

# Hornsea 4



## Hornsea Project Four: Preliminary Environmental Information Report (PEIR)

### Volume 5, Annex 2.1: Benthic and Intertidal Ecology Technical Report

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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.
Cone penetrometer testing (CPT) unit	A method used to determine the geotechnical engineering properties of soils.
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 (NSIP).
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 Impact Assessment (EIA) Report.
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 Four	The proposed Hornsea Project Four offshore wind farm project; the term covers all elements within the DCO (i.e. both the offshore and onshore components).
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.
Multivariate	Involving two or more variable quantities.
Piston corer	A piston-driven cylindrical device for taking samples of material from the seabed.
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.
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.
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
AET	Apparent Effect Threshold
AfL	Agreement for Lease
AGDS	Acoustic Ground Discrimination System
BCS	British Geological Survey
CPT	Cone Penetrometer Testing
DBT	Dibenzothiophene
DCO	Development Consent Order
DTI	Department of Trade and Industry
DDV	Drop Down Video
DECC	Department of Energy and Climate Change
EAOL	East Anglia Offshore Windfarm
ECC	Export Cable Corridor
EIA	Environmental Impact Assessment
ERL	Effects Range Low
ERM	Effects Range Median
EUNIS	European Nature Information System
FOCI	Feature of Conservation Importance
GC	Gas Chromatography
GIS	Geographical Information Systems
HRA	Habitats Regulations Assessment
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee

Acronym	Definition
LOD	Limit of Detection
LOI	Loss on Ignition
MBES	Multi-beam echo sounders
MCZ	Marine Conservation Zone
MDS	Multidimensional Scaling
MHWS	Mean High Water Spring
MLWS	Mean Low Water Spring
MNCR	Marine Nature Conservation Review
MSFD	Marine Strategy Framework Directive
NERC	Natural Environment Research Council
NPD	Naphthalene, Phenanthrene and Dibenzothiophene
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
OWF	Offshore Wind Farm
PAH	Polycyclic Aromatic Hydrocarbons
PEIR	Preliminary Environmental Information Report
PSA	Particle Size Analysis
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
SPA	Special Protected Area
SSS	Side Scan Sonar
TCE	The Crown Estate
TBT	Tributyltin
TOC	Total Organic Carbon
ZoC	Zonal Characterisation

## Units

Unit	Definition
g	gram
m	Meter
km	Kilometre
km <sup>2</sup>	Square kilometre

## 1 Introduction

### 1.1 Introduction

#### 1.1.1 Project Background

- 1.1.1.1 Ørsted 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 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 (please see [Volume 1, 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 Preliminary Environmental Information Report (PEIR) boundary combines the search areas for the offshore infrastructure.
- 1.1.1.2 The Hornsea Four Agreement for Lease (AfL) area was 848 km<sup>2</sup> 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 is currently giving due consideration to the size and location (within the existing AfL area) of the final project that will be taken forward to development consent application (DCO). 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. The combination of Hornsea Four's Proportionality in EIA and Developable Area process has resulted in a marked reduction in the AfL taken forward at the point of PEIR. (see [Figure 1](#)). The evolution of the AfL is detailed in [Volume 1, Chapter 3: Site Selection and Consideration of Alternatives](#) and [Volume 4, Annex 3.2: Selection and Refinement of the Offshore Infrastructure](#). The final developable area taken forward to consent may differ from that presented in [Figure 1](#) due to the results of the EIA, technical considerations and stakeholder feedback.
- 1.1.1.3 GoBe Consultants Ltd. (GoBe) was commissioned 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. In addition to this, benthic subtidal habitat modelling has been developed to address data deficiencies which currently exist, prior to the collection of additional site-specific surveys planned for Q3 2019, across the offshore Export Cable Corridor (ECC) to be reported in the Environmental Statement (ES) accompanying the Hornsea Four DCO application.
- 1.1.1.4 This report has been produced following a full review of the relevant parts of the Scoping Opinion provided by the Planning Inspectorate.



## 1.1.2 Aims and Objectives

- 1.1.2.1 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 site (which incorporates the intertidal and offshore components of Hornsea Four) and the surrounding area.
- 1.1.2.2 Using existing data, including benthic subtidal grab data from former Hornsea Zone, existing Hornsea Offshore Wind Farm projects and Dogger Bank Creyke Beck Offshore Wind Farm, 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 site and surrounding area. The location of the Hornsea Four PEIR boundary is presented in [Figure 1](#).

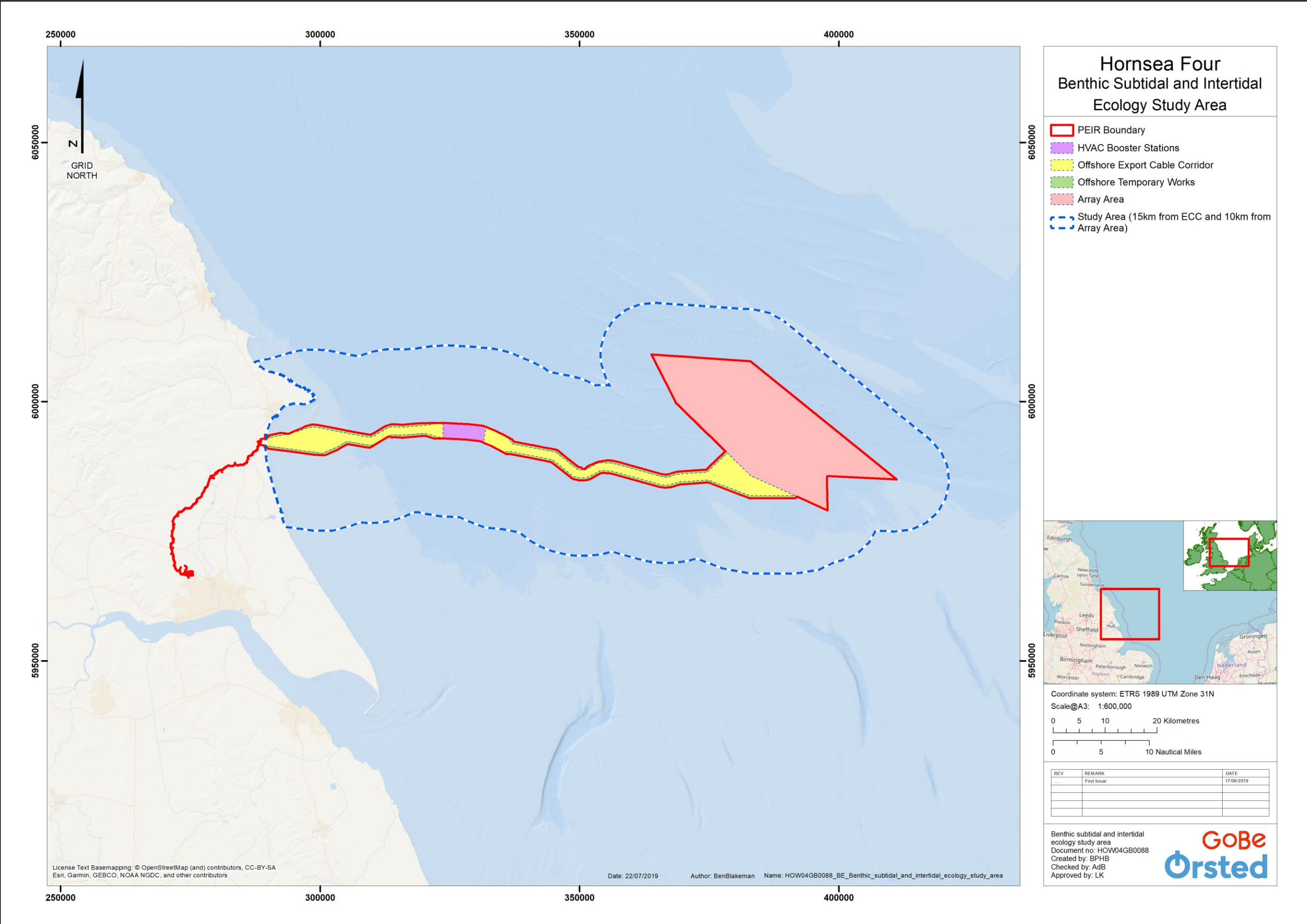


Figure 1: Benthic Subtidal and Intertidal Ecology study area (not to scale).

## 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 and intertidal study area ([Figure 1](#)) has been defined at the following two spatial scales:

- The benthic and intertidal ecology study is defined as the Hornsea Four array area along with the Hornsea Four ECC, where landfall area lies within the Holderness coast between Bridlington and Skipsea; and
- A 15 km buffer surrounding the array area, and a 10 km buffer around the offshore ECC, to represent the tidal ellipse distance, in order to incorporate the maximum distance sediments will travel in one tidal cycle ([Volume 2, Chapter 1.1: Marine Geology, Oceanography and Physical Processes](#)).

2.1.1.2 At the intertidal area, the Hornsea Four intertidal ecology study area considers habitats up to the Mean High Water Spring (MHWS) mark. Habitats landward of MHWS have been considered in the onshore ecology assessment (see [Volume 3, Chapter 3: Ecology and Nature Conservation](#)).

### 2.2 Evidence Plan Process

2.2.1.1 The purpose of the Hornsea Four Evidence Plan process is to agree the environmental information Hornsea Four needs to supply to the Planning Inspectorate, as part of a DCO application. The Evidence Plan seeks to ensure compliance with the EIA and Habitats Regulations Assessment (HRA) requirements.

2.2.1.2 As part of the Evidence Plan process, the Marine Ecology and Processes Evidence Plan Technical Panel was established with representatives from key regulatory bodies, their advisors and statutory nature conservation bodies, including the Marine Management Organisation (MMO), Cefas and Natural England. Marine Ecology and Processes Evidence Plan Technical Panel meetings have been taking place since September 2018 and will continue as required throughout the PEIR and ES drafting process. The purposes of these meetings are to discuss, and gain agreement on, the characterisation of the baseline environment and the impacts to be considered within the impact assessment. The full details of consultation are presented within [Volume 2, Chapter 2: Benthic and Intertidal Ecology](#).

2.2.1.3 Hornsea Four is located within the former Hornsea Zone, for which extensive data and knowledge regarding benthic subtidal ecology is already available. This data has been acquired through zonal studies and surveys and characterisations undertaken for Hornsea Project One, Hornsea Project Two and Hornsea Three. It was therefore proposed and agreed through the Evidence Plan process, that benthic ecology characterisation of the Hornsea Four array area be completed using a combination of desktop data and historic survey data collected as part of the characterisations of the Hornsea Project One, Hornsea Project Two and former Hornsea Zone.

2.2.1.4 The Hornsea Four offshore ECC and intertidal area are unique to Hornsea Four. As such, the existing baseline data at the intertidal area for Hornsea Project One and Hornsea Project Two is not relevant and the evidence-based approach described above was not applied. Therefore, the baseline characterisation of the Hornsea Four offshore ECC and intertidal

area draws upon several Hornsea Four site-specific surveys completed in 2018 and 2019, together with desktop information from third-party surveys. Further site-specific data of the offshore ECC will be collected in Q3 2019 and will be reported in the ES accompanying the DCO application. To address site specific data deficiencies at PEIR, a predictive habitat model strategy has been developed ([Section 7](#)) and is agreed in the Evidence Plan process in consultation with the Marine Ecology and Processes Evidence Plan Technical Panel.

### 3 Desktop Review

3.1.1.1 A detailed desktop review was 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 area surrounding Hornsea Four, for contextualisation.

### 3.2 Data Sources

3.2.1.1 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 characterisation.

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

Source	Summary	Coverage of Hornsea Four
Hornsea Zonal Characterisation 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 epibenthic beam trawl was also deployed at 11 stations within the Hornsea Four array area.	Stratified random sampling across the Hornsea Four array area.
Hornsea 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 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 Creyke Beck ES (Forewind, 2013)	The Dogger Bank Creyke Beck 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	The inshore area of the Dogger Bank Creyke Beck ECC coincides with the Hornsea Four offshore ECC for approximately 16 km from the landfall search area.



Source	Summary	Coverage of Hornsea Four
	characterise the offshore array and ECC to a landfall location on the Holderness coast.	
Humber Regional Environmental Characterisation (REC) (Tappin <i>et al.</i> , 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)	EUNIS Level 4 model, detailing biological zone and substrate.	Complete coverage up to MHWS.
Cefas (2015)	Sediment model detailing multiple different sediment classifications, including Folk and EUNIS substrate.	Complete coverage up to 0m depth (unspecified what datum this refers to in Cefas publication)

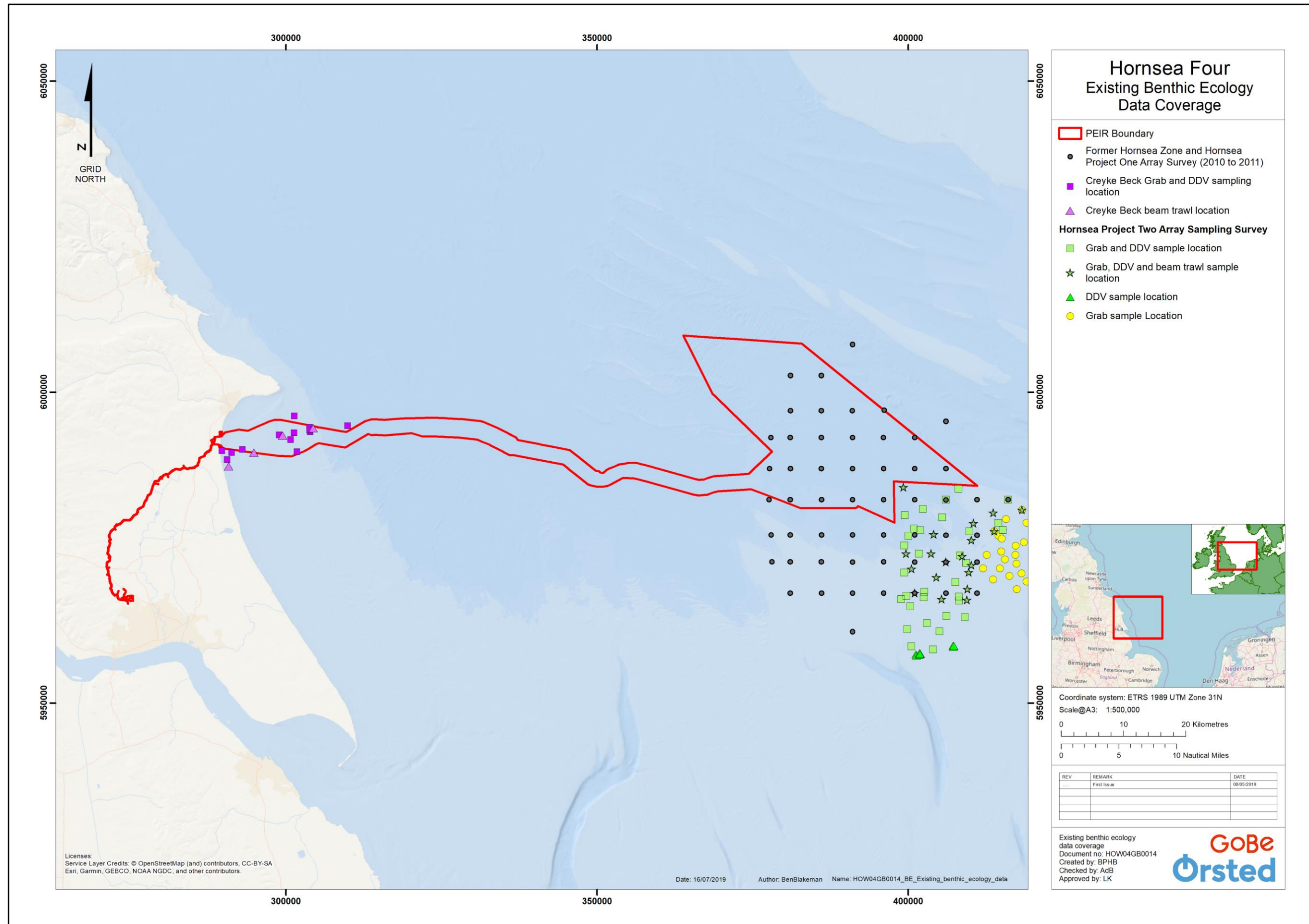


Figure 2: The location of Hornsea Four with key sources of existing benthic subtidal ecology data (not to scale).

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 existing data sets ([Table 1](#)).

### 3.3 Subtidal Habitats

3.3.1.1 Former Hornsea Zone and Hornsea One data collected within the 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 Strategic Environmental Assessment (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 BGS seabed sediment, the Cefas 2015 and 2019 sediment models and JNCC's 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](#)). These data have been used to determine the anticipated habitat type along the offshore ECC in the current absence of site-specific information, (site specific data is to be collected in 2019 and incorporated into the final ES). The central and offshore sections of the offshore ECC is predicted to comprise of the same habitat type that covers the majority of the Hornsea Four 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 European Union Nature Identification System (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 Hornsea Four 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 are predicted by the GoBe habitat model 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 Creyke Beck 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 Creyke Beck Project reported that the inshore area of the Dogger Bank Creyke Beck 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 Creyke Beck 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 off the shore the Dogger Bank Creyke Beck 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.lFiSa.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 Creyke Beck 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 Completed Site-specific Surveys

4.1.1.1 Site-specific baseline characterisation surveys have been conducted within the Hornsea Four study area in 2018 and 2019. [Table 2](#) details the site-specific survey data. The site-specific survey coverage has been plotted in [Figure 3](#).

4.1.1.2 The detailed methods of sample collection and analysis are available as appendices 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  <a href="#">Appendix A and B</a>	Geophysical survey using single-beam and multi-beam echo sounders (SBES and MBES), side scan sonar (SSS), magnetometer and a sub-bottom profiler (SBP).	Hornsea Four array area and partial coverage of offshore ECC ( <a href="#">Figure 3</a> )
Hornsea Four Benthic Survey, 2018  <a href="#">Appendix A</a>	A total of 664 images were collected across 21 benthic sample locations. Benthic sediment grab samples were collected with 0.1m <sup>2</sup> mini-hamon grab at all 21 locations. All benthic grab samples were subject to infaunal species analysis, particle size analysis (PSA) and contaminants analysis.	Hornsea Four array area ( <a href="#">Figure 3</a> ).
Hornsea Four Intertidal Survey, 2019  <a href="#">Appendix C</a>	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. ( <a href="#">Figure 8</a> ).



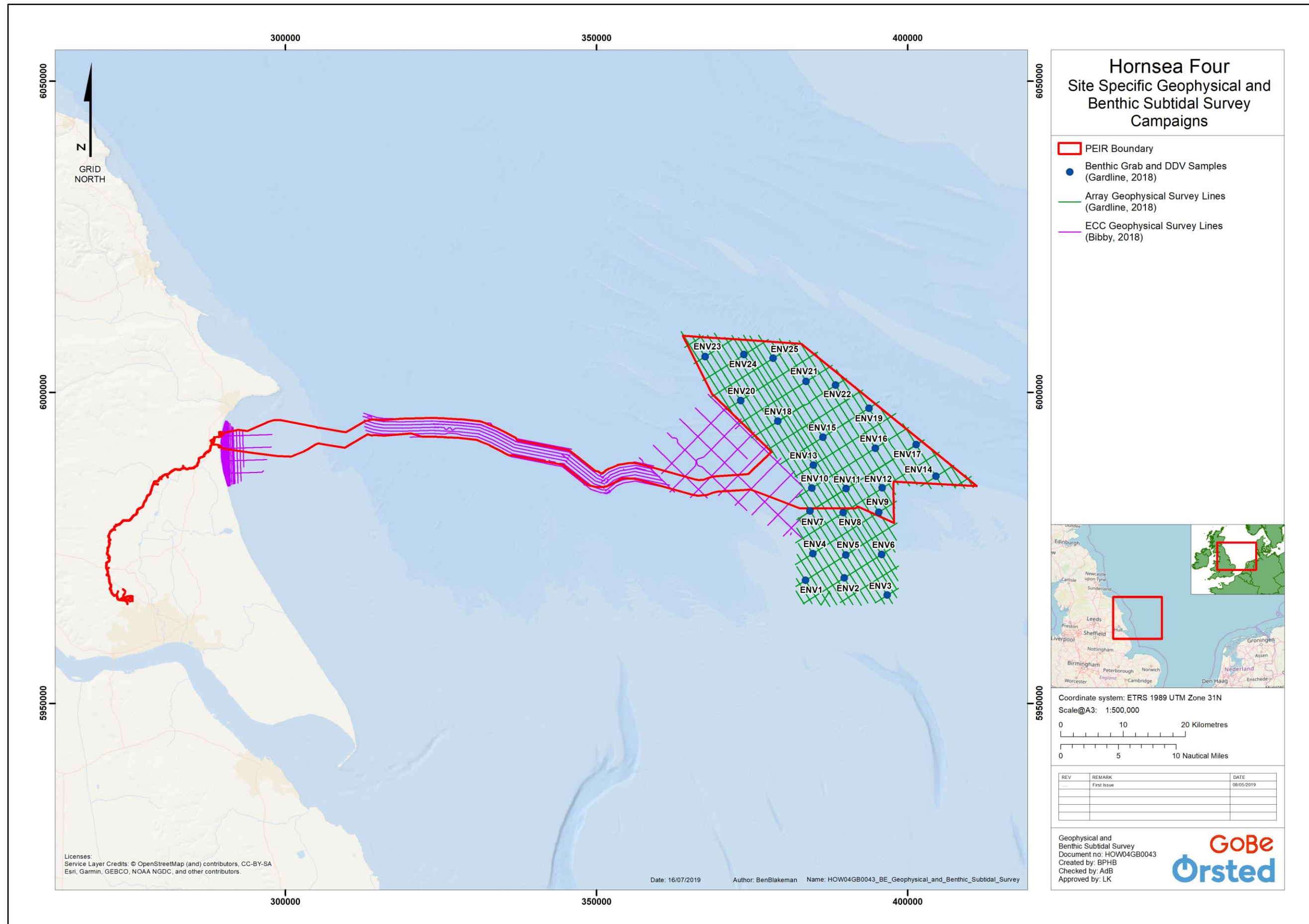


Figure 3: Hornsea Four site specific geophysical and benthic subtidal survey campaigns (not to scale).

## 4.2 Planned Site-specific Surveys

- 4.2.1.1 A further benthic subtidal ecology survey is to be undertaken in Q3 2019 with the aim to infill data gaps across the offshore ECC, for inclusion into the ES. The survey will follow methods already undertaken on Hornsea Four ([Appendix A](#)) by collecting DDV and grab samples for infaunal analysis, PSA and contaminants.
- 4.2.1.2 The 2019 benthic subtidal survey will collect data from 28 sample locations which have been allocated using a strategic and iterative approach, whereby sample locations are coincident with the site-specific geophysical survey lines and representative of key modelled habitats across the offshore ECC ([Section 7](#)). Furthermore, if any conservation features or sensitive habitat are identified from the geophysical and/or benthic grab data, further investigation of 'Area(s) of Focus' by DDV will be undertaken during the 2019 survey campaign to establish the extent and quality of such features.
- 4.2.1.3 The surveys have been designed to fulfil the aims of the EIA to provide a basis for an assessment of the direct and indirect physical disturbance during the construction, operation and decommissioning phases of Hornsea Four. The data obtained will be used to characterise the benthic environment in terms of sediment type and associated benthic and epibenthic communities and will feed into the predictive habitat model to determine likelihood of biotope presence across the array area and offshore ECC.

**Table 3: Hornsea Four proposed site-specific benthic subtidal field data.**

Title	Summary	Coverage of Hornsea Four
2019 Geophysical Survey	Survey lines to complete the 2018 coverage of offshore ECC using single-beam and multi-beam echo sounders (SBES and MBES), side scan sonar (SSS), magnetometer and a sub-bottom profiler (SBP).	Partial coverage of Hornsea Four ECC where there are currently data gaps.
2019 Benthic Subtidal Survey	Benthic sediment DDV and grab samples to be collected with 0.1m <sup>2</sup> mini-hamon grab at 28 locations. All benthic grab samples subject to infaunal species analysis, PSA and contaminants analysis.	Representative coverage across the Hornsea Four ECC.

## 5 Site Specific Benthic Subtidal Ecology Results

- 5.1.1.1 This section provides a detailed description of the results from site specific surveys undertaken to date within the Hornsea Four benthic subtidal ecology study area. The full reports including detailed methodologies and results are included as [Appendix A](#), [B](#) and [C](#).

### 5.2 Geophysical Results

- 5.2.1.1 As presented in [Figure 3](#), 2018 geophysical data was collected across the entire array area, though coverage of the offshore ECC was reduced. This section therefore only presents the geophysical findings where data was acquired.

## 5.2.2 Bathymetry

- 5.2.2.1 Within the Hornsea Four array, 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  $<1^\circ$  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.
- 5.2.2.2 Seabed levels in the offshore section of the ECC are around 46.2 m below LAT in the northern and southernmost survey lines, reaching a maximum depth of 51.5 m below LAT.
- 5.2.2.3 Within the nearshore section of the 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 ECC at an average gradient of around  $0.7^\circ$ . 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.

## 5.2.3 Seabed Features

- 5.2.3.1 Sand megaripples were the most frequently observed bedform across the array area, 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 suggests sand is the predominant seabed sediment, a conclusion supported by the interpreted side scan sonar 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.
- 5.2.3.2 Numerous objects were present on the seabed throughout the Hornsea Four array, identified on both side scan sonar (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 Hornsea Four array.
- 5.2.3.3 Across the ECC seabed sediments generally comprised Holocene sands, although areas of exposed till were found within the inshore survey extent.
- 5.2.3.4 Across the offshore ECC survey extent, the seabed was mobile until the area closest to the array, where sand waves and associated megaripples were noted on the seabed. Sand waves noted within this area were between 0.5 m and 1.8 m high.
- 5.2.3.5 Smithic Sands is a sandbank feature that extends south from the Flamborough Head SAC by over 12 km, with the southern part of the bank crossed by the offshore ECC. The sandbank feature does not form a feature of the SAC and is therefore not characterised as Annex I

habitat. Further detail on this sandbank feature is presented within the [Volume 5, Annex 1.1 Marine Geology, Oceanography and Physical Processes Technical Report](#).

5.2.3.6 **Figure 4** demonstrates the results of the 2018 geophysical seabed sediment feature analysis.



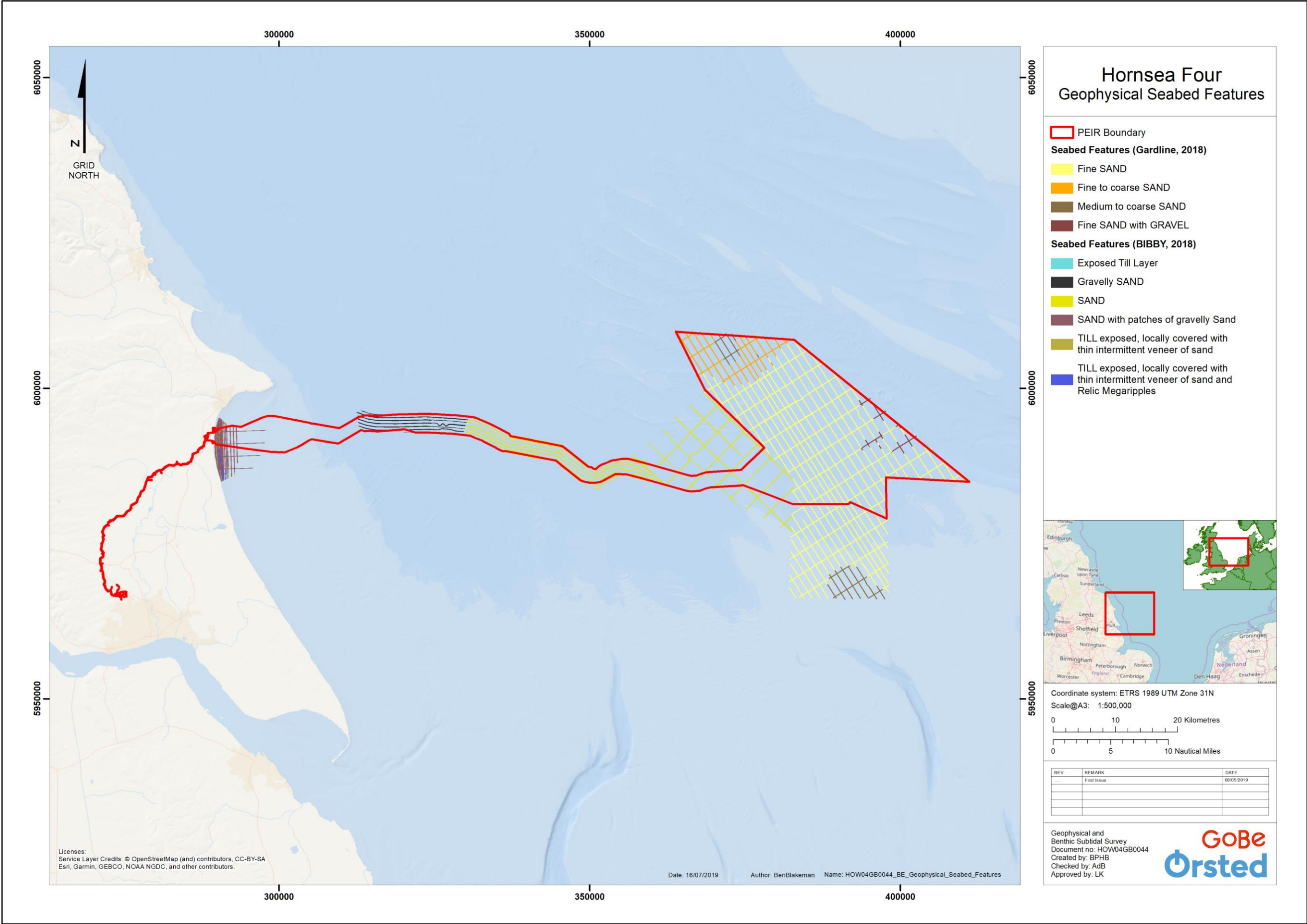


Figure 4: Hornsea Four geophysical seabed sediment features (Gardline, 2019 & Bibby HydroMap, 2019) (not to scale).

### 5.3 Physical Sediment Characteristics

#### 5.3.1 PSA of the Sediments

- 5.3.1.1 Mean particle diameter at stations across the Hornsea Four array varied between 245  $\mu\text{m}$  at Station ENV14 and 648  $\mu\text{m}$  at ENV 17 with an overall mean diameter of 414  $\mu\text{m}$  ( $\pm 117$  SD). The Wentworth classification of the mean grain size (Folk & Ward, 1957) generally presented as medium to coarse sand across the Hornsea Four survey area with the exception of Station ENV9 which presented as fine sand (station locations are presented in [Figure 5](#)).
- 5.3.1.2 The sand fraction ( $\geq 63 \mu\text{m}$  to  $< 2 \text{ mm}$ ) 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 a majority of stations across the Hornsea Four 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 (Folk, 1954) due to the proportion of gravel sized particles ( $\geq 2 \text{ mm}$ ) which accounted for c.4% of the total sediment at both these stations. Under the modified Folk classification (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 ( $< 63 \mu\text{m}$ ; 10%) and classified as muddy sand under the modified Folk classification.
- 5.3.1.3 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 Hornsea Four survey area.
- 5.3.1.4 Sediment sorting ranged from very poorly sorted to moderately well sorted across the Hornsea Four survey area. 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 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.
- 5.3.1.5 The modified Folk classification and the broadscale sediment classification are plotted in [Figure 5](#). Full results and histograms illustrating the particle size distribution at each sampled station are presented in [Appendix A](#).

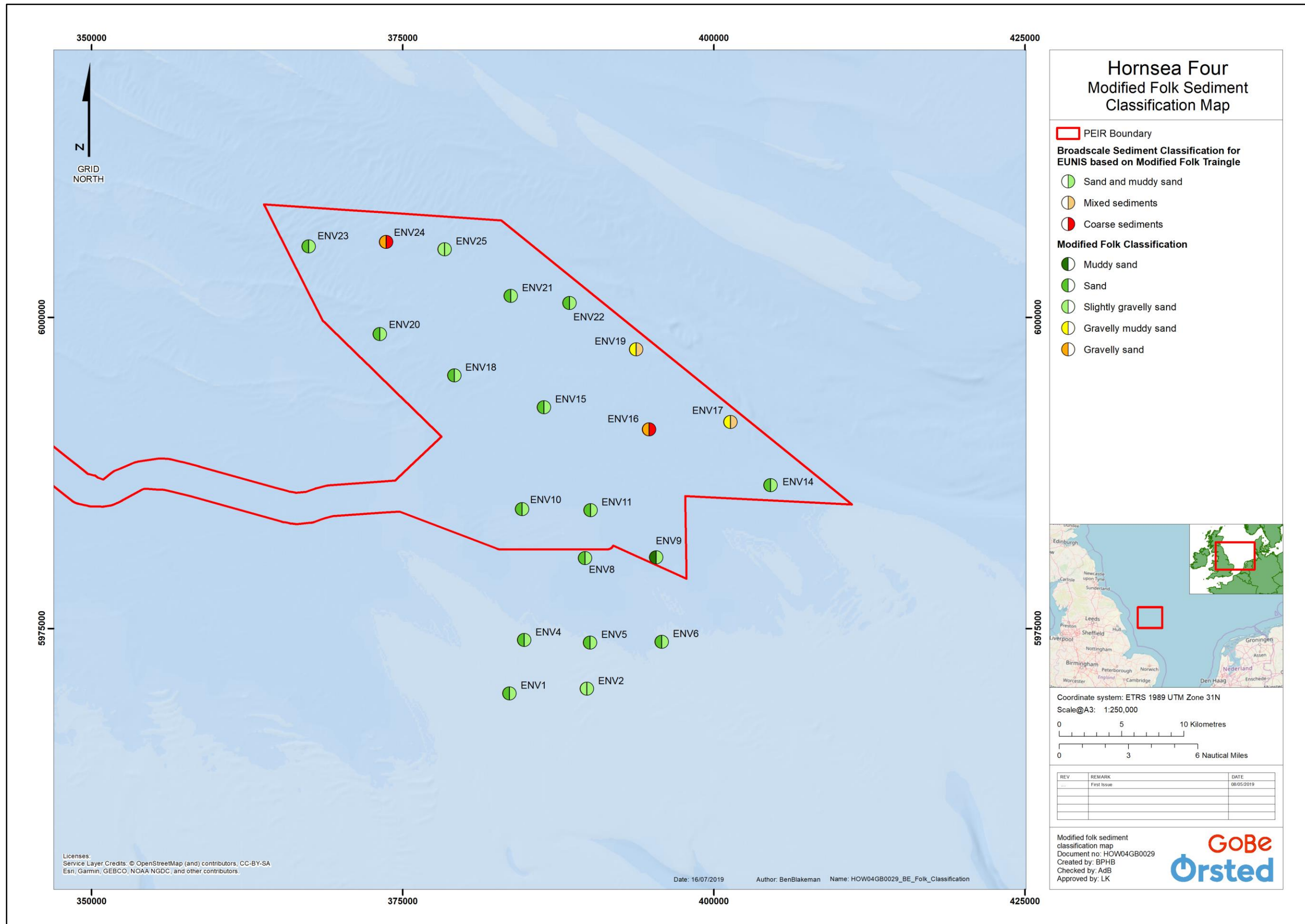


Figure 5: Modified Folk and broadscale sediment classification map (not to scale).



## 5.4 Sediment Contamination

- 5.4.1.1 The results of sediment chemistry data are available for the 21 sampling locations within the Hornsea Four array area. Further contaminant sample collection and analysis will be undertaken in 2019 across the offshore ECC (as described in [Section 4.2](#)) for inclusion in the final ES to accompany the DCO application.
- 5.4.1.2 The following section provides a summary of the sediment contaminant analyses undertaken to date within the Hornsea Four array area, with the full detailed results and methods presented in [Appendix A](#).

### 5.4.2 Contaminant Analysis

- 5.4.2.1 Results of the chemical analyses revealed that the majority of hydrocarbons observed within the Hornsea Four array were within expected background concentrations with some elevation present close to existing infrastructure which was as expected. Gas Chromatography (GC) traces across the Hornsea Four array 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 polycyclic aromatic hydrocarbons (PAH) concentrations ranged between 0.013  $\mu\text{g g}^{-1}$  at Station ENV18 to 0.248  $\mu\text{g g}^{-1}$  at Station ENV17 whilst naphthalene, phenanthrene and dibenzothiophene (NPD) concentrations ranged between 0.007  $\mu\text{g g}^{-1}$  and 0.097  $\mu\text{g g}^{-1}$ . Both total PAHs and PDs, 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. 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 Hornsea Four array area.
- 5.4.2.2 Metals concentrations varied across the Hornsea Four array 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 apparent effect threshold (AET; Buchman, 2008) which indicated that toxicological impacts on the biota were unlikely across the Hornsea Four array area.
- 5.4.2.3 Values of the organotin monobutyltin (MBT) were below the limit of detection (LOD) at all stations with the exception of Stations ENV10, ENV 14, ENV15, ENV17, ENV19, ENV21 and ENV25 where a value of 1  $\text{ng g}^{-1}$  was recorded. Values were below the limit of detection for dibutyltin (DBT) and tributyltin (TBT) across the Hornsea Four array area.

## 5.5 Benthic Subtidal Ecology

- 5.5.1.1 A single 0.1  $\text{m}^2$  faunal sample was collected from each of the 21 stations across the Hornsea Four array and screened through a 1 mm mesh sieve prior to enumeration and biomass analysis. Full details of the analysis methods used by the laboratory can be found in [Appendix A](#).

## 5.5.2 Description of the Benthic Subtidal Fauna

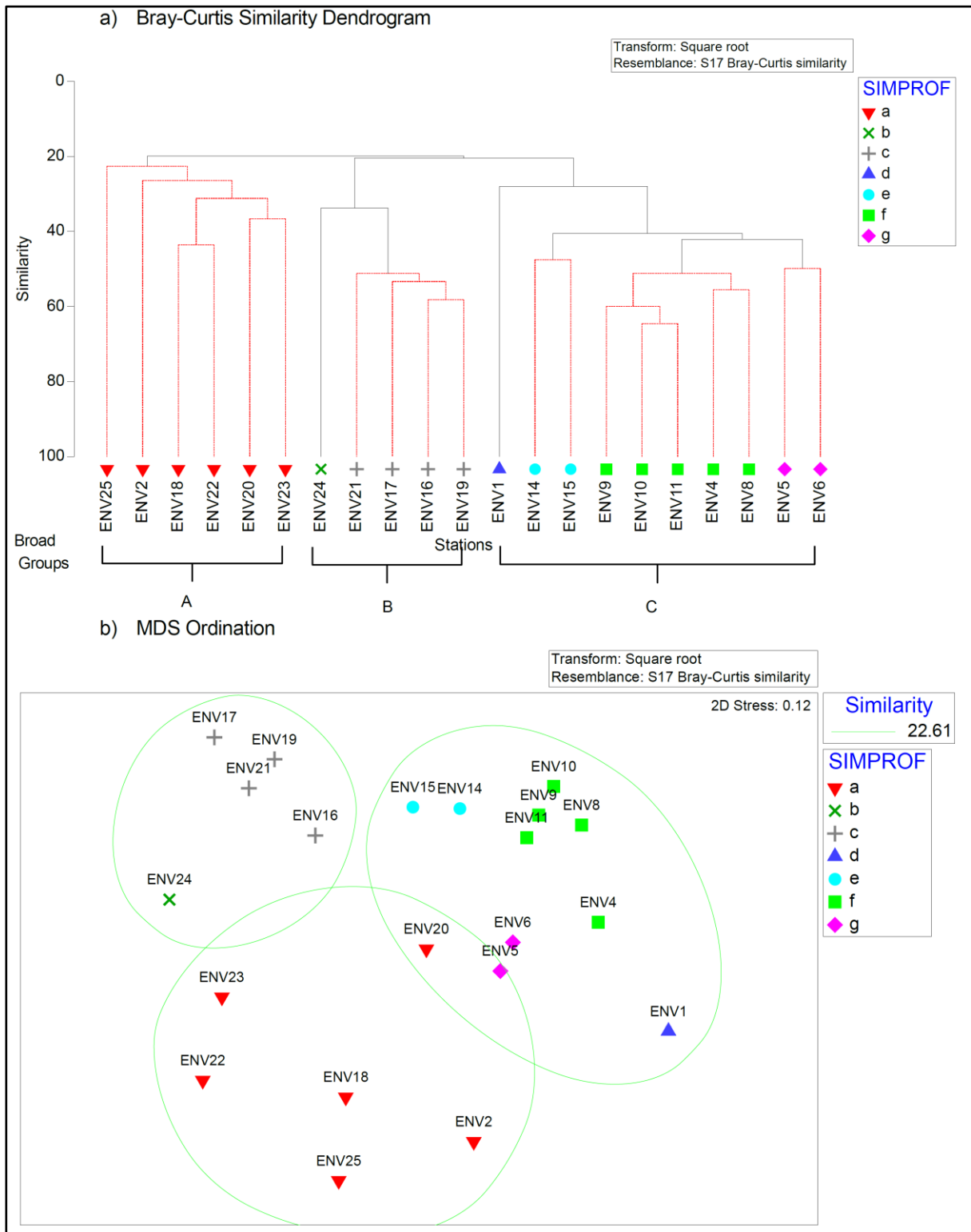
- 5.5.2.1 Across the survey area, a total of 2,678 individuals representing 163 taxa were recorded from the 21 macrofaunal samples acquired. The macrofaunal community was found to be relatively sparse with 54 taxa appearing at a single station and 34 of those taxa represented by a single individual.
- 5.5.2.2 Review of the adult only abundance data set revealed that benthic subtidal communities across the Hornsea Four array 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 >3 g.
- 5.5.2.3 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.

### **Multivariate Analysis of Community Composition**

- 5.5.2.4 The application of multivariate analyses enables subtler trends within the data set to be identified. Multivariate analyses were performed on the rationalised abundance and rationalised biomass adult only data sets using PRIMER v7.
- 5.5.2.5 A SIMPROF permutation test was conducted in conjunction with CLUSTER analysis for the abundance adult only data sets and the results were visualised on a dendrogram. 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 MDS ordination for the adult only abundance data set are presented in [Figure 6](#).
- 5.5.2.6 The CLUSTER analysis and dendrogram of 'variation' in the adult only abundance data set ([Figure 6 - a](#)) 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%.

- 5.5.2.7 The patterns observed within both the adult only abundance data set were corroborated in the nMDS plots (Figure 6 - b). With a stress factor of 0.12 MDS plot, which can be considered a useful representation of rank (dis)similarities and the overall patterns observed in the data.
- 5.5.2.8 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. Broad-scale groups B and C were separated due to relatively higher abundances of *A. filiformis* 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 broad-scale groups identified were due to the absence of *E. cordatum* and *Dosina lupinus* and the absence or relatively lower weight of *A. filiformis*.





**Figure 6: Multivariate analysis of faunal data – adult faunal data by stations.**

### Biotope Classification

5.5.2.9 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 set out within EUNIS.

5.5.2.10 The EUNIS classification hierarchy to biotopes (level 5) within the array was mainly based on depth, sediment type and species composition. A more detailed summary of the key parameters used for EUNIS classification are tabulated in [Appendix A](#).

5.5.2.11 Sample locations across the Hornsea Four array 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 (and corresponding JNCC 04.05 biotope code) identified are presented in [Table 4](#) and [Figure 7](#).

**Table 4: Biotopes found across the Hornsea Four array (Gardline, 2019).**

EUNIS Code	Biotope Name	JNCC 04.05 Code
A5.14	Circalittoral coarse sediment	SS.SCS.CCS
A5.233	<i>Nephtys cirrosa</i> and <i>Bathyporeia</i> spp. in infralittoral sand	SS.SSa.IFiSa.NcirBat
A5.25	Circalittoral fine sand	SS.SSa.CFiSa
A5.251	<i>Echinocyamus pusillus</i> , <i>Ophelia borealis</i> and <i>Abra prismatica</i> in circalittoral fine sand	SS.SSa.CFiSa.EpusOborApri
A5.252	<i>Abra prismatica</i> , <i>Bathyporeia elegans</i> and polychaetes in circalittoral fine sand	SS.SSa.CFiSa.ApriBatPo
A5.261	<i>Abra alba</i> and <i>Nucula nitidosa</i> in circalittoral muddy sand or slightly mixed sediment	SS.SSa.CMuSa.AalbNuc
A5.44	Circalittoral mixed sediment	SS.SMx.CMx
A5.443	<i>Mysella bidentata</i> and <i>Thyasira</i> spp. in circalittoral muddy mixed sediment	SS.SMx.CMx.MysThyMx

5.5.2.12 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. It was not possible to further classify these stations to EUNIS habitat level 5.

5.5.2.13 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 *Nephtys 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*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand and *Abra prismatica*, *Bathyporeia elegans* 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.

5.5.2.14 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).

5.5.2.15 *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*.

5.5.2.16 Overall, the wide range of observed EUNIS classifications supported the conclusion that the habitat across the Hornsea Four array 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.

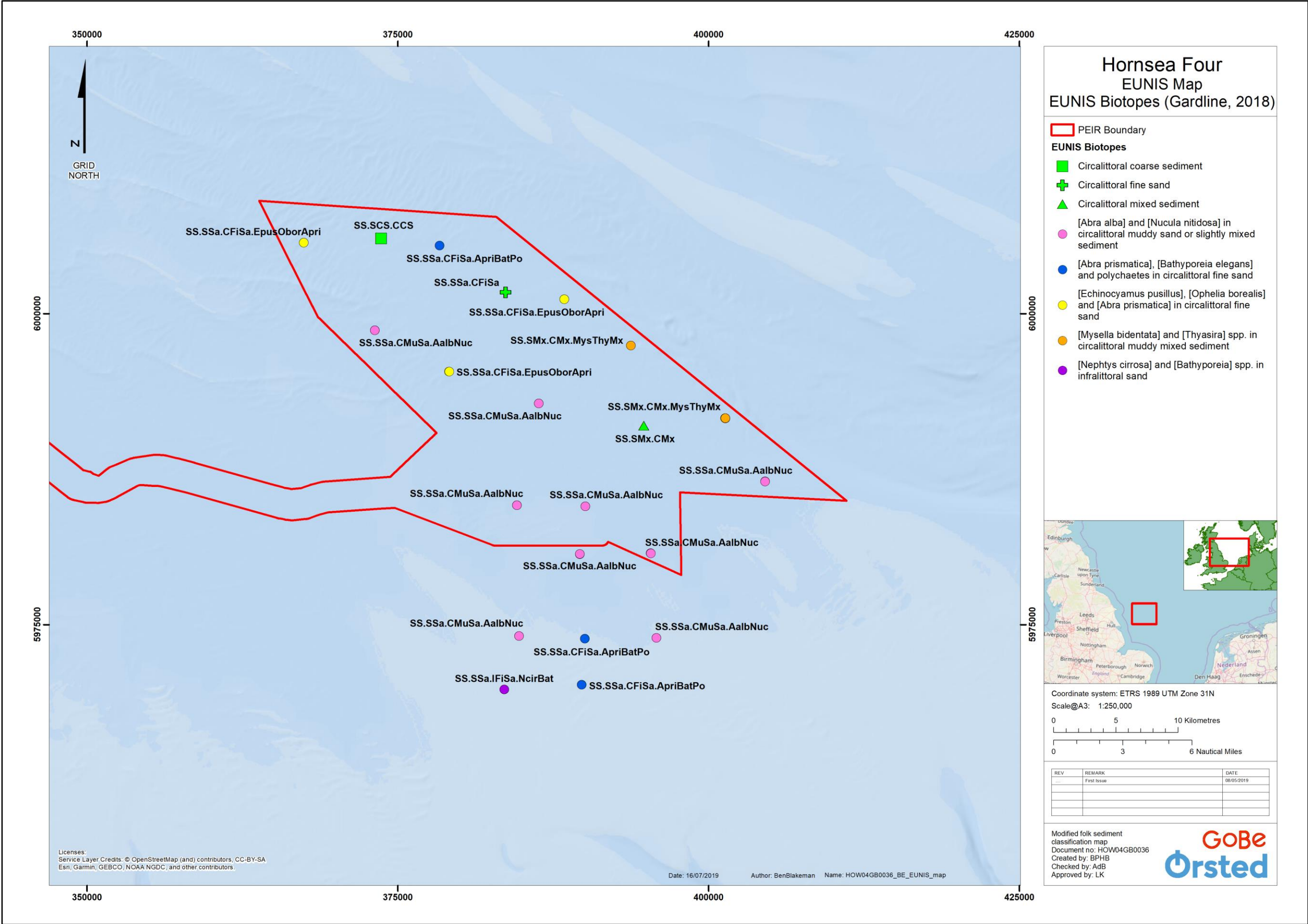


Figure 7: Biotopes across the Hornsea Four array area, as determined by the Gardline 2018 benthic subtidal survey (Gardline, 2019) (not to scale).

### 5.5.3 Seabed Imagery Results

- 5.5.3.1 Seabed images were collected at a total of 21 co-located camera and grab sample locations within the Hornsea Four array area ([Figure 3](#)). A total of 664 images were taken across 21 stations. A selection of seabed photographs are presented in [Appendix A](#).
- 5.5.3.2 Seabed imagery and video footage revealed a range of sediment types across the Hornsea Four array area from gravely sand to muddy sand. Coarse sediments were visibly present at four Stations (two in the north and two in the south of the array area (ENV2, ENV5, ENV24, and ENV25) were described as gravely sand.
- 5.5.3.3 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* Ophiuoridae), Mollusca (Bivalvia, Naticidae, Scaphopoda, Sepiolidae). Small burrows and faunal tubes were observed across the Hornsea Four survey area, particularly where finer sediment was observed.

#### **Sea Pen and Burrowing Megafauna Communities Assessment**

- 5.5.3.4 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 Hornsea Four array area. The observed sediment type across the Hornsea Four 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.
- 5.5.3.5 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 are summarised in [Table 5](#) and full methodology on how the assessment for a 'sea pen and burrowing megafauna communities' habitat was conducted is presented in [Appendix A](#).
- 5.5.3.6 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 25 m<sup>2</sup> 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 Hornsea Four array, 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).

**Table 5: Total Sea Pens and Faunal Burrows Qualification (Gardline, 2019).**

Stations	Number of Images Assessed	Estimated Total Area Investigated (m <sup>2</sup> ) <sup>1</sup>	Burrows			
			Quantity	Size Range (diameter in cm)	Density (Burrows m <sup>2</sup> )	SACFOR Range <sup>2</sup>
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.

### Other Species of Conservation Interest

- 5.5.3.7 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).
- 5.5.3.8 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 Marine Conservation Zone (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 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). Further consideration of sandeel is presented within [Volume 2, Chapter 3: Fish and Shellfish Ecology](#).
- 5.5.3.9 Other than those mentioned above there was no evidence of any other Annex I habitats (1992), species or other habitats listed as 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 IUCN Global Red List of threatened species (IUCN, 2018).

## 6 Site Specific Intertidal Ecology Results

- 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 IECS in March 2019 (IECS, 2019). The full report including detailed methodologies and results is included as [Appendix C](#).
- 6.1.1.2 Five transects were surveyed across the Hornsea Four intertidal ecology study area ([Figure 8](#)). 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<sup>2</sup> 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 8](#) present 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).**



**Plate 3 & 4: Coarse Littoral Sand T1, lower-shore (left). Sparse *Lanice* tubes. T2 (right).**

## 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.**

### **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.



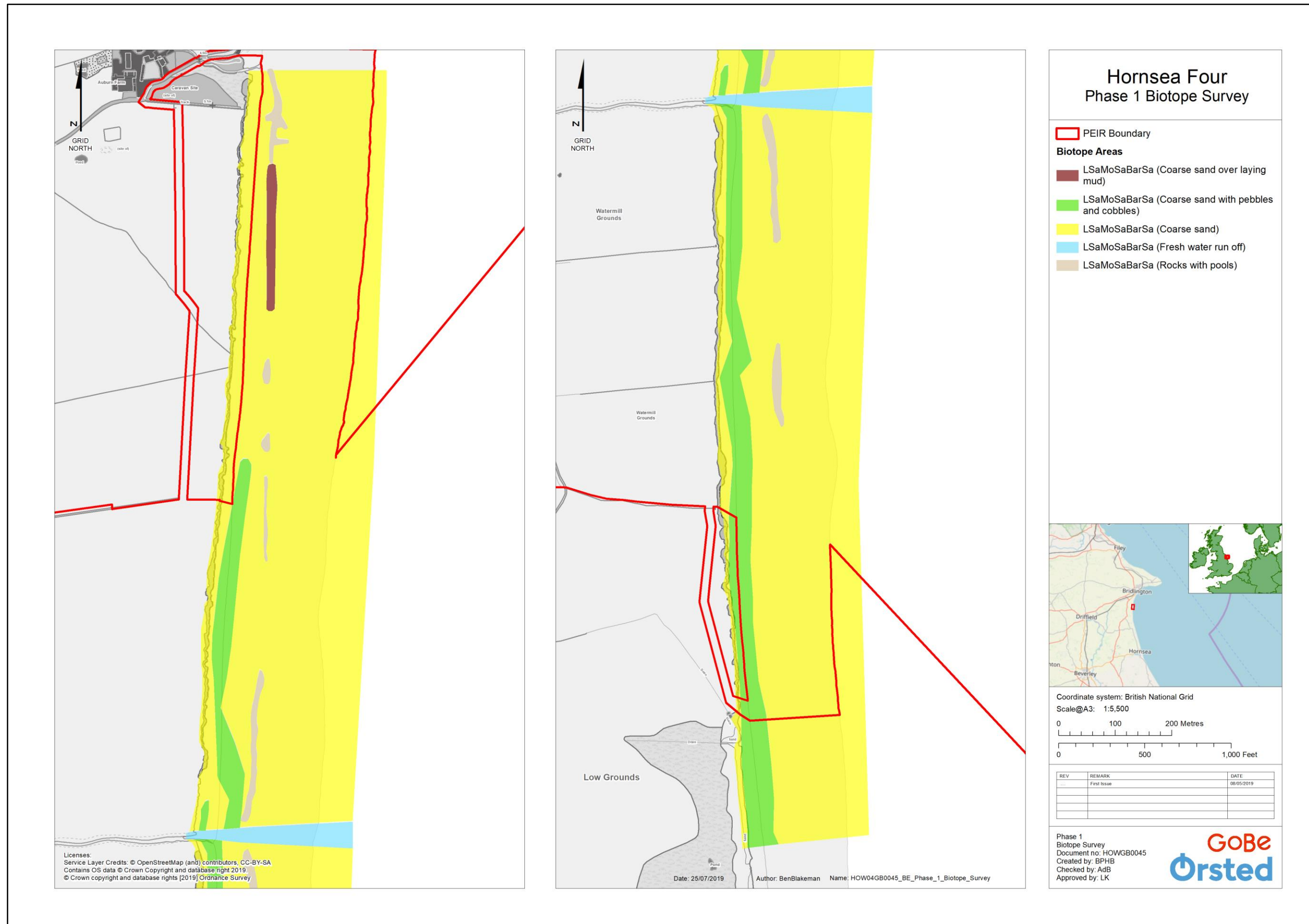


Figure 8: Phase I biotope map of the intertidal Hornsea Four landfall area, showing the designated intertidal biotopes (IECS, 2019) (not to scale).



## 7 Habitat Mapping

### 7.1 Context

- 7.1.1.1 To address the data gaps identified in [Section 2](#), a full coverage model of marine benthic subtidal habitats has been carried out across Hornsea Four for the purposes of PEIR (as agreed through the evidence plan process). This uses survey data from across the region, including the recent collected and extant dataset. Whilst the model improves the benthic subtidal ecology baseline across the whole area, it is of particular use along the offshore ECC where there is no benthic site-specific sampling to date. However, the model will be updated with the 2019 offshore ECC survey data to be presented in the ES and accompany the DCO application.
- 7.1.1.2 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 Regional Environment Characterisations (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 model developed by GoBe.
- 7.1.1.3 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.
- 7.1.1.4 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 Creyke Breck Dogger Bank Offshore Wind Farm 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 9](#). 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 Creyke Beck survey PSA data. However, by simply interpolating all PSA data (from BGS and Hornsea / Dogger Bank Creyke Beck 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 would be to manually modify the boundaries of the Cefas sediment model using the most recent 2018 survey 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 Creyke Beck surveys as shown in [Figure 9](#). The EUNIS substrate categories in [Figure 11](#) were assigned from PSA values using an in-house Excel macro, which is governed by the categorisation shown in [Figure 10](#). (Note this EUNIS categorisation, as also used in the Cefas models, differs slightly from the Regional Environmental Characterisation (REC) studies).

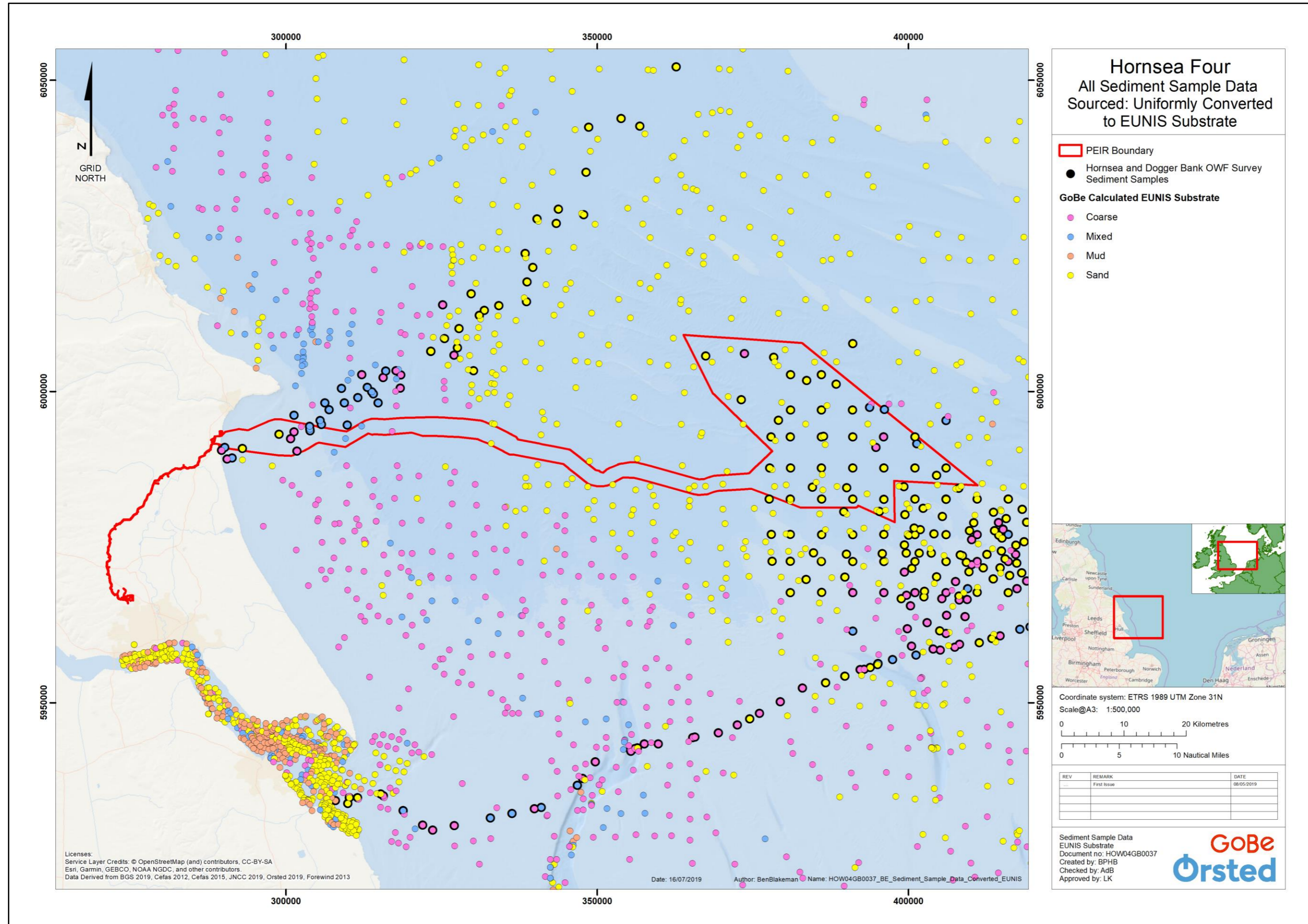


Figure 9: All sediment sample data sourced (not to scale).



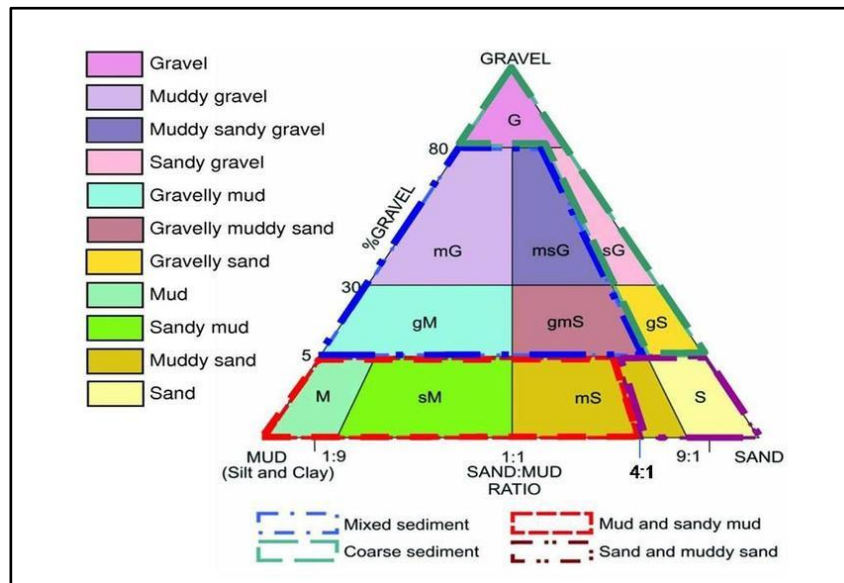


Figure 10: Modified Folk sediment trigon (Connor et al. 2006).

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 most recent 2018 survey data formed the priority data in amending the Cefas 2015 model boundaries, overriding any nearby older data. The 2018 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 GIS using survey data to amend the overall Cefas 2015 model, with results shown in Figure 11. Whilst Hornsea Four is characterised predominantly with sand and muddy sand, there is a large area of mixed sediment and coarse sediment 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.

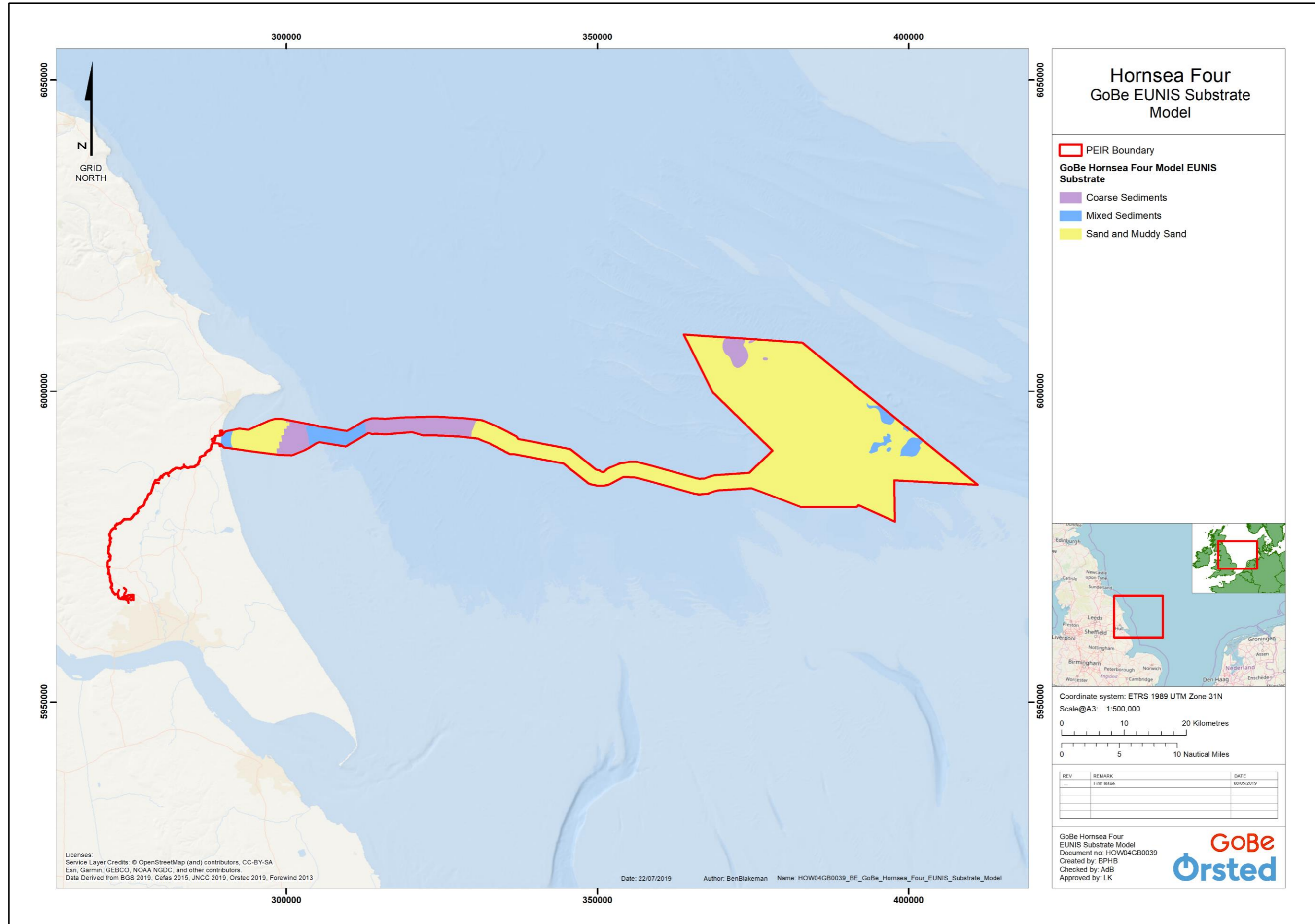


Figure 11: Hornsea Four EUNIS substrate model (not to scale).



## 7.3 Level 4 EUNIS Physical Habitat Model

- 7.3.1.1 The full EUNIS habitat classification scheme provides a hierarchical 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 between the UKSeaMap 2018 biological zones and Hornsea Four sediment model (detailed above). As shown in [Figure 12](#), 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.

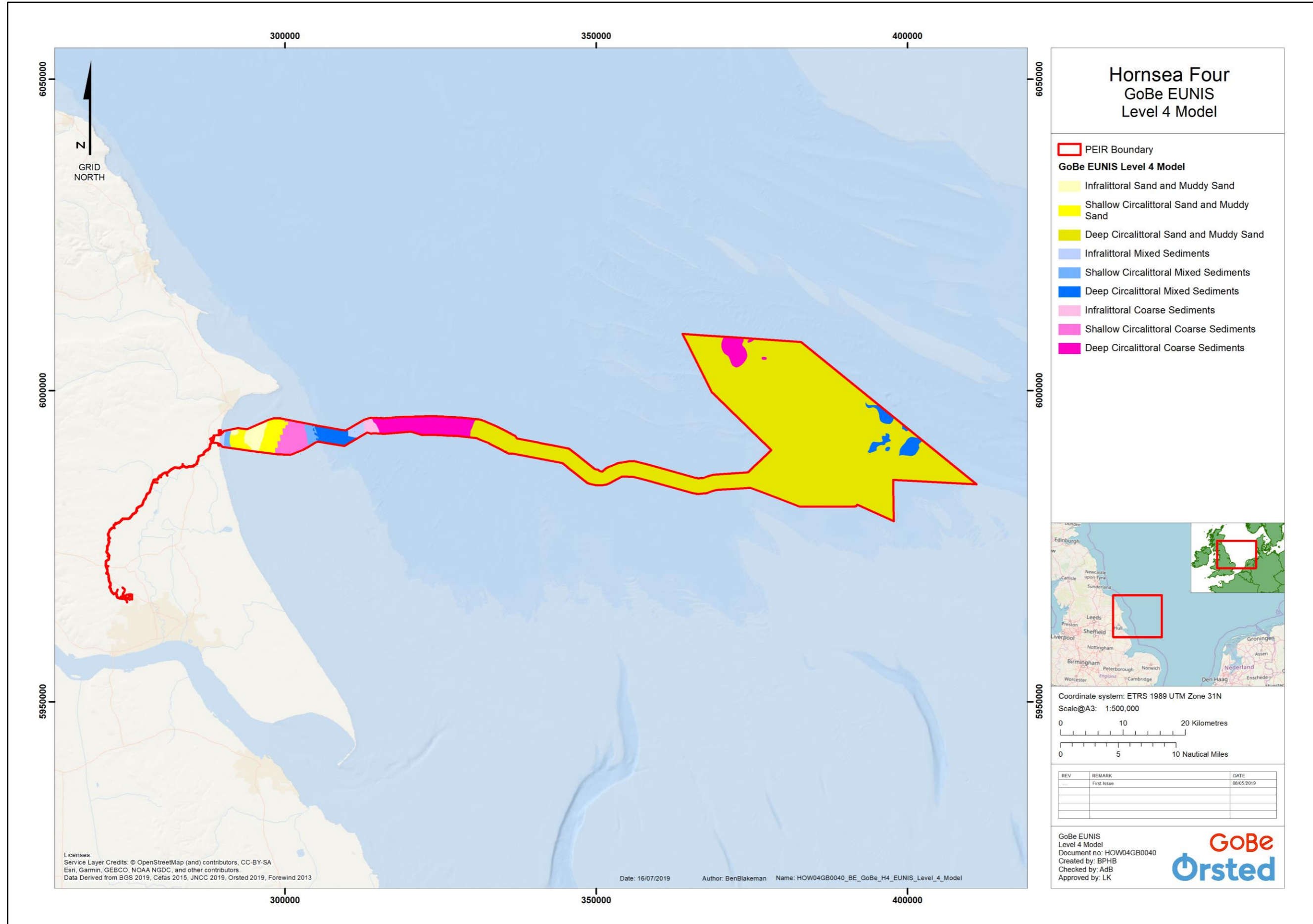


Figure 12: Hornsea Four EUNIS Level Four Model (not to scale).

## 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, other historic Hornsea surveys and Dogger Bank Creyke Beck surveys (where available on the Marine Data Exchange). Starting with a total list of 33 biotopes, these then underwent a screening process to reduce the list from all surveys, whilst keeping all biotopes from the Hornsea Four 2018 site specific survey as a baseline throughout (i.e. no 2018 biotopes were screened out other than physical biotopes, see below).

7.4.2.2 The data were first screened to remove any biotopes outside of the Hornsea Four PEIR boundary that were identified in <3 samples, therefore only leaving those that were better represented at more than three survey locations.

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

7.4.2.4 Thirdly, if a biotope was a combination of two or three different biotope codes, then if all individual biotopes or the first biotope listed was already accounted for by singular biotopes in the dataset then it was removed. This ensured that the biotopes predicted were as distinct as possible. (Note that none of the Gardline 2018 biotopes were combined codes).

7.4.2.5 Fourthly, 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 Creyke Beck array area – remaining points removed as biological zone / substrate not relevant and further away than all other points;
- Dogger Bank Creyke Beck 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.

7.4.2.6 [Table 6](#) and [Figure 13](#) include biotopes that exist in some of the areas listed above because they are also found in Hornsea Four. Any occurrence of each of these five biotopes in any area is used to inform the environmental preferences.

**Table 6: Biotopes selected to model.**

ID	JNCC 04.05	EUNIS name	Coverage	Duplicates	2018 Survey
1	SS.SMx.CMx.MysThyMx	<i>Mysella bidentata</i> and <i>Thyasira</i> spp. in circalittoral muddy mixed sediment	Hornsea Four array area, Hornsea Project One, Hornsea Project Two and Hornsea Three array areas		Yes
2	SS.SSa.CFiSa.ApriBatPo	<i>Abra prismatica</i> , <i>Bathyporeia elegans</i> and polychaetes in circalittoral fine sand	Hornsea Four array area		Yes
3	SS.SSa.CFiSa.EpusOborApri	<i>Echinocyamus pusillus</i> , <i>Ophelia borealis</i> and <i>Abra prismatica</i> in circalittoral fine sand	Hornsea Four array area, Hornsea Project One, Hornsea Project Two and Hornsea Three array areas, Dogger Bank Creyke Beck ECC (near to mid-shore), Dogger Bank Creyke Back array area	Yes	Yes
4	SS.SSa.CMuSa.AalbNuc	<i>Abra alba</i> and <i>Nucula nitidosa</i> in circalittoral muddy sand or slightly mixed sediment	Hornsea Four array area		Yes
5	SS.SSa.lFiSa.NcirBat	<i>Nephtys cirrosa</i> and <i>Bathyporeia</i> spp. in infralittoral sand	Hornsea Four array area (1), Hornsea Four ECC (nearshore), Hornsea Project One, Hornsea Project Two and Hornsea Three ECCs and array areas		Yes

\* From hereon, named as SS.SMx.CMx.FluHyd (first biotope dropped as duplicated from a singular biotope classification)

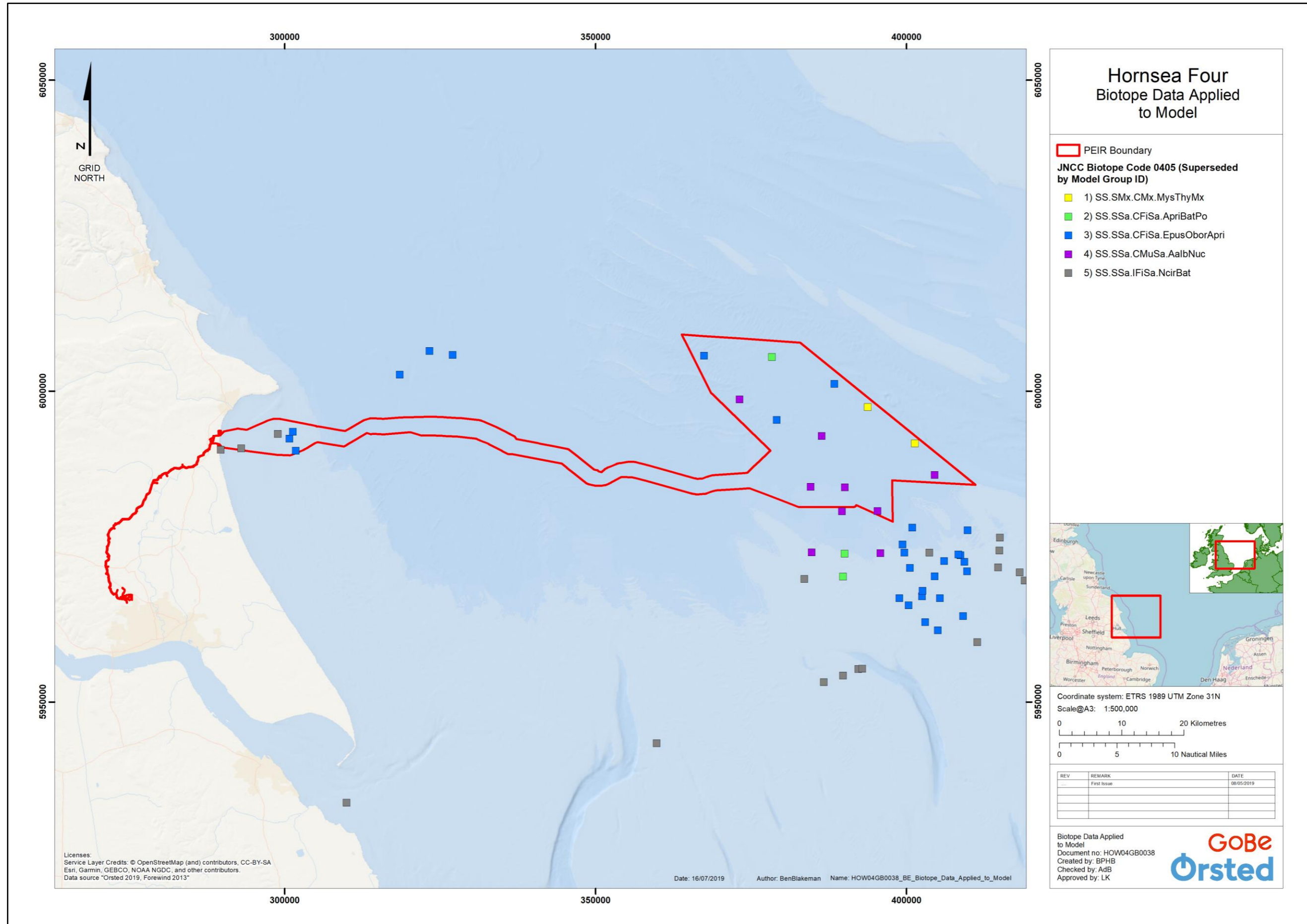


Figure 13: Hornsea Four biotope data applied to model (not to scale).



### 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 7](#).

**Table 7: 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 required processing of data. The water body 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 8](#) 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 8: 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 Creyke Beck array areas/ECCs, uniformly converted to EUNIS substrate. Geophysical line data from Hornsea Four 2018, 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 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 A-G biotopes listed above) and its associated survey EUNIS substrate. The resulting model union-ed layer therefore contained both the Hornsea Four 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 union-ed 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 1 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 9](#).

**Table 9: Environmental preferences.**

Group	Sea Bottom Temperature °C	Summer Water Body	Energy	Biological Zone	Substrate
1	14.5 - 16.0	Frontal Shelf	Low energy Moderate energy	Deep circalittoral	Mixed Sediments
2	14.5 - 15.5	Well Mixed Shelf Frontal Shelf	Moderate energy Low energy	Deep circalittoral	Sand and Muddy Sand
3	13.5 - 16	Well Mixed Shelf Frontal Shelf	Moderate energy Low energy	Shallow circalittoral Deep circalittoral	Coarse Sediments Sand and Muddy Sand
4	14.5 - 16	Well Mixed Shelf Frontal Shelf	Moderate energy	Deep circalittoral	Sand and Muddy Sand
5	15 - 17.5	Well Mixed Shelf	Moderate energy High energy	Deep circalittoral Shallow circalittoral Infralittoral	Coarse 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 1 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 14](#).

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 14** reveals that the five biotopes that are predicted to occur across Hornsea Four 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 5 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 **Figure 14** demonstrates that the biotopes are present in three distinct groups, with the first group (biotope 1) in **Figure 14** predominantly concentrated over mixed sediments and coarse sediments: with 1) SS.SMx.CMx.MysThyMx more likely offshore.

7.4.7.5 The second group (biotopes 2 and 3) are concentrated over sand and muddy sand: with 2) SS.SSa.CFiSa.ApriBatPo, more likely offshore and 3) SS.SSa.CFiSa.EpusOborApri, throughout the Hornsea Four area.

7.4.7.6 The third group of biotopes are biased to the south, with 4), SS.SSa.CMuSa.AalbNuc, in the southern offshore area; and 5), SS.SSa.IFiSa.NcirBat, in the southern nearshore and offshore areas.

7.4.7.7 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 benthic subtidal ecology study area.

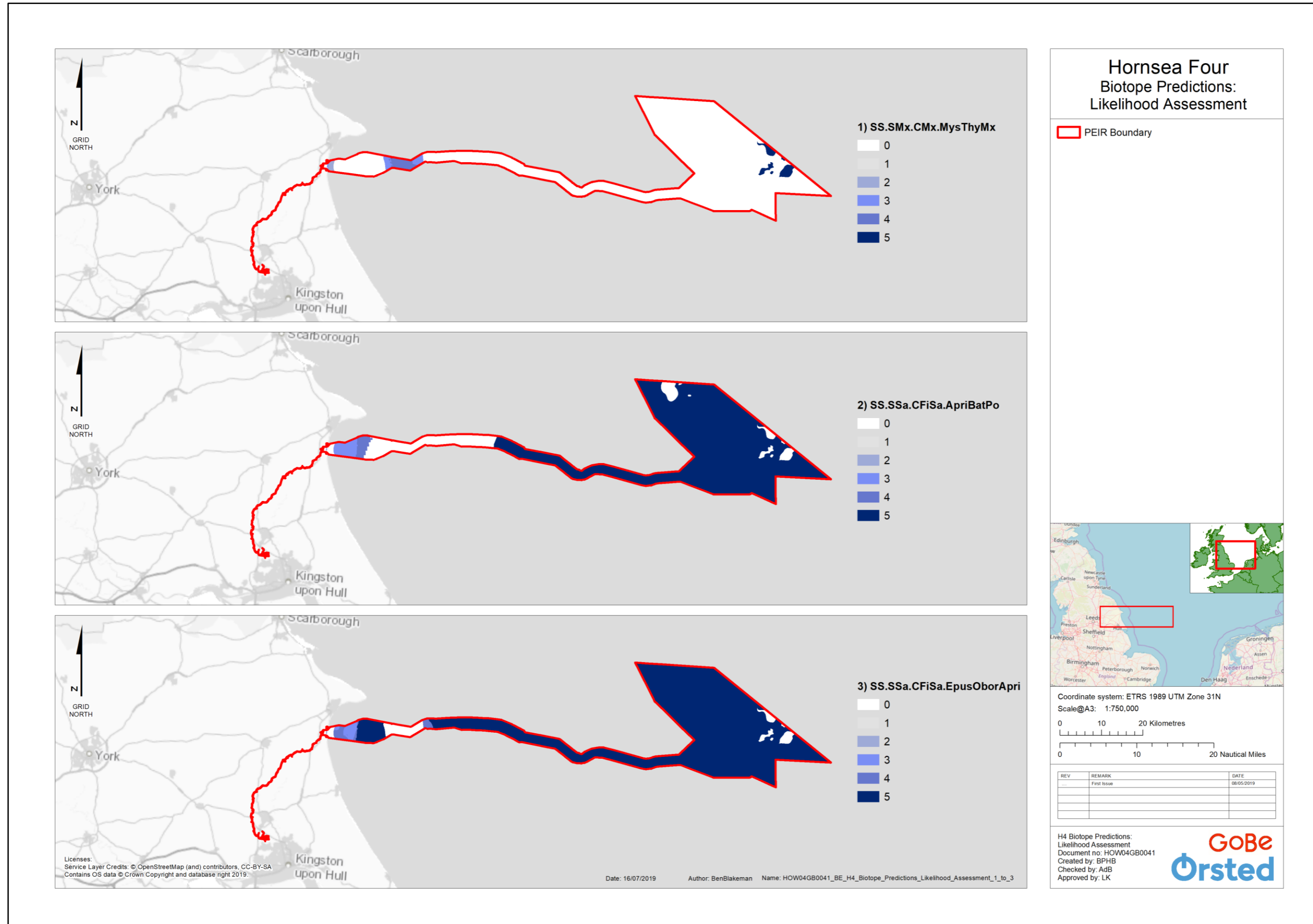


Figure 14: Hornsea Four biotope predictions: likelihood assessment (1 of 2) (not to scale).



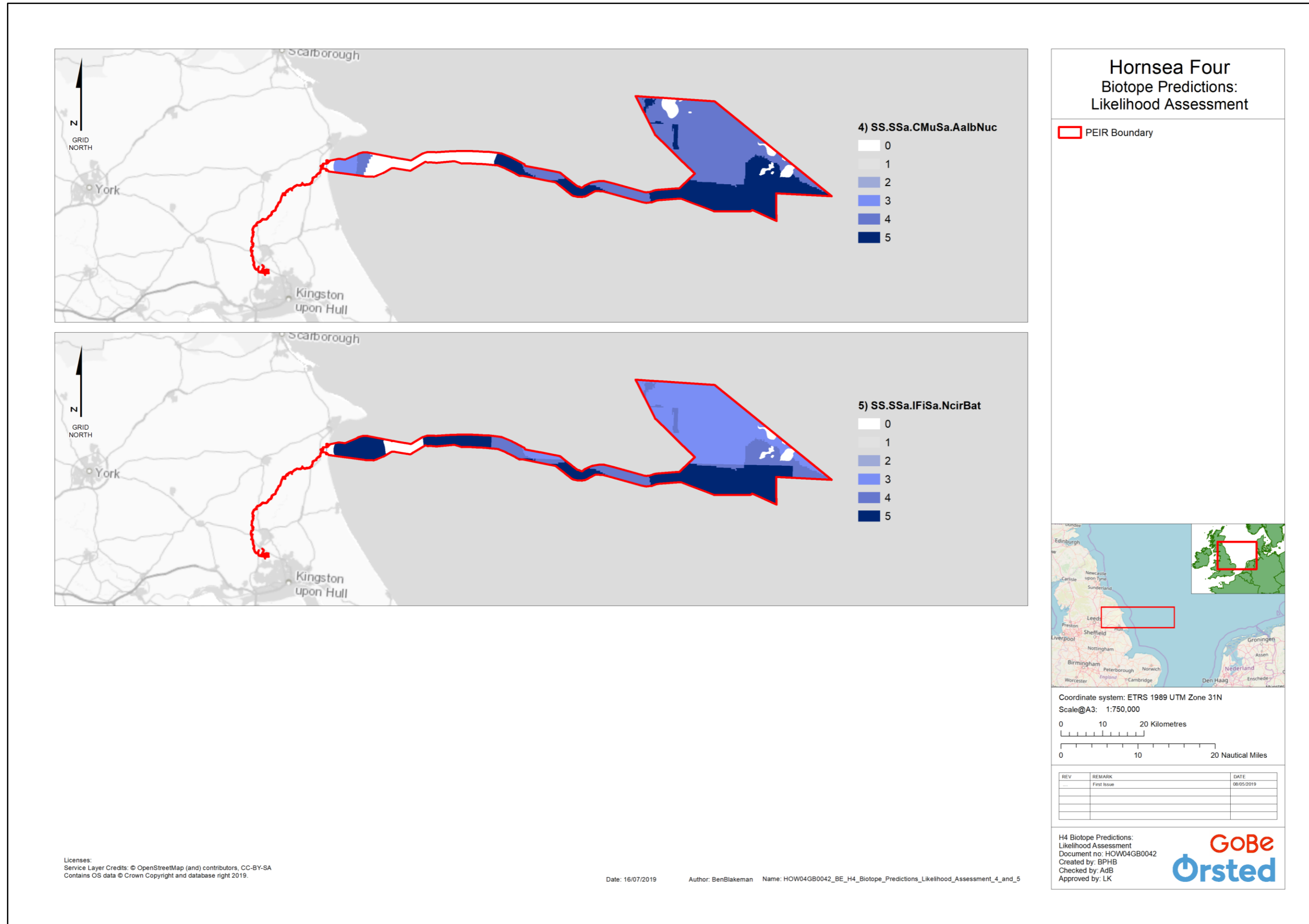


Figure 15: Hornsea Four biotope predictions: likelihood assessment (2 of 2) (not to scale).

## 8 Nature Conservation

### 8.1 Protected Areas

8.1.1.1 The marine nature conservation designations which fall within the vicinity but out with of Hornsea Four comprise international Natura 2000 designations (i.e. Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)) and national designations (i.e. Marine Conservation Zone (MCZs)). This section looks at those sites that have cited qualifying features that relate to seabed habitats and benthic ecology.

8.1.1.2 There are several other designated sites in proximity to Hornsea Four, as presented in [Figure 16](#). 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 10](#). A more detailed description of each site is given within this Section.

**Table 10: 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: <ul style="list-style-type: none"> <li>• Reefs</li> <li>• Vegetated sea cliffs of the Atlantic and Baltic Coasts</li> <li>• Submerged or partially submerged sea caves</li> </ul>	>1 km distance from the nearshore section of the Hornsea Four ECC corridor
Holderness Inshore MCZ	<ul style="list-style-type: none"> <li>• Intertidal sand and muddy sand</li> <li>• Moderate energy circalittoral rock</li> <li>• High energy circalittoral rock</li> <li>• Subtidal coarse sediment</li> <li>• Subtidal mixed sediments</li> <li>• Subtidal sand</li> <li>• Subtidal mud</li> <li>• Spurn head (subtidal geological feature)</li> </ul>	<5 km distance from the nearshore section of the Hornsea Four ECC corridor
Holderness Offshore MCZ	<ul style="list-style-type: none"> <li>• North Sea Glacial Tunnel valleys</li> <li>• Subtidal coarse sediment</li> <li>• Subtidal sand Subtidal mixed sediments</li> <li>• Ocean Quahog (<i>Arctica islandica</i>)</li> </ul>	<1 km distance from the nearshore section of the Hornsea Four ECC corridor

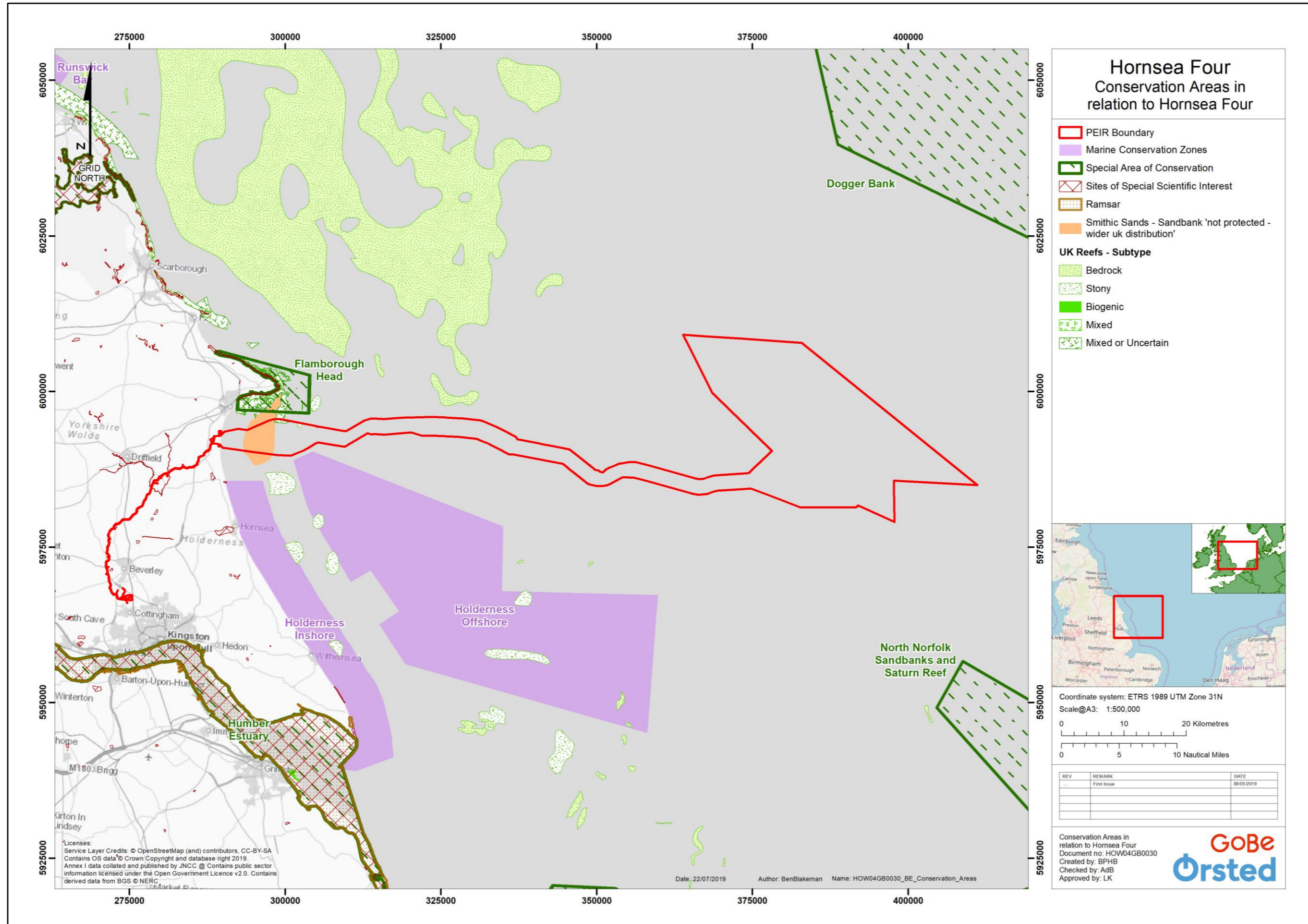


Figure 16: Hornsea Four in relation to national and international conservation areas that have seabed habitat features and benthic ecology interest (not to scale).



### 8.1.2 Flamborough Head SAC

8.1.2.1 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<sup>a</sup>).

### 8.1.3 Holderness Inshore MCZ

8.1.3.1 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.

8.1.3.2 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.

8.1.3.3 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).

### 8.1.4 Holderness Offshore MCZ

8.1.4.1 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).

## 8.1.5 Smithic Sands Sandbank

8.1.5.1 Smithic Sands is a sandbank feature, where the southern part of the bank crosses with the offshore ECC (Figure 16). The sandbank feature does not form a feature of the Flamborough Head SAC and is therefore not characterised as Annex I habitat. Further detail on this sandbank physical structure of this feature is presented within the Volume 5, Annex 1.1 Marine Geology, Oceanography and Physical Processes Technical Report. In terms of 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 and will be assessed as Valued Ecological Receptors (VERs).

## 9 Valued Ecological Receptors

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 11 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 11: 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); Species protected under national law; Annex I habitats not within an SAC boundary;



VER Value	VER Criteria used to define value
	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 MNA.
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); 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 12** presents the VERs, their conservation status and importance within the Hornsea Four benthic 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 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 12**, 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 12: 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	None	UK BAP priority habitat	This habitat is found within the Hornsea Four array area and modelling predicted the presence within the 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	None	UK BAP priority habitat	This habitat is likely to be located across much of the Hornsea Four site, with ApriBatPo, more likely offshore, EpusOborApri found throughout the whole Hornsea Four area and NcirBat, in the southern nearshore and offshore areas.	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 Hornsea Four array area.	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 Sea, Region III – Celtic Sea)	Rare habitat located across the Hornsea Four array. Frequent habitat located outside the Hornsea Four array 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).
Coarse littoral barren sand	LS.LSa.MoS.a.BrSa	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 <i>Arctica islandica</i>	N/A	None	OSPAR List of threatened and/or declining species for the Greater	Three individuals were found within the Hornsea Four array.	National – UK BAP with nationally important populations close to the Hornsea Four benthic subtidal ecology study area.

# Hornsea 4



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
			North Sea (OSPAR Region II). FOCI under the Nature Conservation part (Part 5) of the MCAA 2009		Ocean quahogs are found all around and offshore from, British and Irish coasts, particularly the Southern North Sea and the English Channel

## 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. 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. 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 The overarching aim of this study was to provide an up to date characterisation of the benthic subtidal and intertidal ecological resources within the Hornsea Four benthic subtidal and intertidal ecology study area. The data and evidence provided in this investigation has established a comprehensive baseline characterisation of the site, that will provide supporting information to inform the wider EIA being undertaken for Hornsea Four and presented in the PEIR.

10.1.1.2 The following sections summarise the conclusions that can be drawn from this technical report.

### 10.2 Subtidal Characterisation

#### 10.2.1 Physical Sediment Characteristics

10.2.1.1 PSA of the sediments sampled from stations within the Hornsea Four array area determined that the sediments was generally characterised by medium to coarse sand apart from fine sand at one sample location to the south of the array.

10.2.1.2 The GoBe predictive habitat model identified that most of the Hornsea Four array area and offshore portion of the Hornsea Four ECC could be characterised as circalittoral sand and muddy sand. Discreet patches of mixed and coarse sediment were attributed to the array area and within the nearshore element of the ECC mixed and coarse sediments were more dominant.

10.2.1.3 Results of geophysical analysis identified that sand megaripples were the most frequently observed bedform across the array area, while sand waves were also common. These features were also observed in the offshore portion of the ECC leading into the array area.

#### 10.2.2 Sediment Contamination

10.2.2.1 Results of the chemical analyses revealed that the majority of hydrocarbons observed within the Hornsea Four array were within expected background concentrations with some elevation present close to existing infrastructure which was as expected. All hydrocarbons were below thresholds likely to exert an effect on the faunal community.

10.2.2.2 All metals concentrations were below their respective apparent effect threshold (AET; Buchman, 2008).

10.2.2.3 Values of the organotin MBT were below the LOD at all stations except for Stations ENV10, ENV 14, ENV15, ENV17, ENV19, ENV21 and ENV25 where a value of 1 ng g<sup>-1</sup> was recorded. Values were below the limit of detection for dibutyltin (DBT) and tributyltin (TBT) across the Hornsea Four array area.

10.2.2.4 A full suite of contaminant analyses will be undertaken across the offshore ECC during planned sampling in Q3 2019.

### 10.3 Benthic Subtidal Ecology

10.3.1.1 Across the Hornsea Four 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.

10.3.1.2 Benthic communities across the Hornsea Four 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.

10.3.1.3 Results of seabed imagery collected across the array correlated with those geophysical and benthic grab findings, with footage revealing sandy sediments from gravelly sand to muddy sand. Visible fauna were generally sparse, although at one station (located at the most southerly station outside the array) the habitat 'sea pen and burrowing megafauna community' was identified.

10.3.1.4 The results from GoBe predictive habitat modelling revealed that the biotope *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment (SS.SMx.CMx.MysThyMx) were predominantly concentrated over the mixed sediments and coarse sediments that characterised the benthic subtidal ecology study area and were more likely to be found offshore.

10.3.1.5 The biotopes *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand (SS.SSa.CFiSa.ApriBatPo) and *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand (SS.SSa.CFiSa.EpusOborApri) were modelled as more likely to occur across the sand and muddy sand sediment habitats with SS.SSa.CFiSa.ApriBatPo more likely to characterise these sediments in the offshore portion of the benthic ecology study area and (SS.SSa.CFiSa.EpusOborApri) throughout the entire subtidal benthic ecology study area.

10.3.1.6 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (SS.SSa.CMuSa.AalbNuc) and *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (SS.SSa.lFiSa.NcirBat) were modelled as more likely to occur across the sand and muddy sand sediment habitats with SS.SSa.CMuSa.AalbNuc located in the southern offshore area and SS.SSa.lFiSa.NcirBat in the southern nearshore and offshore areas.

10.3.1.7 The GoBe habitat model produced for Hornsea Four revealed that the biotopes had differing, but also overlapping habitat requirements, which is likely to be reflective of the



homogeneity of ecological conditions across some of the site, particularly in the offshore section of benthic subtidal ecology study area.

## **10.4 Benthic Intertidal Ecology**

10.4.1.1 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.

## **10.5 Conservation**

10.5.1.1 Hornsea Four lies in close proximity (1-5km) to a number of marine protected areas, although the site does not overlap with any designated features. The results of the study also reveal that there is no indication of geogenic or biogenic reef across the Hornsea Four benthic subtidal study area. Further surveys will be undertaken in 2019 and at the pre-construction phase of the development, if any sensitive habitats are recorded at this stage Hornsea Four propose to microsite around these features.

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**Appendix A: Hornsea Four Offshore Wind Farm Lot 6 GP1a 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**



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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<sup>2</sup> 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 (*Ditrupea*, *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<sub>24</sub> to nC<sub>36</sub> 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<sup>-1</sup> at Station ENV18 and 0.248µg g<sup>-1</sup> at Station ENV17. The 2-3 ring naphthalene, phenanthrene and dibenzothiophene (NPD) concentrations recorded values between 0.007µg g<sup>-1</sup> and 0.097µg g<sup>-1</sup>. 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 petrogenic 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<sup>-1</sup> 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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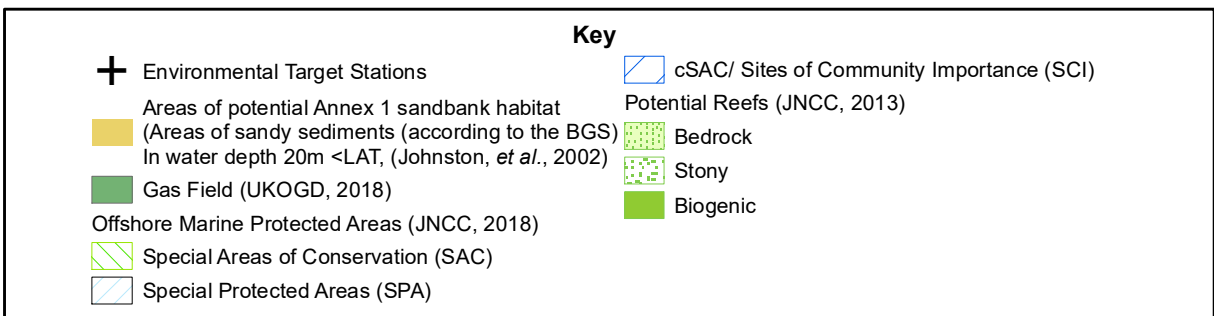
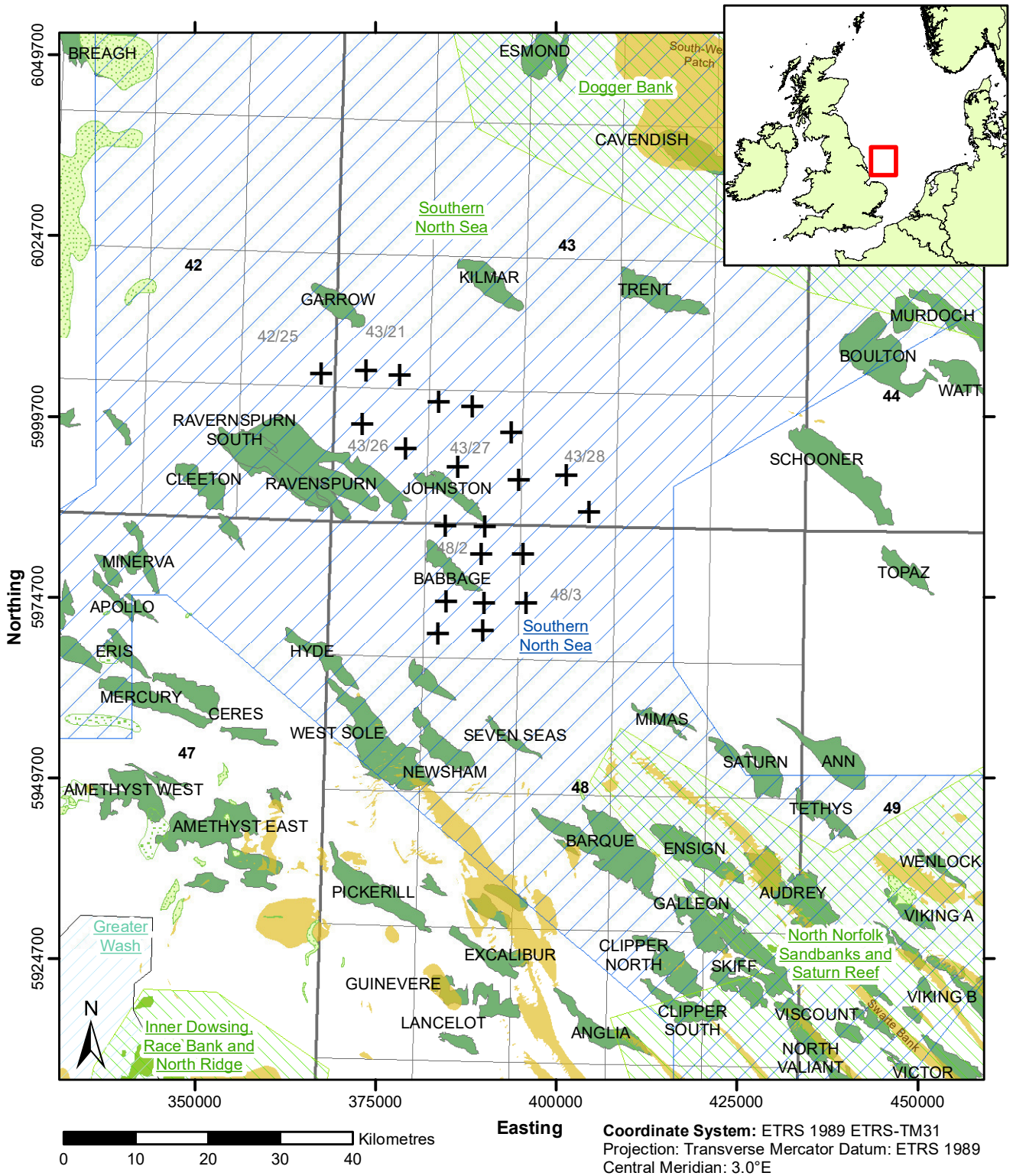
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## LOCATION MAP



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## GLOSSARY OF TERMS AND ABBREVIATIONS

AET	Apparent Effects Threshold	MCZ	Marine Conservation Zone
Aliphatic	An organic compound having open-chain structure (see Alkane)	MF	Macrofauna Sample
Alkane	Any of a series of open-chain, saturated hydrocarbons $C_nH_{2n+2}$ (e.g. methane, ethane)	MNCR	Marine Nature Conservation Review
Aqua Regia	A mixture of nitric and hydrofluoric acids	Mud	Sediment grains <63µm (includes Silt and Clay)
BAC	Background Assessment Criteria	MV	Motor Vessel
BC	Background Concentration(s)	NDIR	Non-dispersive infrared
Benthic	Relating to the seabed	NERC	Natural Environment and Rural Communities
Biogenic	Produced by living organisms	NMBAQC	National Marine Biological Association Quality Control
BSI	British Standards Institute	NPD	Naphthalenes, phenanthrenes and dibenzothiophenes
CEFAS	Centre for Environment, Fisheries and Aquaculture Science	OGA	Oil and Gas Authority
CHEM	Physico-Chemical Sample	Ørsted	Ørsted Wind Power AS
Clay	Sediment grains <3.9µm in diameter	MV	Motor Vessel
CM	Central Meridian	OSPAR	Oslo and Paris convention
CPI	Carbon Preference Index	PAH	Polycyclic aromatic hydrocarbon(s)
CPT	Cone Penetrometer Testing	Petrogenic	Relating to unburned petroleum products
CRM	Certified Reference Material	Ph	Phytane
DBT	Dibutyltin	Pr	Pristane
DCM	Dichloromethane	PRIMER	A statistical analysis program - Plymouth Routines in Multivariate Research
DDC	Drop Down Camera System	PSA/PSD	Particle Size Analysis/ Particle Size Distribution
DGNSS	Differential Global Navigation Satellite System	Pyrogenic	Produced under conditions involving intense heat (see pyrolytic)
DGPS	Differential Global Positioning Service	Pyrolytic	Produced under conditions involving intense heat (see pyrogenic)
EEA	European Environment Agency	QC	Quality Control
ERL	Effects Range Low	SAC	Special Area of Conservation
ERM	Effects Range Medium	SACFOR	JNCC (2013b) density scale classification: Superabundant, abundant, common, frequent, occasional and rare
ETRS	European Terrestrial Reference System	Sand	Sediment grains >63µm and <2mm in diameter
EUNIS	European Union Nature Identification System	SBES	Single Beam Echo Sounder
Fines	Sediment grains <63µm in diameter (same as Mud)	SBP	Sub Bottom Profiler
FOCI	Feature of Conservational Interest	SCI	Site of Community Importance
GC	Gas Chromatography	SEI	Significant Environmental Impact
GC-FID	Gas Chromatography Flame Ionisation Detection	SD	Standard Deviation
GC-MS	Gas Chromatography Mass Spectrometry	Silt	Sediment grains >3.9µm and <63µm in diameter
Gravel	Sediment grains >2mm in diameter	SNS	Southern North Sea
HDD	Portable Hard Disk Drive	Sorting	Measure of the range of grain sizes in a sediment sample
HMW	High Molecular Weight	SOW	Scope of Work
HOW4	Hornsea Project Four Offshore Wind Farm	SSS	Sidescan Sonar
ICP-MS	Inductively Coupled Plasma Mass Spectrometry	THC	Total Hydrocarbon Content
IDA	Industrial Denatured Alcohol	TOC	Total Organic Carbon
IUCN	International Union for Conservation of Nature	TBT	Tributyltin
JNCC	Joint Nature and Conservation Committee	UCM	Unresolved Complex Mixture
LAT	Lowest Astronomical Tide	UHRS	Ultra-High resolution seismic
LMW	Low Molecular Weight	UKAS	United Kingdom Accreditation Service
LOD	Limit of Detection	UKCS	United Kingdom Continental Shelf
Macrofauna	Organisms that are normally larger than the mesh size of the sieve used. In this case 1mm.	UKOGD	United Kingdom Oil and Gas Data (formerly UKDEAL)
MBES	Multi-beam Echo Sounder	USBL	Ultra Short Base Line
MBT	Monobutyltin	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<sup>2</sup> 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 system in order to provide ground truthing prior to sampling with a 0.1m<sup>2</sup> 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) <sup>1</sup>	Easting <sup>2</sup>	Northing <sup>2</sup>	Camera	Acceptable Grab Sample	Grab Samples Acquired <sup>3</sup>				
							Sub Samples				
							Fauna	Particle Size	Metals	Hydrocarbons	Spare <sup>4</sup>
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

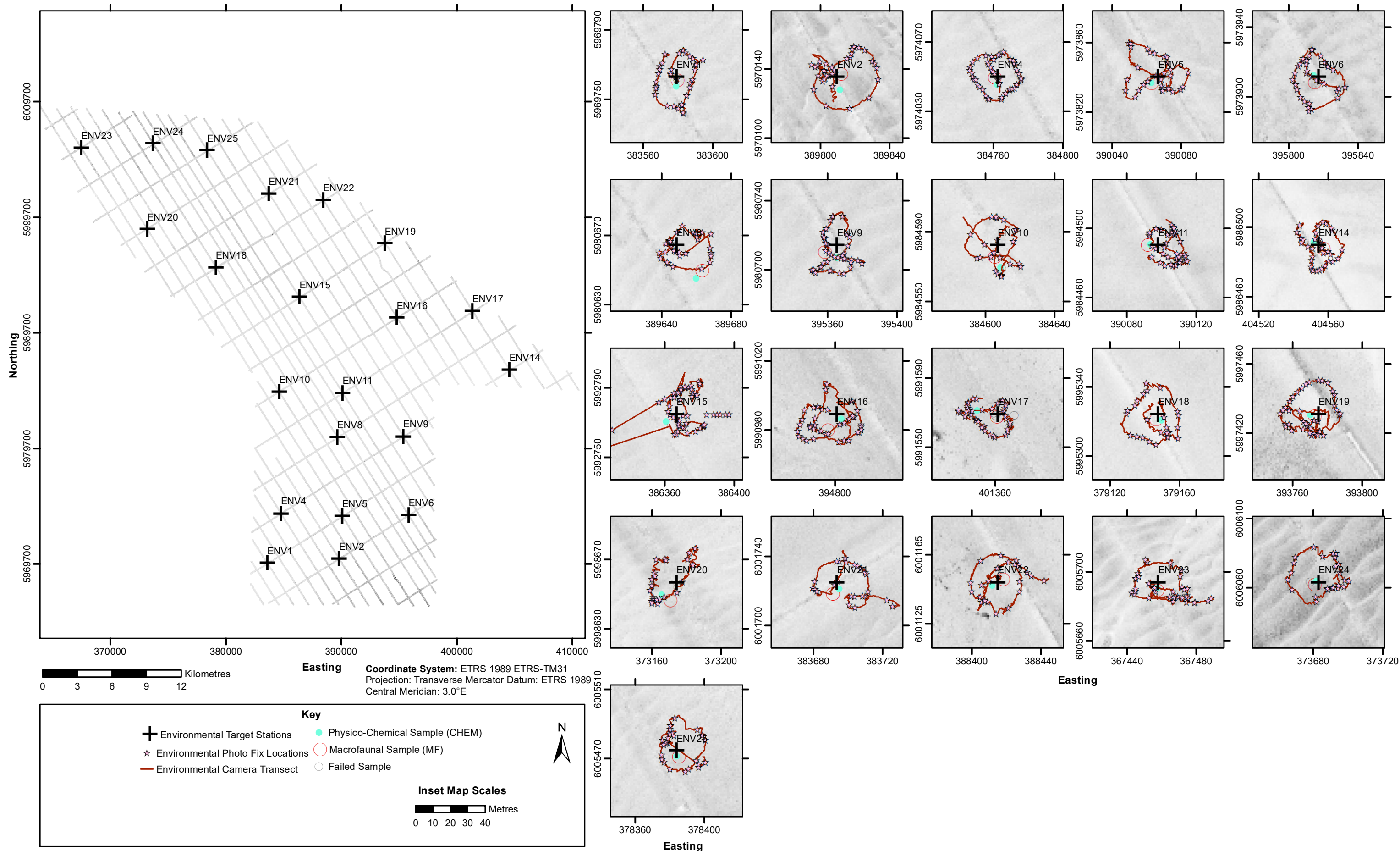
1 CHEM sample depth corrected to lowest astronomical tide (LAT)

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<sup>2</sup> 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<sup>2</sup> 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. marinus* 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

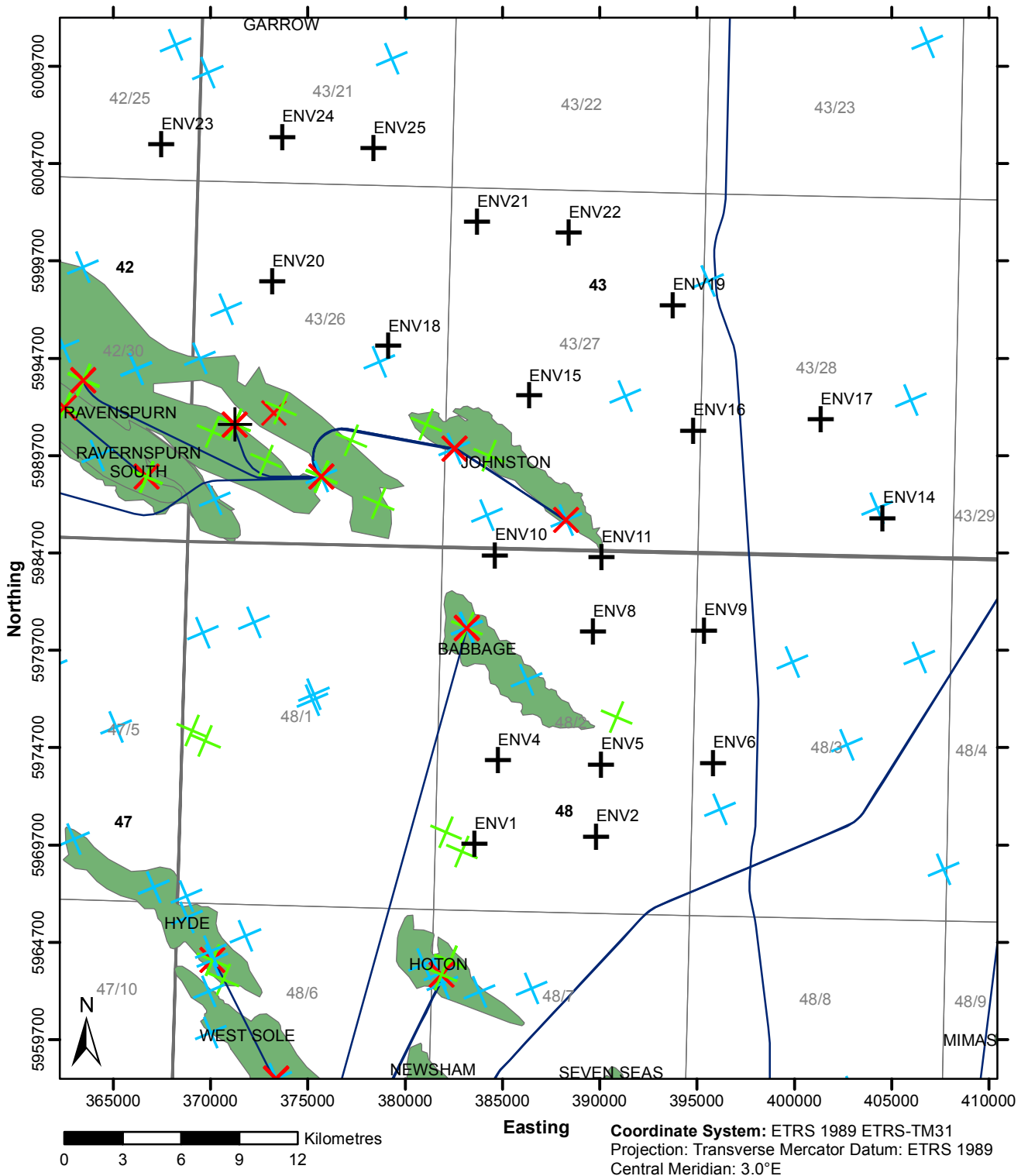
<1km from nearest station	1-2km from nearest station	2-3km from nearest station	3-4km from nearest station	>4km from nearest station
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**Table 1.3**      **Details of Existing Pipelines and Cables**

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



Key	
	Environmental Target Stations
	Existing Pipelines (UKOGD, 2017)
	Hydrocarbon Fields (UKOGA, 2018)
	Gas
	Completed Existing Wells
	Wells in the Process of Drilling
	Plugged and Abandoned Existing Wells
	Suspended Existing Wells

## 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  $<1^\circ$  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.

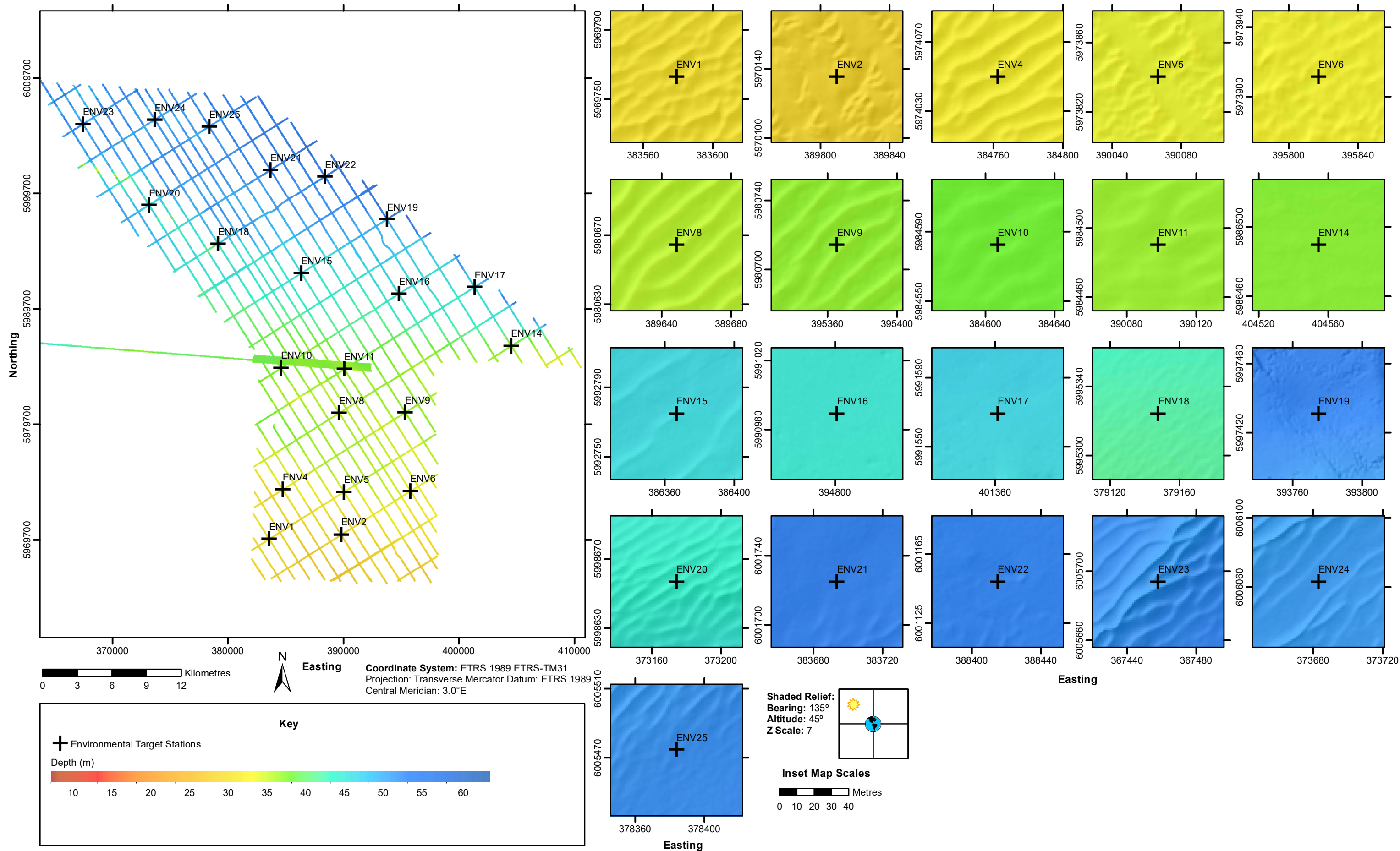
Numerous objects were present at seabed throughout the HOW4 survey area as identified on both SSS and bathymetry data. The majority of these were thought to be boulders (as defined by the USCS) although some were likely to be debris associated with the fishing activity in the area. Due to the mobile 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 megaripples 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 Ravenspurn 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 (*Ditropa*, *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* Ophiuroidea), 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<sup>2</sup> 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 <sup>2</sup> ) <sup>1</sup>	Burrows			
			Quantity	Size Range (diameter in cm)	Density (Burrows m <sup>2</sup> )	SACFOR Range <sup>2</sup>
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 FOCl (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 FOCl, 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 ( $\pm 117$  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 ( $\geq 63\mu\text{m}$  to  $< 2\text{mm}$ ) 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 (Folk, 1954) due to the proportion of gravel sized particles ( $\geq 2\text{mm}$ ) 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 ( $< 63\mu\text{m}$ ; 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% ( $\pm 0.05$  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 <sup>1</sup>	Modified Folk Classification	Broadscale Habitat Classification Based on Modified Folk Classification <sup>2</sup>	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	
<b>This Study</b>	<b>Minimum</b>	245	0.6	0.0	61.0	0.0	Fine to Coarse sand	Very Poor to Moderately well	Muddy sand to Gravelly Sand	Sand and muddy sand to Coarse Sediments	0.05
	<b>Maximum</b>	648	2.0	15.3	100.0	23.8					0.29
	<b>Mean</b>	414	1.3	4.9	92.0	3.1					0.13
	<b>±SD</b>	117	0.4	4.2	9.6	6.2					0.05

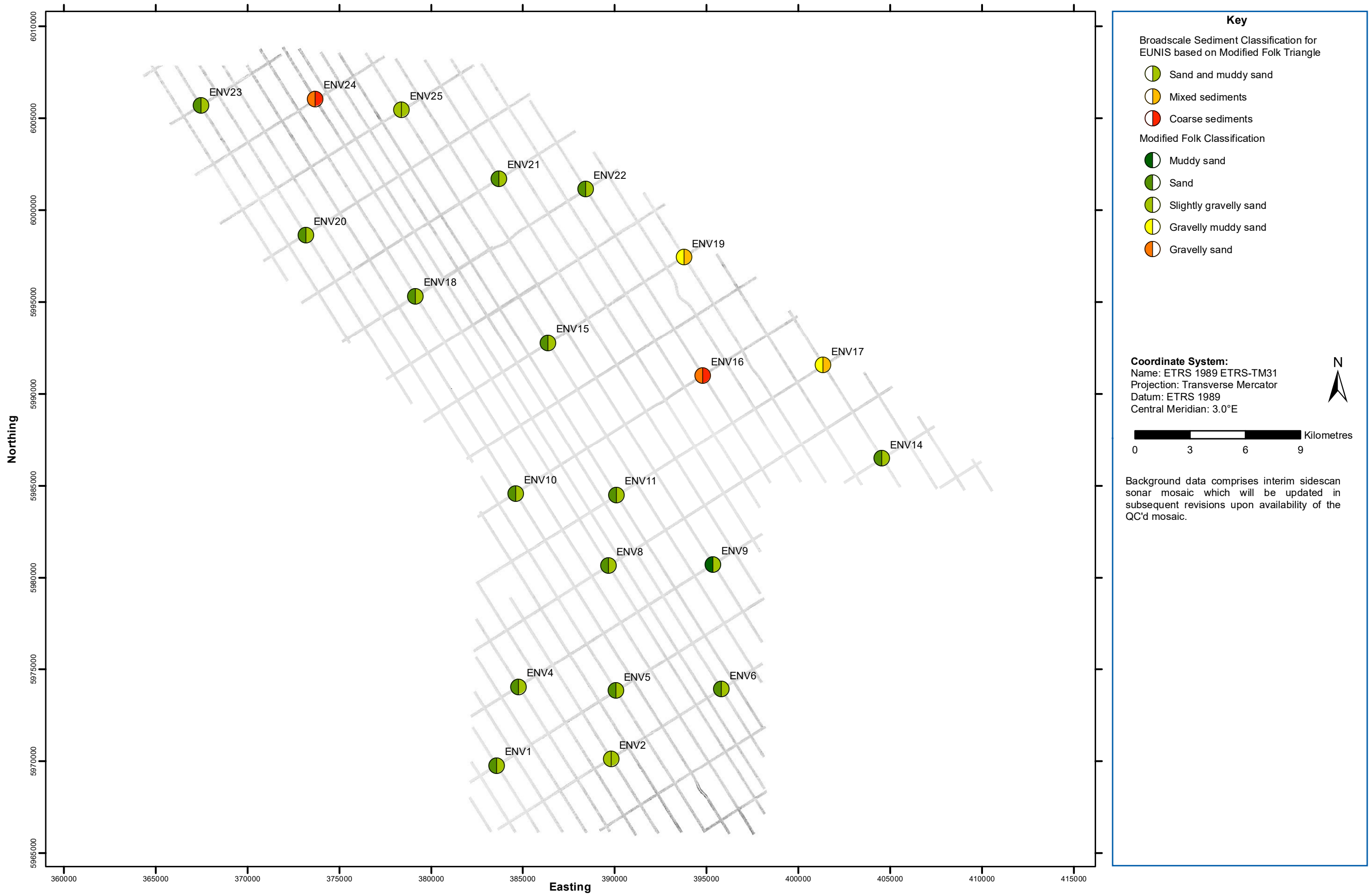
Sediments were not treated to remove carbonates prior to particle size analyses.

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  $1.6\mu\text{g g}^{-1}$  at Station ENV23 to  $8.6\mu\text{g g}^{-1}$  at Station ENV17, with a mean value of  $4.7\mu\text{g g}^{-1}$  ( $\pm 1.8$  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  $4.3\mu\text{g g}^{-1}$  (measured by GC) for stations over 5km from existing infrastructure in the SNS (latitudes below  $55^\circ\text{N}$ ) sampled between 1975 and 1995. Across the HOW4 survey area, THC values at seven stations exceeded the 95<sup>th</sup> percentile of  $11.39\mu\text{g g}^{-1}$  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  $50\mu\text{g g}^{-1}$  (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  $50\mu\text{g g}^{-1}$  to  $60\mu\text{g g}^{-1}$ , and that specific sensitive species may be impacted at levels greater than  $10\mu\text{g g}^{-1}$ . Mair *et al.* (1987) observed a notable increase in the dominance of opportunistic species at THC levels in excess of  $291.4\mu\text{g g}^{-1}$ . 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-alkanes 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  $n\text{C}_{20}$  and  $n\text{C}_{22}$ , around  $n\text{C}_{25}$ , and between  $n\text{C}_{29}$  to  $n\text{C}_{33}$ . Chromatograms with low level, HMW resolved n-alkanes and UCM, peaking from  $n\text{C}_{24}$  to  $n\text{C}_{36}$  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 alkanes. 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  $0.030\mu\text{g g}^{-1}$  at Station ENV18 to  $0.283\mu\text{g g}^{-1}$  at Station ENV17 with a mean value of  $0.128\mu\text{g g}^{-1}$  ( $\pm 0.068$  SD). To put these results into context, UKOOA (2001) recorded a mean n-alkane concentration of  $0.33\mu\text{g g}^{-1}$  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  $0.011\mu\text{g g}^{-1}$  at Station ENV18 to  $0.116\mu\text{g g}^{-1}$  at Station ENV2 with a mean value of  $0.041\text{g g}^{-1}$  ( $\pm 0.025$  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  $\geq 2$ , with values  $\geq 4.0$  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  $\geq 2$ , 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  $\leq 0.01 \mu\text{g g}^{-1}$  other than at Station ENV2 where the phytane concentration was  $0.039 \mu\text{g g}^{-1}$ . Pristane, an isoprenoid often associated with biogenic sources, was recorded at all stations with concentrations ranging between  $0.005 \mu\text{g g}^{-1}$  at Station ENV23 and  $0.048 \mu\text{g g}^{-1}$  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 <sup>1</sup>	Isoprenoids			NPD <sup>2</sup>	Total PAH	NPD <sup>3</sup> /4-6 Ring	
			nC <sub>10-20</sub>	nC <sub>21-37</sub>	nC <sub>10-37</sub>		Pristane (Pr)	Phytane (Ph)	P/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 µg g<sup>-1</sup> 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
nC10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC11	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
nC12	<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
nC13	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
nC14	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
nC15	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
nC16	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
nC17	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
nC18	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
nC19	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
nC20	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
nC21	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
nC22	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
nC23	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
nC24	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
nC25	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
nC26	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
nC27	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
nC28	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
nC29	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
nC30	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
nC31	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
nC32	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
nC33	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
nC34	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
nC35	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
nC36	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
nC37	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
<b>Total</b>	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<sup>-1</sup> 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 0.013 $\mu\text{g g}^{-1}$  at Station ENV18 to 0.248 $\mu\text{g g}^{-1}$  at Station ENV17 with a mean value of 0.093 $\mu\text{g g}^{-1}$  (0.059 SD), while NPD concentrations recorded values between 0.007 $\mu\text{g g}^{-1}$  and 0.097 $\mu\text{g g}^{-1}$  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 than 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 4.022 $\mu\text{g g}^{-1}$  and 44.792 $\mu\text{g g}^{-1}$ , respectively. Concentrations below the ERL represent a range in which toxic effects would rarely be observed, whilst concentrations  $\geq$ ERL but  $\leq$ 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 (1.2 $\mu\text{g g}^{-1}$  and 7.9 $\mu\text{g g}^{-1}$ ) 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

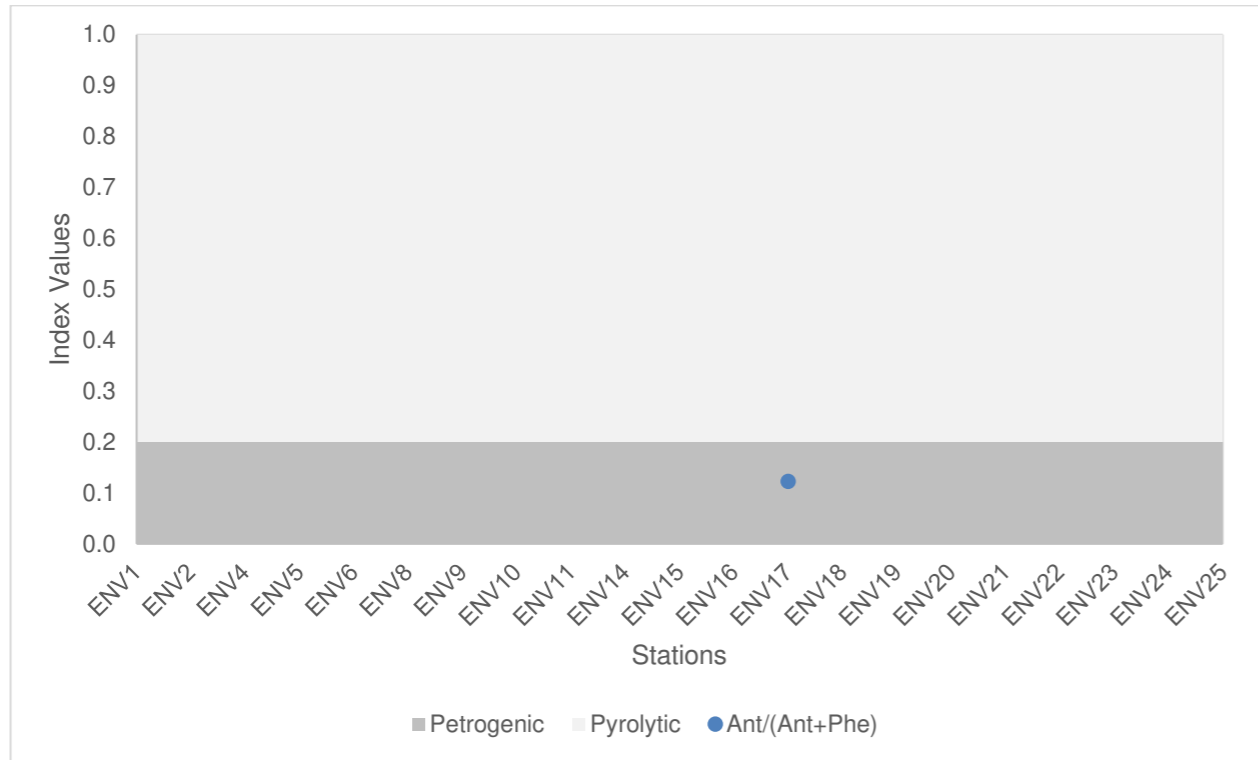
assessment concentrations (BACs; OSPAR, 2005). Comparison to the ERL and ERM requires normalisation of the data to 1% TOC (Long *et al.*, 1995), while comparison to BCs and BACs requires normalisation to 2.5% TOC (OSPAR, 2005), all of which is presented in Appendix I.

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, Fluoranthene, 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.

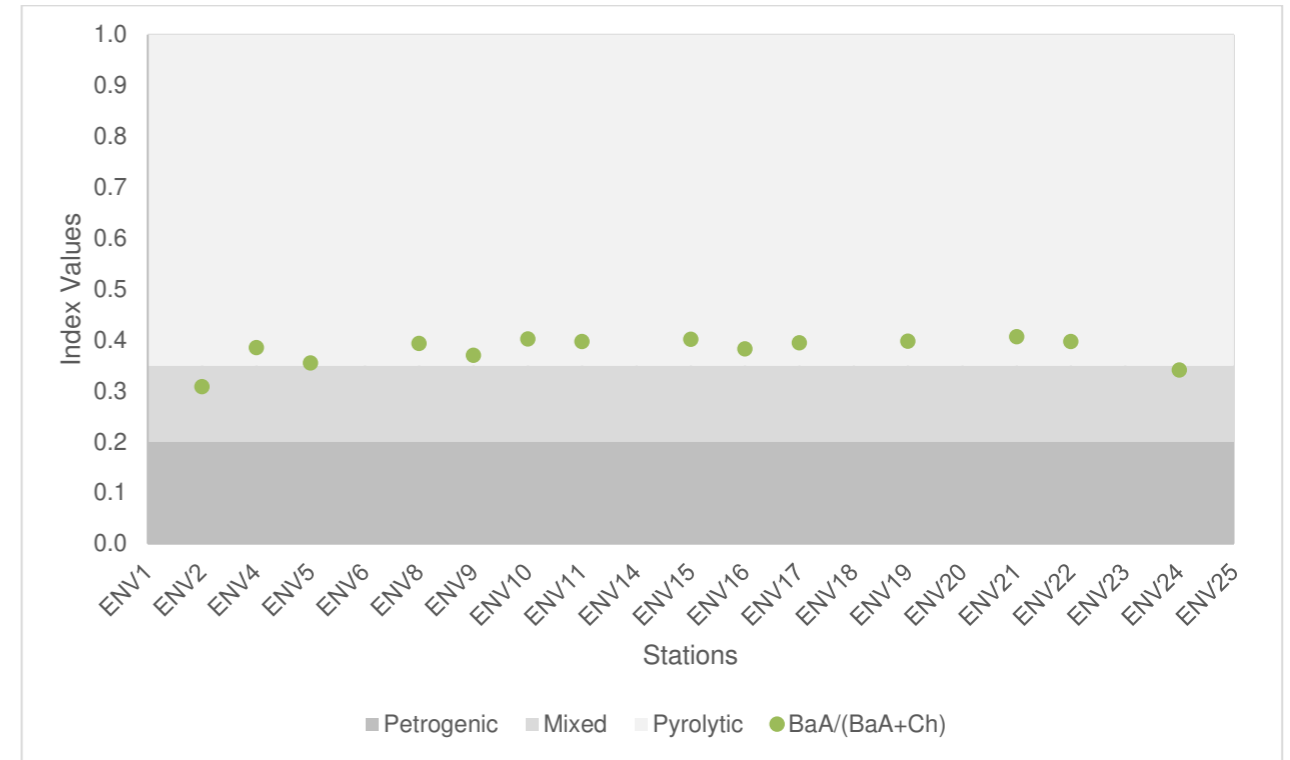
Further information on the origin of the PAHs can be derived from the molecular weight indices as presented in Figure 2.3. Calculated ratios of the 202 and 276 indices identified these US EPA 16 PAHs to be of petrogenic origin whilst the 228 indices predominantly showed a pyrolytic origin with the exception 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

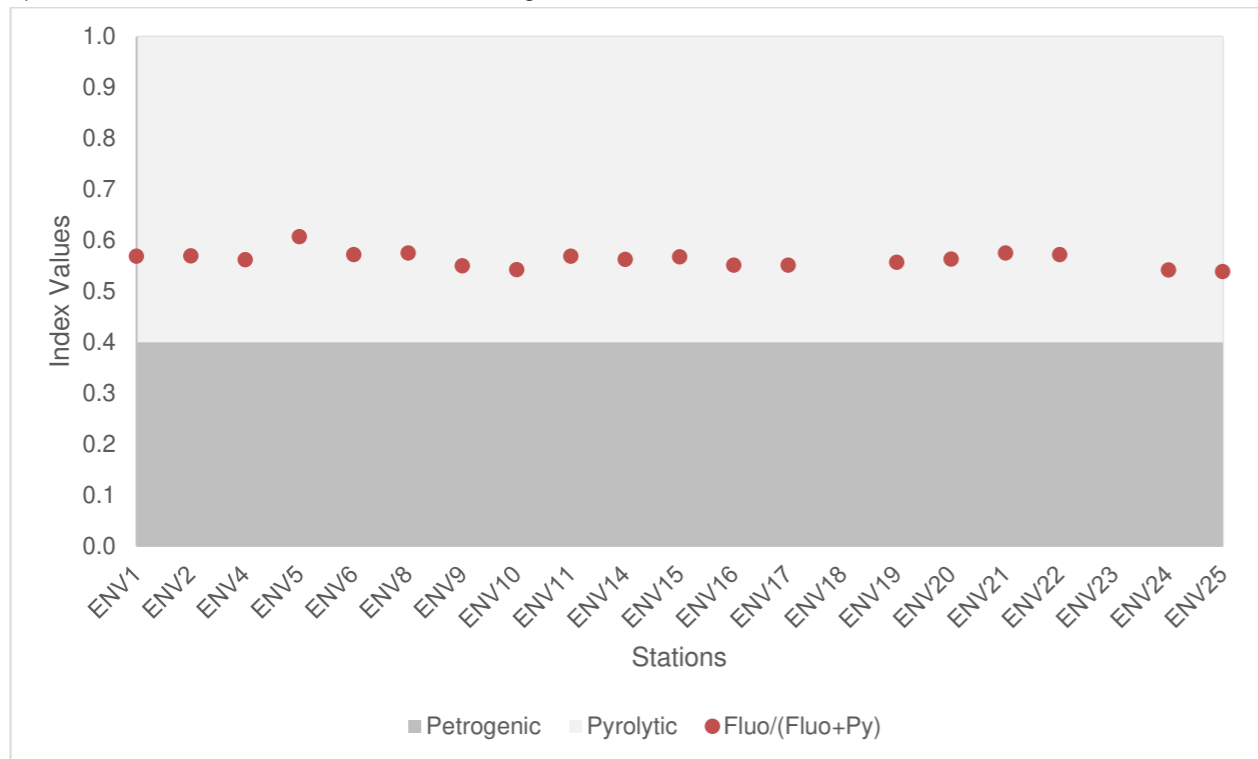
a) Calculated Ratio of 178 Molecular Weights PAH Index



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

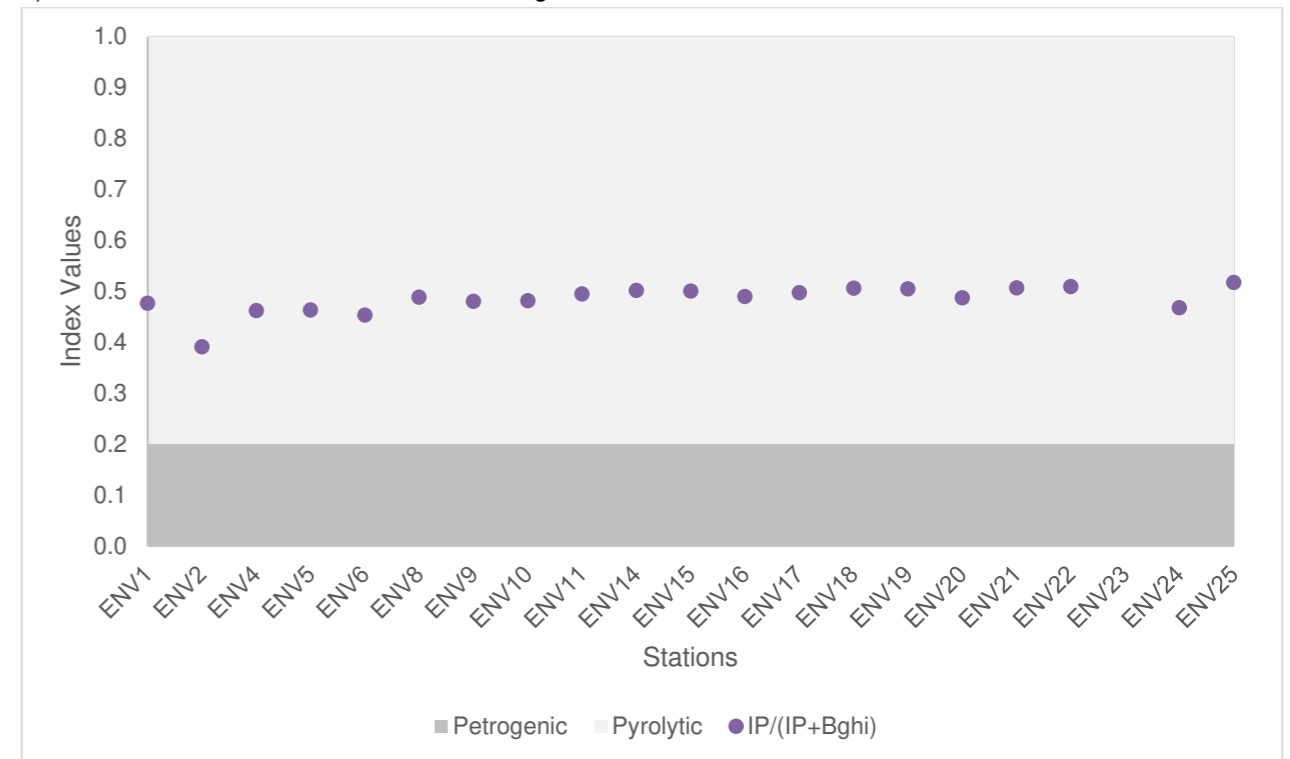


Table 2.5 PAH Concentrations

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
<b>Total 128</b>	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
<b>Total 178</b>	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
<b>Total 184</b>	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
<b>Total 202</b>	8	18	28	15	11	13	24	29	12	11	24	25	40	NC	26	7	17	14	3	17	7
Benzenanthracene/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
<b>Total 228</b>	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
<b>Total 252</b>	6	13	24	11	9	16	24	34	15	13	33	31	52	3	35	7	22	20	3	14	7
Anthranthrenes/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
<b>Total 276</b>	4	7	16	6	7	11	16	22	10	9	24	22	37	3	26	5	15	14	2	11	6
<b>Total NPD<sup>1</sup></b>	15	36	60	19	21	27	50	56	20	20	50	56	97	7	58	14	36	27	10	51	15
<b>Total 2 to 6 ring PAH</b>	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<sup>-1</sup> dry weight sediment

<sup>1</sup> naphthalenes, 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<sup>-1</sup> 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 mineralogy 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  $<1\text{ng g}^{-1}$  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  $1\text{ng g}^{-1}$  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	Mercury <sup>1</sup>	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<sup>2</sup> 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 ENV25 respectively with a total biomass of 7.200\*10<sup>-3</sup>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; Fomnifera (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 contributed 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
<b>Total</b>	<b>2552</b>	<b>100</b>	<b>154</b>	<b>100</b>

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

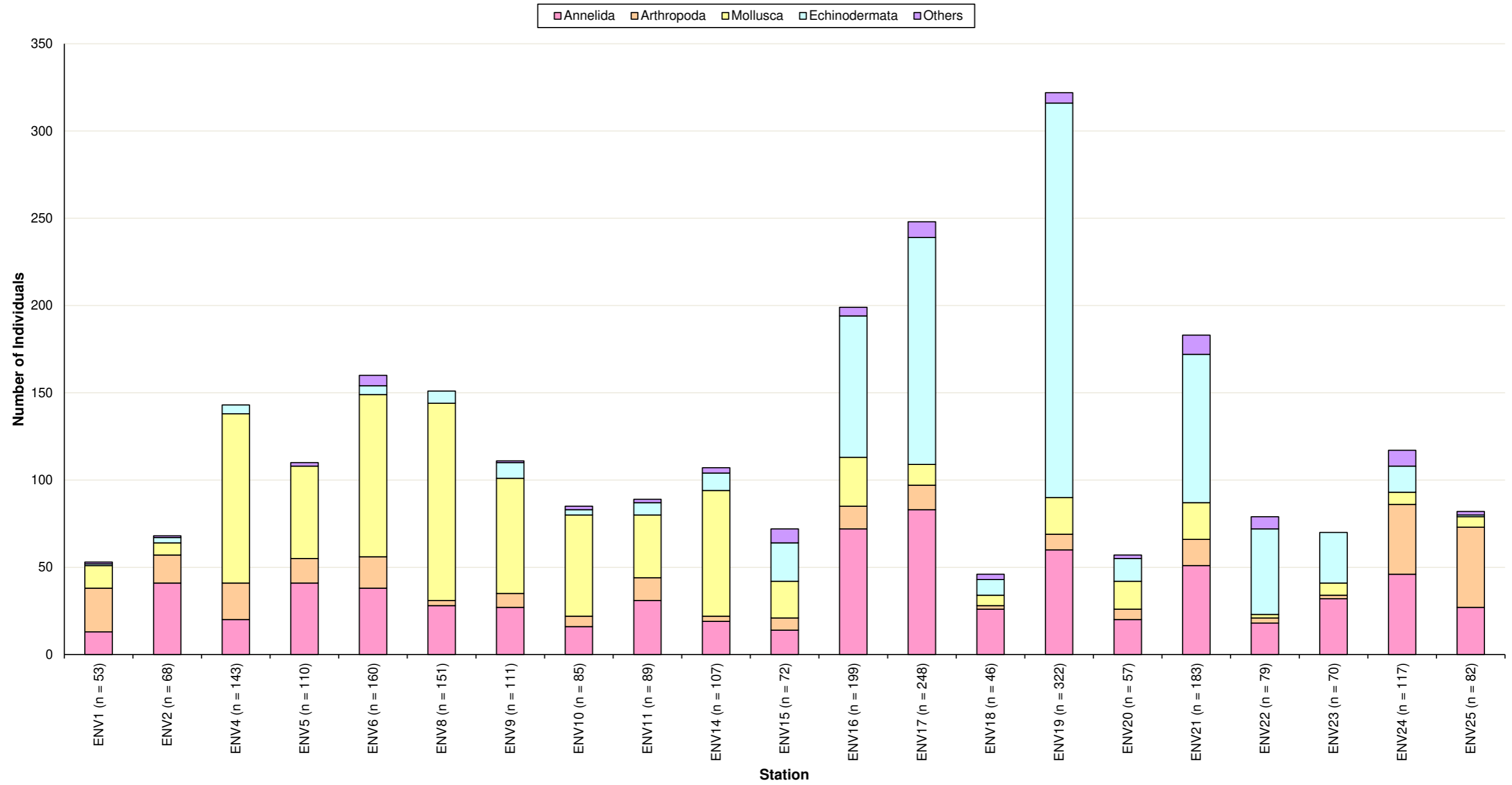
Sample	Sample Biomass (g)					Subtotal
	Annelida	Arthropoda	Mollusca	Echinodermata	Other	
ENV1	0.416	0.030	0.271	4.882	0.228	5.827
ENV2	0.608	0.014	0.272	54.655	0.005	55.555
ENV4	0.416	0.023	0.324	0.008	0.000	0.771
ENV5	0.906	0.012	13.709	0.000	0.007	14.634
ENV6	0.775	0.063	0.210	0.037	0.019	1.104
ENV8	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
<b>Total</b>	<b>12.628</b>	<b>2.419</b>	<b>47.095</b>	<b>134.641</b>	<b>1.254</b>	<b>198.037</b>
<b>Proportional Contribution</b>	<b>6.4</b>	<b>1.2</b>	<b>23.8</b>	<b>68.0</b>	<b>0.6</b>	<b>100.0</b>

Cells highlighted grey where no biomass observed



Figure 2.4 Contributions of Gross Taxonomic Groups – Adult Fauna Data

a) Individuals



b) Taxa

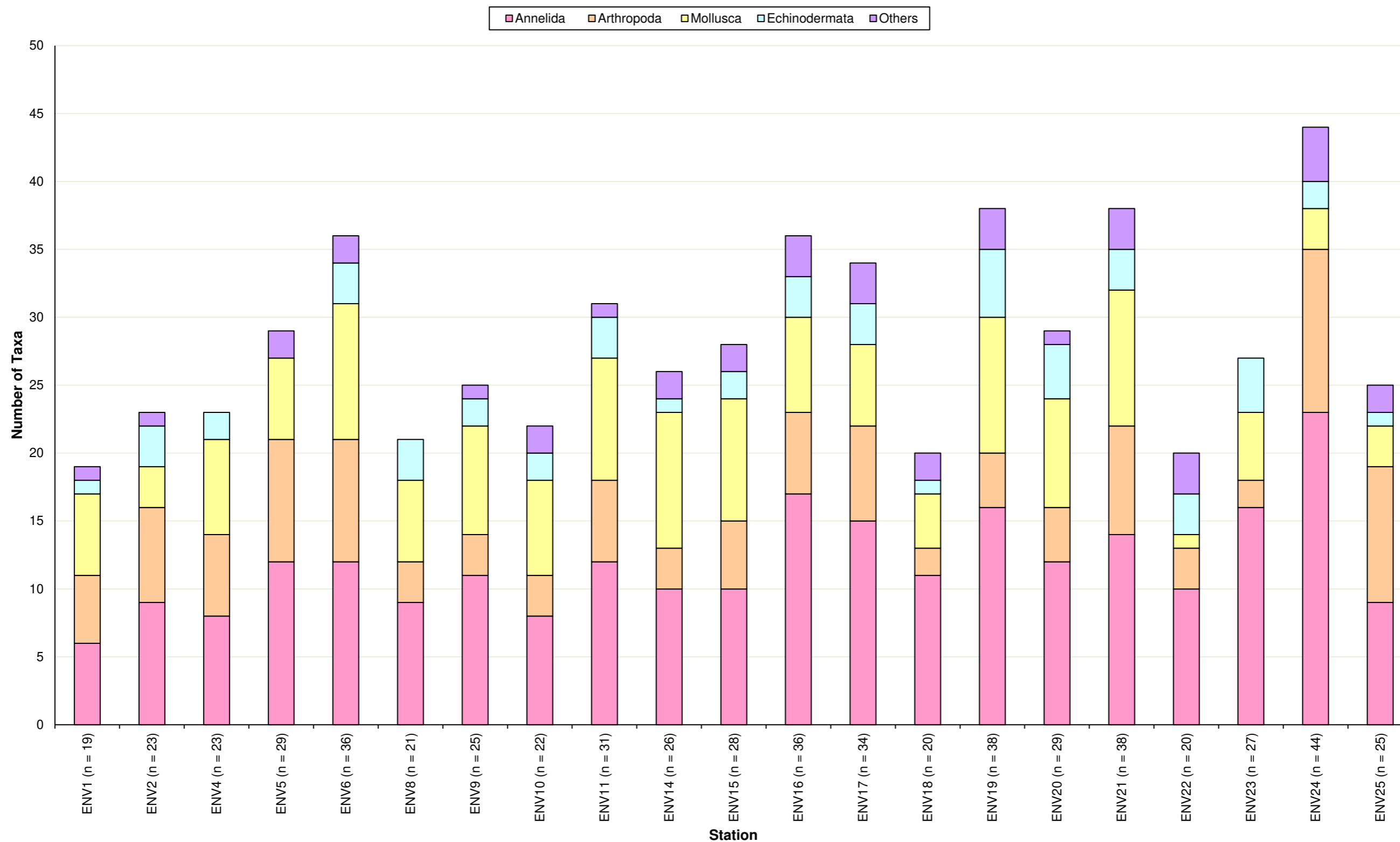
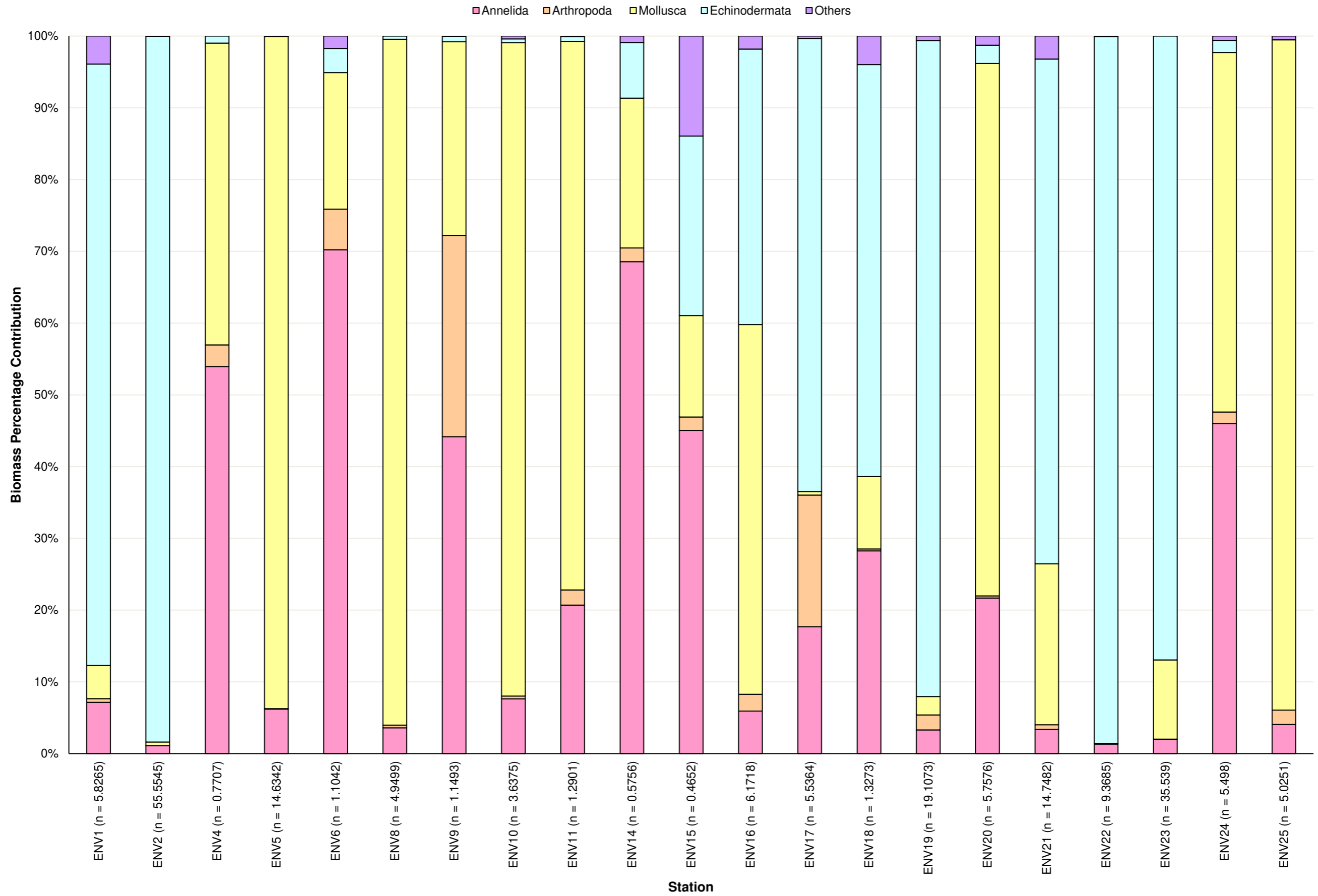


Figure 2.5 Percentage Biomass Contribution to Gross Taxonomic Groups - Adult Fauna Data



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 highest ranking 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 Dalssen *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  $\geq 0.8$  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

Score	Rank		Species/Taxon	Total Rank Score	Fidelity	Total Abundance
	Abundance					
1	2		<i>Abra</i>	124	0.59	458
2	1		<i>Amphiura filiformis</i>	111	0.59	508
3	8		<i>Spiophanes bombyx</i>	89	0.53	59
4	5		<i>Fabulina fabula</i>	76	0.52	72
5	10		<i>Lagis koreni</i>	71	0.56	46
6	13		<i>Scoloplos armiger</i>	68	0.65	43
7	3		Amphiuridae	66	0.79	96
8	10		<i>Amphictene auricoma</i>	64	1.02	46
8	14		Nemertea	64	1.52	36
10	12		<i>Nephtys cirrosa</i>	62	2.95	44
Species which were in top ten abundance rank but not top ten rank score						
14	4		<i>Scalibregma inflatum</i>	49	NC	88
15	6		<i>Echinocyamus pusillus</i>	47	NC	70
17	7		<i>Pholoe</i>	45	NC	60
11	9		<i>Ophelia borealis</i>	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	<i>Amphiura filiformis</i>	79	0.38	6.93
2	1	<i>Echinocardium cordatum</i>	60	0.32	115.33
3	17	<i>Nephtys cirrosa</i>	59	0.35	0.99
4	20	<i>Lagis koreni</i>	46	0.31	0.72
5	2	<i>Dosinia lupinus</i>	40	0.32	14.80
6	14	<i>Sigalion mathildae</i>	39	0.37	1.02
7	27	<i>Sthenelais limicola</i>	37	0.44	0.43
8	16	<i>Scalibregma inflatum</i>	36	0.57	1.00
9	23	<i>Scoloplos armiger</i>	35	0.83	0.59
10	6	<i>Nephtys caeca</i>	34	1.62	3.65
Species which were in top ten biomass rank but not top ten rank score					
36	3	<i>Ensis ensis</i>	10	NC	13.47
21	4	<i>Echinocardium</i>	19	NC	8.0532
18	7	<i>Chamelea striatula</i>	22	NC	3.5616
14	8	<i>Dosinia</i>	28	NC	3.4885
40	9	<i>Gari fervensis</i>	9	NC	3.332
36	10	<i>Macra stultorum</i>	10	NC	3.2345

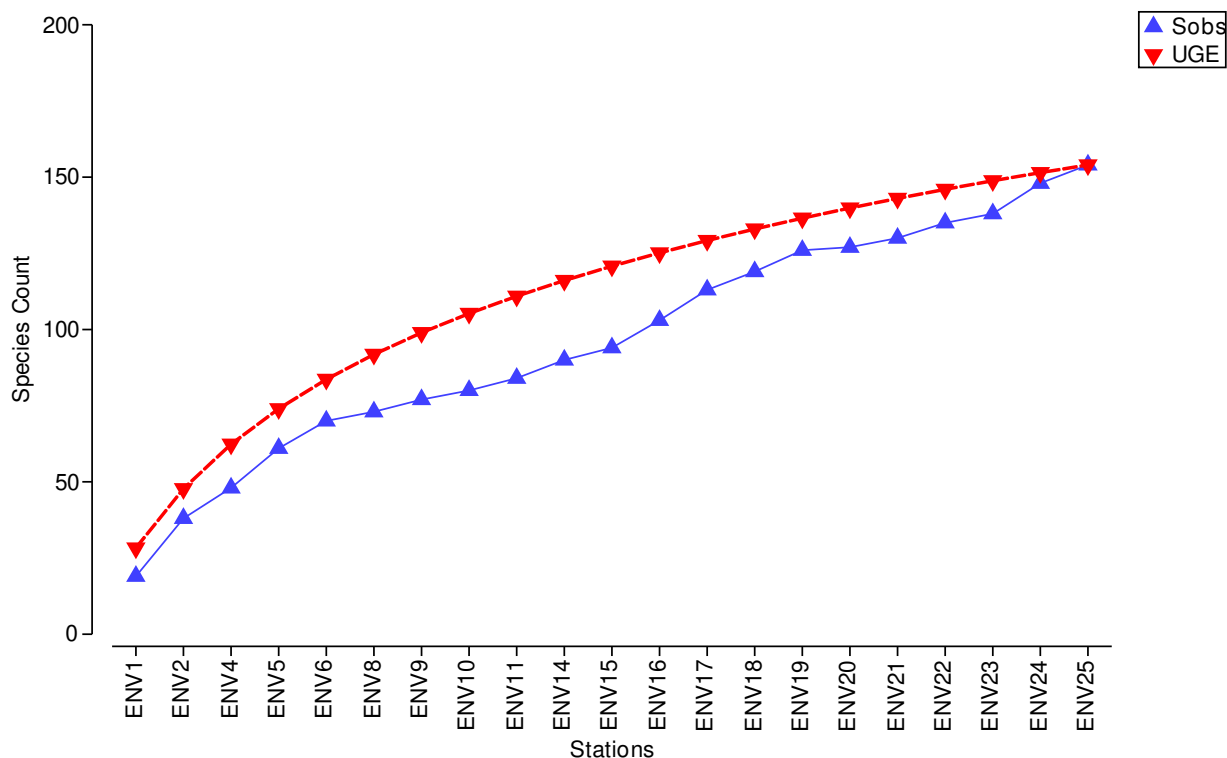
Cells are coloured to indicate the gross taxonomic division. Annelida, Echinodermata and Mollusca.

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 ( $\lambda$ ), 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 ( $\lambda$ )	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.

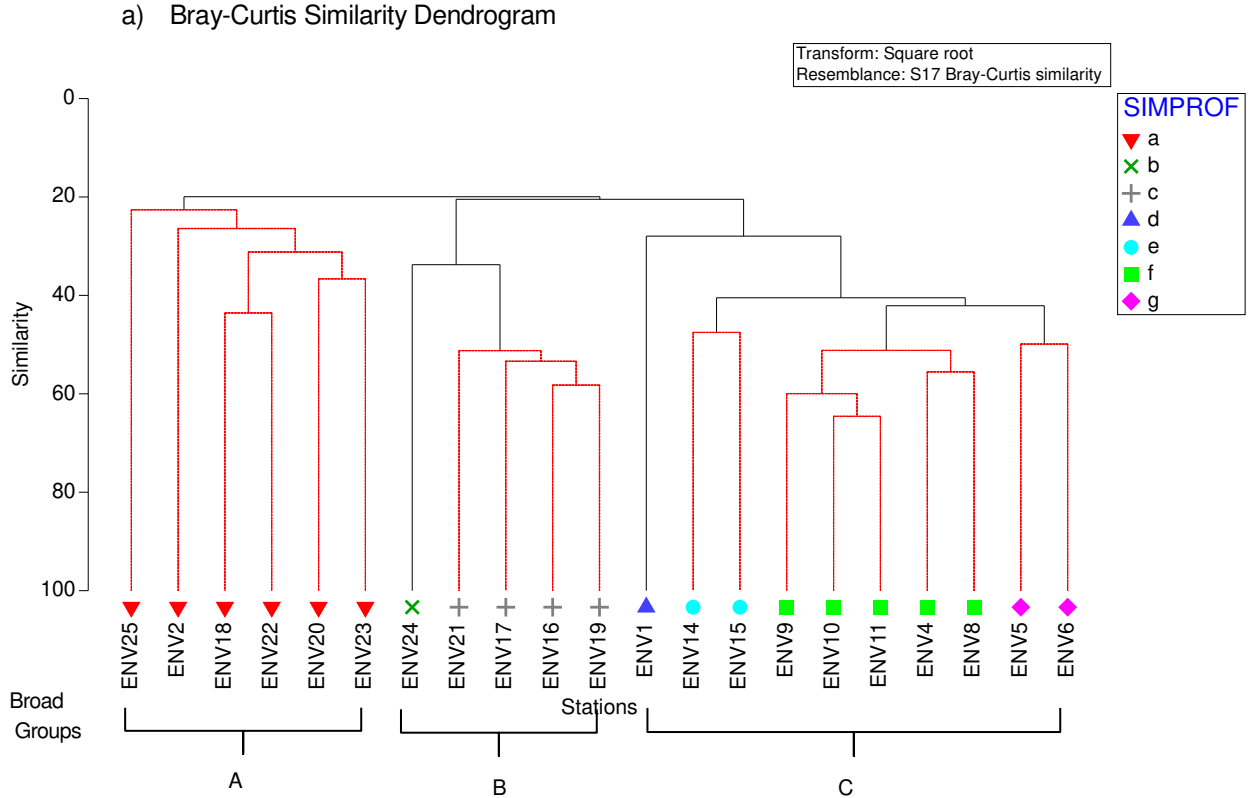
The CLUSTER analysis and dendrogram of showed variation in the adult only abundance data set (Figure 2.7a). The CLUSTER analysis presented three distinct broadscale groups (group A, group B and group C). Broad group A (SIMPROF a; Stations ENV25, ENV2, ENV18, ENV22, ENV20 and ENV23) was separated from 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



b) MDS Ordination

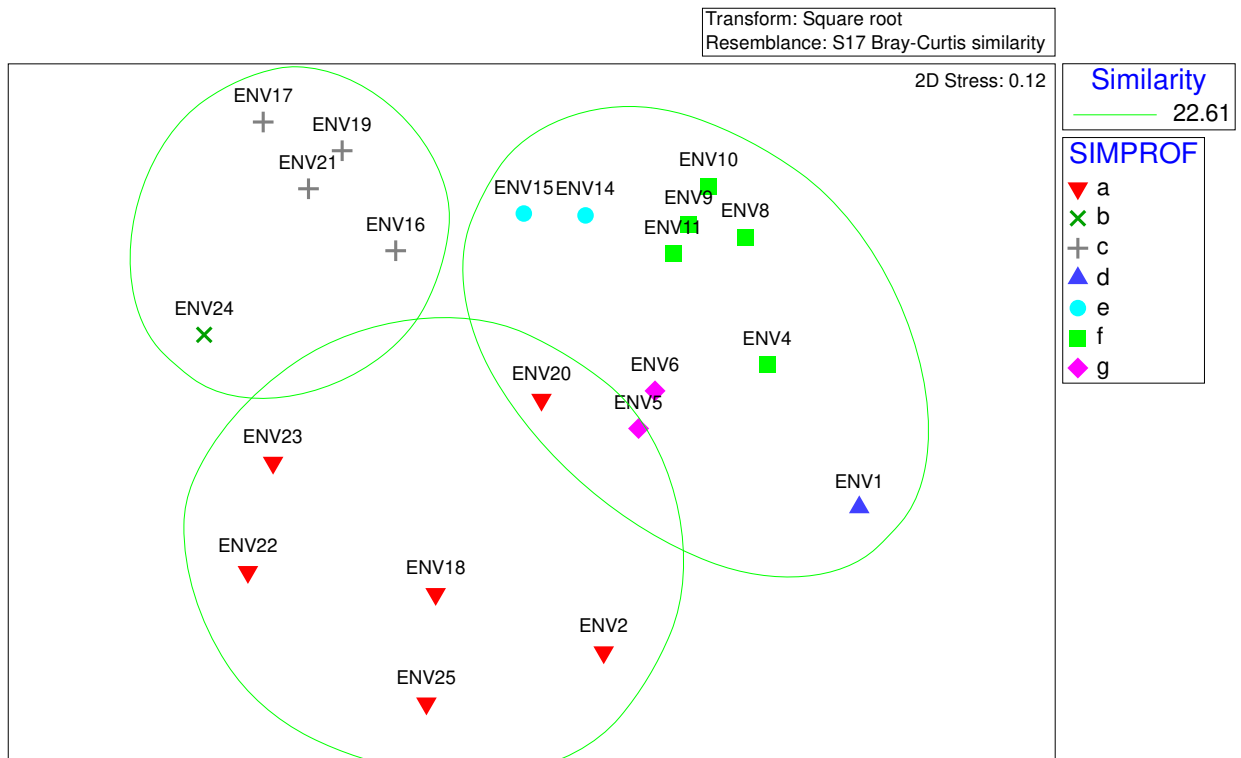
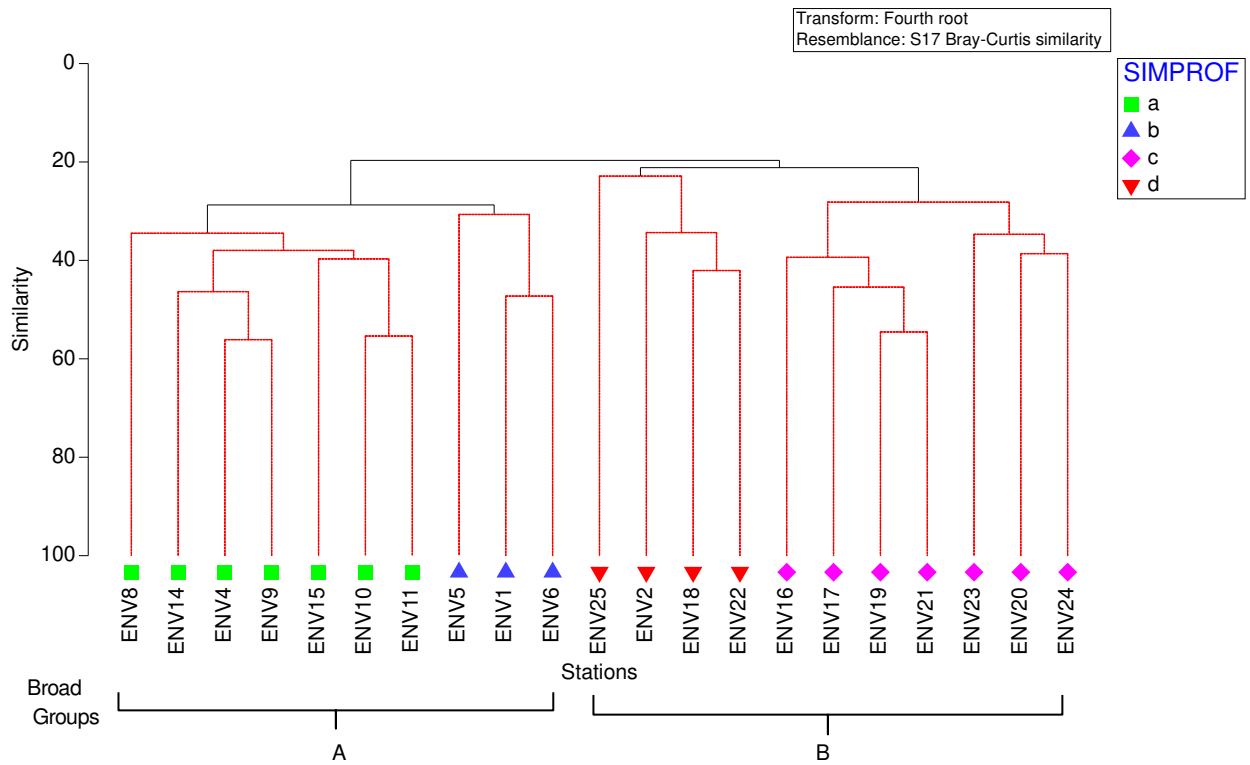
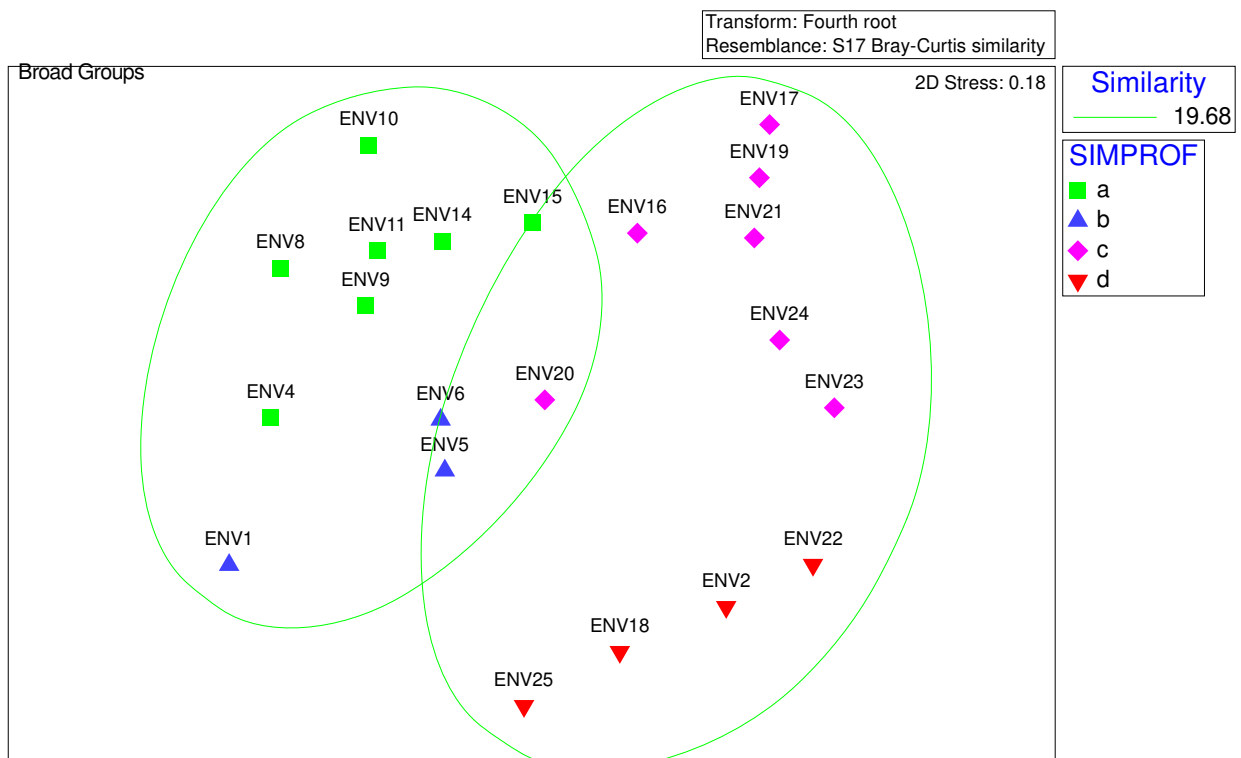


Figure 2.8 Multivariate Analysis of Faunal Biomass Data

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

<sup>2</sup> Observed depth at time of sampling corrected to LAT

<sup>3</sup> 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 FOCl, 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 FOCl (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 ( $\geq 63\mu\text{m}$  to  $< 2\text{mm}$ ) 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 ( $\geq 2\text{mm}$ ) and fines ( $< 63\mu\text{m}$ ) accounted for a greater proportion of the sediment. Where this was the case, sediments were described as muddy sand, slightly gravelly sand, gravelly sand and gravelly 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  $0.013\mu\text{g g}^{-1}$  at Station ENV18 to  $0.248\mu\text{g g}^{-1}$  at Station ENV17 whilst NPD concentrations ranged between  $0.007\mu\text{g g}^{-1}$  and  $0.097\mu\text{g g}^{-1}$ . 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 1 ng g<sup>-1</sup> 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. <i>Ocean Endeavour</i>						
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 ( <i>Asterias rubens</i> , <i>Astropecten irregularis</i> ), 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 occasional shell fragments	Echinodermata ( <i>A. irregularis</i> ), 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 occasional shell fragments	Echinodermata ( <i>A. irregularis</i> ), 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 occasional shell fragments	Echinodermata ( <i>A. irregularis</i> ), 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 occasional shell fragments	Echinodermata, ( <i>A. rubens</i> ), 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, occasional shell fragments present	Echinodermata (Echinoidea), Chordata (Callionymidae, Scorpaeniformes, Pleuronectiformes, Scylorhinidae), Cnidaria (Actinaria, <i>Alcyonium digitatum</i> )	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 ( <i>A. rubens</i> , Ophiuroidea), Chordata (Callionymidae, Pleuronectiformes), Cnidaria (Actinaria, <i>A. digitatum</i> )	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, ( <i>A. rubens</i> ), 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 ( <i>A. irregularis</i> , Ophiuroidea), Chordata (Gadidae, Pleuronectiformes), Cnidaria ( <i>A. digitatum</i> )	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 occasional shell fragments. Burrows were present	Echinodermata, ( <i>A. rubens</i> , <i>A. irregularis</i> ), 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. <i>Ocean Endeavour</i>						
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)							
ENV15	15-Sep-18	21:01:04	21:06:58			2018-09-15_21-01-04_ENV15	Sand with shell fragments	Echinodermata, ( <i>A. rubens</i> , <i>A. irregularis</i> , 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, ( <i>A. rubens</i> , <i>A. irregularis</i> , 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, ( <i>A. rubens</i> , <i>A. irregularis</i> , 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 ( <i>A. rubens</i> , <i>A. irregularis</i> , 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 ( <i>A. irregularis</i> , 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 ( <i>A. rubens</i> , <i>A. irregularis</i> ), 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 ( <i>A. irregularis</i> , 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 ( <i>A. irregularis</i> , 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 ( <i>A. rubens</i> , <i>A. irregularis</i> ), 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 ( <i>A. irregularis</i> ), 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 ( <i>A. rubens</i> , <i>A. irregularis</i> ), 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 ( <i>A. rubens</i> , <i>A. irregularis</i> , 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. <i>Ocean Endeavour</i>						
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 ( <i>A. rubens</i> , Ophiuroidea), Chordata (Plueronectiformes)	GD	34	677	710	

## APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

	Seafloor Sampling Positioning Summary																				
Job No		11210						Vessel		M.V <i>Ocean Endeavour</i>											
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

	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

	Seafloor Sampling Positioning Summary																	
Job No	11210							Vessel	M.V <i>Ocean Endeavour</i>									
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


	Seafloor Sampling Positioning Summary																	
Job No		11210					Vessel		M.V <i>Ocean Endeavour</i>									
Client		Ørsted					Vessel Reference Point (VRP)		CoG									
Project Name		Horsea 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	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

	Seafloor Sampling Positioning Summary																
Job No	11210							Vessel	M.V <i>Ocean Endeavour</i>								
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

	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	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 <i>Ocean Endeavour</i>								
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


	Seafloor Sampling Positioning Summary																			
Job No		11210						Vessel			M.V <i>Ocean Endeavour</i>									
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

	Seafloor Sampling Positioning Summary																
Job No	11210							Vessel	M.V <i>Ocean Endeavour</i>								
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

	Seafloor Sampling Positioning Summary																		
Job No		11210						Vessel			M.V <i>Ocean Endeavour</i>								
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 <i>Ocean Endeavour</i>									
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

	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

	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


	Seafloor Sampling Positioning Summary																
Job No		11210					Vessel		M.V <i>Ocean Endeavour</i>								
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

	Seafloor Sampling Positioning Summary																
Job No		11210						Vessel		M.V <i>Ocean Endeavour</i>							
Client		Ørsted						Vessel Reference Point (VRP)		CoG							
Project Name		Horsea 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

	Seafloor Sampling Positioning Summary																		
Job No		11210						Vessel			M.V <i>Ocean Endeavour</i>								
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	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)		

## APPENDIX D SAMPLING AND SEABED PHOTOGRAPHS

	Seafloor Sampling Positioning Summary																			
Job No		11210						Vessel			M.V <i>Ocean Endeavour</i>									
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) <span style="float: right;">QPRO-0755</span>										
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 <i>Arctica islandica</i> 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 <i>A. islandica</i> 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) <span style="float: right;">QPRO-0755</span>										
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) <span style="float: right;">QPRO-0755</span>										
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 with 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	Annelida (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

	Seafloor Sampling Positioning Summary																		
Job No		11210						Vessel				M.V. <i>Ocean Endeavour</i>							
Client		Ørsted						Vessel Reference Point (VRP)				CoG							
Project Name		Horsea 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. <i>Ocean Endeavour</i>							
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 ( $\beta$ ) by 29.9° vertical ( $\alpha$ )
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<sup>2</sup> 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 than 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 ( $\pm 4.5$  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 <sup>-2</sup>	S	S	S	S
≥1000 m <sup>-2</sup> to <10000 m <sup>-2</sup>	A	S	S	S
≥100 m <sup>-2</sup> to <1000 m <sup>-2</sup>	C	A	S	S
≥10 m <sup>-2</sup> to <100 m <sup>-2</sup>	F	C	A	S
≥1 m <sup>-2</sup> to <10 m <sup>-2</sup>	O	F	C	A
≥0.1 to <1 m <sup>-2</sup>	R	O	F	C
≥0.01 m <sup>-2</sup> to <0.1 m <sup>-2</sup>	R	R	O	F
≥0.001 m <sup>-2</sup> to <0.01 m <sup>-2</sup>	R	R	R	O
<0.001 m <sup>-2</sup>	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 ( $-\log_2(\text{diamm})$ ), Folk & Ward, 1957).

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

where  $M_z$  = The graphic mean particle size in phi  
 $\phi$  = the phi size of the  $n^{\text{th}}$  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.

$$\sigma_1 = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$$

where  $\sigma_1$  = 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.

$$S = \frac{\phi_{16} + \phi_{84} - 2(\phi_{50})}{2(\phi_{84} - \phi_{16})} + \frac{\phi_5 + \phi_{95} - 2(\phi_{50})}{2(\phi_{95} - \phi_5)}$$

where  $S$  = the skewness of the sample

- 4 Graphic Kurtosis – The degree of peakedness or departure from a 'normal' frequency or cumulative curve. Kurtosis classifications are presented in Table B.6.

$$K = \frac{\phi_{95} - \phi_5}{2.44(\phi_{75} - \phi_{25})}$$

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

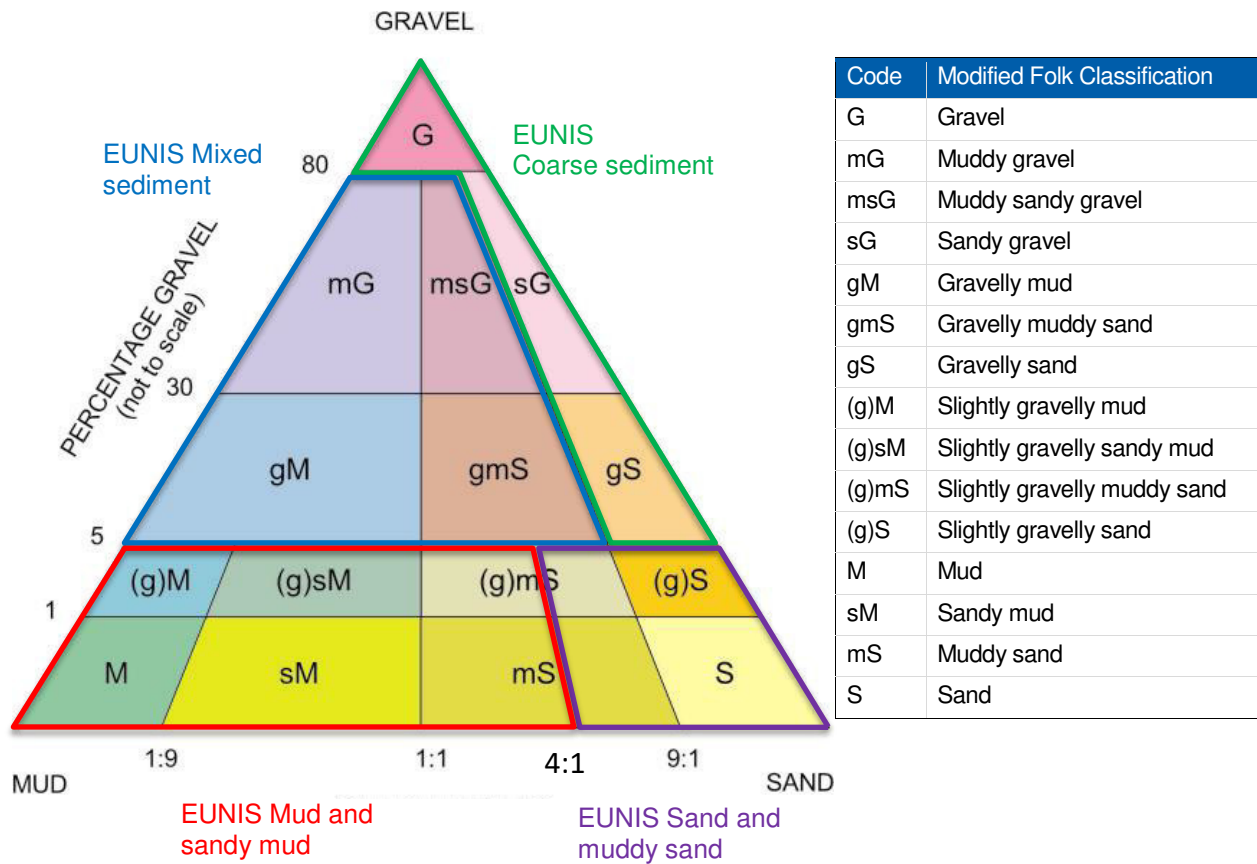
**Table B.5 Skewness Classification**

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
$\leq 0.67$	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	
$\geq 3.00$	Extremely Leptokurtic	

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



### B.6 Total Organic Carbon

A 0.25g aliquot of air dried and ground (particle size <math><118\mu\text{m}</math>) 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<sub>2</sub>) 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 120°C 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<sub>10</sub> – nC<sub>40</sub> alkane groups. The second CCC is a diesel/mineral oil mix which provides the odd alkane group retention times from nC<sub>11</sub> – nC<sub>27</sub>, 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<sub>10</sub>-nC<sub>37</sub> 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<sup>-1</sup> for PAHs, 1ng g<sup>-1</sup> for individual n-alkanes and 100ng g<sup>-1</sup> 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<sup>-1</sup> 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
Element	Atomic Mass Units	LOD ( $\mu\text{g g}^{-1}$ )
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 ( $\mu\text{g g}^{-1}$ )
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 than 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<sub>20</sub> to nC<sub>36</sub> range is most informative, whilst Farrington and Tripp (1977) suggest CPI calculated using nC<sub>27</sub> to nC<sub>33</sub> 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<sub>29</sub>), 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<sub>27</sub> to nC<sub>33</sub> 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  $i^{\text{th}}$  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 will 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  $\lambda$  = Simpson's Dominance Index  
 $p_i$  = proportion of the total number of individuals from the  $i^{\text{th}}$  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<sub>10</sub> to nC<sub>37</sub>), 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<sub>20</sub> and nC<sub>34</sub>, centred on nC<sub>29</sub> 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<sub>n</sub>H<sub>2n+2</sub> (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<sub>18</sub> and nC<sub>19</sub>. 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-alkane 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 1 ng g<sup>-1</sup> in deep-water oceanic sediments up to a few mg g<sup>-1</sup> 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  $0.55\mu\text{g g}^{-1}$  and  $1.70\mu\text{g g}^{-1}$ , respectively. ERM concentrations are  $3.16$  and  $9.60\mu\text{g g}^{-1}$  for LMW and HMW PAHs, respectively. The ERL and ERM concentrations for total PAH concentration in sediments are  $4.022\mu\text{g g}^{-1}$  and  $44.792\mu\text{g g}^{-1}$ , 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 ( $\text{BaSO}_4$ ). In exceptional cases, fine-grained marine sediments may naturally contain in excess of  $1000\mu\text{g g}^{-1}$  barium, but this figure may be greatly enhanced by contamination of sediments with drilling



muds containing up to 450mg g<sup>-1</sup> 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.

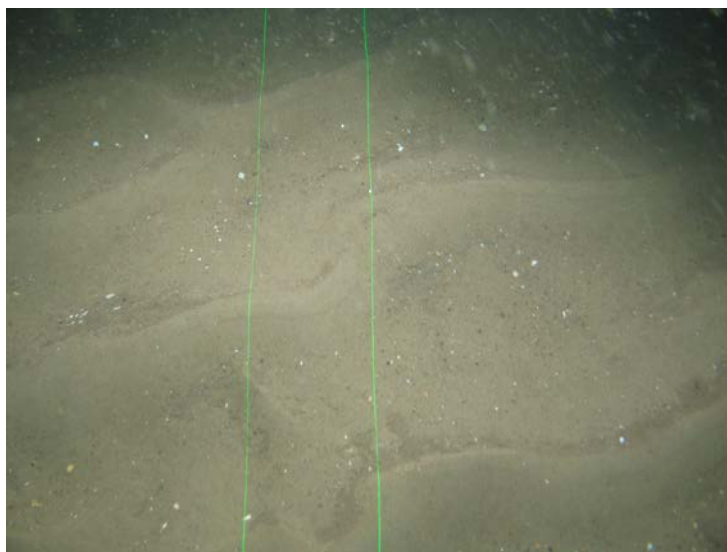
Total sediment metal concentrations have historically been the preferred measurement for offshore surveys. Whilst these provide little information regarding concentrations of metals that may be bioavailable, since they involve total dissolution of the sediment, they are however useful for comparisons 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.

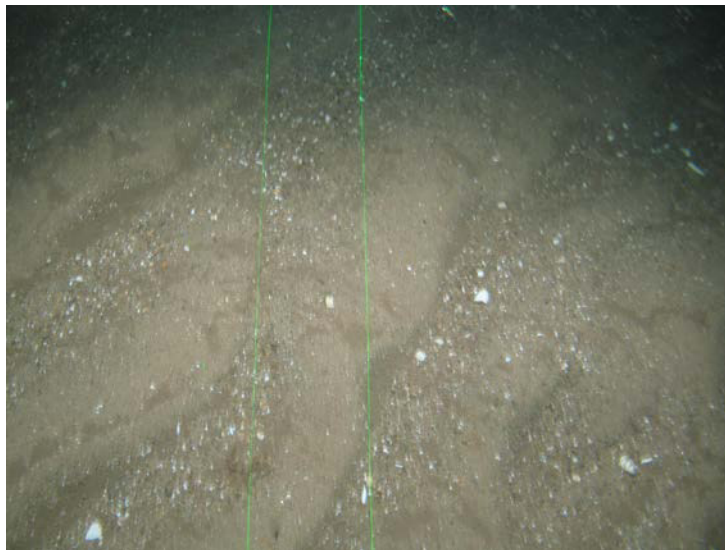
**Sieve:** Shell fragments.

**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 gravelly sand with shell fragments.  
**Broadscale EUNIS Classification:** A5.1

**Fix625:** Rippled gravelly 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

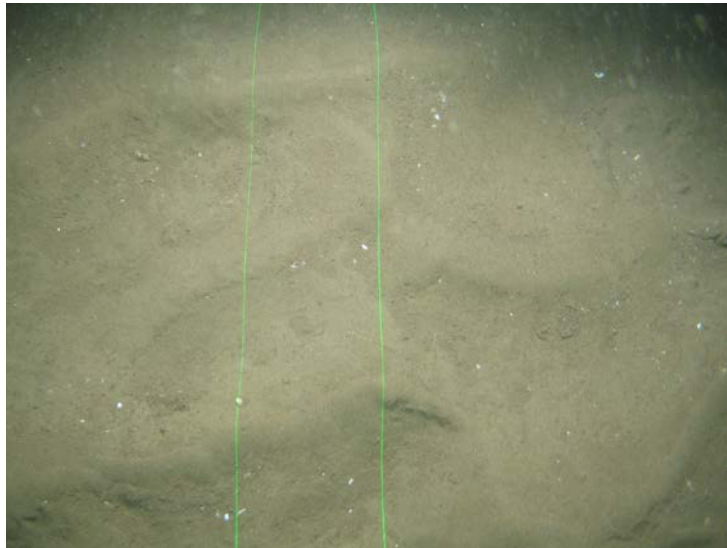
**Station:** ENV2  
**Sediment Description:**  
**Grab:** Sand with shell fragments.

**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

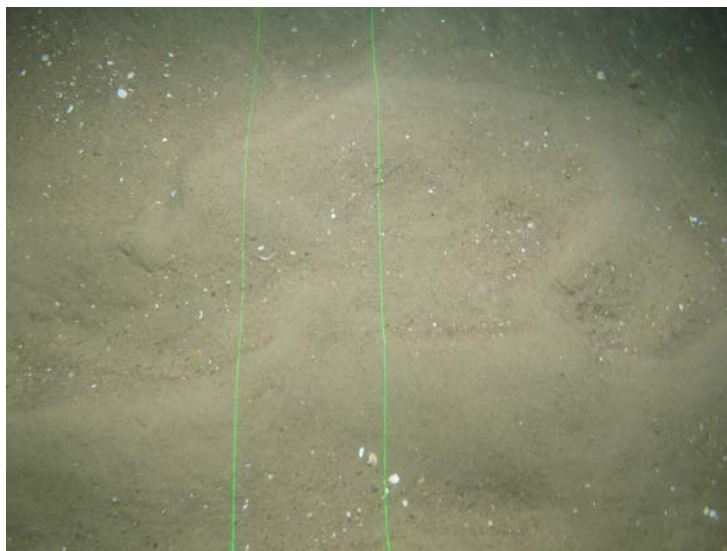


Fix: 42 E: 390063 N: 5973836 Retention: MF

**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:**

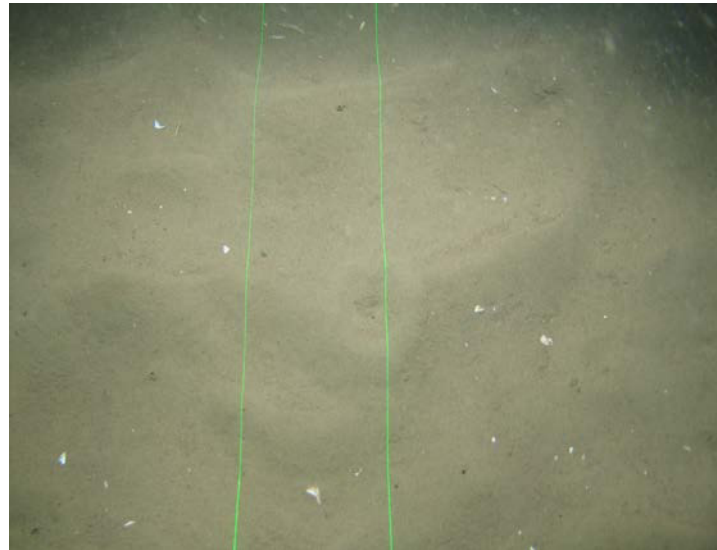
**Grab:** No visible fauna.

**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.

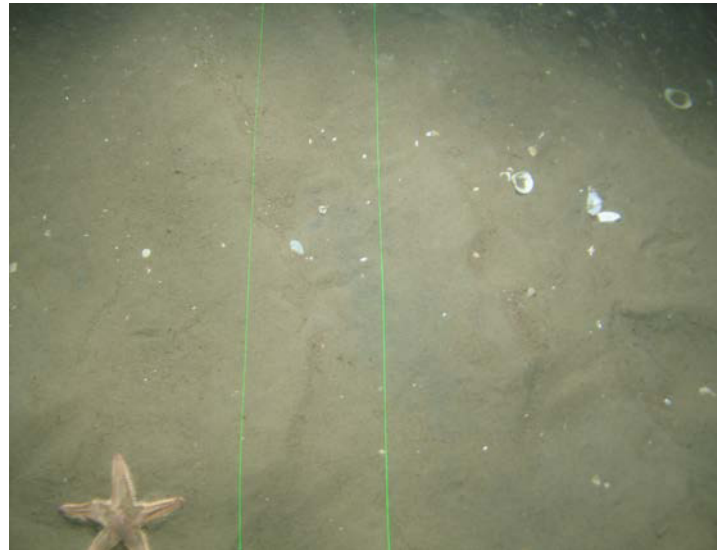
**Sieve:** No visible fauna.



## 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 Megalopa

## 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



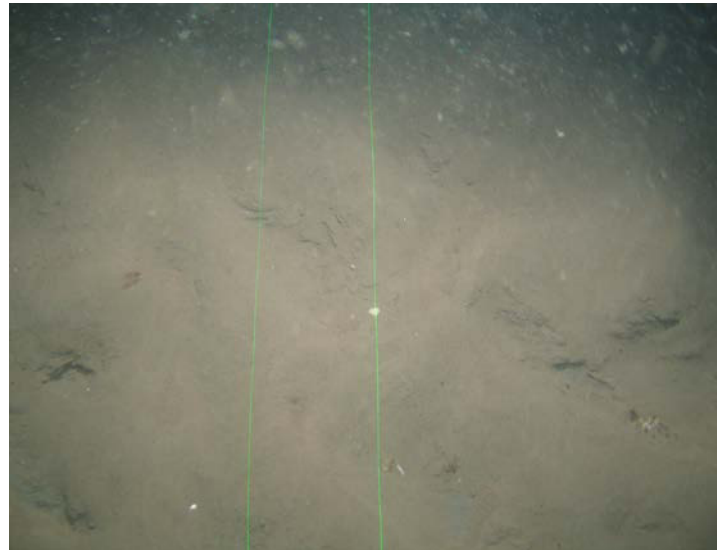
**Fix:** 34 **E:** 390092 **N:** 5984490 **Retention:** MF

**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.

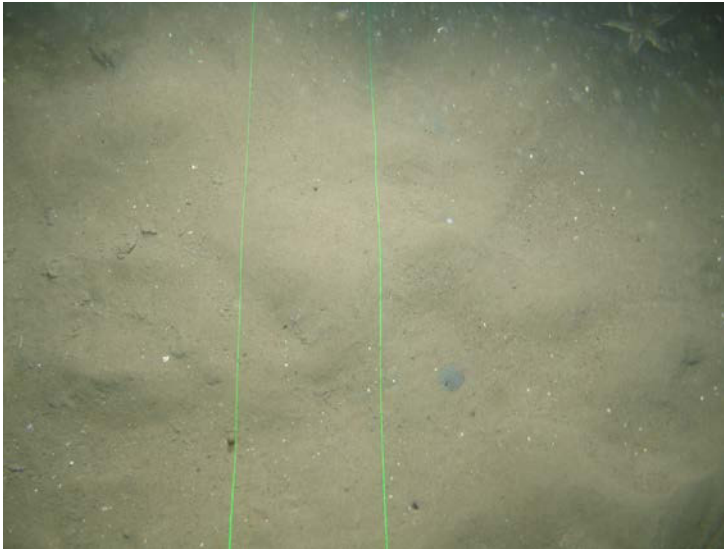
**Sieve:** Shell fragments.

**Fauna Description:**  
**Grab:** No visible fauna.

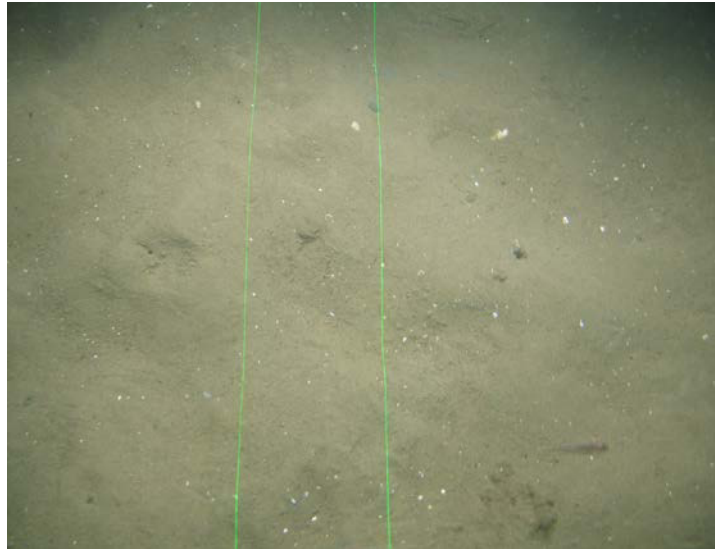
**Sieve:** Annelida (Polycheta), Echinodermata (*Echinocardium* sp.)



## 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.

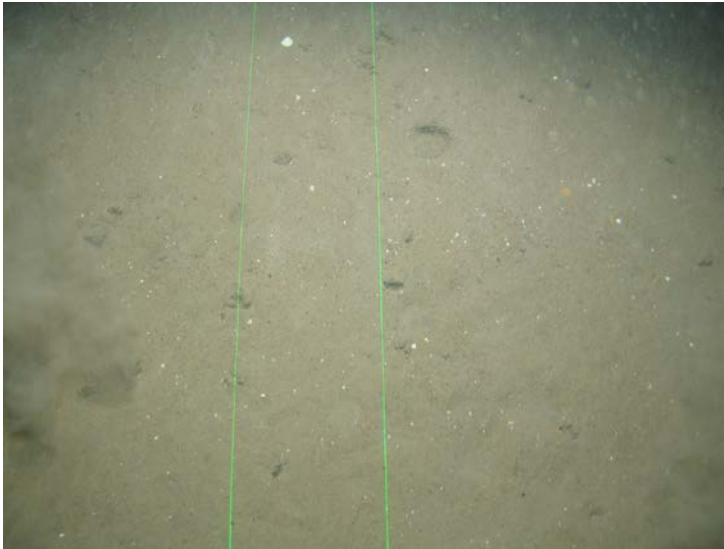
**Sieve:** Shell fragments.

**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.

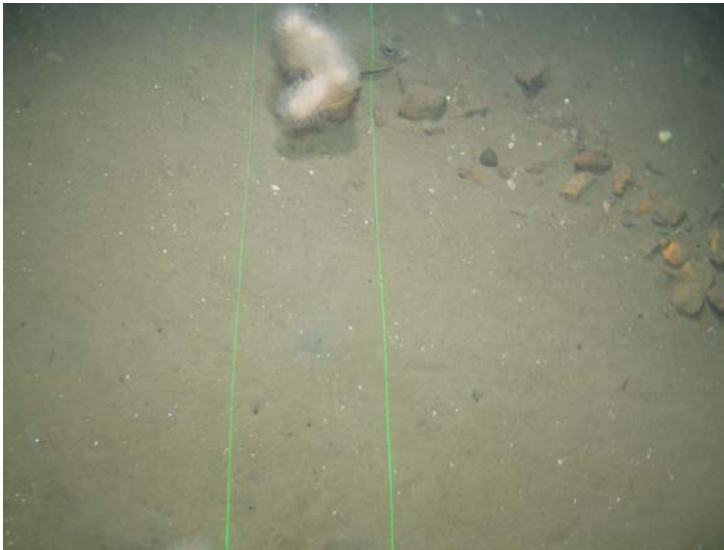
**Sieve:** Shell fragments.

**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

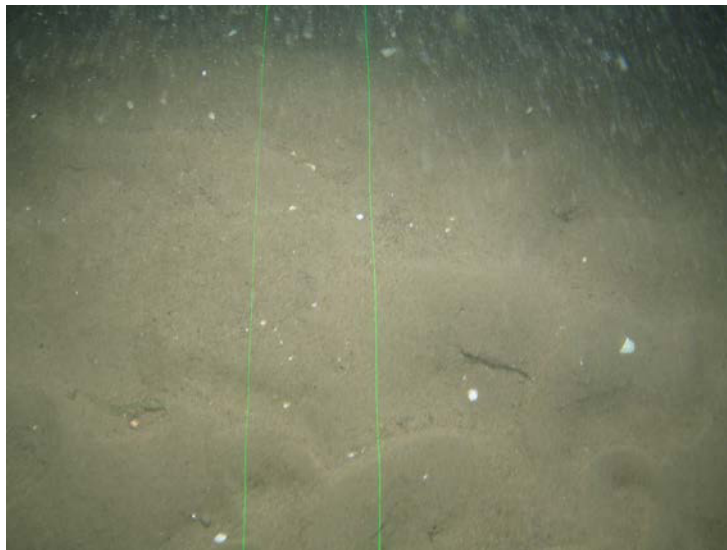
**Station:** ENV19  
**Sediment Description:**  
**Grab:** Silty sand with shell fragments.

**Sieve:** Shell fragments.

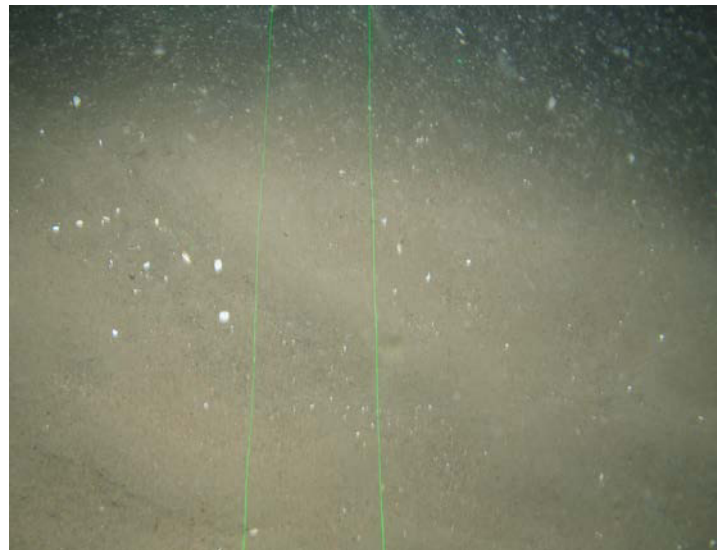
**Fauna Description:**  
**Grab:** No visible fauna.

**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.

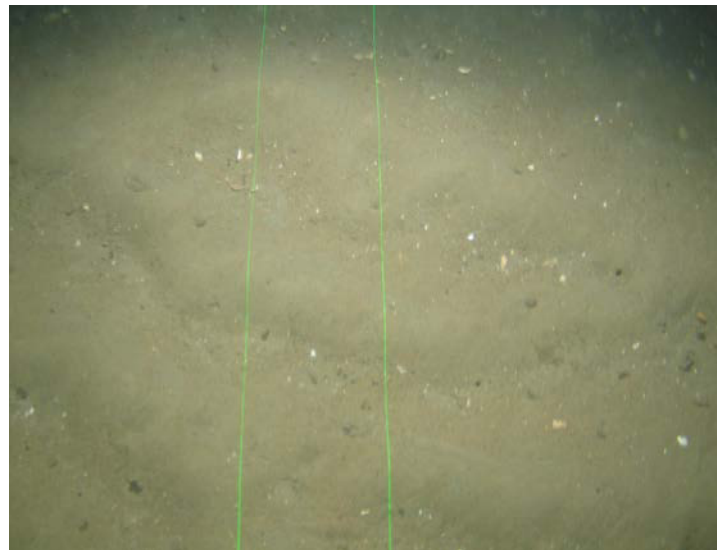
**Fauna Description:**  
**Grab:** No visible fauna.

**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.

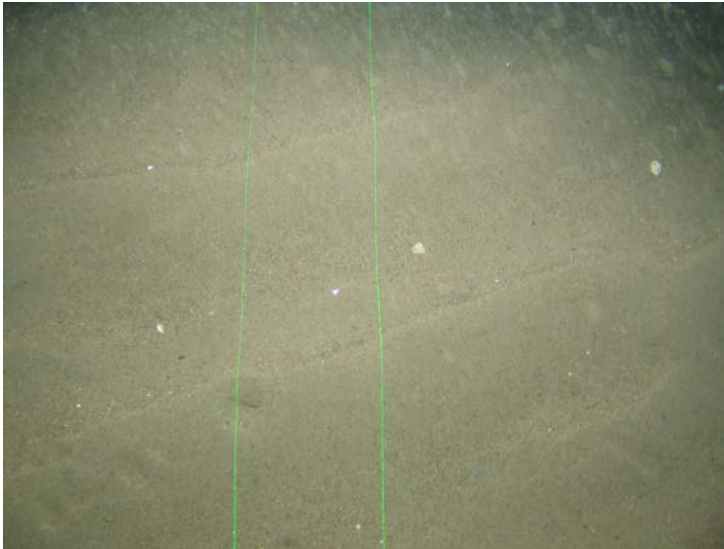
**Sieve:** Shell fragments.

**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

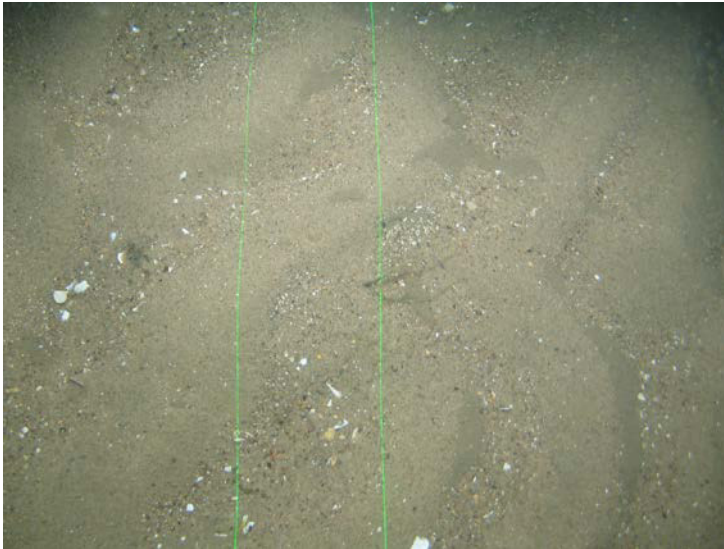
**Station:** ENV23  
**Sediment Description:**  
**Grab:** Brown sand with shells.

**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

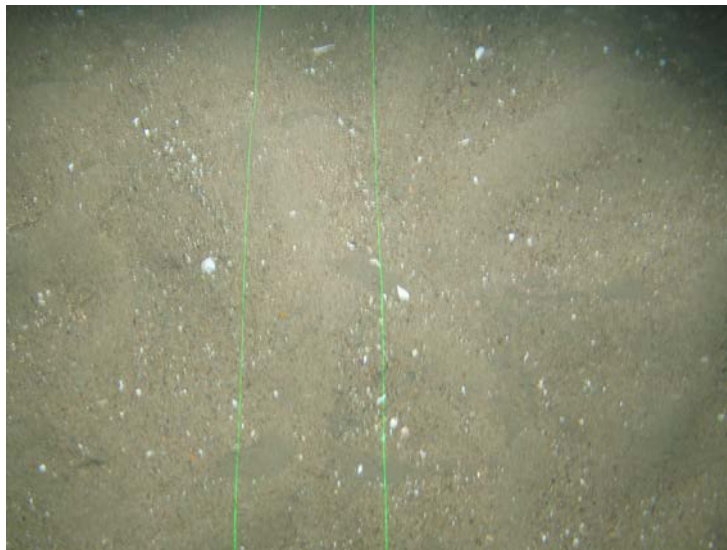


Fix: 7 E: 373681 N: 6006062 Retention: MF

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



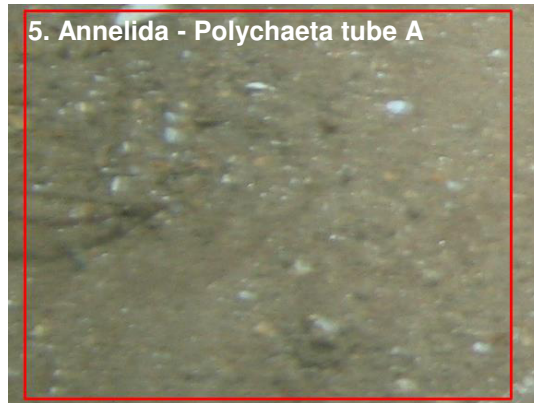
**Fix: 9** E: 378385 N: 6005471 **Retention: MF**

**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



## APPENDIX E FAUNAL CATALOGUE

9. Arthropoda – Brachyura sp. A



13. Arthropoda - Paguridae



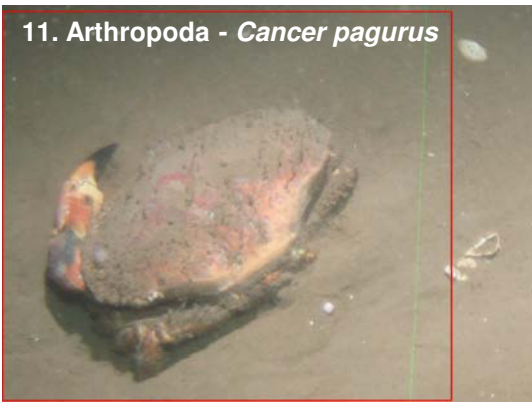
10. Arthropoda - Brachyura sp. B



14. Chordata - Actinopterygii  
indeterminate



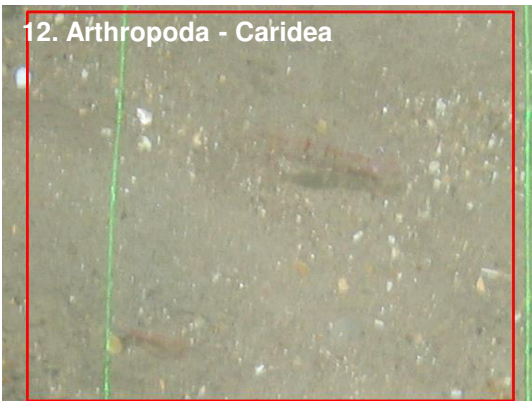
11. Arthropoda - *Cancer pagurus*



15. Chordata - Actinopterygii sp. A



12. Arthropoda - Caridea



16. Chordata - Actinopterygii sp. B





## APPENDIX E FAUNAL CATALOGUE



## APPENDIX E FAUNAL CATALOGUE

25. Cnidaria - *Alcyonium digitatum*



29. Echinodermata - *Asterias rubens*



26. Cnidaria – *Ceriantharia* sp.



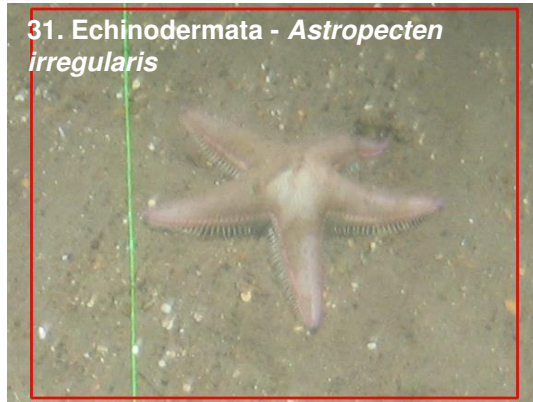
30. Echinodermata - Asteroidea (juv.)



27. Cnidaria - Hydrozoa



31. Echinodermata - *Astropecten irregularis*



28. Cnidaria - *Urticina* sp. A



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 - <i>Ditropa</i> sp.	Annelida - <i>Lanice conchilega</i>	Annelida - Polychaeta tube A	Annelida - Polychaeta tube B	Annelida - Serpulidae	Annelida - Terebellidae	Arthropoda - Brachyura sp. A	Arthropoda - Brachyura sp. B	Arthropoda - <i>Cancer pagurus</i>	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 - Trigidae	Cnidaria - Actiniaria	Cnidaria - <i>Alcyonium digitatum</i>	Cnidaria - <i>Ceriantharia</i> sp.	Cnidaria - Hydrozoa	Cnidaria - <i>Urticina</i> sp. A	Echinodermata - <i>Asterias rubens</i>	Echinodermata - Asteroidea (juv.)	Echinodermata - <i>Astropecten irregularis</i>	Echinodermata - Ophiuroidea sp. A	Echinodermata - Ophiuroidea sp. B	Faunal turf	Mollusca - Bivalvia	Mollusca - Naticidae	Mollusca - Scaphopoda	Mollusca - Sepioidae
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%								

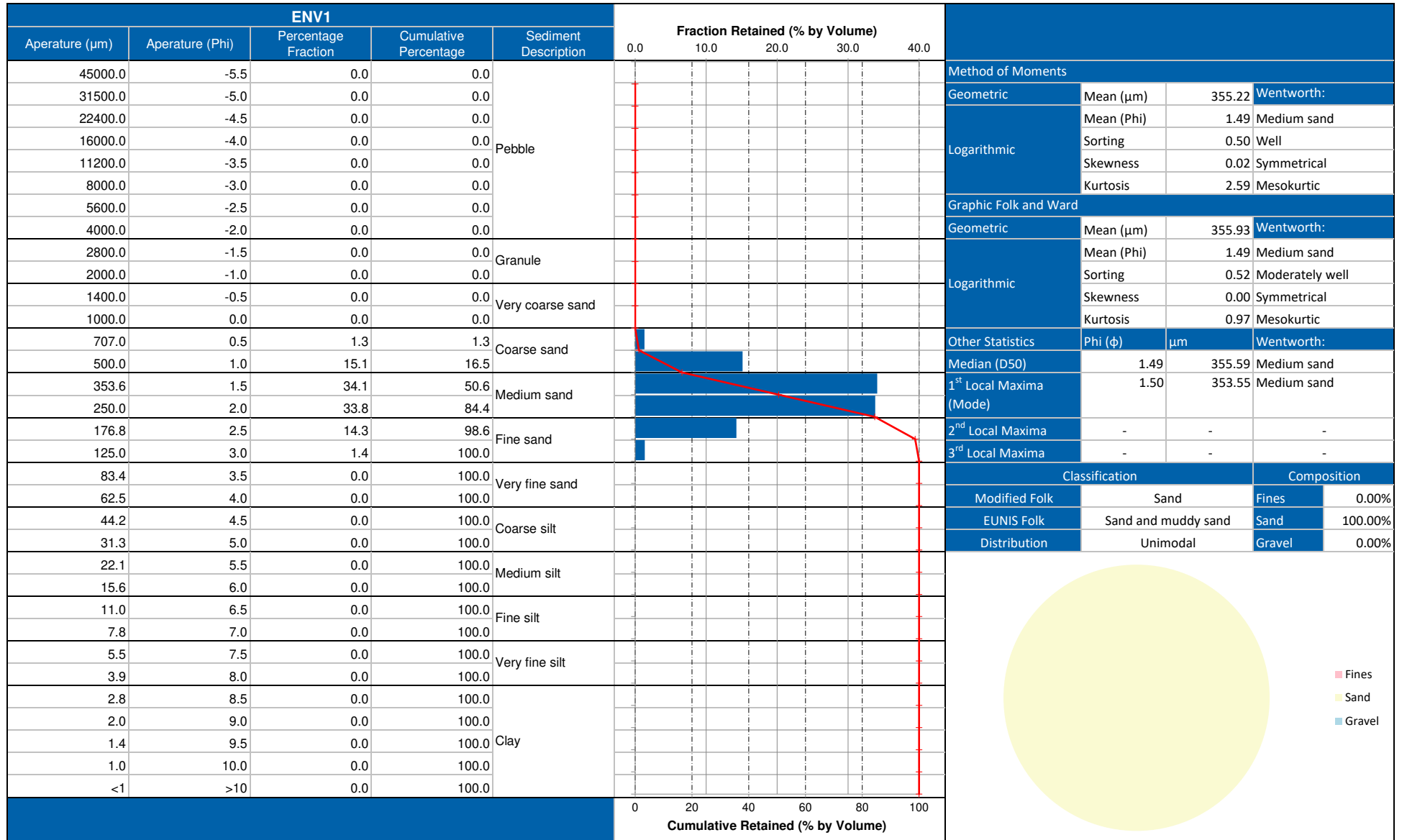
### Protected species and burrows for habitat assessments

NA = not applicable as individuals were enumerated within each image

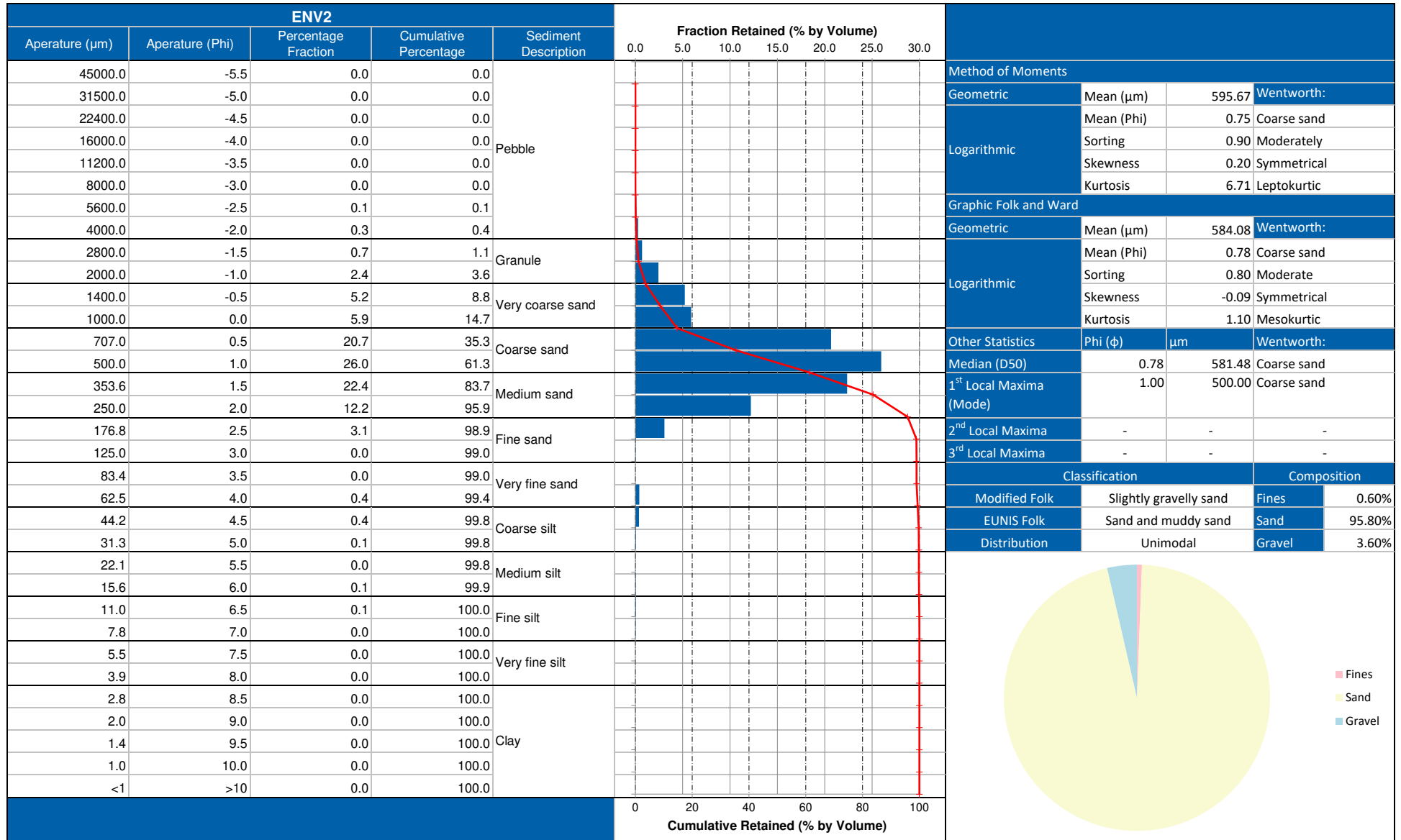
## APPENDIX G PARTICLE SIZE ANALYSIS



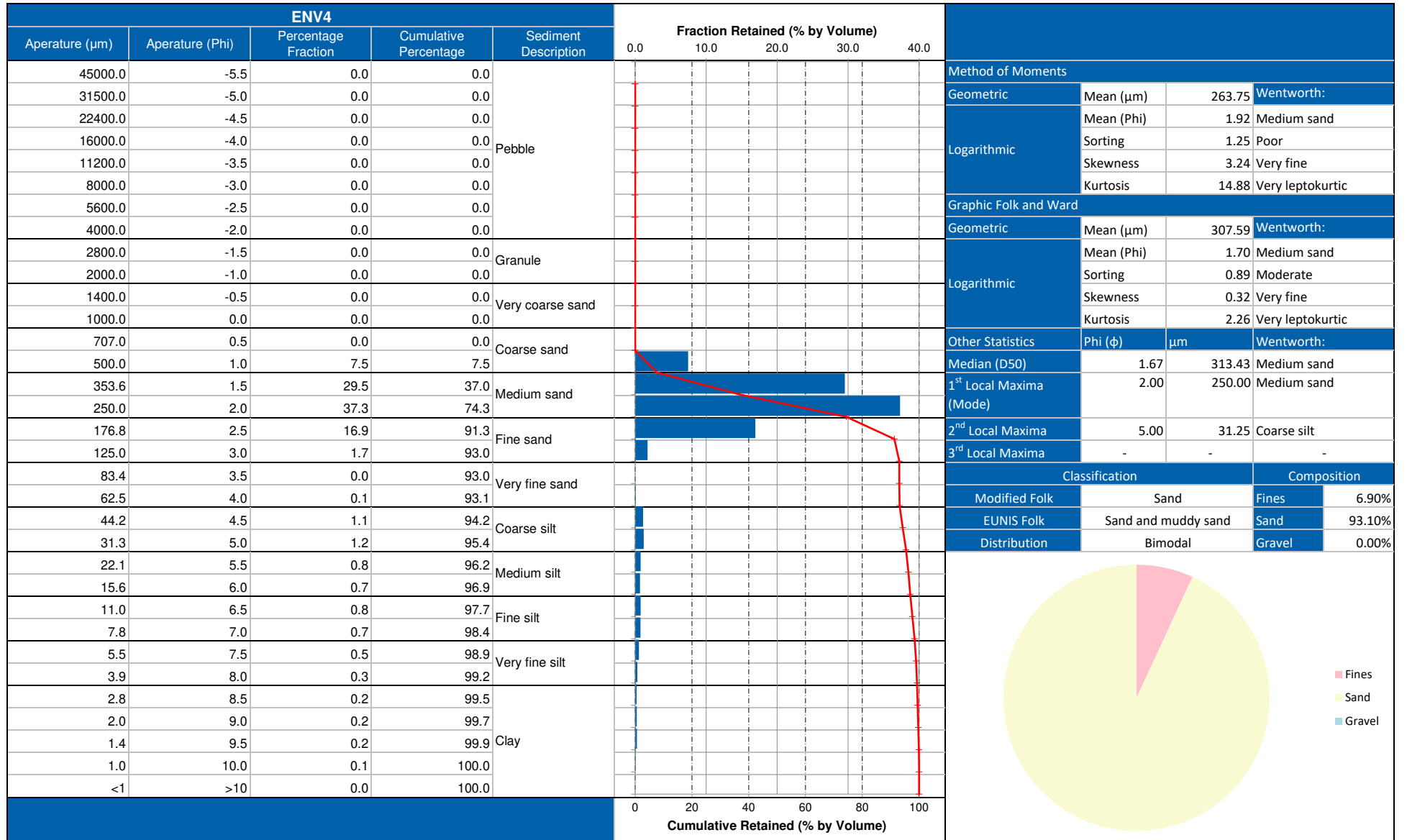
## APPENDIX G PARTICLE SIZE ANALYSIS



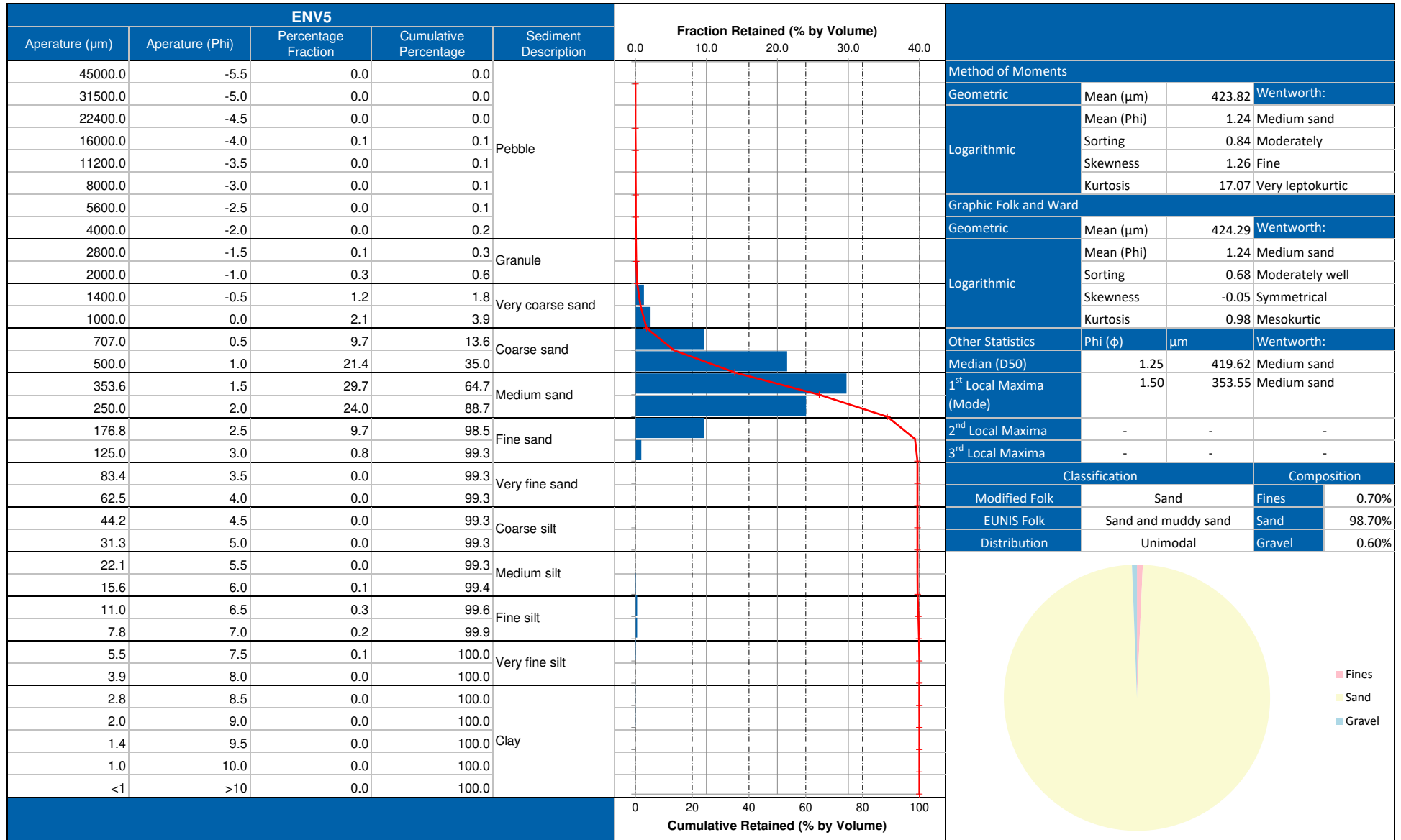
## APPENDIX G PARTICLE SIZE ANALYSIS



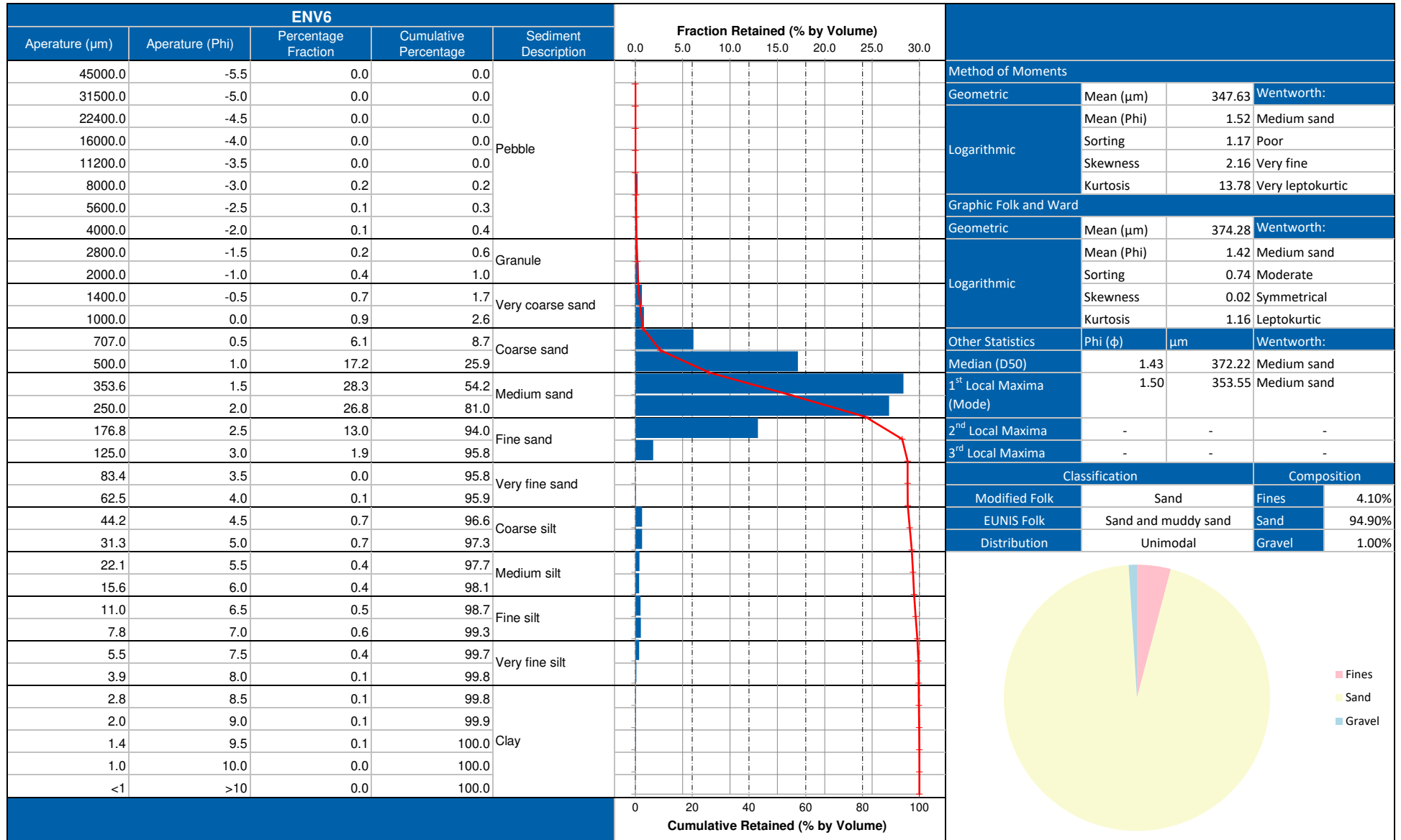
## APPENDIX G PARTICLE SIZE ANALYSIS



## APPENDIX G PARTICLE SIZE ANALYSIS

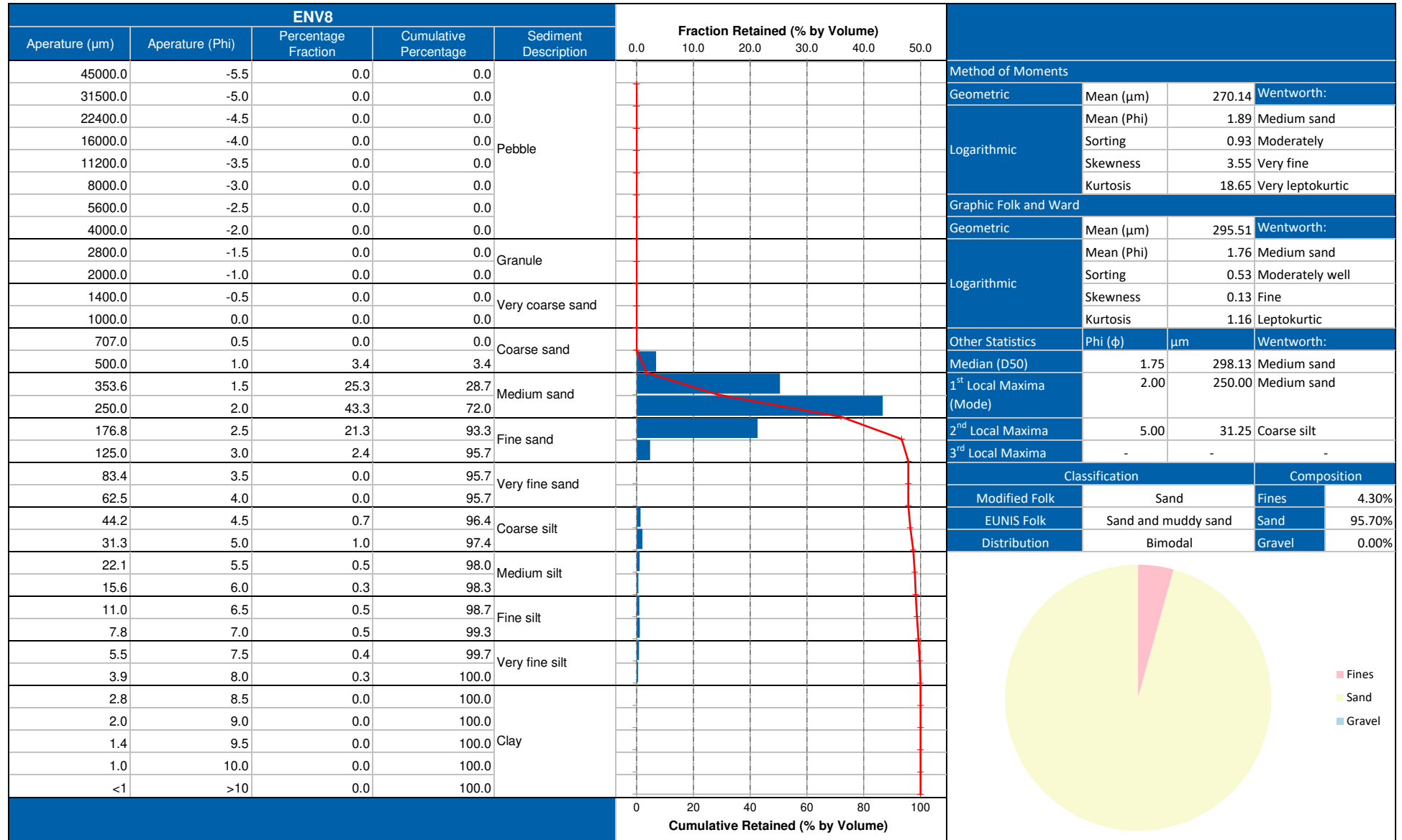


## APPENDIX G PARTICLE SIZE ANALYSIS



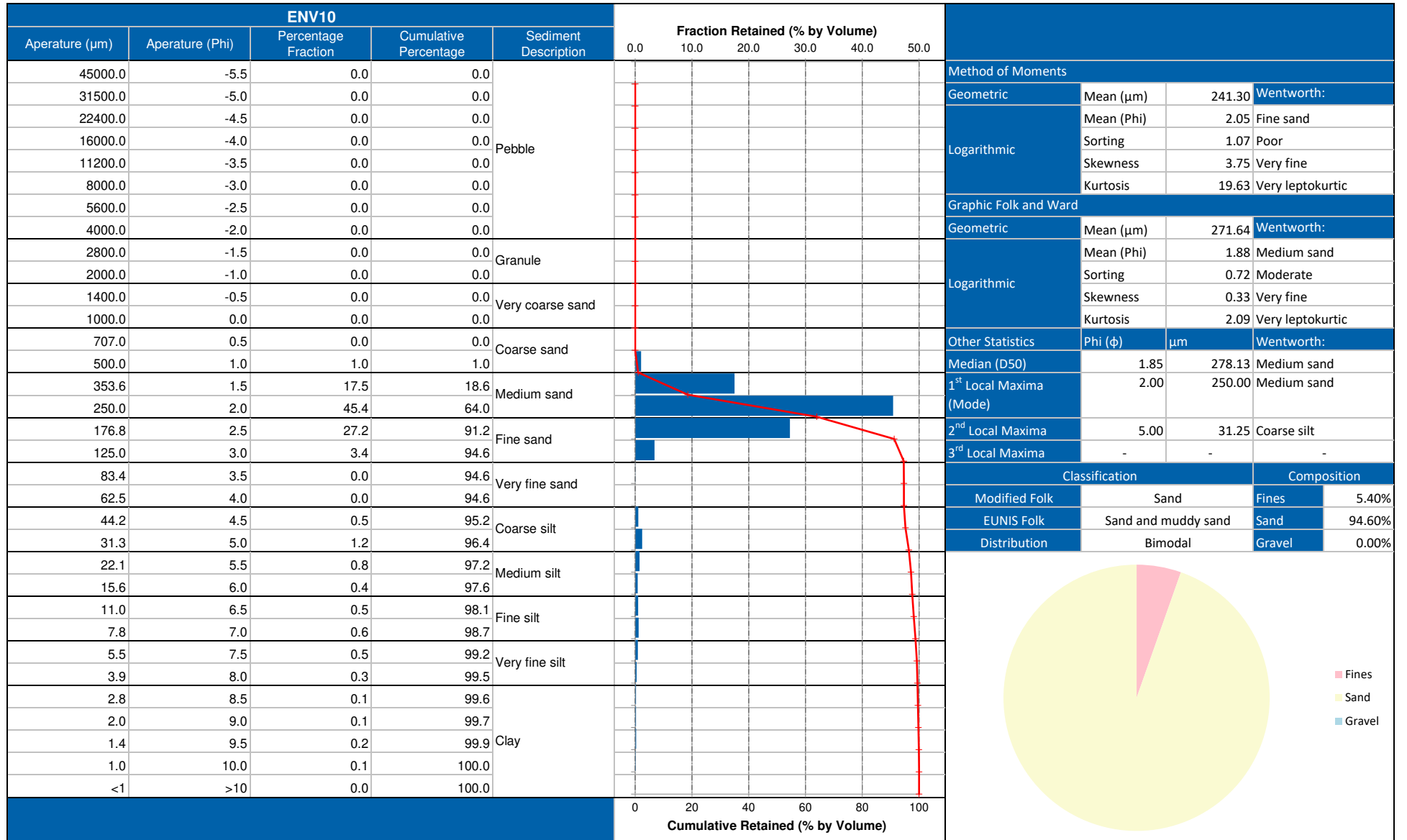


## APPENDIX G PARTICLE SIZE ANALYSIS

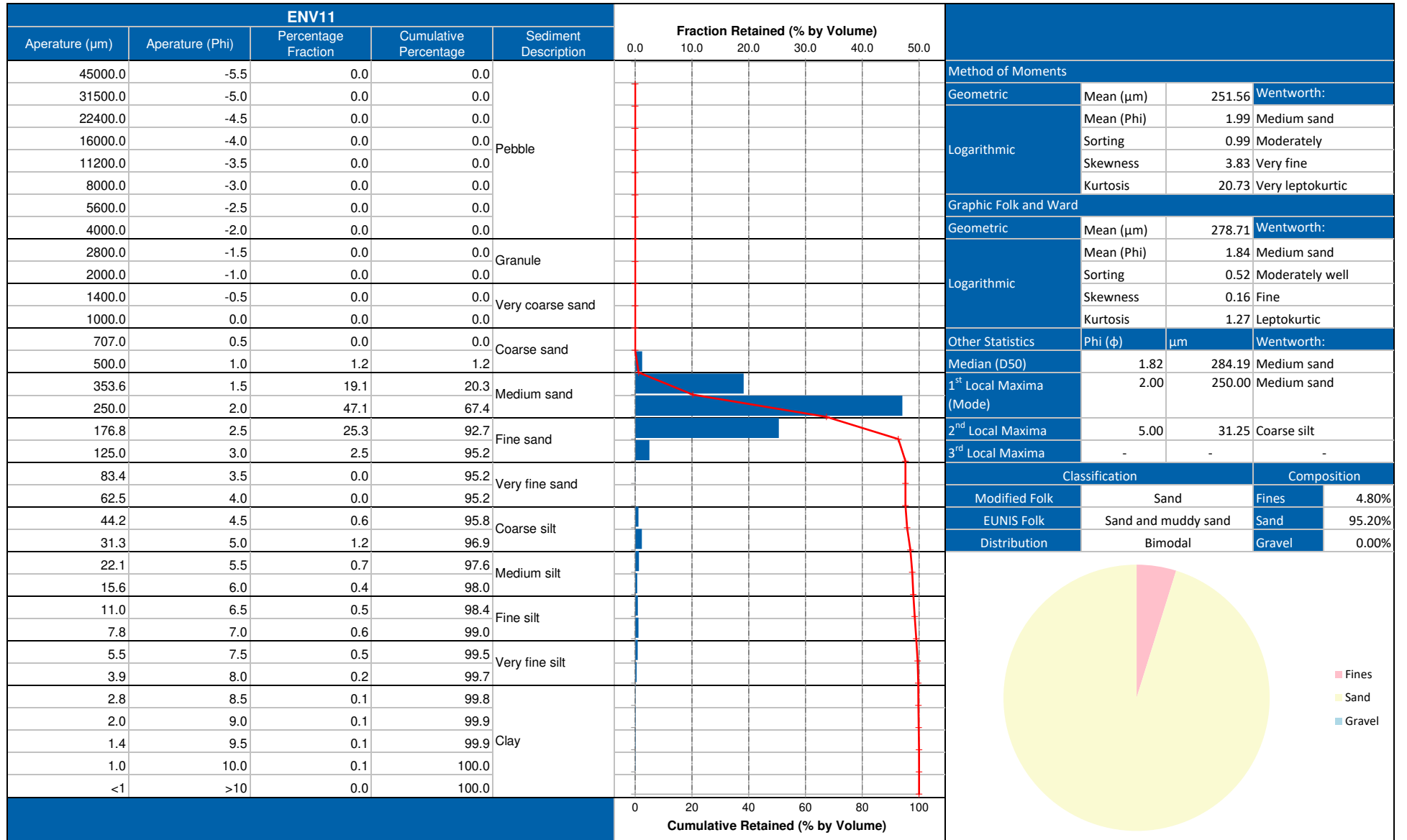




## APPENDIX G PARTICLE SIZE ANALYSIS



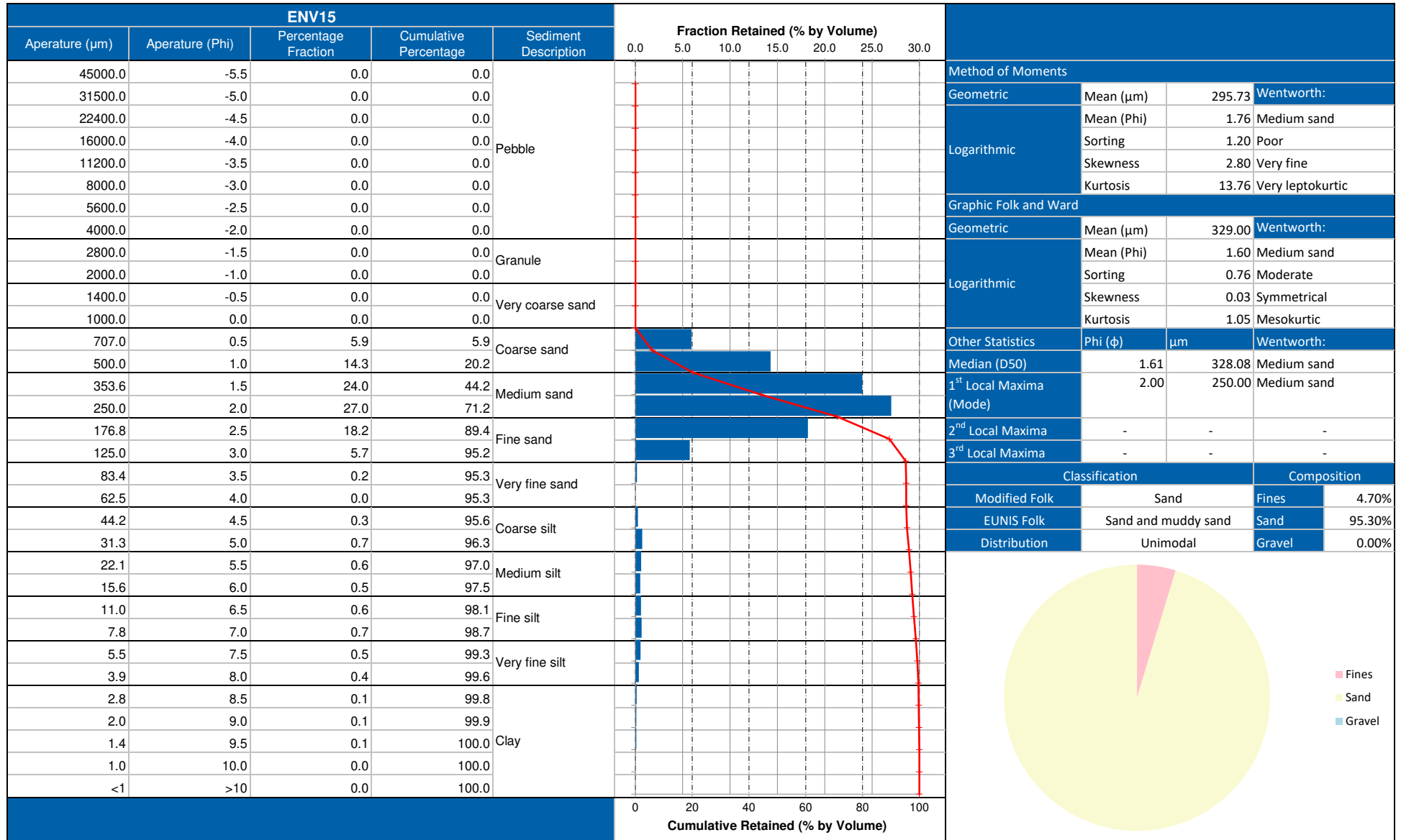
## APPENDIX G PARTICLE SIZE ANALYSIS



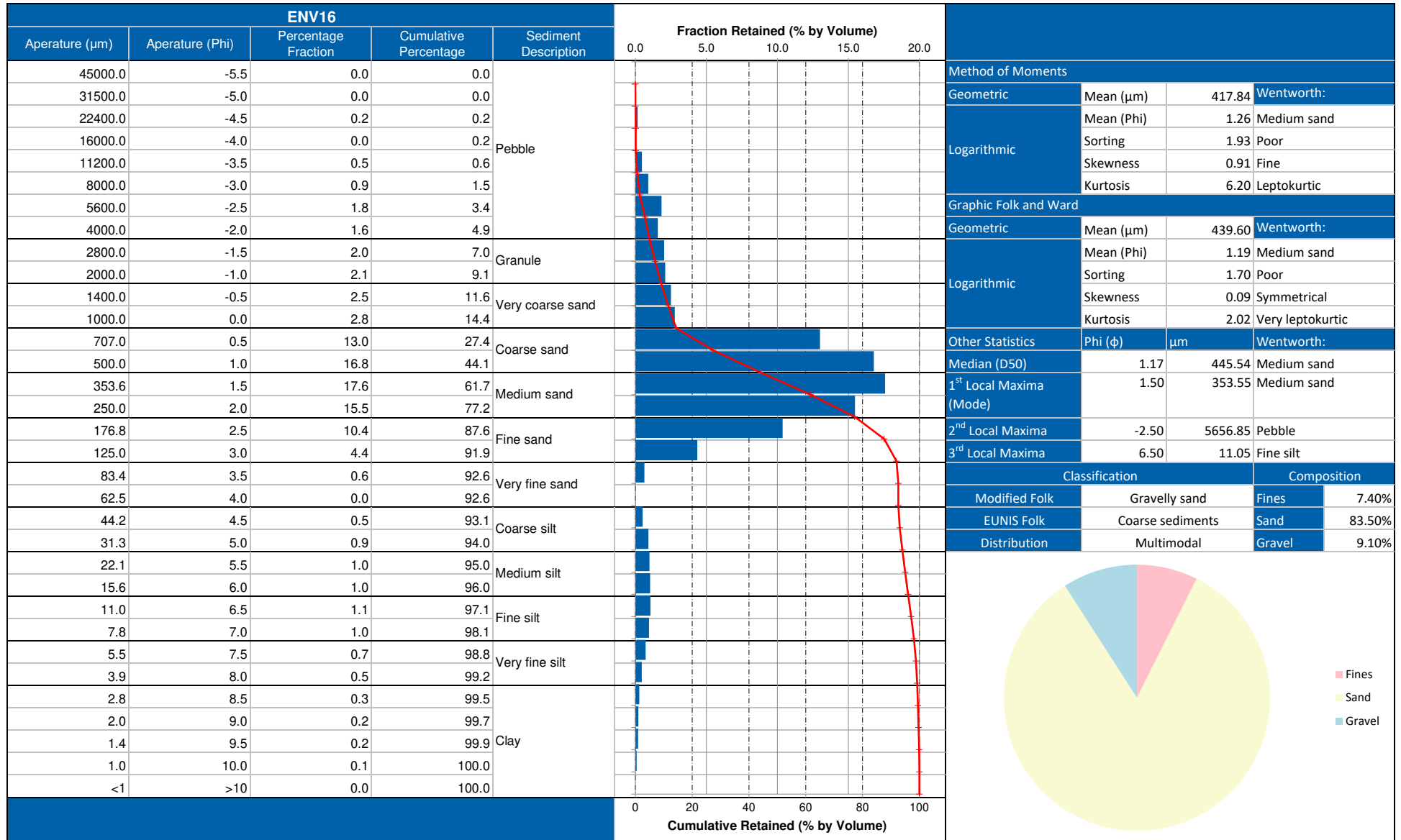




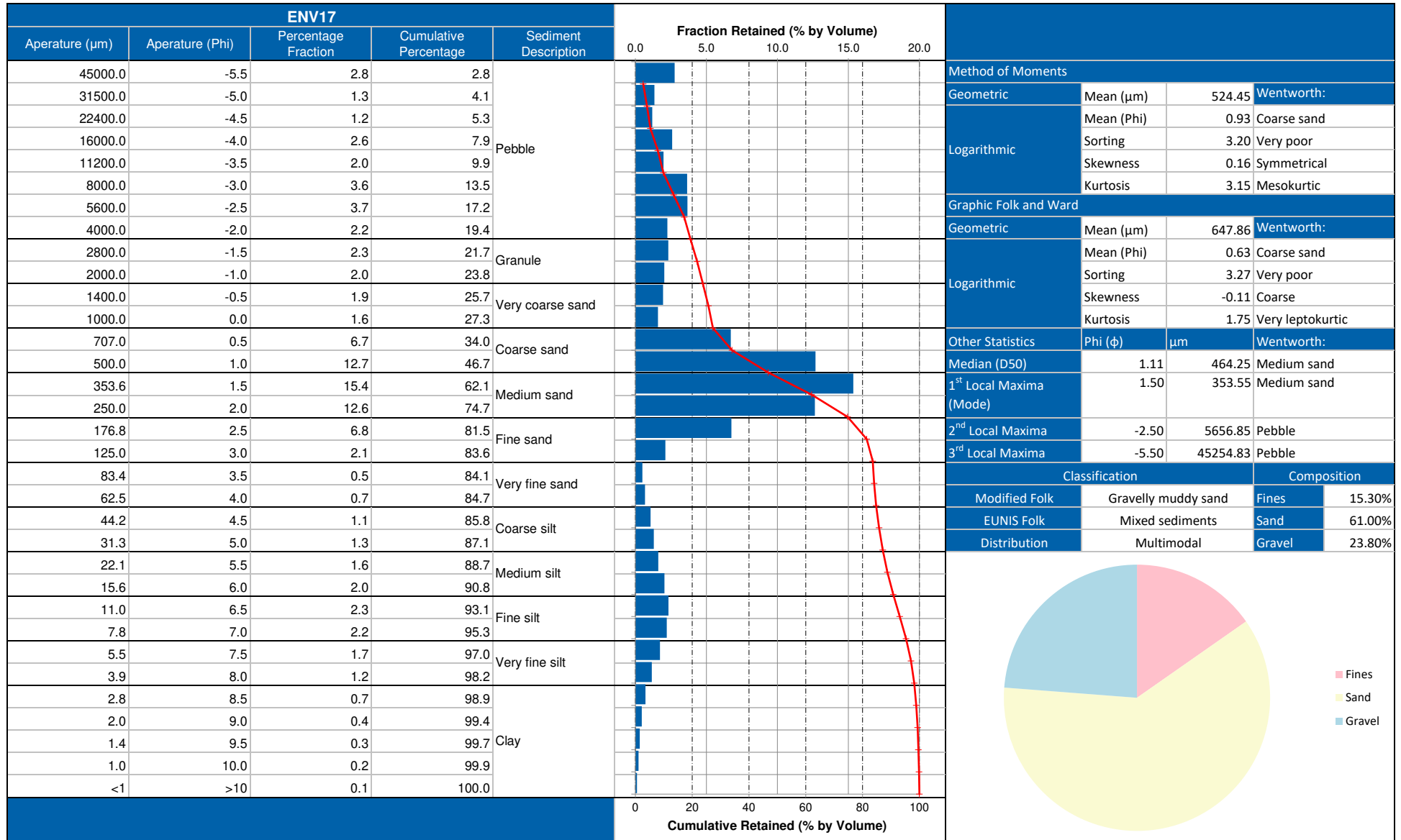
## APPENDIX G PARTICLE SIZE ANALYSIS



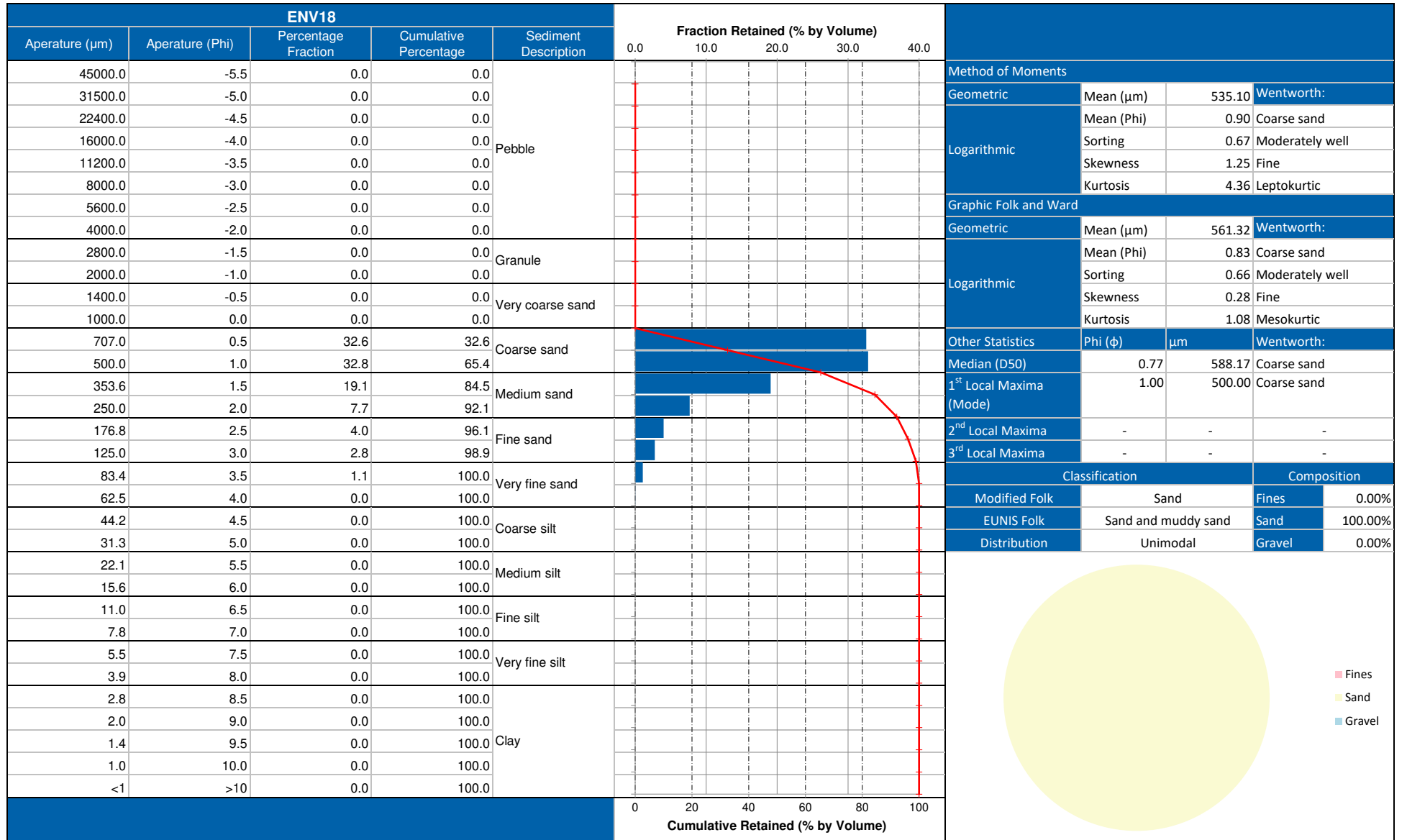
## APPENDIX G PARTICLE SIZE ANALYSIS



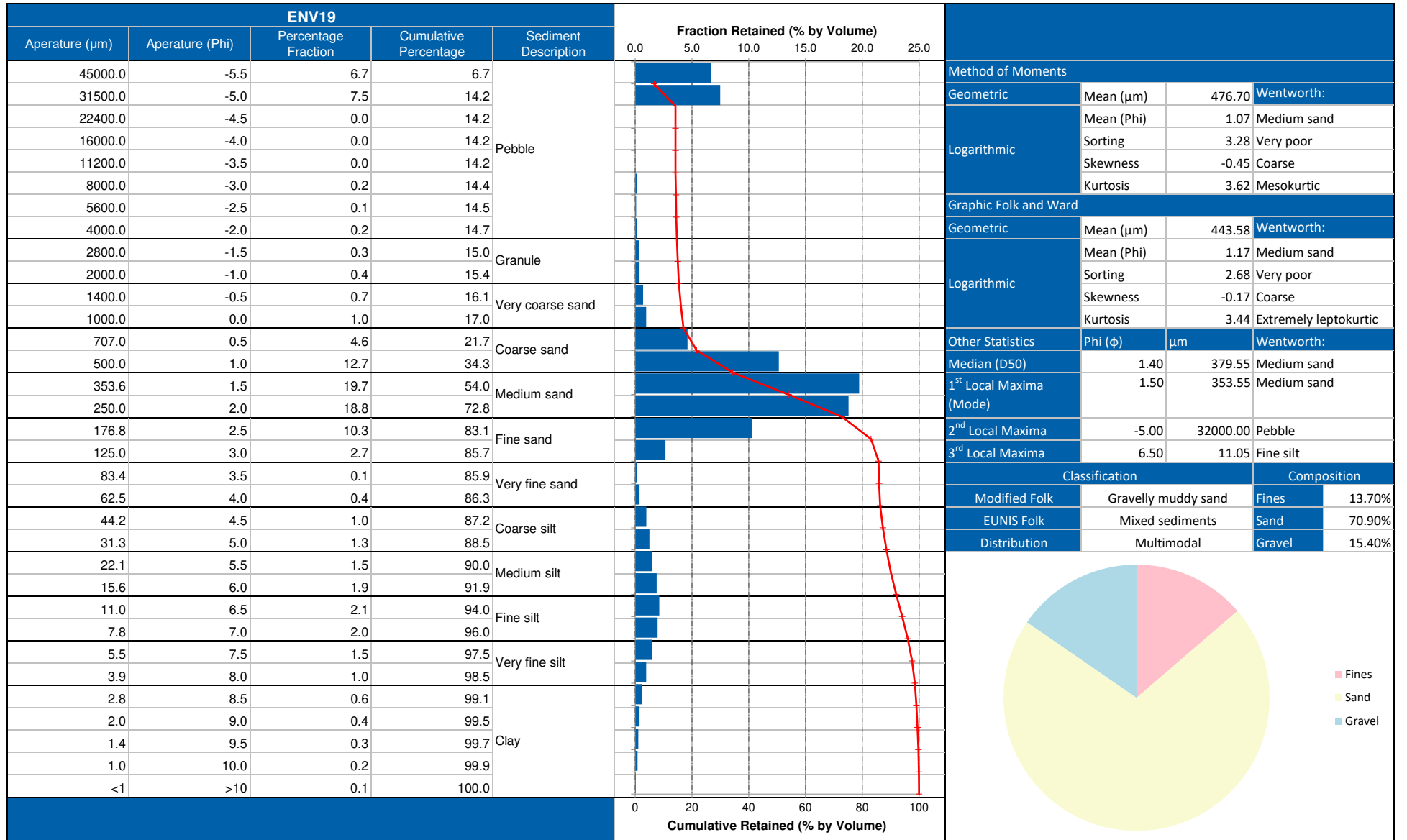
## APPENDIX G PARTICLE SIZE ANALYSIS



## APPENDIX G PARTICLE SIZE ANALYSIS

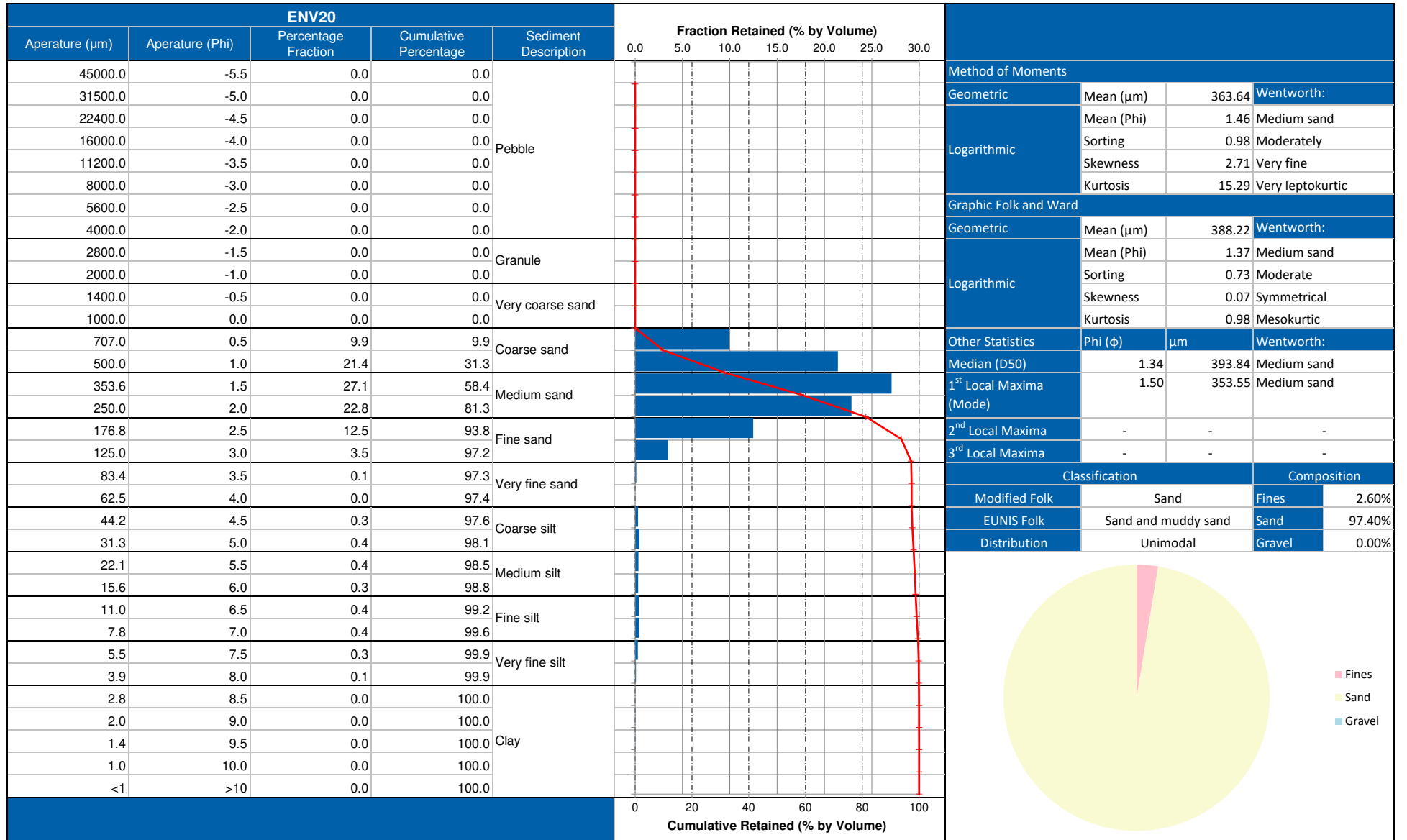


## APPENDIX G PARTICLE SIZE ANALYSIS

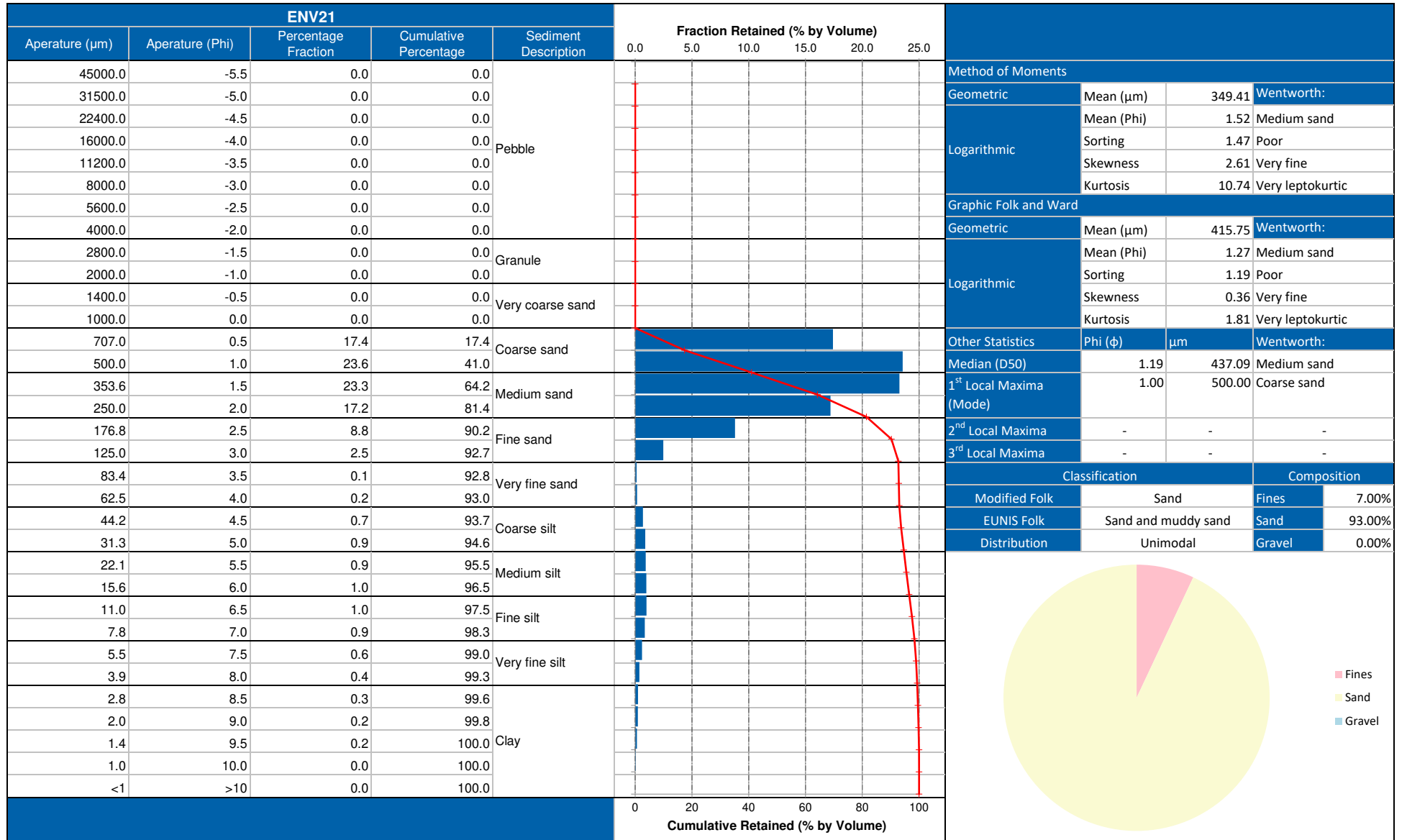




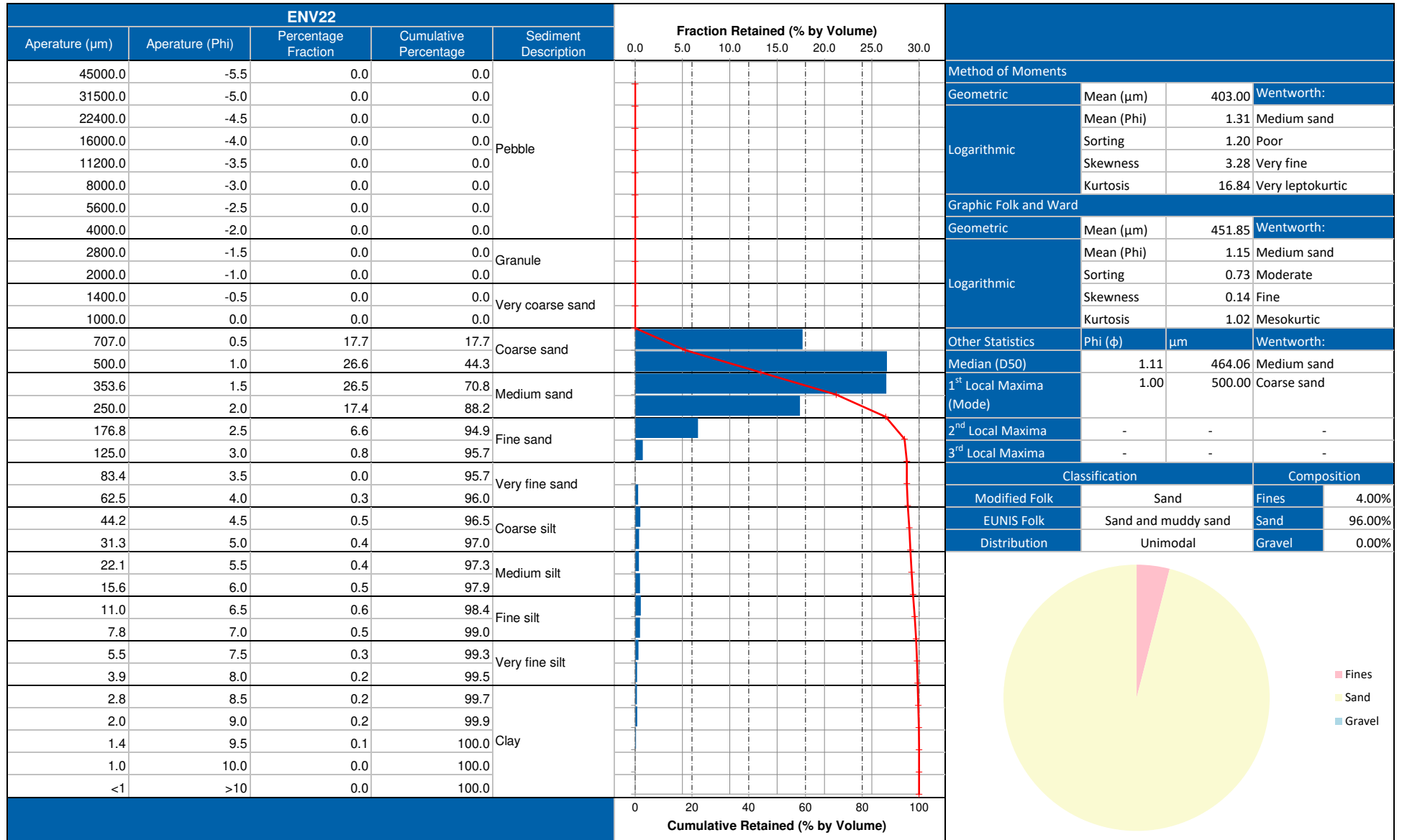
## APPENDIX G PARTICLE SIZE ANALYSIS



## APPENDIX G PARTICLE SIZE ANALYSIS

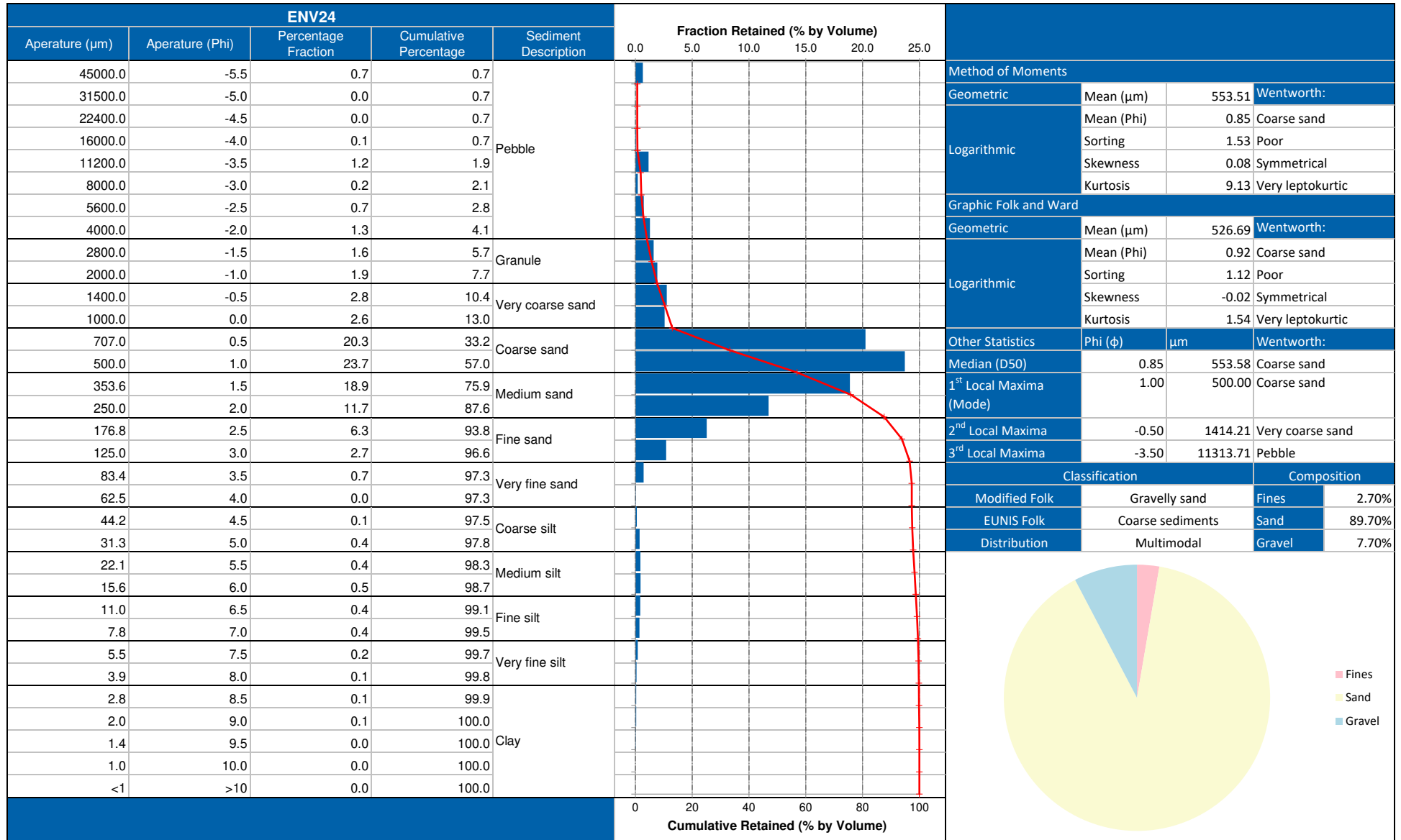


## APPENDIX G PARTICLE SIZE ANALYSIS



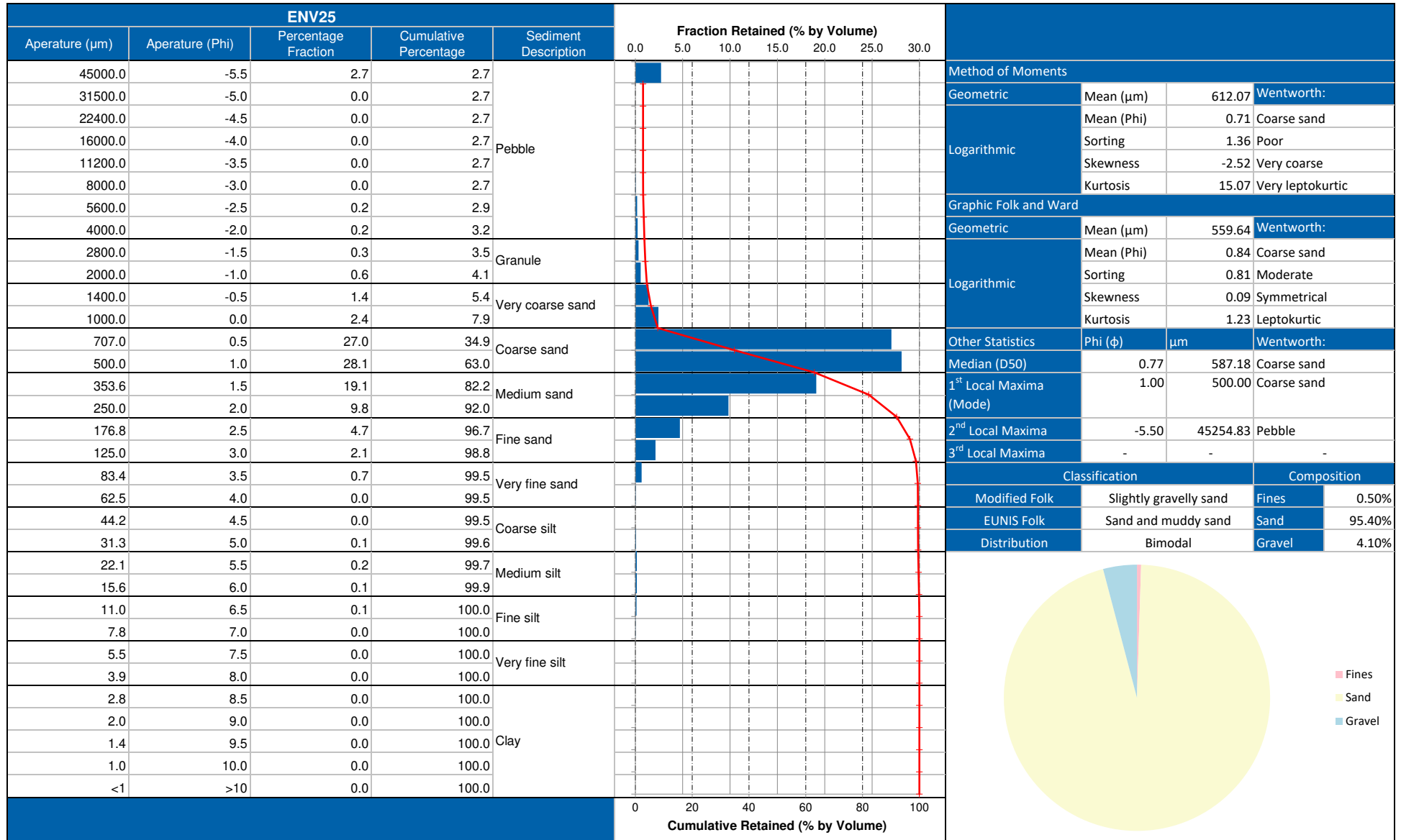


## APPENDIX G PARTICLE SIZE ANALYSIS





## APPENDIX G PARTICLE SIZE ANALYSIS



## APPENDIX H SPEARMAN'S RANK CORRELATIONS

### APPENDIX H SPEARMAN'S RANK CORRELATIONS

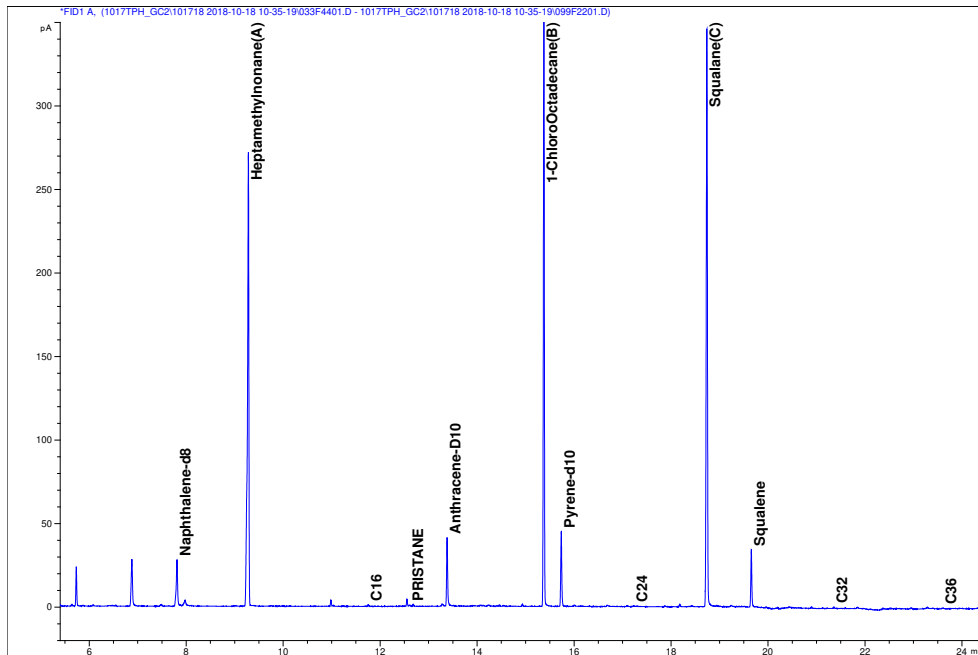
Dixon's test for high outliers (n=14 to 25)	0.10	0.24	0.35	0.08	0.62	0.57	0.45	0.39	0.49	0.69	0.32	0.32	0.45	0.22	0.29	0.45	0.37	0.45	0.46	0.42
Dixon's test for low outliers (n=14 to 25)	0.14	0.11	0.05	0.60	0.00	0.01	0.14	0.01	0.12	0.30	0.07	0.11	0.09	0.25	0.20	0.09	0.10	0.04	0.13	0.15
Stations	Depth (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
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

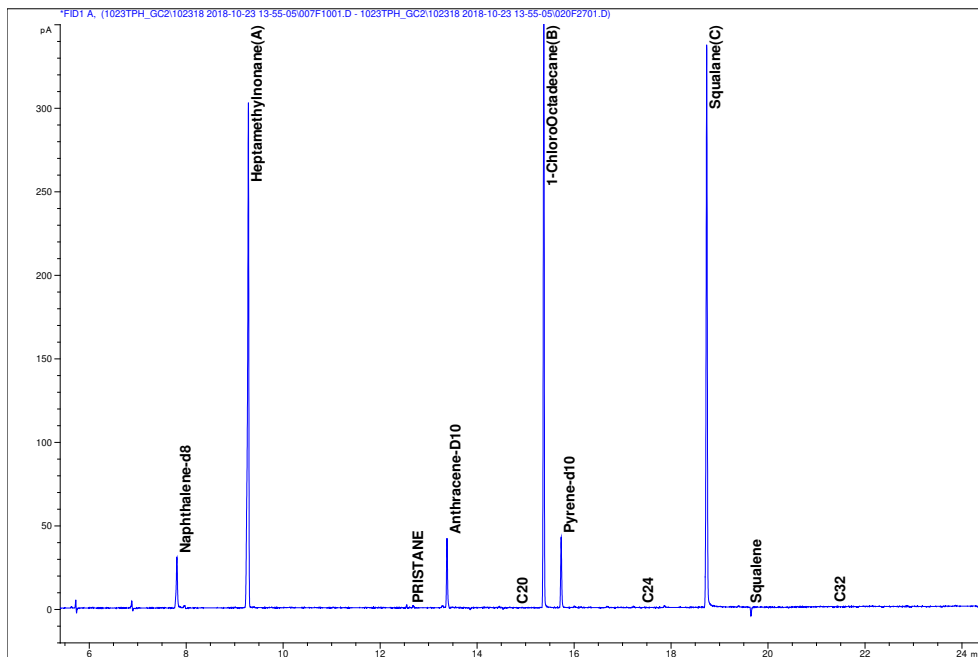
**Critical Values Spearmans Test**  
 p < 0.01 if value >= 0.556  
 p < 0.05 if value >= 0.438

## **APPENDIX I    HYDROCARBON ANALYSIS**

## APPENDIX I HYDROCARBON ANALYSIS



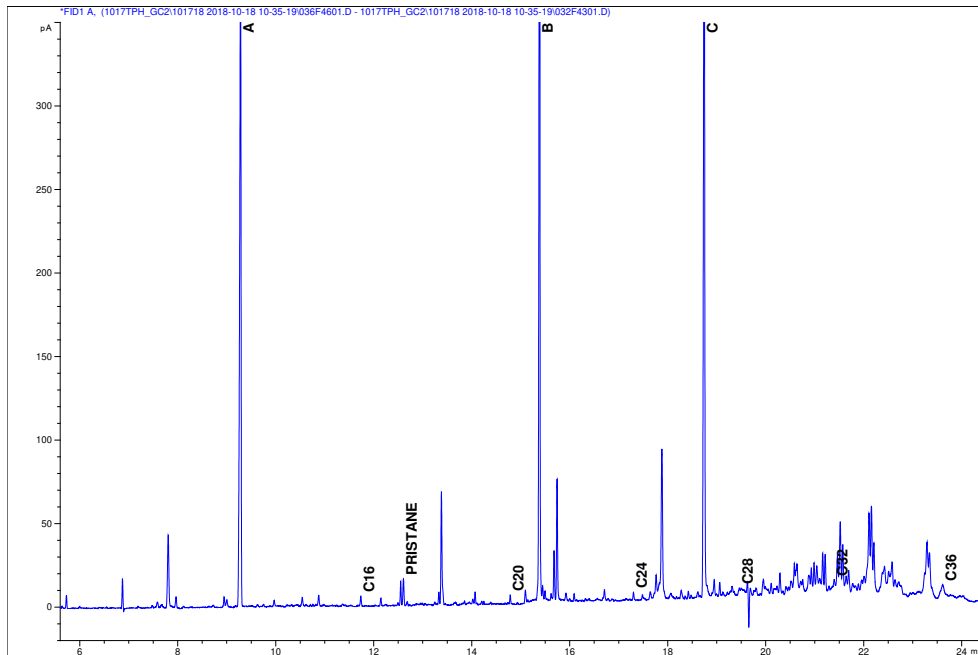
Blank for Batch 1  
(ENV1 to ENV15)



Blank for Batch 2  
(ENV16 to ENV25)



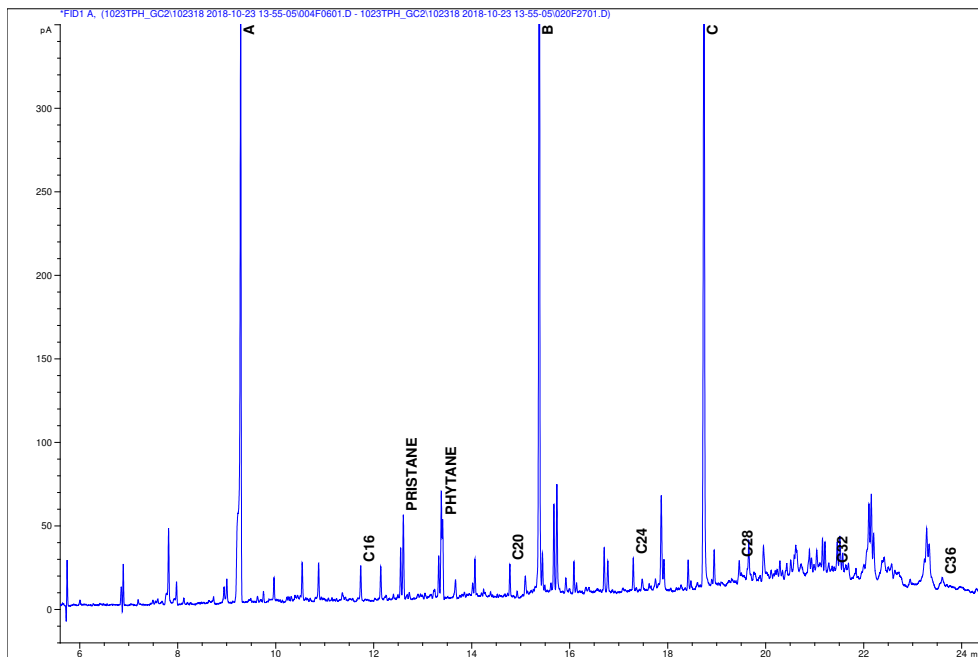
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV1**

**THC: 3.248 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.114 $\mu\text{g g}^{-1}$**

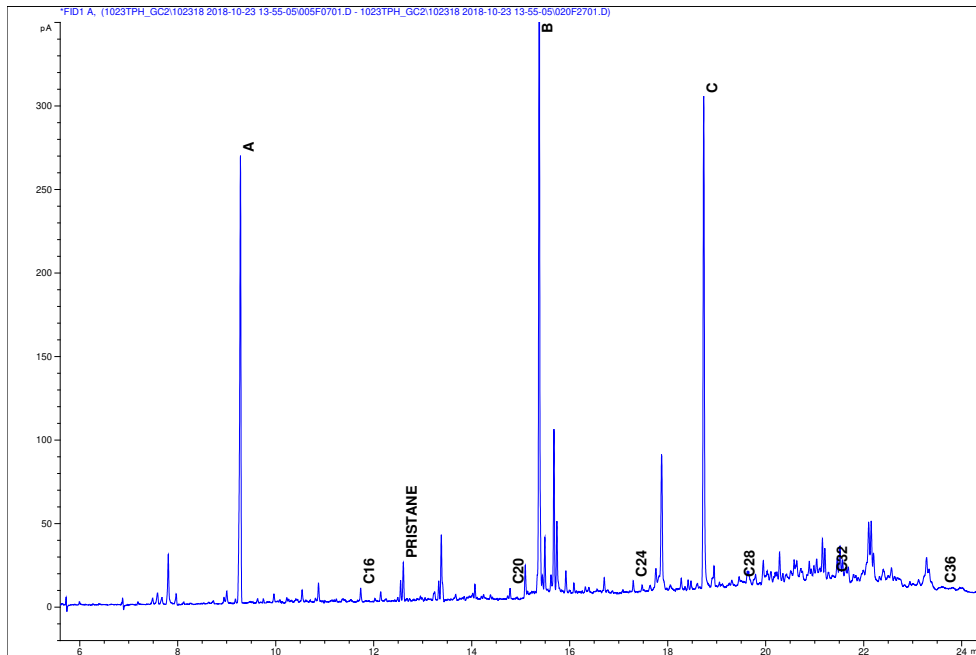


**11210 ENV2**

**THC: 5.547 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.264 $\mu\text{g g}^{-1}$**

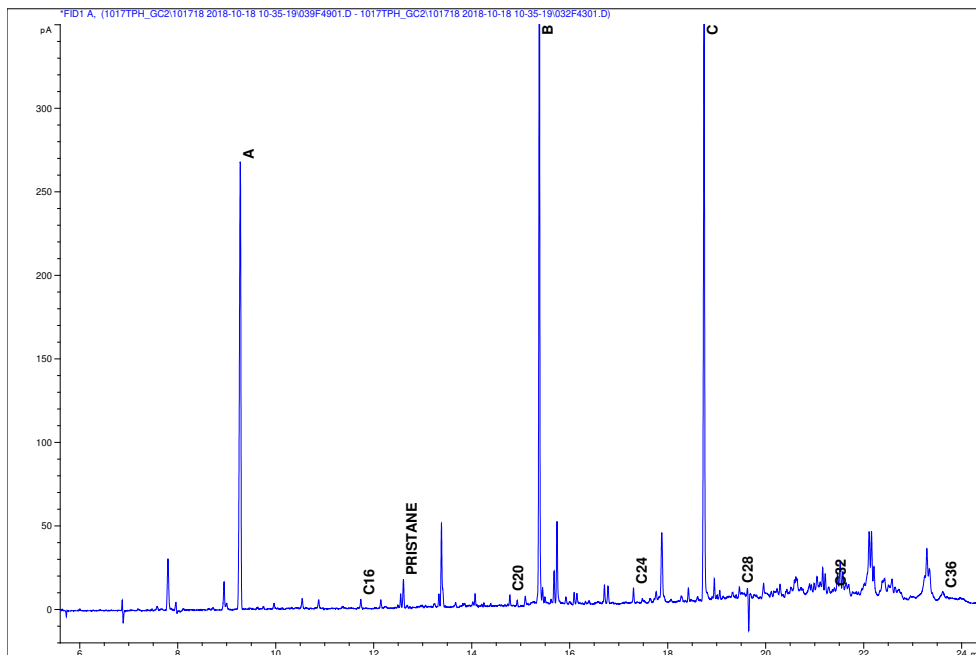
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV4**

**THC:** 6.884 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.220 $\mu\text{g g}^{-1}$

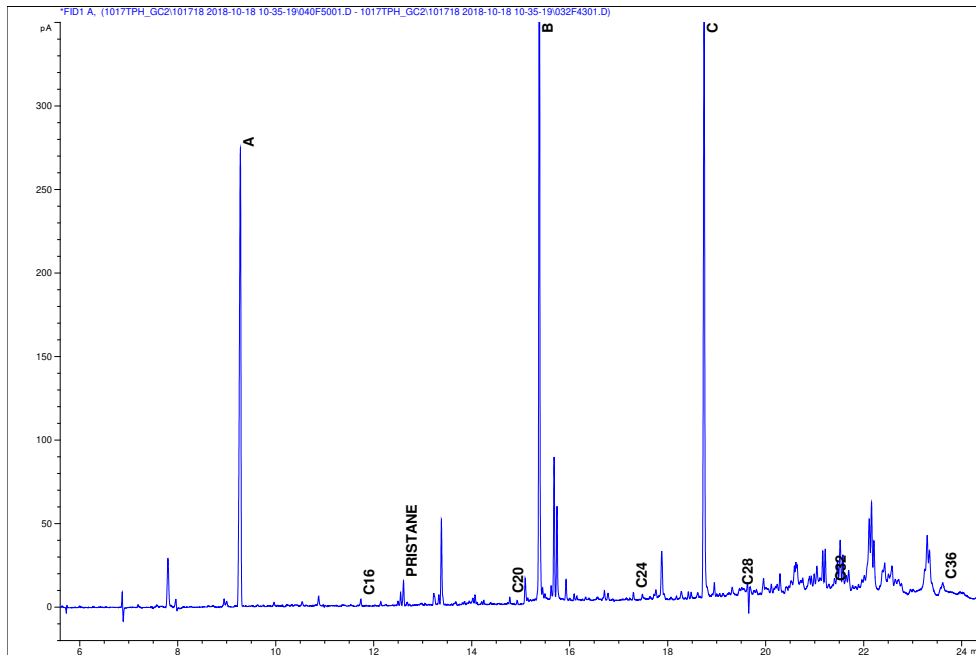


**11210 ENV5**

**THC:** 3.820 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.147 $\mu\text{g g}^{-1}$

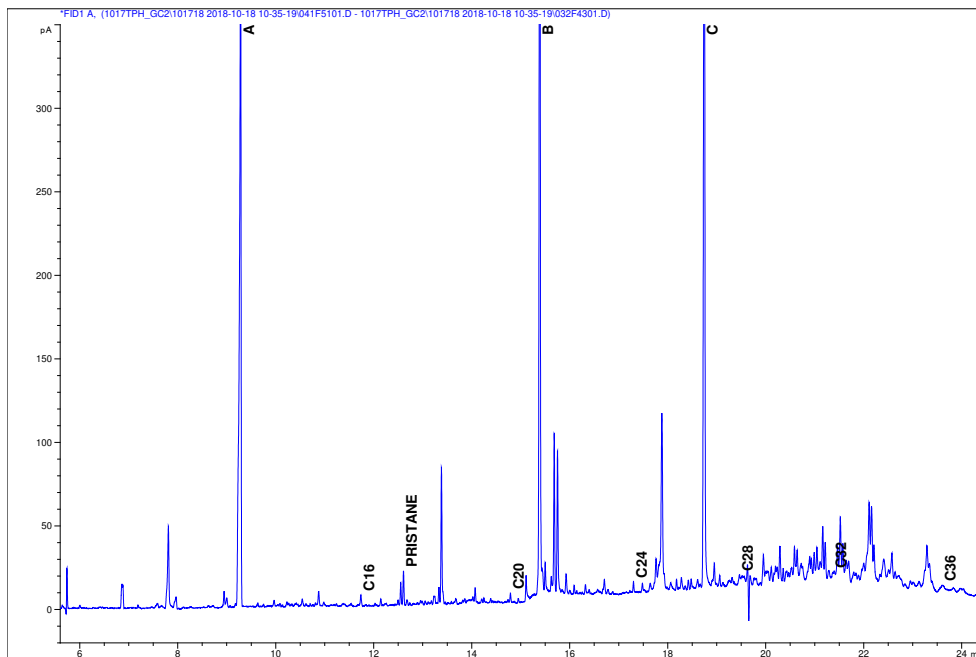
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV6**

**THC: 3.742 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.080 $\mu\text{g g}^{-1}$**

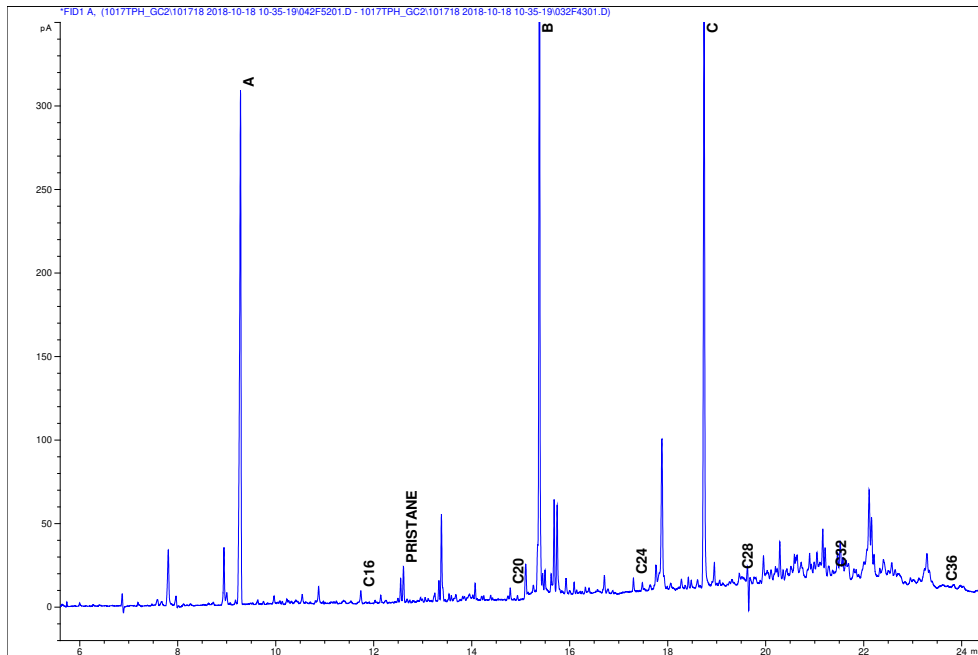


**11210 ENV8**

**THC: 4.035 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.106 $\mu\text{g g}^{-1}$**

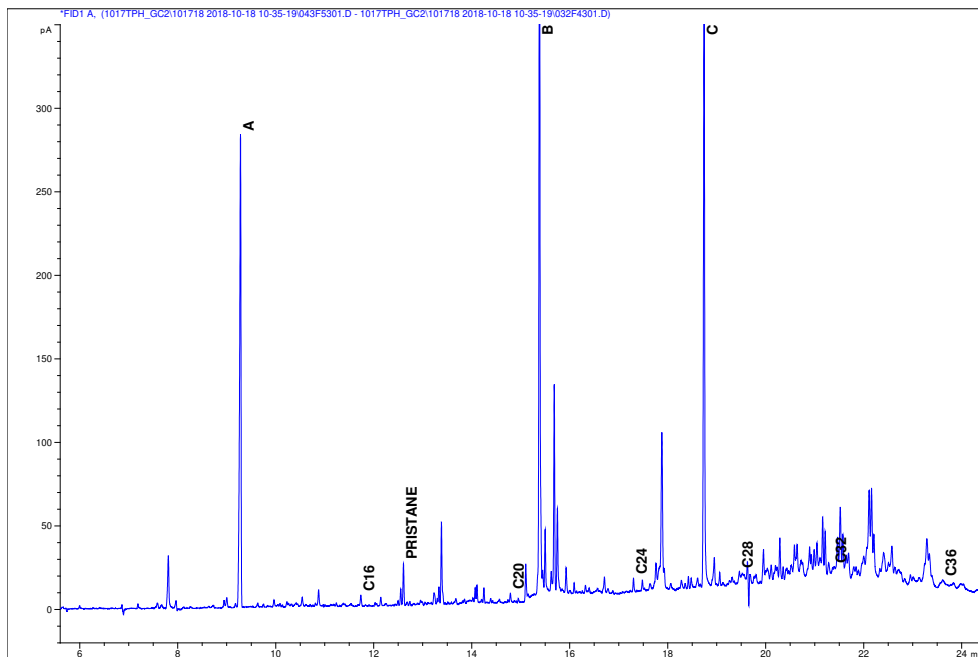
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV9**

**THC:** 6.035 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.163 $\mu\text{g g}^{-1}$

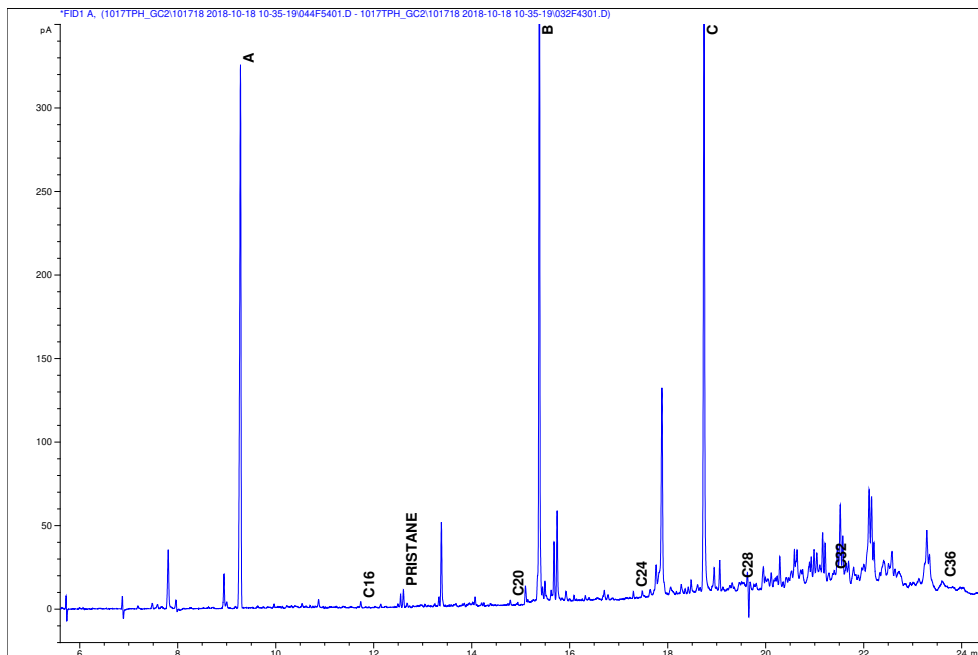


**11210 ENV10**

**THC:** 7.525 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.162 $\mu\text{g g}^{-1}$

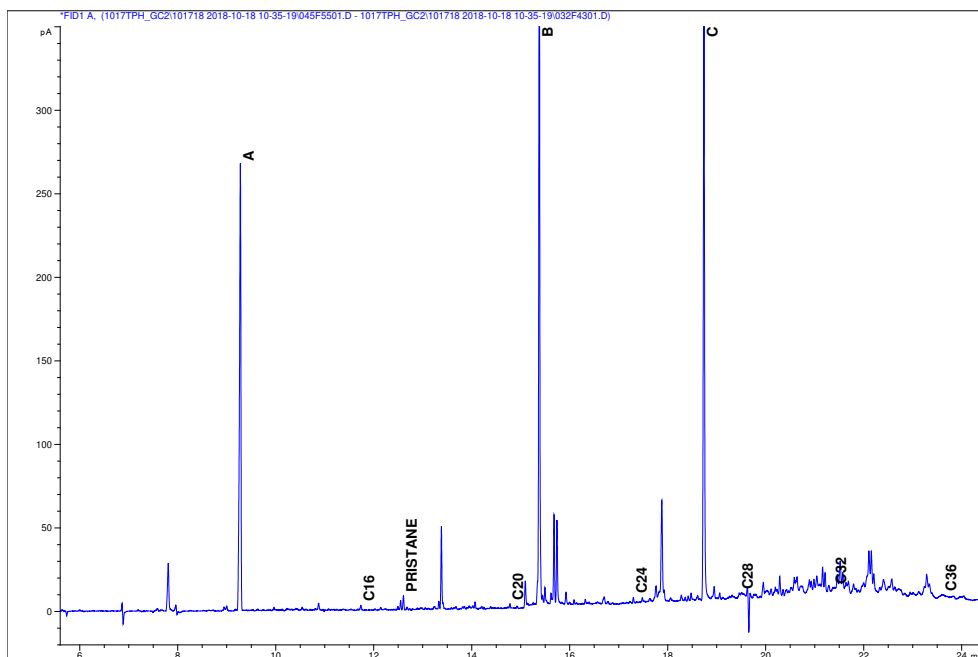
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV11**

**THC: 5.251 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.103 $\mu\text{g g}^{-1}$**



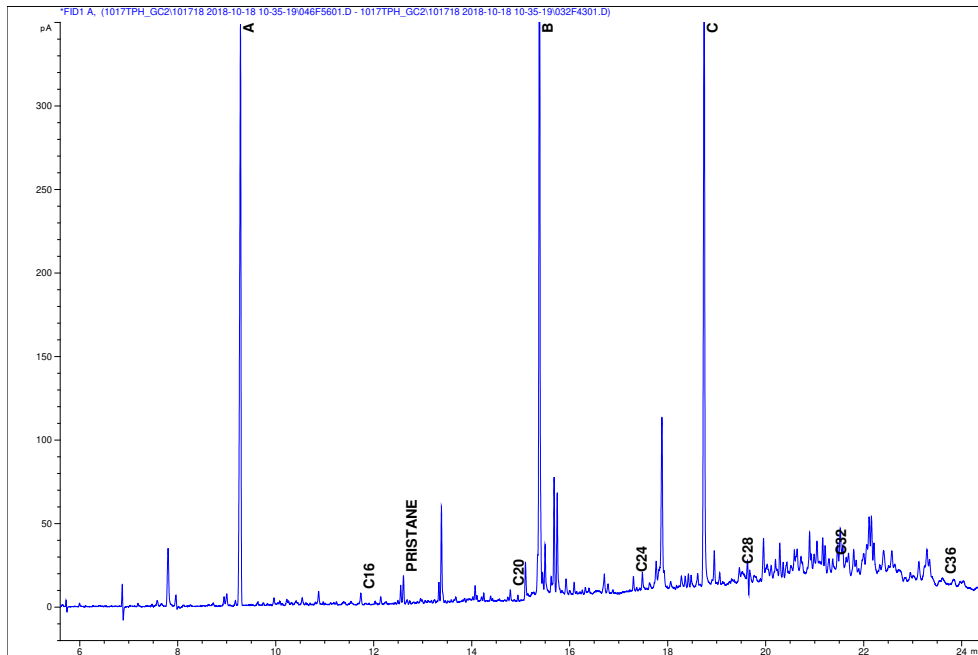
**11210 ENV14**

**THC: 3.698 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.093 $\mu\text{g g}^{-1}$**



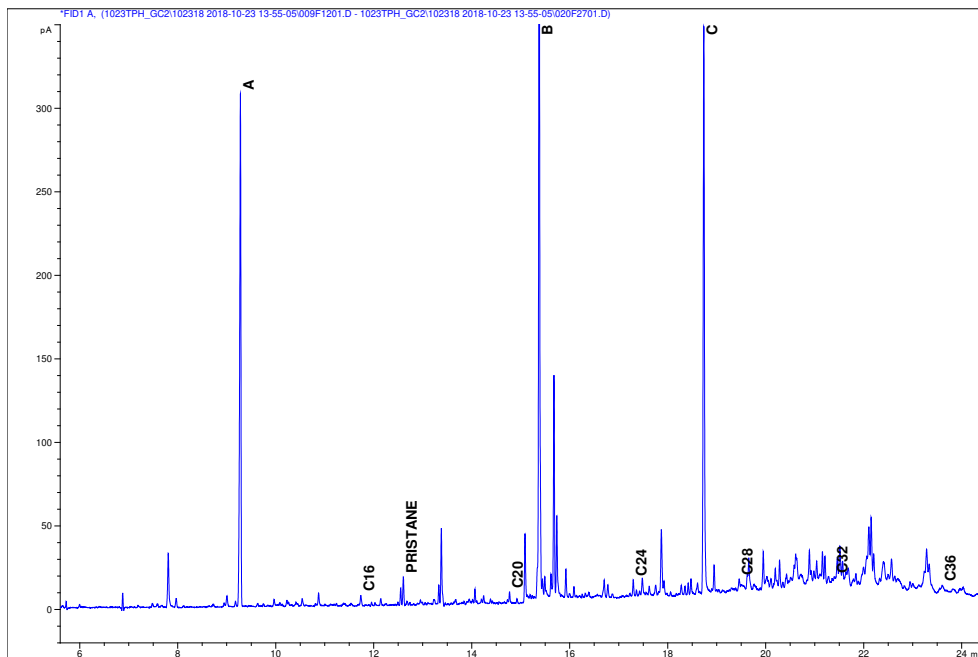
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV15**

**THC:** 5.886 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.182 $\mu\text{g g}^{-1}$

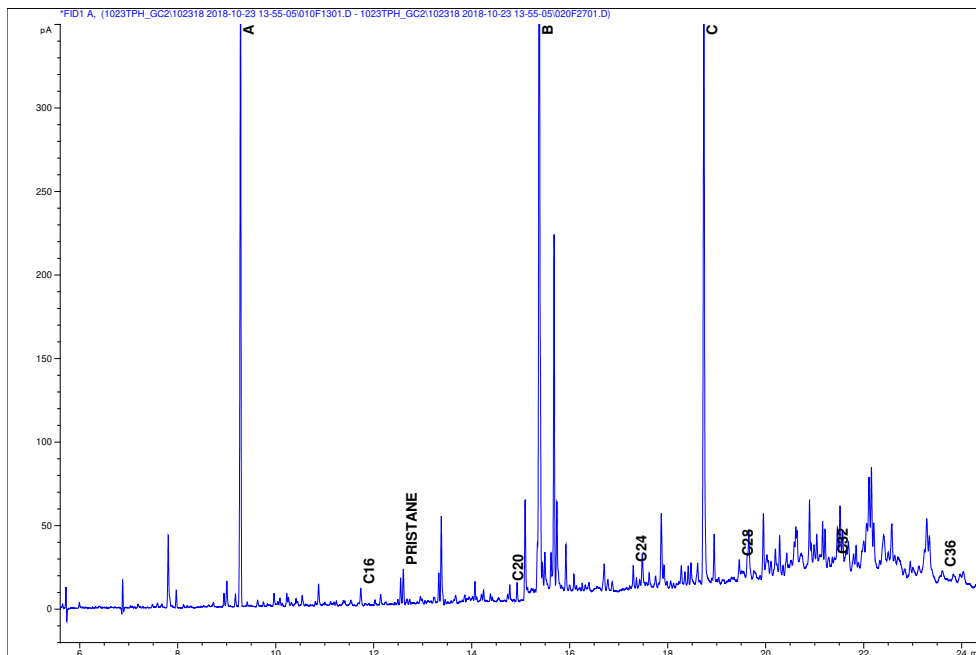


**11210 ENV16**

**THC:** 5.372 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.165 $\mu\text{g g}^{-1}$

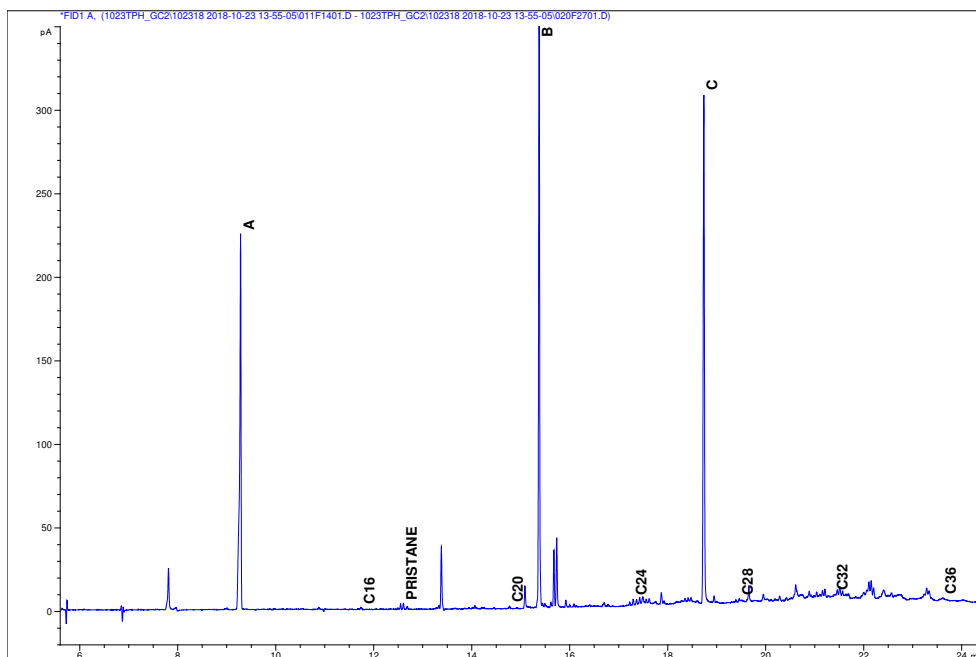
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV17**

**THC: 8.584 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.283 $\mu\text{g g}^{-1}$**

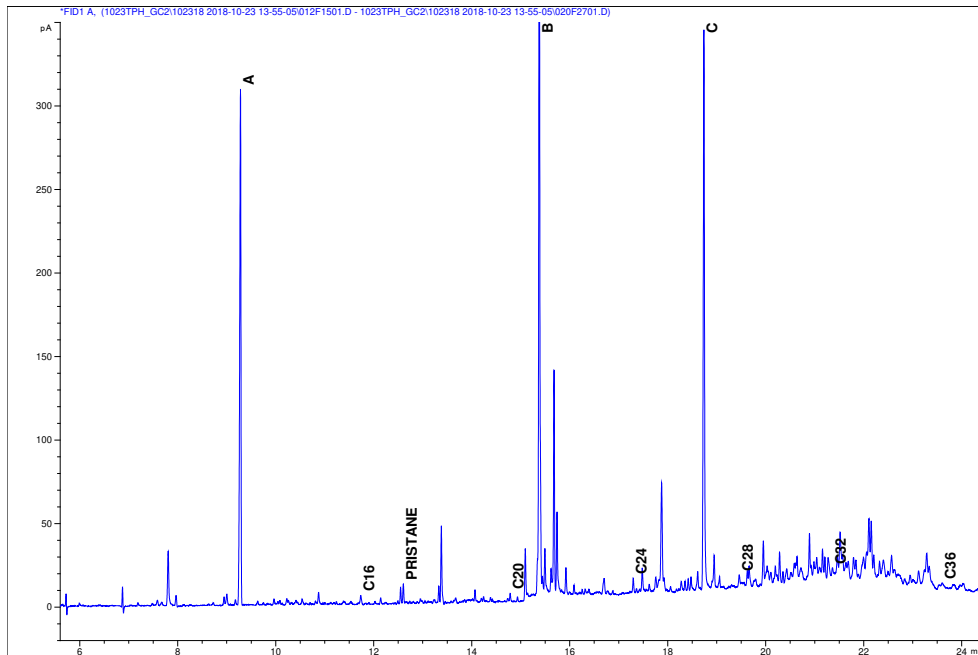


**11210 ENV18**

**THC: 2.696 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.030 $\mu\text{g g}^{-1}$**

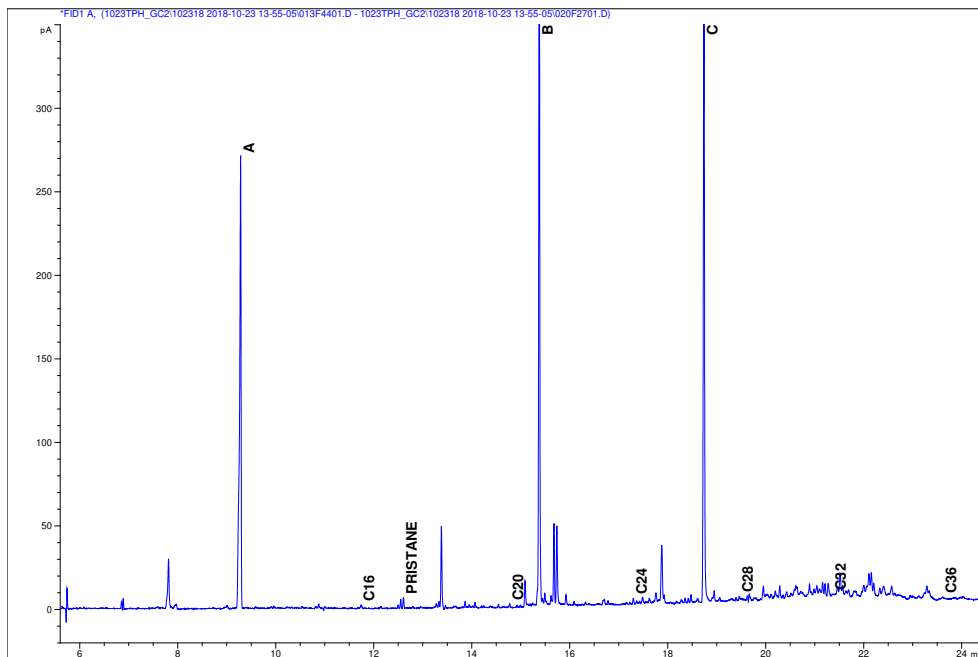
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV19**

**THC:** 6.286 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.195 $\mu\text{g g}^{-1}$

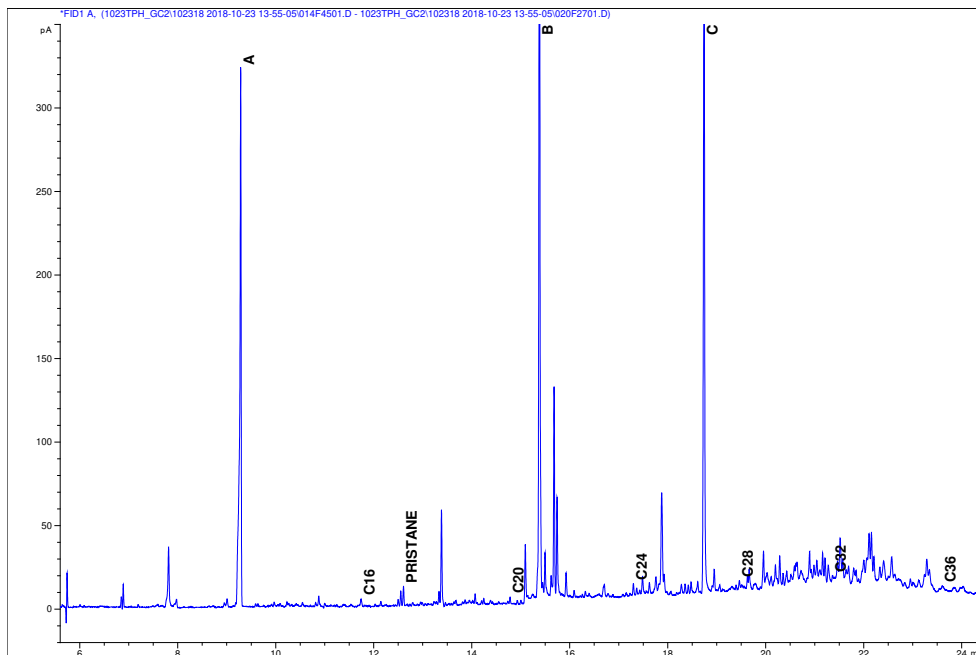


**11210 ENV20**

**THC:** 3.258 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.041 $\mu\text{g g}^{-1}$

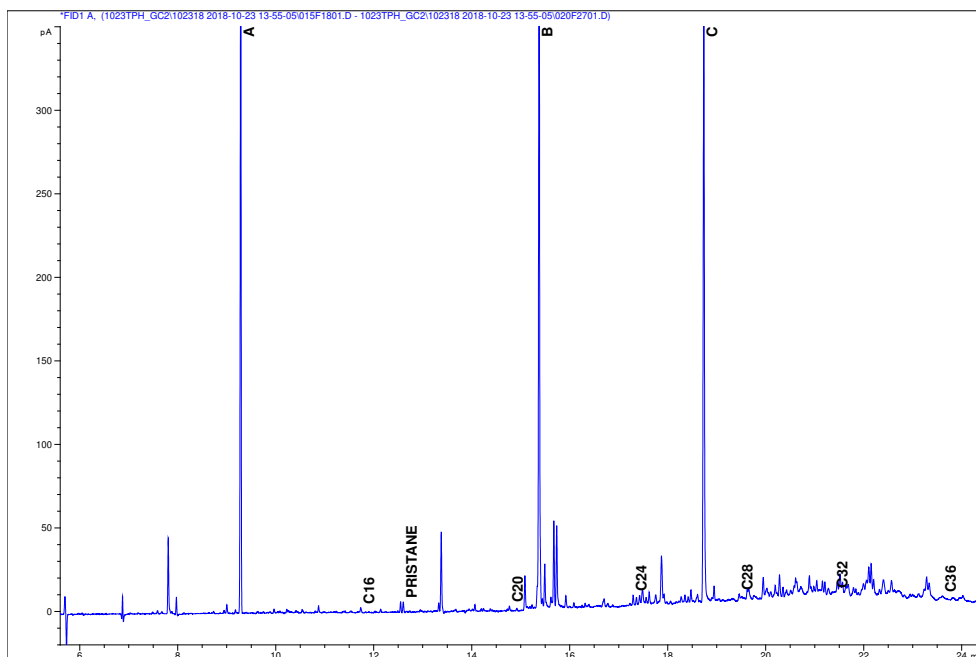
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV21**

**THC:** 5.034 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.099 $\mu\text{g g}^{-1}$

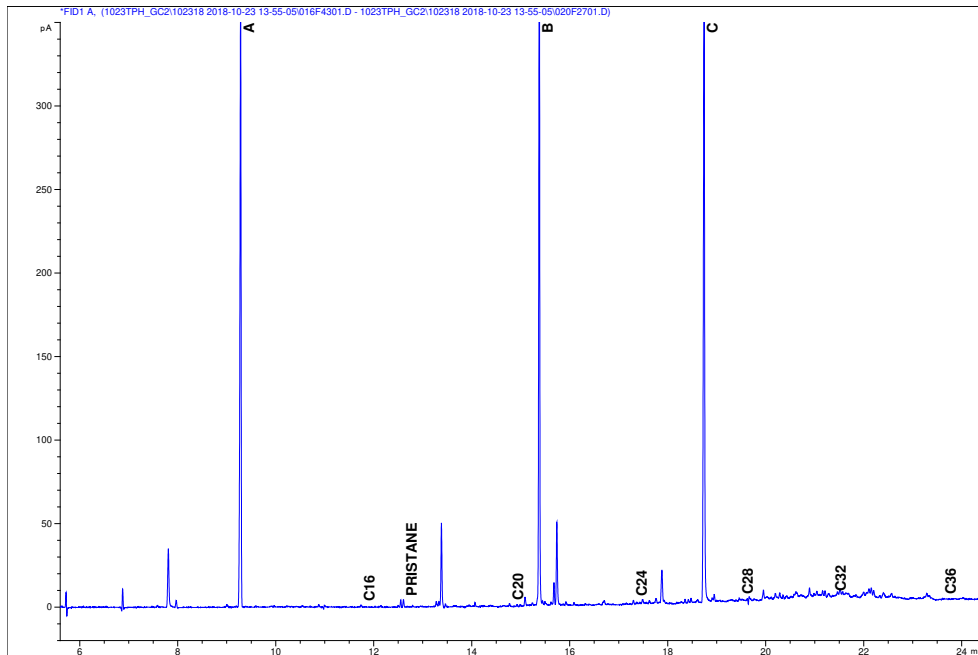


**11210 ENV22**

**THC:** 3.805 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.074 $\mu\text{g g}^{-1}$

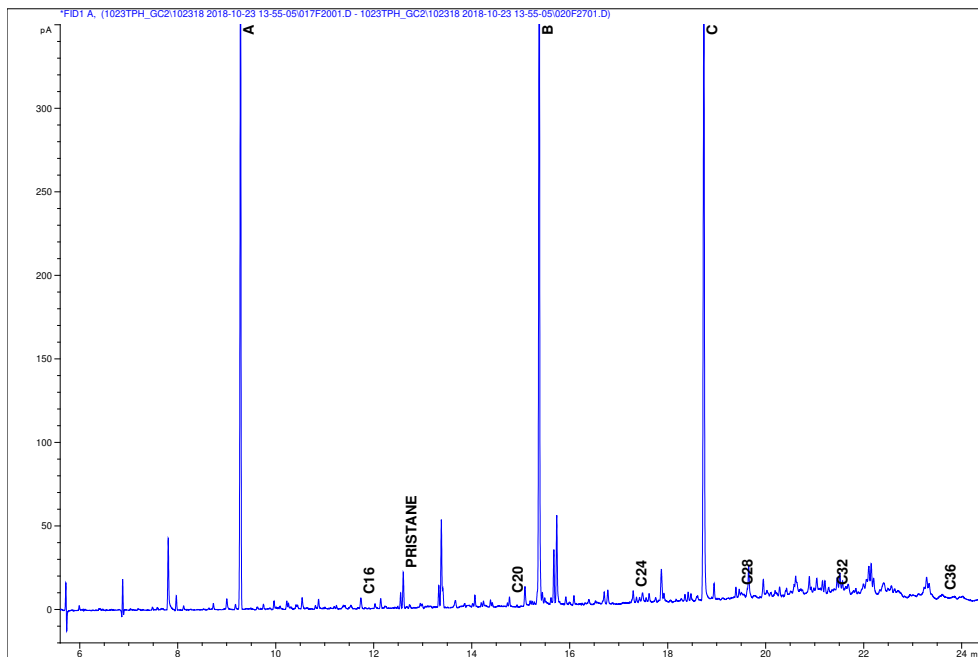
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV23**

**THC:** 1.628 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.047 $\mu\text{g g}^{-1}$

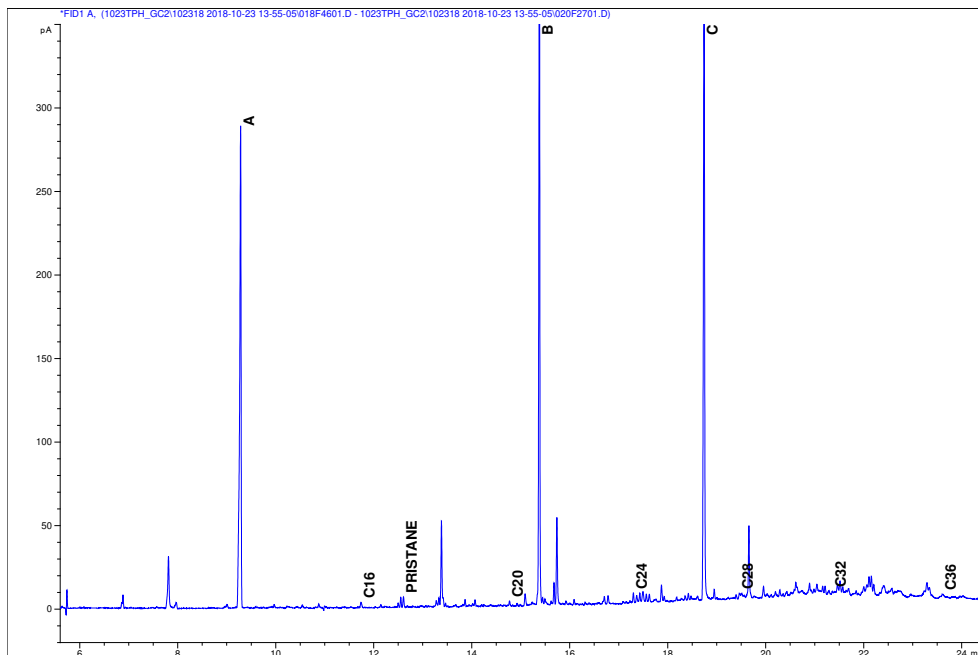


**11210 ENV24**

**THC:** 3.296 $\mu\text{g g}^{-1}$

**n-Alkanes:** 0.097 $\mu\text{g g}^{-1}$

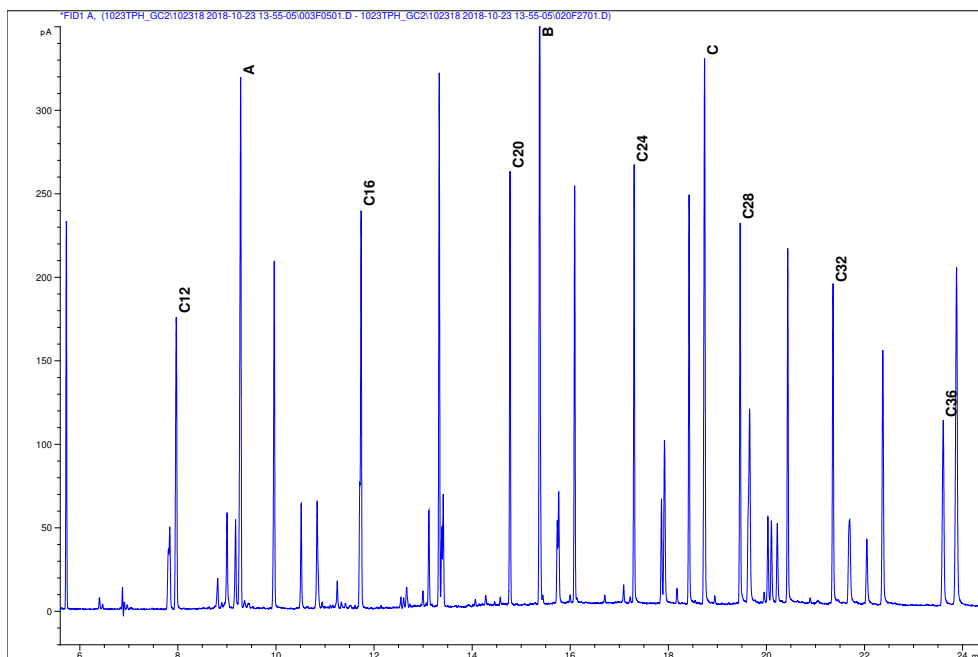
## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV25**

**THC: 2.454 $\mu\text{g g}^{-1}$**

**n-Alkanes: 0.076 $\mu\text{g g}^{-1}$**

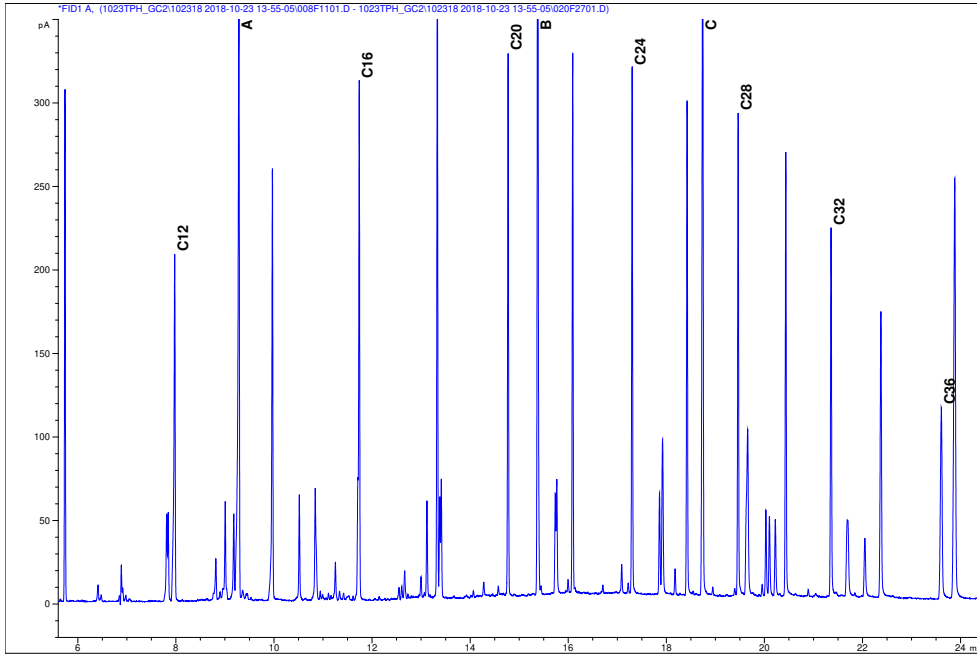


**Reference Material for Batch 1**

**(ENV1 to ENV15)**

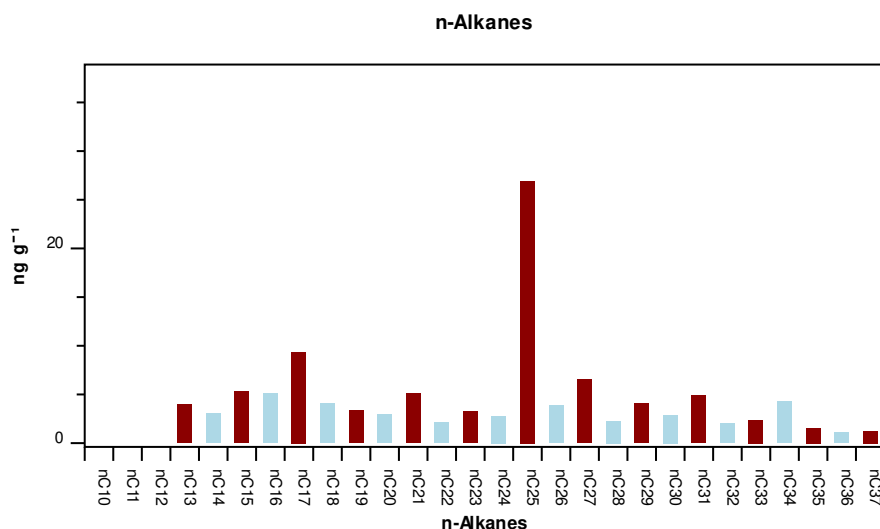


## APPENDIX I HYDROCARBON ANALYSIS



Reference Material for Batch 2  
(ENV16 to ENV25)

## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV1**

**nC10-nC20:** 37ng g<sup>-1</sup>

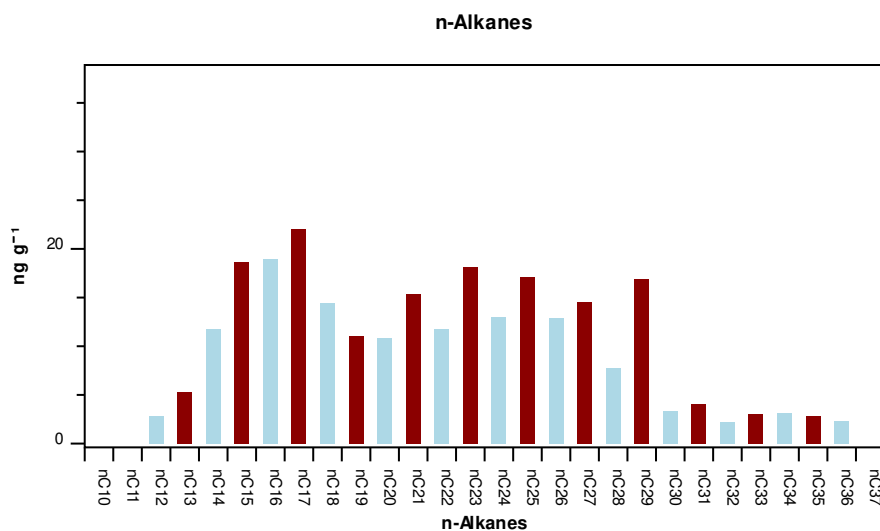
**nC21-nC37:** 77ng g<sup>-1</sup>

**nC10-nC37:** 114ng g<sup>-1</sup>

**Odd Length n-Alkanes:** 78ng g<sup>-1</sup>

**Even Length n-Alkanes:** 36ng g<sup>-1</sup>

**CPI:** 1.9



**11210 ENV2**

**nC10-nC20:** 116ng g<sup>-1</sup>

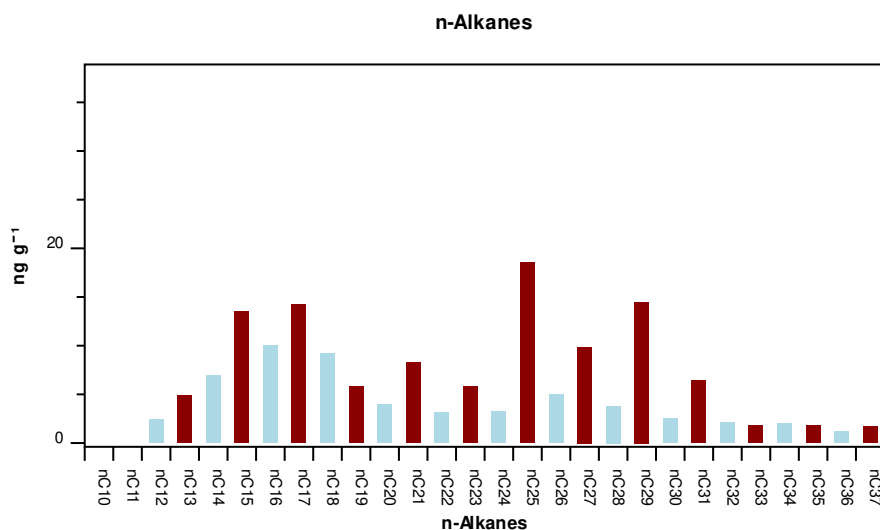
**nC21-nC37:** 148ng g<sup>-1</sup>

**nC10-nC37:** 264ng g<sup>-1</sup>

**Odd Length n-Alkanes:** 149ng g<sup>-1</sup>

**Even Length n-Alkanes:** 115ng g<sup>-1</sup>

**CPI:** 2.0



**11210 ENV4**

**nC10-nC20:** 71ng g<sup>-1</sup>

**nC21-nC37:** 92ng g<sup>-1</sup>

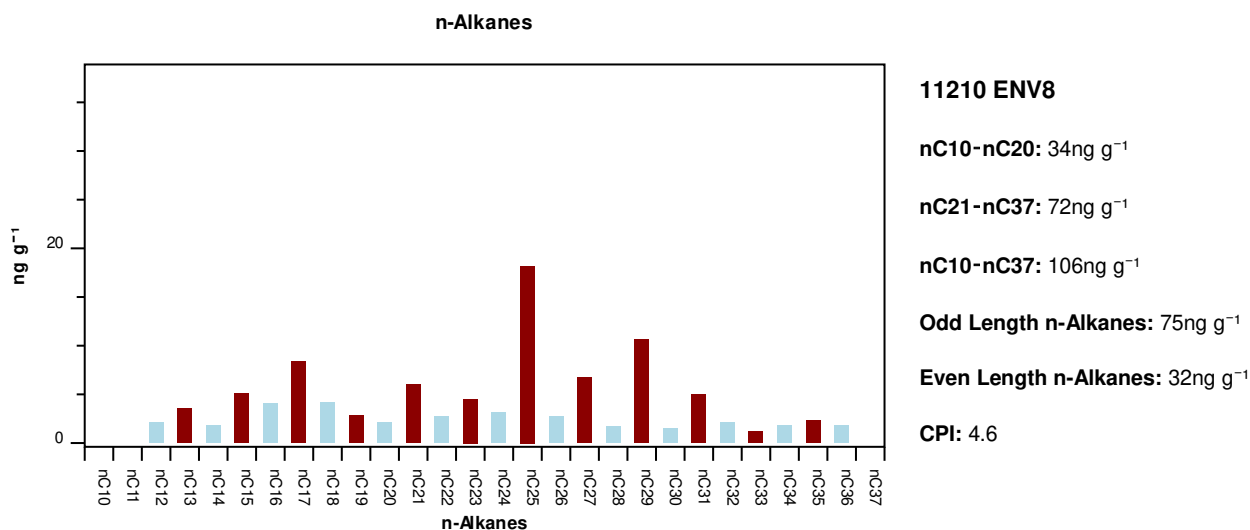
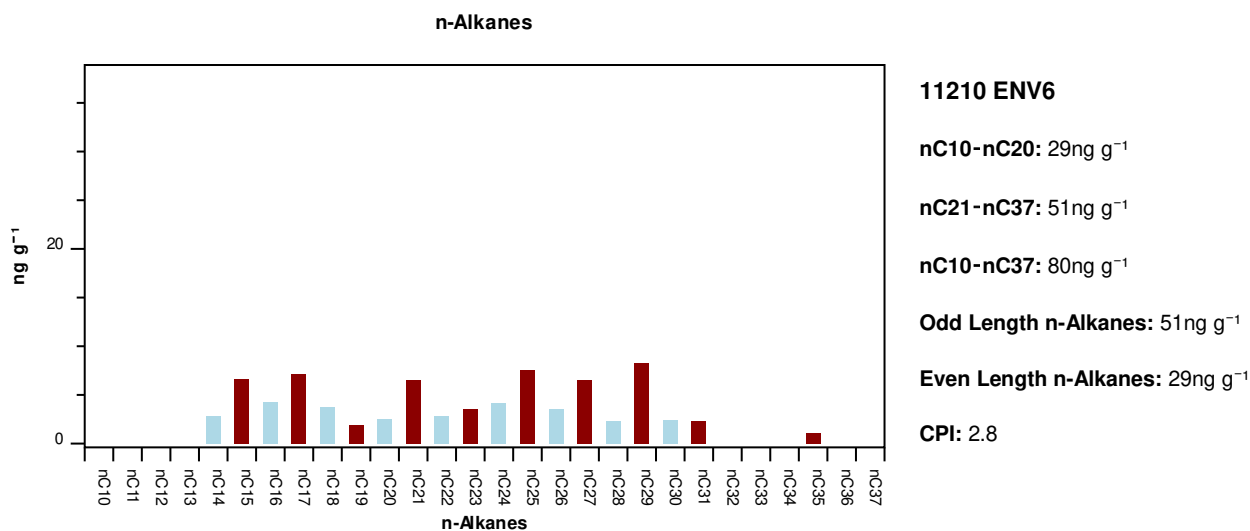
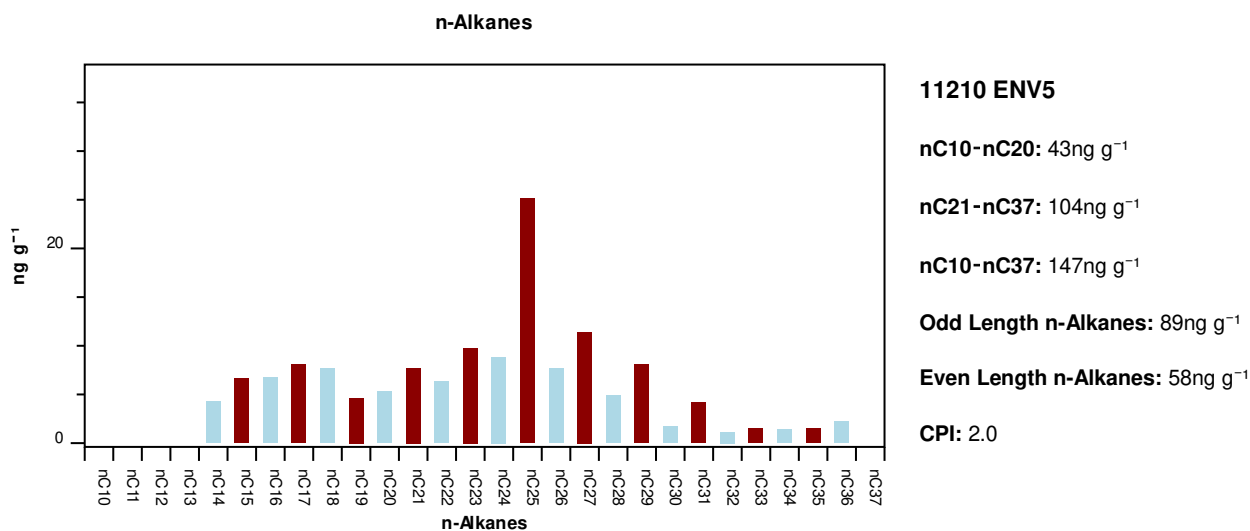
**nC10-nC37:** 163ng g<sup>-1</sup>

**Odd Length n-Alkanes:** 107ng g<sup>-1</sup>

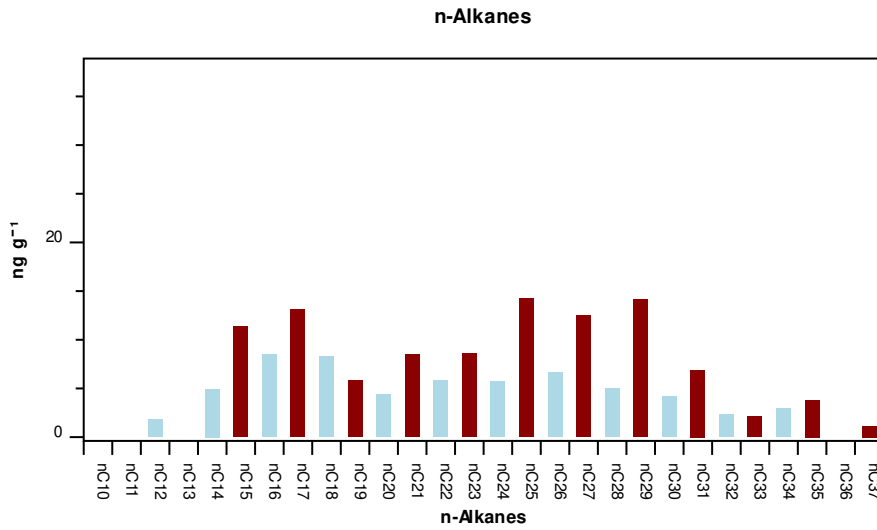
**Even Length n-Alkanes:** 55ng g<sup>-1</sup>

**CPI:** 3.2

## APPENDIX I HYDROCARBON ANALYSIS



## APPENDIX I HYDROCARBON ANALYSIS



**11210 ENV9**

**nC10-nC20:** 58ng g<sup>-1</sup>

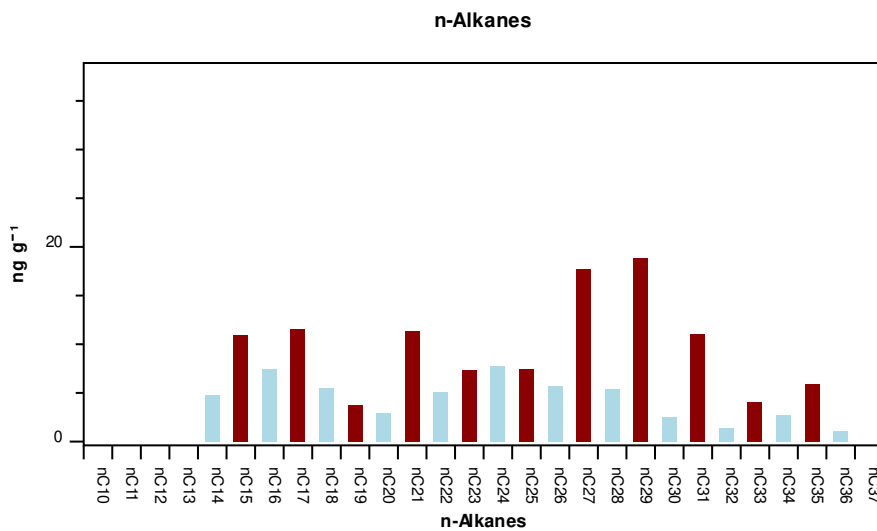
**nC21-nC37:** 105ng g<sup>-1</sup>

**nC10-nC37:** 163ng g<sup>-1</sup>

**Odd Length n-Alkanes:** 102ng g<sup>-1</sup>

**Even Length n-Alkanes:** 60ng g<sup>-1</sup>

**CPI:** 2.6



**11210 ENV10**

**nC10-nC20:** 47ng g<sup>-1</sup>

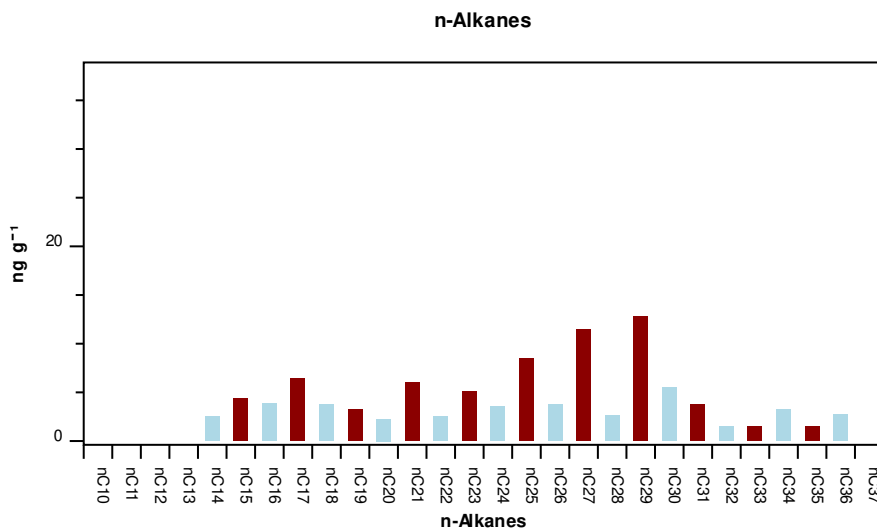
**nC21-nC37:** 115ng g<sup>-1</sup>

**nC10-nC37:** 162ng g<sup>-1</sup>

**Odd Length n-Alkanes:** 110ng g<sup>-1</sup>

**Even Length n-Alkanes:** 52ng g<sup>-1</sup>

**CPI:** 3.8



**11210 ENV11**

**nC10-nC20:** 26ng g<sup>-1</sup>

**nC21-nC37:** 76ng g<sup>-1</sup>

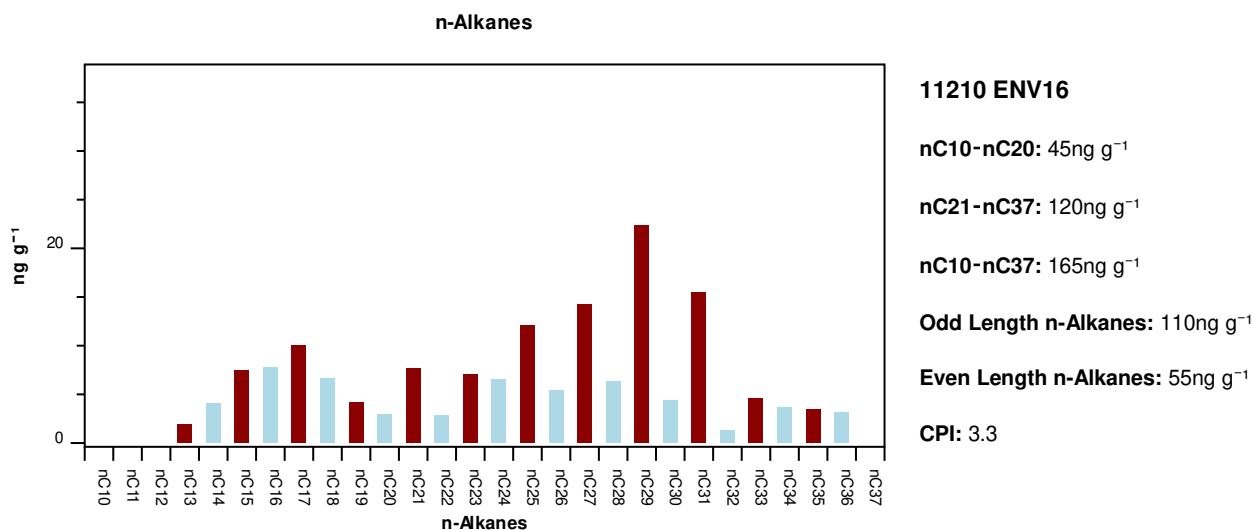
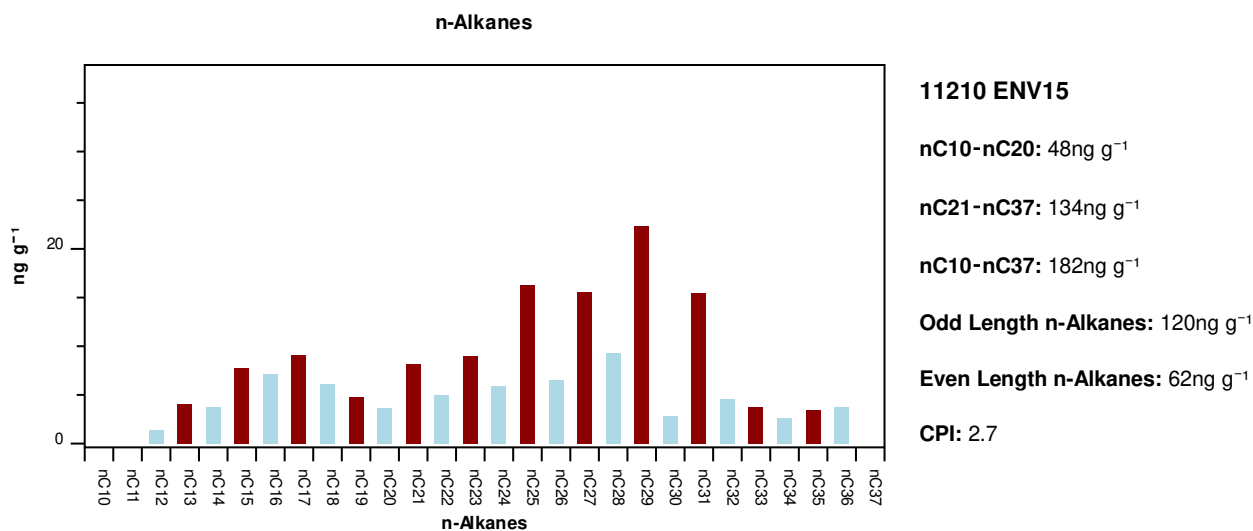
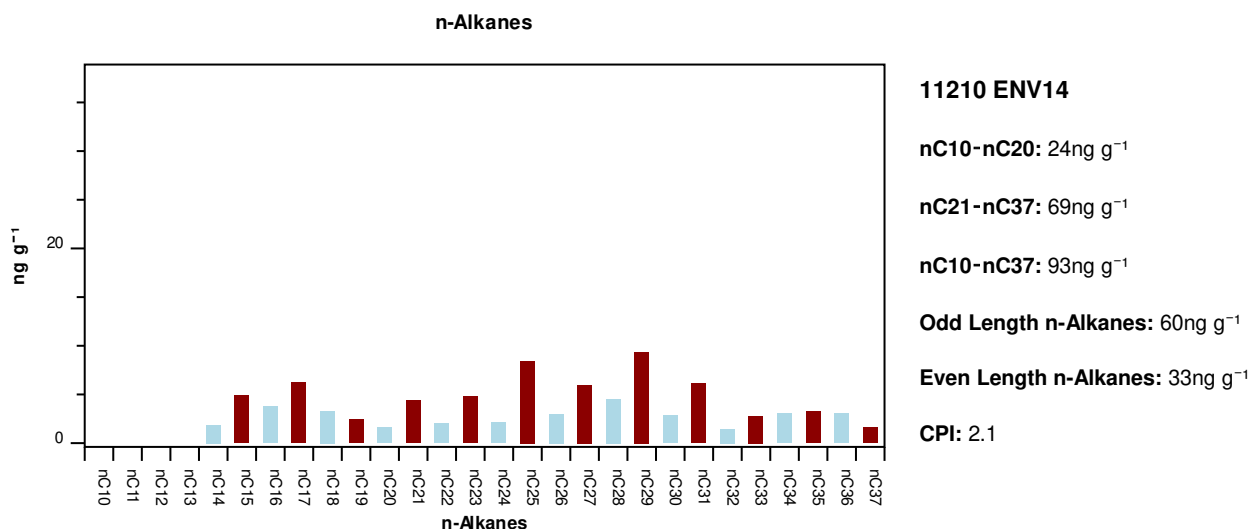
**nC10-nC37:** 103ng g<sup>-1</sup>

**Odd Length n-Alkanes:** 65ng g<sup>-1</sup>

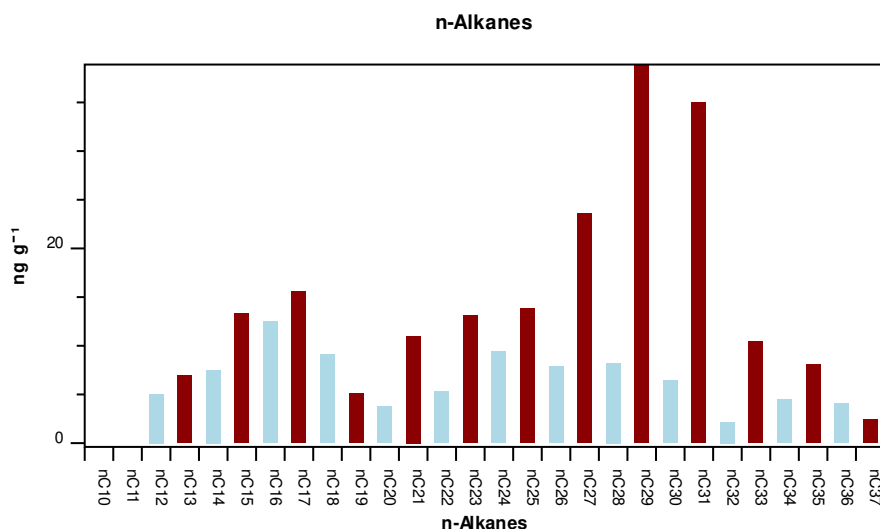
**Even Length n-Alkanes:** 38ng g<sup>-1</sup>

**CPI:** 3.3

## APPENDIX I HYDROCARBON ANALYSIS



## APPENDIX I HYDROCARBON ANALYSIS



### 11210 ENV17

nC10-nC20: 79ng g<sup>-1</sup>

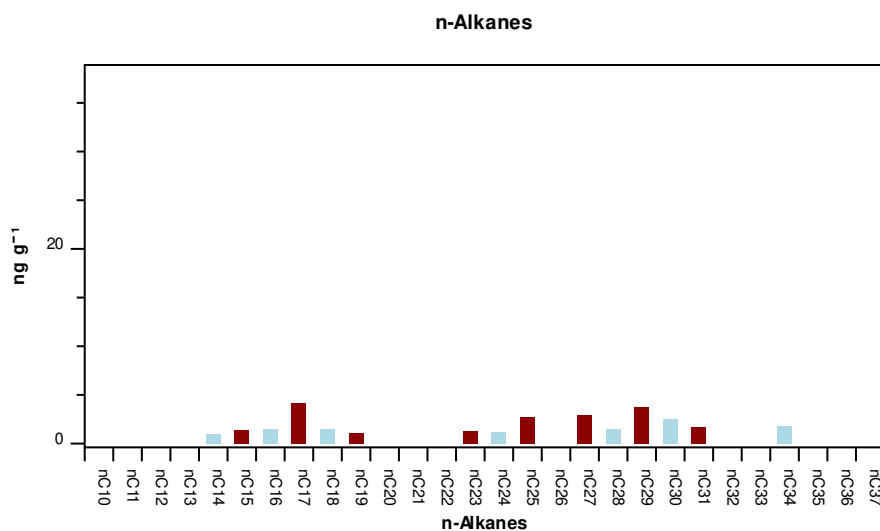
nC21-nC37: 204ng g<sup>-1</sup>

nC10-nC37: 283ng g<sup>-1</sup>

Odd Length n-Alkanes: 197ng g<sup>-1</sup>

Even Length n-Alkanes: 86ng g<sup>-1</sup>

CPI: 4.1



### 11210 ENV18

nC10-nC20: 11ng g<sup>-1</sup>

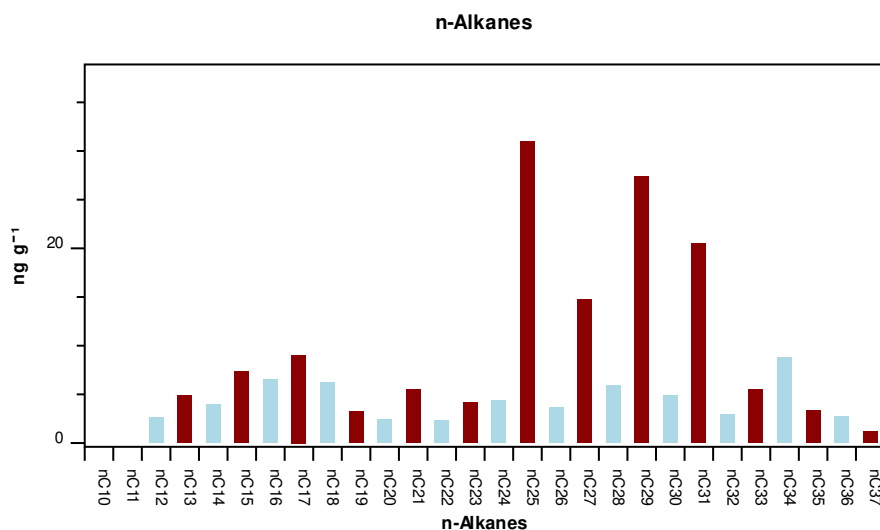
nC21-nC37: 19ng g<sup>-1</sup>

nC10-nC37: 30ng g<sup>-1</sup>

Odd Length n-Alkanes: 19ng g<sup>-1</sup>

Even Length n-Alkanes: 11ng g<sup>-1</sup>

CPI: 2.4



### 11210 ENV19

nC10-nC20: 46ng g<sup>-1</sup>

nC21-nC37: 149ng g<sup>-1</sup>

nC10-nC37: 195ng g<sup>-1</sup>

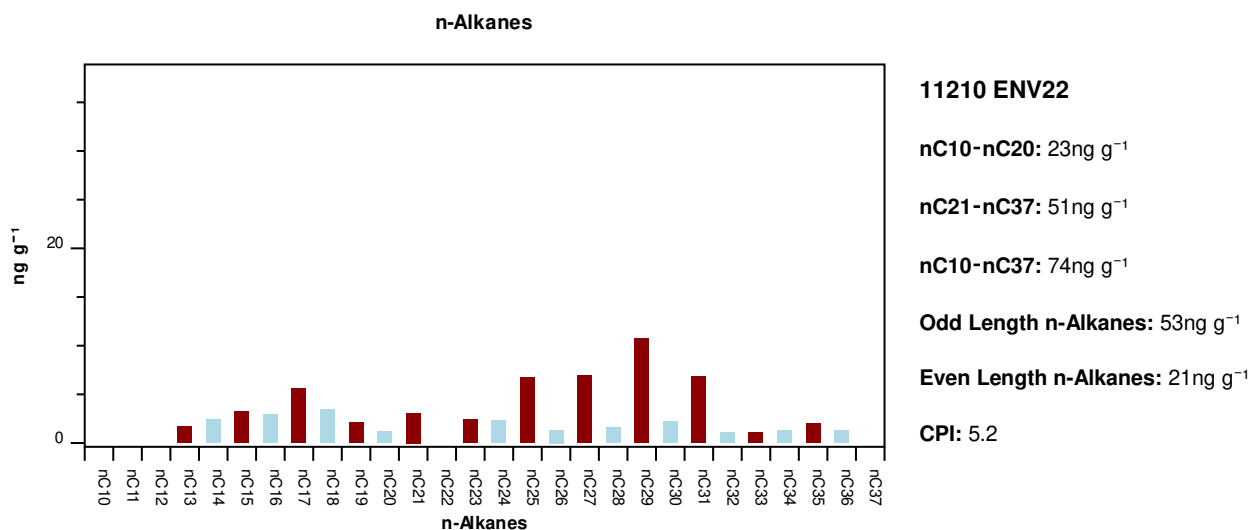
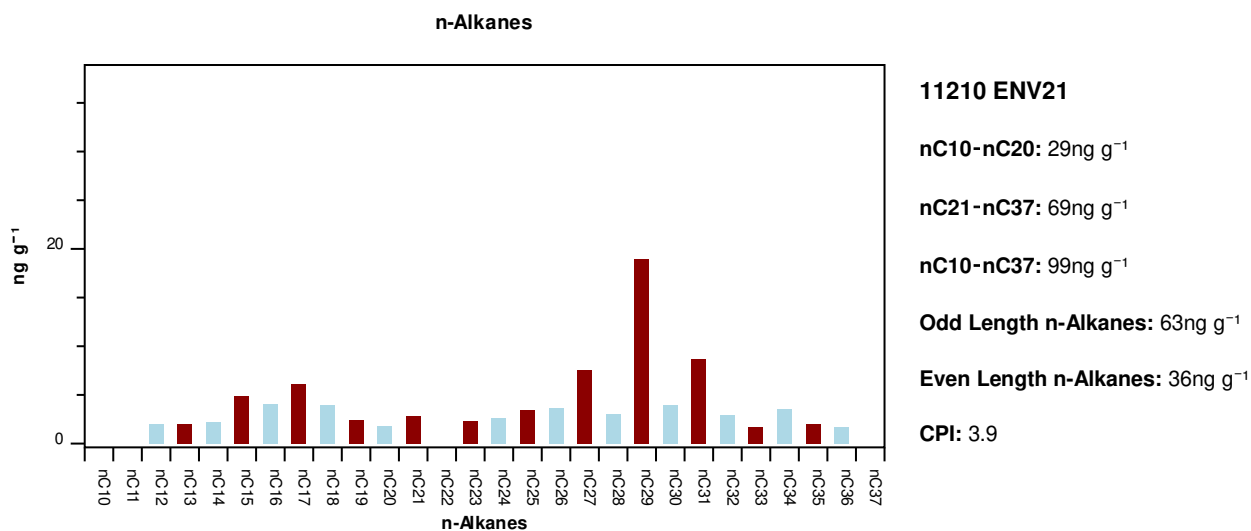
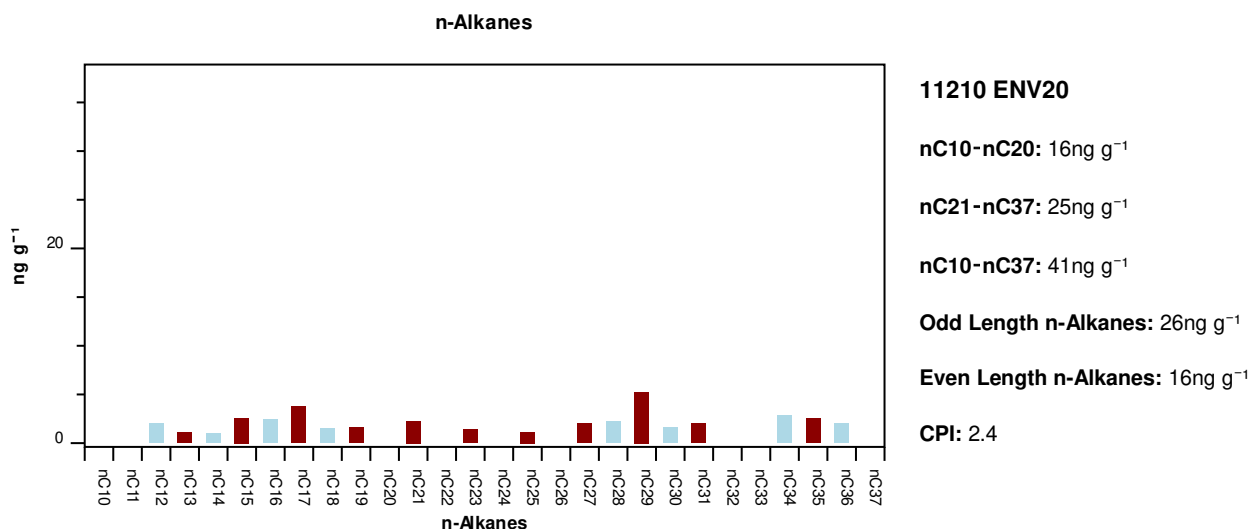
Odd Length n-Alkanes: 138ng g<sup>-1</sup>

Even Length n-Alkanes: 57ng g<sup>-1</sup>

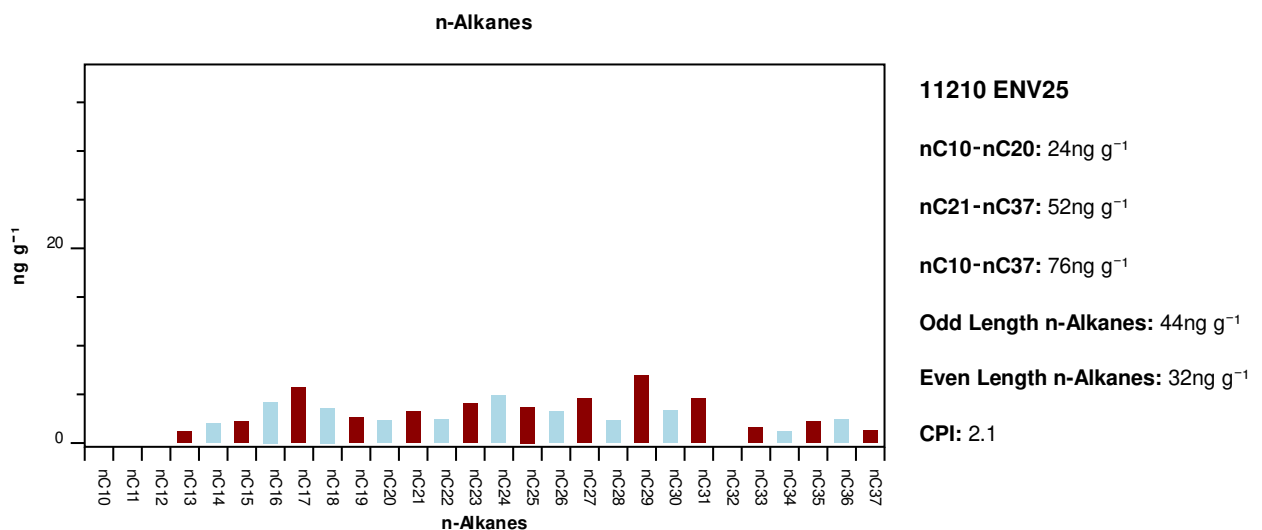
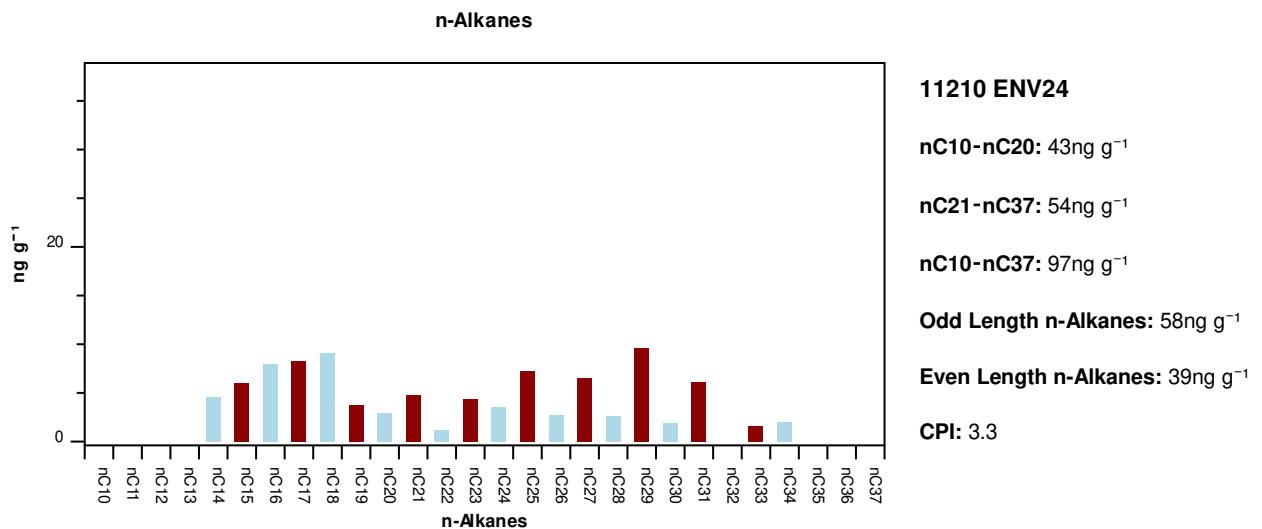
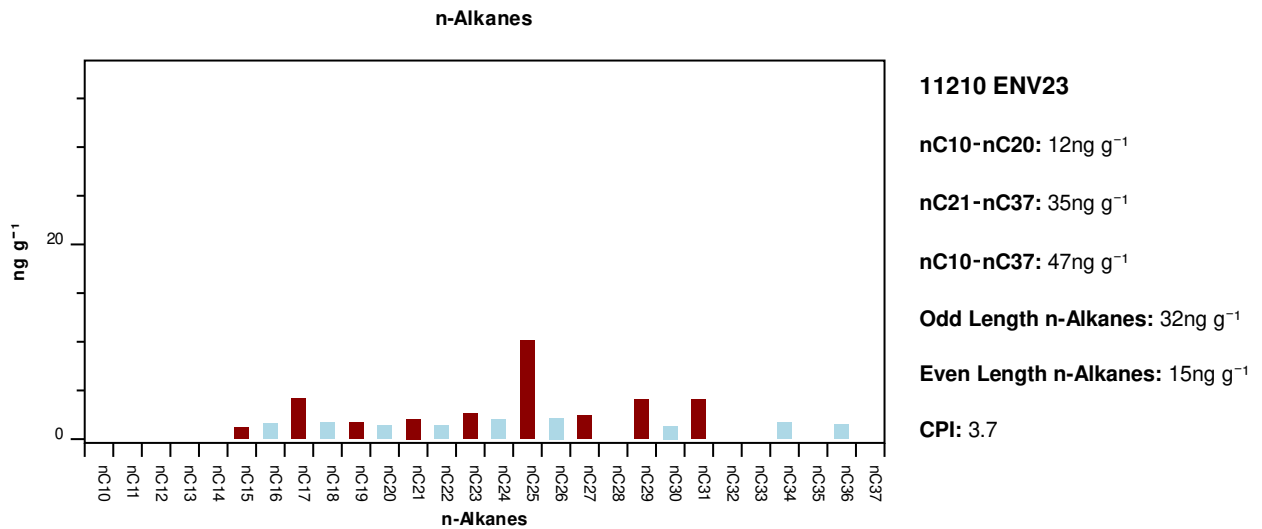
CPI: 4.2



## APPENDIX I HYDROCARBON ANALYSIS

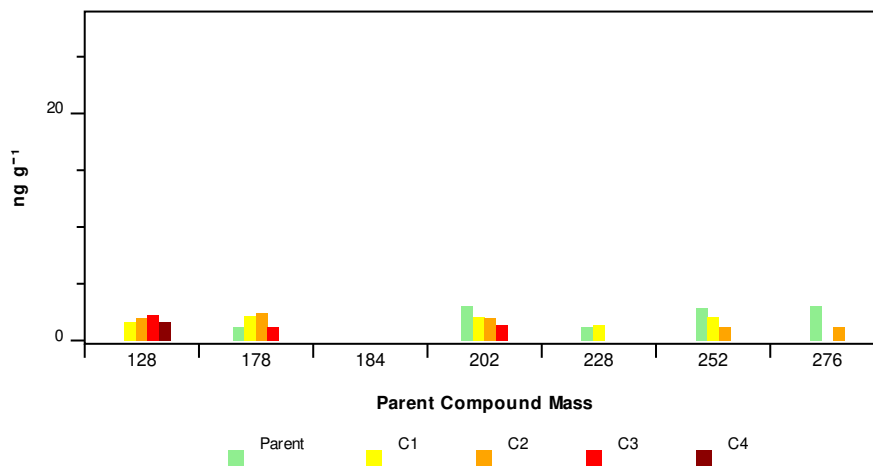


## APPENDIX I HYDROCARBON ANALYSIS



## APPENDIX I HYDROCARBON ANALYSIS

### Polycyclic Aromatic Hydrocarbons

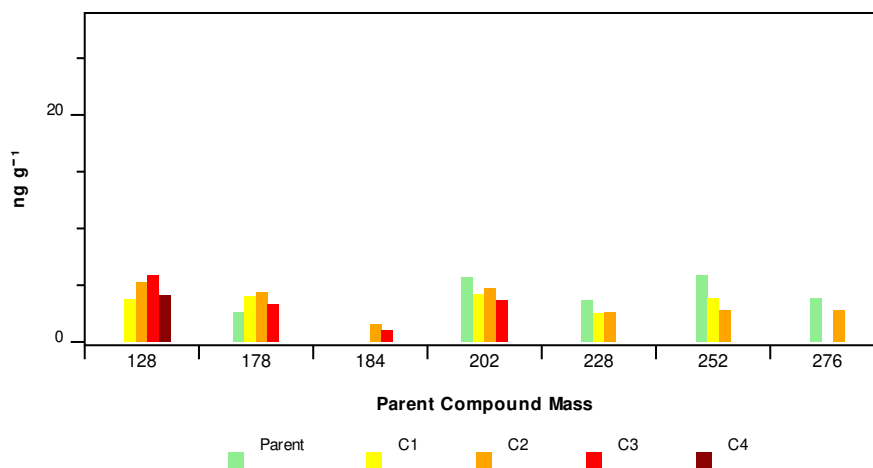


**11210 ENV1**

**Total NPD: 15ng g<sup>-1</sup>**

**Total PAH: 36ng g<sup>-1</sup>**

### Polycyclic Aromatic Hydrocarbons

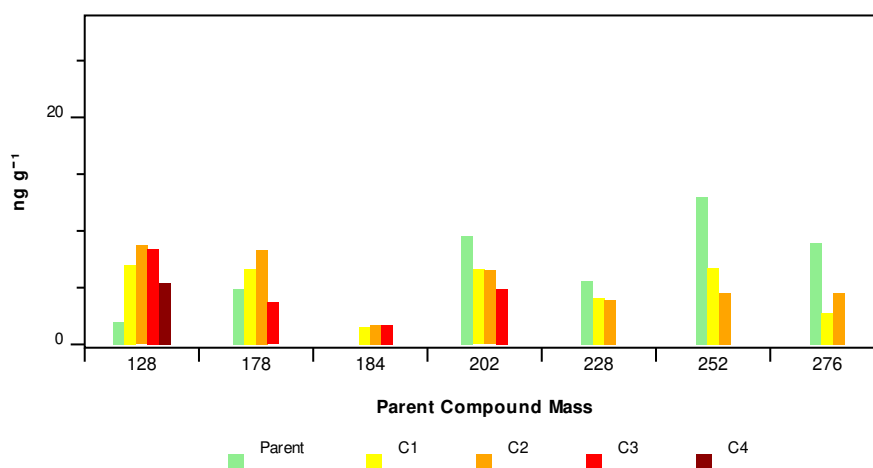


**11210 ENV2**

**Total NPD: 36ng g<sup>-1</sup>**

**Total PAH: 82ng g<sup>-1</sup>**

### Polycyclic Aromatic Hydrocarbons



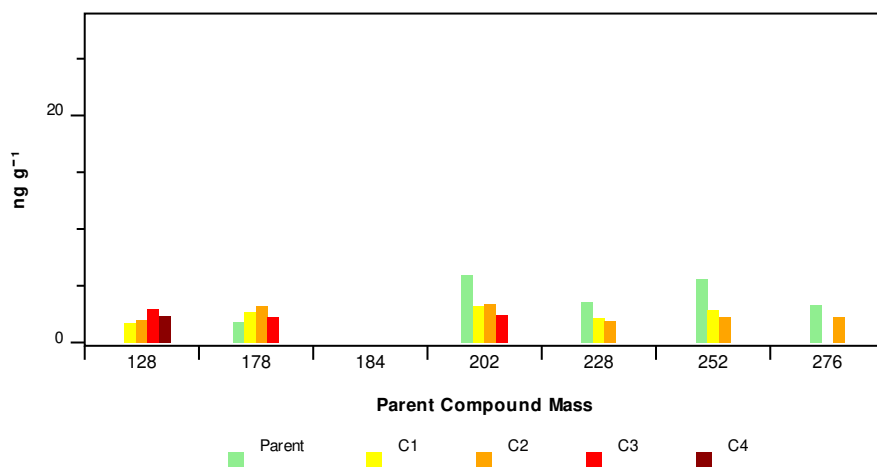
**11210 ENV4**

**Total NPD: 60ng g<sup>-1</sup>**

**Total PAH: 142ng g<sup>-1</sup>**

## APPENDIX I HYDROCARBON ANALYSIS

### Polycyclic Aromatic Hydrocarbons

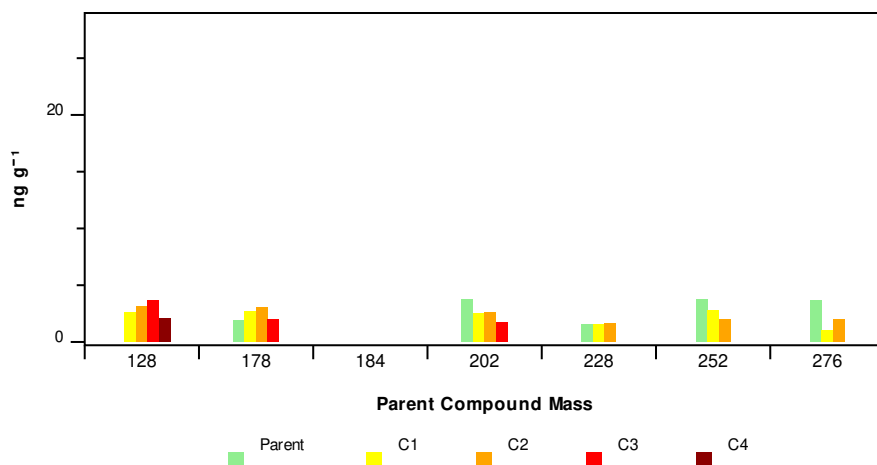


11210 ENV5

Total NPD: 19ng g<sup>-1</sup>

Total PAH: 58ng g<sup>-1</sup>

### Polycyclic Aromatic Hydrocarbons

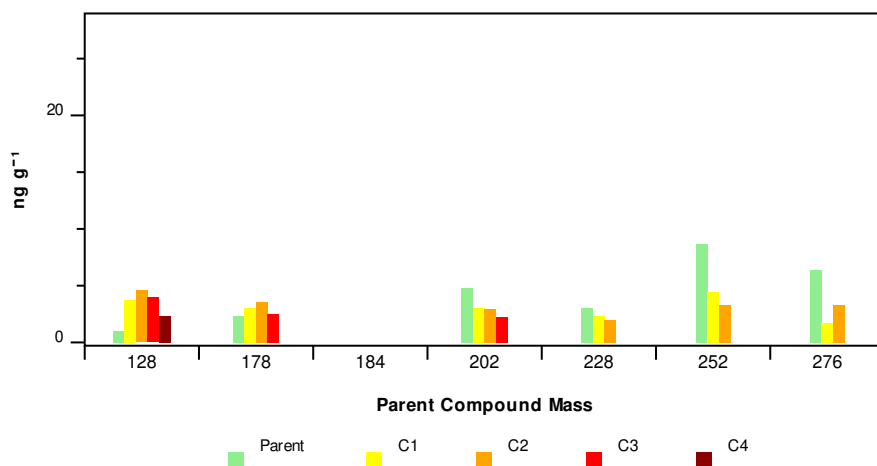


11210 ENV6

Total NPD: 21ng g<sup>-1</sup>

Total PAH: 52ng g<sup>-1</sup>

### Polycyclic Aromatic Hydrocarbons

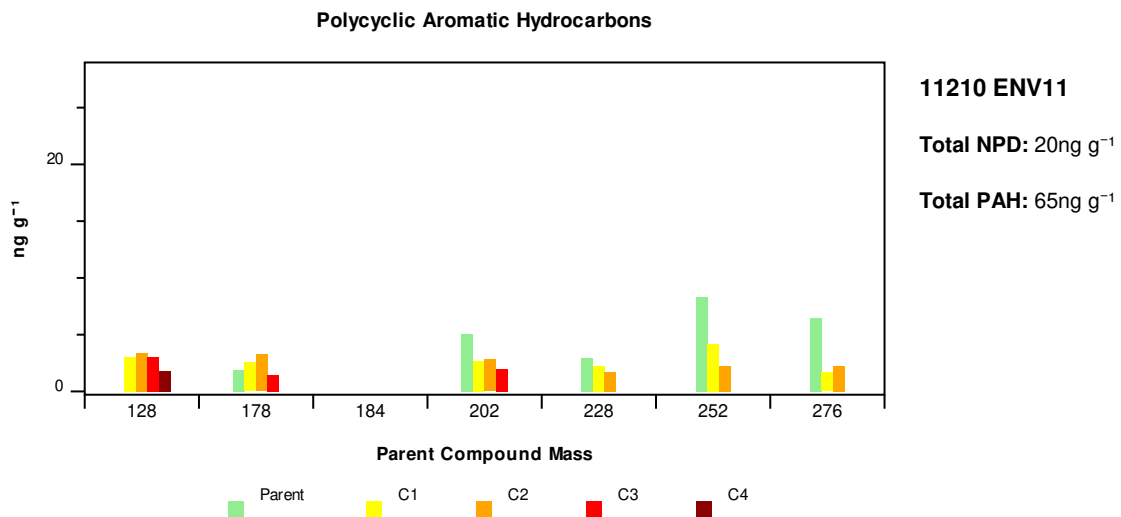
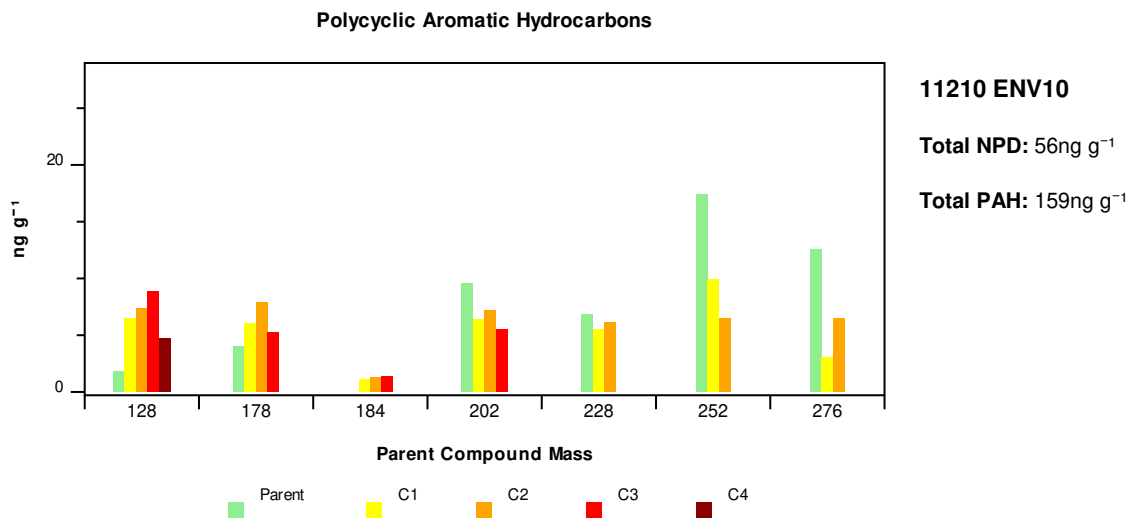
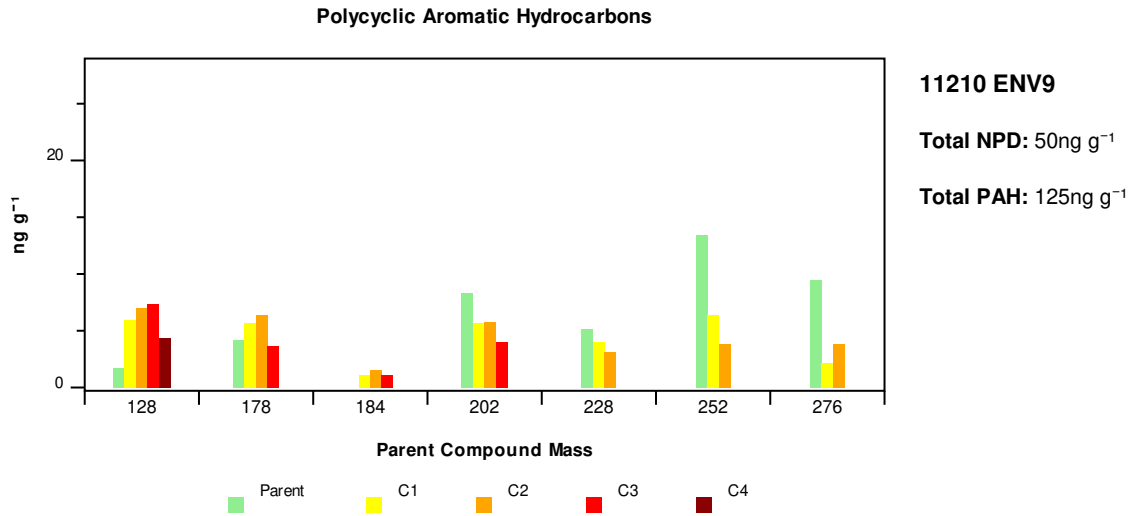


11210 ENV8

Total NPD: 27ng g<sup>-1</sup>

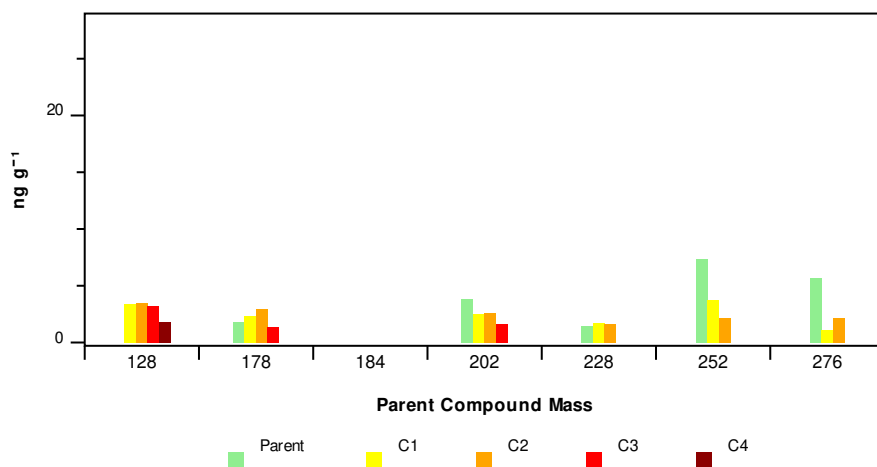
Total PAH: 75ng g<sup>-1</sup>

## APPENDIX I HYDROCARBON ANALYSIS



## APPENDIX I HYDROCARBON ANALYSIS

### Polycyclic Aromatic Hydrocarbons

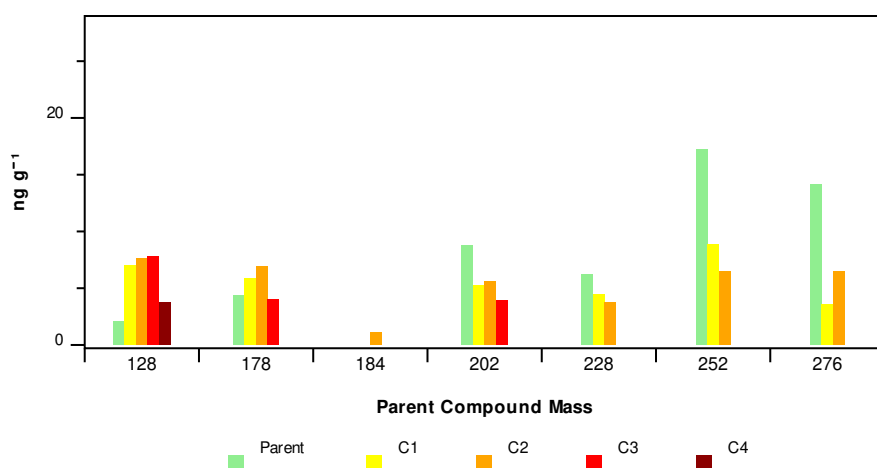


11210 ENV14

Total NPD: 20ng g<sup>-1</sup>

Total PAH: 58ng g<sup>-1</sup>

### Polycyclic Aromatic Hydrocarbons

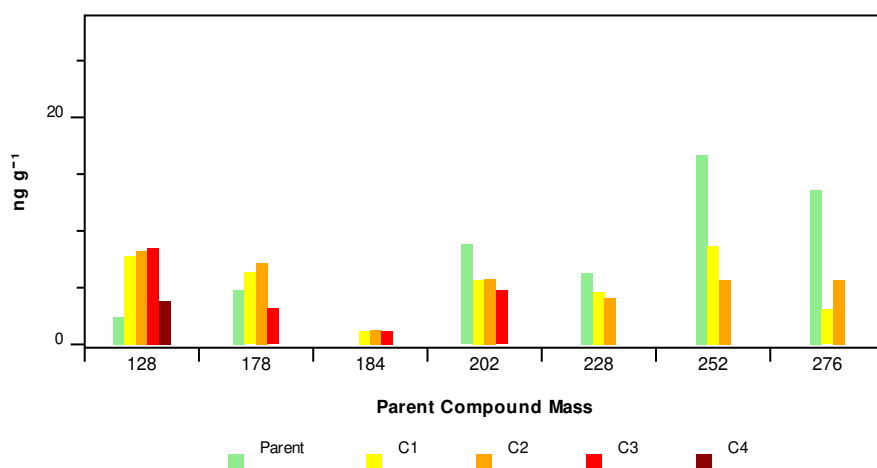


11210 ENV15

Total NPD: 50ng g<sup>-1</sup>

Total PAH: 145ng g<sup>-1</sup>

### Polycyclic Aromatic Hydrocarbons



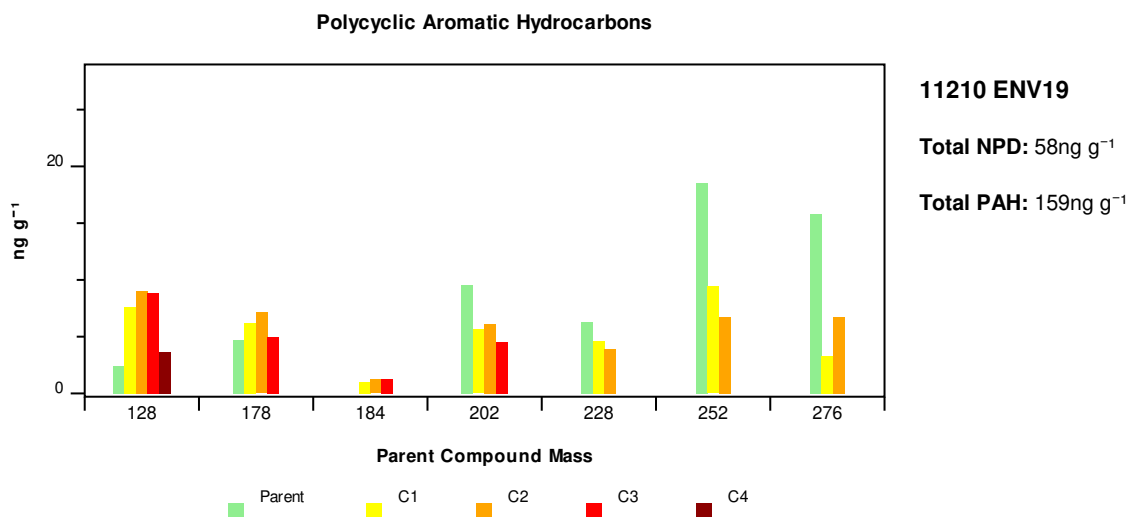
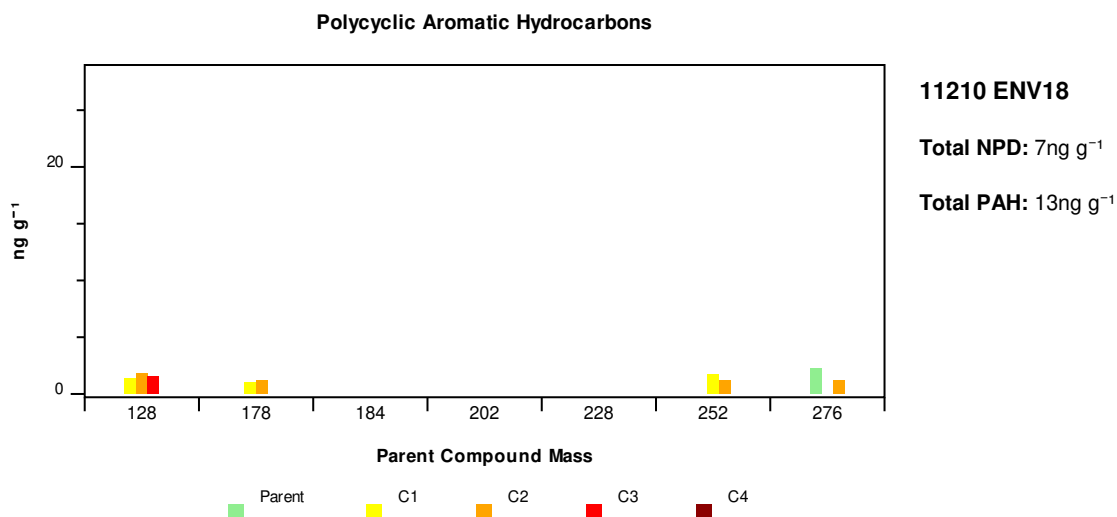
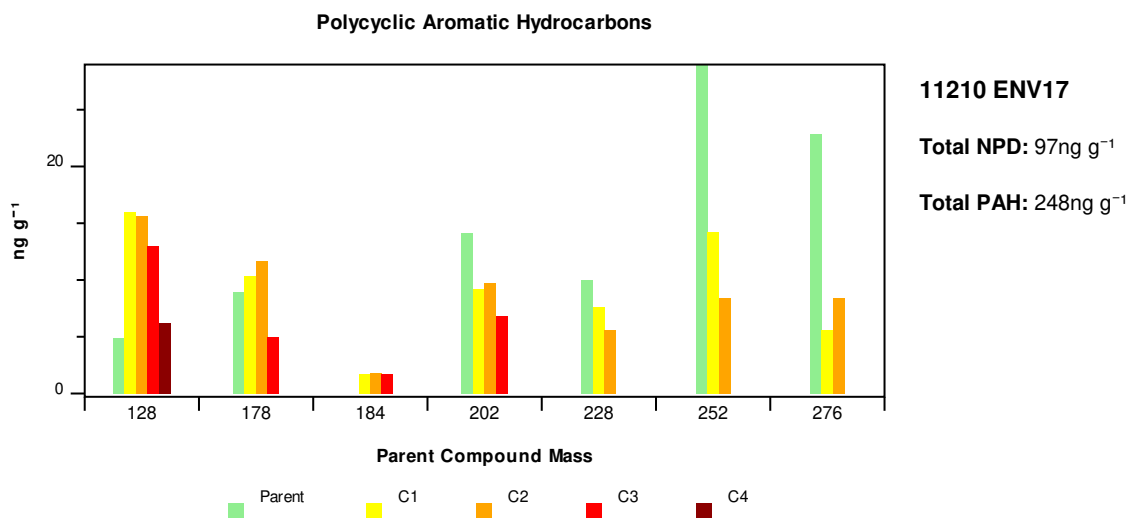
11210 ENV16

Total NPD: 56ng g<sup>-1</sup>

Total PAH: 149ng g<sup>-1</sup>

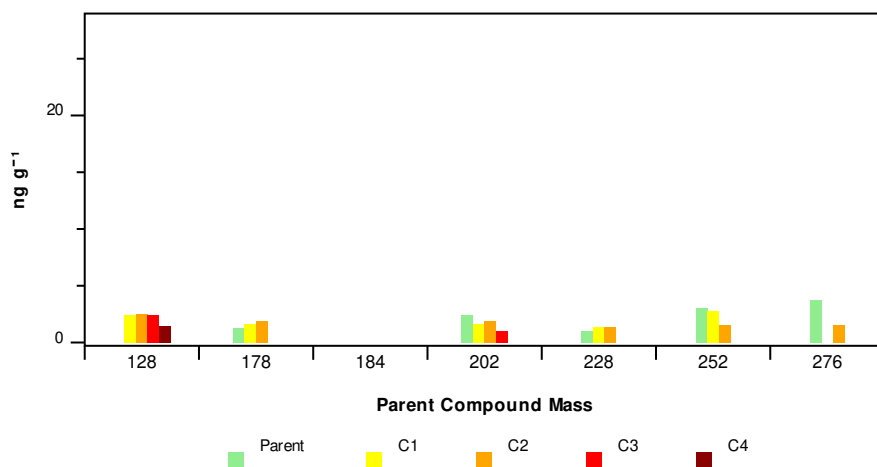


## APPENDIX I HYDROCARBON ANALYSIS



## APPENDIX I HYDROCARBON ANALYSIS

### Polycyclic Aromatic Hydrocarbons

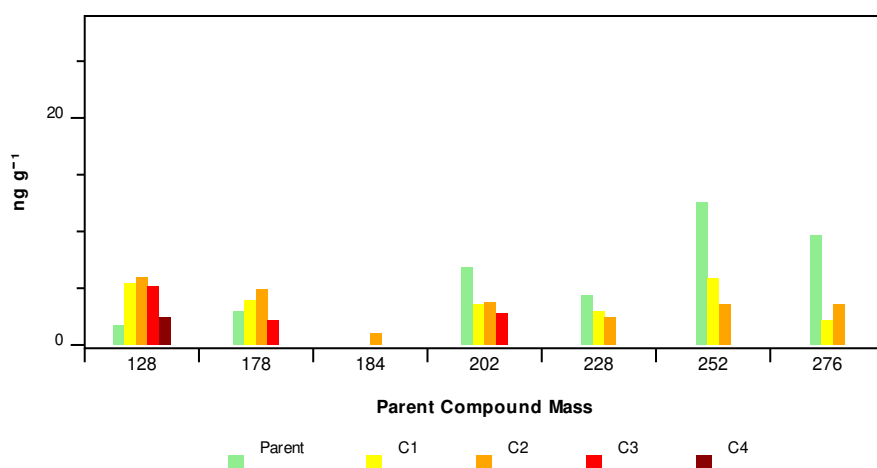


11210 ENV20

Total NPD: 14ng g<sup>-1</sup>

Total PAH: 37ng g<sup>-1</sup>

### Polycyclic Aromatic Hydrocarbons

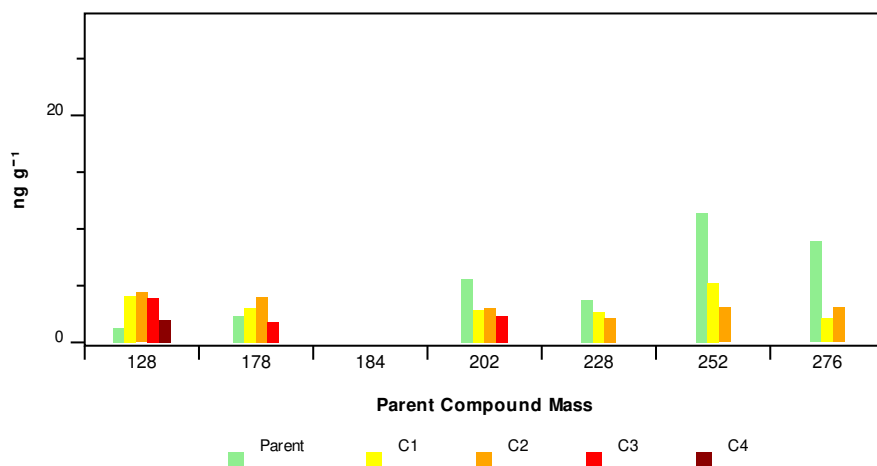


11210 ENV21

Total NPD: 36ng g<sup>-1</sup>

Total PAH: 100ng g<sup>-1</sup>

### Polycyclic Aromatic Hydrocarbons



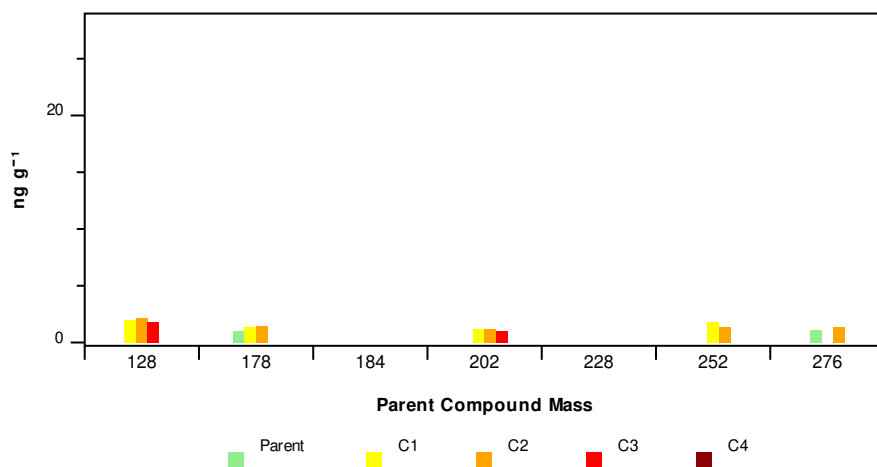
11210 ENV22

Total NPD: 27ng g<sup>-1</sup>

Total PAH: 83ng g<sup>-1</sup>

## APPENDIX I HYDROCARBON ANALYSIS

### Polycyclic Aromatic Hydrocarbons

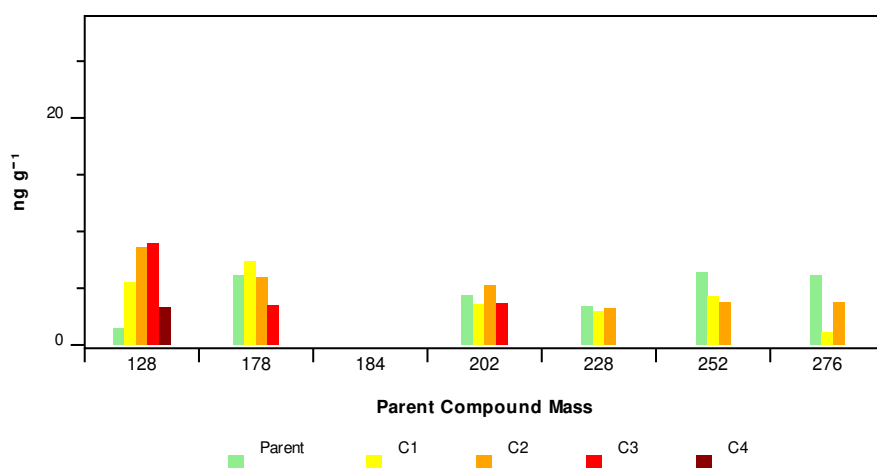


11210 ENV23

Total NPD:  $10\text{ng g}^{-1}$

Total PAH:  $19\text{ng g}^{-1}$

### Polycyclic Aromatic Hydrocarbons

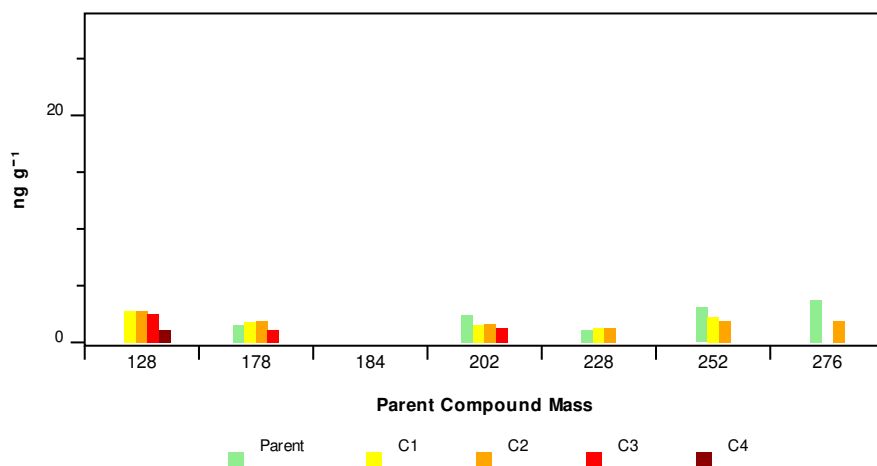


11210 ENV24

Total NPD:  $51\text{ng g}^{-1}$

Total PAH:  $103\text{ng g}^{-1}$

### Polycyclic Aromatic Hydrocarbons



11210 ENV25

Total NPD:  $15\text{ng g}^{-1}$

Total PAH:  $39\text{ng g}^{-1}$

## 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 <sup>1</sup>	Long et al (1995) ERM <sup>2</sup>	
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	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	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	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	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	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<sup>-1</sup> 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	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	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	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	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	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	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<sup>-1</sup> 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 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 consistent 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	<b>Bathyporeia elegans</b>	10	<b>Magelona filiformis</b>	
								2	<b>Nephtys cirrosa</b>	7		
								3	<b>Bathyporeia</b>	6		
								4	<b>Fabulina fabula</b>	5		
								5	<b>Bathyporeia guilliamsoniana</b>	4		
								6	<i>Pericolodes longimanus</i>	3		
								6	<i>Abra prismatica</i>	3		
								8	<i>Chaetozone christiei</i>	2		
								8	<i>Iphinoe trispinosa</i>	2		
								8	<i>Spisula</i>	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	<b>Scoloplos armiger</b>	15	<b>Amphiura filiformis</b>	
								2	<b>Ophelia borealis</b>	12		
								3	<i>Bathyporeia</i>	8		
								4	<i>Nephtys cirrosa</i>	5		
								4	<i>Spisula</i>	5		
								6	<b>Spiophanes bombyx</b>	3		
								7	<i>Hypereteone foliosa</i>	2		
								7	<i>Megaluropus agilis</i>	2		
								7	<i>Diastylis rugosa</i>	2		
								10	<b>Abra prismatica</b>	1		
								Faunal community (in bold) consistent 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	<b>Abra</b>	79	<b>Abra alba</b>	
								2	<b>Fabulina fabula</b>	10		
								3	<i>Bathyporeia elegans</i>	7		
								4	<i>Nephtys cirrosa</i>	5		
								4	<i>Bathyporeia tenuipes</i>	5		
								6	<i>Spisula</i>	4		
								6	<i>Poecilochaetus serpens</i>	4		
								8	<b>Scoloplos armiger</b>	3		
								8	<i>Bathyporeia</i>	3		
								8	<b>Spiophanes bombyx</b>	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	<b>Abra</b>	47	<b>Abra alba</b>	
								2	<i>Nephtys cirrosa</i>	10		
								3	<b>Scoloplos armiger</b>	6		
								4	<b>Spiophanes bombyx</b>	5		
								5	<b>Ophelia borealis</b>	4		
								5	<i>Lagis koreni</i>	4		
								7	<b>Bathyporeia elegans</b>	3		
								7	<i>Poecilochaetus serpens</i>	3		
								9	<i>Bathyporeia tenuipes</i>	2		
								9	<i>Bathyporeia</i>	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	<b>Abra</b>	54	<b>Goniada maculata</b>	
								2	Thracioidea	24		
								3	<i>Nephtys cirrosa</i>	9		
								4	<b>Spiophanes bombyx</b>	8		
								5	<b>Scoloplos armiger</b>	6		
								6	<i>Bathyporeia elegans</i>	5		
								6	Nemertea	5		
								8	<i>Bathyporeia guilliamsoniana</i>	4		
								8	<b>Fabulina fabula</b>	4		
								10	<i>Ophelia borealis</i>	3		
								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 consistent with EUNIS level	Representative Image
		Level	Code	Level	Code			Rank	Taxa	Abundance		
ENV8	41	5	A5.261	5	SS.SSa.CMuSa.AalbNuc	<i>Abra alba</i> and <i>Nucula nitidosa</i> 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	<b><i>Abra</i></b>	103	<b><i>Abra alba</i></b> <b><i>Spiophanes bombyx</i></b> <b><i>Scoloplos armiger</i></b>	
								2	<i>Chaetozone christiei</i>	15		
								3	<b><i>Fabulina fabula</i></b>	4		
								3	<i>Magelona johnstoni</i>	4		
								5	Ophiuridae	3		
								6	<b><i>Scalibregma inflatum</i></b>	2		
								6	<i>Lagis koreni</i>	2		
								6	<i>Amphiuridae</i>	2		
								6	<i>Spatangoida (juv)</i>	2		
								6	<i>Spisula</i>	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	<i>Abra alba</i> and <i>Nucula nitidosa</i> 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	<b><i>Abra</i></b>	34	<b><i>Spiophanes bombyx</i></b> <b><i>Scalibregma inflatum</i></b> <b><i>Abra alba</i></b> <b><i>Scoloplos armiger</i></b> <b><i>Lanice conchilega</i></b>	
								2	<b><i>Fabulina fabula</i></b>	22		
								3	Amphiuridae	7		
								4	<i>Chaetozone christiei</i>	6		
								5	<i>Amphictene auricoma</i>	5		
								5	<i>Euspira nitida</i>	5		
								5	<i>Bathyporeia tenuipes</i>	5		
								8	<i>Magelona johnstoni</i>	4		
								9	<i>Poecilochaetus serpens</i>	3		
								10	<i>Ophiuridae</i>	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	<i>Abra alba</i> and <i>Nucula nitidosa</i> 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	<b><i>Abra</i></b>	41	<b><i>Abra alba</i></b> <b><i>Scoloplos armiger</i></b>	
								2	<b><i>Fabulina fabula</i></b>	8		
								3	<i>Magelona johnstoni</i>	5		
								4	<i>Diastylis bradyi</i>	3		
								4	<i>Sthenelais limicola</i>	3		
								4	<i>Macra</i>	3		
								7	<i>Amphictene auricoma</i>	2		
								7	<i>Euspira nitida</i>	2		
								7	<i>Bathyporeia tenuipes</i>	2		
								7	<i>Spatangoida (juv)</i>	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	<i>Abra alba</i> and <i>Nucula nitidosa</i> 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	<b><i>Abra</i></b>	19	<b><i>Scoloplos armiger</i></b>	
								2	<b><i>Fabulina fabula</i></b>	10		
								3	<b><i>Spiophanes bombyx</i></b>	6		
								4	<i>Magelona johnstoni</i>	5		
								4	<i>Diastylis bradyi</i>	5		
								4	<i>Amphiuridae</i>	5		
								4	<i>Poecilochaetus serpens</i>	5		
								8	<i>Bathyporeia tenuipes</i>	4		
								9	<i>Chaetozone christiei</i>	3		
								9	<i>Notomastus</i>	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	<i>Abra alba</i> and <i>Nucula nitidosa</i> 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	<b><i>Abra</i></b>	49	<b><i>Scoloplos armiger</i></b>	
								2	<i>Amphiura filiformis</i>	10		
								3	<i>Euspira nitida</i>	7		
								4	<b><i>Fabulina fabula</i></b>	4		
								4	<i>Amphictene auricoma</i>	4		
								4	<i>Nucula</i>	4		
								7	<b><i>Spiophanes bombyx</i></b>	3		
								7	<i>Magelona filiformis</i>	3		
								9	<i>Kurtiella bidentata</i>	2		
								9	<i>Spatangoida (juv)</i>	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 consistent 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	<i>Amphiuridae</i>	15	<b>Fabulina fabula</b>	
								2	<b>Abra</b>	9	<b>Spiophanes bombyx</b>	
								3	<i>Amphiura filiformis</i>	7		
								3	<i>Phoronis</i>	7		
								5	<i>Amphictene auricoma</i>	3		
								6	<b>Nucula</b>	2		
								6	<i>Veneridae</i>	2		
								6	<i>Poecilochaetus serpens</i>	2		
								6	<i>Bathyporeia tenuipes</i>	2		
								6	<i>Phaxas pellucidus</i>	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	<b>Amphiura filiformis</b>	66	<b>Nemertea</b>	
								2	<b>Pholoe</b>	17	<b>Glycera alba</b>	
								3	<b>Scalibregma inflatum</b>	15	<b>Scoloplos armiger</b>	
								4	<i>Amphiuridae</i>	14		
								5	<b>Abra</b>	11		
								6	<i>Ophelia borealis</i>	9		
								7	<i>Amphictene auricoma</i>	7		
								8	<i>Pharidae</i>	6		
								9	<b>Spiophanes bombyx</b>	5		
								9	<i>Lagis koreni</i>	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	<i>Mysella bidentata</i> and <i>Thyasira</i> 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	<b>Amphiura filiformis</b>	127	<b>Mediomastus fragilis</b>	
								2	<b>Scalibregma inflatum</b>	50	<b>Spiophanes bombyx</b>	
								3	<b>Nemertea</b>	6		
								4	<b>Pholoe</b>	5		
								4	<i>Cylichna cylindracea</i>	5		
								6	<i>Callianassa subterranea</i>	4		
								6	<i>Notomastus</i>	4		
								8	<i>Amphictene auricoma</i>	3		
								8	<i>Lagis koreni</i>	3		
								8	<i>Kurtiella bidentata</i>	3		
								Faunal community (in bold) consistent with Level 5 EUNIS Code A5.443, MNCR Code SS.SMx.CMx.MysThyMx				
ENV18	47	5	A5.251	5	SS.SSa.CFiSa.EpusOborApri	<i>Echinocyamus pusillus</i> , <i>Ophelia borealis</i> and <i>Abra prismatica</i> in circalittoral fine sand	PSA modified Folk: Sand Wentworth (mean): Coarse Sand Sorting: Moderately Well (0% fines, 100% sand, 0% gravel)	1	<i>Spatangoida (juv)</i>	19	<b>Abra prismatica</b>	
								2	<b>Echinocyamus pusillus</b>	9	<b>Glycera lapidum</b>	
								3	<b>Ophelia borealis</b>	8	<b>Owenia</b>	
								4	<i>Glycinde nordmanni</i>	3		
								4	<i>Nephtys cirrosa</i>	3		
								4	<i>Leiochone</i>	3		
								7	<i>Nemertea</i>	2		
								7	<b>Spiophanes bombyx</b>	2		
								7	<b>Abra</b>	2		
								7	<i>Scoloplos armiger</i>	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	<i>Mysella bidentata</i> and <i>Thyasira</i> 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	<b>Amphiura filiformis</b>	177	<b>Spiophanes bombyx</b>	
								2	<i>Amphiuridae</i>	41	<b>Owenia</b>	
								3	<b>Pholoe</b>	21		
								4	<b>Scalibregma inflatum</b>	10		
								5	<i>Amphictene auricoma</i>	7		
								6	<i>Cylichna cylindracea</i>	5		
								6	<i>Callianassa subterranea</i>	5		
								6	<i>Kurtiella bidentata</i>	5		
								9	<b>Nemertea</b>	4		
								9	<b>Abra</b>	4		
								Faunal community (in bold) consistent with 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 consistent 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	<b>Scoloplos armiger</b> <b>Abra</b> <b>Abra prismatica</b>	
								2	Amphiura filiformis	4		
								2	Nephtys cirrosa	4		
								2	<b>Fabulina fabula</b>	4		
								2	Thracia	4		
								6	Asteroidea (juv)	3		
								6	<b>Goniada maculata</b>	3		
								6	Glycinde nordmanni	3		
								6	Cochlodesma praetenuae	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	<b>Abra</b> <b>Nemertea</b> <b>Scoloplos armiger</b> <b>Spiophanes bombyx</b> <b>Echinocardium cordatum</b>	
								2	Pholoe	12		
								3	Lagis koreni	9		
								4	Phoronis	7		
								4	Amphictene auricoma	7		
								6	Asteroidea (juv)	6		
								7	Magelona alleni	5		
								8	<b>Scalibregma inflatum</b>	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	<b>Echinocyamus pusillus</b>	36	<b>Glycera lapidum</b>	
								2	Spatangoida (juv)	15		
								3	Amphiura filiformis	11		
								4	<b>Ophelia borealis</b>	7		
								5	Astrorhiza	5		
								6	<b>Pholoe</b>	2		
								6	Abra	2		
								6	Echinocardium cordatum	2		
								6	<b>Glycera lapidum</b>	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	<b>Echinocyamus pusillus</b>	16	<b>Glycera lapidum</b>	
								2	Amphiura filiformis	10		
								3	<b>Spiophanes bombyx</b>	6		
								4	Nephtys	5		
								5	<b>Ophelia borealis</b>	3		
								5	Lucinoma borealis	3		
								5	<b>Goniada maculata</b>	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 consistent 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	<i>Urothoe elegans</i>	20	<b><i>Spiophanes bombyx</i></b>	
								2	<i>Lagis koreni</i>	11	<b><i>Scoloplos armiger</i></b>	
								3	<i>Amphiura filiformis</i>	9	<b><i>Cerianthus lloydii</i></b>	
								3	Spatangoida (juv)	9		
								5	Asteroidea (juv)	7		
								6	<b><i>Echinocyamus pusillus</i></b>	6		
								7	<b><i>Glycera lapidum</i></b>	5		
								7	<b><i>Nemertea</i></b>	5		
								9	<i>Callianassa subterranea</i>	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	<i>Abra prismatica</i> , <i>Bathyporeia elegans</i> 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	<i>Urothoe marina</i>	31		
								2	Asteroidea (juv)	11		
								3	Spatangoida (juv)	7		
								3	<i>Amphipoda</i>	7		
								5	<b><i>Spiophanes bombyx</i></b>	6		
								6	<b><i>Aonides paucibranchiata</i></b>	5		
								7	<i>Glycera lapidum</i>	4		
								7	<b><i>Ophelia borealis</i></b>	4		
								7	<b><i>Abra prismatica</i></b>	4		
								10	<i>Poecilochaetus serpens</i>	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 Lot 7 GP1a Export Cable Corridor  
Volume 3: Results Report (Bibby, 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**

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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

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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

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Revision Number	Date of Issue	Comments
00	22/02/2019	For comment

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## Appendices

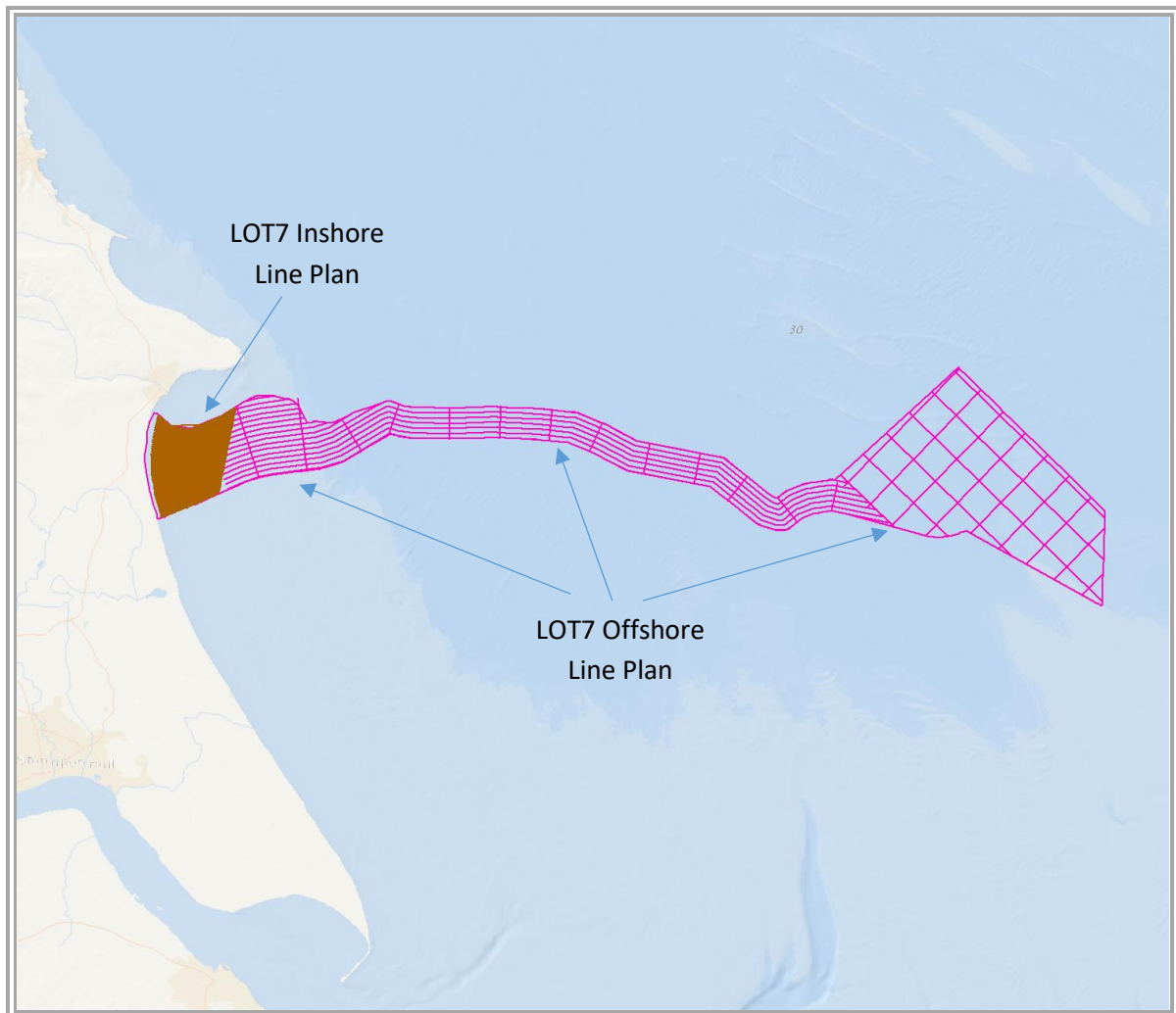
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### Appendix 1: Listings

## 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 recesses being performed by a 3<sup>rd</sup> 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:

<http://www.bibbyhydromap.com/vessels/>

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)	<p>MV Bibby Tethra</p> 	<p>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.</p>

**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

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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.

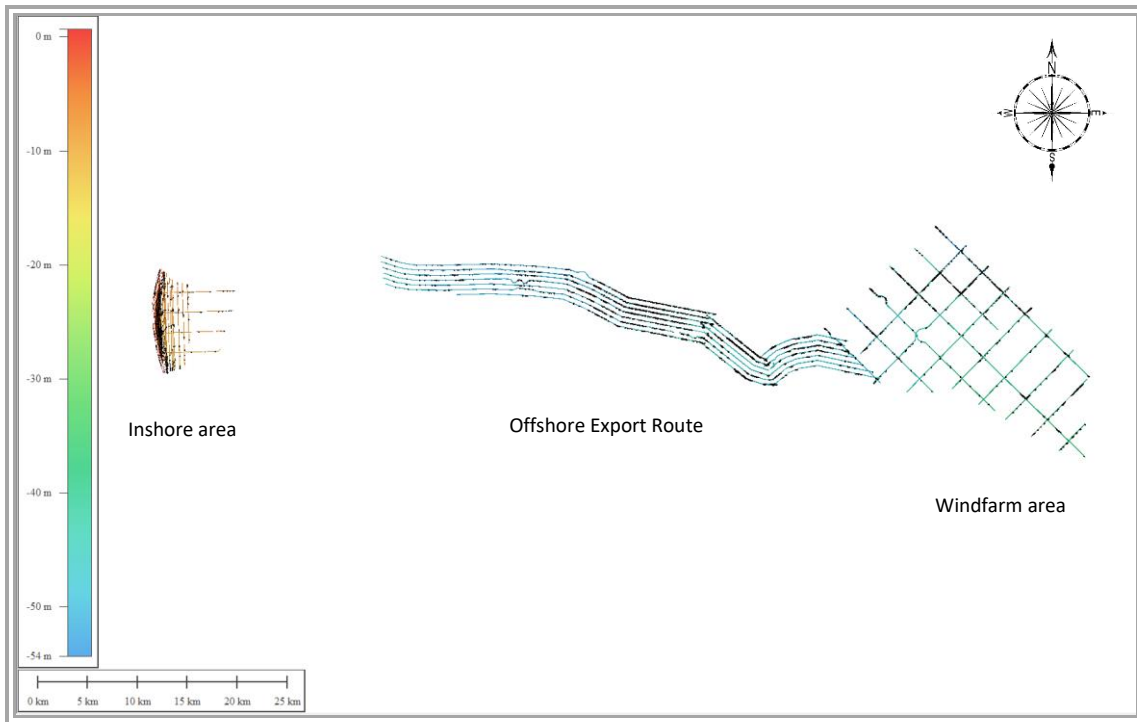
In this report volume, the results of the bathymetry, side scan sonar data, sub-bottom and magnetometer features are discussed along the surveyed export route.

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.

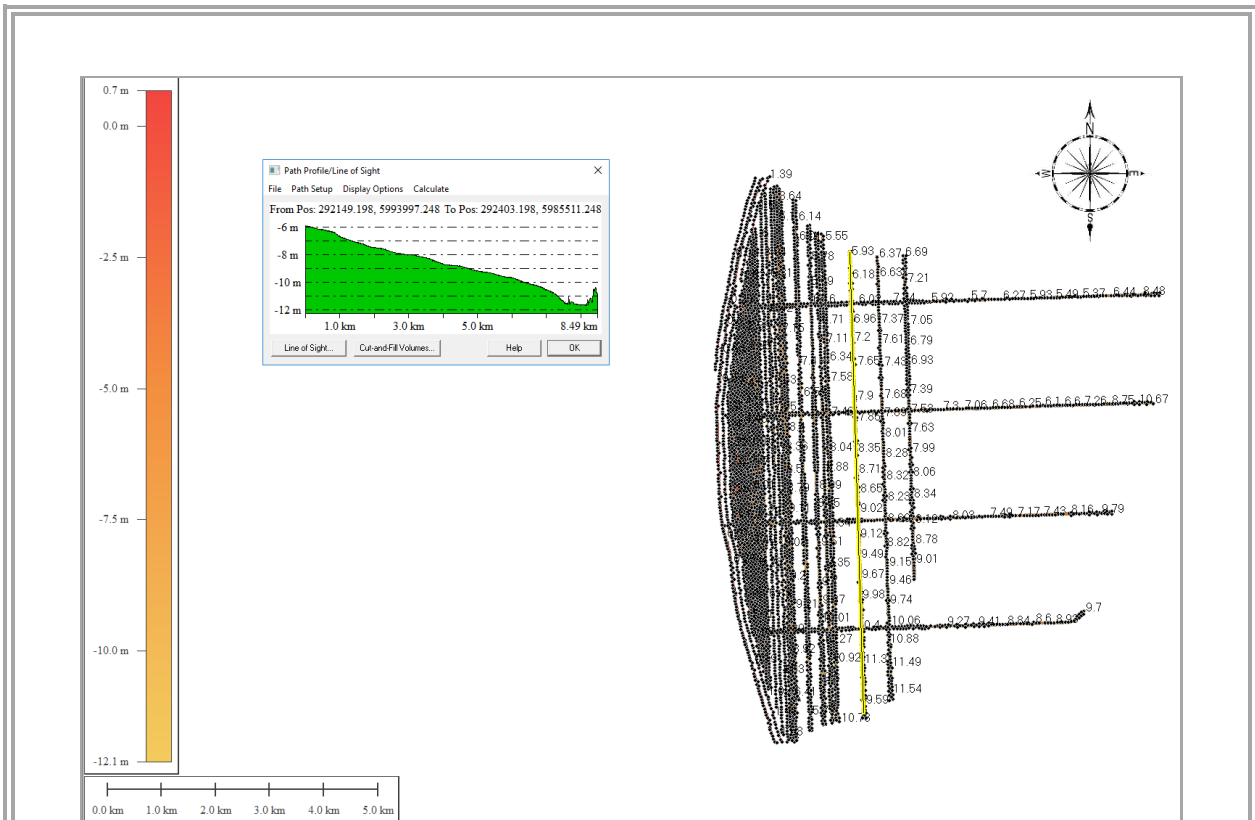
### 3.1 Bathymetry

The bathymetry of the Lot 7 export route has been split into 3 areas as indicated on Figure 2 below.

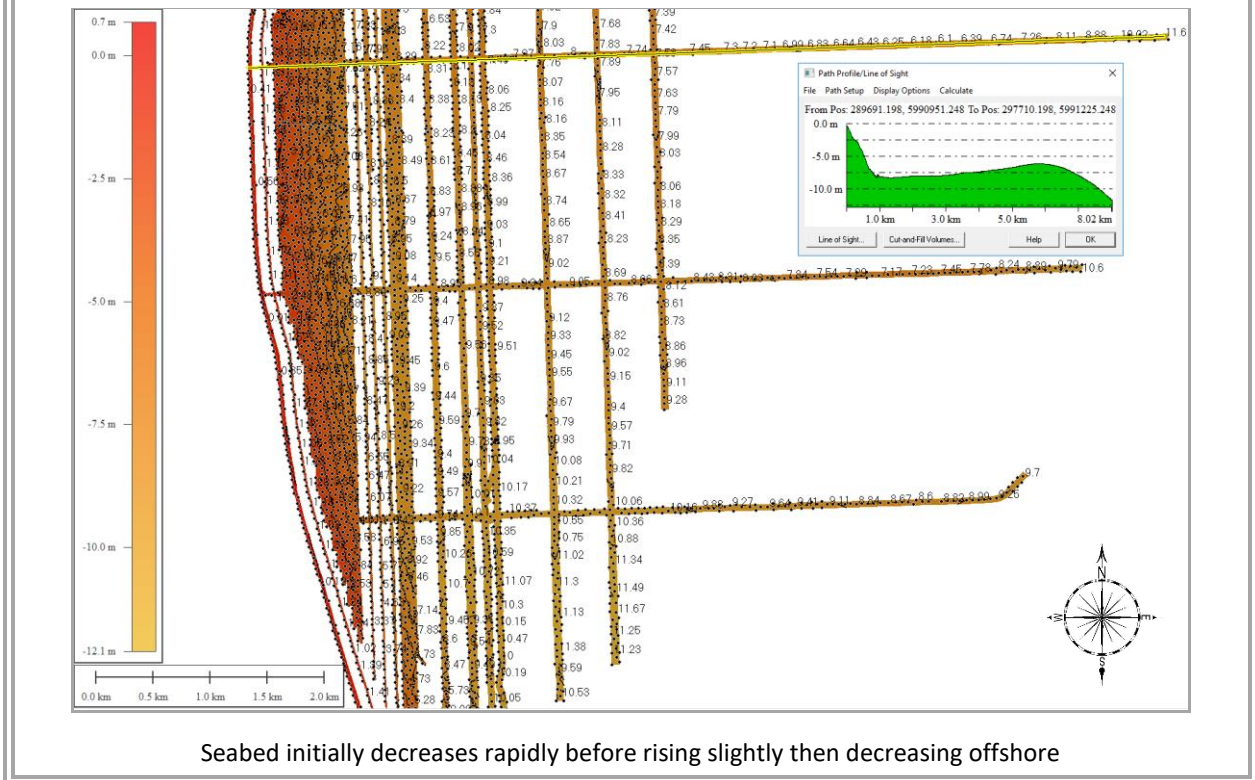


**Figure 2: General Areas Described in Report**

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

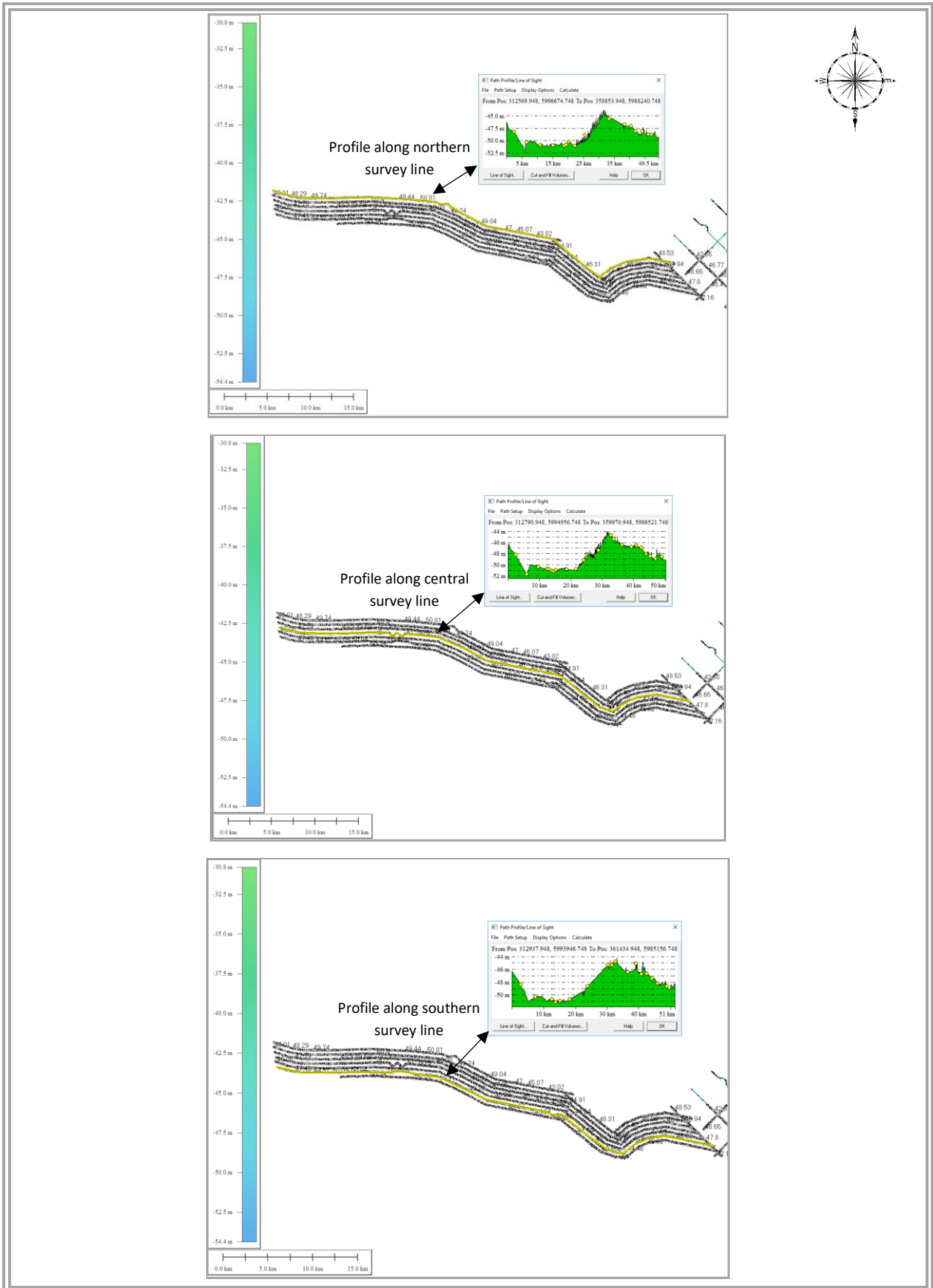
**Figure 3: Bathymetric Trends in Inshore Area**

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.

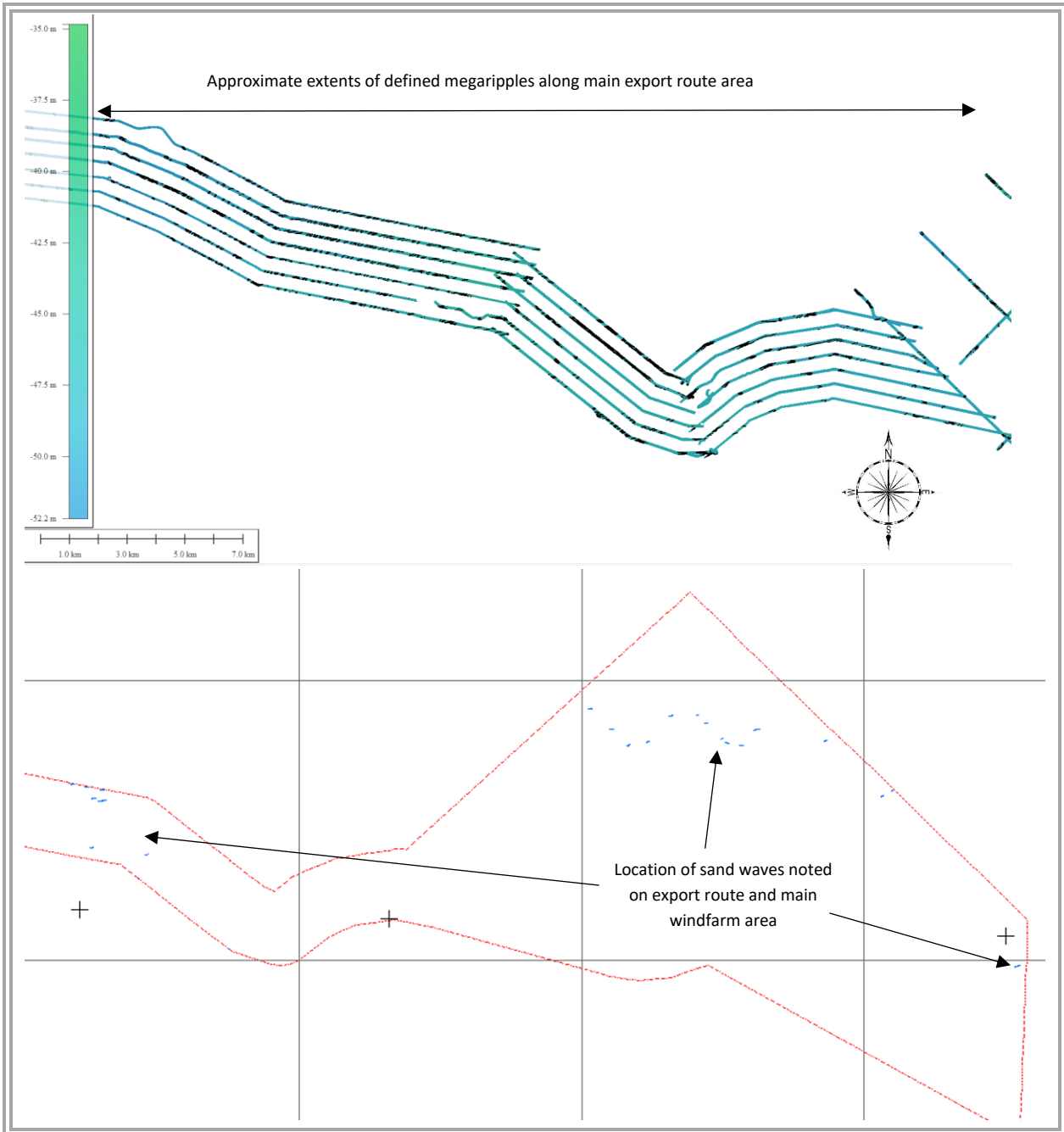
Seabed levels in the main windfarm survey area commence between 44.7m and 48.7m below LAT and generally range from 30.8m below LAT on the crest of a sand wave, to 54.0m below LAT in the north-west extents of the surveyed area of the main windfarm.

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**

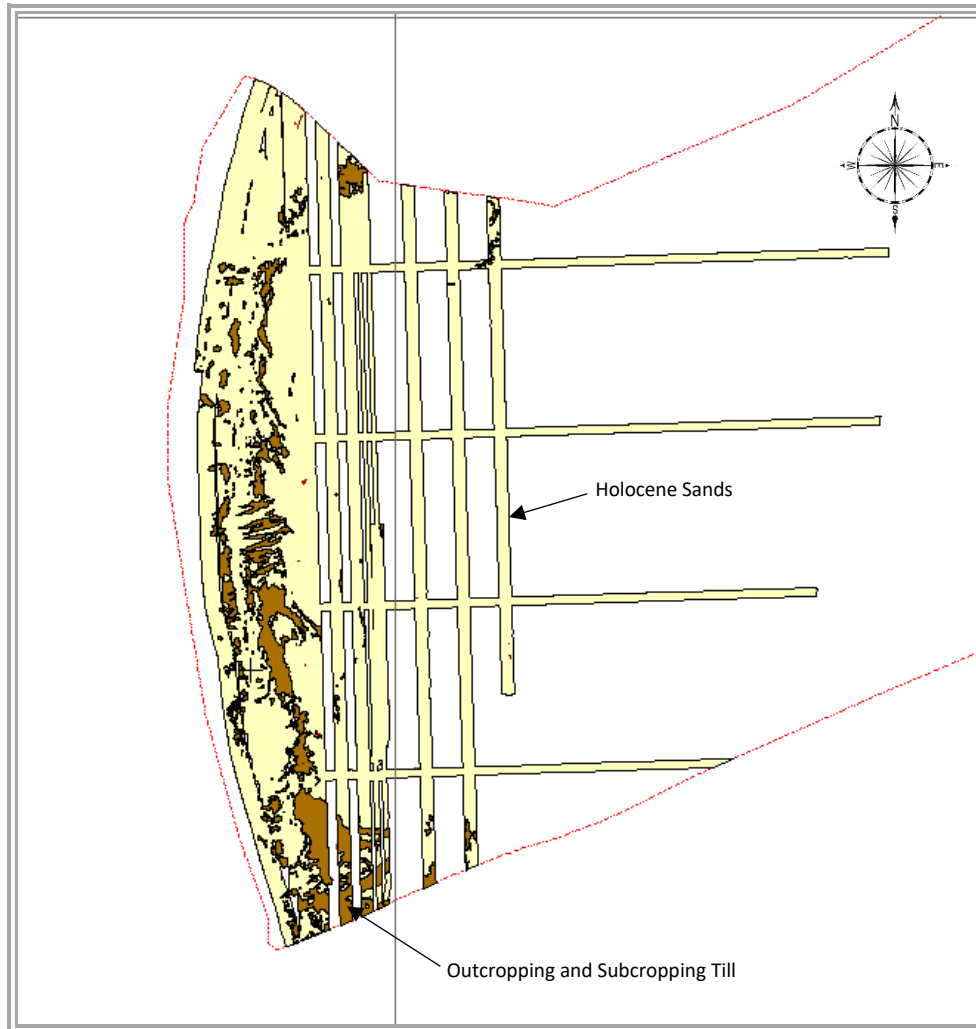




**Figure 5: Approximate Spatial Extents of Mobile Seabed in Main Export Route Area and Windfarm Area**

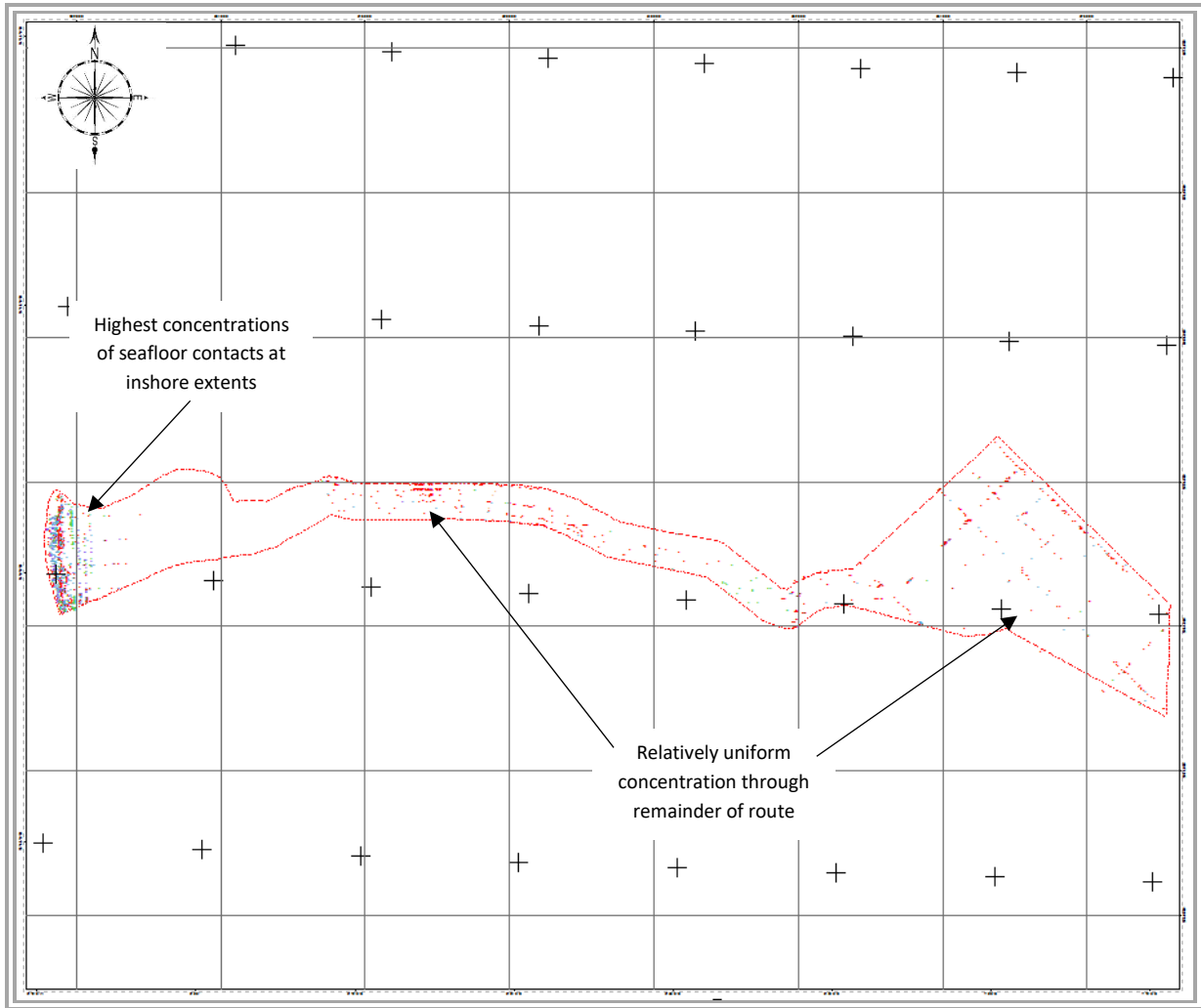
### 3.2 Seabed Features and Magnetic Anomalies

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 seabed 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.

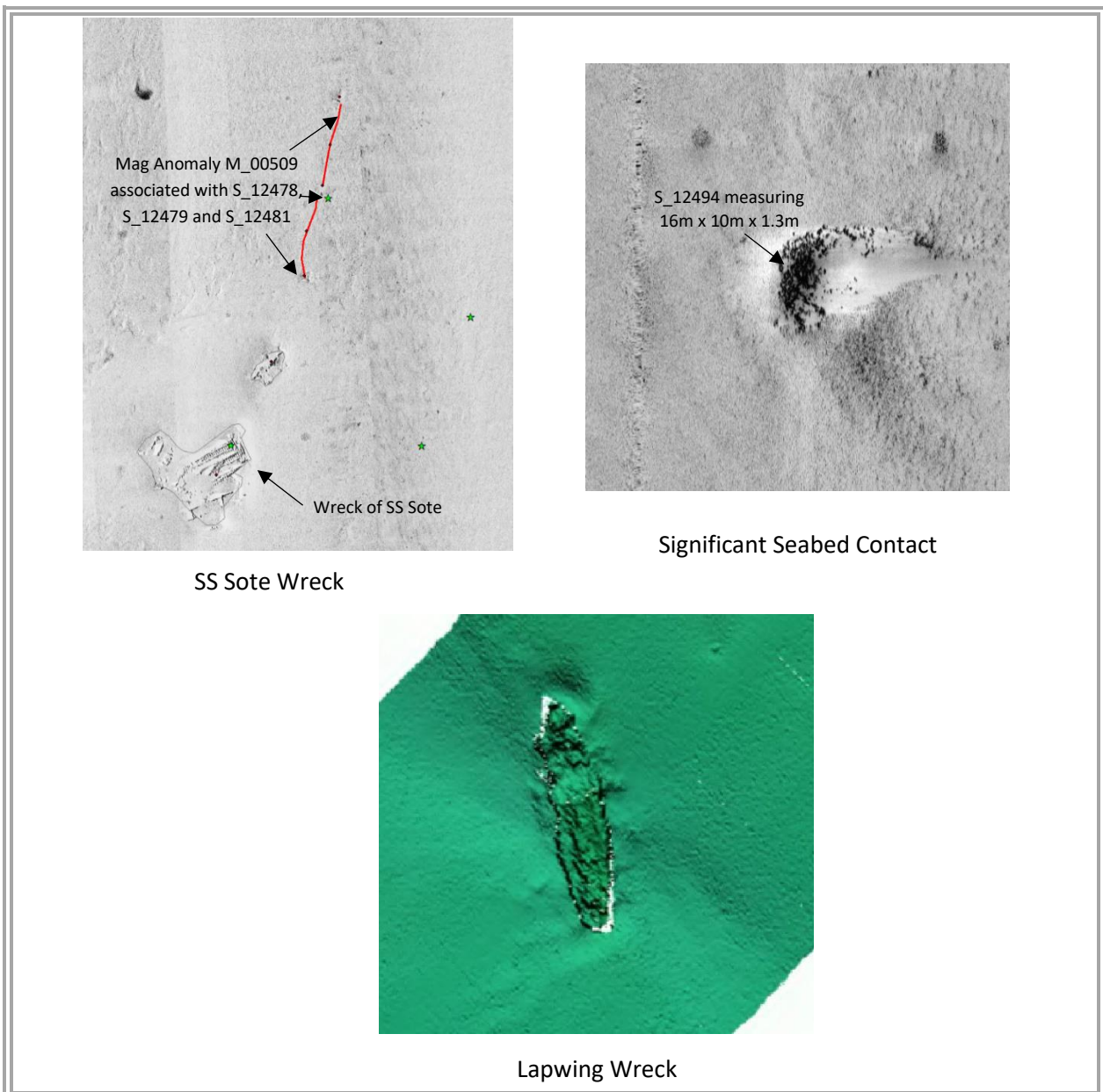
Eleven known pipelines and cables were identified in the side scan sonar, multibeam, magnetometer and sub bottom data, as well as several unidentified pipelines and cables. These include the following, the details of which are presented in Table 5 below:

- 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.



**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
<b>RAVENSPURN NORTH TO WELLHEAD ST2 PIPELINE</b>										
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
<b>JOHNSTON UMBILICAL</b>										
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

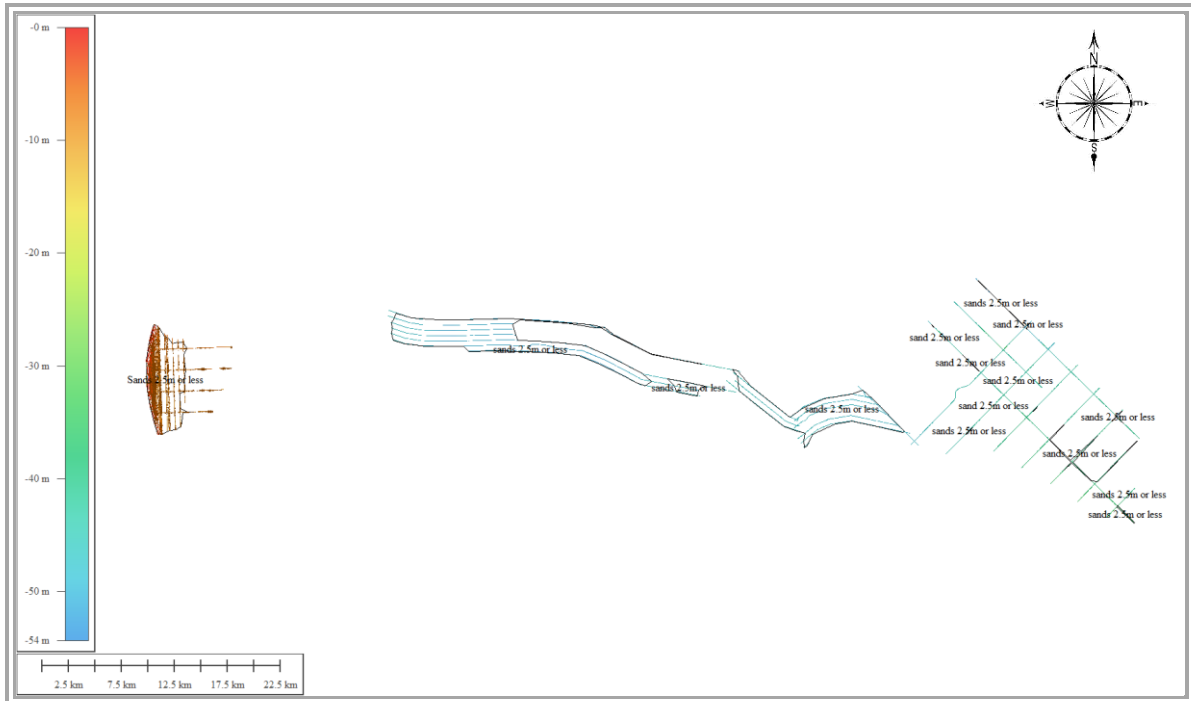
### 3.3 Shallow Soils

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.

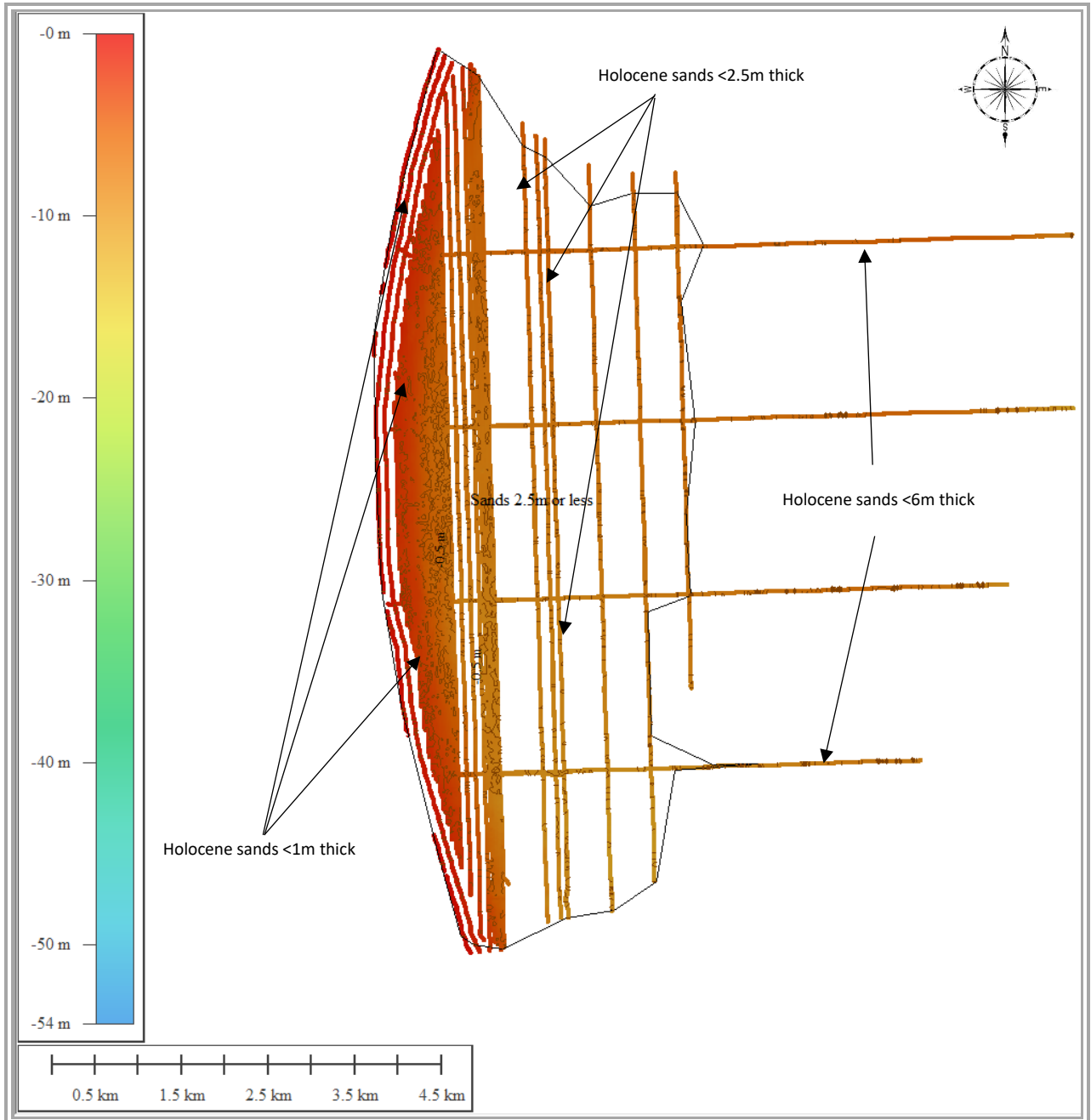


**Figure 9: Spatial Distribution of Holocene Sands <5m Thick**



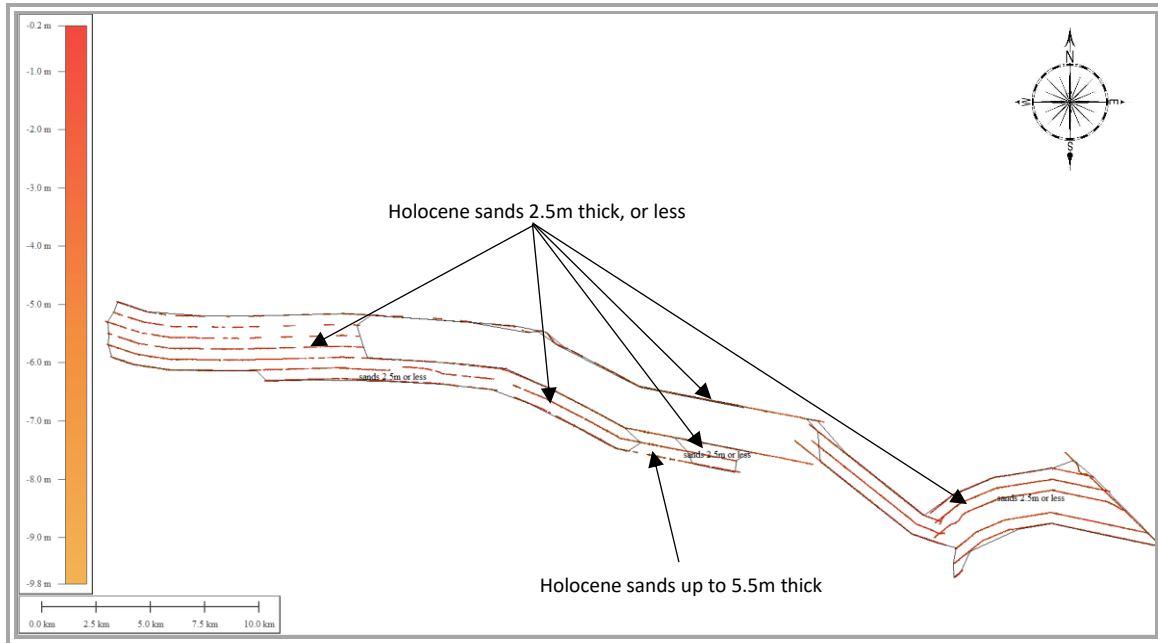
**Figure 10: Spatial Distribution of Holocene Sands 2.5m Thick or Less**

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.

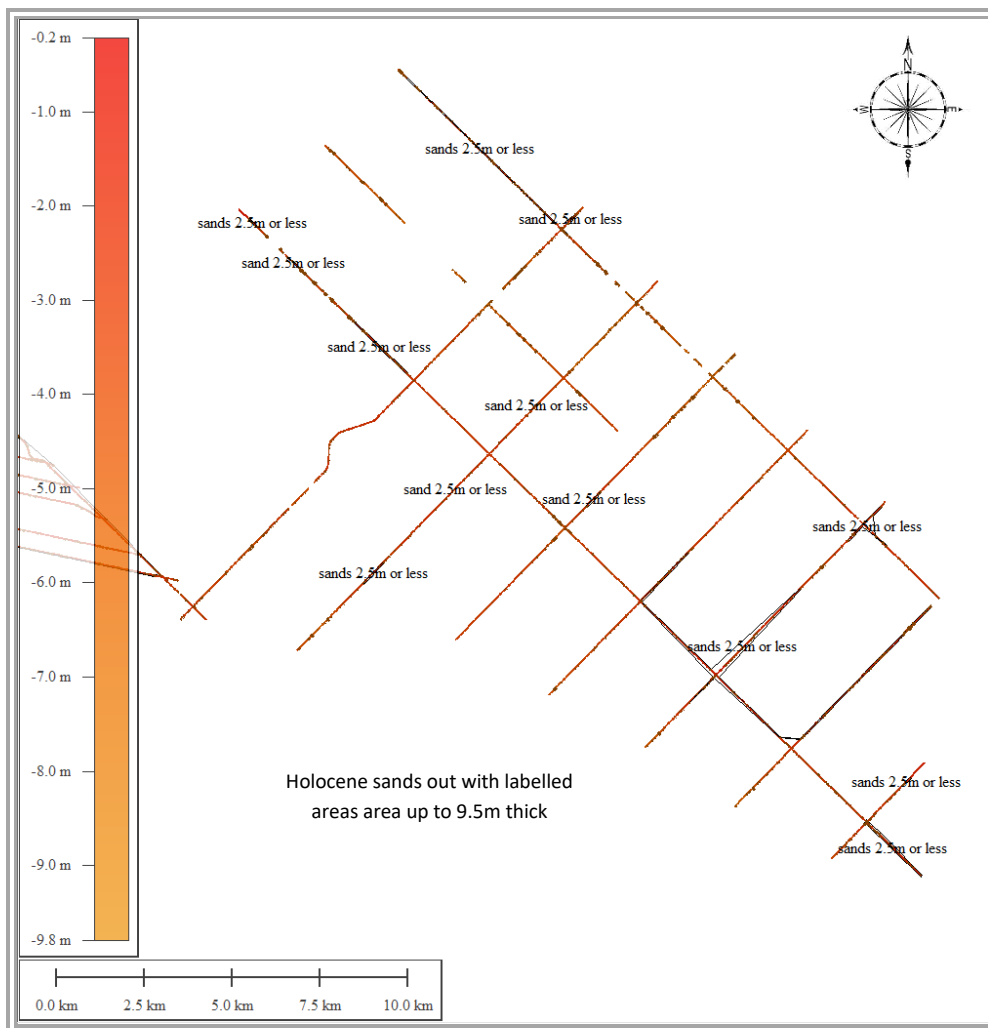


**Figure 11: Holocene Sands 2.5m Thick or Less Inshore Extents of Survey Area**

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**

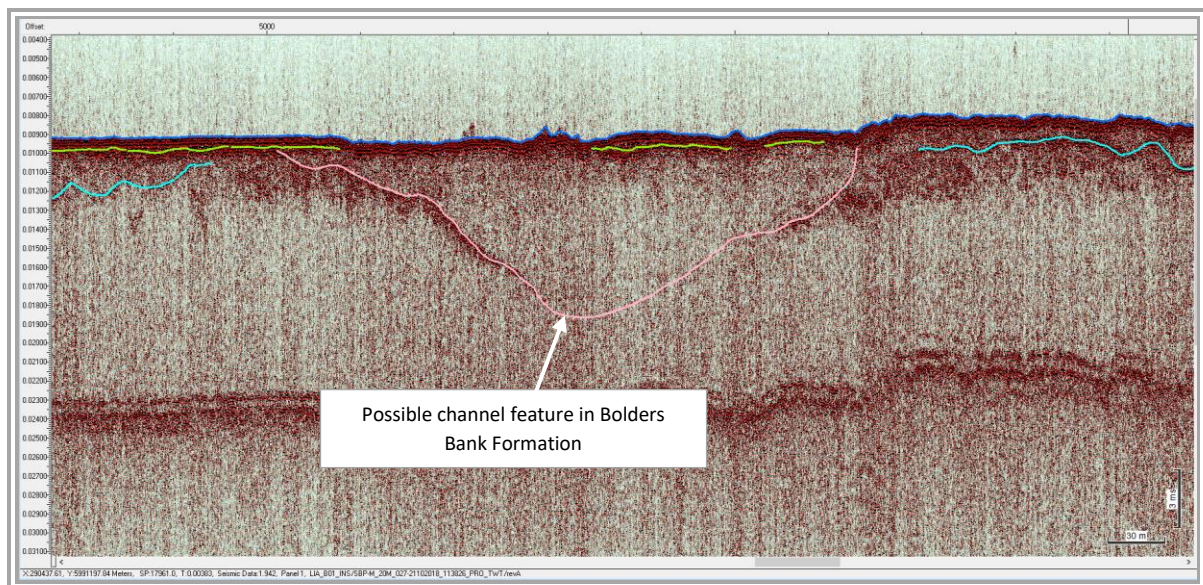


**Figure 13: Holocene Sands Thicknesses within Windfarm Area**

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.

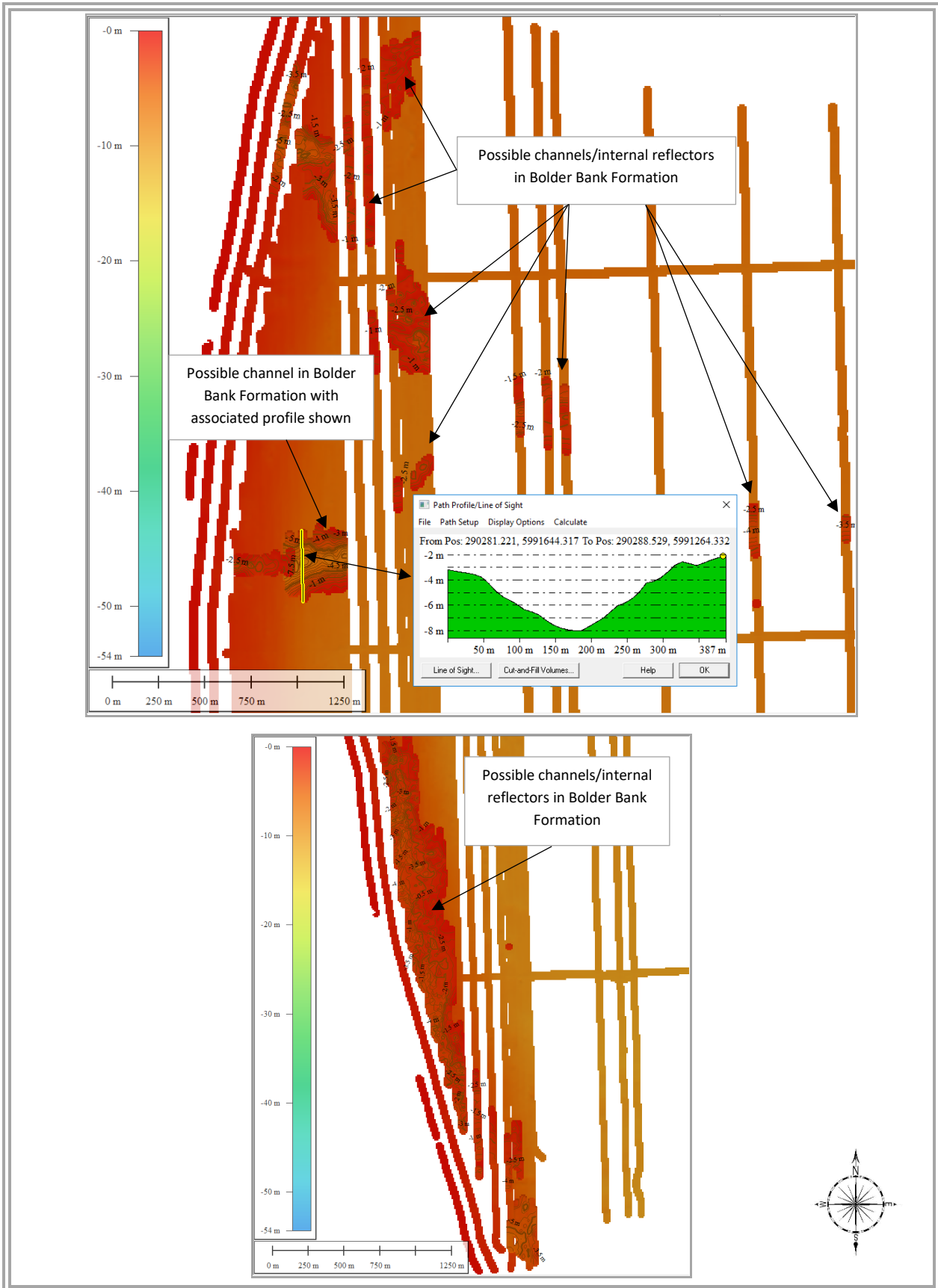
Sediments of the Bolders Bank Formation are noted beneath these Holocene sands along the entire route and internal reflectors are often noted within these clays. These internal reflectors may differentiate changes in density of the till or lenses of sands and gravels etc.

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.



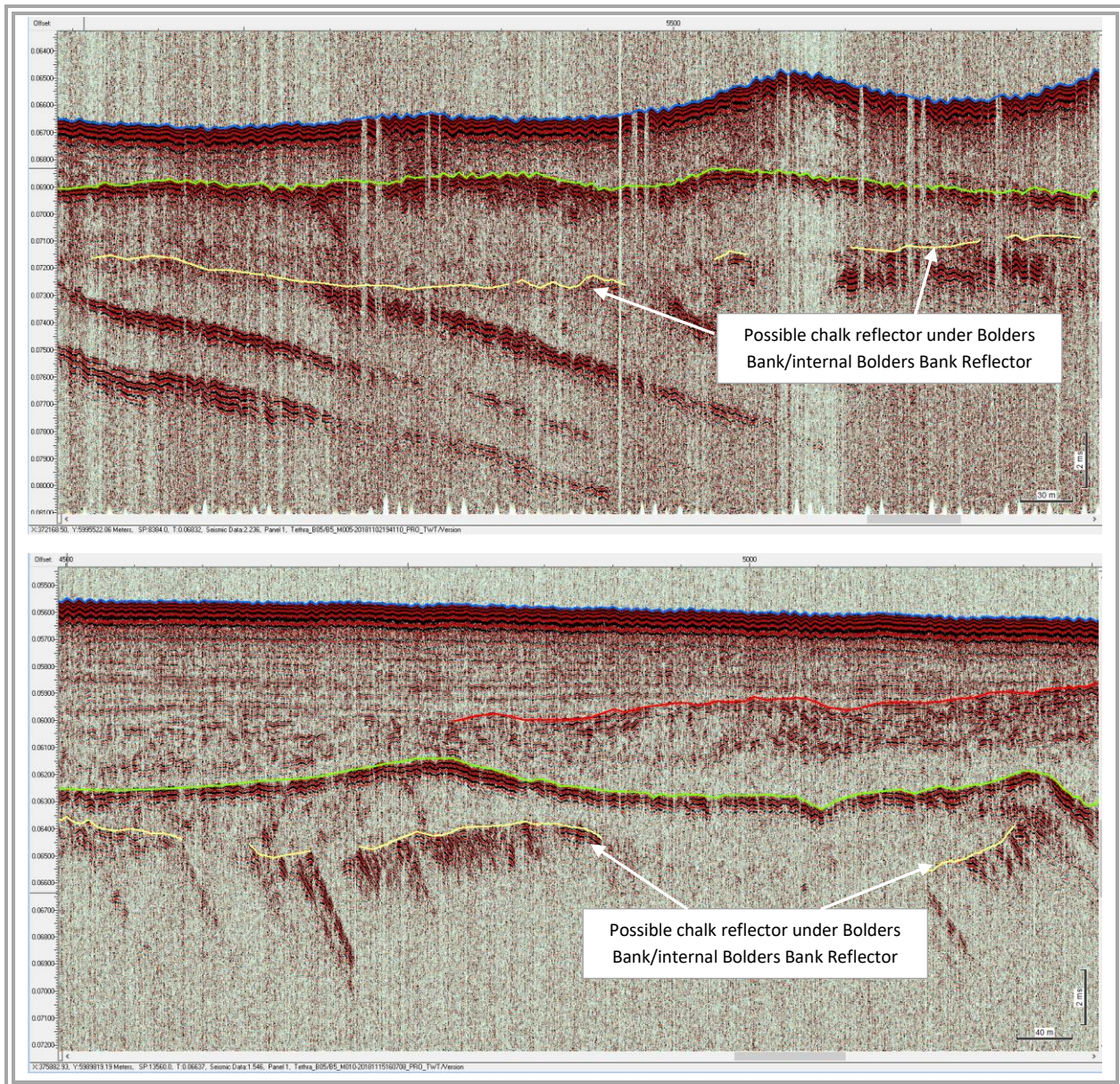
**Figure 14: Seismic Record Showing Reflector of Possible Channel Feature in Bolders Bank Formation**



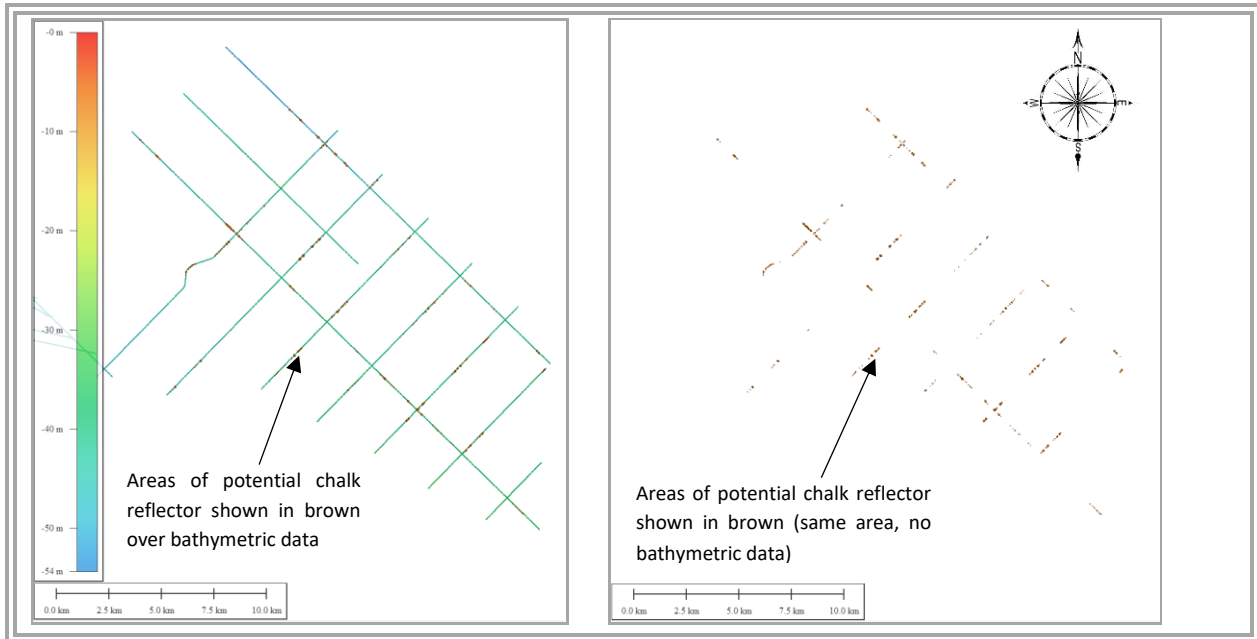


**Figure 15: Spatial Distribution of Channel Type Features/Internal Reflectors in Bolders Bank Formation**

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

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### Appendix 1: Listings

## Appendix 1

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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

21<sup>st</sup> May 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 coarse 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.

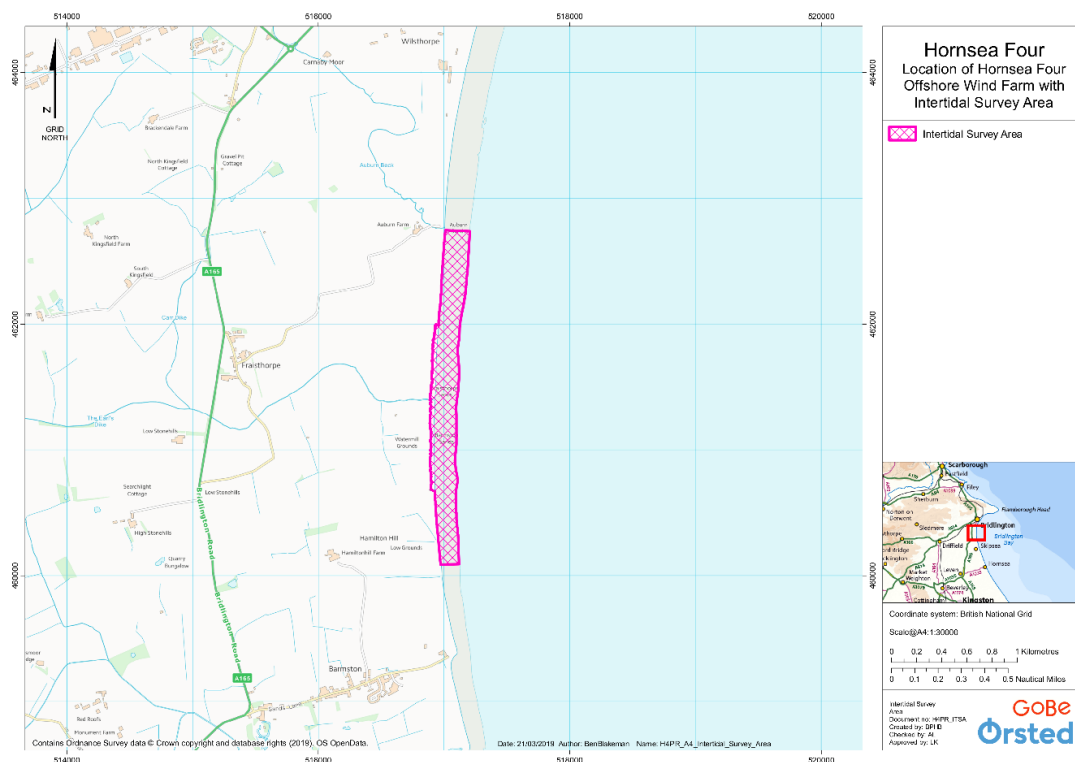


Figure1: Hornsea Four intertidal survey area (Map provided by: RHDHV).

### 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 22<sup>nd</sup> 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 of 30cm<sup>2</sup> 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.MoS.a.Bar.Sa), and coarse sediment (LS.LCS) (Forewind, 2013).

Biotopes identified during this survey were also predominantly coarse littoral sand (LS.LSa.MoS.a.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.

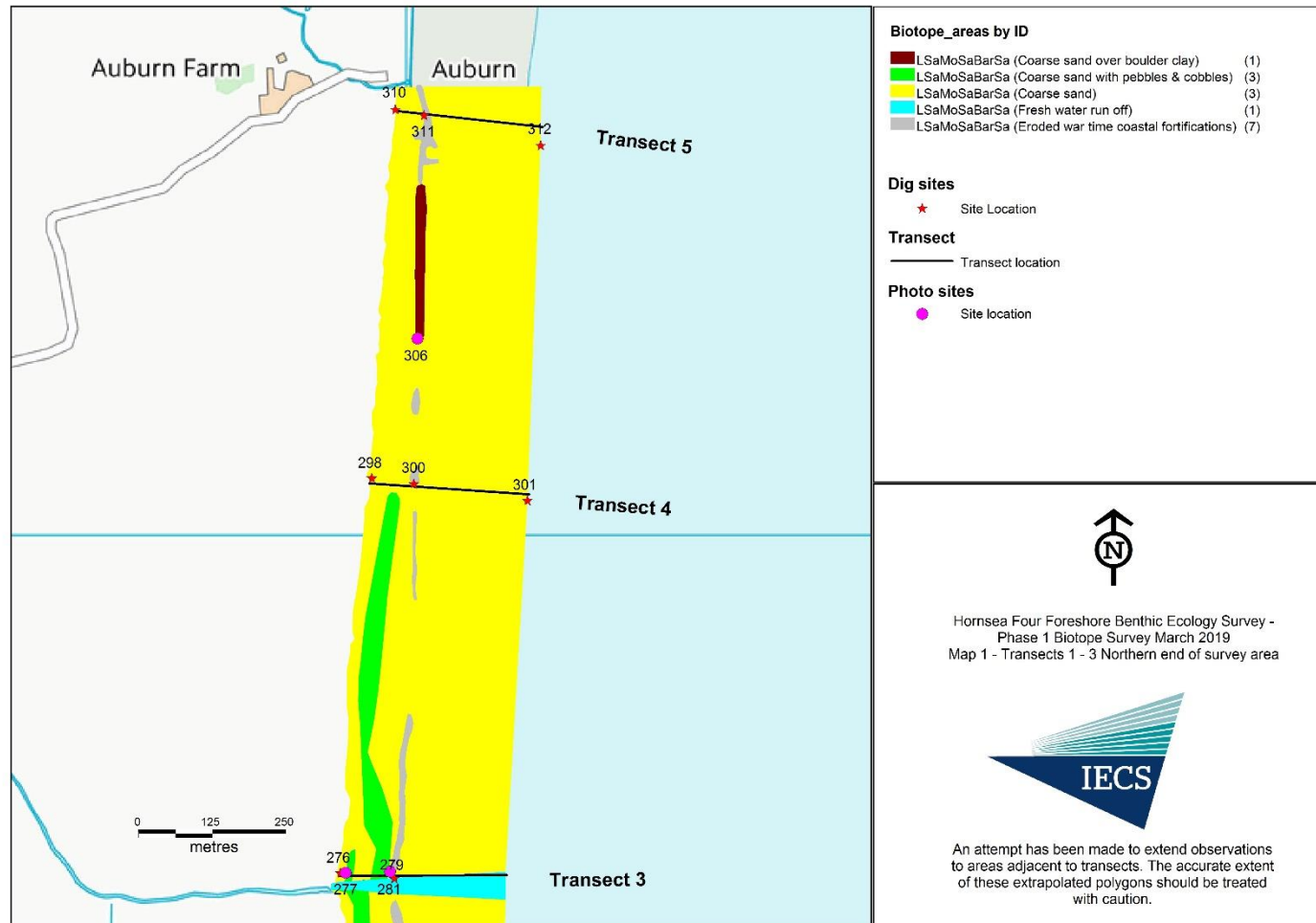
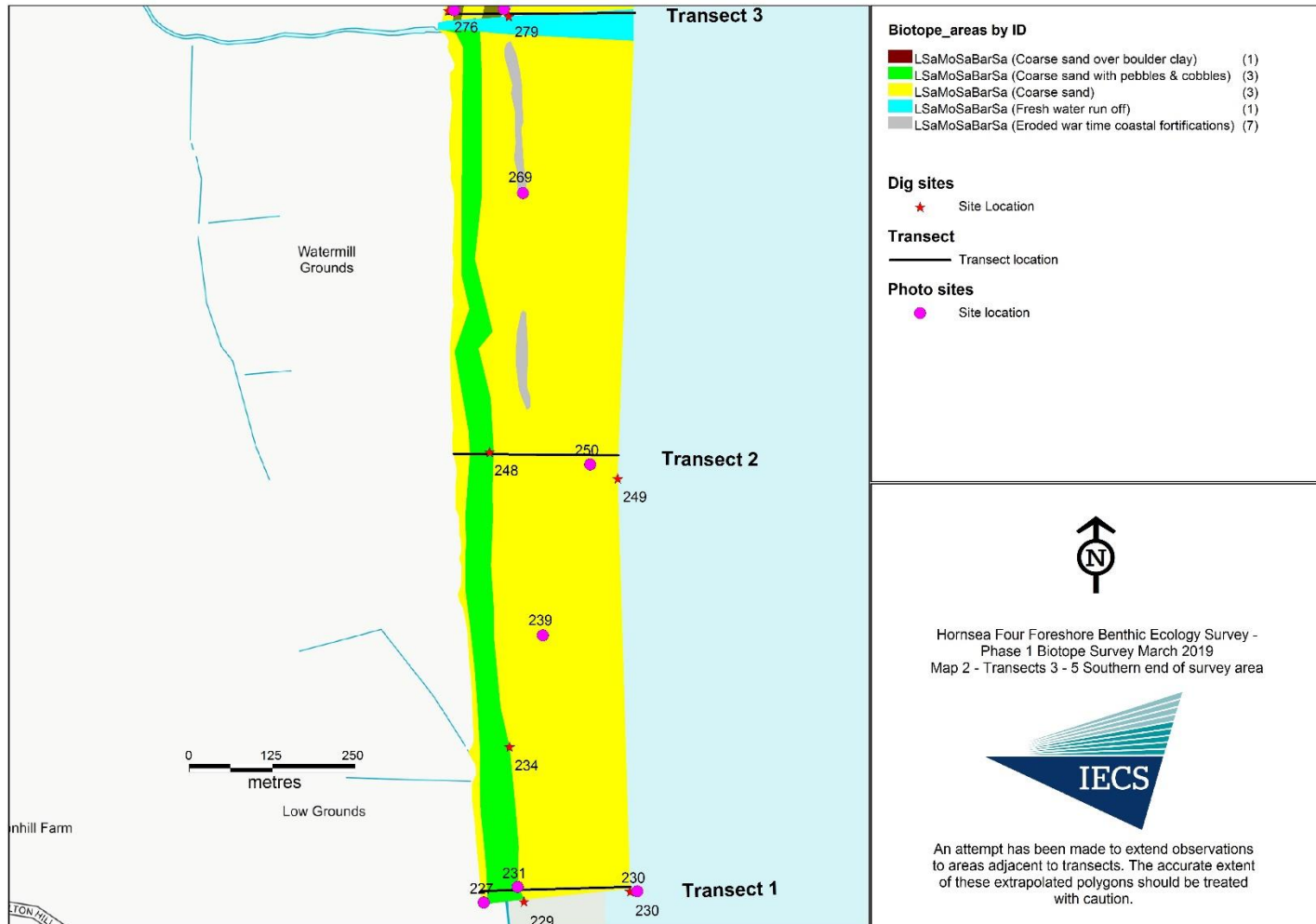


Figure 2. Phase 1 Biotope Map: Hornsea Four (northern end of intertidal survey area), showing designated intertidal biotopes and site references of digovers and noteworthy features.



**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 *Furoid* 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<sup>2</sup> 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 *Furoid 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.MoS.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 foreground. 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<sup>2</sup>. 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 <i>Cirripedia spp. M. edulis</i> and <i>P. vulgata</i> plus <i>Ulva spp.</i> , <i>Porphyra sp</i> and <i>Furoid spp.</i> 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 <i>Furoid spp.</i> present (269-273). Fresh water runoff, Coarse sand below cobbles and boulders (274-275). Sparse <i>L. conchilega</i> tubes (250)
3	Coarse sand	Coarse sand with surficial pebbles and cobbles	Coarse sand	1 x <i>T. saltator</i> (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 <i>L. conchilega</i> (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 <i>L. conchilega</i> tubes (312)



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