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Norwegian Boundary Sediment Plain MPA Monitoring Report 2015

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Executive Summary

The Joint Nature Conservation Committee (JNCC) have produced this report to provide information allowing the Scottish Government to fulfil its obligations in relation to Marine Protected Area (MPA) assessment and reporting. Such reporting is a requirement to help ensure the UK meets its aims and objectives.

The Norwegian Boundary Sediment Plain Nature Conservation MPA (NBSP) is located to the east of Scotland and designated for the protection of two Priority Marine Features (PMFs): ocean quahog (*Arctica islandica)* aggregations and offshore subtidal sands and gravels (representing sediment types suitable for ocean quahog colonisation). The Joint Nature Conservation Committee and Marine Scotland Science completed a survey in November 2015 (1515S) to collect evidence to characterise the site and develop the first point in a monitoring time-series for NBSP. The survey was designed to gather data to address the following objectives, which are also the objectives of this report:

- describe the population distribution of ocean quahog (*A. islandica*) within NBSP, in addition to the extent and distribution of the supporting habitat, offshore subtidal sands and gravels;
- present any evidence of non-indigenous species (MSFD Descriptor 2) and marine litter (MSFD Descriptor 10) within the site;
- recommend future monitoring approaches for the NBSP.

Infaunal and sediment samples were acquired from 120 large (0.25m^2) Hamon grabs within NBSP.

Four sedimentary benthic habitats were identified from particle size analysis (PSA) of 120 Hamon grabs across the site: A5.1 Sublittoral coarse sediment, A5.2 Sublittoral sands, A5.3 Sublittoral mud and A5.4 Sublittoral mixed sediment. Further analysis suggests the sedimentary habitat types sampled are distinctive from each other and differ from previous survey data acquired from the site. The Sublittoral sands (A5.2) habitat had the largest extent in the site with 102 of 117 successful grab samples.

The infaunal community was typified by two assemblages (denoted j and m), within the 13 assemblages identified by multivariate analysis. The samples were composed of similar infaunal assemblages, most associated with A5.2 Sublittoral sands. The biotope, *Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (SS.SSa.OSa.OfusAfil) described the typifying assemblages. The habitats; Circalittoral fine sand (SS.SSa.CFiSa); Circalittoral muddy sand (SS.SSa.CMuSa); Offshore circalittoral sand (SS.SSa.OSa), and Offshore circalittoral coarse sediment (SS.SCS.OCS) described the remainder of assemblages.

A combination of percentage of gravelly sediment and the proxy environmental driver, water depth, were identified as those environmental parameters showing the best correlation with identified infaunal assemblage patterns. Overall, however, this relationship was weak.

Ocean quahog specimens were acquired from grab samples but not in sufficient abundance for meaningful statistical analysis. Hence, the report does not describe the population composition or structure of ocean quahog, but their distribution is presented in this report.

Taxa and habitat features indicative of the Priority Marine Features (PMF) ‘burrowed mud’ and ‘sea pens and burrowing megafauna communities’ were found in grab samples. However, these were not in quantities significant enough to be classed as PMFs. Recommendations to monitor these features in the future with seabed imagery are made.

The survey did not record any non-indigenous species (NIS) and or any marine litter within NBSP. Operational and sampling design recommendations for future monitoring of NBSP, and for the wider MPA network are provided:

- assessment of the human activities and fisheries pressures at the site should be undertaken to inform whether Type 2 or 3 monitoring should be incorporated in any future monitoring of the site;
- future monitoring should endeavour to understand the rate of temporal change at the site, in terms of community structure and change in environmental parameters at the seabed;
- further monitoring should aim to measure environmental parameters as these are poorly understood for the site, and may be the primary drivers in biological shifts at NBSP. Future monitoring surveys should be conducted at the same time of year to limit the influence of seasonal changes;
- future monitoring of the site should include a camera survey to gather evidence on potential PMFs at the site, including ‘sea pens and burrowing megafauna in circalittoral fine mud’ and gain an understanding of the epifaunal communities at NBSP;
- future monitoring of the sediment habitats of the site should employ a 0.1m^2 Hamon grab to allow comparison to previous surveys at NBSP, and across the wider MPA monitoring surveys. a gear comparison study between a 0.25m^2 and 0.1m^2 Hamon grab could be used to improve understanding of differences in regard to infaunal sampling;
- further assessment of the population structure and composition of ocean quahog is inherently difficult. The report recommends that the focus of future monitoring should be the habitats supporting ocean quahog, rather than the species themselves;
- standardised methods of PMF assessment and designation should be agreed for future monitoring efforts of this site and in the wider MPA monitoring network.

Contents

Abbreviations

AUMS	Aberdeen University Marine Studies ltd.
BSH	Broadscale Habitats
EUNIS	European Nature Information System
ERT	Energy Resource Technology
GES	Good Environmental Status
JNCC	Joint Nature Conservation Committee
NMBAQC	North-East Atlantic Marine Biological Analytical Quality Control Scheme
MPA	(Nature Conservation) Marine Protected Area
MSFD	Marine Strategy Framework Directive
NIS	Non-Indigenous Species
OPRU	Oil Pollution Research Unit
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PMF	Priority Marine Feature
PSA	Particle Size Analysis
PSD	Particle Size Distribution
SACFOR	Superabundant, Abundant, Common, Frequent, Occasional, Rare
SPI	Sediment Profile Imagery
SNCB	Statutory Nature Conservation Body
WoRMS	World Register of Marine Species

Glossary

Activity	A human action which may have an effect on the marine environment; e.g. fishing, energy production (Robinson *et al.* 2008).
Anthropogenic	Caused by humans or human activities; usually used in reference to environmental degradation. (NE & JNCC 2010).
Assemblage	A collection of plants and/or animals characteristically associated with a particular environment that can be used as an indicator of that environment. The term has a neutral connotation and does not imply any specific relationship between the component organisms, whereas terms such as 'community' imply interactions (Allaby 2015).
Benthic	A description for animals, plants and habitats associated with the seabed. All plants and animals that live in, on or near the seabed are benthos (e.g. sponges, crabs, seagrass beds) (NE & JNCC 2010).
Biotope	The physical habitat with its associated, distinctive biological communities. A biotope is the smallest unit of a habitat that can be delineated conveniently and is characterised by the community of plants and animals living there (NE & JNCC 2010).
Broadscale Habitats	Habitats which have been broadly categorised based on a shared set of ecological requirements, aligning with level 3 of the EUNIS habitat classification. Examples of Broadscale Habitats are protected across the MCZ network.
Community	A general term applied to any grouping of populations of different organisms found living together in a particular environment; essentially the biotic component of an ecosystem. The organisms interact and give the community a structure (Allaby 2015).
Conservation Objective	A statement of the nature conservation aspirations for the feature(s) of interest within a site, and an assessment of those human pressures likely to affect the feature(s) (NE & JNCC 2010).
Epifauna	Fauna living on the seabed surface.
EUNIS	A European habitat classification system, covering all types of habitats from natural to artificial, terrestrial to freshwater and marine (NE & JNCC 2010).
Favourable Condition	When the ecological condition of a species or habitat is in line with the conservation objectives for that feature. The term 'favourable' encompasses a range of ecological conditions depending on the objectives for individual features (NE & JNCC 2010).
Feature	A species, habitat, geological or geomorphological entity for which an MPA is identified and managed (NE & JNCC 2010).
Feature Attributes	Ecological characteristics defined for each feature within site-specific Supplementary Advice on

	Conservation Objectives (SACO). Feature Attributes are monitored to determine whether condition is favourable.
Impact	The consequence of pressures (e.g. habitat degradation) where a change occurs that is different to that expected under natural conditions (Robinson *et al.* 2008).*
Infauna	Fauna living within the seabed sediment.
Joint Nature Conservation Committee (JNCC)	The statutory advisor to the Government on UK and international nature conservation. Its specific remit in the marine environment ranges from 12 - 200 nautical miles offshore.
Marine (Scotland) Act (2010)	The Marine (Scotland) Act, which applies to Scottish territorial waters only, introduces new powers relating to functions and activities in the Scottish marine area, including provisions concerning marine plans, licensing of marine activities, the protection of the area and its wildlife including seals, and regulation of sea fisheries.
Marine Strategy Framework Directive (MSFD)	The MSFD outlines a transparent legislative framework for an ecosystem-based approach to the management of human activities in the marine environment. The overarching goal of the Directive is to reach 'Good Environmental Status' (GES) by 2020 across Europe's marine environment.
Marine Protected Area (MPA)	A generic term to cover all marine areas that are a 'clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values' (Dudley 2008; NE & JNCC 2010).
Nature Conservation Marine Protected Area	Marine protected areas in Scottish sea areas which were designated by Scottish Ministers through powers granted by the Marine (Scotland) Act and UK Marine and Coastal Access Act.
Non-indigenous Species	A species that has been introduced directly or indirectly by human agency (deliberately or otherwise) to an area where it has not occurred in historical times and which is separate from and lies outside the area where natural range extension could be expected (Eno *et al*. 1997; NE & JNCC 2010).
Pressure	The mechanism through which an activity has an effect on any part of the ecosystem (e.g. physical abrasion caused by trawling). Pressures can be physical, chemical or biological, and the same pressure can be caused by a number of different activities (Robinson *et al.* 2008; NE & JNCC 2010).
Priority Marine Feature (PMF)	Priority marine features are habitats and species that are considered to be marine nature conservation priorities in Scottish waters.
Supplementary Advice on Conservation Objectives (SACO)	Site-specific advice providing more detailed information on the ecological characteristics or 'attributes' of the site's designated feature(s). This advice is issued by Natural England and/or JNCC.

Type 1 (Sentinel) monitoring of long-term trends	Objective: to measure rate and direction of long-term change. This type of monitoring provides the context to distinguish directional trends from short-scale variability in space and time. To achieve this objective efficiently, a long-term commitment to regular and consistent data collection is necessary; this means time-series must be established as their power in identifying trends is far superior to any combination of independent studies (Kröger & Johnston 2016)
Type 2 (Operational) monitoring of pressure-state relationships	Objective: to measure state and relate observed change to possible causes. This objective complements monitoring long-term trends and is best suited to explore the likely impacts of anthropogenic pressures on habitats and species and identify emerging problems. It leads to setting of hypotheses about processes underlying observed patterns and is generally best applied in areas where a gradient of pressure is present (e.g. no pressure increasing gradually to 'high' pressure) (Kröger & Johnston 2016). It relies on finding relationships between observed changes in biodiversity and observed variability in pressures and environmental factors. It provides inference but it is not proof of cause and effect. The spatial and temporal scale for this type of monitoring will require careful consideration of the reality on the ground to ensure inference will be reliable; for example, inference will be poor in situations where the presence of a pressure is consistently correlated to the presence of an environmental driver (e.g. a specific depth stratum) (Kröger & Johnston 2016).
Type 3 (Investigative) monitoring to determine management needs and effectiveness	Objective: to investigate the cause of change. This monitoring type provides evidence of causality. It complements the above types by testing specific hypotheses through targeted manipulative studies (i.e. excluding an impact or causing an impact for experimental purposes). The design and statistical approach that can be used in these cases gives confidence in identifying cause and effect. It is best suited to test state/pressure relationships and the efficacy of management measures (Kröger & Johnston 2016).
UK Marine and Coastal Act (2009)	The Marine Act, which mainly affects England and Wales, provides the legal mechanism to help ensure clean, healthy, safe, productive and biologically diverse oceans and seas by putting in place a new system for improved management and protection of the marine and coastal environment.

1 Introduction

The Norwegian Boundary Sediment Plain Nature Conservation Marine Protected Area (MPA), hereafter referred to as 'NBSP', is part of a network of nationally designated sites designed to meet conservation objectives under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009. These sites also contribute to an ecologically coherent network of MPAs in the North-east Atlantic agreed under the Oslo Paris (OSPAR) Convention and other international commitments to which the UK is signatory. Under the Marine and Coastal Access Act 2009, Scottish Ministers have devolved responsibility to designate MPAs within Scottish Waters and must assess whether those MPAs are meeting their conservation objectives. Marine Scotland and Marine Scotland Science, in partnership with Scottish Natural Heritage (SNH) and the Joint Nature Conservation Committee (JNCC), has developed a Scottish MPA Monitoring Strategy (Scottish Government 2017). The Strategy aims to provide direction for monitoring, assessment and reporting on the MPA network and guidance on standardisation of monitoring objectives, sampling design, and methodologies. The JNCC is the Statutory Nature Conservation Body (SNCB) responsible for nature conservation in the UK offshore environment (from the territorial limit to 200nm from the mean low-water mark of the shore) and conducts a monitoring programme within this area in partnership with the devolved administrations. The aim of this monitoring programme is to collect the necessary information to underpin assessment and reporting obligations of the UK MPA network. Where possible, this monitoring should also inform assessment of the status of the wider UK marine environment; for example, assessment of whether Good Environmental Status (GES) has been achieved.

This initial monitoring report explores data acquired from the first dedicated monitoring survey of NBSP, which will form the first point in a monitoring time series against which feature condition can be assessed in the future. The data will also inform the development of an effective site- and feature-specific monitoring approach for the site. The specific aims of the report are discussed in detail in Section 1.4.3.

1.1 Site overview

NBSP is situated to the east of Scotland, in the Northern North Sea Charting Progress 2 Biogeographic Region (Figure 1). The site covers an area of approximately 164km^2 and ranges in depth from 80-120m. The site is designated for the Priority Marine Features (PMFs) ocean quahog (*Arctica islandica*) aggregations, and offshore subtidal sands and gravels representing sediment types suitable for ocean quahog colonisation (Figure 2). NBSP provides habitat to a range of animals that live both in and on the sand and gravel habitats such as starfish, crabs, and the long-lived bivalve, ocean quahog, the latter of which is on the OSPAR list of threatened and/or declining Species and Habitats (JNCC 2018a; OSPAR 2009).

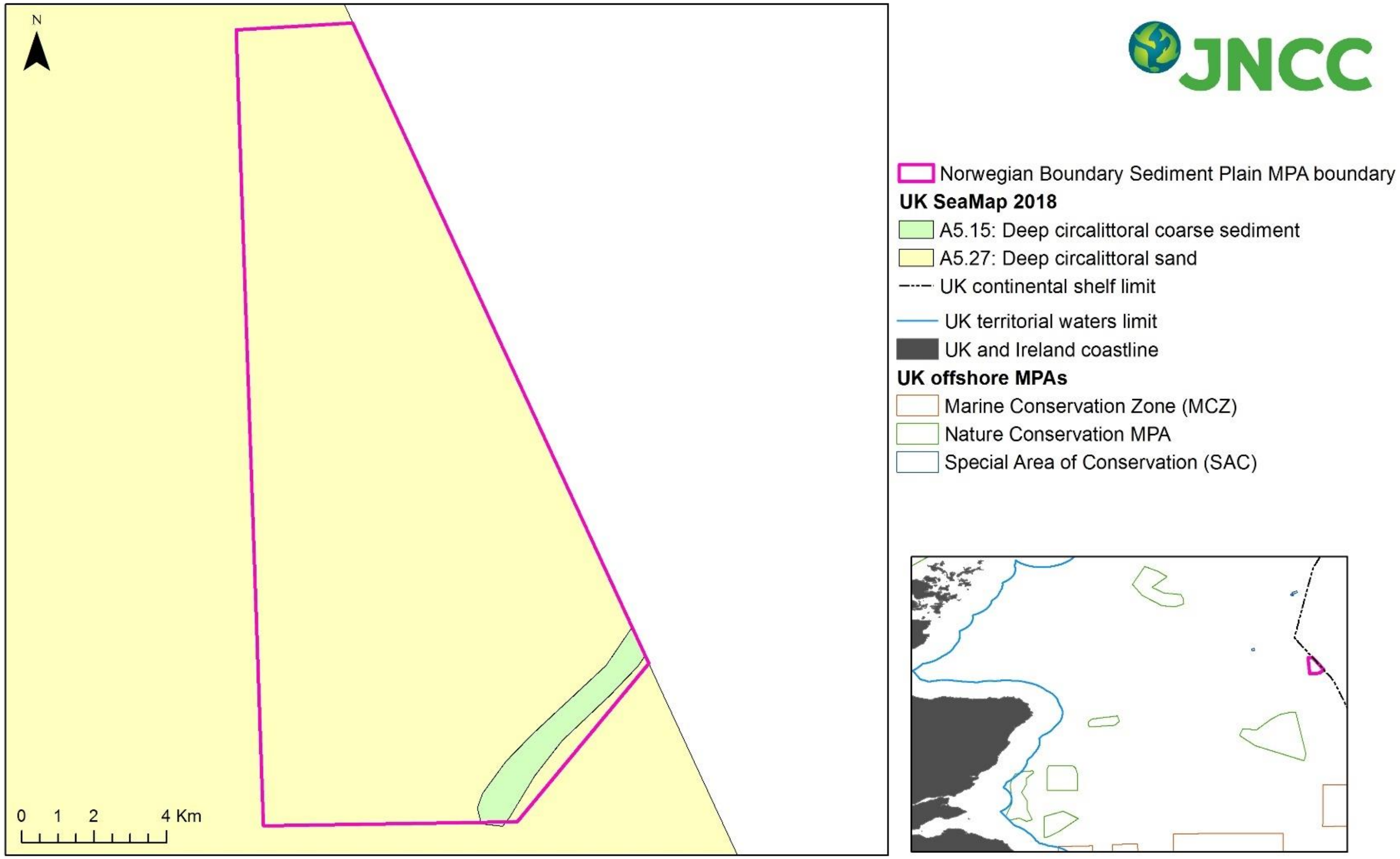

Figure 1: Overview map of the Norwegian Boundary Sediment Plain MPA site, with predicted habitat mapping data (Jaques *et al*. 2017). A regional view inset map shows the location of the MPA boundary and surrounding offshore MPAs.

1.2 Feature Description

The site is designated to protect two PMFs, ocean quahog (*A. islandica*) aggregations and offshore subtidal sands and gravels representing sediment types suitable for ocean quahog colonisation (Scottish Government 2014) (Figure 2).

1.2.1 Ocean quahog aggregations

The ocean quahog is a large, burrowing, cockle-shaped bivalve. The two halves of its hinged, rounded shell are thick, glossy, with a dark brown periostracum covering a white shell, growing up to 13cm across. Ocean quahog aggregations were identified as a PMF and the species is included in the OSPAR List of Threatened and/or Declining Species and Habitats following a notable decline in the population of the North Sea (OSPAR 2009). There is no definition provided in the PMF description or OSPAR guidance for the abundance or density of ocean quahog required before it is considered an 'aggregation' (Tyler-Walters *et al*. 2016; OSPAR 2009). This report is unable to assess the presence of 'aggregations' of ocean quahog, but will assess the population distribution of specimens from NBSP. The species is found in sandy and muddy sediments between depths of 4 and 400m, with evidence to suggest that individuals may live for up to 400 years (Ridgeway & Richardson 2010).

1.2.2 Offshore subtidal sands and gravels representing sediment types suitable for ocean quahog colonisation

Sand and gravel sediments are the most common subtidal habitats around the coast of the British Isles (Tyler-Walters *et al*. 2016).Depending on the exact composition of the sediments (proportions of gravel, sand and finer materials), and structuring factors such as current and wave regime and depth of the sediment over bedrock, the infaunal community will vary and may support tube dwelling polychaetes, brittlestars, burrowing bivalves, sea urchins or amphipods. Alongside infauna, a range of mobile epifauna including flatfish, starfish, crabs and hermit crabs, may be present. Sand and gravel features also support a number of important commercial fisheries such as scallops, flatfish, sandeels and roundfish (Tyler-Walters *et al*. 2016). Offshore subtidal sands and gravels are equivalent of the EUNIS codes detailed in Table 1, below.

1.2.3 Monitoring Habitats

The following habitats were predicted (prior to 1515S survey of NBSP) (Figure 2)

- EUNIS A5.1 'Sublittoral Coarse Sediment': (British Geological Survey 2012); (predicted UK SeaMap 2018 (Jaques *et al*. 2017);
- EUNIS A5.2 'Sublittoral sand' (BGS 2012);
- EUNIS A5.3 'Sublittoral mud' (BGS 2012).

In order to assess condition of the designated features in a 'common language' and for clarity with the collected PSA results, delivered in EUNIS sedimentary habitat description, the EUNIS level 3 sedimentary habitat description will be referenced throughout the report. A conversion table has been provided, showing the corresponding Monitoring habitats taken from the Marine Habitat Classification of Britain and Northern Ireland (JNCC 2015) and EUNIS habitat classification (Table 1). Further detail on the features present at the site, and the associated conversions applied is provided in Appendix 1.

Table 1: The designated features and the corresponding habitat types occurring at NBSP.

Designated feature (PMF)	EUNIS level 3 habitat (broad level)	Corresponding monitoring habitat
Offshore subtidal sands and gravel	A5.1 Sublittoral coarse sediment	Sublittoral coarse sediment (SS.SCS)
	A5.2 Sublittoral sand	Sublittoral sand and muddy sands (SS.SSa)
	A5.4 Sublittoral mixed sediments	Sublittoral mixed sediment (SS.SMx)

1.3 Existing data and habitat maps

The environmental data available, and utilised for the power analysis informing survey design, for NBSP are represented in Figure 2. These were amalgamated from 15 Day grabs (0.1m^2), collected for an environmental survey conducted by the oil and gas industry in September 2008 (O'Connor 2016).

Ocean quahog were recorded from benthic core surveys (volume of core samples unrecorded) conducted in the north of the MPA. The status of the specimens (i.e. alive or dead at the point of sample collection, juvenile or adult) is not described. In summary, we have the following records for the presence of ocean quahog (O'Connor 2016):

- 1979, 1981, 1983 - OPRU (Oil Pollution Research Unit) - Maureen A Phillips (in GeMS v4) - There is one data entry from 1979, 15 data entries from 1981 and 16 from 1983 recording the presence of ocean quahog.

- 1988 - AUMS (Aberdeen University Marine Studies Ltd) - Maureen A Phillips (in GeMS v4) - There are 22 data entries from 1988 recording the presence of ocean quahog.

- 1993 - Gardline - Maureen A Phillips (in GeMS v4) - There is one data entry from 1993 recording the presence of ocean quahog.

- EUSeaMap, version 2012_08 (Cameron & Askew 2011) 2 – The habitat map from a model predicts that suitable habitat for colonisation by ocean quahog occurs throughout the MPA area (Tyler-Walters & Sabatini 2017). The following habitats are predicted to be present: A5.15 Deep circalittoral coarse sediment and A5.27 Deep circalittoral sand

- British Geological Survey (BGS) Marine Particle Size Analysis (PSA) dataset (February 2012) - These data are from sediment sampling undertaken between 1967 and 1987 using mainly sediment grabs (0.1m^2 Day grabs or 0.1m^2 Shipek grabs). Of the 12 sample records evenly distributed across the MPA, ten record the presence of sand and muddy sand and two record the presence of coarse sediment. Both types are considered suitable habitat for ocean quahog colonisation (Witbaard & Bergman 2003; Tyler-Walters & Sabatini 2017).

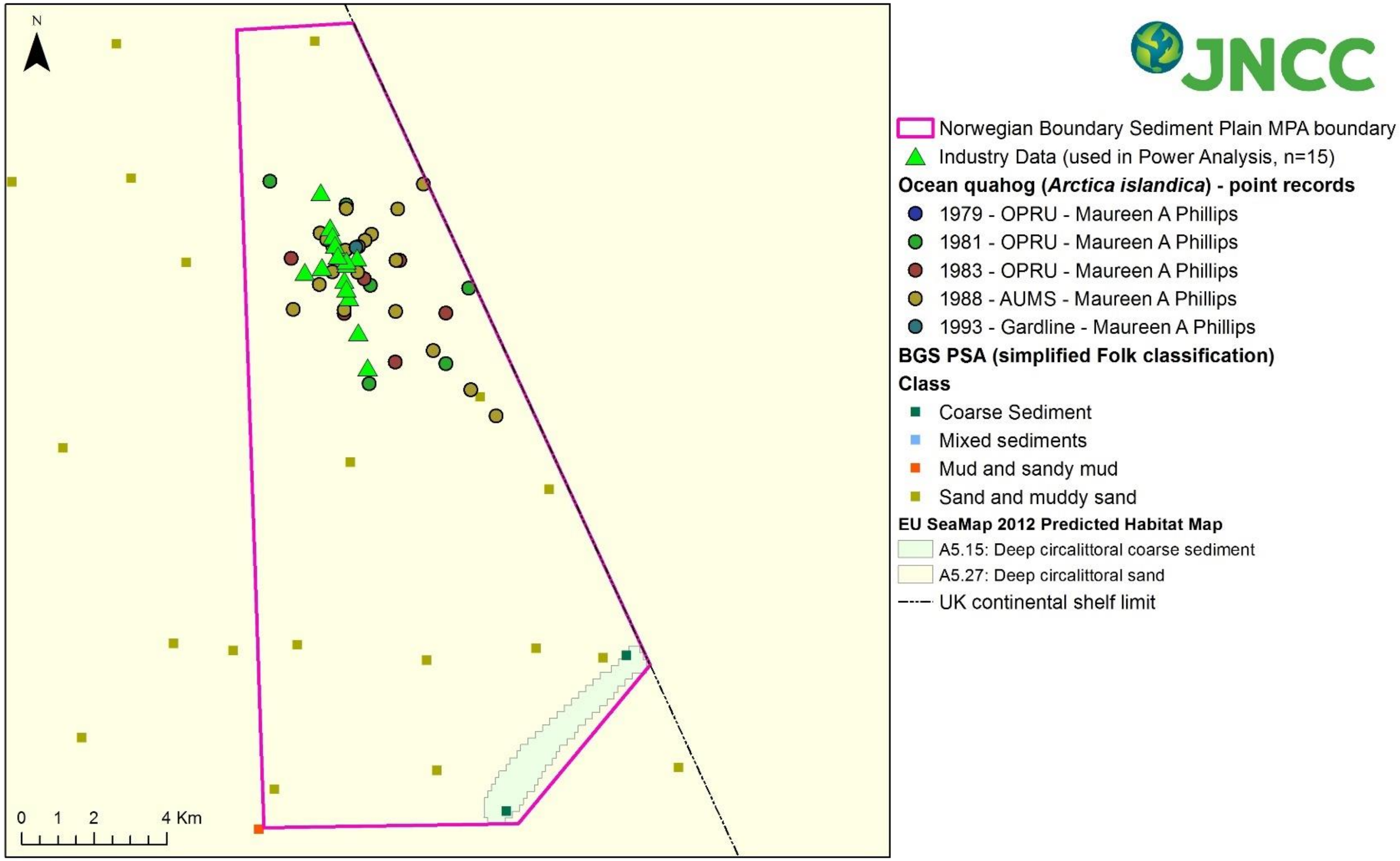

Figure 2: Existing data for NBSP, including point data used to inform power analysis for the survey design undertaken. Please note, ocean quahog point records collected by the Oil Pollution Research Unit (OPRU), Aberdeen University Marine Studies Ltd. (AUMS) and Gardline.

1.4 Aims and objectives

1.4.1 High-level conservation objectives

High-level, site-specific conservation objectives serve as a benchmark against which to monitor and assess the efficacy of management measures, once in place, in protecting designated features within MPAs.

The high-level conservation objectives for NBSP (JNCC 2018a, 2018b) are that the protected features:

- so far as already in favourable condition, remain in such condition; and
- so far as not already in favourable condition, be brought into such condition, and remain in such condition.

With respect to the ocean quahog aggregations (including supporting habitats) within the MPA, this means that the quality and extent of the species' habitat and the composition of its population in terms of number, age and sex ratio are such as to ensure that the population is likely to be maintained in numbers which enable it to thrive, each under a 'conserve' objective (JNCC 2018b).

1.4.2 Definition of 'Favourable Condition'

Specific attributes of the features will be monitored and assessed to determine whether Conservation Objectives have been achieved at the site level, as detailed in Section 1.4.4. The Supplementary Advice on Conservation Objectives (SACO) for this MPA (JNCC 2018b) lists several feature attributes for the two features for which the site is designated. These attributes fall into broad themes, which align with the terminology used in the Designation Order, and are described below (Section 1.4.4). Once these Conservation Objectives are met, the feature is deemed to be in 'Favourable Condition'.

The extent of a habitat feature refers to the total area in the site occupied by the qualifying feature and must also include consideration of its distribution. A reduction in feature extent has the potential to alter the physical and biological functioning of sediment habitat types (Elliott *et al*. 1998). The distribution of a habitat feature influences the component communities present and can contribute to the condition and resilience of the feature (JNCC 2004).

Structure encompasses the physical components of a habitat type and the key and influential species present. Physical structure refers to topography, sediment composition and distribution. Physical structure can have a significant influence on supporting processes such as the hydrodynamic regime operating at varying spatial scales in the marine environment, as well as influencing the presence and distribution of associated biological communities (Elliott *et al*. 1998). The function of habitat features includes processes such as: sediment reworking (e.g. through bioturbation) and habitat modification, primary and secondary production and recruitment dynamics. Habitat features rely on a range of supporting processes (e.g. hydrodynamic regime, water quality and sediment quality) which act to support their functioning as well as their resilience (e.g. the ability to recover following impact).

1.4.3 Report aims and objectives

The primary aim of this monitoring report is to explore and describe the attributes of the features within NBSP to enable future assessments of feature condition as part of a separate process (i.e. to determine whether Conservation Objectives have been achieved). The results presented will be used to develop recommendations for future monitoring, including the operational testing of specific metrics which may indicate whether the condition of the features have been conserved, improved or declined.

The specific objectives of this monitoring report are as follows (feature attributes as defined in the conservation objectives, are in bold):

1) Describe the population distribution of ocean quahog within NBSP, in addition to **the extent** and **distribution** of the **supporting habitat**;
2) Present any evidence of non-indigenous species (MSFD Descriptor 2) and marine litter (MSFD Descriptor 10); and
3) Recommend future monitoring approaches for NBSP.

1.4.4 Feature attributes and supporting processes

To achieve report objectives 1 and 2, this report presents evidence on feature attributes and supporting processes as defined in the SACO developed by JNCC for the designated features within the MPA (JNCC 2018b). It should be noted that it was not possible to address all feature attributes in the monitoring survey, given the comprehensive nature of the attribute lists for each feature. Therefore, the feature attributes were rationalised and prioritised to give a smaller, more manageable sub-set. The list of selected feature attributes and supporting processes considered in this report is presented in Table 2, alongside the generated outputs for each.

Table 2: Feature attributes and supporting processes addressed to achieve report objectives 1 & 2, for NBSP.

Ocean Quahog Aggregations (including sands and gravels as their supporting habitat)		
Feature attributes	**Sub-attributes**	**Outputs**
Extent and distribution	Extent and distribution	Mapped distribution and abundance of ocean quahog. PSA point sample distribution (for offshore subtidal sands and gravels as a supporting habitat)
Structure (ocean quahog)	Structure	Not assessed
Structure (sands and gravels as their supporting habitat)	Physical structure: fine scale topography	PSA and qualitative observations of seabed characteristics
	Sediment composition	
	Biological structure: Key and influential species	Multivariate analysis of infaunal communities Univariate analysis of species of interest
	Biological structure: Characteristic communities	
Function	Nutrition	Not assessed
	Regulatory processes	Not assessed
	Carbon cycling and nutrient regulation	Not assessed
Supporting processes	Hydrodynamic regime	Not assessed

Ocean Quahog Aggregations (including sands and gravels as their supporting habitat)		
Feature attributes	**Sub-attributes**	**Outputs**
	Supporting habitats	PSA point sample distribution, extent, and distribution assessment of supporting habitat.
	Water and sediment quality	Not assessed

The report **does not** aim to assess the condition of the designated features. Statutory Nature Conservation Bodies use evidence from MPA monitoring reports in conjunction with other available evidence (e.g. activities, pressures, sensitivities, historical data, survey data collected from other organisations or collected to address different drivers) to make assessments on the condition of designated features within a marine protected area (MPA).

The possibility of conducting 'Investigative Monitoring' (Type 3) (JNCC 2016) of the proposed fisheries management areas and 'Operational Monitoring' (Type 2) (JNCC 2016) of the effect of fishing pressure on the offshore subtidal sands and gravels habitats at NBSP was considered for the survey (Noble-James *et al*. 2017; JNCC 2016). Following a review of the surface abrasion data, it was determined that the intensity and distribution of surface abrasion gradient within the site was insufficient to conduct a Type 2 gradient study for this pressure. Fisheries management measures for the site at the time of the 2015 survey were not sufficiently defined to allow a targeted Type 3 monitoring survey to investigate the effects of a fisheries closure (O'Connor 2016).

2 Methods

2.1 Survey design

A power analysis was conducted using industry samples from NBSP (n = 15), which were collected in September 2008 using a 0.1m^2 Day grab. The power analysis determined that a total of 120 samples would be required to detect a 20% change in taxon abundance, with a power of 0.8 or higher and significance (p) of 0.05. The results indicated that more samples would be required for taxon abundance than for the other variables because of the much higher variation among samples in abundance levels. As such, the taxon abundance power analysis was chosen to inform the sampling strategy, to ensure a precautionary approach to determining the number of samples if in future metrics are considered for monitoring that exhibit lower spatial variability, and to capture any underestimation of the power analysis, due to the relatively restricted area the industry sample collection was conducted (Figure 2). It is noted that the grab type (Day grab) used in the industry collected data differs from the 0.25m^2 Hamon grab employed for the 1515S survey. The Hamon grab was selected under the rationale of obtaining undamaged ocean quahog samples. Issues of data comparability due to sampled seabed area and sediment volume are discussed further in Section 5.1. The rationale of one grab per station was followed. Further details are given in the 1515S Cruise Report (O'Connor 2016).

A triangular systematic grid, with 1km spacing between points, was employed to deliver an even spatial distribution of grab sampling stations across the site (Figure 3). Samples were not stratified by any environmental factors such as depth or sedimentary habitat type, as the existing habitat model was of low resolution. 'Gaps' in the sampling grid were caused by exclusion zones around oil and gas industry infrastructure (500m around any oil and gas infrastructure and 200m either side of pipelines). A further exclusion zone buffer was created between the boundaries of the Norwegian and UK territorial waters (500m) (Figure 3).More detailed information on survey design is available in the Cruise Report (O'Connor 2016).

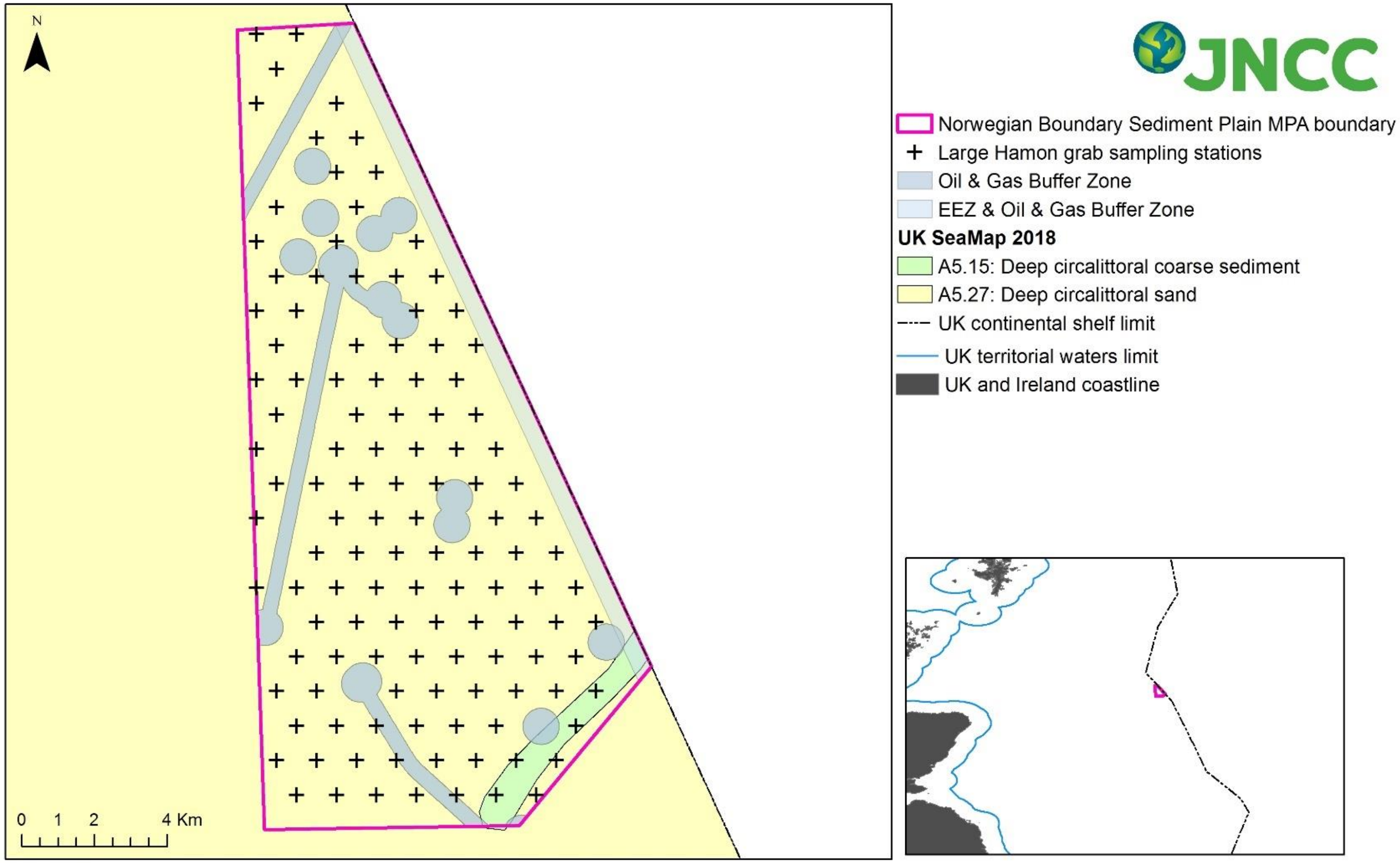

Figure 3: Map of sampling strategy for survey 1515S to Norwegian Boundary Sediment Plain MPA (2015). The map includes the buffer of exclusion zones from sampling due to oil and gas infrastructure and the Economic Exclusion Zone (EEZ) boundary.

2.2 Data acquisition and processing

2.2.1 Sediment samples

Sediment samples were successfully collected from 120 stations using a 0.25m^2 Hamon grab and processed on board the vessel according to the methods described in the Cruise Report (O'Connor 2016).

Grab samples were subsampled for Particle Size Analysis (PSA) prior to sieving. Following the removal of the PSA subsamples, the remaining sample was sieved over a 1 mm mesh to retain the infauna. Following the survey, 120 samples were processed for infaunal identification by Thomson Unicomarine, according to NMBAQC standards (Worsfold & Hall 2010), with external quality assurance provided by Aquatic Environments Ltd. The infaunal analysis report is provided in Appendix 18.

Infaunal samples "NSP004'; 'NSP066' and 'NSP101' were removed from further analysis due to the lack of corresponding PSA samples, and therefore 117 infaunal samples were used in the community analysis. A summary of the acquired samples is given in Table 3.

Ocean quahog specimens visible in grab samples were identified in the field by survey scientists, photographed and measured (length, width, and height) before returning them to the sea (O'Connor 2016). Data from these specimens were added to the data matrix prior to truncation (see 2.3.3).

2.3 Data preparation and analysis

2.3.1 Particle size analysis (PSA)

PSA samples were processed by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) following the survey. PSA was conducted for 120 sediment samples, in accordance with NMBAQC standards (Mason 2011). For three subsamples (sample 'NSP004'; 'NSP066' and 'NSP101') there were no PSA results due to processing complications, 177 sediment samples have available PSA with results presented in this report.

Sediment samples collected at NBSP were analysed for half phi intervals using a combination of laser diffraction (<1mm fraction) and dry sieving techniques (>1mm) as described in National Marine Biological Analytical Quality Control Scheme PSA guidance (Mason 2011). Mean particle size, sorting coefficient, skewness and kurtosis were also calculated for all samples and each sample was classified according to one of four EUNIS sediment classes as defined by Long (2006). GRADISTAT software (Blott & Pye 2001) was then used to produce particle size distribution (PSD) statistics. Particle (grain) size charts used in the GRADISTAT software are provided in Appendix 7 (Blott & Pye 2001).

2.3.2 Data truncation

Prior to any analysis, the infaunal datasets were examined and truncated to ensure subsequent analyses were devoid of erroneous entries, records of juveniles and mobile species, were removed. Full details of the truncation protocol for infauna are available in Appendix 2.

2.3.3 Infaunal data preparation

The infaunal dataset was checked to ensure consistent nomenclature using the World Register of Marine Species (WoRMS) taxon match tool. Discrepancies were resolved using expert judgement following the truncation of the data. Infauna were counted for abundance, numerically, rather than presented as a scale e.g. SACFOR scale[1].

2.3.4 Non-indigenous species

The raw (WoRMs corrected) infaunal taxon lists generated from the infaunal samples were cross-referenced against lists of non-indigenous target species which have been selected for assessment of Good Environmental Status in UK waters under MSFD Descriptor 2 (Stebbing *et al*. 2014) and identified as significant by the UK Non-Native Species Secretariat. The cross-referenced taxa are listed in Appendix 3.

2.3.5 Statistical analyses

Multivariate analyses were conducted using the statistical package PRIMER (version 7; (Clarke & Gorley 2015). Unless otherwise stated, Clarke and Gorleys' (2015) recommendations for statistical analyses were followed.

Infaunal multivariate analysis

Summary statistics and univariate indices of community structure were calculated from infaunal taxa abundance data, generating the following metrics: total abundance per sample, total number of species per sample (species richness), Margalef index, Shannon index and Pielou's evenness. The Margalef index reflects the total number of species relative to the natural log of total abundance, the Shannon Index reflects both the total number of species and the evenness with which total abundance is distributed across species, and Pielou's evenness reflects the abundance of each species, scaled between 0 and 1 where 1 is perfect evenness.

Prior to multivariate analysis, the dataset was visually examined using shade plots before being fourth-root transformed to down weight the influence of any dominant taxa, and allow variation in less abundant species to be detectable. Bray-Curtis similarity resemblance matrices were generated from the transformed data and between each pairing of the 117 sampled stations. The following analyses were subsequently conducted:

- Non-metric multidimensional scaling (nMDS) was used to explore the relationships between samples;
- Hierarchical clustering was used in conjunction with Similarity Profile Analysis (SIMPROF; Clarke *et al*. 2008) to look for divisions in the dataset and to determine where divisions could no longer be made appropriately (i.e. any sub cluster could be randomly permuted);
- SIMPROF was used to determine if the dataset has a structure distinct from that derived by random permutation. It was found that at over 45% similarity the hierarchical clustering showed no multivariate structure in the community groups. Therefore, further assessment was conducted only on groups within and below this similarity to avoid interpretation of unstructured communities. This produced 13 infaunal groups.

[1] The SACFOR abundance scale describes the relative abundance of organisms (as numbers of individuals per unit area or percentage cover). The units of the SACFOR scale are Superabundant (S), Abundant (A), Common (C), Frequent (F), Occasional (O), Rare (R).

- The Similarity Percentage Analysis (SIMPER; Clarke 1993) routine was used to further investigate the results from SIMPROF and hierarchical clustering, informing the taxa that characterised (or typified) each of the identified community groups (or clusters).
- Biota and/or environment matching (BEST) was used to relate measured environmental factors (depth and sediment type) to biological patterns and examine how well these factors (or a combination of them) explain biological variability.
- Principal Components Analysis (PCA) was undertaken on percentage of gravels, sands and fines of the sediment composition to give a visual representation and support interpretation of possible relationships between the faunal clusters and sedimentary composition.

Regarding the BEST analysis, all pairwise combinations of environmental variables were visually examined (using draftsman plots) to assess the possible need for transformation and for co-correlation prior to conducting the BEST analysis. For pairs of variables with a correlation factor ≥0.9, one variable was excluded from the analysis. Variables excluded from analyses and variables requiring log-transformations are listed in the respective results sections. All variables were normalised prior to the BEST analysis.

Additionally, benthic community data were analysed with respect to all of the EUNIS level 3 habitats identified within NBSP from PSA samples acquired in the 1515S survey (A5.1 Sublittoral coarse sediment, A5.2 Sublittoral sand, A5.3 Sublittoral mud, and A5.4 Sublittoral mixed sediment). This would determine the structure of the infaunal communities of each sedimentary habitat, providing a comparison to the generated infaunal assemblages.

2.3.6 Biotope assignment

Biotopes were assigned using the community groups identified from the SIMPER analysis. It should be noted that assignment to biotope(s) were determined by expert opinion, and in cases in which the biota, habitats and/or depths of samples were not an exact match to the full biotope description, the closest match was used.

3 Results

3.1 Extent and Distribution

3.1.1 Particle size analysis

Results of particle size analysis obtained from 117 successful large (0.25m^2) Hamon grabs indicate the presence of four EUNIS BSH at the site: Sublittoral coarse sediment (A5.1), Sublittoral sand (A5.2), Sublittoral mud (A5.3), and Sublittoral mixed sediments (A5.4) (Table 3).

Table 3: Number of grabs taken in four identified sedimentary broadscale habitats, advised from the PSA results, and the percentages of each habitat. All samples from survey 1515S to Norwegian Boundary Sediment Plain MPA (2015).

BSH (EUNIS Code)	Grab – PSA and Infauna
A5.1 Sublittoral coarse sediment	6 (5.1 %)
A5.2 Sublittoral sand	102 (87.2 %)
A5.3 Sublittoral mud	2 (1.7 %)
A5.4 Sublittoral mixed sediments	7 (6.0 %)

The percentage constituent of gravel, sand and mud(fines) for each sedimentary habitat from the NBSP grab samples is shown in Figure 4.

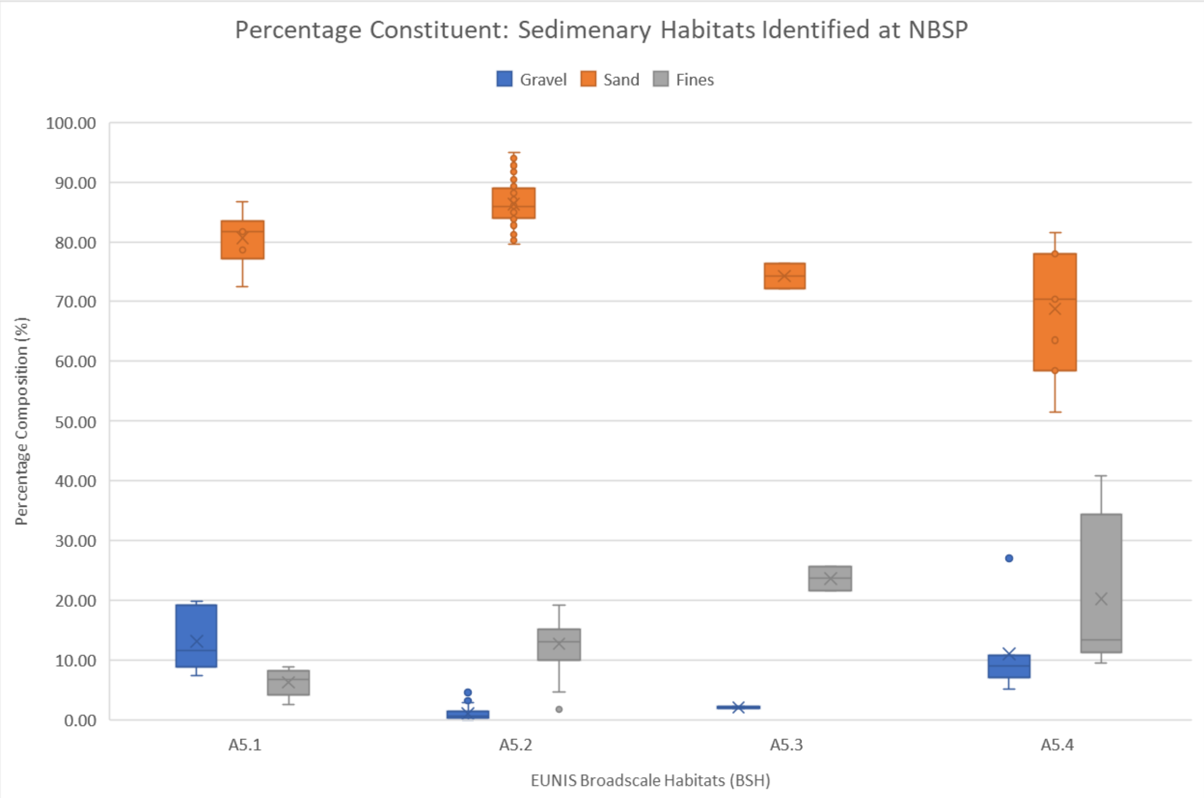

Figure 4: Percentage constituents of each of the identified sedimentary habitats obtained from 117 grab samples in A5.1 (n=6), A5.2 (n=102), A5.3 (n=2), A5.4 (n=7). Boxes represent median and upper quartile values, and whiskers represent the highest and lowest observed values in each category. All samples from survey 1515S to Norwegian Boundary Sediment Plain MPA (2015).

Further analysis using GRADISTAT revealed the samples to be primarily composed of muddy sand, slightly gravelly muddy sand, gravelly sand, sand and silty sand (Figure 5, Figure 6). There is a generally homogenous geospatial distribution of the sedimentary habitats across NBSP (Figure 6, Figure 7) with Sublittoral sands (A5.2) being the most commonly sampled sediment habitat across the whole site. The other sedimentary habitats at the site, Sublittoral coarse sediment (A5.1), Sublittoral mud (A5.3) and Sublittoral mixed sediment (A5.4) are sparsely present in southern areas of the site, with the exception of one sample of mixed sediment in the north of the site (Figure 6, Figure 7). The results differ from the existing data in their spatial distribution and extent (see Section 1.3 and Figure 2), however, this may be largely due to differences in sampling method. Further sedimentary analysis results from GRADISTAT are given in Appendices 8 to 11.

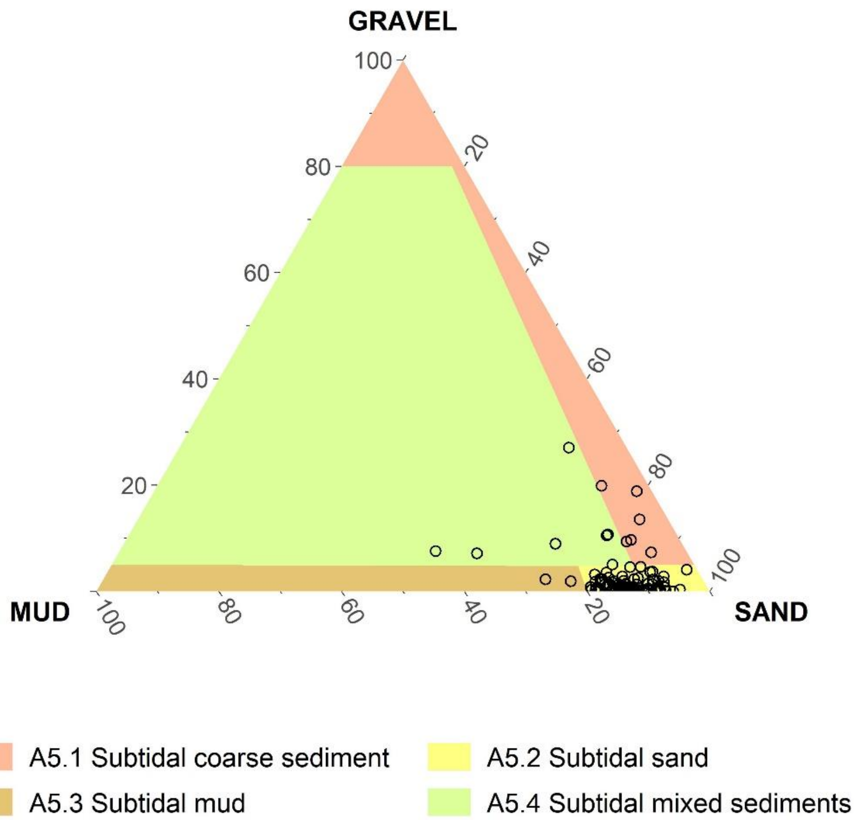

Figure 5: Classification of particle size distribution (half phi) information for each sampling point (black circles) plotted on a true scale subdivision of the Folk triangle. The proportion of gravel, sands and muds is depicted, with the corresponding EUNIS sedimentary habitats.

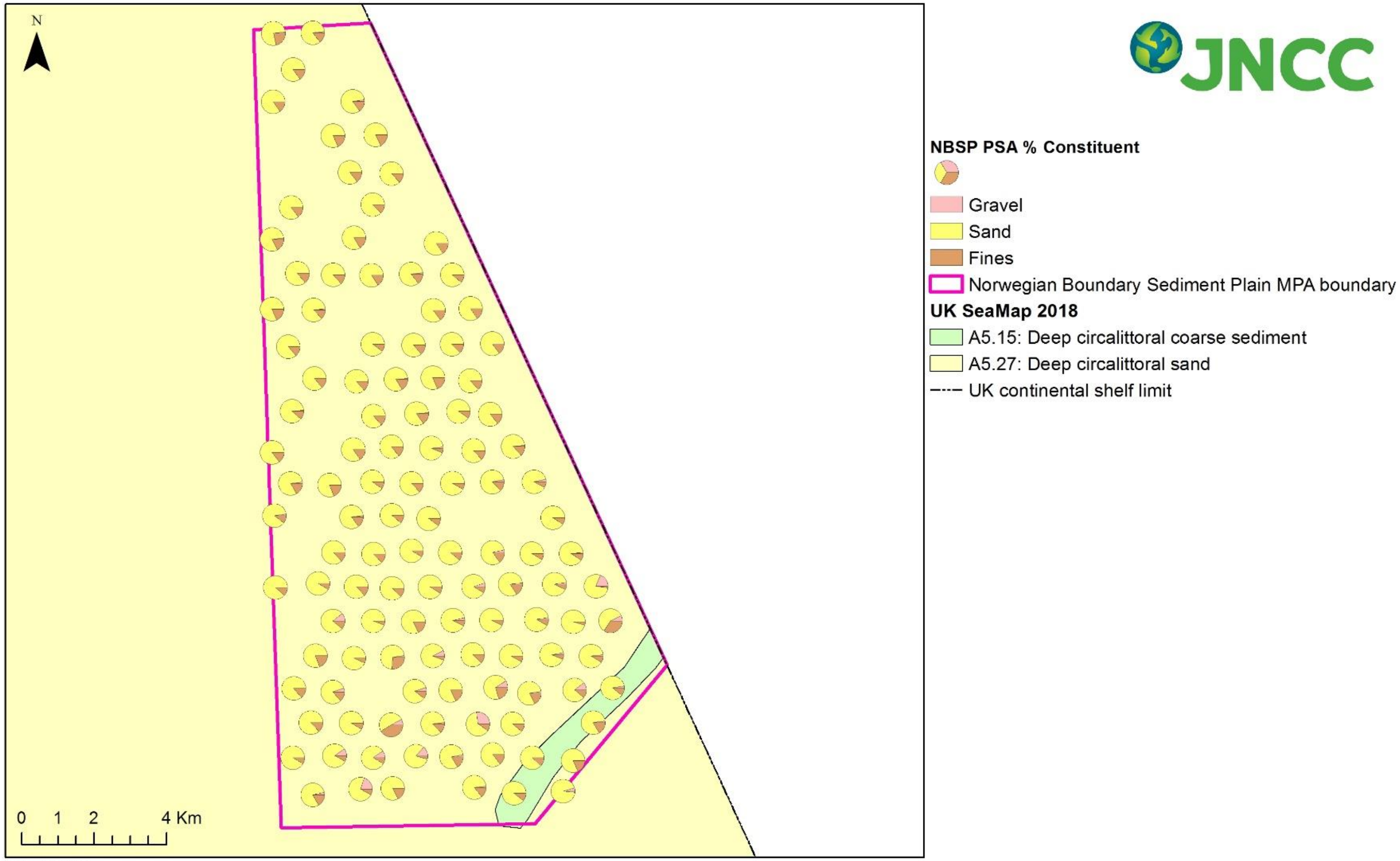

Figure 6: Distribution of particle size groups (percentage of gravel, sand, and fines). All samples from survey 1515S to NBSP (2015).

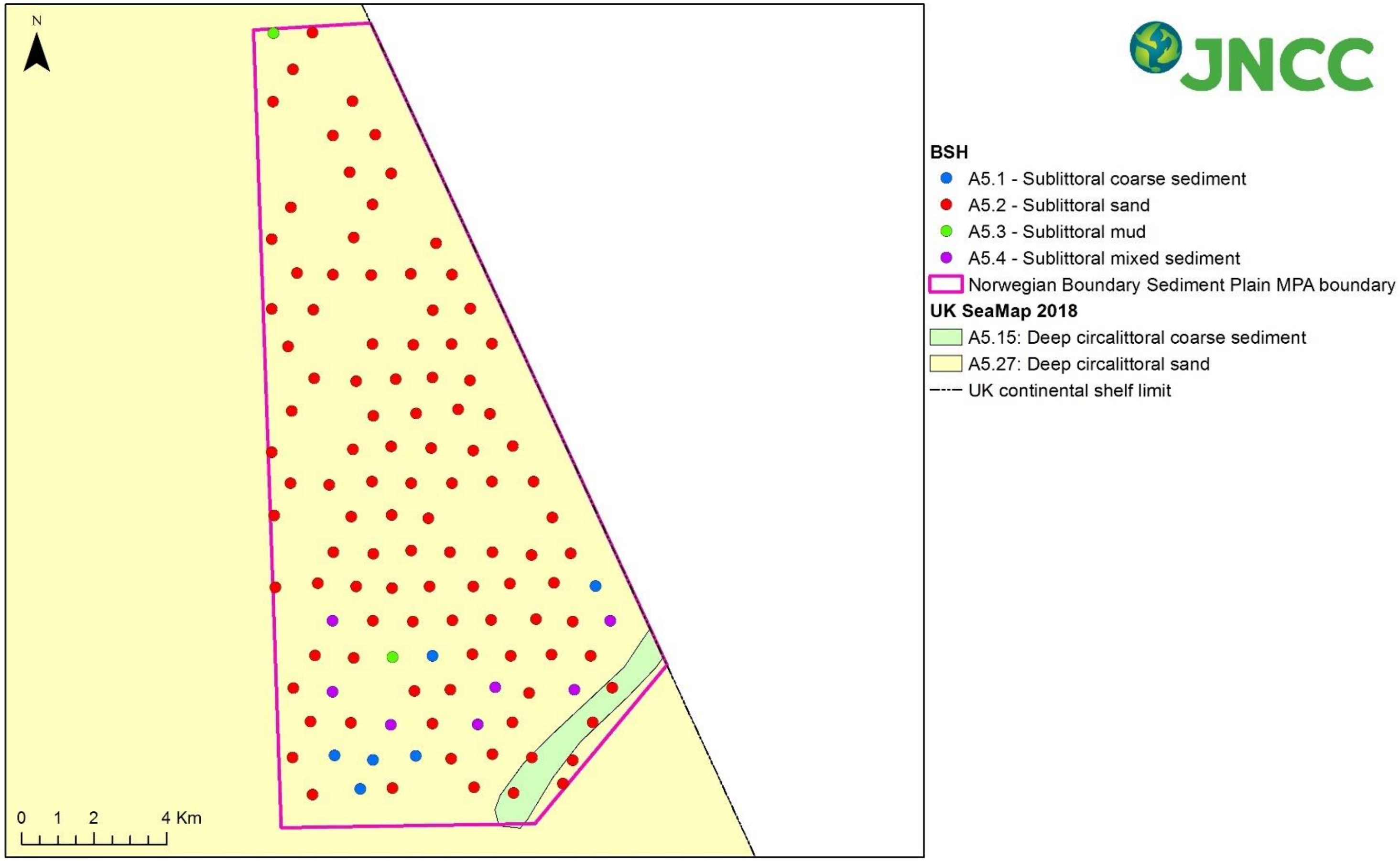

Figure 7: Distribution of EUNIS sedimentary habitats based on particle size analysis from survey 1515S to NBSP (2015). Underlaid is the predictive map of habitats, indicating the subtle differences between predicted and sampled habitat extents.

3.1.2 Offshore subtidal sands and gravels as sediment type suitable for ocean quahog colonisation

The PSA of the grab samples at the NBSP site show the presence of A5.2 Sublittoral sands in 102 of the successfully sampled stations, the presence of A5.1 Sublittoral coarse sediment at six stations and A5.4 Sublittoral mixed sediment at seven stations (Table 3, Figure 7). Both sedimentary habitats are representative of offshore subtidal sands and gravel as defined by Tyler-Walters *et al.* (2016) (and Section 1.2.3).

Particle size analysis shows that the A5.2 subtidal sand is more widespread than previously indicated in predictive mapping (Figure 2, Figure 6, Figure 7), although it is recognised this discrepancy may be largely due to the differences in the predictive map, based on a limited sample number (12 stations), and sampling methods used in each survey.

3.2 Infaunal Community Analysis

The grab sampling from the 1515S survey of NBSP obtained a total of 11,321 individuals from 117 stations across the site. Results from the univariate analysis are shown in Table 4.

The Margalef species richness index (d) shows an average of 6.81 with a range of 6.37 and variance of 1.63, indicating that some stations had richer communities than others. In terms of species evenness, measured by Pielou's evenness (J'), the maximum and averages between all stations are very high at 0.95 and 0.86 respectively, indicating the distribution of individuals among taxa is very even. The average value of 2.96 of Shannon's Diversity (H'(log^e)) among stations indicates a rich, but even, community structure throughout NBSP. The Simpson's diversity index, with an average of 0.08 and maximum of 0.13 further indicates a highly even structure.

The results of the univariate analysis of the infaunal analysis are displayed in (Appendix 12), which shows the summary statistics for all 117 grab sampling stations, independently.

Table 4: Summary of infaunal diversity indices for each of the 117 grab samples. All samples are from survey 1515S (2015) to NBSP MPA.

	Minimum	**Maximum**	**Average**	**Sum**	**Standard deviation**	**Variance**	**Range**
Total species (S)	14.00	53.00	32.07	3752.00	7.34	53.94	39.00
Total individuals (N)	35.00	231.00	96.82	11328.00	30.82	949.84	196.00
Species richness (d)	3.50	9.87	6.81	796.78	1.28	1.63	6.37
Pielou's evenness (J')	0.74	0.95	0.86	100.82	0.03	0.00	0.21
Shannon diversity (H'(loge))	2.32	3.40	2.96	346.68	0.22	0.05	1.08
Simpson's diversity (1-Lambda')	0.05	0.13	0.08	9.32	0.02	0.00	0.09

Structure of the infaunal community groups

The structure of the infaunal communities at NBSP was examined to determine the variation across the site and the possible causes for this variation.

Results from the nMDS ordination (Figure 8) indicate the infaunal samples are tightly clustered, with some sparse samples (six, in particular, belonging to infaunal assemblages a, b, c and d) dispersed to the outside. The 2D stress value (0.22) indicates the ordination should be interpreted as an accurate representation of the data, but with some caution. The 3D modelled ordination had a lower stress value (0.18) (Appendix 4) that warranted further examination of the data using hierarchical cluster analysis (Figure 9) and SIMPROF. The SIMPROF test strongly rejected the null hypothesis that there is no structure in the samples (Appendix 5), with a significant π value of 3.27 ($p<0.001$) for the difference between the sampled profile and 999 randomly permuted profiles. The dendrogram (Figure 9) shows the relationships among the infaunal clusters, and the 45% similarity (dashed line) indicates the groupings identified by SIMPROF, generating 13 groupings.

Of these 13 infaunal community groups (labelled a to m) (Figure 8 and Figure 9), two clusters, groups j and m (red triangles and blue triangles in Figure 8 and Figure 9) include most (~84%) of the samples.

To determine which taxa drive the groupings, an analysis of similarity percentages (SIMPER) was undertaken using 45% similarity. Below this level of similarity, the groupings defined by hierarchical clustering have no structure. Group k and l are within this unstructured bracket; however, these do not change the interpretation of the overall trends in biological community structure observed in NBSP. Average similarity within the groups is low, ranging from 46.57% (group g) to 52.79% (group m). In most cases this is due to the abundance of several taxa, such as *Scoloplos armiger*, *Spiophanes bombyx*, *Amphiura filiformis* and/or *Owenia borealis*, rather than the presence or absence of a single species. The two groups which represent most of the infaunal clusters, j and m, (~84% of all infaunal samples; cumulatively j= 21% and m= 63%) both support *A. filiformis,* which contributes most to this internal similarity. The second most contributory taxa in m, *S.bombyx*, is also present as the third most contributory taxa in j. Furthermore, they share *S. armiger* in the top five contributing taxa (second most contributing in j and fourth most in m) (Table 5).

In terms of community composition dissimilarities between these two infaunal groups, the average dissimilarity between j and m is 56.28. This is driven by the taxa listed in Table 6, namely *Thyasira flexuosa* (1.95% contribution), *Urothoe elegans*(1.89% contribution) and *Chaetoderma nitidulum* (1.82% contribution). These taxa are present in both ‘j’ and ‘m’, but in different abundances, which drives the dissimilarity. In assemblages outwith j and m, the dissimilarities are much higher, with 81.65%. This dissimilarity is driven by the presence or absence of certain taxa. *A. filiformis* and *Echinocyamus pusillis* have been identified as contributing the greatest dissimilarity between c and j with a 2.74% and 2.42% contribution to average dissimilarity respectively (Table 6). *A. filiformis* and *Echinocyamus pusillis* contribute to this difference consistently, with the standard deviation of dissimilarity (Diss/SD) of 7.29 and 5.72, respectively (Table 6).

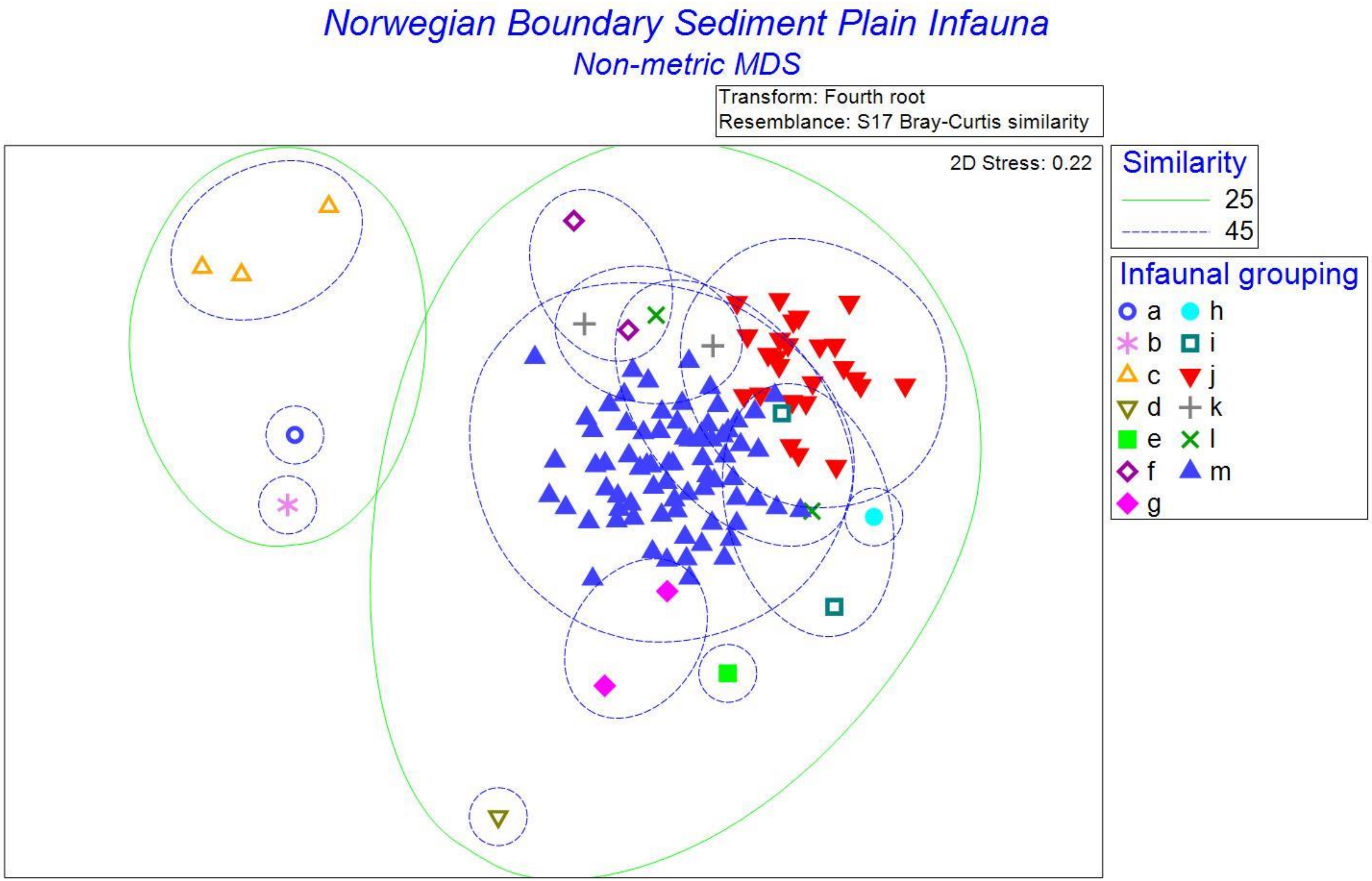

Figure 8: Non-metric multidimensional scaling (nMDS) of fourth-root transformed infaunal data from 117 grab samples taken during survey 1515S to NBSP (2015). Groups a to m were derived from a SIMPROF analysis with a cut-off level of 45% infaunal cluster similarity. Lines are drawn to represent 25% (green) and 45% (purple) group similarity. The high stress value of 0.22 indicates suspect results.

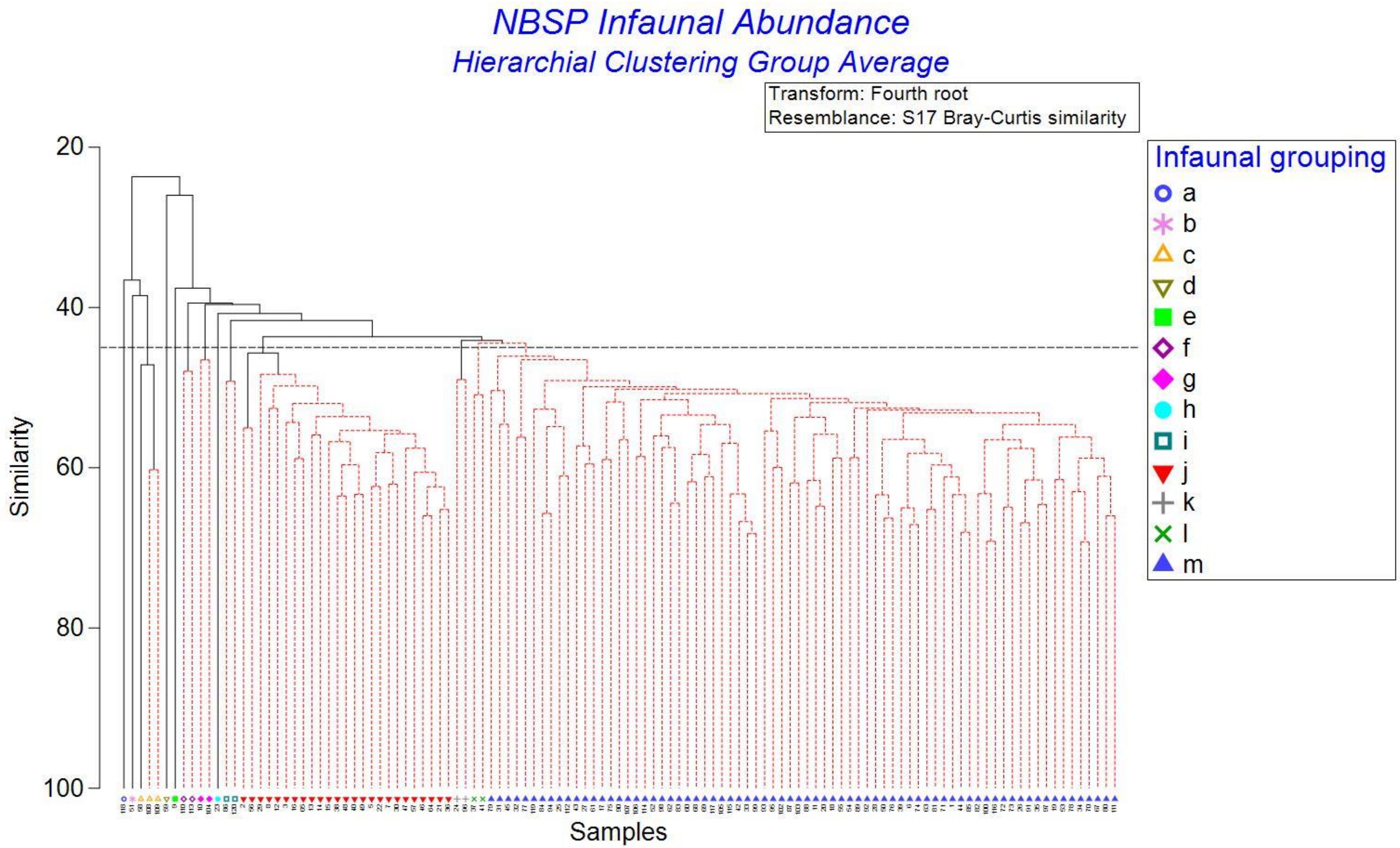

Figure 9: Dendrogram of fourth-root transformed infaunal data from 117 grab samples from survey 1515S to NBSP (2015). The horizontal dashed line indicates the 45% cut-off in infaunal similarity used to define groups for further SIMPER analysis, producing the 13 distinct infaunal groups shown in the key (a-m), The solid black lines of the hierarchical cluster define significant relationships, whereas red dashed lines denote unsupported relationships ($p>0.05$). The correlation of the dendrogram = 0.81301.

Table 5: Results of the SIMPER test at 45% infaunal cluster similarity. The clustering identifies a total of 13 community assemblages, detailing the five species contributing most to average within-cluster similarity including average abundance, average similarity, standard deviation of the similarity and its percentage contribution to the group's overall similarity and cumulative percentage similarity of the taxa. Five groups containing only one sample have been removed. Sim/SD of "n/a" indicates insufficient samples to calculate statistic.

Group c					
Average similarity: 51.52					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib. %**	**Cum.%**
Echinocyamus pusillus	1.86	3.5	11.27	6.79	6.79
Aonides paucibranchiata	1.92	3.39	3.7	6.59	13.38
Paramphinome jeffreysii	1.86	2.95	3.43	5.73	19.11
Cerianthus lloydii	1.69	2.92	7.6	5.67	24.78
Aglaophamus agilis	1.46	2.86	11.27	5.54	30.32
Group f					
Average similarity: 47.97					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib. %**	**Cum.%**
Scoloplos armiger	1.68	4.04	SD=0!	8.43	8.43
Spiophanes bombyx	1.61	3.72	SD=0!	7.75	16.18
Owenia borealis	1.57	3.52	SD=0!	7.33	23.51
Cerianthus lloydii	1.25	2.96	SD=0!	6.16	29.68
Goniada maculata	1.44	2.96	SD=0!	6.16	35.84
Group g					
Average similarity: 46.57					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib. %**	**Cum.%**
Owenia borealis	1.92	6.41	SD=0!	13.77	13.77
Spiophanes bombyx	1.6	5.28	SD=0!	11.35	25.12
Sthenelais limicola	1.47	4.44	SD=0!	9.54	34.66
Goniada maculata	1.55	4.44	SD=0!	9.54	44.2
Abra sp.	1.37	4.44	SD=0!	9.54	53.75
Group i					
Average similarity: 49.23					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib. %**	**Cum.%**
Amphiura filiformis	1.65	6.09	SD=0!	12.38	12.38
Scoloplos armiger	1.64	5.6	SD=0!	11.38	23.76
Goniada maculata	1.45	5.3	SD=0!	10.76	34.52
Owenia borealis	1.71	5.3	SD=0!	10.76	45.29
Pectinaria auricoma	1.19	4.46	SD=0!	9.05	54.34
Group j					
Average similarity: 52.39					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib. %**	**Cum.%**

Amphiura filiformis	2.11	4.44	6.93	8.48	8.48
Scoloplos armiger	1.62	3.32	4.33	6.33	14.81
Spiophanes bombyx	1.62	3.23	4.88	6.16	20.97
Harpinia antennaria	1.52	3.04	4.3	5.81	26.78
Paramphinome jeffreysii	1.56	2.75	2.14	5.26	32.04

Group k

Average similarity: 49.01

Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib. %**	**Cum. %**
Spiophanes bombyx	1.9	4.86	SD=0!	9.93	9.93
Scoloplos armiger	1.89	4.65	SD=0!	9.48	19.41
Amphiura filiformis	1.88	4.25	SD=0!	8.67	28.08
Paramphinome jeffreysii	1.65	4.09	SD=0!	8.35	36.43
Harpinia antennaria	1.45	3.7	SD=0!	7.54	43.97

Group l

Average similarity: 50.91

Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib. %**	**Cum.%**
Spiophanes bombyx	1.68	4.88	SD=0!	9.59	9.59
Scoloplos armiger	1.44	3.95	SD=0!	7.76	17.36
Owenia borealis	1.37	3.95	SD=0!	7.76	25.12
Amphiura filiformis	1.57	3.95	SD=0!	7.76	32.88
Sthenelais limicola	1.3	3.57	SD=0!	7.01	39.9

Group m

Average similarity: 52.79

Species	**Av. Abund.**	**Av.Sim.**	**Sim/SD**	**Contrib. %**	**Cum.%**
Amphiura filiformis	1.83	4.62	7.3	9.06	9.06
Spiophanes bombyx	1.73	4.18	4.1	8.21	17.27
Owenia borealis	1.66	4.03	3.64	7.91	25.17
Scoloplos armiger	1.57	3.85	3.48	7.55	32.72
Goniada maculata	1.37	3.42	4.33	6.7	39.42

Table 6: The dissimilarity between infaunal community groups j and m, and between two of the most dissimilar groups c and j, from the SIMPER cluster analysis, at a 45% split. The clustering identified the five primary contributing species to the dissimilarity, the ratio of their average individual contribution to dissimilarity and standard deviation of this value (Diss/SD) and their percentage contribution to the dissimilarity between groups.

Groups	Average dissimilarity (%)	Primary contributing taxa	Diss/SD	% Contribution to average dissimilarity
j & m	56.28	*Thyasira flexuosa*	1.58	1.95
		Urothoe elegans	1.44	1.89
		Chaetoderma nitidulum	1.48	1.82
		Lanice conchilega	1.33	1.69
		Galathowenia sp.	1.28	1.65
c & j	81.65	*Amphiura filiformis*	7.29	2.74
		Echinocyamus pusillus	5.72	2.42
		Aonides paucibranchiata	3.43	2.42
		Pisione remota	1.32	2.20
		Cerianthus lloydii	4	2.06

BEST Analysis

In order to link biological data to environmental data, a BEST analysis was employed to identify the best combination of environmental variables explaining the observed patterns in infaunal community composition. The following variables were included in the analysis:

- % Fines (Fi)
- % Sand (Sa)
- % Gravel (Gr)
- Water depth (Wa)

For a list of variables excluded from analysis due to high co-correlation please see Appendix 6. The combination of environmental variables best explaining the observed infaunal patterns was percentage of gravel sediment (Gr), percentage of fine sediment (Fi) and water depth (Wa), with a correlation (Rho) value of 0.449. This was the highest correlation for any combination of the four variables. The strongest correlation with a single variable was with percentage of gravel sediment, with a value of 0.291 (Table 7).

Table 7: Correlation values for combinations of environmental variables best explaining observed infaunal community composition patterns. Gr = percentage of gravel, Sa = percentage of sands, Fi = percentage of fines; Wa = water depth. The highest correlation is marked in bold. Date derived from 117 grab samples taken during survey 1515S to Norwegian Boundary Sediment Plain MPA (2015).

BEST results: Infaunal Resemblance		
No. Vars.	**Corr. (Rho)**	**Selections**
1	0.291	Gr
2	0.420	Gr, Wa
3	**0.449**	**Gr, Fi, Wa**
4	0.421	Gr, Sa, Fi, Wa

The variables percentage of gravel, fines, and water depth were further interpreted and added to the nMDS of the infaunal community clusters for visual investigation as bubble plots (Figure 10, Figure 11 and Figure 12). Infaunal cluster group m tends to associate with gravellier and slightly shallower sediment, indicated by larger bubble plots for 'percentage of gravel' and slightly smaller bubbles for 'depth', when compared to group j. Group j tends towards, finer, slightly deeper and less gravelly sediments. A Pearson's correlation between the abiotic variables used in the BEST analysis revealed that the variable of percentage of fines is positively correlated to depth, whereas percentage of gravel and sand is negatively correlated with depth (Table 8). This follows the trends of the major infaunal groups (Figure 13) and supports their statistical distinctness.

Table 8: Pearson's R correlation coefficient values for each environmental variables included in BEST analysis.

	Gravel (%)	Sand (%)	Fines (%)	Water depth (m)
Gravel (%)				
Sand (%)	-0.558			
Fines (%)	-0.125	-0.753		
Water depth (m)	-0.198	-0.094	0.2697	

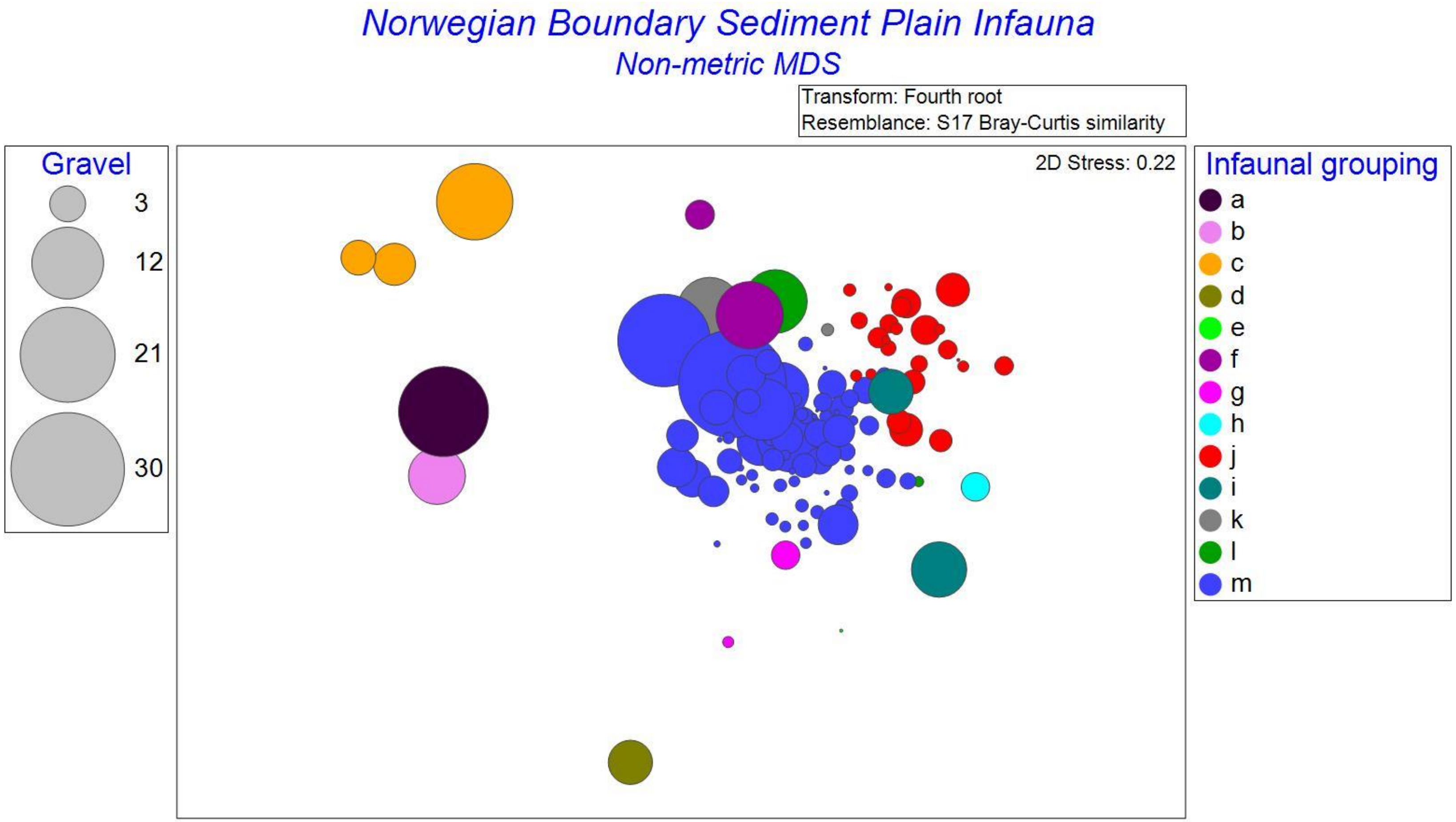

Figure 10: Non-metric multidimensional scaling (nMDS) of fourth-root transformed infaunal data from 117 grab samples taken during survey 1515S to Norwegian Boundary Sediment Plain MPA (2015). Groups a to m were derived from a SIMPROF analyses at a cut-off level of 45% infaunal cluster similarity. The overlain bubble plot shows the distribution of percentage of gravel (maximum of 27%) in the samples.

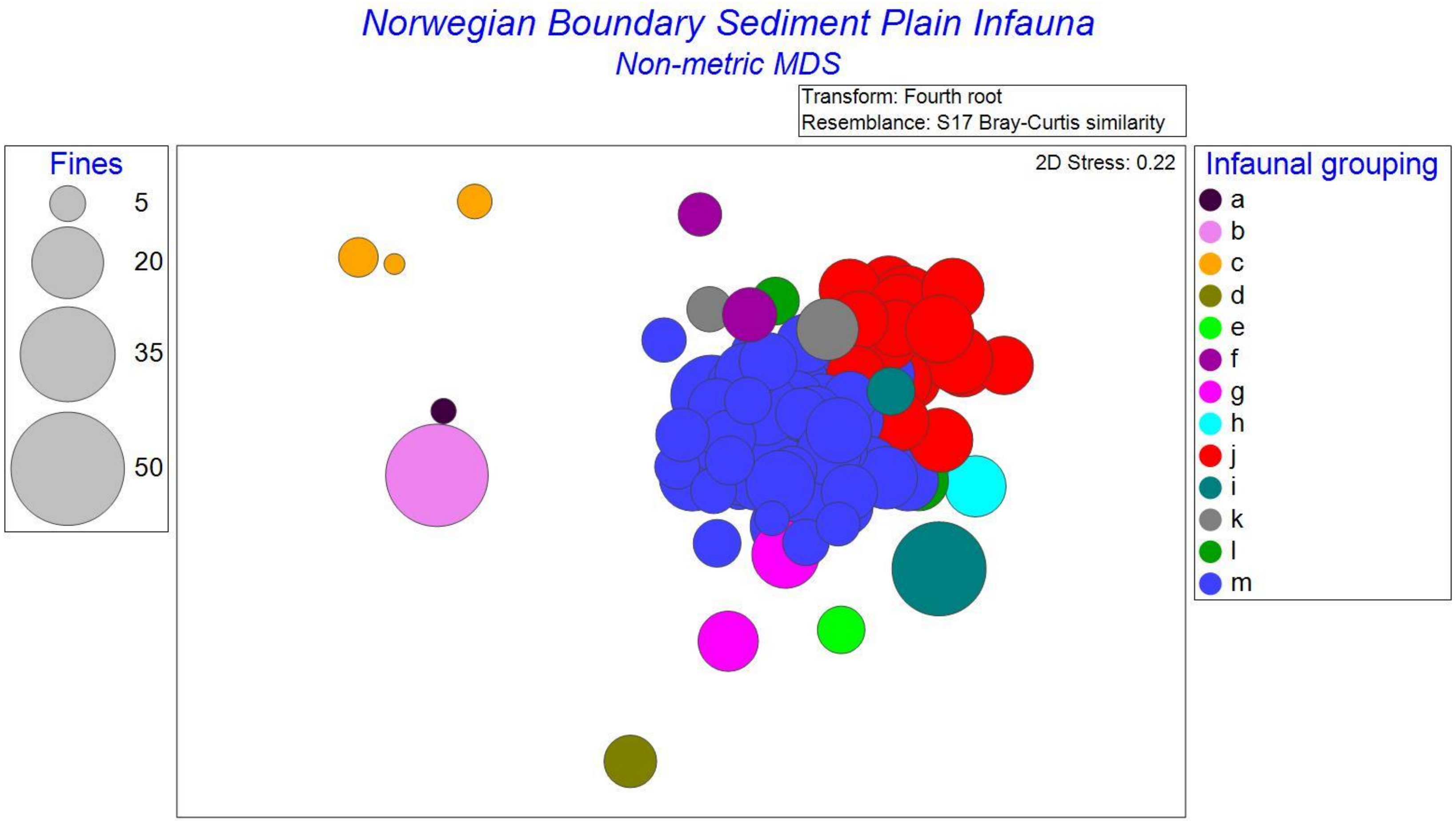

Figure 11: Non-metric multidimensional scaling (nMDS) of fourth-root transformed infaunal data from 117 grab samples taken during survey 1515S to Norwegian Boundary Sediment Plain MPA (2015). Groups a to m were derived from a SIMPROF analyses at a cut-off level of 45% infaunal cluster similarity. The overlain bubble plot shows the distribution of percentage of fine sediment (maximum of 40.8%) in the samples.

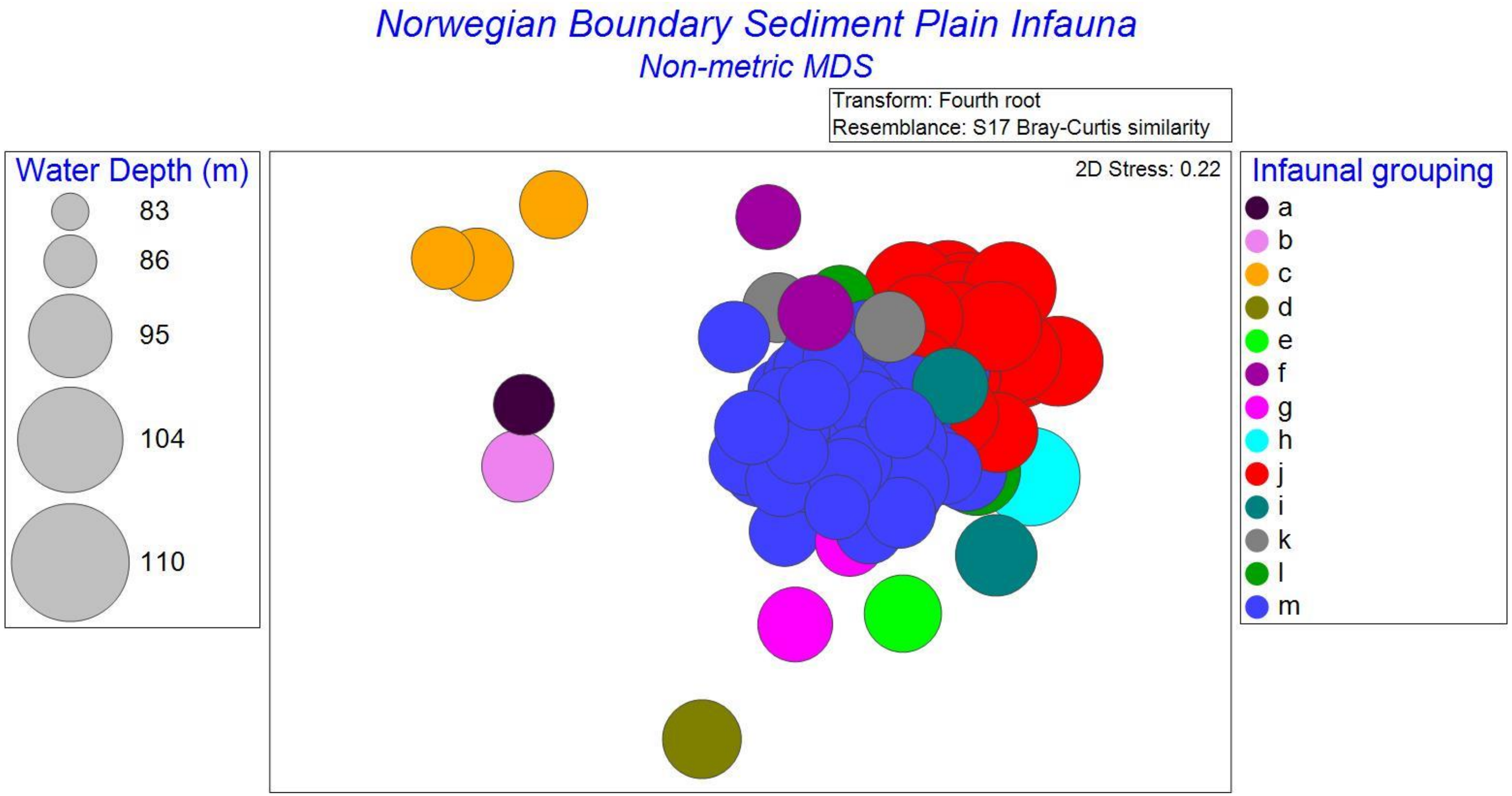

Figure 12: Non-metric multidimensional scaling (nMDS) of fourth-root transformed infaunal data from 117 grab samples taken during survey 1515S to Norwegian Boundary Sediment Plain MPA (2015). Groups a to m were derived from a SIMPROF analyses at a cut-off level of 45% infaunal cluster similarity. The overlain bubble plot shows the distribution of water depth (m) (maximum of 101.4m) in the samples.

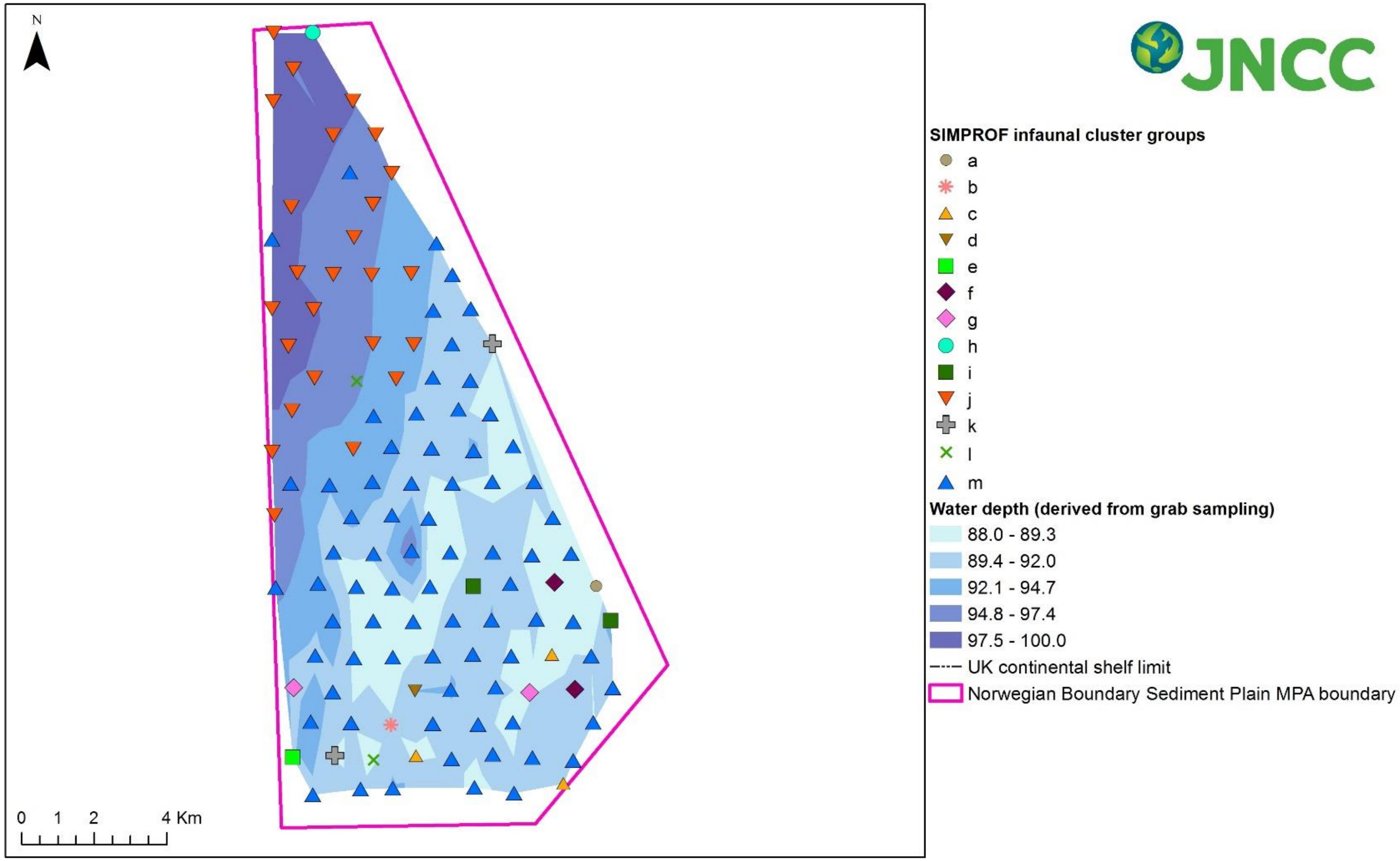

Figure 13: Depth contour map, depths derived from measurements of depth taken at each station before grab sample was deployed. The SIMPROF 45% infaunal communities are also plotted, with the groups ‘j’ and ‘m’, identified as the two prominent groups displayed as larger points. All samples from survey 1515S to NBSP (2015).

Relationship of the infaunal community within sedimentary habitats

The results of the infaunal analysis from 117 grab samples were compared to their corresponding PSA results in order to determine relationships between the identified infaunal assemblages and the sediment values at the site.

There is some variation across the four EUNIS sedimentary habitats regarding infaunal univariate biodiversity indices, such as diversity and richness (Table 9). The total abundance (N) and total species (S) was higher in samples from Sublittoral sand (A5.2) than in those from other identified sedimentary habitats, driven by the greater number of samples in Sublittoral sand, further illustrated in Figure 14, Figure 15 and Figure 16. Average species richness (d), and average diversity (in both Shannon’s and Simpson’s indices), were highest in samples from Sublittoral mud (A5.3), followed closely by samples from Sublittoral coarse sediments (A5.1). Samples from Sublittoral mixed sediment (A5.4) were the least species rich (d = 6.34). The Pielou’s evenness (J’) measurement, across all BSHs, indicates that the infaunal communities between habitats are highly even.

Table 9: Summary statistics of infaunal univariate diversity indices per EUNIS level 3 habitat. All data derived from 117 grab samples taken during survey 1515S of NBSP (2015).

	Total samples in habitat	Total species (S)	Total individuals (N)	Average species richness (d)	Average Pielou’s evenness (J')	Average Shannon’s diversity (H'(loge))	Average Simpson’s diversity (1-Lambda')
Sublittoral coarse sediment (A5.1)	6	217	645	7.55	0.87	3.10	0.94
Sublittoral sand (A5.2)	102	3248	9916	6.76	0.86	2.95	0.93
Sublittoral mud (A5.3)	2	83	229	8.56	0.85	3.15	0.93
Sublittoral mixed sediments (A5.4)	7	200	531	6.34	0.89	2.92	0.94

The nMDS ordination of infaunal assemblages from hierarchical clustering and SIMPROF testing, overlaid with the corresponding EUNIS level 3 habitat for each sample, shows a condensed distribution in the 2D nMDS (Figure 14). This overlap does not equate to an actual overlap in habitats but may indicate that the distinctions are unclear. EUNIS level 3 habitats A5.2 Sublittoral sands is the most representative for the sample, by a high degree, reflective of their distribution throughout the site and frequency of samples, as indicated above (Table 3, Figure 5, Figure 6, Figure 14, Figure 16).

Further analysis of the 45% SIMPROF groups shows that these infaunal assemblages generally aligned with the broadscale sediment classifications identified in NBSP (Figure 15), although there is a mix of sediment types in some infaunal groups. More apparent is the dominance of A5.2 Sublittoral sand across the site. On the nMDS (Figure 14), group a and some sparse representation in c, k, l and m show alignment with the EUNIS habitat classification of Sublittoral coarse sediment (A5.1). The Sublittoral sand (A5.2) shows strong alignment with both j and m, and is further represented by c, d, e, g and h. Sublittoral mud (A5.3) are represented through j and m, only, and Sublittoral mixed sediments (A5.4) are represented by groups b, f, i and a small component of m. The PCA alignment further enforces that % gravel and % fines are driving the observed patterns in community composition (Figure 14). The alignment of groups with EUNIS level 3 habitat types is further illustrated in Figure 15, where it can be seen that some sample groups occur entirely within one sedimentary habitat (e.g. groups b, d, e, g, and h) although it should be noted sample numbers in these groups are consistently low (n≤3).

In Figure 16 the SIMPROF generated groups are superimposed on a map of the identified broadscale habitats within NBSP, groups j and m are both closely aligned with Sublittoral sand sediments (A5.2), therefore the similarities in their community structure may be unsurprising. The infaunal communities of j occupy the northern areas of the site, whereas m dominates the southern areas of the site. The remainder of the infaunal community groups are sparsely distributed throughout, dispersed around group m locations, aligning well with the distribution of the other sedimentary habitats within the NBSP site, indicating these may be more transitional (Figure 13 and Figure 16).

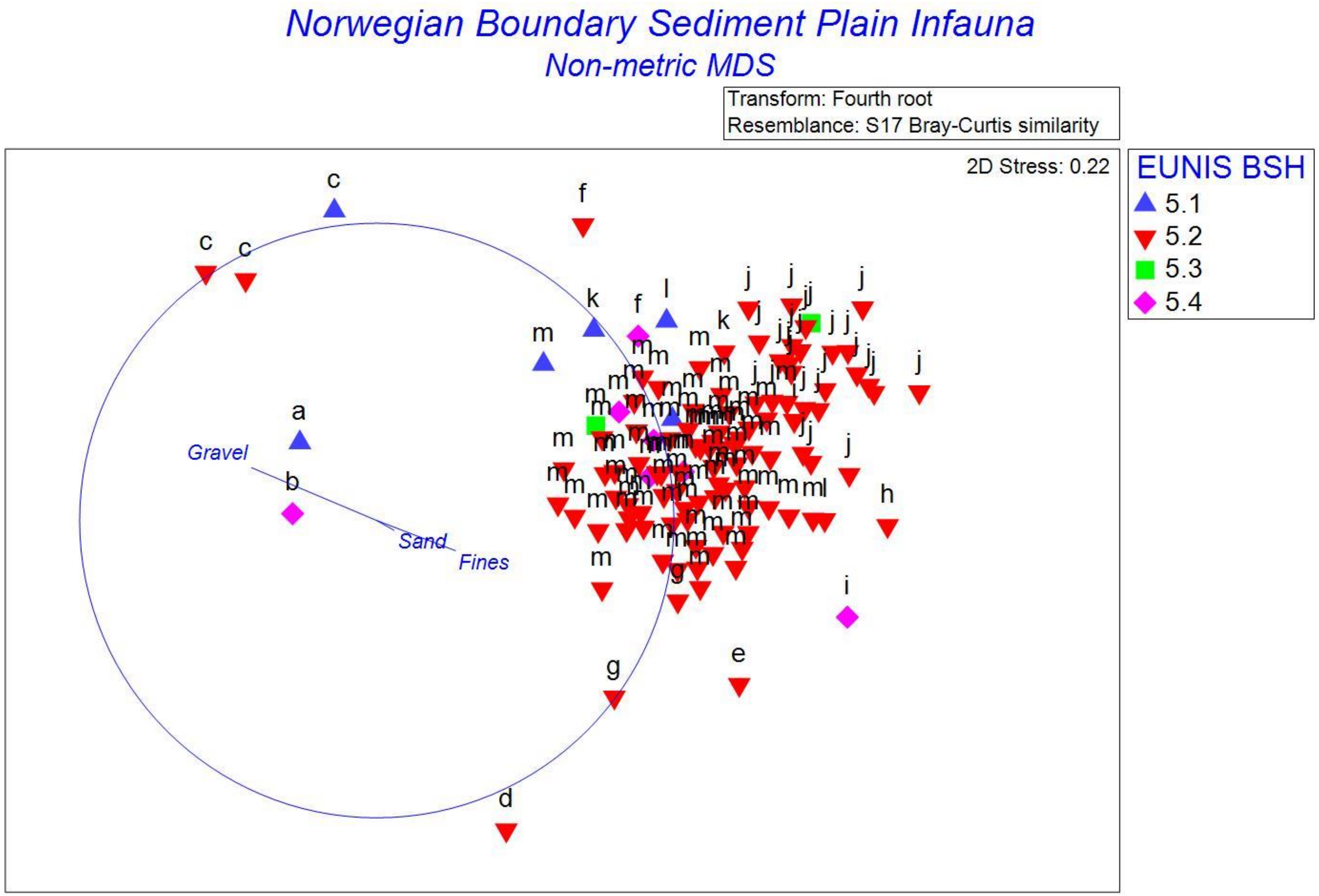

Figure 14: Non-metric multidimensional scaling (nMDS) of infaunal fourth-root transformed abundance data with the EUNIS habitats indicated (see key). The principal component analysis (PCA) of percentage composition of fines, sand and gravel is also overlaid. The infaunal cluster groups, as identified through SIMPROF analysis, are labelled above each symbol. All data are derived from 117 grab samples taken during survey 1515S of Norwegian Boundary Sediment Plain MPA (2015).

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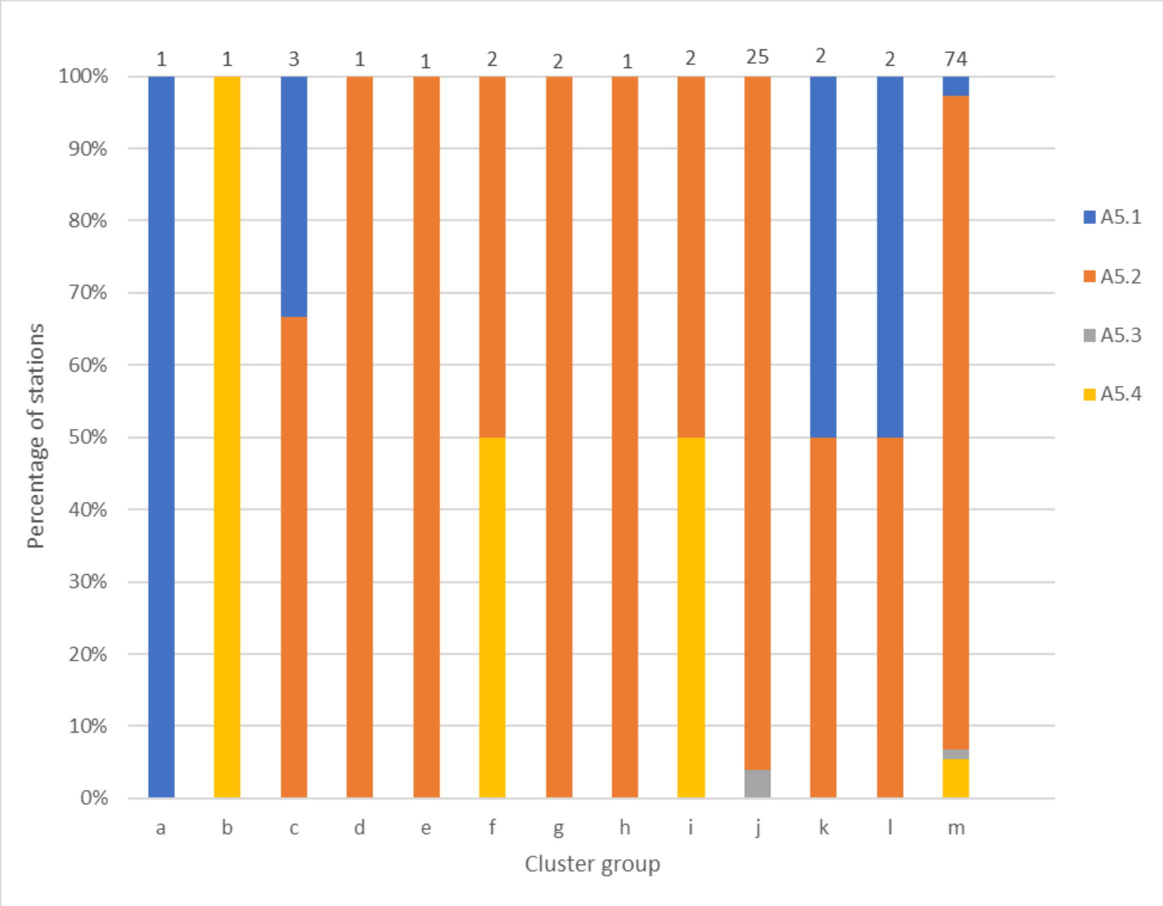

Figure 15: The percentage of stations of each SIMPROF group in the four EUNIS level 3 habitats identified, A5.1 Sublittoral coarse sediment, A5.2 Sublittoral sand, A5.3 Sublittoral mud and A5.4 Sublittoral mixed sediment. The number of stations per group is indicated above each bar. Data based on 117 grab samples taken during survey 1515S (2015) to Norwegian Boundary Sediment Plain MPA.

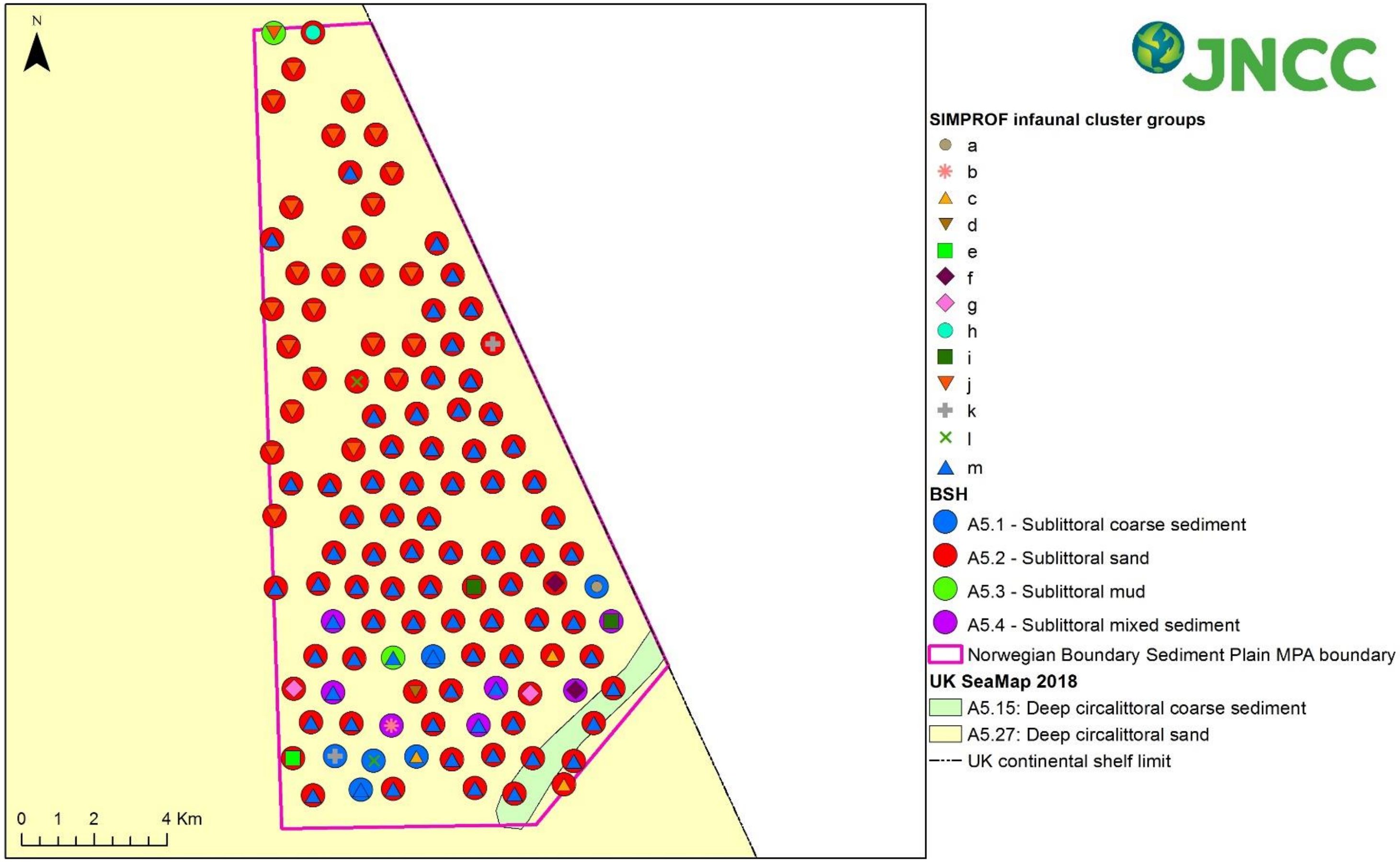

Figure 16: SIMPROF groups (cut off level at 45% similarity) superimposed on distribution of broadscale habitats identified for Norwegian Boundary Sediment Plain MPA. Infaunal data were fourth-root transformed and derived from 117 grab samples taken during survey 1515S of NBSP (2015).

A SIMPER analysis was undertaken using the EUNIS level 3 habitats as a factor to the infaunal dataset in PRIMER, to allow a further investigation of the species contributing to each EUNIS 3 habitat (Table 10). The results of the SIMPER analysis indicate that similar species drive the distinctiveness between sedimentary habitats and the identified infaunal cluster groups, including *Amphiura filiformis, Scoloplos armiger, Owenia borealis Paramphinome jeffreysii,* and *Spiophanes bombyx.* For all four of the EUNIS level 3 habitats the highest typifying and discriminatory species is *O. borealis*, with a 11.11% contribution to overall similarity taxa and consistently contributing (with highest Sim/SD of 6.72) within Sublittoral mixed sediments (A5.4). The Sublittoral coarse sediment (A5.1) was typified by *S. armiger* (with highest 8.55% contribution) and highest discriminating species was *Glycera alba* (Sim/SD 8.53). Sublittoral sand (A5.2) sediments were typified by *A. filiformis* (with highest % contribution of 7.22) with *S. bombyx* representing the most discriminating species (with highest Sim/SD of 3.40).

Table 10: The ten infaunal taxa contributing most % (Contrib.%) to the average similarity of four groups of samples (based on fourth-root transformed infaunal abundances) by EUNIS Level 3 sedimentary habitats. Samples are grouped for broadscale habitat types A5.1 Sublittoral coarse sediment, A5.2 Sublittoral sand, A.5.3 Sublittoral mud and A5.4 Sublittoral mixed sediments. The average abundance (Av. Abun.), average similarity (Av. Sim.), similarity/standard deviation (Sim/SD) and cumulative contribution percentage (Cum.%) are also displayed. Groups with less than 2 samples have been removed, therefore there are no results displayed for A5.3 Sublittoral mud (1515S).

Group (A5.1)					
Average similarity: 39.17					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Scoloplos armiger	1.61	3.35	4.34	8.55	8.55
Glycera alba	1.21	2.77	8.53	7.07	15.62
Paramphinome jeffreysii	1.58	2.62	1.35	6.68	22.30
Antalis entalis	1.21	2.57	5.61	6.55	28.85
Spiophanes bombyx	1.55	2.56	1.27	6.54	35.39
Cerianthus lloydii	1.40	2.28	1.34	5.81	41.20
Owenia borealis	1.29	2.08	1.30	5.32	46.53
Goniada maculata	1.06	1.92	1.33	4.91	51.43
Lanice conchilega	0.97	1.68	1.31	4.28	55.71
Spiophanes kroyeri	0.96	1.56	1.34	3.98	59.69
Group (A5.2)					
Average similarity: 45.80					
Species	**Av. Abund.**	**Av.Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Amphiura filiformis	1.82	4.25	3.01	9.28	9.28
Spiophanes bombyx	1.65	3.86	3.40	8.42	17.71
Scoloplos armiger	1.55	3.66	2.85	7.99	25.70
Owenia borealis	1.52	3.47	2.50	7.57	33.27
Goniada maculata	1.31	3.08	2.86	6.73	40.00
Abra sp.	1.18	2.51	1.65	5.49	45.49
Sthenelais limicola	1.05	2.07	1.37	4.53	50.01
Paramphinome jeffreysii	1.16	2.04	1.29	4.45	54.46
Harpinia antennaria	1.10	1.98	1.23	4.32	58.78
Antalis entalis	1.01	1.95	1.36	4.25	63.03
Group (A5.4)					
Average similarity: 42.87					
Species	**Av. Abund.**	**Av.Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Owenia borealis	1.69	4.77	6.72	11.11	11.11
Scoloplos armiger	1.60	4.64	4.75	10.83	21.95
Goniada maculata	1.42	4.00	4.73	9.33	31.27
Paramphinome jeffreysii	1.14	3.24	4.74	7.55	38.82
Amphiura filiformis	1.39	3.09	1.44	7.21	46.03
Abra sp.	0.98	2.02	1.49	4.71	50.75
Spiophanes bombyx	1.22	1.92	0.92	4.49	55.24
Cerianthus lloydii	0.89	1.55	0.89	3.61	58.84
Phyllodoce groenlandica	0.84	1.52	0.92	3.55	62.40
Lanice conchilega	0.94	1.41	0.91	3.29	65.68

3.2.1 Infaunal Habitats and Biotopes

Biotopes were assigned using the taxa contributing most to each of the 13 identified groups, by percentage contribution, up to a cumulative contribution of 70% (Clarke *et al.* 2008). The biotope assignment is shown in Table 11. Groups in which the SIMPROF analysis identified "less than 2 samples in group" were not assigned a biotope. The assignment of each biotope is described in more detail below.

The main biotope of NBSP was dominated by a variation of "*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (SS.SSa.OSa.OfusAfil)", describing the fauna in Groups i, j, and m. The fauna in these groups was defined by the presence of *O. borealis*, *Amphiura filiformis,* polychaetes such as *Goniada maculata, Spiophanes kroyeri,* and occasional bivalves, such as *Abra sp.,* and *Thyasira flexuosa.* This biotope was suggestive of offshore circalittoral sand or muddy sand habitat types, which were closely supported by the dominance of A5.2 Sublittoral sand and EUNIS habitats, identified by the infaunal groups throughout the site (Figure 16).

The other infaunal groups could only be identified to habitat level, in which "Circalittoral fine sand (SS.SSa.CiSa)" was assigned to group c and "Circalittoral muddy sand (SS.SSa.CMuSa)" assigned to group f, for both of these assemblages the biotope is assigned with the recommendation that the biotope description should be edited to account for deeper variants. "Offshore circalittoral sand (SS.SSa.OSa)" was assigned to g, and "Offshore circalittoral coarse sediment (SS.SCS.OCS)" to groups k and l. Consideration was given to the biotopes of SS.SSa.OSa.OfusAfil and "*Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud (SS.SMu.OMu.PjefThyAfil), and these may be applicable to groups which contained one of the characterising species, such as *P. jeffreysii* in groups c, f, and k, but did not share any further characteristics with the biotope.

Table 11: Infaunal species contributing most (up to 70% cumulative contribution) to each of the 13 identified SIMPROF groups, with details for biotope assignment and summary description.

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	BSHs (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description of Habitat/Biotope and details for assignment
Group c	*Echinocyamus pusillus* *Aonides paucibranchiata* *Paramphinome jeffreysii* *Cerianthus lloydii* *Aglaophamus agilis* *Edwardsiidae sp.* *Owenia borealis* *Acmira cerrutii* *Notomastus sp.* *Pseudonotomastus southerni* *Spiophanes bombyx* *Nemrtea sp.* *Malmgrenia mcintoshi* *Antalis entalis*	6.79 6.59 5.73 5.67 5.54 5.12 4.82 4.66 4.66 4.44 4.31 4.15 4.15 4.15	**A5.2 Sublittoral sand**, A5.1 Sublittoral coarse sediment	88.5 to 91.4	Circalittoral fine sand (SS.SSa.CFiSa)	Characterised by *Echinocyamus pusillus* and polychaetes. Other characterising species include *Cerianthus lloydii* and *Spiophanes bombyx*. The BSH of dominantly A5.2 Sublittoral sand supports this designation, although the presence of A5.1 Sublittoral coarse sediment makes this designation uncertain
Group f	*Scoloplos armiger* *Spiophanes bombyx* *Owenia borealis* *Cerianthus lloydii* *Goniada maculata* *Pectinaria auricoma* *Ampelisca spinipes* *Gattyana cirrhosa* *Harmothoe glabra* *Phyllodoce groenlandica* *Paramphinome jeffreysii*	8.43 7.75 7.33 6.16 6.16 6.16 6.16 5.18 5.18 5.18 5.18	**A5.2 Sublittoral sand, A5.4 Sublittoral mixed sediment**	89.1 to 92.4	Circalittoral muddy sand (SS.SSa.CMuSa)	Characterised by a wide variety of polychaetes. Characterising species which match the biotope description include *Scoloplos armiger*, *Spiophanes bombyx*, *Owenia sp.*, *Cerianthus lloydii* and *Gonida maculata*. The depth range and BSH types are poor

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	BSHs (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description of Habitat/Biotope and details for assignment
	Tharyx killariensis	5.18				matches, as are the absence of some of the main contributory taxa.
Group g	*Owenia borealis* *Spiophanes bombyx* *Sthenelais limicola* *Goniada maculata* *Abra sp.* *Nephtys longosetosa* *Scoloplos armiger*	13.77 11.35 9.54 9.54 9.54 8.62 8.62	**A5.2 Sublittoral sand**	80.4 to 85.6	Offshore circalittoral sand (SS.SSa.OSa)	Biotope is characterised by a diverse range of polychaetes, amphipods, bivalves and echinoderms - group 'g' shows a polychaete-dominated community structure, but also present is the bivalve *Abra sp.*, matching this biotope well. The BSH is a good match to the biotope description.
Group i	*Amphiura filiformis* *Scoloplos armiger* *Goniada maculata* *Owenia borealis* *Pectinaria auricoma* *Phyllodoce groenlandica* *Paramphinome jeffreysii* *Anobothrus gracilis*	12.38 11.38 10.76 10.76 9.05 7.61 7.61 7.61	**A5.2 Sublittoral sand, A5.4 Sublittoral mixed sediment**	92.4	Variation of :*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (SS.SSa.OSa.OfusAfil)	Characterised by *Owenia fusiformis*, where this is absent in the group, *Owenia borealis* is present. The biotope is characterised by an abundance of *Amphiura filiformis*. Other species which characterise this biotope, and are present in the group, are the polychaetes *Gonidia maculata*.

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	BSHs (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description of Habitat/Biotope and details for assignment
						The BSH identified also provide a good match to the biotope.
Group j	*Amphiura filiformis* *Scoloplos armiger* *Spiophanes bombyx* *Harpinia antennaria* *Paramphinome jeffreysii* *Goniada maculata* *Abra sp.* *Thyasira flexuosa* *Owenia borealis* *Galathowenia sp.* *Antalis entalis* *Sthenelais limicola* *Chaetozone setosa*	8.48 6.33 6.16 5.81 5.26 4.72 3.74 3.4 3.38 3.27 3.13 3.02 2.72	**A5.2 Sublittoral sand,** A5.3 Sublittoral mud	93.8 to 101.4	Variation of:Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy sand (SS.SSa.OSa.OfusAfil)	Characterised by *Owenia fusiformis*, where this is absent in the group, *Owenia borealis* is present. The biotope is characterised by an abundance of *Amphiura filiformis*. Other species which characterise this biotope, and are present in the group, are the polychaetes *Gonidia maculata*, *Chaetozone setosa* and *Spiophanes kroyeri*, with occasional bivalves - *Thyasira flexuosa* present here. The BSH identified also provide a good match the biotope.
Group k	*Spiophanes bombyx* *Scoloplos armiger* *Amphiura filiformis* *Paramphinome jeffreysii* *Harpinia antennaria* *Owenia borealis*	9.93 9.48 8.67 8.35 7.54 7.02	**A5.1 Sublittoral coarse sediment, A5.2 Sublittoral sand**	90.5 to 90.9	Offshore circalittoral coarse sediment (SS.SCS.OCS)	Characterised by robust infaunal polychaete and bivalve species, this is shown in group 'k', with the dominance of polychaetes, with some diversity, in the

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	BSHs (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description of Habitat/Biotope and details for assignment
	Goniada maculata *Edwardsia claparedii* *Sthenelais limicola* *Glycera alba*	6.34 5.33 5.33 5.33				presence of *Amphiura filiformis*, *Harpinia antennaria* and *Edwardsia claparedii*. The BSH is a fair fit, with the dominant BSH of A5.1 Sublittoral coarse sediment, and secondly A5.2 Sublittoral sand.
Group l	*Spiophanes bombyx* *Scoloplos armiger* *Owenia borealis* *Amphiura filiformis* *Sthenelais limicola* *Antalis entalis* *Glycera alba* *Goniada maculata* *Hyalinoecia tubicola* *Pectinaria auricoma*	9.59 7.76 7.76 7.76 7.01 7.01 5.9 5.9 5.9 5.9	**A5.1 Sublittoral coarse sediment, A5.2 Sublittoral sand**	87.0 to 90.5	Offshore circalittoral coarse sediment (SS.SCS.OCS)	Characterised by robust infaunal polychaete and bivalve species, this is shown in group 'l', with the dominance of polychaetes, with some diversity, in the presence of *Amphiura filiformis*, *Harpinia antennaria* and *Edwardsia claparedii*. The BSH is a fair fit, with the dominant BSH of A5.1 Sublittoral coarse sediment, and secondly A5.2 Sublittoral sand.
Group m	*Amphiura filiformis* *Spiophanes bombyx* *Owenia borealis*	9.06 8.21 7.91	**A5.2 Sublittoral sand,** A5.4 Sublittoral mixed sediment, A5.1 Sublittoral coarse	88.0 to 99.2	Variation of: Owenia fusiformis and Amphiura filiformis in offshore circalittoral sand or muddy	Biotope defined by the presence of *Owenia fusiformis*, where *Owenia borealis* is present

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	BSHs (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description of Habitat/Biotope and details for assignment
	Scoloplos armiger *Goniada maculata* *Abra sp.* *Sthenelais limicola* *Lanice conchilega* *Paramphinome jeffreysii* *Antalis entalis* *Harpinia antennaria* *Nephtys longosetosa* *Spiophanes kroyeri*	7.55 6.7 5.6 4.59 4.29 4.16 4.13 3.86 2.7 2.54	sediment, A5.3 Sublittoral mud		sand (SS.SSa.OSa.OfusAfil)	here in abundance, and the abundance of *Amphiura filiformis*. Other taxa which are found in this biotope are the polychaetes *Goniada maculata* and *Spiophanes kroyeri*. Occasional bivalves as in the biotope description are present in the form of *Abra sp*. The BSH matches somewhat well, although with less fractions of mud, with sand and mixed fractions dominating.

3.3 Ocean quahog distribution

Individual ocean quahog were recorded across the site in grab samples. The total number of ocean quahog obtained across all sampled stations (120) was 31 individuals from 26 of the stations (Figure 17). Of the ocean quahog specimens, 4 were identified as 'mature' and 20 as 'juvenile' in infaunal analysis by the contractor (Thomson Unicomarine 2016, Appendix 18). An additional seven ocean quahog were acquired during grab operations on the vessel, recorded, and returned to the sea, and therefore were not included in the Thomson Unicomarine (2016) analysis. A visual assessment of the photographs of these samples (Appendix 15) estimates all to be juvenile specimens with the exception of "1515S_NSP52_S321", estimated to be mature by the difference in size from the other specimens, bringing the total of 'mature' specimens to 5 and 'juvenile' to 26 (Appendix 13). Sexual maturity and life history of ocean quahog are poorly known, and the determination of maturity is difficult (Thompson *et al*. 1980), so the results must be interpreted with a degree of caution.

The spatial distribution of ocean quahog recorded from grab samples is shown in Figure 17. As the number of ocean quahog acquired was relatively small, it is difficult to interpret spatial distribution and habitat preference of ocean quahog or its population composition. However, results from the 1515S survey show that the greatest numbers were obtained in the south-west, the north and the north-west of the site (Figure 17).

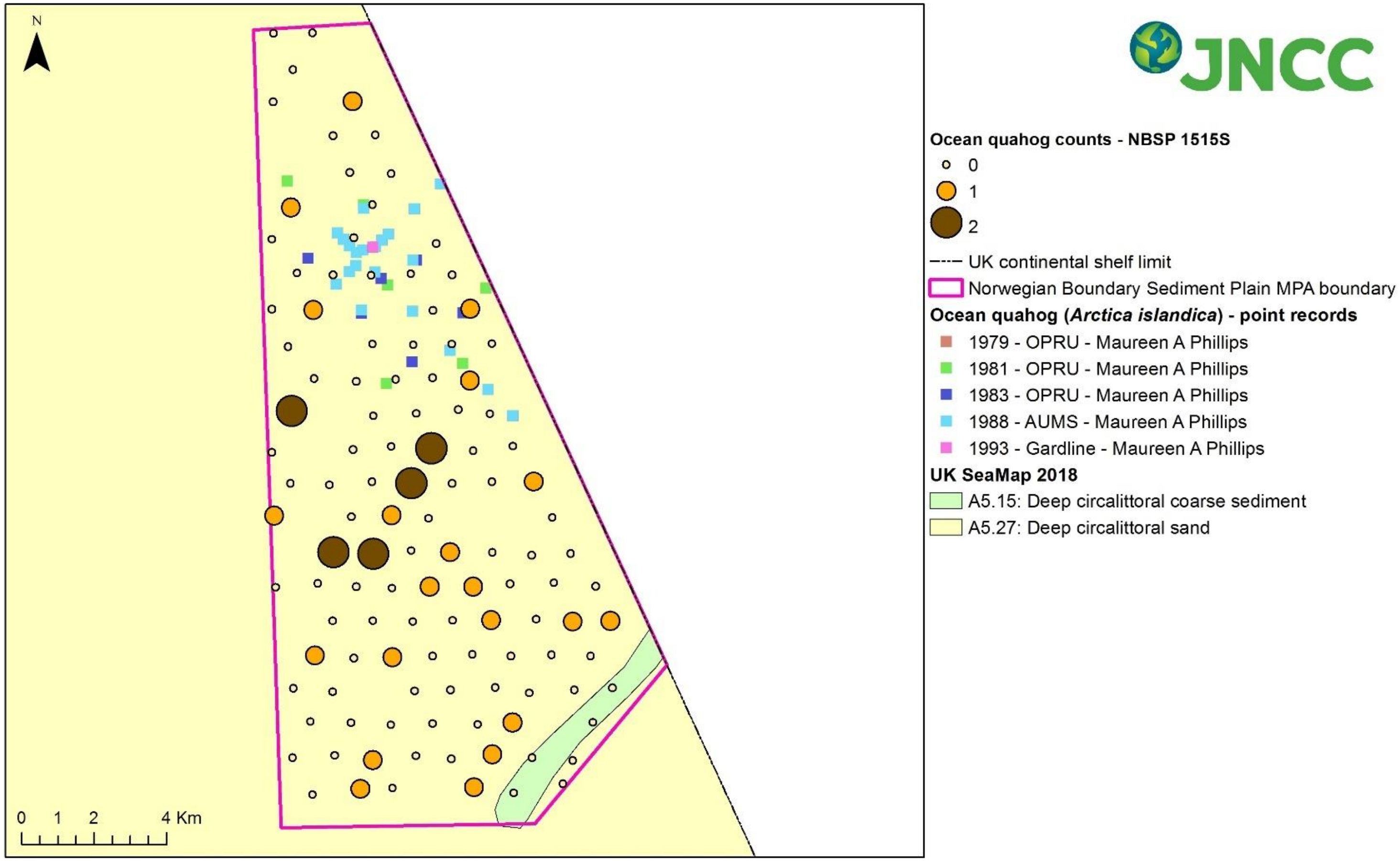

Figure 17: Distribution of sampled ocean quahog obtained from obtained from grab sampling of NBSP during the 1515S survey (2015). The figure shows the relative number of individuals sampled at each station. Previous survey data is also displayed, showing the distribution of ocean quahog point records.

3.3.1 Supporting Habitat of ocean quahog

The total number of sampled ocean quahog from the 117 grabs with PSA results, collected in 24 grabs, confirmed that the highest proportion of the species from successful grabs occurs in the EUNIS level A5.3 Sublittoral muds, followed by A5.1 Sublittoral coarse sediment (Figure 18). Of the two grabs in A5.3, one was successful, sampling one ocean quahog specimen (50% occurrence in grabs, 3.2% of total ocean quahog sampled). In A5.1 Sublittoral coarse sediment, one grab was successful from a total of six, obtaining a total of two ocean quahog specimens (33.3% occurrence in grabs, 6.5% of total ocean quahog sampled). The small sample sizes indicate these highly weighted proportions of ocean quahog in A5.1 and A5.3 habitats may be largely disregarded. In A5.2 Sublittoral sand, which composes most of the site, 21 grabs of 102 were successful, obtaining 27 individuals (26.5% occurrence in grabs, 87.1% of ocean quahog sampled). In A5.4 Sublittoral mixed sediment, one grab was successful in a total of seven for this habitat, attaining one ocean quahog specimen (14.3% occurrence in grabs, 3.2% of total ocean quahog sampled) (Figure 18).

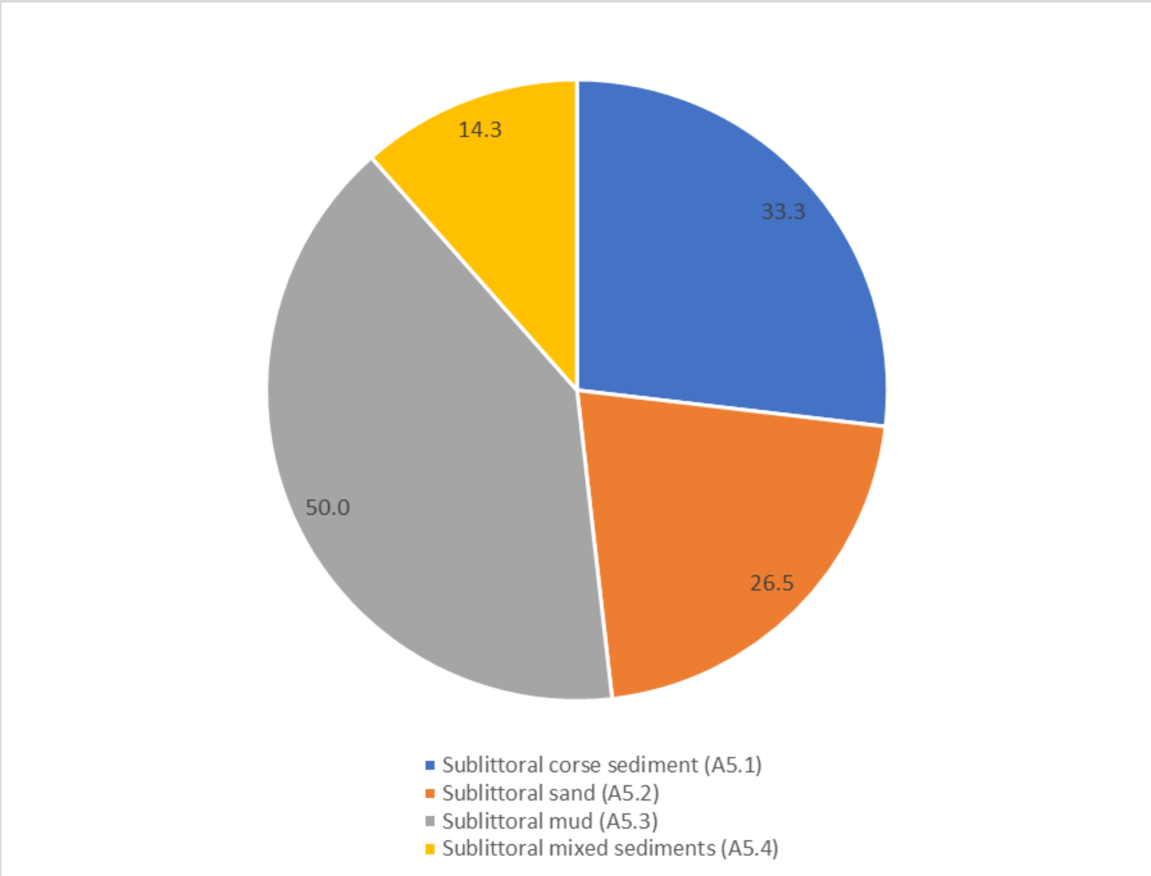

Figure 18: Percentage of ocean quahog from grabs within each of the benthic sedimentary habitats of NBSP. Data are based on 117 grab samples, 6 grabs in A5.1, 102 grabs in A5.2, 2 grabs in A5.3 and 7 grabs in A5.4, taken during survey 1515S of Norwegian Boundary Sediment Plain (2015). A total of 31 ocean quahog individuals were obtained, from 24 of the 117 total grabs, and include both mature and juvenile specimens.

3.4 Additional Priority Marine Features (PMF)

Analysis of the infaunal data identified several accounts of taxa that are considered indicative of the Priority Marine Feature (PMF) “Burrowed mud” and component biotope of “sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg)” were found in the grab sampling data of the monitoring survey. As priority marine features, they are of conservation importance, and furthermore, the presence of these species is indicative of areas of offshore deep-sea muds, indicating this habitat could also be present at NBSP. A total of 19 slender sea pens (*Virgularia mirabilis*) and 11 phosphorescent sea pens (*Pennatula phosphorea*) were obtained from grab sampling of NBSP. No other species of sea pen were obtained from the survey. Of the sites successful in obtaining sea pen specimens, only two stations were identified within the habitat: A5.3 Sublittoral mud, NBSP008 and NBSP052. The grab sampling at station NBSP008 was successful in obtaining one specimen of *V. mirabilis*, whereas sampling at station NBSP052 obtained two specimens of *P. phosphorea*. In general, both species are sparsely distributed throughout the site, with no discernible pattern (Figure 19, Figure 20) In this instance, as the numbers of seapens are relatively low, and there is a sparsity of mud (A5.3) habitats at the site (Table 3, Figure 6, Figure 7), the site would be unlikely to qualify for the designation of PMF "burrowed mud".

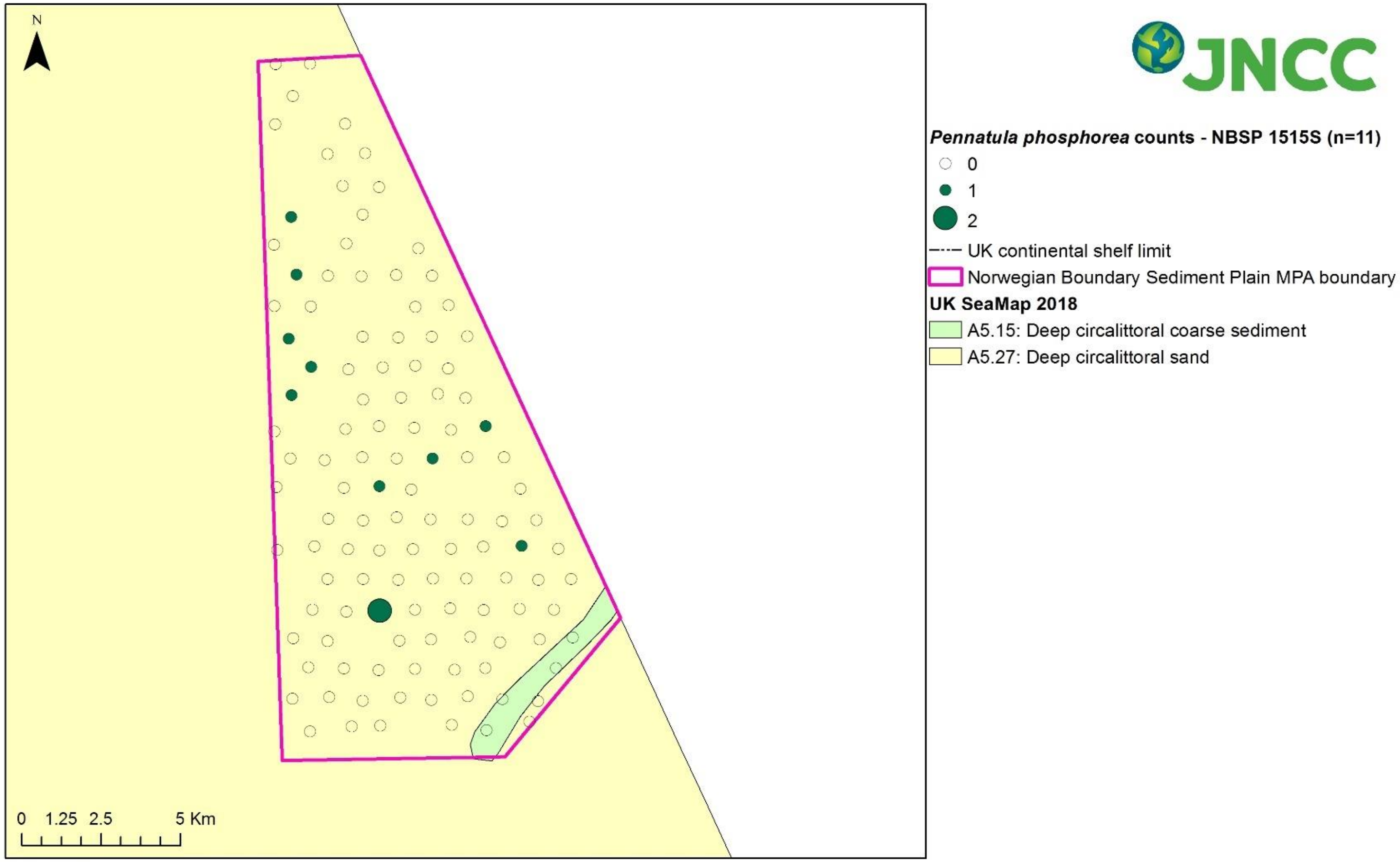

Figure 19: Distribution of sampled *Pennatula phosphorea* obtained from obtained from grab sampling of NBSP during the 1515S survey (2015). The figure shows the relative number of individuals sampled at each station at which *P. phosphorea* was obtained.

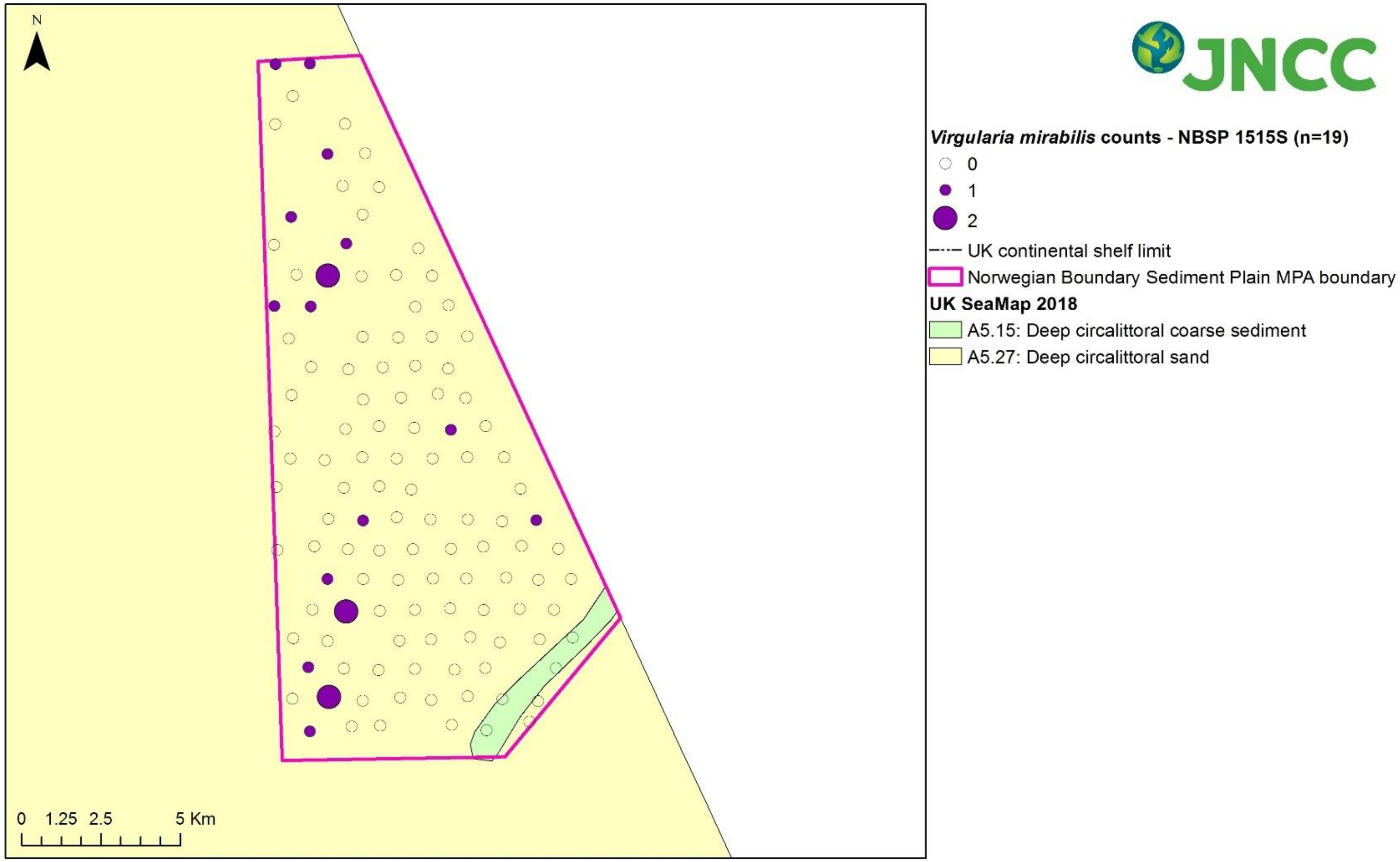

Figure 20: Distribution of sampled *Virgularia mirabilis* obtained from obtained from grab sampling of NBSP during the 1515S survey (2015). The figure shows the relative number of individuals sampled at each station at which *V. mirabilis* was obtained.

In regard to the presence of the PMF ‘Offshore deep sea muds’, only two of the 117 grabs were identified as A5.3 Sublittoral mud (Table 3, Figure 6), however neither of these locations. It is noted however, that species characteristic at the site, such as *Paramphinome jeffreysii* and *Amphiura filiformis*, as well as occasional *Thyasira spp*., are representative of the component species for offshore deep sea muds (Table 5, Table 11) (Tyler-Walters *et al*. 2016), however. Further specificity is required in the designation of the PMF Offshore deep-sea muds to discern it from relatively shallow muddy sand habitats, evident in NBSP.

3.5 Non-indigenous species (NIS)

No instances of the presence of NIS were recorded in the infaunal taxon list generated from the infaunal samples after these were cross-referenced against lists of non-indigenous target species (Appendix 3).

3.6 Marine litter

There were no recorded instances of litter in the sampling undertaken at NBSP in the 1515S survey following the litter categories as specified by the MSFD (EU Commission 2013) detailed in Appendix 16.

4 Discussion

4.1 Benthic and environmental overview

It is evident from the results of the grab sampling of NBSP in 2015 that the extent and distribution of the sedimentary habitats identified within NBSP during this survey are different from previous predicted habitats (2012) (see Section 1.3 and Figure 2). The differences may be largely due to differences in sampling design, with the limited extent of coverage in the 2012 surveys, compared to the extensive sampling method of 1515S (O’Connor 2016). Compared to the results from 2012, the extent and distribution of A5.2 Sublittoral sand has remained similar, however the areas defined as A5.15 deep circalittoral coarse sediment (Figure 2) have been updated with the grab operations undertaken in 1515S. The 2015 data acquired during the 1515S survey indicate that the sedimentary habitats in the south of the site are more variable and sparsely distributed amongst the primarily Sublittoral sand habitat. Sublittoral mud (A5.3) was distributed in the north and south of the site, which were not reported previously, although the report recognises that these are based one grab sample each. Overall, the results of the 1515S can be adopted as the first comprehensive sampling of NBSP, which may allow for change the sedimentary habitats to be detected if the site is revisited in the future.

The results from SIMPROF analysis defined 13 infaunal assemblages. These groups were shown to be statistically distinct, but within-group similarity was variable (see section 3.2). Approximately 84% of all samples belonged to groups j and m.

NBSP is similar to other MPAs of its vicinity in the North Sea. The East of Gannet and Montrose Fields Nature Conservation MPA is similarly designated for ocean quahog aggregations and offshore subtidal sand and gravels as sediment types suitable for ocean quahog colonisation. NBSP shares the same biotope designation as one of the assigned biotopes at East of Gannet and Montrose Fields Nature Conservation MPA: *Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (SS.SSa.OSa.OfusAfil). Fulmar MCZ is similarly designated to protect ocean quahog at the site, and to protect Subtidal sand, mud and mixed sediment. Turbot Bank MPA is designated to protect sand eels, and predominantly a sandy sediment site, therefore similar to NBSP, although no sand eels were recorded at NBSP.

4.2 Offshore subtidal sands and gravels representing sediment types suitable for ocean quahog colonisation

4.2.1 Extent and distribution

The habitats within the NBSP site supporting *A* include offshore subtidal sands and gravels (A5.2 sublittoral sand, A5.1 Sublittoral coarse sediment and A5.4 sublittoral mixed sediments as closest equivalents) (Table 1).

The PSA results from the 1515S grab sampling indicate little change in the known extent of Offshore subtidal sands and gravels (A5.2 sublittoral sand, A5.1 Sublittoral coarse sediment and A5.4 sublittoral mixed sediments, equivalents) from predictive mapping in 2012. The A5.2 Sublittoral sand extends throughout the whole site (Figure 7). The other sedimentary habitats, A5.1 Sublittoral coarse sediment, A5.3 Sublittoral mud, and A5.4 Sublittoral mixed sediment are interspersed with the Sublittoral sand, mostly in the south and south-east of the site (Figure 7). We have an improved and accurate understanding of the offshore subtidal sands and gravels, supporting ocean quahog.

4.2.2 Physical and biological structure

The areas identified as Offshore subtidal sands and gravels (A5.1 Sublittoral coarse sediment, A5.2 Sublittoral sand and A5.4 Sublittoral mixed sediments, as equivalent) (Table 1), covered the full extent of the site, therefore associated with a depth gradient of about 88-100m.

In terms of biological structure, infaunal assemblages j and m, although both occurring most often in A5.2 sublittoral sand, differed in their depth distributions. Infaunal cluster j shows association with the deepest parts of NBSP (93.8m to 101.40m), whereas m is associated with the shallowest (88.0m to 99.2m). Both j and m were typified by the brittlestar, *Amphiura filiformis* and polychaetes *Spiophanes bombyx* and *Scoloplos armiger*. The polychaetes *Scoloplos armiger*, *Paramphinome jeffreysii* and the amphipod *Harpinia antennaria* were important contributors to j. The polychaetes, *Owenia borealis*, and *Gonida maculata* were important to the structure of m. Differences between j and m are driven by the bivalve, *Thyasira flexuosa*, the amphipod *Urothoe elegans*, the mollusc *Chaetoderma nitidulum*, and the polychaetes *Lanice conchilega* and *Galathowenia* sp. For each of these species, depth is not a strong driver of their distribution (Seaward 1990; Lincoln 1979; Hartmann-Schröder 1996), although *C. nitidulum* is noted as a marked inhabitant of shallower open seas (20-150m) (Seaward 1990). However, it is more likely the subtle preferences of each species or taxa to either muddier, or coarser, gravellier sand sediment which contributes to the differences of assemblages j and m, evident in) group m occurring in more gravelly sediment than j (Figure 10). Generally, however, j and m are highly similar, contributing to the A5.2 Sublittoral sands, and by extension, the whole NBSP site can be described as a large infaunal community continuum.

Infaunal assemblages a, c, k, and l were the most closely associated with A5.1 Sublittoral coarse sediment. Infaunal cluster a was composed of one sample, occurring exclusively within A5.1 Sublittoral coarse sediment (Figure 15), therefore, the most representative, but also unable to generate results from SIMPER analysis. Infaunal cluster groups c, k and l indicate that the A5.1 Sublittoral coarse sediment is typified by species such as the urchin, *Echinocyamus pusillus,* and the polychaete, *Aglaophamus agilis* (in assemblage c) and *A. filiformis, S. armiger, S. bombyx,* and *P. jeffreysii* (in assemblages k and l). It is evident that infaunal assemblage c differs from the other infaunal assemblages from its distribution on the edges of the nMDS (Figure 14), however, it maintains association with A5.1 Sublittoral coarse sediment and A5.2 Sublittoral sand. This suggests the differences between the infaunal assemblages are driven by the presence of a few unique species, within largely similar community structures, rather than many distinctively different species.

In terms of A5.4 Sublittoral mixed sediments, infaunal cluster group b was composed entirely of samples within A5.4 Sublittoral coarse sediment (Figure 15), however, again, with only one sample, SIMPER analysis was unfeasible. Groups f and i were composed of samples in A5.4 and A5.2 (Figure 15), and were characterised by species such as *A. filiformis, S. armiger, G. maculata, O. borealis*, *S. bombyx,* the anemone *Cerianthus lloydii,* and polychaete, *Pectinaria auricoma.* These species are similar to those in A5.2 and A5.1 (above), with few differences, again suggesting subtle differences of species composition within a larger community composed of similar species such as *A. filiformis, S. armiger, G. maculata, O. borealis*, *S. bombyx* throughout all of the offshore subtidal sands and gravels habitat.

In general, there is some variability within the infaunal assemblages which occur in offshore subtidal sands and gravels at NBSP. This may be due to the relatively broad classification scale employed, separating the habitats arbitrarily, with little variation in the infaunal communities of each habitat. In order to explain some of the variation across the assemblages may require a greater understanding of the numerous environmental variables which were not measured during the survey, such as temperature, salinity, nutrients, organic and inorganic carbon, as well as others. Understanding these environmental parameters and the further distinctions of habitats, such as any impact from human activities, or physical differences e.g. turbidity, may further explain the community structures across NBSP.

The Sublittoral mud (A5.3) was the least sampled habitat throughout the site. Infaunal assemblages j and m were the only to occur in habitats identified as Sublittoral mud. This indicates that A5.2 and A5.3 are so similar that they are best described as a community continuum. This is supported in the lack of distinctiveness in the particle size distribution trigon (Figure 5) in which the two mud habitats are close in composition to the sand and mixed designations. This highlights the importance of monitoring the changes in communities at the site, rather than alterations in broad sediment categories at the site for future monitoring.

4.3 Ocean quahog distribution

Ocean quahog were mainly recorded within the A5.2 Sublittoral sand habitats, although were also recorded in each of the other identified sedimentary habitats (A5.1 Sublittoral coarse sediments, A5.3 Sublittoral mud, and A5.4 Sublittoral mixed sediment). The sampling success indicates that A5.3 Sublittoral muds and A5.1 Sublittoral coarse sediments were more likely to contain ocean quahog specimens than sampling within A5.2 Sublittoral sands, however, this was deemed to be a product of the low number of samples in A5.1 and A5.3 - skewing sampling success. The results suggest that ocean quahog in NBSP is ubiquitous, however the relatively low number of specimens sampled, and prevalence of A5.2 Sublittoral sand in samples, prevent conclusions on habitat preference. The presence of ocean quahog within Offshore subtidal sands and gravels, and additionally A5.3 Sublittoral mud, supports the designation of the site for the protection of ocean quahog.

The population structure of ocean quahog is commonly skewed in the North Sea, where populations are dominated by the presence of either adults or juveniles of the species (Witbaard & Bergman 2003; OSPAR 2009). With the higher number of juvenile ocean quahog recorded in NBSP, in comparison to mature specimens, this skew may be evident.

However, determination of age and maturity of ocean quahog is difficult without analysis of shell growth and individuals may be of varying sizes even at the same age (Ropes & Murawski 1983). We therefore cannot make any assessment of the population structure of ocean quahog from the sampled individuals.

Aggregations of the ocean quahog could not be determined. The definition of ‘aggregations’ is not defined in OSPAR or PMF descriptions (OSPAR 2009; Tyler-Walters *et al*. 2016). The report recognises that the large Hamon grab may not be optimal gear type to sample ocean quahog, in order to determine the presence of large numbers of specimens in an area. The OSPAR (2009) background document reports that a Triple-D dredge is an effective sampling method for ocean quahog and recommendations from other research groups favouring box coring, dredging, or otherwise (Appendix 17). The report finds that future monitoring efforts would more feasibly and valuably assess the habitats supporting the colonisation of ocean quahog, rather than targeting the species themselves.

4.4 Biotope classification

The major infaunal assemblages (j and m), as well as assemblage i, are assigned to the ‘SS.SSa.OSa.OfusAfil’ biotope. Although there are distinctions and differences across the groups, they can be broadly defined under the same biotope (see 3.2.1 and Table 11). The biotope assigned is quite typical of MPAs in the area. The infaunal communities of East of Gannet and Montrose Fields Nature Conservation MPA are described under *Paramphinome jeffreysii, Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud (SS.SMu.OMu.PjefThyAfil) and *Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (SS.SSa.OSa.OfusAfil). the latter being the same biotope which describes the majority of the infaunal community of NBSP. The assignment of biotopes is subjective and none of the observed groups produced a perfect match to the biotope definitions.

This lack of a perfect match was more evident within the other groups, in which only habitat level descriptions could be defined, including ‘SS.SSa.CiSa’(group c), SS.SSa.CMuSa (group f), SS.SSa.OSa (group g) and SS.SCS.OCS (k and l).

The remaining Groups a, b, d, e, and h were each identified from one sample each and thus were excluded from SIMPER analysis, which is based on pair-wise comparisons. Therefore, these groups could not be assigned to biotopes.

4.5 Additional Priority Marine Features (PMF)

Taxa indicative of the ‘Burrowed mud’ PMF, with the component biotope ‘sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg)’, were identified from grab samples from the 2015 survey of NBSP. Two sea pen species were recorded throughout the site, *Virgularia mirabilis* and *Pennatula phosphorea.* The designation of an area for the PMF Burrowed mud and its component biotope is dependent on the presence of muddy sediment. At NBSP muddy sediments occurred in only 2 of the 117 grab samples taken. With the sparsity of mud identified at NBSP it is thought unlikely that NBSP would qualify for designation of the PMF ‘Burrowed mud’. A lack of specificity in the description, and therefore assignment of the burrowed mud PMF makes the interpretation of results and the identification of the habitat difficult in MPAs. The required density of sea pens, burrow size and density would be welcome additions in order to accurately identify instances of the PMF.

5 Recommendations for future monitoring

5.1 Operational and sampling design

NBSP is a largely homogenous site with one habitat type identified for most of the extent of the site (A5.2). One dominant community structure exists, with little variability. However, the site possesses pockets of smaller areas of differing communities scattered in the southern areas of the site. The extent of the sedimentary grab sampling at the site during the survey allowed for a comprehensive view of the sedimentary habitat and infaunal community structure. To improve future monitoring of this and other sites, the following recommendations are:

- assessment of the human activities and fisheries pressure should be undertaken, and if required, monitoring of the site to incorporate Type 2 or 3 monitoring approaches;
- the temporal variability of the site is, at time of writing, poorly understood. Future monitoring should endeavour to understand the rate of temporal change at the site, in terms of community structure and change in environmental parameters at the seabed;
- further monitoring should aim to measure the environmental parameters, such as seabed temperature, salinity, chlorophyll a, chlorophyll b, organic carbon, oxygen and nutrients. This will aid to identify any environmental drivers which may distinguish the infaunal assemblages, and by extension, community changes at site. Future monitoring surveys should be conducted at the same time of year to limit the influence of seasonal changes;
- A visual survey should be conducted to gather evidence on potential PMFs at the site, including ‘sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg)’, and additionally, gain an understanding of the epifaunal communities at the site;
- the 0.25m^2 Hamon grab proved effective in sampling the habitat supporting ocean quahog, as sediment samples were obtained from 117 of 120 visited stations, despite variation in the coarseness of the seabed. However, the report recommends that for future monitoring of NBSP, and other sites, that a 0.1m^2 Hamon grab be used. The 0.1m^2 Hamon grab is used more widely in the monitoring of UK offshore and inshore MPAs, and samples can be more easily compared to previous results obtained with gears of the same sampling area (0.1 m^2 Day grab). A gear comparison study could be used to improve the understanding of sampling differences of infaunal sampling between a 0.25m^2 and 0.1m^2 Hamon grab;
- from the low sampling success of ocean quahog, a 0.25m^2 Hamon grab may not be the ideal sampling gear for the assessment of the species composition, structure and distribution. The low sampling success may indicate that there is not a large population of ocean quahog at the site. Future monitoring should target the sedimentary habitats supporting the colonisation of ocean quahog, rather than the species themselves.

5.2 Analysis and interpretation

- The recruitment success of ocean quahog is reported to be heavily dependent on water temperature (Witbaard & Bergman 2003). Conservation advice for ocean quahog suggests the recording of seabed temperature in order to assess the impact of climatic change on ocean quahog recruitment and populations. For the monitoring programme to fill this gap in our understanding, it is recommended that a greater understanding of the environmental parameters at the site should be achieved. The collection of environmental parameters, such as temperature, organic carbon, water currents and turbidity will aid in the understanding of environmental drivers for ocean quahog colonisation and maintained presence;

- clarification is needed on the criteria for assignment of the following Priority Marine Features: ‘ocean quahog aggregations’ and ‘offshore deep-sea muds’. There is no definition of the abundance or density of ocean quahog required before it is considered an ‘aggregation’, nor the depth criteria to differentiate ‘deep-sea’ from shallower, similarly muddy habitats. It is advised that a depth, consistent with habitat classification is adopted, such as the <200m depth being considered ‘deep-sea’ as in the Marine Habitat Classification of Britain and Ireland (Parry *et al.* 2015). The criteria for assignment of ‘burrowed mud’ are unspecific, as the number, size and density of burrows are not stated (Tyler-Walters *et al*. 2016). However, this information is required in order to assign this feature confidently and consistently. Standardised methods of PMF assessment and designation should be agreed for future monitoring efforts of this site and in the wider MPA monitoring network.

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Appendices

Appendix 1: Habitat conversion table, allowing the conversion and comparison of the designated and identified habitats within Norwegian Boundary Sediment Plain MPA (Robson 2014).

Priority Marine Features (Scotland)	EUNIS Type 3	EUNIS Corresponding biotopes	EUNIS description
Offshore subtidal sands and gravel	A5.1	A5.14	Circalittoral coarse sediment
		A5.15	Deep circalittoral coarse sediment
	A5.2	A5.25	Circalittoral fine sand
		A5.26	Circalittoral muddy sand
		A5.27	Deep circalittoral sand
	A5.4	A5.44	Circalittoral mixed sediments
		A5.45	Deep circalittoral mixed sediments
	A6.2	n/a	Deep-sea mixed substrata
	A6.3	n/a	Deep-sea sand
	A6.4	n/a	Deep-sea muddy sand

Appendix 2: Infaunal data truncation protocol

Raw taxon abundance and biomass matrices can often contain entries that include the same taxa recorded differently, erroneously or differentiated according to unorthodox, subjective criteria. Therefore, ahead of analysis, data should be checked and truncated to ensure that each row represents a legitimate taxon and they are consistently recorded within the dataset. An artificially inflated taxon list (i.e. one that has not had spurious entries removed) risks distorting the interpretation of pattern contained within the sampled assemblage. It is often the case that some taxa have to be merged to a level in the taxonomic hierarchy that is higher than the level at which they were identified. In such situations, a compromise must be reached between the level of information lost by discarding recorded detail on a taxon's identity and the potential for error in analyses, results and interpretation if that detail is retained.

Details of the data preparation and truncation protocols applied to the infaunal datasets acquired at NBSP ahead of the analyses reported here are provided below:

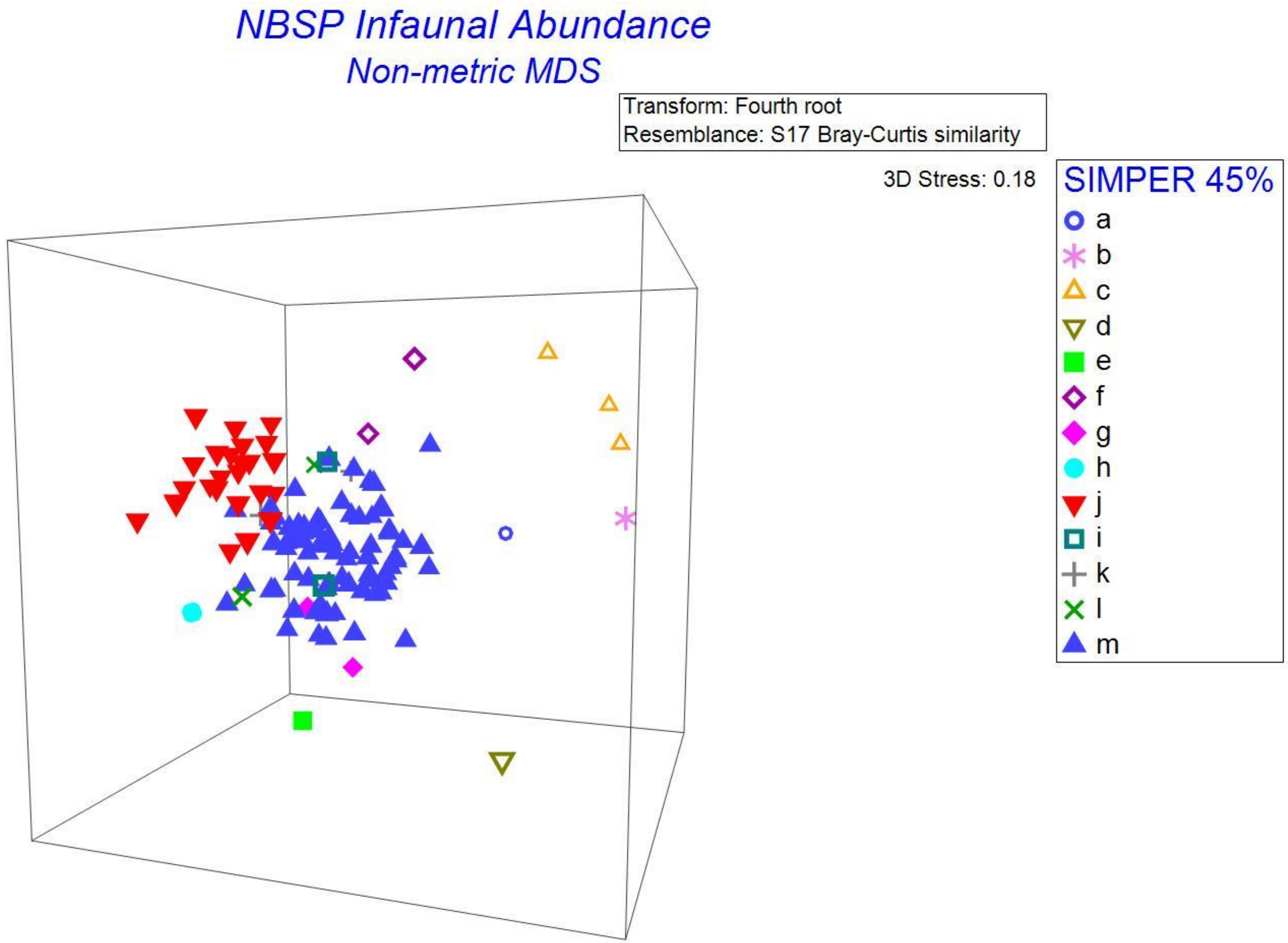
- Where there are records of one named species together with records of members of the same genus (but the latter not identified to species level) the entries are merged, and the resulting entry retains only the name of the genus.
- Taxa are often assigned as 'juveniles' during the identification stage with little evidence for their actual reproductive natural history (with the exception of some well-studied molluscs and commercial species). Many truncation methods involve the removal of all 'juveniles'. However, a decision must be made on whether removal of all juveniles from the dataset is appropriate or whether they should be combined with the adults of the same species where present.

For the macrofaunal data collected at NBSP if 'juvenile' records were recorded at the same taxonomic level as 'adult' records then the two records were combined, whereas if juveniles were recorded at a higher taxonomic level than adults then the 'juvenile' records were removed to avoid having to reduce the taxonomic resolution of the 'adult' records.

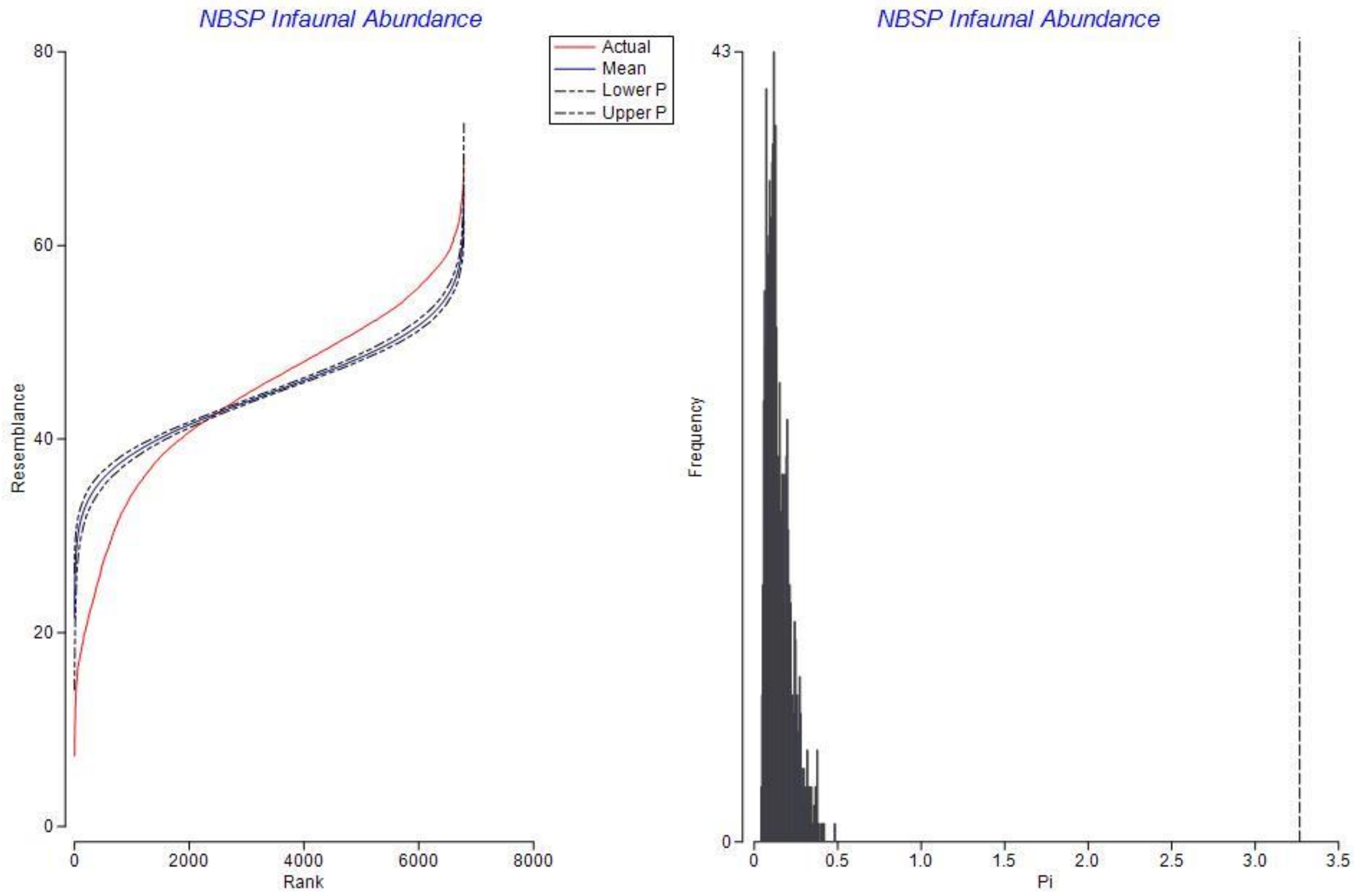
- Records of meiofauna (i.e. nematodes) were removed.
- Records of fish species were removed
- Records of 'eggs' were removed

Appendix 3: Taxa listed as non-indigenous species (present and horizon) which have been selected for assessment of Good Environmental Status in UK waters under MSFD Descriptor 2 (Stebbing *et al*. 2014).

Species name	List	Species name	List
Acartia (Acanthacartia) tonsa	Present	*Alexandrium catenella*	Horizon
Amphibalanus amphitrite	Present	*Amphibalanus reticulatus*	Horizon
Asterocarpa humilis	Present	*Asterias amurensis*	Horizon
Bonnemaisonia hamifera	Present	*Caulerpa racemosa*	Horizon
Caprella mutica	Present	*Caulerpa taxifolia*	Horizon
Crassostrea angulata	Present	*Celtodoryx ciocalyptoides*	Horizon
Crassostrea gigas	Present	*Chama sp.*	Horizon
Crepidula fornicata	Present	*Dendostrea frons*	Horizon
Diadumene lineata	Present	*Gracilaria vermiculophylla*	Horizon
Didemnum vexillum	Present	*Hemigrapsus penicillatus*	Horizon
Dyspanopeus sayi	Present	*Hemigrapsus sanguineus*	Horizon
Ensis directus	Present	*Hemigrapsus takanoi*	Horizon
Eriocheir sinensis	Present	*Megabalanus coccopoma*	Horizon
Ficopomatus enigmaticus	Present	*Megabalanus zebra*	Horizon
Grateloupia doryphora	Present	*Mizuhopecten yessoensis*	Horizon
Grateloupia turuturu	Present	*Mnemiopsis leidyi*	Horizon
Hesperibalanus fallax	Present	*Ocenebra inornata*	Horizon
Heterosigma akashiwo	Present	*Paralithodes camtschaticus*	Horizon
Homarus americanus	Present	*Polysiphonia subtilissima*	Horizon
Rapana venosa	Present	*Pseudochattonella verruculosa*	Horizon
Sargassum muticum	Present	*Rhopilema nomadica*	Horizon
Schizoporella japonica	Present	*Telmatogeton japonicus*	Horizon
Spartina townsendii var. anglica	Present		
Styela clava	Present		
Undaria pinnatifida	Present		
Urosalpinx cinerea	Present		
Watersipora subatra	Present		



Appendix 4: 3D nMDS of infaunal abundance data, with the SIMPER 45% slice groups represented as letters ‘a’ to ‘m’ for the 13 groups observed. Lines are drawn to represent 25% (green) and 45% (purple) group similarity. The high stress value of 0.22 indicates suspect results.



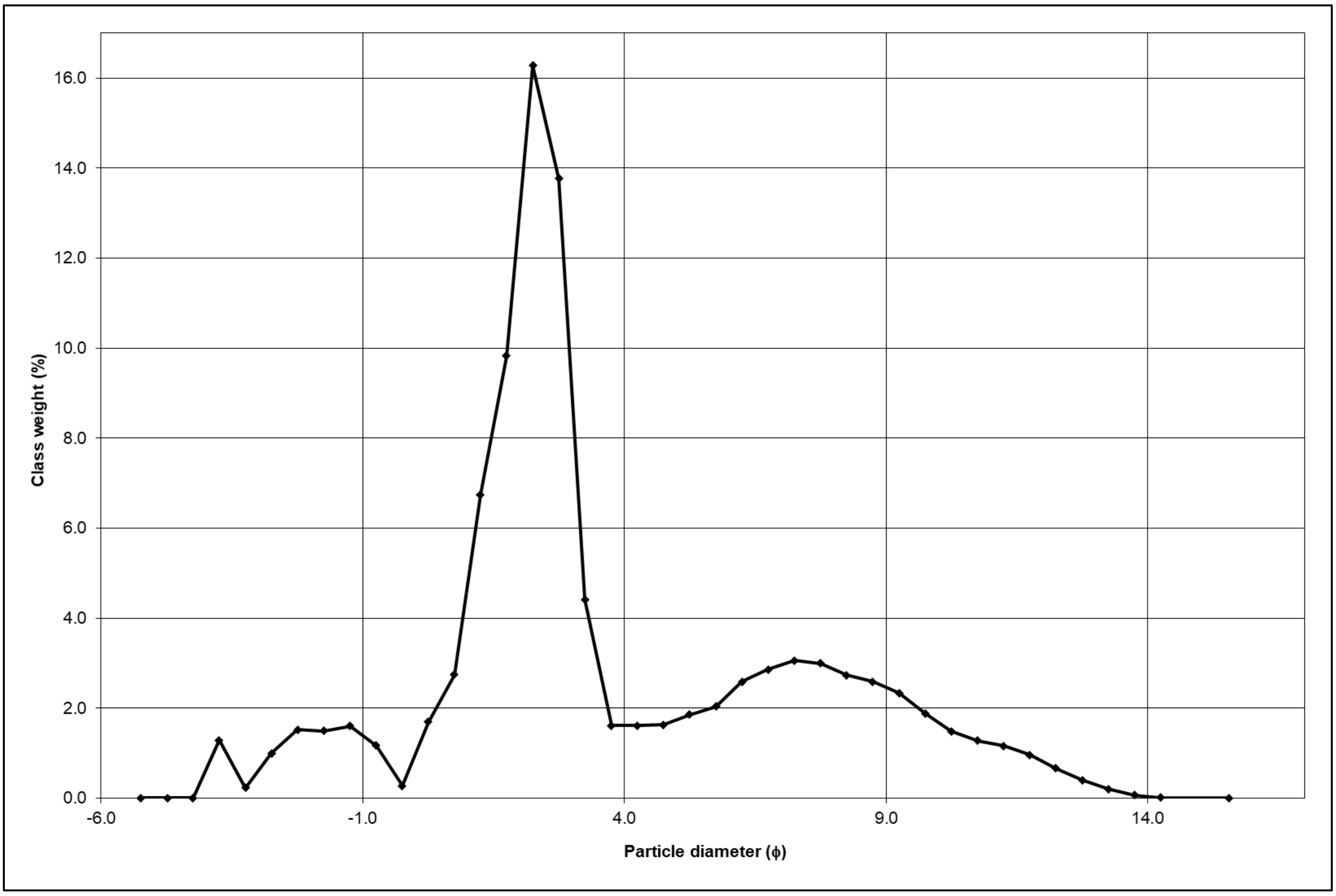
Appendix 5: Results of the SIMPROF analysis to determine the structure of the infaunal resemblance data from the 2015 survey of NBSP. Global test statistics (π=3.267, p<0.001).

Appendix 6: Correlation table for the available measured abiotic factors recorded in the 2015 survey of NBSP. Highlighted fields with red have a correlation >90%, those highlighted in orange have a statistical correlation between 80%-89.99%. For the purposes testing of abiotic factors, it was determined that those >90% could be considered together.

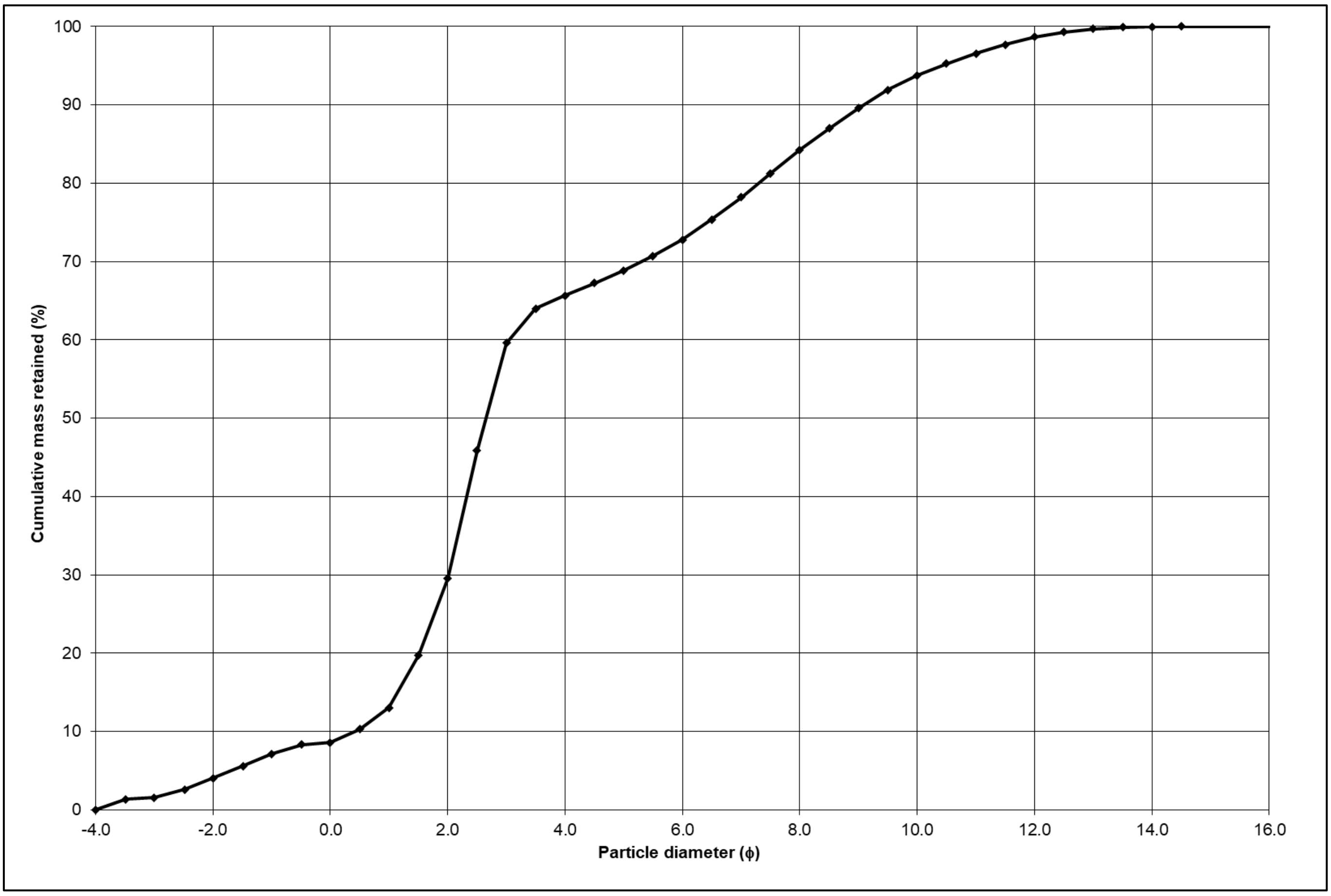
	Latitude	Longitude	BSH	Gravel	Sand	Fines	Water Depth (m)	SurfaceSAR AVG	Subsurface AVG	Log(KWfishingH AVG+1)	% V COARSE GRAVEL:	% COARSE GRAVEL:	% MEDIUM GRAVEL:	% FINE GRAVEL:	% V FINE GRAVEL:	% V COARSE SAND:	% COARSE SAND:	% MEDIUM SAND:	% FINE SAND:	% V FINE SAND:	% V COARSE SILT:	% COARSE SILT:	% MEDIUM SILT:	% FINE SILT:	% V FINE SILT:	% CLAY:
Latitude																										
Longitude	36.752																									
BSH	50.427	52.137																								
Gravel	37.607	59.829	82.051																							
Sand	47.863	54.701	34.188	31.624																						
Fines	68.376	34.188	51.282	41.880	26.496																					
Water Depth (m)	76.068	23.077	57.265	44.444	42.735	70.085																				
SurfaceSAR AVG	21.368	65.812	52.137	64.957	42.735	44.444	31.624																			
Subsurface AVG	41.880	45.299	62.393	66.667	39.316	52.991	48.718	79.487																		
Log(KWfishingH AVG+1)	52.991	39.316	39.316	43.590	52.137	53.846	47.863	56.410	76.923																	
% V COARSE GRAVEL:	56.410	52.991	92.308	76.068	41.880	48.718	59.829	44.444	61.538	38.462																
% COARSE GRAVEL:	52.137	53.846	91.453	82.051	37.607	47.863	53.846	50.427	65.812	42.735	94.017															
% MEDIUM GRAVEL:	42.735	58.120	76.923	89.744	33.333	47.009	46.154	63.248	66.667	45.299	74.359	78.632														
% FINE GRAVEL:	41.026	56.410	80.342	86.325	31.624	43.590	47.863	58.120	63.248	43.590	74.359	75.214	81.197													
% V FINE GRAVEL:	41.026	56.410	87.179	91.453	31.624	43.590	49.573	59.829	64.957	41.880	81.197	82.051	82.906	89.744												
% V COARSE SAND:	41.026	58.120	88.889	91.453	35.043	40.171	49.573	58.120	63.248	40.171	84.615	85.470	82.906	86.325	94.872											
% COARSE SAND:	23.077	67.521	65.812	73.504	49.573	32.479	31.624	76.068	65.812	46.154	64.957	67.521	68.376	68.376	71.795	75.214										
% MEDIUM SAND:	21.368	60.684	47.009	54.701	59.829	22.222	31.624	64.103	57.265	54.701	49.573	50.427	56.410	56.410	54.701	52.991	69.231									
% FINE SAND:	88.034	36.752	41.880	29.060	51.282	70.085	72.650	23.077	36.752	49.573	47.863	41.880	35.897	35.897	30.769	32.479	16.239	19.658								
% V FINE SAND:	83.761	35.897	61.538	48.718	41.880	72.650	75.214	30.769	49.573	45.299	65.812	63.248	50.427	47.009	50.427	52.137	34.188	15.385	78.632							
% V COARSE SILT:	71.795	35.897	51.282	40.171	28.205	93.162	70.085	42.735	52.991	53.846	48.718	47.863	47.009	41.880	41.880	40.171	32.479	22.222	73.504	72.650						
% COARSE SILT:	67.521	36.752	47.009	39.316	32.479	90.598	64.103	43.590	48.718	52.991	44.444	45.299	44.444	39.316	39.316	35.897	28.205	26.496	69.231	66.667	90.598					
% MEDIUM SILT:	70.085	34.188	49.573	41.880	26.496	94.872	66.667	41.026	49.573	55.556	47.009	47.863	47.009	41.880	41.880	38.462	30.769	23.932	68.376	69.231	89.744	90.598				
% FINE SILT:	66.667	35.897	58.120	48.718	21.368	91.453	68.376	42.735	51.282	50.427	55.556	54.701	48.718	50.427	50.427	47.009	37.607	27.350	64.957	69.231	86.325	82.051	91.453			
% V FINE SILT:	64.957	39.316	61.538	52.137	19.658	86.325	64.957	44.444	52.991	48.718	60.684	58.120	50.427	53.846	53.846	50.427	39.316	27.350	63.248	70.940	81.197	78.632	84.615	93.162		
% CLAY:	64.957	41.026	63.248	53.846	19.658	84.615	63.248	47.863	56.410	50.427	62.393	59.829	52.137	53.846	53.846	52.137	41.026	25.641	63.248	72.650	79.487	76.923	82.906	89.744	94.872	

Appendix 7: Sediment particle size (grain size) chart used in the GRADISTAT program, compared with other sources, to determine the PSA for sampled grab stations of NBSP (Blott & Pye 2001).

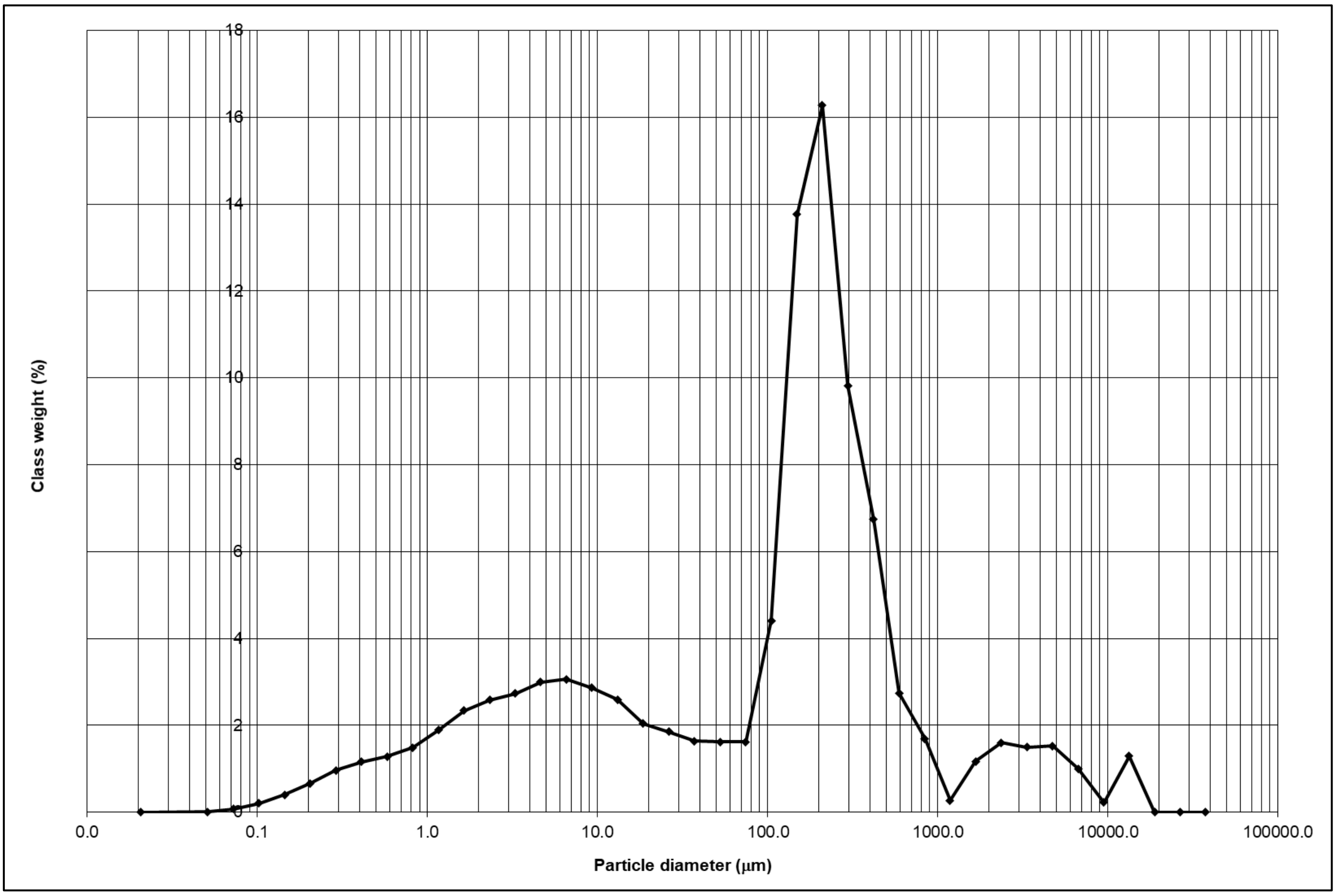
Grain size		Descriptive terminology			
phi	mm/µm	Udden (1914) and Wentworth (1922)	Friedman and Sanders (1978)	GRADISTAT program	
			Very large boulders		
−11	2048 mm				
			Large boulders	Very large	
−10	1024				
			Medium boulders	Large	
−9	512	Cobbles			
			Small boulders	Medium	Boulders
−8	256				
			Large cobbles	Small	
−7	128				
			Small cobbles	Very small	
−6	64				
			Very coarse pebbles	Very coarse	
−5	32				
			Coarse pebbles	Coarse	
−4	16	Pebbles			
			Medium pebbles	Medium	Gravel
−3	8				
			Fine pebbles	Fine	
−2	4				
		Granules	Very fine pebbles	Very fine	
−1	2				
		Very coarse sand	Very coarse sand	Very coarse	
0	1				
		Coarse sand	Coarse sand	Coarse	
1	500 µm				
		Medium sand	Medium sand	Medium	Sand
2	250				
		Fine sand	Fine sand	Fine	
3	125				
		Very fine sand	Very fine sand	Very fine	
4	63				
			Very coarse silt	Very coarse	
5	31				
			Coarse silt	Coarse	
6	16	Silt			
			Medium silt	Medium	Silt
7	8				
			Fine silt	Fine	
8	4				
			Very fine silt	Very fine	
9	2	Clay			
			Clay	Clay	



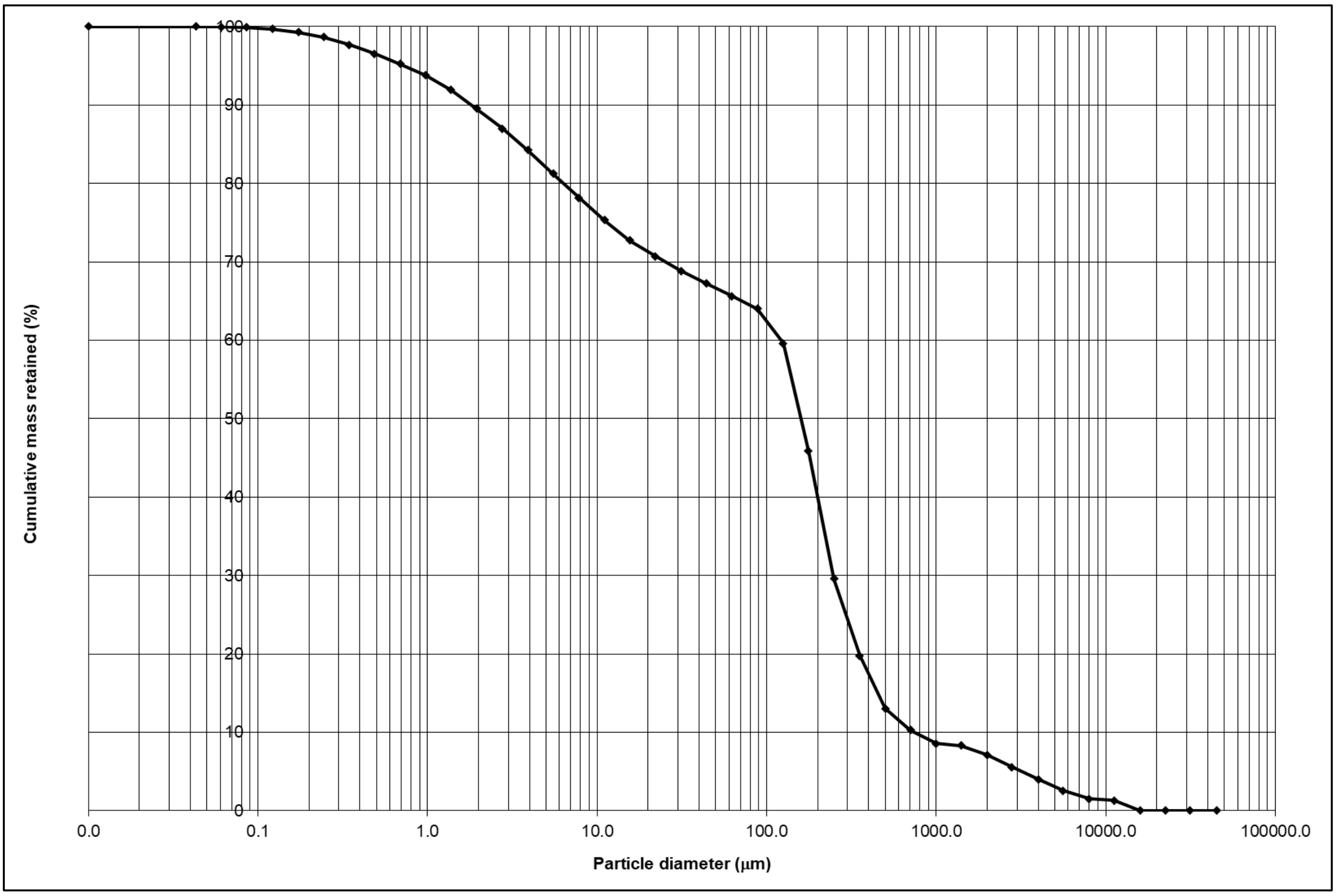
Appendix 8: Sediment particle size distribution (phi) for sampled grab stations of NBSP. Graph generated through GRADISTAT.



Appendix 9: Cumulative distribution (phi) for the NBSP grab samples. Graph generated though GRADISTAT.



Appendix 10: Sediment particle size distribution (microns) for sampled grab stations of NBSP. Graph generated through GRADISTAT.



Appendix 11: Cumulative distribution (micros) for the NBSP grab samples. Graph generated through GRADISTAT.

Appendix 12: Summary statistics of the infaunal analysis of NBSP from grab sampling.

	S	N	d	J'	H'(loge)	1-Lambda'
1	35	41.429	9.130	0.993	3.529	0.994
2	32	40.688	8.365	0.993	3.442	0.992
3	31	38.780	8.201	0.990	3.400	0.991
5	50	61.210	11.910	0.993	3.883	0.995
6	39	46.014	9.924	0.993	3.639	0.995
7	34	41.468	8.859	0.994	3.506	0.993
8	41	47.272	10.374	0.995	3.693	0.996
9	18	21.212	5.565	0.995	2.877	0.990
10	22	25.329	6.498	0.994	3.072	0.992
11	30	35.703	8.111	0.994	3.379	0.993
12	37	42.275	9.615	0.995	3.593	0.995
13	39	47.232	9.857	0.992	3.634	0.994
14	35	42.897	9.045	0.991	3.525	0.993
15	52	65.100	12.213	0.993	3.923	0.995
16	36	40.670	9.445	0.996	3.569	0.996
17	26	30.778	7.295	0.996	3.244	0.993
18	38	46.672	9.628	0.993	3.613	0.994
19	28	32.913	7.728	0.996	3.318	0.993
20	27	33.080	7.431	0.993	3.274	0.991
21	38	45.763	9.677	0.993	3.613	0.994
22	42	48.708	10.551	0.995	3.718	0.996
23	25	30.120	7.048	0.994	3.201	0.991
24	39	47.030	9.868	0.994	3.640	0.994
25	32	38.161	8.512	0.994	3.444	0.993
26	34	38.699	9.027	0.994	3.507	0.995
27	30	35.703	8.111	0.995	3.383	0.993
28	30	33.744	8.241	0.995	3.386	0.995
29	33	39.664	8.695	0.994	3.477	0.993
30	31	39.152	8.180	0.992	3.406	0.991
31	30	35.827	8.104	0.994	3.379	0.993
32	21	23.118	6.368	0.995	3.029	0.994
33	32	37.915	8.527	0.995	3.449	0.994
34	39	47.229	9.857	0.992	3.635	0.994
35	24	30.614	6.722	0.991	3.150	0.988
36	39	45.152	9.974	0.994	3.642	0.995
37	25	29.010	7.127	0.995	3.202	0.993
38	44	55.212	10.720	0.992	3.754	0.994
39	37	45.501	9.430	0.992	3.583	0.993
40	46	52.231	11.376	0.995	3.808	0.996
41	33	37.585	8.824	0.996	3.482	0.995
42	28	33.375	7.697	0.995	3.314	0.993
43	34	39.760	8.960	0.996	3.511	0.995

	S	N	d	J'	H'(loge)	1-Lambda'
44	32	38.667	8.482	0.992	3.439	0.993
45	35	40.744	9.171	0.995	3.537	0.995
46	34	40.864	8.894	0.993	3.502	0.993
47	38	45.726	9.679	0.993	3.610	0.994
48	43	51.023	10.681	0.994	3.740	0.995
49	47	56.346	11.410	0.992	3.821	0.995
50	26	31.685	7.234	0.994	3.238	0.991
51	18	21.886	5.509	0.997	2.880	0.989
52	42	50.233	10.468	0.993	3.711	0.995
53	27	33.418	7.409	0.994	3.275	0.991
54	42	51.237	10.415	0.994	3.716	0.995
55	24	29.545	6.793	0.992	3.152	0.990
56	20	24.919	5.909	0.990	2.965	0.986
57	40	49.640	9.988	0.994	3.667	0.994
58	47	59.470	11.259	0.993	3.823	0.994
59	16	18.301	5.160	0.994	2.755	0.989
60	29	35.608	7.838	0.993	3.344	0.992
61	32	41.063	8.344	0.993	3.442	0.991
62	47	55.707	11.442	0.993	3.822	0.995
63	36	44.270	9.234	0.993	3.559	0.993
64	37	45.064	9.454	0.993	3.584	0.993
65	29	35.948	7.817	0.991	3.338	0.991
67	26	31.029	7.278	0.992	3.231	0.991
68	36	43.102	9.300	0.991	3.551	0.993
69	27	33.015	7.435	0.992	3.271	0.991
70	34	41.675	8.847	0.994	3.507	0.993
71	38	45.950	9.667	0.993	3.613	0.994
72	26	32.285	7.195	0.992	3.231	0.990
73	33	39.261	8.719	0.993	3.471	0.993
74	32	39.060	8.458	0.992	3.436	0.992
75	31	36.003	8.371	0.995	3.416	0.994
76	20	24.967	5.905	0.992	2.971	0.987
77	23	27.982	6.604	0.994	3.118	0.990
78	32	37.562	8.549	0.994	3.446	0.994
79	30	35.447	8.128	0.993	3.376	0.993
80	35	41.520	9.125	0.994	3.533	0.994
81	34	41.612	8.851	0.993	3.500	0.993
82	31	38.562	8.214	0.991	3.405	0.991
83	31	38.943	8.192	0.993	3.411	0.992
84	28	32.379	7.764	0.993	3.308	0.993
85	30	35.537	8.122	0.992	3.374	0.993
86	30	36.142	8.084	0.992	3.376	0.992
87	31	39.131	8.181	0.991	3.404	0.991

	S	N	d	J'	H'(loge)	1-Lambda'
88	32	37.400	8.560	0.992	3.440	0.994
89	27	33.660	7.394	0.991	3.267	0.990
90	26	30.460	7.318	0.993	3.237	0.992
91	36	44.176	9.239	0.992	3.556	0.993
92	37	45.646	9.422	0.991	3.580	0.993
93	39	46.590	9.892	0.991	3.632	0.994
94	18	22.512	5.459	0.994	2.873	0.986
95	31	36.648	8.330	0.992	3.405	0.993
96	23	29.488	6.501	0.988	3.098	0.986
97	32	39.754	8.418	0.991	3.434	0.992
98	35	40.697	9.174	0.994	3.535	0.995
99	28	33.161	7.711	0.993	3.308	0.992
100	31	37.390	8.284	0.991	3.403	0.992
102	47	56.867	11.384	0.993	3.824	0.995
103	24	29.522	6.794	0.994	3.158	0.990
104	27	33.903	7.379	0.990	3.261	0.989
105	23	29.171	6.522	0.990	3.105	0.988
106	27	32.422	7.474	0.991	3.267	0.991
107	25	31.086	6.983	0.990	3.186	0.989
108	37	44.433	9.489	0.993	3.584	0.994
109	33	45.431	8.385	0.986	3.446	0.988
110	32	35.519	8.683	0.996	3.452	0.996
111	28	34.160	7.646	0.991	3.302	0.991
112	25	29.987	7.057	0.993	3.197	0.991
113	38	44.922	9.724	0.995	3.620	0.995
114	31	37.726	8.264	0.991	3.403	0.992
115	33	40.069	8.671	0.992	3.467	0.992
116	30	36.734	8.047	0.990	3.368	0.991
117	32	39.066	8.458	0.991	3.433	0.992
118	32	38.250	8.507	0.993	3.441	0.993
119	20	23.998	5.979	0.993	2.973	0.989
120	14	17.244	4.565	0.993	2.620	0.983

Appendix 13: Table shows the number of ocean quahog (*Arctica islandica*) obtained from 117 grab sample stations. The estimation of age in the ocean quahog identified on survey, which were returned to sea, has been determined from the available photographs of the specimens, and are interpretations only.

Station full code	***Arctica islandica* (mature)**	***Arctica islandica* (juvenile)**	***Arctica islandica* identified on survey (and determination of mature (m) or juvenile (j))**	***Arctica islandica* Total**
NSP001 182 64224	-	-	-	0
NSP002 311 64225	-	1	-	1
NSP003 297 64226	-	-	-	0
NSP005 280 64228	-	-	-	0
NSP006 273 64229	-	-	-	0
NSP007 263 64230	-	-	-	0
NSP008 260 64231	-	-	-	0
NSP009 165 64232	-	-	-	0
NSP010 334 64233	-	-	-	0
NSP011 310 64234	-	-	-	0
NSP012 298 64235	1	-	1 (j)	2
NSP013 283 64236	-	-	-	0
NSP014 274 64237	-	-	-	0
NSP015 269 64238	-	-	1 (j)	1
NSP016 262 64239	-	-	-	0
NSP017 157 64240	-	-	-	0
NSP018 256 64241	-	-	-	0
NSP019 323 64242	-	1	-	1
NSP020 315 64243	-	-	-	0
NSP021 289 64244	-	-	-	0
NSP022 281 64245	-	1	-	1
NSP023 261 64246	-	-	-	0
NSP024 164 64247	-	-	-	0
NSP025 173 64248	-	-	-	0
NSP026 322 64249	-	-	-	0
NSP027 197 64250	1	-	1 (j)	2
NSP028 309 64251	-	-	-	0
NSP029 275 64252	-	-	-	0
NSP030 265 64253	-	-	-	0
NSP031 250 64254	-	-	1 (j)	1
NSP032 166 64255	-	-	-	0
NSP033 174 64256	-	-	-	0
NSP034 183 64257	-	-	-	0
NSP035 312 64258	-	-	-	0
NSP036 299 64259	-	-	-	0
NSP037 290 64260	-	-	-	0
NSP038 272 64261	-	-	-	0
NSP039 268 64262	-	-	-	0
NSP040 264 64263	-	1	-	1

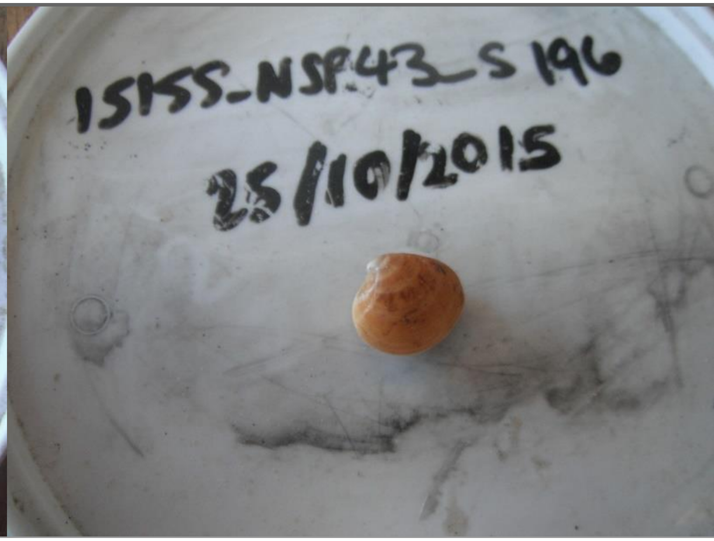
Station full code	***Arctica islandica* (mature)**	***Arctica islandica* (juvenile)**	***Arctica islandica* identified on survey (and determination of mature (m) or juvenile (j))**	***Arctica islandica* Total**
NSP041 253 64264	-	1	-	1
NSP042 181 64265	-	-	-	0
NSP043 196 64266	1	-	1 (j)	2
NSP044 307 64267	-	-		0
NSP045 293 64268	-	-		0
NSP046 284 64269	-	-		0
NSP047 276 64270	-	-		0
NSP048 270 64271	-	-		0
NSP049 266 64272	-	-		0
NSP050 158 64273	-	-		0
NSP051 257 64274	-	-		0
NSP052 321 64275	-	-	1 (j)	1
NSP053 189 64276	-	-		0
NSP054 313 64277	-	1		1
NSP055 306 64278	-	-		0
NSP056 259 64279	-	-		0
NSP057 267 64280	-	-		0
NSP058 163 64281	-	-		0
NSP059 324 64282	-	-		0
NSP060 316 64283	-	-		0
NSP061 195 64343	-	-		0
NSP062 305 64284	-	2		2
NSP063 294 64285	-	-		0
NSP064 285 64286	-	-		0
NSP065 277 64287	-	-		0
NSP067 167 64289	-	-		0
NSP068 175 64290	-	-		0
NSP069 188 64291	1	-		1
NSP070 314 64292	-	-		0
NSP071 300 64293	-	2		2
NSP072 292 64294	-	-		0
NSP073 282 64295	-	-		0
NSP074 271 64296	-	-		0
NSP075 254 64297	-	-		0
NSP076 172 64298	-	-		0
NSP077 180 64299	-	-		0
NSP078 194 64300	-	1		1
NSP079 304 64301	-	-		0
NSP080 295 64302	-	-		0
NSP081 286 64303	-	-		0
NSP082 278 64304	-	-		0
NSP083 159 64305	-	1		1

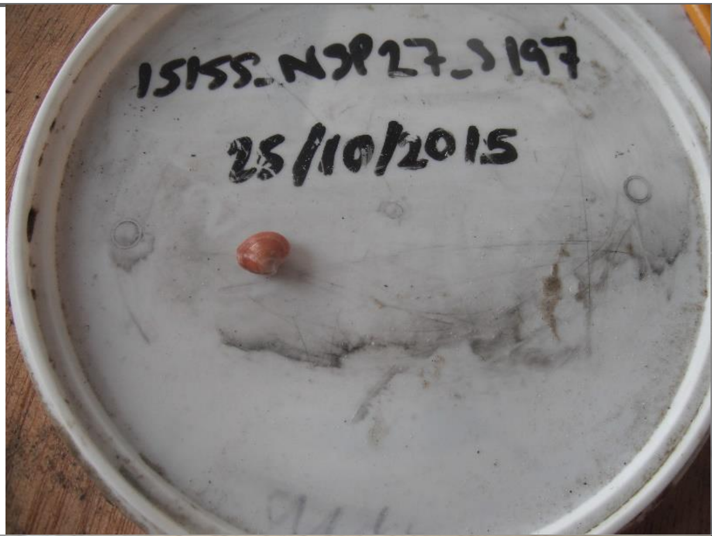
Station full code	***Arctica islandica* (mature)**	***Arctica islandica* (juvenile)**	***Arctica islandica* identified on survey (and determination of mature (m) or juvenile (j))**	***Arctica islandica* Total**
NSP084 258 64306	-	-		0
NSP085 320 64307	-	-		0
NSP086 187 64308	-	1		1
NSP087 308 64309	-	-		0
NSP088 291 64310	-	1		1
NSP089 279 64311	-	1		1
NSP090 162 64312	-	1		1
NSP091 325 64313	-	-		0
NSP092 317 64314	-	-	1 (m)	1
NSP093 193 64315	-	-		0
NSP094 303 64316	-	-		0
NSP095 296 64317	-	-		0
NSP096 287 64318	-	-		0
NSP097 252 64319	-	-		0
NSP098 168 64320	-	1		1
NSP099 176 64321	-	-		0
NSP100 186 64322	-	-		0
NSP102 301 64324	-	-		0
NSP103 255 64325	-	-		0
NSP104 171 64326	-	-		0
NSP105 179 64327	-	-		0
NSP106 192 64328	-	-		0
NSP107 302 64329	-	1		1
NSP108 160 64330	-	-		0
NSP109 319 64331	-	-		0
NSP110 185 64332	-	-		0
NSP111 198 64333	-	-		0
NSP112 161 64334	-	-		0
NSP113 326 64335	-	-		0
NSP114 318 64336	-	1		1
NSP115 190 64337	-	-		0
NSP116 169 64338	-	-		0
NSP117 177 64339	-	-		0
NSP118 184 64340	-	-		0
NSP119 170 64341	-	-		0
NSP120 178 64342	-	1		1
Totals	**4**	**20**	**7 (1 m),(6 j)**	**31**

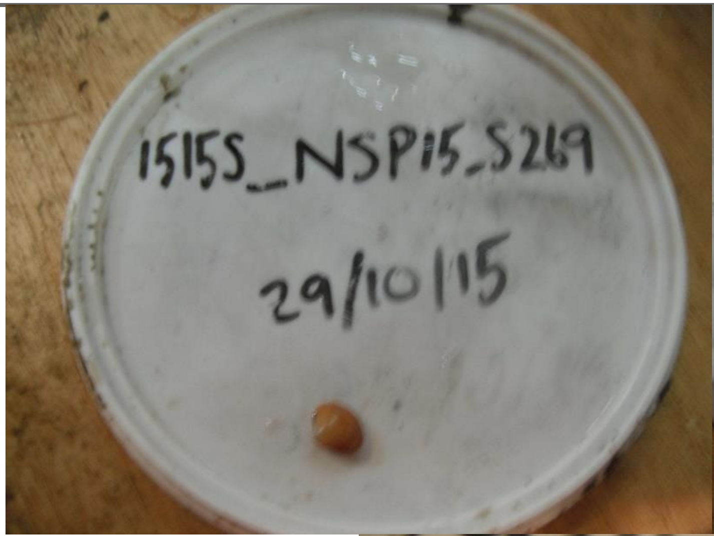
Appendix 14: Observed ocean quahog from grab sampling operations. These ocean quahog specimens were removed from sieved samples of Hamon grab operations, photographed and then returned to sea. No biomass data, nor an estimation of maturity exist for these specimens.

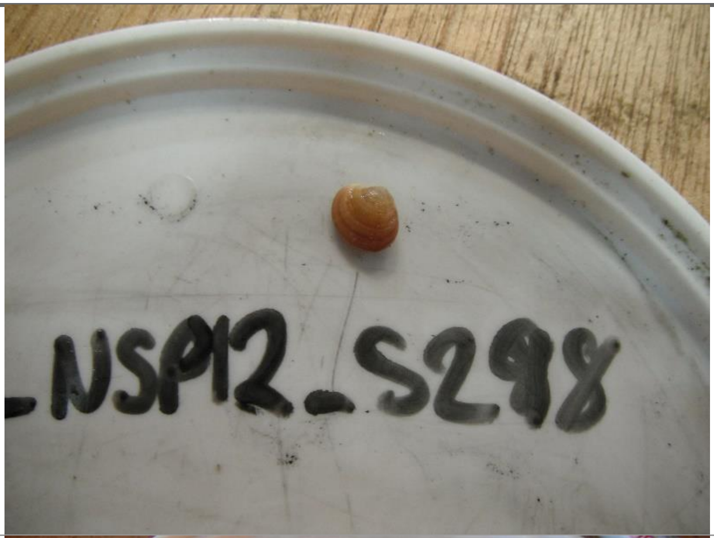
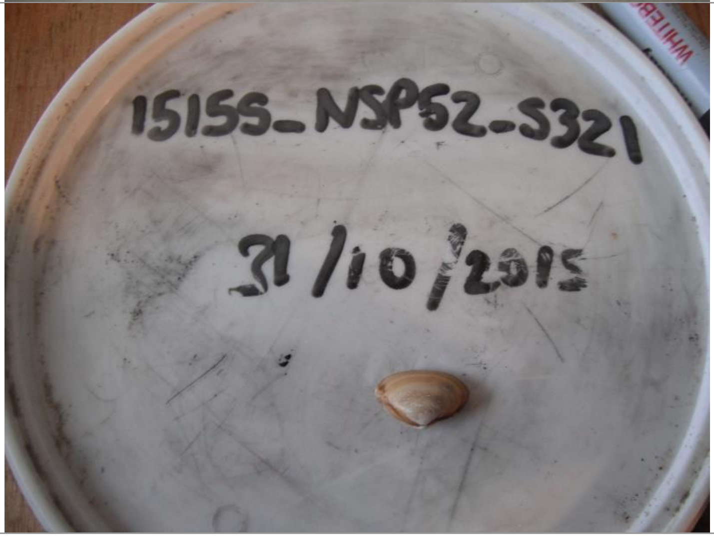
Station Name	Fix times	Date sampled	*Arctica islandica*
1515S_NSP43_S196	25/10/2015 12:02:46	25/10/2015	1
1515S_NSP27_S197	25/10/2015 12:28:51	25/10/2015	1
1515S_NSP31_S250	28/10/2015 08:22:14	28/10/2015	1
1515S_NSP15_S269	29/10/2015 17:01:43	29/10/2015	1
1515S_NSP12_S298	30/10/2015 21:57	30/10/2015	1
1515S_NSP92_S317	31/10/2015 09:04	31/10/2015	1
1515S_NSP52_S321	31/10/2015 11:14	31/10/2015	1

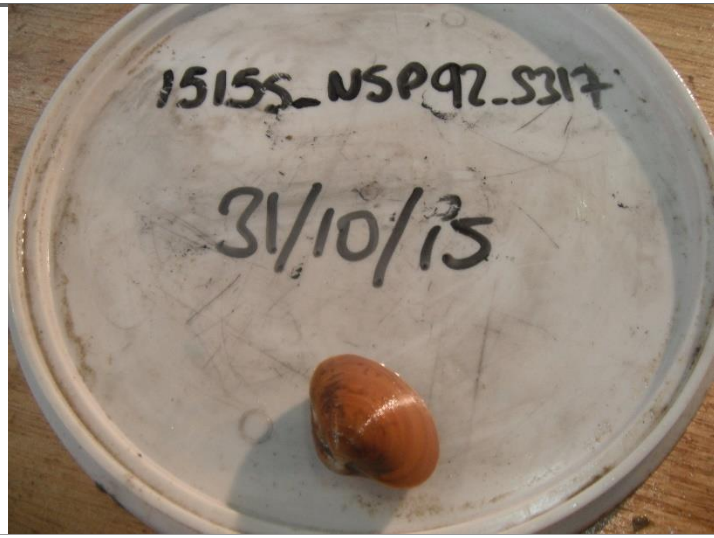
Appendix 15: Observed ocean quahog from grab sampling operations, which were originally not included in infaunal analysis. These ocean quahog specimens were taken out of sieved samples from Hamon grab operations, Photographed and then returned to sea.

Station Name	Sample Image
1515S_NSP43_ S196	 

Station Name	Sample Image
1515S_NSP27_ S197	 
1515S_NSP31_ S250	 

Station Name	Sample Image
1515S_NSP15_ S269	  

Station Name	Sample Image
1515S_NSP12_ S298	
1515S_NSP92_ S317	

Station Name	Sample Image
1515S_NSP52_ S321	

Appendix 16: Categories and sub-categories of litter items for Sea-Floor from the OSPAR/ICES/IBTS for North-East Atlantic and Baltic. Guidance on Monitoring of Marine Litter in European Seas, a guidance document within the Common Implementation Strategy for the Marine Strategy Framework Directive, MSFD Technical Subgroup on Marine Litter, 2013 (EU Commission 2013).

A: Plastic	B: Metals	C: Rubber	D: Glass/ Ceramics	E: Natural products/ Clothes	F: Miscellaneous
A1. Bottle	B1. Cans (food)	C1. Boots	D1. Jar	E1. Clothing/ rags	F1. Wood (processed)
A2. Sheet	B2. Cans (beverage)	C2. Balloons	D2. Bottle	E2. Shoes	F2. Rope
A3. Bag	B3. Fishing related	C3. Bobbins (fishing)	D3. Piece	E3. Other	F3. Paper/ cardboard
A4. Caps/ lids	B4. Drums	C4. Tyre	D4. Other		F4. Pallets
A5. Fishing line (monofilament)	B5. Appliances	C5. Other			F5. Other
A6. Fishing line (entangled)	B6. Car parts				
A7. Synthetic rope	B7. Cables				
A8. Fishing net	B8. Other				
A9. Cable ties					
A10. Strapping band					
A11. Crates and containers					
A12. Plastic diapers					
A13. Sanitary towels/ tampons					
A14. Other					

Related size categories
A: ≤ 5*5cm = 25cm²
B: ≤ 10*10cm = 100cm²
C: ≤ 20*20cm = 400cm²
D: ≤ 50*50cm = 2500cm²
E: ≤ 100*100cm = 10000cm²
F: ≥ 100*100cm = 10000cm²

Appendix 17: Responses from external partners on the most suitable gear type to sample ocean quahog (*Arctica islandica*).

Responder	Recommendation
Dogger Bank Monitoring Sub-Group	**3D Dredge, large box corer**
	Coring/dredging as ground-truthing and imaging/siphon counting as non-destructive approach.
	Undertaking a gear comparison including triple-D and video and comparing different habitats is the right approach
	Box corers to sample whole communities in soft bottoms, dredge to sample larger species/individuals
ICES Benthic Ecology Working Group	**NIOZ corer and Sediment Profile Imagery (SPI)[2], 5 replicates per station, record grain-size, organic matter and temperature**
Joint Monitoring Programme for the North Sea and Celtic Sea Activity C Workshop Benthos Sub-group	**Box corer, dredge**

Appendix 18: Infaunal analysis report

East of Gannet and Montrose Fields (EGM) and Norwegian Boundary Sediment Plain (NSP) Scottish Nature Conservation Marine Protected Areas (NCMPAs)

Project Report No: IMSC105/001/004 (March 2016) provided by Thomson Unicomarine.

This document has been provided as supplemental information and can be downloaded from the report webpage. Please note that this document does not conform to Web Content Accessibility Guidelines (WCAG) 2.0.

[2] SPI was discounted before the 1515S NBSP (2015) survey was undertaken, due to shallow (20cm) penetration and potential issues with deployment in a site with limited available substrate data (O'Connor 2016).

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JNCC/MSS Partnership Report Series **No. 4**. *Norwegian Boundary Sediment Plain MPA Monitoring Report 2015.* McCabe, C., McBreen, F. & O’Connor, J. June 2020. JNCC, Peterborough, ISSN 2634-2081.