The Great Grid Upgrade

Sea Link

Sea Link

Volume 6: Environmental Statement

Document: 6.3.4.2.A
Part 4 Marine
Chapter 2 Appendix 4.2.A
Benthic Characterisation Report (Original Report)

Planning Inspectorate Reference: EN020026

Version: A
March 2025

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 Regulation 5(2)(a)

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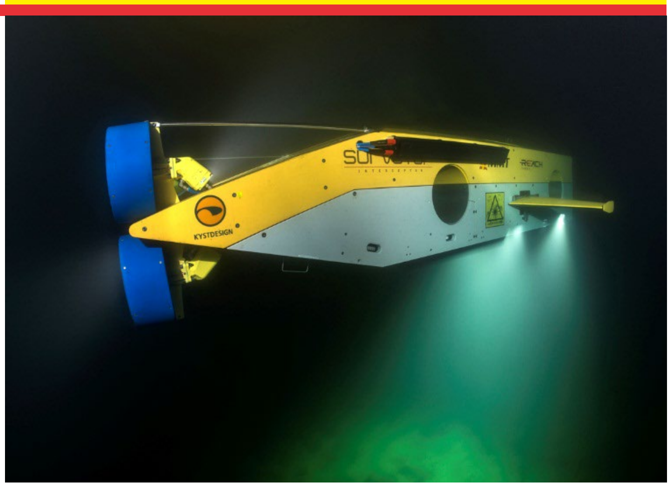
ENVIRONMENTAL SURVEY REPORT

103748-NAT-MMT-SUR-REP-ENVSURRE
REVISION B | ISSUE FOR USE
APRIL 2022



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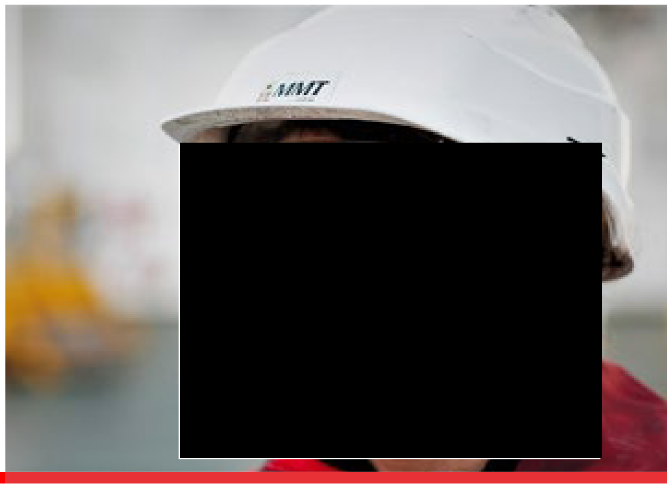

SOUTH EAST ANGLIA LINK MARINE SURVEY

GEOPHYSICAL & ENVIRONMENTAL SURVEY

ENGLAND - SE COAST

SEPTEMBER - OCTOBER 2021

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REVISION HISTORY

REVISION	DATE	STATUS	CHECK	APPROVAL	CLIENT APPROVAL
B	2022-04-13	Issue for Use	RK	MG	
A	2022-04-05	Issue for Use	RK	MG	
03	2022-03-04	Issue for Client Review	ID	MG	
02	2021-12-17	Issue for Client Review	TE	MG	
01	2021-12-17	Issue for Internal Review	RK		

REVISION LOG

DATE	SECTION	CHANGE
2022-04-12	4.4.3 5.12 Multiple	Brief addition to MESH Confidence Assessment scoring text. Additional Appendix, “Appendix N – MESH Confidence”, included Multiple sub-sections revised in line with Client provided document *NG SEA Link Marine Survey Contractor Comment Sheet - Environmental Report_Marine Ecology_AECOM_April 22* A few figures have been updated with higher resolution versions.
2022-04-05	All	Revision conducted in line with Client provided document *Copy of NG SEA Link Marine Survey Contractor Comment Sheet - Environmental Report_Marine Ecology_Code 3_March 22*
2022-02-28	All	Revision conducted in line with Client provided document *NG SEA Link Marine Survey Contractor Comment Sheet - Environmental Report_Marine Ecology_Code 3*

DOCUMENT CONTROL

RESPONSIBILITY	POSITION	NAME
Content, Check	Environmental Supervisor	[redacted]
Content, Check	Environmental Scientist	[redacted]
Content	Environmental Scientist	[redacted]
Content	Environmental Scientist	[redacted]
Content	Environmental Scientist	[redacted]
Check	Reporting Quality Controller	[redacted]
Check	Report Coordinator	[redacted]
Check	Project Manager	[redacted]

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ABBREVIATIONS AND DEFINITIONS

BAP	Biodiversity Action Plan
Cc	Coefficient of Curvature
CCME	Canadian Council of Ministers of the Environment
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CPT	Cone Penetration Test
CTD	Oceanographic instrument – Conductivity, Temperature, Depth
Cu	Uniformity Coefficient
DDV	Drop Down Video
DP	Dynamic Positioning
DPR	Daily Progress Report
DVV	Dual Van Veen grab
EAC	Environmental Assessment Criteria
EC	European Commission
EPA	United States Environmental Protection Agency
EQS	Environmental Quality Standards
ERL	Effect Range-Low
ETRS 89	European Terrestrial Reference System 1989
EUNIS	European Union Nature Identification System
GC-FID	Gas Chromatography-Flame Ionisation
GC-MS	Gas Chromatography–Mass Spectrometry
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
HD	High Definition
HG	Hamon Grab
HMW	High Molecular Weight
HVDC	High Voltage Direct Current
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
ISQG	Interim Sediment Quality Guidelines
JNCC	Joint Nature Conservation Committee
JUV	Juvenile
KP	Kilometre Post
LAT	Lowest Astronomical Tide
LOD	Limit of Detection
LMW	Low Molecular Weight
M/V	Motor vessel
MAC	Mobilisation and Calibration
MBES	Multibeam Echo Sounder
MCZ	Marine Conservation Zone

BAP	Biodiversity Action Plan
MDS	Multi Dimensional Scaling
MPA	Marine Protected Areas
NDIR	Nondispersive Infrared Sensor
NEA	Norwegian Environment Agency
NERC	Natural Environment and Rural Communities
NMBAQC	National Marine Biological Analytical Quality Control Scheme
nMDS	Non-metric Multidimensional Scaling
OSPAR	Oslo and Paris Conventions for the protection of the East Atlantic marine environment of the North-East Atlantic
PAH	Polycyclic Aromatic Hydrocarbon
PCA	Principle Component Analysis
PEL	Probable Effects Levels
ppb	Part per Million
ppm	Part per Billion
PPS	Pulse Per Second
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSA	Particle Size Analysis
PSU	Practical Salinity Unit
RIVM	Rijksinstituut voor Volksgezondheid en Milieu / The National Institute for Public Health and the Environment
RPL	Route Position List
SAC	Special Areas of Conservation
SBET	Smoothed Best Estimated Trajectory
SIMPROF	Similarity Profile Analysis
SIMPER	Similarity of Percentages
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SSS	Side Scan Sonar
SW	Sizewell
SWO	Sizewell Option
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
UKAS	United Kingdom Accreditation Service
USBL	Ultra-Short Base Line
UTC	Coordinated Universal Time
VC	Vibrocore
VORF	Vertical Offshore Reference Frames

EXECUTIVE SUMMARY

This report details the results of the Environmental survey performed at the east coast of England along the proposed routes of the South East Anglia Link.

Geophysical data was acquired to determine water depth, surficial geology, seabed features, seabed roughness, shallow geology and objects present within the survey area. Instruments used during the geophysical survey were a multibeam echo sounder, side scan sonar and sub-bottom profiler.

The environmental data acquisition comprised sediment sampling and imagery to establish the existing habitats and faunal communities along the survey route. In addition, CTD profiles were also collected at each grab sample site. The Environmental survey was performed using a SeaSpyder HD Drop Down Video System, a Dual Van Veen grab, and Hamon grab for grab sampling, as well as a Valeport Midas SVX2 CTD, all deployed from the survey vessel M/V Nora B.

The geophysical interpretation combined with the environmental data was used as the basis for the EUNIS habitat classifications, assessments of potential areas and species of conservation importance, and the associated charts and GIS products.

A total of five (5) video transects, 105-221 m long, and 37 grab sample sites were selected for sampling. At 34 of the grab sample sites, four (4) sample replicates were collected. Three (3) sample replicates at each grab sample site were collected for faunal analysis and one (1) sample for chemical and particle size analysis. At one site, S028, no grab sampling was performed due to the potential presence of sensitive habitat. At two sites, S007 and S031, only two (2) faunal replicate samples and no physico-chemical samples were acquired.

The environmental survey, excluding grab sample sites S036 and S037, commenced on the 8th of September and was completed on the 16th of September, 2021. Grab sample sites S036 and S037 were surveyed on the 6th of October, 2021.

A total of 26 EUNIS habitats/habitat complexes were identified along the survey routes. One (1) Annex I habitat, **Annex I** (1110) – Sandbanks which are slightly covered by sea water all the time, as well as four (4) Habitats of Principal Importance for the conservation of biodiversity in England under The Natural Environment and Rural Communities Section 41 (NERC S41) list, Peat and Clay Exposures, Subtidal Chalks, Subtidal Sand and Gravels, and Blue Mussel Beds were identified within the survey corridor.

The result from the Particle Size Analysis showed a varying sediment composition along the routes. Sand was the dominant sediment fraction at the majority of the grab sample sites. Sites located in the northern part of the main route, including the alternative landfall option, generally had higher mud and gravel content compared to sites located in the southern part of the main route.

Concentrations of metals varied along the routes but were often elevated. Threshold values for one or several metals were exceeded at all grab sample sites, but for site S004. Total Organic Carbon and organic matter levels varied along the routes. Hydrocarbon concentrations varied along the routes, with Polycyclic Aromatic Hydrocarbons exceeding threshold values at 18 sites.

The faunal analysis showed that the phyletic composition, with regards to both total numbers of taxa and abundance, was dominated by annelids. Species richness, evenness and dominance varied across the grab sample sites and the multivariate analysis identified 33 faunal groups in the SIMPROF test.

Five (5) non-native species were identified during the survey, all already well established in the UK.

The Ross worm *Sabellaria spinulosa* was identified at several grab sampling sites, and aggregations were observed in video transect T004, but these did not classify as reefs. The sediment composition indicates suitable habitats for sand eel and spawning grounds for herring, and sand eels *Ammodytes* sp. were identified at two (2) grab sample sites.

1| INTRODUCTION

1.1| PROJECT INFORMATION AND SURVEY AREA

National Grid Electricity Transmission Plc (NGET) are developing a High Voltage Direct Current (HVDC) electricity transmission link of the east coast of England from Kent to Suffolk and have awarded MMT the marine surveys (seabed surveys) for the proposed South East Anglia Link (SEA Link) HVDC Link.

The HVDC Link will connect Pegwell Bay in Kent to Sizewell in Suffolk. The Sizewell to Pegwell Bay route is circa 118.6 km.

The surveys included both geophysical, geotechnical and environmental components of the offshore cable corridors, the nearshore cable corridors and the cable landfalls. An overview of the survey area, including the main route option (SWO_Rev03_210629) and the alternative landfall route option (SW_S6_210709), are shown in Figure 1.

Table 1 Project details.

CLIENT:	National Grid
PROJECT:	South East Anglia Link (SEAL) marine survey
MMT SWEDEN AB (MMT) PROJECT NUMBER:	103748
SURVEY TYPE:	Geophysical, Environmental & Geotechnical
AREA:	Southern North Sea
SURVEY PERIOD:	August - October 2021
SURVEY VESSEL:	[redacted], Mersey Discovery
MMT PROJECT MANAGER:	[redacted]
CLIENT PROJECT MANAGER:	[redacted]

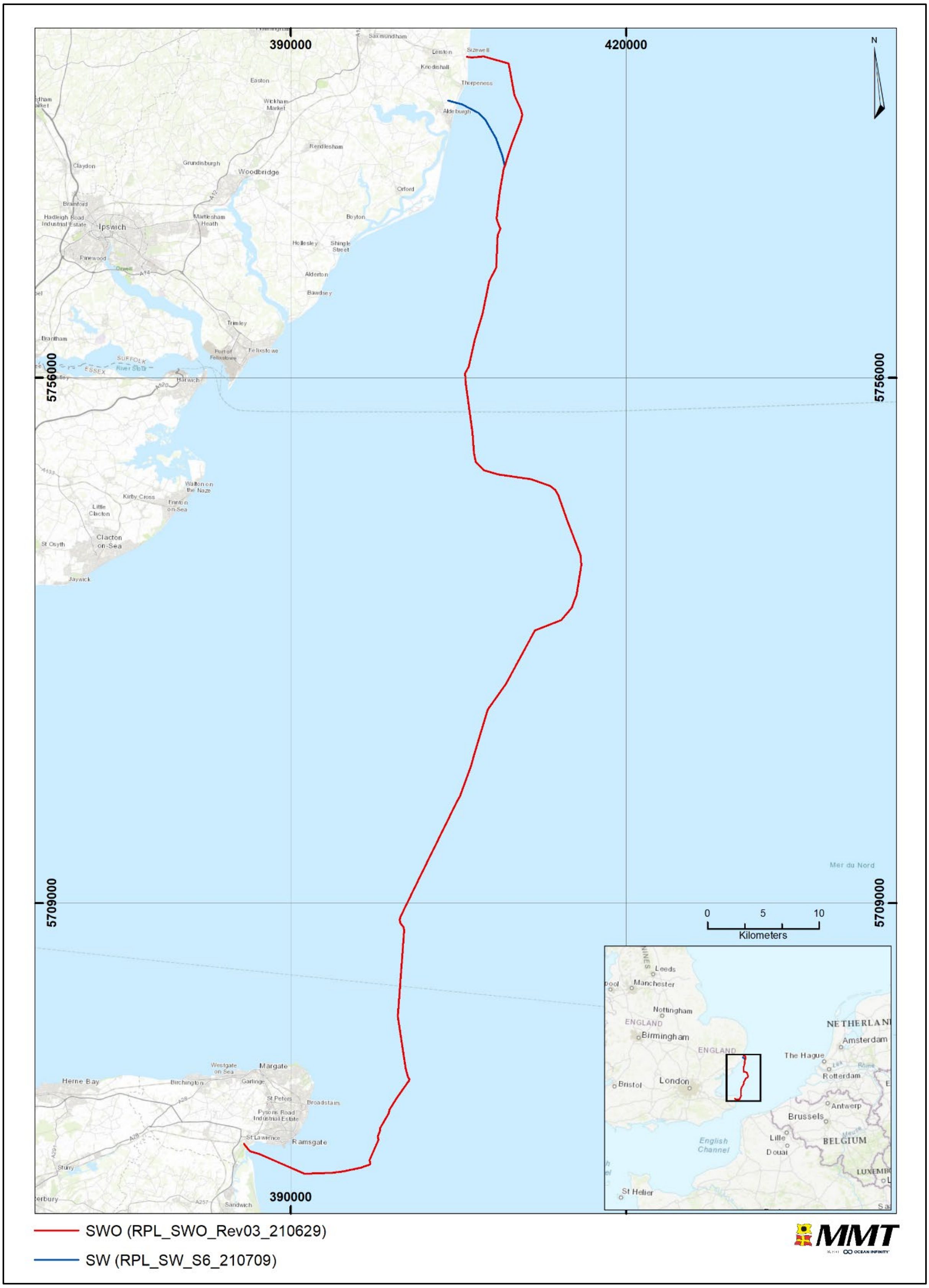


Figure 1 SEAL Survey Route.

1.2| SURVEY INFORMATION

The objective of the SEA Link was to acquire all appropriate data for the confirmation of the preferred route for the high voltage direct current (HVDC) cable, undertaking detailed mapping of shallow geology, seabed features and environmental habitat mapping along the entire route corridor and subsequently provide all geotechnical design data for the whole offshore and nearshore routes.

The Environmental survey comprised grab sampling for faunal and sediment analyses and seabed imagery. In addition, conductivity and temperature were recorded at each grab sample site using a CTD. This report covers the findings of the Environmental Survey.

1.3| SCOPE OF WORK

1.3.1| GEOPHYSICAL OBJECTIVES

The following geophysical survey activities were carried out prior to the environmental survey campaign on survey vessel M/V Franklin and Mersey Discovery:

- Obtain accurate Bathymetric/Topographic (Inc. MBES/UAV) data;
- Obtain accurate high-resolution Side Scan Sonar (SSS) data;
- Obtain accurate high-resolution Sub-Bottom Profiler (SBP) data;
- Obtain high-quality Magnetometer data;
- Obtain high-quality soil samples;
- Obtain high-quality soil Thermal Resistivity data
- Obtain high-quality CPT/VC results;
- Obtain high-quality lab testing results of soil samples;
- Produce full and detailed Survey Reports in accordance with the Technical Specification of the survey;
- Produce a conformant GIS deliverable package in accordance with the Technical Specification of the survey.

1.3.2| ENVIRONMENTAL SURVEY OBJECTIVES

The following environmental survey activities were carried out during the environmental survey campaign on survey vessel M/V Nora B:

- Obtain high-quality Benthic Grab Samples;
- Obtain high-quality Drop Down Video/Stills data;
- Obtain high-quality soil samples;
- Produce full and detailed Survey Reports in accordance with the Technical Specification of the survey;
- Produce a conformant GIS deliverable package in accordance with the Technical Specification of the survey.

The environmental survey was performed using a Drop Down Video system (DDV), a Dual Van Veen (DVV), and Hamon grab (HG) (available in coarse sediment) for grab sampling, all deployed from the survey motor vessel M/V Nora B. The distribution of selected sample sites and designated areas along the survey routes (Figure 2).

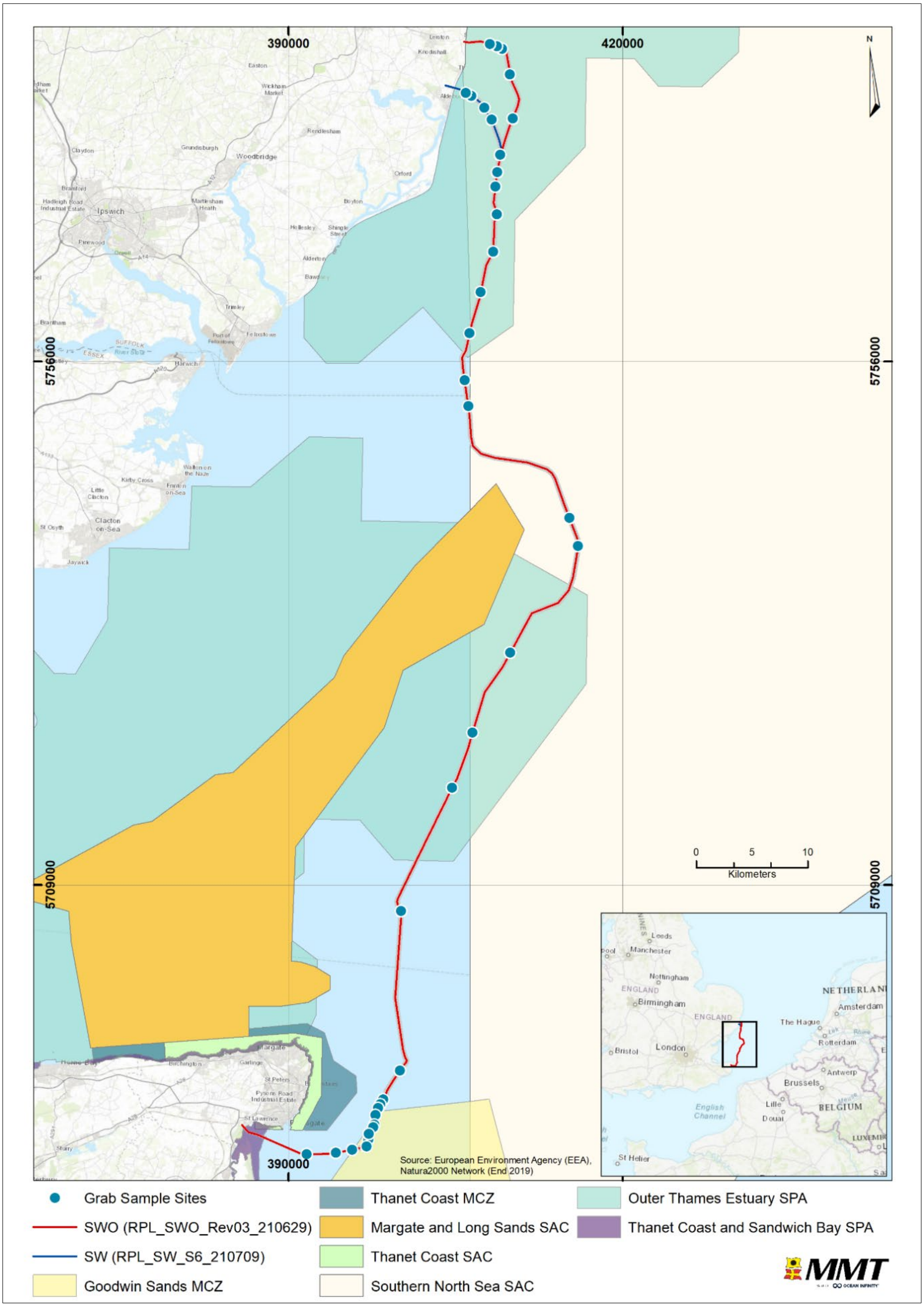


Figure 2 Overview of designated sites and planned grab sample sites.

1.4| PURPOSE OF DOCUMENT

The purpose of this report is to present detailed information on survey performance and processing stages of the work together with the results from the environmental survey.

This report, together with Geographic Information System (GIS) database and charts, presents the environmental survey results.

Areas of special interest along the route corridor and within sites are presented in this report as well as in habitat charts presented in a GIS database. All existing MMT data from the survey corridor is correlated to the environmental survey data to strengthen the accuracy of the interpretations.

It is recommended to read this report in conjunction with the Geophysical report and the Operations Report for a wider understanding of the conditions along the routes.

1.5| REFERENCE DOCUMENTS

The reference documents for the project are presented in Table 2.

Table 2 Reference documents.

DOCUMENT NUMBER	TITLE	AUTHOR
103748-HWL-MMT-QAC-PRO-PROJMANU	Offshore Project Manual	MMT
103748-HWL-MMT-HSE-PRO-HAZOP	Hazard and Operability Study	MMT
103748-HWL-MMT-HSE-PRO-HSEPLAN	HSE Plan	MMT
103748-HWL-MMT-HSE-PRO-ENFFRANKLIN	Emergency Notification Flowchart	MMT
103748-HWL-MMT-HSE-PRO-ENFPULSA	Emergency Notification Flowchart	MMT
103748-HWL-MMT-MAC-REP-FRANKLIN	Mobilisation and Calibration Report	MMT
SEPH Project Execution Plan	Nearshore PEP	SEP
South East Anglia Link (SEAL) Survey Works – Scope of Work, January 2021	Scope of Work	NAT
South East Anglia Link (SEAL) Survey Works – HSE Requirements, December 2020	SEAL specification	NAT
103748-NAT-MMT-MAC-REP-NORAB	Mobilisation and Calibration Report	MMT
103748-NAT-MMT-MAC-REP-NORABGEO	Mobilisation and Calibration Report	MMT
103748-NAT-MMT-MAC-REP-MERSEYDI	Mobilisation and Calibration Report Mersey Discovery	MMT
SEPH-2021-019 Field and Operations Report	Nearshore Operations Report	SEP
103748-NAT-MMT-SUR-REP-OPEREPFR	Offshore Operations Report	MMT
103748-NAT-MMT-SUR-REP-SURVEYRE	Marine Survey Report	MMT
103748-NAT-MMT-MMO-REP-MMOREPFR-02	Marine Mammal Observation and Mitigation Report	MMT

1.5.1| CHART INDEX

The charts produced for the project are presented in Table 3 and Appendix H|.

Table 3 Chart Index.

CHART INDEX	KILOMETRE POST (KP)	AUTHOR
103748-NAT-MMT-SUR-DWG-EN5SW001	0.000 - 8.563	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO001	0.000 - 11.226	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO002	11.026 - 22.430	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO003	22.304 - 33.493	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO004	33.291 - 44.743	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO005	44.543 - 55.946	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO006	55.746 - 67.366	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO007	67.166 - 79.011	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO008	78.811 - 90.881	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO009	90.740 - 102.496	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO010	102.292 - 113.344	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO011	112.871 - 124.474	MMT
103748-NAT-MMT-SUR-DWG-EN5SWO012	124.300 – 127.298	MMT

2| SURVEY PARAMETERS

2.1| GEODETIC DATUM AND GRID COORDINATE SYSTEM

The geodetic and projection reference parameters used during the survey are presented in Table 4 and Table 5.

Table 4 Acquisition Geodetic parameters.

HORIZONTAL DATUM: ITRF2014 WGS84	
Datum	ITRF2014 (WGS84)
EPS Datum Code	9000 (4326)
Spheroid	GRS80
Semi Major Axis	6 378 137.000 m
Semi Minor Axis	6 356 752.3141 m
Inverse Flattening (1/f)	298.257222101
Unit	International metre

Table 5 Geodetic parameters used during processing.

HORIZONTAL DATUM: ETRS89	
Datum	ETRS89
EPS Datum Code	4258
Spheroid	GRS80
Semi-major axis	6 378 137.000 m
Semi-minor axis	6 356 752.3141 m
Inverse Flattening (1/f)	298.257222101
Unit	International metre

2.2| TRANSFORMATION PARAMETERS

The transformation parameters used during the project are presented in Table 6.

Table 6 Transformation parameters.

DATUM SHIFT FROM WGS84 TO ETRS89 (POSITION VECTOR ROTATION)	
PARAMETERS	**EPOCH 2021.5**
Shift dX (m)	0.106650
Shift dY (m)	0.066130
Shift dZ (m)	-0.128730
Rotation rX (“)	-0.00340900
Rotation rY (“)	-0.01406500
Rotation rZ (“)	0.02520700
Scale Factor (ppm)	0.003200

DATUM SHIFT FROM WGS84 TO ETRS89 (POSITION VECTOR ROTATION)	
Rotation Convention	Coordinate Frame Rotation
Direction of Transformation	WGS84 to ETRS89

2.3| PROJECTIONS PARAMETERS

The projection parameters used during the project are presented below in Table 7.

Table 7 Projection parameters.

PROJECTION PARAMETERS (EPSG 25832)	
Geodetic Datum	ETRS89
Zone	UTM31N
Central Meridian	3°E
Latitude origin	0°
False Northing	0m
Central Scale Factor	0.9996
Units	Metres
Time Datum	UTC

2.4| VERTICAL DATUM

Global Navigation Satellite System (GNSS) tide was used to correct the bathymetry data to the defined vertical reference model VORF LAT (Figure 3). The GNSS tide was generated from post-processing of the GNSS data collected by the Applanix PosMV 320 system.

The GNSS data was post-processed using the Applanix software POSPac MMS. POSPac MMS outputs ellipsoidal heights with an accuracy of 0.05 m RMS, corrected for motion and referenced to the MBES reference point. By incorporating the VORF model into the process, the heights were referenced to LAT.

The VORF model was developed by the United Kingdom Hydrographic Office and has accuracy within a decimetre. Comparisons with the closest water level station are performed to ensure that the data is levelled correctly.

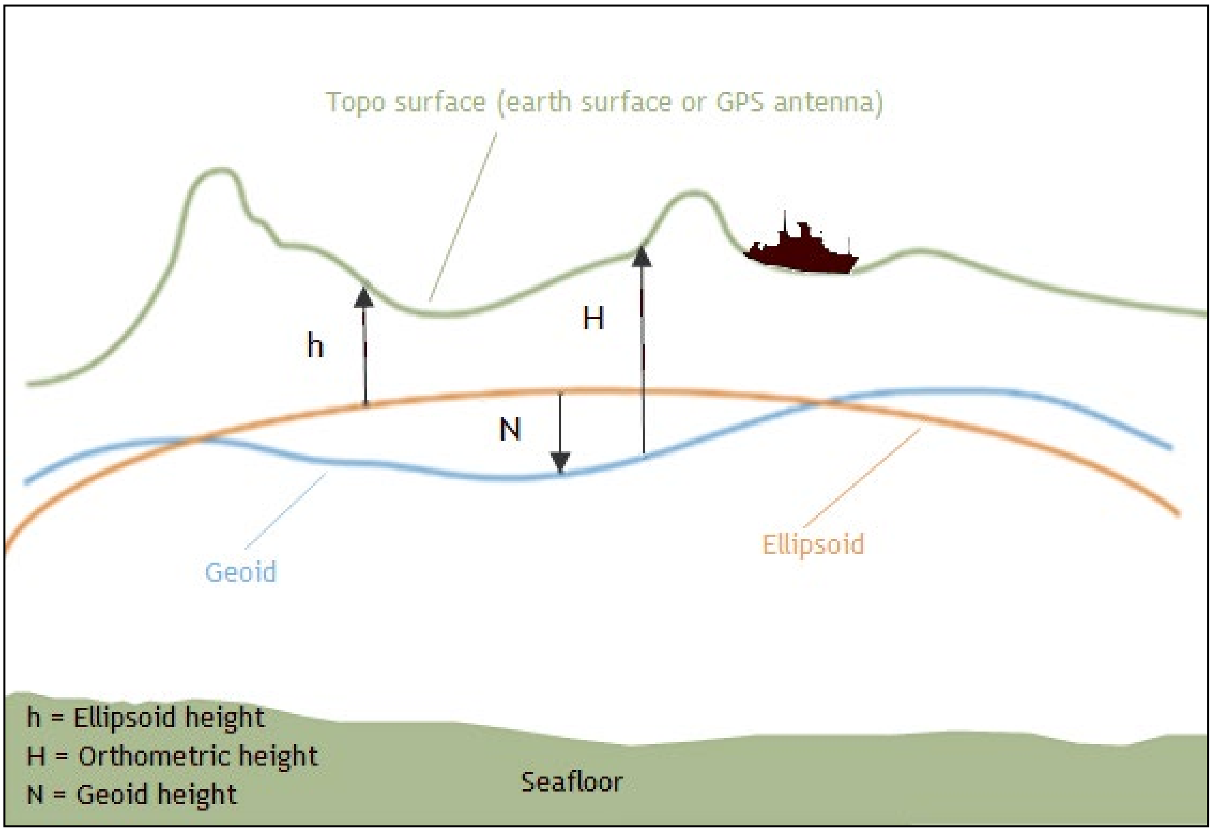


Figure 3 Overview of the relation between different vertical references.

The tidal reduction methodology encompasses all vertical movement of the vessel, including tidal effect and vessel movement due to waves and currents. The short variations in height are identified as heave and the long variations as tide.

This methodology is very robust since it is not limited by the filter settings defined online and provides very good results in complicated wave and swell patterns as well as accounts for any changes in height caused by changes in atmospheric pressure, storm surge, squat, loading or any other effect not accounted for in a tidal prediction. The vessel navigation is exported into a post-processed format, SBET (Smoothed Best Estimated Trajectory), and applied to the MBES data.

The vertical reference parameters used for processing and reporting are presented in Table 8.

Table 8 Vertical reference parameters.

VERTICAL REFERENCE PARAMETERS	
Vertical reference	LAT
Height model	VORF

2.5| TIME DATUM

Coordinated universal time (UTC) is used on all survey systems onboard the vessel. The synchronisation of the vessel's onboard system is governed by the pulse per second (PPS) issued by the primary positioning system. All displays, overlays and logbooks are annotated in UTC as well as the Daily Progress Report (DPR) that is referred to as UTC.

2.6| KP PROTOCOL

The main route option and the alternative landfall route options are specified in Table 9. KPs are calculated based upon ETRS 89, UTM zone 31N and are related to the survey centreline at all times.

Table 9 Route Specification.

ROUTE NAME	ROUTE REVISION	REVISION DATE	START KP	END KP	KP DIRECTION
SEAL_RPL_SWO_Rev03_210629	03	210629	0.000	127.298	Sizewell in Suffolk to Pegwell Bay in Kent (UK).
SEAL_RPL_SW_S6_210709	-	210709	0.000	8.563	SW KP 0.000 intersects with SWO at KP 13.437 and increases towards the landfall.

3| SURVEY PERFORMANCE

3.1| SURVEY TASKS

The survey operations were carried out between the 8th of September and the 16th of September, sites S001-S035, and on the 6th of October, sites S036 and S037, 2021.

A summary of the performed environmental survey tasks is presented in Table 10.

Table 10 Environmental survey tasks – M/V Nora B.

TASK	DATE	DESCRIPTION
1	2021-09-05 to 2021-09-08	Mobilisation and calibration in Lowestoft, UK
2	2021-09-08 to 2021-09-16	Drop Down Video Survey and Benthic grab sampling (S001 to S035)
3	2021-09-16 to 2021-09-17	Demobilisation Great Yarmouth, UK
4	2021-10-05	Mobilisation in Harwich, UK
5	2021-10-06	Drop Down Video Survey and Benthic grab sampling (S036 & S037)
6	2021-10-09	Demobilisation in Great Yarmouth, UK

3.1.1| MOBILISATION AND CALIBRATION TEST

The initial Mobilisation and Calibration (MAC) commenced on the 5th of September 2021 in Lowestoft, UK, and was completed on the 8th of September, 2021. The re-mobilisation for the final two sites took place on the 5th October 2021 in Harwich, UK.

For a detailed description of the calibration performance and results, please refer to the MAC reports 103748-NAT-MMT-MAC-REP-NORAB and 103748-NAT-MMT-MAC-REP-NORABGEO (Table 2).

3.1.2| ENVIRONMENTAL SURVEY OPERATIONS

Out of the 37 planned grab sample sites, 36 sites were sampled, and an additional five (5) video transects were performed.

Please refer to Appendix A| for a detailed description of the sample positions of grab sample sites and video transect.

Due to a technical issue, no imagery was collected at grab sample sites S036 and S037. The geophysical data was reviewed to mitigate for any potential impact on habitats of conservation importance.

Field protocols from the grab sampling and video transects operations can be found in Appendix B| and Appendix D| respectively.

3.1.3| DEMOBILISATION

The equipment and personnel conducting the environmental survey at sites S001-S035 were demobilised in Great Yarmouth, the UK, from the 16th to 17th September 2021. Following the completion of the two final sites, the second demobilisation took place in Great Yarmouth, the UK, on the 9th October 2021.

3.2| SURVEY VESSEL

The Environmental survey operations were conducted by the survey vessel M/V Nora B (Figure 4). A complete list of M/V Nora B survey equipment is provided in Table 11. Vessel specifications are detailed within Table 12.

Figure 4 Multicat M/V Nora B.

Table 11 Vessel Equipment on M/V Nora B.

EQUIPMENT	TYPE
Primary Positioning System	Hemisphere VS330
Secondary Positioning System	Vessel DP positioning
Primary Heading system	Hemisphere VS330
Secondary Heading system	GAPS / vessel DP heading
Underwater Positioning System (USBL)	iXblue GAPS
USBL beacons	iXblue MT9 transponders
Survey Navigation System	QPS QINSy
Sound Velocity and CTD Sensor	Valeport Midas SVX2
Drop Down Video camera system	STR SeaSpyder-HD
Grab samplers	Dual Van Veen grab (Primary; 2x0.1 m^2) Hamon grab (Secondary; 0.1 m^2)

Table 12 M/V Nora B Vessel summary

ITEM	VALUE
Year of built	2019
Dimensions (l x b x d) [m]	36 x 15 x 2.9
Draft (scanting / keel) [m]	1.9 / 2.35
Speed (max / eco) [kn]	11.0 / 8.0
PROPULSION	
Main engines	2 x Cat C-32 970 kW
Electric drives	2 x 192 kW
Propellers	2 x FPP in nozzles
Thrusters	4 x 275 kW tunnel

3.3| DEVIATIONS FROM THE SCOPE OF WORK

A total of (5) video transects were added during the survey and performed in an attempt to further aid habitat classifications and delineations.

No grab sampling was attempted at grab sample site S028 due to the potential presence of habitats of conservation importance.

4| METHODOLOGY

The benthic survey was performed using grab samplers and a video and still camera system. Sample sites were selected using the information provided from the geophysical survey data and in accordance with the requirements of the Client.

A senior marine biologist planned the benthic survey based on the geophysical data and preliminary geological interpretations, ensuring that the different habitats as interpreted from the Side Scan Sonar (SSS) and Multibeam Echo Sounder (MBES) were ground-truthed.

Sample sites were documented by video and still photography and by grab sampling. Where grab sampling was not possible due to coarse substrates or sensitive habitats, only video/still photo was used for sampling.

The methods used correlate the geophysical information from MBES and SSS with information on the substrate through Particle Size Analysis (PSA) and quantitative taxonomic analysis of the infauna. These survey and analytical methods provide a comprehensive overview of present conditions.

4.1| FIELD METHODS

4.1.1| SURVEY DESIGN

The final number and location of environmental sample sites were decided based on depth variation, sediment and habitat changes, as delineated during the acoustic survey, to provide benthic data of all habitats interpreted across the survey route. As a result, the sampling effort was mainly concentrated in areas of heterogeneous and varying seabed, and less so in areas of homogenous seabed.

Grab sampling was planned at 37 sites. Before deploying the Drop Down Video camera system (DDV), CTD measurements were conducted at each grab sample site. A minimum of five (5) still images, with continuous video, were acquired at each grab sample site to connect epifaunal and faunal assemblage.

The sampling area was limited by already existing infrastructure, mainly affecting the nearshore area in S7, as well as shallow water depths, affecting all landfall areas but to a larger extent the landfall in block B5.

4.1.2| PHOTO AND VIDEO SAMPLING

At each grab sample site before grab sampling, a minimum of five still photographs were collected. In addition, approximately 5 minutes of video was recorded at each site and used to provide further information on the habitats and the extent of any features identified.

In areas with hard bottom substrates or sensitive areas that could not be sampled with grab samplers, an extended video transect was performed in agreement with the Client to identify epifauna and habitat transitions and to aid the ground-truthing of the predictive habitat model. The survey line was planned over the area of interest, and still, images were collected along the entire video transect.

A brief log was maintained of each photo and video collection at the grab sample sites and during transects. As a minimum, this included the drop number, start and end location, duration, and a summary of the sediment type and main species observed. A list of the photographs, including the location of each, along with a clear indication of those taken at random for future assessment, and those taken to show particular features of interest, was also maintained. Once the survey was complete, a detailed analysis of the stills imagery was conducted.

The field notes are detailed in Appendix B| and Appendix C|.

A SeaSpyder HD camera system (Figure 5, Figure 6) from STR was used for image acquisition at each grab sampling site prior to grab sampling and along photo transects.

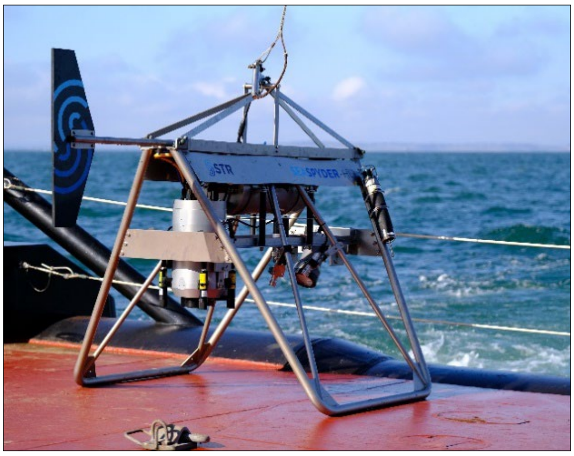


Figure 5 SeaSpyder HD DDV system.

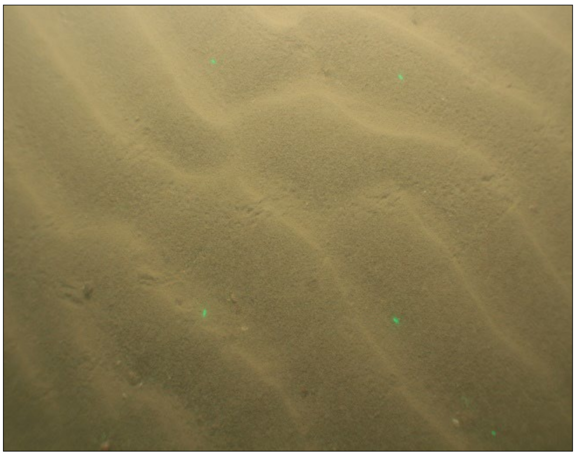


Figure 6 Example image from the survey.

Prior to sampling, the stills of the seabed and geophysical data acquired at each grab sample site were reviewed by experienced marine biologists on board to confirm the presence/absence of any potentially sensitive habitats or features of conservation interest.

The stills were analysed to identify species and density. The different European Union Nature Identification System (EUNIS) habitat criteria were compared to the results of the stills analysis. Particular attention was paid to habitats above the elevated seabed level, together with their spatial extent, percentage biogenic cover and patchiness, as these are key criteria for evaluating areas of conservation interest and reef structures (Irving, 2009; Gubbay, 2007).

4.1.3| CTD

At each grab sample site, prior to deployment of the Drop Down Video Camera System, a Valeport Midas SVX2 CTD was deployed, and a CTD profile was collected.

4.1.4| PARTICLE SIZE ANALYSIS AND CHEMICAL SAMPLING

Sediment was sampled for PSA and chemical analyses at each benthic grab sample site. The PSA and chemical samples were sampled from a separate attempt than the faunal samples, with the Dual Van Veen (DVV) or Hamon Grab (HG) samplers.

Samples for metals, hydrocarbons (Total Hydrocarbon Content, THC, and Polycyclic Aromatic Hydrocarbon, PAH), and organics (Organic matter and Total Organic Carbon, TOC) were sampled from an undisturbed surface. The sediments were collected with a plastic spoon for metals and a metal spoon for hydrocarbon and organics. This was to ensure minimal contamination risk. The grab sampler was cleaned between samples and sample sites.

The sediment for PSA was sampled by taking a representative sample (one litre) from the sample bucket using a big plastic spoon.

For the chemical analyses of hydrocarbons and organics samples, 250 ml tin jars were used. One litre plastic container was used for the metal samples. The different containers ensured that there was no outside contamination to the samples. The sample containers were labelled with a unique sample site ID. All samples were stored frozen or refrigerated according to the analysing lab's recommendations before and during shipment for analysis.

4.1.5| FAUNAL GRAB SAMPLING AND SAMPLE PRESERVATION

At each benthic grab sampling site, four grab samples were planned. One replicate grab sample was used for particle size and chemical analyses, and three replicates were used for faunal analyses.

The primary grab sampler utilized was a Dual Van Veen (2 x 0.1 m^2) and the secondary grab sampler was a Hamon grab (0.1 m^2).

The Dual Van Veen (DVV) comprises two 0.1 m^2 bucket sections mounted within a stainless-steel frame with the capacity to collect 15 litres of sediment per bucket (Figure 7). Dual tensioned bridges retain and trigger bars holding these buckets in the open position on deployment. On contact with the seabed, the trigger bar releases the buckets allowing them to close under and retrieve two replicate samples. On recovery, the grab is landed onto a rectangular base from where the samples can be inspected and then be emptied into sampling containers.

The Hamon grab (HG) sampler covers 0.1 m^2 of the seabed surface, with a maximum volume of 15 litres. The Hamon grab sampler (Figure 8) is mounted on a frame and loaded with a tensioned wire and trigger bar that holds the scoop arm open in suspension. When loaded, the scoop arm is in a horizontal position. Contact with the seabed then releases the tension, the wire becomes slack, allowing the scoop to push sediment into the sampling bucket. As it scoops the sediment, the open end of the bucket comes against a rubber sealed steel plate that encloses the sediment. On recovery, the grab is landed onto a rectangular base from where the sample can then be emptied into a sampling container.

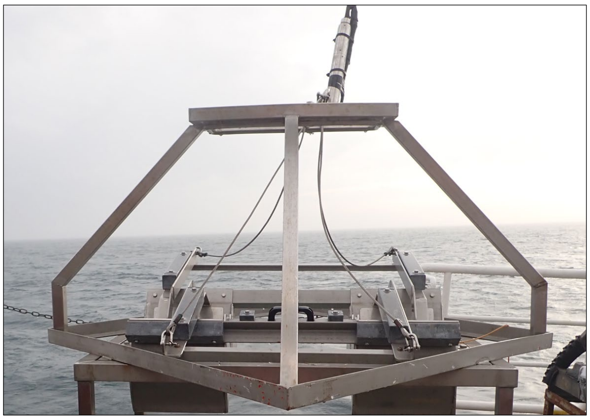


Figure 7 Dual Van Veen grab sampler.

Figure 8 Hamon grab sampler.

A minimum sediment depth of 5 cm (7 cm in fine sediments) was considered to be an acceptable sample. If the first attempt was not acceptable, two additional attempts at each site were conducted. If none of the three samples was acceptable, the attempt with the largest retrieved sample volume was saved with a note highlighting the volume. Samples that were not accepted were not included in any statistical analyses.

The planned grab sample site positions were used as targets to guide the vessel as close as possible to each proposed sample site.

The actual position of each sample was recorded each time the grab landed on the seabed using an attached Ultra-Short Base Line (USBL) transponder. This was conducted by taking a manual fix in online navigation software QINSy.

Upon retrieval, samples were checked for adequate sample volume and samples covering less than 0.1 m^2 of bottom surface sediment were deemed unacceptable. A minimum penetration depth of 5 cm in sands (7 cm in fine sediments/mud) measured in the DVV was considered acceptable.

For the HG, a volume of 7 litres was considered an acceptable sample. The acceptable volume for Particle Size Analysis (PSA) samples is considered to be 2.7 litres (Worsfold & Hall, 2010; Davies, et al., 2001).

If an acceptable sample volume was not achieved within three (3) attempts at the grab sample site (this occurred in areas of coarse sediment) then this was recorded, and the survey continued with the next grab sample site. If the first attempt using the Dual Van Veen grab recovered an inadequate sample volume and it was deemed to be more appropriately sampled with the HG, then the number of failed attempts was reset, and sampling was conducted using the HG.

A field log of sample positions, including time, sediment type, and water depth, was kept for later reference. All samples were photo-documented in situ.

Acquired samples were carefully sieved using seawater in a 5 mm mesh sieve over a 0.5 mm mesh sieve using gentle hose pressure. Faunal samples were preserved on board in 96 % ethanol directly after the sieving was completed. The 5 mm and 0.5 mm fractions were kept in separate jars, labelled with a unique label containing grab sample site ID and replicate number. For further information regarding sample volume and number of attempts, see Appendix B|.

4.2| LABORATORY METHODS

The UK-based company "In Situ Site investigation" conducted particle size analysis and chemical analyses".

4.2.1| PARTICLE SIZE ANALYSIS

Sediment from each grab sample site was analysed to detail the different particle fractions. This was achieved using a combination of sieving and sedimentation methods. Up to one litre of sediment from each sample site was analysed to detail the different particle fraction components.

In line with the British standard 1377 Part 2 1990 (British Standard, 2010), wet sieving was applied in essentially cohesion-less sediments while dry sieving was only used for sediments that did not contain significant amounts of silt and clay, i.e., almost entirely granular sand and/or gravel.

To analyse the finer fractions such as silt and clay (<0.063 mm), sedimentation by the hydrometer method was applied. This analysis is carried out when a certain percentage of material passing through the 0.0063 mm wet/dry sieve is reached. This is usually 10 or 15 % due to that, at this level, the ratio of silt and/or clay can have a substantial effect on the physical or engineering properties of soil.

The particle sizes are grouped into the five large textural groups for descriptions purposes Table 13. The samples are described according to British standard 1377 (British Standard, 2010) and Folk (1954).

Table 13 British standard (2010) sieve sizes.

CLASSIFICATION	PARTICLE SIZE INTERVALS (DIAMETER MM)	GROUPED CLASSIFICATION
Boulder	>75	Boulders/cobbles
Cobble	75-63	
Coarse Gravel	63-20	Gravel
Medium Gravel	20-6	
Fine Gravel	6-2	

CLASSIFICATION	PARTICLE SIZE INTERVALS (DIAMETER MM)	GROUPED CLASSIFICATION
Coarse Sand	2-0.6	Sand
Medium Sand	0.6-0.2	
Fine Sand	0.2-0.063	
Coarse Silt	0.063-0.02	Silt
Medium Silt	0.02-0.006	
Fine Silt	0.006-0.002	
Clay	<0.002	Clay

4.2.2| CHEMICAL ANALYSIS

The different compounds that were analysed along with detection limits are stated in Table 14 to Table 16. The analyses included concentration analysis of metals, hydrocarbons (THC and PAH) and organics (organic matter and TOC).

Where metal suites overlapped, only one of the analyses has been included in this report. The suite resulting in the highest levels has primarily been used, and if no apparent differences were observed, the suite with the lowest LOD was used.

Table 14 Metal analysis minimum limits of detection.

METALS	DETECTION LIMITS (µg/g)	Method of analysis
As*, Cr*†, Cu*, Pb*, Ni*	0.5	ICPMSS
Cd*	0.04	ICPMSS
Hg*	0.01	ICPMSS
Zn*	2	ICPMSS
Be*	0.1	SEDOES
Ba*, V*	1	SEDOES
Cr*, Cu*†, Ni*†, Zn*†	2	SEDOES
Mn*, Sr*	5	SEDOES
Al*,	10	SEDOES
Fe*, P*	45	SEDOES

** United Kingdom Accreditation Service (UKAS) accreditation.*
† See Appendix G| for results

Total Hydrocarbon Content was analysed using Gas Chromatography-Flame Ionisation (GC-FID). Polycyclic Aromatic Hydrocarbons were analysed using Gas Chromatography-Mass Spectrometry (GC-MS). Polycyclic Aromatic Hydrocarbons (16 EPA + Dibenzthiophene & Benzo(e)pyrene) are accredited by the United Kingdom Accreditation Service (UKAS).

Table 15 Hydrocarbon analysis minimum limits of detection.

HYDROCARBONS	DETECTION LIMITS (µg/Kg)	METHOD OF ANALYSIS
THC	100	GC-FID
PAH	1	GC-MS

Organic matter was analysed by dichromate oxidation and colourimetric determination.

Total Organic Carbon (TOC) was analysed by carbonate removal using sulphurous acid and combustion at 1600°C using an induction furnace fitted with an NDIR cell.

Table 16 Organics analyses and minimum limits of detection.

ORGANICS	DETECTION LIMITS
Organic matter	0.2%
TOC	0.02 %

4.2.3| BIOLOGICAL ANALYSIS

FAUNAL ANALYSIS

The faunal analysis was conducted by the UK based company APEM Ltd. Analysis was conducted in accordance with the National Marine Biological Analytical Quality Control (NMBAQC) scheme (Worsfold & Hall, 2010), and all of the samples were quality controlled.

The faunal samples were sorted from sediment residue, and the fauna was identified to the most detailed level possible, mainly species and enumerated. When the species could not be identified, the specimen was grouped into the nearest identifiable taxon of a higher rank, i.e., genus, family or order etc.

If the species remained unknown but separated from any other found specimen within the same genus, it was assigned a “Type” denomination, i.e., Type A or Type B. Juveniles were marked with the qualifier “juvenile” and later excluded from further statistical analyses. For a more detailed description, view Appendix C|.

Sub-sampling was performed for specific taxa when considered necessary and after the Client approval. After all non-target taxa were extracted from the sample, subsampling using a Quarteriser usually (¼ or 1/8) was performed following NMBAQC guidelines (Worsfold & Hall, 2010). The Quarteriser has been proven to be the most accurate sub-sampling method producing a mean value close to the true value and low standard deviation (Proudfoot, et al., 2003). The subsample was re-sorted, and all target taxa were extracted and recorded.

The remaining fractions (3/4 or 7/8) are kept physically separated at all times from the completely analysed fraction. The number entered into the database is the corrected number (i.e. total for sample), and any details of any sub-sampling undertaken would be provided in the report and included on sample pot labels, data sheets and database. Sub-sampling was performed at sites S005, S007, S008, S009, S013, S021, S026, S027, S031 and S037 primarily due to very high quantities of *Jassa* spp. and juvenile *Mytilus edulis*.

4.3| DATA ANALYSES

4.3.1| VISUAL DATA ANALYSIS

The stills were analysed to identify species and densities, including seabed substrate. The video recordings were used to aid in the assessment of features and extent of habitats. Particular attention was paid to the elevation of habitats above ambient seabed level, together with their spatial extent, percentage biogenic cover and patchiness, as these are key criteria for evaluating areas of conservation importance and reef structures (Gubbay, 2007; Irving, 2009).

Quantitative methods were used for the identification of biota in grab samples and still photographs, with all the data presented as individuals per square metre and percentage cover of colonial species. Stills were analysed in AutoCAD Map 3D, where visual epibenthic fauna was counted, and results were summarised in a log containing scientific name, position, date, time, and stills ID. For a more detailed description of species, view Appendix C| and Appendix E|.

4.3.2| PARTICLE SIZE ANALYSIS

Sediment particle size distribution statistics for each sample were calculated from the raw data by the In Situ Site Investigation laboratory. The distribution curves of sediment composition, along with uniformity coefficient (Cu) and coefficient of curvature (Cc), are provided in Appendix D|.

4.3.3| CHEMICAL ANALYSES

Environmental Quality Standards (EQS) for metals and hydrocarbons in sediments are not yet developed for UK waters.

Assessment criteria developed by the Canadian Council of Ministers of the Environment (CCME) together with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) guideline action levels for disposal of dredged material have been considered common practice to use.

OSPAR Environmental Assessment Criteria (EAC) have also been used as guidelines for metal and PAH concentrations, when applicable, within this report.

The Canadian sediment quality guidelines include two values as assessment criteria, the Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL). The ISQG are threshold levels that are set to protect all aquatic life during an indefinite period of exposure, and for values above PEL, adverse effects are expected to occur frequently (CCME, 1995; CCME, 2001). For concentrations between the ISQG and PEL, adverse effects occur occasionally.

CEFAS Action Levels are used as a part of assessing the contamination status in dredged material, where material below Action Level 1 (AL1) generally indicates that contaminant levels are of no concern, while contaminant levels above Action Level 2 (AL2) generally are considered unsuitable for disposal in the sea (MMO, 2015).

OSPAR's Environmental Assessment Criteria's (EACs) are under development, and OSPAR uses "Effect range-low" (ERL) values for sediment assessment of metals and PAH, where EACs are not available. The ERL value indicates a concentration below which adverse effects on organisms are rarely observed (OSPAR, 2011).

Condition classes established by the Norwegian Environmental Agency (NEA) for contamination in coastal sediments (NEA, 2016, revised 2020) for metals, PAH and other organic compounds were also used. This system uses five classes, class 1 - Background levels, class 2 - Good, with no known toxic effects, class 3 - Moderate, with chronic effects at long term exposure, class 4 - Poor, with acute toxic effects at short term exposure and class 5 - Very Poor, with extensive toxic effects.

There are no OSPAR or UK contamination threshold values regarding THC for marine sediments. In the absence of such guidelines, Dutch intervention levels for aquatic sediments can offer a useful comparison. Concentrations above the Dutch intervention values represent a serious level of contamination, where functional properties of the sediment are seriously impaired or threatened (Hin, 2010). Detailed chemical results are presented in Appendix G|.

4.3.4| UNIVARIATE STATISTICAL ANALYSES

Univariate analysis was undertaken using the Plymouth Routines in Multivariate Ecological Research (PRIMER) v7.0 statistical package (Clarke & Gorley, 2015).

Univariate analyses included the primary variables, i.e. the number of taxa (S) and abundance (N), together with the Margalef's index of Richness (d), Pielou's index of Evenness (J), Shannon- Wiener index of Diversity (H') and the Simpson's index of Dominance (1-λ) and are summarised in Table 17. Abundances were expressed as the mean number of individuals per 0.1 m^2 for each grab site, whereas number of taxa is the combined total number of taxa found at each site (0.3 m^2).

Table 17 Univariate statistical analyses.

ANALYSES	PARAMETERS	FORMULA	DESCRIPTION
No. of Taxa (S)	Species richness	S	The number of species (taxa) in each sample.
No. of individuals (N)	Abundance	N	The number of individuals in each sample.
Margalef's index of Richness (d)	Richness	$d = (S-1) / \ln(N)$	A measure of the number of species present for a given number of individuals
Shannon-Wiener index of Diversity (H')	Diversity	$H' = \Sigma_i P_i \ln(P_i)$	The diversity index incorporating both species richness and equitability, where Pi is the proportion of the total count arising from the i^{th} species. Lower value equals a high chance that all abundance is concentrated to one species.
Pielou's index of Evenness (J)	Evenness	$J = H' / \ln(s)$	Measures how evenly individuals are distributed between species. Gives a value between 0 to 1, where a higher value equals a more even community.
Simpson's index of Dominance (1-λ)	Dominance	$\lambda = (\Sigma p_i^2)$	Dominance index between 0 - 1 where 0 corresponds to assemblages whose total abundance is dominated by one or very few of the species present and 1 represents a more evenly species distribution.

4.3.5| MULTIVARIATE STATISTICAL ANALYSES

Multivariate analyses were undertaken using the Plymouth Routines in Multivariate Ecological Research (PRIMER) v7.0 statistical package (Clarke & Gorley, 2015). The statistical analyses were based on macrofaunal data derived from the taxonomic analyses of three replicates from each grab sample site. Grab samples with insufficient sample volume were excluded from the statistical analyses. Abundances were expressed as the number of individuals per 0.1 square metre.

The macrofaunal organisms were separated into non-colonial and sessile colonial fauna. Colonial fauna was not quantified in the laboratory analysis and was treated separately in the statistical analyses.

All colonial fauna was also considered being epifauna. Juvenile (JUV) taxa, fragments of an animal and foraminiferans were excluded from the datasets. The faunal composition was linked to physical variables such as depth and sediment composition.

Square root transformation was applied to the non-colonial enumerated fauna datasets before calculating the Bray-Curtis similarity measures. This transformation was made to prevent abundant species from influencing the Bray Curtis similarity index measures excessively and also to take the rarer species into account (Clarke & Warwick, 2001).

The faunal laboratory results were compared for faunal composition within and between sampling sites. Site-related differences in community structure were examined in a clustering analysis using Euclidean distance and the Bray-Curtis similarity coefficient. This method is common when measuring ecological distance in biological sample data.

Multi-Dimensional Scaling (MDS) analysis was undertaken in conjunction with the cluster analysis. The Non-metric Multidimensional Scaling (nMDS) analysis is based on the same similarity matrix as that of the cluster analysis and produces a multidimensional ordination of samples. The number of restarts was set to 999 with minimum stress of 0.1. The nMDS plot visualises the relative (dis)similarities between samples; the closer they are, the more similar the species composition between the samples. The degree to which these relations can be satisfactorily represented is expressed as the stress coefficient statistic, low values (<0.1) indicate a good ordination with low probabilities of misleading interpretation. Generally, the higher the stress, the greater the likelihood of non-optimal solutions (Clarke & Warwick, 2001).

A Similarity profiling algorithm (SIMPROF) test was run in conjunction with the cluster analysis, which was used to identify significantly different natural occurring groups among grab samples. Significance levels were set to 5 %. The results are presented in the cluster dendrogram as black lines indicating significant statistical differences, and red lines represent samples that are not statistically different. The SIMPROF is based on taxa and the abundance of each taxon in each sample. Thus, different SIMPROF groups may host similar fauna, which differs in abundance.

A Similarity Percentage (SIMPER) analysis was performed on transformed data to obtain dissimilarities between groups and to identify the most important percentage contribution seen in the Bray-Curtis similarities.

PSA data were analysed in PRIMER and normalised before being included in any statistical analysis. Data for the percentage composition was analysed in a cluster analysis using the Euclidean distance. A Principal Component Analysis (PCA) was undertaken on the sediment data set to identify spatial patterns and relationships between variables.

To further explore the data, multivariate statistical analyses were also performed on the average abundances at each site. Lastly, to provide a broad characterisation of the survey area a second stage dendrogram was constructed, based on the square root transformed average abundances in the groups found in the SIMPROF analysis based on the average abundances at each site. This method has not been widely used but has been implemented in at least one other survey on the coast of England (Tappin, et al., 2011).

The relationship between the faunal composition and the percentage sediment composition from the PSA was tested using the BIOENV method, with Spearman rank correlations, in the BEST procedure in PRIMER v.7. This analysis identifies variables that exert the greatest influence on the spatial distribution of the input datasets.

4.4| MBES DERIVATIVES

A number of the surveyed grab samples sites and transects suffered from diminished visibility due to significant turbidity in the water column. During the post-processing and assessment of benthic data, additional MBES data derivatives were produced to further strengthen the accuracy of the interpretations with the primary focus on the grab sample sites with diminished visibility.

The MBES data derivatives included normalised Backscatter values as well as Rugosity measurements.

4.4.1| BACKSCATTER DATA ANALYSIS

The use of backscatter data to assist habitat interpretations and mapping is a methodology under development, which is becoming increasingly used in these types of analyses (Lurton and Lamarche, 2015).

Backscatter Normalised Values are a measurement of the MBES echo that is scattered in the direction of the transducer. This data records the intensity, in decibel (dB), of the echo that returns to the transducer after the emitted pulse interacts with the seabed. The backscatter amplitude varies with several factors such as frequency, beam pattern, range and losses due to absorption and spreading, angle with the seabed as well as sediment type and other factors.

The raw data was processed with the Fledermaus (FMGT) software, which applied various standard normalisations to the data to compensate for how the intensity varied across the swath producing a grayscale floating-point raster image gridded at 1 m, where each gridded cell contains a measured intensity value.

The intensity decibel value interval, varied between the datasets acquired by the nearshore respectively offshore systems due to their varying sensitives and equipment settings. The range is typically +10 (white, hard seabed) to -70 (black, soft seabed) for the exported raster data.

Offshore survey vessel Franklin conducted all aspects of the Offshore geophysical survey work in water depths of >10 m Lowest Astronomical Tide (LAT). Nearshore vessel Mersey Discovery performed geophysical survey work in water depths ≤10 m LAT (Nearshore).

For survey and data management purposes the route options were divided into several Blocks. Block 1 to 5 contains the main route option (SEAL_RPL_SWO_Rev03_210629) with nearshore areas at each landfall and Block 1 contains an alternative landfall route option (SEAL_RPL_SW_S6_210709) at Sizewell. Due to the data being collected by different vessels and systems the backscatter data will be presented independently, as detailed in Table 18 and Figure 9.

Backscatter values varied across a small spatial scale, making interpretations on a larger scale challenging due to the small-scale variation. To mitigate for this, the Focal Statistics tool in ArcGIS was used to reduce the variation in the values. The backscatter raster data was imported into ArcGIS and a raster image was created based on the measured intensity values for each cell and plotted. Within ArcGIS, a secondary raster image was created through the calculation of the cell value with the Focal Statistics tool. The tool calculates a new value for each input cell based on the neighbouring cell values. The new value output was based on the average value of the neighbouring cells in a 3x3 m area (3x3 cells). The new cells maintained the original cell size of 1x1 m.

Ground-truthing data (photos, video, physical samples such as fauna, PSA samples and geotechnical samples) together with geophysical data were used to align the backscatter reflectivity intervals based on the trends interpreted, with regards to substrate and habitats (Lurton and Lamarche, 2015). However, there were limiting factors due to the numerous and morphologically different ripple features in the area as well as the particle density in the water column.

The difficulties, that features such as ripples, impose on backscatter data are due to changes in elevation and angle of the seabed. These affect the amount of reflected sound, resulting in values indicating too hard or too soft a substrate. These potential errors are partially mitigated for by using the Focal Statistics tool in ArcGIS, as the interpolation used in the tool averages out the overestimated and underestimated values from the backscatter.

Outlier values from the outermost ranges from the data sets were naturally excluded as the grouping of the intervals were set and these are detailed in Table 18.

Table 18 Backscatter Intensity colour schema for each area (intensity is presented in dB).

		OUTLIERS (dB)
DEFAULT		N/A
B1 – B5 **MAIN ROUTE**	Mobile Sediments (-32.9 - -25.9) Sandy Mud (-25.9 - -21.0) Sands/ Muddy Sand (-21.0 - -14.5) Mixed Sediments (-14.5 - -11.4) Coarse Sediments (Cobbles, Boulders) (-11.4 - -5.7)	-45 - -33, -5 - 2
BLOCK 5 NEARSHORE	Mobile Sediments (-37.9 - -27.7) Mixed Sediments (-27.7 - -17.7) Coarse Sediments (Cobbles, Boulders) (-17.7 - -12.2)	-48 - -38. -11 - -8
BLOCK S6 NEARSHORE	Sandy Mud (-37.9 - -27.2) Muddy Sand (-27.2 - -24.2) Mixed (subsurface stiff Clay) Sediments (-24.2 - -18)	-46 - -38, -17 - -16
BLOCK 1 S7 NEARSHORE	Fine Sand (-39.9 - -33.2) Sands (-33.2 - -29.3) Muddy Compacted Sand (-29.3 - -18)	-43 - -40, -18 - -15

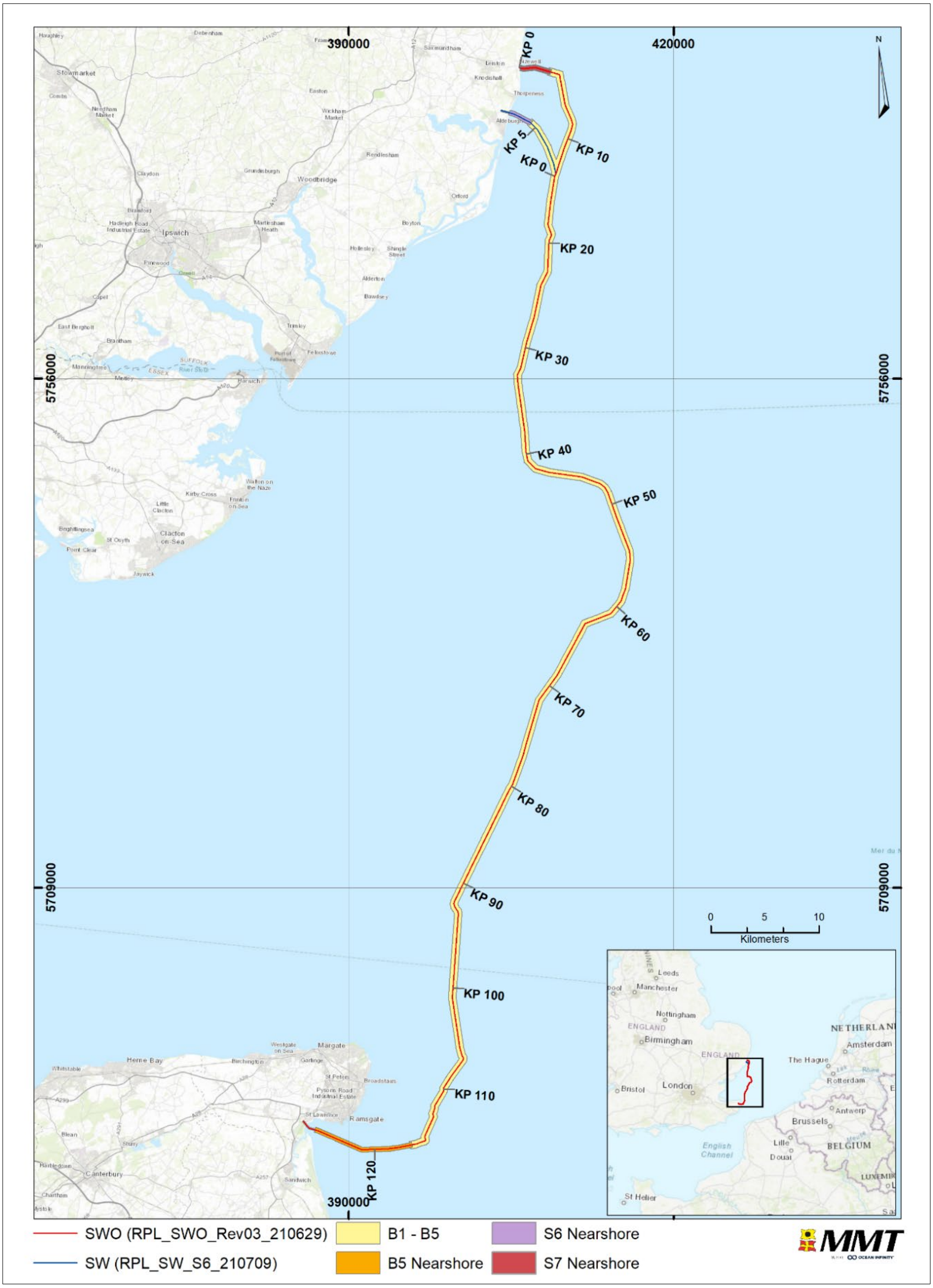


Figure 9 Survey blocks overview.

4.4.2| RUGOSITY

Rugosity is a measurement of the seabed roughness and an indicator of seabed variability and complexity. An ArcGIS toolbox, MarineTools, was used to produce the seabed rugosity. The tool Terrain Ruggedness (VRM) measures seabed roughness as the variation in the three-dimensional orientation of grid cells within a neighbourhood. The tool is based on the Benthic Terrain Modeler for ArcGIS (Walbridge, S., Slocum, N., Pobuda, M., & Wright, D., 2018). High-resolution MBES data was used to calculate the rugosity, a unitless scale, and the classification intervals presented in the resolution sections are mapped based on the Standard Deviation (SD) of the data.

ArcGIS Tool Description

> *"The tool uses vector analysis to calculate the dispersion of vectors normal (orthogonal) to grid cells within a specified neighbourhood of cells. This method incorporates the slope variability and aspect into a single measure. The scale for the produced raster image raster can range from 0, indicating no variation i.e. flat, to 1 indicating complete variation. Values for natural variation tend to range between 0 and 0.4."*

4.4.3| MESH CONFIDENCE ASSESSMENT

The MESH (Mapping European Seabed Habitats) confidence assessment is a tool for assessing the confidence and/or accuracy of seabed habitat maps (MESH, 2010). This evaluation addresses three main questions:

- How good is the remote sensing;
- How good is the ground-truthing;
- How good is the data interpretation?

Each of these questions are further divided into four to six sub-questions, in total 15 questions were included in the original assessment tool. The weight of each question was left at the default settings. The map is scored based on these criteria and the scores are combined to produce an overall confidence score. To achieve the top score of 100, both physical and biological survey data are required. It is possible to score different sections of a map separately if the data/interpretation varied across the area.

An overall MESH value was initially assigned to the entire survey area, based solely on remote sensing and data interpretation. These values were then revised and increased for polygons that have ground-truthing data (grab samples, seabed imagery, geotechnical samples), depending on the quality of the ground-truthing data. If multiple sample sites with ground-truthed data were located within a single polygon, the sample site with the highest MESH score represents the entire polygon.

4.5| HABITAT CLASSIFICATION

Habitats were classified to the lowest hierarchic level possible and based on interpretations that combine biotope descriptions of species abundance, diversity, depth and seabed features from grab samples, video and photos acquired at each sample site.

The classification of the communities of the different habitat types is based on physical characteristics such as benthic geology, wave exposure, tidal currents, temperature and salinity, together with key species present in the area. In addition, normalized backscatter data from MBES was used to delineate habitats in areas of homogenous sediments.

The EUNIS classification (EEA, 2019) is divided into six hierarchic levels (Figure 10). At Level 1, the habitats are divided into marine, coastal and terrestrial habitats.

At Level 2, the biological zone and presence/ absence of rock is a classification criterion, and at Level 3, the softer substrata are divided into different sediment types. Hence, these three levels of classification are based on physical characters.

Level 4 gives references to specific taxa. For rocky substrates, the major epifauna is used, and for softer substrates, the classification relies on both zonation and physical attributes. Further, at Level 5, the classification is based on both the physical and biological characters of the habitats, and classes are defined with both infauna and epifauna on different substrates. At the highest level, level 6, the different characterising taxa are associated with different environmental characteristics of the habitat.

Where applicable, a combination/matrix of habitat codes was assigned. This approach was applied where substrate and depth varied between two sites, but the faunal assemblage was similar.

During this survey, the limit between infralittoral and circalittoral habitats was set to 10 m.

Level 1	(A) Marine Habitats
Level 2	(A5) Sublittoral sediment
Level 3	(A5.5) Sublittoral macrophyte-dominated sediment
Level 4	(A5.53) Sublittoral seagrass beds
Level 5	(A5.533) Zostera beds in full salinity infralittoral sediments
Level 6	(A5.5331) *Zostera marina / angustifolia* beds on lower shore or infralittoral clean or muddy sand

Figure 10 Example of EUNIS Hierarchy.

4.6| PROTECTED HABITAT AND SPECIES ASSESSMENTS

The following legislations and guidelines have been applied when relevant for the assessment and classification of potential areas and/or species of conservation importance.

The European Commission (EC) Habitat Directive specifies the European nature conservation policy. Species and habitats of special interest for conservation are specified in the different annexes to the directive. Annex I states the habitats of special conservation interest, and Annex II states the species of special conservation interest. Among the habitats specified in Annex I are the “Reefs” (code 1170). Reefs can be of biogenic, e.g., mussel beds or corals, or geogenic origin, e.g., stony areas with epifauna.

Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 lists species and habitats of Principal Importance for the conservation of biodiversity in England. These lists include the habitats and species in England that were identified as requiring action under the UK Biodiversity Action Plan (BAP) (Brig, 2008 (Updated Dec 2011)), which has been superseded in England. The UK BAP species and habitats are defined nationally by the UK. Threatened species and habitats are listed to aid in the survival of species in accordance with the Convention of Biological Diversity (UN, 5 June 1992).

The Marine Protected Area (MPA) network is a term describing areas in the ocean which are protected in part or closed off completely by strict regulations. One example of MPAs is the Special Areas of Conservation (SAC), which are defined in the European Commission (EC) Habitats Directive.

The Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic (OSPAR) lists protected species and habitats, as well as sensitive habitats and species in need of protection in the North-East Atlantic. This also serves as a complement to the EC Habitats Directive.

In the Habitat Directive’s interpretation manual (EUR 28, 2013), reefs are explained as follows:

> *“Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions.”*

The distinction between what is to be considered a "reef" is not yet precise. This is particularly the case in relation to colonies of the tube-building polychaete, *Sabellaria spinulosa* and stony reefs. For example, if *S. spinulosa* or horse mussel (*Modiolus modiolus)* is found in an area, it does not automatically make the area a potential **Annex I** (1170) – Reefs, Biogenic Reef habitat.

A scoring system based on a series of physical, biological and spatial characteristic reef features was established to assess the degree of "reefiness". The reefiness is weighted according to the perceived importance of each feature. Furthermore, the reefiness is increased with a score indicating confidence in the feature score. Threshold ranges proposed, for the reef characteristics elevation, spatial extent and patchiness of *S. spinulosa* are provided by Gubbay (2007)(Table 19) and further modified by Collins (2010) (Table 20) and for Stony Reefs by Irving (2009) (Table 21).

Table 19 Proposed chart for Sabellaria spinulosa reef identification (Gubbay, 2007).

CHARACTERISTIC	NOT A REEF	"REEFINESS"		
		LOW	MEDIUM	HIGH
Elevation (cm) (average tube height)	<2	2-5	5-10	>10
Extent (m^2)	<25	25 - 10,000	10,000 – 1,000,000	>1,000,000
Patchiness (% cover)	<10	10 - 20	20-30	>30

To assess potential *S. spinulosa* reefs, the methods suggested by Jenkins et al. (2018) were used. Video recordings were broken up into 5-second segments, and each segment was assessed for coverage and elevation of *S. spinulosa* according to Collins (2010) Step 1. Based on these assessments, the number of patches with reefs and their lengths, i.e. the number of sequential video segments classified as reefs, were calculated and presented in table format.

Areas that did not meet the criteria for reef are referred to as *S. spinulosa* aggregations within this report to further provide contextual information on possible distribution patterns.

Table 20 S. Spinulosa *Reef Structure Matrix (Step 1) and* S. spinulosa *Reef Structure Matrix vs Area Matrix (Step 2) to determine final "Reefiness" (Collins, 2010).*

<table>
<tr><th colspan="7">STEP 1</th></tr>
<tr><th colspan="3" rowspan="3">REEF STRUCTURE MATRIX</th><th colspan="4">Elevation (cm)</th></tr>
<tr><th><2</th><th>2 – 5</th><th>5 - 10</th><th>>10</th></tr>
<tr><th>Not a reef</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><th rowspan="4">Patchiness (%)</th><th><10</th><th>Not a reef</th><td>Not a reef</td><td>Not a reef</td><td>Not a reef</td><td>Not a reef</td></tr>
<tr><th>10 – 20</th><th>Low</th><td>Not a reef</td><td>Low</td><td>Low</td><td>Low</td></tr>
<tr><th>20 – 30</th><th>Medium</th><td>Not a reef</td><td>Low</td><td>Medium</td><td>Medium</td></tr>
<tr><th>>30</th><th>High</th><td>Not a reef</td><td>Low</td><td>Medium</td><td>High</td></tr>
<tr><th colspan="7">STEP 2</th></tr>
<tr><th colspan="2" rowspan="3">REEF STRUCTURE VS AREA</th><th colspan="4">Area (m^2)</th></tr>
<tr><th><25</th><th>25 – 10 000</th><th>10 000 – 1 000 000</th><th>>1 000 000</th></tr>
<tr><th>Not a reef</th><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><th>Reef Structure</th><th>Not a reef</th><td>Not a reef</td><td>Not a reef</td><td>Not a reef</td><td>Not a reef</td></tr>
</table>

	Low	Not a reef	Low	Low	Low
	Medium	Not a reef	Low	Medium	Medium
	High	Not a reef	Medium	High	High

For Stony Reefs with a low resemblance, the methodology proposed by Brazier (2020) was implemented to assess whether or not an area would meet the criteria for inclusion in **Annex I** (1170) – Reefs, Stony Reefs (Table 22).

Table 21 Guidelines used to categorise resemblance of stony reefs (Irving, 2009).

MEASURE OF RESEMBLANCE	NOT A STONY REEF	LOW	MEDIUM	HIGH
Composition	<10 %	10-40 % Matrix supported	40-95 %	>95 % Clast supported
Notes: Diameter of cobbles/boulders being greater than 64 mm. Percentage cover relates to a minimum area of 25 m^2. This 'composition' characteristic also includes 'patchiness'.				
Elevation	Flat Seabed	<0.064 m	0.064 m-5 m	>5 m
Notes: Minimum height (64 mm) relates to a minimum size of constituent cobbles. This characteristic could also include 'distinctness' from the surrounding seabed.				
Extent	<25 m^2	>25 m^2		
Biota	Dominated by infaunal species			>80 % of species present are composed of epifaunal species.

This scoring system indicates that stony reefs should be elevated by at least 0.064 m and with a composition of at least 10 % stones, covering an area of at least 25 m^2 and having an associated community of largely epifaunal species.

In Irving (2009), it is noted that a strong justification is needed if an area scored 'Low' in any of the four main characteristics measures for the area to be considered an **Annex I** (1170) - Reefs, Stony Reefs.

A method has been proposed by Brazier (2020) to provide such justification. It consists of three steps where the first is an assessment of whether the habitat can be considered a reef habitat or not, i.e. is there a presence of a stable epifaunal community such as perennial kelp. This is followed by counting the number of key reef species, and lastly, counting the number of reef species (Table 22). The working paper by Brazier describing the method is included as Appendix 7 in Golding et al. (2020) and further discussed in that report.

Together, these three parameters provide the justification needed to assess where or not a particular area of Low-Grade resemblance would be included within **Annex I** (1170) – Reefs, Stony Reefs.

Table 22 Guidelines used to assess if 'low grade' stony reefs should be included under Annex I (Brazier, 2020).

REEF	STEP 1 REEF BIOTOPES	STEP 2 KEY REEF SPECIES	STEP 3 REEF SPECIES RICHNESS
Reef	Reef Biotope	≥3	>20
Possible Reef	Possible Reef Biotope	1-3	5-20
Not Reef	Non-Reef Biotope	0	<5

Habitat suitability for herring spawning was assessed based on sediment composition, as indicated by the results of the particle size analysis.

Herring spawning grounds are located within coarse sediments, such as gravel and coarse sand, with a low proportion of mud and well-oxygenated water (Ellis, MIlligan, Readdy, Taylor, & Brown, 2012). To assess habitat suitability, grab sample sites were classified into four sediment preference classes based on sediment composition according to MarineSpace Ltd (2018) as outlined in Table 23.

Table 23 Herring spawning sediment preference, MarineSpace Ltd (2018) and Reach et al *(2013).*

PERCENTAGE CONTRIBUTION OF MUD AND GRAVEL	FOLK SEDIMENT UNIT	HABITAT SEDIMENT PREFERENCE	
		MARINESPACE LTD	REACH ET AL
<5% muds, >50% gravel	Gravel and part sandy Gravel	Preferred	Prime
<5% muds, >25% gravel	Part sand Gravel and part gravelly Sand	Preferred	Sub-prime
<5% muds, >10% gravel	Part gravelly Sand	Marginal	Suitable
>5% mud, <10% gravel	Everything except Gravel, part sandy Gravel and part gravelly Sand	Unsuitable	Unsuitable

Habitat suitability for sand eels, *Ammodytes spp.* and *Hyperoplus lanceolatus,* was assessed based on sediment composition as indicated by the Particle Size Analysis results. Sand eels require medium to coarse sand with less than 10 % mud (Latto, et al., 2013). with a low proportion of mud, and well-oxygenated water (Ellis, MIlligan, Readdy, Taylor, & Brown, 2012). To assess habitat suitability, grab sample sites were classified into four sediment preference classes based on sediment composition according to MarineSpace Ltd (2018), as outlined in Table 24.

Table 24 Sand eels sediment preference, based on MarineSpace Ltd (2018).

PERCENTAGE CONTRIBUTION OF MUD AND GRAVEL	FOLK SEDIMENT UNIT	HABITAT SEDIMENT PREFERENCE
<1% muds, >85% Sand	Part Sand, part slightly gravelly Sand and part gravelly Sand	Preferred
<4% muds, >70% Sand	Part Sand, part slightly gravelly Sand and part gravelly Sand	Preferred
<10% muds, >50% Sand	Part gravelly Sand and part sandy Gravel	Marginal
>10% muds, <50% Sand	Everything excluding Gravel, part sandy Gravel and part gravelly Sand	Unsuitable

5| RESULTS

A total of 37 grab sample sites were selected for video/photo documentation and grab sampling, as well as five video transects (Table 25). A CTD cast was performed at each of the grab sample sites.

At site S007, no third faunal replicate sample (F3) nor physico-chemical sample was acquired as sampling was aborted due to the potential presence of habitats of conservation importance.

The third faunal replicate sample (F3) at site S027 comprised insufficient sample volume and was thus excluded from statistical analysis.

No third faunal replicate sample (F3) nor physico-chemical sample was acquired at site S031 and the first and second faunal replicates (F1 and F2) comprised insufficient sample volume and were thus excluded from statistical analyses.

No grab sampling was attempted at site S028 due to the potential presence of habitats of conservation importance.

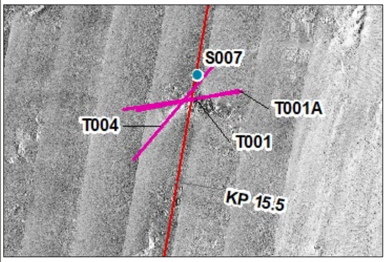
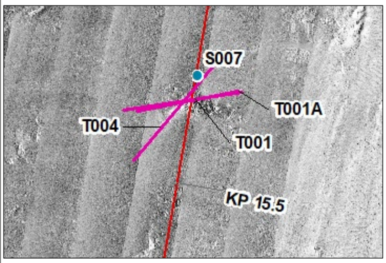
See Table 26 and Table 27 for details regarding the positions of the performed video transects and grab sample sites. The positions listed in Table 27 represent the position from the first grab sample replicate or photo if no grab sample was acquired. The red line overlain the geophysical overview images indicates the centre line of the main route option (SWO), and the blue line indicates the centre line for the alternative landfall route option (SW). Any KP referenced is referred to the SWO route unless stated otherwise.

For a detailed list of positions for video transects, grab sample sites and samples, photos, as well as CTD's, see Appendix A|.

Table 25 Number of sample sites.

NUMBER OF SAMPLE SITES	VIDEO TRANSECTS	GRAB SAMPLE SITES	PSA/CHEM SAMPLE SITES	CTD
	5	36	36	37

Table 26 List of performed video transects.

TRANSECT ID	KP	EAST START	NORTH START	EAST END	NORTH END	LENGTH (M)	SSS OVERIEW
T001	15.399	408775	5772998	408656	5772980	120	
T001A	15.398	408772	5772999	408669	5772979	105	

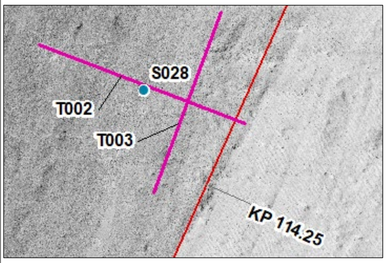
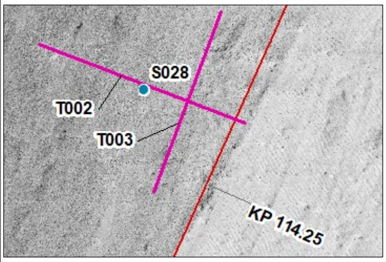
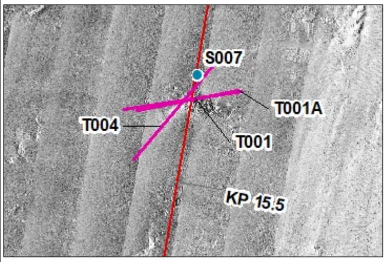
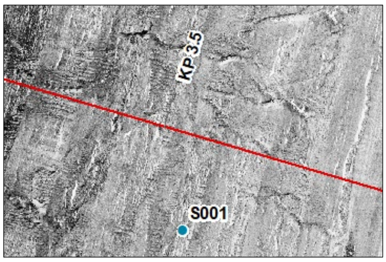
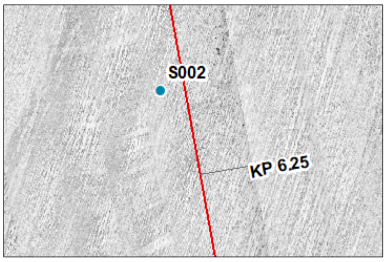
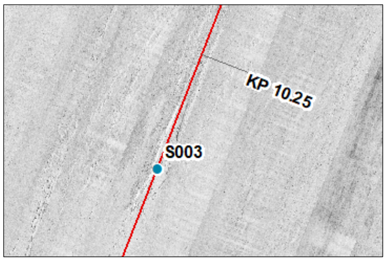
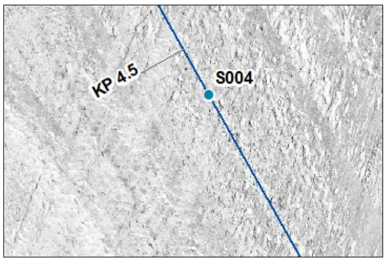
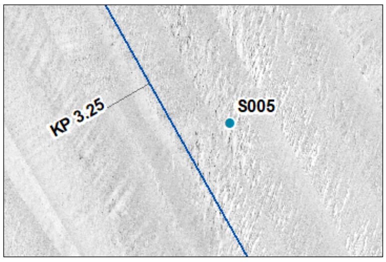
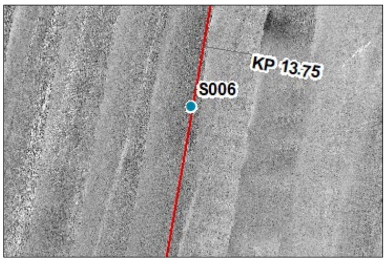
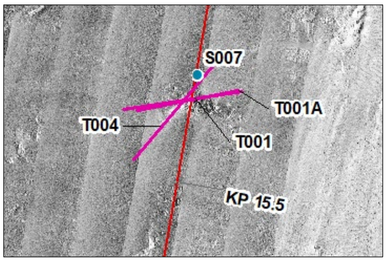
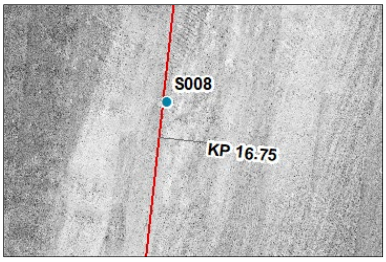
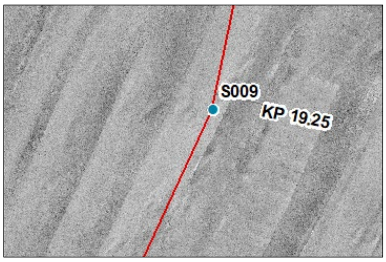
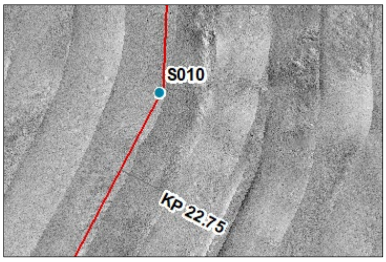
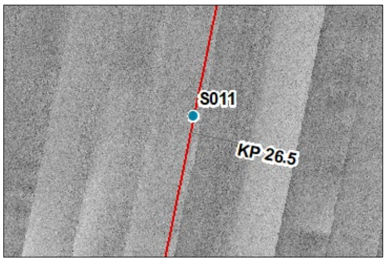
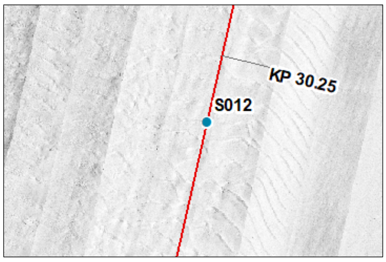
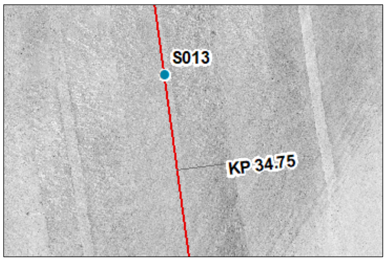
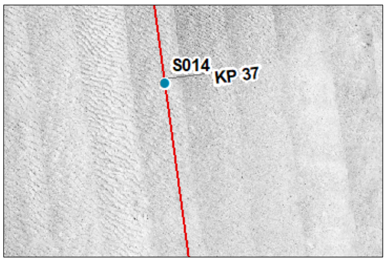
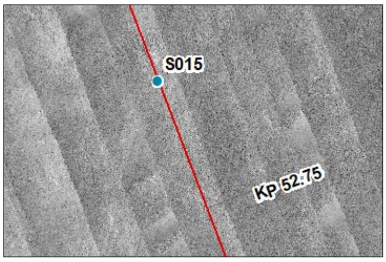
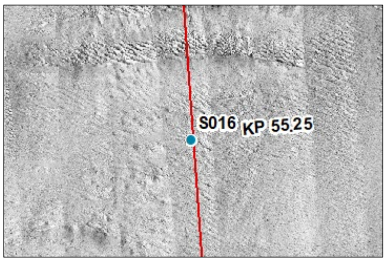
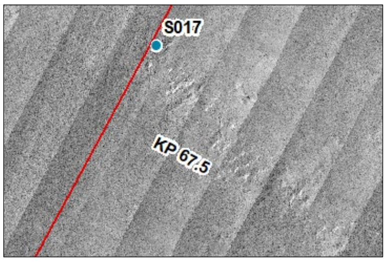
TRANSECT ID	KP	EAST START	NORTH START	EAST END	NORTH END	LENGTH (M)	SSS OVERIEW
T002	114.178	397299	5686625	397092	5686705	221	
T003	114.085	397275	5686738	397207	5686555	196	
T004	15.372	408751	5773029	408666	5772929	131	

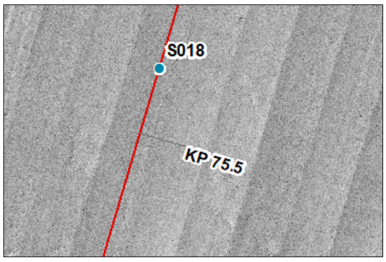
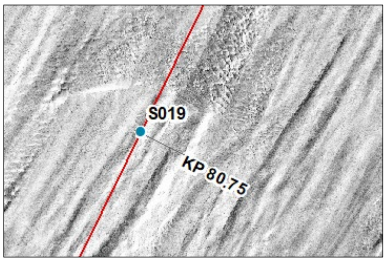
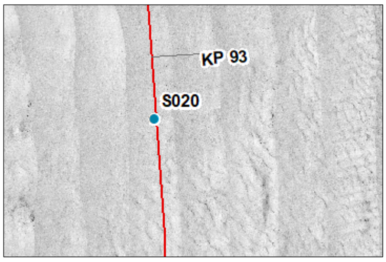
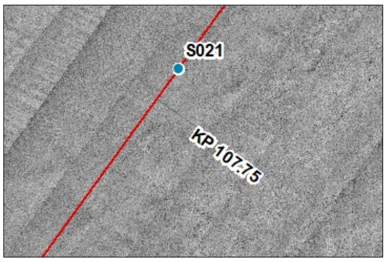
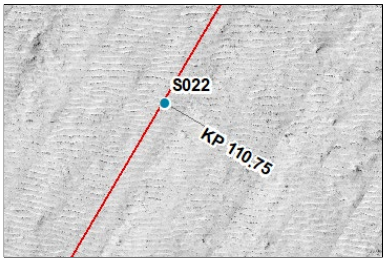
Table 27 List of performed grab samples sites.

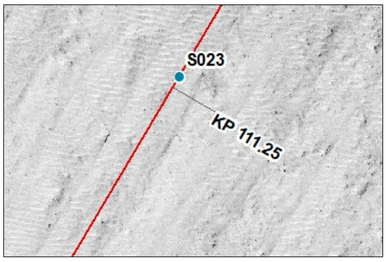
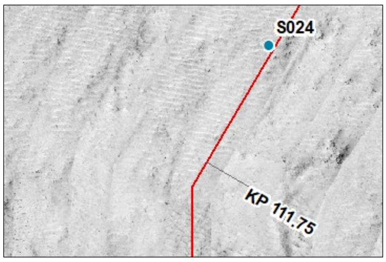
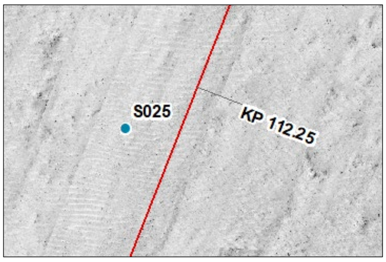
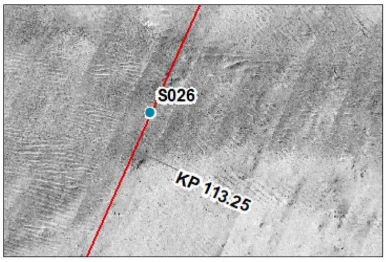
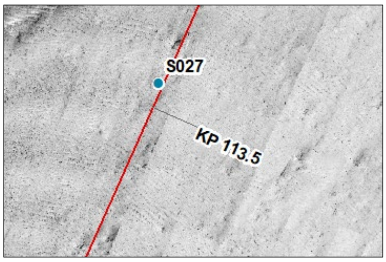
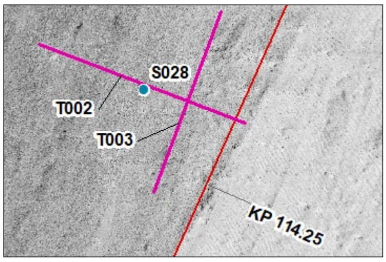
SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S001	3.548	409167	5784073	
S002	6.159	409852	5781786	

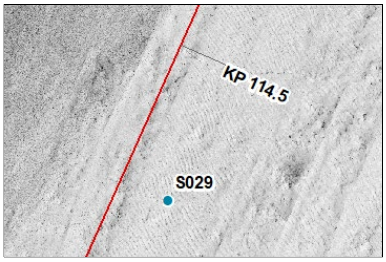
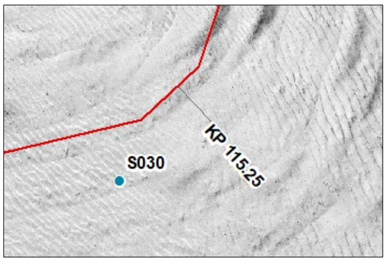
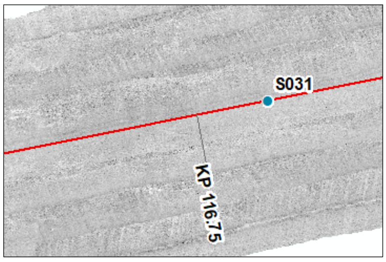
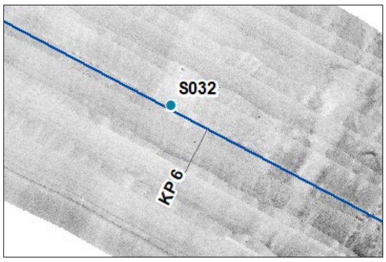
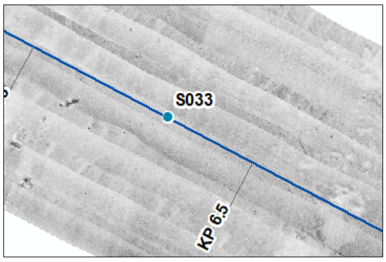
SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S003	10.373	410103	5777823	
S004	4.447	407545	5778806	
S005	3.176	408213	5777723	
S006	13.812	408998	5774570	
S007	15.390	408731	5773014	

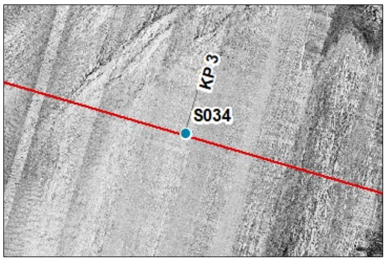
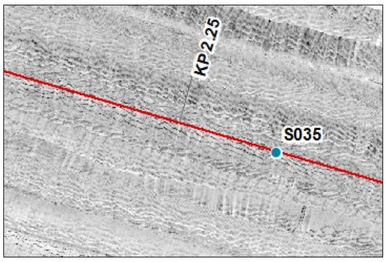
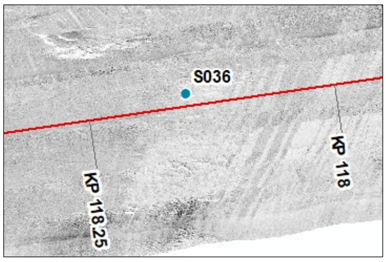
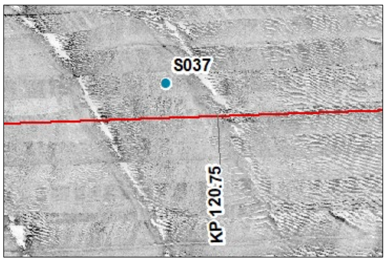
SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S008	16.713	408560	5771703	
S009	19.265	408689	5769215	
S010	22.663	408355	5765867	
S011	26.483	407229	5762253	
S012	30.318	406235	5758551	

SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S013	34.653	405797	5754346	
S014	37.003	406114	5752017	
S015	52.613	415192	5741974	
S016	55.264	415951	5739456	
S017	67.419	409899	5729858	

SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S018	75.431	406505	5722705	
S019	80.747	404659	5717737	
S020	93.062	400089	5706668	
S021	107.712	399994	5692335	
S022	110.750	398467	5689748	

SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S023	111.237	398218	5689329	
S024	111.616	398020	5689006	
S025	112.315	397783	5688366	
S026	113.208	397684	5687515	
S027	113.475	397572	5687273	
S028	114.189	397198	5686659	

SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S029	114.648	397146	5686179	
S030	115.335	396985	5685537	
S031	116.676	395685	5685228	
S032	6.043	406388	5779865	
S033	6.597	405897	5780121	

SITE ID	KP	EASTING	NORTHING	SSS OVERIEW
S034	3.001	408670	5784321	
S035	2.353	408048	5784501	
S036	118.149	394235	5684974	
S037	120.801	391591	5684847	

5.1| SUMMARY OF IDENTIFIED HABITATS

A total of 26 EUNIS habitats, including six (6) habitat complexes, are indicated to be present within the survey corridor (Table 28). One habitat of conservation importance, **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time, was identified within the survey corridor.

The ID column defines the colour in the GIS charts for the specific habitat type.

Table 28 Habitat description.

ID	HABITAT CLASSIFICATION	HABITAT CODE	SITE ID
	Communities on soft circalittoral rock	A4.23	T001, T001A & T004
	Communities on soft circalittoral rock/ Circalittoral mixed sediments	A4.23/ A5.44	S017

ID	HABITAT CLASSIFICATION	HABITAT CODE	SITE ID
	Infralittoral coarse sediment	A5.13	-
	Circalittoral coarse sediment	A5.14	-
	Circalittoral coarse sediment/ Circalittoral mixed sediments	A5.14/ A5.44	S019
	Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles	A5.141	S031
	Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles/ Circalittoral coarse sediment	A5.141/ A5.14	S036
	Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles/ Circalittoral mixed sediments	A5.141/ A5.44	S021
	Mediomastus fragilis, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel	A5.142	S015
	Infralittoral fine sand	A5.23	-
	Infralittoral mobile clean sand with sparse fauna	A5.231	S035
	Nephtys cirrosa and *Bathyporeia* spp. in infralittoral sand	A5.233	S022, S023, S024, S025, S027, S029 & S030
	Infralittoral muddy sand	A5.24	-
	Circalittoral fine sand	A5.25	S012 & S016
	Circalittoral muddy sand	A5.26	S001, S004, S014 & S020
	Abra alba and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	A5.261	S003 & S005
	Abra alba and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment/ *Ampelisca* spp., *Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud	A5.261/ A5.335	S018
	Infralittoral sandy mud	A5.33	-
	Circalittoral sandy mud	A5.35	S002
	Lagis koreni and *Phaxas pellucidus* in circalittoral sandy mud	A5.355	S032, S033 & S034
	Lagis koreni and *Phaxas pellucidus* in circalittoral sandy mud/ Circalittoral mixed sediments	A5.355/ A5.44	S013
	Circalittoral fine mud	A5.36	-
	Infralittoral mixed sediments	A5.43	S037
	Circalittoral mixed sediments	A5.44	T002, T003, S008, S010, S011, S026 & S028
	Sabellaria spinulosa on stable circalittoral mixed sediment	A5.611	S006 & S009
	Mytilus edulis beds on sublittoral sediment	A5.625	T001, T001A, T004 & S007
N/A	Sandbanks which are slightly covered by sea water all the time	Annex I (1110)	S012, S017, S021, S022, S023, S024, S025, S026 & S035

5.2| DETAILED AREA DESCRIPTIONS

5.2.1| ROUTE OVERVIEW

In shallow areas, in the northernmost sections of SWO, the seabed at KP 0.216 comprises **A5.23** - Infralittoral fine sand, followed by **A5.33** - Infralittoral sandy mud, with two potential areas of **A4.23** - Communities of soft circalittoral rock, one on each side of the centre line as well as an area of **A5.24** - Infralittoral muddy sand. These shallow habitats are interpreted based on the acquired geophysical data.

Habitat **A5.33** proceeds to an area of mobile sediment with rippled sands and sparse fauna, indicating the presence of habitat **A5.231** - Infralittoral mobile clean sand with sparse fauna. A section of this habitat, KP 1.507 to KP 2.653, is also classifieds as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time. The delineation of the **Annex I** (1110) habitat is based on the acquired geophysical data.

Following the **A5.231**, the seabed comprises alternations of **A5.26** - Circalittoral muddy sand and **A5.35** - Circalittoral sandy mud including patches of **A5.261** - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand on slightly mixed sediment in addition to **A5.355** - *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud. The alternation between **A5.26** and **A5.35** persists to approximately KP 12.330.

The seabed then transitions into coarse mixed sediments southwards, interpreted as **A5.611** - *Sabellaria spinulosa* on stable circalittoral mixed sediment, interspersed with small patches of potential **A4.23** - Communities on circalittoral soft rock, as interpreted from the geophysical data. Habitat **A5.611** continues until and beyond the intersection with the alternative landfall route option, SW, at KP 13.437.

Habitat **A5.611** continues towards the landfall along SW until KP 2.431, where the seabed composition changes and distinct eroded depressions are noted in the geophysical data. There is a similar presence of habitats compared to the nearshore sections of SWO, with alternations of **A5.26** and **A5.35,** including sections of **A5.261** and **A5.355**. Areas of potential **A4.23** are also interpreted to be present closest to shore, based on the interpretations of the geophysical data**,** surrounded by **A5.33** intermixed with streaks of **A5.43** - Infralittoral mixed sediments.

From the SWO and SW route intersection at KP 13.437, habitat **A5.611** extends further southwards before entering an area of eroded depression and mottled seabed primarily dominated by coarse or mixed sediments. From KP 14.792, the seabed comprises habitat **A5.625** - *Mytilus edulis* beds on sublittoral sediment, with interspersed patches of potential **A4.23**. The eastern section of the route corridor in this area exhibits rippled mixed sediments classified as **A5.44** - Circalittoral mixed sediment. Habitat **A5.44** extends from the easternmost route corridor boundary and inward, covering the majority of the route corridor to KP 27.812. The **A5.44** habitat is interrupted by areas of **A5.14** - Circalittoral coarse sediment with patches of **A5.35** and minor presence of potential **A4.23** and **A5.611**.

Following the end of **A5.44**, to KP 37.163, the seabed exhibits higher reflectivity and is dominated by **A5.25** and **A5.26** with one isolated area classified as **A5.355**/ **A5.44**.

From KP 37.163, coarser substrates are present, which alternate between **A5.14** and **A5.44**. A large trawl mark area is interpreted to be present within **A5.142** – *Mediomastus fragilis*, *Lumbrineris spp*. and venerid bivalves in circalittoral coarse sand or gravel, extending from KP 43.189 to KP 54.097. An initial segment of the **A5.142**, between KP 43.862 and KP 46.088, is also classified as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time.

From KP 54.643, the seabed is more heterogenous, including areas of trawl mark, ripples and mega ripples. The composition moving southwards traverses over primarily coarser material such as **A5.44** followed by **A5.25** and **A5.14** at KP 59.852, at which point the alternation comprises primarily softer sediments such as **A5.26** followed by **A5.35** and **A5.25**.

Beyond KP 65.222, the seabed is dominated by coarse sediments, primarily **A5.14** with sections of **A5.44** and scattered features of potential **A4.23** and **A4.23/ A5.44**. The seabed extending from KP 67.397 to KP 73.757 is also classified as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time. The coarse seabed is interrupted by a section of muddy mixed sediments classified as **A5.261**/ **A5.335**.

Coarse sediments prevail when moving further southwards to KP 90.905 with occasional patches of **A5.36** - Circalittoral fine mud, **A5.24,** as well as **A5.26**. The seabed between 81.887 and KP 85.301 is further classified as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time.

Habitat **A5.26** extends to KP 101.118 and transitions back into coarser substrates classified as **A5.14** followed by **A5.141** – *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles/ **A5.44**, with minor isolated features of **A4.23**.

An extensive area of mottled seabed is interpreted to be present between KP 109.842 and KP 115.642 and includes **A5.233** – *Nephtys cirrosa* and *Bathyporeia spp*. in infralittoral sand, with some patches of **A5.44** in the westernmost parts of the survey route corridor. Sections extending between KP 101.883 and KP 112.727 as well as between KP 113.128 and KP 113.301 are also classified as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time.

A large area classified as **A5.141** extends towards KP 119.847 with isolated patches of **A4.23**. The coarse and mixed seabed traverses further towards the landfall and alternates between **A5.13** – Infralittoral coarse sediment and **A5.43**, with some smaller patches of **A4.23**. Large sections of the seabed between KP 120.004 and 123.679 are also classified as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time.

5.2.2| DETAILED SITE DESCRIPTIONS

Grab sample site S035 is situated at KP 2.353, DCC 1, at a depth of 4 m (Figure 11). The sediment at the site comprised Sand with relatively sparse fauna, including amphipod *Urothoe brevicornis* and *Bathyporeia pelagica.* Substrate and faunal composition indicate the presence of **A5.231** - Infralittoral mobile clean sand with sparse fauna (Table 29). Grab sample site S035 is situated within an area further classified as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time.

Table 29 Example images from samples at S035.

Grab sample site S034 is situated at KP 3.001, DCC -3, at a depth of 13 m (Figure 11). The sediment at the site comprised sandy Mud, including the polychaete *Scalibregma inflatum*, polychaete *Notomastus* sp. and *Lagis koreni* (Table 30). Substrate and faunal composition indicate the presence of **A5.355** - *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud.

Table 30 Example images from samples at S034.

Grab sample site S032 is situated at SW KP 6.043, DCC 4, at a depth of 9 m (Figure 11). The sediment at the site comprised muddy Sand with polychaetes *S. bombyx* and *L. koreni*, and bivalve *N. nitidosa*. Substrate and faunal composition indicate the presence of **A5.355** - *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud (Table 31).

Table 31 Example images from samples at S032.

Grab sample site S033 is situated at SW KP 6.597, DCC 1, at a depth of 8 m (Figure 11). The sediment at the site comprised muddy Sand with polychaetes *S. bombyx* and *L. koreni*, bivalves *Limecola balthica*, and abundant juvenile *Ensis* sp., polychaetes in the genus *Nephtys* and taxa of the bivalve family Nuculidae including *N. nitidosa*. Substrate and faunal composition indicate the presence of **A5.355** - *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud (Table 32).

Table 32 Example images from samples at S033.

Grab sample site S001 is situated at KP 3.548, DCC 95, at a depth of 15 m (Figure 11). The sediment at the site comprised muddy Sand heavily dominated by the polychaete *S. inflatum*, the polychaete *Notomastus* sp. and amphipod *Corophium volutator*. Substrate and faunal composition indicate the presence of **A5.26** - Circalittoral muddy sand (Table 33).

Table 33 Example images from samples at S001.

Grab sample site S002 is situated at KP 6.159, DCC 23, at a depth of 18 m (Figure 11). The sediment at the site comprised sandy Mud heavily dominated by the amphipod *C. volutator,* the polychaetes *S. inflatum* and *Notomastus* sp., as well as juvenile white piddocks *Barnea candida*. Substrate and faunal composition indicate the presence of **A5.35** - Circalittoral sandy mud (Table 34).

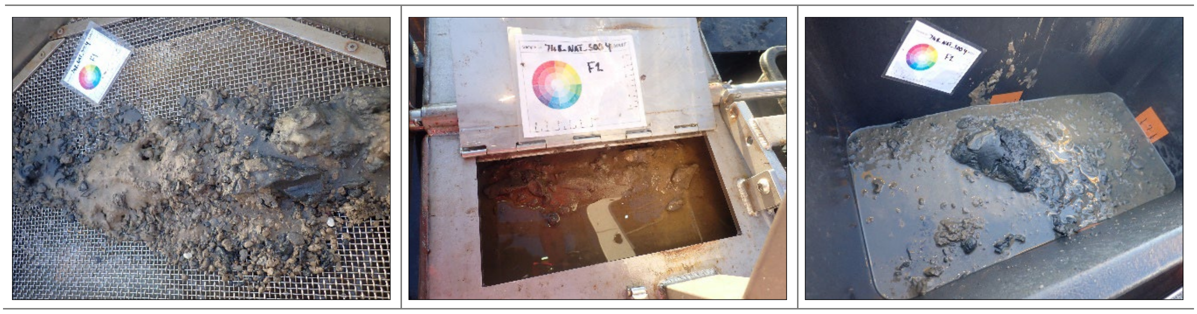
Table 34 Example images from samples at S002.

Grab sample site S003 is situated at KP 10.373, DCC -1, at a depth of 22 m (Figure 11). The sediment at the site comprised sandy Mud dominated by the polychaete *S. inflatum*, with polychaetes *Spiophanes bombyx* and *L. koreni,* as well as the bivalves *Nucula nitidosa* and *Abra alba* present. The faunal composition indicates the presence of **A5.261** - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (Table 35).

Table 35 Example images from samples at S003.

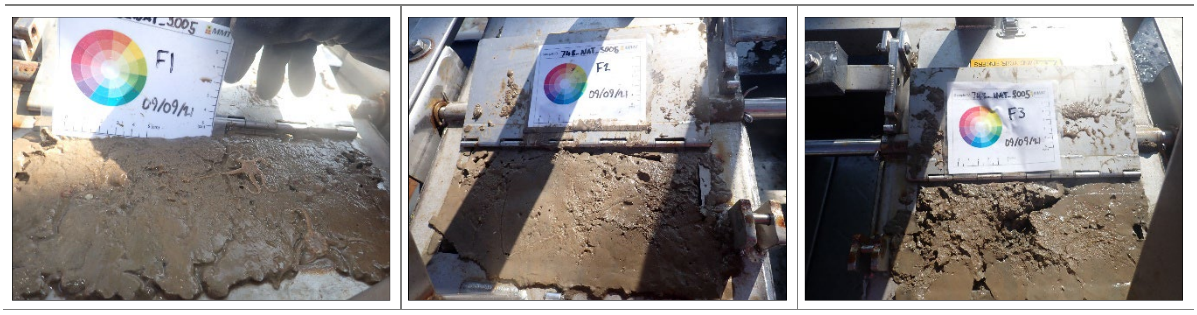
Grab sample site S004 is situated at SW KP 4.447, DCC 0, at a depth of 13 m (Figure 11). The sediment at the site comprised Sand heavily dominated by the polychaete *S. inflatum*. Substrate and faunal composition indicate the presence of **A5.26** (Table 36).

Table 36 Example images from samples at S004.



Grab sample site S005 is situated at SW KP 3.176, DCC 51, at a depth of 20 m (Figure 11). The sediment at the site comprised muddy Sand dominated by the polychaete *S. inflatum* with polychaete *Nephtys* spp. and bivalves *A. alba, Kurtiella bidentata* and *N. nitidosa* are also present. Substrate and faunal composition indicate the presence of **A5.261** - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (Table 37).

Table 37 Example images from samples at S005.



Grab sample site S006 is situated at KP 13.812, DCC 2, at a depth of 19 m (Figure 11). The sediment at the site comprised muddy sandy Gravel dominated by Actinaria, juvenile *Mytilus edulis*, and polychaete *Sabellaria spinulosa*. Furthermore, Nematoda, the polychaetes *Aphelochaeta marioni* and *L. koreni*, the amphipods *Unciola crenatipalma*, *Ampelisca spinipes* and juvenile *Ampelisca* sp., bivalve *A. alba* and juvenile brittle stars Ophiuridae were also present. Substrate and faunal composition indicate the presence of **A5.611** - *Sabellaria spinulosa* on stable circalittoral mixed sediment (Table 38).

Table 38 Example images from samples at S006.

Grab sample site S007 is situated at KP 15.390, DCC -2, at a depth of 19 m (Figure 11). At grab sample site S007, only two fauna replicates were acquired, thus no PSA was analysed for S007. The fauna is dominated by dense aggregations of blue mussels *M. edulis*, Nematoda, Actiniaria and the polychaete *S. spinulosa*. Polychaetes *L. koreni*, *S. inflatum*, juvenile Maldanidae, *Notomastus* sp. and *Pholoe inornate*, as well as bivalve *A. alba*, brittle stars *Amphipholis squamata* and juvenile Ophiuridae and sea squirts Ascidiacea, were also present. The faunal composition indicates the presence of **A5.625** - *Mytilus edulis* beds on sublittoral sediment (Table 39).

Table 39 Example images from samples at S007.

Transect T001 extends from KP 15.399, DCC -48, and KP 15.437, DCC 66. The depth ranges from 17 to 19 m along the 120 m transect. The visibility was poor along the transect due to suspended sediment and organic material, and no fauna could be visually identified.

Transect T001A extends from KP 15.398, DCC -45, and KP 15.436, DCC 53 and is located parallel to T001. The depth ranges from 17 to 19 m along the 105 m transect. The visibility was poor along the transect due to suspended sediment and organic material, and no fauna could be visually identified.

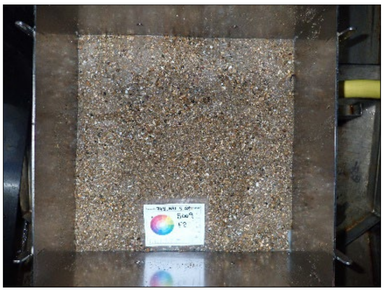
Transect T004 extends from KP 15.372, DCC -19, and KP 15.485, DCC 47, crossing transects T001 and T001A. The depth ranges from 17-19 m along the 131 m transect. The visibility was poor along the transect due to suspended sediment and organic material. Minor *S. spinulosa* tubes were observed, and a reef assessment *sensu* (Jenkins, Eggleton, Barry, & O'Connor, 2018) was performed, and three patches of 'low reef' were observed, see 5.10.4| for full assessment and details. Further, the bryozoan *Flustra foliacea*, sea stars Asteroidea and brittle stars Ophiurida were also observed.

Grab sample site S008 is situated at KP 16.713, DCC -5, at a depth of 19 m (Figure 11). The sediment at the site comprised muddy sandy Gravel, and the most abundant fauna in the samples were juvenile blue mussels *M. edulis*. Substrate and faunal composition indicate the presence of **A5.44** - Circalittoral mixed sediments (Table 40).

Table 40 Example images from samples at S008.

Grab sample site S009 is situated at KP 19.265, DCC -2, at a depth of 19 m (Figure 11). The sediment at the site comprised muddy sandy Gravel and is dominated by the polychaete *S. spinulosa* with juvenile blue mussels *M. edulis* and juvenile brittle stars Ophiuridae. Further, Actiniaria, Nematoda, the polychaetes *Harmothoe impar, Eulalia aurea, Exogone verugera, Leiochone* sp., *Praxillella affinis*, and *L. koreni*, the amphipods *A. spinipes, Photis longicaudata*, cumacean *Bodotria scorpioides*, bivalves *K. bidentata, A. alba* as well as juvenile sea squirts Ascidiacea were present. Substrate and faunal composition indicate the presence of **A5.611** - *Sabellaria spinulosa* on stable circalittoral mixed sediment (Table 41).

Table 41 Example images from samples at S009.

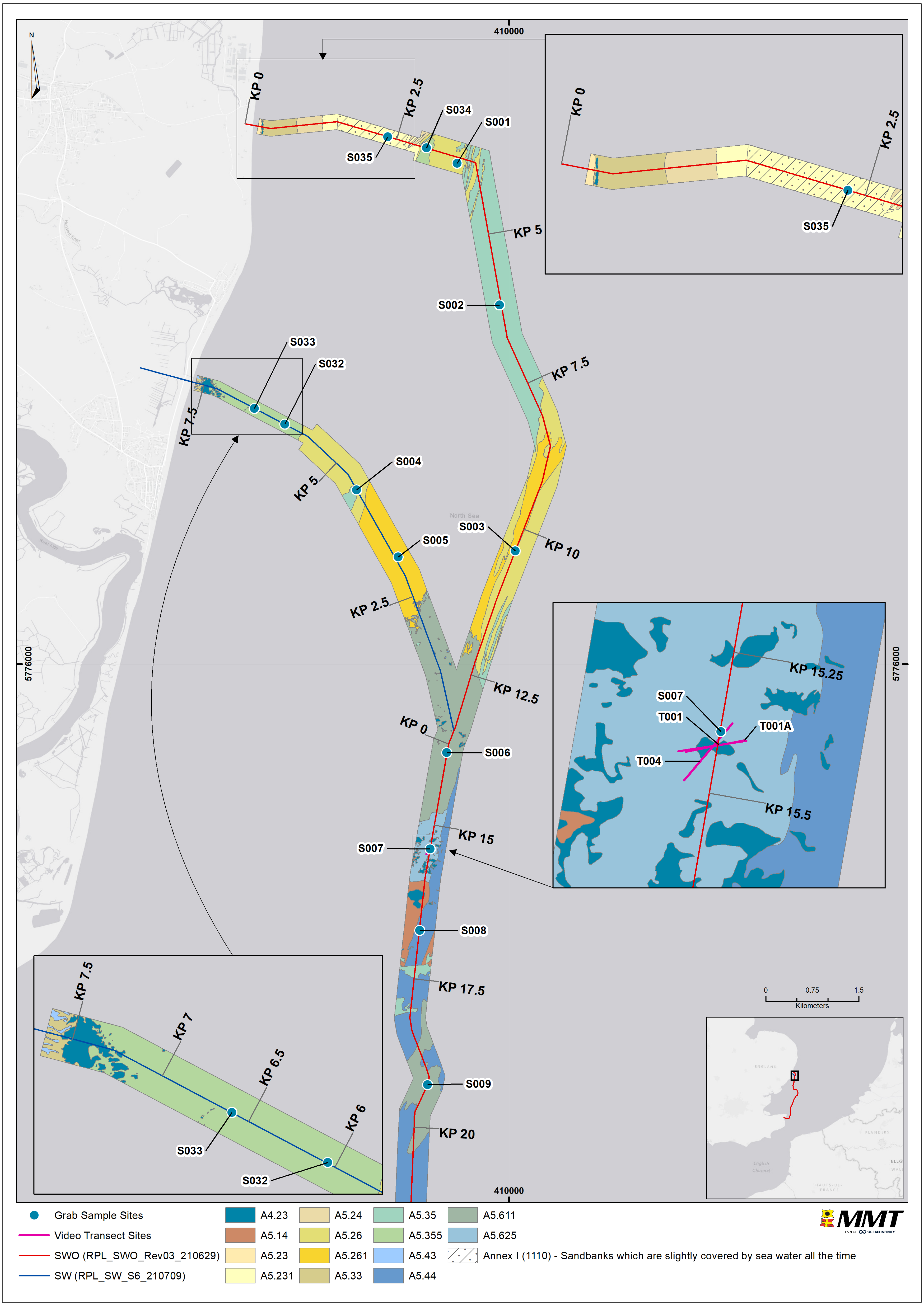
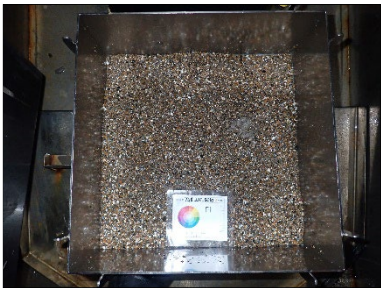


Figure 11 Overview of habitats between SWO KP 0.000 – KP 21.207, SW KP 0.000 – KP 8.563.

Grab sample site S010 is situated at KP 22.663, DCC 1, at a depth of 24 m (Figure 12). The sediment at the site comprised muddy sandy Gravel with Actiniaria, polychaetes *Lumbrineris cingulate, Aphelochaeta marioni* and *L. koreni*, amphipods *A. spinipes* and *P. longicaudata*, Copepoda, and the bivalve *A. alba* and juvenile blue mussels *M. edulis*. Substrate and faunal composition indicate the presence of **A5.44** - Circalittoral mixed sediments (Table 42).

Table 42 Example images from samples at S010.

Grab sample site S011 is situated at KP 26.483, DCC 1, at a depth of 21 m (Figure 12). The sediment at the site comprised muddy sandy Gravel with ribbon worms Nemertea, polychaetes *S. bombyx, L. koreni* and *Ampharete lindstroemi*, amphipod *A. spinipes*, bivalve *A. alba* and juvenile blue mussels *M. edulis,* as well as Brittle stars *Ophiura albida* and juvenile Ophiuridae. Substrate and faunal composition indicate the presence of **A5.44** - Circalittoral mixed sediments (Table 43).

Table 43 Example images from samples at S011.

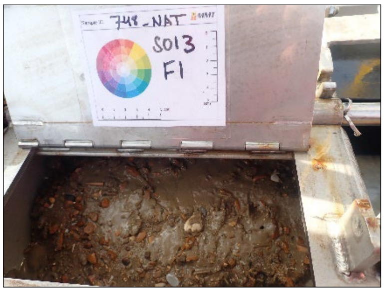
Grab sample site S012 is situated at KP 30.318, DCC 0, at a depth of 19 m (Figure 12). The sediment at the site comprised muddy Sand with a relatively sparse fauna dominated by the polychaete *Magelona johnstoni*. Substrate and faunal composition indicate the presence of **A5.25** - Circalittoral fine sand (Table 44).

Table 44 Example images from samples at S012.

Grab sample site S013 is situated at KP 34.653, DCC -1, at a depth of 23 m (Figure 12). The sediment at the site comprised gravelly muddy Sand dominated by the polychaete *L. koreni* with ribbon worms Nermertea, polychaetes *Eunereis longissimi, Notomastus* sp. and *S. spinulosa.* Present are also bivalves *K. bidentata, A. alba* and juvenile blue mussels *M. edulis.* Substrate and faunal composition indicate the presence of **A5.355** - *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud/ **A5.44** - Circalittoral mixed sediments (Table 45).

Table 45 Example images from samples at S013.

Grab sample site S014 is situated at KP 37.003, DCC -1, at a depth of 22 m (Figure 12). The sediment at the site comprised Sand with relatively sparse fauna, including bivalve *K. bidentata* and *Goodallia triangularis*. Substrate and faunal composition indicate the presence of **A5.26** - Circalittoral muddy sand (Table 46).

Table 46 Example images from samples at S014.

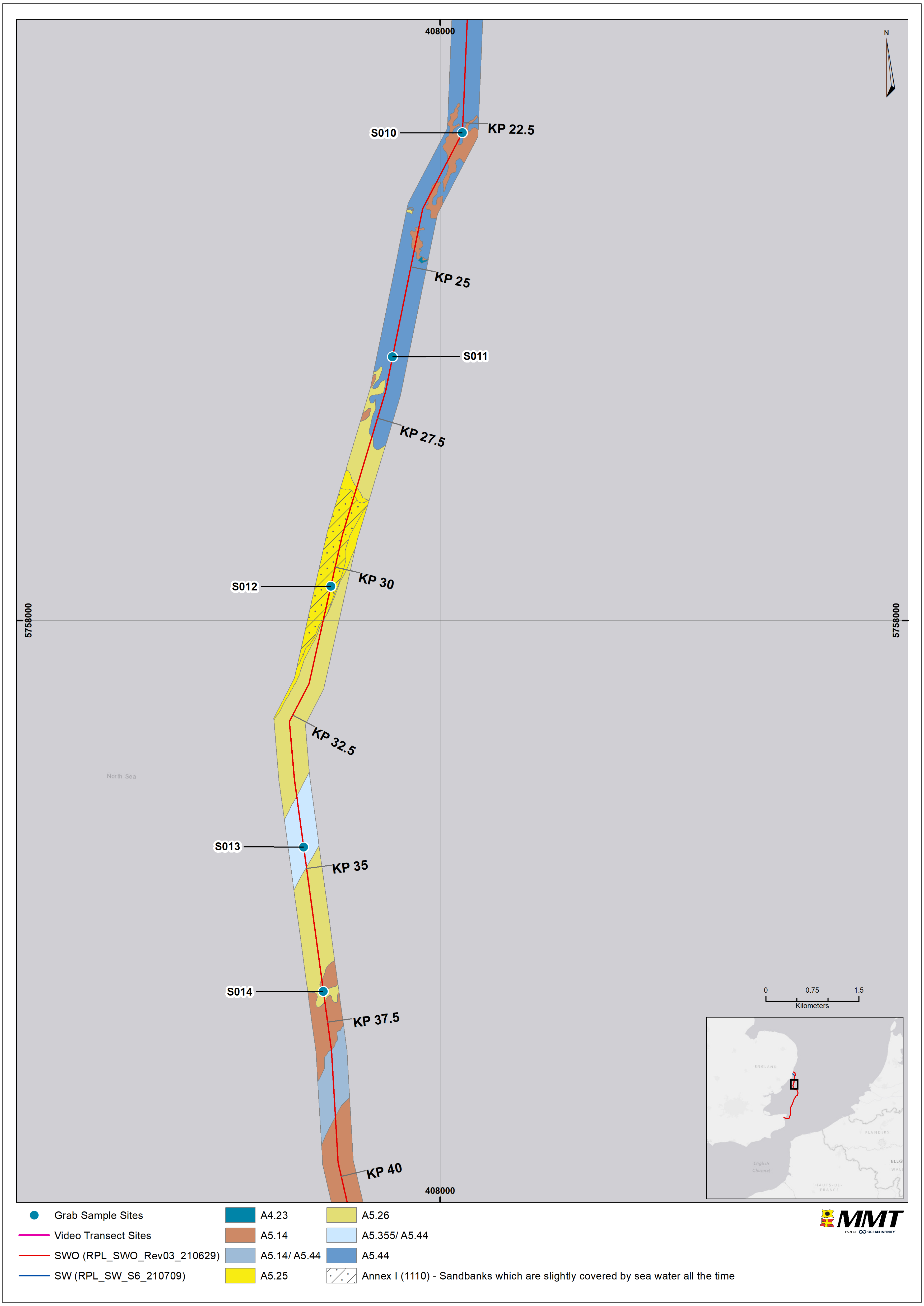


Figure 12 Overview of habitats between SWO KP 20.851 – KP 40.430.

Grab sample site S015 is situated at KP 52.613, DCC 1, at a depth of 46 m (Figure 13). The sediment at the site comprised muddy sandy Gravel relatively sparse fauna, including Nematoda, polychaete *Paradoneis lyra*, *M. fragilis*, *L. cingulata* and bivalve *K. bidentata*. Substrate and faunal composition indicate the presence of **A5.142** - *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel (Table 47).

Table 47 Example images from samples at S015.



Grab sample site S016 is situated at KP 55.264, DCC 2, at a depth of 27 m (Figure 13). The sediment at the site comprised Sand with sparse fauna, including low abundances of *M. edulis*, *G. triangularis* and *Asbjornsenia pygmaea* with polychaete *Hesionura elongate*, *Glycera lapidum* and *L. cingulata*. Hermit crabs Paguridae and swimming crabs Portunidae were observed in the seabed imagery acquired at the site. Substrate and faunal composition indicate the presence of **A5.25** - Circalittoral fine sand (Table 48).

Table 48 Example images from samples at S016.



Grab sample site S017 is situated at KP 67.419, DCC -6, at a depth of 20 m (Figure 13). The sediment at the site comprised muddy sandy Gravel, including the amphipod *A. spinipes* and juvenile blue mussels *M. edulis*. Substrate and faunal composition indicate the presence of **A5.44** - Circalittoral mixed sediments (Table 49). The geophysical data indicates that S017 is located at the edge of a feature comprising clays, potentially further indicating the presence of **A4.23** - Communities on soft circalittoral rock.

Table 49 Example images from samples at S017.



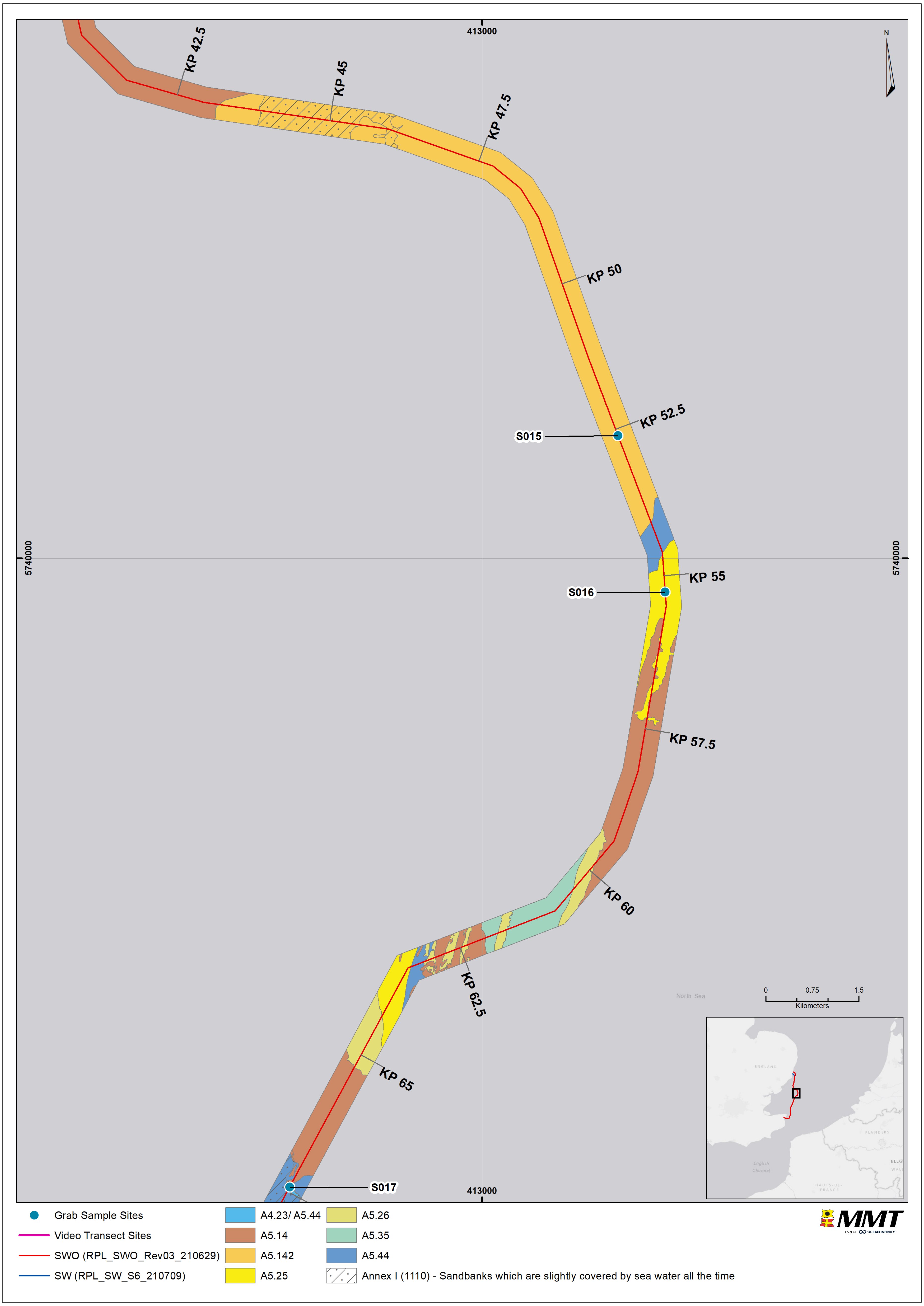


Figure 13 Overview of habitats between SWO KP 40.378 – KP 67.689.

Grab sample site S018 is situated at KP 75.431, DCC -1, at a depth of 21 m (Figure 14). The sediment at the site comprised muddy sandy Gravel dominated by polychaete *L. koreni* and bivalve *K. bidentata*. Additional common taxa identified were Nematoda, Polychaetes *Pholoe baltica, L. cingulata, S. bombyx, Chaetozone zetlandica* and *A. lindstroemi*, amphipods *A. spinipes* and *P. longicaudata*, bivalve *A. alba* and brittle star *O. albida* were. Substrate and faunal composition indicate the presence of a habitat complex between **A5.261** - *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment/ **A5.335** - *Ampelisca* spp., *Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud (Table 50). Habitat **A5.335** is considered to be a part of a wider muddy sand community that varies depending on sedimentation and recruitment and has been reported in the Irish Sea to be a temporal variant of **A5.261**.

Table 50 Example images from samples at S018.

Grab sample site S019 is situated at KP 80.747, DCC 1, at a depth of 26 m (Figure 14). The sediment at the site comprised gravelly Sand with polychaetes *S. bombyx* and *S. spinulosa,* and bivalve *K. bidentata* are the most abundant taxa. Substrate and faunal composition indicate the presence of **A5.14** - Circalittoral coarse sediment/ **A5.44** - Circalittoral mixed sediments (Table 51).

Table 51 Example images from samples at S019.

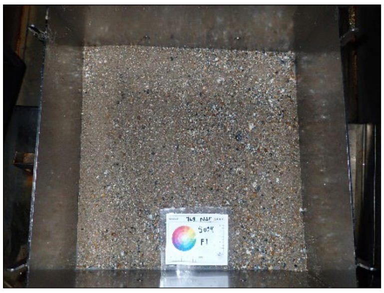
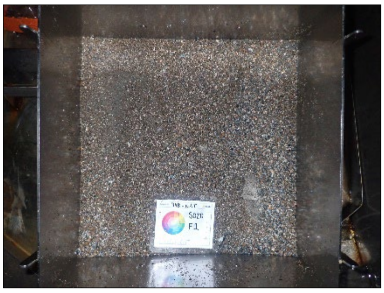
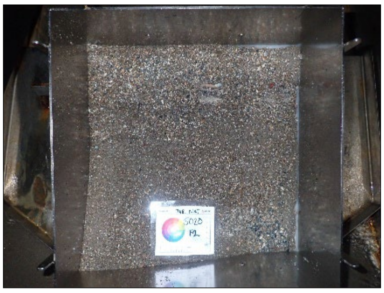
		

Figure 14 Overview of habitats between SWO KP 67.566 and KP 88.634.

Grab sample site S020 is situated at KP 93.062, DCC 1, at a depth of 21 m (Figure 15). The sediment at the site comprised Sand with polychaete *Aricidea minuta*, Nephtys, *L. koreni* and bivalve *A. alba* were the most abundant taxa. Substrate and faunal composition indicate the presence of **A5.26** - Circalittoral muddy sand (Table 52).

Table 52 Example images from samples at S020.

Grab sample site S021 is situated at KP 107.712, DCC 0, at a depth of 14 m (Figure 15). The sediment at the site comprised muddy sandy Gravel with polychaetes *L. koreni, S. spinulosa, A. lindstroemi* and Serpulidae, including *Spirobranchus lamarcki*, Copepoda, amphipods *P. longicaudata* and *Ericthonius punctatus*, bivalve *A. alba*, juvenile blue mussels *M. edulis* and brittle star *A. squamata*. In the seabed imagery acquired, sea urchins Echinoidea and hermit crabs Paguridae were observed. Substrate and faunal composition indicate the presence of **A5.141** - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles/ **A5.44** - Circalittoral mixed sediments (Table 53).

Table 53 Example images from samples at S021.

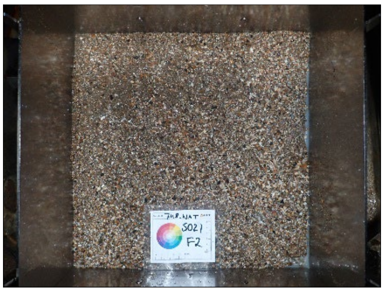
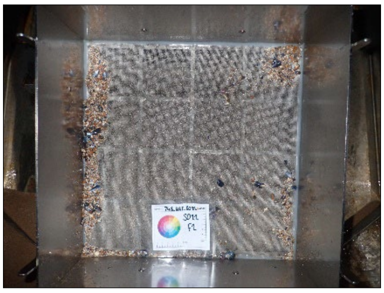
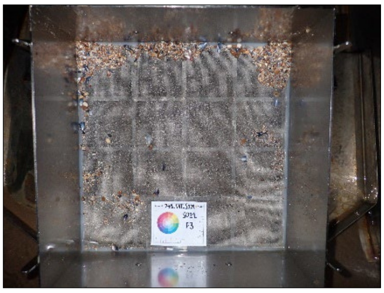
		

Figure 15 Overview of habitats between SWO KP 88.397 and 108.371.

Grab sample site S022 is situated at KP 110.750, DCC -2, at a depth of 10 m (Figure 16). The sediment at the site comprised Sand with the amphipods *U. brevicornis* and *B. pelagica* and juvenile blue mussels *M. edulis* as the most abundant taxa. Substrate and faunal composition indicate the presence of **A5.233** - *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (Table 54).

Table 54 Example images from samples at S022.

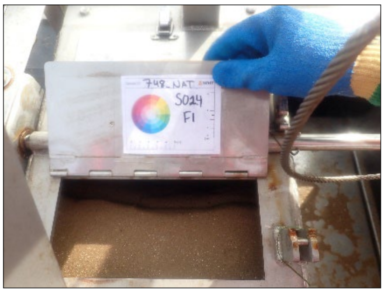




Grab sample site S023 is situated at KP 111.237, DCC -1, at a depth of 10 m (Figure 16). The sediment at the site comprised Sand dominated by amphipod *B. pelagica*. Substrate and faunal composition indicate the presence of **A5.233** - *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (Table 55).

Table 55 Example images from samples at S023.


Grab sample site S024 is situated at KP 111.616, DCC 6, at a depth of 10 m (Figure 16). The sediment at the site comprised Sand with relatively sparse fauna. Only the amphipod *U. brevicornis* and juvenile blue mussels *M. edulis* were identified as commonly occurring. Substrate and faunal composition indicate the presence of **A5.233** - *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (Table 56).

Table 56 Example images from samples at S024.




Grab sample site S025 is situated at KP 112.315, DCC 51, at a depth of 11 m (Figure 16). The sediment at the site comprised Sand with relatively sparse fauna. Only the amphipod *U. brevicornis* and juvenile blue mussels *M. edulis* were identified as commonly occurring. Substrate and faunal composition indicate the presence of **A5.233** - *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (Table 57).

Table 57 Example images from samples at S025.

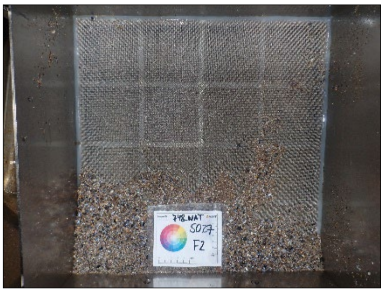
Grab sample site S026 is situated at KP 113.208, DCC 1, at a depth of 10 m (Figure 16). The sediment at the site comprised gravelly Sand with fauna heavily dominated by juvenile blue mussels *M. edulis*. Substrate and faunal composition indicate the presence of **A5.44** - Circalittoral mixed sediments (Table 58).

Table 58 Example images from samples at S026.

Grab sample site S027 is situated at KP 113.475, DCC 4, at a depth of 12 m (Figure 16). The sediment at the site comprised Sand dominated by juvenile blue mussels *M. edulis* and the amphipod *B. pelagica*. Substrate and faunal composition indicate the presence of **A5.233** - *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (Table 59).

Table 59 Example images from samples at S027.

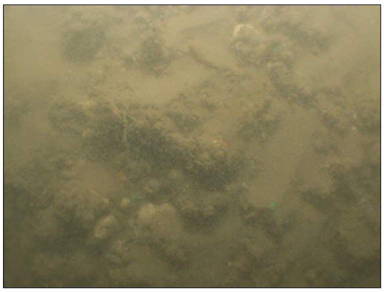
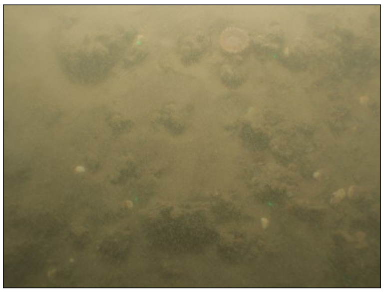
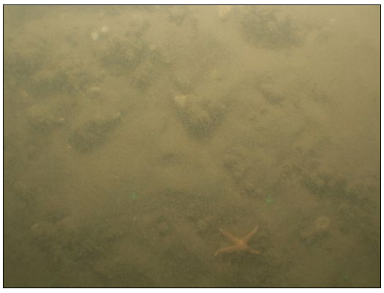
		

Transect T003 extends for 196 m between KP 114.085, DCC 58, and KP 114.280, DCC 45, at a depth of 12 m (Figure 16). The visibility was poor along the transect due to suspended sediment and organic material.

Transect T002 extends for 221 m between KP 114.178, DCC -10, and KP 114.190, DCC 211, at a depth of 11-12 m (Figure 16). The visibility was poor along the transect due to suspended sediment and organic material. For large parts of the transect, the seabed was not visible. However, in the sections with some visibility, sea squirts, possibly *Molgula* sp., were observed in large numbers, hydrozoan turfs and the bryozoan *F. foliacea* were also observed.

Grab sample site S028 is situated at KP 114.189, DCC 96, at a depth of 12 m (Figure 16). No grab sampling was performed at site S028 due to the potential presence of habitats of conservation importance. The seabed imagery details a seabed with boulders and cobbles mixed with fine muddy sediment that partly covers the coarser sediment. Large numbers of sea squirts *Molgula* sp. as well as Actinaria, hydrozoan *Nemertesia antennina*, sea stars *Asterias rubens* and bryozoan *Alcyonidium diaphanum* were noted (Table 60). The imagery indicates the presence of **A5.44** - Circalittoral mixed sediments and includes transects T002 and T003.

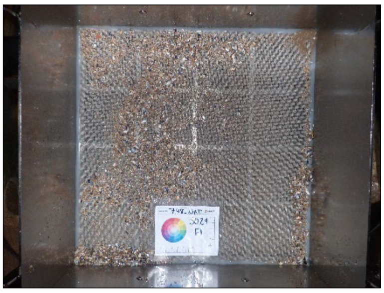
Table 60 Example images from site S028.

Grab sample site S029 is situated at KP 114.648, DCC -53, at a depth of 13 m (Figure 16). The sediment at the site comprised Sand dominated by juvenile blue mussels *M. edulis*, amphipod *U. brevicornis, N. cirrosa*, *B. pelagica*. Substrate and faunal composition indicate the presence of **A5.233** - *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (Table 61).

Table 61 Example images from samples at S029.





Grab sample site S030 is situated at KP 115.335, DCC -55, at a depth of 12 m (Figure 16). The sediment at the site comprised Sand with sparse fauna dominated by *N. cirrosa*, *B. pelagica*, amphipod *Jassa spp.*, *U. brevicornis* and the long-clawed porcelain crab *Pisidia longicornis*. Substrate and faunal composition indicate the presence of **A5.233** - *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (Table 62).

Table 62 Example images from samples at S030.

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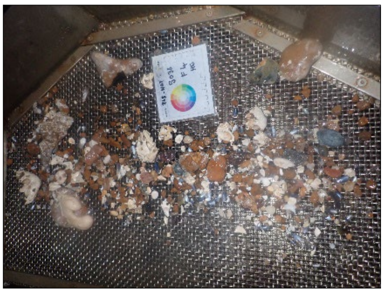
Grab sample site S031 is situated at KP 116.676, DCC 0, at a depth of 10 m (Figure 16). No PSA sample was obtained at site S031, and only two faunal sample replicates were obtained, however, with insufficient sample volume. The samples were dominated by the amphipod *Jassa* spp., including *Jassa herdmani,* juvenile blue mussels *M. edulis,* and the long-clawed porcelain crab *P. longicornis*. Further identified are Nematoda, polychaetes *H. impar, P. inornate, S. spinulosa* and Serpulidae, including *S. lamarcki*, sea spider *Achelia echinate,* barnacle *Verruca stroemia*, amphipod *Gammaropsis maculata*, isopod *Anthura gracilis*, gastropod *Odostomia turrita*, brittle star *A. squamata* and juvenile sea squirts Ascidiacea. Substrate and faunal composition indicate the presence of **A5.141** - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles (Table 63).

Table 63 Example images from samples at S031.

Grab sample site S036 is situated at KP 118.149, DCC 12, at a depth of 10 m (Figure 16). The sediment at the site comprised sandy Gravel dominated by juvenile blue mussels *M. edulis*, Actiniaria, Nematoda, polychaete *S. spinulosa*, barnacles Sessilia and *Balanus crenatus*. Substrate and faunal composition indicate the presence of **A5.141** - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles/ **A5.14** - Circalittoral coarse sediment (Table 64).

Table 64 Example images from samples at S036.

Grab sample site S037 is situated at KP 120.801, DCC 35, at a depth of 8 m (Figure 16). The sediment at the site comprised gravelly Sand with Nematoda, barnacle *B. crenatus*, ghost shrimp *Pariambus typicus,* gastropod *Brachystomia scalaris*, blue mussels *M. edulis,* sea squirts *Molgula* sp. and juvenile Ascidiacea. Substrate and faunal composition indicate the presence of **A5.43** - Infralittoral mixed sediments (Table 65).

Table 65 Example images from samples at S037.

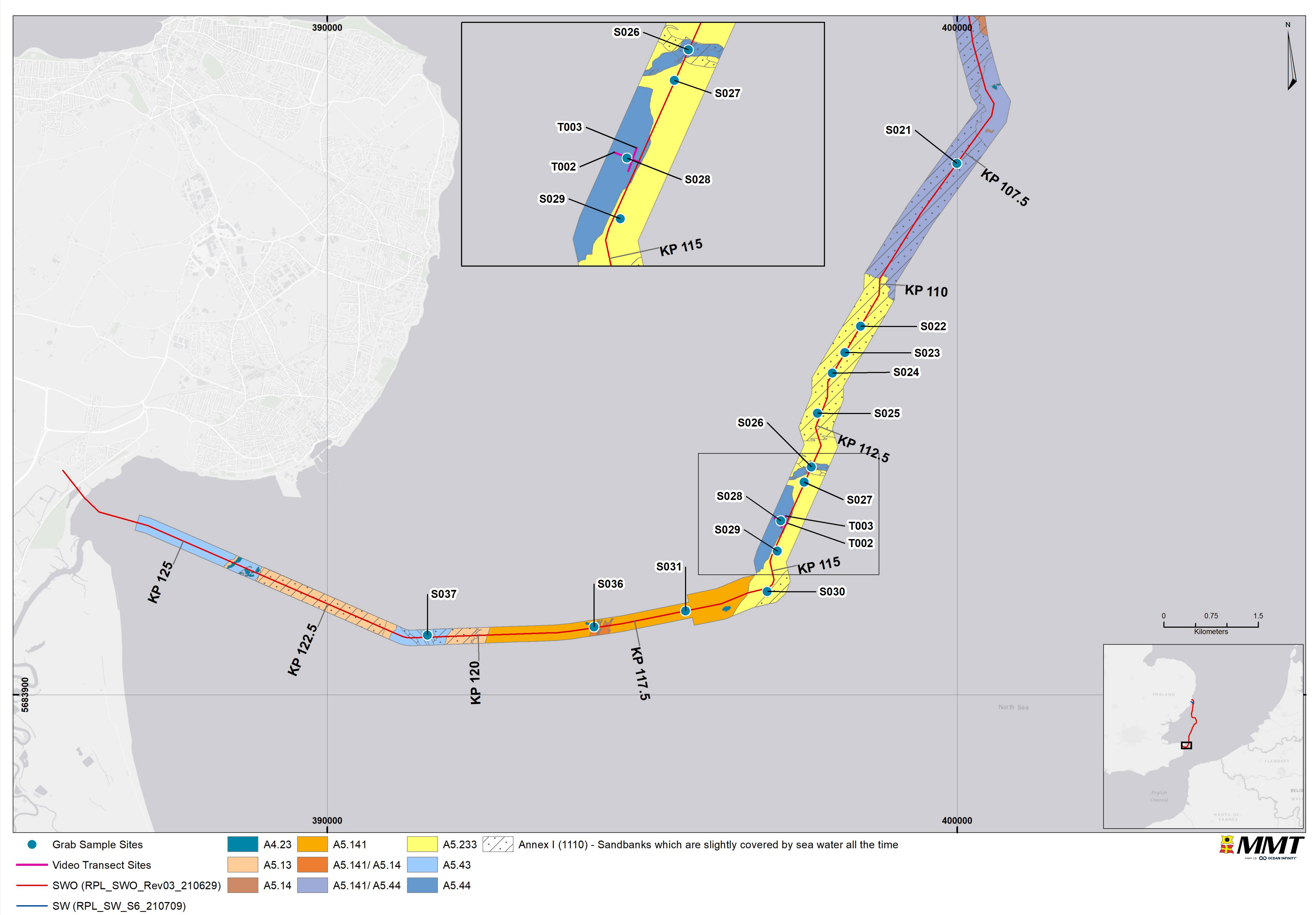


Figure 16 Overview of habitats between SWO KP 105.142 and KP 127.298.

5.3| CTD

A CTD profile was recorded at each of the 37 grab sampling sites. The results presented various levels of salinity between 33.8-34.8 (PSU), density between 1024.4-1025.6 (Kg/m^3) and temperature between 16.0-18.8 (°C) (Table 66). The salinity, temperature and density plotted profiles are presented in detail in Appendix I| with positions detailed in Appendix A|.

Table 66 Summary of CTD profiles results.

SALINITY (PSU)		DENSITY (KG/M^3)		TEMPERATURE (°C)	
MIN	MAX	MIN	MAX	MIN	MAX
33.8	34.8	1024.2	1025.6	16.0	18.8

5.4| PARTICLE SIZE DISTRIBUTION

Thirty-seven (37) grab sample sites were selected for Particle Size Analysis (PSA). No sample for PSA analysis was acquired for sites S007 and S028 due to the potential presence of habitats of conservation importance, nor from site S031 due to coarse sediment. Detailed results from the PSA analysis are stated in Appendix F|.

The result from the PSA shows that the sediment composition varied across the survey area, with sand being the dominating sediment class with a mean of 66.5% (SD=24.1). This was followed by gravel with 15.1 % (SD=19.9), silt with 11.8% (SD=10.6) and clay with 6.6% (SD=8.7) (Table 67, Figure 17). The particle size distribution is further illustrated spatially in Figure 18, with size based on sand content.

Out of the 34 sites where PSA samples were collected, 12 are classified as Sand, nine (9) as muddy sandy Gravel, five (5) as muddy Sand, three (3) as sandy Mud, three (3) as gravelly Sand, one (1) as sandy Gravel and one (1) as gravelly muddy Sand (Table 67).

Table 67 Summary of PSA results for grab sample sites.

GRAB SAMPLE ID	DEPTH (M)	SEDIMENT FRACTION (%)				MUD (%) (SILT + CLAY)	FOLK CLASSIFICATION
		GRAVEL	SAND	SILT	CLAY		
S001	15	0	56	25	19	44	muddy Sand
S002	18	1	28	40	31	71	sandy Mud
S003	22	0	45	32	23	55	sandy Mud
S004	13	0	94	5	1	6	Sand
S005	20	0	58	24	18	42	muddy Sand
S006	19	44	44	8	4	12	muddy sandy Gravel
S008	19	52	29	13	6	19	muddy sandy Gravel
S009	19	48	44	6	2	8	muddy sandy Gravel
S010	24	45	38	11	6	17	muddy sandy Gravel
S011	21	48	38	9	5	14	muddy sandy Gravel
S012	19	0	83	15	2	17	muddy Sand
S013	23	17	45	23	15	38	gravelly muddy Sand
S014	22	2	92	5	1	6	Sand

GRAB SAMPLE ID	DEPTH (M)	SEDIMENT FRACTION (%)				MUD (%) (SILT + CLAY)	FOLK CLASSIFICATION
		GRAVEL	SAND	SILT	CLAY		
S015	46	31	53	11	5	16	muddy sandy Gravel
S016	27	2	91	6	1	7	Sand
S017	20	42	45	8	5	13	muddy sandy Gravel
S018	21	40	43	11	6	17	muddy sandy Gravel
S019	26	12	81	6	1	7	gravelly Sand
S020	21	1	90	8	1	9	Sand
S021	14	46	45	6	3	9	muddy sandy Gravel
S022	10	0	94	5	1	6	Sand
S023	10	0	98	2	0	2	Sand
S024	10	0	94	5	1	6	Sand
S025	11	0	97	2	1	3	Sand
S026	10	12	85	2	1	3	gravelly Sand
S027	12	2	84	11	3	14	Sand
S029	13	0	97	3	0	3	Sand
S030	12	0	95	5	0	5	Sand
S032	9	0	51	29	20	49	muddy Sand
S033	8	0	56	25	19	44	muddy Sand
S034	13	0	42	34	24	58	sandy Mud
S035	4	0	96	3	1	4	Sand
S036	10	44	54	2	0	2	sandy Gravel
S037	8	24	76	0	0	0	gravelly Sand
Mean		15.1	66.5	11.8	6.6	18.4	
SD		19.9	24.1	10.6	8.7	19.2	
Min		0.0	28.0	0.0	0.0	0.0	
Max		52.0	98.0	40.0	31.0	71.0	
Median		1.5	57.0	8.0	2.5	10.5	

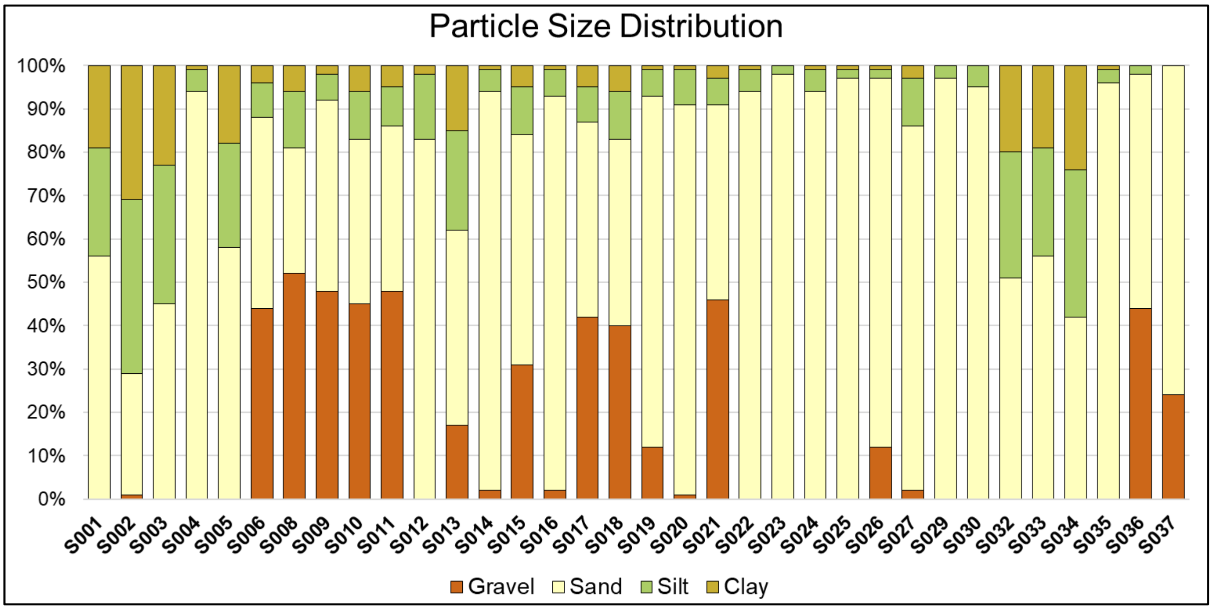


Figure 17 Particle size distribution across sample sites.

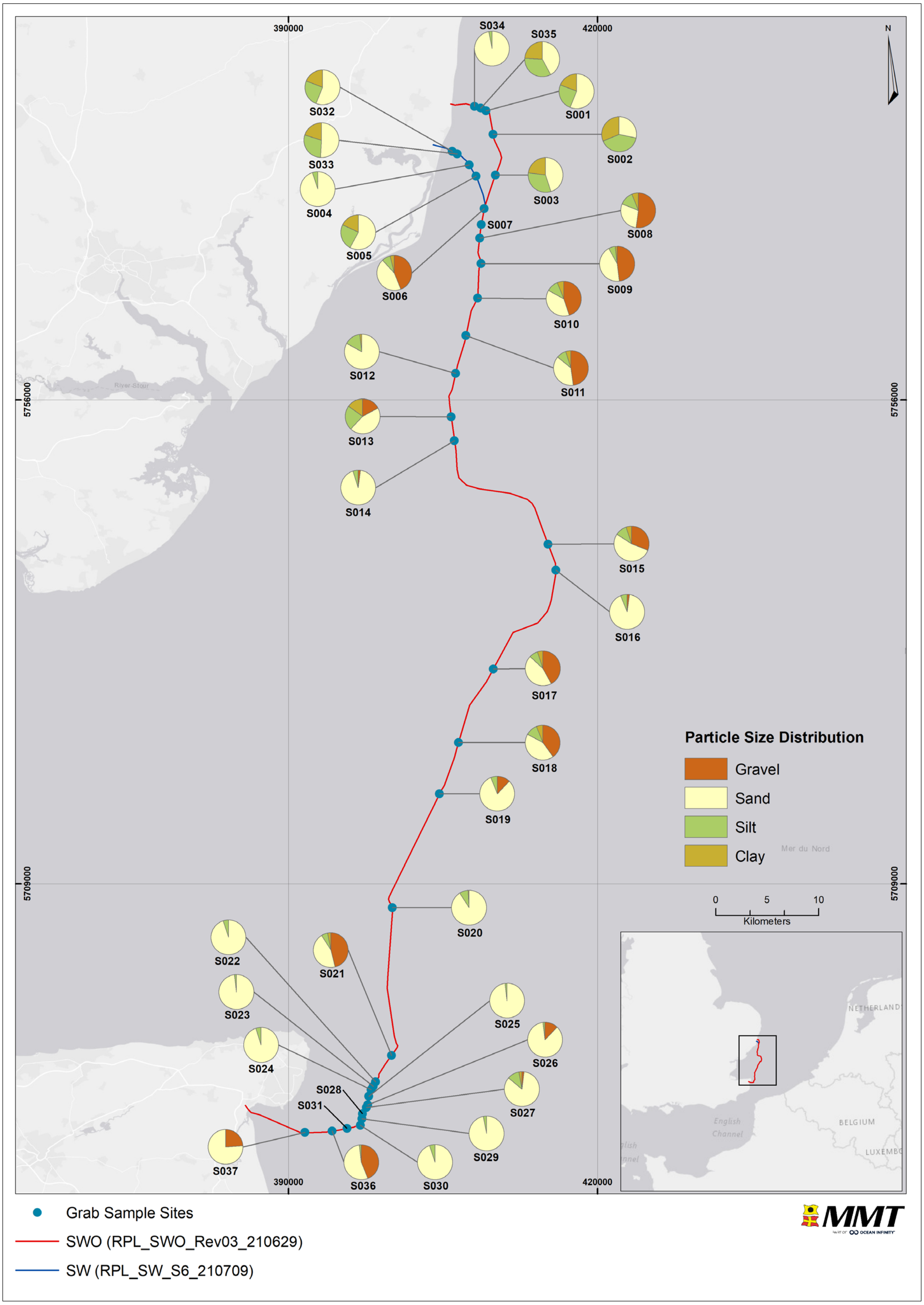


Figure 18 Overview of Particle Size Distribution, with symbol size based on sand content.

5.4.1| MULTIVARIATE ANALYSIS OF SEDIMENT

Multivariate analyses were undertaken on the PSA data set, to identify spatial patterns in the sediment distribution. Analyses included hierarchical clustering employing the Euclidean distance resemblance matrix, SIMPROF analysis and principal component analysis (PCA). The dataset was normalised prior to the analysis being undertaken.

The SIMPROF analysis on the sediment composition produced 13 distinct groups separating the 34 grab sample sites (Figure 19).

Principal component 1 (PC1), explaining 58.8 % of the variation, separated the sites based on the sand content. Principal component 2 (PC2), explaining 41.2 % of the variation, separated the sites based on the mud to gravel ratio (Figure 20).

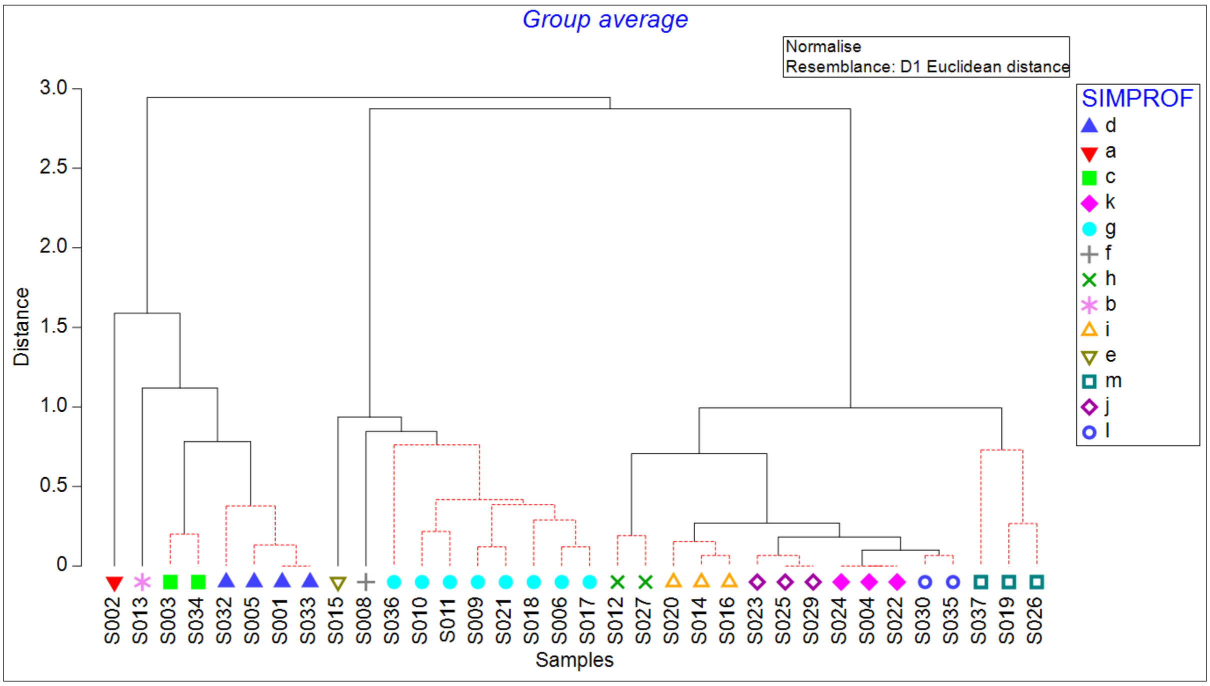


Figure 19 Dendrogram based on Euclidian distance for the sediment composition, showing SIMPROF groups with a 5 % significance level.

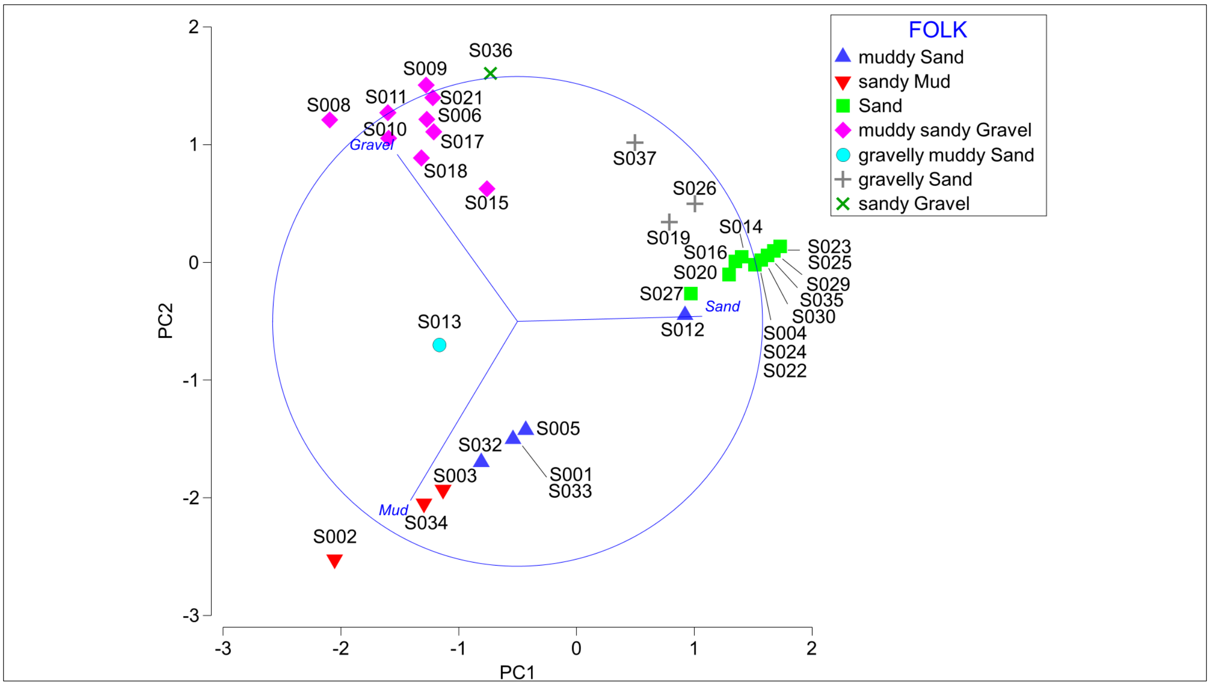


Figure 20 PCA plot of sediment composition for each grab sample site, showing groups based on the FOLK classifications.

5.5| CHEMICAL ANALYSES

Thirty-seven (37) grab sample sites were selected for analyses of concentrations of metals, organics, PAH, and THC. No samples for chemical analyses were acquired for sites S007 and S028 due to the potential presence of habitats of conservation importance, nor from site S031 due to coarse sediment. Detailed results from the chemical analyses are presented in Appendix G|.

5.5.1| METALS

Metal concentrations varied along the survey route. Threshold values were exceeded at 32 sites for arsenic (As), two sites for cadmium (Cd), five sites for chromium (Cr), one site for copper (Cu), one site for lead (Pb), 22 sites for mercury (Hg), two sites for nickel (Ni) and two sites for Zink (Zn) (Table 68).

The threshold value for arsenic according to CCME's PEL 41.6 µg/g was exceeded at S006, and the CEFAS' AL1 20 µg/g threshold value was exceeded at sites S008, S010-S011, S013-S015, S017-S021, S026 and at S036 and S037. Further, the NEA's class 2 – Good 15 µg/g threshold value was exceeded at S025 and S029-S030, and the CCME's ISQG 7.24 µg/g threshold value was exceeded at S001-S003, S005, S009, S016, S022-S024, S027 and S032-S034 (Figure 21).

The threshold value for cadmium (Cd) according to NEA's class 2 – Good 0.2 µg/g was exceeded at sites S006 and S008 (Figure 22).

The threshold value for chromium (Cr) according to CEFAS' AL1 40 µg/g was exceeded at sites S001-S003, S032 and S034 (*Figure* 23).

The threshold value for copper (Cu) according to NEA's class 4 – Poor 48 µg/g was exceeded at site S036 (Figure 24).

The threshold value for lead (Pb) according to CEFAS' AL1 50 µg/g was exceeded at site S036 (Figure 25).

The threshold value for mercury (Hg) according to the NEA's class 2 – Good 0.05 µg/g was exceeded at sites S001-S006, S008-S013, S020-S023, S026-S027, S029 and S032-S034 (Figure 26).

The threshold value for nickel (Ni) according to NEA's class 2 – Good 30 µg/g was exceeded at site S017. Further, CEFAS' AL1, with a threshold value of 20 µg/g, was exceeded at site S008 (Figure 27).

The threshold value for zinc (Zn) according to NEA's class 2 – Good 90 µg/g was exceeded at sites S033 and S036 (Figure 28).

No correlation between metals and TOC, organic matter or sediment composition was observed.

Table 68 Summary of metal concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values. Highlighted cells indicate where threshold values have been exceeded.

ANALYTE	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Al	Ba	Be	Fe	Mg	P	Sr	V
Method	ICPMSS	ICPMSS	SEDOES	ICPMSS	ICPMSS	ICPMSS	ICPMSS	ICPMSS	SEDOES	SEDOES	SEDOES	SEDOES	SEDOES	SEDOES	SEDOES	SEDOES
Limit of Detection	0.5	0.04	2	0.5	0.5	0.01	0.5	2	10	1	0.1	45	5	45	5	1
NEA 1 Background	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-
NEA 2 Good	15	0.2	60	20	25	0.05	30	90	-	-	-	-	-	-	-	-
NEA 3 Moderate	18	2.5	620	-	150	0.52	42	139	-	-	-	-	-	-	-	-
NEA 4 Poor	71	16	6000	48	1480	0.75	271	750	-	-	-	-	-	-	-	-
NEA 5 Very Poor	580	147	15500	147	2000	1.45	533	6690	-	-	-	-	-	-	-	-
OSPAR, ERL	-	1.2	81	34	47	0.15	-	150	-	-	-	-	-	-	-	-
CEFAS AL2	100	5	400	400	500	3	200	800	-	-	-	-	-	-	-	-
CEFAS AL1	20	0.4	40	40	50	0.3	20	130	-	-	-	-	-	-	-	-
CCME PEL	41.6	4.2	160	108	112	0.7	-	271	-	-	-	-	-	-	-	-
CCME ISQG	7.24	0.7	52.3	18.7	30.2	0.13	-	124	-	-	-	-	-	-	-	-
Dutch RIVM	85	14	380	190	580	10	210	2000	-	-	-	-	-	-	-	-
Units	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
S001	13.5	0.14	41.1	12.0	19.2	0.09	14.3	49.3	35800	196.0	1.0	19500	238.0	454	135.0	59.8
S002	13.7	0.16	51.9	13.2	23.1	0.09	16.9	55.2	44600	263.0	1.1	23100	368.0	573	181.0	69.0
S003	11.8	0.14	41.1	11.5	17.0	0.08	15.1	54.4	37000	228.0	0.9	19500	262.0	405	139.0	59.0
S004	6.8	0.05	11.3	4.5	5.4	0.05	3.7	16.7	9290	138.0	0.3	6790	95.0	141	51.6	15.3
S005	10.1	0.08	38.4	8.8	12.7	0.07	10.2	32.7	26500	211.0	0.8	16400	218.0	397	115.0	48.8
S006	45.4	0.37	22.2	6.4	13.5	0.06	13.9	39.8	14000	110.0	0.9	22300	481.0	18900	738.0	57.5
S008	40.0	0.25	34.7	17.4	10.5	0.07	28.3	48.1	27000	117.0	1.1	27100	338.0	12700	497.0	82.0
S009	13.0	0.10	12.1	5.6	5.9	0.05	6.6	14.4	8250	116.0	0.4	10300	123.0	1350	310.0	22.8
S010	25.2	0.16	22.4	6.9	8.8	0.06	10.8	29.2	14300	140.0	0.6	21600	205.0	5240	459.0	45.2
S011	25.8	0.18	19.7	7.9	8.6	0.07	9.3	32.1	12700	132.0	0.6	19600	219.0	5180	462.0	46.2
S012	8.6	0.06	12.8	5.3	4.8	0.05	3.9	16.0	12800	183.0	0.4	8850	112.0	285	88.3	20.5
S013	26.2	0.06	22.5	7.6	7.3	0.06	10.9	24.2	13000	136.0	0.5	28600	174.0	827	228.0	42.6
S014	21.1	<0.04*	11.7	4.8	7.9	0.03	4.1	20.9	6760	97.6	0.3	13500	247.0	482	234.0	35.1
S015	22.9	0.16	20.2	7.1	9.6	0.04	10.1	26.1	13200	597.0	0.6	16900	292.0	7580	480.0	44.5
S016	9.1	<0.04*	3.9	4.5	3.4	0.03	3.3	14.0	2670	64.8	0.1	5220	106.0	594	439.0	14.2
S017	39.2	0.14	18.3	7.0	7.0	0.04	36.0	30.1	11700	130.0	0.6	20200	200.0	4540	298.0	36.8
S018	20.9	0.08	15.5	6.0	5.3	0.03	9.2	21.1	9190	129.0	0.4	15200	151.0	1810	292.0	35.7
S019	22.9	0.12	10.2	4.6	3.8	0.03	5.8	19.9	5380	97.4	0.3	11600	194.0	2570	314.0	22.8
S020	23.6	0.07	12.1	4.4	7.4	0.05	4.9	23.1	12200	183.0	0.4	14200	197.0	492	220.0	28.9
S021	22.5	0.06	8.9	4.5	5.2	0.05	4.8	23.3	5380	65.9	0.3	14100	163.0	606	252.0	27.7
S022	14.9	0.06	9.9	3.7	4.0	0.05	4.4	17.2	12700	153.0	0.4	9050	119.0	220	98.4	17.5
S023	12.7	0.08	10.2	4.3	3.5	0.05	3.8	14.0	12800	152.0	0.4	9400	120.0	222	89.6	17.6
S024	13.6	0.05	11.5	3.6	3.6	0.04	3.8	13.6	12400	156.0	0.4	9600	132.0	239	121.0	18.6
S025	16.2	0.08	7.2	4.0	4.2	0.04	4.1	15.3	11300	149.0	0.4	9640	142.0	233	162.0	19.2
S026	23.9	0.08	6.4	3.9	4.5	0.06	4.9	17.7	7080	99.9	0.3	12700	252.0	415	417.0	21.9
S027	14.5	0.09	7.3	4.5	4.6	0.06	4.3	23.3	11000	148.0	0.4	8590	138.0	231	186.0	18.4
S029	17.4	0.05	9.8	3.8	3.7	0.05	4.3	14.7	10600	141.0	0.4	9080	122.0	231	129.0	18.7
S030	16.0	0.05	13.3	3.6	3.7	0.03	4.4	51.5	12000	153.0	0.4	10300	142.0	259	120.0	20.1
S032	12.1	0.13	40.8	10.8	15.0	0.07	12.3	83.4	29700	262.0	0.9	18200	324.0	503	144.0	51.9
S033	10.7	0.09	32.8	9.0	12.4	0.06	9.7	112.0	24900	247.0	0.7	15300	277.0	427	125.0	42.6
S034	12.7	0.12	44.0	10.6	16.2	0.06	13.7	74.4	37100	228.0	1.0	20500	359.0	507	147.0	62.2
S035	5.9	<0.04*	5.4	4.2	3.8	0.03	2.4	17.7	5950	106.0	0.2	5000	70.5	118	34.8	9.3
S036	25.9	0.08	25.7	53.8	103.0	0.02	13.6	96.4	9480	113.0	0.8	95601	529.0	519	200.0	50.1
S037	26.9	0.07	8.6	4.9	9.2	<0.01*	4.9	19.5	7210	96.1	0.3	14700	231.0	366	264.0	24.4
Mean	19.0	0.11	10.8	19.5	8.1	7.0	11.1	0.05	9.2	9.9	34.2	24.0	15469	162.9	0.5	17124.1
SD	9.4	0.07	6.9	13.2	8.7	9.5	17.0	0.02	7.2	7.2	25.1	16.8	10631	92.6	0.3	15114.0
Min	5.9	0.05	3.5	3.9	3.6	2.0	3.4	0.02	2.4	2.8	13.6	5.8	2670	64.8	0.1	5000.0
Max	45.4	0.37	32.3	51.9	53.8	51.3	103.0	0.09	36.0	36.4	112.0	83.6	44600	597.0	1.1	95601.0
Median	16.1	0.08	7.5	13.1	5.5	4.5	7.2	0.05	6.2	6.1	23.3	20.4	12300	140.5	0.4	14450.0

**Not included in statistical analyses of Mean, SD, Min, Max and Median*

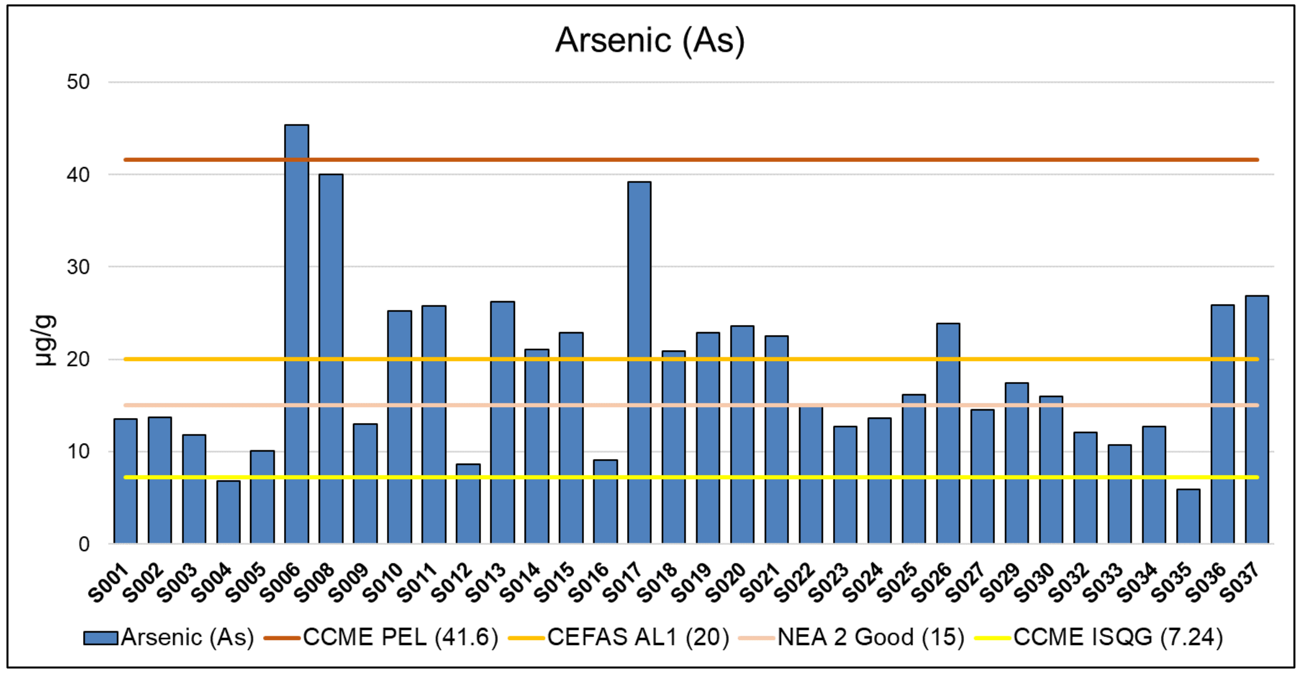


Figure 21 Arsenic (As) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

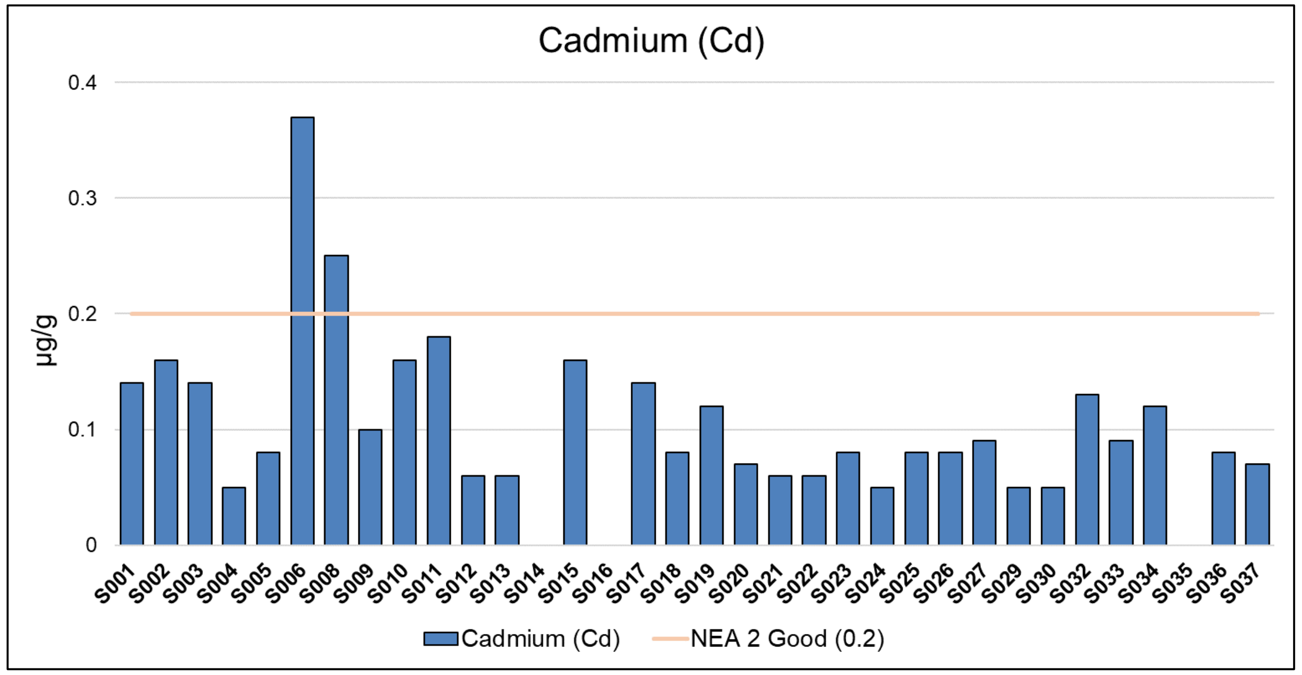


Figure 22 Cadmium (Cd) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

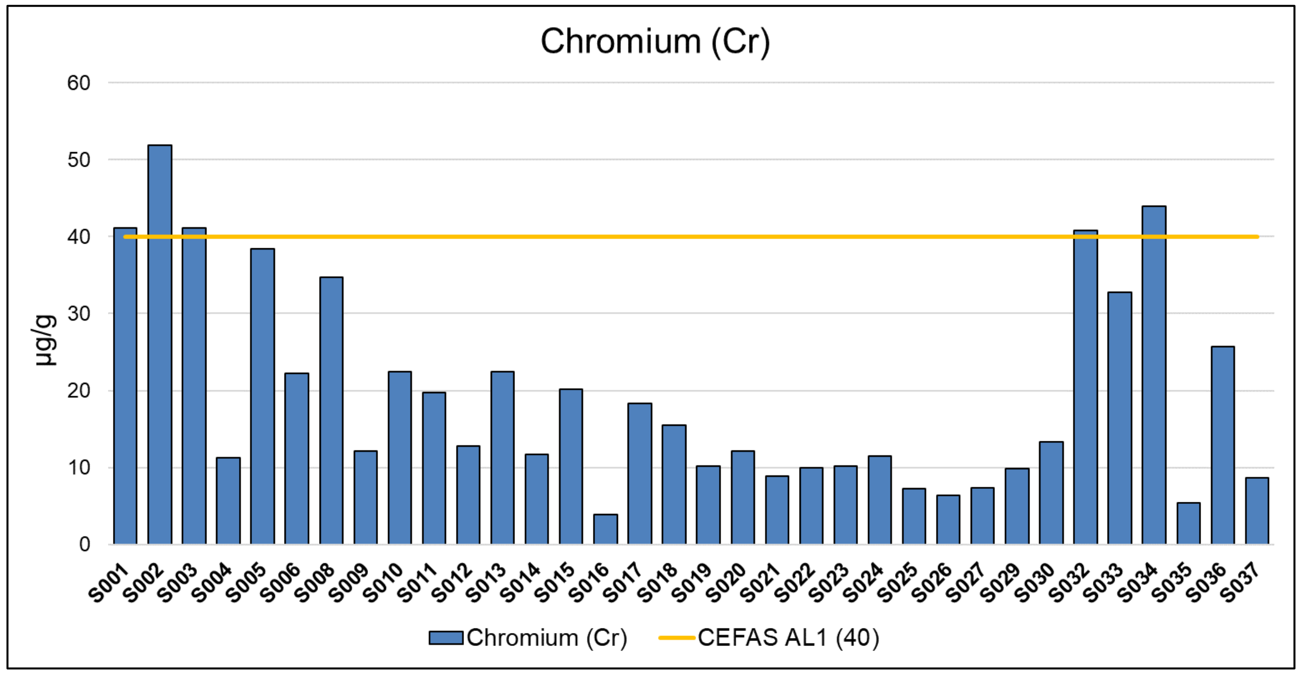


Figure 23 Chromium (Cr) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

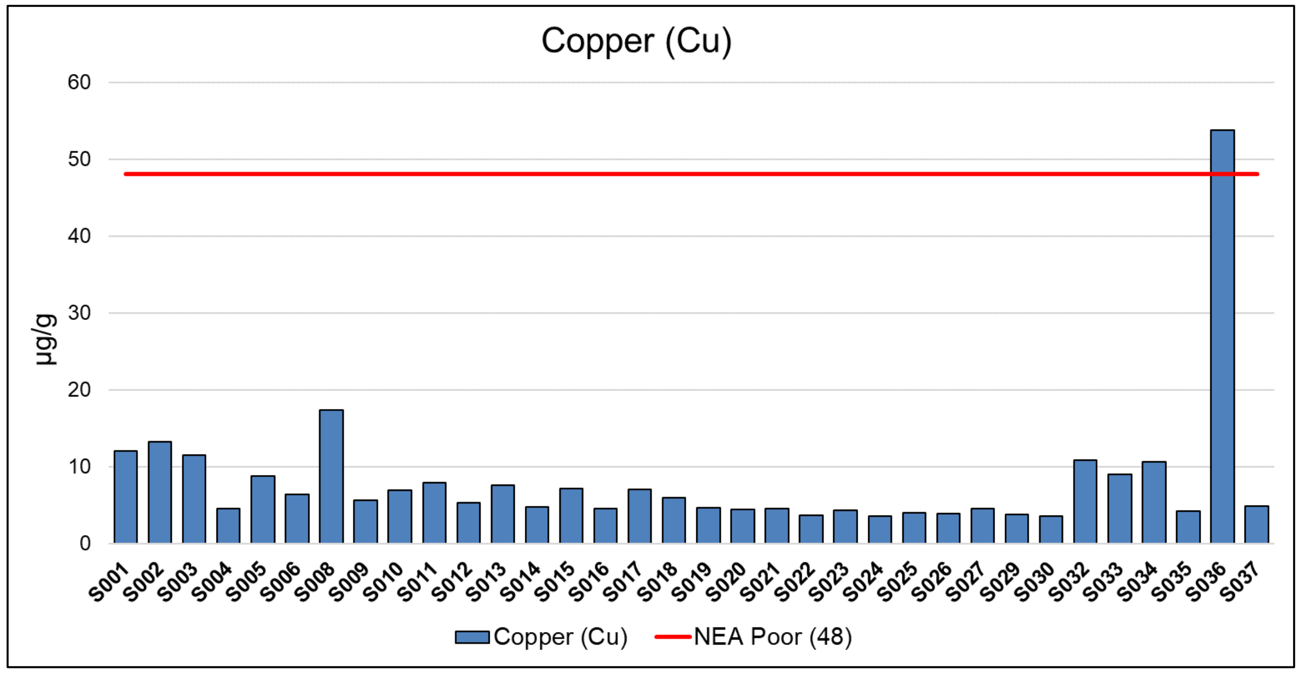


Figure 24 Copper (Cu) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

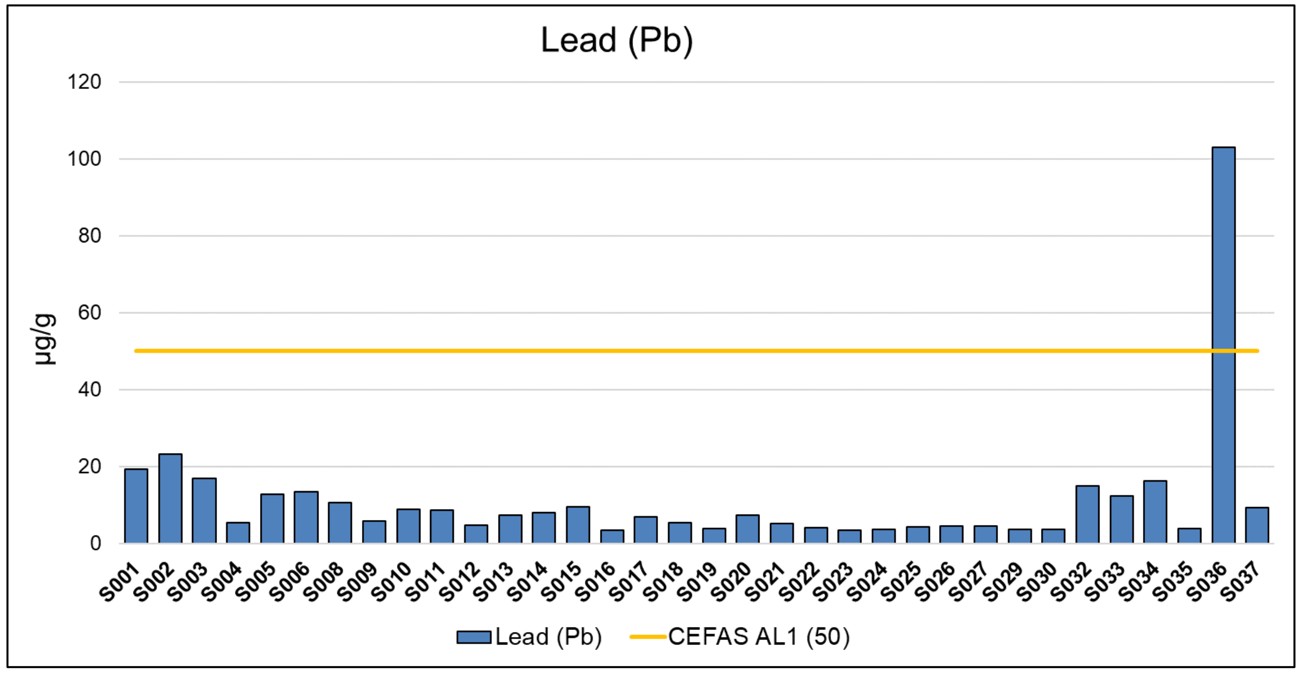


Figure 25 Lead (Pb) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

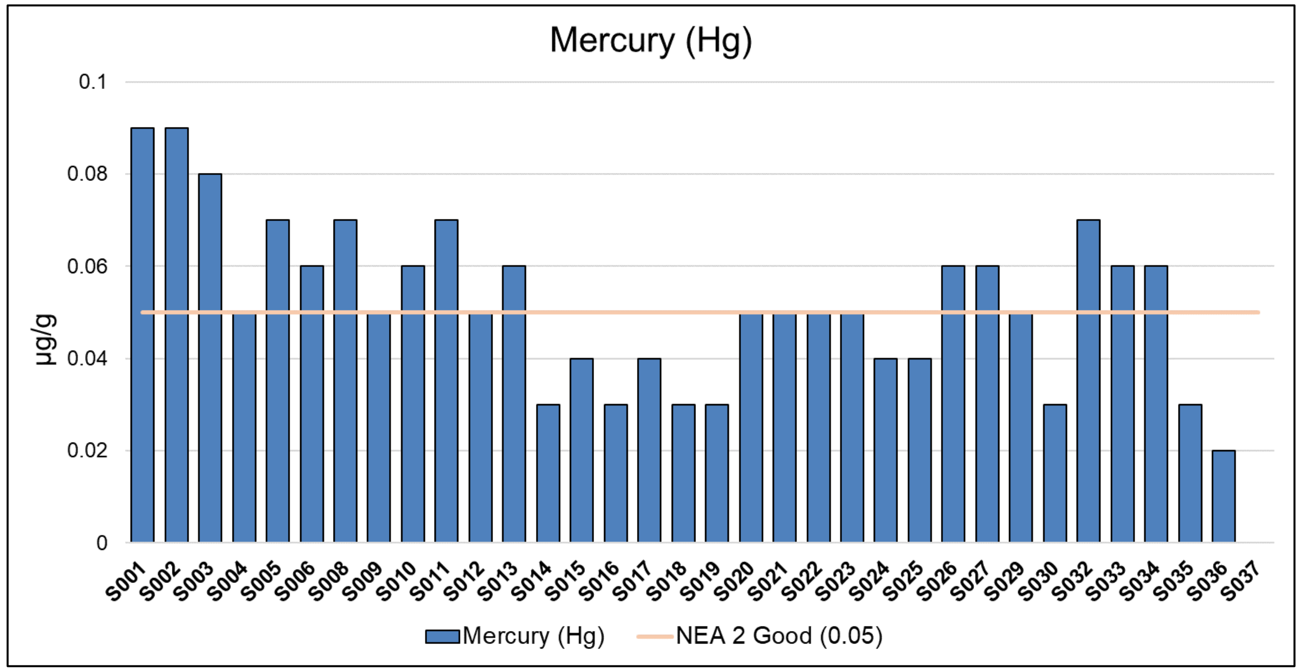


Figure 26 Mercury (Hg) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

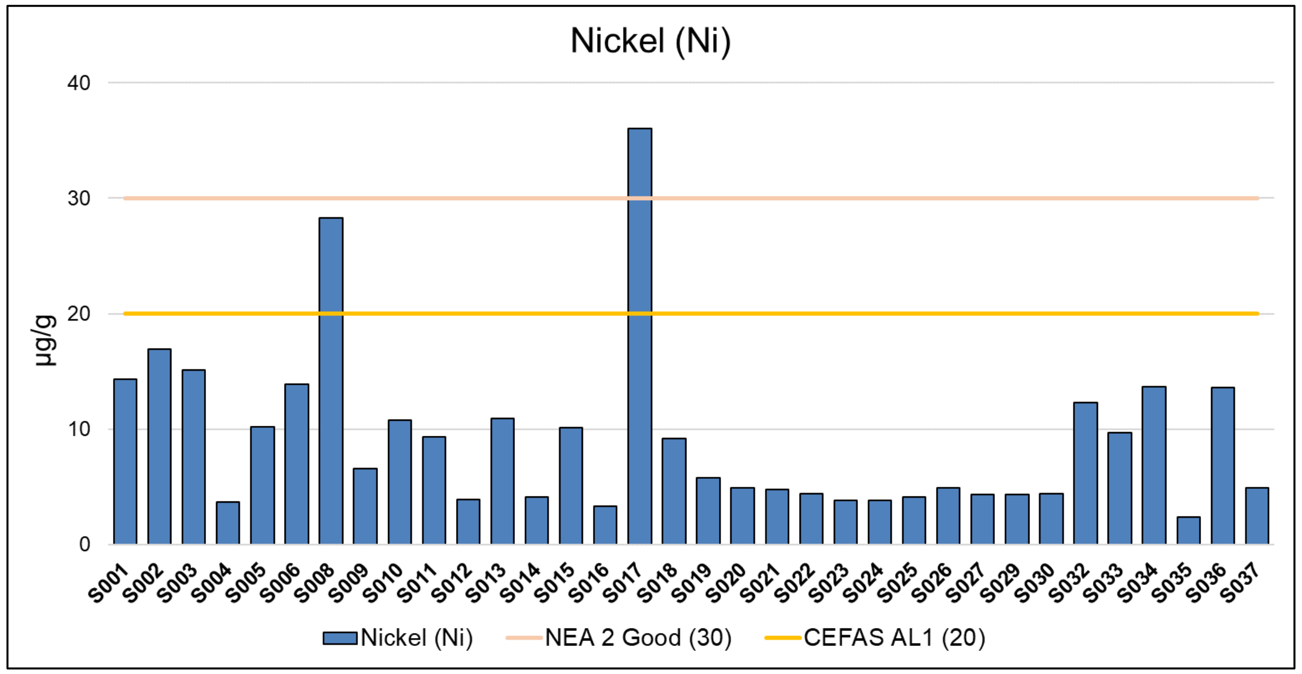


Figure 27 Nickel (Ni) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

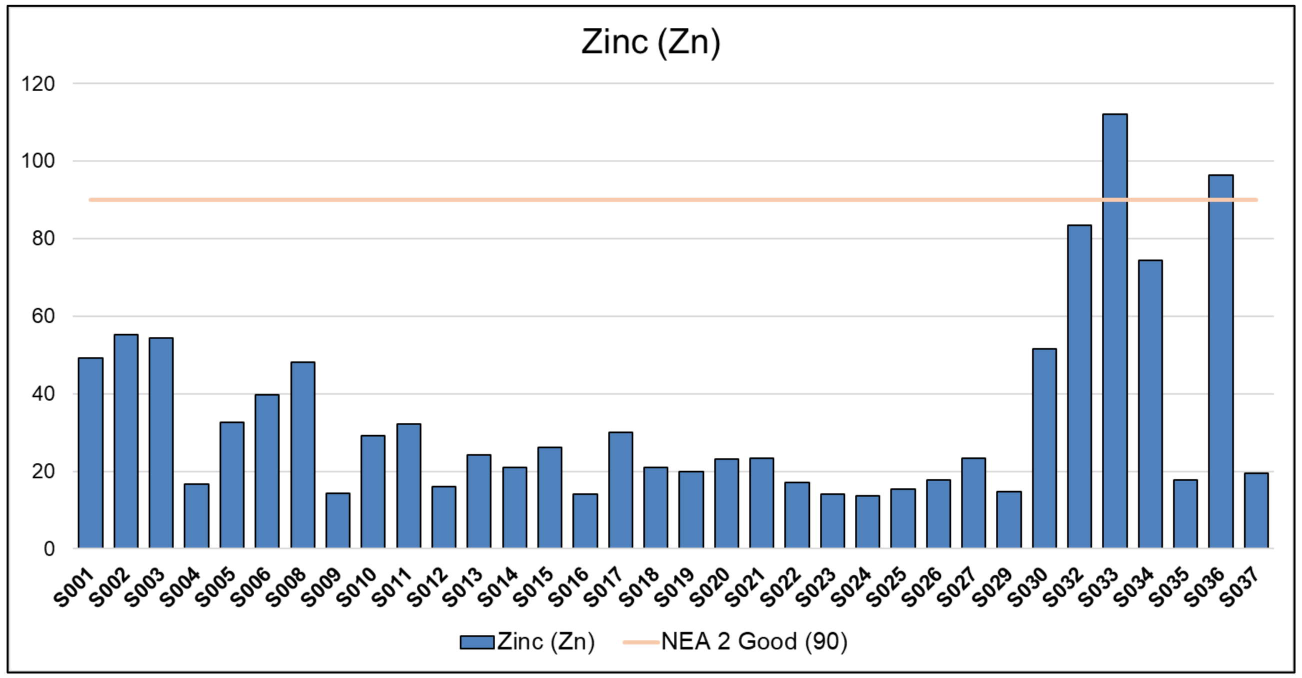


Figure 28 Zinc (Zn) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

5.5.2| ORGANICS

Total organic carbon (TOC) and organic matter varied along the survey route, with an average content of 0.3 % (SD=0.2) and 1.1 % (SD=0.6). Detailed results are presented in Table 69 and illustrated in Figure 29.

Table 69 Summary of organics in sediment across grab sample sites.

ANALYTE	TOC	ORGANIC MATTER
Limit of Detection	0.02	0.2
Units	%M/M	%M/M
S001	0.60	1.3
S002	0.78	1.6
S003	0.59	1.4
S004	0.11	0.3
S005	0.43	1.3
S006	0.61	0.6
S008	0.34	0.3
S009	0.20	<0.2*
S010	0.38	0.2
S011	0.35	0.4
S012	0.14	<0.2*
S013	0.29	1.3
S014	0.11	0.7
S015	0.32	0.7
S016	0.10	0.6
S017	0.23	1.1
S018	0.37	1.1
S019	0.10	1.2
S020	0.09	0.6
S021	0.14	2.6
S022	0.07	0.8
S023	0.07	1.4
S024	0.08	1.2
S025	0.07	1.4
S026	0.12	0.3
S027	0.26	0.9
S029	0.07	0.4
S030	0.08	0.7
S032	0.67	2.1
S033	0.50	1.5
S034	0.75	2.2
S035	0.08	0.6
S036	0.17	0.9
S037	0.09	2.4
Mean	0.3	1.1
SD	0.2	0.6
Min	0.1	0.2
Max	0.8	2.6
Median	0.2	1.0

**Not included in statistical analyses of Mean, SD, Min, Max and Media*

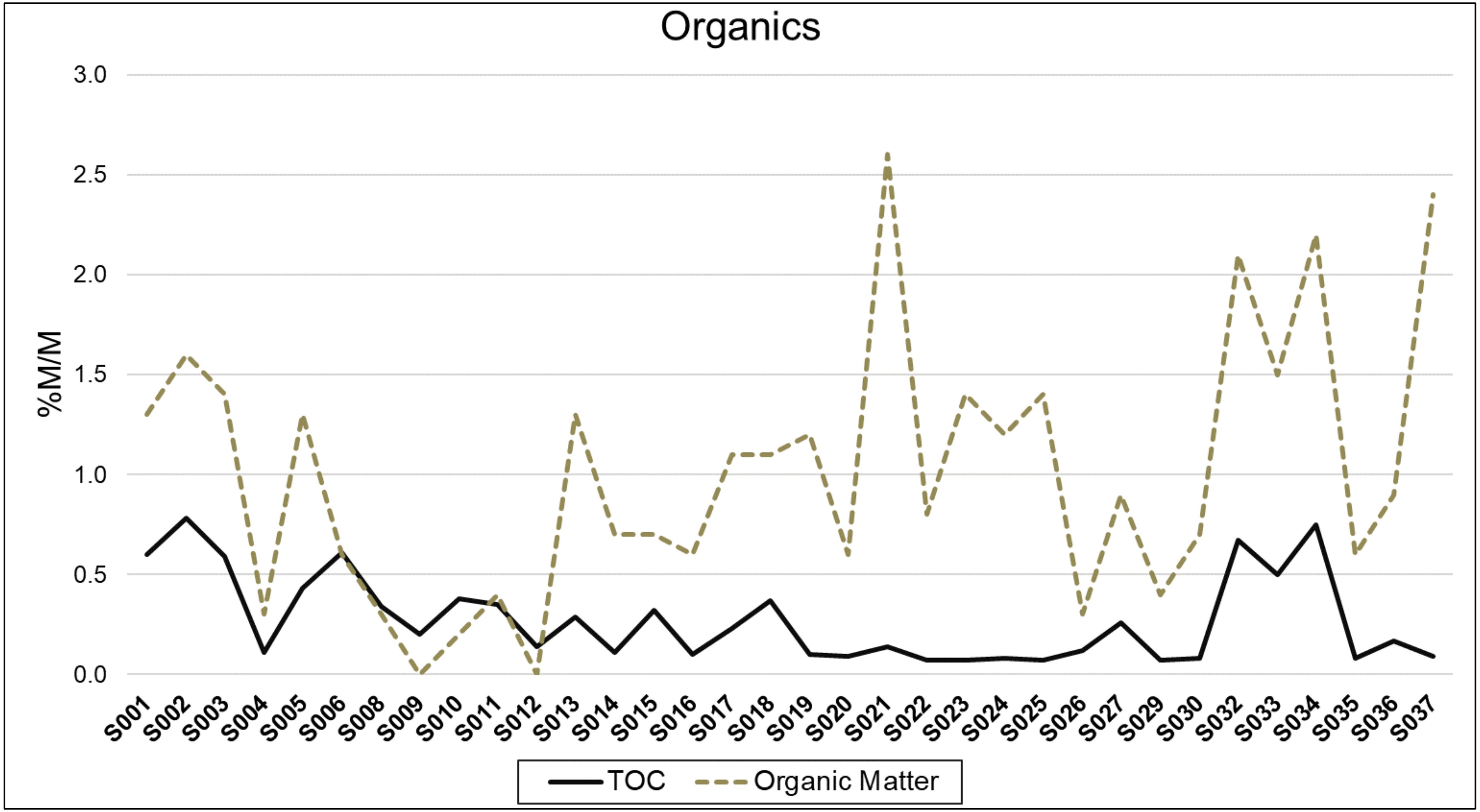


Figure 29 Levels of carbon and organics across the survey area.

5.5.3| THC AND PAH

Total Hydrocarbon Content (THC) concentrations varied along the survey route and did not exceed the Dutch RIVM intervention value at any of the grab sample sites (Table 70).

Table 70 Summary of THC (µg/Kg dry weight) across grab sample sites.

ANALYTE	THC	TOTAL N ALKANES	CARBON PREFERENCE INDEX	PRISTANE	PHYTANE	PRISTANE / PHYTANE RATIO
Limit of Detection	100	28	1	1	1	1
Dutch RIVM	5 000 000	-	-	-	-	-
Units	µg/Kg	µg/Kg	-	µg/Kg	µg/Kg	-
S001	29 700	1 491	3.05	99.1	63.5	1.56
S002	40 500	2 109	2.70	154	67.5	2.28
S003	13 000	309	1.66	19.3	<1*	-*
S004	2 540	151	4.04	5.77	<1*	-*
S005	20 900	1 106	2.79	72.8	82.2	0.88
S006	4 510	139	2.31	13.2	8.62	1.53
S008	4 200	252	2.72	17.0	9.31	1.83
S009	3 400	202	5.79	14.1	5.81	2.43
S010	16 800	631	2.56	53.1	17.4	3.06
S011	17 100	619.3	2.18	48.5	64.5	0.75
S012	11 200	256	1.35	12.6	<1*	-*
S013	9 190	331	1.92	19.2	7.67	2.51
S014	2 730	52.7	2.20	3.65	2.74	1.33
S015	9 220	279	2.56	8.60	3.55	2.42
S016	1 050	<28*	-*	<1*	<1*	-*
S017	6 120	86.6	2.12	2.90	1.19	2.44
S018	10 900	217	2.49	14.5	4.89	2.96
S019	253	<28*	-*	<1*	<1*	-*
S020	3 690	53.1	3.61	2.2	<1*	-*
S021	3 020	38.1	1.95	2.70	<1*	-*
S022	335	<28*	-*	<1*	<1*	-*
S023	382	<28*	-*	<1*	<1*	-*
S024	363	<28*	-*	<1*	<1*	-*
S025	340	<28*	-*	<1*	<1*	-*

ANALYTE	THC	TOTAL N ALKANES	CARBON PREFERENCE INDEX	PRISTANE	PHYTANE	PRISTANE / PHYTANE RATIO
Limit of Detection	100	28	1	1	1	1
Dutch RIVM	5 000 000	-	-	-	-	-
Units	µg/Kg	µg/Kg	-	µg/Kg	µg/Kg	-
S026	582	<28*	-*	<1*	<1*	-*
S027	<100*	<28*	-*	<1*	<1*	-*
S029	425	<28*	-*	<1*	<1*	-*
S030	<100*	<28*	-*	<1*	<1*	-*
S032	23 000	1 140	2.39	84.3	45.4	1.86
S033	8 060	1 120	11.14	25.7	12.4	2.07
S034	31 400	1 610	2.32	127	69.0	1.84
S035	572	<28*	3.73	1.89	<1*	-*
S036	5 440	37.6	0.87	1.76	<1*	-*
S037	3 060	32.7	1.24	1.38	<1*	-*
Mean	8 874	533	3	34	29	2
SD	10 382	597	2	43	30	1
Min	253	33	1	1	1	1
Max	40 500	2 109	11	154	82	3
Median	4 355	256	2	14	11	2

**Not included in statistical analyses of Mean, SD, Min, Max and Median*

Polycyclic Aromatic Hydrocarbons (PAH) concentrations varied along the survey route. Threshold values were exceeded at several sites (Table 71). No correlations were observed between PAHs and TOC, organic matter or sediment composition.

The PAH levels were higher at the northern sites of the survey corridor compared to the central and southern sites (Figure 30).

Table 71 Summary of PAH concentrations (µg/Kg dry weight) across the grab sample sites. Highlighted cells indicate where threshold values have been exceeded.

ANALYTE	NAPHTHALENE	ACENAPHTHYLENE	ACENAPHTHENE	FLUORENE	PHENANTHRENE	DIBENZOTHIOPHENE*	ANTHRACENE	FLUORANTHENE	PYRENE	BENZO[A]ANTHRACENE	CHRYSENE	BENZO[B]FLUORANTHENE	BENZO[K]FLUORANTHENE	BENZO[E]PYRENE*	BENZO[A]PYRENE	PERLENE*	INDENO[123,CD]PYRENE	DIBENZO[A,H]ANTHRACENE	BENZO[GHI]PERYLENE	SUM OF EPA 16 PAHS
Limit of Detection	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-
NEA-1-Background	0	0	0	0	0	-	0	0	0	0	0	0	0	-	0	-	0	0	0	0
NEA-2-Good	2	1.6	2.4	6.8	6.8	-	1.2	8	5.2	3.6	4.4	90	90	-	6	-	20	12	18	30
NEA-3-Moderate	27	33	96	150	780	-	4.8	-	84	60	-	-	-	-	183	-	-	27	-	2000
NEA-4-Poor	1754	85	195	694	2500	-	30	400	840	501	280	140	135	-	230	-	63	273	84	6000
NEA-5-Very-Poor	8769	8500	19500	34700	25000	-	295	2000	8400	50100	2800	10600	7400	-	13100	-	2300	2730	1400	20000
OSPAR-ERL	160	-	-	-	240	190	85	600	665	-	384	-	-	-	430	-	240	-	85	-
CEFAS-AL1	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	-
CCME-PEL	391	128	88.9	144	544	-	245	1494	1398	693	846	-	-	-	763	-	-	135	-	-
CCME-ISQG	34.6	5.87	6.71	21.2	86.7	-	46.9	113	153	74.8	108	-	-	-	88.8	-	-	6.22	-	-
Units	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg	µg/Kg
S001	40.8	4.2	6.8	11.9	79.0	8.4	16.1	106.0	90.9	43.5	56.0	53.3	33.3	55.8	50.5	23.3	53.8	12.7	64.6	723.4
S002	61.7	5.2	8.5	16.4	84.6	9.7	16.4	84.5	80.2	46.4	59.1	63.4	38.2	67.1	56.0	38.6	57.4	12.8	73.9	764.7
S003	6.3	<1	1.3	1.7	7.6	1.1	1.5	6.1	7.0	2.9	4.0	4.6	3.1	5.0	3.1	2.9	3.7	<1	5.8	58.7
S004	2.6	<1	<1	<1	3.7	<1	<1	3.0	3.0	1.5	2.4	2.0	1.3	2.7	1.8	1.3	2.2	<1	3.0	26.3
S005	27.3	3.2	3.8	7.5	43.8	5.1	7.5	38.9	38.3	20.9	31.4	32.5	17.0	37.8	30.1	17.8	33.7	7.2	41.3	384.5
S006	5.4	1.9	<1	1.1	12.2	<1	1.7	29.1	25.7	9.6	15.3	14.8	8.4	14.0	14.6	4.8	14.0	2.4	14.3	170.4
S008	7.5	1.5	1.4	2.1	13.1	2.0	3.5	12.2	11.8	5.6	6.9	5.8	3.9	7.5	4.6	3.7	3.8	1.5	5.5	90.6
S009	4.8	<1	<1	1.2	8.1	<1	2.4	7.8	7.5	3.4	5.1	3.7	2.5	5.4	4.0	2.5	3.0	<1	4.0	57.5
S010	12.8	1.6	1.4	2.7	21.4	2.3	3.9	36.4	34.1	15.4	22.5	23.7	12.7	24.6	18.8	11.0	14.0	3.2	17.8	242.3
S011	13.2	1.7	3.7	4.1	54.3	4.1	13.4	136.0	119.0	60.2	71.0	63.9	34.2	59.8	68.8	25.8	41.7	8.7	44.8	738.6
S012	2.1	<1	<1	<1	3.6	<1	<1	5.6	5.8	2.6	4.1	3.6	3.0	4.7	3.0	2.0	2.2	<1	2.9	38.4
S013	3.3	<1	<1	<1	9.6	<1	2.1	19.5	17.8	8.5	11.0	9.4	7.0	9.9	9.0	5.1	5.8	1.0	7.1	111.1
S014	3.6	<1	<1	1.0	4.8	<1	<1	1.9	1.6	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	12.9
S015	3.0	<1	<1	<1	4.5	<1	1.0	8.6	8.0	3.8	5.9	7.2	4.2	7.4	5.3	3.5	4.7	<1	5.5	61.7
S016	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S017	<1	<1	<1	<1	1.2	<1	<1	2.0	2.1	<1	1.4	1.3	<1	1.5	<1	<1	<1	<1	<1	8.0
S018	3.5	<1	<1	<1	6.8	<1	1.3	9.3	9.3	3.9	6.1	7.6	3.7	7.3	4.8	3.1	3.5	<1	4.9	64.6
S019	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S020	<1	<1	<1	<1	1.2	<1	<1	4.0	3.5	1.9	2.7	2.1	1.4	2.1	1.9	1.5	1.2	<1	1.3	21.1
S021	<1	<1	<1	<1	<1	<1	<1	1.5	1.5	<1	<1	1.2	<1	1.2	<1	<1	<1	<1	<1	4.2
S022	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S023	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S024	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S025	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S026	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S027	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S029	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S030	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S032	18.2	1.8	2.4	4.0	32.5	3.5	7.0	52.3	49.5	22.4	34.9	33.8	17.2	34.5	26.9	16.3	19.1	3.9	27.5	353.4
S033	5.6	<1	<1	1.3	10.2	<1	1.7	13.9	13.2	5.7	9.0	9.1	4.2	9.8	6.9	4.8	5.5	1.2	7.6	95.1
S034	38.8	6.7	5.0	9.8	65.1	6.9	12.2	59.2	59.3	29.7	42.3	44.4	18.6	44.7	34.1	21.4	33.8	6.1	44.3	509.4
S035	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S036	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0
S037	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0.0

**Not included in the EPA 16 PAHs*

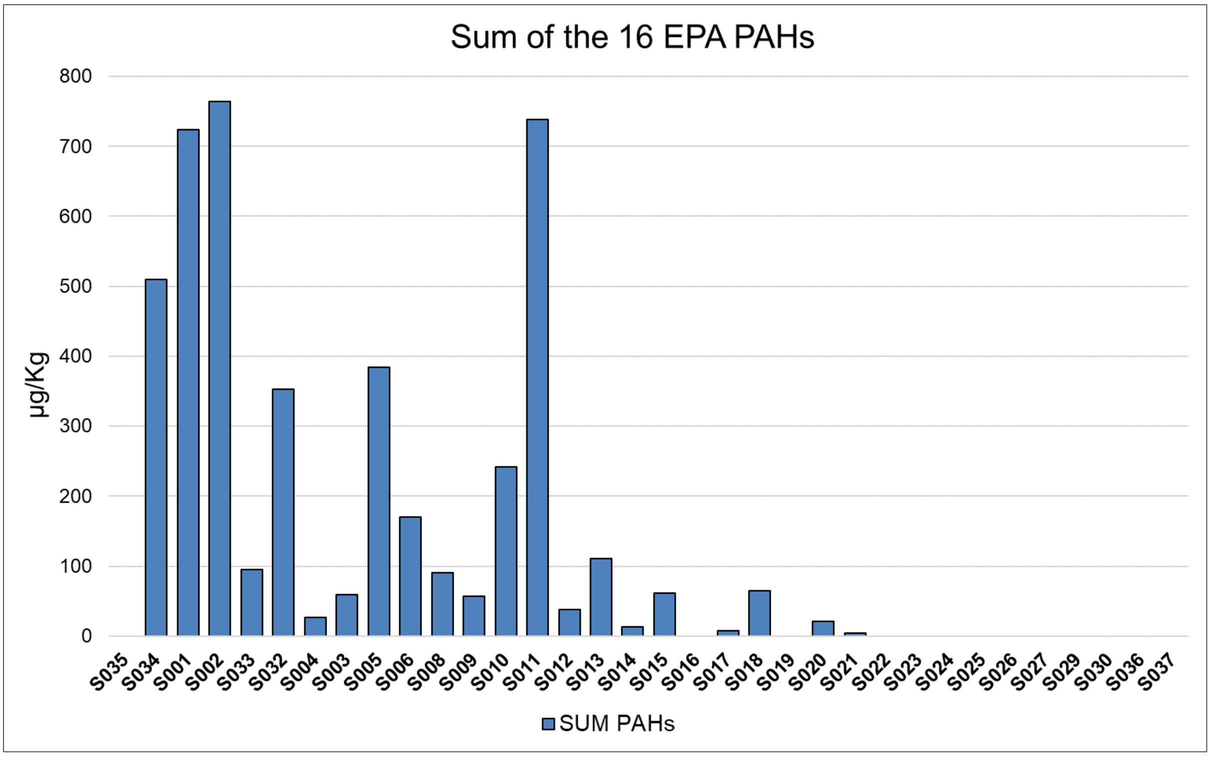


Figure 30 PAH levels (16 EPA PAHs summarized) plotted north to south.

5.6| NON-COLONIAL FAUNA FROM GRAB SAMPLES

Non-colonial epifauna was identified to the lowest taxonomic level possible. Infauna and non-colonial epifauna were combined and analysed together. When analysing phyletic composition, the following phylum; Chaetognatha, Chordata, Hemichordata, Nematoda, Nemertea, Phoronida, Platyhelminthes, Porifera, Sipuncula were combined into the group "Others".

Grab sample replicates S027_F3, S031_F1 and S031_F2 comprised insufficient sample volume and were excluded from all statistical analyses.

The colonial epifauna was identified to the lowest taxonomic level possible. The colonial epifauna was recorded as absent/present and analysed separately. The results are presented in section 5.8|.

Full species lists of fauna from grab samples is presented in Appendix C|.

5.6.1| PHYLETIC COMPOSITION

The phyletic composition of the non-colonial fauna identified from the grab samples is summarised in Figure 31 and Figure 32, as well as Table 72. Annelida comprised the most abundant taxa and the highest abundance, followed by Arthropoda and Mollusca. These three phyla contributed 91% of the recorded taxa and 92% of the individuals. An overview of the total abundance and the total number of species per grab sampling site along the survey routes is presented in Figure 33 and Figure 34.

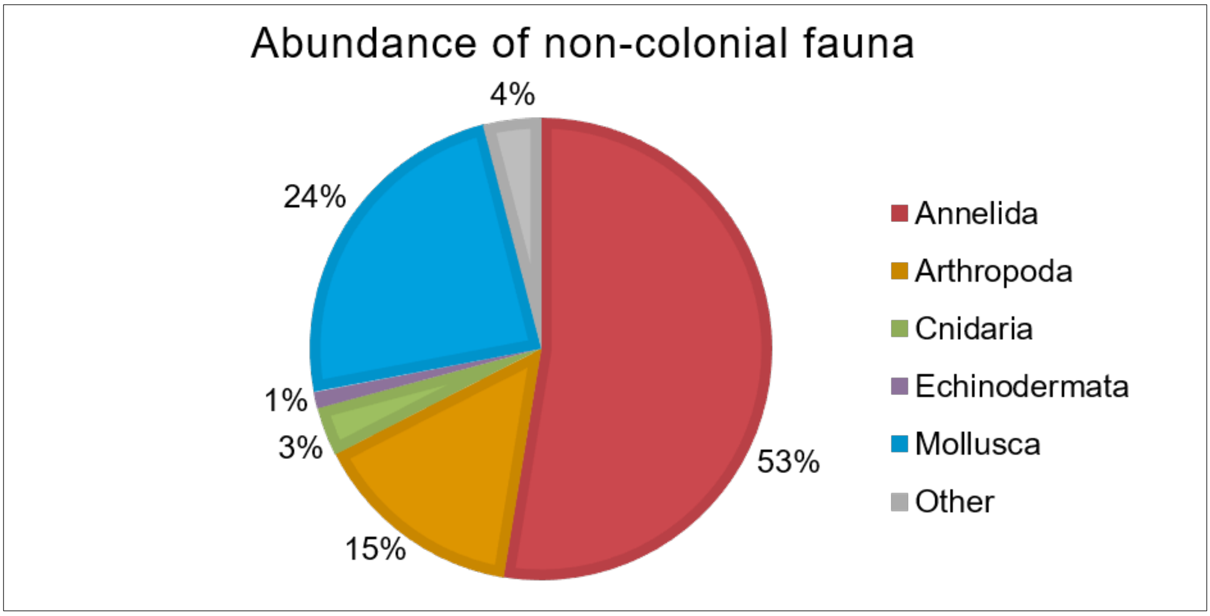


Figure 31 Abundance of non-colonial fauna in grab samples.

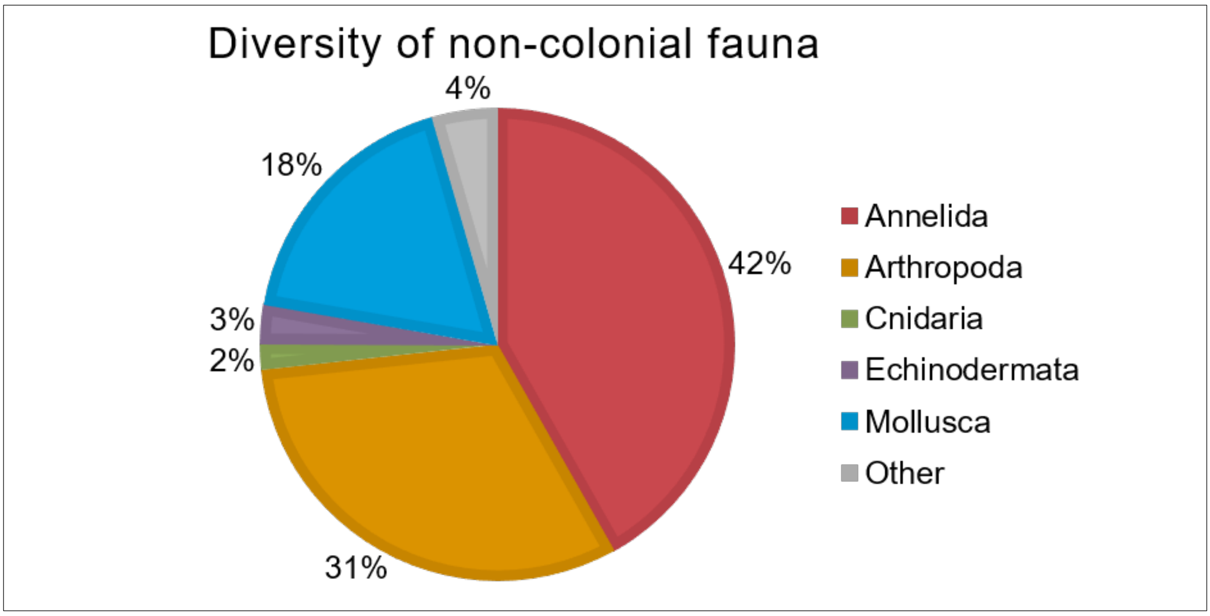


Figure 32 Diversity of non-colonial fauna in grab samples.

Table 72 Phyletic composition of non-colonial fauna from grab samples.

PHYLUM	NUMBER OF TAXA	ABUNDANCE (TOTAL NUMBER OF INDIVIDUALS)
ANNELIDA	141	17658
ARTHROPODA	106	4994
CNIDARIA	6	1143
ECHINODERMATA	9	375
MOLLUSCA	60	8054

PHYLUM	NUMBER OF TAXA	ABUNDANCE (TOTAL NUMBER OF INDIVIDUALS)
OTHER	15	1338
TOTAL	337	33562

A list of the 10 most abundant taxa, with total mean abundance and frequency of occurrence, is presented in Table 73. The most abundant taxon is the annelid *Scalibregma inflatum,* with a total of 6510 individuals recorded, and the species occurred in 54% of the grab samples.

Table 73 The ten most abundant taxa in grab samples, together with frequency of occurrence.

PHYLUM	TAXA	TOTAL ABUNDANCE	MEAN ABUNDANCE	SD	FREQUENCY OF OCCURRENCE (%)
Annelida	*Scalibregma inflatum*	6510	63	180	54
Mollusca	*Mytilus edulis*	4003	39	285	15
Annelida	*Sabellaria spinulosa*	3992	39	179	33
Annelida	*Lagis koreni*	2237	22	59	59
Arthropoda	*Corophium volutator*	1689	16	118	9
Mollusca	*Limecola balthica*	1214	12	75	6
Cnidaria	Actiniaria	1126	11	39	32
Mollusca	*Abra alba*	1118	11	18	52
Mollusca	*Kurtiella bidentata*	970	9	27	45
Nematoda	Nematoda	785	8	25	41

A list of the 10 most frequently occurring taxa, with total mean abundance, is presented in Table 74. The most frequently occurring taxon was the annelid *Lagis koreni*, which occurred in 59% of the grab samples with a total abundance of 2237 individuals.

Table 74 The ten most frequently occurring taxa in grab samples, with total and mean abundance.

PHYLUM	TAXA	FREQUENCY OF OCCURRENCE (%)	TOTAL ABUNDANCE
Annelida	*Lagis koreni*	59	2237
Annelida	*Spiophanes bombyx*	57	691
Nemertea	Nemertea	55	236
Annelida	*Scalibregma inflatum*	54	6510
Mollusca	*Abra alba*	52	1118
Annelida	*Lumbrineris cingulata*	48	303
Mollusca	*Kurtiella bidentata*	45	970
Nematoda	Nematoda	41	785
Annelida	*Notomastus*	41	466
Annelida	*Pholoe baltica* (sensu Petersen)	41	166

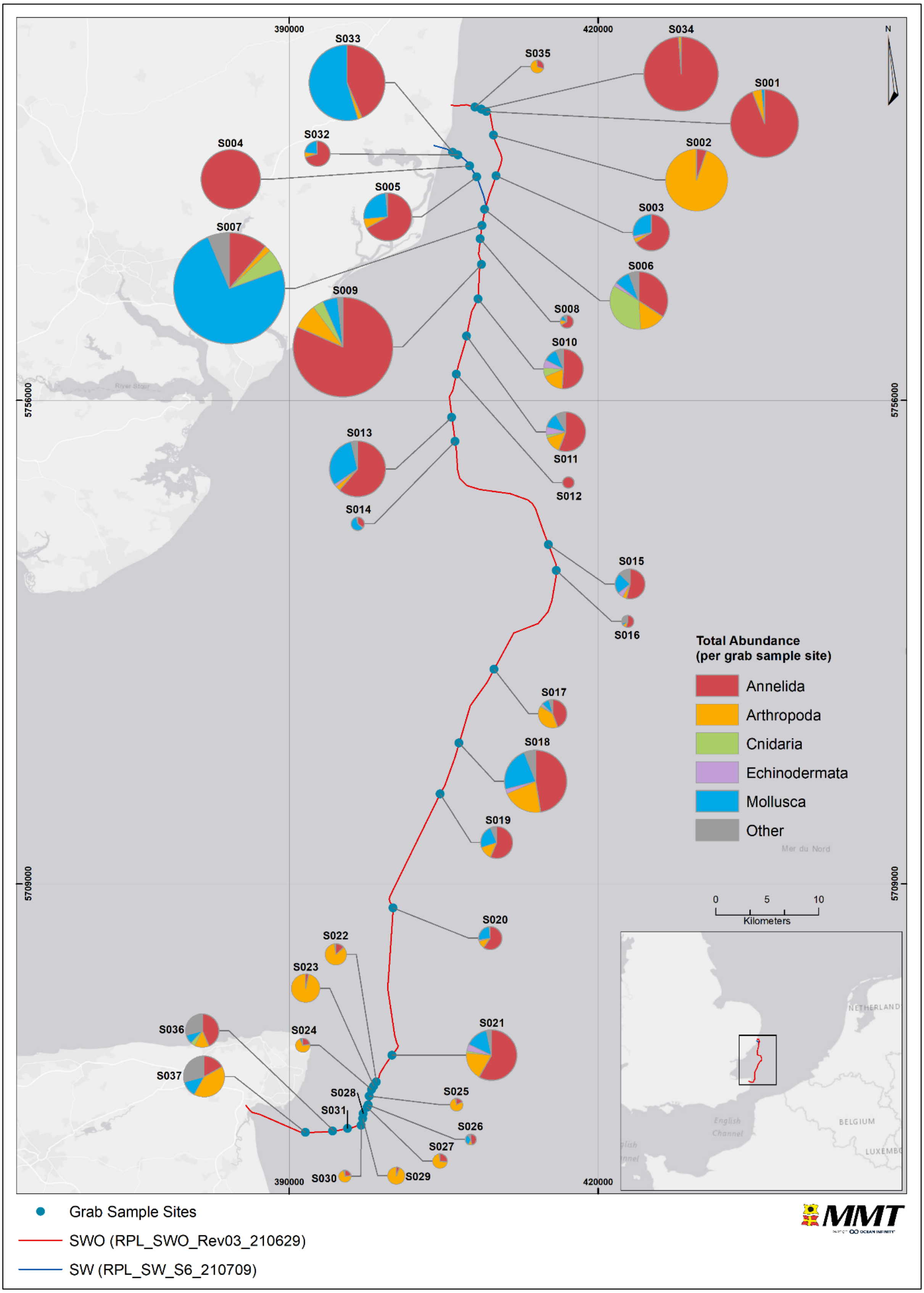


Figure 33 Overview of the Total Abundance per grab sampling site along the survey route.

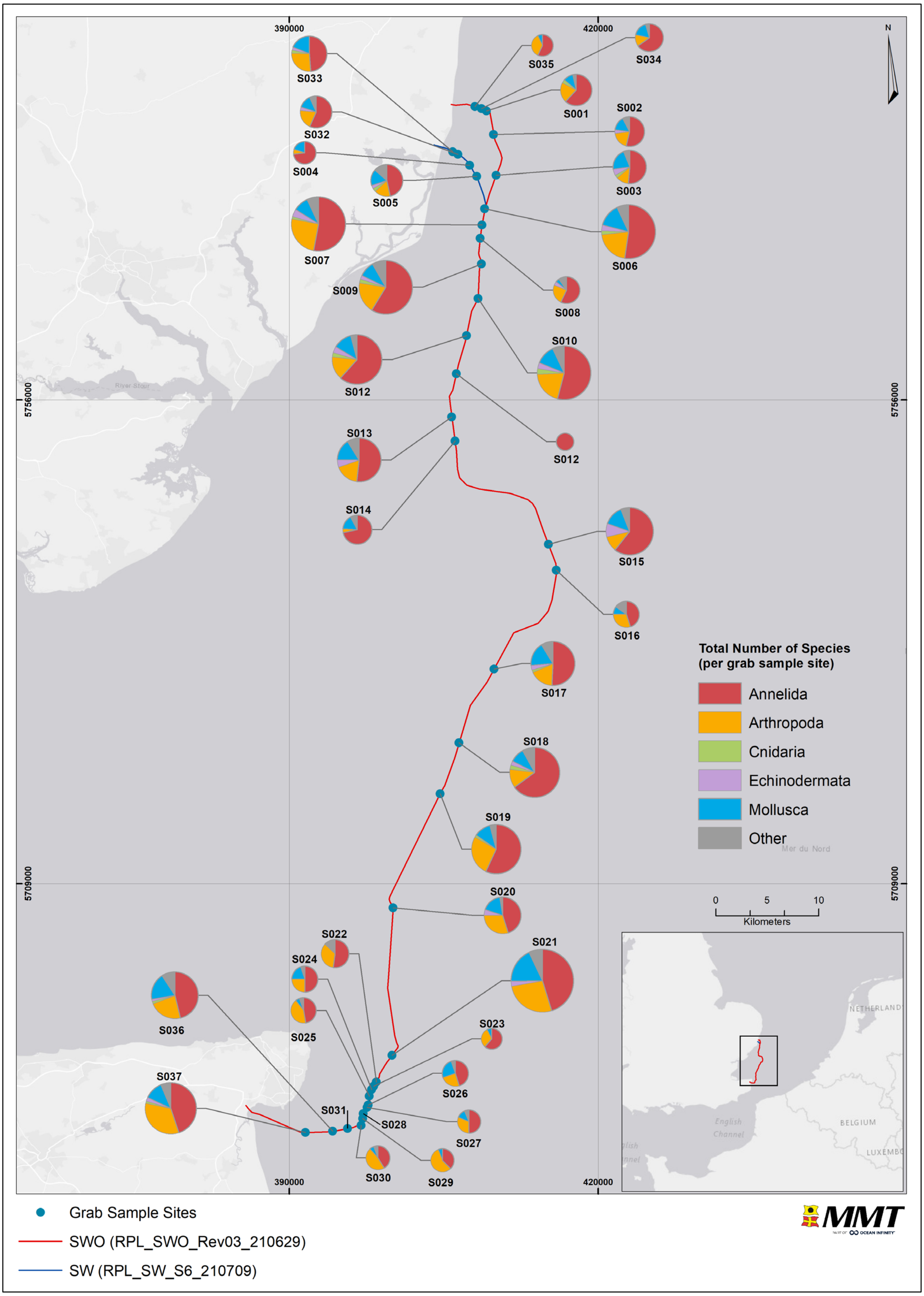


Figure 34 Overview of the Total Number of species per grab sampling site along the survey route.

5.6.2| UNIVARIATE STATISTICAL ANALYSES

Univariate analyses were performed to assess the non-colonial faunal richness, diversity, evenness and dominance. Results from the univariate analyses are presented as average values from each grab sampling site (Table 75), with the number of taxa (S) being the combined total number of taxa identified at the grab site. For the univariate indices and overview maps presenting non-colonial fauna with replicates samples at each grab sampling site, please refer to Appendix J|.

The number of taxa (S) per site varied with a mean of 43 (SD=29) where S021 contained the highest number of taxa (115 different taxa), and grab sampling site S012 comprised the lowest with nine (9) different taxa. An overview map of the number of taxa (S) identified per grab sampling site along the survey route is presented in Figure 35.

The average number of individuals (N) per site (expressed as mean per 0.1 m^2) varied with a mean of 346 (SD=528) where S007 contained the highest number of individuals (2762 individuals) and S026 the lowest with 18 individuals. An overview map of the number of individuals (N) identified per grab sampling site along the survey route is presented in Figure 36.

The species richness measured with Margalef's diversity index (D) varied between 2.24 and 19.19, with grab sample S021 having the highest value of 19.19.

The Shannon-Wiener index (H') varied from 0.17 to 3.76, with grab sampling site S021 presenting the highest value of 3.76. An overview of the Shannon-Wiener Index (H') identified per grab sampling site along the survey route is presented in Figure 37.

Pielou's evenness index (J′) ranged between 0.06 to 0.88, with grab sampling site S026 having the highest value of 0.88.

Simpson's index of dominance (1-λ) ranged between 0.05 to 0.96, with grab sampling site S026 having the highest value of 0.96.

Table 75 Univariate indices of average fauna values from each grab sample site. The number of taxa (S) is the combined total number of taxa identified at the site.

ID	NUMBER OF TAXA (S)	NUMBER OF INDIVIDUALS (N)	MARGALEF'S RICHNESS INDEX (D)	SHANNON-WIENER INDEX (H')	PIELOU'S EVENNESS INDEX (J′)	SIMPSON'S INDEX OF DOMINANCE (1-Λ)
S001	31	687	4.59	0.83	0.24	0.33
S002	26	572	3.94	0.38	0.12	0.12
S003	33	197	6.06	2.16	0.62	0.79
S004	15	525	2.24	0.17	0.06	0.05
S005	30	339	4.98	1.90	0.56	0.69
S006	86	499	13.68	2.79	0.63	0.85
S007	87	2762	10.85	1.36	0.30	0.48
S008	20	26	5.86	2.46	0.82	0.91
S009	85	1475	11.51	1.59	0.36	0.50
S010	85	236	15.38	3.63	0.82	0.96
S011	73	232	13.22	3.53	0.82	0.96
S012	9	19	2.70	1.13	0.51	0.52
S013	56	465	8.96	2.19	0.54	0.78

ID	NUMBER OF TAXA (S)	NUMBER OF INDIVIDUALS (N)	MARGALEF'S RICHNESS INDEX (D)	SHANNON-WIENER INDEX (H')	PIELOU'S EVENNESS INDEX (J')	SIMPSON'S INDEX OF DOMINANCE (1-Λ)
S014	25	26	7.37	2.21	0.69	0.78
S015	66	133	13.30	3.47	0.83	0.96
S016	20	22	6.15	2.49	0.83	0.93
S017	57	121	11.68	3.27	0.81	0.93
S018	74	579	11.48	2.92	0.68	0.90
S019	72	152	14.14	3.36	0.79	0.94
S020	40	79	8.92	2.80	0.76	0.90
S021	115	381	19.19	3.76	0.79	0.96
S022	23	69	5.20	1.57	0.50	0.64
S023	13	122	2.50	0.40	0.16	0.14
S024	20	31	5.55	1.96	0.65	0.74
S025	19	25	5.62	1.85	0.63	0.71
S026	20	18	6.62	2.64	0.88	0.96
S027	16	48	3.88	1.82	0.65	0.75
S029	16	44	3.96	1.16	0.42	0.49
S030	17	22	5.18	2.14	0.76	0.86
S032	30	96	6.35	2.04	0.60	0.80
S033	37	857	5.33	1.54	0.43	0.68
S034	23	823	3.28	0.43	0.14	0.14
S035	14	25	4.02	1.95	0.74	0.79
S036	65	166	12.52	2.93	0.70	0.89
S037	78	253	13.92	3.20	0.73	0.92
Mean	43	346	8.00	2.12	0.59	0.71
SD	29	528	4.41	0.99	0.23	0.27
Min	9	18	2.24	0.17	0.06	0.05
Max	115	2762	19.19	3.76	0.88	0.96
Median	30	152	6.15	2.14	0.65	0.79

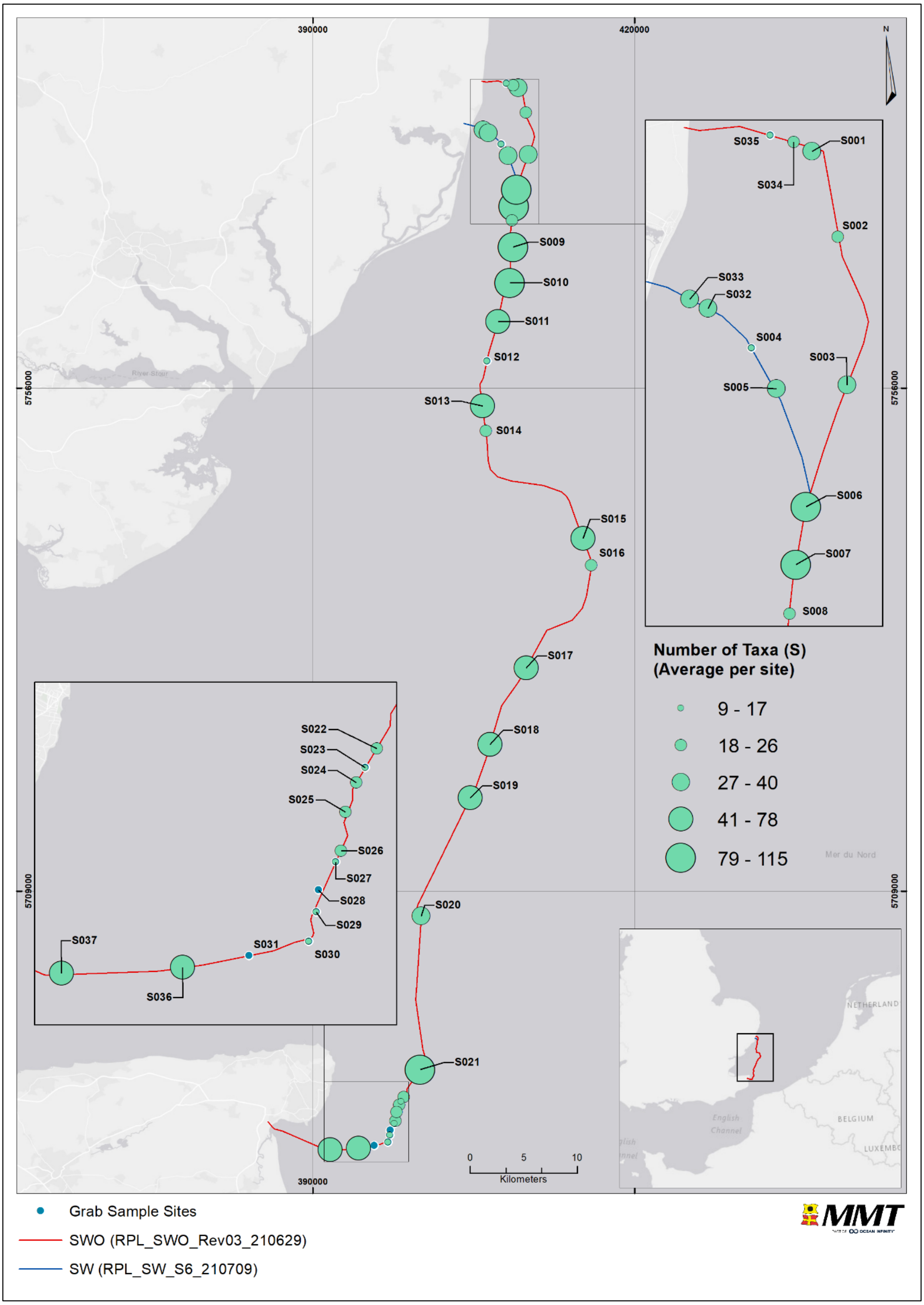


Figure 35 Overview of the Number of Taxa (S) with average values per site.

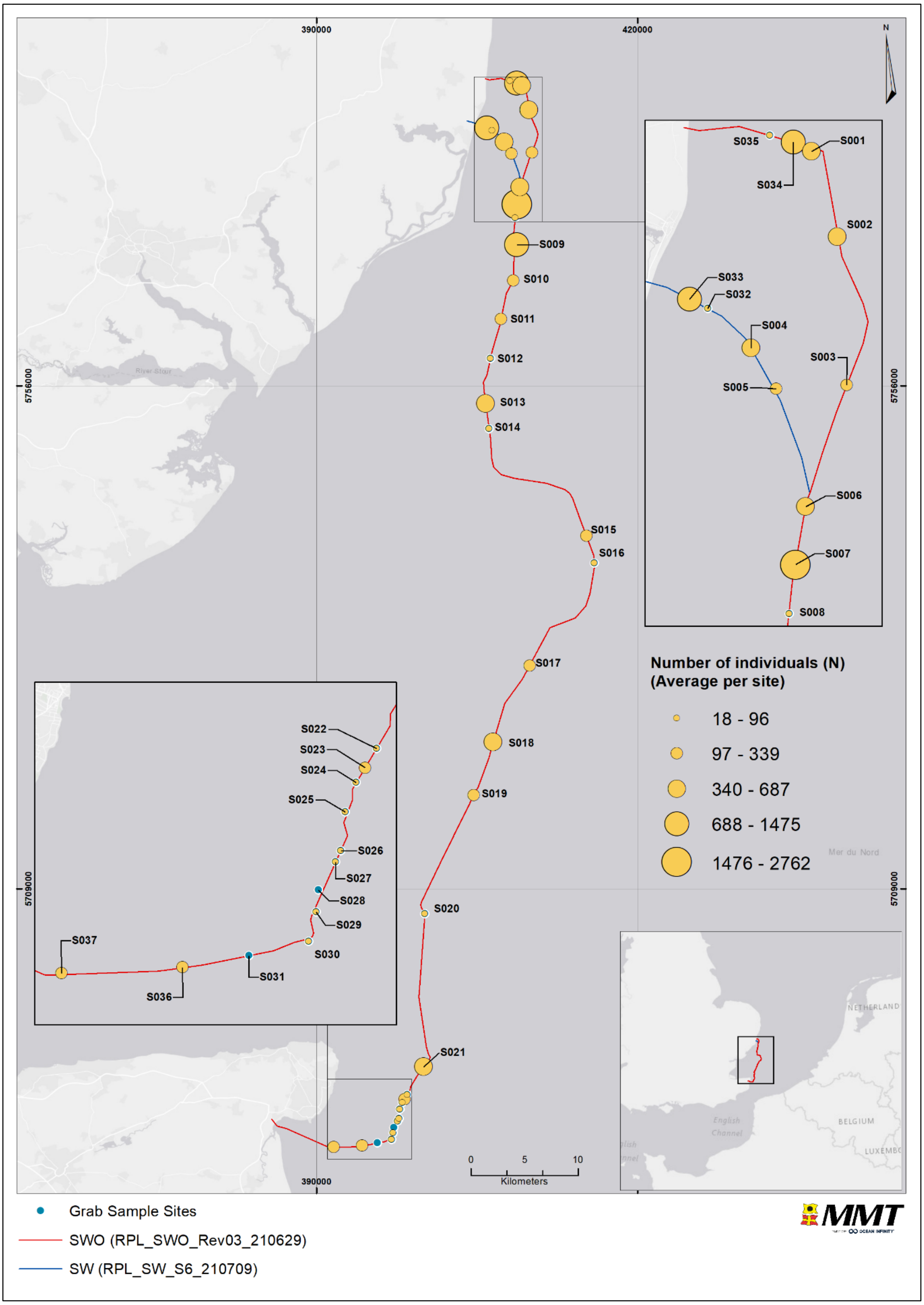


Figure 36 Overview of the Number of Individuals (N) with average values per site.

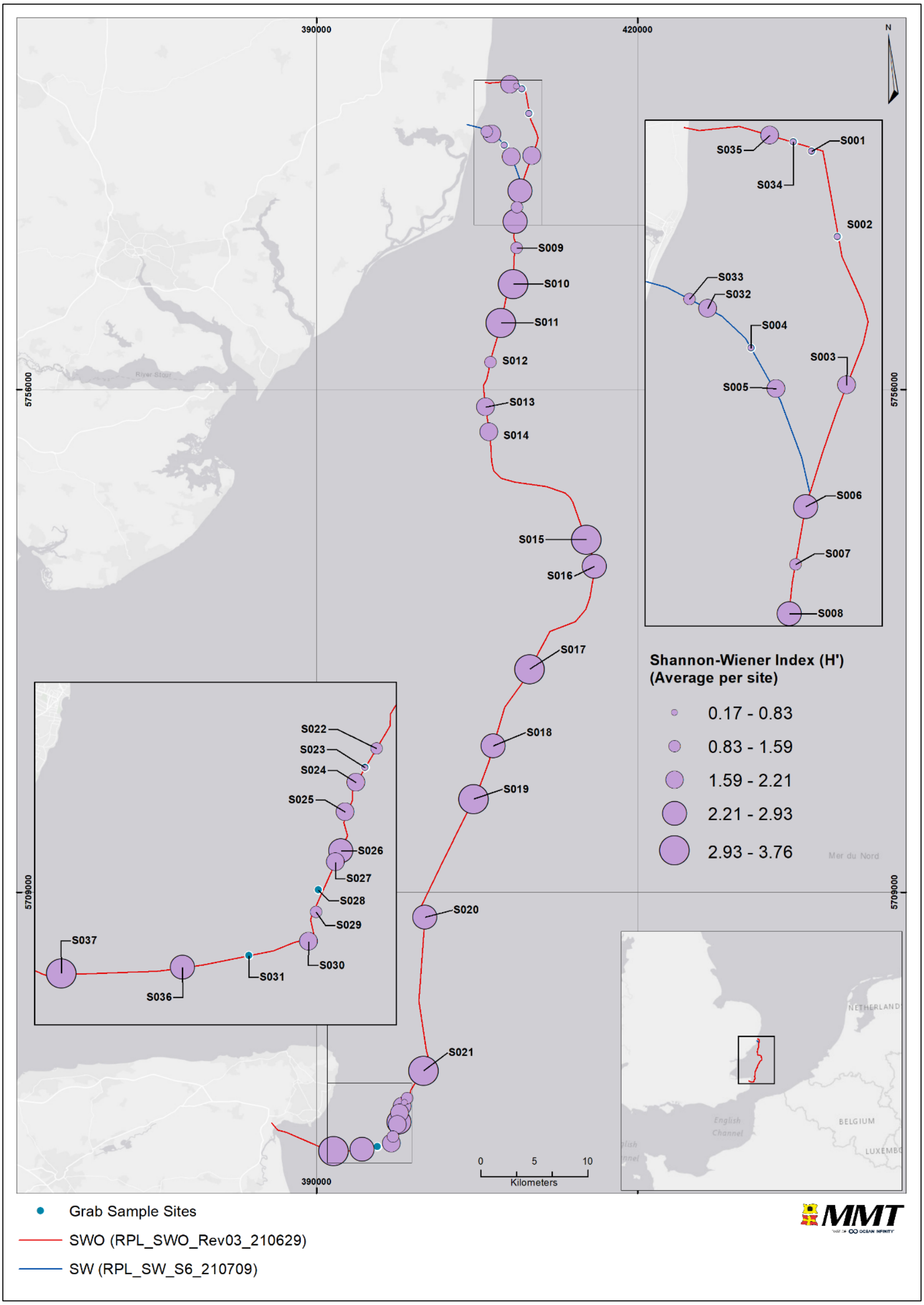


Figure 37 Overview of the Shannon-Wiener Index (H') with average values per site.

5.6.3| MULTIVARIATE STATISTICAL ANALYSES REPLICATE SAMPLES

Square root transformation was applied to the dataset before calculating the Bray-Curtis similarity measures in the SIMPROF and SIMPER analyses. This transformation was made to prevent abundant species from influencing the Bray Curtis similarity index measures excessively and also to take the rarer species into account (Clarke & Gorley, 2015). The statistical analyses were based on macrofaunal data derived from the taxonomic analyses of the grab samples.

Due to the great variation in the survey area, several analyses were conducted to understand the high complexity of the macrofaunal data. The multivariate statistical analyses of replicate samples were divided into sections of all sites, nearshore sites, offshore sites, mixed cluster sites. For multivariate statistical analyses of average per site please view Section 5.6.4|. Please refer to Appendix L| for the multivariate analyses presenting non-colonial fauna with replicates samples at each grab sampling site.

SIMPROF AND SIMPER ANALYSIS ALL SITES

The SIMPROF analysis of the non-colonial faunal composition, including all grab sample sites, produced 33 statistically distinct groups (black lines) and is presented in a hierarchical dendrogram in Figure 38. Sample similarity for all sites is further explored in the nMDS-plot, presented in Figure 39, which reflects the dendrogram including all sites and displays the similarity between and within-sample sites at 20% to highlight homogenous species compositions.

To further explore the sample similarity between the macrofaunal data, EUNIS habitats, and sediment composition, two nMDS-plots of the same data set but with groups based on EUNIS habitats and FOLK classification are presented in Figure 40 and Figure 42.

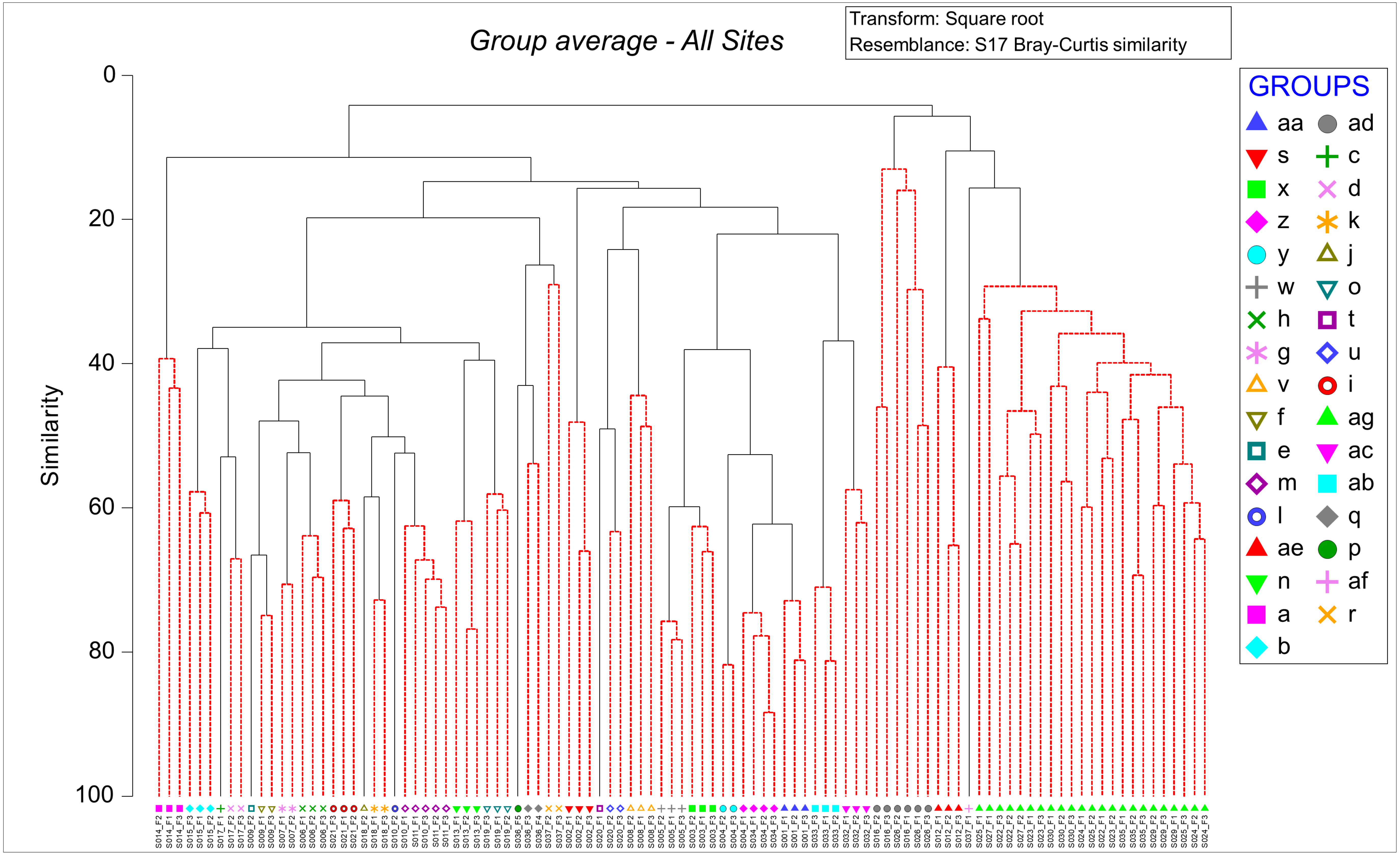


Figure 38 SIMPROF dendrogram based on non-colonial faunal composition for all grab sample sites and replicates.

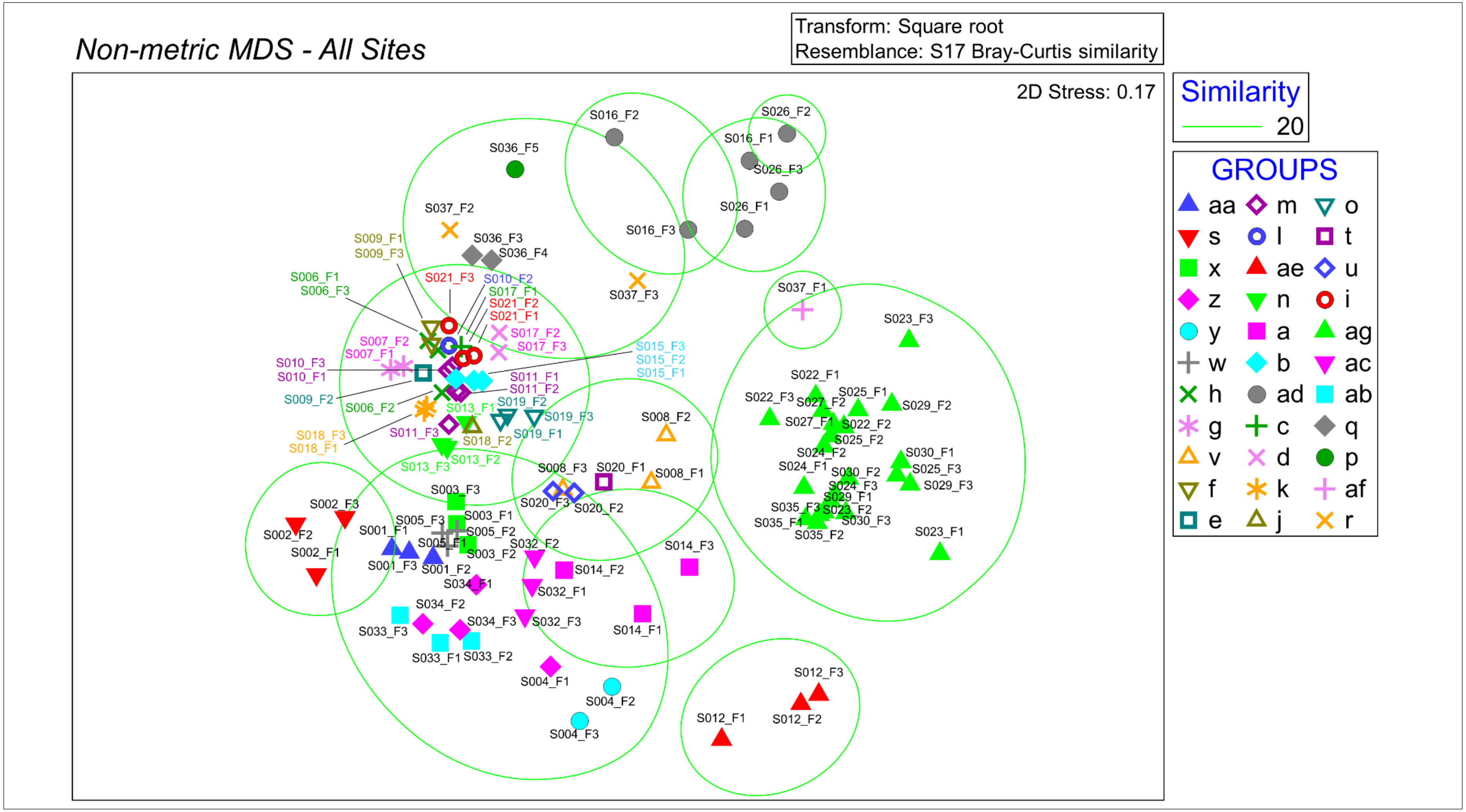


Figure 39 nMDS plot on non-colonial faunal composition for all grab sample sites and replicates with groups based on all sites SIMPROF analysis.

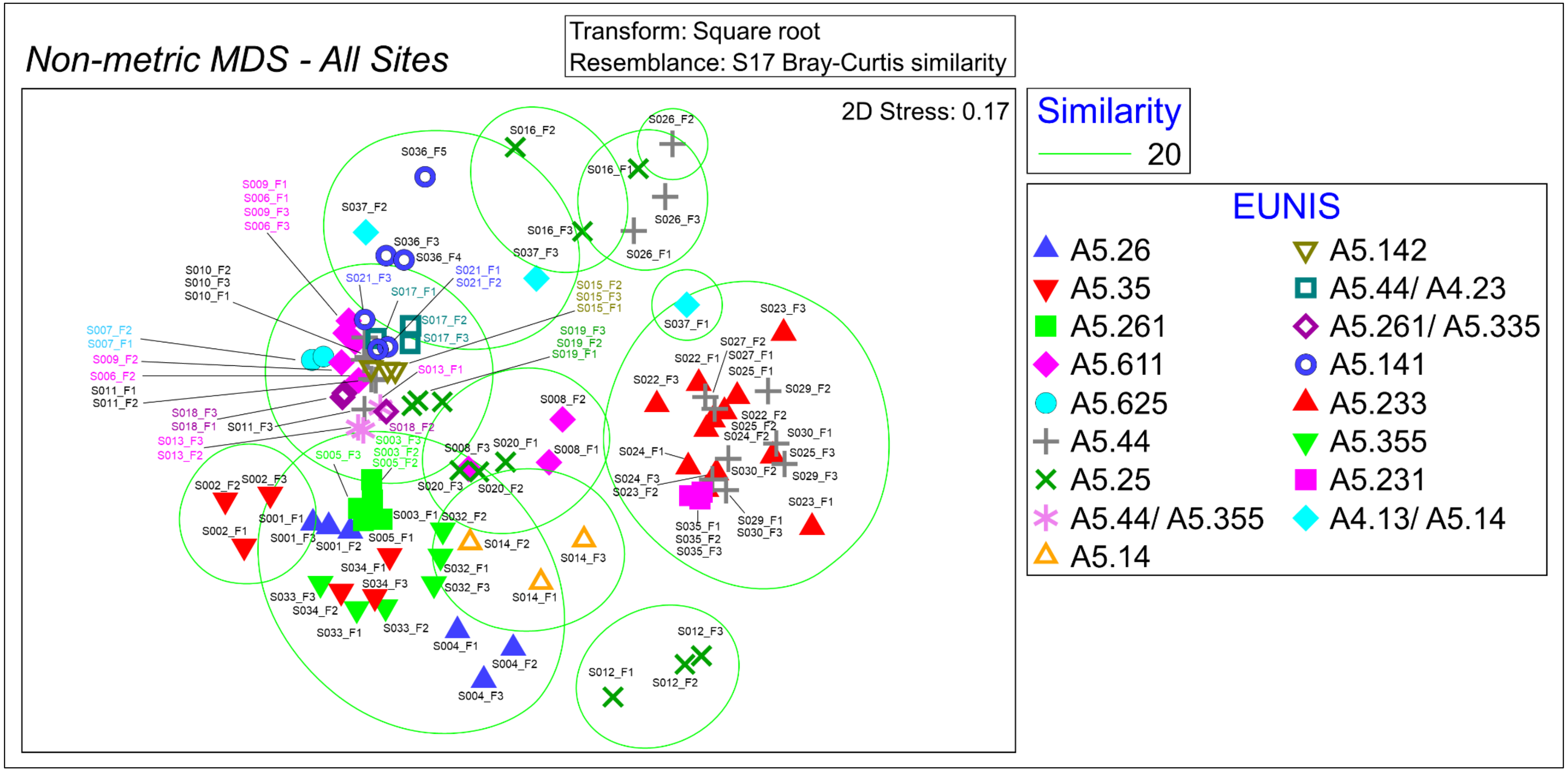


Figure 40 nMDS plot on non-colonial faunal composition for all grab sample sites and replicates superimposed with EUNIS habitats.

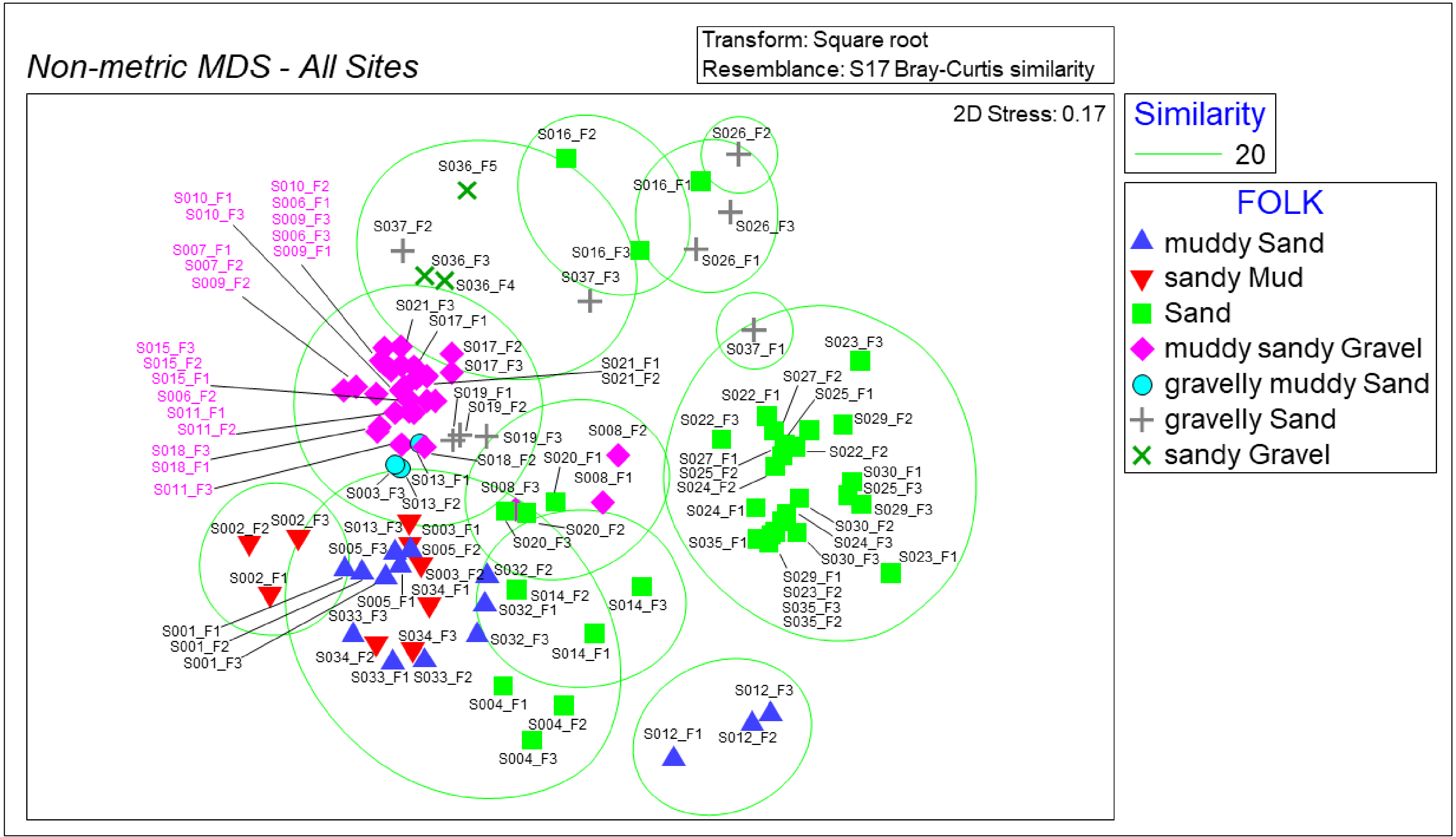


Figure 41 nMDS plot on non-colonial faunal composition for all grab sample sites and replicates superimposed with FOLK classification.

A SIMPER test, displaying the percentage contribution of the most important species seen in the Bray-Curtis similarities test is presented in Table 76with average species abundance for each SIMPROF-group.

Average abundance refers to square root transformed data and is expressed as the mean value per 0.1 m^2 within the multivariate groups.

Table 76 Summary of characteristics of the non-colonial faunal groups derived from the SIMPER test performed on all grab sample sites.

GROUP	SAMPLES	DEPTH	FOLK	SPECIES	AVERAGE ABUNDANCE	CONTR. (%)
aa Average similarity: 75.64 %	S001_F1, S001_F2, S001_F3	15 m	muddy Sand	*Scalibregma inflatum* *Notomastus* *Corophium volutator* *Kurtiella bidentata* *Mediomastus fragilis*	23.62 7.94 4.97 2.86 1.86	51.80 16.11 9.47 4.87 2.57
s Average similarity: 54.06%	S002_F1, S002_F2, S002_F3	18 m	sandy Mud	*Corophium volutator* *Scalibregma inflatum* *Notomastus* *Mediomastus fragilis* *Ophiura albida*	20.88 3.23 2.78 2.19 1.05	59.23 11.48 10.78 8.80 1.94
x Average similarity: 63.77%	S003_F1, S003_F2, S003_F3	22 m	sandy Mud	*Scalibregma inflatum* *Abra alba* *Spiophanes bombyx* *Lagis koreni* *Nucula nitidosa*	8.65 5.63 3.64 3.44 3.43	22.08 16.71 9.70 8.30 7.04
z Average similarity: 77.93%	S004_F1, S034_F1, S034_F2, S034_F3	13 m	Sand, sandy Mud	*Scalibregma inflatum* *Notomastus* *Spiophanes bombyx* *Diastylis bradyi* *Kurtiella bidentata*	27.69 3.67 2.80 2.46 2.07	71.35 7.17 6.66 5.13 4.03
y Average similarity: 81.76%	S004_F2, S004_F3	13 m	Sand	*Scalibregma inflatum* *Nephtys cirrosa* *Fabulina fabula* *Goniada maculata*	19.4 1.71 1.21 1.00	84.55 6.40 4.53 4.53
w Average similarity: 76.59%	S005_F1, S005_F2, S005_F3	20 m	muddy Sand	*Scalibregma inflatum* *Abra alba* *Nucula nitidosa* *Kurtiella bidentata* *Lagis koreni*	13.38 5.91 4.97 3.59 3.14	24.66 10.90 8.12 7.03 4.61
h Average similarity: 65.80%	S006_F1, S006_F2, S006_F3	19 m	muddy sandy Gravel	*Actiniaria* *Sabellaria spinulosa* *Abra alba* *Ampelisca spinipes* *Unciola crenatipalma* *Nematoda*	13.02 8.17 5.40 4.96 4.44 4.44	15.30 7.96 6.51 5.02 4.91 3.95
g Average similarity: 70.61%	S007_F1, S007_F2	19 m	-	*Mytilus edulis* *Actiniaria* *Sabellaria spinulosa* *Nematoda* *Abra alba*	43.86 13.16 12.32 11.89 7.66	27.57 8.91 6.73 6.60 5.30
v Average similarity: 45.85%	S008_F1, S008_F2, S008_F3	19 m	muddy sandy Gravel	*Spiophanes bombyx* *Nucula nucleus* *Lagis koreni* *Bathyporeia elegans* *Aphelochaeta marioni*	2.34 1.79 2.13 0.94 1.00	27.97 21.81 20.12 7.15 4.50

GROUP	SAMPLES	DEPTH	FOLK	SPECIES	AVERAGE ABUNDANCE	CONTR. (%)
f Average similarity: 74.95%	S009_F1, S009_F3	19 m	muddy sandy Gravel	*Sabellaria spinulosa* *Ampelisca spinipes* *Actiniaria* *Abra alba* *Bodotria scorpioides*	34.26 7.48 7.47 5.00 4.29	33.07 7.30 6.89 4.72 3.94
e Average similarity: NA	S009_F2	19 m	muddy sandy Gravel	*Less than 2 samples in group*	-	-
m Average similarity: 66.54%	S010_F1, S010_F3, S011_F1, S011_F2, S011_F3	24 m	muddy sandy Gravel	*Lagis koreni* *Abra alba* *Ampelisca spinipes* *Ampharete lindstroemi* *Lumbrineris cingulata*	5.04 4.21 3.84 3.24 3.23	6.63 5.92 5.72 4.58 4.46
l Average similarity: NA	S010_F2	21 m	muddy sandy Gravel	Less than 2 samples in group	-	-
ae Average similarity: 48.70%	S012_F1, S012_F2, S012_F3	19 m	muddy Sand	*Magelona johnstoni* *Nephtys cirrosa* *Goniada maculata*	3.53 1.39 0.67	75.48 13.20 11.32
n Average similarity: 66.82%	S013_F1, S013_F2, S013_F3	23 m	gravelly muddy Sand	*Kurtiella bidentata* *Lagis koreni* *Abra alba* *Notomastus* *Nemertea*	9.34 11.54 6.80 5.20 3.86	15.31 10.56 9.74 8.29 6.44
a Average similarity: 40.66%	S014_F1, S014_F2, S014_F3	22 m	Sand	*Kurtiella bidentata* *Goodallia triangularis* *Lagis koreni* *Myrianida*	3.49 1.61 1.14 0.80	53.99 24.18 17.10 4.73
b Average similarity: 58.73%	S015_F1, S015_F2, S015_F3	46 m	muddy sandy Gravel	*Kurtiella bidentata* *Paradoneis lyra* *Lumbrineris cingulata* *Nematoda* *Schistomeringos rudolphi*	4.04 3.34 3.01 3.26 2.23	8.77 6.87 6.81 6.65 5.49
ad Average similarity: 20.39%	S016_F1, S016_F2, S016_F3, S026_F1, S026_F2, S026_F3	10 m	Sand, gravelly Sand	*Nemertea* *Glycera lapidum* *Hesionura elongata* *Lumbrineris cingulata* *Nematoda*	1.02 1.16 1.22 0.79 0.77	28.52 17.88 16.49 8.71 4.65
c Average similarity: NA	S017_F1	20 m	muddy sandy Gravel	Less than 2 samples in group	-	-
d Average similarity: 67.06%	S017_F2, S017_F3	20 m	muddy sandy Gravel	*Ampelisca spinipes* *Photis longicaudata* *Lumbrineris cingulata* *Sabellaria spinulosa* *Ampharete lindstroemi*	5.48 3.0 2.82 2.37 2.50	14.33 7.52 7.04 4.61 5.32
k Average similarity: 72.80%	S018_F1, S018_F3	21 m	muddy sandy Gravel	*Lagis koreni* *Kurtiella bidentata* *Photis longicaudata* *Ampelisca spinipes* *Ampharete lindstroemi*	11.21 11.85 8.15 8.62 6.28	9.08 8.74 7.32 6.77 5.61
j Average similarity: NA	S018_F2	21 m	muddy sandy Gravel	Less than 2 samples in group	-	-

GROUP	SAMPLES	DEPTH	FOLK	SPECIES	AVERAGE ABUNDANCE	CONTR. (%)
o Average similarity: 58.82%	S019_F1, S019_F2, S019_F3	26 m	gravelly Sand	*Sabellaria spinulosa* *Kurtiella bidentata* *Abra alba* *Spiophanes bombyx* *Scalibregma inflatum*	4.84 4.61 3.04 3.12 2.51	11.03 9.69 6.88 6.67 6.11
t Average similarity: NA	S020_F1	21 m	Sand	Less than 2 samples in group	-	-
u Average similarity: 63.31%	S020_F2, S020_F3	21 m	Sand	*Lagis koreni* *Abra alba* *Tubificoides diazi* *Aricidea minuta* *Spiophanes bombyx*	4.52 4.24 3.00 2.41 2.19	17.95 16.93 11.97 8.46 7.33
i Average similarity: 60.26%	S021_F1, S021_F2, S021_F3	14 m	muddy sandy Gravel	*Spirobranchus lamarcki* *Serpulidae* *Abra alba* *Lagis koreni* *Sabellaria spinulosa*	6.52 6.12 5.64 3.77 4.47	6.91 6.87 6.26 4.10 4.03
ag Average similarity: 36.90%	S022_F1, S022_F2, S022_F3, S023_F1, S023_F2, S023_F3, S024_F1, S024_F2, S024_F3, S025_F1, S025_F2, S025_F3, S027_F1, S027_F2, S029_F1, S029_F2, S029_F3, S030_F1, S030_F2, S030_F3, S035_F1, S035_F2, S035_F3	4, 10, 11, 13, 12 m	Sand	*Urothoe brevicornis* *Bathyporeia pelagica* *Nephtys cirrosa* *Ophelia borealis* *Magelona johnstoni*	3.42 3.14 0.95 0.67 0.51	48.83 21.81 10.05 4.27 4.05
ac Average similarity: 59.00%	S032_F1, S032_F2, S032_F3	9 m	muddy Sand	*Spiophanes bombyx* *Nucula nitidosa* *Lagis koreni* *Magelona johnstoni* *Diastylis rathkei*	5.62 4.40 4.40 2.39 1.39	27.57 22.38 19.77 11.04 3.09
ab Average similarity: 74.42%	S033_F1, S033_F2, S033_F3	8 m	muddy Sand	*Limecola balthica* *Lagis koreni* *Spiophanes bombyx* *Nucula nitidosa* *Abra alba*	19.5 15.54 9.49 6.81 2.99	24.93 22.27 13.5 10.02 4.45
q Average similarity: 53.88%	S036_F3, S036_F4	10 m	sandy Gravel	*Sabellaria spinulosa* *Nematoda* *Actiniaria* *Serpulidae* *Spirobranchus lamarcki*	5.83 5.19 3.23 2.88 3.22	13.07 8.62 8.18 6.68 6.68

GROUP	SAMPLES	DEPTH	FOLK	SPECIES	AVERAGE ABUNDANCE	CONTR. (%)
p Average similarity: NA	S036_F5	10 m	sandy Gravel	Less than 2 samples in group	-	-
af Average similarity: NA	S037_F1	8 m	gravelly Sand	Less than 2 samples in group	-	-
r Average similarity: 29.02 %	S037_F2, S037_F3	8 m	gravelly Sand	*Balanus crenatus* *Abludomelita obtusata* *Sabellaria spinulosa* *Monocorophium acherusicum* *Nematoda*	6.35 3.66 3.38 2.99 4.16	19.75 11.76 11.22 6.14 7.93

SIMPROF ANALYSIS NEARSHORE SITES

The SIMPROF analysis of the non-colonial faunal composition, including the nearshore sites S032 - S037, produced nine (9) statistically district groups (black lines) and is presented in a hierarchical dendrogram in Figure 42. Sample similarity for the nearshore sites is further explored in the nMDS-plot, presented in Figure 43, which reflects the nearshore sites dendrogram and displays the similarity between and within-sample sites at 20% to highlight homogenous species compositions.

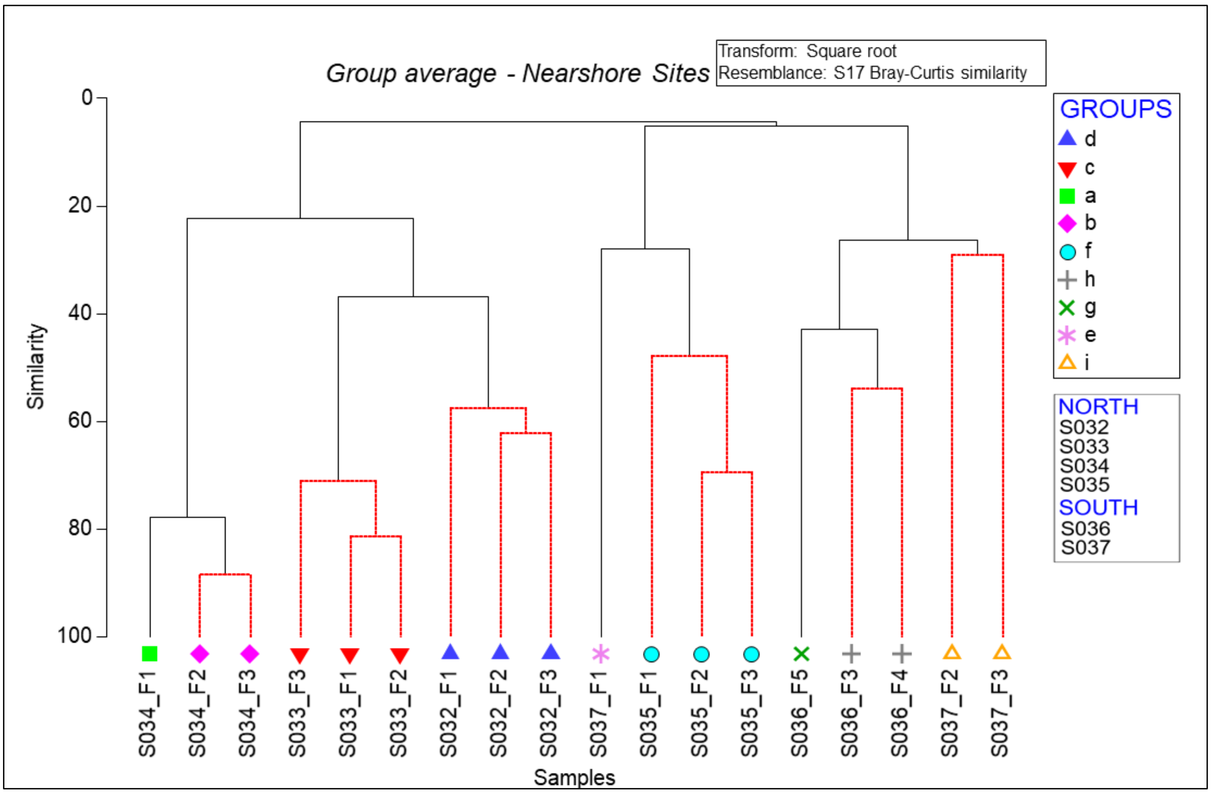


Figure 42 SIMPROF dendrogram based on non-colonial faunal composition for the nearshore grab sampling sites and replicates.

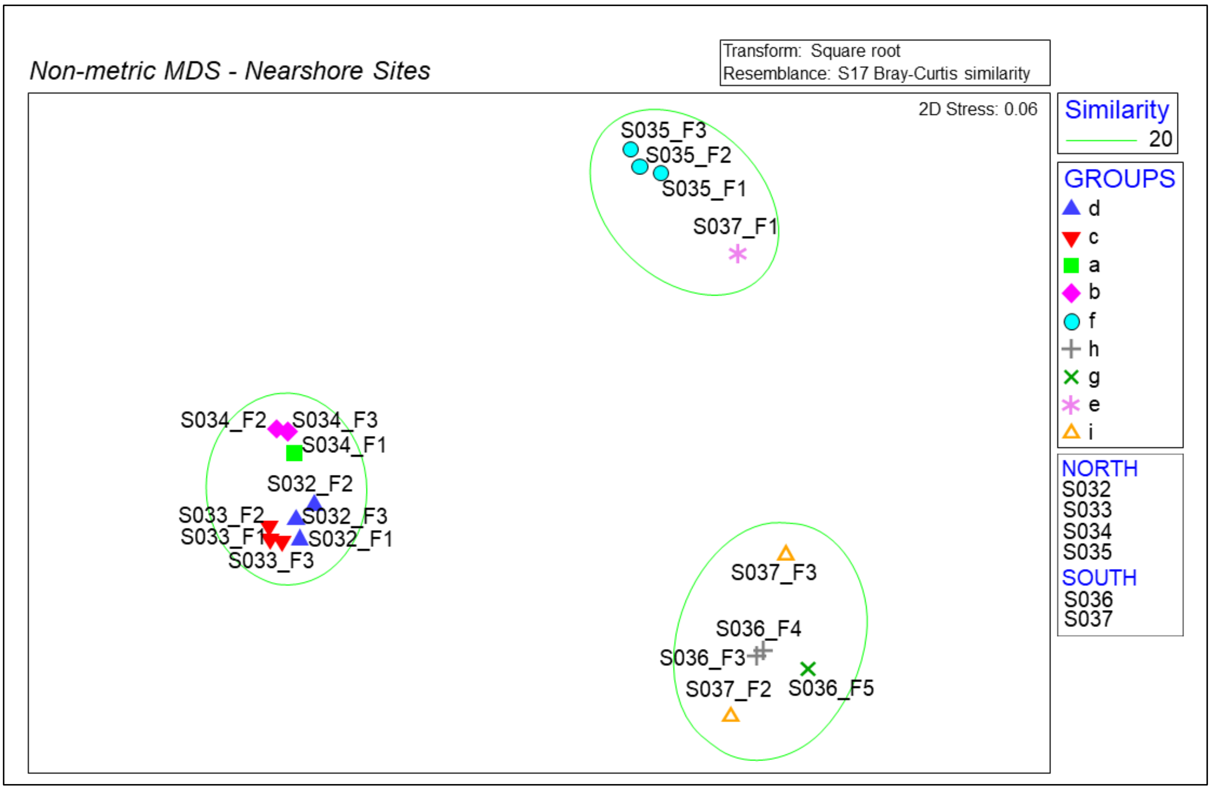


Figure 43 nMDS plot on non-colonial faunal composition for the nearshore grab sample sites and replicates with groups based on the nearshore grab sampling sites SIMPROF analysis.

SIMPROF ANALYSIS OFFSHORE SITES

The SIMPROF analysis of the non-colonial faunal composition, including the offshore sites; S001 - S030, produced 26 statistically district groups (black lines) and is presented in a hierarchical dendrogram in Figure 44. Sample similarity for the offshore sites is further explored in the nMDS-plot, presented in Figure 45, which reflects the offshore sites dendrogram and displays the similarity between and within-sample sites at 20% to highlight homogenous species compositions.

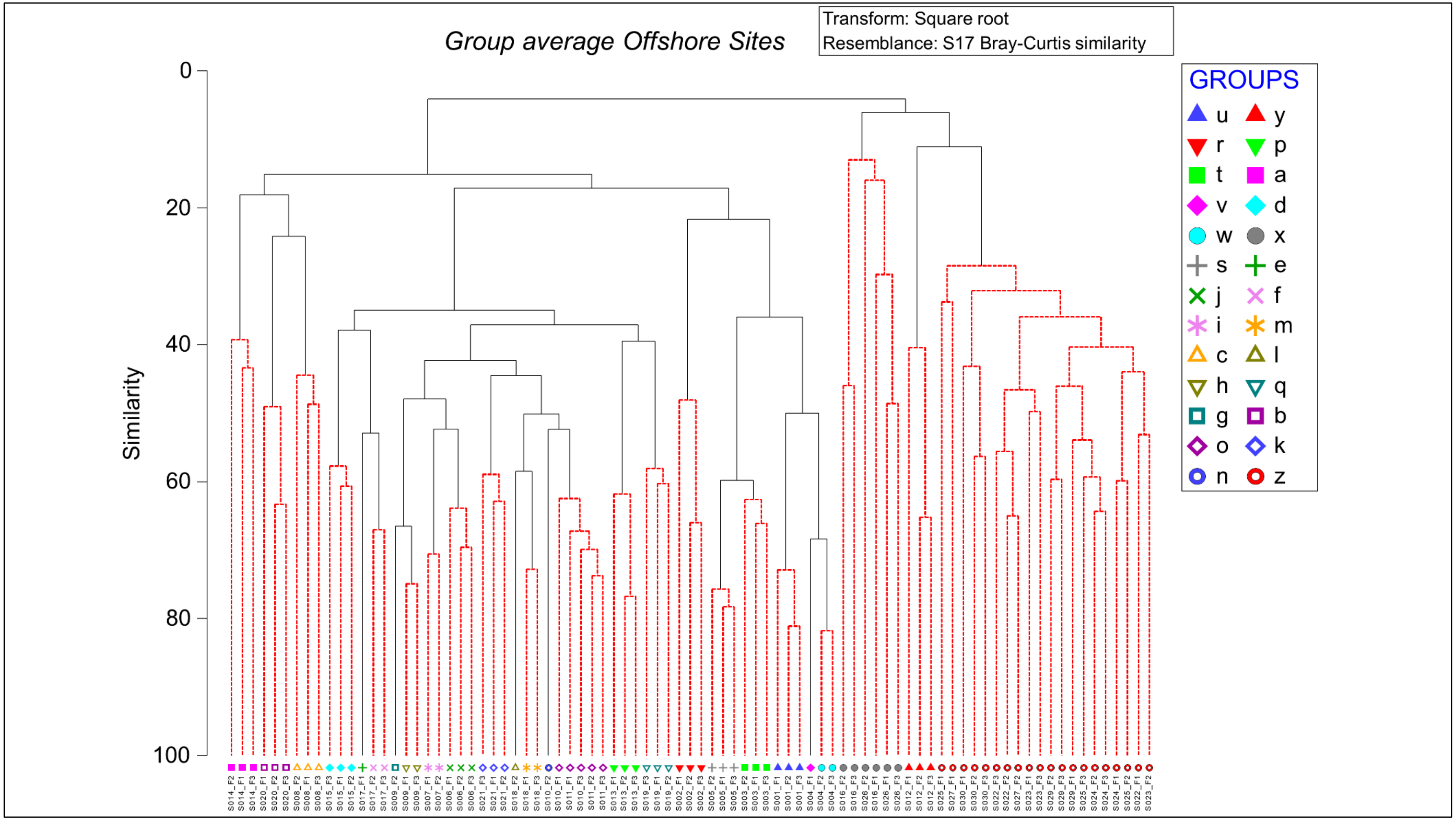


Figure 44 SIMPROF dendrogram based on non-colonial faunal composition for the offshore grab sample sites and replicates.

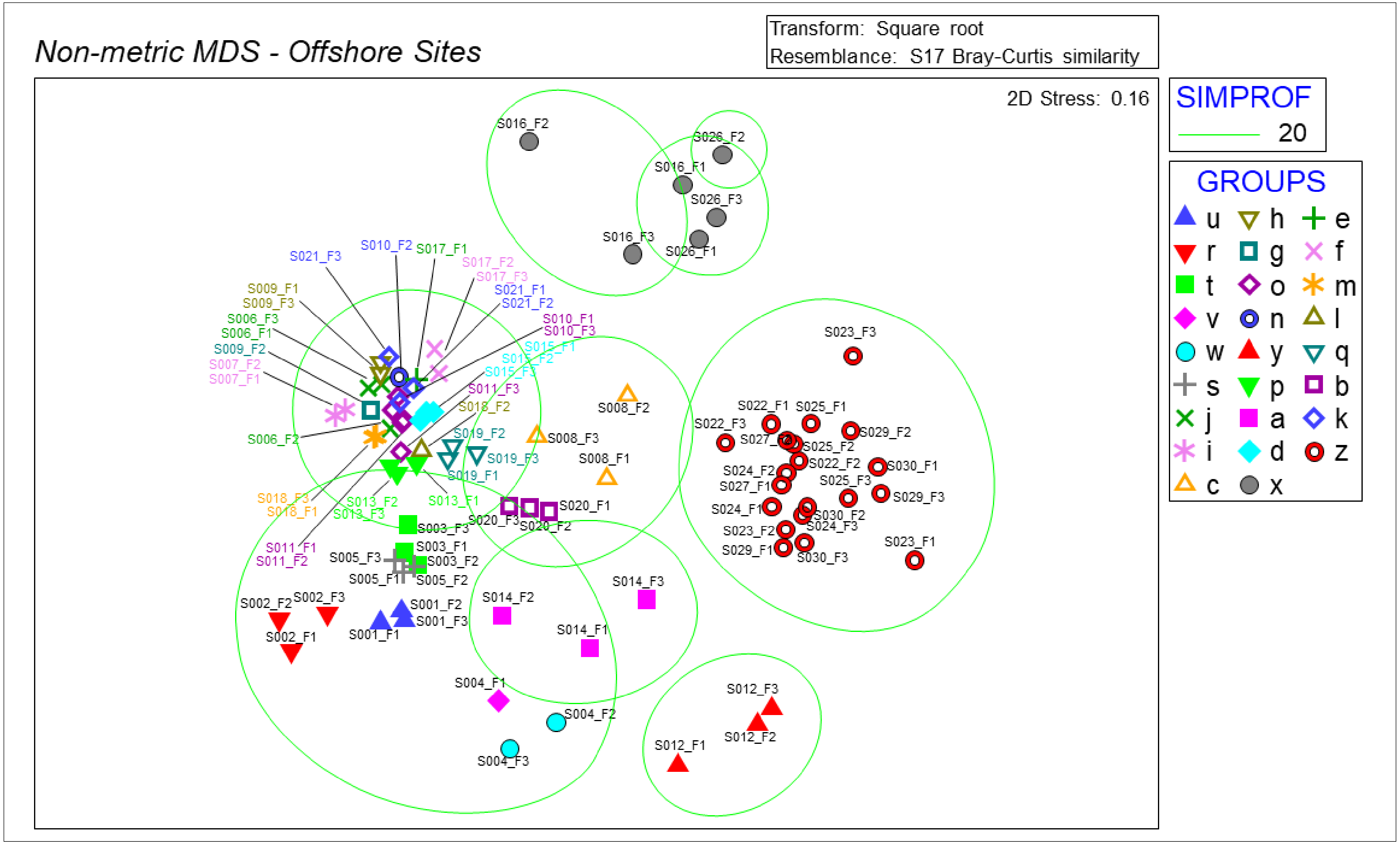


Figure 45 nMDS plot of non-colonial faunal composition for the offshore grab sample sites and replicates with groups based on sites SIMPROF analysis.

SIMPROF ANALYSIS MIXED CLUSTER SITES

To present statistically significant defences within one of the mixed clusters seen in Figure 39, an additional SIMPROF analysis of the non-colonial faunal composition was conducted. It produced 14 statistically distinct groups and is presented in the dendrogram in Figure 46. The mixed cluster includes sites; S006, S007, S009 - S011, S013, S015, S017 - S019 and S021. Sample similarity for the mixed cluster sites is further explored in nMDS-plot, presented in Figure 47, which reflects the mixed sites dendrogram and displays the similarity between and within-sample sites at 20% to highlight homogenous species compositions.

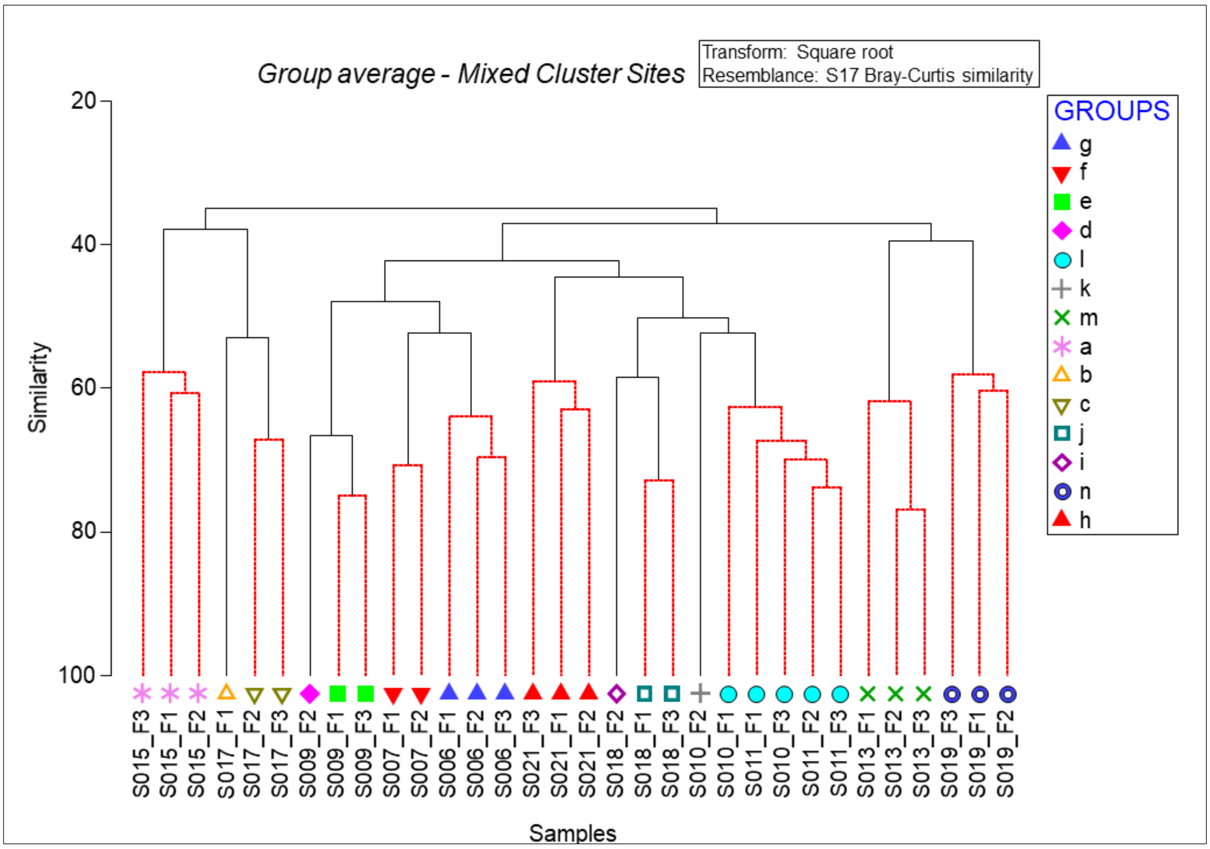


Figure 46 SIMPROF dendrogram based on non-colonial faunal composition for the mixed cluster grab sample sites and replicates.

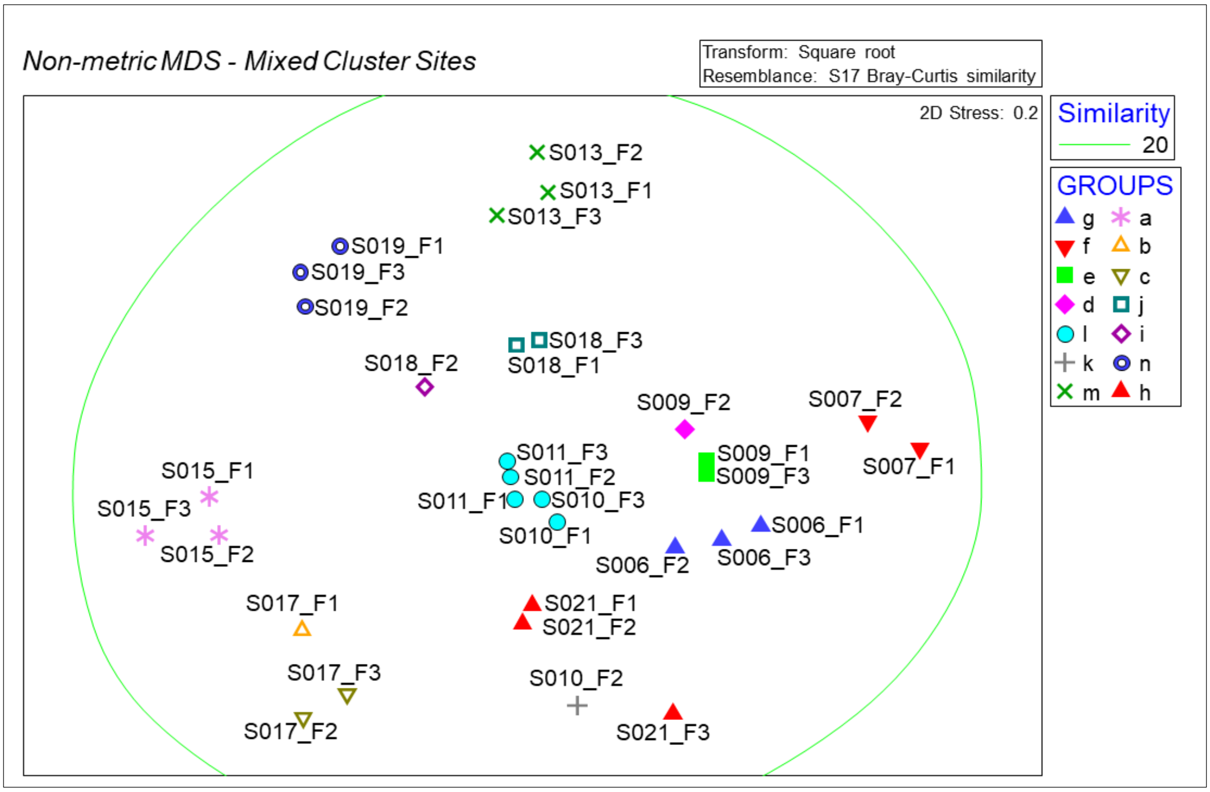


Figure 47 nMDS plot on non-colonial faunal composition for the mixed cluster grab sample sites with groups based on the mixed cluster grab sampling sites SIMPROF analysis.

5.6.4| MULTIVARIATE STATISTICAL ANALYSES AVERAGE PER SITE

To test statistically significant differences between all grab sampling sites, an additional multivariate analysis was conducted presenting the average value per site. Square root transformation was applied to the dataset before calculating the Bray-Curtis similarity measures in the SIMPROF and SIMPER analyses. This transformation was made to prevent abundant species from influencing the Bray Curtis similarity index measures excessively and also to take the rarer species into account (Clarke & Gorley, 2015). The statistical analyses were based on macrofaunal data derived from the taxonomic analyses of the grab samples. The average values were calculated from the three replicate samples at each grab sampling site. Please refer to Appendix L| for the multivariate analyses presenting non-colonial fauna with average values per grab sampling site.

SIMPROF ANALYSIS AVERAGE PER SITE

The SIMPROF analysis of the non-colonial faunal composition, including the averages values for all grab sampling sites; S001 - S037, produced 16 statistically district groups (black lines) and is presented in a hierarchical dendrogram in Figure 48. Sample similarity for the offshore sites is further explored in the nMDS-plot, presented in Figure 49, which reflects average values dendrogram and displays the similarity between and within-sample sites at 20% to highlight homogenous species compositions.

To further explore the sample similarity between the macrofaunal data, EUNIS habitats, and sediment composition, two nMDS-plot of the same data set but with groups based on the EUNIS habitats and FOLK classification is presented in Figure 50 and Figure 51. For SIMPROF analysis with groups based on the EUNIS habitat level three, please refer to Appendix K|.

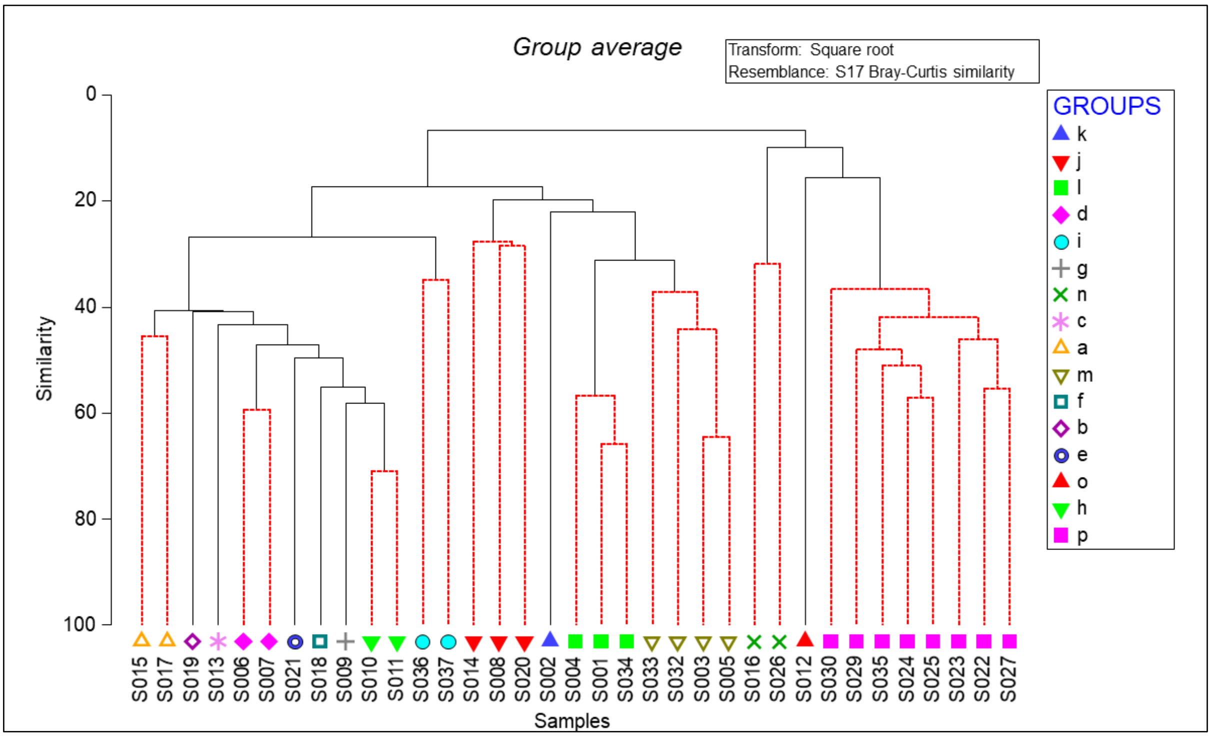


Figure 48 SIMPROF dendrogram based on non-colonial faunal composition presenting average values for all grab sample sites.

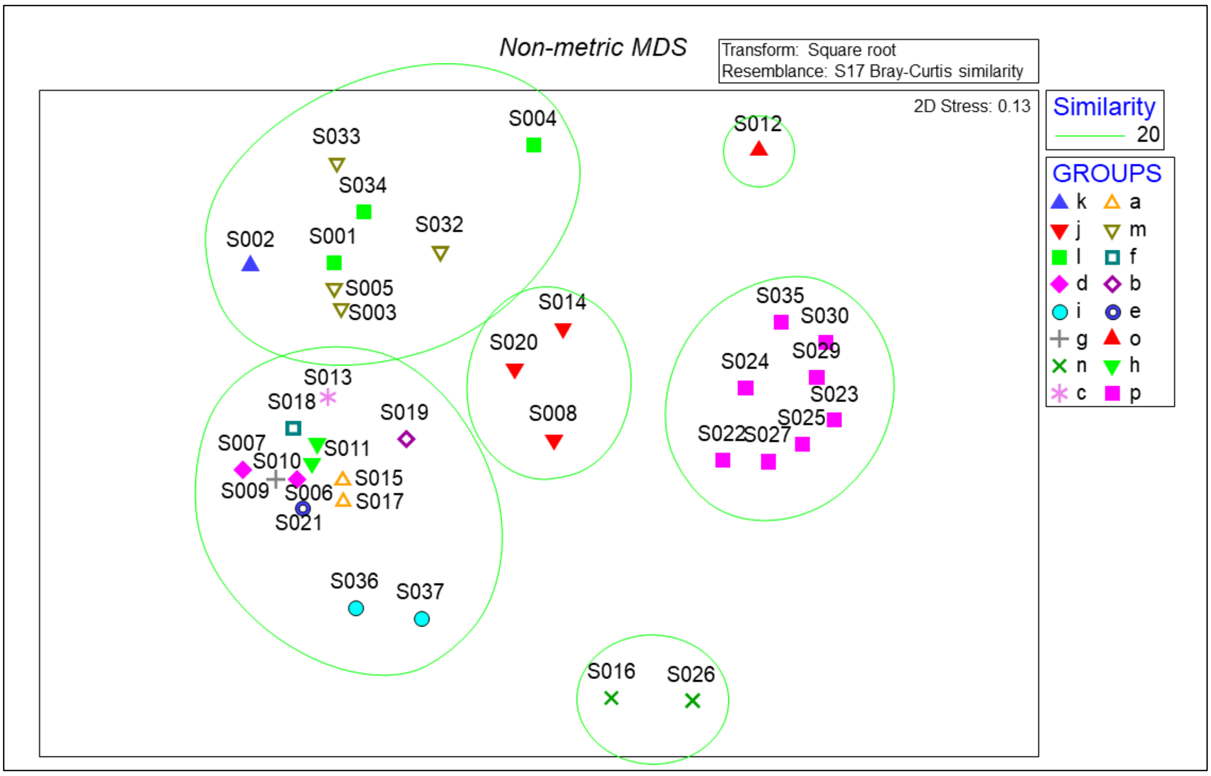


Figure 49 nMDS plot on non-colonial faunal composition presenting the average values for all grab sampling sites.

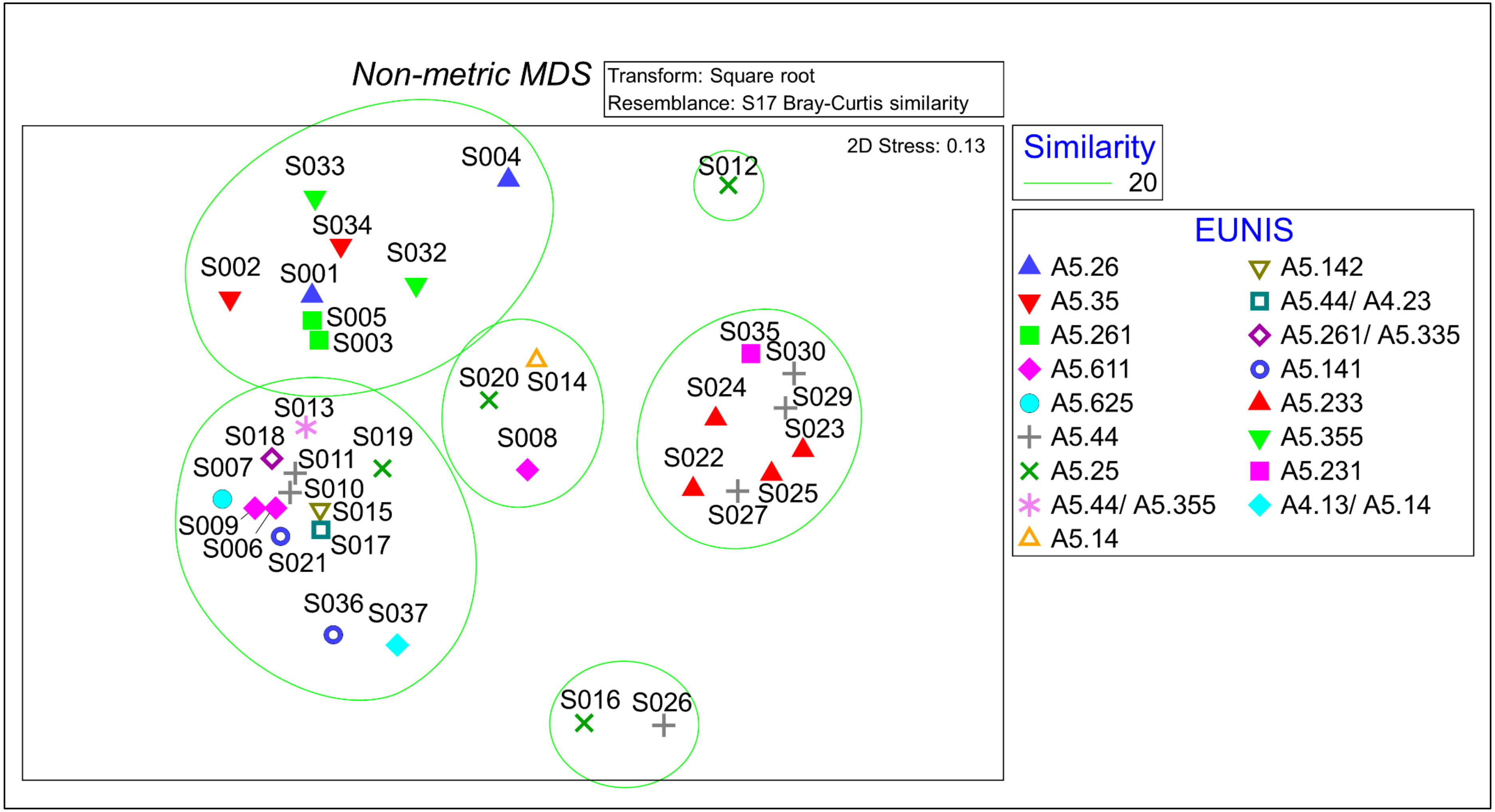


Figure 50 nMDS plot on non-colonial faunal composition presenting the average values for all grab sampling sites superimposed with EUNIS habitats

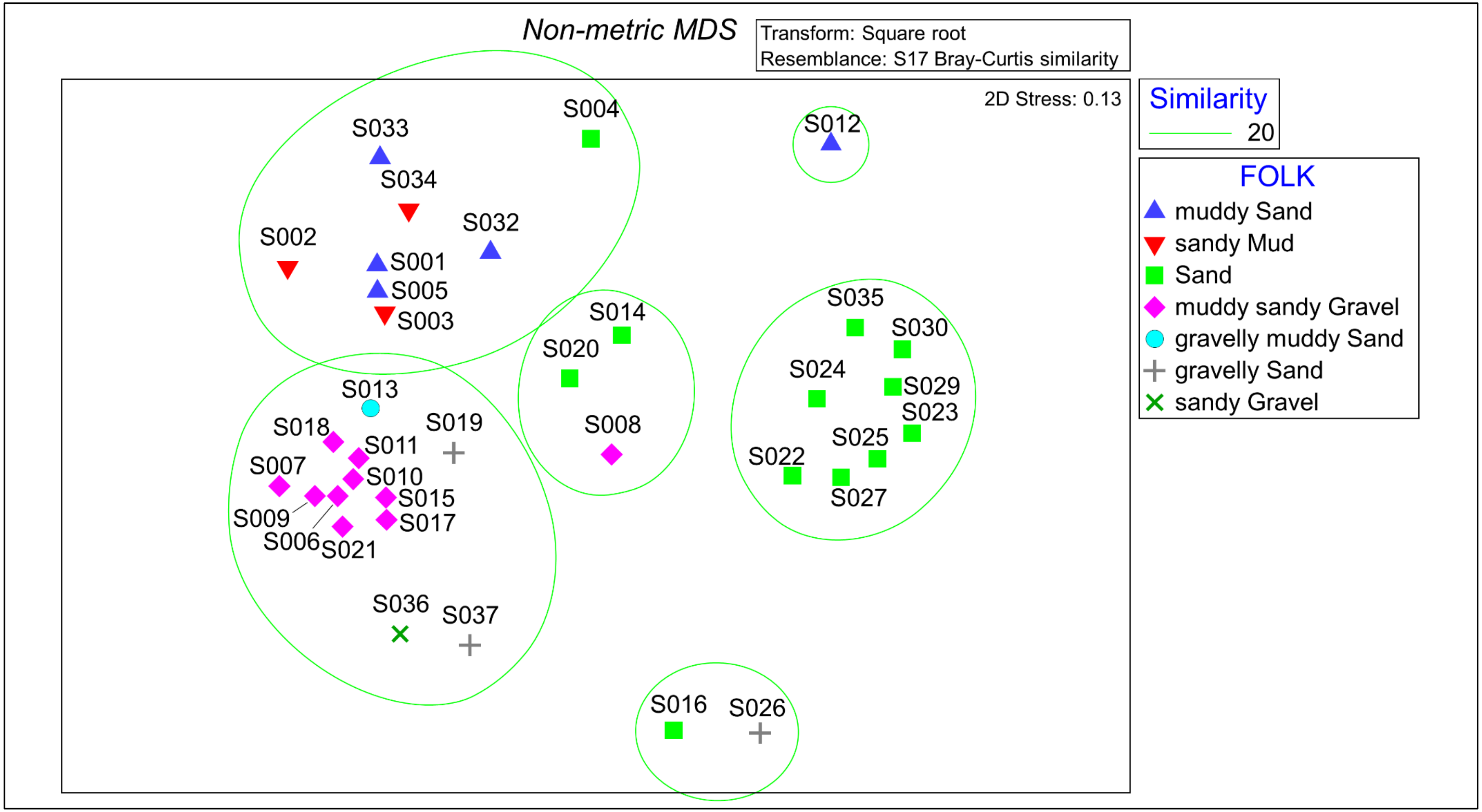


Figure 51 nMDS plot on non-colonial faunal composition presenting the average values for all grab sampling sites superimposed with FOLK classification.

A SIMPER test, displaying the percentage contribution of the most important species seen in the Bray-Curtis similarities test is presented in Table 77 with average species abundance for each SIMPROF-group.

Average abundance refers to square root transformed average data and is expressed as the mean value per 0.1 square metre within the multivariate groups.

Table 77 Summary of characteristics of the non-colonial faunal groups derived from the SIMPER test performed on the average values for all grab sample sites.

GROUP	SAMPLES	DEPTH	FOLK	SPECIES	AVERAGE ABUNDANCE	CONTR. (%)
l Average similarity: 59.71%	S001, S004, S034	15, 13, 13 m	muddy Sand, Sand, sandy Mud	*Scalibregma inflatum* *Notomastus* *Kurtiella bidentata* *Diastylis bradyi* *Spiophanes bombyx*	24.62 4.42 2.01 1.88 1.78	74.01 5.93 3.57 3.98 3.63
k Average similarity: NA	S002	18 m	sandy Mud	Less than 2 samples in group	-	-
m Average similarity: 44.0%	S003, S005, S032, S033	22, 20, 9, 8 m	sandy Mud, muddy Sand, muddy Sand, muddy Sand	*Lagis koreni* *Scalibregma inflatum* *Spiophanes bombyx* *Nucula nitidosa*	6.81 5.98 5.25 5.07	13.62 7.53 11.94 15.7
d Average similarity: 59.30%	S006, S007	19, 19 m	muddy sandy Gravel, NA	*Actiniaria* *Sabellaria spinulosa* *Nematoda* *Abra alba*	13.15 10.64 8.50 6.55	12.87 8.38 4.65 5.32
j Average similarity: 27.90%	S008, S014, S020	19, 22, 21 m	muddy sandy Gravel, Sand	*Lagis koreni* *Spiophanes bombyx* *Kurtiella bidentata* *Ophelia borealis*	2.57 1.62 1.6 1.1	19.54 12.57 4.69 9.2
g Average similarity: NA	S009	19 m	muddy sandy Gravel	*Sabellaria spinulosa* *Lagis koreni* *Ampelisca spinipes* *Abra alba* *Kurtiella bidentata*	9.14 6.19 5.88 5.04 4.49	1.60 5.92 5.48 5.49 2.53
h Average similarity: 70.92%	S010, S011	24, 21 m	muddy sandy Gravel, muddy sandy Gravel	*Lagis koreni* *Abra alba* *Ampelisca spinipes* *Aphelochaeta marioni* *Lumbrineris cingulata*	4.96 4.24 3.74 3.67 3.16	5.8 5.2 4.64 3.79 3.93
o Average similarity: NA	S012	19 m	muddy Sand	Less than 2 samples in group	-	-
c Average similarity: NA	S013	23 m	gravelly muddy Sand	Less than 2 samples in group	-	-
a Average similarity: 45.49%	S015, S017	46, 20 m	muddy sandy Gravel, muddy sandy Gravel	*Ampelisca spinipes* *Kurtiella bidentata* *Lumbrineris cingulata* *Paradoneis lyra* *Chaetozone zetlandica*	3.51 2.95 2.82 2.02 1.97	5.19 5.19 7.74 1.73 4.24

GROUP	SAMPLES	DEPTH	FOLK	SPECIES	AVERAGE ABUNDANCE	CONTR. (%)
n Average similarity: 31.84%	S016, S026	27, 10 m	Sand, gravelly Sand	*Hesionura elongata* *Glycera lapidum* Nemertea *Lumbrineris cingulata*	1.6 1.41 1.15 1.05	22.83 14.44 17.68 10.21
f Average similarity: NA	S018	21 m	muddy sandy Gravel	Less than 2 samples in group	-	-
b Average similarity: NA	S019	26 m	gravelly Sand	Less than 2 samples in group	-	-
e Average similarity: NA	S021	14 m	muddy sandy Gravel	Less than 2 samples in group	-	-
p Average similarity: 43.25%	S022, S023, S024, S025, S027, S029, S030, S035	10, 10, 10, 11, 12, 13, 12, 4 m	Sand, Sand, Sand, Sand, Sand, Sand, Sand, Sand	*Bathyporeia pelagica* *Urothoe brevicornis* *Nephtys cirrosa* *Ophelia borealis* *Magelona johnstoni*	3.82 3.52 1.17 0.91 0.63	23.61 35.07 12.62 6.31 4.88
i Average similarity: 34.82%	S036, S037	10, 8 m	sandy Gravel, gravelly Sand	Nematoda *Balanus crenatus* *Sabellaria spinulosa* *Abludomelita obtusata*	4.12 3.76 3.05 1.8	11.82 10.79 8.75 5.16

SECOND STAGE DENDROGRAM

A second stage dendrogram was constructed based on the 16 groups identified in the SIMPROF analyses conducted for the group averages in Figure 48. The second stage dendrogram follows the methodology used for previous multivariate analysis, described in Sections 4.3.5| and 5.6.4|.

The second stage analysis resulted in 10 statistically distinct groups (black lines) and is presented in a hierarchical dendrogram in Figure 52.

Sample similarity for the 10 groups is further explored in the nMDS-plot in Figure 53, which reflects the average values dendrogram (Figure 48) but with groups based on the second stage analysis. It displays the similarity between the groups at 20% to highlight homogenous species compositions.

An overview of the 10 distinct groups produced in the second stage dendrogram is presented along the survey routes in Figure 54.

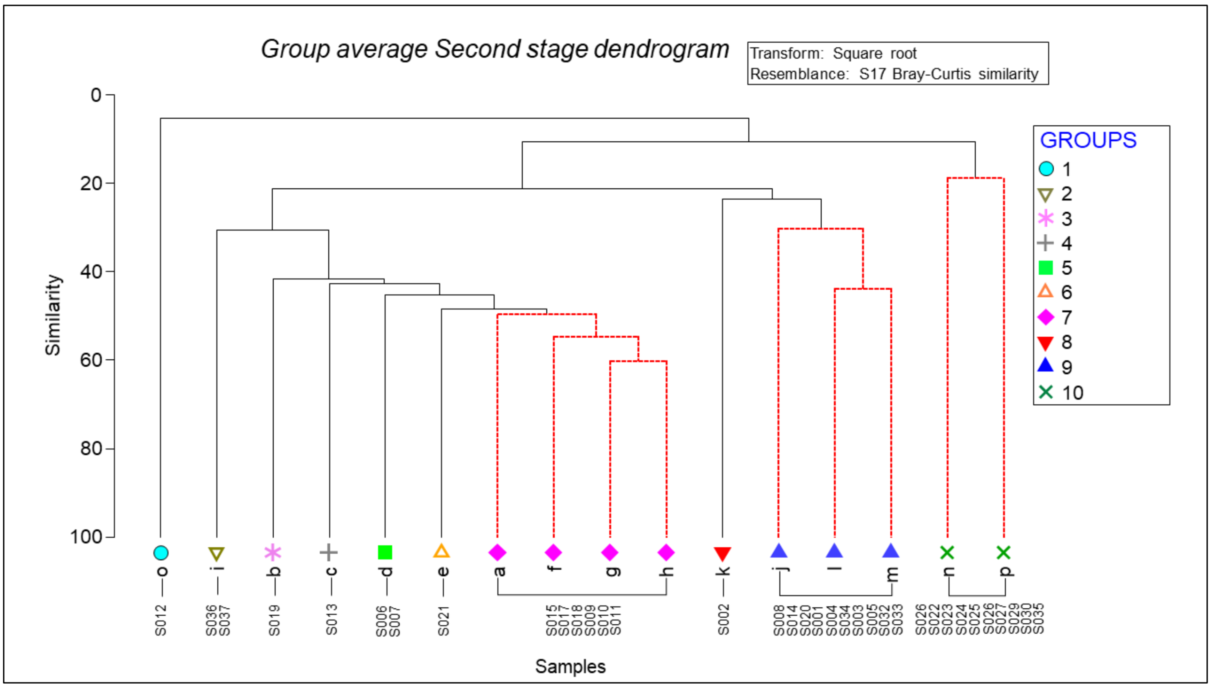


Figure 52 Second stage dendrogram based on the 16 groups identified in the SIMPROF analyses conducted for the average values.

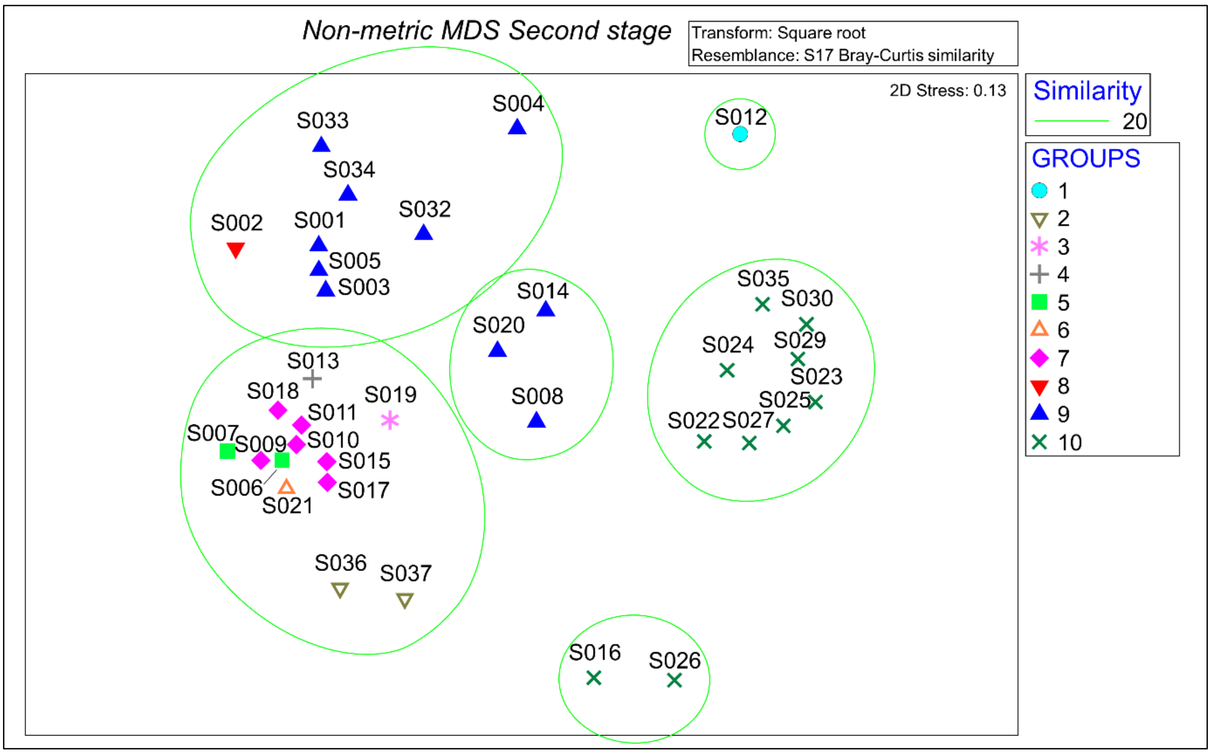


Figure 53 nMDS plot on non-colonial faunal composition presenting the average values superimposed with the groups identified in second stage dendrogram.

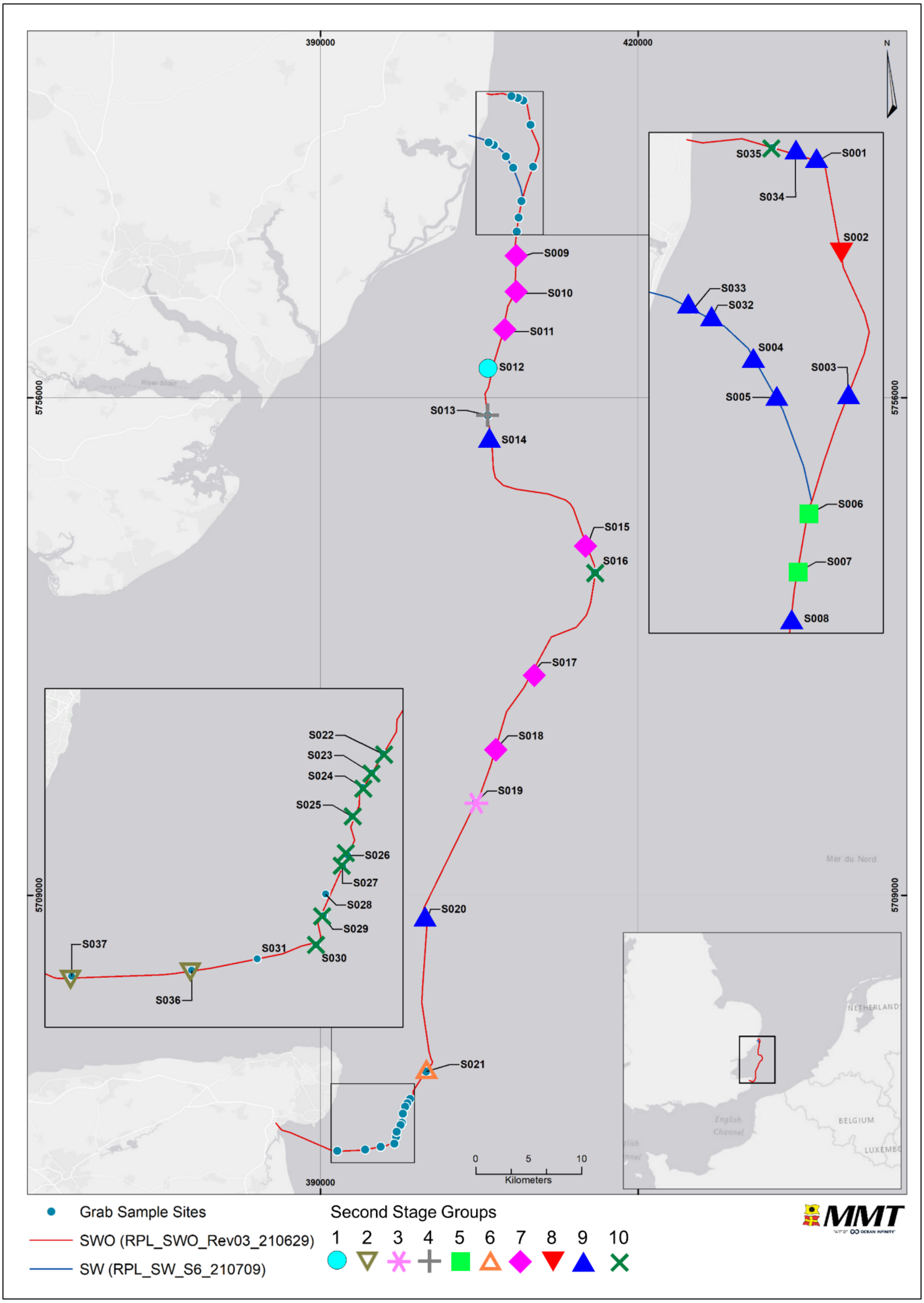


Figure 54 Spatial overview of the 10 groups produced in the second stage dendrogram.

5.7| RELATIONSHIP BETWEEN PHYSICAL AND BIOLOGICAL DATA

The relationship between PSA and faunal communities was assessed by applying the BEST analysis from the PRIMER suite. The BEST test identifies which of the sediment variables best explains the macrofaunal distribution across the survey area.

Results showed that gravel and mud together constituted the variables that best explained the observed pattern of spatial distribution for fauna (rho = 0.585, P = 0.1 %), and was a statistically significant variable for the distribution of the fauna.

5.8| SESSILE COLONIAL EPIFAUNA FROM GRAB SAMPLES

The phyletic composition of sessile colonial epifauna identified from grab samples is summarised in Table 78, Figure 55 and Figure 56.

A total of three (3) major phyla were identified, and the phylum; Entoprocta and Arthropoda were combined into “Other”.

The dominant phyla were Bryozoa, which contributed with 53 % of the total taxa, followed by Cnidaria with 33 % of the total taxa and finally “Other” and Porifera 9% and 5%, respectively. A total of 43 different taxa were identified. Abundance was also dominated by Bryozoa with a total of 179 colonies, followed by Cnidaria and “Other” with a total of 85 and 5 colonies, respectively. Four (4) colonies of Porifera were identified. A total of 273 different colonies of colonial taxa were identified.

Table 78 Phyletic composition of colonial epifauna from grab samples.

PHYLUM	NUMBER OF TAXA	ABUNDANCE OF COLONIES
BRYOZOA	23	179
CNIDARIA	14	85
OTHER	4	5
PORIFERA	2	4
TOTAL	**43**	**273**

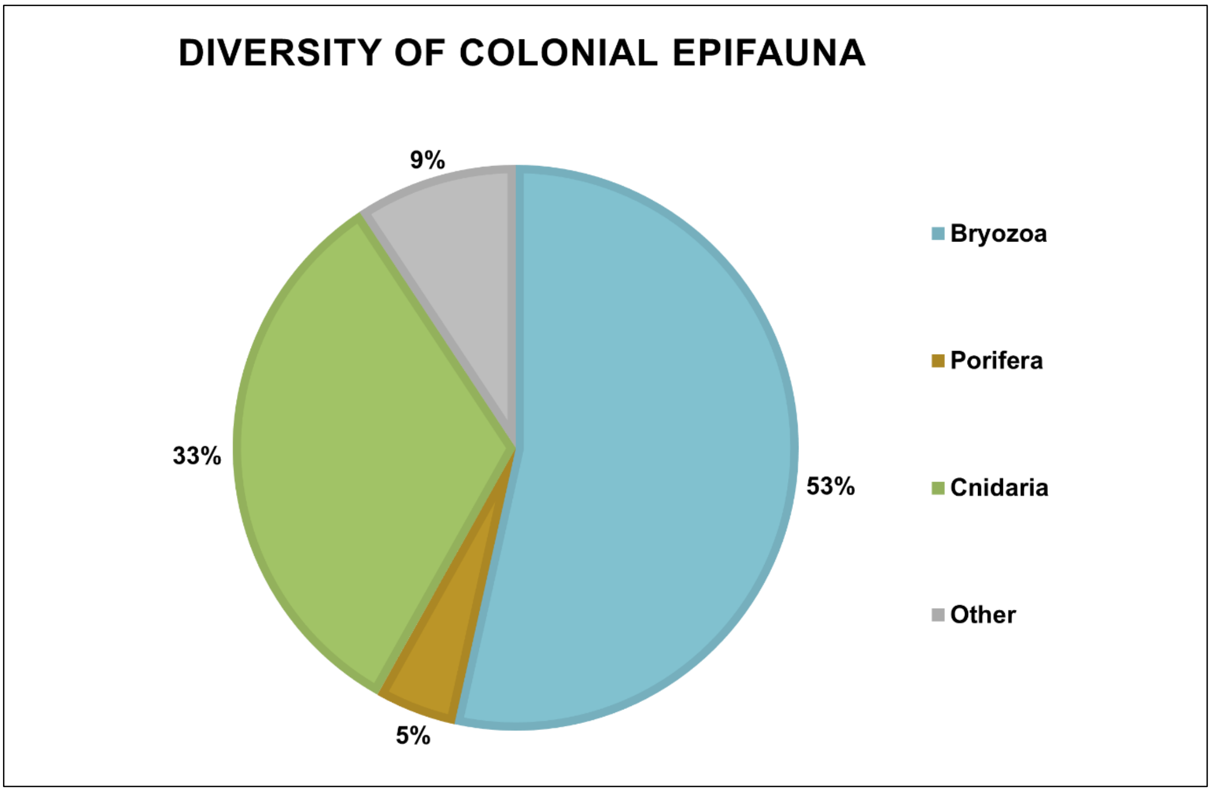


Figure 55 Diversity of colonial epifauna in grab samples.

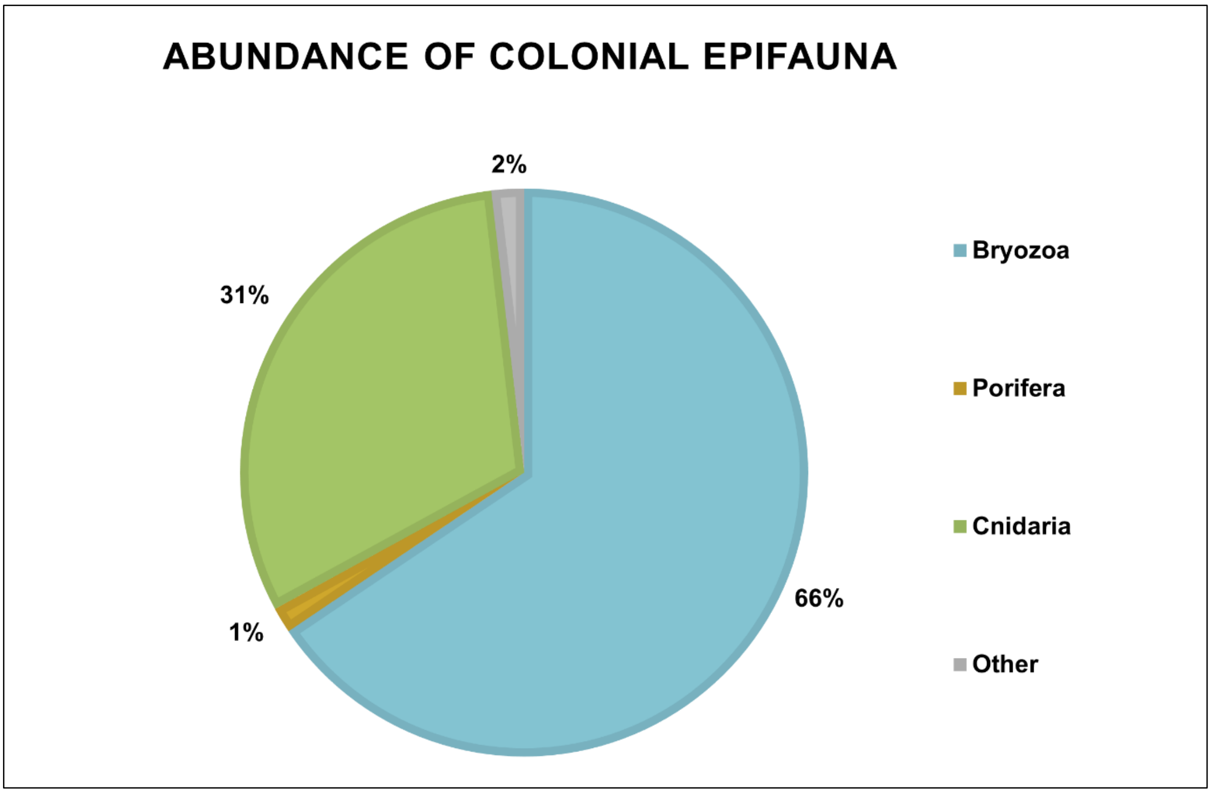


Figure 56 Abundance of colonial epifauna in grab samples.

5.9| NOTABLE TAXA

5.9.1| NON-NATIVE TAXA

The non-native polychaete *Goniadella gracilis* was identified at grab sample site S027 (Table 79). The species was described from eastern North America, and the first British records are from 1970 in Liverpool Bay (Eno, Clark, & Sanderson, 1997).

The non-native barnacle *Austrominius modestus* was identified at grab sample sites S036 and S037 (Table 79).

The species is originally from Southern Australia and New Zealand, and the first British records are from 1945, already well established in Chichester Harbour (Bishop, 1947). In the mid-1950s, the species was spread along the English coast as well as in other places around the North Sea (Crisp, 1958), Table 79.

The non-native ostracod *Eusarsiella zostericola* was identified at grab sample sites S003, S005, S032 and S033 (Table 79). The species is originally from the east coast of North America, and the first British records are from 1967-1968 in the Blackwater estuary, and it was probably transported with American cupped oysters *Crassostrea virginica* (Kornicker, 1975). The species has also been found in the Netherlands (Faasse, 2013).

The non-native slipper limpet *Crepidula fornicata* was identified at grab sample sites S015, S017, S019 and S031 (Table 79). The species is originally from the east coast of North America, and the first British records are from 1872 in Liverpool Bay. This population is now extinct, but the species was also introduced to Essex in the late 1880s. It was likely introduced with the import of American cupped oysters *Crassostrea virginica,* and other shellfish. The species is now well established and can be found along much of the English coast and as well as in other countries around the North Sea (Eno, Clark, & Sanderson, 1997).

The non-native American piddock *Petricolaria pholadiformis* was identified at sample site S004 (Table 79). The species is originated from the east coast of North America, and it was introduced to Britain before 1890 and is most common in Essex and the Thames estuary. It was likely introduced with the import of American cupped oysters *Crassostrea virginica* (Eno, Clark, & Sanderson, 1997).

Table 79 Non-native taxa found during the survey.

NON-NATIVE TAXA	GRAB SAMPLE	ABUNDANCE / 0.1 M^2
Goniadella gracilis	S027_F3	1
Austrominius modestus	S036_F4	1
	S037_F2	1
	S037_F3	4
Eusarsiella zostericola	S003_F3	3
	S005_F1	5
	S005_F2	8
	S005_F3	14
	S032_F1	3
	S032_F2	1
	S032_F3	2
	S033_F1	6

NON-NATIVE TAXA	GRAB SAMPLE	ABUNDANCE / 0.1 M^2
	S033_F3	12
Crepidula fornicata	S015_F2	1
	S017_F2	1
	S017_F3	1
	S019_F1	1
	S031_F1	1
Petricolaria pholadiformis	S004_F1	1

5.9.2| RARE TAXA

Five species not formally recorded in the UK were identified during the survey (Table 80). All of these species were polychaetes; *Syllis columbretensis, Syllis garciai, Syllis pontxioi, Paradoneis ilvana* and *Spio symphyta*. *S. columbretensis, S. garciai* and *P. ilvana* were originally described from the Mediterranean Sea, *S. pontxioi* from the Bay of Biscay and *S. symphyta* from the Danish North Sea.

Table 80 Species not formally recorded in the UK identified during the survey.

SPECIES NOT FORMALLY RECORDED FROM THE UK	GRAB SAMPLE	ABUNDANCE / 0.1 M^2
Syllis columbretensis	S036_F5	1
Syllis garciai	S006_F1	1
	S015_F1	2
	S031_F1	1
Syllis pontxioi	S024_F1	1
Paradoneis ilvana	S018_F1	1
Spio symphyta	S003_F1	1
	S013_F3	2
	S015_F2	1
	S018_F1	1
	S019_F1	1
	S019_F2	4
	S021_F2	1
	S021_F3	3
	S025_F1	1
	S036_F3	1

Two rarely recorded species were identified during the survey; the isopod *Prodajus ostendensis* and the polychaete *Scolelepis foliosa*. *P. ostendensis* is an ectoparasite of *Gastrosaccus spinifex* and was identified at grab sample site S023, and *S. foliosa* was found at grab sample site S017.

Two bivalve species with a more southern British distribution were also identified during the survey; *Modiolus adriaticus* and *Rocellaria dubia.* Both species are mainly found along the south coast of England. *M. adriaticus* was identified at grab sample sites S006, S015, and S018, and *R. dubia* was identified at grab sample site S036.

5.10| POTENTIAL AREAS AND SPECIES OF CONSERVATION VALUE

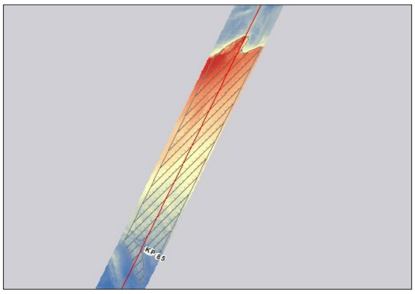
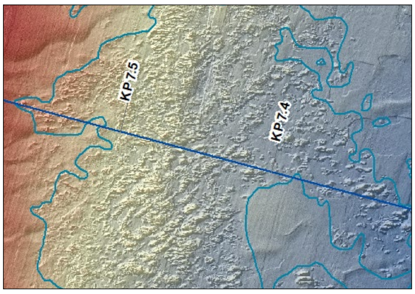
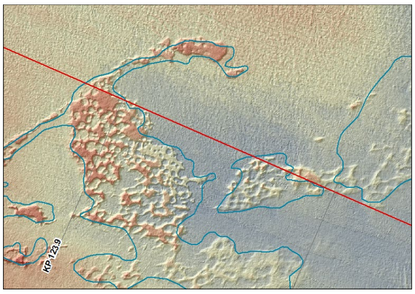
Potential areas and species of conservation interest identified within the two route corridors are presented in Table 81. The delineations are based on the findings within the route corridors with regards to descriptive qualifiers outlined by designators.

The assessments are considered in conjunction with reported information on the presence of habitats and the conservation status of habitat types and species by the UK, to the Habitats Directive as required by Article 17 (JNCC, 2019).

No other **Annex I** features, as described within the Habitats Directive (EUR 28, 2013), except for **Annex I** (1110) were identified within the two survey route corridors.

NERC 41 Habitats Subtidal sands and gravels, Blue mussel beds as well as NERC 41 listed species Ammodytes spp. were identified within the surveys. Furthermore, the geophysical data and geotechnical data indicates the presence of NERC 41 listed habitats Peat and Clay Exposures as well as Subtidal Chalk.

Table 81 Annex I habitats identified within the survey corridors.

HABITAT IMAGE	ANNEX I	NERC/OSPAR	DESIGNATED SITES	SITE ID
	Annex I (1110) Sandbanks which are slightly covered by sea water all the time	NERC Subtidal sands and gravels	Outer Thames Estuary SPA Goodwin Sands MCZ	S012, S017, S021 - S026 and S035
	-	NERC Peat and Clay Exposures	Outer Thames Estuary SPA Goodwin Sands MCZ	S017
	-	NERC Subtidal Chalk	Goodwin Sands MCZ	-

HABITAT IMAGE	ANNEX I	NERC/OSPAR	DESIGNATED SITES	SITE ID
	-	NERC Subtidal sands and gravels	Outer Thames Estuary SPA Goodwin Sands MCZ	S001, S003-S005, S014-S016, S018-S020, S027, S029-S031, and S036.
	-	NERC Blue mussel beds	Outer Thames Estuary SPA	S007, T001, T001A and T004.
	-	NERC *Ammodytes* spp.	-	S016 and S022

5.10.1 | STONY REEFS

No features qualifying as **Annex I** (1170) – Reefs, Stony Reefs were identified within the survey corridors.

Areas within the nearshore parts of survey Block 5 were identified to comprise the coarsest seabed. The easternmost area of the B5 segment is probably the coarsest with regards to large fractions such as cobbles and boulders. Out of the three grab sample sites (S037, S036 and S031) located within this section, S031 would have the highest potential to meet the qualifying criteria of **Annex I** (1170) - Stony Reefs. However, these are believed to be partly buried and as they do not appear in the geophysical data. The rugosity measurements also indicate this area to be relatively flat. The overall assessment concludes that it is not likely that areas of **Annex I** - Stony Reefs are located within the route corridor.

5.10.2 | SANDBANKS WHICH ARE SLIGHTLY COVERED BY SEA WATER ALL THE TIME

Annex I (1110) – Sandbanks which are slightly covered by sea water all the time, are associated with areas of sand that are distinctly elevated from the surrounding seabed and are located in less than 20 m of depth (Figure 57).

The habitat was identified within the main survey route corridor, and it is interpreted to be present at several locations along the route corridor between SWO KP 1.507 and KP 123.679. The delineations of sandbanks are primarily based on the interpreted geophysical data detailing distinctly elevated features consisting of sandy sediments.

Grab sample sites S012, S017, S021 - S026, and S035 are located within such areas.

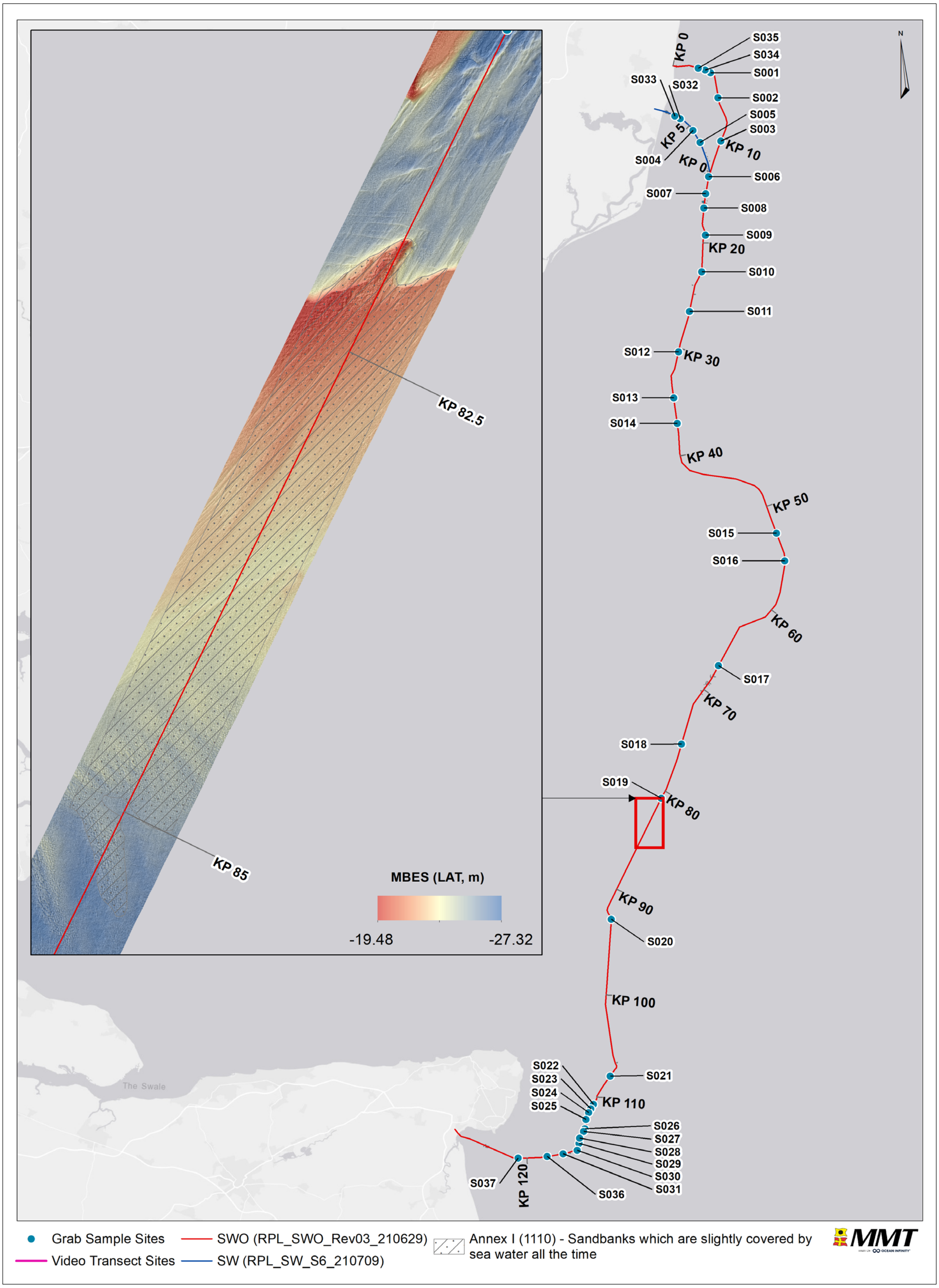


Figure 57 Bathymetric overview of Annex I (1110) between SWO KP 81.879 and KP 85.306.

5.10.3| COMMUNITIES ON SOFT CIRCALITTORAL ROCK

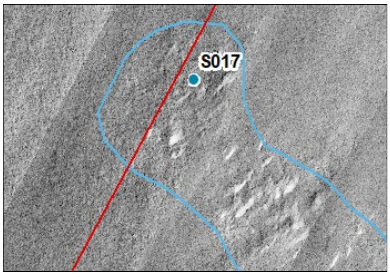
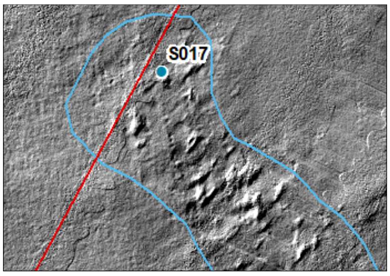
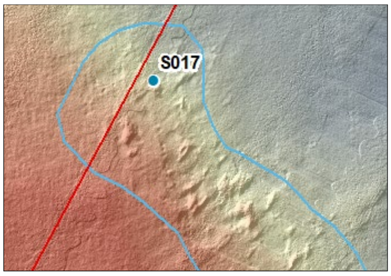
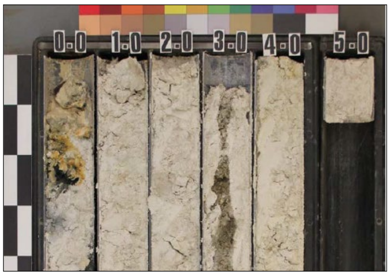
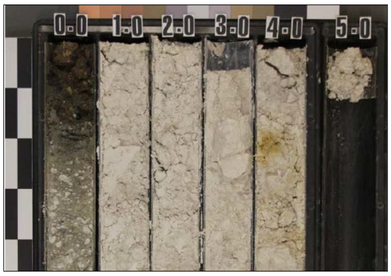
Two subtypes of A4.23 – Communities on soft circalittoral rock, which include both clay outcrops and soft chalk, were identified as potentially present in the geophysical data acquired.

Habitat Peat and Clay Exposures are distributed along the entire south and east coast of England, but very little is known of the sublittoral extent. The habitat can be difficult to assess with regards to distribution and extent due to periodic coverage of mobile sediments and subsequent emergence. Sublittoral chalk is considered to occur most frequently in the southeast of England, around Kent and Sussex. The habitats Peat and Clay Exposures and Subtidal Chalks are listed as Habitats of Principal Importance for the conservation of biodiversity in England under The Natural Environment and Rural Communities Section 41 (NERC S41) list (Brig, 2008 (Updated Dec 2011)).

The data collected indicates the presence of scattered areas of outcropping clays or clay covered by a thin veneer of sand and/or gravel, primarily in the northern and central parts of the SWO survey route corridor between KP 0.000 and KP 101.109. Similar features are also interpreted to be present along the SW between SW KP 0.000 and KP 7.571. One grab sample site, S017, is located at the edge of one of these features (Table 82).

Soft chalk is primarily present in the southernmost areas, well outside of the Thanet Coast MCZ, in the main survey route corridor between SWO KP 101.109 and KP 127.298. The soft chalk is noted in the geotechnical vibrocore samples (VC-63 to 70 and 73) collected along this section, occasionally appearing to be surficial but is predominantly located subsurface (Table 82).

Table 82 Example images of A4.23.

GEOPHYSICAL AND GRAB SAMPLE EXAMPLES OF FEATURES OF A4.23 (CLAY) AT S017		
		
		
GEOTECHNICAL EXAMPLES OF FEATURES OF A4.23 (CHALK) AT VC-63, VC-64 AND VC-65		
		

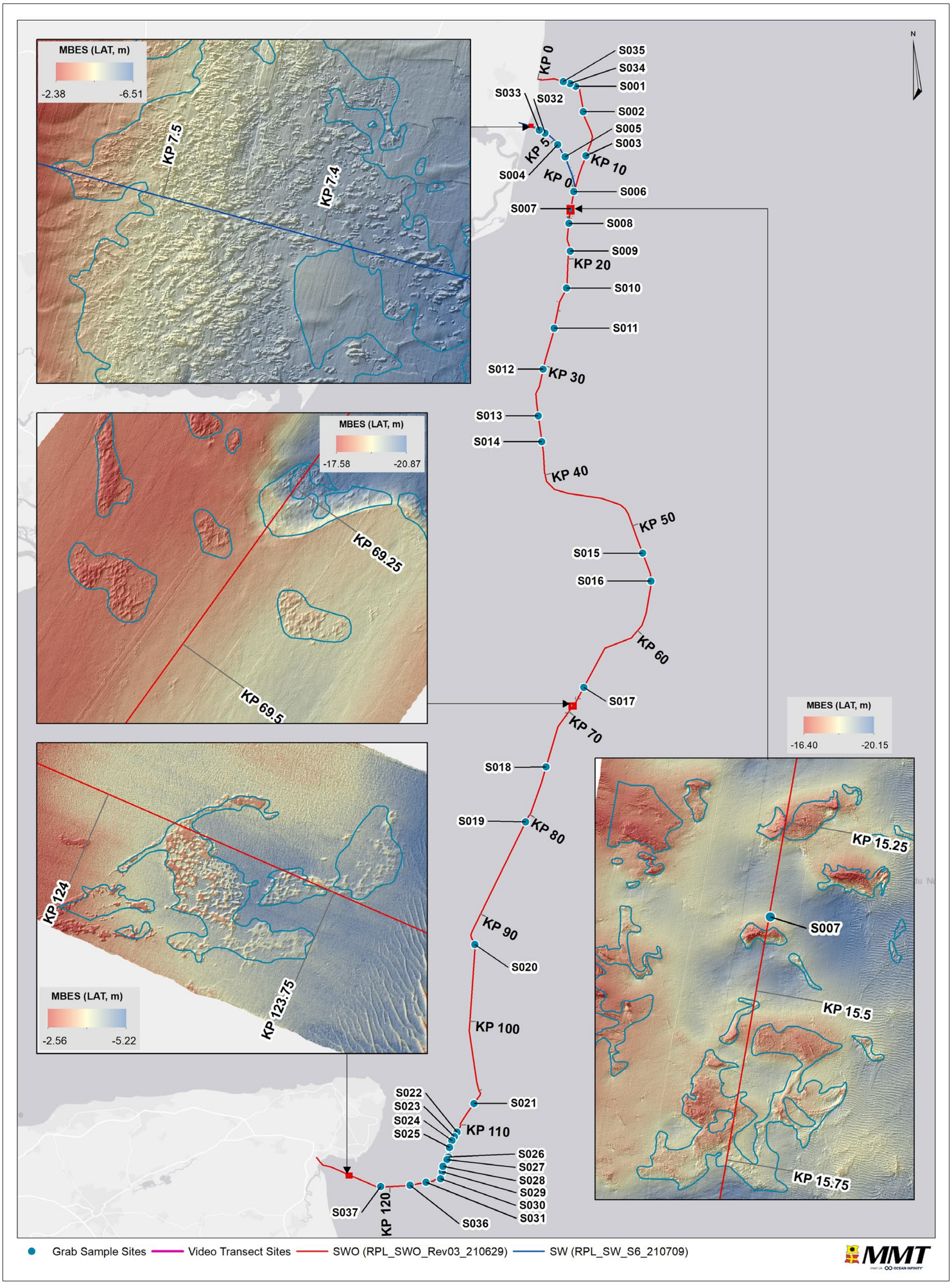


Figure 58 Bathymetric overview of features interpreted as potential A4.23 along SWO and SW.

5.10.4| SUBTIDAL SAND AND GRAVELS

The habitat Subtidal Sands and Gravels was observed at grab sample sites S001, S003-S005, S012, S014-S016, S018-S025, S027, S029-S031, and S035-S036.

Subtidal Sands and Gravels is listed as a Habitat of Principal Importance for the conservation of biodiversity in England under NERC S41 and was also previously listed as a BAP habitat under the same name. There is an overlap between this habitat and **Annex I** (1110) – Sandbanks which are slightly covered by sea water all the time. Subtidal Sands and Gravels are a wider habitat not limited to sandbanks but include other sandy and gravelly habitats (Brig, 2008 (Updated Dec 2011)).

All subtype habitats of **A5.1** - Sublittoral coarse sediment and **A5.2** - Sublittoral sand, including habitat complexes where such habitats are included, have been interpreted to qualify as Subtidal Sands and Gravels.

5.10.5| SABELLARIA SPINULOSA

The Ross-worm *Sabellaria spinulosa* qualifies for conservation interest where it forms reef features, and the species occurs commonly on sand with shell gravel.

Sabellaria spinulosa was identified across the majority of the survey area except for the nearshore areas in S6 and S7 (Table 83). Larger quantities were identified at grab sample sites S006, S007 and S009. , However, none of the samples contained large clusters/ aggregations of tubes.

The area close to grab sample site S006 was homogenous with occasional features of outcropping stiff clay. The sediment was predominantly gravelly and some *S. spinulosa* tubes, which were mainly encrusting, were observed in the acquired samples.

Grab sample site S007 was located in a mainly homogenous area with more numerous features of outcropping stiff clay. The sediment composition was similar to that of site S006 but lacked a PSA sample. A notable amount of *S. spinulosa* tubes were observed in the acquired samples which were mainly encrusting and often overgrown by *M. edulis.*

At grab sample site S009, the surrounding area is quite heterogeneous with frequently occurring mounds, associated with sub surface stiff clay. The sediment was made up of mainly coarse material and *S. spinulosa* tubes, mainly encrusting, were observed in the acquired samples.

Table 83 Summary of S. spinulosa *quantities per replicate sample.*

SITE ID	ABUNDANCE OF *SABELLARIA SPINULOSA* / 0.1 M^2
S001_F3	2
S006_F1	131
S006_F2	32
S006_F3	55
S007_F1	243
S007_F3	82
S009_F1	1130
S009_F2	756
S009_F3	1218
S010_F1	7
S010_F3	3
S011_F1	3

SITE ID	ABUNDANCE OF *SABELLARIA SPINULOSA* / 0.1 M^2
S011_F2	9
S013_F1	32
S013_F2	13
S013_F3	3
S015_F3	1
S017_F1	1
S017_F2	9
S017_F3	3
S018_F2	1
S019_F1	23
S019_F2	18
S019_F3	30
S021_F1	8
S021_F2	18
S021_F3	40
S027_F2	5
S027_F3	2
S031_F1	45
S031_F2	21
S036_F1	23
S036_F3	23
S036_F4	47
S036_F5	22
S037_F2	10
S037_F3	13

At transect T004, aggregations of *S. spinulosa* were noted, and an assessment in line with Jenkins et al. (2018) was carried out. The visibility was generally low, and due to this, large sections (85%) of the transect could not be assessed. However, three patches (a total of 5.3% of the transect) were noted where the structure of the *S. spinulosa* aggregations was assessed to fulfil the criteria of Low-Reefiness (Collins, 2010; Gubbay, 2007) (Table 84). Based on this assessment combined with the geophysical data, which does not indicate the presence of reef formations, transect T004 *does not* meet the qualifying criteria of Annex I (1170) – Biogenic Reefs.

Table 84 Assessment of S. spinulosa *at transect T004 per Jenkins et al. (2018).*

% OF VIDEO						NO. OF PATCHES	AVE. PATCH LENGTH	MEDIAN PATCH LENGTH	PATCH SIZE RANGE
NO VISIBILITY	NO *S. SPINULOSA*	NOT A REEF	LOW	MEDIUM	HIGH				
85.1	9.5	0	5.3	0	0	3	4.3	3	3-7

5.10.6 | BLUE MUSSEL BEDS

The habitat Blue Mussel Beds was identified at grab sample site S007 and transects T001, T001A and T004.

Blue Mussel Beds is listed as a Habitat of Principal Importance for the conservation of biodiversity in England under NERC S41 and was also previously listed as a BAP habitat under the name Blue Mussel Beds on Sediment. The habitat includes beds of blue mussels *Mytilus edulis* on various sediments, both intertidal and subtidal, in various conditions. Blue mussel beds provide an area with enhanced biodiversity and play an important role in a healthy ecosystem (Brig, 2008 (Updated Dec 2011)).

At grab sample site S007 high numbers of adult blue mussels *M. edulis*, both juvenile and adult specimens, were identified. This, together with the geophysical data is the basis for the delineation. No distinct features of reef formations were visible in the geophysical data and the mussel bed is interpreted to comprise patches rather than a continuous reef, thus no Annex I (1170) – Biogenic Reefs has been assigned.

5.10.7 | SAND EEL HABITATS

Raitt's sand-eel *Ammodytes marinus* is listed as a Species of Principal Importance for the conservation of biodiversity in England under The Natural Environment and Rural Communities Section 41 (NERC S41) list. Further, lesser sand-eel *A. tobianus* is listed as DD (Data Deficient) by the IUCN Red List of Threatened Species (IUCN, 2021).

Based on the sediment composition, six (6) grab sample sites (S023, S025, S026, S029, S035 and S037) were classified as “Preferred” sand eel habitat and nine (9) sites (S004, S014, S016, S019, S020, S022, S024, S030 and S036) were classified as “Marginal” sand eel habitat. The remaining sites, where PSA was analysed, were classified as “Unsuitable” sand eel habitats (Table 85).

Sand eel *Ammodytes sp.* was identified at grab sample sites S016 and S022.

5.10.8 | HERRING SPAWNING GROUNDS

Based on the sediment composition, two (2) grab sample sites (S026 and S037) were classified as “Marginal”/ ”Suitable” for herring spawning ground preference. The remaining sites, where PSA was analysed, were classified as “Unsuitable” for herring spawning (Table 85).

Table 85 Herring spawning ground and sand eel habitat classification.

SITE ID	FOLK CLASSIFICATION	SEDIMENT FRACTION (%)			SAND EEL HABITAT PREFERENCE	HERRING SPAWNING GROUND HABITAT PREFERENCE	
		GRAVEL	SAND	MUD		MARINESPACE LTD	REACH ET AL
S001	muddy Sand	0	56	44	Unsuitable	Unsuitable	Unsuitable
S002	sandy Mud	1	28	71	Unsuitable	Unsuitable	Unsuitable
S003	sandy Mud	0	45	55	Unsuitable	Unsuitable	Unsuitable
S004	Sand	0	94	6	Marginal	Unsuitable	Unsuitable
S005	muddy Sand	0	58	42	Unsuitable	Unsuitable	Unsuitable
S006	muddy sandy Gravel	44	44	12	Unsuitable	Unsuitable	Unsuitable
S008	muddy sandy Gravel	52	29	19	Unsuitable	Unsuitable	Unsuitable

SITE ID	FOLK CLASSIFICATION	SEDIMENT FRACTION (%)			SAND EEL HABITAT PREFERENCE	HERRING SPAWNING GROUND HABITAT PREFERENCE	
		GRAVEL	SAND	MUD		MARINESPACE LTD	REACH ET AL
S009	muddy sandy Gravel	48	44	8	Unsuitable	Unsuitable	Unsuitable
S010	muddy sandy Gravel	45	38	17	Unsuitable	Unsuitable	Unsuitable
S011	muddy sandy Gravel	48	38	14	Unsuitable	Unsuitable	Unsuitable
S012	muddy Sand	0	83	17	Unsuitable	Unsuitable	Unsuitable
S013	gravelly muddy Sand	17	45	38	Unsuitable	Unsuitable	Unsuitable
S014	Sand	2	92	6	Marginal	Unsuitable	Unsuitable
S015	muddy sandy Gravel	31	53	16	Unsuitable	Unsuitable	Unsuitable
S016	Sand	2	91	7	Marginal	Unsuitable	Unsuitable
S017	muddy sandy Gravel	42	45	13	Unsuitable	Unsuitable	Unsuitable
S018	muddy sandy Gravel	40	43	17	Unsuitable	Unsuitable	Unsuitable
S019	gravelly Sand	12	81	7	Marginal	Unsuitable	Unsuitable
S020	Sand	1	90	9	Marginal	Unsuitable	Unsuitable
S021	muddy sandy Gravel	46	45	9	Unsuitable	Unsuitable	Unsuitable
S022	Sand	0	94	6	Marginal	Unsuitable	Unsuitable
S023	Sand	0	98	2	Preferred	Unsuitable	Unsuitable
S024	Sand	0	94	6	Marginal	Unsuitable	Unsuitable
S025	Sand	0	97	3	Preferred	Unsuitable	Unsuitable
S026	gravelly Sand	12	85	3	Preferred	Marginal	Suitable
S027	Sand	2	84	14	Unsuitable	Unsuitable	Unsuitable
S029	Sand	0	97	3	Preferred	Unsuitable	Unsuitable
S030	Sand	0	95	5	Marginal	Unsuitable	Unsuitable
S032	muddy Sand	0	51	49	Unsuitable	Unsuitable	Unsuitable
S033	muddy Sand	0	56	44	Unsuitable	Unsuitable	Unsuitable
S034	sandy Mud	0	42	58	Unsuitable	Unsuitable	Unsuitable
S035	Sand	0	96	4	Preferred	Unsuitable	Unsuitable
S036	sandy Mud	44	54	2	Marginal	Unsuitable	Unsuitable
S037	Sand	24	76	0	Preferred	Marginal	Suitable

5.11| MBES DATA DERIVATIVES AND CONFIDENCE ASSESSMENT

5.11.1| BACKSCATTER DATA AND RUGOSITY MEASURMENTS

BLOCK 1 S7 NEARSHORE KP 0.000 TO KP 2.849

The seabed within S7 Nearshore is comprised predominantly of sands with areas of clays and/or subsurface stiff clays. The interpreted backscatter data from S7 indicate limited variability with regards to intensity and appears to be quite homogenous.

One environmental grab sample site, S035, was located within S7, on top of a sandbank. The acquired sample returned clean fine sand and was used to further guide the intensity intervals as illustrated in Figure 59. The lower reflectivity is likely due to the mobility of the fine sand, resulting in less compacted sediment.

The sandbank of mobile fine sand is separated by sands from areas of high reflectivity. The areas of high reflectivity comprise muddy compacted sand, which characterises the majority of S7. The interpretation is based on the higher reflectivity seen in the backscatter data in the wester to mid sections of S7, as well as the eastern most section.

The rugosity measurements showed little to no seabed variability and present relatively flat areas in the wester to mid sections of S7. The intervals in Figure 59 were set based on the Standard Deviation (SD) of the data values. The rugosity increases moving eastwards as the seabed becomes more dominated by rippled features and features of stiff clays. These features are interpreted to be associated with the higher rugosity as seen in the eastern most sections of S7.

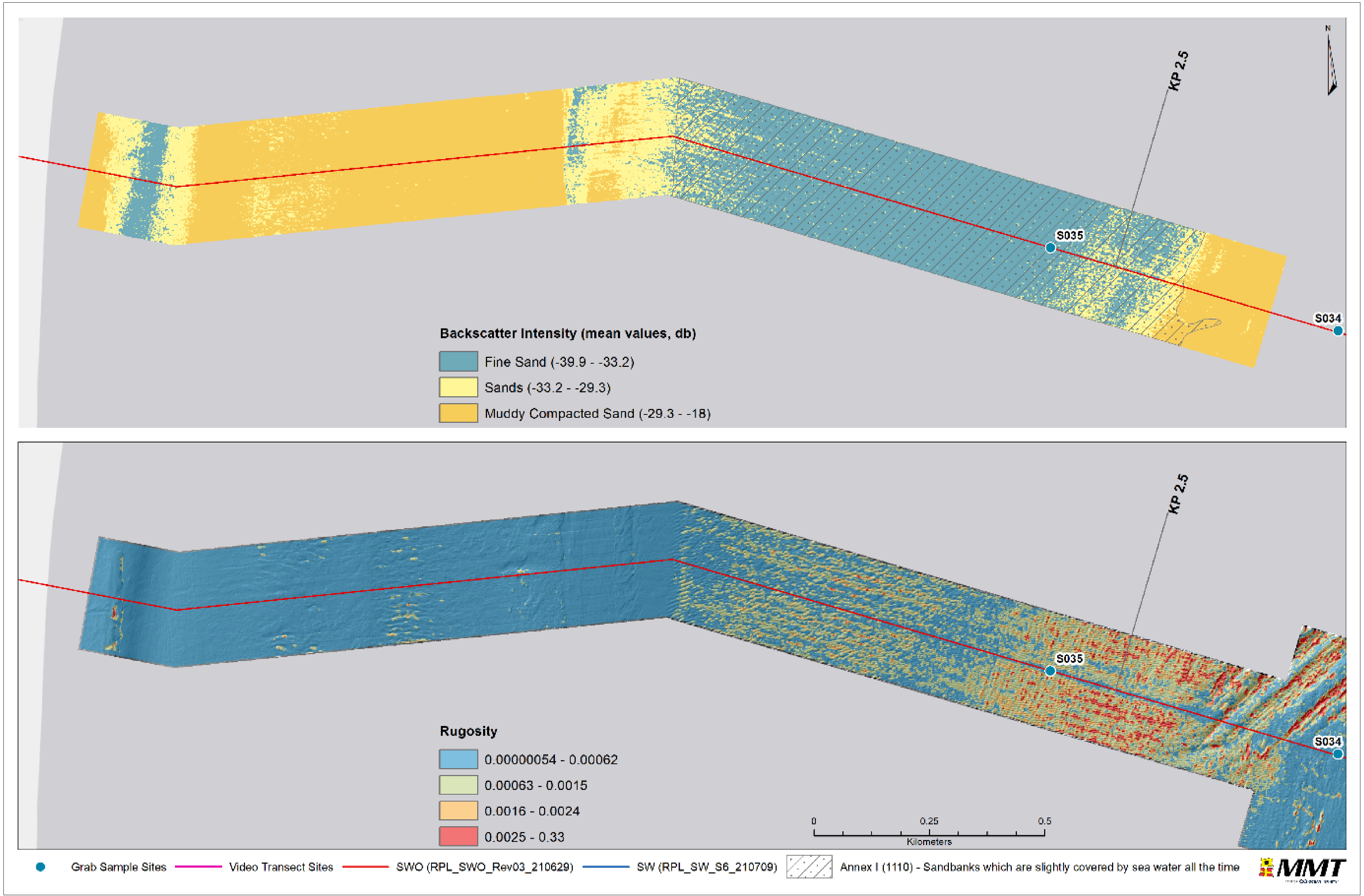


Figure 59 Overview of backscatter and rugosity data (draped over MBES hillshade) at S7 nearshore.

BLOCK 1 S6 NEARSHORE SW KP 5.624 TO KP 8.563

The seabed within S6 Nearshore exhibits similar substrate composition to that of S7 nearshore although areas of subsurface stiff clays are more prominent within S6. The interpreted backscatter data from S6 indicates limited variability with regards to intensity and presents a quite homogenous appearance.

Two environmental grab sample site sites, S032 and S033, were located within S6. The acquired samples returned muddy sands and were used to further guide the intensity intervals as illustrated in Figure 60. The seabed substrate composition alternated between sandy mud and muddy sands with areas of higher reflectivity interpreted to be associated with mixed, gravelly, sediments overlaying the area of stiff clays.

As was noted in S7, the rugosity measurement shows little to no seabed variability and present relatively flat areas within S6. The intervals in Figure 60 were set based on the Standard Deviation (SD) of the data values. The rugosity increases moving westwards and is at its highest closest to shore where the seabed is characterised by features of stiff clays likely protruding from the seabed.

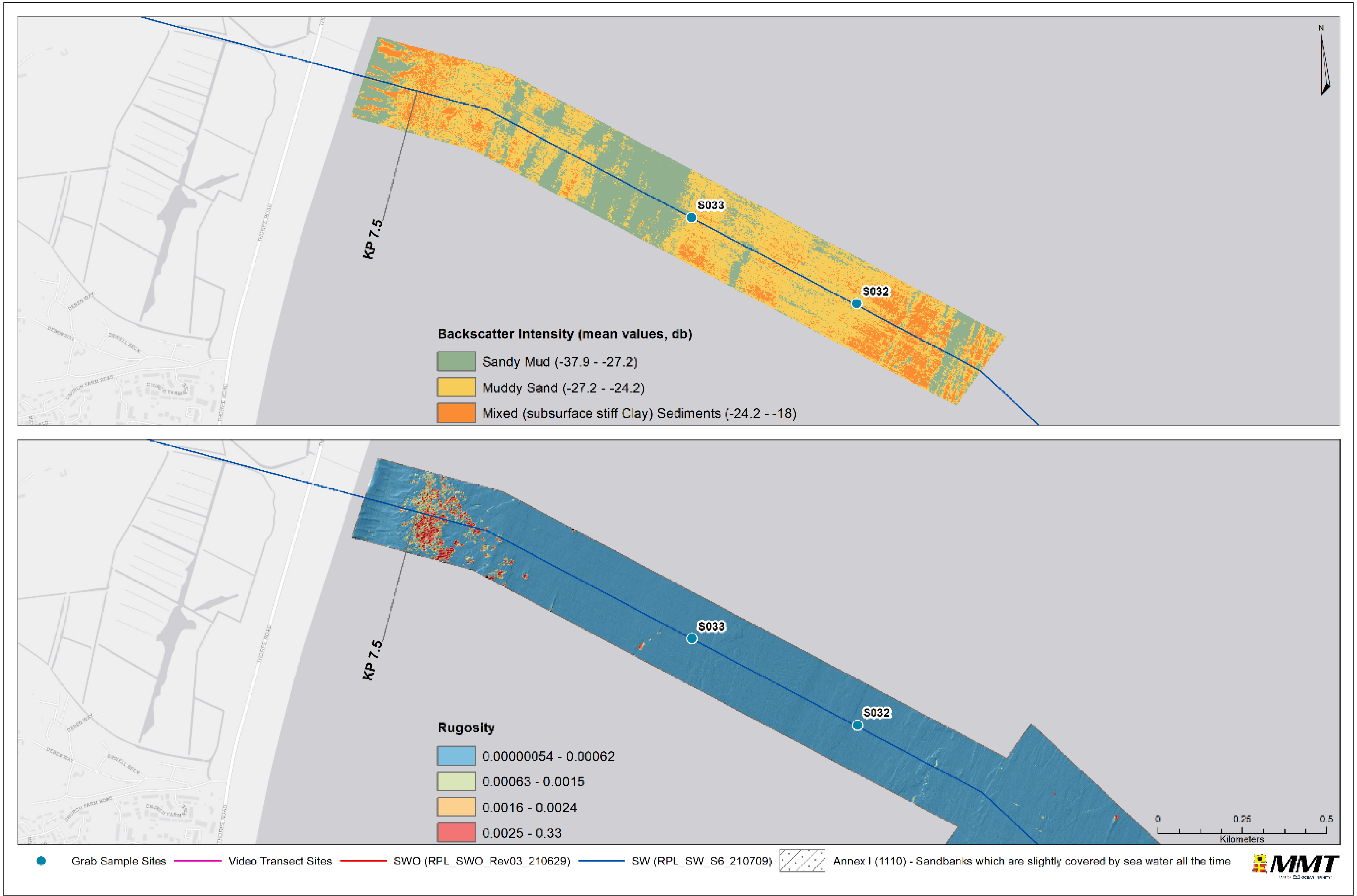


Figure 60 Overview of backscatter and rugosity data (draped over MBES hillshade) at S6 nearshore.

OFFSHORE BLOCK 1 – BLOCK 5

The seabed within Block 1 along route SW is characterized by eroded depressions with a scattered presence of stiff clays at or just below the seabed surface. Two environmental grab sample sites, S004 and S005, as well as two ground-truthing grab sample sites (part of the geophysical survey) and two vibrocore locations were located between SW KP 0.000 to KP 5.624.

The acquired samples returned sand and muddy gravelly sands and were used to further guide the intensity intervals as illustrated in Figure 61. The seabed substrate composition primarily alternates between sandy mud and muddy sand. Areas of higher reflectivity are interpreted to be consistent with mixed, gravelly, sediments overlying areas of stiff clays. The reflectivity increases with increasing KP.

The rugosity measurement generally showed minor variation, except for the sections of the SW which were associated with eroded depressions. These eroded depressions account for the highest seabed variability noted at SW.

The seabed within Block 1, along the SWO route, is characterized by megaripples, with intermittent bands of clay and eroded depressions, and a scattered presence of stiff clays at or just below the seabed surface. Five environmental grab sample sites, S034, S001 – S003 and S006 as well as two ground-truthing grab sample sites (part of the geophysical survey), and six vibrocore locations were located between SWO KP 2.832 and KP 14.933.

The acquired samples returned sand and muddy gravelly sands and were used to further guide the intensity intervals as illustrated in Figure 61. The substrate composition alternates between sandy mud and muddy sand. Areas of higher reflectivity are interpreted to be consistent with mixed, gravelly, sediments overlying areas of stiff clays and interpreted to commence from the intersect of SW and SWO progressing southwards.

The rugosity measurement generally shows minor variation, except for the sections of SWO which are associated with eroded depressions. These eroded depressions account for the highest seabed variability together with the initial section of SWO, which is characterised by megaripples.

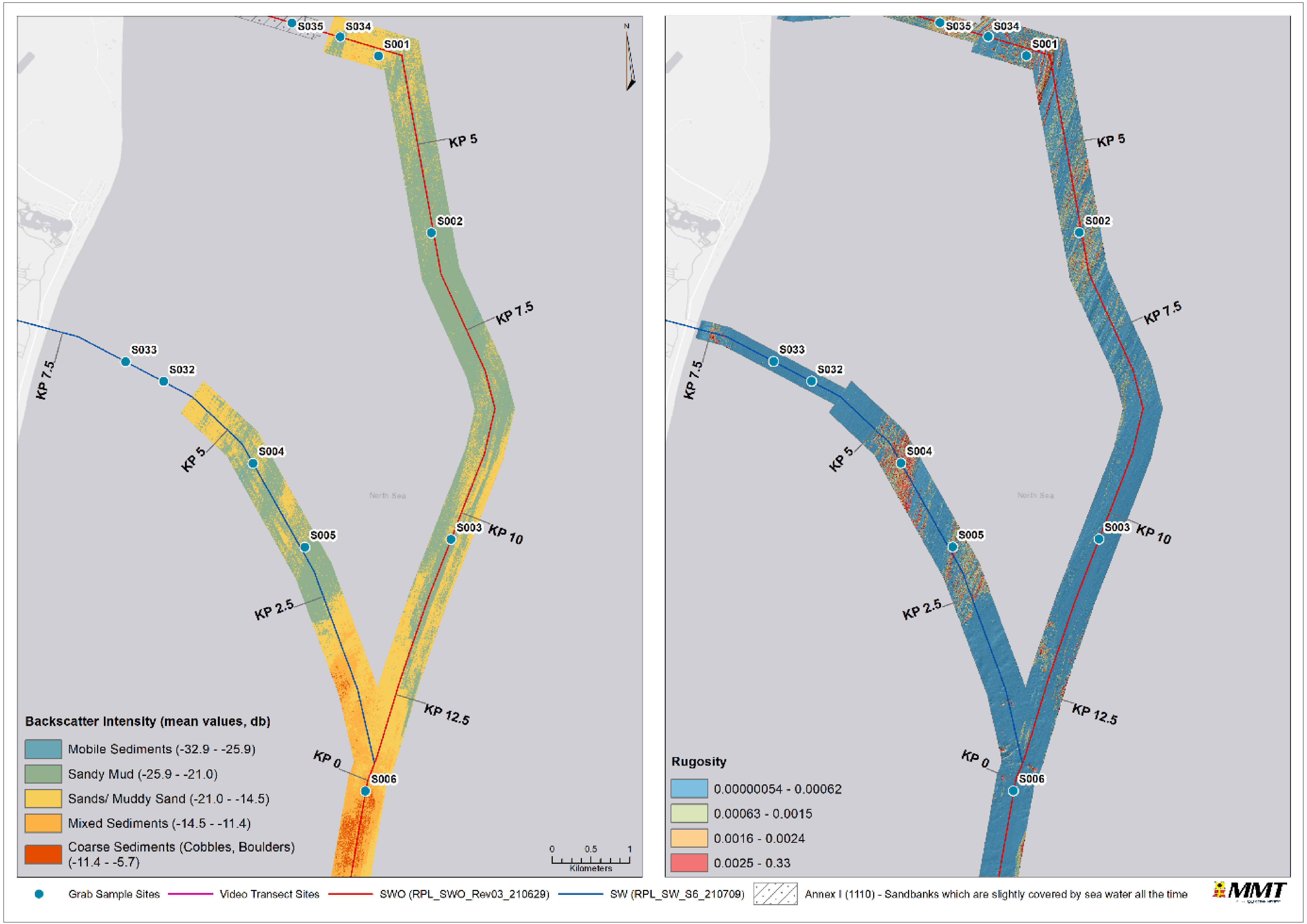


Figure 61 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 2.832 and KP 14.933 (SW KP 0.000 to KP 5.624).

The seabed between KP 14.062 to KP 30.998 is characterised by a high reflectivity across the majority of the section interpreted to be associated with mixed and coarse sediments.

Progressing from north to south, the seabed initially comprises sand and muddy sand bordered by mixed sediments with a surface of dense pebbles resulting in the high reflectivity, before transitioning to sandy mud. Mottled areas with underlying and outcropping stiff clays are present scattered within the whole corridor of this section.

Six environmental grab sample sites, S007 – S012, as well as two ground-truthing grab sample sites (part of the geophysical survey), and two vibrocore locations are located along SWO. The acquired samples returned muddy sandy gravel and muddy sand and were used to further guide the intensity intervals as illustrated in Figure 62.

At KP 28.656 the route corridor moves into an area of lower reflectivity dominated by megaripples comprising muddy sand and is situated on top of a sandbank.

The rugosity measurement generally shows a variation that is highly associated with subsurface and outcropping clays as well as areas of megaripples.

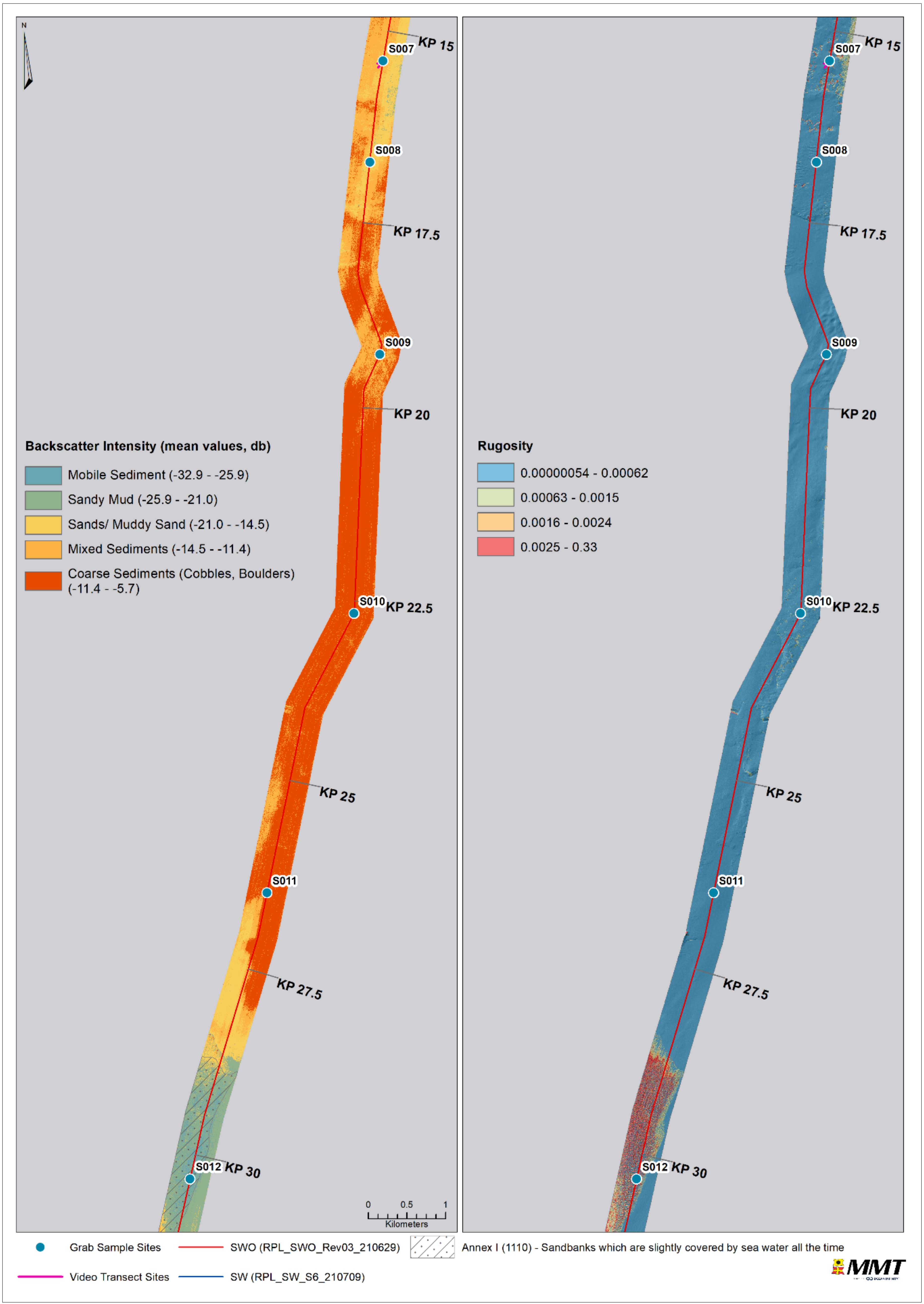


Figure 62 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 14.933 and KP 30.998

The seabed around and directly following the sandbank continues to exhibit a relatively low reflectivity, with a well-defined section of mixed sediment of higher reflectivity at grab sample site S013. This indicates that sands and muddy sand continue to dominate, up until an increase in reflectivity is noted around approximate SWO KP 39.069.

Beyond SWO KP 39.069 the seabed continues to exhibit high reflectivity and alternates between coarse and mixed sediments. There is very little to no seabed variability that is not associated with the ripple features within this section of the route corridor (Figure 63).

The high reflectivity extends to and beyond KP 45.351 to approximate KP 54.615 (Figure 64) comprising environmental grab sample site S015 as well as six vibrocore locations. The samples acquired returned muddy sandy gravel and a dense pebbles/cobbles seabed surface: These locations were used to further guide the intensity intervals as illustrated in Figure 64. The rugosity measurement showed little to no seabed variability and presents a relatively flat area except for a few isolated ripple features.

Moving further southward the backscatter shows an influx of softer sediments interpreted as sands/ Muddy sands which is confirmed by grab sample site S016 (Figure 64). Five vibrocore locations and two ground-truthing grab sample sites (part of the geophysical survey) were located within the section spanning from KP 54.615 to KP 64.599 (Figure 64) and were used to further guide the intensity intervals as illustrated in Figure 64.

The rugosity measurement showed little to no seabed variability and presents a relatively flat area with exception of a few isolated ripple/ megaripple features.

Figure 63 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 30.998 and KP 45.351.

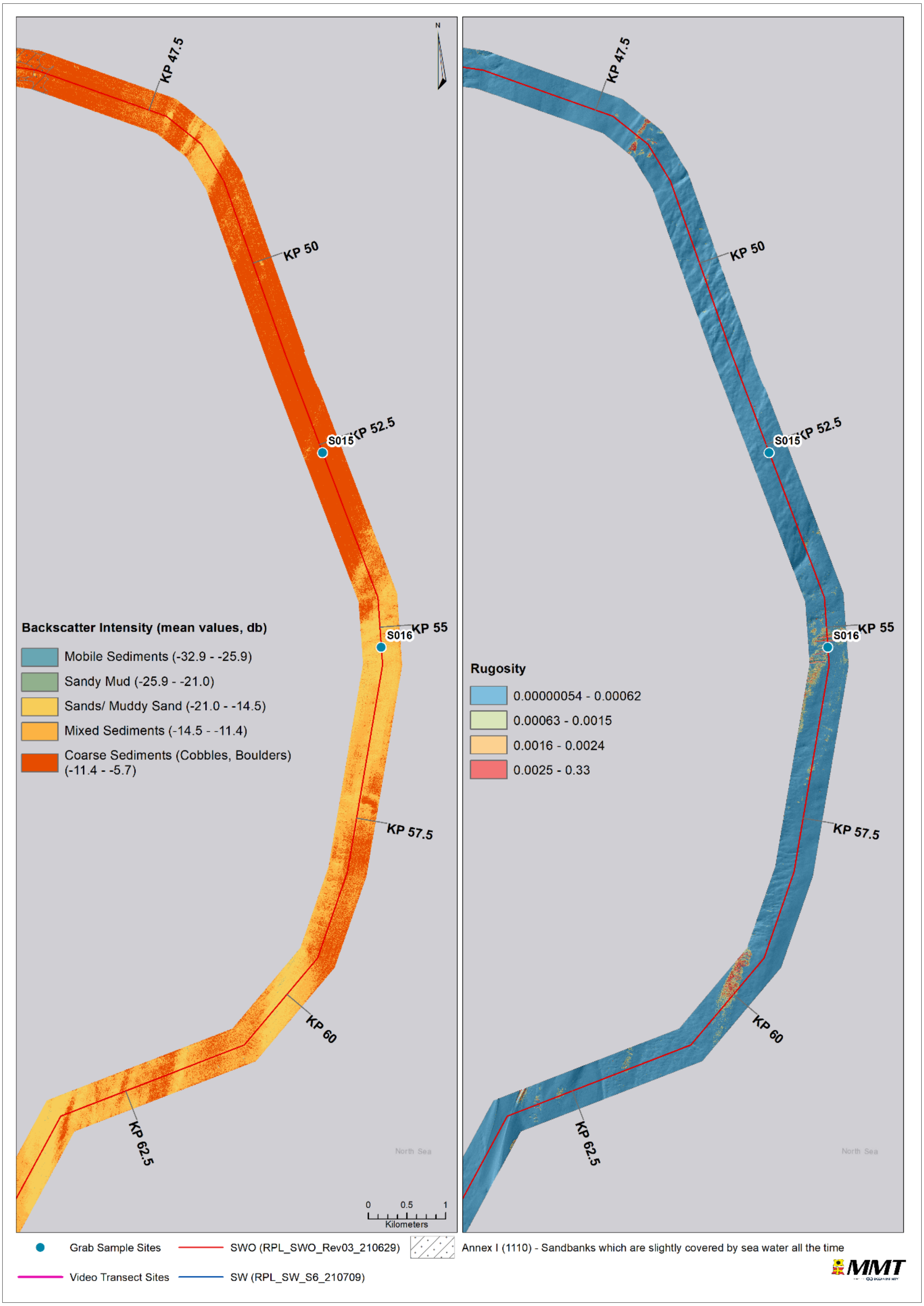


Figure 64 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 45.351 and KP 64.599.

The seabed between KP 64.599 and KP 77.500 continued to exhibit a similar pattern of high reflectivity interpreted as mixed and coarse sediments (Figure 65). Stiff clays are scattered within the route corridor, typically at or near the seabed surface.

Environmental grab sample sites S017 and S018 were located within the area of higher reflectivity and the samples returned muddy sandy gravel. In addition, this area also comprised seven vibrocore locations and two ground-truthing grab samples (part of the geophysical survey) that were further advised in assigning the intervals as illustrated in Figure 65. The rugosity measurement showed little to no seabed variability and present a relatively flat area (Figure 65).

This composition stretches on until approximate KP 78.291 where an influx of lower reflectivity is noted entering the route corridor from the western edge, coinciding with the introduction of ripple and megaripple features. These features occur frequently and encompass a sandbank (Figure 66).

Extending from KP 78.291 towards KP 88.239 the seabed again exhibits lower reflectivity substrates such as sands/ Muddy sand as well as mixed sediments. Environmental grab sample site S019 was located within this section and returned gravelly sand. In addition, seven vibrocore locations were also located within this section and returned gravelly sand/ coarse sand top surface samples (Figure 66).

The highest rugosity noted was associated with the sandbank area comprising ripple and megaripple features, however high variability is also noted in areas with underlaying stiff clays (Figure 66).

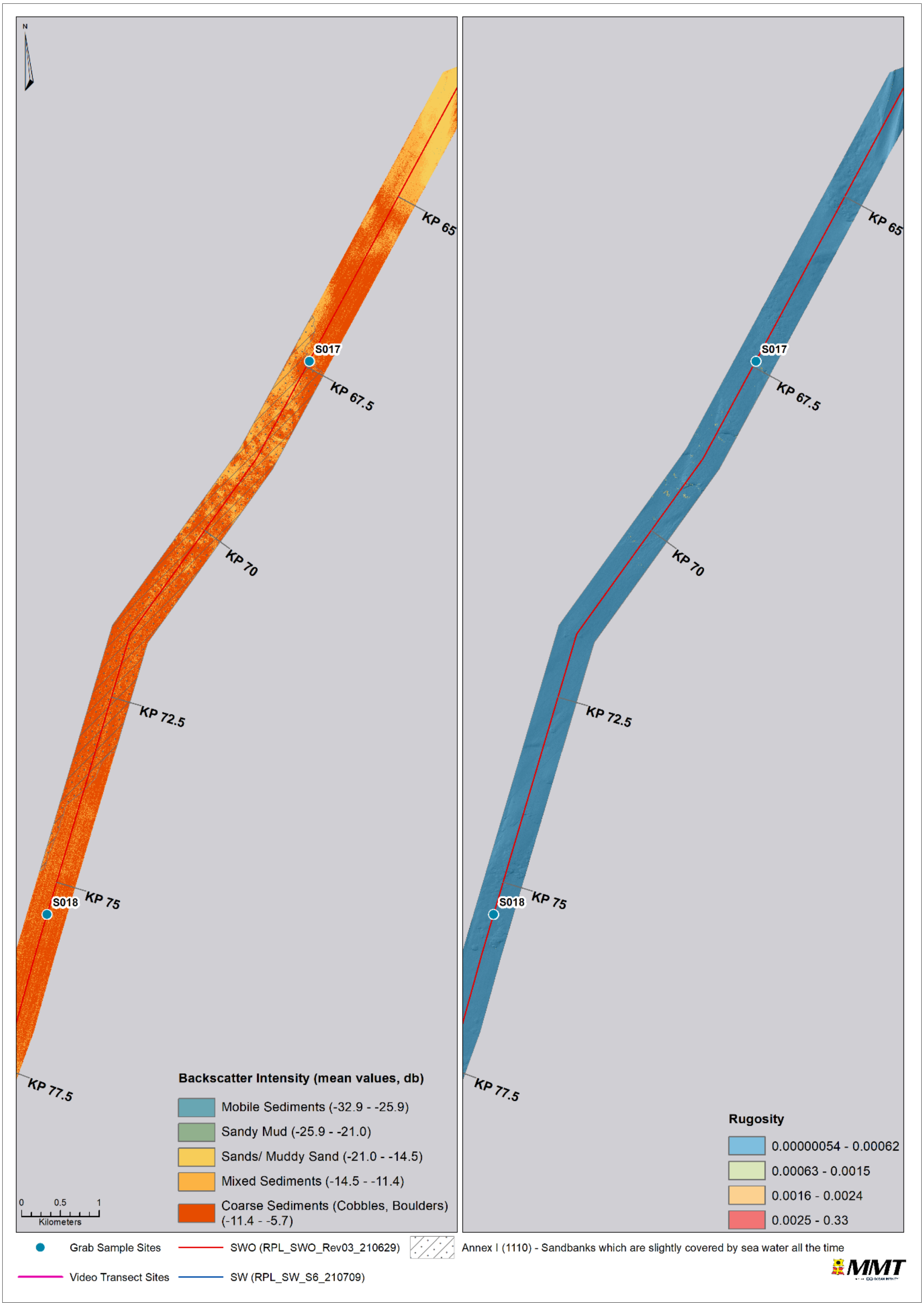


Figure 65 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 63.884 and KP 77.500.

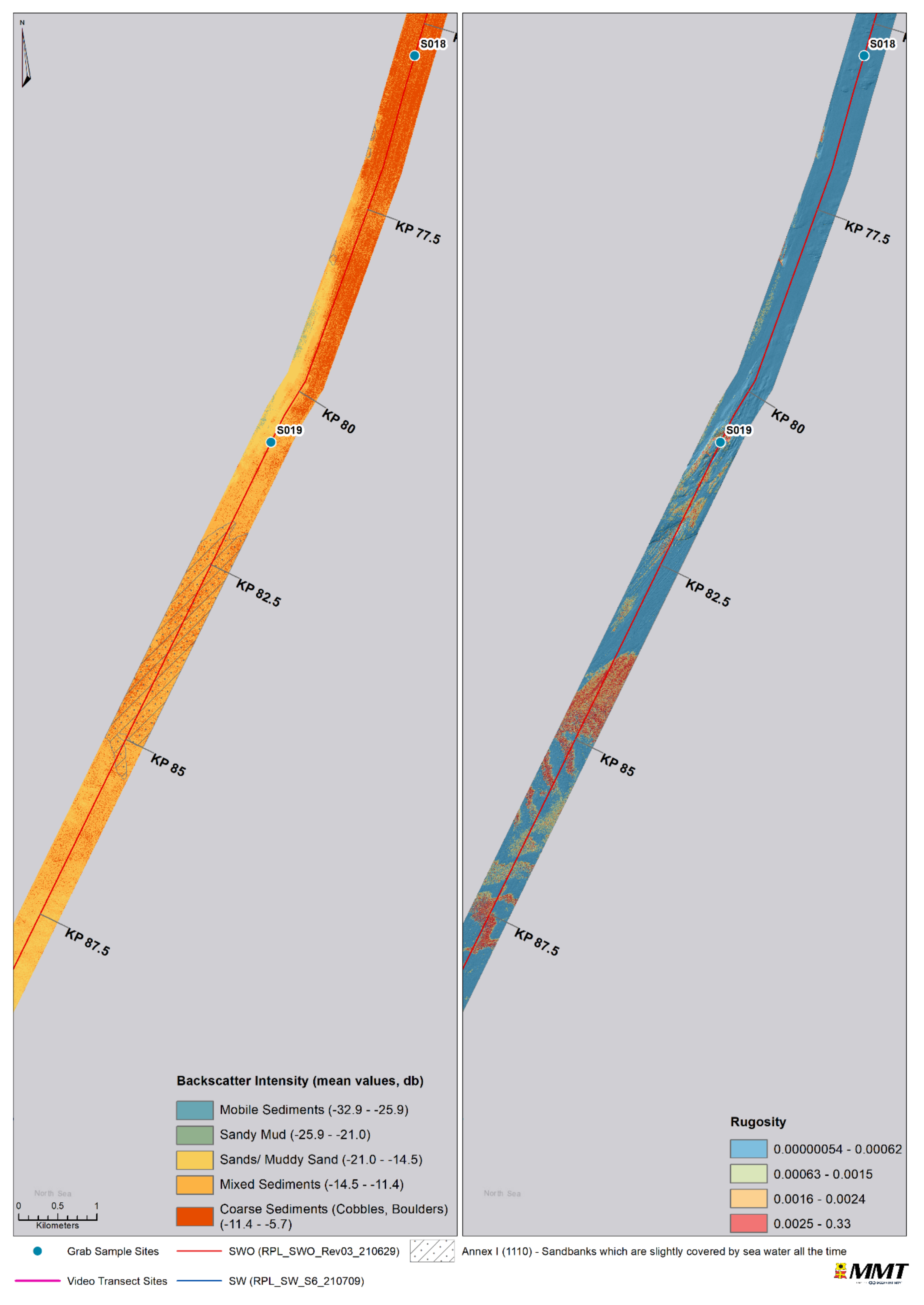


Figure 66 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 74. 899 and KP 88.239.

Continuing southwards from KP 88.239, the seabed exhibits predominantly low reflectivity, until approximate KP 104.017 (Figure 67). The low reflectivity within this section is indicative of sands and muddy sand.

One environmental grab sample site, S020, as well as two ground-truthing grab sample sites (part of the geophysical survey) and ten vibrocore locations, were located within this section. The samples acquired returned finer substrates and were used to further guide the intensity intervals as illustrated in Figure 67. The highest rugosity measurement noted was associated ripple and megaripple features while the majority of seabed showed little seabed variability.

The seabed reflectivity begins to increase from KP 101.113, moving southwards to approximate KP 109.852. At KP 109.852 a significant shift in the substrate is noted resulting in much lower reflectivity which prevails for several kilometres until approximate KP 116.160. An area identified as a sandbank is located between KP 101.883 and KP 112.728 and encompasses both sections of the high and low reflectivity.

Ten environmental grab sample sites, S021 – S030, as well as three ground-truthing grab sample sites (part of the geophysical survey) and seven vibrocore locations, were located within this section. The samples acquired returned sands and muddy sand as well as coarse sediments and were used to further guide the intensity intervals as illustrated in Figure 68.

The highest rugosity measurement was associated with ripple and megaripple features while the remainder of this section showed little seabed variability.

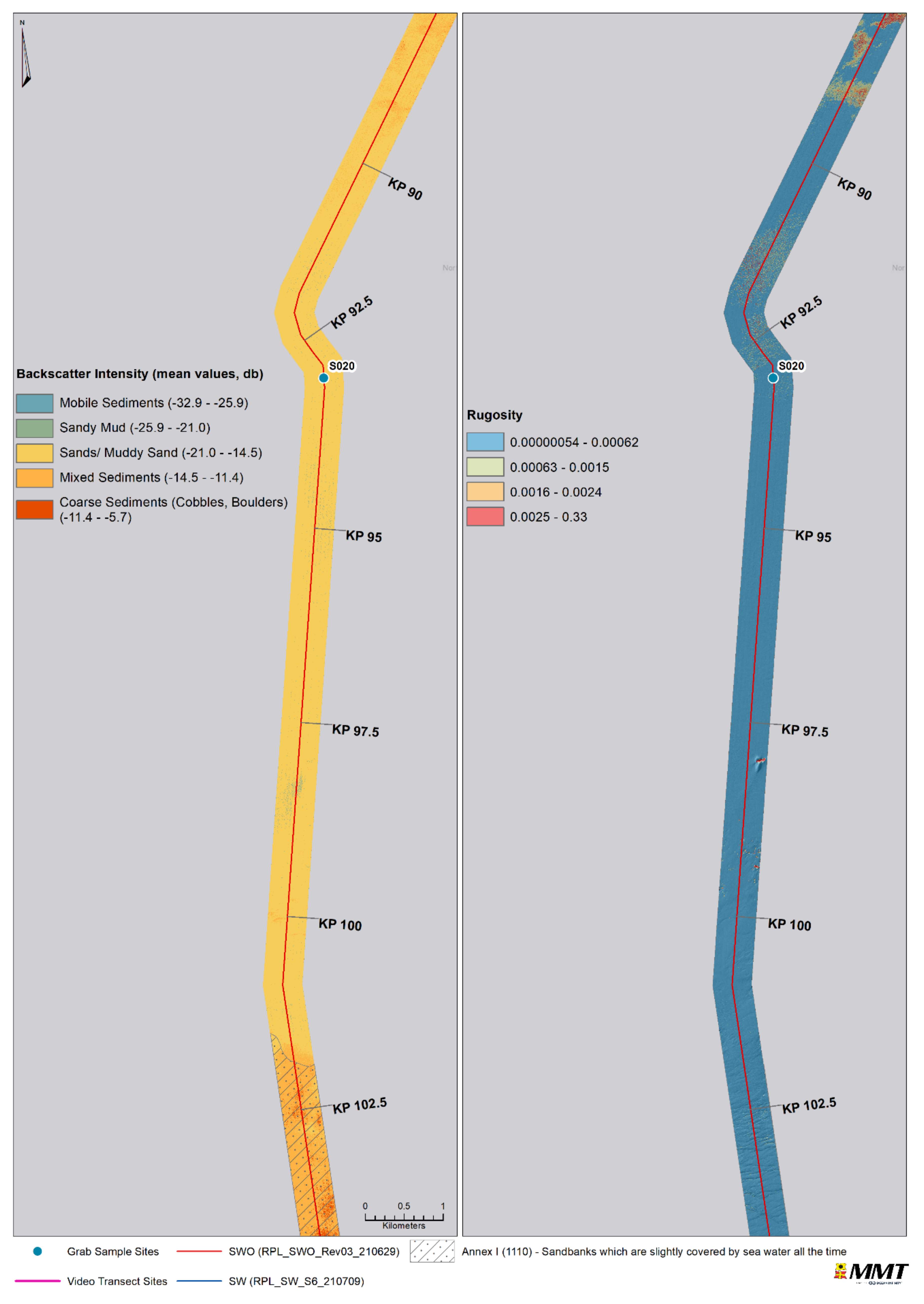


Figure 67 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 88.275 and KP 104.017.

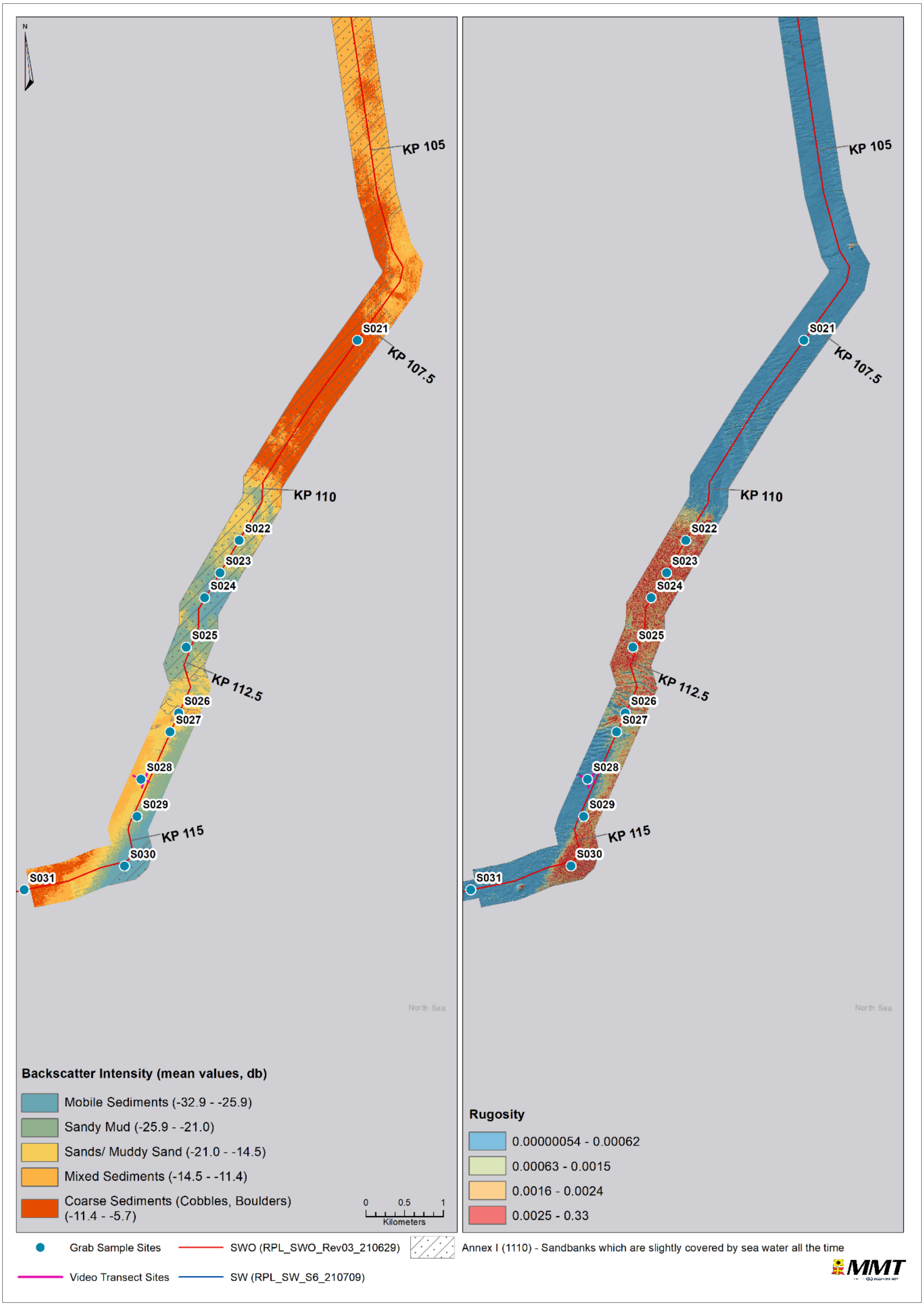


Figure 68 Overview of backscatter and rugosity data (draped over MBES hillshade) between SWO KP 103.94 and KP 116.597.

BLOCK 5 NEARSHORE KP 116.596 TO KP 127.298

The seabed within B5 Nearshore exhibits high reflectivity in the easternmost to midsections with lower reflectivity going westwards toward the landfall.

Three environmental grab sample sites, S036 – S037 and S031 as well as two vibrocore locations, were located within this section. The samples acquired returned muddy mixed sediments with cobbles and boulders and were used to further guide the intensity intervals as illustrated in Figure 69.

The seabed substrate composition was dominated by very coarse sediment in the east, with sections of mixed sediments moving westwards towards the landfall. The midsection of the route corridor traversed across areas of sandbanks expressing low reflectivity mobile sediments indicating loosely packed sands. Scattered clusters of stiff clay patches were interpreted throughout the corridor as well as areas of soft chalk close to, or at the seabed surface covered by a thin layer of sand.

Samples from environmental grab sample sites S036 and S037 returned very coarse material in the form of cobbles and boulders. In addition, the samples comprised coarse sands as well as muddy gravelly sediments confirming the presence of intermediate or overlaying sediments thus decreasing the likelihood that these two sites would qualify as Stony Reefs. The SSS and MBES interpretations did not identify any boulder field areas that encompass these sample sites.

Grab sample site S031 was located in an area comprising the coarsest substrates along this section of the route. This was supported by the sample returned at S031 which comprised large cobbles and boulders. The geophysical data reviewed showed an overall higher reflectivity at S031 when compared to S036 and S037. The comparison was conducted by reviewing the min and max backscatter intensity values at the different sites which showed a higher absorption of noise at S036 and S037.

Unstable cobbles and boulders comprising Spirobranchus communities suggest a biotope with opportunistic and ephemeral species, long-lived and more fragile species are usually not found. This was supported by the faunal sample, as a large number of the opportunistic amphipod *Jassa* spp., with annual generation time, were found at S031.

No features were identified in the geophysical data at S031 to be topographically distinct from the surrounding seabed. The SSS data further indicates that the cobbles and boulders in this area were buried to an extent by sand and gravel.

The rugosity measurement was at its highest in the midsections where the seabed is characterised by sandbanks and by features of stiff clays and/or chalk.

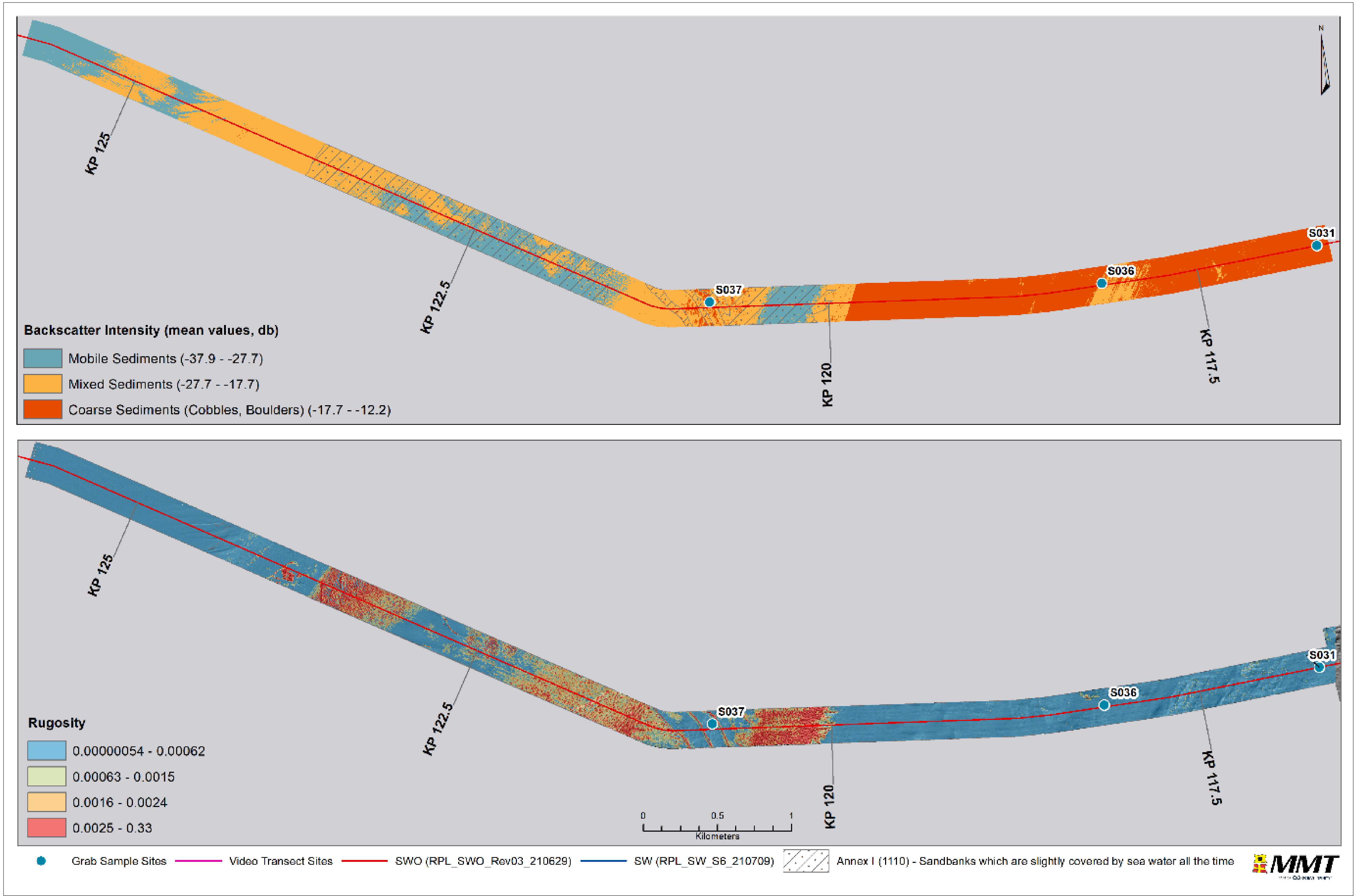


Figure 69 Overview of backscatter and rugosity data (draped over MBES hillshade) at B5 nearshore.

5.11.2| MESH CONFIDENCE ASSESSMENTS

The MESH confidence assessment yielded seven (7) different scores: Polygons with a score of 55 have no ground-truthing, polygons with a score of 80 were ground-truthed by vibrocores alone, polygons with a score of 87 were ground-truthed with imagery alone, and polygons with a score of 91, 92 and 95 where all ground-truthed by grab sampling as part of the Environmental sampling campaign.

The range of scores for the grab sample polygons is due to not all sites having acceptable visibility and/or a sample for PSA. Polygons that had no ground-truthed data could obtain a maximum score of 58, whereas polygons with ground-truthed data could obtain a maximums core of 100.

A summary of the MESH confidence scores can be seen in Table 86.

Table 86 Summary of MESH confidence assessment scores.

MESH SCORE	MESH MAX POSSIBLE SCORE	SAMPLING METHODOLOGY	SUM OF AREA (m^2)	PERCENTAGE OF TOTAL AREA
55	58	No ground-truth data	6092381	9.7
80	100	Vibrocore alone	20872174	33.2
87	100	Seabed imagery alone	312744	0.5
91	100	Grab sampling but no seabed imagery nor PSA	1551690	2.5
92	100	Grab sampling and PSA but no seabed imagery	28066438	44.7
95	100	Grab sampling, PSA and seabed imagery	5882804	9.4

Close to a tenth of the survey area had a MESH confidence score of 55. These areas were mainly located in the nearshore area of Block 5 closest to the landfall, between SWO KP 60 and KP 65, scattered smaller areas from SWO KP 2.5 to KP 20, and the areas close to the S6 and S7 landfalls (Figure 70 - Figure 75).

A third of the survey area had a MESH confidence score of 80. These areas were mainly located between SWO KP 38 and KP43, SWO KP 54 and KP 91, SWO KP 101 and 105 with scattered smaller areas from SWO KP 9 to KP 34 (Figure 70 - Figure 75).

A very limited fraction of the survey area, 0.5 %, had a MESH confidence score of 87. These areas were located at SWO KP 15.4 and between SWO KP 114 and KP 115 (Figure 70 and Figure 75).

A limited fraction of the survey area, 2.5 %, had a MESH confidence score of 91. These areas were located between SWO KP 14.7 and KP 16, and SWO KP 115.5 and KP 119.9 (Figure 70 and Figure 75).

Close to half of the survey area had a MESH confidence score of 92, and these areas were located throughout the survey corridor (Figure 70 - Figure 75).

Approximately a tenth of the survey area had a MESH confidence score of 95. These areas were located between SWO KP 54.5 and KP 57.5, and SWO KP 105 and KP 115.5 (Figure 72, Figure 74 and Figure 75).

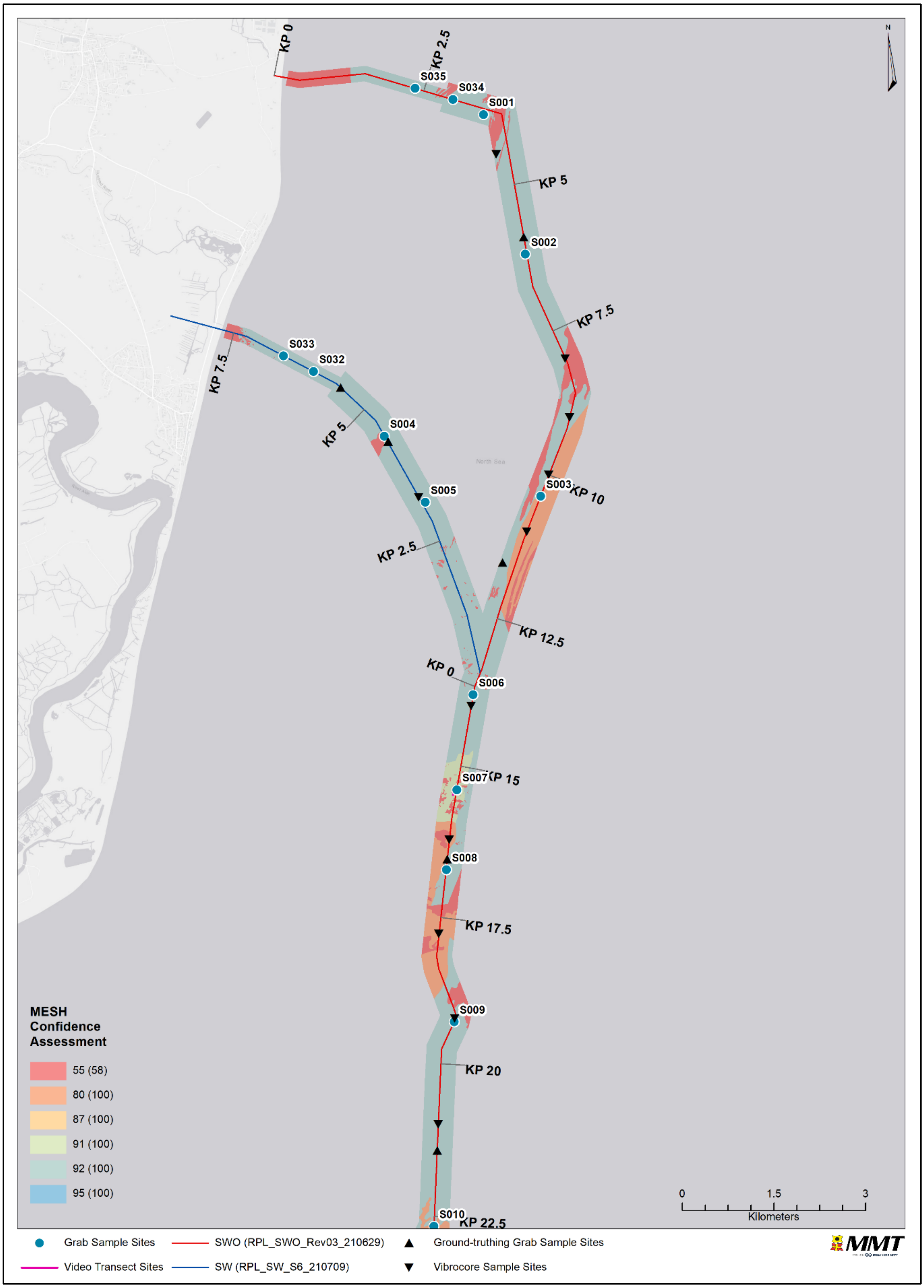


Figure 70 Overview of MESH scores between SWO KP 0.000 to KP 22.5 and SW KP 0.000 to KP 8.563.

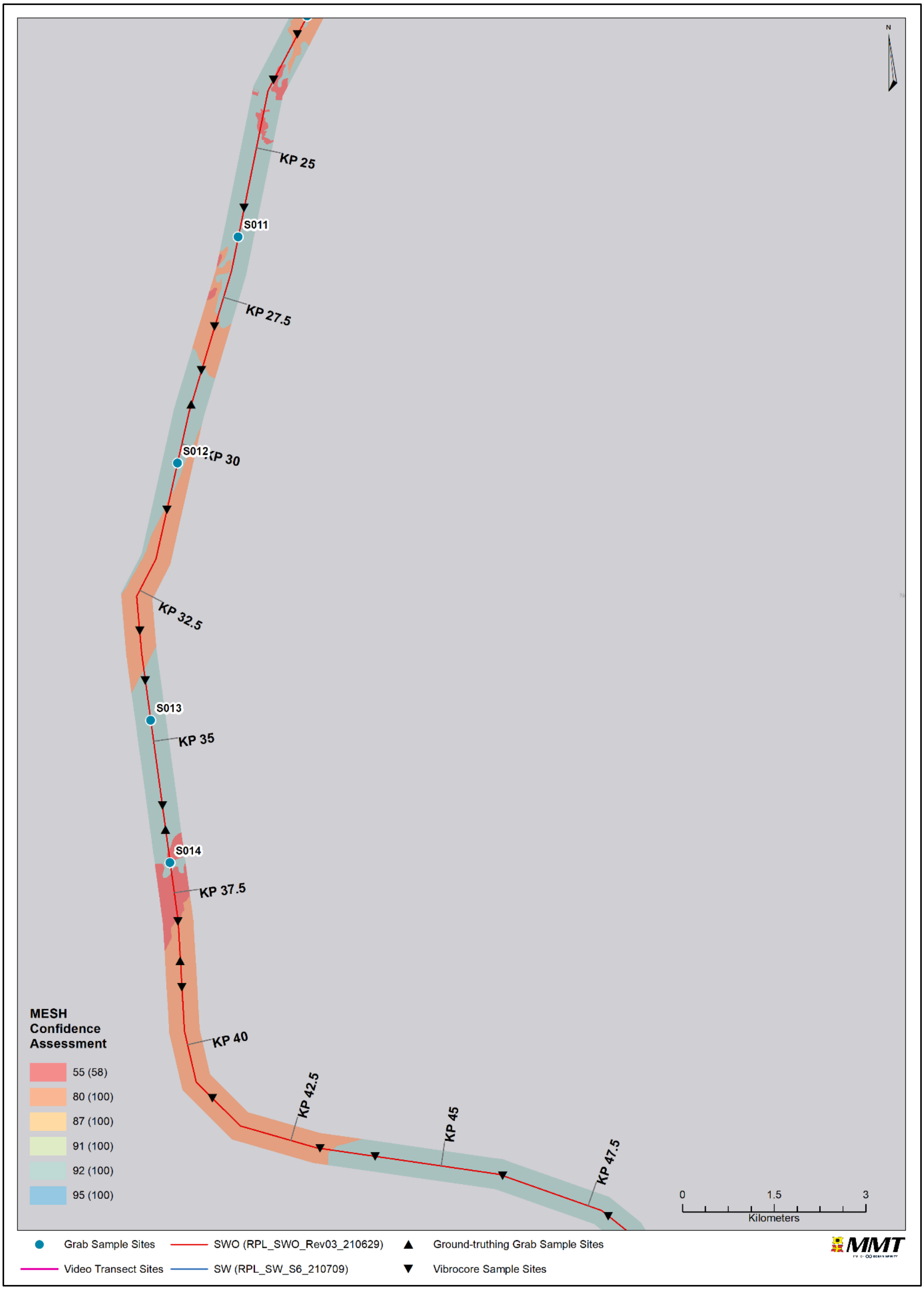


Figure 71 Overview of MESH scores between SWO KP 22.5 to KP 48.

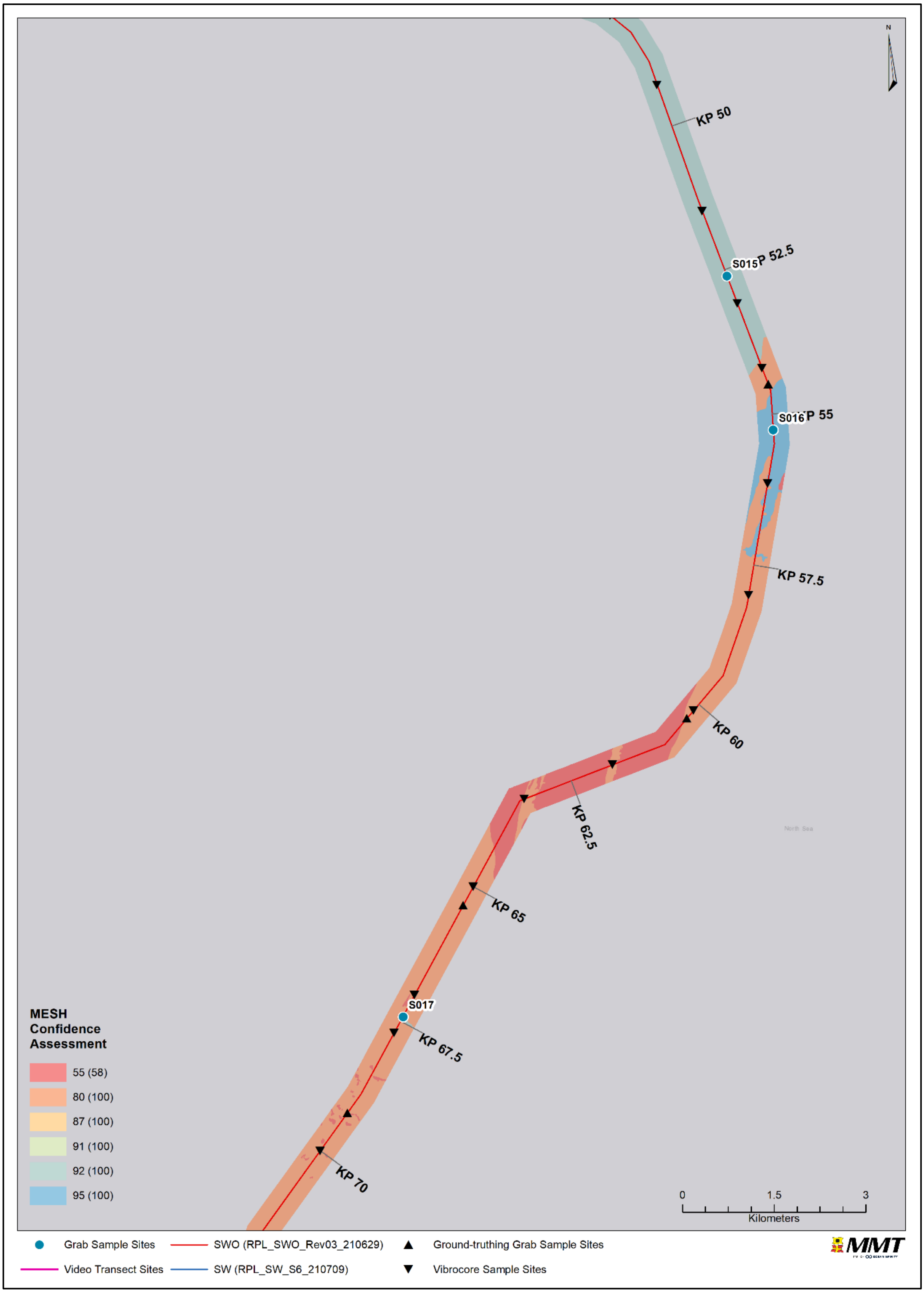


Figure 72 Overview of MESH scores between SWO KP 48 to KP 72.

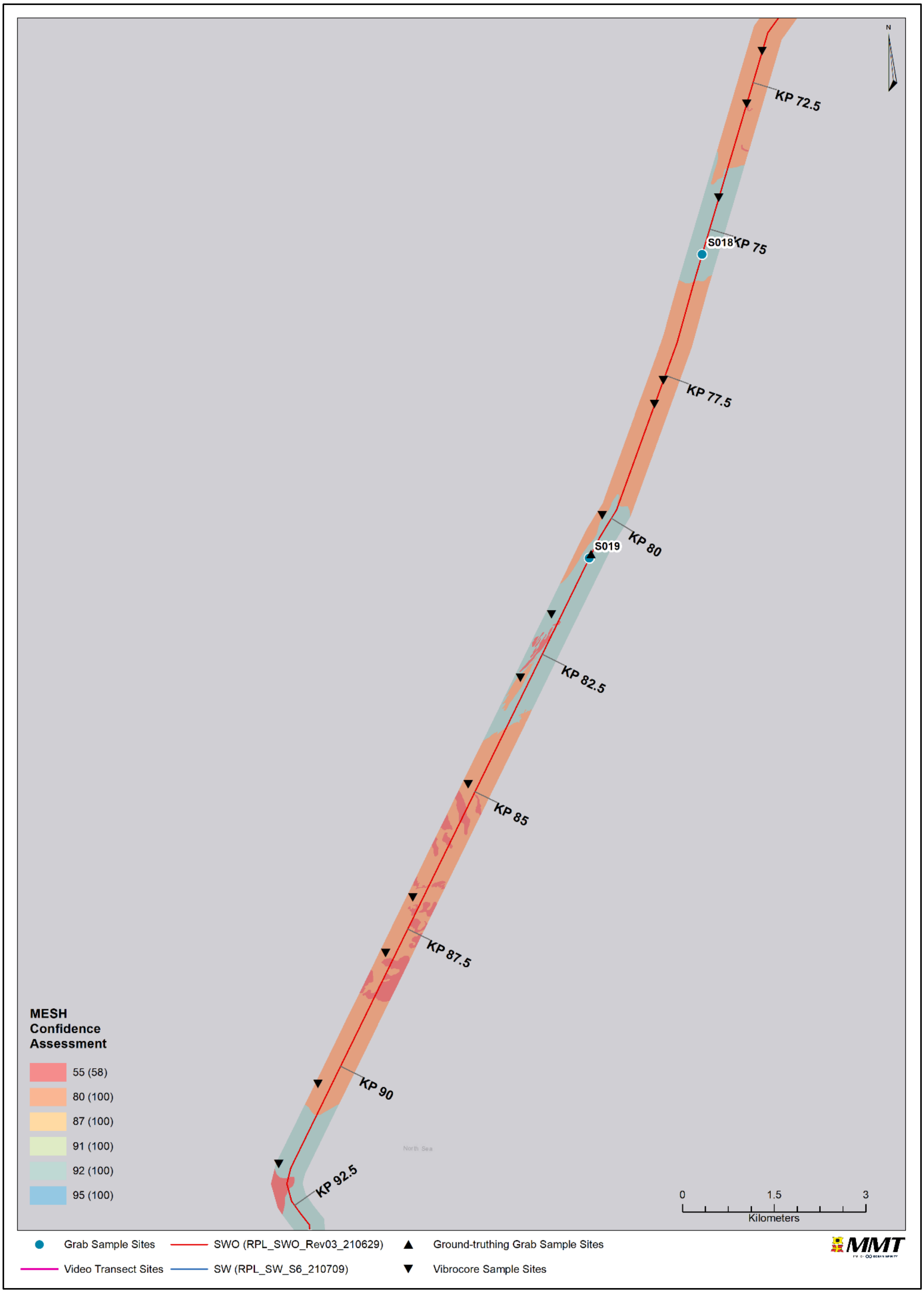


Figure 73 Overview of MESH scores between SWO KP 72 to KP 93.

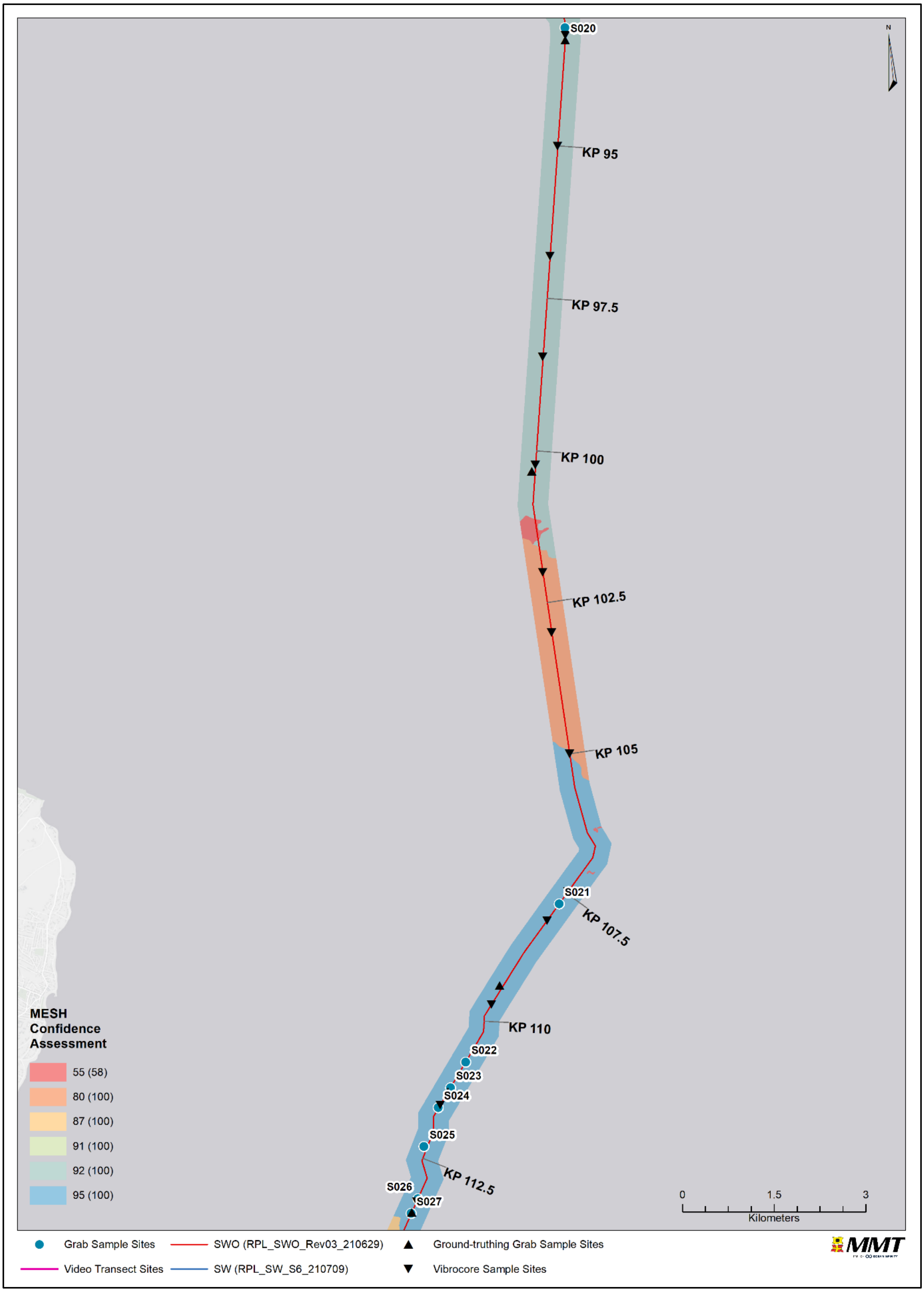


Figure 74 Overview of MESH scores between SWO KP 93 to KP 113.

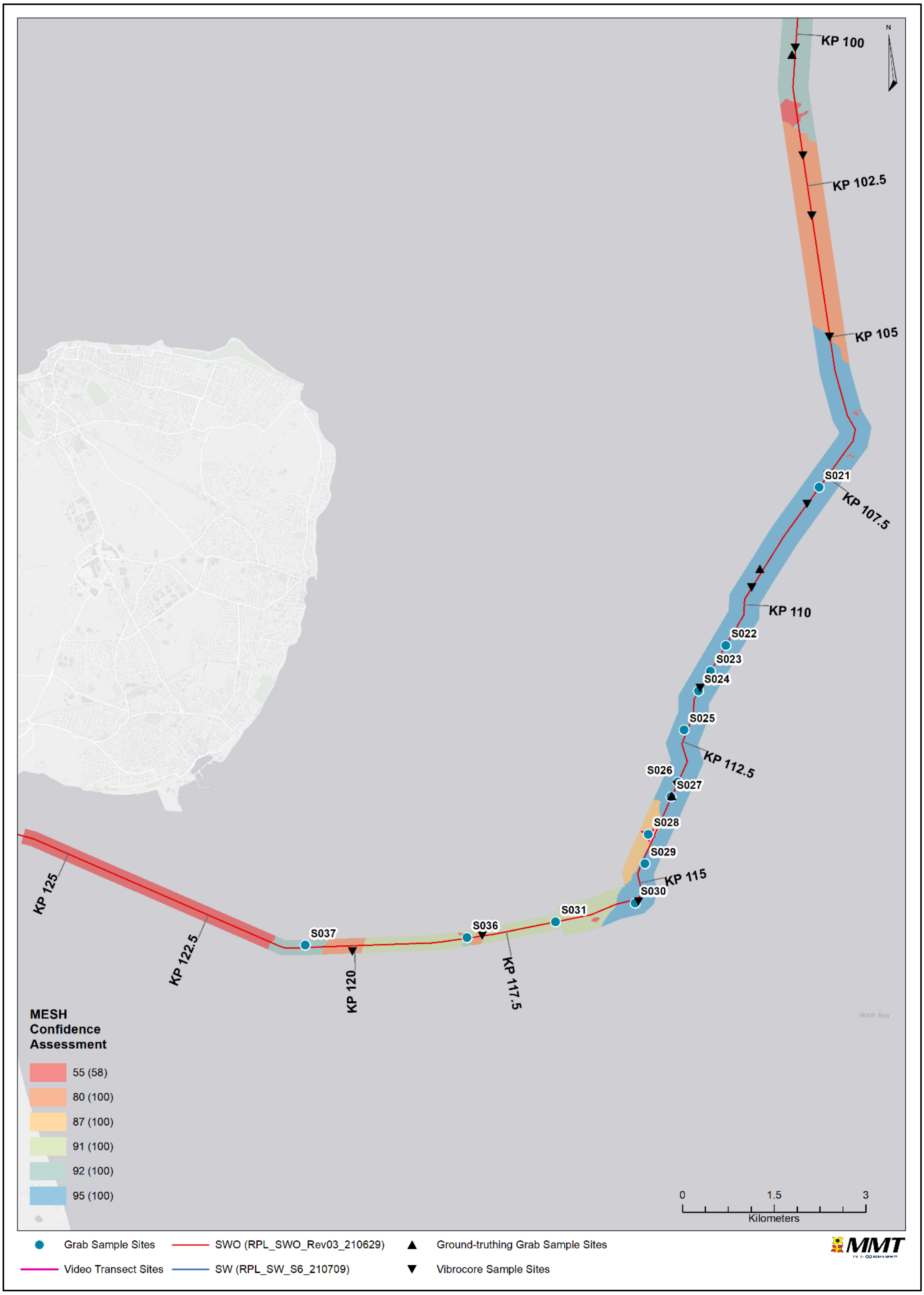


Figure 75 Overview of MESH scores between SWO KP 100 to KP 125.791.

5.12| DESIGNATED SITES

The SW and SWO survey corridors are located partly within two Special Protection Areas (SPA), Outer Thames Estuary and Thanet Coast and Sandwich Bay, one Special Area of Conservation (SAC), Southern North Sea, as well as one Marine Conservation Zone (MCZ), Goodwin Sands. Moreover, the survey corridors are located close to three further protected areas, namely Thanet Coast MCZ, Margate and Long Sands SAC, and Thanet Coast SAC.

5.12.1| OUTER THAMES ESTUARY SPA

The main survey route corridor crosses the Outer Thames Estuary SPA between KP 0.151 and KP 32.216 and between KP 58.897 and KP 88.019. The alternative landfall route option is located within the SPA between KP 0 and KP 7.677.

Grab sample sites S001 - S012, S017-S019 and S032-S035, as well as transects T001, T001A and T004, are located within the SPA. The SPA was designated to protect a large wintering population of red-throated diver *Gavia stellata* (38% of the wintering UK population). It also supports breeding populations of common tern *Sterna hirundo* (2.7% of the UK breeding population) and little tern *Sternula albifrons* (19.6% of the UK breeding population) (JNCC, 2017).

Out of the grab sample sites located within the SPA, sites S004 and S019 had classified as “Marginal” for sand eels, site S035 had sediment classified as “Preferred”. Sand eels are an important food source for many seabirds, including the ones protected by the SPA.

None of the sample sites located within the SPA comprised a sediment composition suitable for herring spawning.

5.12.2| THANET COAST AND SANDWICH BAY SPA

The survey route corridor crosses the Thanet Coast and Sandwich Bay SPA between KP 124.868 and KP 126.968. The SPA was designated to protect a breeding population of little tern *Sternula albifrons* (1% of the UK breeding population) and wintering populations of European golden plover *Pluvialis apricaria* (1% of the wintering UK population) and ruddy turnstones *Arenaria interpres* (3% of the wintering UK population).

Moreover, it supports nationally important wintering populations of four more bird species, ringed plover *Charadrius hiaticula*, grey plover *Pluvialis squatarola*, sanderling *Calidris alba* and Lapland bunting *Calcarius lapponicus* (Secretary of State for the Environment, 1996).

No sampling was conducted within the Thanet Coast and Sandwich Bay SPA.

5.12.3| SOUTHERN NORTH SEA SAC

The route corridor crosses the Southern North Sea SAC between KP 0.151 and KP 30.021, and KP 38.934 and 76.164 for the SWO route and between KP 0 and 6.832 for the SW route. Grab sample sites S001-S011, S015-S018, and S032-S035 as well as transects T001, T001A, and T004 are located within the SAC. The SAC was designated to protect harbour porpoise *Phocoena phocoena,* the site is estimated to support 17.5% of the UK North Sea population (JNCC, 2017).

Harbour porpoises prefer coarser sediment, like sand and gravel, over fine sediment, e.g., mud. Of the grab sample sites located within the SAC, the sediment consisted mainly of sand and gravel at sites S001, S004-S011, S015-S018, S032-S033, and S035. No Harbour porpoise was observed during the survey, please refer to the Marine Mammal Observation and Mitigation Report, 103748-NAT-MMT-MMO-REP-MMOREPFR-02 (Table 2).

5.12.4| GOODWIN SANDS MCZ

The survey route corridor crosses the Goodwin Sand MCZ between KP 112.627 and KP 116.585 and grab sample sites S026 - S030, as well as transects T002 and T003, are located within the MCZ.

The MCZ was designated to protect English Channel outburst flood features, subtidal coarse sediment, subtidal sand, blue mussel beds, moderate energy circalittoral rock and Ross worm *Sabellaria spinulosa* Reefs (Department for Environment, Food and Rural Affairs, 2019).

Out of the protected features only subtidal sands were identified. However, juvenile blue mussels *M. edulis* were identified from the grab samples at sites S026, S027 and S029.

5.12.5| THANET COAST MCZ

Thanet Coast MCZ is located west of the survey route corridor and was designated to protect Blue mussel (*Mytilus edulis*) beds, Moderate energy circalittoral rock, Moderate energy infralittoral rock, Peat and clay exposures, Ross worm (*Sabellaria spinulosa*) reefs, Stalked jellyfish *(Calvadosia cruxmelitensis*), Stalked jellyfish (*Haliclystus spp*), Subtidal chalk, Subtidal coarse sediment, Subtidal mixed sediments, and Subtidal sand.

No sampling was conducted within the Thanet Coast MCZ.

5.12.6| THANET COAST SAC

Thanet Coast SAC is located west of the survey route corridor and was designated to protect Reefs and Submerged or partially submerged sea caves.

No sampling was conducted within the Thanet Coast SAC.

5.12.7| MARGATE AND LONG SANDS SAC

Margate and Long Sand SAC is located west of the survey route corridor and was designated to protect Sandbanks which are slightly covered by sea water all the time.

No sampling was conducted within the Margate and Long Sands SAC.

6| DISCUSSION

SEDIMENT COMPOSITION AND CONTAMINANTS

The sediment in the northernmost part of the main route and the alternative landfall option was predominantly mud and sand. Further south, the sediment becomes more mixed and later becomes dominated by the sand fraction in the central and southern parts of the main route.

The analyses indicate that arsenic is the most prominent contaminant within the current survey, ranging from 5.9-45.4 mg/kg, mean of 19 mg/kg (SD=9.4). It exceeds the CCME ISQG at 32 grab sample sites (94%) and PEL at one (1) grab sample site (3%). Levels exceeding the PEL threshold value indicate that the substance is expected to have frequent adverse effects on aquatic ecosystems. Previous studies show high concentrations of arsenic in several areas of the North Sea, including the outer Themes estuary. The London Array Offshore Wind Farm Report (London Array Limited, 2005) showed high levels of arsenic exceeding ISQG levels at 34 sites (81%) and exceeding PEL at two (2) sites (5%) with values ranging from 2-51 mg/kg and a mean 24.8 mg/kg (SD=12.7). East Anglia ONE North Site Characterisation Report (SPR, 2005) shows arsenic levels (20.8 mg/kg) above CEFAS AL1 and CCME ISQG in close proximity to current survey grab sample sites S001, S034 and S035.

Site S036, located approximately 5 km southeast of the port of Ramsgate, stands out in having the highest concentrations of lead and copper measured (51.8 mg/kg and 103 mg/kg, respectively). Values are above both CCME ISQG and CEFAS AL1, and lead values are 9 mg/kg from reaching the CCME PEL limit (112 mg/kg).

The high values of lead and copper are only found at grab sample site S036, with the neighbouring sites having normal background values. An explanation could be the presence of many former licensed dredge spoil disposal sites in the area, combined with a sediment transport prediction made by CEFAS regarding the material disposed within Pegwell Bay and Port Ramsgate (CEFAS, 2001). Since then, many more disposal sites in the area have come into existence, possibly increasing the distribution of contaminants.

The highest concentration of an individual PAH was recorded at sites S011 with a Fluoranthene concentration of 136.0 µg/Kg, which exceeded the CCME ISQG (113.0 µg/Kg) threshold value. When summarising the EPA 16 PAHs total of 16 sites exceeded the NEA's class 2 – Good threshold value (30.0 µg/Kg). Examining the Environmental Protection Agency (EPA) ∑16PAH contaminants, sites S001, S002 and S011 all have values above 700 mcg/kg, followed by site S034 which has above 500 mcg/kg. Examining the Environmental Protection Agency (EPA) ∑16PAH contaminants, sites S001, S002 and S011 all have values above 700 mcg/kg, followed by site S034 which has above 500 mcg/kg.

PAHs are commonly classified into two groups based on their molecular weight. Low molecular weight (LMW) PAHs and high molecular weight (HMW). The molecular weight is a major toxicity factor, where LMW-PAHs are considered acute toxic although non-cancerogenic and HMW-PAHs generally not acutely toxic, but some are cancerogenic. Low molecular weight-PAHs higher water solubility compared to HMW-PAHs increases their negative effects on marine organisms (CCME, 1999). The LMW group exceeding CCME ISQG are naphthalene (S001, S002, S034), acenaphthylene (S034), acenaphthene (S001 and S002). The HMW group exceeding CCME ISQG are fluoranthene (S011) and dibenzo[a,h]anthracene (S001, S002 and S005).

In August 2020, CEFAS released a proposal to revise the action levels for dredge materials, including trace metals and PAHs (CEFAS, 2020). Current and proposed new action level values are presented in Table 87. The new proposed action level values for trace metals do not significantly impact the current survey results, and the current survey values are well below the action Level 1s for both LMW and HMW PAHs.

Table 87 Proposed revised actions levels, CEFAS 2020.

CONTAMINANT	UNITS (DRY WEIGHT)	CURRENT ACTION LEVEL 1	PROPOSED ACTION LEVEL 1	CURRENT ACTION LEVEL 2	PROPOSED ACTION LEVEL 2
As	ppm	20	20	100	70
Cd	ppm	0.4	0.4	5	4
Cr	ppm	40	50	400	370
Cu	ppm	40	30	400	300
Hg	ppm	0.3	0.25	3	1.5
Ni	ppm	20	30	200	150
Pb	ppm	50	50	500	400
Zn	ppm	130	130	800	600
PAH LMW	ppb	-	552	-	3160
PAH HMW	ppb	-	1700	-	9600

WATER COLUMN DATA

Salinity was stable and varied between approximately 34 and 35 PSU, with salinities being marginally lower at the sites in the northern end of the route. Temperature and density were stable but showed variation between sites sampled in September, S001-S0035, and the two sits sampled in October, S036 and S037. Sites S001 - S035 had a temperature of 18 to 19 °C and a density of 1024 to 1025 kg/$m^{3,}$ whereas sites S036 and S037 had a temperature of around 16 °C and a density of 1025 to 1026 kg/m^3. The drop in temperature and increase in density is likely explained by sites S036 and S037 being sampled three weeks later in the autumn. There was no sign of a pycnocline at any of the sites.

FAUNAL STATISTICS

The species richness, as well as abundance and evenness, varied between grab sample sites, which can be seen in the indices listed in Table 75. This variation could partly explain the large number of groups seen in the SIMPROF analyses, it also shows that the route stretches over a varied and complex area with many different habitats.

The SIMPROF analysis including the replicate samples produced 33 statistical groups. A large majority of these groups consists of samples from only one site, indicating large between site heterogeneity. Further, in several cases the replicate samples from the same sites are divided into two groups, indicating large within site heterogeneity as well. When the replicate samples from each grab sampling site were combined into an average abundance value, to eliminate within site heterogeneity, the SIMPROF analysis produced 16 groups. The general pattern is similar between the two analyses and the main driving factor for the faunal community is likely the sediment composition, which can be seen in Figure 41 and Figure 51, as well as in the BEST analysis.

The relationship between sediment and fauna has long been known (Sanders, 1958), but the sediment composition does not fully explain the groups found in the SIMPROF analyses. An example are groups with sediment classified as Sand, as Sand is found in several groups in both of the analyses. This is possibly explained by other factors, such as depth, playing a role in forming the faunal composition. However, it can also be an indication that the boundaries between sediment classes are not aligned with how they affect the species composition. Both of these explanations are likely affecting the faunal communities identified along the route.

To provide additional broad-scale characterisation of the survey area, a second stage dendrogram was performed based on the groups found in the average abundance SIMPROF analysis.

This resulted in 10 groups, which can be considered as broad benthic assemblages (Tappin, et al., 2011). The 10 groups are geographically distributed to some extent, e.g., the southern nearshore sites S036 and S037 forming a separate group. However, as can be seen in Figure 53, not all groups cluster together but are separated between clusters or the cluster contain other groups, again highlighting the complex and varying habitats found within the survey route.

HABITATS AND SPECIES OF NOTE

A potential presence of outcropping clay and soft chalk was noted within the survey corridors. These habitats are classified as **A4.23** – Communities on soft circalittoral rock. Outcropping clay was primarily classified in the northern and central parts, and soft chalk was primarily noted in the southernmost section of the route, where the chalk seems to mainly be located subsurface. The habitats Peat and Clay Exposures and Subtidal Chalks are listed as Habitats of Principal Importance for the conservation of biodiversity in England under The Natural Environment and Rural Communities Section 41 (NERC S41) list. The extent and distribution of these habitats are subject to change as surrounding mobile sediments shift, covering and exposing various sections of clay.

The Subtidal sands and gravels habitat was identified at 21 sites across the survey corridor. The habitat has some overlap with **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time but also includes areas that are not raised above the surrounding seabed. Subtidal sands and gravels is listed as a Habitat of Principal Importance for the conservation of biodiversity in England under The Natural Environment and Rural Communities Section 41 (NERC S41) list.

The ross worm *Sabellaria spinulosa* was found in the grab samples at 16 sites, and aggregations were observed in the video from transect T004 but were assessed not to cover a large enough area to be classified as a reef under Annex I. The low visibility limited the assessment, and it is largely based on the grab samples combined with geophysical data.

Blue mussel beds were identified in the area around grab sample site S007. The habitat is listed as a Habitat of Principal Importance for the conservation of biodiversity in England under The Natural Environment and Rural Communities Section 41 (NERC S41) list.

Five non-native species were observed during the survey: the polychaete *Goniadella gracilis,* barnacle *Austrominius modestus,* ostracod *Eusarsiella zostericola,* slipper limpet *Crepidula fornicata,* American piddock *Petricolaria pholadiformis.*

The barnacle *Austrominius modestus,* native to S. Australia and New Zealand, compete with native barnacles and is a fouling organism that will settle on artificial hard surfaces, including ships' hulls and buoys (Eno, Clark, & Sanderson, 1997). The ostracod *Eusarsiella zostericola,* native to the east coast of N. America, has a slow rate of dispersal and has a limited distribution in the UK despite being established for a long time (Eno, Clark, & Sanderson, 1997).

The slipper limpet *Crepidula fornicata;* native to the east coast of N. America, is a pest on oyster beds, where it competes for space and food, as well as increasing the deposition of mud, rendering the habitat unsuitable for the recruitment of young oysters (Eno, Clark, & Sanderson, 1997). The American piddock *Petricolaria pholadiformis,* native to the east coast of N. America, is known to be able to replace the native piddock *Barnea candida,* but this does not seem to have happened in the UK (Eno, Clark, & Sanderson, 1997).

There is a lack of information regarding the polychaete *Goniadella gracilis,* native to the east coast of N. America, and its potential impact on the environment or commercial interests. It is also worth noting that three of the species, *E. zostericola, C. fornicate* and *P. pholadiformis,* probably were introduced via the import of American cupped oysters *Crassostrea virginica.*

During the survey, five polychaetes not formally recorded in the UK were found: *Syllis columbretensis, Syllis garciai, Syllis pontxioi, Paradoneis ilvana* and *Spio symphyta*. All of these are originally described from European waters.

MBES DERIVATIVES

The visibility during the survey was generally low due to suspended and/or dissolved particles. On a majority of the grab sample sites, the imagery could not be used to identify fauna or otherwise contribute to the description of the habitat. The water clarity has decreased in the central and south North Sea from the 1950s and is the lowest in the East Anglia Plume, where the survey area is located. It is especially low during spring and autumn (Capuzzo, Stephans, Silva, Barry, & Forster, 2015). Further, the visibility has decreased by 70% during Spring and Autumn in the East Anglia Plume since the 1950s. The change in visibility is likely driven by an increase in suspended sediments rather than an increase in phytoplankton.

The backscatter intensity data detailed muddy sand/ sandy mud primarily in the northern sections of the SWO, including the SW route. Some finer substrates were also located in the southern sections of the SWO route. The majority of the offshore route is interpreted to be exhibiting intensity values ranging from sand to mixed and coarse sediments.

Differences in the classification, between the EUNIS habitats and backscatter intensity intervals, were noted primarily for SWO route data in the offshore B1 – B5. This concerned more specifically the ranges for mixed and coarse substrates and the boundary between the two.

A section of the SWO route between KP 11.963 and KP 27.810 was predominantly classified as mixed sediments, within the EUNIS habitat classifications, while the backscatter intensity values classified the same area as coarse sediments. The intensity values indicated very high reflectivity in the ranges of dense cobbles and/or boulders while the environmental grab samples along this section returned samples that were classified as muddy sandy Gravel, according to the FOLK classification. This disconnect in classification is due to the section of the route comprising small, densely packed pebbles that are situated at the very surface creating a very homogenous rocky pavement resulting in the high reflectivity noted in the backscatter.

MESH CONFIDENCE ASSESSMENTS

The MESH confidence assessment resulted in overall high scores, with 90.3 % of the survey area having a MESH confidence score of 80 or above. A third of the total area where ground-truthed as either part of the geophysical ground-truthing of the remote sensing data or as part of the geotechnical survey campaign. As these samples/ sample sites did not comprise any biological assessment or seabed imagery, they were scored lower compared to the samples acquired as part of the Environmental survey campaign. The remaining 9.7 % of the survey area comprised polygons with no ground-truthing data a received a score of 55, out of a possible maximum score of 58, thus indicating high-quality remote sensing data as well as high-quality analysis.

7| CONCLUSIONS

A total of 37 grab sample sites and five (5) video transects were surveyed as part of the Environmental Survey for the South East Anglia Link High Voltage Direct Current cable, located between Pegwell Bay in Kent and Sizewell in Suffolk, UK.

A total of 26 EUNIS habitats, including six (6) habitat complexes, were identified within the survey corridor. Areas interpreted as **Annex I** (1110) - Sandbanks which are slightly covered by sea water all the time, as well as four Habitats of Principal Importance for the conservation of biodiversity in England under The Natural Environment and Rural Communities Section 41 (NERC S41) list were identified throughout the survey corridor. The Ross worm *Sabellaria spinulosa* was identified throughout the survey area, however, no aggregations were assessed to qualify as **Annex I** (1170) – Biogenic Reefs.

The sediment composition varied across the route. The most dominant sediment fraction was sand, which had a content of 50 % or more at 22 sites.

The chemical analyses resulted in varying and often elevated levels of several metals. Threshold values for metals were exceeded at all grab sample sites, but for site S004. The levels of metals showed no geographical trends and did not correlate with sediment composition, TOC, nor organic matter. Concentrations of organics and hydrocarbons varied greatly, and threshold values for one or multiple PAHs were exceeded at 18 sites. Levels of PAHs were notably higher in the northern parts of the survey route, but no correlation was found with either TOC, organic matter, nor sediment composition.

The phyletic composition, regarding both the total number of taxa and abundance, was dominated by annelids. However, the two most abundant taxa were the annelid *Scalibregma inflatum* and the mollusc *Mytilus edulis*. *Scalibregma inflatum* had a total abundance of 6510 individuals and occurred in 54% of the grab samples. Species richness, Shannon-Wiener index, Evenness and Dominance varied across the grab samples.

The number of taxa (S) and the number of individuals (N) varied between 9-115 taxa and 18-2762 individuals/0.1 m^2, respectively per grab sample site. The SIMPROF analysis, including all grab sample sites, produced 33 district faunal groups. In addition, the SIMPROF analysis conducted separately for the nearshore sites, offshore sites, and the mixed cluster sites produced nine (9), 26 and 14 statistically distinct groups, respectively. The SIMPROF analysis conducted on average abundances for each grab sample site produced 16 statistically distinct groups, and finally, a second stage dendrogram based on these 16 groups produced 10 distinct groups.

Bryozoans dominated the phyletic composition of the sessile colonial epifauna in grab samples with regards to the number of taxa and abundance of colonies.

The survey corridor is partly inside four designated sites, two Special Protection Areas (SPA), Outer Thames Estuary and Thanet Coast and Sandwich Bay, one Marine Conservation Zone (MCZ), Goodwin Sands, and one the Special Area of Conservation (SAC), Southern North Sea.

Rugosity measurements for the SWO and SW exhibited associative patterns with regard to seabed variability. Areas of ripples and megaripples exhibited the highest seabed variability as did areas of outcropping/ underlying stiff clays and eroded depressions.

The majority of the delineated habitat polygons had ground-truthed data collected resulting in 90.3 % of the survey area having a MESH confidence score of ≥80. Additionally, 56.6 % of the area had a confidence score of ≥90. The remaining 9.7 % of the survey area had a confidence score of 55, as these polygons lacked ground-truthed data. The overall high scores indicate a robust assessment and confidence of the habitats identified within the survey corridor.

Five (5) non-native species were observed during the survey, as well as five (5) species of polychaetes not formally recorded in the UK.

8| RESERVATIONS AND RECOMMENDATIONS

The results in this report are based on the grab, video, and photo data together with chemical analysis from each sample site obtained within this survey, together with interpretations of geophysical data obtained during the geophysical survey conducted in conjunction with the benthic survey. It should be considered that there is a natural limitation in the accuracy of interpretation. Where considered applicable, the sampling results have been extrapolated to constitute a base for verifications also in the surroundings.

The survey area is impacted by high turbidity along almost the entire length of the survey route, which has also been the experience of previous surveys conducted in the area. There is a large amount of suspended and/or dissolved material in the water column, significantly reducing the amount of light passing through.

Future surveys could consider a DDV system that utilizes a freshwater lens. However, the benefits of using such a system may be limited as the visibility for the majority of the route was zero to none, and during such conditions, there is little to no gain from a freshwater lens. A freshwater lens could improve the visibility in areas with marginal visibility, although on a higher level of identification and not to a high species-level resolution.

It should be noted that the accepted name for *Pomatoceros triqueter* has changed to *Spirobranchus triqueter,* but the EUNIS habitat code **A5.141** - *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles still holds the unaccepted name.

The definition of a reef is still subject to debate within and among the member countries in the EU.

The JNCC report No. 405 “*Defining and managing Sabellaria spinulosa reefs: Report of an inter-agency workshop1-2 May*” (Gubbay, 2007), presents methods for defining *S. spinulosa* reef structures and setting different criteria to assess the quality of the reef. The report stated the following as the baseline for the definition of *S. spinulosa* reefs:

“The simplest definition of Sabellaria spinulosa reef in the context of the Habitats Directive was considered to be an area of Sabellaria spinulosa which is elevated from the seabed and has a large spatial extent. Colonies may be patchy within an area defined as reef and show a range of elevations.”

A number of evaluation criteria were agreed upon in this report to be considered as “*a starting point for wider discussion rather than accepted and fully agreed thresholds for* Sabellaria spinulosa *reef identification”* (Gubbay, 2007).

9 | REFERENCES

Bishop, M. (1947). Establishment of an Immigrant Barnicle in British Coastal Waters. *Nature*, 501-502.

Brazier, P. (2020). *Defining 'Reefiness' - inclusion of 'low stony reef' as Annex I Reef feature.* Working paper by Natural Resources Wales NRW.

Brig, M. (2008 (Updated Dec 2011)). *UK Biodiversity Action Plan Priority Habitat Descriptions.* JNCC.

British Standard. (2010). *Methods of test for soils for civil engineering purposes 1377-2:1990.* BSI.

Capuzzo, E., Stephans, D., Silva, T., Barry, J., & Forster, R. (2015). Decrease in water clarity of the southern and central North Sea during the 20th century. *Global Change Biology*, 2206-2214.

CCME. (1995). *Protocol for the derivation of Canadian sediment quality guidelines for the protection of aquatic life.*

CCME. (1999). *POLYCYCLIC AROMATIC HYDROCARBONS (PAHs).* Canadian Council of Ministers of the Environment.

CCME. (2001). *Canadian sediment quality guidelines for the protection of aquatic life: Introduction. Updated.*

CEFAS. (2001). *The impact of disposal of marine dredged material on the Thanet Coast and Sandwich Bay Candidate Special Areas of Conservation.* Centre for Environment Fisheries and Aquaculture Science.

CEFAS. (2020). *Review of Action Levels used for assessing dredging and disposal marine licences.* Centre for Environment Fisheries and Aquaculture Science.

Clarke, K. R., & Warwick, R. M. (2001). *Change in marine communities: An approach to statisctical analysis and interpretation, 2nd edition.* Plymouth: PRIMER-E.

Clarke, K., & Gorley, R. (2015). *PRIMER v7: User Manual/Tutorial. Plymouth: PRIMER-E.*

Collins, P. (2010). *Modified EC Habitats Directive Modified EC Habitats Directive Annex I Sabellaria spinulosa Reefiness Assessment Method (after Gubbay, 2007) .*

Crisp, D. (1958). The spread of Elminius modestus Darwin in north-west Europe. *Journal of the Marine Biological Association of the United Kingdom*, 483-520.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., . . . Vincent, M. (. (2001). *Marine Monitoring Handbook.* Peterborough: JNCC.

Department for Environment, Food and Rural Affairs. (2019). *Goodwin Sands Marine Conservation Zone.*

EEA. (2019, 08 28). *European Environment Agency (EEA)*. Retrieved from EUNIS habitat classification: https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification#tab-based-on-data

Ellis, J., MIlligan, S., Readdy, L., Taylor, N., & Brown, M. (2012). *Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep.* Lowestoft: Cefas.

Eno, N. C., Clark, R. A., & Sanderson, W. G. (1997). *Non-native marine species in British waters: a review and directory.* Peterborough: JNCC.

EUR 28. (2013). Interpretation manual of European Union Habitats. COMMISSION, EUROPEAN.

Faasse, M. (2013). The North American ostracod Eusarsiella zostericola (Cushman, 1906) arrives in mainland Europe. *BioInvasions Records*, 47-50.

Folk, R. L. (1954). The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature. *The Journal of Geology 62 (4)*, 344–359.

Golding, N., Albrecht, J., & McBreen, F. (2020). *JNCC Report No. 656: Refining the criteria for defining areas with a 'low resemblance' to Annex I stony reefs.* Peterborough: JNCC.

Gubbay, S. (2007). *Defining and managing Sabellaria spinulosa reefs: Report of an inter-agency workshop Report of an inter-agency workshop.* Joint Nature Conservation Committee.

Hin, J. A. (2010). *Guidance document for Sediment Assessment.* Ministry of Infrastructure and the Environment.

Irving, R. (2009). *The identification of the main characteristics of stony reef habitats under the Habitats Directive. Summary report of an inter-agency workshop 26-27 March 2008.* Peterborough: JNCC Report No.432.

IUCN. (2021). *The IUCN Red List of Threatened Species. Version 2021-1.*

Jenkins, C., Eggleton, J., Barry, J., & O'Connor, J. (2018). Advances in assesing Sabellaria spinulosa reefs for ongoing monitoring. *Ecology and Evolution*, 1-15.

JNCC. (2017). *Natura 2000 - Standard data form UK9020309 Outer Thames Estuary.*

JNCC. (2017). *SAC Selection Assessment: Southern North Sea.* Joint Nature Conservation Committee.

JNCC. (2019). *Article 17 Habitats Directive Report 2019.* JNCC.

Kornicker, L. (1975). Spreas of Ostracodes to exotic environs on transplated Oysters. *Bulletines of American paleontology*, 129-139.

Latto, P. L., Reach, I., Alexander, D., S., A., Backstrom, J., Beagley, E., . . . Seiderer, L. (2013). *Screening Spatial Interactions between Marine Aggregate Application Areas and Sandeel Habitat.* A Method Statement produced for BMAP.

London Array Limited. (2005). *Environmental Statment Volume 1: Offshore Works.* RPS Group Plc.

Lurton and Lamarche. (2015). *Backscatter measurements by seafloor-mapping sonars.* GeoHab. Retrieved from http://geohab.org/wp-content/uploads/2014/05/BSWG-REPORT-MAY2015.pdf

MarineSpace Ltd. (2018). *Atlantic Herring Potential Spawning Habitat and Sandeel Habitat Assessment Baseline 2018 - Humber Region.* A report for British Marine Aggregates Producers Association.

MESH. (2010). *MESH Confidence Assessment*. Retrieved from https://webarchive.nationalarchives.gov.uk/ukgwa/20101014083419/http://www.searchmesh.net/Default.aspx?page=1635

MMO. (2015). High level review of current UK action level guidance. A report produced for the Marine. *MMO Project No. 1053.*

NEA. (2016, revised 2020). *Grenseverdier for klassifisering av vann, sediment of biota. report M-608.* Norwegian Environmental Authority (Miljødirektoratet).

OSPAR. (2011). *CEMP 2011 assessment report.*

Proudfoot, R., Elliott, M., Dyer, M., Barnett, B., Allen, J. H., Proctor, N., . . . Mackie, T. (2003). *Proceedings of the Humber Benthic Field Methods Workshop, Hull University 1997. Collection and Processing of Macrobenthic samples from soft sediments; a best practice review.* Bristol: Environmental Agency.

Reach, I. L. (2013). *Screening Spatial Interactions between Marine Aggregate Application Areas and Atlantic Herring Potential Spawning Areas.* A Method Statement produced for BMAPA.

Sanders, H. L. (1958). Benthic Studies in Buzzards Bay. I. Animal-Sediment Relationships. *Limnology and Oceanography*, 245-258.

Secretary of State for the Environment. (1996). *EC Directive 79/409 on the Concervation of Wild Birds: Special Protection Area Thanet Coast (Ken).*

SPR. (2005). *East Anglia ONE North Site Characterisation Report (Windfarm Site).* ScottishPower Renewables (SPR) UK Limited).

Tappin, D. R., Pearce, B., Fitch, S., Dove, D., Gearey, B., Hill, J. M., . . . Fielding, H. (2011). *The Humber Regional Environmental Characterisation: British Geological Survey Open Report OR/10/54.* Marine Aggregate Levy Sustainability Fund.

UN. (5 June 1992). Convention on Biological Diversity. (pp. 1-28). Rio De Janeiro: UN.

Walbridge, S., Slocum, N., Pobuda, M., & Wright, D. (2018). *Unified Geomorphological Analysis Workflows with Benthic Terrain Modeler*. Retrieved from https://doi.org/10.3390/geosciences8030094

Worsfold, T., & Hall, D. (2010). *Guidelines for processing marine marcobenthic invertebrate samples: a Processing Requirements Protocol.* NMBAQC.

APPENDIX A | SAMPLE POSITION LIST

APPENDIX B | GRAB FIELD PROTOCOLS

APPENDIX C | GRAB IDENTIFICATION PROTOCOLS

APPENDIX D | TRANSECT FIELD PROTOCOLS

APPENDIX E | TRANSECT ANALYSIS PROTOCOLS

APPENDIX F | PARTICLE SIZE ANALYSIS RESULTS

APPENDIX G | CHEMICAL ANALYSIS RESULTS

APPENDIX H | CHARTS

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APPENDIX J | UNIVARIATE ANALYSES

APPENDIX K | PRIMER ANALYSIS

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APPENDIX M | FAUNA TO PRIMER

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