Natura Impact Statement

NISA
North Irish Sea Array

Volume 2: Appendices

Appendix 5
Array Area Benthic Survey Report

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NISA Benthic Ecology Baseline

Array Area Benthic Survey Report

17 August 2022

Statkraft

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Acronym	Definition
ANOSIM	Analysis of Similarity
ANOVA	Analysis of Variance
BGS	British Geological Society
DDV	Drop Down Video
DGPS	Differential Geographic Positioning System
EIAR	Environmental Impact Assessment Report
EMODnet	European Marine Observation and Data Network
GIS	Geographic Information System
GPS	Global Positioning System
LOI	Loss on Ignition
JAMP	Joint Assessment and Monitoring Programme
MEDIN	Marine Environmental Data and Information Network
MNCR	Marine Nature Conservation Review

Acronym	Definition
NMDS	Non-Metric Multi-dimensional Scaling
NIS	Natura Impact Statement
NISA	North Irish Sea Array
NISA Ltd	North Irish Sea Array Windfarm Limited
NMBAQC	National Marine Biological Analytical Quality Control
OSPAR	Oslo and Paris Conventions
OWF	Offshore Wind Farm
PAH	Polyaromatic Hydrocarbons
PSA	Particle Size Analysis
SACFOR	Super Abundant, Abundant, Common, Frequent, Occasional, Rare
SIMPER	Similarity Percentages Breakdown
SIMPROF	Similarity Profile Analysis
TDP	Taxonomic Discrimination Protocol
THC	Total Hydrocarbon Content
TOC	Total Organic Carbon
WoRMS	Word Register of Marine Species

1. Introduction

1.1. Project Background

North Irish Sea Array Windfarm Limited (NISA Ltd) are pursuing the development of an Offshore Wind Farm (OWF) located between 7-17km off the coast of the counties of Dublin, Meath, and Louth in the Republic of Ireland. The proposed OWF once operational, would have the capacity to provide renewable energy for up to 500,000 homes.

Natural Power Consultants Ltd (Natural Power), were appointed to manage and execute the delivery of a benthic subtidal ecology survey covering the North Irish Sea Array (NISA) OWF array area. The purpose of the survey was to map and characterise the distribution and extent of marine benthic biological communities and habitats within the OWF array area to validate existing benthic ecology datasets and provide robust site-specific baseline characterisation to inform the Environmental Impact Assessment Report (EIAR) and Natura Impact Statement (NIS) consent requirements.

In December 2019, NISA Ltd submitted a Foreshore Licence application for site investigation works, which included benthic surveying of the OWF array as one of the planned work schedules to be licenced. The licence was granted on 1st October 2021 (licence number: FS007031), and Natural Power conducted the benthic survey between 1-4th May 2022.

1.2. Document Purpose

This report has been produced in order to provide NISA Ltd with the findings of the benthic subtidal ecology survey covering the NISA OWF array area in order to meet two specific objectives of the survey:

- To characterise the benthic subtidal environment that is present across the footprint of the NISA OWF array area; and
- To identify the occurrence and distribution of any habitats or species of conservation.

2. Baseline Benthic Survey Methodology

2.1. Summary of Existing Data

Geophysical and geotechnical surveys of the NISA OWF array area were not available to inform the scope of the benthic surveys and therefore the survey design was based on publicly available data. A desk-based review of benthic ecology literature and publicly available data sources were reviewed by Natural Power to assist with survey planning and are summarised below.

In 2009, the Irish Sea Marine Assessment was conducted using geophysical data (multibeam echo sounder and shallow seismic survey) and ground-truthed samples (surface grabs and shallow cores) to create broadscale habitat maps. This data identified two potential broadscale sediment habitats within the OWF array area: sandy mud to muddy sand, and sand substrates. A review of Folk data (British Geological Society (BGS)) showed potentially more patchiness in the seabed conditions, indicating coarser substrates within the OWF array area, including gravelly muddy sand and gravelly sand.

2.2. Survey Design

Prior to designing the survey, a desktop study was undertaken to ensure sampling stations avoid any existing seabed artefacts such as known wrecks. The following publicly available seabed habitat and sediment type datasets were reviewed:,

- BGS Folk Sediment Classifications (1989);
- INFOMAR Seabed Substrate (2018);
- EUSeamap Substrate Type (2019);
- EUSeamap MSFD Benthic Broad Habitat Types (2021); and
- EMODnet Bathymetry Mean Depth.

This review identified four potential sediment types within the survey area and sampling stations were derived using a random stratified sampling approach for each of the substrate types identified as follows:

- 15 stations in sand;
- 15 stations in muddy sand;
- 5 stations in gravelly sand; and
- 5 stations in gravelly muddy sand.

20 Drop Down DDV (DDV) transects were identified for the south-west corner of the survey area, where EU SeaMap Substrate Type (2019) indicated an area of coarse sediment where benthic grabbing may not have been feasible and a cluster of five benthic grab stations, were placed close together in a small area in the south-east section of the site where BGS Folk data (1989) suggested the sediment was gravelly Sand (Figure 2.1)

The offshore survey was carried out using the vessel *Husky* operating out of Howth harbour. Envision Marine Ltd were subcontracted by Natural Power to provide and operate the DDV equipment. A detailed Risk Assessment and Method Statement (RAMS) was produced outlining the Health and Safety arrangements in place to ensure a safe system of work whilst undertaking the contracted survey work. The benthic survey campaign, including survey design and analysis was produced in line with the Department of Communications, Climate Action & Environment Guidance (2018).

2.3. Benthic Grab Survey Methodology

The grab survey was undertaken at 40 sampling stations in the survey area, in order to collect information on the physical nature of the seafloor and the composition of the infauna, as per Limpenny *et al.,* (2010), Coggan *et al*., (2007), and JNCC Marine Monitoring Handbook Procedural Guidance 3.5 (2001).

Benthic sampling was undertaken using a 0.1 m^2 Day grab. At each sampling station the grab was deployed, and once fired on the seabed, recovered. After successful grabs were recovered, providing each grab sample was deemed acceptable by the lead surveyor (according to the relevant protocols), the samples were fully described (sediment and biological characterisation) and a photograph taken. Up to three failed attempts per sampling station were allowed, prior to abandoning the sampling station. The sample was deemed unacceptable if; the sample represented less than half the total capacity, the grab had not struck the seabed in a flat area resulting in an incomplete sample, or the grab jaws were not fully closed. All locations where a grab failed were recorded using GPS positions.

At each station a separate grab was deployed for collecting samples for Particle Size Analysis (PSA), Total Organic Carbon (TOC) and contaminants analysis, from an undisturbed sediment surface. Samples were taken with the appropriate metal or plastic scoop and transferred to appropriate containers for transportation in a cool box prior to analysis. The samples were stored in accordance with the guidelines for sampling / storage of sediments for chemical analyses (from OSPAR JAMP guidelines for monitoring contaminants in sediments) (Cronin *et al*., 2006).

Each acceptable benthic fauna sample was sieved on board through a 1 mm sieve, larger rocks/shells were placed directly into the sample pot. The sieved residues were then gently backwashed into sealable containers and preserved by adding borax buffered 4-5% saline formalin solution. Each sample was labelled clearly on the lid and an additional waterproof label placed in the container which recorded the client, survey name, date, area, station number and grab number.

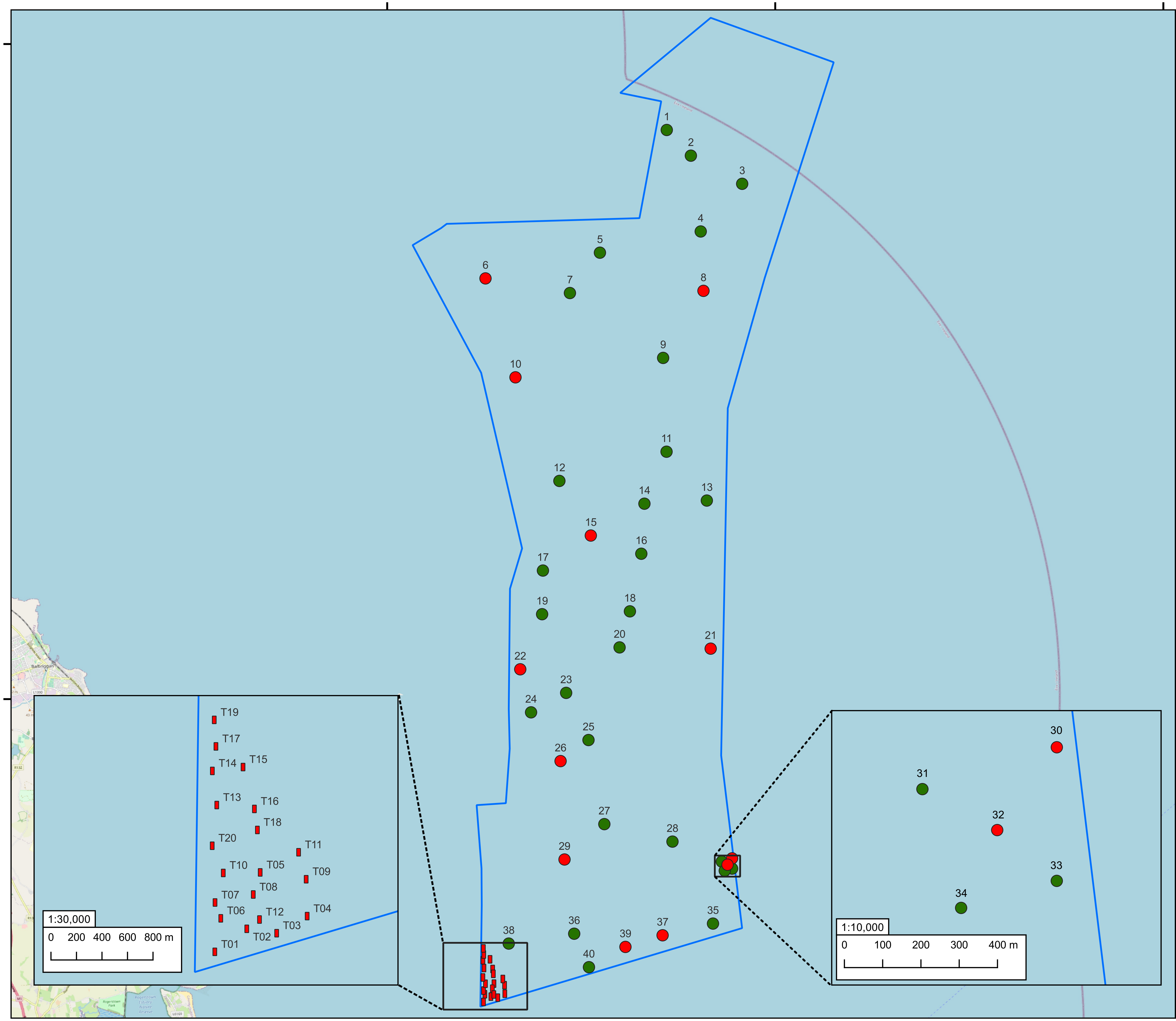
On successful completion of the work at that sampling station, the vessel moved to the next station where the procedure was repeated until all stations were sampled. A full survey log was maintained throughout the survey detailing time of sampling, GPS position, number of attempts required, station number, water depth, physical characteristics of the sample, digital image number and presence of any other relevant features. The benthic grab stations sampled during the survey are shown in Figure 2.1.

2.4. DDV Survey Methodology

DDV transects were conducted at 20 locations in the designated survey area using JNCC protocol (Davies *et al*., 2001) and the more current Epibiota Remote Monitoring from Digital Imagery: Operational Guidelines (Hitchin *et al*., 2015), with stations selected to cover all survey types and habitats.

The DDV survey utilised a combined DDV and digital stills camera system with appropriate lighting and strobe flash which could be deployed in either drop down or towed mode. The stills/DDV system was linked by umbilical to the surface to allow a real-time DDV feed (to ensure sufficient image quality was being attained) and external recording incorporating a Differential Geographic Positioning System (DGPS) overlay.

Surveys were undertaken during appropriate tides/weather conditions to allow optimum DDV capture. At each station, the immediate survey area was checked for obstructions e.g., static gear. The camera equipment was prepared for deployment while the vessel moved into position to start the drop. The vessel approached the sample location identified and positioned itself so that wind and tide caused the vessel to drift away from the camera whilst deployed.



Project:

North Irish Sea Array (NISA) Offshore Wind Farm

Title:

Figure 2.1: Benthic Grab Stations, DDV Stations and Transects Sampled

Key

- Site boundary
- Benthic grab station
- DDV and benthic grab station
- DDV transect

Scale @ A3: 1:130,000

Coordinate System: IRENET95 Irish Transverse Mercator
Graticules: WGS84

0 1.5 3 4.5 6 km

N

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The camera was lowered slowly to the seafloor to limit the disturbance to the seabed and to maintain underwater visibility and was approximately 50 cm-1 m above seabed over the course of a transect. Short DDV drifts were used along all sampling stations with DDV recorded along a minimum of 50 m length transects. The camera landed on the seabed a minimum of three times on each transect to capture still images a few metres apart and to enable an assessment of spatial variability. The DDV feed/image was reviewed as the data was collected to enable the confirmation of the quality of DDV and any seabed features recorded. An appropriate scaling system was incorporated into the camera system to allow an assessment of scale of the ecological features

Notes on the visible sediment conditions, seabed features and fauna were made in-situ together with DGPS position, water depth and date/time. Positions were fixed at the start and end of each deployment and a continuous log of GPS data was recorded whilst the camera was deployed. The camera was recovered to the vessel and the haul line was coiled into a box to ensure it did not tangle for any subsequent deployments and to avoid trip hazards. The vessel then moved to the next sampling station. Where tide and timescales allowed, the camera was also used to check suitability and ensure no Annex I (EU Habitats Directive 92/43/EEC) or sensitive habitats) were present at benthic grab stations. DDV stations and transects sampled are shown in Figure 2.1.

2.5. **Sample Analysis**

2.5.1. **Benthic Faunal Sample Analysis**

All biota was extracted and identified according to the National Marine Biological Analytical Quality Control (NMBAQC) Taxonomic Discrimination Protocol (TDP – Worsfold *et al*., 2010). Samples were washed with tap water through sieves to remove the preserving agent, with different sized sieves used to aid in sorting. To further aid sorting and to avoid damage to specimens, light organic matter and fauna were elutriated (floated off) and sorted separately. The larger retained contents were sorted in a white sorting tray, whilst the smaller fauna were sorted under a stereomicroscope.

Fauna were identified to the lowest taxonomic level practicable using appropriate keys and references and enumerated. Species that were present as juveniles were differentiated from adults where possible. Colonial organisms were recorded as present or absent. Broken or damaged specimens that may not be fully identified were described as ‘Taxa Indet.’ (indeterminate). Juvenile specimens not displaying adult characteristics necessary for identification to species were described as ‘Taxa juv.’, and groups not generally identified to species because of taxonomic or morphological reasons were recorded as Taxa sp.

2.5.2. **PSA and TOC Analyses**

PSA were determined to fractions ranging between <63 mm to >63 µm, using NMBAQC methodology which utilises stacked sieves for >1mm fraction and laser granulometry for the <1mm fraction. Sediment samples were processed through stacked sieves at particle size diameters of 0.5 phi intervals over the range 64 mm to 63 µm (Wentworth Scale), sieve sizes are provided in table 2.1. The sieves were shaken for 15 minutes, and the contents of each sieve subsequently weighed. Finer fractions (<63 µm) were oven dried and weighed as a separate fraction, with further laser diffraction analysis if this fraction is >5 % of the total sample.

The classification system used for sediment type and sorting index were carried out according to the methods of Buchanan *et al*., (2004). For reporting purposes, the PSA results per sampling station were expressed as a cumulative percentage of each particle size passing through each sieve. These percentages were then converted to absolute percentages retained on each sieve.

All samples were analysed for TOC) through Loss on Ignition (LOI) whereby each sample is weighed before being heated to a high temperature (105^{o}C) until all the carbon dioxide from carbonates is burned off and the sample is weighed again. The difference in weights is the LOI which is then converted to TOC using a conversion factor.

Table 2.1: Sieve sizes at 0.5 phi intervals.

Phi Value	Equivalent sieve size (mm)
-6	63
-5.5	45
-5	31.5
-4.5	22.4
-4	16
-3.5	11.2
-3	8
-2.5	5.6
-2	4
-1.5	2.8
-1	2
-0.5	1.4
0	1

Source: NMBAQC's Best Practice Guidance (nmbaqcs.org)

2.5.3. Contaminants Analyses

Samples were analysed for the Marine Institute full suite of analyses as detailed in the Material Analysis Reporting Form by a UKAS accredited laboratory and the results compared against Cefas Action levels and Canadian and Irish guideline levels, where levels exist for each contaminant (Appendix D).

2.5.4. DDV Imagery Analysis

DDV and still images were reviewed, processed and analysed in accordance with current guidelines, such as the standards for analysis in Visual Seabed Surveys (BS EN 16260:2012) and (Turner *et al*., 2016). The imagery has also been reviewed for features of conservation interest, including Annex I reef assessment following the appropriate JNCC guidance notes (Gubbay, 2007; Irving, 2009; Golding *et al*., 2020). The main purpose of the analysis of the imagery was to identify what fauna and broadscale habitats exist in a DDV record or still image, provide quantitative and semi-quantitative data and to note where one substrate type changes to another.

The DDV record was initially viewed rapidly in order to segment it into sections representing different broadscale habitats. At normal speed, the start and end points of each segment were logged, and each segment treated as a separate record and subsequently subjected to more detailed analysis. Brief changes in substrate type lasting less than 5 m were considered as incidental patches and were recorded as part of the habitat description, or as a 'habitat mosaic'.

The DDV footage was then viewed at normal or slower than normal speed, noting the physical and biological characteristics, such as substrate type and percent cover (in line with current guidelines), seabed character, conspicuous taxa and life forms along with any modifiers or visible impacts present. Taxa were identified to the most detailed taxonomic level possible and recorded with abundance counts for erect species and percent cover estimated visually for colonial/encrusting species, as well as categories based upon the Marine Nature Conservation Review (MNCR) Super-abundant, Abundant, Common, Frequent, Occasional, Rare (SACFOR) abundance scale. Where appropriate, any relevant features of conservation interest or Habitats Directive Annex 1 Habitats were noted at each sample location. Quantification of epifauna was performed manually for DDV analysis and recorded directly in a proforma spreadsheet.

Enumeration of taxa from still images was undertaken within BIIGLE, with abundance counts for solitary and erect taxa added as point annotations. Where percentage covers of colonial/encrusting taxa were recorded from still images, taxa were identified with point annotations in BIIGLE, and percentage cover categories (associated with SACFOR) added as a second label. Annotations from BIIGLE were exported in Excel spreadsheets and translated into the results proforma spreadsheet as required.

All data were recorded as each DDV clip or still image was analysed and an European Marine Observation and Data Network (EMODnet) /Marine Environmental Data and Information Network (MEDIN) compliant proforma spreadsheet was used to input imagery data and metadata, with reference to the latest species dictionary from the World Register of Marine Species (WoRMS) database.

A reference collection was built as the analysis progressed with good quality images for each taxon identified, noted and collated to aid consistency and quality of analysis, with the taxon or species clearly highlighted. In addition to a species/taxon reference collection, a habitat/biotope reference collection was also built with images and DDV clips of each habitat or biotope.

2.5.4.1. **Annex I Assessment**

The DDV footage has been reviewed and analysed in accordance with current guidance to identify any potential Annex 1 features. Where rock was recorded within DDV footage current assessment methods for biogenic or stony reefs were used (Turner *et al*., 2016, Gubbay, 2007; Irving, 2009; Golding *et al*., 2020).

2.6. **Data Analysis**

2.6.1. **Benthic Grab Analysis**

All data collected from surveys, including up to date species nomenclature in accordance with the WoRMs database, abundance, and physical parameters such as PSA, and depth were collated in excel spreadsheets. Based on PSA results, each sampling station was assigned a folk classification using the Folk Ternary diagram provided in the JNCC guidance (Parry, 2015). The percentage composition of gravel, sand and mud was calculated for each sampling station.

A suite of statistical analyses on the data collected from the grab survey work were undertaken using the “vegan” package in R, with some univariate indices calculated manually in R. General R packages used in the statistical analysis and production of outputs were: "tidyverse", "magrittr", "ggpubr","janitor","taxize","rstatix", "readxl","bookdown","pander","plotrix", "cluster", “clustig”, "factoextra", "ggrepel", "dendextend", and "patchwork".

2.6.1.1. **Univariate Statistics**

The following species diversity indices were calculated for the benthic infaunal and epibenthic species data:

- Number of Species (S): the number of species present in a sample, with no indication of relative abundances;
- Number of individuals (n): total number of individuals counted;
- Species Diversity - Shannon-Wiener index (H’): measures the uncertainty in predicting the identity of the next species withdrawn from a sample;
- Species Richness - Margalef’s index (d): a measure of the number of species present for a given number of individuals. The higher the index, the greater the diversity;
- Simpson’s indexes (1-λ): a measure of the probability of choosing two individuals from a sample that are different species. D = 0 (minimum diversity), D = 1.0 (maximum diversity); and
- Pielou’s evenness (J’): shows how evenly the individuals in a sample are distributed. J’ is a range of zero to
- one. The less variation in the samples, the higher J’ is.

- These univariate indices enable the reduction of large datasets into useful metrics, which can be used to describe community structures.

2.6.1.2. **Multivariate Statistics**

Multivariate analysis is an effective method for detecting subtle changes in benthic community datasets. Multivariate analysis was undertaken in R, on the whole dataset, including individual replicates. Due to the partially skewed nature of the fauna data, and its varying abundances, a square root transformation was applied to normalise the data distribution, reducing dominant effects of highly abundant taxa.

A Bray-Curtis resemblance matrix was applied to the transformed infaunal data. Non-Metric Multidimensional Scaling (NMDS) plots were produced to examine the similarity between sampling stations. The similarity profile analysis (SIMPROF) routine was utilised to determine the statistically significant groups (i.e., samples that would naturally group as communities). One-way Analysis of Similarity (ANOSIM) revealed whether there were any statistically significant results and, if significant, the Similarity Percentages (SIMPER) was used to provide information on the main species driving the groupings, which would aid in determining community structure and biotopes.

2.6.2. **Biotope Assignment**

Infauna survey results groupings and characterising species were identified through the SIMPROF, NMDS and SIMPER analyses and these were used in combination with the PSA results and physical characteristics (such as depth and zone) to classify the grab sample station biotopes according to the Marine Habitat Classification for Britain and Ireland (Connor *et al*., 2004).

DDV samples were assigned habitat classifications based on species present according to the most current classification. Where appropriate, broadscale habitats, Features of Conservation Interest or Habitats Directive Annex I Habitat were also assigned to each sampling station and still image. Guidance notes provided by JNCC report 546 (Parry, 2015) were used to assist this process.

Infauna (grab) and epibenthic (DDV) biotope classifications were incorporated into an Excel spreadsheet alongside physical characteristics such as depth and PSA, and final benthic habitats assigned to each sampling station. The majority of infauna and epibenthic habitat assignment at a sampling station were consistent or complimentary. At the DDV transect stations, where no benthic grabs were taken, the DDV classification was carried forward. Classification was supported by use of JNCC comparative tables and guidance (Parry M.E.V. 2019).

3. Results

The benthic survey campaign was carried out between the 01st May 2022 and the 4th May 2022. A total of 40 grab stations, 12 DDV stations where benthic grabs were collected and 20 DDV transects where no benthic grabs were taken (Figure 2.1). Field logs are provided in Appendix A.

3.1. DDV and Stills

A total of 12 DDV samples were collected from 12 sample stations where grab samples were also being taken and a total of 54 still images were captured from the DDV footage. DDV footage was also collected from 20 transects, with an associated 100 still images captured from the DDV footage.

The results from the analysis of the DDV footage and still imagery showed that the seabed at all stations were comprised of soft sediments with a notable silt component. The majority of the NISA Array site was recorded as the broadscale habitat 'Subtidal Mud', with burrows (including *Nephrops* burrow systems) observed, particularly within the northern sector of the area. Very little epifauna was observed in this area, with mainly starfish (*Asterias rubens*), brittle stars (*Ophiuroidea*) and fish (*Pleuronectiformes, Callionymidae*) recorded, and fewer instances of crustacea, pycnogonids and seapens (*Virgularia mirabilis*).

Stations within the southern sector of the Array area, including all 20 transect sample stations, had elevated levels of coarse sediments (mainly shell) which in combination with the silt component allowed them to be attributed as 'Subtidal Mixed Sediment'. Epifauna was more abundant at these locations, with higher numbers of starfish (*Asterias rubens, Luidia ciliaris*), brittle stars (*Ophiuroidea*) and fish recorded (*Triglidae, Gadidae, Pleuronectiformes, Callionymidae*), as well as bivalves (*Pectinidae*), tube worms (*Sabellidae, Chaetopteridae*), anemones (*Metridium senile, Actiniaria, Ceriantharia*) and crustacea (*Brachyura*). The larger pieces of coarse sediment or shell also provide a hard substrate which sessile epifauna such as hydroids, bryozoans and anemones can colonise.

The imagery collected during the DDV survey of the NISA Array site has been reviewed and no Annex I features were identified. DDV sample station images and stills and DDV analysis proformas can be found in Appendix C.

3.2. Infauna

In total 2,335 individuals were found within the infaunal samples, representing 162 taxa, the full species list are provided in Appendix F. The most abundant species across the survey area was the bivalve *Abra sp* which was present within 60% of the sampling stations, followed by *Abyssoninoe hibernica*, present in 47.5% of sampling stations and *Abra nitida*, present in 30% of stations (Table 3.1).

Table 3.1: Ten most abundant species and stations at which they were present.

Species	Total abundance	Stations
Abra	98	4,6,7,9,10,12,14,15,16,17,18,20,21,22,23,27,28,30,31,32,33,34,35,38
Abra nitida	51	9,11,12,14,15,16,17,18,20,21,23,30
Abyssoninoe hibernica	67	1,2,3,4,6,7,8,9,10,11,12,13,14,15,16,17,18,20,21
Amphiura filiformis	233	19,22,23,24,25,26,27,28,29,30,31,32,34,35,36,37,38,39,40
Amphiuridae	293	19,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40
Antalis entalis	76	22,23,24,25,26,27,28,29,32,33,34,35,37,38,39,40
Balanomorpha	52	25,36
Diplocirrus glaucus	122	6,10,11,12,14,15,16,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,35, 36,37,38,39,40
Kurtiella bidentata	96	19,22,23,24,25,26,27,28,30,32,33,34,35,36,37,38,40
Phoronis	92	14,19,22,23,24,25,26,27,29,30,31,32,33,35,36,37,38,39,40

3.2.1. Diversity

Number of taxa ranged from 3 (Station 3) to 38 (Station 22). Number of individuals ranged from 4 (Station 3) to 154 (Station 36). Richness ranged from 0.43 (Station 30) to 17.3 (Station 1). Evenness is high and relatively consistent across the array area, whereas Diversity, Richness, numbers of species and individuals are generally lower in stations to the north of the array area where the sediment has a higher silt concentration. Diversity results are shown in Figure 3.1 and Appendix B table B1.

3.2.2. Biomass

Taxa from all stations sampled were separated in the main faunal groupings for biomass measurements to be made. For each benthic grab faunal station, the biomass of each major faunal groups, as a proportion of overall biomass, is shown in Figure 3.2. Stations to the north of the array area tend to be dominated by Annelida (segmented worms), in the middle of the array area, where the sediment type contains slightly less fine mud fractions, higher proportions of Mollusca and Crustacea are found. To the south of the array area where the sediment is dominated by larger sand particle sizes, higher proportions of Echinoderms and Molluscs are found with smaller proportions of Annelida than stations to the north.

3.2.3. PSA and TOC

PSA was undertaken on a representative sample from each sampling station (Figures 3.3, 3.4 & 3.5;). There were two sediment types (Folk, 1954) across the survey area, the majority of stations in the south of the site were muddy sand and the majority of stations in the north of the site were sandy mud (Figure 3.4). Figure 3.5 also demonstrates the split in sediment types across the array area, with stations in the north having a higher proportion of silt (mud) and stations in the south having a higher proportion of sand.

TOC values for the majority of sampling stations were less than 1% with one exception (sampling station two) which had a value of 1.01% (Figure 3.3). Stations with a higher proportion of sand to silt had lower %TOC than stations dominated by silt. The full list of the percentages of each particle size for each sample is provided in Appendix F.

3.2.4. **Contaminants**

At all stations samples were collected and analysed for a range of contaminants. Contaminants levels were assessed against Irish (Cronin *et al.,* 2006), Canadian (CCME, 2001) and Cefas action levels. When assessed against Irish and Canadian guidelines, no contaminants were above the Category 2 levels upper or lower limits. When assessed against Cefas guidelines, levels of Chromium were slightly above action level one (AL1), however none were above action level two (AL2). For polyaromatic hydrocarbons (PAH); Station 6 had an Acenapth slightly above AL1 but not above AL2. No other contaminants assessed were above Cefas AL1 or AL2. A full breakdown of contaminant results can be found in Appendix D.

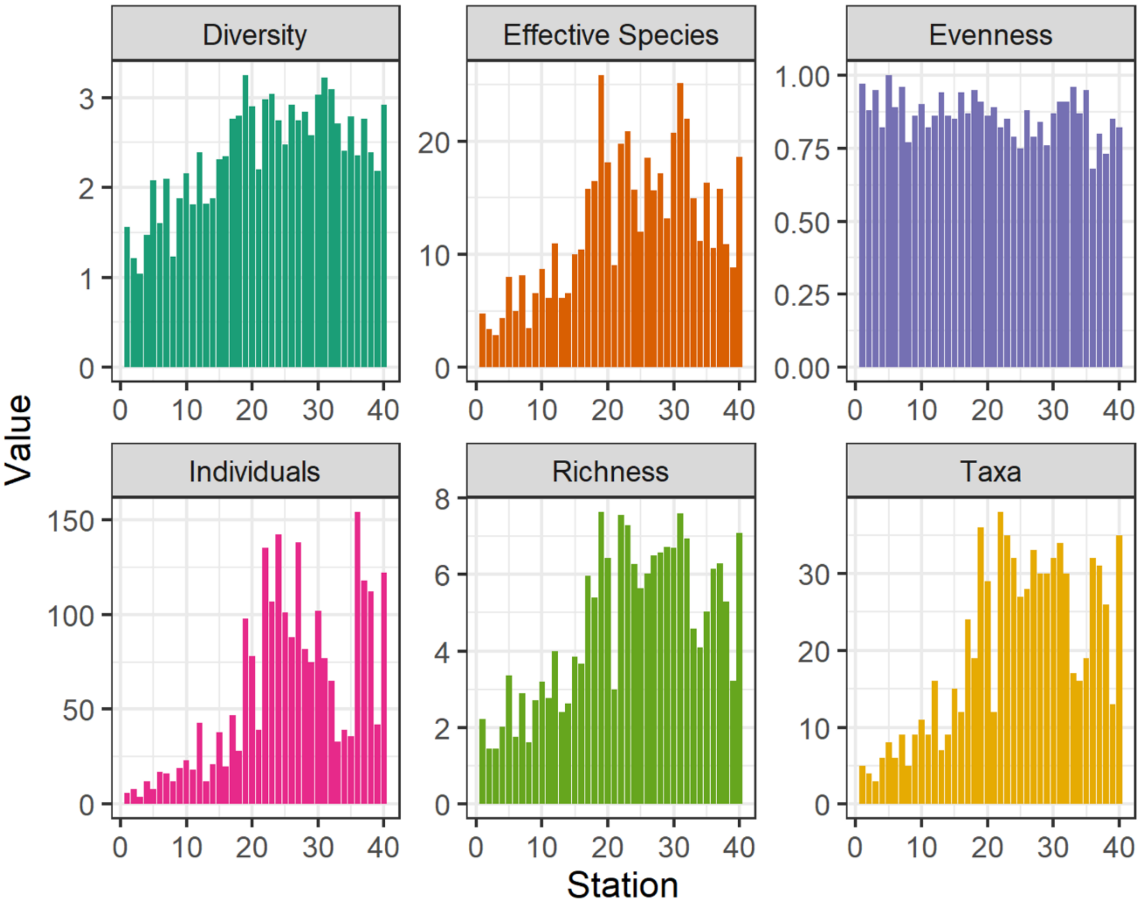
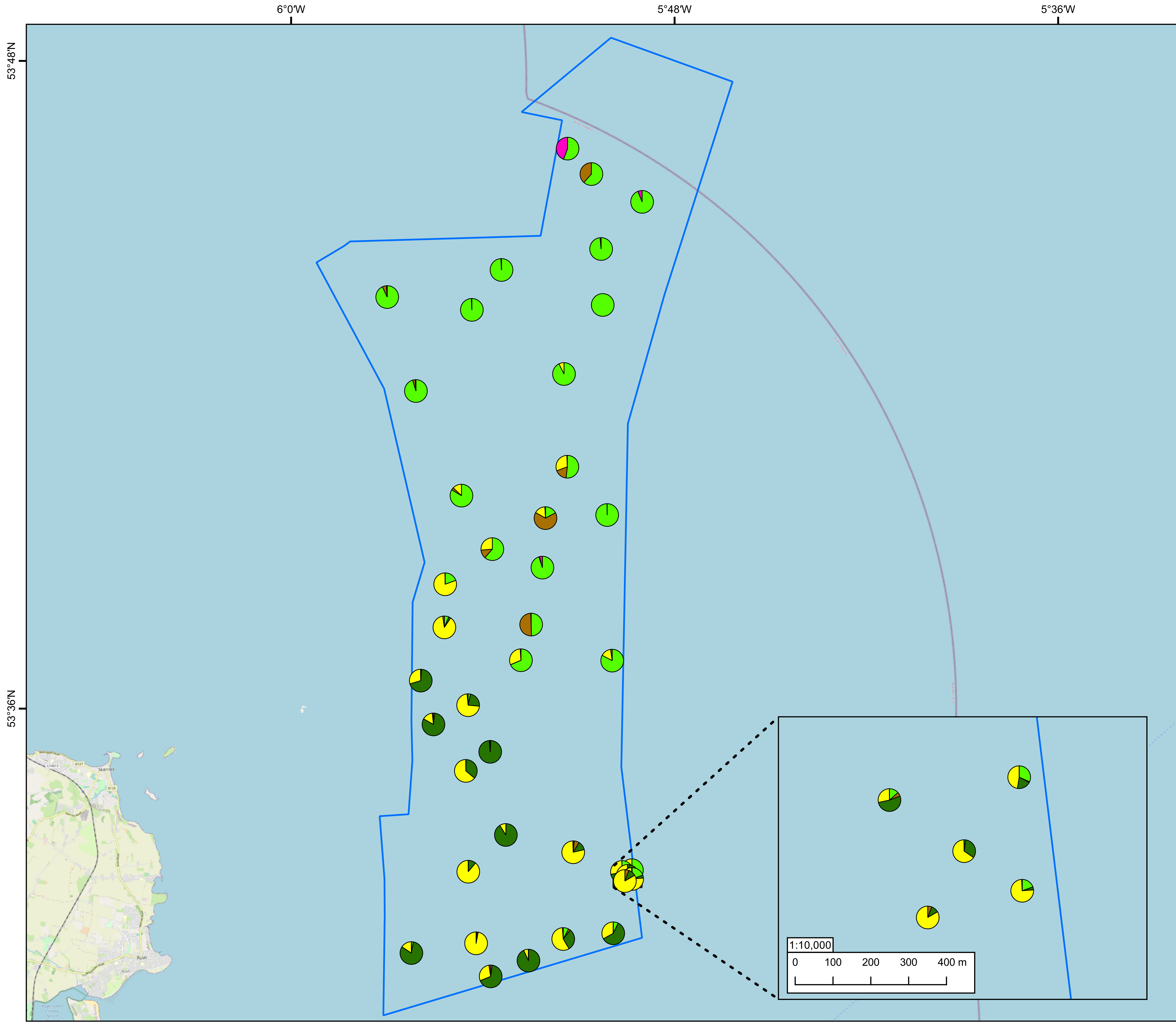


Figure 3.1: **Univariate diversity indices at benthic grab sampling stations.**



Project:

North Irish Sea Array (NISA) Offshore Wind Farm

Title:

Figure 3.2: Grab Station Proportions of Faunal Groupings

Key

Site boundary

Faunal biomass

- Annelida
- Crustacea
- Echinoderm
- Mollusca
- Other

Scale @ A3: 1:130,000

Coordinate System: IRENET95 Irish Transverse Mercator
Graticules: WGS84

0 1.5 3 4.5 6 km

N

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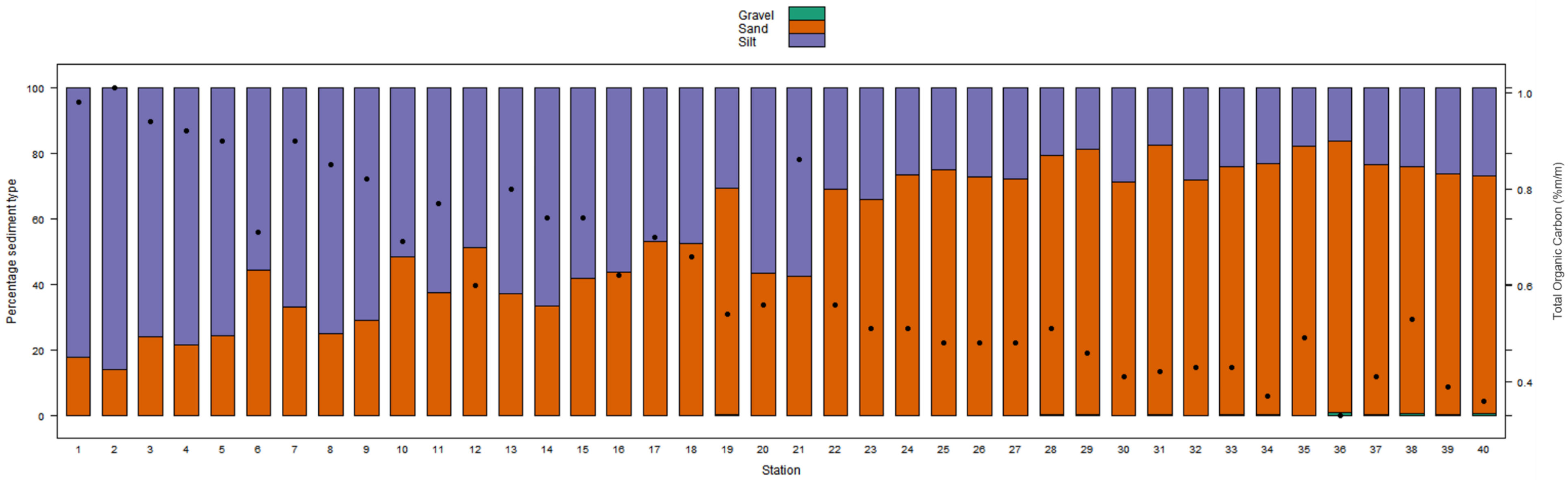
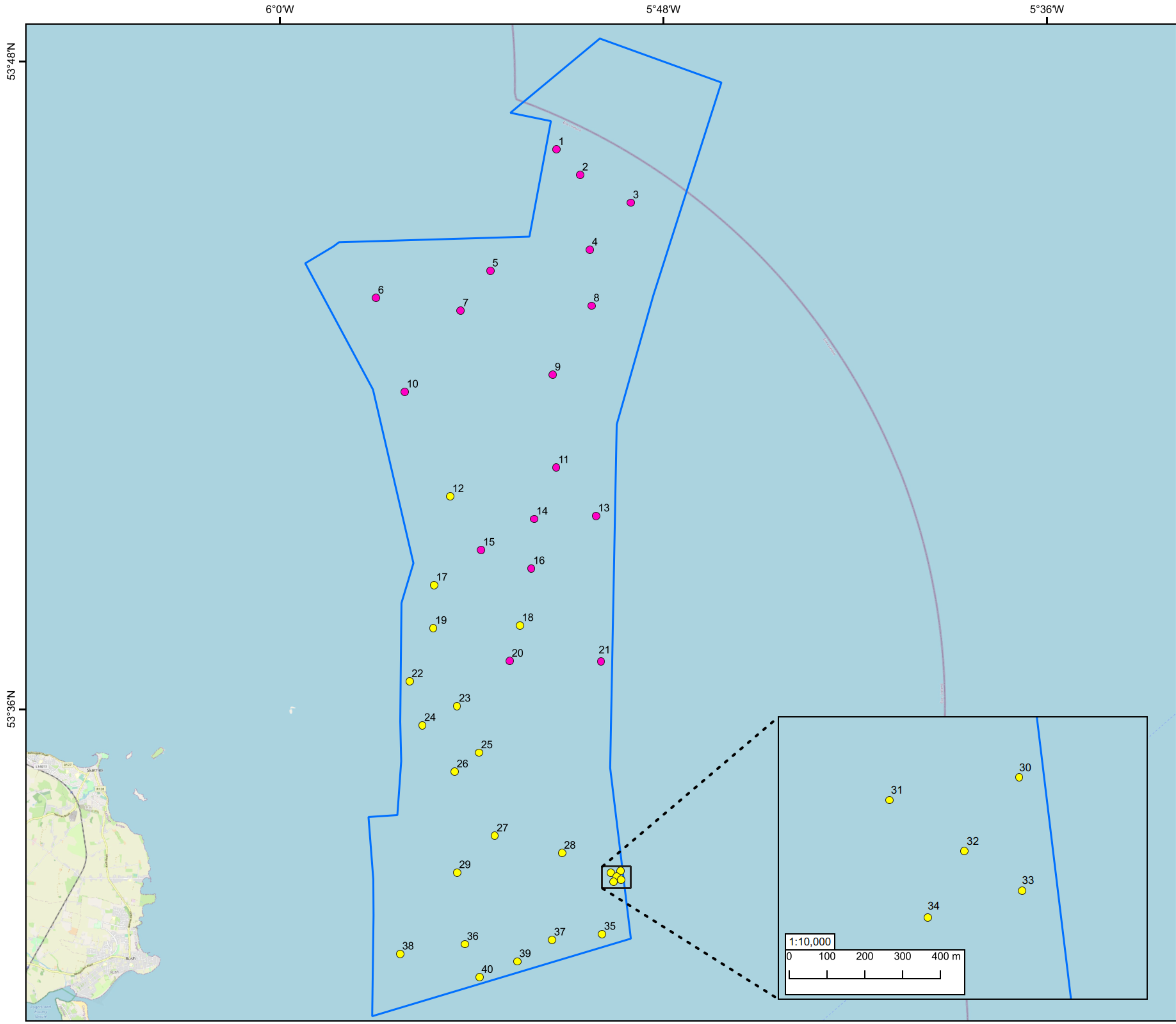


Figure 3.3 PSA results based on Folk Classification and TOC results for all benthic grab stations



Project:

North Irish Sea Array (NISA) Offshore Wind Farm

Title:

Figure 3.4: Grab Station Particle Size Analysis Folk Classification

Key

Site boundary

Grab station folk classification

mS

sM

Scale @ A3: 1:130,000

Coordinate System: IRENET95 Irish Transverse Mercator
Graticules: WGS84

0 1.5 3 4.5 6 km

N

Date: 12-09-22	Prepared by: JO	Checked by: ME
Ref: IE202180_M_075_A		

Drawing by:

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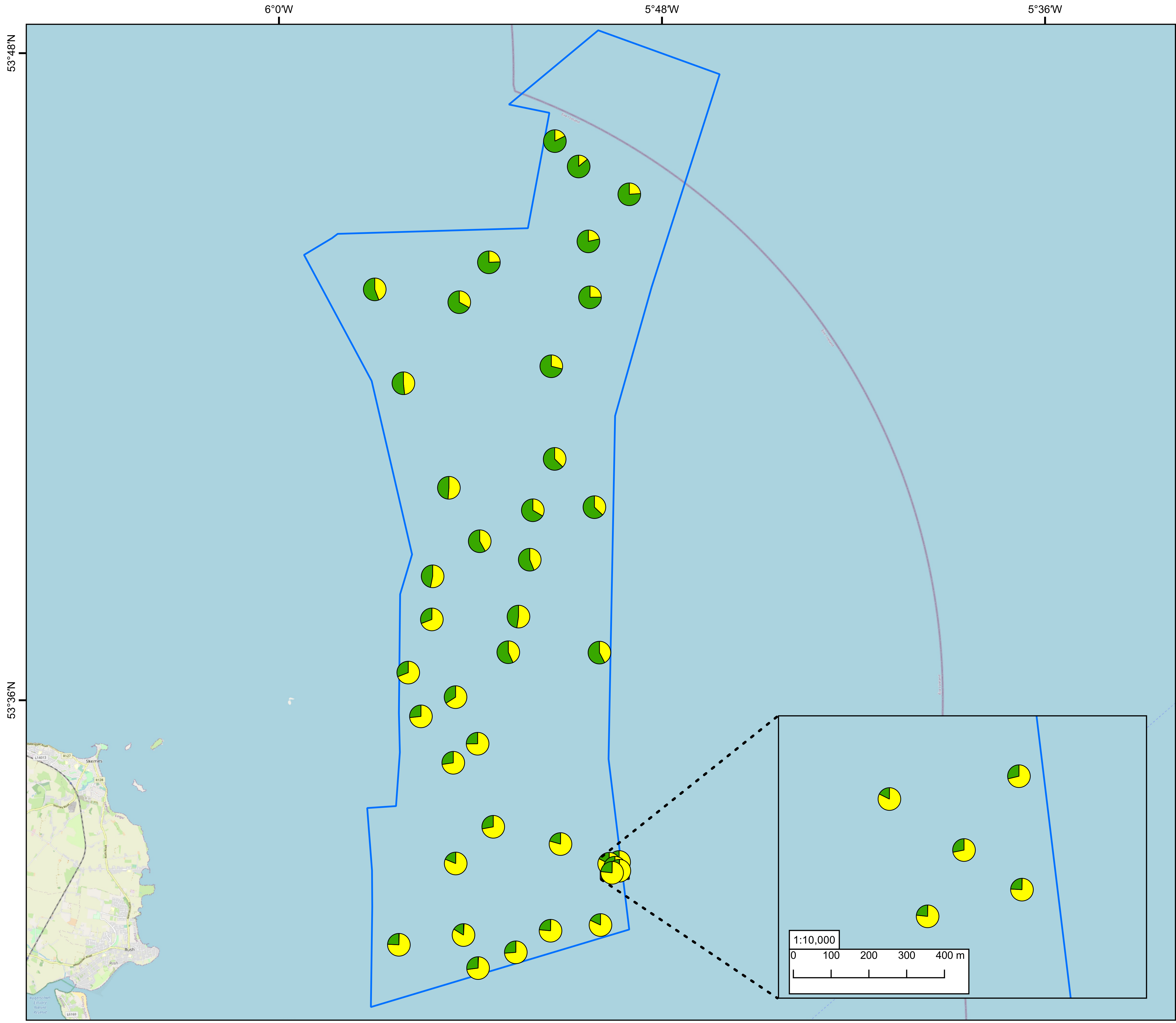

Project:

North Irish Sea Array (NISA) Offshore Wind Farm

Title:

Figure 3.5: Grab Station Ratio of Particle Sizes

Key

Site boundary

Particle size range

% Gravel

% Sand

% Silt

Scale @ A3: 1:130,000

Coordinate System: IRENET95 Irish Transverse Mercator

Graticules: WGS84

0 1.5 3 4.5 6 km

N

Date: 12-10-22	Prepared by: JO	Checked by: ME

Ref: IE202180_M_076_C

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3.3. Community Analysis

SIMPROF found 10 statistically significant groups of stations (P<0.05) based on relatedness of species composition (Figure 3.6., Table 3.2). Groups a, b, and h contain a single sampling station and groups c, g, and j consist of only two sampling stations (Table 3.2). Given this, these groups have higher similarity values, however, are unlikely to represent distinct biotope types. Group i represents benthic communities in areas with higher silt content, whereas groups d, e, f, and g represent benthic communities in areas with higher sand content.

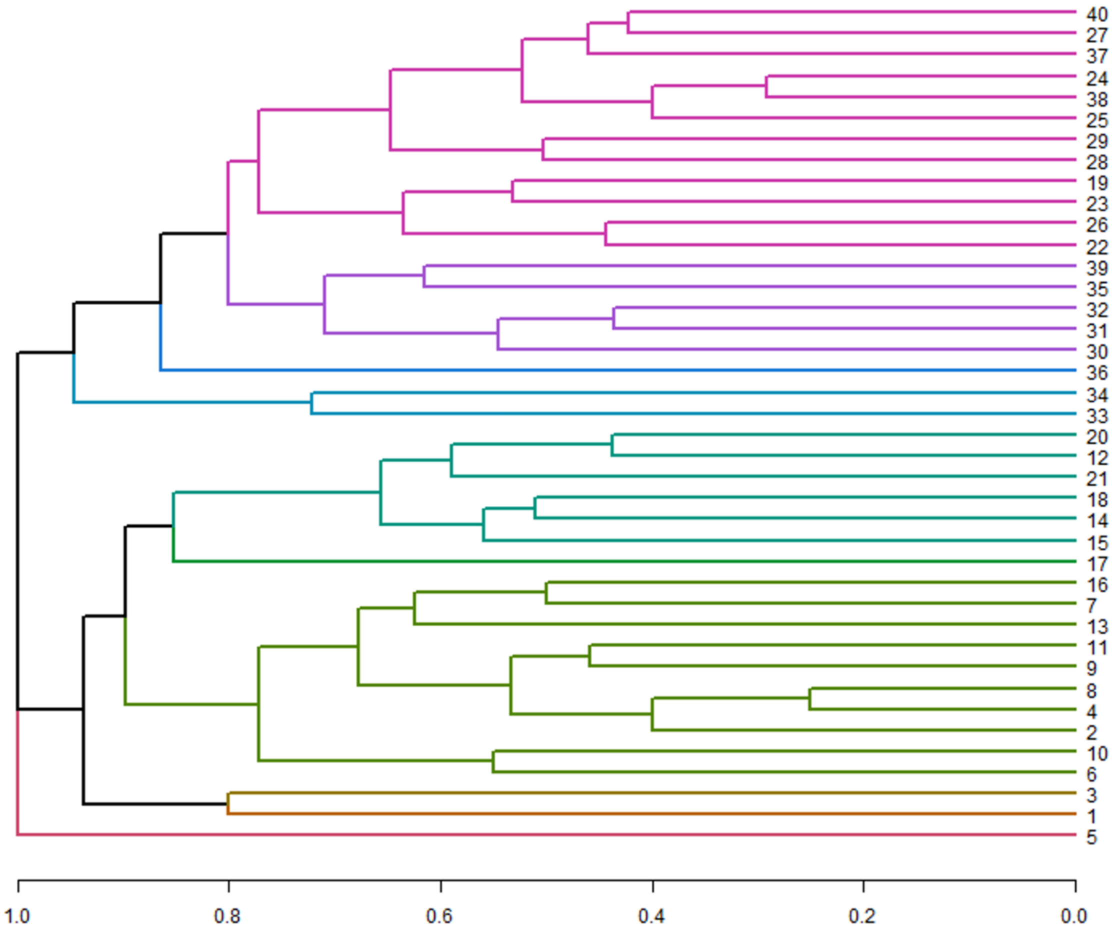

Figure 3.6. Bray-Curtis cluster analysis dendrogram of sampled infauna

Table 3.2: Station groupings discovered through clustering analysis of benthic sampling stations.

Groupings	Stations
a	36
b	17
c	20; 30
d	25; 35; 39
e	22; 24; 26; 27; 29; 37; 38; 40
f	19; 23; 28; 31; 32
g	33; 34
h	5
i	10; 11; 12; 13; 14; 15; 16; 18; 2; 21; 4; 6; 7; 8; 9
j	1; 3

ANOSIM was run to compare the species composition between SIMPROF groupings, the NMDS ordination plot (Figure 3.7) stress values of 0.115 showing a good representation of the scatter of samples. When species assemblages were compared between Folk classifications by ANOSIM (Figure 3.8), a significant result was found ($p = 0.001$, $R = 0.777$). This illustrates the split in benthic communities across sediment types from fine mud to coarser sand sediments.

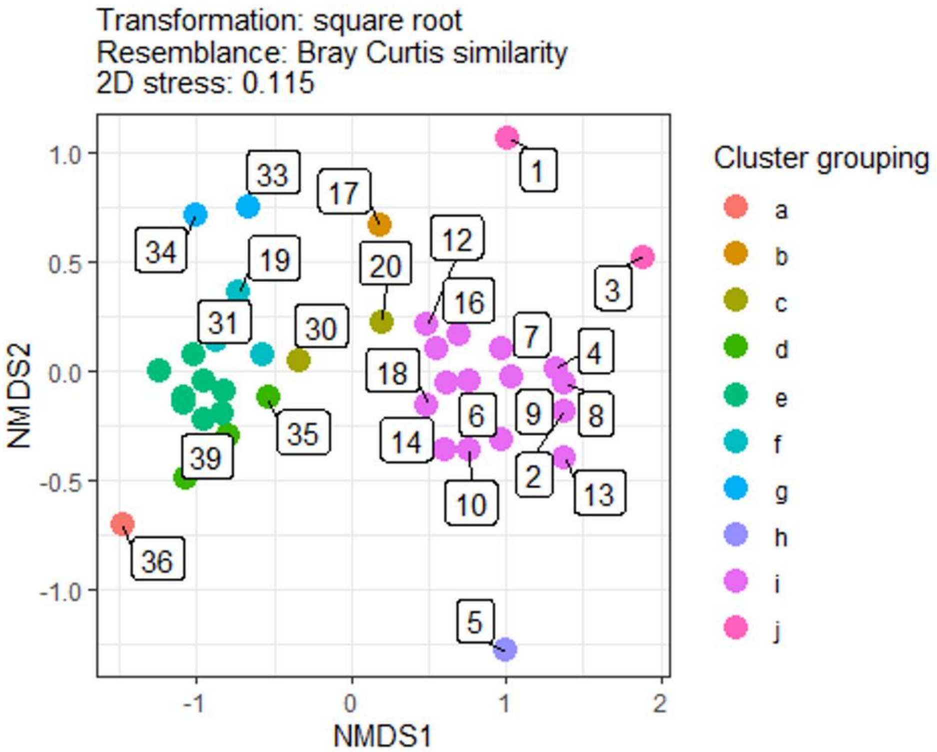

Figure 3.7: NMDS plot showing clustering of stations based on species composition.

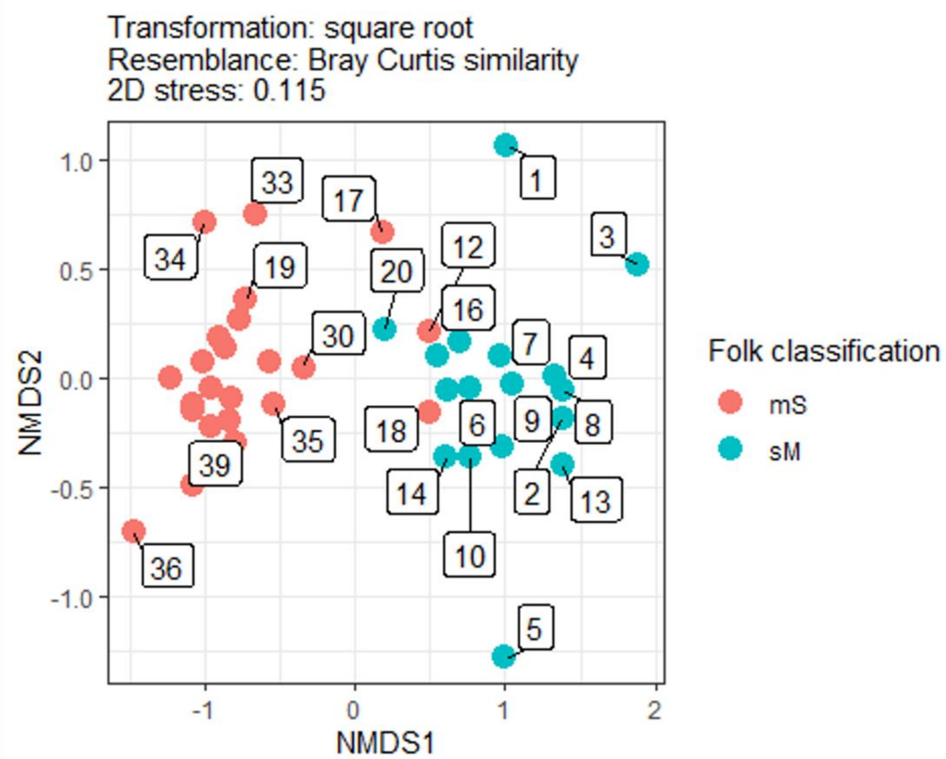

Figure 3.8: NMDS plot showing clustering of stations based on species composition, coloured by the Folk classification of the station.

3.4. Biotope Assignment

SIMPER was run to determine species contributing greatest variation between Folk classifications and the top contributors to the SIMPROF station groupings are provided in Table 3.3. Brittle stars *Amphiuridae sp* and *Amphiura filiformis* are within the species driving similarity at stations of muddy sand. Polychaetes and burrowing mud shrimp are among the species driving similarity at sandy mud stations. In group c where the sediment is sandy mud/muddy sand the species driving similarity are bivalves *Abra sp* and *Abra nitida*, suggesting a different benthic community in areas in between muddy sand and sandy mud where the proportions of sand to mud are more even (Figure 3.5).

Table 3.3: Average contributions of species most similar between station groupings, according to SIMPER.

Station grouping	Most influential species driving similarity	Folk sediment classification	Approx. depth range (m)	Average similarity
a	*Balanomorpha, Lanice conchilega, Nematoda, Amphiuridae.*	muddy sand	41.4	N/A
b	*Turritellinella tricarinata, Magelona alleni, Abra sp,* *Glycera unicornis, Abyssoninoe Hibernica.*	muddy sand	43.6	N/A
c	*Abra sp, Abra nitida, Nephtys sp, Diplocirrus glaucus.*	muddy sand/sandy mud	56.1	10.42
d	*Amphiura filiformis, Amphiuridae, Kurtiella bidentata, Phoronis sp.*	muddy sand	72.9	14.1
e	*Amphiuridae, Amphiura filiformis, Antalis entails,* *Kurtiella bidentata.*	muddy sand	40.7	12.1
f	*Amphiuridae, Diplocirrus glaucus, Phoronis sp, Amphiura filiformis*	muddy sand	50.96	9
g	*Polydora ciliate, Phaxas pellucidus, Kurtiella bidentata.*	muddy sand	58.45	11.11
h	*Bopyridae, Callianassa subterranean, Capitellidae, Glycera unicornis, Kirkegaardia.*	sandy mud	48.6	N/A
i	*Abyssoninoe Hibernica, Abra sp, Nephtys incisa, Abra nitida, Diplocirrus glaucus.*	sandy mud	53.41	10.18
j	*Abyssoninoe Hibernica, Notomastus, Copepoda, Nemertea, Platyhelminthes.*	sandy mud	53.1	16

3.4.1. DDV biotopes

A total of three habitats/biotopes were observed at the sample stations surveyed by DDV in the NISA Array site, including 'Circalittoral mixed sediment' (SS.SMx.CMx), 'Sublittoral cohesive mud and sandy mud communities' (SS.SMu) and 'Seapens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.SpnMeg). The substrates observed were homogenous in nature, and none of the DDV samples required splitting into different segments due to changes in habitat. The habitats/biotopes that were identified within the NISA Array site are summarised in Table 3.4 and the DDV sample station images and stills and DDV analysis proformas in Appendix C.

Table 3.4: Biotopes identified from DDV and still imagery analysis.

Biotope	MNCR Classification Description	EUNIS Code	Sample or Transect Stations
SS.SMu.CFiMu.SpnMeg	Seapens and burrowing megafauna in circalittoral fine mud	A5.361	Stations 6, 8,10, 30
SS.SMx.CMx	Circalittoral mixed sediment	A5.44	Stations 15, 21, 22, 26
SS.SMu	Subtidal mud	A5.3	Stations 32, 37, 39 and transects 1-20

3.4.2. Final Biotope Classification

Infauna (grab) and epibenthic (DDV) biotope classifications were incorporated into an Excel spreadsheet alongside physical characteristics such as depth and PSA, and final benthic habitats assigned to each sampling station. The majority of infauna and epibenthic habitat assignment at a sampling station were consistent or complimentary. At the DDV transect stations, where no benthic grabs were taken, the DDV classification was carried forward. Final biotope classification of all stations sampled are provided in Table 3.5 and Figure 3.9.

Table 3.5: Final biotopes assignment.

Final Biotope	MNCR Classification Description	EUNIS Code	Stations/Transects
SS.SMx.CMx.	Circalittoral mixed sediment	A5.44	Transects 1-20
SS.SSa.OS.OfusAfil	*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand	A5.272	Stations 22, 24-27, 29,38-40
SS.SMu.CSaMu.AfilKurAnit	*Amphiura filiformis*, *Kurtiella bidentata* and *Abra nitida* in circalittoral sandy mud	A5.351	Stations 17,19,20,23,28, 31-34
SS.SMu.CFiMu.MegMax	Burrowing megafauna *Maxmuelleria lankesteri* in circalittoral mud	A5.362	Stations 1-16, 18, 21
SS.SMu.CFiMu.SpnMeg	Seapens and burrowing megafauna in circalittoral fine mud	A5.361	Station 30

Disparities between DDV and grab benthic biotope assignation occurred due to the incorporation of PSA analysis; it was considered that data from the benthic grab gave a better representation of sediment characteristics. However, it was also important to consider infaunal and epibenthic communities in assigning the final biotopes. At stations 1-16, 18 and 21, the PSA data indicated a lower percentage of silt than that described in the SS.SMu.CFiMu.MegMax biotope, however the benthic grab and DDV data showed species characteristic of this biotope such as the burrowing mud shrimp *Callianassa subterranea*, *Nephrops* burrows and mounds. It was not classified as the closely related SS.SMu.CFiMu.SpnMeg due to the lack of seapens present. Only station 30, on the eastern periphery of the south of the site had abundant seapens and was classified as SS.SMu.CFiMu.SpnMeg. This station sits on the boundary of the array area and may represent the extent of an area of this biotope that sits out with the array area as the surrounding stations (within the cluster of stations) are the SS.SMu.CSaMu.AfilKurAnit biotope.

An intermediate area of sandy mud contains the biotope SS.SMu.CSaMu.AfilKurAnit and this habitat transitions into the sandier SS.SSa.OS.OfusAfil to the south, both biotopes are characterised by brittle star and bivalve species. In the southwest corner there is a small section of circalittoral mixed sediment will relatively high numbers of epifaunal species. In the eastern cluster of sampling stations, on the array area boundary is the sensitive “Seapens and burrowing megafauna in circalittoral fine mud” biotope where several individuals of the seapen *Virgula mirabilis* were present.

Total of five biotopes have been identified with the NISA array area and a full biotope description of each is provided in Annex E.

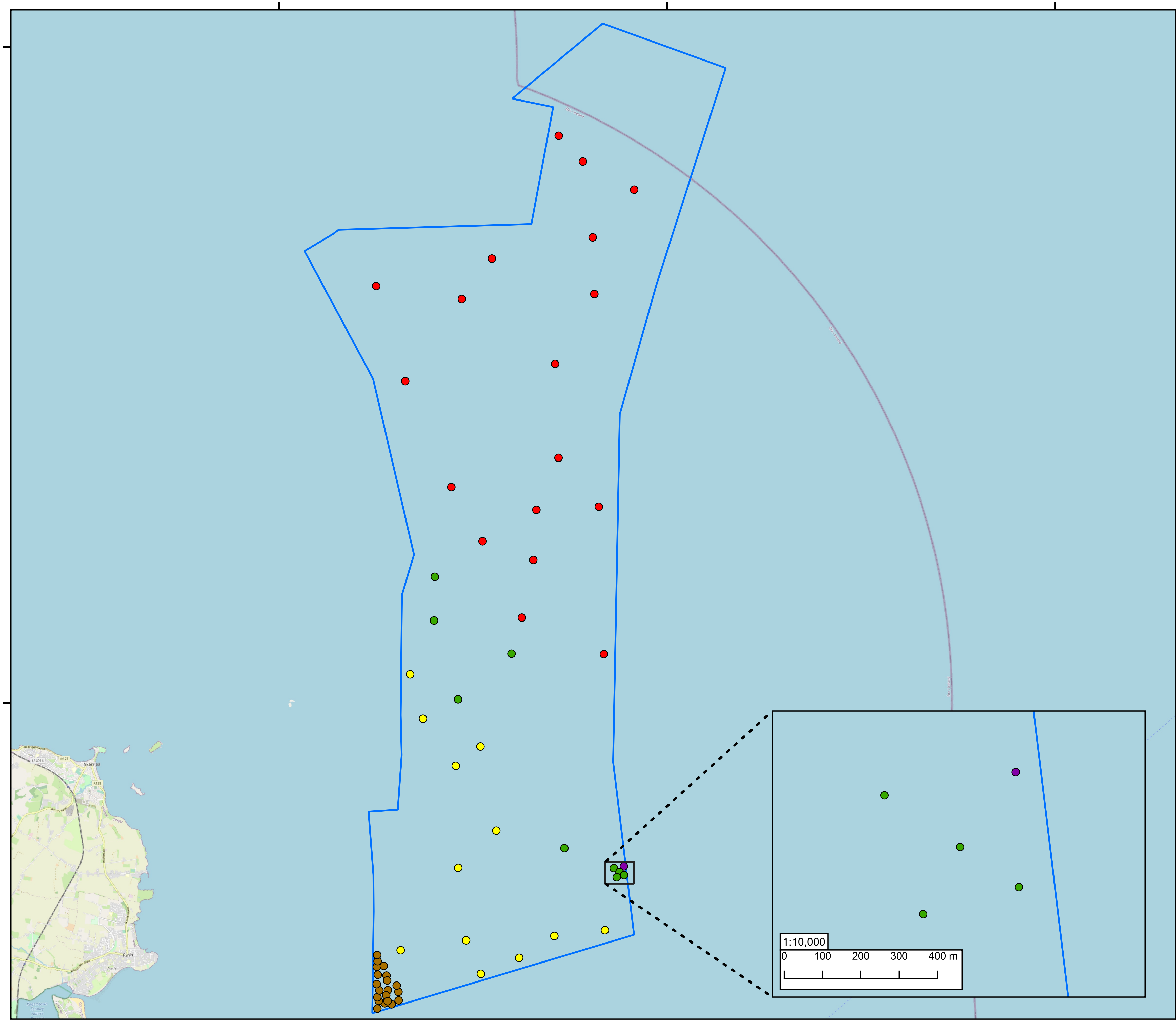

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Figure 3.9: All Stations Final Biotopes

Key

Site boundary

Station biotopes

- SS.SMu.CFiMu.MegMax
- SS.SMu.CFiMu.SpnMeg
- SS.SMu.CSaMu.AfilKurAnit
- SS.SSa.OSa.OfusAfil
- SS.SMx.CMx

Scale @ A3: 1:130,000

Coordinate System: IRENET95 Irish Transverse Mercator
Graticules: WGS84

0 1.5 3 4.5 6 km

N

Date: 16-09-22	Prepared by: JO	Checked by: ME

Ref: IE202180_M_077_B

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4. Discussion

The array area mainly consists of finer muddy sediment to the north and coarser sand sediment to the south, with four main biotope types which change with sediment type across the area. The northern section is characterised by circalittoral fine mud, where numbers of species and taxa are relatively few and *Nephrops* burrows and burring mud shrimp mounds can be seen. The biotope here is “Burrowing megafauna *Maxmuelleria lankesteri* in circalittoral mud” (SS.SMu.CFiMu.MegMax) and covers the largest area of the site. The southern section of the array area is characterised by predominately sandy sediment, with an abundant brittle star community. The biotope in this region is SS.SSa.OS.OfusAfil. In the area between these two distinct biotopes the sediment transitions and sandy mud and muddy sand sediment types are interspersed. The biotope has been classified as SS.SMu.CSaMu.AfilKurAnit based on physical characteristics and characterising species such as *Amphuira filiformis* and *Abra nitida*. However, in this transitional area, biotopes and their boundaries are less distinct and it is noted within the biotope description that several variants of this biotope can be described in transitionary environments including SS.SSa.OSa.OfusAfil in sandier environments offshore. All other variants are provided in the biotope description given in Appendix E. In total five biotopes have been identified within the NISA OWF array area.

No Annex I features were identified during the array area benthic survey campaign. However, one station was classified as the OSPAR habitat “Seapens and burrowing megafauna in circalittoral fine mud” (SS.SMu.CfiMu.SpnMeg). OPSAR habitats those which have been agreed need protection under the Oslo and Paris Conventions. This station lies on the periphery of the NISA OWF array area.

Appendices

Appendix A – Survey Field logs

See accompanying Excel documents:

Field Survey Log

Appendix B – Faunal Univariate Results

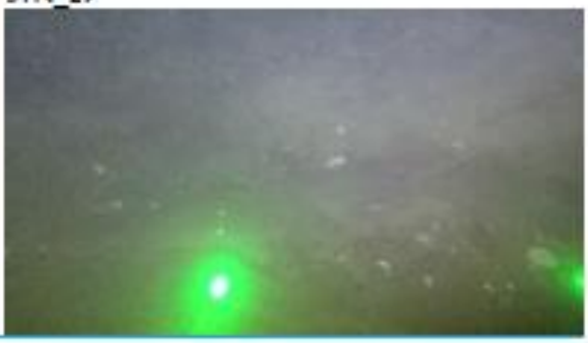
Table B1. Benthic grab sampling stations univariate measures of community structure.

Station	No. Taxa	No. Individuals	Shannon-Wiener Diversity	Richness	Evenness	Effective Species Number
1	5	6	1.56	2.23	0.97	4.76
2	4	8	1.21	1.44	0.88	3.36
3	3	4	1.04	1.44	0.95	2.83
4	6	12	1.47	2.01	0.82	4.36
5	8	8	2.08	3.37	1.00	8.00
6	6	17	1.60	1.76	0.89	4.95
7	9	16	2.10	2.89	0.96	8.17
8	5	12	1.23	1.61	0.77	3.44
9	9	19	1.88	2.72	0.86	6.56
10	11	23	2.16	3.19	0.90	8.70
11	9	18	1.81	2.77	0.82	6.12
12	16	43	2.39	3.99	0.86	10.96
13	7	12	1.82	2.41	0.94	6.17
14	9	21	1.88	2.63	0.86	6.56
15	15	38	2.31	3.85	0.85	10.03
16	12	20	2.35	3.67	0.94	10.44
17	24	47	2.76	5.97	0.87	15.77
18	19	28	2.80	5.40	0.95	16.44
19	36	98	3.25	7.63	0.91	25.85
20	29	78	2.90	6.43	0.86	18.11
21	12	39	2.20	3.00	0.89	9.04
22	38	135	2.98	7.54	0.82	19.78
23	35	107	3.04	7.28	0.85	20.86
24	32	142	2.75	6.26	0.79	15.71
25	27	101	2.48	5.63	0.75	11.97
26	28	88	2.92	6.03	0.88	18.55
27	33	138	2.75	6.49	0.79	15.67
28	30	82	2.84	6.58	0.84	17.16
29	30	75	2.58	6.72	0.76	13.20
30	32	102	3.03	6.70	0.87	20.72
31	34	77	3.22	7.60	0.91	25.15
32	30	65	3.09	6.95	0.91	21.98
33	17	33	2.71	4.58	0.96	14.98
34	16	39	2.41	4.09	0.87	11.18
35	19	36	2.79	5.02	0.95	16.34

Station	No. Taxa	No. Individuals	Shannon-Wiener Diversity	Richness	Evenness	Effective Species Number
36	32	154	2.36	6.15	0.68	10.56
37	31	118	2.76	6.29	0.80	15.80
38	26	112	2.39	5.30	0.73	10.92
39	13	42	2.18	3.21	0.85	8.86
40	35	122	2.92	7.08	0.82	18.63

Appendix C – DDV Sample Station Images and Stills and DDV Analysis Proformas

Table 4.1: Sample Station and Transect Images

STN_06 	STN_08 
STN_10 	STN_15 
STN_21 	STN_22 
STN_26 	STN_29 

STN_30

STN_32

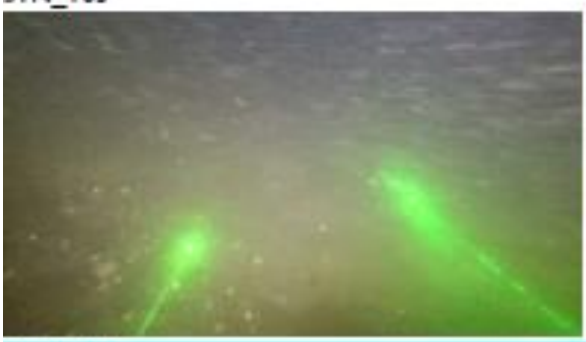
STN_37

STN_39

STN_T01

STN_T02

STN_T03



STN_T04

STN_T05

STN_T06

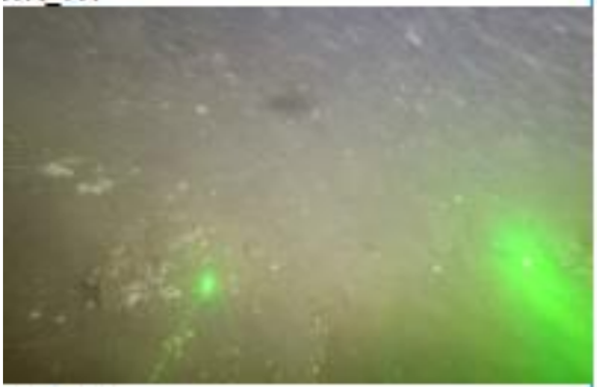
STN_T07

STN_T08

STN_T09

STN_T10

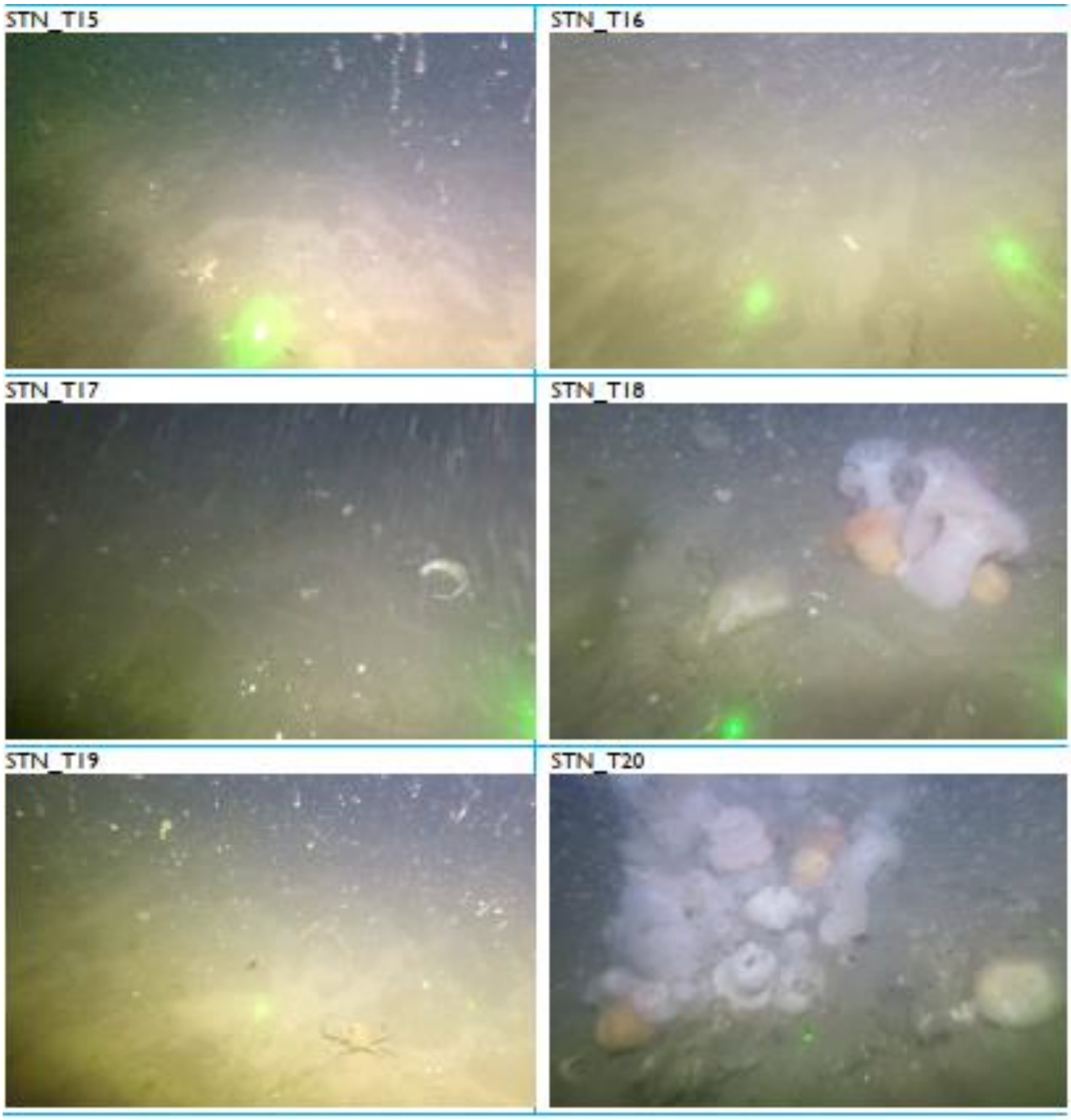
STN_T11



STN_T12

STN_T13

STN_T14



See accompanying Excel documents:

NISA_DDV_stills_analysis_prfoorms_20220503

NISA_DDV_video_analysis_prfoorms_20220503

Appendix D – Contaminated Sediment Results

See accompanying Excel documents:

NISA_Contaminated sediment results graphs_CANADA

NISA_Contaminated sediment results graphs_CEFAS

NISA_Contaminated sediment results graphs_IRELAND

Appendix E – Biotope Descriptions

SS.SMx.CMx. – Circalittoral mixed sediment

Mixed (heterogeneous) sediment habitats in the circalittoral zone (generally below 15-20 m) including well mixed muddy gravelly sands or very poorly sorted mosaics of shell, cobbles and pebbles embedded in or lying upon mud, sand or gravel. Due to the variable nature of the seabed a variety of communities can develop which are often very diverse. A wide range of infaunal polychaetes, bivalves, echinoderms and burrowing anemones such as *Cerianthus lloydii* are often present in such habitats and the presence of hard substrata (shells and stones) on the surface enables epifaunal species to become established, particularly hydroids such as *Nemertesia* spp. And *Hydrallmania falcata*. The combination of epifauna and infauna can lead to species rich communities. Coarser mixed sediment communities may show a strong resemblance, in terms of infauna, to biotopes within the SS.SCS complex. However, infaunal data for this biotope complex is limited to that described under the biotope SS.SMx.CMx.KurThyMx, and so are not representative of the infaunal component of this biotope complex.

SS.Ssa.OS.OfusAfil – Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy sand

Areas of slightly muddy sand (generally <20% mud) in offshore waters may be characterised by high numbers of the tube building oweniid polychaete Owenia fusiformis and Galathowenia sp., often with the brittlestar Amphiura filiformis. Whilst O. fusiformis is also found in other circalittoral or offshore biotopes it usually occurs in lower abundances than in SS.Ssa.Osa.OfusAfil. Other species found in this community are the polychaetes Goniada maculata, Pholoe inornata, Diplocirrus glaucus, Chaetozone setosa and Spiophanes kroyeri with occasional bivalves such as Timoclea ovata and Thyasira equalis. The sea cucumber Labidoplax buski and the cumacean Eudorella truncatula are also commonly often found in this biotope. This biotope along with SS.Smu.CsaMu.ThyEten, SS.Smu.CsaMu.AfilKurAnit, SS.Smu.CsaMu.AfilEten and SS.Smu.Omu.PjefThyAfil, may comprise the Amphiura dominated components of the ‘offshore muddy sand association’ (Jones 1951; Mackie 1990) and the infralittoral etage described by Glemarec (1973). Variants of the biotope may contain the characteristic high numbers of Owenia fusiformis and Amphiura filiformis, but may also include Arctica islandica and Ennucula tenuis. Where these occur, the biotope may be considered a transitionary variant between SS.SSa.OSa.OfusAfil and SS.Smu.CsaMu.AfilKurAnit.

SS.Smu.CsaMu.AfilKurAnit – Amphiura filiformis, Kurtiella bidentata and Abra nitida in circalittoral sandy mud

Cohesive sandy mud off wave exposed coasts with weak tidal streams can be characterised by super-abundant Amphiura filiformis with Kurtiella bidentata and Abra nitida. This community occurs in muddy sands in moderately deep water (Hiscock 1984; Picton *et al*., 1994) and may be related to the 'offshore muddy sand association' described by other workers (Jones 1951; Thorson 1957; Mackie 1990). This community is also characterised by the sipunculid Thysanocardia procera and the polychaetes Nephtys incisa, Phoronis sp. and Pholoe sp., with cirratulids, such as Notomastus latericeus or Mediomastus fragilis, and terebellids, such as Polycirrus plumosus or Diplocirrus glaucus, also common in some areas. Other taxa such as Nephtys hombergii, Echinocardium cordatum, Nucula nitidosa, Callianassa subterranea and Eudorella truncatula may also occur in offshore examples of this biotope. Additionally, several variants of this biotope can be described in transitionary environments between biotopes such as SS.SMx.CMx.KurThyMx where coarser material is present, SS.SSa.OSa.OfusAfil in sandier environments offshore or SS.SMu.ISaMu.MelMagThy in shallower waters. Collectively the biotopes SS.SMu.CSaMu.ThyEten, SS.SMu.CSaMu.AfilKurAnit, SS.SMu.CSaMu.AfilEten, SS.SMu.OMu.PjefThyAfil, and SS.SSa.OSa.OfusAfil, may form the Amphiura dominated components of the 'off-shore muddy sand association' described by other workers (Jones 1951; Thorson 1957; Mackie 1990) and the infralittoral etage described by Glemarec (1973).

SS.SMu.CFiMu.MegMax - Burrowing megafauna Maxmuelleria lankesteri in circalittoral mud

In circalittoral stable mud distinctive populations of megafauna may be found with a range of component fauna. This biotope may include the decapod crustaceans *Nephrops norvegicus*, *Munida rugosa, Calocaris macandreae* and

Callianassa subterranea, the seapens *Pennatula phosphorea* and *Virgularia mirabilis* (although in reduced numbers than in SS.SMu.CFiMu.SpnMeg) and the echiuran *Maxmuelleria lankesteri* sometimes present in large mounds. Whilst this biotope is primarily identified from epifauna, the infaunal species present may include *Nephtys hystricis*, *Chaetozone setosa, Amphiura chiajei* and *Abra alba*. This biotope is closely related to the biotope SS.SMu.CFiMu.SpnMeg and may have infaunal communities similar to the biotopes SS.SMu.CSaMu.AfilKurAnit or SS.SMu.CSaMu.ThyEten, depending on environmental factors and/or the sampling gear used to describe the record.

SS.SMu.CFiMu.SpnMeg - Seapens and burrowing megafauna in circalittoral fine mud

Deep muds, especially in sea lochs, support forests of the nationally scarce *Funiculina quadrangularis*, in addition to populations of the seapens *Virgularia mirabilis* and *Pennatula phosphorea*. The sediment is usually extensively burrowed by crustaceans, the most common of which is *Nephrops norvegicus*, but *Calocaris macandreae* and *Callianassa subterranea* may also be present (the latter is likely to be under-recorded by grab sampling because it is deep burrowing). The burrowing anemone *Cerianthus lloydii* is present in low numbers in this biotope and the rare anemone *Pachycerianthus multiplicatus* may also be found occasionally. *Amphiura* spp. are also often present in high densities. This biotope is closely related to the biotope SS.SMu.CFiMu.SpnMeg.

Appendix F - Full PSA dataset and Full Species list

See accompanying Excel documents:

NISA_Full_PSA_PSD_results

NISA_Full_Species_list

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