Environmental Survey Report

SSE ScotWind

Geophysical and Environmental Survey

East-1-East

CLIENT
SSE Renewables

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Abbreviations and Definitions

AL1 .....Action Level 1
AL2 .....Action Level 2
CCME.....Canadian Council of Ministers of the Environment
CEFAS .....Centre for Environment, Fisheries and Aquaculture Science
DBT.....Dibutyltin
DDV .....Drop Down Video
DPR.....Daily Progress Report
EAC.....Environmental Assessment Criteria
EC .....European Commission
EQS.....Environmental Quality Standards
ERL.....Effect range-low
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
ISQG .....Interim Sediment Quality Guidelines
JNCC .....Joint Nature Conservation Committee
LAT .....Lowest Astronomical Tide
LOI .....Loss of Ignition
M/V .....Motor Vessel
MAC.....Mobilisation and Calibration
MBES .....Multibeam Echo Sounder
MDS.....Multi-Dimensional Scaling
MPA.....Marine Protected Area
NEA.....Norwegian Environmental Agency
NMBAQC .....North-East Atlantic Marine Biological Analytical Quality Control Scheme
nMDS.....Non-metric Multidimensional Scaling
OI.....Ocean Infinity
OSPAR .....The Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic
PAH.....Polycyclic Aromatic Hydrocarbons
PAM.....Passive Acoustic Monitoring
PCA .....Principal Component Analysis
PCB .....Polychlorinated Biphenyls
PEL.....Probable Effect Level
PMF .....Priority Marine Feature
PPS .....Pulse Per Second

PRIMER.....Plymouth Routines in Multivariate Ecological Research
PSA .....Particle Size Analysis
RIVM.....Rijksinstituut voor Volksgezondheid en Milieu
SAC .....Special Area of Conservation
SBET.....Smoothed Best Estimated Trajectory
SBL.....Scottish Biodiversity List
SIMPER .....Similarity Percentage
SIMPROF.....Similarity profiling algorithm
SSS .....Side Scan Sonar
TBT .....Tributyltin
THC.....Total Hydrocarbons
TOC.....Total Organic Carbon
TOM .....Total Organic Matter
UHRS .....Ultra High Resolution Seismic
UK.....United Kingdom
UKAS.....United Kingdom Accreditation Service
UTC.....Coordinated Universal Time
UTM.....Universal Transverse Mercator

Executive Summary

This report details the results from the environmental survey performed off the east coast of Scotland at the SSE ScotWind project East-1-East lease area.

The environmental data acquisition included sediment sampling and imagery, with continuous video, and epibenthic trawls to establish a baseline for the habitats and faunal communities within the survey area.

The survey was performed using a towed High-Definition camera, a Day grab, and a Hamon grab for grab sampling. A scientific 2 m Beam Trawl with a cod-end mesh of 5 mm was utilised for epibenthic sampling.

The geophysical data were acquired to determine water depths, surficial geology, seabed features, shallow geology, and objects present within the survey area. Instruments used during the geophysical survey were Multibeam Echo Sounder, Side Scan Sonar, Magnetometer as well as Innomar Sub Bottom Profiler and 2D Ultra Hight Resolution Seismic.

All geophysical and environmental equipment was deployed from the survey vessel M/V Northern Maria.

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 GIS charts.

A total of 80 grab sample sites were selected, based on geophysical data, and sampled for taxonomic identification as well as Particle Size Analyses. A total of ten (10) grab sample sites were further selected for contaminants analyses. Epibenthic sampling was allocated at ten (10) sample sites within the survey area.

The environmental survey started on the 7th of July 2022 and was completed on the 20th of July 2022.

A total of four (4) EUNIS habitats were identified within the survey area, as well as two habitats of conservation importance. Thirteen species of conservation importance were identified within the survey area.

The results of the Particle Size Analysis showed limited variation in the sediment composition across the survey area, with sand being the dominant sediment fraction.

Levels of contaminants were low, with threshold values for arsenic being exceeded at one site (S002) and Polycyclic Aromatic Hydrocarbons at one site (S051). Polychlorinated Biphenyls, Dibutyltin and Tributyltin had levels below the detection limit at all sites.

The faunal analyses of the grab samples showed that the phyletic composition was dominated by annelids, primarily *Lanice conchilega* and *Spiophanes bombyx*. The colonial fauna was dominated by cnidarians and bryozoans. Echinoderms comprised the majority of the biomass.

The non-colonial fauna from trawl samples showed that the phyletic composition was dominated by arthropods. The total biomass of non-colonial and sessile colonial fauna from trawl samples was dominated by chordates, and the most abundant fish species was long rough dab *Hippoglossoides platessoides*.

Species richness, Shannon-Wiener index, evenness and dominance had a low variation across the grab sample sites, with the SIMPROF test identifying three (3) faunal groups. The most abundant non-colonial phyla in still photographs were annelids followed by cnidarians, and the colonial fauna with the highest coverage was the bryozoans.

1. Introduction

1.1 Project Information

Ocean Infinity (OI) were awarded the Geophysical and 2D UHRS (Ultra High-Resolution Seismic) and Environmental survey off the east coast of Scotland in the North Sea for the SSE ScotWind project.

1.2 Project Information

OI conducted a Geophysical and 2D UHRS survey off the east coast of Scotland in the North Sea for the SSE ScotWind project. The 858 km^2 seabed in the East-1-East (E1E) area in the Firth of Forth off the Angus Coast is one of the largest lease areas offered by Crown Estate Scotland for the installation of one of the largest floating offshore wind farms. Following the completion of the Geophysical and 2D UHRS scopes, an Environmental survey was conducted.

M/V Northern Maria conducted all aspects of the offshore 2D UHRS, geophysical and environmental survey works.

The project details are summarised in Table 1.

Table 1 Project details.

Client:	SSE Renewables
Project:	ScotWind
OI Sweden AB Project Number:	103995
Survey Type:	Geophysical / 2DUHRS / Environmental
Area:	East-1-East
Survey Period:	March 2022 – July 2022
Survey Vessels:	M/V Northern Maria
OI Project Manager:	Edward Lloyd Rich
Client Project Manager:	David Hinshelwood

1.3 Survey Area

The locations for the environmental sampling were to be based on the preliminary interpretation of the data collected during the geophysical survey acquired during Phase 1. Sampling sites were planned and selected to collect samples that provide a representational analysis of the survey area.

The survey area is located approximately 100 km offshore from Montrose, on the east coast of Scotland. The water depths within the survey area range from 63.82 m to 88.66 m LAT. The survey area was further divided into blocks for geophysical acquisition purposes.

The East-1-East survey area is illustrated in Figure 1.

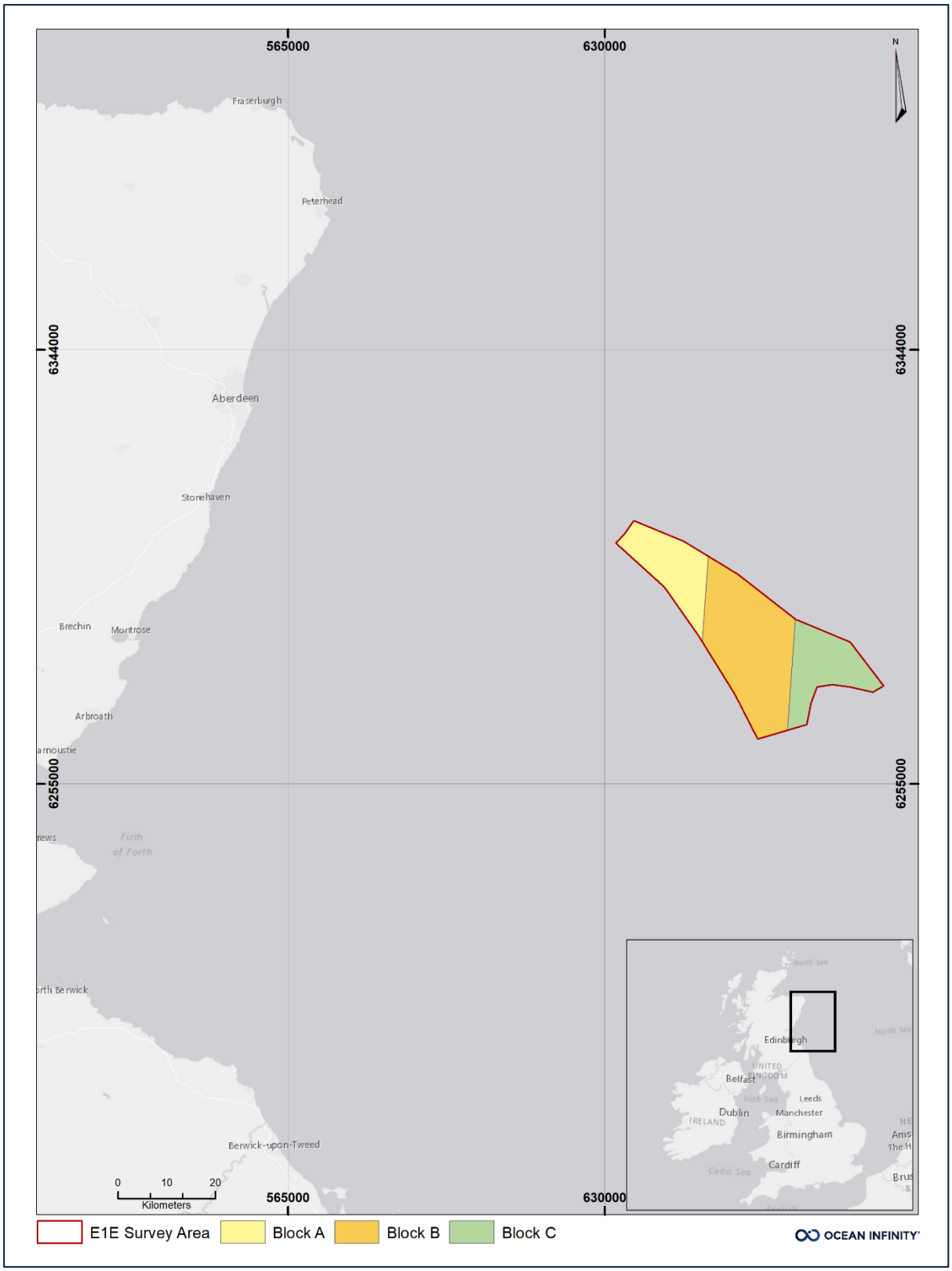


Figure 1 East-1-East reconnaissance survey site overview.

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 from within the survey area are presented in this report as well as in GIS charts presented in a GIS database. All existing OI data from the survey area 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 within the East-1-East survey area.

Scope of Work

The environmental sampling was conducted to ground-truth the interpretation of the geophysical survey data and identify potential ecological constraints for the infrastructure siting. The summary of the benthic operations was as below:

- Drop down video,
- Macrofaunal and Physico-Chemical Grab Sampling,
- Epibenthic Beam Trawls.

The benthic sampling scope involved a multi-dimensional survey approach, which involved visual inspection (photo and video) prior to any grab sampling. Photo and video were used at locations characterised by hard substrates and/or sensitive habitats, whereas benthic grab sampling took place in more homogenous areas alongside visual investigation.

A summary of the minimum number of sites required as part of the Environmental survey for each of the tasks is highlighted in Table 2.

Table 2 Environmental survey settings.

Environmental survey settings	No. samples/Photos per site	No. of sites	No. of attempts
Photos (pre-grab DDV check, with continuous video)	5	80	-
Macrofaunal grab samples	1	80	The site is abandoned after three failed attempts
PSA and TOC/TOM grab samples	1		
Contaminant grab samples	1	10 (of the 80 macrofaunal and PSA sites)	
Epibenthic Trawls	1 x 200 m Trawl	10	1

A total of 80 sites were selected for combined Drop Down Video (DDV) and grab sampling, to ensure adequate data coverage for both infaunal and epifaunal communities at each site. At 10 of the 80 sites, samples for contaminants were additionally acquired using a Day grab.

Ten (10) trawl transects, using a 2 m beam trawl, were conducted. The locations were distributed across the representative sediment types to characterise epifaunal communities. The distribution of the proposed sites is illustrated in (Figure 2).

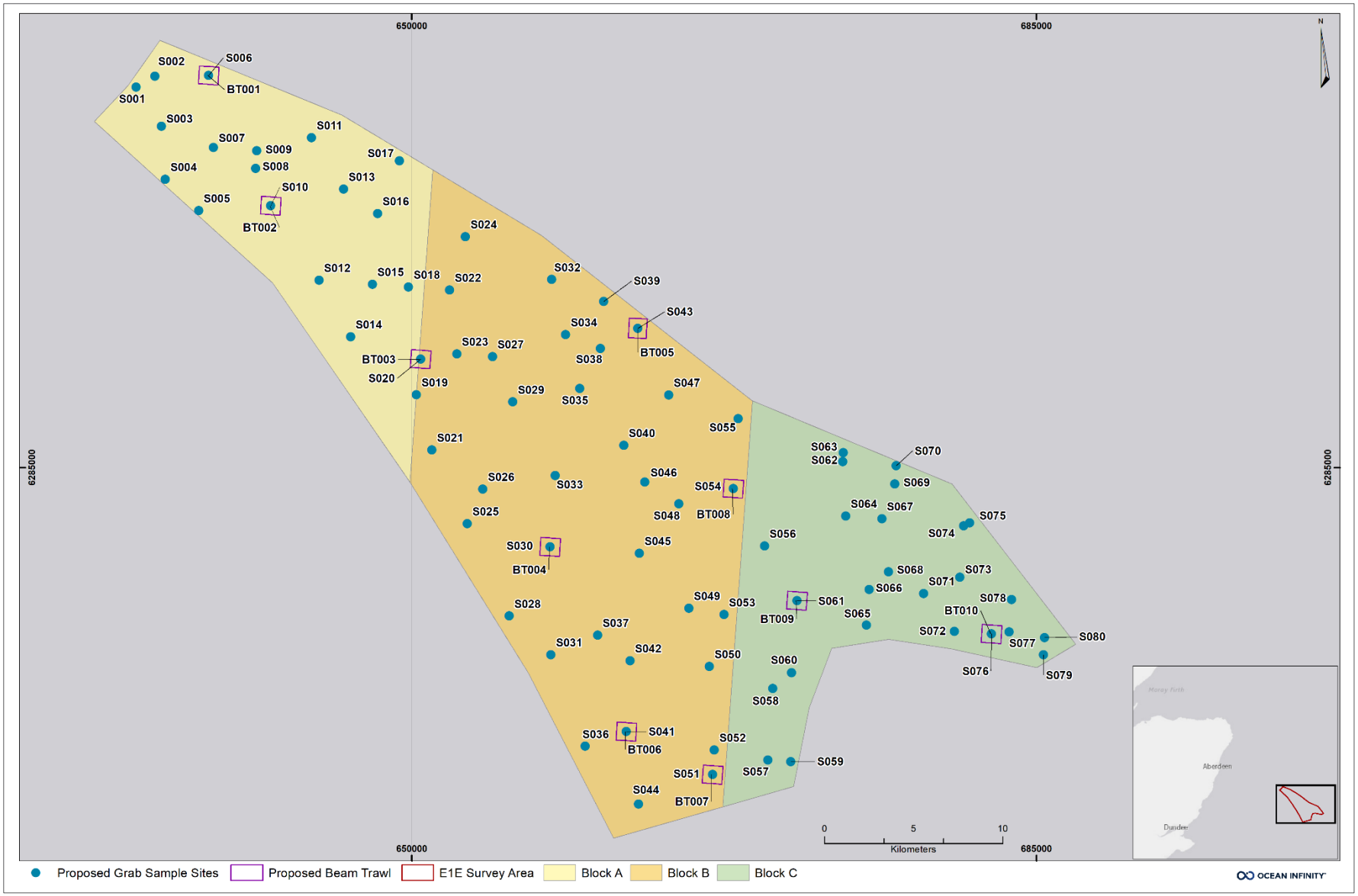


Figure 2 Overview of proposed sample sites.

1.4.1 Reference Documents

The documents used as references to this Environmental Survey Report are presented in Table 3.

Table 3 Reference documents.

Document Number	Title	Author
QUA_W-QUA-QASSURAN-MAN	MMT Quality Assurance Manual	OI
103995-SSE-MMT-HSE-PRO-HAZOP	Hazard and Operability Study Incl. Operational Procedures	OI
103995-SSE-MMT-HSE-PRO-HSEPLAN	HSE Plan – Northern Maria	OI
103995-SSE-MMT-HSE-PRO-ENFMARIA	Emergency Notification Flowchart – Northern Maria	OI
103995-SSE-MMT-QAC-PRO-CADGIS	CAD and GIS Specification	OI
103995-SSE-MMT-MAC-PRO-NMARIA	Mobilisation and Calibration Procedures - Northern Maria	OI
103995-SSE-MMT-MAC-REP-NMARIA	Mobilisation and Calibration Report – Northern Maria	OI
103995-SSE-MMT-SUR-REP-ENVFIERE	Environmental Field Report (this document)	OI
Scope of Work -Scotwind Geophysics_2022	ScotWind Reconnaissance Geophysical Surveys Scope of Work	SSE
SSE Recon Geophysical Technical Specifications_Scotwind Geophysical Surveys_2022 -	ScotWind Reconnaissance Geophysical Surveys Technical Specifications	SSE

2. Survey Parameters

2.1 Geodetic Datum and Grid Coordinate System

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

Table 4 Geodetic parameters.

Horizontal Datum: WGS 84 (EPSG: 4326)	
Datum	World Geodetic System 1984 (6326)
Ellipsoid	World Geodetic System 1984 (7030)
Prime Meridian	Greenwich (8901)
Semi-major axis	6 378 137.000 m
Semi-minor axis	6 356 752.3142 m
Inverse Flattening (1/f)	298.257223563
Unit	International metre

OI treat the ITRF2014 realisation to be equivalent to WGS84.
(Reference https://confluence.qps.nl/qinsy/en/international-terrestrial-reference-frame-2014-itrf2014-29856813.html)

Table 5 Projection parameters.

Projection Parameters	
Projection	UTM
Zone	30 N
Central Meridian	03° 00’ 00’’ W
Latitude origin	0
False Northing	0 m
False Easting	500 000 m
Central Scale Factor	0.9996
Units	metres

2.2 Vertical Datum

The bathymetric survey data was reduced to Lowest Astronomical Tide (LAT) through the usage of the UKHO Vertical Offshore Reference Frame (VORF) model.

Global Navigation Satellite System (GNSS) tides were used to correct the bathymetry data to the project vertical reference level. The GNSS tide is obtained by post-processing GNSS data collected by an Applanix PosMV 320 system. The GNSS data is then post-processed and applied to the data. This tidal reduction methodology encompasses all vertical movement of the vessel, including the tidal effect and vessel movement due to waves and currents.

The short variations in height are identified as heave and the long variations are identified as the tide. This methodology is very robust since it is not limited by the filter settings defined in the online systems and provides very good results in complicated environmental conditions.

The output from POSPac is a so-called SBET (Smoothed Best Estimated Trajectory) solution with ellipsoidal heights with accuracies of 5 cm RMS, which are corrected for motion and referenced to the MBES reference point.

The procedure has proven to be very accurate as it 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. By incorporating a height model of the defined vertical datum into the process, all heights used the same vertical reference which is valid at the location of the actual measurement independent of the size of the survey area, instead of choosing a single mean value. Comparisons with the closest water-level station were performed to ensure that the data is levelled correctly.

The vertical reference datum parameters and height model used during the project are presented in Table 6.

Table 6 Vertical reference parameters.

Vertical Reference Parameters	
Vertical reference	LAT
Height model	VORF

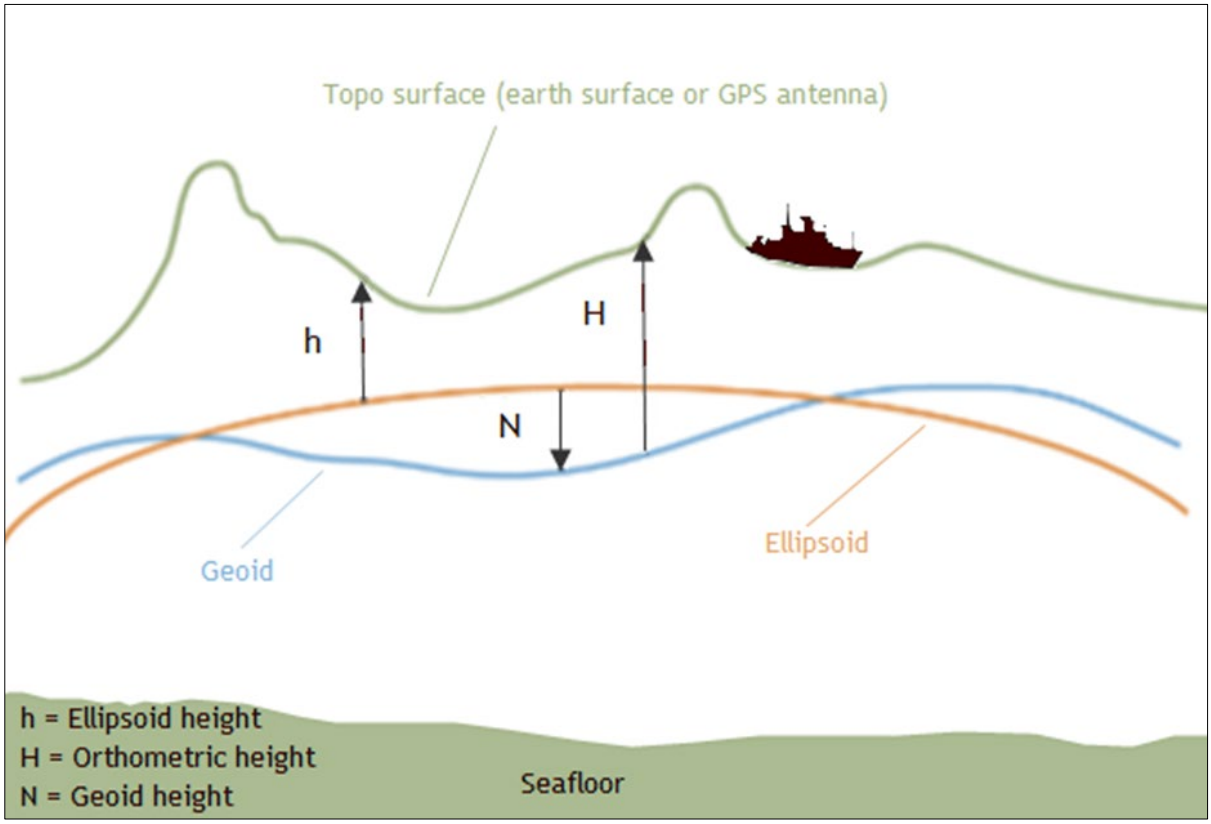


Figure 3 Overview of the relation between different vertical references

2.3 Time Datum

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

3. Survey Performance

3.1 Survey Tasks

The environmental survey operations were conducted between the 7th of July and the 20th of July 2022 and are presented in Table 7.

Table 7 Environmental survey operation schedule.

Task	Date	Description
1.	2022-07-07 to 2022-07-08	Mobilisation and Calibration in Aberdeen.
2.	2022-07-08	Transit to Site
3.	2022-07-09 to 2022-07-12	Operation – Drop Down Video and Grab Sampling
4.	2022-07-12 to 2022-07-13	Transit from and to the Site for Crew Change
5.	2022-07-14 to 2022-07-18	Operation – Drop Down Video and Grab Sampling
6.	2022-07-18 to 2022-07-19	Operation – Benthic Trawling
7.	2022-07-19	Transit to Aberdeen
8.	2022-07-19 to 2022-07-20	Demobilisation in Aberdeen.

3.1.1 Mobilisation and Calibration Test

Mobilisation and Calibration (MAC) commenced on the 7th of July 2022 in Aberdeen and was completed on the 8th of July 2022.

For a detailed description of the calibration performance and results please refer to the MAC 103995-SSE-MMT-MAC-REP-NMARIA-A.

3.2 Survey Vessel and Equipment

The Environmental survey operations were conducted by the offshore survey vessel M/V Northern Maria (Figure 4).

The vessel was equipped with a DP1 system able to perform geophysical seabed mapping (including UXO surveys) and geotechnical/environmental sampling assignments. Deployment of equipment could be performed via a stern A-frame.

The vessel was equipped with navigation and position systems as stated in Table 8 and Table 9.

Figure 4 M/V Northern Maria.

Table 8 Vessel equipment.

Instrument	Name
Primary Positioning System	Applanix POS MV 320 with Fugro Starfix.G4 corrections
Secondary Positioning System	Fugro Startfix.XP2 corrections
Primary Gyro and INS System	Applanix POS MV 320
Secondary Gyro and INS System	Fugro Starpack GNSS heading
Underwater Positioning System	Kongsberg HiPAP 502
Survey Navigation System	QPS Qinsy
Multibeam Echo Sounder (Medium to Shallow Water)	Kongsberg EM2040D (200-400 kHz)
Surface Pressure Sensor	Vaisala Pressure Sensor
Sound Velocity Sensor	Valeport SVX2, deployed over the side Real-time SVS Valeport miniSVS, hull-mounted at the MBES transducers rapidCAST or SVX2 MVP
Side Scan Sonar	Edgetech CSS2000
Sub-bottom Profiler	Innomar SES100 Medium
Magnetometer	2+1 Geometrics G882
PAM	4 channel Standard tow, Seiche

Table 9 M/V Northern Maria environmental survey equipment.

Equipment	Name
Grab sampler	Hamon Grab 0.1 m^2 (Fauna and PSA) Day Grab 0.1 m^2 (Contaminants)
Drop Down Camera System	STR SeaSpyder HD
Epibenthic Trawl	Beam Trawl (2 m)

4. Methodology

The benthic survey was conducted 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 Benthic Ecologist 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), Multibeam Echo Sounder (MBES), including normalised backscatter values, were ground-truthed. A detailed account of selected sites, including a geophysical overview, is presented in Appendix A.

The full SSS data coverage available was reviewed and interpreted based on texture and reflectivity. The SSS data were compared and correlated with MBES and backscatter. Selected sites were primarily positioned in the nadir of the SSS data where Magnetometer data coverage was present, and safe sampling could be ensured. The sites were selected where MBES and backscatter showed the presence of the same habitat on both sides of the nadir.

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 sample sites were decided based on depth variation, sediment, and habitat changes, delineated during the acoustic survey, to provide data of all habitats interpreted within the survey area.

Grab sampling was planned at a total of 80 sites. Before conducting grab sampling the Drop-Down Video camera system (DDV) was deployed 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.

Epibenthic trawling was planned at a total of ten (10) sites. The trawl transects were all co-located with grab sample sites.

4.1.2 Photo and Video Sampling

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.

Figure 5 SeaSpyder HD DDV system.

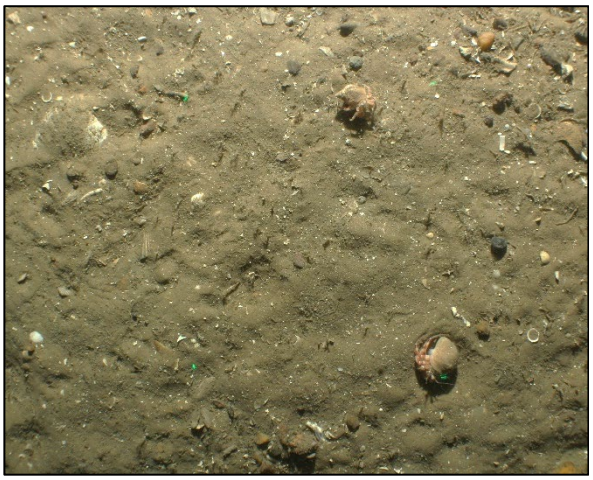


Figure 6 Example image from the survey.

A minimum of five (5) still photographs were acquired at each grab sample site prior to any grab sampling being conducted.

Stills were acquired at the centre location of each proposed grab site as well as approximately 10 m North, East, South and West of each site's centre location. In addition to the stills, video was recorded at each site which would be used to provide further information on the habitats and the extent of any features identified.

The stills of the seabed and geophysical data acquired at each grab sample site were reviewed by the on-shift Benthic Ecologist to confirm the presence/absence of any potentially sensitive habitats or features of conservation interest.

A brief log was maintained during photo and video collection at each site and as a minimum, this included the drop number, position in relation to the proposed location, duration, and a summary of the sediment type and conspicuous fauna 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 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 C and Appendix D.

4.1.3 Grab Sampling and Sample Preservation

At each of the 80 benthic grab sampling sites, a single faunal sample together with PSA (including TOC/TOM), which was sub-sampled from fauna, was acquired. The grab sampler used was a Hamon grab (0.1 m^2) (Figure 7).

A minimum sediment volume of 7 litres is considered to be an acceptable sample volume for fauna, and 2.7 litres for PSA (Worsfold & Hall, 2010; Davies, et al., 2001) thus the minimum required sample volume was 7 litres. If the sample volume was below 7 litres but exceeded 3 litres the sample was considered acceptable for PSA.

The retrieved samples were documented, including but not limited to, digital photographs, sample numbers, coordinates, and water depth.

The grab samplers were inspected between attempts and sites to ensure that they were free from obvious defects that could impair the ability to collect a valid sample and to ensure that it was clean and free from residual sediment from previous deployments.

If the first attempt was not acceptable, two re-attempts were made at that same site. If three failed attempts were acquired at a site (this occurred in areas of coarse sediment) then this was to be recorded, and the survey moved on to the next site.

Samples that were not accepted were not included in any statistical analyses but were used as guidance when assigning habitat codes. No pooling of samples was undertaken.

The sediment for PSA was sampled by taking a representative sample of one (1) litre from the sample bucket using a big plastic spoon. Prior to laboratory analysis, a sub-sample was taken from the PSA samples for TOC and TOM analyses.

The remaining sample was then decanted and sieved using a 5 mm over 1 mm sieve. A preliminary description and documentation of characteristic fauna and flora were performed before the samples were preserved and stored. The biological material together with any remaining coarse material was stored for further sorting and identification at the designated laboratory.

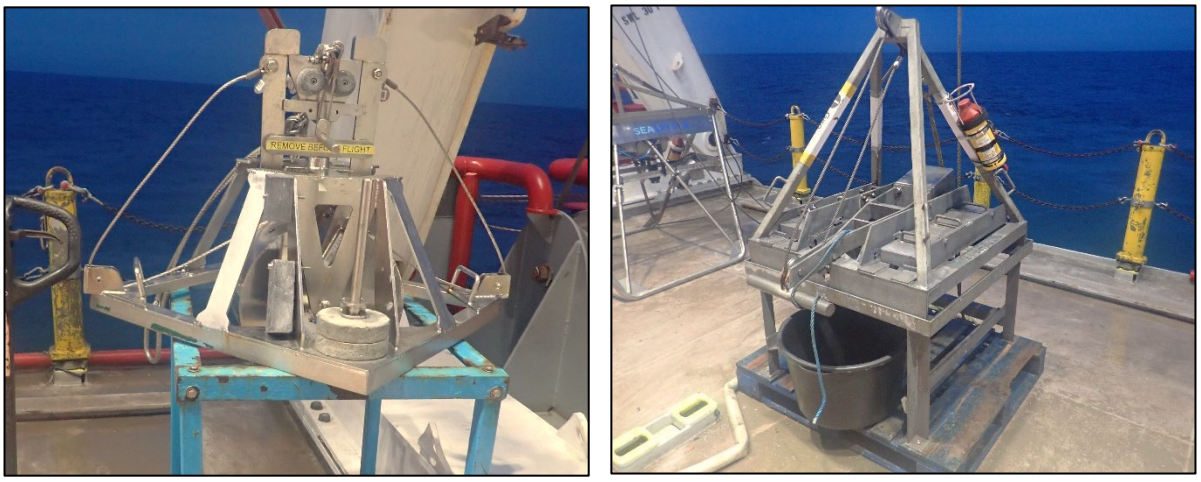


Figure 7 Day grab (left) and Hamon grab (right).

4.1.4 Contaminant Sampling

Sediment was sampled for contaminants at ten (10) of the 80 combined DDV/grab sample sites. The contaminants were sampled from a separate grab sample, using a Day grab (0.1 m^2) with sample inspection lids (Figure 7).

Samples for metals, hydrocarbons (Total Hydrocarbons (THC) and Polycyclic Aromatic Hydrocarbon (PAH)), Polychlorinated Biphenyls (PCB) and organotins (Dibutyltin (DBT) and Tributyltin (TBT)) were sampled from an undisturbed surface. The sediments were collected with a plastic spoon for metals and a metal spoon for organics, hydrocarbons, PCB and organotins, to ensure minimal contamination risk. The grab sampler was cleaned with seawater between samples and sample sites, and the spoons were cleaned with ethanol followed by seawater.

For the contaminants analyses of organics, hydrocarbons, PCBs and organotins a 250 ml tin container was used for storage. A one (1) litre plastic container was used for the metal samples. The different containers ensured that there was no outside contamination of the samples. The sample containers were labelled with a unique sample site ID. All samples were stored frozen according to the analysing lab's recommendations before and during shipment for analyses.

4.1.5 Epibenthic Trawls

A scientific 2 m Beam Trawl was used to conduct ten (10), 200 m long trawls for the duration of approximately 5 min. The beam trawl has a 22 mm mesh nylon body and a 5 mm mesh (knot to knot) liner in the cod-end to allow sampling of small-size classes. The belly of the trawl is covered with a chafer net for protection and the trawl is fitted with a 6 mm chain footrope with rubber discs and a single tickle chain to optimise fishing efficiency.

An approximate vessel speed of 1.5 - 2 knots was maintained for the duration of the trawl. The catch of each trawl was recovered into a container and the net was then checked for any remaining epifauna and fish.

Each accepted sample was initially cleared of large debris and the total catch was photographed. Fish species were sorted from epifaunal invertebrates, divided into species groups, identified to species level, and counted.

All samples were preliminarily processed and documented onboard, with larger fauna being weighted and measured. All sample specimens were preserved (large fauna frozen and small fauna preserved in ethanol) and delivered to the designated laboratory.

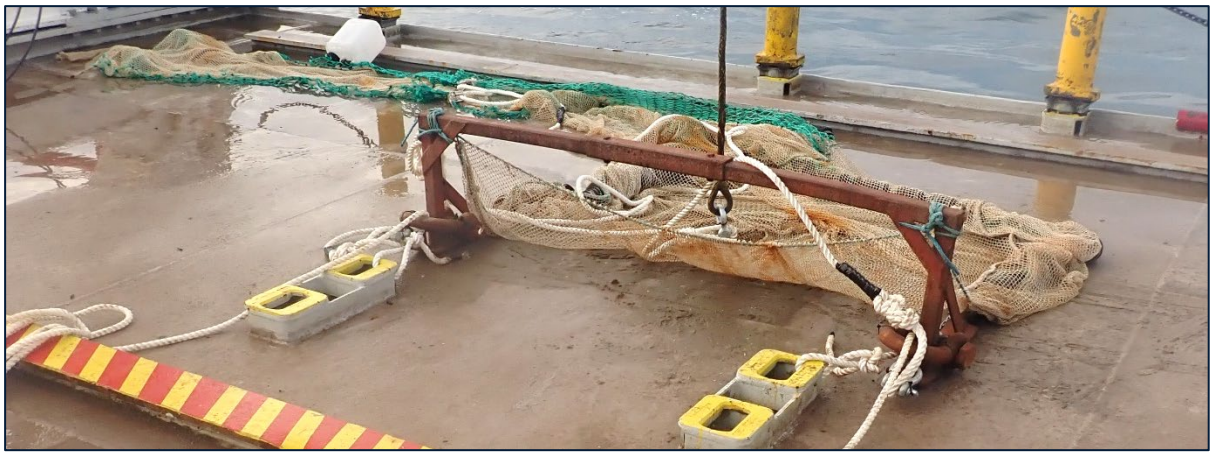


Figure 8 Scientific 2m Beam Trawl.

4.2 Laboratory Methods

4.2.1 Particle Size Analysis

The Particle Size Analysis (PSA) was conducted by UK-based company Kenneth Pye Associates Limited (KPAL).

Prior to analysis, a sub-sample was acquired from each container and sent for analysis of TOC and TOM.

Up to one litre of sediment from each sample site was analysed to detail the different particle fraction components with a combination of sieving and sedimentation methods.

PSA samples were analysed in accordance with NMBAQC Guidelines for Particle Size Analysis (PSA) for Supporting Biological Analysis (Mason, 2022) to provide data over the complete particle size range allowing determination of the gravel to sand plus mud ratio. KPAL also hold MMO accreditation for particle size analysis.

Samples were wet separated at 2.0 mm. The >2.0 mm fraction, where present, was analysed using nested British Standard sieves at 'half' phi intervals. The sub-2.0 mm fraction was analysed via laser diffraction (size range 0.04 µm to 2.0 mm). The laser and sieve data were mathematically merged and calculations of particle size summary parameters (percentages of mud, sand, and gravel, silt/clay ratio, sand/mud ratio, median, mean, d10, d90, etc.) were calculated using GRADISTAT software (Blott & Pye, 2001).

The particle sizes were grouped into five large textural groups for description purposes Table 10. The samples were described according to British standard 1377 (British Standard, 2010) and BGS modified Folk classification (Long, 2006).

Table 10 British standard (2010) sieve sizes.

Classification	Particle Size Intervals (Diameter mm)	Grouped Classification
Boulder	>75	Boulders/cobbles
Cobble	75-64	
Coarse Gravel	64-20	Gravel
Medium Gravel	20-6	
Fine Gravel	6-2	
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

Classification	Particle Size Intervals (Diameter mm)	Grouped Classification
Medium Silt	0.02-0.006	
Fine Silt	0.006-0.002	
Clay	<0.002	Clay

4.2.2 Contaminants Analyses

The contaminant analyses were conducted by the UK-based company SOCOTEC. The different compounds that were analysed along with detection limits are stated in Table 11. The analyses included concentrations/contents of metals, TOM, TOC, THC, PAH, PCB, DBT and TBT.

Table 11 Marine sediment contaminant analyses.

Test Marine Sediment Contaminant analysis	Method	Accreditation U = UKAS M = MMO	Method Reporting Limit, PPM Unless Stated Otherwise
Total Organic Carbon	Carbonate removal and sulphurous acid/combustion at 1600°C/NDIR.	U	0.02%
Total Organic Matter by LOI	Determination of loss on ignition at 450°C by gravimetry		0.20%
Metals Suite: **As (0.5), Cd (0.2; 0.1*),** **Cr (2), Cu (2), Ni (2),** **Pb (1.2), V (1), Zn (3)**	Documented method using Microwave assisted HF/Boric & ICPMS	U	Detection Limits in brackets
Metals Suite: **Al (10), Ba (1), Fe (45)**	Documented method using Microwave assisted HF/Boric & ICPOES	U	Detection Limits in brackets
Metals Suite: **Hg (0.01)**	Documented method using Nitric/Peroxide extraction & ICP-MS		Detection Limits in brackets
THC (inc. saturates)	Documented method using Solvent extraction & GC-FID		100 µg/kg (total), 1µg/kg (individual alkanes)
PAHs: 2 to 6 ring aromatics by GC-MS and/or + 16 USEPA (as required)	Documented method Solvent extraction & GC-MS	U	0.001
TBT & DBT (Tributyltin & Dibutyltin)	Acid digest and solvent extraction GC-MS	U	1µg/kg
PCBs (25 congeners inc. ICES 7)	Solvent extraction & GC Triple Quad	U	0.08µg/kg

**Additional test performed due to values of the original test being below the detection limit. Not UKAS accredited.*

4.3 Biological Analysis

4.3.1 Faunal Analyses

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 lowest taxonomic 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 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 excluded from further statistical analyses.

Biomass analysis was conducted on the infauna from grab samples following identification and enumeration. Biomass was measured for each taxon for each sample, using the blotted wet-weight method, to the nearest 0.0001 g. All infaunal analyses followed the NMBAQC scheme. For a more detailed description, view Appendix F and Appendix G.

For fish species, all distinctions between adult and juvenile specimens were based on length, typically being less than 10 % of the maximum size, when classified as a juvenile. All specimens recorded as juvenile within the current project were <4 cm and so would also have been sexually immature. Gonadal maturity was not a part of the required specifications and was therefore not conducted. Biomass for the specimens from the trawl samples was weighed for each taxon for each sample, when applicable, using the blotted wet-weight method. Larger taxa were weighted to the nearest gram, whereas smaller taxa were weighed to the nearest 0.0001 g

4.4 Data Analysis

4.4.1 Visual Data Analyses

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 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 the species composition for each grab sample site, view Appendix E.

4.4.2 Particle Size Analysis

Sediment particle size distribution statistics for each sample were calculated from the raw data by the laboratory. Main sediment fractions and percentages were plotted to examine sediment composition changes across the survey area and used to aid the habitat assessment. Detailed results for each grab sample site are provided in Appendix H.

4.5 Contaminants 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.

The Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic (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 (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 results are presented in Appendix I.

4.6 Statistical Analyses

4.6.1 Univariate Statistical Analyses

Univariate analysis was 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 one replicate from each grab sample site.

Univariate analyses included the primary variables, the number of taxa (S) and abundance (N), together with 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 12. Abundance is expressed as the number of individuals per 0.1 m^2 for each grab sample, whereas the number of taxa is the total number of taxa found in each grab sample.

Table 12 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' = Σi Pi ln(Pi)	The diversity index incorporates both species richness and equitability, where Pi is the proportion of the total count arising from the /th species. A lower value equals a high chance

Analyses	Parameters	Formula	Description
			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	$\lambda = (\Sigma pi2)$	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.

4.6.2 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 one replicate 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 m^2.

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 epifauna. Juvenile taxa, fragments of an animal and Protists (Ciliophora, Foraminifera) were excluded from the datasets. The faunal composition was linked to physical variables such as depth and sediment composition.

No transformation was applied to the non-colonial enumerated fauna datasets before calculating the Bray-Curtis similarity. The largest abundances in the current dataset were generally <20 individuals per sample and thus it was deemed that there was no need for reducing the influence of highly abundant or rarer species.

The faunal laboratory results were compared for faunal composition 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 naturally 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 differ in abundance.

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

PSA results 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.

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.

4.7 MBES Derivatives

During the post-processing and assessment of benthic data, an additional MBES data derivative, backscatter, was produced to further strengthen the accuracy of the interpretations.

4.7.1 Backscatter Data Analyses

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 decibels (dB), of the echo that returns to the transducer after the emitted pulse interacts with the seabed.

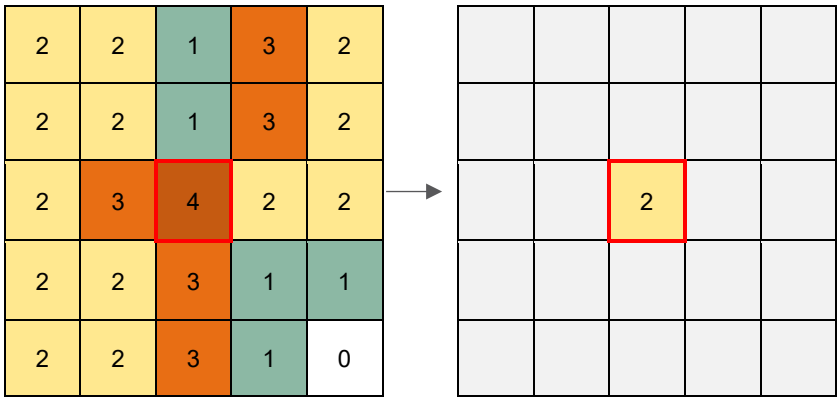
The backscatter amplitude varies with several factors such as frequency, beam pattern, range and losses due to absorption and spreading, angle with the seabed as well as sediment type and other factors.

The raw dataset 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 ranged typically from +10 (white, hard seabed) to -70 (black, soft seabed) for the exported raster data.

Backscatter values can vary across a small spatial scale, making interpretations on a larger scale challenging due to the small-scale variation. To mitigate this, the Focal Statistics tool in ArcGIS was used to reduce the variation in the values. The 1 m backscatter raster data was imported into ArcGIS at 5 m resolution 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 values with the Focal Statistics tool. The tool calculates a new value for each input cell based on the neighbouring cell values (Table 13). The new value output was based on the average value of the neighbouring cells in a 5x5 m area (5x5 cells).

Table 13 Focal Statistics settings.



Ground-truthing data (photos, video, physical samples such as fauna and PSA 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 some limiting factors due to the presence of ripples.

The difficulties, with features such as ripples, imposed 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 were partially mitigated 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 raw data sets were naturally excluded as the grouping of the intervals was set and these are detailed in Table 14.

Table 14 Backscatter Intensity colour schema for each area (intensity presented in dB).

		OUTLIERS (dB)
Default		N/A
E1E Area		-65 - -30; -17 - 10

4.8 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 was 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, 2022) is divided into six hierarchic levels, Figure 9. At Level 1, the habitats are divided into marine, coastal and terrestrial habitats. The marine habitats are further divided into three separate categories: benthic, pelagic and ice-associated habitats.

At Level 2, the biological zone and presence/ absence of rock is a classification criterion, and at Level 3, the classifications are separated into marine regions.

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.

L1	(M) Marine Habitats
L2	(MC4) Circalittoral mixed sediment
L3	(MC42) Atlantic circalittoral mixed sediment
L4	(MC421) Faunal communities of Atlantic circalittoral mixed sediment
L5	(MC4211) *Cerianthus lloydii* and other burrowing anemones in circalittoral muddy mixed sediment
L6	(MC42111) *Cerianthus lloydii* with *Nemertesia* spp. and other hydroids in circalittoral muddy mixed sediment

Figure 9 Example of 2022 EUNIS Hierarchy.

4.9 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 (EUR 28, 2013). 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.

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) list 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 (European Commission) 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 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) and further modified by Collins (2010) (Table 15) and for Stony Reefs by Irving (2009) (Table 16).

Table 15 S. Spinulosa Reef Structure Matrix (Step 1) and S. spinulosa Reef Structure Matrix vs Area Matrix (Step 2) to determine final "Reefiness" (Collins, 2010).

Step 1						
Reef Structure Matrix			Elevation (cm)			
			<2	2 – 5	5 - 10	>10
			Not a reef	Low	Medium	High
Patchiness (%)	**<10**	**Not a reef**	Not a reef	Not a reef	Not a reef	Not a reef
	10 – 20	**Low**	Not a reef	Low	Low	Low
	20 – 30	**Medium**	Not a reef	Low	Medium	Medium
	>30	**High**	Not a reef	Low	Medium	High
Step 2						
Reef Structure vs Area			Area (m^2)			
			<25	25 – 10 000	10 000 – 1 000 000	>1 000 000
			Not a reef	Low	Medium	High
Reef Structure		**Not a reef**	Not a reef	Not a reef	Not a reef	Not a reef
		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 16).

Table 16 Guidelines used to categorise the 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.

In addition to the above-mentioned policies and guidelines, the Scottish Biodiversity List (SBL) (Scottish Biodiversity Forum, 2009) identifying the species and habitats which are the highest priority for biodiversity conservation in Scotland was also consulted.

The species and habitats found in this survey were compared to the list of Scottish Priority Marine Features (PMF) (Tyler-Walters, 2016) which further defines the habitats and species which are considered to be marine nature conservation priorities in Scottish waters.

5. Results

A total of 80 sites were chosen for photo documentation and grab sampling. In addition, 10 sites were chosen for epibenthic trawls (Table 17, Figure 10). All the sampling sites were successfully photographed with good quality photos acquired. A geophysical overview of each site can be viewed in Appendix A with further information regarding sampled sites in Appendix B. To illustrate the geophysical coverage within the survey area, MBES (the MBES depth data is draped over a shaded relief to show topography) and SSS data are shown in Figure 10 and Figure 13.

Faunal samples from grab sample sites S007, S008, S018, S023, S0025, S029, S038, S042, S049, S052 and S070 comprised insufficient sample volume, due to cobbles, and are excluded from statistical analyses.

Table 17 Number of surveyed sample sites.

Number of Sampled Sites	Video Transects	Grab Sample Sites	PSA /Contaminants Sites	Beam Trawl Sites
	80	80	10	10

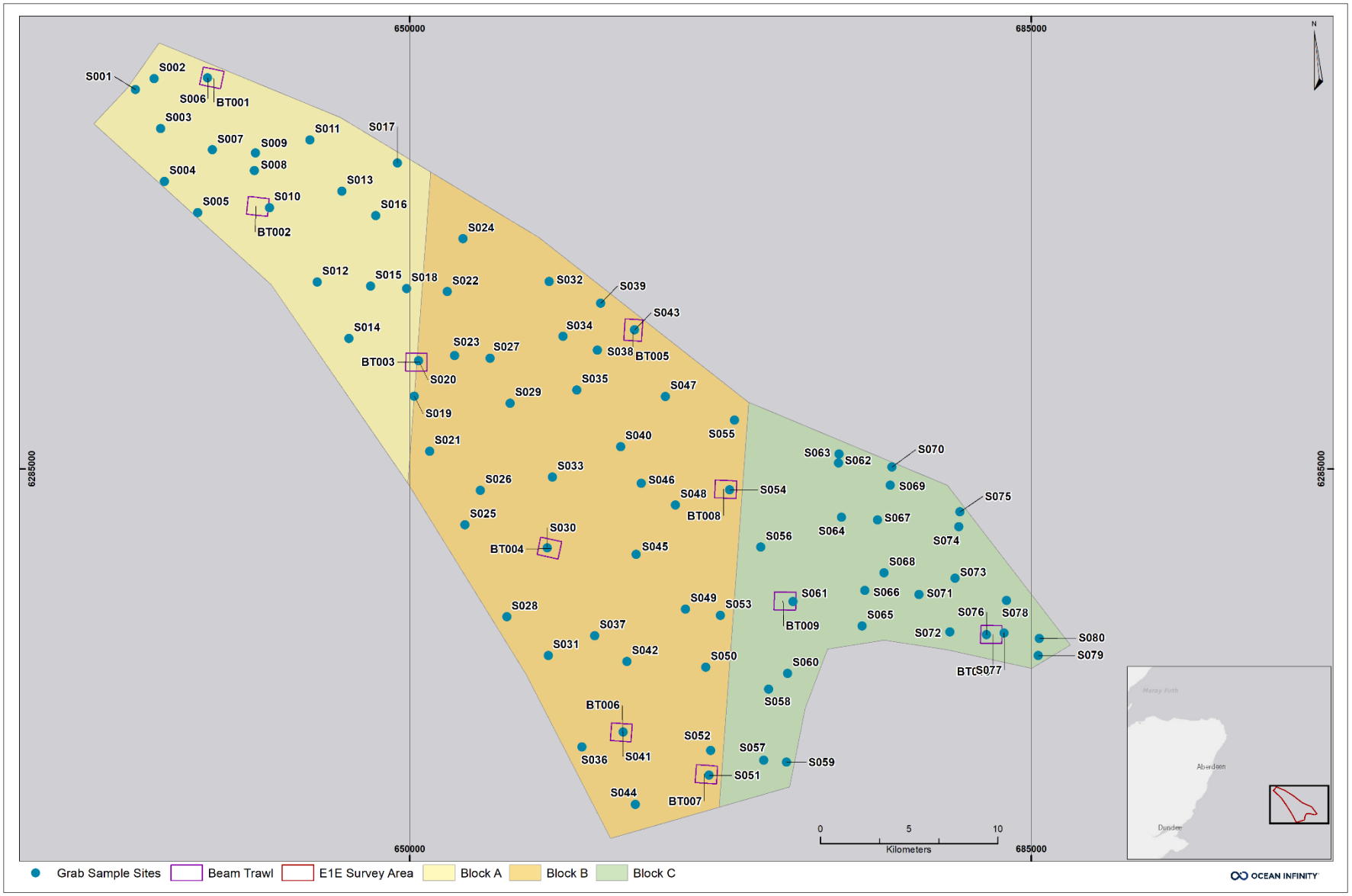


Figure 10 Overview of sampled sites.

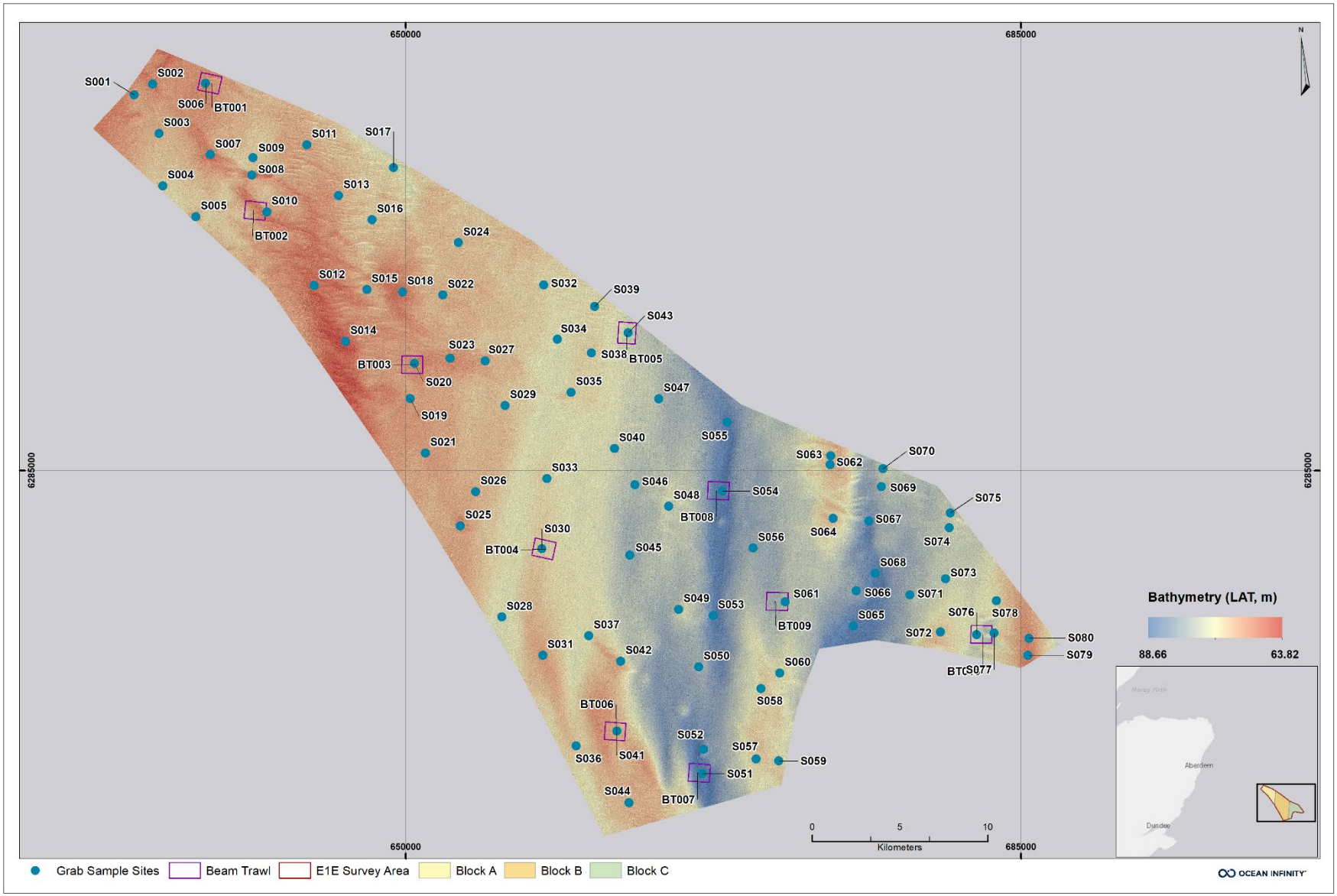


Figure 11 Overview of sampled sites with depth data draped over a shaded relief.

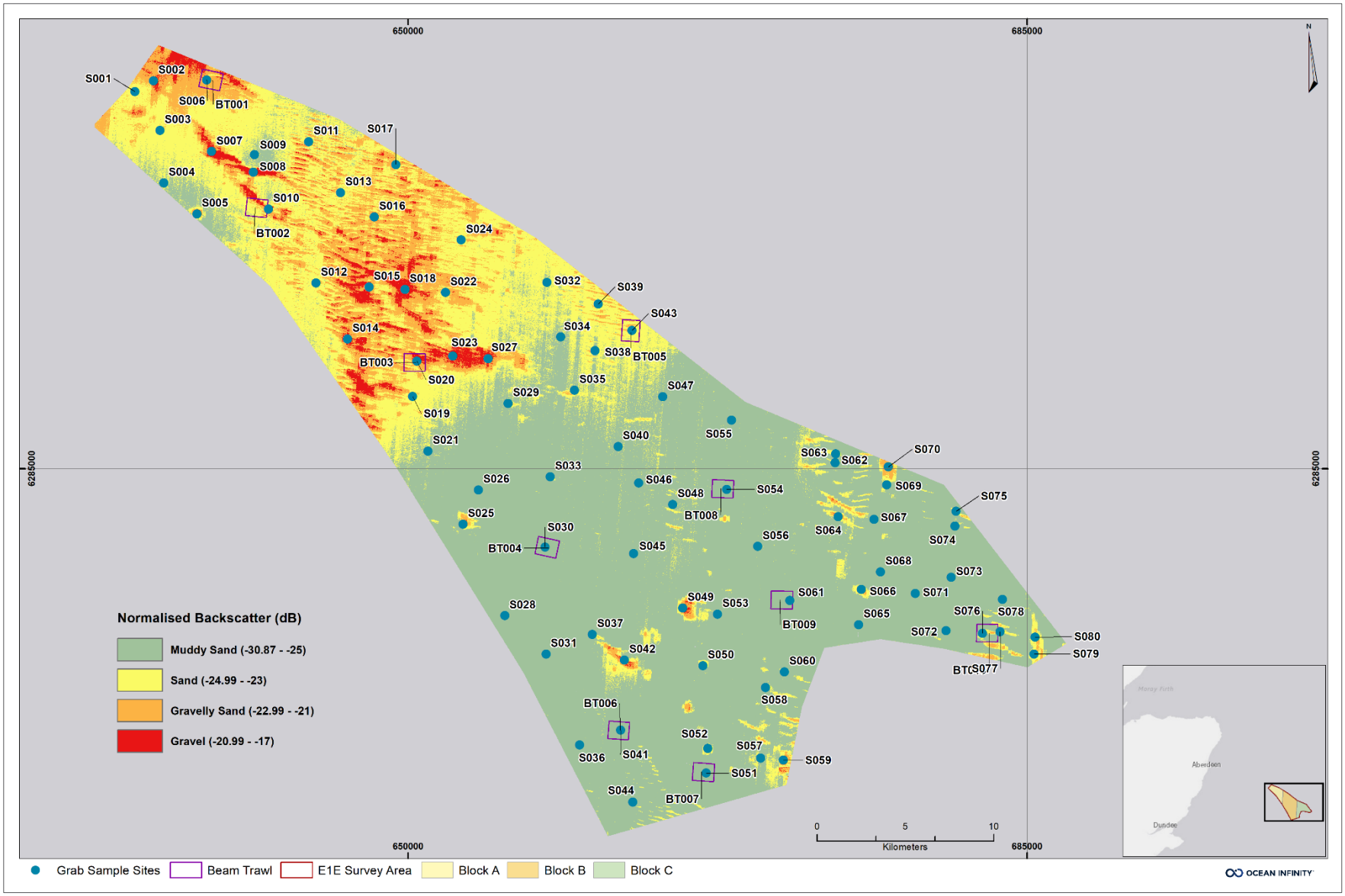


Figure 12 Overview of sampled sites with normalised backscatter data.

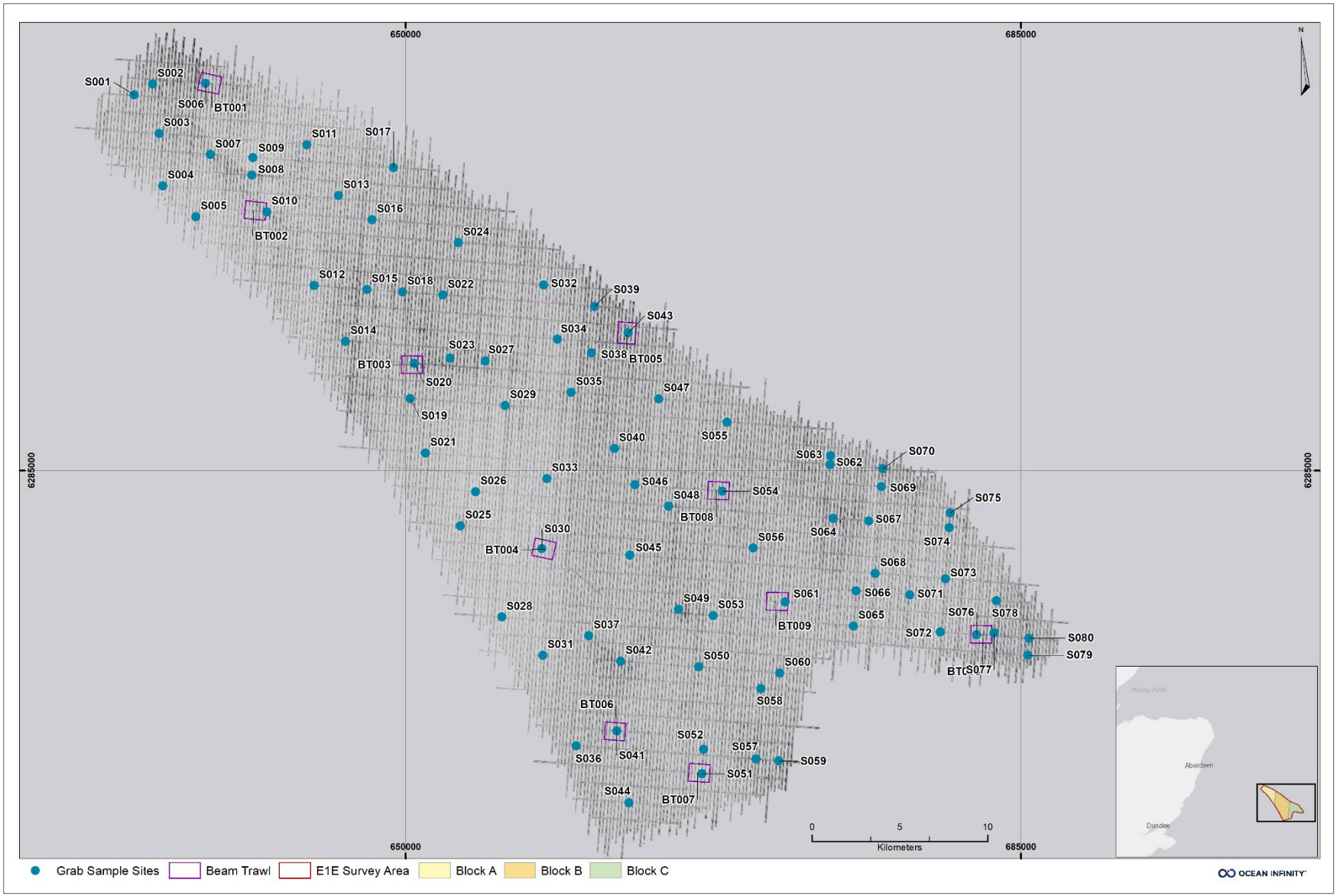


Figure 13 Overview of sampled sites with SSS data.

5.1 Summary of Identified Habitats

A total of two habitats, **MC421** - Faunal communities of Atlantic circalittoral mixed sediment and **MC521** - communities of Atlantic circalittoral sand, were interpreted to characterise the E1E survey area. An overview of the distribution of habitats and grab sample sites as well as trawl locations is presented in Table 18 and Figure 14.

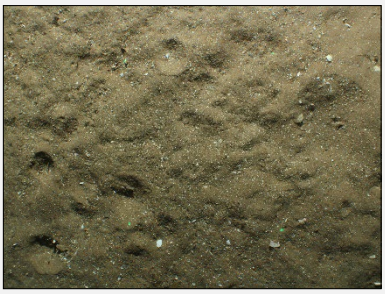
The taxonomic assemblages from the acquired grab sample data indicate the presence of species-specific habitats **MC5211** - *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand and **MC5212** - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand.

One PMF habitat, Offshore subtidal sands and gravels, and one SBL habitat, Subtidal sands and gravels, are interpreted to be present within the E1E survey area. Both habitats are very common subtidal habitats around the British Isles and throughout the North Sea (Brig, 2008 (Updated Dec 2011)).

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

Table 18 Habitat description.

ID	Example Image	Classification	Site	ANNEX I	PMF/SBL
		MC521 Faunal communities of Atlantic circalittoral sand	S068, S074	-	Offshore subtidal sands and gravels Subtidal sands and gravels
		MC421 Faunal communities of Atlantic circalittoral mixed sediment	S08, S025, S029	-	-
		MC5211 Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand	S001, S004, S005, S006 to S007, S009, S013, S014, S016, S017, S019, S027, S030, S037, S049 to S054, S056, S059, S060, S065, S066,	-	Offshore subtidal sands and gravels Subtidal sands and gravels

ID	Example Image	Classification	Site	ANNEX I	PMF/SBL
		MC5212 *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	S002 - S003, S010 - S012, S015, S018, S020 - S024, S026, S028, S031 - S036, S038 - S048, S055, S057, S058, S061 - S064, S067, S069 - S073, S075 - S080	-	Offshore subtidal sands and gravels Subtidal sands and gravels

5.2 Area Description

The habitat classifications within the E1E survey area were derived based on the interpreted geophysical data in combination with environmental sample sites (Figure 14). The habitat interpretations at the environmental sample sites were extrapolated to similar areas, where similarity was based on geophysical interpretations of substrate, texture, topography, and depth.

For further details regarding results from the photo analyses and grab samples sites, see Appendix E and Appendix F, Habitats and Species of interest are further detailed in Section 5.14.

The E1E survey is dominated by sand classified as **MC521** - Faunal communities of Atlantic circalittoral sand. Mixed sediments are interpreted predominantly in the north-western sections of the survey area and are classified as **MC421** - Faunal communities of Atlantic circalittoral mixed sediment. **MC421** decreases towards the southeast and occurs occasionally, often associated with ripple features. The central and south-eastern sections comprise higher mud content.

The seabed appears to be relatively homogenous but for the areas comprising mega ripples and sand waves. The central and south-eastern sections of the E1E also exhibit some traces of trawl marks.

The faunal presence in imagery was generally sparse across the survey area and comprised bryozoan *Flustra foliacea,* Paguridae*,* Tubularia, sand mason worm *Lanice conchilega*, scattered colonies of *Epizoanthus* sp. Echinoderms *Asterias rubens* and *Echinus esculentus* are predominantly present in the northern sections of the survey area while *Spatangus purpureus* and *Ophiura sarsii* appear more common in the central and southern sections of the survey area. Sea pen *Pennatula phosphorea* is noted in the southern most sections of the survey area.

Scattered individuals of horse mussel *Modiolus modiolus* are present southeast, at the outer most boundary of the survey area while individuals of *Arctica islandica* are found across the entire extent.

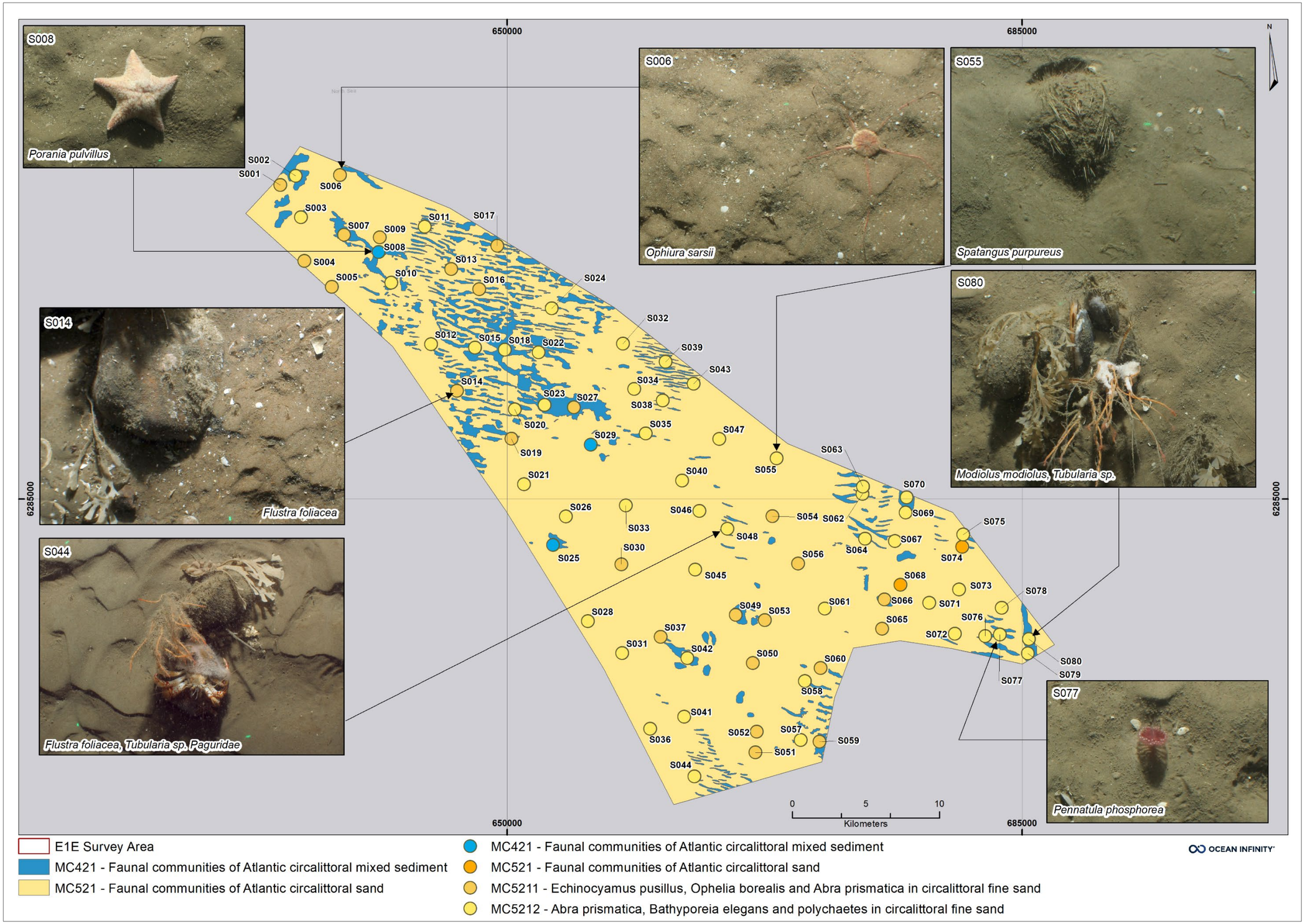


Figure 14 Overview of classified habitats within the E1E Survey Area.

5.3 Epibenthic Trawls

The epibenthic fauna from the conducted beam trawls was identified to the lowest taxonomic level possible. When analysing the phyletic composition of non-colonial fauna from trawl samples, the following phylum was combined into the group “Others”: Cnidaria and Nemertea. Colonial epifauna was recorded as present (P) and analysed separately.

Full species lists of fauna from the beam trawl catch are presented in Appendix G.

5.3.1 Non-Colonial Epibenthic Fauna

The phyletic composition of non-colonial fauna identified from the beam trawl samples is summarised in Table 19 and illustrated in Figure 15 and Figure 16. Arthropoda had the highest abundance and diversity, followed by Chordata and Mollusca. These three phyla contributed 62 % of the recorded taxa and 74 % of the individuals.

Table 19 Phyletic composition of non-colonial fauna from trawl samples.

Phylum	Diversity (Number of Taxa)	Abundance (Total Number of Individuals)
Arthropoda	46	669
Chordata	16	77
Mollusca	10	56
Echinodermata	11	45
Annelida	12	31
Other	3	23
Total	**98**	**901**

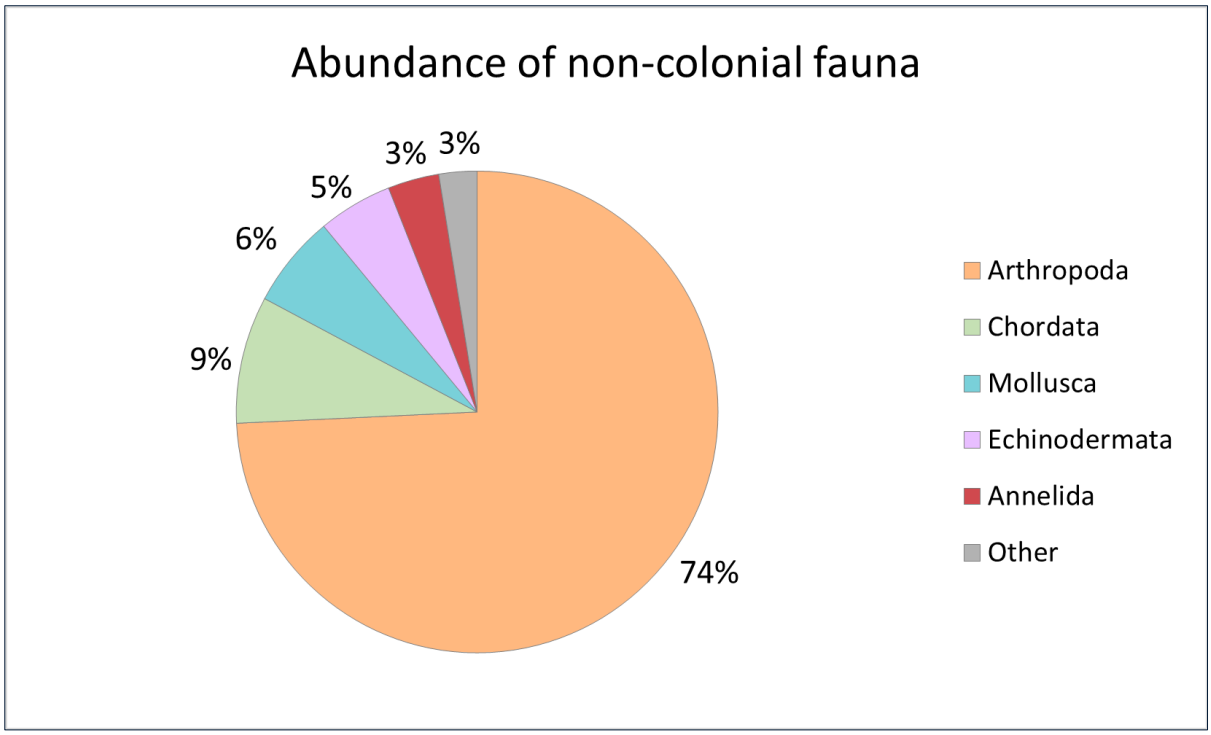


Figure 15 Abundance of non-colonial fauna from trawl samples.

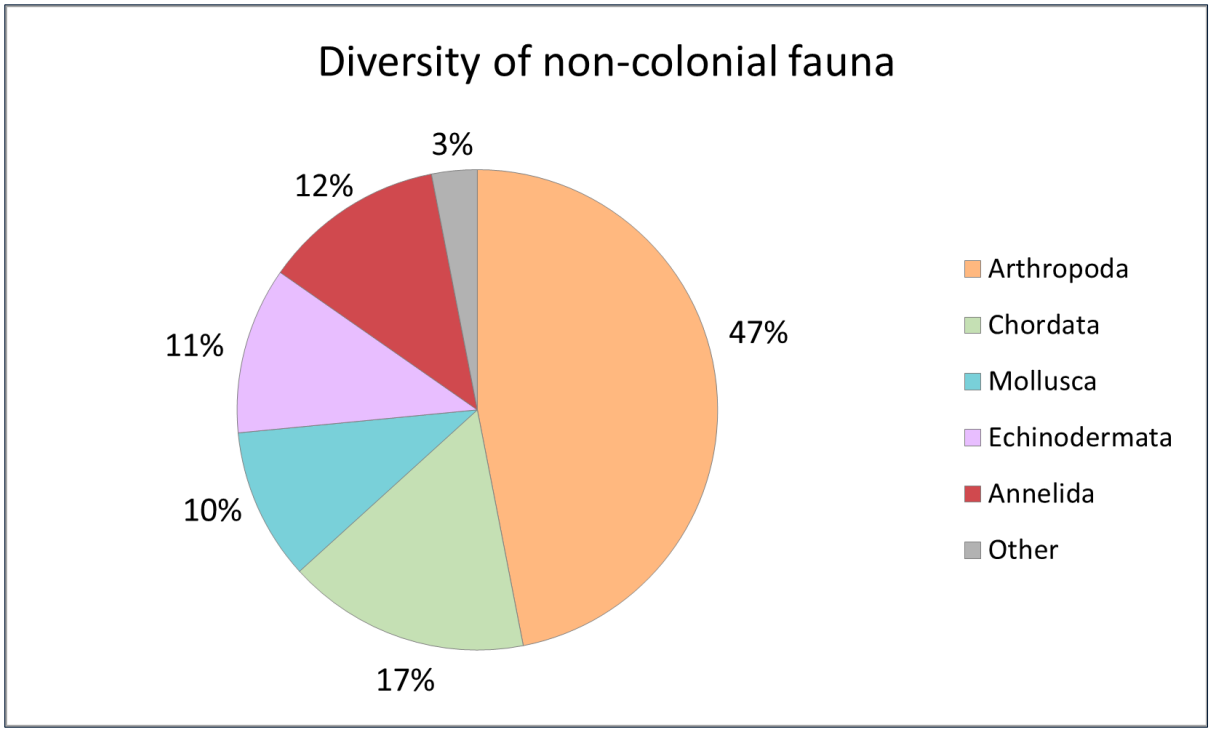


Figure 16 Diversity of non-colonial fauna from trawl samples.

5.3.2 Total Biomass Epibenthic Trawl

The total biomass, non-colonial and sessile colonial epifauna combined, was dominated by Chordata, with 67 % of the total biomass. The second largest group was Echinodermata with 15 %, followed by Bryozoa with 7 % (Figure 17).

The total biomass varied from 0.0 g in sample BT010, to 1860.82 g in sample BT001 (Table 20). The mean biomass across all sites was 4362.29 g/sample (SD=550.61).

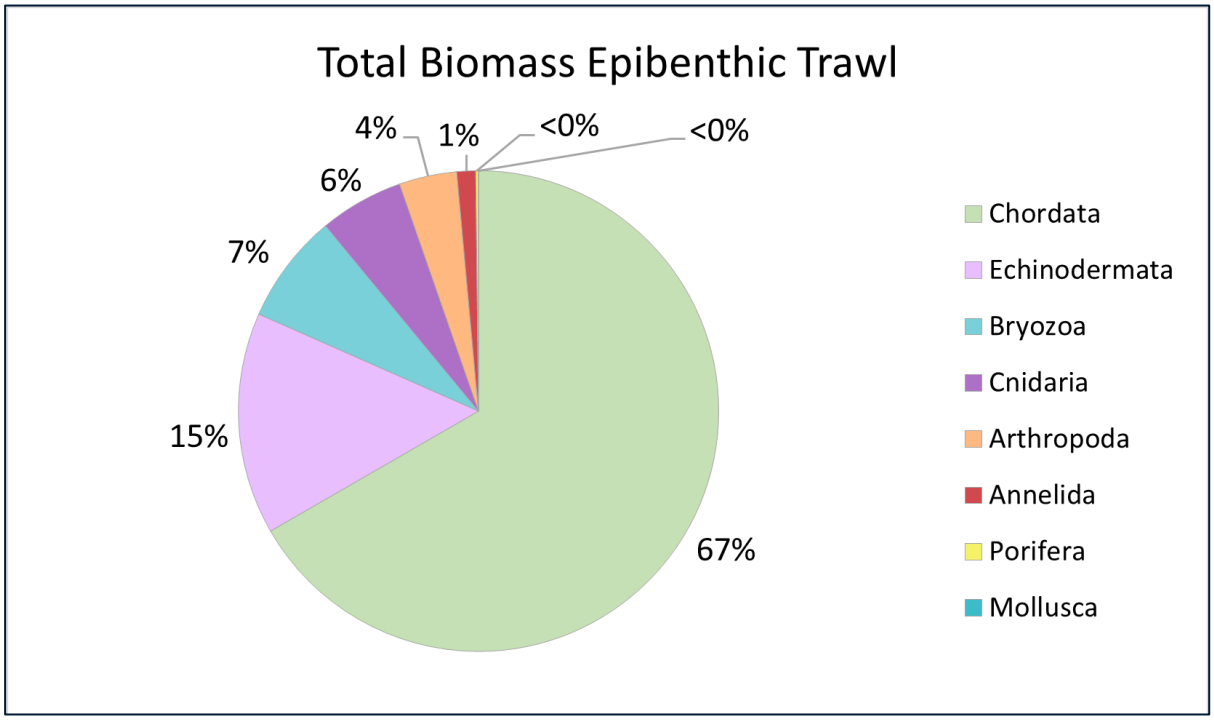


Figure 17 Total biomass (blotted wet weight) composition of major phyla.

Table 20 Total Biomass (blotted wet weight in g/per trawl sample).

Site ID/ Phylum	Annelida	Arthropoda	Bryozoa	Chordata	Cnidaria	Echinodermata	Mollusca	Porifera	Total
BT001	0.00	115.24	68.00	1372.93	32.03	267.36	0.00	5.27	1860.82
BT002	55.00	24.65	32.16	410.11	12.94	157.00	0.00	0.00	691.86
BT003	0.00	0.28	25.98	0.00	0.00	0.00	0.10	0.00	26.36
BT004	0.00	0.40	36.56	321.00	0.00	26.40	0.00	0.00	384.35
BT005	0.00	3.75	59.00	39.50	105.07	32.67	0.00	0.00	239.98
BT006	0.00	2.17	27.62	200.85	70.81	3.94	0.00	0.00	305.39
BT007	0.00	3.63	48.26	196.25	14.17	5.36	0.10	2.74	270.52
BT008	0.00	7.41	11.52	0.00	0.00	0.74	0.00	0.00	19.67
BT009	0.00	12.05	13.74	368.00	11.69	157.86	0.00	0.00	563.34
BT010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**55.00**	**169.58**	**322.84**	**2908.64**	**246.71**	**651.33**	**0.20**	**8.01**	**4362.29**
Min	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Max	**55.00**	**115.24**	**68.00**	**1372.93**	**105.07**	**267.36**	**0.10**	**5.27**	**1860.82**
Mean	**5.50**	**16.96**	**32.28**	**290.86**	**24.67**	**65.13**	**0.02**	**0.80**	**436.23**
SD	**17.39**	**35.35**	**21.45**	**411.77**	**35.74**	**94.54**	**0.04**	**1.79**	**550.61**
Median	**0.00**	**3.69**	**29.89**	**198.55**	**12.32**	**15.88**	**0.00**	**0.00**	**287.96**

**Biomass smaller than the mesh of the trawl or that was encrusting, is not included in the table.*

5.3.3 Fish from Trawl Samples

The ten most abundant taxa of fish species from trawl samples, with total abundance and biomass (g), are presented in Table 21.

The most abundant taxon is adult *Hippoglossoides platessoides*, with a total abundance of 11 individuals and a total biomass of 466.0 g. The total biomass of fish (g/per trawl sample) from trawl samples is presented in Figure 18.

Table 21 The ten most abundant taxa of fish from trawl samples, together with the total biomass.

Life Stage	Taxa	Total Abundance	Total Biomass (g)	Mean Abundance	SD
Adult	*Hippoglossoides platessoides*	11	466	1.1	1.524
Adult	*Pleuronectes platessa*	9	820	0.9	0.876
Adult	*Limanda limanda*	8	410	0.8	1.549
Adult	*Trisopterus esmarkii*	7	7.02	0.7	2.214
Adult	*Ammodytes marinus*	6	2.42	0.6	1.578
Adult	*Microstomus kitt*	6	334	0.6	0.699
Juvenile	*Hippoglossoides platessoides*	5	0.27	0.5	1.08
Juvenile	*Eutrigla gurnardus*	4	0.48	0.4	0.516
Adult	*Eutrigla gurnardus*	4	224	0.4	1.265
Juvenile	*Trisopterus esmarkii*	4	2.29	0.4	0.699

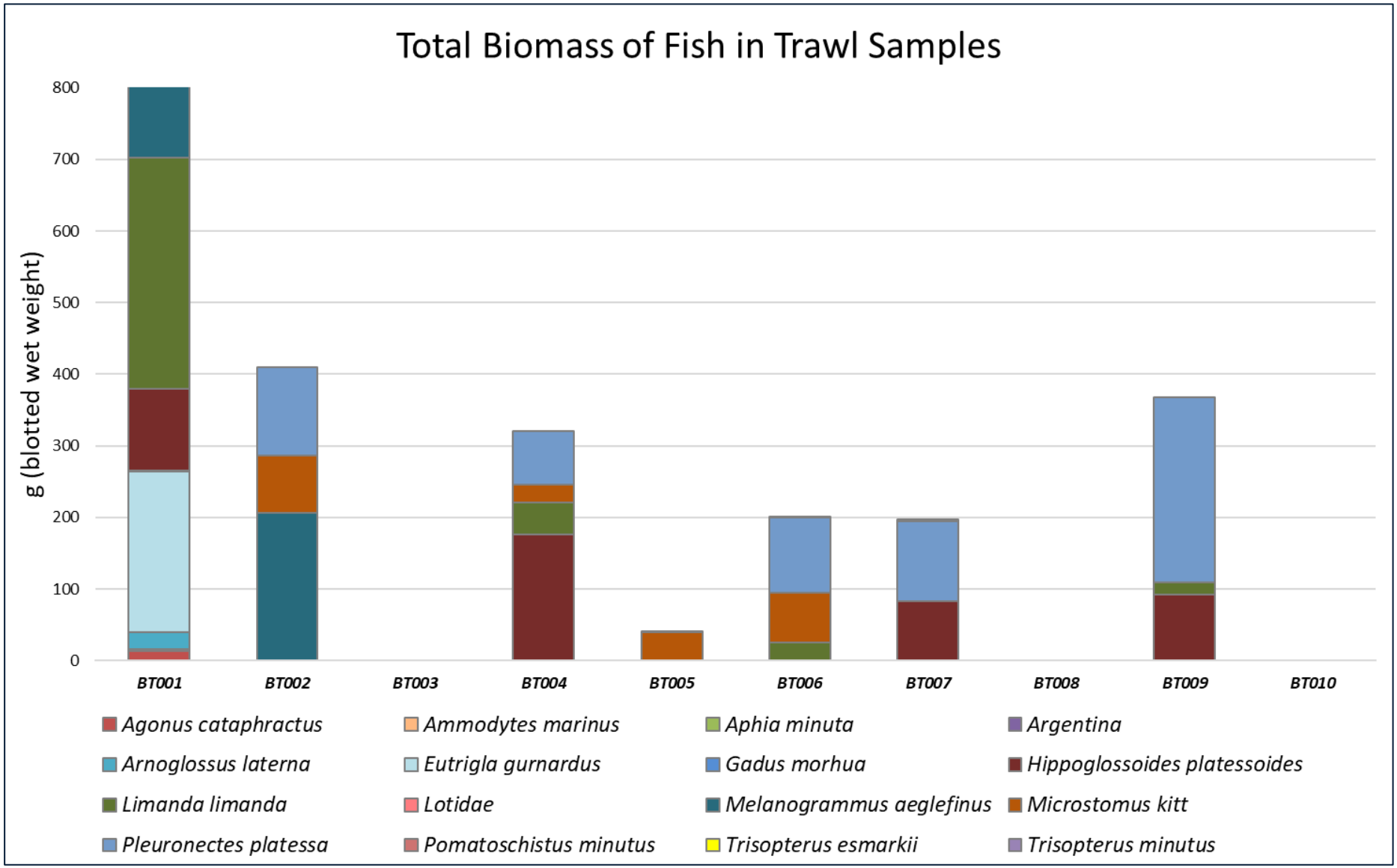


Figure 18 Total biomass (g/per trawl sample) of fish species.

5.3.4 Sessile Colonial Epifauna

The phyletic composition of sessile colonial epifauna identified from the trawl samples is summarised in Table 22 and illustrated in Figure 19 and Figure 20.

A total of three (3) major phyla were identified. The dominant phyla were Cnidaria, contributing to 55 % of the total taxa, followed by Bryozoa and Porifera, with 30 % and 15 % respectively.

A total of 20 different taxa were identified. Abundance was dominated by Cnidaria with a total of 33 colonies, followed by Bryozoa and Porifera, with a total of 21 and 8 colonies respectively. A summary of sessile colonial epifauna for each trawl sample, using the SACFOR scale, can be viewed in Table 23.

Table 22 Phyletic composition of colonial epifauna from the trawl samples.

Phylum	Number of Taxa	Abundance of Colonies
Cnidaria	11	33
Bryozoa	6	21
Porifera	3	8
Total	**20**	**62**

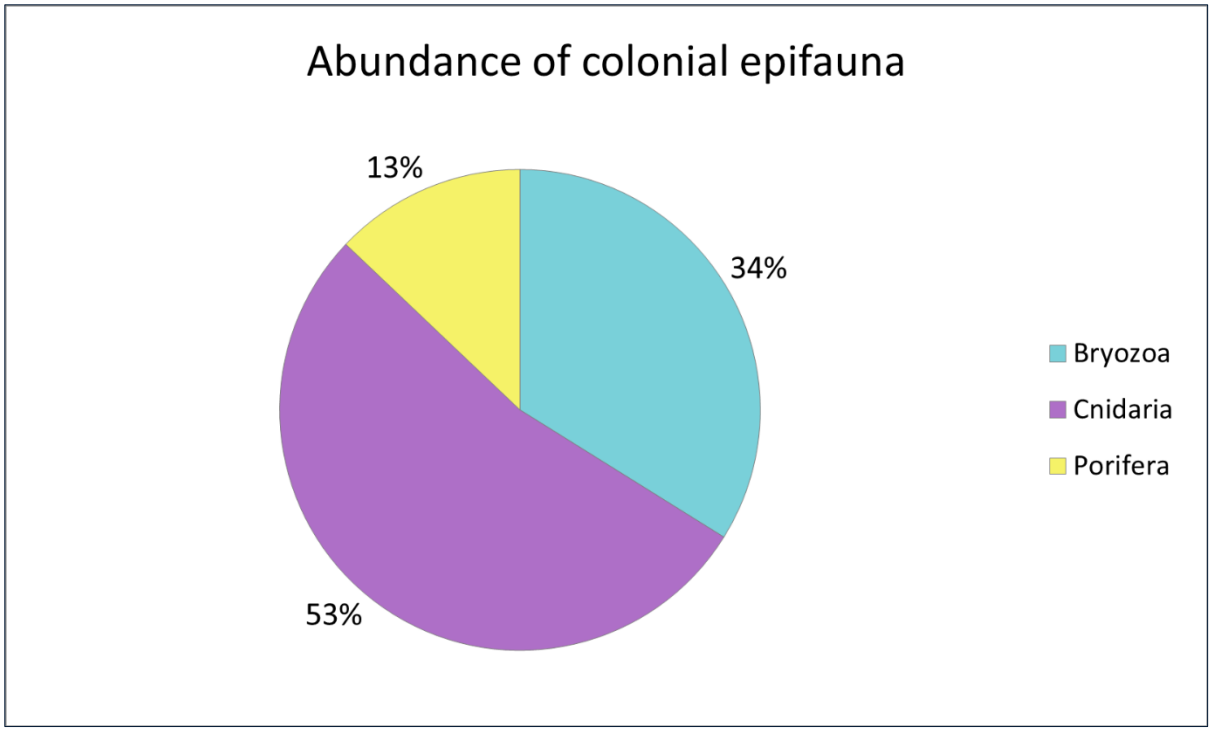


Figure 19 Abundance of colonial epifauna from the trawl samples.

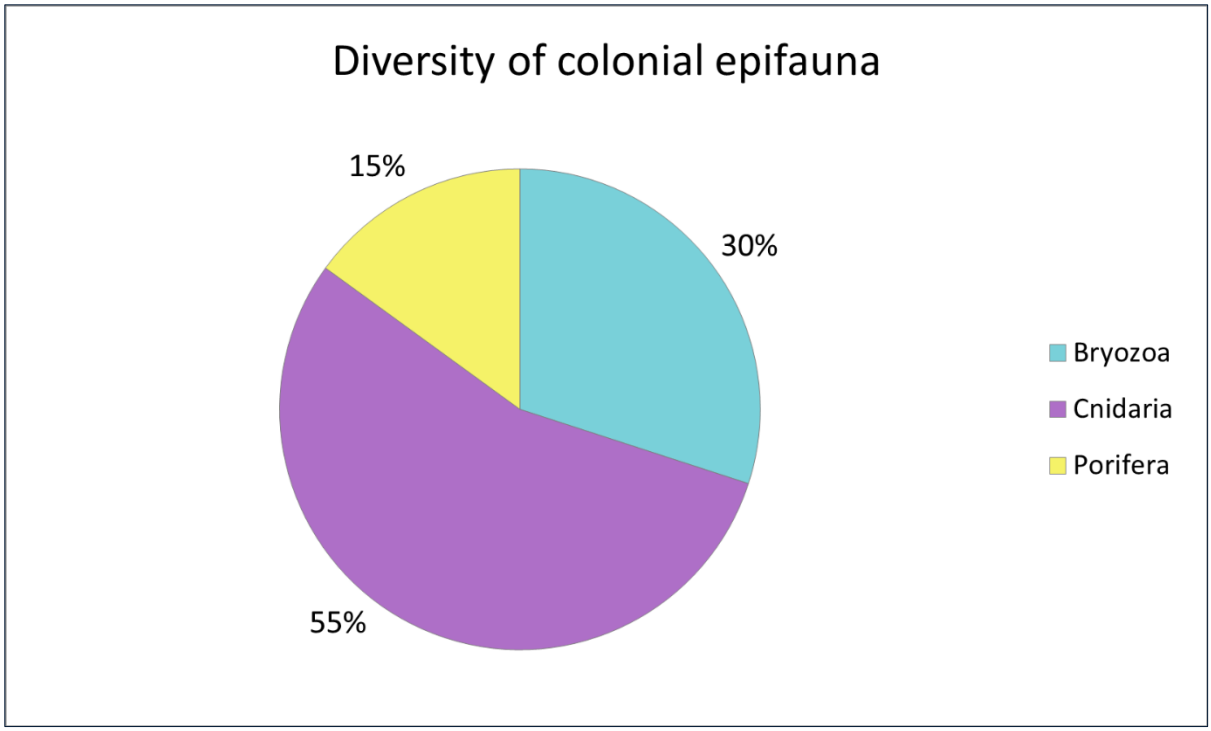


Figure 20 Diversity of colonial epifauna from the trawl samples.

Table 23 SACFOR abundance scale for sessile colonial epifauna from the trawl samples.

Phylum	Taxa	BT001	BT002	BT003	BT004	BT005	BT006	BT007	BT008	BT009	BT010
Porifera	Porifera	R						R			
Porifera	Sycon	R									
Porifera	Suberites	R						R			
Cnidaria	Tubulariidae	C									
Cnidaria	Bougainvilliidae					R					
Cnidaria	Hydractinia									R	
Cnidaria	*Lafoea dumosa*	C				R		R			
Cnidaria	*Abietinaria abietina*					R					
Cnidaria	*Hydrallmania falcata*	O						R			
Cnidaria	Sertularella					R		R			
Cnidaria	Sertularia	O									
Cnidaria	*Tamarisca tamarisca*					R		R			
Cnidaria	Campanulariidae						R	R			
Cnidaria	*Alcyonium digitatum*	R	O			R	O	O		O	
Bryozoa	Tubulipora					R		R			
Bryozoa	*Alcyonidioides mytili*					R					
Bryozoa	*Electra pilosa*									R	
Bryozoa	*Flustra foliacea*	A	O	R	O	A	O	C	R	R	
Bryozoa	*Securiflustra securifrons*							R		R	
Bryozoa	*Callopora dumerilii*					R					

5.4 Particle Size Distribution

Eighty (80) grab sample sites were selected for PSA sampling and acquired at all sites. It should be noted that the sample acquired at site S008 had a rock caught in the jaw of the grab resulting in a washout of the sample on the first and third attempts made, whilst the second attempt was too low volume. Site S025 also comprised of low volume despite three attempts. Imagery and video acquired at both sites indicate a patchy presence of cobbles which may lie just below the sediment surface, however, the target areas at each site appeared clear initially and suitable for grab attempts to be undertaken. The sites were abandoned in line with the agreed protocols and scope of work.

Detailed results from the PSA analysis are stated in Appendix H. The results of the PSA showed that the sediment composition had limited variation across the survey area, mainly comprising sand, with a few sites comprising higher Gravel content (Figure 21).

Sand was the dominating sediment fraction, with a mean content of 86.4 % (SD=9.8). The Mud content was overall low with a mean content of 9.1 % (SD=3.6), comprising 8.0 % (SD=3.3) Silt and 1.2 % (SD=0.4) Clay. The Gravel content was low but variable with a mean content of 4.5 % (SD=10.2) (Table 24).Interpreting the spatial variation, Mud content increased towards the south-eastern end of the survey area, with areas of coarser sediments (Gravel and Gravelly Sand) mainly located in the northwest (Figure 22).

Table 24 Summary of PSA results for grab samples sites.

Sample ID	Depth (m)	Sediment Fraction (%)				Mud (%) (Silt + Clay)	Folk Classification
		Gravel	Sand	Silt	Clay		
S001	70	0.4	95.8	3.1	0.7	3.8	Sand
S002	68	6.6	91.1	1.7	0.6	2.3	Gravelly Sand
S003	71	11.9	84.1	3.3	0.8	4.1	Gravelly Sand
S004	74	0.6	90.8	7.5	1.1	8.6	Sand
S005	71	1.1	93.3	4.8	0.9	5.7	Slightly Gravelly Sand
S006	69	0.8	94.9	3.5	0.8	4.3	Sand
S007	68	39.5	56.3	3.6	0.6	4.2	Sandy Gravel
S008*	68	63.2	28.9	6.5	1.4	7.9	Muddy Sandy Gravel
S009	73	0.1	91.1	7.8	1.1	8.8	Sand
S010	70	4.2	87.6	7.2	1.0	8.2	Slightly Gravelly Sand
S011	71	2.0	89.1	7.8	1.1	8.9	Slightly Gravelly Sand
S012	66	0.1	95.1	3.9	0.9	4.8	Sand
S013	71	0.3	93.8	5.0	0.9	5.9	Sand
S014	65	4.9	91.1	3.3	0.7	4.0	Slightly Gravelly Sand
S015	71	1.5	92.5	5.1	0.8	5.9	Slightly Gravelly Sand
S016	73	0.4	91.0	7.6	1.1	8.6	Sand
S017	75	0.5	90.5	8.0	1.0	9.1	Sand
S018	67	1.8	95.0	2.6	0.7	3.3	Slightly Gravelly Sand
S019	71	0.1	92.5	6.5	1.0	7.5	Sand
S020	69	0.5	97.0	1.9	0.6	2.4	Sand
S021	70	0.5	91.2	7.3	1.0	8.3	Sand

Sample ID	Depth (m)	Sediment Fraction (%)				Mud (%) (Silt + Clay)	Folk Classification
		Gravel	Sand	Silt	Clay		
S022	72	10.7	85.5	3.2	0.6	3.8	Gravelly Sand
S023	69	5.5	90.5	3.3	0.7	4.0	Gravelly Sand
S024	73	0.2	93.0	5.9	0.9	6.9	Sand
S025**	69	11.4	83.9	3.9	0.8	4.7	Gravelly Sand
S026	71	0.2	88.9	9.6	1.3	10.9	Muddy Sand
S027	71	6.4	89.7	3.3	0.7	3.9	Gravelly Sand
S028	75	0.0	87.6	10.9	1.4	12.4	Muddy Sand
S029	71	46.8	50.3	2.4	0.5	2.9	Sandy Gravel
S030	73	0.1	90.0	8.8	1.1	9.9	Sand
S031	71	0.0	90.3	8.5	1.1	9.6	Sand
S032	74	0.2	89.9	8.8	1.1	9.9	Sand
S033	74	3.6	83.7	11.3	1.4	12.7	Slightly Gravelly Muddy Sand
S034	75	0.1	88.5	10.1	1.2	11.3	Muddy Sand
S035	74	0.3	88.7	9.7	1.3	11.0	Muddy Sand
S036	73	0.0	92.3	6.8	0.9	7.7	Sand
S037	74	3.3	84.9	10.5	1.3	11.8	Slightly Gravelly Muddy Sand
S038	74	2.3	90.4	6.3	0.9	7.3	Slightly Gravelly Sand
S039	74	1.3	93.2	4.7	0.8	5.5	Slightly Gravelly Sand
S040	76	0.4	88.9	9.4	1.3	10.7	Muddy Sand
S041	71	0.1	87.9	10.6	1.5	12.0	Muddy Sand
S042	72	22.5	66.8	9.5	1.2	10.7	Gravelly Muddy Sand
S043	76	5.0	87.8	6.5	0.8	7.3	Slightly Gravelly Sand
S044	72	0.5	89.6	8.8	1.2	10.0	Muddy Sand
S045	79	0.2	85.4	12.7	1.7	14.5	Muddy Sand
S046	78	0.5	86.2	11.6	1.6	13.3	Muddy Sand
S047	77	0.2	88.1	10.3	1.4	11.6	Muddy Sand
S048	76	0.8	87.7	10.1	1.4	11.5	Muddy Sand
S049	76	6.8	84.9	7.2	1.1	8.3	Gravelly Sand
S050	78	6.8	80.4	11.2	1.5	12.7	Gravelly Muddy Sand
S051	86	0.1	83.2	14.6	2.1	16.7	Muddy Sand
S052	80	11.0	76.3	11.1	1.6	12.7	Gravelly Muddy Sand
S053	85	0.5	86.2	11.6	1.6	13.3	Muddy Sand
S054	85	1.2	87.6	9.7	1.5	11.1	Slightly Gravelly Muddy Sand
S055	85	0.2	84.9	13.1	1.8	14.9	Muddy Sand
S056	80	1.0	86.0	11.5	1.5	13.0	Slightly Gravelly Muddy Sand
S057	73	0.5	88.7	9.5	1.3	10.8	Muddy Sand

Sample ID	Depth (m)	Sediment Fraction (%)				Mud (%) (Silt + Clay)	Folk Classification
		Gravel	Sand	Silt	Clay		
S058	73	1.3	89.8	7.8	1.1	8.9	Slightly Gravelly Sand
S059	73	9.4	83.2	6.4	0.9	7.3	Gravelly Sand
S060	74	0.0	86.3	12.2	1.4	13.6	Muddy Sand
S061	77	0.5	85.8	12.1	1.6	13.7	Muddy Sand
S062	72	0.1	91.0	7.8	1.1	8.9	Sand
S063	71	1.0	91.3	6.7	1.0	7.8	Sand
S064	72	1.4	93.2	4.6	0.8	5.4	Slightly Gravelly Sand
S065	85	0.3	83.1	14.5	2.1	16.6	Muddy Sand
S066	80	7.0	79.6	11.9	1.6	13.5	Gravelly Muddy Sand
S067	83	0.4	85.7	12.1	1.7	13.9	Muddy Sand
S068	85	0.5	81.7	15.5	2.3	17.8	Muddy Sand
S069	78	0.2	87.9	10.5	1.4	11.9	Muddy Sand
S070	77	19.0	70.9	8.9	1.2	10.1	Gravelly Muddy Sand
S071	78	0.1	88.2	10.4	1.3	11.7	Muddy Sand
S072	73	0.9	88.0	9.9	1.2	11.0	Muddy Sand
S073	76	0.2	87.9	10.5	1.4	11.9	Muddy Sand
S074	76	2.0	90.5	6.6	0.9	7.6	Slightly Gravelly Sand
S075	76	6.7	83.1	8.9	1.3	10.2	Gravelly Muddy Sand
S076	76	0.1	88.2	10.4	1.3	11.7	Muddy Sand
S077	75	12.2	81.5	5.4	0.9	6.3	Gravelly Sand
S078	74	0.0	90.6	8.2	1.1	9.4	Sand
S079	68	1.4	92.7	4.9	1.0	5.9	Slightly Gravelly Sand
S080	69	4.3	87.6	7.0	1.1	8.1	Slightly Gravelly Sand
Mean		**4.5**	**86.4**	**8.0**	**1.2**	**9.1**	
SD		**10.2**	**9.8**	**3.3**	**0.4**	**3.6**	
Min		**0.0**	**28.9**	**1.7**	**0.5**	**2.3**	
Max		**63.2**	**97.0**	**15.5**	**2.3**	**17.8**	
Median		**0.7**	**88.2**	**7.9**	**1.1**	**9.0**	

**Rock caught in jaws of the grab*

***Low volume*

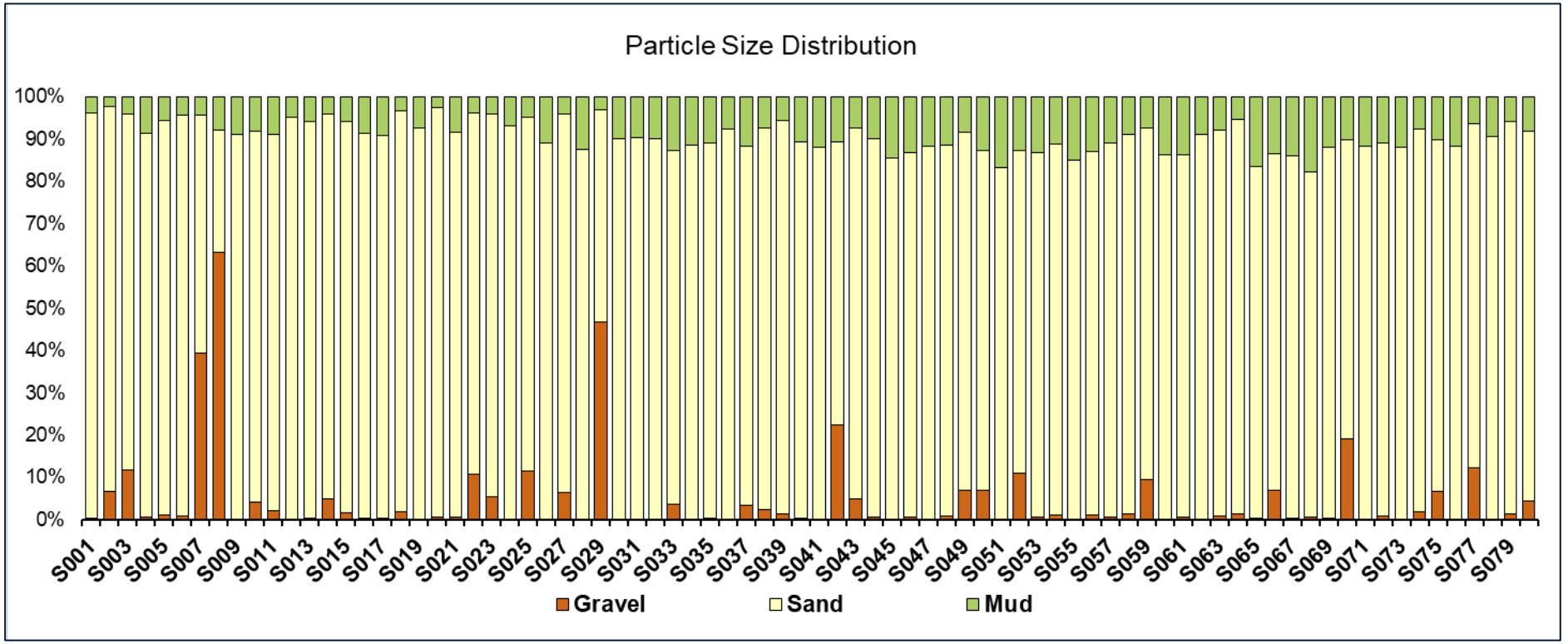


Figure 21 Particle size distribution across sample sites.

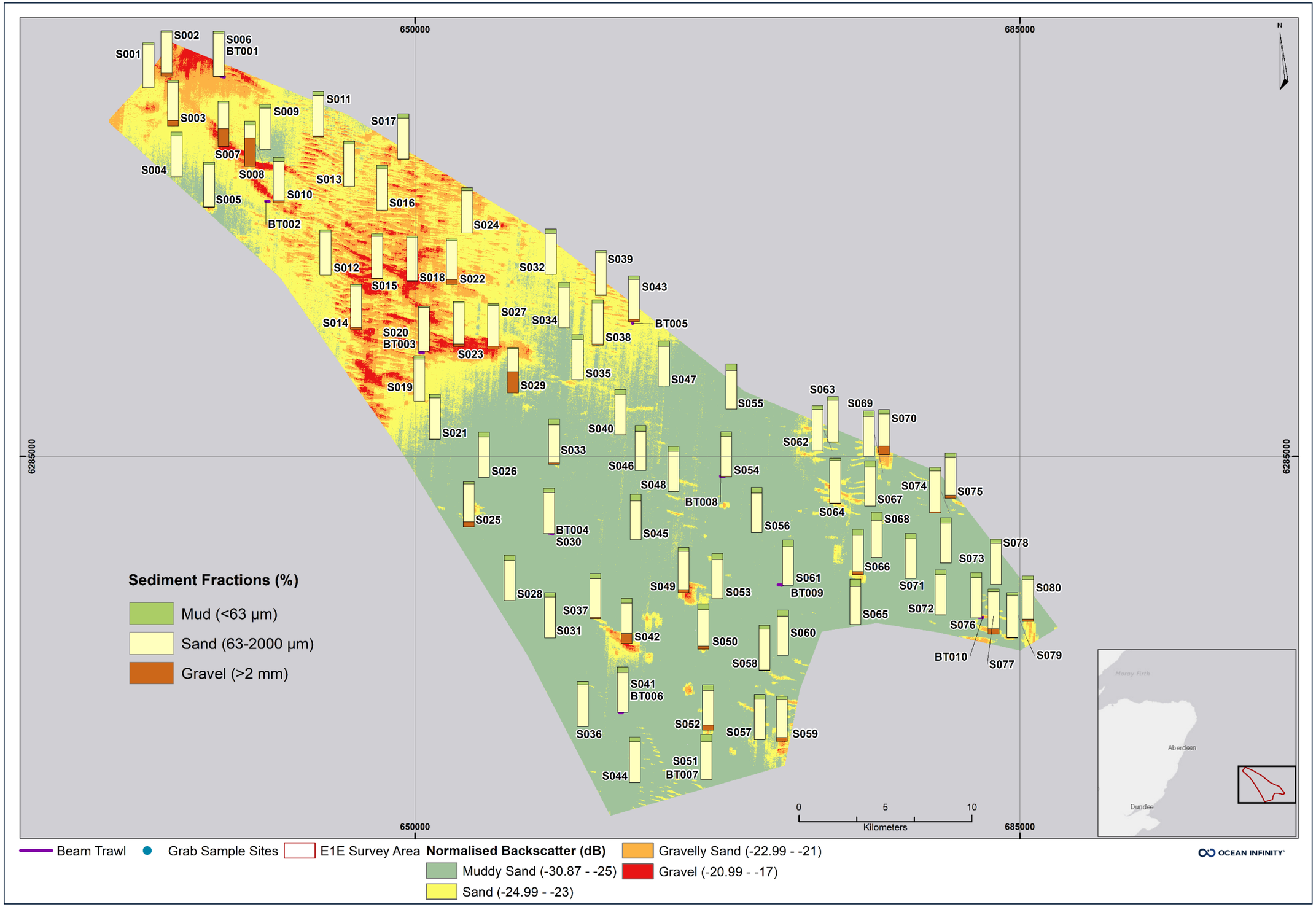


Figure 22 Overview of Particle Size Distribution and backscatter data.

5.4.1 Multivariate Analysis of Sediment

Multivariate analyses were undertaken on the PSA data set, to identify 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 analyses being performed.

All Samples

The SIMPROF analysis of the sediment composition produced 17 distinct groups separating the 80 grab samples (Figure 23).

Principal component 1 (PC1), explaining 65.1 % of the variation, separated the sites based on the sand-to-gravel ratio. Principal component 2 (PC2), explaining 34.9 % of the variation, separated the sites based on the mud content (Figure 24).

SIMPROF groups a and c comprise mixed sediment composition, corresponding to the Folk class Gravelly Muddy Sand; Groups b, d, e, f, g, h and i comprise sand with a noticeable mud content, corresponding to the Folk classes Muddy Sand, and Slightly Gravelly Muddy Sand; Groups j, k, l, m, n, o and p comprise sand with low gravel and mud content, corresponding to the Folk classes Gravelly Sand, Slightly Gravelly Sand, and Sand; Group q comprises coarse material, corresponding to Folk classes Muddy Sandy Gravel, and Sandy Gravel.

Note: PSA samples from grab sample sites S008, which had some washout of the sample, and S025, which comprised low volume, have been included in these analyses for representative purposes.

Samples S008 and S025 Excluded

The SIMPROF analysis of the sediment composition produced 26 distinct groups separating the 78 samples fulfilling the acceptance critieria (Figure 25).

Principal component 1 (PC1), explaining 63.3 % of the variation, separated the sites based on the sand-to-gravel ratio. Principal component 2 (PC2), explaining 36.7 % of the variation, separated the sites based on the mud content (Figure 26).

SIMPROF groups b, d and t comprise mixed sediment composition, corresponding to the Folk class Gravelly Muddy Sand; Groups c, e, f, g, h, i, j, k, l, m and n comprise sand with a noticeable mud content, corresponding to the Folk classes Muddy Sand, and Slightly Gravelly Muddy Sand; Groups o, p, q, r, s, u, v, w, x, y and z comprise sand with low gravel and mud content, corresponding to the Folk classes Gravelly Sand, Slightly Gravelly Sand, and Sand; Group a comprises coarse material, corresponding to Folk classes Sandy Gravel.

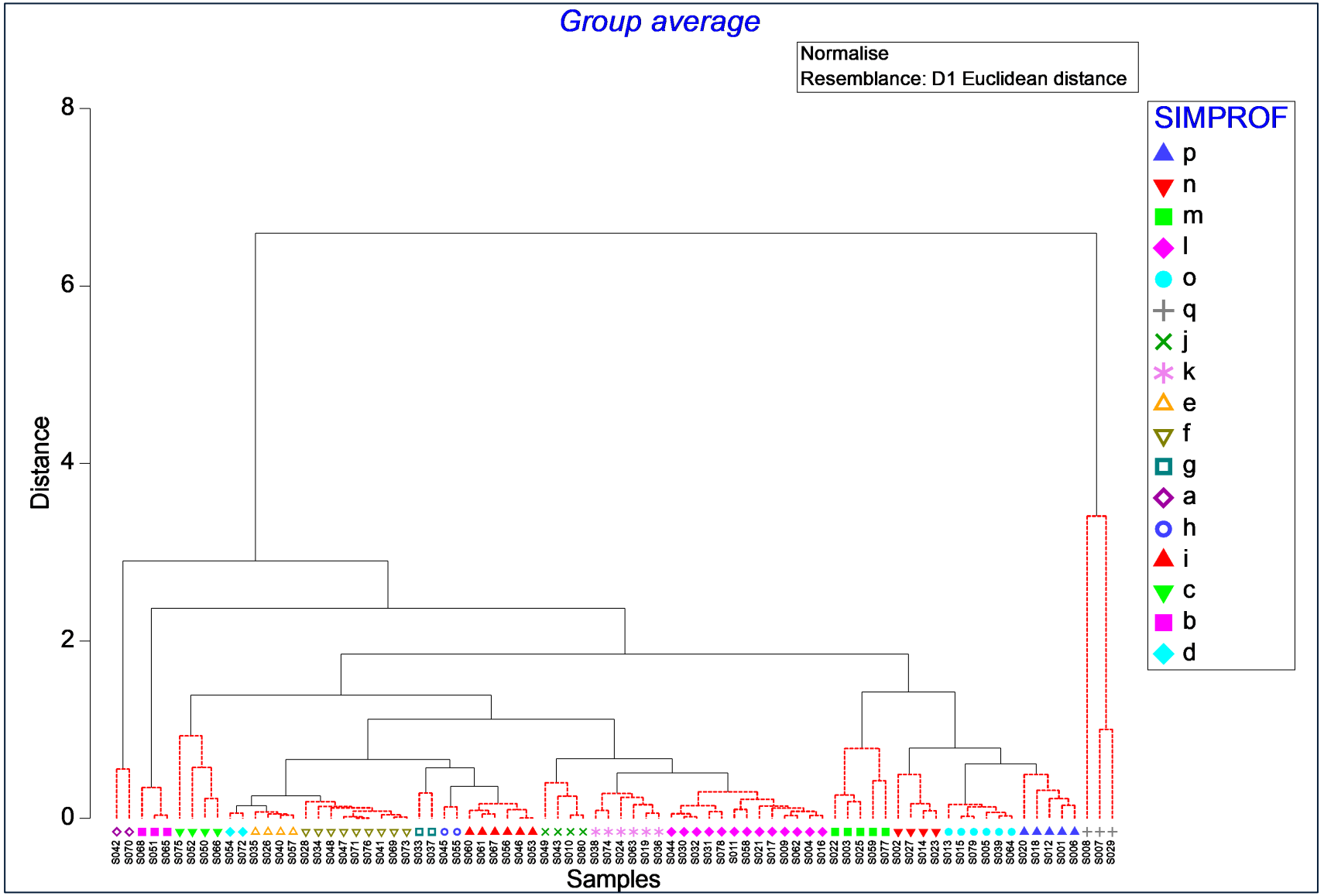


Figure 23 Dendrogram based on Euclidian distance for the sediment composition of all samples, showing SIMPROF groups with a 5 % significance level.

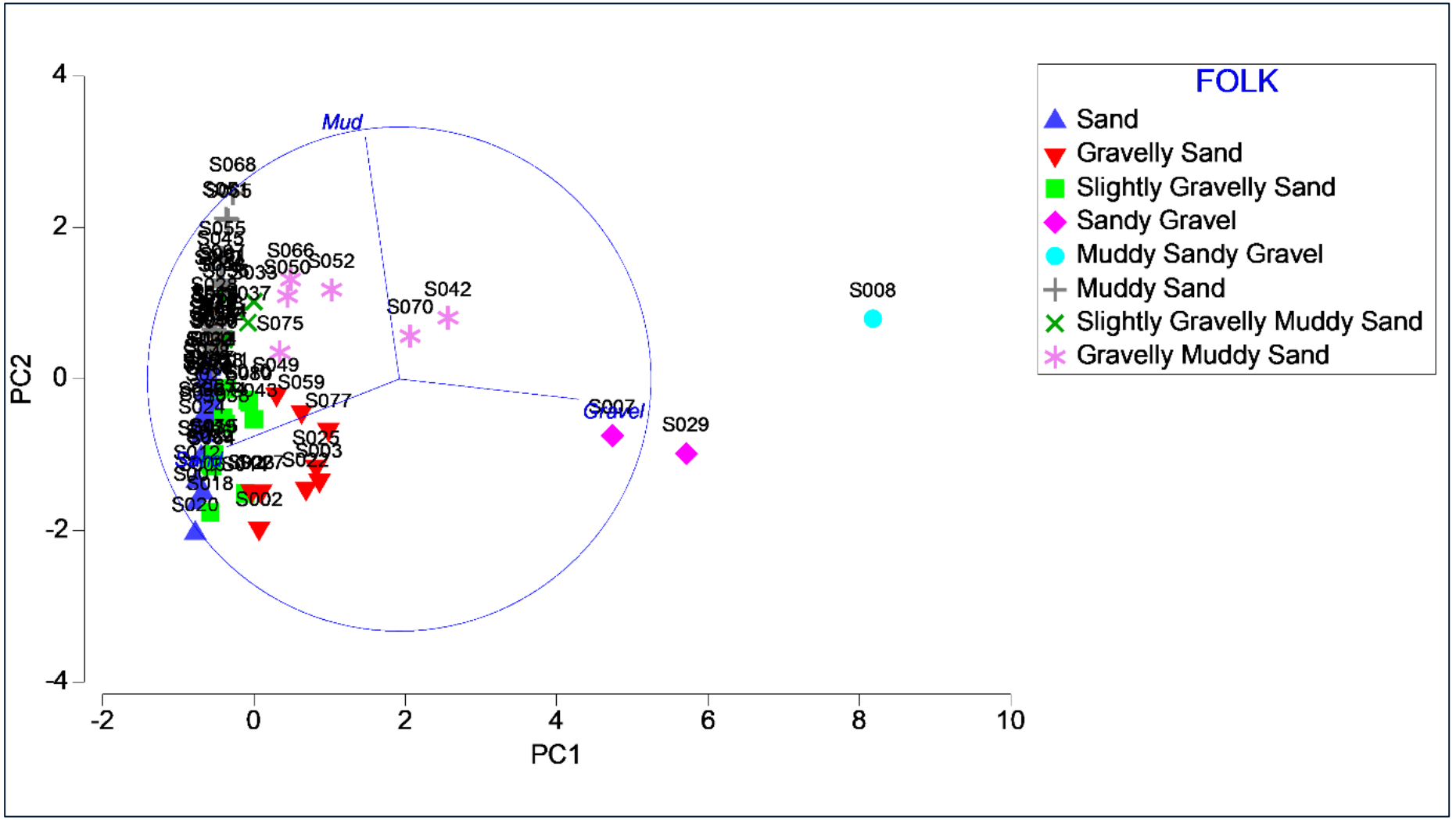


Figure 24 PCA plot of sediment composition for all samples, showing groups based on the FOLK classifications.

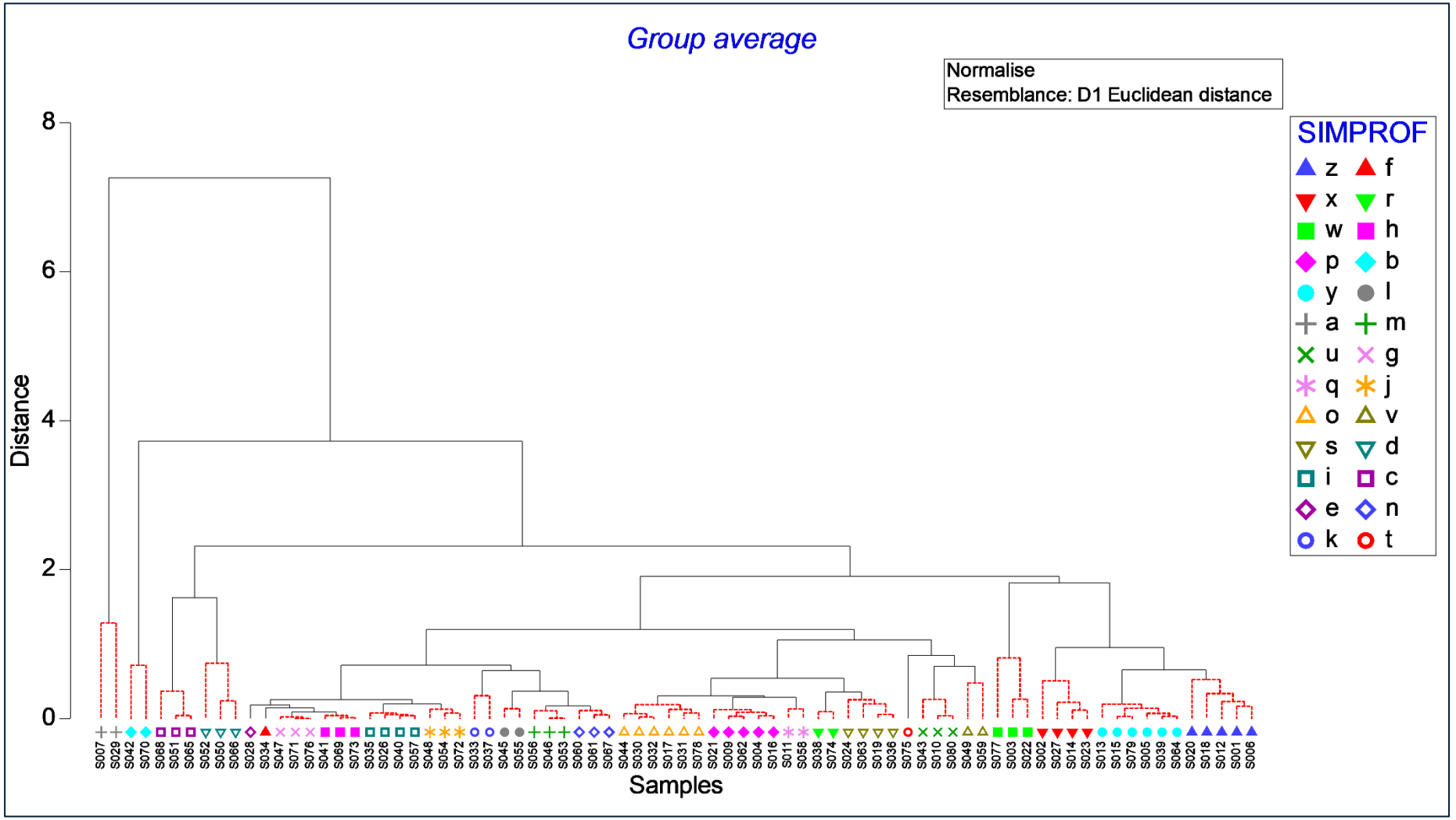


Figure 25 Dendrogram based on Euclidian distance for the sediment composition of accepted samples, showing SIMPROF groups with a 5 % significance level.

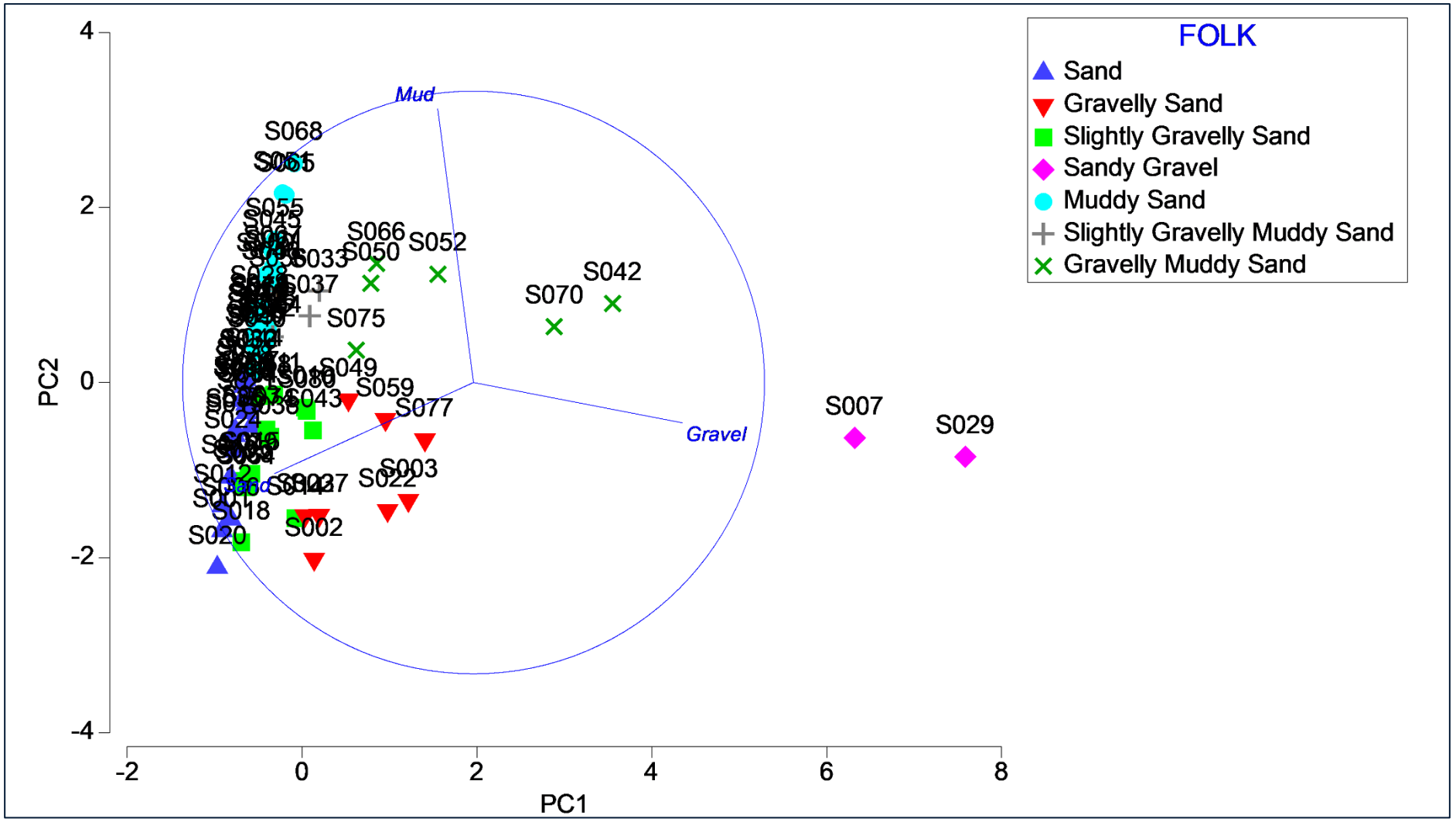


Figure 26 PCA plot of sediment composition for accepted samples, showing groups based on the FOLK classifications

5.5 Contaminants Analyses

Out of the total 80 grab sample sites, ten sites were selected for additional analyses of metals, hydrocarbons, polychlorinated biphenyls and organotins. These sites were selected to represent the survey area in terms of locations and sediment composition. All 80 sites were analysed for organic content.

Detailed results from the analyses are presented in Appendix I.

5.5.1 Metals

Metal concentrations varied little across the survey area and were overall low. Threshold values were exceeded at one grab sample site (Table 25).

The lower threshold value for arsenic (As) according to the Norwegian Environment Agency's (NEA) class 2 - Good (15 µg/g) was exceeded at site S002 (Figure 27). The As concentrations in the sample measured 16.7 µg/g, thereby exceeding the expected natural background threshold levels (class 1 - Background), according to NEA. Having a lower threshold value, the threshold value for the Canadian Council of Ministers of the Environment's (CCME) ISQG (7.24 µg/g) was also exceeded, indicating "the possible effect range within which adverse effects occasionally occur" (CCME, 2001).

Additionally, the concentrations of other metals (copper Cu, lead Pb, mercury Hg, nickel Ni, vanadium V, zink Zn and iron Fe) were higher at site S002 compared to the other analysed sites. Reviewing magnetometer, SSS, and MBES data revealed no nearby potential sources of increased concentrations.

Table 25 Summary of metal concentrations (µg/g dry weight) in sediment together with threshold values. Highlighted cells indicate where threshold values have been exceeded.

Analyte	As	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	Al	Ba	Fe
Method	SEDMS	SEDMS	SEDMS	SEDMS	SEDMS	TMMS1	SEDMS	SEDMS	SEDMS	SEDOES	SEDOES	SEDOES
Limit of Detection	0.5	0.2	2	2	1.2	0.01	2	1	3	10	1	45
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	-	-	-
CCM 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
S002	16.7	<0.2*	17.0	3.1	11.7	0.02	3.9	31.1	15.0	16400	225	9050
S009	1.7	<0.2*	13.8	2.1	8.5	0.01	3.4	12.8	9.9	17000	249	4940
S010	5.4	<0.2*	13.0	2.5	9.2	0.01	3.4	15.0	10.4	17600	255	6000
S021	3.9	<0.2*	12.9	2.4	8.3	0.01	3.4	12.6	8.7	16700	243	4970
S027	5	<0.2*	14.2	2.7	9.5	0.01	3.2	14.9	10.8	18500	267	6240
S031	3.1	<0.2*	14.0	2.2	7.8	0.01	3.2	11.3	9.5	14600	214	4680
S040	3.4	<0.2*	12.5	2.5	8.4	<0.01*	3.3	11.7	9.2	16400	238	4920
S051	3.1	<0.2*	12.6	2.3	8.3	0.01	3.5	11.4	9.7	16000	235	4610
S054	3	<0.2*	13.7	2.4	8.3	<0.01*	3.6	11.5	9.3	16700	237	4840
S068	3.1	<0.2*	21.5	2.6	8.7	0.01	3.6	11.4	9.6	16300	247	4680
Mean	**4.8**	**N/A**	**14.5**	**2.5**	**8.9**	**0.011**	**3.5**	**14.4**	**10.2**	**16620**	**241**	**5493**
SD	**4.3**	**N/A**	**2.8**	**0.3**	**1.1**	**0.004**	**0.2**	**6.0**	**1.8**	**1017**	**15**	**1370**
Min	**1.7**	**N/A**	**12.5**	**2.1**	**7.8**	**0.01**	**3.2**	**11.3**	**8.7**	**14600**	**214**	**4610**
Max	**16.7**	**N/A**	**21.5**	**3.1**	**11.7**	**0.02**	**3.9**	**31.1**	**15.0**	**18500**	**267**	**9050**
Median	**3.3**	**N/A**	**13.8**	**2.5**	**8.5**	**0.01**	**3.4**	**12.2**	**9.7**	**16550**	**241**	**4930**

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

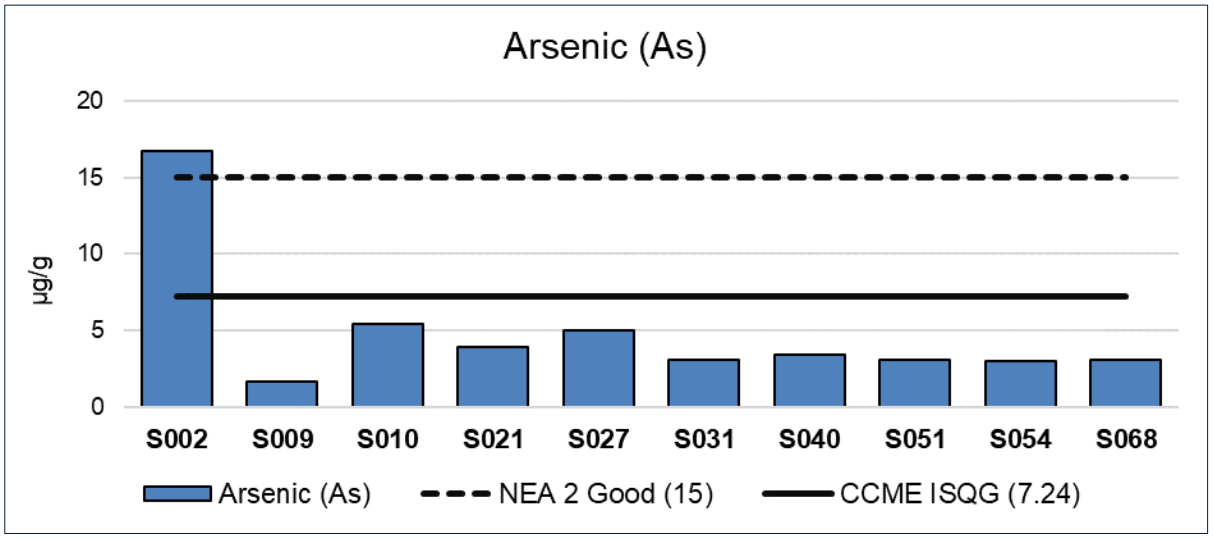


Figure 27 Arsenic (As) concentrations (µg/g dry weight) in sediment across grab sample sites together with threshold values.

5.5.2 Organics (TOM & TOC)

Total organic matter (TOM) and total organic carbon (TOC) varied, with an average content of 0.8 % (SD=0.3) and 0.2 % (SD=0.1) respectively (Table 26 and Figure 28). Both TOM and TOC contents were generally higher in the southern and eastern sections of the survey area.

Table 26 Summary of organic and carbon content in sediment across grab sample sites.

Grab Sample ID	Total Organic Matter	Total Organic Carbon
Method	Loss On Ignition (LOI)	WSLM59
Limit of Detection	0.2	0.2
Units	**%**	**%**
S001	0.6	0.13
S002	0.8	0.14
S003	0.6	0.17
S004	0.8	0.16
S005	0.6	0.12
S006	0.6	0.12
S007	0.6	0.14
S008	0.8	0.22
S009	0.6	0.14
S010	0.6	0.63
S011	0.8	0.12
S012	0.3	0.08
S013	0.4	0.10
S014	0.3	0.08
S015	0.4	0.11
S016	0.6	0.13
S017	0.6	0.13

Grab Sample ID	Total Organic Matter	Total Organic Carbon
S018	0.3	0.08
S019	0.5	0.13
S020	0.3	0.08
S021	0.7	0.18
S022	1.1	0.15
S023	0.6	0.14
S024	0.6	0.15
S025	0.6	0.16
S026	0.6	0.18
S027	0.6	0.15
S028	1.1	0.22
S029	0.6	0.16
S030	0.8	0.20
S031	0.7	0.18
S032	0.7	0.18
S033	0.8	0.22
S034	0.6	0.18
S035	0.8	0.18
S036	0.7	0.14
S037	0.9	0.24
S038	0.6	0.24
S039	0.8	0.15
S040	1.0	0.19
S041	0.8	0.16
S042	1.0	0.21
S043	0.8	0.19
S044	0.9	0.16
S045	1.1	0.23
S046	1.0	0.22
S047	1.0	0.19
S048	1.0	0.22
S049	1.0	0.21
S050	1.2	0.26
S051	1.3	0.25
S052	1.4	0.35
S053	1.0	0.25
S054	1.1	0.24

Grab Sample ID	Total Organic Matter	Total Organic Carbon
S055	0.9	0.22
S056	1.0	0.22
S057	0.9	0.18
S058	0.9	0.18
S059	0.7	0.16
S060	1.0	0.22
S061	1.1	0.23
S062	0.8	0.14
S063	0.9	0.16
S064	0.8	0.14
S065	1.3	0.31
S066	1.4	0.29
S067	1.1	0.24
S068	1.2	0.25
S069	1.1	0.21
S070	1.2	0.34
S071	1.0	0.22
S072	1.0	0.19
S073	1.0	0.21
S074	0.8	0.16
S075	0.9	0.20
S076	1.0	0.21
S077	1.0	0.19
S078	1.0	0.15
S079	0.8	0.11
S080	0.8	0.13
Mean	**0.8**	**0.2**
SD	**0.3**	**0.1**
Min	**0.3**	**0.1**
Max	**1.4**	**0.6**
Median	**0.8**	**0.2**

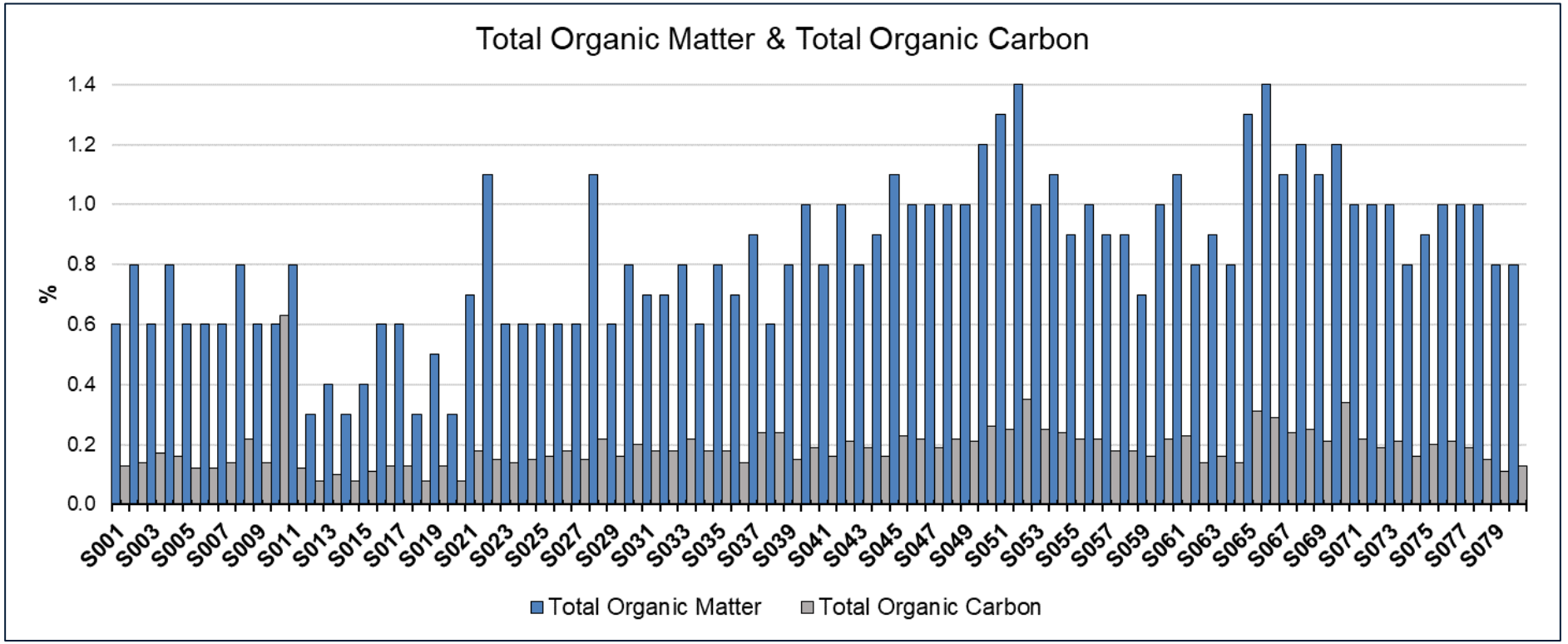


Figure 28 Summary of organic matter and carbon content across grab sample sites.

5.5.3 Hydrocarbons (THC & PAH)

Total Hydrocarbons

Total Hydrocarbon Content (THC) concentrations varied across the survey area and did not exceed the Dutch RIVM intervention values at any of the grab sample sites (Table 27).

Concentrations of THC were generally higher in the southern and eastern sections of the survey area.

Table 27 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	5000000	-	-	-	-	-
Units	µg/kg	µg/kg	-	µg/kg	µg/kg	-
S002	6210	61.9	1.22	11.8	1.06	11.1
S009	11200	103	1.06	10.6	1.20	8.88
S010	9260	111	1.42	11.5	1.26	9.09
S021	9910	126	1.86	20.0	<1*	-*
S027	9470	96.0	1.34	16.1	1.28	12.5
S031	10900	138	1.10	13.5	1.29	10.4
S040	11500	112	1.28	16.3	1.37	12.0
S051	13300	216	0.94	15.4	<1*	-*
S054	13700	159	1.45	20.6	1.68	12.3
S068	9650	95.2	1.35	10.2	1.93	5.26
Mean	**10510**	**121.8**	**1.30**	**14.6**	**1.38**	**10.19**
SD	**2155**	**42.2**	**0.26**	**3.7**	**0.28**	**2.43**
Min	**6210**	**61.9**	**0.94**	**10.2**	**1.06**	**5.26**
Max	**13700**	**216.0**	**1.86**	**20.6**	**1.93**	**12.50**
Median	**10405**	**111.5**	**1.31**	**14.5**	**1.29**	**10.75**

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

Polycyclic Aromatic Hydrocarbons

Polycyclic Aromatic Hydrocarbons (PAH) concentrations were overall low but variable across the survey area.

No threshold values were exceeded for individual congeners but the sum of the 16 EPA congeners exceeded the lower threshold value of NEA's class 2 – Good of 30 µg/kg at grab sample site S051, thus exceeding the expected background value (Table 28 and Figure 29).

Concentrations of PAH were higher in the southern and eastern sections of the survey area.

Table 28 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	Perylene *	Indeno[123,cd]pyrene	Dibenzo[a,h]anthracene	Benzo[ghi]perylene	SUM (EPA 16)
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	0.00	0.00	0	0.00	0.00	-	0.00	0.00	0	0.00	0.00	0	0.00	-	0	-	0.00	0	0.00	0.00
NEA 2 Good	2	1.6	2.4	6.8	6.8	-	1.2	8.00	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
S002	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.17	<1	1.11	2.28
S009	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.51	<1	<1	<1	<1	2.49	<1	2.31	6.31
S010	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.19	<1	<1	<1	<1	2.24	<1	1.87	5.30
S021	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.65	<1	1.04	<1	<1	3.12	<1	2.87	7.64
S027	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1.12	<1	<1	<1	<1	2.00	<1	1.87	4.99
S031	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.1	<1	1.2	<1	<1	3.63	<1	3.45	9.18
S040	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.15	<1	1.28	<1	<1	3.92	<1	3.57	9.64
S051	<1	<1	<1	<1	1.19	<1	<1	1.45	1.04	1.08	1.45	5.75	2.69	3.46	3.32	1.02	8.61	1.15	7.41	35.14
S054	<1	<1	<1	<1	<1	<1	<1	1.10	<1	<1	<1	2.72	1.27	1.92	1.04	<1	5.92	<1	5.28	17.33
S068	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2.28	1.17	1.34	<1	<1	3.96	<1	3.63	11.04

**Not included in the EPA 16 PAHs*

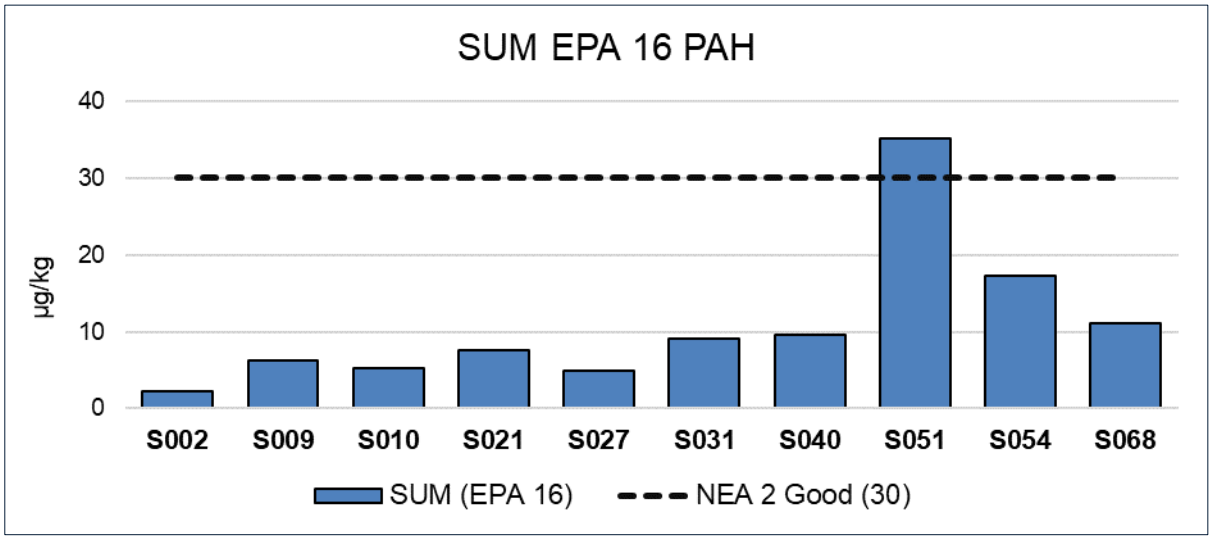


Figure 29 Levels of EPA 16 PAHs summarized together with threshold values.

5.5.4 Polychlorinated Biphenyls (PCB)

Levels of all the 25 individual Polychlorinated Biphenyls (PCB) congeners were all below the detection limit of <0.08 µg/kg at all ten (10) sites.

5.5.5 Organotins (DBT & TBT)

Levels of both Dibutyltin (DBT) and Tributyltin (TBT) were below the detection limit of <1 µg/kg at all ten (10) sites.

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, Cnidaria, Hemichordata, Nematoda, Phoronida, Platyhelminthes and Sipuncula were combined into the group "Other".

Grab sample sites S007, S008, S018, S023, S0025, S029, S038, S042, S049, S052, and S070, 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 (P) and analysed separately. The results are presented in Section 5.6.1.

A full species list of fauna identified in the grab samples is presented in Appendix F.

5.6.1 Phyletic Composition

The phyletic composition of the non-colonial fauna identified in the grab samples is illustrated in Figure 30 and Figure 31 and summarised in Table 29. Annelida had the highest abundance and diversity, followed by Mollusca and Arthropoda. These three phyla contributed 88 % of the recorded taxa and 89 % of the individuals.

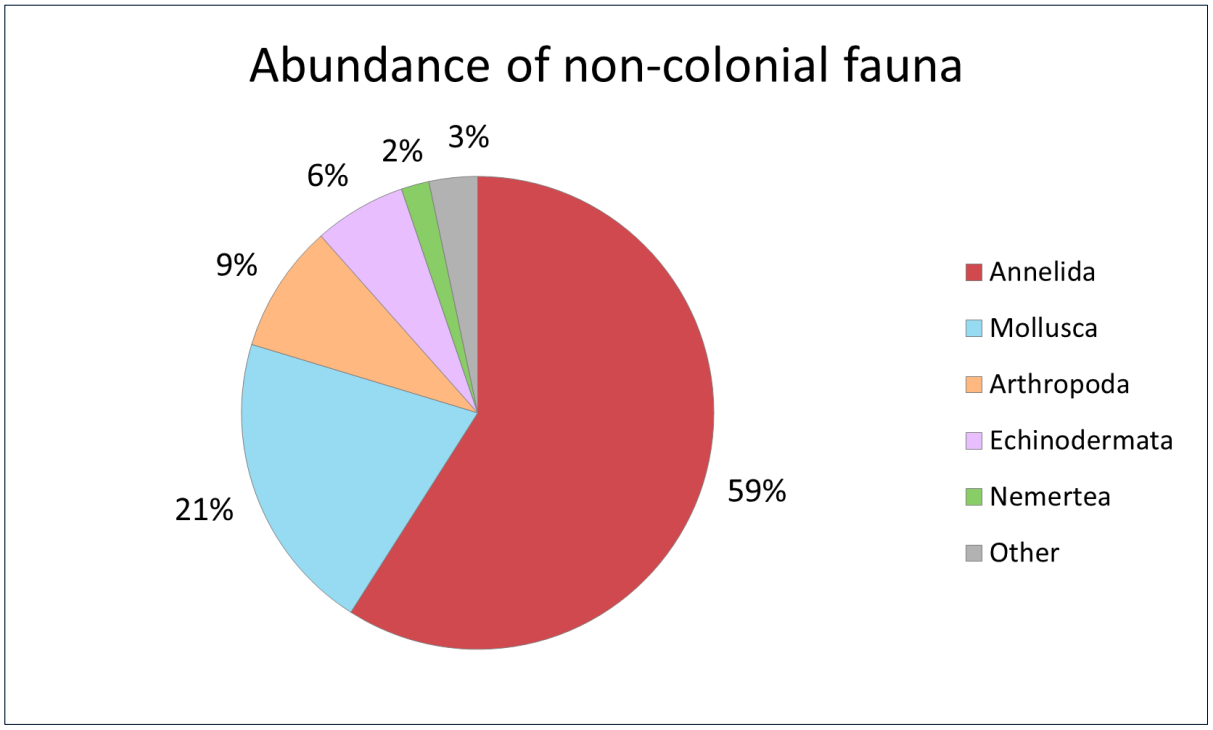


Figure 30 Abundance of non-colonial fauna from grab samples.

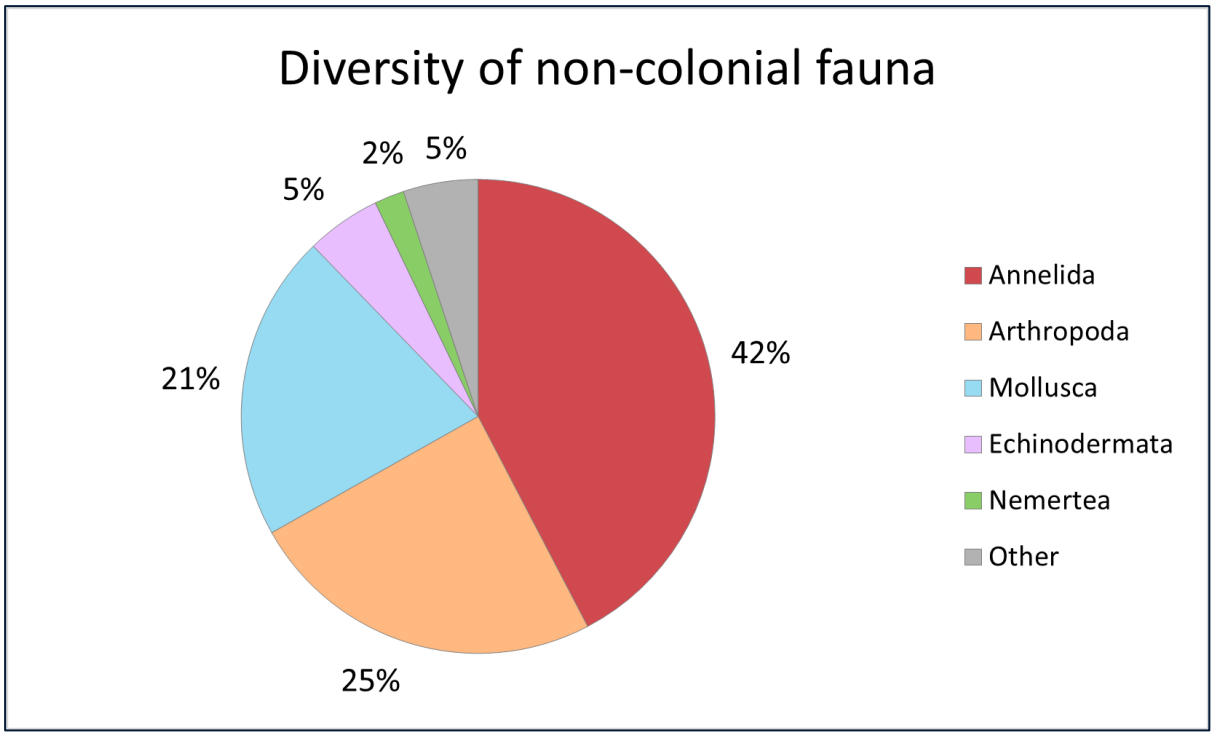


Figure 31 Diversity of non-colonial fauna from grab samples.

Table 29 Phyletic composition of non-colonial fauna from grab samples.

Phylum	Number of Taxa	Abundance (Total Number of Individuals)
Annelida	83	3090
Arthropoda	48	457
Mollusca	41	1060
Echinodermata	10	315
Nemertea	4	105
Other	10	172
Total	**196**	**5199**

A list of the ten (10) most abundant taxa, with total abundance and frequency of occurrence, is presented in Table 30. The most abundant taxon is the *Lanice conchilega*, with a total of 1064 individuals recorded, and the species occurred in 91 % of the grab samples.

Table 30 The ten most abundant taxa from grab samples, together with the frequency of occurrence.

Phylum	Taxa	Total Abundance	Mean Abundance	SD	Frequency Of Occurrence (%)
Annelida	*Lanice conchilega*	1064	15.62	11.48	91
Annelida	*Spiophanes bombyx*	652	9.53	8.58	91
Mollusca	*Abra prismatica*	385	5.51	2.84	91
Annelida	*Scoloplos armiger*	329	4.78	2.97	87
Echinodermata	*Echinocyamus pusillus*	220	3.16	2.88	80
Arthropoda	*Bathyporeia elegans*	196	2.87	3.47	69

Phylum	Taxa	Total Abundance	Mean Abundance	SD	Frequency Of Occurrence (%)
Annelida	*Spiophanes kroyeri*	125	1.84	1.66	69
Annelida	*Scolelepis bonnieri*	99	1.46	1.4	63
Sipuncula	*Phascolion strombus*	90	1.31	1.77	53
Mollusca	*Thyasira flexuosa*	86	1.26	2.04	51

A list of the ten (10) most frequently occurring taxa, with total abundance, is presented in Table 31. The most frequently occurring taxon was the sand mason worm *Lanice conchilega*, which occurred in 91 % of the grab samples with a total abundance of 1064 individuals.

An overview of the total abundance and the total number of species per grab sampling site in the survey area is presented in Figure 32 and Figure 33.

Table 31 The ten most frequently occurring taxa from grab samples, with total abundance.

Phylum	Taxa	Frequency Of Occurrence (%)	Total Abundance
Annelida	*Lanice conchilega*	91	1064
Annelida	*Spiophanes bombyx*	91	652
Mollusca	*Abra prismatica*	91	385
Annelida	*Scoloplos armiger*	87	329
Echinodermata	*Echinocyamus pusillus*	80	220
Arthropoda	*Bathyporeia elegans*	69	196
Annelida	*Spiophanes kroyeri*	69	125
Annelida	*Scolelepis bonnieri*	63	99
Sipuncula	*Phascolion strombus*	53	90
Mollusca	*Thyasira flexuosa*	51	86

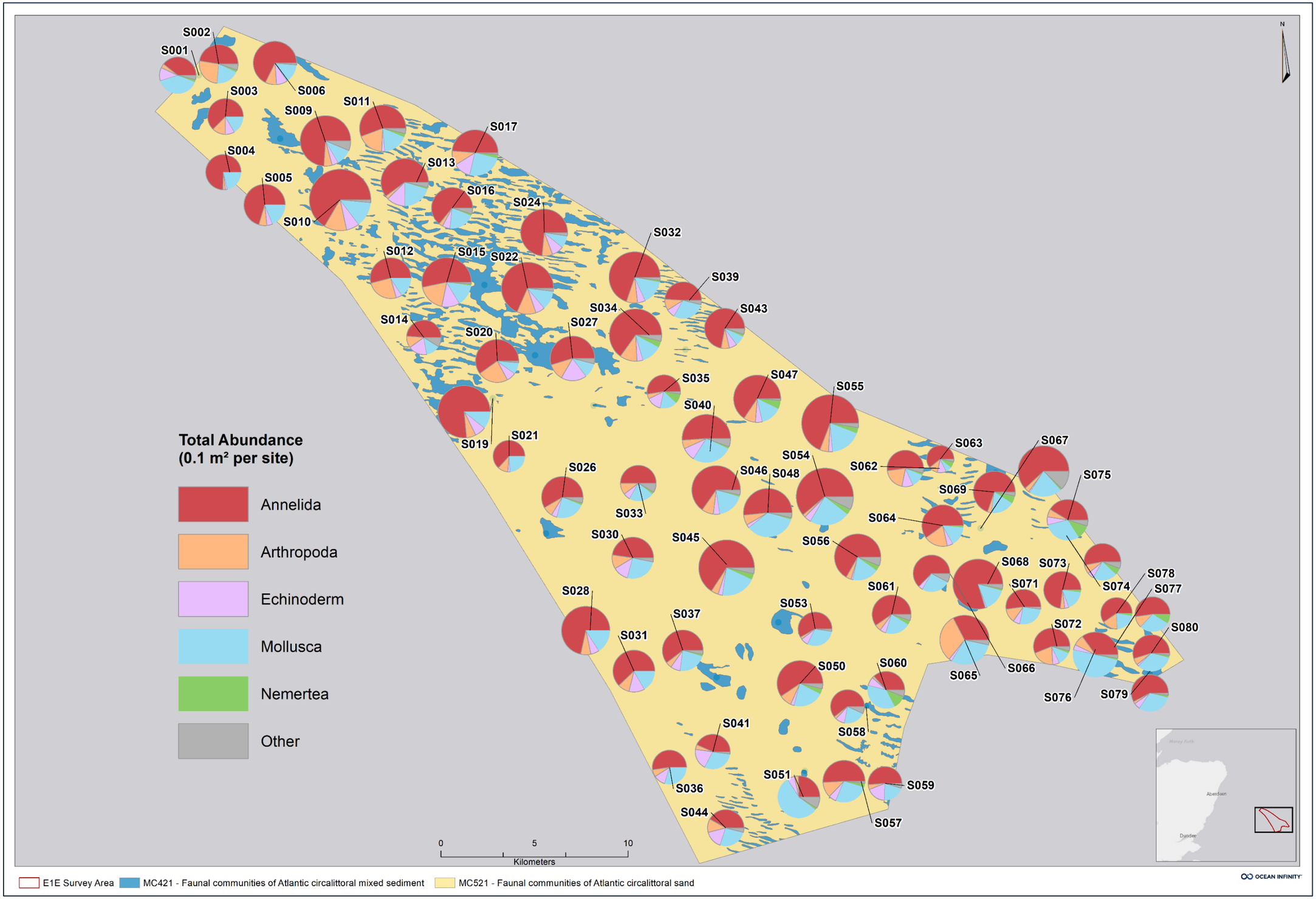


Figure 32 Overview of the Total Abundance per site, pie chart size varying based on the sum of the Total Abundance.

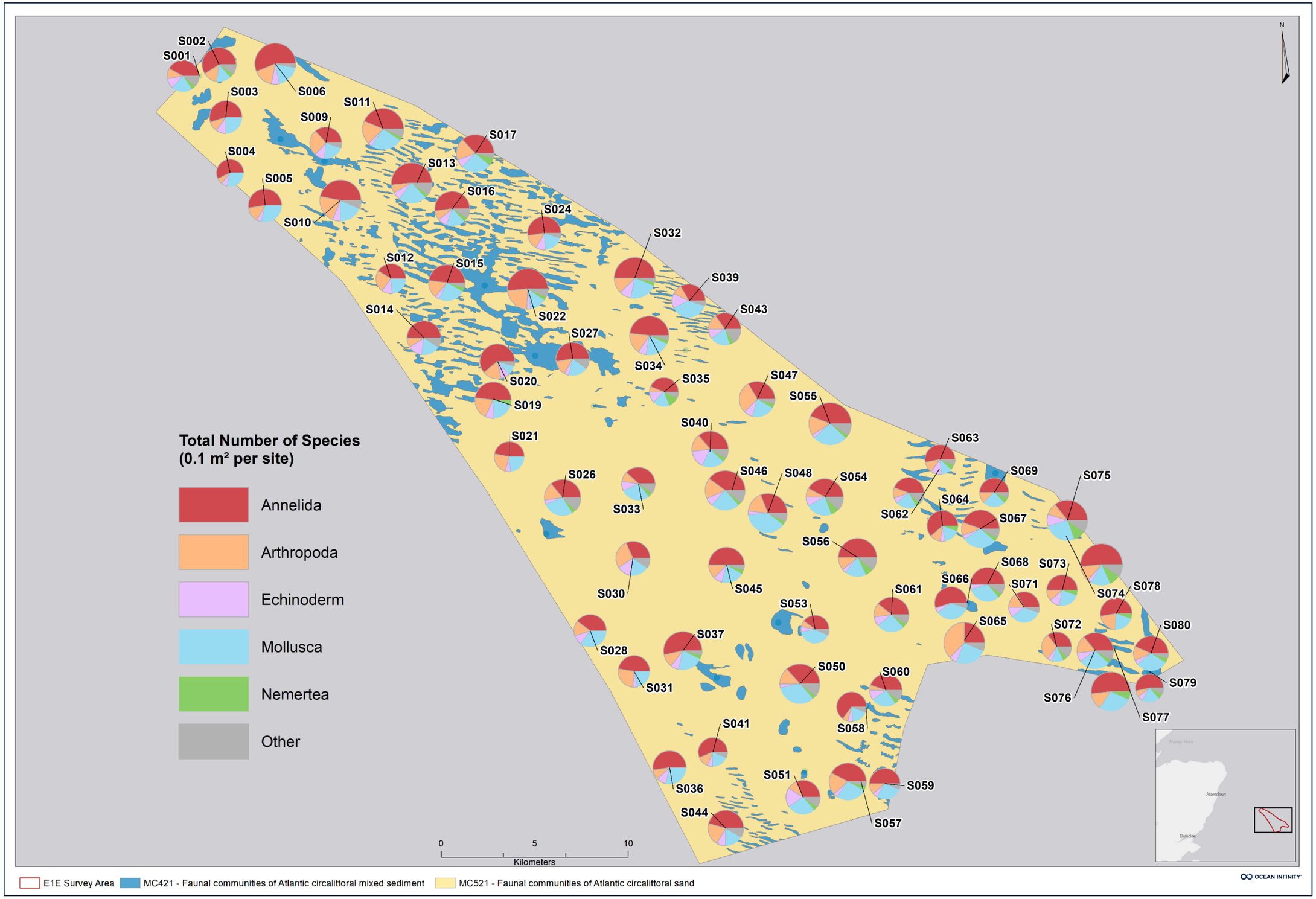


Figure 33 Overview of the Total number of species per grab sample site in the survey area, with pie chart size varying based on the sum of the Total Number of species.

5.7 Biomass

The non-colonial fauna species biomass expressed as blotted wet weight (g per 0.1m^2) is illustrated in Figure 34 and Figure 35 and summarised in Table 32. Biomass was grouped into Echinodermata, Mollusca, Annelida, Arthropoda, Nemertea, Sipuncula and "Other". The group Other included Phoronida, Cnidaria, Hemichordata, Platyhelminthes, Chaetognatha and Nematoda.

The biomass was dominated by Echinodermata, with 65 % of the total biomass, where one individual of the burrowing sea urchin *Spatangus purpureus* constituted 19 % of the total Echinoderm weight.

The second largest group was Mollusca with 28 %, followed by Annelida with 6 % and Nemertea and "Other" with 1 % respectively. Phoronida comprised 0.13 % and Cnidaria and Hemichordata comprised 0.03 % and 0.020 % respectively of the total biomass.

Non-colonial fauna biomass varied between 0.129 (g/0.1 m^2) in sample S064, to 61.936 (g/0.1 m^2) in sample S061. The mean biomass across all sites was 7.005 (g/0.1 m^2) (SD=13.952).

One specimen of the mollusc *Arctica islandica* was found at the grab sampling site S013 with the measured shell dimensions of 7 x 6 x 4 cm. As this species is listed as a Priority Marine Feature (PMF) in Scottish waters, this identified specimen was returned to sea and not incorporated in the total biomass composition.

The spatial distribution of biomass across the survey area is illustrated in Figure 36 and Figure 37.

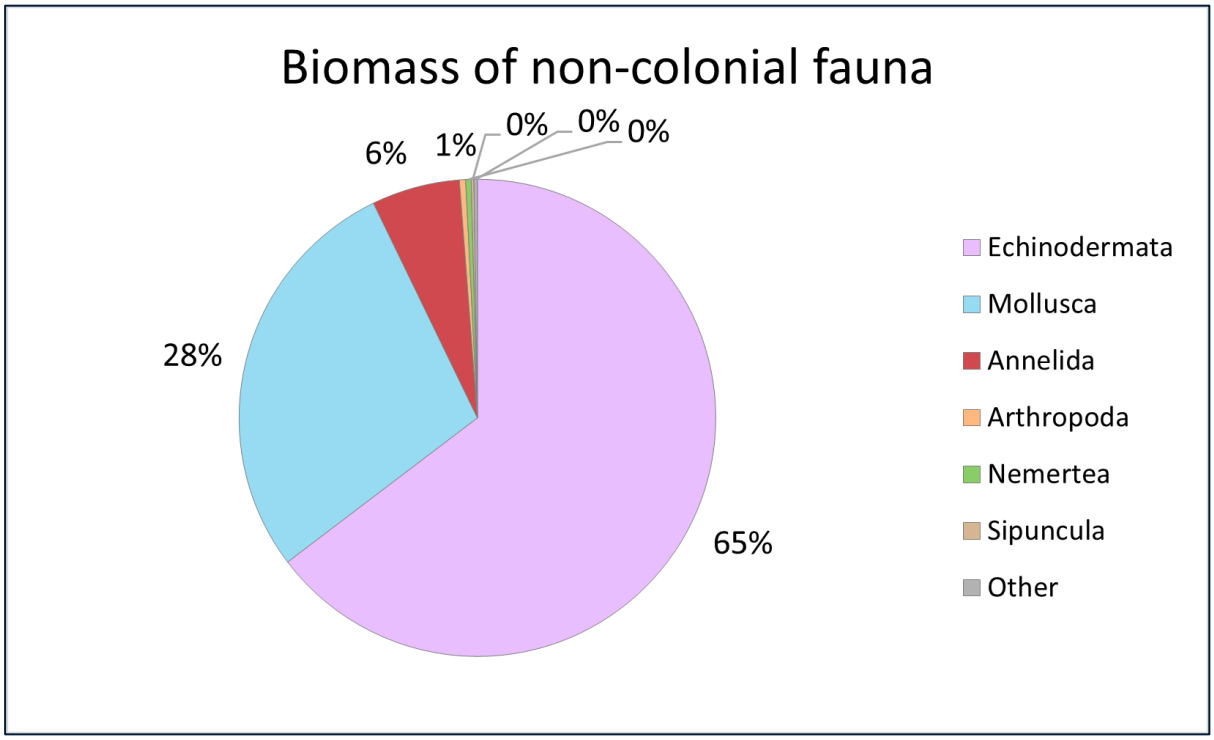


Figure 34 Total biomass (blotted wet weight in g/0.1 m^2) composition of major phyla.

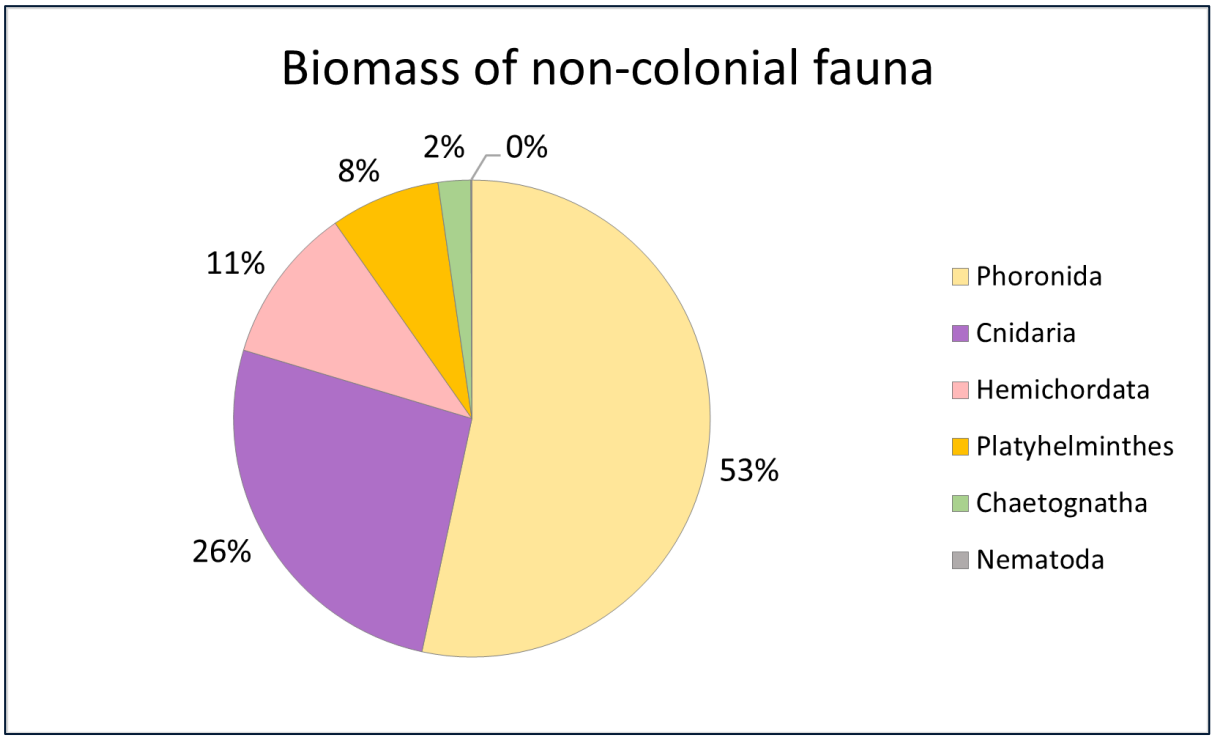


Figure 35 Total biomass (blotted wet weight in g/0.1 m²) of "Other".

Table 32 Biomass (blotted wet weight in g/0.1 m²).

Site Id	Annelida	Arthropoda	Echinodermata	Mollusca	Nemertea	Sipuncula	Other	Total
S001	0.1859	0.0009	0.0716	0.1651	0.0001	0.0521	0.019	0.4947
S002	0.2524	0.0599	0	1.1754	0.0034	0.061	0.0014	1.5535
S003	0.5767	0.0196	0.1814	3.9551	0	0	0	4.7328
S004	0.1183	0.0014	0.059	0.1183	0	0	0	0.297
S005	0.2484	0.0111	0.0083	0.6369	0	0	0	0.9047
S006	0.512	0.0221	0.1077	0.0295	0	0	0.0007	0.672
S009	0.5473	0.0146	0.0513	0.0617	0	0	0.1028	0.7777
S010	0.8213	0.0215	0.0589	1.1364	0	0	0.0547	2.0928
S011	0.3814	0.0313	0.0099	4.6104	0.0008	0	0.0185	5.0523
S012	0.1979	0.0111	0.0102	0.0962	0	0	0	0.3154
S013	0.6132	0.005	0.0295	0.9827	0.0011	0	0.0171	1.6486
S014	0.7906	0.0065	15.8349	0.0143	0	0.0145	0.0039	16.6647
S015	0.307	0.0219	0.0136	0.5172	0.0001	0	0.0016	0.8614
S016	0.4001	0.0018	0.0999	0.1437	0.0011	0.0055	0.0359	0.688
S017	0.452	0.0095	0.1832	0.1551	0.0067	0.0001	0	0.8066
S019	0.5145	0.0052	0.0727	0.0573	0.0001	0	0.0089	0.6587
S020	0.239	0.0225	0.098	0.2482	0.038	0.0001	0	0.6458
S021	0.2566	0.006	0.0128	0.0229	0	0	0	0.2983

Site Id	Annelida	Arthropoda	Echinodermata	Mollusca	Nemertea	Sipuncula	Other	Total
S022	0.3734	0.0189	0.0868	2.937	0.0007	0	0.1071	3.5239
S024	0.4765	0.0062	0.0841	0.0253	0.0052	0	0.0728	0.6701
S026	0.2977	0.0189	0.0037	3.0865	0.0014	0.0001	0.0178	3.4261
S027	0.1892	0.0105	0.0157	0.1739	0	0.1001	0.0006	0.49
S028	0.7652	0.0043	0.0732	3.2821	0.0018	0	0	4.1266
S030	0.2069	0.0201	6.4777	0.8026	0	0.0047	0.0119	7.5239
S031	0.3409	0.0272	0.0079	2.4682	0	0	0	2.8442
S032	2.5614	0.0075	23.1101	3.9081	0.0025	0.0247	0	29.6143
S033	0.462	0.0068	0.7049	1.2552	0.0009	0.0007	0.0061	2.4366
S034	0.4091	0.0114	0.1709	0.7043	0.0057	0.0017	0.0242	1.3273
S035	0.1179	0.002	0.0546	0.2819	0.1175	0	0.0025	0.5764
S036	0.5168	0.0024	0.0769	0.655	0	0	0	1.2511
S037	0.4287	0.0011	0.1365	0.859	0.0029	0.0014	0	1.4296
S039	0.3746	0.0053	13.4596	0.1371	0	0.0749	0	14.0515
S040	0.1996	0.0108	4.7193	3.2917	0.0059	0.0061	0.0735	8.3069
S041	0.5625	0.0033	5.9416	0.1461	0	0	0.0049	6.6584
S043	0.1785	0.3644	0.0091	0.016	0.0037	0.0648	0.0359	0.6724
S044	0.4717	0.0072	0.0231	0.5012	0	0.0007	0.0122	1.0161
S045	1.1384	0.01	0.1268	1.5113	0.0105	0.0056	0	2.8026
S047	0.3558	0.002	0.0099	0.716	0.0234	0.0004	0.0036	1.1111
S046	0.2884	0.0389	4.8025	3.5298	0.0049	0.0007	0.0358	8.701
S048	0.3146	0.0085	27.1409	2.3849	0.0032	0.1021	0.0073	29.9615
S050	0.5242	0.034	0.0022	0.3871	0.0082	0.0014	0.0448	1.0019
S051	0.1892	0.0039	59.9634	0.9939	0.0039	0.0266	0.0008	61.1817
S053	1.2858	0.0022	0.0032	0.3909	0	0.0002	0	1.6823
S054	0.8482	0.005	0.0526	0.7167	0.4725	0.0091	0.0385	2.1426
S055	0.9022	0.0077	7.6967	0.5675	0.0055	0.051	0.0089	9.2395
S056	0.3813	0.0096	0.0045	0.0912	0.01	0.0074	0.0345	0.5385
S057	0.2171	0.019	0.0037	0.4294	0.0039	0	0.0012	0.6743
S058	0.1796	0.0009	5.15	0.029	0	0.0495	0	5.409
S059	0.1791	0.0025	0.0096	0.1353	0	0.0827	0	0.4092
S060	0.3463	0.0005	0.1234	0.1267	0.0112	0.0111	0.0023	0.6215
S061	0.3861	0.0078	60.7961	0.6946	0.004	0.0007	0.0468	61.9361
S062	0.2465	0.0128	0.0074	0.2524	0.0014	0	0.0547	0.5752

Site Id	Annelida	Arthropoda	Echinodermata	Mollusca	Nemertea	Sipuncula	Other	Total
S063	0.1487	0.0028	0.0766	0.0105	0.0031	0.0003	0	0.242
S064	0.1458	0.016	0.0036	0.0258	0.002	0	0.0031	0.1963
S065	0.2022	0.9627	23.1009	21.8606	0	0.0001	0.0336	46.1601
S066	0.1874	0.0006	0.0021	0.1855	0	0.0743	0	0.4499
S067	0.4549	0.0031	0.0015	1.9528	0.0012	0.0063	0.0219	2.4417
S068	0.1867	0.0001	0.0839	0.5337	0.0005	0.0008	0.0203	0.826
S069	0.417	0.0015	0	0.0806	0.0072	0.0001	0	0.5064
S071	0.1307	0.0066	0.1564	0.0773	0	0	0.016	0.387
S072	0.3559	0.0192	1.4725	0.08	0.0051	0.0053	0.0239	1.9619
S073	0.7981	0.0018	13.2099	1.2367	0.0014	0	0.0158	15.2637
S074	0.2345	0.0042	0.0027	0.7141	0.0183	0.0023	0.0065	0.9826
S075	0.3919	0.0033	19.6553	0.4539	0.0677	0	0.0973	20.6694
S076	0.1655	0.0104	16.8316	0.9948	0.0015	0.0335	0.0017	18.039
S077	0.2896	0.0122	0	55.8896	0.0138	0	0	56.2052
S078	0.1689	0.0045	0	0.1599	0.7923	0	0	1.1256
S079	0.1317	0.0012	0.0464	0.0895	0.0044	0.0013	0	0.2745
S080	0.3549	0.0152	0.004	0.0619	0.0919	0	0.0004	0.5283
Total	**28.894**	**2.031**	**312.599**	**136.022**	**1.773**	**0.886**	**1.154**	**483.358**
Mean	**0.419**	**0.029**	**4.530**	**1.971**	**0.026**	**0.013**	**0.017**	**7.005**
SD	**0.355**	**0.122**	**11.611**	**7.145**	**0.111**	**0.026**	**0.026**	**13.952**
Min	**0.118**	**0.000**	**0.000**	**0.011**	**0.000**	**0.000**	**0.000**	**0.196**
Max	**2.561**	**0.963**	**60.796**	**55.890**	**0.792**	**0.102**	**0.267**	**61.936**
Median	**0.355**	**0.008**	**0.073**	**0.454**	**0.001**	**0.000**	**0.001**	**1.251**

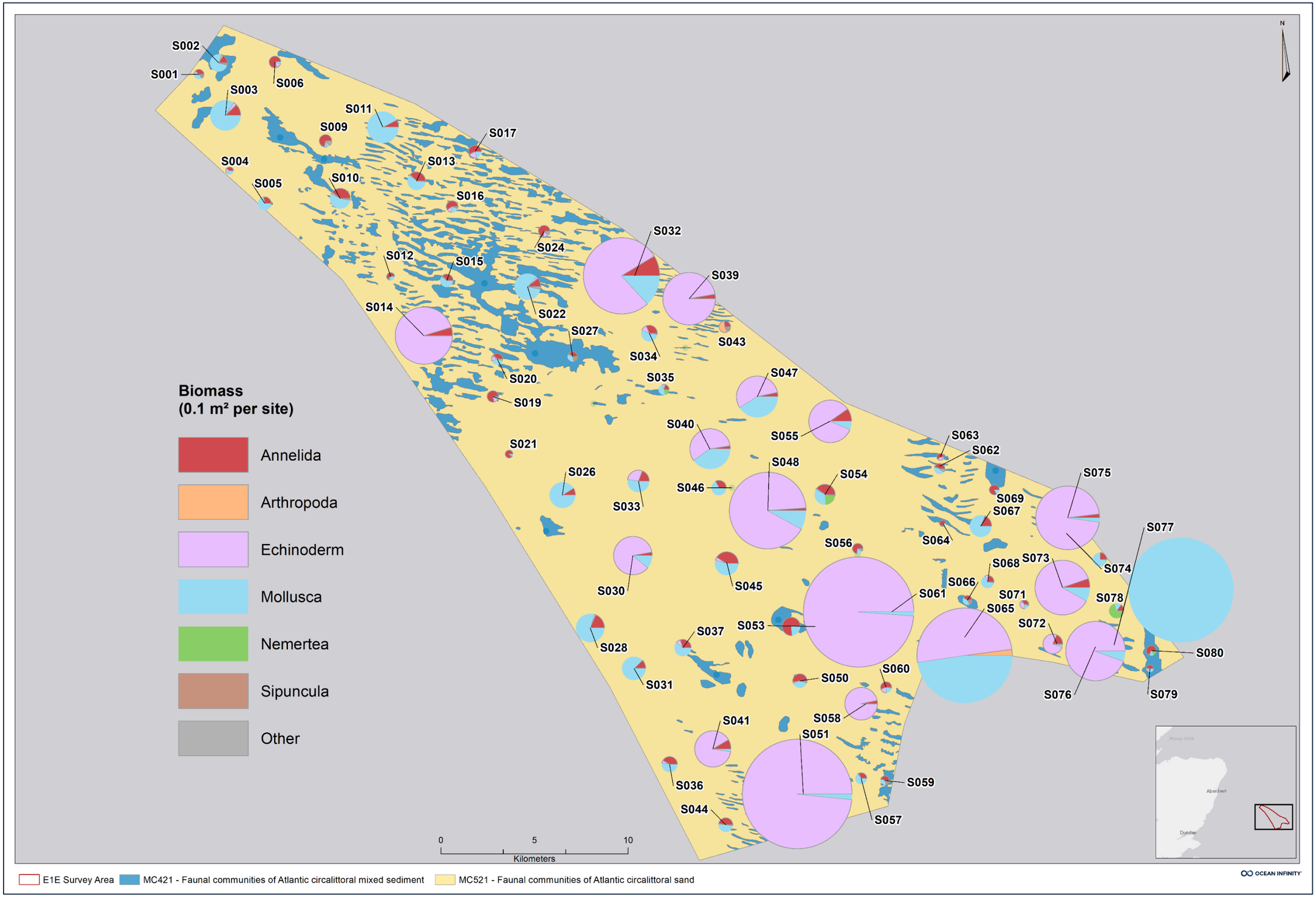


Figure 36 Composition of biomass (blotted wet weight in g/0.1 m²) in the survey area, with pie chart size varying based on the sum of the biomass composition.

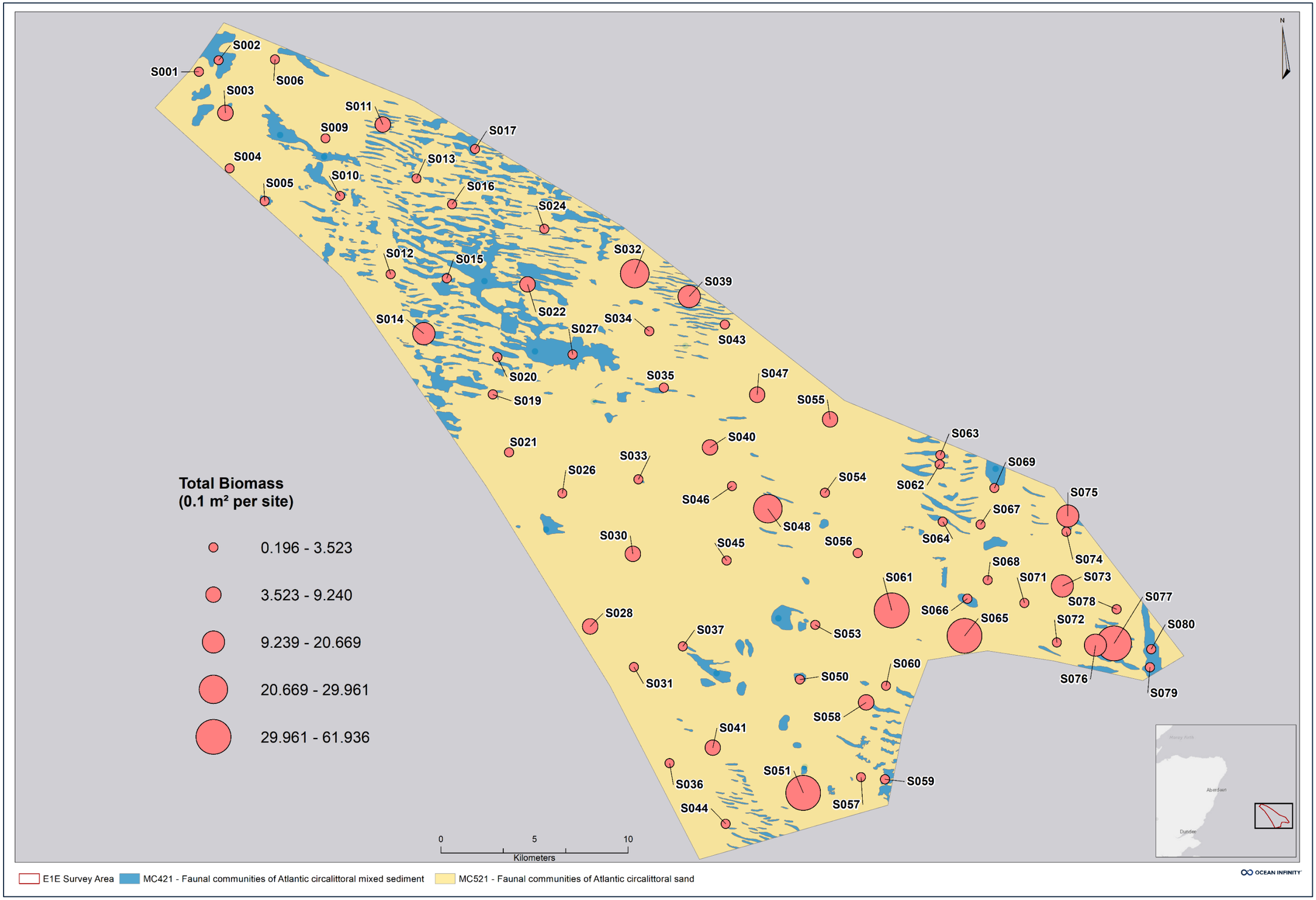


Figure 37 Total biomass (blotted wet weight in g/0.1 m²) per site in the survey area.

5.8 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 for each grab sampling site in Table 33, with the number of taxa (S) being the total number of taxa identified at the grab site.

The number of taxa (S) per site varied with a mean of 23 (SD=5.35) where S055 contained the highest number of taxa (34 different taxa), and grab sampling site S004 comprised the lowest with 14 different taxa. An overview of the number of taxa (S) identified per grab sampling site is presented in Figure 38.

The number of individuals (N) per site (expressed per 0.1 m^2) varied with a mean of 69 (SD=23.84) where S010 contained the highest number of individuals (143 individuals) and S063 was the lowest with 28 individuals. An overview map of the number of individuals (N) identified per grab sampling site is presented in Figure 39.

The species richness measured with Margalef's diversity index (D) varied between 3.38 and 8.14, with grab sample S074 having the highest value of 8.14. Pielou's evenness index (J') ranged from 0.69 to 0.95, with grab sampling site S077 having the highest value of 0.95.

The Shannon-Wiener index (H') varied from 1.99 to 3.19, with grab sampling site S077 presenting the highest value of 3.19. An overview of the Shannon-Wiener Index (H') identified per grab sampling site along the survey area is presented in Figure 40.

Simpson's index of dominance (1-λ) ranged from 0.76 to 0.95, with grab sampling site S077 having the highest value of 0.95.

Table 33 Univariate indices of fauna values from each grab sample site.
The number of taxa (S) is the total number of taxa identified at the site.

ID	NUMBER OF TAXA (S)	NUMBER OF INDIVIDUALS (N)	Margalef's Richness index (d)	Pielou's evenness index (J')	SHANNON-WIENER INDEX (H')	Simpson's Index of DOMINANCE (1-λ)
S001	19	51	4.58	0.87	2.55	0.89
S002	22	57	5.19	0.84	2.61	0.89
S003	20	48	4.91	0.88	2.65	0.89
S004	14	47	3.38	0.80	2.12	0.82
S005	21	64	4.81	0.77	2.34	0.80
S006	32	71	7.27	0.83	2.86	0.89
S009	19	96	3.94	0.72	2.12	0.81
S010	32	143	6.25	0.74	2.57	0.84
S011	32	81	7.05	0.84	2.92	0.91
S012	17	63	3.86	0.79	2.25	0.86
S013	31	85	6.75	0.84	2.87	0.91
S014	22	45	5.52	0.92	2.85	0.93
S015	25	92	5.31	0.78	2.52	0.86
S016	23	64	5.29	0.84	2.64	0.88
S017	27	80	5.93	0.85	2.81	0.91
S019	25	103	5.18	0.69	2.24	0.79

ID	NUMBER OF TAXA (S)	NUMBER OF INDIVIDUALS (N)	Margalef's Richness index (d)	Pielou's evenness index (J')	SHANNON-WIENER INDEX (H')	Simpson's Index of DOMINANCE (1-λ)
S020	23	70	5.18	0.84	2.62	0.89
S021	17	38	4.40	0.85	2.40	0.86
S022	31	102	6.49	0.76	2.61	0.87
S024	21	83	4.53	0.71	2.16	0.76
S026	25	65	5.75	0.85	2.72	0.90
S027	21	75	4.63	0.78	2.36	0.86
S028	20	88	4.24	0.76	2.27	0.83
S030	22	65	5.03	0.85	2.63	0.90
S031	19	66	4.30	0.79	2.33	0.85
S032	32	99	6.75	0.78	2.71	0.85
S033	21	48	5.17	0.89	2.70	0.90
S034	29	103	6.04	0.79	2.66	0.85
S035	16	42	4.01	0.87	2.43	0.88
S036	21	44	5.29	0.91	2.76	0.92
S037	28	63	6.52	0.84	2.81	0.89
S039	21	51	5.09	0.87	2.65	0.89
S040	25	88	5.36	0.86	2.78	0.91
S041	16	46	3.92	0.84	2.33	0.87
S043	20	61	4.62	0.79	2.37	0.84
S044	24	50	5.88	0.89	2.82	0.91
S045	24	117	4.83	0.78	2.49	0.86
S046	30	89	6.46	0.83	2.82	0.90
S047	24	84	5.19	0.77	2.46	0.85
S048	29	89	6.24	0.82	2.78	0.89
S050	30	79	6.64	0.79	2.70	0.85
S051	22	67	4.99	0.84	2.59	0.89
S053	15	43	3.72	0.83	2.25	0.84
S054	26	123	5.20	0.79	2.56	0.88
S055	34	123	6.86	0.75	2.63	0.84
S056	28	81	6.14	0.78	2.60	0.86
S057	26	67	5.95	0.84	2.73	0.90
S058	17	43	4.25	0.89	2.51	0.89

ID	NUMBER OF TAXA (S)	NUMBER OF INDIVIDUALS (N)	Margalef's Richness index (d)	Pielou's evenness index (J')	SHANNON-WIENER INDEX (H')	Simpson's Index of DOMINANCE (1-λ)
S059	18	43	4.52	0.90	2.61	0.91
S060	20	52	4.81	0.86	2.56	0.89
S061	23	57	5.44	0.85	2.68	0.89
S062	18	50	4.35	0.83	2.39	0.87
S063	17	28	4.80	0.92	2.61	0.91
S064	18	65	4.07	0.80	2.32	0.86
S065	32	92	6.86	0.88	3.04	0.93
S066	20	51	4.83	0.86	2.58	0.88
S067	27	97	5.68	0.79	2.61	0.89
S068	22	94	4.62	0.71	2.21	0.81
S069	16	66	3.58	0.84	2.33	0.86
S071	18	46	4.44	0.89	2.58	0.91
S072	17	50	4.09	0.88	2.48	0.89
S073	18	52	4.30	0.80	2.32	0.84
S074	33	51	8.14	0.91	3.18	0.94
S075	31	63	7.24	0.90	3.09	0.93
S076	25	77	5.53	0.78	2.50	0.85
S077	29	46	7.31	0.95	3.19	0.95
S078	19	37	4.99	0.93	2.73	0.92
S079	15	52	3.54	0.74	1.99	0.77
S080	23	51	5.60	0.85	2.67	0.90
Mean	**23.14**	**69.01**	**5.27**	**0.83**	**2.58**	**0.87**
SD	**5.35**	**23.84**	**1.06**	**0.06**	**0.25**	**0.04**
Min	**14.00**	**28.00**	**3.38**	**0.69**	**1.99**	**0.76**
Max	**34.00**	**143.00**	**8.14**	**0.95**	**3.19**	**0.95**
Median	**22**	**65**	**5.18**	**0.84**	**2.61**	**0.89**

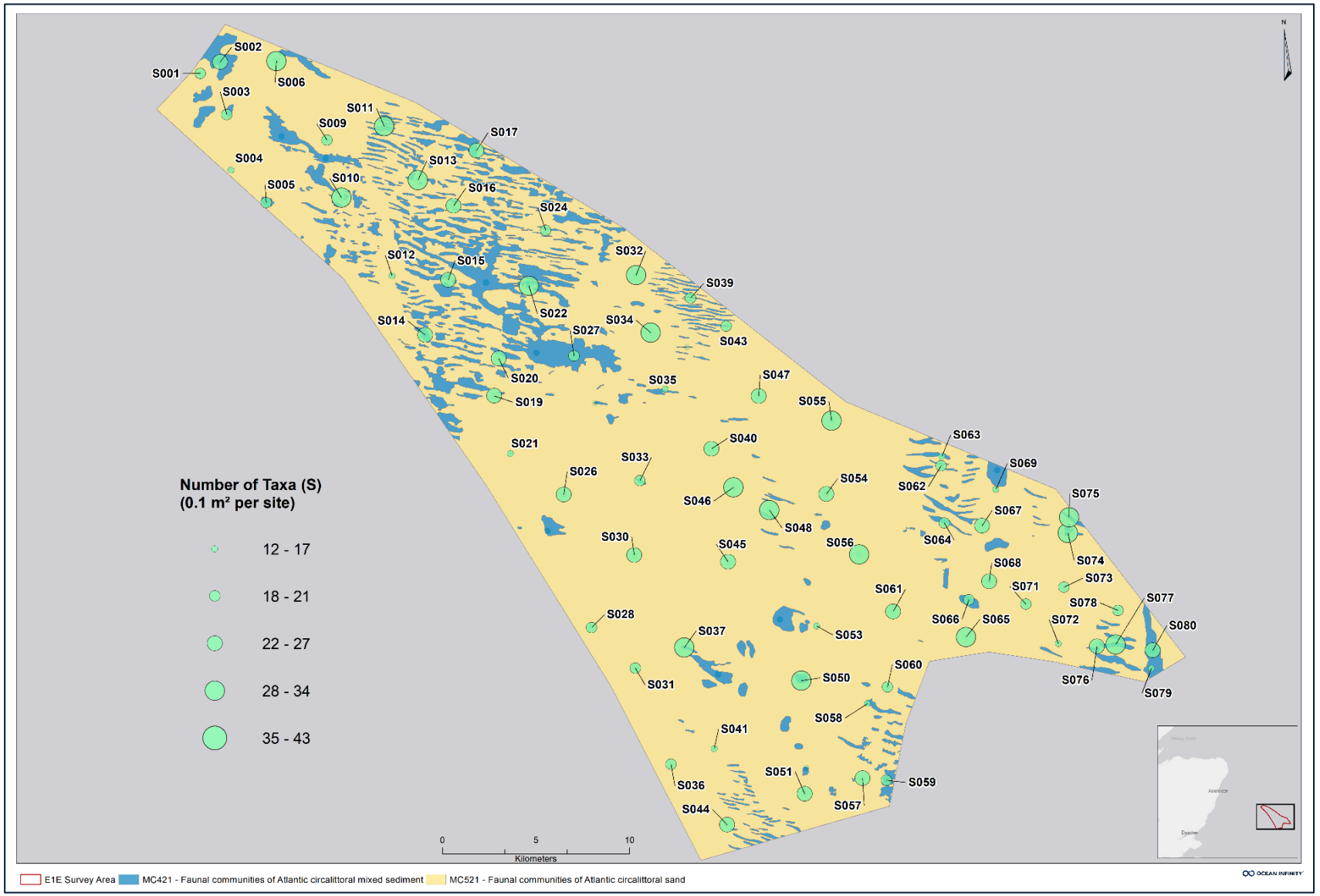


Figure 38 Overview of the Number of Taxa (S) per grab sampling site.

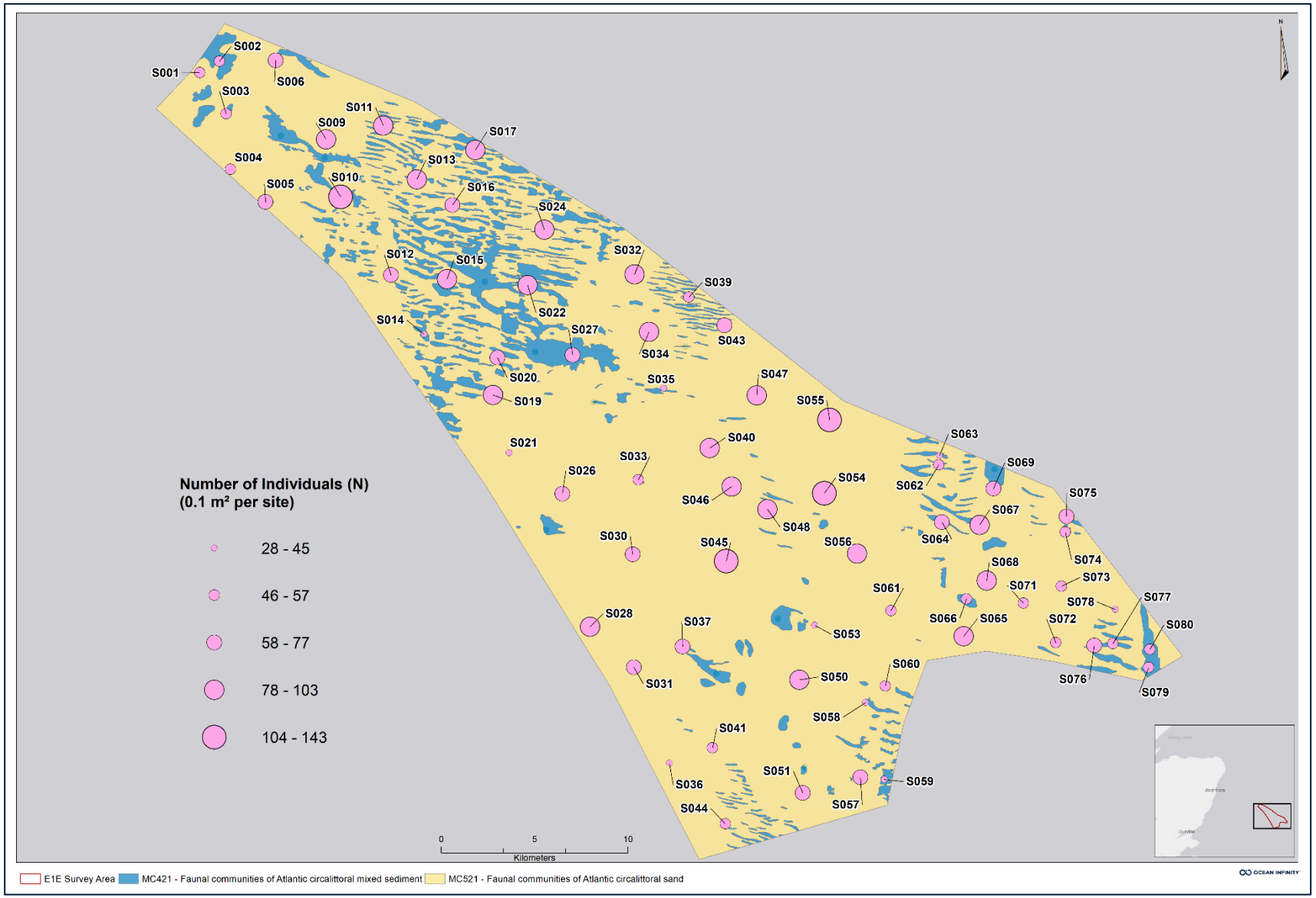


Figure 39 Overview of the Number of Individuals (N) per grab sampling site.

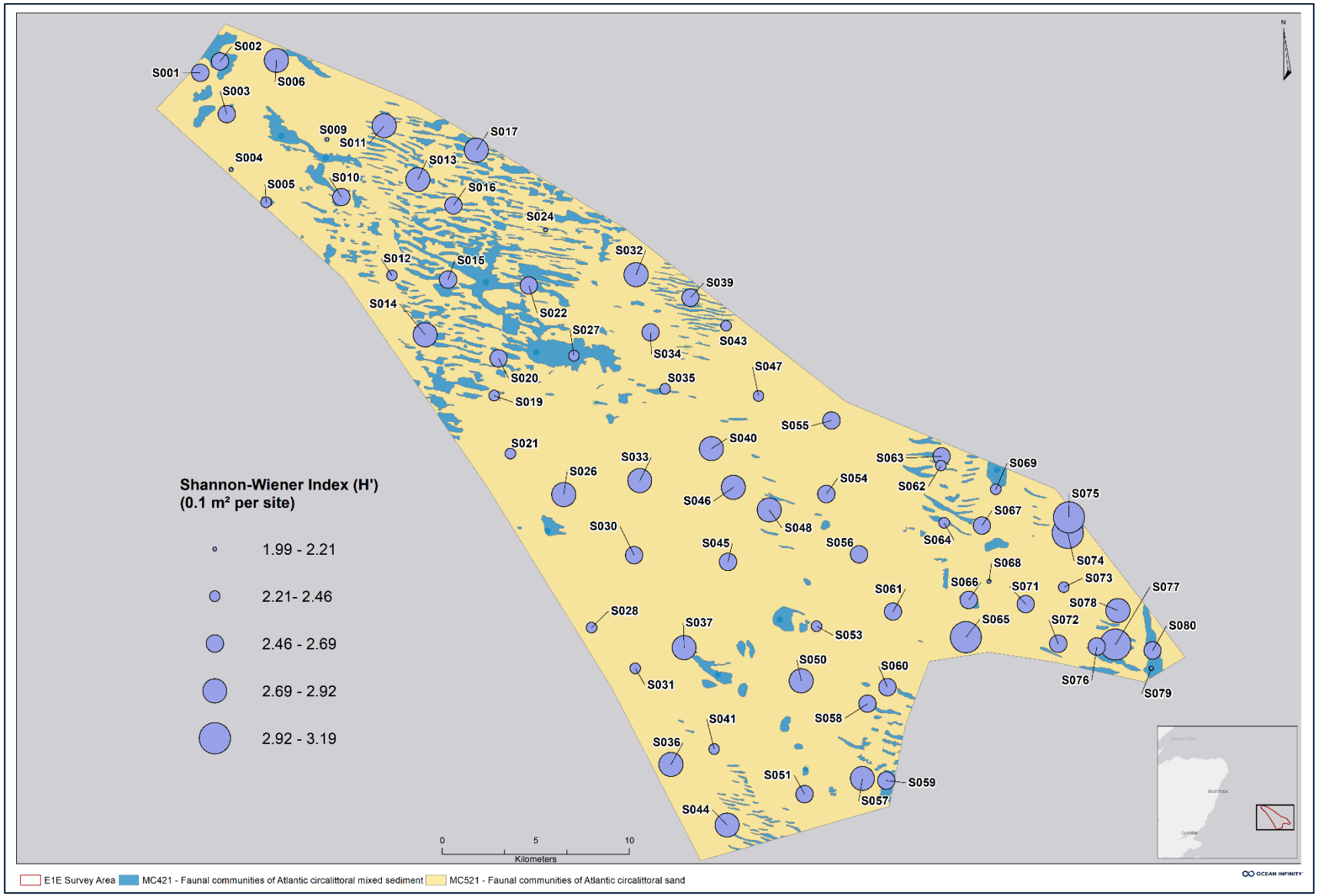


Figure 40 Overview of the Shannon-Wiener Index (H') per grab sampling site.

5.9 Multivariate Statistical Analyses

Bray-Curtis similarity measures in the SIMPROF and SIMPER analyses were applied to the untransformed dataset. No transformation was applied to the non-colonial enumerated fauna datasets before calculating the Bray-Curtis similarity. The largest abundances in the current dataset were generally <20 individuals per sample and thus it was deemed that there was no need for reducing the influence of highly abundant or rarer species (Clarke & Gorley, 2015). The statistical analyses were based on macrofaunal data derived from the taxonomic analyses of the grab samples. For multivariate statistical analyses included in the pre-treated dataset please view Section 5.9.2.

5.9.1 SIMPROF and SIMPER Analyses

The SIMPROF analysis of the non-colonial faunal composition produced three (3) statistically distinct groups (black lines) and is presented in a hierarchical dendrogram in Figure 41.

Sample similarity for all sites is further explored in the nMDS-plot, presented in Figure 42. The nMDS plot reflects the dendrogram and displays the similarity between sample sites at 20 % to highlight homogenous species compositions.

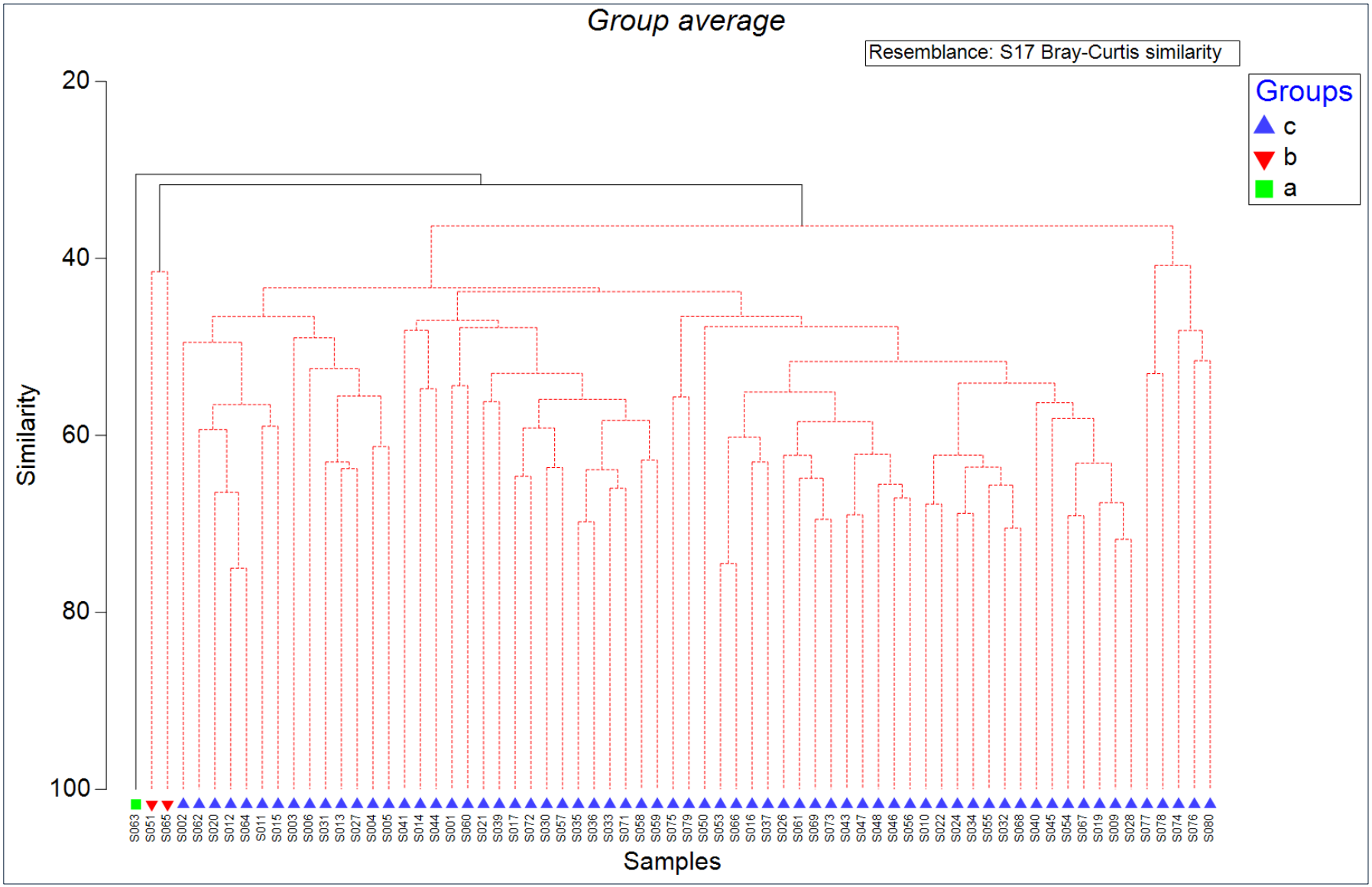


Figure 41 SIMPROF dendrogram based on non-colonial faunal composition for all sites.

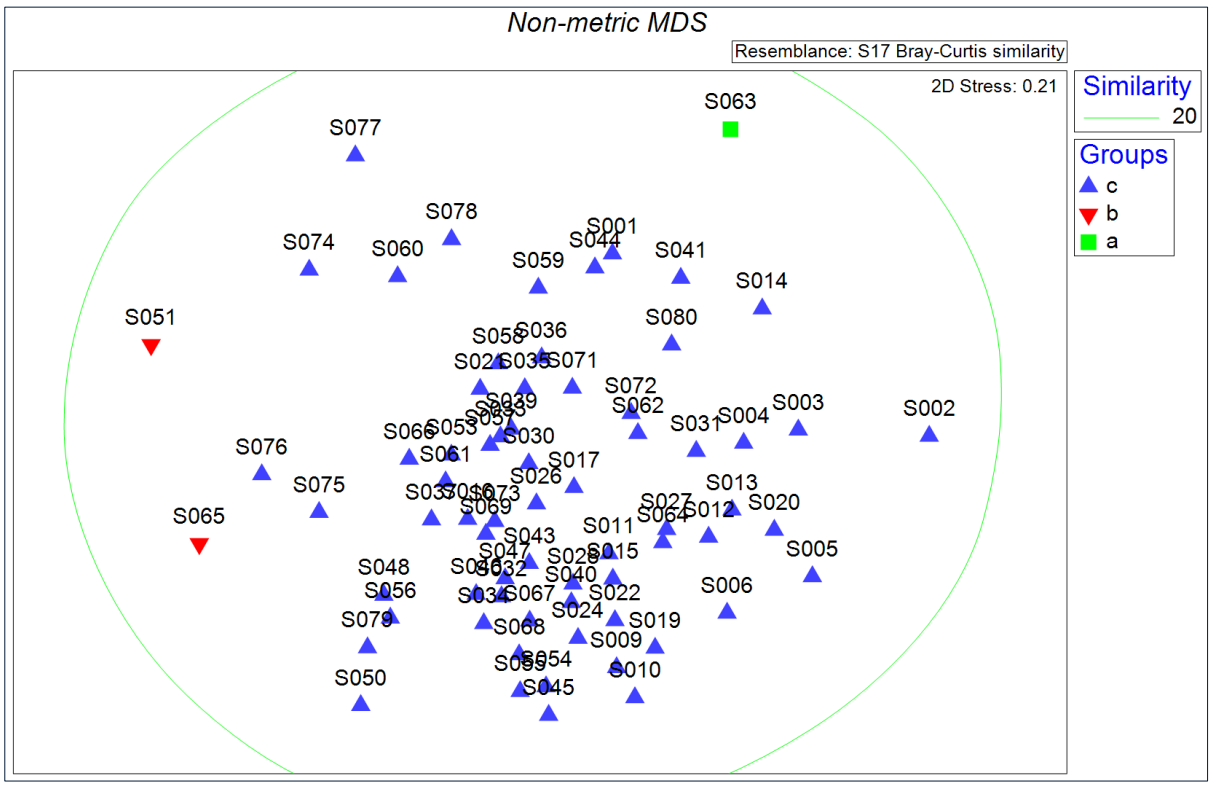


Figure 42 nMDS plot on non-colonial faunal composition presenting an untransformed dataset with groups based on the SIMPROF analysis.

A SIMPER test, displaying the percentage contribution of the most important species seen in the Bray-Curtis similarities test is presented in Table 34 with species abundance for each SIMPROF group. Average abundance refers to untransformed data and is expressed per 0.1 m^2 within the multivariate groups.

Table 34 Summary of characteristics of non-colonial faunal groups derived from SIMPER test performed.

Group	Samples	Average Depth	Species	Average Abundance	Contr. (%)
c **Average similarity: 45.33**	S001, S002, S003, S004, S005, S006, S009, S010, S011, S012, S013, S014, S015, S016, S017, S019, S020, S021, S022, S023, S024, S026, S027, S028, S030, S031, S032, S033, S034, S035, S036, S037, S039, S040, S041, S043, S044, S045, S046, S047, S048, S050, S053, S054, S055, S056, S057, S058, S059, S060, S061, S062, S064, S066, S067, S068, S069, S070, S071, S072, S073, S074, S075, S076, S077, S078, S079, S080	74 m	*Lanice conchilega*	15.86	30.12
			Spiophanes bombyx	9.77	16.05
			Abra prismatica	5.64	13.54
			Scoloplos armiger	4.76	10.13
			Echinocyamus pusillus	3.27	5.62
			Bathyporeia elegans	2.94	3.96
			Spiophanes kroyeri	1.86	2.90
			Kurtiella bidentata	1.48	0.56
			Scolelepis bonnieri	1.42	2.15
			Phascolion strombus	1.26	1.44

Group	Samples	Average Depth	Species	Average Abundance	Contr. (%)
b **Average similarity: 41.51**	S051, S065	86 m	*Abra nitida*	8.5	18.18
			Lanice conchilega	8.5	15.15
			Thyasira flexuosa	8	6.06
			Scoloplos armiger	7	18.18
			Abra prismatica	6	15.15
			Montacuta substriata	3.5	9.09
			Phascolion strombus	3	3.03
			Phaxas pellucidus	2.5	3.03
a **Average similarity: NA**	S063	71 m	Less than 2 samples in the group	-	-

5.9.2 SIMPROF Analysis Pre-treated

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 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.

5.9.3 SIMPROF and SIMPER Analyses Pre-treated

The SIMPROF analysis of the non-colonial faunal composition produced five (5) statistically distinct groups (black lines) and is presented in a hierarchical dendrogram in Figure 43.

Sample similarity for all sites is further explored in the nMDS plot, presented in Figure 44. The nMDS plot reflects the dendrogram including all sites and displays the similarity between and within-sample sites at 20 % to highlight homogenous species compositions.

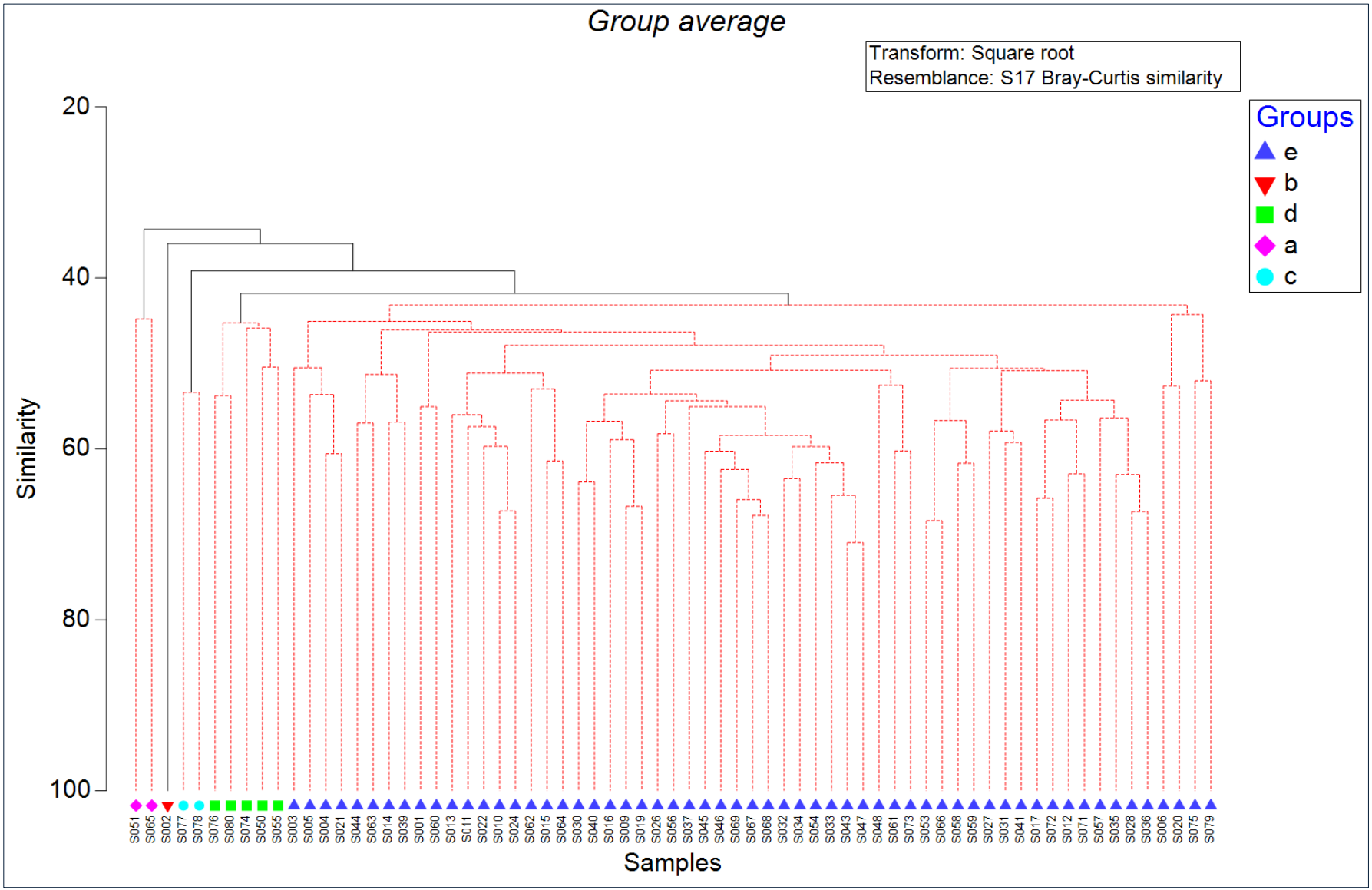


Figure 43 SIMPROF dendrogram based on square root transformed non-colonial faunal composition for the grab sample sites.

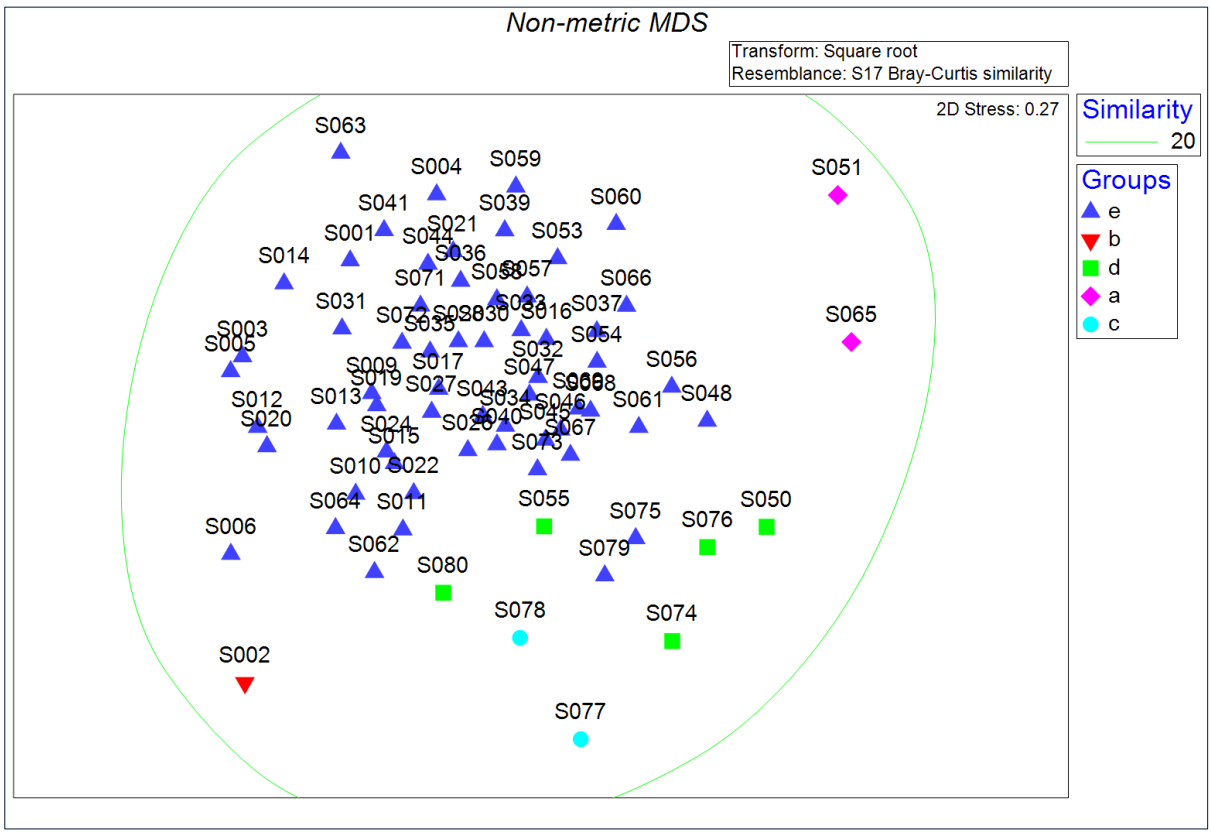


Figure 44 nMDS plot on non-colonial faunal composition presenting square root transformed dataset.

5.10 Relationship Between Physical and Biological Data

The relationship between PSA and faunal communities was assessed by applying the BEST analysis within the PRIMER suite. The BEST test identifies which of the sediment variables best explains the macrofaunal distribution across the survey area. Results indicate that two variables gravel and mud together constituted the best-explained pattern of spatial distribution for fauna (rho = 0.292, P = 0.01), and were statistically significant variables for the distribution of the fauna.

5.11 Sessile Colonial Epifauna from Grab Samples

The phyletic composition of sessile colonial epifauna identified from grab samples is summarised in Table 35 and illustrated in Figure 45 and Figure 46. A total of four (4) major phyla were identified. The dominant phyla were Cnidaria, which contributed 54 % of the total taxa, followed by Bryozoa with 31 % and Entoprocta and Porifera with 11 % and 4 % respectively. A total of 26 different taxa were identified. Abundance was dominated by Bryozoa with a total of 43 colonies, followed by Cnidaria and Entoprocta with a total of 36 and 26 colonies, respectively. One (1) colony of Porifera was identified. A total of 106 different colonies of colonial taxa were identified.

Table 35 Phyletic composition of sessile colonial epifauna from grab samples.

Phylum	Number of Taxa	Abundance of Colonies
Cnidaria	14	36
Bryozoa	8	43
Entoprocta	3	26
Porifera	1	1
Total	**26**	**106**

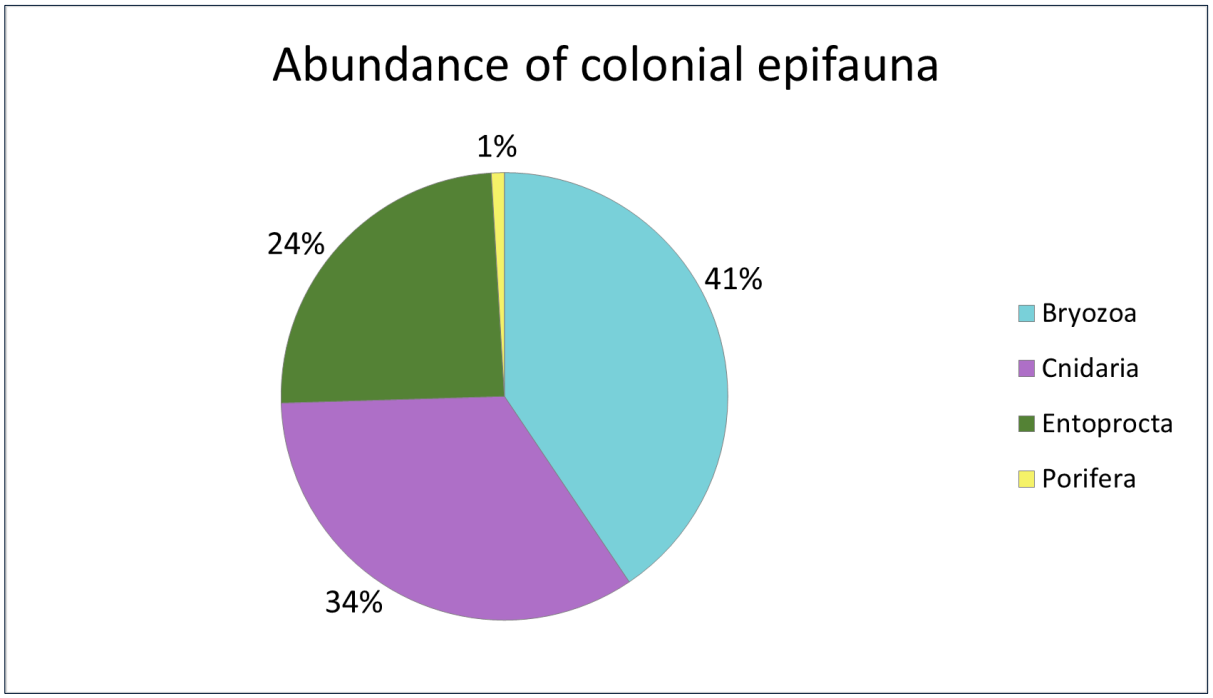


Figure 45 Abundance of colonial epifauna from grab samples.

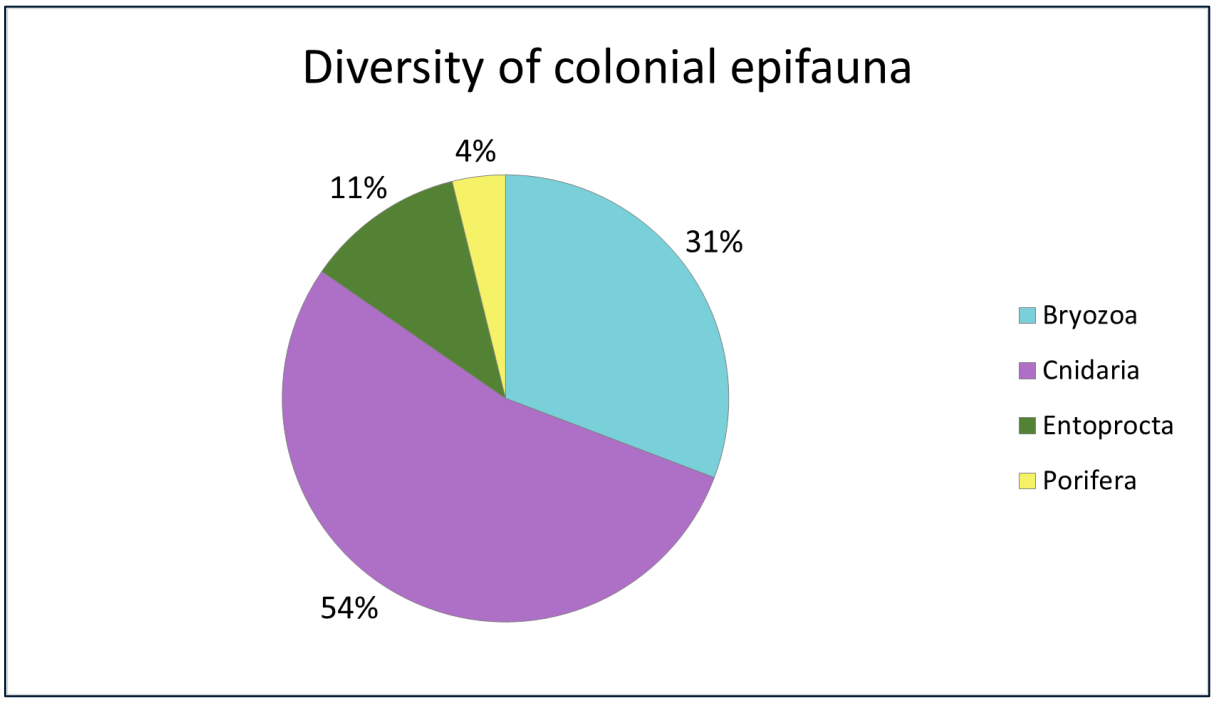


Figure 46 Diversity of colonial epifauna from grab samples.

5.12 Epibenthic Fauna from Visual Survey

The results from the analysis of the stills from grab sample sites showed habitats generally dominated by sand, muddy sand with occasional shell debris, cobbles, and pebbles. Conspicuous fauna were annelids and cnidarians, mostly organisms associated with sandy substrate. Three out of the total 80 sites have no fauna recorded (S012, S026, S064). These empty sites showed habitats consisting of sand or muddy sand with occasional shell debris and no visual fauna. The top 10 sites with the highest number of species are presented in Table 36. The total average number of species is four (4) per site.

Figure 47 presents a still photo from S066, which had the greatest species diversity of all sites.

Table 36 Top 10 sites with the greatest species diversity.

Site	S066	S008	S014	S025	S029	S038	S059	S042	S073	S027
Annelida	2	3	2	4	5	3	3	0	2	3
Arthropoda	6	1	0	3	2	1	1	3	1	2
Bryozoa	2	2	4	1	1	1	2	0	0	2
Bryozoa/Cnidaria	0	1	1	0	0	0	0	0	0	0
Chordata	1	2	1	0	2	1	1	2	2	1
Cnidaria	4	3	3	6	3	4	6	7	3	2
Echinodermata	1	2	3	0	0	0	0	0	4	1
Mollusca	1	0	0	0	0	3	0	0	0	0
Porifera	0	0	0	0	1	0	0	0	0	0
Total No. of Taxa	**17**	**14**	**14**	**14**	**14**	**13**	**13**	**12**	**12**	**11**

Figure 47 Site photo still from S066 showing circalittoral fine sand with Caridea, Paguridae, Gastropoda, Urticina sp., Idotea sp, Scalpellum sp.

5.12.1 Non-Colonial Epibenthic Fauna in Site Stills

The total relative abundance of the number of individuals recorded from the different phyla from the grab site stills is presented in Figure 48.

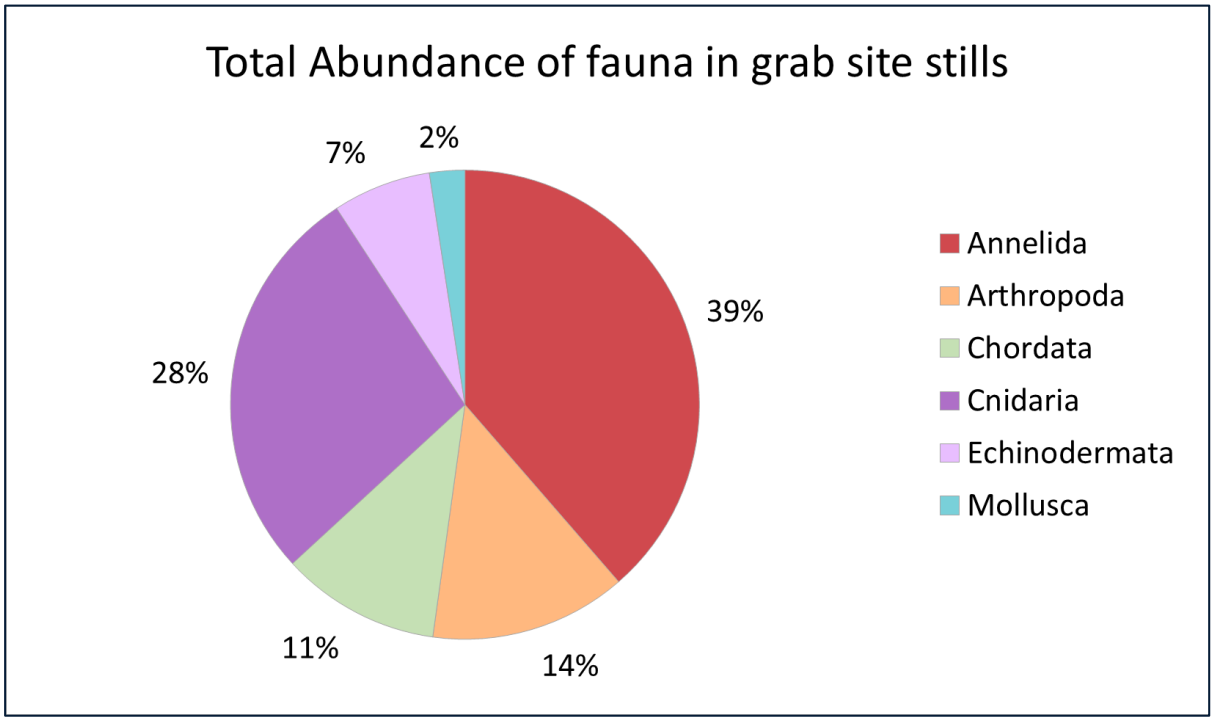


Figure 48 Total relative abundance of non-colonial fauna in grab site stills.

The average abundance of individuals per square meter for each grab site and phyla are presented in Figure 49.

The abundance varied from zero individuals per square meter (ind./m^2) to 30 (ind./m^2) (S029). The average abundance was 8 (SD=7.745) (ind./m^2).

The most abundant phyla in the site stills were Annelida, which represented 39 % of all individuals recorded in the stills. Most of the abundance was represented by *Lanice conchilega*, which constituted 38 % of the total abundance of fauna in the grab site stills. Four additional taxa of Annelida were recorded in the stills i.e., *Aphrodita aculeata*, *Spirobranchus triqueter*, Serpulidae and Polychaeta.

The second most abundant phylum was Cnidaria, of which *Epizoanthus sp*. constituted the majority.

The Arthropoda phylum comprised mainly of different species of Paguridae, and Chordata's most dominating taxa were Pleuronectiformes (juveniles).

The sand mason worm, *L. conchilega* was the overall most abundant and common species, with a total of over 1234 individuals per metre square in the site stills. *L. conchilega* was recorded in 30 % of the stills. The largest number of *L. conchilega* was observed at site S029 with an average of 67 (ind./m^2) per site still.

The second most common taxa were juvenile Pleuronectiforms. It had the largest abundance at site S039, with an average of 5 (ind./m^2) in stills where it occurred. Overall, it was recorded in 11 % of the site stills.

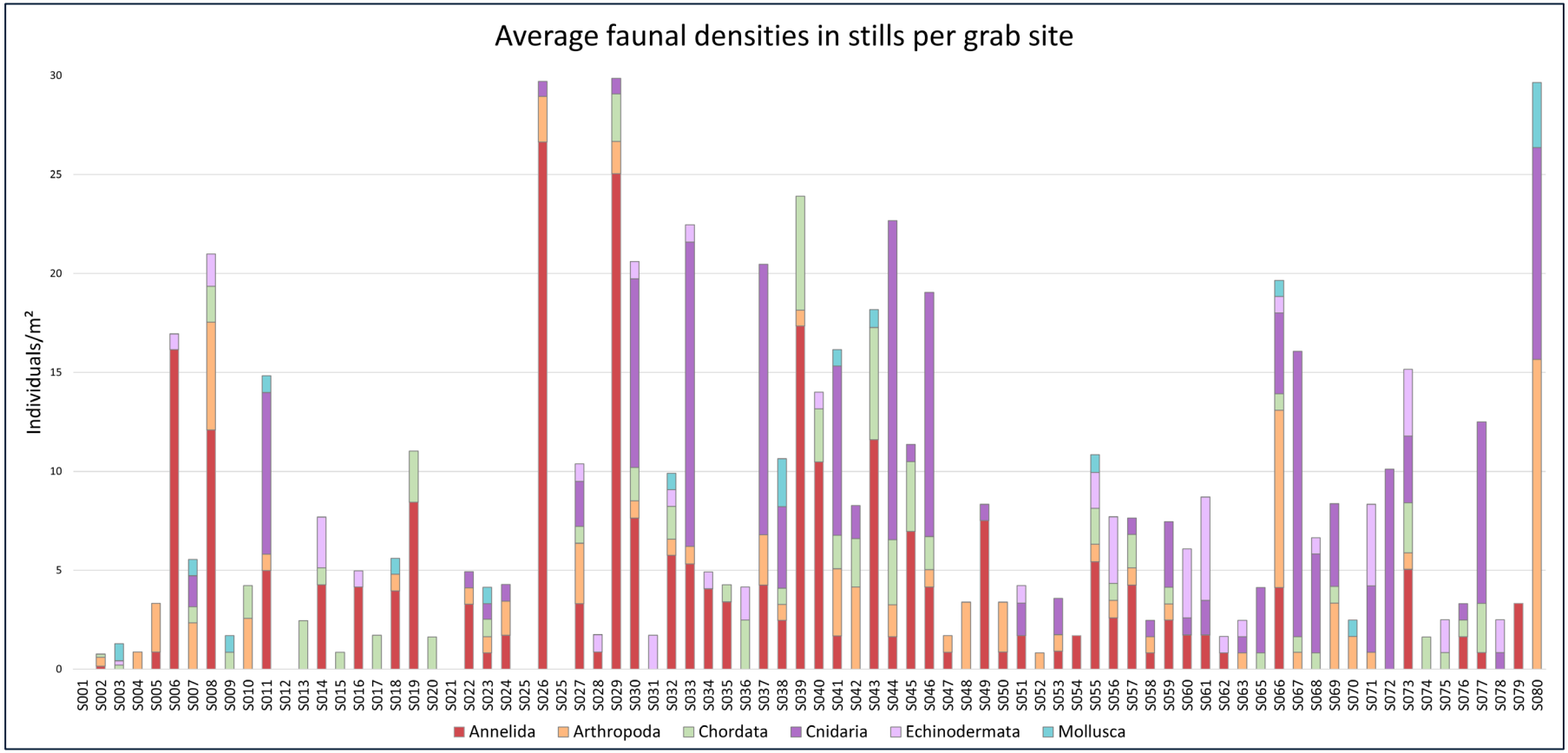


Figure 49 Average faunal densities from (individuals/m²) in stills per grab sample site.

5.12.2 Colonial Epifauna from Site Stills

The total relative coverage of colonial species, recorded from the different phyla from the grab site stills is presented in Figure 50. The average coverage of colonial species in the grab sites is presented in Figure 51.

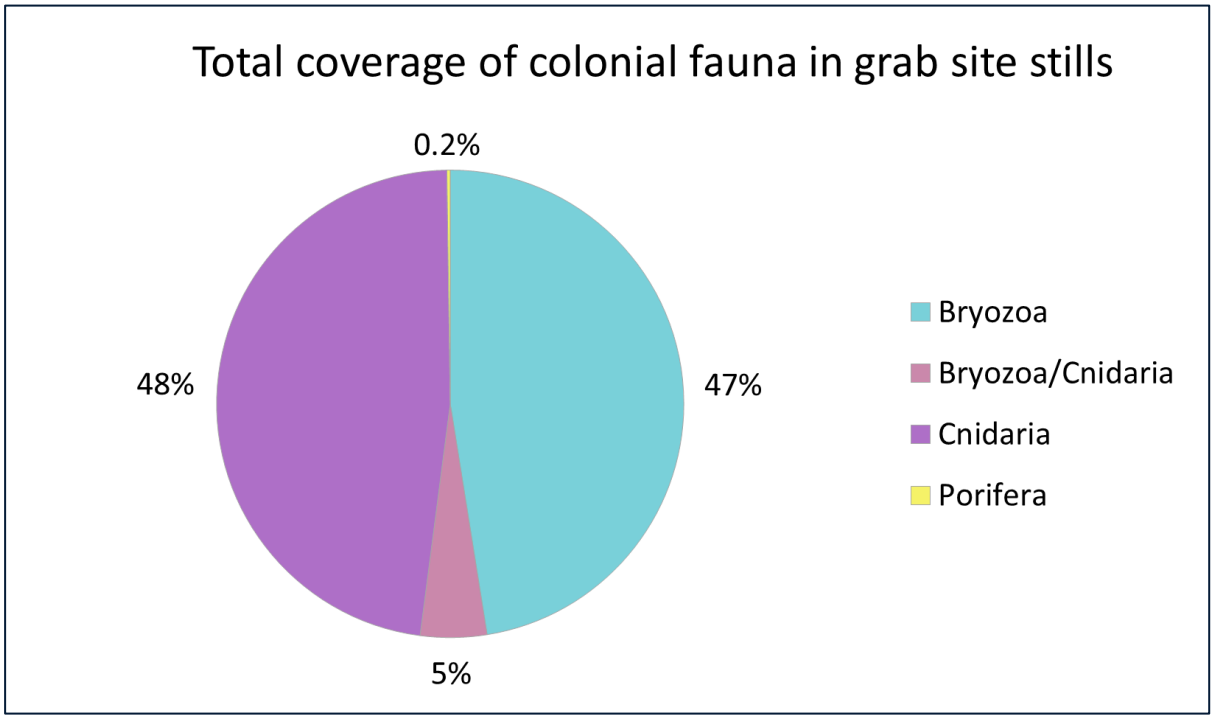


Figure 50 Total coverage of colonial fauna in grab site stills.

The phylum Cnidaria represented the phylum with taxa covering the largest surface area, with a total contribution of 48 %. Bryozoa and Bryozoa/Cnidaria contributed 47 % and 5 % of the recorded taxa respectively, followed by Porifera with 0.2 %.

The coverage of colonial epifauna varied between 0 % to 6 % (S018). The average cover of epifauna was 0.9 % ± 1 %.

Cnidarians were presented at 44 sites out of the total 80 sites. A range of indistinguishable species of hydrozoans were the most common cnidarians, recorded in 7 % of all the 400 site stills. Sites S044 had the highest coverage of hydrozoans.

Bryozoans were recorded at 38 of the 80 sites. The most common taxa overall were *Flustra foliacea*, which appeared in 9 % of all the stills. It had average coverage of 2 % of the seabed in the stills where it was recorded.

Many turf-forming hydrozoan and bryozoan species had a morphology that made it hard to discriminate species from each other and was therefore merged into the combined taxa “Bryozoan/Hydrozoan turfs”. It had average coverage of 2 % and occurred in 1 % of all the site stills.

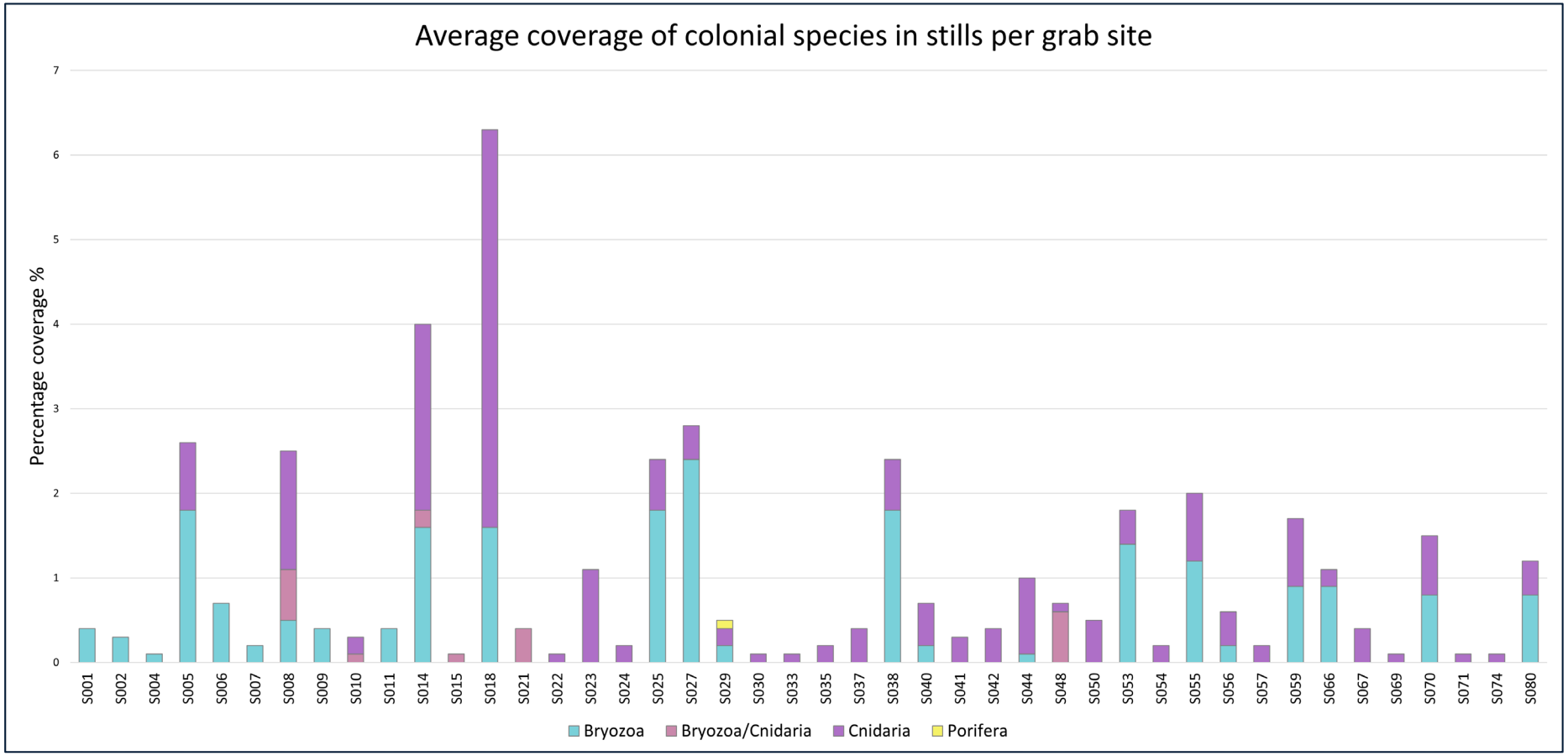


Figure 51 Average percentage coverage per square meter by colonial taxa in stills per site.

5.13 Notable Taxa

5.13.1 Non-Native Taxa

No non-native species were identified during the survey.

5.13.2 Rare Taxa

Two species previously not formally recorded in the UK were identified during the survey (Table 37).

Table 37 Species not formally recorded in the UK were identified during the survey.

Species not Formally Recorded in the UK	Grab Sample	Abundance / 0.1 m^2
Cirratulus caudatus	S044, S061	1, 1
Paradoneis ilvana	S010, S023, S070	1, 1, 2

5.14 Potential Areas and Species of Conservation Importance

No **Annex I** features, as described within the Habitats Directive (EUR 28, 2013).

A total of 13 different taxa were identified as species of conservation importance from the video, still photos from grab sites, trawl transect and grab sample sites. The spatial distribution of the identified species of conservation importance can be seen in Figure 52.

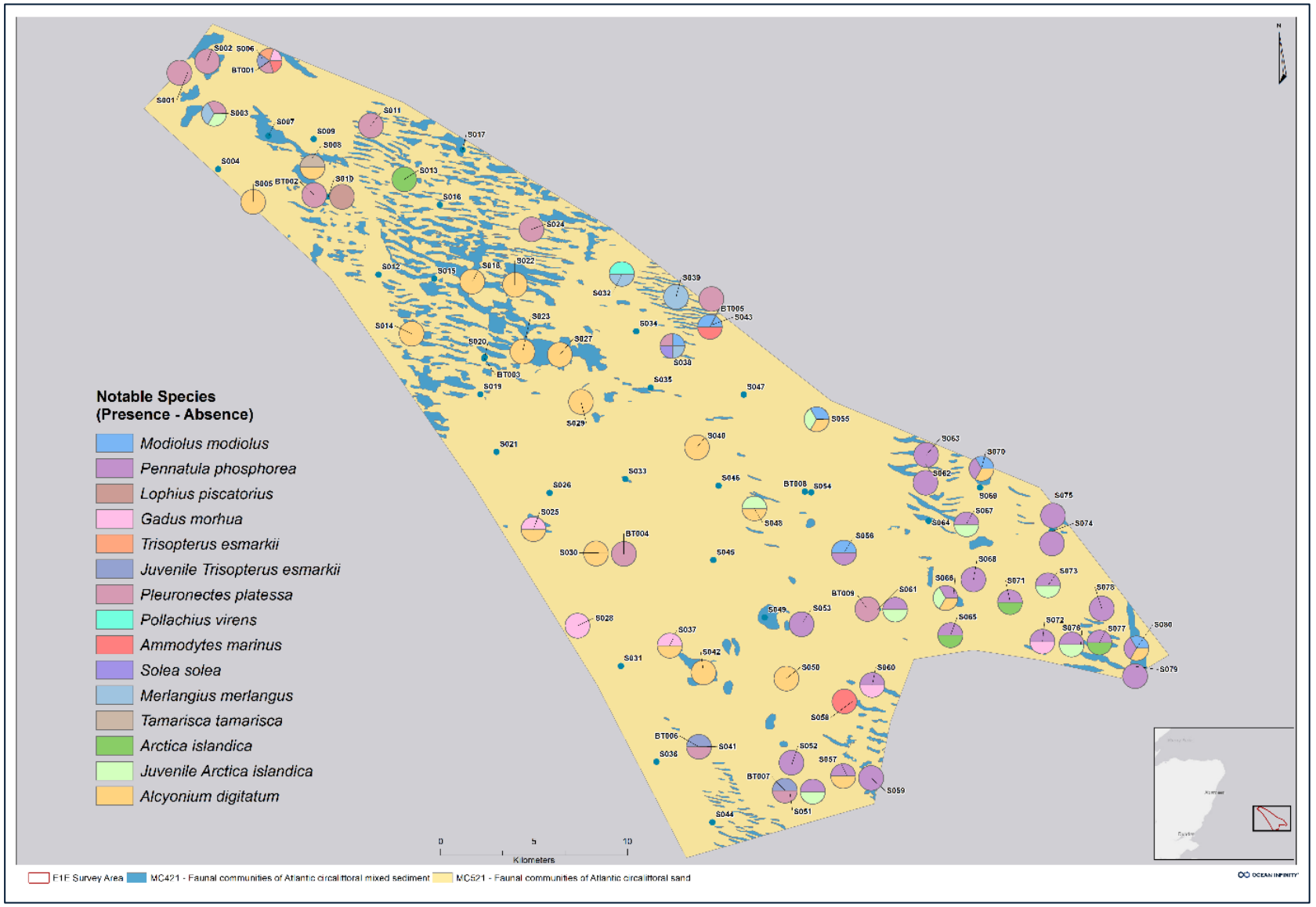


Figure 52 Overview of the Notable Species (Presence-Absence) in the survey area.

Offshore Subtidal Sands and Gravels (PMF)& Subtidal Sand and Gravels (SBL)

The PMF habitat Offshore subtidal sands and gravels and SBL habitat Subtidal sands and gravels were both identified across most of the survey area and grab sample sites. Offshore subtidal sands and gravels are one of the most commonly occurring PMF habitats around the UK coast. Similarly, subtidal sands and gravels are the most commonly occurring SBL habitat around the UK coast and throughout the North Sea (Brig, 2008 (Updated Dec 2011)).

The EUNIS habitats corresponding to these habitats are **MC521** - Faunal communities of Atlantic circalittoral sand, **MC5211** - *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand, and **MC5212** - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand.

Horse Mussel Beds (PMF, OSPAR & SBL)

Individuals of adult horse mussels *Modiolus modiolus* were identified in the video and still photos from grab sites S038, S055, S056, S070, and S080, as well as in the sample from trawl transect BT005.

No *M. modiolus* beds (reefs) were identified within the survey area.

Sea-Pen and Burrowing Megafauna (OSPAR) & Burrowed Mud (PMF)

The sea pen *Pennatula phosphorea* was identified in the video and still photos from grab sites S051 - S053, S056, S057, S059 - S063, S065 - S068, and S070 - S080. The species is characteristic of the OSPAR habitat Sea-Pen and Burrowing Megafauna, and PMF habitat Burrowed Mud. The absence of frequent burrows or mounds and the absence of other key components such as Norway lobster *Nephrops norvegicu* in addition to the more overall sandy composition of the seabed within the survey area, indicates neither of the habitats is present.

Anglerfish (PMF & SBL)

Adult anglerfish *Lophius piscatorius* was identified in the video and still photo from grab site S010.

Cod (PMF, OSPAR & SBL)

Juvenile cod *Gadus morhua* was identified in the sample from trawl transect BT001, and the video at grab sites S025, S028, S037, S060, and S072

Norway pout (PMF & SBL)

Adult Norway pout *Trisopterus esmarkii* was identified in the samples from trawl transect BT001 and juvenile *T. esmarkii was* identified at trawl transects BT001, BT006, and BT007

Plaice (SBL)

Adult plaice *Pleuronectes platessa* was identified in the samples from trawl transects BT001. BT002, BT004, BT006, BT007, and BT009. *Pleuronectes platessa* was also identified in the video and still photo from grab sites S001, S002, S003, S011, S024, S038, and S043.

Saithe (PMF)

Adult saithe *Pollachius virens* was identified in the video at grab sample site S032.

Sand eels (PMF & SBL)

Adult sand eel *Ammodytes marinus* was identified in the samples from trawl transects BT001 and BT005. Sand eel *Ammodytes* sp. was also identified in the grab sample, from the second attempt, at grab sample site S058. The specimen was returned to sea.

Sole (SBL)

Adult sole, likely *Solea solea,* was identified in the video from grab sample site S038.

Whiting (PMF & SBL)

Adult whiting *Merlangius merlangus* was identified in the video from grab sites S003, S032, S038, and S039.

Hydroid Tamarisca tamarisca (SBL)

The hydroid *Tamarisca tamarisca* was identified in the samples acquired at grab sample site S008.

Ocean quahog (PMF & OSPAR)

Adult ocean quahog *Arctica islandica* was identified in the grab samples at sites S013, S071, and S077. Juvenile *A. islandica* were identified in the samples from grab sites S003, S048, S051, S055, S061, S066, S067, S073, and S076. Additionally, fragments of adult *A. islandica* were identified in the sample from grab site S065.

A total of 3 adults and 10 juveniles were identified in the grab samples across the survey area. *A. islandica* is typically found in sand/ sandy mud habitats from the low intertidal zone to 400 m throughout the North Sea. The habitats where *A. islandica* was identified were all circalittoral sand (EUNIS classifications MC5211 and MC5212).

Octocorallia (SBL)

Two species of Octocorallia were identified. The first species was dead man's fingers *Alcyonium digitatum*, which was identified in the video and still photos from grab sites S005, S008, S014, S018, S022, S023, S025, S027, S029, S030, S037, S040, S042, S048, S050, S055, S057, S066, S070, and S080. The second species was the sea pen *P. phosphorea*, which was identified in the video and still photos from grab sites S051 - S053, S056, S057, S059 - S063, S065 - S068, and S070 - S080.

5.14.1 Habitats Directive

Stony Reefs

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

Biogenic Reefs

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

6. Discussion

The sample acquired at grab sample site S008 had a rock caught in the jaws of the grab which could have led to much of the finer sediment being washed out, in turn leading to a higher percentage of coarser sediment. This could explain why the site is an outlier in the PCA plot, which shows the site has a higher content of gravel compared to the other sites (Figure 24).

Biomass varied between grab sampling sites which can be seen in Table 32. Six (6) major phyla were identified, where Echinoderms dominated the blotted wet weight composition with a total of 65 %. The dominant contribution of Echinoderms in the measures of biomass is most likely due to the highly influenced species *Spatangus purpureus* and *Echinocardium cordatum* occurring at several grab sampling sites.

Species richness, as well as diversity and evenness, presented relatively low variation between grab sample sites, which can be seen in the indices listed in Table 12. The low variation seen in the univariate indices could partly be explained by the limited variation in the sediment composition.

The SIMPROF analysis produced three (3) statistical groups. A large majority of the grab sample sites were included in group C, which indicates large in-between site homogeneity. The main driving factor for the faunal community is likely the sediment composition of gravel and mud, which is explained in the BEST analysis.

The majority of the sampled sites share components, to a varying degree, of both **MC5211** - *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand and **MC5212** - *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand.

As the E1E survey area is mainly featureless, a full delineation of habitat boundaries proved challenging. There is minor variation in the sediment composition at the respective sites, and the species composition is overlapping, with some variation in composition and abundance between the sites. Thus, the overall area has been delineated at a lower level as **MC521** - Faunal communities of Atlantic circalittoral sand, and **MC421** - Faunal communities of Atlantic circalittoral mixed sediment.

Each of the grab sample sites was further classified individually and to a higher level where possible. It was deemed most appropriate to present these high-level classifications overlaid on the extrapolated lower-level classifications.

7. Conclusion

A total of 80 grab sample sites and 10 epibenthic trawl transects were surveyed as part of the Environmental Survey for the SSE ScotWind project, located 100 km east of Montrose, Scotland. A total of four (4) EUNIS habitats were identified within the survey area.

The PMF habitat Offshore subtidal sands and gravels and the SBL habitat Subtidal sands and gravels were identified within the survey area. These two habitats fully overlap each other within the survey area. Horse mussel *M. modiolus* was identified at several locations but no beds/reefs were identified. The sea pen *P. phosphorea* was identified at multiple grab sample sites, but the closely associated OPSAR habitat Sea-Pen and Burrowing Megafauna and PMF habitat Burrowed Mud was not identified within the survey area.

Thirteen species of conservation importance were identified within the survey area.

The sediment composition had limited variation across the survey. Sand was the dominant sediment fraction at all grab sample sites. The PCA mainly grouped the sites based on the sand to gravel ratio and a lesser extent on mud content.

Metal concentrations were generally low, with the NEA's class 2 – Good threshold value being marginally exceeded for arsenic at grab sample site S002. Total organic- and total carbon content varied across the survey area and increased towards the southern and eastern ends of the survey area. Hydrocarbon content was low and variable, with the NEA's class 2 – Good threshold for the sum of the 16 EPA PAH congeners exceeded at site S051. Concentrations of hydrocarbons were generally higher in the southern and eastern sections of the survey area.

Levels of PCBs, DBT and TBT were below the detection limit at all grab-sampled sites.

The phyletic composition of the non-colonial fauna identified from the trawl samples, regarding both the total number of taxa and the abundance was dominated by arthropods, with a total abundance of 699 individuals.

The non-colonial and sessile colonial epifauna species' total biomass was dominated by chordates with 67 % of the total biomass. The total fauna biomass varied between 0.0 g in sample BT010, to 1860.82 g in sample BT001. The mean biomass across all sites was 4362.29 g/ sample (SD=550.61).

The most abundant taxon of fish species was the adult *Hippoglossoides platessoides* with a total abundance of 11 individuals recorded and with a total biomass of 466.0 g in the trawl samples. The phyletic composition of sessile colonial epifauna was dominated by cnidarians regarding both the total number of individuals and the abundance of colonies.

The phyletic composition from grab samples, regarding both the total number of taxa and abundance, was dominated by annelids, and the two most abundant taxa were the annelids *Lanice conchilega* and *Spiophanes bombyx*. *Lanice conchilega* had a total abundance of 1064 individuals and occurred in 91% of the grab samples.

The biomass was dominated by echinoderms at 65% of the total biomass, followed by molluscs at 28%. Non-colonial fauna biomass varied between 0.129 (g/0.1 m^2) in sample S064, to 61.936 (g/0.1 m^2) in sample S061. The mean biomass across all sites was 7.005 (g/0.1 m^2) (SD=13.952).

Species richness, Shannon-Wiener index, Evenness and Dominance presented low variation across the grab samples. The number of taxa (S) and the number of individuals (N) varied between 14 - 34 taxa and 28 - 143 individuals/0.1 m^2, respectively per grab sample site. The SIMPROF analysis of the non-colonial faunal composition produced three (3) statistically distinct groups. The sample similarity explored in the nMDS-plot presented a stress value of 0.21.

In addition, the SIMPROF analysis conducted separately with square root transformation produced five (5) statistically distinct groups. The sample similarity explored in the nMDS-plot for the square root transformed dataset presented a stress value of 0.27.

Results from the BEST test, indicate that gravel and mud together constituted the variables that best explained the observed pattern of spatial distribution for fauna (rho = 0.292, P = 0.1 %) and was statistically significant variables for the distribution of the fauna.

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

The most abundant non-colonial epibenthic fauna identified in the visual survey was Annelida with a total abundance of 39 %, followed by Cnidaria with 28 %. The abundance varied from zero individuals per square meter (ind./m2) to 30 (ind./m2) (S029). The average abundance was 8 (SD=7.745) (ind./m^2).

The grab sampling site S066 presented the greatest species diversity from the analysis of the stills, with a total of 17 taxa.

The phylum Cnidaria represented the phylum with taxa covering the largest surface area, with a total contribution of 48 %. Bryozoa and Bryozoa/Cnidaria contributed 47 % and 5 % of the recorded taxa respectively, followed by Porifera with 0.2 %. The coverage of colonial epifauna varied from 0 % to 6 % (S018). The average cover of epifauna was 0.9 % ± 1 %.

8. Reservations and Recommendations

The results detailed within this report are based on the data derived from the faunal grab sample-, epibenthic trawl-, sediment- and contaminant analyses, as well as photo and video recordings. The data has been reviewed in conjunction with the geophysical data and interpretations.

It should be taken into account that there is a natural limitation in the accuracy of interpretations. Where considered applicable, the sampling results have been extrapolated to constitute a base for verifications also in the surroundings.

The definition of a “Reef” is not defined within the EC Habitats Directive. Areas interpreted as potential stony reefs in this report are based on methods defined in the JNCC report No. 432 “The identification of the main characteristics of stony reef habitats under the Habitats Directive” (Irving, 2009).

The PSA samples acquired at grab sample sites S008 and S025 comprised washed-out samples and low sample volume, respectively. The samples were included in one of the two datasets used for the multivariate analyses. The samples were included to give a better understanding of the similarities and dissimilarities between the grab sample sites.

9. References

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Appendix A Geophysical Sites Overview

Appendix B Sample Position List

Appendix C Grab Field Protocols

Appendix D Epibenthic Beam Trawl Field Protocols

Appendix E Photo Identification Results

Appendix F Grab Identification Results

Appendix G Epibenthic Beam Trawl Results

Appendix H Particle Size Analysis Results

Appendix I Contaminants Analyses Results

Appendix J GIS Database