The Great Grid Upgrade

Eastern Green Link 5 (EGL 5)

Preliminary Environmental Information Report

Volume 2
Part 3
Appendix 18.A Intertidal Environmental Survey Report

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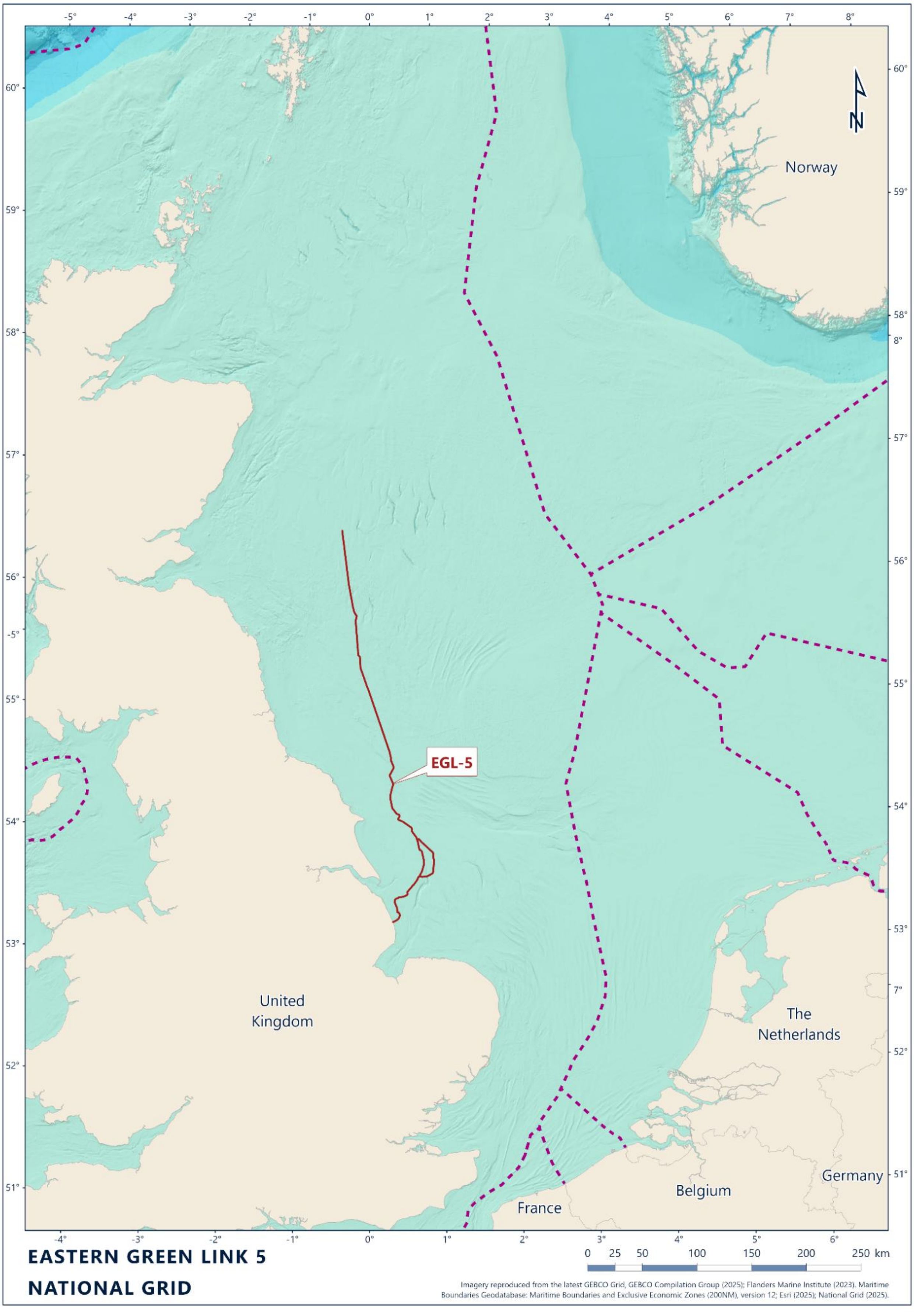

Executive Summary

Introduction

On the instruction of National Grid, Fugro performed a cable route survey, including geophysical and environmental data acquisition along the proposed Eastern Green Link 5 (EGL-5) cable route. The proposed cable route runs from the east coast of Scotland to the Lincolnshire coast in the southern North Sea.

Fugro performed an intertidal survey at the proposed cable landfall (within a 500 m wide corridor), which was located at Anderby Creek on the Lincolnshire coast. Operations were conducted over a spring tide occasion between 3 and 5 December 2025.

This report details the results of the intertidal environmental survey.

Survey Strategy and Field Operations

The intertidal survey followed a modified Joint Nature Conservation Committee (JNCC) phase 1 walkover methodology to identify and map the habitat types present between the upper and lower reaches of the shore, and to evaluate the physico-chemical and biological properties present within the survey area.

Sediment samples were analysed for sediment particle size distribution (PSD), hydrocarbons (HC) and heavy metals (HM), macrofauna and environmental deoxyribonucleic acid (eDNA) for taxonomic classification of invertebrates, eukaryotes and bacteria taxa. Results were used to derive habitats and biotopes in line with the European Nature Information System (EUNIS) habitat classification.

The entire vertical profile of the shore was investigated, from the supralittoral zone to the low water spring tide level (where safe access allowed).

Across the intertidal survey area, nine stations were successfully sampled for physico-chemical and macrofaunal analysis. Three stations were successfully sampled for eDNA analysis.

Sediment Characteristics

The intertidal survey area was represented predominantly by sand, with a low gravel content. Fines were absent from the intertidal survey area, most likely owing to the local hydrodynamics.

Using the Wentworth (1922) scale, two categories of sediments were described, ‘coarse sand’ at the three upper shore stations (ST01 to ST03) and ‘medium sand’ at the remaining stations.

In general, the coarseness of the sediment decreased towards low water, where the sediment was less heterogeneous compared to that at high water. This was reflected in a decrease of the sediment sorting and sediment classes at low shore.

Sediment Hydrocarbons

The gas chromatograms were typical of background conditions across the region. The profiles show a range of low-level, well-resolved n-alkanes, with a slight prevalence of the odd-numbered heavier n-alkanes (those from nC_{25}), which is indicative of plant waxes originating from terrestrial run-off.

THC levels were lower than the Cefas Guideline Action Levels (AL1; 100 µg/g) and the ecological effects threshold (EET) of 50 µg/g.

The total 2 to 6 ring polycyclic aromatic hydrocarbon (PAH) concentrations were low across the intertidal survey area. The United States Environmental Protection Agency's 16 priority PAH pollutants (US EPA 16 PAH) were below their respective effects range low (ERL) values at all stations. When normalised to 2.5 % TOC, naphthalene, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene and chrysene exceeded their BAC values at stations ST04A to ST09A Anthracene exceeded the BAC at four stations and benzo(a)pyrene at two stations.

Examination of naphthalenes, phenanthrenes/anthracenes and dibenzothiophenes (NPD) content and the parent/alkyl distributions within the PAH data suggested inputs from both petrogenic and pyrolytic sources.

Sediment Metals

Concentrations of all 16 metals analysed were below the Cefas AL1 and ERL across the intertidal survey area.

Sediment Macrofauna

Three taxa were recorded in the core samples, represented by Arthropoda and Platyhelminthes. The intertidal macrofaunal communities were characterised by low richness and diversity, likely associated with the exposure of the survey area, the coarseness of the mobile sediment and limited water retention between tides. Only taxa which can withstand such a harsh environment are capable of living in such environments.

Seafloor Environmental Deoxyribonucleic Acid (eDNA) Analysis

Marine Sediment Invertebrate

Only four invertebrate taxa were detected within two successful invertebrate sediment environmental DNA (eDNA) samples. Operational taxonomic units (OTUs) matching the aceol *Baltalimania ylvae* and the annelid *Protodriloides symbioticus* contributed the highest proportions of eDNA within sample ST08 and ST05A respectively.

Marine Sediment Eukaryote

A total of 386 eukaryote taxa were detected within the three sediment eDNA samples. Amongst the Animalia, the phylum Platyhelminthes contributed the highest proportion of OTUs, followed by the family Electridae, the class Polychaeta and the order Harpacticoida. These taxa all occurred at all three stations, except for the bryozoan family Electridae.

Marine Sediment Bacteria

A total of 563 bacteria taxa were detected within the three sediment eDNA samples. The classes Gammaprotobacteria and Actinomycetia, together with the phyla Actinobacteria, the order Planctomycetales and the family Acidobacteriaceae were the top 5 taxa contributing the highest proportions of OTUs and were detected within each eDNA sediment sample.

Habitats and Species Assessments

One biotope complex was found across the survey area.

The EUNIS 4 biotope complex 'Barren or amphipod-dominated Atlantic littoral mobile sand' (MA523) was identified across the intertidal survey area. These shores usually support a limited range of species, ranging from no macrofaunal communities to communities of isopods, amphipods and a limited range of polychaetes.

The survey area supported a macrofaunal community including the amphipod *Pontocrates arenarius* and the isopod *Eurydice pulchra* as well as Platyhelminthes.

Document Arrangement

Volume 1	Environmental Baseline Survey Field Report
Volume 2	Environmental Baseline Survey
Volume 3	Intertidal Field Report
Volume 4	**Intertidal Habitat Report**

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Abbreviations

AFDW	Ash free dry weight
AL	Action level
BAC	Background assessment concentration
BAP	Biodiversity Action Plan
BC	Background concentration
BS	British Standards
BRIG	Biodiversity Reporting and Information Group
CBD	Convention on Biological Diversity
CEMP	Coordinated Environmental Monitoring Programme
CM	Central meridian
CPI	Carbon preference index
DCM	Dichloromethane
DTI	Department of Trade and Industry
EC	European Commission
ED	Evolutionary diversity
eDNA	Environmental deoxyribonucleic acid
EEA	European Environment Agency
EET	Ecological effects threshold
EGL-5	Eastern Green Link 5
EMODnet	European Marine Observation Data Network
ERL	Effects range low
ETRS89	European Terrestrial Reference System 1989
EU	European Union
EUNIS	European Nature Information System
FA/FB	Faunal sample A or B
FID	Flame ionisation detection
GC	Gas chromatography
GC-FID	Gas chromatography – flame ionisation detection
GC-MS	Gas chromatography - mass spectrometry
GDS	Government Digital Service
GES	Good environmental status
GPS	Global Positioning System
GRS80	Geodetic Reference System 1980
HC	Hydrocarbon sample
HM	Heavy metal sample
HVDC	High-voltage direct current
HWM	High water mark
ICES	International Council for the Exploration of the Sea
ICP-MS	Inductively coupled plasma-mass spectrometry
ICP-OES	Inductively coupled plasma-optical emission spectrometry
ISO	International Organisation for Standardization
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
LOI	Loss on ignition
LWM	Low water mark
MCZ	Marine Conservation Zone

MMO	Marine Management Organisation
MPA	Marine Protected Area
MPS	Marine Policy Statement
MRV	Minimum reporting value
nC_{12-36}	n-alkane carbon number range
NERC	Natural Environment and Rural Communities
NG	National Grid
NMBAQC	NE Atlantic Marine Biological Analytical Quality Control
NNS	Non-native species
NNSS	Non-native Species Secretariat
NPD	Naphthalenes, phenanthrenes/anthracenes and dibenzothiophenes
NS	No sample
NSTF	North Sea Task Force
OSPAR	Oslo and Paris Commission
OTU	Operational taxonomic unit
PAH	Polycyclic aromatic hydrocarbon
PC	Physico-chemical sample
PCR	Polymerase chain reaction
Ph	Phytane
Pr	Pristane
Pr/Ph	Ratio of pristane to phytane
PSA	Particle size analysis
PSD	Particle size distribution
rRNA	Ribosomal ribonucleic acid
RSD	Relative standard deviation
SAC	Special Area of Conservation
SBAS	Satellite-based augmentation signals
SD	Standard deviation
SDC	Species Directory Code
SSSI	Site of Special Scientific Interest
THC	Total hydrocarbon content
TOC	Total organic carbon
TOM	Total organic matter
UCM	Unresolved complex mixture
UKOOA	United Kingdom Offshore Operators Association
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

1. Introduction

1.1 General Project Description

National Grid (NG) are developing a high-voltage direct current (HVDC) electricity transmission link from the maritime boundary between Scotland and England to Lincolnshire. The main route of the proposed cable route runs around the Holderness Offshore Marine Conservation Zone (MCZ) and an alternative section runs across the Holderness Offshore MCZ rejoining the main route on the northern side of the MCZ.

The landfall of the cable route is situated at Anderby Creek in Lincolnshire which is located between Saltfleet and Gibraltar Point.

Operations were conducted over a spring tide occasion between 3 and 5 December 2025.

Appendix A outlines the guidelines for use of this report.

1.2 Scope of Work

The intertidal survey followed a modified phase 1 walkover methodology by identifying and mapping the habitat types present in the survey area using in situ observations and photographs of each habitat and habitat boundary with notes and descriptions (Joint Nature Conservation Committee [JNCC], 2016). In addition, sediment samples were collected to evaluate the physico-chemical and biological properties within the survey area.

1.3 Environmental Legislation

Table 1.1 summarises of the marine nature conservation legislation that guide the identification of habitats and species of conservation importance in the study area.

Table 1.1: Environmental legislation

Legislation	Key Aims
Conservation of Habitats and Species (Amendment (EU Exit) Regulations 2019), referred to as the 2019 Regulations	Transposes the requirements of the European Union (EU) Habitats Directive and some elements of the Wild Birds Directive (together forming the Nature Directives) into UK law; aims at conserving biodiversity through measures for protection of habitats listed in Annex I and species listed in Annex II of the Directives through the establishment of a national site network of protected sites, referred to as Special Areas of Conservation (SACs) and Special Protection Area (SPA)
UK Marine Strategy	Provides a framework for community action in the field of marine environmental policy through three components: 1. assessment of the state of UK seas and revised objectives for good environmental status (GES) for 2018 to 2024; 2. monitoring progress against set targets and indicators; measuring the achievement of GES
Marine and Coastal and Access Act 2009	Enables the designation of MCZs in England, Wales and UK offshore waters

Legislation	Key Aims
Natural Environment and Rural Communities Act 2006 (NERC)	Requires the relevant Secretary of State to compile a list of habitats and species of principal importance for the conservation of biodiversity
The Wildlife and Countryside Act 1981 (as amended)	Regulates the designation of Site of Special Scientific Interest (SSSIs), which underpins the designation of Ramsar sites
Oslo and Paris (OSPAR) Convention	Establishes Marine Protected Areas (MPAs)
Convention on Biological Diversity (CBD)	Conservation of biological diversity and sustainable use of its components
Ramsar Convention	Aims at the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development
The UK Marine Policy Statement (MPS)	Provides a framework for achieving sustainable development in the marine environment
National Policy Statement for Renewable Energy Infrastructure (EN-3)	Guidance for developing renewable energy infrastructure

1.4 Regional Habitats, Species and Protected Areas

Based on the European Marine Observation and Data Network (EMODnet) seafloor habitats map (European Marine Observation and Data Network [EMODnet], 2026), the survey area lies in an area likely to comprise the European Nature Information System (EUNIS) habitat 'Atlantic infralittoral coarse sediment' (MB32).

The survey area is close to the Inner Dowsing, Race Bank and North Ridge Special Area of Conservation (SAC) which protects *Sabellaria spinulosa* reefs and sandbanks. Additionally, the Saltfleetby-Theddlethorpe Dunes and Gibraltar Point SAC nearby protects Annex I habitats 'Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)' and 'Fixed coastal dunes with herbaceous vegetation (grey dunes)'.

Table 1.2 lists the relevant protected areas within 35 km of the survey area, summarising the sensitive habitats and species for which they were designated to protect.

Figure 1.1 spatially displays the protected areas in relation to the survey area.

Table 1.2: Summary of nearby protected areas

Protected Area	Status	Distance* [km]	Direction*	Protected Habitats/Species
Inner Dowsing, Race Bank and North Ridge	Special Area of Conservation	7	SE	*Sabellaria spinulosa* reefs Sandbanks which are slightly covered by sea water all the time
Saltfleetby-Theddlethorpe Dunes and Gibraltar Point	Special Area of Conservation	11	NW	Annex I habitats: Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) Fixed coastal dunes with herbaceous vegetation (grey dunes)
Humber Estuary	Special Area of Conservation	18	NW	**Species:** Grey seal (*Halichoerus grypus*) Sea lamprey (*Petromyzon marinus*) **Habitats:** Atlantic salt meadows (*Glauco- Puccinellietalia maritimae*) Estuaries Mudflats and sandflats not covered by seawater at low tide *Salicornia* and other annuals colonising mud and sand Sandbanks which are slightly covered by sea water all the time
Holderness Inshore	Marine Conservation Zone	34	NW	High energy circalittoral rock Intertidal sand and muddy sand Moderate energy circalittoral rock Spurn Head (subtidal) and "the Binks" Subtidal coarse sediment Subtidal mixed sediments Subtidal mud Subtidal sand

Notes
* = Distance (to nearest kilometre) and direction from the cable landfall site

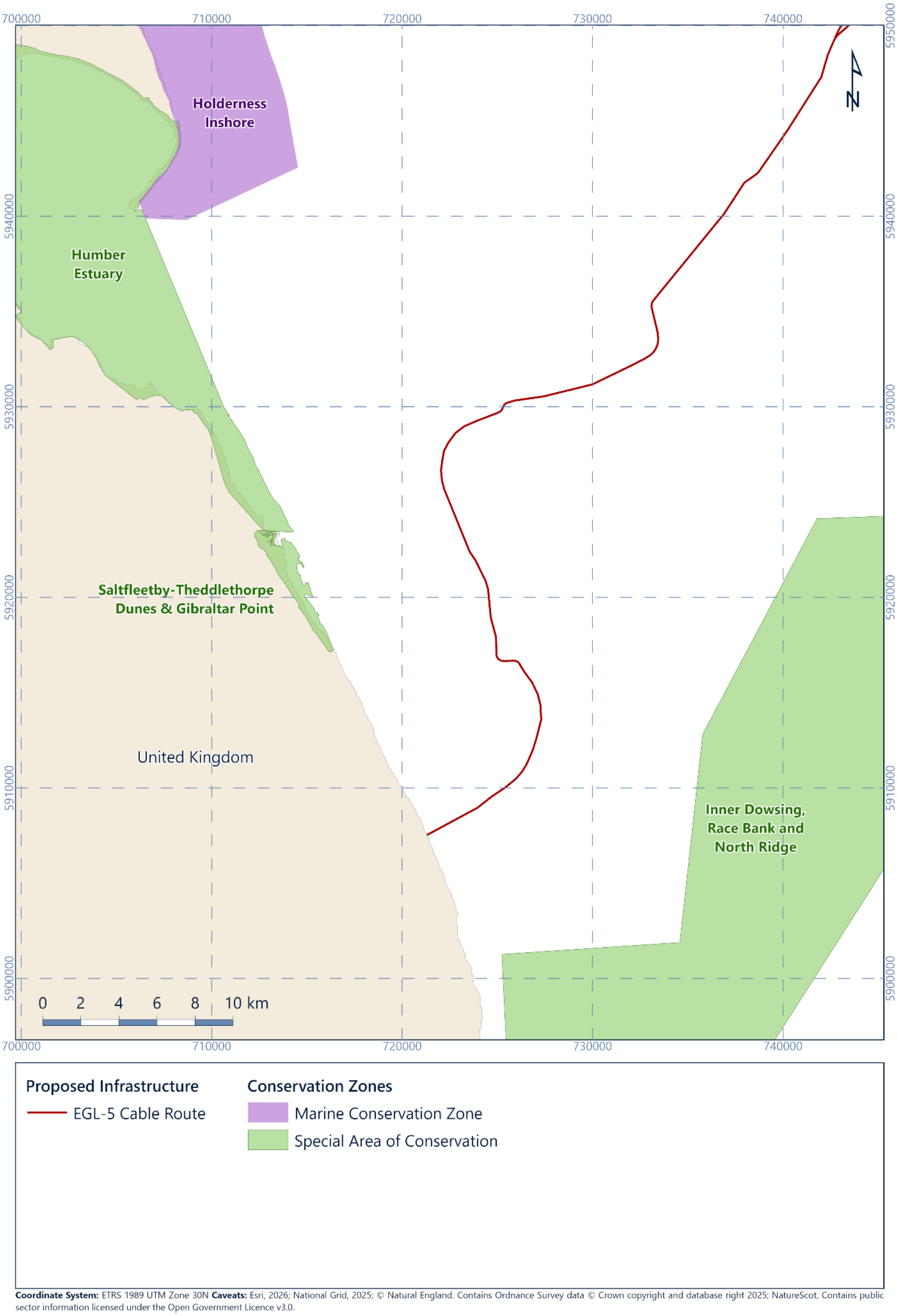


Figure 1.1: Protected areas relevant to the survey area (UTM Zone 30N)

1.5 Environmental Quality Standards for Sediment Chemical Concentrations

Selected data have been compared to the OSPAR effects range low (ERL) concentrations (Oslo and Paris Commission [OSPAR], 2014), where available. The ERL thresholds represent the low point (10th percentile) and are therefore indicative of concentrations below which adverse effects rarely occur (OSPAR, 2009, 2014).

Selected data have been compared to the Cefas Action Levels when appropriate. These levels serve as proxies for assessing potential risks to marine life, such as fish and benthic organisms. Each contaminant has two thresholds; this report uses Action Level 1 (AL1), the lower threshold. Concentrations below AL1 are generally considered not detrimental to the marine environment and unlikely to affect licensing decisions (Marine Management Organisation [MMO], 2015) .

Selected data have also been compared to the Coordinated Environmental Monitoring Programme (CEMP) Assessment Criteria (OSPAR, 2014) background concentration (BC) and background assessment concentration (BAC) for select hydrocarbons (see Appendix E).

1.6 Coordinate Reference System

All coordinates detailed in this report are referenced to the European Terrestrial Reference System 1989 (ETRS89) datum, projected in Universal Transverse Mercator (UTM) Zone 30N, with a central meridian (CM) at 3° West longitude. Table 1.3 provides the detailed geodetic and projection parameters.

Table 1.3: Project geodetic and projection parameters

Global Navigation Satellite System (GNSS) Geodetic Parameters*	
Datum:	European Terrestrial Reference System 1989
Spheroid:	Geodetic Reference System 1980 (GRS80)
Semi major axis:	a = 6 378 137.000 m
Inverse flattening:	I/f = 298.257 222 101
Project Projection Parameters	
Grid Projection:	Universal Transverse Mercator (UTM)
UTM Zone:	30N
Central Meridian:	3° W
Latitude of Origin:	00° 00′ 00″ North
Longitude of Origin:	003° 00′ 00″ West
False Easting:	500 000 m
False Northing:	0 m
Scale factor on Central Meridian:	0.9996
Units:	metre

2. Survey Strategy

At the landfall location, habitats were mapped down the shore from the approximate high water mark (HWM) to low water mark (LWM) within a 500 m wide corridor. Each transect ran from HWM to LWM and consisted of three sediment sampling locations from the three heights on the shore: HWM, mid shore, and LWM. Two macrofauna samples and duplicate physico-chemical samples were collected from each height on the shore. Environmental DNA samples were collected from the stations along the proposed cable route of the survey area.

Table 2.1 provides the stations, data to be acquired and rationale for each proposed survey location.

Table 2.1: Proposed intertidal sampling locations

Station	Rationale	Sample Acquisition
ST01	Upper shore (HWM), the survey corridor centre line	PC, FA, FB
ST02	Upper shore (HWM), the survey corridor centre line	PC, FA, FB, eDNA
ST03	Upper shore (HWM), the survey corridor centre line	PC, FA, FB
ST04	Mid shore, the survey corridor centre line	PC, FA, FB
ST05	Mid shore, the survey corridor centre line	PC, FA, FB, eDNA
ST06	Mid shore, the survey corridor centre line	PC, FA, FB
ST07	Lower shore (LWM), the survey corridor centre line	PC, FA, FB
ST08	Lower shore (LWM), the survey corridor centre line	PC, FA, FB, eDNA
ST09	Lower shore (LWM), the survey corridor centre line	PC, FA, FB

Notes
LWM = Low water mark
HWM = High water mark
PC = Physico-chemical sample
FA/FB = Faunal sample A and B
eDNA = Environmental deoxyribonucleic acid

3. Methods

3.1 Survey Methods

The sections below provide a summary of the intertidal survey methods. Survey methods were based on those from the JNCC Marine monitoring handbook (JNCC, 2001).

3.1.1 Survey Positioning

Garmin GPSmap 78 handheld Global Positioning System (GPS) units, utilising satellite-based augmentation signals (SBAS), were used to georeference photographs, sampling locations and target notes. Assuming availability of augmentation signal, these units typically achieve positioning accuracies of better than 3 m. Positioning accuracy was monitored throughout operations and suggested that both GPS and SBAS signals were available throughout.

3.1.2 Modified Phase 1 Walkover Survey

In the survey area, a cable route corridor of 500 m width was surveyed.

A phase I biotope mapping survey was conducted to record conspicuous intertidal fauna, flora and habitats within the survey area. The entire vertical profile of the shore was investigated, from HWM to the LWM (where safe access allowed).

Georeferenced Environmental Systems Research Institute colour aerial photographs covering the survey area were produced as field maps. Habitat boundaries were established and manually mapped onto field maps and any associated faunal and floral assemblages recorded. Photographs were captured within each biotope to facilitate detailed ground-truthing.

Target notes, with accompanying GPS fixes, were used to record further information, including features that were too small (< 5 m^2) to be portrayed accurately on a map or that couldn't be distinguished from satellite imagery. Target notes were also made for each photographic sampling location such as small changes in sediment type or notable faunal.

3.1.2.1 Sediment Sampling

Sediment samples for macrofaunal analysis (two replicates FA and FB) were acquired using a 11.2 cm diameter (0.01 m^2) push corer. Target sample depth was 20 cm, although smaller cores were accepted if this penetration could not be achieved in coarser sediments. The acquired core samples were transferred to 5 L buckets and fixed with buffered formal saline solution. One sample (FA) was to be analysed, and the second sample (FB) was collected as a backup sample.

Sediment samples for physico-chemical analysis were sampled directly from the surface of an area of undisturbed sediment. Duplicates for particle size distribution (PSD), hydrocarbons (HC) and heavy metals (HM) were collected.

For eDNA analysis, a composite sample of 4 x 10 mL subsamples were taken to provide representation of the sediment community.

3.2 Laboratory Methods

See Appendix B.1 of full methodologies carried out.

Below are analysis methods that have been tailored to suit the intertidal survey data collected.

3.2.1 Sediment Macrofaunal Univariate and Multivariate Analysis

Univariate and multivariate statistical analyses were not undertaken for the macrofaunal dataset due to the very low abundances of both taxa and individuals across the survey area. Applying such methods would risk producing unreliable or misleading statistical outputs.

3.2.1 Environmental DNA Analysis

NatureMetrics carried out laboratory extraction and sequencing. DNA was extracted from the sediment samples using a DNeasy Blood and Tissue Kit (Qiagen). The original eDNA data analyses were carried out by NatureMetrics, with additional eDNA visualisation and interpretation carried out by Fugro GB Limited. The results are presented within Section 9 below.

To evaluate taxonomic assignment completeness, the percentage of operational taxonomic units (OTUs) identified to a taxonomic level was categorised as low (< 30 %), moderate (30-70 %) or high (> 70 %). Values below high indicate low taxonomic resolution.

See Section 3 within Volume 2 of this report series for further details on the laboratory methods conducted.

3.3 Data Analysis

To assess the habitats, present within the survey area, the locations of any observed changes in sediment type and/or associated faunal community were noted.

3.3.1 Habitat Mapping

The habitat maps and notes produced during the intertidal fieldwork were reviewed in conjunction with the photographs acquired. Habitat boundaries that were drawn in situ together with associated positional fix data, were then digitised in *ArcGIS* to produce the final habitat maps.

Descriptions of the substrate composition, corresponding to sediment changes, were undertaken. These descriptions were based on a reclassification of the Folk (1954) sediment classes and were developed to support the EUNIS habitat identification (Long, 2006) in conjunction with the Wentworth (1922) classification, the latter differentiating between ‘pebbles’, ‘cobbles’, and ‘boulders’ based on their dimensions. The Folk (1954) sediment classification was initially reclassified into four categories, namely ‘coarse sediment’, ‘mixed sediment', 'mud and sandy mud', and 'sand and muddy sand' to be more aligned with the EUNIS classification. During this reclassification, elements of 'muddy sand' were contained within both latter categories (Long, 2006). For the purposes of this habitat assessment, aligned with the EMODnet substrate classification scheme, 'mud to muddy sand' and 'sand' are considered separately, with the former including the sub-categories 'mud', 'sandy mud', and 'muddy sand' (Kaskela et al., 2019). The Folk categories and sub-categories are defined by the proportions of 'mud', 'sand', and 'gravel'. For example, a description of muddy sand defines sediments that have sand as the principal component (50 % to 90 %) with a secondary component of mud (10 % to 50 %) and < 5 % gravel (Kaskela et al., 2019). The EMODnet Geology Consortium further revised the above categories to include the category 'rock and boulders' (Kaskela et al., 2019) which includes the Wentworth (1922) categories boulders and cobbles. The presence of shell fragments and observed anthropogenic features were also noted.

Table 3.1 presents a summary of the sediment particle sizes and corresponding classifications.

Table 3.1: Sediment particle size and classification terms

Particle Size	Wentworth (1922)	Folk (1954)	Folk, 5 classes (Kaskela et al., 2019)			
> 256 mm	Boulder	Gravel	Rock and boulders			
64 mm to 256 mm	Cobble					
32 mm to < 64 mm	Pebbles		Coarse sediment: (Gravel ≥ 80 %, or Gravel ≥ 5 % and Sand ≥ 90 %)	Mixed sediment: (Mud ≥ 10 % - 95 % Sand < 90 % Gravel ≥ 5%)	Mud to muddy sand*: (Mud 10 % - 95 % Sand < 90 % Gravel < 5 %)	Sand: (Mud < 10 % Sand ≥ 90 % Gravel < 5%)
16 mm to < 32 mm						
8 mm to < 16 mm						
4 mm to < 8 mm						
2 mm to < 4 mm	Granules					
1 mm to < 2 mm	Very coarse sand	Sand				
0.5 mm to < 1 mm	Coarse sand					
0.25 mm to < 0.5 mm	Medium sand					
0.125 mm to < 0.25 mm	Fine sand					
62.5 µm to 0.125 mm	Very fine sand					
> 4 µm to 62.5 µm	Silt	Mud	-			
> 1 µm to 4 µm	Clay					

Notes
* = Mud to muddy sand includes:
Mud (Mud ≥ 90 %, Sand <10 %, Gravel < 5%);
Sandy mud (Mud 50 % to 90 %, Sand 10 % to 50 %, Gravel < 5%);
Muddy sand (Mud 10 % to 50 %, Sand 50 % to 90 %, Gravel < 5%) (Kaskela et al., 2019)

Habitats within the survey area have been classified in accordance with the EUNIS habitat classification (European Environment Agency [EEA], 2022). Table 3.2 summarises the EUNIS hierarchy and provides an example of the coding system. The EUNIS classification system is designed to incorporate small-scale temporal variations (e.g. seasonal) into the biotope/habitat categories. The equivalent classification from 'The Marine Habitat Classification for Britain and Ireland – Version 22.04' (JNCC, 2022) was also noted. The JNCC classification formed the basis of the marine section of the EUNIS habitat classification scheme (Davies et al., 2004).

EUNIS classifications were coded for each habitat type observed following assessment of the sediment type and species recorded within the survey area, biotopes could be classified. When assigning a biotope, field maps, photographs, target notes and sediment sample data (PSD and macrofauna) were considered.

Although, theoretically, a biotope can be assigned to any sized area of seafloor, for the purposes of this assessment, the commonly accepted minimum habitat size of 25 m^2 was adopted (Parry, 2019).

Table 3.2: EUNIS (EEA, 2022) biotope classification hierarchy example

Level	Example Classification Name	Example Classification Code
1. Environment	Marine benthic habitats	M
2. Biological zone and substrate	Circalittoral sand	MC5
3. Biogeographical marine region	Atlantic circalittoral sand	MC52
4. Biotope complex	Faunal communities of Atlantic circalittoral sand	MC521
5 & 6. Biotope and sub-biotope	*Amphiura brachiata* with *Astropecten irregularis* and other echinoderms in circalittoral muddy sand	MC5215

3.3.2 Sensitive Habitats and Species

Intertidal habitat and species recorded across the survey area were assessed for their conservation status. Conservation status was assessed against those listed under Annex I or Annex II of the of the Conservation of Habitats and Species Regulations 2019 (JNCC, 2019a, 2019b), on the OSPAR list of threatened and/or declining habitats and (OSPAR, 2026) and on the UK Biodiversity Framework 2024, formerly Biodiversity Action Plan [BAP] (Biodiversity Reporting and Information Group [BRIG], 2011)

The International Union for Conservation of Nature (IUCN) red list of threatened species (International Union for Conservation of Nature [IUCN], 2026) was also consulted, although the latter is not a list of conservation priorities, rather a comprehensive inventory of the global conservation status of species and is used to assist with decision making about conserving biodiversity at local and global levels.

4. Field Operations

Appendix C.1 provides the full sampling log and Appendix C.2 provides the walkover photographic log.

4.1 Modified Phase 1 Walkover Survey

As part of the intertidal walkover survey, 24 georeferenced photographs and 7 georeferenced videos were acquired along with accompanying target notes (this total excludes additional photographs taken at all sampling locations)

Figure 4.1 presents example photographs from the walkover survey.

4.2 Sediment Sampling

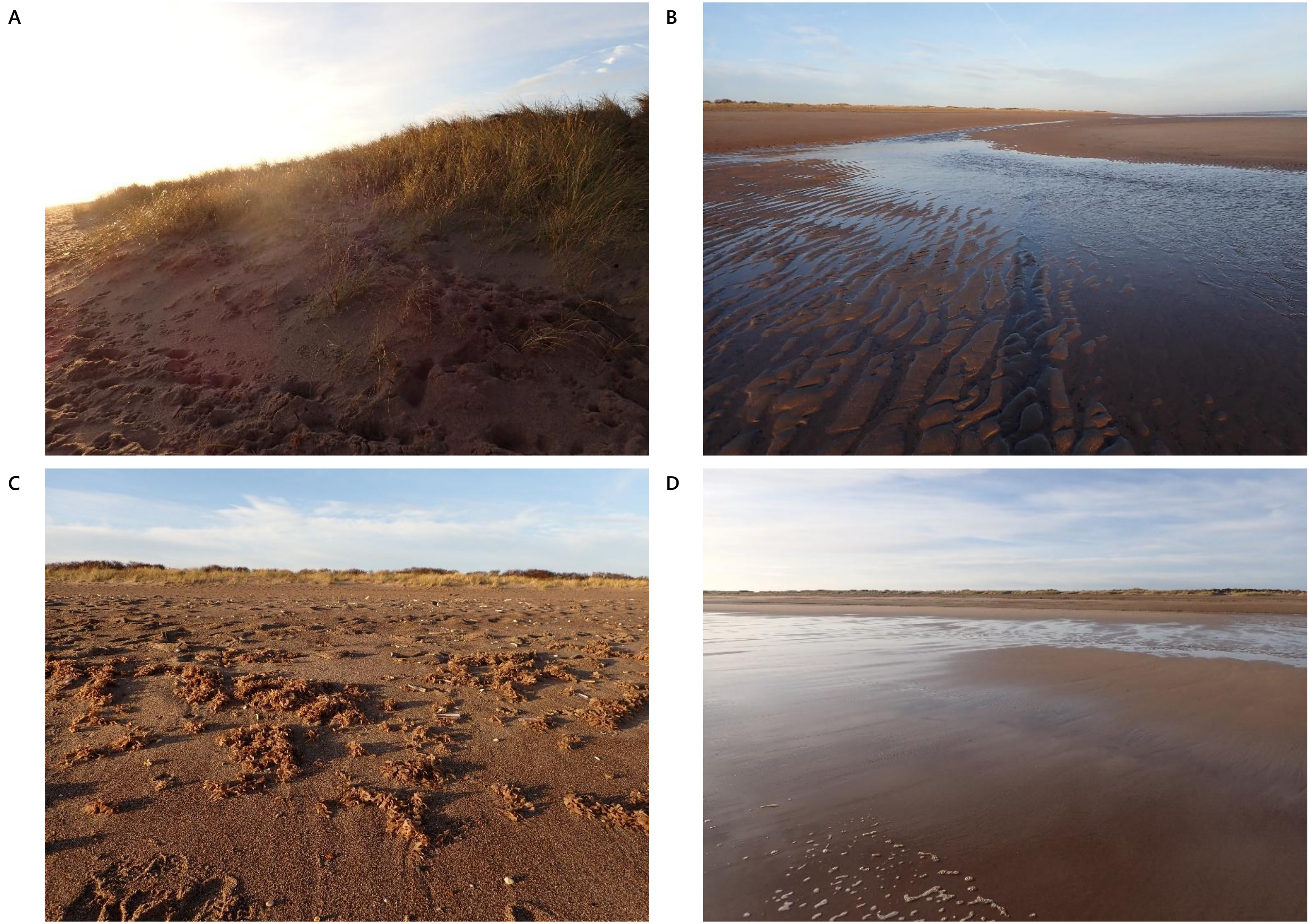
All stations were successfully sampled. Three stations were re-sampled after GIS analysis showed they were located outside the intended target area. Stations ST04, ST05 and ST09 were therefore repeated and named with the suffix 'A'.

Table 4.1 summarises the intertidal sediment sampling undertaken and Figure 4.2 spatially displays the sediment sampling, photograph and video locations.

Table 4.1: Completed sediment sampling stations

Geodetic Parameters:	ETRS89, UTM Zone 30N, CM 3° W [m]*		ETRS89, UTM Zone 31N, CM 3° E [m]†			
Station	Easting	Northing	Easting	Northing	Position on Shore	Sample Acquisition
ST01	721 272.9	5 907 767.7	321 207.9	5 905 983.3	Upper shore	PC, FA, FB
ST02	721 357.2	5 907 555.0	321 274.1	5 905 764.3	Upper shore	PC, FA, FB, eDNA
ST03	721 471.7	5 907 324.7	321 368.9	5 905 525.3	Upper shore	PC, FA, FB
ST04A	721 346.2	5 907 783.2	321 282.2	5 905 992.6	Mid shore	PC, FA, FB
ST05A	721 427.4	5 907 588.4	321 346.9	5 905 791.8	Mid shore	PC, FA, FB, eDNA
ST06	721 564.6	5 907 365.5	321 464.9	5 905 558.1	Mid shore	PC, FA, FB
ST07	721 416.6	5 907 870.5	321 359.7	5 906 073.7	Lower shore	PC, FA, FB
ST08	721 526.8	5 907 615.1	321 448.1	5 905 810.0	Lower shore	PC, FA, FB, eDNA
ST09A	721 616.3	5 907 404.0	321 519.6	5 905 592.1	Lower shore	PC, FA, FB

Notes
PC = Physico-chemical sample
FA/FB = Faunal sample A and B
eDNA = Environmental DNA
* = Intertidal survey spanned two UTM zones. Coordinates were recorded in UTM zone 30N to be consistent with the subtidal survey
† = UTM zone 30N coordinates converted to UTM 31N for ease of comparison to the drone survey



A: Photograph Fix 2

Sand dunes north-west of the survey corridor

B: Photograph Fix 13

Midpoint tide facing north

C: Photograph Fix 16

Flustra foliacea strandline facing west

D: Photograph Fix 25

Overall beach view facing west

Figure 4.1: Example photographs of the survey area

Coordinate System: ETRS 1989 UTM Zone 30N Caveats: Esri, 2026; Microsoft, Vantor

Figure 4.2: Completed sediment sampling, photograph and video locations overlaid on aerial imagery (UTM Zone 30N)

5. Sediment Characterisation

5.1 Introduction

Sediment samples were analysed for their PSD using a combination of two techniques: sieve analysis for all material retained by a 1.0 mm sieve followed by laser diffraction analysis of the finer material. The PSD parameters include the descriptive statistics derived in Gradistat (Blott, 2010) and based on the Folk and Ward (1957) method. The sediment descriptions are based on the Wentworth (1922) scale and Folk classification (Folk, 1954).

The proportion of total organic matter (TOM) present in each sediment sample was determined by loss on ignition (LOI) at 450 °C for four hou (Snelgrove & Butman, 1994)rs, whilst the proportion of total organic carbon (TOC) was determined by combustion and non-dispersive infrared detection following inorganic carbon removal.

Appendix B provides full details of the analytical techniques employed and Appendix D.3 displays the histograms of particle size class summary for each station.

5.2 Results

Table 5.1 presents the sediment characteristics, including granulometry and organic content (TOM and TOC).

Figure 5.1 presents the granulometry of the sediments at each station, while Figure 5.2 presents the fractional composition and Figure 5.3 presents the mean particle size spatially across the survey area.

The mean TOM content was 0.39 % with low variability in TOM content across the intertidal survey area (relative standard deviation [RSD] 22 %).

The TOC content ranged from 0.04 % at station ST04A, to 0.54 % at station ST01 with a mean of 0.15 % across the intertidal survey area and high variability (RSD 101 %).

Sand was the dominant fraction across the intertidal survey area. Sand values ranged from 98.32 % at station ST03 to 100.00% at station ST01, with a mean of 99.70% and low variability (RSD 1 %). The gravel content was low throughout the survey area with values ranging from 0.00 % at ST01 to 1.68 % at station ST03, with a mean of 0.30 % and high variability (RSD 178 %). Gravel was absent from station ST01. Fines were absent from the intertidal survey area at the time of the survey.

The Folk description classify sediment by the relative proportion of sediment fractions (gravel, sand and fines). The Folk description (1954) categorised the sediments as sand at all stations.

Table 5.2 presents the physical composition of the sediments (Folk & Ward, 1957) at each station, which was broadly similar across the survey area. The mode (or modal distribution) represents the peak of the particle size frequency distribution. Within the current survey, distributions were unimodal at all stations.

The mean particle size (μm) ranged from 262 μm at station ST07 to 659 μm at station ST03, with a mean value of 424 μm and moderate variability (RSD 34 %).

The mean particle size (phi) ranged from 0.60 phi at station ST03 to 1.93 phi at station ST07, with a mean of 1.31 phi.

The median particle size (μm) ranged from 261 μm at ST07 to 666 μm at station ST03, with a mean of 424 μm and moderate variability (RSD 35 %).

The Wentworth description, assigned from mean particle size, categorised the sediments as coarse sand at stations ST01 to ST03 with the remaining stations classified as ‘medium sand’.

The sorting coefficient 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 are fairly homogeneous (well sorted) while high values suggest a relatively large scatter of particle sizes about the mean (poorly sorted). Stations ST01 and ST02 were classed as well sorted, stations ST03 to ST08 were classed as moderately well sorted and station ST09A was classed as moderately sorted.

Skewness indicates the tendency of particle size classes to be skewed about the mean, either towards finer sediment (negative skewness) or coarser sediment (positive skewness). Skewness was symmetrical at all stations in the intertidal area.

Table 5.1: Summary of sediment characteristics

Station	TOM [%]*	TOC [%]*	Fractional Composition			Fines		Folk Description
			Gravel [%]	Sand [%]	Fines [%]	Silt [%]	Clay [%]	
ST01	0.39	0.54	0.00	100.00	0.00	0.00	0.00	Sand
ST02	0.36	0.22	0.01	99.99	0.00	0.00	0.00	Sand
ST03	0.51	0.07	1.68	98.32	0.00	0.00	0.00	Sand
ST04A	0.37	0.04	0.02	99.98	0.00	0.00	0.00	Sand
ST05A	0.34	0.09	0.13	99.87	0.00	0.00	0.00	Sand
ST06	0.35	0.12	0.08	99.92	0.00	0.00	0.00	Sand
ST07	0.35	0.05	0.10	99.90	0.00	0.00	0.00	Sand
ST08	0.30	0.11	0.43	99.57	0.00	0.00	0.00	Sand
ST09A	0.57	0.14	0.27	99.73	0.00	0.00	0.00	Sand
Minimum	**0.30**	**0.04**	**0.00**	**98.32**	**0.00**	**0.00**	**0.00**	-
Maximum	**0.57**	**0.54**	**1.68**	**100.00**	**0.00**	**0.00**	**0.00**	
Median	**0.36**	**0.11**	**0.10**	**99.90**	-	-	-	
Mean	**0.39**	**0.15**	**0.30**	**99.70**	-	-	-	
Standard Deviation	**0.088**	**0.155**	**0.535**	**0.535**	-	-	-	
RSD [%]	**22**	**101**	**178**	**1**	-	-	-	

Notes
Fines = Silt and clay content
RSD = Relative standard deviation
Silt = +4.0 to +8.0 ø units or 3.9 µm to 62.5 µm
* = Concentrations expressed as % dry weight
Clay = +8.0 to +10.0 ø units or 0.98 µm to 3.9 µm

Table 5.2: Summary of particle size distribution

Station	Modality	Median [µm]†	Mean Particle Size			Sorting Coefficient		Skewness	
			[µm]*	[phi]*	Wentworth (1922) Description†	[µm]*	Description‡	[µm]*	Description‡
ST01	Unimodal	590	586	0.77	Coarse sand	1.37	Well sorted	-0.03	Symmetrical
ST02	Unimodal	583	579	0.79	Coarse sand	1.37	Well sorted	-0.02	Symmetrical
ST03	Unimodal	666	659	0.60	Coarse sand	1.49	Moderately well sorted	0.02	Symmetrical
ST04A	Unimodal	385	387	1.37	Medium sand	1.48	Moderately well sorted	-0.01	Symmetrical
ST05A	Unimodal	374	376	1.41	Medium sand	1.46	Moderately well sorted	0.00	Symmetrical
ST06	Unimodal	326	326	1.62	Medium sand	1.48	Moderately well sorted	0.03	Symmetrical
ST07	Unimodal	261	262	1.93	Medium sand	1.46	Moderately well sorted	0.01	Symmetrical
ST08	Unimodal	313	314	1.67	Medium sand	1.52	Moderately well sorted	0.04	Symmetrical
ST09A	Unimodal	318	324	1.63	Medium sand	1.70	Moderately sorted	0.06	Symmetrical
Minimum	-	**261**	**262**	**0.60**	-	**1.37**	-	**-0.03**	-
Maximum		**666**	**659**	**1.93**		**1.70**		**0.06**	
Median		**374**	**376**	**1.41**		**1.48**		**0.01**	
Mean		**424**	**424**	**1.31**		**1.48**		**0.01**	
Standard Deviation		**148**	**145**	**0.473**		**0.098**		**0.028**	
RSD [%]		**35**	**34**	**-**		**7**		**258**	

Notes
RSD = Relative standard deviation
* = Folk and Ward method (Gradistat statistics)
† = Wentworth description (Wentworth, 1922)
‡ = Sorting and skewness based on geometric Folk and Ward (1957) graphical measures (Gradistat statistics)

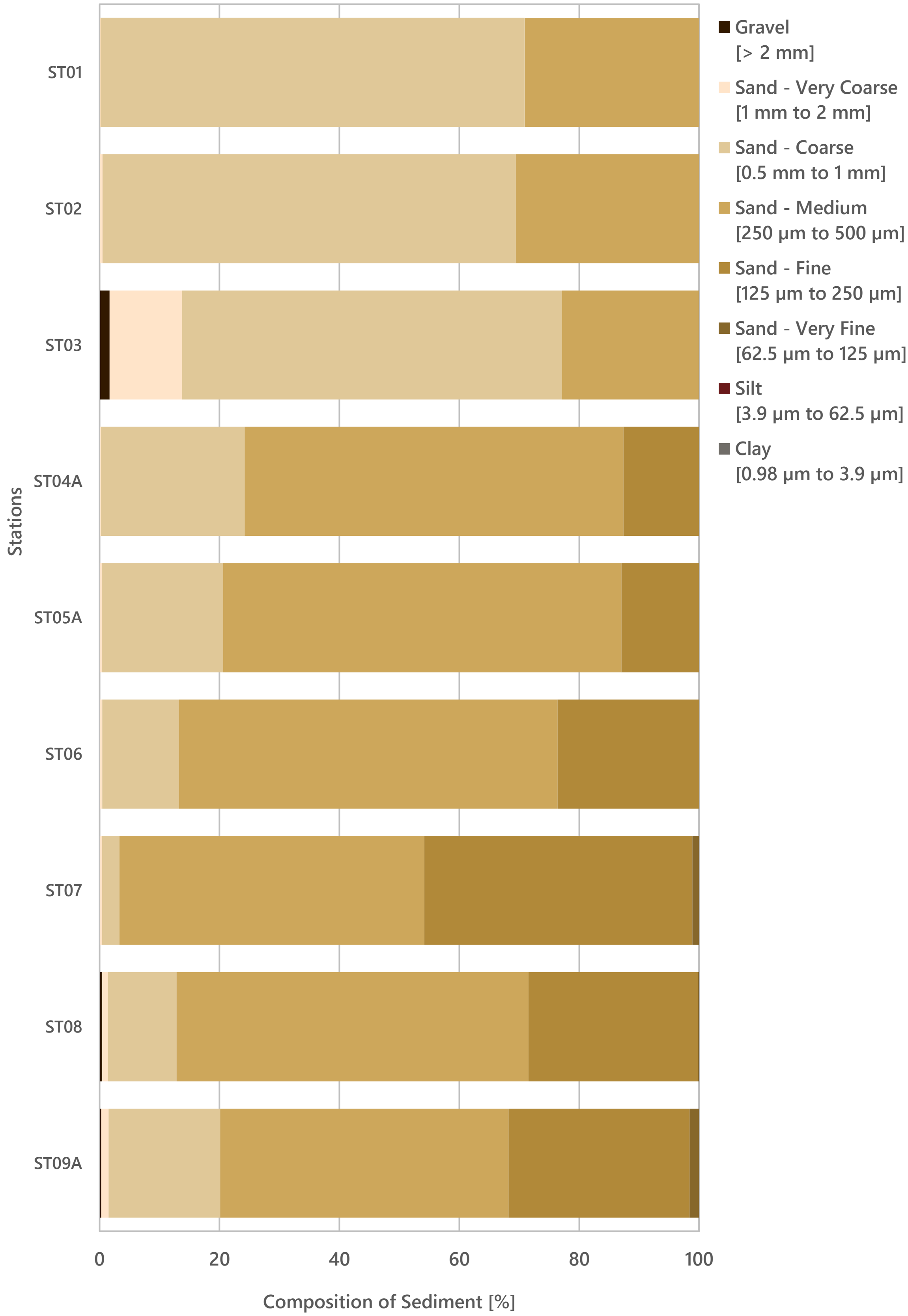


Figure 5.1: Sediment composition at each station

Figure 5.2: Sediment fractional composition overlaid on aerial imagery (UTM Zone 30N)

Figure 5.3: Sediment mean particle size (µm) overlaid on aerial imagery (UTM Zone 30N)

6. Sediment Hydrocarbons

6.1 Introduction

The sediment samples were analysed for hydrocarbon content, including total hydrocarbon content (THC), total n-alkanes (nC_{12} to nC_{36}) and polycyclic aromatic hydrocarbons (PAHs), specifically the United States Environmental Protection Agency's 16 priority PAH pollutants (US EPA 16 PAHs) and alkylated PAHs.

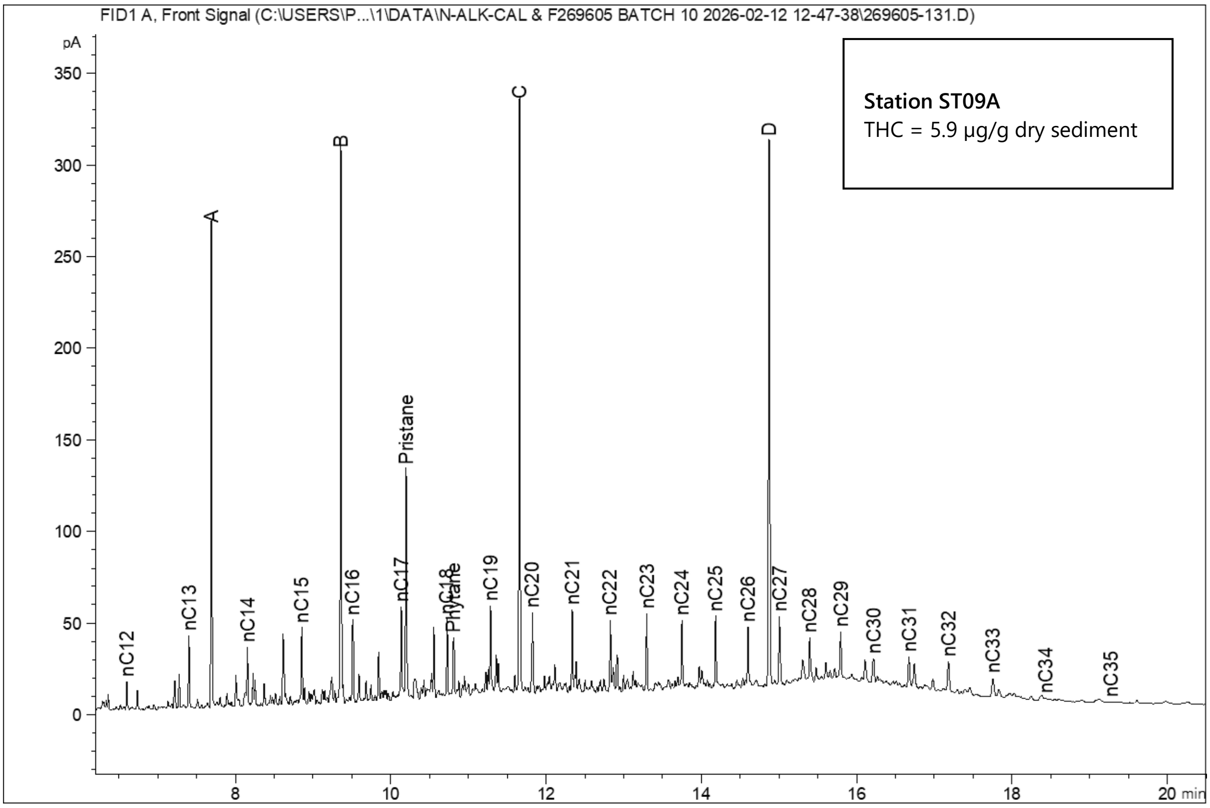
Appendix B provides full details of the analytical techniques employed.

6.2 Results

6.2.1 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 sediment 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 (Section 11.3.1) relating to the hydrocarbon components identified by GC-FID analysis of the sediments, Figure 6.1 displays an example gas chromatograms representative of the grab samples across the intertidal survey area.

The GC-FID profiles obtained from all sediment samples were broadly similar to the profile displayed in Figure 6.1. This profile is characterised by a range of low-level resolved n-alkanes. The slight prevalence of the odd numbered heavier n-alkanes (those from nC_{25}) is indicative of plant waxes originating from terrestrial run off. The profile also shows a potential petrogenic input, shown by a low-level unresolved complex mixture (UCM) between ca. nC_{12} and nC_{26} with a corresponding series of n-alkanes over a similar carbon number range.



Notes
THC = Total hydrocarbon content
A, B, C and D peaks refer to the internal standards added for quantification

Figure 6.1: Gas chromatographic profile for typical surface sediment (station ST09A)

6.2.2 Total Hydrocarbon and n-Alkanes (nC_{12} to nC_{36}) Content

Table 6.1 presents the concentrations of total hydrocarbons, UCM and total n-alkanes along with the carbon preference index (CPI) (nC_{12} to nC_{36}) and pristane/phytane ratios reported from the surface sediment. Appendix E.2 presents individual n-alkane concentrations for the sediments analysed.

The mean THC value (1.8 µg/g)) was lower than the Cefas Guideline Action Levels (AL1; 100 µg/g), with values ranging from 0.7 µg/g at stations ST01 to ST03 to 5.9 µg/g at station ST09A. Variability in THC values across the survey area was high (RSD 86 %). All values were below the ecological effects threshold (EET) of 50 µg/g

The UCM concentrations ranged from < 0.5 µg/g at stations ST01 to ST04A to 3.7 µg/g at station ST09A, with a mean of 1.1 µg/g. Variability in UCM concentrations across the intertidal survey area was high (RSD 82 %).

The total n-alkane (nC_{12} to nC_{36}) concentrations ranged from 0.09 µg/g at station ST01 to 0.54 µg/g at station ST09A, with a mean of 0.16 µg/g. Variability in total n-alkane (nC_{12} to nC_{36}) concentrations across the intertidal survey area was high (RSD 69 %).

The CPI ratio (nC_{12} to nC_{36}) reflects the relationship between odd- and even-carbon n-alkanes and can indicate the source of hydrocarbon inputs. The mean CPI ratio value ranged from

1.07 at station ST03 to 1.19 at station ST08, with a mean of 1.13. Variability in the CPI ratio across the survey area was low (RSD 4 %).

The pristane/phytane (Pr/Ph) ratios (2.65) ranged from 1.91 at station ST03 to 4.02 at station ST09A. Variability in the pristane/phytane (Pr/Ph) ratio across the survey area was low (RSD 26 %).

Table 6.1: Summary of sediment hydrocarbon analysis

Station	THC*	UCM*	n-alkanes*			CPI Ratio			Pristane*	Phytane*	Pr/Ph Ratio
			nC_{12-20}	nC_{21-36}	nC_{12-36}	nC_{12-20}	nC_{21-36}	nC_{12-36}			
ST01	0.7	< 0.5	0.03	0.06	0.09	0.91	1.20	1.09	0.0032	0.0014	2.29
ST02	0.7	< 0.5	0.03	0.07	0.10	0.89	1.21	1.10	0.0035	0.0013	2.67
ST03	0.7	< 0.5	0.05	0.12	0.17	0.84	1.19	1.07	0.0047	0.0025	1.91
ST04A	0.8	< 0.5	0.04	0.06	0.10	0.95	1.36	1.19	0.0079	0.0030	2.65
ST05A	1.8	1.1	0.06	0.09	0.16	0.93	1.29	1.13	0.0190	0.0061	3.09
ST06	3.0	2.1	0.11	0.15	0.26	0.89	1.30	1.10	0.0411	0.0118	3.48
ST07	1.9	1.3	0.07	0.09	0.16	1.00	1.34	1.18	0.0161	0.0071	2.28
ST08	2.2	1.4	0.11	0.13	0.24	1.02	1.35	1.19	0.0253	0.0131	1.93
ST09A	5.9	3.7	0.25	0.29	0.54	1.02	1.27	1.14	0.0948	0.0236	4.02
Minimum	**0.7**	**< 0.5**	**0.03**	**0.06**	**0.09**	**0.84**	**1.19**	**1.07**	**0.0032**	**0.0013**	**1.91**
Maximum	**5.9**	**3.7**	**0.25**	**0.29**	**0.54**	**1.02**	**1.36**	**1.19**	**0.0948**	**0.0236**	**4.02**
Mean	**1.8**	**1.1**	**0.06**	**0.09**	**0.16**	**0.93**	**1.29**	**1.13**	**0.0161**	**0.0061**	**2.65**
Median	**2.0**	**1.2**	**0.08**	**0.12**	**0.20**	**0.94**	**1.28**	**1.13**	**0.0240**	**0.0078**	**2.70**
Standard Deviation	**1.16**	**1.06**	**0.069**	**0.072**	**0.140**	**0.064**	**0.066**	**0.046**	**0.0293**	**0.00734**	**0.713**
RSD [%]	**86**	**98**	**83**	**61**	**69**	**7**	**5**	**4**	**122**	**95**	**26**
Cefas Guideline Action Levels (MMO, 2015)†											
AL1	**100**	-	-	-	-	-	-	-	-	-	-
EET (OSPAR, 2006)											
EET	**50**	-	-	-	-	-	-	-	-	-	-

Notes

THC = Total hydrocarbon content
UCM = Unresolved complex mixture
CPI = Carbon preference index
Pr/Ph = Ratio of pristane to phytane
RSD = Relative standard deviation
EET = Ecological effects threshold

For statistical evaluation, where < 50 % of results < MRV, summary stats have been calculated using MRV/2

* = Concentrations expressed as µg/g of dry sediment

† = Centre for Environmental Fisheries & Aquaculture Science

Key	Below Cefas Guideline Action Level 1	Above Cefas Guideline Action Level 1	Above EET

6.2.3 Aromatic Hydrocarbon Content

The distribution and concentration of aromatic compounds in sediments were analysed by gas chromatography-mass spectrometry (GC-MS). The aromatic compounds quantified were the naphthalenes (2 ring aromatics), 3 to 6 ring PAHs and the dibenzothiophenes (sulphur containing heteroaromatics). Table 6.1 summarises the total concentrations of aromatic hydrocarbons, including the US EPA 16 PAH and naphthalenes, phenanthrenes/anthracenes and dibenzothiophenes (NPD).

Appendix E.3.1 presents the concentrations of individual aromatic hydrocarbons and their alkyl homologues across the survey area, and Appendix E.3.2 presents the US EPA 16 PAH concentrations, including reference values where available. The distributions of aromatic hydrocarbons are displayed as three-dimensional plots for ease of interpretation in Appendix E.4.

Total 2 to 6 ring PAH concentrations are calculated as the sum of individual PAHs, some of which were less than the Minimum reporting value (MRV). For the purposes of calculating the total 2 to 6 ring and US EPA 16 PAH concentrations, values below the MRV have been treated as absolute values, with the total 2 to 6 ring PAH and total US EPA 16 PAH concentrations assigned a less-than value. For the purposes of this report, the total 2 to 6 ring PAH, US EPA 16 PAH and total NPD concentrations are treated as absolute values to provide comparison between stations.

Total 2 to 6 ring PAH concentrations ranged from < 0.0099 µg/g at station ST01 to 0.424 µg/g at station ST09A, with a mean of 0.0589 µg/g. Variability in total 2 to 6 ring PAH concentrations was high (RSD 148 %). The total US EPA 16 PAH concentrations ranged from <3.2 ng/g at station ST01 to 71.7 ng/g at station ST09A.

The total NPD concentrations ranged from< 0.0044 µg/g at station ST01 to 0.299 µg/g at station ST09A, with a mean of 0.030 µg/g and high variability (RSD 167 %).

All individual US EPA 16 PAH concentrations were below their respective ERL values (Appendix E.3.2). When normalised to 2.5 % TOC, naphthalene, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene and chrysene exceeded their BAC values at stations ST04A to ST09A Anthracene exceeded the BAC at four stations and benzo(a)pyrene at two stations (Appendix E.3.3.).

The proportion of petrogenically derived NPD to total 2 to 6 ring PAH material ranged from < 45 % at stations ST01 and ST03 to 71 % at ST09A, with a mean of 54 %. Variability in the mean proportion of petrogenically derived NPD to total 2 to 6 ring PAH material across the intertidal survey area was low (RSD 15 %).

Figure 6.2 displays graphically the concentrations of total 2 to 6 ring PAH in relation to THC across the survey area. Generally, total 2 to 6 ring PAH concentrations followed the same trend as THC.

Table 6.2: Summary of sediment aromatic hydrocarbon analysis

Station	Total 2 to 6 Ring PAH*	Total US EPA 16 PAH†	NPD	
			Total*	[%]
ST01	< 0.0099	< 3.2	< 0.0044	< 45
ST02	< 0.0136	< 3.6	< 0.0070	< 52
ST03	< 0.0102	< 3.2	< 0.0045	< 45
ST04A	0.0239	< 6.0	0.0122	51
ST05A	0.0820	18.3	0.0488	60
ST06	0.114	< 23.6	0.0630	55
ST07	0.0601	< 13.6	0.0341	57
ST08	0.0589	< 14.0	0.0301	51
ST09A	0.424	71.7	0.299	71
Minimum	**< 0.0099**	**< 3.2**	**< 0.0044**	**< 45**
Maximum	**0.424**	**71.7**	**0.299**	**71**
Mean	**0.0589**	**13.6**	**0.0301**	**52**
Median	**0.0885**	**17.5**	**0.0559**	**54**
Standard Deviation	**0.131**	**21.6**	**0.0935**	**8.1**
RSD [%]	**148**	**124**	**167**	**15**

Notes
Total 2 to 6 ring PAH = Total 2 to 6 ring polycyclic aromatic hydrocarbons (PAH), including alkyl homologues
Total US EPA 16 PAH = Total United States Environmental Protection Agency's 16 (US EPA PAH) polycyclic aromatic hydrocarbons
Total NPD = Total naphthalenes, phenanthrenes/anthracenes and dibenzothiophenes
NPD [%] = Percentage of total 2 to 6 ring PAH concentration comprised of NPD
AL1 = Action Level 1
* = Concentrations expressed as µg/g of dry sediment
† = Concentrations expressed as ng/g of dry sediment

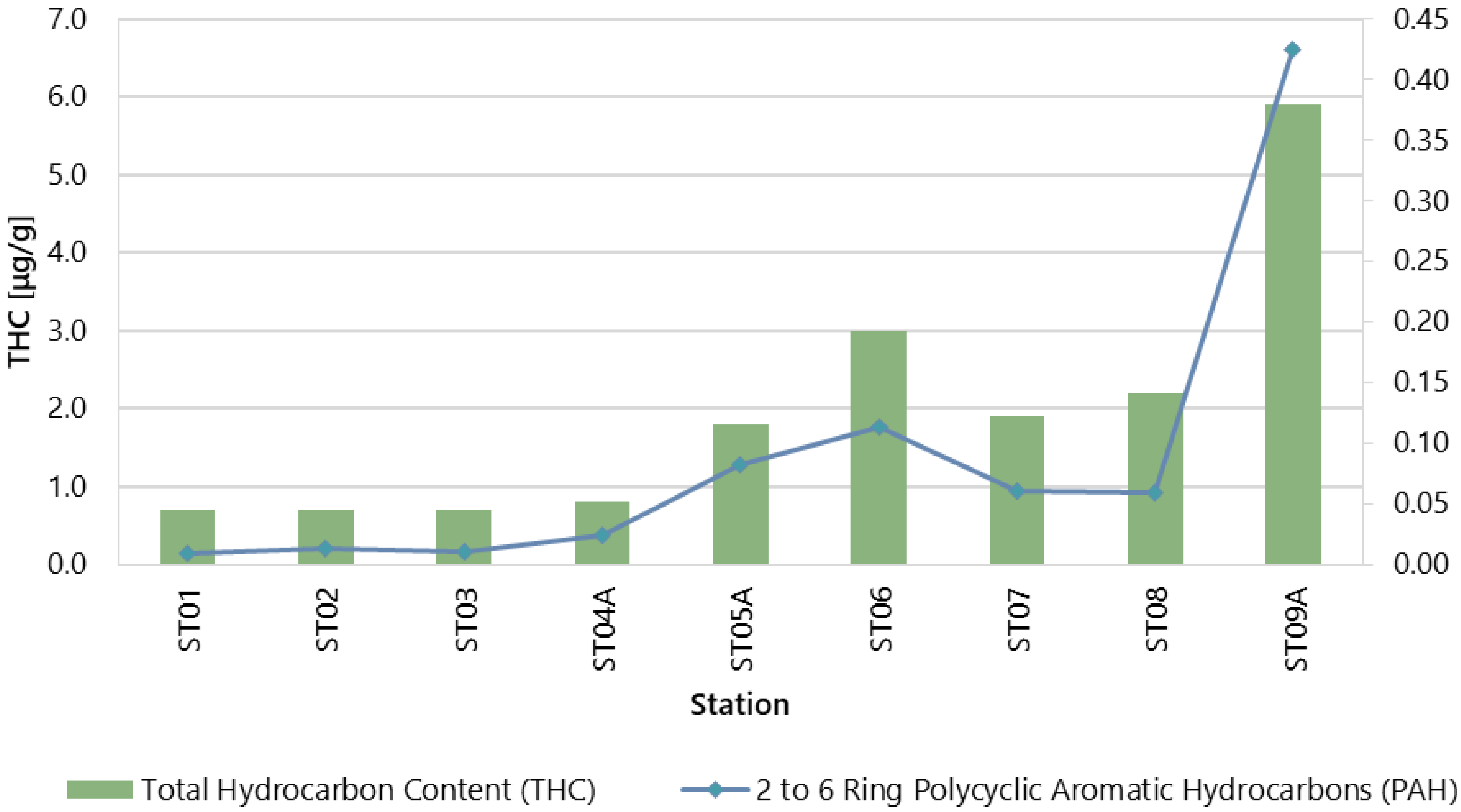


Figure 6.2: Comparison of sediment total hydrocarbon content (THC) and total 2 to 6 ring polycyclic aromatic hydrocarbon (PAH) concentrations

7. Sediment Metals

7.1 Introduction

Sediments collected within the intertidal survey area were analysed for major and trace metals.

The sediment samples underwent an aqua regia digest followed by multi-element analysis by ICP-MS (As, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sr and Zn) and ICP-OES (Al, Ba, Fe, Mn, P, and V). This provides a strong partial digest, releasing into solution all metals associated that are not tightly bound within silicate matrices, and therefore considered to be more bioavailable to receptors.

The normalisation of heavy metals against aluminium content is typically undertaken to account for natural variations derived from differences in sediment characteristics. The data presented in this report have not been normalised as the aluminium content was below the pivot point detailed in OSPAR (2015), precluding normalisation by pivot values and co-factors.

Appendix B provides full details of the analytical techniques employed.

7.2 Results

Table 7.1 summarises the concentrations of the extractable metals in the sediment samples from an aqua regia digest.

All metals were below their respective Cefas Guideline AL1 values.

The mean cadmium concentration (0.01 µg/g) was lower than the AL1 (0.4 µg/g) and the ERL value (1.20 µg/g) at all stations. The highest value (0.02 µg/g) was observed at stations ST01, ST02 and ST03. Variability in cadmium concentrations was low (RSD 44 %).

The mean chromium concentration (6.50 µg/g) was lower than the AL1 (40 µg/g). All values were below the AL1 and the ERL values (81.0 µg/g). Variability in chromium values across the site was low (RSD 24 %).

The mean copper concentration (1.4 µg/g) was lower than the AL1 value (40 µg/g). All values were below the AL1 and the ERL value (34.0 µg/g). Variability in copper values across the site was low (RSD 28 %).

Mercury concentrations across the survey area were below the MRV (< 0.03 µg/g) at all stations. All values were below the AL1 (0.3 µg/g) and the ERL value (0.150 µg/g).

The mean nickel concentration (5.5 µg/g) was below the AL1 value (20 µg/g). Variability in nickel values across the site was moderate (RSD 34%).

The mean lead concentration (5.6 µg/g) was below the AL1 (50 µg/g) and ERL (47.0 µg/g) values. Variability in lead values across the site was low (RSD 15 %).

The mean zinc concentration (19.4 µg/g) was lower than the AL1 (130 µg/g) and the ERL value (150 µg/g). All stations had concentrations below the AL1 and ERL values. Variability in zinc values across the survey area was low (RSD 25 %).

The mean barium concentration was 10.8 µg/g with moderate variability (RSD 45 %).

Table 7.1: Summary of sediment metals analysis

Station	Al	As	Ba	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	P	Pb	Sr	V	Zn
ST01	3590	16.3	11.8	< 2.00	0.02	7.63	1.9	15300	< 0.03	379	8.1	511	6.3	114	26.0	29.9
ST02	3180	13.9	14.6	< 2.00	0.02	7.41	1.5	14500	< 0.03	322	6.5	492	5.6	152	24.4	20.8
ST03	3170	16.5	10.5	< 2.00	0.02	9.83	1.8	15500	< 0.03	413	8.8	356	6.5	128	27.8	23.3
ST04A	2090	8.45	13.7	< 2.00	0.01	5.10	1.0	8900	< 0.03	187	4.1	260	4.6	79.8	16.5	15.5
ST05A	2070	8.65	8.5	< 2.00	0.01	5.55	1.1	8480	< 0.03	188	4.3	271	4.6	93.0	15.8	15.3
ST06	2210	7.60	8.3	< 2.00	< 0.01	4.92	1.0	7680	< 0.03	172	4.0	186	4.6	103	15.3	14.1
ST07	2230	8.72	23.8	< 2.00	0.01	6.58	1.4	10600	< 0.03	205	4.5	265	6.2	64.9	19.0	19.4
ST08	1960	7.57	10.7	< 2.00	0.01	5.32	1.2	9110	< 0.03	187	4.2	189	5.7	74.9	17.6	17.8
ST09A	3030	9.50	26.0	< 2.00	0.01	6.20	2.1	8400	< 0.03	199	4.7	253	6.4	113	15.8	18.1
Minimum	1960	7.6	8.3	< 2.00	< 0.01	4.92	1.0	7680	< 0.03	172	4.0	186	4.6	64.9	15.3	14.1
Maximum	3590	16.5	26.0	< 2.00	0.02	9.83	2.1	15500	< 0.03	413	8.8	511	6.5	152.0	27.8	29.9
Median	2230	8.7	11.8	-	0.01	6.20	1.4	9110	-	199	4.5	265	5.7	103.0	17.6	18.1
Mean	2610	10.8	14.2	-	0.01	6.50	1.4	10900	-	250	5.5	309	5.6	102.5	19.8	19.4
Standard Deviation	619	3.69	6.43	-	0.006	1.58	0.41	3220	-	94.1	1.86	120	0.81	27.7	4.90	4.90
RSD [%]	24	34	45	-	44	24	28	29	-	38	34	39	15	27	25	25
Cefas Guideline Action Levels (MMO, 2015)																
AL1	-	20	-	-	0.4	40	40	-	0.3	-	20	-	50	-	-	130
AL2	-	100	-	-	5	400	400	-	3	-	200	-	500	-	-	800
CEMP Assessment Criteria (OSPAR, 2014)																
ERL	-	-	-	-	1.20	81.0	34.0	-	0.150	-	-	-	47.0	-	-	150

Notes

Concentrations expressed in µg/g dry sediment

For statistical evaluation, results < MRV have been taken as absolute values determined by MRV/2

Al = Aluminium; As = Arsenic; Ba = Barium; Be = Beryllium; Cd = Cadmium
Cr = Chromium; Cu = Copper; Fe = Iron; Hg = Mercury; Mn = Manganese
Ni = Nickel; P = Phosphorous; Pb = Lead; Sr = Strontium; V = Vanadium
Zn = Zinc
RSD = Relative standard deviation; Cefas = Centre for Environment, Fisheries and Aquaculture Science; AL1 = Action level 1; AL2 = Action level 2
CEMP = Coordinated Environmental Monitoring Programme; OSPAR = Oslo and Paris Commission; ERL = Effects range low

Key	Below Cefas Guideline Action Level 1	Above Cefas Guideline Action Level 1	Above ERL

8. Sediment Macrofauna

This section presents the results of the macrofaunal analysis of samples collected within the cable corridor. At all stations, one 0.01 m^2 sample (FA) was processed for analysis.

The macrofauna is defined as those animals living in or on the sediment that are retained on a sieve mesh of 1 mm.

The macrofaunal dataset comprised three taxa and six individuals. No juveniles or damaged fauna were found in the samples.

A full list of taxa identified, enumerated (individuals per 0.01 m^2) from the survey area, along with biomass per Phylum and other supplementary material, are presented in Appendix F.

8.1 Infaunal and Solitary Epifauna

8.1.1 Phyletic Composition

Table 8.1 summarises the abundance of taxonomic groups identified within the intertidal survey area and Figures 8.1 and 8.2 illustrate the phyletic composition of taxa and individuals for each station (per 0.01 m^2), respectively.

Arthropoda comprised most of the enumerated taxa composition and macrofaunal abundance (66.7 %), followed by Other phyla (33.3 %) which were represented by Platyhelminthes.

Table 8.1: Taxonomic groups

Taxonomic Group	Number of Taxa	Composition of Taxa [%]	Abundance	Composition of Individuals [%]
Arthropoda	2	66.7	4.0	66.7
Other phyla	1	33.3	2.0	33.3
Total	**3**	**100**	**6**	**100**

Notes
Macrofaunal samples were processed through a 1.0 mm sieve
Other phyla = Platyhelminthes
Total = Rationalised data across the whole survey area

Out of the nine stations sampled, six were abiotic (ST01. ST02, ST03, ST05A, ST07 and ST09A). Arthropoda including the amphipod *Pontocrates arenarius* and the isopod *Eurydice pulchra* were present at stations ST04A, ST06 and ST08. At station ST06, Platyhelminthes were recorded and were presented within Other phyla.

Coordinate System: ETRS 1989 UTM Zone 30N **Caveats:** Esri, 2026; Microsoft, Vantor

Figure 8.1: Spatial distribution of macrofaunal abundance [per 0.01 m^2] overlaid on aerial imagery (UTM Zone 30N)

8.1.2 Biomass

Table 8.2 presents the percentage contribution of phyla to biomass across the survey area. Table 8.3 presents the biomass of major taxonomic groups at each station. Figure 8.2 illustrates the spatial variations of the total macrofaunal biomass from the grab samples. Appendix F.3 presents the raw macrofaunal biomass data (blotted weight wet).

Arthropoda comprised most of the macrofaunal biomass (95.8 %), followed by Other Phyla (4.2 %).

Table 8.2: Taxonomic groups of macrofaunal biomass

Phylum	Biomass [AFDW g/0.01 m^2]	Biomass [%]
Arthropoda	0.001418	95.8
Other phyla	0.000062	4.2
Total	**0.00148**	**100**

Notes
AFDW = Ash free dry weight
Macrofaunal samples were processed through a 1 mm mesh sieve
Other phyla = Platyhelminthes

Biomass values across the intertidal survey area were low with six stations abiotic. The highest value of biomass across the survey area was seen at the mid shore station ST04A (0.001283 AFDW g/0.01 m^2) and was associated with the presence of the amphipod *Pontocrates arenarius* (1 individual) and the isopod *Eurydice pulchra* (1 individual).

Table 8.3: Phyletic composition of macrofaunal biomass [AFDW g/0.01 m^2]

Station	Biomass [AFDW g/0.01m^2]					
	Annelida	Arthropoda	Mollusca	Echinodermata	Other Phyla	Total
ST01	-	-	-	-	-	-
ST02	-	-	-	-	-	-
ST03	-	-	-	-	-	-
ST04A	-	0.0012825	-	-	-	**0.0012825**
ST05A	-	-	-	-	-	-
ST06	-	0.0001125	-	-	0.000062	**0.0001745**
ST07	-	-	-	-	-	-
ST08	-	0.0000225	-	-	-	**0.0000225**
ST09A	-	-	-	-	-	-

Notes
AFDW = Ash free dry weight

Figure 8.2: Spatial distribution of macrofaunal biomass [AFDW g/0.01 m^2] overlaid on aerial imagery (UTM Zone 30N)

9. Sediment Environmental DNA (eDNA)

9.1 Introduction

The sediment samples collected at three stations were analysed for eDNA taxonomic classification of invertebrate, eukaryote and bacteria taxa.

The proportions of taxa OTUs and their frequency of occurrence are included in the results. These are presented in the form of bar plots and bubble plots. In bubble plots, the bubble size corresponds to the proportion of DNA within a sample, with larger bubbles indicating higher OTU counts.

The species richness and the evolutionary diversity (ED), calculated and provided by Naturemetrics, are presented in horizontal bar plots where the blue portion of each bar indicates the number of OTUs identified to species level, whilst the red portion of the bar indicates the number of OTUs identified to a higher taxonomic level at each station.

A summary of the results for each taxonomic group is reported below. Complete laboratory results are presented in Appendix G.

9.2 Marine Sediment Invertebrates

9.2.1 Taxonomic Composition

Invertebrate data were successfully obtained from two of three eDNA samples. eDNA was extracted from sample ST02; however, no sequences could be extracted. Therefore, no results were reported for this station (Appendix G.1). A high proportion of non-target taxa were identified and removed from the analysis. These can indicate potentially low occurrence of invertebrate eDNA in the environment, especially given that sand environments often have lower eDNA concentrations generally.

Table 9.1 presents the percentage of the target OTUs matched at each taxonomic level. A total of four OTU target taxa were detected, with three matched to species level.

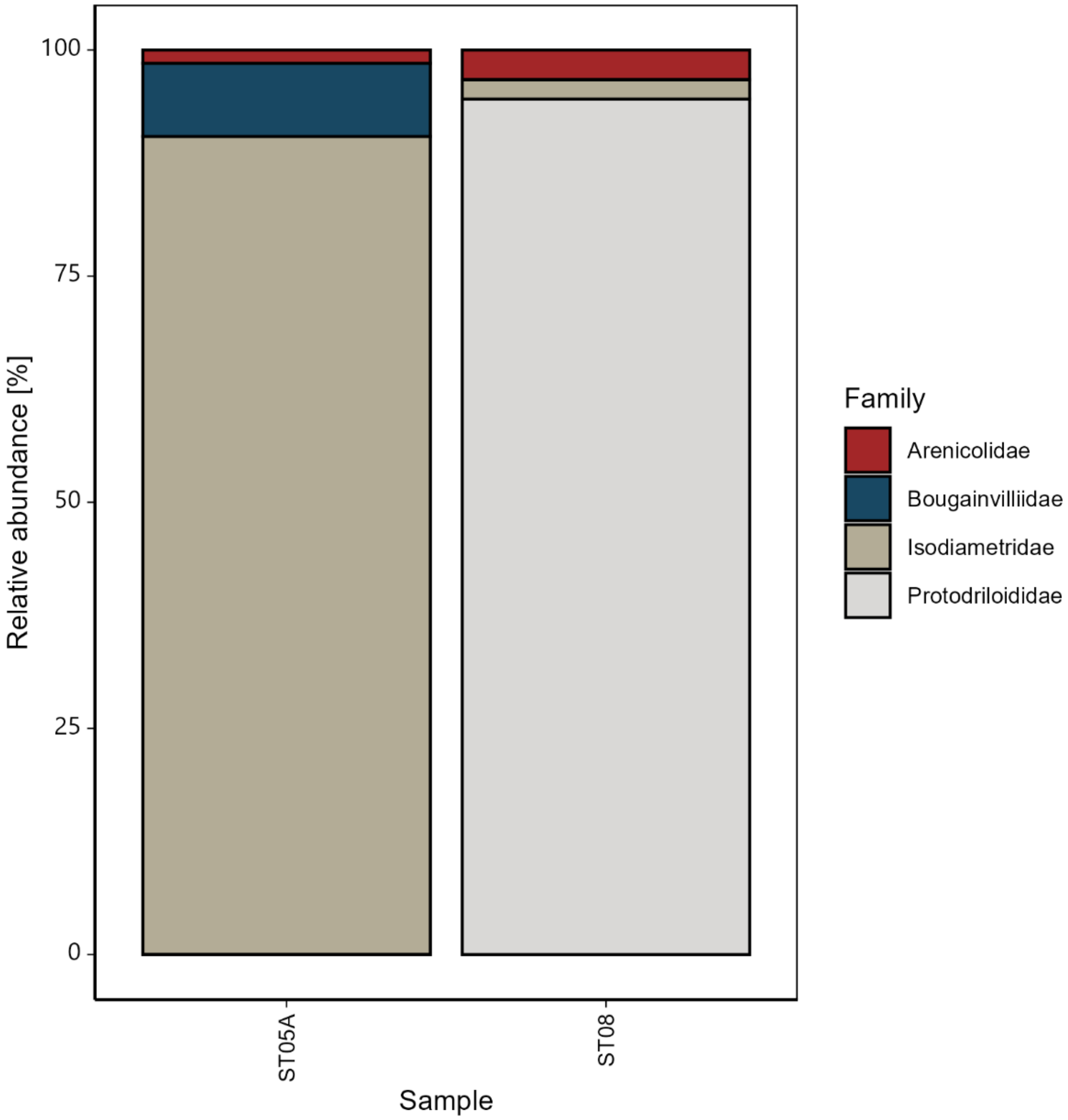
Table 9.1: Proportions of invertebrate taxa OTUs in the sediment samples

Number of OTUs	Phylum [%]	Class [%]	Order [%]	Family [%]	Genus [%]	Species [%]
4	100	100	100	100	100	75

Notes
OTU = Operational taxonomic unit

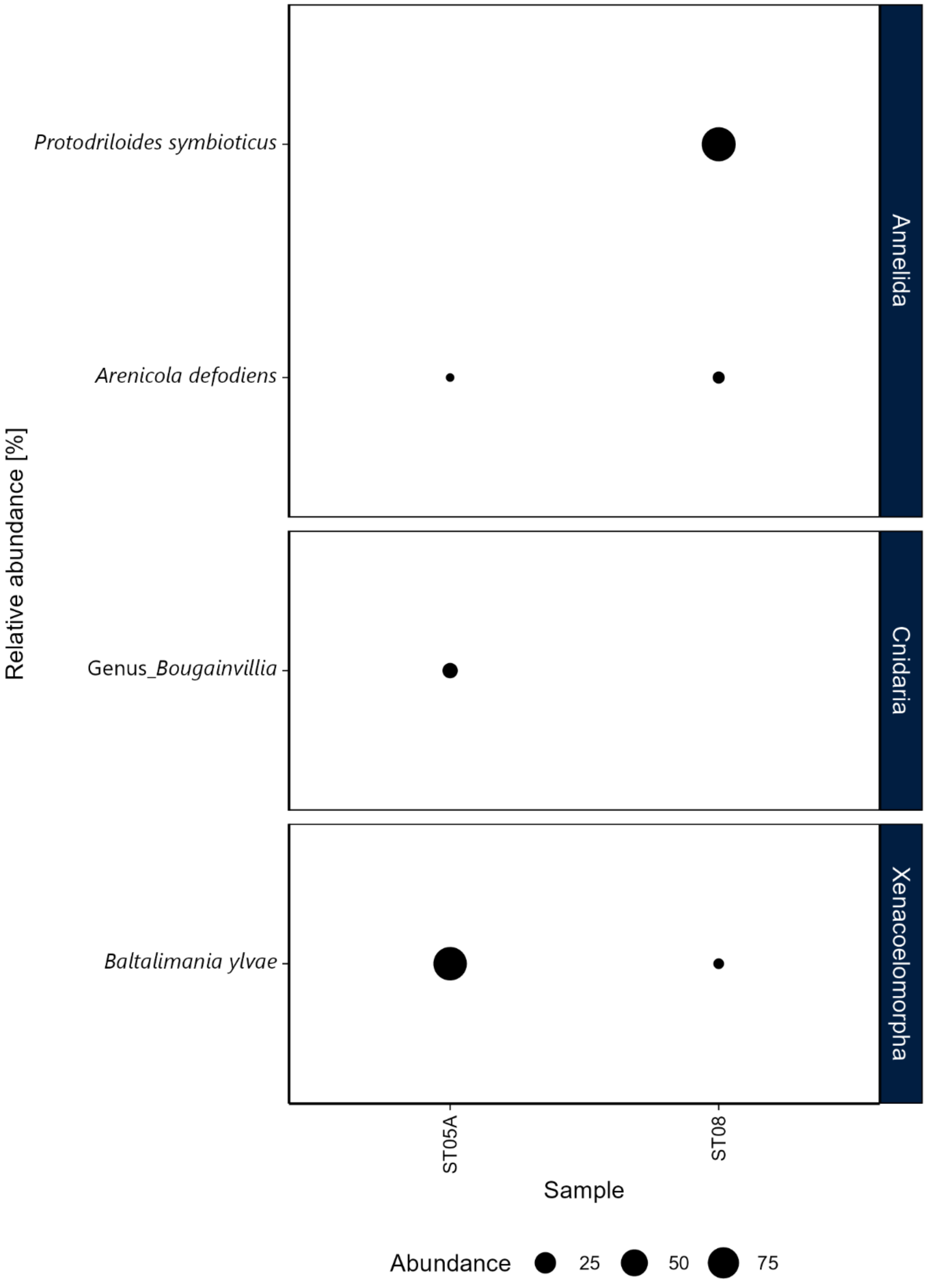
Figure 9.1 displays the bar plot of the relative OTU counts of the invertebrate taxa detected by sediment eDNA sampling, rationalised to the 'family' taxonomic level for each sample. Within ST05A, the highest proportion of OTUs was expressed by the family Isodiametridae, whilst for ST08A, the highest proportion of OTUs was expressed by the family Protodriloididae.

Figure 9.2 lists the invertebrate taxa found in each sediment sample and their relative proportion of eDNA OTUs. On review of the taxa list, the highest proportion of OTUs was expressed by the annelid *Protodriloides symbioticus* (ST08) and the aceol *Baltalimania ylvae* (ST05A).



Notes
Non-target taxa were excluded from the plot
OTUs = Operation taxonomic unit

Figure 9.1: Relative OTU counts of target invertebrate taxa detected at the family level in the sediment samples



Notes
Non-target taxa were excluded from the plot
OTUs = Operation taxonomic unit

Figure 9.2: Taxonomic composition and proportion [%] of invertebrate OTUs within the sediment eDNA samples

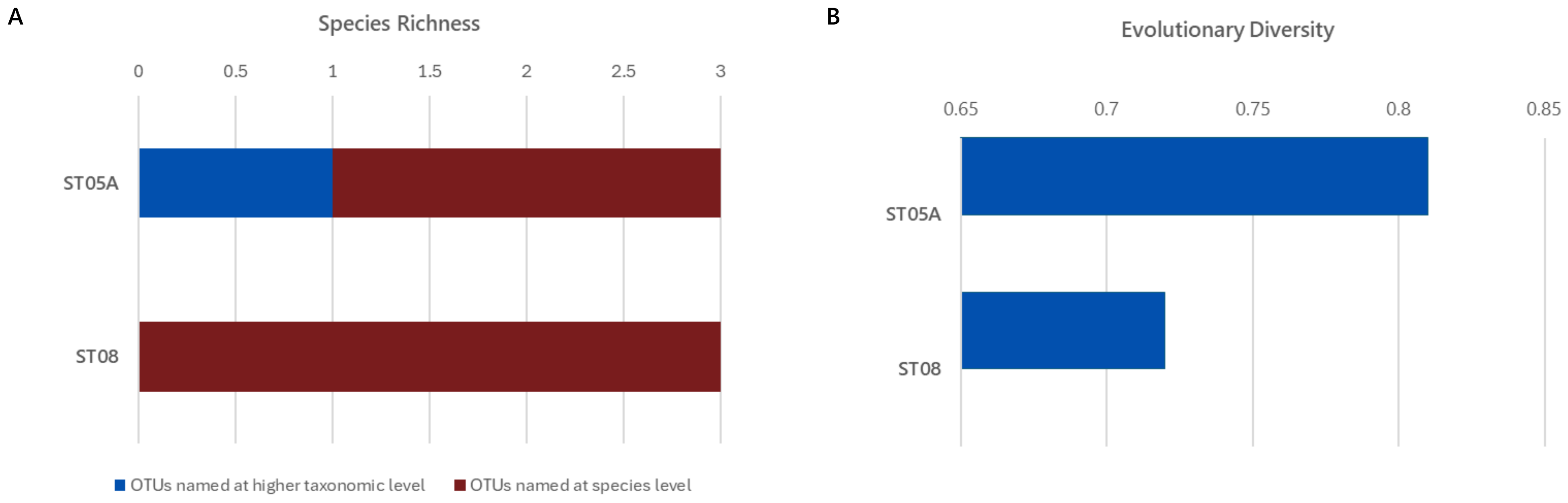
9.2.2 Community Statistics

Table 9.2 displays species richness, represented by the total count of OTUs detected in each sediment sample, alongside evolutionary diversity. Figure 9.3 visually presents these community statistics for samples acquired within the survey area.

Table 9.2: Sediment samples, invertebrate OTUs eDNA community statistics

Station	Species Richness (Number of OTUs)	Number of OTUs (Species level)	Evolutionary Diversity
ST05A	3	2	0.81
ST08	3	3	0.72
Mean	**3**	**3**	**0.77**
SD	**0**	**1**	**0.064**

Notes
OTU = Operational taxonomic unit
SD = Standard deviation



Notes
The samples are ordered high water to low water stations from top to bottom of the chart
OTUs = Operational taxonomic unit

Figure 9.3: Invertebrate Species Richness (A) and Evolutionary Diversity (B) of each sediment eDNA sample

9.3 Marine Sediment Eukaryotes

9.3.1 Taxonomic Composition

High-quality eukaryotes data were successfully obtained from all three eDNA samples. A low percentage of OTUs were identified at the species level.

Table 9.3 presents the percentage of the target OTUs identified at each taxonomic level. A total of 386 OTU taxa were detected with only 11.14 % (43 taxa) being matched at species level.

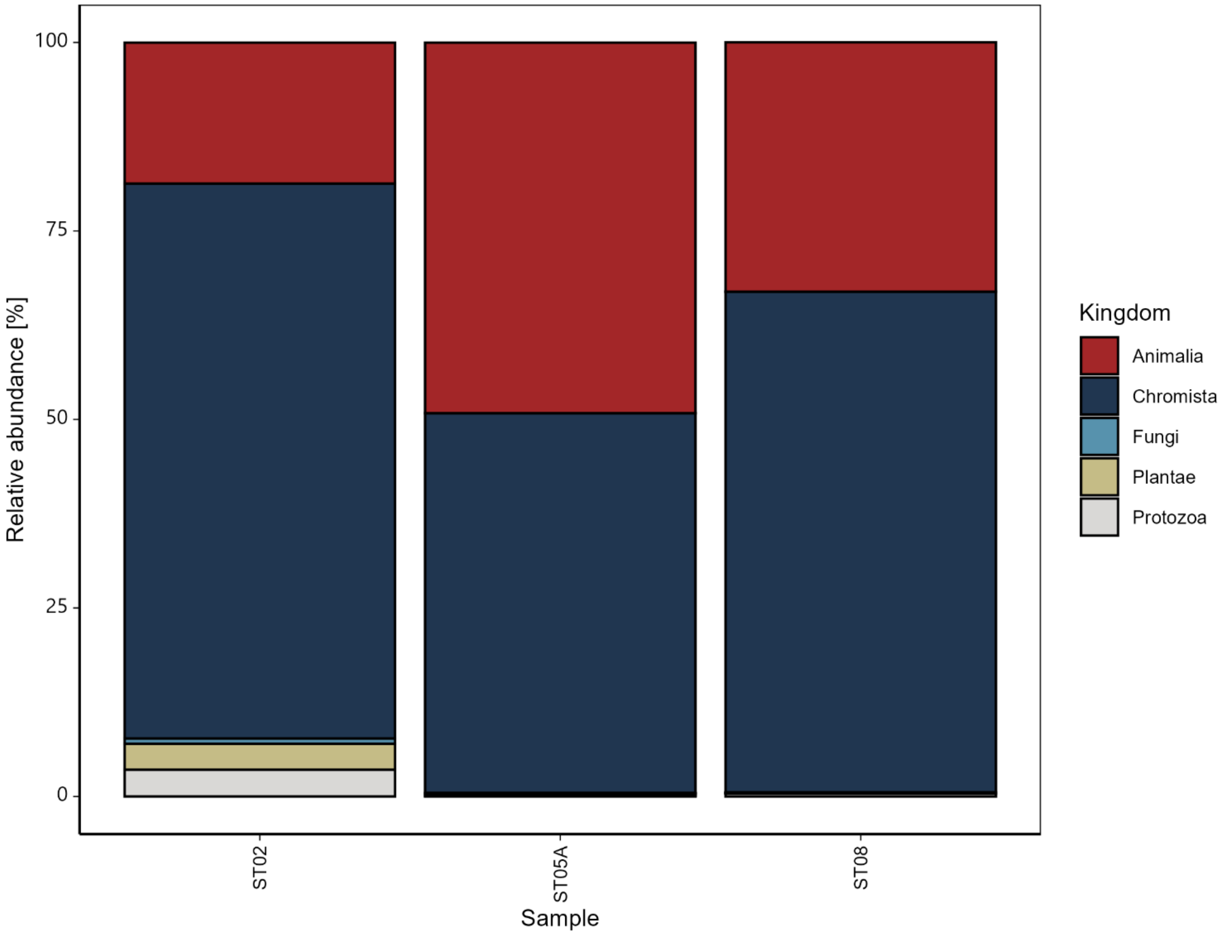
Table 9.3: Proportions of eukaryote taxa OTUs in the sediment samples

Number of OTUs	Phylum [%]	Class [%]	Order [%]	Family [%]	Genus [%]	Species [%]
386	98.7	83.68	66.06	55.44	25.13	11.14

Notes
OTU = Operational taxonomic unit

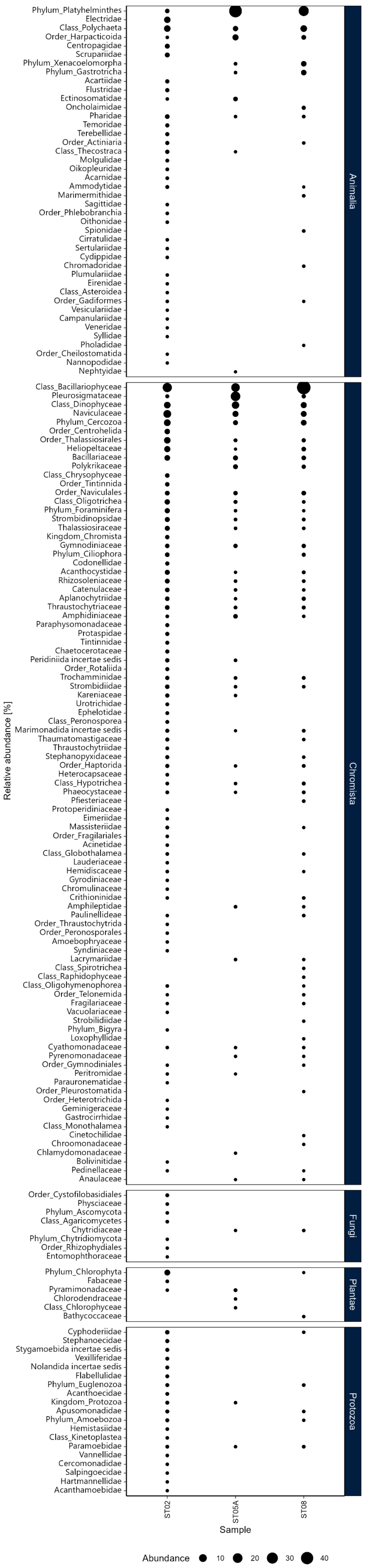
Figure 9.4 displays the bar plot of the relative OTU counts of the eukaryote taxa detected by sediment eDNA sampling, rationalised to the 'kingdom' taxonomic level for each sample. Within the intertidal survey area, Chromista (63.5 %) and Animalia (33.6 %) were the two dominating kingdoms amongst the eukaryotes from sediment eDNA samples. The remaining kingdoms contributed to < 5 %.

Figure 9.5 lists the eukaryote taxa found in each sediment sample and their relative proportion of DNA sequences within each sample. The most frequently occurring taxa were the diatom class Bacillariophyceae and the annelid phylum Platyhelminthes, which were both detected at all stations. Within Animalia, Platyhelminthes was followed by the bryozoan family Electridae and the annelid class Polychaeta in contributing the highest proportions of OTUs.



Notes
Non-target taxa were excluded from the plot
OTUs = Operation taxonomic unit

Figure 9.4: Relative OTU counts of target eukaryote taxa detected to kingdom level in the sediment samples



Notes

Non-target taxa were excluded from the plot

OTUs = Operation taxonomic unit

Figure 9.5: Taxonomic composition and proportion [%] of eukaryote OTUs within the sediment eDNA samples

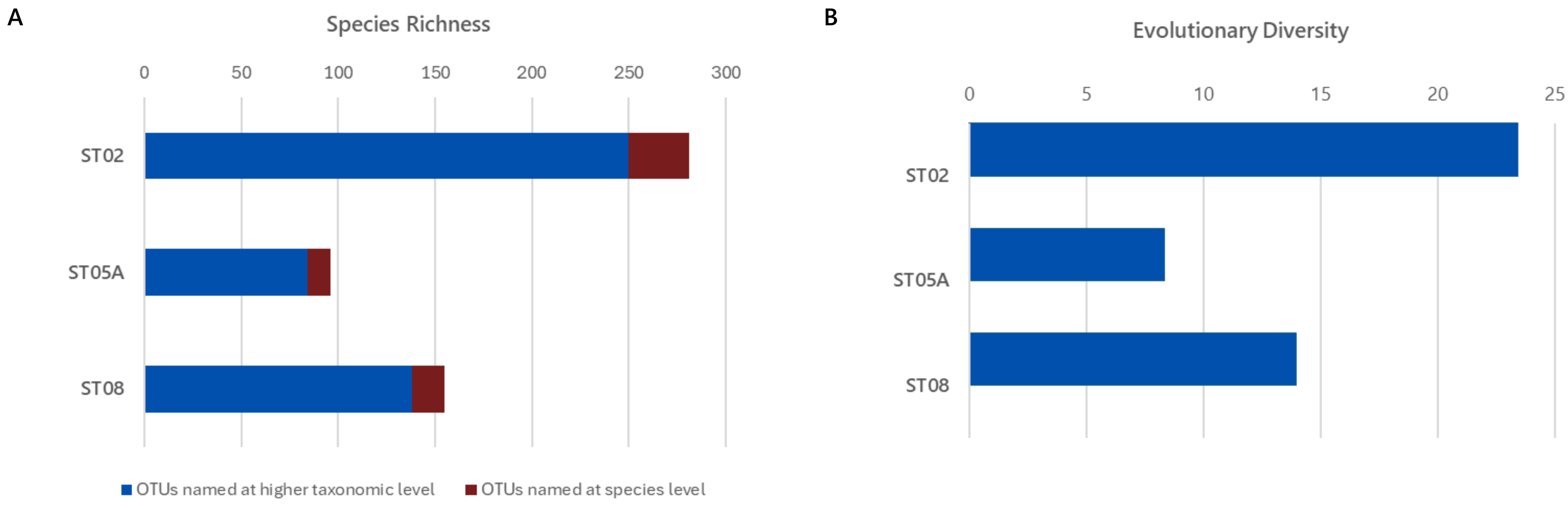
9.3.2 Community Statistics

Table 9.2 and Figure 9.6 present species richness and evolutionary diversity in terms of OTUs for the sediment samples taken within the intertidal survey area.

Table 9.4: Sediment samples, eukaryote OTUs eDNA community statistics

Station	Species Richness (Number of OTUs)	Number of OTUs (Species level)	Evolutionary Diversity
ST02	281	31	23.42
ST05A	96	12	8.34
ST08	155	17	13.97
Mean	**177**	**20**	**15.24**
SD	**95**	**10**	**7.62**

Notes
OTU = Operational taxonomic unit
SD = Standard deviation



Notes
The samples are ordered high water to low water stations from top to bottom of the chart
OTUs = Operational taxonomic unit

Figure 9.6: Eukaryote species richness (A) and evolutionary diversity (B) of each sediment eDNA sample

9.4 Marine Sediment Bacteria

9.4.1 Taxonomic Composition

High-quality bacteria eDNA data were successfully obtained from all three sediment samples analysed (Appendix G.3).

Table 9.5 presents the percentage of the target OTUs identified at each taxonomic level. A total of 563 OTUs were detected, with only 1.42 % (8 OTUs) being matched at species level.

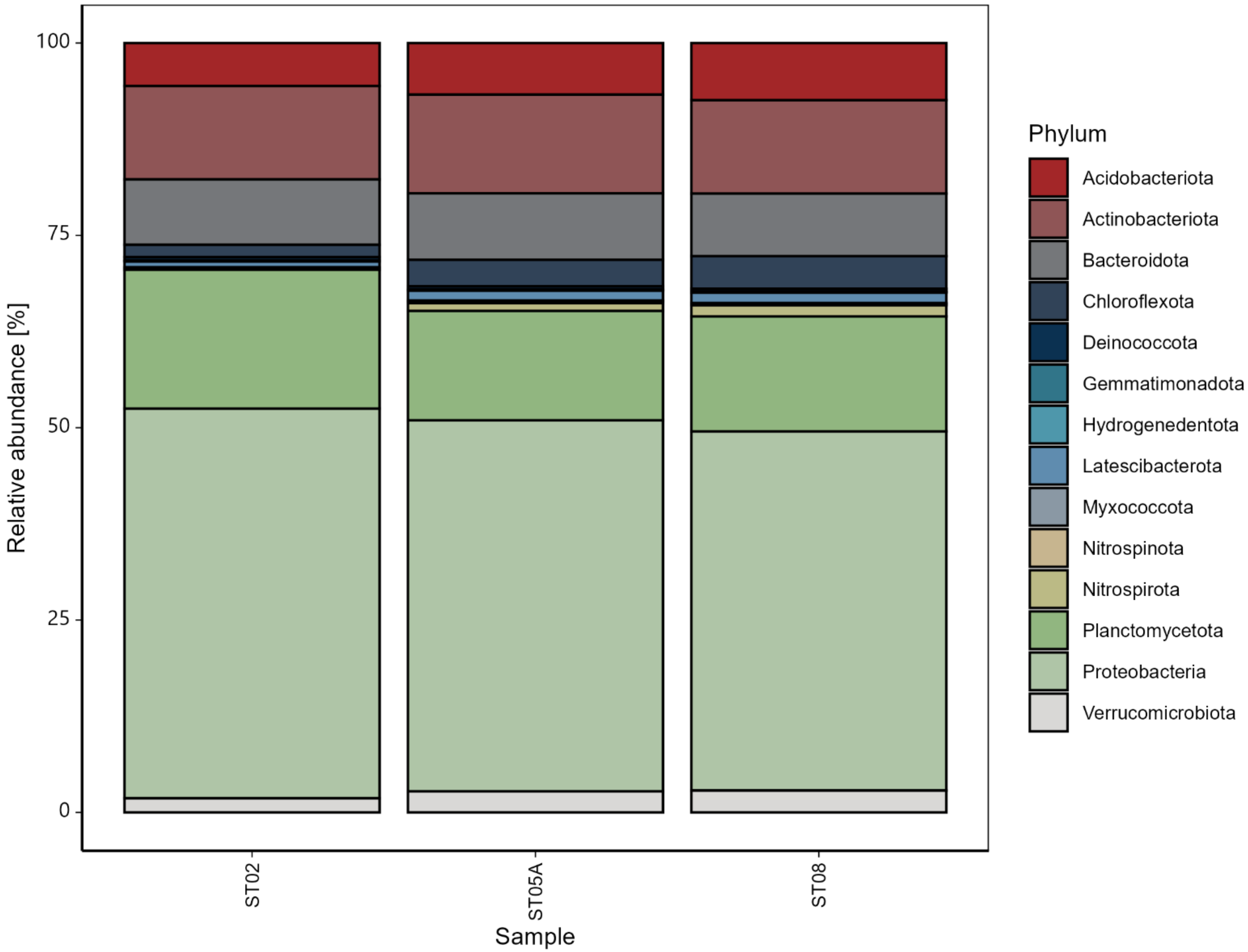
Table 9.5: Proportions of bacterial taxa OTUs in the sediment samples

Number of OTUs	Phylum [%]	Class [%]	Order [%]	Family [%]	Genus [%]	Species [%]
563	100	80.99	52.58	34.1	6.75	1.42
Notes OTU = Operational taxonomic unit						

Figure 9.7 displays the bar plot of the relative OTU counts of the bacterial taxa detected by sediment eDNA sampling, rationalised to the 'phylum' taxonomic level for each sample. Within the intertidal survey area, Proteobacteria was the phylum that contributed the highest proportions of OTUs within each sample.

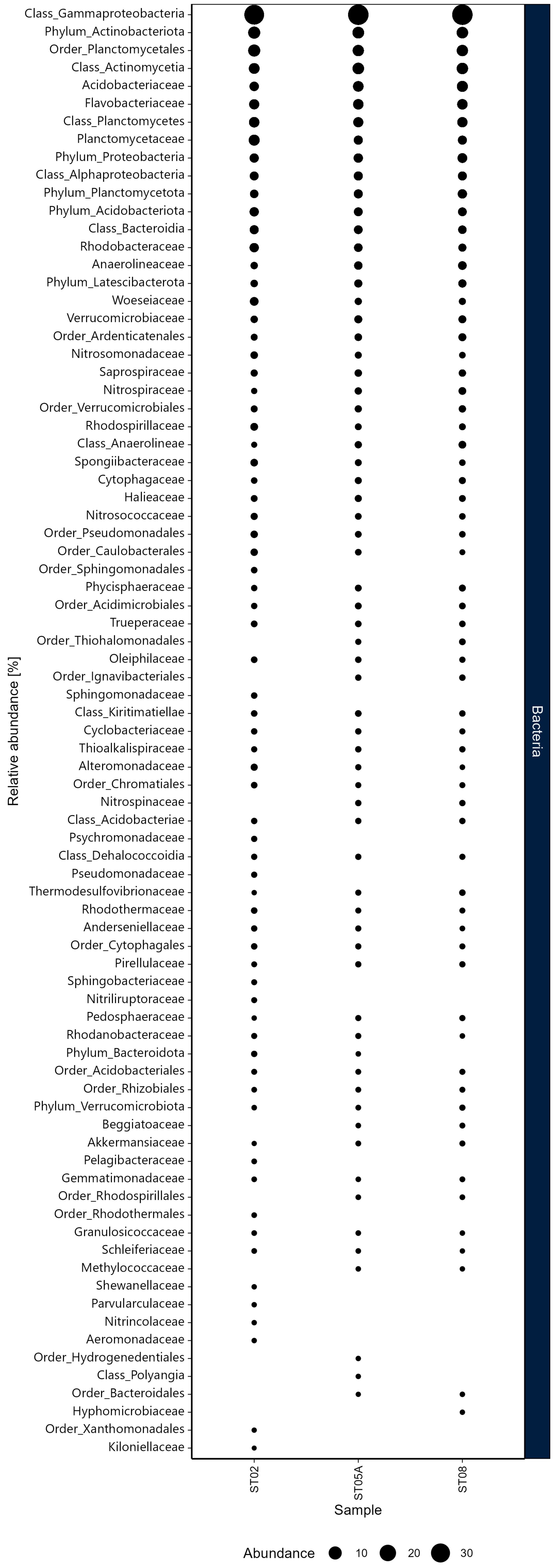
Figure 9.8 lists the bacterial taxa, rationalised to family level, found in each sediment sample and their relative proportion of eDNA sequences.

On review of the taxa list, the classes Gammaprotobacteria and Actinomycetia, together with the phyla Actinobacteriota, the order Planctomycetales and the family Acidobacteriaceae were the top five taxa contributing the highest proportions of OTUs. The top five taxa together contributed 52.7 % of bacterial OTUs, with Gammaprotobacteria contributing the highest proportion at 33.8 %. The top five taxa were also detected within each eDNA sediment sample.



Notes
Non-target taxa were excluded from the plot
OTUs = Operation taxonomic unit

Figure 9.7: Relative OTU counts of target bacteria taxa detected at the phylum level in the sediment samples



Notes

Non-target taxa were excluded from the plot

OTUs = Operation taxonomic unit

Figure 9.8: Taxonomic composition and proportion [%] of bacteria OTUs within the sediment eDNA samples

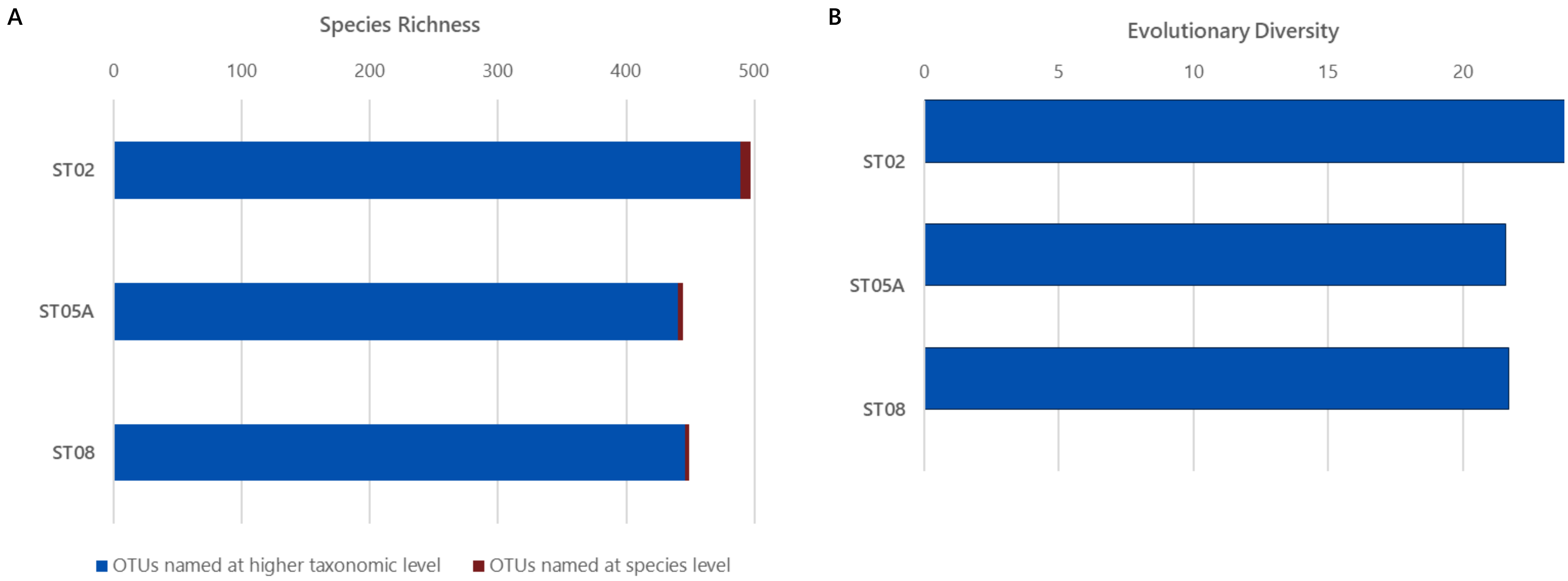
9.4.2 Community Statistics

Table 9.6 and Figure 9.9 present species richness and evolutionary diversity in terms of OTUs for the sediment samples taken within the intertidal survey area.

Table 9.6: Sediment samples bacterial OTUs eDNA community statistics

Station	Species Richness (Number of OTUs)	Number of OTUs (Species level)	Evolutionary Diversity
ST02	497	8	24.31
ST05A	444	4	21.6
ST08	449	3	21.69
Mean	463	**5**	22.53
SD	29	**3**	1.54

Notes
OTU = Operational taxonomic unit
SD = Standard deviation



Notes
The samples are ordered high water to low water stations from top to bottom of the chart
OTUs = Operational taxonomic unit

Figure 9.9: Bacteria species richness (A) and evolutionary diversity (B) of each sediment eDNA sample

10. Intertidal Habitats and Species

One biotope complex was identified across the intertidal survey area 'Barren or amphipod-dominated Atlantic littoral mobile sand' (MA523). This biotope is defined as shores consisting of mobile sands with very little fines present. These shores usually support a limited range of species, ranging from no macrofaunal communities to communities of isopods, amphipods and a limited range of polychaetes. Species which can characterise mobile sand communities include *Scolelepis (scolelepis) squamata, Pontocrates arenarius, Bathyporeia pelagica, Bathyporeia pilosa, Haustorius arenarius* and *Eurydice pulchra* (EEA, 2022).

Results of the core samples indicated that the sediments across the intertidal survey area were abiotic or species poor (detailed in Section 8).

Table 10.1 summarises the hierarchy of the assigned EUNIS classifications (EEA, 2022), and equivalent JNCC (2022) classifications, based on the core samples, photographic, PSD and eDNA data.

Table 10.1: Habitat classifications

EUNIS (EEA, 2022) Habitat Classification				Equivalent JNCC (2022) Classifications
Environment Level 1	Biological Zone and Substrate Level 2	Biogeographical Marine Region Level 3	Biotope Complex Level 4	
M Marine benthic habitat	MA5 Littoral sand	MA52 Atlantic Mobile Littoral sand	MA523 Barren or amphipod-dominated Atlantic littoral mobile sand	LS.LSa.MoSa Barren or amphipod-dominated mobile sand shores
Notes EUNIS = European Nature Information System EEA = European Environment Agency JNCC = Joint Nature Conservation Committee				

'Barren or amphipod-dominated Atlantic littoral mobile sand' (MA523) is characterised by species such as *Pontocrates arenarius*, which were found in the macrofaunal core samples along with *Eurydice pulchra* (Section 8.1.1). The PSD data showed that the sediments were clean sands with no fines present which is supported by the absence of annelids in the core samples. From the eDNA analysis, a limited number of characterising taxa were identified across the survey area. No amphipods or isopods were identified and a limited number of polychaetes (Terebeillidae, Spionidae, Syllidae, Cirratulidae, Nephtyidae, *Protodriloides symbioticus* and *Arenicola defodiens*) were identified.

There were no sensitive habitats or species found in the intertidal survey area.

10.1 Non-native Species (NNS)

Non-native species (NNS) are those that have reached the UK by accidental human transport, deliberate human introduction, or which have arrived by natural dispersion from a non-native population in Europe (Government Digital Service [GDS], 2021). Once introduced, some NNS can become established (grow and reproduce successfully) and their subsequent dispersal from the point of introduction can result in environmental and economic impact (Cottier-Cook et al., 2017). The NNS that have a negative impact on biodiversity, through the spread of disease, competition for resources, or by direct consumption, parasitism, or hybridisation, are termed ‘invasive’ (GDS, 2021).

There were no NNS found in the intertidal survey area.

Figure 10.1: EUNIS habitat biotope of the survey area overlaid on aerial imagery (UTM Zone 30N)

11. Discussion

11.1 Introduction

The previous sections of this report have presented the data from the analysis stated above with the aid of data tables and graphics. This discussion section reviews the data with respect to cited threshold values (MMO, 2015; OSPAR, 2006).

In addition to the comparison of the analytical data against available references, statistical correlations of the sediment parameters recorded with the chemical and biological determinants in the survey are summarised (for the main environmental parameters) in Appendix H. The statistical analysis selected was the Spearman's rank correlation coefficient (Spearman, 1904) sometimes referred to as Spearman's rho. This coefficient is used to evaluate the association between two reported values for statistical dependence. It is a measure of rank correlation, or the similarity of the orderings of the data when ranked by each of the values. Correlations can only suggest a relationship and do not prove a causal link between status of the chemical or physical nature of the seafloor and the infaunal community composition.

Some positive correlations were observed within the data however, due to the low concentrations or low variability within the dataset meant these were not considered to be environmentally significant.

11.2 Sediment Characterisation

The sediment type recorded across the intertidal survey area was dominated by sand. Stormy winter conditions result in destructive, high-energy waves that remove lighter sediment such as fines and silt from the coastline leaving behind heavier, larger particles such as coarser sand and gravel. No fines were present at the intertidal survey area with the high tide stations classified as 'coarse sand' and the mid tide and low tide stations classified as 'medium sand' (Folk & Ward, 1957).

The Saltfleet to Gibraltar Point beach replenishment scheme was enacted to reduce flood risk and the use of hard defences. Over three years, 400 000 $m^3$of sand was used to renourish beaches including at Anderby Creek that had been receding due to storms. (Environment Agency, 2024). Sand dominated intertidal areas are typical of a high-energy beach that has undergone recent beach replenishment.

Organic content was low across the intertidal survey area, with TOC and TOM less than 1 %. Organic matter performs an important role in marine ecosystems, providing a source of food for suspension and deposit feeders, suggesting that the availability in organic carbon and organic matter may influence the variation in benthic communities (Snelgrove & Butman, 1994). In the current study the TOC or TOM concentrations present are unlikely to influence the macrofauna present.

11.3 Sediment Chemistry

11.3.1 Sediment Hydrocarbons

11.3.1.1 Total and Aliphatic Hydrocarbons

The gas chromatographic profiles (Appendix E.1) obtained for sediments collected within the National Grid intertidal survey area showed trace levels of hydrocarbons with a barely discernible UCM. The UCM is composed of a wide range of compounds, including cyclo-alkanes, which remain after substantial weathering and biodegradation of petrogenic hydrocarbons (Farrington et al., 1977). Evidence of terrestrial run-off was present at some stations, shown by the slight prevalence of the odd-numbered heavier n-alkanes (nC_{27}, nC_{29}, nC_{31} and nC_{33}), which are typical of plant cuticular waxes.

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 (Bush & McInerney, 2013; Douglas & Eglington, 1966; Eglinton et al., 1962) 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).

All stations had THC concentrations below the Cefas Guideline Action Levels and the EET (OSPAR, 2006) and therefore unlikely to influence the macrofauna communities present. Across the intertidal survey area THC values were < 5.9 µg/g with all values being below the Cefas AL1 (100 µg/g). Overall, results from this study are indicative of low anthropogenic input, as in general, marine sediments are considered background if the THC is below 10 µg/g (Farrington et al., 1977; Readman et al., 2002; Volkman et al., 1992). This is further supported by comparison to the North Sea Quality Status Report (North Sea Task Force [NSTF], 1993), which suggests that typical THC levels (i.e. 'background') in sediments remote from anthropogenic activities range from 0.2 µg/g to 5 µg/g, however, in some areas, values may be as high as 15 µg/g.

The ratio of odd- to even-numbered normal alkanes is referred to as the CPI and has been calculated across various chain-length ranges. Elevated ratios (i.e. those > 1.00) over the nC_{12} to nC_{36} carbon range are due to the domination of the odd-chain length n-alkanes (nC_{27} to nC_{33}) and are typically associated/observed with inputs from terrestrial run-off (leaf waxes, etc., discussed previously). All CPI (nC_{12} to nC_{36}) ratios recorded were greater than 1.00, demonstrating the influence of odd-chain length n-alkanes (nC_{27} and nC_{33}) and biogenic material in most sediment samples.

The isoprenoidal alkanes pristane (Pr) and phytane (Ph) were reported in low concentrations in each of the sediment samples analysed. These compounds are present in significant concentrations in crude oils (Berthou & Friocourt, 1981). They may also be biosynthesised

(Gunkel & Gassmann, 1980), and pristane, a breakdown product of the phytol moiety of chlorophyll, is widespread in the marine ecosystem, probably being derived from zooplankton. Phytane is generally absent or present in only relatively low levels in uncontaminated natural systems (Blumer & Snyder, 1965). The Pr/Ph ratios reported in the sediments ranged from 1.91 to 4.02 (mean 2.65,Table 6.1). These values typically suggest that the higher pristane proportion in the sediments was derived from non-petrogenic sources.

11.3.1.2 Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) contain carbon and hydrogen atoms and consist of two or more fused benzene rings in linear, angular or cluster arrangements (Balmer et al., 2019). 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. Petroleum sources are rich in aromatic hydrocarbons, particularly 1 to 3 ring compounds (benzenes, naphthalenes and phenanthrenes); the levels of 4 to 6 ring compounds being relatively low. In addition, significant concentrations of organosulphur compounds (dibenzothiophenes) are normally present (Friocourt et al., 1982). The relative proportion of these compounds will vary between crude oils and refined petroleum.

PAHs are widely spread in the environment (Butler et al., 1984) with natural sources occurring primarily through synthesis by plants (Neff, 1979; Sims & Overcash, 1983), related to natural seeps of petroleum (Kennicutt et al., 1988; National Research Council [NRC], 1983) and to formation during natural forest and prairie fires (Wakeham et al., 1980; Youngblood & Blumer, 1975). By far the highest proportion of PAHs released into the environment are formed during fossil fuel combustion and anthropogenic forest and agricultural fires (Edwards, 1983; Haritash & Kaushik, 2009; Sims & Overcash, 1983). PAHs primarily enter marine sediments from atmospheric and riverine inputs and tend to adsorb to suspended inorganic and organic particulate matter, ultimately settling on the seafloor where they accumulate to relatively high concentrations (Culotta et al., 2006; Latimer & Zheng, 2003).

Monitoring of aromatic hydrocarbon type and content is important due to the particularly toxic nature (mutagenic/carcinogenic) of several PAHs, particularly the heavier-weight PAHs. 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 anthropogenic combustion sources.

Across the intertidal survey area, the individual US EPA 16 PAH concentrations present in the intertidal sediments were assessed by comparison with their assigned ERL threshold values (OSPAR, 2014). All individual PAH concentrations for all stations were below their respective ERL values (Appendix E.3.2). The highest concentrations were observed at station ST09A situated on the low tide, while the lowest values were found in the high tide stations.

PAHs are lipophilic and bind strongly to organic matter in sediments (Davies, 2004), therefore, contaminant concentrations will be closely related to the distribution of fine grained and organic material (International Council for the Exploration of the Sea [ICES], 2009, 2012). Normalisation of PAH concentrations to total organic carbon provides a basis for reliable assessment of temporal trends and facilitates a meaningful comparison of sediment substances with OSPAR BC and BAC thresholds (ICES, 2009, 2012; OSPAR, 2014). When normalised to 2.5 % TOC, BAC values were exceeded for multiple PAHs (Appendix E.3.3; naphthalene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene and benzo(a)pyrene). Concentrations that exceed BAC values are considered to be 'above background' but at levels where it can be assumed that little or no risks are posed to the environment and its living resources at the population or community level (OSPAR, 2013). OSPAR guidance indicates that such exceedances reflect low-level anthropogenic influence, with little evidence of risk to benthic communities at both population and ecosystem scales. As these PAHs are below the ERL there would likely not be any adverse effect on the macrofaunal communities. Additionally, the low TOC values throughout the survey area potentially resulted in an overestimation of PAH concentrations.

The source of the PAHs may be determined by investigation of the relative proportions of individual PAH concentrations (Budzinski et al., 1997; Neff, 1979; Yunker et al., 2002) as well as examining the overall distributions of parent and alkylated PAHs present. Pyrogenically (or pyrolytic) derived PAHs signatures (i.e. forest fires, etc.) are dominated by higher molecular weight compounds (mainly 4 to 6 ring) and are predominantly unsubstituted. In contrast, PAH formed during the slow geological maturation of petroleum are dominated by alkylated, low molecular weight (mainly 1 to 3 ring) compounds (Neff, 1979; Stogiannidis & Laane, 2015). The trend of parent and alkylated PAHs is represented graphically in Appendix E.4 using three-dimensional plots that represent the PAHs concentrations in terms of parent compound and alkyl homologue distribution of the aromatic material in the sediments analysed. The plots suggest that PAHs detected across the intertidal survey area originate from mixed petrogenic and pyrolytic sources.

11.3.2 Sediment 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 (Boening, 1999; Páez-Osuna & Ruiz-Fernandez, 1995). 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. A potential industrial source of metals is the UKCS oil and gas industry and this is assessed in the OSPAR status reports (Region II Greater North Sea; OSPAR, 2000, 2010) and the OSPAR CEMP Assessment Report 2013 (OSPAR, 2014).

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 (Dang et al., 2015; Wang et al., 2015; Warren

& Zimmerman, 1993). 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 (Du Laing et al., 2009; Tessier et al., 1979; Warren & Zimmerman, 1993). Residual trace metals are defined as those that 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 & Voutsinou, 1981), which are of comparatively lesser environmental significance because of their low reactivity and availability.

In this study, an aqua regia partial digestion was employed to analyse the elemental content of the sediments. Aqua regia is an acid mixture that mainly dissolves the non-residual fraction of heavy metals—those not firmly bound within the crystalline mineral matrix. Consequently, it offers an estimate of the potentially bioavailable and environmentally mobile metal content, rather than the total metal concentration.

The metal concentrations in the sediments showed low to moderate variability across the intertidal survey area. All measured metal concentrations were below the Cefas AL1 threshold their respective ERL values, where available. ERLs are defined as the lower tenth percentile of the sediment concentration data associated with observed biological effects (OSPAR, 2017). Concentrations below the ERL are unlikely to cause adverse effects on biota and influence the composition of macrofaunal communities.

11.4 Macrofaunal Communities

Intertidal and subtidal 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 that 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.

Beach replenishment can have substantial impacts on infaunal community. A study by Wooldridge et al. (2016), found that replenished beaches had only 48 % as many invertebrates as control beaches after 15 months. The same study reported that amphipod densities increased at similar levels between replenished sites as control sites whereas other species such as the annelid *Scolelepis* sp. decreased within the same timeframe . Moreover, the large negative effect of replenishment on polychaetes, combined with their overall importance to the invertebrate community, resulted in a 50 % decrease in overall invertebrate abundance on replenished beaches at 15 months (Wooldridge et al., 2016).

The biotic communities of littoral sediments are also determined by the degree of exposure to hydrodynamics, which in turn determines the sediment type. Generally, intertidal communities can tolerate variation in air temperature, reduced salinity and some degree of drainage at low tide (JNCC, 2022). Very coarse sediments tend to support few macrofaunal species owing to their mobility and the high degree of drying at low tide. Finer sediments tend to be more stable and retain some water between high tides and therefore support a greater diversity of species, particularly annelids. Stormy winter conditions can also exacerbate the degree of exposure to hydrodynamics that macrofauna face, frequent high-energy erosive waves can remove the finer sediment of the intertidal area and the infauna such as annelids that inhabit it (Goad et al., 2025).

The species richness of the macrofaunal community of the intertidal survey area could be lower than expected due to the recent beach replenishment however, generally intertidal ecosystems are species poor especially in winter when this survey was carried out and the findings could be representative of a winter intertidal ecosystem.

11.4.1 Biomass

Biomass was minimal across the intertidal survey area. Station ST04A had the highest biomass across they intertidal survey area and contained presence of the amphipod *Pontocrates arenarius* and the isopod *Eurydice pulchra*. *P. arenarius* can reach an adult size of 6.5 mm and males of *E. pulchra* can reach sizes of < 8 mm which were responsible for the biomass values found (World Register of Marine Species Editorial Board [WoRMS Editorial Board], 2026).

11.5 Sediment Environmental DNA (eDNA)

In sediment, eDNA is sampled by extraction from a mini-core and subsequently analysed to detect the taxa present. Decay rates of eDNA in sediment vary but are generally lower than the decay rates of eDNA in aqueous form, meaning sediment eDNA generally persists longer in the environment (Holman et al., 2022; Sakata et al., 2020). The average half-life of eDNA varies depending on environmental conditions such as temperature, UV exposure and whether the eDNA is bound to particles (Collins et al., 2018; Strickler et al., 2015).

Within the intertidal survey area, SeDNA samples were collected to detect invertebrates, eukaryotes and bacteria. For invertebrates, a high proportion of taxa were identified to species level (75 %), however, only four taxa were detected within the invertebrate analysis. A low proportion of taxa were identified to species level for eukaryotes (11.14 %) and bacteria (1.42 %). This may be due to low eDNA concentrations, low data resolution in the region, or natural inhibitors affecting the analysis. It should be noted that bacteria are not commonly identified to species level due to the challenges of isolating and describing prokaryotic taxa.

eDNA can be used to complement traditional macrofaunal sampling. Recent studies show that eDNA metabarcoding often detects a broader range of taxa than morphology-based methods. Hale et al. (2024) demonstrated that eDNA surveys of intertidal sediments identified numerous taxa, including nematodes, platyhelminths, and ascidians, that were overlooked in traditional assessments due to identification challenges.

However, a direct comparison can only be done at a very high level due to methodological and technical differences between eDNA and traditional methods, especially for studies with low eDNA replicates and relatively small spatial or short temporal scales (Beentjes et al., 2019; Burian et al., 2021; Mathieu et al., 2020). eDNA can provide the presence and relative abundance of an organism's eDNA whereas macrofaunal data can provide the precise location, number of individuals, and biomass of organisms at a point in time. Additionally, at this site macrofaunal samples were collected at a greater number of sites, were processed using a 1 mm sieve, and had colonial taxa removed during data rationalisation whilst eDNA samples were collected at only three sites, were not sieved, and retained taxa that would have been removed from macrofaunal rationalisation.

11.5.1 Marine Sediment Invertebrates

Invertebrate eDNA analysis identified four target taxa within the intertidal survey area. This may be reflective of the littoral mobile sand habitat present (Section 10), which usually supports a limited number of species (EEA, 2022). It is also possible that the infaunal communities present may have been impacted by the recent beach replenishment (Wooldridge et al., 2016). Additionally, sand sediments generally provide low concentrations of eDNA, resulting in fewer detected taxa sequences.

Within the invertebrate eDNA analysis, the mid shore (ST05A) was dominated by a high proportion of OTUs matching the aceol *Baltalimania ylvae*, whilst the lower shore (ST08) was dominated by OTUs matching the polychaete *Arenicola defodiens*. The taxa identified were typical for intertidal and/or coastal areas within the North Sea (Chamberlain et al., 2025; Global Biodiversity Information Facility [GBIF], 2023; WoRMS Editorial Board, 2026).

Comparative analysis showed low numbers of taxa detected by sediment invertebrate eDNA metabarcoding and traditional macrofaunal sampling. No taxa were identified by both methods. Macrofaunal analysis identified Platyhelminthes and two Arthropoda taxa whilst invertebrate eDNA analysis detected two Annelids, one Cnidarian, and one Xenacoelomorpha. Arthropods and hard shelled taxa are generally underrepresented in eDNA analyses due to comparatively lower eDNA shedding rates.

eDNA analysis detected three invertebrate taxa at station ST05A whilst traditional macrofaunal techniques noted the station to be abiotic. Similarly, eDNA methods detected three invertebrate taxa at station ST08 whilst one taxon was identified in the macrofaunal core (*Pontocrates arenarius*, which was not detected by eDNA analysis). eDNA often detects a broader range of taxa than traditional methods. This can be due to detection of cryptic taxa, and increased persistence of organism traces, especially in sediment. Variations in methods may also account for some of the differences.

Differences between eDNA and macrofaunal data may also have been influenced by the small spatial differences observed in macrofaunal communities (Beentjes et al., 2019, 2019, 2019; Kendall & Widdicombe, 1999). Similarly, low replicates of eDNA samples decrease confidence that uncommon or rare taxa will be detected. Overall, the results highlight the importance of eDNA sampling techniques in complementing traditional sampling methods.

11.5.2 Marine Sediment Eukaryotes

Within the eukaryote eDNA analysis, Chromista and Animalia were the kingdoms contributing the highest proportion of OTUs. Within the phylum Animalia, OTUs matching Platyhelminthes dominated overall, though were detected in varying proportions across the low, mid and upper shores. OTUs matching Polychaeta and Copepoda taxa were also commonly detected across the intertidal survey area. The taxa identified were typical for intertidal and/or coastal areas within the North Sea (Chamberlain et al., 2025; GBIF, 2023; WoRMS Editorial Board, 2026)).

Platyhelminthes were the only taxon detected by both eukaryote eDNA metabarcoding and traditional macrofaunal methods. Moreover, eDNA detected several taxa within Platyhelminthes to lower taxonomic levels, including the family Otoplanidae. No other taxa were detected by both eukaryote eDNA and traditional macrofaunal methods, even at higher taxonomic levels. Macrofaunal taxa identified in eukaryote analysis but not in invertebrate analysis are likely due to a combination of methodological differences and potential small differences between samples. Methodological differences can include primer specificity and reference library incompleteness. Small differences in samples are present in all sampling methods; however, this effect is magnified in small eDNA datasets or where environmental eDNA concentration is low. Overall, eDNA sampling techniques were complementary to traditional sampling methods.

OTUs matching the family Ammodytidae and the order Gadiformes were detected by eukaryote eDNA analysis, which may indicate the potential presence of certain protected species. For example, OTUs matching Ammodytidae may indicate the potential presence of the UK BAP species *Ammodytes marinus*. This species is not found intertidally, but may be present in the nearby coastal habitat (Marine Scotland; WoRMS Editorial Board, 2026). Similarly, OTUs matching Gadiformes may indicate the possible presence of UK BAP species such as *Gadus morhua*. Whilst no UK BAP Gadiformes are found intertidally, some, including *Gadus morhua*, can be found within shallow coastal waters (Pollet-Calderini et al., 2026; WoRMS Editorial Board, 2026).

11.5.3 Marine Sediment Bacteria

Microbes dominate life in the oceans and play critical roles in ecosystem functioning and biogeochemical processes both on local and global scales (Logares et al., 2014).

The microbial benthic community is a potentially powerful yet underexplored source of sediment-quality bioindicators, given its role in biogeochemical cycles, carbon sequestration, and pollutant mitigation, and its specific responses to contaminant types (Pawlowski et al., 2018). There is increasing recognition of the value of the microbial fraction of the environment, and the ecosystem services it provides, such as bioremediation of pollutants and plastics, as well as its potential as a reservoir of novel bioprocesses. The direct link between sediment chemistry and microbial metabolic activity means that microbes can be ecosystem indicators, providing additional context for understanding potential environmental processes and sediment chemistry. Microorganisms in marine sediments are usually abundant and exhibit high metabolic diversity; therefore, they are a key factor in nutrient remineralisation and strongly influence the biogeochemical cycles of coastal and marine ecosystems (Aldeguer-Riquelme et al., 2022).

Within the intertidal survey area, the classes Gammaprotobacteria and Actinomycetia, the phyla Actinobacteria, the order Planctomycetales and the family Acidobacteriaceae were amongst the top 5 taxa contributing the highest proportions of OTUs and were detected within each eDNA sediment sample.

The class Gammaproteobacteria comprises numerous marine and estuarine bacteria, many of which can degrade hydrocarbons. They play a crucial role in bioremediation and the decomposition of organic matter. These bacteria are widespread in marine environments, including areas contaminated with oil (Gutierrez, 2017). Some of the other bacterial taxa detected also play roles in the cycling of nutrients and/or in the degradation of aromatic hydrocarbons, including Actinobacteriota (Xu et al., 2022; Zhang et al., 2025).

The taxa detected by bacterial eDNA analysis, with the highest proportions of OTUs, were all typical of coastal areas and/or the North Sea, with many found ubiquitously in sediment (Liu et al., 2022; Lucas et al., 2015; Payne et al., 2025; WoRMS Editorial Board, 2026; Wyness et al., 2021).

11.6 Seafloor Habitats and Biotopes

One habitat was identified in the intertidal survey area.

Littoral mobile sand is defined as shores consisting of mobile sands with very little fines present. These shores usually support a limited number of species which can tolerate exposed shores. This is due to constant sediment reworking which prevent the establishment of stable faunal communities. Temporal variation can also occur within these habitats with storm events prevalent in the winter months causing erosion of fine particulates and consequently reducing habitat types available for colonisation and recruitment of juveniles that can withstand high-energy conditions (Defeo & Martínez, 2003; Goad et al., 2025; JNCC, 2022; McLachlan & Dorvlo, 2005; Wooldridge et al., 2016)

12. Conclusions

The aim of this report has been to evaluate the existing physical, chemical and biological components within the intertidal survey area. A review of the environmental data in context with other cited studies from the region and estimated sediment effects threshold values (MMO, 2015; OSPAR, 2014; United Kingdom Offshore Operators Association [UKOOA], 2001) was also undertaken. Based on the overall assessment of the survey area, the following key conclusions can be stated:

- The sediment type across the intertidal survey area was homogenous and dominated by sand, with a low organic content. Three stations (ST01 to ST03) were classed as 'coarse sand' with the rest of the stations classed as 'medium sand' using the Wentworth Description (1922);
- GC-FID profiles were typical of background marine sediment;
- Sediment THC values were typical of background marine sediments;
- Total 2 to 6 ring PAH exceeded the Cefas AL1 at stations ST06 and ST09A. The US EPA 16 PAH concentrations were below their respective OSPAR ERL values at all stations. When normalised to 2.5 % TOC, seven US EPA 16 PAH concentrations were above their respective BAC values at six stations. However, as these PAHs are below the ERL there would likely not be any adverse effect on the macrofaunal communities. PAH source assignment indicated a predominantly pyrolytic source of aromatic material;
- All metal concentrations were below their respective ERL values at all stations and were therefore considered to be of no ecological concern;
- Three taxa and six individuals were found across the survey area;
- The species identified were the amphipod *Pontocrates arenarius,* the isopod *Eurydice pulchra* and Platyhelminthes, which are typical of the EUNIS level 4 biotope complex 'Barren and amphipod dominated littoral sand' (MA523). These taxa contributed to the minimal biomass seen across the survey area;
- Variation in the communities present have been influenced by beach replenishment, the exposure to hydrodynamics and sediment type;
- eDNA sampling methods complemented macrofaunal analysis;
- The taxa detected by invertebrate, eukaryote, and bacteria eDNA analysis, with the highest proportions of OTUs, were typical of those occurring within the intertidal, coastal and/or surrounding areas of the North Sea;
- eDNA analysis detected OTUs matching Ammodytidae and Gadiformes, both of which may indicate the potential presence of UK BAP species. However, the potentially present species are not found intertidally, though some can be present in shallow coastal waters.

The physico-chemical properties and macrofaunal communities observed in this survey were considered to be typical of a sandy beach habitat that is subject to wave action and has undergone recent beach replenishment, within this region of the North Sea.

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Appendix A

Guidelines on Use of Report

This report (the “Report”) was prepared as part of the services (the “Services”) provided by Fugro GB 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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Appendix B

Methods

B.1 Laboratory Analysis for Sediment Samples

B.1.1 Particle Size Analysis

B.1.1.1 Dry Sieve Analysis

Dry sieve PSD analysis was undertaken in accordance with Fugro's in-house methods based on the NE Atlantic Marine Biological Analytical Quality Control (NMBAQC) scheme's best practice guidance document – Particle Size Analysis (PSA) for Supporting Biological Analysis (2022), and BS1377: Parts 1: 2016 and 2: 1990.[1]

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)[2]. The weight of the sediment fraction retained on each mesh was subsequently measured and recorded.

B.1.1.2 Laser Diffraction

Laser diffraction PSD analysis was undertaken in accordance with Fugro's in-house methods based on the NMBAQC scheme's best practice guidance document – Particle Size Analysis (PSA) for Supporting Biological Analysis (2022) and BS ISO 13320: 2020[1].

Representative material < 1 mm was removed from the bulk subsample for laser analysis, with a minimum of two triplicate analyses performed using the laser sizer at 0.5 phi intervals between < 1 mm to < 0.98 µm.

B.1.1.3 Sample Analysis Outputs and Deliverables

Sieve and laser data were 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. PSD analysis followed MMO requirements, presenting more detailed data from 63 000 down to less than 0.04 µm.

B.1.2 Total Organic Carbon (TOC)

Sediment samples were analysed for TOC by Element Materials Technology. 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 infra-red analysis. This method does not quantify volatile organic carbon,

[1] NE Atlantic Marine Biological Analytical Quality Control Coordinating Committee (NMBAQC) (2022). *NE Atlantic marine biological analytical quality control's best practice guidance. Particle size analysis (PSA) for supporting biological analysis*. NE Atlantic Marine Biological AQC Coordinating Committee (NMBAQC). https://www.nmbaqcs.org/scheme-components/particle-size-analysis/reports.aspx
[2] Wentworth, C. K. (1922). A scale of grade and class terms for clastic sediments. *The Journal of Geology*, *30*(5), 377–392.

which should be determined by another technique. The limit of detection for this method was < 0.02 % w/w.

B.1.3 Total Organic Matter (TOM)

TOM content was determined by LOI; a pre-dried aliquot of the sediment was weighed before being ignited in a muffle furnace at 450 °C for 4 hours. The organic content of the sediment was then calculated using the weight difference from the original dry weight to the ignited residue.

B.1.4 Hydrocarbon Analysis in Sediments

B.1.4.1 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 glassware was cleaned using an acid/base machine wash. The glassware was rinsed with acetone prior to use;
- Procedural blanks and a laboratory reference material were run with each batch. Certified reference materials and replicate analyses were run within the project.

B.1.4.2 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. Dichloromethane (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.1.4.3 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 GC and 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.1.4.4 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 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 MRV is 0.5 µg/g dry weight.

B.1.4.5 n-Alkanes, Pristane and Phytane

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 (and pristane and phytane) were taken to be equivalent to closely eluting compounds. The MRV of individual n-alkanes is 0.1 ng/g dry weight.

The n-alkanes between nC_{12} and nC_{36} were reported, as were the ranges between nC_{12} and nC_{20} and nC_{21} and nC_{36}. CPI values (the ratio of odd to even carbon numbered compounds) for the same ranges were also calculated. Pristane and phytane (and associated ratio) were also determined.

B.1.4.6 Polycyclic Aromatic Hydrocarbons (PAHs)

A full range of PAH and alkylated PAH were quantified as specified by Department of Trade and Industry regulations (1993).[3]

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 MRV of individual and alkylated PAHs is 0.1 ng/g.

B.1.4.7 Metals in Sediments

Sediment samples were dried at 40 °C 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 and does not release those associated with the alumino-silicate matrix of the sediment. The resulting digests were then analysed by inductively coupled plasma – mass spectrometry (ICP-MS) for As, Cd, Cr, Cu, Hg, Ni, Pb, Sr and Zn and inductively coupled plasma-optical emission spectrometry (ICP-OES) for Al, Ba, Fe, Mn, P, and V.

RPS analysed the sediment samples for berrylium. Samples were dried at 40 °C and then sieved to the required size fraction (2000 µm). Samples were subjected to a microwave

[3] Department of Trade and Industry. (1993). *Conditions for the discharge of oil contaminated cuttings resulting from offshore drilling.* Department of Trade and Industry (DTI).

digestion using aqua regia with the resulting digests analysed by ICP-MS and/or inductively coupled plasma – optical emission spectrometry (ICP-OES).

B.1.4.8 eDNA

Sediment samples were analysed for eukaryotes, bacteria and invertebrates. NatureMetrics carried out laboratory extraction and sequencing. Fugro carried out additional data analysis and interpretation.

The DNA collected was purified to remove polymerase chain reaction (PCR) inhibitors and amplified with PCR for a hypervariable region of the 12S r-ribonucleic acid (ribosomial RNA) gene to target fish (excluding sharks and rays).

DNA was extracted from the 0.8 µm PES filters using a DNeasy Blood and Tissue Kit (Qiagen). A negative control, consisting of molecular-grade water, was processed with each batch of samples to monitor for exogenous DNA contamination. Replicate PCRs were performed for each sample and extraction blank, using a two-step PCR protocol. Positive and negative controls, consisting of proprietary synthetic sequences (that do not match known biological records) and PCR-grade water, respectively, were included with every PCR plate to verify amplification performance. Amplification was performed with commercially available Hot Start DNA polymerases targeting the mitochondrially encoded Cytochrome c oxidase subunit I (mt-COI) gene for the target taxa, and the resulting products were sequenced on an Illumina MiSeq system using a V3 600-cycle reagent kit. Initial DNA sequences from different samples were separated and prepared using specialised software.

Appendix C

Logs

C.1 Survey Log

Projection: ETRS 1989 UTM Zone 30N 3°W/ 31N 3°E																
Date	Time [UTC]	Station	Waypoint	Event	Sample Type	Photo Number	Actual Location (30N)		Actual Location (31N)		Direction	Redox Potential			Description	Biotope Notes
							Easting	Northing	Easting	Northing		Temperature [°C]	mV	pH		
04/12/2025	08:24:00	ST02	4	PC/FA/FB	PSD/HM/HC/eDNA	1&2	721 357.2	5 907 555.0	321 274.1	5 905 764.3	SW	-	-	-	Coarse sand with very few shell fragments	*Flustra foliacea*
04/12/2025	09:02:00	ST05	5	PC/FA/FB	PSD/HM/HC/eDNA	3&4	721 468.1	5 907 608.7	321 389.1	5 905 808.5	SW	14.8	131	7.01	Sand with very few shell fragments	
04/12/2025	09:33:00	ST06	6	PC/FA/FB	PSD/HM/HC	5&6	721 564.6	5 907 365.5	321 464.9	5 905 558.1	SW	14.6	183	7.00	Sand with shell fragments	
04/12/2025	10:10:00	ST04	7	PC/FA/FB	PSD/HM/HC	7&8	721 402.2	5 907 814.0	321 340.6	5 906 018.6	SW	14.9	177	7.12	Sand	
04/12/2025	10:36:00	ST01	8	PC/FA/FB	PSD/HM/HC	9&10	721 272.9	5 907 767.7	321 207.9	5 905 983.3	SW	14.9	114	7.05	Coarse sand	
04/12/2025	11:30:00	ST07	9	PC/FA/FB	PSD/HM/HC	11&12	721 416.6	5 907 870.5	321 359.7	5 906 073.7	SW	14.5	163	7.07	Fine sand	
04/12/2025	11:50:00	ST08	10	PC/FA/FB	PSD/HM/HC/eDNA	13&14	721 526.8	5 907 615.1	321 448.1	5 905 810.0	SW	15	194	7.08	Fine sand	
04/12/2025	12:10:00	ST09	11	PC/FA/FB	PSD/HM/HC	15&16	721 629.6	5 907 353.0	321 528.5	5 905 540.2	SW	15.2	183	7.12	Fine sand	
04/12/2025	13:10:00	ST03	12	PC/FA/FB	PSD/HM/HC	17&18	721 471.7	5 907 324.7	321 368.9	5 905 525.3	SW	14.7	137	7.17	Coarse sand with pebbles	
05/12/2025	10:21:00	ST04A	13	PC/FA/FB	PSD/HM/HC		721 346.1	5 907 783.2	321 282.2	5 905 992.6	SW	-	-	-	Fine sand	
05/12/2025	10:56:00	ST05A	14	PC/FA/FB	PSD/HM/HC/eDNA		721 427.4	5 907 588.4	321 346.9	5 905 791.8	SW	-	-	-	Compact fine sand	
05/12/2025	12:06:00	ST09A	15	PC/FA/FB	PSD/HM/HC		721 616.3	5 907 403.9	321 519.6	5 905 592.1	SW	-	-	-	Coarse sand	

C.2 Photo Log

Projection: ETRS 1989 UTM Zone 30N 3°W /31N 3°E												
Date	Time [UTC]	Station	Waypoint	Event	Sample Type	Photo Number	Actual Location (30N)		Actual Location (31N)		Direction	Description
							Easting	Northing	Easting	Northing		
05/12/2025	08:28:00	-	1	Still	-	1	721 216.9	5 907 742.2	321 150.0	5 905 962.6	NE	Main beach entrance
05/12/2025	08:33:00	-	2	Still	-	2	721 224.5	5 907 748.2	321 158.1	5 905 967.9	SW	Sand dunes and foliage
05/12/2025	08:34:00	-	3	Still	-	3	721 238.4	5 907 739.7	321 171.2	5 905 958.3	NA	Gravel
05/12/2025	-	-	4	Video	-	-	721 266.9	5 907 684.5	321 195.0	5 905 900.9	SW	Video 1
05/12/2025	08:38:00	-	5	Still	-	4	721 281.0	5 907 676.8	321 208.4	5 905 892.1	NA	Shells on upper beach
05/12/2025	-	-	6	Video	-	-	721 300.5	5 907 629.9	321 223.9	5 905 843.7	NE	Video 2
05/12/2025	08:47:00	-	7	Still	-	5	721 366.9	5 907 482.6	321 277.7	5 905 691.3	NA	Second beach entrance
05/12/2025	08:50:00	-	8	Still	-	6	721 397.7	5 907 455.5	321 306.1	5 905 661.8	NA	*Flustra sp.*
05/12/2025	08:57:00	-	9	Still	-	7	721 462.7	5 907 330.2	321 360.4	5 905 531.5	N	End of corridor
05/12/2025	08:59:00	-	10	Still	-	8	721 469.2	5 907 335.8	321 367.3	5 905 536.5	NE	Sediment closeup 1
05/12/2025	-	-	11	Video	-	-	721 482.3	5 907 353.1	321 381.8	5 905 552.7	NE	Video 3
05/12/2025	09:04:00	-	12	Still	-	10	721 502.8	5 907 380.0	321 404.5	5 905 577.8	NE	Whelk (Buccinidae)
05/12/2025	09:06:00	-	13	Still	-	11	721 499.1	5 907 393.8	321 401.9	5 905 591.8	N	Tide
05/12/2025	09:08:00	-	14	Still	-	12	721 495.2	5 907 407.7	321 399.2	5 905 606.0	N	Sediment closeup 2
05/12/2025	09:10:00	-	15	Still	-	13	721 479.3	5 907 463.4	321 388.1	5 905 662.8	SE	Sediment closeup 3
05/12/2025	09:14:00	-	16	Still	-	14	721 419.0	5 907 415.2	321 324.0	5 905 619.9	W	Strand line
05/12/2025	-	-	17	Video	-	15	721 397.7	5 907 517.0	321 311.3	5 905 723.0	N	Video 4
05/12/2025	09:21:00	-	18	Still	-	16	721 387.0	5 907 587.7	321 306.6	5 905 794.4	NW	Water Channel
05/12/2025	09:22:00	-	19	Still	-	17	721 382.9	5 907 585.2	321 302.3	5 905 792.2	W	Sand ridge
05/12/2025	09:24:00	-	20	Still	-	18	721 388.9	5 907 619.2	321 311.1	5 905 825.6	NA	Razor clam shells (*Ensis sp.*)
05/12/2025	-	-	21	Video	-	-	721 366.8	5 907 711.1	321 296.8	5 905 919.0	N	Video 5
05/12/2025	09:31:00	-	22	Still	-	19	721 322.8	5 907 768.6	321 257.7	5 905 980.0	W	Beach entrance
05/12/2025	09:32:00	-	23	Still	-	20	721 320.4	5 907 776.0	321 256.0	5 905 987.6	NA	Razor clam shells 2 (*Ensis sp.)*
05/12/2025	09:39:00	-	24	Still	-	21	721 378.3	5 907 820.2	321 317.4	5 906 026.7	NE	Tide 2
05/12/2025	09:42:00	-	25	Still	-	22	721 442.3	5 907 707.0	321 371.6	5 905 908.7	W	Overall beach view
05/12/2025	-	-	26	Video	-	-	721 527.6	5 907 497.5	321 439.1	5 905 692.7	NA	Video 6
05/12/2025	-	-	27	Video	-	-	721 610.3	5 907 394.6	321 512.8	5 905 583.3	NA	Video 7
05/12/2025	13:21:00	-	28	Still	-	23	721 597.0	5 907 419.2	321 501.6	5 905 608.9	NA	Exposed rock
05/12/2025	13:21:00	-	29	Still	-	24	721 592.8	5 907 467.1	321 501.4	5 905 657.0	NA	*Flustra sp.*
05/12/2025	13:25:00	-	30	Still	-	25	721 556.7	5 907 562.4	321 473.5	5 905 754.9	N	Low tide
05/12/2025	13:25:00	-	31	Still	-	26	721 541.8	5 907 589.1	321 460.8	5 905 782.8	NA	Sediment close up 4

Appendix D

Sediment Particle Size and

Sediment Surface Photographs

D.1 Sediment Particle Size Data

Test Results:	Particle Size Distribution by Dry Sieving (63000 - 1000 µm) and Laser Diffraction (< 1000 - < 0.98 µm) @ 0.5 Phi Intervals								
SAMPLE ID:	ST01	ST02	ST03	ST04A	ST05A	ST06	ST07	ST08	ST09A
LAB ID:	WL046965	WL046966	WL046967	WL046968	WL046969	WL046970	WL046971	WL046972	WL046973
Aperture [µm]	Fractional [%]	Fractional [%]	Fractional [%]	Fractional [%]	Fractional [%]	Fractional [%]	Fractional [%]	Fractional [%]	Fractional [%]
63000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5600	0.00	0.00	0.36	0.00	0.07	0.00	0.00	0.00	0.00
4000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2800	0.00	0.00	0.46	0.00	0.01	0.00	0.00	0.09	0.10
2000	0.00	0.01	0.86	0.02	0.05	0.08	0.10	0.34	0.17
1400	0.00	0.04	2.39	0.07	0.08	0.08	0.11	0.36	0.41
1000	0.13	0.42	9.70	0.14	0.17	0.26	0.18	0.59	0.83
707.11	27.07	24.92	30.57	4.52	2.93	1.50	0.05	1.44	5.58
500.00	43.69	44.05	32.78	19.45	17.31	11.33	2.88	10.00	13.04
353.55	25.63	26.89	18.93	34.06	34.94	28.63	16.59	25.52	21.95
250.00	3.45	3.63	3.88	29.15	31.50	34.52	34.24	33.20	26.13
176.78	0.03	0.03	0.07	11.46	11.97	19.75	31.78	22.18	20.64
125.00	0.00	0.00	0.00	1.14	0.99	3.83	12.98	6.11	9.57
88.39	0.00	0.00	0.00	0.00	0.00	0.01	1.11	0.18	1.57
62.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
44.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
< 0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL:	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

D.2 Sediment Particle Size Certificate

Click on icon below to open Sediment Particle Size Certificate.

D.2 Sediment
Particle Size Certifica

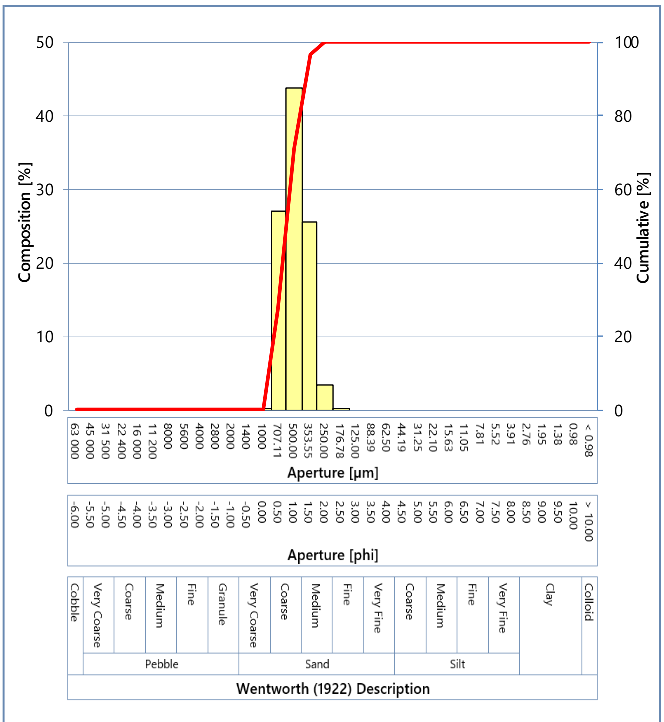
D.3 Sediment Particle Size and Sediment Surface Photographs

STATION: ST01

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.00	0.00
4000	-2.00	0.00	0.00
2800	-1.50	0.00	0.00
2000	-1.00	0.00	0.00
1400	-0.50	0.00	0.00
1000	0.00	0.13	0.13
707.11	0.50	27.07	27.20
500.00	1.00	43.69	70.89
353.55	1.50	25.63	96.52
250.00	2.00	3.45	99.97
176.78	2.50	0.03	100.00
125.00	3.00	0.00	100.00
88.39	3.50	0.00	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]*	604	Coarse sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	590	Coarse sand
Median [phi]*	0.76	
Mean [µm]*†	586	Coarse sand
Mean [phi]*†	0.77	
Sorting [µm]†	1.37	Well sorted
Sorting [phi]†	0.45	
Skewness [µm]†	-0.03	Symmetrical
Skewness [phi]†	0.03	
Gravel [%]‡	0.00	Sand
Sand [%]‡	100.00	
Fines [%]‡	0.00	

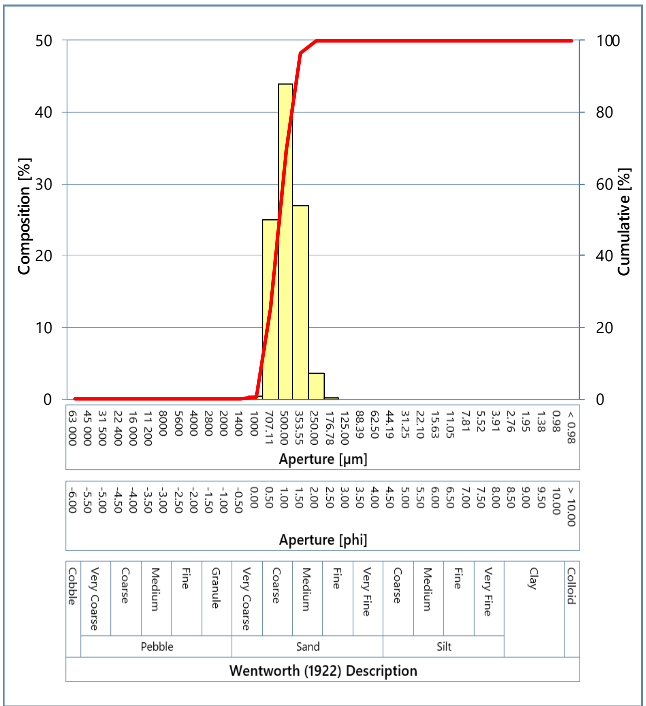
Notes
Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals
* = Particle size expressed in accordance with Wentworth (1922) scale
† = Statistics calculated using Folk and Ward (1957) method
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST02

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.00	0.00
4000	-2.00	0.00	0.00
2800	-1.50	0.00	0.00
2000	-1.00	0.01	0.01
1400	-0.50	0.04	0.05
1000	0.00	0.42	0.47
707.11	0.50	24.92	25.39
500.00	1.00	44.05	69.44
353.55	1.50	26.89	96.33
250.00	2.00	3.63	99.97
176.78	2.50	0.03	100.00
125.00	3.00	0.00	100.00
88.39	3.50	0.00	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]*	604	Coarse sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	583	Coarse sand
Median [phi]*	0.78	
Mean [µm]*†	579	Coarse sand
Mean [phi]*†	0.79	
Sorting [µm]†	1.37	Well sorted
Sorting [phi]†	0.45	
Skewness [µm]†	-0.02	Symmetrical
Skewness [phi]†	0.02	
Gravel [%]‡	0.01	Sand
Sand [%]‡	99.99	
Fines [%]‡	0.00	

Notes

Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals

* = Particle size expressed in accordance with Wentworth (1922) scale

† = Statistics calculated using Folk and Ward (1957) method

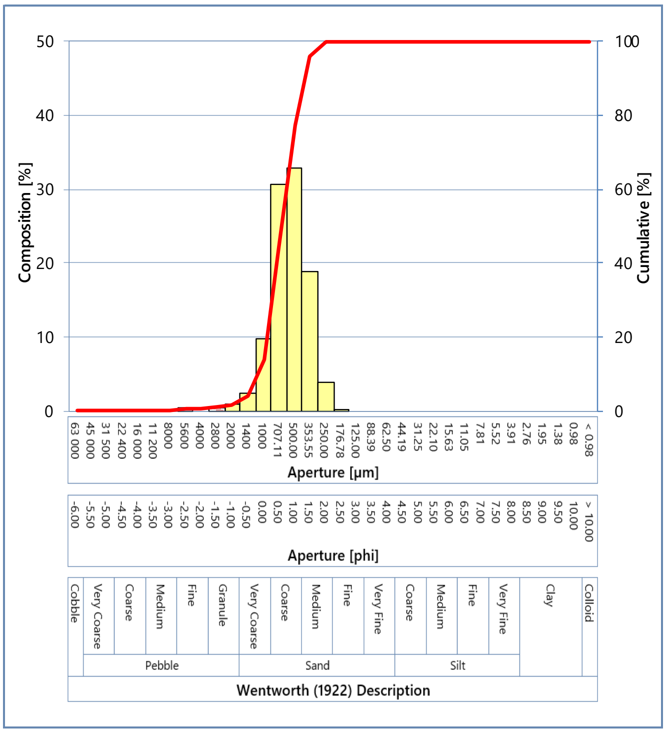
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST03

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.36	0.36
4000	-2.00	0.00	0.36
2800	-1.50	0.46	0.81
2000	-1.00	0.86	1.68
1400	-0.50	2.39	4.06
1000	0.00	9.70	13.76
707.11	0.50	30.57	44.33
500.00	1.00	32.78	77.12
353.55	1.50	18.93	96.04
250.00	2.00	3.88	99.93
176.78	2.50	0.07	100.00
125.00	3.00	0.00	100.00
88.39	3.50	0.00	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]*	604	Coarse sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	666	Coarse sand
Median [phi]*	0.59	
Mean [µm]*†	659	Coarse sand
Mean [phi]*†	0.60	
Sorting [µm]†	1.49	Moderately well sorted
Sorting [phi]†	0.58	
Skewness [µm]†	0.02	Symmetrical
Skewness [phi]†	-0.02	
Gravel [%]‡	1.68	Sand
Sand [%]‡	98.32	
Fines [%]‡	0.00	

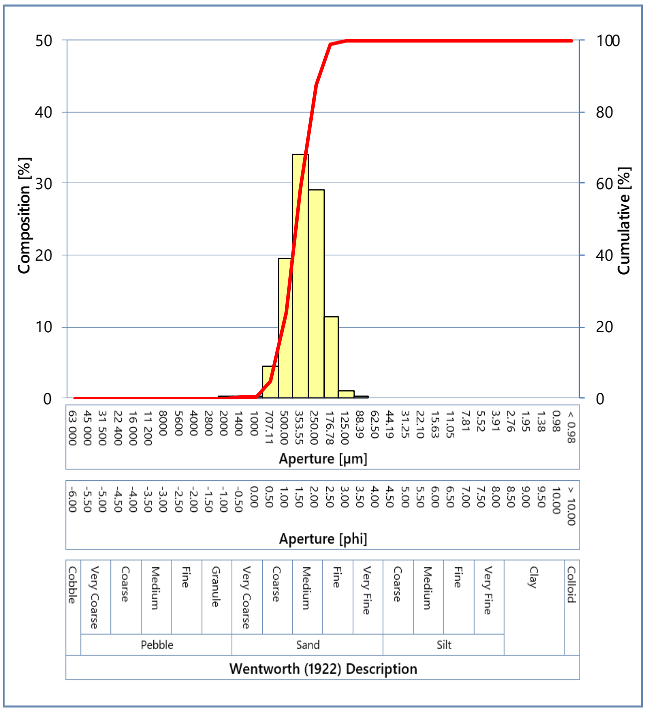
Notes
Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals
* = Particle size expressed in accordance with Wentworth (1922) scale
† = Statistics calculated using Folk and Ward (1957) method
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST04A

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.00	0.00
4000	-2.00	0.00	0.00
2800	-1.50	0.00	0.00
2000	-1.00	0.02	0.02
1400	-0.50	0.07	0.09
1000	0.00	0.14	0.23
707.11	0.50	4.52	4.74
500.00	1.00	19.45	24.19
353.55	1.50	34.06	58.25
250.00	2.00	29.15	87.40
176.78	2.50	11.46	98.86
125.00	3.00	1.14	100.00
88.39	3.50	0.00	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		**100.00**	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]†	427	Medium sand
Mode 2 [µm]†	-	-
Mode 3 [µm]†	-	-
Median [µm]†	385	Medium sand
Median [phi]†	1.38	
Mean [µm]†‡	387	Medium sand
Mean [phi]†‡	1.37	
Sorting [µm]‡	1.48	Moderately well sorted
Sorting [phi]‡	0.56	
Skewness [µm]‡	-0.01	Symmetrical
Skewness [phi]‡	0.01	
Gravel [%]#	0.02	Sand
Sand [%]#	99.98	
Fines [%]#	0.00	

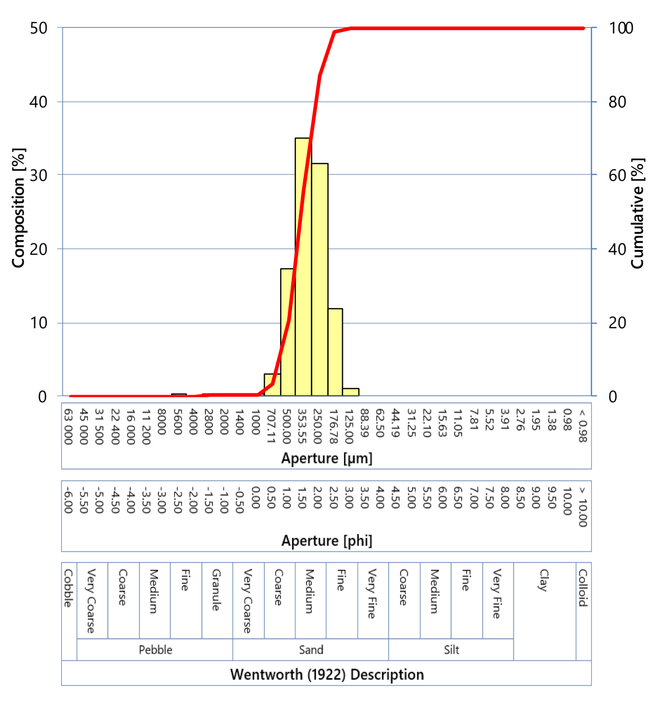
Notes
Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals
* = Particle size expressed in accordance with Wentworth (1922) scale
† = Statistics calculated using Folk and Ward (1957) method
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST05A

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.07	0.07
4000	-2.00	0.00	0.07
2800	-1.50	0.01	0.08
2000	-1.00	0.05	0.13
1400	-0.50	0.08	0.20
1000	0.00	0.17	0.37
707.11	0.50	2.93	3.30
500.00	1.00	17.31	20.61
353.55	1.50	34.94	55.55
250.00	2.00	31.50	87.05
176.78	2.50	11.97	99.01
125.00	3.00	0.99	100.00
88.39	3.50	0.00	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]*	427	Medium sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	374	Medium sand
Median [phi]*	1.42	
Mean [µm]*†	376	Medium sand
Mean [phi]*†	1.41	
Sorting [µm]†	1.46	Moderately well sorted
Sorting [phi]†	0.54	
Skewness [µm]†	0.00	Symmetrical
Skewness [phi]†	0.00	
Gravel [%]‡	0.13	Sand
Sand [%]‡	99.87	
Fines [%]‡	0.00	

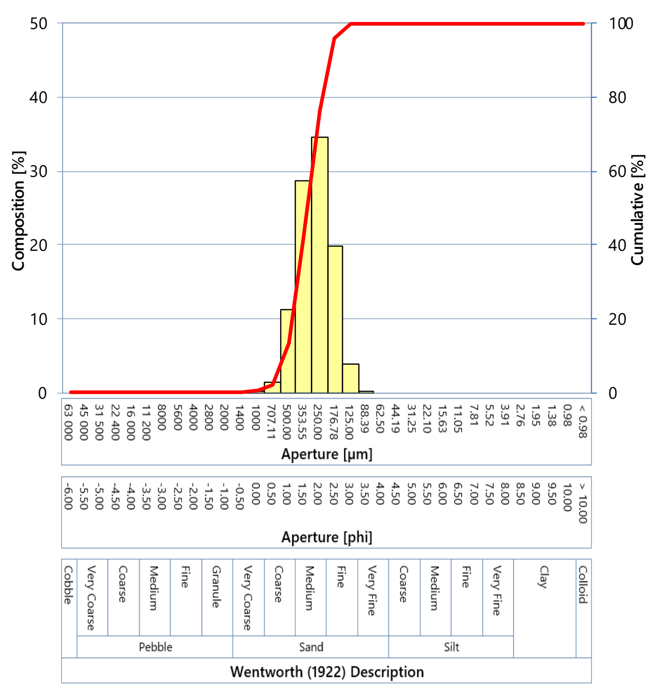
Notes
Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals
* = Particle size expressed in accordance with Wentworth (1922) scale
† = Statistics calculated using Folk and Ward (1957) method
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST06

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.00	0.00
4000	-2.00	0.00	0.00
2800	-1.50	0.00	0.00
2000	-1.00	0.08	0.08
1400	-0.50	0.08	0.16
1000	0.00	0.26	0.43
707.11	0.50	1.50	1.93
500.00	1.00	11.33	13.26
353.55	1.50	28.63	41.89
250.00	2.00	34.52	76.41
176.78	2.50	19.75	96.16
125.00	3.00	3.83	99.99
88.39	3.50	0.01	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]*	302	Medium sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	326	Medium sand
Median [phi]*	1.62	
Mean [µm]*†	326	Medium sand
Mean [phi]*†	1.62	
Sorting [µm]†	1.48	Moderately well sorted
Sorting [phi]†	0.56	
Skewness [µm]†	0.03	Symmetrical
Skewness [phi]†	-0.03	
Gravel [%]‡	0.08	Sand
Sand [%]‡	99.92	
Fines [%]‡	0.00	

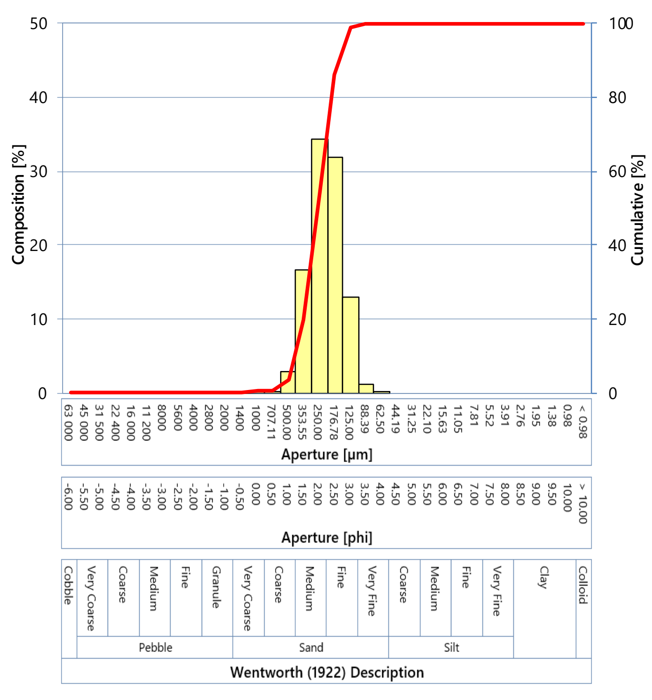
Notes
Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals
* = Particle size expressed in accordance with Wentworth (1922) scale
† = Statistics calculated using Folk and Ward (1957) method
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST07

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.00	0.00
4000	-2.00	0.00	0.00
2800	-1.50	0.00	0.00
2000	-1.00	0.10	0.10
1400	-0.50	0.11	0.21
1000	0.00	0.18	0.38
707.11	0.50	0.05	0.43
500.00	1.00	2.88	3.31
353.55	1.50	16.59	19.90
250.00	2.00	34.24	54.14
176.78	2.50	31.78	85.91
125.00	3.00	12.98	98.89
88.39	3.50	1.11	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]*	302	Medium sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	261	Medium sand
Median [phi]*	1.94	
Mean [µm]*†	262	Medium sand
Mean [phi]*†	1.93	
Sorting [µm]†	1.46	Moderately well sorted
Sorting [phi]†	0.54	
Skewness [µm]†	0.01	Symmetrical
Skewness [phi]†	-0.01	
Gravel [%]‡	0.10	Sand
Sand [%]‡	99.90	
Fines [%]‡	0.00	

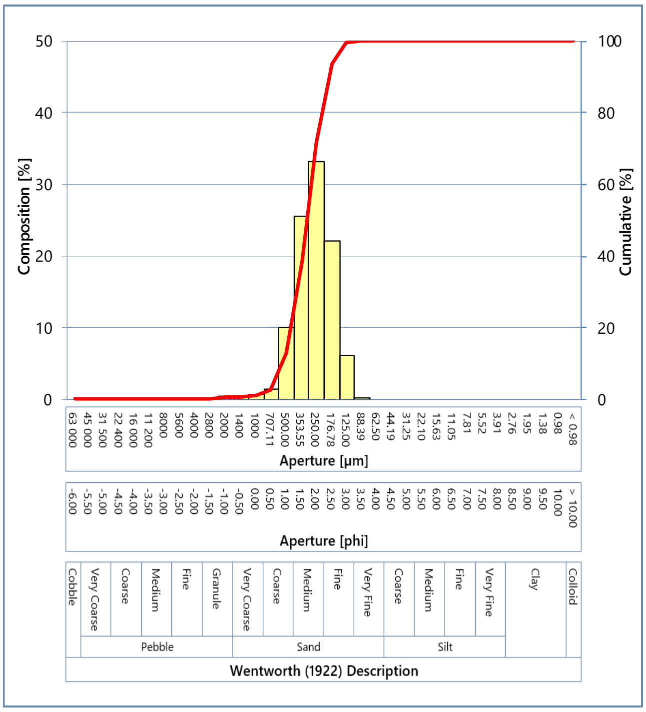
Notes
Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals
* = Particle size expressed in accordance with Wentworth (1922) scale
† = Statistics calculated using Folk and Ward (1957) method
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST08

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.00	0.00
4000	-2.00	0.00	0.00
2800	-1.50	0.09	0.09
2000	-1.00	0.34	0.43
1400	-0.50	0.36	0.78
1000	0.00	0.59	1.37
707.11	0.50	1.44	2.81
500.00	1.00	10.00	12.81
353.55	1.50	25.52	38.33
250.00	2.00	33.20	71.53
176.78	2.50	22.18	93.72
125.00	3.00	6.11	99.82
88.39	3.50	0.18	100.00
62.50	4.00	0.00	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

Mode 1 [µm]*	302	Medium sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	313	Medium sand
Median [phi]*	1.68	
Mean [µm]*†	314	Medium sand
Mean [phi]*†	1.67	
Sorting [µm]†	1.52	Moderately well sorted
Sorting [phi]†	0.61	
Skewness [µm]†	0.04	Symmetrical
Skewness [phi]†	-0.04	
Gravel [%]‡	0.43	Sand
Sand [%]‡	99.57	
Fines [%]‡	0.00	

Notes

Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals

* = Particle size expressed in accordance with Wentworth (1922) scale

† = Statistics calculated using Folk and Ward (1957) method

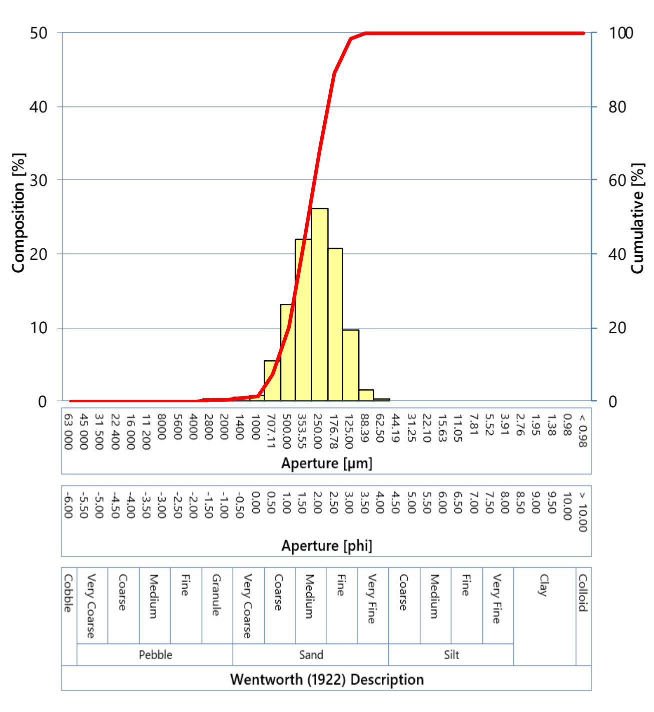
‡ = Description based on BGS modified Folk classification (Long, 2006)

STATION: ST09A

FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
63 000	-6.00	0.00	0.00
45 000	-5.50	0.00	0.00
31 500	-5.00	0.00	0.00
22 400	-4.50	0.00	0.00
16 000	-4.00	0.00	0.00
11 200	-3.50	0.00	0.00
8000	-3.00	0.00	0.00
5600	-2.50	0.00	0.00
4000	-2.00	0.00	0.00
2800	-1.50	0.10	0.10
2000	-1.00	0.17	0.27
1400	-0.50	0.41	0.68
1000	0.00	0.83	1.51
707.11	0.50	5.58	7.08
500.00	1.00	13.04	20.12
353.55	1.50	21.95	42.07
250.00	2.00	26.13	68.20
176.78	2.50	20.64	88.84
125.00	3.00	9.57	98.41
88.39	3.50	1.57	99.98
62.50	4.00	0.02	100.00
44.19	4.50	0.00	100.00
31.25	5.00	0.00	100.00
22.10	5.50	0.00	100.00
15.63	6.00	0.00	100.00
11.05	6.50	0.00	100.00
7.81	7.00	0.00	100.00
5.52	7.50	0.00	100.00
3.91	8.00	0.00	100.00
2.76	8.50	0.00	100.00
1.95	9.00	0.00	100.00
1.38	9.50	0.00	100.00
0.98	10.00	0.00	100.00
< 0.98	> 10.00	0.00	100.00
Total		100.00	-

PARTICLE SIZE DISTRIBUTION



SUMMARY STATISTICS

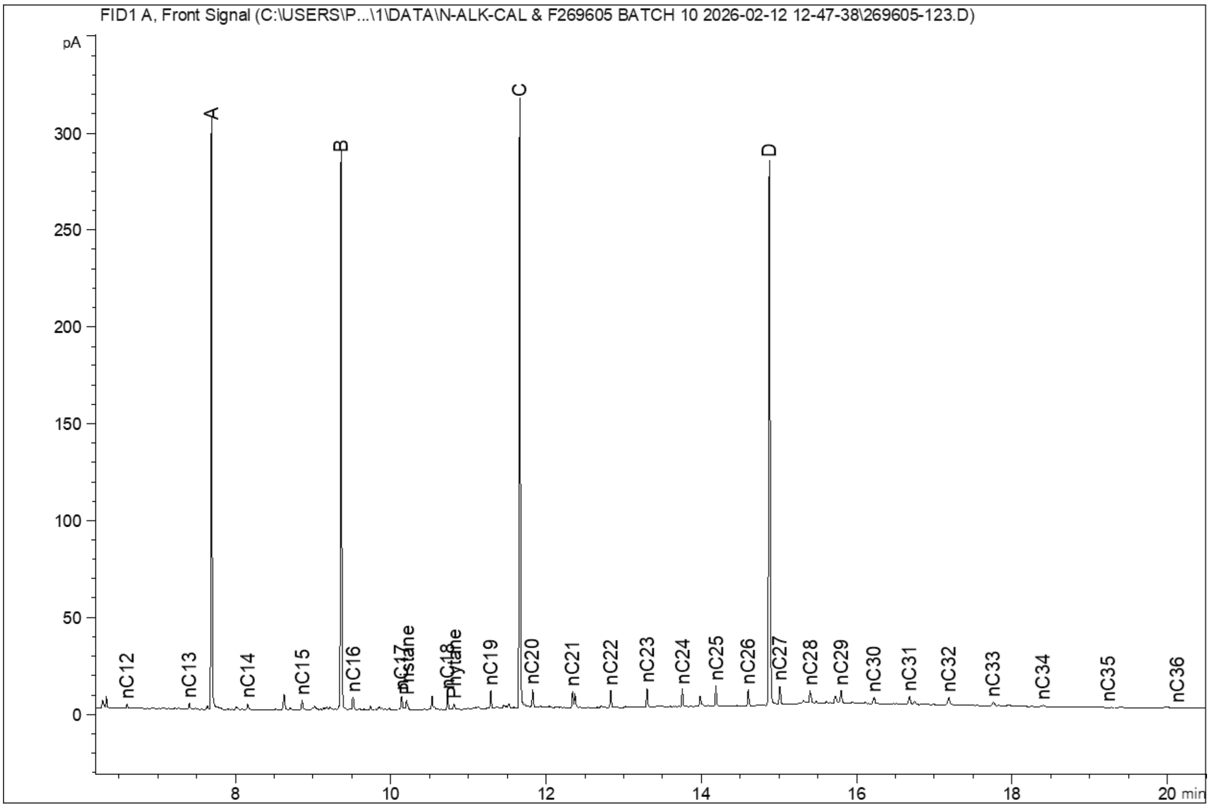
Mode 1 [µm]*	302	Medium sand
Mode 2 [µm]*	-	-
Mode 3 [µm]*	-	-
Median [µm]*	318	Medium sand
Median [phi]*	1.65	
Mean [µm]*†	324	Medium sand
Mean [phi]*†	1.63	
Sorting [µm]†	1.70	Moderately sorted
Sorting [phi]†	0.77	
Skewness [µm]†	0.06	Symmetrical
Skewness [phi]†	-0.06	
Gravel [%]‡	0.27	Sand
Sand [%]‡	99.73	
Fines [%]‡	0.00	

Notes
Particle Size Distribution by Dry Sieving (63 000 µm - 1000 µm) and Laser Diffraction (< 1000 µm - < 0.98 µm) at 0.5 phi Intervals
* = Particle size expressed in accordance with Wentworth (1922) scale
† = Statistics calculated using Folk and Ward (1957) method
‡ = Description based on BGS modified Folk classification (Long, 2006)

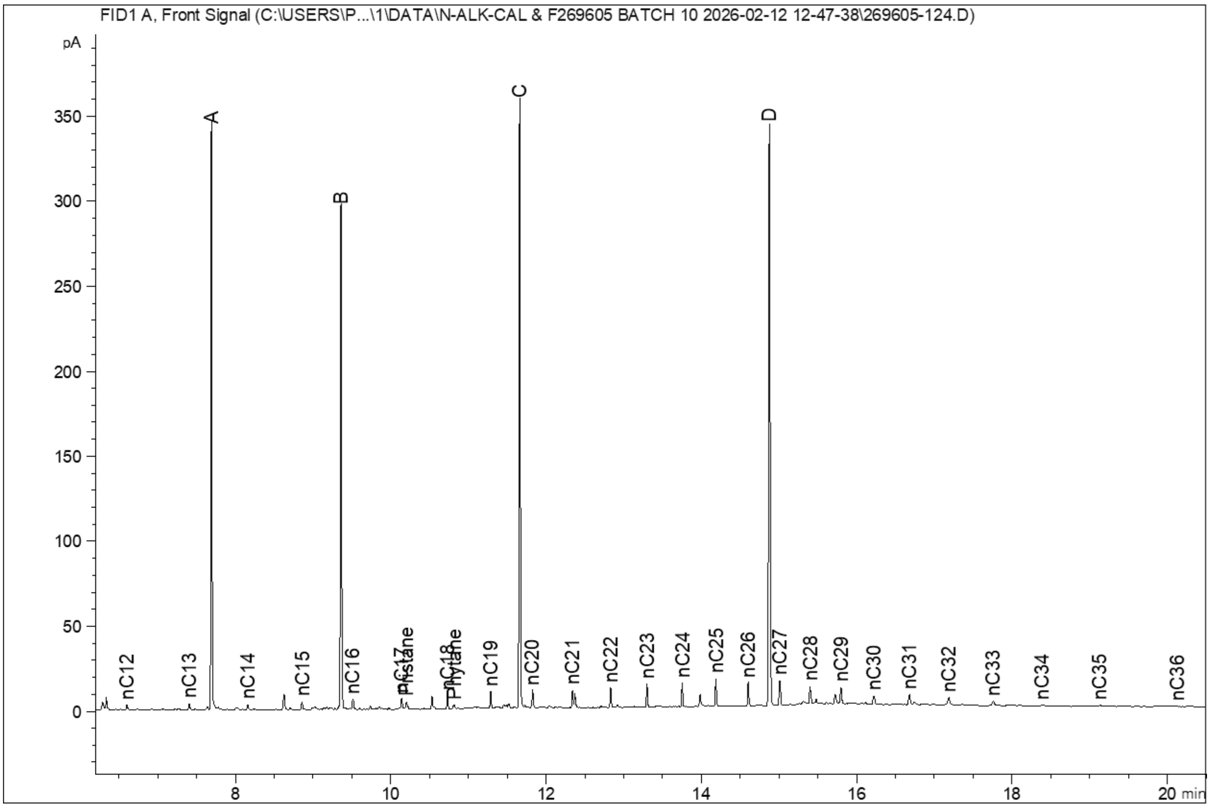
Appendix E

Hydrocarbon Analysis

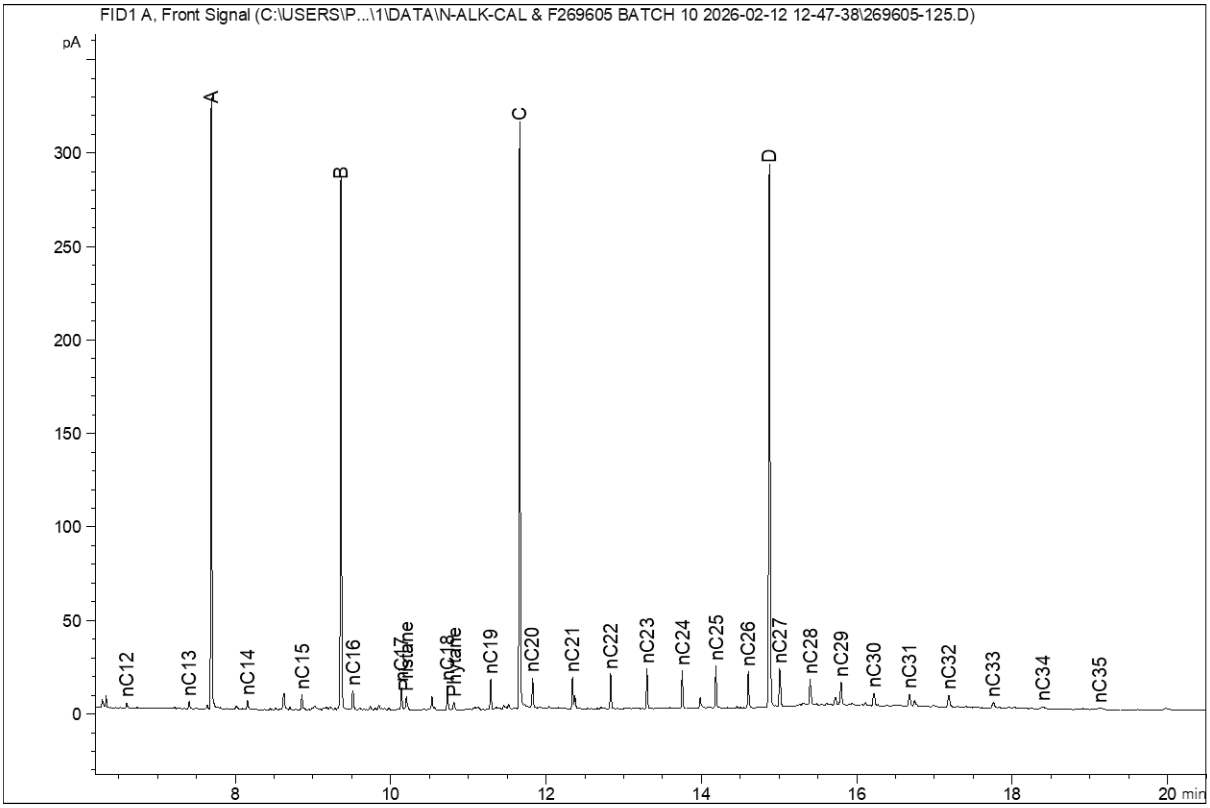
E.1 Gas Chromatography Traces



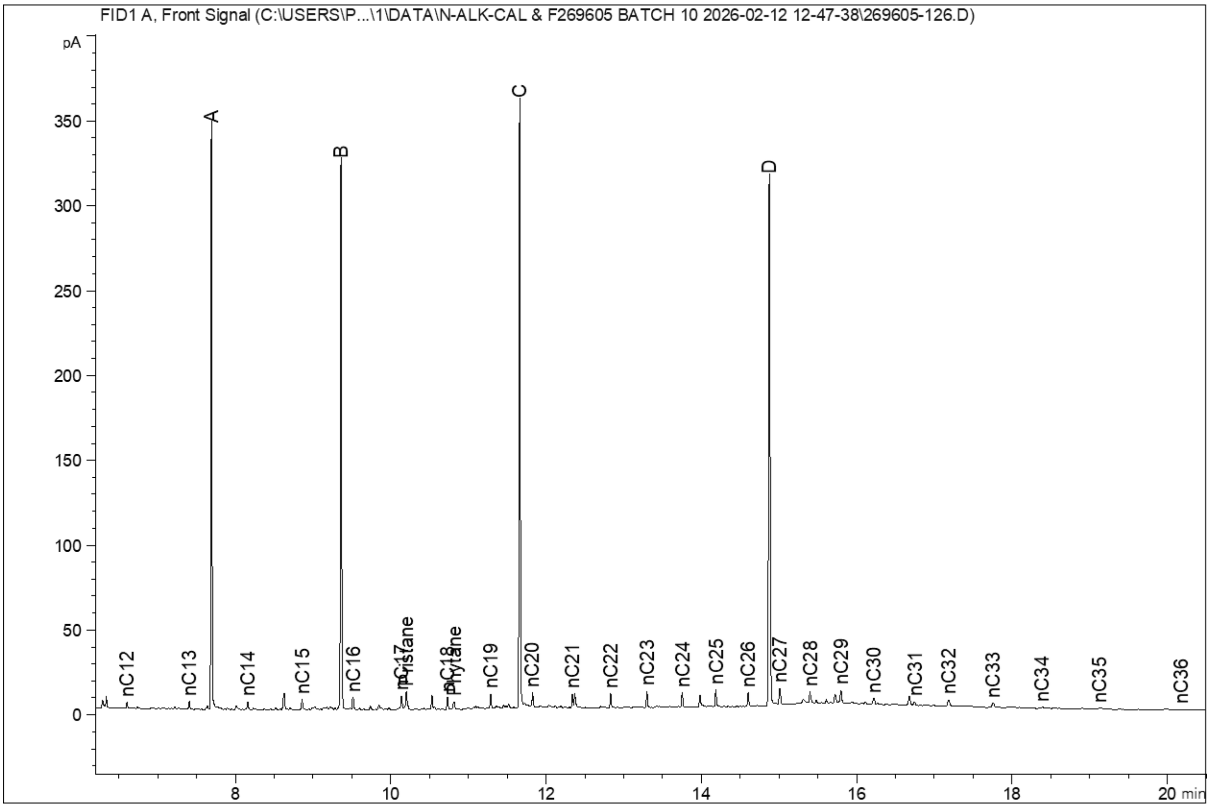
ST01



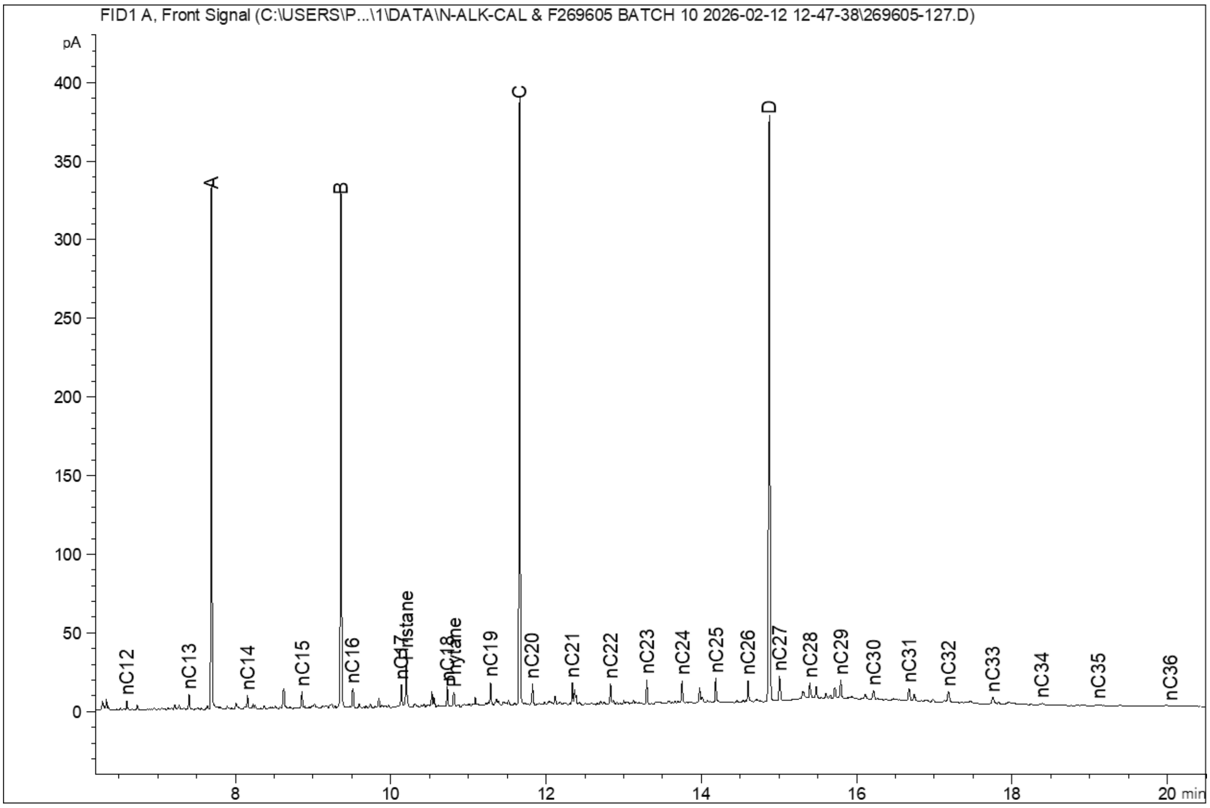
ST02


FID1 A, Front Signal (C:\USERS\P...\1\DATA\N-ALK-CAL & F269605 BATCH 10 2026-02-12 12-47-38\269605-125.D)
pA
A
B
C
D
nC12
nC13
nC14
nC15
nC16
nC17
Pristane
nC18
Phytane
nC19
nC20
nC21
nC22
nC23
nC24
nC25
nC26
nC27
nC28
nC29
nC30
nC31
nC32
nC33
nC34
nC35
min

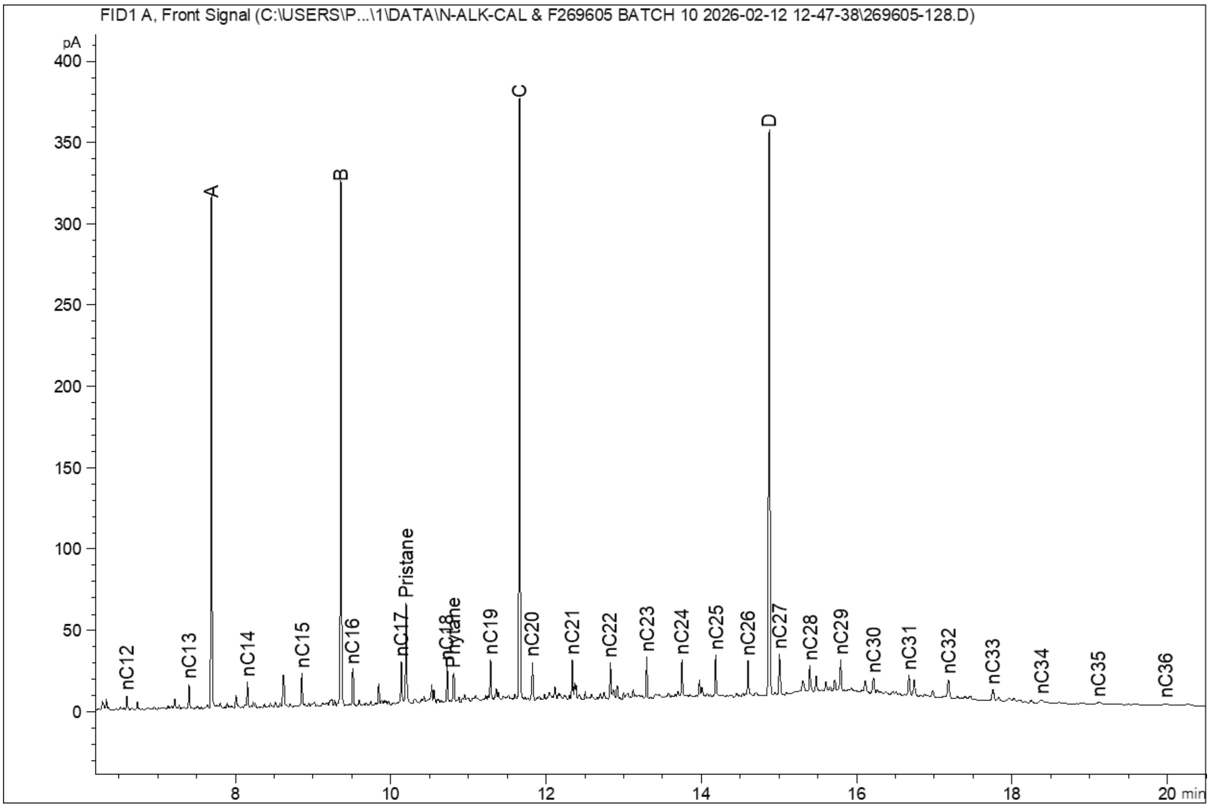
ST03


FID1 A, Front Signal (C:\USERS\P...\1\DATA\N-ALK-CAL & F269605 BATCH 10 2026-02-12 12-47-38\269605-126.D)
pA
A
B
C
D
nC12
nC13
nC14
nC15
nC16
nC17
Pristane
nC18
Phytane
nC19
nC20
nC21
nC22
nC23
nC24
nC25
nC26
nC27
nC28
nC29
nC30
nC31
nC32
nC33
nC34
nC35
nC36
min

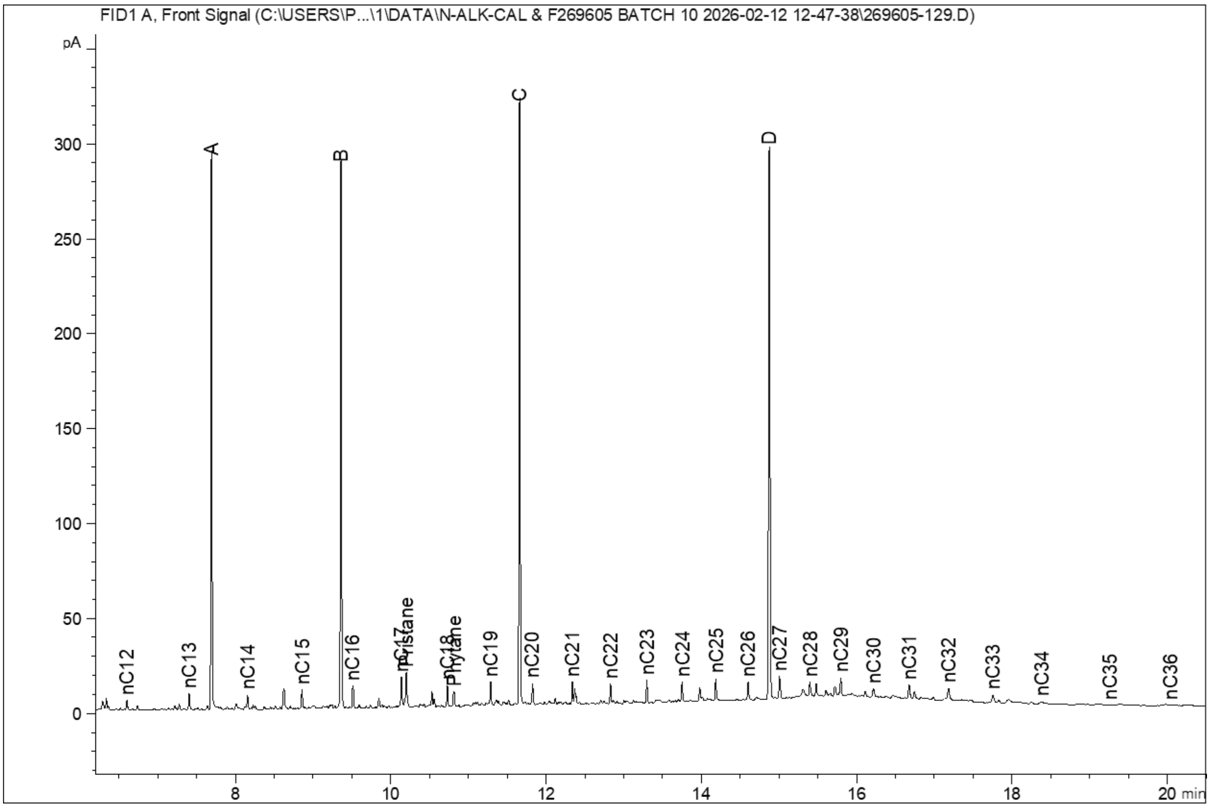
ST04A


FID1 A, Front Signal (C:\USERS\P...\1\DATA\N-ALK-CAL & F269605 BATCH 10 2026-02-12 12-47-38\269605-127.D)
pA
400
350
300
250
200
150
100
50
0
A
B
C
D
nC12
nC13
nC14
nC15
nC16
nC17
Pristane
nC18
Phytane
nC19
nC20
nC21
nC22
nC23
nC24
nC25
nC26
nC27
nC28
nC29
nC30
nC31
nC32
nC33
nC34
nC35
nC36
8
10
12
14
16
18
20 min

ST05A


FID1 A, Front Signal (C:\USERS\P...\1\DATA\N-ALK-CAL & F269605 BATCH 10 2026-02-12 12-47-38\269605-128.D)
pA
400
350
300
250
200
150
100
50
0
A
B
C
D
nC12
nC13
nC14
nC15
nC16
nC17
Pristane
nC18
Phytane
nC19
nC20
nC21
nC22
nC23
nC24
nC25
nC26
nC27
nC28
nC29
nC30
nC31
nC32
nC33
nC34
nC35
nC36
8
10
12
14
16
18
20 min

ST06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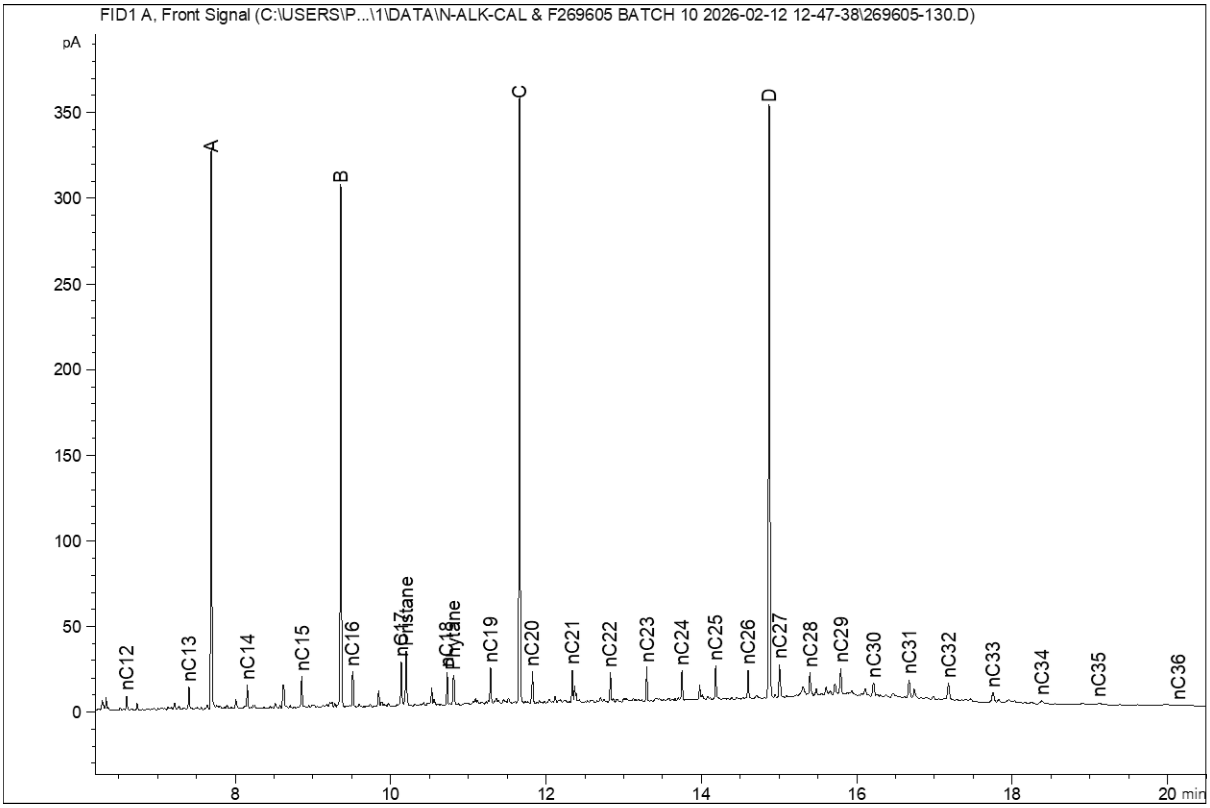
pA
A
B
C
D
nC12
nC13
nC14
nC15
nC16
nC17
Pristane
nC18
Phytane
nC19
nC20
nC21
nC22
nC23
nC24
nC25
nC26
nC27
nC28
nC29
nC30
nC31
nC32
nC33
nC34
nC35
nC36
min

ST07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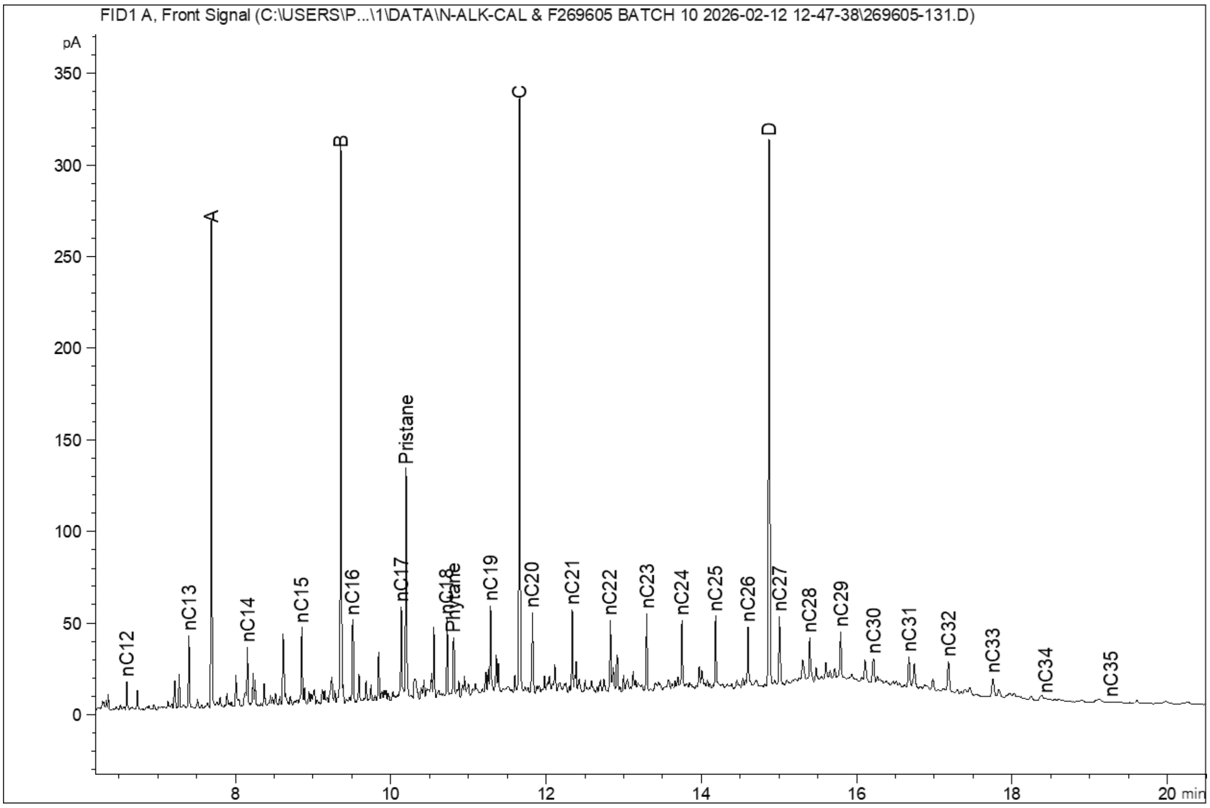
pA
A
B
C
D
nC12
nC13
nC14
nC15
nC16
nC17
Pristane
nC18
Phytane
nC19
nC20
nC21
nC22
nC23
nC24
nC25
nC26
nC27
nC28
nC29
nC30
nC31
nC32
nC33
nC34
nC35
nC36
min

ST08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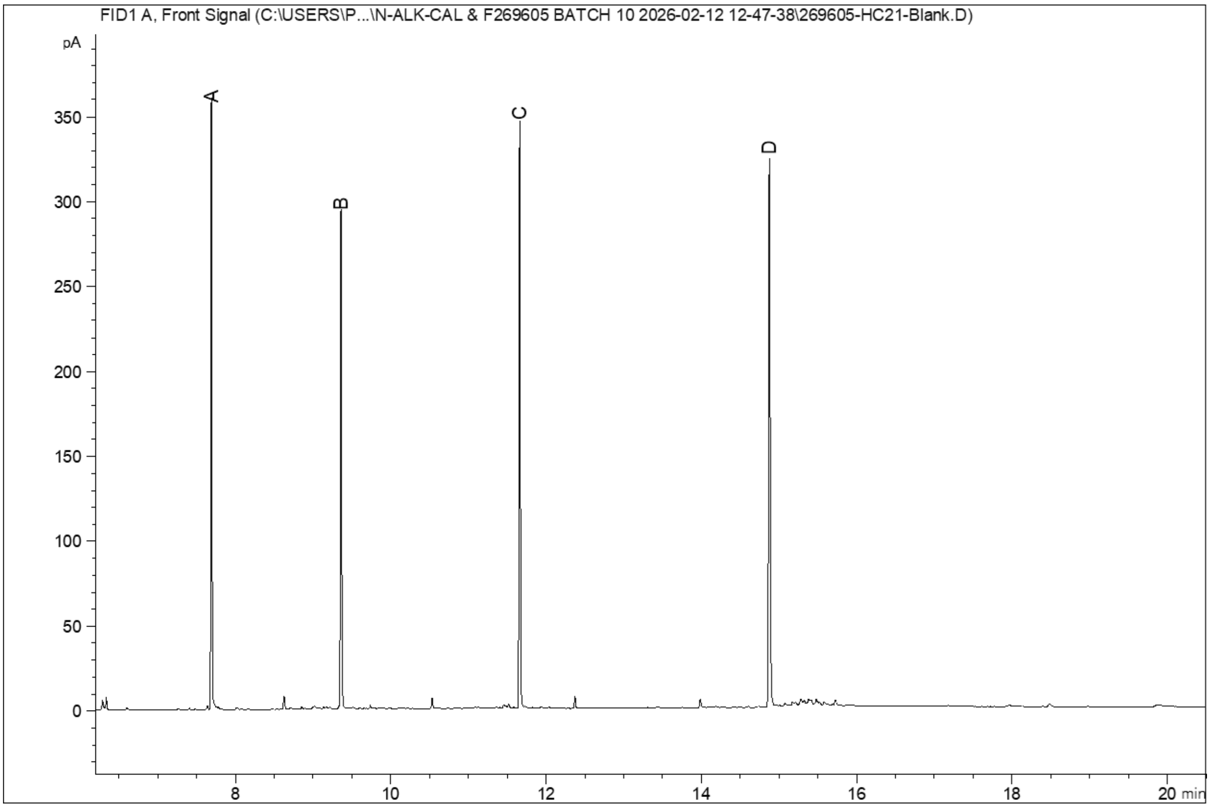
pA
350
300
250
200
150
100
50
0
A
B
C
D
Pristane
Phytane
nC12
nC13
nC14
nC15
nC16
nC17
nC18
nC19
nC20
nC21
nC22
nC23
nC24
nC25
nC26
nC27
nC28
nC29
nC30
nC31
nC32
nC33
nC34
nC35
8
10
12
14
16
18
20 min

ST09A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pA
350
300
250
200
150
100
50
0
A
B
C
D
8
10
12
14
16
18
20 min

Blank

E.2 Sediment n-Alkane Concentrations

n-Alkane [ng/g]	Station								
	ST01	ST02	ST03	ST04A	ST05A	ST06	ST07	ST08	ST09A
nC_{12}	1.2	1.5	1.9	2.3	3.6	5.0	3.7	5.5	10.9
nC_{13}	1.5	1.9	2.6	2.7	6.2	8.9	6.8	8.9	27.1
nC_{14}	1.8	2.0	3.5	2.9	5.8	10.2	5.7	9.3	21.6
nC_{15}	3.0	3.1	5.3	4.3	6.8	12.7	7.6	13.6	31.9
nC_{16}	3.4	3.3	6.0	4.0	8.1	14.9	9.1	14.0	32.1
nC_{17}	4.5	4.0	7.2	5.3	9.4	14.7	11.6	17.3	33.4
nC_{18}	4.2	4.4	7.8	4.3	7.6	13.2	8.1	11.9	26.6
nC_{19}	5.0	5.6	9.0	5.1	8.6	15.5	8.7	14.6	32.5
nC_{20}	4.9	5.2	9.4	5.0	8.4	14.8	8.2	12.6	31.8
nC_{21}	4.8	5.0	9.9	5.3	7.0	11.9	7.8	10.7	28.2
nC_{22}	5.2	5.9	10.9	5.0	7.3	11.9	7.3	9.8	25.9
nC_{23}	5.5	6.5	12.4	5.9	8.4	13.6	7.8	11.3	28.2
nC_{24}	5.0	6.6	11.3	5.0	7.5	11.9	6.7	10.1	26.7
nC_{25}	5.6	7.8	12.6	6.0	8.4	14.4	8.1	11.2	28.4
nC_{26}	4.8	6.7	11.0	4.9	7.0	11.7	6.8	9.6	22.8
nC_{27}	5.0	7.3	11.9	6.1	8.9	14.6	8.0	12.1	26.8
nC_{28}	3.8	5.2	8.8	4.4	5.7	9.6	5.4	7.9	18.7
nC_{29}	4.5	5.4	8.7	5.0	7.2	11.5	7.8	11.4	19.8
nC_{30}	2.4	3.4	5.4	2.8	4.2	6.8	3.9	6.0	12.6
nC_{31}	3.3	4.2	6.2	4.9	6.3	9.2	6.8	9.8	15.4
nC_{32}	3.3	3.3	6.1	3.8	6.4	9.6	6.9	8.8	17.8
nC_{33}	2.1	2.9	3.7	3.1	4.2	6.7	5.0	6.2	14.1
nC_{34}	1.2	1.4	1.3	0.8	1.1	1.6	1.3	1.4	2.3
nC_{35}	0.7	0.6	0.9	0.8	0.6	1.3	0.8	1.1	1.3
nC_{36}	0.6	0.5	0.6	0.5	0.5	0.9	0.6	0.9	1.1
Total Alkane (µg/g)	**0.087**	**0.104**	**0.175**	**0.100**	**0.155**	**0.257**	**0.160**	**0.236**	**0.538**
Pristane	**3.2**	**3.5**	**4.7**	**7.9**	**19.0**	**41.1**	**16.1**	**25.3**	**94.8**
Phytane	**1.4**	**1.3**	**2.5**	**3.0**	**6.1**	**11.8**	**7.1**	**13.1**	**23.6**

Notes
Concentrations expressed as ng/g dry sediment
Total n-alkane concentrations expressed as µg/g of dry sediment

E.3 Sediment Aromatic Hydrocarbon Concentrations

E.3.1 Total 2 to 6 Ring Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

PAH [ng/g]	Station								
	ST01	ST02	ST03	ST04A	ST05A	ST06	ST07	ST08	ST09A
Naphthalene (128)	0.1	0.2	0.1	0.2	1.0	0.7	1.0	0.5	5.7
C1 128	0.3	0.5	0.3	0.7	3.2	2.8	3.5	2.2	29.6
C2 128	0.5	0.8	0.5	1.3	6.7	6.1	4.9	3.7	41.8
C3 128	0.7	1.0	0.6	1.8	8.8	9.7	5.2	4.3	51.0
C4 128	0.5	0.8	0.5	1.8	6.4	8.0	3.4	3.5	36.2
TOTAL 128	**2.1**	**3.3**	**2.0**	**5.8**	**26.1**	**27.3**	**18.0**	**14.2**	**164**
Phenanthrene/anthracene (178)	0.3	0.4	0.3	0.8	3.4	4.3	2.5	2.1	23.8
C1 178	0.5	0.8	0.5	1.4	5.6	8.5	4.0	3.5	37.5
C2 178	0.6	1.1	0.7	2.0	7.5	12.2	5.1	5.2	39.7
C3 178	0.5	1.0	0.6	1.5	4.5	8.1	3.2	3.6	25.1
TOTAL 178	**1.9**	**3.3**	**2.1**	**5.7**	**21.0**	**33.1**	**14.8**	**14.4**	**126**
Dibenzothiophene (DBT)	< 0.1	< 0.1	< 0.1	0.1	0.2	0.3	0.2	0.2	1.2
C1 184	0.1	0.1	0.1	0.2	0.5	0.7	0.3	0.4	2.6
C2 184	0.1	0.1	0.1	0.2	0.6	0.9	0.5	0.5	2.8
C3 184	0.1	0.1	0.1	0.2	0.4	0.7	0.3	0.4	1.7
TOTAL 184	**< 0.4**	**< 0.4**	**< 0.4**	**0.7**	**1.7**	**2.6**	**1.3**	**1.5**	**8.3**
Fluoranthene/pyrene (202)	0.7	0.7	0.7	1.6	5.4	7.5	3.7	4.4	17.4
C1 202	0.4	0.6	0.4	1.1	3.6	6.8	2.8	2.8	17.8
C2 202	0.3	0.4	0.3	0.9	2.7	5.0	2.1	2.2	13.7
C3 202	0.2	0.3	0.2	0.5	1.5	2.5	1.2	1.3	7.2
TOTAL 202	**1.6**	**2.0**	**1.6**	**4.1**	**13.2**	**21.8**	**9.8**	**10.7**	**56.1**
Benzanthracenes/benzphenanthrenes (228)	0.7	0.7	0.7	1.3	4.1	6.2	3.1	3.1	14.8
C1 228	0.4	0.4	0.3	0.8	2.3	3.8	1.8	1.9	9.9
C2 228	0.4	0.5	0.4	0.9	2.4	3.8	2.0	2.2	10.7
TOTAL 228	**1.5**	**1.6**	**1.4**	**3.0**	**8.8**	**13.8**	**6.9**	**7.2**	**35.4**
m/z 252	1.2	1.3	1.2	2.1	5.0	6.6	4.2	4.9	14.0
C1 252	0.3	0.4	0.3	0.6	1.6	2.3	1.4	1.5	5.8
C2 252	0.1	0.2	0.2	0.3	0.8	1.0	0.6	0.7	3.0
TOTAL 252	**1.6**	**1.9**	**1.7**	**3.0**	**7.4**	**9.9**	**6.2**	**7.1**	**22.8**
m/z 276	0.6	0.7	0.6	1.1	2.5	3.4	2.0	2.5	6.6
C1 276	0.1	0.2	0.2	0.3	0.8	1.0	0.6	0.8	2.4
C2 276	0.1	0.2	0.2	0.2	0.5	0.7	0.5	0.5	1.6
TOTAL 276	0.8	1.1	1.0	1.6	3.8	5.1	3.1	3.8	10.6
NPD	< 4.4	< 7.0	< 4.5	12.2	48.8	63.0	34.1	30.1	299
% NPD	< 45	< 52	< 45	51	60	55	57	51	71
Total 2 to 6 Ring PAH	< 9.9	< 13.6	< 10.2	23.9	82.0	114	60.1	58.9	424

Notes
Concentrations expressed as ng/g dry sediment
m/z 252 = Benzfluoranthenes/benzpyrenes/perylene
m/z 276 = Anthanthrene/indenopyrenes/benzperylenes
NPD = Total of all naphthalenes, phenanthrenes and dibenzothiophenes

E.3.2 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

PAH [ng/g]	Station									
	ST01	ST02	ST03	ST04A	ST05A	ST06	ST07	ST08	ST09A	CEMP Assessment Criteria (OSPAR, 2014) ERL
Naphthalene	0.1	0.2	0.1	0.2	1.0	0.7	1.0	0.5	5.7	**160**
Acenaphthylene	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	0.1	-
Acenaphthene	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	0.1	0.6	-
Fluorene	0.1	0.1	< 0.1	0.1	0.3	0.3	0.3	0.3	1.5	-
Phenanthrene	0.3	0.4	0.3	0.7	3.0	3.9	2.3	1.9	22.2	**240**
Anthracene	< 0.1	< 0.1	< 0.1	0.1	0.4	0.4	0.2	0.2	1.6	**85**
Fluoranthene	0.3	0.3	0.3	0.7	2.6	3.5	1.7	2.0	7.9	**600**
Pyrene	0.4	0.4	0.4	0.9	2.8	4.0	2.0	2.4	9.5	**665**
Benzo(a)anthracene	0.2	0.2	0.2	0.4	1.4	1.7	0.8	0.8	4.4	**261**
Chrysene	0.2	0.3	0.2	0.5	1.4	2.1	1.0	1.0	4.6	**384**
Benzo(b)fluoranthene	0.5	0.5	0.5	0.7	1.6	2.2	1.3	1.6	4.5	-
Benzo(k)fluoranthene	0.1	0.1	0.1	0.2	0.4	0.5	0.3	0.4	0.9	-
Benzo(a)pyrene	0.1	0.2	0.1	0.3	1.0	1.1	0.6	0.6	2.4	**430**
Indeno(123cd)pyrene	0.2	0.2	0.2	0.3	0.7	0.8	0.6	0.6	1.5	**240**
Benzo(ghi)perylene	0.3	0.3	0.3	0.6	1.3	1.9	1.1	1.3	3.7	**85**
Dibenzo(ah)anthracene	0.1	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.6	-
Total EPA 16	**< 3.2**	**< 3.6**	**< 3.2**	**< 6.0**	**18.3**	**< 23.6**	**< 13.6**	**< 14.0**	**71.7**	-

Notes
Concentrations expressed as ng/g dry sediment
PAH = Polycyclic aromatic hydrocarbon
EPA 16 = (United States) Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbons
CEMP = Coordinated environmental monitoring programme
OSPAR = Oslo and Paris Commission
ERL = Effects range low

E.3.3 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations Normalised to 2.5 % Total Organic Carbon (TOC)

PAH [ng/g]	Stations									CEMP Assessment Criteria (OSPAR, 2014)	
	ST01	ST02	ST03	ST04A	ST05A	ST06	ST07	ST08	ST09A	BC	BAC
Naphthalene	0.5	2.3	3.6	12.5	27.8	14.6	50.0	11.4	102	5	8
Acenaphthylene	-	-	-	-	2.8	-	-	-	1.8	-	-
Acenaphthene	-	-	-	-	2.8	2.1	5.0	2.3	10.7	-	-
Fluorene	0.5	1.1	-	6.3	8.3	6.3	15.0	6.8	26.8	-	-
Phenanthrene	1.4	4.5	10.7	43.8	83.3	81.3	115	43.2	396	17	32
Anthracene	-	-	-	6.3	11.1	8.3	10.0	4.5	28.6	3	5
Fluoranthene	1.4	3.4	10.7	43.8	72.2	72.9	85.0	45.5	141	20	39
Pyrene	1.9	4.5	14.3	56.3	77.8	83.3	100	54.5	170	13	24
Benzo(a)anthracene	0.9	2.3	7.1	25.0	38.9	35.4	40.0	18.2	78.6	9	16
Chrysene	0.9	3.4	7.1	31.3	38.9	43.8	50.0	22.7	82.1	11	20
Benzo(b)fluoranthene	2.3	5.7	17.9	43.8	44.4	45.8	65.0	36.4	80.4	-	-
Benzo(k)fluoranthene	0.5	1.1	3.6	12.5	11.1	10.4	15.0	9.1	16.1	-	-
Benzo(a)pyrene	0.5	2.3	3.6	18.8	27.8	22.9	30.0	13.6	42.9	15	30
Indeno(1,2,3-cd)pyrene	0.9	2.3	7.1	18.8	19.4	16.7	30.0	13.6	26.8	50	103
Benzo(ghi)perylene	1.4	3.4	10.7	37.5	36.1	39.6	55.0	29.5	66.1	45	80
Dibenzo(a,h)anthracene	0.5	1.1	3.6	6.3	5.6	6.3	10.0	4.5	10.7	-	-
Total US EPA 16	**13.4**	**37.5**	**100**	**363**	**508**	**490**	**675**	**316**	**1280**	-	-

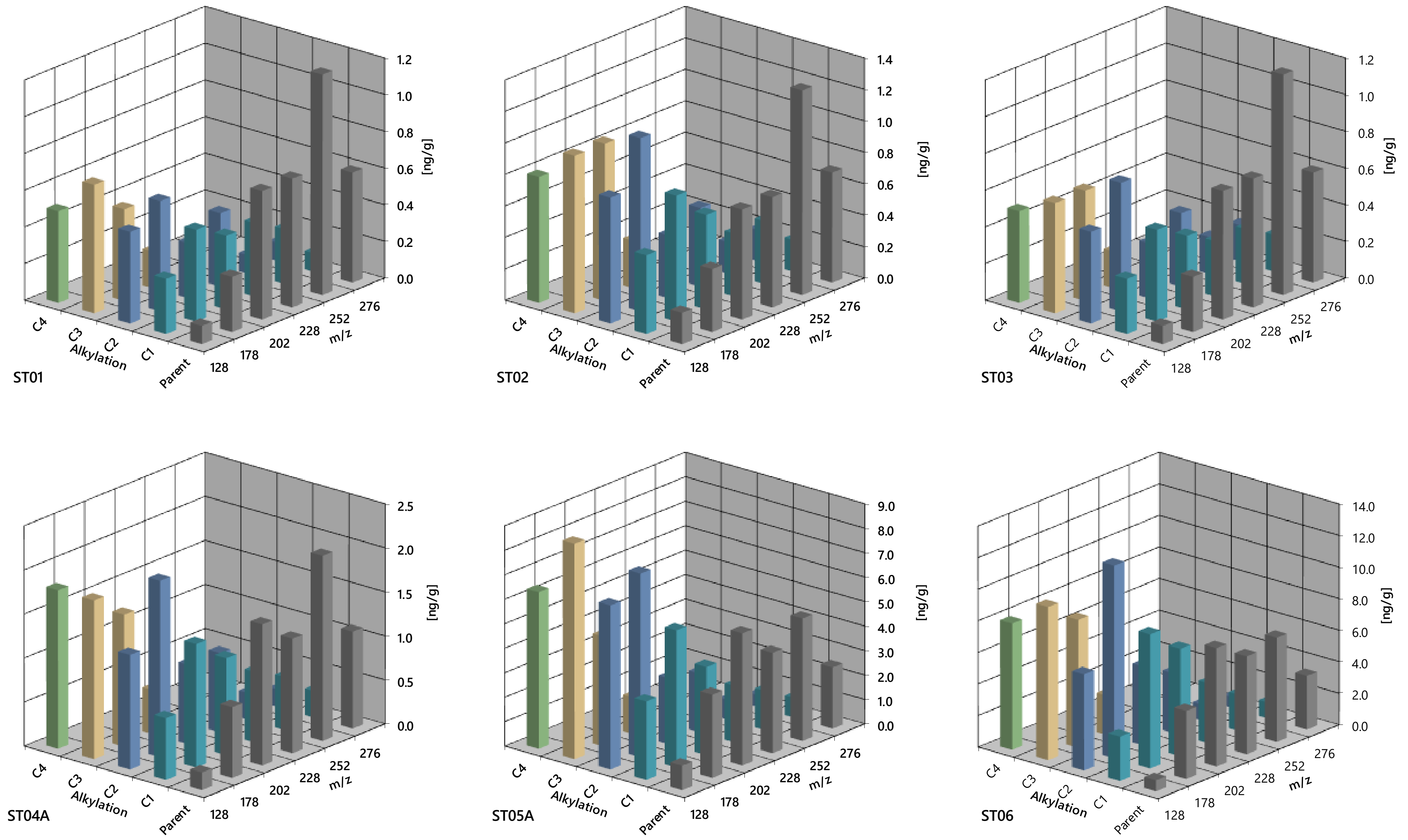
Notes
Concentrations expressed as ng/g dry sediment
PAH = Polycyclic aromatic hydrocarbon
CEMP = Coordinated environmental monitoring programme
OSPAR = Oslo and Paris Commission
BC = Background concentration
BAC = Background assessment concentration
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbons

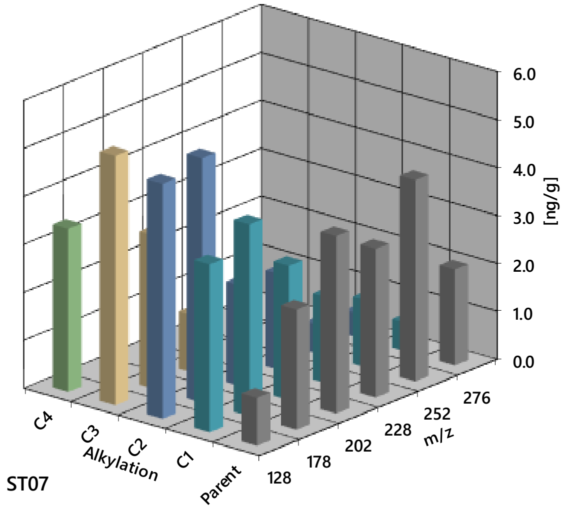
Key:	Below BC	Above BC	Above BAC

E.4 Distribution of Aromatic Compounds

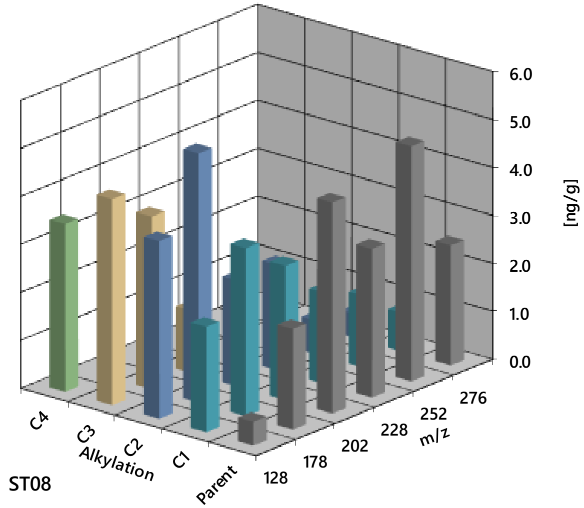
The layout of the three-dimensional plots are as follows:

- 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).

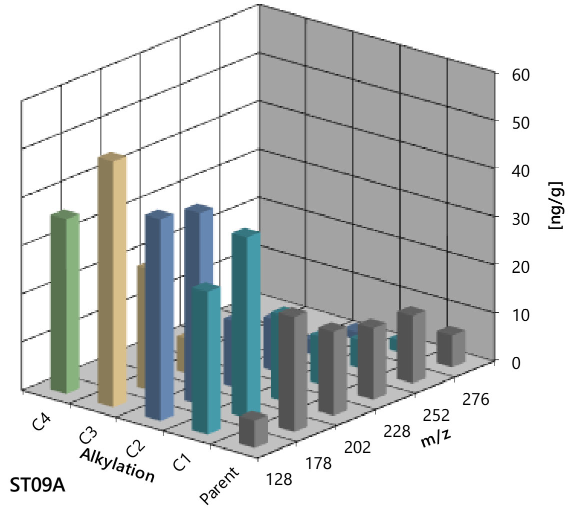

ST01
C4
C3
C2
C1
Parent
Alkylation
128
178
202
228
252
276
m/z
0.0
0.2
0.4
0.6
0.8
1.0
1.2
[ng/g]
ST02
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
ST03
ST04A
0.0
0.5
1.0
1.5
2.0
2.5
ST05A
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
ST06
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0



6.0
5.0
4.0
3.0
2.0
1.0
0.0
[ng/g]
C4
C3
C2
C1
Parent
Alkylation
128
178
202
228
252
276
m/z
ST07



6.0
5.0
4.0
3.0
2.0
1.0
0.0
[ng/g]
C4
C3
C2
C1
Parent
Alkylation
128
178
202
228
252
276
m/z
ST08



60
50
40
30
20
10
0
[ng/g]
C4
C3
C2
C1
Parent
Alkylation
128
178
202
228
252
276
m/z
ST09A

Appendix F

Macrofaunal Analysis

F.1 Macrofaunal Abundance Data

Taxon	Qualifier	SDC	AphiaID	Authority	ST01	ST02	ST03	ST04A	ST05A	ST06	ST07	ST08	ST09A	Total
					ABIOTIC	ABIOTIC	ABIOTIC		ABIOTIC		ABIOTIC		ABIOTIC	
					Sample									
PLATYHELMINTHES														
PLATYHELMINTHES		F0001	793	Minot, 1876						2				2
ARTHROPODA														
Pontocrates arenarius		S0135	102918	(Spence Bate, 1858)				1		1		1		3
Eurydice pulchra		S0854	118852	Leach, 1816				1						1
Taxa					0	0	0	2	0	2	0	1	0	3
Abundance					0	0	0	2	0	3	0	1	0	6

Notes
SDC = Species Directory Code

F.2 Macrofaunal Abundance Analysis Certificate

Click on icon to open Macrofaunal Abundance Analysis Certificate

F.2 F269605
National Grid EGL5_

F.3 Macrofaunal Biomass Data

Taxon	SDC	AphiaID	Authority	ST01	ST02	ST03	ST04A	ST05A	ST06	ST07	ST08	ST09A	Total [g]
				ABIOTIC	ABIOTIC	ABIOTIC		ABIOTIC		ABIOTIC		ABIOTIC	
				Sample									
CNIDARIA	D0001	1267	Hatschek, 1888	-	-	-		-		-		-	0
ANNELIDA	P0001	882	Lamarck, 1802	-	-	-		-		-		-	0
ARTHROPODA	Q0000	1065	Gravenhorst, 1843	-	-	-	0.0057	-	0.0005	-	0.0001	-	0.0063
MOLLUSCA	W0001	51	-	-	-	-		-		-		-	0
ECHINODERMATA	ZB0001	1806	Klein, 1778	-	-	-		-		-		-	0
CHORDATA	ZD0000	1821	Haeckel, 1874	-	-	-		-		-		-	0
OTHERS	-	-	-	-	-	-		-	0.0004	-		-	0.0004
Total Biomass blotted wet weight (g)				0.0000	0.0000	0.0000	0.0057	0.0000	0.0009	0.0000	0.0001	0.0000	0.0067

Notes
Others = Platyhelminthes

F.4 Macrofaunal Biomass Analysis Certificate

Click on icon to open Macrofaunal Biomass Analysis Certificate

F.4 F269605
National Grid EGL5_

Appendix G

Sediment Environmental DNA (eDNA)

G.1 Marine Sediment Sample eDNA – Invertebrates

Click on icon to open the laboratory analysis results.

Appendix G.1
Invertebrates eDNA.xl

G.2 Marine Sediment Sample eDNA - Eukaryotes

Click on icon to open the laboratory analysis results.

Appendix G.2
Eukaryote eDNA.xlsx

G.3 Marine Sediment Sample eDNA - Bacteria

Click on icon to open the laboratory analysis results.

Appendix G.3
Bacteria eDNA.xlsx

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Appendix H

Correlations

H.1 Correlation Matrix

	Gravel	Sand	TOM	TOC	THC	UCM	n-alkanes	CPI	Pr/Ph Ratio	Total 2 to 6 Ring PAH	Al	As	Ba	Cd	Cr	Cu	Fe	Mn	Ni	P	Pb	Sr	V	Zn	Taxa	Individuals
Sand	-1.000																									
TOM	-0.059	0.059																								
TOC	-0.383	0.383	0.201																							
THC	0.373	-0.373	-0.238	-0.051																						
UCM	0.409	-0.409	-0.227	0.096	0.974																					
n-alkanes	0.723	-0.723	-0.030	-0.042	0.812	0.851																				
CPI	0.126	-0.126	-0.426	-0.471	0.521	0.369	0.144																			
Pr/Ph Ratio	-0.283	0.283	0.109	0.367	0.492	0.470	0.277	0.042																		
Total 2 to 6 Ring PAH	0.317	-0.317	-0.234	-0.100	0.915	0.888	0.740	0.420	0.683																	
Al	-0.417	0.417	0.711	0.550	-0.542	-0.426	-0.370	-0.723	-0.033	-0.517																
As	-0.100	0.100	0.728	0.300	-0.644	-0.531	-0.345	-0.731	-0.200	-0.550	0.883															
Ba	-0.167	0.167	0.427	0.067	0.068	0.044	-0.126	0.353	0.083	0.033	0.350	0.283														
Cd	-0.168	0.168	0.458	0.317	-0.853	-0.759	-0.583	-0.554	-0.466	-0.839	0.727	0.839	0.224													
Cr	0.017	-0.017	0.510	0.267	-0.661	-0.522	-0.361	-0.630	-0.450	-0.633	0.783	0.933	0.283	0.894												
Cu	0.109	-0.109	0.668	0.527	-0.187	-0.048	0.013	-0.422	-0.092	-0.251	0.728	0.778	0.527	0.646	0.795											
Fe	-0.067	0.067	0.259	0.050	-0.831	-0.749	-0.571	-0.445	-0.783	-0.900	0.583	0.700	0.133	0.894	0.850	0.477										
Mn	-0.025	0.025	0.555	0.234	-0.689	-0.564	-0.401	-0.633	-0.427	-0.644	0.803	0.954	0.301	0.898	0.996	0.777	0.845									
Ni	0.050	-0.050	0.603	0.350	-0.610	-0.470	-0.286	-0.647	-0.350	-0.583	0.800	0.950	0.300	0.894	0.983	0.862	0.783	0.979								
P	-0.383	0.383	0.335	0.267	-0.881	-0.801	-0.765	-0.580	-0.300	-0.750	0.700	0.817	0.150	0.894	0.833	0.494	0.783	0.854	0.800							
Pb	0.390	-0.390	0.630	0.203	-0.138	-0.018	0.171	-0.368	-0.407	-0.288	0.576	0.695	0.390	0.550	0.763	0.885	0.559	0.740	0.797	0.322						
Sr	-0.200	0.200	0.603	0.617	-0.525	-0.409	-0.160	-0.815	0.150	-0.417	0.767	0.733	-0.033	0.671	0.583	0.536	0.383	0.594	0.667	0.567	0.339					
V	-0.059	0.059	0.319	0.075	-0.800	-0.717	-0.536	-0.439	-0.770	-0.887	0.619	0.720	0.192	0.898	0.862	0.529	0.996	0.857	0.803	0.762	0.613	0.402				
Zn	-0.133	0.133	0.544	0.333	-0.644	-0.531	-0.437	-0.496	-0.517	-0.733	0.817	0.850	0.417	0.894	0.933	0.803	0.883	0.929	0.917	0.767	0.780	0.517	0.912			
Taxa	-0.090	0.090	-0.330	-0.299	0.344	0.198	0.191	0.447	0.090	0.199	-0.578	-0.777	-0.369	-0.635	-0.837	-0.770	-0.498	-0.825	-0.837	-0.707	-0.608	-0.408	-0.500	-0.667		
Individuals	-0.079	0.079	-0.353	-0.248	0.383	0.253	0.245	0.394	0.119	0.238	-0.564	-0.782	-0.416	-0.664	-0.842	-0.766	-0.525	-0.835	-0.842	-0.733	-0.604	-0.386	-0.527	-0.683	0.994	
Biomass	-0.099	0.099	-0.303	-0.347	0.302	0.140	0.135	0.494	0.059	0.158	-0.584	-0.762	-0.317	-0.598	-0.822	-0.766	-0.465	-0.805	-0.822	-0.673	-0.604	-0.426	-0.467	-0.644	0.994	0.976

Notes

Correlations based on n = 9 (Fowler et al., 2013)[1]

Significance:
- $P < 0.05$ at $0.683 \le rs \le 0.833$
- $P < 0.01$ at $rs \ge 0.833$
- $P < 0.05$ at $-0.683 \ge rs \ge -0.833$
- $P < 0.01$ at $rs \le -0.833$
- Not significant ($-0.683 \le rs \ge 0.683$)

[1] Fowler, J., Cohen, L. and Jarvis, P. (2013). Practical Statistics for Field Biology. John Wiley & Sons.

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