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ALCATEL SUBMARINE NETWORK

Havhingsten

Appendix I3- Benthic Characterisation Report - Ireland

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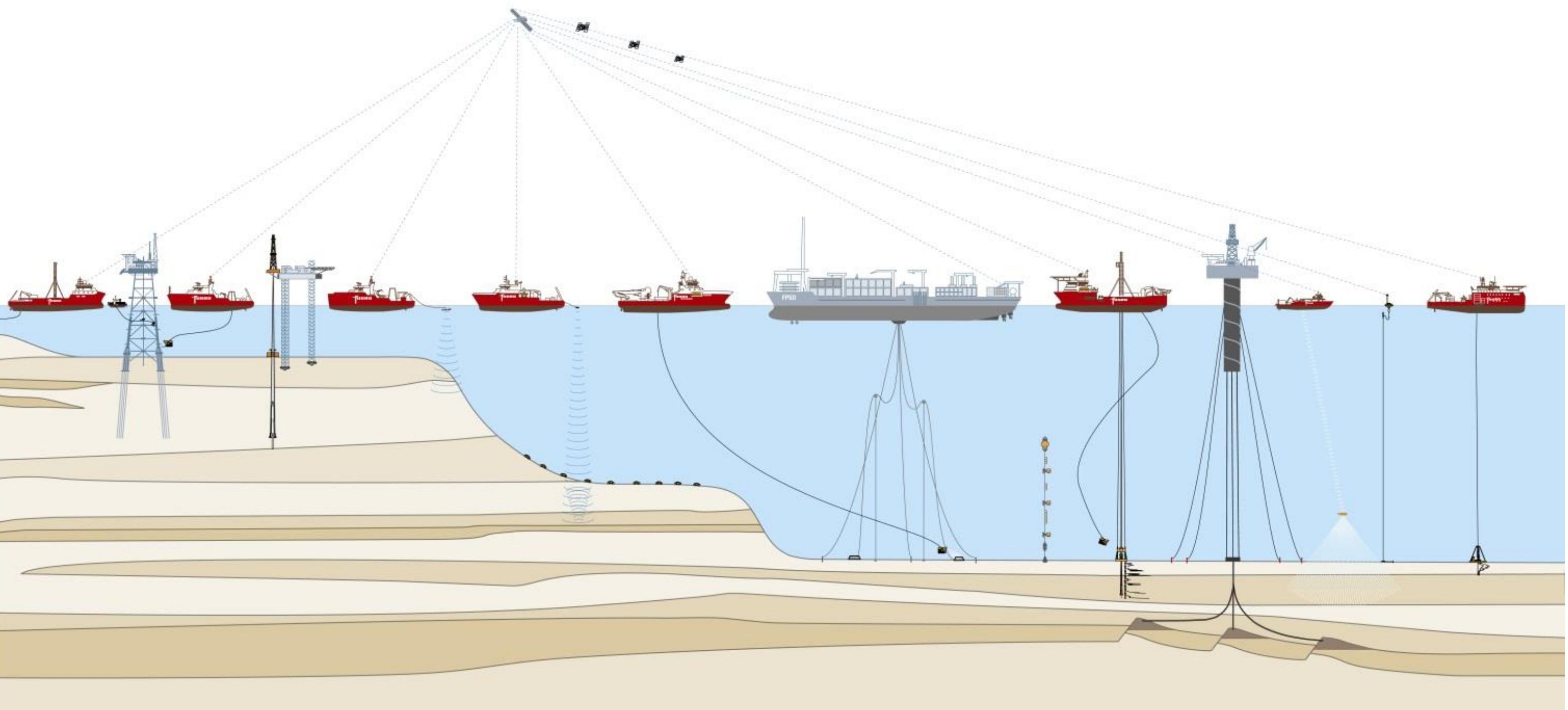
Benthic Characterisation Report
Havhingsten Cable Route
Ireland

Fugro Document No.: 181275-R-015(02)
4 July 2019

Alcatel Submarine Networks UK Limited

Final report



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Final report

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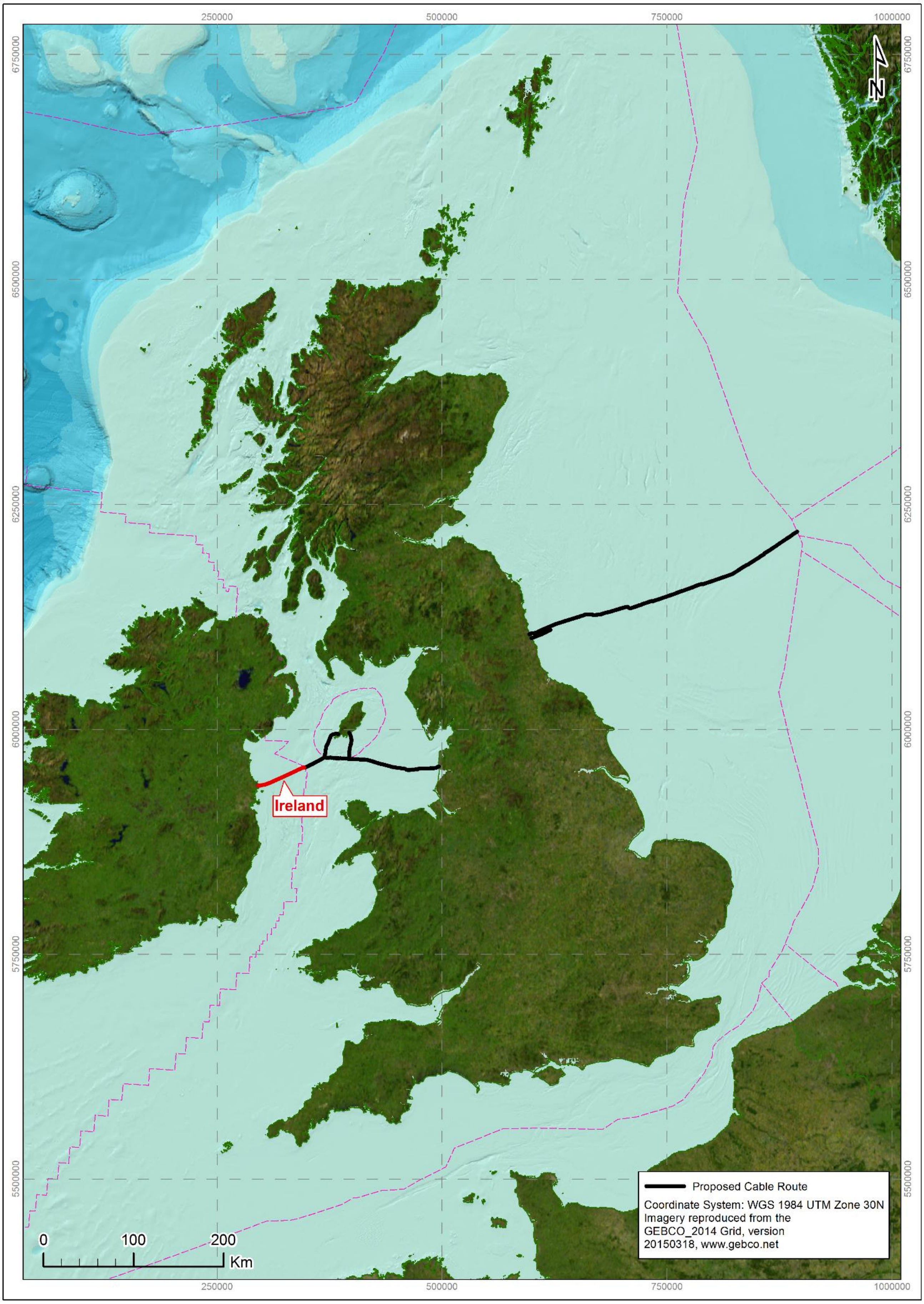

FRONTISPIECE

EXECUTIVE SUMMARY

Introduction

On the instruction of Alcatel Submarine Networks UK Limited, Fugro performed a benthic characterisation survey for the installation of a telecommunications cable along the Irish section of the proposed Havhingsten cable route. The offshore survey was conducted using the RV Prince Madog during the survey period 23 to 24 February 2019. The nearshore survey was conducted using the MV Fastnet Petrel during the period 21 to 22 March 2019.

The benthic characterisation survey was conducted to establish the presence of any sensitive habitats or species within the cable route corridor, specifically habitats listed under Annex I of the European Commission (EC) Habitats Directive and habitats or species considered threatened and/or declining under the Oslo-Paris (OSPAR) convention (OSPAR, 2008). Grab samples were also collected to establish physico-chemical and biological properties of the sediment.

Survey Strategy

A total of six environmental stations were selected along the Irish section of the Havhingsten cable route. At each of these stations, drop-down camera was undertaken prior to grab sampling.

Sediment Characterisation

The sediments within the Irish section of the Havhingsten cable route demonstrated moderate variability in mean diameter and low to high variability for the proportions of sand, gravel and fines, indicating the presence of varied sediments. Using the Wentworth description, sediments varied from fine sand to coarse silt across the survey area.

Sediment Chemistry

The gas chromatographic profiles shared a common underlying hydrocarbon distribution, characterised by a ‘hump’ of unresolved material (UCM) peaking late in the chromatogram window and a range of low-level resolved n-alkanes.

Variation in total hydrocarbon content (THC) concentrations was moderate (RSD 43 %). Higher concentrations of THC were generally found at stations with a greater total organic matter content.

The total 2 to 6 ring polycyclic aromatic hydrocarbon (PAH) concentrations across the survey area were below the effects range low (ERL) value. The United States Environmental Protection Agency 16 (US EPA 16) PAH concentrations were below their respective effects range low (ERL) values at all stations. When normalised to 2.5 % total organic carbon (TOC), the US EPA 16 PAH concentrations (individual and total) exceeded background assessment concentration (BAC) values, for naphthalene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene and benzo(a)pyrene at all stations and benzo(ghi)perylene at one station. However, TOC levels were low and may lead to overestimation of normalised PAH values.

Variability of metals concentrations across the survey area ranged from low to moderate (≤ 47 %), with the highest variability observed for aluminium. All metals concentrations were below their respective ERL value.

Macrofauna

There was a low to moderate degree of infaunal similarity between the stations sampled. The most nearshore of the stations sampled a community dominated by the bivalve mollusc *Abra alba.* Slightly further offshore, a diverse and densely populated community characterised by the brittlestar *Amphiura filiformis* and bivalve *Kurtiella bidentata* was identified. The stations located along the offshore, easterly end of the route were shown to have variably rich communities of bivalves and polychaetes.

Benthic Habitats and Biotopes

Two European Nature Information System (EUNIS) biotopes and two biotope complexes were recorded along the route. One biotope complex was associated with bedrock and/or boulder habitat adjacent to Loughshinny Bay and the remainder were sediment biotopes/biotope complexes.

Due to the occurrence of sea pens and faunal burrows on the offshore section of the route, these were assessed to determine their resemblance to the OSPAR threatened and/or declining habitat ‘sea pens and burrowing megafauna communities’. None of the stations/transects assessed were thought to strongly resemble this priority habitat.

Boulder and/or cobble substrata identified adjacent to Loughshinny Bay (station LS_ST01) were assessed to determine their resemblance to ‘stony reef’ habitat listed under Annex I of the EC Habitats Directive. While the results of this assessment suggested that these areas only demonstrated a ‘low’ level of resemblance to this priority habitat, bedrock substrata, which could be considered Annex I ‘bedrock reef’, were also thought to be present in this area. There are currently no guidelines available for the assessment of the potential conservation importance of ‘bedrock reef’ habitats.

No other OSPAR threatened and/or declining species and habitats, Annex I habitats or Annex II species were observed within the survey area.

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FIGURES IN THE MAIN TEXT

ABBREVIATIONS

1-λ	Simpson's diversity index
BAC	Background assessment concentration
BC	Background concentration
BSH	Broadscale habitats
BSL	Below sea level
CBD	Convention on Biological Diversity
CEMP	Coordinated Environmental Monitoring Programme
CITES	Convention on International Trade in Endangered Species
CLUSTER	Hierarchical agglomerative clustering
CM	Central meridian
CPIs	Carbon preference indices
CV-AFS	Cold vapour-atomic fluorescence spectroscopy
DCM	Dichloromethane
DOEHLG	Department of the Environment, Heritage and Local Government
DTI	Department of Trade and Industry
DVV	Dual van Veen grab
EC	European Community
EMODnet	European Marine Observation Data Network
EOL	End of line
ERL	Effects range low
EU	European Union
EUNIS	European Nature Information System
FA/FB	Fauna sample FA or FB
FID	Flame ionisation detection
FGBML	Fugro GB Marine Limited
GC	Gas chromatography
GC-FID	Gas chromatography – flame ionisation detection
GC-MS	Gas chromatography with mass spectrometry
$H'Log_2$	Shannon-Wiener index
Hb	Brillouin's diversity index
ICP-MS	Inductively coupled plasma-mass spectrometry
ICP-OES	Inductively coupled plasma-optical emission spectroscopy
IDA	Industrial denatured alcohol
J	Pielou's evenness
JNCC	Joint Nature Conservation Committee
KP	Kilometre point
MCS	Marine Conservation Society
MRV	Minimum reporting value
MSFD	Marine Strategy Framework Directive
MV	Motor vessel
NHA	Natural Heritage Area
NM	Nautical miles
NMBAQC	National Marine Biological Association Quality Control
nMDS	Non-metric multidimensional scaling
NOAA	National Oceanic and Atmospheric Administration
NPWS	National Parks and Wildlife Service
NS	No sample
OSPAR	Oslo and Paris

PAH	Polycyclic aromatic hydrocarbon
PC	Physico-chemical (sample)
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSA	Particle size analysis
PSD	Particle size distribution
RSD	Relative standard deviation
RV	Research vessel
SAC	Special Area of Conservation
SACFOR	Super-abundant, abundant, common, frequent, occasional and rare
SCI	Site of Community Importance
SD	Standard deviation
SIMPROF	Similarity profiling
SOL	Start of line
SPA	Special Protection Areas
SSS	Side scan sonar
THC	Total hydrocarbon content
TOC	Total organic carbon
TOM	Total organic matter
UCM	Unresolved complex mixture
UNESCO	United Nation Educational, Scientific and Cultural Organisation
USB	Universal serial bus
US EPA	United States Environmental Protection Agency
US EPA 16	United States Environmental Protection Agency's 16 priority PAH pollutants
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984

1. INTRODUCTION

1.1 Background

On the instruction of Alcatel Submarine Networks UK Limited, Fugro performed a benthic characterisation survey for the installation of a telecommunications cable along the Irish section of the Havhingsten Cable Route. Offshore survey operations were conducted using the RV Prince Madog during the survey period 23 to 24 February 2019, while nearshore operations were undertaken from the MV Fastnet Petrel during the period 21 to 22 March 2019.

The Havhingsten cable system is a planned subsea telecommunication network and the design spans nearly 920 km with initial landing points in four markets, including Denmark, England, Isle of Man and Ireland.

Appendix A outlines the guidelines for use of this report.

1.2 Scope of Work

The benthic characterisation survey was conducted to establish whether any sensitive habitats or species are present within the cable route corridor, specifically habitats listed under Annex I of the European Community (EC) Habitats Directive and habitats or species considered threatened and/or declining under the Oslo-Paris (OSPAR) convention (OSPAR, 2008). In addition, grab samples were collected to establish physico-chemical and biological properties of the sediment.

In addition, a habitat assessment was required at the cable crossing with the interconnector near the eastern boundary of the Irish sector. The results of this survey are included in this report, but also reported separately (Fugro, 2019a).

1.3 Environmental Legislation

Marine legislation in Ireland has been developed in a sectoral way, with national, European and international laws applied for the protection of marine habitats and species.

At a national level, the Wildlife Acts 1976-2000 provide a wide-ranging basis for the protection of wildlife throughout Ireland. The original Wildlife Act 1976 legislated to protect wildlife reserves and refuges and placed restrictions on hunting of certain birds and mammals. A later revision of the Act in 2000 expanded the original national legislation and incorporated reference to implementation of the EC Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora, as amended).

Within the European Union (EU) the key legislative measures requiring the protection of habitats and species are the Habitats Directive, and the Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council on the Conservation of Wild Birds). These Directives fulfil the EU’s commitment to international conventions and provide a framework for the designation of a network of protected sites for species and features across all EU member states, known as the Natura 2000 network.

An additional European measure applicable to the marine environment is the Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy). This provides a legislative framework for marine biodiversity and sets out a target of achieving or maintaining good environmental status of the EU's marine waters. The targets are outlined by several indicators, many linking to habitats and ecological status to be reached by 2020.

Internationally, Ireland is a signatory to the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species (CITES) of Wild Flora and Fauna, the Bonn Convention on Wetlands of International Importance as Waterfowl Habitat, the Bern Convention on the Conservation of European Wildlife and Natural Habitats, the Ramsar Convention on Wetlands of International Importance and the OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic.

The National Parks and Wildlife Service (NPWS) is part of the Department of the Environment, Heritage and Local Government (DOEHLG) and manages the Irish State's nature conservation responsibilities under national, European and international law. The NPWS is responsible for the designation and protection of conservation areas within Ireland. The Wildlife (Amendment) Act 2000 makes provision for the creation of a national network of Natural Heritage Areas (NHAs) throughout Ireland. The EU Habitats and Birds Directives allow for the designation of Special Areas of Conservation (SACs) which act to protect ecologically vulnerable or valuable habitats; and Special Protection Areas (SPAs) for sites that are considered important for bird populations.

1.4 Protected Sites and Potentially Sensitive Habitats

The Irish section of the proposed Havhingsten cable route passes through the large (273 km^2) Rockabill to Dalkey Island SAC, which extends from Rockabill (approximately 7.3 km north of the proposed route) to Dalkey Island (approximately 31.0 km south of the route). This SAC has been designated for the protection of the marine Annex I habitat 'reef' and the Annex II species *Phocoena phocoena* (harbour porpoise). The Annex I habitat comprises intertidal and subtidal reef communities. The intertidal reef community comprises exposed reef on the east side of Dalkey Island, on the east and southern shores of Ireland's Eye and on all shores of Rockabill and the Muglins. The subtidal reef community occurs off the islands and off the coast between Lambay Island and Rush Village, in moderately exposed to exposed conditions. The substrate ranges from flat and sloping bedrock, to bedrock with boulders and cobbles. Vertical rock walls occur on the north and east of Ireland's Eye and to the east of Lambay Island (NPWS, 2013a). The shallow areas of this community (less than 10 m depth) comprise the kelp *Laminaria hyperborea* and an undercover of red algae (*Hypoglossum hypoglossoides*, *Brongniartella byssoides*, *Membranoptera alata*, *Phycodrys rubens* and *Delesseria sanguinea*). Deeper water (greater than 10 m depth) hosts cnidarians (*Alcyonium digitatum* and *Metridium* sp.), with faunal crusts of bryozoans (*Flustra foliacea* and *Chartella papyracea*), hydroids (*Nemertesia antennina*) and ascidians (*Aplidium punctum*). The onshore areas of Rockabill and Dalkey Island are designated as SPAs for supporting Annex II bird species, namely the roseate tern (*Sterna dougallii*), common tern (*Sterna hirundo*) and arctic tern (*Sterna paradisea*).

The Rogerstown Estuary SAC and SPA, 4.6 km south of the proposed cable route landfall, is separated from the sea by a sand and shingle bar and drains almost completely at low tide, resulting in a salinity range from near full sea water to near full fresh water. This SAC is designated for the protection of the marine Annex I habitats 'estuaries' and 'mudflats and sandflats not covered by seawater at low tides' and coastal Annex I habitats 'saltmarsh' and 'sand dune'. The Annex I marine habitats comprise four community types, including a mussel (*Mytlis edulis*) dominated community and a seagrass (*Zostera noltii*) dominated community, in addition to two sedimentary communities. The Rogerstown Estuary SPA is the most important estuary for wildfowl and waders in County Dublin after North Bull Island. Much of the outer part of the estuary is designated as a nature reserve (NPWS, 2013b).

Lambay is the largest Irish east coast island and lies approximately 5.7 km south of the proposed cable route. The Lambay Island SAC is designated for the protection of the Annex I 'reef' habitats. Of most relevance to the current project are the subtidal reefs, which are documented to contain a kelp (*Laminaria* spp.) dominated community complex, which occurs off the north, east and southern shores of the island and in a narrow band on its western shore, in water depths of up to 20 m. The substrate of this community comprises bedrock, often overlain with boulders, cobble and pebbles. Vertical or near vertical faces are recorded throughout. The species associated with this community are algae (*L. hyperborea*, *Phycodrys rubens*, *Delesseria sanguinea*, *H. hypoglossoides*, *M. alata*, *P. palmata* and Corallinaceae), barnacles (*Balanus crenatus*), echinoderms (*Asterias rubens*), crustaceans (*Necora puber*), cnidarians (*A. digitatum*) and bryozoans (*Membranipora membranacea*). Lambay Island supports a long-established breeding colony of grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*), which are listed as Annex II species under the EU Habitats Directive (NPWS, 2013c).

Lying approximately 11.2 km south-south-west of the proposed landfall, the Malahide Estuary SAC, SPA and Site of Community Importance (SCI) comprises the River Broadmeadow estuary. This SAC is designated for the protection of the marine Annex I habitats 'estuaries' and 'mudflats and sandflats not covered by seawater at low tides' and coastal Annex I habitats 'saltmarsh' and 'sand dune'. The mudflat and sandflat habitats contain five community types, including a seagrass (*Zostera* sp.) dominated community and a mussel (*Mytilus edulis*) dominated community, in addition to sandy and sandy mud habitats and associated biotic communities (NPWS, 2013d). The Malahide Estuary SPA is designated for regularly supporting wintering seabird assemblages of national and international importance and it has been classified as an SCI for supporting a good diversity of over-wintering, migratory water-birds (NPWS, 2013e).

Ireland's Eye is a small uninhabited island which lies approximately 15.3 km south of the proposed cable route. It is a SAC designated for the protection of Annex I 'shingle beach' and 'sea cliff' habitats and SPA for holding significant assemblages of migratory birds of national and international importance. The island is also a nesting site for peregrine (*Falco peregrinus*) and contains a gannet (*Morus bassanus*) colony; several pairs of shelduck (*Tadorna tadorna*), oystercatchers (*Haematopus ostralegus*) and ringed plover (C*haradrius hiaticula*) breed on the island (NPWS, 2017).

The North Dublin Bay SAC covers the inner part of north Dublin Bay, with the seaward boundary extending from the Bull Wall Lighthouse across to the Martello Tower at Howth Head. The northern boundary of this SAC lies approximately 17.8 km south of the proposed Havhingsten cable route landfall. The North Dublin Bay SAC is designated for the protection of the marine Annex I habitats 'mudflats and sandflats not covered by sea water at low tide' and coastal Annex I habitats 'saltmarsh' and 'sand dunes'. The North Dublin Bay is also a designated National Nature Reserve (NNR), Wildlife Sanctuary, Ramsar site and United Nation Educational, Scientific and Cultural Organisation (UNESCO) Biosphere Reserve (NPWS, 2013f). The North Bull island SPA and the Baldoyle Island SPA lie within the North Dublin Island SAC and are designated for regularly supporting wintering seabird assemblages of national and international importance (NPWS, 2012; 2014).

The South Dublin Bay and River Tolka Estuary SAC lies approximately 23.6 km south-south-west of the proposed cable route landfall and is designated for the protection of the Annex I marine habitat 'mudflats and sandflats not covered by seawater at low tide'. In the south bay, the intertidal flats comprise predominantly well-aerated sands, while in the Tolka Estuary sediments vary from organically rich soft muds in the inner estuary, to exposed and well-aerated sands off the Bull Wall (NPWS, 2013g). The South Dublin Bay and River Tolka Estuary area is also SPA designated for regularly supporting wintering seabird assemblages of national and international importance (NPWS, 2014).Relevant Marine Habitats of Conservation Importance

The sensitive intertidal and subtidal habitats and species that may occur in the survey area are listed in Table 1.1, with the current relevant legislation and designation. Descriptions of potentially relevant sensitive habitats are provided in Sections 1.4.1.1 to 1.4.1.4.

Table 1.1: Relevant Sensitive Habitats, Havhingsten Cable Route, Ireland

Protected Feature	Legislation	Feature type	Designation/Status
Mudflats and sandflats not covered by sea water at low tide	EC Habitats Directive	Littoral sediment	Annex I habitat
	OSPAR	Intertidal mudflats	Threatened and/or declining habitat
Stony reefs	EC Habitats Directive	Geogenic reefs	Annex I habitat
Mytilus edulis beds	OSPAR	Littoral biogenic reef	Threatened and/or declining habitat
Estuaries	EC Habitats Directive	Estuarine sedimentary habitat	Annex I habitat
Zostera beds	OSPAR	Intertidal seagrass beds	Threatened and/or declining habitat
Sea pen and burrowing megafauna communities	OSPAR	Sea pen and burrowing megafauna communities	Threatened and/or declining habitat
Notes: EC = European Community OSPAR = Oslo and Paris			

1.4.1.1 Mudflats and Sandflats Not Covered by Seawater at Low Tide

The physical structure of intertidal flats ranges from mobile, coarse-sand beaches on wave-exposed coasts to stable, fine-sediment mudflats in estuaries and other marine inlets (JNCC, 2016a). Intertidal mudflats are highly productive providing, at low tide, feeding and resting areas for internationally important populations of migratory and wintering waterfowl. At high tide, they are important nursery areas for flatfish such as sole (*Solea solea*), dab (*Limanda limanda*), flounder (*Platichthys flesus*) and plaice (*Pleuronectes platessa*). Intertidal areas dissipate wave energy, thus reducing the risk of eroding saltmarshes, damaging coastal defences and flooding low-lying land. The mud surface also plays an important role in nutrient chemistry. In areas receiving pollution, organic sediments sequester contaminants and may contain high concentrations of heavy metals (OSPAR, 2009a).

1.4.1.2 Geogenic Reefs and *Mytilus edulis* Beds

Two types of reef are recognised in Irish waters; geogenic and biogenic reefs. Both are listed under Annex I of the EC Habitats Directive and on the OSPAR List of Threatened and/or Declining Species and Habitats (OSPAR, 2008).

Geogenic Reefs

Geogenic reefs are variable in structure but can be classified into two broad categories: bedrock reefs, which comprise sloping or flat bedrock; and stony reefs, which comprise aggregations of boulders and cobbles. Geogenic reefs are characterised by communities of attached algae and invertebrates, usually associated with mobile fauna. The specific communities that occur vary dependent on water depth and turbidity, wave and tidal exposure and substratum type and morphology.

Biogenic Reefs: Mussel (*Mytilus edulis*) Beds

Biogenic reefs are defined as structures made by marine animals that arise from the surrounding seafloor. Mussel (*M*. edulis) beds are important in sediment dynamics of coastal systems as they stabilise the substrate by collecting sediment while the shell layers are relatively erosion resistant thus able to keep up with sea level rise. Mussel beds are an important food source for birds and, in areas of soft sediment, they provide suitable habitat for species such as sea anemones, hydroids and seagrass, by providing hard substrate and shelter in the tidal pools between the ridges formed by the mussels themselves. Other invertebrates, especially deposit feeding worms, profit from the organic matter that is deposited as pseudofaeces (OSPAR, 2015).

1.4.1.3 Estuaries

Estuaries are habitat complexes that comprise a mosaic of subtidal and intertidal habitats, including mudflats and sandflats, which are closely associated with surrounding terrestrial habitats. The structure of estuaries is largely determined by geomorphological and hydrographic factors. The intertidal and subtidal sediments of estuaries support biological communities that vary according to the type of sediment and salinity gradients within the estuary, together with geographic location and the strength of tidal streams. In addition to the sedentary subtidal and intertidal communities, estuaries are a conduit for fish and the juvenile stages of benthic plants and animals and are the transition between the marine and freshwater environments for migratory fish (JNCC, 2016b).

1.4.1.4 Seagrass (*Zostera* sp.) Beds

Seagrasses (*Zostera* sp.) stabilise the substratum and provide shelter and habitat for many organisms. The leaves may be colonised by diatoms, algae, stalked jellyfish and anemones. Seagrass beds are important nursery areas for flatfish and, in some areas, for cephalopods. The diversity of the species will depend on exposure and density of the seagrass microhabitats, but it is generally high in perennial, fully marine, subtidal seagrass beds compared to in intertidal or estuarine, annual beds. Seagrass bed productivity is a major source of food for wildfowl, particularly brent goose and widgeon, but also for mute and whooper swans. Dead plants are a source of organic matter for marine systems (OSPAR, 2009b).

1.4.1.5 Sea Pen and Burrowing Megafauna Communities

Sea pens and burrowing megafauna were identified from the previous Cable Crossing Habitat Assessment undertaken on the Irish section of the Havhingsten cable route (Fugro, 2019a).

‘Sea pen and burrowing megafauna communities’ is a habitat feature listed on the OSPAR List of Threatened and/or Declining Species and Habitats (OSPAR, 2008). This biotope comprises plains of fine mud, in water depths ranging from 15 m to 200 m or more, heavily bioturbated by burrowing megafauna and with conspicuous populations of sea pens (*Virgularia mirabilis* and *Pennatula phosphorea*). The burrowing megafauna may include the crustaceans *N. norvegicus*, *Calocaris macandreae* or *C. subterranea*. In the Irish sector, this habitat may be encountered in sheltered sea loughs and in deeper offshore waters of the Irish Sea (OSPAR, 2010).

1.5 Regional Standards for Sediment Chemical Concentrations

Comparison was made to OSPAR background values that were derived from data collected from pristine marine sediments in the wider north-east Atlantic (OSPAR, 2014). The OSPAR background concentrations (BCs) reflect contaminant concentrations at “pristine” or “remote” sites, whilst background assessment concentrations (BACs) are statistically derived from background data and are defined as “values for testing whether the concentrations at a location are at or close to background” (OSPAR, 2005; 2009c). Both BCs and BACs are normalised concentrations, with organic substances e.g. polycyclic aromatic hydrocarbons (PAHs) normalised to 2.5 % total organic carbon (TOC) and metals normalised to 5 % aluminium (OSPAR, 2009c; 2014).

Selected data have been compared to the OSPAR effects range low (ERL) concentrations, where available (OSPAR, 2014). ERLs represent the low point (10th percentile) on a continuum of chemical concentrations over which adverse biological effects have been observed from ecotoxicological studies (OSPAR, 2009c). Adverse effects on marine organisms are rarely observed when concentrations are below the ERL value (OSPAR, 2014).

1.6 Coordinate Reference System

All coordinates detailed in this report are referenced to World Geodetic System 1984 (WGS84) Universal Transverse Mercator (UTM) Projection Zone 30N Central Meridian 3° West (CM 3° W). Table 1.2 provides the detailed geodetic and projection parameters.

Table 1.2: Project Geodetic and Projection Parameters

Global Positioning System Geodetic Parameters	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Reciprocal flattening:	1/f = 298.257 223 563
Project Projection Parameters	
Grid Projection:	Universal Transverse Mercator (UTM)
UTM Zone:	30 N
Central Meridian:	3° 00′ 00″ West
Latitude of Origin:	00° 00′ 00″ North
False Easting:	500 000 m
False Northing:	0 m
Scale factor on Central Meridian:	0.9996
Units:	metre

2. ENVIRONMENTAL SURVEY METHODS

2.1 Survey Strategy

The acquired side scan sonar (SSS) data were reviewed prior to survey operations to propose locations for camera investigations and grab sampling. Emphasis was placed on locating areas of potential conservation value, on boundaries between areas of differing sonic reflectivity and areas characteristic of the general background conditions of the site.

Five grab sampling stations were selected along the Irish section of the cable route. At each of these stations, drop-down camera transects were undertaken prior to grab sampling.

Additionally, the interconnector cable crossing location was selected by the client and investigated by means of two perpendicular camera transects, centred on the cable crossing position. A grab sampling station was also positioned 300 m from the interconnector.

Table 2.1 provides the coordinates, data to be acquired and rationale for the selection for each environmental sampling station.

Table 2.1: Proposed Environmental Stations, Havhingsten Cable Route, Ireland

Geodetic Parameters: WGS84 UTM 30N					
Station	**KP***	**Easting [m]**	**Northing [m]**	**Rationale**	**Data/Sample Acquisition**
LS_ST01	1.120	296 655	5 937 208	Differing reflectivity covering two habitat types. Grab sample location to be defined following video review	Video and stills PC, FA, FB
LS_ST02	2.940	298 411	5 937 630	Representative habitat	Video and stills PC, FA, FB
LS_ST03	8.500	303 849	5 938 838	Differing reflectivity	Video and stills PC, FA, FB
LS_ST04	11.960	307 143	5 939 833	Differing reflectivity	Video and stills PC, FA, FB
LS_ST05	20.570	314 915	5 943 502	Representative habitat	Video and stills PC, FA, FB
CC05 (Client ID 2)	54.920	346 662	5 957 525	Interconnector cable crossing	Video and stills
CC05_ST01	55.220	346 363	5 957 528	Positioned 300 m from the interconnector cable crossing	Video and stills PC, FA, FB
Notes: KP = Kilometre point PC = Physico-chemical sample FA/FB = Faunal sample FA or FB * = Approximate KP from landfall at Loughshinny (segment 1.1)					

2.2 Survey Methods

2.2.1 Sediment Grab Sampling

Seabed grab samples were collected using a 0.1 m² dual van Veen grab during both the offshore and nearshore survey operations. Two accepted grab samples were retained for faunal analysis and one grab sample was retained and subsampled for physico-chemical analysis. Seabed grab samples were primarily collected for analysis of physico-chemical and biological baseline characterisation; however, observations from the grab sampling have also been used to supplement the seabed video/photographic data in describing the benthic habitat, where appropriate.

2.2.2 Seabed Video/Photography

Seabed photographic data were acquired using a Kongsberg OE 14-208 underwater camera system mounted within purpose-built camera frames, complete with a separate strobe and two lights. Parallel lasers (which provide a scale for faunal size classes and sediment descriptions, specifically cobbles and boulders) were fitted to the video frames. A video overlay was used to display a navigation string from the ship's reference point, including the time, date, station/transect number and location (easting and northing). During operations where visibility was reduced, a freshwater lens system was used. Laser scaling was used with the conventional camera frame (not freshwater lens), with the lasers positioned 17.0 cm to 19.5 cm apart.

Further detail can be found within the Havhingsten cable route field reports (Fugro, 2019a, 2019b) and in Appendix B.1.

2.3 Analytical Strategy

The following list briefly describes the suites of analyses carried out. Further description of the methods used for the analyses are detailed in Appendix B.

- Sediment particle size distribution (PSD) analysis and characterisation including total organic matter (TOM) and total organic carbon (TOC) content (Section 4);
- Sediment chemistry (Section 5), including:
  - Total hydrocarbon content (THC) and n-alkane content by gas chromatography–flame ionisation detection (GC-FID; Section 5.2.2);
  - 2 to 6 ring aromatic hydrocarbons, including the United States Environmental Protection Agency's (US EPA) 16 priority PAHs by gas chromatography-mass spectrometry (GC-MS; Section 5.2);
  - Metals predominantly by aqua regia digest and subsequent instrumental analysis. Arsenic, cadmium, chromium, copper, lead and nickel analysed by inductively coupled plasma-mass spectrometry (ICP-MS), aluminium and tin by inductively coupled plasma-optical emission spectroscopy (ICP-OES) and mercury by cold vapour-atomic fluorescence spectroscopy (CV-AFS) (Section 5.3);
- Macrofauna (as retained on a 1 mm mesh sieve) were identified and enumerated from one sample at each station (Section 6).
- Habitats and biotopes were classified using the European Nature Information Service (EUNIS) Habitat Classification (EUNIS, 2012) with equivalent classifications from the Joint Nature Conservation Committee (JNCC) 'Marine Habitat Classification for Britain and Ireland' (JNCC, 2015) and 'A Guide to Habitats in Ireland' (Fossitt, 2000) also provided (Section 7);
- Sensitive habitat assessments ('Sea pen and burrowing megafauna communities' and 'Geogenic reef') were undertaken in accordance with published guidelines (Section 7.2.3)

3. FIELD OPERATIONS

The majority of the survey along the Loughshinny section of the proposed cable route was conducted onboard the RV Prince Madog during the survey period 23 to 24 February 2019. Due to shallow water depths, and the poor visibility for photographic data collection, encountered during operations on the RV Prince Madog, two stations (LS_ST01 and LS_ST02) were sampled onboard the MV Fastnet Petrel during the survey period 21 to 22 March 2019.

3.1 Seabed Sampling

A complete suite of samples (two macrofauna and one physico-chemical sample) were acquired at each of the six stations originally proposed along the Irish section of the Havhingsten cable route. Figure 3.1 presents the spatial distribution of the survey stations.

All but one of the samples was acquired within the radius of accuracy originally proposed (within 50 m of the proposed location). Due to the water being too shallow to safely survey at station LS_ST01, the grab sampling station was moved to a position approximately 374 m away from that originally proposed. The camera transect undertaken at this station was also relocated for safety reasons (Section 3.2) and the grab sampling station then targeted sediments amenable to sampling that were identified following *in situ* review of the seabed video data.

Table 3.1 presents the details of the acquired samples, together with the approximate kilometre point (KP) of each station.

Table 3.1: Completed Environmental Survey Sampling Stations, Havhingsten Cable Route, Ireland

Geodetic Parameters: WGS84 UTM 30N					
Station	**KP***	**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Sample Acquisition**
LS_ST01	1.120	296 285.6	5 937 148.2	9	PC, FA, FB
LS_ST02	2.940	298 426.0	5 937 601.7	17	PC, FA, FB
LS_ST03	8.500	303 889.9	5 938 821.5	32	PC, FA, FB
LS_ST04	11.960	307 185.5	5 939 829.5	41	PC, FA, FB
LS_ST05	20.570	314 900.5	5 943 474.5	66	PC, FA, FB
CC05_ST01	55.220	346 332.3	5 957 528.3	81	PC, FA, FB

Notes:
KP = Kilometre point
BSL = Below sea level
PC = Physico-chemical sample
FA/FB = Faunal sample FA or FB
* = Approximate KP from landfall at Loughshinny (segment 1.1)

3.2 Seabed Video/Photography

Photographic stills and video footage were successfully acquired at all proposed camera stations and transects. Due to very poor visibility at stations LS_ST01 and LS_ST02 during the offshore phase of operations, these were revisited during the nearshore operations, with data successfully acquired during this phase of work. As previously mentioned with regard to the grab sampling, station LS_ST01 had to be relocated for safety reasons; the proposed transect was moved approximately 151 m south-east of the line originally proposed and extended to target the rock features of interest which occur on either side of Loughshinny bay.

Table 3.2 provides the coordinates for the camera transects undertaken and a summary of the data acquired and Figure 3.1 provides a spatial representation of their positions. As some transects had to be re-run due to poor visibility, only the successful attempts have been shown within the table and figure.

Table 3.2: Completed Environmental Survey Camera Transects, Havhingsten Cable Route, Ireland

Geodetic Parameters: WGS84 UTM 30N							
Station		**KP***	**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Length [m]**	**Data Acquisition**
LS_ST01A	SOL	1.310	296 293.1	5 937 015.3	7	249	11 mins 34 secs 19 stills
	EOL		296 258.6	5 937 262.1			
LS_ST02	SOL	2.940	298 418.7	5 937 591.1	15	65	9 mins 34 secs 32 stills
	EOL		298 408.3	5 937 655.2			
LS_ST03	SOL	8.500	303 870.6	5 938 724.0	35	157	6 mins 2 secs 23 stills
	EOL		303 833.3	5 938 876.9			
LS_ST04	SOL	11.960	307 144.3	5 939 797.0	41	85	5 mins 26 secs 19 stills
	EOL		307 133.1	5 939 881.0			
LS_ST05	SOL	20.570	314 922.3	5 943 446.6	66	184	5 mins 3 secs 19 stills
	EOL		314 882.9	5 943 626.6			
CC05_T01	SOL	54.920	347 174.7	5 957 085.5	83	829	33 mins 38 secs 68 stills
	EOL		346 542.0	5 957 621.4			
CC05_T02	SOL	54.920	346 779.4	5 957 515.0	82	272	10 mins 15 secs 26 stills
	EOL		346 508.0	5 957 501.8			
CC05_ST01	SOL	55.220	346 266.4	5 957 592.1	82	146	19 mins 59 secs 26 stills
	EOL		346 385.9	5 957 508.6			
Notes: KP = Kilometre point BSL = Below sea level SOL = Start of line EOL = End of line * = Approximate KP from landfall at Loughshinny (segment 1.1)							

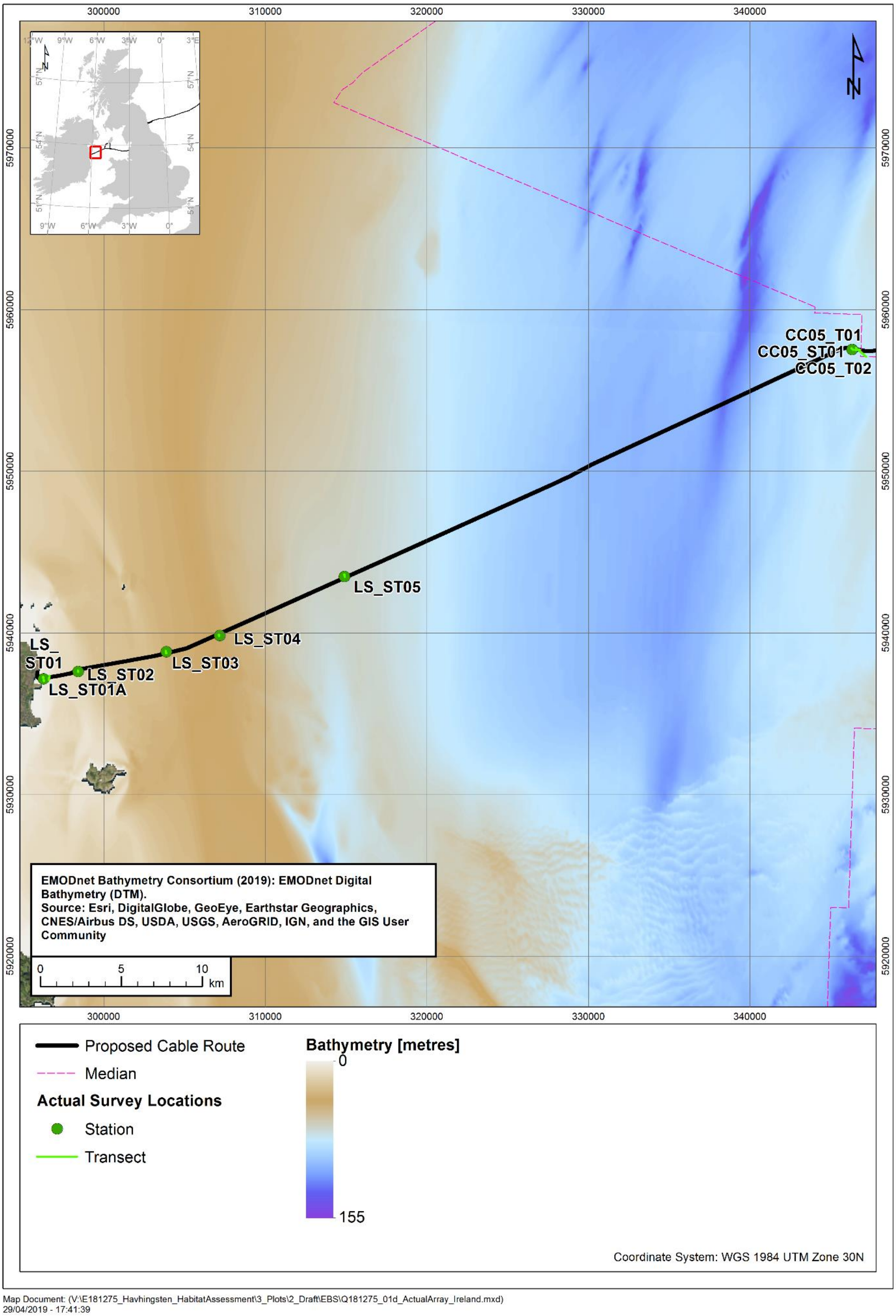


Figure 3.1: Completed environmental sampling locations overlaid on bathymetry, Havhingsten cable route, Ireland

4. SEDIMENT CHARACTERISATION

4.1 Introduction

Sediment samples were analysed for their PSD using a combination of two techniques; sieve analysis for all material retained by a 1 mm sieve followed by laser diffraction analysis of the finer material. The results of the particle size analysis were treated statistically to characterise the sediment type (Wentworth scale) and particle size homogeneity (sorting).

The proportion of TOM present in each sediment sample was determined by loss on ignition at 440 °C for 4 hours, whilst the proportion of TOC was determined by combustion and non-dispersive infrared detection following inorganic carbon removal.

Relative standard deviation (RSD) indicates the extent of variability in a dataset in relation to the mean value. The RSD value expresses the standard deviation as a percentage of the mean. For the purpose of this report, RSD of less than 30 % will be considered low variability, 30 % to 70 % will be considered moderate variability and more than 70 % will be considered high variability.

Appendix B provides full details of the analytical techniques employed and Appendix D displays the histograms of particle size class summary for each station.

4.2 Results

Table 4.1 summarises the particle size distribution, whilst Table 4.2 summarises the sediment characteristics, including granulometry and organic content (TOM and TOC), across the Irish section of the Havhingsten cable route. Figure 4.1 shows the spatial distribution of sediment composition along the surveyed route.

Median particle size across the across the survey area demonstrated moderate variation (RSD 38 %) and ranged from 75.2 µm at station LS_ST05 to 199 µm at station LS_ST03, with a mean of 123 µm (Table 4.1).

Mean particle size across the across the survey area demonstrated moderate variability (RSD 67 %) and ranged from 41.5 µm at station LS_ST05 to 192 µm at station LS_ST03, with a mean of 90.0 µm (Table 4.1). Sediment description using the Wentworth description varied from fine sand to coarse silt (Wentworth, 1922).

Standard deviation (SD) of particle size indicates the degree of spread of individual size classes about the mean and provides the basis of a sorting index, in which low values indicate sediments to be fairly homogeneous (good sorting) while high values suggest a relatively large scatter of particle sizes about the mean (poor sorting). The sorting coefficient ranged from 1.37 phi at station LS_ST04 to 2.29 phi at station LS_ST01, with a mean of 1.93 phi. Poorly sorted to very poorly sorted sediments were recorded across the Irish section of the Havhingsten cable route.

Skewness indicates the tendency of particle size classes to be skewed about the mean, either towards coarser sediment (negative skewness) or finer sediment (positive skewness). Skewness across all stations ranged from 0.26 phi (fine skewed) at station LS_ST03 to 0.66 phi (very fine skewed) at station LS_ST02, with a mean of 0.51 phi.

The sediment across the Irish section of the Havhingsten cable route were comprised predominantly of sand particles, with varying portions of gravel and fines (Table 4.2 and Figure 4.1). Sand content ranged from 57.0 % at station LS_ST05 to 84.5 % at station LS_ST04, with a mean of 71.4 % and low variability (RSD 16 %). Gravel content ranged from 0.00 % at stations LS_ST01 and LS_ST05 to 2.73 % at station LS_ST03, with a mean of 0.68 % and high variability (RSD 158 %) which was predominantly influenced by the comparatively high gravel content at stations LS_ST02 and LS_ST03. The fines fraction ranged from 14.7 % at station LS_ST03 to 43.0 % at station LS_ST05, with moderate variability (RSD 44 %). Sediments description using the modified Folk description (Long, 2006) classed sediments as muddy sand at four stations and slightly gravelly muddy sand at two stations.

The TOM content across the Irish section of the Havhingsten cable route was low and demonstrated low variability (RSD 21 %). TOM content ranged from 1.93 % at station LS_ST03 to 3.31 % at station LS_ST01, with a mean of 2.50 % (Table 4.2).

TOC values were low and demonstrated moderate variability (RSD 38 %). TOC values ranged from 0.27 % at station LS_ST03 to 0.66 % at station LS_ST01, with a mean of 0.39 % (Table 4.2).

Table 4.1: Summary of Particle Size Distribution, Havhingsten Cable Route, Ireland

Station	KP*	Median [µm]†	Mean [µm]†	Mean [phi]†	SD [phi]†	Skewness [phi]†	Wentworth Description‡	Sorting^
LS_ST01	1.120	87.4	50.8	4.30	2.29	0.48	Coarse silt	Very poorly sorted
LS_ST02	2.940	133	69.2	3.85	2.06	0.66	Very fine sand	Very poorly sorted
LS_ST03	8.500	199	192	2.38	1.71	0.26	Fine sand	Poorly sorted
LS_ST04	11.960	152	134	2.90	1.37	0.51	Fine sand	Poorly sorted
LS_ST05	20.570	75.2	41.5	4.59	2.15	0.55	Coarse silt	Very poorly sorted
CC05_ST01	55.220	94.2	53.0	4.24	2.01	0.60	Coarse silt	Very poorly sorted
Minimum	**-**	**75.2**	**41.5**	**2.38**	**1.37**	**0.26**	**-**	**-**
Maximum	**-**	**199**	**192**	**4.59**	**2.29**	**0.66**	**-**	**-**
Mean	**-**	**123**	**90.0**	**3.71**	**1.93**	**0.51**	**-**	**-**
Standard Deviation	**-**	**47.2**	**60.0**	**0.887**	**0.334**	**0.137**	**-**	**-**
RSD [%]	**-**	**38**	**67**	**-**	**-**	**-**	**-**	**-**

Notes:
KP = Kilometre point
RSD = Relative standard deviation
* = Approximate KP from landfall at Loughshinny (segment 1.1)
† = Folk and Ward method (Gradistat statistics)
‡ = Wentworth description (Wentworth, 1922)
^ = Sorting based on geometric Folk and Ward (1957) graphical measures (Gradistat statistics)

Table 4.2: Summary of Sediment Characteristics, Havhingsten Cable Route, Ireland

Station	KP*	Fractional Composition			Fines		Folk Description[†]	TOM [%]	TOC [%]
		Gravel [%]	Sand [%]	Fines [%]	Silt [%]	Clay [%]			
LS_ST01	1.120	0.00	59.4	40.6	31.2	9.44	Muddy sand	3.31	0.66
LS_ST02	2.940	1.06	77.0	22.0	14.9	7.05	Slightly gravelly muddy sand	2.34	0.33
LS_ST03	8.500	2.73	82.5	14.7	9.93	4.80	Slightly gravelly muddy sand	1.93	0.27
LS_ST04	11.960	0.03	84.5	15.5	10.5	5.04	Muddy sand	2.08	0.28
LS_ST05	20.570	0.00	57.0	43.0	33.2	9.84	Muddy sand	2.94	0.46
CC05_ST01	55.220	0.28	68.1	31.6	23.8	7.85	Muddy sand	2.41	0.35
Minimum	**-**	**0.00**	**57.0**	**14.7**	**9.93**	**4.80**	**-**	**1.93**	**0.27**
Maximum	**-**	**2.73**	**84.5**	**43.0**	**33.2**	**9.84**	**-**	**3.31**	**0.66**
Mean	**-**	**0.68**	**71.4**	**27.9**	**20.6**	**7.34**	**-**	**2.50**	**0.39**
Standard Deviation	**-**	**1.08**	**11.8**	**12.4**	**10.3**	**2.13**	**-**	**0.526**	**0.148**
RSD [%]	**-**	**158**	**16**	**44**	**50**	**29**	**-**	**21**	**38**

Notes:
Fines = silt and clay content
Silt = +4.0 to +8.0 ø units or 3.9 µm to 62.5 µm
Clay = +8.0 to +10.0 ø units or 0.98 µm to 3.9 µm
TOM = Total organic matter
TOC = Total organic carbon
RSD = Relative standard deviation
* = Approximate KP from landfall at Loughshinny (segment 1.1)
† = BGS modified Folk description from Long (2006)

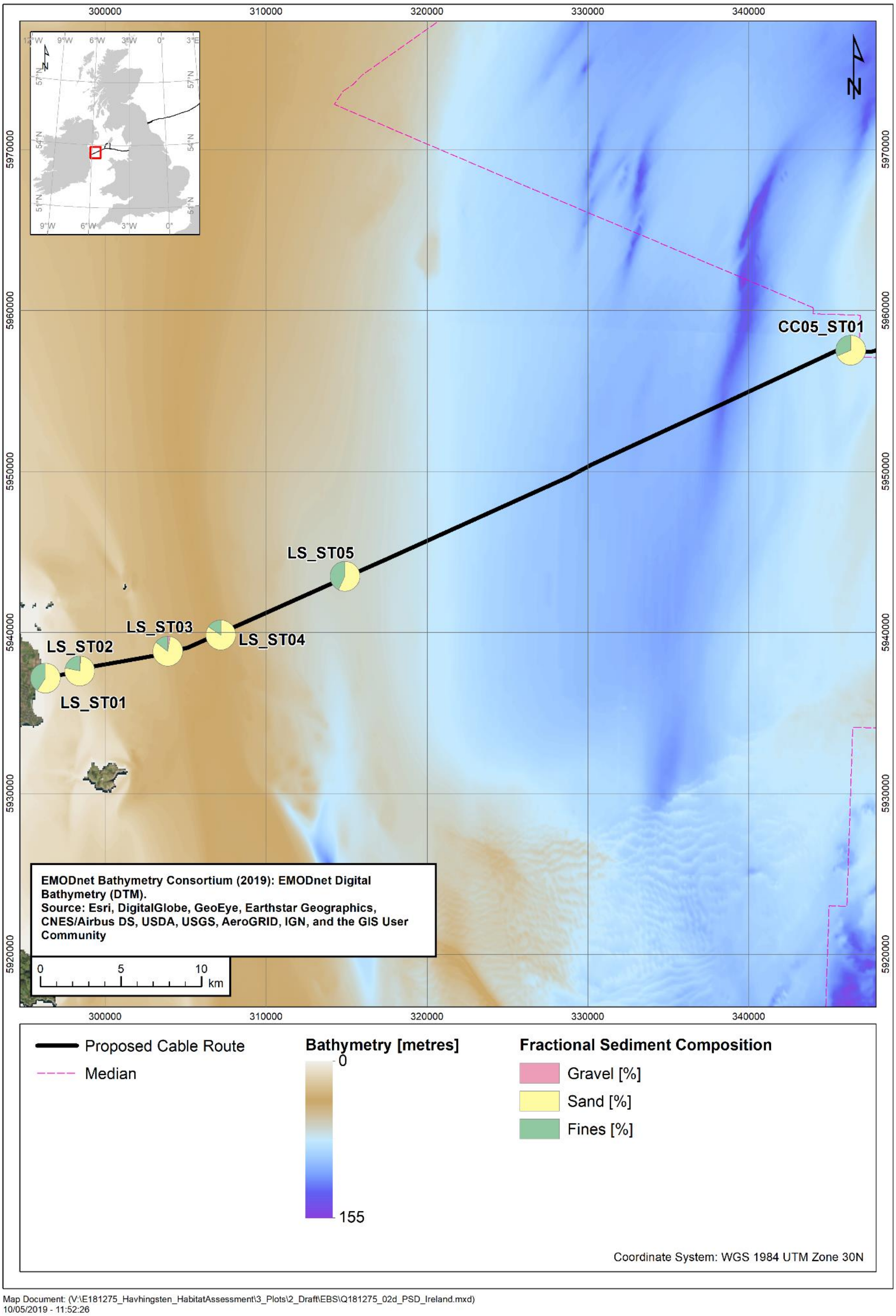


Figure 4.1: The spatial distribution of sediment composition, Havhingsten cable route, Ireland

5. SEDIMENT CHEMISTRY

5.1 Introduction

Sediment samples underwent analysis to assess concentrations of key hydrocarbon and metal analytes, which were compared to published background and probable effect criteria (OSPAR, 2009c; 2014) to establish the likelihood of anthropogenic contamination of sediments within the Irish section of the Havhingsten cable route.

The sediment samples were analysed for hydrocarbon content including THC, total n-alkanes (nC_{12} to nC_{36}) and PAHs, specifically the US EPA 16 PAHs. Samples were extracted by ultrasonication of wet sediments with mixed solvents. The sample extracts were then cleaned-up using absorption column chromatography. The extracts were analysed for THC, unresolved complex mixture (UCM) and n-alkanes (nC_{12} to nC_{36}). Aromatic hydrocarbons were analysed by GC-MS.

Sediments collected were also analysed for selected elements (metals). The majority (aluminium, arsenic, cadmium, chromium, copper, lead, nickel and tin) were quantified after an aqua regia digest followed by multi-element analysis by inductively coupled plasma-mass spectrometry (ICP-MS) or by inductively coupled plasma-optical emission spectroscopy (ICP-OES). Analysis of mercury was by cold vapour-atomic fluorescence spectroscopy (CV-AFS).

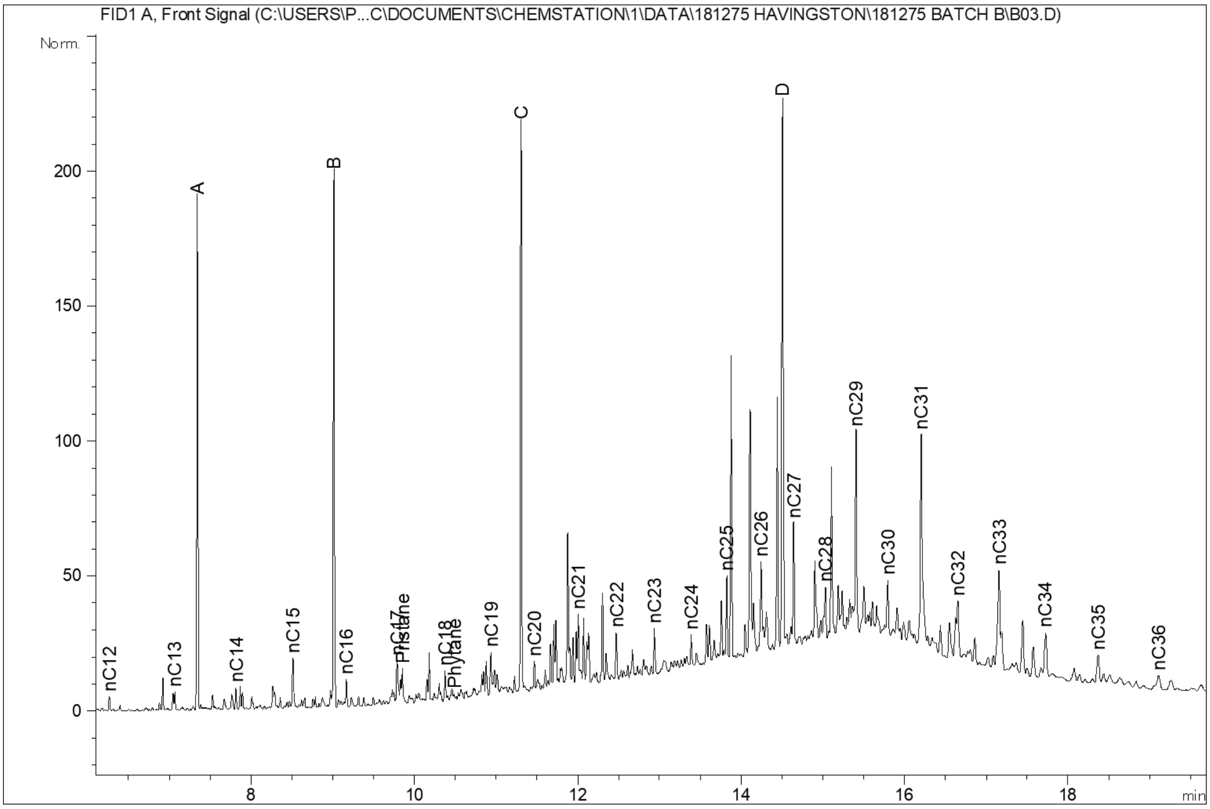
Appendix B provides full details of the analytical techniques employed.

5.2 Sediment Hydrocarbons

5.2.1 Gas Chromatography–Flame Ionisation Detection (GC-FID) Hydrocarbon Profiles

A visual comparison of the GC-FID profiles can provide information on the potential origins of the hydrocarbons present in marine sediments samples. The GC-FID profiles illustrating the hydrocarbon components detected in each of the sediment samples are provided in Appendix E.1. To support more detailed discussions relating to the hydrocarbon components identified by GC-FID analysis of the sediments. Figure 5.1 displays example gas chromatograms, representative of the grab samples across the Irish section of the Havhingsten cable route.

The GC-FID profiles obtained for the majority of the sediment samples were broadly similar to the profile of station LS_ST03 in Figure 5.1. This profile is characterised by a ‘hump’ of UCM peaking late in the chromatogram window and a range of low level resolved n-alkanes. The prevalence of the odd-numbered heavier n-alkanes (those from nC_{25}) are indicative of leaf cuticle waxes originating from terrestrial run-off. A cluster of peaks around nC_{21} was present in some samples and is often seen in marine sediments and thought to be branched isoprenoids of biogenic origin.



Notes:

THC = Total hydrocarbon content

A, B, C and D peaks refer to the internal standards added for quantification

Figure 5.1: Gas chromatographic profile for typical surface sediment Havhingsten cable route, Ireland

5.2.2 Total Hydrocarbon and n-Alkane (nC_{12} to nC_{36}) Content

Table 5.1 presents the concentrations of total hydrocarbons, UCM, total n-alkanes and CPI ratios (nC_{12} to nC_{36}) and pristane/phytane ratios reported from the surface sediment across the Irish section of the Havhingsten cable route. Appendix E.2 presents individual n-alkane concentrations for the sediments analysed.

THC concentrations reported for the survey area ranged from 3.9 µg/g at station LS_ST04 to 12.6 µg/g at station LS_ST01, with a mean concentration of 6.2 µg/g. Variation across all stations was moderate (RSD 54 %).

UCM concentrations ranged from 2.5 µg/g at stations LS_ST04 and CC05_ST01 to 9.2 µg/g at station LS_ST01, with a mean concentration of 4.2 µg/g and moderate variability (RSD 61 %).

The total n-alkane (nC_{12} to nC_{36}) concentrations displayed moderate variability (RSD 52 %), ranging from 0.23 µg/g at station LS_ST04 to 0.76 µg/g at station LS_ST01, with a mean concentration of 0.38 µg/g.

5.2.3 Sediment Aromatic Hydrocarbon Content

The distribution and concentration of aromatic compounds in seabed sediments were analysed by GC-MS. The aromatic compounds quantified were the naphthalenes (2 ring aromatics), 3 to 6 ring PAHs and the dibenzothiophenes (sulphur containing heteroaromatics). Table 5.1 summarises the total concentrations of aromatic hydrocarbons and the sum of the US EPA 16 PAHs. Appendix E.3 presents the individual US EPA 16 PAH concentrations, which are compared to OSPAR (2014) ERL values, and US EPA 16 PAH values normalised to 2.5 % TOC content, which are compared to OSPAR (2009; 2014) BC and BAC criteria.

Total 2 to 6 ring PAH concentrations ranged from 0.171 µg/g at station LS_ST04 to 0.650 µg/g at station LS_ST01, with a mean concentration of 0.309 µg/g and moderate variability (RSD 57 %). All total 2 to 6 ring PAH concentrations were below the ERL value (4.10 µg/g; OSPAR, 2014).

The total US EPA 16 PAH concentrations ranged from 0.060 µg/g to 0.328 µg/g at stations LS_ST04 and LS_ST01 respectively, with a mean concentration of 0.130 µg/g. Variation between stations was high (RSD 77 %). All individual US EPA 16 PAHs and alkylated PAHs were below their respective ERL values (OSPAR, 2014) across the survey area (Appendix E.3).

When normalised to 2.5 % TOC, individual US EPA 16 PAH concentrations exceeded BAC values (OSPAR, 2014) for naphthalene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene and benzo(a)pyrene at all stations and benzo(ghi)perylene at one station (Appendix E.3).

Table 5.1: Summary of Sediment Hydrocarbon Analysis, Havhingsten Cable Route, Ireland

Station	KP*	THC	UCM	n-alkanes (nC_{12-36})	Total 2-6 Ring PAH	Total US EPA 16 PAH
LS_ST01	1.120	12.6	9.2	0.76	0.650	0.328
LS_ST02	2.940	5.6	3.9	0.31	0.192	0.073
LS_ST03	8.500	6.6	4.4	0.41	0.253	0.088
LS_ST04	11.960	3.9	2.5	0.23	0.171	0.060
LS_ST05	20.570	4.3	2.7	0.28	0.326	0.142
CC05_ST01	55.220	4.1	2.5	0.28	0.262	0.093
Minimum		**3.9**	**2.5**	**0.23**	**0.171**	**0.061**
Maximum		**12.6**	**9.2**	**0.76**	**0.650**	**0.328**
Mean		**6.2**	**4.2**	**0.38**	**0.309**	**0.130**
Standard Deviation		**3.31**	**2.58**	**0.196**	**0.176**	**0.100**
RSD [%]		**54**	**61**	**52**	**57**	**77**
CEMP Assessment Criteria (OSPAR, 2014)						
ERL		**-**	-	-	**4.10**	-

Notes:
THC = Total hydrocarbon content
UCM = Unresolved complex mixture
Total 2 to 6 ring PAH = Total 2 to 6 ring polycyclic aromatic hydrocarbons (PAH), including alkyl homologues
Total US EPA16 PAH = Total United States Environmental Protection Agency's 16 (US EPA 16 PAH) priority polycyclic aromatic hydrocarbons (PAHs)
RSD = Relative standard deviation
Concentrations expressed as µg/g of dry sediment
KP = Kilometre point
ERL = Effects range low (CEMP assessment criteria; OSPAR, 2014)
CEMP = Coordinated Environmental Monitoring Programme
* = Approximate KP from landfall at Loughshinny (segment 1.1)

5.3 Sediment Metals

Sediments collected from the Irish section of the Havhingsten cable route were analysed for selected elements: aluminium, arsenic, cadmium, chromium, copper, lead, mercury, nickel, and tin by ICP-OES and ICP-MS.

Table 5.2 summarises the concentrations of the extractable metals in the sediment samples from an aqua regia digest, which are compared to OSPAR (2014) ERL values. Appendix E.6 presents aluminium-normalised metals concentrations for comparison to OSPAR (2009; 2014) BC and BAC criteria.

The concentrations of aqua regia extractable metals did not exceed their respective ERL values at any station. Variability across the survey area ranged from low to moderate (≤ 47 %), with the highest variability observed for aluminium.

Arsenic concentrations ranged from 5.23 µg/g at station LS_ST04 to 6.82 µg/g at station LS_ST05, with a mean of 6.00 µg/g and low variability (RSD 10 %).

Cadmium concentrations were below the MRV at all stations.

Concentrations of chromium displayed moderate variability (RSD 43 %), ranging from 4.13 µg/g at station LS_ST01 to 30.6 µg/g at station LS_ST05, with a mean of 20.0 µg/g.

Concentrations of copper displayed moderate variability (RSD 43 %), ranging from below the MRV (2 µg/g) at station LS_ST01 to 7.42 µg/g at station LS_ST05, with a mean of 5.08 µg/g.

Concentrations of mercury displayed moderate variability (RSD 41 %), ranging from below the MRV (0.01 µg/g) at station LS_ST01 to 0.0245 µg/g at station LS_ST05, with a mean of 0.0168 µg/g.

Nickel concentrations displayed moderate variability (RSD 42 %), with concentrations ranging from 2.65 µg/g at station LS_ST01 to 15.5 µg/g at station LS_ST05, with a mean of 10.2 µg/g.

Concentrations of lead ranged from 5.69 µg/g at station LS_ST01 to 15.1 µg/g at station LS_ST05, with a mean of 11.8 µg/g and low variability (RSD 28 %).

Concentrations of tin ranged from below the MRV (1 µg/g) at five stations to 1.00 µg/g at station LS_ST05.

In general, the highest metal concentrations were found at station LS_ST05 and the lowest at station LS_ST01.

The sediment metals results were also normalised to 5 % aluminium values (Appendix E.4) and compared to OSPAR BAC values (OSPAR, 2014). BAC values were exceeded for chromium, nickel and lead at all stations and mercury and arsenic at two stations.

Table 5.2: Summary of Sediment Metals Analysis, Havhingsten Cable Route, Ireland

Station	KP*	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Sn
LS_ST01	1.120	1880	6.23	< 0.08	4.13	< 2	< 0.01	2.65	5.69	< 1
LS_ST02	2.940	11100	5.35	< 0.2	21.2	5.37	0.0199	10.1	12.4	< 1
LS_ST03	8.500	12200	6.11	< 0.2	22.5	5.22	0.0132	11.8	13.6	< 1
LS_ST04	11.960	10600	5.23	< 0.2	19.0	5.16	0.0175	9.69	11.3	< 1
LS_ST05	20.570	17900	6.82	< 0.2	30.6	7.42	0.0245	15.5	15.1	1.00
CC05_ST01	55.220	12400	6.23	< 0.2	22.0	6.31	0.0209	11.2	13.2	< 1
Minimum		**1880**	**5.23**	**-**	**4.13**	**< 2**	**< 0.01**	**2.65**	**5.69**	**< 1**
Maximum		**17900**	**6.82**	**-**	**30.6**	**7.42**	**0.0245**	**15.5**	**15.1**	**1.00**
Mean		**11000**	**6.00**	**-**	**20.0**	**5.08**	**0.0168**	**10.2**	**11.8**	**-**
Standard Deviation		**5180**	**0.601**	**-**	**8.68**	**2.18**	**0.00690**	**4.22**	**3.28**	**-**
RSD [%]		**47**	**10**	**-**	**43**	**43**	**41**	**42**	**28**	**-**
OSPAR CEMP 2013 (OSPAR, 2014)										
ERL	**-**	**-**	**-**	**1.20**	**81.0**	**34.0**	**0.150**	**-**	**47.0**	**-**

Notes:
Concentrations expressed in µg/g dry sediment
Al = Aluminium; As = Arsenic; Cd = Cadmium; Cr = Chromium; Cu = Copper; Hg = Mercury
Ni = Nickel; Pb = Lead; Sn = Tin
KP = Kilometre Point
ERL = Effects Range Low
RSD = Relative standard deviation
Where results were less than the minimum reporting value (MRV), summary statistics were calculated by assigning absolute values generated by MRV/2
* = Approximate KP from landfall at Loughshinny (segment 1.1)

Key:	Below ERL	Above ERL

6. SEDIMENT MACROFAUNA

6.1 Introduction

This section presents the results of the macrofaunal analysis of samples collected across the survey area. A total of six stations were sampled for macrofaunal content using a 0.1 m^2 dual van Veen grab. Appendix B provides full details of the analytical techniques employed.

The sediment macrofauna is defined as those animals living in or on the seabed that are retained on a sieve mesh of 1.0 mm. Before any analysis was undertaken, the reported macrofaunal dataset underwent rationalisation to prevent spurious enhancement of community statistics and allow comparison to historical datasets. Analysis was completed with juveniles removed from the dataset as juveniles are not considered part of the permanent community. Protists and any phyla considered meiofaunal or pelagic were also removed for this reason. Colonial epifauna (e.g. hydroids and bryozoans) and macroalgae could not be enumerated from the analysis so were also excluded from statistical analyses. Appendix F lists the records excluded from the analysis.

In order to focus the analysis of macrofaunal data on characterisation of the biotopes present along the surveyed route an initial multivariate analysis was undertaken to statistically define the different communities present (Section 6.2.1). The phyletic composition of these communities was then calculated (Section 6.2.2), characterising taxa identified (Section 6.2.3) and community structure quantified using a range of community statistics (Section 6.2.4). The results of the macrofaunal analysis are presented in the form of figures and tables, with the main features of the communities highlighted in the text. Appendix F presents the full list of taxa identified and the number enumerated (individuals per 0.1 m^2) from the surveyed route.

6.2 Results

6.2.1 Investigation of Faunal Similarities

Univariate statistics (Section 6.2.4) can summarise large and complex datasets to a certain extent, however, multivariate techniques will condense a large data matrix to a much more manageable form and compare each variable with all others in the process (Appendix B.3). In doing so, subtle trends in the data may be elucidated.

Various multivariable techniques were applied to the survey area data to investigate such patterns of similarity within the macrobenthic community, which were then further considered with the results from the univariate analyses.

Figures 6.1 and 6.2 present the multivariate statistical analyses of the community: hierarchical agglomerative clustering (CLUSTER) and non-metric multidimensional scaling (nMDS) from PRIMER.

6.2.1.1 Cluster Analysis

CLUSTER analysis groups stations according to their faunal similarity and the results are presented in the form of a dendrogram. Figure 6.1 presents the CLUSTER analysis dendrogram and demonstrates the pattern of similarity of square root transformed station data. The SIMPROF algorithm was used to identify statistically significant ($P = 0.05$) differences between stations, with significant splits depicted as black lines and non-significant splits as red lines.

The intra-station similarities along the proposed route ranged between 0.0 % and 58.0 %, indicative of a moderate to very high degree of variability within the macrofaunal communities. The dendrogram indicates that there were two statistically significant clusters and one ungrouped station:

- Cluster A, comprised three of the six stations, specifically stations LS_ST02, LS_ST03 and LS_ST04, grouped together with at least 53.6 % similarity to each other. These stations were located between KP 2.940 and KP 11.960 in water depths of 17 m BSL to 41 m BSL;
- Cluster B comprised stations LS_ST05 and CC05_ST01, which were 25.4 % similar to each other and shared a group average similarity of 21.0 % with cluster A. Stations LS_ST05 and CC05_ST01 were the furthest offshore of the stations sampled (located at KP 20.570 and KP 55.220, respectively) in water depths of 66 m BSL and 81 m BSL, respectively;
- Ungrouped station LS_ST01 was 10.6 % similar to all other stations. This station was located at the nearshore end of the proposed route (KP 1.120) in a water depth of 9 m BSL.

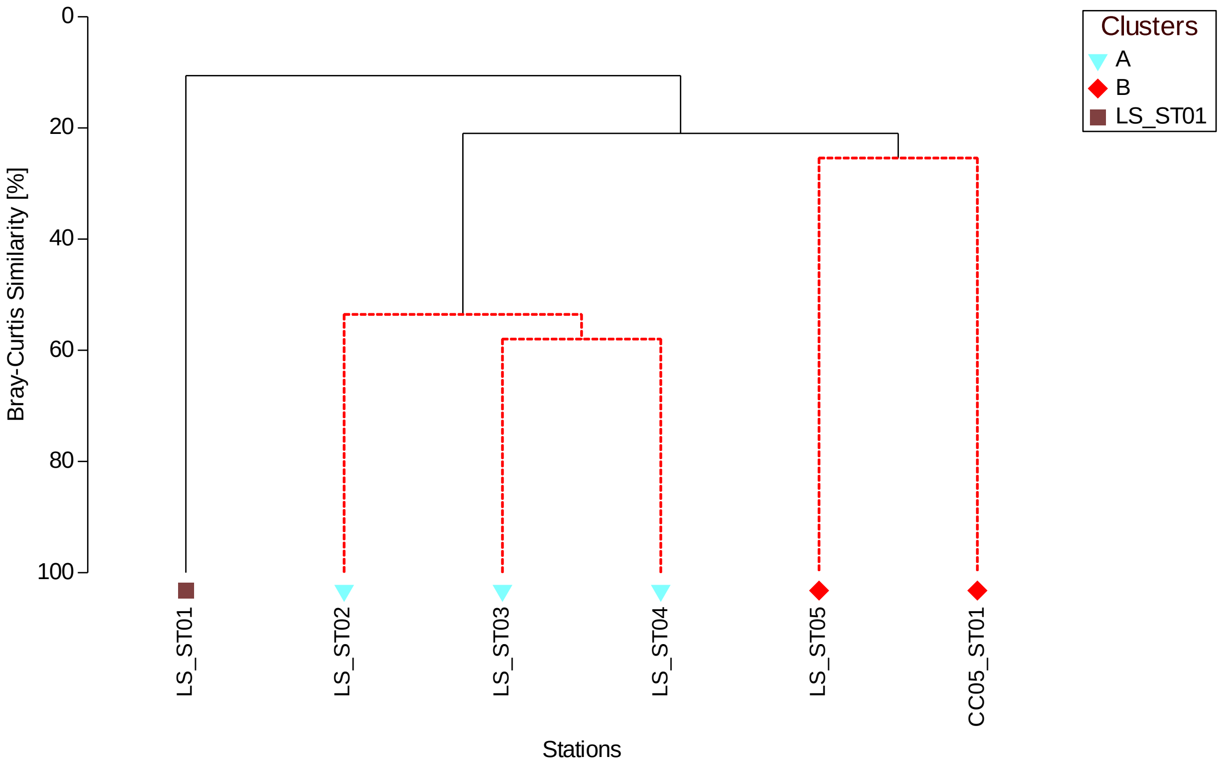


Figure 6.1: Classification by Bray-Curtis similarity for square root transformed macrofaunal abundance station (0.1 m^2) data, Havhingsten cable route, Ireland

6.2.1.2 Non-metric Multidimensional Scaling (nMDS)

Figure 6.2 displays the results of the nMDS, which is an ordination technique that arranges stations on a two-dimensional plot, so that their relative distances from each other reflect their faunal similarities. The stress coefficient of 0 indicates an excellent ordination of the intra-station similarities within the dataset, with little chance of misinterpretation (Clarke and Warwick, 2001). This plot clearly shows the moderate level of similarity between the cluster A stations, the loose association between the cluster B stations and the fact that the ungrouped station LS_ST01 is clearly different from the two clusters.

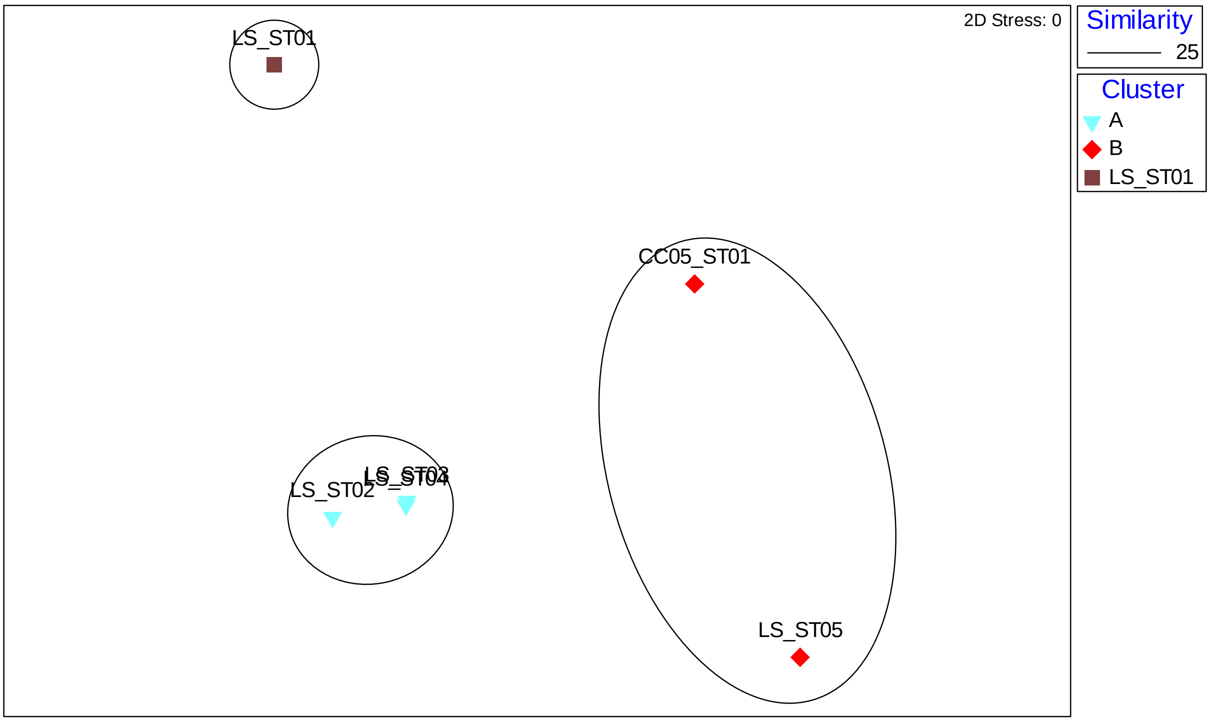


Figure 6.2: Non-metric multidimensional scaling (nMDS) orientation by Bray-Curtis for square root transformed macrofaunal abundance station (0.1 m^2) data, Havhingsten cable route, Ireland

6.2.2 Phyletic Composition

Table 6.1 summarises the abundance of taxonomic groups identified across the survey area and Figures 6.3 and 6.4 display the data graphically. The phyletic composition for each of the clusters identified has been calculated (the mean phyletic composition of the clusters' constituent stations) and this is contrasted with the phyletic composition of the entire dataset.

Over all of the stations sampled within the Irish section of the Havhingsten cable route, a total of 130 taxa and 960 individuals were identified. Of these taxa, 34 were representative of protozoan, meiofaunal, pelagic or juvenile specimens or of colonial epifauna or algae; to avoid spurious enhancement of diversity indices, the dataset was rationalised, and these taxa removed, prior to statistical analysis (Appendix F). The rationalised data comprised 96 benthic taxa, of which 47 (49.0 %) were annelids, 28 (29.2 %) were molluscs, 10 (10.4 %) were arthropods, 4 (4.2 %) were echinoderms and 7 (7.3 %) were representative of other phyla. A total of 877 individual animals were identified in the rationalised data, of which 347(39.6 %) were molluscs, 226 (25.8 %) were echinoderms, 217 (24.7 % were annelids 14 (1.6 %) were arthropods and 73 (8.3 %) belonged to other phyla (Table 6.1).

Although annelids contributed the highest number of taxa within Cluster A (mean of 16 taxa (43.5 %) across its three constituent stations) the Mollusca and Echinodermata contributed the highest abundance of individuals. Across the three stations sampled the Mollusca contributed a mean of 12 taxa per station (32.4 %), with mean abundance of 78 individuals per station (34.6 %). The Echinodermata contributed a mean number of taxa of only 2 per station (6.5 %), with a mean abundance of 75 individuals per station (33.3 %). Representatives of other phyla contributed a mean abundance of 21 individuals (9.3 %) of 4 taxa (10.2 %) per station and arthropods were poorly represented within the community, contributing a mean abundance of 2 individuals (2.7 %) of 2 taxa (5.4 %) per station.

Within cluster B, the Annelida again contributed the highest number of taxa (mean of 16 taxa; 43.5 %), but in contrast to cluster A, also comprised a significant proportion of the total abundance (mean of 49 individuals; 42.0 %). Despite this, the Mollusca were again the most abundant phylum overall, with a mean of 36 individuals (48.0 %) of 8 taxa recorded from the Cluster B stations. Arthropods, echinoderms and other phyla made up relatively small proportions of the cluster B community, with mean contributions of 3 or fewer taxa and 5 or fewer individuals.

Molluscs were numerically-dominant at the ungrouped station LS_ST01 contributing 41 individuals (80.4 %) and 4 taxa (36.4 %). Annelids contributed 8 individuals (15.7 %) of 6 taxa (54.5 %) and arthropods 2 individuals (3.9 %) of 1 taxon (9.1 %). Echinoderms and representatives of other phyla were absent from station LS_ST01.

Table 6.1: Taxonomic Groups, Havhingsten Cable Route, Ireland

Taxonomic Group	Number of Taxa	Composition of Taxa [%]	Abundance	Composition of Abundance [%]
Overall				
Annelida	47	49.0	217	24.7
Arthropoda	10	10.4	14	1.6
Mollusca	28	29.2	347	39.6
Echinodermata	4	4.2	226	25.8
Other Phyla	7	7.3	73	8.3
Total	**96**	**100**	**877**	**100**
Cluster A (Stations LS_ST02, LS_ST03 and LS_ST04)				
Annelida	16	43.5	49	21.6
Arthropoda	3	7.4	3	1.2
Mollusca	12	32.4	78	34.6
Echinodermata	2	6.5	75	33.3
Other Phyla	4	10.2	21	9.3
Total	**36**	**100**	**225**	**100**
Cluster B (Stations LS_ST05 and CC05_ST01)				
Annelida	16	55.4	32	42.0
Arthropoda	2	5.4	2	2.7
Mollusca	8	26.8	36	48.0
Echinodermata	1	1.8	1	0.7
Other Phyla	3	10.7	5	6.7
Total	**28**	**100**	**75**	**100**
Ungrouped Station LS_ST01				
Annelida	6	54.5	8	15.7
Arthropoda	1	9.1	2	3.9
Mollusca	4	36.4	41	80.4
Total	**11**	**100**	**51**	**100**

Notes:
Other phyla include: Cnidaria, Turbellaria, Nemertea, Sipuncula and Phoronida
Macrofaunal sample were processed through a 1.0 mm sieve

Figures 6.3 and 6.4 illustrate the phyletic composition of taxa and individuals for each cluster (per 0.1 m^2). Figure 6.3 shows the broadly similar contribution to the number of taxa made by annelids, arthropods and molluscs in the two clusters and at the ungrouped station and the broadly similar mean proportions of echinoderm taxa and taxa from other phyla within clusters A and B. Figure 6.4 clearly illustrates the differences in the phyletic composition of abundance between the clusters and ungrouped station. The numerical dominance of echinoderms in cluster A, which comprised half of the stations sampled, leads to these contributing the second highest proportion of the total abundance recorded along the surveyed route. The dominance, or codominance, of molluscs in both clusters and at the ungrouped station LS_ST01 is also clearly apparent, with this leading to these making the greatest contribution to the total abundance sampled along the route.

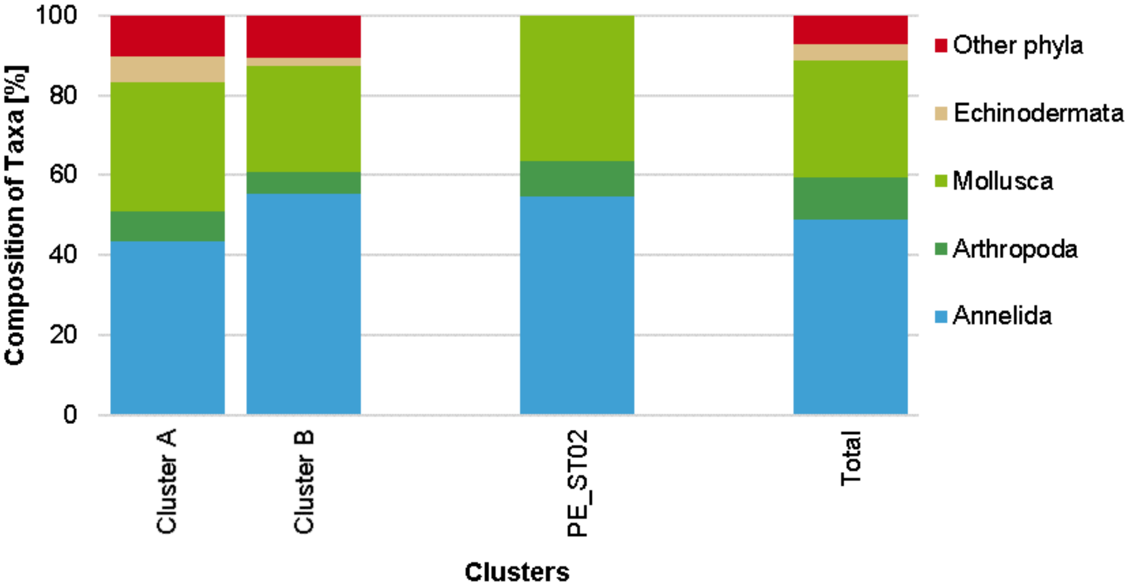


Figure 6.3: Phyletic composition of taxa, Havhingsten cable route, Ireland

Figure 6.4: Phyletic composition of abundance, Havhingsten cable route, Ireland

6.2.3 Characteristic Taxa

Table 6.2 presents the dominant taxa within the Irish section of the Havhingsten cable route overall and within each of the macrofaunal clusters identified. The top ten most abundant taxa over the overall area are presented and the top five taxa within each cluster.

Members of several phyla were represented within the top ten most abundant taxa within the overall community of the Irish section of the Havhingsten cable route. The most abundant taxon was the brittlestar (echinoderm) *Amphiura filiformis*, which occurred at a mean abundance of 36 individuals per station and was recorded from half of the stations sampled. The bivalve mollusc *Kurtiella bidentata* and polychaete *Diplocirrus glaucus* both occurred at four stations (66.7 % frequency of occurrence) and were recorded at mean abundances of 23 and 10 individuals per station, respectively. The remaining dominant taxa all occurred at mean abundances of 7 or fewer individuals per station and comprised the horseshoe worm (phoronid) *Phoronis* sp., four bivalve molluscs (*Nucula nitidosa*, Abra alba, *Corbula gibba* and *Thyasira flexuosa*) and two polychaetes (*Pholoe baltica* and *Galathowenia oculata*).

The top five taxa of cluster A were the same as those of the survey area overall (Table 6.2); this was due to the fact that this cluster comprised three of the six stations sampled and represented the richest infaunal community (Section 6.2.4). All of the top five taxa were recorded from all of its constituent stations (100 % frequency of occurrence) and there were 7 other taxa within this cluster that also occurred at all stations (Appendix F). The most abundant taxon within the cluster, *A. filiformis*, occurred at mean abundance of 72 individuals per station, followed by *K. bidentata* (45 individuals per station), *D. glaucus* (19 individuals per station), *Phoronis* sp. (14 individuals per station) and *N. nitidosa* (10 individuals per station).

The cluster B community had a noticeably lower abundance of fauna than cluster A (Section 6.2.4) and its dominant taxa were distinctly different from that of cluster A and the survey area overall. The cluster comprised two stations and its top five taxa were clearly not evenly distributed, with most of those listed only occurring at one of the two stations (frequency of occurrence of 50.0 %). The most abundant taxon in this cluster was the bivalve *Thyasira flexuosa*, which occurred at a mean abundance of 8 individuals per station. The second and third most abundant taxa were also bivalve molluscs, with *Abra nitida* occurring at a mean abundance of 7 individuals per station and *N. nitidosa* at a mean abundance of 5 individuals per station. The remaining taxa comprised two additional bivalves (*Ennucula tenuis* and *Abra alba*) and two polychaetes (*Notomastus* sp. and *Mediomastus fragilis*).

The ungrouped station LS_ST01 was dominated by *A. alba*, which occurred at an abundance of 34 individuals. The remaining top five taxa occurred at relatively low abundances of between 2 and 4 individuals and comprised the bivalves *N. nitidosa* and *K. bidentata*, the polychaete *Nephtys hombergii* and the amphipod crustacean *Ampelisca brevicornis*. Only six other taxa were recorded from this station and all occurred at abundances of 1 individual (Appendix F).

Table 6.2: Dominant Taxa by Rank Abundance and Frequency, Havhingsten Cable Route, Ireland

Taxon	Rank Abundance	Mean Station Abundance [0.1 m^2]	Frequency* [%]
Overall			
Amphiura filiformis	1	36	50.0
Kurtiella bidentata	2	23	66.7
Diplocirrus glaucus	3	10	66.7
Phoronis sp.	4	7	66.7
Nucula nitidosa	5	7	83.3
Abra alba	6	7	50.0
Corbula gibba	7	5	66.7
Pholoe baltica (sensu Petersen)	8	4	66.7
Thyasira flexuosa	8	4	66.7
Galathowenia oculata	10	3	83.3
Cluster A (Stations LS_ST02, LS_ST03 and LS_ST04)			
Amphiura filiformis	1	72	100
Kurtiella bidentata	2	45	100
Diplocirrus glaucus	3	19	100
Phoronis sp.	4	14	100
Nucula nitidosa	5	10	100
Cluster B (Stations LS_ST05 and CC05_ST01)			
Thyasira flexuosa	1	8	50.0
Abra nitida	2	7	100
Nucula nitidosa	3	5	50.0
Notomastus sp.	4	4	100
Mediomastus fragilis	5	4	50.0
Ennucula tenuis	5	4	50.0
Abra alba	5	4	50.0
Ungrouped Station LS_ST01			
Abra alba	1	34	-
Nucula nitidosa	2	4	-
Nephtys hombergii	3	3	-
Ampelisca brevicornis	4	2	-
Kurtiella bidentata	5	2	-

Notes:
* = Percentage of the stations from which the taxa were recorded

6.2.4 Community Statistics

Table 6.3 presents the number of taxa and individuals identified from each station along with several commonly used diversity and evenness indices. Summary statistics (minima, maxima, means, standard deviations and RSD) are presented for the Irish section of the Havhingsten cable route as a whole and for each of the macrofaunal clusters differentiated by the multivariate analysis.

Across the Irish section of the Havhingsten cable route as a whole the number of taxa per 0.1 m^2 ranged from 11 (station LS_ST01) to 40 (station SG_ST09), with a mean of 29. The number of individuals per 0.1 m^2 ranged from 24 (station LS_ST05) to 326 (station LS_ST02), with a mean of 146 across the survey area. There was moderate variability in the number of taxa (RSD 43 %) and high variability in the number of individuals (RDS 77 %) along the route.

Across the route as whole mean diversity could be considered good, when based on the mean Shannon-Wiener diversity index (H'Log$_2$) calculated for all stations (3.57) and referenced to the five ecological statuses outlined in Dauvin et al. (2012), classified as: bad if 0.00 to 1.00, poor if 1.00 to 2.00, moderate if 2.00 to 3.00, good if 3.00 to 4.00 and high if ≥ 4.00. Values of the Shannon-Wiener index ranged between 1.13 (station LS_ST01) and 4.75 (station CC05_ST01) and showed strong association with the Brillouin index of diversity which ranged from 1.13 to 2.89 (at the same stations). The variability of diversity across the survey area was moderate (RSD 27 % and 28 % for the two measures used).

The Pielou's index of evenness ranged between 0.564 (station LS_ST01) and 0.943 (station LS_ST05), with a mean of 0.754 across the survey area, and showed low variability across the survey area (RSD 21 %). The high Pielou's index value at station LS_ST05 was associated with the low numbers of taxa and individuals at this station, which resulted in an equitable spread of the faunal abundance across the taxa present, whereas the low value at station LS_ST01 was associated with numerical dominance of *A. alba* (abundance of 34 individuals) in a community which contained only 11 taxa. The Simpson's index of evenness (expressed as $1 - \lambda$, i.e. the complement of dominance), ranged from 0.551 (station LS_ST01) to 0.957 (station CC05_ST01), with a mean of 0.836.

The variability within the number of taxa and diversity and evenness statistics calculated for cluster A was low (RSD ≤15 %), but variability in abundance was moderate (RSD 44 %). Of the clusters identified cluster A had the highest number of taxa (mean of 36 taxa) and highest abundance (mean of 225 individuals). It's mean diversity (mean Shannon-Wiener diversity of 3.65) was good (Dauvin et al., 2012) and evenness moderate (mean Pielou's evenness of 0.707 and Simpson's index of 0.852). Due to the numerical dominance of characteristic taxa such as *A. filiformis* (mean of 72 individuals per station) and *K. bidentata* (mean of 45 individuals per station) the diversity and evenness within cluster A were however, lower than recorded from cluster B.

Within cluster B the number of taxa (16 to 40 taxa) and abundance (24 to 126 individuals) were highly variable (RSD 61 % and 96 %, respectively), however derived measures of diversity and evenness showed low to moderate variability (RSD 0 % to 27 %). The equitable distribution of abundance across the taxa present at its two constituent stations resulted in this cluster having high mean diversity (mean Shannon-Wiener diversity of 4.26) and evenness (mean Pielou's evenness of 0.917 and Simpson's index of 0.955).

The ungrouped station LS_ST01 had the lowest number of taxa (11 taxa) of all stations sampled and second lowest abundance (51 individuals). The aforementioned dominance of *A. alba* at this station resulted in the minima of all derived diversity and evenness indices being calculated for this station.

Table 6.3: Macrofaunal Community Statistics (0.1 m^2), Havhingsten Cable Route, Ireland

Station	Numbers		Diversity Indices		Evenness	
	Taxa [S]	Individuals [N]	Shannon-Wiener [H'Log$_2$]	Brillouin [Hb]	Pielou [J]	Simpson [1-λ]
LS_ST01	11	51	1.95	1.13	0.564	0.551
LS_ST02	35	326	3.19	2.07	0.622	0.796
LS_ST03	40	222	3.57	2.26	0.672	0.842
LS_ST04	33	128	4.18	2.57	0.828	0.918
LS_ST05	16	24	3.77	1.97	0.943	0.953
CC05_ST01	40	126	4.75	2.89	0.892	0.957
Overall						
Minimum	**11**	**24**	**1.95**	**1.13**	**0.564**	**0.551**
Maximum	**40**	**326**	**4.75**	**2.89**	**0.943**	**0.957**
Mean	**29**	**146**	**3.57**	**2.15**	**0.754**	**0.836**
Standard Deviation	**13**	**112**	**0.95**	**0.60**	**0.155**	**0.153**
RSD [%]	**43**	**77**	**27**	**28**	**21**	**18**
Cluster A (Stations LS_ST02, LS_ST03 and LS_ST04)						
Minimum	**33**	**128**	**3.19**	**2.07**	**0.622**	**0.796**
Maximum	**40**	**326**	**4.18**	**2.57**	**0.828**	**0.918**
Mean	**36**	**225**	**3.65**	**2.30**	**0.707**	**0.852**
Standard Deviation	**4**	**99**	**0.50**	**0.25**	**0.108**	**0.062**
RSD [%]	**10**	**44**	**14**	**11**	**15**	**7**
Cluster B (Stations LS_ST05 and CC05_ST01)						
Minimum	**16**	**24**	**3.77**	**1.97**	**0.892**	**0.953**
Maximum	**40**	**126**	**4.75**	**2.89**	**0.943**	**0.957**
Mean	**28**	**75**	**4.26**	**2.43**	**0.917**	**0.955**
Standard Deviation	**17**	**72**	**0.69**	**0.65**	**0.036**	**0.003**
RSD [%]	**61**	**96**	**16**	**27**	**4**	**0**

Notes:
RSD = Relative standard deviation

7. BENTHIC HABITATS AND BIOTOPES

7.1 Introduction

To assess the habitats and biotopes present within the survey area, detailed analysis of video and stills photography data were undertaken by experienced Fugro marine biologists/taxonomists. Video photography data were reviewed in conjunction with the still photographs, noting the locations of any observed changes in sediment type and/or associated faunal community.

Appendix C.3 provides the detailed video and photographic log. Appendix G provides example seabed photographs.

Seabed substrata were logged based on the seabed video/photographic data. For the purpose of habitat classification, descriptions are based on the BGS modified Folk classification (Long, 2006), which uses the descriptive terms ‘mud’, ‘sand’ and ‘gravel’ in combination, depending on the estimated proportions of each component. For example, a description of ‘muddy sand’ defines sediment that has sand as the principle component and a mud proportion of between > 10 % and < 50 % Further descriptive terms have been used to better describe the observations where necessary, such as ‘shell fragments’. Any anthropogenic features evident were also recorded.

Seabed substrata observations were then linked to the particle size data (Section 4.2) to provide further detail regarding the composition of sediment areas. The PSD analysis categorised sediment granulometry into ‘gravel’, ‘sand’ and ‘fines’ fractions, with fines referred to as mud within this section of the report.

Epifaunal communities were described from the video/photographic data and the macrofaunal data (Section 6.2.4) were utilised to provide detailed information regarding infaunal community structure.

7.1.1 Seabed Habitats Classification

Habitats within the survey area have been classified in accordance with the hierarchical EUNIS habitat classification (EUNIS, 2012), which has compiled habitat information from across Europe into a single database. The equivalent classification from ‘The Marine Habitat Classification for Britain and Ireland – Version 15.03’ (JNCC, 2015) was also noted, along with the classification from ‘A Guide to Habitats in Ireland’ (Fossitt, 2000).

Although, theoretically, a biotope can be assigned to any sized area of seabed, for the purposes of this assessment the commonly accepted minimum habitat size of 25 m^2 (JNCC, 2015) was adopted.

7.1.2 Sensitive Habitats and Species Assessments

Section 1.4 details the sensitive habitats and species for which protected areas have been designated within 25 km of the Irish section of the Havhingsten cable route (summarised in Table 1.1). All data (video/photographic and grab sample data) were reviewed in detail to assess the potential presence of these habitats and species.

To better assess key habitats of concern, assessment protocols have been developed by regulatory bodies. Sections 7.1.2.1 to 7.1.2.2 detail the sensitive habitat assessments utilised in this report.

7.1.2.1 Sea Pens and Burrowing Megafauna Communities

Following an initial assessment of the seabed video and photographs, a full assessment would be performed if faunal burrows were present. To assess the abundance and density of sea pens and burrowing megafauna, the numbers of each species and burrows visible in each video transect would be counted. The total area of view along the video was calculated and used to convert the number of sea pens and burrows to the SACFOR (Super-abundant, Abundant, Common, Frequent, Occasional, Rare) semi-quantitative abundance scale used by Marine Nature Conservation Review and JNCC to record the abundance and density of marine benthic flora and fauna (JNCC, 2017b). When assessing density, the SACFOR scale considers the size of the species being assessed, using size classes to group species, although the guidance provided in Connor et al. (2004) suggests the species take precedence over their actual size in deciding which scale to use. The slender sea pen (*V. mirabilis*) and the phosphorescent sea pen (*P. phosphorea*) were classed as 3 cm to 15 cm (Greathead et al., 2011; Allan et al., 2012, Connor et al., 2004), whilst the tall sea pen (*F. quadrangularis*) was classed as > 15 cm (Connor et al., 2004). The Norway lobster (*N. norvegicus*) has also been listed as > 15 cm in Connor et al. (2004), however, megafauna responsible for creating burrows may also include the mud shrimps *C. subterranea* and *C. macandreae* (JNCC, 2014a). Both of which are described as burrowers sized between 3 cm and 10 cm (MarLIN, 2015a; 2015b). Due to the difficulties of identifying species from burrow type, the size class of 3 cm to 15 cm was used to allow for the size variation of possible species responsible for creating the burrows. Using the visible laser scale, the calculated average width of view along the video transects was approximately 2 m. Table 7.1 summarises the size classes applied to each species and the SACFOR scale conversion used.

Table 7.1: The SACFOR Scale used for Sea Pen and Burrow Density Assessment

SACFOR Scale	Individuals per m²			
	3 cm to 15 cm*		> 15 cm†	
Super-abundant	100.0 – 1000.0	1–9/0.01 m² (10 × 10 cm)	10.0 – 99.0	1–9/0.1 m²
Abundant	10.0 – 99.0	1–9/0.1 m²	1.0 – 9.0	1–9/m²
Common	1.0 – 9.0	1–9/ m²	0.1 – 0.99	1–9/10 m² (3.16 × 3.16 m)
Frequent	0.1 – 1.0	1–9/10 m² (3.16 × 3.16 m)	0.01 – 0.09	1–9/100 m² (10 × 10 m)
Occasional	0.01 – 0.09	1–9/100 m² (10 × 10 m)	0.001 – 0.009	1–9/1000 m² (31.6 × 31.6 m)
Rare	0.001 – 0.009	1–9/1000 m² (31.6 × 31.6 m)	0.0001 – 0.0009	< 1/1000 m²

Notes:
SACFOR = Super-abundant, Abundant, Common, Frequent, Occasional, Rare
* = 3 cm to 15 cm: *Pennatula phosphorea*, *Virgularia mirabilis*, megafaunal burrows
† = > 15 cm: *Funiculina quadrangularis*

To confirm this habitat type, sightings of burrows and/or mounds must be present as at least ‘frequent’ abundance on the SACFOR scale (JNCC, 2014).

7.1.2.2 Annex I Geogenic Reef – Stony Reef

When considering the potential of an area as geogenic reef, the composition of the substrate is an important characteristic. Stony reef is defined as comprising coarse sediments with a diameter greater than 64 mm (cobbles and boulders) that provide a hard substratum. The relationship between the coarse material and sediment in which it lies is integral in determining 'reefiness'. Matrix (soft sediment) supported material is likely to have a patchier distribution than clast (coarse sediment) supported and so have lower 'reefiness', additionally matrix supported material is likely to have a larger infaunal component which again reduces its 'reefiness' (Irving, 2009). Reefs are also defined as having relief from the seafloor, and as such relief is used as another criterion for assessment. The epifaunal community of potential reef habitat is also a key determinant of its 'reefiness'; therefore percentage cover of fauna is included as an assessment criterion. Within the Irving (2009) scheme, areas of potential stony reef habitat must have an area of greater than 25 m^2 to be classified as reef; this report also adopts this minimum area. Table 7.2 summarise these criteria. During the video interpretation, habitat transitions (i.e. changes in sediment type and/or bedform) were logged.

Table 7.2: Measures of 'Reefiness' of the Stony Reef Habitat

'Reefiness'*				
Characteristic	**Not a Reef**	**Low**	**Medium**	**High**
Cover of cobbles and boulders	< 10 %	10 % – 40 %	> 40 % – 95 %	> 95 %
Elevation above seabed	Flat seabed	< 64 mm	64 mm – 5 m	> 5 m
Cover of visible epifauna	Predominately infaunal species	NA		> 80 %
Colour Coding:				

Notes:
* = 'Reefiness' criteria proposed by JNCC (Irving, 2009)
† = Diameter > 64 mm

7.2 Results

7.2.1 Benthic Habitat and Biotope Classification

Statistical analysis of the infaunal data from grab sample stations undertaken during the survey indicated two statistically significant clusters of stations and one ungrouped station (Table 7.3).

Table 7.3: Summary of Macrofaunal Community CLUSTER Analysis Groupings, Havhingsten Cable Route, Ireland

Cluster A	Cluster B	Ungrouped Station
LS_ST02 LS_ST03 LS_ST04	LS_ST05 CC05_ST01	LS_ST01

The PSD and macrofaunal analysis results, together with the video analysis results, have been used to allocate a biotope to each survey location. Soft sediment habitats are often defined on the sediment type and infaunal community composition. Therefore, soft sediments within the survey area have been predominantly classified using the PSD and macrofaunal data, with the video analysis results providing additional habitat information. Habitats comprising hard substrates, where grab sampling was not achieved, have been classified using video analysis data only.

Table 7.4 presents the habitat and biotope classification hierarchy for the Irish section of the Havhingsten cable route.

Table 7.4: Habitat Classification Hierarchy, Havhingsten Cable Route, Ireland

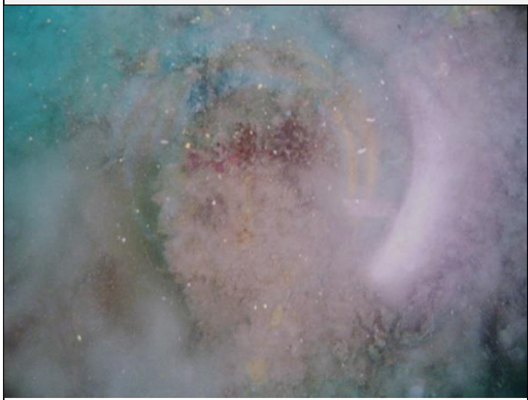
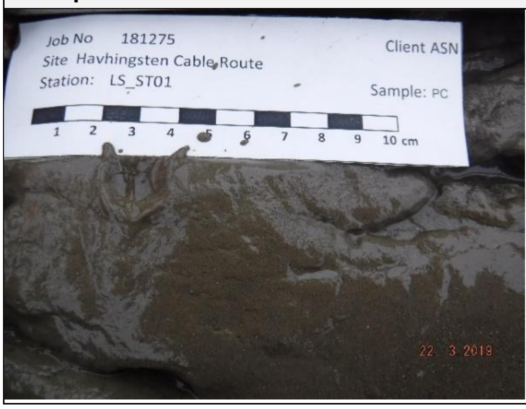
EUNIS (2012) Habitat Classification					**Equivalent JNCC Habitat Classification (JNCC, 2015)**	**Equivalent Irish Habitat Classification (Fossitt, 2000)**
Environment	**Broad Habitat**	**Habitat**	**Biotope Complex**	**Biotope**		
Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**		
A Marine habitats	A4 Circalittoral rock and other hard substrata	A4.2 Atlantic and Mediterranean moderate energy circalittoral rock	A4.21 Echinoderms and crustose communities on circalittoral rock	-	CR.MCR.EcCr Echinoderms and crustose communities on circalittoral rock	SR5 Moderately exposed circalittoral rock
	A5 Sublittoral sediment	A5.2 Sublittoral sand	A5.26 Circalittoral muddy sand	-	SS.SMu.CMuSa Circalittoral muddy sand	SS6 Circalittoral muddy sand
				A5.261 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	SS.SSa.CMuSa.AalbNuc *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	
		A5.3 Sublittoral mud	A5.35 Circalittoral sandy mud	A5.351 *Amphiura filiformis*, *Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud	SS.SMu.CSaMu.AfilMysAnit *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud	SS7 Circalittoral muds

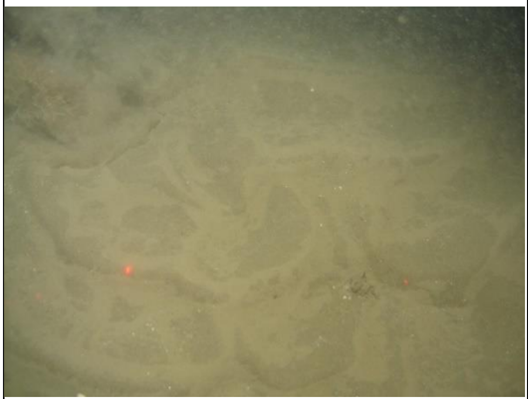
Notes:
EUNIS = European Nature Information Service
JNCC = Joint Nature Conservation Committee

7.2.2 Biotope Descriptions

Table 7.5 summarise the habitats and biotopes observed, including details of their distribution and physical and biological characteristics, along with example photographs. Biotopes assigned are relevant to the time of year, with this survey completed in winter. Sections 7.2.2.1 to 7.2.2.4 detailed descriptions of each biotope. Appendix G provides further example photographs. Figure 7.1 spatially presents the extrapolated distribution of the habitats defined along the Irish section of the Havhingsten cable route. Two biotope complexes and two biotopes were assigned to the stations surveyed.

Table 7.5: Summary of Benthic Biotope Characteristics, Havhingsten Cable Route, Ireland

Example Photograph	Distribution	Physical Characteristics	Dominant Taxa
Biotope A4.21: Echinoderms and crustose communities on circalittoral rock			
	**Stations:** - **Transects:** LS_ST01A **KP:** 1.120	**Sediment type:** Boulder/bedrock outcrops with sand **Water Depth:** Circalittoral 7 m to 8 m BSL	**Infauna:** - **Epibiota:** Starfish (*Asterias rubens*), Anemones (including *Metridium* sp.) Red seaweed (including *Palmaria palmata*), Faunal turf (Hydrozoa/ Bryozoa) Tube worms (Serpulidae)
Biotope complex A5.26: Circalittoral muddy sand			
	**Stations:** LS_ST05, CC05_ST01 **Transects:** CC05_T01, CC05_T02 **KP:** 20.570 to 55.220	**Sediment type:** Muddy sand **Water Depth:** Circalittoral 66 m to 82 m BSL	**Infauna:** **Cluster B** Bivalves (*Abra nitida, Thyasira flexuosa, Nucula nitidosa*) Polychaetes (*Nephtys incisa, Notomastus* sp.) Worm (*Phoronis* sp.) **Epibiota:** Hermit crabs (Paguridae) Sea pen (*Virgularia mirabilis*) Norway lobster (*Nephrops norvegicus*) Cat shark (*Scyliorhinus canicula*) Worm tubes (Polychaeta)
Biotope A5.261: *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment			
	**Stations:** LS_ST01 **Transects:** LS_ST01A **KP:** 1.120	**Sediment type:** Muddy sand **Water Depth:** Circalittoral 8 m BSL	**Infauna:** **Ungrouped station LS_ST01** Bivalves (*Abra alba, Nucula nitidosa, Kurtiella bidentata*) Polychaetes (*Nephtys hombergii*) **Epibiota:** Hermit crab (Paguridae)

Example Photograph	Distribution	Physical Characteristics	Dominant Taxa
Biotope A5.351: *Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud			
	**Stations:** LS_ST02 LS_ST03 LS_ST04 **KP:** 2.940 to 11.960	**Sediment type:** Muddy sand or slightly gravelly muddy sand **Water Depth:** Circalittoral 17 m to 41 m BSL	**Infauna:** **Cluster A** Brittlestar (*Amphiura filiformis*) Bivalves (*K. bidentata,* *N. nitidosa,*) Polychaete (*Diplocirrus glaucus*) Horseshoe worm (*Phoronis* sp.) **Epibiota:** Hermit crab (Paguridae) Anemone (Actiniaria, including *Metridium* sp.) Brittlestar (Ophiuroidea) Fish (Gadidae)
Notes: KP = Kilometre point BSL = Below sea level * = Approximate KP from landfall at Loughshinny (segment 1.1)			

7.2.2.1 A4.21: Echinoderms and Crustose Communities on Circalittoral Rock

The 'Echinoderms and crustose communities' (A4.21) biotope complex is described as occurring on wave-exposed, moderately strong to weakly tide-swept, circalittoral bedrock and boulders. Echinoderms, faunal and algal crusts dominate this biotope complex, giving a sparse appearance (EUNIS, 2012).

This biotope complex was recorded along two short sections of transect LS_ST01A, with its distribution, as ground-truthed by seabed photography, clearly corresponding to SSS data that delineated bedrock outcrops and/or boulder fields extending from the headland to either side of Loughshinny Bay (Figure 7.1). The biotope complex was identified at approximately KP 1.120 in water depths of 7 m to 8 m BSL. Although such shallow depths would often be considered infralittoral (i.e. within the zone of light penetration, where algal communities dominate the epibiota), the minimal algal cover present suggested that the seabed received little light and should therefore be considered circalittoral. The high levels of turbidity evident during camera operations likely limit light penetration to the seabed communities.

Video and still photographic data from this biotope complex identified bedrock outcrops of various morphologies, ranging from steep sided to flat, with what appeared to be sediment isolated boulders. Many of the surfaces were covered with a thin layer of sediment (mud or muddy sand) and similar sediments were identified in low lying areas between the outcropping rocks/boulders.

Consistent with the EUNIS (2012) description of this biotope complex, faunal cover was sparse. The most prominent taxa were the plumose sea anemone *Metridium* sp., the starfish *Asterias rubens* and faunal turf, thought to comprise hydroids (Hydrozoa) and/or bryozoans (Bryozoa). Occasional polychaetes (Serpulidae) were recorded, along with a sponge (Porifera, possibly *Haliclona* sp.). The only macroalgae present were red seaweeds (Rhodophyceae), including *Palmaria palmata*; the presence of only red seaweeds is considered indicative of low light levels, as their distribution extends to greater depths than green or brown seaweed.

Although the rock community encountered during the survey could not be classified to biotope level, some of the constituent fauna do occur in the EUNIS biotope 'Cushion sponges and hydroids on turbid tide-swept sheltered circalittoral rock' (A4.251). However, application of this biotope was not considered appropriate, as the community encountered lacked the sponge taxa characteristic of the biotope.

Due to the presence of cobble and/or boulder substrata within this biotope complex, it has been assessed to determine its potential as the Annex I habitat 'Geogenic reef' (Section 7.1.2.2).

7.2.2.2 A5.26: Circalittoral Muddy Sand

The 'Circalittoral muddy sand' (A5.26) biotope complex characterises circalittoral non-cohesive muddy sands with the silt content of the substratum typically ranging from 5 % to 20 %. This habitat is generally found in water depths of over 15 m to 20 m and supports animal-dominated communities characterised by a wide variety of polychaetes, bivalves and echinoderms (EUNIS, 2012).

During the current survey, this biotope complex was recorded across the offshore sections of the proposed cable route, extending between stations LS_ST05 and CC05_ST01 (KP 20.570 to KP 55.220). Water depths at these stations ranged between 66 m and 81 m BSL. Sediments within this biotope complex were found to comprise muddy sand, with between 31.6 % and 43.0 % mud content (higher than typical for the biotope complex) and little or no gravel.

The infaunal community recorded from this biotope complex was characterised by cluster B of the multivariate analysis of macrofauna data (Section 6.2.1). Although the two stations within this biotope complex were statistically grouped by the analysis undertaken, they shared relatively few dominant taxa, with only the bivalve *A. nitida* and polychaete *Notomastus* sp. recorded at notable abundance (four or more individuals) from both stations. This suggested that the two stations may represent different communities within the A5.26 biotope complex. The macrofaunal sample analysed from station LS_ST05 comprised a lower abundance of individuals (24) and fewer taxa (16) than were recorded from station CC05_ST01. The dominant taxa at station LS_ST05 were the polychaete *Nephtys incisa* and horseshoe worm *Phoronis* sp. At station CC05_ST01, 126 individuals of 40 taxa were recorded and the dominant taxa were the bivalves *T. flexuosa*, *A. nitida* and *N. nitidosa*. The station CC05_ST01 community bore some resemblance to the EUNIS biotope '*Thyasira* spp. and *Nuculoma tenuis* in circalittoral sandy mud' (A5.352) but contained only a low abundance of *Ennucula tenuis* (currently recognised synonym of *N. tenuis*).

The epifauna present in this biotope complex comprised hermit crabs (Paguridae, including *Pagurus bernhardus*), sea pens (*Virgularia mirabilis*), Norway lobsters (*Nephrops norvegicus*), lesser-spotted cat sharks (*Scyliorhinus canicula*) and worm tubes (Polychaeta).

Due to the presence of *V. mirabilis*, *N. norvegicus,* and burrows formed by *N. norvegicus* or other burrowing crustacea, occurrences of this biotope complex have been assessed to determine whether they could be considered as the OSPAR (2008) threatened and/or declining habitat 'Sea pens and burrowing megafauna communities' (Section 7.2.3.1).

7.2.2.3 A5.261: *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment

The biotope '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' (A5.261) is defined by EUNIS (2012) as areas of non-cohesive muddy sands or slightly shelly/gravelly muddy sand characterised by the bivalves *A. alba* and *N. nitidosa*.

Along the Irish section of the Havhingsten cable route, this biotope was only recorded from station LS_ST01, which was located at KP 1.120 in a water depth of 8 m BSL. The biotope is expected to extend into Loughshinny bay itself and possibly slightly further offshore from station LS_ST01 (Figure 7.1). The sediment at station LS_ST01 comprised muddy sand (40.6 % mud content).

Station LS_ST01 was an ungrouped station within the multivariate analysis of macrofauna data (Section 6.2.1). The bivalve *A. alba* was dominant (abundance of 34 individuals); other characterising taxa occurred at lower abundance (four or fewer individuals) and included the bivalves *N. nitidosa* and *K. bidentata*, the polychaete *N. hombergii* and the amphipod *A. brevicornis* (Table 6.2). The only epifaunal taxon observed from seabed photographic data acquired in this biotope was a hermit crab (Paguridae).

7.2.2.4 A5.351: *Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud

The biotope '*Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud' (A5.351) occurs in cohesive sandy mud off wave exposed coasts with weak tidal streams or in muddy sands in moderately deep water. It can be characterised by a high abundance of the brittlestar *A. filiformis* with the bivalves *K. bidentata* and *A. nitida* (EUNIS, 2012).

Along the Irish section of the Havhingsten cable route this biotope was recorded from stations LS_ST02, LS_ST03 and LS_ST04, extending from KP 2.940 to KP 11.960 across water depths that ranged from 17 m to 41 m BSL. Particle size analysis data from the biotope's constituent stations identified sediments of muddy sand or slightly gravelly muddy sand, with mud content that ranged from 9.93 % to 14.9 % and gravel content that ranged from 0.03 % to 2.73 % (Section 4.2). Seabed photographic data suggested that the gravel-sized sediment particles were likely comprised of shell fragments.

The stations within this biotope were grouped within cluster A in the multivariate analysis of macrofauna data (Section 6.2.1). This grouping was characterised by an abundance of *A. filiformis* (mean abundance of 72 individuals per station) and *K. bidentata* (45 individuals per station). Other prominent taxa included *D. glaucus*, *Phoronis* sp. and *N. nitidosa*. Unusually for this biotope, only a single individual of *A. nitida* was recorded across the three stations sampled.

Epifauna was comparatively sparsely distributed within this biotope and comprised hermit crabs (Paguridae), anemones (Actiniaria, including *Metridium* sp.), brittlestar (Ophiuroidea, which may have included *A. filiformis*) and occasional fish (Gadidae).

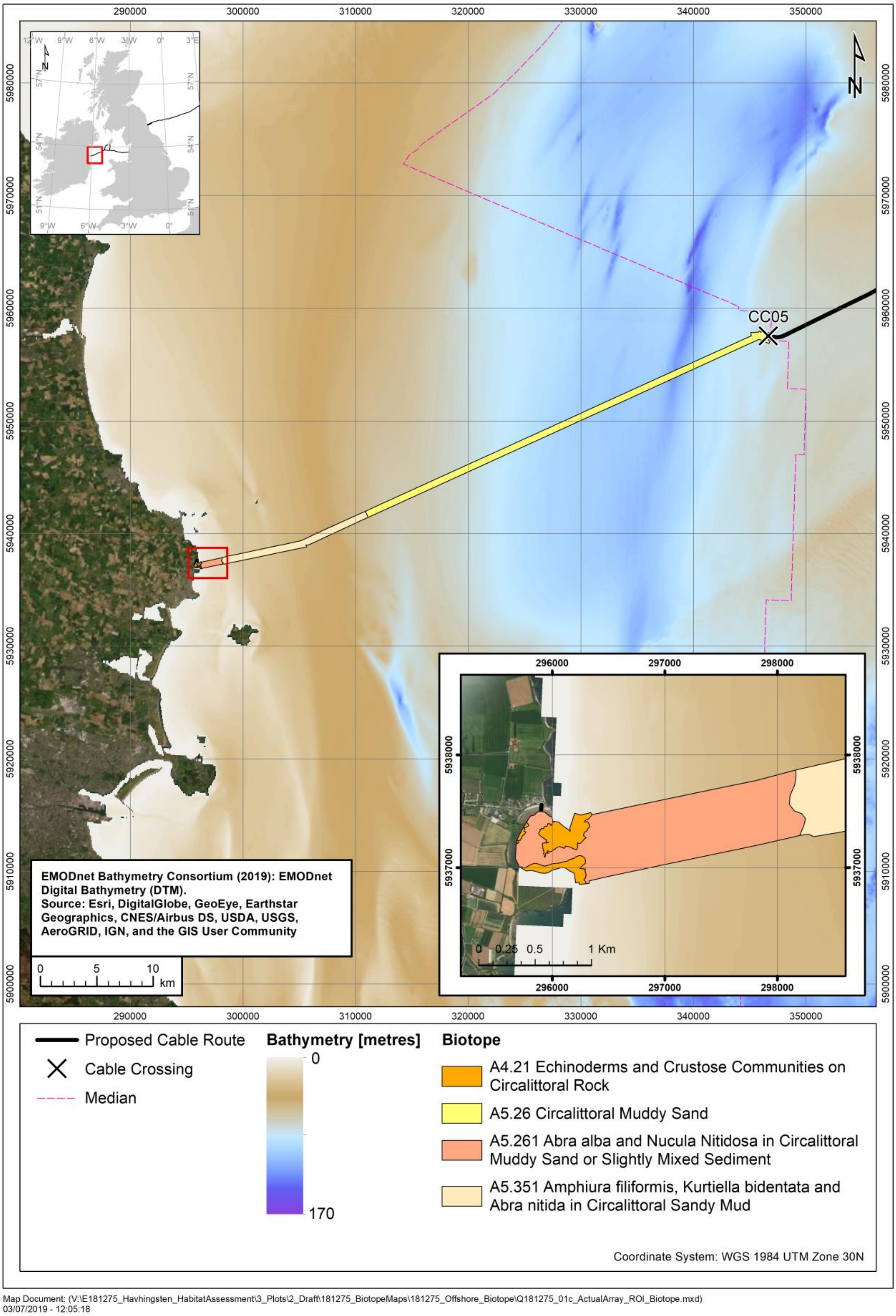


Figure 7.1: The spatial distribution of benthic habitats and biotopes, Havhingsten cable route, Ireland

7.2.3 Potentially Sensitive Habitats and Species

Analysis of seabed video and stills photography data was undertaken to establish whether any potentially sensitive habitats were likely to be present within the survey area.

7.2.3.1 Annex I Geogenic Reef

Cobbles and boulders were recorded from two sections of the transect undertaken at station LS_ST01, located at approximately KP 1.120 in water depths of 7 m BSL to 8 m BSL.

Table 7.6 presents a summary of the stony reef assessment. Appendix H.1 presents the full stony reef assessment. Figure 7.2 spatially presents the geogenic reef assessment within the Irish section of the Havhingsten cable route.

Table 7.6: Stony Reef Assessment Summary, Havhingsten Cable Route, Ireland

Station/Transect	% Cobbles/boulders	Elevation	Overall Geogenic Reef Classification
LS_ST01A Section 2	10 % - 20 %	64 mm – 5 m	Low
LS_ST01A Section 4	20 % – 30 %	64 mm – 5 m	Low

Key:	Not a Reef	Low	Medium	High

The presence of cobbles and boulders in two areas of station LS_ST01 were classified as 'low' resemblance to stony reef. The seabed appeared to be predominantly bedrock with a cobble and boulder component interspersed with rippled sand. Where cobbles and boulders were present, they were elevated from the surrounding seabed (although at the lower end of the 64 mm to 5 m category). The percentage of cobbles and boulders ranged from approximately 10 % to 30 % coverage. However, underwater visibility was poor at this station, and the percentage coverage has been based on small visible sections of the seabed.

Annex I reefs also include bedrock reef and a wide range of topographical reef forms meet the EU definition of this habitat type (JNCC, 2018c). Bedrock reefs may include vertical rock walls, horizontal ledges, sloping or flat bedrock and broken rock. More extensive rock structures, thought likely to be bedrock outcrops, were seen during camera operations at station LS_ST01. These ranged in morphology from flat, sediment covered surfaces to sloping structures outcropping from muddy sand sediments. No assessment criteria are currently available to assess the quality of bedrock reef habitat and it is therefore not possible to comment on the potential conservation importance of these areas.

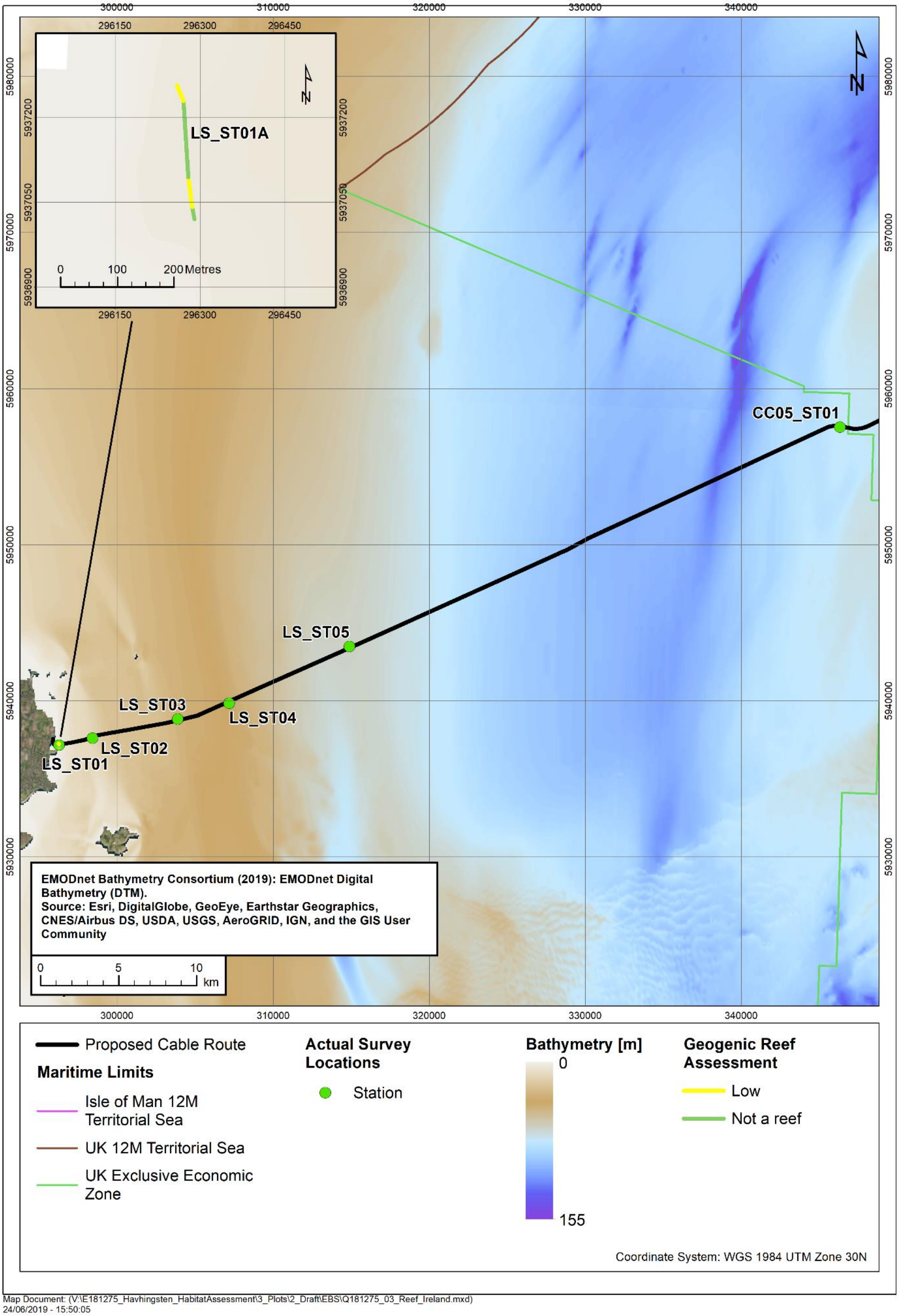


Figure 7.2: Geogenic reef assessment, Havhingsten cable route, Ireland

7.2.3.2 Sea Pens and Burrowing Megafauna Communities

Sea pens (*V. mirabilis*) and/or faunal burrows were recorded at stations LS_ST05 and CC05_ST01 and transects CC05_TR01 and CC05_TR02, all located in the eastern extents of the surveyed route (KP 20.570 to KP 55.220), in water depths ranging from 66 m BSL to 81 m BSL.

The video and photographs were analysed for the presence of the habitat 'Sea pen and burrowing megafauna communities'. Section 7.1.2.1 presents details of the assessment method. Table 7.7 presents the assessment results. Figure 7.3 spatially presents the burrow assessment, whist Figure 7.4 spatially presents the sea pen assessment within the Irish section of the Havhingsten cable route.

Table 7.7: SACFOR Densities of Sea Pens and Burrows, Havhingsten Cable Route, Ireland

Geodetic Parameters: WGS84 UTM 30N						
Transect/Station	**Time [UTC]**	**Easting [m]**	**Northing [m]**	**Length [m]**	***V. mirabilis* [3 cm to 15 cm Size Class]**	**Burrows [3 cm to 15 cm Size Class]**
LS_ST05	22:03:33	314922.3	5943446.6	184	Occasional	Common
	22:08:36	314882.9	5943626.6			
CC05_TR01A	02:29:09	347 174.7	5 957 085.5	829	Rare	Frequent
	03:02:47	346 542.0	5 957 621.4			
CC05_TR02	03:26:17	346 779.4	5 957 515.0	272	Absent	Frequent
	03:36:31	346 508.0	5 957 501.8			
CC05_ST01	03:57:10	346 266.4	5 957 592.1	146	Absent	Common
	04:17:09	346 385.9	5 957 508.6			

Notes:
SACFOR Classifications (3 cm to 15 cm)
S = 1–9/0.01 m2 F = 1–9/10 m2
A = 1–9/0.1 m2 O = 1–9/100 m2
C = 1–9/1 m2 R = 1–9/1000 m2

Key:	Absent	Rare	Occasional	Frequent	Common	Abundant	Super abundant

The sea pen *V. mirabilis* was occasionally recorded at station LS_ST05, and rarely recorded along transect CC05_TR01A. Burrows were recorded as 'common' or 'frequent', with both small and large burrows recorded, some of which were created by the Norway lobster (*N. norvegicus*). One individual of *N. norvegicus* was photographed emerging from a burrow on transect CC05_TR01 (Figure 7.5c).

Although the sediments were burrowed, mounds and burrows were not a prominent feature of the seabed.

No other Annex I habitats or Annex II species or threatened and/or declining species and habitats (OSPAR, 2008) were observed within the survey area.

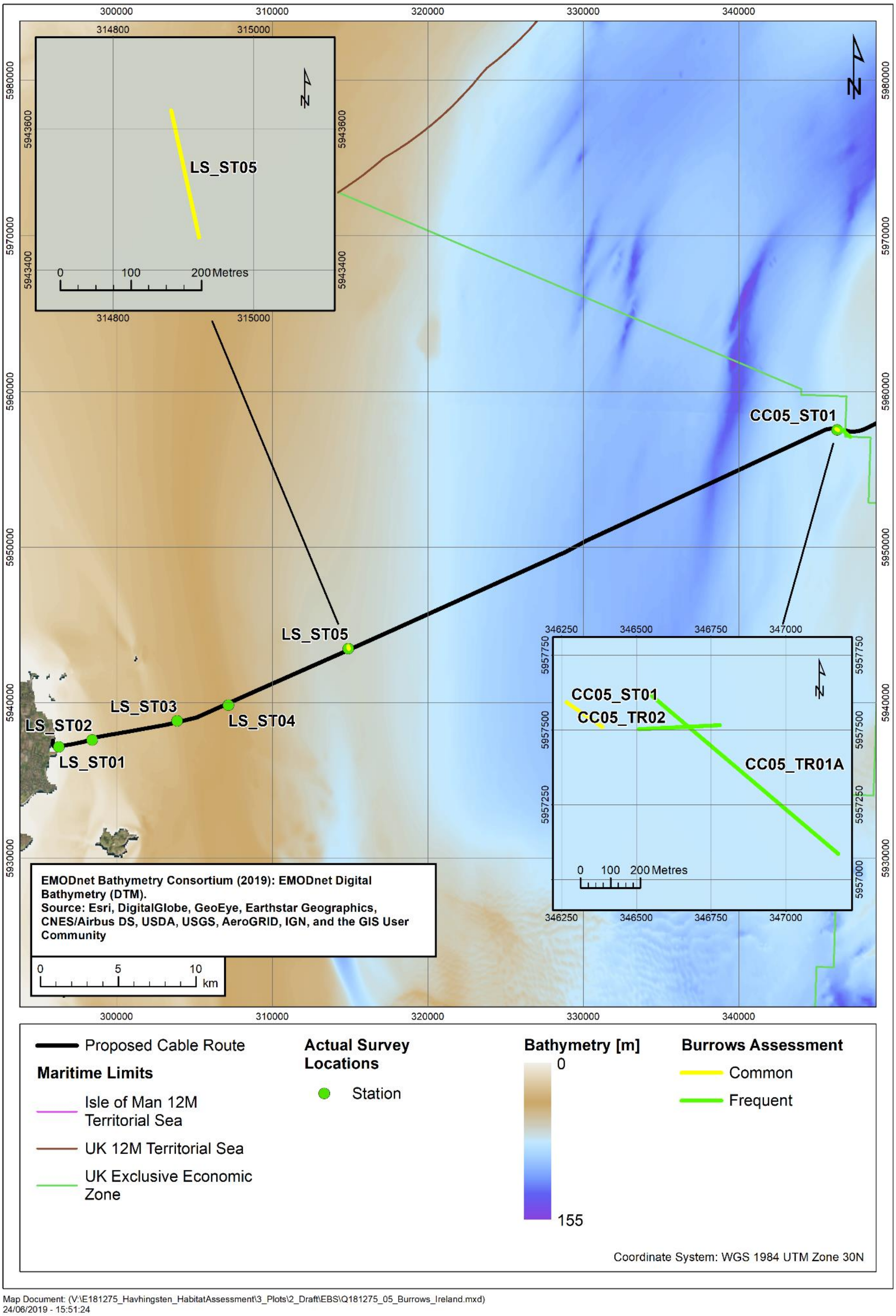
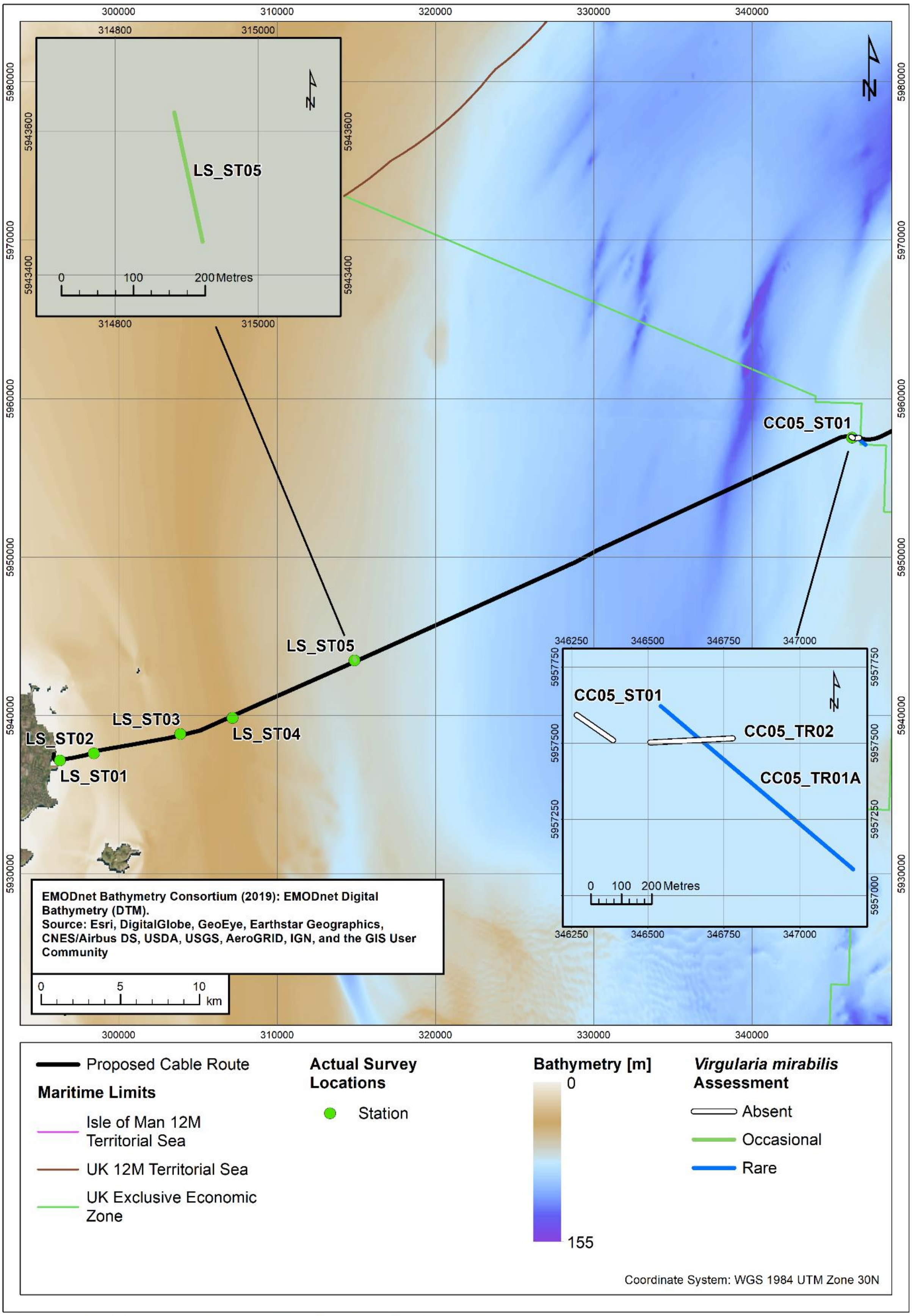


Figure 7.3: Burrows assessment, Havhingsten cable route, Ireland



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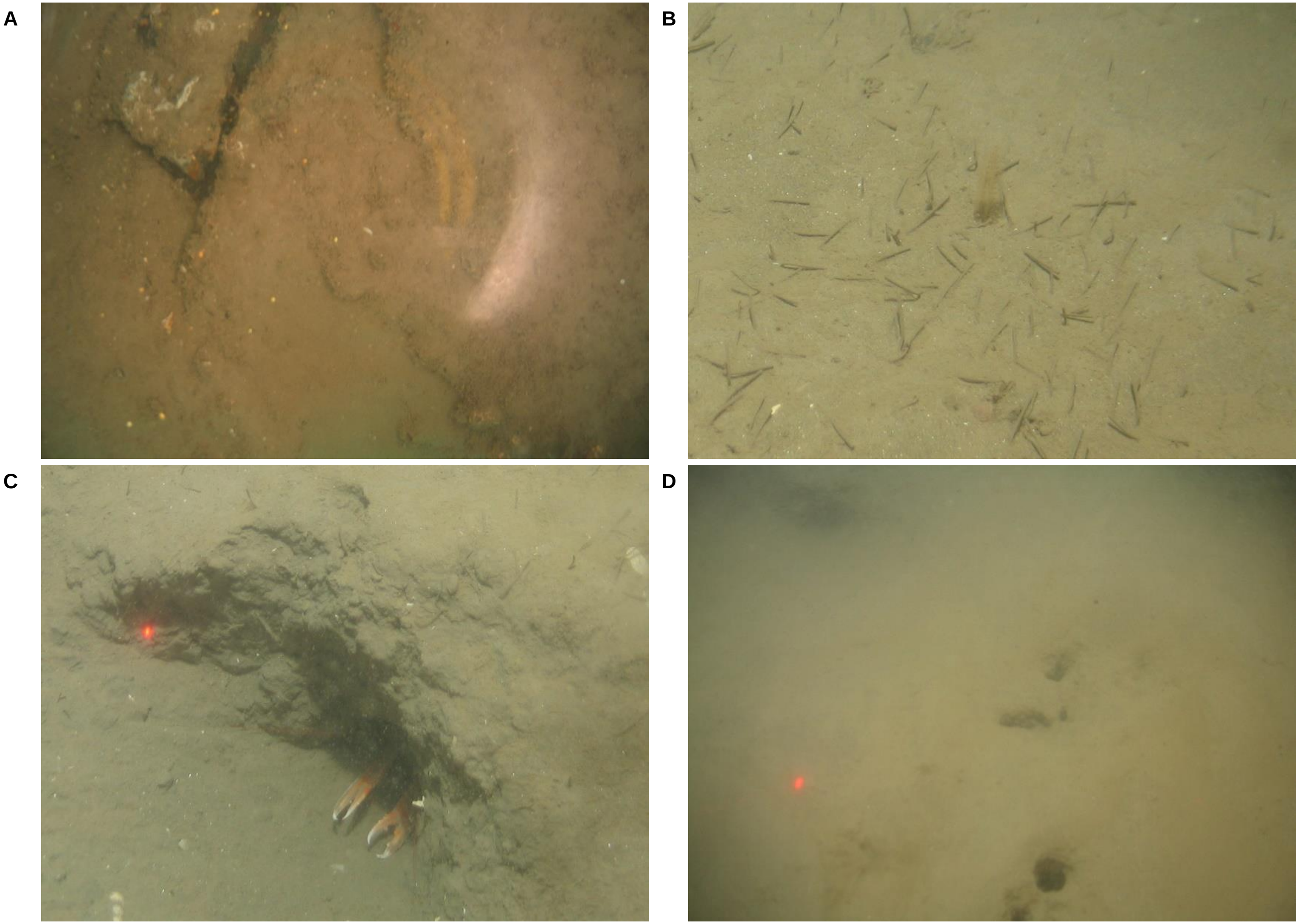
24/06/2019 - 15:50:37

Figure 7.4: Sea pen (*Virgularia mirabilis*) assessment, Havhingsten cable route, Ireland



A: Photograph LS_ST01A_2_18

Boulder/bedrock covered and muddy sand
Faunal turf (Hydrozoa/Bryozoa)
Worm tubes (Serpulidae)

B: Photograph CC05_TR01A_30

Muddy sand
Sea pen (*Virgularia mirabilis*)
Worm tubes (Polychaeta)

C: Photograph CC05_TR01A_46

Muddy sand
Norway lobster (*Nephrops norvegicus*)

D: Photograph LS_ST05_09

Muddy sand
Burrows

Figure 7.5: Example seabed photographs of potentially sensitive habitats, Havhingsten Cable Route, Ireland

8. DISCUSSION

8.1 Introduction

This survey was undertaken to characterise benthic environmental conditions prior to the proposed cable laying operations along the Irish section of the Havhingsten cable route. The survey and analytical strategies were designed to provide a comprehensive baseline dataset of the biological and physico-chemical characteristics of the seabed along the route, with sampling stations positioned to target variations in seabed habitat identified from the preceding geophysical survey operations. A key aim of the survey was to determine the distribution of seabed habitats and biotopes that may be impacted by the cable laying operations, with particular attention paid to identification of habitats that may be protected under regional, national, European and international laws.

The sampling plan included the collection of surface sediment from six stations for physico-chemical and macrofaunal analysis; sampling was successfully completed at all of these proposed stations. Selected physical characteristics (particle size and TOM) were analysed using surface sediment samples of taken between 0 cm to 5 cm depth (Section 3). Further surface (0 cm to 2 cm depth) sediment samples were analysed for TOC, hydrocarbons (including 2 to 6 ring aromatics) and heavy and trace metal content. Macrofaunal analysis (> 1 mm) was carried out on single 0.1 m^2 grab samples acquired from each station.

8.2 Sediment Characterisation

The general physical and chemical characteristics of sediment particles have a significant effect on how other chemical components and biological species interact with seabed sediments. For example, the silt/clay fraction is known to adsorb petroleum hydrocarbons/heavy metals from seawater and through this pathway, these chemicals become incorporated into the sediment system (Meyers and Quinn, 1973). Granulometry data can therefore be critical when interpreting chemical and biological data obtained in this type of benthic study. In addition, since waste discharges (such as drill cuttings) often possess significantly different physical characteristics from the natural sediments present in the area, such data may also provide some information on the spread of discharged material.

With regard to macrofaunal communities, the species distributions and community structure can be greatly influenced by the nature of the sediment, which represents the effects of a complex set of hydrological factors, such as water movement, turbulence and suspended load, at one particular point in time. Some animals have a behavioural preference for sediment of a particular grain size (Meadows, 1964; Gray, 1981), while this factor and organic matter content are closely associated with other properties of the sediment such as density, porosity, permeability, oxygenation and bacterial count (Buchanan, 1984), all of which affect animal functions such as locomotion, attachment, tube construction and feeding. Specifically, the proportion of fine (silt/clay) material often influences the distribution of macrofaunal communities.

The sediments within the survey area demonstrated moderate variability in mean diameter and low to high variability for the proportions of sand, gravel and fines, indicating the presence of varied sediments. The Wentworth (1922) classification described sediments across all survey areas as fine sand to coarse silt (Section 4). Sediment sorting ranged from poorly sorted to very poorly sorted. The sampling regime consisted of stations ranging from 11 m to 82 m depth BSL, so high variability in sediment composition would be expected and similar variability was observed by McBreen et al. (2008).

In the marine environment, TOM is a primary source of food for the benthos and plays a role in partitioning of contaminants in sediments (Trannum et al., 2006). TOM content displayed low variability across the survey area, with no consistent spatial patterns observed. TOC content was low and displayed moderate variability.

8.3 Sediment Chemistry

The previous sections of this report have presented the data generated from the analysis programme with the aid of data tables and graphics. This discussion section will review the data with respect to cited background and predicted effect levels. The OSPAR CEMP provides assessment criteria for contaminants in sediments in the form of BC, BAC and ERL threshold values. Adverse effects on organisms are rarely observed when concentrations are present below the ERL value (OSPAR, 2009c).

8.3.1 Total and Aliphatic Hydrocarbons

Marine sediments contain hydrocarbons derived from many sources which enter the marine environment via three general processes: biosynthesis (marine and land organisms biosynthesise hydrocarbons), geochemical processes (submarine and coastal/terrestrial oil-seeps) and anthropogenic sources (from accidental or intentional discharge of fossil fuel) (Farrington and Meyer, 1975; Myers and Gunnerson, 1976). Anthropogenic hydrocarbon inputs to the marine environment include marine transportation, offshore oil production, coastal oil refineries, accidental shipping losses, industrial and municipal waste (which includes sewage and dredged spoils). A significant contribution to the global budget enters the marine environment via urban and river run-off, atmospheric deposition (from combustion sources including PAHs) and natural seepages (Johnston, 1980; Dicks et al., 1987; NSTF, 1993; OSPAR, 2000; 2010).

Biosynthesised hydrocarbons are ubiquitous in the marine environment (Harada et al., 1995; Parinos et al., 2013). Odd carbon number, long chain n-alkanes are widely distributed in the plant kingdom (Eglinton et al., 1962; Douglas and Eglinton, 1966; Bush and McInerney, 2013) as components of cuticle waxes. These are common on the surfaces of leaves, stems, flowers and pollen and their presence in sediment is indicative of terrestrial inputs from adjacent land masses. Relatively high concentrations of nC_{29}, nC_{31} and nC_{33} are therefore a common feature of many marine sediments (Farrington et al., 1977), particularly inshore marine sediments (Bouloubassi et al., 1997), but are also evident in sediments from deepwater regions like the Atlantic Margin/west of Shetland regions of the United Kingdom Continental Shelf (McDougall, 2000) and regions such as the South China Sea and West Africa (Fugro, unpublished data).

Anthropogenic hydrocarbon inputs enter the marine environment from a number of sources. For example, from marine transportation, offshore oil production, coastal oil refineries, accidental shipping losses, industrial and municipal waste (which includes sewage and dredged spoils) with a significant contribution to the global budget entering via urban and river run-off, atmospheric deposition (from combustion sources; including PAHs) and natural seepages (e.g. Johnston, 1980; Dicks et al., 1987; NSTF, 1993; OSPAR, 2000, 2010).

The gas chromatographic profiles in sediments collected within the survey area shared a common underlying hydrocarbon distribution. The chromatograms all contained a trace level homologous series of resolved n-alkanes from nC_{12} to nC_{36} and a low-level unresolved hump covering the nC_{13} to nC_{36} range. This feature is the UCM and is composed of a wide range of compounds, including cycloalkanes, which remain after substantial weathering and biodegradation of petrogenic hydrocarbons (Farrington et al., 1977). The presence of the UCM in the samples suggests some contribution to the sediments from petroleum hydrocarbon sources, which may be attributed to fossil fuel discharges from historic or current industrial activities in the marine environment (such as shipping or oil and gas development) or via terrestrial run-off. A cluster of peaks around nC_{21} was present at some stations. This signature is often seen in marine sediments and thought to be branched isoprenoids of biogenic origin.

Variation in THC concentrations was moderate (RSD 54 %), predominantly influenced by the higher concentration at station LS_ST01 (12.6 µg/g). THC content was higher at stations with a higher total organic matter content and concentrations appeared to be highest closest to the shoreline. The observed variability in THC concentrations may be influenced by terrestrial run-off, inputs from shipping or natural heterogeneity in sediment characteristics and associated THC concentrations.

8.3.2 Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) and their alkyl homologues have been detected in a wide range of marine sediments (Youngblood and Blumer, 1975; Laflamme and Hites, 1978; Neff, 1979). These compounds consist of two or more fused benzene rings in linear, angular or cluster arrangements. Polycyclic aromatic hydrocarbons technically contain only carbon and hydrogen atoms. However, other atoms (e.g. nitrogen, sulphur and oxygen) may be readily substituted into the benzene ring to form heterocyclic compounds that are present in significant concentrations in petroleum and refined products.

Monitoring of aromatic hydrocarbon type and content is important due to the particularly toxic nature (mutagenic/carcinogenic) of several PAHs even at very low concentrations. The US EPA has identified 16 priority PAHs to be monitored (Keith, 2015) and the CEMP specifies 9 PAHs of specific concern (OSPAR, 2014), which primarily reflect inputs from man-made combustion sources (further alkylated and parent compounds are normally studied because of the information they provide on PAH origin and fate). Many PAHs have long been recognised as universal environmental pollutants with the heavier molecular weight PAHs (mainly 4 to 6 ring PAH) generally being regarded as carcinogens and mutagens. Indeed, 11 of 40 PAHs ranging from 3 to 6 ring structures have been listed as being strongly carcinogenic or mutagenic with a further 10 listed as weakly carcinogenic or mutagenic (Edwards, 1983).

All total 2 to 6 ring PAH concentrations were below the ERL value (OSPAR, 2014) at all stations (Table 5.1), therefore the concentrations of total 2 to 6 ring PAHs present are unlikely to result in detrimental effects on the benthic community. For all the EPA 16 PAH compounds assessed (individual and total), the concentrations reported within the survey area were below their respective ERL values (OSPAR, 2014) across the survey area (Appendix E.3).

Most natural and anthropogenic contaminants have a higher affinity to fine particulate matter than coarse, due to the increased adsorption capacity of organic matter and clay minerals. Natural sediment contaminant concentrations will be closely related to the distribution of fine-grained material with the effects of other sources of contaminants, for example anthropogenic sources, at least partly obscured by sediment characteristics (ICES, 2009; 2012). PAHs are lipophilic and bind strongly to organic matter in sediments (Davies, 2004). Normalisation of PAH concentrations to total organic carbon content provides a basis for reliable assessment of temporal trends and facilitates a meaningful comparison of sediment substances with OSPAR BC and BAC thresholds (Appendix E.3; ICES, 2009; 2012). When normalised to 2.5 % TOC, individual US EPA 16 PAH concentrations exceeded BAC values (OSPAR, 2014) for naphthalene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene and benzo(a)pyrene at all stations and benzo(ghi)perylene at one station (Appendix E.3). However, TOC content within the survey area was generally low (≤ 0.66 %; Table 4.2), possibly resulting in an overestimate of the normalised PAH concentrations.

Information on the source(s) of PAHs in the sediment may be obtained from a study of their alkyl homologue distributions (i.e. the degree of methyl, ethyl, substitution of the parent compounds). Pyrolytically derived PAH is predominantly unalkylated whereas petrogenically derived PAH is formed at relatively low temperatures (< 150 °C) and contains mainly alkylated species. The distribution of parent 2 to 6 ring PAH compounds also reflects whether the source is petrogenic or pyrolytic. The trend of parent and alkylated PAHs is represented graphically in Appendix E.3 using three-dimensional plots that present the PAH concentrations in terms of parent compound and alkyl homologue distribution of the aromatic material in the sediments analysed. These figures further indicate that the PAHs recorded within the survey area originated from predominately pyrolytic sources.

8.3.3 Heavy and Trace Metals

Metals and metalloids occur naturally in the marine environment and are widely distributed in both dissolved and sedimentary forms. Some are essential to marine life while others have no biological function and therefore are toxic to numerous organisms at certain levels (Paez-Osuna and Ruiz-Fernandez, 1995; Boening, 1999). Metals can enter the environment via natural methods such as riverine transport, coastal discharges, geological weathering and atmospheric fallout (Brady et al., 2015). Other routes into marine sediments are from anthropogenic activities such as direct discharges from industrial activities.

Trace metal contaminants in the marine environment tend to form associations with the non-residual phases of mineral matter, such as iron and manganese oxides and hydroxides, metal sulphides, clays, organics and carbonates (Warren and Zimmerman, 1993; Dang et al., 2015; Wang et al., 2015). Non-residual trace metals are associated with more reactive and available sediment components through processes such as adsorption onto mineral surfaces and organic complexation. Metals associated with these more reactive phases are prone to various environmental interactions and transformations (physical, chemical and biological) potentially increasing their mobility and biological availability (Tessier et al., 1979; Warren and Zimmerman, 1993; Du Laing et al., 2009). Residual trace metals are defined as those which are part of the crystal structure of the component minerals and are generally unavailable to organisms (de Orte et al., 2018). Therefore, in monitoring trace metal contamination of the marine environment, it is important to distinguish the more mobile non-residual trace metals from the residual metals held tightly in the sediment lattice (Chester and Voutsinou, 1981), which are of comparatively lesser environmental significance because of their low reactivity and availability.

The current CEMP's environmental focus around heavy metals is on cadmium, mercury and lead (OSPAR, 2014). Cadmium and lead both occur naturally in the marine environment; however, they are toxic and liable to bio-accumulate so there is a concern for both the overall health of the environment and for the human consumption of seafood. Mercury is an extremely rare element in the earth's crust but does occur naturally in young geologically active areas (volcanic regions). It is extremely toxic to humans and biota and can be transformed once in the environment into more toxic organometallic compounds (OSPAR, 2009c). ERL threshold values have also been established for several other metals and the results obtained have been compared to these (Table 5.2). The CEMP has also defined BC and BAC concentrations for assessing whether metal levels in sediments are at, or close to, background levels (OSPAR, 2014). In Appendix E.6 aluminium-normalised elemental concentrations from the current survey have been compared to CEMP BC and BAC concentrations.

In this study, an analytical procedure involving the digestion of sediment in aqua regia was employed to analyse the elemental content of the sediments. The aqua regia digest releases for analysis the 'non-residual' heavy metals, which are not incorporated in the mineral matrix and are therefore potentially available for biological uptake.

The concentrations of aqua regia extractable metals across the survey area displayed low to moderate variability (≤ 47 %), with the highest variability observed for aluminium. The variability observed in the dataset was expected to be a result of natural variation in sediment characteristics and the currents affecting sedimentation and deposition.

The partially enclosed nature and restrictive dispersive capacity of the Irish Sea can result in sediment accumulation of contaminants such as metals (Charlesworth et al., 2006). However, comparison of the concentrations of CEMP metals (cadmium, lead and mercury) analysed in the sediment samples against their respective assessment criteria (ERL) showed that concentrations were all below the respective ERL values. Although current environmental interest in metals contamination is focused mainly around cadmium, lead and mercury (OSPAR, 2014), ERL values have also been established for several other metals, of which no stations in the survey area exceeded. Therefore, concentrations of these metals are unlikely to result in detrimental effects on the macrofaunal community.

When normalised to 5 % aluminium, concentrations were compared with the cited BAC reference values (OSPAR, 2014; Appendix E.4). BAC values were exceeded for chromium, nickel and lead at all stations and mercury and arsenic at three stations. Aluminium concentrations were low (≤ 1.8 %), potentially resulting in the overestimation of normalised metals concentrations.

8.4 Macrofaunal Communities

Seabed sediments provide support, protection and the food source for many macrofaunal species. The sediment macrofauna, most of which are infaunal (living within the sediment), are therefore particularly vulnerable to external influences which alter the sediments' physical, chemical or biological nature. Such infaunal animals are largely sedentary and are thus unable to avoid unfavourable conditions. Each species has its own response and degree of sensitivity to changes in the physical and/or chemical environment and consequently the species composition and their relative abundance in a particular location provides a reflection of the health and condition of the immediate environment, both current and historical. The recognition that aquatic contaminant inputs may alter sediment characteristics, together with the relative ease of obtaining quantitative samples from specific locations, has led to the widespread use of infaunal communities in monitoring the impact of disturbances to the marine environment over a long period of time.

There was a low to moderate degree of infaunal similarity across the stations sampled, with inter-station similarities ranging between 0.0 % and 58.0 %. Within the multivariate analysis the most nearshore of the stations sampled (station LS_ST01, which was ungrouped by the cluster analysis) was shown to contain a community dominated by the bivalve mollusc *A. alba*, with only low abundances of other taxa recorded. Slightly further offshore, the cluster A stations (stations LS_ST02, LS_ST03 and LS_ST04) identified a diverse and densely populated community dominated by the brittlestar *A. filiformis* and bivalve *K. bidentata*. The stations located along the offshore, easterly section of the route (stations LS_ST05 and CC05_ST01) were grouped within cluster B and shown to have a community of bivalves (including *T. flexuosa* and *A. nitida*) and polychaetes (including *N. incisa* and *Notomastus* sp.). Despite the lack of statistical differentiation of these stations, the communities they represented appeared different, with station LS_ST05 containing fewer taxa and individuals than station CC05_ST01.

The BIOENV algorithm in the PRIMER BEST routine was an additional technique used to identify the environmental variables that correlated significantly with the patterns observed in community structure. BIOENV was run for single variables and a combination of two and three variables, highlighting the physical or chemical parameters that may influence community structure. The single variable that correlated most strongly with the macrofaunal community structure was copper concentration ($P \leq 0.05$; rho = 0.846). When two combined variables were considered, the additive influence of aluminium concentration and depth demonstrated the most significant correlation with the community structure present ($P \leq 0.05$; rho = 0.904). When three combined variables were considered, the concentrations of aluminium and nickel, in conjunction with depth, correlated most strongly with the macrofaunal community ($P \leq 0.05$; rho = 0.950). Although metals concentrations feature in all of the significant correlations identified, these are unlikely to be causative of the community structure seen, as all metals were recorded at concentrations unlikely to negatively impact benthic communities (Section 5.3). It is possible that the variation in metal concentrations was instead indicative of slight variations in sediment particle size (which was not, in itself, significantly correlated with community structure) and that particle size and depth were the main factors influencing benthic community structure.

8.5 Seabed Habitats and Biotopes

Seabed habitats and biotopes within the survey area were classified in accordance with the EUNIS habitat classification (EUNIS, 2012), 'The Marine Habitat Classification for Britain and Ireland – Version 15.03' (JNCC, 2015) and 'A Guide to Habitats in Ireland' (Fossitt, 2000). The primary tool for identification of habitats and their associated communities along the surveyed route was seabed video/photographic data, but further detail regarding sediment composition and infaunal community was provided by integration of the results from laboratory analysis.

Two EUNIS biotope complexes and two EUNIS biotopes were recorded in the survey area, the majority of which were sedimentary, with one rock biotope complex recorded (Section 7.2.1). The 'Echinoderms and crustose communities' (A4.21) biotope complex was recorded from bedrock and/or boulder substrata adjacent to the headlands projecting from either side of Loughshinny Bay (station LS_ST01).

The biotope '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' (A5.261) was found in shallow sediments in the mouth of Loughshinny Bay (station LS_ST01A) and was expected to extend into the bay itself and possibly for some distance offshore. As water depth increased with distance along the route, biotope A5.261 transitioned into the biotope '*Amphiura filiformis, Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud' (A5.351), which was found at stations LS_ST02, LS_ST03 and LS_ST04, located between KP 2.940 to KP 11.960 in water depths that ranged from 17 m to 41 m BSL. Towards the eastern end of the Irish section of the route, biotope A5.351 transitioned into the biotope complex 'Circalittoral muddy sand' (A5.26), which was recorded from stations LS_ST05 and CC05_ST01 and transects CC05_TR01 and CC05_TR02; these stations were located between KP 20.570 and KP 55.220 in water depths of between 66 m and 81 m BSL. This distribution of reported habitats broadly corresponds with the European Marine Observation Data Network (EMODnet) broadscale habitat map for the Irish Sea (EMODnet, 2019), which predicts a transition from predominantly sand habitats in nearshore waters to mud sediments further offshore.

All sediments sampled along the Irish section of the Havhingsten cable route were classified as either muddy sand or slightly gravelly muddy sand (Section 4.2), but mud content and the size of the sand fractions present was variable. This was reflected in the faunal composition of the route's sediment biotopes. Comparatively high mud content (40.6 %) was recorded from station LS_ST01, where biotope A5.261 was identified. Lower mud content (14.7 % to 22.0 %) was evident from stations LS_ST02, LS_ST03 and LS_ST04, where biotope A5.351 was recorded and mud content increased again (31.6 % to 43.0 %) at the offshore stations LS_ST05 and CC05_ST01 where biotope complex A5.26 was identified.

Due to the cobble and boulder coverage adjacent to the headland near Loughshinny (station LS_ST01), there was the potential for the Annex I 'stony reef' habitat to occur and data were assessed in accordance with JNCC guidelines for identifying the quality of this habitat (Irving, 2009). The guidelines state that "*when determining whether an area of seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive*". Potential stony reef habitat at station LS_ST01 was classified as having a 'low' resemblance to stony reef overall (Section 7.2.3.1). However, there did appear to be outcropping bedrock in this area, which could qualify as bedrock reef. No assessment criteria are currently available to assess the quality of bedrock reef habitat.

Due to the observation of sea pens (*V. mirabilis*) and faunal burrows at stations LS_ST05 and CC05_ST01 and on transects CC05_TR01 and CC05_TR02, located in the easternmost extents of the survey area, there was the potential for the OSPAR listed threatened and/or declining habitat 'sea pens and burrowing megafauna communities' to occur along the route. To qualify as a 'sea pens and burrowing megafauna community', the seabed must be "*heavily bioturbated by burrowing megafauna with burrows and mounds typically forming a prominent feature of the sediment surface*" (JNCC, 2014). Sea pens were absent from two of the stations/transects surveyed and, where found, were only recorded as 'occasional' or 'rare' in accordance with the SACFOR abundance scale (Section 7.2.3.1). Burrows were recorded as 'common' or 'frequent' on the SACFOR scale, and included both small and large burrows, some of which were created by the Norway lobster, *N. norvegicus*. A single *N. norvegicus* was observed from a burrow on transect CC05_TR01 (Figure 7.5c). *Nephrops norvegicus*, which are also known as langoustines or Dublin Bay prawns, are a commercially important fishery in Ireland. In 2016, 9600 tonnes of *N. norvegicus* were landed, with a total market value of €63 million, making it Ireland's most valuable fishery (BIM, 2016).

No other OSPAR threatened and/or declining species and habitats, Annex I habitats or Annex II species, were observed within the survey area.

9. CONCLUSIONS

The aim of this report has been to evaluate the existing physical/chemical and biological components in the marine environment along the Irish section of the Havhingsten cable route. Based on the overall assessment of the route surveyed, the following key conclusions can be stated:

Sediments ranged from fine sand to coarse silt across the survey area using the Wentworth description. Moderate variability was observed in mean diameter and low to high variability for the proportions of sand, gravel and fines, indicating the presence of varied sediments.

The gas chromatographic profiles for the survey area sediments were characteristic of background marine sediments influenced by biogenic inputs. The profiles contained a range of low-level resolved n-alkanes and a UCM peaking late in the chromatogram window. Total 2 to 6 ring PAH concentrations and US EPA 16 PAH concentrations were all below their respective ERL values and therefore unlikely to result in deleterious effects on the macrofaunal community. Source appointment suggested a predominantly pyrolytic source of hydrocarbons to the sediments.

All metals concentrations were below their respective ERL value. Variability in concentrations ranged from low to moderate (≤ 43 %) and was expected to be a result of natural variation in sediment characteristics and the currents affecting sedimentation and deposition.

The macrofaunal community of the most nearshore of the stations sampled (station LS_ST01) was dominated by the bivalve mollusc *A. alba*, with only low abundances of other taxa recorded. Slightly further offshore (stations LS_ST02, LS_ST03 and LS_ST04), a diverse and densely populated community dominated by the brittlestar *A. filiformis* and bivalve *K. bidentata* was identified. The stations located along the offshore, easterly section of the route (stations LS_ST05 and CC05_ST01) were shown to have a community of bivalves (including *T. flexuosa* and *A. nitida*) and polychaetes (including *N. incisa* and *Notomastus* sp.).

Two EUNIS biotopes and two biotope complexes were recorded along the route. One biotope complex was associated with bedrock and/or boulder habitat adjacent to Loughshinny Bay and the remainder with sedimentary habitat.

Due to the occurrence of sea pens (*V. mirabilis*) and faunal burrows at stations LS_ST05 and CC05_ST01 and on transects CC05_TR01 and CC05_TR02, these were assessed to determine their resemblance to the OSPAR threatened and/or declining habitat ‘sea pens and burrowing megafauna communities’. None of the stations/transects were thought to strongly resemble this priority habitat.

Boulder and/or cobble substrata identified adjacent to Loughshinny Bay (station LS_ST01) were assessed to determine their resemblance to Annex I ‘stony reef’ habitat; the results suggested that these areas only demonstrated a ‘low’ level of resemblance to this priority habitat. Photographic data also suggested that bedrock substrata occurred in this area. ‘Bedrock reef’ can also be considered as an Annex I habitat but, in the absence of guidance for assessment of this habitat type, its potential conservation importance could not be assessed.

No other OSPAR threatened and/or declining species and habitats, Annex I habitats or Annex II species, were observed within the survey area.

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APPENDICES

A. GUIDELINES ON USE OF REPORT

This report (the "Report") was prepared as part of the services (the "Services") provided by Fugro GB Marine Limited ("Fugro") for its client (the "Client") under terms of the relevant contract between the two parties (the "Contract"). The Services were performed by Fugro based on requirements of the Client set out in the Contract or otherwise made known by the Client to Fugro at the time.

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B. METHODOLOGIES

B.1 SURVEY

Survey operations were conducted using the RV Prince Madog during the period 23 to 24 February 2019 and the MV Fastnet Petrel during the survey period 21 to 22 March 2019. Survey positioning on the RV Prince Madog was achieved using Hemisphere V100 differential global positioning system antennae, configured with Trimble Hydropro navigation software. Whilst positioning on the MV Fastnet Petrel was achieved using a Koden KGP913MKII GPS.

B.1.1 Seabed Video/Photography

Prior to grab sampling, seafloor video footage and stills images were collected. Seabed photography was acquired using a Kongsberg OE 14-208 underwater camera system mounted within purpose built camera frame complete with a separate strobe and two lights. During operations where visibility was reduced or high turbidity the freshwater lens system was used. Table B.1 presents the specifications of the Kongsberg camera systems used.

Table B.1: Kongsberg OE 14-208 Camera System

Camera Specifications	
Weight:	350 kg
Dimensions:	1.0 m × 1.0 m × 1.0 m
Required clearance:	3 m
Image Resolution	2592 × 1944 (max) at 5.3 MP
Framing Video	PAL 625 Line/60 Hz NTSC
Sensor type	1/1.8” format high density CCD sensor
Operating Tolerances	
Water Depth	400 metres
Optical	
Optical Zoom	× 5
ISO Sensitivity	50 to 400
Standard Lens	35 mm format equivalent to 38-140 mm
Angle of View	60° Diagonal in water

Standard video frame

Seabed video footage was displayed on a computer monitor and recorded directly onto a computer hard drive using a Climax Digital video/universal serial bus (USB) converter, with a backup recorded to Mini-DV tape. A Black Box overlay was used to overlay a navigation string from the ship’s reference point, including the date, time and video frame position. Where applicable, the station number was updated on the navigation string automatically through the Hydropro software or was captured by taking a still of the photo slate at the beginning of the video.

Footage was viewed in real time, assisting in the control of the camera in the water. Where the video passed over sediment type boundaries, additional seabed video was collected, as appropriate, to provide sufficient footage for the analysis phase. Review of the video data also allowed assessment of the sites prior to grab deployment.

Positions for the video footage were logged at the beginning and the end of each station/transect and at each static image location.

Two subsea lasers were used to provide a scale on the video footage, these were set apart initially at 17.7 cm and then adjusted to 19.5 cm and 17.0 cm on the standard video frame.

Operational procedures for the seabed photography were as follows:

- The camera system was set-up on deck prior to deployment and a station number slate picture taken;
- The camera was deployed into the water until just below the sea surface, at which point the lights were switched on;
- The camera was lowered to the seabed and when the seabed was visible recording started and stills were acquired;
- Still photography commenced with the environmental scientist manually triggering the camera while the camera moved over the seabed;
- At the end of a camera station/transect the video recording stopped;
- The camera was recovered to the deck and the lamps were switched off just beneath the surface.

On completion, photographs were downloaded and backed up onto an external hard drive.

B.1.2 Sediment Grab Sampling

Seabed samples were acquired using a 0.1 m^2 dual van Veen grab (Figure B.1).

Figure B.1: Dual Van Veen grab (0.1 m^2)

Operational procedures for the grab deployment and recovery were as follows:

- The grab was prepared for operations prior to arrival on station. The Bridge communicated to the deck when the vessel was steady and on location, and the grab was deployed;
- When the mate/AB operating the winch observed that the grab had reached the seabed (evidenced through a distinct slackening of the wire rope and snatch block), a positional fix was taken;
- On recovery to the deck, the sample was inspected and judged acceptable or otherwise (see below for rejection criteria);
- Two accepted grab samples were retained for faunal analysis and one grab sample was retained and subsampled for physico-chemical analysis;
- Deck logs were completed for each sample acquired (including no samples) with: date, time, sample number, fix number, sediment type, depth and colour of strata in the sediment (if any), odour (i.e. H_2S), bioturbation or debris.

Samples were considered unacceptable in the following instances:

- Evidence of sediment washout caused through improperly closed grab jaws or inspection hatch;
- Sediment sample taken on an angle; where the grab jaws have not been parallel to the seabed when the grab fired;
- Disruption of the sample through striking the side of the vessel;
- Sample represented less than approximately 7 cm bite depth of the grab or 40 % by volume;
- Sample is more than 50 m from the target location, unless otherwise specified in the proposed locations.

Samples deemed acceptable were photographed. For each of the samples, notes were made on sediment type, and conspicuous species.

Each macrofaunal sample was then transferred into a clean plastic box to be washed though a 1 mm sieve with seawater using the chute and stand method. The residue remaining on the sieve was then carefully transferred into a pre-labelled bucket and fixed using 10 % buffered formal saline solution (4 % formaldehyde). An additional sample label written on waterproof paper, including date and project reference, was placed inside the bucket in addition to labels on the side and lid of the bucket. The fauna samples were stored in a designated crate on the deck of the survey vessel until demobilisation, upon which they were transferred to Fugro’s benthic laboratories.

The third grab sample was used for physico-chemical (particle size distribution (PSD) and chemistry) samples, subsamples of this grab sample were taken as follows:

- A subsample (of approximately 300 mL) was collected for PSD analysis, using a plastic scoop to a nominal depth of 5 cm. The samples were sealed in polythene bags to ensure no loss of fines. The samples were frozen at and stored on the vessel until demobilisation and transfer to the analysis laboratory;
- Hydrocarbon samples were collected using a cleaned metal scoop to a nominal depth of 2 cm and stored in a prelabelled glass jar. The samples were frozen and stored on the vessel until demobilisation and transfer to the analysis laboratory;

- Samples for heavy metals were collected using a plastic scoop to a nominal depth of 2 cm. The samples were sealed in polythene bags to ensure no loss of fines. The samples were frozen at and stored on the vessel until demobilisation and transfer to the analysis laboratory.

B.2 LABORATORY ANALYSIS

B.2.1 Particle Size Analysis (PSA)

B.2.1.1 Dry Sieve Analysis

Particle size distribution analysis was undertaken in accordance with Fugro GB Marine Limited (FGBML) in-house methods based on the National Marine Biological Association Quality Control (NMBAQC) scheme's best practice guidance document – Particle Size Analysis (PSA) for Supporting Biological Analysis, and BS1377: Parts 1: 2016 and 2: 1990.

Representative material > 1 mm was split from the bulk subsample and oven dried before sieving through a series of sieves with apertures corresponding to 0.5 phi intervals between 63 mm and 1 mm as described by the Wentworth scale (Wentworth, 1922). The weight of the sediment fraction retained on each mesh was subsequently measured and recorded.

B.2.1.2 Laser Diffraction

Particle size distribution analysis was undertaken in accordance with FGBML in-house methods based on the NMBAQC scheme's best practice guidance document –PSA for Supporting Biological Analysis, and BS ISO 13320: 2009.

Representative material < 1 mm was removed from the bulk subsample for laser analysis, a minimum of three triplicate analyses (mixed samples) or one triplicate analyses (sands) were analysed using the laser sizer at 0.5 phi intervals between < 1 mm to < 3.9 µm. Laser diffraction was carried out using a Malvern Mastersizer 2000 with a Hydro 2000G dispersion unit.

Sieve and laser data are merged and entered into GRADISTAT to derive statistics including mass and percentage retained within each size fraction, mean and median grain size, bulk sediment classes (percentage gravel, sand and silt/clay), skewness, sorting coefficients and Folk classification.

B.2.2 Total Organic Carbon (TOC)

Sediment samples were analysed for total organic carbon (TOC) by Exova Jones Environmental. The dry, homogenised sample was treated with hydrochloric acid, then rinsed with deionised water to remove mineral carbon. The sample was then combusted in an Eltra TOC furnace/analyser in the presence of oxygen. Organic carbon was oxidised to CO_2 and measured by non-dispersive infrared analysis. This method does not quantify volatile organic carbon, which should be determined by another technique. The limit of detection for this method was < 0.02 % w/w.

B.2.3 Hydrocarbon Analysis in Sediments

Hydrocarbon analysis of sediments was carried out by FGBML.

B.2.3.1 General Precautions

To effectively eliminate all possible sources of hydrocarbon contamination from the analysis the following precautionary measures were taken prior to sample work-up:

- All solvents were purchased as high purity grade. Each batch was checked for purity by concentrating approximately 400 mL down to a small volume (< 1 mL) and analysing by gas chromatography (GC);
- All water used was distilled through an all glass still and dichloromethane (DCM) extracted to minimise contamination from plasticisers;
- All glassware was cleaned using an acid/base machine wash. The glassware was rinsed with acetone then finally with DCM prior to use;
- Procedural blanks, replicate analyses and laboratory reference material were run with each batch.

B.2.3.2 Ultrasonication Extraction for Hydrocarbons in Sediment

Sediment samples were thawed, homogenised and accurately weighed into a 250 mL conical flask. A solution containing an appropriate amount of the following internal standards was added to each sample using a microsyringe.

Aliphatic Standards	**Aromatic Standards**
Heptamethylnonane	d_8 naphthalene
D_{34} Hexadecane	d_{10} acenaphthene
D_{42} Eicosane	d_{10} phenanthrene
Squalane	d_{10} pyrene
	d_{12} chrysene
	d_{12} perylene

Methanol (50 mL) and solvent were mixed with the sediment. DCM (60 mL) was then added and the sample mixed again. The flasks were then capped with solvent cleaned aluminium foil and ultrasonicated for 30 minutes.

After being allowed to settle the solvent was decanted through a GF-C filter paper into a 1 L separating funnel. The extract was then partitioned with 100 mL of DCM extracted distilled water and the DCM layer run-off into a clean 500 mL round-bottomed flask. The ultrasonic extraction was repeated a further two times using 50 mL DCM and 15 minutes of ultrasonication. Each time the filtered extract was partitioned with the remaining methanol/water in the separating funnel. The DCM extracts were bulked and reduced in volume to approximately 2 mL using a rotary evaporator, then further reduced to approximately 1 mL under a gentle stream of nitrogen prior to clean-up.

Correction factors for wet/dry sediments were obtained by drying a subsample of the homogenised sediment to constant weight at 105 °C.

B.2.3.3 Clean-Up of Extracts by Column Chromatography

Removal of polar material, including lipids was carried out using a silica gel column. The silica gel used was 70 to 230 mesh which was heated at 400 °C for at least 4 hours to remove impurities and residual moisture and then stored at 200 °C prior to use. The sample extract was added to the silica gel column, containing 5 g of adsorbent and eluted with 35 mL of DCM/pentane (1:2). The eluant was reduced in volume using the evaporator to approximately 2 mL, with activated copper powder (for removal of free sulphur), before being further reduced under a gentle stream of nitrogen to an appropriate volume and analysed by both gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS).

	Gas Chromatography [GC]	**Gas Chromatography-Mass Spectrometry [GC-MS]**
Instrument	HP 6890 Series GC with 7673 autoinjector	HP 7890 Series GC with autoinjector and 5977A MSD
Column	100 %-dimethylpolysiloxane bonded fused silica, 60 m, 0.25 µm film thickness, 0.32 mm internal diameter	(5 %phenyl)-methylpolysiloxane bonded fused silica, 60 m, 0.32 µm film thickness 0.25 mm internal diameter
Carrier Gas	Hydrogen (constant flow 3.5 mL/min)	Hydrogen (constant flow 1.4 mL/min)
Injector	On–column (2 µL injection)	Splitless, 280 °C, split flow 40 mL/min, vent time 1.5 min (1 µL injection)
Oven Temperature Programme	80 °C – 2 min 80 °C to 320 °C at 18 °C/min 320 °C – 13 min 320 °C to 350 °C at 30 °C/min	60 °C – 1 min 60 °C to 180 °C at 11 °C/min 180 °C to 260 °C at 6 °C/min 260 °C to 320 °C at 6 °C/min 330 °C – 7 min
Source/Detector Temperature	350 °C (FID)	230 °C
Electron Energy		70 eV
Selected Ion Monitoring (SIM)		9 groups - 6 ions per group
Dwell Time (per ion)		0.035 second

B.2.3.4 Total Hydrocarbons by Gas Chromatography–Flame Ionisation Detection (GC-FID)

The total hydrocarbon material present was quantified using response factors calculated from the analysis of mixed oil standard solutions over an appropriate range. The unresolved complex mixture (UCM) was determined by subtracting the area of all the resolved peaks from the total hydrocarbon area and applying the total hydrocarbon response factor. The minimum reporting value is 0.5 µg/g dry weight.

B.2.3.5 n-Alkanes

The n-alkanes between nC_{12} and nC_{36} were reported. Calibration was undertaken using a range of n-alkane standard solutions containing the even carbon number compounds between nC_{12} and nC_{36}, and a range of suitable internal standards. Individual response factors were calculated for each of the n-alkanes present in the calibration solution. Response factors for the non-calibrated n-alkanes were taken to be equivalent to closely eluting compounds. The minimum reporting value of individual n-alkanes is 0.5 ng/g dry weight.

B.2.3.6 Polycyclic Aromatic Hydrocarbons (PAHs)

A full range of polycyclic aromatic hydrocarbon (PAH) and alkylated PAH were quantified as specified by Department of Trade and Industry (DTI) regulations (DTI, 1993).

Calibration was undertaken using a range of PAH standard solutions, a number of alkylated PAH, dibenzothiophene and a range of suitable internal standards. Individual response factors were calculated for each of the compounds present in the calibration solution. Response factors for the non-calibrated alkylated PAH were taken to be equivalent to closely related compounds. The minimum reporting value of individual PAHs is 0.1 ng/g and 1 ng/g dry weight for alkylated PAHs.

B.2.4 Total Organic Matter (TOM)

Total organic matter (TOM) analysis was carried out by FGBML. TOM was determined by ignition after the removal of calcium carbonate (shell debris) by treatment with hydrochloric acid. A pre-dried aliquot of the sediment was weighed and then treated with hydrochloric acid to remove inorganic carbon in the form of carbonate. Fresh acid was added until all effervescence ceased; the sediment was then washed over a glass-fibre filter and the residue dried to a constant weight before being ignited in a muffle furnace at 440 °C for 4 hours. The organic content of the sediment is then calculated using the weight difference from the original dry weight to the ignited residue (taking into account the loss of carbonate).

B.2.5 Heavy and Trace Metals in Sediments

Sediment samples were freeze dried and then sieved to the required size fraction (2000 µm). Samples were subjected to an aqua regia microwave digestion. This acid mixture allows a partial dissolution of metals from most soil and sediment types which allows the bioavailable metals content to be analysed. The resulting digests were then analysed by inductively coupled plasma-mass spectrometry (ICP-MS) and/or inductively coupled plasma-optical emission spectroscopy (ICP-OES).

Mercury content was determined by sieving the sample to < 2000 µm followed by a microwave assisted aqua-regia digest, acidic stannous chloride reduction and determination by cold vapour-atomic fluorescence spectroscopy (CV-AFS).

B.2.6 Macrofaunal Analysis

Macrofaunal analysis was carried out by APEM Limited.

On return to the laboratory, the samples were removed from formalin and washed through 1.0 mm mesh sieves. The material retained was then processed to remove fauna. The animals were separated by hand from the retained sediment by using a combination of stereo microscopes for the fine sediments and in white trays for any coarser material. Processed sediment is stored in Phenoxetol (2 %) or returned to the original formalin.

Following extraction, the animals were identified and enumerated by specialist taxonomists. Identification was to species level where possible. Specimens which, due to their immaturity, damage incurred during processing or lack of suitable taxonomic literature, cannot be identified to species level are identified at higher taxonomic levels as appropriate. After identification, samples were stored in 70 % industrial denatured alcohol (IDA) or a mixture of 70 % ethanol/1 % propylene glycol/29 % water. A minimum of 10 % of samples within the project were re-analysed (for extraction, species identification, enumeration and data entry) as per NMBAQC quality control guidelines (Worsfold, 2010).

Species abundances were entered on file in a spreadsheet package, which stores and sorts entries into taxonomic order and provides output files for numerical analysis. Nomenclature follows that given on the World Register of Marine Species (WoRMS Editorial Board, 2019). The taxonomic order is based on Species Directory codes (Howson and Picton, 1997) to give an idea of 'evolutionary rank'. Once all the entries had been checked, the resulting quantitative data were subjected to various statistical techniques to investigate community structure. All quantitative analyses were performed on species abundances from single samples from each station, thus the sample size was 0.1 m^2 at all stations.

Prior to statistical analysis, the macrofaunal abundance data was manipulated to avoid spurious enhancement of community statistics. This involved the removal of all meiofaunal taxa (e.g. COPEPODA), pelagic taxa (e.g. CHAETOGNATHA), damaged taxa, fish and juvenile specimens, as they are not considered to be a permanent part of the community. Colonial taxa, which could not be enumerated, were also removed from the dataset.

B.3 STATISTICAL ANALYSIS

B.3.1 Multivariate Analysis

Macrofauna abundance data were analysed by multivariate techniques using the statistical package PRIMER v6. Approaches followed those outlined in Clarke and Gorley (2006). The main techniques used to interrogate the data are detailed below.

Pre-treatment and Transformations: prior to analysis data typically undergo transformation to down weight the effect of dominant data components in determining inter-sample similarities. These transformations vary in their effect through: no transform; square root (√); fourth root/double square root (√√); logarithmic, and; reduction to presence/absence. At the former end of the spectrum (no transform) all attention is focused on the dominant components of the dataset, and at the latter end (reduction to presence/absence) equal weighting is applied to all components (Clarke and Gorley, 2006). Square root transformation was used in this instance, as detailed within the report.

Similarity Matrices: a triangular similarity matrix was produced from the square root transformed data, by calculating the similarity between every pair of samples. The Bray-Curtis similarity coefficient was used for macrofaunal data (Bray and Curtis, 1957). This similarity measure is considered the most suitable as it maintains independence of joint absence (i.e. will not infer similarity between samples based on the absence of a certain parameter in them).

Hierarchical Agglomerative Clustering (CLUSTER) and Similarity Profile Testing (SIMPROF): the CLUSTER programme uses the similarity matrix to successively fuse samples into groups and groups into clusters according to their level of similarity. The end point of this process is a single cluster containing all the samples, which is displayed by means of a dendrogram with similarity displayed on one axis and samples on the other. Similarity profile permutation tests (SIMPROF) were also performed, to look for evidence of genuine statistically significant clusters, in samples that are a-priori unstructured (i.e. with no prior statistical design). By combining this significance testing with the CLUSTER function, dendrograms are produced indicating those clusters that are statistically significant.

Non-metric Multidimensional Scaling (nMDS): non-metric multidimensional scaling (nMDS) uses the similarity matrix to ordinate samples in a two-dimensional plane. The representation of the multidimensional (multiple variable) dataset in two dimensions will inevitably result in some distortion of the real data relationships and this distortion is expressed as a stress value. Stress values above 0.3

indicate arbitrary points and the ordination should be considered unreliable. Stress values between 0.2 and 0.3 are poor representations of the data. Stress < 0.2 can provide meaningful ordinations, while stress < 0.1 demonstrate a good interpretation of the data.

Correlations with Environmental Variables: BEST analysis was also performed on log (X+1) transformed aggregated chemical data and crude particle size data. The BIO-ENV algorithm was adopted, which correlates individual variables and combinations of variables to the macrofauna. Environmental variables that strongly covaried were assessed from draftsman's plots and the correlations analysis and one or other variable was removed from the analysis.

B.3.2 Primary Variables and Diversity Indices

A range of primary variables and derived indices were calculated that attempt to quantify the species richness, evenness and a combination of both. The primary variables (number of individuals and species) and diversity indices (Shannon-Wiener diversity, Brillouin's diversity, Simpson's diversity and Pielou's evenness) were calculated for both the samples and the pooled replicates for each station using the PRIMER v6 DIVERSE procedure.

Shannon Wiener Index (H' or more specifically H'Log_2)

The Shannon-Wiener index (or Shannon-Wiener information function) is essentially a measure of how difficult it would be to predict correctly the species of the next individual collected from the community under study. It is a measure of uncertainty and was originally developed to assess the information content of codes. Information content is a measure of uncertainty, so that the larger the value of the index, the greater the uncertainty. It is usually expressed as:

$$= -\sum_i P_i \, \mathrm{Log}(P_i)$$

Where pi is the proportion of the ith species. For practical application, the formula can be expanded to:

$$= C\left(\log_{10} N - \frac{1}{N}\sum n_i \log_{10} n_i\right)$$

Where N = total number of individuals

ni = number of individuals of ith species

C = conversion factor $\log_{10} - \log_2$.

Two components of diversity are combined in the Shannon-Wiener index. These are species richness (i.e. numbers of species) and the equitability or evenness of distribution of individuals among the species. A greater number of species increases the index value as does more even distribution of individuals amongst species. Theoretically, the Shannon-Wiener index should only be used on random samples drawn from a large community in which the total number of species is known. This is, of course, not usually possible and so the use of the index is always a compromise.

Simpsons (1-λ)

Simpson's index of diversity is derived from probability theory. It is simply a measure of the probability of picking two individuals from a community at random that are different species. The index is calculated from:

$$= 1 - \sum_{i=1}^{s} (p_i)^2$$

Where pi is the proportion of the ith species. An expanded and more practicable formula is:

$$= 1 - \sum \frac{n_i(n_i - 1)}{N(N - 1)}$$

Where	ni	=	number of individuals of ith species
	N	=	total number of individuals.

Simpson's index assigns relatively little weight to rare species, and more weight to the common ones. It ranges in value from 0 (low diversity) to a maximum of (1 to 1/s) where s = the number of species.

Brillouin's Index (Hb)

This index, like that of Shannon-Wiener, is concerned with information content. However, unlike the Shannon-Wiener index, which provides an estimate of the community diversity, Brillouin's index provides the actual diversity of the fully censused sample. It is not a statistical estimate but an actual measurement of the diversity of the sample unit. The formula, displayed below, contains factorials that can involve very large numbers in computation. In the past, this has been a serious drawback to the use of the index by practical ecologists. This is no longer the case with the advent of personal computers capable of high speed calculations.

The formula for Brillouin's index is:

$$H_b = \frac{1}{N} \log_e \frac{N!}{N_1! N_2! \ldots . N_s!}$$

Where	N	=	total number of individuals
	Ni	=	number of individuals of the i^{th} species
	S	=	total number of species in the collection.

As the index provides the exact diversity of the sample, it is most appropriate in surveys where it is not possible to define the limits of the population. Since this is nearly always the case when dealing with benthic communities, Brillouin's index has much to commend it in offshore pollution monitoring studies.

Pielou's Equitability (J)

Equitability refers to the evenness with which individuals are distributed amongst species. Equitability is clearly a component of species diversity and certainly enters into diversity indices such as $H'Log_2$, Hb, and λ.

Equitability can be assessed in several ways, the most commonly used approach being to calculate the theoretical diversity for a given species abundance list if all the species were equal in abundance. The equitability of the sample can then be defined as the ratio of the actual diversity to the theoretical maximum.

This is usually done using the Shannon-Wiener index (H'Log_2)

If all species are equally represented, then the equation can be written:

$$H'(max) = -S\left(\frac{1}{s}log2\frac{1}{s}\right) = log_s S$$

The equitability ratio is therefore:

$$J = \frac{H_s}{log_2 S}$$

Where J = equitability measure (Pielou)
H' = calculated Shannon-Wiener diversity
S = total number of species.

C. LOGS

C.1 SURVEY LOG

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
21/03/2019	10:57:20	LS_ST01A	Video	SOL	-	6.8	296 270	5 937 063	296 287.8	5 937 016.9	49.1	System crashed - no fixes
21/03/2019	10:57:53	LS_ST01A	Still	181275_LS_ST01A_02	NF	-	-	-	-	-	-	
21/03/2019	11:10:06	LS_ST01A	Video	EOL	-	8.3	296 270	5 937 063	296 262.7	5 937 262.3	199.6	
21/03/2019	11:39:46	LS_ST01A_2	Video	SOL	-	6.8	296 270	5 937 063	296 293.1	5 937 015.3	52.7	
21/03/2019	11:40:32	LS_ST01A_2	Still	181275_LS_ST01A_2_02	3		296 270	5 937 063	296 288.7	5 937 032.5	35.5	
21/03/2019	11:41:00	LS_ST01A_2	Still	181275_LS_ST01A_2_03	4		296 270	5 937 063	296 285.9	5 937 044.8	23.9	
21/03/2019	11:41:17	LS_ST01A_2	Still	181275_LS_ST01A_2_04	5		296 270	5 937 063	296 285.3	5 937 050.9	19.2	
21/03/2019	11:41:26	LS_ST01A_2	Still	181275_LS_ST01A_2_05	6		296 270	5 937 063	296 285.4	5 937 053.4	17.8	
21/03/2019	11:41:44	LS_ST01A_2	Still	181275_LS_ST01A_2_06	7		296 270	5 937 063	296 285.5	5 937 060.0	15.5	
21/03/2019	11:42:00	LS_ST01A_2	Still	181275_LS_ST01A_2_07	8		296 270	5 937 063	296 284.6	5 937 065.7	14.6	
21/03/2019	11:42:19	LS_ST01A_2	Still	181275_LS_ST01A_2_08	9		296 270	5 937 063	296 283.8	5 937 073.8	17.4	
21/03/2019	11:43:00	LS_ST01A_2	Still	181275_LS_ST01A_2_09	10		296 270	5 937 063	296 281.4	5 937 088.2	27.7	
21/03/2019	11:43:59	LS_ST01A_2	Still	181275_LS_ST01A_2_10	11		296 270	5 937 063	296 279.3	5 937 108.0	46.1	
21/03/2019	11:44:26	LS_ST01A_2	Still	181275_LS_ST01A_2_11	12		296 270	5 937 063	296 278.0	5 937 117.7	55.4	
21/03/2019	11:45:25	LS_ST01A_2	Still	181275_LS_ST01A_2_12	13		296 270	5 937 063	296 276.4	5 937 139.6	77.0	
21/03/2019	11:46:17	LS_ST01A_2	Still	181275_LS_ST01A_2_13	14		296 270	5 937 063	296 274.0	5 937 158.4	95.7	
21/03/2019	11:47:18	LS_ST01A_2	Still	181275_LS_ST01A_2_14	15		296 270	5 937 063	296 269.9	5 937 179.8	117.0	
21/03/2019	11:48:00	LS_ST01A_2	Still	181275_LS_ST01A_2_15	16		296 270	5 937 063	296 270.6	5 937 198.7	135.8	
21/03/2019	11:49:10	LS_ST01A_2	Still	181275_LS_ST01A_2_16	17		296 270	5 937 063	296 271.2	5 937 223.5	160.7	
21/03/2019	11:49:43	LS_ST01A_2	Still	181275_LS_ST01A_2_17	18		296 270	5 937 063	296 269.4	5 937 233.2	170.4	
21/03/2019	11:50:14	LS_ST01A_2	Still	181275_LS_ST01A_2_18	19		296 270	5 937 063	296 265.4	5 937 241.0	178.3	
21/03/2019	11:50:52	LS_ST01A_2	Still	181275_LS_ST01A_2_19	20		296 270	5 937 063	296 260.1	5 937 253.5	191.0	
21/03/2019	11:51:20	LS_ST01A_2	Video	EOL	-	8.3	296 270	5 937 063	296 258.6	5 937 262.1	199.6	
21/03/2019	12:05:56	LS_ST02	Video	SOL	-	15.0	298 411	5 937 630	298 418.7	5 937 591.1	39.7	
21/03/2019	12:06:21	LS_ST02	Still	181275_LS_ST02_02	21		298 411	5 937 630	298 420.0	5 937 595.4	35.7	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
21/03/2019	12:06:27	LS_ST02	Still	181275_LS_ST02_03	22		298 411	5 937 630	298 420.3	5 937 596.5	34.8	
21/03/2019	12:07:05	LS_ST02	Still	181275_LS_ST02_04	23		298 411	5 937 630	298 420.7	5 937 603.1	28.6	
21/03/2019	12:07:53	LS_ST02	Still	181275_LS_ST02_05	24		298 411	5 937 630	298 416.3	5 937 608.4	22.2	
21/03/2019	12:08:30	LS_ST02	Still	181275_LS_ST02_06	25		298 411	5 937 630	298 415.1	5 937 613.9	16.6	
21/03/2019	12:08:40	LS_ST02	Still	181275_LS_ST02_07	26		298 411	5 937 630	298 416.0	5 937 615.8	15.0	
21/03/2019	12:08:54	LS_ST02	Still	181275_LS_ST02_08	27		298 411	5 937 630	298 416.3	5 937 618.3	12.8	
21/03/2019	12:09:22	LS_ST02	Still	181275_LS_ST02_09	28		298 411	5 937 630	298 417.8	5 937 622.6	10.1	
21/03/2019	12:09:35	LS_ST02	Still	181275_LS_ST02_10	29		298 411	5 937 630	298 417.8	5 937 625.0	8.5	
21/03/2019	12:09:44	LS_ST02	Still	181275_LS_ST02_11	30		298 411	5 937 630	298 416.4	5 937 626.6	6.3	
21/03/2019	12:10:15	LS_ST02	Still	181275_LS_ST02_12	31		298 411	5 937 630	298 415.0	5 937 629.7	4.0	
21/03/2019	12:10:30	LS_ST02	Still	181275_LS_ST02_13	32		298 411	5 937 630	298 413.2	5 937 631.6	2.7	
21/03/2019	12:10:38	LS_ST02	Still	181275_LS_ST02_14	33		298 411	5 937 630	298 412.8	5 937 631.7	2.5	
21/03/2019	12:11:00	LS_ST02	Still	181275_LS_ST02_15	34		298 411	5 937 630	298 411.4	5 937 633.9	3.9	
21/03/2019	12:11:17	LS_ST02	Still	181275_LS_ST02_16	35		298 411	5 937 630	298 409.2	5 937 637.0	7.2	
21/03/2019	12:11:32	LS_ST02	Still	181275_LS_ST02_17	36		298 411	5 937 630	298 407.9	5 937 639.4	9.9	
21/03/2019	12:11:46	LS_ST02	Still	181275_LS_ST02_18	37		298 411	5 937 630	298 407.7	5 937 640.7	11.2	
21/03/2019	12:12:26	LS_ST02	Still	181275_LS_ST02_19	38		298 411	5 937 630	298 410.9	5 937 643.2	13.2	
21/03/2019	12:12:31	LS_ST02	Still	181275_LS_ST02_20	39		298 411	5 937 630	298 411.4	5 937 643.4	13.4	
21/03/2019	12:12:59	LS_ST02	Still	181275_LS_ST02_21	40		298 411	5 937 630	298 412.5	5 937 650.0	20.1	
21/03/2019	12:13:06	LS_ST02	Still	181275_LS_ST02_22	41		298 411	5 937 630	298 412.6	5 937 650.6	20.7	
21/03/2019	12:13:15	LS_ST02	Still	181275_LS_ST02_23	42		298 411	5 937 630	298 411.8	5 937 652.1	22.1	
21/03/2019	12:13:25	LS_ST02	Still	181275_LS_ST02_24	43		298 411	5 937 630	298 412.0	5 937 652.5	22.5	
21/03/2019	12:13:32	LS_ST02	Still	181275_LS_ST02_25	44		298 411	5 937 630	298 412.2	5 937 652.6	22.6	
21/03/2019	12:13:55	LS_ST02	Still	181275_LS_ST02_26	45		298 411	5 937 630	298 413.4	5 937 653.2	23.3	
21/03/2019	12:14:03	LS_ST02	Still	181275_LS_ST02_27	46		298 411	5 937 630	298 413.4	5 937 653.3	23.5	
21/03/2019	12:14:26	LS_ST02	Still	181275_LS_ST02_28	47		298 411	5 937 630	298 412.9	5 937 653.1	23.2	
21/03/2019	12:14:31	LS_ST02	Still	181275_LS_ST02_29	48		298 411	5 937 630	298 413.1	5 937 652.6	22.7	
21/03/2019	12:15:02	LS_ST02	Still	181275_LS_ST02_30	49		298 411	5 937 630	298 410.6	5 937 652.7	22.7	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
21/03/2019	12:15:23	LS_ST02	Still	181275_LS_ST02_31	50		298 411	5 937 630	298 408.6	5 937 654.7	24.8	
21/03/2019	12:15:30	LS_ST02	Still	181275_LS_ST02_32	51		298 411	5 937 630	298 408.3	5 937 655.2	25.3	
21/03/2019	12:15:30	LS_ST02	Video	EOL	-	15.0	298 411	5 937 630	298 408.3	5 937 655.2	25.3	
22/03/2019	12:09:49	LS_ST01	DVV	FA/FB	52	8.6	298 411	5 937 630	296 285.6	5 937 148.2	13.3	
22/03/2019	12:25:32	LS_ST01	DVV	PC	53	8.6	298 411	5 937 630	296 277.1	5 937 144.1	5.2	
23/02/2019	08:57:42	LS_ST02	Still	181275_LS_ST02_01	-		-	-	-	-	-	Site slate
23/02/2019	09:10:44	LS_ST02	Still	181275_LS_ST02_02	200	15	298 411	5 937 630	298 430.7	5 937 554.8	78	
23/02/2019	09:11:21	LS_ST02	Still	181275_LS_ST02_03	201	15	298 411	5 937 630	298 420.8	5 937 596.7	35	
23/02/2019	09:33:26	LS_ST02A	Still	181275_LS_ST02A_01	-		-	-	-	-	-	Site slate
23/02/2019	09:39:30	LS_ST02A	Video	SOL	203	15	298 411	5 937 630	298 398.8	5 937 662.0	34	
23/02/2019	09:39:30	LS_ST02A	Still	181275_LS_ST02A_02	203		298 411	5 937 630	298 398.8	5 937 662.0	34	
23/02/2019	09:39:47	LS_ST02A	Still	181275_LS_ST02A_03	204		298 411	5 937 630	298 395.7	5 937 656.6	31	
23/02/2019	09:40:12	LS_ST02A	Still	181275_LS_ST02A_04	205		298 411	5 937 630	298 393.8	5 937 646.7	24	
23/02/2019	09:41:12	LS_ST02A	Still	181275_LS_ST02A_05	206		298 411	5 937 630	298 387.1	5 937 631.7	24	
23/02/2019	09:41:29	LS_ST02A	Still	181275_LS_ST02A_06	207		298 411	5 937 630	298 384.1	5 937 631.2	27	
23/02/2019	09:41:50	LS_ST02A	Still	181275_LS_ST02A_07	208		298 411	5 937 630	298 383.1	5 937 631.0	28	
23/02/2019	09:42:29	LS_ST02A	Still	181275_LS_ST02A_08	209		298 411	5 937 630	298 385.1	5 937 620.5	28	
23/02/2019	09:42:47	LS_ST02A	Still	181275_LS_ST02A_09	210		298 411	5 937 630	298 389.1	5 937 615.5	26	
23/02/2019	09:43:43	LS_ST02A	Still	181275_LS_ST02A_10	211		298 411	5 937 630	298 395.8	5 937 610.4	25	
23/02/2019	09:43:52	LS_ST02A	Still	181275_LS_ST02A_11	212		298 411	5 937 630	298 396.8	5 937 613.0	22	
23/02/2019	09:45:24	LS_ST02A	Still	181275_LS_ST02A_12	213		298 411	5 937 630	298 398.2	5 937 628.8	13	
23/02/2019	09:46:02	LS_ST02A	Still	181275_LS_ST02A_13	214		298 411	5 937 630	298 401.5	5 937 625.7	11	
23/02/2019	09:47:09	LS_ST02A	Still	181275_LS_ST02A_14	215		298 411	5 937 630	298 408.3	5 937 612.9	17	
23/02/2019	09:47:54	LS_ST02A	Still	181275_LS_ST02A_15	216		298 411	5 937 630	298 416.0	5 937 604.5	26	
23/02/2019	09:47:54	LS_ST02A	Video	EOL	216	15	298 411	5 937 630	298 416.0	5 937 604.5	26	
23/02/2019	10:00:30	LS_ST02	DVV	PC/FA	217	17	298 411	5 937 630	298 426.0	5 937 601.7	32	
23/02/2019	10:26:00	LS_ST02	DVV	FB	218	16	298 411	5 937 630	298 395.1	5 937 617.1	21	
23/02/2019	13:51:17	LS_ST01	Still	181275_LS_ST01_01	-		-	-	-	-	-	Site slate

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
23/02/2019	14:25:48	LS_ST01A	Still	181275_ST01A_01	-		-	-	-	-	-	Site slate
23/02/2019	14:40:18	LS_ST01A	Still	181275_ST01A_02	221	11	296 655	5 937 208	296 631.8	5 937 201.5	24	
23/02/2019	15:07:56	LS_ST01B	Still	181275_LS_ST01B_01	-		-	-	-	-	-	Site slate
23/02/2019	15:13:22	LS_ST01B	Video	SOL	226	11	296 655	5 937 208	296 652.9	5 937 305.4	97	
23/02/2019	15:13:22	LS_ST01B	Still	181275_LS_ST01B_02	226		296 655	5 937 208	296 652.9	5 937 305.4	97	
23/02/2019	15:14:30	LS_ST01B	Still	181275_LS_ST01B_03	228		296 655	5 937 208	296 649.0	5 937 283.4	76	
23/02/2019	15:15:26	LS_ST01B	Still	181275_LS_ST01B_04	229		296 655	5 937 208	296 646.5	5 937 265.4	58	
23/02/2019	15:16:49	LS_ST01B	Still	181275_LS_ST01B_05	230		296 655	5 937 208	296 642.3	5 937 238.9	33	
23/02/2019	15:18:42	LS_ST01B	Still	181275_LS_ST01B_06	231		296 655	5 937 208	296 632.3	5 937 204.8	23	
23/02/2019	15:20:12	LS_ST01B	Still	181275_LS_ST01B_07	234		296 655	5 937 208	296 623.5	5 937 178.8	43	
23/02/2019	15:20:57	LS_ST01B	Still	181275_LS_ST01B_08	235		296 655	5 937 208	296 619.8	5 937 165.9	55	
23/02/2019	15:22:19	LS_ST01B	Still	181275_LS_ST01B_09	236		296 655	5 937 208	296 612.4	5 937 141.9	79	
23/02/2019	15:23:04	LS_ST01B	Still	181275_LS_ST01B_10	237		296 655	5 937 208	296 607.8	5 937 129.1	92	
23/02/2019	15:23:49	LS_ST01B	Still	181275_LS_ST01B_11	238		296 655	5 937 208	296 604.0	5 937 115.4	106	
23/02/2019	15:24:56	LS_ST01B	Still	181275_LS_ST01B_12	239		296 655	5 937 208	296 598.4	5 937 096.2	125	
23/02/2019	15:25:30	LS_ST01B	Still	181275_LS_ST01B_13	240		296 655	5 937 208	296 595.9	5 937 086.4	135	
23/02/2019	15:25:30	LS_ST01B	Video	EOL	240	11	296 655	5 937 208	296 595.9	5 937 086.4	135	
23/02/2019	16:23:10	LS_ST03	Still	181275_LS_ST03_01	-		-	-	-	-	-	Site slate
23/02/2019	16:34:36	LS_ST03	Video	SOL	242	35	303 849	5 938 838	303 870.6	5 938 724.0	116	
23/02/2019	16:34:36	LS_ST03	Still	181275_LS_ST03_02	242		303 849	5 938 838	303 870.6	5 938 724.0	116	
23/02/2019	16:34:56	LS_ST03	Still	181275_LS_ST03_03	243		303 849	5 938 838	303 867.6	5 938 731.1	109	
23/02/2019	16:35:14	LS_ST03	Still	181275_LS_ST03_04	244		303 849	5 938 838	303 865.4	5 938 737.6	102	
23/02/2019	16:35:27	LS_ST03	Still	181275_LS_ST03_05	245		303 849	5 938 838	303 864.6	5 938 742.6	97	
23/02/2019	16:35:41	LS_ST03	Still	181275_LS_ST03_06	246		303 849	5 938 838	303 864.8	5 938 748.4	91	
23/02/2019	16:36:19	LS_ST03	Still	181275_LS_ST03_07	247		303 849	5 938 838	303 870.3	5 938 764.5	77	
23/02/2019	16:36:46	LS_ST03	Still	181275_LS_ST03_08	248		303 849	5 938 838	303 872.3	5 938 781.4	61	
23/02/2019	16:36:56	LS_ST03	Still	181275_LS_ST03_09	249		303 849	5 938 838	303 870.9	5 938 787.5	55	
23/02/2019	16:37:15	LS_ST03	Still	181275_LS_ST03_10	250		303 849	5 938 838	303 867.1	5 938 797.3	45	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
23/02/2019	16:37:32	LS_ST03	Still	181275_LS_ST03_11	251		303 849	5 938 838	303 862.7	5 938 805.0	36	
23/02/2019	16:37:48	LS_ST03	Still	181275_LS_ST03_12	252		303 849	5 938 838	303 858.2	5 938 810.5	29	
23/02/2019	16:38:04	LS_ST03	Still	181275_LS_ST03_13	253		303 849	5 938 838	303 854.4	5 938 815.5	23	
23/02/2019	16:38:21	LS_ST03	Still	181275_LS_ST03_14	254		303 849	5 938 838	303 851.4	5 938 824.1	14	
23/02/2019	16:38:36	LS_ST03	Still	181275_LS_ST03_15	255		303 849	5 938 838	303 850.7	5 938 833.4	5	
23/02/2019	16:39:02	LS_ST03	Still	181275_LS_ST03_16	256		303 849	5 938 838	303 848.1	5 938 847.3	9	
23/02/2019	16:39:13	LS_ST03	Still	181275_LS_ST03_17	257		303 849	5 938 838	303 846.9	5 938 852.5	15	
23/02/2019	16:39:24	LS_ST03	Still	181275_LS_ST03_18	258		303 849	5 938 838	303 845.6	5 938 857.1	19	
23/02/2019	16:39:50	LS_ST03	Still	181275_LS_ST03_19	259		303 849	5 938 838	303 841.8	5 938 865.6	29	
23/02/2019	16:40:05	LS_ST03	Still	181275_LS_ST03_20	260		303 849	5 938 838	303 839.2	5 938 869.1	33	
23/02/2019	16:40:16	LS_ST03	Still	181275_LS_ST03_21	261		303 849	5 938 838	303 837.0	5 938 871.6	36	
23/02/2019	16:40:27	LS_ST03	Still	181275_LS_ST03_22	262		303 849	5 938 838	303 835.2	5 938 873.9	39	
23/02/2019	16:40:38	LS_ST03	Still	181275_LS_ST03_23	263		303 849	5 938 838	303 833.3	5 938 876.9	42	
23/02/2019	16:40:38	LS_ST03	Video	EOL	263	35	303 849	5 938 838	303 833.3	5 938 876.9	42	
23/02/2019	15:07:56	LS_ST01B	Still	181275_LS_ST01B_01	-		-	-	-	-	-	Site slate
23/02/2019	15:13:22	LS_ST01B	Video	SOL	226		296 655	5 937 208	296 652.9	5 937 305.4	97	
23/02/2019	15:13:22	LS_ST01B	Still	181275_LS_ST01B_02	226		296 655	5 937 208	296 652.9	5 937 305.4	97	
23/02/2019	15:14:30	LS_ST01B	Still	181275_LS_ST01B_03	228		296 655	5 937 208	296 649.0	5 937 283.4	76	
23/02/2019	15:15:26	LS_ST01B	Still	181275_LS_ST01B_04	229		296 655	5 937 208	296 646.5	5 937 265.4	58	
23/02/2019	15:16:49	LS_ST01B	Still	181275_LS_ST01B_05	230		296 655	5 937 208	296 642.3	5 937 238.9	33	
23/02/2019	15:18:42	LS_ST01B	Still	181275_LS_ST01B_06	231		296 655	5 937 208	296 632.3	5 937 204.8	23	
23/02/2019	15:20:12	LS_ST01B	Still	181275_LS_ST01B_07	234		296 655	5 937 208	296 623.5	5 937 178.8	43	
23/02/2019	15:20:57	LS_ST01B	Still	181275_LS_ST01B_08	235		296 655	5 937 208	296 619.8	5 937 165.9	55	
23/02/2019	15:22:19	LS_ST01B	Still	181275_LS_ST01B_09	236		296 655	5 937 208	296 612.4	5 937 141.9	79	
23/02/2019	15:23:04	LS_ST01B	Still	181275_LS_ST01B_10	237		296 655	5 937 208	296 607.8	5 937 129.1	92	
23/02/2019	15:23:49	LS_ST01B	Still	181275_LS_ST01B_11	238		296 655	5 937 208	296 604.0	5 937 115.4	106	
23/02/2019	15:24:56	LS_ST01B	Still	181275_LS_ST01B_12	239		296 655	5 937 208	296 598.4	5 937 096.2	125	
23/02/2019	15:25:30	LS_ST01B	Still	181275_LS_ST01B_13	240		296 655	5 937 208	296 595.9	5 937 086.4	135	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
23/02/2019	15:25:30	LS_ST01B	Video	EOL	240	11	296 655	5 937 208	296 595.9	5 937 086.4	135	
23/02/2019	16:23:10	LS_ST03	Still	181275_LS_ST03_01	-		-	-	-	-	-	Site slate
23/02/2019	16:34:36	LS_ST03	Video	SOL	242	35	303 849	5 938 838	303 870.6	5 938 724.0	116	
23/02/2019	16:34:36	LS_ST03	Still	181275_LS_ST03_02	242	35	303 849	5 938 838	303 870.6	5 938 724.0	116	
23/02/2019	16:34:56	LS_ST03	Still	181275_LS_ST03_03	243		303 849	5 938 838	303 867.6	5 938 731.1	109	
23/02/2019	16:35:14	LS_ST03	Still	181275_LS_ST03_04	244		303 849	5 938 838	303 865.4	5 938 737.6	102	
23/02/2019	16:35:27	LS_ST03	Still	181275_LS_ST03_05	245		303 849	5 938 838	303 864.6	5 938 742.6	97	
23/02/2019	16:35:41	LS_ST03	Still	181275_LS_ST03_06	246		303 849	5 938 838	303 864.8	5 938 748.4	91	
23/02/2019	16:36:19	LS_ST03	Still	181275_LS_ST03_07	247		303 849	5 938 838	303 870.3	5 938 764.5	77	
23/02/2019	16:36:46	LS_ST03	Still	181275_LS_ST03_08	248		303 849	5 938 838	303 872.3	5 938 781.4	61	
23/02/2019	16:36:56	LS_ST03	Still	181275_LS_ST03_09	249		303 849	5 938 838	303 870.9	5 938 787.5	55	
23/02/2019	16:37:15	LS_ST03	Still	181275_LS_ST03_10	250		303 849	5 938 838	303 867.1	5 938 797.3	45	
23/02/2019	16:37:32	LS_ST03	Still	181275_LS_ST03_11	251		303 849	5 938 838	303 862.7	5 938 805.0	36	
23/02/2019	16:37:48	LS_ST03	Still	181275_LS_ST03_12	252		303 849	5 938 838	303 858.2	5 938 810.5	29	
23/02/2019	16:38:04	LS_ST03	Still	181275_LS_ST03_13	253		303 849	5 938 838	303 854.4	5 938 815.5	23	
23/02/2019	16:38:21	LS_ST03	Still	181275_LS_ST03_14	254		303 849	5 938 838	303 851.4	5 938 824.1	14	
23/02/2019	16:38:36	LS_ST03	Still	181275_LS_ST03_15	255		303 849	5 938 838	303 850.7	5 938 833.4	5	
23/02/2019	16:39:02	LS_ST03	Still	181275_LS_ST03_16	256		303 849	5 938 838	303 848.1	5 938 847.3	9	
23/02/2019	16:39:13	LS_ST03	Still	181275_LS_ST03_17	257		303 849	5 938 838	303 846.9	5 938 852.5	15	
23/02/2019	16:39:24	LS_ST03	Still	181275_LS_ST03_18	258		303 849	5 938 838	303 845.6	5 938 857.1	19	
23/02/2019	16:39:50	LS_ST03	Still	181275_LS_ST03_19	259		303 849	5 938 838	303 841.8	5 938 865.6	29	
23/02/2019	16:40:05	LS_ST03	Still	181275_LS_ST03_20	260		303 849	5 938 838	303 839.2	5 938 869.1	33	
23/02/2019	16:40:16	LS_ST03	Still	181275_LS_ST03_21	261		303 849	5 938 838	303 837.0	5 938 871.6	36	
23/02/2019	16:40:27	LS_ST03	Still	181275_LS_ST03_22	262		303 849	5 938 838	303 835.2	5 938 873.9	39	
23/02/2019	16:40:38	LS_ST03	Still	181275_LS_ST03_23	263		303 849	5 938 838	303 833.3	5 938 876.9	42	
23/02/2019	16:40:38	LS_ST03	Video	EOL	263	35	303 849	5 938 838	303 833.3	5 938 876.9	42	
23/02/2019	17:00:32	LS_ST03	DVV	NS/NS	264	34	303 849	5 938 838	303 831.7	5 938 833.1	18	
23/02/2019	17:16:30	LS_ST03	DVV	NS/NS	265	34	303 849	5 938 838	303 874.5	5 938 836.5	26	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
23/02/2019	17:36:03	LS_ST03	DVV	NS/NS	266	33	303 849	5 938 838	303 843.4	5 938 833.9	7	
23/02/2019	17:46:48	LS_ST03	DVV	NS/NS	267	33	303 849	5 938 838	303 862.7	5 938 819.2	23	
23/02/2019	17:53:50	LS_ST03	DVV	NS/NS	268	33	303 849	5 938 838	303 858.8	5 938 799.8	40	
23/02/2019	18:35:00	LS_ST03	DVV	PC/FA	269	32	303 849	5 938 838	303 889.9	5 938 821.5	44	
23/02/2019	18:54:40	LS_ST03	DVV	NS/NS	270	33	303 849	5 938 838	303 835.1	5 938 852.6	20	
23/02/2019	18:55:33	LS_ST03	DVV	NS/NS	271	32	303 849	5 938 838	303 836.5	5 938 847.2	16	
23/02/2019	19:05:29	LS_ST03	DVV	FB	272	32	303 849	5 938 838	303 829.1	5 938 867.0	35	
23/02/2019	20:03:59	LS_ST04	Still	181275_LS_ST04_01	-		-	-	-	-	-	Site slate
23/02/2019	20:25:48	LS_ST04	Video	SOL	274	41	307 143	5 939 833	307 144.3	5 939 797.0	36	
23/02/2019	20:25:48	LS_ST04	Still	181274_LS_ST04_02	274		307 143	5 939 833	307 144.3	5 939 797.0	36	
23/02/2019	20:26:19	LS_ST04	Still	181274_LS_ST04_03	275		307 143	5 939 833	307 143.3	5 939 803.8	29	
23/02/2019	20:26:34	LS_ST04	Still	181274_LS_ST04_04	276		307 143	5 939 833	307 143.0	5 939 807.5	26	
23/02/2019	20:26:50	LS_ST04	Still	181274_LS_ST04_05	277		307 143	5 939 833	307 142.4	5 939 811.9	21	
23/02/2019	20:27:03	LS_ST04	Still	181274_LS_ST04_06	278		307 143	5 939 833	307 141.9	5 939 815.5	18	
23/02/2019	20:27:14	LS_ST04	Still	181274_LS_ST04_07	279		307 143	5 939 833	307 141.5	5 939 818.3	15	
23/02/2019	20:27:33	LS_ST04	Still	181274_LS_ST04_08	280		307 143	5 939 833	307 140.9	5 939 823.0	10	
23/02/2019	20:27:52	LS_ST04	Still	181274_LS_ST04_09	281		307 143	5 939 833	307 140.5	5 939 827.6	6	
23/02/2019	20:28:10	LS_ST04	Still	181274_LS_ST04_10	282		307 143	5 939 833	307 139.5	5 939 831.0	4	
23/02/2019	20:28:29	LS_ST04	Still	181274_LS_ST04_11	283		307 143	5 939 833	307 138.8	5 939 835.8	5	
23/02/2019	20:28:45	LS_ST04	Still	181274_LS_ST04_12	284		307 143	5 939 833	307 138.4	5 939 839.6	8	
23/02/2019	20:29:34	LS_ST04	Still	181274_LS_ST04_13	286		307 143	5 939 833	307 137.4	5 939 852.9	21	
23/02/2019	20:29:46	LS_ST04	Still	181274_LS_ST04_14	287		307 143	5 939 833	307 136.8	5 939 856.2	24	
23/02/2019	20:30:00	LS_ST04	Still	181274_LS_ST04_15	288		307 143	5 939 833	307 136.4	5 939 859.7	28	
23/02/2019	20:30:11	LS_ST04	Still	181274_LS_ST04_16	289		307 143	5 939 833	307 136.0	5 939 862.3	30	
23/02/2019	20:30:43	LS_ST04	Still	181274_LS_ST04_17	290		307 143	5 939 833	307 134.4	5 939 872.3	40	
23/02/2019	20:31:03	LS_ST04	Still	181274_LS_ST04_18	291		307 143	5 939 833	307 133.8	5 939 878.1	46	
23/02/2019	20:31:14	LS_ST04	Still	181274_LS_ST04_19	292		307 143	5 939 833	307 133.1	5 939 881.0	49	
23/02/2019	20:31:14	LS_ST04	Video	EOL	292	41	307 143	5 939 833	307 133.1	5 939 881.0	49	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
23/02/2019	20:48:32	LS_ST04	DVV	PC/FA	293	41	307 143	5 939 833	307 185.5	5 939 829.5	43	
23/02/2019	21:04:36	LS_ST04	DVV	FB	294	42	307 143	5 939 833	307 129.0	5 939 813.1	24	
23/02/2019	-	LS_ST05	Still	181275_LS_ST05_01	-		-	-	-	-	-	Site slate
23/02/2019	22:03:51	LS_ST05	Video	SOL	295	66	314 915	5943502	314920.0	5943457.1	45	
23/02/2019	22:03:51	LS_ST05	Still	181275_LS_ST05_02	295		314 915	5943502	314920.0	5943457.1	45	
23/02/2019	22:04:05	LS_ST05	Still	181275_LS_ST05_03	296		314 915	5943502	314917.9	5943464.6	38	
23/02/2019	22:04:15	LS_ST05	Still	181275_LS_ST05_04	297		314 915	5943502	314916.5	5943471.4	31	
23/02/2019	22:04:36	LS_ST05	Still	181275_LS_ST05_05	298		314 915	5943502	314913.6	5943484.3	18	
23/02/2019	22:04:53	LS_ST05	Still	181275_LS_ST05_06	299		314 915	5943502	314911.6	5943493.6	9	
23/02/2019	22:05:02	LS_ST05	Still	181275_LS_ST05_07	300		314 915	5943502	314909.8	5943499.7	6	
23/02/2019	22:05:13	LS_ST05	Still	181275_LS_ST05_08	301		314 915	5943502	314908.2	5943506.5	8	
23/02/2019	22:05:25	LS_ST05	Still	181275_LS_ST05_09	302		314 915	5943502	314906.5	5943513.6	14	
23/02/2019	22:05:36	LS_ST05	Still	181275_LS_ST05_10	303		314 915	5943502	314905.1	5943520.1	21	
23/02/2019	22:05:55	LS_ST05	Still	181275_LS_ST05_11	304		314 915	5943502	314902.7	5943531.5	32	
23/02/2019	22:06:17	LS_ST05	Still	181275_LS_ST05_12	305		314 915	5943502	314900.2	5943543.5	44	
23/02/2019	22:06:27	LS_ST05	Still	181275_LS_ST05_13	306		314 915	5943502	314898.4	5943550.7	52	
23/02/2019	22:06:43	LS_ST05	Still	181275_LS_ST05_14	307		314 915	5943502	314896.6	5943560.6	61	
23/02/2019	22:07:06	LS_ST05	Still	181275_LS_ST05_15	308		314 915	5943502	314893.7	5943574.0	75	
23/02/2019	22:07:18	LS_ST05	Still	181275_LS_ST05_16	309		314 915	5943502	314891.9	5943580.8	82	
23/02/2019	22:07:44	LS_ST05	Still	181275_LS_ST05_17	310		314 915	5943502	314888.9	5943595.5	97	
23/02/2019	22:07:58	LS_ST05	Still	181275_LS_ST05_18	311		314 915	5943502	314887.1	5943603.0	105	
23/02/2019	22:08:17	LS_ST05	Still	181275_LS_ST05_19	312		314 915	5943502	314885.0	5943613.9	116	
23/02/2019	22:08:17	LS_ST05	Video	EOL	312	65.7	314 915	5943502	314885.0	5943613.9	116	
23/02/2019	22:31:26	LS_ST05	DVV	PC/FA	313	66.2	314 915	5943502	314900.5	5943474.5	31	
23/02/2019	22:50:31	LS_ST05	DVV	NS/NS	314	66.8	314 915	5943502	314910.4	5943498.5	6	
23/02/2019	22:59:26	LS_ST05	DVV	FB	315	66.3	314 915	5943502	314912.6	5943512.4	11	
24/02/2019	02:00:16	CC05_T01	Still	181275_CC05_T01_01	-		-	-	-	-	-	Site slate
24/02/2019	02:17:17	CC05_T01A	Still	181275_CC05_T01A_01	-		-	-	-	-	-	Site slate

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
24/02/2019	02:29:09	CC05_T01A	Video	SOL	318	83.0	346 662	5 957 525	347 174.7	5 957 085.5	675	
24/02/2019	02:29:09	CC05_T01A	Still	181275_CC05_T01A_02	318		346 662	5 957 525	347 174.7	5 957 085.5	675	
24/02/2019	02:29:41	CC05_T01A	Still	181275_CC05_T01A_03	319		346 662	5 957 525	347 164.0	5 957 092.9	662	
24/02/2019	02:30:08	CC05_T01A	Still	181275_CC05_T01A_04	320		346 662	5 957 525	347 156.0	5 957 098.2	652	
24/02/2019	02:30:47	CC05_T01A	Still	181275_CC05_T01A_05	321		346 662	5 957 525	347 144.7	5 957 106.2	639	
24/02/2019	02:31:16	CC05_T01A	Still	181275_CC05_T01A_06	322		346 662	5 957 525	347 136.0	5 957 113.1	627	
24/02/2019	02:31:27	CC05_T01A	Still	181275_CC05_T01A_07	323		346 662	5 957 525	347 132.0	5 957 116.1	623	
24/02/2019	02:31:48	CC05_T01A	Still	181275_CC05_T01A_08	324		346 662	5 957 525	347 125.7	5 957 121.6	614	
24/02/2019	02:32:01	CC05_T01A	Still	181275_CC05_T01A_09	325		346 662	5 957 525	347 121.7	5 957 124.6	609	
24/02/2019	02:32:21	CC05_T01A	Still	181275_CC05_T01A_10	326		346 662	5 957 525	347 115.6	5 957 129.8	601	
24/02/2019	02:32:36	CC05_T01A	Still	181275_CC05_T01A_11	327		346 662	5 957 525	347 111.0	5 957 134.2	595	
24/02/2019	02:32:44	CC05_T01A	Still	181275_CC05_T01A_12	328		346 662	5 957 525	347 108.1	5 957 136.7	591	
24/02/2019	02:33:01	CC05_T01A	Still	181275_CC05_T01A_13	329		346 662	5 957 525	347 103.3	5 957 141.1	584	
24/02/2019	02:33:19	CC05_T01A	Still	181275_CC05_T01A_14	330		346 662	5 957 525	347 097.7	5 957 146.4	577	
24/02/2019	02:33:33	CC05_T01A	Still	181275_CC05_T01A_15	331		346 662	5 957 525	347 093.9	5 957 149.4	572	
24/02/2019	02:33:45	CC05_T01A	Still	181275_CC05_T01A_16	332		346 662	5 957 525	347 089.8	5 957 153.4	566	
24/02/2019	02:34:09	CC05_T01A	Still	181275_CC05_T01A_17	333		346 662	5 957 525	347 083.0	5 957 158.7	558	
24/02/2019	02:34:54	CC05_T01A	Still	181275_CC05_T01A_18	334		346 662	5 957 525	347 071.2	5 957 168.9	542	
24/02/2019	02:36:05	CC05_T01A	Still	181275_CC05_T01A_19	335		346 662	5 957 525	347 050.0	5 957 184.9	515	
24/02/2019	02:36:22	CC05_T01A	Still	181275_CC05_T01A_20	336		346 662	5 957 525	347 044.8	5 957 188.6	509	
24/02/2019	02:36:38	CC05_T01A	Still	181275_CC05_T01A_21	337		346 662	5 957 525	347 039.5	5 957 192.7	502	
24/02/2019	02:36:53	CC05_T01A	Still	181275_CC05_T01A_22	338		346 662	5 957 525	347 035.0	5 957 196.0	497	
24/02/2019	02:37:30	CC05_T01A	Still	181275_CC05_T01A_23	339		346 662	5 957 525	347 022.8	5 957 205.3	482	
24/02/2019	02:37:56	CC05_T01A	Still	181275_CC05_T01A_24	340		346 662	5 957 525	347 014.5	5 957 212.1	471	
24/02/2019	02:38:10	CC05_T01A	Still	181275_CC05_T01A_25	341		346 662	5 957 525	347 010.1	5 957 215.9	465	
24/02/2019	02:38:29	CC05_T01A	Still	181275_CC05_T01A_26	342		346 662	5 957 525	347 003.6	5 957 220.6	457	
24/02/2019	02:39:14	CC05_T01A	Still	181275_CC05_T01A_27	343		346 662	5 957 525	346 988.9	5 957 232.8	438	
24/02/2019	02:39:25	CC05_T01A	Still	181275_CC05_T01A_28	344		346 662	5 957 525	346 985.2	5 957 235.3	434	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
24/02/2019	02:40:05	CC05_T01A	Still	181275_CC05_T01A_29	345		346 662	5 957 525	346 972.9	5 957 244.8	418	
24/02/2019	02:40:38	CC05_T01A	Still	181275_CC05_T01A_30	346		346 662	5 957 525	346 963.1	5 957 252.5	406	
24/02/2019	02:41:03	CC05_T01A	Still	181275_CC05_T01A_31	347		346 662	5 957 525	346 956.5	5 957 258.1	397	
24/02/2019	02:41:46	CC05_T01A	Still	181275_CC05_T01A_32	348		346 662	5 957 525	346 944.2	5 957 270.0	380	
24/02/2019	02:42:12	CC05_T01A	Still	181275_CC05_T01A_33	349		346 662	5 957 525	346 937.3	5 957 276.7	370	
24/02/2019	02:43:33	CC05_T01A	Still	181275_CC05_T01A_34	351		346 662	5 957 525	346 914.6	5 957 299.7	338	
24/02/2019	02:43:59	CC05_T01A	Still	181275_CC05_T01A_35	352		346 662	5 957 525	346 906.6	5 957 306.4	328	
24/02/2019	02:44:40	CC05_T01A	Still	181275_CC05_T01A_36	353		346 662	5 957 525	346 894.1	5 957 318.2	310	
24/02/2019	02:45:34	CC05_T01A	Still	181275_CC05_T01A_37	354		346 662	5 957 525	346 877.8	5 957 333.0	288	
24/02/2019	02:46:13	CC05_T01A	Still	181275_CC05_T01A_38	355		346 662	5 957 525	346 864.8	5 957 342.5	272	
24/02/2019	02:46:51	CC05_T01A	Still	181275_CC05_T01A_39	356		346 662	5 957 525	346 852.3	5 957 350.6	258	
24/02/2019	02:47:24	CC05_T01A	Still	181275_CC05_T01A_40	357		346 662	5 957 525	346 841.9	5 957 357.7	245	
24/02/2019	02:48:20	CC05_T01A	Still	181275_CC05_T01A_41	358		346 662	5 957 525	346 824.9	5 957 370.5	224	
24/02/2019	02:48:43	CC05_T01A	Still	181275_CC05_T01A_42	359		346 662	5 957 525	346 817.8	5 957 375.6	215	
24/02/2019	02:49:21	CC05_T01A	Still	181275_CC05_T01A_43	360		346 662	5 957 525	346 805.2	5 957 386.6	199	
24/02/2019	02:49:48	CC05_T01A	Still	181275_CC05_T01A_44	361		346 662	5 957 525	346 796.8	5 957 393.1	188	
24/02/2019	02:50:23	CC05_T01A	Still	181275_CC05_T01A_45	362		346 662	5 957 525	346 785.9	5 957 401.9	174	
24/02/2019	02:51:07	CC05_T01A	Still	181275_CC05_T01A_46	363		346 662	5 957 525	346 772.0	5 957 414.2	156	
24/02/2019	02:51:36	CC05_T01A	Still	181275_CC05_T01A_47	364		346 662	5 957 525	346 762.8	5 957 422.7	143	
24/02/2019	02:52:19	CC05_T01A	Still	181275_CC05_T01A_48	365		346 662	5 957 525	346 748.0	5 957 434.1	125	
24/02/2019	02:52:51	CC05_T01A	Still	181275_CC05_T01A_49	366		346 662	5 957 525	346 737.0	5 957 441.4	112	
24/02/2019	02:53:17	CC05_T01A	Still	181275_CC05_T01A_50	367		346 662	5 957 525	346 728.7	5 957 446.7	102	
24/02/2019	02:53:46	CC05_T01A	Still	181275_CC05_T01A_51	368		346 662	5 957 525	346 719.8	5 957 451.9	93	
24/02/2019	02:54:23	CC05_T01A	Still	181275_CC05_T01A_52	369		346 662	5 957 525	346 706.7	5 957 457.5	81	
24/02/2019	02:54:39	CC05_T01A	Still	181275_CC05_T01A_53	370		346 662	5 957 525	346 701.3	5 957 460.8	75	
24/02/2019	02:55:16	CC05_T01A	Still	181275_CC05_T01A_54	371		346 662	5 957 525	346 687.2	5 957 469.7	60	
24/02/2019	02:55:36	CC05_T01A	Still	181275_CC05_T01A_55	372		346 662	5 957 525	346 680.2	5 957 476.1	52	
24/02/2019	02:56:18	CC05_T01A	Still	181275_CC05_T01A_56	373		346 662	5 957 525	346 668.2	5 957 493.7	32	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
24/02/2019	02:57:25	CC05_T01A	Still	181275_CC05_T01A_57	374		346 662	5 957 525	346 650.2	5 957 526.1	12	
24/02/2019	02:58:04	CC05_T01A	Still	181275_CC05_T01A_58	375		346 662	5 957 525	346 640.7	5 957 546.1	31	
24/02/2019	02:58:22	CC05_T01A	Still	181275_CC05_T01A_59	376		346 662	5 957 525	346 636.0	5 957 555.2	40	
24/02/2019	02:58:36	CC05_T01A	Still	181275_CC05_T01A_60	377		346 662	5 957 525	346 631.9	5 957 562.3	49	
24/02/2019	02:59:15	CC05_T01A	Still	181275_CC05_T01A_61	378		346 662	5 957 525	346 618.7	5 957 578.4	69	
24/02/2019	02:59:36	CC05_T01A	Still	181275_CC05_T01A_62	379		346 662	5 957 525	346 612.2	5 957 585.7	79	
24/02/2019	03:00:05	CC05_T01A	Still	181275_CC05_T01A_63	380		346 662	5 957 525	346 601.7	5 957 592.9	91	
24/02/2019	03:01:16	CC05_T01A	Still	181275_CC05_T01A_64	381		346 662	5 957 525	346 575.7	5 957 606.7	119	
24/02/2019	03:01:42	CC05_T01A	Still	181275_CC05_T01A_65	382		346 662	5 957 525	346 566.2	5 957 611.3	130	
24/02/2019	03:02:08	CC05_T01A	Still	181275_CC05_T01A_66	383		346 662	5 957 525	346 556.1	5 957 615.2	140	
24/02/2019	03:02:36	CC05_T01A	Still	181275_CC05_T01A_67	384		346 662	5 957 525	346 546.3	5 957 619.1	150	
24/02/2019	03:02:47	CC05_T01A	Still	181275_CC05_T01A_68	385		346 662	5 957 525	346 542.0	5 957 621.4	154	
24/02/2019	03:02:47	CC05_T01A	Video	EOL	385	82	346 662	5 957 525	346 542.0	5 957 621.4	154	
24/02/2019	03:16:20	CC05_T02	Still	181275_CC05_T02_01	-		-	-	-	-	-	Site slate
24/02/2019	03:26:17	CC05_T02	Video	SOL	387	82	346 662	5 957 525	346 779.4	5 957 515.0	117	
24/02/2019	03:26:17	CC05_T02	Still	181275_CC05_T02_02	387		346 662	5 957 525	346 779.4	5 957 515.0	117	
24/02/2019	03:26:50	CC05_T02	Still	181275_CC05_T02_03	388		346 662	5 957 525	346 761.5	5 957 519.3	99	
24/02/2019	03:27:04	CC05_T02	Still	181275_CC05_T02_04	NF		346 662	5 957 525	-	-	-	
24/02/2019	03:27:25	CC05_T02	Still	181275_CC05_T02_05	389		346 662	5 957 525	346 742.8	5 957 522.8	80	
24/02/2019	03:27:40	CC05_T02	Still	181275_CC05_T02_06	390		346 662	5 957 525	346 735.8	5 957 524.7	73	
24/02/2019	03:27:55	CC05_T02	Still	181275_CC05_T02_07	391		346 662	5 957 525	346 727.8	5 957 525.9	65	
24/02/2019	03:28:13	CC05_T02	Still	181275_CC05_T02_08	392		346 662	5 957 525	346 719.8	5 957 526.9	57	
24/02/2019	03:28:26	CC05_T02	Still	181275_CC05_T02_09	393		346 662	5 957 525	346 713.7	5 957 528.0	51	
24/02/2019	03:28:40	CC05_T02	Still	181275_CC05_T02_10	394		346 662	5 957 525	346 707.8	5 957 527.5	45	
24/02/2019	03:29:06	CC05_T02	Still	181275_CC05_T02_11	395		346 662	5 957 525	346 696.0	5 957 528.6	34	
24/02/2019	03:29:38	CC05_T02	Still	181275_CC05_T02_12	396		346 662	5 957 525	346 682.4	5 957 531.2	21	
24/02/2019	03:30:11	CC05_T02	Still	181275_CC05_T02_13	397		346 662	5 957 525	346 668.2	5 957 531.7	9	
24/02/2019	03:30:31	CC05_T02	Still	181275_CC05_T02_14	398		346 662	5 957 525	346 660.2	5 957 531.6	7	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
24/02/2019	03:31:05	CC05_T02	Still	181275_CC05_T02_15	399		346 662	5 957 525	346 646.3	5 957 530.8	17	
24/02/2019	03:31:26	CC05_T02	Still	181275_CC05_T02_16	400		346 662	5 957 525	346 637.4	5 957 529.5	26	
24/02/2019	03:32:06	CC05_T02	Still	181275_CC05_T02_17	401		346 662	5 957 525	346 621.3	5 957 527.7	41.2	
24/02/2019	03:32:33	CC05_T02	Still	181275_CC05_T02_18	402		346 662	5 957 525	346 610.0	5 957 525.2	52.4	
24/02/2019	03:33:03	CC05_T02	Still	181275_CC05_T02_19	403		346 662	5 957 525	346 597.3	5 957 521.2	65.2	
24/02/2019	03:33:38	CC05_T02	Still	181275_CC05_T02_20	404		346 662	5 957 525	346 581.9	5 957 517.2	80.9	
24/02/2019	03:34:29	CC05_T02	Still	181275_CC05_T02_21	405		346 662	5 957 525	346 562.0	5 957 512.0	101.3	
24/02/2019	03:34:56	CC05_T02	Still	181275_CC05_T02_22	406		346 662	5 957 525	346 550.0	5 957 509.7	113.4	
24/02/2019	03:35:22	CC05_T02	Still	181275_CC05_T02_23	407		346 662	5 957 525	346 539.7	5 957 506.5	124.1	
24/02/2019	03:35:46	CC05_T02	Still	181275_CC05_T02_24	408		346 662	5 957 525	346 528.8	5 957 505.1	135.1	
24/02/2019	03:36:22	CC05_T02	Still	181275_CC05_T02_25	409		346 662	5 957 525	346 513.1	5 957 502.3	151.0	
24/02/2019	03:36:31	CC05_T02	Still	181275_CC05_T02_26	410		346 662	5 957 525	346 508.0	5 957 501.8	156.1	
24/02/2019	03:36:31	CC05_T02	Video	EOL	410	82	346 662	5 957 525	346 508.0	5 957 501.8	156.1	
24/02/2019	03:43:58	CC05_ST01	Still	181275_CC05_ST01_01	-							Site slate
24/02/2019	03:57:10	CC05_ST01	Video	SOL	412	82	346 363	5 957 528	346 266.4	5 957 592.1	115.5	
24/02/2019	03:57:10	CC05_ST01	Still	181275_CC05_ST01_02	412		346 363	5 957 528	346 266.4	5 957 592.1	115.5	
24/02/2019	03:58:06	CC05_ST01	Still	181275_CC05_ST01_03	413		346 363	5 957 528	346 276.1	5 957 576.5	99.1	
24/02/2019	03:58:22	CC05_ST01	Still	181275_CC05_ST01_04	414		346 363	5 957 528	346 278.7	5 957 571.8	94.6	
24/02/2019	03:58:47	CC05_ST01	Still	181275_CC05_ST01_05	415		346 363	5 957 528	346 281.0	5 957 564.7	89.4	
24/02/2019	03:59:05	CC05_ST01	Still	181275_CC05_ST01_06	416		346 363	5 957 528	346 281.2	5 957 560.3	87.5	
24/02/2019	04:00:10	CC05_ST01	Still	181275_CC05_ST01_07	417		346 363	5 957 528	346 274.3	5 957 560.0	93.8	
24/02/2019	04:02:19	CC05_ST01	Still	181275_CC05_ST01_08	418		346 363	5 957 528	346 250.4	5 957 582.9	124.8	
24/02/2019	04:02:29	CC05_ST01	Still	181275_CC05_ST01_09	419		346 363	5 957 528	346 249.5	5 957 584.7	126.4	
24/02/2019	04:03:19	CC05_ST01	Still	181275_CC05_ST01_10	420		346 363	5 957 528	346 250.1	5 957 591.7	129.1	
24/02/2019	04:05:25	CC05_ST01	Still	181275_CC05_ST01_11	421		346 363	5 957 528	346 259.1	5 957 591.9	121.5	
24/02/2019	04:08:03	CC05_ST01	Still	181275_CC05_ST01_12	422		346 363	5 957 528	346 285.3	5 957 575.1	90.5	
24/02/2019	04:08:38	CC05_ST01	Still	181275_CC05_ST01_13	423		346 363	5 957 528	346 292.3	5 957 570.0	81.8	
24/02/2019	04:09:21	CC05_ST01	Still	181275_CC05_ST01_14	424		346 363	5 957 528	346 302.0	5 957 561.6	69.2	

Geodetic Parameters: WGS84, UTM 30N												
Date	Time [UTC]	Transect/ Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m BSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
24/02/2019	04:10:16	CC05_ST01	Still	181275_CC05_ST01_15	425		346 363	5 957 528	346 314.7	5 957 556.8	55.8	
24/02/2019	04:10:42	CC05_ST01	Still	181275_CC05_ST01_16	426		346 363	5 957 528	346 320.9	5 957 556.0	50.1	
24/02/2019	04:11:24	CC05_ST01	Still	181275_CC05_ST01_17	427		346 363	5 957 528	346 330.4	5 957 556.0	42.6	
24/02/2019	04:11:51	CC05_ST01	Still	181275_CC05_ST01_18	428		346 363	5 957 528	346 335.4	5 957 554.5	37.9	
24/02/2019	04:12:31	CC05_ST01	Still	181275_CC05_ST01_19	429		346 363	5 957 528	346 342.1	5 957 552.1	31.5	
24/02/2019	04:13:32	CC05_ST01	Still	181275_CC05_ST01_20	430		346 363	5 957 528	346 350.1	5 957 544.4	20.5	
24/02/2019	04:15:53	CC05_ST01	Still	181275_CC05_ST01_21	431		346 363	5 957 528	346 373.4	5 957 518.8	14.3	
24/02/2019	04:16:07	CC05_ST01	Still	181275_CC05_ST01_22	432		346 363	5 957 528	346 376.1	5 957 516.1	18.1	
24/02/2019	04:16:27	CC05_ST01	Still	181275_CC05_ST01_23	433		346 363	5 957 528	346 379.3	5 957 513.5	22.3	
24/02/2019	04:16:38	CC05_ST01	Still	181275_CC05_ST01_24	434		346 363	5 957 528	346 380.9	5 957 511.6	24.7	
24/02/2019	04:16:59	CC05_ST01	Still	181275_CC05_ST01_25	435		346 363	5 957 528	346 384.2	5 957 509.9	28.3	
24/02/2019	04:17:09	CC05_ST01	Still	181275_CC05_ST01_26	436		346 363	5 957 528	346 385.9	5 957 508.6	30.4	
24/02/2019	04:17:09	CC05_ST01	Video	EOL	436		346 363	5 957 528	346 385.9	5 957 508.6	30.4	
24/02/2019	04:42:59	CC05_ST01	DVV	PC/FA	437	81	346 363	5 957 528	346 332.3	5 957 528.3	30.3	
24/02/2019	05:06:38	CC05_ST01	DVV	FB	438	81	346 363	5 957 528	346 339.6	5 957 506.9	31.3	

Notes:

UTC = Coordinated Universal Time
BSL = Below sea level
SOL = Start of line
NF = No fix
EOL = End of line
DVV = Dual van Veen grab
FA/FB = Fauna sample FA or FB
PC = Physico-chemical sample
NS = No sample

C.2 GRAB LOG

Date	Time [UTC]	Station	Sample Rep	Fix No.	Sample Volume [cm]	Sediment Description	Comments (fauna, smell, bioturbation, debris)
22/03/2019	12:09:00	LS_ST01	FA	52	12	Muddy sand	Anoxic streaks
22/03/2019	12:09:00	LS_ST01	FB	52	7	Muddy sand	Anoxic streaks
22/03/2019	12:25:00	LS_ST01	PC	53	15	Muddy sand	Anoxic streaks
23/02/2019	10:00:30	LS_ST02	PC	217	14	Muddy sand	1 cm depth anoxic layer, H_2S smell
23/02/2019	10:00:30	LS_ST02	FA	217	12	Muddy sand	1 cm depth anoxic layer, H_2S smell; brittlestars (Ophiuroidea)
23/02/2019	10:26:00	LS_ST02	FB	218	10	Muddy sand	1 cm anoxic depth; brittlestars (Ophiuroidea) and sea urchin (Brissidina)
23/02/2019	17:00:32	LS_ST03	NS	264	0		Water only
23/02/2019	17:00:32	LS_ST03	NS	264	0		Water only
23/02/2019	17:16:30	LS_ST03	NS	265	5	Sandy mud	
23/02/2019	17:16:30	LS_ST03	NS	265	6	Sandy mud	
23/02/2019	17:36:03	LS_ST03	NS	266	0		Water only
23/02/2019	17:36:03	LS_ST03	NS	266	0		Water only
23/02/2019	17:46:48	LS_ST03	NS	267	0		Water only
23/02/2019	17:46:48	LS_ST03	NS	267	0		Water only
23/02/2019	17:53:50	LS_ST03	NS	268	0		Water only
23/02/2019	17:53:50	LS_ST03	NS	268	0		Water only
23/02/2019	18:35:00	LS_ST03	PC	269	13	Sandy mud	
23/02/2019	18:35:00	LS_ST03	FA	269	9	Sandy mud	Bivalves, brittlestars (Ophiuroidea)
23/02/2019	18:54:40	LS_ST03	NS	270	7		Not triggered
23/02/2019	18:54:40	LS_ST03	NS	270	0		Not triggered
23/02/2019	18:55:33	LS_ST03	NS	271	0		Water only
23/02/2019	18:55:33	LS_ST03	NS	271	0		Water only
23/02/2019	19:05:29	LS_ST03	FB	272	13	Sandy mud	Bivalves, brittlestars (Ophiuroidea) and sea urchin (Brissidina)
23/02/2019	20:48:32	LS_ST04	PC	293	12	Mud	1 cm Anoxic depth
23/02/2019	20:48:32	LS_ST04	FA	293	11	Mud	1 cm anoxic depth; bivalves, brittlestars (Ophiuroidea) and sea urchin (Brissidina)
23/02/2019	21:04:36	LS_ST04	FB	294	14	Mud	1 cm anoxic depth; H_2S; bivalves and brittlestars (Ophiuroidea)
23/02/2019	22:31:26	LS_ST05	PC	313	20	Mud	

Date	Time [UTC]	Station	Sample Rep	Fix No.	Sample Volume [cm]	Sediment Description	Comments (fauna, smell, bioturbation, debris)
23/02/2019	22:31:26	LS_ST05	FA	313	20	Mud	
23/02/2019	22:50:31	LS_ST05	NS	314	0		Water only
23/02/2019	22:50:31	LS_ST05	NS	314	0		
23/02/2019	22:59:26	LS_ST05	FB	315	20	Mud	
24/02/2019	04:42:59	CC05_ST01	PC	437	16	Mud	1 cm Anoxic layer depth, Turritellidae shells
24/02/2019	04:42:59	CC05_ST01	FA	437	15	Mud and clay	1 cm Anoxic layer depth, Turritellidae shells
24/02/2019	05:06:38	CC05_ST01	FB	438	16	Mud	1 cm Anoxic layer depth, Turritellidae shells

Notes:
UTC = Coordinated Universal Time
FA/FB = Faunal sample FA or FB
PC = Physico-chemical sample
NS = No sample

C.3 VIDEO AND PHOTOGRAPHIC LOG

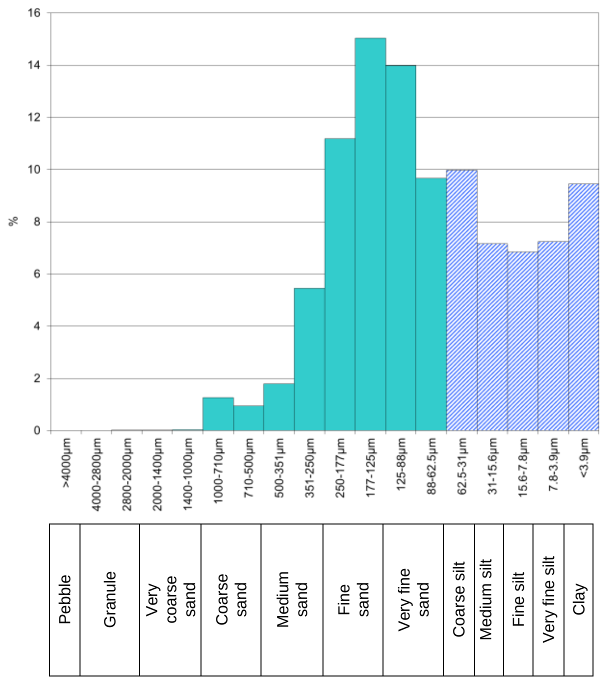
Geodetic Parameters: WGS84, UTM 30N									
Date	Transect/ Station	Point on Line	Time [UTC]	Video Coordinates Easting [m]	Video Coordinates Northing [m]	Length [m]	Still Nos.	Sediment Description	Fauna/Bioturbation/Debris
21/03/2019	LS_ST01A	SOL	11:39:50	296 290.6	5 937 020.5	22	1-2	Rippled sand with shell fragments	Starfish (*Asterias rubens*)
		-	11:40:40	296 286.2	5 937 041.8				
		-	11:40:40	296 286.2	5 937 041.8	54	3-9	Boulder/bedrock outcrops with sand	Starfish (*Asterias rubens*), anemone (Actiniaria including *Metridium dianthus*), sponge (Porifera), red seaweed (Rhodophyceae), faunal turf (Hydrozoa/Bryozoa), encrusting polychaete tubes (Serpulidae). Anthropogenic debris (glass bottle)
		-	11:43:08	296 279.4	5 937 095.0				
		-	11:43:08	296 279.4	5 937 095.0	135	10-16	Rippled muddy sand	Hermit crab (Paguridae)
		-	11:49:15	296 270.8	5 937 229.7				
		-	11:49:15	296 270.8	5 937 229.7	30	17-19	Sand with boulder/bedrock outcrops	Starfish (*Asterias rubens*), sponge (Porifera: possible *Haliclona* sp.), red seaweed (Rhodophyceae, including *Palmaria palmata*), faunal turf (Hydrozoa/Bryozoa), encrusting polychaete tubes (Serpulidae)
		EOL	11:50:49	296 259.3	5 937 256.9				
21/03/2019	LS_ST02	SOL	12:05:54	298 419.1	5 937 592.8	63	1-32	Rippled muddy sand with shell fragments	Starfish (*Asterias rubens*), anemone (Actiniaria). Faunal burrows
		EOL	12:15:20	298 408.4	5 937 655.3				
23/02/2019	LS_ST03	SOL	16:34:25	303 872.4	5 938 719.9	177	1-23	Rippled muddy sand with shell fragments. Single boulder	Brittlestar (Ophiuroidea), hermit crab (Paguridae), faunal turf (Hydrozoa/Bryozoa), fish (possible Gadidae), possible soft coral (*Alcyonium digitatum*), whelk (Buccinidae), starfish (Asteroidea), anemone (*Metridium dianthus*)
		EOL	16:41:23	303 835.2	5 938 892.6				
23/02/2019	LS_ST04	SOL	20:25:42	307 144.6	5 939 795.5	87	1-19	Muddy sand	Hermit crab (Paguridae), brittlestar (Ophiuroidea), possible anemone (?Actiniaria), spider crab (*Macropodia* sp.), foliose bryozoan (Cellariidae: possible *Cellaria* sp.), faunal turf (Hydrozoa/Bryozoa), fish (Gadidae). Faunal tube (Sabellidae) and burrows
		EOL	20:31:14	307 132.8	5 939 881.6				
23/02/2019	LS_ST05	SOL	22:03:33	314 922.3	5 943 446.6	193	1-19	Muddy sand	Sea pen (*Virgularia mirabilis*), fish (Pisces). Faunal burrows and tubes (Polychaeta)
		EOL	22:08:36	314 882.9	5 943 626.6				

Geodetic Parameters: WGS84, UTM 30N									
Date	Transect/ Station	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna/Bioturbation/Debris
				Easting [m]	Northing [m]				
24/02/2019	CC05_ST01 CC05_T01A	SOL	03:57:10	346 266.4	5 957 592.1	146	1-26	Rippled muddy sand with shell fragments	Hermit crab (Paguridae, including *Pagurus bernhardus*), faunal turf (Hydrozoa/Bryozoa), lesser spotted catshark (*Scyliorhinus canicula*), flatfish (Pleuronectiformes), unidentified fish (Pisces). Faunal tracks, burrows and tubes (Polychaeta)
		EOL	04:17:09	346 385.9	5 957 508.6				
24/02/2019		SOL	02:29:09	347 174.7	5 957 085.5	829	1-68	Rippled muddy sand with shell fragments	Sea pen (Pennatulacea, including *Virgularia mirabilis*), hermit crab (Paguridae, including *Pagurus bernhardus*), Norway lobster (*Nephrops norvegicus),* faunal turf (Hydrozoa/Bryozoa), gurnard (Triglidae), unidentified fish (Pisces), lesser spotted catshark (*Scyliorhinus canicula*), flatfish (Pleuronectiformes). Faunal tracks, burrows and tubes (Polychaeta)
		EOL	03:02:47	346 542.0	5 957 621.4				
24/02/2019	CC05_T02	SOL	03:26:17	346 779.4	5 957 515.0	272	1-26	Rippled muddy sand with shell fragments	Hermit crab (Paguroidea), Norway lobster (*Nephrops norvegicus*), faunal turf (Hydrozoa/Bryozoa). Lesser spotted catshark (*Scyliorhinus canicula*). Faunal burrows and tubes (Polychaeta)
		EOL	03:36:31	346 508.0	5 957 501.8				

Notes:
UCT = Coordinated Universal Time
SOL = Start of line
EOL = End of line

D. SEDIMENT PARTICLE SIZE

STATION LS_ST01



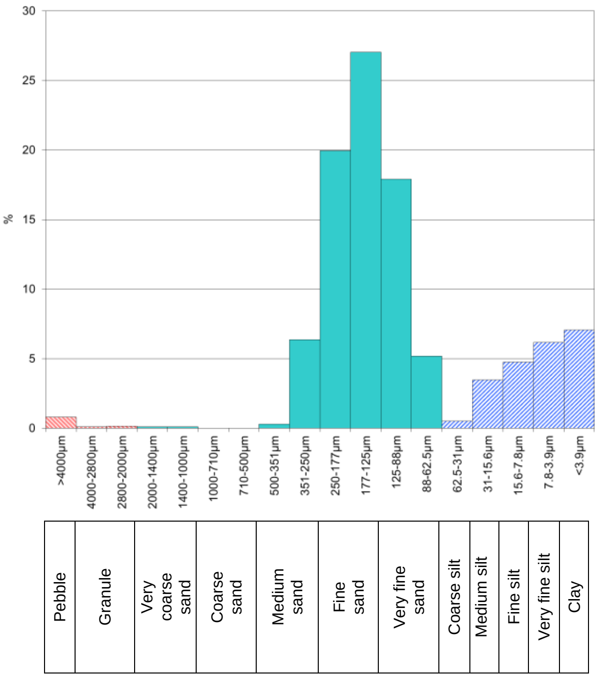
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.00	0.00
1400	-0.49	0.02	0.02
1000	0.00	0.03	0.05
707	0.49	1.27	1.32
500	1.00	0.94	2.25
354	1.51	1.79	4.04
250	2.00	5.45	9.49
177	2.50	11.2	20.7
125	3.00	15.0	35.7
88.0	3.51	14.0	49.7
62.5	4.00	9.67	59.4
31.2	5.01	9.97	69.3
15.6	6.00	7.15	76.5
7.81	7.00	6.84	83.3
3.91	8.00	7.24	90.6
< 3.91	> 8.00	9.44	100
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.29	Very poorly sorted
Skewness [phi]	0.48	Very fine skewed
Mean [µm]	50.8	Coarse silt
Mean [phi]	4.30	
Gravel [%]	0.00	Muddy sand
Sand [%]	59.4	
Mud [%]	40.6	

STATION LS_ST02



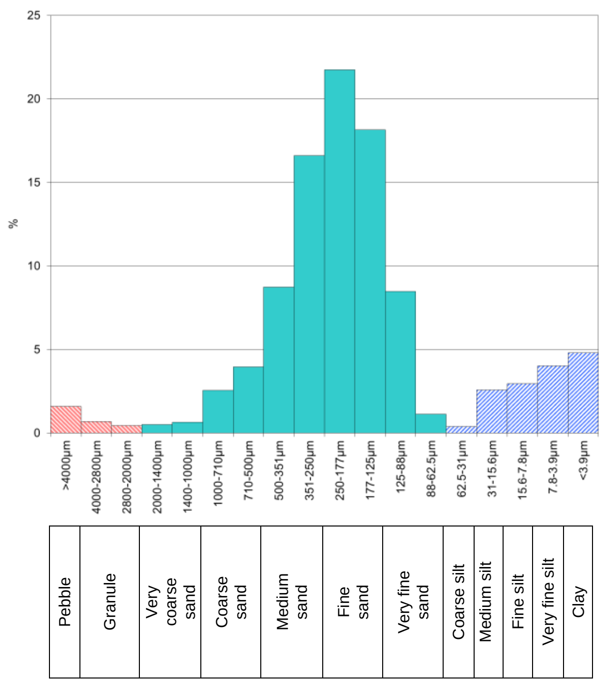
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.81	0.81
2800	-1.49	0.10	0.92
2000	-1.00	0.15	1.06
1400	-0.49	0.10	1.17
1000	0.00	0.11	1.27
707	0.49	0.00	1.27
500	1.00	0.00	1.27
354	1.51	0.29	1.57
250	2.00	6.37	7.94
177	2.50	20.0	27.9
125	3.00	27.0	54.9
88.0	3.51	17.9	72.8
62.5	4.00	5.18	78.0
31.2	5.01	0.52	78.5
15.6	6.00	3.49	82.0
7.81	7.00	4.75	86.8
3.91	8.00	6.18	93.0
< 3.91	> 8.00	7.05	100
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.06	Very poorly sorted
Skewness [phi]	0.66	Very fine skewed
Mean [µm]	69.2	Very fine sand
Mean [phi]	3.85	
Gravel [%]	1.06	Slightly gravelly muddy sand
Sand [%]	77.0	
Mud [%]	22.0	

STATION LS_ST03



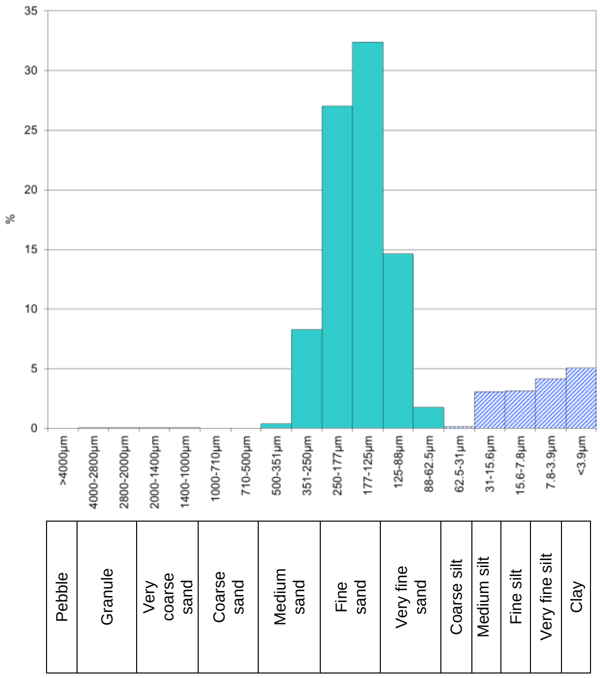
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	1.60	1.60
2800	-1.49	0.68	2.28
2000	-1.00	0.45	2.73
1400	-0.49	0.50	3.23
1000	0.00	0.65	3.88
707	0.49	2.56	6.44
500	1.00	3.96	10.4
354	1.51	8.74	19.1
250	2.00	16.6	35.8
177	2.50	21.8	57.5
125	3.00	18.2	75.7
88.0	3.51	8.48	84.1
62.5	4.00	1.13	85.3
31.2	5.01	0.39	85.7
15.6	6.00	2.57	88.2
7.81	7.00	2.95	91.2
3.91	8.00	4.02	95.2
< 3.91	> 8.00	4.80	100
Total		**100**	**100**

STATISTICS

Sorting [phi]	1.71	Poorly sorted
Skewness [phi]	0.26	Fine skewed
Mean [µm]	192	Fine sand
Mean [phi]	2.38	
Gravel [%]	2.73	Slightly gravelly muddy sand
Sand [%]	82.6	
Mud [%]	14.7	

STATION LS_ST04



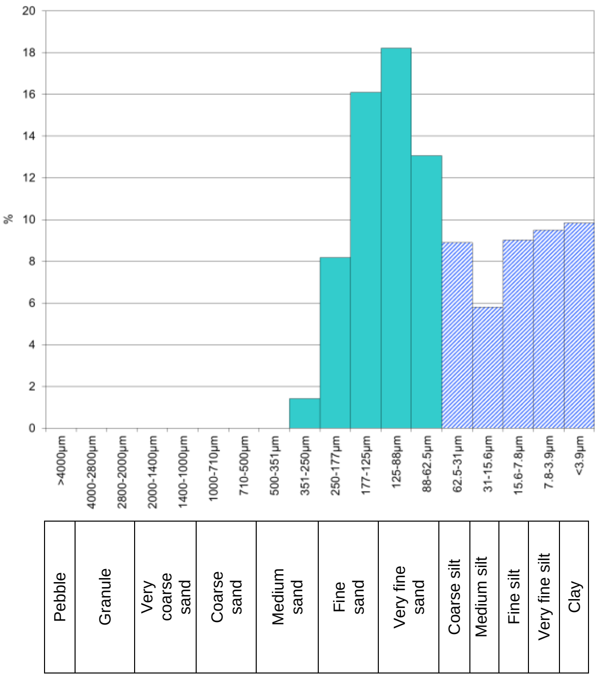
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.02	0.02
2000	-1.00	0.01	0.03
1400	-0.49	0.02	0.05
1000	0.00	0.04	0.09
707	0.49	0.00	0.09
500	1.00	0.00	0.09
354	1.51	0.36	0.45
250	2.00	8.27	8.72
177	2.50	27.0	35.8
125	3.00	32.4	68.1
88.0	3.51	14.6	82.8
62.5	4.00	1.75	84.5
31.2	5.01	0.12	84.6
15.6	6.00	3.07	87.7
7.81	7.00	3.13	90.8
3.91	8.00	4.13	95.0
< 3.91	> 8.00	5.04	100
Total		**100**	**100**

STATISTICS

Sorting [phi]	1.37	Poorly sorted
Skewness [phi]	0.51	Very fine skewed
Mean [µm]	134	Fine sand
Mean [phi]	2.90	
Gravel [%]	0.03	Muddy sand
Sand [%]	84.5	
Mud [%]	15.5	

STATION LS_ST05



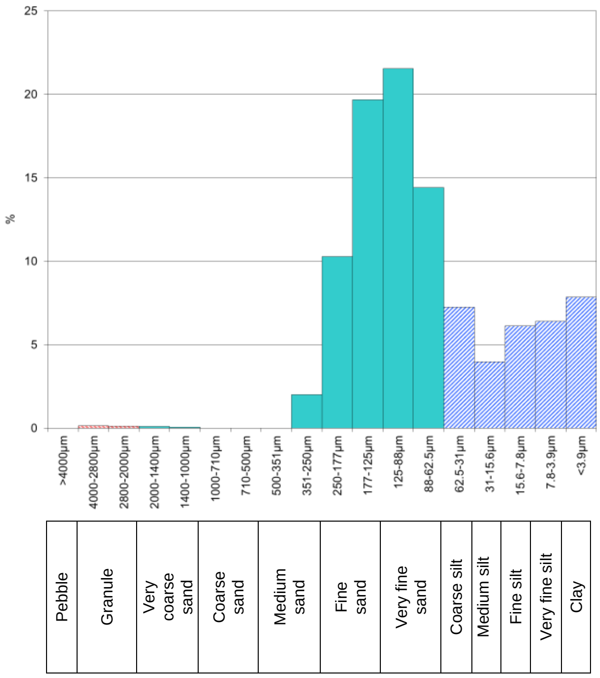
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.00	0.00
1400	-0.49	0.00	0.00
1000	0.00	0.00	0.00
707	0.49	0.00	0.00
500	1.00	0.00	0.00
354	1.51	0.00	0.00
250	2.00	1.41	1.41
177	2.50	8.18	9.59
125	3.00	16.1	25.7
88.0	3.51	18.2	43.9
62.5	4.00	13.1	57.0
31.2	5.01	8.90	65.9
15.6	6.00	5.80	71.7
7.81	7.00	9.01	80.7
3.91	8.00	9.50	90.2
< 3.91	> 8.00	9.84	100
Total		**100**	**100**

STATISTICS

Sorting [phi]	2.15	Very poorly sorted
Skewness [phi]	0.55	Very fine skewed
Mean [µm]	41.5	Coarse silt
Mean [phi]	4.59	
Gravel [%]	0.00	Muddy sand
Sand [%]	57.0	
Mud [%]	43.0	

STATION CC05_ST01



FRACTIONAL DATA

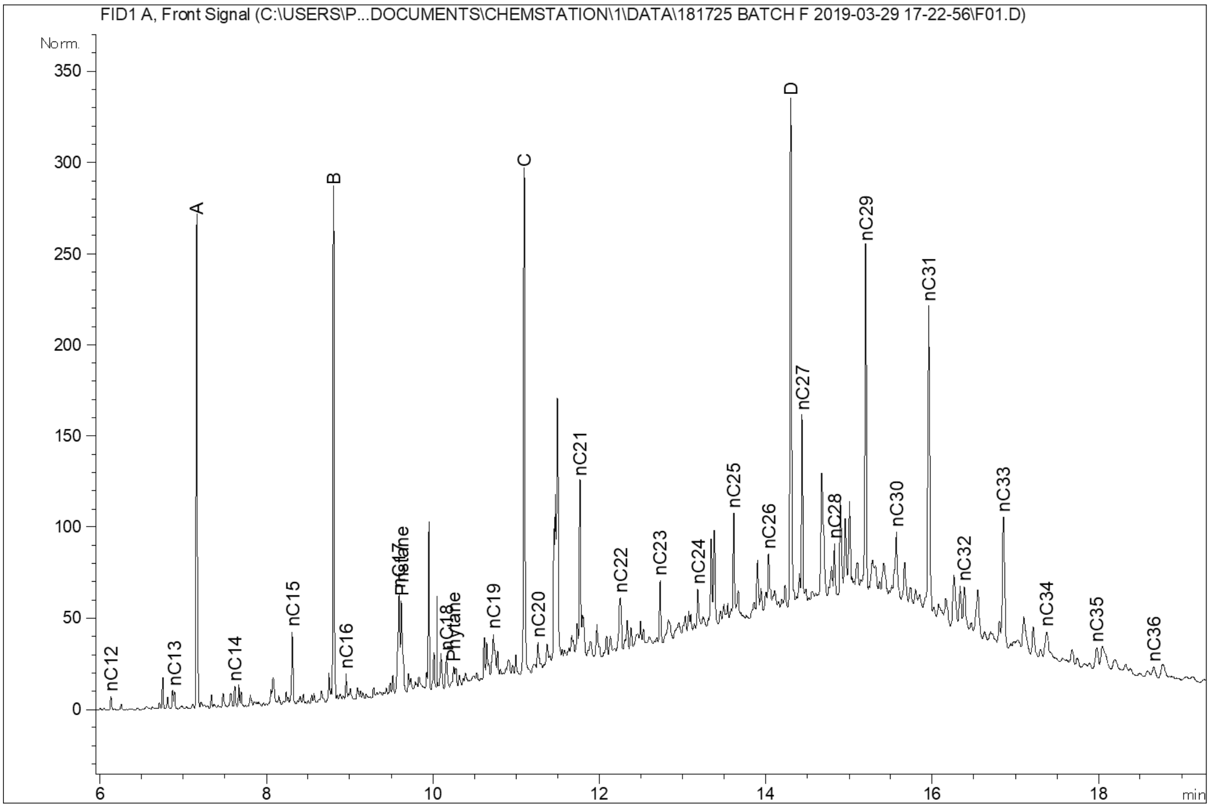
Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.15	0.15
2000	-1.00	0.13	0.28
1400	-0.49	0.11	0.38
1000	0.00	0.06	0.44
707	0.49	0.00	0.44
500	1.00	0.00	0.44
354	1.51	0.00	0.44
250	2.00	2.01	2.45
177	2.50	10.3	12.7
125	3.00	19.7	32.4
88.0	3.51	21.6	54.0
62.5	4.00	14.4	68.4
31.2	5.01	7.25	75.6
15.6	6.00	3.98	79.6
7.81	7.00	6.13	85.8
3.91	8.00	6.40	92.2
< 3.91	> 8.00	7.85	100
Total		**100**	**100**

STATISTICS

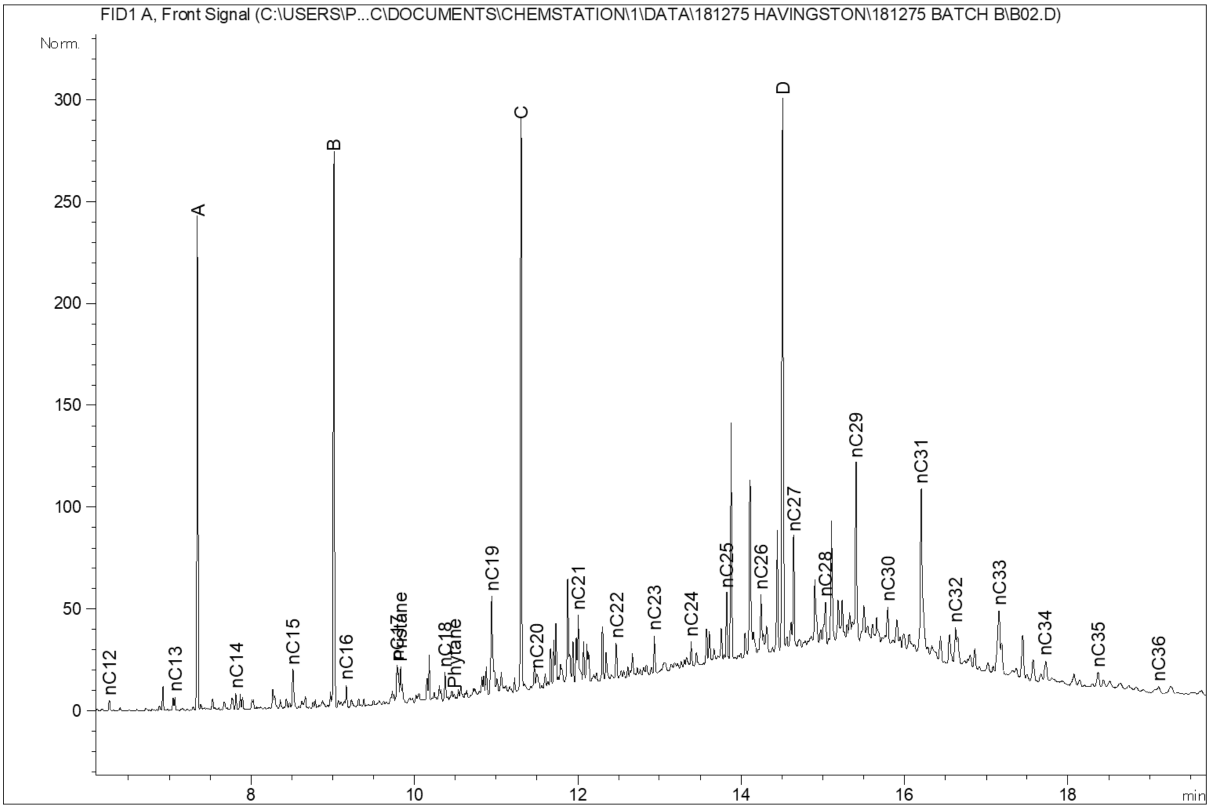
Sorting [phi]	2.01	Very poorly sorted
Skewness [phi]	0.60	Very fine skewed
Mean [µm]	53.0	Coarse silt
Mean [phi]	4.24	
Gravel [%]	0.28	Muddy sand
Sand [%]	68.1	
Mud [%]	31.6	

E. SEDIMENT CHEMISTRY

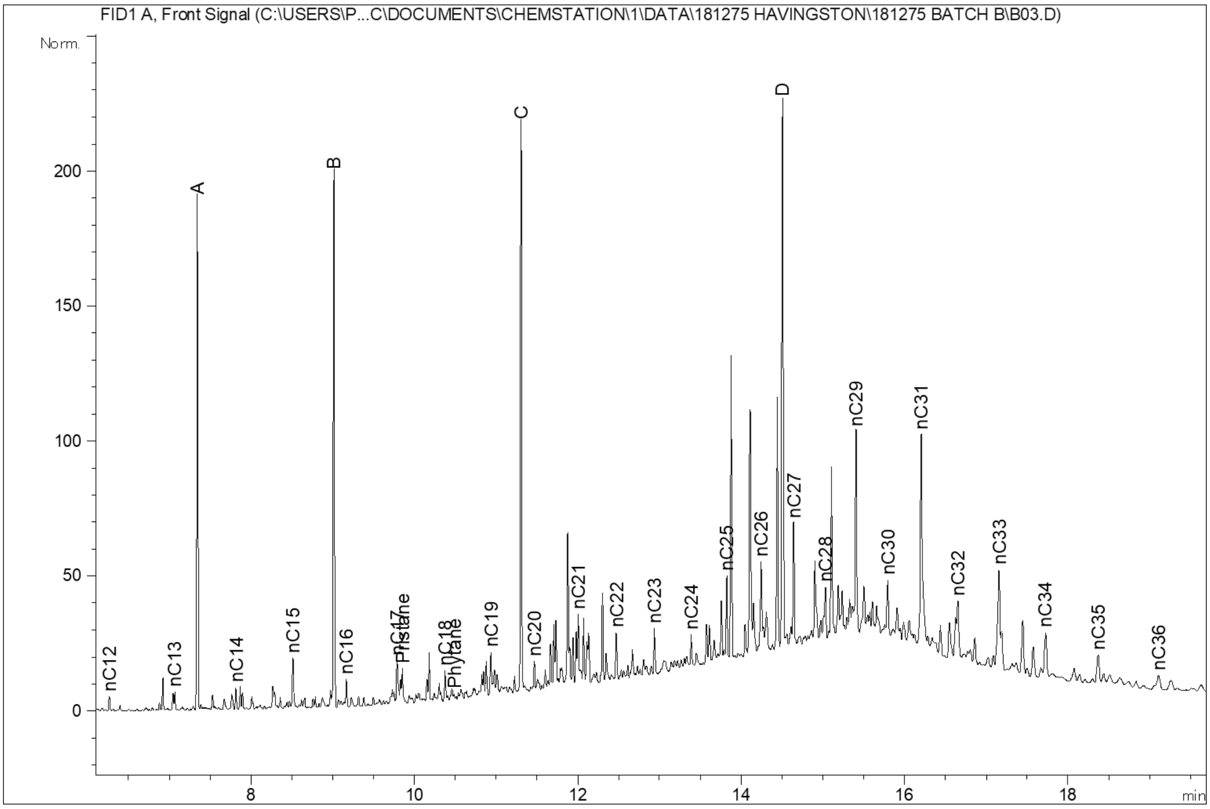
E.1 GAS CHROMATOGRAPHY TRACES



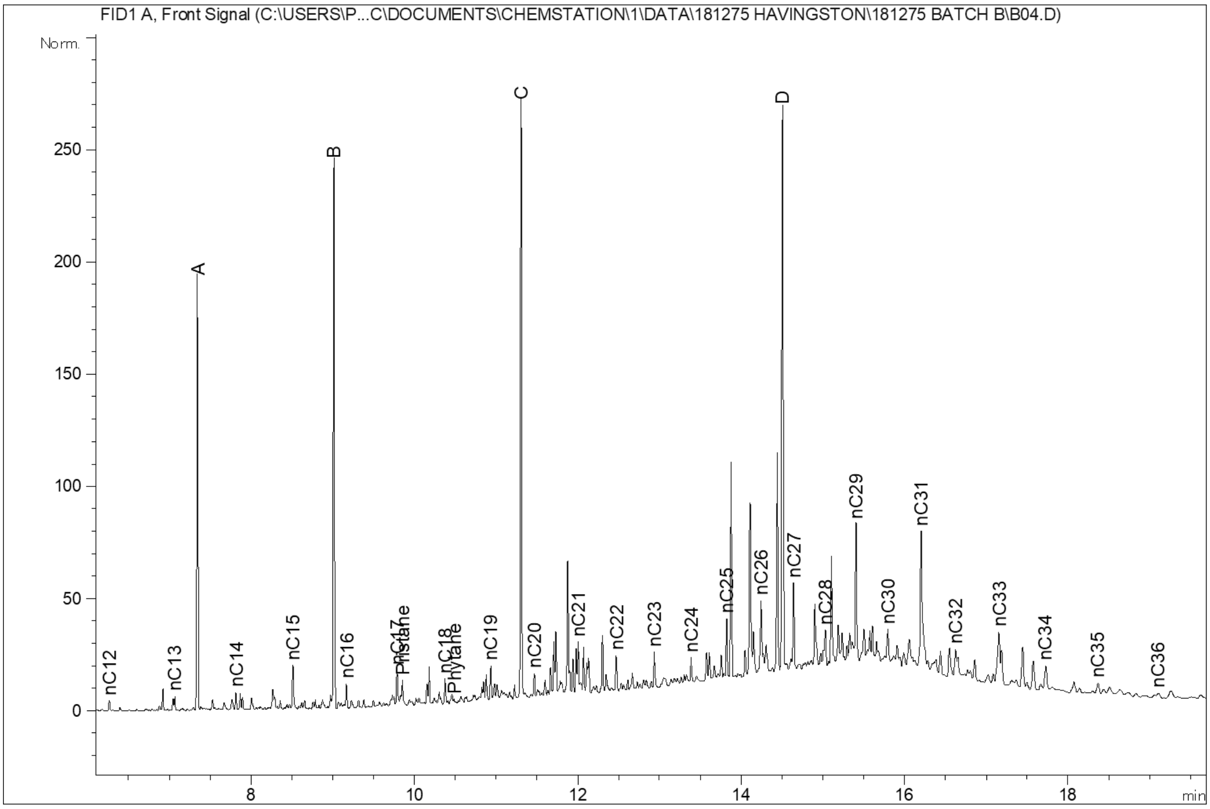
Station LS_ST01



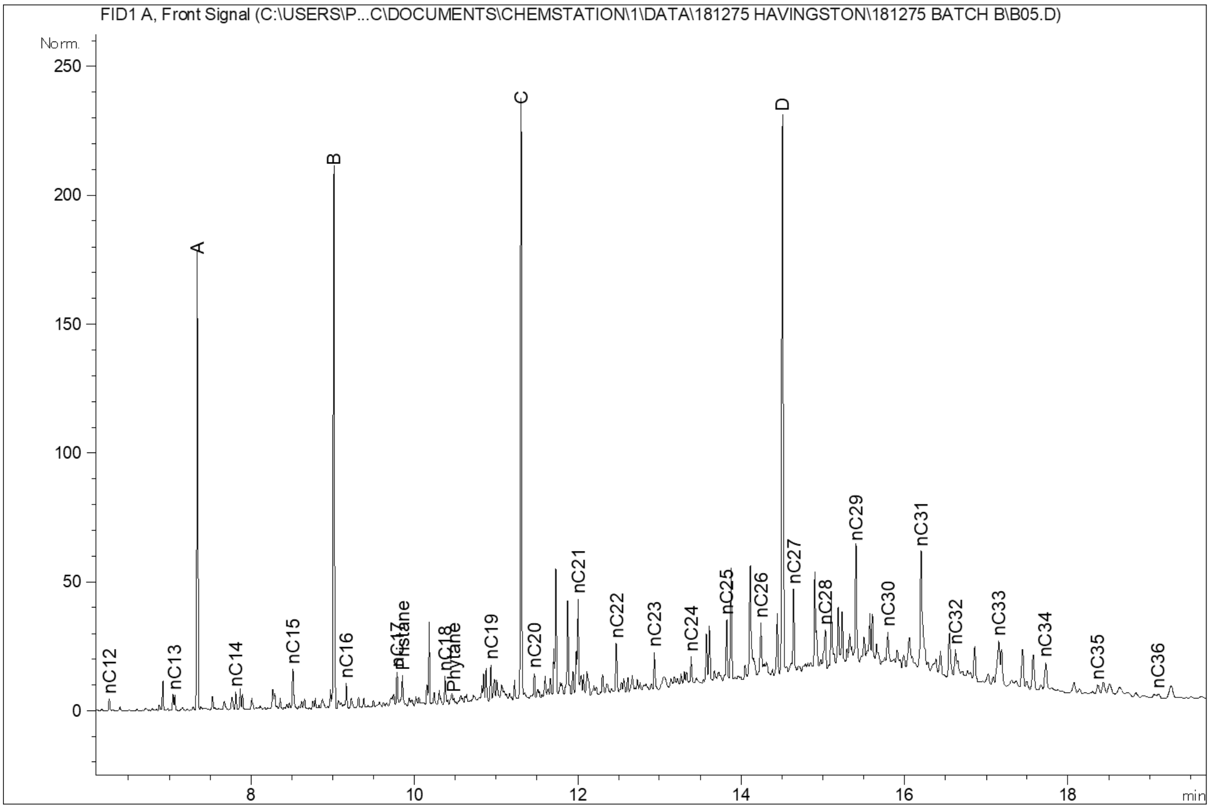
Station LS_ST02



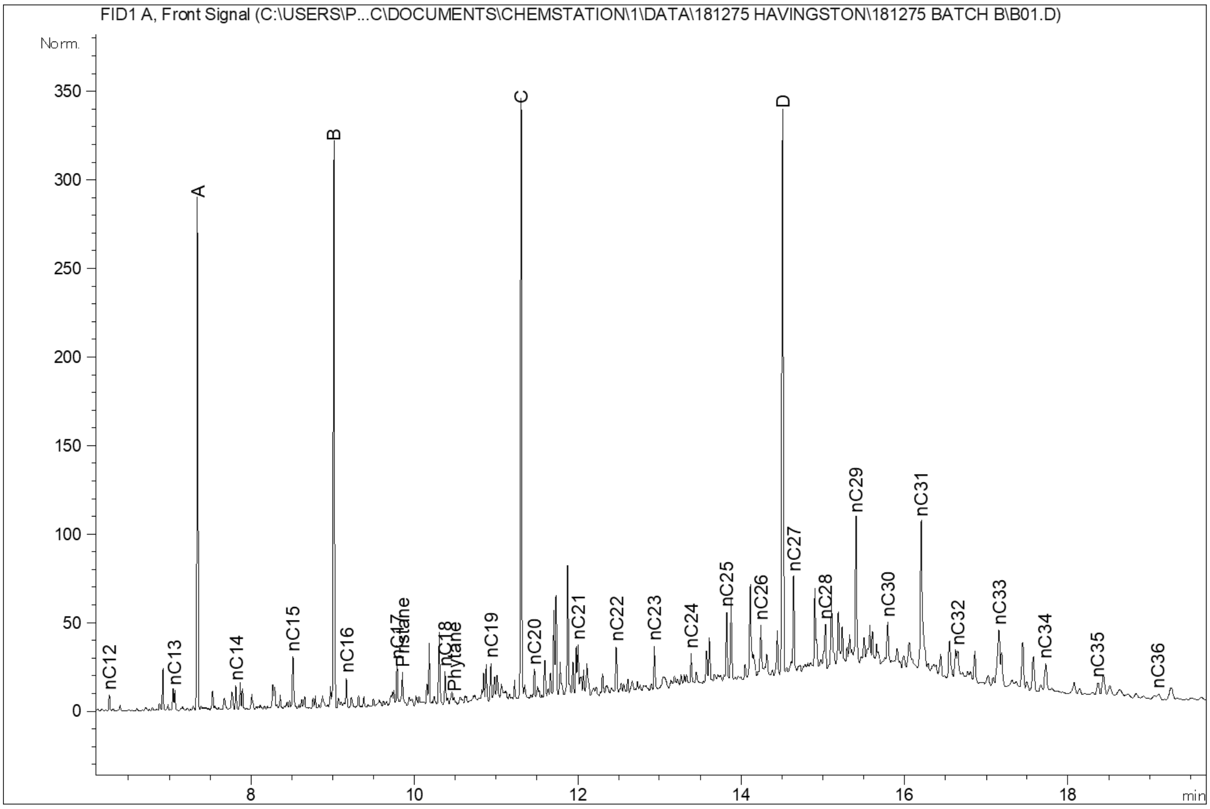
Station LS_ST03



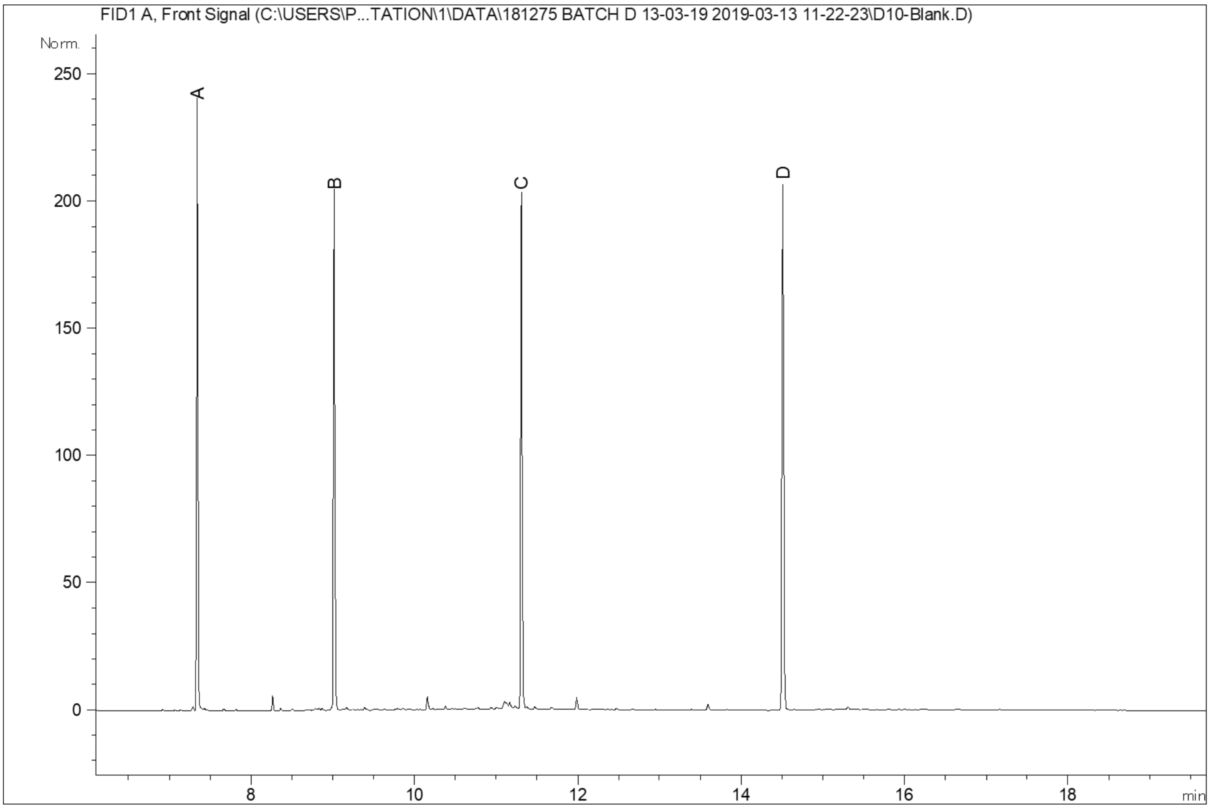
Station LS_ST04



Station LS_ST05



Station CC05_ST01


FID1 A, Front Signal (C:\USERS\P...TATION\1\DATA\181275 BATCH D 13-03-19 2019-03-13 11-22-23\D10-Blank.D)
Norm.
250
200
150
100
50
0
A
B
C
D
8
10
12
14
16
18
min

Blank

E.2 INDIVIDUAL N-ALKANE CONCENTRATIONS

n-Alkane [ng/g]	Station					
	LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01
nC_{12}	4.1	2.0	2.9	1.9	2.6	2.9
nC_{13}	5.3	2.5	3.7	2.5	3.3	3.7
nC_{14}	6.5	3.2	4.6	3.4	4.1	4.7
nC_{15}	25.8	8.4	10.9	9.0	9.5	11.7
nC_{16}	7.1	4.5	6.4	4.9	5.7	6.4
nC_{17}	33.1	7.6	8.4	7.1	7.9	7.7
nC_{18}	14.9	6.9	7.4	5.3	6.8	7.4
nC_{19}	19.6	32.7	12.3	7.8	10.3	9.2
nC_{20}	9.8	3.7	6.1	4.6	5.6	5.4
nC_{21}	47.9	8.8	10.1	7.7	20.4	8.9
nC_{22}	16.3	8.5	11.9	7.8	12.4	11.1
nC_{23}	19.5	7.6	9.5	6.6	8.3	8.8
nC_{24}	13.7	4.8	6.2	4.4	5.4	5.9
nC_{25}	29.8	14.2	18.4	11.0	13.9	15.4
nC_{26}	17.0	3.2	24.1	16.6	13.3	10.5
nC_{27}	56.5	23.2	28.3	18.2	19.2	20.6
nC_{28}	16.7	10.1	12.9	7.5	10.0	10.1
nC_{29}	120	43.6	52.9	30.2	31.0	33.8
nC_{30}	28.3	9.2	16.5	7.9	8.0	10.9
nC_{31}	134	50.0	65.5	34.7	38.7	40.8
nC_{32}	22.8	8.6	18.6	4.8	4.0	6.3
nC_{33}	69.7	27.5	39.0	16.4	18.4	20.9
nC_{34}	18.8	6.9	17.5	7.7	10.0	9.4
nC_{35}	12.8	6.1	11.9	3.8	4.2	4.4
nC_{36}	7.5	3.3	0.5	0.2	2.6	3.1
Total n-alkane [µg/g]	**0.759**	**0.307**	**0.407**	**0.232**	**0.276**	**0.280**
Pristane [ng/g]	27.8	7.0	6.8	4.7	7.4	6.1
Phytane [ng/g]	7.7	2.5	3.6	2.6	1.2	3.6

Notes:
Individual n-alkane, pristane and phytane concentrations expressed as ng/g of dry sediment
Total n-alkane concentrations expressed as µg/g of dry sediment

E.3 US EPA 16 PAH CONCENTRATIONS

E.3.1 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

PAH [ng/g of Dry Sediment]	LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01	CEMP Assessment Criteria (OSPAR, 2014) ERL
Naphthalene	6.5	3.1	4.1	2.8	4.6	5.4	**160**
Acenaphthylene	1.0	0.3	0.2	0.1	0.8	0.2	**-**
Acenaphthene	3.4	0.5	0.5	0.3	0.6	0.5	**-**
Fluorene	6.2	2.0	2.5	1.7	3.1	2.9	**-**
Phenanthrene	36.9	7.3	8.5	5.7	14.7	9.8	**240**
Anthracene	8.2	1.3	1.2	0.8	2.2	1.2	**85**
Fluoranthene	46.2	7.5	8.8	5.8	20.1	9.5	**600**
Pyrene	39.2	6.1	6.5	4.3	14.6	6.6	**665**
Benzo(a)anthracene	24.1	3.9	4.5	3.0	8.6	4.5	**261**
Chrysene	21.0	4.0	5.0	3.1	8.7	5.5	**384**
Benzo(b)fluoranthene	42.8	12.3	15.6	11.4	21.5	16.4	**-**
Benzo(k)fluoranthene	13.7	3.7	4.6	3.3	6.6	4.6	**-**
Benzo(a)pyrene	25.3	4.9	5.3	3.6	8.9	5.3	**430**
Indeno(1,2,3-cd)pyrene	25.1	7.9	10.4	7.3	13.4	10.2	**240**
Benzo(ghi)perylene	22.2	6.4	8.6	6.0	11.2	8.6	**85**
Dibenzo(a,h)anthracene	5.9	1.5	1.9	1.3	2.5	2.0	**-**
Total US EPA 16	**328**	**72.7**	**88.2**	**60.5**	**142**	**93.2**	**-**

Notes:
PAH = Polycyclic aromatic hydrocarbon
OSPAR = Oslo and Paris Convention
ERL = Effects range low
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbons

Key:	Below ERL	Above ERL

E.3.2 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations, Normalised to 2.5 % Total Organic Carbon (TOC)

PAH [ng/g of Dry Sediment]	LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01	CEMP Assessment Criteria (OSPAR, 2014)	
							BC	BAC
Naphthalene	25	23	38	25	25	39	**5**	**8**
Acenaphthylene	4	2	2	1	4	1	**-**	**-**
Acenaphthene	13	4	5	3	3	4	**-**	**-**
Fluorene	23	15	23	15	17	21	**-**	**-**
Phenanthrene	140	55	79	51	80	70	**17**	**32**
Anthracene	31	10	11	7	12	9	**3**	**5**
Fluoranthene	175	57	81	52	109	68	**20**	**39**
Pyrene	148	46	60	38	79	47	**13**	**24**
Benzo(a)anthracene	91	30	42	27	47	32	**9**	**16**
Chrysene	80	30	46	28	47	39	**11**	**20**
Benzo(b)fluoranthene	162	93	144	102	117	117	**-**	**-**
Benzo(k)fluoranthene	52	28	43	29	36	33	**-**	**-**
Benzo(a)pyrene	96	37	49	32	48	38	**15**	**30**
Indeno(1,2,3-cd)pyrene	95	60	96	65	73	73	**50**	**103**
Benzo(ghi)perylene	84	48	80	54	61	61	**45**	**80**
Dibenzo(a,h)anthracene	22	11	18	12	14	14	**-**	**-**
Total US EPA 16	**1240**	**551**	**817**	**540**	**772**	**666**	**-**	**-**

Notes:
PAH = Polycyclic aromatic hydrocarbon
OSPAR = Oslo and Paris Convention
BC = Background concentration
BAC = Background assessment concentration
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbons

Key:	Below BC	Above BC	Above BAC

E.4 TOTAL 2 TO 6 RING PAH CONCENTRATIONS

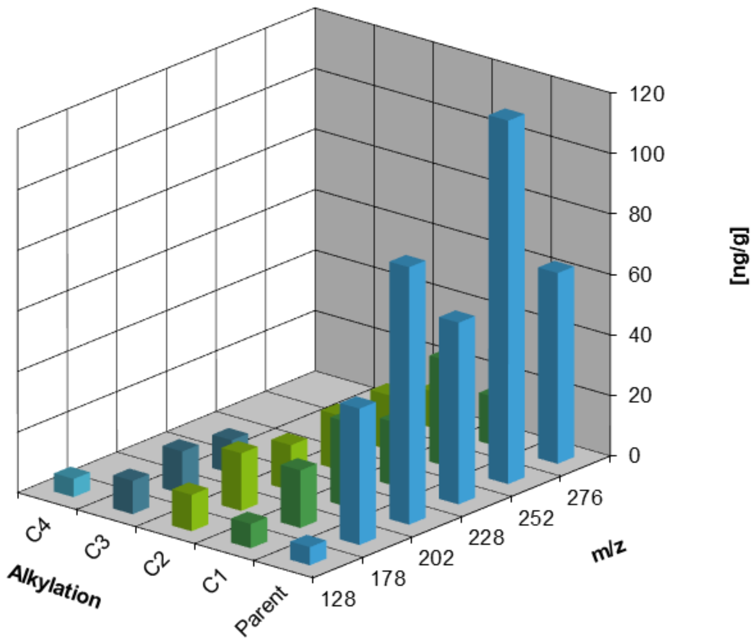
PAH	Station					
	LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01
Naphthalene (128)	6	3	4	3	5	5
C_1 128	8	5	7	5	8	9
C_2 128	12	7	10	7	10	12
C_3 128	11	3	3	1	1	1
C_4 128	6	3	5	3	5	5
TOTAL 128	**43**	**21**	**29**	**19**	**29**	**32**
Phenanthrene/anthracene (178)	45	8	9	7	17	11
C_1 178	19	7	10	7	11	11
C_2 178	19	8	12	8	12	12
C_3 178	14	6	9	6	9	9
TOTAL 178	**97**	**29**	**40**	**28**	**49**	**43**
Dibenzothiophene (184)	2	1	1	<1	1	1
C_1 184	2	1	1	1	1	1
C_2 184	2	1	2	1	2	1
C_3 184	2	1	1	1	1	1
TOTAL 184	**8**	**4**	**5**	**3**	**5**	**4**
Fluoranthene/pyrene (202)	85	14	15	10	35	17
C_1 202	28	7	10	6	13	9
C_2 202	15	7	10	6	10	10
C_3 202	11	7	10	7	10	10
TOTAL 202	**139**	**35**	**45**	**29**	**68**	**46**
Benzanthracenes/ benzphenanthrenes (228)	60	11	14	9	23	15
C_1 228	21	7	9	6	11	10
C_2 228	18	7	11	7	11	10
TOTAL 228	**99**	**25**	**34**	**22**	**45**	**35**
m/z 252*	120	31	38	27	54	39
C_1 252	35	11	14	10	17	15
C_2 252	18	8	11	8	12	11
TOTAL 252	**173**	**50**	**63**	**45**	**83**	**65**
m/z 276†	63	18	24	17	32	24
C_1 276	16	5	6	4	8	6
C_2 276	12	5	7	4	7	7
TOTAL 276	**91**	**28**	**37**	**25**	**47**	**37**
NPD‡	**148**	**54**	**74**	**50**	**83**	**79**
NPD [%]	**23**	**28**	**29**	**29**	**25**	**30**
Total 2 to 6 ring PAH	**650**	**192**	**253**	**171**	**326**	**262**

Notes:
* = m/z 252 - benzfluoranthenes/benzpyrenes/perylene
† = m/z 276 - anthanthrene/indenopyrenes/benzperylenes
‡ = NPD - naphthalenes, phenanthrenes and dibenzothiophenes (totals)
Concentrations expressed as ng/g dry sediment

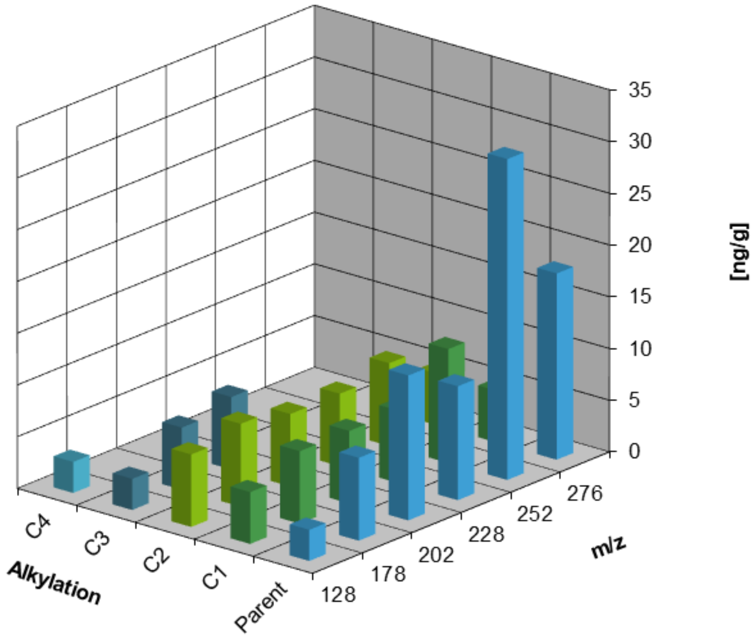
E.5 DISTRIBUTION OF AROMATIC HYDROCARBONS

The layout of the three-dimensional plots are as follows:

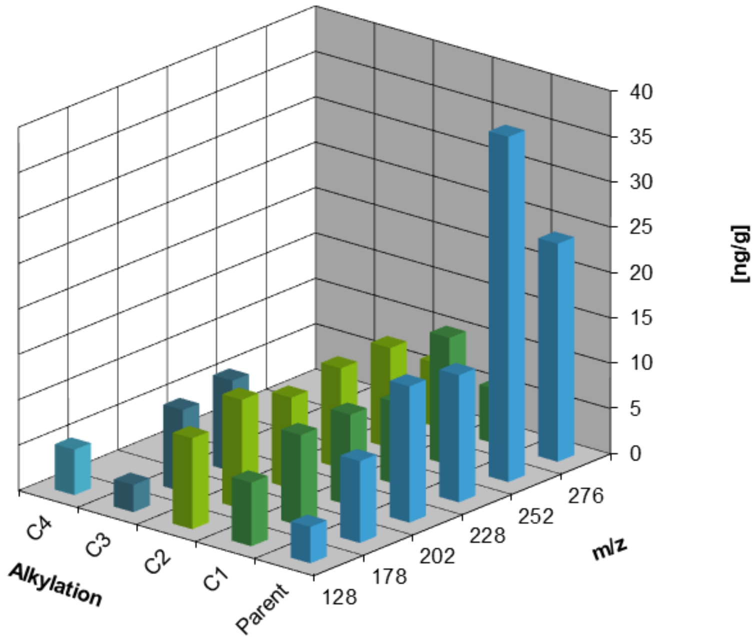
- Naphthalenes (molecular mass 128, 142, 156, 170, 184);
- Phenanthrenes/anthracenes (molecular mass 178, 192, 206, 220);
- Fluoranthenes/pyrenes (molecular mass 202, 216, 230, 244);
- Chrysene/benzanthracenes (molecular mass 228, 242, 256);
- Benzfluoranthenes/benzpyrenes/perylenes (molecular mass 252, 266, 280);
- Anthanthrenes/indenopyrenes/benzoperylenes (molecular mass 276, 290, 304).



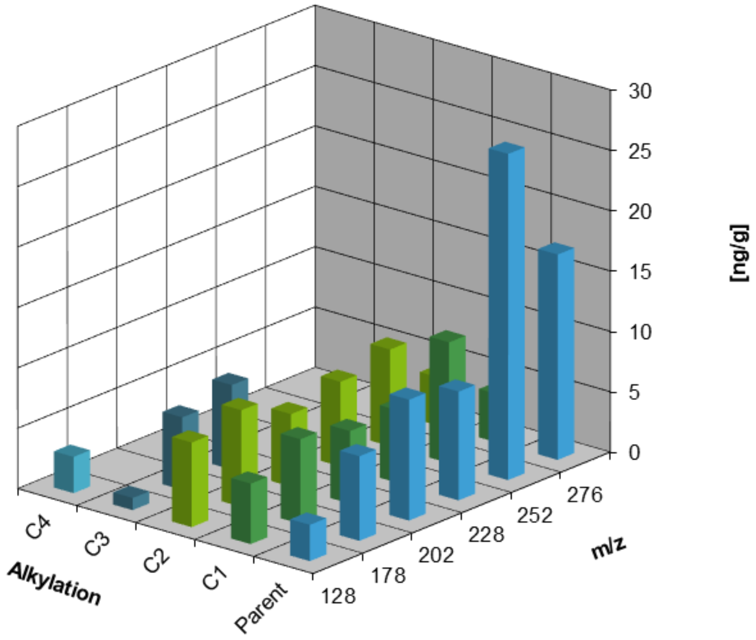
Station LS_ST01



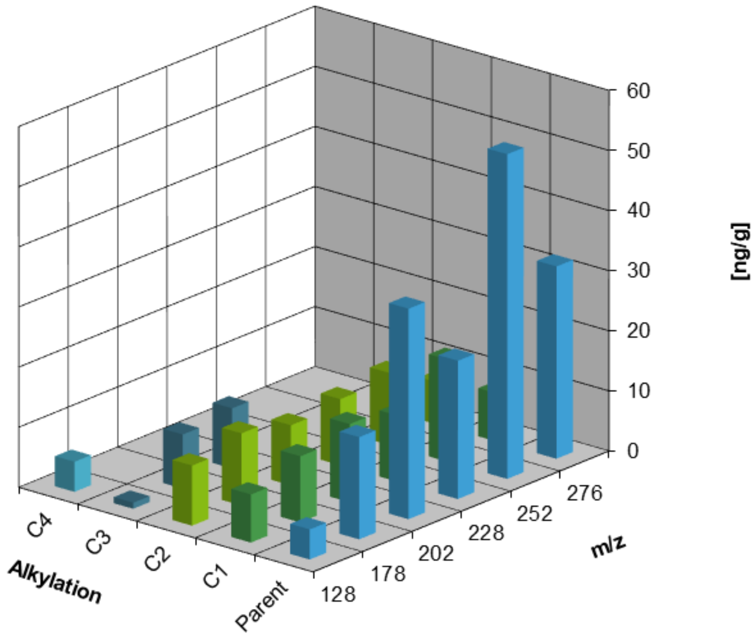
Station LS_ST02



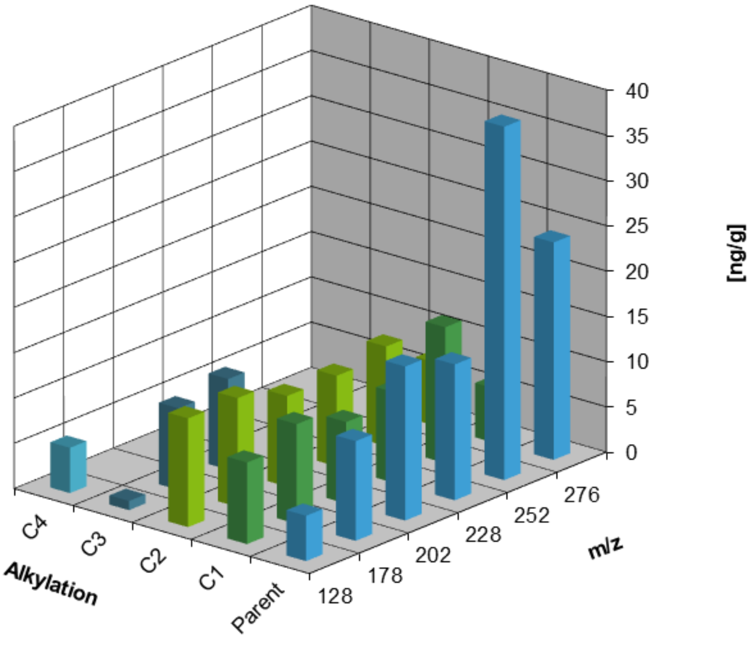
Station LS_ST03



Station LS_ST04



Station LS_ST05



Station CC05_ST01

E.6 5 % ALUMINIUM-NORMALISED HEAVY AND TRACE METAL CONCENTRATIONS

Station	As	Cd	Cr	Cu	Hg	Ni	Pb	Sn
LS_ST01	166	-	110	-	-	70.5	151	-
LS_ST02	24.1	-	95.5	24.2	0.0896	45.5	55.9	-
LS_ST03	25.0	-	92.2	21.4	0.0541	48.4	55.7	-
LS_ST04	24.7	-	89.6	24.3	0.0825	45.7	53.3	-
LS_ST05	19.1	-	85.5	20.7	0.0684	43.3	42.2	2.79
CC05_ST01	25.1	-	88.7	25.4	0.0843	45.2	53.2	-
Minimum	**19.1**	**-**	**85.5**	**20.7**	**0.0541**	**43.3**	**42.2**	**2.79**
Maximum	**166**	**-**	**110**	**25.4**	**0.0896**	**70.5**	**151**	**2.79**
Mean	**47.2**	**-**	**93.6**	**23.2**	**0.0758**	**49.8**	**68.6**	**-**
Standard Deviation	**58.0**	**-**	**8.66**	**2.04**	**0.0144**	**10.2**	**40.8**	**-**
RSD [%]	**123**	**-**	**9**	**9**	**19**	**20**	**60**	**-**
CEMP Assessment Criteria (OSPAR, 2014)								
BC	**15.0**	**0.200**	**60.0**	**20.0**	**0.05**	**30.0**	**25.0**	**-**
BAC	**25.0**	**0.310**	**81.0**	**27.0**	**0.07**	**36.0**	**38.0**	**-**

Notes:

Concentrations expressed in µg/g dry sediment

Summary statistics exclude concentrations below MRV

As = Arsenic Cd = Cadmium Cr = Chromium Cu = Copper Hg = Mercury Ni = Nickel

Pb = Lead Sn = Tin

RSD = Relative standard deviation

BC = Background concentration

BAC = Background assessment concentration

Key:	Below BC and BAC	Above BC	Above BAC

F. MACROFAUNAL ANALYSIS

MCS Code	Taxa	Sample							Total
		LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01		
D0759	Edwardsiidae		2	6	5	1	1		15
F0002	Turbellaria				1		1		2
G0001	Nemertea			2			2		4
G0034	*Tubulanus polymorphus*		2						2
G0039	Cerebratulus		3	1					4
N0034	*Phascolion strombus*						2		2
P0092	*Pholoe baltica* (sensu Petersen)		7	6	7		2		22
P0141	*Phyllodoce groenlandica*	1							1
P0164	*Eumida bahusiensis*			1					1
P0256	*Glycera alba*	1		1					2
P0263	*Glycera unicornis*			1	1	1	2		5
P0268	*Glycinde nordmanni*			1					1
P0291	*Sphaerodorum gracilis*	1							1
P0313	*Oxydromus flexuosus*				1				1
P0319	*Podarkeopsis capensis*		1						1
P0340	*Glyphohesione klatti*						1		1
P0358	*Syllis garciai*			1					1
P0421	*Parexogone hebes*			1					1
P0475	*Eunereis longissima*		1						1
P0499	*Nephtys hombergii*	3	1	3					7
P0501	*Nephtys incisa*					4	2		6
P0502	*Nephtys kersivalensis*				1	1			2
P0574	*Lumbrineris cingulata*		3	1	1				5
P0580	*Abyssoninoe hibernica*					2	4		6
P0643	*Schistomeringos rudolphi*						1		1
P0672	*Scoloplos armiger*		1						1
P0699	*Paradoneis lyra*			1					1

MCS Code	Taxa	Sample						Total
		LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01	
P0746	*Prionospio cf. multibranchiata*						4	4
P0751	*Dipolydora caulleryi*			1				1
P0765	*Prionospio fallax*						1	1
P0766	*Aurospio banyulensis*					1		1
P0794	*Spiophanes bombyx*	1	1		1			3
P0796	*Spiophanes kroyeri*				1		1	2
P0804	*Magelona alleni*		4		2			6
P0807	*Magelona johnstoni*	1						1
P0834	*Chaetozone setosa*				2			2
P0843	*Kirkegaardia*						1	1
P0846	*Tharyx killariensis*		1	1				2
P0878	*Diplocirrus glaucus*		31	14	11		2	58
P0919	*Mediomastus fragilis*						7	7
P0923	*Notomastus*			1	1	1	7	10
P0925	*Peresiella clymenoides*			1				1
P0971	*Praxillella affinis*				2		1	3
P1014	*Ophelina acuminata*				1			1
P1093	*Galathowenia oculata*		6	5	4	1	1	17
P1094	Myriochele						2	2
P1098	*Owenia*						1	1
P1102	*Amphictene auricoma*			1	2	1	1	5
P1107	*Lagis koreni*			3	5		1	9
P1124	*Melinna palmata*		1					1
P1135	*Ampharete falcata*						3	3
P1139	*Ampharete lindstroemi*						2	2
P1174	*Terebellides*			1		1	3	5
Q0044	*Anoplodactylus petiolatus*		1		1			2
S0177	*Leucothoe incisa*						2	2

MCS Code	Taxa	Sample							Total
		LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01		
S0410	*Nototropis falcatus*			1					1
S0427	*Ampelisca brevicornis*	2		1					3
S0440	*Ampelisca tenuicornis*		1						1
S0951	*Astacilla dilatata*					1			1
S1142	*Tanaopsis graciloides*		1						1
S1208	*Eudorella truncatula*			1					1
S1251	*Diastylis laevis*						1		1
S1456	*Pagurus bernhardus*			1					1
W0009	*Chaetoderma nitidulum*			1	2				3
W0011	*Falcidens crossotus*						1		1
W0410	*Hyala vitrea*					1			1
W0909	*Odostomia acuta*		1						1
W0960	*Ondina divisa*			1			1		2
W1026	*Cylichna cylindracea*		1	1	2				4
W1048	*Laona pruinosa*					1			1
W1519	*Antalis entalis*			1	4				5
W1569	*Nucula nitidosa*	4	19	9	1		10		43
W1571	*Nucula sulcata*						2		2
W1577	*Ennucula tenuis*						7		7
W1827	*Myrtea spinifera*						6		6
W1837	*Thyasira flexuosa*		2	2	2		15		21
W1902	*Tellimya ferruginosa*			3	2				5
W1906	*Kurtiella bidentata*	2	60	57	19				138
W1950	*Parvicardium minimum*				1	1			2
W1972	*Mactra stultorum*		1						1
W1978	*Spisula subtruncata*			1					1
W2004	*Pharus legumen*		2						2
W2006	*Phaxas pellucidus*		3						3

MCS Code	Taxa	Sample							Total
		LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01		
W2019	*Fabulina fabula*	1	1						2
W2059	*Abra alba*	34			1		7		42
W2061	*Abra nitida*			1		3	11		15
W2098	*Chamelea striatula*		3	2					5
W2128	*Dosinia lupinus*				2				2
W2157	*Corbula gibba*		18	4	2		5		29
W2166	*Hiatella arctica*						1		1
W2231	*Thracia phaseolina*		2						2
ZA0003	*Phoronis*		13	18	10	3			44
ZB0152	*Amphiura chiajei*		1				1		2
ZB0154	*Amphiura filiformis*		128	63	26				217
ZB0223	*Echinocardium cordatum*		2		4				6
ZB0292	*Leptosynapta bergensis*		1						1
Number of Taxa		**11**	**35**	**40**	**33**	**16**	**40**		**96**
Abundance		**51**	**326**	**222**	**128**	**24**	**126**		**877**
The following taxa were excluded from the statistical analysis									
Protists									
A5021	*Astrorhiza*			2					2
A5025	Ciliophora	P							P
A5050	Folliculinidae					P			P
Meiofauna									
HD0001	Nematoda						1		1
Pelagic									
R2413	Myodocopida				1				1
Eggs									
C0000	Animalia			P	P		P		P
ZG0001	Actinopterygii						1		1
Juvenile									

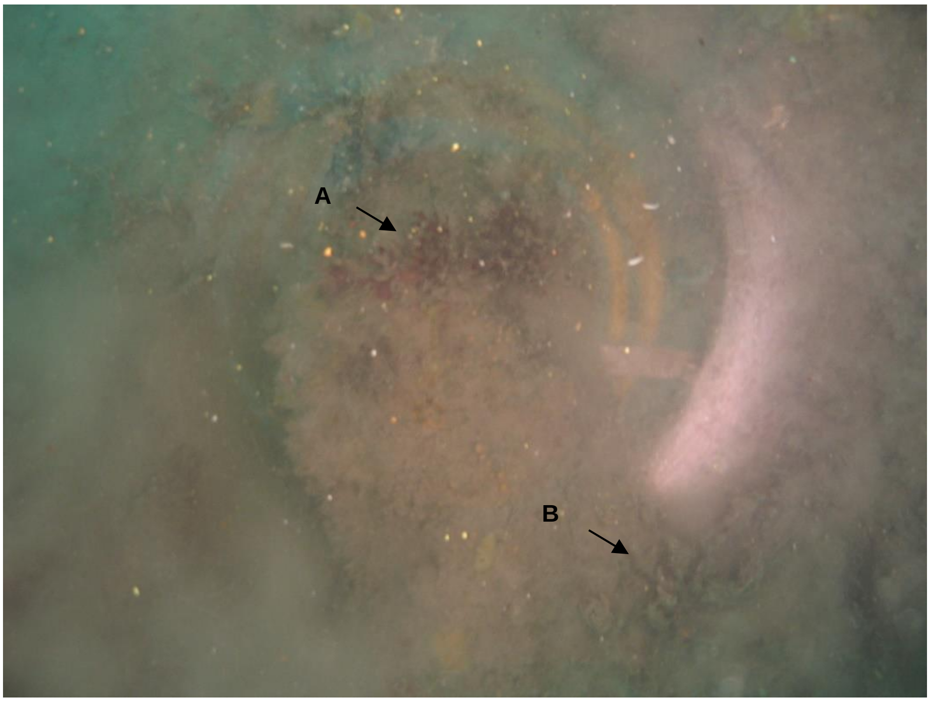
MCS Code	Taxa	Sample							Total
		LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01		
P0017	Aphroditidae						1		1
P0096	Sigalionidae		2						2
P0494	*Nephtys*	3				1			4
W0270	*Turritella communis*			1					1
W1696	*Mytilus edulis*	2	1						3
W1978	*Spisula subtruncata*			1	1				2
W2041	*Donax vittatus*	13							13
W2098	*Chamelea striatula*		2		1				3
W2126	*Dosinia*			1					1
W2227	*Thracia*		1						1
ZB0148	Amphiuridae		4	7	10				21
ZB0165	Ophiuridae		7	7	11				25
ZB0213	Spatangoida				1				1
Colonial									
D0216	Filifera		P				P		P
D0240	*Leuckartiara octona*				P				P
D0272	*Hydractinia*			P					P
D0335	*Lovenella clausa*		P		P				P
D0491	Campanulariidae			P					P
Y0008	*Crisidia cornuta*	P							P
Y0013	*Crisia*	P	P						P
Y0081	*Alcyonidium parasiticum*		P						P
Y0165	*Eucratea loricata*				P				P
Y0239	Bugulidae	P							P
Y0279	*Scrupocellaria scruposa*	P							P
Algae									
ZM0443	*Plocamium cartilagineum*	P							P
ZM0655	*Polysiphonia*	P							P

MCS Code	Taxa	Sample							Total
		LS_ST01	LS_ST02	LS_ST03	LS_ST04	LS_ST05	CC05_ST01		
ZS0195	*Cladophora*	P							P

Notes:
MCS = Marine Conservation Society

G. SEABED PHOTOGRAPHS

STATION LS ST01



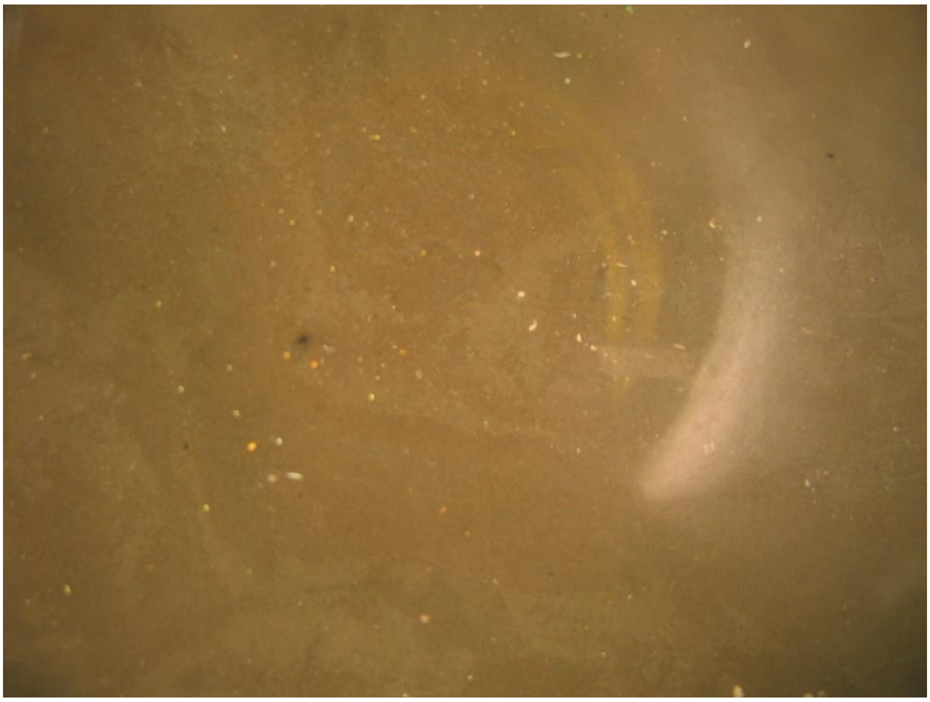
Photograph:
181275_LS_ST01A_04

Easting: 296 285.3 mE
Northing: 5 937 050.9 mN
Depth: 7 m BSL

Sediment Type:
Rippled sand with bedrock/boulder

Fauna:
A: Red seaweed (Rhodophyceae)
B: Faunal turf (Hydrozoa/Bryozoa)

STATION LS_ST02



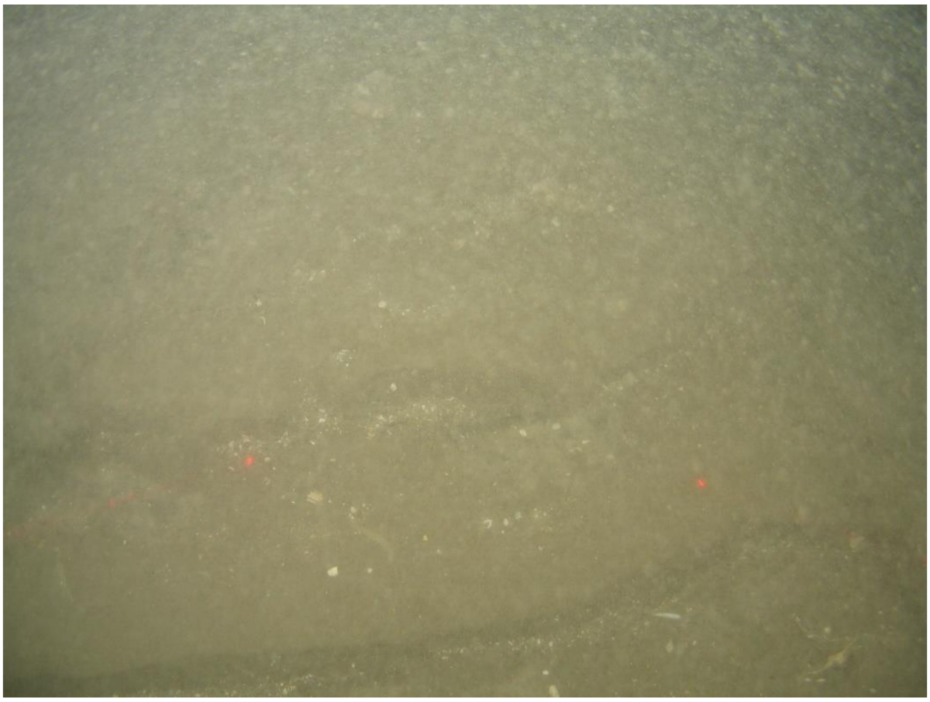
Photograph:
181275_LS_ST02_05

Easting: 298 416.3 mE
Northing: 5 937 608.4 mN
Depth: 15 m BSL

Sediment Type:
Rippled muddy sand with shell fragments

Fauna:
No observed fauna

STATION LS_ST03



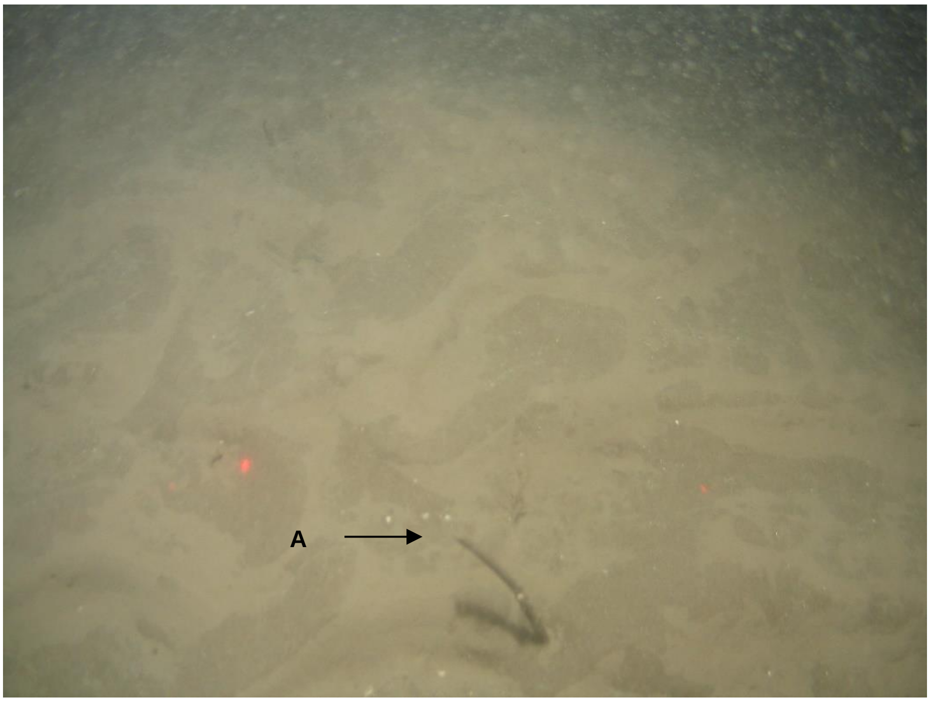
Photograph:
181275_LS_ST03_02

Easting: 303 870.6 mE
Northing: 5 938 724.0 mN
Depth: 35 m BSL

Sediment Type:
Rippled muddy sand with shell fragments

Fauna:
No observed fauna

STATION LS_ST04



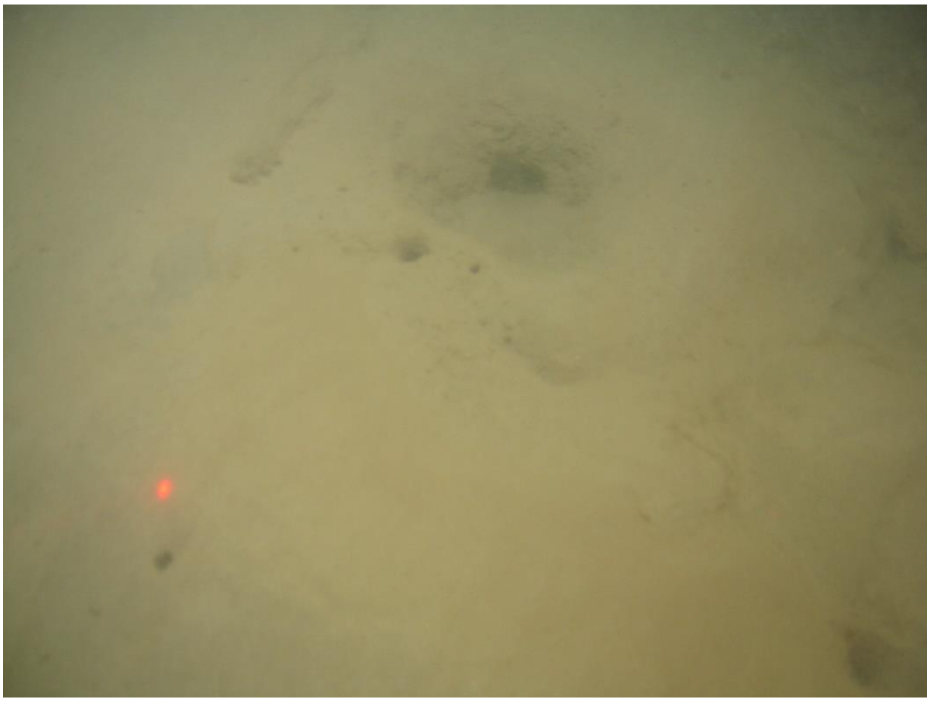
Photograph:
181275_LS_ST04_04

Easting: 307 143.0 mE
Northing: 5 939 807.5 mN
Depth: 41 m BSL

Sediment Type:
Muddy sand

Fauna:
A: Polychaete tubes (Sabellidae)

STATION LS_ST05



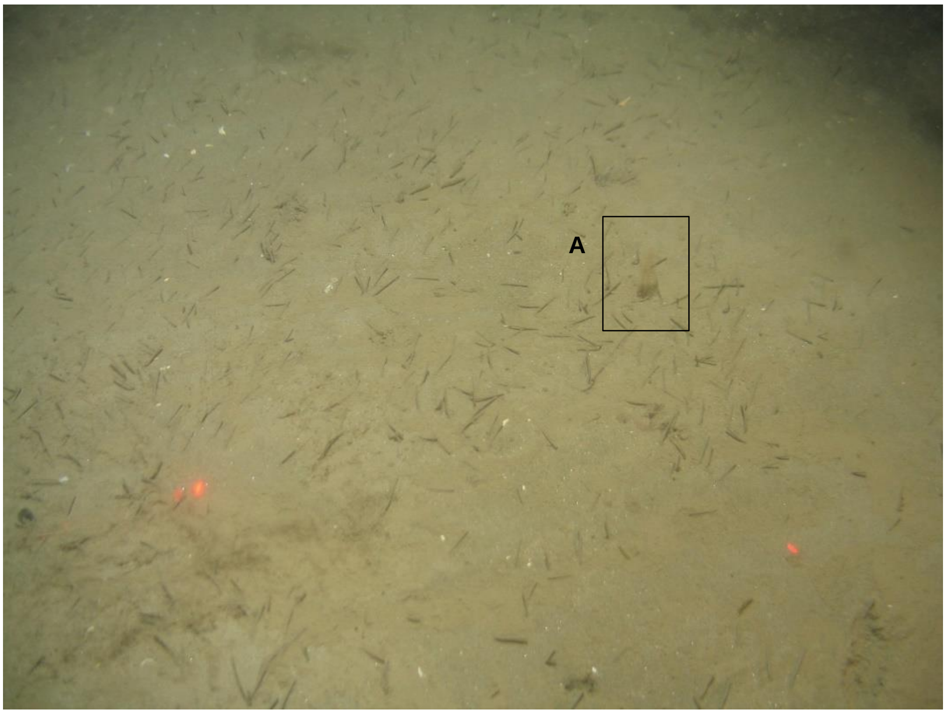
Photograph:
181275_LS_ST05_11

Easting: 314 902.7 mE
Northing: 5 943 531.5 mN
Depth: 66 m BSL

Sediment Type:
Muddy sand

Fauna:
Faunal burrows

TRANSECT CC05_TR01A



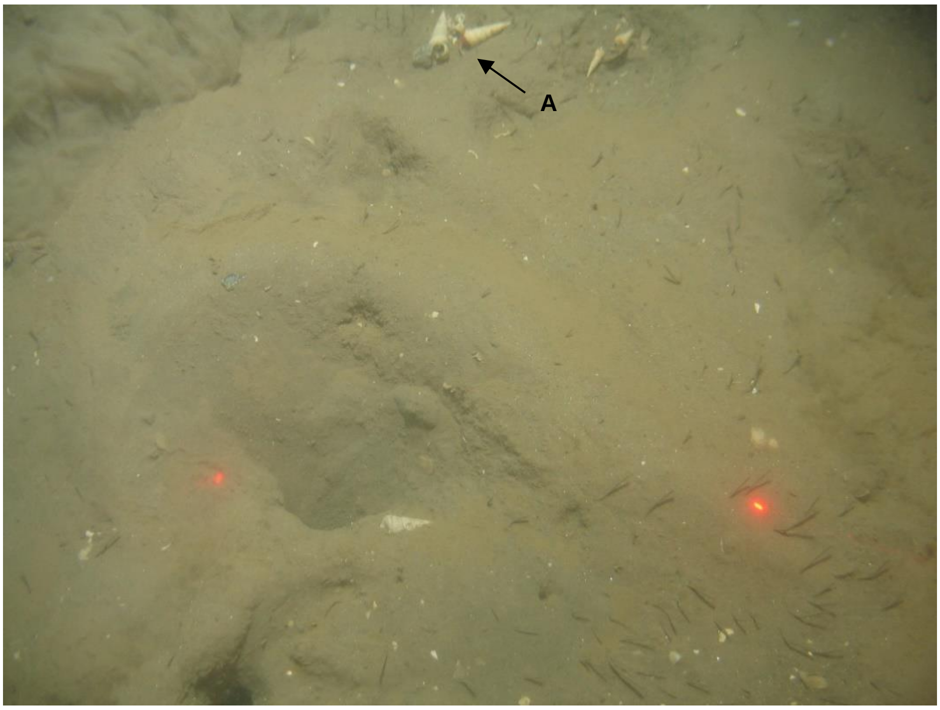
Photograph:
CC05_TR01A_30

Easting: 346 963.1 mE
Northing: 5 957 252.5 mN
Depth: 83.0 m BSL

Sediment Type:
Mud with shell fragments

Fauna:
A. Sea pen
(*Virgularia mirabilis*)
Faunal turf and faunal tubes (Sabellidae)

TRANSECT CC05_TR02



Photograph:
CC05_TR02_22

Easting: 346 550.0 mE
Northing: 5 957 509.7 mN
Depth: 82.0 m BSL

Sediment Type:
Mud with shell fragments

Fauna:
A. Hermit crab (Paguridae)
Faunal turf and faunal burrow

STATION CC05_ST01

Photograph:
CC05_ST01_07

Easting: 346 274.3 mE
Northing: 5 957 560.0 mN
Depth: 82.0 m BSL

Sediment Type:
Mud with shell fragments

Fauna:
Faunal turf and faunal tubes (Polychaeta)

H. SENSITIVE HABITAT ASSESSMENT

H.1 STONY REEF ASSESSMENT

Station/ Transect	Geogenic Classification				Substrate Description and Associated Species	Representative Photograph
	% Cobbles/ Boulders	Elevation	% Epibiota Cover	Overall Geogenic Reef Classification		
LS_ST01A Habitat 2	10 - 20	64 mm – 5 m	20 - 30	Low	**Substrate:** Predominantly bedrock, with areas of cobbles and boulders interspersed with areas of rippled sand **Cobble/Boulder Component:** Cobbles and boulders embedded in sediment **Epibiota Community:** Encrusting fauna and sparse faunal turf covered hard substrate **Typical Taxa:** Red seaweed (Rhodophyceae) Faunal turf (Hydrozoa/Bryozoa) Encrusting polychaete tubes (Serpulidae)	
LS_ST01A Habitat 4	20 – 30	64 mm – 5 m	20 - 30	Low	**Substrate:** Predominantly bedrock, with areas of cobbles and boulders interspersed with areas of rippled sand **Cobble/Boulder Component:** Cobbles and boulders embedded in sediment **Epibiota Community:** Encrusting fauna and sparse faunal turf covered hard substrate **Typical Taxa:** Red seaweed (Rhodophyceae) Faunal turf (Hydrozoa/Bryozoa) Encrusting polychaete tubes (Serpulidae)