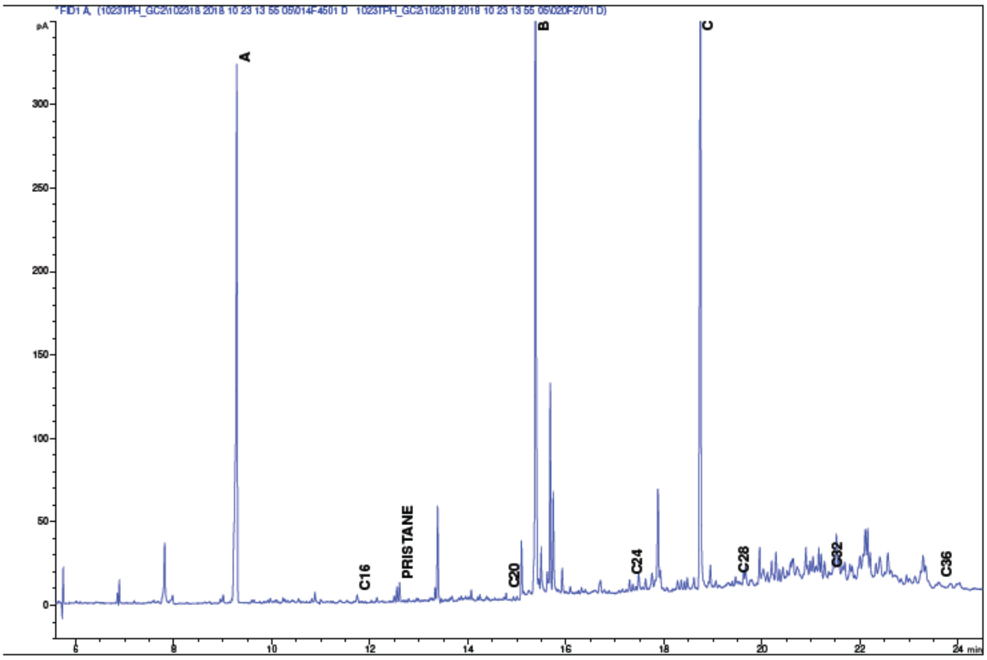


11210 ENV20

THC: 3.258µg g^{-1}

n-Alkanes: 0.041µg g^{-1}

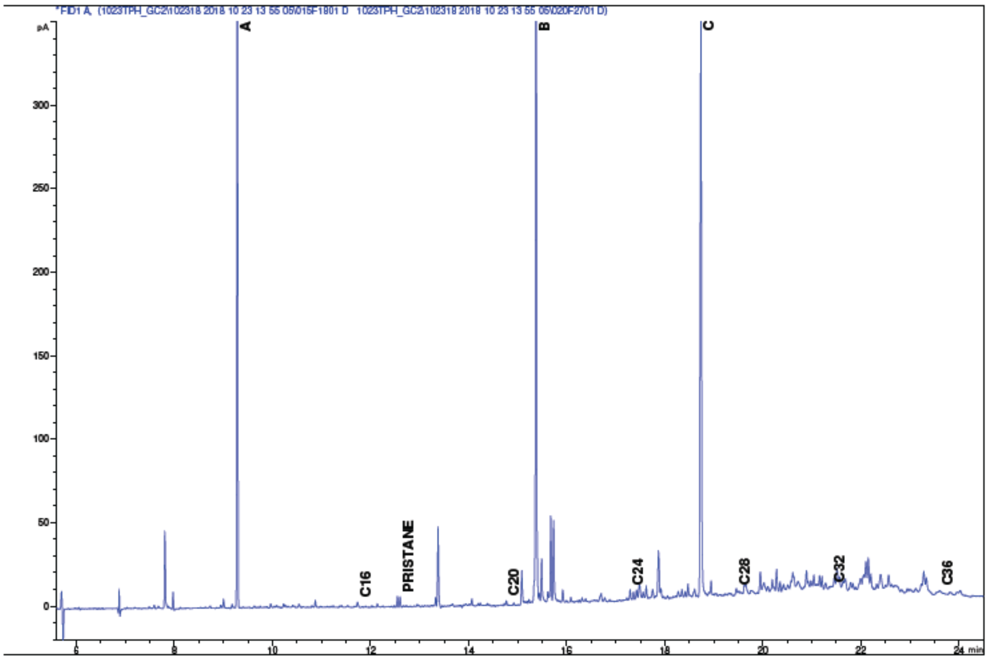
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV21

THC: 5.034µg g^{-1}

n-Alkanes: 0.099µg g^{-1}

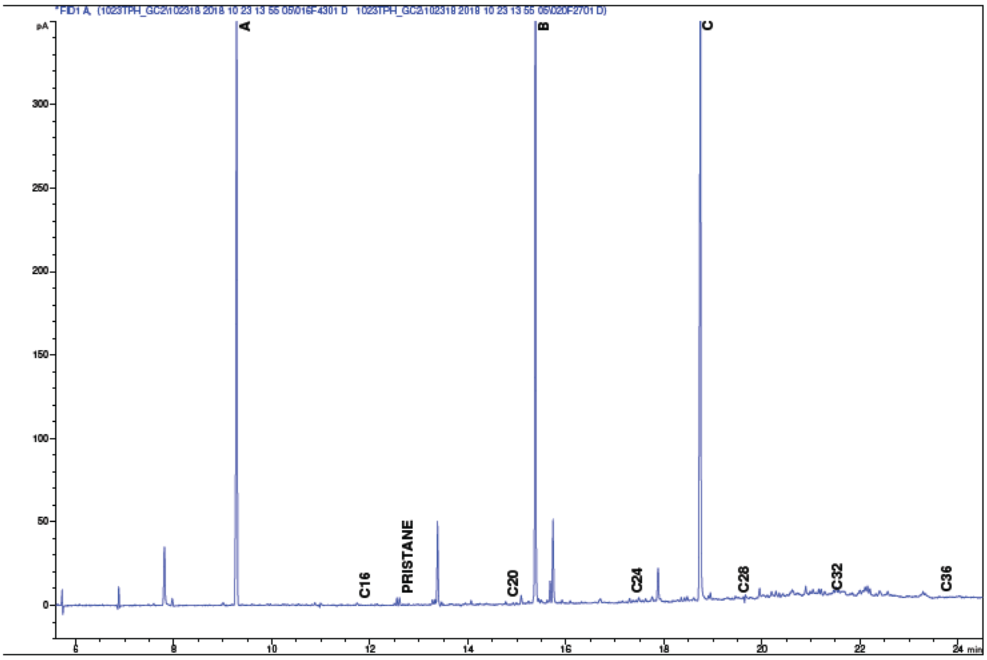


11210 ENV22

THC: 3.805µg g^{-1}

n-Alkanes: 0.074µg g^{-1}

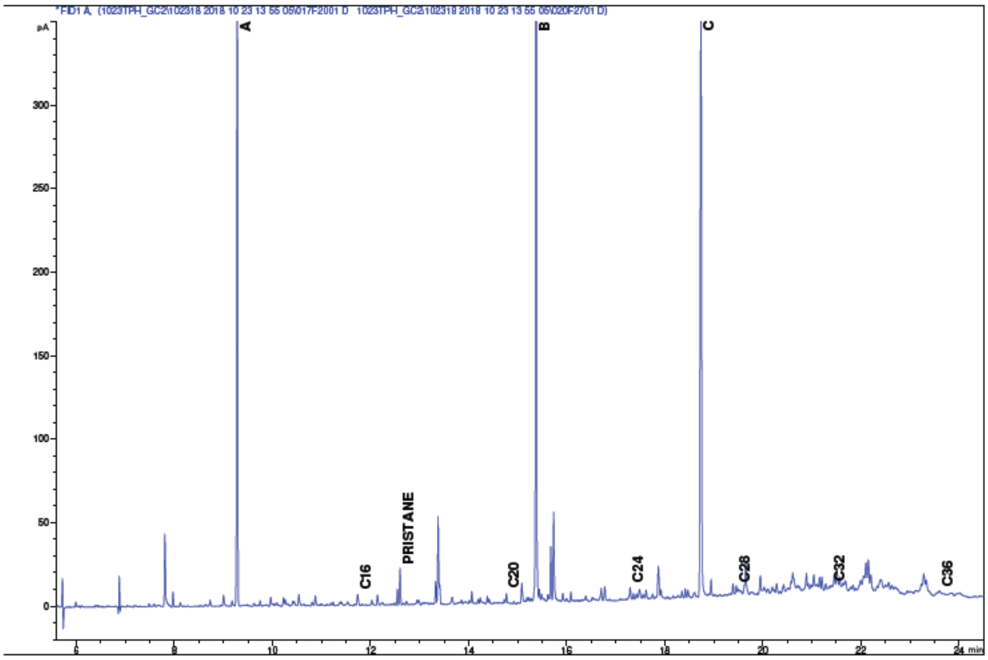
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV23

THC: 1.628µg g^{-1}

n-Alkanes: 0.047µg g^{-1}

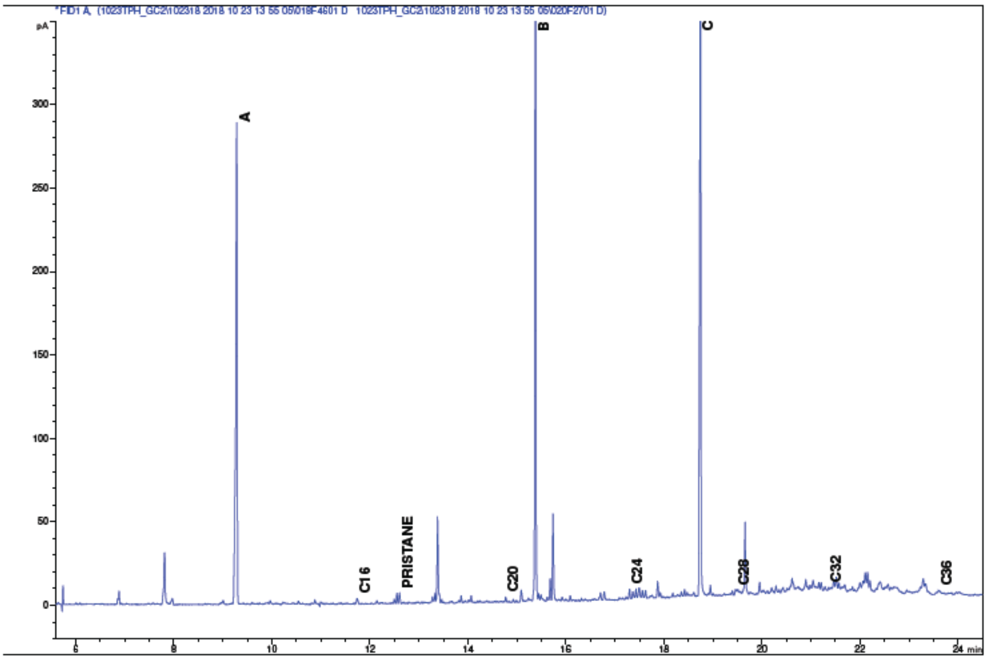


11210 ENV24

THC: 3.296µg g^{-1}

n-Alkanes: 0.097µg g^{-1}

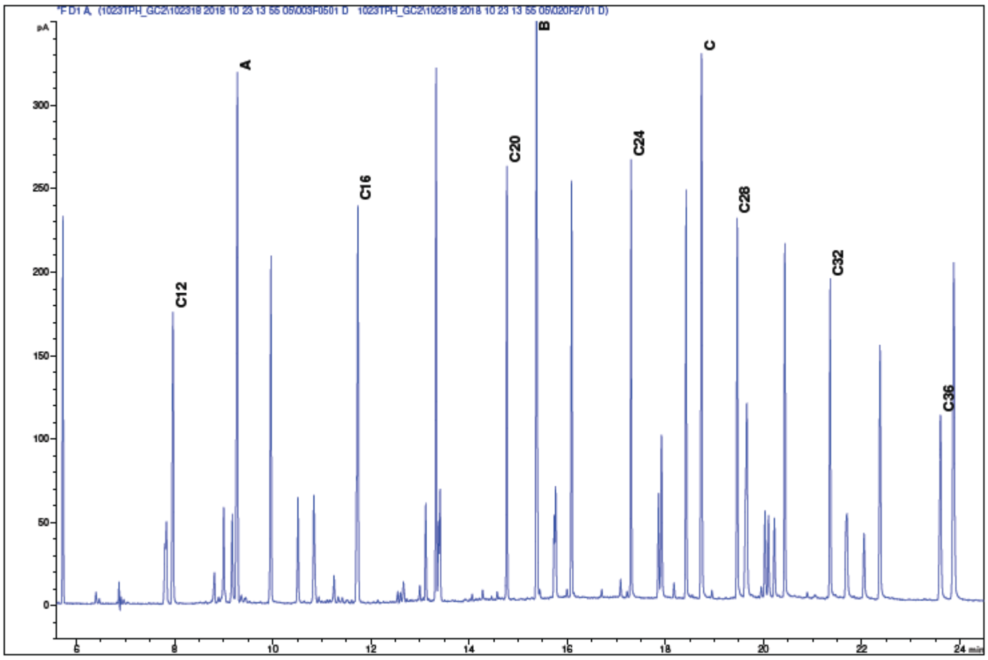
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV25

THC: 2.454µg g⁻¹

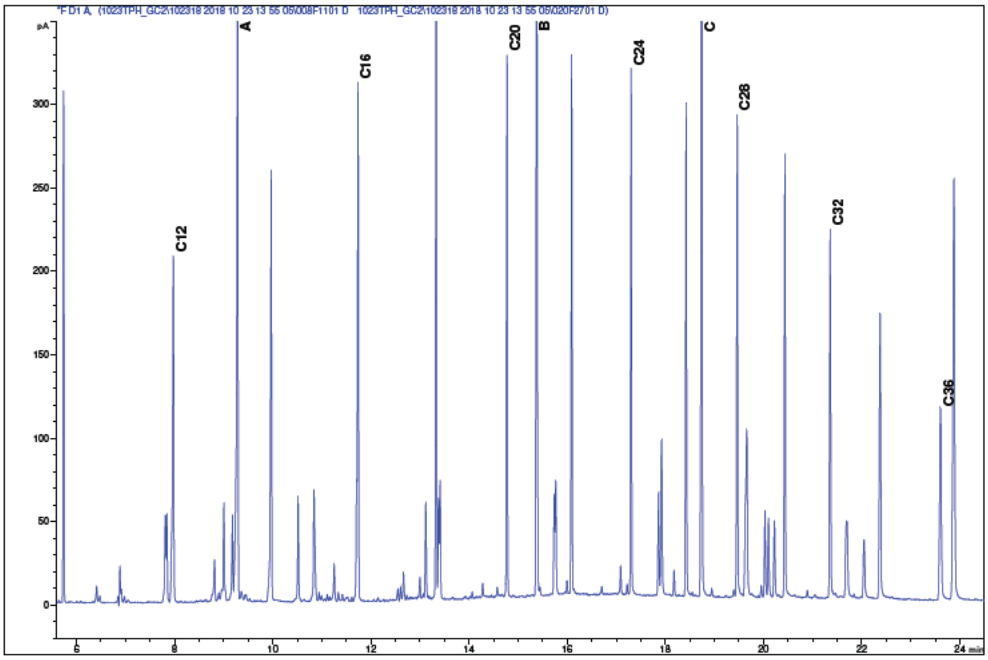
n-Alkanes: 0.076µg g⁻¹



Reference Material for Batch 1

(ENV1 to ENV15)

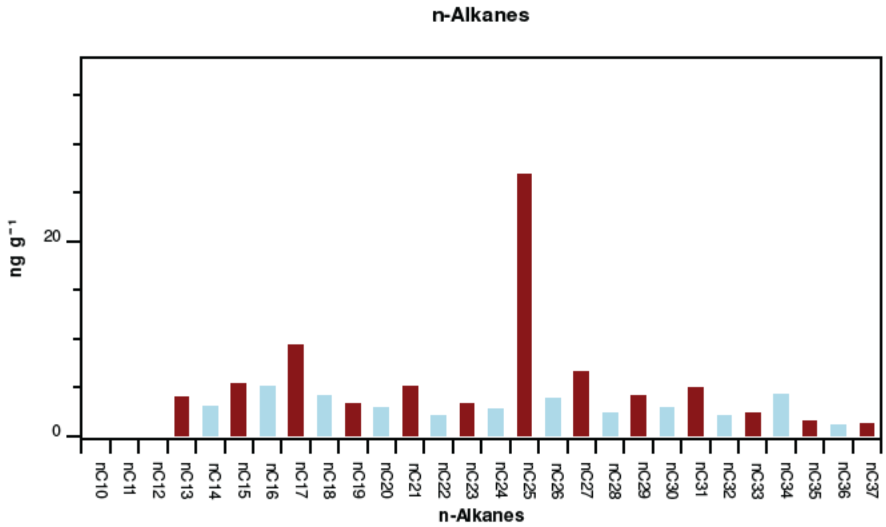
APPENDIX I HYDROCARBON ANALYSIS



Reference Material for Batch 2

(ENV16 to ENV25)

APPENDIX I HYDROCARBON ANALYSIS



11210 ENV1

nC10-nC20: 37ng g^{-1}

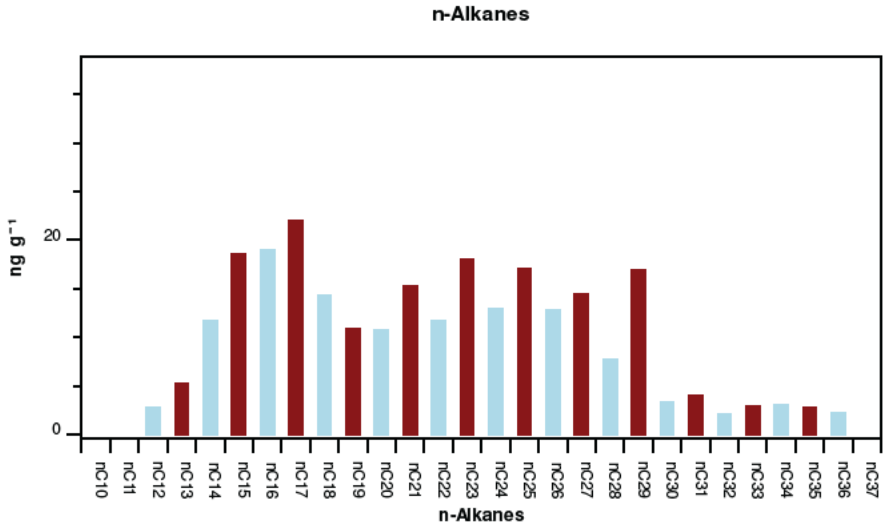
nC21-nC37: 77ng g^{-1}

nC10-nC37: 114ng g^{-1}

Odd Length n-Alkanes: 78ng g^{-1}

Even Length n-Alkanes: 36ng g^{-1}

CPI: 1.9



11210 ENV2

nC10-nC20: 116ng g^{-1}

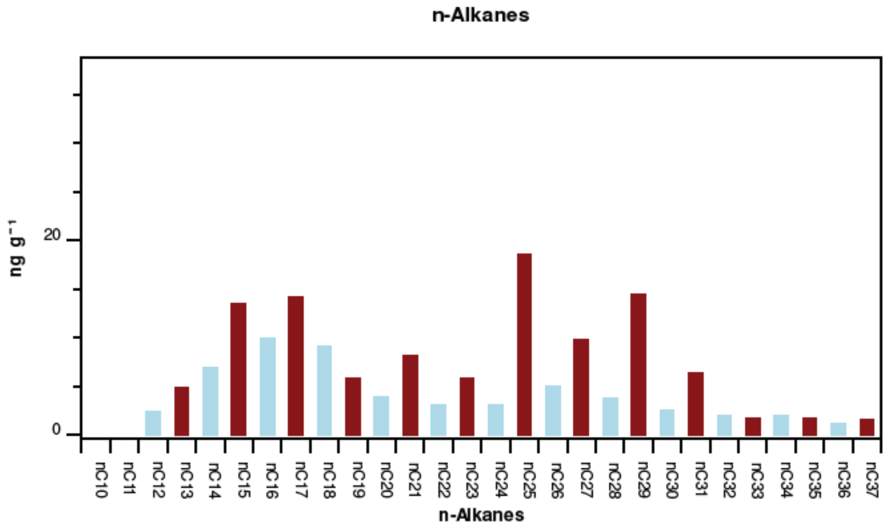
nC21-nC37: 148ng g^{-1}

nC10-nC37: 264ng g^{-1}

Odd Length n-Alkanes: 149ng g^{-1}

Even Length n-Alkanes: 115ng g^{-1}

CPI: 2.0



11210 ENV4

nC10-nC20: 71ng g^{-1}

nC21-nC37: 92ng g^{-1}

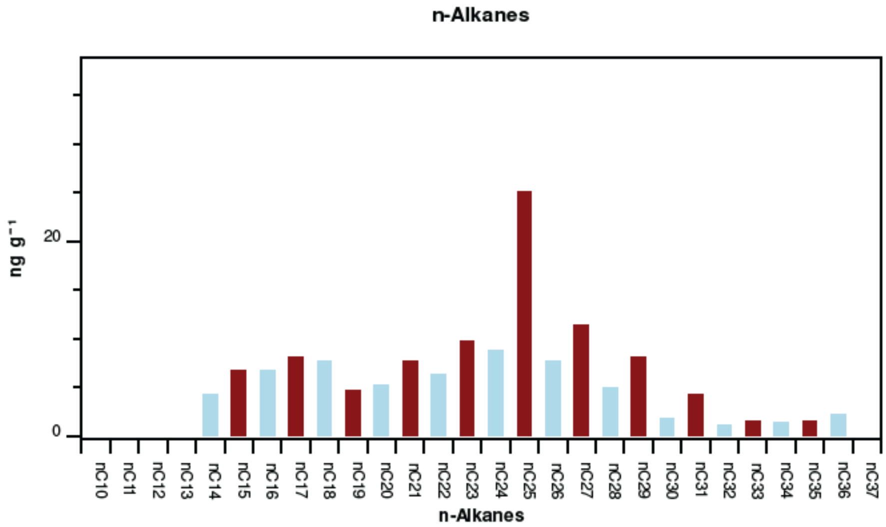
nC10-nC37: 163ng g^{-1}

Odd Length n-Alkanes: 107ng g^{-1}

Even Length n-Alkanes: 55ng g^{-1}

CPI: 3.2

APPENDIX I HYDROCARBON ANALYSIS



11210 ENV5

nC10-nC20: 43ng g^{-1}

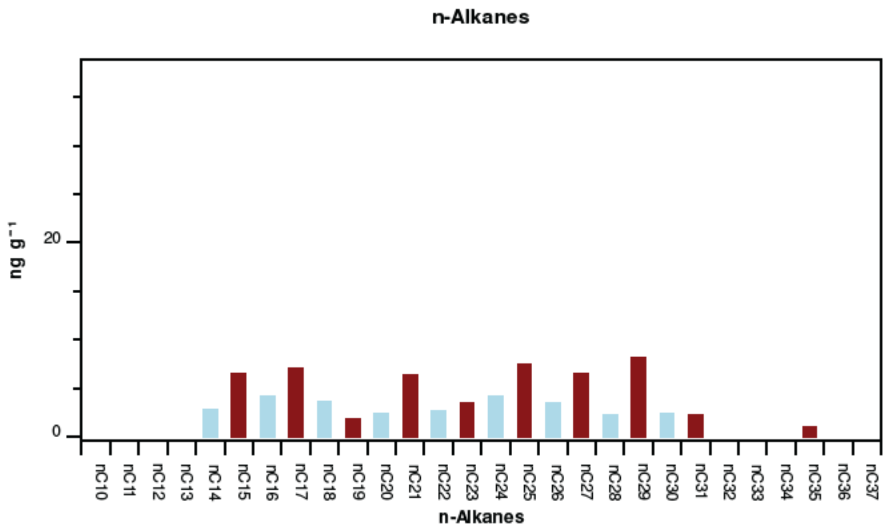
nC21-nC37: 104ng g^{-1}

nC10-nC37: 147ng g^{-1}

Odd Length n-Alkanes: 89ng g^{-1}

Even Length n-Alkanes: 58ng g^{-1}

CPI: 2.0



11210 ENV6

nC10-nC20: 29ng g^{-1}

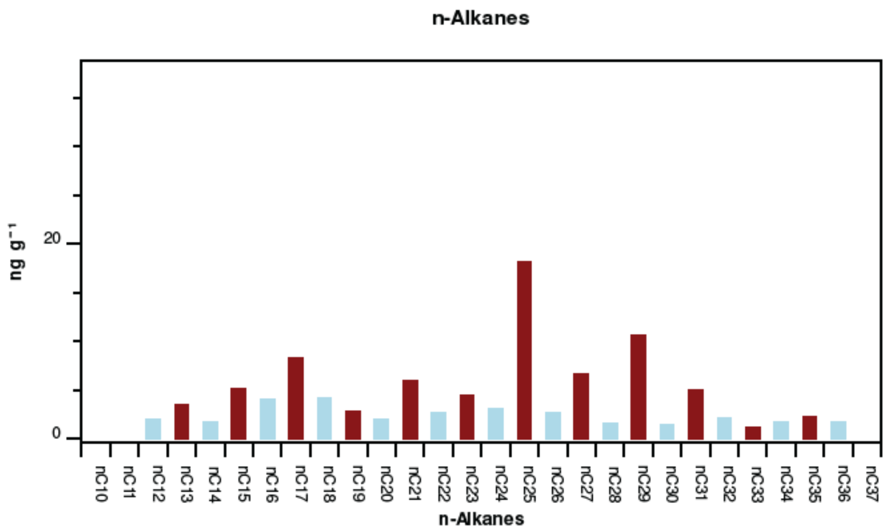
nC21-nC37: 51ng g^{-1}

nC10-nC37: 80ng g^{-1}

Odd Length n-Alkanes: 51ng g^{-1}

Even Length n-Alkanes: 29ng g^{-1}

CPI: 2.8



11210 ENV8

nC10-nC20: 34ng g^{-1}

nC21-nC37: 72ng g^{-1}

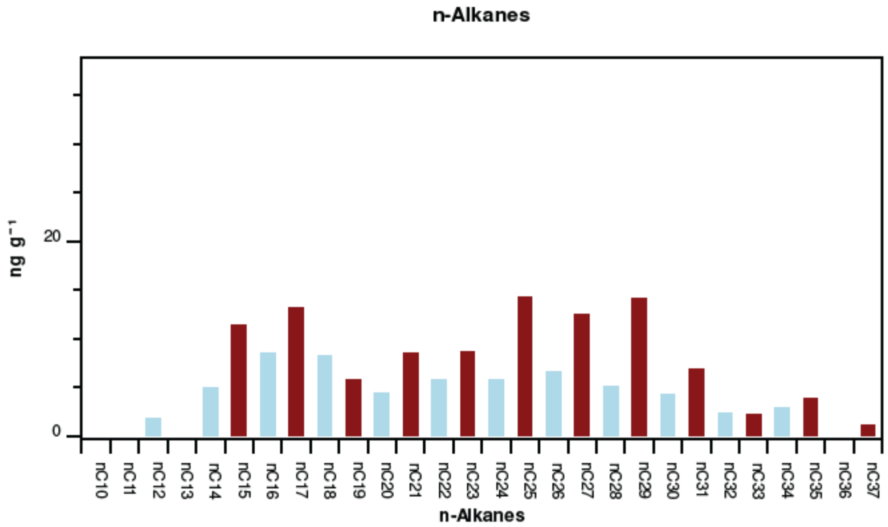
nC10-nC37: 106ng g^{-1}

Odd Length n-Alkanes: 75ng g^{-1}

Even Length n-Alkanes: 32ng g^{-1}

CPI: 4.6

APPENDIX I HYDROCARBON ANALYSIS



11210 ENV9

nC10-nC20: 58ng g^{-1}

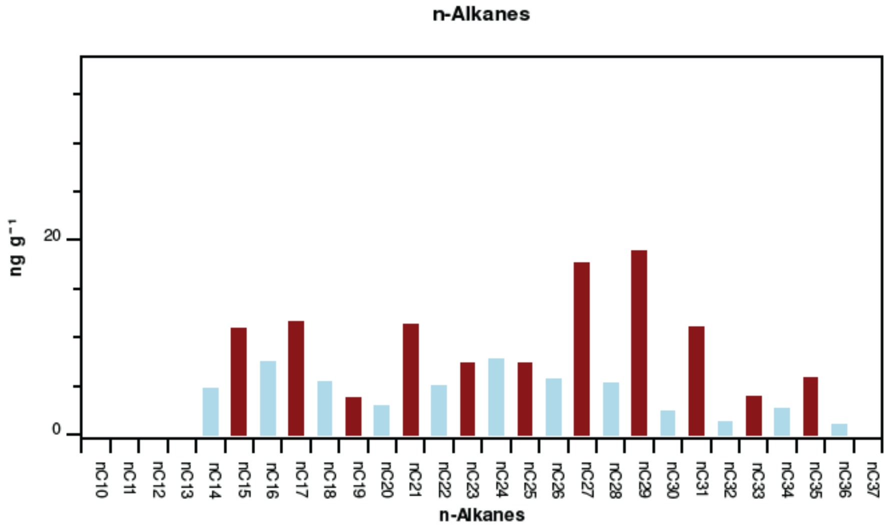
nC21-nC37: 105ng g^{-1}

nC10-nC37: 163ng g^{-1}

Odd Length n-Alkanes: 102ng g^{-1}

Even Length n-Alkanes: 60ng g^{-1}

CPI: 2.6



11210 ENV10

nC10-nC20: 47ng g^{-1}

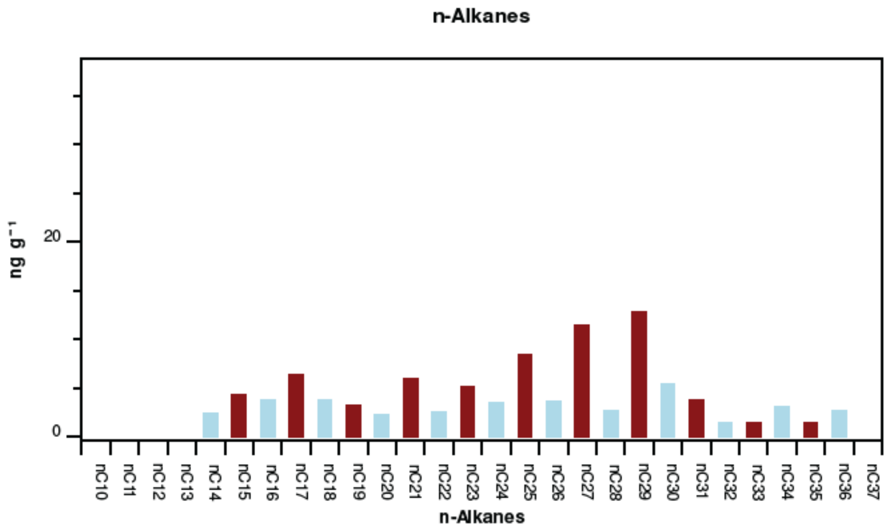
nC21-nC37: 115ng g^{-1}

nC10-nC37: 162ng g^{-1}

Odd Length n-Alkanes: 110ng g^{-1}

Even Length n-Alkanes: 52ng g^{-1}

CPI: 3.8



11210 ENV11

nC10-nC20: 26ng g^{-1}

nC21-nC37: 76ng g^{-1}

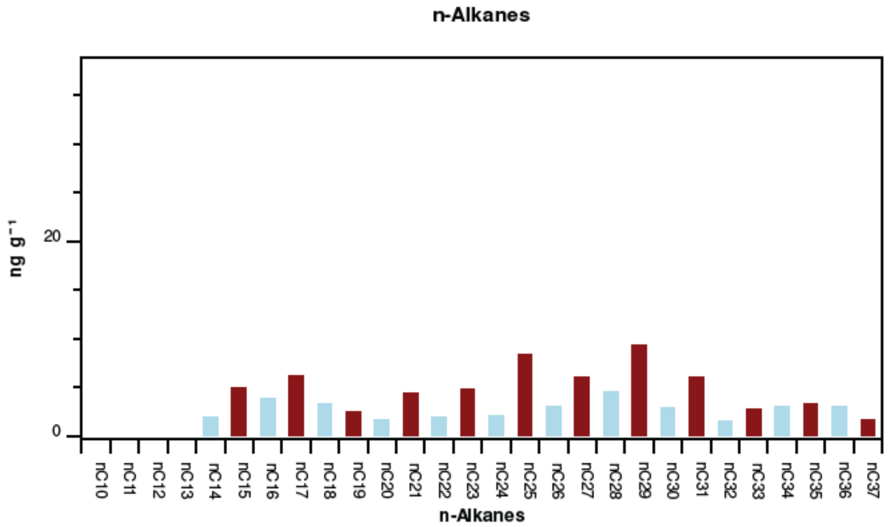
nC10-nC37: 103ng g^{-1}

Odd Length n-Alkanes: 65ng g^{-1}

Even Length n-Alkanes: 38ng g^{-1}

CPI: 3.3

APPENDIX I HYDROCARBON ANALYSIS



11210 ENV14

nC10-nC20: 24ng g^{-1}

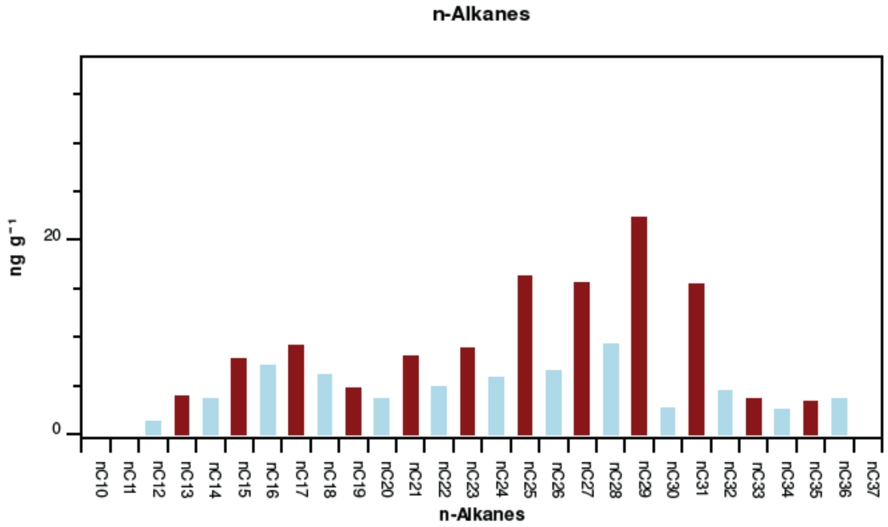
nC21-nC37: 69ng g^{-1}

nC10-nC37: 93ng g^{-1}

Odd Length n-Alkanes: 60ng g^{-1}

Even Length n-Alkanes: 33ng g^{-1}

CPI: 2.1



11210 ENV15

nC10-nC20: 48ng g^{-1}

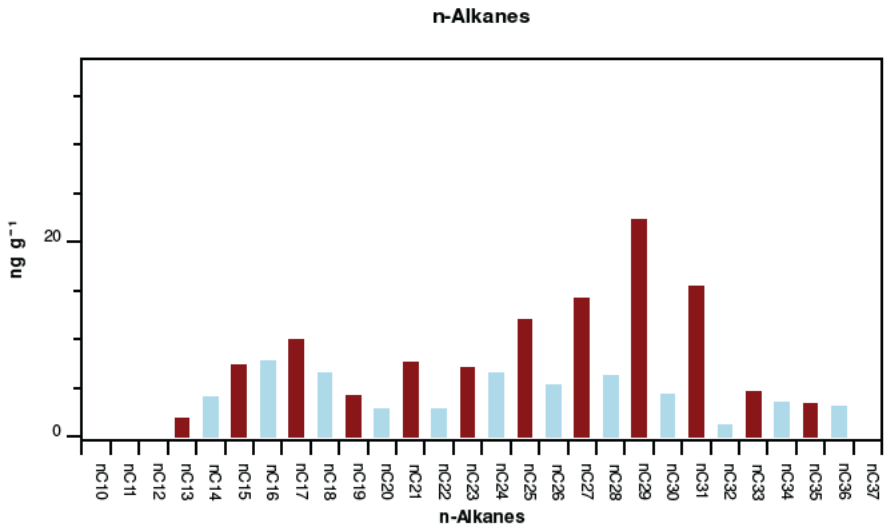
nC21-nC37: 134ng g^{-1}

nC10-nC37: 182ng g^{-1}

Odd Length n-Alkanes: 120ng g^{-1}

Even Length n-Alkanes: 62ng g^{-1}

CPI: 2.7



11210 ENV16

nC10-nC20: 45ng g^{-1}

nC21-nC37: 120ng g^{-1}

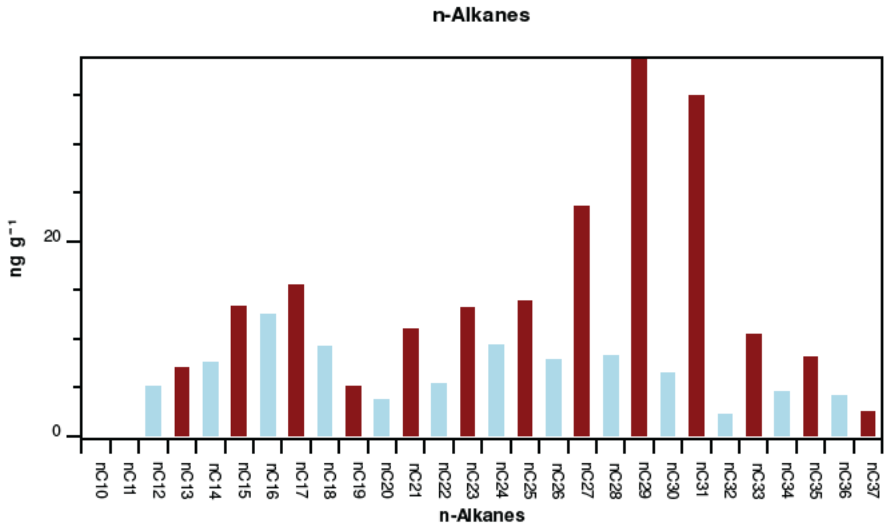
nC10-nC37: 165ng g^{-1}

Odd Length n-Alkanes: 110ng g^{-1}

Even Length n-Alkanes: 55ng g^{-1}

CPI: 3.3

APPENDIX I HYDROCARBON ANALYSIS



11210 ENV17

nC10-nC20: 79ng g^{-1}

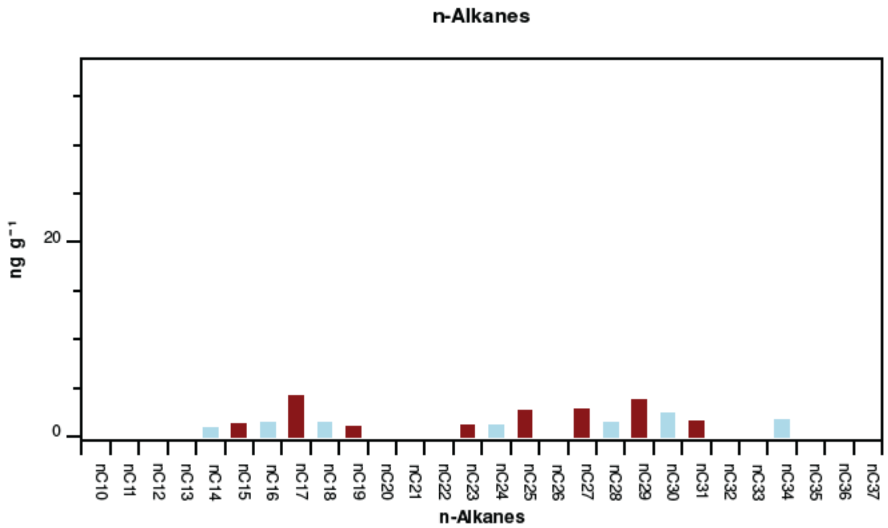
nC21-nC37: 204ng g^{-1}

nC10-nC37: 283ng g^{-1}

Odd Length n-Alkanes: 197ng g^{-1}

Even Length n-Alkanes: 86ng g^{-1}

CPI: 4.1



11210 ENV18

nC10-nC20: 11ng g^{-1}

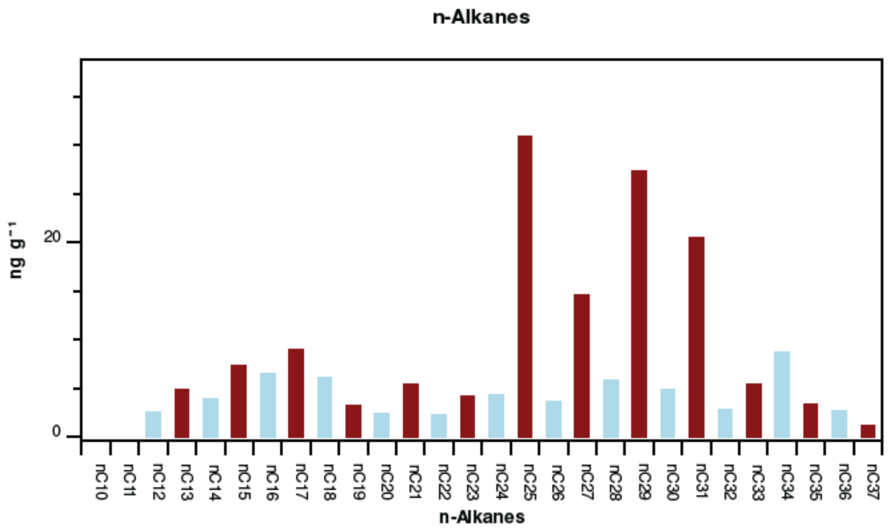
nC21-nC37: 19ng g^{-1}

nC10-nC37: 30ng g^{-1}

Odd Length n-Alkanes: 19ng g^{-1}

Even Length n-Alkanes: 11ng g^{-1}

CPI: 2.4



11210 ENV19

nC10-nC20: 46ng g^{-1}

nC21-nC37: 149ng g^{-1}

nC10-nC37: 195ng g^{-1}

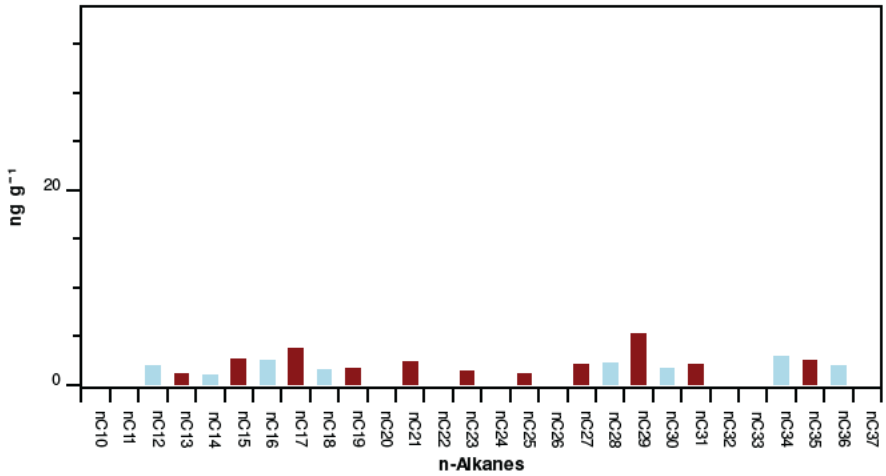
Odd Length n-Alkanes: 138ng g^{-1}

Even Length n-Alkanes: 57ng g^{-1}

CPI: 4.2

APPENDIX I HYDROCARBON ANALYSIS

n-Alkanes



11210 ENV20

nC10-nC20: 16ng g^{-1}

nC21-nC37: 25ng g^{-1}

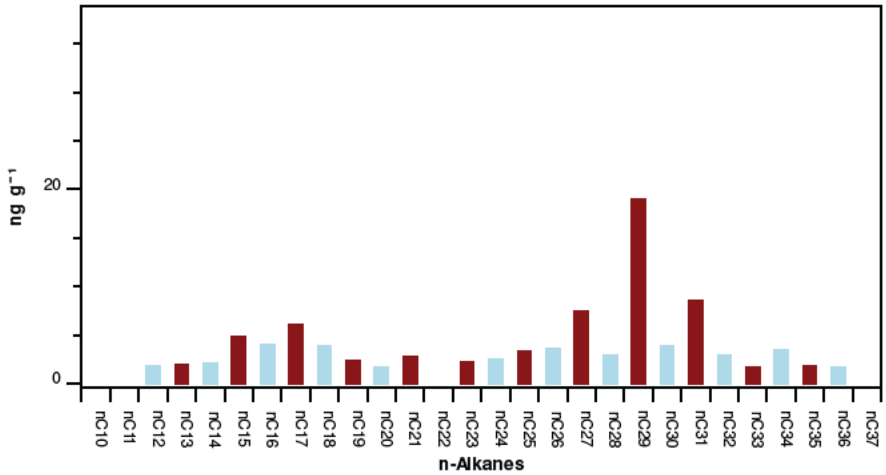
nC10-nC37: 41ng g^{-1}

Odd Length n-Alkanes: 26ng g^{-1}

Even Length n-Alkanes: 16ng g^{-1}

CPI: 2.4

n-Alkanes



11210 ENV21

nC10-nC20: 29ng g^{-1}

nC21-nC37: 69ng g^{-1}

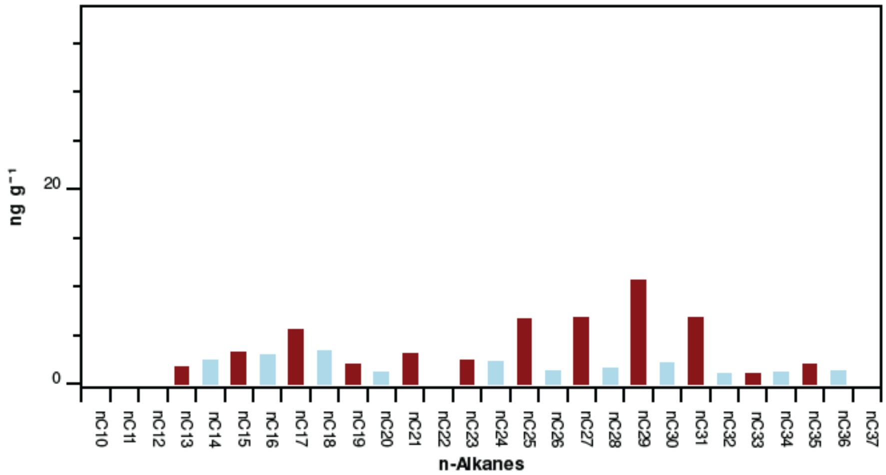
nC10-nC37: 99ng g^{-1}

Odd Length n-Alkanes: 63ng g^{-1}

Even Length n-Alkanes: 36ng g^{-1}

CPI: 3.9

n-Alkanes



11210 ENV22

nC10-nC20: 23ng g^{-1}

nC21-nC37: 51ng g^{-1}

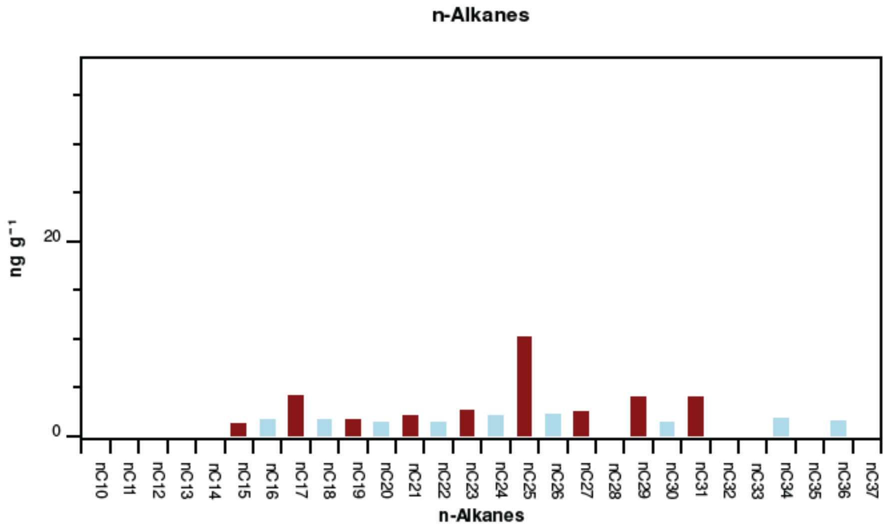
nC10-nC37: 74ng g^{-1}

Odd Length n-Alkanes: 53ng g^{-1}

Even Length n-Alkanes: 21ng g^{-1}

CPI: 5.2

APPENDIX I HYDROCARBON ANALYSIS



11210 ENV23

nC10-nC20: 12ng g^{-1}

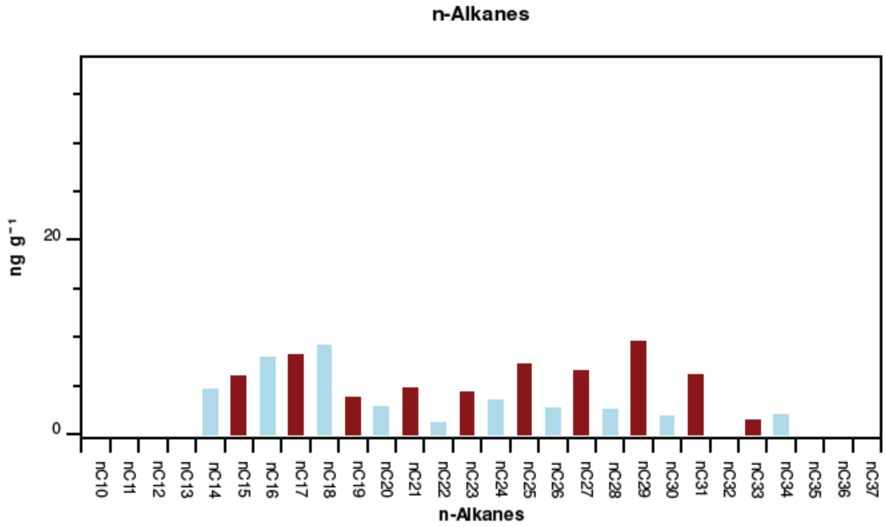
nC21-nC37: 35ng g^{-1}

nC10-nC37: 47ng g^{-1}

Odd Length n-Alkanes: 32ng g^{-1}

Even Length n-Alkanes: 15ng g^{-1}

CPI: 3.7



11210 ENV24

nC10-nC20: 43ng g^{-1}

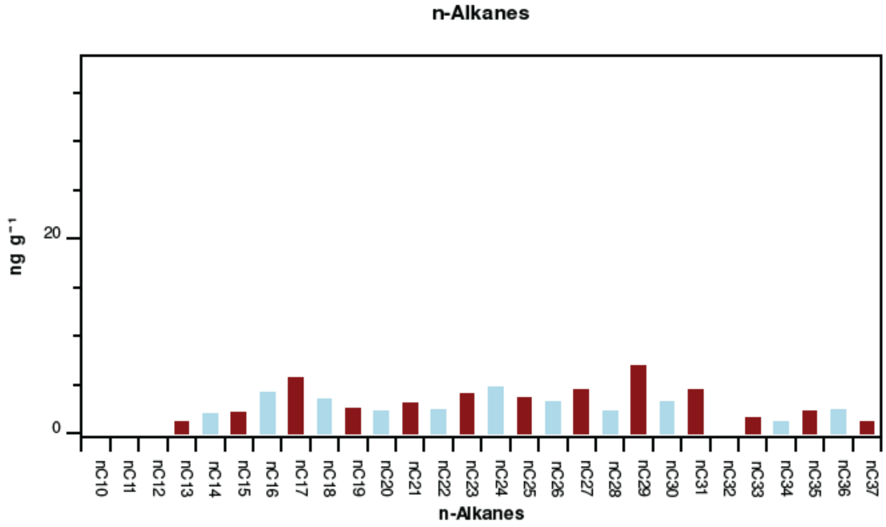
nC21-nC37: 54ng g^{-1}

nC10-nC37: 97ng g^{-1}

Odd Length n-Alkanes: 58ng g^{-1}

Even Length n-Alkanes: 39ng g^{-1}

CPI: 3.3



11210 ENV25

nC10-nC20: 24ng g^{-1}

nC21-nC37: 52ng g^{-1}

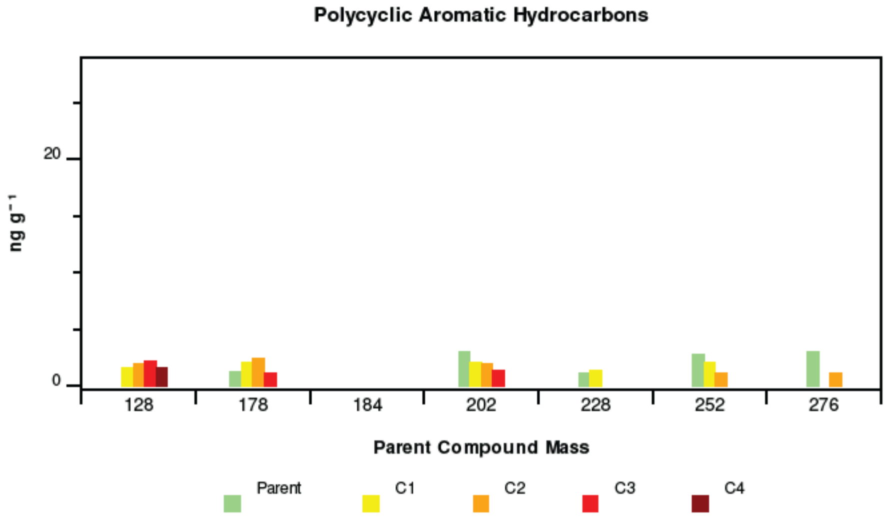
nC10-nC37: 76ng g^{-1}

Odd Length n-Alkanes: 44ng g^{-1}

Even Length n-Alkanes: 32ng g^{-1}

CPI: 2.1

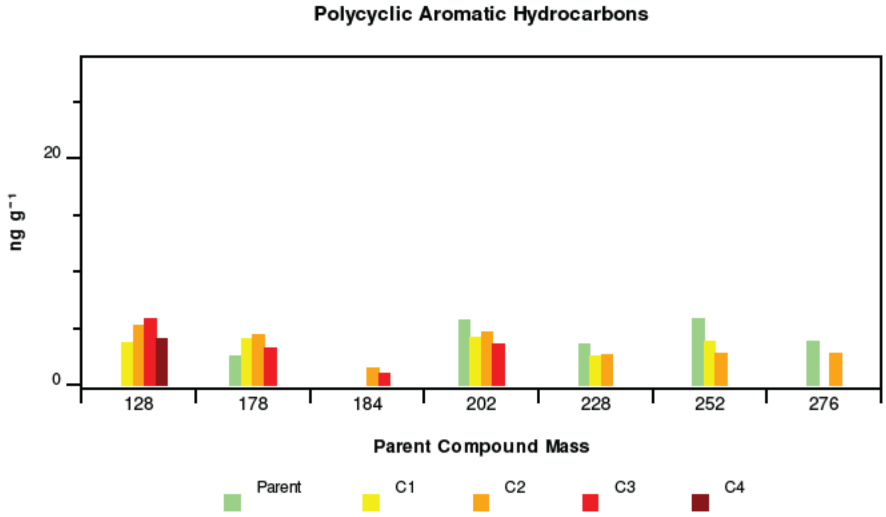
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV1

Total NPD: 15ng g^{-1}

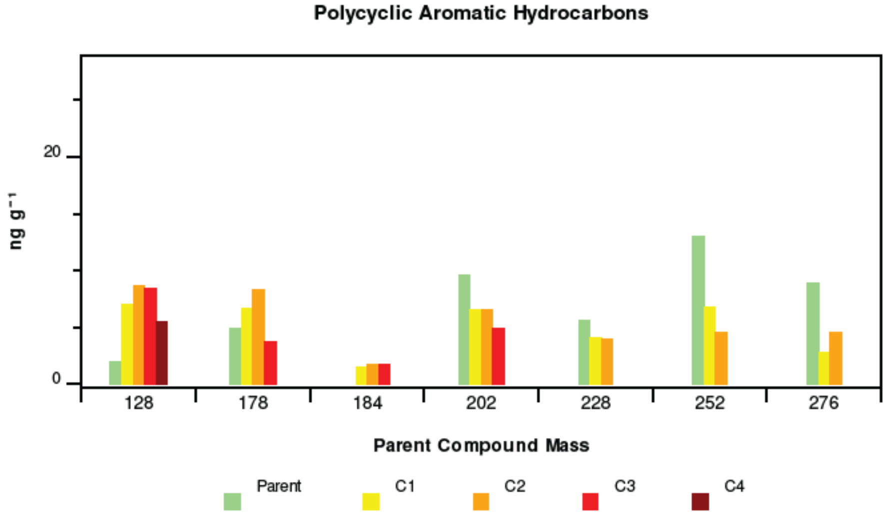
Total PAH: 36ng g^{-1}



11210 ENV2

Total NPD: 36ng g^{-1}

Total PAH: 82ng g^{-1}



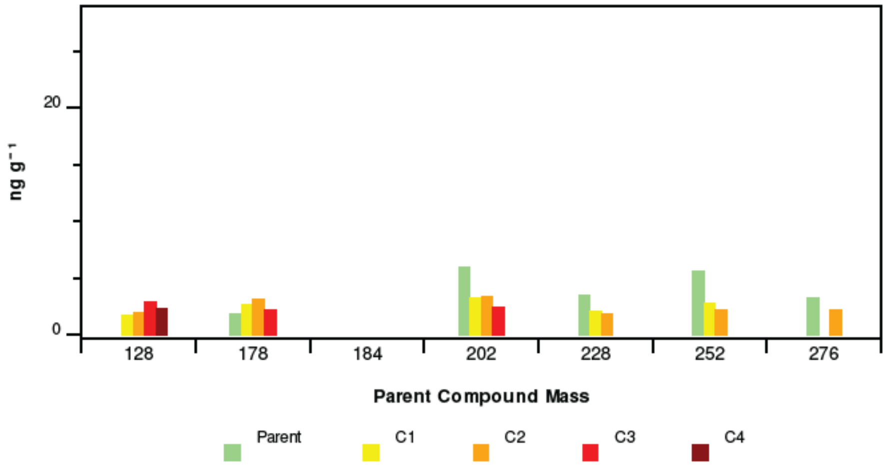
11210 ENV4

Total NPD: 60ng g^{-1}

Total PAH: 142ng g^{-1}

APPENDIX I HYDROCARBON ANALYSIS

Polycyclic Aromatic Hydrocarbons

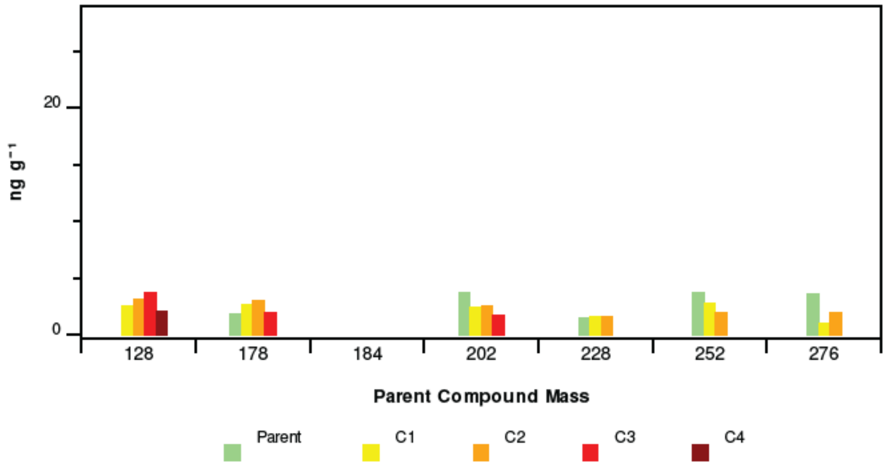


11210 ENV5

Total NPD: 19ng g^{-1}

Total PAH: 58ng g^{-1}

Polycyclic Aromatic Hydrocarbons

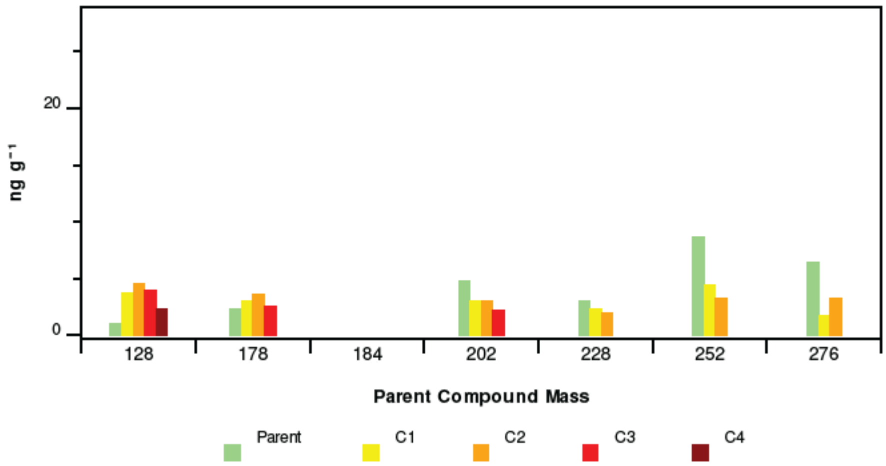


11210 ENV6

Total NPD: 21ng g^{-1}

Total PAH: 52ng g^{-1}

Polycyclic Aromatic Hydrocarbons



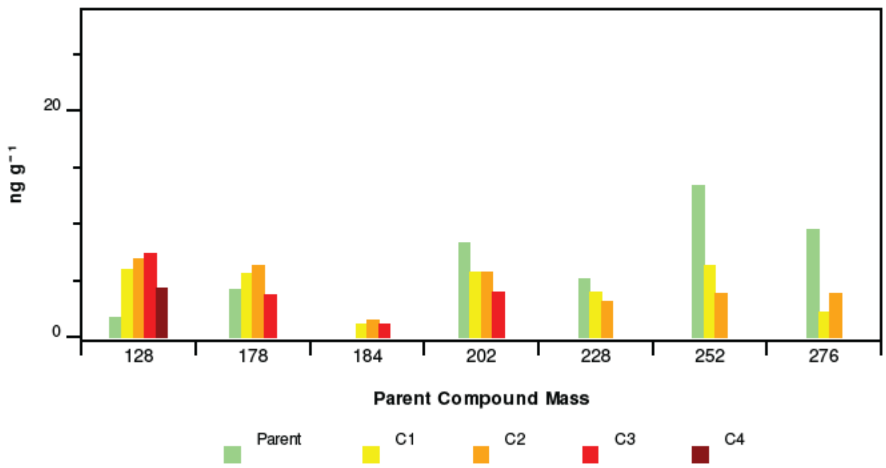
11210 ENV8

Total NPD: 27ng g^{-1}

Total PAH: 75ng g^{-1}

APPENDIX I HYDROCARBON ANALYSIS

Polycyclic Aromatic Hydrocarbons

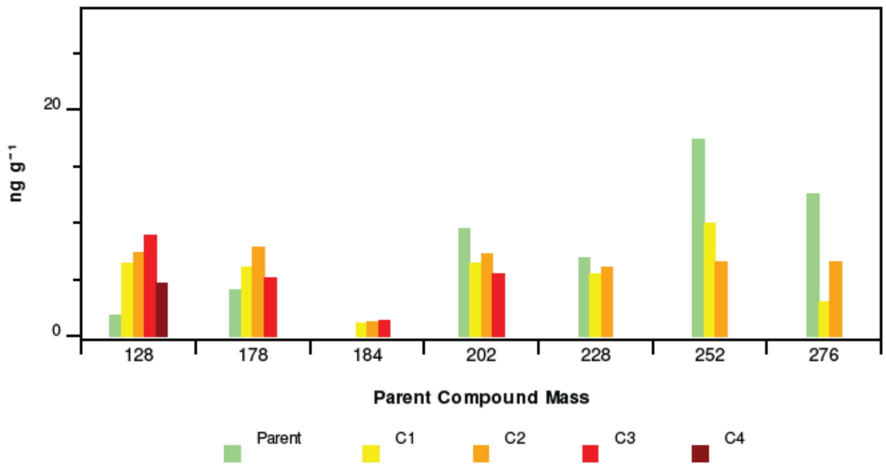


11210 ENV9

Total NPD: 50ng g^{-1}

Total PAH: 125ng g^{-1}

Polycyclic Aromatic Hydrocarbons

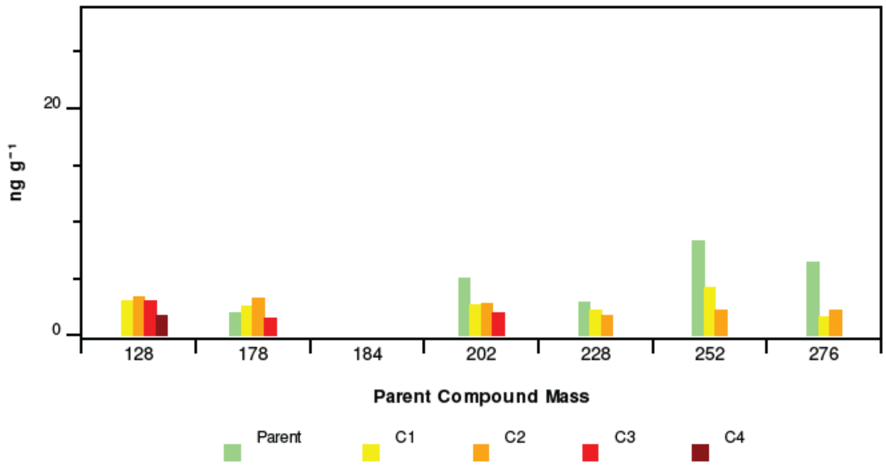


11210 ENV10

Total NPD: 56ng g^{-1}

Total PAH: 159ng g^{-1}

Polycyclic Aromatic Hydrocarbons

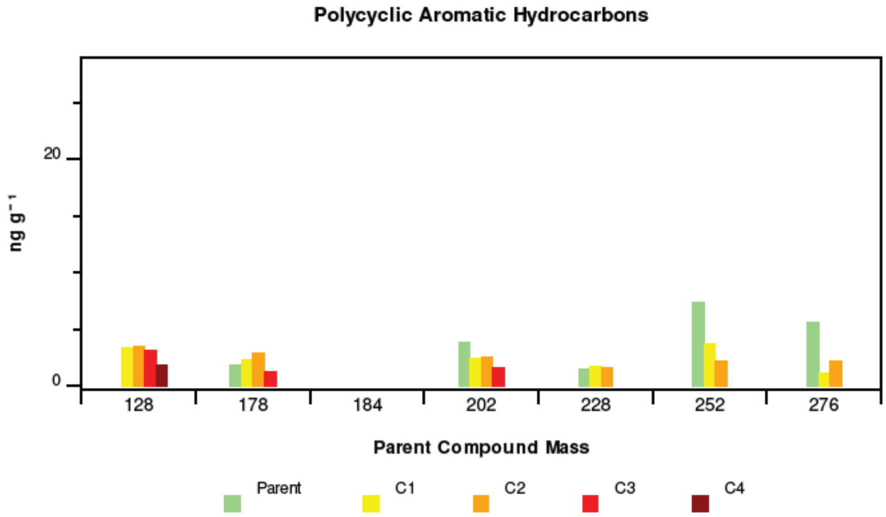


11210 ENV11

Total NPD: 20ng g^{-1}

Total PAH: 65ng g^{-1}

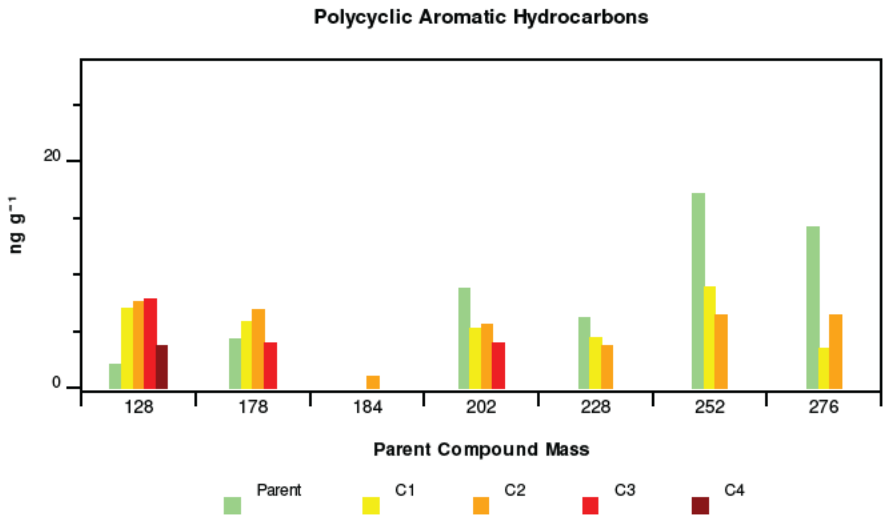
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV14

Total NPD: 20ng g^{-1}

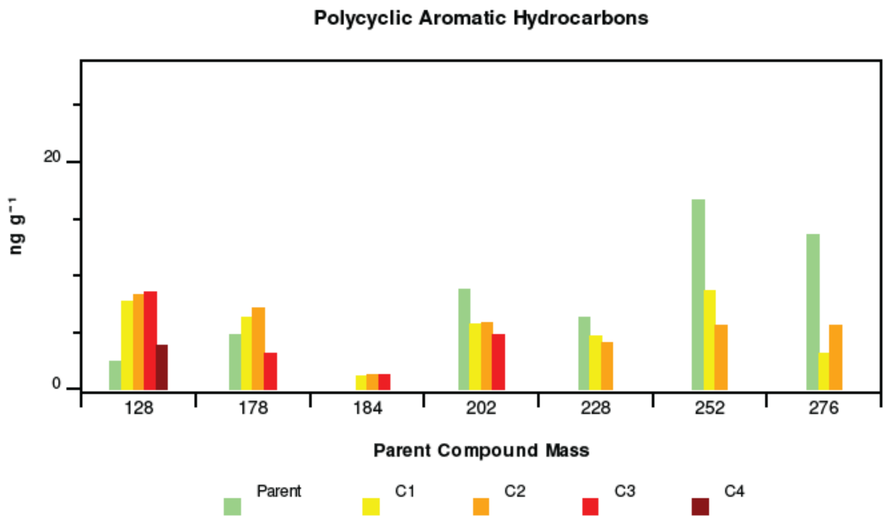
Total PAH: 58ng g^{-1}



11210 ENV15

Total NPD: 50ng g^{-1}

Total PAH: 145ng g^{-1}

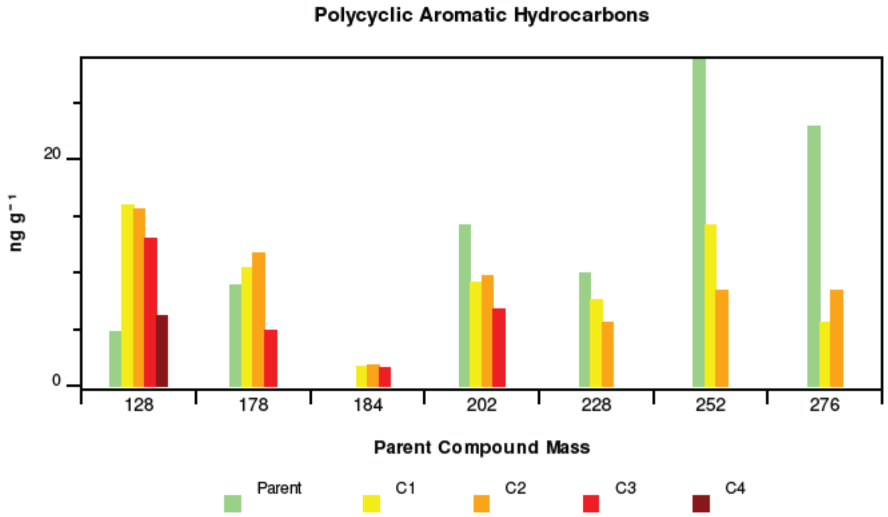


11210 ENV16

Total NPD: 56ng g^{-1}

Total PAH: 149ng g^{-1}

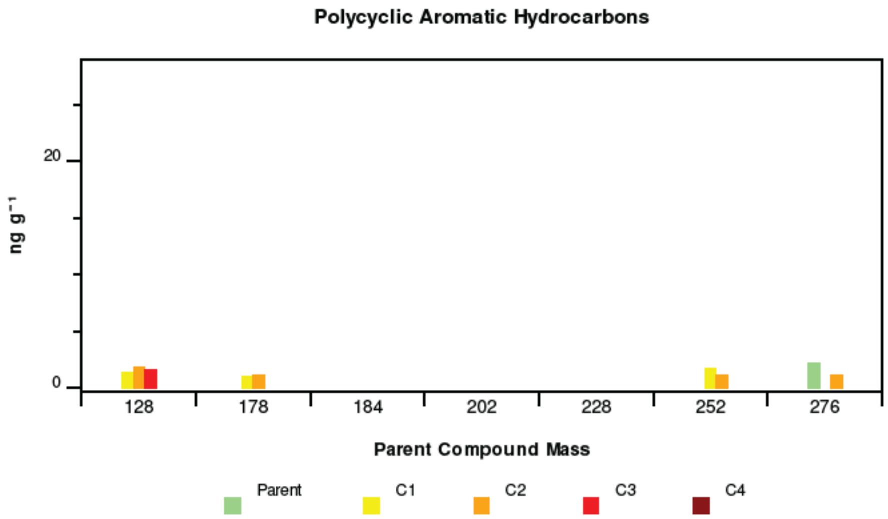
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV17

Total NPD: 97ng g^{-1}

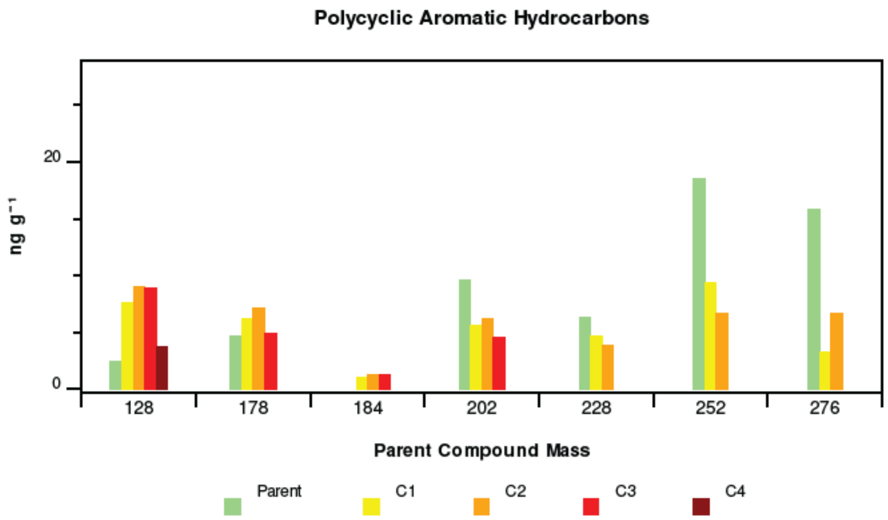
Total PAH: 248ng g^{-1}



11210 ENV18

Total NPD: 7ng g^{-1}

Total PAH: 13ng g^{-1}



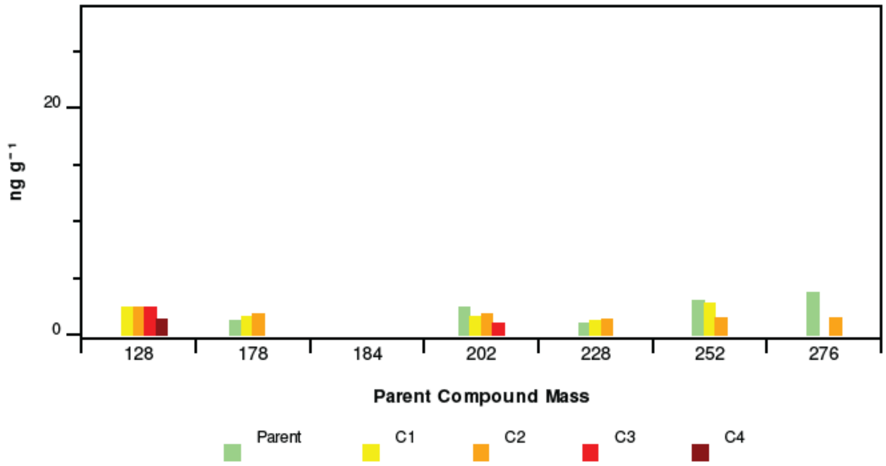
11210 ENV19

Total NPD: 58ng g^{-1}

Total PAH: 159ng g^{-1}

APPENDIX I HYDROCARBON ANALYSIS

Polycyclic Aromatic Hydrocarbons

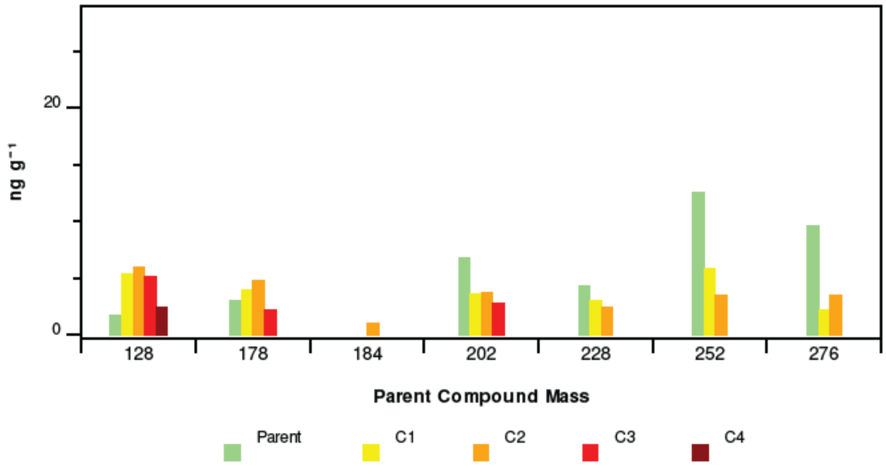


11210 ENV20

Total NPD: 14ng g^{-1}

Total PAH: 37ng g^{-1}

Polycyclic Aromatic Hydrocarbons

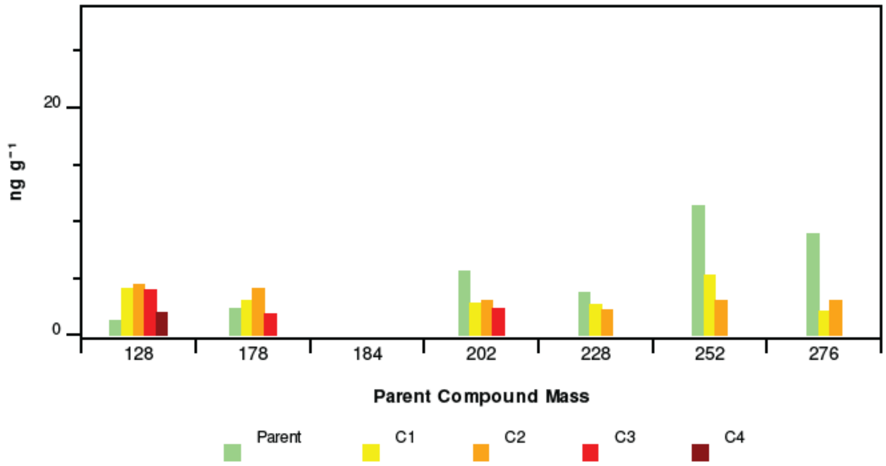


11210 ENV21

Total NPD: 36ng g^{-1}

Total PAH: 100ng g^{-1}

Polycyclic Aromatic Hydrocarbons

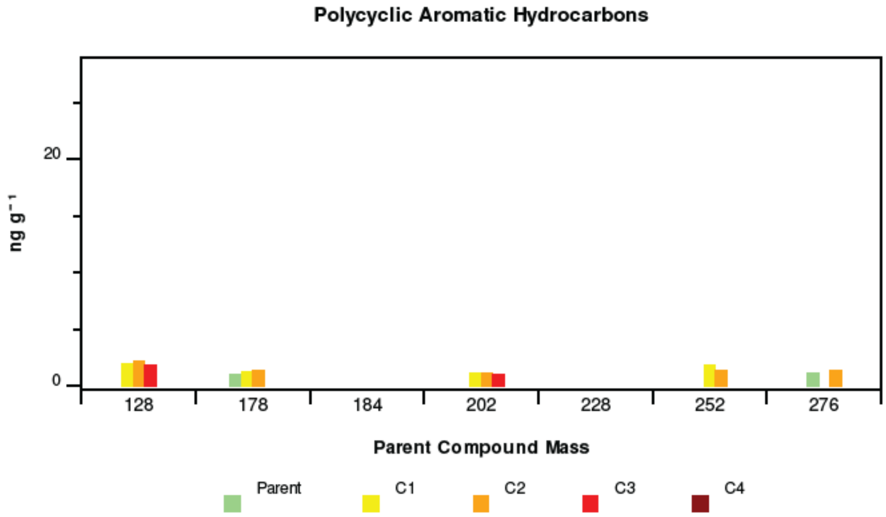


11210 ENV22

Total NPD: 27ng g^{-1}

Total PAH: 83ng g^{-1}

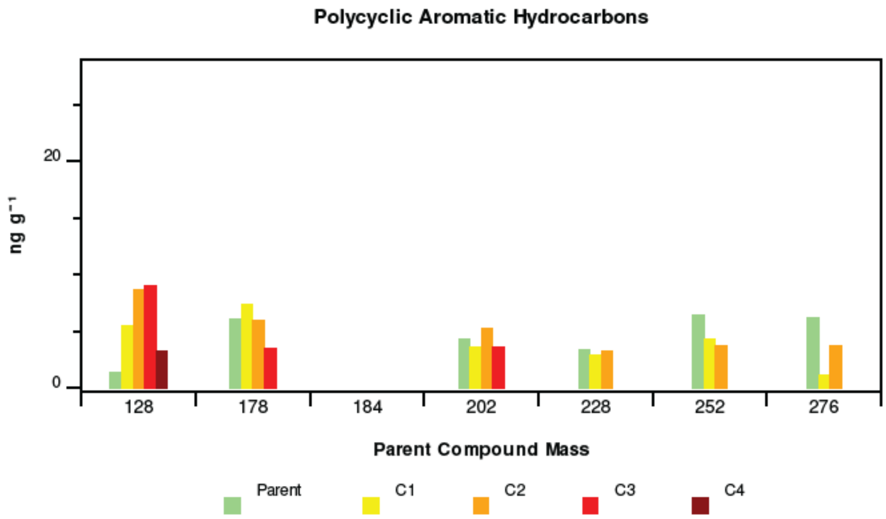
APPENDIX I HYDROCARBON ANALYSIS



11210 ENV23

Total NPD: 10ng g^{-1}

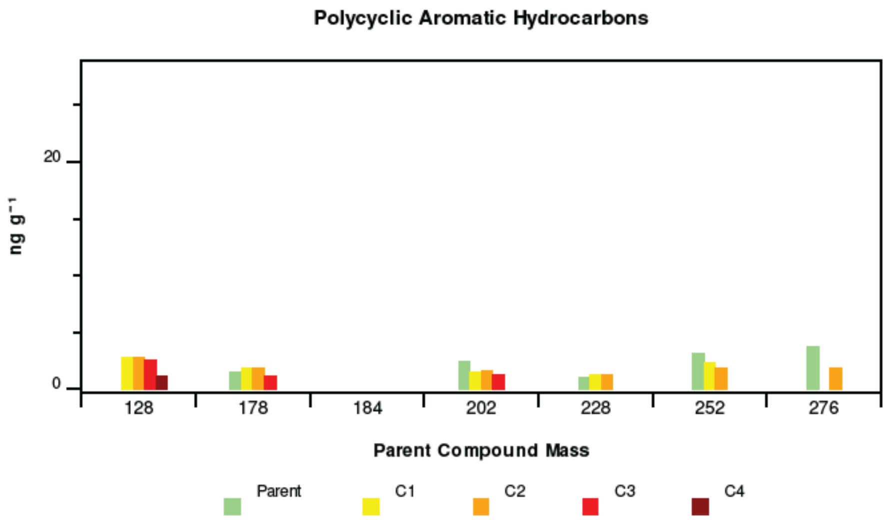
Total PAH: 19ng g^{-1}



11210 ENV24

Total NPD: 51ng g^{-1}

Total PAH: 103ng g^{-1}



11210 ENV25

Total NPD: 15ng g^{-1}

Total PAH: 39ng g^{-1}

APPENDIX I HYDROCARBON ANALYSIS

Table I.1 US EPA 16 PAH Concentrations Normalised to 1% TOC

Station	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	Long et al (1995) ERL[1]	Long et al (1995) ERM[2]
Naphthalene	NC	NC	11.8	NC	NC	7.7	6.0	12.1	NC	NC	18.9	15.2	25.5	NC	12.6	NC	14.0	13.8	NC	13.0	NC	160	2100
Acenaphthylene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	44	640
Acenaphthene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	16	500
Fluorene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	6.5	NC	NC	NC	NC	NC	NC	NC	NC	19	540
Phenanthrene	13.6	23.4	28.6	12.1	15.8	17.7	14.5	26.9	19.1	14.1	39.8	30.0	41.2	NC	24.7	15.6	24.9	26.0	21.2	55.5	21.6	240	1500
Dibenzothiophene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	NA
Anthracene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	5.7	NC	NC	NC	NC	NC	NC	NC	NC	85	1100
Fluoranthene	19.1	29.6	31.7	24.3	17.8	21.1	15.8	34.5	28.7	16.5	45.4	30.4	41.1	NC	28.0	17.1	32.8	35.6	NC	21.5	18.6	600	5100
Pyrene	14.4	22.4	24.6	15.7	13.3	15.5	12.9	29.1	21.7	12.8	34.5	24.7	33.4	NC	22.2	13.3	24.2	26.6	NC	18.2	15.9	665	2600
Benzo[a]anthracene	NC	10.2	12.6	8.3	NC	9.1	6.6	18.4	11.6	NC	22.8	14.9	20.7	NC	13.1	NC	14.7	16.6	NC	10.5	NC	261	1600
Chrysene	12.8	22.8	20.1	15.1	12.7	14.0	11.1	27.3	17.6	11.3	34.0	24.1	31.8	NC	19.8	12.6	21.4	25.1	NC	20.2	15.1	384	2800
Benzo[b]fluoranthene	16.8	24.1	28.2	17.6	17.8	26.8	16.7	40.3	32.0	21.8	61.8	36.8	53.7	NC	38.9	21.1	41.3	47.1	NC	23.5	24.1	NA	NA
Benzo[k]fluoranthene	NC	NC	11.1	NC	NC	9.7	7.0	18.0	11.9	9.1	20.9	16.1	26.5	NC	12.9	NC	13.7	19.8	NC	NC	NC	NA	NA
Benzo[a]pyrene	NC	9.5	14.1	6.7	NC	11.7	8.7	22.9	15.5	9.6	29.1	19.5	27.8	NC	17.8	NC	19.5	22.6	NC	12.1	NC	430	1600
Indeno[123,cd]pyrene	16.1	13.7	24.2	10.3	13.8	24.1	15.7	40.3	32.0	21.8	59.3	38.6	55.3	18.8	38.6	22.8	40.8	50.3	NC	26.2	27.4	NA	NA
Dibenzo[a,h]anthracene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	10.5	6.4	9.5	NC	6.7	NC	NC	NC	NC	NC	NC	63	260
Benzo[ghi]perylene	17.7	21.4	28.2	11.9	16.7	25.2	16.9	43.3	32.6	21.6	59.1	40.2	55.8	18.3	37.7	23.9	39.6	48.4	22.4	29.7	25.6	NA	NA

Concentrations are expressed as ng g^{-1} dry weight sediment.

APPENDIX I HYDROCARBON ANALYSIS

Table I.2 US EPA 16 PAH Concentrations Normalised to 2.5% TOC

Station	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	OSPAR (2005) BC	PSPAR (2005) BAC
Naphthalene	NC	NC	29.6	NC	NC	19.2	15.1	30.3	NC	NC	47.3	38.0	63.8	NC	31.4	NC	35.0	34.4	NC	32.5	NC	5	8
Acenaphthylene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	NA
Acenaphthene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	NA
Fluorene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	16.2	NC	NC	NC	NC	NC	NC	NC	NC	NA	NA
Phenanthrene	33.9	58.4	71.6	30.3	39.4	44.2	36.2	67.3	47.8	35.2	99.5	75.0	102.9	NC	61.7	39.1	62.3	65.0	53.0	138.6	53.9	17	32
Dibenzothiophene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NA	NA
Anthracene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	14.3	NC	NC	NC	NC	NC	NC	NC	NC	3	5
Fluoranthene	47.8	74.1	79.3	60.7	44.4	52.7	39.6	86.3	71.8	41.2	113.4	75.9	102.6	NC	70.0	42.8	81.9	88.9	NC	53.9	46.4	20	39
Pyrene	36.1	55.9	61.6	39.2	33.1	38.8	32.3	72.7	54.3	31.9	86.1	61.7	83.4	NC	55.5	33.1	60.4	66.4	NC	45.5	39.6	13	24
Benzo[a]anthracene	NC	25.5	31.5	20.8	NC	22.7	16.4	46.0	29.0	NC	57.0	37.3	51.8	NC	32.8	NC	36.7	41.4	NC	26.1	NC	9	16
Chrysene	31.9	57.0	50.3	37.8	31.7	35.0	27.8	68.3	44.0	28.3	85.0	60.3	79.6	NC	49.6	31.6	53.5	62.8	NC	50.5	37.9	11	20
Benzo[b]fluoranthene	41.9	60.2	70.6	44.0	44.4	67.1	41.8	100.7	80.0	54.4	154.5	92.0	134.2	NC	97.2	52.8	103.3	117.8	NC	58.9	60.4	NA	NA
Benzo[k]fluoranthene	NC	NC	27.8	NC	NC	24.2	17.6	45.0	29.8	22.7	52.3	40.2	66.3	NC	32.4	NC	34.2	49.4	NC	NC	NC	NA	NA
Benzo[a]pyrene	NC	23.6	35.3	16.7	NC	29.2	21.8	57.3	38.8	24.0	72.7	48.8	69.5	NC	44.6	NC	48.8	56.4	NC	30.2	NC	15	30
Indeno[123,cd]pyrene	40.3	34.3	60.6	25.7	34.6	60.2	39.2	100.7	80.0	54.4	148.2	96.6	138.2	47.1	96.4	56.9	101.9	125.8	NC	65.5	68.6	50	103
Dibenzo[a,h]anthracene	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	26.4	16.1	23.7	NC	16.7	NC	NC	NC	NC	NC	NC	NA	NA
Benzo[ghi]perylene	44.2	53.4	70.4	29.7	41.7	62.9	42.3	108.3	81.5	54.0	147.7	100.5	139.5	45.8	94.3	59.7	99.0	121.1	56.0	74.3	63.9	45	80

Concentrations are expressed as ng g^{-1} dry weight sediment.
Cells highlighted in red correspond to concentrations above the BC when normalised to 2.5% TOC (OSPAR, 2005).

APPENDIX J MACROFAUNA ANALYSIS

APPENDIX J MACROFAUNA ANALYSIS

Table J.1 Faunal Abundance Matrix

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	STATIONS																					Total
					ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	
Taxa included in Statistical Analysis																										
		ANNELIDA																								
130707	P0015	Polychaeta	Southern, 1914	*Pisione remota*																		1				1
938	P0017		Malmgren, 1867	Aphroditidae (juv.)	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	1	-	-	-	-	-	4
571832	P0062		Malmgren, 1865	*Harmothoe glabra*												1		1								2
147008	P0051		McIntosh, 1874	*Malmgrenia andreapolis*															3							3
129439	P0091		Johnston, 1839	*Pholoe*			1									17	5		21		12	2		2		60
131072	P0104		Audouin & Milne Edwards in Cuvier, 1830	*Sigalion mathildae*			1				2	1	1	1												6
131077	P0109		Ehlers, 1864	*Sthenelais limicola*				1			1	3	1		2	1	1	1		1	2	1	1	1		17
931	P0114		Örsted, 1843	Phyllodocidae																		1			1	2
130644	P0167		Orsted, 1843	*Eumida sanguinea* (agg.)									1								1					2
152250	P0124		Quatrefages, 1865	*Hypereteone foliosa*		2		2																		4
129455	P0178		Lamarck, 1818	*Phyllodoce*													1							1		2
334506			Orsted, 1842	*Phyllodoce groenlandica*			1																			1
334514			McIntosh, 1877	*Phyllodoce rosea*																	1					1
130116	P0256		O.F. Müller, 1776	*Glycera alba*				2					1			2							2			7
130123	P0260		Quatrefages, 1866	*Glycera lapidum*														1				2	1	5	4	13
130136	P0268		Malmgren, 1866	*Glycinde nordmanni*		1									1	2		3		3			1		2	13
130140	P0271		Örsted, 1843	*Goniada maculata*					2			1					2		1	3			3	1		13
710680			Delle Chiaje, 1827	*Oxydromus flexuosus*											1		1		1		2		1			6
757970			Webster & Benedict, 1884	*Parexogone hebes*																					1	1
129370	P0494		Cuvier, 1817	*Nephtys*													1						5	1		7
130355	P0496		Fabricius, 1780	*Nephtys caeca*				1												1			1	1		4
130357	**P0498**		**Ehlers, 1868**	***Nephtys cirrosa***	**7**	**5**	**5**	**10**	**9**									**3**		**4**		**1**				**44**
130359	P0499		Savigny in Lamarck, 1818	*Nephtys hombergii*										2					1				1			4
130364	P0503		Orsted, 1842	*Nephtys longosetosa*	1				1																	2
129837	P0518		McIntosh, 1868	*Paramphinome jeffreysii*																				2		2
130238	P0574		Fauchald, 1974	*Lumbrineris aniara* (agg.)												1			2							3
130537	**P0672**		**Müller, 1776**	***Scoloplos armiger***		**15**	**3**	**6**	**6**	**1**	**1**			**1**		**1**		**2**		**2**	**1**	**1**	**2**	**1**		**43**
130585	P0699		Southern, 1914	*Paradoneis lyra*																				2		2
130711	P0718		Allen, 1904	*Poecilochaetus serpens*			4	3	2		3		5	1	2	1				1				1	3	26
913	P0720		Grube, 1850	Spionidae										1												1
131107	P0723		Southern, 1914	*Aonides paucibranchiata*																		1		1	5	7
478336			Laubier & Ramos, 1974	*Atherospio guillei*													3									3
129623	P0777		Blainville, 1828	*Scolelepis*					1						1											2
131171	P0779		Mesnil, 1896	*Scolelepis bonnieri*						1			1			1				1						4
157566	P0783		O.F. Muller, 1806	*Scolelepis (Scolelepis) squamata*														1								1
129625	P0787		Fabricius, 1785	*Spio*		1				1																2
131187	**P0794**		**Claparède, 1870**	***Spiophanes bombyx***		**3**	**3**	**5**	**8**	**1**	**2**		**6**	**3**	**1**	**5**	**1**	**2**	**3**		**2**		**6**	**2**	**6**	**59**
130266	P0804		Wilson, 1958	*Magelona alleni*										2		2			1		5			1		11
130268	P0805		Wilson, 1959	*Magelona filiformis*	1			1						3									1			6
130269			Fiege, Licher & Mackie, 2000	*Magelona johnstoni*	1				1	4	4	5	5													20
152217			Chambers, 2000	*Chaetozone christiei*	2		2			15	6	1	3													29
130100	P0878		Malmgren, 1867	*Diplocirrus glaucus*													3		1		2			1		7
129892	P0919		Rasmussen, 1973	*Mediomastus fragilis*													3									3
129220	P0920		M. Sars, 1851	*Notomastus*							1	1	3		1	1	4		1	1						13
923	P0938		Malmgren, 1867	Maldanidae																		1				1
146991			Grube, 1868	*Leiochone*														3								3
130491	P0999		Quatrefages, 1866	*Ophelia borealis*		12		4	3							9		8	3	1		7	3		4	54
130500	P1014		Örsted, 1843	*Ophelina acuminata*															2							2
130980	P1027		Rathke, 1843	*Scalibregma inflatum*	1				1	2	1					15	50		10		4		2	2		88
146949	P1091		Kirkegaard, 1959	*Galathowenia*											1						1			2		4
129427	P1097		Delle Chiaje, 1844	*Owenia*														1	1		2		1	1		6
130590			**O.F. Müller, 1776**	***Amphictene auricoma***				**2**	**3**	**1**	**5**	**2**	**2**	**4**	**3**	**7**	**3**		**7**		**7**					**46**
152367	**P1107**		**Malmgren, 1866**	***Lagis koreni***		**1**		**4**	**1**	**2**		**2**	**2**	**1**	**1**	**5**	**3**		**2**	**1**	**9**			**11**	**1**	**46**
129781	P1139		Malmgren, 1867 sensu Hessle, 1917	*Ampharete lindstroemi* (agg.)																				2		2
131495	P1195		Pallas, 1766	*Lanice conchilega*							1															1
129710	P1235		Grube, 1850	*Polycirrus*		1											2			1			1			5
985	P1257		Latreille, 1825	Sabellidae												1								1		2
988	P1324		Rafinesque, 1815	*Serpulidae*																				1		1
131009	P1334		Gunnerus, 1768	*Hydroides norvegica*																				3		3
		CRUSTACEA																								
1135	S0097	Amphipoda	Latreille, 1816	Amphipoda																					7	7
102915	S0131		Spence Bate & Westwood, 1868	*Perioculodes longimanus*	3		2		1				1					1			1	1		1	1	12
101702	S0132		Boeck, 1871	*Pontocrates*		1																				1
102460	S0177		Robertson, 1892	*Leucothoe incisa*				1					1													2
103228	S0248		Spence Bate, 1857	*Urothoe elegans*											1		3		1		1			20	1	27
103233	S0249		Spence Bate, 1857	*Urothoe marina*																					31	31
103235	S0250		Reibish, 1905	*Urothoe poseidonis*					1																	1
102960	S0254		Meinert, 1890	*Harpinia antennaria*											1						2					3
102495	S0275		Spence Bate & Westwood, 1861	*Acidostoma neglectum*													1							1		2
102570	S0296		Spence Bate, 1857	*Hippomedon denticulatus*																				1		1
101658	S0335		Stebbing, 1906	*Tmetonyx*																					1	1
102139			Metzger, 1871	*Nototropis falcatus*		1																				1
179538	S0413		Spence Bate & Westwood, 1862	*Nototropis vedlomensis*																					1	1
101891	S0427		Costa, 1853	*Ampelisca brevicornis*										1		2			1		4					8
101742	S0451		Lindström, 1855	*Bathyporeia*	6	8	3	2	1			1	1		2										1	25
103058	S0452		Watkin, 1938	*Bathyporeia elegans*	10		7	3	5											1						26
103059	S0453		Sars, 1891	*Bathyporeia gracilis*					1									1				1				3

APPENDIX J MACROFAUNA ANALYSIS

Table J.1 Faunal Abundance Matrix

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	Total
					STATIONS																					
103060	S0454		Spence Bate, 1857	Bathyporeia guilliamsoniana	4		3	1	4				1							2						15
103076	S0459		Meinert, 1877	Bathyporeia tenuipes			5	2		1	5	2	4	1	2					1						23
102783	S0489		Hoek, 1889	Megaluropus agilis		2																				2
102795	S0505		G.O. Sars, 1894	Cheirocratus intermedius																				1		1
101368	S0577		Stebbing, 1899	Aoridae																				4		4
397383	S0611		Bruzelius, 1859	Crassicorophium crassicorne																			1	1		2
1059643	S0617		Just, 1983	Centraloecetes				1																		1
101857	S0651		Krøyer, 1844	Pariambus typicus				1																		1
110462	S1203	Cumacea	Goodsir, 1843	Iphinoe trispinosa	2				1																	3
110398	S1247		Say, 1818	Diastylis				2																		2
110472	S1248		Norman, 1879	Diastylis bradyi		1	1		2	1	2	3	5			2				2						19
110481	S1251		Norman, 1869	Diastylis laevis													1									1
110488	S1254		Sars, 1865	Diastylis rugosa		2									1	1	1		2		1				1	9
1130	S1276	Decapoda	Latreille, 1802	Decapoda		1																			1	2
1130	S1276		Latreille, 1802	Decapoda (zoea)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
107054	S1362		Leach, 1815 [in Leach, 1815-1875]	Processa												1								1		2
107552	S1385		Linnaeus, 1758	Crangon crangon																					1	1
107557	S1386		Hailstone, 1835	Philocheras bispinosus					2														1			3
106670			Burkenroad, 1963	Pleocyemata										1			2							3		6
107729	S1415		Montagu, 1808	Callianassa subterranea				1								5	4		5		4			4		23
107739	S1419		Leach, 1816	Upogebia deltaura												2	2				1			1		6
106738	S1445		Latreille, 1802	Paguridae																		1				1
106834	S1470		Fabricius, 1793	Galathea																				2		2
107277	S1552		Pennant, 1777	Corystes cassivelaunus							1										1					2
106925	S1577		Stimpson, 1871	Liocarcinus						1															1	2
		MOLLUSCA																								
139106	W0009	Caudofoveata	Lovén, 1844	Chaetoderma nitidulum															1							1
140129	W0410	Gastropoda	Montagu, 1803	Hyala vitrea													1									1
151894	W0491		Donovan, 1804	Euspira nitida			1		2	1	5	2	1	7	1											20
138432	W1074		T. Brown, 1827	Retusa									1													1
161	W1035		Gray, 1850 1815	Philinidae																	2					2
139476	W1028		Pennant, 1777	Cylichna cylindracea									1		2		5		5		3					16
138262	W1565	Bivalvia	Lamarck, 1799	Nucula										4	2						2					8
140584			Montagu, 1808	Ennucula tenuis															1		3					4
138831	W1929		Montagu, 1803	Goodallia triangularis														2								2
140283	W1829		Linnaeus, 1767	Lucinoma borealis												1				1	1		3			6
141662	W1837		Montagu, 1803	Thyasira flexuosa																	1					1
140365	W1898		Malard, 1904	Devonia perrieri															1							1
345281	W1906		Montagu, 1803	Kurtiella bidentata									1	2		5	3		5							16
146952	W1902		Montagu, 1808	Tellimya ferruginosa													1		1							2
137732	W1940		J.E. Gray, 1851	Acanthocardia (juv.)	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	-	-	-	-	-	-	4
138158	W1969		Linnaeus, 1767	Mactra								3	1													4
140299	W1972		Linnaeus, 1758	Mactra stultorum								2														2
138159	W1973		Gray, 1837	Spisula	2	5	4			2				1												14
146907	W2019		Gmelin, 1791	Fabulina fabula	5		10		4	4	22	8	10	4	1					4						72
138388	W2044		Schumacher, 1817	Gari					2															2		4
140870	W2051		Gmelin, 1791	Gari fervensis																			1			1
138474	W2058		Lamarck, 1818	Abra	1		79	47	54	103	34	41	19	49	9	11		2	4	1	2	2				458
141433	W2059		W. Wood, 1802	Abra alba			1	2		2	1			1												7
141436	W2062		Montagu, 1808	Abra prismatica	3	1	1		1		1			1				1		1					4	14
138802	W2072		Linnaeus, 1767	Arctica islandica (juv.)	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	3
243	W2086		Rafinesque, 1815	Veneridae				1	1		1	1		2	2											8
141908			da Costa, 1778	Chamelea striatula															1		2				1	4
138636	W2126		Scopoli, 1777	Dosinia	1				1		1				1	2							1			7
141912	W2128		Linnaeus, 1758	Dosinia lupinus						1										1				2	1	5
141929	W2104		Pennant, 1777	Timoclea ovata												1	1									2
23091	W1995		H. Adams & A. Adams, 1856	Pharidae			1									6	1									8
138333	W1996		Schumacher, 1817	Ensis		1			2																	3
140733	W1999		Linnaeus, 1758	Ensis ensis				1																		1
140737	W2006		Pennant, 1777	Phaxas pellucidus							1			1	2	2			1	1	1		1	3		13
138211	W2144		Linnaeus, 1758	Mya (juv.)	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
139410	W2157		Olivi, 1792	Corbula gibba	1			1					1													3
382318			Stoliczka, 1870 1839	Thracioidea				1	24						1			1	1		4					32
138549	W2227		Blainville, 1824	Thracia					2			1	1							4			1			9
181373	W2239		Pulteney, 1799	Cochlodesma praetenue																3						3
		ECHINODERMATA																								
123080	ZB0018	Asteroidea	de Blainville, 1830	Asteroidea (juv.)	-	-	-	-	-	-	-	-	-	-	1	1	1	-	4	3	6	-	1	7	11	35
123084	ZB0105	Ophiuroidea	Gray, 1840	Ophiuroidea (juv.)	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	3
123206	ZB0148		Ljungman, 1867	Amphiuridae			2		1	2	7		5		15	14	2		41	7						96
236130	ZB0151		Montagu, 1804	Acrocnida brachiata																			1			1
125080	ZB0154		O.F. Müller, 1776	Amphiura filiformis		1				2		2	1	10	7	66	127		177	4	81	11	10	9		508
123200	ZB0165		Müller & Troschel, 1840	Ophiuridae			3		3	3	2	1	1						1	1						15
124913	ZB0168		Forbes, 1839	Ophiura albida		1																				1
124273	ZB0212	Echinoidea	O.F. Müller, 1776	Echinocyamus pusillus					1									9		1		36	16	6	1	70
123106	ZB0213		L. Agassiz, 1840	Spatangoida (juv.)	-	-	2	-	1	2	1	2	-	2	1	1	2	19	1	1	2	15	2	9	7	70
123426	ZB0222		Gray, 1825	Echinocardium	1																3					4
123426	ZB0222		Gray, 1825	Echinocardium (juv.)	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	1	-	-	4
124392	ZB0223		Pennant, 1777	Echinocardium cordatum		1											1		4		1	2	2			11
124394	ZB0224		O.F. Müller, 1776	Echinocardium flavescens												1										1

APPENDIX J MACROFAUNA ANALYSIS

Table J.1 Faunal Abundance Matrix

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	STATIONS ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	Total
124462	ZB0292	Holothuroidea	Östergren, 1905	*Leptosynapta bergensis*															3							3
283798	D0632	CNIDARIA	Gosse, 1859	*Cerianthus lloydii*		1																1		1		3
1360	D0662			Actiniaria				1																		1
100665	D0759		Andres, 1881	Edwardsiidae																				1	1	2
100880	D0766		Panceri, 1869	*Edwardsia claparedii*								1				2	2		1							6
793	F0001	PLATYHELMINTHES	Minot, 1876	Platyhelminthes												1						1				2
152391	G0001	NEMERTEA		Nemertea	1			1	5		1	1	2	1	1	2	6	2	4					5	1	6
128545	ZA0003	PHORONIDA	Wright, 1856	*Phoronis*					1					2	7				1	2	7			2		22
1820	ZC0012	HEMICHORDATA	Gegenbaur, 1870	Enteropneusta														1			1					2
112299		FORAMINIFERA	Sandahl, 1858	*Astrorhiza*													1					5				6
				Individuals	**53**	**68**	**145**	**110**	**162**	**153**	**112**	**88**	**89**	**111**	**76**	**205**	**252**	**66**	**329**	**62**	**191**	**95**	**75**	**134**	**102**	**2678**
				Taxa	**19**	**23**	**24**	**29**	**38**	**22**	**26**	**24**	**31**	**28**	**32**	**41**	**37**	**22**	**41**	**32**	**40**	**22**	**31**	**47**	**29**	**163**

Juvenile Record
Taxa in Blue are the top 10 dominant in the adult data set
Taxa in red are species of interest
P = Present

Taxa excluded from Statistical Analysis

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	Total
1337	D0138	CNIDARIA	Owen, 1843	Hydrozoa		P		P	P						P					P				P		P
13552	D0296		Cornelius, 1992	Leptothecata	P				P	P	P	P	P	P	P			P		P		P	P	P	P	P
1614	D0407		Lamouroux, 1812	Sertulariidae			P																			P
117890	D0424		(Linnaeus, 1758)	*Hydrallmania falcata*		P													P							P
1606	D0491		Johnston, 1836	Campanulariidae																	P	P				P
799	HD0001	NEMATODA		Nematoda													1		1					2	1	5
1271	K0001	ENTOPROCTA	Nitsche, 1869	Entoprocta					P	P			P	P												P
2081	L0001	CHAETOGNATHA		Chaetognatha																1						1
1080	R0142	ARTHROPODA	Milne Edwards, 1840	Copepoda	1	3																			2	6
		ANNELIDA																								
883	P0002	Polychaeta	Grube, 1850	Polychaeta														P								P
131077	P0109		(Ehlers, 1864)	*Sthenelais limicola*										P					P							P
129455	P0178		Lamarck, 1818	*Phyllodoce*					P			P					1			P				1		2
130136	P0268		(Malmgren, 1866)	*Glycinde nordmanni*																				P		P
130140	P0271		Orsted, 1843	*Goniada maculata*				P																		P
946	P0293		Grube, 1850	Hesionidae														P								P
710680			(Delle Chiaje, 1827)	*Oxydromus flexuosus*												P										P
129370	P0494		Cuvier, 1817	*Nephtys*																	P					P
130238	P0574		Fauchald, 1974	*Lumbrineris aniara*													P									P
130537	P0672		(Müller, 1776)	*Scoloplos armiger*	P																					P
913	P0720		Grube, 1850	Spionidae								P														P
129341	P0803		F. Müller, 1858	*Magelona*								P														P
919	P0822		Ryckholt, 1851	Cirratulidae											P											P
923	P0938		Malmgren, 1867	Maldanidae																					P	P
130980	P1027		Rathke, 1843	*Scalibregma inflatum*		P																				P
1130	S1276	Decapoda	Latreille, 1802	Decapoda													P									P
		ECHINODERMATA																								
123206	ZB0148	Ophiuroidea	Ljungman, 1867	Amphiuridae				P																	P	P
123106	ZB0213	Echinoidea	L. Agassiz, 1840	Spatangoida																			P			P
123426	ZB0222		Gray, 1825	*Echinocardium*										P												P
111604	Y0081	BRYOZOA	Fleming, (1828)	*Alcyonidium parasiticum*			P	P											P					P		P
111669	Y0131		(Linnaeus, 1758)	*Vesicularia spinosa*			P	P						P												P
111361	Y0165		(Linnaeus, 1758)	*Eucratea loricata*	P																					P
128545	ZA0003	PHORONIDA	Wright, 1856	*Phoronis*								P														P
1692		CILIOPHORA	Dons, 1914	*Folliculinidae*					P				P		P	P				P						P
104906		CHORDATA	Pallas, 1774	*Branchiostoma lanceolatum*																				1		1
126752	ZG0444		Linnaeus, 1758	*Ammodytes tobianus*		1																				1

Gardline

APPENDIX J MACROFAUNA ANALYSIS

Table J.2 Faunal Biomass Matrix

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	STATIONS ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	Total
Taxa included in Statistical Analysis																										
		ANNELIDA																								
130707	P0015	Polychaeta	Southern, 1914	*Pisione remota*																		0.0001				0.0001
938	P0017		Malmgren, 1867	Aphroditidae (juv.)											0.0012	0.0008				0.0004						0.0024
571832	P0062		Malmgren, 1865	*Harmothoe glabra*												0.0095		0.0020								0.0115
147008	P0051		McIntosh, 1874	*Malmgrenia andreapolis*															0.1285							0.1285
129439	P0091		Johnston, 1839	*Pholoe*			0.0004									0.0144	0.0057		0.0150		0.0109	0.0016		0.0029		0.0509
131072	P0104		Audouin & Milne Edwards in Cuvier, 1830	*Sigalion mathildae*			0.3310				0.3420	0.0017	0.0919	0.2566												1.0232
131077	P0109		Ehlers, 1864	*Sthenelais limicola*				0.0194			0.0119	0.1022	0.0145		0.0787	0.0033	0.0151	0.0299		0.0768	0.0242	0.0175	0.0241	0.0158		0.4334
931	P0114		Örsted, 1843	Phyllodocidae																		0.0002			0.0001	0.0003
130644	P0167		Örsted, 1843	*Eumida sanguinea* (agg.)									0.0038								0.0410					0.0448
152250	P0124		Quatrefages, 1865	*Hypereteone foliosa*		0.0778		0.0030																		0.0808
129455	P0178		Lamarck, 1818	*Phyllodoce*													0.0261							0.0042		0.0303
334506			Örsted, 1842	*Phyllodoce groenlandica*			0.0253																			0.0253
334514			McIntosh, 1877	*Phyllodoce rosea*																	0.0047					0.0047
130116	P0256		O.F. Müller, 1776	*Glycera alba*				0.0609					0.0087			0.0485							0.0995			0.2176
130123	P0260		Quatrefages, 1866	*Glycera lapidum*														0.0015				0.0085	0.0034	0.0230	0.0295	0.0659
130136	P0268		Malmgren, 1866	*Glycinde nordmanni*		0.0430									0.0273	0.0049		0.0442		0.0675			0.0041		0.0094	0.2004
130140	P0271		Örsted, 1843	*Goniada maculata*					0.0618			0.0470					0.0157		0.0018	0.0627			0.0336	0.0107		0.2333
710680			Delle Chiaje, 1827	*Oxydromus flexuosus*											0.0547		0.0059		0.0238		0.0435		0.0241			0.1520
757970			Webster & Benedict, 1884	*Parexogone hebes*																					0.0001	0.0001
129370	P0494		Cuvier, 1817	*Nephtys*													0.0057						0.0490	0.0385		0.0932
130355	P0496		Fabricius, 1780	*Nephtys caeca*				0.2550												0.8640			0.2471	2.2805		3.6466
130357	P0498		Ehlers, 1868	*Nephtys cirrosa*	0.1391	0.1620	0.0307	0.2320	0.1913									0.1244		0.0836		0.0223				0.9854
130359	P0499		Savigny in Lamarck, 1818	*Nephtys hombergii*										0.0496					0.1384				0.0624			0.2504
130364	P0503		Örsted, 1842	*Nephtys longosetosa*	0.2250				0.1937																	0.4187
129837	P0518		McIntosh, 1868	*Paraphinome jeffreysii*																				0.0014		0.0014
130238	P0574		Fauchald, 1974	*Lumbrineris aniara* (agg.)												0.0286			0.0365							0.0651
130537	P0672		Müller, 1776	*Scoloplos armiger*		0.2216	0.0037	0.0793	0.0482	0.0056	0.0233			0.0132		0.0124		0.0364		0.0284	0.0410	0.0571	0.0110	0.0067		0.5879
130585	P0699		Southern, 1914	*Paradoneis lyra*																				0.0007		0.0007
130711	P0718		Allen, 1904	*Poecilochaetus serpens*			0.0088	0.0045	0.0067		0.0090		0.0069	0.0022	0.0052	0.0136				0.0018				0.0061	0.0056	0.0704
913	P0720		Grube, 1850	Spionidae										0.0069												0.0069
131107	P0723		Southern, 1914	*Aonides paucibranchiata*																		0.0012		0.0016	0.0110	0.0138
478336			Laubier & Ramos, 1974	*Atherospio guillei*													0.0027									0.0027
129623	P0777		Blainville, 1828	*Scolelepis*					0.0031						0.0150											0.0181
131171	P0779		Mesnil, 1896	*Scolelepis bonnieri*						0.0013			0.0038			0.0112				0.0445						0.0608
157566	P0783		O.F. Muller, 1806	*Scolelepis (Scolelepis) squamata*														0.0634								0.0634
129625	P0787		Fabricius, 1785	*Spio*		0.0002				0.0004																0.0006
131187	P0794		Claparède, 1870	*Spiophanes bombyx*		0.0075	0.0102	0.0172	0.0252	0.0043	0.0188		0.0191	0.0163	0.0079	0.0117	0.0002	0.0055	0.0169		0.0042		0.0258	0.0059	0.0802	0.2769
130266	P0804		Wilson, 1958	*Magelona alleni*										0.0362		0.0092			0.0560		0.1958			0.0150		0.3122
130268	P0805		Wilson, 1959	*Magelona filiformis*	0.0020			0.0015						0.0049									0.0020			0.0104
130269			Fiege, Licher & Mackie, 2000	*Magelona johnstoni*	0.0106				0.0006	0.0362	0.0305	0.0280	0.0255													0.1314
152217			Chambers, 2000	*Chaetozone christiei*	0.0045		0.0057			0.0670	0.0165	0.0022	0.0027													0.0986
130100	P0878		Malmgren, 1867	*Diplocirrus glaucus*													0.0161		0.0127		0.0169			0.0104		0.0561
129892	P0919		Rasmussen, 1973	*Mediomastus fragilis*													0.0039									0.0039
129220	P0920		M. Sars, 1851	*Notomastus*							0.0060	0.0261	0.0678		0.0034	0.0040	0.0564		0.0056	0.0045						0.1738
923	P0938		Malmgren, 1867	Maldanidae																		0.0002				0.0002
146991			Grube, 1868	*Leiochone*														0.0193								0.0193
130491	P0999		Quatrefages, 1866	*Ophelia borealis*		0.0607		0.0076	0.0099							0.0273		0.0439	0.0140	0.0054		0.0164	0.0203		0.0670	0.2725
130500	P1014		Örsted, 1843	*Ophelina acuminata*															0.0530							0.0530
130980	P1027		Rathke, 1843	*Scalibregma inflatum*	0.0346				0.0589	0.0198	0.0293					0.0981	0.6031		0.0935		0.0387		0.0055	0.0230		1.0045
146949	P1091		Kirkegaard, 1959	*Galathowenia*											0.0008						0.0002			0.0141		0.0151
129427	P1097		Delle Chiaje, 1844	*Owenia*														0.0044	0.0016		0.0074		0.0871	0.0344		0.1349
130590			O.F. Müller, 1776	*Pectinaria (Amphictene) auricoma*				0.0057	0.0141	0.0034	0.0138	0.0048	0.0020	0.0060	0.0026	0.0097	0.0028		0.0122		0.0041					0.0812
152367	P1107		Malmgren, 1866	*Lagis koreni*		0.0067		0.2200	0.1619	0.0401		0.0657	0.0205	0.0027	0.0140	0.0591	0.0247		0.0212	0.0036	0.0665			0.0133	0.0020	0.7220
129781	P1139		Malmgren, 1867 sensu Hessle, 1917	*Ampharete lindstroemi* (agg.)																				0.0188		0.0188
131495	P1195		Pallas, 1766	*Lanice conchilega*							0.0065															0.0065
129710	P1235		Grube, 1850	*Polycirrus*		0.0287											0.1950			0.0057			0.0141			0.2435
985	P1257		Latreille, 1825	Sabellidae												0.0008								0.0003		0.0011
988	P1324		Rafinesque, 1815	Serpulidae																				0.0002		0.0002
131009	P1334		Gunnerus, 1768	*Hydroides norvegica*																				0.0025		0.0025
		CRUSTACEA																								
1135	S0097	Amphipoda	Latreille, 1816	*Amphipoda*																					0.0003	0.0003
102915	S0131		Spence Bate & Westwood, 1868	*Perioculodes longimanus*	0.0023		0.0014		0.0014				0.0008					0.0018			0.0013	0.0040		0.0008	0.0008	0.0146
101702	S0132		Boeck, 1871	*Pontocrates*		0.0024																				0.0024
102460	S0177		Robertson, 1892	*Leucothoe incisa*				0.0014					0.0007													0.0021
103228	S0248		Spence Bate, 1857	*Urothoe elegans*											0.0017		0.0012		0.0004		0.0012			0.0351	0.0009	0.0405
103233	S0249		Spence Bate, 1857	*Urothoe marina*																					0.0842	0.0842
103235	S0250		Reibish, 1905	*Urothoe poseidonis*					0.0007																	0.0007
102960	S0254		Meinert, 1890	*Harpinia antennaria*											0.0010						0.0039					0.0049
102495	S0275		Spence Bate & Westwood, 1861	*Acidostoma neglectum*													0.0120							0.0061		0.0181
102570	S0296		Spence Bate, 1857	*Hippomedon denticulatus*																				0.0124		0.0124
101658	S0335		Stebbing, 1906	*Tmetonyx*																					0.0022	0.0022
102139			Metzger, 1871	*Nototropis falcatus*		0.0025																				0.0025
179538	S0413		Spence Bate & Westwood, 1862	*Nototropis vedlomensis*																					0.0004	0.0004
101891	S0427		Costa, 1853	*Ampelisca brevicornis*										0.0096		0.0102			0.0063		0.0162					0.0423
101742	S0451		Lindström, 1855	*Bathyporeia*	0.0051	0.0040	0.0017	0.0015	0.0005			0.0008	0.0005		0.0019										0.0008	0.0168
103058	S0452		Watkin, 1938	*Bathyporeia elegans*	0.0129		0.0094	0.0020	0.0113											0.0017						0.0373
103059	S0453		Sars, 1891	*Bathyporeia gracilis*					0.0019									0.0018				0.0007				0.0044

Gardline

APPENDIX J MACROFAUNA ANALYSIS

Table J.2 Faunal Biomass Matrix

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	STATIONS																					Total
					ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	
103060	S0454		Spence Bate, 1857	*Bathyporeia guilliamsoniana*	0.0060		0.0037	0.0008	0.0104				0.0061							0.0033						0.0303
103076	S0459		Meinert, 1877	*Bathyporeia tenuipes*			0.0052	0.0031		0.0005	0.0069	0.0047	0.0054	0.0007	0.0026					0.0006						0.0297
102783	S0489		Hoek, 1889	*Megaluropus agilis*		0.0001																				0.0001
102795	S0505		G.O. Sars, 1894	*Cheirocratus intermedius*																				0.0024		0.0024
101368	S0577		Stebbing, 1899	*Aoridae*																				0.0043		0.0043
397383	S0611		Bruzelius, 1859	*Crassicorophium crassicorne*																			0.0006	0.0007		0.0013
1059643	S0617		Just, 1983	*Centraloecetes*				0.0009																		0.0009
101857	S0651		Krøyer, 1844	*Pariambus typicus*				0.0002																		0.0002
110462	S1203	Cumacea	Goodsir, 1843	*Iphinoe trispinosa*	0.0040				0.0045																	0.0085
110398	S1247		Say, 1818	*Diastylis*				0.0012																		0.0012
110472	S1248		Norman, 1879	*Diastylis bradyi*		0.0023	0.0018		0.0192	0.0020	0.0112	0.0087	0.0136			0.0103				0.0116						0.0807
110481	S1251		Norman, 1869	*Diastylis laevis*													0.0031									0.0031
110488	S1254		Sars, 1865	*Diastylis rugosa*		0.0021									0.0014	0.0013	0.0013		0.0029		0.0011				0.0014	0.0115
1130	S1276	Decapoda	Latreille, 1802	*Decapoda*		0.0007																				0.0007
1130	S1276		Latreille, 1802	*Decapoda (zoea)*																			0.0008		0.0013	0.0021
107054	S1362		Leach, 1815 [in Leach, 1815-1875]	*Processa*												0.0061								0.0029		0.0090
107552	S1385		Linnaeus, 1758	*Crangon crangon*																					0.0056	0.0056
107557	S1386		Hailstone, 1835	*Philocheras bispinosus*					0.0127														0.0075			0.0202
106670			Burkenroad, 1963	*Pleocyemata*										0.0007			0.0014							0.0033		0.0054
107729	S1415		Montagu, 1808	*Callianassa subterranea*				0.0013								0.1137	0.0782		0.3901		0.0365			0.0147		0.6345
107739	S1419		Leach, 1816	*Upogebia deltaura*												0.0022	0.9186				0.0012			0.0025		0.9245
106738	S1445		Latreille, 1802	*Paguridae*																		0.0016				0.0016
106834	S1470		Fabricius, 1793	*Galathea*																				0.0018		0.0018
107277	S1552		Pennant, 1777	*Corystes cassivelaunus*							0.3045										0.0314					0.3359
106925	S1577		Stimpson, 1871	*Liocarcinus*						0.0159															0.0034	0.0193
		MOLLUSCA																								
139106	W0009	Caudofoveata	Lovén, 1844	*Chaetoderma nitidulum*															0.0303							0.0303
140129	W0410	Gastropoda	Montagu, 1803	*Hyala vitrea*													0.0018									0.0018
151894	W0491		Donovan, 1804	*Euspira nitida*			0.0085		0.0002	0.0008	0.0176	0.0063	0.0014	0.0132	0.0255											0.0735
138432	W1074		T. Brown, 1827	*Retusa*									0.0019													0.0019
161	W1035		Gray, 1850 1815	*Philinidae*																	0.0067					0.0067
139476	W1028		Pennant, 1777	*Cylichna cylindracea*									0.0035		0.0075		0.0120		0.0127		0.0063					0.0420
138262	W1565	Bivalvia	Lamarck, 1799	*Nucula*										0.0109	0.0064						0.0040					0.0213
140584			Montagu, 1808	*Ennucula tenuis*															0.0570		0.0103					0.0673
138831	W1929		Montagu, 1803	*Goodallia triangularis*														0.0050								0.0050
140283	W1829		Linnaeus, 1767	*Lucinoma borealis*												0.0264				0.4758	0.1135		0.0928			0.7085
141662	W1837		Montagu, 1803	*Thyasira flexuosa*																	0.0450					0.0450
140365	W1898		Malard, 1904	*Devonia perrieri*															0.0057							0.0057
345281	W1906		Montagu, 1803	*Kurtiella bidentata*									0.0022	0.0032		0.0080	0.0037		0.0069							0.0240
146952	W1902		Montagu, 1808	*Tellimya ferruginosa*													0.0081		0.0037							0.0118
137732	W1940		J.E. Gray, 1851	*Acanthocardia* (juv)												0.0084	0.0031		0.0045							0.0160
138158	W1969		Linnaeus, 1767	*Mactra*								0.0037	0.9380													0.9417
140299	W1972		Linnaeus, 1758	*Mactra stultorum*								3.2345														3.2345
138159	W1973		Gray, 1837	*Spisula*	0.0037	0.2127	0.0171			0.0061				0.0003												0.2399
146907	W2019		Gmelin, 1791	*Fabulina fabula*	0.1178		0.0717		0.0434	0.0119	0.1850	0.0215	0.0138	0.0050	0.0011					0.0084						0.4796
138388	W2044		Schumacher, 1817	*Gari*					0.0011															0.0007		0.0018
140870	W2051		Gmelin, 1791	*Gari fervensis*																			3.3320			3.3320
138474	W2058		Lamarck, 1818	*Abra*	0.0006		0.1302	0.0403	0.0316		0.0330	0.0257	0.0138	0.0367	0.0044	0.0064		0.0038	0.0056	0.0006	0.0044	0.0023				0.3394
141433	W2059		W. Wood, 1802	*Abra alba*			0.0677	0.1950		0.1978	0.0171			0.0065												0.4841
141436	W2062		Montagu, 1808	*Abra prismatica*	0.1195	0.0250	0.0270		0.0234		0.0072			0.0106				0.1242		0.0065					0.6616	1.0050
138802	W2072		Linnaeus, 1767	*Arctica islandica (juv.)*					0.0035						0.0026										0.0011	0.0072
243	W2086		Rafinesque, 1815	*Veneridae*				0.0011	0.0016		0.0012	0.0009		0.0019	0.0020											0.0087
141908			da Costa, 1778	*Chamelea striatula*															0.3641		3.1071				0.0904	3.5616
138636	W2126		Scopoli, 1777	*Dosinia*	0.0222				0.0221		0.0373				0.0059	2.9560							0.4450			3.4885
141912	W2128		Linnaeus, 1758	*Dosinia lupinus*						4.5148										3.6747				2.6670	3.9410	14.7975
141929	W2104		Pennant, 1777	*Timoclea ovata*												0.0010	0.0012									0.0022
23091	W1995		H. Adams & A. Adams, 1856	*Pharidae*			0.0020									0.0044	0.0012									0.0076
138333	W1996		Schumacher, 1817	*Ensis*		0.0346			0.0598																	0.0944
140733	W1999		Linnaeus, 1758	*Ensis ensis*				13.4700																		13.4700
140737	W2006		Pennant, 1777	*Phaxas pellucidus*							0.0115			0.0319	0.0123	0.1786			0.0025	0.0731	0.0035		0.0408	0.0881		0.4423
138211	W2144		Linnaeus, 1758	*Mya* (juv.)												0.0014										0.0014
139410	W2157		Olivi, 1792	*Corbula gibba*	0.0070			0.0014					0.0059													0.0143
382318			Stoliczka, 1870 1839	*Thracioidea*				0.0007	0.0123						0.0007			0.0011	0.0007		0.0081					0.0236
138549	W2227		Blainville, 1824	*Thracia*					0.0145			0.0201	0.0058							0.0164			0.0083			0.0651
181373	W2239		Pulteney, 1799	*Cochlodesma praetenue*																0.0166						0.0166
		ECHINODERMATA																								
123080	ZB0018	Asteroidea	de Blainville, 1830	Asteroidea (juv.)											0.0008	0.0004	0.0004		0.0028	0.0015	0.0028		0.0003	0.0456	0.0072	0.0618
123084	ZB0105	Ophiuroidea	Gray, 1840	Ophiuroidea (juv.)										0.0008										0.0002		0.0010
123206	ZB0148		Ljungman, 1867	Amphiuridae			0.0054		0.0006	0.0016	0.0069		0.0035		0.0162	0.0051	0.0005		0.0148	0.0049						0.0595
236130	ZB0151		Montagu, 1804	*Acrocnida brachiata*																			0.0333			0.0333
125080	ZB0154		O.F. Müller, 1776	*Amphiura filiformis*		0.0065				0.0137		0.0186	0.0044	0.0447	0.1002	0.5134	0.9870		3.9580	0.1386	0.9603	0.0121	0.1016	0.0730		6.9321
123200	ZB0165		Müller & Troschel, 1840	Ophiuridae			0.0021		0.0019	0.0067	0.0021	0.0002	0.0005						0.0003	0.0005						0.0143
124913	ZB0168		Forbes, 1839	*Ophiura albida*		0.0876																				0.0876
124273	ZB0212	Echinoidea	O.F. Müller, 1776	*Echinocyamus pusillus*					0.0348									0.7620		0.0021		0.1721	0.0840	0.0195	0.0020	1.0765
123106	ZB0213		L. Agassiz, 1840	Spatangoida (juv.)			0.0138		0.0300	0.0052	0.0006	0.0015		0.0013	0.0038	0.0070	0.0030	0.0303	0.0007	0.0029	0.0045	0.0095	0.0038	0.0276	0.0113	0.1568
123426	ZB0222		Gray, 1825	*Echinocardium*	4.8820																3.1712					8.0532
123426	ZB0222		Gray, 1825	*Echinocardium* (juv.)								0.0105						0.7650				0.2090	0.8235			1.8080
124392	ZB0223		Pennant, 1777	*Echinocardium cordatum*		54.5606											2.5080		12.2900		6.2430	9.0440	30.6800			115.3256

APPENDIX J MACROFAUNA ANALYSIS

Table J.2 Faunal Biomass Matrix

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	STATIONS ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	Total
124394	ZB0224		O.F. Müller, 1776	*Echinocardium flavescens*												1.8511										**1.8511**
124462	ZB0292	Holothuroidea	Ostergren, 1905	*Leptosynapta bergensis*															1.2078							**1.2078**
283798	D0632	CNIDARIA	Gosse, 1859	*Cerianthus lloydii*		0.0052																0.0013		0.0050		**0.0115**
1360	D0662			*Actiniaria*																						**0.0000**
100665	D0759		Andres, 1881	*Edwardsiidae*																				0.0021	0.0084	**0.0105**
100880	D0766		Panceri, 1869	*Edwardsia claparedii*								0.0137				0.0394	0.0052		0.0148							**0.0731**
793	F0001	PLATYHELMINTHES	Minot, 1876	*Platyhelminthes*												0.0265						0.0053				**0.0318**
152391	G0001	NEMERTEA		*Nemertea*	0.2276			0.0072	0.0187		0.0002	0.0004	0.0011	0.0005	0.0052	0.0454	0.0128	0.0026	0.0640		0.0103			0.0204	0.0168	**0.4332**
128545	ZA0003	PHORONIDA	Wright, 1856	*Phoronis*					0.0002					0.0046	0.0596				0.0380	0.0737	0.1174			0.0052		**0.2987**
1820	ZC0012	HEMICHORDATA	Gegenbaur, 1870	*Enteropneusta*														0.0501			0.3452					**0.3953**
112299		FORAMINIFERA	Sandahl, 1858	*Astrorhiza*																						**0.0000**
				Individuals	**5.8265**	**55.5545**	**0.7845**	**14.6342**	**1.1377**	**4.9551**	**1.1499**	**3.6495**	**1.2901**	**0.5777**	**0.4736**	**6.1898**	**5.5429**	**2.1226**	**19.1153**	**5.7624**	**14.7555**	**9.5870**	**36.3674**	**5.5714**	**5.0460**	**200.0936**
				Taxa	**19**	**23**	**24**	**28**	**38**	**21**	**26**	**24**	**31**	**28**	**32**	**41**	**36**	**22**	**41**	**32**	**40**	**21**	**31**	**47**	**29**	**161**

Juvenile Record
Taxa in Blue are the top 10 dominant in the adult data set
Taxa in red are species of interest
P = Present

Aphia ID	MCS Code	Phylum Class/Order	Authority	Taxon	ENV1	ENV2	ENV4	ENV5	ENV6	ENV8	ENV9	ENV10	ENV11	ENV14	ENV15	ENV16	ENV17	ENV18	ENV19	ENV20	ENV21	ENV22	ENV23	ENV24	ENV25	Total
Taxa excluded from Statistical Analysis																										
1337	D0138	CNIDARIA	Owen, 1843	Hydrozoa																						**0.0000**
13552	D0296		Cornelius, 1992	Leptothecata																						**0.0000**
1614	D0407		Lamouroux, 1812	Sertulariidae																						**0.0000**
117890	D0424		(Linnaeus, 1758)	*Hydrallmania falcata*																						**0.0000**
1606	D0491		Johnston, 1836	Campanulariidae																						**0.0000**
799	HD0001	NEMATODA		Nematoda													0.0001		0.0001					0.0001	0.0001	**0.0004**
1271	K0001	ENTOPROCTA	Nitsche, 1869	Entoprocta																						**0.0000**
2081	L0001	CHAETOGNATHA		Chaetognatha																0.0016						**0.0016**
1080	H0142	ARTHROPODA	Milne Edwards, 1840	Copepoda	0.0007	0.0007																			0.0001	**0.0015**
		ANNELIDA																								**0.0000**
883	P0002	Polychaeta	Grube, 1850	Polychaeta														0.0021								**0.0021**
131077	P0109		(Ehlers, 1864)	*Sthenelais limicola*										0.0058					0.0023							**0.0081**
129455	P0178		Lamarck, 1818	*Phyllodoce*					0.0284			0.0028								0.0065						**0.0377**
130136	P0268		(Malmgren, 1866)	*Glycinde nordmanni*																				0.0026		**0.0026**
130140	P0271		Orsted, 1843	*Goniada maculata*				0.0215																		**0.0215**
946	P0293		Grube, 1850	Hesionidae														0.001								**0.0010**
710680			(Delle Chiaje, 1827)	*Oxydromus flexuosus*												0.0037										**0.0037**
129370	P0494		Cuvier, 1817	*Nephtys*																	0.3905					**0.3905**
130238	P0574		Fauchald, 1974	*Lumbrineris aniara*													0.0075									**0.0075**
130537	P0672		(Müller, 1776)	*Scoloplos armiger*	0.0009																					**0.0009**
913	P0720		Grube, 1850	Spionidae								0.0006														**0.0006**
129341	P0803		F. Müller, 1858	*Magelona*								0.0008														**0.0008**
919	P0822		Ryckholt, 1851	Cirratulidae											0.0017											**0.0017**
923	P0938		Malmgren, 1867	Maldanidae																		0.0002			0.0087	**0.0089**
130980	P1027		Rathke, 1843	*Scalibregma inflatum*	0.0346	0.0022			0.0589	0.0198	0.0293					0.0981	0.6031		0.0935		0.0387		0.0055	0.023		**1.0067**
1130	S1276	Decapoda	Latreille, 1802	Decapoda													0.0012									**0.0012**
		ECHINODERMATA																								**0.0000**
123206	ZB0148	Ophiuroidea	Ljungman, 1867	Amphiuridae				0.0132																	0.0001	**0.0133**
123106	ZB0213	Echinoidea	L. Agassiz, 1840	Spatangoida																			0.214			**0.2140**
123426	ZB0222		Gray, 1825	*Echinocardium*										3.0012												**3.0012**
111604	Y0081	BRYOZOA	Fleming, (1828)	*Alcyonidium parasiticum*																						**0.0000**
111669	Y0131		(Linnaeus, 1758)	*Vesicularia spinosa*																						**0.0000**
111361	Y0165		(Linnaeus, 1758)	*Eucratea loricata*																						**0.0000**
128545	ZA0003	PHORONIDA	Wright, 1856	*Phoronis*								0.0086														**0.0086**
1692		CILIOPHORA	Dons, 1914	*Folliculinidae*																						**0.0000**
104906		CHORDATA	Pallas, 1774	*Branchiostoma lanceolatum*																				0.0002		**0.0002**
126752	ZG0444		Linnaeus, 1758	*Ammodytes tobianus*		1.8045																				**1.8045**

APPENDIX K EUNIS HABITAT CLASSIFICATION

APPENDIX K EUNIS HABITAT CLASSIFICATION

Station	Water Depth (m LAT)	EUNIS Habitat Classification		MNCR Habitat Classification		MNCR/EUNIS Habitat Type	PSA	Abundance Top 10 Full Fauna			Other Fauna consistentt with EUNIS level	Representative Image
		Level	Code	Level	Code			Rank	Taxa	Abundance		
ENV1	35	5	A5.233	5	SS.SSa.IFiSa.NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderately Well (0% fines, 100% sand, 0% gravel)	1	***Bathyporeia elegans***	10	***Magelona filiformis***	
								2	***Nephtys cirrosa***	7		
								3	***Bathyporeia***	6		
								4	***Fabulina fabula***	5		
								5	***Bathyporeia guilliamsoniana***	4		
								6	*Perioculodes longimanus*	3		
								6	*Abra prismatica*	3		
								8	*Chaetozone christiei*	2		
								8	*Iphinoe trispinosa*	2		
								8	*Spisula*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.233, MNCR Code SS.SSa.IFiSa.NcirBat				
ENV2	33	5	A5.252	5	SS.SSa.CFiSa.ApriBatPo	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	PSA modified Folk: Slightly gravelly sand Wentworth (mean): Coarse Sand Sorting: Moderate (0.62% fines, 95.82% sand, 3.56% gravel)	1	***Scoloplos armiger***	15	***Amphiura filiformis***	
								2	***Ophelia borealis***	12		
								3	*Bathyporeia*	8		
								4	*Nephtys cirrosa*	5		
								4	*Spisula*	5		
								6	***Spiophanes bombyx***	3		
								7	*Hypereteone foliosa*	2		
								7	*Megaluropus agilis*	2		
								7	*Diastylis rugosa*	2		
								10	***Abra prismatica***	1		
								Faunal community (in bold) consistentt with Level 5 EUNIS Code A5.252, MNCR Code SS.SSa.CFiSa.ApriBatPo				
ENV4	37	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderate (6.88% fines, 93.12% sand, 0% gravel)	1	***Abra***	79	***Abra alba***	
								2	***Fabulina fabula***	10		
								3	*Bathyporeia elegans*	7		
								4	*Nephtys cirrosa*	5		
								4	*Bathyporeia tenuipes*	5		
								6	*Spisula*	4		
								6	*Poecilochaetus serpens*	4		
								8	***Scoloplos armiger***	3		
								8	*Bathyporeia*	3		
								8	***Spiophanes bombyx***	3		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				
ENV5	38	5	A5.252	5	SS.SSa.CFiSa.ApriBatPo	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderately Well (0.7% fines, 98.69% sand, 0.61% gravel)	1	***Abra***	47	***Abra alba***	
								2	*Nephtys cirrosa*	10		
								3	***Scoloplos armiger***	6		
								4	***Spiophanes bombyx***	5		
								5	***Ophelia borealis***	4		
								5	*Lagis koreni*	4		
								7	***Bathyporeia elegans***	3		
								7	*Poecilochaetus serpens*	3		
								9	*Bathyporeia tenuipes*	2		
								9	*Bathyporeia*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.252, MNCR Code SS.SSa.CFiSa.ApriBatPo				
ENV6	39	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderate (4.09% fines, 94.92% sand, 1% gravel)	1	***Abra***	54	***Goniada maculata***	
								2	Thracioidea	24	***Scalibregma inflatum***	
								3	*Nephtys cirrosa*	9		
								4	***Spiophanes bombyx***	8		
								5	***Scoloplos armiger***	6		
								6	*Bathyporeia elegans*	5		
								6	Nemertea	5		
								8	*Bathyporeia guilliamsoniana*	4		
								8	***Fabulina fabula***	4		
								10	*Ophelia borealis*	3		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				

Gardline

APPENDIX K EUNIS HABITAT CLASSIFICATION

Station	Water Depth (m LAT)	EUNIS Habitat Classification		MNCR Habitat Classification		MNCR/EUNIS Habitat Type	PSA	Abundance Top 10 Full Fauna			Other Fauna consistentt with EUNIS level	Representative Image
		Level	Code	Level	Code			Rank	Taxa	Abundance		
ENV8	41	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderately Well (4.29% fines, 95.71% sand, 0% gravel)	1	***Abra***	103	***Abra alba***	
								2	*Chaetozone christiei*	15	***Spiophanes bombyx***	
								3	***Fabulina fabula***	4	***Scoloplos armiger***	
								3	*Magelona johnstoni*	4		
								5	Ophiuridae	3		
								6	***Scalibregma inflatum***	2		
								6	*Lagis koreni*	2		
								6	*Amphiuridae*	2		
								6	*Spatangoida (juv)*	2		
								6	*Spisula*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				
ENV9	43	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Muddy sand Wentworth (mean): Medium Sand Sorting: Poor (10.09% fines, 89.91% sand, 0% gravel)	1	***Abra***	34	***Spiophanes bombyx***	
								2	***Fabulina fabula***	22	***Scalibregma inflatum***	
								3	Amphiuridae	7	***Abra alba***	
								4	*Chaetozone christiei*	6	***Scoloplos armiger***	
								5	*Amphictene auricoma*	5	***Lanice conchilega***	
								5	*Euspira nitida*	5		
								5	*Bathyporeia tenuipes*	5		
								8	Magelona johnstoni	4		
								9	*Poecilochaetus serpens*	3		
								10	*Ophiuridae*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				
ENV10	43	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderate (5.37% fines, 94.63% sand, 0% gravel)	1	***Abra***	41		
								2	***Fabulina fabula***	8		
								3	*Magelona johnstoni*	5		
								4	*Diastylis bradyi*	3		
								4	*Sthenelais limicola*	3		
								4	Mactra	3		
								7	*Amphictene auricoma*	2		
								7	*Euspira nitida*	2		
								7	*Bathyporeia tenuipes*	2		
								7	*Spatangoida (juv)*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				
ENV11	42	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderately Well (4.79% fines, 95.21% sand, 0% gravel)	1	***Abra***	19		
								2	***Fabulina fabula***	10		
								3	***Spiophanes bombyx***	6		
								4	*Magelona johnstoni*	5		
								4	*Diastylis bradyi*	5		
								4	*Amphiuridae*	5		
								4	*Poecilochaetus serpens*	5		
								8	*Bathyporeia tenuipes*	4		
								9	*Chaetozone christiei*	3		
								9	Notomastus	3		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				
ENV14	42	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Fine Sand Sorting: Moderate (6.34% fines, 93.66% sand, 0% gravel)	1	***Abra***	49	***Scoloplos armiger***	
								2	*Amphiura filiformis*	10		
								3	*Euspira nitida*	7		
								4	***Fabulina fabula***	4		
								4	*Amphictene auricoma*	4		
								4	*Nucula*	4		
								7	***Spiophanes bombyx***	3		
								7	*Magelona filiformis*	3		
								9	*Kurtiella bidentata*	2		
								9	*Spatangoida (juv)*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				

APPENDIX K EUNIS HABITAT CLASSIFICATION

Station	Water Depth (m LAT)	EUNIS Habitat Classification		MNCR Habitat Classification		MNCR/EUNIS Habitat Type	PSA	Abundance Top 10 Full Fauna			Other Fauna consistentt with EUNIS level	Representative Image
		Level	Code	Level	Code			Rank	Taxa	Abundance		
ENV15	52	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderate (4.66% fines, 95.34% sand, 0% gravel)	1	*Amphiuridae*	15	***Fabulina fabula***	
								2	***Abra***	9	***Spiophanes bombyx***	
								3	*Amphiura filiformis*	7		
								3	*Phoronis*	7		
								5	*Amphictene auricoma*	3		
								6	***Nucula***	2		
								6	*Veneridae*	2		
								6	*Poecilochaetus serpens*	2		
								6	Bathyporeia tenuipes	2		
								6	*Phaxas pellucidus*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				
ENV16	47	4	A5.44	4	SS.SSMx.CMx	Circalittoral mixed sediment	PSA modified Folk: Gravelly sand Wentworth (mean): Medium Sand Sorting: Poor (7.43% fines, 83.50% sand, 9.08% gravel)	1	***Amphiura filiformis***	66	**Nemetea**	
								2	**Pholoe**	17	***Glycera alba***	
								3	***Scalibregma inflatum***	15	***Scoloplos armiger***	
								4	*Amphiuridae*	14		
								5	***Abra***	11		
								6	*Ophelia borealis*	9		
								7	*Amphictene auricoma*	7		
								8	*Pharidae*	6		
								9	***Spiophanes bombyx***	5		
								9	*Lagis koreni*	5		
								Faunal community (in bold) consistent with Level 4 EUNIS Code A5.44, MNCR Code SS.SMx.CMx				
ENV17	50	5	A5.443	5	SS.SMx.CMx.MysThyMx	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	PSA modified Folk: Gravelly muddy sand Wentworth (mean): Coarse Sand Sorting: Very Poor (15.25% fines, 60.98% sand, 23.77% gravel)	1	***Amphiura filiformis***	127	***Mediomastus fragilis***	
								2	***Scalibregma inflatum***	50	***Spiophanes bombyx***	
								3	**Nemertea**	6		
								4	***Pholoe***	5		
								4	*Cylichna cylindracea*	5		
								6	*Callianassa subterranea*	4		
								6	*Notomastus*	4		
								8	*Amphictene auricoma*	3		
								8	*Lagis koreni*	3		
								8	*Kurtiella bidentata*	3		
								Faunal community (in bold) consistentwith Level 5 EUNIS Code A5.443, MNCR Code SS.SMx.CMx.MysThyMx				
ENV18	47	5	A5.251	5	SS.SSa.CFiSa.EpusOborApri	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	PSA modified Folk: Sand Wentworth (mean): Coarse Sand Sorting: Moderatelly Well (0% fines, 100% sand, 0% gravel)	1	*Spatangoida (juv)*	19	***Abra prismatica***	
								2	***Echinocyamus pusillus***	9	***Glycera lapidum***	
								3	***Ophelia borealis***	8	***Owenia***	
								4	*Glycinde nordmanni*	3		
								4	*Nephtys cirrosa*	3		
								4	*Leiochone*	3		
								7	*Nemertea*	2		
								7	***Spiophanes bombyx***	2		
								7	***Abra***	2		
								7	*Scoloplos armiger*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.251, MNCR Code SS.SSa.CFiSa.EpusOborApri				
ENV19	57	5	A5.443	5	SS.SMx.CMx.MysThyMx	*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment	PSA modified Folk: Gravelly muddy sand Wentworth (mean): Medium Sand Sorting: Very Poor (13.73% fines, 70.9% sand, 15.37% gravel)	1	***Amphiura filiformis***	177	***Spiophanes bombyx***	
								2	*Amphiuridae*	41	***Owenia***	
								3	**Pholoe**	21		
								4	***Scalibregma inflatum***	10		
								5	*Amphictene auricoma*	7		
								6	*Cylichna cylindracea*	5		
								6	*Callianassa subterranea*	5		
								6	*Kurtiella bidentata*	5		
								9	**Nemertea**	4		
								9	***Abra***	4		
								Faunal community (in bold) consistentwith Level 5 EUNIS Code A5.443, MNCR Code SS.SMx.CMx.MysThyMx				

APPENDIX K EUNIS HABITAT CLASSIFICATION

Station	Water Depth (m LAT)	EUNIS Habitat Classification		MNCR Habitat Classification		MNCR/EUNIS Habitat Type	PSA	Abundance Top 10 Full Fauna			Other Fauna consistentt with EUNIS level	Representative Image
		Level	Code	Level	Code			Rank	Taxa	Abundance		
ENV20	47	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Moderate (2.65% fines, 97.35% sand, 0% gravel)	1	Amphiuridae	7	***Scoloplos armiger***	
								2	*Amphiura filiformis*	4	***Abra***	
								2	*Nephtys cirrosa*	4	***Abra prismatica***	
								2	***Fabulina fabula***	4		
								2	*Thracia*	4		
								6	*Asteroidea (juv)*	3		
								6	***Goniada maculata***	3		
								6	*Glycinde nordmanni*	3		
								6	*Cochlodesma praetenue*	3		
								10	*Phoronis*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.261, MNCR Code SS.SSa.CMuSa.AalbNuc				
ENV21	61	4	A5.25	4	SS.SSa.CFiSa	Circalittoral fine sand	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Poor (6.99% fines, 93.01% sand, 0% gravel)	1	*Amphiura filiformis*	81	***Abra***	
								2	*Pholoe*	12	**Nemertea**	
								3	*Lagis koreni*	9	***Scoloplos armiger***	
								4	*Phoronis*	7	***Spiophanes bombyx***	
								4	*Amphictene auricoma*	7	***Echinocardium cordatum***	
								6	*Asteroidea (juv)*	6		
								7	*Magelona alleni*	5		
								8	***Scalibregma inflatum***	4		
								8	*Callianassa subterranea*	4		
								8	*Thracioidea*	4		
								Faunal community (in bold) consistent with Level 4 EUNIS Code A5.25, MNCR Code SS.SSa.CFiSa				
ENV22	59	5	A5.251	5	SS.SSa.CFiSa.EpusOborApri	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	PSA modified Folk: Sand Wentworth (mean): Medium Sand Sorting: Poor (4.01% fines, 95.99% sand, 0% gravel)	1	***Echinocyamus pusillus***	36		
								2	*Spatangoida (juv)*	15		
								3	*Amphiura filiformis*	11		
								4	***Ophelia borealis***	7		
								5	*Astrorhiza*	5		
								6	***Pholoe***	2		
								6	*Abra*	2		
								6	*Echinocardium cordatum*	2		
								6	***Glycera lapidum***	2		
								10	*Echinocardium*	1		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.251, MNCR Code SS.SSa.CFiSa.EpusOborApri				
ENV23	58	5	A5.251	5	SS.SSa.CFiSa.EpusOborApri	*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	PSA modified Folk: Sand Wentworth (mean): Coarse Sand Sorting: Poor (1.47% fines, 98.53% sand, 0% gravel)	1	***Echinocyamus pusillus***	16	***Glycera lapidum***	
								2	*Amphiura filiformis*	10		
								3	***Spiophanes bombyx***	6		
								4	*Nephtys*	5		
								5	***Ophelia borealis***	3		
								5	*Lucinoma borealis*	3		
								5	***Goniada maculata***	3		
								8	Spatangoida (juv)	2		
								8	*Echinocardium cordatum*	2		
								8	*Scoloplos armiger*	2		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.251, MNCR Code SS.SSa.CFiSa.EpusOborApri				

APPENDIX K EUNIS HABITAT CLASSIFICATION

Station	Water Depth (m LAT)	EUNIS Habitat Classification		MNCR Habitat Classification		MNCR/EUNIS Habitat Type	PSA	Abundance Top 10 Full Fauna			Other Fauna consistentt with EUNIS level	Representative Image
		Level	Code	Level	Code			Rank	Taxa	Abundance		
ENV24	56	4	A5.14	4	SS.SCS.CCS	Circalittoral coarse sediment	PSA modified Folk: Gravelly Sand Wentworth (mean): Coarse Sand Sorting: Poor (2.68% fines, 89.66% sand, 7.66% gravel)	1	*Urothoe elegans*	20	***Spiophanes bombyx***	
								2	*Lagis koreni*	11	***Scoloplos armiger***	
								3	*Amphiura filiformis*	9	***Cerianthus lloydii***	
								3	Spatangoida (juv)	9		
								5	Asteroidea (juv)	7		
								6	***Echinocyamus pusillus***	6		
								7	***Glycera lapidum***	5		
								7	**Nemertea**	5		
								9	*Callianassa subterranea*	4		
								9	Aoridae	4		
								Faunal community (in bold) consistent with Level 4 EUNIS Code A5.14, MNCR Code SS.SCS.CCS				
ENV25	58	5	A5.252	5	SS.SSa.CFiSa.ApriBatPo	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	PSA modified Folk: Sand Wentworth (mean): Coarse Sand Sorting: Poor (0.51% fines, 95.43% sand, 4.06% gravel)	1	*Urothoe marina*	31		
								2	Asteroidea (juv)	11		
								3	Spatangoida (juv)	7		
								3	*Amphipoda*	7		
								5	***Spiophanes bombyx***	6		
								6	***Aonides paucibranchiata***	5		
								7	*Glycera lapidum*	4		
								7	***Ophelia borealis***	4		
								7	***Abra prismatica***	4		
								10	*Poecilochaetus serpens*	3		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.252, MNCR Code SS.SSa.CFiSa.ApriBatPo				

Appendix B: Hornsea Four Offshore Wind Farm Export Cable Corridor Volume 3: Results Report (Bibby Hydromap 2019)

Hornsea 4 Offshore Wind Farm

Lot 7 GP1a Export Cable Corridor

Volume 3: Results Report

Bibby HydroMap Project No. 2019-023A

Date: February 2019

Prepared For	Roland Gotfredsen [redacted]
Project Manager	Simon Baldwin [redacted]
Report Author	Cherri-Ann Bones
Report Review and Authorisation	Hugh Fraser
Bibby HydroMap Project Reference	2018-023a_Vol3_rev00
Report Reference Code and Revision	REP-F-005 Rev 1

Services Warranty

Based upon an agreed contract ("Contract") between Bibby HydroMap Limited ("Bibby HydroMap") and the client as named at the front of this report ("Client"), this report and all it contains, together with its associated works and services, has been designed solely to meet the requirements of the Contract.

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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Report Revisions

Revision Number	Date of Issue	Comments
00	22/02/2019	For comment

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Appendix 1: Listings

1. Introduction

1.1. Project Overview

Bibby HydroMap were commissioned in May 2018 by Ørsted to carry out geophysical and benthic surveys at Hornsea 4 Lot 7. The survey was completed under Bibby HydroMap's Terms and Conditions. The offshore segment of the survey was undertaken with MV Bibby Tethra, between 17/10/2018 and 05/12/2018. An overview of the survey area is presented in Figure 1 below.

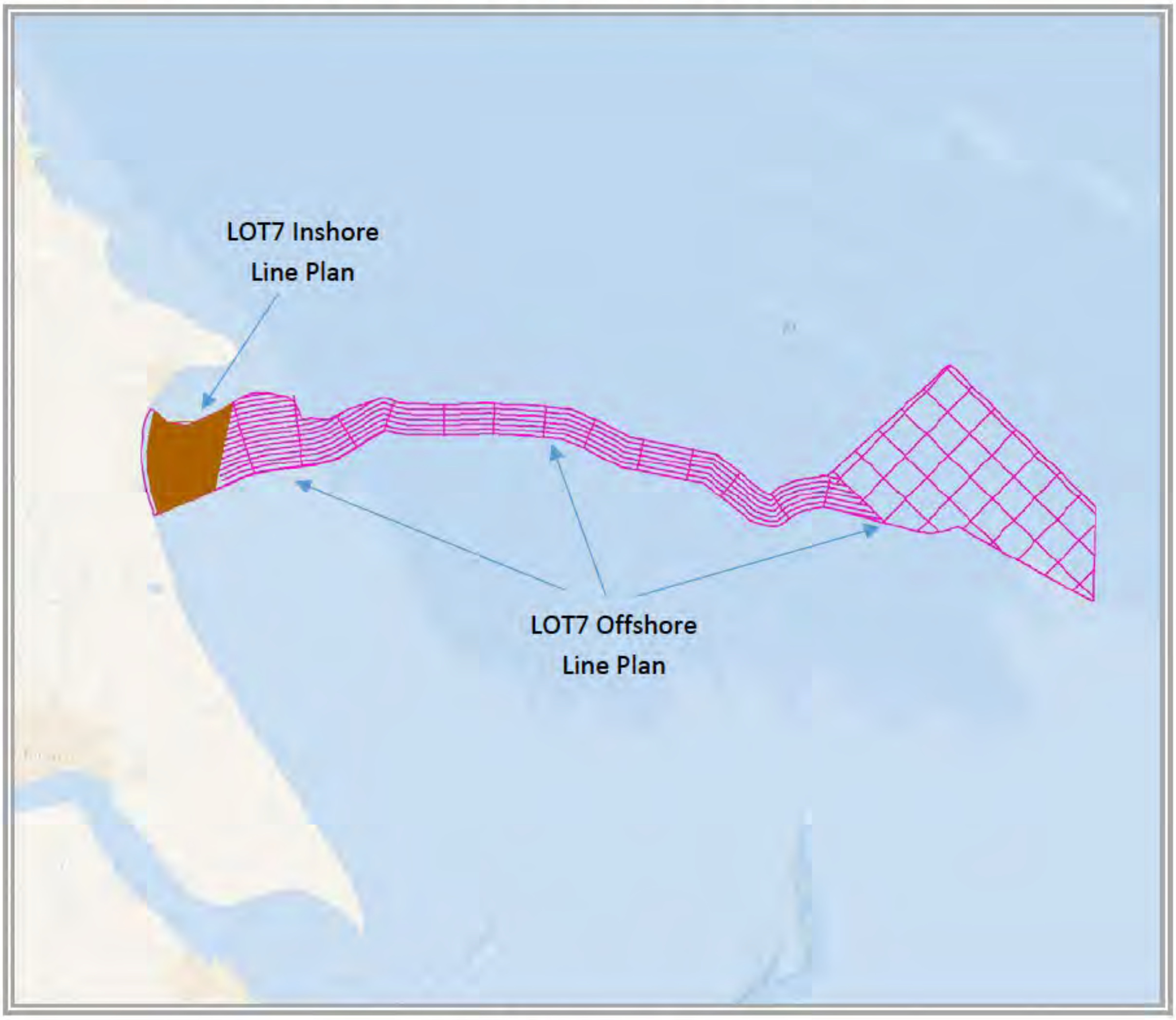


Figure 1: Site Location Plan

The survey was designed to provide information for the following:

- Cable route engineering;
- Geo-hazard assessment;
- Consenting requirements:
  - Identifying archaeological restrictions,
  - Identifying protected ecological habitats;
- Planning of Geotechnical investigations; and
- UXO clearance for Geotechnical investigations.

Therefore, the main objectives of the survey are as follows:

- Accurate bathymetry;
- Seabed sediment classification;
- Mapping of seabed morphology;
- Shallow seismic stratigraphic and structural model (<10m below seabed);
- Information on ferromagnetic objects;
- Information on archaeological features; and
- Information on geo-hazards.

In addition to the geophysical survey, locations for grab sampling and video recording were expected to be defined within the survey areas covered by Bibby Tethra. The final positions of these are to be agreed upon, based on a recommendation from the Contractor following on-board preliminary assessment of the side scan sonar and magnetometer data. The acquisition of these locations has subsequently been deferred to summer 2019.

The purpose of the grab sampling was to:

- Ground truth the seabed sediment classification to be derived from the side scan sonar data, multibeam echosounder data and the SBP data
- Provide benthic ecology information to support the consenting process on HOW04.

This report details the results of the data, and forms part of a larger reporting structure which is summarised below:

Volume	Report Description
1	Operations Report
2	Processing Report
3	Lot 7 Results Report (this volume)

Table 1: Reporting Structure

1.2. Summary of Fieldwork

The Hornsea LOT7 cable route geophysical investigation corridor was defined by a corridor, stretching some 93km from Skipsea Beach on the North Yorkshire coast, out to the proposed Hornsea 4 wind farm development. The survey corridor and line plan were designed to provide full coverage on the inshore section which was being covered by the MV Lia. The offshore section of the survey corridor which was covered by the MV Bibby Tethra, was designed to provide only grid coverage of the survey area to help inform route planning.

The vessel began acquisition on 17/10/2018 after completing scheduled operations on HOW03 and demobilisation was undertaken on 06/12/2018.

The areas which involved close approach to fishing equipment were run in daylight hours and recces being performed by a 3rd party scout vessel, initially the 'Inger Lis' and later the 'Louise Thomsen', to find areas clear of fishing gear to enable work in hours of darkness. There was occasion when Bibby Tethra had to stand by during darkness when no cleared areas were available. Where fishing gear was present on the line plan, the survey would deviate around the fishing gear then continue on the mainline.

Information relating to the quantity of data acquired, environmental conditions, system configurations are presented in the 2018-023A Volume 1 Operations Report, along with a full diary of operations.

1.3. Survey Vessel

MV Bibby Tethra was mobilised at Grimsby Royal Dock, which was approximately 6 hours transit time from the site.

MV Bibby Tethra is a 27.5m semi SWATH (Small Waterplane Area Twin Hull) catamaran, which carries Category 1 certification under the current MCA Code of Practice for Small Workboats and Pilot Boats. Details of vessel specifications can be found at the following address:

[redacted]

All staff members and visitors were inducted to the vessel and made aware of the vessel HSE plan along with Bibby HydroMap's company policies and procedures. Details of this are held within the vessel HSE plan and can be provided on request.

Health & Safety meetings were held on board and attended by all members of the survey crew and client representatives.

The vessel offsets are provided in the Mobilisation Report.

Category	Details	Comments
24h Coastal Survey Vessel (up to 150 miles from a safe haven)	MV Bibby Tethra 	Launched in 2011 from Boulogne in France, Bibby Tethra is a 27.5m purpose built aluminium semi SWATH survey catamaran. She has a cruising speed of 12 knots and with a draft of 3.3m she has a minimum safe working water depth of 5m. Eight twin cabins allow provision of 2 client representatives in separate cabins.

Table 2: MV Bibby Tethra

1.4. Project Personnel

The following personnel were involved during various stages of the project:

Management	
Project Manager	Simon Baldwin
Party Chief	Peter Allanson, Wendy Cooney-Kane, Ivan Smith
Project Team Leader	Liliana Trindade

Acquisition							
Personnel	Party Chief	Geophysicist	Surveyor	Engineer	Vessel Crew	Client Rep	Fish Rep
Peter Allanson	✓						
Wendy Cooney-Kane	✓						
Ivan Smyth	✓						
Nick Darley			✓				
Dean Newman			✓				
Alice Bamkin			✓				
Alex Crook				✓			
Karl Cregeen				✓			
Yann Roue						✓	
James Brand						✓	
Finlay Munro					✓		
Mark Farrer					✓		
Neil Bossom					✓		
Rob Thompson					✓		
Robin Attley					✓		
Cliff Warren					✓		
Oliver Carrigher					✓		
David Blyth					✓		
Giles Simmons					✓		
Marvic Maltese					✓		

On-Site Processing and Reporting							
Personnel	Team Leader	Geophysicist	Surveyor	CAD	GIS	Reporting	QC
Jo Devall			✓				
Alex Smith			✓				
Ben Walters		✓	✓				
Rob Drew		✓					
Aleksei Shafiev		✓					
Roderick Finlayson		✓					

Table 3: Project Personnel

1.5. Equipment List

The following equipment was utilised during survey data acquisition:

Equipment Utilised
CNAV 3050 GNSS
Hemisphere R330u GNSS
IXBLUE HYDRINS
IXBLUE Octans
IXBLUE Octans 3000

Equipment Utilised
Sonardyne Mini Ranger 2 USBL
Kongsberg 2040
KNUDSEN 1600 with Neptune 77 Series SBES Transducer (33/210kHz)
Valeport mini SVS
Coda Technologies DA4G Digital Data Acquisition System
EdgeTech 4200 Side Scan Sonar System 300/600kHz
T-Count System
MacArtney Cormac Q4
Innomar SES-2000 Medium Parametric Echo Sounder
Geometrics G882 Magnetometer with Altimeter
Valeport Monitor Sound Velocity Probe
Sonardyne Mini Ranger 2 WSM 6+ Transponder

Table 4: Equipment Utilisation

1.6. Equipment Calibration

Details of all equipment calibrations can be found in the Mobilisation Report presented in Appendix 1 of the 2018-023A Volume 1 Operations Report.

1.7. Data Quality and Processing

Details of data quality and processing are presented in the 2018-023A Volume 2 Processing Report.

2. Geological Background

Anticipated regional geology indicates that the following units may be anticipated:

Unit	Formation	Description	Age
A	Surficial sediment	Muddy, sandy and gravelly sediments	Holocene
B	Botney Cut Formation (BCT)	Infill sediments of partially to completely infilled channels. Parallel bedded laminated clays and sands	Pleistocene
C	Bolders Bank Formation (BDK)	A blanket deposit of stiff glacial till. Mainly structureless on seismic profiles, but can be divided into two units in some places and these represent a lodgement till and an ablation till.	Pleistocene
D	Egmond Ground Formation (EGG)	Very fine to medium-grained, slightly gravelly marine sands	Pleistocene
E	Swarte Bank Formation (SWK)	Infill sediments of subglacial valleys trending predominantly NNE to SSW. Chaotic reflector configuration on seismic profiles suggesting poorly sorted, gravelly, coarse-grained sands. Possible glaciolacustrine depositional environment	Pleistocene
F	Yarmouth Roads/Winterton Shoal Formation (YMR/WSH)	YMR: Westward thinning sequence of structureless or chaotic character with some recognisable channel features. Fine and medium-grained sands with interbedded silty clay, marine sand and some reworked peat. Fluvial or deltaic depositional environment. WSH: Gently inclined, parallel reflectors probably formed of sands and silty clays. Formed by delta-front and nearshore deposits of rivers.	Pleistocene
G	Cretaceous Chalk (CCH)	Very fine grained, consistently pure, relatively soft, white limestone consisting of debris from planktonic algae. The formation appears in several channel-like basins / synclines across the western part of the site. Heavily faulted and this may be a function of its relatively structural weakness / brittle nature in comparison to the underlying Jurassic geology	Pre-Quaternary

Areas where the Yarmouth Roads or Cretaceous Chalk comes within 30m of the seabed, the location and extent of any channels (especially where infill sediments may be soft); and accurate mapping of the thickness of the Holocene sediments is of specific interest to the project.

3. Results and Interpretation

The results of the geophysical survey within the Lot 7 export cable route survey area are presented as a GIS chart deliverable, in line with the scope of works.

Datasets were reduced to VORF LAT, which involved applying the UKHO Vertical Offshore Reference Frame (VORF) Geoid model to the data during post processing.

In this report volume, the results of the bathymetry, side scan sonar data, sub-bottom and magnetometer features are discussed along the surveyed export route.

Listings for all sonar, magnetometer and sub-bottom contacts across the site are presented as a digital deliverable. This report is designed to be a summary of the information contained within the GIS deliverables and should therefore be read in conjunction with these, and the following information:

1. Side scan sonar contacts within the site boundary have been picked, listed and recorded to IHO-S44 standards in digital format.
2. All seabed contacts (side scan sonar, magnetometer and bathymetric) are provided as a digital deliverable.
3. Sub-bottom targets are characterised by the presence of hyperbolae and the strength of these is dependent on variations such as surface sediments, vessel speed and the object itself. It is not possible to provide any dimensions for these features, other than depth to top of the target. A full list of sub-bottom targets is presented as a digital deliverable.
4. Seabed targets which are considered related to each other have been identified within the listings. The digital deliverable for seabed contacts also indicates which datasets targets/anomalies were identified on and a confidence level for each pick, as indicated in the scope of works.
5. Figures contained within this report have a representative colour bar for the bathymetric seabed levels to illustrate the line spacing, and the spatial distribution of those items being discussed.

3.1 Bathymetry

The bathymetry of the Lot 7 export route has been split into 3 areas as indicated on Figure 2 below.

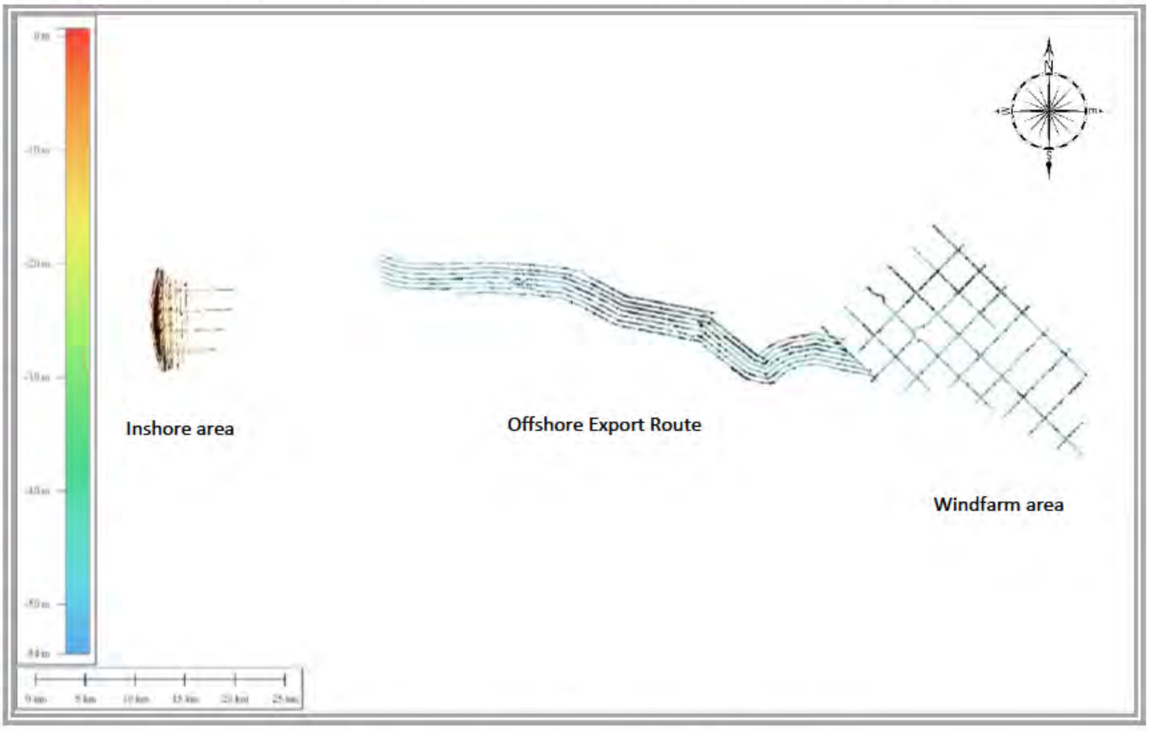
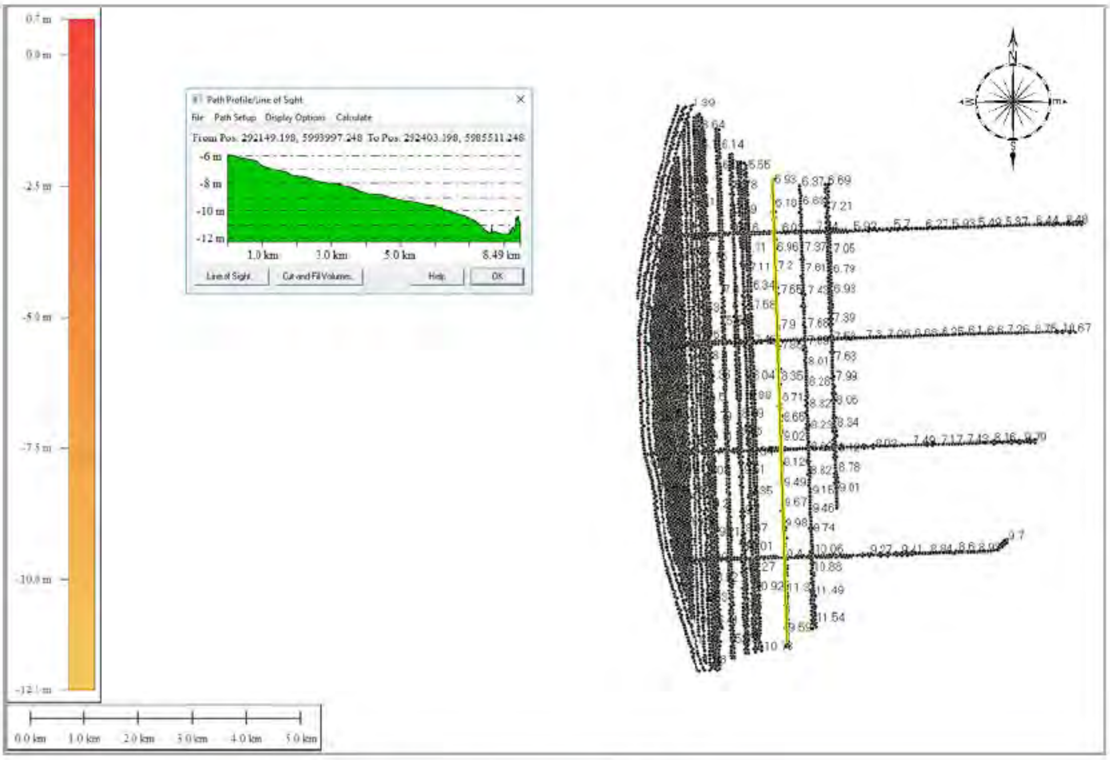
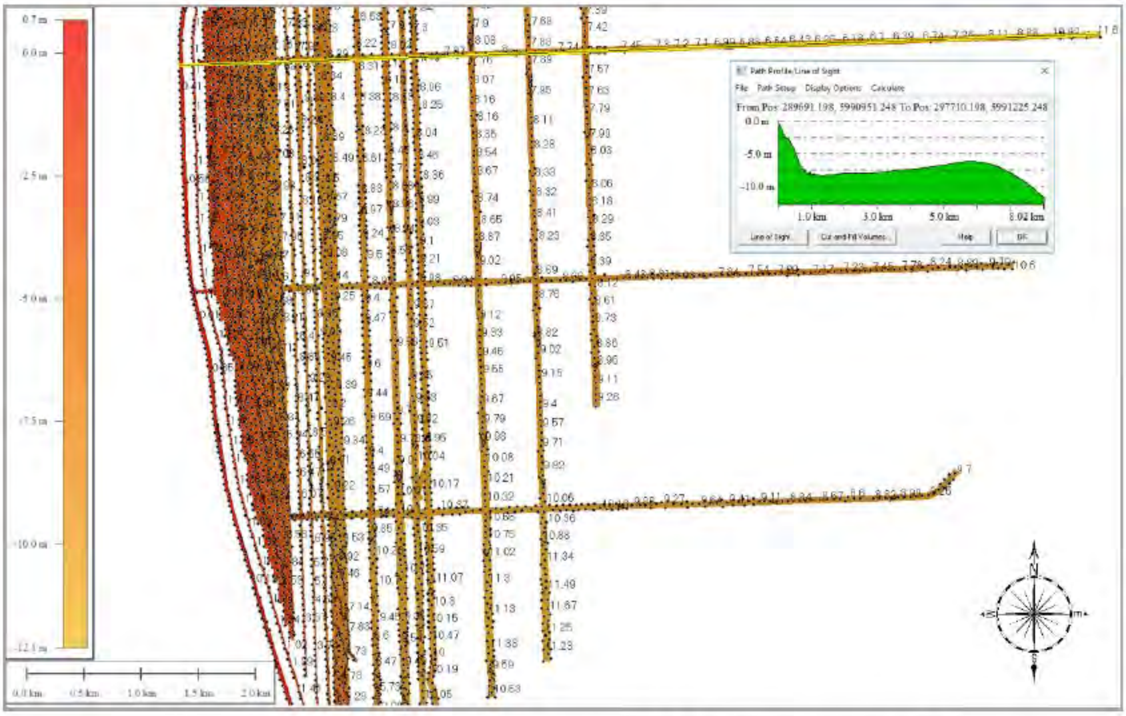


Figure 2: General Areas Described in Report

Seabed levels in the inshore area generally range from 0.4m above LAT in parts of the most inshore section to 11.9m below LAT in the southern portion of this area. Bed levels deepen from around LAT to 8.5m in the initial portion of the survey area at an average gradient of around 0.7°. As the survey lines space out further, bed levels generally range from 2.1m below LAT (in the southern portion of this area) to 11.5m below LAT in the southern portion of this inshore surveyed area with the deepest bed levels in the south-eastern portion of this area. Survey lines leading offshore indicate that the bed levels increase slightly over a sand bank before deepening again as indicated in Figure 3 below.



Seabed deepens to the south



Seabed initially decreases rapidly before rising slightly then decreasing offshore

Figure 3: Bathymetric Trends in Inshore Area

Seabed levels in the offshore export route commence around 46.2m below LAT in the northern and southernmost survey lines, reaching a maximum depth of 51.5m below LAT around grid reference 318116.7mE, 5995801.9mN, on the northernmost survey line.

In general, seabed levels deepen over the western third of this surveyed area, then flatten out until approximately 20km along the surveyed area of the export route, before increasing to the maximum of 51.5m below LAT detailed above, between 30km and 35km along the route. Bed levels then decrease to between 47.7m and 49.3m below LAT at the start of the main windfarm area. The bathymetric trends of this portion of the export route are illustrated in Figure 4 below.

Seabed levels in the main windfarm survey area commence between 44.7m and 48.7m below LAT and generally range from 30.8m below LAT on the crest of a sand wave, to 54.0m below LAT in the north-west extents of the surveyed area of the main windfarm.

The seabed is mobile from an area centred around 327905mE, 5994483mN until the main windfarm area where sand waves and associated megaripples were noted on the seabed. Megaripples are poorly defined on the main export route until approximately 331111mN, 5993870mE and these features extend up to, and into, the windfarm area where they are once again less well defined. Sand waves noted within the main windfarm area are between 0.5m and 1.8m high and bedforms are orientated north-east to south-west through to east-west. The approximate spatial extents of the more defined megaripples are shown in Figure 5 below.

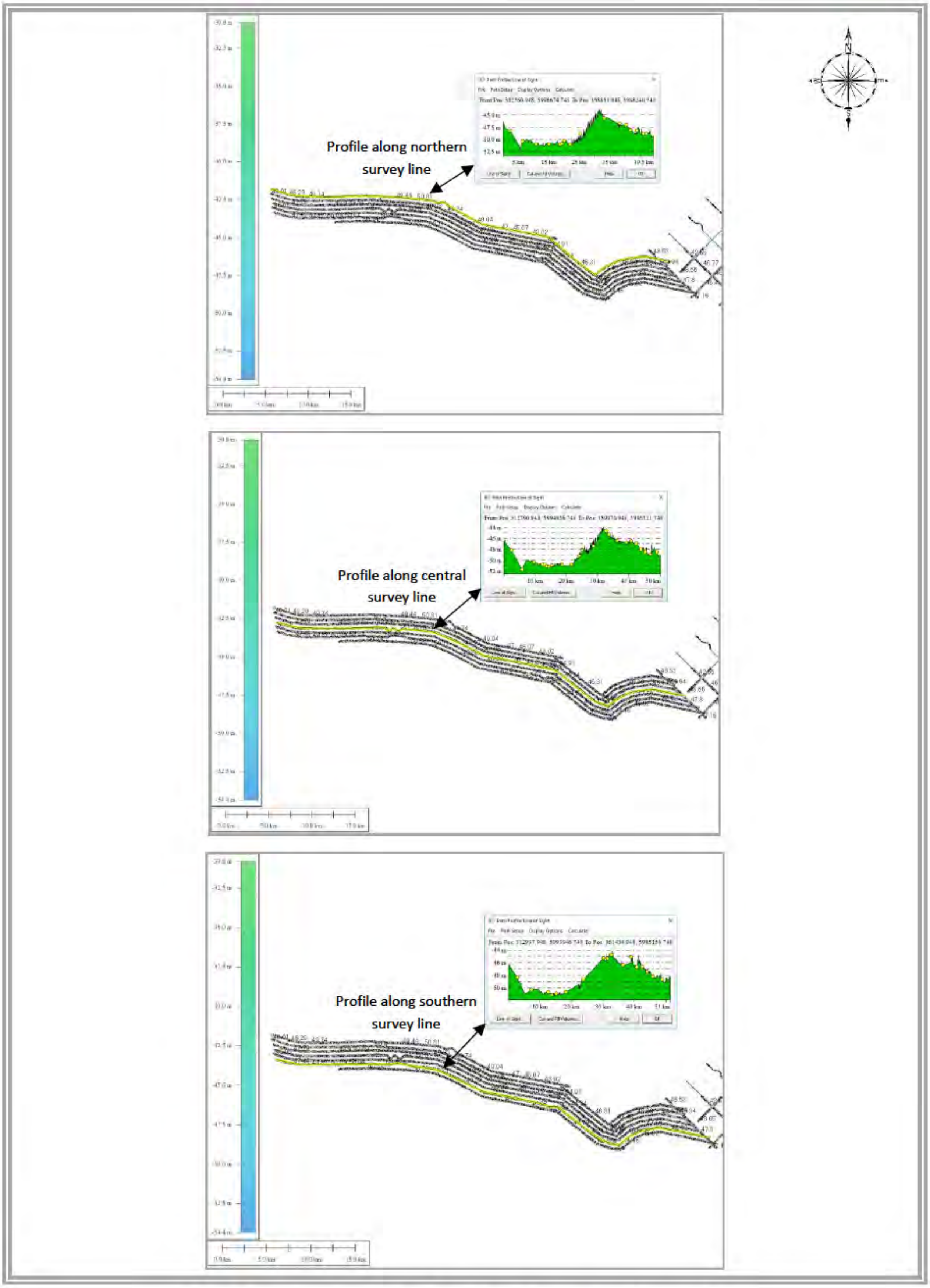


Figure 4: Bathymetric Trends Along Main Export Route Survey Area

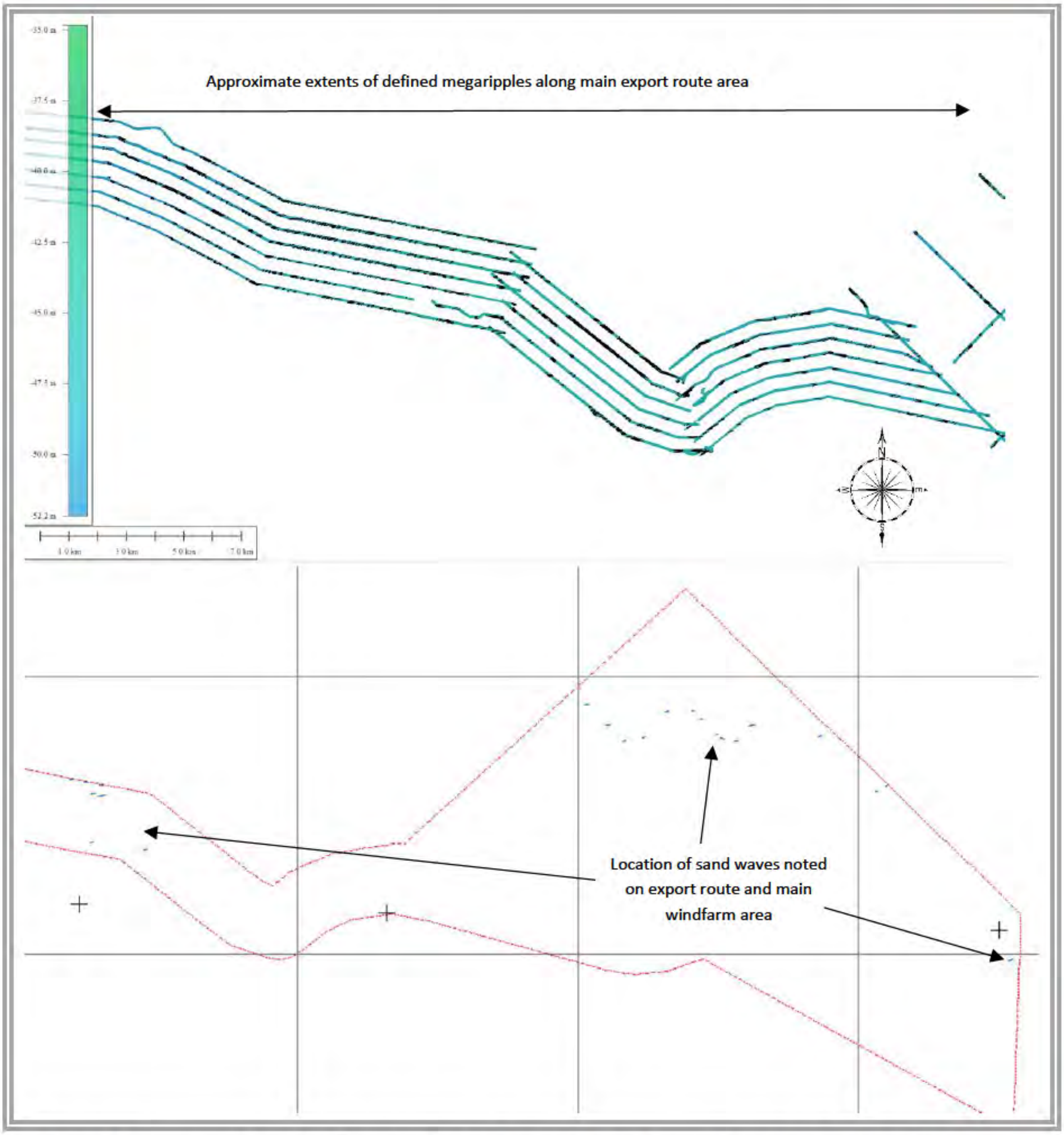


Figure 5: Approximate Spatial Extents of Mobile Seabed in Main Export Route Area and Windfarm Area

3.2 Seabed Features and Magnetic Anomalies

Seabed sediments along the Lot 7 export route generally comprise sands with outcropping till noted at the inshore survey extents as indicated in Figure 6 below.

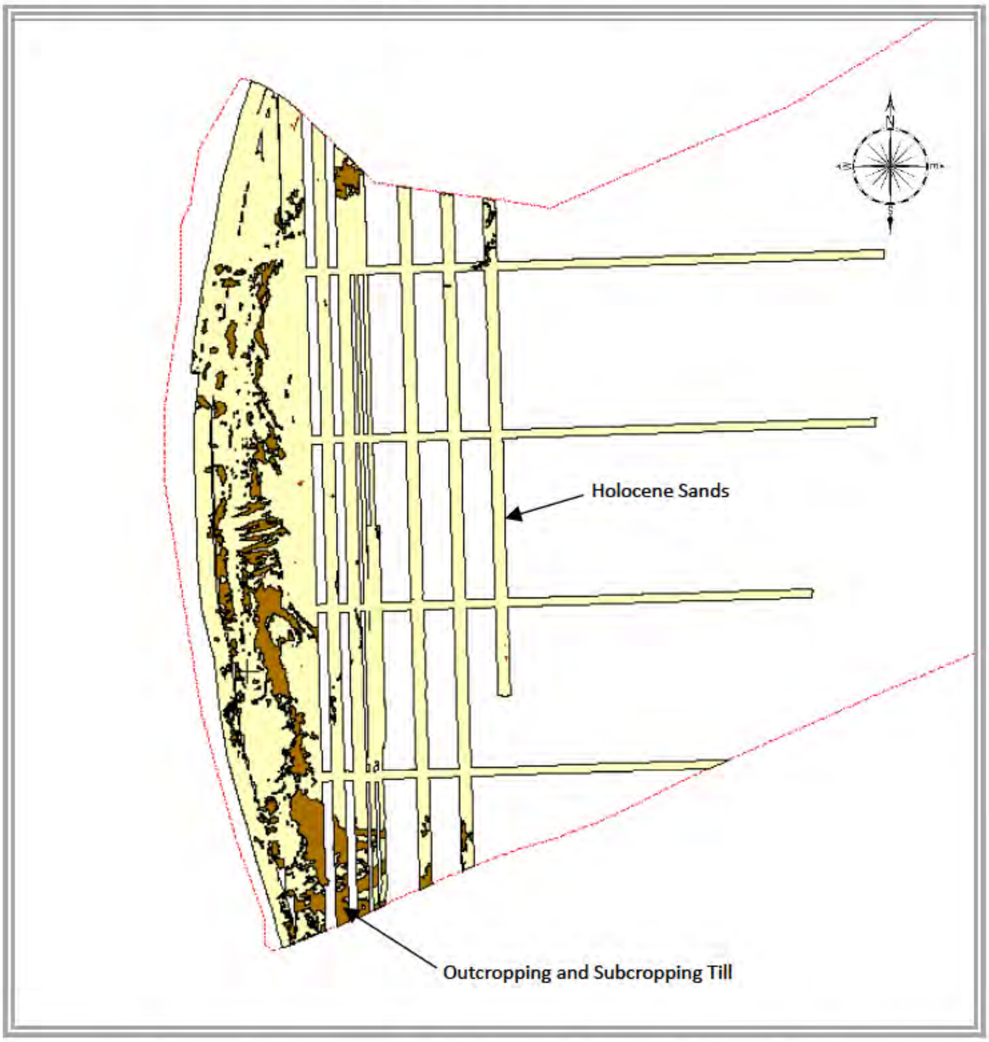


Figure 6: Outcropping Till at Inshore Extents of Survey Area

A total of 2250 seabed contacts were identified within the export route survey area. These include 378 bathymetric contacts (163 of which were also identified on the side scan sonar, sub-bottom or magnetometer data) and 1872 sonar contacts. Seafloor contacts are generally found in highest concentrations at the inshore extents of the surveyed area, although they are relatively evenly distributed along the remainder of the surveyed corridor as illustrated in Figure 7 below.

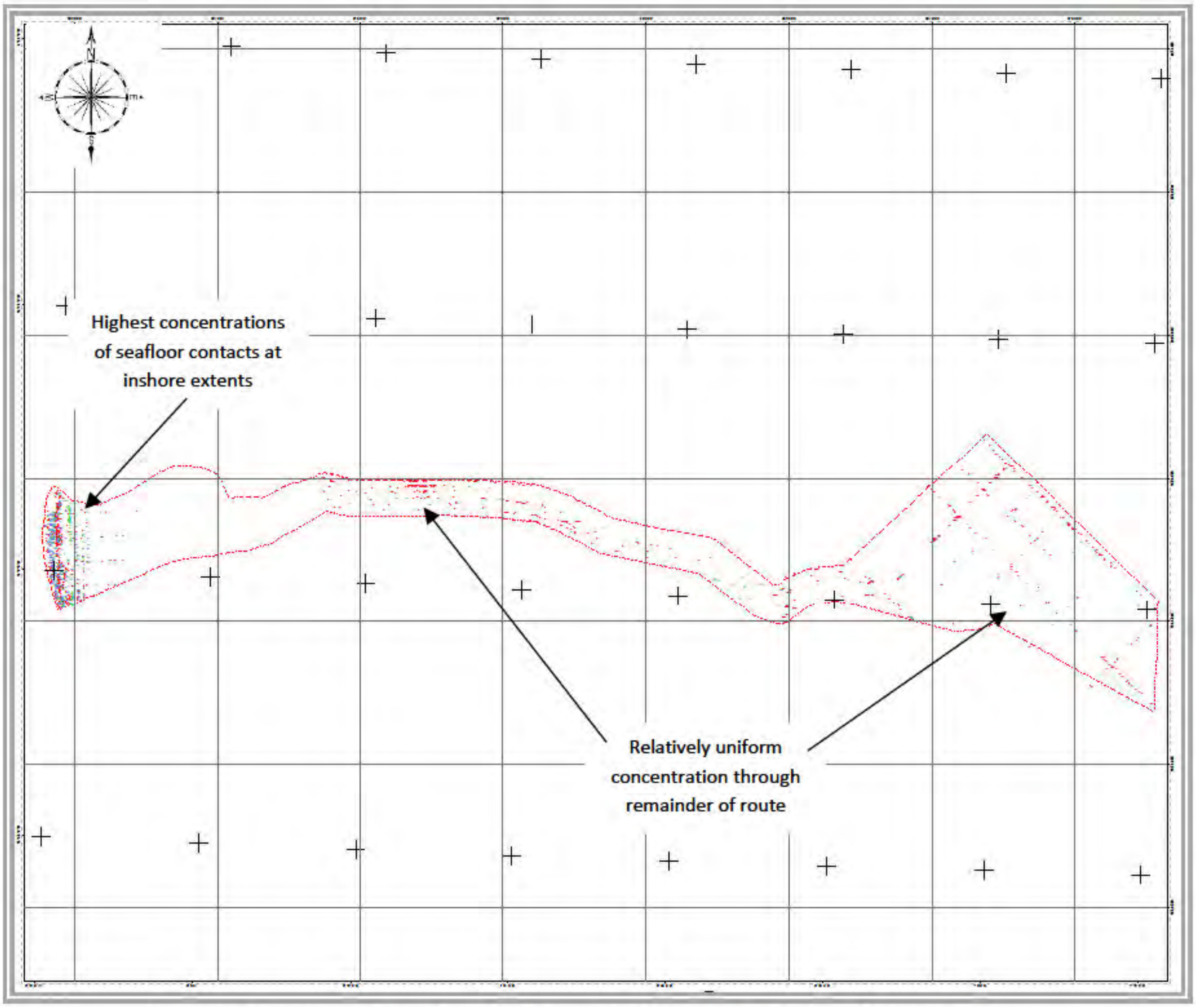


Figure 7: Concentrations of Seabed Contacts Across Lot 7 Surveyed Export Route

A total of 712 of these seafloor contacts were identified as debris, rope or possible fishing gear and 5 more were identified as possible wrecks. A table detailing locations of potential fishing gear is provided in Appendix 1 of this report.

In addition, 887 magnetic anomalies were also identified within the export route survey area along with 96 sub-bottom targets, 39 of which relate to pipelines, cables, or wrecks.

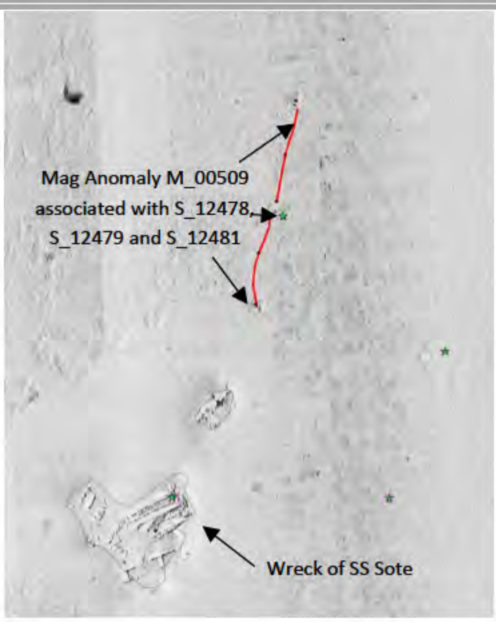
Eleven known pipelines and cables were identified in the side scan sonar, multibeam, magnetometer and sub bottom data, as well as several unidentified pipelines and cables. These include the following, the details of which are presented in Table 5 below:

- PL2071 Sleipner to Easington Gas Pipeline
- PL447 Cleeton to Dimlington Gas Pipeline
- Cleeton to Neptune Pipeline
- Ravenspurn to Cleeton Gas Pipeline
- Piggyback ST3-Ravenspurn C Platform Pipeline
- Ravenspurn North To Wellhead ST2 Pipeline
- Johnston Umbilical
- Babbage Export to West Sole Pipeline
- C0161 - Cleeton to Minerva Umbilical
- C1710 - Minerva Gas Export Pipeline

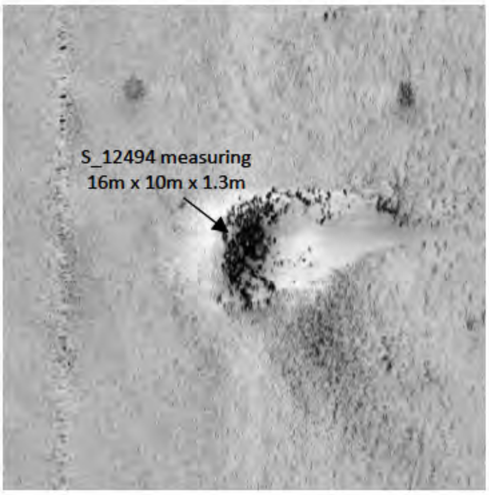
- PL7 - 3inch Service Piggyback Minerva to Cleeton
- Unknown cable and pipeline

The wrecks of the Lapwing and SS Sote were identified in the side scan sonar, multibeam, magnetometer and sub bottom data and these are presented in Table 6 below. Magnetic anomalies, side scan sonar contacts and sub-bottom targets possibly relating to nearby wrecks have been identified within this table also, along with another significant seabed contact. This contact (S_12494) is identified as an item of unknow debris, however, the associated magnetic signature may indicate that it could be a wooden wreck with ballast.

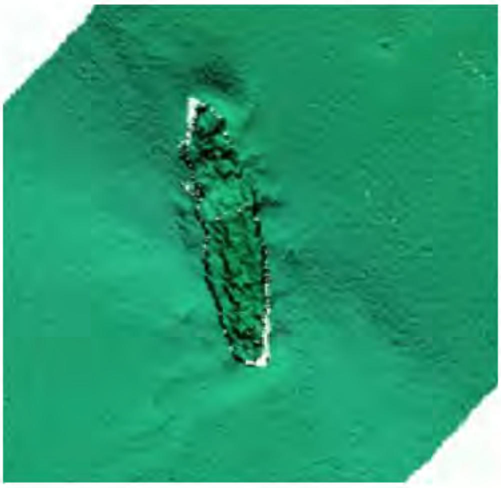
Images of the wrecks of the Lapwing, SS Sote and this significant seabed object are presented in Figure 8 below.



SS Sote Wreck



Significant Seabed Contact



Lapwing Wreck

Figure 8: Sonar Images of SS Sote, Lapwing and Other Significant Object

GAS PIPELINE PL2071 - SLEIPNER TO EASINGTON										
Seafloor Contact ID	**Easting (m)**	**Northing (m)**	**Length (m)**	**Width (m)**	**Height (m)**	**Datasets**	**Associated Mag Anomaly ID**	**Associated SBP Target ID**	**Comment**	**Confidence Level**
B_01008	326408.0	5993752.3	94.5	0.9	0.4	MBES MAG	M_00691	SBP_00054	Linear MBES Feature, Gas Pipeline PL2071 - Sleipner to Easington	5
B_01009	326752.6	5994804.2	105.9	0.9	0.5	MBES MAG	M_00692		Linear MBES Feature, Gas Pipeline PL2071 - Sleipner to Easington	5
B_01010	326877.5	5995183.0	104.8	0.9	0.4	MBES MAG	M_00694		Linear MBES Feature, Gas Pipeline PL2071 - Sleipner to Easington	5
S_25825	326090.6	5992802.7	76.7	0.9	0.1	SSS MBES			Linear Contact, Gas Pipeline PL2071 - Sleipner to Easington	5
S_25827	327042.9	5995676.7	96.3	0.9	0.1	SSS MBES MAG	M_00695		Linear Contact, Gas Pipeline PL2071 - Sleipner to Easington	5
S_25829	326310.1	5993446.2	147.3	0.9	0.1	SSS MBES			Linear Contact, Gas Pipeline PL2071 - Sleipner to Easington	5
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00689	326074.4	5992758.2		6309.6		MAG			Sleipner to Easington Gas Pipeline	5
M_00690	326325.9	5993505.0		3274.9		MAG			Sleipner to Easington Gas Pipeline	5
M_00691	326405.4	5993740.2		5214.1		MAG MBES	B_01008		Sleipner to Easington Gas Pipeline	5
M_00692	326722.8	5994717.9		9391.4		MAG MBES	B_01009		Sleipner to Easington Gas Pipeline	5
M_00694	326898.4	5995247.3		3711.9		MAG MBES	B_01010		Sleipner to Easington Gas Pipeline	5
M_00695	327048.6	5995694.1		4493.0		MAG SSS MBES	S_25827		Sleipner to Easington Gas Pipeline	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00052	326086.0	5992788.3		-0.4		SBP SSS MBES			Gas Pipeline PL2071 - Sleipner to Easington	5

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00053	326310.9	5993459.2		-0.1		SBP SSS MBES			Gas Pipeline PL2071 - Sleipner to Easington	5
SBP_00054	326409.4	5993756.1		-0.5		SBP MBES MAG	B_01008		Gas Pipeline PL2071 - Sleipner to Easington	5
SBP_00055	327056.7	5995719.1		-1.1		SBP MBES			Gas Pipeline PL2071 - Sleipner to Easington	5
GAS PIPELINE PL447 - CLEETON TO DIMLINGTON										
Seafloor Contact ID	**Easting (m)**	**Northing (m)**	**Length (m)**	**Width (m)**	**Height (m)**	**Datasets**	**Associated Mag Anomaly ID**	**Associated SBP Target ID**	**Comment**	**Confidence Level**
B_01022	348191.8	5987731.7	21.1	0.9	1.1	MBES			Linear MBES Feature, Gas Pipeline PL447 - Cleeton to Dimlington	5
B_01026	346350.5	5986643.8	17.2	0.9	0.8	MBES			Linear MBES Feature, Gas Pipeline PL447 - Cleeton to Dimlington	5
B_01029	347231.4	5987163.8	108.6	0.9	0.9	MBES			Linear MBES Feature, Gas Pipeline PL447 - Cleeton to Dimlington	5
B_01030	348606.1	5987986.5	107.7	0.9	1.1	MBES SBP		SBP_00064	Linear MBES Feature, Gas Pipeline PL447 - Cleeton to Dimlington	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00059	347690.8	5987442.4		0.5		SBP			Gas Pipeline PL447 - Cleeton to Dimlington	5
SBP_00061	348151.5	5987706.7		0.6		SBP			Gas Pipeline PL447 - Cleeton to Dimlington	5
SBP_00064	348610.8	5987990.7		0.4		SBP MBES	B_01030		Gas Pipeline PL447 - Cleeton to Dimlington	5
CLEETON TO NEPTUNE PIPELINE										
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00774	352597.2	5987991.1		510.4		MAG SBP		SBP_00069	Cleeton to Neptune Pipeline (SBP target outside of mag grid)	5

Mag Anomaly ID	Easting (m)	Northing (m)	Blank	Amplitude	Blank	Dataset	Associated Seafloor Contact ID	Associated SBP Target ID	Comments	Confidence Level
M_00778	352860.8	5987545.1		304.9		MAG SBP		SBP_00070	Cleeton to Neptune Pipeline	5
M_00780	353121.8	5987112.1		632.6		MAG SBP		SBP_00071	Cleeton to Neptune Pipeline	5
M_00782	353619.0	5986261.2		2461.7		MAG SBP		SBP_00072	Cleeton to Neptune Pipeline	5
M_00784	353917.5	5985758.8		635.8		MAG SBP		SBP_00074	Cleeton to Neptune Pipeline	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00069	352610.8	5987966.2		1.0		SBP MAG		M_00774	C121 - Cleeton to Neptune Pipeline (target outside of mag grid coverage)	5
SBP_00070	352864.1	5987536.4		1.0		SBP MAG		M_00778	C121 - Cleeton to Neptune Pipeline	5
SBP_00071	353118.3	5987107.5		1.0		SBP MAG		M_00780	C121 - Cleeton to Neptune Pipeline	5
SBP_00072	353642.7	5986225.1		0.8		SBP MAG		M_00782	C121 - Cleeton to Neptune Pipeline (target outside of mag grid coverage)	5
SBP_00074	353891.0	5985805.5		1.0		SBP MAG		M_00784	C121 - Cleeton to Neptune Pipeline	5
RAVENSPURN TO CLEETON GAS PIPELINE										
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00788	357158.2	5989216.7		419.8		MAG SBP		SBP_00075	Ravenspurn to Cleeton Gas Pipeline	5
M_00798	361497.1	5987991.6		618.8		MAG			Ravenspurn to Cleeton Gas Pipeline	5
M_00802	364134.4	5990688.7		2059.3		MAG			Ravenspurn to Cleeton Gas Pipeline	5
M_00805	364808.9	5987073.5		445.8		MAG SBP		SBP_00076	Ravenspurn to Cleeton Gas Pipeline	5
M_00810	366098.8	5989070.3		2995.7		MAG SBP		SBP_00077	Ravenspurn to Cleeton Gas Pipeline	5
M_00830	370333.0	5988420.3		330.6		MAG SBP		SBP_00080	Ravenspurn to Cleeton Gas Pipeline	5
M_00833	370852.9	5988436.8		1467.8		MAG SBP		SBP_00081	Ravenspurn to Cleeton Gas Pipeline	5
M_00855	374630.5	5988565.5		400.9		MAG SBP		SBP_00085	Ravenspurn to Cleeton Gas Pipeline	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00075	357170.8	5989205.6		0.8		SBP MAG		M_00788	Gas Pipeline PL664 - Ravenspurn to Cleeton	5

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00076	364814.8	5987078.1		1.7		SBP MAG		M_00805	Gas Pipeline PL664 - Ravenspurn to Cleeton	5
SBP_00077	366089.2	5989079.0		1.4		SBP MAG		M_00810	Gas Pipeline PL664 - Ravenspurn to Cleeton	5
SBP_00080	370317.6	5988425.5		1.3		SBP MAG		M_00830	Gas Pipeline PL664 - Ravenspurn to Cleeton	5
SBP_00081	370828.7	5988440.4		0.6		SBP MAG		M_00833	Gas Pipeline PL664 - Ravenspurn to Cleeton	5
SBP_00085	374670.7	5988570.8		0.6		SBP MAG		M_00855	Gas Pipeline PL664 - Ravenspurn to Cleeton	5
PIGGYBACK ST3-RAVENSPURN C PLATFORM PIPELINE										
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00806	365389.2	5991974.0		639.9		MAG			Piggyback ST3-Ravenspurn C Platform Pipeline	5
M_00807	365414.8	5992000.1		20.7		MAG			Piggyback ST3-Ravenspurn C Platform Pipeline	5
M_00818	368226.4	5990570.1		267.5		MAG SBP		SBP_00078	Piggyback ST3-Ravenspurn C Platform Pipeline	5
M_00824	369084.8	5990165.7		776.1		MAG			Piggyback ST3-Ravenspurn C Platform Pipeline	5
M_00835	371067.6	5989178.8		81.1		MAG SBP		SBP_00082	Piggyback ST3-Ravenspurn C Platform Pipeline (SBP target outside of mag grid)	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00078	368232.0	5990581.5		0.6		SBP MAG		M_00818	Gas Pipeline PL729/730 Piggyback ST3-Ravenspurn C platform	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00079	369028.1	5990199.0		0.7		SBP			Gas Pipeline PL729/730 Piggyback ST3-Ravenspurn C platform (target outside of mag grid coverage)	5
SBP_00082	371064.8	5989199.2		0.9		SBP MAG		M_00835	Gas Pipeline PL729/730 Piggyback ST3-Ravenspurn C platform (target outside of mag grid coverage)	5

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00086	374733.9	5988635.4		2.0		SBP MAG		M_00856	Possible Gas Pipeline PL729/730 Piggyback ST3-Ravenspurn C platform	5
RAVENSPURN NORTH TO WELLHEAD ST2 PIPELINE										
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00812	366217.8	5992822.3		12.7		MAG			Possibly associated with Ravenspurn North to Wellhead ST2 Pipeline	5
M_00814	366435.8	5992750.6		41.2		MAG			Possibly associated with Ravenspurn North to Wellhead ST2 Pipeline	5
M_00829	369446.4	5991814.8		7.9		MAG			Possibly associated with Ravenspurn North to Wellhead ST2 Pipeline	5
M_00839	371716.4	5989840.5		14.4		MAG SBP		SBP_00083	Ravenspurn North to Wellhead ST2 Pipeline	5
M_00856	374698.8	5988635.0		408.2		MAG SBP		SBP_00086	Ravenspurn North to Wellhead ST2 Pipeline	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00083	371707.0	5989856.2		1.0		SBP MAG		M_00839	Gas Pipeline PL670 - Ravenspurn North to Wellhead ST2 (target outside of mag grid coverage)	5
JOHNSTON UMBILICAL										
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00857	375290.7	5989239.1		314.1		MAG		SBP_00089, SBP_00090	Johnston Umbilical	5
M_00860	376710.7	5991100.8		236.3		MAG SBP		SBP_00092	Johnston Umbilical	5
M_00861	376762.0	5991051.6		15.5		MAG SBP		SBP_00093	Johnston Umbilical	5
M_00863	377064.1	5991062.7		293.4		MAG SBP		SBP_00095	Johnston Umbilical	5

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00089	375290.5	5989204.6		0.6		SBP MAG		M_00857	Johnston Umbilical	5
SBP_00090	375316.3	5989230.4		0.8		SBP MAG		M_00857	Possible Pipeline - Johnston Umbilical	5
SBP_00092	376699.3	5991096.5		0.7		SBP MAG		M_00860	Johnston Umbilical	5
SBP_00093	376742.6	5991054.1		0.6		SBP MAG		M_00861	Johnston Umbilical	5
SBP_00095	377092.1	5991055.9		0.6		SBP MAG		M_00863	Johnston Umbilical	5

BABBAGE EXPORT TO WEST SOLE PIPELINE

Mag Anomaly ID	Easting (m)	Northing (m)	Blank	Amplitude	Blank	Dataset	Associated Seafloor Contact ID	Associated SBP Target ID	Comments	Confidence Level
M_00884	382122.0	5977415.5		221.2		MAG			Babbage Export to West Sole Pipeline	5
M_00885	382220.2	5977319.6		37.9		MAG			Possibly Associated with Babbage Export to West Sole Pipeline	5
M_00887	382714.5	5979615.3		337.9		MAG			Babbage Export to West Sole Pipeline	5

POSSIBLE CABLE C0161 - CLEETOG TO MINERVA UMBILICAL

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00062	348537.1	5986770.7		-0.2		SBP			Possible Cable- C0161 - Cleeton to Minerva Umbilical	1
SBP_00067	349252.6	5987480.5		-0.1		SBP			Possible Cable- C0161 - Cleeton to Minerva Umbilical	1

C1710 - MINERVA GAS EXPORT PIPELINE

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00063	348551.2	5986760.2		-0.6		SBP			Possible Pipeline C1710 - Minerva Gas Export Pipeline	1
SBP_00065	348915.9	5987099.1		-0.1		SBP			Possible Pipeline C1710 - Minerva Gas Export Pipeline	1

PL7 - 3INCH SERVICE PIGGYBACK MINERVA TO CLEETON										
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00066	348916.1	5987099.0		-0.1		SBP			Possible Pipeline - PL7 - 3inch Service Piggyback Minerva to Cleeton	1
UNKNOWN CABLES AND PIPELINES										
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00817	368138.3	5990479.5		27.0		MAG			Possibly Associated with Unknown Cable	5
M_00854	374560.8	5988493.7		642.2		MAG SBP		SBP_00084	Unknown Cable	5
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00084	374607.6	5988506.8		1.6		SBP MAG		M_00854	Unknown Cable	5
SBP_00088	375273.6	5989187.4		1.1		SBP			Unknown Buried Anomaly - Possible Pipeline	5
SBP_00094	377053.2	5991017.5		0.7		SBP			Unknown Buried Anomaly - Possible Pipeline	5

Table 5: Pipeline and Cables Noted in Data

LAPWING WRECK										
Seafloor Contact ID	**Easting (m)**	**Northing (m)**	**Length (m)**	**Width (m)**	**Height (m)**	**Datasets**	**Associated Mag Anomaly ID**	**Associated SBP Target ID**	**Comment**	**Confidence Level**
S_50300	382351.1	5983582.5	36.0	15.5	8.0	SSS MBES SBP		SBP_00096	Sonar Contact, possible Lapwing Wreck	4
Mag Anomaly ID	**Easting (m)**	**Northing (m)**	**Blank**	**Amplitude (nT)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated SBP Target ID**	**Comments**	**Confidence Level**
M_00886	382370.5	5983598.8		1938.4		MAG SBP		SBP_00096	Wreck - Lapwing	5

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00096	382352.9	5983571.5		-2.8		SBP SSS MBES MAG	S_50300	M_00886	Wreck Site - Possible Lapwing wreck	5

WRECK - SS SOTE

Seafloor Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_12407	290939.4	5990524.9	12.9	7.5	0.1	SSS MBES MAG	M_00499		Sonar Contact, possible Wreck or debris relating to SS Sote	4
S_12408	290923.6	5990492.1	25.5	15.9	0.5	SSS MBES MAG SBP	M_00499	SBP_00037	Sonar Contact, possible Wreck SS Sote	4

Mag Anomaly ID	Easting (m)	Northing (m)	Blank	Amplitude (nT)	Blank	Dataset	Associated Seafloor Contact ID	Associated SBP Target ID	Comments	Confidence Level
M_00499	290927.8	5990500.7		9581.9		MAG SSS MBES SBP	S_12407, S_12408	SBP_00037	Wreck - SS Sote	5
M_00509	290955.9	5990572.0		21.9		MAG SSS	S_12478, S_12479, S_12481		Possibly associated with nearby wreck of SS Sote	4

SBP Target ID	Easting (m)	Northing (m)	Blank	Depth of Target (m)	Blank	Dataset	Associated Seafloor Contact ID	Associated Mag Anomaly ID	Comment	Confidence Level
SBP_00037	290925.0	5990488.4		-0.5		SBP SSS MBES MAG	S_12408	M_00499	Wreck Site - Possible SS Sote	5

POSSIBLY ASSOCIATED WITH NEARBY WRECK

Mag Anomaly ID	Easting (m)	Northing (m)	Blank	Amplitude (nT)	Blank	Dataset	Associated Seafloor Contact ID	Associated SBP Target ID	Comments	Confidence Level
M_00487	290905.2	5990428.2		47.2		MAG			Possibly associated with nearby wreck	5
M_00515	290982.9	5990500.6		119.3		MAG			Possibly associated with nearby wreck	5
M_00517	290985.5	5990403.7		26.9		MAG			Possibly associated with nearby wreck	5

Mag Anomaly ID	Easting (m)	Northing (m)	Blank	Amplitude (nT)	Blank	Dataset	Associated Seafloor Contact ID	Associated SBP Target ID	Comments	Confidence Level
M_00523	290997.1	5990537.8		20.0		MAG			Possibly associated with nearby wreck	5
M_00526	290999.6	5990457.9		16.1		MAG			Possibly associated with nearby wreck	5
M_00536	291022.4	5990541.0		118.5		MAG			Possibly associated with nearby wreck	5
SONAR_CONTACT, POSSIBLE WRECK										
Seafloor Contact_ID	**Easting (m)**	**Northing (m)**	**Length (m)**	**Width (m)**	**Height (m)**	**Datasets**	**Associated Mag Anomaly ID**	**Associated SBP Target ID**	**Comment**	**Confidence Level**
S_12348	290938.4	5988320.3	13.4	3.0	0.4	SSS			Sonar_Contact, possible Wreck	3
S_12357	290847.9	5989562.7	15.5	4.2	0.1	SSS MBES			Sonar_Contact, possible Wreck	4
SBP Target ID	**Easting (m)**	**Northing (m)**	**Blank**	**Depth of Target (m)**	**Blank**	**Dataset**	**Associated Seafloor Contact ID**	**Associated Mag Anomaly ID**	**Comment**	**Confidence Level**
SBP_00036	290921.2	5990613.1		-0.3		SBP			Possible wreck debris	1
OTHER SIGNIFICANT SEABED OBJECT										
Seafloor Contact_ID	**Easting (m)**	**Northing (m)**	**Length (m)**	**Width (m)**	**Height (m)**	**Datasets**	**Associated Mag Anomaly ID**	**Associated SBP Target ID**	**Comment**	**Confidence Level**
S_12494	290814.3	5994746.5	16.0	10.0	1.3	SSS MBES MAG	M_00439		Sonar_Contact, unknown but possible debris.	4

Table 6: Wrecks Noted in Data

3.3 Shallow Soils

As discussed above, seabed sediments generally comprise Holocene sands, although there are areas of exposed till in the inshore survey extents. The base of Holocene sands is seen, near continuously, along the surveyed export route and these granular sediments are generally between 0.1m and 9.8m thick, with an average thickness of 2m. Sediment thicknesses generally range between 0.05m and 6.4m (averaging 1.1m thick) in the inshore portion of the survey area, and between 0.1m and 9.8m thick (with an average of 2.6m) in the offshore sections of the surveyed export route.

It is understood that the upper 5m of sediment are of most interest to the client and therefore areas where Holocene sands are equal to, or less than, 5m thick are illustrated in Figure 9 below. As the image indicates, most of the surveyed area contains up to 5m of Holocene cover.

Figure 9: Spatial Distribution of Holocene Sands <5m Thick

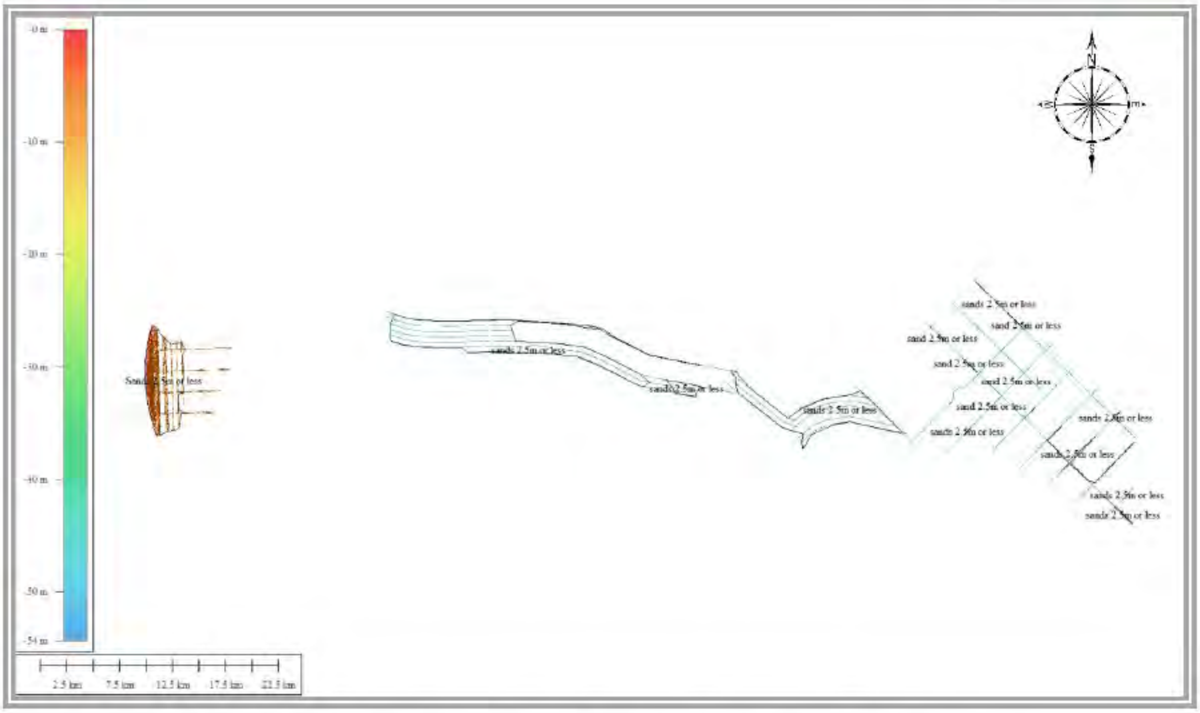


Figure 10: Spatial Distribution of Holocene Sands 2.5m Thick or Less

The spatial distribution of Holocene sediments which are 2.5m thick or less are illustrated in Figure 10 above. As this image indicates, most of the inshore portion of the survey area is covered with Holocene sands although these are generally less than 1m thick inshore of the following 290906.0mE, 5995009.9mE and 291223.96mE, 5985002.5mN, which is around 6m to 7m below LAT.

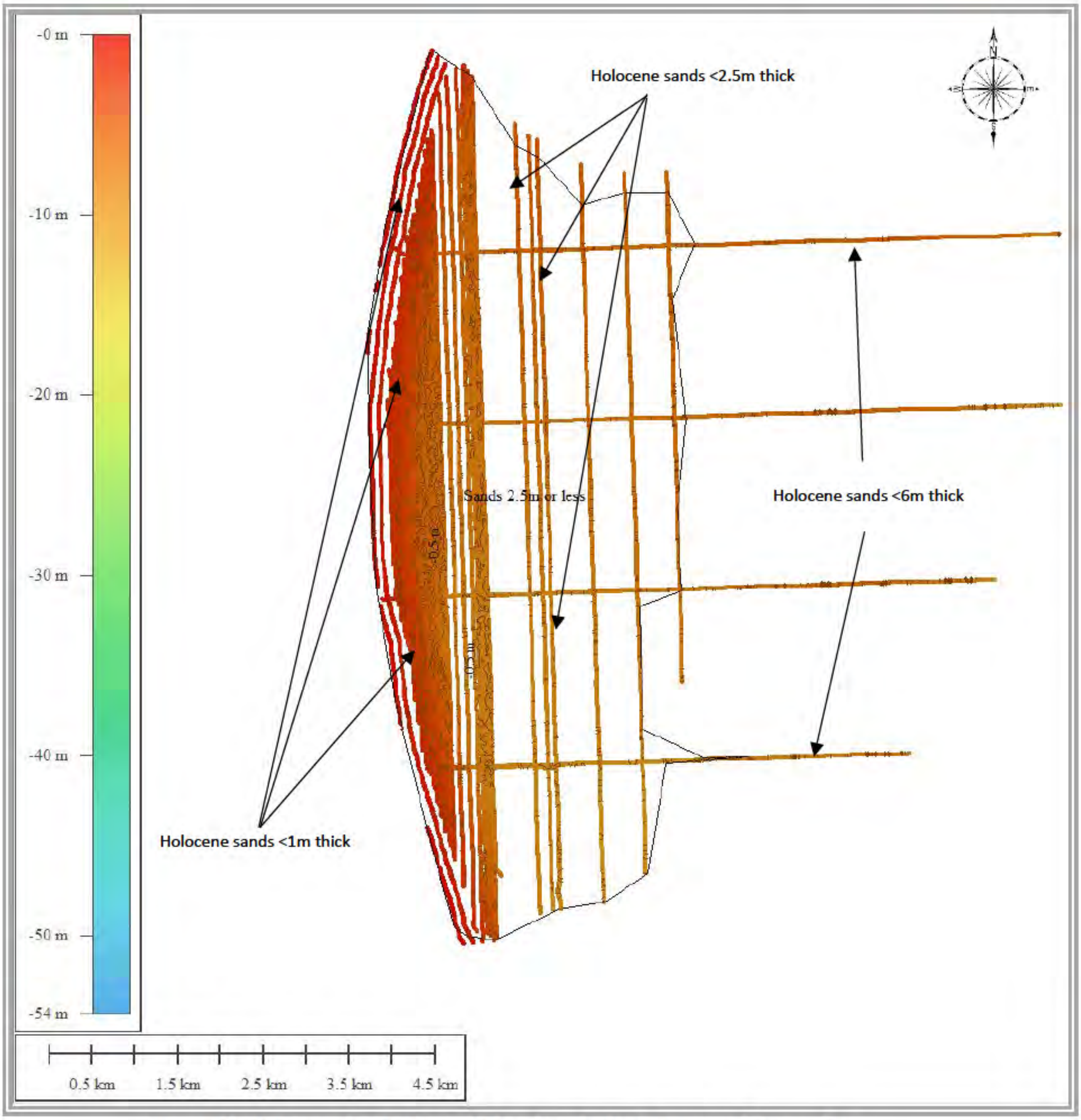


Figure 11: Holocene Sands 2.5m Thick or Less Inshore Extents of Survey Area

Holocene sediments are generally between 0.5m and 2.5m thick along the majority of the main export route of the surveyed area. There is, however, an area, centred around 338286.5mE, 5989749.8mN where Holocene sediments are up to 5.5m thick as indicated in Figure 12 below.

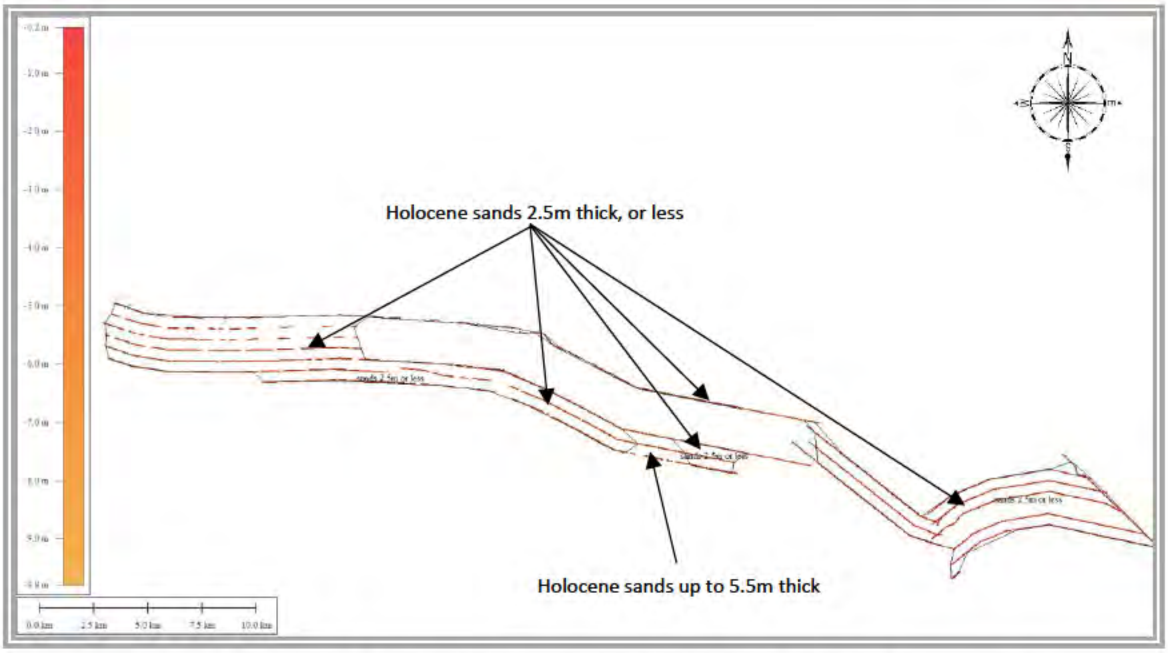


Figure 12: Holocene Sands Thicknesses Along Main Export Route of Survey Area

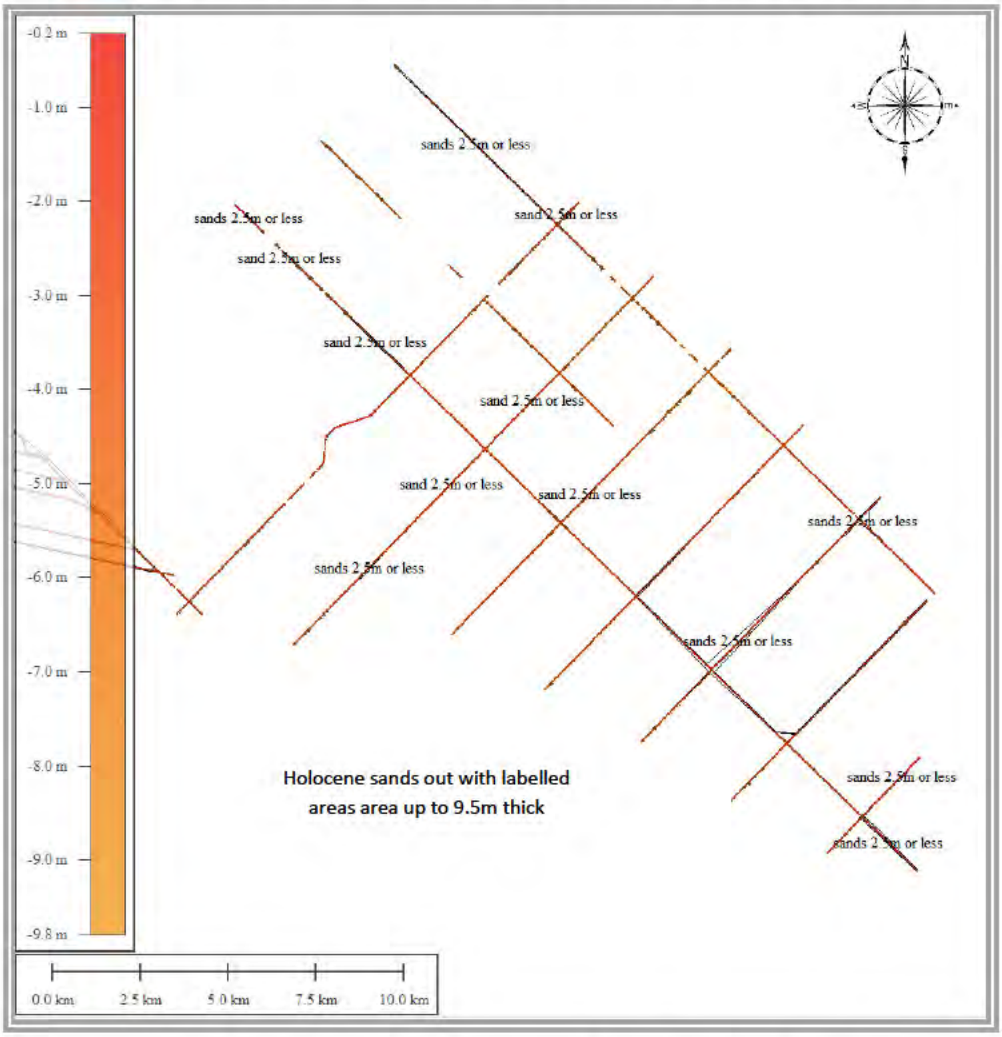


Figure 13: Holocene Sands Thicknesses within Windfarm Area

Thicker deposits of Holocene sediments are generally encountered within the main windfarm area and these reach a maximum of approximately 9.5m thick, around 371437.2mE, 5993869.6mN. Areas where these sediments are less than 2.5m thick are illustrated in Figure 13 above.

Sediments of the Bolders Bank Formation are noted beneath these Holocene sands along the entire route and internal reflectors are often noted within these clays. These internal reflectors may differentiate changes in density of the till or lenses of sands and gravels etc.

There are no indications of channels within the Holocene sands which may be infilled with soft deposits however areas of possible channel type features have been identified in the Bolders Bank Formation in the areas illustrated in Figure 14 below. These channels may, however, represent internal reflectors within the till. There is only one channel type feature with characteristic straighter sides, and this is indicated in the figure below, with a yellow line and associated profile, and is centred around 290321.7mE, 5991461.1mN. The seismic record for this channel feature is presented in Figure 15 below. The areas identified in Figure 15 have been provided for future intrusive geotechnical ground investigations.

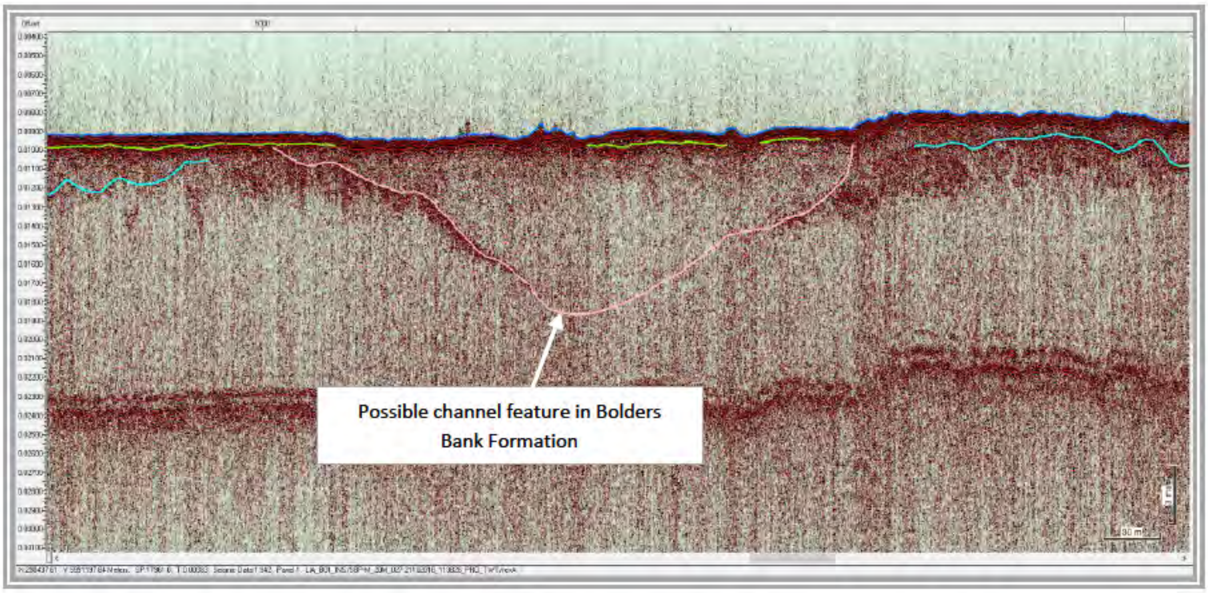


Figure 14: Seismic Record Showing Reflector of Possible Channel Feature in Bolders Bank Formation

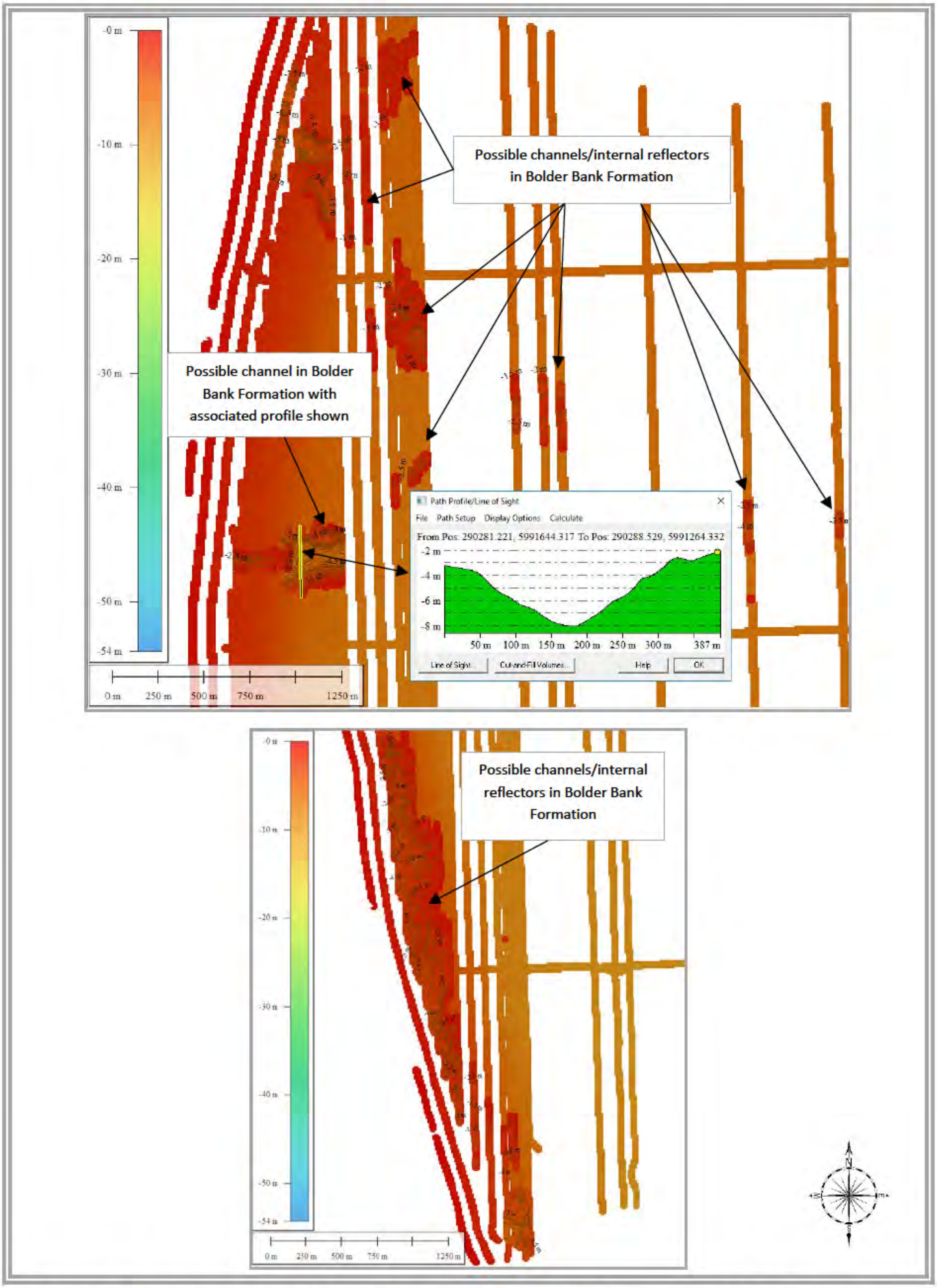


Figure 15: Spatial Distribution of Channel Type Features/Internal Reflectors in Bolders Bank Formation

Chalk underlying the Bolders Bank Formation may be visible in the main windfarm area, however this is unclear in the geophysical records. Examples of the reflectors interpreted to be possible chalk are presented in Figure 16 below and the broad area of this reflector is summarised in Figure 17.

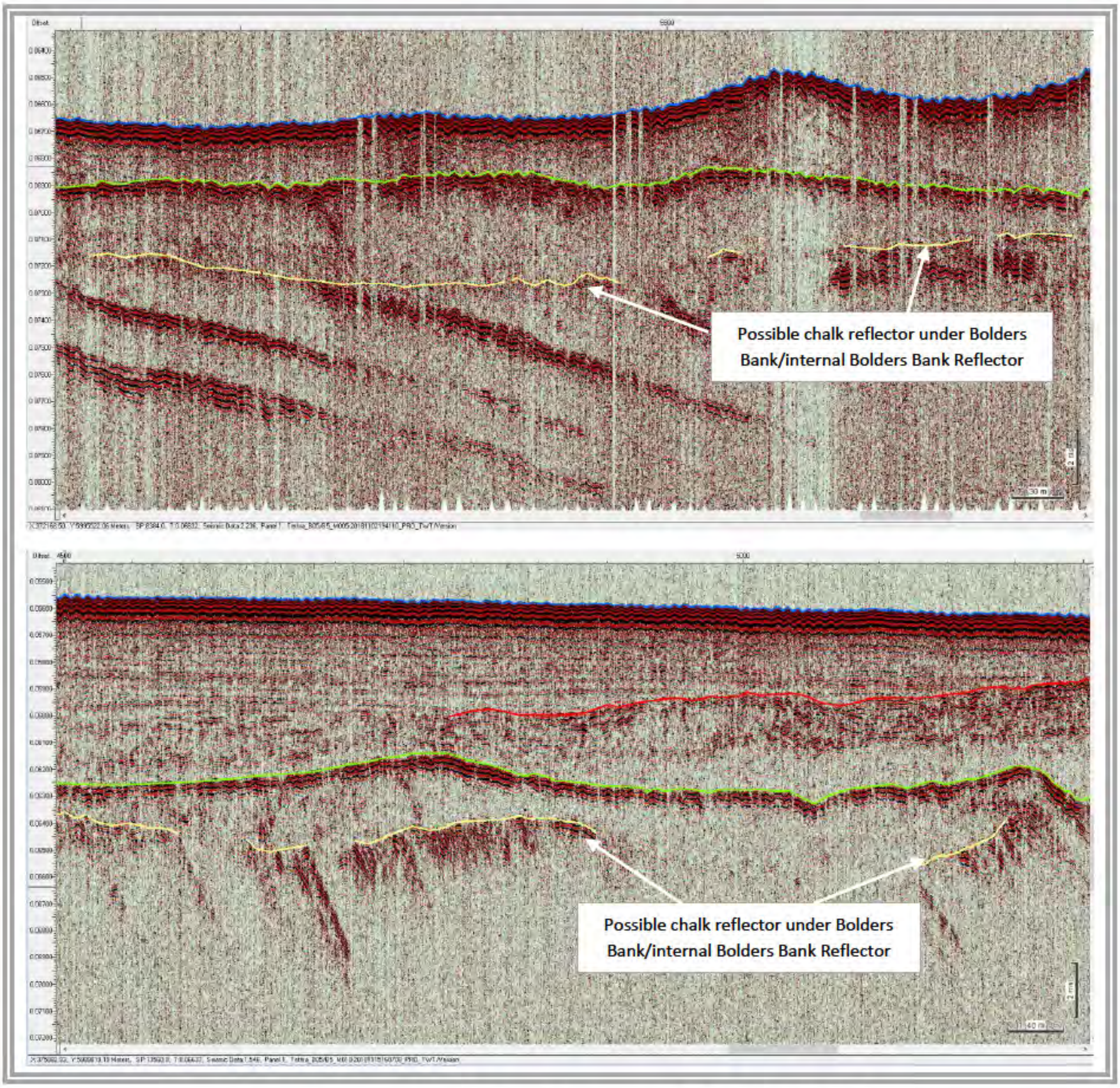


Figure 16: Examples of Reflector Interpreted to be Possible Chalk

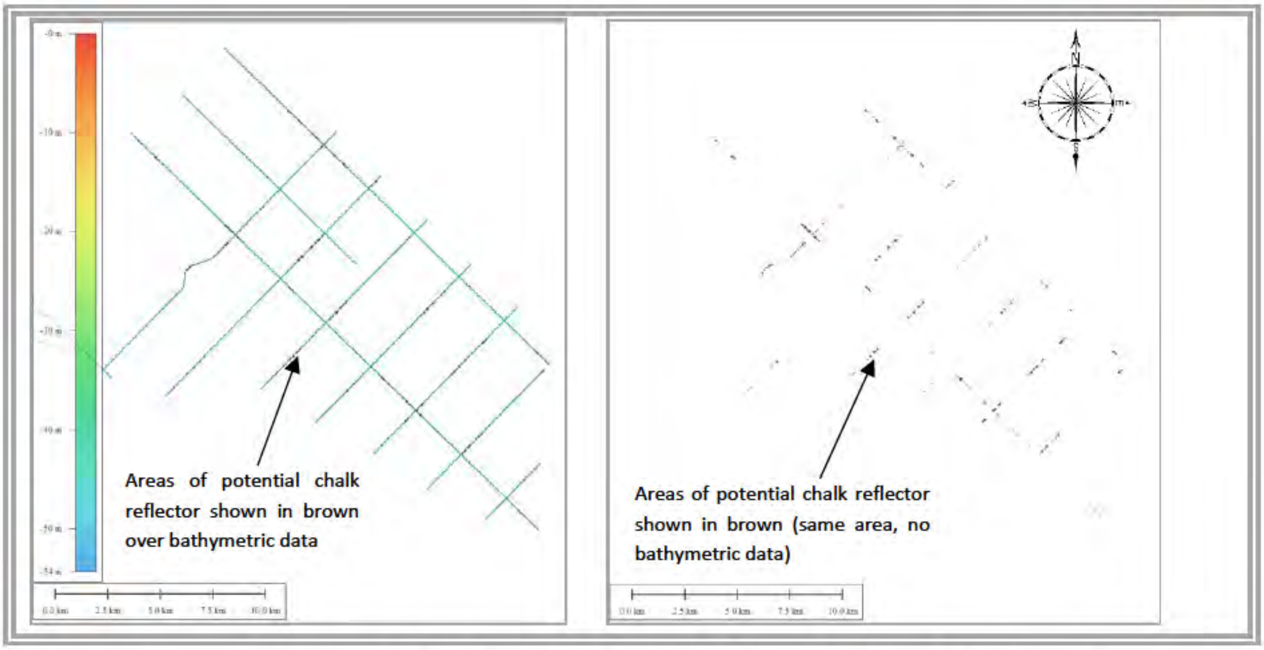


Figure 17: Potential Spatial Extents of Possible Chalk Beneath Bolders Bank Formation

There is no indication of any shallow gas within the seismic records acquired along the surveyed portion of the export route.

A total of 96 sub-bottom contacts were identified along the export route survey area and 39 of these relate to pipelines, cables or wrecks as indicated in Tables 5 and 6 above.

The remaining 57 sub-bottom contacts are either buried or present on the seabed as indicated in the table in Appendix 1 below.

List of Standard Abbreviations

ADCP	Acoustic Doppler Current Profiler	MLWN	Mean Low Water Neaps
CAD	Computer Aided Design	MLWS	Mean Low Water Springs
CD	Chart Datum	MNR	Mean Neap Range
CM	Central Meridian	MSL	Mean Sea Level
CPU	Central Processing Unit	MSR	Mean Spring Range
CTD	Conductivity Temperature Depth	OD(N)	Ordnance Datum (Newlyn)
dGPS	differential Global Positioning System	OSGB	Ordnance Survey of Great Britain
dxf	Drawing Exchange Format (AutoCAD file)	OSTN02	Ordnance Survey Transformation Network
ED50	European Datum 1950	PCS	Processing Control System
EGM96	Earth Gravitational Model 1996	PPE	Personal Protective Equipment
EGNOS	Euro Geostationary Navigation Overlay Service	PPM	Parts Per Million
ESA	European Space Agency	PPP	Precise Point Positioning
GAMS	GPS Azimuth Measurement Subsystem	PPS	Pulse per Second
GLA	General Lighthouse Authority	QC	Quality Control
GNSS	Global Navigation Satellite System	RIB	Rigid Inflatable Boat
GSM	Global System for Mobile Communications	RPL	Route Position List
HAT	Highest Astronomical Tide	RMS	Route Mean Square
HF	High Frequency	RTCM	Radio Technical Commission for Maritime Services
Hz	Hertz	RTK	Real Time Kinematic
IHO	International Hydrographic Organisation	SBAS	Satellite Based Augmentation System
IMO	International Maritime Organisation	SD	Standard Deviation
INS	Inertial Navigation System	SVP	Sound Velocity Probe
kHz	Kilohertz	SVP	Sound Velocity Profile
km	Kilometre	SVS	Sound Velocity Sensor
KP	Kilometre Post	TPU	Total Propagated Uncertainty
LAT	Lowest Astronomical Tide	TVG	Time Variable Gain
LRK	Long Range Kinematic	UHF	Ultra High Frequency
MCA	Maritime & Coastguard Agency	USBL	Ultra Short Base Line
MF	Medium Frequency	UTM	Universal Transverse Mercator
MHWI	Mean High Water Interval	VHF	Very High Frequency
MHWN	Mean High Water Neaps	WAAS	Wide Area Augmentation System
MHWS	Mean High Water Springs	WGS84	World Geodetic System 1984
MHz	Megahertz	WSM	Wideband Sub Mini
MLWI	Mean Low Water Interval		

Appendices

Appendix 1: Listings

Appendix 1

Listings

Seabed Contacts – Fishing Gear and Debris

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_10001	289944.1	5990913.9	0.9	0.2	0.1	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10002	290569.9	5987287.3	1.2	0.3	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10007	289977.6	5989982.7	0.6	0.4	0.1	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10015	290451.6	5987175.3	1.0	0.4	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10018	290241.5	5988406.5	246.0	0.1	0.1	SSS MBES			Linear_Contact, rope with fishing pots	CONF 4
S_10028	290423.0	5991526.6	1.5	1.0	0.5	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10035	290511.4	5987414.0	1.1	0.3	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10036	290495.5	5987066.7	1.0	0.4	0.3	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10037	290519.5	5987031.9	0.5	0.3	0.2	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10039	290500.2	5986883.5	1.3	0.4	0.3	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10040	290417.0	5990097.4	1.6	0.3	0.1	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10048	290347.2	5991657.8	3.0	0.3	0.6	SSS MBES MAG	M_00205		Sonar_Contact, possible debris	CONF 4
S_10054	290479.8	5987103.5	1.2	0.4	0.4	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10055	290485.4	5986868.7	0.9	0.7	0.1	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10059	290105.7	5989186.5	1.0	0.3	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10061	290408.4	5987307.7	0.9	0.1	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10062	290287.7	5991520.6	0.5	0.4	0.2	SSS MBES MAG	M_00163		Sonar_Contact, possible debris	CONF 4
S_10066	290326.2	5989187.7	1.0	0.3	0.3	SSS MBES MAG	M_00192		Sonar_Contact, possible debris	CONF 4
S_10067	290407.4	5987259.4	1.1	0.2	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10073	290243.6	5991184.3	1.5	0.6	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10085	290216.9	5991489.9	0.6	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 3

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_10090	290286.4	5988478.8	0.7	0.5	0.1	SSS MBES MAG	M_00161		Sonar_Contact, possible fishing gear	CONF 4
S_10091	290287.6	5988318.1	0.7	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_10092	290277.1	5988320.8	0.9	0.5	0.1	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10096	290256.1	5988331.8	0.7	0.6	0.2	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10097	290241.7	5988359.9	1.0	0.3	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_10098	290239.3	5988419.4	0.8	0.4	0.2	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_10099	290248.9	5988438.7	0.9	0.5	0.1	SSS MBES MAG	M_00134		Sonar_Contact, possible fishing gear	CONF 4
S_10102	290143.3	5992475.2	0.7	0.5	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10104	290166.7	5991066.0	0.8	0.5	0.1	SSS MBES MAG	M_00081		Sonar_Contact, possible debris	CONF 4
S_10113	290239.0	5988746.4	1.1	0.3	0.1	SSS MBES MAG	M_00126		Sonar_Contact, possible debris	CONF 4
S_10126	290115.9	5989415.4	2.0	1.3	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_10128	290181.4	5988529.1	0.5	0.3	0.1	SSS MBES MAG	M_00091		Sonar_Contact, possible debris	CONF 4
S_10208	290400.2	5988747.2	1.5	0.3	0.3	SSS MBES MAG	M_00239		Sonar_Contact, possible debris	CONF 4
S_12002	290577.9	5993482.0	6.8	0.3	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12003	290583.2	5993476.2	0.8	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12004	290573.0	5993486.9	0.5	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12018	290576.9	5993084.3	1.6	0.5	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12028	290544.5	5992815.4	1.6	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12049	290632.9	5991681.0	1.4	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12051	290633.6	5991508.2	2.5	1.9	0.3	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_12068	290600.5	5991129.1	4.3	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12083	290618.7	5990766.6	0.8	0.4	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12087	290658.8	5990598.8	1.3	0.7	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12092	290655.8	5990484.5	1.2	0.4	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12094	290665.1	5990426.5	2.2	1.0	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_12095	290608.6	5990402.7	3.2	0.6	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12125	290692.5	5989531.3	11.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12132	290745.3	5987953.8	1.3	1.0	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12146	290776.1	5986937.7	2.6	2.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12152	290802.6	5986449.7	1.5	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12155	290801.0	5986012.4	1.5	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12184	290906.9	5986728.3	1.1	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12186	290869.8	5986937.6	1.9	0.4	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_12189	290815.9	5987176.4	1.6	0.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12190	290810.0	5987262.7	2.5	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12199	290738.8	5990001.0	1.0	0.4	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12200	290799.4	5990151.8	30.6	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12202	290784.5	5990403.6	26.8	0.1	0.1	SSS			Linear_Contact, rope with fishing pots	CONF 3
S_12208	290720.7	5990797.9	1.5	0.6	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12209	290753.9	5990896.3	1.1	0.4	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12214	290715.7	5991165.6	1.5	0.7	0.6	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12223	290613.8	5994881.3	8.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_12224	290570.8	5994707.4	8.1	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12225	290639.9	5994678.0	5.4	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12226	290595.0	5994631.3	5.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12227	290625.5	5994611.2	15.8	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12240	290660.3	5993340.2	0.7	0.5	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12242	290617.6	5993271.3	5.8	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12252	290652.6	5992456.8	4.1	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12253	290649.8	5992452.5	5.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12262	290740.3	5991895.7	1.6	0.6	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12267	290748.8	5991651.1	1.1	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 3
S_12272	290697.9	5991147.3	1.4	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12276	290725.6	5990630.4	6.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12277	290648.8	5992456.5	17.1	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12278	290692.1	5990806.3	0.8	0.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12281	290763.7	5990422.8	1.4	0.6	0.2	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_12303	290975.8	5985845.4	0.7	0.4	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12304	290967.9	5985844.8	0.7	0.6	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12307	291035.5	5985868.5	1.5	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12311	290965.7	5985925.6	1.1	0.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_12315	290953.7	5985999.4	0.7	0.7	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_12318	290950.8	5986151.3	1.7	0.7	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12323	290981.6	5986364.9	1.6	0.7	0.8	SSS			Sonar_Contact, possible debris	CONF 1
S_12327	290942.9	5986892.4	2.0	0.8	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12328	290927.0	5986906.2	1.2	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12331	290986.8	5987005.2	2.6	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 3
S_12332	290936.7	5986982.2	1.4	0.6	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12349	290870.5	5988647.0	8.3	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12360	290823.6	5990424.8	2.3	1.2	0.3	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_12362	290803.7	5990404.3	1.2	0.6	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_12363	290853.1	5990437.7	1.1	0.5	0.4	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_12364	290808.6	5990871.8	1.2	0.7	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_12365	290790.5	5991095.4	1.1	0.6	0.3	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_12369	290843.3	5991488.2	1.6	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12376	290778.7	5991874.8	1.0	0.4	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12378	290764.3	5991907.4	2.3	1.0	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12382	290762.8	5993430.6	0.8	0.6	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_12383	290758.7	5993742.5	3.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12386	290806.6	5994350.4	30.2	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12387	290820.0	5993880.7	5.8	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12394	290829.4	5993485.4	1.6	0.8	0.2	SSS MBES MAG	M_00448		Sonar_Contact, possible debris	CONF 4

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_12401	290873.7	5991847.4	1.0	0.7	0.2	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_12404	290892.9	5990928.0	1.4	0.7	0.5	SSS MBES MAG	M_00479		Sonar_Contact, possible debris	CONF 4
S_12409	290876.6	5990466.6	1.3	1.1	0.2	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_12431	291005.6	5987622.7	1.6	1.5	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12438	291027.8	5987138.7	1.1	0.5	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12448	291050.8	5986025.9	1.1	0.5	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12459	291038.1	5985721.6	1.4	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12464	291084.4	5985935.6	2.2	0.8	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12471	290998.0	5986864.6	1.6	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12477	290949.0	5990549.6	0.8	0.6	0.3	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_12478	290949.6	5990562.5	24.2	0.1	0.1	SSS MAG	M_00509		Linear_Contact, rope with fishing pots	CONF 4
S_12479	290954.2	5990575.7	1.0	0.7	0.2	SSS MBES MAG	M_00509		Sonar_Contact, possible fishing gear	CONF 4
S_12480	290959.1	5990601.3	1.7	0.9	0.2	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_12481	290956.4	5990587.5	27.0	0.1	0.1	SSS MAG	M_00509		Linear_Contact, rope with fishing pots	CONF 4
S_12482	290938.2	5991204.6	2.0	1.0	0.1	SSS MBES MAG	M_00503		Sonar_Contact, possible debris	CONF 4
S_12483	290920.7	5991766.2	0.5	0.4	0.1	SSS MAG	M_00494		Sonar_Contact, possible debris	CONF 4
S_12484	290917.1	5991852.3	21.3	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 3
S_12485	290831.7	5992419.2	0.7	0.5	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12490	290840.4	5993969.9	1.0	0.6	0.2	SSS MBES MAG	M_00451		Sonar_Contact, possible debris	CONF 4
S_12492	290849.7	5993984.5	1.0	0.5	0.1	SSS MBES MAG	M_00458		Sonar_Contact, possible debris	CONF 4

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_12494	290814.3	5994746.5	16.0	10.0	1.3	SSS MBES MAG	M_00439		Sonar_Contact, possible debris	CONF 4
S_12495	290777.8	5994952.3	14.0	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 3
S_12497	290806.2	5993825.6	3.3	0.3	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_12509	291050.6	5987546.6	0.9	0.4	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12512	291083.9	5987122.2	2.9	1.5	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12515	291046.5	5986048.8	0.9	0.5	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12518	291109.6	5985174.0	1.2	0.5	0.4	SSS MBES MAG	M_00564		Sonar_Contact, possible debris	CONF 4
S_12522	291116.4	5986116.7	1.9	1.4	0.7	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12525	291118.0	5986813.9	1.0	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 3
S_12528	291089.5	5987115.8	0.8	0.6	0.2	SSS MBES MAG	M_00561		Sonar_Contact, possible debris	CONF 4
S_12533	290981.3	5990969.7	2.5	0.2	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_12536	290930.7	5992606.1	1.7	0.6	0.2	SSS MBES MAG	M_00502		Sonar_Contact, possible debris	CONF 4
S_12539	290868.4	5993783.4	1.2	0.4	0.5	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12541	290970.4	5991876.4	22.9	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 3
S_12547	291068.7	5987108.1	1.1	0.4	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12561	290942.5	5991861.8	19.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 3
S_12567	290613.9	5993000.0	1.9	1.1	1.0	SSS MBES MAG	M_00385		Sonar_Contact, possible debris	CONF 4
S_12573	290943.2	5986986.5	0.9	0.7	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_12574	290978.0	5987002.0	2.3	0.8	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_12578	290807.6	5986986.9	1.0	0.9	0.3	SSS			Sonar_Contact, possible debris	CONF 3
S_12580	290576.5	5993482.3	0.5	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_12586	290827.2	5994395.7	2.4	0.1	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_12588	290883.9	5991844.2	27.1	0.1	0.1	SSS MBES			Linear_Contact, possible wire or rope debris	CONF 4
S_12590	291159.1	5985217.1	0.6	0.4	0.3	SSS MBES MAG	M_00574		Sonar_Contact, possible debris	CONF 4
S_12645	290716.8	5990414.9	1.6	0.9	0.3	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_12646	290738.5	5990422.8	0.7	0.4	0.3	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_12650	290794.1	5990407.8	1.1	0.5	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 3
S_12792	290751.4	5990422.1	99.5	0.1	0.1	SSS			Linear_Contact, rope with fishing pots	CONF 3
S_12793	290843.6	5990435.5	132.2	0.1	0.1	SSS			Linear_Contact, rope with fishing pots	CONF 3
S_14003	292792.5	5989088.1	1.3	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_14004	292767.3	5989092.0	0.7	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_14005	292725.1	5989083.6	0.5	0.3	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_14006	292649.2	5989086.0	0.5	0.3	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_14007	292605.9	5989072.9	0.5	0.3	0.1	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_14037	289961.6	5988952.8	6.6	0.3	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_14068	289783.8	5990993.3	19.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_14138	294456.4	5991093.8	0.9	0.2	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_14139	294461.3	5991087.6	0.6	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_14140	294451.7	5991102.6	0.9	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_14141	294454.9	5991097.1	0.5	0.3	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_14155	290207.6	5990961.8	1.1	0.4	0.2	SSS MBES MAG	M_00103		Sonar_Contact, possible debris	CONF 4
S_14393	290422.2	5986511.1	0.9	0.2	0.4	SSS MBES MAG	M_00261		Sonar_Contact, possible debris	CONF 4
S_14394	290426.4	5986506.8	0.5	0.4	0.3	SSS MBES MAG	M_00261		Sonar_Contact, possible debris	CONF 4
S_14395	290422.3	5986516.2	0.9	0.2	0.2	SSS MBES MAG	M_00261		Sonar_Contact, possible debris	CONF 4
S_14396	290421.7	5986514.9	0.6	0.4	0.3	SSS MBES MAG	M_00261		Sonar_Contact, possible debris	CONF 4
S_16018	291313.1	5988138.4	2.0	0.6	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_16021	291353.1	5988301.4	1.9	0.8	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_16022	291355.2	5988514.8	2.8	0.7	0.1	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_16036	291394.4	5985640.1	1.9	1.4	0.6	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_16064	291630.3	5985571.1	3.2	2.5	0.5	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_16074	291579.1	5986310.0	1.8	0.8	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_16079	291637.7	5988300.5	2.1	1.5	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_16084	291434.3	5992025.7	7.7	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_16096	292425.3	5986738.1	1.0	0.9	0.2	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_16097	292410.3	5986739.1	1.2	0.6	0.3	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_16098	292391.9	5986722.9	1.3	0.6	0.4	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_16099	292357.7	5986699.1	0.8	0.5	0.2	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_16100	292320.9	5986692.7	1.0	0.4	0.1	SSS			Sonar_Contact, possible fishing gear	CONF 1
S_16101	292348.0	5986675.5	1.2	0.9	0.2	SSS MBES			Sonar_Contact, possible fishing gear	CONF 4
S_16139	292633.8	5993355.6	3.5	1.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_16156	294796.5	5993084.9	3.4	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_16211	291371.0	5994106.0	2.4	0.6	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_16214	292248.0	5989152.5	0.8	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_16233	292897.5	5988235.2	1.8	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_16235	293253.4	5990096.7	1.1	0.2	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_16238	296176.0	5991200.3	3.6	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_16239	294357.0	5991135.4	1.4	0.8	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_16274	292252.2	5989121.6	53.3	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_16275	292308.9	5986636.9	41.0	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_16276	297329.8	5993249.2	13.6	0.1	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_16277	291464.9	5985358.1	6.6	2.2	1.1	SSS			Sonar_Contact, possible debris	CONF 1
S_16338	292162.5	5991002.0	3.2	1.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_16347	290921.3	5993070.7	2.6	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_16349	290997.7	5991898.3	49.3	0.1	0.1	SSS MBES			Linear_Contact, possible wire or rope debris	CONF 4
S_16351	291015.0	5991280.8	9.1	0.2	0.1	SSS			Linear_Contact, possible debris	CONF 1
S_16368	291112.2	5988314.1	11.4	0.7	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_16391	291142.1	5987354.2	3.7	0.3	0.1	SSS			Linear_Contact, possible wire or rope debris	CONF 1
S_16406	291355.7	5988520.0	16.9	0.1	0.1	SSS			Linear_Contact, rope with fishing pots	CONF 1
S_25001	342042.3	5991607.2	1.2	0.7	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25004	339858.8	5992023.3	0.8	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25006	335117.4	5993666.2	1.5	0.8	0.1	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_25021	327393.8	5995628.8	1.1	1.0	0.7	SSS			Sonar_Contact, possible debris	CONF 1
S_25022	327422.5	5995627.5	1.0	0.4	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25023	328093.1	5995606.5	1.2	0.7	0.6	SSS			Sonar_Contact, possible debris	CONF 1
S_25029	329869.6	5995420.9	1.2	0.6	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25036	325233.8	5995742.6	1.0	0.5	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25045	320497.2	5995805.9	7.8	1.0	0.4	SSS MBES			Linear_Contact, debris	CONF 4
S_25065	319318.2	5995769.9	0.9	0.2	0.6	SSS			Sonar_Contact, possible debris	CONF 1
S_25069	313720.7	5996199.4	1.3	0.3	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25074	318672.4	5995311.0	1.4	0.4	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25087	318897.5	5994822.0	1.0	0.6	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25092	323136.4	5995434.1	1.0	0.2	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25103	320666.2	5995375.2	1.6	0.3	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25111	321758.6	5994393.5	3.6	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25112	321972.2	5993827.9	0.9	0.3	0.5	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25114	324144.5	5993935.6	0.7	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25115	324165.0	5993948.3	2.5	0.7	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25116	324207.0	5993859.0	6.2	0.4	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25117	317300.0	5993730.1	1.1	0.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25119	315096.9	5993913.4	1.8	0.6	0.7	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25126	328075.6	5992712.9	1.0	0.6	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_25127	328047.4	5992704.8	1.5	0.7	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_25128	328017.9	5992695.0	1.9	0.6	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_25129	327990.9	5992685.9	1.1	0.5	0.6	SSS			Sonar_Contact, fishing pot	CONF 1
S_25135	327222.4	5992755.8	1.3	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_25151	323996.4	5992926.9	3.6	0.5	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25156	330432.9	5992458.9	2.0	0.7	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25159	333071.2	5991428.3	3.4	0.9	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25160	341625.2	5988684.3	1.5	0.6	0.7	SSS MBES MAG	M_00762		Sonar_Contact, possible debris	CONF 4
S_25163	328397.0	5993095.1	1.6	0.4	0.6	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25164	328434.5	5993102.6	1.3	0.4	0.6	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25174	333236.6	5992412.2	0.9	0.3	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25175	333206.2	5992411.8	0.7	0.3	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25176	333336.3	5992411.3	1.9	0.5	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25177	333304.2	5992411.2	1.1	0.5	0.8	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25178	333270.8	5992411.7	0.9	0.4	0.8	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25179	333143.9	5992414.0	1.2	0.2	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25180	333112.5	5992416.9	0.9	0.7	0.4	SSS MAG	M_00730		Sonar_Contact, possible fishing pot	CONF 4
S_25181	333080.7	5992417.8	1.8	0.8	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25182	333049.4	5992418.9	1.1	0.6	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25183	333019.1	5992419.9	1.2	0.6	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25184	335952.9	5991027.4	1.5	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25185	340346.0	5989910.4	1.1	0.8	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25186	340238.0	5989390.1	1.7	0.9	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25187	331628.2	5992635.7	1.2	0.8	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25189	332970.2	5992059.3	1.2	0.6	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25190	333413.5	5991842.5	1.1	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25191	333742.5	5991691.2	1.1	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25192	334079.5	5991488.1	1.3	0.5	0.2	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_25193	334087.8	5991383.0	0.9	0.6	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25197	335163.8	5991442.8	0.9	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25198	333948.4	5991993.2	1.1	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25199	333442.0	5992261.9	0.9	0.2	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25200	333474.4	5992343.0	1.7	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25224	328353.3	5993108.0	1.2	0.6	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25227	329040.7	5993042.6	1.1	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25228	331181.9	5992683.8	1.8	0.6	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25233	330450.8	5992419.2	0.7	0.4	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25243	319325.1	5995216.4	1.6	0.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25244	318681.9	5995329.6	1.2	0.8	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25245	317172.7	5995217.2	0.7	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25256	319857.2	5995746.7	0.5	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25260	321259.1	5994330.0	1.4	0.3	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25264	328101.7	5992721.1	1.0	0.7	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_25270	313749.9	5996206.4	0.6	0.5	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25273	314640.3	5995910.5	0.7	0.4	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25274	319339.9	5995779.2	0.9	0.1	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25308	330488.5	5995343.7	0.9	0.7	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25311	329520.2	5995474.8	1.3	0.2	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25317	325584.5	5995721.5	1.4	0.7	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25318	323564.5	5995831.7	1.4	0.4	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25328	316866.7	5995776.7	0.5	0.2	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25387	323722.3	5993832.9	3.1	0.7	0.1	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_25388	313426.5	5994187.6	0.9	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25389	323635.7	5993856.5	3.8	1.5	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25400	331618.6	5993095.1	1.0	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25402	332758.8	5992513.2	1.8	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25403	333702.4	5992199.5	0.8	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25404	334141.5	5991867.0	0.9	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25405	338064.9	5990348.0	0.7	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25406	340214.3	5989927.8	1.5	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25407	344477.2	5989152.3	0.9	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25410	318116.9	5993321.7	1.9	0.4	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25411	321042.3	5993354.2	1.3	0.4	0.6	SSS			Sonar_Contact, possible debris	CONF 1
S_25415	337615.9	5989919.7	0.9	0.1	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25416	337503.9	5989916.5	0.8	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25417	335554.9	5990609.1	1.6	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25419	333838.2	5991576.8	1.7	0.3	0.6	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25421	333004.2	5992037.9	0.8	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25422	327843.6	5993275.9	1.1	0.3	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25423	327929.4	5993318.1	0.9	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25424	328497.6	5993188.7	0.7	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25425	330573.2	5992943.0	1.7	0.2	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25426	330578.2	5992893.3	1.2	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25427	330786.1	5992956.9	1.0	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25428	330913.5	5992927.5	1.7	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25429	330945.9	5992817.6	1.6	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_25430	329148.6	5993095.2	0.6	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25432	326328.1	5993541.4	1.6	0.3	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25478	320487.1	5992856.9	0.8	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25491	329920.4	5992481.7	0.6	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25492	330346.0	5992426.3	0.9	0.3	0.6	SSS			Sonar_Contact, possible debris	CONF 1
S_25500	330341.6	5992470.6	0.6	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25503	328968.3	5992592.0	0.8	0.3	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25506	333696.4	5991120.2	0.7	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25520	339402.7	5990659.2	1.2	0.5	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25522	339212.4	5990649.1	0.7	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25523	341038.8	5990313.6	1.4	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25524	334238.5	5992409.2	2.3	0.8	0.7	SSS			Sonar_Contact, possible debris	CONF 1
S_25526	334282.9	5992354.7	0.9	0.8	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25527	334314.9	5992357.3	1.3	0.5	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25528	334350.0	5992354.6	0.8	0.4	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25529	334384.1	5992351.3	1.3	0.4	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25530	334416.5	5992347.1	0.8	0.6	0.6	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25531	334447.7	5992342.9	0.8	0.5	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25532	334483.2	5992341.1	1.5	0.3	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25533	334513.3	5992344.1	2.5	0.5	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_25534	334550.1	5992344.5	1.4	0.8	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25535	335878.1	5991575.4	0.9	0.6	0.6	SSS			Sonar_Contact, possible debris	CONF 1
S_25536	330184.7	5993973.7	1.6	1.0	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25537	331383.4	5993681.5	1.8	0.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_25538	331464.6	5993759.6	1.3	0.5	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25539	331586.5	5993581.4	2.3	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25540	332902.5	5993133.8	1.0	0.6	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25542	326252.9	5994296.1	1.1	0.2	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25543	326280.7	5994294.6	0.8	0.5	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25544	326333.7	5994294.2	1.1	0.6	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25545	326367.9	5994289.5	0.9	0.3	0.6	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25546	326427.1	5994278.7	1.0	0.1	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25547	326535.1	5994270.0	0.8	0.4	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25548	327965.2	5994176.8	1.3	0.7	0.7	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_25550	328124.6	5994166.6	0.6	0.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25551	328123.9	5994163.5	0.6	0.3	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25552	328144.1	5994155.8	1.3	0.2	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25553	328473.7	5994147.0	0.7	0.6	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25554	328522.9	5994136.4	1.1	0.6	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25555	328544.1	5994073.5	2.7	1.3	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25557	329272.3	5994047.2	0.8	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25558	329340.4	5993988.0	0.9	0.5	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25559	329383.6	5993975.3	3.0	0.6	0.6	SSS			Sonar_Contact, possible debris	CONF 1
S_25560	329582.1	5994016.7	1.6	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25561	329753.0	5993931.8	0.8	0.6	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25562	329788.6	5993929.7	0.9	0.5	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25563	329823.1	5993922.4	1.9	0.8	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25564	329852.7	5993917.8	0.8	0.6	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_25565	329885.5	5993911.9	1.4	0.8	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25566	329918.1	5993900.5	1.3	0.8	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25567	329950.1	5993894.7	0.9	0.5	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_25632	339361.7	5990549.8	0.9	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25643	329790.2	5995420.5	0.7	0.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25644	330438.2	5995365.8	0.7	0.2	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25649	315115.5	5995848.8	0.7	0.2	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25661	326739.5	5992763.7	0.7	0.4	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25690	323914.3	5994379.3	12.4	0.7	0.4	SSS			Linear_Contact, debris	CONF 1
S_25704	328062.8	5992708.3	197.8	0.1	0.1	SSS MBES			Linear_Contact, possible rope between fishing pot	CONF 4
S_25802	334276.0	5994103.7	1.1	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25804	320675.6	5995765.7	0.8	0.4	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25812	321064.5	5994891.0	1.4	0.5	0.4	SSS			Sonar_Contact, possible debris	CONF 1
S_25813	320941.7	5994909.0	2.3	1.4	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25814	315085.5	5994975.7	1.2	0.6	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25815	313525.5	5995267.3	1.8	0.9	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25816	313524.5	5995269.6	1.6	0.8	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25817	329842.1	5993920.7	251.7	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_25821	342590.7	5989430.6	0.9	0.3	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_25822	313883.7	5993564.3	1.6	1.1	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_25823	323995.5	5993460.3	3.0	1.0	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_25826	331991.9	5991911.4	1.2	0.7	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_25828	327038.3	5995668.1	1.6	0.9	0.3	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_40003	352612.1	5988027.8	1.0	0.5	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_40004	352611.2	5988039.1	1.7	0.4	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_40005	352613.4	5988048.5	1.5	0.6	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_40008	351519.7	5986728.1	1.4	1.3	0.5	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40009	351483.5	5986727.4	1.5	1.2	0.5	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40010	350955.8	5986261.1	0.8	1.1	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40011	350922.3	5986264.7	0.5	0.7	0.6	SSS			Sonar_Contact, fishing pot	CONF 1
S_40012	350884.9	5986265.9	1.0	0.5	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40013	350824.1	5986264.2	1.4	0.7	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40014	350800.6	5986261.4	1.2	0.5	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40015	350780.9	5986259.1	1.2	0.8	0.6	SSS			Sonar_Contact, fishing pot	CONF 1
S_40020	352566.4	5985045.7	1.1	0.6	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40021	352529.4	5985046.4	1.4	0.6	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40022	352489.1	5985047.3	1.5	0.8	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40023	352504.8	5985047.7	72.3	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40026	351956.9	5984579.2	1.9	0.6	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40027	351922.7	5984579.7	1.8	0.8	0.4	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40028	351884.1	5984576.8	0.9	0.8	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40031	351666.3	5984331.1	1.2	0.7	0.6	SSS			Sonar_Contact, fishing pot	CONF 1
S_40032	351627.2	5984330.7	1.0	0.6	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40033	351589.6	5984331.8	1.4	0.7	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40037	351704.0	5984330.7	1.7	0.5	0.5	SSS MBES MAG	M_00770		Sonar_Contact, fishing pot	CONF 4
S_40038	351741.3	5984330.5	1.1	0.8	0.5	SSS			Sonar_Contact, fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_40039	351780.9	5984330.6	1.7	0.6	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40040	352024.0	5984581.9	1.1	0.6	0.4	SSS MBES MAG	M_00771		Sonar_Contact, fishing pot	CONF 4
S_40041	352060.0	5984582.4	1.8	0.6	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40042	352094.8	5984584.4	1.0	0.6	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40043	352055.1	5984581.3	65.6	0.1	0.1	SSS MAG	M_00771		Linear_Contact, rope between fishing pot	CONF 4
S_40045	352603.5	5985044.6	1.1	0.6	0.4	SSS MBES MAG	M_00775		Sonar_Contact, fishing pot	CONF 4
S_40046	352641.0	5985044.9	1.0	0.5	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40058	356602.5	5986175.2	0.7	0.4	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40078	350795.7	5986265.2	66.5	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40079	350903.0	5986260.9	78.9	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40116	351418.2	5986673.7	1.2	0.5	0.6	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40117	351447.0	5986689.1	0.9	0.8	0.3	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40118	351388.1	5986662.2	0.8	0.6	0.7	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40119	351475.3	5986704.5	1.4	1.1	0.3	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40120	351504.1	5986719.2	1.5	0.7	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40121	351533.6	5986735.9	1.5	0.8	0.3	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40122	351559.1	5986748.8	2.0	0.7	0.6	SSS			Sonar_Contact, fishing pot	CONF 1
S_40123	351592.0	5986763.2	1.4	0.8	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40124	351621.1	5986776.6	1.4	0.7	0.2	SSS			Sonar_Contact, fishing pot	CONF 1
S_40125	351647.9	5986791.1	1.5	0.8	0.2	SSS			Sonar_Contact, fishing pot	CONF 1
S_40126	351569.8	5986760.1	167.1	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_40134	356450.9	5988218.9	44.5	0.1	0.1	SSS MBES			Linear_Contact, rope/possible abandoned fishing gear	CONF 4
S_40165	358820.6	5987308.6	0.7	0.4	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40166	358801.2	5987293.8	1.6	0.5	0.6	SSS			Sonar_Contact, fishing pot	CONF 1
S_40168	358746.8	5987251.2	0.8	0.4	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40169	358701.2	5987227.2	1.2	0.6	0.4	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40170	358677.6	5987216.4	0.6	0.4	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40171	358723.3	5987239.9	1.3	0.6	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40173	358044.1	5987378.2	3.1	0.2	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40185	352044.7	5986523.9	0.8	0.6	0.6	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40186	352012.2	5986523.0	0.9	0.7	0.6	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40187	351982.3	5986523.2	1.1	0.7	0.4	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40188	352078.5	5986523.9	1.0	1.0	0.5	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40189	352111.0	5986523.4	2.2	1.2	0.9	SSS			Sonar_Contact, fishing pot	CONF 1
S_40190	352144.9	5986523.0	0.6	0.8	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40191	352111.1	5986522.2	62.2	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40205	352267.5	5986702.0	1.8	1.4	0.1	SSS MBES			Sonar_Contact, fishing pot	CONF 4
S_40206	352302.4	5986699.1	2.7	0.8	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40219	351768.0	5983913.2	3.4	1.1	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40220	351798.1	5983913.5	1.3	1.1	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40221	351824.5	5983911.6	1.6	1.3	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40222	351853.5	5983910.1	0.8	1.0	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40223	351912.2	5983906.7	1.0	0.7	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40224	351934.7	5983904.2	1.4	0.7	0.4	SSS			Sonar_Contact, fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_40228	351805.7	5983913.8	59.7	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40229	351856.8	5983911.2	19.4	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40230	351917.0	5983906.1	68.9	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40234	358552.6	5986223.7	1.9	0.5	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40235	358577.1	5986235.8	2.0	0.5	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40237	358709.5	5986295.1	1.0	0.2	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40238	358732.9	5986305.9	1.2	0.6	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40239	358685.2	5986283.3	0.5	0.4	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40241	358529.3	5986215.1	24.7	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40242	358598.0	5986244.8	45.6	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40248	359014.1	5986232.0	0.5	0.2	0.1	SSS			Sonar_Contact, scattered debris / disturbed seabed	CONF 1
S_40249	359012.6	5986233.4	0.9	0.3	0.1	SSS			Sonar_Contact, scattered debris / disturbed seabed	CONF 1
S_40250	359015.7	5986232.5	1.1	0.3	0.1	SSS			Sonar_Contact, scattered debris / disturbed seabed	CONF 1
S_40251	359013.9	5986231.2	0.8	0.1	0.1	SSS			Sonar_Contact, scattered debris / disturbed seabed	CONF 1
S_40252	359017.2	5986230.3	0.7	0.3	0.1	SSS			Sonar_Contact, scattered debris / disturbed seabed	CONF 1
S_40253	359016.1	5986231.5	0.6	0.2	0.1	SSS			Sonar_Contact, scattered debris / disturbed seabed	CONF 1
S_40254	359014.5	5986233.3	0.7	0.3	0.1	SSS			Sonar_Contact, scattered debris / disturbed seabed	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_40255	356452.6	5988219.5	0.5	0.3	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40256	352033.7	5985194.4	2.1	0.8	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40257	351993.5	5985196.1	2.7	1.0	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40258	351959.5	5985196.7	1.2	1.3	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40259	351884.6	5985196.1	1.1	0.7	0.2	SSS			Sonar_Contact, fishing pot	CONF 1
S_40260	351844.9	5985195.1	1.3	1.0	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40261	351807.2	5985195.8	0.9	0.3	0.1	SSS			Sonar_Contact, fishing pot	CONF 1
S_40262	351895.9	5985246.2	1.6	1.1	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40263	351927.6	5985242.9	0.8	0.7	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40264	351960.1	5985239.1	0.8	0.7	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40265	351981.5	5985238.0	0.7	0.5	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_40266	352008.7	5985236.1	1.2	0.6	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40267	352037.8	5985234.1	1.1	0.8	0.5	SSS			Sonar_Contact, fishing pot	CONF 1
S_40268	352064.4	5985234.7	0.7	0.5	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40269	351962.6	5985195.9	60.2	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40270	352036.4	5985234.3	47.1	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40271	351922.8	5985245.7	20.2	0.1	0.1	SSS			Linear_Contact, rope between fishing pot	CONF 1
S_40290	356447.5	5988219.1	0.7	0.4	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40291	356448.9	5988218.8	0.7	0.4	0.3	SSS			Sonar_Contact, fishing pot	CONF 1
S_40294	358526.7	5986213.7	0.9	0.3	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_40295	358784.2	5987277.7	1.2	0.5	0.3	SSS			Sonar_Contact, possible fishing pith	CONF 1
S_40297	352173.4	5986705.6	1.4	1.0	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_40298	352139.5	5986706.2	1.7	0.9	0.1	SSS			Sonar_Contact, possible fishing pith	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_40300	352197.2	5986704.1	152.9	0.1	0.1	SSS MBES			Linear_Contact, rope between fishing pot	CONF 4
S_40403	352161.3	5986604.4	66.2	0.1	0.1	SSS			Linear_Contact, rope between fishing pots	CONF 1
S_40404	351929.2	5984578.6	57.2	0.1	0.1	SSS			Linear_Contact, rope between fishing pots	CONF 1
S_50002	358932.3	5987378.9	0.7	0.6	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50003	358951.4	5987393.6	1.1	1.0	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50004	358971.9	5987406.7	1.8	0.8	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50008	359012.7	5987433.2	1.3	1.0	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50009	359034.0	5987448.4	1.4	0.9	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50010	359054.0	5987459.8	1.0	0.8	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50027	362358.0	5984156.5	1.7	0.8	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50028	362335.3	5984186.8	1.4	1.2	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50029	362317.8	5984213.8	2.3	0.8	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50030	362298.7	5984240.7	2.5	1.6	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50031	362277.8	5984268.5	1.7	1.4	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50032	362256.8	5984291.7	2.7	1.8	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50033	362232.2	5984313.1	1.0	0.8	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50037	362274.4	5984270.6	270.6	0.1	0.1	SSS MBES			Linear_Contact, possible rope between fishing pot	CONF 4
S_50054	377808.9	5989959.2	1.3	0.8	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_50056	378140.5	5989609.9	5.0	1.6	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_50060	379139.2	5988647.8	1.7	0.8	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50073	378275.9	5989621.2	0.7	0.3	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50086	375418.0	5992293.7	1.0	0.6	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_50089	375623.0	5992108.2	1.2	0.7	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50092	375936.3	5991753.8	1.0	0.7	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50093	375963.5	5991754.4	1.4	0.9	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50094	375996.7	5991753.3	1.3	0.8	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50095	376026.8	5991752.6	0.8	0.8	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50096	375954.2	5991752.6	66.6	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_50107	376055.9	5991750.3	1.3	0.7	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50108	376087.7	5991747.3	1.1	0.7	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50109	376117.0	5991745.1	1.0	0.7	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50110	376147.0	5991741.6	1.2	1.0	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50111	376100.7	5991744.9	90.7	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_50129	373176.5	5994450.4	8.5	3.6	0.6	SSS			Sonar_Contact, possible debris	CONF 1
S_50131	373280.8	5994405.9	1.7	1.6	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50134	373225.2	5994401.2	1.1	0.5	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50139	374101.0	5993548.7	1.0	0.9	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50140	374132.4	5993554.7	1.6	1.1	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50141	374162.9	5993561.4	0.8	0.7	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50142	374192.7	5993568.3	0.7	0.7	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50143	374222.3	5993577.2	1.5	1.3	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50144	374253.3	5993585.8	1.0	1.0	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50149	373363.1	5994414.8	1.5	1.2	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50150	373394.8	5994424.2	1.0	0.4	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50151	373335.9	5994412.3	0.6	0.3	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_50154	372343.1	5995401.6	3.5	2.4	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50157	368427.3	5999256.3	2.5	1.5	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_50166	369720.0	5997876.9	1.3	0.7	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50209	368515.3	5994999.7	1.2	0.9	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50210	368488.1	5995001.4	1.4	0.9	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50211	368460.9	5995003.0	1.1	0.9	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50212	368435.4	5995005.4	0.7	0.5	0.4	SSS			Sonar_Contact, fishing pot	CONF 1
S_50215	368385.3	5995010.3	1.2	0.8	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50216	368360.9	5995014.3	1.4	0.9	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50217	368335.1	5995018.2	1.4	0.8	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50218	368311.2	5995022.5	3.4	0.8	0.6	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50219	368284.9	5995028.9	1.5	1.0	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50220	368343.6	5995016.4	121.3	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_50222	368469.1	5995029.5	155.1	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1
S_50226	367899.3	5995609.7	3.5	1.6	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50253	370909.5	5992534.5	1.3	0.8	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50262	372755.4	5990854.5	5.0	2.7	0.5	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50266	372224.0	5991205.4	4.0	1.9	0.5	SSS			Sonar_Contact, possible debris	CONF 1
S_50293	379083.1	5980180.4	1.6	0.7	0.2	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50313	382467.7	5977157.3	1.4	0.4	0.1	SSS			Sonar_Contact, possible abandoned fishing pot	CONF 1
S_50318	380043.1	5979393.8	2.7	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50325	380797.8	5978622.7	1.3	0.6	0.1	SSS			Sonar_Contact, possible abandoned fishing pot	CONF 1
S_50326	380968.8	5978500.4	2.8	1.3	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_50327	381180.6	5978267.9	2.7	1.1	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50331	378371.2	5981004.1	1.0	0.5	0.1	SSS			Sonar_Contact, possible abandoned fishing pot	CONF 1
S_50352	376203.9	5983149.5	1.2	0.2	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50354	375793.1	5983660.0	3.4	1.5	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50362	372023.8	5987240.2	0.6	0.3	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50368	370716.6	5988460.3	1.8	0.7	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50372	371095.3	5988230.9	2.7	0.7	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_50387	367104.1	5992148.3	1.3	0.7	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50391	366323.0	5992776.4	1.5	0.2	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50392	366355.2	5992780.4	1.1	1.6	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50393	366484.1	5992659.0	0.9	0.9	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50396	366485.2	5992788.7	3.0	1.4	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50397	366451.4	5992787.7	2.3	1.0	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50400	365917.4	5993332.3	0.9	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50402	365623.7	5993624.3	1.2	0.5	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50403	365595.5	5993651.4	2.2	0.7	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50404	365589.7	5993632.3	1.8	1.1	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50405	365570.9	5993670.1	2.7	1.4	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50406	365543.4	5993690.6	1.9	1.0	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50407	365521.5	5993712.1	1.1	0.6	0.2	SSS			Sonar_Contact, fishing pot	CONF 1
S_50408	365503.3	5993739.3	0.9	0.7	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50409	365584.3	5993659.8	124.3	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_50410	365600.7	5993651.8	67.1	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_50411	365582.9	5993645.5	73.5	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1
S_50412	363709.9	5995313.2	1.3	1.0	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50413	363741.3	5995324.8	1.3	0.8	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50414	363804.3	5995347.9	1.8	0.9	0.6	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50415	363837.3	5995359.2	2.0	1.0	0.8	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50416	363890.6	5995302.7	1.3	0.9	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50420	364737.0	5994438.9	4.0	1.2	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50427	370491.8	5997099.1	33.5	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1
S_50428	370211.5	5996797.2	1.1	0.7	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50429	370180.6	5996795.8	1.1	0.8	0.6	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50430	370153.4	5996797.8	1.5	0.9	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50431	370096.6	5996801.3	0.9	0.8	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50432	370066.6	5996803.9	1.0	0.7	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50433	370038.5	5996805.9	0.8	0.8	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50440	369366.9	5996047.5	0.8	0.7	0.5	SSS MAG	M_00828		Sonar_Contact, possible fishing pot	CONF 4
S_50463	366260.0	5992764.3	2.4	0.6	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50464	366226.6	5992758.5	1.3	0.8	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50465	366196.3	5992753.4	1.3	0.9	0.3	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50467	366165.3	5992747.9	1.4	0.7	0.8	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50468	366039.5	5992733.1	1.6	1.0	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50470	366069.8	5992736.3	2.0	1.2	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50471	366102.5	5992739.8	2.0	1.4	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50475	364129.7	5990716.0	18.2	0.1	0.1	SSS			Linear_Contact, possible abandoned rope	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_50476	364080.2	5990690.9	20.3	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_50477	364053.9	5990676.0	37.9	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_50480	364571.1	5991100.4	0.8	0.9	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50484	364597.0	5991116.4	1.9	1.3	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50488	364737.7	5991197.1	26.1	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_50492	364261.2	5990912.4	2.2	0.5	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50502	361181.0	5987571.9	48.5	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1
S_50548	361386.1	5987796.5	1.3	0.8	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50549	361404.6	5987811.8	2.4	1.4	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50550	361427.5	5987825.7	2.4	1.6	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50551	361367.6	5987780.7	2.0	1.0	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50552	361327.7	5987749.0	2.7	1.5	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50553	361285.1	5987719.8	1.4	0.9	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50554	361446.8	5987839.4	1.6	1.0	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50560	380878.1	5977813.9	2.5	1.0	0.5	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50561	370855.6	5993336.4	1.0	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50562	370855.1	5993337.0	1.5	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50564	371038.2	5993352.8	0.9	0.9	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50565	371046.3	5993372.1	1.5	1.0	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_50566	371061.9	5993409.3	3.4	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50567	371059.6	5993413.1	1.2	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50568	371054.0	5993414.3	2.1	0.6	0.3	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50570	371864.2	5994334.9	1.8	0.9	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_50572	364930.4	5987150.2	0.9	0.6	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50573	362205.8	5984334.6	1.1	0.9	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50574	362161.6	5984348.8	3.7	1.0	0.7	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50577	369527.2	5987668.8	1.4	0.6	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_50579	372907.9	5991012.6	2.3	1.1	0.3	SSS			Sonar_Contact, possible debris	CONF 1
S_50582	370746.6	5988803.5	0.8	0.7	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_50585	376671.0	5990650.6	2.1	1.7	0.5	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50589	372219.8	5981842.3	8.8	5.8	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_50591	376358.0	5986078.4	3.3	1.7	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_50592	379267.8	5989042.9	1.8	0.7	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_50593	379136.2	5988934.1	4.2	1.6	0.8	SSS			Sonar_Contact, possible debris	CONF 1
S_52002	369338.1	5996039.3	1.3	1.1	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52003	369309.5	5996032.6	1.4	1.1	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52004	369280.3	5996025.5	1.4	1.1	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52005	369423.5	5996063.1	1.6	0.8	0.7	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52006	369452.7	5996070.4	1.1	0.8	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52007	369482.0	5996076.9	1.4	1.0	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52008	369510.4	5996080.7	1.3	0.9	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52009	369447.1	5996201.3	1.6	0.7	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52010	369476.0	5996208.3	1.5	0.9	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52011	369505.1	5996212.8	1.3	1.3	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52012	369587.6	5996226.2	1.9	1.1	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52013	369618.2	5996229.2	1.5	1.1	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52014	365871.9	5992537.3	1.1	0.9	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_52015	365901.3	5992536.3	1.0	0.9	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52016	365933.1	5992537.4	0.9	0.9	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52017	365962.2	5992537.6	0.8	0.8	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52018	365993.3	5992540.2	0.9	0.9	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52019	365985.6	5992488.0	0.9	0.8	0.2	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52020	366026.3	5992542.1	1.2	0.9	0.5	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52021	366057.4	5992544.3	1.1	1.1	0.2	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52027	364032.8	5990671.1	1.6	0.7	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52028	364058.6	5990684.8	1.2	0.9	0.5	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52029	364085.0	5990699.9	1.5	1.0	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52030	364111.2	5990714.3	1.3	0.8	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52031	364137.4	5990727.0	1.0	0.7	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52032	364163.7	5990739.7	1.0	0.5	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52033	364190.5	5990751.9	1.2	0.8	0.3	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52034	364216.8	5990765.1	0.8	0.4	0.7	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52035	364240.6	5990779.4	1.2	0.4	0.6	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52036	364267.6	5990791.5	1.2	0.4	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52037	364293.9	5990804.9	1.2	0.8	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52038	364321.1	5990818.4	0.9	1.0	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52039	364346.4	5990831.7	1.3	0.7	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52040	364370.9	5990844.7	1.0	0.9	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52041	364396.4	5990858.4	1.3	0.9	0.4	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52042	364423.4	5990872.0	1.6	0.8	0.4	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52043	364285.4	5990927.2	1.1	0.5	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_52044	364311.2	5990943.8	2.1	1.0	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52045	364336.6	5990959.3	1.7	1.1	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52046	364362.9	5990973.7	1.2	0.8	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52047	364390.2	5990986.7	1.6	1.1	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52048	364415.2	5991002.8	1.6	1.0	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52049	364441.8	5991020.1	1.4	1.0	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52050	364622.9	5991131.7	1.6	0.6	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52051	364647.7	5991151.1	1.3	1.0	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52052	364673.5	5991166.8	1.0	0.6	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52053	364700.8	5991181.7	1.4	1.1	0.1	SSS MBES			Sonar_Contact, possible fishing pot	CONF 4
S_52054	364728.5	5991192.0	1.8	0.8	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_52055	361185.7	5987574.7	1.2	0.8	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_53008	375601.2	5992108.5	79.6	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1
S_53009	368496.9	5995000.5	88.1	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53012	371056.0	5993385.0	73.6	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53013	369300.2	5996032.0	60.3	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53015	366092.1	5992738.3	62.7	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53016	378367.1	5981009.8	19.0	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1
S_53017	369648.1	5996228.8	1.6	0.6	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_53018	361118.2	5987645.4	1.0	0.3	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_53019	361271.5	5987711.5	46.7	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_53021	364309.2	5990803.6	47.2	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53022	364360.8	5990831.1	48.4	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53023	364398.7	5990992.9	118.3	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53025	366014.6	5992541.0	102.2	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53026	366245.1	5992761.7	82.3	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53027	369467.3	5996075.0	109.5	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53028	369464.1	5996204.0	72.8	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53031	364931.7	5987150.9	1.0	0.8	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_53040	378830.6	5980011.5	1.6	1.0	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_53045	370906.5	5996821.8	1.6	0.3	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_53046	373258.9	5994403.6	74.1	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53047	374138.7	5993557.4	62.8	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53048	374232.9	5993586.6	20.6	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53049	374385.8	5993413.1	2.8	0.8	0.2	SSS			Sonar_Contact, possible debris	CONF 1
S_53050	375585.5	5992108.3	0.9	0.6	0.1	SSS			Sonar_Contact, possible fishing pot	CONF 1
S_53051	375593.9	5992108.3	1.5	1.0	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_53052	375603.9	5992121.8	44.8	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53058	376353.0	5986083.1	2.1	1.0	0.1	SSS			Sonar_Contact, possible debris	CONF 1

Seabed Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Datasets	Associated Mag Anomaly ID	Associated SBP Target ID	Comment	Confidence Level
S_53059	376352.7	5986081.9	2.1	0.9	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_53062	371513.5	5989610.0	3.0	2.7	0.4	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_53063	372336.4	5990565.5	1.1	0.4	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_53065	372812.2	5986566.1	1.7	1.2	0.1	SSS MBES			Sonar_Contact, possible debris	CONF 4
S_53066	370719.9	5988628.7	1.8	0.9	0.1	SSS			Sonar_Contact, possible abandoned fishing pot	CONF 1
S_53067	370728.1	5988625.8	33.6	0.1	0.1	SSS			Linear_Contact, possible rope	CONF 1
S_53068	366440.0	5992786.1	83.9	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53070	366339.8	5992776.6	0.7	0.5	0.1	SSS			Sonar_Contact, possible debris	CONF 1
S_53071	366326.7	5992775.4	23.8	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1
S_53072	365534.4	5993702.9	64.0	0.1	0.1	SSS			Linear_Contact, possible rope between fishing pot	CONF 1

Sub-Bottom Targets – Buried and Seabed

Sub-Bottom Target ID	Easting (m)	Northing (m)	DOB (m)	Associated Seabed Contact ID	Associated Mag Anomaly ID	Confidence Level	Comment
SBP_00001	289965.7	5989599.8	1.8			1	Buried Target
SBP_00002	290019.4	5991778.8	-0.2	S_10168		4	Target on seabed
SBP_00003	290116.0	5989498.5	2.2			1	Buried Target
SBP_00004	290125.9	5990495.7	2.8			1	Buried Target
SBP_00005	290163.2	5988476.0	-0.1			4	Target on seabed in Area of Boulders
SBP_00006	290163.5	5988469.6	0.0			4	Target on seabed in Area of Boulders

Sub-Bottom Target ID	Easting (m)	Northing (m)	DOB (m)	Associated Seabed Contact ID	Associated Mag Anomaly ID	Confidence Level	Comment
SBP_00007	290163.6	5988463.0	-0.2			4	Target on seabed in Area of Boulders
SBP_00008	290195.3	5988260.8	-0.2			4	Target on seabed in Area of Boulders
SBP_00009	290230.8	5992025.2	1.0			1	Buried Target
SBP_00010	290230.8	5992017.3	1.1			1	Buried Target
SBP_00011	290271.9	5992615.5	1.3			1	Buried Target
SBP_00012	290281.0	5991928.9	2.2			1	Buried Target
SBP_00013	290294.7	5989995.2	-0.2			4	Target on seabed in Area of Boulders
SBP_00014	290323.5	5989063.4	-0.3			1	Target on seabed in Area of Boulders
SBP_00015	290363.8	5990973.4	0.0			4	Target on seabed in Area of Boulders
SBP_00016	290365.0	5990931.1	0.0			4	Target on seabed in Area of Boulders
SBP_00017	290371.3	5991568.6	0.0	B_00692		4	Target on seabed
SBP_00018	290383.2	5989946.0	-0.5			4	Target on seabed in Area of Boulders
SBP_00019	290438.3	5989867.2	-0.2			4	Target on seabed in Area of Boulders
SBP_00020	290440.1	5988089.4	-0.2			4	Target on seabed - Possible exposed till
SBP_00021	290441.7	5989787.0	-0.2			4	Target on seabed in Area of Boulders
SBP_00022	290454.4	5992762.9	0.0			4	Target on seabed in Area of Boulders
SBP_00023	290455.2	5992705.1	0.0			1	Target on seabed in Area of Boulders

Sub-Bottom Target ID	Easting (m)	Northing (m)	DOB (m)	Associated Seabed Contact ID	Associated Mag Anomaly ID	Confidence Level	Comment
SBP_00024	290457.8	5988785.4	0.0			4	Target on seabed in Area of Boulders
SBP_00025	290461.9	5988653.8	0.0			4	Target on seabed in Area of Boulders
SBP_00026	290471.5	5990828.2	-0.2			4	Target on seabed
SBP_00027	290473.5	5989578.1	0.1			1	Buried Target
SBP_00028	290484.5	5989228.5	0.0			1	Target on seabed in Area of Boulders
SBP_00029	290485.6	5989205.3	0.0			4	Target on seabed in Area of Boulders
SBP_00030	290486.2	5989166.4	0.1			1	Target on seabed in Area of Boulders
SBP_00031	290499.7	5988747.9	0.1			4	Target on seabed in Area of Boulders
SBP_00032	290557.0	5988258.9	-0.2			1	Target on seabed in Area of Boulders
SBP_00033	290557.2	5988266.0	-0.2			4	Target on seabed in Area of Boulders
SBP_00034	290557.3	5988246.3	-0.3			4	Target on seabed in Area of Boulders
SBP_00035	290562.9	5989286.9	0.0			1	Target on seabed in Area of Boulders
SBP_00038	290955.5	5988748.7	-0.2			4	Target on seabed in Area of Boulders
SBP_00039	320453.6	5995811.4	-0.1			1	Target on seabed
SBP_00040	320465.2	5995811.7	-0.1			1	Target on seabed
SBP_00041	320768.3	5995325.9	-0.2			1	Target on seabed
SBP_00042	321197.6	5995831.3	-0.1			1	Target on seabed
SBP_00043	321397.8	5995837.1	-0.1			1	Target on seabed
SBP_00044	321458.4	5995345.1	-0.6			1	Target on seabed

Sub-Bottom Target ID	Easting (m)	Northing (m)	DOB (m)	Associated Seabed Contact ID	Associated Mag Anomaly ID	Confidence Level	Comment
SBP_00045	321460.5	5995838.9	-0.1			1	Target on seabed
SBP_00046	321528.1	5995840.2	-0.1			1	Target on seabed
SBP_00047	321656.2	5995844.2	-0.2			1	Target on seabed
SBP_00048	323225.5	5995887.6	1.0			1	Buried Target
SBP_00049	323936.0	5995882.3	-0.2			1	Target on seabed
SBP_00050	325049.8	5995824.5	-0.1			4	Target on seabed
SBP_00051	325728.8	5995788.5	-0.2			1	Target on seabed
SBP_00056	328003.6	5995669.3	-0.2			4	Target on seabed
SBP_00057	328892.4	5993578.6	-0.2			1	Target on seabed
SBP_00058	329081.9	5993558.2	-0.2			1	Target on seabed
SBP_00060	347845.2	5987950.6	0.7			1	Buried Target
SBP_00068	350935.1	5985830.7	3.5			1	Buried Target
SBP_00073	353876.1	5986328.1	2.2			1	Buried Target
SBP_00087	375229.4	5980572.3	2.5			1	Buried Target
SBP_00091	375735.1	5989666.9	0.6			1	Buried Target

Appendix C: Hornsea Four Offshore Wind Farm Foreshore Survey – Intertidal Benthic Community Characterisation (IECS 2019)

Hornsea Four Foreshore Survey 2019:

Intertidal Benthic Community Characterisation

Report to Royal HaskoningDHV

Institute of Estuarine and Coastal Studies
University of Hull

21st May 2019

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Report: YBB423-F-2019

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21/05/2019	V1	Final Report	Nick Cutts	IECS	21/05/2019

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1. INTRODUCTION

1.1 Background

The landfall area of the Hornsea Project Four Offshore Wind Farm (Hornsea Four) is situated along the Holderness Coast between Bridlington and Skipsea. Previous studies (e.g. Forewind, 2013) have found the landfall area to be characterised by long sandy beaches with cliffs at the upper shore. Intertidal biotopes have previously been identified as littoral sand (LS.LSa.MoSa.Bar.Sa), and course sediment (LS.LCS).

As identified by the Planning Inspectorate in November 2018, baseline data were found to be insufficient to characterise the Hornsea Four area and thus subtidal and intertidal surveys to supplement existing benthic data have been required. The intertidal survey area covering the potential cable landfall is shown below in Figure 1. Royal HaskoningDHV (RHDHV) commissioned IECS to conduct a Phase 1 walkover survey of the intertidal survey area and this was performed in March 2019, with the purpose of characterising the intertidal benthic community present and deriving biotope maps.

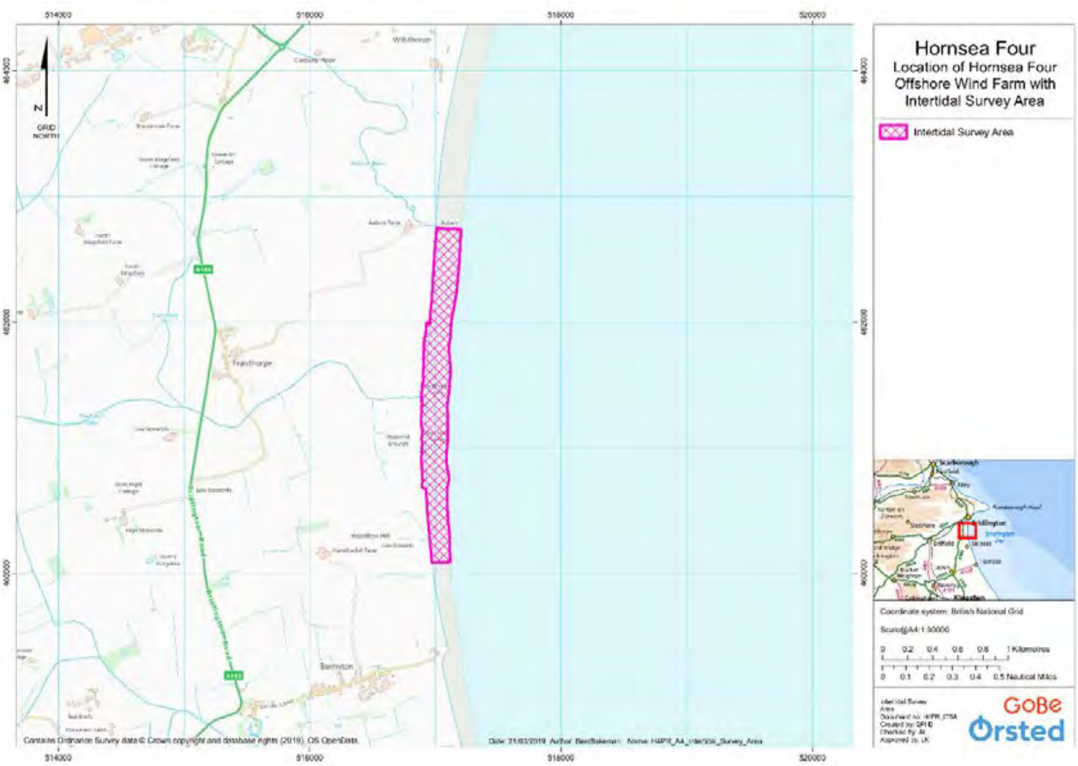

Figure1: Hornsea Four intertidal survey area (Map provided by: RHDHV).

1.2. Aims and Objectives

The intertidal Phase 1 walk over survey aimed to characterise the benthic environment in the vicinity of the cable landfall, in terms of benthic and epibenthic communities, as well as identifying biotopes present in the intertidal area. The objectives were to:

- Determine the species present
- Identify and map the biotopes present

2. METHODS

2.1 Intertidal Field Methods

A Phase 1 habitat survey was undertaken on the 22nd March 2019 around mean low water 11:44 BST (0.71m) and information on the following was obtained:

- Biotope composition
- Biotope distribution
- Extent of sub features and notable biotopes

Additionally, evidence of impacts from human activities were looked for as well as any evidence of ongoing change to littoral habitats.

A systematic route within the survey area was covered and the distribution of biotopes was mapped following standardised Phase 1 mapping methodology (Marine Monitoring Handbook procedural guidance No 3-1 (Wyn & Brazier, 2001); CCW Intertidal Monitoring Handbook (Wyn *et al*., 2006) and Cefas Data Acquisition Guidelines (Judd, 2011)).

Five transects were surveyed, covering the intertidal survey area in Figure 1. At each transect, periodic assessments of biotopes were carried out, (High-shore, Mid-shore, Low-shore). Using a 1mm sieve, a dig-over was also performed on an area or 30cm^2 to a depth of 15cm to assess the presence of fauna and surface features along with boundaries of any biotopes. Digital geo-referenced photographs were also taken of characteristic biotopes, habitats and noteworthy features.

2.2 Data Analysis / Mapping

On conclusion of the Phase 1 walkover survey, the information and biotopes recorded were collated and saved digitally onto a laptop. The data were then redrawn in ArcGIS (Geographical Information System) and used together with the survey data (standard MNCR) to derive biotope maps. Photographs taken were cross-referenced to features and positions within the sites and compiled onto GIS.

The data were then used to derive the biotope maps showing the distribution of biotopes along each transect and other features of interest. Other features and dig-over sites have been digitised as referenced target notes or point data.

3. RESULTS AND DISCUSSION

3.1 Biotope Composition and Distribution

Figures 2 and 3 map all biotopes and noted features found during the survey and show the location of dig-over sites, transect lines and photo sites. Site locations (photos and dig sites) are numbered and referred to in the text. For the purpose of the discussion below, the biotopes and features have been discussed in relation to transect area, i.e. transect area 1 refers to the area of shore running from transect 1 to transect 2. Table 1 provides an overview of all features identified, including fauna found in the dig-overs.

Intertidal biotopes have previously been identified in the area as littoral sand (LS.LSa.MoSa.Bar.Sa), and course sediment (LS.LCS) (Forewind, 2013).

Biotopes identified during this survey were also predominantly coarse littoral sand (LS.LSa.MoSa.Bar.Sa), characteristic of clean sands in areas of high hydrodynamic energy.

It was expected that a strandline biotope (LS.LSa.St.Tal) would have been present at the high-shore tide line along this stretch of coast. However, no strand line features were identified during this survey. A single *Talitrus saltator* was found in the upper shore of transect area 3, (site ref 276), but this would not constitute the designation of a biotope.

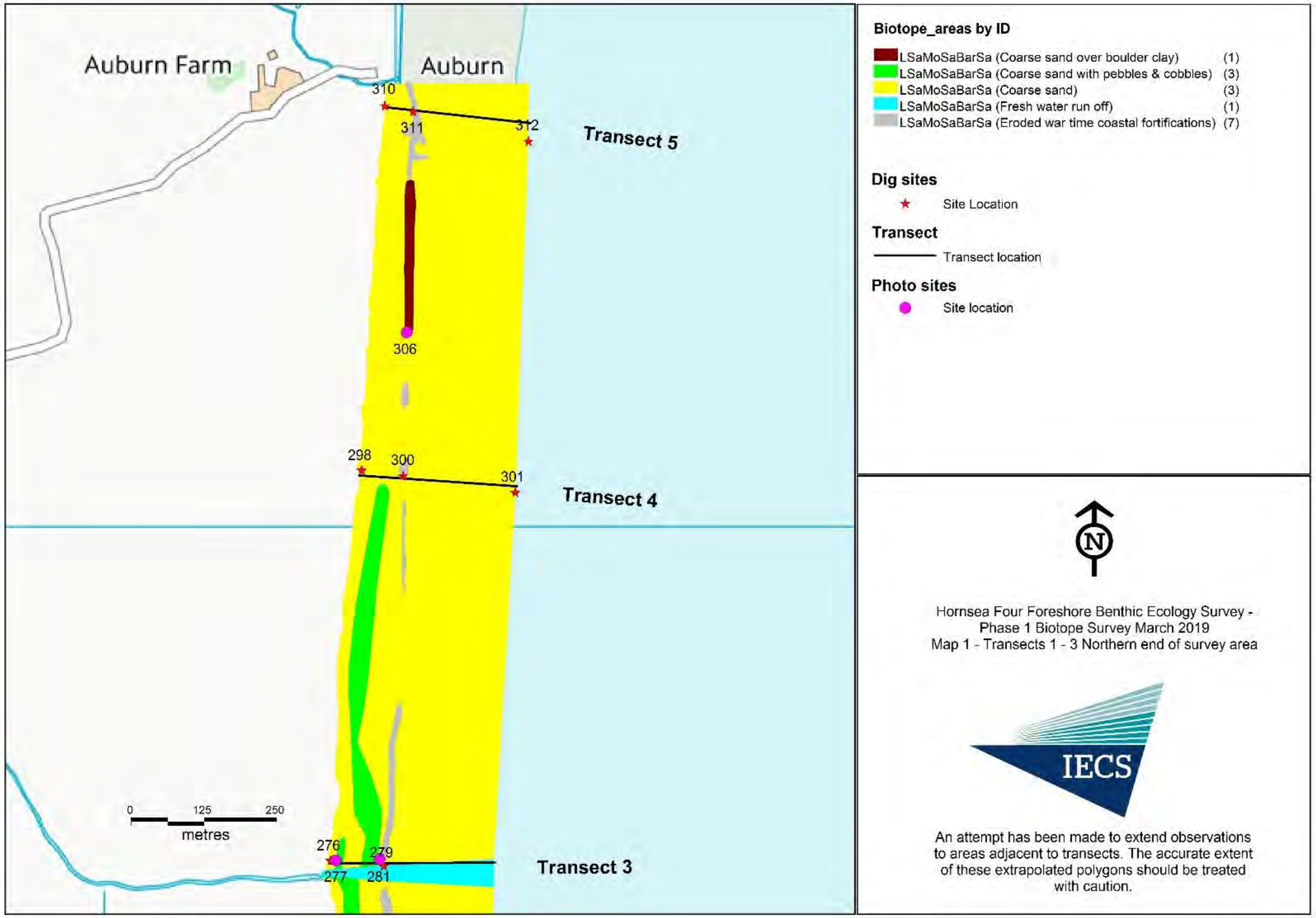

Figure 2. Phase 1 Biotope Map: Hornsea Four (northern end of intertidal survey area), showing designated intertidal biotopes and site references of digovers and noteworthy features.

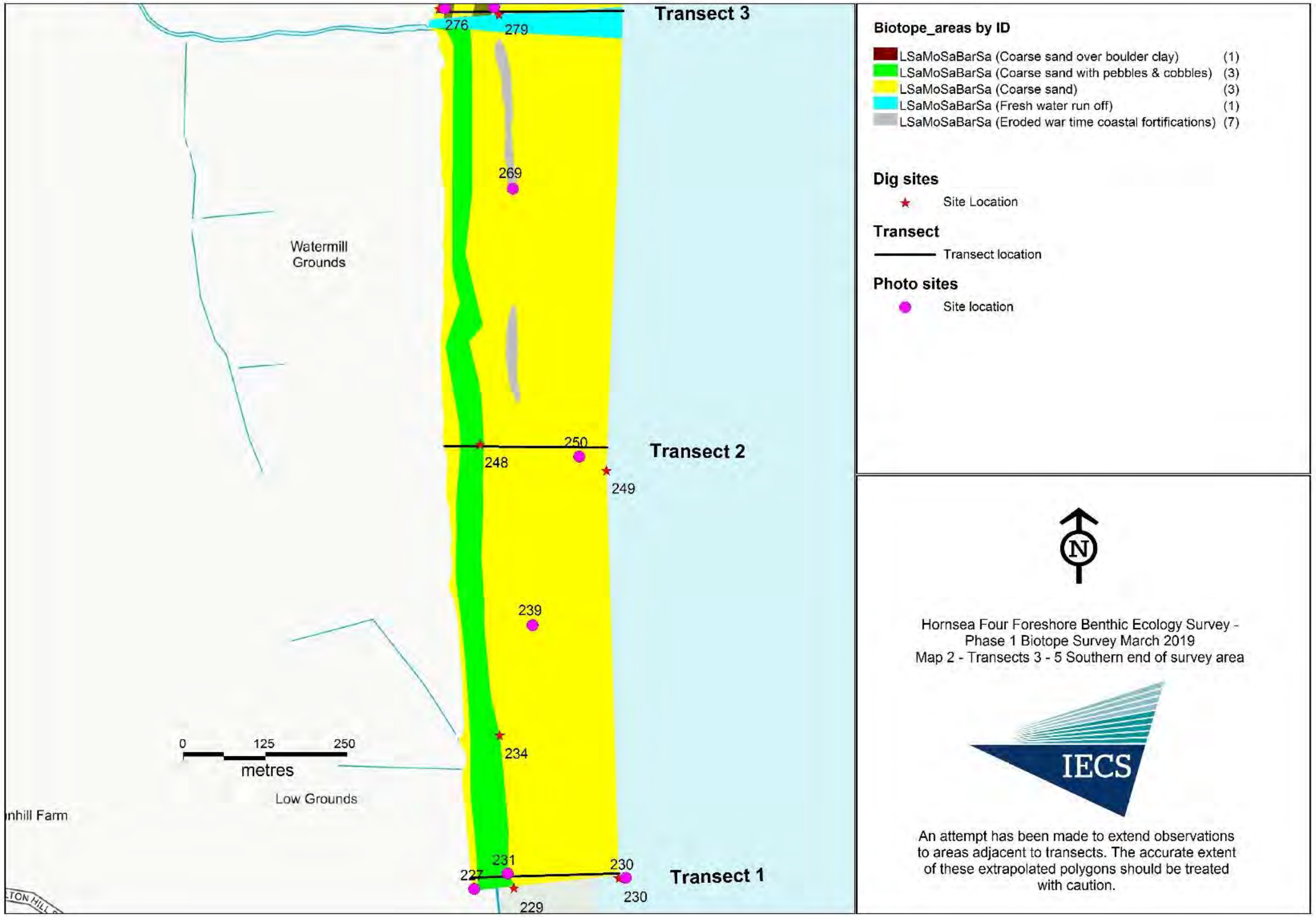

Figure 3. Phase 1 Biotope Map: Hornsea Four (southern End of intertidal survey area), showing designated intertidal biotopes and site references of digovers and noteworthy features.

3.1.1 TRANSECT AREA 1 (T1)

The upper and lower shore were characterised by coarse littoral barren sand (LS.LSa.MoSa.Bar.Sa), Plates 1 & 3, with surficial cobbles and pebbles found at mid-shore Plate 2.

No animals were found in the dig-overs. Other features of note were large 'boulders', identified as anthropogenic, most probably eroded war time coastal fortifications with attached algal species, (*Ulva spp.*, *Porphyra sp.* and *Fucoid spp.,* (predominantly *Fucus vesiculosus*)). *Semibalanus balanoides*, *Mytilus edulis*, *Littorina saxatilis* and *Patella vulgata* were also present on the boulder features, Plate 4. Pools at the base of the coastal fortifications are scour pits caused by erosion.

Plate 1. Coarse littoral sand. T1 upper-shore (site ref 227).

Plate 2. Coarse littoral sand with surficial cobbles and pebbles. T1 mid-shore (site ref 231).

Plate 3. Coarse littoral sand. T1 low-shore (site ref 230).

Plate 4. Eroded war time coastal fortifications with attached algae and fauna. T1 mid-shore (site ref 239).

3.1.2 TRANSECT AREA 2 (T2)

As with the previous section, T2 was characterised at the upper and lower shore by coarse littoral barren sand (LS.LSa.MoSa.Bar.Sa), with surficial cobbles and pebbles found at mid-shore. No animals were found in the dig-overs, however an area of sparse *Lanice conchilega* tubes was observed in this transect area, Plate 5. The numbers of *L. conchilega* tubes visible were estimated to be well below 100 per m^2 and so numbers of *L. conchilega* were not expected to be suitably abundant (SACFOR), to constitute LS.LSa.MuSa.Lan. Further analysis and a more detailed Phase 2 biotope survey would identify, more accurately, numbers and densities of these sparse beds. Other features of note were, again, eroded war time coastal fortifications, Plate 6, with attached algal and faunal species, *Ulvas spp.*, *Porphyra sp.* and *Fucoid spp.,* (predominantly *F. vesiculosus*) and *S. balanoides*.

Plate 5. Sparse *L. conchilega* Tubes. T2 mid to low shore (site ref 250)

Plate 6. Eroded war time coastal fortifications with attached algae and fauna. T2 mid-shore (site ref 269).

3.1.3 TRANSECT AREA 3 (T3)

T3 was again characterised at the upper and lower shore by coarse littoral barren sand (LS.LSa.MoSa.Bar.Sa), with surficial cobbles and pebbles found at mid-shore. From the dig-overs, no animals were present in the mid and lower shore sieves, however at the upper shore dig location, a single *T. saltator* was found. This would be a species associated with a strand line biotope which would be expected on the high shore. However, no significant strand line features, such as washed up algae and detritus were identified during this survey, possibly as a result of high tides. Freshwater runoff was noted along this section, Plate 7, and again, eroded war time fortifications with scour pools were noted, Plate 8.

Plate 7. Fresh water run off. T3 upper-shore (site ref 277)

Plate 8. Eroded war time coastal fortifications with attached algae and scour pools. T3 mid-shore (site ref 281).

3.1.4 TRANSECT AREA 4 (T4)

T4 was characterised by coarse littoral sand at the upper, mid and low shore points along the full section (LS.LSa.MoSa.Bar.Sa). Eroded war time coastal fortifications with scour pools at the base were present again and it was also noted that an area of coarse sand over hard boulder clay was present, Plate 9. No animals were found in the dig-overs at high and mid shore with a single *L. conchilega* found at low-shore (site reference 301).

Plate 9. Coarse sand over hard boulder clay showing erroded war time coastal fortifications with scour pools in the foregeound. T4 mid-shore (site ref: 306).

3.1.5 TRANSECT AREA 5 (T5)

T5 was characterised by coarse littoral sand at the upper, mid and low shore points along the full section (LS.LSa.MoSa.Bar.Sa). An area of very sparse *L. conchilega* tubes (site ref 312) was observed at this location and again the tubes were observed to be <100 per m^2. No animals were found in the dig-overs and thus a further, more detailed, Phase 2 survey would need to be carried out to determine the possible presence of an LS.LSa.MuSa.Lan biotope.

Table 1. Overview of Features and Biotopes (site references numbered).

Transect Area	Sediment Type			Fauna Present in Dig-over			Assigned Biotope	Other Noteworthy Features
	High	Mid	Low	High	Mid	Low		
1	Coarse sand	Coarse sand with surficial pebbles and cobbles	Coarse sand	None	None	None	LS.LSa.MoSa.Bar.Sa	Fresh water run off (236). Eroded war time coastal fortifications with scour pools, with *Cirripedia spp. M. edulis* and *P. vulgata* plus *Ulva spp*, *Porphyra sp* and *Fucoid spp.* attached (239). Rare casts on lower shore.
2	Coarse sand	Coarse sand with surficial pebbles and cobbles	Coarse sand	None	None	None	LS.LSa.MoSa.Bar.Sa	Eroded war time coastal fortifications with scour pools, 10m wide strip with *Fucoid spp.* present (269-273). Fresh water runoff, Coarse sand below cobbles and boulders (274-275). Sparse *L. conchilega* tubes (250)
3	Coarse sand	Coarse sand with surficial pebbles and cobbles	Coarse sand	1 x *T. saltator* (276)	None	None	LS.LSa.MoSa.Bar.Sa	Eroded war time coastal fortifications with scour pools (281-287, 294-295).
4	Coarse sand	Coarse sand	Coarse sand	None	None	1 x *L. conchilega* (301)	LS.LSa.MoSa.Bar.Sa	Eroded war time coastal fortifications with scour pools along mid-shore (302-305 and 308-309). Coarse sand over hard boulder clay feature with surficial pebbles and cobbles (306-307)
5	Coarse sand	Coarse sand	Coarse sand	None	None	None	LS.LSa.MoSa.Bar.Sa	Sparse *L. conchilega* tubes (312)

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Appendix D: Hornsea Four Offshore Wind Farm Export Cable Corridor, Benthic Ecology Baseline Characterisation Report (GoBe 2020)

Hornsea Project Four: Environmental Statement (ES)

Appendix D of ES Annex 2.1: Export Cable Corridor, Benthic Ecology Baseline Characterisation

Prepared GoBe Consultants Ltd. August 2021
Checked GoBe Consultants Ltd. August 2021
Accepted David King, Orsted. August 2021
Approved Julian Carolan, Orsted. September 2021

Appendix D of A5.2.1
Version A

Executive Summary

An environmental baseline survey of benthic resources was undertaken across the Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four') offshore Export Cable Corridor (ECC), by Benthic Solutions Ltd. (BSL), between the 6th and 15th June 2019. The survey was conducted on behalf of Orsted Hornsea Project Four Limited (hereafter the 'Applicant'). The aim was to acquire biological and physico-chemical data to elucidate any environmental sensitivities, including habitats and species of conservation interest, in order to inform the Environmental Impact Assessment (EIA) for the proposed Hornsea Four development. Methods entailed a combined benthic drop-down video (DDV) and grab survey at 28 target stations (of which grabs were successfully retrieved at 26) along the Hornsea Four offshore ECC. An additional survey to assess for the presence of and extent of any potential Annex I stony reef habitat was also commissioned by the Applicant; this was undertaken by Ocean Ecology Limited (OEL) in January 2020.

Sediment types across Hornsea Four offshore ECC were characterised by three main classes, these were sand, muddy sandy gravel and gravelly muddy sand. While most stations were dominated by sands, a section of the cable route between 11 km and 35 km from the landfall presented relatively high proportions of gravel, silt and clay, typical of a mixed sediment. Total organic carbon (TOC) levels were generally low throughout the offshore ECC reflecting an organically deprived environment, but levels were elevated at stations with larger proportions of silt and clay, as would be expected.

Total hydrocarbon concentrations (THC) were variable across the survey area, with higher levels (exceeding published 95th percentile background concentrations for the southern North Sea) found in a subset of the stations closer to shore, although this was most likely due to land run-off. The Canadian Interim Sediment Quality Guideline (ISQG) limits were mostly marginally exceeded for several Polycyclic Aromatic Hydrocarbons (PAH) analytes at two stations, except for fluoranthene at one of those which also exceeded (albeit relatively marginally) the higher Canadian Probable Effects Level (PEL) threshold. Further analysis revealed the presence of mixed PAH sources of slight petrogenic origin within the survey area.

Metal concentrations were generally low, except for arsenic, which exceeded the Centre for Environment, Fisheries and Aquaculture Science (Cefas) Action Level AL1 at 14 stations. The ISQG level for lead was exceeded at two stations, while that for nickel was very slightly exceeded at one station. The concentrations of both metals and PAHs were found to correlate positively with the proportions of silt and clay within the sediments.

Macrofaunal analyses showed reasonable variation in terms of abundance, richness and species composition, as would be expected given the heterogeneity of the sediment. Taxa belonging to the phylum Annelida dominated the benthic assemblages both in terms of organism abundance and number of taxa. Arthropoda and Mollusca also made significant contributions to total taxa and number of individuals, while echinoderms and other phyla collectively contributed less than 10% to these community attributes.

Community diversity and richness was generally lowest within approximately 18 km of landfall, peaked approximately 18 to 35 km off the coast, but beyond that in the eastern half of the study area these indices were broadly similar. Both the total number of individual organisms and total number of taxa were also found to peak in the coastal zone between 18 km and 35 km from landfall.

Within that portion of the Hornsea Four offshore ECC, the seabed is characterised by mixed sediments that comprise an additional gravel component (as well as significant silt and clay fractions). The greater stability and broader range of ecological niches offered by these mixed substrates are likely to be the main factors driving the elevated univariate indices.

As a result of the heterogeneous nature of the survey area, four habitat types were identified. These conform (to varying degrees) to the Joint Nature Conservation Committee (JNCC) Habitat Classifications (JNCC 2015) and the equivalent European Nature Information System (EUNIS) habitat classification codes (EEA 2017) as follows:

- SS.SSa.IMuSa.FfabMag (A5.242) - *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand;
- SS.SSa.CFiSa.ApriBatPo (A5.252) - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand;
- SS.SMX.CMx.FluHyd (A5.444) - *Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment; and
- SS.SMx.IMx (A5.4) - Infralittoral mixed sediment.

SS.SSa.IMuSa.FfabMag was the most commonly occurring habitat type identified within the Hornsea Four offshore ECC and encompassed 14 of the 26 stations sampled, all of which were located at sampling locations farthest offshore.

No obvious geographical trend was apparent in the total biomass throughout the offshore ECC. Echinodermata were generally found to contribute the greatest proportions to biomass at stations in the eastern half of the Hornsea Four offshore ECC and at two stations at the very western extent, closest to landfall. In the western half of the Hornsea Four offshore ECC, Mollusca most commonly dominated the biomass, although Annelida accounted for greater proportions at a few stations.

DDV and seabed imagery ground-truthing data reflected that of the Particle Size Distribution (PSD) and faunal grab data that indicated a relatively heterogenous benthos along the ECC. Epifauna that were observed included hydroids, bryozoans, anthozoans and echinoderms (both echinoids and asteroids). Free swimming megafauna were limited to demersal teleosts (bony fish) including pleuronectiforms and dragonets.

At two sample locations towards the inshore portion of the offshore ECC, there was question over the presence of potential Annex I stony reef (as defined under the Council Directive 92/43/EEC) due to the patchy nature of the substrate in an area of sandy gravels and boulders. Further survey efforts (OEL 2020) revealed that four discreet patches of stony reef habitat were recorded as present although were scored as 'low' resemblance as per the qualifying criteria set out in regulatory guidance on assessing stony reef habitats (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that *"When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive"*. This suggests that the patches identified during this survey would not be considered as contributing to the National Site Network unless there is strong justification. Based on these results and evidence from geophysical studies across the site (Bibby Hydro Map 2019), the area of 'Sandy gravel with boulders' encompassing stations ECC_22 and ECC_23 is expected to comprise a patchy mosaic of stony substrate surrounded by gravels and coarse sands.

Evidence acquired during the benthic characterisation did not reveal the presence of any other potential Annex I habitats (as defined under the Council Directive 92/43/EEC) or other protected habitats/species within the Hornsea Four offshore ECC. Although individuals of *Sabellaria spinulosa* were identified within the benthic grab samples at five stations, these were not recorded in numbers that would constitute reef (Gubbay 2007) and the only aggregation observed in the DDV footage was a small patch encrusting a pebble that would not itself be classified an Annex I reef. Detailed review of the Side Scan Sonar (SSS) and multi-beam echosounder (MBES) bathymetry datasets acquired within the Hornsea Four offshore ECC by Bibby HydroMap found no evidence of the distinctive signatures which would be typically associated with the presence of biogenic reefs.

No benthic ecology constraints to development have been identified as a result of this characterisation of benthic resources across the Hornsea Four offshore ECC; the potential impacts on the benthos has been subject to a detailed assessment within the Environmental Statement (ES) (**Volume A2, Chapter 2: Benthic and Intertidal Ecology**).

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Glossary

Term	Definition
Annelida	Phylum consisting of ringed or segmented worms, including earthworms, lugworms, ragworms and leeches.
Bathymetry	The depth of water in an ocean, sea or lake.
Benthic ecology	Benthic ecology encompasses the study of the organisms living in and on the sea floor, the interactions between them and impacts on the surrounding environment.
Benthic	"Bottom dwelling", pertaining to the sea or estuary bed
Biotope	A region of habitat associated with a particular ecological community.
Bray-Curtis Similarity	Statistic that compares fauna samples in terms of abundance and number of taxa
Drop Down Video (DDV)	A survey method in which imagery of habitat is collected, used predominantly to survey marine environments.
Environmental Impact Assessment (EIA)	A statutory process by which certain planned projects must be assessed before a formal decision to proceed can be made. It involves the collection and consideration of environmental information, which fulfils the assessment requirements of the EIA Directive and EIA Regulations, including the publication of an Environmental Statement.
Echinodermata	A phylum of marine invertebrates of radial symmetry including starfish, brittle stars, crinoids and sea cucumbers.
EUNiS habitat classification	A pan-European system which facilitates the harmonised description and classification of all types of habitat, through the use of criteria for habitat identification.
Gas Chromatography (GC)	Mainly used in analytical chemistry to separate and analyse compounds that can be vaporised without decomposition.
Geophysical	Relating to the physics of the earth.
Hornsea Project Four Offshore Wind Farm	The term covers all elements of the project (i.e. both the offshore and onshore). Hornsea Four infrastructure will include offshore generating stations (wind turbines), electrical export cables to landfall, and connection to the electricity transmission network. Hereafter referred to as Hornsea Four.
Hydrocarbon	A compound consisting of both Hydrogen and Carbon.
Intertidal	The area of the shoreline which is covered at high tide and uncovered at low tide.
Macro	Large scale.
Magnetometer	A device which measure's magnetism; the direction, strength or relative change of a magnetic field.
Margalef's species richness	A measure of the variety of species present.
Multi-Dimensional Scaling (MDS)	Multi-Dimensional Scaling, a statistical manipulation used to identify groups of distinct fauna (communities).
Megafauna	Large animals of a particular region, habitat or geological period.
Mega-ripples	An extensive undulation of the surface of a sandy beach or seabed, typically tens of meters from crest to crest and tens of centimetres in height.
Mini-hamon grab	Comprises of a stainless-steel box shaped sampling scoop mounted in a triangular frame, ideal for sampling seabed sediment's, as well as sampling for benthic macrofauna.
Mollusca	Phylum of invertebrates which have a soft unsegmented body, commonly protected by a calcareous shell.
Multivariate	Involving two or more variable quantities.

Term	Definition
Orsted Hornsea Project Four Ltd.	The Applicant for the proposed Hornsea Project Four Offshore Wind Farm Development Consent Order (DCO).
Pielou's evenness	A measure of relative abundance of each taxa.
Shannon Wiener diversity	An index (single number) which increases with fauna diversity.
Side Scan Sonar (SSS)	Side-imaging sonar used to create an image of the seafloor.
SIMPER	Multi-variate statistical routine used to examine the species contributions to similarities and differences in community structure between groups
SIMPROF	Statistical technique for determining the significance of clusters of station similarities produced during multi-variate analyses.
Simpson's Index	Another index of fauna diversity, increases with fauna diversity.
Single-beam and multi-beam echosounders (SBES and MBES)	A type of sonar which transmits soundwaves, using the time taken between emission and return to establish a depth. This can be done using singular or multiple beams.
Sub-bottom profiler	Used to identify and measure various marine sediment layers using sound.
Subtidal	The region of shallow waters which are below the level of low tide.
Taxon	A grouping of the fauna, may be a species or, if different species are indistinguishable, it may be based on a higher taxonomic group such as the genus or family.
Topography	The arrangement of natural and artificial physical features of an area.
Total Organic Carbon (TOC)	The total amount of carbon found within an organic compound.
Univariate	The use of one variate or variable quantity.

Acronyms

Acronym	Definition
AFDW	Ash-Free Dry Weight
AL	Action Level
Al	Aluminimum
AQC	Analytical Quality Control
AR	Aqua Regia
As	Arsenic
BAC	Background Assessment Concentration
BC	Background Concentration
BHL	Bibby HydroMap Limited
BIIGLE	Bio-Image Indexing and Graphical Labelling Environment
BSL	Benthic Solutions Limited
CCME	Canadian Council of Ministers for the Environment
Cd	Cadmium
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEMP	Coordinated Environmental Monitoring Programme
CPI	Carbon Preference Index
Cr	Chromium
Cu	Copper
CV	Coefficient of Variation
DBT	Dibenzothiophene
DCM	Dichloromethane

Acronym	Definition
DCO	Development Consent Order
DDV	Drop Down Video
EAC	Environmental Assessment Criteria
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
EQS	Environmental Quality Standards
ES	Environmental Statement
EUNIS	European Nature Information System
FID	Flame Ionisation Detection
FOCI	Feature of Conservation Importance
GC	Gas Chromatography
GCMS	Gas Chromatography–Mass Spectrometry
HC	Hydrocarbon
HCl	Hydrogen Chloride
HD	High Definition
Hg	Mercury
HM	Heavy Metals
ICP-MS	Inductively Coupled Plasma - Mass Spectrometry
ICP-OES	Inductively Coupled Plasma - Optical Emission Spectrometry
IMS	Industrial Methylated Spirit
ISQG	Interim Sediment Quality Guideline
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LAT	Lowest Astronomical Tide
LED	Light-Emitting Diode
Li	Lithium
MBES	Multi-Beam Echosounder
MCZ	Marine Conservation Zone
MDL	Mean Detection Limit
MDS	Multi-Dimensional Scaling
MPA	Marine Protected Area
NERC	Natural Environment and Rural Communities
Ni	Nickel
NMBAQC	National Marine Biological Quality Assurance
NPD	Naphthalene, Phenanthrene and Dibenzothiophene
OEL	Ocean Ecology Limited
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCA	Principle Component Analysis
PCB	Polychlorinated Biphenyl
PEL	Probable Effects Level
PSA	Particle Size Analysis
PSD	Particle Size Distribution
P/B	Petrogenic/Biogenic
Pr/Ph	Pristane/Phytane
QA	Quality Assurance

Acronym	Definition
QC	Quality Control
SAC	Special Area of Conservation
SBES	Single-Beam Echosounder
SBP	Sub-Bottom Profiler
SD	Standard Definition
SIC	Single Ion Current
SIMPER	Similarity Percentage Analysis
SIMPROF	Similarity Profile Analysis
Sn	Tin
SNS	Southern North Sea
SPA	Special Protection Area
SSS	Side Scan Sonar
SSSI	Site of Special Scientific Interest
TBT	Tributylin
TC	Total Carbon
TEL	Threshold Effect Level
THC	Total Hydrocarbon Concentrations
TIC	Total Inorganic Carbon
TOC	Total Organic Carbon
TOM	Total Organic Matter
UCM	Unresolved Complex Mixtures
UKAS	United Kingdom Accreditation Service
UKOOA	United Kingdom Offshore Operators Association
US EPA	United States Environmental Protection Agency
V	Vanadium
WAS	Wilson Auto-Siever
Zn	Zinc

Units

Unit	Definition
g	Gram
km	Kilometre
km^2	Square kilometre
m	Metre
m^2	Square metre
mm	Millimetre
ppm	Parts per million
µg	Microgram

1 Introduction

1.1 Project Background

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter the Applicant) is proposing to develop Hornsea Project Four Offshore Wind Farm (hereafter Hornsea Four). Hornsea Four will be located approximately 69 km offshore the East Riding of Yorkshire in the southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network.

1.1.1.2 This proposed development is now undergoing rigorous environmental and technical assessment prior to making an application for consent. The final consent application requires a supporting Environmental Impact Assessment (EIA) presenting, amongst other issues, detailed appraisals of the potential effects of the construction and operation of the development on benthic habitats and species.

1.1.1.3 Bibby HydroMap Limited (BHL) and Benthic Solutions Limited (BSL) were commissioned by the Applicant to carry out an environmental baseline survey of the Hornsea Four offshore export cable corridor (ECC) for the purposes of collecting physical, chemical and biological data suitable for informing an EIA and development of an Environmental Statement (ES). Ocean Ecology Limited (OEL) were commissioned to undertake an additional potential Annex I habitat assessment survey for stony reef habitat in an area of 'Sandy gravel with boulders' which was identified at an inshore portion of the offshore ECC.

1.1.1.4 This technical appendix has been produced by GoBe Consultants Ltd., to collate and present the data collected across the Hornsea Four offshore ECC in order to provide a comprehensive characterisation of the benthic baseline environment for the Hornsea Four offshore ECC, to inform and support the EIA for benthic ecology.

1.2 Aims and Objectives

1.2.1.1 The overall aim of this technical appendix is to present the biological and physical data acquired across the Hornsea Four offshore ECC to sufficiently describe the habitats and species present and subsequently elucidate any environmental sensitivities that would require extra consideration during the EIA. Focus was placed on identifying any habitats and species of conservation interest including potential Annex I habitats as identified in the EU Habitats Directive.

1.2.1.2 Specific objectives were:

- To provide site characterisation in terms of benthic habitats, surficial sediments, and seabed features;
- To assess presence of potentially sensitive and/or protected habitats and species;
- To assess significance, spatial distribution and extent of contamination; and
- To provide a baseline from which to assess potential impacts from future development.

2 Methodology

2.1 Benthic Baseline Survey Operations

2.1.1.1 The combined benthic drop-down video (DDV) and grab survey of representative habitats across the Hornsea Four offshore ECC was carried out between the 6th and the 15th of June 2019. All survey operations were undertaken by BSL who were supported by BHL on board the MV *Bibby Tethra*.

2.1.1.2 Prior to the benthic survey, geophysical data were acquired along the Hornsea Four offshore ECC using side scan sonar (SSS), multi-beam echosounder (MBES), sub-bottom profiler (SBP) and magnetometer, with the objective of achieving good spatial coverage along the offshore ECC. The results of which are presented in **Appendix E** of **Volume A5, Annex 2.1: Export Cable Corridor Benthic Environmental Baseline Survey** (Bibby HydroMap 2019).

2.1.1.3 An additional DDV survey to assess the presence and extent of potential Annex I stony reef was carried out on 12th January 2020, by OEL on board the *Seren Las*. The fully comprehensive stony reef assessment is presented in **Appendix D8** of **Volume A5, Annex 2.1: Annex I Habitat Assessment Survey 2020**.

2.2 Subtidal Benthic Sampling

2.2.1.1 A total of 28 stations were selected for grab sampling, DDV and still image analysis ground-truthing along the Hornsea Four offshore ECC. Benthic sampling station locations were selected based on interpretation of the geophysical data acquired using SSS and MBES to ensure that stations were representative and had a good coverage of seabed features identified across the offshore ECC.

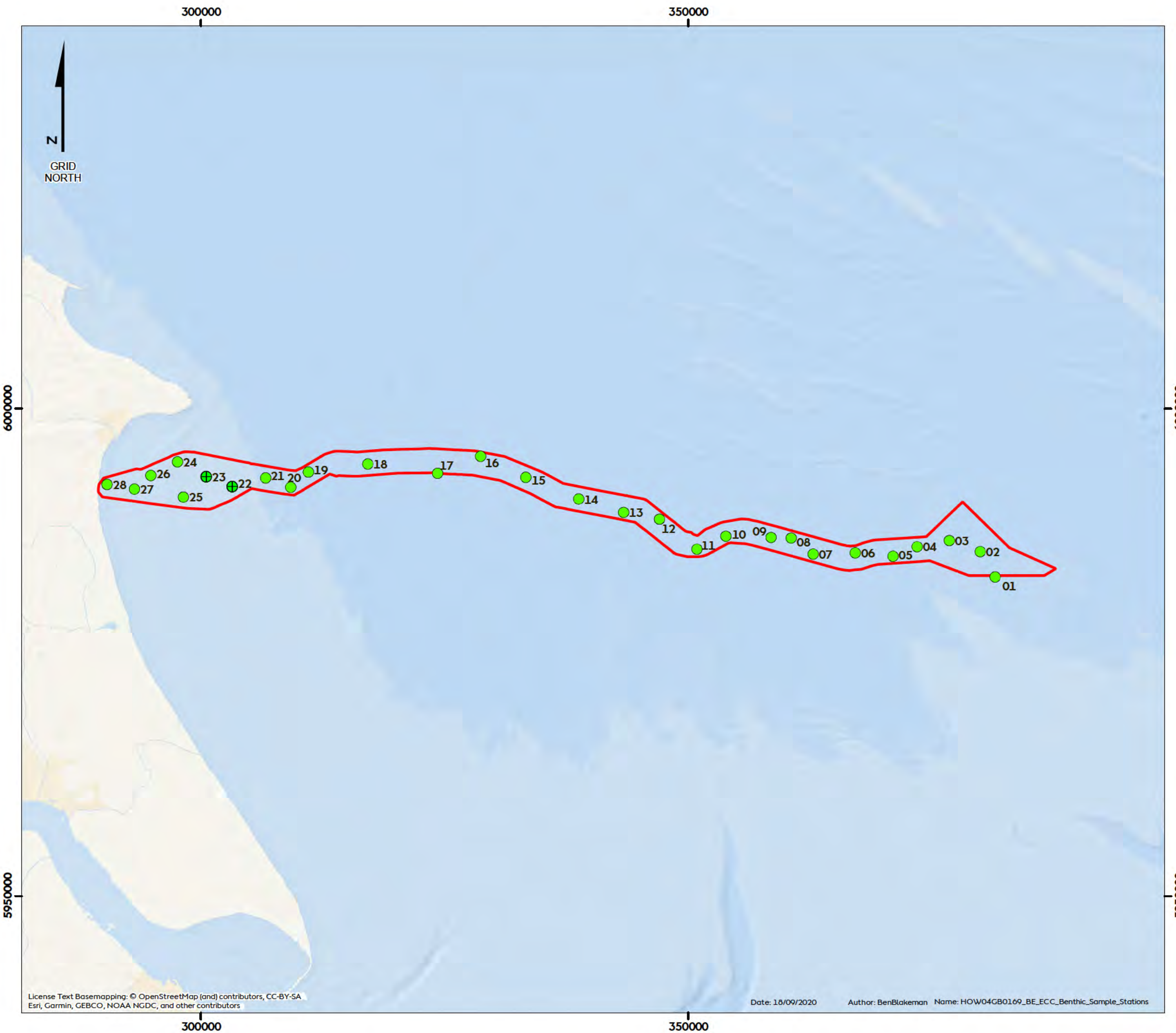
2.2.1.2 **Figure D 1** demonstrates the position of benthic ecology sampling stations across the Hornsea Four offshore ECC. The station coordinates (including the geodetic parameters) and a summary of the data acquired at each sample station are listed in **Appendix D1**. It is important to note that since the survey was undertaken, the ECC has been refined in the fan region where the ECC meets the array area. The locations of all sampling stations were chosen based on the older ECC and as such. one of the sampling stations (ECC_01) is located on the border of the ECC.

2.2.1.3 The additional DDV samples that were collected to assess the presence and extent of potential Annex I stony reef habitat, were undertaken at station ECC_22 and ECC_23. Further details of the extent of this survey are presented in **Section 2.2.5** below.

Hornsea Four

Figure D 1

Location of benthic sample stations within the Hornsea Four Offshore ECC



Order Limit (Export Cable Corridor)

Benthic DDV and Infaunal Grab Station

Additional Annex I Stony Reef Investigation

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Location of benthic sample stations within ECC

Document no: HOW04GB0169

Created by: BPHB

Checked by: AdB

Approved by: LK

GoBe

Ørsted

2.2.2 Macrofauna Grab Sampling

2.2.2.1 Quantitative macrofauna samples were collected by deploying a single 0.1 m^2 mini-Hamon grab sampler at each station. Upon retrieval, each grab was brought on board the survey vessel and subject to quality control. To maintain quality assurance, samples were considered acceptable if:

- Water above sample was undisturbed;
- Bucket closure complete (no sediment washout);
- Penetration of the grab was sufficient to seal;
- Sampler was retrieved perfectly upright;
- Inspection/access doors had closed properly;
- No disruption of sample;
- No contamination in the sample by other sampling equipment;
- Sample was taken inside the acceptable target range (<30 m from intended location);
- Sample size was greater than seven litres (ca. 50% of the sampler's maximum capacity); and
- No hagfish (*Myxine glutinosa*) and/or mucus coagulants were present.

2.2.2.2 Following recovery, the whole sample was inspected, described and photographed prior to processing. Key observations from samples included total sample volume, sediment description, layering (including evidence of redox layer) and conspicuous fauna.

2.2.2.3 Faunal samples were processed onsite using a Wilson Auto-Siever (WAS) over a 1 mm sieve. The residue (≥1 mm) was transferred into a labelled plastic container and preserved in 5% buffered formalin and a vital stain (Rose Bengal). The fauna samples were retained for subsequent faunal extraction and quantitative analysis at the BSL laboratory.

2.2.2.4 Due to the nature of the sediment, benthic grab samples were successfully achieved at 26 of the 28 targeted stations.

2.2.3 Physico-Chemical Sampling

2.2.3.1 Sub-sampling of a second mini-Hamon grab sample at each station was undertaken for physico-chemical analysis of the benthic sediment. The sub-sampling was required for Total Organic Carbon (TOC), Hydrocarbon analysis, Particle Size Analysis (PSA) and Heavy & trace metals analysis.

2.2.3.2 The preservation of materials was undertaken using standard techniques. All physico-chemical samples were stored in appropriate containers (i.e. glass for hydrocarbons, polychlorinated biphenyl (PCBs) and organotins, and plastics for metals, TOC, total organic matter (TOM) and PSA) and immediately frozen and stored.

2.2.4 DDV and Still Image Sampling

2.2.4.1 Ground-truthing using DDV was undertaken at all 28 stations. DDV was acquired using BSL's mini live streaming camera that was mounted onto the mini-Hamon grab sampler (with a Light-Emitting Diode (LED) lamp). A live feed from the camera provided real-time monitoring on the surface whilst a minimum of 10 seconds of both Standard Definition (SD) and High Definition (HD) video footage was also recorded at each sampling station. SD video footage was overlaid with the date, time, position and site details and recorded at the surface, whilst HD video was recorded to a secured digital SD card within the camera for later download. The number of still images obtained at each station is provided in **Appendix D4**. A minimum of four and maximum of 14 still images were obtained at each station (average number of images for each station was seven).

2.2.5 Annex I Habitat Assessment Sampling

2.2.5.1 A detailed cruciform transect survey approach was adopted at each of the potential Annex I target stations (ECC_22 and ECC_23). Seabed imagery was collected along 200 m transects orientated in a cruciform arrangement extending out from the original sampling station in a north, east, south and west direction. When present, the transects were to be extended until the boundary of the potential Annex I habitat was crossed or the edge of the offshore ECC was reached, whichever came first.

2.2.5.2 The full survey methodologies are presented in **Appendix D8** of **Volume A5, Annex 2.1: Annex I Habitat Assessment Survey 2020**.

2.3 Laboratory Analysis

2.3.1 Macrofauna Analysis

2.3.1.1 Macrofauna analysis was carried out at the BSL laboratory, which participates in the National Marine Biological Quality Assurance (NMBAQC) scheme.

2.3.1.2 Faunal samples were thoroughly washed with freshwater on a 1 mm sieve to remove traces of formalin, placed in gridded white trays and subsequently sorted by eye, followed by binocular microscope, to remove all fauna. Sorted organisms were preserved in 70% Industrial Methylated Spirit (IMS) and 5% glycerol.

2.3.1.3 Where possible, all organisms were identified to species level according to appropriate keys for the region. Colonial and encrusting organisms were recorded by presence alone and, where colonies could be identified as a single example, these were also recorded, although these datasets have not been considered in the overall statistical analysis of the material. The presence of anthropogenic components was also recorded where relevant.

2.3.1.4 Following completion of the macrofaunal analysis, all samples were retained for quality assurance (QA) purposes. Each stage of the laboratory analysis process (extraction, identification, enumeration and biomass of benthic fauna) was subject to quality control (QC) and QA for 10% of the samples.

2.3.2 Biomass Determination

2.3.2.1 Biomass determination was undertaken for all macrofaunal specimens identified using the wet blot method and recorded to the nearest 0.001 g. The data was then converted into ash-free dry weight (AFDW) using a phylum specific conversion factor as documented by Riccardi and Bourget (1998). This method down-weights groups such as molluscs which can give unrepresentative biomass values. This data was separated by major phyla.

2.3.3 Particle Size Distribution (PSD)

2.3.3.1 The sediment samples were subject to PSD analysis by BSL which is also accredited under the NMBAQC for PSD analysis. Methods used a combination of dry sieving and laser diffraction and are further detailed in **Appendix D2**.

2.3.3.2 To ensure quality control, all datasets were run through the Mastersizer in triplicate and the variations in sediment distributions assessed to be within the 95% percentile. The separate assessments of the fractions were combined using a computer programme and followed a manual input of the sieve results for fractions 16 mm–8 mm, 8 mm–4 mm and 4 mm–2 mm fractions and the electronic data captured by the Mastersizer below 2000 µm. This method defines the particle size distributions in terms of Phi mean, median, fraction percentages (i.e. coarse sediments, sands and fines), sorting (mixture of sediment sizes) and skewness (weighting of sediment fractions above and below the mean sediment size; Folk 1954).

2.3.4 Organic Matter Content

2.3.4.1 TOC of sediment samples was analysed using an Eltra combustion method (detailed further in **Appendix D2**). The samples were treated with 10% hydrogen chloride (HCl) to remove inorganic carbon (Carbonates) before washing to remove residual acids and further dried. The Carbon Analyser heats the sample in a flow of oxygen and any carbon present is converted to carbon dioxide which is measured by infra-red absorption. The percentage carbon is then calculated with respect to the original sample weight.

2.3.5 Contaminants Analysis

2.3.5.1 All contaminants analysis was carried out by SOCOTEC UK Ltd. Laboratory analyses techniques are presented in **Appendix D2**.

2.4 Data Analyses

2.4.1 Macrofaunal Data

2.4.1.1 In accordance to OSPAR Commission (The Convention for the Protection of the Marine Environment of the North-East Atlantic) (2004) guidelines, all species falling into juvenile, colonial, planktonic of meiofaunal taxa are excluded from the macrofaunal analysis. This processing of the data is intended to reduce variability if subsequent data is collected during different periods within the year for example.

2.4.1.2 Two statistical approaches have been applied during the analysis of the data to describe the spatial variability and composition of the benthic communities (and any correlations relating to abiotic environmental parameters such as depth and sediment character) across the Hornsea Four offshore ECC. All statistical analysis has been carried out using the PRIMER v6 software package (Clarke and Warwick 1994).

2.4.1.3 Simple univariate statistics such as mean number of taxa per sample, mean number of individuals per sample, mean proportion of sediment in each major particle size band, and diversity/equitability indices such as the Shannon Wiener diversity index, Margalef species richness and Pielou's evenness have been calculated and compared for each station.

2.4.1.4 Multivariate methods of data analysis are considered to provide a more sensitive measure of community composition than univariate methods (Clarke and Green 1988), since all the data are analysed collectively with no loss of information such as that which occurs when reducing the data to a single number or univariate statistic. Community analysis techniques incorporating multivariate statistics such as the Bray-Curtis similarity measure (Bray and Curtis 1957), MDS (multi-dimensional scaling), SIMPROF (similarity profile analysis) and SIMPER (similarity percentage analysis) analysis (which calculates species contributions to assemblage similarities/differences), were used to compare community assemblages both in terms of their constituent taxa and relative abundance at each station, as well as within each habitat type that was identified.

2.4.1.5 Prior to multivariate analysis, in order to reduce the influence of very abundant taxa on the analysis, the data set was subjected to a single square root transformation. The faunal data were also compared with sediment particle size distributions, which have been shown to affect the variation in faunal diversity and abundance between sampling stations (Rhoads 1974).

2.4.2 DDV Data

2.4.2.1 All seabed imagery analysis was undertaken in line with Joint Nature Conservation Committee (JNCC) epibiota remote monitoring interpretation guidelines (Turner et al. 2016), to determine the seabed substrata, identify key species and assign biotopes. Where there was any indication of potential Annex I habitat or conservation features, further Annex I habitat assessment was undertaken, as detailed in **Section 2.4.3**.

2.4.3 Potential Annex I Habitat Assessment

2.4.3.1 A full potential Annex I habitat assessment was conducted at two sample locations (ECC_22 and ECC_23), to determine the presence and extent of potential Annex I stony features that had been identified during the DDV characterisation survey. The full methodologies of this assessment are presented in **Appendix D8** of **Volume A5, Annex 2.1: Annex I Habitat Assessment Survey 2020** and summarised below.

2.4.3.2 Potential Annex I habitat assessment images were analysed using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE) annotation platform (Langenkämper et al. 2017). Analysis of still images within BIIGLE was undertaken in two stages: -

- Tier 1 Analysis: consisted of assigning labels that referred to the whole image, providing appropriate metadata for the image. Depending on reef type, this included:
  - Extent: As it is not possible to fully determine the extent of reef habitats from a single image alone this label was used to identify areas that were highly unlikely to constitute reef habitats. An example being an image that showed a large boulder being preceded and succeeded by images of unconsolidated sandy sediments.
  - Biota: Labels assigned to determine whether epifauna dominated the biological community observed.
  - Elevation: Labels assigned depending on reef type. Laser points were used to assist in the assignment of categories.
  - Additional labels of image quality and European Nature Information System (EUNIS) level three broadscale habitat were also assigned to each image.

- Tier 2 Analysis: was used to assign percentage cover of reef types. This was achieved by drawing polygons around instances of key qualifying features (e.g. particles >64 mm) within the image.

2.4.3.3 All images were assigned an Annex I stony reef category of 'not a reef', 'low', and 'medium' (**Table D 1**). These outputs from the BIIGLE analysis were utilised alongside the acoustic information to manually delineate the boundaries of potential Annex I stony reef areas. Confidence scores were therefore assigned to all polygons to give an indication of their accuracy. Values ranged from 1 (no distinct boundaries) to 2 (ground-truth and acoustic information show distinct boundaries). Highest scores were given to areas where both data sources identified obvious presence of potential Annex I stony reef habitat, with distinct boundaries. Lower scores were assigned to areas where the boundaries were not obvious. In these cases, polygons were drawn based upon expert judgement, given the information available.

Table D 1: Characteristics of Potential Annex I 'stony reef' (from Irving (2009)).

Characteristic	Not a Reef	Low	Medium	High
Composition (proportion of boulders/cobbles (>64 mm))	10%	10-40% matrix supported	40-95%	>95% clast-supported
Elevation	Flat seabed	<64 mm	64 mm - 5 m	>5 m
Extent	<25 m^2	>25 m^2		
Biota	Dominated by infaunal species			>80% of species present composed of epibiotal species

3 Results

3.1 Survey Bathymetry and Seabed Features

3.1.1.1 Seabed levels across the inshore section of the ECC were found to range from a minimum of approximately 2.4 m below Lowest Astronomical Tides (LAT) to a maximum of 15.4 m below LAT. Seabed levels across the offshore section of the ECC ranged from a minimum of approximately 10.6 m below LAT at the nearshore extents of the area (297492 mE, 5991536 mN), to a maximum of >51.0 m below LAT at several points within a broad channel feature, centred at approximately 327105 mE, 5994470 mN.

3.1.1.2 Seabed sediments were interpreted to comprise a veneer of gravelly sands overlying glacial till and relic mega-ripples up to 0.5 m high at the inshore extent of the offshore ECC. The inshore section of the Hornsea Four offshore ECC also encompassed a boulder field with densities ranging from 0.9 to 1.8 boulders per 100 m^2. Maximum boulder sizes were approximately 3.0 x 1.8 x 0.5 m (L x W x H) (a number of anchor scars were also observed in this area).

3.1.1.3 To the east the seabed was more mobile with mega-ripples up to 0.5 m high, oriented ENE-WSW or NE-SW with wavelengths of 1.5 – 25 m. Some seabed scars were also noted along the central portion of the offshore ECC.

3.1.1.4 The full geophysical results are presented in **Appendix B** and **Appendix E** of **Volume A5, Annex 2.1: Export Cable Corridor Benthic Environmental Baseline Survey** (Bibby HydroMap 2019). The seabed features identified during the geophysical survey campaigns are presented in **Figure D 18**.

3.2 Particle Size Distribution (PSD)

3.2.1.1 The detailed PSD data (expressed as percentage distribution by weight) of the surface sediments from the 26 stations along the Hornsea Four offshore ECC are presented in **Appendix D3** (descriptions of the relevant parameters and analysis techniques are provided in **Appendix D2**). These data have been summarised in **Table D 2** and include the percentage composition of the silt and clay (<0.063 mm), sand (0.063 mm to <2 mm) and gravel (≥ 2 mm) at each station.

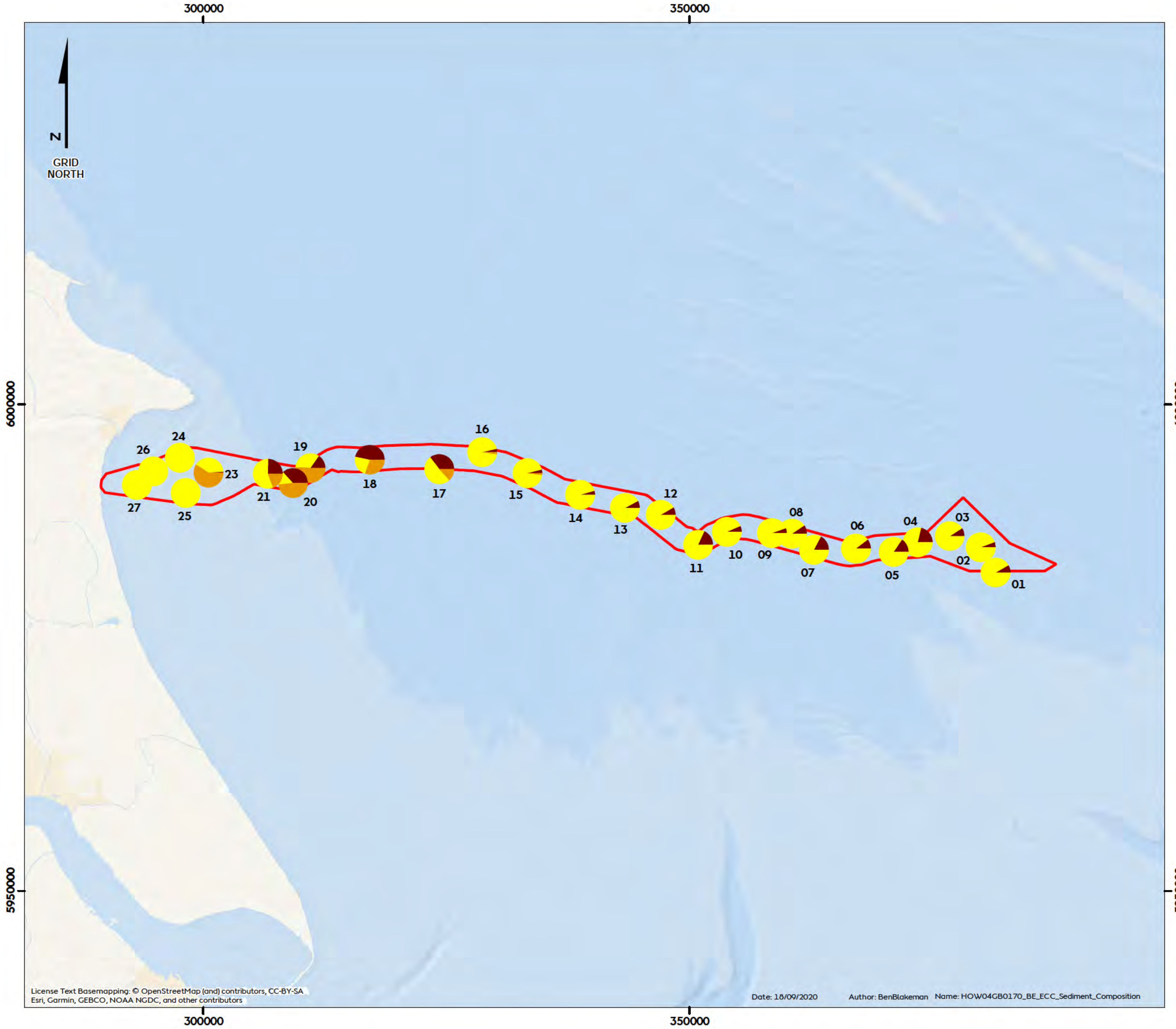
Table D 2: Summary of surface PSD.

Station	Mean mm	Mean Phi (Φ)	Sorting	Skew-ness	Kurtosis	Silt & Clay (%)	Sands (%)	Gravel (%)	Folk Classification
ECC_01	0.19	2.38	1.04	0.34	2.42	8.31	91.62	0.07	Sand
ECC_02	0.21	2.23	1.02	0.18	1.76	5.8	94.05	0.15	Sand
ECC_03	0.17	2.54	0.95	0.36	2.6	8.83	91.09	0.09	Sand
ECC_04	0.09	3.52	1.84	0.68	2.3	21.38	78.51	0.11	Muddy sand
ECC_05	0.15	2.71	1.2	0.47	2.99	15.48	84.44	0.09	Muddy sand
ECC_06	0.16	2.66	1.02	0.39	2.8	10.43	89.39	0.18	Muddy sand
ECC_07	0.1	3.28	1.65	0.68	2.86	17.36	82.55	0.09	Muddy sand
ECC_08	0.17	2.59	0.98	0.37	2.69	9.34	90.49	0.17	Sand
ECC_09	0.18	2.49	0.82	0.26	1.88	5.41	94.33	0.26	Sand
ECC_10	0.17	2.53	0.82	0.29	2.27	6.51	93.35	0.14	Sand
ECC_11	0.1	3.29	1.69	0.66	2.51	18.19	81.68	0.13	Muddy Sand
ECC_12	0.2	2.36	1	0.3	2.41	8.33	91.03	0.64	Sand
ECC_13	0.19	2.36	0.94	0.33	2.34	7.86	92.03	0.11	Sand
ECC_14	0.25	2	0.67	0.07	1.13	4.37	95.17	0.46	Sand
ECC_15	0.28	1.82	0.96	-0.08	1.25	4.18	93.77	2.06	Slightly gravelly sand
ECC_16	0.29	1.8	0.98	-0.15	1.33	3.63	94.08	2.29	Slightly gravelly sand
ECC_17	0.13	2.94	3.58	0.17	0.7	35.43	51.31	13.26	Gravelly muddy sand
ECC_18	0.14	2.82	4.44	-0.01	0.6	46.91	23.02	30.08	Muddy gravel
ECC_19	1.72	-0.78	4.17	0.27	0.81	15.36	33.67	50.97	Muddy Sandy Gravel
ECC_20	0.46	1.11	4.48	0.57	0.55	36.75	14.82	48.44	Muddy gravel
ECC_21	0.26	1.93	3.56	0.08	1.22	24.83	55.87	19.3	Gravelly Muddy Sand
ECC_23*	3.09	-1.63	2.63	0.37	0.6	1.07	39.86	59.07	Sandy Gravel
ECC_24	0.21	2.25	0.56	0	0.94	0	99.96	0.04	Sand
ECC_25	0.28	1.85	0.84	-0.07	0.95	0	99.72	0.28	Sand
ECC_26	0.19	2.38	0.54	0	0.98	0	99.92	0.08	Sand

Station	Mean mm	Mean Phi (Φ)	Sorting	Skew-ness	Kurtosis	Silt & Clay (%)	Sands (%)	Gravel (%)	Folk Classification
ECC_27	0.19	2.36	0.49	0.01	0.99	0	99.86	0.14	Sand
Mean	*0.37*	*2.15*	*1.65*	*0.25*	*1.69*	*12.14*	*79.06*	*8.8*	-

3.2.1.2 According to the Folk scale (Folk 1954), the dominant sediment types across the Hornsea Four offshore ECC was 'muddy sand' and 'sand', with sediment characteristics from 18 out of the 26 stations being accurately described by one of these two categories.

3.2.1.3 **Figure D 2** shows how the relative proportions of silt and clay, sand and gravel in surface sediments vary spatially across the offshore ECC. Sediments closest to landfall were comprised almost entirely of sand, while those between 10 km and 30 km offshore were more mixed with varying additional proportions of silt and clay (15 – 46%) and gravel (13 – 50%). Beyond 30 km from the shore the sand fractions become dominant again with sediments comprising almost no gravel fraction and generally proportions of silt and clay less than 10%, although silt and clay accounted for 18% and 21% of the sample volume at stations ECC_11 and ECC_4 respectively.



Hornsea Four

Figure D 2

Relative proportions of silt and clay, sand and gravel across Hornsea Four Offshore ECC

Order Limit (Export Cable Corridor)

Sediment composition (%)

- Silt and Clay
- Sands
- Gravel

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Proportions of silt and clay, sand and gravel

Document no: HOW04GB0170

Created by: BPHB

Checked by: AdB

Approved by: LK

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3.2.2 Multivariate Statistical Analysis of PSD Data

3.2.2.1 The PSD results presented above provide an overview of the sediment character across the offshore ECC. More detailed analysis of the PSD data has been carried out using multivariate analysis techniques within the PRIMER v6 software package (Clarke and Warwick 1994).

3.2.2.2 The dendrogram in Figure D 3 is based upon Euclidean distances and illustrates the similarities and differences in sediment character between stations. The significance of the groupings has been determined using the SIMPROF (Similarity Profile Analysis) routine, the results of which are represented using red lines that indicate statistically similar stations and black lines that indicate significant differences.

3.2.2.3 A Euclidean distance of 5.5 was applied to the SIMPROF analysis in order to prevent over-differentiation of the data set and to group the sediment particle size at a level relevant to the baseline survey objectives. This manipulation of the data resulted in the identification of three main sediment groups or 'clusters' as labelled '1' to '3' in Figure D 3.

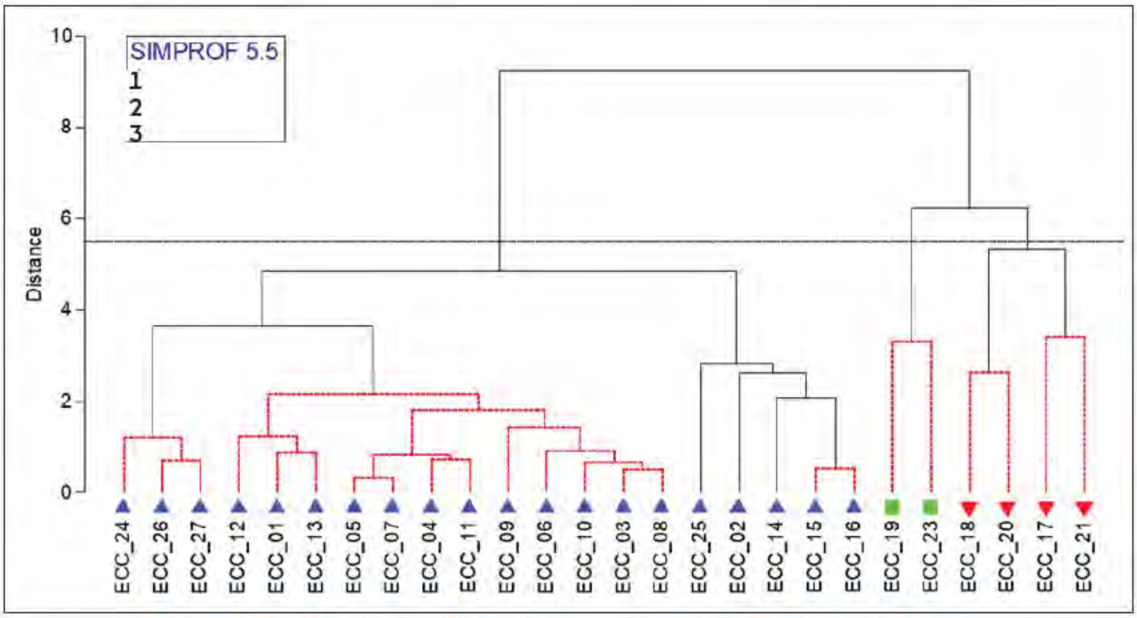
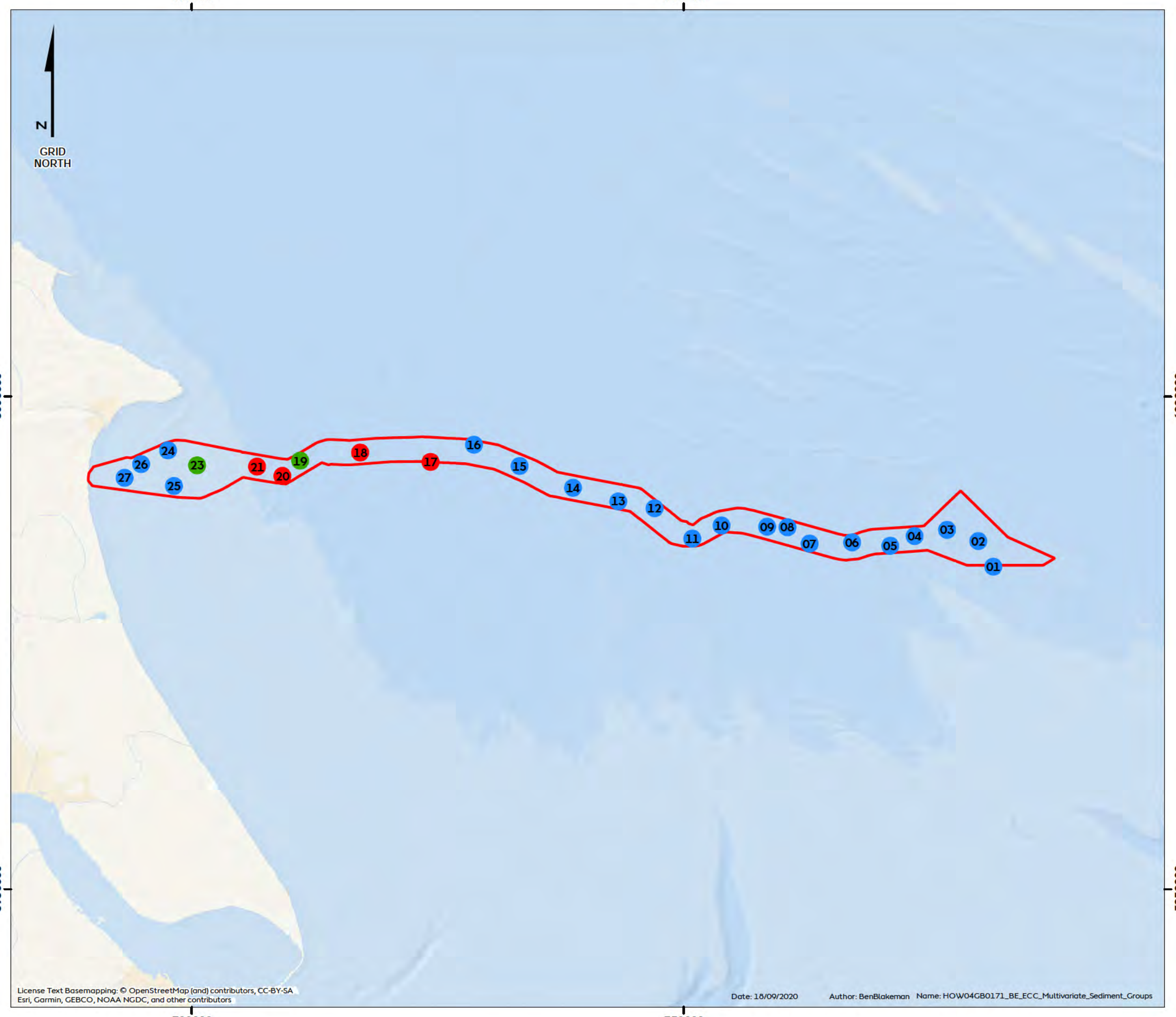


Figure D 3: PSD similarity dendrogram based on Euclidean distance.

3.2.2.4 Group 1 includes 20 of the 26 stations and comprises sediments characterised by large proportions of sand (78.1% to 99.86%). Group 2 consists of two stations which are set apart by their large gravel components (50.97% to 59.07%). Group 3 represents mixed sediments that are not dominated by either fine or coarse sediments. The mean proportions of silt and clay, sand and gravel analysed within each group are outlined in Table D 3 together with the Folk scale classifications that were captured within each group. Figure D 4 represents the spatial distribution of sediment groups.

Table D 3: Mean proportions of silt and clay, sand and gravel within each of the sediment groups identified using multivariate analysis techniques.

Sediment Group	Mean % Silt & Clay	Mean % Sand	Mean % Gravel	Folk Scale Classifications
Group 1	7.8	91.9	0.4	Sand (S)
Group 2	8.2	36.8	55.0	muddy sandy Gravel (msG)
Group 3	36.0	36.3	27.8	gravelly muddy Sand (gmS)



Hornsea Four

Figure D 4

Sediment groups identified from the PSD data obtained across the Hornsea Four Offshore ECC, using multivariate techniques

Order Limit (Export Cable Corridor)

Multivariate Sediment Group

1

2

3

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Multivariate Sediment Groups
Document no: HOW04GB0171
Created by: BPHB
Checked by: AdB
Approved by: LK

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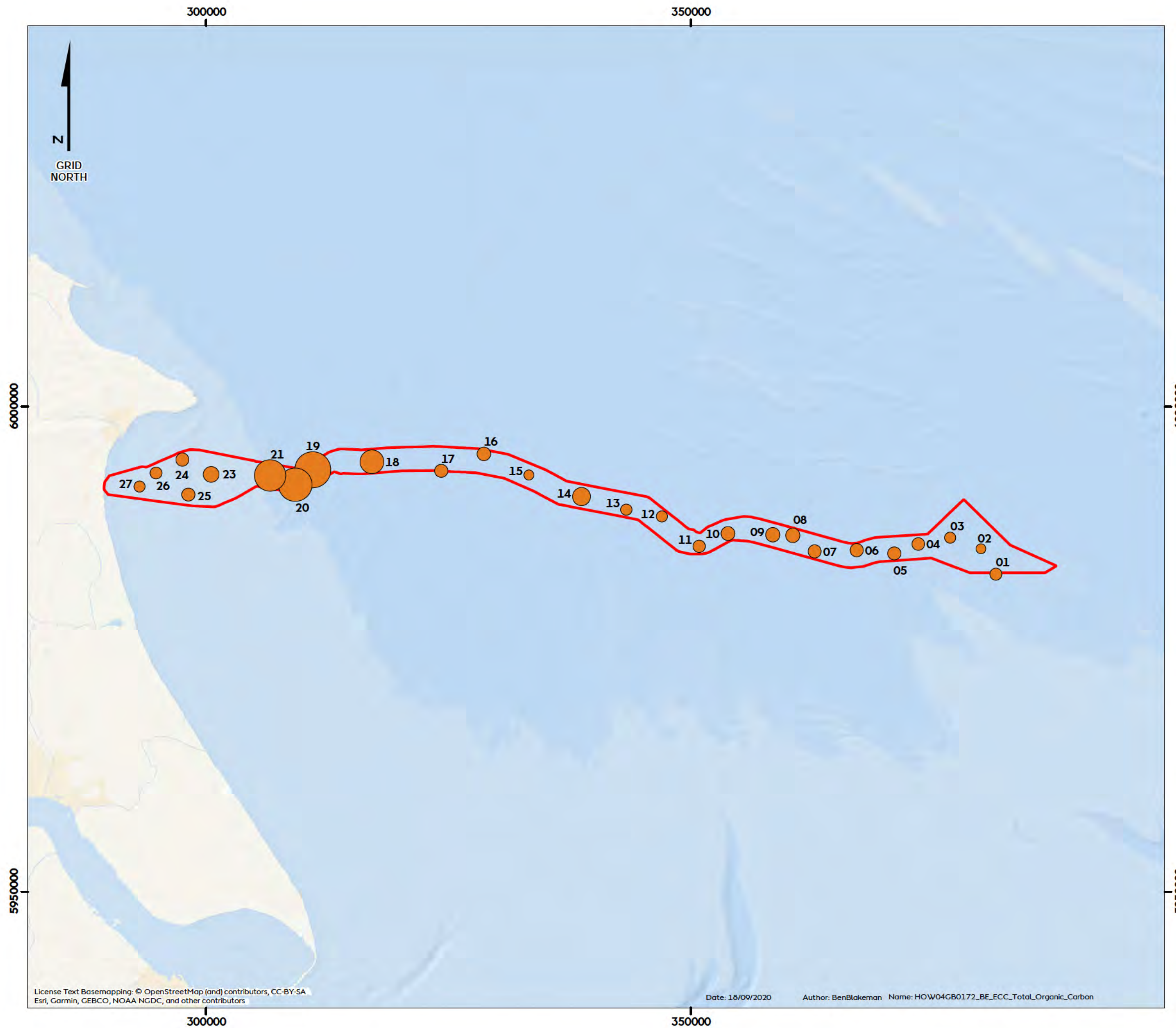
3.3 Total Organic Carbon (TOC)

3.3.1.1 Terrestrially derived carbon from run-off and fluvial systems, combined with primary production from sources such as phytoplankton blooms, contribute to the TOC levels recorded in marine sediments. TOC represents the proportion of organic detritus present. Organic detritus is metabolised by heterotrophic bacteria but is also consumed directly by a wide range of marine invertebrates (UK MPA 2001), it is therefore an important source of food for benthic fauna (Snelgrove and Butman 1994). Although unlikely in open coast environment such as the offshore ECC, an over-abundance of TOC (also termed organic enrichment) may lead to community changes and a reduction in diversity by favouring detritivore groups or those tolerant of low oxygen levels (as increased oxygen demand can be brought about by elevated bacterial respiration).

3.3.1.2 The results of the sediment TOC at the 26 stations sampled are presented in **Table D 4**. TOC levels were low (ranging between 0.09% at ECC_02 and 1.12% at ECC_19) and reflect an organically deprived environment throughout the offshore ECC. **Figure D 5** presents the results in a geographical context within the offshore ECC. When comparing this figure with the PSD data (**Figure D 4**), it can be seen that the higher TOC values generally corresponded to those stations with greater proportions of silt and clay (although these stations also had the greatest proportions of gravel). As would be expected the lower concentrations were generally found at stations dominated by sand. This relationship has been demonstrated using the RELATE routine which explored the correlation of TOC with the proportion of sand, the results show a reasonably strong (negative) Spearman's Rank correlation between these two sediment parameters of 0.532, which is significant (0.2%).

Table D 4: TOC recorded at stations across the Hornsea Four offshore ECC.

Station	Total Organic Carbon (% wet weight)	Station	Total Organic Carbon (% wet weight)
ECC_01	0.13	ECC_15	0.09
ECC_02	0.09	ECC_16	0.17
ECC_03	0.12	ECC_17	0.15
ECC_04	0.14	ECC_18	0.49
ECC_05	0.16	ECC_19	1.12
ECC_06	0.15	ECC_20	0.96
ECC_07	0.16	ECC_21	0.88
ECC_08	0.18	ECC_23	0.22
ECC_09	0.18	ECC_24	0.15
ECC_10	0.17	ECC_25	0.16
ECC_11	0.14	ECC_26	0.13
ECC_12	0.11	ECC_27	0.12
ECC_13	0.11	*Mean*	*0.26*
ECC_14	0.29		



Hornsea Four

Figure D 5

TOC recorded from stations across the Hornsea Four Offshore ECC (% wet weight)

Order Limit (Export Cable Corridor)

Total Organic Carbon (% w/w)

- 0.1
- 0.5
- 1

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Total Organic Carbon
Document no: HOW04GB0172
Created by: BPHB
Checked by: AdB
Approved by: LK

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3.4 Macrofauna

3.4.1.1 As mentioned above, quantitative macrofaunal samples were successfully collected at 26 stations. Failed attempts to achieve representative samples at two stations was caused by the presence of cobbles/boulders at ECC_22, and a sub-surface layer of highly compacted clay at station ECC_28 (sample log sheets are provided in Appendix D4).

3.4.1.2 The results of the macrofaunal analysis, including the numerical abundance of each taxon by station, are presented in Appendix D5. A total of 259 taxa and 2813 individuals were recorded throughout the offshore ECC, with a mean number of 26 taxa and 108 individuals per station. Collectively, the faunal assemblages were comprised of 102 Annelida species, 51 Arthropoda, 40 Mollusca, 12 Echinodermata, whilst all other phyla accounted for the remaining seven taxa or 2% of individuals. Colonial epifauna (which were not quantified) were represented by 47 taxa.

3.4.1.3 The relative contribution of the main phyla to the macrofaunal assemblages throughout the Hornsea Four offshore ECC are presented in Figure D 6. The figure shows that taxa belonging to the phylum Annelida dominate the benthic assemblages both in terms of organism abundance and number of taxa. Arthropoda account for approximately 25% of the total taxa and number of individuals, while Mollusca account for 19% of each. Echinoderms and miscellaneous phyla collectively contribute less than 10% to these community attributes.

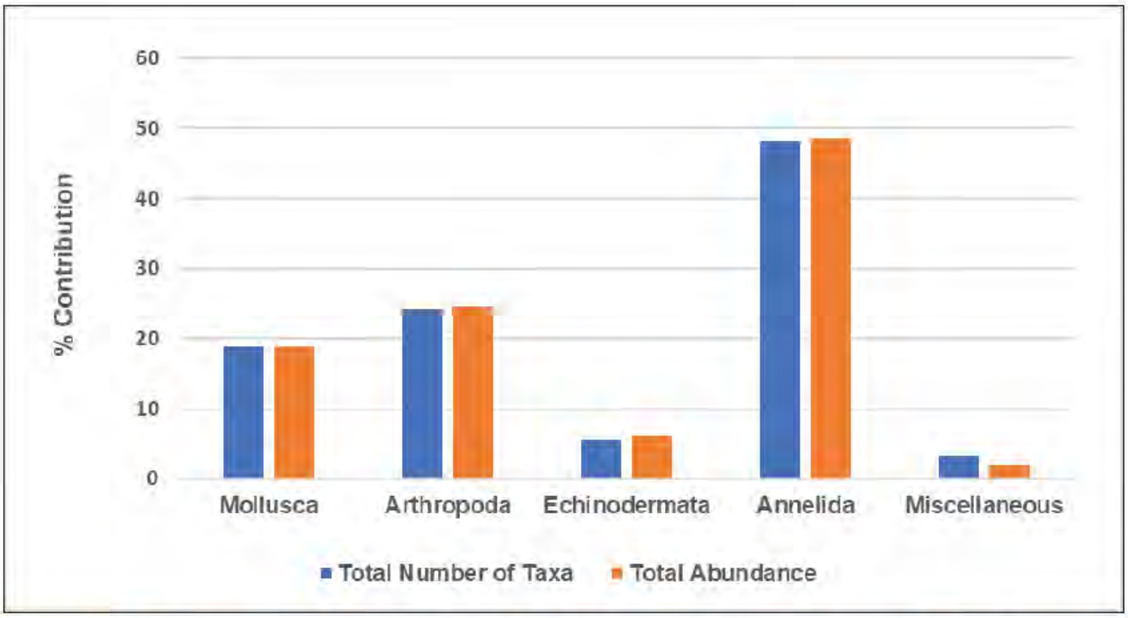

Figure D 6: The percentage contribution of the main phyla to total number of taxa and total abundance.

3.4.1.4 The contribution of top ten taxa to the overall abundance is illustrated in Figure D 7. The highest contributing taxa was the polychaete *Sabellaria spinulosa*. Despite the proportionally high contribution to abundance, examination of the data shows that the species was found at just six stations (ECC_17, 18, 19, 20, 21 and 23) in numbers of between 18 and 109 individuals, and notably, did not constitute any reef habitat (Gubbay 2007).

3.4.1.5 The second and third highest contributing taxa to abundance were the barnacles *Balanus crenatus* and *Verruca stroemia*. Again, either one or both species were found at just five stations (ECC_9, 17, 20, 21 and 23) but in relatively high abundance. Their presence reflects the coarser sediments at those stations which provide comparatively stable substrate for these sessile organisms to attach to.

3.4.1.6 Figure D 8 illustrates the taxa that were recorded at the highest proportion of sample stations. The polychaete *Spiophanes bombyx* which is ubiquitous in clean sand around the UK coast occurred most frequently, being recorded at 69% of stations. The polychaete *Magelona johnstoni and* bivalve *Fabulina fabula* followed in close succession being present at 58% of stations. The absence of *S. spinulosa*, *B. crenatus* and *V. stroemia* illustrates that these species were not frequently occurring across stations (despite the dominance of these species in terms of their abundance).

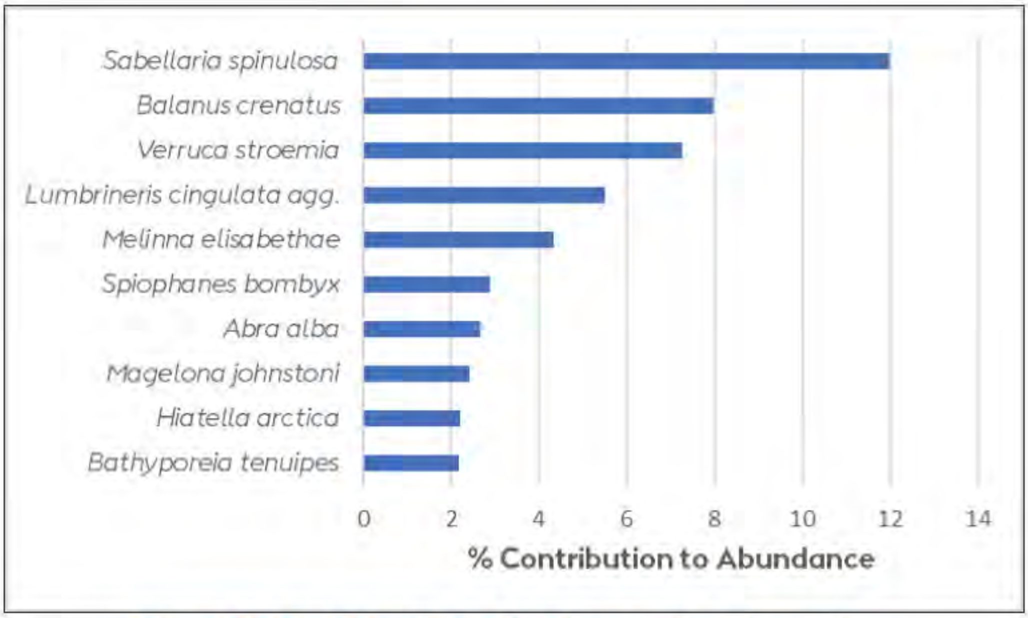

Figure D 7: The 10 most abundant taxa captured in samples.

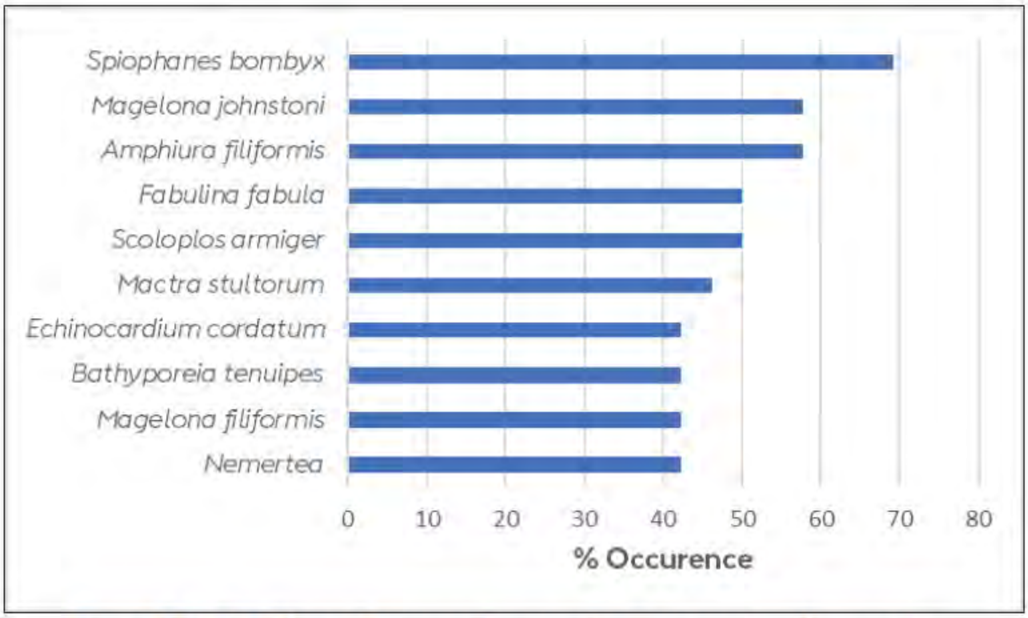

Figure D 8: The 10 most commonly occurring taxa captured in samples.

3.4.2 Univariate Analysis

3.4.2.1 The univariate statistics that have been derived from faunal abundance data are summarised in **Table D 5**. The summary statistics for the Shannon Wiener diversity index, Margalef's species richness, the total number of taxa per station and total number of individuals are also shown spatially as proportional or graduated bubble plots in **Figure D 9** to **Figure D 12**.

3.4.2.2 The data and plots show that all the univariate indices were generally lowest within approximately 18 km of landfall. Taxonomic diversity peaked at station ECC_17, which is situated 20 km off the coast, but beyond that to the east of the Hornsea Four offshore ECC, diversity was broadly similar. Taxonomic richness showed a similar spatial pattern to diversity, although the elevated richness indices were more pronounced and were derived from a greater number of stations (situated between 18 km and 35 km from the coast). Both the total number of individual organisms and total number of taxa were also found to peak in the coastal zone between 18 km and 35 km from landfall.

3.4.2.3 Within that portion of the Hornsea Four offshore ECC (18 km and 35 km from landfall) the seabed is characterised by mixed sediments that comprise an additional gravel component (as well as significant silt and clay fractions) (**Figure D 2**). The greater stability and broader range of ecological niches offered by these mixed substrates are likely to be the main factors driving the elevated univariate indices. The higher numbers of individual organisms are partly driven by the high abundance of polychaetes including *Sabellaria spinulosa* and *Melinna elisabethae*, as well as Lumbrineridae polychaetes, at some sample locations.

Table D 5: Univariate faunal statistics.

Station	Total Number of Taxa: S	Total Number of Individuals: N	Margalef's Species Richness: d	Pielou's Evenness: J'	Shannon Weiner Index: H'(loge)	Simpson Diversity Index: 1-Lambada
ECC_01	25	54	6.02	0.86	2.77	0.92
ECC_02	24	55	5.74	0.89	2.84	0.94
ECC_03	21	27	6.07	0.97	2.97	0.98
ECC_04	14	21	4.27	0.96	2.53	0.96
ECC_05	14	23	4.15	0.96	2.52	0.95
ECC_06	24	52	5.82	0.94	2.99	0.96
ECC_07	10	14	3.41	0.96	2.21	0.95
ECC_08	21	72	4.68	0.89	2.70	0.93
ECC_09	21	91	4.43	0.71	2.17	0.78
ECC_10	18	45	4.47	0.92	2.66	0.93
ECC_11	13	43	3.19	0.85	2.18	0.87
ECC_12	21	60	4.88	0.86	2.62	0.91
ECC_13	18	46	4.44	0.91	2.63	0.93
ECC_14	26	94	5.50	0.85	2.76	0.92
ECC_15	15	55	3.49	0.75	2.04	0.78
ECC_16	24	55	5.74	0.91	2.89	0.94
ECC_17	74	252	13.20	0.85	3.67	0.96
ECC_18	57	242	10.20	0.64	2.60	0.78
ECC_19	35	111	7.22	0.80	2.83	0.90
ECC_20	80	602	12.34	0.73	3.21	0.92

Station	Total Number of Taxa: S	Total Number of Individuals: N	Margalef's Species Richness: d	Pielou's Evenness: J'	Shannon Weiner Index: H'(loge)	Simpson Diversity Index: 1-Lambada
ECC_21	55	405	8.99	0.69	2.75	0.86
ECC_23	30	303	5.08	0.50	1.70	0.63
ECC_24	10	34	2.55	0.70	1.61	0.68
ECC_25	7	15	2.22	0.88	1.71	0.83
ECC_26	8	14	2.65	0.92	1.91	0.89
ECC_27	14	28	3.90	0.91	2.39	0.92

Hornsea Four

Figure D 9

Spatial variability of taxonomic diversity in samples obtained across the Hornsea Four Offshore ECC

Order Limit (Export Cable Corridor)

Diversity

Shannon index (H')

- 0.00
- 0.01 - 2.21
- 2.22 - 2.70
- 2.71 - 2.99
- 3.00 - 3.67

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
----	First Issue	21/09/2020

Taxonomic Diversity in samples

Document no: HOW04GB0173

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Approved by: LK

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Hornsea Four

Figure D 10

Spatial variability of taxonomic richness in samples obtained across the Hornsea Four Offshore ECC

Order Limit (Export Cable Corridor)

Richness

d

- 0.00 - 2.65
- 2.66 - 4.88
- 4.89 - 7.22
- 7.23 - 13.20

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Taxonomic Richness in samples

Document no: HOW04GB0174

Created by: BPHB

Checked by: AdB

Approved by: LK

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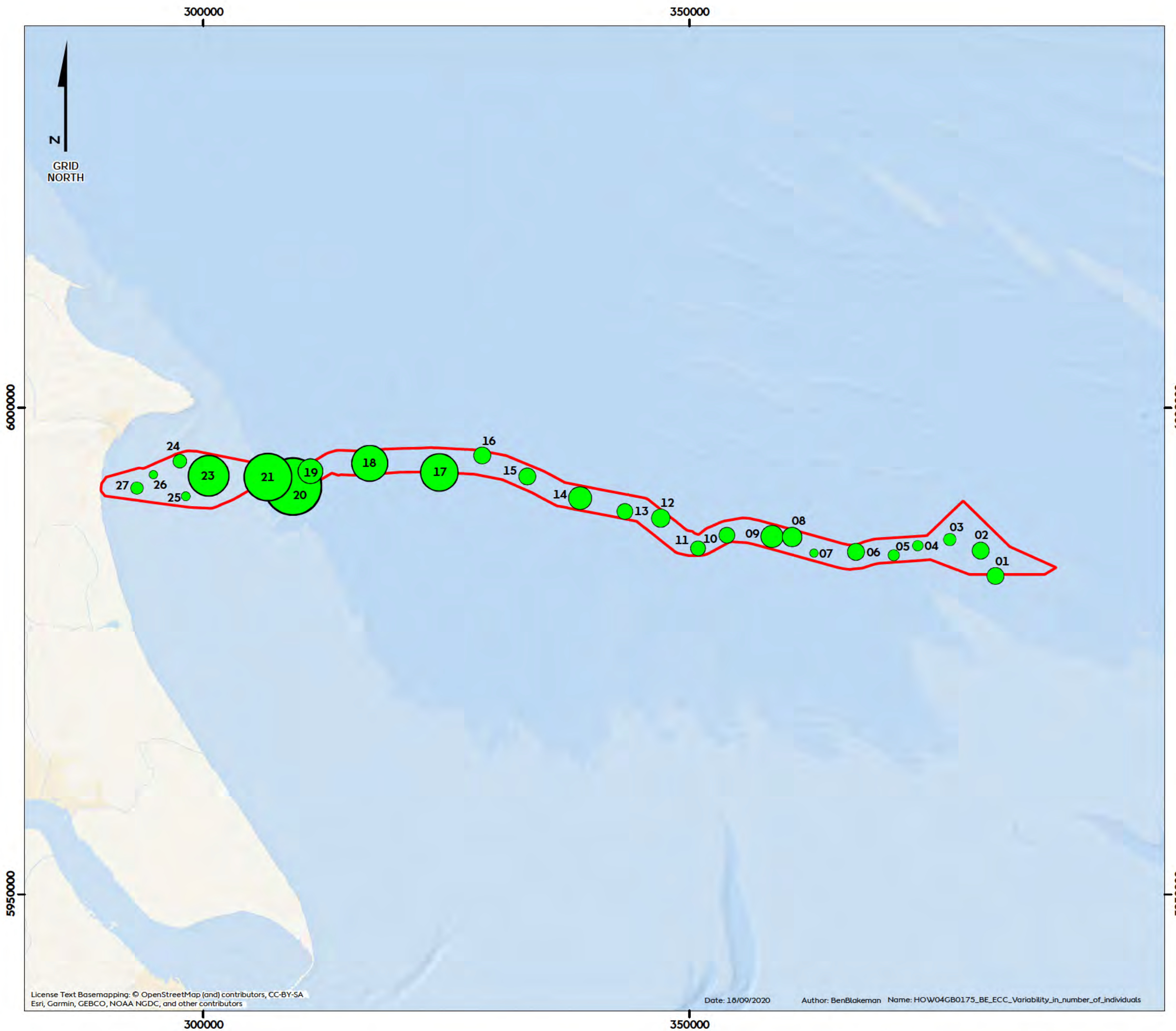

Hornsea Four

Figure D 11

Spatial variability in total number of individuals sampled across the Hornsea Four Offshore ECC

Order Limit (Export Cable Corridor)

Total no. Individuals
N

- 10
- 100
- 1000

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Spatial variability in total number of individuals
Document no: HOW04GB0175
Created by: BPHB
Checked by: AdB
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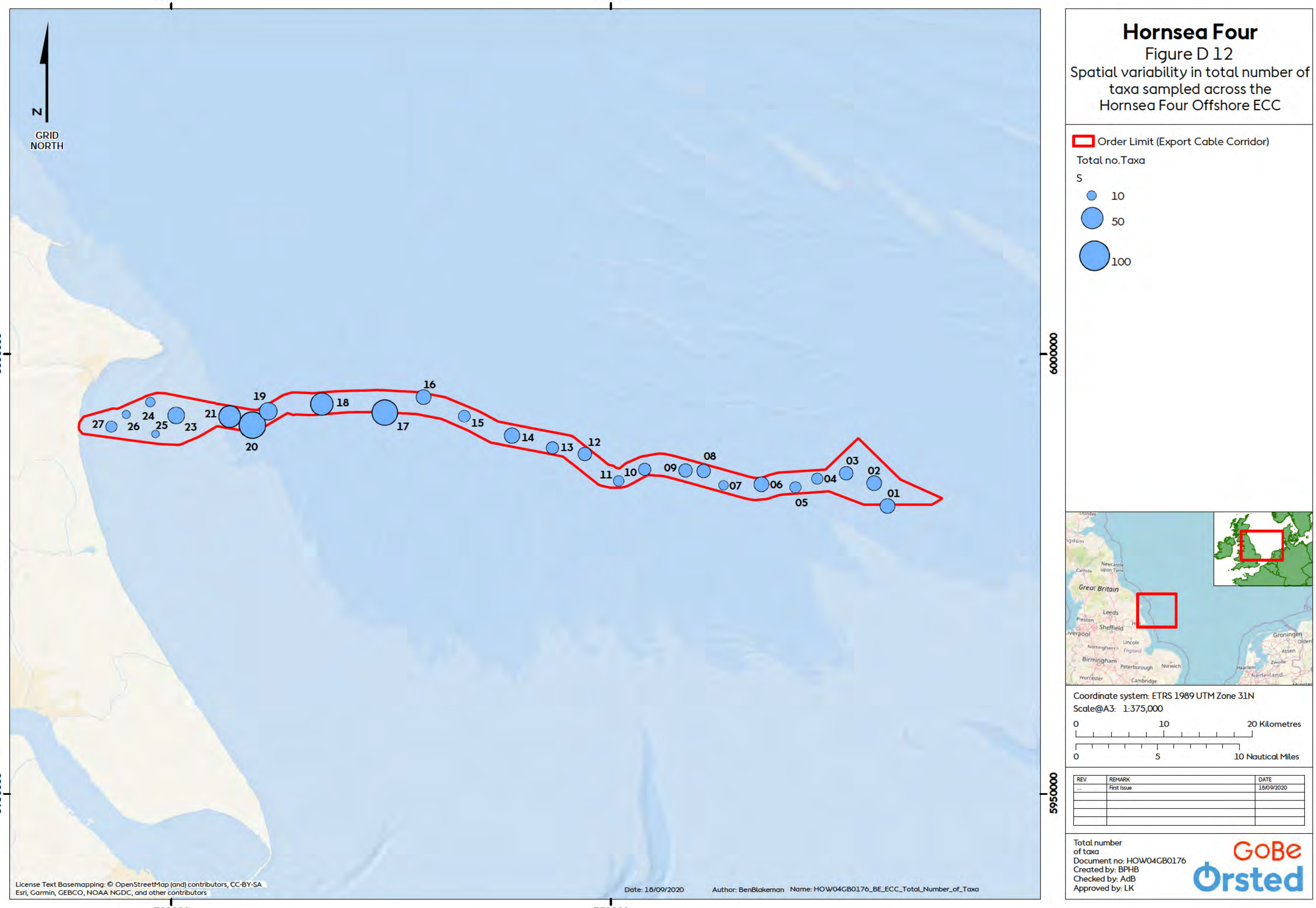

Hornsea Four

Figure D 12

Spatial variability in total number of taxa sampled across the Hornsea Four Offshore ECC

REV	REMARK	DATE
...	First Issue	18/09/2020

Total number of taxa
Document no: HOW04GB0176
Created by: BPHB
Checked by: AdB
Approved by: LK

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3.4.3 Multivariate Analysis

3.4.3.1 SIMPER analysis determined 20.6% similarity between all stations. A group average sorting dendrogram based on the benthic faunal abundance data has been derived from a Bray-Curtis similarity matrix (Figure D 13). The SIMPROF routine has identified 6 statistically different faunal groups as numbered "1" to "6" in the plot.

3.4.3.2 An MDS plot has been subsequently produced to illustrate the community similarities where the distance between the points is proportional to the similarity in community structure. The resulting MDS plot is shown in Figure D 14.

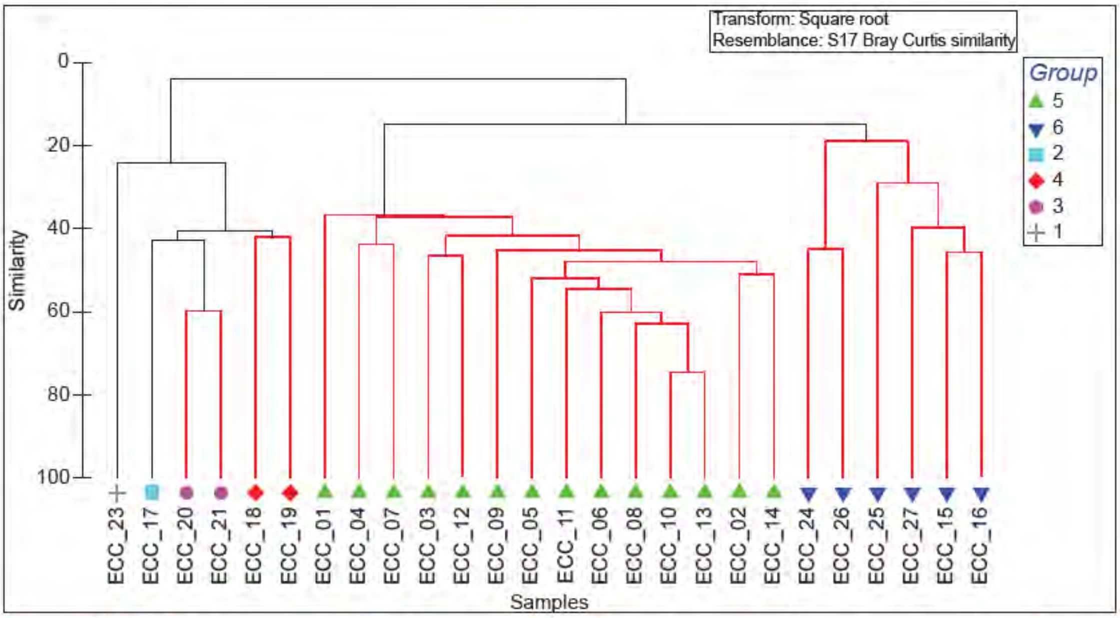


Figure D 13: Group average dendrogram of benthic community data, based on Bray-Curtis Similarity.

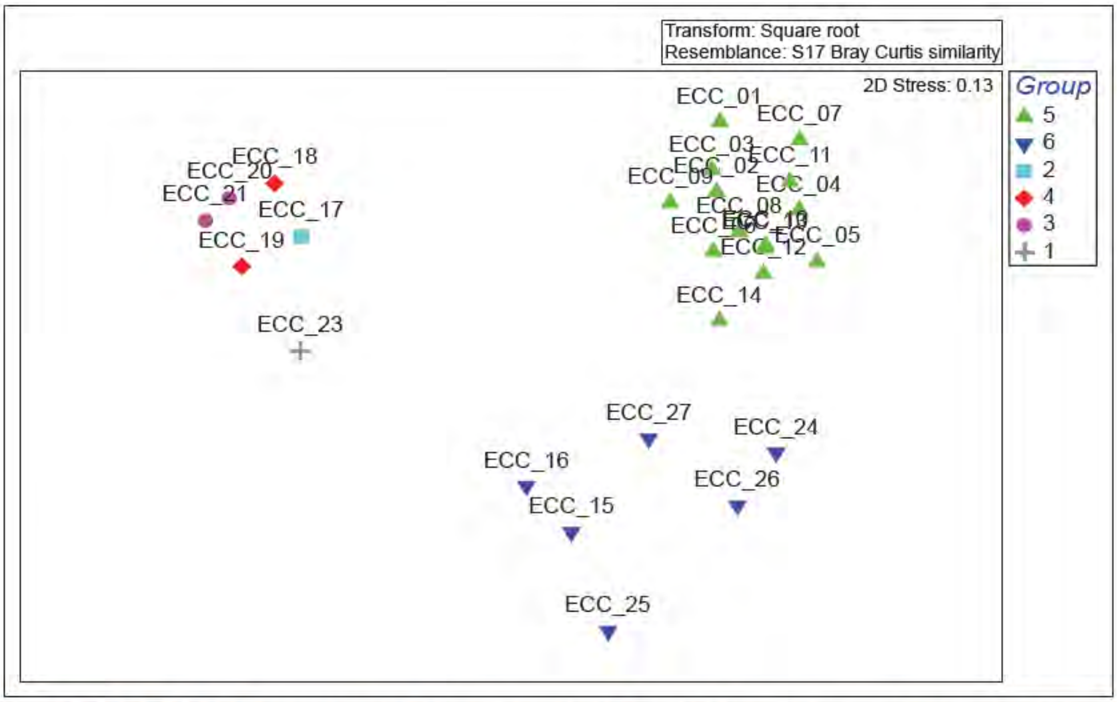


Figure D 14: MDS plot representing the similarities in benthic fauna between sample stations.

3.4.3.3 SIMPER analysis has been used to determine the main contributing species within each of the six groups identified. Those species that contribute to the top 50% of similarity within each group (where data from two or more stations is available) is presented in **Table D 6**.

3.4.3.4 Group 5 was the most commonly occurring group identified within the Hornsea Four offshore ECC and encompassed 14 of the 26 stations sampled, all of which were located at the most offshore sampling locations. The SIMPER routine returned a community similarity of 44% between the Group 5 sampling stations, which although is of the highest compared to the other groups identified within the Hornsea Four ECC (which range between 27% and 60%), this value is moderately low when considering absolute community similarity. The bivalve *Fabulina fabula* was the most commonly occurring species accounting for c.15% of the community sampled within the group, closely followed by the Amphipod *Bathyporeia tenuipes* and the polychaetes *Spiophanes bombyx* and *Magelona johnstoni*; all these species favour sand or muddy sand substrates.

3.4.3.5 Group 6 was the second most frequently sampled group, with data derived from 6 stations. These stations were located furthest inshore and at the middle portion of the Hornsea Four offshore ECC. Community similarity within this group was low at just 27%. Just three species accounted for 50% of the similarity between the stations which is the lowest of that of the groups within the Hornsea Four offshore ECC. These species were the bivalve *Abra prismatica* (which favours sandier sediments than *Fabulina fabula* that characterised Group 5 above), the Amphipod *Bathyporeia elegans* and the polychaete *Nephtys cirrosa*, each of which contributed 19%, 18% and 17% respectively to the community similarities.

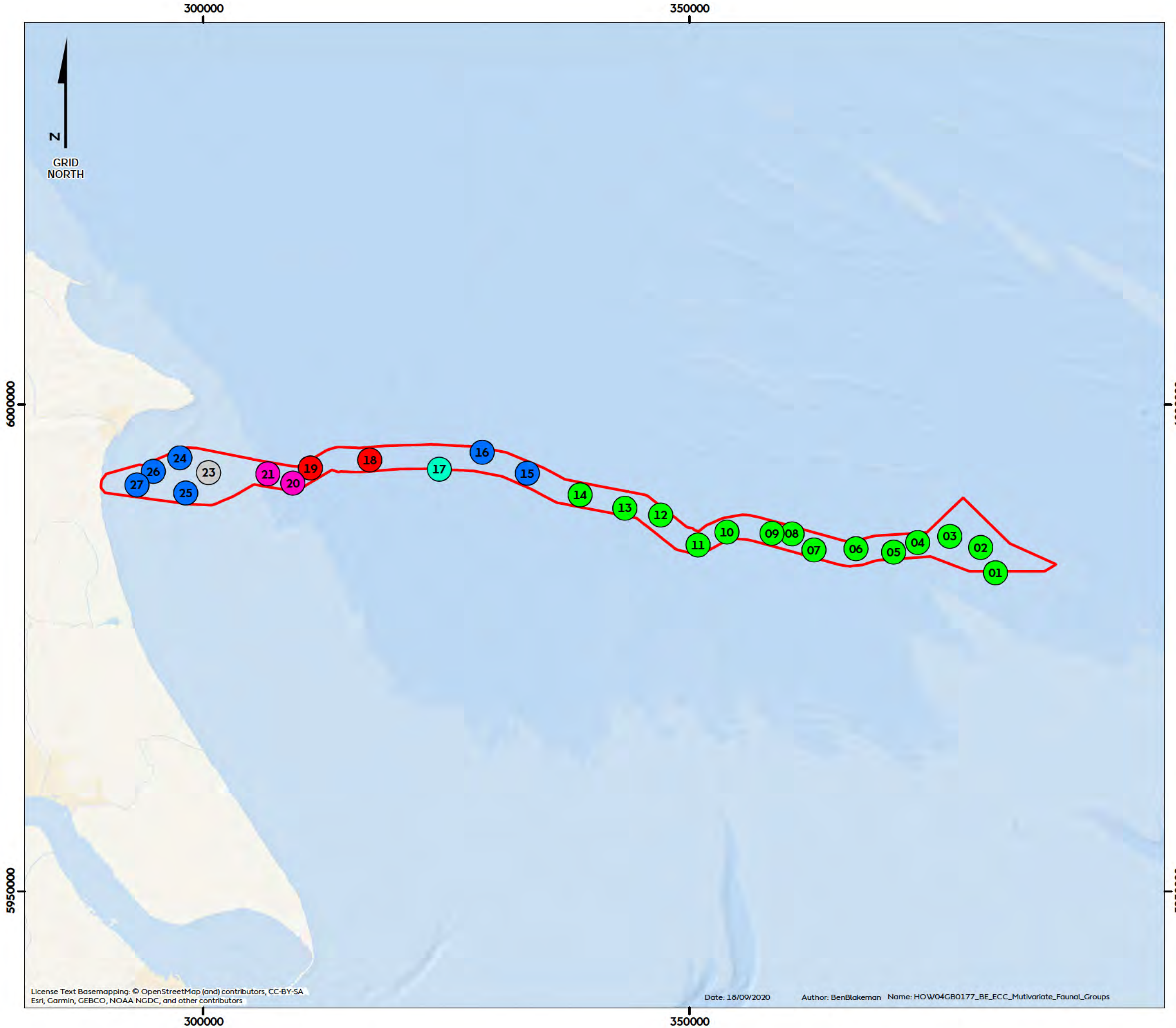
3.4.3.6 Groups 3 and 4 are broadly similar owing to the fact that the polychaetes *Sabellaria spinulosa* and *Lumbrineris cingulata* agg represent the highest contributing species in both groups. These groups were found at stations towards the inshore portion of the Hornsea Four ECC. *Sabellaria spinulosa* contributes 9% and 18% in Groups 3 and 4 respectively, while *Lumbrineris cingulata* agg. contributes 7% and 17% to those groups respectively. Groups 3 and 4 are set apart statistically as a result of the absence of the barnacle *Verruca streomia* in Group 4, and the greater abundance of the polychaete *Melinna elisabethae*, brittle star *Ophiura albida* and bivalve *Abra alba* in faunal group 3.

3.4.3.7 Faunal Groups 1 and 2 were represented by individual samples. However, **Figure D 14** demonstrates that these samples group with Groups 3 and 4, at a higher level. Further investigation of the data revealed that this grouping to the top left-hand side of the MDS plot is largely influenced by the presence of *Sabellaria spinulosa* individuals.

3.4.3.8 The geographical distribution of each of the faunal groups is shown in **Figure D 15**. It is well documented that sediment granulometry is an important factor in determining the structure of benthic communities (Rhoads 1974; Ellingsen 2002). A comparison of the geographical distribution of PSD Groups (determined using SIMPROF analysis) in **Figure D 4** with that of the faunal communities in **Figure D 15** demonstrates some correlation. The relationship between the sediment character and benthic communities is further explored in **Section 3.4.4**.

Table D 6: Species that contribute to the top 50% of similarity within each group.

Species	Average abundance	Average similarity	% Contribution	Cumulative % Contribution	Group Average Similarity
Group 1 Less than two sample stations					
Group 2 Less than two sample stations					
Group 3					
Sabellaria spinulosa	8.66	5.27	8.8	8.8	60%
Lumbrineris cingulata agg.	6.19	4.26	7.11	15.91	
Verruca stroemia	8.36	3.73	6.22	22.13	
Ophiura albida	5.06	3.27	5.45	27.58	
Abra alba	5.22	3.01	5.03	32.61	
Hiatella arctica	4.12	2.92	4.88	37.49	
Nucula nucleus	3.74	2.73	4.56	42.05	
Achelia echinata	3.37	2.19	3.66	45.71	
Nuculana minuta	3.41	2.07	3.45	49.16	
Parvicardium pinnulatum	2.7	1.63	2.73	51.89	
Group 4					
Sabellaria spinulosa	7.72	7.37	17.51	17.51	42%
Lumbrineris cingulata agg.	5.23	7.22	17.16	34.67	
Ampelisca spinipes	1.41	2.08	4.95	39.62	
Hiatella arctica	1.41	2.08	4.95	44.57	
Nucula nucleus	1.71	2.08	4.95	49.52	
Nuculana minuta	1.57	2.08	4.95	54.48	
Group 5					
Fabulina fabula	1.82	6.52	14.87	14.87	44%
Bathyporeia tenuipes	1.88	5.49	12.51	27.38	
Spiophanes bombyx	1.78	4.62	10.53	37.92	
Magelona johnstoni	1.79	4.44	10.12	48.03	
Mactra stultorum	1.12	3.49	7.96	56	
Group 6					
Abra prismatica	1.31	5.26	19.25	19.25	27%
Bathyporeia elegans	1.7	4.88	17.88	37.13	
Nephtys cirrosa	1.09	4.56	16.69	53.82	



Hornsea Four

Figure D 15

Spatial distribution of faunal groups identified using SIMPROF analysis across the Hornsea Four Offshore ECC

Order Limit (Export Cable Corridor)

SIMPROF Faunal Group

- Group 1
- Group 2
- Group 3
- Group 4
- Group 5
- Group 6

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
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Multivariate Faunal Groups

Document no: HOW04GB0177

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3.4.4 The Relationship between Sediment Character and Benthic Fauna

3.4.4.1 The relationship between the community structure of the benthic macrofauna and the proportions of silt and clay, sand and gravel at each respective station has been explored using the RELATE routine in PRIMER v6 which provides a means of testing for correlations in the environmental data. The results of the analysis demonstrate a reasonably strong Spearmans Rank correlation of 0.532 which is significant (0.1%).

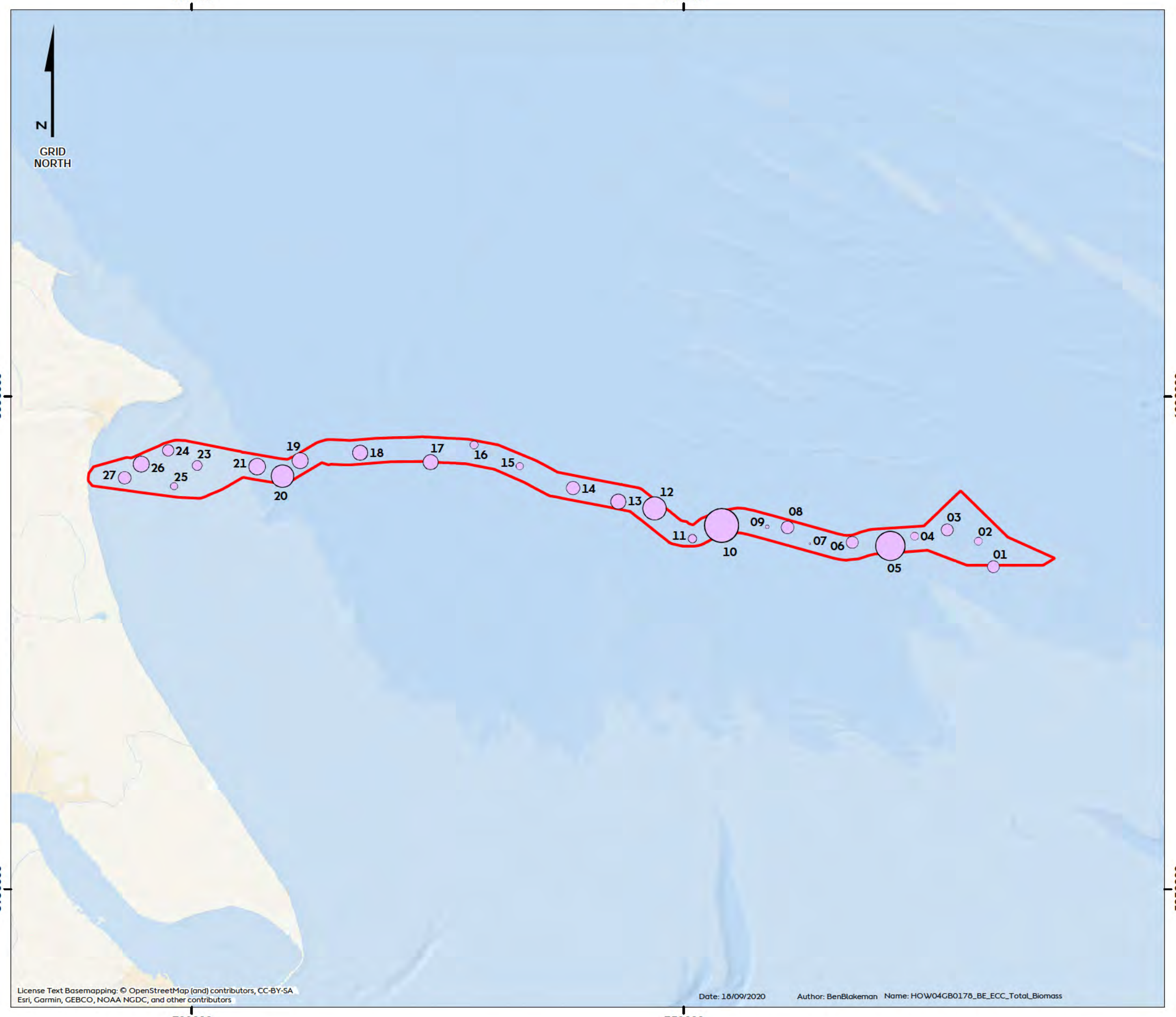
3.4.4.2 In order to establish which aspects of the sediment granulometry account for the correlation observed, further analysis using the BIOENV routine was carried out. It revealed that the best individual correlation between the multivariate faunal data and the PSD data was the proportion of sand in the sediments, but the best overall correlation observed was associated with the combined proportions of silt, clay and sand. Both correlations were moderately high (0.716 and 0.719 respectively).

3.4.4.3 A multitude of other environmental parameters can also influence benthic community assemblages, although on open coasts such as is being considered within the offshore ECC, sediment granulometry and depth are likely to be the main influencing factors. As such, the correlation between depth and the community assemblages was explored but found to be weak (0.283).

3.4.5 Faunal Biomass

3.4.5.1 The AFDW for each major phylum sampled is listed in **Appendix D6**. In order to ensure that the data is as representative as possible it has been manipulated using a phylum specific conversion factor (Riccardi and Bourget 1998).

3.4.5.2 The total biomass measured at each station has been plotted spatially in **Figure D 16**. The percentage composition of the biomass by each phyla has been plotted spatially in **Figure D 17**. These plots show that there is no obvious geographical trend in the total biomass throughout the offshore ECC. With regards to the main contributing phyla however, Echinodermata generally contribute the greatest proportions to biomass at stations in the eastern half of the Hornsea Four offshore ECC and at two stations at the very western extent, closest to landfall. There are exceptions at a few stations where Molluscs and/or Annelida contribute significantly to the total biomass, and the sum of 'other phyla' contribute approximately 50% at two stations in the east. In the western half of the Hornsea Four offshore ECC, Mollusca most commonly dominate the biomass, although Annelida account for greater proportions at a few stations.



Hornsea Four

Figure D 16

Total biomass recorded from benthic samples at each station across the Hornsea Four Offshore ECC

Order Limit (Export Cable Corridor)

Total Ash-Free Dry Weight (g)

- 0.01
- 0.1
- 1

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Total Biomass recorded from Benthic Samples
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Checked by: AdB
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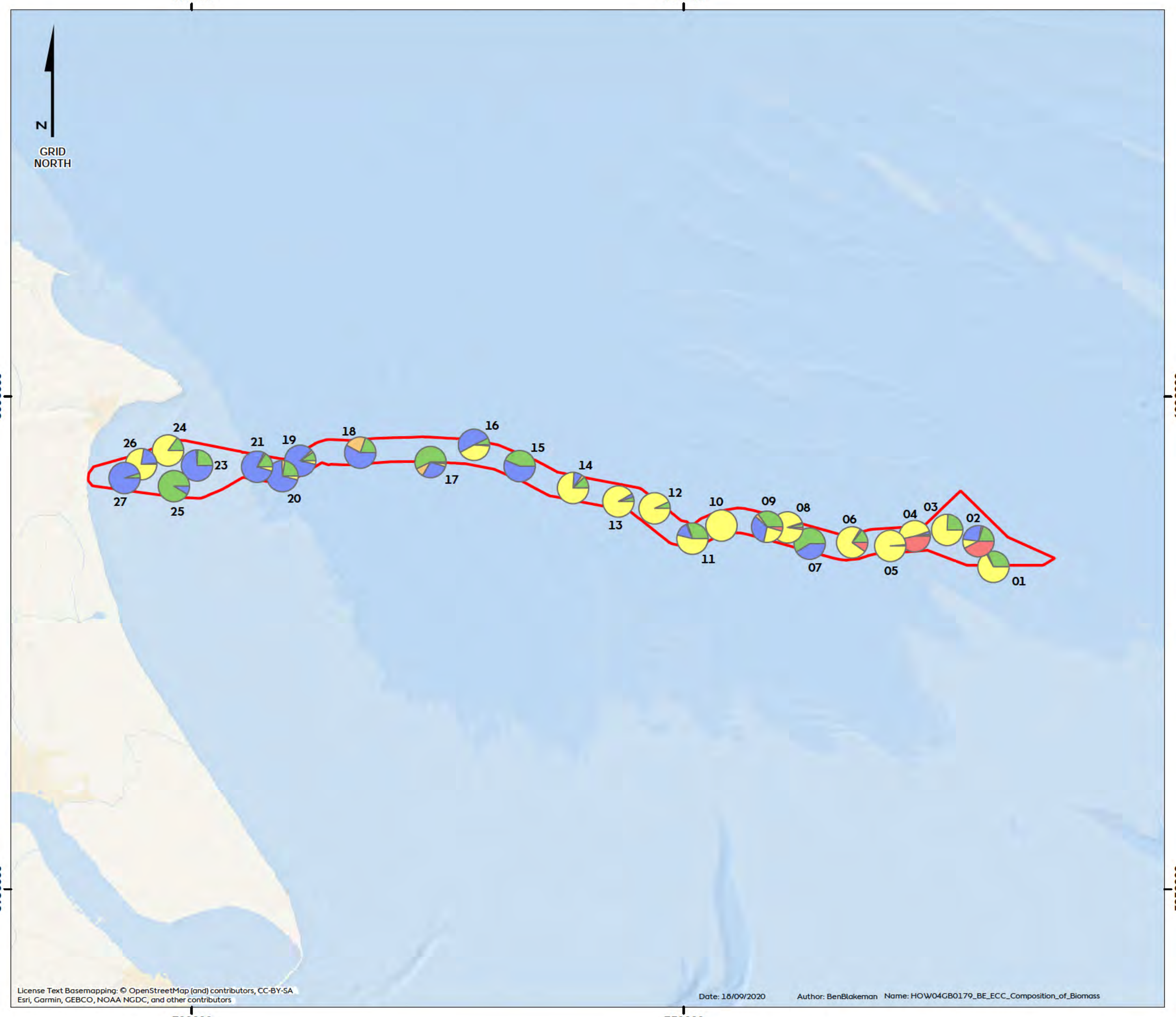

Hornsea Four

Figure D 17

Percentage composition of biomass by each phyla across the Hornsea Four Offshore ECC

Order Limit (Export Cable Corridor)

% Biomass per Phyla

- Annelida
- Arthropoda
- Mollusca
- Echinodermata
- Other

Coordinate system: ETRS 1989 UTM Zone 31N

Scale@A3: 1:375,000

0 10 20 Kilometres

0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	18/09/2020

Composition of Biomass

Document no: HOW04GB0179

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3.4.6 DDV Survey Results

3.4.6.1 DDV and seabed images were obtained at 28 locations within the Hornsea Four offshore ECC. In addition to this, further cruciform transect data were collected at Stations ECC_22 and ECC_23 to further examine the potential for Annex I habitats.

3.4.6.2 Analysis of seabed images corroborated the PSD and faunal sample data, which indicated a relatively heterogenous benthos along the offshore ECC, which ranged from muddy sand to sandy gravel. A list of the ground-truth sites and their locations is provided in **Appendix D1**. Summary data, sample photographs and numbers of still images collected from each of the stations are provided in **Appendix D4**. Within **Appendix D4** it can be seen that at Stations ECC_22 and ECC_28 which were characterised based on image analysis alone, a total of six and seven still images respectively were obtained.

3.4.6.3 As could be expected, given the variability in the substrate and water depth between stations, the conspicuous fauna recorded was also variable. Epifauna that were observed included hydroids, bryozoans, anthozoans and echinoderms (both echinoids and asteroids). Free swimming megafauna were limited to demersal teleosts (bony fish) including pleuronectiforms and dragonets. Evidence of burrowing macrofauna was also present throughout much of the offshore ECC.

3.4.6.4 Burrows were observed at 18 stations within the seabed imagery obtained within the offshore portion of the ECC, however, sea pens (*Pennatulacea*) were not observed within any of the seabed imagery data acquired and burrow density revealed a SACFOR score of 'rare' at all stations.

3.4.6.5 Stations ECC_22 and ECC_23 were characterised by patchy coarse sediments with cobbles and boulders. Following the review of this data, Annex I stony reef was discussed as potentially occurring at these stations but could not be confirmed due to the patchy nature of the substrate. Therefore, as previously described, a further survey was commissioned at these stations to undertake an assessment of potential Annex I habitat. Further details and the results of this assessment are presented in **Section 3.5.1**.

3.4.6.6 Ground truthing methods did not identify any other potential Annex I habitats or other conservation features within the Hornsea Four offshore ECC.

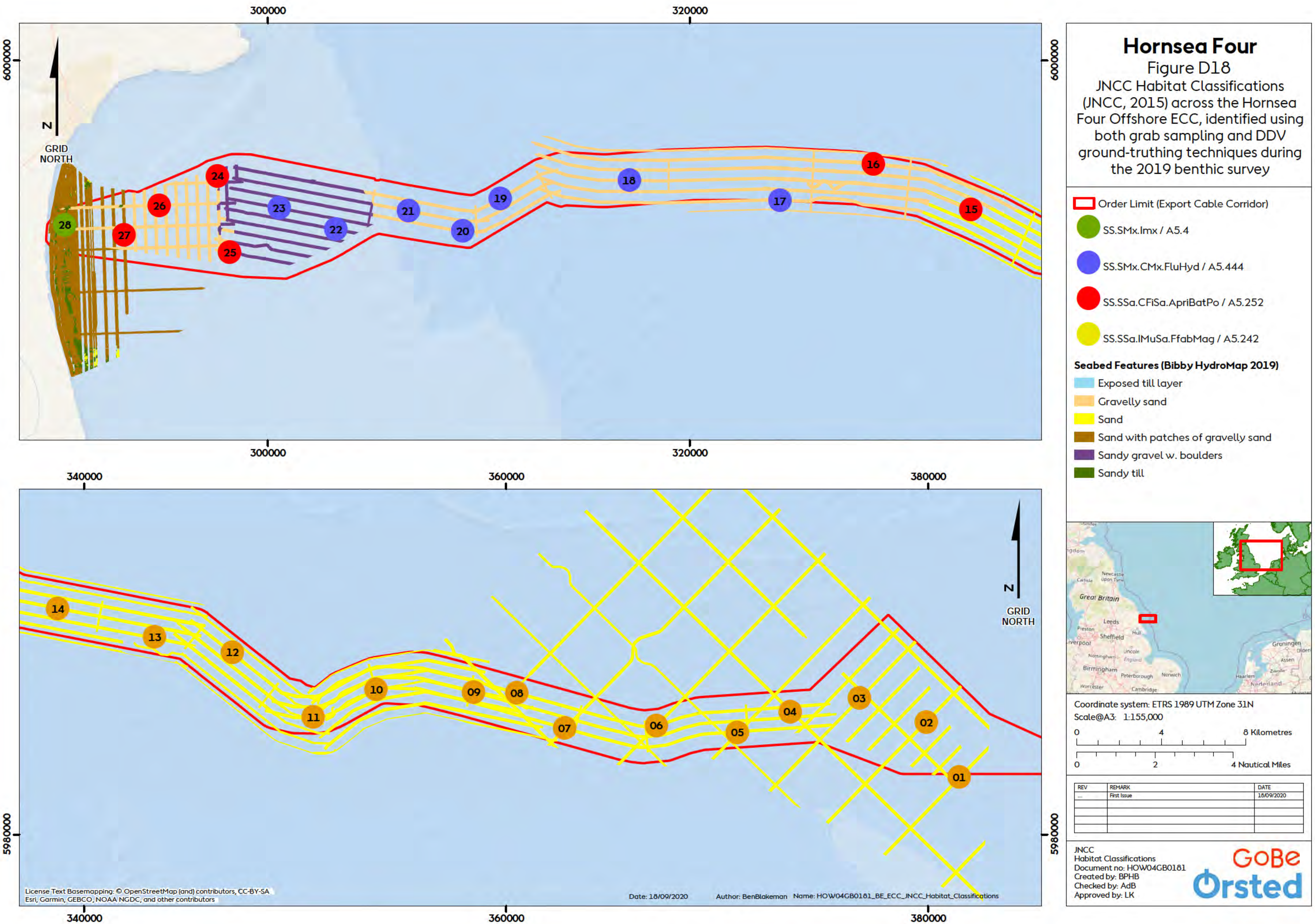
3.4.7 Determination of Habitat Classifications

3.4.7.1 By cross-referencing the results of the faunal multivariate analysis in **Section 3.4.3** above, with the results of the DDV ground-truthing data, four habitat types were identified across the Hornsea Four offshore ECC. These are listed as follows according to the JNCC Habitat Classifications (JNCC 2015) and the equivalent EUNIS habitat classification codes (EEA 2017).

- SS.SSa.IMuSa.FfabMag (A5.242) - *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand;
- SS.SSa.CFiSa.ApriBatPo (A5.252) - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand;

- SS.SMX.CMx.FluHyd (A5.444) - *Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment; and
- SS.SMx.IMx (A5.4) - Infralittoral mixed sediment.

3.4.7.2 **Figure D 18** shows the geographical distribution of the four habitat types that were identified within the offshore ECC. Site specific summary descriptions of each of the habitat type follow. Seabed features identified during the geophysical survey campaigns are also presented (Bibby HydroMap 2019).


Hornsea Four
Figure D18
JNCC Habitat Classifications (JNCC, 2015) across the Hornsea Four Offshore ECC, identified using both grab sampling and DDV ground-truthing techniques during the 2019 benthic survey
Order Limit (Export Cable Corridor)
SS.SMx.Imx / A5.4
SS.SMx.CMx.FluHyd / A5.444
SS.SSa.CFiSa.ApriBatPo / A5.252
SS.SSa.IMuSa.FfabMag / A5.242
Seabed Features (Bibby HydroMap 2019)
Exposed till layer
Gravelly sand
Sand
Sand with patches of gravelly sand
Sandy gravel w. boulders
Sandy till
Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:155,000
0 4 8 Kilometres
0 2 4 Nautical Miles
REV
REMARK
DATE
First Issue
18/09/2020
JNCC
Habitat Classifications
Document no: HOW04GB0181
Created by: BPHB
Checked by: AdB
Approved by: LK
GoBe
Ørsted
300000
320000
340000
360000
380000
6000000
5980000
N
GRID NORTH
01
02
03
04
05
06
07
08
09
10
11
12
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28
Great Britain
Leeds
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Date: 18/09/2020
Author: BenBlakeman
Name: HOW04GB0181_BE_ECC_JNCC_Habitat_Classifications

***Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (SS.SSa.IMuSa.FfabMag / A5.242)**

3.4.7.3 The community data that was gleaned from the benthic grabs within this habitat type is described above in **Section 3.4.3** as faunal 'Group 5'. The infaunal communities sampled fit relatively well with those described within the Marine Habitat Classification (JNCC 2015) and therefore, in combination with the sediment character, have been the main influence in assigning the habitat type. The main characterising taxa *Fabulina fabula* and *Magellona* spp were found in sediments at all fourteen stations that were sampled within the habitat type, while *Bathyporeia spp.* amphipods were captured at all but two stations.

3.4.7.4 Example images of the infralittoral muddy sand habitat are presented below in **Figure D 19**. Conspicuous fauna that were observed within the muddy sand habitat during surveys included: Chordata (Pleuronectiformes and *Callionymus* sp.), Arthropoda (*Corystes cassivelaunus*), polychaetes (including Sabellidae and possible *Lanice conchilega*), and Echinodermata (both Asteroidea and Ophuroidea).

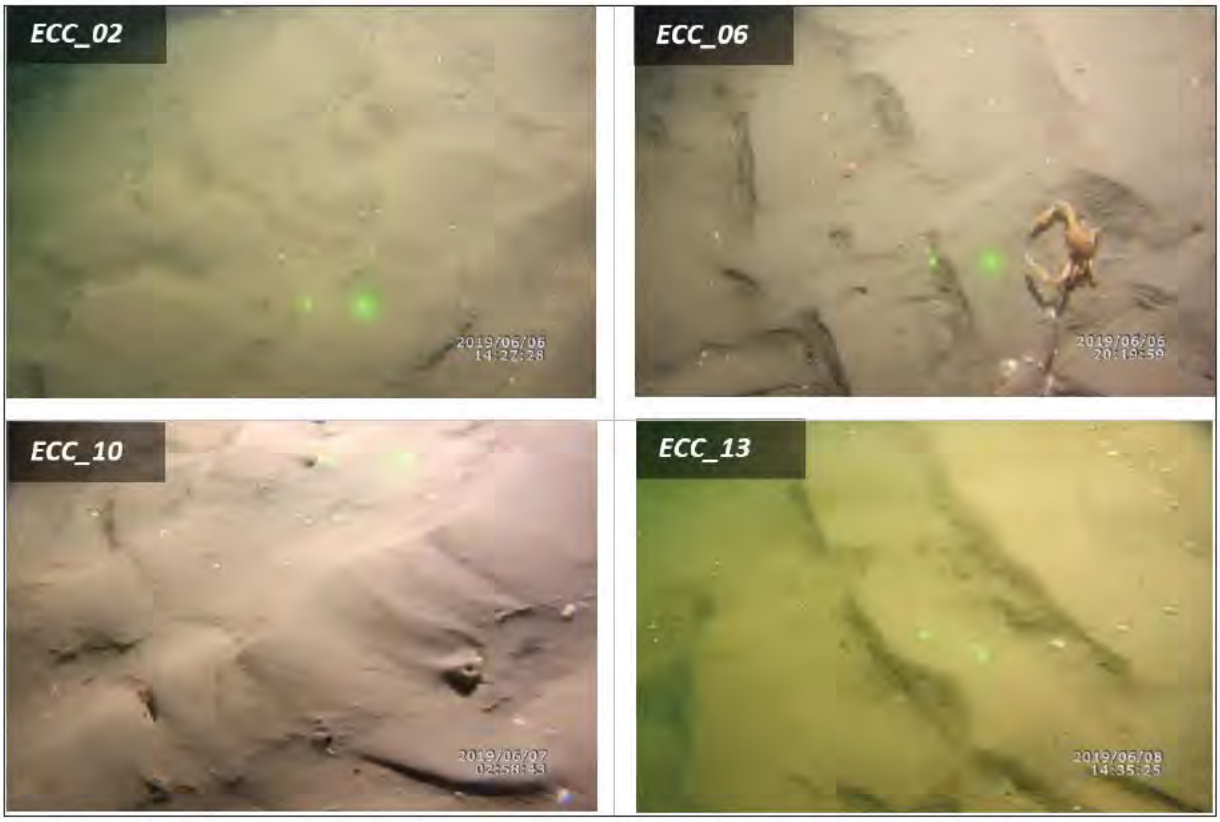


Figure D 19: Example images of the SS.SSa.IMuSa.FfabMag / A5.242 habitat type within the Hornsea Four offshore ECC. Figure D 18 identifies the location of samples. Photographs collected between the 6th and the 15th of June 2019 during the benthic survey.

Abra prismatica, Bathyporeia elegans and polychaetes in circalittoral fine sand (SS.SSa.CFiSa.ApriBatPo / A5.252)

3.4.7.5 The infaunal community data gathered from within this habitat type is described above in Section 3.4.3 as faunal 'Group 6'. The prevalence of the two main characterising species *Abra prismatica* and *Bathyporeia elegans* at five of the six stations sampled within the habitat type, combined with the fine sand sediment character suggests a relatively close conformity with the habitat type described within the classification (JNCC 2015). However, a deviation from the JNCC habitat description is the frequent presence of *Nephtys cirrosa* and variable presence and abundance of numerous other polychaetes.

3.4.7.6 Conspicuous fauna and epifauna were limited to Pleuronectiforms (flat fish) and Bryozoa (*Flustra foliacea*). Example images of the fine sand habitat are presented below in Figure D 20.

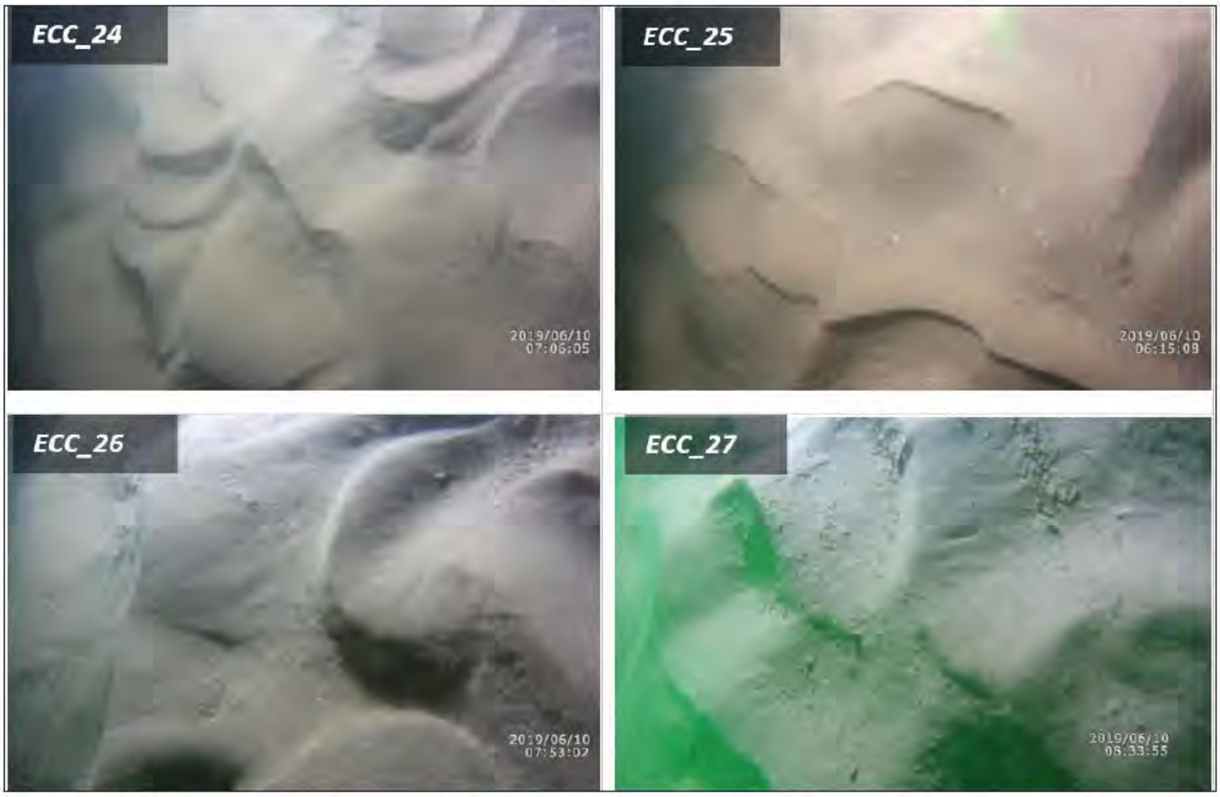


Figure D 20: Example images of the SS.SSa.CFiSa.ApriBatPo / A5.252 habitat type within the Hornsea Four offshore ECC. Figure D 18 identifies the location of samples. Photographs collected between the 6th and the 15th of June 2019 during the benthic survey.

***Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment (SS.SMX.CMx.FluHyd / A5.444)**

3.4.7.7 The sediments across this habitat type were heterogenous with varying proportions of silt and clay, sand and gravel, with stations ECC_17 and ECC_23 being additionally characterised by the presence of cobbles and boulders (Figure D 21). However, collectively the sediment types mostly resembled circalittoral mixed sediments.

3.4.7.8 Given the heterogeneity of the sediments, the infaunal communities were also variable. Consequently, according to the SIMPROF analysis in **Section 3.4.3**, four statistically separate infaunal groups were found within the habitat type. These groups are referred to as Groups 1, 2, 3 and 4 and are described accordingly in **Section 4.2.2**. Despite the infaunal variability, the epifaunal assemblages across those four groups were broadly similar and ultimately informed the habitat type assignment (although if communities are considered at the 20% similarity level the four groups would converge, see **Figure D 13**).

3.4.7.9 Conspicuous fauna within the circalittoral mixed sediment habitat within the Hornsea Four offshore ECC included: Anthozoa (*Alcyonium digitatum*), Bryozoa (*Flustra foliacea* and *Alcyonidium diaphanum*), Echinodermata (both Asteroidea and Ophiuroidea), bivalves (*Pecten maximus*), Annelida (*Pomatoceros triqueter*), Decapoda (possible *Carcinus maenas* and *Crangon crangon*), Actiniaria and Hydrozoa (*Hydrallmania falcata*).

3.4.7.10 The two major characterising species within the SS.SMX.CMx.FluHyd / A5.444 communities were recorded within the grab samples at most stations and were also frequently observed in the benthic imaging. Other characterising species that were recorded include the soft coral *Alcyonium digitatum*, the barnacle *Balanus crenatus*, robust bryozoans *Alcyonidium diaphanum* and *Vesicularia spinosa* as well as the tube worm polychaetes *Sabella pavonina* and *Lanice conchilega*.

3.4.7.11 The additional presence of cobbles and boulders at stations ECC_22 and ECC_23 was reflected by the epifaunal communities that were observed in the images captured at those stations. However, these are considered to be localised variations in the physical environment, and as such, the overarching habitat type assigned is considered to remain the same at the seven stations assigned the SS.SMX.CMx.FluHyd / A5.444 habitat type. Images of the SS.SMX.CMx.FluHyd / A5.444 communities are presented in **Figure D 21** and illustrate the variability of the substrates. Further assessment on the presence of potential stony reef habitat is presented in **Section 3.5.1**.

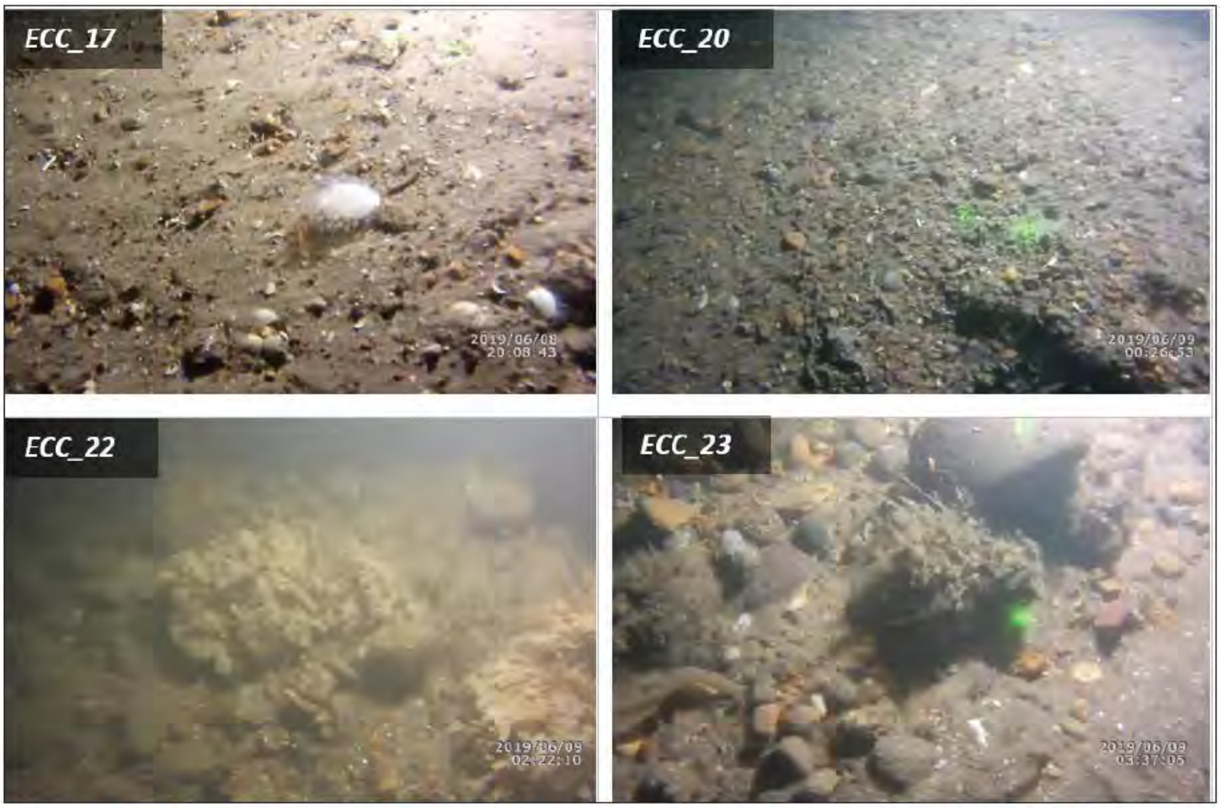


Figure D 21: Example images of the SS.SMX.CMx.FluHyd / A5.444 habitat type within the Hornsea Four offshore ECC. Figure D 18 identifies the location of samples. Photographs collected between the 6th and the 15th of June 2019 during the benthic survey.

Infralittoral mixed sediment (SS.SMx.IMx / A5.4)

3.4.7.12 Station ECC_28 was the only station to be assigned the higher level classification SS.SMx.IMx / A5.4. It was the closest of all the stations to landfall being located just 1 km away. The habitat type was determined using photographic analysis owing to the inability to achieve the necessary grab sample depth at the station due to the sand overlying strongly consolidated clay.

3.4.7.13 The seabed feature interpretation that was carried out classified the area around station ECC_28 as comprising sandy till, however, in considering the image analysis and partial grab contents the sediments at station ECC_28 have been described as heterogenous sandy sediment with a pebble and cobble mosaic. It has been assumed that this substrate is subcropping (as opposed to outcropping) in this area. Images of the seabed at the station is presented in Figure D 22.

3.4.7.14 Due to the lack of infaunal data from grabs and absence of epifaunal assemblages within the image analysis, it has not been possible to describe the communities at station ECC_28. However, species that are often associated with the infralittoral mixed sediment habitat are: Mollusca (*Crepidula fornicata* and *Buccinum undatum*), polychaetes (*Sabella pavonina*), Arthropoda (*Apseudes latreillii)* and Cnidaria *(Urticina felina).*

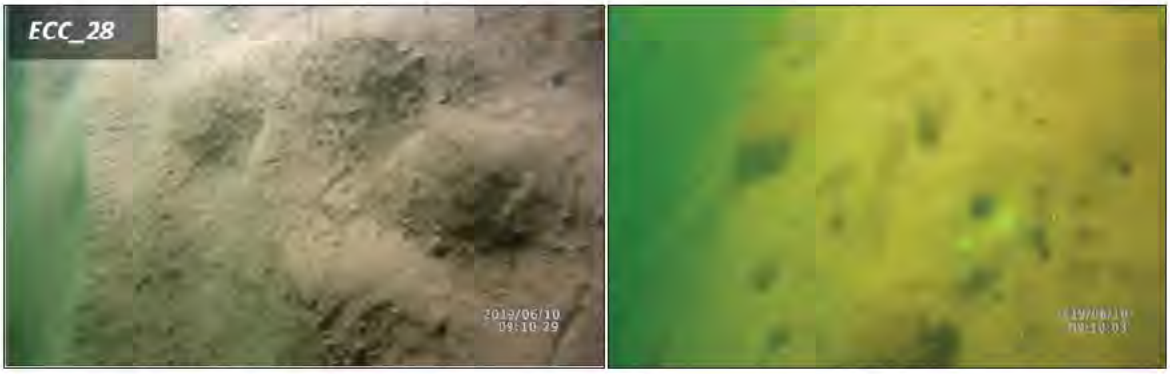


Figure D 22: Images of the SS.SMx.IMx / A5.4 habitat type within the Hornsea Four offshore ECC. Figure D 18 identifies the location of samples. Photographs collected between the 6th and the 15th of June 2019 during the benthic survey.

3.5 Nature Conservation and Features of Conservation Interest

3.5.1 Stony Reef

3.5.1.1 Two stations within the inshore portion of the offshore ECC (stations ECC_22 and ECC_23) were located within an area of seabed classified by biotope *Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment (SS.SMX.CMx.FluHyd / A5.444) and as 'Sandy gravel with boulders' as identified by the geophysical seabed interpretation (Bibby HydroMap 2019). The analysis of DDV data collected at these stations revealed the presence of coarse sediments with boulders and cobbles also visible. The data also revealed a high percentage of finer matrix surrounding the coarser sediments. The quality of the BSL survey data did not allow for a robust assessment of stony reef to be undertaken, therefore an additional DDV study at these locations was commissioned (OEL 2020), the full details of which are presented within **Appendix D8** of **Volume A5, Annex 2.1: Annex I Habitat Assessment Survey 2020** and summarised below.

3.5.1.2 The potential Annex I habitat assessment survey at stations ECC_22 and ECC_23 followed robust analyses against the various Annex I stony reef qualifying criteria (composition, elevation and extent) (**Table D 1**), the results were then overlain on the most recent acoustic survey data (MBES and SSS) available for the areas of interest which allowed for manual delineation of the areas deemed to qualify as potential Annex I stony reef habitat. A total of 4,381.8 m^2 and 173.1 m^2 of 'low' resemblance Annex I stony reef was determined to occur surrounding Stations ECC_22 (**Appendix D8, Figure 6**) and ECC_23 (**Appendix D8, Figure 7**) respectively.

3.5.1.3 The patches of stony reef habitat recorded during this survey were scored as 'low' resemblance, as per the qualifying criteria set out in regulatory guidance on assessing stony reef habitats (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not be considered to contributing to the National Site Network unless there is strong justification. Given that none of these reefs are designated features of any sites within the National Site Network or any other Marine Protected Areas (MPAs) and that 'low' was generally scored against each of the qualifying criteria for the majority of seabed images in each area, it is unlikely that any impacts associated with the installation of the proposed Hornsea Four offshore export cables will be of any significance in the context of the National Site Network.

3.5.1.4 Based on these results, the area of 'Sandy gravel with boulders' encompassing stations ECC_22 and ECC_23 (**Figure D 18**) is expected to comprise a patchy mosaic of stony substrate surrounded by gravels and coarse sands. Further review of the SSS mosaic from this area highlighted the presence of a number of north-south aligned ribbons of rippled sands and gravelly sand (**Figure D 7**), although the majority of the area was expected to be 'sandy gravel with boulders'.

3.5.2 Other Habitats of Nature Conservation Importance within the Hornsea Four offshore ECC

3.5.2.1 Although individuals of *Sabellaria spinulosa* were identified within the benthic grab samples at five stations (ECC_17 to ECC_21), the only aggregation observed in the DDV footage was a small patch encrusting a pebble that would not itself be classified as a potential Annex I reef. Detailed review of the SSS and multibeam bathymetry datasets acquired within the Hornsea Four offshore ECC (Bibby HydroMap 2019) found no evidence of the distinctive signatures which would be typically associated with the presence of biogenic reefs.

3.5.2.2 Stations closest to landfall (in water depth less than 20 m) were characterised by mobile clean sand substrates. These substrates are a sediment depository known as the sandbank feature Smithic Bank and are formed by a supply of sediment which arrives into Bridlington Bay having been brought around Flamborough Head by currents that flow north to south (Williams 2018). The sandbank feature does not form a qualifying feature of any Special Area of Conservation (SAC), Special Protection Area (SPA) or Ramsar site. The Flamborough Head SAC N2k Standard data form states its representativity is grade D i.e. no need to establish conservation objectives or conservation measures. This is reflected in the conservation objectives for the Flamborough Head SAC – which does not include subtidal sandbanks as a qualifying feature. In terms of benthic ecology, communities found on sandbank crests are predominantly those typical of mobile sediment environments and tend to have low diversity. Troughs or areas between banks generally contain more stable gravelly sediments and support diverse infaunal and epifaunal communities. Here sediment movement is reduced and therefore the areas support an abundance of attached bryozoans, hydroids and sea anemones. The benthic and epifaunal communities typical of such features fall into the category of sublittoral sands and gravels that have been identified across the site.

3.5.2.3 Other than those discussed above there was no evidence of any other potential Annex I habitats (1992), species or other habitats listed as Features of Conservation Importance (FOCI) (Natural England and JNCC 2010). No other species or habitats listed under Section 41 of the Natural Environment and Rural Communities (NERC) Act (2006). No additional species or habitats listed on the OSPAR (2008) list of threatened and/or declining species and habitats were recovered in the samples. No species on the International Union for Conservation of Nature (IUCN) Global Red List of threatened species (IUCN 2018).

3.5.3 Sites Protected Under UK and European Nature Conservation Legislation

3.5.3.1 Several sites in the vicinity of Hornsea Four have been designated for protection under UK and international conservation legislation. The location of these designated sites relative to the Hornsea Four offshore ECC are shown in **Figure D 23**.

3.5.3.2 Approximately 50% of the Hornsea Four offshore ECC falls within the boundary of the Southern North Sea SAC (SNS SAC). The SNS SAC was designated in February 2019 for the protection of harbour porpoise *Phocoena phocoena* (JNCC 2019), it covers an area of 36,951 km^2, making it the largest designated site in UK and European waters. This site is not designated for any benthic features.

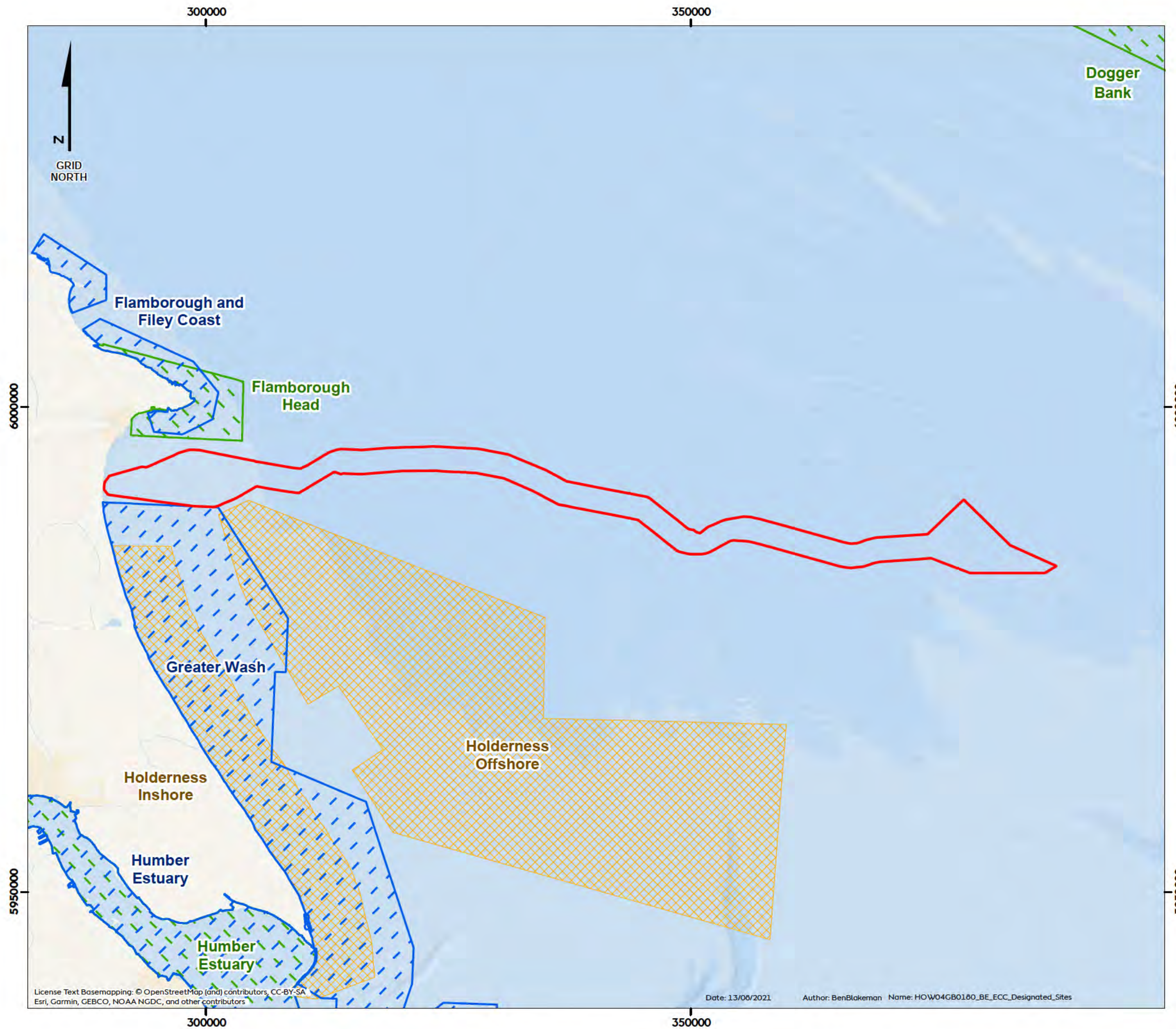
3.5.3.3 Other statutory designations that are found nearby, but which fall outside of the Hornsea Four offshore ECC include the Flamborough Head SAC, which at its closest point lies 1.15 km from the Hornsea Four offshore ECC boundary. The Flamborough Head SAC has been designated for the presence of species associated with chalk reefs, submerged or partially submerged sea caves and vegetated sea cliffs (all of which are Annex I habitats under the European Council Directive 92/43/EEC on the conservation of natural habitats and wild flora and fauna). The Humber Estuary SAC also falls approximately 50 km to the south of the Hornsea Four offshore ECC and has been designated for a number of intertidal and dune features, but also for Grey seal populations (*Halichoerus grypus*).

3.5.3.4 The Humber Estuary Site of Special Scientific Interest (SSSI) (**Figure D 23**) is located approximately 45 km from the Hornsea Four offshore ECC boundary, this site is designated for broad habitats which include coastal and habitats including littoral sediment and supralittoral sediment.

3.5.3.5 **Figure D 23** also illustrates the location of the Holderness offshore and inshore Marine Conservation Zones (MCZs) which are located 0.75 km and 4.5 km respectively from the southern boundary of the Hornsea Four offshore ECC. MCZs are designated under the Marine and Coastal Access Act (2009). The Holderness offshore MCZ has been designated for geological features as well as marine ecological features of conservation importance that include: the bivalve known commonly as the Ocean quahog (*Arctica islandica*), subtidal coarse sediments, subtidal mixed sediments and subtidal sand habitats. The marine ecological features which the inshore MCZ has been designated for include intertidal sand and muddy sand, moderate energy circalittoral rock, high energy circalittoral rock, subtidal coarse sediment, subtidal mixed sediment, subtidal sand, and subtidal mud. It is important to note that the specific management and protection of these MCZ sites is yet to be finalised. A detailed MCZ assessment is presented within **Volume A5, Annex 2.3 Marine Conservation Zone Assessment**.

3.5.3.6 The Greater Wash SPA (which is designated under the European Council Directive 2009/147/EC on the conservation of wild birds) also meets with the southern boundary of the Hornsea Four offshore ECC (although there is no overlap). The SPA is designated for the protection of several breeding and migratory bird species, including the Little tern (*Sterna albifrons*) and the Red throated diver (*Gavia stellata*). This site is not designated for any benthic features.

3.5.3.7 The Flamborough and Filey Coast SPA is located approximately 1.8 km north of the Hornsea Four offshore ECC. The SPA is designated for the protection of several breeding bird species including gannet (*Morus bassanus*), guillemot (*Uria aalge*), kittiwake (*Rissa tridactyla*), razorbill (*Alca torda*) and seabird assemblages. This site is not designated for any benthic features.



Hornsea Four

Figure D 23

Hornsea Four Offshore ECC relative to nationally and internationally designated sites

- Order Limit (Export Cable Corridor)
- Marine Conservation Zone (MCZ)
- Special Area of Conservation (SAC)
- Special Protection Area (SPA)

Coordinate system: ETRS 1989 UTM Zone 31N
Scale@A3: 1:375,000

0 10 20 Kilometres
0 5 10 Nautical Miles

REV	REMARK	DATE
...	First Issue	13/08/2021

Hornsea Four relative to designated sites
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Checked by: AdB
Approved by: LK

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3.6 Sediment Contaminants

3.6.1 Total Hydrocarbons and Alkanes

3.6.1.1 A summary of the hydrocarbon analysis results are presented in **Table D 7**. Total Hydrocarbon Concentrations (THC) (which comprise total Polycyclic Aromatic Hydrocarbons (PAH), total n-alkanes, pristane and phytane) ranged from 2.8 mg kg^{-1} at ECC_12 to 61.4 mg kg^{-1} at ECC_20. THC levels above the United Kingdom Offshore Operators Association (UKOOA) (2001) 95th percentile of 11.39 mg kg^{-1} for THC in the southern North Sea were found at five stations (ECC_18 to ECC_21, and ECC_08). The higher THC levels observed at stations ECC_18 to ECC_21 are consistent with the elevated TOC at those stations as described in **Section 2.3.4**.

3.6.1.2 The mean proportion of unresolved complex mixtures (UCM) of hydrocarbons was 96.53% (±2.07 SD) with no spatial pattern of distribution evident across the Hornsea Four offshore ECC.

Table D 7: Summary of Sediment Hydrocarbon Analysis.

Station	THC (mg kg^{-1})	Total n-alkanes (ng g^{-1})	CPI*	Pristane/ Phytane Ratio	Petrogenic /Biogenic (P/B) Ratio	Proportion of Alkanes (%)	Total PAHs (µg kg^{-1})	NPD** (µg kg^{-1})
ECC_01	7.16	164	1.78	3.23	0.23	2.29	0.115	0.047
ECC_02	5.79	77	1.24	3.44	0.26	1.34	0.054	0.022
ECC_03	6.85	118	2.01	3.77	0.44	1.72	0.08	0.027
ECC_04	7.64	106	1.98	6.08	0.24	1.38	0.074	0.025
ECC_05	9.10	102	1.72	5.29	0.31	1.12	0.075	0.025
ECC_06	9.54	158	1.99	7.30	0.37	1.66	0.1	0.038
ECC_07	10.01	179	1.73	3.74	0.33	1.79	0.153	0.063
ECC_08	13.19	239	1.98	12.2	0.30	1.81	0.227	0.093
ECC_09	9.39	178	1.26	8.97	0.41	1.89	0.18	0.083
ECC_10	10.89	194	1.57	9.20	0.44	1.78	0.2	0.091
ECC_11	7.73	134	1.94	10.8	0.66	1.73	0.117	0.044
ECC_12	5.31	100	1.37	6.74	0.31	1.89	0.131	0.06
ECC_13	2.80	94	2.02	3.35	0.26	3.35	0.083	0.032
ECC_14	4.27	75	1.53	5.18	0.31	1.76	0.051	0.018
ECC_15	7.55	209	1.33	4.33	0.33	2.76	0.196	0.088
ECC_16	4.87	130	1.60	3.01	0.30	2.66	0.126	0.06
ECC_17	5.44	285	1.55	2.41	0.46	5.23	0.22	0.114
ECC_18	18.40	966	1.23	1.64	0.92	5.25	1.134	0.632
ECC_19	25.97	1,428	1.39	2.48	0.69	5.50	2.299	1.164
ECC_20	61.64	3,599	1.36	3.97	0.80	5.84	5.048	2.63
ECC_21	43.79	2,415	1.35	4.77	0.92	5.51	3.604	1.888
ECC_23	9.21	467	0.80	5.16	0.93	5.07	0.257	0.138
ECC_24	10.78	751	1.08	9.70	1.39	6.97	0.217	0.092
ECC_25	7.85	502	1.27	8.68	1.07	6.39	0.252	0.124
ECC_26	6.77	436	1.27	10.73	1.27	6.44	0.211	0.099
ECC_27	6.95	488	1.15	6.71	1.02	7.02	0.27	0.101
Mean	*12.27*	*523*	*1.52*	*5.88*	*0.57*	*3.47*	*0.595*	*0.300*

Station	THC (mg kg^{-1})	Total n-alkanes (ng g^{-1})	CPI*	Pristane/ Phytane Ratio	Petrogenic /Biogenic (P/B) Ratio	Proportion of Alkanes (%)	Total PAHs (µg kg^{-1})	NPD** (µg kg^{-1})
SD	*13.03*	*814*	*0.34*	*2.98*	*0.35*	*2.07*	*1.208*	*0.063*

* Carbon Preference Index

** Naphthalene, Phenanthrene and Dibenzothiophene

3.6.1.3 Further insight into the origin of hydrocarbons in marine sediments may be gained by measuring concentrations of individual alkanes. Concentrations of n-alkanes from nC_{10} to nC_{37}, pristane and phytane are also summarised in **Table D 7** (with individual n-alkane concentrations presented in **Appendix D7** (Table A).

3.6.1.4 Across the offshore ECC, the total n-alkaline concentrations were variable and ranged from 75.1 ng g^{-1} to 3599 ng g^{-1} (mean 522.74 ng g^{-1} ± 813.51 SD). The sediments at four stations had n-alkane concentrations above the UKOOA 95th percentile of 780 ng g^{-1} for the southern North Sea (UKOOA 2001), stations ECC_18 to ECC_21 contained levels of 966 ng g^{-1}, 1428 ng g^{-1}, 3599 ng g^{-1} and 2415 ng g^{-1} respectively. The high total n-alkane concentration at these stations is in line with the THC and UCM data. Alkanes contributed on average 3.47% (± 2.07 SD) to the THC levels recovered, which is a relatively low level and as would be expected for uncontaminated marine sediments where background hydrocarbons are continuously replenished by a low but consistent source of alkanes.

3.6.1.5 All samples were analysed for n-alkanes using gas chromatography (GC) with flame ionisation detection (FID). Inspection of the individual gas chromatograms provided evidence of a large envelope of hydrocarbons that are consistent with an UCM in the range of nC_{24} and nC_{37} at all stations. This envelope may reflect a combination of general contaminants from terrestrial runoff and shipping activity (e.g. heavy greases and fuel oils, lubricants or waxes), while the alkanes associated with this signature may correspond to an input of terrigenous plant materials which typically comprise the long-chain, odd carbon-numbered alkanes (nC_{25}-nC_{33}) (Harborne 1999; McDougall 2000; Bouloubassi et al. 2001).

3.6.1.6 Stations ECC_01 to ECC_17 displayed similar signatures with little evidence of the lighter hydrocarbons (<nC_{20}) associated with petrogenic input (i.e. produced from incomplete combustion of petroleum). Stations at the western end of the Hornsea Four offshore ECC closest to the coastline (ECC_18 to ECC_27) were of a different character and analysis revealed a homologous series of alkanes in the range nC_{12}-nC_{24}, which may indicate trace levels of refined diesel-based fuel from shipping activities.

3.6.1.7 The higher THC measured in a subset of the stations closer to shore (ECC_18 to ECC_21) is evident in the GC traces in the form of an elevated baseline of UCM. The presence of a consistent hydrocarbon signature from stations ECC_18 to ECC_21 is consistent with diffuse input of hydrocarbons from runoff and shipping activity, as opposed to point source input of hydrocarbons from oil and gas exploration and production where hydrocarbon contamination would typically be limited to an area of less than 1 km diameter.

3.6.1.8 The source of different organic components can sometimes be identified by examining trends in the different proportions of n-alkanes within the data (although low concentrations can skew such indices making them unrepresentative). The ratios have been reviewed as follows:

- **Carbon Preference Index (CPI):** The CPI was fairly consistent across the sample stations ranging from 0.80 to 2.02 (mean 1.52 ± 0.34 SD) for the full saturate range (**Table D 7**). The CPI at all stations was consistent with background levels calculated for the southern North Sea which have an upper 95th percentile of 2.12 (UKOOA 2001). The results indicate dominance of the more biogenic (odd- carbon-numbered) alkanes which are likely to be mostly allochthonous in origin;
- **Petrogenic/Biogenic (P/B) Ratio:** The P/B ratio compares the lighter more petrogenic aliphatics with the heavier, and more biogenic aliphatics. The ratio was variable across the Hornsea Four ECC ranging from 0.23 to 1.39 (mean 0.57 ± 0.35 SD), with the higher levels being present at the stations closest to landfall suggesting a petrogenic dominance, most likely from terrestrial run off. Further offshore, the lower values are indicative of dominance of aliphatics derived from natural biogenic origins; and
- **Pristane/Phytane (Pr/Ph) Ratio:** The isoprenoid phytane is rarely produced biogenically, only pristane is naturally biosynthesised and therefore commonly found in the marine environment. The presence of both isoprenoids at similar levels is therefore typically taken as an indication of petroleum contamination. Within the Hornsea Four offshore ECC the ratios were high at all stations (**Table D 7**) indicating a biogenic origin. However, the Pr/Ph ratio can often be difficult to interpret due to its erratic nature and use of the ratio in interpretative discourse is open to criticism, mainly owing to the natural occurrence of Ph in some older sediments and the confusing variation of sedimentary Pr, induced by the variability of phytoplankton numbers (Blumer and Snyder 1965).

3.6.2 Polycyclic Aromatic Hydrocarbons (PAHs)

3.6.2.1 A summary of the total PAH and total NPD concentrations are presented in **Table D 7**. Total PAH concentrations ranged from 0.051 $\mu g\ l^{-1}$ at station ECC_14 to 5.048 $\mu g\ l^{-1}$ at station ECC_20 (mean 0.595 $\mu g\ l^{-1}$ ± 1.208 SD), while NPD concentrations recorded values between 0.022 $\mu g\ l^{-1}$ at station ECC_02 and 2.630 $\mu g\ l^{-1}$ at station ECC_20 (mean 0.300 $\mu g\ l^{-1}$ ± 0.063 SD). Results of the single ion current (SIC) analyses are detailed in **Appendix D7** (Table B) where concentrations for both parent compounds and their alkyl derivatives are presented.

3.6.2.2 The NPDs accounted for a relatively consistent proportion of the total PAHs among the stations, with a mean of 43.7% ± 6.72 SD suggesting a mixed input of petrogenic and pyrolytic PAHs to the sediments at all stations. The NPD proportions for stations ECC_17 to ECC_23 were in excess of 50% which is consistent with the higher silt and clay content at those stations, suggesting that PAH distribution is correlated with natural variation in the sediment character throughout the Hornsea Four offshore ECC. Natural and anthropogenic contaminants often appear elevated within fine sediments and particulate matter when compared to coarse sediments due to the increased adsorption capacity of organic matter and clay minerals (OSPAR 2008). This relationship has been illustrated in the Principle Component Analysis Plot (PCA) in **Figure D 24**. Within the plot, the bubble size corresponds to the total PAH at each station, while PC1 represents smaller proportions of sand and PC2 represents larger proportions of silt and clay. The greater total PAH values tend to occur at stations with smaller proportions of sand and larger proportions of silt and clay. The correlation between total PAH and proportion of silt and clay was tested using the RELATE routine which revealed a moderate Spearman's Rank correlation of 0.451 which is significant (0.2%).

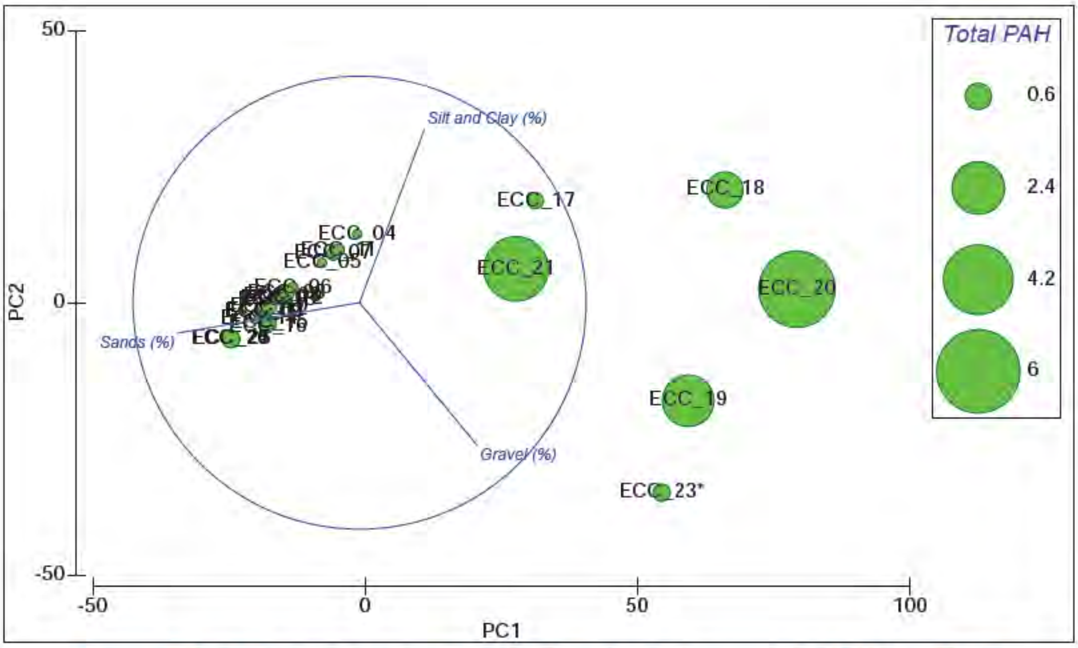

Figure D 24: PCA plot showing the relationship between total PAH and PSD.

3.6.2.3 The OSPAR background assessment concentrations (BACs) (OSPAR 2014) provide threshold concentrations below which contaminants can be considered to be representative of background levels (OSPAR 2008). Given the variation in sediment character within the Hornsea Four offshore ECC, the spatial patterns in concentrations of many contaminants, including PAHs, may be partly obscured by the varying proportions of silt and clay in the sediments in particular. Therefore, the total PAH data was normalised to the 2.5% total organic carbon content of the sediment at each station to enable comparison of results with the OSPAR BACs. The normalised data is presented in Table D 8 and have been compared with the BAC value of 357 ng g^{-1} (OSPAR 2014).

Table D 8: Normalised Total PAH

Station	Total PAH (ng g^{-1})
ECC_01	617
ECC_02	390
ECC_03	487
ECC_04	392
ECC_05	333
ECC_06	463
ECC_07	574
ECC_08	755
ECC_09	610
ECC_10	690
ECC_11	558
ECC_12	714
ECC_13	540
ECC_14	125
ECC_15	1,315
ECC_16	475

Station	Total PAH (ng g^{-1})
ECC_17	841
ECC_18	1,300
ECC_19	1,327
ECC_20	3,058
ECC_21	2,550
ECC_23	707
ECC_24	880
ECC_25	939
ECC_26	928
ECC_27	1,887
Mean	*902*
SD	*679*

3.6.2.4 From **Table D 8**, it can be seen that the mean PAH calculated from the data at all stations exceeded the OSPAR BAC threshold (OSPAR 2014). The normalised PAH data displayed a similar spatial pattern to the non-normalised data in **Table D 7** which showed elevated concentrations at stations ECC_18 to ECC_21. Station ECC_27 (the station closed to the shore) had a comparatively high normalised PAH value of 1.887 µg g^{-1}. It is suggested that the low TOC levels and relatively small proportions of silt and clay at all stations may have led to an exaggeration of the normalised total PAH values.

3.6.2.5 A breakdown of the individual PAHs are presented in **Table D 9** and **Table D 10** together with the guideline limits for each analyte where they exist. In the absence of quantified Environmental Quality Standards (EQS) for marine sediment quality, the Canadian marine sediment quality guidelines for the protection of aquatic life (Canadian Council of Ministers for the Environment (CCME) 1999) have been used to compare the PAH data against. Within these guidelines there are two threshold levels which are considered for each analyte, the first is the ISQG level which is often referred to as the Threshold Effect Level (TEL) i.e. the concentration that may affect certain sensitive species; the second is the Probable Effects Level (PEL) i.e. the concentration at which adverse biological effects are likely to occur in a wide range of species. UK Centre for Environment, Fisheries and Aquaculture Science (Cefas) AL limits do not exist for PAHs.

Table D 9: PAH analysis results compared to the Canadian sediment quality guidelines (all units are in µg kg-1).

Analyte	ISQG Level	PEL Level	ECC_01	ECC_02	ECC_03	ECC_04	ECC_05	ECC_06	ECC_07	ECC_08	ECC_09	ECC_10	ECC_11	ECC_12	ECC_13
Naphthalene	34.6	391	2.16	<1	1.42	<1	<1	1.68	2.18	3.47	3.3	2.77	1.41	1.94	1.64
Acenaphthylene	5.87	128	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Acenaphthene	6.71	88.9	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluorene	21.2	144	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Phenanthrene	86.7	544	5.98	2.19	2.68	3.27	2.56	3.64	4.67	7.46	8.09	8.06	4.59	5.08	2.75
Dibenzothiophene	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Anthracene	46.9	245	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	113	149	3.99	2.38	3.04	2.95	3.08	3.75	5.46	7.89	5.94	6.83	4.33	4.53	3.42
Pyrene	153	1398	3.08	1.69	2.37	2.24	2.24	2.82	4.41	6.14	4.69	5.34	3.41	3.66	2.61
Benzo[a]anthracene	74.8	693	1.86	<1	1.36	1.35	1.35	1.6	2.45	3.58	2.69	3.12	2.02	2.16	1.51
Chrysene	108	846	3.35	1.66	2.24	2.25	2.26	2.75	3.97	5.8	4.59	4.93	3.33	3.45	2.38
Benzo[b]fluoranthene	-	-	4.83	3.02	4.07	3.86	3.65	4.78	5.98	8.68	6.78	7.28	5.63	4.93	4.11
Benzo[k]fluoranthene	-	-	2.72	1.42	1.78	1.68	1.63	2.27	1.97	3.64	3.36	2.63	1.8	2.24	1.58
Benzo[e]pyrene	-	-	3.69	2.13	2.98	2.88	2.99	3.48	4.44	6.52	4.81	5.39	3.9	3.8	2.92
Benzo[a]pyrene	88.8	763	2.24	<1	1.72	1.78	1.63	2.06	2.7	4	2.87	3	2.22	2.23	1.81
Perylene	-	-	<1	<1	<1	<1	<1	<1	<1	1.77	<1	<1	<1	<1	<1
Indeno[123,cd]pyrene	-	-	4.27	2.89	4.09	3.98	3.8	4.59	4.91	7.96	5.47	6.31	4.87	3.82	3.56
Dibenzo[a,h]anthracene	6.22	135	<1	<1	<1	<1	<1	<1	<1	1.32	<1	<1	<1	<1	<1
Benzo[ghi]perylene	-	-	5.14	3.24	4.45	4.13	4.38	4.85	5.99	8.04	6.26	6.53	5.06	4.55	4.08

Levels within the ISQG threshold | Levels above the ISQG threshold | Levels above the PEL threshold

Table D 10: PAH analysis results compared to the Canadian marine sediment quality guidelines (all units are in µg kg^{-1}).

Analyte	ISQG Level	PEL Level	ECC_14	ECC_15	ECC_16	ECC_17	ECC_18	ECC_19	ECC_20	ECC_21	ECC_23	ECC_24	ECC_25	ECC_26	ECC_27
Naphthalene	*34.6*	*391*	<1	2.84	3.45	5.95	26.2	75.6	114	123	8.73	3.97	5.7	4.39	5.01
Acenaphthylene	*5.87*	*128*	<1	<1	<1	<1	1.92	5.06	6.75	7.11	<1	<1	<1	<1	<1
Acenaphthene	*6.71*	*88.9*	<1	<1	<1	<1	3.52	10.3	17.7	15.6	<1	<1	<1	<1	<1
Fluorene	*21.2*	*144*	<1	<1	<1	1.3	6.12	18.5	29.1	29.2	1.57	<1	1.47	<1	<1
Phenanthrene	*86.7*	*544*	1.61	9.25	6.42	10.2	58.5	93.1	258	149	12	6.39	9.91	7.65	8.73
Dibenzothiophene	-	-	<1	<1	<1	<1	4.49	8.71	22.2	14	<1	<1	<1	<1	<1
Anthracene	*46.9*	*245*	<1	<1	<1	<1	6	15	30.3	24	1.66	<1	1.44	<1	3.5
Fluoranthene	*113*	*149*	2.66	7.92	4.23	6.22	29.1	82.4	157	118	8.45	9.25	8.81	7.01	15.9
Pyrene	*153*	*1398*	1.86	6.1	3.34	6.39	30.3	75.4	156	108	7.88	9.3	8.65	7.5	14.5
Benzo[a]anthracene	*74.8*	*693*	1.08	3.31	2.02	3.42	18.2	49.1	93	73.1	4.63	3.85	4.4	3.3	8.66
Chrysene	*108*	*846*	1.85	5.2	3.65	5.25	25.1	58.3	117	88.3	6.46	7.55	7.15	6.18	11.4
Benzo[b]fluoranthene	-	-	3.13	6.18	4.03	5.16	22.9	59.3	94.4	81.3	4.93	5.85	6.04	4.64	9.51
Benzo[k]fluoranthene	-	-	<1	1.98	1.4	2.33	8.44	25	32.2	30	2.15	2.33	1.81	1.7	4.33
Benzo[e]pyrene	-	-	2.29	4.96	3.39	5.4	21.4	50.2	89.8	74.4	5.61	6.7	6.68	6.31	9.13
Benzo[a]pyrene	*88.8*	*763*	<1	2.99	2.17	3.33	17.6	46.5	81.7	67.1	4.14	3.34	4.28	3.12	8.3
Perylene	-	-	<1	<1	<1	<1	4.2	11.1	19.2	15.4	<1	1.35	1.37	<1	2.58
Indeno[123,cd]pyrene	-	-	2.53	4.21	3.19	4.08	16	40	57.8	56.4	3.04	3.33	3.78	3.06	6.47
Dibenzo[a,h]anthracene	6.22	135	<1	<1	<1	<1	3.58	9.65	14.3	13.3	<1	<1	<1	<1	1.52
Benzo[ghi]perylene	-	-	2.95	5.5	3.81	5.62	23.2	50.3	86.9	76.8	5.23	5.86	6	6.04	8.05

Levels within [redacted] Levels above the ISQG threshold Levels above the PEL threshold

3.6.2.6 **Table D 10** demonstrates that the ISQG limits were mostly marginally exceeded for a number of analytes (including naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene and dibenzoa[h]anthracene) mainly at stations ECC_20 and ECC_21 with the exception of fluoranthene at station ECC_20 which also exceeded (albeit relatively marginally) the higher PEL threshold. The ISQG for benzo[a]anthracene and chrysene were also exceeded at station ECC_20, while only acenaphthene was exceeded at station ECC_19.

3.6.3 Heavy and Trace Metal Concentrations

3.6.3.1 All the heavy metals analysed (aluminium (Al), tin (Sn), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), vanadium (V) and zinc (Zn)), underwent a single Aqua Regia (AR) digestion and extraction for total sediment metals.

3.6.3.2 The results of the heavy and trace metal analysis are provided in **Table D 11**. The concentrations have been compared with both the Canadian sediment quality guideline ISQG and PEL thresholds described above, as well as the UK's Cefas (Cefas 1994) Action Level (AL) limits. Cefas's ALs are used to assess sediments suitability for disposal at sea, they are not statutory contaminant concentrations but are used as part of a weight of evidence approach to decision making. Neither are the ALs pass or fail criteria, but thresholds for further assessment. For example, if concentrations are below AL 1, then a Marine Licence to dispose at sea is likely to be granted. If concentrations fall between AL 1 and AL 2 then further assessment is usually required. If concentrations exceed AL 2 then sediments may not be suitable for disposal at sea.

3.6.3.3 It can be seen from **Table D 10** that metal concentrations were generally low across all stations, except for As. As concentrations were quite variable across the offshore ECC, a minimum concentration of 3.7 mg kg^{-1} was found at ECC_04 and maximum of 48.7 mg kg^{-1} at ECC_14 (mean 14.8 mg kg^{-1}±11.9 SD). The Cefas AL 1 was exceeded at 14 stations, while the PEL was also marginally exceeded at station ECC_14. Notably, the sediments at all 13 stations (ECC_14 to ECC_27) within 50 km of the landfall contained As concentrations in excess of the Cefas AL 1, while only two of the 13 stations further offshore only slightly exceeded the Cefas AL 1 threshold. This spatial pattern is elucidated but comparing the means of the 13 closest stations to landfall (mean 23.7 mg kg^{-1} ± 10.9 SD) with the 13 stations furthest offshore (mean 6.0 mg kg^{-1} ± 1.7 SD). The ISQG level for Pb was exceeded at stations ECC_17 and ECC_19, while that for Ni was very slightly exceeded at station ECC_21.

3.6.3.4 Stations ECC_17, 18, 19, 20 and 21 generally contained higher concentrations of all metals except Hg which was similar throughout the Hornsea Four offshore ECC. As previously discussed for PAHs in **Section 3.6.2** above, the sediments at these stations were mixed in character but comprised larger proportions of silt and clay when compared to the stations to the west and east of the grouping within the Hornsea Four offshore ECC which may therefore explain the elevated metal concentrations found at these stations. The relationship between particle size and the normalised sum of metals is shown in the PCA plot in **Figure D 25** where bubble sizes correspond to the proportion of silt and clay in the sediments at stations. Again, PC1 represents smaller proportions of sand and PC2 larger proportions of silt and clay. The correlation between the proportions of silt and clay and total (normalised) metals was similar but slightly stronger and more significant to that observed for total PAHs with a moderate Spearman's correlation of 0.473 which was significant at the level of 0.1%.

Table D 11: Sediment metal concentrations (all units are in mg kg^{-1}).

Station	As	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	Al	Sn	Li
ECC_01	5.6	<0.04	6.9	5	5.1	<0.015	3.8	15.9	17.9	1940	<0.5	4.6
ECC_02	8.9	<0.04	8.1	4.6	5.7	<0.015	4.3	23.2	23.3	1840	<0.5	4.2
ECC_03	4.2	<0.04	7.1	5.6	5.5	<0.015	3.7	14.8	22.6	1770	<0.5	4
ECC_04	3.7	<0.04	6.8	5.3	5.6	<0.015	3.8	13.6	22.3	1690	<0.5	4.1
ECC_05	4.9	<0.04	8.1	6	6.9	<0.015	4.6	16.1	21.1	1950	<0.5	4.4
ECC_06	5.4	0.05	8.8	6.2	7.9	0.06	4.9	17.2	19.7	2080	<0.5	4.6
ECC_07	4.6	0.04	7	5.4	7.1	<0.015	3.9	14.9	36.7	1700	<0.5	4
ECC_08	5.4	0.06	7.9	7	7.8	<0.015	4.6	16	33.8	1930	<0.5	4.6
ECC_09	7.8	<0.04	9.7	6.3	8.3	<0.015	5.3	22.4	25.9	2160	<0.5	5.1
ECC_10	6.4	<0.04	8.6	5.5	8.6	<0.015	4.6	18	22.3	1880	<0.5	4.3
ECC_11	5.3	0.07	6.7	6	7	<0.015	3.8	15	22.9	1680	<0.5	4
ECC_12	9.4	<0.04	7.2	4.8	7.6	<0.015	3.9	19.4	16.4	1610	<0.5	4
ECC_13	6	0.05	8	6.7	7.7	0.03	4.2	16.7	19.9	1680	<0.5	3.7
ECC_14	48.7	0.13	10.3	5.6	20.7	<0.015	9.4	53.7	32.7	2860	<0.5	9.3
ECC_15	18.7	0.06	9.6	4.8	15.7	<0.015	4.9	29	29.2	1500	<0.5	4.7
ECC_16	20.2	<0.04	9.5	5.5	18.8	<0.015	6.1	33.4	31.6	1760	<0.5	5.3
ECC_17	37	0.04	12	5.6	35.6	<0.015	7.5	54.8	35.2	2310	<0.5	6.4
ECC_18	38	0.08	14.4	7.2	25.3	<0.015	10.8	50.4	43.8	3900	0.5	13.1
ECC_19	24	0.13	17	11.5	41.9	0.03	13.3	50	68.2	5960	1	22
ECC_20	23.3	<0.04	13.2	8.9	19	0.02	12.8	37.1	48.8	6040	1	19.9
ECC_21	15.8	0.06	20.1	15.7	24.3	0.03	20.1	40.4	63	9890	1.9	34.6
ECC_23	23.3	0.06	6.9	6.6	9.2	<0.015	9.6	29	34.5	3180	1.1	10.9
ECC_24	17.2	<0.04	8.5	6.6	17.7	<0.015	7.5	29.2	43.6	2100	1	5.8
ECC_25	15.4	<0.04	7.5	7.2	20.5	0.04	7.3	25.9	37.3	2190	1	6.6
ECC_26	12.7	<0.04	7.2	6.7	18.7	0.05	6.5	21	38.6	2120	0.9	5.8
ECC_27	14.1	<0.04	7.8	6.6	16.9	0.10	6.6	23	35.8	2190	0.9	5.8
CEFAS Action Level 1	*20*	*0.4*	*40*	*40*	*50*	*0.3*	*20*	-	*130*	-	-	-
CEFAS Action Level 2	*100*	*5*	*400*	*400*	*500*	*3*	*200*	-	*800*	-	-	-
CCME Guideline ISQG Level	*7.24*	*0.7*	*52.3*	*18.7*	*30.2*	*0.13*	-	-	*124*	-	-	-
CCME Guideline PEL Level	*41.6*	*4.2*	*160*	*108*	*112*	*0.7*	-	-	*271*	-	-	-

Levels within the ISQG and Cefas AL 1 — Levels over the ISQG or Cefas AL 1 — Levels over the PEL of Cefas AL 2

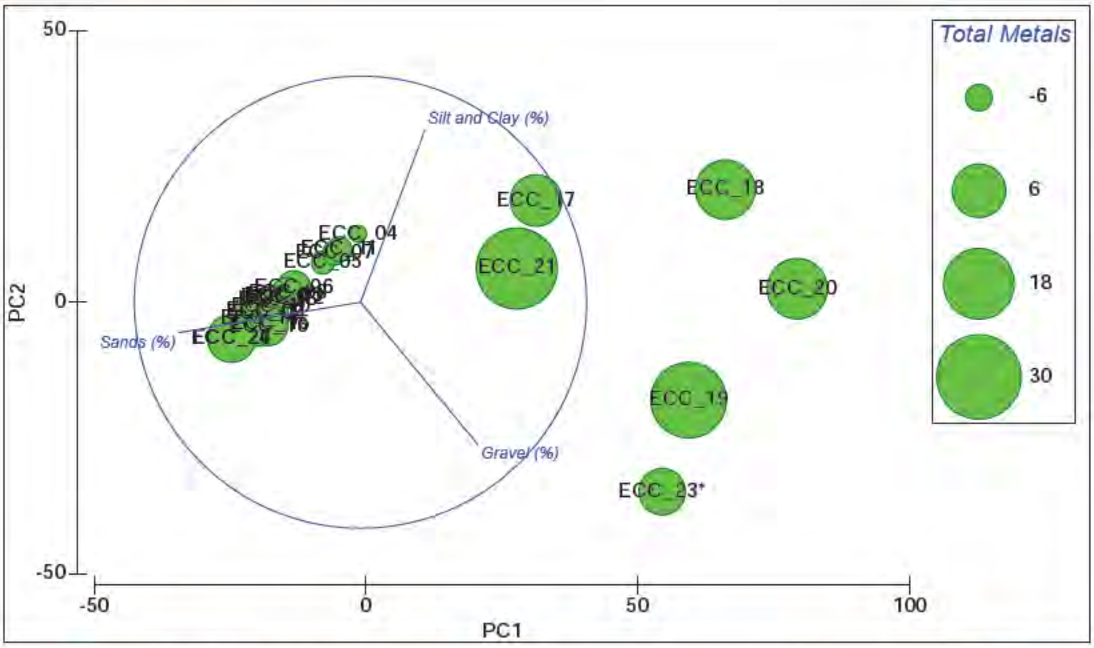

Figure D 25: PCA plot showing the relationship between total metals and PSD.

3.6.4 Normalisation of Heavy Metals

3.6.4.1 Metals data were normalised (to 52 parts per million (ppm) lithium) to enable comparison of results with OSPAR Background Concentrations (BCs) and BACs (OSPAR 2014). The resulting normalised data is shown in Table D 12 alongside the BC and BAC thresholds. BCs have been derived from analysis of sub-surface core samples to quantify pristine, pre-industrial metal concentrations, while BACs provide threshold concentrations below which contaminants can be considered to be at background levels (OSPAR 2008).

3.6.4.2 Normalisation of the Cu, Hg, Sn and Zn data was undertaken using pivot tables in accordance the current Coordinated Environmental Monitoring Programme (CEMP) normalisation procedure (OSPAR 2008). The remaining seven metals were normalised using a simple ratio approximation as some concentrations were too low to utilise pivot values (such metals are denoted with an asterisk in Table D 12).

3.6.4.3 The relationship between metal concentrations and sediment character that was identified in Section 3.6.3 above, is far less evident following normalisation of the data; this corroborates the postulation that the higher concentrations at stations with higher proportions of silt and clay are likely to be due to natural variability in the sediment character rather than due to any contaminant source/input at these stations.

3.6.4.4 V, Al, Sn and lithium (Li) have not been assigned assessment criteria within the CEMP data assessment (OSPAR 2014). With the exception of Cd and Cr, the mean of all other normalised metal concentrations exceeded the BAC levels (see Table D 12). However, it is suggested that these exceedances are most likely to be attributable to the relatively low lithium concentrations that were found throughout the offshore ECC. Furthermore, as stated above, the normalisation procedure using pivot values could not be used for several of the metals as their measured concentrations were below the pivot values. As previously seen in Table D 11, metals were generally present at low concentrations. Therefore, despite the apparent exceedances of the BACs by numerous metal analytes, metal concentrations are considered to be at background levels.

Table D.12: Normalised sediment metal concentrations (all units are in mg kg^{-1}).

Station	As*	Cd*	Cr*	Cu	Pb*	Hg	Ni*	V*	Zn	Al*	Sn	Li
ECC_01	63.9	0.23	78.7	22.8	58.2	0.1	43.3	181	56	22123	0.3	52
ECC_02	111.3	0.25	101.3	20	71.3	0.1	53.8	290	129	23000	0.3	52
ECC_03	54.1	0.26	91.4	33.5	70.8	0.1	47.6	191	124	22782	0.3	52
ECC_04	47.4	0.26	87.1	29.5	71.7	0.1	48.7	174	119	21645	0.3	52
ECC_05	57.7	0.24	95.3	35.3	81.2	0.1	54.1	189	95	22941	0.3	52
ECC_06	61.2	0.57	99.7	36.3	89.5	0.7	55.5	195	76	23564	0.3	52
ECC_07	60	0.52	90.6	31	91.8	0.1	50.4	193	307	21990	0.3	52
ECC_08	61.7	0.69	90.3	45.7	89.1	0.1	52.6	183	238	22057	0.3	52
ECC_09	79.5	0.2	98.9	33.6	84.6	0.1	54	228	132	22024	0.3	52
ECC_10	77.8	0.24	104.5	30.4	104.5	0.1	55.9	219	113	22841	0.3	52
ECC_11	69.3	0.91	87.5	39.2	91.5	0.1	49.6	196	129	21950	0.3	52
ECC_12	122.2	0.26	93.6	23.4	98.8	0.1	50.7	252	44	20930	0.3	52
ECC_13	85.5	0.71	114	52.7	109.7	0.4	59.8	238	98	23934	0.4	52
ECC_14	271.4	0.72	57.4	14.5	115.4	0	52.4	299	110	15940	0.1	52
ECC_15	207.8	0.67	106.7	20	174.4	0.1	54.4	322	180	16667	0.3	52
ECC_16	199.7	0.2	93.9	24.7	185.9	0.1	60.3	330	184	17399	0.2	52
ECC_17	299.2	0.32	97.1	21	287.9	0.1	60.7	443	180	18681	0.2	52
ECC_18	150.8	0.32	57.2	16.7	100.4	0	42.9	200	122	15481	2	52
ECC_19	56.7	0.31	40.2	20.1	99	0.1	31.4	118	130	14087	2.4	52
ECC_20	60.8	0.05	34.5	15.4	49.6	0.1	33.4	97	94	15783	2.6	52
ECC_21	23.8	0.09	30.2	19.1	36.5	0.00	30.2	61	75	14864	2.9	52
ECC_23	111.2	0.29	32.9	17.2	43.9	0.00	45.8	138	103	15171	5.2	52
ECC_24	153.7	0.18	76	32.2	158.1	0.1	67	261	273	18763	8.9	52
ECC_25	120.6	0.16	58.7	32.9	160.5	0.3	57.2	203	190	17151	7.8	52
ECC_26	113.9	0.18	64.6	33.2	167.7	0.5	22.4	188	230	19007	8.1	52
ECC_27	126.9	0.18	70.2	32.4	152	0.9	23.4	207	205	19702	8.1	52
Mean	*109.5*	*0.3*	*78.9*	*28.2*	*109.4*	*0.2*	*48.4*	*215.2*	*143.7*	*19633.7*	*2.0*	*52.0*
OSPAR BC	*15*	*0.2*	*60*	*20*	*25*	*0.05*	*30*	*-*	*90*	*-*	*-*	*-*

Note: where levels were below the detection limit, a value of half the detection limit was applied in the calculations.

** Pivot value not applied due to low initial concentration of metal.*

Levels above the OSPAR BC (yellow) Levels above the OSPAR BAC (orange)

3.6.5 Organotins

3.6.5.1 Organotin compounds, principally tributyltin (TBT), have historically been used in marine antifouling products, but their use in Europe is now prohibited for use on vessels under 25 m. Nonetheless these compounds may still be present at a background level in marine sediment. No formal BAC (BACs were developed by the OSPAR Commission for testing whether concentrations are near background levels) or Environmental Assessment Criteria (EAC) values for organotin compounds have been set, however a provisional EAC for TBT of 0.01 ng g^{-1} has been proposed by (OSPAR 2009).

3.6.5.2 The three organotin compounds which were assessed during the present survey were dibutyltin, tributyltin and monobutyltin, the concentrations of which were determined to be below detectable limits at all stations. However, the limit of detection of the method used was higher than the proposed EAC threshold.

4 Conclusions

4.1.1.1 This technical appendix has satisfied the aims and the objectives of the study by providing a comprehensive characterisation in terms of the benthic habitats, surficial sediments and seabed features across the Hornsea Four offshore ECC. This data has been used to inform the EIA and ES to accompany the development application.

4.1.1.2 The biotopes recorded are typical of the wider region and were characterised by four habitat types. These largely conform to the JNCC Habitat Classifications (JNCC 2015) and the equivalent EUNIS habitat classification codes (EEA 2017), as follows:

- SS.SSa.IMuSa.FfabMag (A5.242) - *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand;
- SS.SSa.CFiSa.ApriBatPo (A5.252) - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand;
- SS.SMX.CMx.FluHyd (A5.444) - *Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment; and
- SS.SMx.IMx (A5.4) - Infralittoral mixed sediment.

4.1.1.3 Four discreet patches of stony reef habitat were recorded as present across a portion of the Hornsea Four offshore ECC, although were scored as 'low' resemblance to Annex I stony reef, as per the qualifying criteria set out in regulatory guidance (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not be considered as contributing to the National Site Network unless there is strong justification. Based on these results and evidence from geophysical studies across the site (Bibby Hydro Map 2019), the area of 'Sandy gravel with boulders' encompassing stations ECC_22 and ECC_23 is expected to comprise a patchy mosaic of stony substrate surrounded by gravels and coarse sands, rather than extensive areas of unbroken stony reef. This habitat is typical of the wider region and has been recorded within several other development projects in the region including Dogger Bank Creyke Beck (Forewind 2013) and the Tolmount to Easington Pipeline (Premier Oil 2018).

4.1.1.4 Evidence acquired during the benthic characterisation did not reveal the presence of any other potential Annex I habitats (as defined under the Council Directive 92/43/EEC) or other protected habitats/species within the Hornsea Four offshore ECC. Although individuals of *Sabellaria spinulosa* were identified within the benthic grab samples at five stations, these were not recorded in numbers that would constitute reef (Gubbay 2007) and the only aggregation observed in the DDV footage was a small patch encrusting a pebble that would not itself be classified an Annex I reef. Detailed review of the SSS and multibeam bathymetry datasets acquired within the Hornsea Four offshore ECC by Bibby HydroMap found no evidence of the distinctive signatures which would be typically associated with the presence of biogenic reefs.

4.1.1.5 No benthic ecology constraints to development have been identified as a result of this characterisation of benthic resources across the Hornsea Four offshore ECC, although this will be subject to a detailed assessment within the ES.

5 References

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Appendix D1 – Station Data and Co-ordinates

Table A. All coordinates stated are based on the following geodetic parameters:

Datum transformation:	ETRS89	*Projection:*	UTM Zone 31 North
Ellipsoid:	GRS1980	*Latitude of Origin:*	0° North
Semi-major Axis:	6378137m	*Central Meridian:*	3° East
Inverse Flattening 1/f:	297	*False Easting:*	500000m
False Northing:	0m	*Scale Factor:*	0.9996
Datum Shift Parameters WGS84 to ETRS89 (Epoch 2019)			
dX =	+0.05400 m	rX =	+0.00243°
dY =	+0.05120 m	rY =	+0.01470°
dZ =	-0.09270 m	rZ =	-0.02376"
Scale =	+0.00286 ppm		

Vertical Datum: Lowest Astronomical Tide (LAT).

Table B. Acquired grab samples and DDV footage

Station	Actual Sampling Coordinates		Sample Acquired	Video Acquired	Comments
	Easting [m]	Northing [m]			
ECC_01	381470.77	5982723.25	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_02	379925.81	5985310.82	PSA, HM, HC1 HC2, Spare, Fauna	3xSD, 3xHD	
ECC_03	376744.59	5986468.77	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_04	373464.14	5985826.83	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_05	370970.77	5984843.37	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_06	367119.01	5985177.96	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_07	362780.00	5985049.38	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_08	360525.11	5986714.36	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_09	358473.29	5986765.23	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_10	353849.01	5986886.13	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_11	350877.49	5985575.97	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_12	347041.30	5988636.22	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_13	343353.63	5989357.74	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_14	338763.11	5990703.59	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_15	333340.29	5992932.41	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_16	328698.24	5995085.75	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_17	324284.67	5993345.90	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_18	317132.25	5994311.12	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_19	311025.14	5993455.38	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_20	309242.44	5991903.85	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_21	306662.97	5992868.30	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_22	303233.99	5991984.09	PSA	3xSD, 3xHD	Three unsuccessful attempts.
ECC_23	300550.28	5993001.01	PSA, HM, HC1 HC2, Spare, Fauna	5xSD, 5xHD	No sample on first deployment; Good fauna sample on second attempt. PC samples acquired from the small amount of sediment

Station	Actual Sampling Coordinates		Sample Acquired	Video Acquired	Comments
	Easting [m]	Northing [m]			
					acquired in the other attempts. Five grab attempts in total.
ECC_24	297615.07	5994519.05	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_25	298216.12	5990898.22	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_26	294868.70	5993108.70	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_27	293200.64	5991731.66	PSA, HM, HC1, HC2, Spare, Fauna	2xSD, 2xHD	
ECC_28	290393.35	5992199.12	No samples acquired	3xSD, 3xHD	Three attempts made but no sample due to hard clay or underlying bedrock. Station abandoned.

**PC = HC (Hydrocarbons), HM (Heavy Metals), PSA (Particle Size Analysis)*

Appendix D2 – Laboratory Analysis Methods

Particle Size Distribution

The samples recovered from each site were analysed by BSL which is accredited under the NMBAQC scheme for PSA analysis.

The sample was homogenised and split into a small sub-sample for laser diffraction and the remaining material was sieved through stainless steel sieves with mesh apertures of 8000 µm, 4000 µm and 2000 µm. In most cases almost the entire sample would pass through the sieve stack, but any material retained on the sieve, such as small shells, shell fragments and stones were removed, and the weight was recorded.

The smaller sub-sample was wet screened through a 2000 µm sieve and determined using a Malvern Mastersizer 2000 particle sizer according to standard operating procedures. The results obtained by a laser sizer have been previously validated by comparison with independent assessment by wet sieving (Hart 1996). The range of sieve sizes, together with their Wentworth classifications, is given in **Table A**. For additional quality control, all datasets were run through the Mastersizer in triplicate and the variations in sediment distributions assessed to be within the 95% percentile.

The separate assessments of the fractions above and below 2000 µm were combined using a computer programme. This followed a manual input of the sieve results for fractions 16 mm-8 mm, 8 mm-4 mm and 4 mm-2 mm fractions and the electronic data captured by the Mastersizer below 2000 µm.

This method defines the particle size distributions in terms of Phi mean, median, fraction percentages (i.e. coarse sediments, sands and fines), sorting (mixture of sediment sizes) and skewness (weighting of sediment fractions above and below the mean sediment size; Folk 1954).

Formulae and classifications for particle calculations made are given below:

Graphic Mean (M) - a very valuable measure of average particle size in Phi units (Folk and Ward 1957).

$$M = \frac{\text{ø}16 + \text{ø}50 + \text{ø}84}{3}$$

Where: M = The graphic mean particle size in Phi
ø = the Phi size of the 16th, 50th and 84th percentile of the sample

Table A. Phi and Sieve Apertures with Wentworth Classifications

Aperture in microns	Aperture in Phi Unit	Sediment Description	
2000	-1	Granule	Gravel
1400	-0.5	Very Coarse Sand	Sands
1000	0		
710	0.5	Coarse Sand	
500	1		
355	1.5	Medium Sand	
250	2		
180	2.5	Fine Sand	
125	3		
90	3.5	Very Fine Sand	
63	4		
44	4.5	Coarse Silt	Fines (Silts)
31.5	5		
22	5.5	Medium Silt	
15.6	6		
11	6.5	Fine Silt	
7.8	7		
5.5	7.5	Very Fine Silt	
3.9	8		
2	9	Clay	Fines (Clays)
1	10		

Sorting (D) – the inclusive graphic standard deviation of the sample is a measure of the degree of sorting (Table B).

$$D = \frac{ø84 + ø16}{4} + \frac{ø95 + ø5}{6.6}$$

Where: D = the inclusive graphic standard deviation

ø = the Phi size of the 84^{th}, 16^{th}, 95^{th} and 5^{th} percentile of the sample

Table B. Sorting Classifications

Sorting Coefficient (Graphical Standard Deviation)	*Sorting Classifications*
0.00 < 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

Skewness (S) – the degree of asymmetry of a frequency or cumulative curve (**Table C**).

$$S = \frac{\varnothing 84 + \varnothing 16 - (\varnothing 50)}{2(\varnothing 84 - \varnothing 16)} + \frac{\varnothing 95 + \varnothing 5 - 2(\varnothing 50)}{2(\varnothing 95 - \varnothing 5)}$$

Where: S = the skewness of the sample
ø = the Phi size of the 84th, 16th, 50th, 95th and 5th percentile of the sample

Table C. Skewness Classifications

Skewness Coefficient	Mathematical Skewness	Graphical Skewness
+1.00 > +0.30	Strongly positive	Strongly coarse skewed
+0.30 > +0.10	Positive	Coarse skewed
+0.10 > -0.10	Near symmetrical	Symmetrical
-0.10 > -0.30	Negative	Fine skewed
-0.30 > -1.00	Strongly negative	Strongly fine skewed

Graphic Kurtosis (K) – The degree of peakedness or departure from the 'normal' frequency or cumulative curve (**Table D**).

$$K = \frac{\varnothing 95 - \varnothing 5}{2.44(\varnothing 75 - \varnothing 25)}$$

Where: K = Kurtosis
ø = the Phi size of the 95th, 5th, 75th and 25th percentile of the sample

Table D. Kurtosis Classifications

Kurtosis Coefficient	Kurtosis Classification	Graphical meaning
0.41 < 0.67	Very Platykurtic	Flat-peaked; the ends are better sorted than the centre
0.67 < 0.90	Platykurtic	
0.90 < 1.10	Mesokurtic	Normal; bell shaped curve
1.11 < 1.50	Leptokurtic	Curves are excessively peaked; the centre is better sorted than the ends.
1.50 < 3.00	Very Leptokurtic	
3.00 +	Extremely Leptokurtic	

Sediment TOC and TOM

Organic and carbon sediments are analysed using a combination of tests. These include Total Carbon (TC), analysed using a known weight of dried soil and combusted at 1,300°C and the amount of carbon determined by Infra-Red detection, and TOC (see below). In addition to the standard accreditation as outlined below, additional analytical quality control (AQC), is carried out with every batch where a soil of known value is determined (every batch of 20 samples or part thereof). Blank determinations are also carried out routinely where required.

Total Inorganic Carbon (TIC) is determined by calculation: TC –TOC = TIC

TOC was analysed using an Eltra combustion method. This method is used for total carbon analysis of dried, crushed rock powder and environmental soil samples. The samples are previously treated with 10% HCl to remove inorganic carbon (Carbonates) before washing to remove residual acids and further dried. The Carbon Analyser heats the sample in a flow of oxygen and any carbon present is converted to carbon dioxide which is measured by infra-red absorption. The percentage carbon is then calculated with respect to the original sample weight. The range for the method is 0.01% - 100%.

TOM was analysed using 1 g of air dried and ground sample (<200 µm) placed in a crucible and dried in an oven at 50±2.5°C until constant weight was achieved. The final sample weight was recorded to the nearest 0.01% and the sample was allowed to cool in a desiccator. The sample was then placed in a muffle furnace and heated to 440±25°C for 4 hours. The crucible was removed from the furnace and allowed to cool to room temperature in a desiccator. The crucible was then reweighed and the percentage loss on ignition calculated. This test is reported to 0.01% and is accredited under the United Kingdom Accreditation Service (UKAS) scheme.

Hydrocarbon Concentrations (THC and Aliphatics)

General Precautions

High purity solvents were used throughout the analyses. Solvent purity was assessed by evaporating an appropriate volume to 1 ml and analysing the concentrate by GC for general hydrocarbons, target n-alkanes and aromatics. All glassware and extraction sundries were cleaned prior to use by thorough rinsing with hydrocarbon-free deionised water followed by two rinses with dichloromethane (DCM). All glassware was heated in a high temperature oven at 450°C for 6 hours.

Extraction Procedure for Hydrocarbons

Each analytical sample (15±0.1 g) was spiked with an internal standard solution containing the following components: aliphatics - heptamethylnonane, 1-chlorooctadecane and squalane. The sample was then wet vortex extracted using three successive aliquots of dichloromethane (DCM/)Methanol. The extracts were combined and water partitioned to remove the methanol and any excess water from the sample.

Solvent extracts were chemically dried and then reduced to approximately 1 ml using a Kuderna Danish evaporator with micro Snyder.

Column fractionation for Aliphatic and Aromatic Fractions

The concentrated extract was transferred to a pre-conditioned flash chromatography column containing approximately 1 g of activated Silica gel. The compounds were eluted with 3 ml of Pentane/DCM (2:1). An aliquot of the extract was then taken and analysed for THC content and individual n-alkanes by large volume injection GC-FID.

Quality Control Samples

The following quality control samples were prepared with the batches of sediment samples:

- A method blank comprising 15±0.1 g of baked anhydrous sodium sulphate (organic free) treated as a sample.
- A matrix matched standard sample consisting of 15±0.1 g baked sand spiked with Florida mix and treated as sample.

- A sample duplicate - any one sample from the batch, dependent upon available sample mass, analysed in duplicate.

Hydrocarbon Analysis

Analysis of THC and aliphatics was performed by using an Agilent 6890 with an FID detector. Appropriate column and GC conditions were used to provide sufficient chromatographic separation of all analytes and the required sensitivity.

Carbon Preference Index

The carbon preference index is calculated as follows:

$$CPI = \frac{\text{odd homologues } (nC_{11} \text{ to } nC_{35})}{\text{even homologues } (nC_{10} \text{ to } nC_{34})}$$

Petrogenic/Biogenic or (P/B) Ratio

The Petrogenic/Biogenic Ratio is calculated as follows:

$$P/B \text{ Ratio} = \frac{P = \text{sum of } nC_{10} \text{ to } nC_{20}}{B = \text{sum of } nC_{21} \text{ to } nC_{35}}$$

Calibration and Calculation

GC techniques require the use of internal standards in order to obtain quantitative results. The technique requires addition of non-naturally occurring compounds to the sample, allowing correction for varying recovery.

Target analytes concentrations were calculated by comparison with the nearest eluting internal standards. A relative response factor was applied to correct the data for the differing responses of target analytes and internal standards. Response factors were established prior to running samples, from solutions containing United States Environmental Protection Agency (US EPA) (16) PAHs + Dibenzothiophene (DBT) for the gas chromatography–mass spectrometry (GCMS), Florida mix (even n-Alkanes nC_{10}-nC_{40}) for individual GC-FID targets and a Diesel/Mineral Oil mix for total oil determination.

The mean detection limits used for the sediment total hydrocarbons and n-alkanes were:

- n-alkane – 1 $ng.g^{-1}$ (ppb)
- Total Hydrocarbons – 100 $ng.g^{-1}$ (ppb)

Heavy and Trace Metal Concentrations

Sediment samples were homogenised and a 50 g portion of each sample was air dried at room temperature. Each sample was then ground down to a fine powder (<100 μm) by hand using a metal free mortar and pestle. A clean sand sample was hand ground prior to preparation of the field samples as a blank.

Sample Digestion Procedure

Approximately 1 g of the sediment was accurately weighed out and transferred to a beaker and wet with approximately 20 ml of distilled water. Hydrochloric acid (6 ml) and Nitric acids (2 ml) were added, and the covered sample left to digest for 4 hours in a steam bath.

After digestion, the sample was filtered through a Whatman 542 filter paper into a 100 ml standard flask. The watch-glass and beaker were rinsed thoroughly, transferring the washings to the filter paper. The filter paper was rinsed until the volume was approximately 90 ml. The filter funnel was rinsed into the flask and then the flask was made up to volume and mixed well. The filtrate was then analysed by inductively coupled plasma - optical emission spectrometry ICP-OES and/or inductively coupled plasma - mass spectrometry (ICP-MS).

The mean detection limits are given in **Table E** for easily leachable (Aqua Regia) digestions.

Table E. Heavy Metals - Mean Detection Limits (MDL)

Analyte	*Unit*	*MDL*
Ni	$\mu g.g^{-1}$	0.5
V	$\mu g.g^{-1}$	0.5
Al	$\mu g.g^{-1}$	10
Zn	$\mu g.g^{-1}$	2
Cu	$\mu g.g^{-1}$	0.5
Cr	$\mu g.g^{-1}$	0.5
As	$\mu g.g^{-1}$	0.5
Cd	$\mu g.g^{-1}$	0.04
Pb	$\mu g.g^{-1}$	0.5
Sn	$\mu g.g^{-1}$	0.5
Hg	$\mu g.g^{-1}$	0.015

Mercury Digestion Procedure

Approximately 1 g of the sediment was accurately weighed and transferred to a beaker. Hydrogen peroxide (10 ml of 30 volumes) was added, and the covered sample left to digest for 0.5 hour in the fume cupboard. 10 ml of nitric acid was added and the sample placed on the hotplate for 1 hour.

After digestion, the sample was filtered through a Whatman 542 filter paper into a 100 ml standard flask. The watch-glass and beaker were rinsed thoroughly, transferring the washings to the filter paper. The filter paper was rinsed until the volume was approximately 90 ml. Subsequently, the filter funnel was rinsed into the flask and then the flask was made up to 100 ml volume and mixed well. The filtrate was then analysed by ICP-MS.

Analytical Methodology

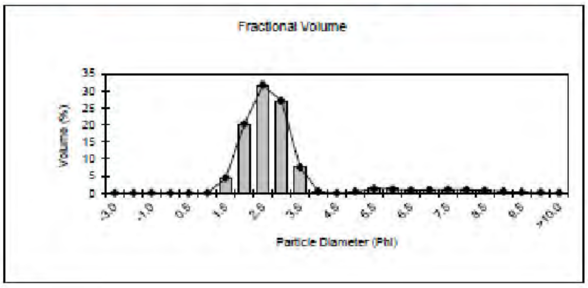
Inductively Coupled-Plasma Optical Emission Spectrometry
The instrument is calibrated using dilutions of the 1 ml (=10 mg) spectroscopic solutions. The final calibration solutions are matrix matched with the relevant acids. The calibration line consists of five standards.

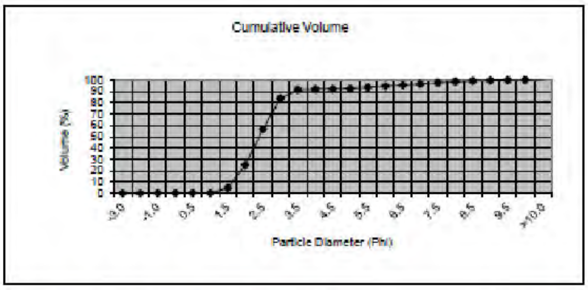
Inductively Coupled Plasma- Mass Spectrometry
The instrument is calibrated using dilutions of the 1 ml (=10 mg) spectroscopic solutions. The calibration line consists of seven standards.

The analytes are scaled against internal standards to take account of changes in plasma conditions as a result of matrix differences for standards and samples. The internal standards have a similar mass and ionisation properties to the target metals.

Appendix D3 – Particle Size Distribution

Sample No.:	ECC_01	Operator	ER
Source Data:	Orsted _LOT 7	Date&Time:	24/06/2019 10:08

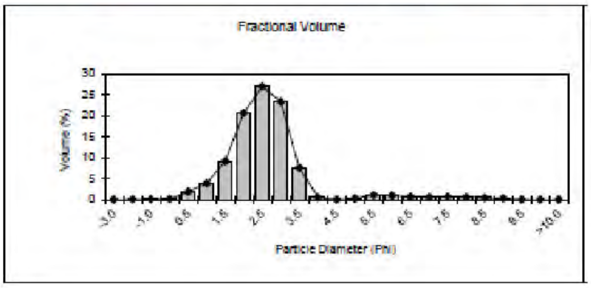


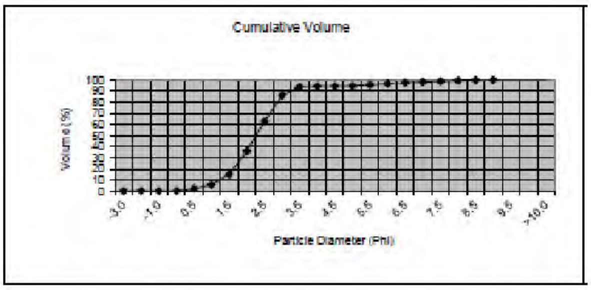


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.02	0.0	
2.0000	-1.0	0.06	0.1	Granule
1.0000	0.0	0.04	0.1	V.Coarse Sand
0.7100	0.5	0.00	0.1	Coarse Sand
0.5000	1.0	0.07	0.2	
0.3550	1.5	4.50	4.7	Medium Sand
0.2500	2.0	20.25	24.9	
0.1800	2.5	31.64	56.6	Fine Sand
0.1250	3.0	27.00	83.6	
0.0900	3.5	7.66	91.2	V.Fine Sand
0.0630	4.0	0.47	91.7	
0.0440	4.5	0.00	91.7	Coarse Silt
0.0315	5.0	0.41	92.1	
0.0220	5.5	1.27	93.4	Medium Silt
0.0156	6.0	1.08	94.5	
0.0110	6.5	0.86	95.3	Fine silt
0.0078	7.0	0.92	96.2	
0.0055	7.5	1.07	97.3	V.Fine Silt
0.0039	8.0	0.99	98.3	
0.0028	8.5	0.73	99.0	Coarse Clay
0.0020	9.0	0.47	99.5	
0.0014	9.5	0.28	99.8	Medium Clay
0.0010	10.0	0.15	99.9	
<0.001	>10.0	0.07	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.192	0.116	2.38
Median	0.195		2.36
Sorting Coefficient	Value: 1.04	Inference: Poorly Sorted	
Skewness	0.34	Very Positive (Coarse)	
Kurtosis	2.42	Very Leptokurtic	
% Fines	8.31%	Fine Sand	
% Sands	91.62%		
% Gravel	0.07%		

Sample No.:	ECC_02	Operator	ER
Source Data:	Orsted _LOT 7	Date&Time:	24/06/2019 10:43

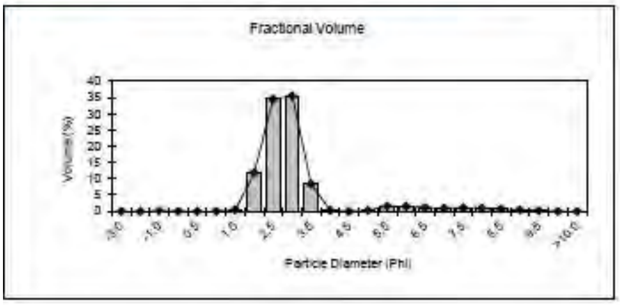


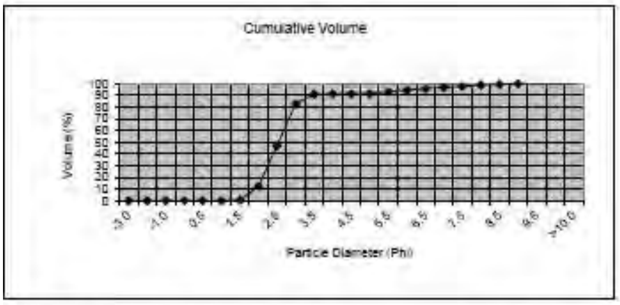


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.05	0.0	
2.0000	-1.0	0.10	0.1	Granule
1.0000	0.0	0.12	0.3	V.Coarse Sand
0.7100	0.5	1.86	2.1	Coarse Sand
0.5000	1.0	3.83	6.0	
0.3550	1.5	9.19	15.1	Medium Sand
0.2500	2.0	20.66	35.8	
0.1800	2.5	26.97	62.8	Fine Sand
0.1250	3.0	23.28	86.0	
0.0900	3.5	7.61	93.7	V.Fine Sand
0.0630	4.0	0.54	94.2	
0.0440	4.5	0.00	94.2	Coarse Silt
0.0315	5.0	0.27	94.5	
0.0220	5.5	1.15	95.6	Medium Silt
0.0156	6.0	0.99	96.6	
0.0110	6.5	0.68	97.3	Fine silt
0.0078	7.0	0.62	97.9	
0.0055	7.5	0.70	98.6	V.Fine Silt
0.0039	8.0	0.64	99.2	
0.0028	8.5	0.45	99.7	Coarse Clay
0.0020	9.0	0.28	100.0	
0.0014	9.5	0.03	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.213	0.171	2.23
Median	0.213		2.23
Sorting Coefficient	Value: 1.02	Inference: Poorly Sorted	
Skewness	0.18	Positive(Coarse)	
Kurtosis	1.76	Very Leptokurtic	
% Fines	5.80%	Fine Sand	
% Sands	94.05%		
% Gravel	0.15%		

Sample No.:	ECC_03	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 11:18

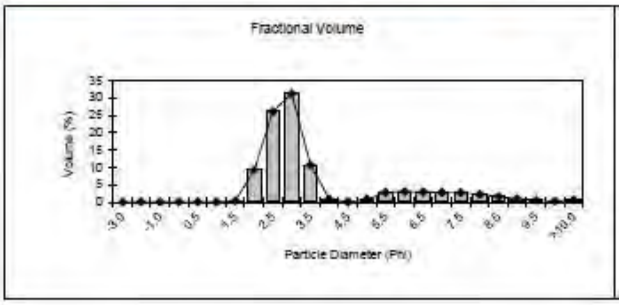


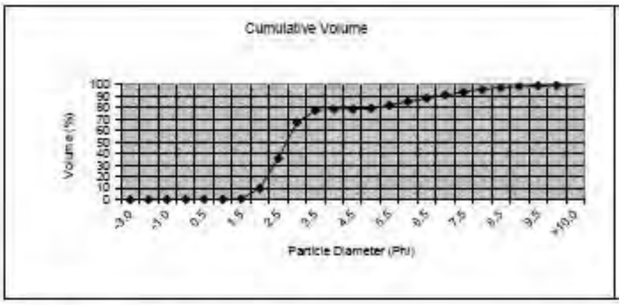


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.01	0.0	
2.0000	-1.0	0.08	0.1	Granule
1.0000	0.0	0.03	0.1	V.Coarse Sand
0.7100	0.5	0.00	0.1	Coarse Sand
0.5000	1.0	0.00	0.1	
0.3550	1.5	0.45	0.6	Medium Sand
0.2500	2.0	11.78	12.4	
0.1800	2.5	34.59	46.9	Fine Sand
0.1250	3.0	35.57	82.5	
0.0900	3.5	8.40	90.9	V.Fine Sand
0.0630	4.0	0.27	91.2	
0.0440	4.5	0.00	91.2	Coarse Silt
0.0315	5.0	0.27	91.4	
0.0220	5.5	1.53	93.0	Medium Silt
0.0156	6.0	1.52	94.5	
0.0110	6.5	1.15	95.6	Fine silt
0.0078	7.0	1.00	96.6	
0.0055	7.5	1.06	97.7	V.Fine Silt
0.0039	8.0	0.96	98.7	
0.0028	8.5	0.69	99.4	Coarse Clay
0.0020	9.0	0.42	99.8	
0.0014	9.5	0.23	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.172	0.096	2.54
Median	0.175		2.51
Sorting	**Value**	**Inference**	
Coefficient	0.95	Moderately Sorted	
Skewness	0.36	Very Positive (Coarse)	
Kurtosis	2.60	Very Leptokurtic	
% Fines	8.83%	Fine Sand	
% Sands	91.09%		
% Gravel	0.09%		

Sample No.:	ECC_04	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 11:26

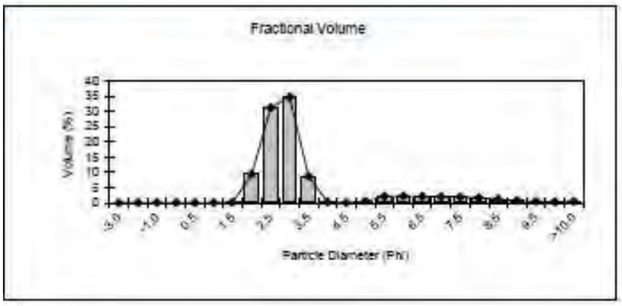


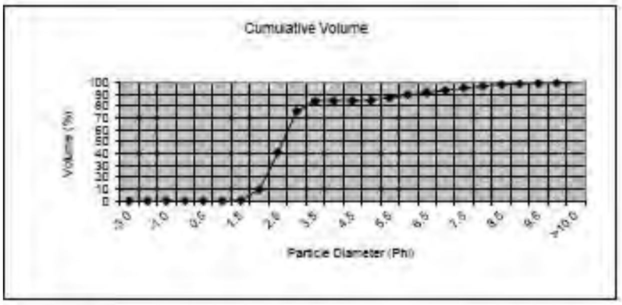


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.05	0.0	
2.0000	-1.0	0.06	0.1	Granule
1.0000	0.0	0.06	0.2	V.Coarse Sand
0.7100	0.5	0.00	0.2	Coarse Sand
0.5000	1.0	0.00	0.2	
0.3550	1.5	0.41	0.6	Medium Sand
0.2500	2.0	9.25	9.8	
0.1800	2.5	26.05	35.9	Fine Sand
0.1250	3.0	31.21	67.1	
0.0900	3.5	10.64	77.7	V.Fine Sand
0.0630	4.0	0.88	78.6	
0.0440	4.5	0.00	78.6	Coarse Silt
0.0315	5.0	0.81	79.4	
0.0220	5.5	2.77	82.2	Medium Silt
0.0156	6.0	3.05	85.3	
0.0110	6.5	2.93	88.2	Fine silt
0.0078	7.0	2.80	91.0	
0.0055	7.5	2.70	93.7	V.Fine Silt
0.0039	8.0	2.24	95.9	
0.0028	8.5	1.56	97.5	Coarse Clay
0.0020	9.0	0.98	98.5	
0.0014	9.5	0.58	99.0	Medium Clay
0.0010	10.0	0.35	99.4	
<0.001	>10.0	0.61	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.087	0.115	3.52
Median	0.155		2.69
Sorting	**Value**	**Inference**	
Coefficient	1.84	Poorly Sorted	
Skewness	0.68	Very Positive (Coarse)	
Kurtosis	2.30	Very Leptokurtic	
% Fines	21.38%	V.Fine Sands	
% Sands	78.51%		
% Gravel	0.11%		

Sample No.:	ECC_05	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 11:41

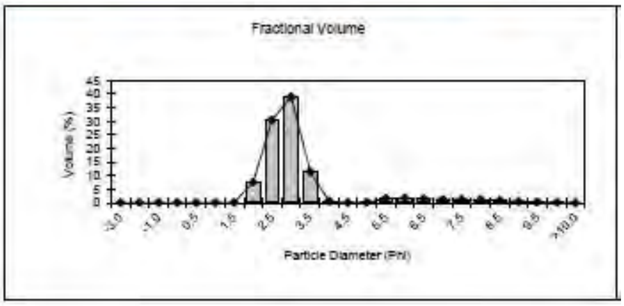


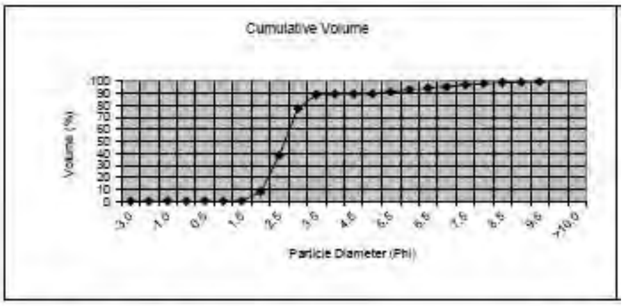


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.02	0.0	
2.0000	-1.0	0.07	0.1	Granule
1.0000	0.0	0.07	0.2	V.Coarse Sand
0.7100	0.5	0.00	0.2	Coarse Sand
0.5000	1.0	0.00	0.2	
0.3550	1.5	0.22	0.4	Medium Sand
0.2500	2.0	9.35	9.7	
0.1800	2.5	31.15	40.9	Fine Sand
0.1250	3.0	34.67	75.5	
0.0900	3.5	8.69	84.2	V.Fine Sand
0.0630	4.0	0.30	84.5	
0.0440	4.5	0.00	84.5	Coarse Silt
0.0315	5.0	0.53	85.1	
0.0220	5.5	2.18	87.2	Medium Silt
0.0156	6.0	2.26	89.5	
0.0110	6.5	2.01	91.5	Fine silt
0.0078	7.0	1.92	93.4	
0.0055	7.5	1.94	95.4	V.Fine Silt
0.0039	8.0	1.65	97.0	
0.0028	8.5	1.16	98.2	Coarse Clay
0.0020	9.0	0.73	98.9	
0.0014	9.5	0.42	99.3	Medium Clay
0.0010	10.0	0.25	99.6	
<0.001	>10.0	0.43	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.153	0.105	2.71
Median	0.166		2.59
Sorting	**Value**	**Inference**	
Coefficient	1.20	Poorly Sorted	
Skewness	0.47	Very Positive (Coarse)	
Kurtosis	2.99	Very Leptokurtic	
% Fines	15.48%	Fine Sand	
% Sands	84.44%		
% Gravel	0.09%		

Sample No.:	ECC_06	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 11:59

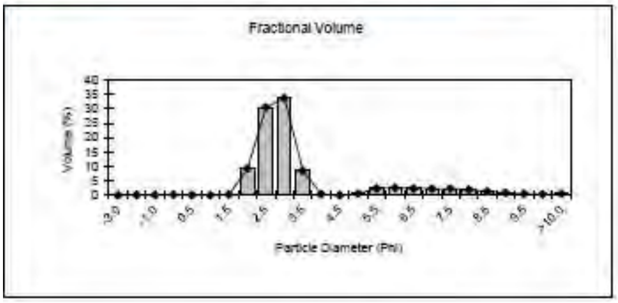


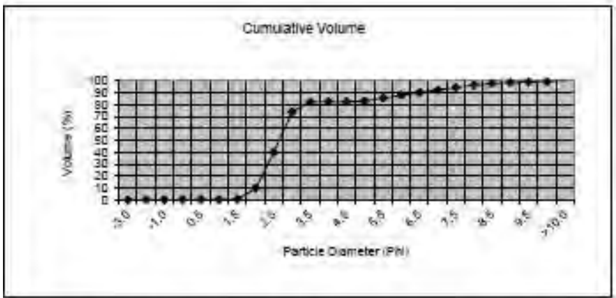


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.04	0.0	Pebble
4.0000	-2.0	0.04	0.1	
2.0000	-1.0	0.10	0.2	Granule
1.0000	0.0	0.05	0.2	V.Coarse Sand
0.7100	0.5	0.00	0.2	Coarse Sand
0.5000	1.0	0.00	0.2	
0.3550	1.5	0.08	0.3	Medium Sand
0.2500	2.0	7.61	7.9	
0.1800	2.5	30.44	38.4	Fine Sand
0.1250	3.0	39.10	77.5	
0.0900	3.5	11.53	89.0	V.Fine Sand
0.0630	4.0	0.57	89.6	
0.0440	4.5	0.00	89.6	Coarse Silt
0.0315	5.0	0.23	89.8	
0.0220	5.5	1.64	91.4	Medium Silt
0.0156	6.0	1.75	93.2	
0.0110	6.5	1.38	94.6	Fine silt
0.0078	7.0	1.22	95.8	
0.0055	7.5	1.28	97.1	V.Fine Silt
0.0039	8.0	1.16	98.2	
0.0028	8.5	0.83	99.1	Coarse Clay
0.0020	9.0	0.52	99.6	
0.0014	9.5	0.29	99.9	Medium Clay
0.0010	10.0	0.14	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.159	0.097	2.66
Median	0.164		2.61
Sorting	**Value**	**Inference**	
Coefficient	1.02	Poorly Sorted	
Skewness	0.39	Very Positive (Coarse)	
Kurtosis	2.80	Very Leptokurtic	
% Fines	10.43%	Fine Sand	
% Sands	89.39%		
% Gravel	0.18%		

Sample No.:	ECC_07	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 12:10

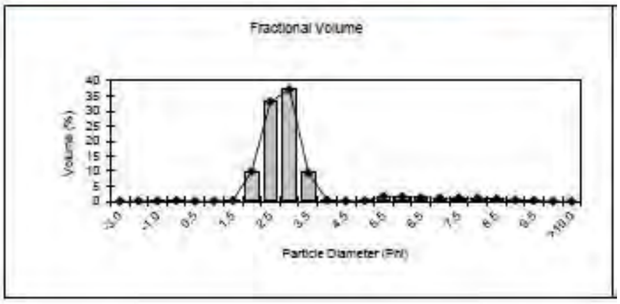


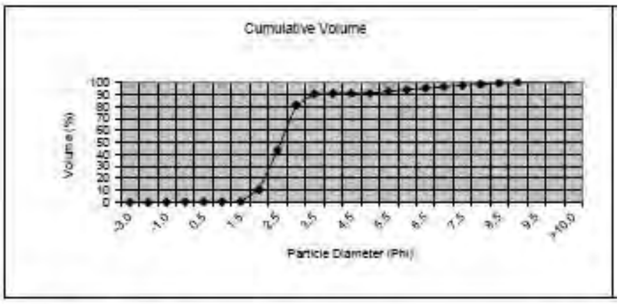


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.02	0.0	
2.0000	-1.0	0.07	0.1	Granule
1.0000	0.0	0.19	0.3	V.Coarse Sand
0.7100	0.5	0.00	0.3	Coarse Sand
0.5000	1.0	0.00	0.3	
0.3550	1.5	0.21	0.5	Medium Sand
0.2500	2.0	9.20	9.7	
0.1800	2.5	30.43	40.1	Fine Sand
0.1250	3.0	33.71	73.8	
0.0900	3.5	8.50	82.3	V.Fine Sand
0.0630	4.0	0.31	82.6	
0.0440	4.5	0.00	82.6	Coarse Silt
0.0315	5.0	0.54	83.2	
0.0220	5.5	2.30	85.5	Medium Silt
0.0156	6.0	2.49	88.0	
0.0110	6.5	2.30	90.3	Fine silt
0.0078	7.0	2.23	92.5	
0.0055	7.5	2.24	94.7	V.Fine Silt
0.0039	8.0	1.89	96.6	
0.0028	8.5	1.31	97.9	Coarse Clay
0.0020	9.0	0.81	98.8	
0.0014	9.5	0.46	99.2	Medium Clay
0.0010	10.0	0.28	99.5	
<0.001	>10.0	0.50	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.103	0.112	3.28
Median	0.164		2.61
Sorting Coefficient	Value 1.65	Inference Poorly Sorted	
Skewness	0.68	Very Positive (Coarse)	
Kurtosis	2.86	Very Leptokurtic	
% Fines	17.36%	v.Fine Sands	
% Sands	82.55%		
% Gravel	0.09%		

Sample No.:	ECC_08	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 12:21

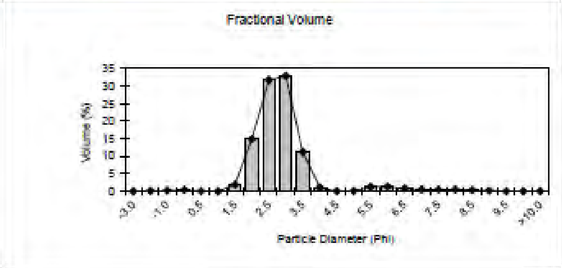


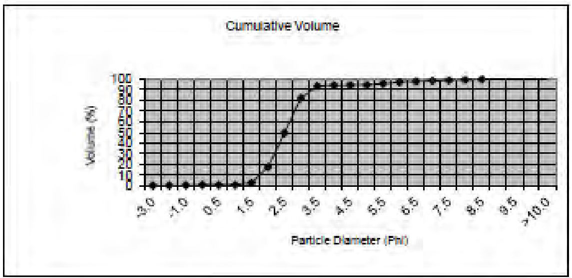


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.01	0.0	Pebble
4.0000	-2.0	0.04	0.0	
2.0000	-1.0	0.13	0.2	Granule
1.0000	0.0	0.24	0.4	V.Coarse Sand
0.7100	0.5	0.00	0.4	Coarse Sand
0.5000	1.0	0.00	0.4	
0.3550	1.5	0.25	0.7	Medium Sand
0.2500	2.0	9.91	10.6	
0.1800	2.5	33.05	43.6	Fine Sand
0.1250	3.0	37.16	80.8	
0.0900	3.5	9.52	90.3	V.Fine Sand
0.0630	4.0	0.35	90.7	
0.0440	4.5	0.00	90.7	Coarse Silt
0.0315	5.0	0.22	90.9	
0.0220	5.5	1.56	92.4	Medium Silt
0.0156	6.0	1.59	94.0	
0.0110	6.5	1.20	95.2	Fine silt
0.0078	7.0	1.06	96.3	
0.0055	7.5	1.15	97.4	V.Fine Silt
0.0039	8.0	1.06	98.5	
0.0028	8.5	0.77	99.3	Coarse Clay
0.0020	9.0	0.47	99.7	
0.0014	9.5	0.26	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.166	0.093	2.59
Median	0.171		2.55
Sorting Coefficient	Value 0.98	Inference Moderately Sorted	
Skewness	0.37	Very Positive (Coarse)	
Kurtosis	2.69	Very Leptokurtic	
% Fines	9.34%	Fine Sand	
% Sands	90.49%		
% Gravel	0.17%		

Sample No.:	ECC_09	Operator	ER
Source Data:	Orsted _LOT 7	Date&Time:	24/06/2019 12:42

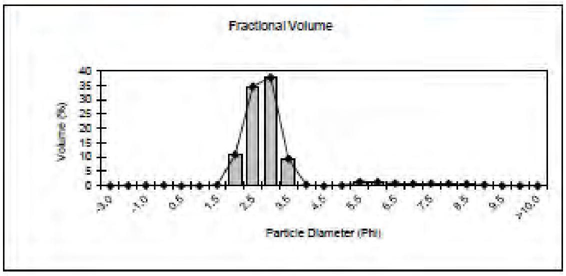


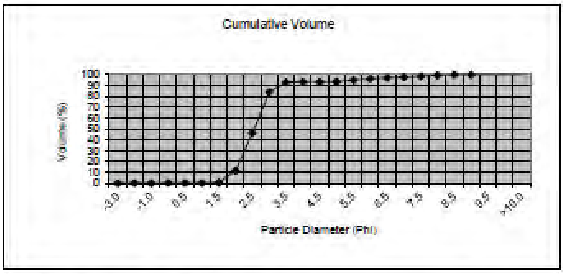


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.09	0.1	
2.0000	-1.0	0.17	0.3	Granule
1.0000	0.0	0.38	0.6	V.Coarse Sand
0.7100	0.5	0.00	0.6	Coarse Sand
0.5000	1.0	0.02	0.7	
0.3550	1.5	1.92	2.6	Medium Sand
0.2500	2.0	14.98	17.6	
0.1800	2.5	31.78	49.3	Fine Sand
0.1250	3.0	32.95	82.3	
0.0900	3.5	11.26	93.6	V.Fine Sand
0.0630	4.0	1.04	94.6	
0.0440	4.5	0.00	94.6	Coarse Silt
0.0315	5.0	0.10	94.7	
0.0220	5.5	1.29	96.0	Medium Silt
0.0156	6.0	1.28	97.3	
0.0110	6.5	0.75	98.0	Fine silt
0.0078	7.0	0.48	98.5	
0.0055	7.5	0.51	99.0	V.Fine Silt
0.0039	8.0	0.50	99.5	
0.0028	8.5	0.35	99.9	Coarse Clay
0.0020	9.0	0.15	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.177	0.102	2.49
Median	0.179		2.48
Sorting	**Value**	**Inference**	
Coefficient	0.82	Moderately Sorted	
Skewness	0.26	Positive(Coarse)	
Kurtosis	1.88	Very Leptokurtic	
% Fines	5.41%	Fine Sand	
% Sands	94.33%		
% Gravel	0.26%		

Sample No.:	ECC_10	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:01

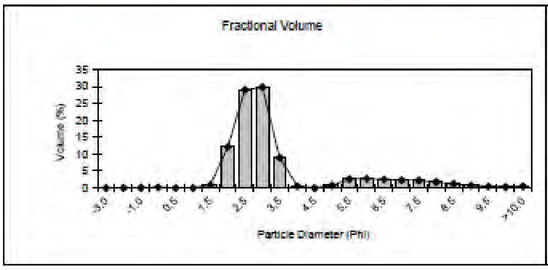


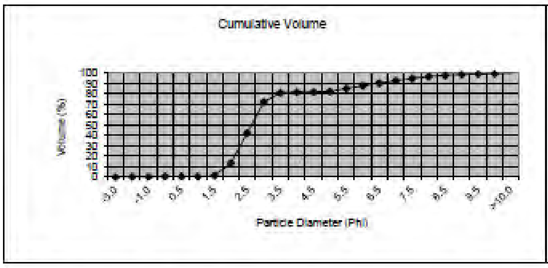


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.05	0.1	
2.0000	-1.0	0.09	0.1	Granule
1.0000	0.0	0.15	0.3	V.Coarse Sand
0.7100	0.5	0.00	0.3	Coarse Sand
0.5000	1.0	0.00	0.3	
0.3550	1.5	0.30	0.6	Medium Sand
0.2500	2.0	10.79	11.4	
0.1800	2.5	34.60	46.0	Fine Sand
0.1250	3.0	37.79	83.8	
0.0900	3.5	9.40	93.2	V.Fine Sand
0.0630	4.0	0.32	93.5	
0.0440	4.5	0.00	93.5	Coarse Silt
0.0315	5.0	0.11	93.6	
0.0220	5.5	1.36	95.0	Medium Silt
0.0156	6.0	1.31	96.3	
0.0110	6.5	0.84	97.1	Fine silt
0.0078	7.0	0.65	97.8	
0.0055	7.5	0.73	98.5	V.Fine Silt
0.0039	8.0	0.70	99.2	
0.0028	8.5	0.49	99.7	Coarse Clay
0.0020	9.0	0.28	100.0	
0.0014	9.5	0.03	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.173	0.091	2.53
Median	0.174		2.52
Sorting	**Value**	**Inference**	
Coefficient	0.82	Moderately Sorted	
Skewness	0.29	Positive(Coarse)	
Kurtosis	2.27	Very Leptokurtic	
% Fines	6.51%	Fine Sand	
% Sands	93.35%		
% Gravel	0.14%		

Sample No.:	ECC_11	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:20



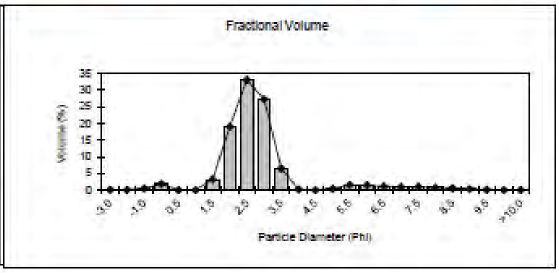


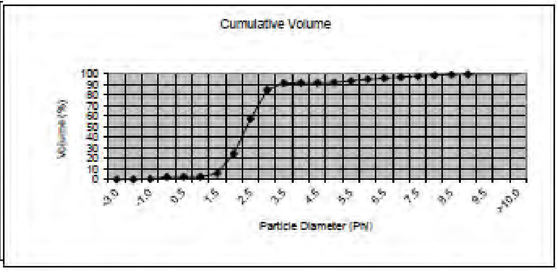
Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.06	0.1	
2.0000	-1.0	0.07	0.1	Granule
1.0000	0.0	0.20	0.3	V.Coarse Sand
0.7100	0.5	0.00	0.3	Coarse Sand
0.5000	1.0	0.00	0.3	
0.3550	1.5	0.88	1.2	Medium Sand
0.2500	2.0	12.13	13.3	
0.1800	2.5	29.11	42.5	Fine Sand
0.1250	3.0	29.83	72.3	
0.0900	3.5	8.95	81.2	V.Fine Sand
0.0630	4.0	0.58	81.8	
0.0440	4.5	0.00	81.8	Coarse Silt
0.0315	5.0	0.76	82.6	
0.0220	5.5	2.61	85.2	Medium Silt
0.0156	6.0	2.77	88.0	
0.0110	6.5	2.54	90.5	Fine silt
0.0078	7.0	2.33	92.8	
0.0055	7.5	2.19	95.0	V.Fine Silt
0.0039	8.0	1.78	96.8	
0.0028	8.5	1.21	98.0	Coarse Clay
0.0020	9.0	0.75	98.8	
0.0014	9.5	0.45	99.2	Medium Clay
0.0010	10.0	0.29	99.5	
<0.001	>10.0	0.51	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.102	0.121	3.29
Median	0.166		2.59

Sorting	Value	Inference
Coefficient	1.69	Poorly Sorted
Skewness	0.66	Very Positive (Coarse)
Kurtosis	2.51	Very Leptokurtic
% Fines	18.19%	V.Fine Sands
% Sands	81.68%	
% Gravel	0.13%	

Sample No.:	ECC_12	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:32





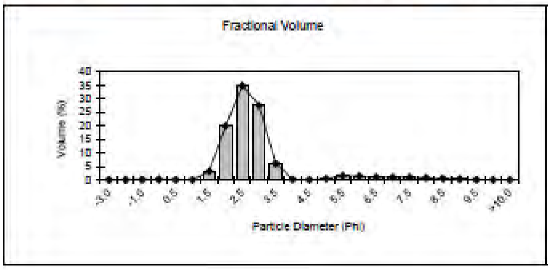
Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.08	0.1	Pebble
4.0000	-2.0	0.06	0.1	
2.0000	-1.0	0.49	0.6	Granule
1.0000	0.0	1.85	2.5	V.Coarse Sand
0.7100	0.5	0.00	2.5	Coarse Sand
0.5000	1.0	0.02	2.5	
0.3550	1.5	3.15	5.7	Medium Sand
0.2500	2.0	19.01	24.7	
0.1800	2.5	33.10	57.8	Fine Sand
0.1250	3.0	27.21	85.0	
0.0900	3.5	6.47	91.5	V.Fine Sand
0.0630	4.0	0.22	91.7	
0.0440	4.5	0.00	91.7	Coarse Silt
0.0315	5.0	0.42	92.1	
0.0220	5.5	1.54	93.6	Medium Silt
0.0156	6.0	1.44	95.1	
0.0110	6.5	1.12	96.2	Fine silt
0.0078	7.0	0.99	97.2	
0.0055	7.5	0.99	98.2	V.Fine Silt
0.0039	8.0	0.83	99.0	
0.0028	8.5	0.56	99.6	Coarse Clay
0.0020	9.0	0.32	99.9	
0.0014	9.5	0.12	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

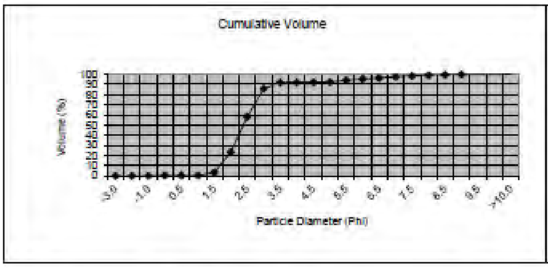
Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.195	0.120	2.36
Median	0.196		2.35

Sorting	Value	Inference
Coefficient	1.00	Poorly Sorted
Skewness	0.30	Positive(Coarse)
Kurtosis	2.41	Very Leptokurtic
% Fines	8.33%	Fine Sand
% Sands	91.03%	
% Gravel	0.64%	

Sample ECC_13

Sample No.:	ECC_13	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:44





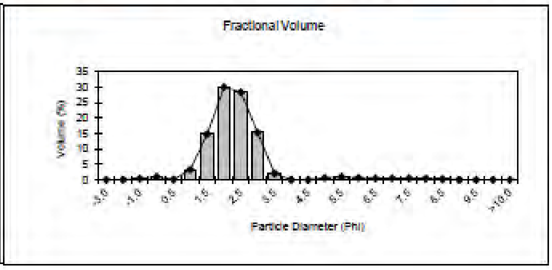
Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.03	0.0	
2.0000	-1.0	0.08	0.1	Granule
1.0000	0.0	0.24	0.4	V.Coarse Sand
0.7100	0.5	0.00	0.4	Coarse Sand
0.5000	1.0	0.01	0.4	
0.3550	1.5	3.18	3.5	Medium Sand
0.2500	2.0	19.97	23.5	
0.1800	2.5	34.88	58.4	Fine Sand
0.1250	3.0	27.59	86.0	
0.0900	3.5	6.02	92.0	V.Fine Sand
0.0630	4.0	0.14	92.1	
0.0440	4.5	0.00	92.1	Coarse Silt
0.0315	5.0	0.44	92.6	
0.0220	5.5	1.53	94.1	Medium Silt
0.0156	6.0	1.37	95.5	
0.0110	6.5	1.04	96.5	Fine silt
0.0078	7.0	0.93	97.4	
0.0055	7.5	0.94	98.4	V.Fine Silt
0.0039	8.0	0.78	99.2	
0.0028	8.5	0.52	99.7	Coarse Clay
0.0020	9.0	0.30	100.0	
0.0014	9.5	0.03	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

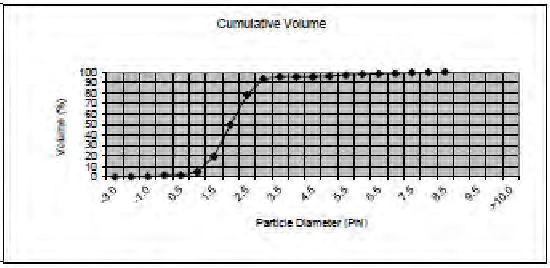
Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.194	0.110	2.36
Median	0.197		2.34

Sorting	Value	Inference
Coefficient	0.94	Moderately Sorted
Skewness	0.33	Very Positive (Coarse)
Kurtosis	2.34	Very Leptokurtic
% Fines	7.86%	Fine Sand
% Sands	92.03%	
% Gravel	0.11%	

Sample ECC_14

Sample No.:	ECC_14	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 15:03



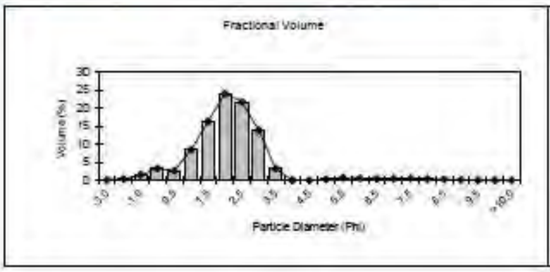


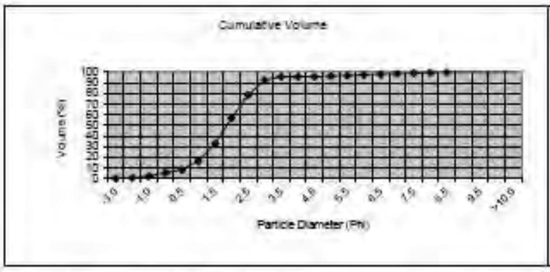
Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.05	0.1	
2.0000	-1.0	0.41	0.5	Granule
1.0000	0.0	1.00	1.5	V.Coarse Sand
0.7100	0.5	0.11	1.6	Coarse Sand
0.5000	1.0	3.30	4.9	
0.3550	1.5	14.84	19.7	Medium Sand
0.2500	2.0	30.10	49.8	
0.1800	2.5	28.41	78.2	Fine Sand
0.1250	3.0	15.31	93.5	
0.0900	3.5	2.10	95.6	V.Fine Sand
0.0630	4.0	0.00	95.6	
0.0440	4.5	0.01	95.6	Coarse Silt
0.0315	5.0	0.61	96.2	
0.0220	5.5	0.96	97.2	Medium Silt
0.0156	6.0	0.65	97.9	
0.0110	6.5	0.49	98.4	Fine silt
0.0078	7.0	0.50	98.9	
0.0055	7.5	0.50	99.4	V.Fine Silt
0.0039	8.0	0.39	99.7	
0.0028	8.5	0.23	100.0	Coarse Clay
0.0020	9.0	0.02	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.250	0.145	2.00
Median	0.250		2.00

Sorting	Value	Inference
Coefficient	0.67	Moderately Well Sorted
Skewness	0.07	Symmetrical
Kurtosis	1.13	Leptokurtic
% Fines	4.37%	Fine Sand
% Sands	95.17%	
% Gravel	0.46%	

Sample No.:	ECC_15	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 15:15



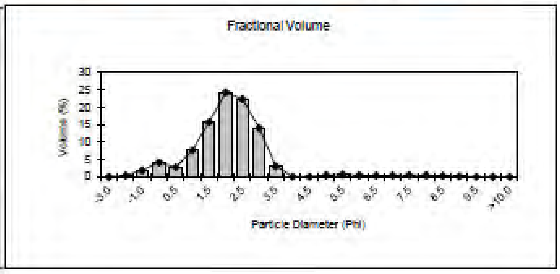


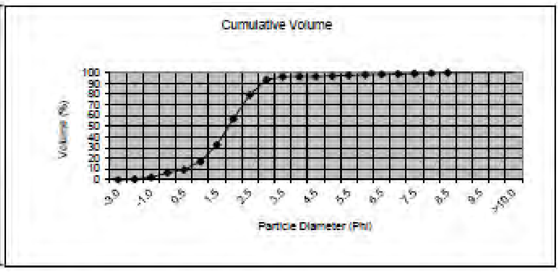
Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.15	0.2	Pebble
4.0000	-2.0	0.41	0.6	
2.0000	-1.0	1.49	2.1	Granule
1.0000	0.0	3.34	5.4	V.Coarse Sand
0.7100	0.5	2.68	8.1	Coarse Sand
0.5000	1.0	8.42	16.5	
0.3550	1.5	16.40	32.9	Medium Sand
0.2500	2.0	23.96	56.9	
0.1800	2.5	21.71	78.6	Fine Sand
0.1250	3.0	13.93	92.5	
0.0900	3.5	3.23	95.7	V.Fine Sand
0.0630	4.0	0.06	95.8	
0.0440	4.5	0.00	95.8	Coarse Silt
0.0315	5.0	0.36	96.2	
0.0220	5.5	0.73	96.9	Medium Silt
0.0156	6.0	0.58	97.5	
0.0110	6.5	0.50	98.0	Fine silt
0.0078	7.0	0.54	98.5	
0.0055	7.5	0.56	99.1	V.Fine Silt
0.0039	8.0	0.46	99.6	
0.0028	8.5	0.30	99.9	Coarse Clay
0.0020	9.0	0.14	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.283	0.331	1.82
Median	0.280		1.84

	Value	Inference
Sorting Coefficient	0.96	Moderately Sorted
Skewness	-0.08	Symmetrical
Kurtosis	1.25	Leptokurtic
% Fines	4.18%	Medium Sand
% Sands	93.77%	
% Gravel	2.06%	

Sample No.:	ECC_16	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 15:40



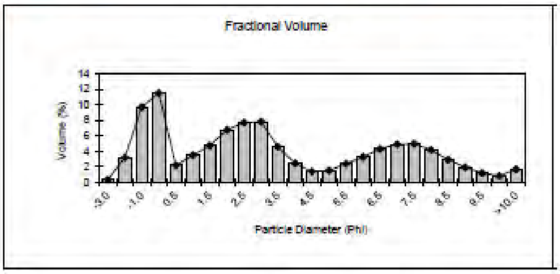


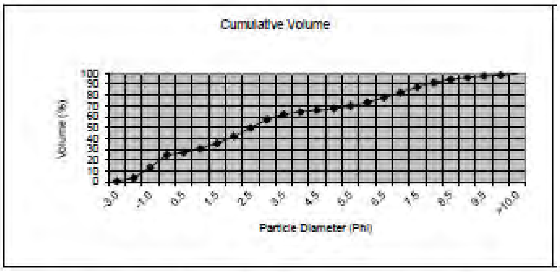
Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.41	0.4	
2.0000	-1.0	1.88	2.3	Granule
1.0000	0.0	4.20	6.5	V.Coarse Sand
0.7100	0.5	2.72	9.2	Coarse Sand
0.5000	1.0	7.66	16.9	
0.3550	1.5	15.73	32.6	Medium Sand
0.2500	2.0	24.28	56.9	
0.1800	2.5	22.37	79.2	Fine Sand
0.1250	3.0	14.04	93.3	
0.0900	3.5	3.03	96.3	V.Fine Sand
0.0630	4.0	0.06	96.4	
0.0440	4.5	0.01	96.4	Coarse Silt
0.0315	5.0	0.45	96.8	
0.0220	5.5	0.68	97.5	Medium Silt
0.0156	6.0	0.44	97.9	
0.0110	6.5	0.35	98.3	Fine silt
0.0078	7.0	0.41	98.7	
0.0055	7.5	0.47	99.2	V.Fine Silt
0.0039	8.0	0.41	99.6	
0.0028	8.5	0.28	99.9	Coarse Clay
0.0020	9.0	0.13	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.287	0.398	1.80
Median	0.280		1.84

	Value	Inference
Sorting Coefficient	0.98	Moderately Sorted
Skewness	-0.15	Negative (Fine)
Kurtosis	1.33	Leptokurtic
% Fines	3.63%	Medium Sand
% Sands	94.08%	
% Gravel	2.29%	

Sample No.:	ECC_17	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 15:57

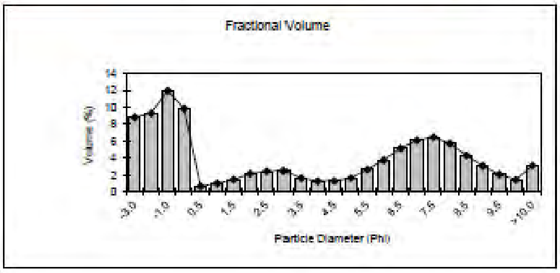


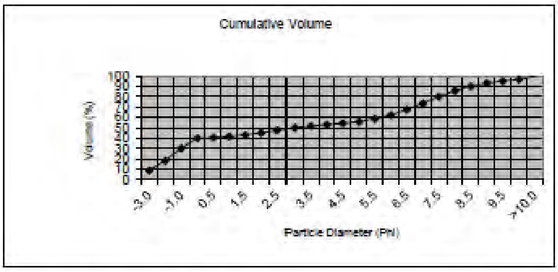


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.35	0.3	Pebble
4.0000	-2.0	3.21	3.6	
2.0000	-1.0	9.71	13.3	Granule
1.0000	0.0	11.53	24.8	V.Coarse Sand
0.7100	0.5	2.21	27.0	Coarse Sand
0.5000	1.0	3.49	30.5	
0.3550	1.5	4.74	35.2	Medium Sand
0.2500	2.0	6.77	42.0	
0.1800	2.5	7.70	49.7	Fine Sand
0.1250	3.0	7.83	57.5	
0.0900	3.5	4.59	62.1	V.Fine Sand
0.0630	4.0	2.45	64.6	
0.0440	4.5	1.39	66.0	Coarse Silt
0.0315	5.0	1.51	67.5	
0.0220	5.5	2.40	69.9	Medium Silt
0.0156	6.0	3.26	73.1	
0.0110	6.5	4.31	77.4	Fine silt
0.0078	7.0	4.90	82.3	
0.0055	7.5	4.96	87.3	V.Fine Silt
0.0039	8.0	4.15	91.4	
0.0028	8.5	2.94	94.4	Coarse Clay
0.0020	9.0	1.93	96.3	
0.0014	9.5	1.21	97.5	Medium Clay
0.0010	10.0	0.80	98.3	
<0.001	>10.0	1.67	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.130	1.382	2.94
Median	0.178		2.49
Sorting Coefficient	Value 3.58	Inference Very Poorly Sorted	
Skewness	0.17	Positive(Coarse)	
Kurtosis	0.70	Platykurtic	
% Fines	35.43%	Fine Sand	
% Sands	51.31%		
% Gravel	13.26%		

Sample No.:	ECC_18	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 16:11

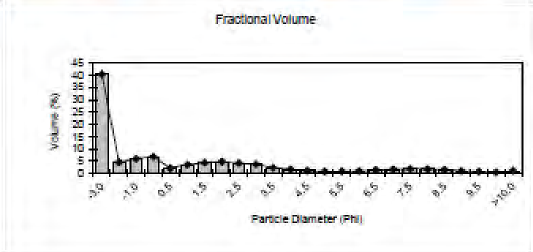


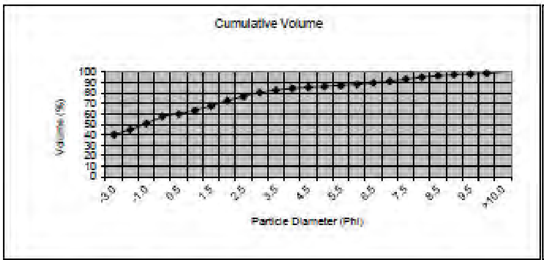


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	8.83	8.8	Pebble
4.0000	-2.0	9.30	18.1	
2.0000	-1.0	11.94	30.1	Granule
1.0000	0.0	9.85	39.9	V.Coarse Sand
0.7100	0.5	0.67	40.6	Coarse Sand
0.5000	1.0	1.00	41.6	
0.3550	1.5	1.46	43.1	Medium Sand
0.2500	2.0	2.17	45.2	
0.1800	2.5	2.45	47.7	Fine Sand
0.1250	3.0	2.50	50.2	
0.0900	3.5	1.64	51.8	V.Fine Sand
0.0630	4.0	1.28	53.1	
0.0440	4.5	1.31	54.4	Coarse Silt
0.0315	5.0	1.67	56.1	
0.0220	5.5	2.67	58.8	Medium Silt
0.0156	6.0	3.76	62.5	
0.0110	6.5	5.17	67.7	Fine silt
0.0078	7.0	6.11	73.8	
0.0055	7.5	6.47	80.3	V.Fine Silt
0.0039	8.0	5.72	86.0	
0.0028	8.5	4.32	90.3	Coarse Clay
0.0020	9.0	3.06	93.4	
0.0014	9.5	2.08	95.4	Medium Clay
0.0010	10.0	1.44	96.9	
<0.001	>10.0	3.12	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.141	3.740	2.82
Median	0.129		2.96
Sorting Coefficient	Value 4.44	Inference Extremely Poorly Sorted	
Skewness	-0.01	Symmetrical	
Kurtosis	0.60	Very Platykurtic	
% Fines	46.91%	Fine Sand	
% Sands	23.02%		
% Gravel	30.08%		

Sample No.:	ECC_19	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 16:43

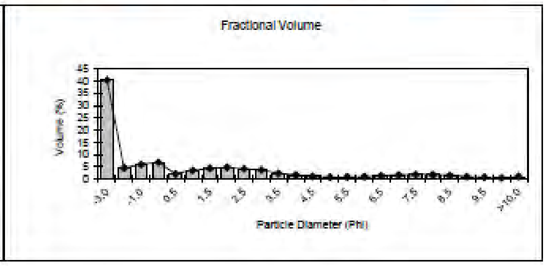


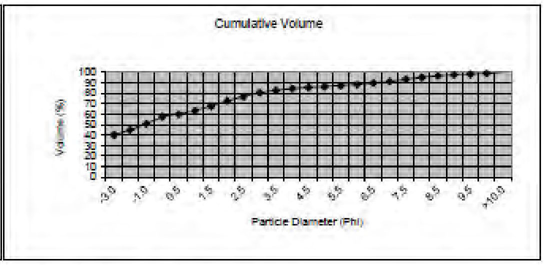


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	40.45	40.4	Pebble
4.0000	-2.0	4.52	45.0	
2.0000	-1.0	6.00	51.0	Granule
1.0000	0.0	6.76	57.7	V.Coarse Sand
0.7100	0.5	2.19	59.9	Coarse Sand
0.5000	1.0	3.58	63.5	
0.3550	1.5	4.38	67.9	Medium Sand
0.2500	2.0	4.82	72.7	
0.1800	2.5	4.20	76.9	Fine Sand
0.1250	3.0	3.72	80.6	
0.0900	3.5	2.35	83.0	V.Fine Sand
0.0630	4.0	1.67	84.6	
0.0440	4.5	1.11	85.7	Coarse Silt
0.0315	5.0	0.79	86.5	
0.0220	5.5	0.85	87.4	Medium Silt
0.0156	6.0	1.01	88.4	
0.0110	6.5	1.37	89.8	Fine silt
0.0078	7.0	1.67	91.4	
0.0055	7.5	1.88	93.3	V.Fine Silt
0.0039	8.0	1.78	95.1	
0.0028	8.5	1.45	96.5	Coarse Clay
0.0020	9.0	1.09	97.6	
0.0014	9.5	0.77	98.4	Medium Clay
0.0010	10.0	0.53	98.9	
<0.001	>10.0	1.07	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	1.715	16.938	-0.78
Median	2.323		-1.22
Sorting	Value	Inference	
Coefficient	4.17	Extremely Poorly Sorted	
Skewness	0.27	Positive(Coarse)	
Kurtosis	0.81	Platykurtic	
% Fines	15.36%	V.Coarse Sand	
% Sands	33.67%		
% Gravel	50.97%		

Sample No.:	ECC_19	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 16:43

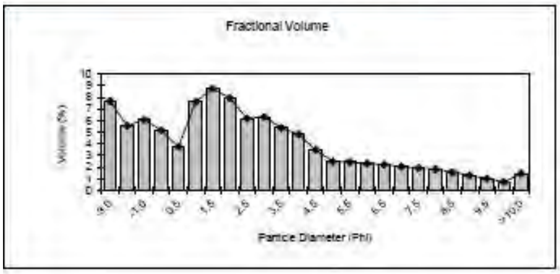


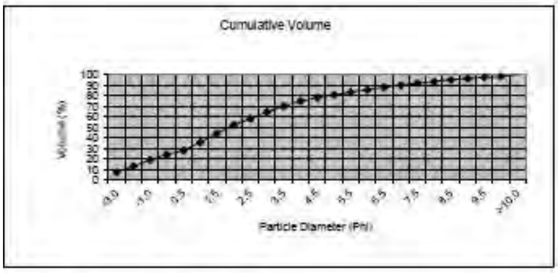


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	40.45	40.4	Pebble
4.0000	-2.0	4.52	45.0	
2.0000	-1.0	6.00	51.0	Granule
1.0000	0.0	6.76	57.7	V.Coarse Sand
0.7100	0.5	2.19	59.9	Coarse Sand
0.5000	1.0	3.58	63.5	
0.3550	1.5	4.38	67.9	Medium Sand
0.2500	2.0	4.82	72.7	
0.1800	2.5	4.20	76.9	Fine Sand
0.1250	3.0	3.72	80.6	
0.0900	3.5	2.35	83.0	V.Fine Sand
0.0630	4.0	1.67	84.6	
0.0440	4.5	1.11	85.7	Coarse Silt
0.0315	5.0	0.79	86.5	
0.0220	5.5	0.85	87.4	Medium Silt
0.0156	6.0	1.01	88.4	
0.0110	6.5	1.37	89.8	Fine silt
0.0078	7.0	1.67	91.4	
0.0055	7.5	1.88	93.3	V.Fine Silt
0.0039	8.0	1.78	95.1	
0.0028	8.5	1.45	96.5	Coarse Clay
0.0020	9.0	1.09	97.6	
0.0014	9.5	0.77	98.4	Medium Clay
0.0010	10.0	0.53	98.9	
<0.001	>10.0	1.07	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	1.715	16.938	-0.78
Median	2.323		-1.22
Sorting	Value	Inference	
Coefficient	4.17	Extremely Poorly Sorted	
Skewness	0.27	Positive(Coarse)	
Kurtosis	0.81	Platykurtic	
% Fines	15.36%	V.Coarse Sand	
% Sands	33.67%		
% Gravel	50.97%		

Sample No.:	ECC_21	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 09:26

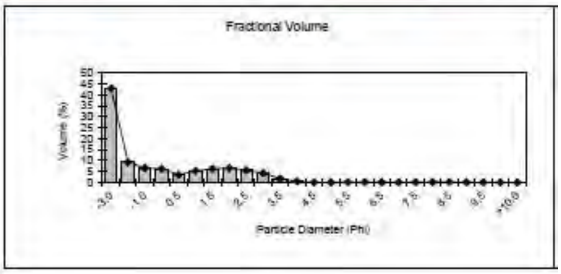


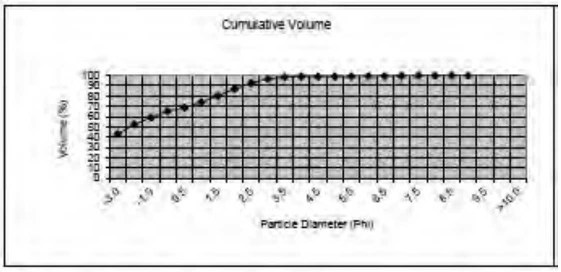


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	7.68	7.7	Pebble
4.0000	-2.0	5.54	13.2	
2.0000	-1.0	6.08	19.3	Granule
1.0000	0.0	5.16	24.5	V.Coarse Sand
0.7100	0.5	3.76	28.2	Coarse Sand
0.5000	1.0	7.61	35.8	
0.3550	1.5	8.73	44.6	Medium Sand
0.2500	2.0	7.92	52.5	
0.1800	2.5	6.18	58.7	Fine Sand
0.1250	3.0	6.33	65.0	
0.0900	3.5	5.37	70.4	V.Fine Sand
0.0630	4.0	4.82	75.2	
0.0440	4.5	3.50	78.7	Coarse Silt
0.0315	5.0	2.49	81.2	
0.0220	5.5	2.45	83.6	Medium Silt
0.0156	6.0	2.30	85.9	
0.0110	6.5	2.22	88.1	Fine silt
0.0078	7.0	2.04	90.2	
0.0055	7.5	1.96	92.1	V.Fine Silt
0.0039	8.0	1.82	93.9	
0.0028	8.5	1.57	95.5	Coarse Clay
0.0020	9.0	1.30	96.8	
0.0014	9.5	1.01	97.8	Medium Clay
0.0010	10.0	0.73	98.6	
<0.001	>10.0	1.44	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.263	3.564	1.93
Median	0.283		1.82
Sorting	**Value**	**Inference**	
Coefficient	3.56	Very Poorly Sorted	
Skewness	0.08	Symmetrical	
Kurtosis	1.22	Leptokurtic	
% Fines	24.83%	Medium Sand	
% Sands	55.87%		
% Gravel	19.30%		

Sample No.:	ECC_23	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 09:38

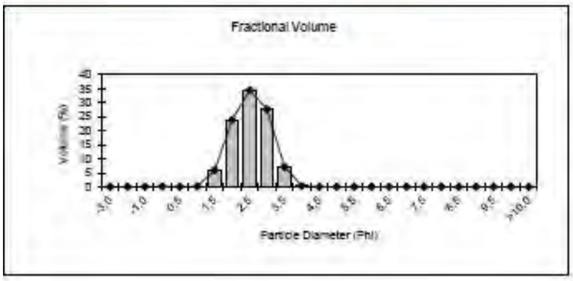


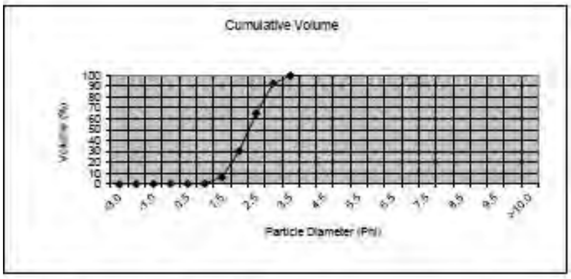


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	43.15	43.1	Pebble
4.0000	-2.0	9.33	52.5	
2.0000	-1.0	6.59	59.1	Granule
1.0000	0.0	6.21	65.3	V.Coarse Sand
0.7100	0.5	3.49	68.8	Coarse Sand
0.5000	1.0	5.30	74.1	
0.3550	1.5	6.23	80.3	Medium Sand
0.2500	2.0	6.65	86.9	
0.1800	2.5	5.52	92.5	Fine Sand
0.1250	3.0	4.22	96.7	
0.0900	3.5	1.78	98.5	V.Fine Sand
0.0630	4.0	0.48	98.9	
0.0440	4.5	0.00	98.9	Coarse Silt
0.0315	5.0	0.07	99.0	
0.0220	5.5	0.18	99.2	Medium Silt
0.0156	6.0	0.16	99.3	
0.0110	6.5	0.12	99.5	Fine silt
0.0078	7.0	0.12	99.6	
0.0055	7.5	0.13	99.7	V.Fine Silt
0.0039	8.0	0.12	99.8	
0.0028	8.5	0.10	99.9	Coarse Clay
0.0020	9.0	0.07	100.0	
0.0014	9.5	0.01	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	3.089	10.506	-1.63
Median	5.063		-2.34
Sorting	**Value**	**Inference**	
Coefficient	2.63	Very Poorly Sorted	
Skewness	0.37	Very Positive (Coarse)	
Kurtosis	0.60	Very Platykurtic	
% Fines	1.07%	Granule	
% Sands	39.86%		
% Gravel	59.07%		

Sample No.:	ECC_24	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 09:49

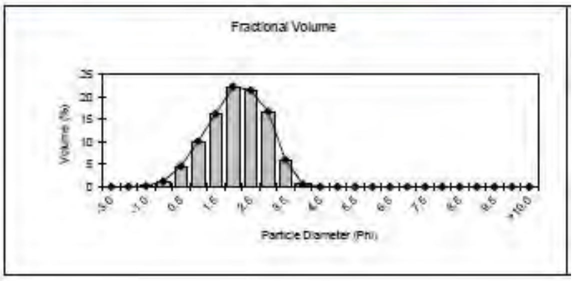


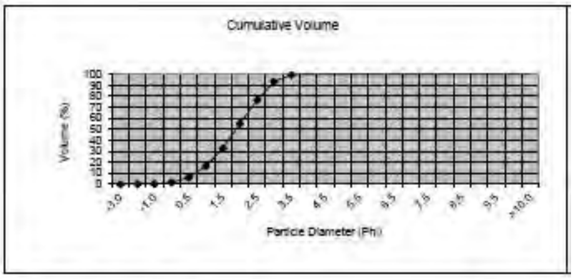


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.01	0.0	
2.0000	-1.0	0.03	0.0	Granule
1.0000	0.0	0.14	0.2	V.Coarse Sand
0.7100	0.5	0.00	0.2	Coarse Sand
0.5000	1.0	0.19	0.4	
0.3550	1.5	6.01	6.4	Medium Sand
0.2500	2.0	23.87	30.3	
0.1800	2.5	34.52	64.8	Fine Sand
0.1250	3.0	27.71	92.5	
0.0900	3.5	7.24	99.7	V.Fine Sand
0.0630	4.0	0.27	100.0	
0.0440	4.5	0.00	100.0	Coarse Silt
0.0315	5.0	0.00	100.0	
0.0220	5.5	0.00	100.0	Medium Silt
0.0156	6.0	0.00	100.0	
0.0110	6.5	0.00	100.0	Fine silt
0.0078	7.0	0.00	100.0	
0.0055	7.5	0.00	100.0	V.Fine Silt
0.0039	8.0	0.00	100.0	
0.0028	8.5	0.00	100.0	Coarse Clay
0.0020	9.0	0.00	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.210	0.102	2.25
Median	0.210		2.25
Sorting	**Value**	**Inference**	
Coefficient	0.56	Moderately Well Sorted	
Skewness	0.00	Symmetrical	
Kurtosis	0.94	Mesokurtic	
% Fines	0.00%	Fine Sand	
% Sands	99.96%		
% Gravel	0.04%		

Sample No.:	ECC_25	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 10:02

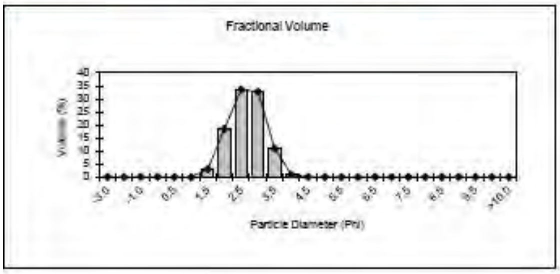


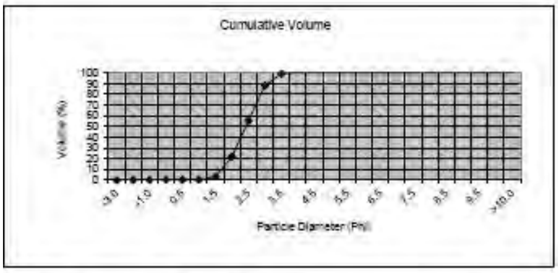


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.05	0.1	
2.0000	-1.0	0.23	0.3	Granule
1.0000	0.0	1.28	1.6	V.Coarse Sand
0.7100	0.5	4.59	6.1	Coarse Sand
0.5000	1.0	10.17	16.3	
0.3550	1.5	16.28	32.6	Medium Sand
0.2500	2.0	22.37	55.0	
0.1800	2.5	21.57	76.5	Fine Sand
0.1250	3.0	16.83	93.4	
0.0900	3.5	6.05	99.4	V.Fine Sand
0.0630	4.0	0.59	100.0	
0.0440	4.5	0.00	100.0	Coarse Silt
0.0315	5.0	0.00	100.0	
0.0220	5.5	0.00	100.0	Medium Silt
0.0156	6.0	0.00	100.0	
0.0110	6.5	0.00	100.0	Fine silt
0.0078	7.0	0.00	100.0	
0.0055	7.5	0.00	100.0	V.Fine Silt
0.0039	8.0	0.00	100.0	
0.0028	8.5	0.00	100.0	Coarse Clay
0.0020	9.0	0.00	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.278	0.241	1.85
Median	0.273		1.87
Sorting	**Value**	**Inference**	
Coefficient	0.84	Moderately Sorted	
Skewness	-0.07	Symmetrical	
Kurtosis	0.95	Mesokurtic	
% Fines	0.00%	Medium Sand	
% Sands	99.72%		
% Gravel	0.28%		

Sample No.:	ECC_26	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 10:21

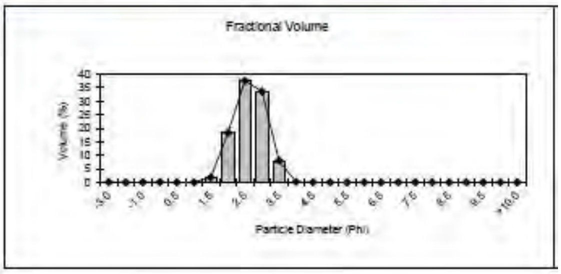


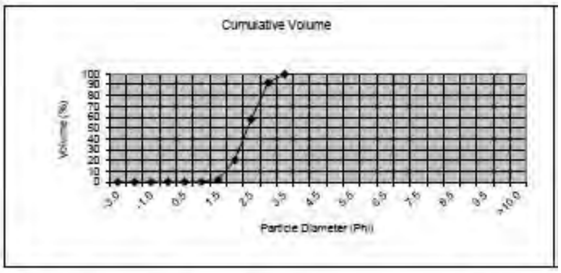


Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.00	0.0	Pebble
4.0000	-2.0	0.03	0.0	
2.0000	-1.0	0.05	0.1	Granule
1.0000	0.0	0.09	0.2	V.Coarse Sand
0.7100	0.5	0.00	0.2	Coarse Sand
0.5000	1.0	0.01	0.2	
0.3550	1.5	3.09	3.3	Medium Sand
0.2500	2.0	18.49	21.8	
0.1800	2.5	33.56	55.3	Fine Sand
0.1250	3.0	32.81	88.1	
0.0900	3.5	10.96	99.1	V.Fine Sand
0.0630	4.0	0.92	100.0	
0.0440	4.5	0.00	100.0	Coarse Silt
0.0315	5.0	0.00	100.0	
0.0220	5.5	0.00	100.0	Medium Silt
0.0156	6.0	0.00	100.0	
0.0110	6.5	0.00	100.0	Fine silt
0.0078	7.0	0.00	100.0	
0.0055	7.5	0.00	100.0	V.Fine Silt
0.0039	8.0	0.00	100.0	
0.0028	8.5	0.00	100.0	Coarse Clay
0.0020	9.0	0.00	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.192	0.091	2.38
Median	0.191		2.39
Sorting Coefficient	Value: 0.54	Inference: Moderately Well Sorted	
Skewness	0.00	Symmetrical	
Kurtosis	0.98	Mesokurtic	
% Fines	0.00%	Fine Sand	
% Sands	99.92%		
% Gravel	0.08%		

Sample No.:	ECC_27	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 10:30





Aperture (mm)	Aperture (Phi unit)	Percentage Fractional	Cumulative	Sediment Description
8.0000	-3.0	0.07	0.1	Pebble
4.0000	-2.0	0.02	0.1	
2.0000	-1.0	0.05	0.1	Granule
1.0000	0.0	0.09	0.2	V.Coarse Sand
0.7100	0.5	0.00	0.2	Coarse Sand
0.5000	1.0	0.00	0.2	
0.3550	1.5	1.84	2.1	Medium Sand
0.2500	2.0	18.32	20.4	
0.1800	2.5	37.65	58.0	Fine Sand
0.1250	3.0	33.69	91.7	
0.0900	3.5	8.04	99.8	V.Fine Sand
0.0630	4.0	0.24	100.0	
0.0440	4.5	0.00	100.0	Coarse Silt
0.0315	5.0	0.00	100.0	
0.0220	5.5	0.00	100.0	Medium Silt
0.0156	6.0	0.00	100.0	
0.0110	6.5	0.00	100.0	Fine silt
0.0078	7.0	0.00	100.0	
0.0055	7.5	0.00	100.0	V.Fine Silt
0.0039	8.0	0.00	100.0	
0.0028	8.5	0.00	100.0	Coarse Clay
0.0020	9.0	0.00	100.0	
0.0014	9.5	0.00	100.0	Medium Clay
0.0010	10.0	0.00	100.0	
<0.001	>10.0	0.00	100.0	Fine Clay

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.195	0.084	2.36
Median	0.195		2.36
Sorting Coefficient	Value: 0.49	Inference: Well Sorted	
Skewness	0.01	Symmetrical	
Kurtosis	0.99	Mesokurtic	
% Fines	0.00%	Fine Sand	
% Sands	99.86%		
% Gravel	0.14%		

Appendix D4 – Sample and Seabed Photography Log Sheets

Photo Position: 381471 mE, 5982724 mN

Habitat Summary Information: ECC_01

Survey Area: HOW04

No. of Stills: 7

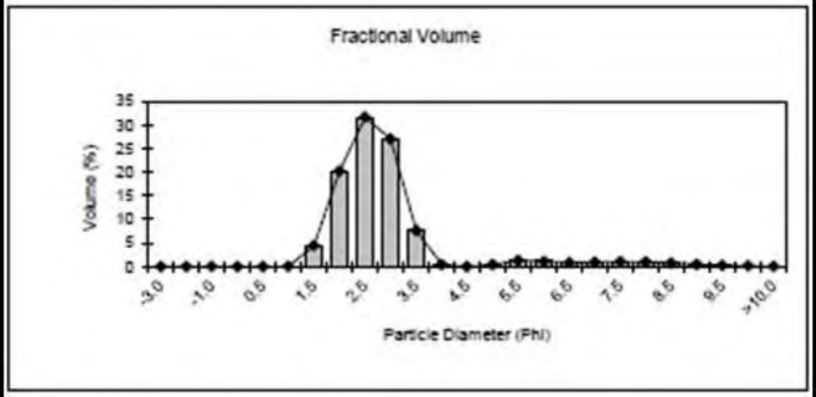
Site Selection Criteria
Provided by Orsted

In Field Sediment Description
Medium brown, slightly muddy sand with small amounts of shell fragments

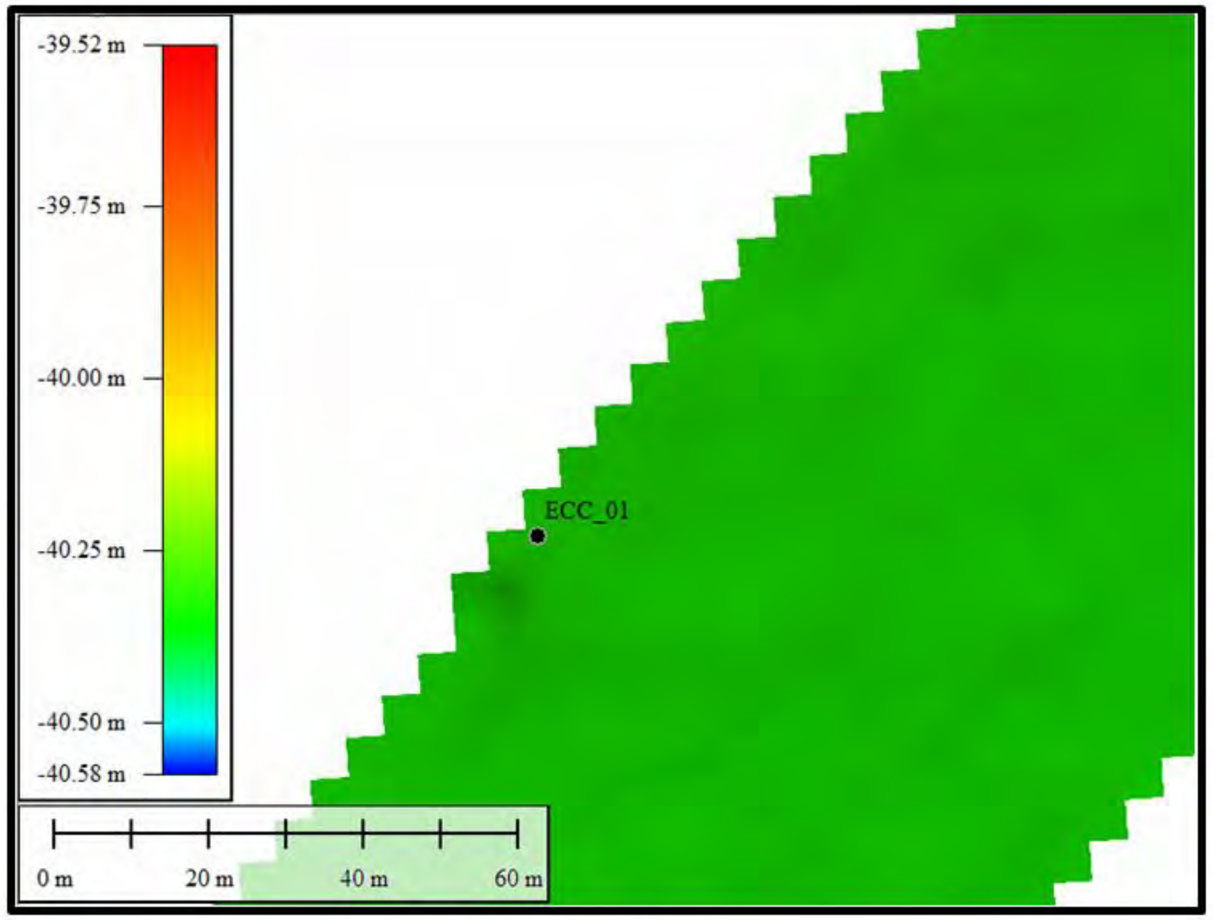
Conspicuous Fauna
Echinodermata: possibly *Asterias rubens* (Common starfish), *Echinocardium cordatum*.

Photo Position: 381471 mE, 5982724 mN

Sample No.:	ECC_01	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 10:08



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.192	0.116	2.38
Median	0.195		2.36
Sorting	**Value**	**Inference**	
Coefficient	1.04	Poorly Sorted	
Skewness	0.34	Very Positive (Coarse)	
Kurtosis	2.42	Very Leptokurtic	
% Fines	8.31%	Fine Sand	
% Sands	91.62%		
% Gravel	0.07%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Sieved Sample Image

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

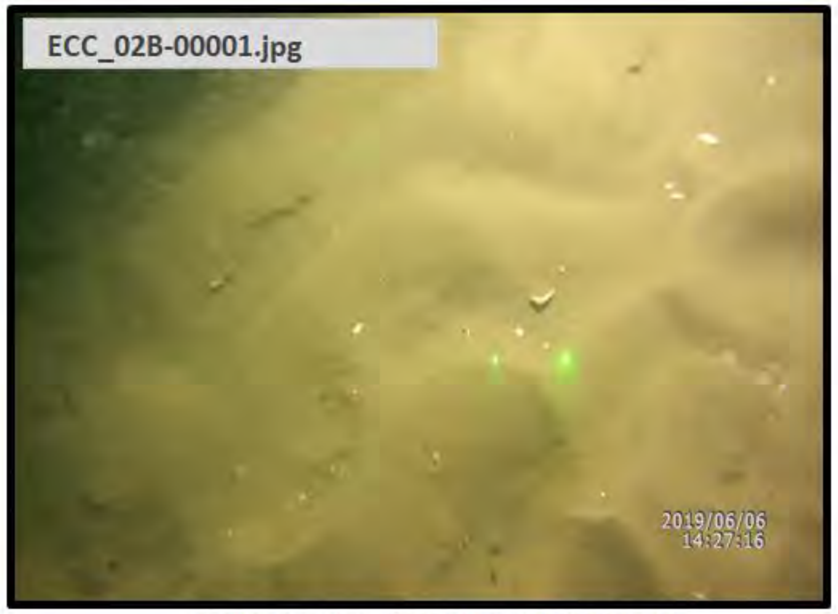


Photo Position: 379926 mE, 5985309 mN

Habitat Summary Information: ECC_02

Survey Area: HOW04

No. of Stills: 8

Site Selection Criteria

Provided by Orsted

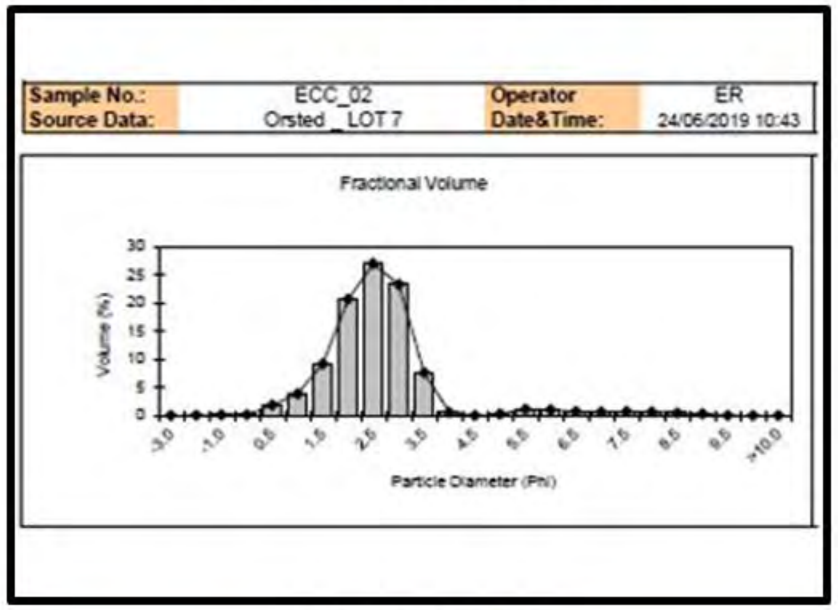
In Field Sediment Description

Medium brown, slightly muddy sand with small amounts of shell debris

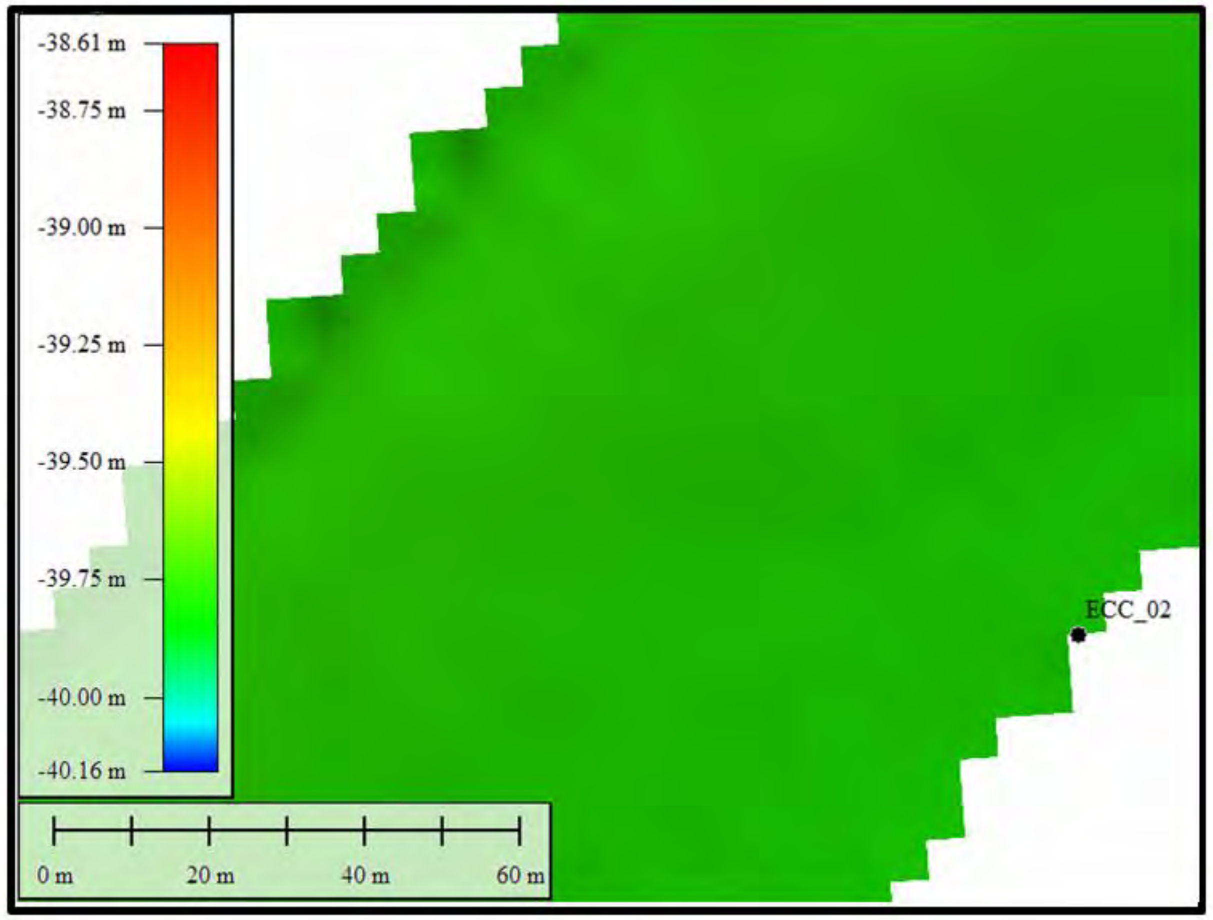
Conspicuous Fauna

Annelida: Polychaeta.

Photo Position: 379926 mE, 5985309 mN

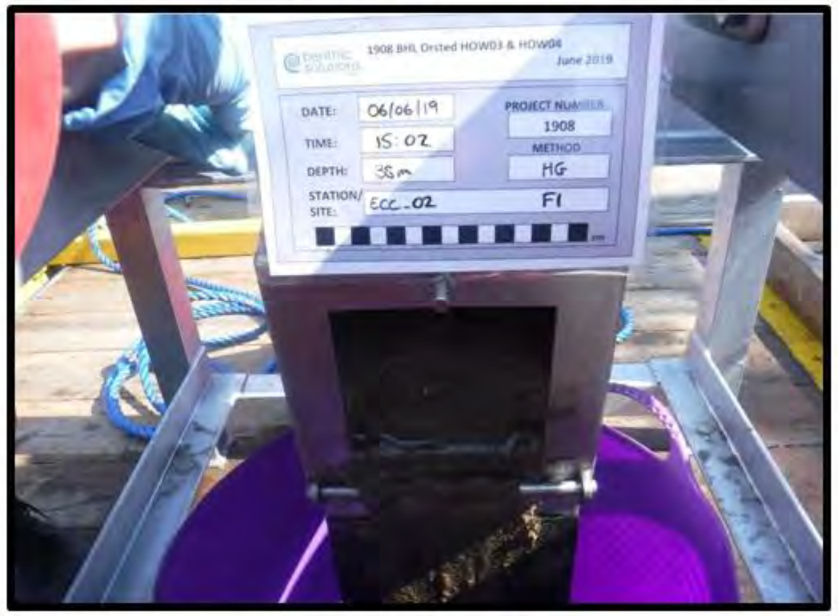


Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.213	0.171	2.23
Median	0.213		2.23
Sorting Coefficient	Value 1.02	Inference Poorly Sorted	
Skewness	0.18	Positive(Coarse)	
Kurtosis	1.76	Very Leptokurtic	
% Fines	5.80%	Fine Sand	
% Sands	94.05%		
% Gravel	0.15%		

Sediment Characteristics



Sediment Example Image

Client

Contractors

● Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_03

Survey Area: HOW04

No. of Stills: 7

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, slightly muddy sand with small amounts of shell debris

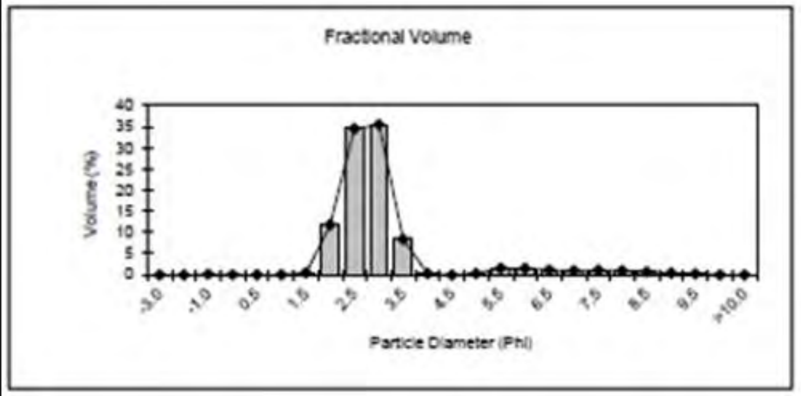
Conspicuous Fauna

Echinodermata: Asteroidea. , *Echinocardium cordatum* .

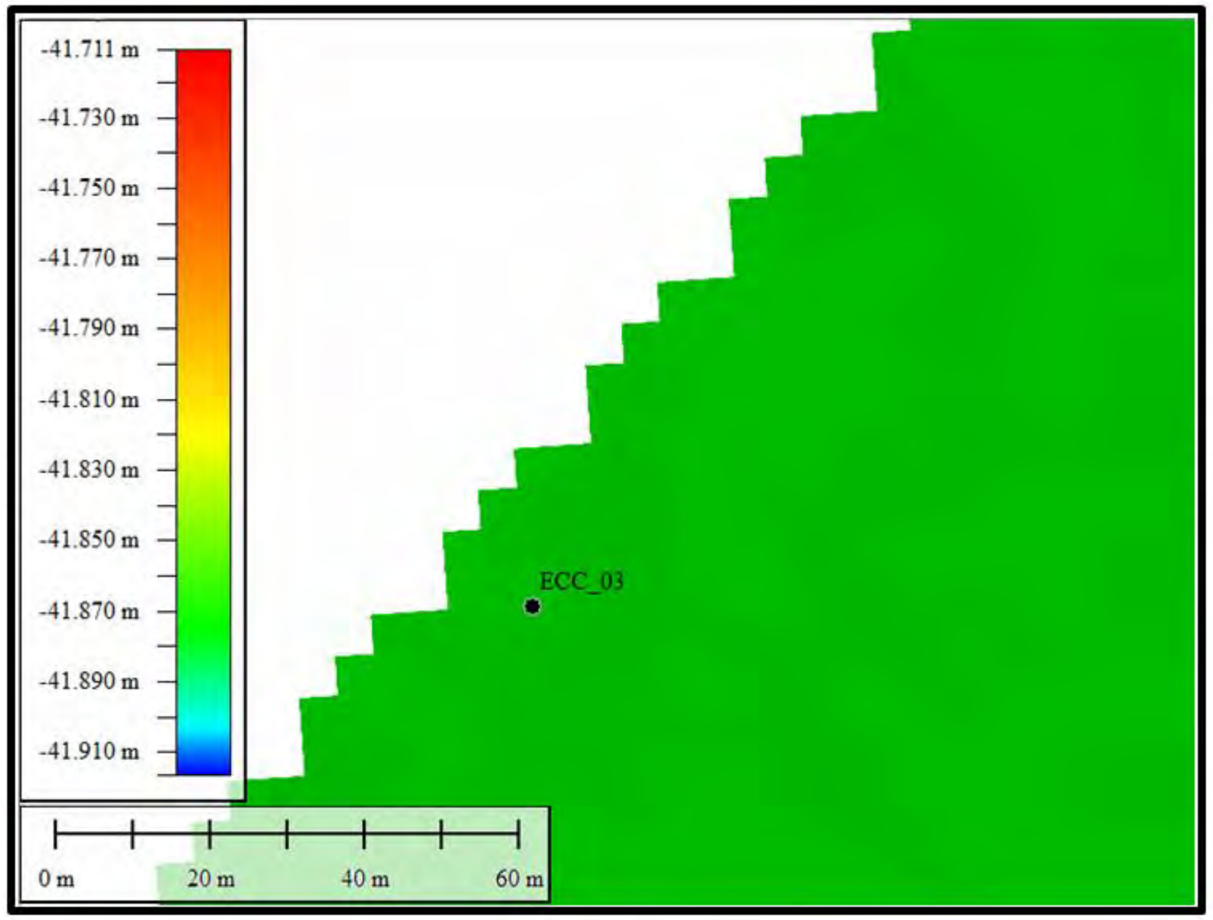
Photo Position: 376745 mE, 5986469 mN

Photo Position: 376745 mE, 5986469 mN

Sample No.:	ECC_03	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 11:18



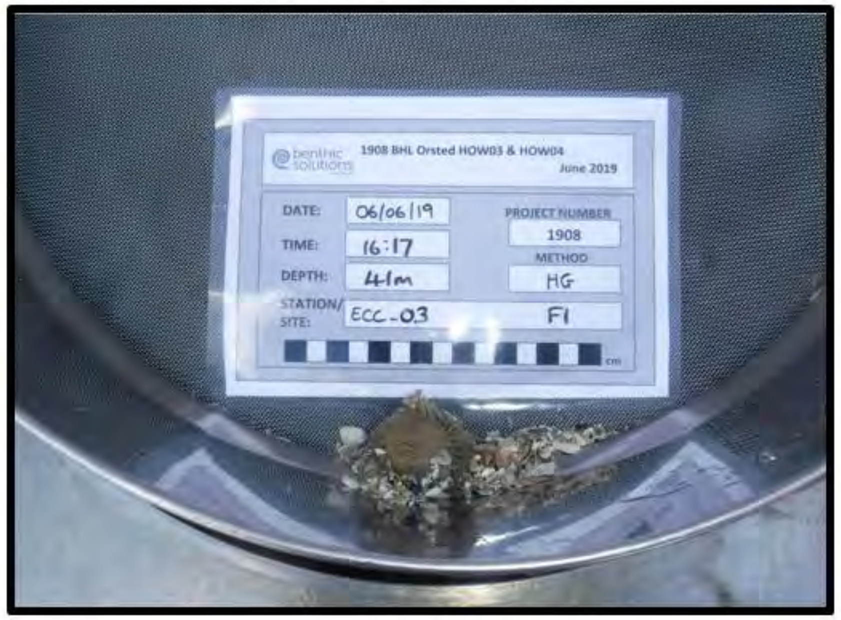
Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.172	0.096	2.54
Median	0.175		2.51
Sorting	Value	Inference	
Coefficient	0.95	Moderately Sorted	
Skewness	0.36	Very Positive (Coarse)	
Kurtosis	2.60	Very Leptokurtic	
% Fines	8.83%	Fine Sand	
% Sands	91.09%		
% Gravel	0.09%		

Sediment Characteristics

Sediment Example Image



Sieved Sample Image

Client

Contractors

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 373464 mE, 5985830 mN

Habitat Summary Information: ECC_04

Survey Area: HOW04

No. of Stills: 10

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

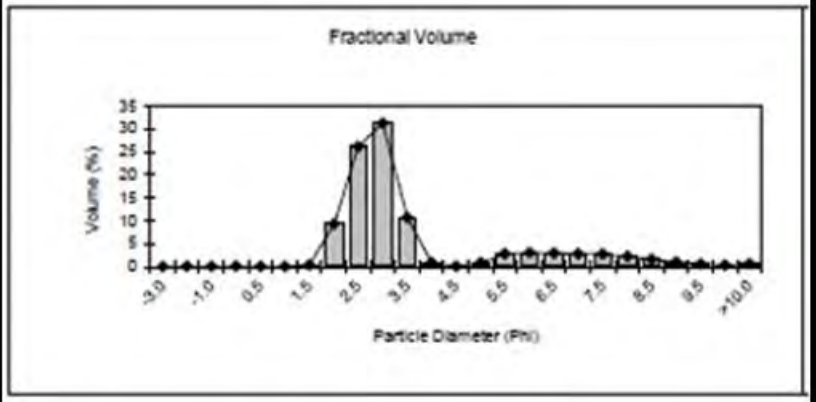
Medium brown, slightly muddy sand with small amounts of shell debris

Conspicuous Fauna

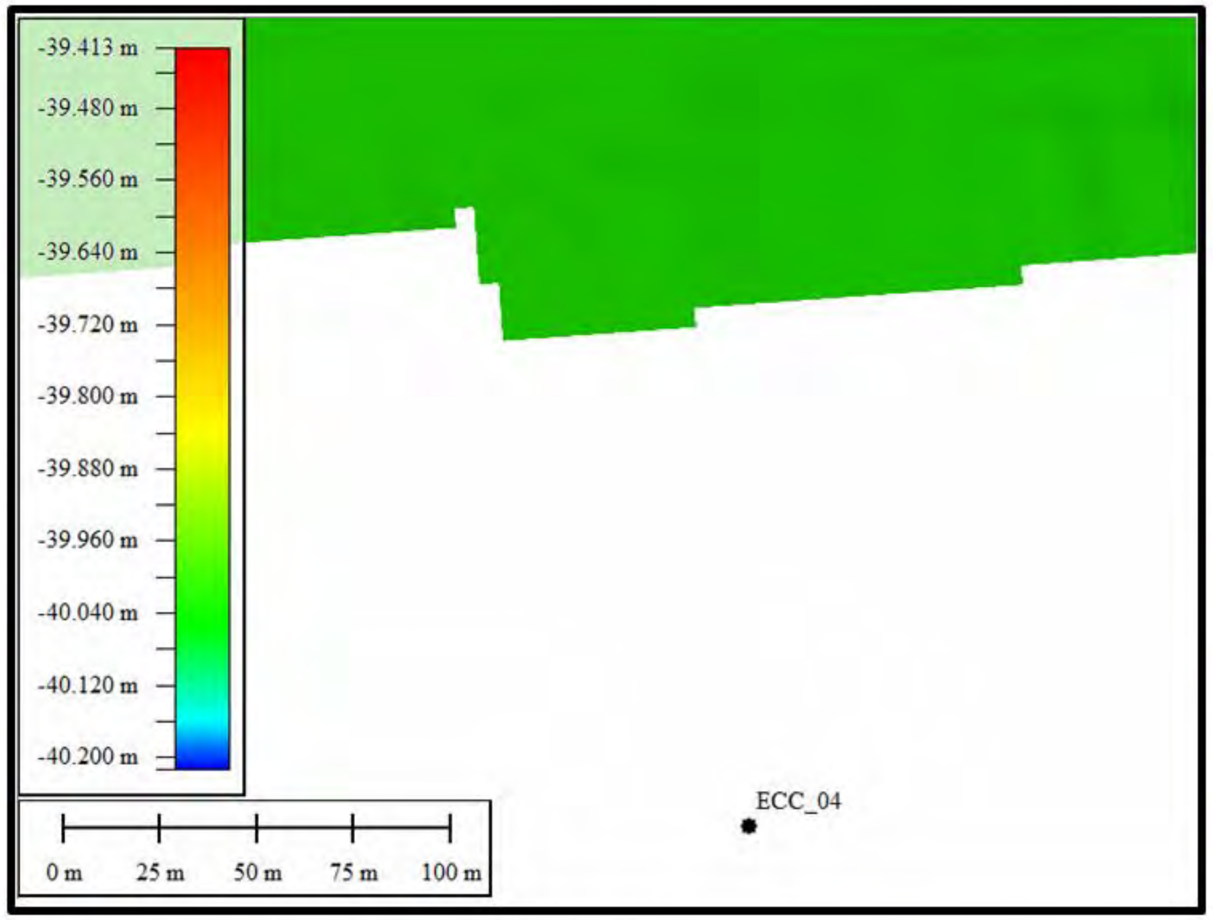
Echinodermata: possibly *Asterias rubens* (Common starfish), *Echinocardium cordatum*.

Photo Position: 373464 mE, 5985830 mN

Sample No.:	ECC_04	Operator	ER
Source Data:	Orsted _LOT 7	Date&Time:	24/06/2019 11:28

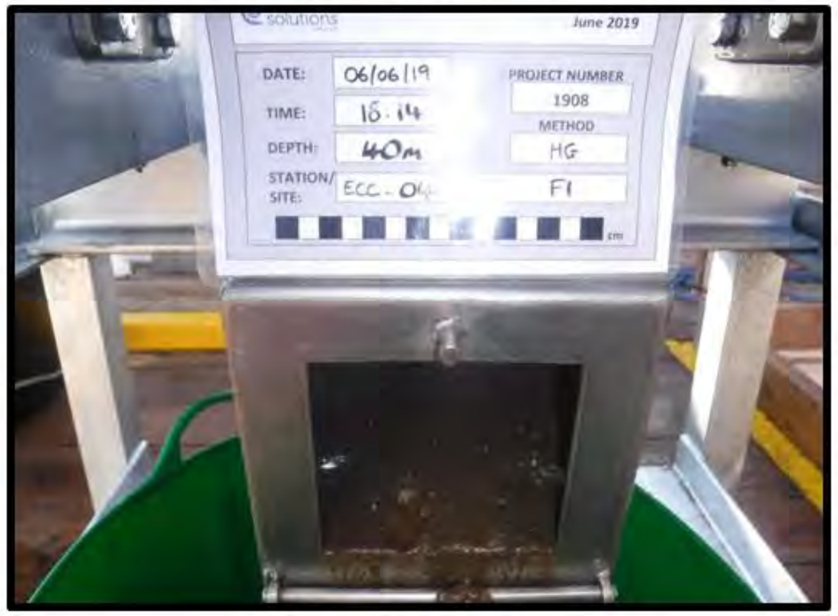


Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.087	0.115	3.52
Median	0.155		2.69
Sorting Coefficient	Value 1.84	Inference Poorly Sorted	
Skewness	0.68	Very Positive (Coarse)	
Kurtosis	2.30	Very Leptokurtic	
% Fines	21.38%	V.Fine Sands	
% Sands	78.51%		
% Gravel	0.11%		

Sediment Characteristics



Sediment Example Image

Client

Contractors

Sieved Sample Image

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 370974 mE, 5984837 mN

Habitat Summary Information: ECC_05

Survey Area: HOW04

No. of Stills: 6

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

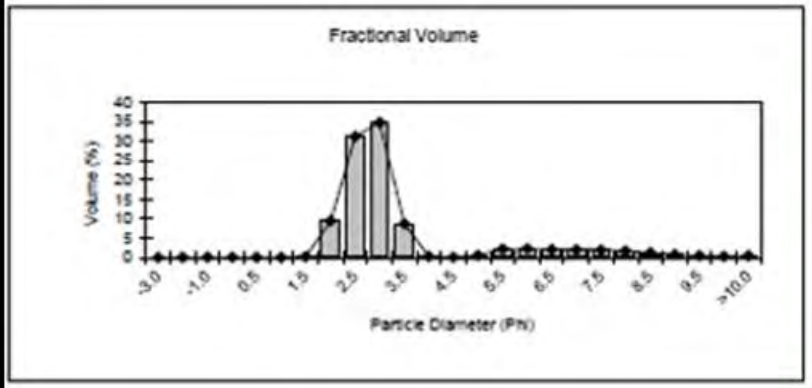
Medium brown, slightly muddy sand with small amounts of shell debris

Conspicuous Fauna

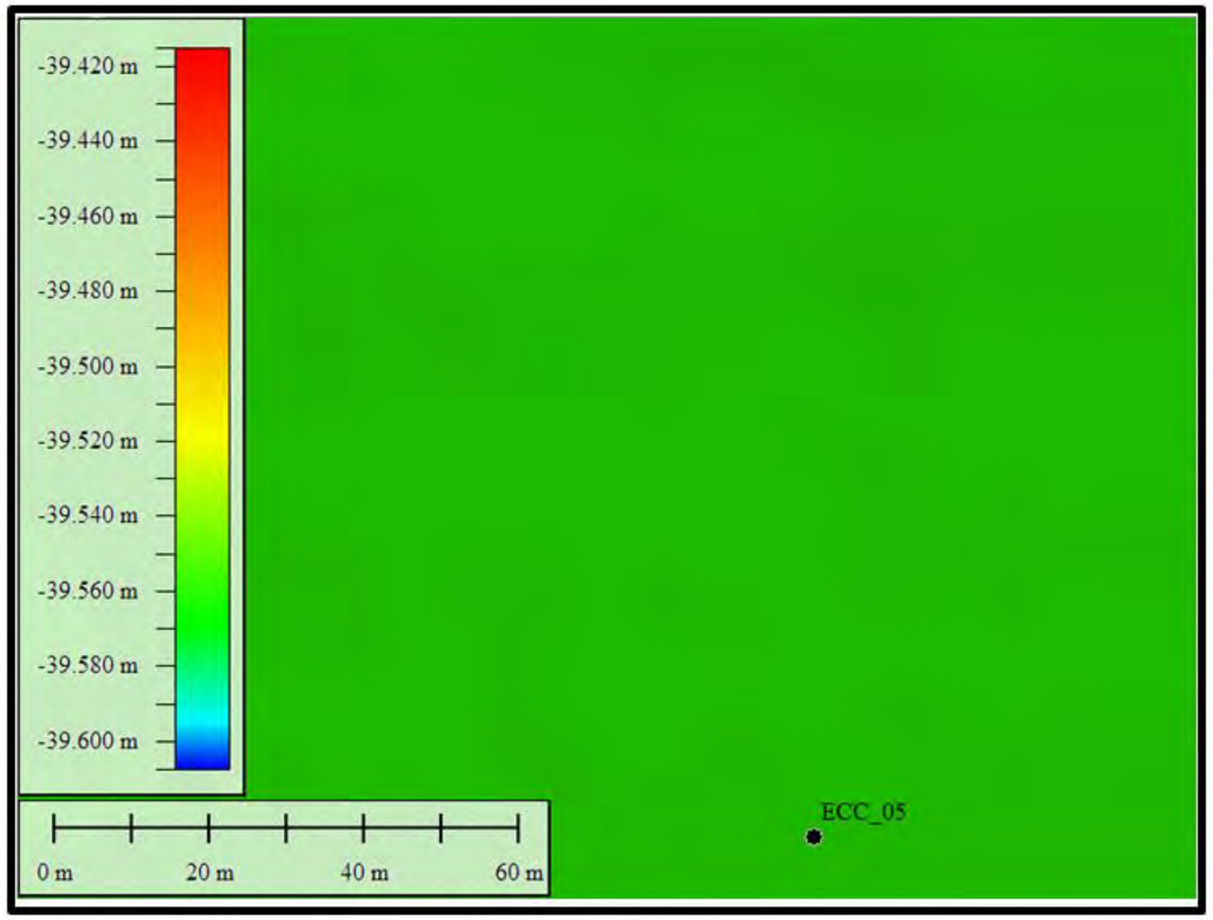
Annelida: Polychaeta. **Echinodermata:** *Echinocardium cordatum*.

Photo Position: 370974 mE, 5984837 mN

Sample No.:	ECC_05	Operator	ER
Source Data:	Orsted _LOT 7	Date&Time:	24/06/2019 11:41



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.153	0.105	2.71
Median	0.166		2.59
Sorting Coefficient	Value 1.20	Inference Poorly Sorted	
Skewness	0.47	Very Positive (Coarse)	
Kurtosis	2.99	Very Leptokurtic	
% Fines	15.48%	Fine Sand	
% Sands	84.44%		
% Gravel	0.09%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Sieved Sample Image

Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 367118 mE, 5985176 mN

Habitat Summary Information: ECC_06

Survey Area: HOW04

No. of Stills: 8

Site Selection Criteria

Provided by Orsted

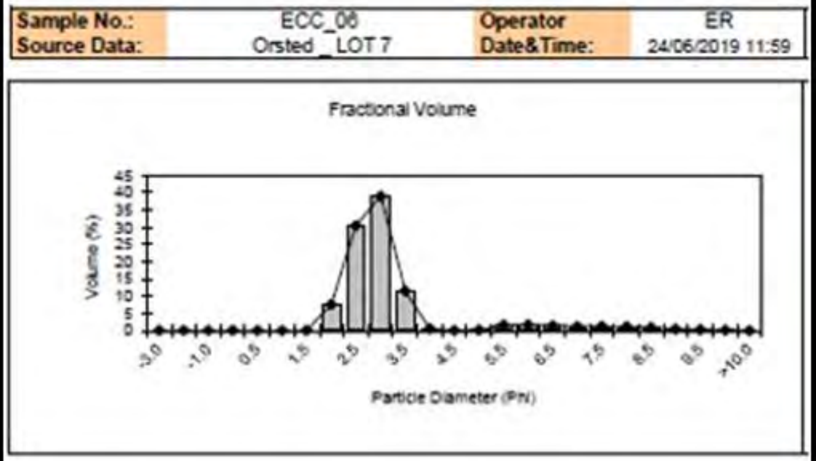
In Field Sediment Description

Medium brown, slightly muddy sand with small amounts of shell debris

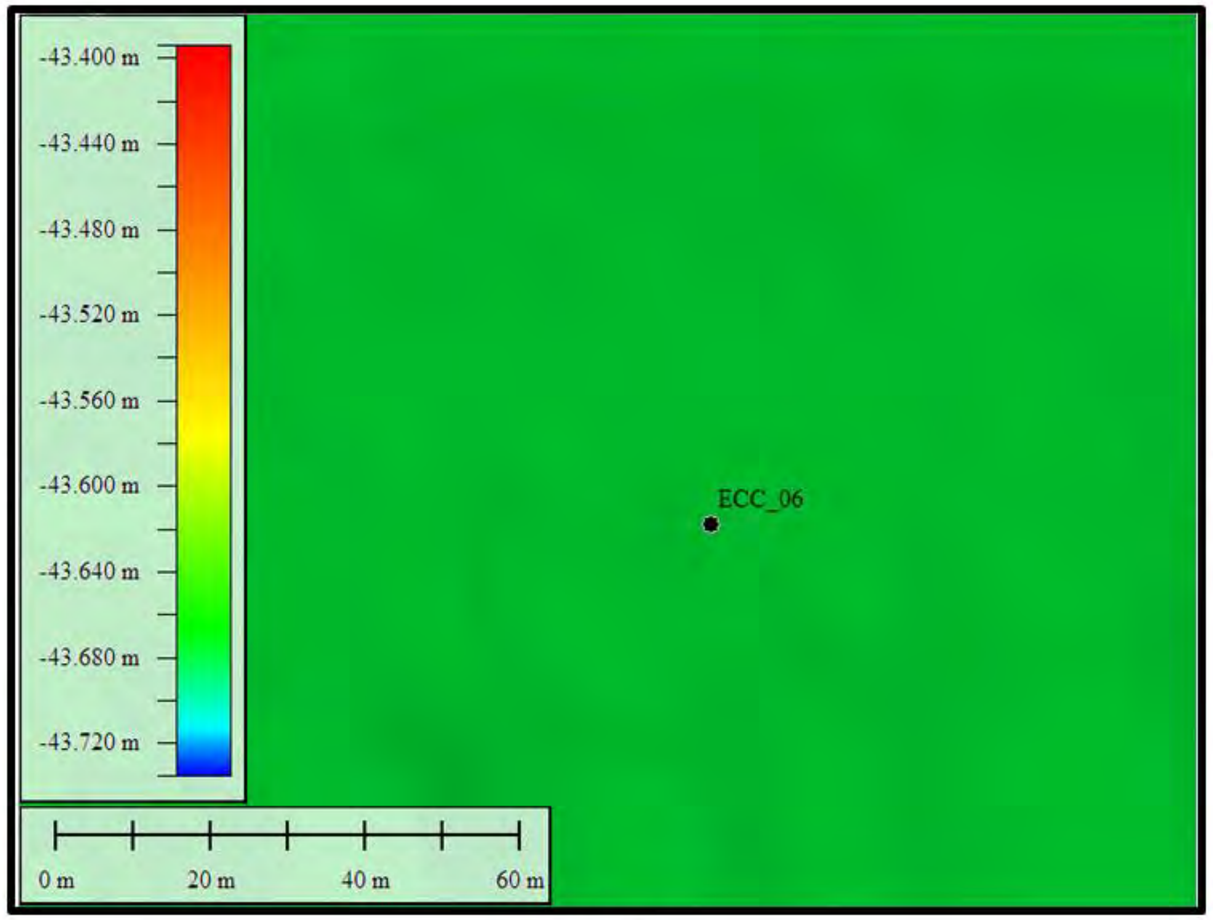
Conspicuous Fauna

Annelida: possibly *Lanice conchilega* (Sand Mason). **Arthropoda:** *Corystes cassivelaunus* (Masked crab). **Echinodermata:** possibly *Asterias rubens* (Common starfish), *Ophiura albida*. **Chordata:** *Callionymus lyra* (Common dragonet).

Photo Position: 367118 mE, 5985176 mN



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.159	0.097	2.66
Median	0.164		2.61
Sorting	**Value**	**Inference**	
Coefficient	1.02	Poorly Sorted	
Skewness	0.39	Very Positive (Coarse)	
Kurtosis	2.80	Very Leptokurtic	
% Fines	10.43%	Fine Sand	
% Sands	89.39%		
% Gravel	0.18%		

Sediment Characteristics

Client

Contractors

Sediment Example Image

Sieved Sample Image

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 362779 mE, 5985048 mN

Habitat Summary Information: ECC_07

Survey Area: HOW04

No. of Stills: 8

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

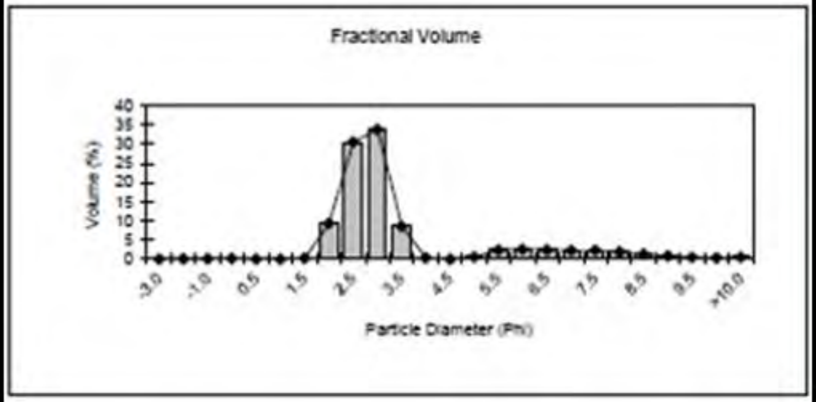
Medium brown, muddy sand with very small amounts of shell debris

Conspicuous Fauna

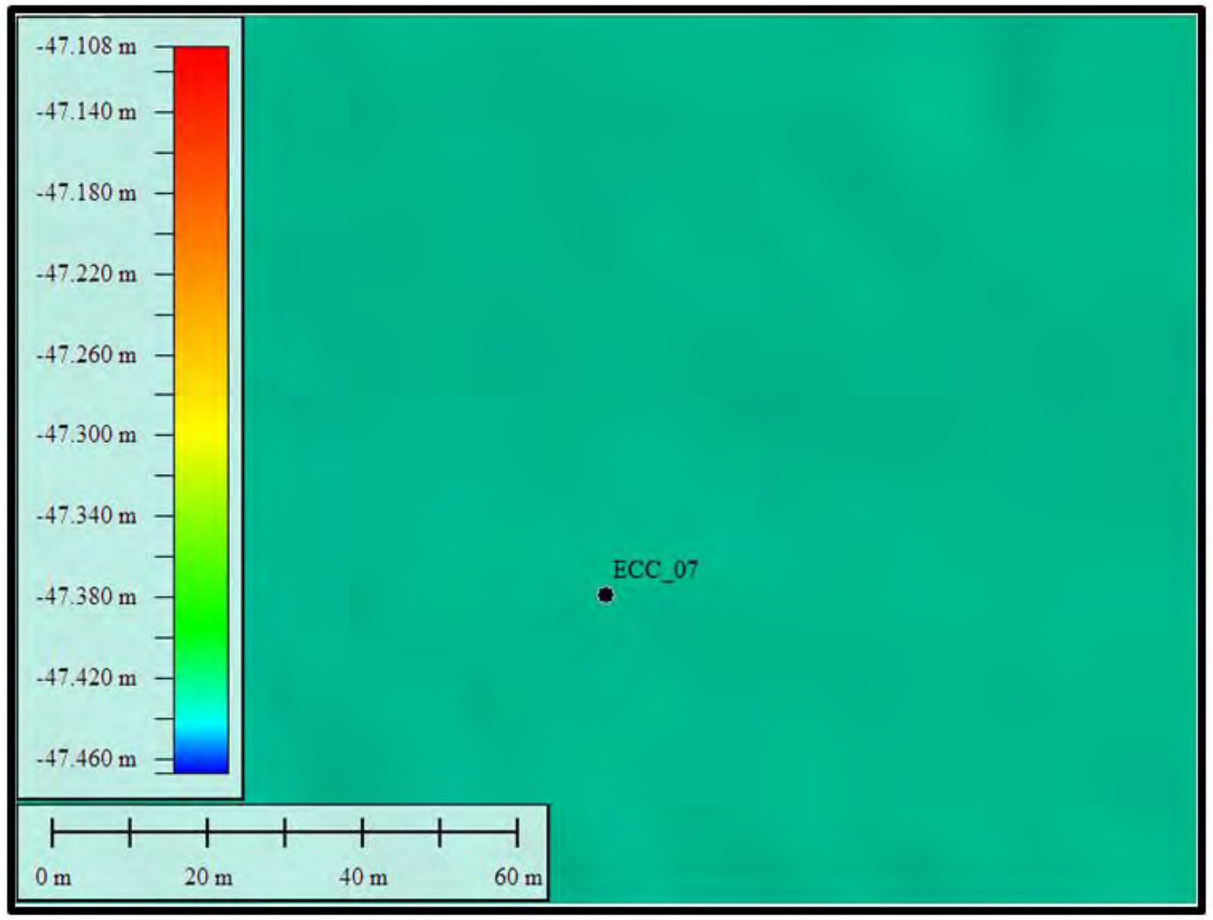
Echinodermata: Asteroidea. **Chordata:** Pleuronectiformes.

Photo Position: 362779 mE, 5985048 mN

Sample No.:	ECC_07	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 12:10



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.103	0.112	3.28
Median	0.164		2.61
Sorting Coefficient	Value	Inference	
	1.65	Poorly Sorted	
Skewness	0.68	Very Positive (Coarse)	
Kurtosis	2.86	Very Leptokurtic	
% Fines	17.36%	v.Fine Sands	
% Sands	82.55%		
% Gravel	0.09%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_08

Survey Area: HOW04

No. of Stills: 11

ECC_08A-00002.jpg

Photo Position: 360525 mE, 5986715 mN

ECC_08A-00006.jpg

Photo Position: 360525 mE, 5986715 mN

Site Selection Criteria

Provided by Orsted

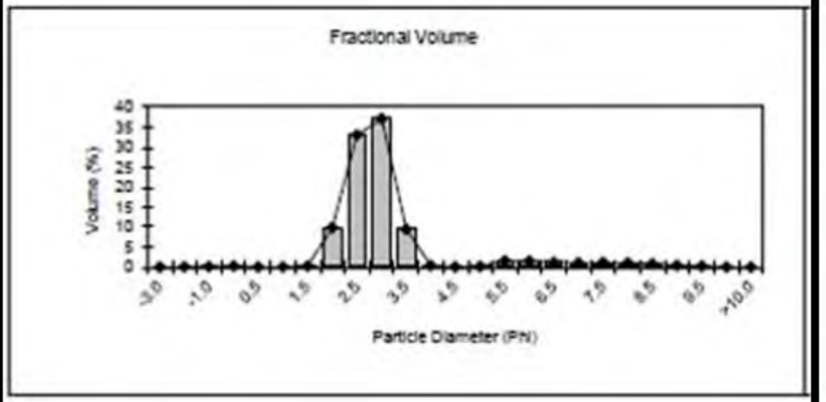
In Field Sediment Description

Medium brown, slightly muddy sand with small amounts of shell debris

Conspicuous Fauna

Annelida: Polychaeta. **Arthropoda:** *Corystes cassivelaunus* (Masked crab). **Echinodermata:** *Ophiura sp.*. **Chordata:** possibly *Callionymus lyra* (Common dragonet).

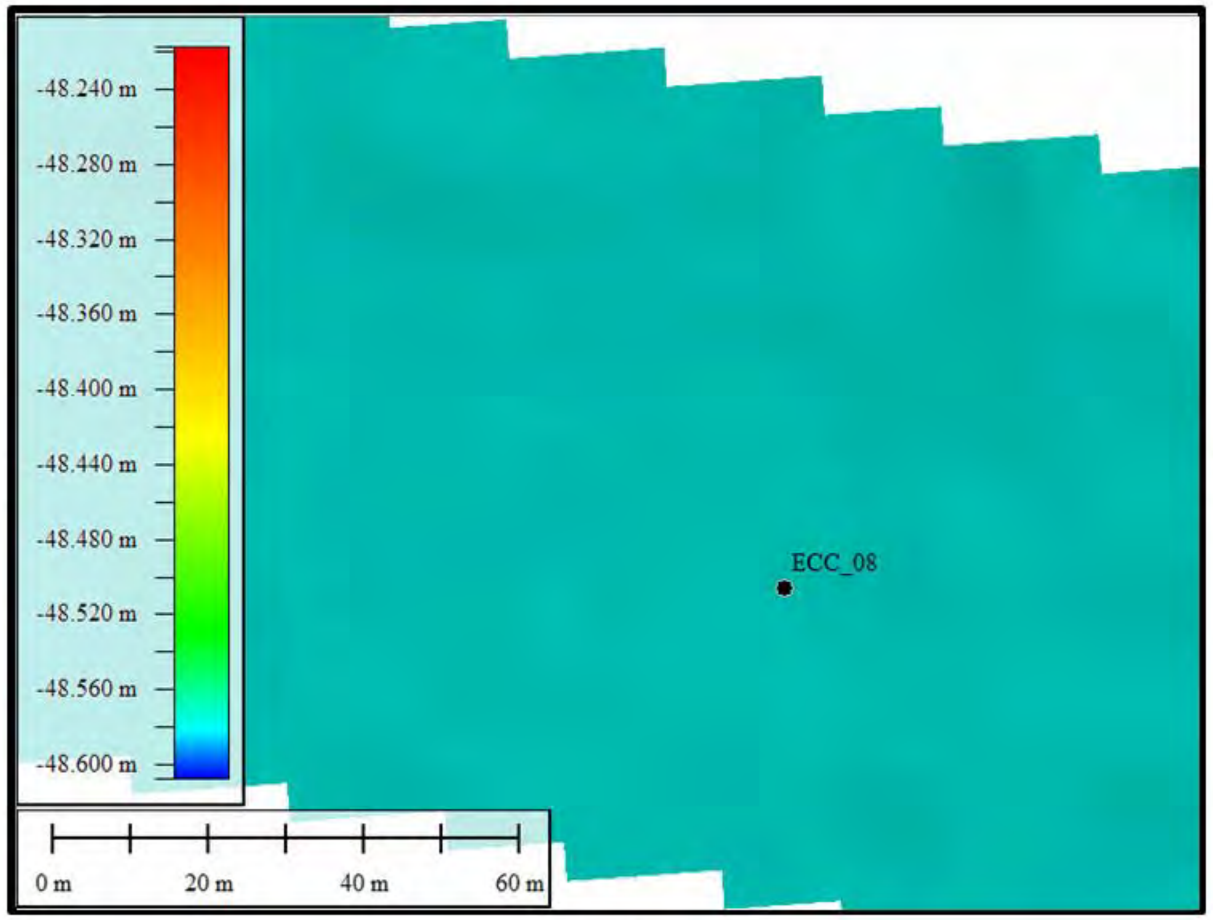
Sample No.:	ECC_08	Operator	ER
Source Data:	Orsted _ LOT 7	Date&Time:	24/06/2019 12:21



Particle Size Distribution

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.166	0.093	2.59
Median	0.171		2.55
Sorting	**Value**	**Inference**	
Coefficient	0.98	Moderately Sorted	
Skewness	0.37	Very Positive (Coarse)	
Kurtosis	2.69	Very Leptokurtic	
% Fines	9.34%	Fine Sand	
% Sands	90.49%		
% Gravel	0.17%		

Sediment Characteristics

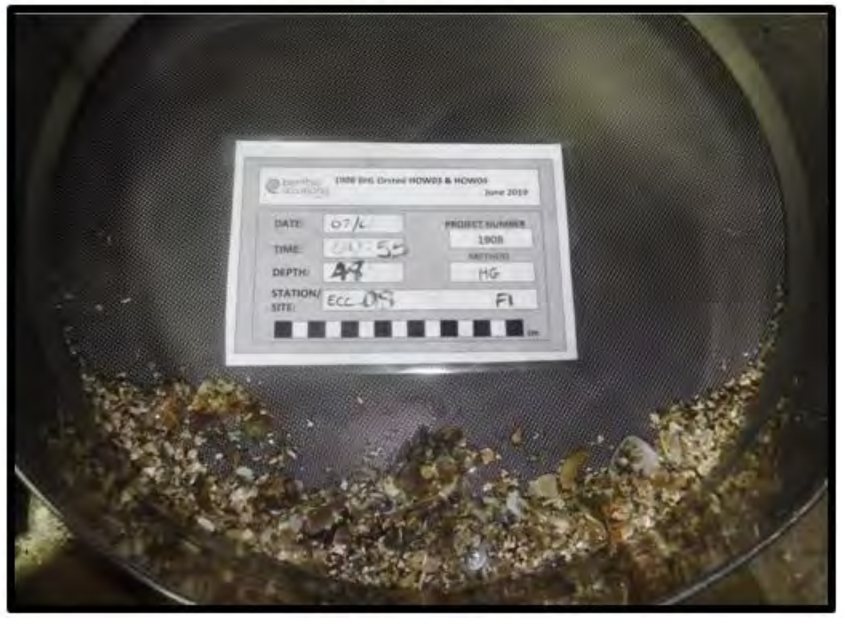


Client

Contractors

Sediment Example Image

● Current station



Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 358475 mE, 5986766 mN

Habitat Summary Information: ECC_09

Survey Area: HOW04

No. of Stills: 9

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, slightly muddy sand with small amounts of shell debris

Conspicuous Fauna

Chordata: Pleuronectiformes.

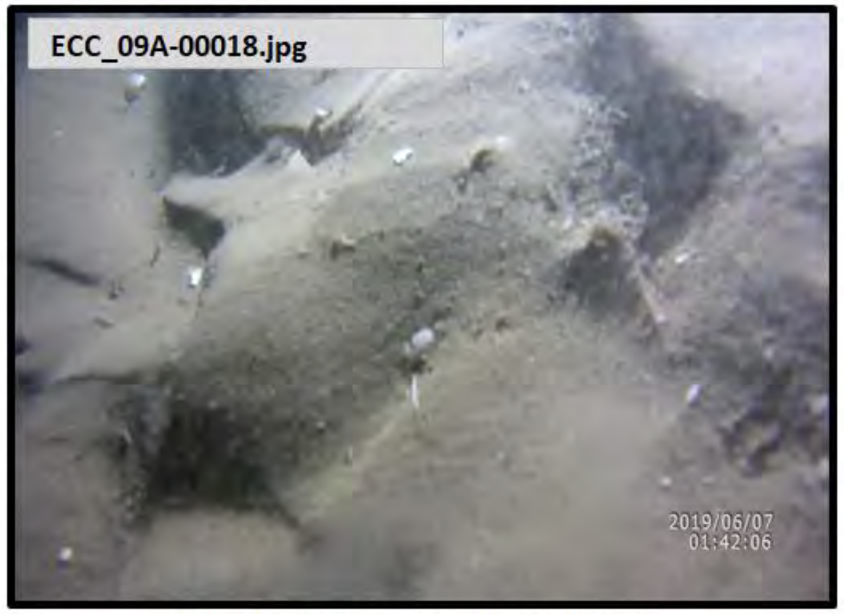
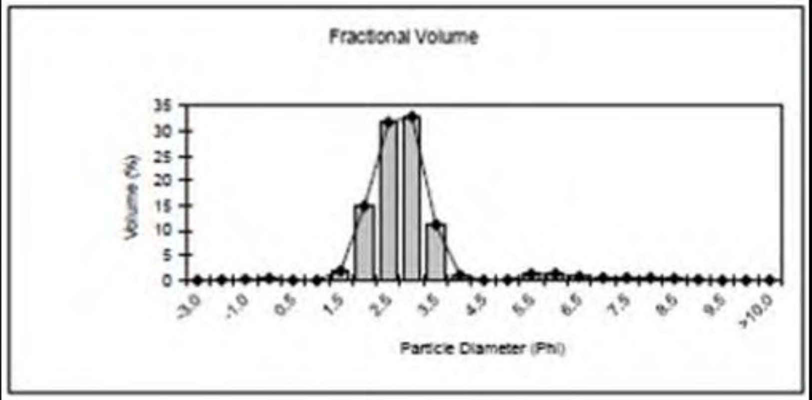
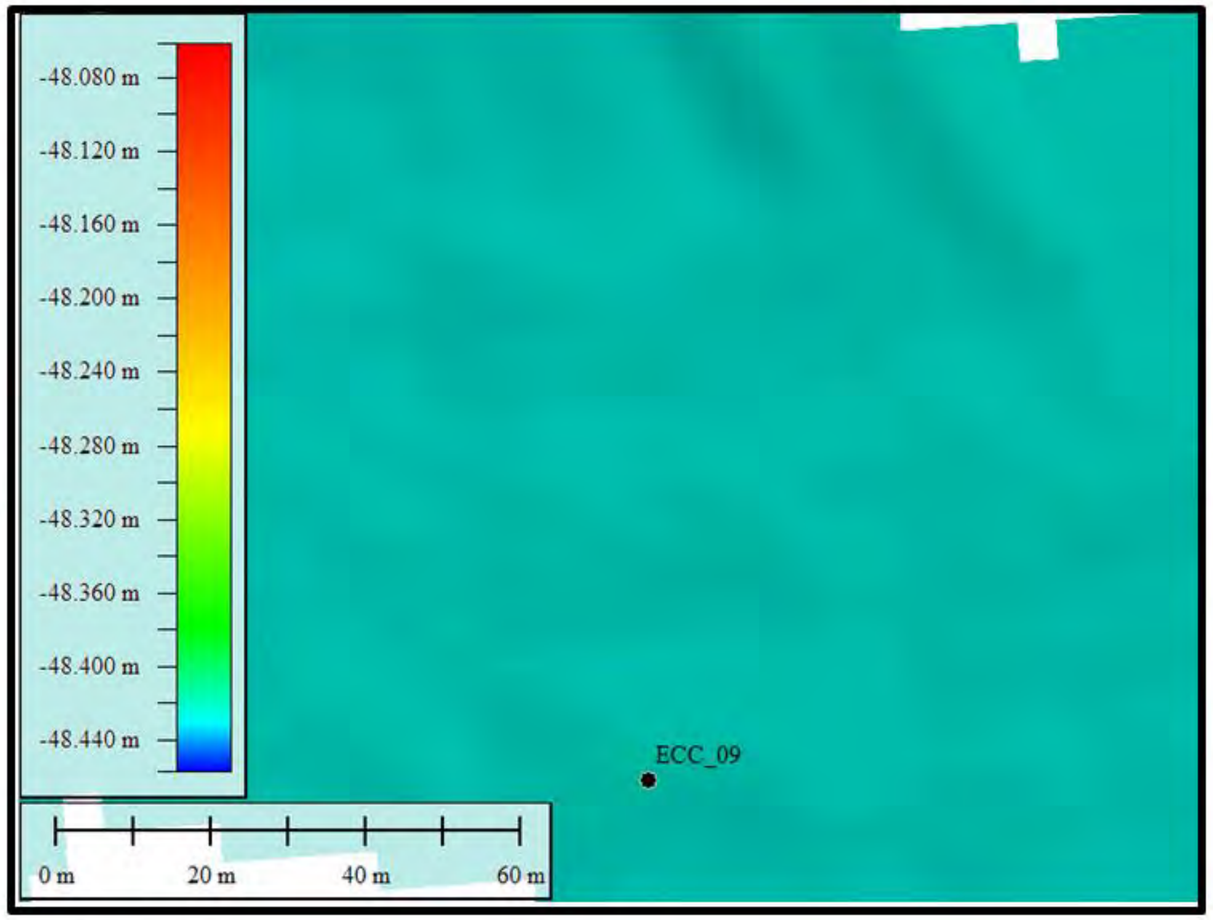


Photo Position: 358475 mE, 5986766 mN

Sample No.:	ECC_09	Operator	ER
Source Data:	Orsted _LOT 7	Date&Time:	24/06/2019 12:42



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.177	0.102	2.49
Median	0.179		2.48
Sorting	Value	Inference	
Coefficient	0.82	Moderately Sorted	
Skewness	0.26	Positive(Coarse)	
Kurtosis	1.88	Very Leptokurtic	
% Fines	5.41%	Fine Sand	
% Sands	94.33%		
% Gravel	0.26%		

Sediment Characteristics

Client

Contractors

Sediment Example Image

Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 353849 mE, 5986886 mN

Habitat Summary Information: ECC_10

Survey Area: HOW04

No. of Stills: 9

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

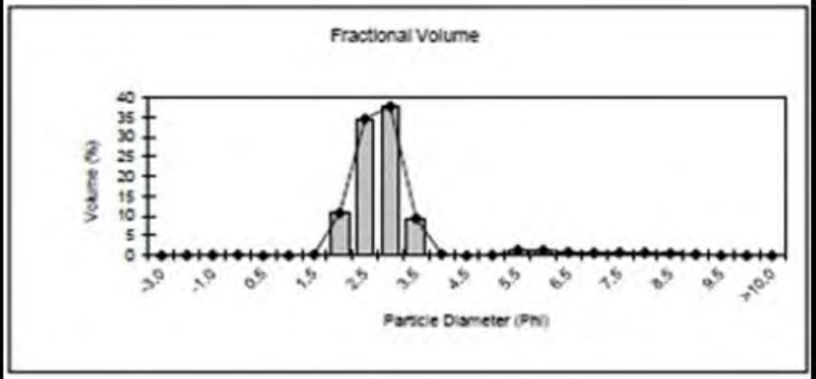
Medium brown, slightly muddy sand with small amounts of shell debris

Conspicuous Fauna

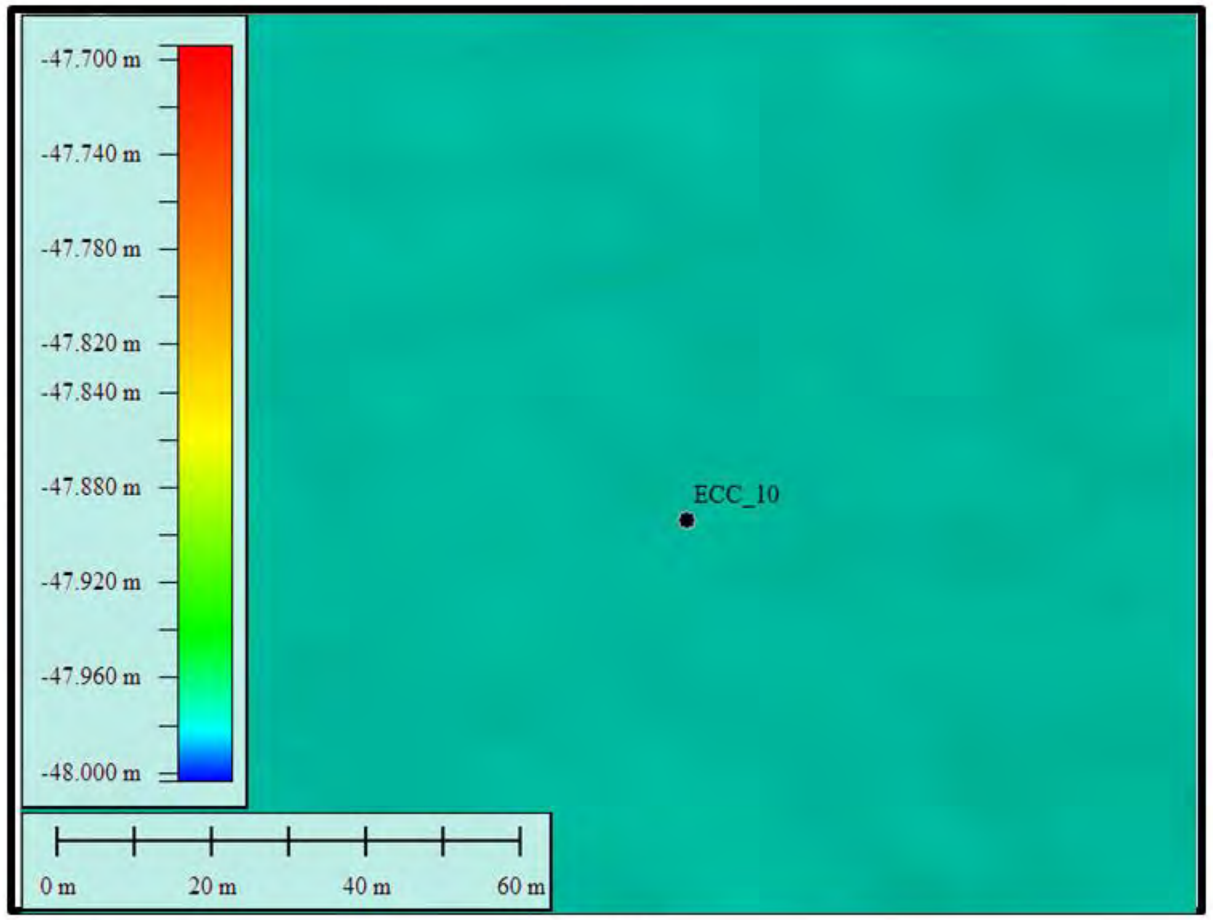
Annelida: *Polychaeta* . **Echinodermata:** *Anasterias antarctica* , *Echinocardium cordatum* . **Chordata:** possibly *Callionymus lyra* (Common dragonet).

Photo Position: 353849 mE, 5986886 mN

Sample No.:	ECC_10	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:01



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.173	0.091	2.53
Median	0.174		2.52
Sorting Coefficient	Value 0.82	Inference Moderately Sorted	
Skewness	0.29	Positive(Coarse)	
Kurtosis	2.27	Very Leptokurtic	
% Fines	6.51%	Fine Sand	
% Sands	93.35%		
% Gravel	0.14%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 350877 mE, 5985576 mN

Habitat Summary Information: ECC_11

Survey Area: HOW04

No. of Stills: 8

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, muddy sand with very small amounts of shell debris

Conspicuous Fauna

Echinodermata: *Echinocardium cordatum*.

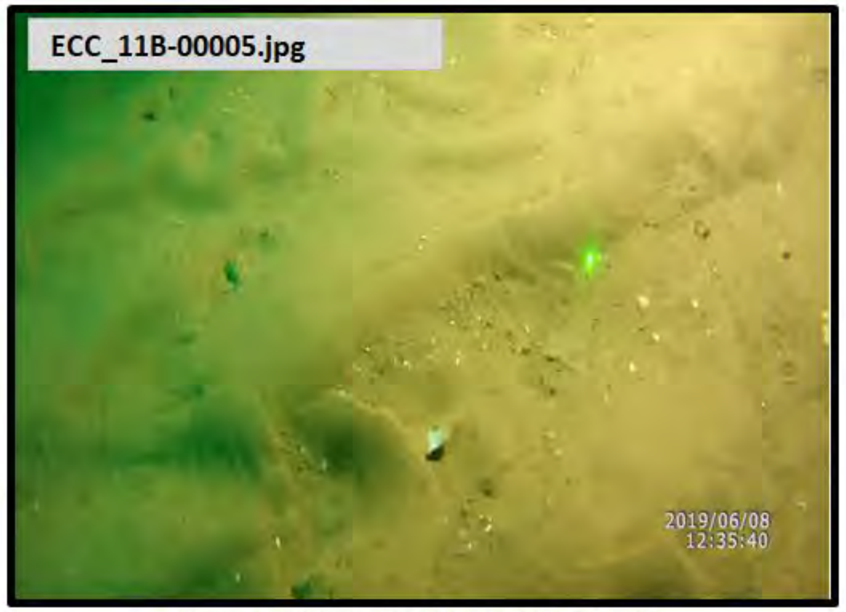
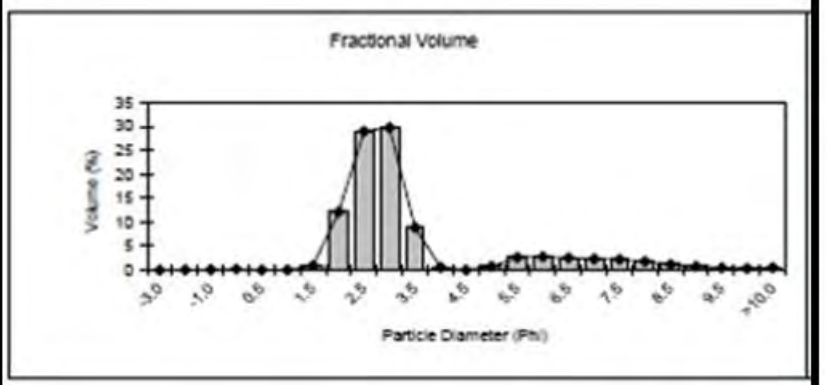
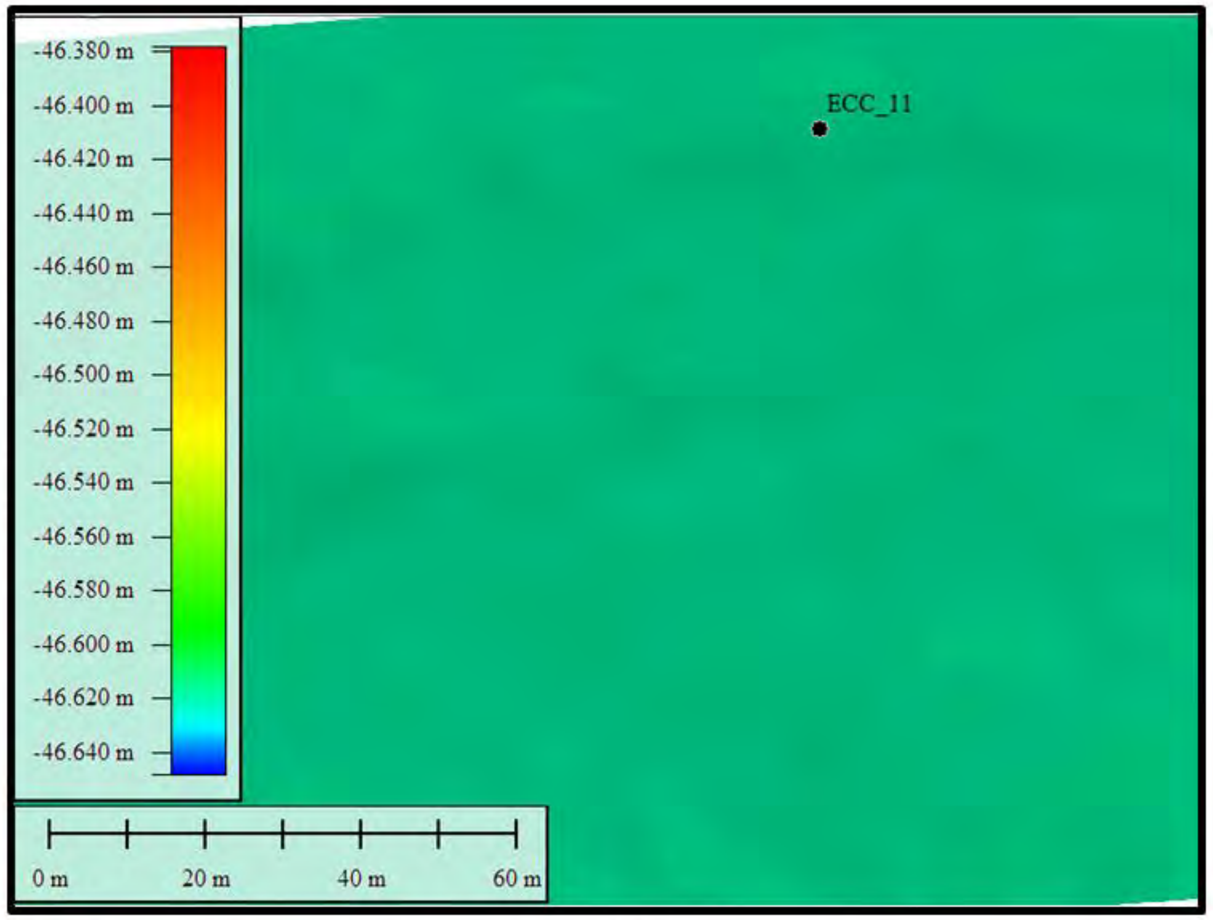


Photo Position: 350877 mE, 5985576 mN

Sample No.:	ECC_11	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:20

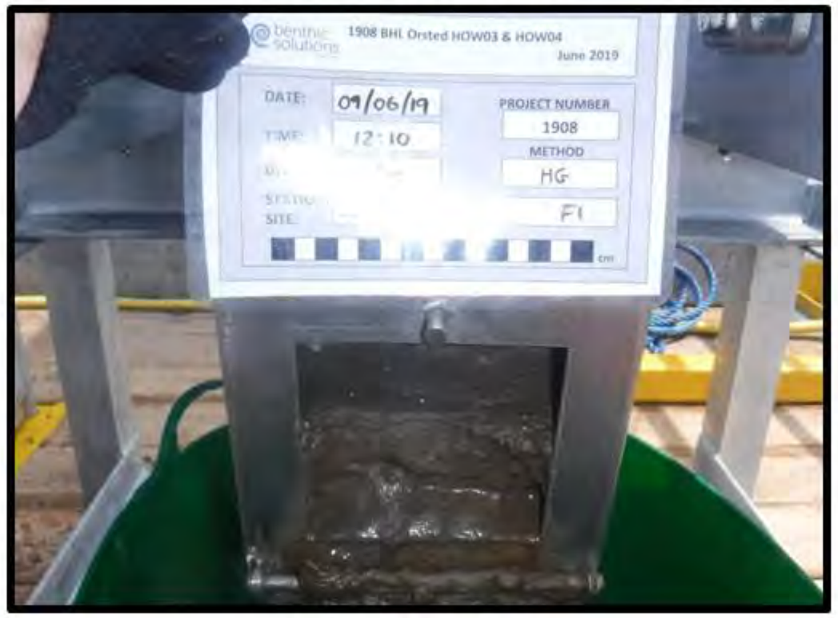


Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.102	0.121	3.29
Median	0.166		2.59
Sorting Coefficient	Value	Inference	
	1.69	Poorly Sorted	
Skewness	0.66	Very Positive (Coarse)	
Kurtosis	2.51	Very Leptokurtic	
% Fines	18.19%	V.Fine Sands	
% Sands	81.68%		
% Gravel	0.13%		

Sediment Characteristics



Sediment Example Image

Client

Contractors

Sieved Sample Image

Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_12

Survey Area: HOW04

No. of Stills: 7

Site Selection Criteria
Provided by Orsted

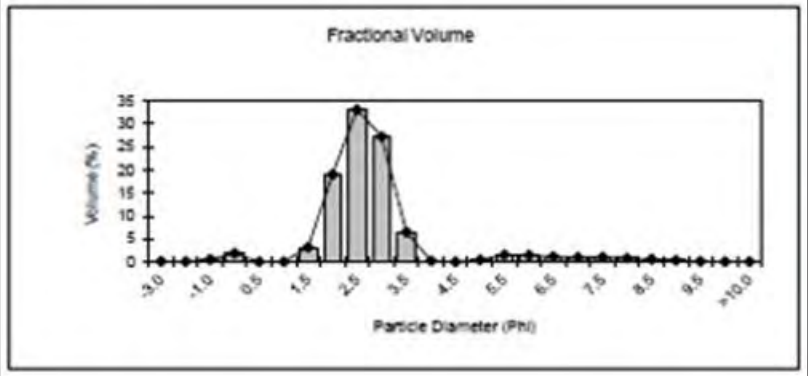
In Field Sediment Description
Medium brown, slightly muddy sand with small amounts of shell debris

Conspicuous Fauna
Echinodermata: *Echinocardium cordatum*.

Photo Position: 347043 mE, 5988634 mN

Photo Position: 347043 mE, 5988634 mN

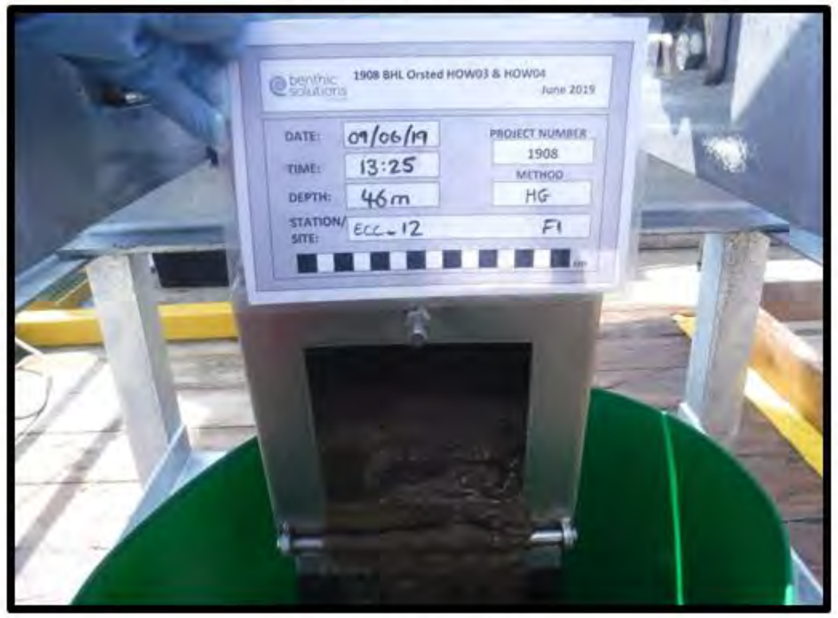
Sample No.:	ECC_12	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:32



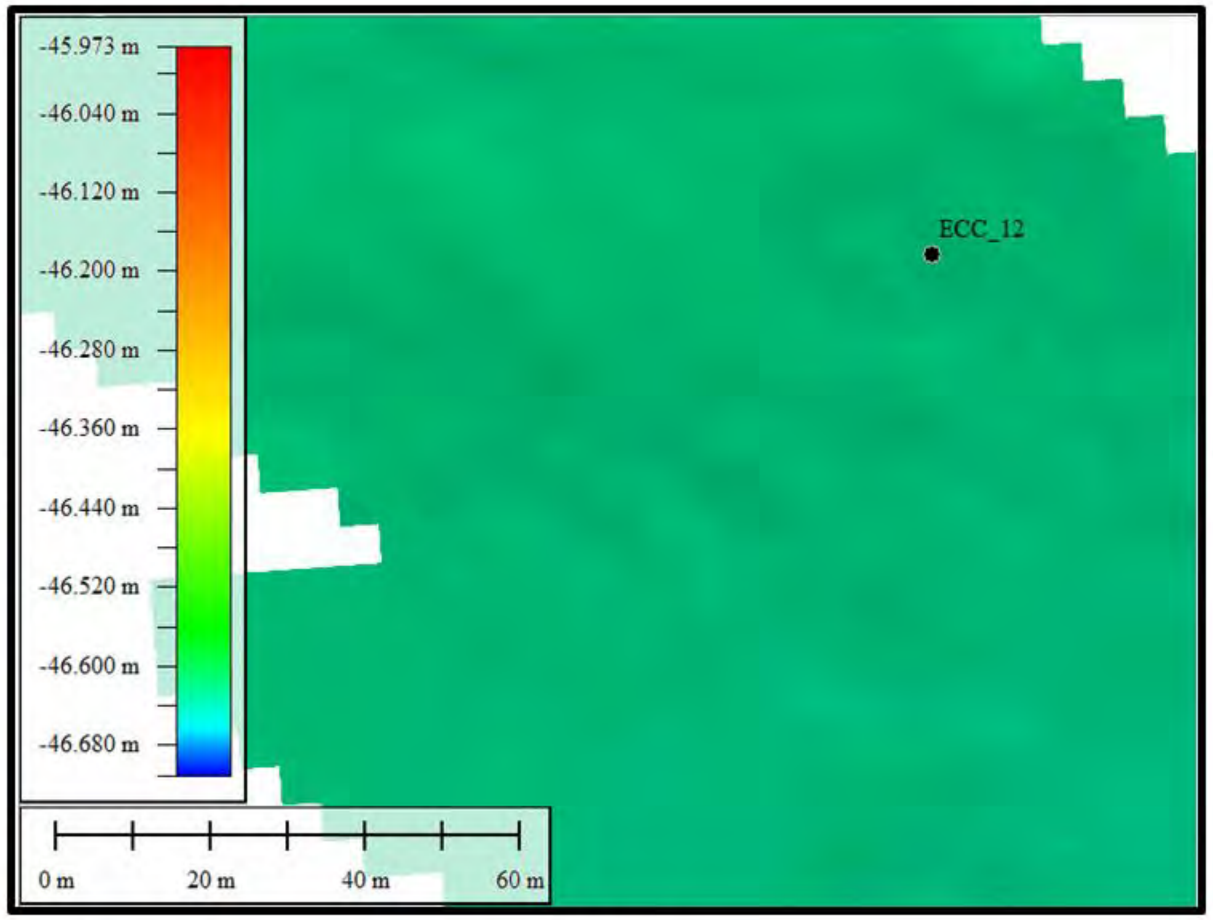
Particle Size Distribution

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.195	0.120	2.36
Median	0.196		2.35
Sorting Coefficient	**Value**		**Inference**
	1.00		Poorly Sorted
Skewness	0.30		Positive(Coarse)
Kurtosis	2.41		Very Leptokurtic
% Fines	8.33%		Fine Sand
% Sands	91.03%		
% Gravel	0.64%		

Sediment Characteristics



Sediment Example Image



Sieved Sample Image

Client

Ørsted

Contractors

BIBBY HYDROMAP

benthic solutions limited

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

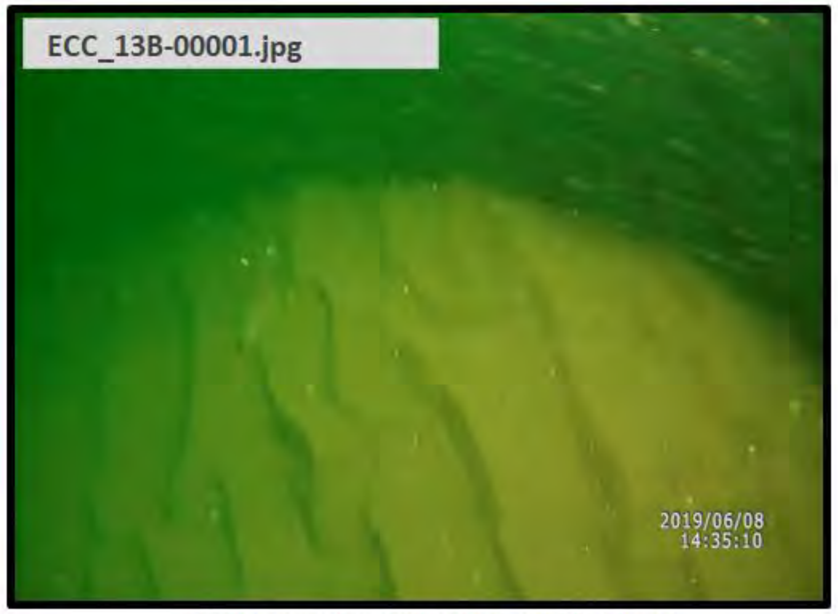


Photo Position: 343356 mE, 5989351 mN

Habitat Summary Information: ECC_13

Survey Area: HOW04

No. of Stills: 5

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

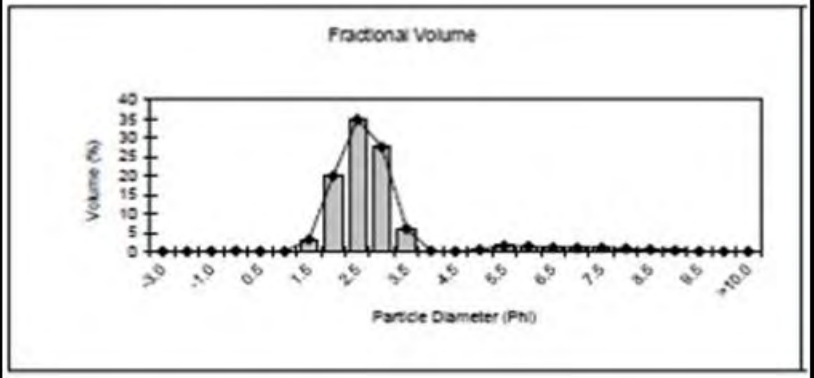
Medium brown, slightly muddy sand with small amounts of shell debris

Conspicuous Fauna

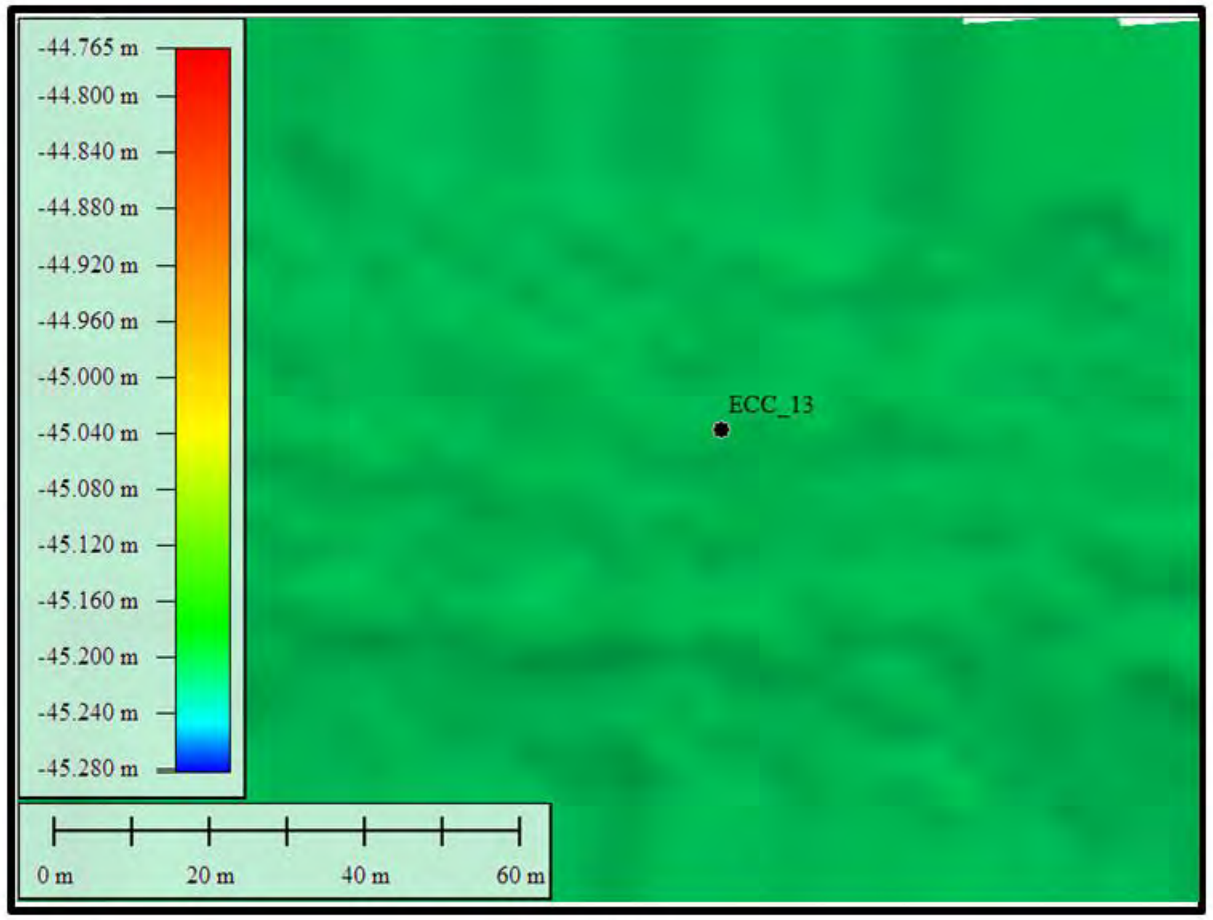
Annelida: *Lanice conchilega* (Sand Mason).

Photo Position: 343356 mE, 5989351 mN

Sample No.:	ECC_13	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 13:44



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.194	0.110	2.38
Median	0.197		2.34
Sorting	Value	Inference	
Coefficient	0.94	Moderately Sorted	
Skewness	0.33	Very Positive (Coarse)	
Kurtosis	2.34	Very Leptokurtic	
% Fines	7.86%	Fine Sand	
% Sands	92.03%		
% Gravel	0.11%		

Sediment Characteristics

Sediment Example Image

Client

Orsted

Contractors

BIBBY HYDROMAP

benthic solutions limited

Sieved Sample Image

Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 338761 mE, 5990705 mN

Habitat Summary Information: ECC_14

Survey Area: HOW04

No. of Stills: 10

Site Selection Criteria

Provided by Orsted

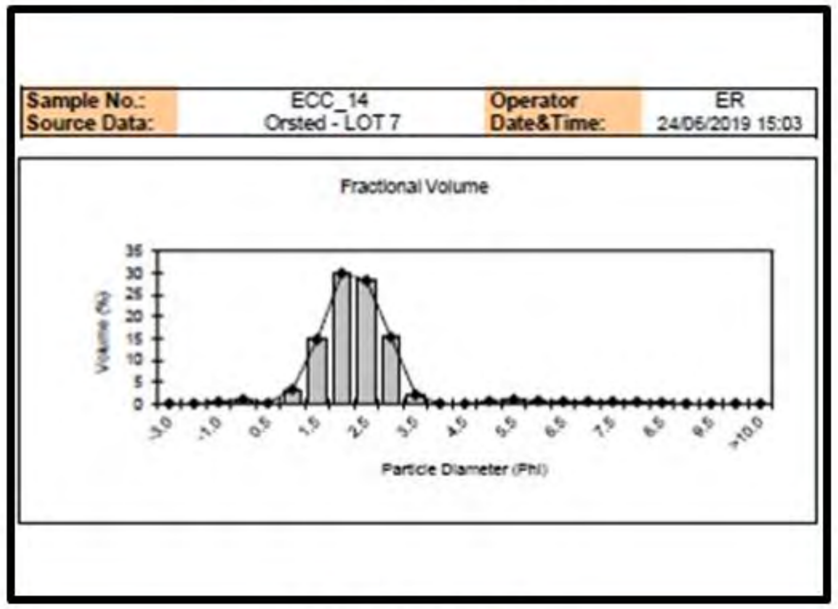
In Field Sediment Description

Medium brown, slightly muddy sand with relatively high levels of shell debris.

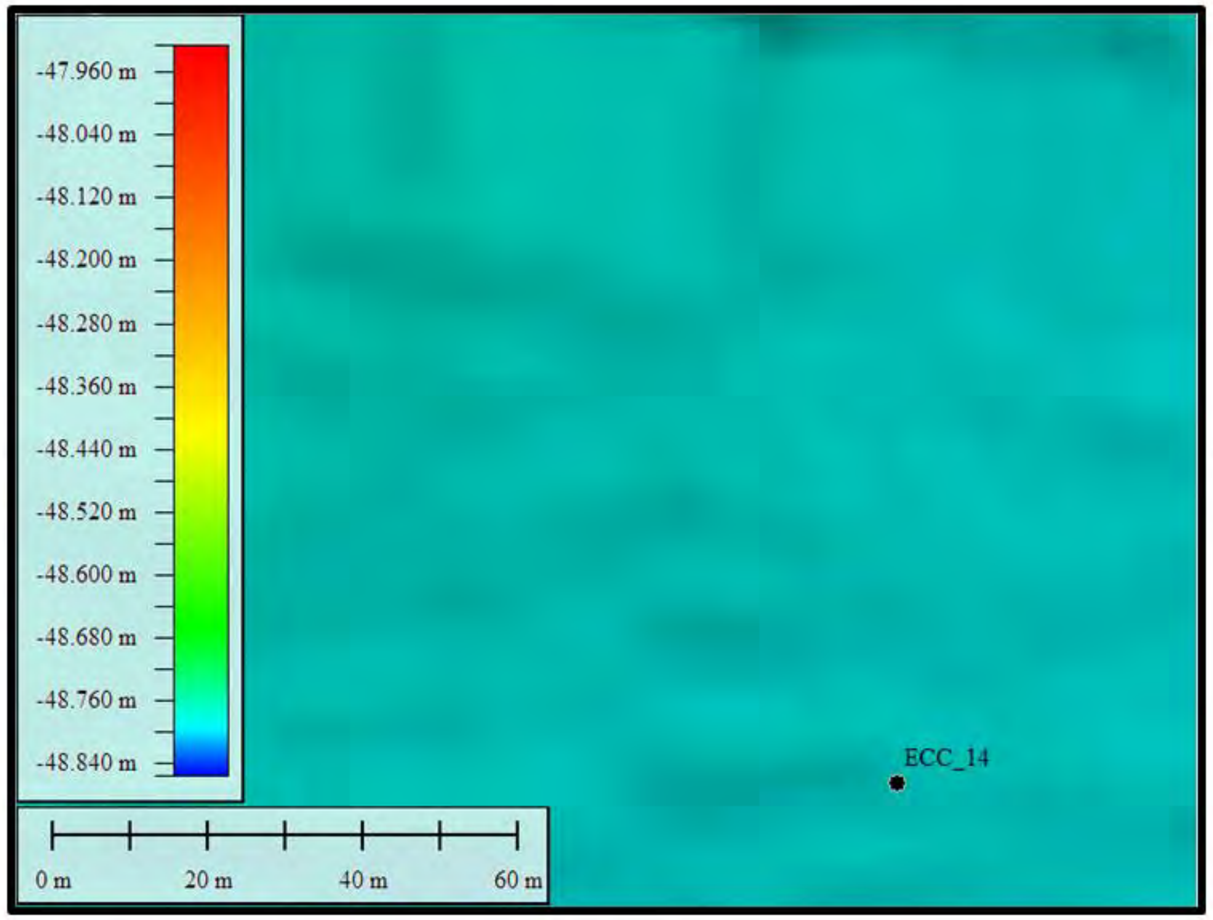
Conspicuous Fauna

Annelida: possibly *Lanice conchilega* (Sand Mason). **Mollusca:** Bivalvia. **Echinodermata:** *Echinocardium cordatum*.

Photo Position: 338761 mE, 5990705 mN



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.250	0.145	2.00
Median	0.250		2.00
Sorting Coefficient	Value 0.67	Inference Moderately Well Sorted	
Skewness	0.07	Symmetrical	
Kurtosis	1.13	Leptokurtic	
% Fines	4.37%	Fine Sand	
% Sands	95.17%		
% Gravel	0.46%		

Sediment Characteristics

Sediment Example Image

Client

Orsted

Contractors

BIBBY HYDROMAP

benthic solutions limited

● Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 333340 mE, 5992934 mN

Habitat Summary Information: ECC_15

Survey Area: HOW04

No. of Stills: 7

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, coarse sand with high levels of shell debris

Conspicuous Fauna

No fauna was observed.

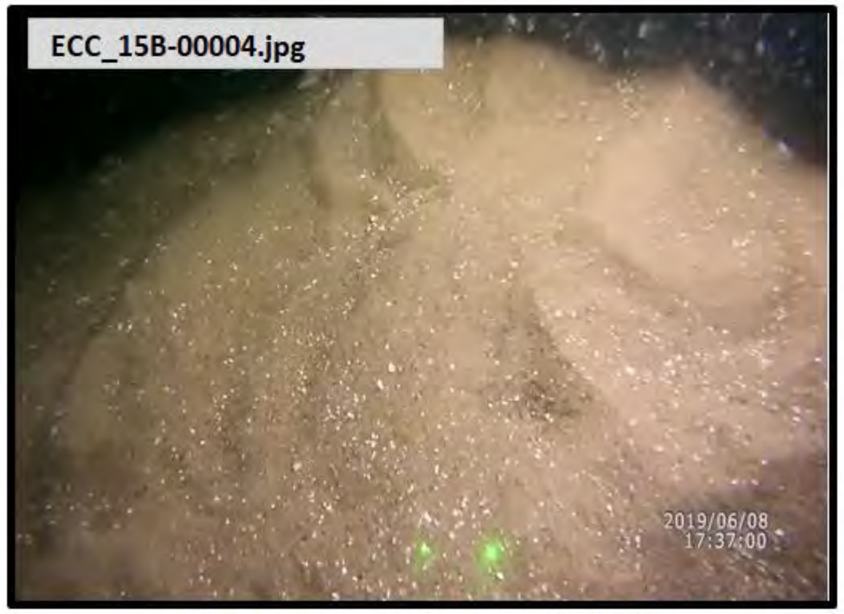
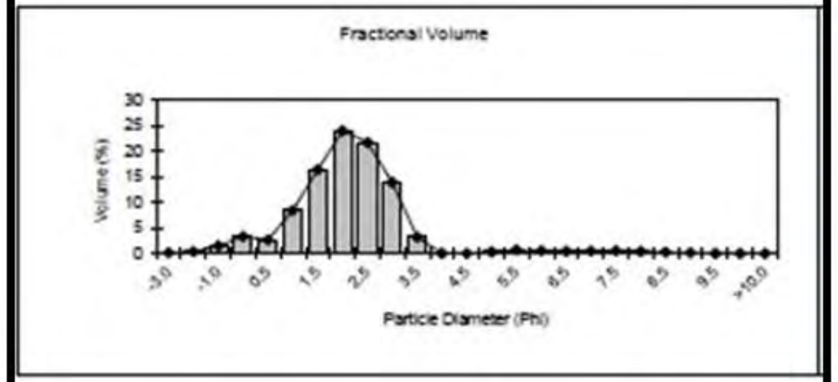
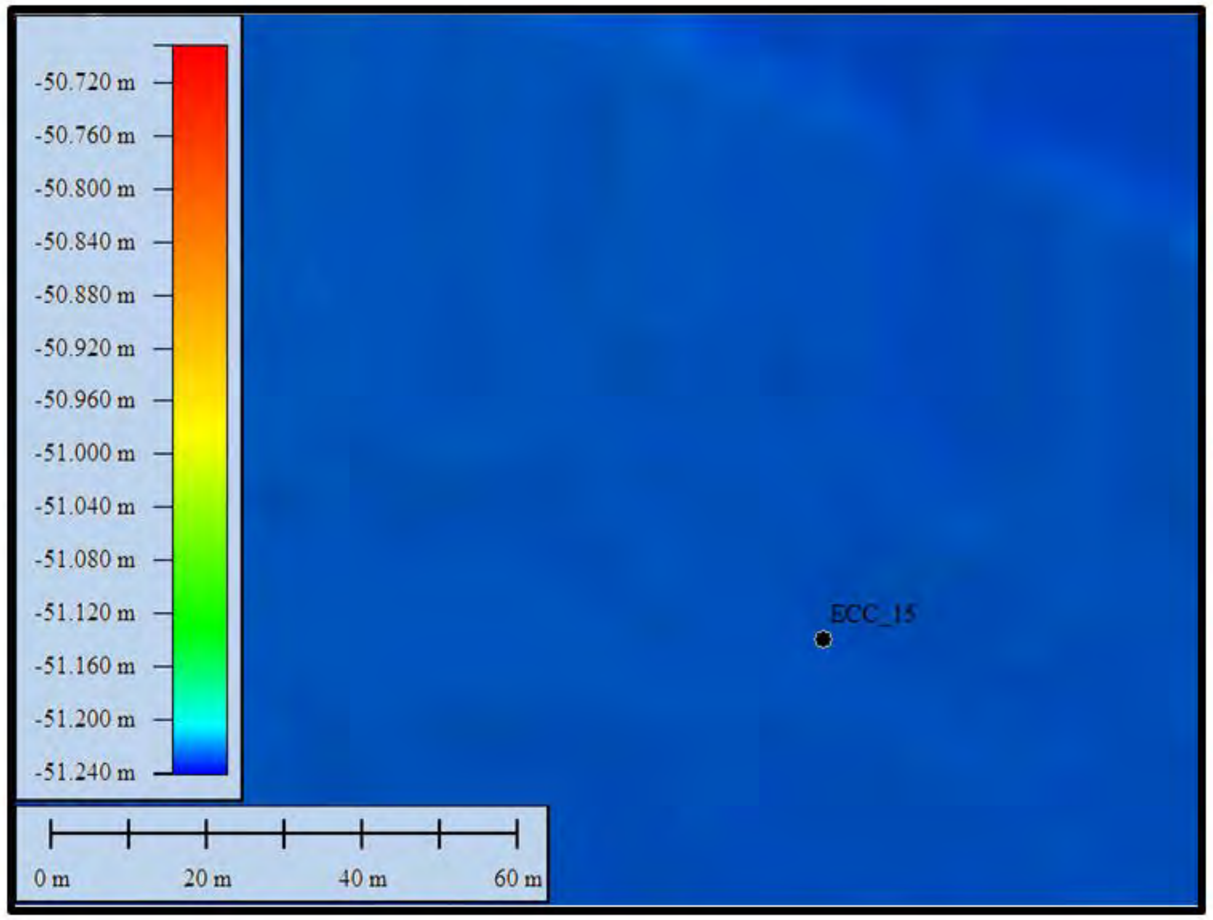


Photo Position: 333340 mE, 5992934 mN

Sample No.:	ECC_15	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 15:15



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.283	0.331	1.82
Median	0.280		1.84
Sorting Coefficient	Value 0.96	Inference Moderately Sorted	
Skewness	-0.08	Symmetrical	
Kurtosis	1.25	Leptokurtic	
% Fines	4.18%	Medium Sand	
% Sands	93.77%		
% Gravel	2.06%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

ECC_16B-00003.jpg

Photo Position: 367118 mE, 5985176 mN

Habitat Summary Information: ECC_16

Survey Area: HOW04

No. of Stills: 6

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, coarse sand with high levels of shell debris

Conspicuous Fauna

Annelida: possibly *Lanice conchilega* (Sand Mason). **Echinodermata:** *Echinocardium cordatum* .

ECC_16B-00006.jpg

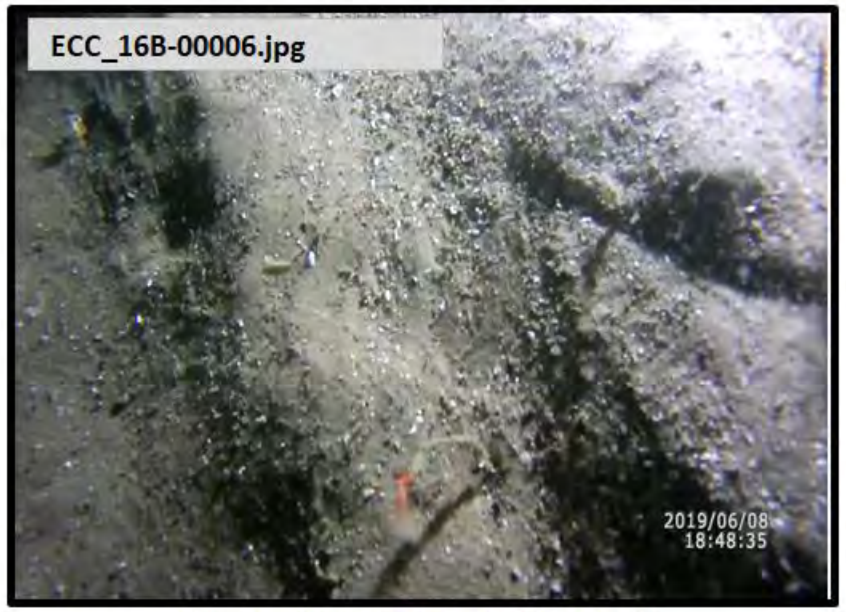
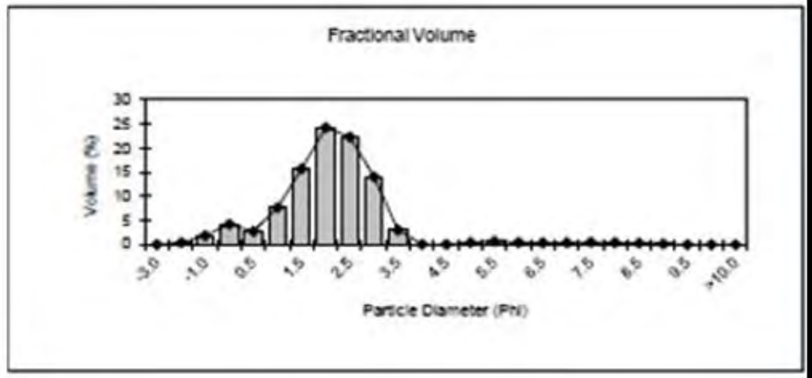
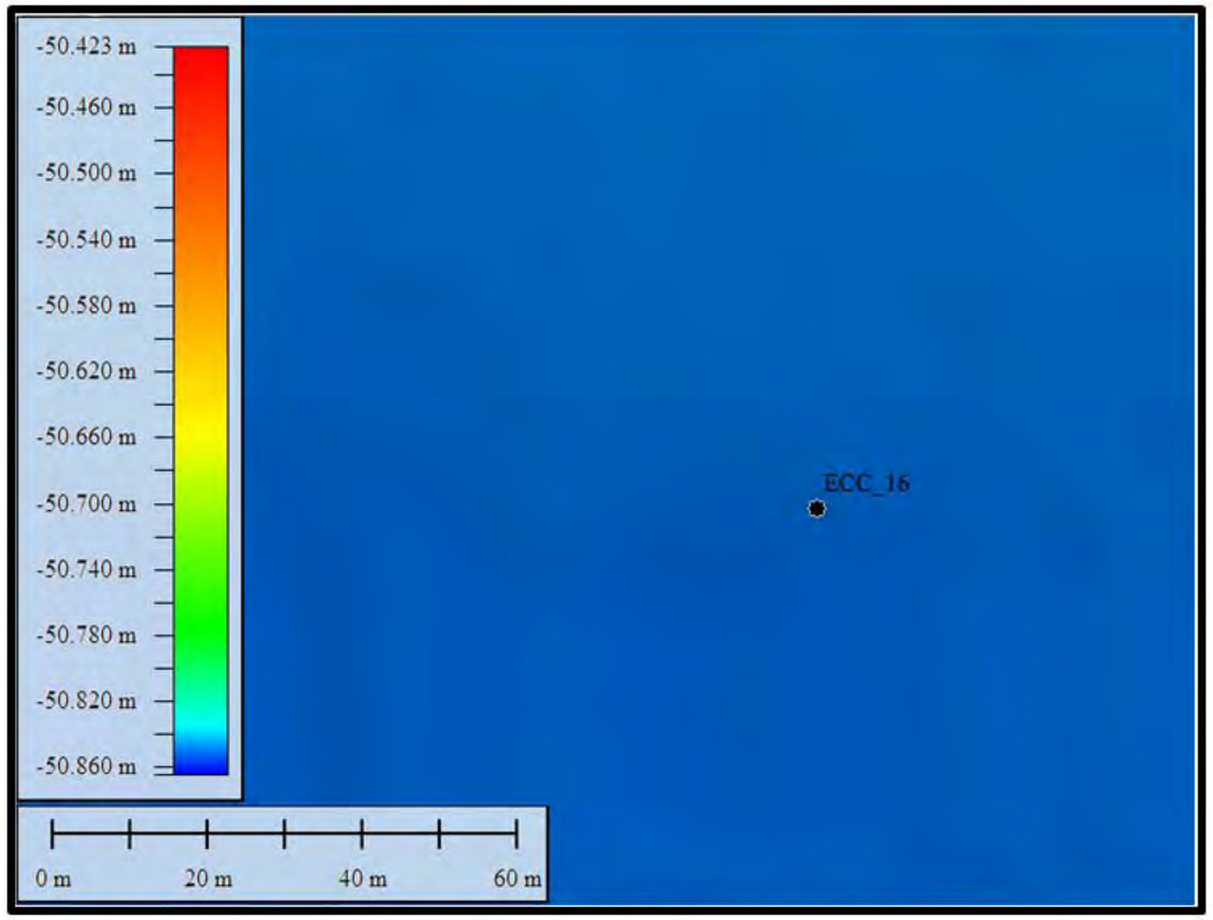


Photo Position: 367118 mE, 5985176 mN

Sample No.:	ECC_16	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 15:40



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.287	0.398	1.80
Median	0.280		1.84
Sorting	Value	Inference	
Coefficient	0.98	Moderately Sorted	
Skewness	-0.15	Negative (Fine)	
Kurtosis	1.33	Leptokurtic	
% Fines	3.63%	Medium Sand	
% Sands	94.08%		
% Gravel	2.29%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Sieved Sample Image

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 324285 mE, 5993344 mN

Habitat Summary Information: ECC_17

Survey Area: HOW04

No. of Stills: 6

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, gravelly sand

Conspicuous Fauna

Cnidaria: *Alcyonium digitatum* (Dead man's fingers), Hydroid. **Annelida:** Polychaeta. **Arthropoda:** *Liocarcinus depurator* (Sandy swimming crab). **Bryozoa:** *Flustra foliacea* (Hornwrack).

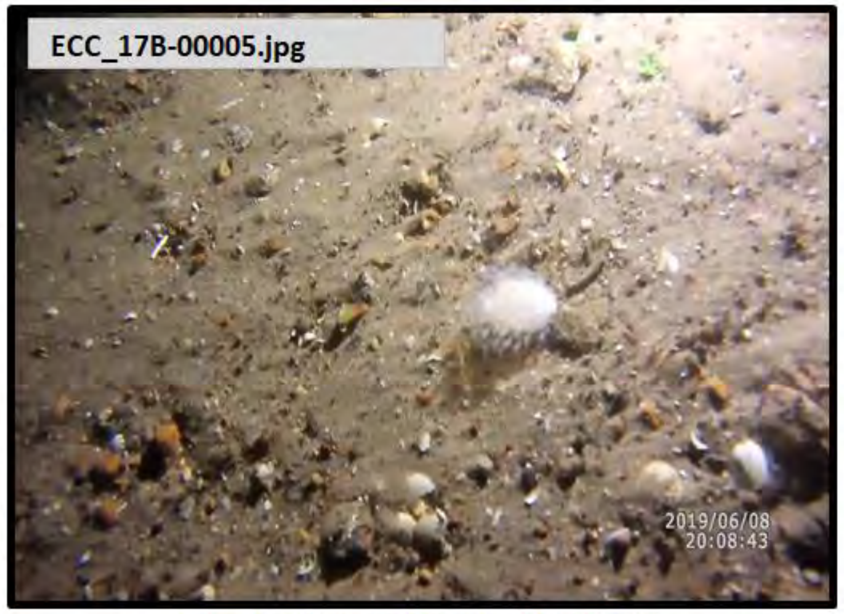
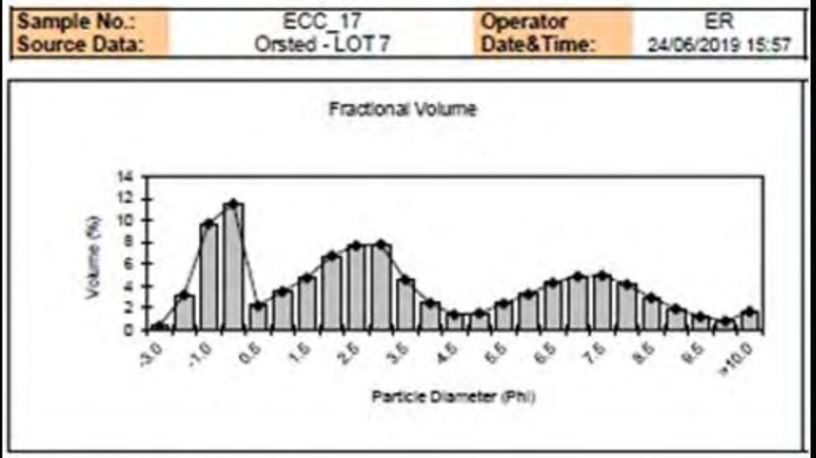
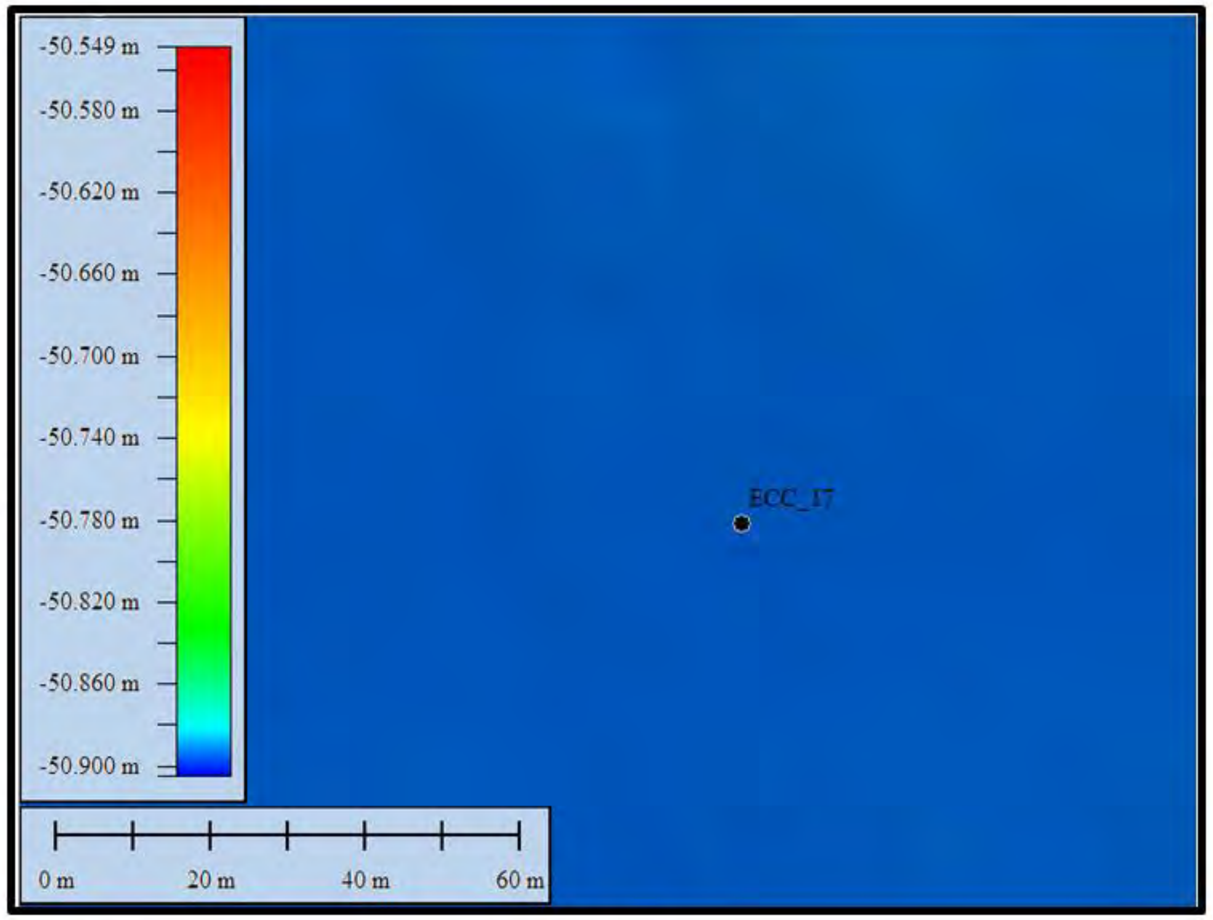


Photo Position: 324285 mE, 5993344 mN

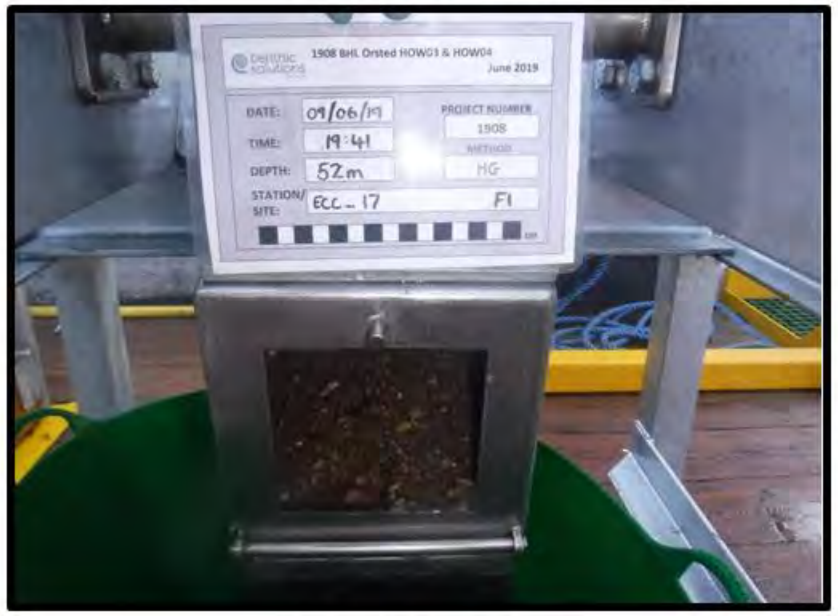


Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.130	1.382	2.94
Median	0.178		2.49
Sorting Coefficient	Value 3.58	Inference Very Poorly Sorted	
Skewness	0.17	Positive(Coarse)	
Kurtosis	0.70	Platykurtic	
% Fines	35.43%	Fine Sand	
% Sands	51.31%		
% Gravel	13.26%		

Sediment Characteristics



Sediment Example Image

Client

Orsted

Contractors

BIBBY HYDROMAP

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Sieved Sample Image

● Highlighted station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_18

Survey Area: HOW04

No. of Stills: 6

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, slightly muddy gravelly sand

Conspicuous Fauna

Cnidaria: *Alcyonium digitatum* (Dead man's fingers). **Annelida:** *Sabellaria spinulosa*.

ECC_18B-00001.jpg

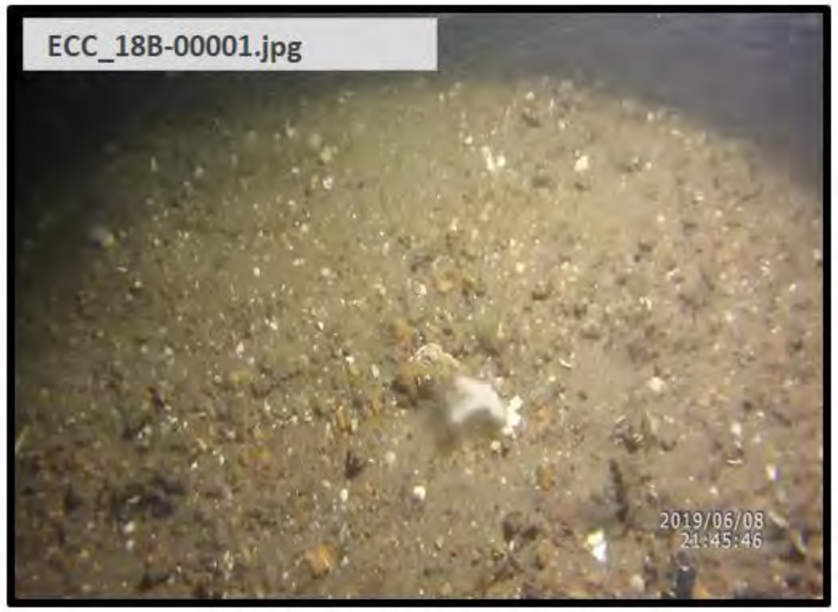


Photo Position: 317131 mE, 5994309 mN

ECC_18B-00006.jpg

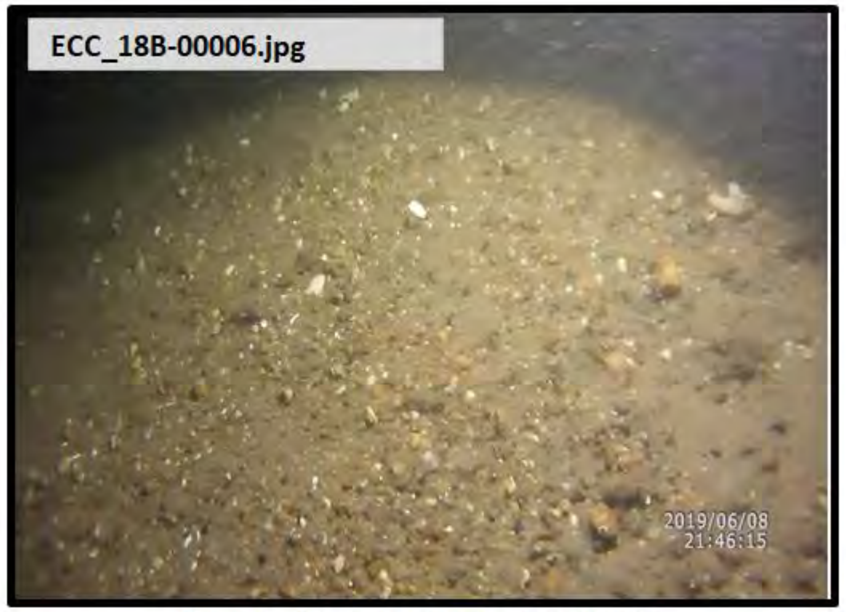
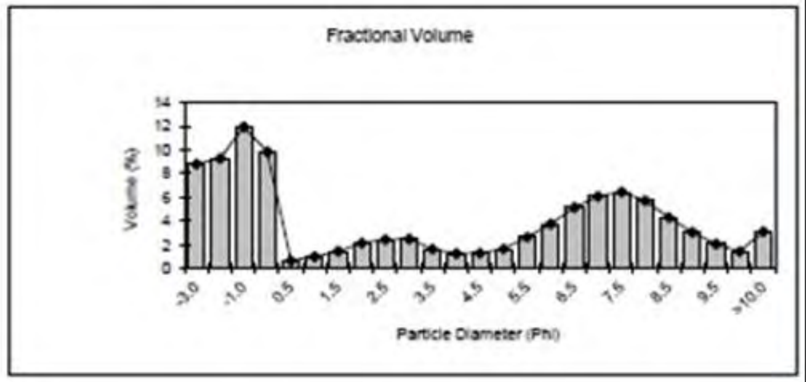


Photo Position: 317131 mE, 5994309 mN

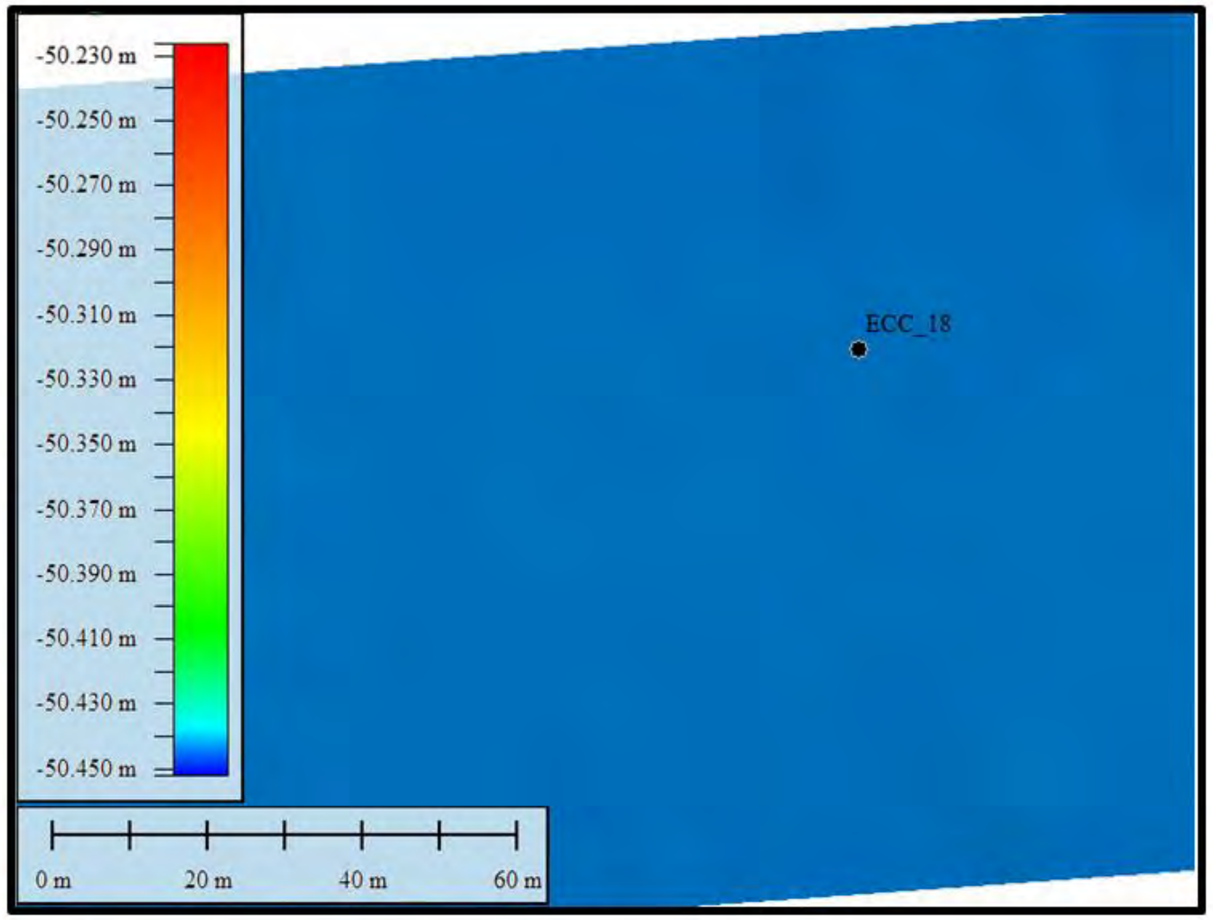
Sample No.:	ECC_18	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 16:11



Particle Size Distribution

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.141	3.740	2.82
Median	0.129		2.96
Sorting Coefficient	Value 4.44	Inference Extremely Poorly Sorted	
Skewness	-0.01	Symmetrical	
Kurtosis	0.60	Very Platykurtic	
% Fines	46.91%	Fine Sand	
% Sands	23.02%		
% Gravel	30.08%		

Sediment Characteristics



● Current station

Sediment Example Image

Sieved Sample Image

Client

Ørsted

Contractors

BIBBY HYDROMAP

benthic solutions limited

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

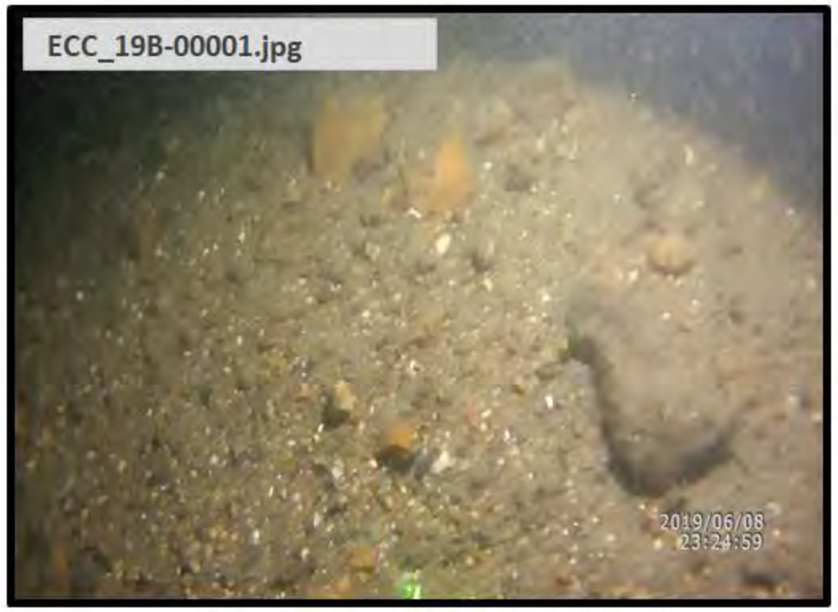


Photo Position: 311025 mE, 5993455 mN

Habitat Summary Information: ECC_19

Survey Area: HOW04

No. of Stills: 5

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

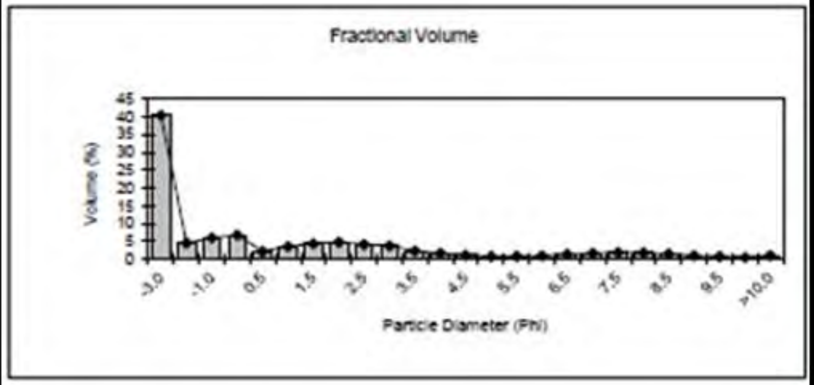
Medium brown, slightly muddy gravelly sand

Conspicuous Fauna

Annelida: *Sabellaria spinulosa* . **Echinodermata:** *Ophiura sp.* . **Bryozoa:** *Flustra foliacea* (Hornwrack).

Photo Position: 311025 mE, 5993455 mN

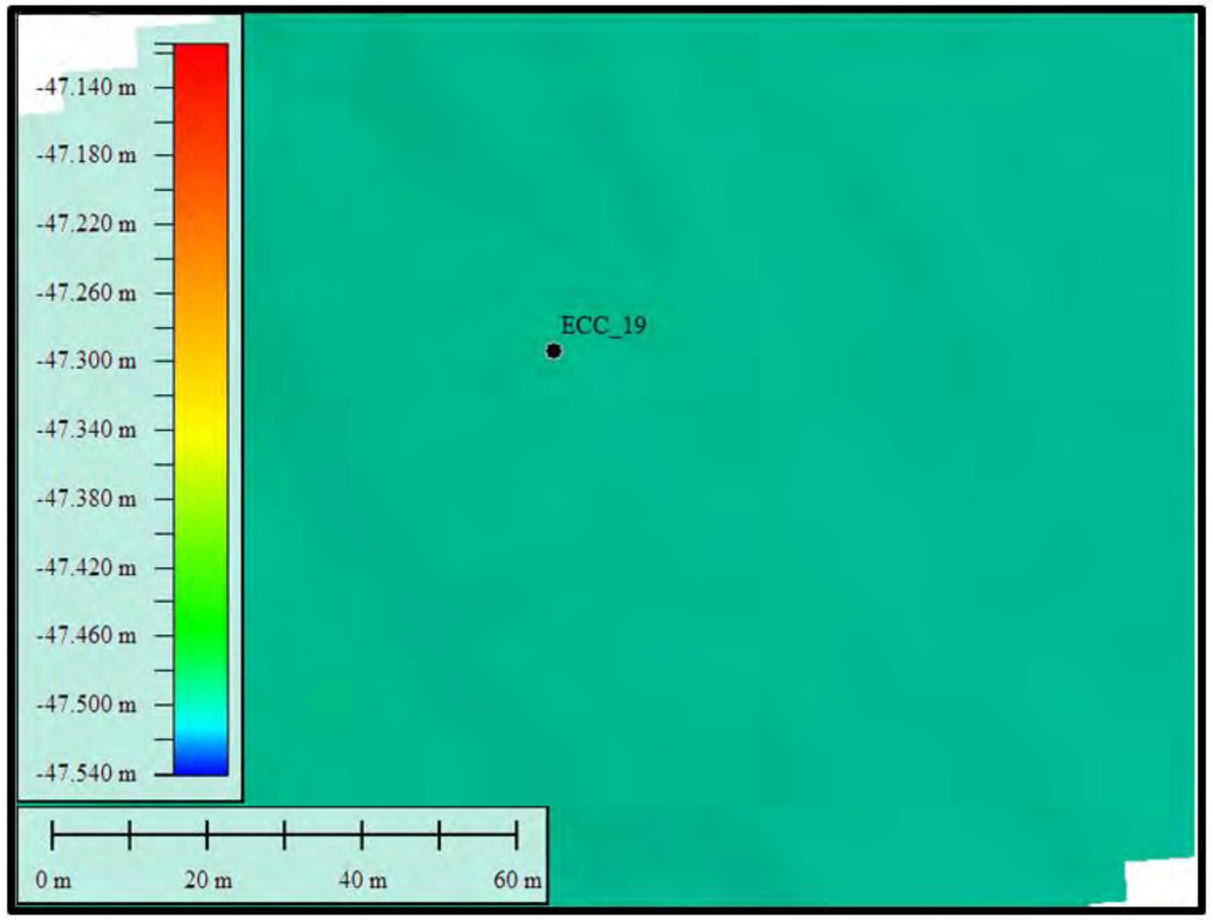
Sample No.:	ECC_19	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	24/06/2019 16:43



Particle Size Distribution

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	1.715	16.938	-0.78
Median	2.323		-1.22
Sorting Coefficient	Value 4.17		Inference Extremely Poorly Sorted
Skewness	0.27		Positive(Coarse)
Kurtosis	0.81		Platykurtic
% Fines	15.36%		V.Coarse Sand
% Sands	33.67%		
% Gravel	50.97%		

Sediment Characteristics



Sediment Example Image

Client

Orsted

Contractors

BIBBY HYDROMAP

benthic solutions limited

Sieved Sample Image

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

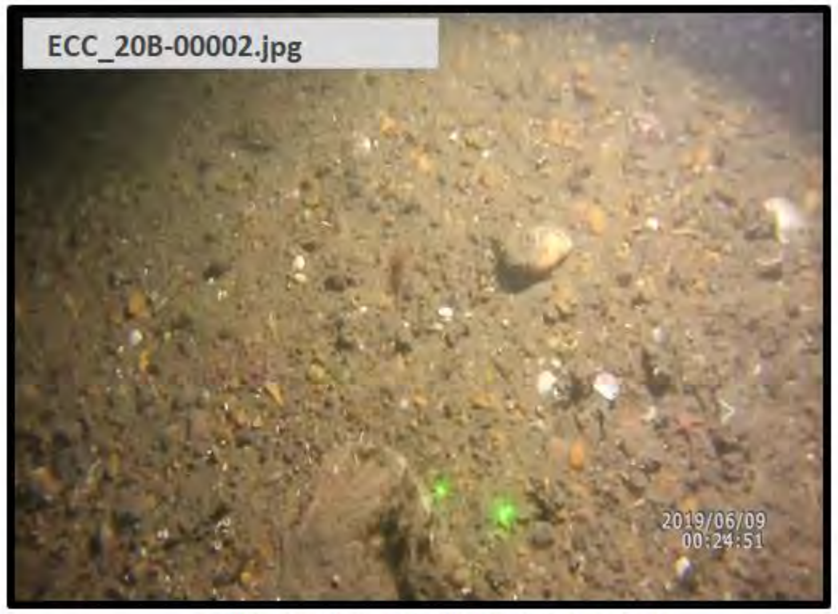


Photo Position: 309244 mE, 5991904 mN

Habitat Summary Information: ECC_020

Survey Area: HOW04

No. of Stills: 12

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

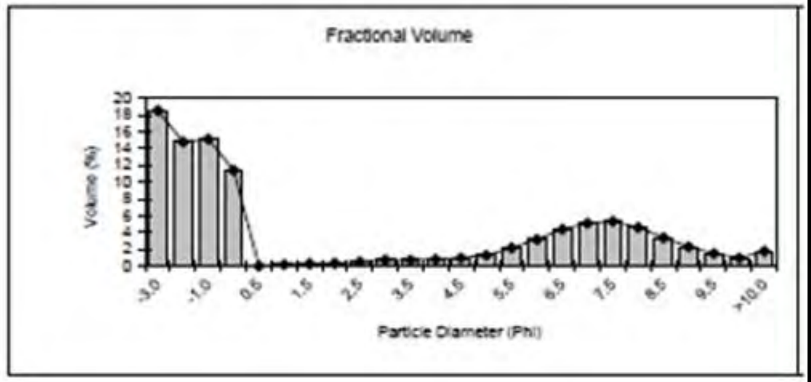
Medium brown, slightly muddy gravelly sand

Conspicuous Fauna

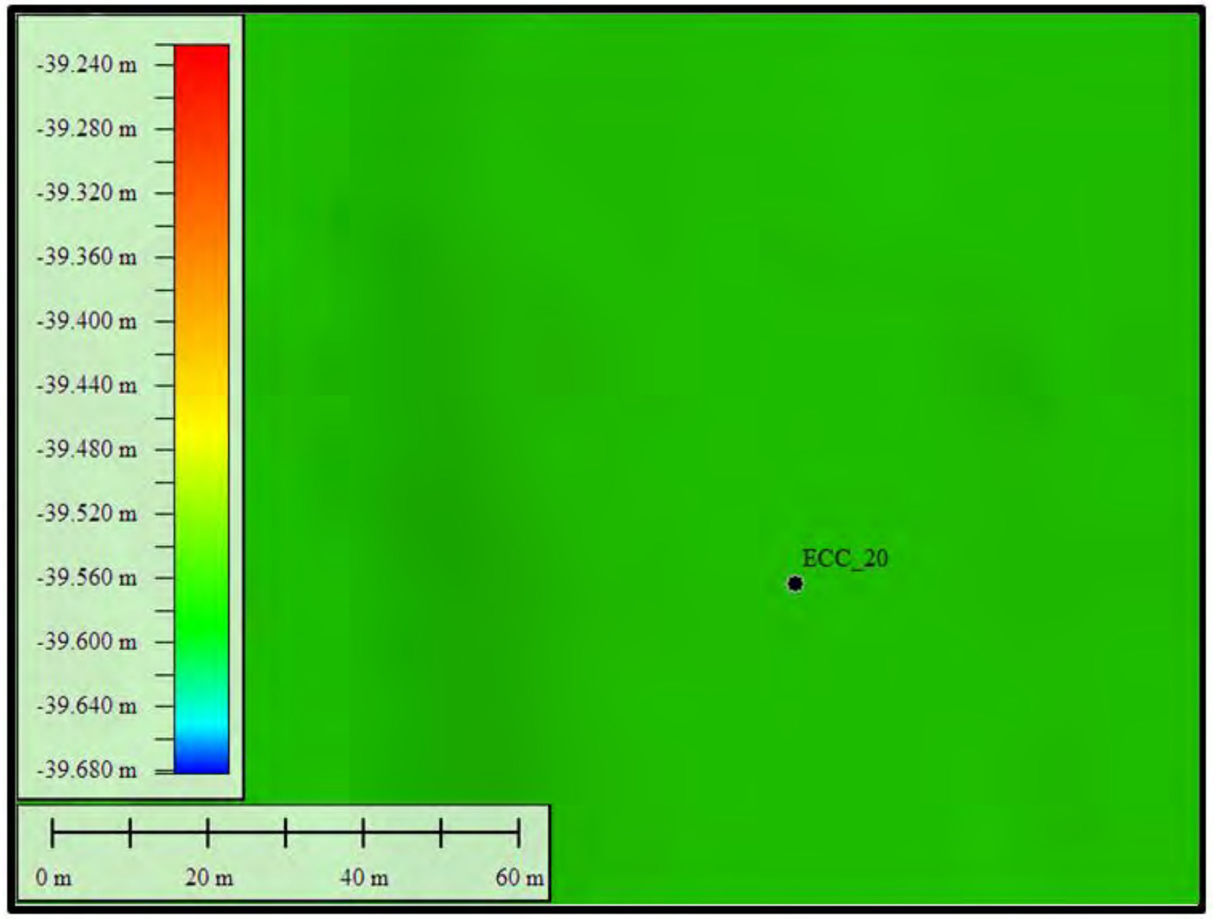
Annelida: possibly *Pomatoceros triqueter* (Keel worm). **Arthropoda:** *Carcinus maenus* (Common shore crab), possibly Crangonidae sp. **Mollusca:** possibly *Pecten maximus* (King scallop). **Echinodermata:** *Ophiura sp.* . **Bryozoa:** *Flustra foliacea* (Hornwrack).

Photo Position: 309244 mE, 5991904 mN

Sample No.:	ECC_20	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 08:59



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.464	4.912	1.11
Median	1.864		-0.90
Sorting Coefficient	Value 4.48	Inference Extremely Poorly Sorted	
Skewness	0.57	Very Positive (Coarse)	
Kurtosis	0.55	Very Platykurtic	
% Fines	36.75%	Medium Sand	
% Sands	14.82%		
% Gravel	48.44%		

Sediment Characteristics

Sediment Example Image

Client

Orsted

Contractors

BIBBY HYDROMAP

benthic solutions limited

● Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_21

Survey Area: HOW04

No. of Stills: 5

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Medium brown, slightly muddy gravelly sand

Conspicuous Fauna

Cnidaria: Actinaria. **Annelida:** *Sabellaria spinulosa* . **Bryozoa:** Bryozoan turf.

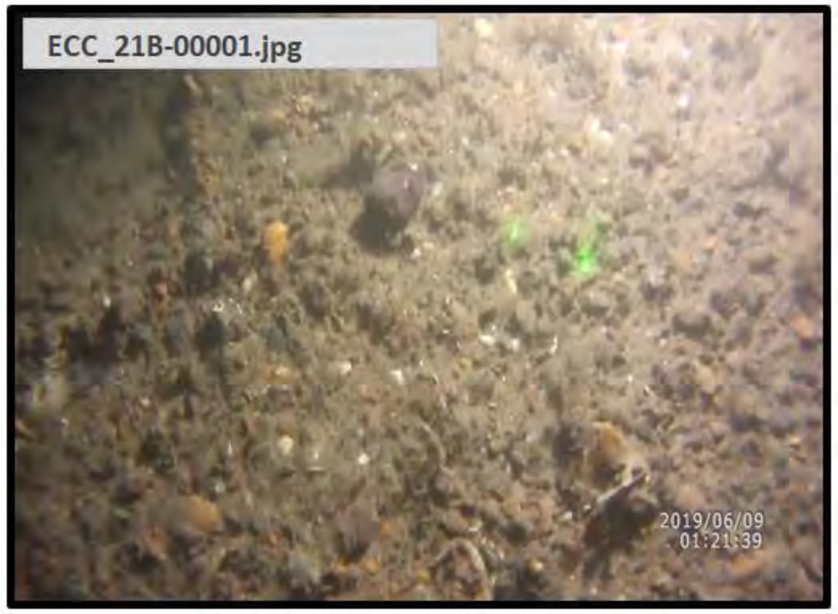


Photo Position: 306664 mE, 5992866 mN

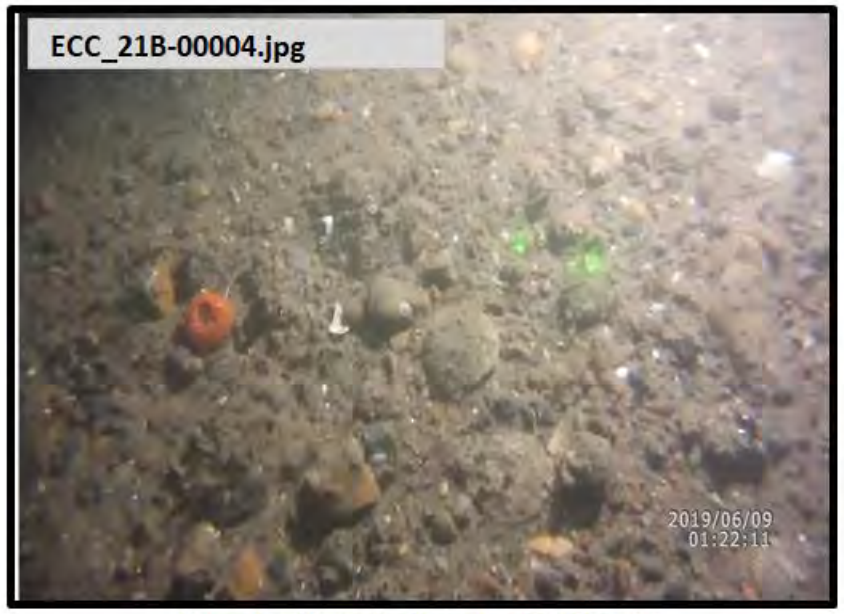
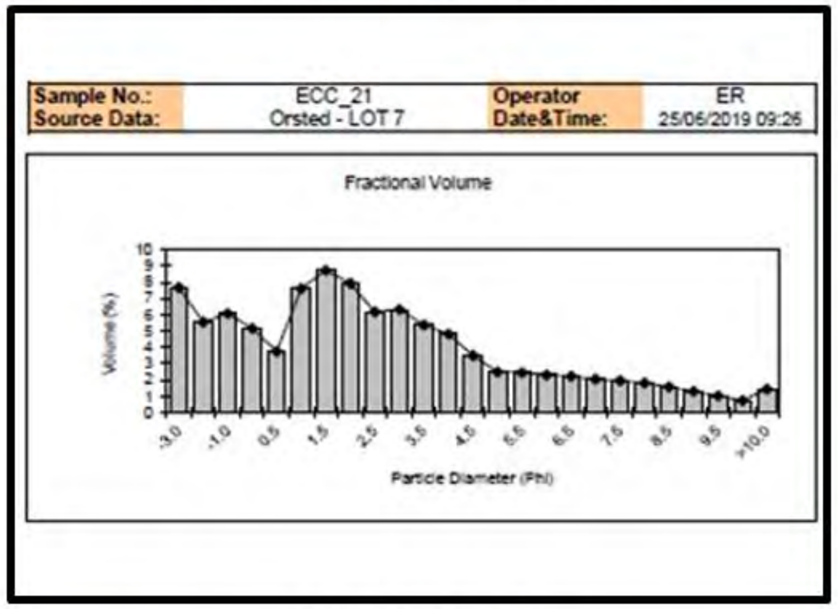


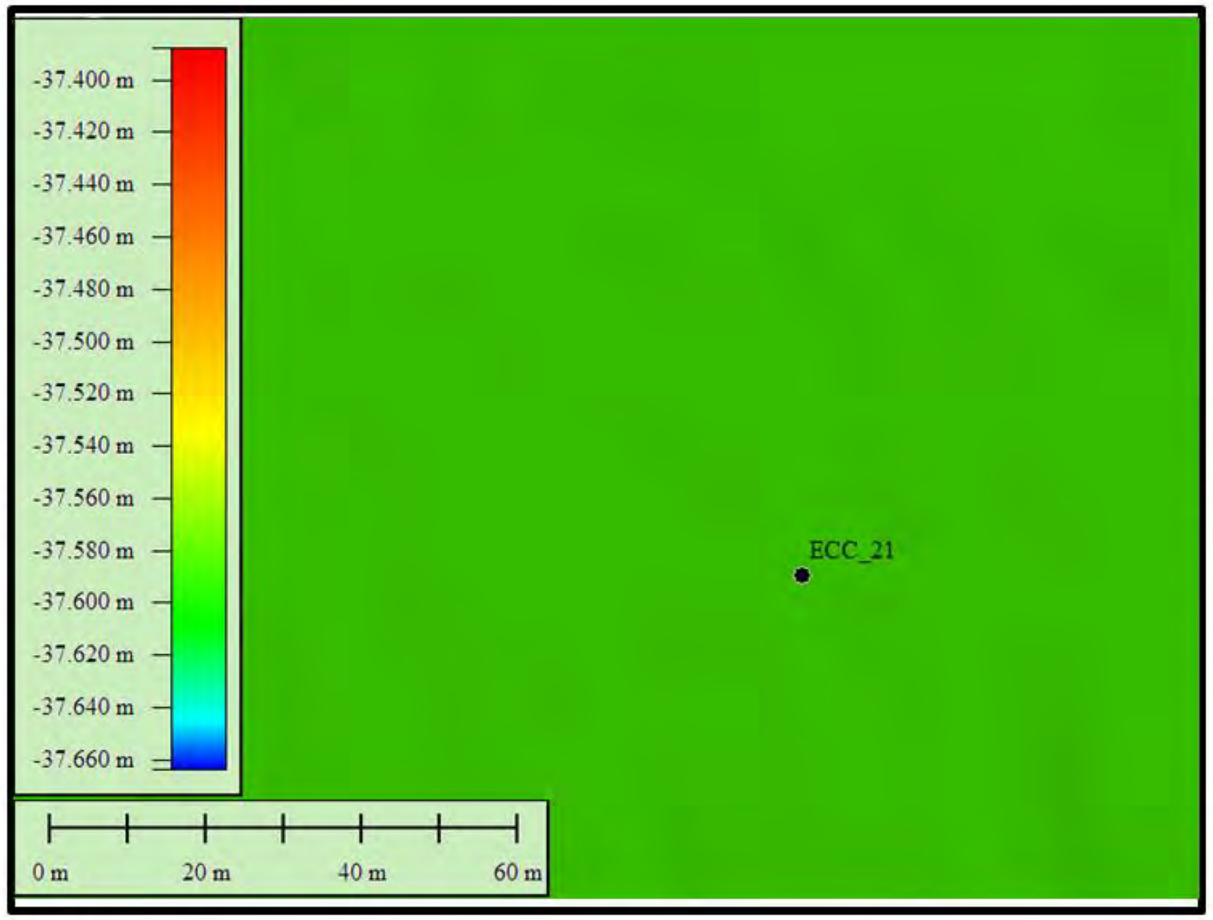
Photo Position: 306664 mE, 5992866 mN



Particle Size Distribution

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.263	3.564	1.93
Median	0.283		1.82
Sorting Coefficient	Value 3.56	Inference Very Poorly Sorted	
Skewness	0.08	Symmetrical	
Kurtosis	1.22	Leptokurtic	
% Fines	24.83%	Medium Sand	
% Sands	55.87%		
% Gravel	19.30%		

Sediment Characteristics



Sediment Example Image

Client

Orsted

Contractors

BIBBY HYDROMAP

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● Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_22

Survey Area: HOW04

No. of Stills: 6

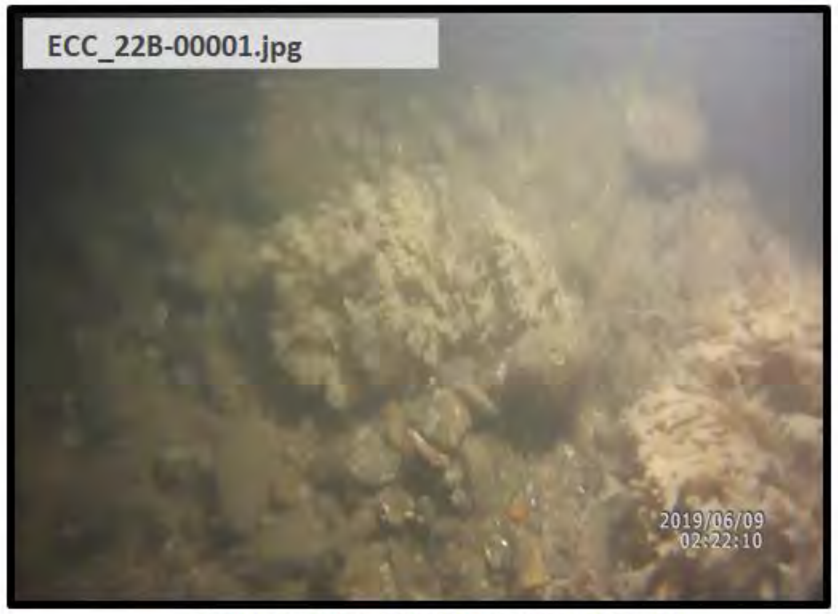


Photo Position: 303238 mE, 5991986 mN

Photo Position: 303238 mE, 5991986 mN

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Cobbles and boulders.

Conspicuous Fauna

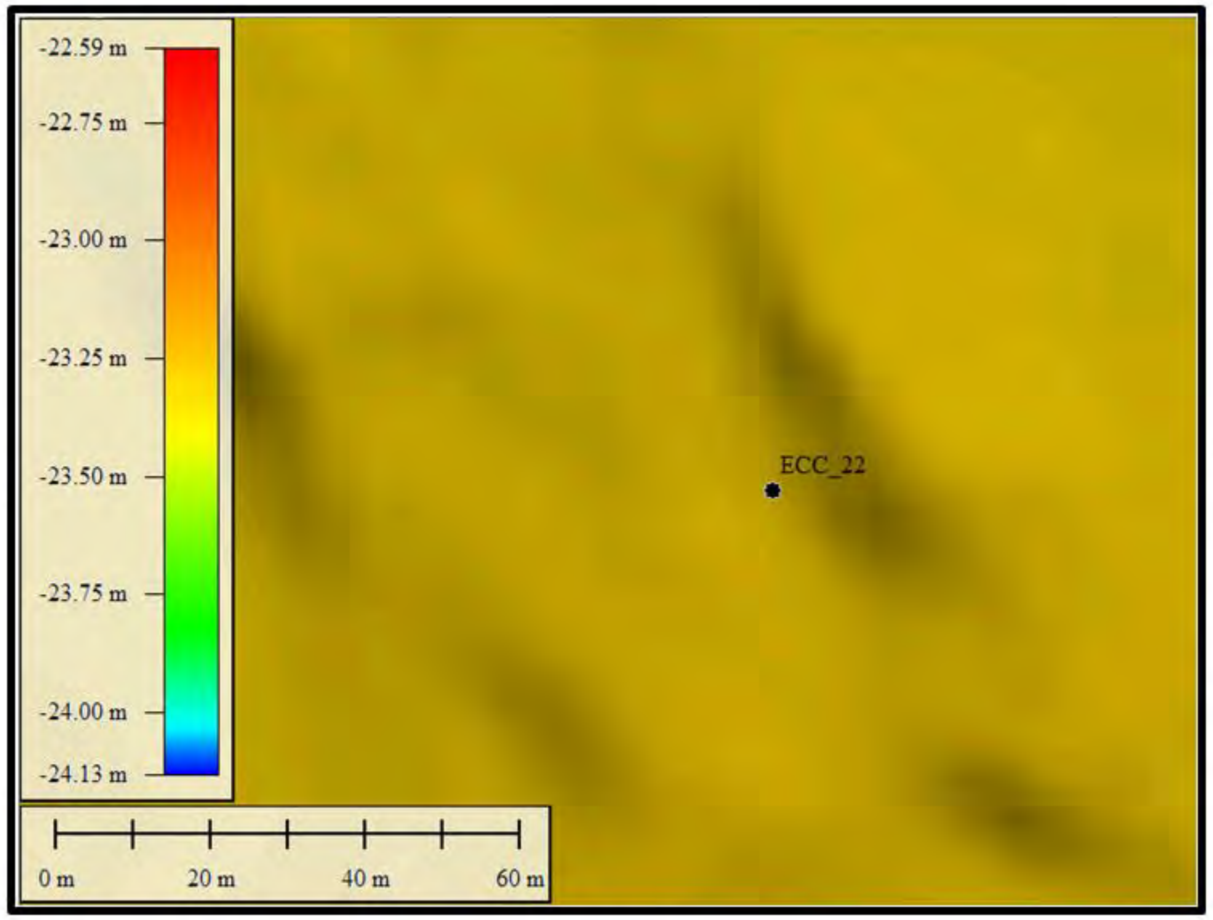
Cnidaria: Actinaria, *Alcyonium digitatum* (Dead man's fingers), *Hydroid turf*. **Annelida:** *possibly Pomatoceros triqueter (Keel worm)*. **Bryozoa:** *Flustra foliacea* (Hornwrack).

NO SAMPLE

Particle Size Distribution

NO SAMPLE

Sediment Characteristics



Sediment Example Image

Sieved Sample Image

Client

Contractors

Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_23

Survey Area: HOW04

No. of Stills: 14

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

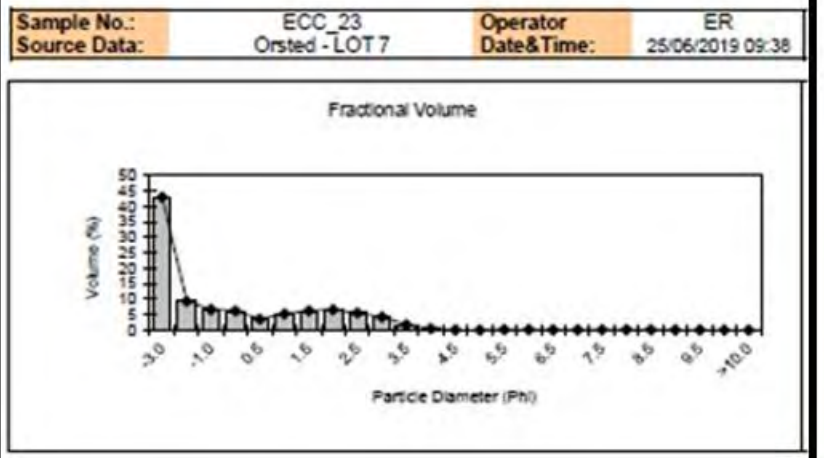
Medium brown, gravel with cobbles

Conspicuous Fauna

Cnidaria: *Alcyonium digitatum* (Dead man's fingers), Hydrozoan turf. **Arthropoda:** Carcinus maenas (Common shore crab). **Echinodermata:** possibly *Henricia sp.* . **Bryozoa:** Bryozoan turf, *Alcyonidium diaphanum* .

Photo Position: 300550 mE, 5993001 mN

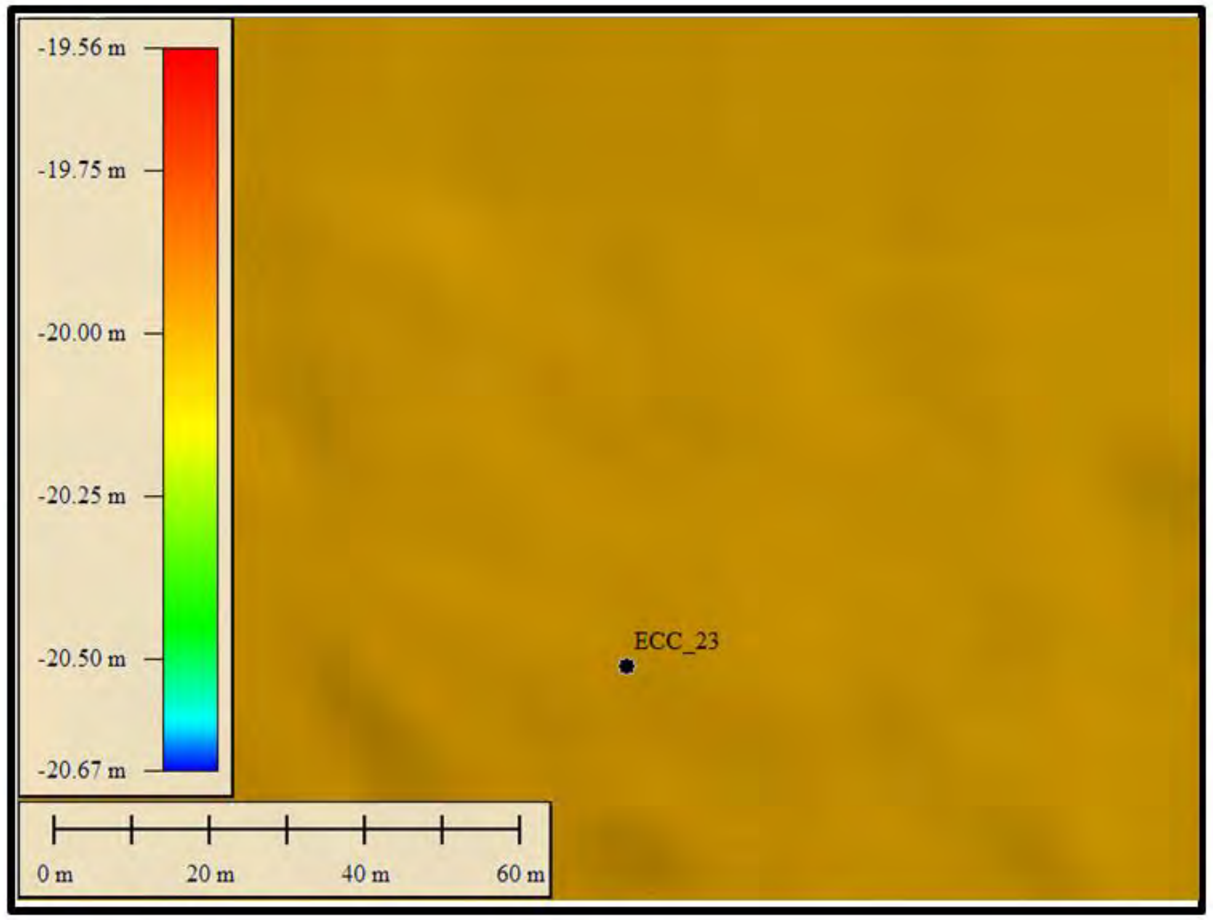
Photo Position: 300550 mE, 5993001 mN



Particle Size Distribution

Graphical	mm	StDev (mm)	Phi
Mean (MZ)	3.089	10.506	-1.63
Median	5.063		-2.34
Sorting	**Value**		**Inference**
Coefficient	2.63		Very Poorly Sorted
Skewness	0.37		Very Positive (Coarse)
Kurtosis	0.60		Very Platykurtic
% Fines	1.07%		Granule
% Sands	39.86%		
% Gravel	59.07%		

Sediment Characteristics



Client

Orsted

Contractors

BIBBY HYDROMAP

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Current station

Sediment Example Image

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Habitat Summary Information: ECC_24

Survey Area: HOW04

No. of Stills: 4

Site Selection Criteria

Provided by Orsted

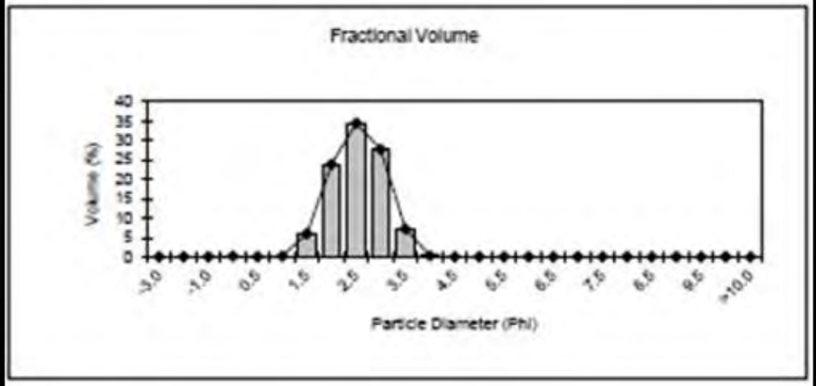
In Field Sediment Description

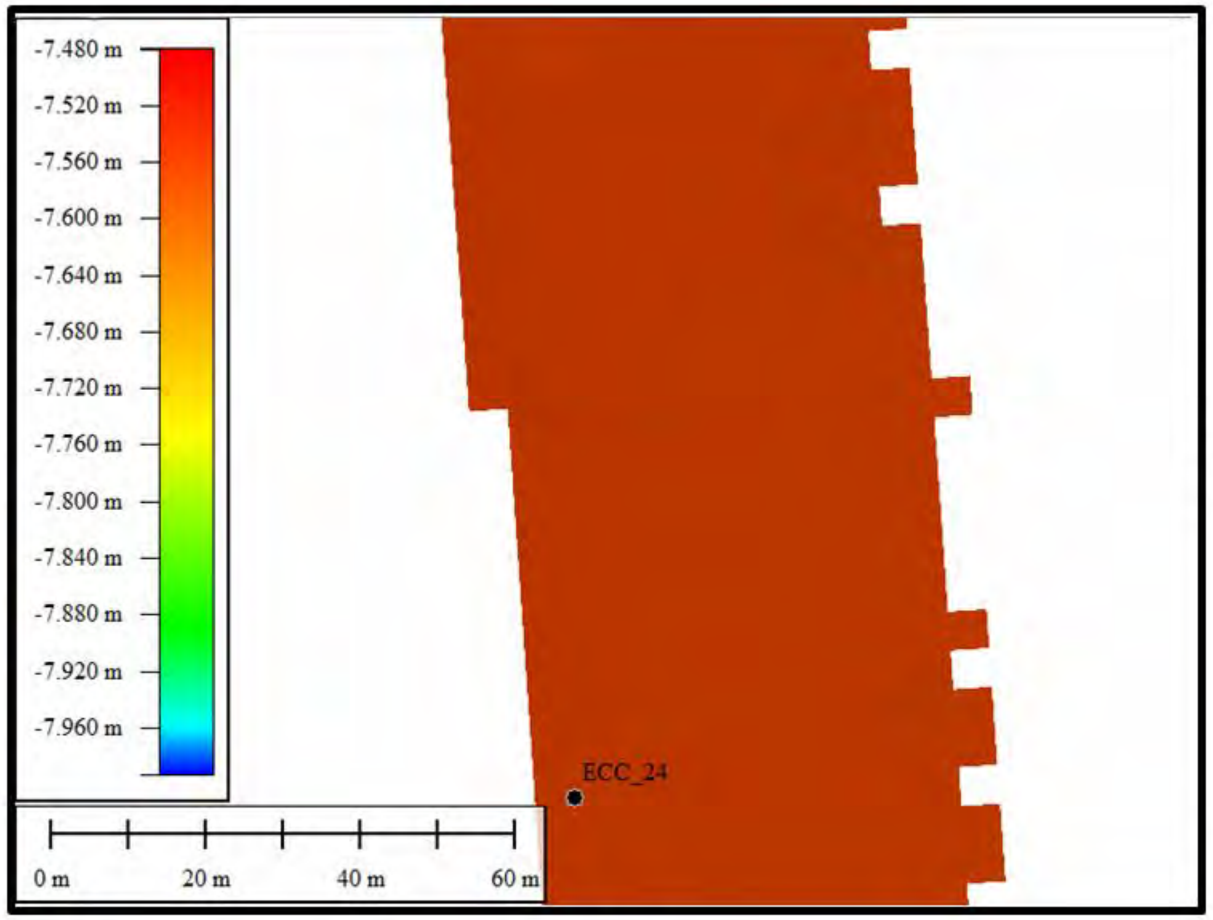
Sandy brow, fine sand with little to none shell fragments

Conspicuous Fauna

Echinodermata: *Echinocardium cordatum* , *Ophiura sp.* .

Sample No.:	ECC_24	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 09:49





Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.210	0.102	2.25
Median	0.210		2.25
Sorting	Value	Inference	
Coefficient	0.56	Moderately Well Sorted	
Skewness	0.00	Symmetrical	
Kurtosis	0.94	Mesokurtic	
% Fines	0.00%	Fine Sand	
% Sands	99.96%		
% Gravel	0.04%		

Client

Ørsted

Contractors

BIBBY HYDROMAP

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● Current station

Photo Position: 298217 mE, 5990897 mN

Habitat Summary Information: ECC_25

Survey Area: HOW04

No. of Stills: 5

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

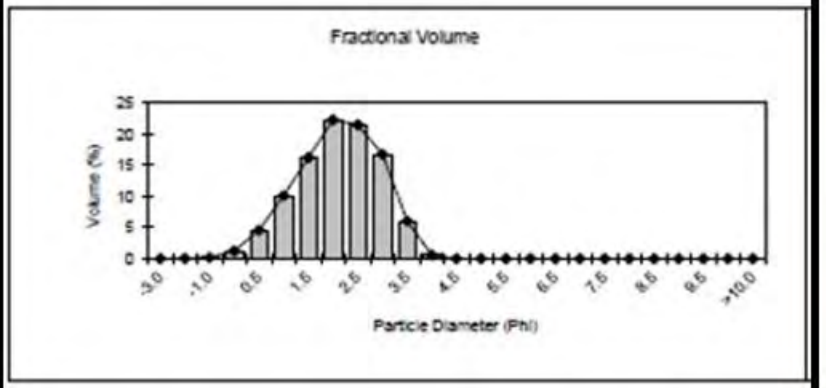
Sandy brown sand with very small amounts of shell fragments

Conspicuous Fauna

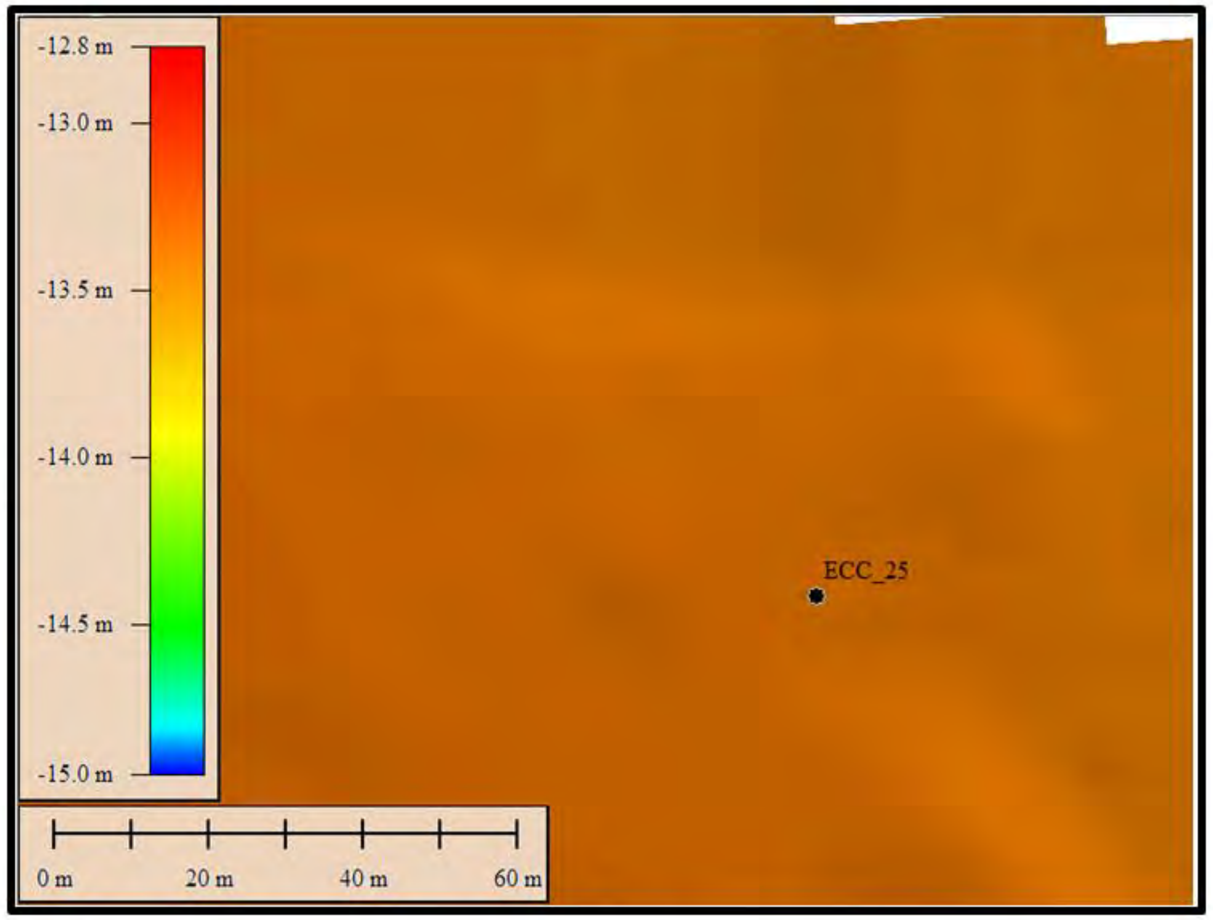
Annelida: Polychaeta. **Chordata:** Pleuronectiformes.

Photo Position: 298217 mE, 5990897 mN

Sample No.:	ECC_25	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 10:02



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.278	0.241	1.85
Median	0.273		1.87
Sorting Coefficient	**Value** 0.84		**Inference** Moderately Sorted
Skewness	-0.07		Symmetrical
Kurtosis	0.95		Mesokurtic
% Fines	0.00%		Medium Sand
% Sands	99.72%		
% Gravel	0.28%		

Sediment Characteristics

Client

Contractors

Sediment Example Image

● Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 294868 mE, 5993107 mN

Habitat Summary Information: ECC_26

Survey Area: HOW04

No. of Stills: 6

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

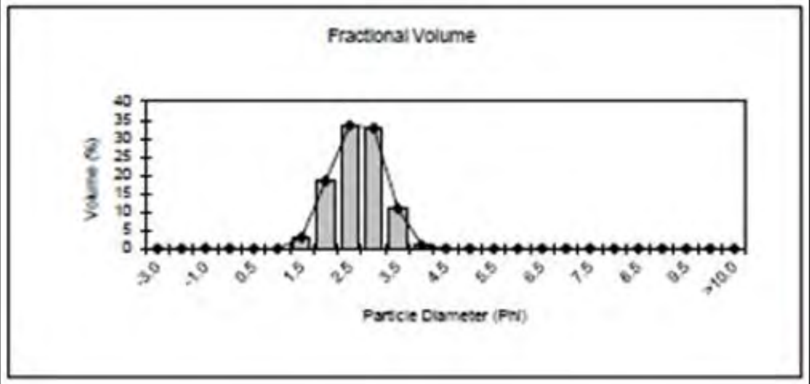
Sandy brown sand with very small amounts of shell fragments

Conspicuous Fauna

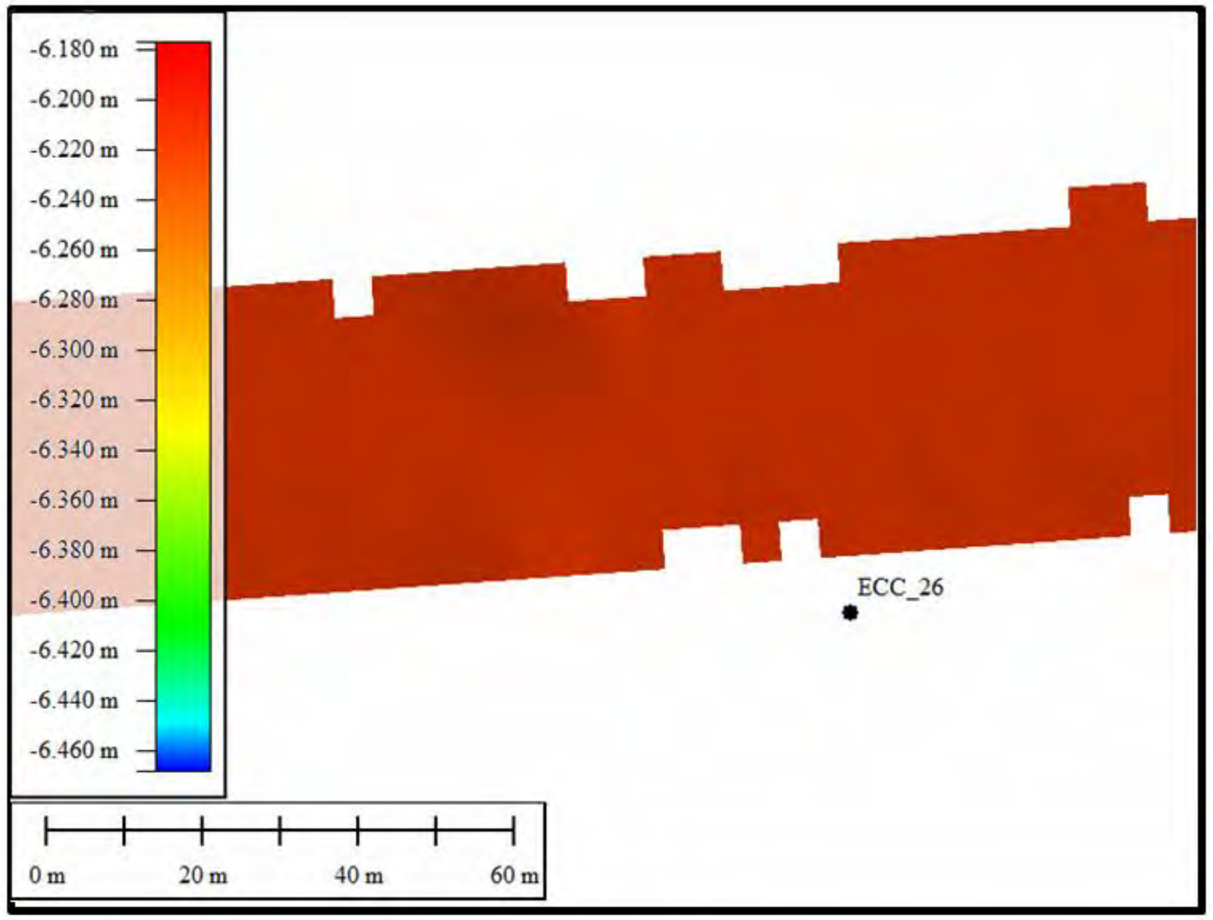
Echinodermata: *Echinocardium cordatum* . **Bryozoa:** *Flustra foliacea* (Hornwrack).

Photo Position: 294868 mE, 5993107 mN

Sample No.:	ECC_26	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 10:21



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.195	0.084	2.36
Median	0.195		2.36
Sorting Coefficient	**Value**		**Inference**
	0.49		Well Sorted
Skewness	0.01		Symmetrical
Kurtosis	0.99		Mesokurtic
% Fines	0.00%		Fine Sand
% Sands	99.86%		
% Gravel	0.14%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Current station

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 293201 mE, 5991733 mN

Habitat Summary Information: ECC_27

Survey Area: HOW04

No. of Stills: 5

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Sandy brown fine sand with very little shell fragments.

Conspicuous Fauna

Annelida: Polychaeta. Mollusca: Bivalvia

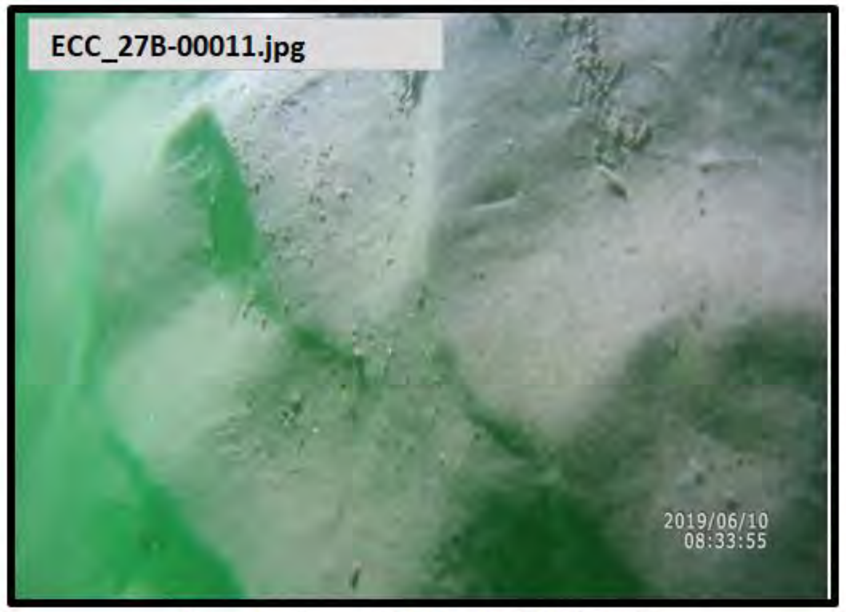
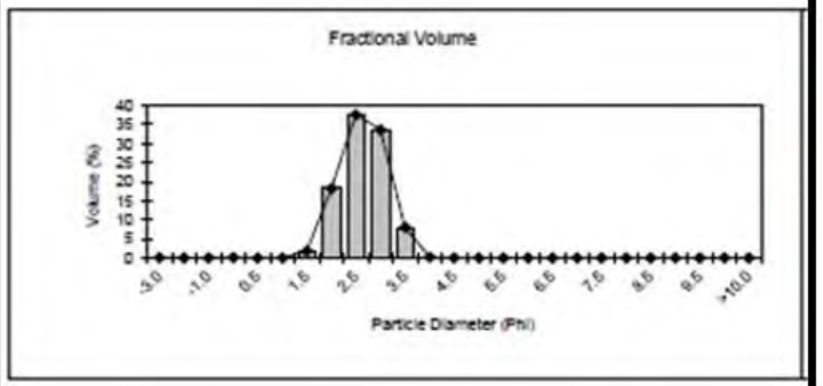
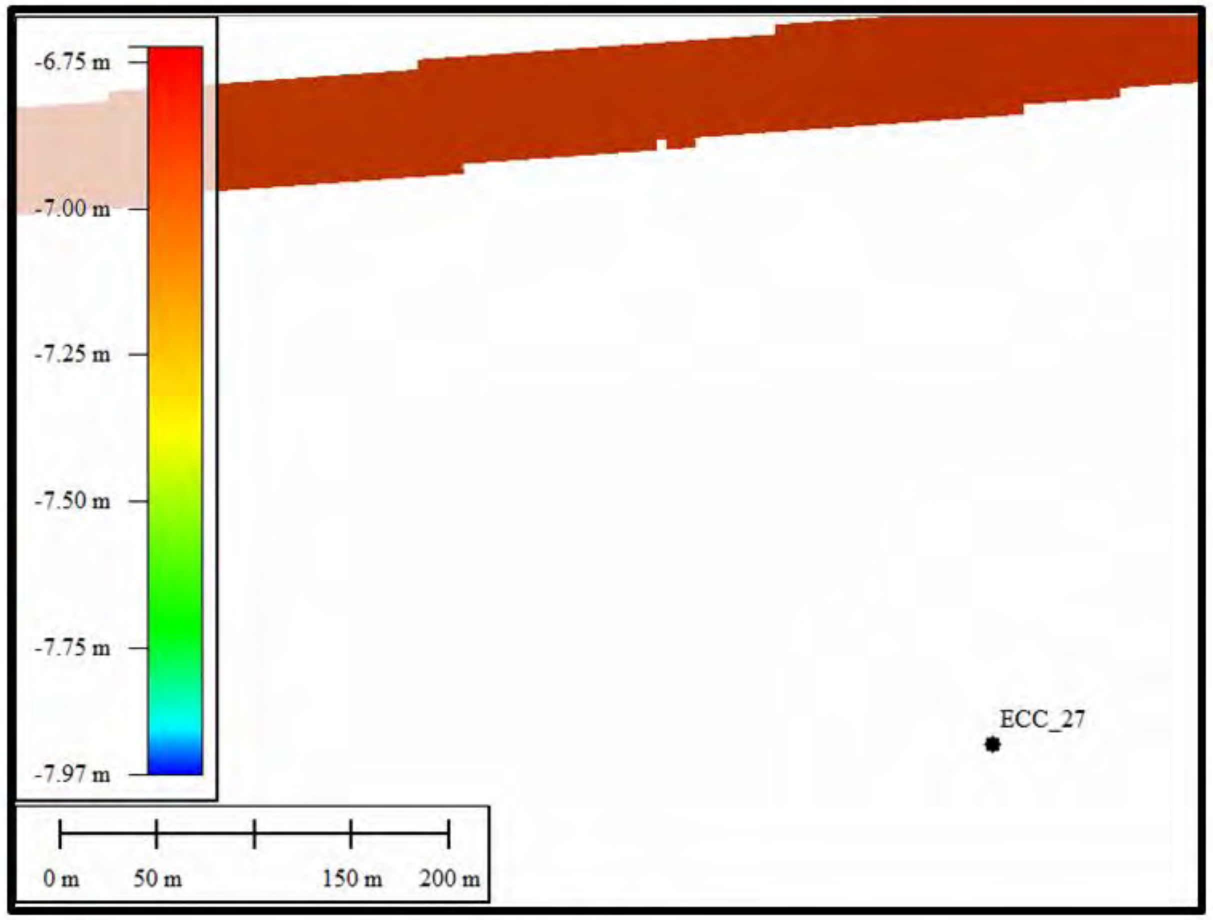


Photo Position: 293201 mE, 5991733 mN

Sample No.:	ECC_27	Operator	ER
Source Data:	Orsted - LOT 7	Date&Time:	25/06/2019 10:30



Particle Size Distribution



Graphical	mm	StDev (mm)	Phi
Mean (MZ)	0.195	0.084	2.36
Median	0.195		2.36
Sorting	Value		Inference
Coefficient	0.49		Well Sorted
Skewness	0.01		Symmetrical
Kurtosis	0.99		Mesokurtic
% Fines	0.00%		Fine Sand
% Sands	99.86%		
% Gravel	0.14%		

Sediment Characteristics

Sediment Example Image

Client

Contractors

Sieved Sample Image

● Current station

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Photo Position: 290393 mE, 5992198 mN

Habitat Summary Information: ECC_28

Survey Area: HOW04

No. of Stills: 7

Site Selection Criteria

Provided by Orsted

In Field Sediment Description

Yellow brown, with potentially a sandy layer on top of a layer of strongly consolidated clay.

Conspicuous Fauna

No fauna was observed.

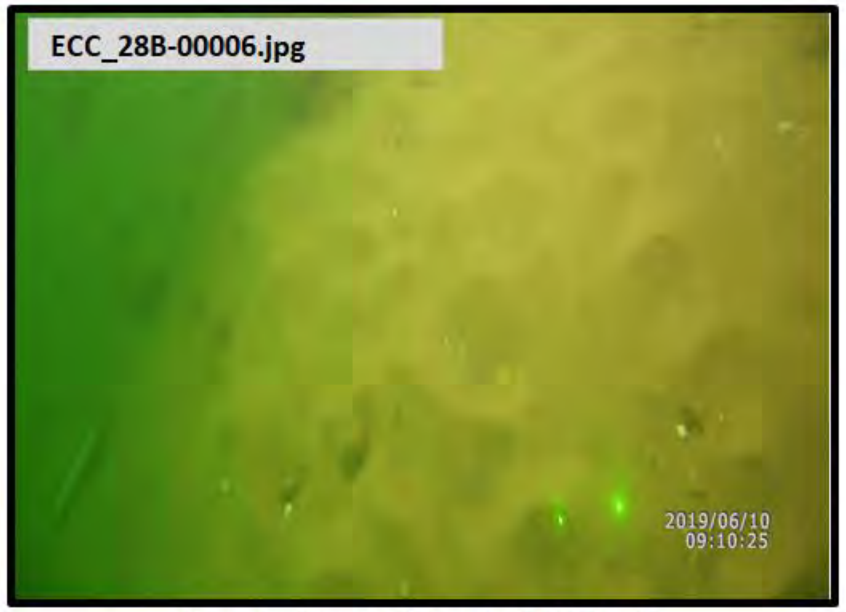
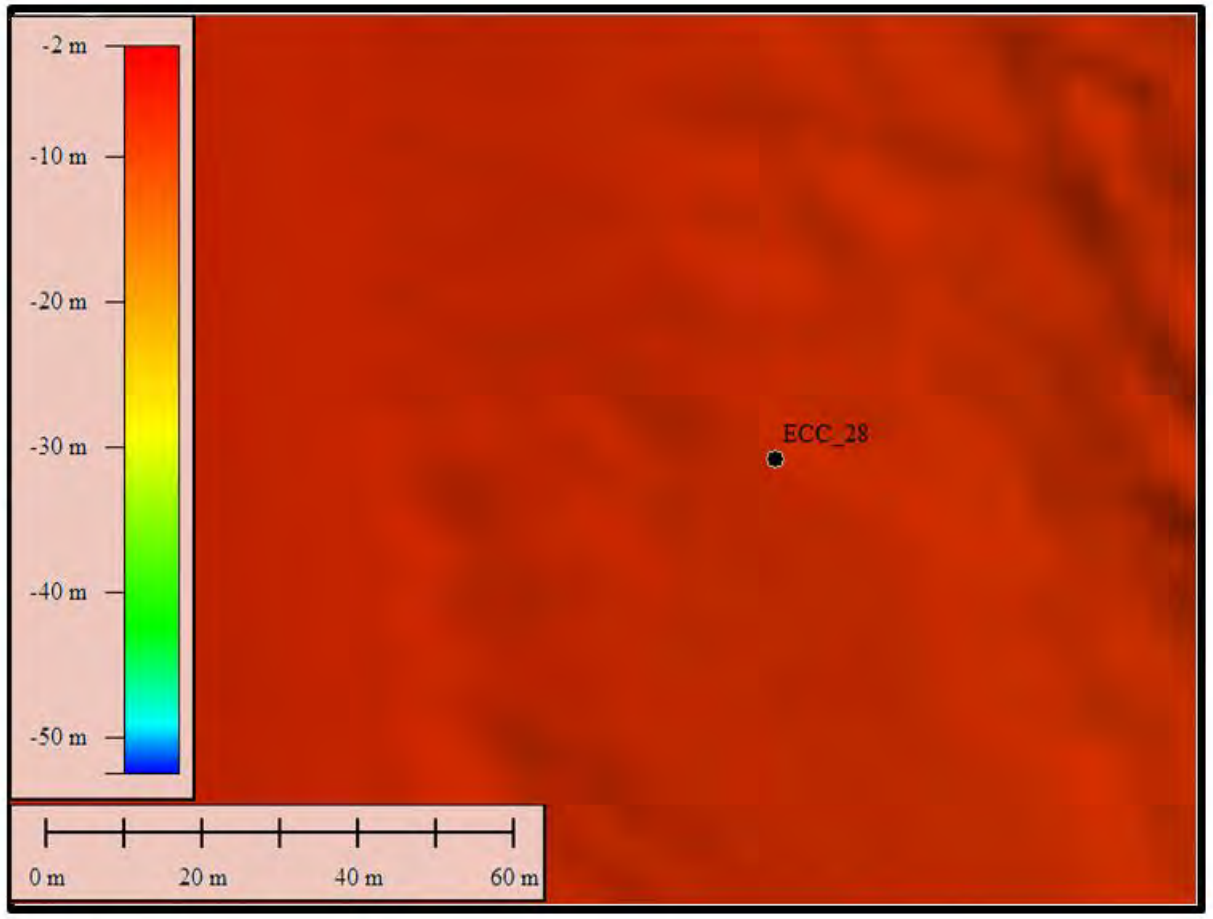


Photo Position: 290393 mE, 5992198 mN

NO SAMPLE

Particle Size Distribution



NO SAMPLE

Sediment Characteristics

Sediment Example Image

Client

Contractors

Highlighted station

NO SAMPLE

Sieved Sample Image

Geodetic Infomation: Datum: ETRS89 Projection: UTM Zone: 31 North Central Meridian: 3° E

Appendix D5 – Macrofauna Abundance Tables

1908 ORSTED Priority samples - Macrofauna Abundance Matrix												
AphiaID	Phylum	Taxa	Authority	ECC_01_F01	ECC_02_F01	ECC_03_F01	ECC_04_F01	ECC_05_F01	ECC_06_F01	ECC_07_F01	ECC_08_F01	ECC_09_F01
Infaunal Species												
793	Platyhelminthes	*Platyhelminthes*	Minot, 1876		1				1			
152391	Nemertea	*Nemertea*				1			3			2
799	Nematoda	*Nematoda*										
175026	Sipuncula	*Golfingia (Golfingia) elongata*	(Keferstein, 1862)									
136060	Sipuncula	*Nephasoma (Nephasoma) minutum*	(Keferstein, 1862)									
130749	Annelida	*Gattyana cirrhosa*	(Pallas, 1766)									
152357	Annelida	*Malmgrenia castanea*	McIntosh, 1876									
130762	Annelida	*Harmothoe extenuata*	(Grube, 1840)									
571832	Annelida	*Harmothoe glabra*	(Malmgren, 1865)								1	
130770	Annelida	*Harmothoe impar agg.*	(Johnston, 1839)									
130801	Annelida	*Lepidonotus squamatus*	(Linnaeus, 1758)									
130601	Annelida	*Pholoe inornata*	Johnston, 1839									
130599	Annelida	*Pholoe baltica*	Örsted, 1843	3					1			
131072	Annelida	*Sigalion mathildae*	Audouin & Milne Edwards in Cuvier, 1830			1			1	1	2	3
131077	Annelida	*Sthenelais limicola*	(Ehlers, 1864)			1		1				
130616	Annelida	*Eteone longa agg.*	(Fabricius, 1780)								1	
334506	Annelida	*Phyllodoce groenlandica*	Örsted, 1842								1	
130623	Annelida	*Eulalia aurea*	Gravier, 1896									
130624	Annelida	*Eulalia bilineata*	(Johnston, 1840)									
130639	Annelida	*Eulalia viridis*	(Linnaeus, 1767)									
130644	Annelida	*Eumida sanguinea*	(Örsted, 1843)									
130116	Annelida	*Glycera alba*	(O.F. Müller, 1776)		1							
130123	Annelida	*Glycera lapidum*	Quatrefages, 1866									
130136	Annelida	*Glycinde nordmanni*	(Malmgren, 1866)	2	1	1						
130140	Annelida	*Goniada maculata*	Örsted, 1843	1	2	2			1	1		
131100	Annelida	*Sphaerodorum gracilis*	(Rathke, 1843)									
130185	Annelida	*Nereimyra punctata*	(Müller, 1788)									
131415	Annelida	*Syllis armillaris*	(O.F. Müller, 1776)									
131290	Annelida	*Eusyllis blomstrandi*	Malmgren, 1867									
757970	Annelida	*Parexogone hebes*	(Webster & Benedict, 1884)									
327985	Annelida	*Exogone naidina*	Örsted, 1845									1
333456	Annelida	*Exogone verugera*	(Claparède, 1868)									
238180	Annelida	*Epigamia alexandri*	(Malmgren, 1867)									
130375	Annelida	*Eunereis longissima*	(Johnston, 1840)									
130343	Annelida	*Aglaophamus agilis*	(Langerhans, 1880)									
130353	Annelida	*Nephtys assimilis*	Örsted, 1843					1	1			
130355	Annelida	*Nephtys caeca*	(Fabricius, 1780)									
130357	Annelida	*Nephtys cirrosa*	Ehlers, 1868								1	
130359	Annelida	*Nephtys hombergii*	Savigny in Lamarck, 1818			1	1					
130363	Annelida	*Nephtys kersivalensis*	McIntosh, 1908	1	1							1
130364	Annelida	*Nephtys longosetosa*	Örsted, 1842									
130352	Annelida	*Nephtys pente*	Rainer, 1984									
129837	Annelida	*Paramphinome jeffreysii*	(McIntosh, 1868)									
130240	Annelida	*Lumbrineris cingulata agg.*	Ehlers, 1897									
130041	Annelida	*Protodorvillea kefersteini*	(McIntosh, 1869)									
130537	Annelida	*Scoloplos armiger*	(Müller, 1776)	1	3	1	1	2	2	2		1
730747	Annelida	*Aricidea (Aricidea) minuta*	Southward, 1956									
525497	Annelida	*Aricidea (Acmira) cerrutii*	Laubier, 1966									
731235	Annelida	*Aricidea (Acmira) simonae*	Laubier & Ramos, 1974									
130585	Annelida	*Paradoneis lyra*	(Southern, 1914)									
130711	Annelida	*Poecilochaetus serpens*	Allen, 1904	1		1						1
131116	Annelida	*Dipolydora caulleryi*	(Mesnil, 1897)									
131118	Annelida	*Dipolydora flava*	(Claparède, 1870)									
131123	Annelida	*Dipolydora saintjosephi*	(Eliason, 1920)									
146532	Annelida	*Aurospio banyulensis*	(Laubier, 1966)									
131171	Annelida	*Scolelepis bonnieri*	(Mesnil, 1896)									1
868182	Annelida	*Scolelepis finmarchicus*	Sikorski & Pavlova, 2015									
131174	Annelida	*Scolelepis korsuni*	Sikorski, 1994									
131180	Annelida	*Spio armata*	(Thulin, 1957)									
152314	Annelida	*Spio decorata*	Bobretzky, 1870		1							
131184	Annelida	*Spio goniocephala*	Thulin, 1957									
131187	Annelida	*Spiophanes bombyx*	(Claparède, 1870)	1	10	1	2		8	2	5	3
131188	Annelida	*Spiophanes kroyeri*	Grube, 1860									
130266	Annelida	*Magelona alleni*	Wilson, 1958						1		1	1
130268	Annelida	*Magelona filiformis*	Wilson, 1959		2	1			2	1	11	3
130269	Annelida	*Magelona johnstoni*	Fiege, Licher & Mackie, 2000	1	3		1	1	1		6	4
129938	Annelida	*Aphelochaeta marioni*	(Saint-Joseph, 1894)									
129943	Annelida	*Caulleriella alata*	(Southern, 1914)									
336485	Annelida	*Chaetozone zetlandica*	McIntosh, 1911	1								
152217	Annelida	*Chaetozone christiei*	Chambers, 2000		1			3	2		3	3
152269	Annelida	*Tharyx killariensis*	(Southern, 1914)									
130113	Annelida	*Pherusa plumosa*	(Müller, 1776)									
129892	Annelida	*Mediomastus fragilis*	Rasmussen, 1973									
129220	Annelida	*Notomastus*	M. Sars, 1851	7	1	2						
129906	Annelida	*Peresiella clymenoides*	Harmelin, 1968									
146991	Annelida	*Leiochone*	Grube, 1868									
130322	Annelida	*Praxillella affinis*	(M. Sars in G.O. Sars, 1872)									

AphiaID	Phylum	Taxa	Authority	ECC_01_F01	ECC_02_F01	ECC_03_F01	ECC_04_F01	ECC_05_F01	ECC_06_F01	ECC_07_F01	ECC_08_F01	ECC_09_F01
1908 ORSTED Priority samples - Macrofauna Abundance Matrix												
Infaunal Species												
793	Platyhelminthes	*Platyhelminthes*	Minot, 1876		1				1			
130491	Annelida	*Ophelia borealis*	Quatrefages, 1866									
130512	Annelida	*Travisia forbesii*	Johnston, 1840									
130980	Annelida	*Scalibregma inflatum*	Rathke, 1843	1								
146950	Annelida	*Galathowenia oculata*	(Zachs, 1923)									
129427	Annelida	*Owenia*	Delle Chiaje, 1844									
152448	Annelida	*Amphictene auricoma*	(O.F. Müller, 1776)									
152367	Annelida	*Lagis koreni*	Malmgren, 1866	1		1	1				2	
130867	Annelida	*Sabellaria spinulosa*	(Leuckart, 1849)									
129805	Annelida	*Melinna elisabethae*	McIntosh, 1914									
129781	Annelida	*Ampharete lindstroemi agg.*	Malmgren, 1867 sensu Hessle, 1917									
129789	Annelida	*Anobothrus gracilis*	(Malmgren, 1866)									
332932	Annelida	*Amphicteis octocirrata*	(Sars, 1835)									
129717	Annelida	*Terebellides*	Sars, 1835									
868065	Annelida	*Pista maculata*	(Dalyell, 1853)									
131495	Annelida	*Lanice conchilega*	(Pallas, 1766)				1					
131507	Annelida	*Nicolea venustula*	(Montagu, 1819)									
131508	Annelida	*Nicolea zostericola*	Örsted, 1844									
131513	Annelida	*Phisidia aurea*	Southward, 1956									
129710	Annelida	*Polycirrus*	Grube, 1850									
882443	Annelida	*Dialychone dunerificta*	(Tovar-Hernández, Licciano, Giangrande, 2007)									
325958	Annelida	*Parasabella*	Bush, 1905									
130909	Annelida	*Euchone rubrocincta*	(Sars, 1862)									
130921	Annelida	*Jasmineira elegans*	Saint-Joseph, 1894									
129548	Annelida	*Pseudopotamilla*	Bush, 1905									
530920	Annelida	*Parasabella cambrensis*	(Knight-Jones & Walker, 1985)									
131009	Annelida	*Hydroides norvegica*	Gunnerus, 1768									
129582	Annelida	*Spirobranchus*	Blainville, 1818									
560033	Annelida	*Spirobranchus lamarcki*	(Quatrefages, 1866)									
555935	Annelida	*Spirobranchus triqueter*	(Linnaeus, 1758)									
989	Annelida	*Spirorbinae*	Chamberlin, 1919									
150520	Arthropoda	*Nymphon brevirostre*	Hodge, 1863									
134599	Arthropoda	*Achelia echinata*	Hodge, 1864									
134643	Arthropoda	*Callipallene brevirostris*	(Johnston, 1837)									
106257	Arthropoda	*Verruca stroemia*	(O.F. Müller, 1776)									
106213	Arthropoda	*Balanus balanus*	(Linnaeus, 1758)									
106215	Arthropoda	*Balanus crenatus*	Bruguière, 1789									41
102202	Arthropoda	*Eusirus longipes*	Boeck, 1861									
102915	Arthropoda	*Perioculodes longimanus*	(Spence Bate & Westwood, 1868)			1						
102460	Arthropoda	*Leucothoe incisa*	Robertson, 1892	1								
103166	Arthropoda	*Stenothoe marina*	(Spence Bate, 1857)									
103228	Arthropoda	*Urothoe elegans*	Spence Bate, 1857			1						
103233	Arthropoda	*Urothoe marina*	(Spence Bate, 1857)									
103235	Arthropoda	*Urothoe poseidonis*	Reibish, 1905	1								
102570	Arthropoda	*Hippomedon denticulatus*	(Spence Bate, 1857)	1								
102771	Arthropoda	*Tryphosella sarsi*	Bonnier, 1893									1
102345	Arthropoda	*Iphimedia minuta*	G. O. Sars, 1883									
102139	Arthropoda	*Nototropis falcatus*	(Metzger, 1871)									
101896	Arthropoda	*Ampelisca diadema*	(Costa, 1853)									
101928	Arthropoda	*Ampelisca spinipes*	Boeck, 1861									
101930	Arthropoda	*Ampelisca tenuicornis*	Liljeborg, 1856									
101933	Arthropoda	*Ampelisca typica*	(Spence Bate, 1856)									
101958	Arthropoda	*Haploops tubicola*	Liljeborg, 1856									
103058	Arthropoda	*Bathyporeia elegans*	Watkin, 1938						2			
103060	Arthropoda	*Bathyporeia guilliamsoniana*	(Spence Bate, 1857)		1							
103076	Arthropoda	*Bathyporeia tenuipes*	Meinert, 1877	3	7	2		3	3		8	7
102798	Arthropoda	*Cheirocratus sundevallii*	(Rathke, 1843)									
534781	Arthropoda	*Othomaera othonis*	(H. Milne Edwards, 1830)									
102831	Arthropoda	*Maerella tenuimana*	(Spence Bate, 1862)									
102377	Arthropoda	*Megamphopus cornutus*	Norman, 1869									
102364	Arthropoda	*Gammaropsis maculata*	(Johnston, 1828)									
101368	Arthropoda	*Aoridae*	Stebbing, 1899									
102036	Arthropoda	*Leptocheirus hirsutimanus*	(Spence Bate, 1862)									
397383	Arthropoda	*Crassicorophium crassicorne*	(Bruzelius, 1859)									
1059646	Arthropoda	*Centraloecetes kroyeranus*	(Spence Bate, 1857)									
102057	Arthropoda	*Unciola crenatipalma*	(Spence Bate, 1862)									
101857	Arthropoda	*Pariambus typicus*	(Krøyer, 1844)									
136458	Arthropoda	*Tanaopsis graciloides*	(Lilljeborg, 1864)									
110445	Arthropoda	*Bodotria scorpioides*	(Montagu, 1804)									
110628	Arthropoda	*Pseudocuma (Pseudocuma) simile*	G.O. Sars, 1900									
110472	Arthropoda	*Diastylis bradyi*	Norman, 1879									
107651	Arthropoda	*Pandalus montagui*	Leach, 1814									
107739	Arthropoda	*Upogebia deltaura*	(Leach, 1816)									
107150	Arthropoda	*Galathea intermedia*	Lilljeborg, 1851									
107188	Arthropoda	*Pisidia longicornis*	(Linnaeus, 1767)									
107301	Arthropoda	*Ebalia tuberosa*	(Pennant, 1777)									
107302	Arthropoda	*Ebalia tumefacta*	(Montagu, 1808)									

1908 ORSTED Priority samples - Macrofauna Abundance Matrix												
AphiaID	Phylum	Taxa	Authority	ECC_01_F01	ECC_02_F01	ECC_03_F01	ECC_04_F01	ECC_05_F01	ECC_06_F01	ECC_07_F01	ECC_08_F01	ECC_09_F01
Infaunal Species												
793	Platyhelminthes	*Platyhelminthes*	Minot, 1876		1				1			
107319	Arthropoda	*Eurynome spinosa*	Hailstone, 1835									
107277	Arthropoda	*Corystes cassivelaunus*	(Pennant, 1777)	1	1		1	1	2	1	1	
107273	Arthropoda	*Atelecyclus rotundatus*	(Olivi, 1792)									
107388	Arthropoda	*Liocarcinus holsatus*	(Fabricius, 1798)									
107473	Arthropoda	*Pinnotheres pisum*	(Linnaeus, 1767)									
139106	Mollusca	*Chaetoderma nitidulum*	Lovén, 1844									
140199	Mollusca	*Leptochiton asellus*	(Gmelin, 1791)									
141905	Mollusca	*Velutina velutina*	(O. F. Müller, 1776)									
151894	Mollusca	*Euspira nitida*	(Donovan, 1804)									
876825	Mollusca	*Tritia incrassata*	(Strøm, 1768)									
141799	Mollusca	*Gibbula tumida*	(Montagu, 1803)									
139272	Mollusca	*Mangelia costata*	(Pennant, 1777)									
139371	Mollusca	*Raphitoma linearis*	(Montagu, 1803)									
139476	Mollusca	*Cylichna cylindracea*	(Pennant, 1777)	1					1	1	2	
137916	Mollusca	*Doto*	Oken, 1815									
175	Mollusca	*Onchidorididae*	Gray, 1827									
140590	Mollusca	*Nucula nucleus*	(Linnaeus, 1758)									
140577	Mollusca	*Nuculana minuta*	(O. F. Müller, 1776)									
140480	Mollusca	*Mytilus edulis*	Linnaeus, 1758									
140467	Mollusca	*Modiolus modiolus*	(Linnaeus, 1758)									
140461	Mollusca	*Modiolula phaseolina*	(Philippi, 1844)									
506128	Mollusca	*Musculus subpictus*	(Cantraine, 1835)									
138751	Mollusca	*Pododesmus patelliformis*	(Linnaeus, 1761)									
141655	Mollusca	*Thyasira biplicata*	(Philippi, 1836)									
246148	Mollusca	*Hemilepton nitidum*	(W. Turton, 1822)									
146952	Mollusca	*Tellimya ferruginosa*	(Montagu, 1808)					1				
345281	Mollusca	*Kurtiella bidentata*	(Montagu, 1803)	10	4				4	1	9	
181343	Mollusca	*Parvicardium pinnulatum*	(Conrad, 1831)									
140299	Mollusca	*Mactra stultorum*	(Linnaeus, 1758)	2	1	1	3	2	3		1	1
140300	Mollusca	*Spisula elliptica*	(T. Brown, 1827)									
140302	Mollusca	*Spisula subtruncata*	(da Costa, 1778)									
140737	Mollusca	*Phaxas pellucidus*	(Pennant, 1777)		5		2	1		1	3	1
146907	Mollusca	*Fabulina fabula*	(Gmelin, 1791)	1	2	2	3	2	3	3	1	6
141433	Mollusca	*Abra alba*	(W. Wood, 1802)		1	1			2			
141436	Mollusca	*Abra prismatica*	(Montagu, 1808)									
141908	Mollusca	*Chamelea striatula*	(da Costa, 1778)			1		1	2			1
141929	Mollusca	*Timoclea ovata*	(Pennant, 1777)									
745846	Mollusca	*Polititapes rhomboides*	(Pennant, 1777)									
141912	Mollusca	*Dosinia lupinus*	(Linnaeus, 1758)		1							
140431	Mollusca	*Mya truncata*	Linnaeus, 1758									
140432	Mollusca	*Sphenia binghami*	W. Turton, 1822									
139410	Mollusca	*Corbula gibba*	(Olivi, 1792)	1			1					
140103	Mollusca	*Hiatella arctica*	(Linnaeus, 1767)									
152378	Mollusca	*Thracia phaseolina*	(Lamarck, 1818)	1	1		1					
181373	Mollusca	*Cochlodesma praetenue*	(Pulteney, 1799)									
128545	Phoronida	*Phoronis*	Wright, 1856						1		3	1
125131	Echinodermata	*Ophiothrix fragilis*	(Abildgaard in O.F. Müller, 1789)									
125110	Echinodermata	*Ophiactis balli*	(W. Thompson, 1840)									
125125	Echinodermata	*Ophiopholis aculeata*	(Linnaeus, 1767)									
125073	Echinodermata	*Amphiura chiajei*	Forbes, 1843									
125080	Echinodermata	*Amphiura filiformis*	(O.F. Müller, 1776)	9	3	3	2	1	3		8	8
125064	Echinodermata	*Amphipholis squamata*	(Delle Chiaje, 1828)									
124913	Echinodermata	*Ophiura albida*	Forbes, 1839									
124273	Echinodermata	*Echinocyamus pusillus*	(O.F. Müller, 1776)									
123426	Echinodermata	*Echinocardium*	Gray, 1825	1								
124392	Echinodermata	*Echinocardium cordatum*	(Pennant, 1777)			1	1	3	2		2	
124661	Echinodermata	*Pseudothyone raphanus*	(Düben & Koren, 1846)									
124463	Echinodermata	*Leptosynapta decaria*	(Östergren, 1905)									
1820	Hemichordata	*Enteropneusta*	Gegenbaur, 1870		1							
			S	25	24	21	14	14	24	10	21	21
			N	54	55	27	21	23	52	14	72	91
			d	6.017	5.739	6.068	4.27	4.146	5.821	3.41	4.677	4.434
			J'	0.8608	0.8932	0.975	0.9597	0.9567	0.9422	0.9579	0.8862	0.7115
			H'(log2)	3.997	4.095	4.282	3.654	3.642	4.32	3.182	3.893	3.125
			1-Lambda'	0.9231	0.9367	0.9801	0.9571	0.9526	0.957	0.9451	0.9276	0.7795

1908 ORSTED Priority samples - Macrofauna Abundance Matrix

AphiaID	Phylum	Taxa	ECC_10_F01	ECC_11_F01	ECC_12_F01	ECC_13_F01	ECC_14_F01	ECC_15_F01	ECC_16_F01	ECC_17_F01	ECC_18_F01	ECC_19_F01	ECC_20_F01	ECC_21_F01	ECC_23_F01	ECC_24_F01	ECC_25_F01	ECC_26_F01	ECC_27_F01
Infaunal Species																			
793	Platyhelminthes	*Platyhelminthes*																	
152391	Nemertea	*Nemertea*							3	9	1	2	2	1	1	1			
799	Nematoda	*Nematoda*								2									
175026	Sipuncula	*Golfingia (Golfingia) elongata*									1								
136060	Sipuncula	*Nephasoma (Nephasoma) minutum*								4	1								
130749	Annelida	*Gattyana cirrhosa*								1	2								
152357	Annelida	*Malmgrenia castanea*	1						1										
130762	Annelida	*Harmothoe extenuata*									1								
571832	Annelida	*Harmothoe glabra*								2	1								
130770	Annelida	*Harmothoe impar agg.*								2		1							
130801	Annelida	*Lepidonotus squamatus*									2		3	1					
130601	Annelida	*Pholoe inornata*								3			2						
130599	Annelida	*Pholoe baltica*								2	3	1							
131072	Annelida	*Sigalion mathildae*	2	1		2	1												
131077	Annelida	*Sthenelais limicola*				1	1												
130616	Annelida	*Eteone longa agg.*																	
334506	Annelida	*Phyllodoce groenlandica*													1				
130623	Annelida	*Eulalia aurea*								1			1						
130624	Annelida	*Eulalia bilineata*											1						
130639	Annelida	*Eulalia viridis*								2									
130644	Annelida	*Eumida sanguinea*								2	1		3						
130116	Annelida	*Glycera alba*					1				2		1	1					
130123	Annelida	*Glycera lapidum*							2	4	4		1		1				
130136	Annelida	*Glycinde nordmanni*		2		1	1			1		1							
130140	Annelida	*Goniada maculata*			1						1								
131100	Annelida	*Sphaerodorum gracilis*												1					
130185	Annelida	*Nereimyra punctata*											1						
131415	Annelida	*Syllis armillaris*								1				4					
131290	Annelida	*Eusyllis blomstrandi*								1			1						
757970	Annelida	*Parexogone hebes*													1				
327985	Annelida	*Exogone naidina*											1						
333456	Annelida	*Exogone verugera*								7	5		3	1					
238180	Annelida	*Epigamia alexandri*												1					
130375	Annelida	*Eunereis longissima*											1						
130343	Annelida	*Aglaophamus agilis*						1											
130353	Annelida	*Nephtys assimilis*			1											3			
130355	Annelida	*Nephtys caeca*										1							
130357	Annelida	*Nephtys cirrosa*					2	1	2								2	1	3
130359	Annelida	*Nephtys hombergii*			1														
130363	Annelida	*Nephtys kersivalensis*										3	3	2					
130364	Annelida	*Nephtys longosetosa*															2		
130352	Annelida	*Nephtys pente*											1						
129837	Annelida	*Paramphinome jeffreysii*								1	1		1						
130240	Annelida	*Lumbrineris cingulata agg.*								21	31	24	43	34		1		1	
130041	Annelida	*Protodorvillea kefersteini*											1		2				
130537	Annelida	*Scoloplos armiger*	1		1		2	5								3	6		
730747	Annelida	*Aricidea (Aricidea) minuta*						1							1				
525497	Annelida	*Aricidea (Acmira) cerrutii*							2										
731235	Annelida	*Aricidea (Acmira) simonae*							1	1									
130585	Annelida	*Paradoneis lyra*								3	1		2	1					
130711	Annelida	*Poecilochaetus serpens*			1				1	2	2								
131116	Annelida	*Dipolydora caulleryi*								1	1								
131118	Annelida	*Dipolydora flava*								3									
131123	Annelida	*Dipolydora saintjosephi*								3			2	1					
146532	Annelida	*Aurospio banyulensis*											1						
131171	Annelida	*Scolelepis bonnieri*																	
868182	Annelida	*Scolelepis finmarchicus*							1										
131174	Annelida	*Scolelepis korsuni*									1								
131180	Annelida	*Spio armata*													2				
152314	Annelida	*Spio decorata*																	
131184	Annelida	*Spio goniocephala*															1		1
131187	Annelida	*Spiophanes bombyx*	5		4	3	17	4	9	3					1		1		2
131188	Annelida	*Spiophanes kroyeri*								9	6	1	3	4					
130266	Annelida	*Magelona alleni*																	
130268	Annelida	*Magelona filiformis*	4	1	2	1	1												
130269	Annelida	*Magelona johnstoni*	8	10	14	6	7	1								2			3
129938	Annelida	*Aphelochaeta marioni*											1		1				
129943	Annelida	*Caulleriella alata*												1					
336485	Annelida	*Chaetozone zetlandica*																	
152217	Annelida	*Chaetozone christiei*	1			1	2								2	1			1
152269	Annelida	*Tharyx killariensis*								1									
130113	Annelida	*Pherusa plumosa*											1	1					
129892	Annelida	*Mediomastus fragilis*									1		5	2					
129220	Annelida	*Notomastus*		3	5														
129906	Annelida	*Peresiella clymenoides*										1							
146991	Annelida	*Leiochone*						2	4	6	2		4						7
130322	Annelida	*Praxillella affinis*											10	5					

1908 ORSTED Priority samples - Macrofauna Abundance Matrix

AphiaID	Phylum	Taxa	ECC_10_F01	ECC_11_F01	ECC_12_F01	ECC_13_F01	ECC_14_F01	ECC_15_F01	ECC_16_F01	ECC_17_F01	ECC_18_F01	ECC_19_F01	ECC_20_F01	ECC_21_F01	ECC_23_F01	ECC_24_F01	ECC_25_F01	ECC_26_F01	ECC_27_F01
Infaunal Species																			
793	Platyhelminthes	Platyhelminthes																	
130491	Annelida	*Ophelia borealis*						25	4										1
130512	Annelida	*Travisia forbesii*						4									1		
130980	Annelida	*Scalibregma inflatum*											1						
146950	Annelida	*Galathowenia oculata*								4		3	4	3					
129427	Annelida	*Owenia*								1		1	2						
152448	Annelida	*Amphictene auricoma*								1			1						
152367	Annelida	*Lagis koreni*			1					1									
130867	Annelida	*Sabellaria spinulosa*								18	109	25	102	52	31				
129805	Annelida	*Melinna elisabethae*									4		115	3					
129781	Annelida	*Amphartete lindstroemi agg.*									3		1						
129789	Annelida	*Anobothrus gracilis*								1	2	1	10	2					
332932	Annelida	*Amphartete octocirrata*									5		2						
129717	Annelida	*Terebellides*										1	2	2					
868065	Annelida	*Pista maculata*											5						
131495	Annelida	*Lanice conchilega*							1		1		1			1			
131507	Annelida	*Nicolea venustula*											1						
131508	Annelida	*Nicolea zostericola*								1									
131513	Annelida	*Phisidia aurea*								3				2					
129710	Annelida	*Polycirrus*							1	6			2	2					
882443	Annelida	*Dialychone dunerificta*								3									
325958	Annelida	*Parasabella*											1						
130909	Annelida	*Euchone rubrocincta*									1								
130921	Annelida	*Jasmineira elegans*											1						
129548	Annelida	*Pseudopotamilla*												1					
530920	Annelida	*Parasabella cambrensis*									1								
131009	Annelida	*Hydroides norvegica*								8	4	1	8	4					
129582	Annelida	*Spirobranchus*													1				
560033	Annelida	*Spirobranchus lamarcki*								3	1		5		4				
555935	Annelida	*Spirobranchus triqueter*								5			16	3					
989	Annelida	*Spirorbinae*											5	5					
150520	Arthropoda	*Nymphon brevirostre*									3								
134599	Arthropoda	*Achelia echinata*									4	1	9	14	2				
134643	Arthropoda	*Callipallene brevirostris*											3						
106257	Arthropoda	*Verruca stroemia*								38			26	135	5				
106213	Arthropoda	*Balanus balanus*								1				2					
106215	Arthropoda	*Balanus crenatus*											1	2	180				
102202	Arthropoda	*Eusirus longipes*											1						
102915	Arthropoda	*Perioculodes longimanus*																	
102460	Arthropoda	*Leucothoe incisa*			1														
103166	Arthropoda	*Stenothoe marina*								1									
103228	Arthropoda	*Urothoe elegans*								2					1				
103233	Arthropoda	*Urothoe marina*		1															
103235	Arthropoda	*Urothoe poseidonis*					2												
102570	Arthropoda	*Hippomedon denticulatus*	1																
102771	Arthropoda	*Tryphosella sarsi*																	
102345	Arthropoda	*Iphimedia minuta*								1									
102139	Arthropoda	*Nototropis falcatus*					1		1										
101896	Arthropoda	*Ampelisca diadema*								1			2	3					
101928	Arthropoda	*Ampelisca spinipes*								2	2	2	4		1				
101930	Arthropoda	*Ampelisca tenuicornis*								1									
101933	Arthropoda	*Ampelisca typica*									1								
101958	Arthropoda	*Haploops tubicola*											2						
103058	Arthropoda	*Bathyporeia elegans*			2		8	2	2							19		4	1
103060	Arthropoda	*Bathyporeia guilliamsoniana*			2		13												
103076	Arthropoda	*Bathyporeia tenuipes*	3	4	6	7	8												
102798	Arthropoda	*Cheirocratus sundevallii*												1					
534781	Arthropoda	*Othomaera othonis*									2								
102831	Arthropoda	*Maerella tenuimana*							1										
102377	Arthropoda	*Megamphopus cornutus*								1									
102364	Arthropoda	*Gammaropsis maculata*								3			5						
101368	Arthropoda	*Aoridae*								1									
102036	Arthropoda	*Leptocheirus hirsutimanus*									1								
397383	Arthropoda	*Crassicorophium crassicorne*													1				
1059646	Arthropoda	*Centraloecetes kroyeranus*			2														
102057	Arthropoda	*Unciola crenatipalma*										1	2	2					
101857	Arthropoda	*Pariambus typicus*								1									
136458	Arthropoda	*Tanaopsis graciloides*											1						
110445	Arthropoda	*Bodotria scorpioides*																	1
110628	Arthropoda	*Pseudocuma (Pseudocuma) simile*						2	1										
110472	Arthropoda	*Diastylis bradyi*					1												
107651	Arthropoda	*Pandalus montagui*								1									
107739	Arthropoda	*Upogebia deltaura*									1								
107150	Arthropoda	*Galathea intermedia*								1				1					
107188	Arthropoda	*Pisidia longicornis*									1								
107301	Arthropoda	*Ebalia tuberosa*								1	1	4	3	1					
107302	Arthropoda	*Ebalia tumefacta*									2	1	2						

1908 ORSTED Priority samples - Macrofauna Abundance Matrix																			
AphiaID	Phylum	Taxa	ECC_10_F01	ECC_11_F01	ECC_12_F01	ECC_13_F01	ECC_14_F01	ECC_15_F01	ECC_16_F01	ECC_17_F01	ECC_18_F01	ECC_19_F01	ECC_20_F01	ECC_21_F01	ECC_23_F01	ECC_24_F01	ECC_25_F01	ECC_26_F01	ECC_27_F01
Infaunal Species																			
793	Platyhelminthes	*Platyhelminthes*																	
107319	Arthropoda	*Eurynome spinosa*											1						
107277	Arthropoda	*Corystes cassivelaunus*	2	1			1			2									
107273	Arthropoda	*Atelecyclus rotundatus*													1				
107388	Arthropoda	*Liocarcinus holsatus*								1									
107473	Arthropoda	*Pinnotheres pisum*					1												
139106	Mollusca	*Chaetoderma nitidulum*											1						
140199	Mollusca	*Leptochiton asellus*								3	1	3	5	3	1				
141905	Mollusca	*Velutina velutina*									1								
151894	Mollusca	*Euspira nitida*							1										
876825	Mollusca	*Tritia incrassata*										1	1	1					
141799	Mollusca	*Gibbula tumida*									1								
139272	Mollusca	*Mangelia costata*												1					
139371	Mollusca	*Raphitoma linearis*											1						
139476	Mollusca	*Cylichna cylindracea*				1													
137916	Mollusca	*Doto*									1			2	1				
175	Mollusca	*Onchidorididae*								1					9				
140590	Mollusca	*Nucula nucleus*									2	4	14	14					
140577	Mollusca	*Nuculana minuta*								2	3	2	16	8					
140480	Mollusca	*Mytilus edulis*													27				
140467	Mollusca	*Modiolus modiolus*								1		1	3						
140461	Mollusca	*Modiolula phaseolina*								4				2					
506128	Mollusca	*Musculus subpictus*											1						
138751	Mollusca	*Pododesmus patelliformis*												1					
141655	Mollusca	*Thyasira biplicata*											1						
246148	Mollusca	*Hemilepton nitidum*												2					
146952	Mollusca	*Tellimya ferruginosa*	2			2				1						2		3	1
345281	Mollusca	*Kurtiella bidentata*	1	2		5	5												
181343	Mollusca	*Parvicardium pinnulatum*										1	10	5					
140299	Mollusca	*Mactra stultorum*	2	4		1	1												1
140300	Mollusca	*Spisula elliptica*							2										1
140302	Mollusca	*Spisula subtruncata*																1	
140737	Mollusca	*Phaxas pellucidus*	1		1					1	1								
146907	Mollusca	*Fabulina fabula*	5	11	7	6	1											1	
141433	Mollusca	*Abra alba*									2	1	40	17	9				2
141436	Mollusca	*Abra prismatica*					5	3	4	1		1			1		2	1	3
141908	Mollusca	*Chamelea striatula*	1			1													
141929	Mollusca	*Timoclea ovata*						1	1	2	1	6	5	2	1				
745846	Mollusca	*Polititapes rhomboides*									1	1			1				
141912	Mollusca	*Dosinia lupinus*								1									
140431	Mollusca	*Mya truncata*								1	1	2	5	1					
140432	Mollusca	*Sphenia binghami*											2						
139410	Mollusca	*Corbula gibba*																	
140103	Mollusca	*Hiatella arctica*								13	2	2	16	18	11				
152378	Mollusca	*Thracia phaseolina*																	
181373	Mollusca	*Cochlodesma praetenue*							2										
128545	Phoronida	*Phoronis*			1	1					3			3	2				
125131	Echinodermata	*Ophiothrix fragilis*										5							
125110	Echinodermata	*Ophiactis balli*											1	1					
125125	Echinodermata	*Ophiopholis aculeata*								1			1	2					
125073	Echinodermata	*Amphiura chiajei*			1	2	2												
125080	Echinodermata	*Amphiura filiformis*	2	2	5	3	8	2				1							
125064	Echinodermata	*Amphipholis squamata*								1	1			1					
124913	Echinodermata	*Ophiura albida*										4	32	20					
124273	Echinodermata	*Echinocyamus pusillus*					1	1	7	6									
123426	Echinodermata	*Echinocardium*																	
124392	Echinodermata	*Echinocardium cordatum*	3	1	1	2	1		1							1		2	
124661	Echinodermata	*Pseudothyone raphanus*									1								
124463	Echinodermata	*Leptosynapta decaria*								1									
1820	Hemichordata	*Enteropneusta*																	
			18	13	21	18	26	15	25	76	58	36	82	56	31	10	7	8	14
			45	43	60	46	94	55	57	255	243	113	606	408	309	34	15	14	28
			4.466	3.19	4.885	4.44	5.503	3.494	5.936	13.53	10.38	7.404	12.64	9.149	5.233	2.552	2.216	2.652	3.901
			0.9188	0.8503	0.8603	0.9086	0.8457	0.7517	0.9125	0.8532	0.6434	0.7997	0.7325	0.6887	0.5129	0.6973	0.8809	0.9178	0.907
			3.831	3.147	3.779	3.789	3.975	2.937	4.238	5.331	3.769	4.134	4.657	4	2.541	2.316	2.473	2.753	3.453
			0.9343	0.8693	0.9113	0.9314	0.9213	0.7785	0.9467	0.9572	0.7811	0.8998	0.9182	0.859	0.6409	0.6809	0.8286	0.8901	0.9153

Appendix D6 – Faunal Biomass

Table A. Biomass by Major Group - Converted to grams Ash-free Dry Weight (AFDW)

Station	Phylum				
	Annelida	Arthropoda	Mollusca	Echinodermata	Other
ECC_01_F01	0.0810	0.0012	0.0032	0.1701	0.0000
ECC_02_F01	0.0237	0.0021	0.0310	0.0111	0.0499
ECC_03_F01	0.0628	0.0007	0.0010	0.1954	0.0001
ECC_04_F01	0.0024	0.0004	0.0031	0.0510	0.0492
ECC_05_F01	0.0178	0.0008	0.0024	1.4736	0.0000
ECC_06_F01	0.0382	0.0009	0.0055	0.1957	0.0263
ECC_07_F01	0.0033	0.0000	0.0023	0.0000	0.0000
ECC_08_F01	0.0113	0.0007	0.0041	0.2762	0.0066
ECC_09_F01	0.0110	0.0011	0.0103	0.0076	0.0014
ECC_10_F01	0.0128	0.0020	0.0092	2.0158	0.0000
ECC_11_F01	0.0394	0.0015	0.0192	0.0700	0.0000
ECC_12_F01	0.0678	0.0020	0.0080	0.8804	0.0035
ECC_13_F01	0.0180	0.0008	0.0144	0.3677	0.0008
ECC_14_F01	0.0397	0.0099	0.0276	0.2424	0.0000
ECC_15_F01	0.0443	0.0005	0.0569	0.0006	0.0000
ECC_16_F01	0.0082	0.0005	0.0575	0.0466	0.0012
ECC_17_F01	0.2392	0.0395	0.1194	0.0118	0.0084
ECC_18_F01	0.0823	0.0954	0.2437	0.0027	0.0016
ECC_19_F01	0.0442	0.0106	0.3895	0.0160	0.0001
ECC_20_F01	0.2056	0.0277	0.6403	0.0324	0.0019
ECC_21_F01	0.0795	0.0086	0.3849	0.0227	0.0024
ECC_23_F01	0.0446	0.0029	0.1355	0.0000	0.0001
ECC_24_F01	0.0337	0.0017	0.0004	0.1903	0.0000
ECC_25_F01	0.0832	0.0000	0.0079	0.0000	0.0000
ECC_26_F01	0.0073	0.0004	0.0973	0.3657	0.0000
ECC_27_F01	0.0142	0.0002	0.2678	0.0000	0.0000
Mean	*0.0506*	*0.0082*	*0.0978*	*0.2556*	*0.0059*
SD	*0.0571*	*0.0200*	*0.1605*	*0.4845*	*0.0139*
%Coefficient of Variation (CV)	*112.9*	*245.4*	*164.1*	*189.6*	*235.6*

Appendix D7 – Contaminants Analysis

Table A. Total Aliphatic Concentrations (ng g^{-1})

Station	ECC_01	ECC_02	ECC_03	ECC_04	ECC_05	ECC_06	ECC_07	ECC_08	ECC_09	ECC_10	ECC_11	ECC_12	ECC_13
nC_{10}	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC_{11}	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC_{12}	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC_{13}	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC_{14}	<1	<1	<1	<1	<1	<1	<1	<1	2.74	3.98	3.51	<1	<1
nC_{15}	<1	<1	7.11	2.65	3.27	17.2	7.84	9.67	8.11	11.1	16.1	1.77	3.08
nC_{16}	3.90	1.36	3.55	1.91	1.90	3.37	7.50	4.39	7.21	6.05	5.79	<1	2.20
nC_{17}	9.84	4.63	7.93	4.61	7.37	7.82	10.2	13.6	10.2	12.8	9.4	5.52	2.76
Pristane	24.0	11.9	19.7	14.5	16.5	17.0	27.4	42.1	35.9	34.5	29.0	38.4	14.0
nC^{18}	4.23	2.83	5.03	2.07	3.40	4.18	5.07	8.14	6.75	8.02	5.51	3.64	3.44
Phytane	7.42	3.46	5.21	2.38	3.12	2.32	7.32	3.44	4.00	3.75	2.67	5.70	4.17
nC_{19}	6.11	3.85	6.62	5.12	4.77	5.44	6.95	10.4	8.10	8.53	5.68	7.05	4.75
nC_{20}	6.16	3.89	5.78	3.87	3.11	4.45	6.49	8.80	8.79	8.47	7.23	5.51	2.81
nC_{21}	9.11	3.68	9.86	5.99	4.96	9.57	11.2	19.1	10.9	12.9	7.75	1.85	3.13
nC_{22}	4.74	2.59	3.07	1.93	2.61	3.13	4.01	8.04	5.90	4.88	3.86	3.59	1.79
nC_{23}	6.73	2.69	4.62	1.92	5.22	7.55	9.10	11.9	7.55	8.18	6.89	4.93	4.40
nC_{24}	5.89	3.59	4.51	3.15	4.00	4.70	7.15	8.64	7.54	7.61	5.04	5.43	2.90
nC_{25}	2.33	2.36	7.78	7.25	1.53	7.92	9.42	11.2	9.03	11.0	7.72	5.82	3.44
nC_{26}	6.38	2.95	4.62	2.56	3.55	5.28	6.73	10.1	7.72	7.24	4.45	6.52	4.27
nC_{27}	24.5	8.88	13.4	12.7	11.5	19.8	17.9	23.4	19.8	22.2	13.2	7.55	12.2
nC_{28}	5.11	3.36	4.26	2.34	2.66	4.49	7.20	7.48	6.25	7.90	4.35	4.50	3.45
nC_{29}	22.2	9.53	14.9	10.4	16.8	14.9	16.2	22.2	12.7	14.7	10.8	12.2	11.0
nC_{30}	11.4	5.09	2.44	4.49	5.22	5.52	4.42	5.29	5.07	3.77	5.69	5.23	6.07
nC_{31}	15.1	4.98	4.65	10.75	3.95	5.45	14.7	19.1	5.53	7.13	6.41	8.98	11.4
nC_{32}	4.55	2.68	2.06	6.06	2.50	4.23	7.98	4.98	3.66	7.98	<1	2.78	2.27
nC_{33}	7.21	4.06	1.96	5.49	3.70	4.91	7.26	7.81	5.18	5.12	4.23	2.44	6.55
nC_{34}	4.67	4.38	2.46	5.70	5.35	8.89	5.29	11.8	13.5	6.85	<1	3.47	1.80
nC_{35}	1.83	1.85	<1	1.70	1.39	2.47	3.03	5.98	1.86	2.98	<1	<1	<1
nC_{36}	2.12	1.75	1.44	1.31	3.09	4.56	3.80	2.74	3.70	2.70	<1	1.58	<1
nC_{37}	<1	<1	<1	1.65	<1	2.13	<1	4.48	<1	1.41	<1	<1	<1
Total Oil (mg.kg^{-1})	*7,157*	*5,790*	*6,852*	*7,638*	*9,103*	*9,543*	*10,012*	*13,194*	*9,389*	*10,885*	*7,734*	*5,305*	*2,797*
Total n-alkanes (ng.g^{-1})	*164*	*77*	*118*	*106*	*102*	*158*	*179*	*239*	*178*	*194*	*134*	*100*	*93.7*

Table A contd. **Total Aliphatic Concentrations (ng g^{-1})**

Station	ECC_14	ECC_15	ECC_16	ECC_17	ECC_18	ECC_19	ECC_20	ECC_21	ECC_23	ECC_24	ECC_25	ECC_26	ECC_27
nC_{10}	<1	<1	<1	<1	<1	<1	80.1	53.5	4.25	11.2	<1	<1	<1
nC_{11}	<1	<1	<1	<1	2.66	7.03	104	81.5	7.46	10.4	<1	<1	<1
nC_{12}	<1	<1	<1	<1	24.7	31.9	94.0	65.5	17.5	19.7	<1	<1	<1
nC_{13}	<1	<1	<1	<1	36.5	34.5	166	129	13.0	26.2	18.2	17.1	15.5
nC_{14}	<1	<1	<1	<1	46.9	54.1	151	107	21.6	38.3	27.4	26.1	22.9
nC_{15}	<1	<1	<1	12.1	73.4	83.3	192	128	31.0	56.9	43.1	42.3	29.2
nC_{16}	<1	6.73	5.39	6.76	77.9	94.0	156	136	31.0	73.9	21.5	28.3	52.7
nC_{17}	3.34	11.7	7.24	18.6	60.8	79.1	215	139	31.0	61.7	46.8	40.5	38.5
Pristane	14.7	68.5	29.3	55.5	225	242	898	376	59.9	96.5	82.5	64.7	65.4
nC_{18}	2.60	8.54	4.82	14.4	42.8	57.2	121	90.2	23.6	48.2	34.7	30.4	30.0
Phytane	2.83	15.8	9.74	23.1	137	97.4	226	78.8	11.6	9.94	9.50	6.03	9.75
nC_{19}	7.23	11.6	6.28	19.6	46.3	68.1	120	101	21.7	47.8	32.1	29.8	29.3
nC_{20}	4.41	12.7	6.34	18.7	50.7	73.8	203	126	23.1	42.6	35.4	29.4	29.0
nC_{21}	4.67	9.47	8.87	23.7	60.1	120	299	195	25.8	42.8	27.4	24.4	30.4
nC_{22}	3.65	10.3	5.21	12.5	35.9	49.4	120	80.8	18.1	29.7	22.6	18.5	21.2
nC_{23}	5.83	14.8	7.01	15.3	44.2	58.3	152	105	19.7	30.7	24.5	21.0	23.3
nC_{24}	4.29	11.2	5.72	12.3	38.2	56.3	155	87.2	17.7	29.3	20.1	18.4	21.9
nC_{25}	7.79	8.97	9.85	15.8	40.5	59.7	171	100	8.99	25.5	24.3	17.2	40.8
nC_{26}	6.13	12.5	6.58	12.8	39.2	60.9	151	93.4	18.0	25.4	19.6	17.2	17.3
nC_{27}	5.55	16.4	8.74	16.6	49.3	70.5	201	100	15.6	22.9	18.8	14.7	15.5
nC_{28}	3.96	8.27	4.42	9.5	31.8	37.0	107	68.1	12.1	15.4	15.6	9.47	11.4
nC_{29}	5.48	19.7	12.8	21.1	55.4	90.2	197	132	15.8	29.5	19.2	17.1	14.8
nC_{30}	3.31	7.21	4.69	11.3	27.4	49.9	116	75.7	11.7	13.1	12.8	7.36	10.8
nC_{31}	3.94	14.5	10.4	17.1	38.2	92.0	140	102	11.6	19.4	14.9	11.1	13.6
nC_{32}	1.32	5.28	2.47	4.79	10.2	18.4	31.8	22.4	59.8	9.06	5.91	4.10	5.87
nC_{33}	1.57	7.49	7.21	8.53	17.9	50.6	83.3	60.2	4.19	7.92	6.55	7.49	6.14
nC_{34}	<1	3.13	1.80	6.53	3.96	12.1	28.1	16.1	1.95	4.29	3.79	2.60	4.14
nC_{35}	<1	4.39	<1	2.21	5.19	10.0	12.9	7.15	1.32	5.54	3.20	1.73	2.26
nC_{36}	<1	3.72	2.42	2.08	2.96	3.70	6.85	5.36	<1	1.64	1.76	<1	<1
nC_{37}	<1	<1	1.49	2.43	2.51	6.44	23.5	7.07	<1	2.01	1.47	<1	1.69
Total Oil (mg.kg^{-1})	*4,274*	*7,546*	*4,874*	*5,441*	*18,403*	*25,975*	*61,644*	*43,790*	*9,210*	*10,778*	*7,854*	*6,774*	*6,955*
Total n-alkanes (ng.g^{-1})	*75.1*	*209*	*130*	*285*	*966*	*1,428*	*3,599*	*2,415*	*467*	*751*	*502*	*436*	*488*

Table B. Aromatic Hydrocarbon Concentration (ng g^{-1})

Station	ECC_01	ECC_02	ECC_03	ECC_04	ECC_05	ECC_06	ECC_07	ECC_08	ECC_09	ECC_10	ECC_11	ECC_12	ECC_13
Naphthalene	2.16	<1	1.42	<1	<1	1.68	2.18	3.47	3.30	2.77	1.41	1.94	1.64
C1 Naphthalenes	7.02	3.63	4.67	3.81	4.10	5.86	7.52	13.7	12.3	13.5	5.04	7.21	5.50
C2 Naphthalenes	6.64	3.69	4.38	3.96	3.82	5.57	7.69	12.1	11.4	13.2	5.20	8.90	5.19
C3 Naphthalenes	6.08	3.33	3.88	4.19	3.29	5.63	8.33	12.9	10.8	12.2	5.91	9.18	4.53
C4 Naphthalenes	3.51	2.11	<1	<1	2.19	3.15	6.02	7.73	6.60	8.16	4.25	5.74	2.95
Sum Naphthalenes	25.4	12.8	14.3	12.0	13.4	21.9	31.7	50.0	44.4	49.8	21.8	33.0	19.8
Phenanthrene / Anthracene	5.98	2.19	2.68	3.27	2.56	3.64	4.67	7.46	8.09	8.06	4.59	5.08	2.75
C1 178	6.37	2.76	3.45	4.50	3.21	4.94	8.38	10.9	10.2	11.5	6.50	7.43	3.78
C2 178	5.43	2.75	3.80	3.58	3.75	5.02	7.86	10.8	8.91	9.50	6.29	6.84	3.77
C3 178	2.95	1.47	2.30	1.76	2.00	2.74	5.35	6.93	5.58	6.11	3.46	4.20	2.39
Sum 178	20.7	9.2	12.2	13.1	11.5	16.3	26.3	36.1	32.8	35.2	20.8	23.6	12.7
Dibenzothiophene	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
C1 Dibenzothiophenes	<1	<1	<1	<1	<1	<1	1.71	2.52	1.80	2.32	<1	1.43	<1
C2 Dibenzothiophenes	1.33	<1	<1	<1	<1	<1	1.99	2.60	2.07	2.48	1.48	1.55	<1
C3 Dibenzothiophenes	<1	<1	<1	<1	<1	<1	1.44	2.15	1.49	1.70	<1	<1	<1
Sum Dibenzothiophenes	1.33	0.00	0.00	0.00	0.00	0.00	5.14	7.27	5.35	6.49	1.48	2.98	0.00
Fluoranthene / Pyrene	7.07	4.07	5.41	5.19	5.32	6.57	9.86	14.0	10.6	12.2	7.74	8.19	6.03
C1 202	4.89	2.20	3.38	3.08	3.22	4.14	7.21	9.77	7.80	7.78	4.92	5.73	3.32
C2 202	4.94	2.26	3.36	3.09	3.32	3.81	7.66	11.4	7.70	10.3	4.90	5.62	3.72
C3 202	3.29	1.39	2.21	2.04	2.18	2.41	4.82	7.68	5.11	6.10	3.45	4.25	2.32
Sum 202	20.2	9.92	14.4	13.4	14.0	16.9	29.6	42.8	31.2	36.3	21.0	23.8	15.4
Benzoanthracene / Chrysene	5.22	1.66	3.60	3.60	3.61	4.35	6.43	9.38	7.28	8.06	5.34	5.60	3.89
C1 228	3.43	1.85	2.54	2.51	2.56	3.12	5.31	7.27	5.40	6.51	4.01	3.97	2.74
C2 228	2.80	<1	1.68	1.54	1.99	2.25	3.41	6.46	4.95	5.59	3.11	3.31	1.79
Sum 228	11.4	3.51	7.82	7.65	8.17	9.72	15.1	23.1	17.6	20.2	12.5	12.9	8.42

Table B contd. Aromatic Hydrocarbon Concentration (ng g^{-1})

Station	ECC_01	ECC_02	ECC_03	ECC_04	ECC_05	ECC_06	ECC_07	ECC_08	ECC_09	ECC_10	ECC_11	ECC_12	ECC_13
Benzofluoranthenes / Benzopyrenes	13.5	6.56	10.6	10.2	9.90	12.6	15.1	22.8	17.8	18.3	13.5	13.2	10.4
C1 252	5.91	3.27	5.16	4.64	5.43	5.78	7.90	11.39	8.03	8.51	6.77	6.74	4.57
C2 252	4.36	1.72	3.56	2.26	3.13	3.65	5.41	9.55	5.42	6.82	4.70	3.68	3.07
Sum 252	23.7	11.6	19.3	17.1	18.5	22.0	28.4	43.8	31.3	33.6	25.0	23.6	18.1
Aranthanthrenes / Indenopyrene / Benzoperylene	9.41	6.12	8.54	8.11	8.18	9.44	10.9	17.3	11.7	12.8	9.93	8.38	7.64
C1 276	1.43	<1	1.90	1.44	1.51	1.79	2.83	3.31	2.79	3.19	1.44	1.39	<1
C2 276	1.48	1.31	1.46	1.38	<1	1.98	2.87	3.52	2.57	2.83	2.86	1.78	1.37
Sum 276	12.3	7.44	11.9	10.9	9.69	13.2	16.6	24.1	17.1	18.9	14.2	11.5	9.00
Sum of all PAHs	115	54.4	79.9	74.2	75.3	100	153	227	180	200	117	131	83.4
Sum of NPD fraction	47.5	22.0	26.6	25.1	24.9	38.2	63.1	93.3	82.5	91.5	44.1	59.5	32.5
NPD/4-6 Ring PAH Ratio	0.70	0.68	0.50	0.51	0.49	0.62	0.70	0.70	0.85	0.84	0.61	0.83	0.64

Table B contd. Aromatic Hydrocarbon Concentration (ng g^{-1})

Station	ECC_14	ECC_15	ECC_16	ECC_17	ECC_18	ECC_19	ECC_20	ECC_21	ECC_23	ECC_24	ECC_25	ECC_26	ECC_27
Naphthalene	<1	2.84	3.45	5.95	26.2	75.6	114	123	8.73	3.97	5.70	4.39	5.01
C1 Naphthalenes	3.22	11.7	11.7	20.7	97.5	227	395	387	26.3	13.9	19.7	14.8	15.6
C2 Naphthalenes	2.91	12.1	9.33	17.6	92.2	180	357	308	19.4	11.2	17.3	12.5	12.9
C3 Naphthalenes	2.56	12.4	8.21	15.2	85.6	163	381	268	18.7	10.7	17.9	14.7	10.8
C4 Naphthalenes	1.70	6.43	4.60	8.29	58.4	74.3	193	121	8.97	7.19	9.20	7.52	6.48
Sum Naphthalenes	10.4	45.5	37.3	67.8	360	721	1439	1207	82.1	47.0	69.8	53.9	50.8
Phenanthrene / Anthracene	1.61	9.25	6.42	10.2	64.5	108	289	173	13.7	6.39	11.3	7.65	12.2
C1 178	2.22	12.0	6.90	12.8	69.3	110	324	187	14.1	10.3	13.3	11.8	12.6
C2 178	2.30	9.23	5.85	10.8	62.6	103	264	137	12.6	11.6	12.8	11.3	10.0
C3 178	1.41	6.46	3.46	6.75	42.1	59.2	167	86.7	9.25	9.46	9.37	7.99	8.50
Sum 178	7.55	37.0	22.6	40.6	238	379	1044	583	49.6	37.8	46.8	38.7	43.3
Dibenzothiophene	<1	<1	<1	<1	4.49	8.71	22.2	14.0	<1	<1	<1	<1	<1
C1 Dibenzothiophenes	<1	2.02	<1	1.78	10.2	18.1	48.7	28.9	2.12	2.09	2.38	1.92	2.03
C2 Dibenzothiophenes	<1	2.18	<1	2.12	12.5	21.1	41.5	30.8	2.54	2.96	3.07	2.30	2.90
C3 Dibenzothiophenes	<1	1.71	<1	1.55	6.73	16.0	34.9	24.9	1.81	2.59	2.06	1.94	1.92
Sum Dibenzothiophenes	0.00	5.91	0.00	5.44	33.9	63.8	147	98.6	6.47	7.64	7.51	6.16	6.85
Fluoranthene / Pyrene	4.53	14.0	7.56	12.6	59.4	158	313	226	16.3	18.5	17.5	14.5	30.4
C1 202	2.18	8.61	4.79	8.17	41.9	87.5	245	146	10.8	9.45	10.7	9.95	11.9
C2 202	2.06	13.3	5.61	9.25	47.6	85.3	270	136	10.3	9.7	10.1	9.83	9.28
C3 202	1.50	7.07	3.75	7.26	33.6	60.7	178	100	6.88	7.58	7.81	6.34	7.06
Sum 202	10.3	43.0	21.7	37.3	182	391	1006	608	44.2	45.3	46.1	40.6	58.7
Benzoanthracene / Chrysene	2.93	8.51	5.67	8.67	43.3	107	210	161	11.1	11.4	11.6	9.48	20.1
C1 228	2.02	6.07	3.84	6.57	32.9	68.9	155	107	7.58	7.61	7.85	6.61	8.51
C2 228	1.52	4.18	2.79	5.27	26.9	53.3	138	79.8	5.91	6.49	6.62	6.65	5.97
Sum 228	6.47	18.8	12.3	20.5	103	230	503	348	24.6	25.5	26.0	22.7	34.6
Benzofluoranthenes / Benzopyrenes	5.42	16.1	11.0	16.2	70.3	181	298	253	16.8	18.2	18.8	15.8	31.3

Table B contd. Aromatic Hydrocarbon Concentration (ng g^{-1})

Station	ECC_14	ECC_15	ECC_16	ECC_17	ECC_18	ECC_19	ECC_20	ECC_21	ECC_23	ECC_24	ECC_25	ECC_26	ECC_27
C1 252	3.31	7.98	5.76	9.47	45.4	100	198	161	10.7	11.5	11.6	11.0	14.0
C2 252	2.30	7.30	4.78	7.74	37.4	84.3	170	125	7.95	9.33	9.42	6.88	7.79
Sum 252	11.0	31.4	21.6	33.4	153	365	666	538	35.4	39.0	39.8	33.7	53.0
Aranthanthrenes / Indenopyrene /Benzoperylene	5.49	9.71	7.00	9.70	42.9	100	159	146	8.27	9.19	9.78	9.09	16.0
C1 276	<1	1.85	1.36	2.30	8.91	23.7	40.9	38.3	2.50	2.51	2.30	2.65	3.09
C2 276	<1	3.16	2.31	2.62	11.5	24.8	43.7	37.2	3.45	3.46	3.63	3.35	3.23
Sum 276	5.49	14.7	10.7	14.6	63.2	148	244	222	14.2	15.2	15.7	15.1	22.4
Sum of all PAHs	51.2	196	126	220	1134	2299	5048	3604	257	217	252	211	270
Sum of NPD fraction	17.9	88.4	59.9	114	632	1164	2630	1888	138	92.4	124	98.8	101
NPD/4-6 Ring PAH Ratio	0.54	0.82	0.90	1.08	1.26	1.03	1.09	1.10	1.17	0.74	0.97	0.88	0.60

Appendix D8 – Hornsea Project Four Offshore Wind Farm, Annex I Habitat Assessment Survey 2020 (Ocean Ecology Limited 2020)

Hornsea Project Four Offshore Wind Farm

Annex I Habitat Assessment Survey 2020

Ref: ORSHFO1219

Prepared for

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List of Abbreviations

BIIGLE	Bio-Image Indexing and Graphical Labelling Environment
BHL	Bibby Hydromap Limited
BSL	Benthic Solutions Limited
CD	Chart Datum
DDC	Drop Down Camera
dML	deemed Marine Licence
EBS	Environmental Baseline Survey
EC	European Commission
ECC	Export Cable Corridor
ES	Environmental Statement
ETRS	European Terrestrial Reference System
EUNIS	European Nature Information System
FOCI	Feature of Conservation Importance
GPS	Global Positioning System
HOCI	Habitat of Conservation Importance
JNCC	Joint Nature Conservation Committee
MMO	Marine Management Organisation
NMBAQC	NE Atlantic Marine Biological Quality Control
OEL	Ocean Ecology Limited
UTM	Universal Transverse Mercator

Contents

1. NON-TECHNICAL SUMMARY

Ocean Ecology Limited was commissioned by Ørsted Hornsea Project Four Limited to undertake a benthic survey to assess for the presence of and map any Annex I stony reef habitat along the Hornsea Project Four export cable route.

Efforts were targeted at two locations where potential Annex I stony reef habitat had been recorded during previous surveys. The survey was undertaken in early January 2020 and involved the collection of high-resolution seabed video and stills along cruciform transects using a low visibility drop-down camera system fitted with a freshwater housing. Following data collection all images were analysed using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE) annotation platform by experienced marine ecologists. This ensured the assessment of the imagery against the various Annex I stony reef qualifying criteria (composition, elevation and extent) was undertaken in an auditable and transparent manner that can easily be reviewed and validated by regulatory bodies (and others) if required. The results were then overlain on the most recent acoustic survey data (multibeam bathymetry and side scan sonar) available for the areas of interest which allowed for manual delineation of the areas deemed to qualify as Annex I stony reef habitat. Each polygon was attributed a 'low', 'medium' or 'high' resemblance classification and accompanying confidence score.

Areas of cobble substrate deemed to qualify as Annex I stony reef habitat were observed at both locations. Patches of seemingly stable large cobbles were frequently observed at Station ECC_22 which were colonised by diverse epifaunal communities interspersed with areas of sands and gravel. The majority of seabed images assessed at this location were, however, classified as 'low' resemblance stony reef although occasional images were also classified as medium resemblance reef. Three distinct patches of 'low' resemblance Annex I stony reef were therefore mapped in this area covering a combined area of 4,381.8 m^2. Due to the relatively 'low' quality of the acoustic data available combined with the inherent difficulty in accurately mapping 'low' lying stony reef habitats when interspersed with mosaics of coarse sands and gravels the mapping of these patches were assigned a 'low' confidence score. As such, their delineation should be treated with a degree of caution. No observations of the biogenic reef forming species such as Ross worm (*Sabellaria spinulosa*) or horse mussel (*Modiolus modiolus*) were made at this location.

Station ECC_23 was mainly characterised by coarse sediment comprising gravel and pebbles with occasional cobbles. The majority of seabed images assessed at this location were not deemed to meet the qualifying criteria of Annex I stony reef, mainly due to the dominance of gravel and pebble substrate rather than cobbles. A few images at this location were, however, classified as 'low' resemblance stony reef although these were sparsely distributed and isolated. A small cluster of these images indicated that a small patch of stony reef covering an area of 173.1 m^2 was present at this location although a 'low' confidence was assigned to its delineation do to the same reasons given for the mapping at ECC_22 and should therefore also be treated with a degree of caution. No observations of the biogenic reef forming species such as Ross worm (*S. spinulosa*) or horse mussel (*M. modiolus*) were made at this location.

The four distinct patches of Annex I stony reef habitat recorded during this survey were scored as 'low' resemblance as per the qualifying criteria set out in regulatory guidance on assessing stony reef habitats (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not necessarily be considered to be contributing to the Marine Natura site network unless there is strong justification. Given that none of these reefs are designated features of any Marine Natura sites or any other marine protected areas and that ‘low’ was generally scored against each of the qualifying criteria for the majority of seabed images in each area, it is unlikely that any impacts associated with the installation of the Hornsea Project Four export cable route will be of any significance in the context of the Marine Natura site network.

2. INTRODUCTION

2.1. Hornsea Offshore Wind Farm Project Four

Ørsted Hornsea Project Four Limited is proposing to develop Hornsea Project Four Offshore Wind Farm (hereafter 'Hornsea Four'). Hornsea Four will be located approximately 65 km offshore the East Riding of Yorkshire in the Southern North Sea and will be the fourth project to be developed in the former Hornsea Zone. Hornsea Four will include both offshore and onshore infrastructure including an offshore generating station (wind farm), export cables to landfall, and connection to the electricity transmission network.

Water depths are generally from around 30 m below Chart Datum (CD) in the south of the Hornsea Four array area to greater than 60 m below CD in the north, although the greatest depths are on the north-eastern flank which shelves into Outer Silver Pit. Sandwaves are present within the Hornsea Four array area, particularly across the north western corner and along the southern margin. Surficial sediments across the Hornsea Four array area are typically sandy material with small amounts of gravel and muds. The main exception is along the southern boundary where there is a slightly higher percentage of gravels and a coarser substrate described as slightly gravelly sand. Depths across the Hornsea Four offshore export cable corridor are similar to the Hornsea Four array area until closer to the coastline. Sediments across the Hornsea Four offshore ECC show an increasing gravel content towards the coast, transiting from the sandy Hornsea Four array area into slightly gravelly sand, gravelly sand to sandy gravel. The beach at landfall, south of Bridlington, itself is a thin veneer of sand over rock.

2.2. Background Information

The pre-construction environmental baseline survey (EBS) of the Hornsea Four windfarm export cable routes was conducted by Bibby HydroMap Limited (BHL), supported by Benthic Solutions Limited (BSL) in June 2019 (Bibby Hydromap 2019).

An area of 'Sandy gravel with boulders' was identified in the inshore areas of the cable route, which encompassed stations ECC_22 and ECC_23. Annex I stony reef habitat was discussed as potentially occurring at these stations but could not be confirmed due to the patchy nature of the substrate. Sporadic individuals of the ross worm *Sabellaria spinulosa* and a single small tube aggregation were observed, but it was deduced that no evidence of the distinct signatures characteristic of *S. spinulosa* reefs were present in the detailed review of the side scan sonar and multibeam bathymetry (Bibby Hydromap 2019). No other potential Habitats Directive (92/43/EEC) Annex I habitats or other protected habitats and/or species were identified during the Hornsea Four EBS.

2.3. Survey Objectives

Ocean Ecology Limited (OEL) was contracted by Ørsted Hornsea Project Four Limited to conduct a benthic survey to assess for the presence of and map any Annex I stony reef habitat at the two locations (ECC_22 and ECC_23) where it was previously noted as potentially occurring. The primary and secondary objectives of this survey were to therefore:

1. Assess for the presence of and map any Annex I stony reef habitat at stations ECC_22 and ECC_23.
2. Assess for the presence of and map any other habitats of conservation, ecological and economic importance (CEEI) at stations ECC_22 and ECC_23.

2.4. Annex I Reef Habitats

Several important and sensitive habitats occur within the North Sea and have the potential to occur within the survey area. These include both geogenic and biogenic reef habitats.

2.4.1. Geogenic Reef

Geogenic reefs can be variable in terms of both their structure and the communities that they support. They provide a home to many species such as corals, sponges and sea squirts as well as giving shelter to fish and crustaceans such as lobsters and crabs. These reefs can be classified as either bedrock or stony reefs depending on the nature of the substrate.

2.4.1.1. Stony Reef

Stony reef habitats occur when stable hard substrata, namely cobbles and boulders > 64 mm in diameter arise from the surrounding habitat, creating a habitat colonised by a variety of fauna and flora. Numerous sites have been designated in UK waters to protect stony reef habitats and associated communities. Such communities can be highly diverse, supporting assemblages of various coral, sponges, ascidians, fish and crustaceans. These associated communities vary dramatically according to environmental variables and may incorporate species that occupy a range of trophic levels. The complexity of habitat created by stony reefs often supports a higher abundance of mobile fauna such as echinoderms and various crabs, hermit crabs, and squat lobsters, as well as fish species for which these species represent key prey items. To be regarded as Annex I stony reef under the EC Habitats directive it is generally accepted that areas of cobble/boulder substrate must meet a number of qualifying criteria as defined by Irving (2009) (Table 1).

Table 1. Characteristics of Annex I 'stony reef' (from Irving (2009)).

Characteristic	Not a Reef	Low	Medium	High
Composition (proportion of boulders/cobbles (>64 mm))	<10 %	10-40 % matrix supported	40-95 %	>95 % clast-supported
Elevation	Flat seabed	<64 mm	64 mm - 5 m	>5 m
Extent	<25 m²	>25 m²		
Biota	Dominated by infaunal species			>80 % of species present composed of epibiotal species

2.4.1.2. Bedrock Reef

Similar to stony reef, Annex I bedrock reef habitat occurs where hard bedrock arises from the surrounding seabed, providing a stable habitat for attachment for a diverse range of epibiota. Bedrock reefs and associated biological communities can be highly variable due to the diverse nature of these habitats in terms of topography, structural complexity and exposure to tidal streams. In the photic zone communities associated with bedrock reefs are often dominated by attached algae, and often support various invertebrate species such as corals, sponges and sea squirts. These epibiotic communities further increase structural complexity and represent key prey items that in turn attract more mobile and commercially valuable species of fish and crustaceans.

2.4.2. Biogenic Reefs

Biogenic reefs are those that are created by the animals themselves. In UK offshore waters the main types of biogenic reef are *Sabellaria spinulosa* reefs and *Modiolus modiolus* reefs.

2.4.2.1. *Sabellaria spinulosa*

Dense subtidal aggregations of the Ross worm *S. spinulosa* may form biogenic reefs that can stabilise cobble, pebble and gravel habitats and provide a consolidated habitat for epibenthic species (Pearce et al. 2011). *S. spinulosa* reefs form solid, raised structures above the surrounding seabed, thus increasing local habitat complexity and creating a biogenic habitat onto which various other species may become established. Those *S. spinulosa* reefs of greatest conservation importance are those which occur on predominantly sediment or mixed sediment areas that allow settlement of fauna that would not otherwise occur in such areas. Biological assemblages in areas of *S. spinulosa* reefs therefore often support a rich diversity of flora and fauna compared to surrounding areas of relatively homogenous habitat.

Such reefs form in areas of favourable environmental conditions, largely areas of muddy sand with coarse material for attachment and high suspended sediment concentrations for tube construction. The species is common around the British Isles, with a relatively widespread distribution throughout the north east Atlantic, the North Sea and the English Channel. Due to their high biological importance *S. spinulosa* reefs have been identified as Section 41 priority habitats and also comprise Features of Conservation Importance (FOCI)[1]. *S. spinulosa* aggregations are generally assessed against three metrics/categories (elevation, patchiness and area), which together, can be used to a) determine whether *S. spinulosa* aggregations qualify as Annex I biogenic reef habitat under the EC Habitats Directive and b) provide a measure of 'reefiness' for monitoring and assessment purposes (Table 2, Gubbay 2007).

Table 2. Characteristics of *S. spinulosa* reef (Gubbay 2007).

Characteristic	Not a Reef	Low	Medium	High
Elevation (cm) Average tube height	< 2	2 - 5	5 – 10	> 10
Extent (m^2)	< 25	25 – 10,000	10,000 – 1,000,000	> 1,000,000
Patchiness (% Cover)	< 10	10 - 20	20 – 30	> 30

2.4.2.2. *Modiolus modiolus*

Horse mussels (*Modiolus modiolus*) may form biogenic reef structures. *M. modiolus* can form dense raised beds which can significantly modify the underlying habitat and provide substratum and refuge for a wide variety of species, including brittlestars, featherstars, crabs, whelks, sponges, sea firs, sea mats and sea squirts (Baxter et al. 2011). Furthermore, they can be important settling grounds for commercially important bivalve molluscs such as scallops (Baxter et al. 2011). Due to their high biological importance *M. modiolus* beds have been identified as Section 41 priority habitats and comprise Habitats of Conservation Importance (HOCI)[2].

The current definition of *M. modiolus* reefs is present in the OSPAR agreement 2008-7 (OSPAR 2008) as patches that extend over > 10 m^2 with > 30% cover by mussels. Mosaics can occur where frequent smaller clumps of mussels can influence ecosystem function and so lower thresholds can be accepted. However, scattered populations of isolated full-grown individuals or of spat at quite high densities should not be classified as 'beds (OSPAR 2008). An inter-agency workshop conducted in 2014 (Morris 2015) concluded that the following criteria should be met for classification of *M. modiolus* reef habitat:

- Live adult *M. modiolus* individuals are present;

[1] http://jncc.defra.gov.uk/pdf/UKBAP_BAPHabitats-47-SabellariaSpinulosaReefs.pdf
[2] jncc.defra.gov.uk/Docs/UKBAP_BAPHabitats-18-HorseMusselBeds.doc

- the associated reef biota/communities are distinct from the surrounding habitat; and
- the distinct region containing *M. modiolus* is greater than 25 m^2 in extent.

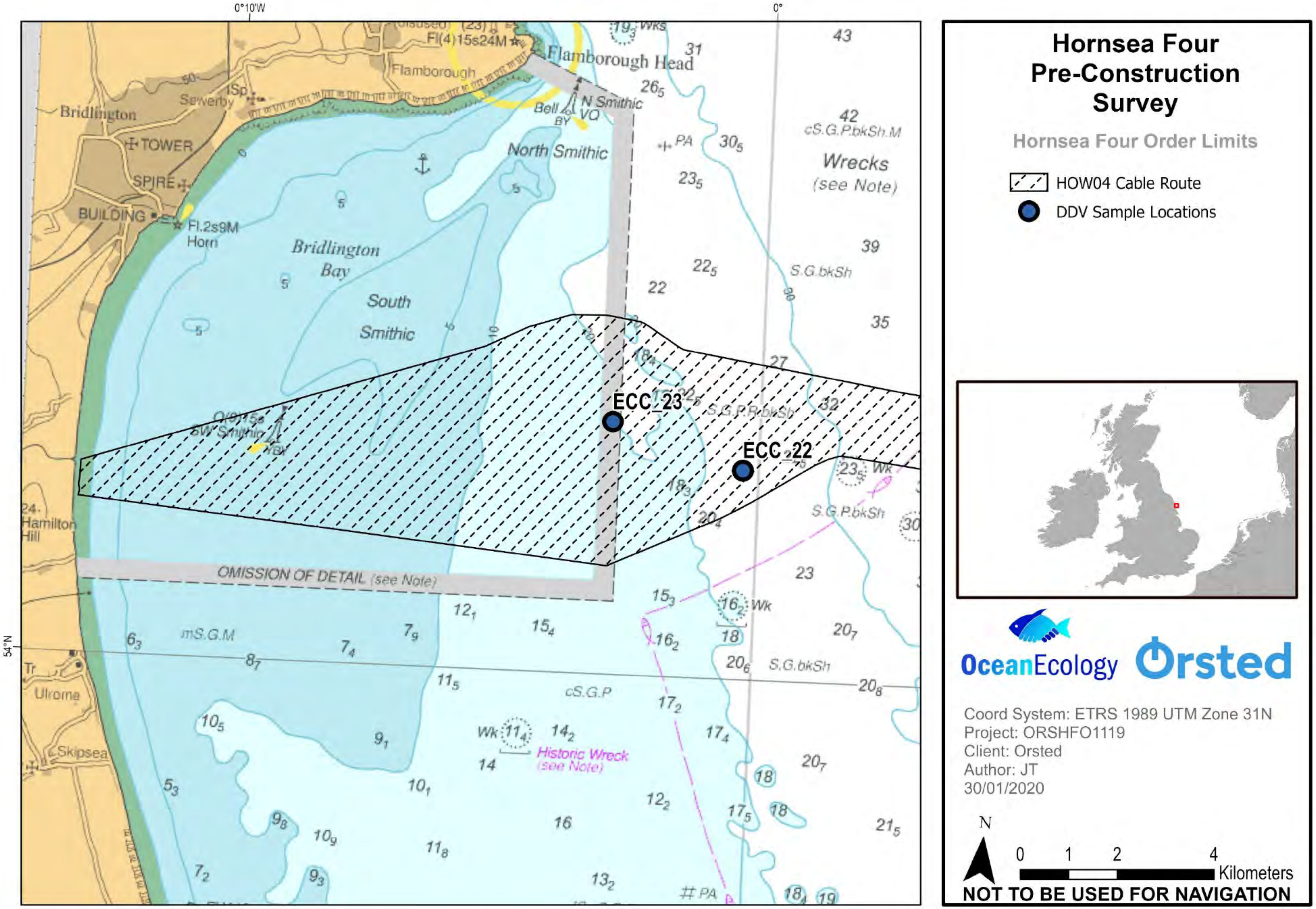

Figure 1. Overview of sampling stations in the Hornsea Four Annex I Habitat Assessment Survey 2020.

3. METHODS

3.1. Sampling Rationale

A detailed cruciform transect approach was adopted at each of the target stations. Seabed imagery was collected along 200 m transects orientated in a cross-hair arrangement extending out from the original sampling station in a north, east, south and west direction. When present, the transects were to be extended until the boundary of the potential Annex I habitat was crossed or the edge of the ECC was reached, whichever came first. Sampling locations are shown in Figure 1 and sample logs are presented in Appendices I and II.

3.2. Geodetic Parameters

All co-ordinates were based on European Terrestrial Reference System 1989 (ETRS89) with projected grid coordinates based on Universal Transverse Mercator (UTM) zone 31N with a Central Meridian of 03°E. A summary of geodetic and projection parameters is provided in Table 3.

Table 3. Details of geodatic datum parameters used for the Hornsea Four Annex I Habitat Assessment Survey 2020.

Local Geodetic Datum Parameters	
Datum:	European Terrestrial Reference System 1989 (ETRS89)
Spheroid:	International 1924
Project Projection Parameters	
Grid Projection:	Universal Transverse Mercator, Northern Hemisphere
UTM Zone:	31 N
Central Meridian:	03° 00' 00" East
Latitude of Origin:	00° 00' 00" North
False Easting:	500 000 m
False Northing:	0 m
Scale factor on Central Meridian:	0.9996
Units:	Metre

3.3. Field Methods

3.3.1. Survey Progress

All seabed imagery was obtained on 12th January 2020 during which 140 minutes of video and 150 high-resolution stills were collected along a total of six transects across the ECC_22 and EC_23. Due to the continued observation of cobbles in the seabed imagery at the southern end of transect A (north to south) at EC_22, it was necessary for additional seabed imagery to be collected to help fully delineate the potential Annex I stony reef in this area. Due to the direction of tidal flow combined with weather conditions on site, the additional imagery was collected along two further 100 m transects running south to north.

3.3.2. Survey Vessel

All seabed imagery was collection aboard OEL's 10.0 m dedicated survey vessel, 'Seren Las'. The vessel was equipped with a Hemisphere V104s GPS Compass system that provided an accurate offset position of the DDC system when deployed from the stern. This provided a GPS feed to a dedicated survey navigation PC operating TimeZero Navigator v3 marine navigation with routing module and SeaTraceR Class B AIS.

Plate 1 Dedicated survey vessel, Seren Las, for the Hornsea Four Annex I Habitat Assessment Survey 2020.

3.3.3. Survey Equipment

Seabed imagery was collected using OEL's ROVTech subsea camera system which obtained 1080p High Definition (HD) video and 20 Megapixel (MP) still images, mounted in a hydrostatic freshwater housing and bespoke mounting frame. Two laser pointers separated by 10 cm were mounted in the frame and projected into the field of view for a measure of scale.

3.4. Drop-Down Camera Sampling

All camera stations and transects were sampled in line with the Joint Nature Conservation Committee (JNCC) epibiota remote monitoring operational guidelines (Hitchin et al. 2015). Images were taken every 10 – 20 m, at the interface between different habitats and of any notable features along the transects. All video footage was reviewed in situ by the lead marine ecologist.

The camera system was deployed as follows:

- Vessel approached target location and alerted deck personnel to prepare camera and umbilical.
- Sea fastening on camera frame was released to allow deployment from the deck.
- Umbilical released overboard with sufficient length paid out to cover water depth.
- Camera raised and lowered into the water column to within 5 m of the seabed.
- Ecologist switched on video recording and the camera lowered until gently landing on the seabed at which point a positional fix was taken.
- The ecologist then waited for any suspended sediments in the field of view to disperse before taking an image and confirming with the skipper to move on.
- The camera was then raised from the seabed and moved along the transect at approximately 1 - 2 knots. Where possible the seabed was maintained in view at all times.
- Following the capture of the final image, the camera was lifted, video recording was stopped, and the camera was retrieved to the surface.
- The winch operator then took tension on the winch cable and the ecologist ensured the camera umbilical was free for recovery.
- Once the camera was at the surface, the vessel was positioned to minimise pitch and roll (e.g. into wind/tide).
- The vessel skipper then confirmed sea conditions were suitable for retrieval and the camera system was recovered aboard.
- The camera frame was then lowered onto the deck and the tension released.

3.5. Seabed Imagery Analysis

All seabed imagery analysis was undertaken in line with JNCC epibiota remote monitoring interpretation guidelines (Turner et al. 2016). A full Annex I habitat assessment was conducted on all images to determine whether habitats met the definitions of Annex I reef habitats as detailed in Section 2.4.

All images were analysed using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE[3]) annotation platform (Langenkämper et al. 2017). BIIGLE is a cloud-based image annotation platform which allows for increased accuracy, repeatability and improved quality assurance in the analysis of both video and stills data. Images are organised into projects and are made accessible to all users working on the project. All those working on the project can view annotations made by other uses to ensure consistency throughout. Project users can also be assigned specific roles, depending on the level of access required. Editors can create and modify annotations, annotation labels and image labels. However, they cannot delete annotation labels or image labels that were created by other users. A project admin has no restrictions and can create and modify annotations, annotation labels and image labels, including those of other users.

3 [redacted]

BIIGLE can handle volumes with many thousands of images. The volume overview allows users to explore the images in an effective and efficient way by providing tools to navigate, filter, and sort images. This enables efficient checking of specific labels and querying of images e.g. by filenames.

Label trees are then assigned to each project in BIIGLE. Only the labels of these label trees will be available when annotations or image labels are created in the project. A label tree is a collection of labels that may be flat or in a tree-like structure. Label trees can relate to taxonomy, habitat, or any other custom classification scheme. The label tree used during analysis had major headings for each of Annex I reef type. Under each reef type labels are assigned for each of the key reef qualifying criteria (see Table 1 and Table 2). The full label tree used in the project can be found in Appendix IV. Analysis of still images within BIIGLE was undertaken in two stages as described below.

3.5.1. Tier 1 Analysis

The first stage, "Tier 1", consisted of assigning labels that referred to the whole image, providing appropriate metadata for the image. Depending on reef type, this included:

- Extent: As it is not possible to fully determine the extent of reef habitats from a single image alone this label was used to identify areas that were highly unlikely to constitute reef habitats. An example being an image that showed a large boulder being preceded and succeeded by images of unconsolidated sandy sediments.
- Biota: Labels assigned to determine whether epifauna dominated the biological community observed.
- Elevation: Labels assigned depending on reef type. Laser points were used to assist in the assignment of categories.

Additional labels of image quality and EUNIS level three broadscale habitat[4] were also assigned to each image.

3.5.2. Tier 2 Analysis

The second stage, "Tier 2", was used to assign percentage cover of reef types. This was achieved by drawing polygons around instances of key qualifying features (e.g. particles >64 mm) within the image as shown in Plate 2.

3.6. Mapping

All images were assigned an Annex I stony reef category of 'not a reef', 'low', and 'medium' based upon the criteria assessed during the analysis described (Table 1). These outputs from the BIIGLE analysis were utilised alongside the acoustic information to manually delineate the boundaries of Annex I stony reef areas. The acoustic information available was limited in extent and quality. As a result, it was difficult at times to delineate accurate boundaries of reef areas. Confidence scores were therefore assigned to all polygons to give an indication of their accuracy. Values ranged from 1 (no distinct boundaries) to 2 (ground-truth and acoustic information show distinct boundaries). Highest scores were given to areas where both data sources identified obvious presence of Annex I stony reef habitat, with distinct boundaries. Lower scores were assigned to areas where the boundaries were not obvious. In these cases, polygons were drawn based upon expert judgement, given the information available.

[4] https://eunis.eea.europa.eu/habitats-code-browser.jsp?expand=A,A1,A2,A3,A4,A5#level_A5

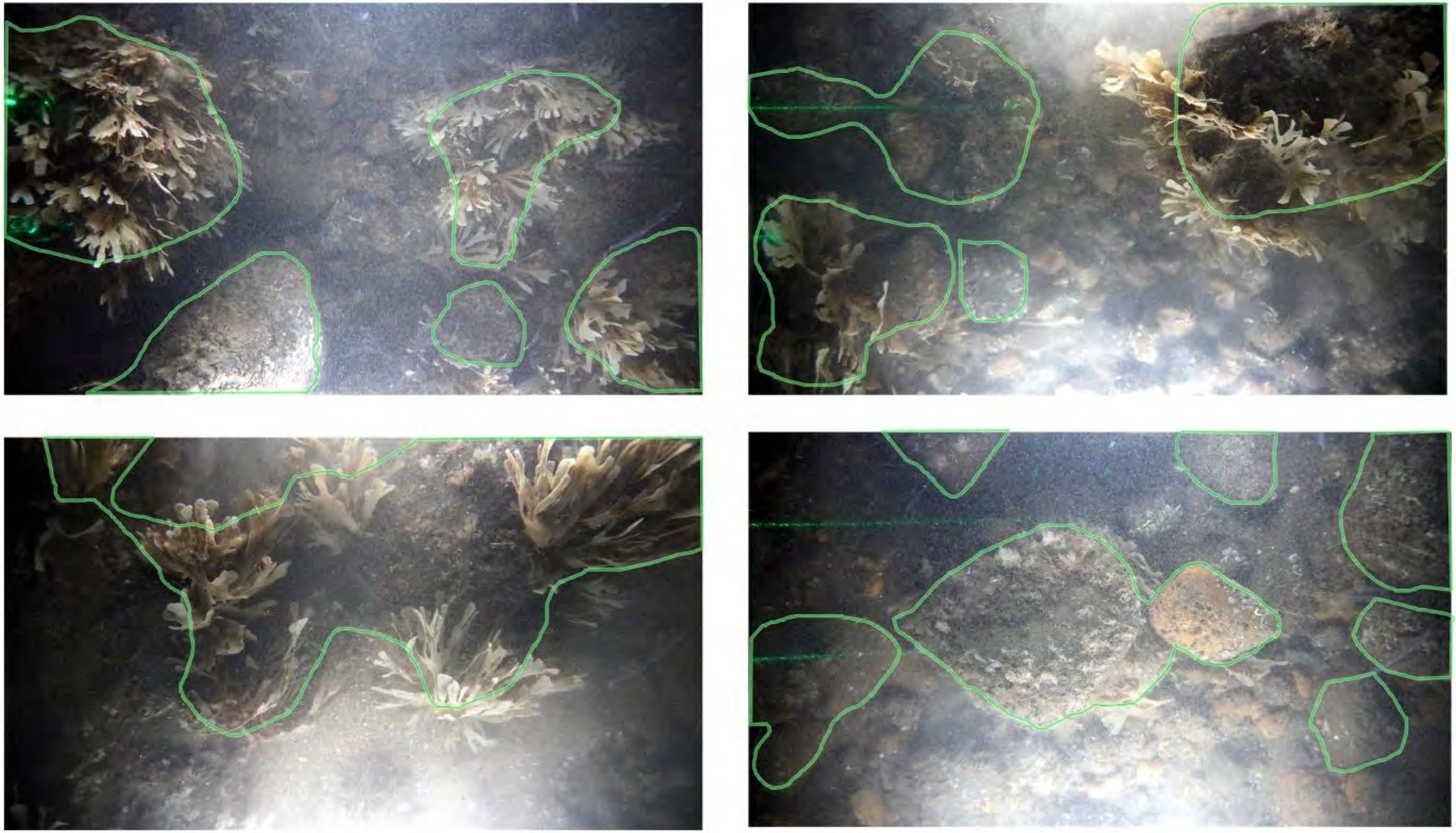

Plate 2. Example image analysis in BIIGLE. Green polygons identify cobbles / boulders.

4. RESULTS

4.1. Station ECC_22

As observed during the EBS survey, Station ECC_22 was characterised by patchy coarse sediments constituted mainly by cobbles and pebbles surrounded by coarse sand and gravel. Patches of seemingly stable large cobbles were frequently observed at Station ECC_22 which were colonised by diverse epifaunal communities interspersed with areas of sands and gravel. The majority of seabed images assessed at this location were, however, classified as ‘low’ resemblance stony reef although occasional images were also classified as ‘medium’ resemblance reef (Figure 2, Plate 3). Three distinct patches of ‘low’ resemblance Annex I stony reef were therefore mapped in this area covering a combined area of 4,381.8 m^2 (Figure 3 and Figure 6). Due to the relatively low quality of the acoustic data available combined with the inherent difficulty in accurately mapping low lying stony reef habitats when interspersed with mosaics of coarse sands and gravels, the mapping of these patches was assigned a ‘low’ confidence score. As such, their delineation should be treated with a degree of caution. No observations of Annex I biogenic reef forming species such as Ross worm (*Sabellaria spinulosa*) or horse mussel (*Modiolus modiolus*) were made at this location.

Conspicuous fauna observed was similar to that observed in the EBS. Dense patches of the bryozoan *Flustra foliacea* were often associated with the larger boulders as well as other epifauna including anemones (Actinaria), Hydrozoa, other encrusting fauna (bryozoan and hydroid turf), and occasional dead-man’s fingers (*Alcyonium digitatum*). Mobile epifauna was sparse, where only occasional Decapoda (*Carcinus maenas*, *Cancer pagurus*, *Munida rugosa*) and Echinodermata (*Henricia* sp.) were observed. No instances of *S. spinulosa* either in its solitary or gregarious form were observed. Seabed imagery for Station ECC_22 is provided as Appendix III.

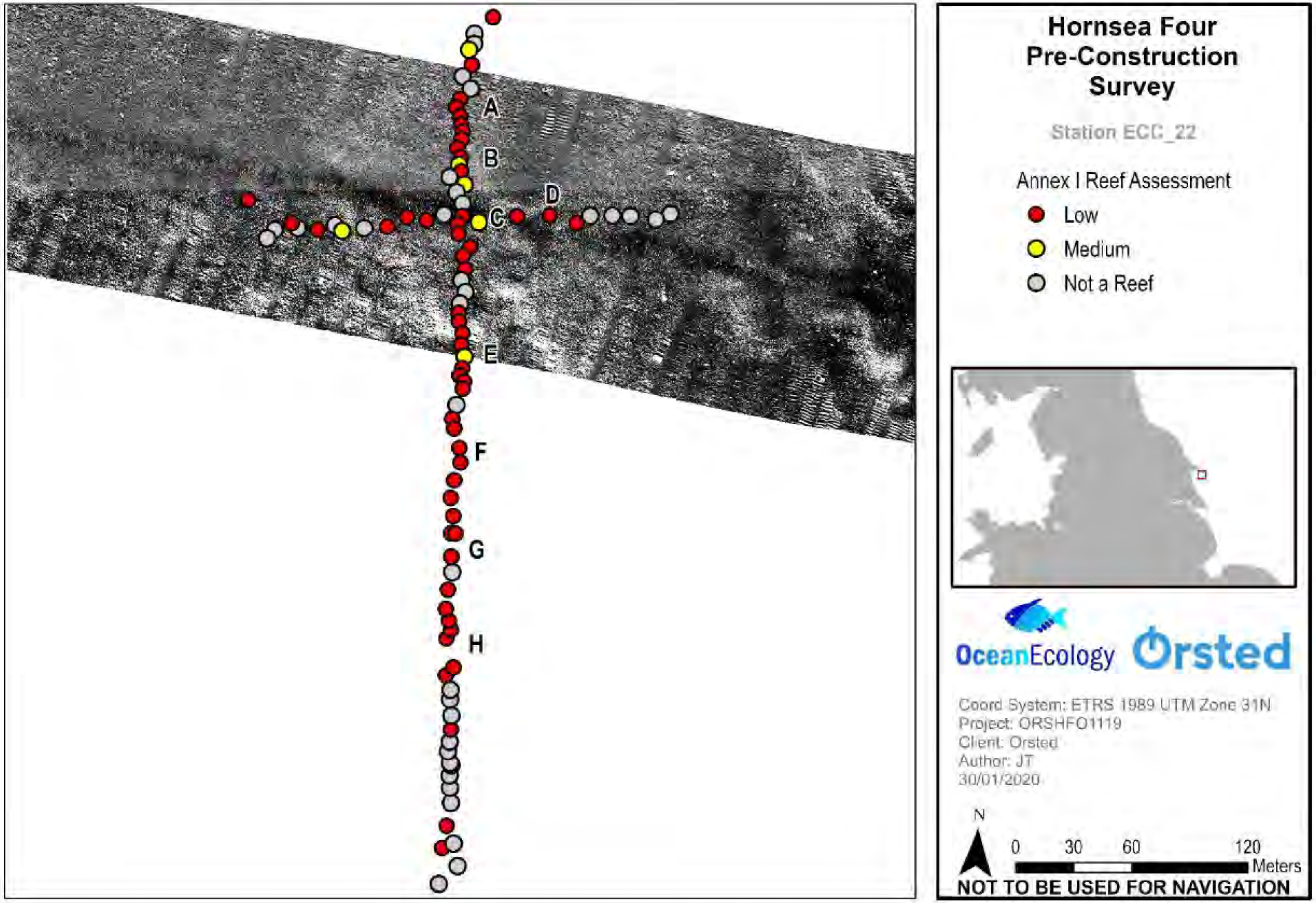

Figure 2. Annex I reef categories assigned to still images collected at Station ECC_22 during the survey overlain on high-frequency side-scan sonar. Letters correspond to images in Plate 2.

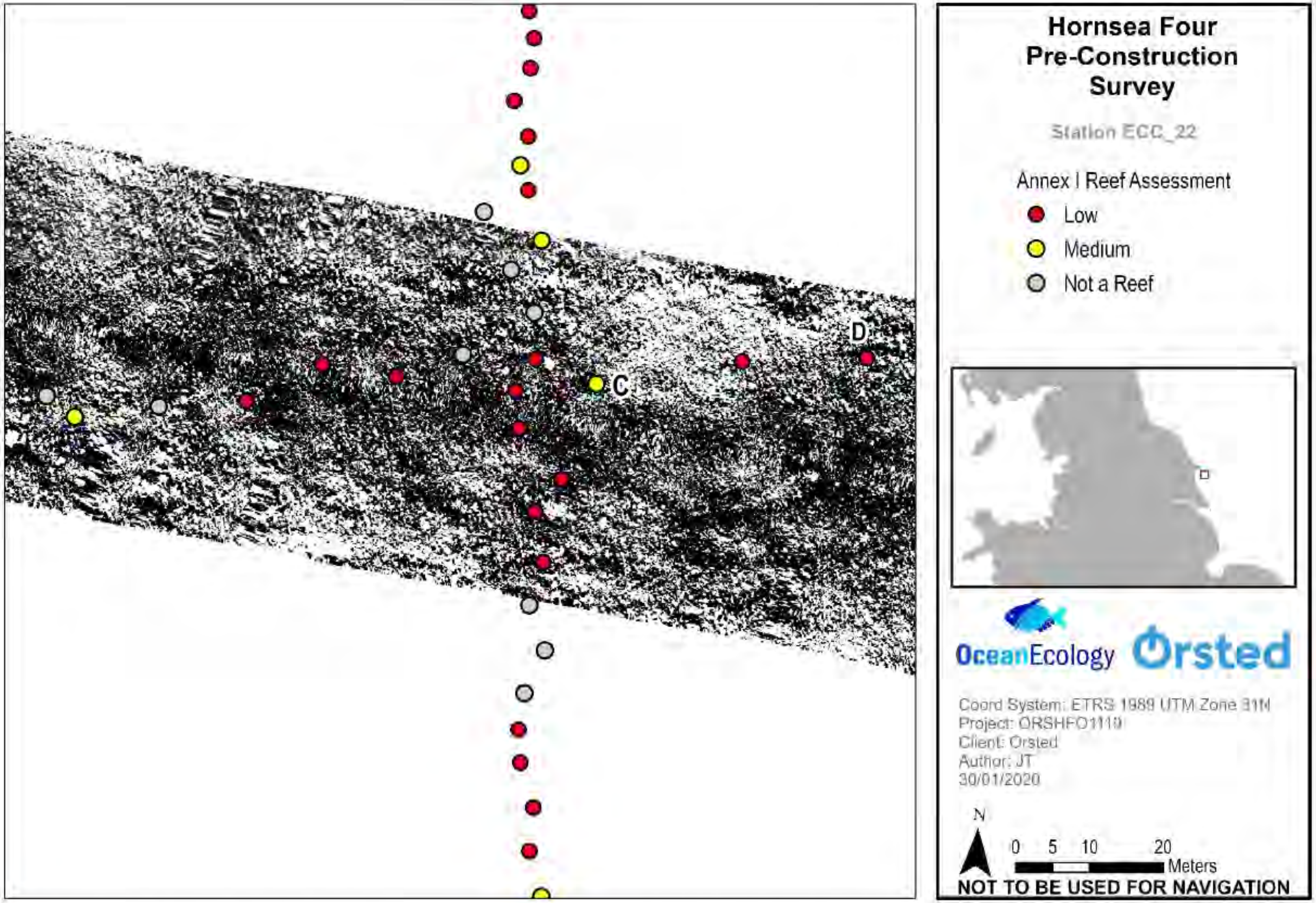

Figure 3. Close-up of Annex I reef categories assigned to still images collected at Station ECC_22 during the survey overlain on ultra-high-frequency side-scan sonar. Letters correspond to images in Plate 2.

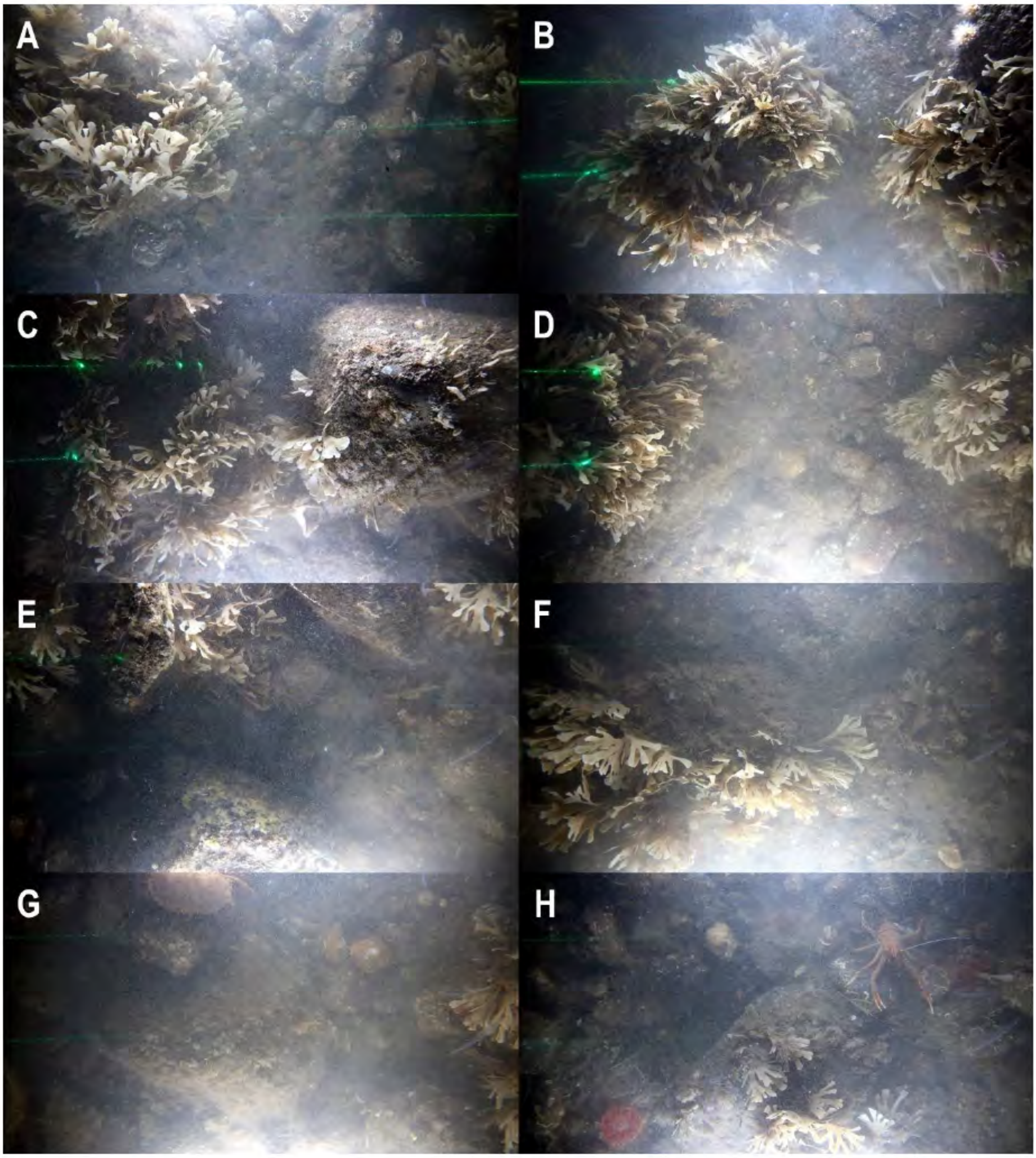

Plate 3. Example images collected at Station ECC_22 showing patches of 'low' (A, D, F, G, H) and 'medium' (B, C, E) resemblance Annex I stony reef. Letters correspond to Figure 2 and Figure 3.

4.2. Station ECC_23

Station ECC_23 was mainly characterised by coarse sediment comprising gravel and pebbles with occasional cobbles. The majority of seabed images assessed at this location were not deemed to meet the qualifying criteria of Annex I stony reef, mainly due to the dominance of gravel and pebble substrate rather than cobbles (Figure 4, Plate 4). A few images at this location were, however, classified as 'low' resemblance stony reef although these were sparsely distributed and isolated. A small cluster of these images indicated that a small patch of stony reef covering an area of 173.1 m^2 was present at this location (Figure 5 and Figure 7) although a 'low' confidence was assigned to its delineation due to the same reasons given for the mapping at ECC_22. No observations of Annex I biogenic reef forming species such as Ross worm (*S. spinulosa*) or horse mussel (*M. modiolus*) were made at this location.

Conspicuous fauna observed was similar to that observed at Station ECC_22 though in even lower abundances. The bryozoan *Flustra foliacea* was often associated with the larger boulders as well as other epifauna including anemones (Actinaria), Hydrozoa, and other encrusting fauna (bryozoan and hydroid turf). Mobile epifauna was very sparse, where only the occasional swimming crab (*Liocarcinus* sp.) was observed observed. No instances of *S. spinulosa* either in its solitary or gregarious form were observed. Seabed imagery for Station ECC_23 is provided as Appendix III.

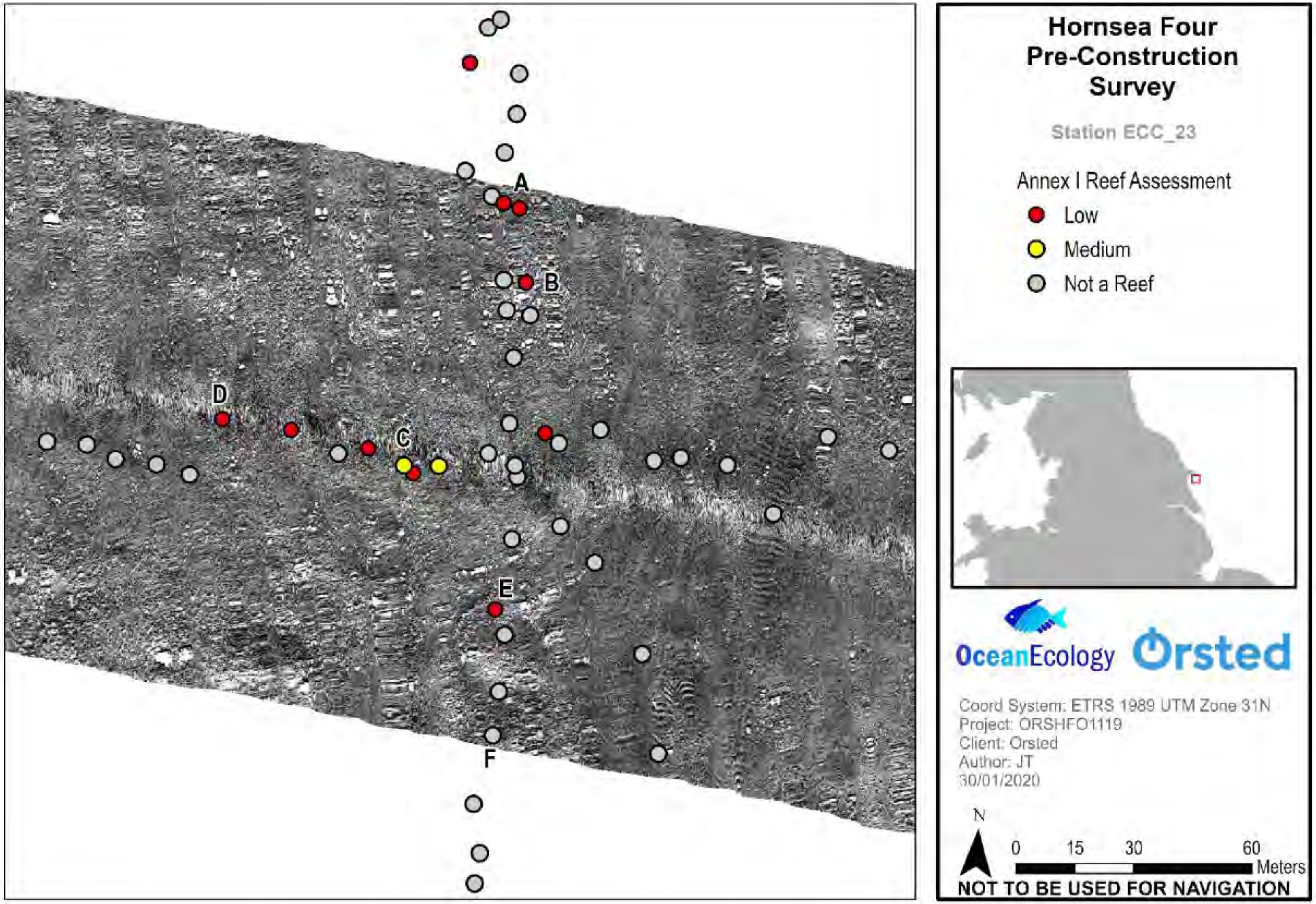

Figure 4. Annex I reef categories assigned to still images collected at Station ECC_23 during the survey overlain on ultra-high-frequency side-scan sonar. Letters correspond to images in Plate 3.

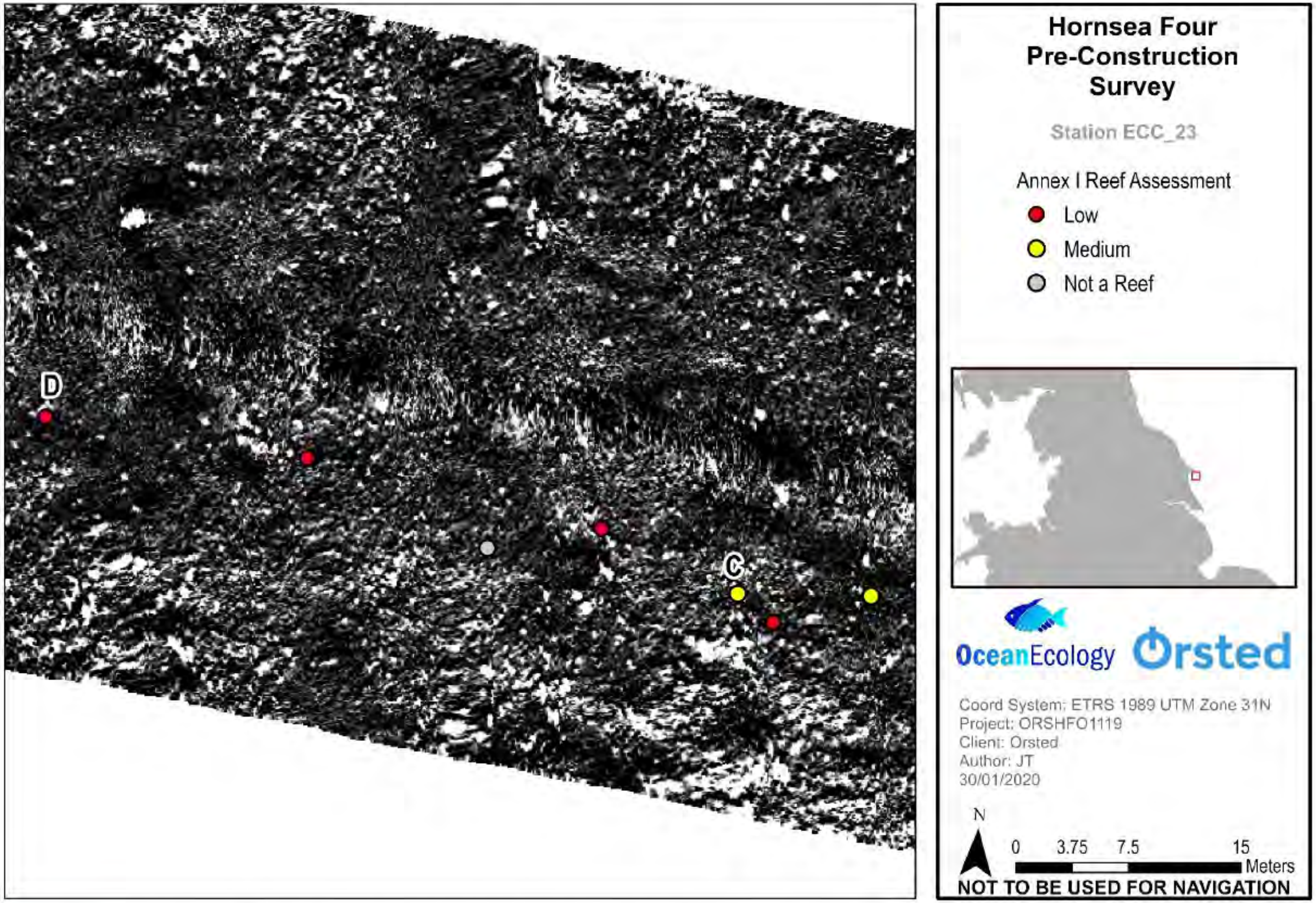

Figure 5. Close-up of Annex I reef categories assigned to still images collected at Station ECC_23 during the survey overlain on ultrahigh-frequency side-scan sonar. Letters correspond to images in Plate 3.

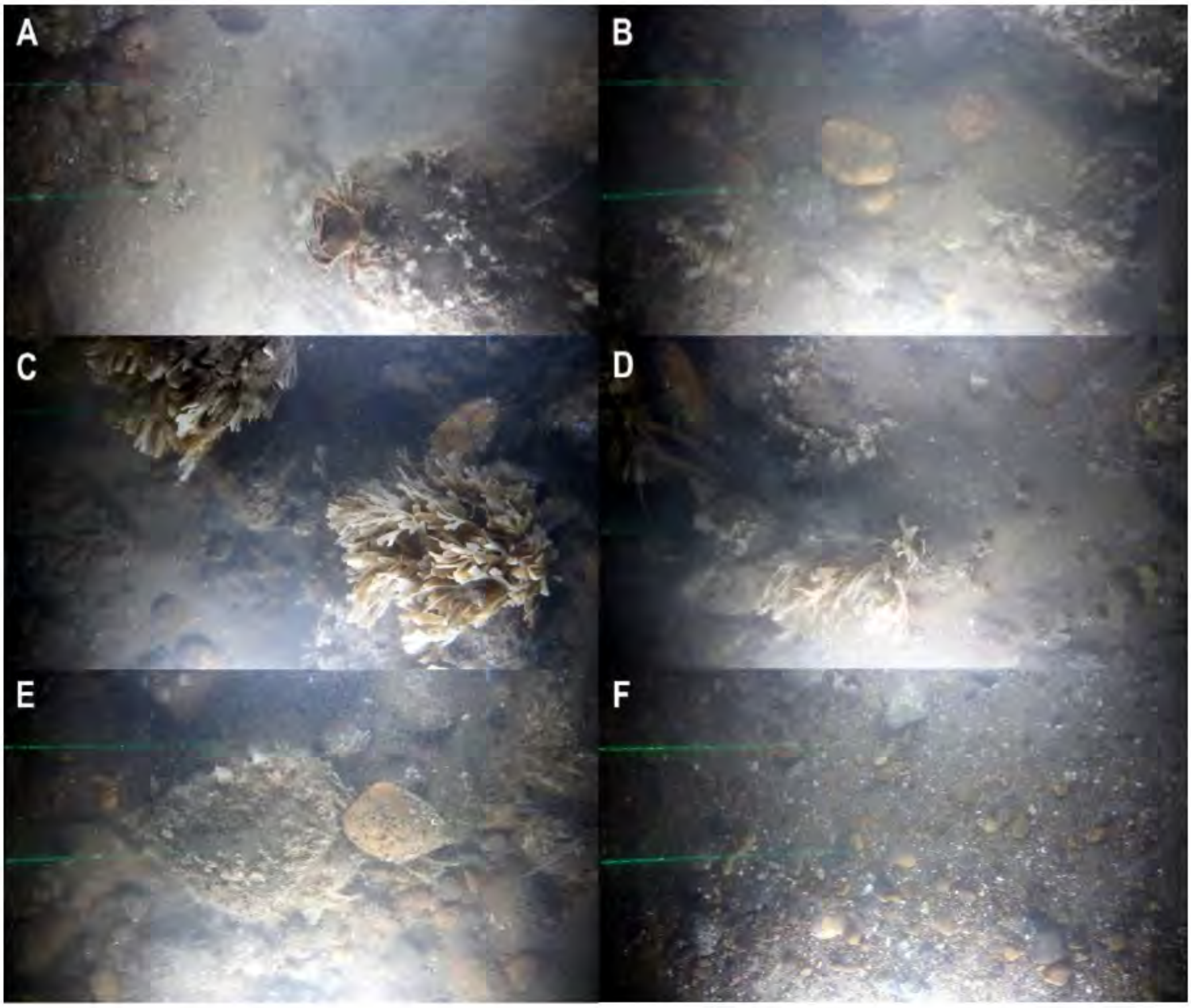

Plate 4. Example images collected at Station ECC_23 showing patches of 'low' (A, B, D, E) and 'medium' (C) Annex I stony reef and 'no reef present' (F). Letters correspond to Figure 4 and Figure 5.

4.3. Annex I Reef Extent

The DDC imagery and acoustic data were used to determine the likely extent of the Annex I stony reef features encountered. This was based on a manual process as described in Section 3.6 and involved assignment of confidence levels to each polygon based on whether there was a distinct boundary in the acoustic data or the polygon tightly fitted the ground truth information. Values were either 1 (no distinct boundary) to 2 (distinct boundary). A total of 4,381.8 m^2 and 173.1 m^2 of 'low' resemblance Annex I stony reef was determined to occur at Stations ECC_22 (Figure 6) and ECC_23 (Figure 7) respectively. Details relating to the Annex I stony reef mapping can be found in Appendix VI.

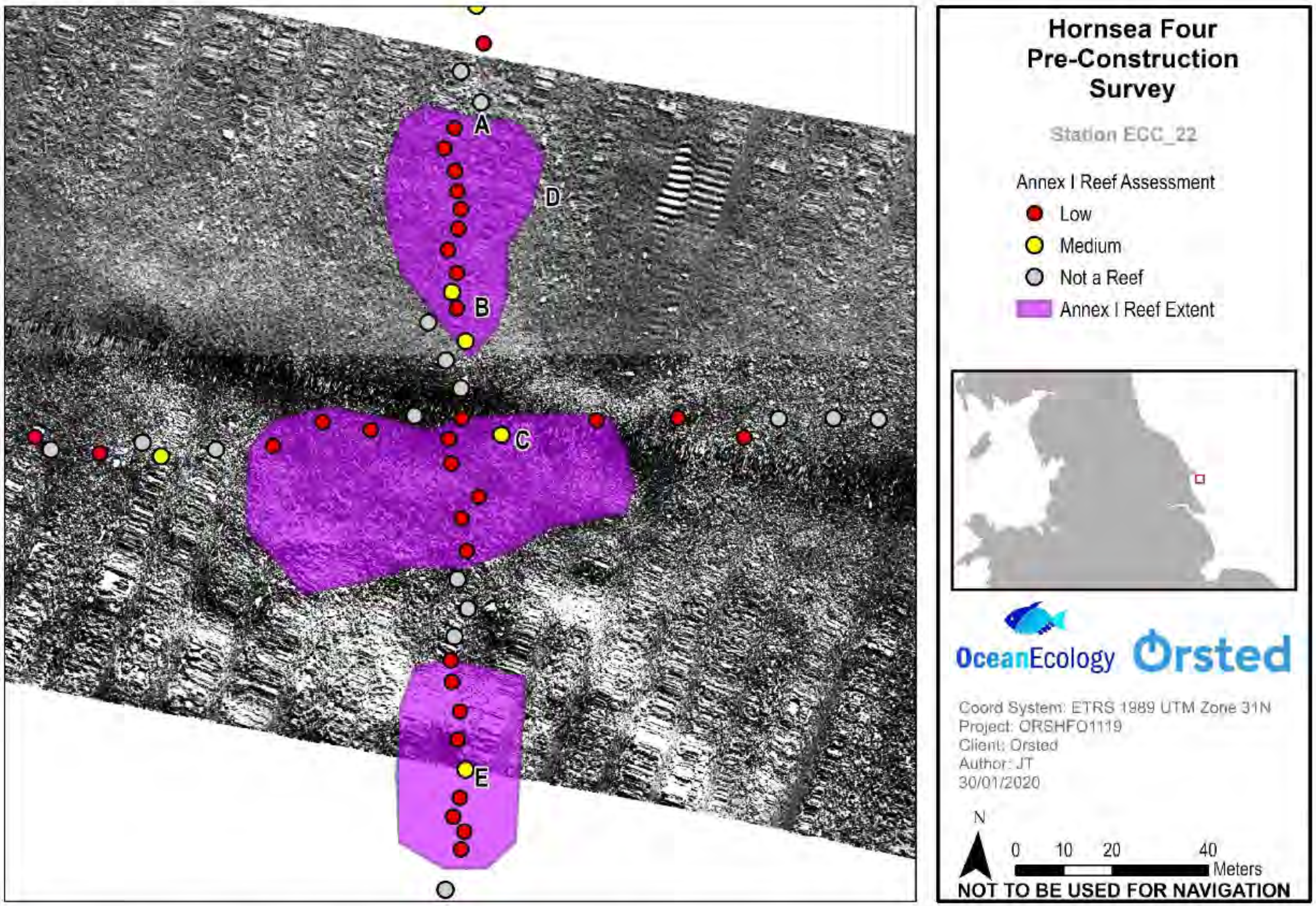

Figure 6. Annex I reef extent at Station ECC_22 observed during the Hornsea Four Annex I Habitat Assessment Survey 2020. Letters relate to images in Plate 3.

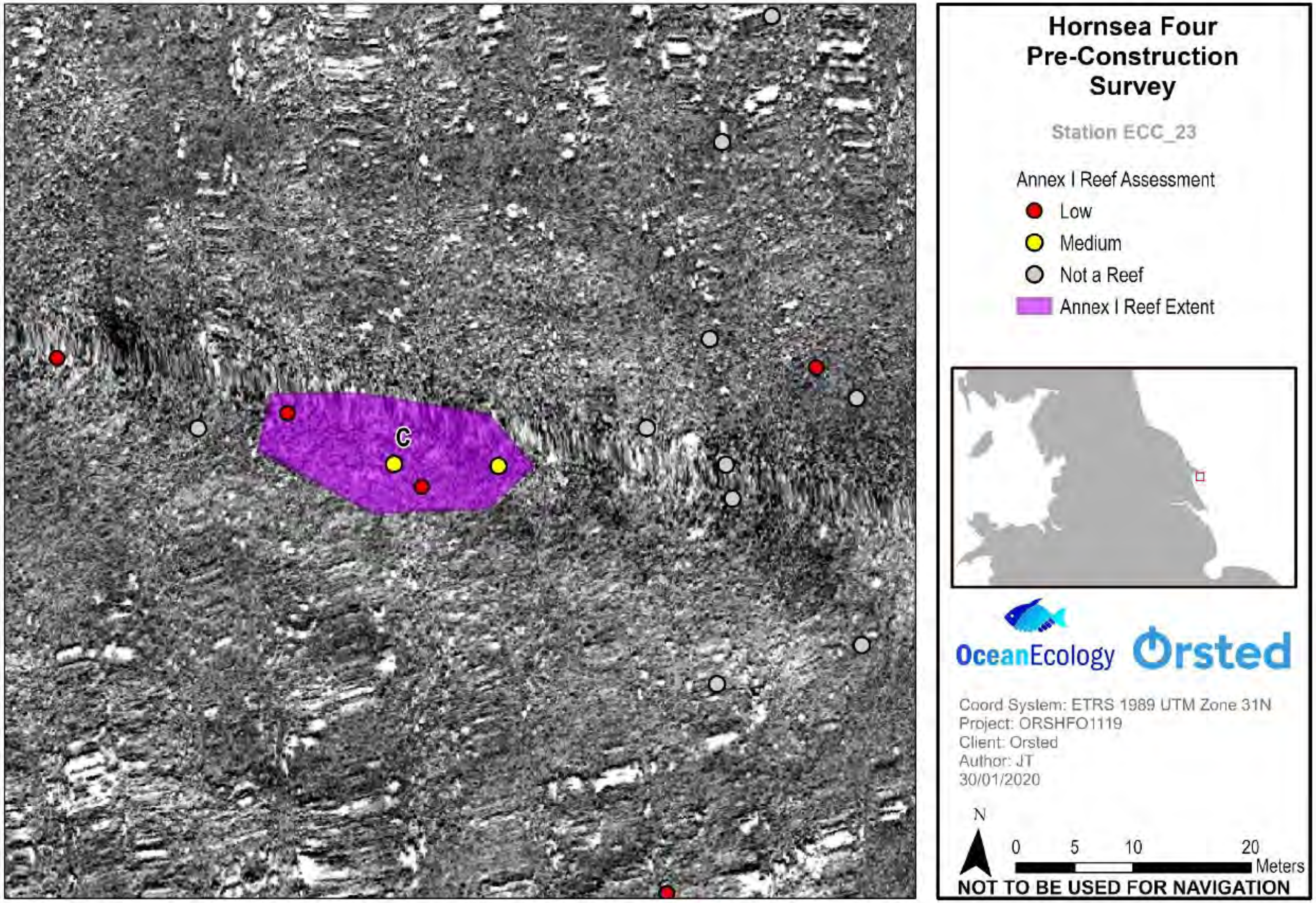

Figure 7. Annex I reef extent at Station ECC_23 observed during the Hornsea Four Annex I Habitat Assessment Survey 2020. Letters relate to images in Plate 4.

5. DISCUSSION & CONCLUSIONS

Ocean Ecology Limited was commissioned by Ørsted Hornsea Project Four Limited to undertake a benthic survey to assess for the presence of and map any Annex I stony reef habitat along the Hornsea Project Four export cable route. Efforts were targeted at two locations where potential Annex I stony reef habitat had been recorded during previous surveys. The survey was undertaken in early January 2020 and involved the collection of high-resolution seabed video and stills along cruciform transects using a low visibility drop-down camera system fitted with a freshwater housing. Following data collection all images were analysed using BIIGLE annotation platform by experienced marine ecologists. This ensured the assessment of the imagery against the various Annex I stony reef qualifying criteria (composition, elevation and extent) was undertaken in an auditable and transparent manner that can easily be reviewed and validated by regulatory bodies (and others) if required. The results were then overlain on the most recent acoustic survey data (multibeam bathymetry and side scan sonar) available for the areas of interest which allowed for manual delineation of the areas deemed to qualify as Annex I stony reef habitat. Each polygon was attributed a 'low', 'medium' or 'high' resemblance classification and accompanying confidence score.

The four distinct patches of Annex I stony reef habitat recorded during this survey were scored as 'low' resemblance as per the qualifying criteria set out in regulatory guidance on assessing stony reef habitats (Irving 2009). Additional to setting out the reef qualifying criteria thresholds, this guidance also suggests that "*When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". This suggests that the patches identified during this survey would not necessarily be considered to be contributing to the Marine Natura site network unless there is strong justification. Given that none of these reefs are designated features of any Marine Natura sites or any other marine protected areas and that 'low' was generally scored against each of the qualifying criteria for the majority of seabed images in each area, it is unlikely that any impacts associated with the installation of the proposed Hornsea Project Four export cable route will be of any significance in the context of the Marine Natura site network. The Hornsea Four Environmental Statement (ES) will, however, consider any impacts to potential low-grade reef present.

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Appendix E: Hornsea Four Offshore Wind Farm Export Cable Corridor, Geophysical Results Report (Bibby HydroMap 2019)

Hornsea 4 Offshore Wind Farm

Geophysical 1a Export Cable Corridor 2019

Volume 3: Results Report

Bibby HydroMap Project No. 2019-005 and -005A combined

August 2019

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Report Review and Authorisation	Hugh Fraser
Bibby HydroMap Project Reference	2019-005_Vol3_rev01
Report Reference Code and Revision	REP-F-005 Rev 1

Services Warranty

Based upon an agreed contract ("Contract") between Bibby HydroMap Limited ("Bibby HydroMap") and the client as named at the front of this report ("Client"), this report and all it contains, together with its associated works and services, has been designed solely to meet the requirements of the Contract.

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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Report Revisions

Revision Number	Date of Issue	Comments
00	21/08/2019	For comment
01	18/09/2019	Final

Contents

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Tables

Appendices

Appendix 1: Listings

1. Introduction

1.1. Project Overview

Bibby HydroMap were commissioned in December 2018 by Ørsted Wind Power A/S to undertake a geophysical and bathymetric survey of the HOW04 export cable route of the Hornsea 4 Offshore Wind Farm (HOW04). Bibby HydroMap were also commissioned to undertake the HOW03 surveys, as shown in Figure 2 below, using MV Proteus, with these works reported under separate cover. The HOW04 survey was carried out as two discrete surveys (an inshore and an offshore section), undertaken using two vessels:

- The inshore section of the route in water depths less than -10m LAT, which was undertaken by MV Proteus.

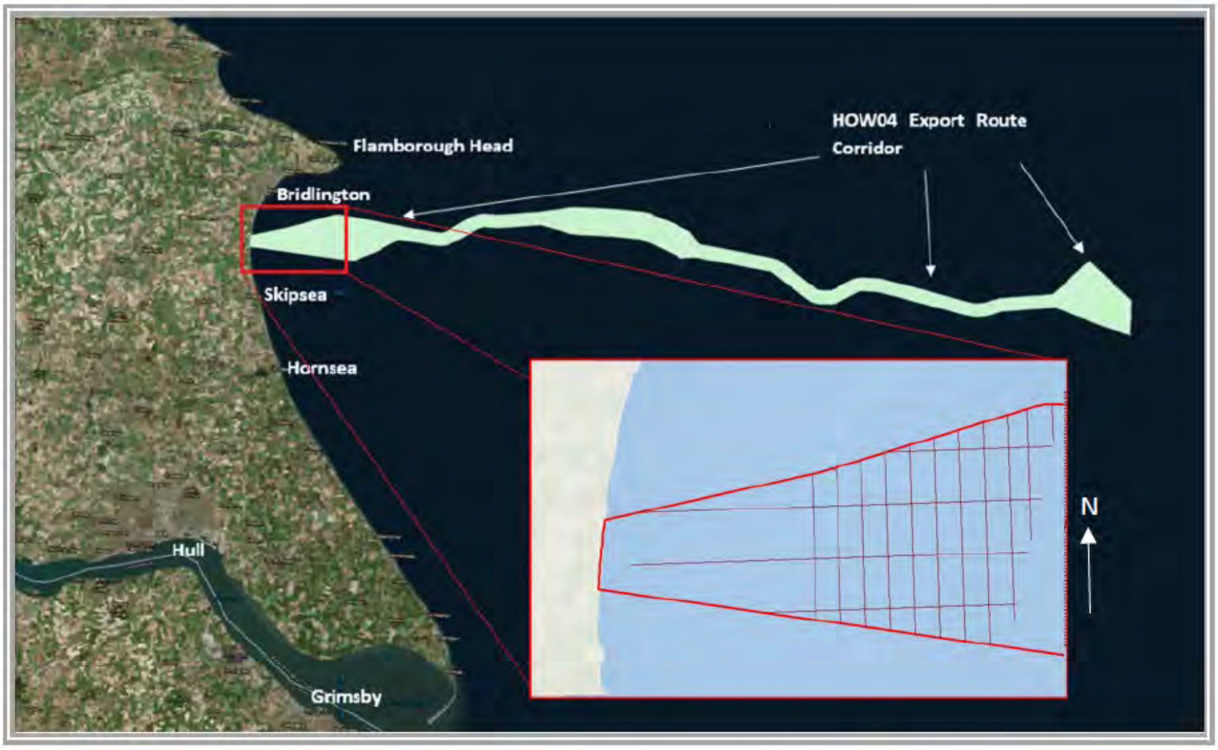

Figure 1: Site Location Plan (inshore survey section)

- The offshore section of the route in water depths greater than -10m LAT, which was undertaken by MV Bibby Tethra.

Figure 2: Site Location Plan (offshore survey section)

The geophysical survey was planned for spring/summer 2019 and the main export route was surveyed between 15 May and 14 July 2019, whilst the inshore section of the route was undertaken between 1st March and 10th April 2019. The survey was required to provide information for the following:

- Reactive compensation station (RCS) foundation concept confirmation and positioning
- Cable route engineering
- Geo-hazard assessment
- Consenting requirements
    - Identifying archaeological restrictions
    - Identifying protected ecological habitats
- Planning of geotechnical investigations

The main objectives of this survey were to provide the following:

- Accurate bathymetry
- Seabed sediment classification
- Mapping of seabed morphology
- Shallow seismic stratigraphic and structural model (<5.0m below seabed)
- Information on ferromagnetic objects
- Information on archaeological features
- Information on geo-hazards

Post contract award, this full coverage survey was subsequently significantly reduced in terms of both coverage and acquisition km, resulting in a grid style survey for both the inshore/offshore sections. Figures 3 and 4 below illustrate the full coverage survey and the survey lines acquired during the survey:

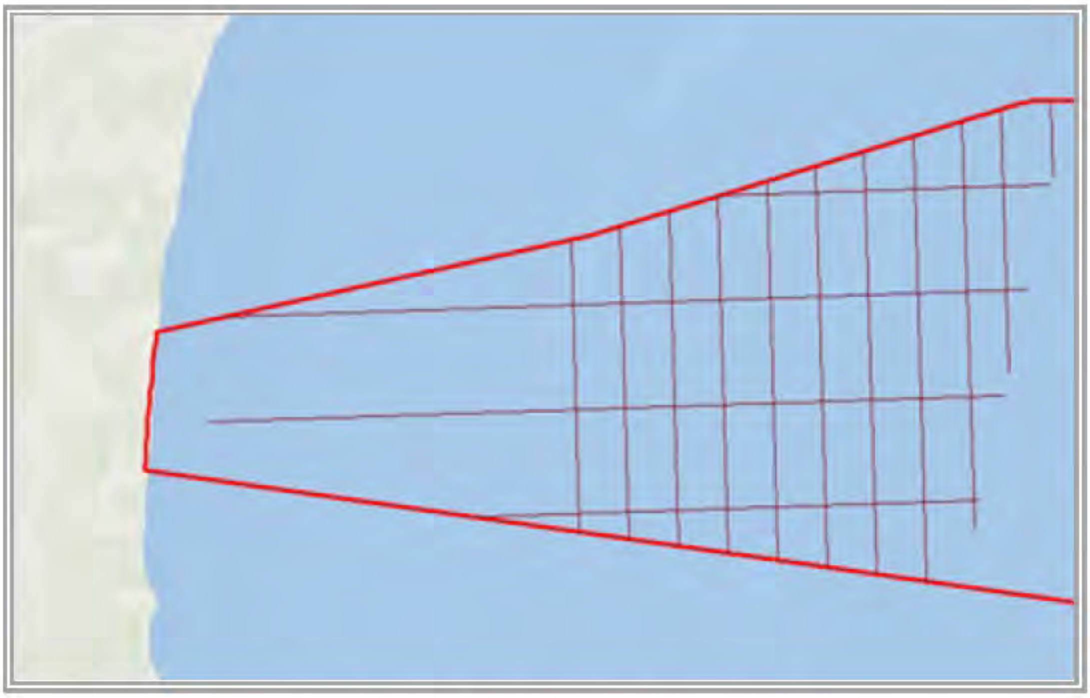

Figure 3: Survey lines acquired (inshore section)

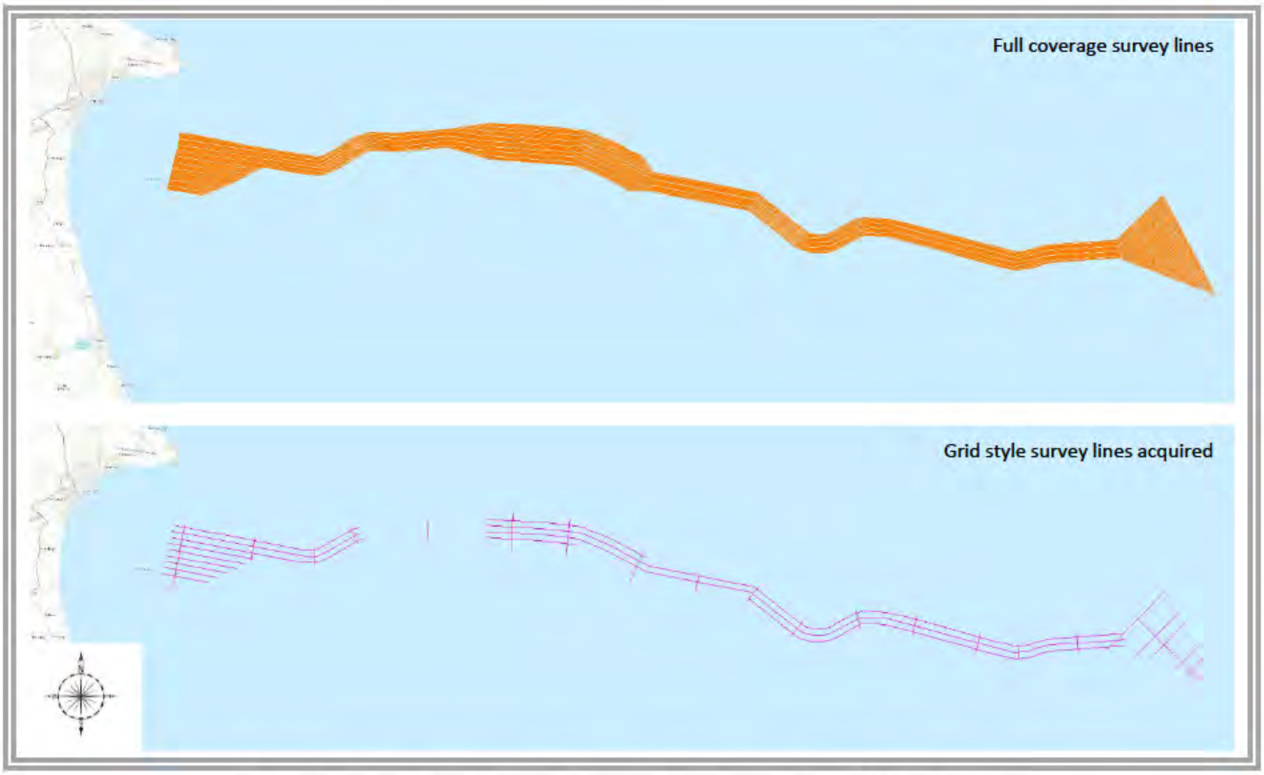

Figure 4: Survey lines planned vs survey lines acquired (offshore section)

There was an overlapping section of between 150m and 700m, between the inshore and offshore surveys

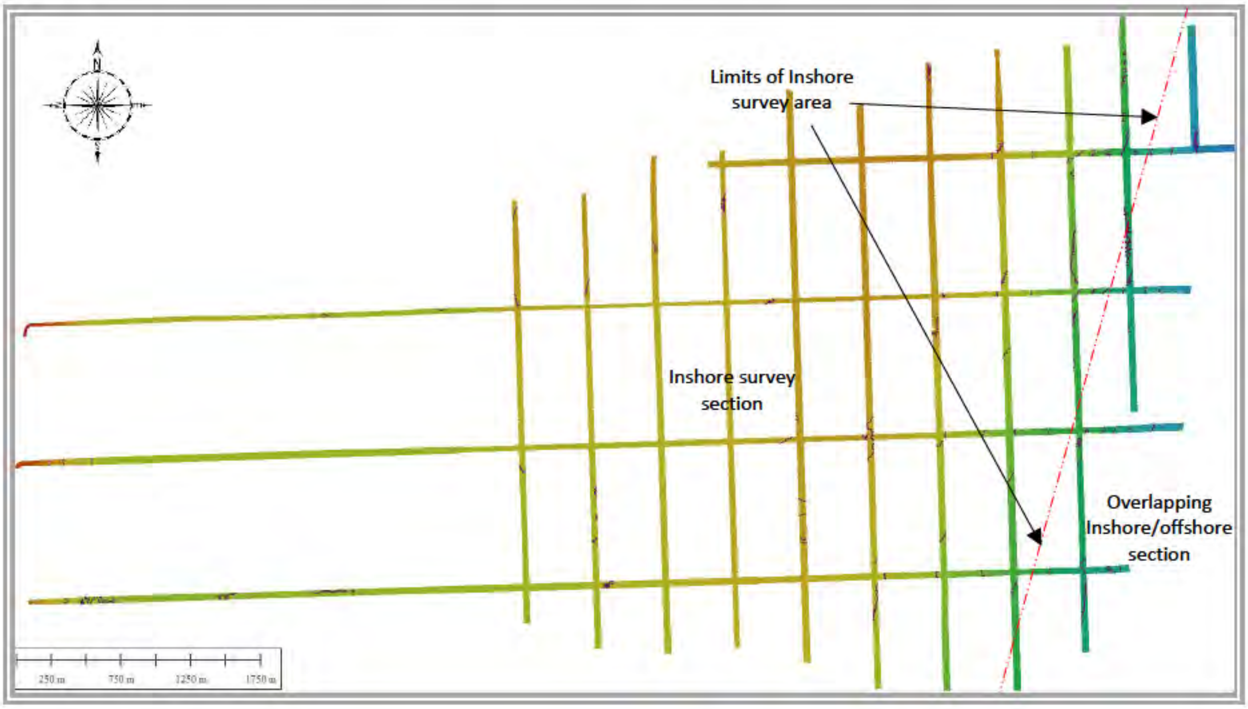

Figure 5: Inshore survey area, showing section overlapping with offshore survey area

This report details the results of the survey undertaken along both the inshore and offshore sections of the export route and forms part of a larger reporting structure, which is summarised below.

Volume	Report Description
1	Operations Report
2	Processing Report
3	**Results Report**

Table 1: Reporting Structure

1.2. Summary of Fieldwork (inshore survey)

The inshore survey was initially planned for MV Lia; however, an incident on board, post mobilisation, meant that the survey was actually undertaken using MV Proteus, which began survey works on 22/03/2019. Further details of the safety incidents on board MV Lia have been presented to the client separately in Incident Report 2019-005A_Incident Investigation001_STBD Engine_Rev00_08042019 and Incident Report 2019-005A-002_IP.

Survey Planning:	Hornsea 04 offshore wind farm export cable survey corridor. Inshore section in water depths of up to -10m LAT. 500m line spacing – 11 lines 1000m Cross lines – 4 lines	
Schedule / Diary:	01/03/2019	Vessel readying for transit to Scarborough. Initial node checks and heading check started alongside North Shields
MV Lia	02/03/2019	Vessel transit to Scarborough. On route the over the side poles were tested at survey speed and greater. Vessel arrived alongside Scarborough, HSE representative arrived and the method statement for LRT deployment and recovery was discussed. An abandon ship discussion was held on board.

	03/03/2019	General mobilisation of equipment ongoing. Networking and general interfacing still ongoing.
	04/03/2019	General mobilisation of equipment ongoing. Networking and general interfacing still ongoing. Kick off meeting for the job held in the Royal Hotel, Scarborough.
	05/03/2019	MBES calibration completed on site. On the transit to Scarborough a suspected engine fire was detected in the STBD engine bay. Preventative measures were taken by the marine crew & survey crew assisted when instructed to. Filey lifeboat was deployed and survey crew were transferred to the lifeboat. The vessel was towed to Scarborough where the emergency services awaited at the quay. The engine bay was inspected by the fire crews and deemed safe to depart the vessel. All crew were alongside and safe at 21:30. (All details of this incident delivered to Orsted wind Power within incident report (2019-005A_Incident Investigation001_STBD Engine_Rev00_08042019)
	06/03/2019	Vessel alongside Scarborough. The engine is being planned to be lifted out on the 7th of March 2019. General reporting and admin ongoing.
	07/03/2019	Vessel alongside Scarborough. The STBD engine was lifted out by Roystons. An incident occurred which resulted in an injury sustained to a member of Bibby HydroMap marine management who were in attendance and were assisting with moving the vessel within the harbour.
	08/03/2019	Vessel alongside. Incident reports ongoing.
	09/03/2019	Vessel alongside Scarborough. STBD engine inspection underway. Party chief and hydrographic surveyor depart vessel.
	10/03/2019	Vessel alongside Scarborough. STBD engine inspection underway.
	11/03/2019	Vessel alongside Scarborough. STBD engine inspection underway. Vessel Master returns to vessel.
	12/03/2019	Vessel alongside Scarborough. STBD engine inspection underway.
	13/03/2019	Vessel Lia alongside Scarborough. STBD engine inspection underway.
	14/03/2019	Vessel Lia alongside Scarborough. STBD engine inspection underway.
	15/03/2019	Vessel Lia alongside Scarborough. STBD engine inspection underway.
	16/03/2019	Vessel Lia alongside Scarborough. STBD engine inspection underway.
	17/03/2019	Vessel Lia alongside Scarborough. STBD engine inspection underway.
	18/03/2019	Vessel Lia alongside Scarborough. STBD engine inspection underway.
	19/03/2019	Vessel Lia alongside Scarborough. STBD engine inspection underway. Vessel Proteus lifted onto the hardstand in Liverpool. Vessel being readied for transit.
MV Proteus	20/03/2019	Heading and node checks completed onboard Proteus. Proteus to travel to North Shields via road transport, survey crew to travel to Scarborough to start the demobilisation of Lia.
	21/03/2019	Lia demobilised alongside Scarborough. The equipment was transported via van to north shields where Proteus mobilisation will start on the 22nd of March.
	22/03/2019	Topside units installed for the Innomar, magnetometer, SSS & T20 topsides installed. Antennas replaced on the monkey island which were removed for the road transport and cable protection applied. Installation of hemisphere smartlink and interfaced with QINSy. Magnetometer tested with deck leads and interfaced with the survey Nav PC.
	23/03/2019	General interfacing ongoing and providing data for mobilisation acceptance test. USBL tested with beacon in the water. Two toolbox talks for the deployment of the moonpool pole & the Innomar pole.
	24/03/2019	Orsted vessel inspection completed onboard Proteus. Innomar, QINSy, Mag and SSS installed and interfaced.
	25/03/2019	General equipment interfacing ongoing. SSS & Magnetometer functionality tests completed.

	26/03/2019	Walkthrough of USBL deployment and recovery procedure. Following the walk through the method statement has been amended. Wet test of beacons into the USBL software. Vessel safety meeting conducted by the vessel master.
	27/03/2019	Permission to sail was granted by Orsted wind power. A USBL calibration & GAMS calibration was carried out whilst at sea.
	28/03/2019	Deck frame and winches lifted onto the vessel. The large Ago is too large to remove the vessel moonpool cheese wedge hatch, a new plan for the Large AGO winch position will have to be considered.
	29/03/2019	Vessel transits to Scarborough. Planning for the A-frame to be lifted onto the vessel and large AGO to be swapped with a smaller AGO onboard Lia. Proteus deck frame to be fitted with the twist lock to the vessel.
	30/03/2019	Lia moved to the quay for smaller AGO winch lifting to the quay. Smaller AGO transferred to the quay and Lia returned to the pontoon. Proteus moved to the quay. Large AGO transferred to quay and replaced with the smaller AGO. A-Frame, tow bar & vessel winch fitted to the vessel. Winches installed and verified that they are working.
	31/03/2019	Load test completed on vessel. MOB system fails load test on the basis of a lack of certification to substantiate one of the rope slings in use. Review recovery of MOB system. Alongside run through of deployment and recovery of SSS & Mag. Wet test of SSS and Magnetometer. Grinding operations completed on the vessel moonpool.
	01/04/2019	Ongoing Innomar, SSS, Mag setup and. Vessel readying to sail to site for EVT on the 2nd of April 2019.
	02/04/2019	Transit to site to complete the USBL mag and SSS target. Issues with the USBL meant that the Mag verification was not completed. The aim for the following day is to complete the Mag, SSS and Innomar verifications.
	03/04/2019	Transit to Scarborough Outfall pipe. Innomar verification and Mag over the site. No clear image for the MBES. Transit to site where the 2018-023A Innomar verification site was performed. Innomar and Mag verified over the site with targets visible for the MBES. Discrete target for an additional SSS verification. Weather increasing so depart from site and transit to Scarborough Harbour. Weather is increasing over the coming days; the data will be reviewed at the onsite office.
	04/04/2019	Vessel alongside Scarborough. Review of data collected from the 3rd of March 2019 at the site office.
	05/04/2019	Vessel alongside Scarborough. Review of data collected from the 3rd of March 2019 at the site office. Mobilisation checklist completed. Vessel refuels at fuel berth at 16:00.
	06/04/2019	Vessel onsite and started acquisition. High priority lines were started.
	07/04/2019	Vessel completes Orsted high priority lines. Data review is needed to assess the quality of the data. Weather conditions assessed tomorrow morning for the potential for MBES re-run lines.
	08/04/2019	Waiting on weather standby.
	09/04/2019	Waiting on weather standby.
	10/04/2019	Demobilisation.
Additional Information:	Fishing gear was seen on site and the vessel "Huntress" was on site to provide reconnaissance and the positions of any fishing gear seen. Scarborough Harbour was a 1:45-2.5 hour transit to site and was tidally restricted at low tide. Access was only possible when the tide was at 2.8m LAT due to a bank at the entrance to the harbour. The line plan was changed mid-contract with the vessel given priority lines to allow an overview of the site. Two days of marginal weather were utilised to complete the survey. Data collected was seen to be of good quality.	

Table 2: Operational Summary Table (inshore survey)

1.3. Summary of Fieldwork (offshore survey)

Data acquisition was undertaken from Bibby HydroMap's own dedicated shallow draft vessel MV Bibby Tethra, equipped with multibeam, side scan sonar, magnetometer, parametric echosounder and benthic sampling systems.

Survey Planning:	HOW04 Lot7, Grid Survey Block 1 88.84km, 500m mainline spacing, various crossline spacing Block 2 95.65km, 500m mainline spacing, various crossline spacing Block 3 87.90km, 500m mainline spacing, 1km crossline spacing Funnel 28.04km, 1km mainline spacing, 1 cross line bisecting site HOW04 Lot 7 Benthic Sampling 28 Sample locations	
Schedule / Diary:	15/05/2019	The vessel mobilised alongside Lowestoft. Project kick off meetings were held for both shifts. The vessel walkaround was completed and a tabletop exercise was held for the procedure in the event of snagging fishing equipment
	16/05/2019	The vessel arrived in the calibration area, MBES calibrations and verifications were completed. A recce was completed for fishing activity and the EVT was deployed, fishing gear was seen in the SSS whilst running the verification lines. The EVT was recovered to deck. The increasing weather conditions and darkness prevented the EVT being re-deployed. Innomar testing was started
	17/05/2019	The vessel completed Innomar testing before transiting to Grimsby for shelter. Whilst alongside, engineering subcontractors came onboard to assess the alarms and Schottels. The cook was replaced after injuring their hand. All survey systems were tested and are working well. The galley was out of use with no persons onboard able to enter whilst the vessel was without a cook.
	18/05/2019	The vessel slipped ropes and transited to site. A member of the crew was seriously ill with seasickness and the vessel returned to port. All survey equipment was tested alongside
	19/05/2019	The vessel remained alongside Grimsby. Systems checks were completed on all survey equipment. A fault was found on the USBL system. The pole was lifted, and damage assessed. A replacement USBL system was sourced. The GAPs was demobilised, and mobilisation of the Mini Ranger 2 was started. The new cook and engineer joined the vessel
	20/05/2019	The Sonardyne USBL was installed and tested alongside, the vessel slipped ropes and transited to site where the USBL calibration was completed over the EVT, the towed equipment was deployed and the SSS verifications started. Louise Thomsen was on site, completed the reconnaissance of the inshore area on HOW04 and found a large number of fish pots
	21/05/2019	The vessel continued trouble shooting on the USBL system, results have been improved but may not be suitable for operations still due to large periods of drift. The Verifications of the Mag and SSS were completed and the EVT recovered. The vessel started transit to Grimsby so a survey team member could depart.
	22/05/2019	The vessel arrived in Grimsby, S. Newnes departed and the vessel returned to site, Mag signal testing was completed, and Mag background checks completed over the site of the EVT. The vessel attempted survey operations, however, the USBL positioning was too poor, testing was attempted online. The vessel recovered the towed equipment and ran three crosslines on HOW04 B02 whilst waiting for a technical support response. The internet and networking issues on

		the vessel are preventing smooth operations with the internet connectivity limited at best and non-existent for the remainder. The MBES density averages at the correct density according to the Kongsberg hit count calculator (48hits per meter). However, the density is low in some areas caused by vessel motion. The hit count is not being evenly distributed across the swath as the vessel rolls.
	23/05/2019	Three of the crosslines run today were rerun due to noise in the Innomar data caused by vessel motion
	24/05/2019	The vessel arrived alongside Grimsby where crew changed was completed. The USBL pole was lifted, the Sonardyne demobilised and the GAPs mobilised. The alongside Beacon checks were completed. Bibby Hydromap IT department were onboard to attempt to resolve the issues with the internet and the server. The vessel took stores, fuel and fresh water whilst alongside.
	25/05/2019	Systems testing was completed. The vessel transited to site, completing USBL alignment on the transit. The EVT was deployed and SSS and Mag verifications completed. Noise is seen in the Port MBES head when running above 4knts through the water
	26/05/2019	The vessel started survey operations, 3 reruns for SSS and Mag were completed, and the vessel started virgin lines on B02, these will require partial rerun for the Stbd MBES due to low hit count caused by incorrect settings applied whilst attempting to resolve the noise in the Port MBES. The weather on site increased to 1.4m Sig and the vessel transited to Grimsby for shelter
	27/05/2019	The vessel remained alongside Grimsby; testing was completed in the river for the MBES port head. The vessel slipped ropes at 19:35 to transit to site
	28/05/2019	The vessel ran survey operations on B01 and B02 of HOW04. Weather conditions offshore were marginal with some sections of MBES and Innomar requiring rerun, these will be added to the rerun list once reviewed. The Hydrins is dropping out causing nav jumps, the data affected will be replayed using the Hemisphere. The Hemisphere has been set to primary in QINSy online. The MBES issues are still occurring at speeds greater than 3.5knts through the water.
	29/05/2019	The vessel continued survey operations on HOW04 B01, Crosslines were completed when the towed equipment data was marginal. Internet has been intermittent throughout the day
	30/05/2019	The vessel continued operations until 04:00. The equipment was recovered, and the vessel transited to Teesside for dry docking. During the dry docking, the vessel moved, and damage was observed on the MBES. The situation was assessed, and the decision made to continue draining. On further inspection, it was decided to review further in the morning with daylight. The team departed the vessel for accommodation
	31/05/2019	The vessel remained in dry dock. The MBES and mounting bracket were demobilised. Hull inspection was completed
	01/06/2019	The vessel was moved aft in the dry dock, MBES cables were demobilised from the top end
	02/06/2019	The vessel was inspected and prepared for the T-Foil lift on the 3rd
	03/06/2019	The T-Foil was removed from the vessel and the vessel floated off the dock bottom, the vessel departed dry dock and transited to Grimsby
	04/06/2019	The vessel arrived alongside Grimsby where the Benthic mobilisation was started
	05/06/2019	Benthic mobilisation completed & all joining crew received a vessel and project induction

	06/06/2019	The vessel transited to HOW04 to commence benthic operations. Benthic operations were started
	07/06/2019	Benthic operations were continued on HOW04. The vessel transited to Grimsby on weather
	08/06/2019	Engineers from Go Central onboard investigating fault with starboard Schottel. Fault not resolved.
	09/06/2019	The vessel transited to HOW04 to resume benthic operations. Benthic operations were continued
	10/06/2019	Benthic operations complete on HOW4. No samples were collected at ECC_22 & ECC_28 despite multiple attempts.
	11/06/2019	Vessel alongside Grimsby on weather
	12/06/2019	Octans 3000 MRU from T-Foil returned to vessel after inspection by manufacturer. Will be further tested onboard during weather downtime
	13/06/2019	Vessel alongside Grimsby on weather. Fuel, water & stores all replenished ready for sailing. Safety walk around carried out
	14/06/2019	Vessel transited to HOW03. Benthic operations started on HOW03
	15/06/2019	Benthic operations completed on HOW03 and HOW04, Benthic sampling equipment demobilisation started in Grimsby
	16/06/2019	Benthic demobilisation completed, vessel transited to site to start Innomar reruns on HOW04 B01
	17/06/2019	Innomar reruns on HOW04 B01 completed, vessel transited to Middlesbrough for dry dock
	18/06/2019	MBES transducers and bracket fit to T-Foil ready for dimensional control survey Fresh water system super chlorinated as part of maintenance schedule
	19/06/2019	MBES dry tested and all system working.
	20/06/2019	The vessel remained in dry dock, project personnel joined the vessel and inductions were completed. All systems were tested. Dock bottom inspection was completed by PC, Master, BHM Vessel manager and dry dock representative. The dock was flooded and the vessel started transit to Silver Pit for MBES calibrations
	21/06/2019	The MBES calibrations and Verifications were completed before transiting to HOW04 B02 to run survey operations.
	22/06/2019	The vessel continued survey operations on HOW04 B02, B03 and Funnel
	23/06/2019	The vessel completed all planned lines on HOW04 including crosslines. Reruns were run on B02. The vessel transited to Grimsby for an MCA audit
	24/06/2019	The vessel was alongside Grimsby for an MCA audit. Processing is ongoing on all data acquired. The vessel slipped ropes and started transit to HOW04 B02 for infill operations. It has been confirmed that small gaps exist between each 900khz SSS file split
	25/06/2019	The vessel arrived on site and completed all planned infills on HOW04. Mag coverage was received from the office and QC'd onboard, all reruns and infills are now completed. The vessel transited to Grimsby for shelter.
	26/06/2019	The vessel remained alongside Grimsby waiting on weather. HOW04 data drop was completed. HOW04 prelim data was submitted to the client. HOW04 sign off was received and the 900khz SSS was demobilised and the standalone mag mobilised for HOW03. A new SVP was tested onboard but found to be unsuitable for the project so will not be used. Vessel moved to HOW03 survey operations.

Additional Information:	The areas which involved close approach to fishing equipment were ran in daylight hours and on HOW04 recces were performed by a 3rd party scout vessel the Louise Thomsen. Where fishing gear was present on the line plan the survey deviated around the fishing gear then continued the mainline.

Table 3: Operational Summary Table (offshore survey)

1.4. Survey Vessel (inshore survey)

MV Proteus was partially mobilised in North Shields, before transiting and completing mobilisation in Scarborough, which was approximately 1.45 - 2.5 hrs transit time from the site.

MV Proteus is a 12-hour, 14m long purpose-built survey vessel, which carries Category 2 certification under the current MCA Code of Practice for Small Workboats and Pilot Boats. Details of vessel specifications can be found at the following address: [redacted]

All staff members and visitors were inducted to the vessel and made aware of the vessel HSE plan, along with Bibby HydroMap's company policies and procedures. Details of this are held within the vessel HSE plan and can be provided on request.

Details of the vessel are tabulated below:

Category	Details	Comments
12hr Coastal Survey Vessel. MCA SVC Category 2 (up to 60 miles from a safe have unrestricted)	MV Proteus 	Launched in 2013 from Essex, UK, Proteus is a 14m purpose built day running survey vessel. She has a maximum speed of 24 knots and a draft of 1.1m allowing her to work in a minimum safe working water depth of 3m.

Table 4: MV Proteus

1.5. Survey Vessel (offshore survey)

MV Bibby Tethra was partially mobilised at the port of Lowestoft, which was approximately 10 hours transit time from the HOW04 site.

MV Bibby Tethra is a 24-hour, 27.5m long purpose-built survey vessel, which carries Category 1 certification under the current MCA Code of Practice for Small Workboats and Pilot Boats. Details of vessel specifications can be found at the following address: [redacted]

All staff members and visitors were inducted to the vessel and made aware of the vessel HSE plan, along with Bibby HydroMap's company policies and procedures. Details of this are held within the vessel HSE plan and can be provided on request.

Details of the vessel are tabulated below:

Category	Details	Comments
24h Coastal Survey Vessel – MCA Cat 1 (up to 150 miles from a safe haven)	MV Bibby Tethra 	Launched in 2011 from Boulogne in France, Bibby Tethra is a 27.5m purpose built aluminium semi SWATH survey catamaran. She has a cruising speed of 12 knots and with a draft of 3.3m she has a minimum safe working water depth of 5m. Eight twin cabins allow provision of 2 client representatives in separate cabins.

Table 5: MV Bibby Tethra

1.6. Project Personnel

The following personnel were involved during the various stages of the project:

Management	
Project Manager	Simon Baldwin
Party Chief	Larry Andrews (Geophysical) Mike Pownall (Benthic) Pete Allanson (Geophysical) Greg Tandy (Surveyor)
Project Team Leaders	Adam Gould, Liliana Trindade

Acquisition							
Personnel	Party Chief	Surveyor	Geo / Engineer	Environmental	Vessel Crew	Offshore Supervisor	OFIR
Larry Andrews	✓						
Pete Allanson	✓						
Mike Pownall	✓						
Greg Tandy	✓		✓				
Jim Gorrie		✓					
Jack Oliver		✓					
Alice Bamkin		✓					
Victor Kiselev		✓					
Sergei Nikitin		✓					
Jo Davies		✓					
Steph Rhodes		✓					
James Bushell		✓					
Rob Drew		✓					
Matt Regan		✓					
Neil McLoughlin			✓				
Alistair Blower			✓				
Garth Cupido			✓				
Robert Patterson			✓				
Adam Pease			✓				
Vincent Kelly			✓				
Suzanne Ballard				✓			
Kent Tebbut				✓			
Edward Lavallin				✓			

Acquisition							
Personnel	Party Chief	Surveyor	Geo / Engineer	Environmental	Vessel Crew	Offshore Supervisor	OFIR
Isabelle Eady				✓			
Paul McGarry					✓		
Finlay Munro					✓		
Matthew Morgan					✓		
Mark Farrer					✓		
Neil Bossom					✓		
Robin Attley					✓		
Giles Simmons					✓		
Keeran Stephenson					✓		
Glenn Kensall					✓		
Viktor Jemeljascenkov					✓		
David Blyth					✓		
Alexander Downie					✓		
Mike Moore					✓		
Konstantine Levedevs					✓		
Ollie Carragher					✓		
Alan Scrase						✓	
George Kingdom Mackintosh						✓	
Chris Emmerson							✓
Acquisition							
Personnel	Party Chief	Surveyor	Geo / Engineer	Environmental	Vessel Crew	Offshore Supervisor	OFIR
David Mundy							✓
Phil Baker						✓	
On-Site Processing and Reporting							
Personnel	Team Leader	Geophysicist	Surveyor	CAD	GIS	Reporting	QC
Steph Rhodes		✓					
Jo Davies			✓				

Table 6: Project Personnel (combined inshore and offshore surveys)

1.7. Equipment List (inshore survey)

The following equipment was utilised during survey data acquisition:

Equipment Utilised
Applanix IMU V5
Trimble Antenna 540AP
CNAV CNAV286
Hemisphere Smart AtlasLink Smart
Hemisphere VS330 Vector GPS
Edgetech 4200 MP Towfish (300/600kHz)
T count 14" 5T SWL sheave block / T count antenna/ STR remote DTD254 LCD Readout Display unit
AGO Electric Sidescan Winch
Innomar SES-2000 Standard Parametric Echosounder surface unit/ transducer
Transducer SES-2000 Standard Transducer
Geometrics G882 Cesium Vapour Magnetometer
Sonardyne WSM6+ MF Omni
AML base X2
QINSy version 8.18.2

Equipment Utilised
Coda Version 7.2.0
Teledyne Reson 7125 SV2 MBES
Kongsberg Simrad EA400 (SBES)
Octans Gyro
Valeport Mini SVP

Table 7: Equipment Utilisation

1.8. Equipment List (offshore survey)

The following equipment was utilised during survey data acquisition:

Equipment Utilised
C-NAV 3050
Hemisphere R330u
Edgetech 4200 MP 300/900kHz
Edgetech 4200 MP 300/900kHz
Edgetech 4200 MP 300/600kHz
Edgetech 4200 MP 300/600kHz
14" diameter aluminium sheave block with T-count sensor and proximity limit sender T-count cable readout
Coda DA4G
Geometrics G882 Caesium Vapour Magnetometer
Geometrics G882 Caesium Vapour Magnetometer
iXblue GAPS USBL
Applied Acoustics 1000 Series
Applied Acoustics 1000 Series
Applied Acoustics 1000 Series
Applied Acoustics 1000 Series
Valeport Mini SVP
Valeport Mini SVP
QPS QINSy 8.18.3
Kongsberg EM2040
Benthic Solution Day Grab
Benthic Solution Mini Hamon Grab
Benthic Solution Wilson Auto Sieve
Benthic Solution Mini Camera
Benthic Solution Back up Camera
Benthic Solutions Consumables
Benthic Solution Freezer

Table 8: Equipment Utilisation

1.9. Equipment Calibration

Details of all equipment calibrations can be found in the Mobilisation Reports, presented in Appendix 1 of the respective inshore (2019-005A_Vol1) and offshore (2019-005_Vol1) Operations Reports.

1.10. Acquired Data Quality and Processing

Details of the data quality and processing are presented in the combined inshore and offshore 2019-005 Volume 2 Processing Report.

2. Anticipated Geology

The following units have been identified within the HOW04 survey area. The inshore section of the survey area is expected to comprise surficial sediments overlying a stiff glacial till of the Bolders Bank Formation.

Unit	Formation	Description	Age
A	Surficial sediment	Muddy, sandy and gravelly sediments	Holocene
B	Botney Cut Formation (BCT)	Infill sediments of partially to completely infilled channels. Parallel bedded laminated clays and sands	Pleistocene
C	Bolders Bank Formation (BDK)	A blanket deposit of stiff glacial till. Mainly structureless on seismic profiles but can be divided into two units in some places.	Pleistocene
D	Egmond Ground Formation (EGG)	Very fine to medium-grained, slightly gravelly marine sands	Pleistocene
E	Swarte Bank Formation (SWK)	Infill sediments of subglacial valleys trending predominantly NNE to SSW. Chaotic reflector configuration on seismic profiles suggesting poorly sorted, gravelly, coarse-grained sands. Possible glaciolacustrine depositional environment	Pleistocene
F	Yarmouth Roads/Winterton Shoal Formation (YMR/WSH)	YMR: Westward thinning sequence of structureless or chaotic character with some recognisable channel features. Fine and medium-grained sands with interbedded silty clay, marine sand and some reworked peat. Fluvial or deltaic depositional environment. WSH: Gently inclined, parallel reflectors probably formed of sands and silty clays. Formed by delta-front and nearshore deposits of rivers.	Pleistocene
G	Cretaceous Chalk (CCH)	Very fine grained, consistently pure, relatively soft, white limestone consisting of debris from planktonic algae. The formation appears in several channel-like basins / synclines across the western part of the site. Heavily faulted and this may be a function of its relatively structural weakness / brittle nature in comparison to the underlying Jurassic geology	Pre-Quaternary

Table 9: Anticipated Geological Formations

3. Results and Interpretation

The results of the geophysical survey within the HOW04 survey area are presented as a GIS deliverable.

Datasets were reduced to VORF LAT, which involved applying the UKHO Vertical Offshore Reference Frame (VORF) Geoid model to the data, during post processing.

In this report volume, the results of the bathymetry, side scan sonar data, and magnetometer features are discussed within the inshore and offshore survey areas.

Listings for all seafloor contacts across the surveyed area are presented as a digital deliverable. This report is designed to be a summary of this, together with the following information:

a) Side scan sonar contacts within the site boundary have been picked, listed and recorded to IHO-S44 standards in digital format. All sonar contacts are presented as a digital deliverable, with any significant contacts outlined within section 3.2 of this report.
b) The sub-bottom data was acquired by Bibby HydroMap. It has subsequently been agreed that no interpretation of this data set will take place by Bibby HydroMap and is therefore not discussed within this report.
c) Magnetic anomalies that are considered to relate to a side scan sonar contact (these generally lie within a 10m radius of each other) have been identified within the report. Note that the use of a single magnetometer and the wide grid spacings of this coarse grid survey will lead to weaker associations between seafloor contacts and magnetic anomalies. A complete listing of magnetic anomalies is provided as a digital deliverable.

Confidence intervals (1-5) have been associated with all identified objects (seafloor contacts (SSS/MBES/Backscatter), MAG anomalies and buried contacts) to indicate contacts, which have been identified on multiple data files from an individual sensor, or on other acquired datasets.

The purpose of these intervals is to provide a quantified indication of the accuracy of interpretation and positioning for each identified contact. The following intervals should be applied:

1. Identified on one data file from one sensor only
2. Identified on multiple overlapping data files from the same sensor, where contacts are too dense and are difficult to reconcile
3. Identified on multiple data files from one or more sensors (other than MBES), with position reconciled between two or more data files
4. Identified on the MBES in isolation, or in correlation with other sensors
5. Position and interpretation verified with background information (wreck site, etc.)

3.1 Bathymetry

3.1.1 Inshore Section

Seabed levels across the inshore section of the export cable route range from a minimum of approximately 2.4m below LAT to a maximum of 15.4m below LAT.

Seabed trends are difficult to comment on, given the coarse grid nature of the survey undertaken; however, the shallowest levels are present at the nearshore, western extents of the survey area, where a minimum level of 2.4m below LAT was noted at 290142mE, 5992953mN.

Moving eastwards from the nearshore area, seabed levels gradually deepen to between 7.5m and 8.0m below LAT, before gently shoaling again further eastwards.

A broad, low-lying sand bank is present between 3.1 and 4.1km offshore (see Figure 3 below). This sand bank is approximately 3.5km wide (as delineated by the 7.0m below LAT contour) and extends north-northeast to south-southwest across much of the central section of the inshore survey area. Minimum heights on this sand bank lie towards the north-east of this feature, with a value of 4.9m below LAT noted, close to 296652mE, 5994789mN.

Offshore of the sand bank feature, seabed levels deepen towards the south-east or east-southeast, with maximum seabed gradients of < 1.0° noted on the north-eastern edge of the sand bank. Seabed levels of deeper than 15.0m below LAT were noted to the east of 298560mE, 5994250mN, within the northern section of the inshore survey area.

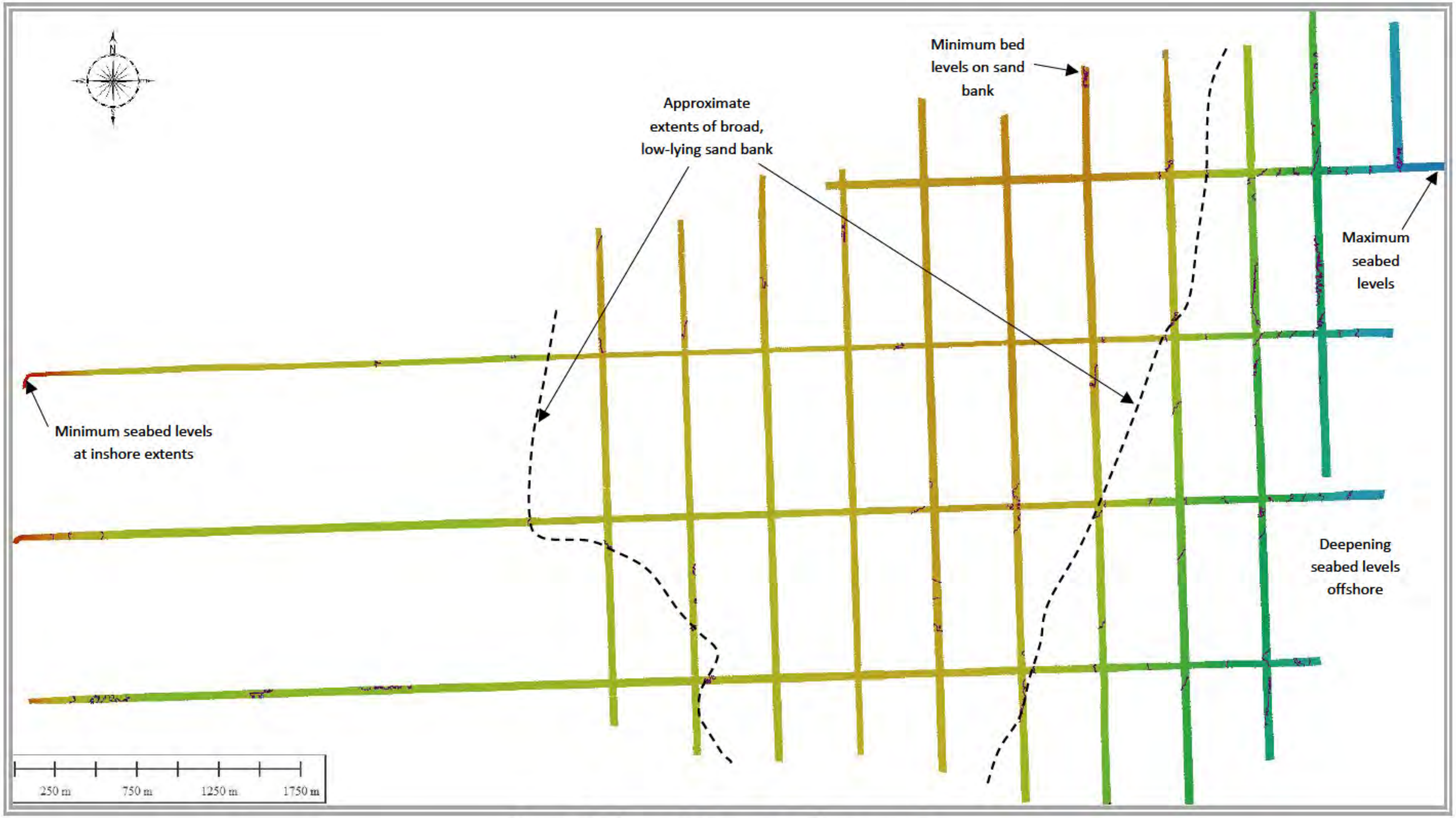

Figure 6: Bathymetric Summary (inshore survey)

3.1.2 Offshore Section

Seabed levels across the offshore section of the export cable route range from a minimum of approximately 10.6m below LAT at the nearshore extents of the area (297492mE, 5991536mN), to a maximum of >51.0m below LAT at several points within a broad channel feature, centred at approximately 327105mE, 5994470mN.

Seabed trends are difficult to comment on, given the coarse grid nature of the survey undertaken; however, the shallowest levels are present at the western extents of the survey area, where a minimum level of 10.6m below LAT was noted at 297492mE, 5991536mN.

Moving eastwards, seabed levels initially deepen towards the east to approximately 15.0m below LAT, at average gradients of 0.5 – 1.0°, before gently deepening to 45.0m below LAT towards the east-northeast, at average gradients of 0.2 - 0.3°.

Seabed levels reach 45.0m below LAT at 310215mE, 5992455mN, before deepening further to between 45.0m and 51.0m LAT, with the deepest section of the export route lying at approximately 327105mE, 5994470mN.

To the east of approximately 327105mE, 5994470mN, seabed levels gently shoal to reach 44.0 - 45.0m below LAT at approximately 344025mE, 5989880mN, before gently deepening to >49.0m below LAT at approximately 359400mE, 5986600mN.

To the east of 359400mE, 5986600mN, seabed levels gently shoal once again, reaching 38.4m below LAT at 372695mE, 5985446mN, before gently undulating between 37.5m and 42.5m below LAT towards the eastern extents of the export route.

A brief overview of the bathymetry along the export cable route is presented in Figure 7, below and a generalised profile along the route is presented in Figure 8.

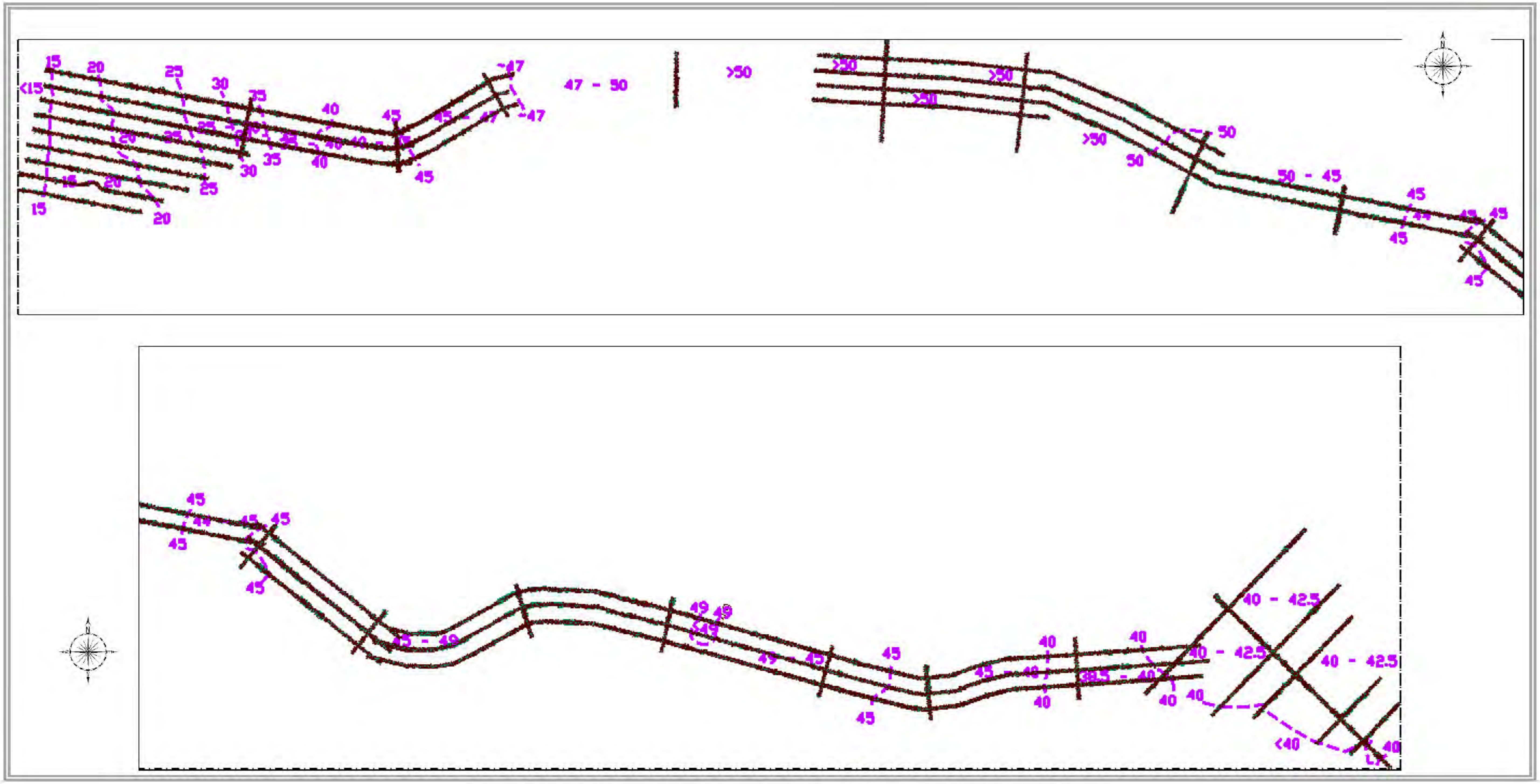

Figure 7: Bathymetric Summary (offshore survey - approximate depths shown in metres below LAT)

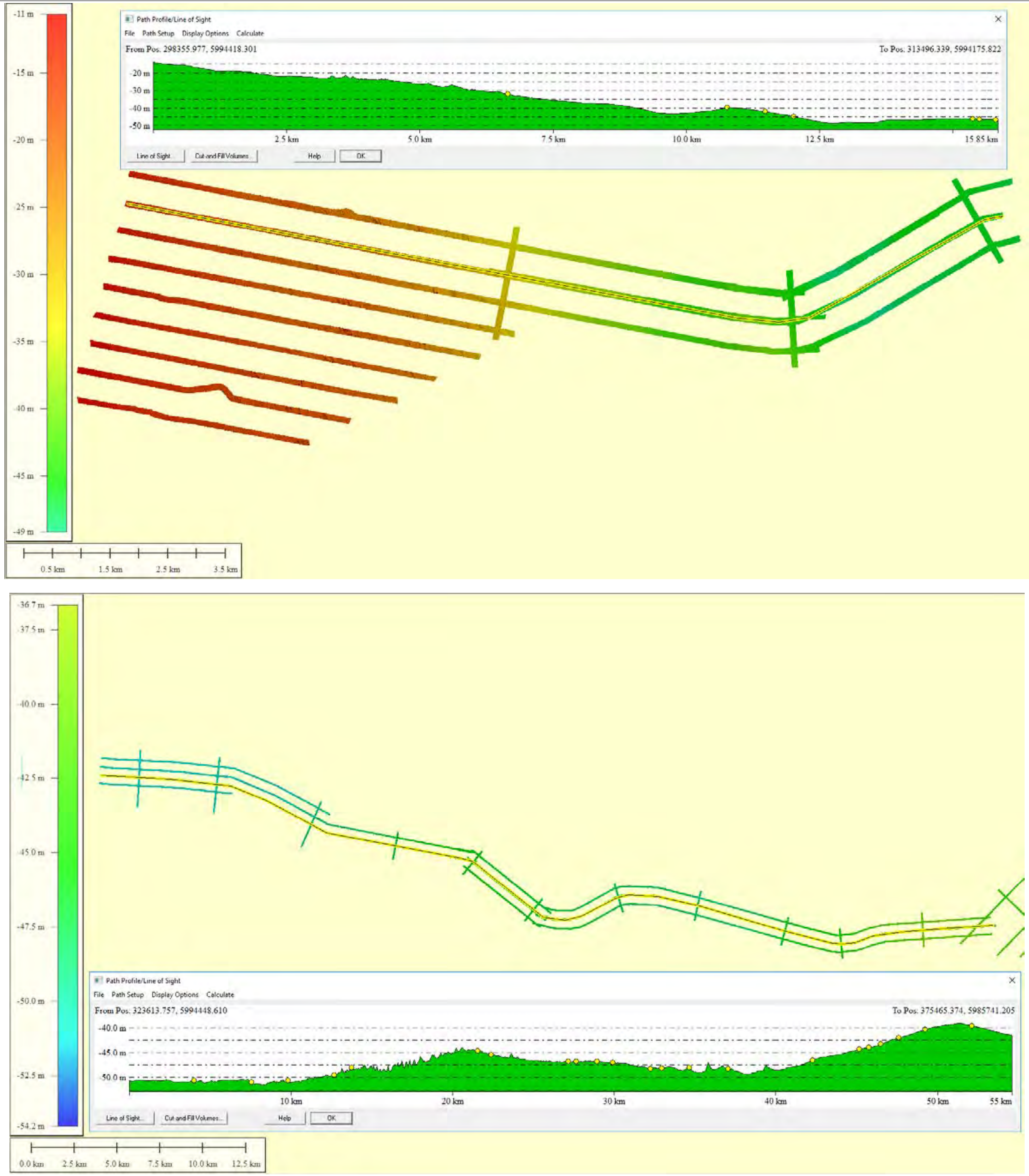

Figure 8: Bathymetric Profile Summary

3.2 Seabed Features and Magnetometer Data

3.2.1 Inshore Section

Seabed sediments across the inshore section of the export cable route generally comprise sand. Patches of gravelly sand were noted near the north-eastern and eastern extents of the survey area, with several patches of exposed till, intermittently covered by a veneer of sand, were noted near the western and north-western extents. Sonar images of these gravelly sands and till are highlighted in Figure 9 below. There was a relatively good correlation between the side scan sonar and the backscatter data; however, the side scan sonar data does highlight the differences in seabed sediments much more clearly, and areas of gravelly sands were not clearly evident on the backscatter data.

Megaripple bed forms were noted within the areas of gravelly sand. These features are less than 0.5m high, are orientated either north-northeast to south-southwest or north-east to south-west and have wavelengths ranging from 4m - 20m. Two small areas of boulders were noted near the north-eastern extents of the survey area. Boulder densities in these areas ranged from 2.7 to 5.9 (per 10m x 10m area), with individual boulder dimensions ranging from 0.4m x 0.2m x 0.1m to 1.5m x 1.2m x 0.4m. The presence of seafloor contacts picked in the bathymetric data, in particular, may indicate that the underlying glacial till lies close to the seabed, although this cannot be verified without interpretation of the sub-bottom data.

A total of 211 sonar contacts identified within the side scan sonar and/or multibeam data, were encountered within the inshore section of the cable route and, as indicated in Figure 10 below, these contacts have a relatively uniform distribution across the survey area. A listing of these contacts is presented as a digital deliverable.

In addition to these, 45 magnetic anomalies were identified within the same area and details of these are also presented as a digital deliverable. None of the magnetic anomalies appear to be associated with any seafloor contacts. It should be noted however, that the use of a single magnetometer and the wide grid spacings of this coarse grid survey will make it difficult to associate any seafloor contacts with the magnetic anomalies.

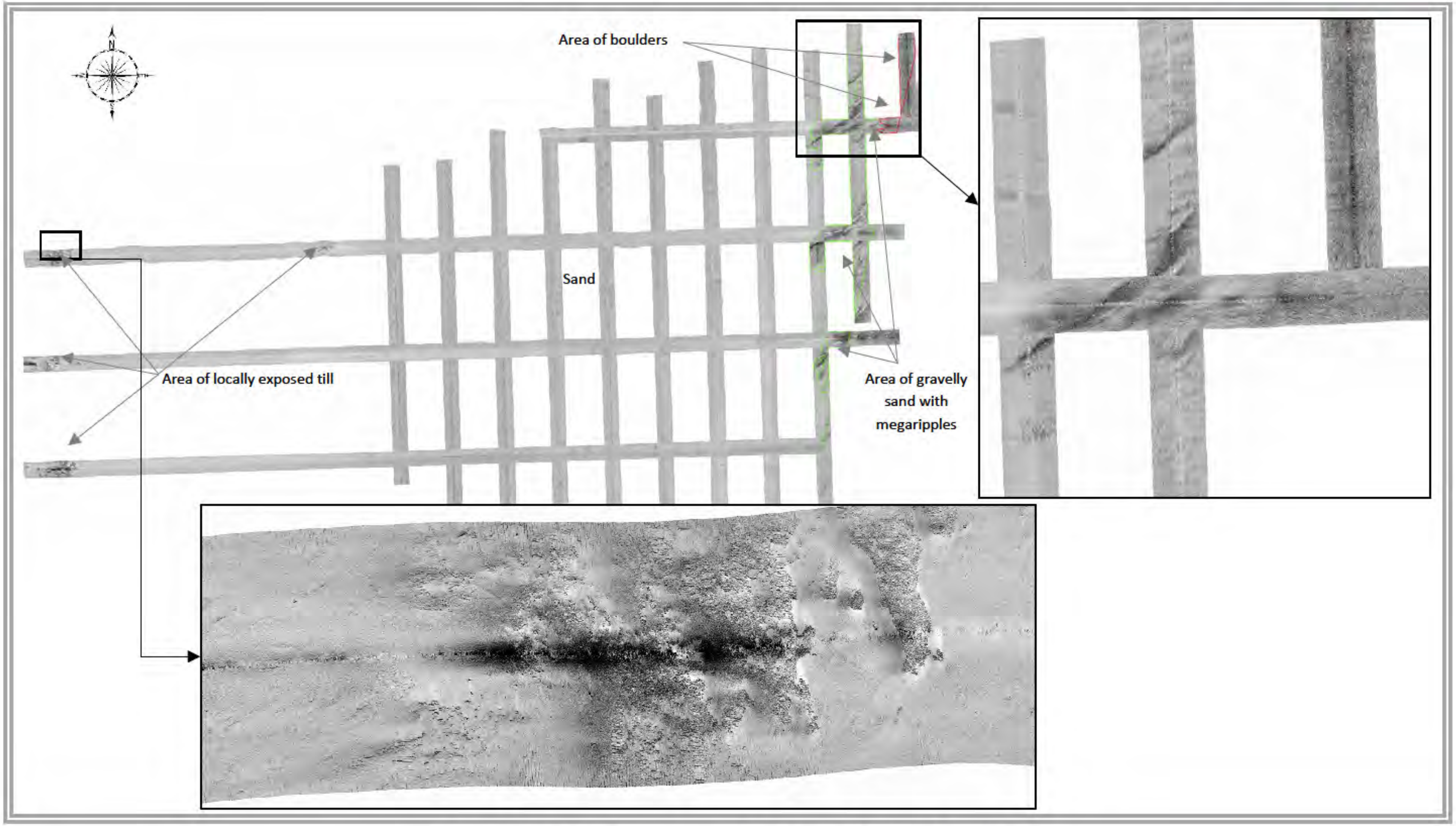

Figure 9: Seabed Features – Areas of Till, Gravelly Sands and Boulders

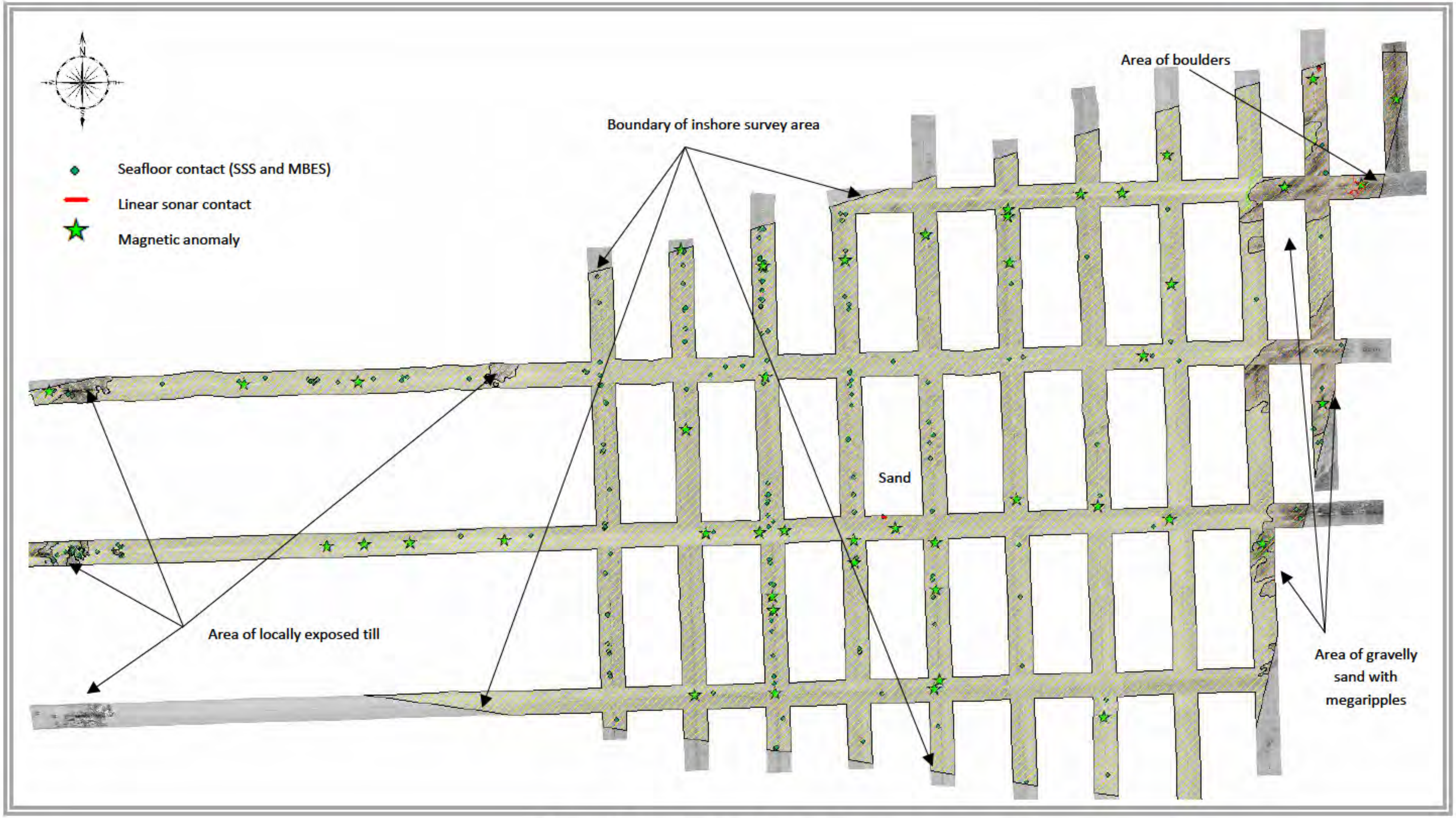

Figure 10: Distribution of Seafloor Contacts

3.2.2 Offshore Section

Seabed sediments across the offshore section of the cable route generally comprise a veneer of gravelly sands overlying till and relic megaripples, which are up to 0.5m high orientated W-E or WNW-ESE. These gravelly sands continue to dominate the seabed up to approximately half-way along the main export route area, before more generalised sandy sediments dominate for the remainder of the route.

The seabed is mobile along much of the export route, with megaripples up to 0.5m high, orientated ENE-WSW or NE-SW with wavelengths of 1.5m-25m. Localised sand waves were noted in the centre of the surveyed portion of the export route, and along the main NW-SE survey line noted in the funnel area. These sand waves are 0.5m-2.5m high and are orientated NE-SW or ESE-WSW. Seabed scars were also noted along the central portion of the offshore section. The distribution of these bedforms is shown in Figure 11 below.

A boulder field is present close to the inshore section of the export route, with average densities ranging from 0.9 to 1.8 boulders per 100m^2. Boulders in this area generally range from 0.3 x 0.2 x 0.1m to 3.0 x 1.8 x 0.5m (L x W x H), and the distribution of this boulder field is illustrated in Figure 12, below. A number of anchor scars were also noted in this area.

A total of 1451 seafloor contacts were noted within the offshore section of the cable route and these include the following:

- 6 contacts relating the Sleipner-Easington and Cleeton-Dimlington gas pipelines;
- 88 contacts relating to possible fishing gear;
- 19 contacts relating to items of debris;
- 41 contacts identified on multibeam data only;
- 1147 sonar contacts; and
- 3 linear sonar contacts.

The most significant contacts identified are presented in Table 10 below and a full listing is provided as a digital deliverable.

The two gas pipelines noted to cross the export route are identified in the side scan sonar, multibeam and magnetometer data. Figure 12 illustrates the distribution of these seafloor contacts and the pipeline crossings.

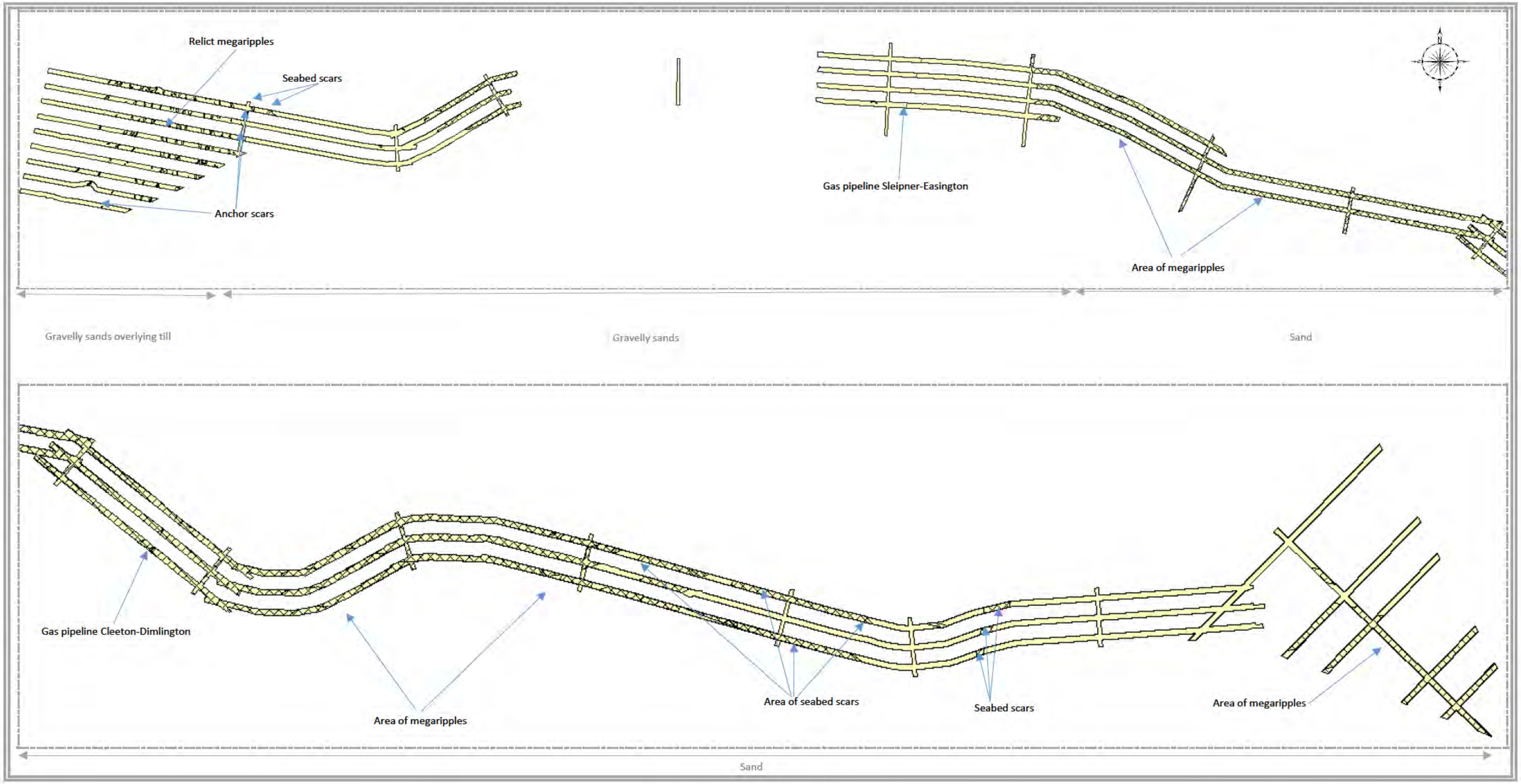

Figure 11: Generalised Seabed Features

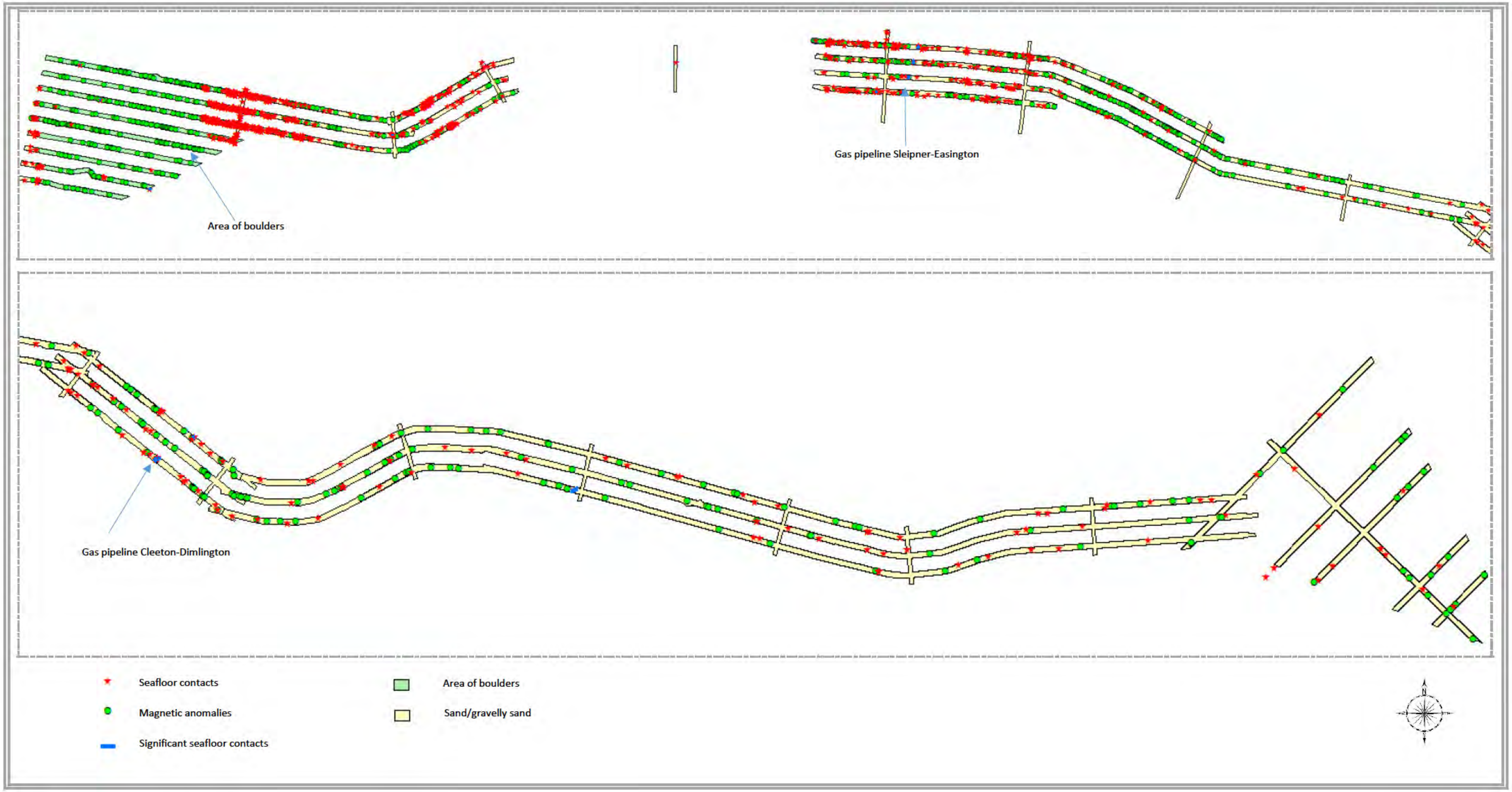

Figure 12: Generalised Distribution of Seafloor Contacts

Significant Seafloor Contact ID	Description	Datasets	Associated Magnetic Anomaly ID	Associated Seafloor Contact ID
SSC_0001	Linear Contact, Debris	HF SSS		B01_SSS_0411
SSC_0003	Linear Contact, Debris	HF SSS		B01_SSS_0645
SSC_0004	Linear Contact, Fishing Gear	UHF SSS		B01_SSS_1438
SSC_0005	Linear Contact, Gas Pipeline Sleipner - Easington	HF SSS, MBES	M_19_0605	B02_SSS_0036
SSC_0006	Linear Contact, Debris	HF SSS		B02_SSS_0064
SSC_0007	Linear Contact, Gas Pipeline Sleipner - Easington	HF SSS, MBES	M_19_0602	B02_SSS_0160
SSC_0008	Linear Contact, Gas Pipeline Sleipner - Easington	HF SSS, MBES	M_19_0595	B02_SSS_0148
SSC_0009	Linear Contact, Gas Pipeline Cleeton - Dimlington	HF SSS, MBES	M_19_0905	B02_SSS_0189
SSC_0010	Linear Contact, Gas Pipeline Cleeton - Dimlington	HF SSS, MBES		B02_SSS_0193
SSC_0011	Linear Contact, Gas Pipeline Sleipner - Easington	HF SSS, MBES	M_19_0604	B02_SSS_0123
SSC_0012	Linear Contact, Debris	UHF SSS		B02_SSS_1169
SSC_0013	Linear Contact, Fishing Gear	UHF SSS		B02_SSS_1217
SSC_0014	Linear Contact, Debris	UHF SSS		S_0002
SSC_0015	Linear Contact, Debris	SSS		S_0020

Table 10: Significant Seafloor Contacts

In addition, a total of 1027 magnetic anomalies were identified within the offshore section of the cable route and these are presented as a digital deliverable. A total of 33 of the seafloor contacts were associated with magnetic anomalies and these are presented in Table 11 below. It should be noted however, that the use of a single magnetometer and the wide survey line spacings of this coarse grid survey will make it difficult to associate any seafloor contacts with the magnetic anomalies.

Seafloor Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Associated Magnetic Anomaly ID	Confidence Level	Comment
B01_SSS_0039	310737.9	5992129	1	0.7	0.5	M_19_0481	3	Sonar Contact, debris
B01_SSS_0105	310348.5	5993078	0.7	0.5	1.5	M_19_0470	4	Sonar Contact, fishing pot
B01_SSS_0426	306336.1	5992925	1.3	1	1	M_19_0396	4	Sonar Contact, possible debris
B01_SSS_0433	305771.2	5993033	0.8	0.7	0.7	M_19_0391	3	Sonar Contact
B01_SSS_0460	304753.2	5993226	0.8	0.5	1.6	M_19_0374	3	Sonar Contact
B01_SSS_0526	298309.1	5993423	1.1	0.6	0.9	M_19_0003	4	Sonar Contact
B01_SSS_0611	305774.1	5993560	.6	.5	.3	M_19_0390	3	Sonar Contact, possible debris
B01_SSS_0642	306574.9	5993398	1.5	0.3	0.3	M_19_0405	3	Linear Contact, linear debris
B01_SSS_0655	304505.1	5993784	0.5	0.4	1.1	M_19_0371	3	Sonar Contact
B01_SSS_0707	305638.6	5993582	1	0.8	0.4	M_19_0387	4	Sonar Contact
B01_SSS_1089	305992.6	5993502	0.8	0.4	0.7	M_19_0394	4	Sonar Contact
B01_SSS_1243	311252.4	5992404	0.6	0.5	0.2	M_19_0486	3	Sonar Contact
B01_SSS_1319	304148.2	5992831	0.9	0.9	1.2	M_19_0362	4	Sonar Contact
B01_SSS_1440	303863.8	5993915	2.1	2.1	0.3	M_19_0353	4	Sonar Contact, possible debris

Seafloor Contact ID	Easting (m)	Northing (m)	Length (m)	Width (m)	Height (m)	Associated Magnetic Anomaly ID	Confidence Level	Comment
B02_SSS_0022	325197.6	5995330	0.7	0.7	0.4	M_19_0558, M_19_0559	4	Sonar Contact
B02_SSS_0023	325197	5995332	0.5	0.4	0.3	M_19_0558, M_19_0559	4	Sonar Contact
B02_SSS_0024	325196.5	5995333	1.9	1.6	1.1	M_19_0558, M_19_0559	4	Sonar Contact
B02_SSS_0025	325200.4	5995332	2	1.6	0.9	M_19_0558, M_19_0559	4	Sonar Contact
B02_SSS_0027	325246.2	5995320	0.6	0.6	0.8	M_19_0563	4	Sonar Contact
B02_SSS_0036	326890.9	5995225	155	1	1.5	M_19_0605	5	Linear Contact, Gas Pipeline Sleipner - Easington
B02_SSS_0041	327546.5	5995200	0.8	0.5	0.8	M_19_0611	4	Sonar Contact
B02_SSS_0051	330313.4	5994928	0.9	0.7	0.6	M_19_0666	4	Sonar Contact
B02_SSS_0069	334773.3	5993296	0.6	0.5	0.5	M_19_0789	4	Sonar Contact, possible fishing pot
B02_SSS_0078	325197.2	5995329	0.5	0.5	0.4	M_19_0558 M_19_0559	4	Sonar Contact
B02_SSS_0079	325197.3	5995327	0.5	0.3	0.2	M_19_0558	4	Sonar Contact
B02_SSS_0080	325198.1	5995324	0.8	0.6	0.2	M_19_0558	3	Sonar Contact
B02_SSS_0121	327082.6	5994714	1.1	1	0.9	M_19_0606	4	Sonar Contact
B02_SSS_0189	347233.2	5987165	168	1	1.1	M_19_0905	5	Linear Contact, Gas Pipeline Cleeton - Dimlington
B02_SSS_0190	348804.1	5985842	1.4	1.3	0.2	M_19_0922	4	Sonar Contact
B02_SSS_0211	327959.2	5994176	1	1	1.2	M_19_0618	3	Sonar Contact
B02_SSS_1059	325193.2	5995338	2.7	0.4	0.1	M_19_0559	3	Sonar Contact
B03_MBES_0001	352027.9	5986457	2.4	1.7	0.4	M_19_0940	4	MBES Feature, indistinguishable on SSS
B03_SSS_1038	352019.1	5986461	1.2	1.2	0.7	M_19_0940	4	Sonar Contact

Table 11: Seafloor Contacts Associated with Magnetic Anomalies

3.3 Shallow Soils

Sub-bottom profiler data has been acquired as part of the survey; however, the client subsequently indicated that no interpretation was required from this dataset. Therefore, no comment is provided regarding the interpreted units/surfaces, including unit/surface characteristics, and their relation to other units and possible chronostratigraphic correlation.

List of Standard Abbreviations

ADCP	Acoustic Doppler Current Profiler	MNR	Mean Neap Range
CAD	Computer Aided Design	MSL	Mean Sea Level
CD	Chart Datum	MSR	Mean Spring Range
CM	Central Meridian	OD(N)	Ordnance Datum (Newlyn)
CPU	Central Processing Unit	OSGB	Ordnance Survey of Great Britain
CTD	Conductivity Temperature Depth	OSTN02	Ordnance Survey Transformation Network
dGPS	differential Global Positioning System	PCS	Processing Control System
dxf	Drawing Exchange Format (AutoCAD file)	PPE	Personal Protective Equipment
ED50	European Datum 1950	PPM	Parts Per Million
EGM96	Earth Gravitational Model 1996	PPP	Precise Point Positioning
EGNOS	Euro Geostationary Navigation Overlay Service	PPS	Pulse per Second
EGN	Empirical Gain Normalisation	QC	Quality Control
ESA	European Space Agency	RIB	Rigid Inflatable Boat
GAMS	GPS Azimuth Measurement Subsystem	RPL	Route Position List
GLA	General Lighthouse Authority	RMS	Route Mean Square
GNSS	Global Navigation Satellite System	RTCM	Radio Technical Commission for Maritime Services
GSM	Global System for Mobile Communications	RTK	Real Time Kinematic
HAT	Highest Astronomical Tide	SBAS	Satellite Based Augmentation System
HF	High Frequency	SBES	Single Beam Echo Sounder
Hz	Hertz	SBP	Sub-Bottom Profiler
IHO	International Hydrographic Organisation	SD	Standard Deviation
IMO	International Maritime Organisation	SVP	Sound Velocity Probe
INS	Inertial Navigation System	SVP	Sound Velocity Profile
kHz	Kilohertz	SVS	Sound Velocity Sensor
km	Kilometre	THU	Total Horizontal Uncertainty
KP	Kilometre Post	TPU	Total Propagated Uncertainty
LAT	Lowest Astronomical Tide	TVG	Time Variable Gain
LRK	Long Range Kinematic	TVU	Total Vertical Uncertainty
MBES	Multi-Beam Echo Sounder	UHF	Ultra High Frequency
MCA	Maritime & Coastguard Agency	UKHO	United Kingdom Hydrographic Office
MF	Medium Frequency	USBL	Ultra Short Base Line
MHWI	Mean High Water Interval	UTM	Universal Transverse Mercator
MHWN	Mean High Water Neaps	VHF	Very High Frequency
MHWS	Mean High Water Springs	VORF	Vertical Offshore Reference Frame
MHz	Megahertz	WAAS	Wide Area Augmentation System
MLWI	Mean Low Water Interval	WGS84	World Geodetic System 1984
MLWN	Mean Low Water Neaps	WSM	Wideband Sub Mini
MLWS	Mean Low Water Springs		

Appendices

Appendix 1: Listings

Appendix 1

Listings

Listings are presented as a digital deliverable due to the number of contacts and anomalies identified