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East of Gannet and Montrose Fields MPA Monitoring Report 2015 (Version 2)

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EQA:

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Please Note:

Version 2 (April 2021) This report has been revised to amend an error in Table 4 (section 3.1.2), where the detailed EUNIS codes text for *Sample type Stills (n = 622) / Broadscale Habitat (EUNIS Code) A5.3 Sublittoral mud (609)*, now reads 'A5.354 *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud'.

Executive Summary

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

The East of Gannet and Montrose Fields Nature Conservation MPA (EGM) is located to the east of Scotland and designated for the protection of three Priority Marine Features (PMFs): ocean quahog aggregations, offshore subtidal sands and gravels (representing sediment types suitable for ocean quahog colonisation) and offshore deep-sea muds. 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 EGM. The survey was designed to gather data to address the following objectives, which are also the objectives of this report:

- describe the extent and distribution, structure and functions, and supporting processes of offshore deep-sea muds within EGM;
- describe the population distribution of ocean quahog (*Arctica islandica*) within EGM, in addition to the extent and distribution of the sediment types suitable for ocean quahog colonisation, offshore subtidal sands and gravels;
- describe the character and distribution of any PMFs observed that are not designated features of the site;
- present any evidence of non-indigenous species (MSFD Descriptor 2) and marine litter (MSFD Descriptor 10); and
- recommend future monitoring approaches for EGM.

Infaunal and sediment samples were acquired from 155 large (0.25m^2) Hamon grabs within EGM. Epifauna and further sedimentary habitat information were recorded in video and stills footage from 58 camera tows across the site.

Three EUNIS sedimentary habitat types were identified from particle size analysis of 155 large (0.25m^2) Hamon grabs across the site: A5.2 Sublittoral sand, A5.3 Sublittoral mud and A5.4 Sublittoral mixed sediment. The sedimentary habitats diverged from observations made from previous grab samples within the site, requiring a change in the habitat map. Generally, coarser, more sandy sedimentary habitats were distributed in the north-west half of the site, and finer, more muddy habitats were distributed in the south-east half of the site. Mixed sediment was sparsely distributed throughout.

The infaunal community was typified by three assemblages (denoted c, e and j), which correlated well with the three sedimentary habitats. The biotopes, following the Marine Habitat Classification of Britain and Ireland, *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) were found to represent the infaunal communities and habitats identified at EGM.

The main drivers influencing the distribution and distinctiveness of the infaunal assemblages were the percentage of fine sediments and water depth. Benthic community composition was weakly correlated with these drivers.

The epifaunal communities were unable to be analysed in depth, due to the sparsity of the data, however biotopes indicative of Sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg), Circalittoral sandy mud (SS.SMu.CSaMu), Circalittoral

mixed sediment (SS.SMx.CMx) and *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud (SS.SMu.CSaMu.VirOphPmax) were identified. The report accepts the assignment of SS.SMu.CFiMu.SpnMeg due to the high proportion of sea pens at EGM. The report identifies the need for a sea pen biotope, encompassing high densities of sea pens, in areas of low densities or absence of megafaunal burrows.

Ocean quahog specimens were acquired from grab samples but not in sufficient abundance for statistical analysis to be undertaken. The report is therefore unable to describe the population composition of ocean quahog aggregations within EGM. Their distribution is presented in this report.

There were high densities of seapens in EGM in areas of low density, or absence, of megafaunal burrows. Epifauna and habitat features indicative of the PMF ‘Burrowed mud’ were recorded from 58 video camera tows across the site according to the contractor that analysed the video camera tow data. Approaches to verify examples of burrowed mud are still being developed; where both sea pen density and/or burrow density are considered. This report classes recordings of burrowed mud at EGM as ‘offshore deep-sea mud’ until such time that a comprehensive method of burrowed mud identification is further developed.

Non-indigenous species were not found. Seven instances of marine litter were recorded in video camera tows.

A number of operational and sampling design recommendations for future monitoring of EGM, and for the wider MPA network, are provided:

- a stratified monitoring design should be adopted for any future monitoring of EGM.
- an 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.
- 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.
- future monitoring should target the sedimentary habitats supporting the colonisation of ocean quahog, rather than the species themselves;
- 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.
- camera footage should be tested before and reviewed during survey operations to ensure the data collected is suitable for analysis.
- 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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Contents

Abbreviations

BAP	Biodiversity Action Plan
BGS	British Geological Survey
BSH	Broadscale Habitats
EUNIS	European Nature Information System
ERT	Energy Resource Technology
GES	Good Environmental Status
IOE	Institute of Offshore Engineering
JNCC	Joint Nature Conservation Committee
NMBAQC	North East Atlantic Marine Biological Analytical Quality Control Scheme
MNCR	Marine Nature Conservation Review
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
NIS	Non-Indigenous Species
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
RV	Research Vessel
SACFOR	Superabundant, Abundant, Common, Frequent, Occasional, Rare
SPI	Sediment Profile Imagery
SNCB	Statutory Nature Conservation Body

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 East of Gannet and Montrose Fields Nature Conservation Marine Protected Area (MPA), hereafter referred to as "EGM", is part of a network of nationally designated sites designed to meet the requirements of the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009. These sites will also contribute to an ecologically coherent network of MPAs across 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. JNCC is the 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. The aim of this monitoring programme is to collect the necessary information from the UK MPA network to underpin assessment and reporting obligations. 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 EGM, 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

EGM lies within a relatively shallow sediment plain (~80-100m below sea level) to the east of Scotland, comprising mainly sand and mud habitats (Figure 4). The site area is approximately 1839km^2. The MPA is designated for the protection of the Scottish Priority Marine Features (PMFs) 'ocean quahog aggregations' (including sands and gravels as their supporting habitat), and also protects the full extent of an area of the PMF 'offshore deep-sea muds'. This is one of the few examples of Atlantic-influenced offshore deep-sea mud habitats on the continental shelf in the region. Furthermore, EGM is the only MPA designated in the 'Northern North Sea' Charting Progress 2 Biogeographic Region for the protection of offshore deep-sea muds.

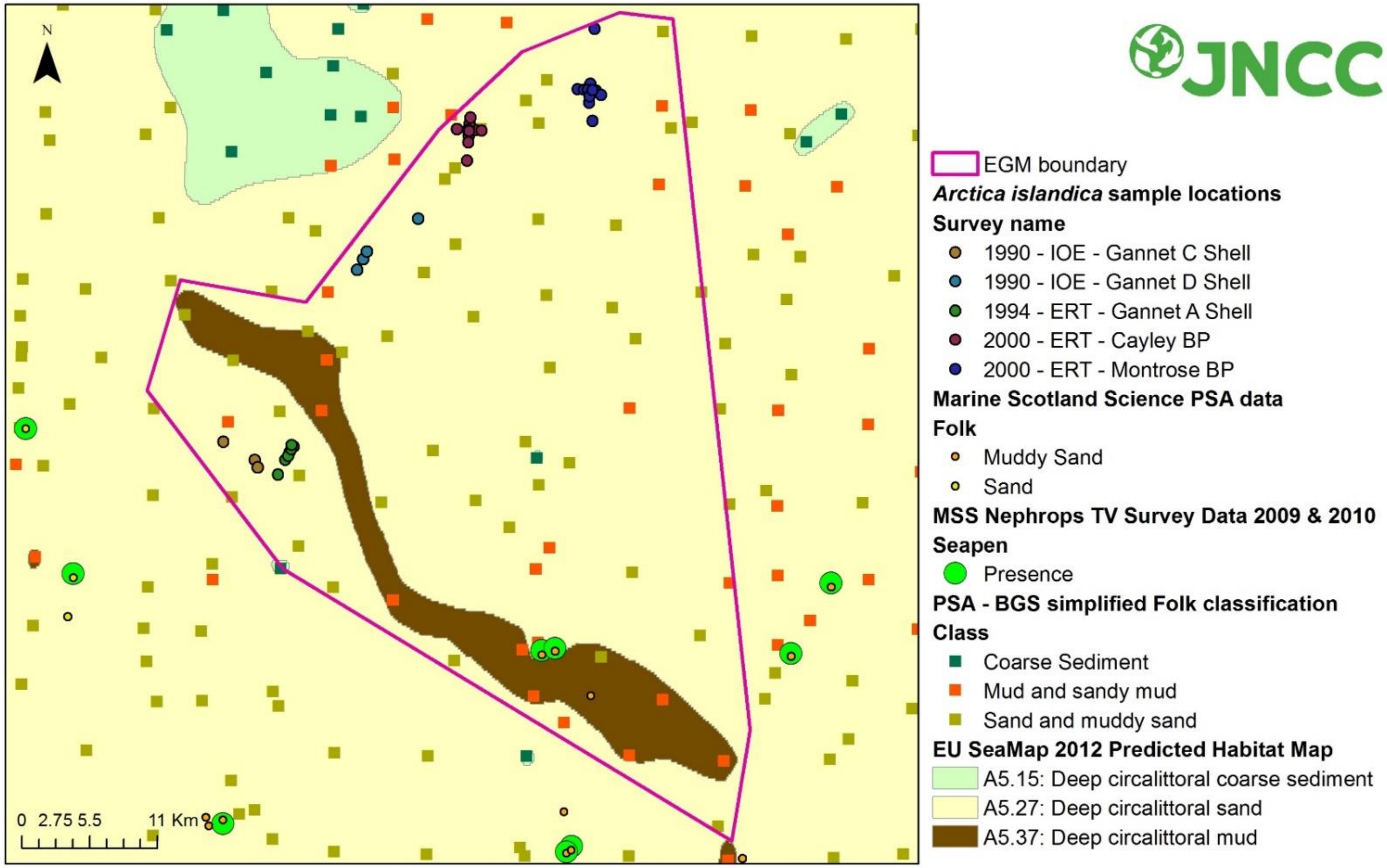

Figure 1: Map of the protected features of East of Gannet and Montrose Fields MPA: ocean quahog (*Arctica islandica*) aggregations, collected by industry representatives, Institute of Offshore Engineering (IOE) and Energy Resource Technology (ERT) on behalf of Shell Ltd. Predictive habitat data used to inform sampling effort for the 1515S survey of East of Gannet and Montrose Fields MPA (Cameron & Askew 2011). The habitat A5.37 directly correlates to offshore deep-sea mud.

1.2 Feature Description

The site is designated to protect three PMFs (Scottish Government 2014), ocean quahog aggregations, offshore subtidal sands and gravels representing sediment types suitable for ocean quahog colonisation, and offshore deep-sea muds (Figure 1).

1.2.1 Ocean quahog aggregations

The ocean quahog, *A. islandica*, 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 population distribution of specimens from EGM. The species is found in sandy and muddy sediments between 4 and 400m below sea level. It is long-lived, 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, bivalves, crabs and hermit crabs, may be present. The habitat features 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 Offshore deep-sea muds

Offshore deep-sea muds are found in offshore waters down to depths of 2500m, and widely distributed in the offshore waters to the north and west of Scotland (Tyler-Walters *et al.* 2016). The relatively stable conditions associated with deep mud habitats often lead to the establishment of communities of burrowing megafaunal species where bathyal species may co-occur with coastal species. The burrowing megafaunal species include burrowing crustaceans such as the Norway Lobster, *Nephrops norvegicus,* and *Callianassa subterranea*. The mud habitats in deep water can also support sea pen populations and communities with brittlestars, including *Amphiura* spp. (UK BAP 2008).

1.2.4 Monitoring Habitats

The following habitats were predicted, prior to 1515S survey of EGM (Figure 4):

- EUNIS A5.1 'Sublittoral Coarse Sediment' (predicted UKSeaMap 2018 (Jaques *et al*. 2017)
- EUNIS A5.2 'Sublittoral sand' (predicted UKSeaMap 2018 (Jaques *et al.* 2017)
- EUNIS A5.3 'Sublittoral mud' (predicted UKSeaMap 2018 (Jaques *et al.* 2017)

In order to assess condition of the designated features in a 'common language' and for clarity with the obtained 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 at the site and corresponding the habitat types occurring at the site.

Designated feature (PMF)	EUNIS level 3 habitat (broad level)	Corresponding monitoring habitat
Offshore subtidal sands and gravel	A5.2 Sublittoral sand	Sublittoral sand and muddy sands (SS.SSa)
	A5.4 Sublittoral mixed sediments	Sublittoral mixed sediment (SS.SMx)
Offshore deep-sea muds	A5.3 Sublittoral mud	Sublittoral cohesive mud and sandy mud communities (SS.SMu)

1.3 Existing data

Infaunal data were amalgamated from 61 industry samples acquired in 2007, 2010 and 2013 (see Figure 1 and Appendix 2). Samples were collected using a 0.1m^2 dual van Veen grab (see Section 2.1). These data were used to conduct a power analysis to inform the required sampling effort (see section 2.1).

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 in protecting designated features within MPAs.

The high-level conservation objectives for EGM (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 offshore deep-sea muds within the MPA, this means that:

- the feature's extent and distribution, under a 'conserve' objective, are stable or increasing; and
- structures and functions, quality, and the composition of characteristic biological communities (which includes a reference to the diversity and abundance of species forming part of or living within the habitat), under a 'recover' objective, are such as to ensure that they remain in a condition which is healthy and not deteriorating (JNCC 2018a, 2018b).

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 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 designated features will be monitored and assessed to aid determination of whether Conservation Objectives have been achieved at the site level as detailed in Section 1.4.1. Supplementary Advice on Conservation Objectives (SACO) for this MPA (JNCC 2018b) lists several feature attributes for the three features for which the site is designated. These attributes fall into broad attribute 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 the distribution of the habitat within the site. 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 associated communities 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 of the habitat feature. Physical structure can have a significant influence on the hydrodynamic regime, and vice versa, especially at the scale of the benthic boundary layer, 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 aim and objectives

The primary aim of this monitoring report is to explore and describe the attributes of the features within EGM 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 has been conserved, improved or declined.

The specific objectives of this monitoring report are as follows;

1) describe the **extent and distribution** and **structure** of offshore deep-sea muds within EGM;
2) describe the population distribution of ocean quahog within EGM, in addition to **the extent** and **distribution** of the sediment types suitable for ocean quahog colonisation, offshore subtidal sands and gravels;
3) describe the character and **distribution** of any Priority Marine Features (PMFs) observed which are not designated features of the site;

4) present any evidence of non-indigenous species (MSFD Descriptor 2) and marine litter (MSFD Descriptor 10); and
5) recommend future monitoring approaches for EGM.

1.4.4 Feature attributes and supporting processes

In order to achieve report objectives 1 and 2, this report will present evidence on a number of 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. The feature attributes were therefore rationalised and prioritised, resulting in a smaller 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 and 2 for EGM.

Offshore deep-sea muds		
Feature attributes	**Sub-attributes**	**Analyses/Outputs**
Extent and distribution	Extent and distribution	PSA point sample distribution
Structure	Physical structure: fine scale topography	PSA and qualitative observations of seabed characteristics
	Sediment composition	
	Biological structure: Key and influential species	Multivariate analysis of infaunal and epifaunal communities Univariate analysis of species of interest
	Biological structure: Characteristic communities	
Supporting processes	Hydrodynamic regime	Not assessed
	Water quality	Not assessed
	Sediment quality	Not assessed

Ocean quahog aggregations (including sands and gravels as their supporting habitat)		
Feature attributes		**Analyses/Outputs**
Extent and distribution	Extent and distribution	Mapped distribution and abundance of the ocean quahog (*Arctica islandica*). PSA point sample distribution (for sands and gravels as a supporting habitat only)
Structure	Structure	Not assessed
Function	Nutrition	Not assessed
	Regulatory processes	Not assessed
	Scientific study	Not assessed
	Carbon cycling and nutrient regulation	Not assessed
Supporting processes	Hydrodynamic regime	Not assessed
	Supporting habitats	PSA point sample distribution, extent and distribution assessment of supporting habitat

Ocean quahog aggregations (including sands and gravels as their supporting habitat)		
Feature attributes		**Analyses/Outputs**
	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 deep-sea muds, and offshore subtidal sands and gravels habitats at EGM 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 were 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 EGM (n = 61), of which 14 were collected in June 2007, 11 in August 2010 and the remaining 36 in August 2013. Samples were collected using a 0.1m^2 dual Van Veen grab. It should be noted that all of these samples correspond to sand habitats only. No data were available to run power analyses on mud habitats. The power analysis determined that a total of 78 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. As a precautionary approach to sampling of the mud habitat in EGM, the total number of grab samples required was doubled, under the assumption that half of the site could be composed of muddy sediments (O'Connor 2016), to give a total of 156 grab samples required to account for both sand and mud habitats. 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 was employed to deliver an even spatial distribution of grab sampling stations across the site (Figure 2), providing for distribution of features to be accurately evaluated. 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).

Camera sledge transects were carried out at a subset of grab sampling stations to sample epifauna associated with the offshore deep-sea muds feature (Figure 2). Camera station selection was based on the following rationale:

- sea pens are a key feature of the offshore deep-sea mud feature, so stations where sea pens were found in grab samples were selected for camera operations;
- following this, a preliminary review of grab samples collected at EGM during the 1515S survey suggested a potentially greater extent of offshore deep-sea muds, with all sampled stations containing some potentially muddy sediments. Stratification by sediment type was therefore not feasible, and camera station selection was randomised within the 156 grab stations to reduce station selection bias;
- the number of camera sledge transects carried out was thus determined by both the number of grab samples collected containing sea pens and the time available following completion of grabbing operations.

In total, 57 camera sledge transects, each approximately 300m in length, were completed during the survey (Figure 2).

More detailed information on survey design is available in the Cruise Report (O'Connor 2016).

Figure 2: Map of sampling strategy for survey 1515S to East of Gannet and Montrose Fields MPA (2015).

2.2 Data acquisition and processing

2.2.1 Sediment and infaunal samples

Sediment samples were successfully collected from 156 stations using a 0.25m^2 large Hamon grab and processed onboard the vessel according to the methods described in the 1515S Cruise Report (O'Connor 2016).

Grab samples were subsampled for Particle Size Analysis (PSA) prior to sieving. PSA was conducted for 155 sediment samples by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) in accordance with NMBAQC standards (Mason 2011). For one subsample (sample 'EGM011 007 6077') there was no PSA analysis.

Following the collection of the PSA subsamples, the remaining Hamon grab contents were sieved over a 1mm mesh to retain the infauna. A total of 156 infaunal 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. (Thomson Unicomarine 2016), the infaunal report is provided alongside this report (Appendix 22). Infaunal sample "EGM011 007 6077" was removed from further analysis due to the lack of a corresponding PSA sample, and therefore 155 infaunal samples were used in the subsequent 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 for these specimens were added to the infaunal data matrix prior to truncation of the data (see 2.3.1).

2.2.2 Seabed imagery and epifaunal samples

Fifty-eight camera sledge transects, approximately 300m in length, across fifty-seven stations[1] were undertaken to collect video and still imagery data which resulted in 622 still images of which 611[2] were examined for habitat information, and 607 for epifauna. The midpoint of each camera sledge transect was as close as was feasible to the corresponding grab sample location (i.e. given sea and weather conditions at time of camera sledge deployment).

The imagery data were collected in accordance with MESH guidelines (Coggan *et al*. 2007), analysed by Envision Mapping Ltd. and subjected to Envision Mapping Ltd. internal quality assurance (QA). This QA was applied to six video tows and 66 associated stills (Envision Mapping Ltd. 2016), equating to >10% of the initial video and stills analyses. A summary of the acquired video and stills data is given in Table 3.

[1] The total number of video tows in the survey was 58, however, this includes parts one and two of the same station. "1515S_EGM130_S233_S1" and "1515S_EGM130_S233_S2". An analysis of the GIS data of these tows confirms that the total distance of the two 'halves' comes to the intended distance of ~300m. Therefore, the EGM130 station videos are treated as one tow in all analyses.

[2] Of the 622 still images provided to the contractor, 10 were excluded due to the absence of complementary PSA samples (n=10) or lacking metadata (n=1). Those of which were found to be of 'zero' quality for scoring, due to the image being in compete darkness, or positioning of the camera system preventing a view of the substrate (n=4) were excluded from epifaunal interpretation (Envision Mapping Ltd 2016).

2.3 Data preparation and analysis

2.3.1 Particle size analysis (PSA)

Sediment samples collected at EGM 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.

2.3.1 Data truncation

Prior to any analysis, the infaunal and epifaunal datasets were examined and truncated to ensure subsequent analyses were robust and any erroneous entries, including records of juveniles and mobile species, were removed. Full details of the truncation protocol for infauna and epifauna are available in Appendix 3 and Appendix 4.

2.3.2 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. A total of 287 species were identified from the 155 grab samples, which contained a total of 27,279 individuals. Infauna were counted for abundance, numerically, rather than presented as a scale, e.g. SACFOR scale[3].

2.3.3 Epifaunal data preparation

Fifty-eight videos from 57 stations within EGM were analysed and faunal counts and SACFOR scores were derived for all taxa observed, including the three species of sea pen *Pennatula phosphorea, Virgularia mirabilis* and *Funiculina quadrangularis*. Evidence of anthropogenic disturbances such as trawl scars, fishing gears and litter was also documented at each station.

The epifaunal dataset was checked to ensure consistent nomenclature using the WoRMS taxon match tool. Discrepancies were resolved using expert judgement following the truncation of the data. In the still imagery a total of 28 taxa were identified, post-truncation. Of these, only 19 were found to occur in in more than five of the total 607 images, with many of the remaining taxa at low taxonomic resolution, e.g. ‘Decapoda’, ‘Echinoidea’. Due to the sparse nature of the stills data and low resolution it was decided not to undertake multivariate analysis of the stills data. The video and stills data were therefore analysed for the following parameters:

- to identify habitat;
- to provide an estimation of sea pen relative abundance; and
- to provide an estimation of megafaunal burrow relative abundance.

Video tow data were analysed for the frequency of megafaunal burrows following standard methods typically used for underwater television surveys (UWTV) to assess *Nephrops*

[3] 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).

populations in UK and Irish waters (ICES 2007). Two segments of all video tows (each representing 10% of the total tows) were selected for a second count to ensure data quality assurance.

Estimates of relative abundance (per m) of three species of sea pen, *P. phosphorea, V. mirabilis* and *F. quadrangularis*, and of megafaunal burrows were calculated using counts within the field of view from video data. As the towed video camera footage lacked a 'laser gate' (lasers oriented to give a fixed field of view) the relative abundance of sea pen species was calculated by obtaining the 'true' length of the video tows undertaken, taking the recorded start and end points of the video tow, and the position of stills taken within the tow, to give an accurate calculation of length, corrected for lateral movement of the towed camera. The total count for each sea pen species per tow was then divided by the 'true' length of the tow to give a 'count per metre', or relative abundance (ratio of sea pen abundance relative to transect length). Relative abundances were mapped to give a better understanding of sea pen distribution. This rationale was similarly implemented for megafaunal burrows.

2.3.4 Non-indigenous species (NIS)

The raw (WoRMs corrected) infaunal and epifaunal taxon lists generated from the infaunal samples and seabed imagery data 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 5.

2.3.5 Statistical analyses

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

Infaunal multivariate analysis

From infaunal taxa abundance data summary statistics and univariate indices of community structure were calculated, generating 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 downweight the influence of any dominant taxa and allow variation in less abundant species to be detectable. Bray-Curtis similarity resemblance matrices were generated employing the transformed data and between each pairing of the 155 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 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. Clusters which should no multivariate structure beyond random permutation were not interpreted further;
- 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, sediment type, latitude and longitude) 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 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 EGM from PSA samples acquired in the 1515S survey (A5.2 Sublittoral sand, A5.3 Sublittoral mud, and A5.4 Sublittoral mixed sediment). This analysis should distinguish ecologically the identified infaunal groups, after the identification of statistically distinct groups by multivariate analysis.

Epifaunal multivariate analysis

Multivariate analysis was attempted using stills data acquired during the 58 video tows. In total, 607 stills were analysed. Epifaunal taxa abundance data reported in the SACFOR scale (post-truncation) were imported into PRIMER (v7) (Clarke & Gorley 2015) to calculate univariate indices of community structure. In order to allow for comparison of abundance, the SACFOR scale was converted to a numeric scale with “6” assigned to “S”, and so on until “1” was assigned to “R”; taxa without records were denoted as “0”. Total abundance per sample, total number of species per sample (species richness), Margalef Index, and Shannon Index were calculated for the epifauna. Further analysis was not conducted on the data, as the epifauna were too sparse, and attempts to define any indication of community structure using nMDS and hierarchical clustering with SIMPROF showed the data to be unsuitable for multivariate analysis.

The abundance counts of the three sea pen species at the site were analysed. Prior to multivariate analysis, the dataset was visually examined using shade plots before being fourth-root transformed to downweight the influence of dominant sea pen species and detect variation in less abundant species. Bray-Curtis similarity resemblance matrices were generated employing the transformed data, between each pairing of the 57 sampled stations. Following this, nMDS was used to explore the relationships between the samples, and then a hierarchical clustering alongside SIMPROF in order to determine a structure to the data beyond random permutation. SIMPER was run on the data to assess the contribution of each sea pen species to the groupings. The groups were then analysed with respect to all of the EUNIS sedimentary habitats identified as present within EGM (A5.2, A5.3 and A5.4) to see if there was a relationship between sea pen composition and sedimentary habitat.

2.3.6 Biotope assignment

Biotopes were assigned on the basis of the infaunal and epifaunal community structure, separately, using the resultant community groups identified from SIMPER analysis, or in the case of epifauna, an investigation of the species identified from each stations and visual assessment of the associated sedimentary habitats, from PSA and depth sampled from the EGM site. 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 (PSA)

PSA results from 155 successful large (0.25m^2) Hamon grabs indicate the presence of three EUNIS BSH at the site: Sublittoral sand (A5.2), Sublittoral mud (A5.3) and Sublittoral mixed sediments (A5.4) (Table 3, Figure 4).

Table 3: Number of grabs, video tows and stills taken in three identified sedimentary broadscale habitats, advised from the PSA results, and the percentages of each habitat per sampling method. All samples from survey 1515S to East of Gannet and Montrose Fields MPA (2015).

Broadscale Habitat (EUNIS Code)	Grab – PSA and Infauna	Grab – PSA only	Video	Stills
A5.2 Sublittoral sand	72 (46.2%)	72 (46.5%)	31 (54.4%)	343 (55.1%)
A5.3 Sublittoral mud	74 (47.4%)	74 (47.7%)	21 (36.8%)	225 (36.2%)
A5.4 Sublittoral mixed sediments	9 (5.8%)	9 (5.8%)	4[4] (7.0%)	44 (7.1%)
Undefined[5] samples not suitable for analysis	1 (0.6%)	0 (0.0%)	1 (1.8%)	10 (1.6%)
Totals	156	155	58	622

The percentage constituents of gravel, sand and fines for each sedimentary habitat from the EGM grab samples is shown in Figure 3.

[4] Note that this habitat type includes parts one and two of the video tow, 1515S_EGM_130_S233, and treated here as one tow.
[5] Note that this records the absence of data from 1515S_EGM011_S209_S1, which lacked PSA data and therefore was removed from community analysis. The number of stills reflects the number of individual stills taken as part of the video tow for the station.

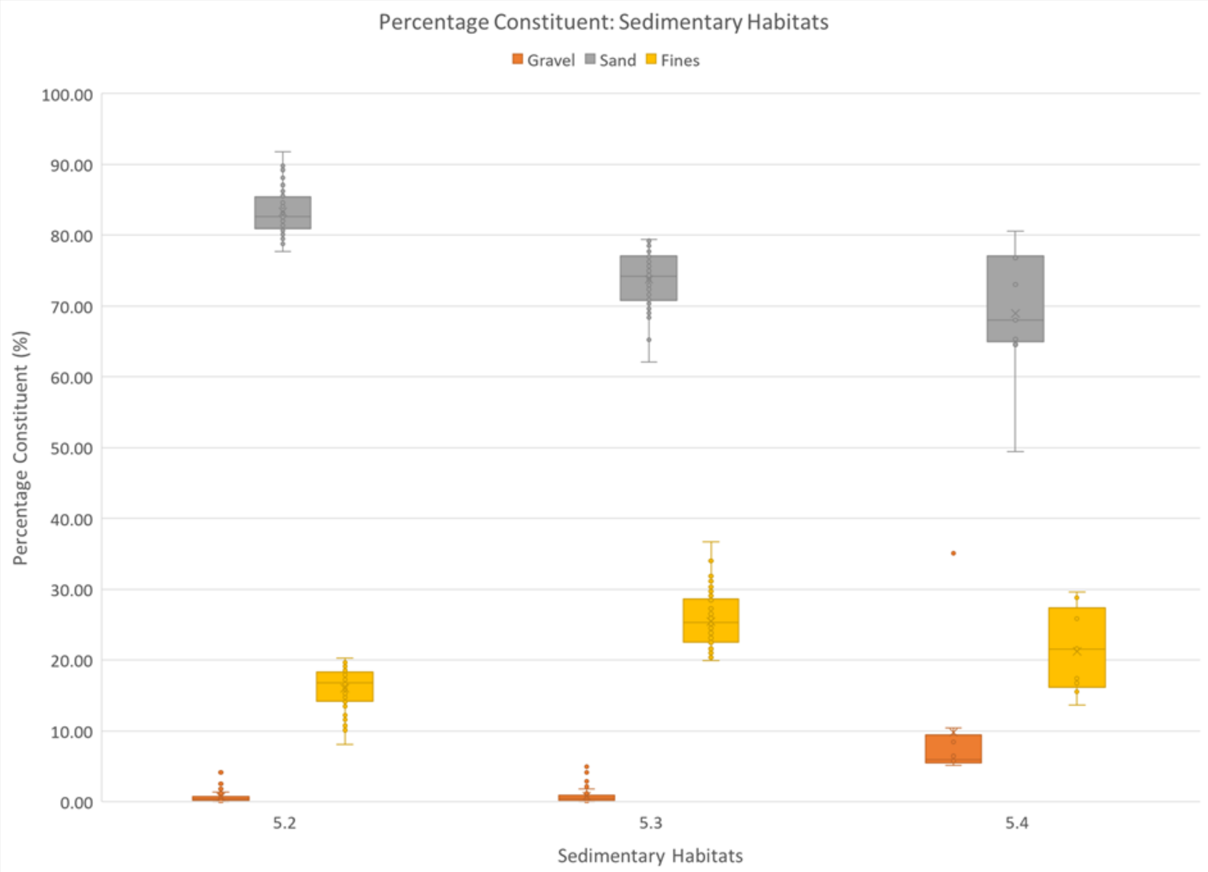

Figure 3: Percentage constituents of each of the identified sedimentary habitats obtained from 155 grab samples in A5.2 (n=72), A5.3 (n=74) and A5.4 (n=9). Boxes represent median and upper and lower quartile values, and whiskers represent the highest and lowest observed values in each category. All samples from survey 1515S to East of Gannet and Montrose Fields MPA (2015).

Further analysis using GRADISTAT revealed the samples to be composed primarily of muddy sand, slightly gravelly muddy sand, gravelly muddy sand and sand (Figure 5 and Appendix 6 - Appendix 10). There is a clear pattern in the spatial distribution of the substrates (Figure 6 and Figure 7), with Sublittoral mud (A5.3) samples being most commonly found in the east and south east areas of the site, Sublittoral sands (A5.2) dominating the west and north west of the site with Sublittoral mixed sediment (A5.4) in a sparsely transitioning between them (Figure 6). The divergence of the results of the 1515S survey from previous habitat information (Figure 1) has required an update in the habitat map for the site, presented above (Figure 4), and in all supporting figures throughout the report. The procedures used in the analysis are detailed in the British Geological Survey (BGS) reports (Marchant 2019), published with this report (Appendix 23).

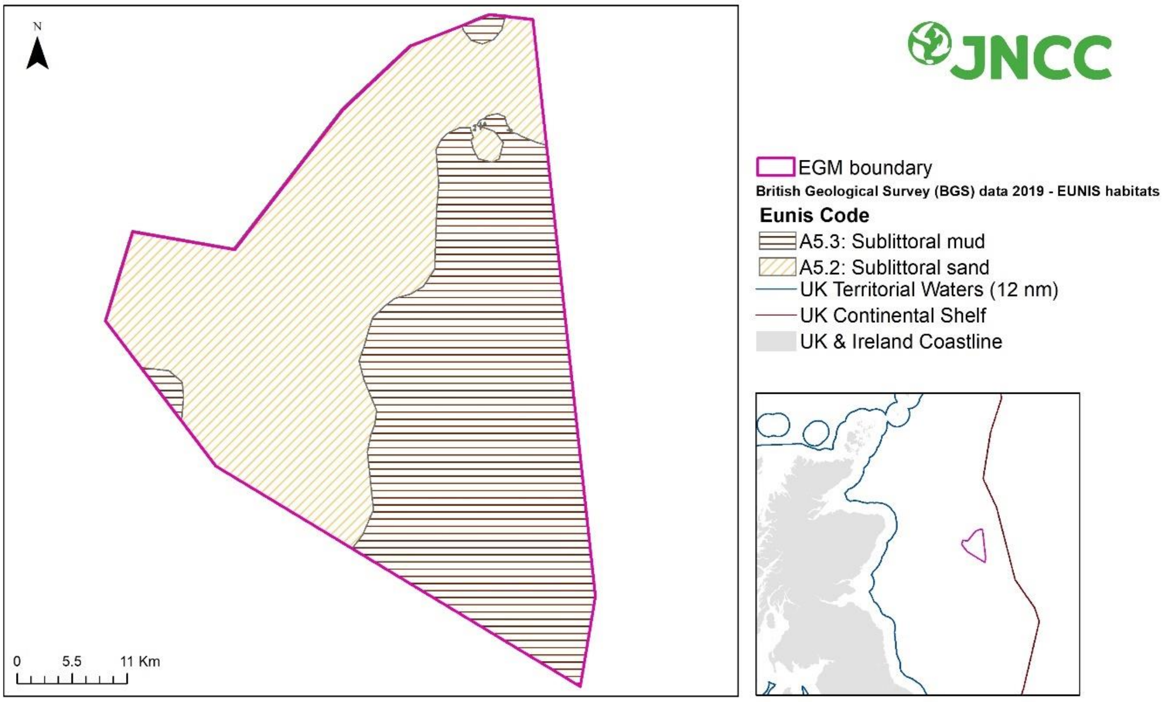

Figure 4: Overview map of the East of Gannet and Montrose Fields MPA site, with updated habitat mapping data acquired from grab sampling data from the 1515S survey of East of Gannet and Montrose Fields MPA (2015) (Marchant 2019). A regional view inset map shows the location of the MPA boundary.

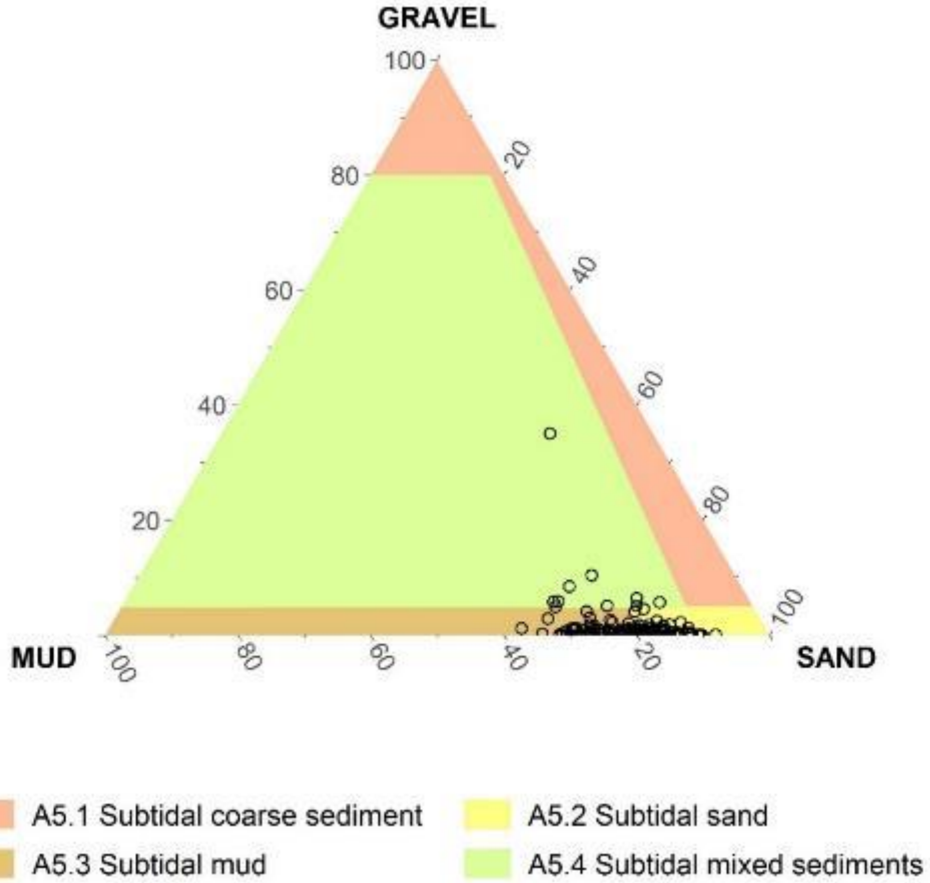

Figure 5: Classification of particle size distribution (half phi) for each sampling point (closed black circles) plotted on a true scale subdivision of the Folk triangle. The proportion of gravel, sands and muds is depicted, with the corresponding EUNIS sedimentary habitats indicated by colour. All samples from survey 1515S to East of Gannet and Montrose Fields MPA (2015).

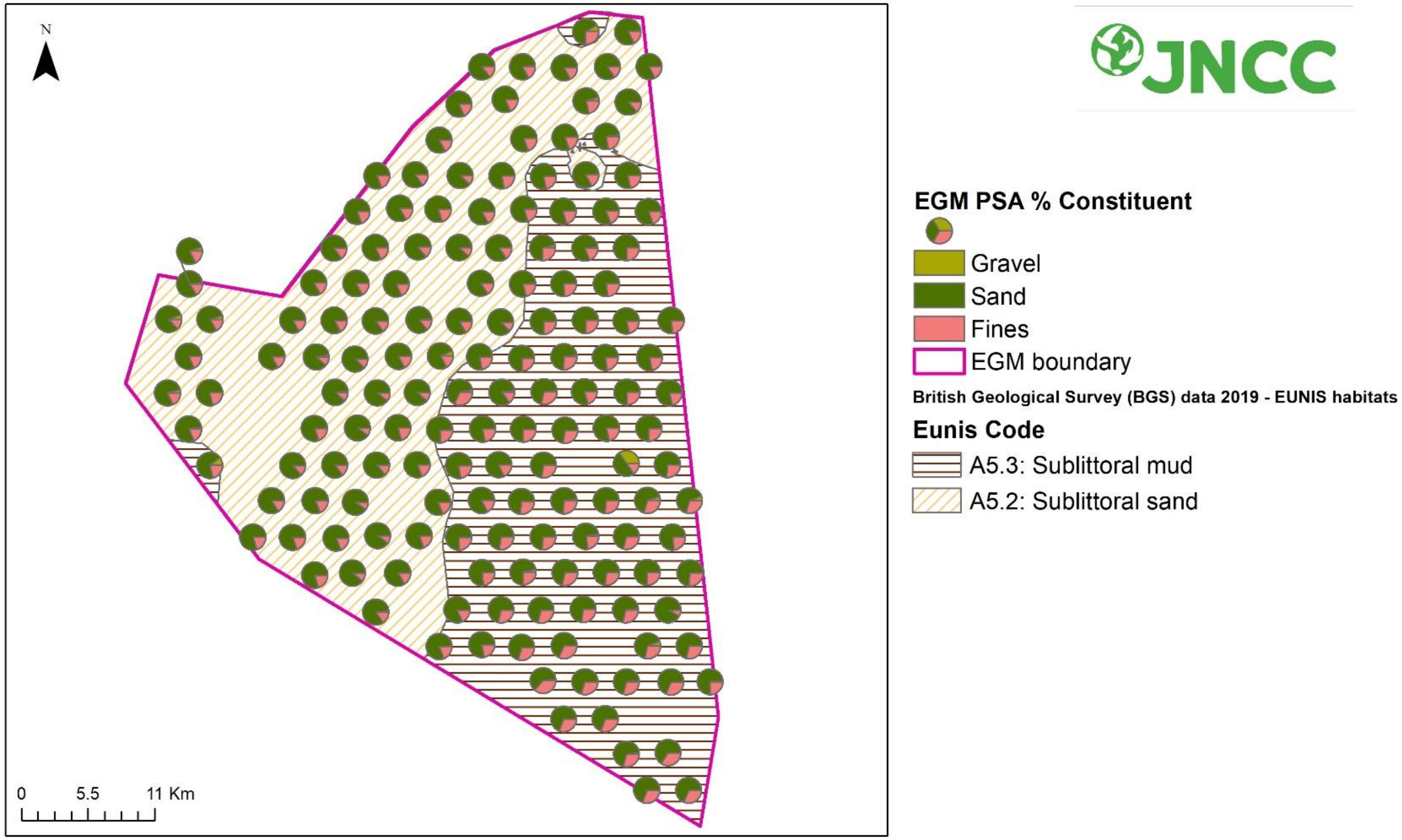

Figure 6: Spatial distribution of particle size groups (percentage of gravel, sand, and fines). All samples from survey 1515S to East of Gannet and Montrose Fields MPA (2015).

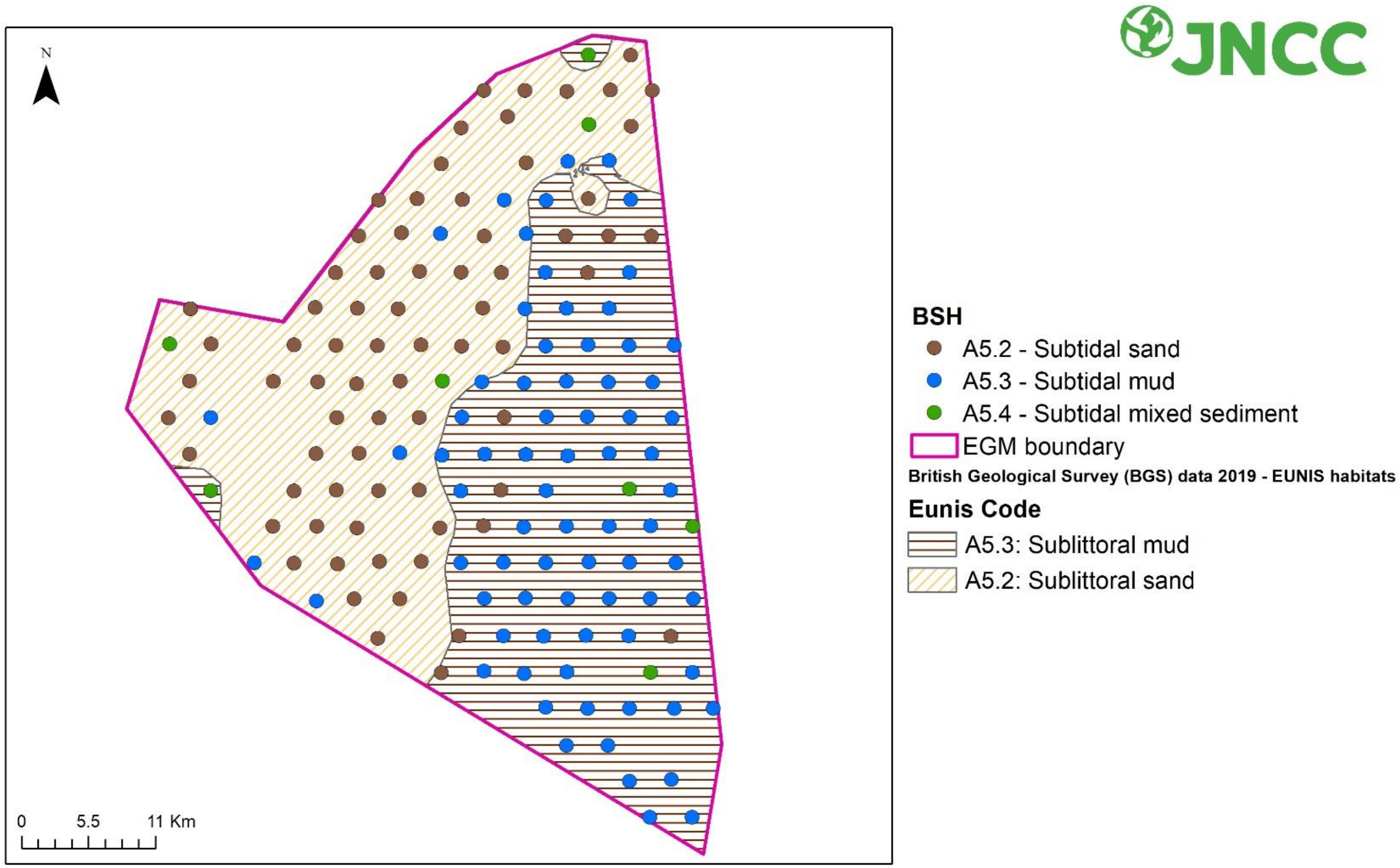

Figure 7: Distribution of EUNIS sedimentary habitats based on particle size analysis from survey 1515S to East of Gannet and Montrose Fields MPA (2015). Underlaid is the predictive map of habitats, indicating the difference between predicted and sampled habitat extents.

3.1.2 Offshore deep-sea muds and supporting habitat for ocean quahog colonisation (sands and gravels)

The PSA of the grab samples at the EGM site show the presence of A5.3 Sublittoral mud in 74 of the sampled 155 stations (Table 3), which can be equated to the presence of deep-sea mud as defined by Tyler-Walters *et al.* ((2016) and Section 1.2.3). In terms of sands and gravels designated to support ocean quahog colonisation, A5.2 Sublittoral sand was sampled in 72 and A5.4 Sublittoral mixed sediments were sampled in 9 of the 155 grab-sampled stations (Table 3, Figure 7).

The results from the imagery analysis, as undertaken and interpreted by the contractor Envision Mapping Ltd., show the presence of A5.3 Sublittoral mud in 609 of the total 622 still images and 55 of the total 58 video tows (Table 4) (Benson & Sotheran 2016). The presence of mud has been identified as the PMF 'burrowed mud' in 511 of the stills and all of the video tows (58) (Table 4). In terms of supporting habitats for ocean quahog colonisation (sands and gravels), A5.4 Sublittoral mixed sediments in 12 of the still images and 3 of the video tows. Identification of the PMF sea pens and burrowing megafauna in circalittoral fine mud, will be discussed further below in Section 3.5..

Particle size analysis and interpretation from the imagery analysis show that the offshore deep-sea muds feature is more widespread than previously indicated in predictive mapping (Figure 7). Sands are widespread across the north and north-west of EGM, providing an extensive area to support ocean quahog (Figure 7); this is discussed further in Section 3.4.

Table 4: The observed habitats and biotopes identified from video and stills analysis by the contractor, and the number of stills and video tows in which the habitats were identified, given in brackets. All samples from survey 1515S to East of Gannet and Montrose Fields MPA (2015).

Sample type	Broadscale Habitat (EUNIS Code)	Detailed EUNIS codes	Priority Marine Features
Stills (n = 622)	A5.3 Sublittoral mud (609)	A5.354 *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud. (3)	Burrowed mud (511)
		A5.35 Circalittoral sandy mud (595)	
		A5.361 Sea pens and burrowing megafauna in circalittoral fine mud (11)	
	A5.4 Sublittoral mixed sediments (12)	A5.44 Circalittoral mixed sediments (12)	
Blanks in category	1	1	111
Video (n = 58)	A5.3 Sublittoral mud (55)	A5.35 Circalittoral sandy mud (40)	Burrowed mud (58)
		A5.361 Sea pens and burrowing megafauna in circalittoral fine mud (15)	
	A5.4 Sublittoral mixed sediments (3)	A5.44 Circalittoral mixed sediments (3)	
Blanks in category	0	0	0

3.2 Infaunal community analysis

The grab sampling from the 1515S survey of EGM obtained a total of 27,279 individuals from 155 stations across the site. Results of the univariate metrics analysis are shown in Table 5.

The Margalef species richness index (d) shows an average of 8.30 and range and variance of 6.63 and 1.55, respectively, indicating that some of the stations had richer communities than others. In terms of species evenness, measured by Pielou's evenness (J'), the maximum and averages between all stations high at 0.93 and 0.83 respectively, which indicates that the distribution of individuals among taxa are even. The average value of 3.10 in Shannon's Diversity among stations indicating a rich, but even, community structure throughout EGM. The Simpson's diversity index, with an average of 0.08 further indicates an even structure.

Results from the univariate analysis of the infauna are displayed in Appendix 11, showing the summary statistics for each of the 155 grab samples.

Table 5: Summary of infaunal diversity indices for each of 155 grab samples. All samples are from survey 1515S (2015) to EGM MPA.

	Minimum	Maximum	Average	Sum	Standard deviation	Variance	Range
Total species (S)	24.00	71.00	43.63	6762.00	8.66	74.94	47.00
Total individuals (N)	62.00	383.00	175.99	27279.00	64.30	4134.54	321.00
Species richness (d)	5.45	12.08	8.30	1285.90	1.24	1.55	6.63
Pielou's evenness (J')	0.67	0.93	0.83	128.25	0.04	0.00	0.26
Shannon diversity (H'(loge))	2.63	3.53	3.10	481.12	0.18	0.03	0.90
Simpson's diversity (Lambda')	0.04	0.20	0.08	12.171	0.02	0.00	0.16

Structure of the infaunal community groups

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

Results of the nMDS ordination (Figure 8) indicate that infaunal samples are clustered together in the middle but more dispersed towards the outside. The 2D stress value (0.16) indicates that the ordination can be interpreted as an accurate representation of the data, which warranted further examination 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 12), with a significant π value of 5.16 (p<0.001) for the difference between the sampled profile structure and 999 randomly permuted profiles. The dendrogram (Figure 9) shows the relationships among infaunal clusters, and the 47% similarity (dashed line) indicates the groupings identified by SIMPROF.

Of these 11 infaunal community groups (labelled a to k) (Figure 8 and Figure 9), three infaunal clusters, groups c, e and j (green squares, yellow-outlined triangles and blue triangles in Figure 8 and Figure 9) include most (~92%) of the samples.

To determine which taxa drive the groupings, an analysis of similarity percentages (SIMPER) was undertaken using 47% similarity. Average similarity within the groups is generally low (Table 6) ranging from 49.17 (Group h) to 58.1 (Group i), and in most cases is due to the abundance of several taxa, such as *Paramphinome jeffreysii, Spiophanes bombyx* and *Scoloplos armiger*, rather than the presence or absence of single species. Of the three groups which represent most of the infaunal clusters, groups c, e and j (representing almost 92% of all infaunal samples, cumulatively (c=16.77%, e=38.71%, j=36.13%)), c and e share the typifying taxon *P. jeffreysii*, which is third highest in group j. Groups c and j share *S. bombyx* and *Amphiura filiformis* within the top five highest percentage contributors to overall similarity, with *A. filiformis* absent from the top five contributors in group e. *Amphiura filiformis* contributes consistently to similarity in multiple groups, indicated in high values of 'Sim/SD' (Table 6), with 8.06, 68.70 and 6.62 in groups c, h and j.

In terms of dissimilarities between these three infaunal groups with regard to community composition (Table 7), e and j are more dissimilar (68.15% dissimilarity), whereas c and e are less dissimilar (54.23%), corresponding with the nMDS plot (Figure 8). The species contributing to the dissimilarities include *Notomastus* sp., *Scoloplos armiger, Amphiura chiajei and Lumbrineris* sp., each contributing over 2% of the dissimilarity. Dissimilarity was driven by the average abundance of each of these species, or by the presence/absence of species, e.g. *A. chiajei* is completely absent from samples of group j. *Scoloplos armiger* was a highly discriminatory species between both c and e and between e and j with an average individual contribution to dissimilarity and standard deviation (Diss./SD) of 2.81 and 3.88 respectively. *Notomastus* sp. is similarly important in dissimilarity between groups e and j (Diss./SD=3.01). In Figure 12 the SIMPROF-generated groups are superimposed on a map of the identified broadscale habitats in EGM. Group e samples are more aligned with mud and finer sediments whereas j (and other cluster groups) are aligned with coarser materials, with c being transitionary (Figure 10).

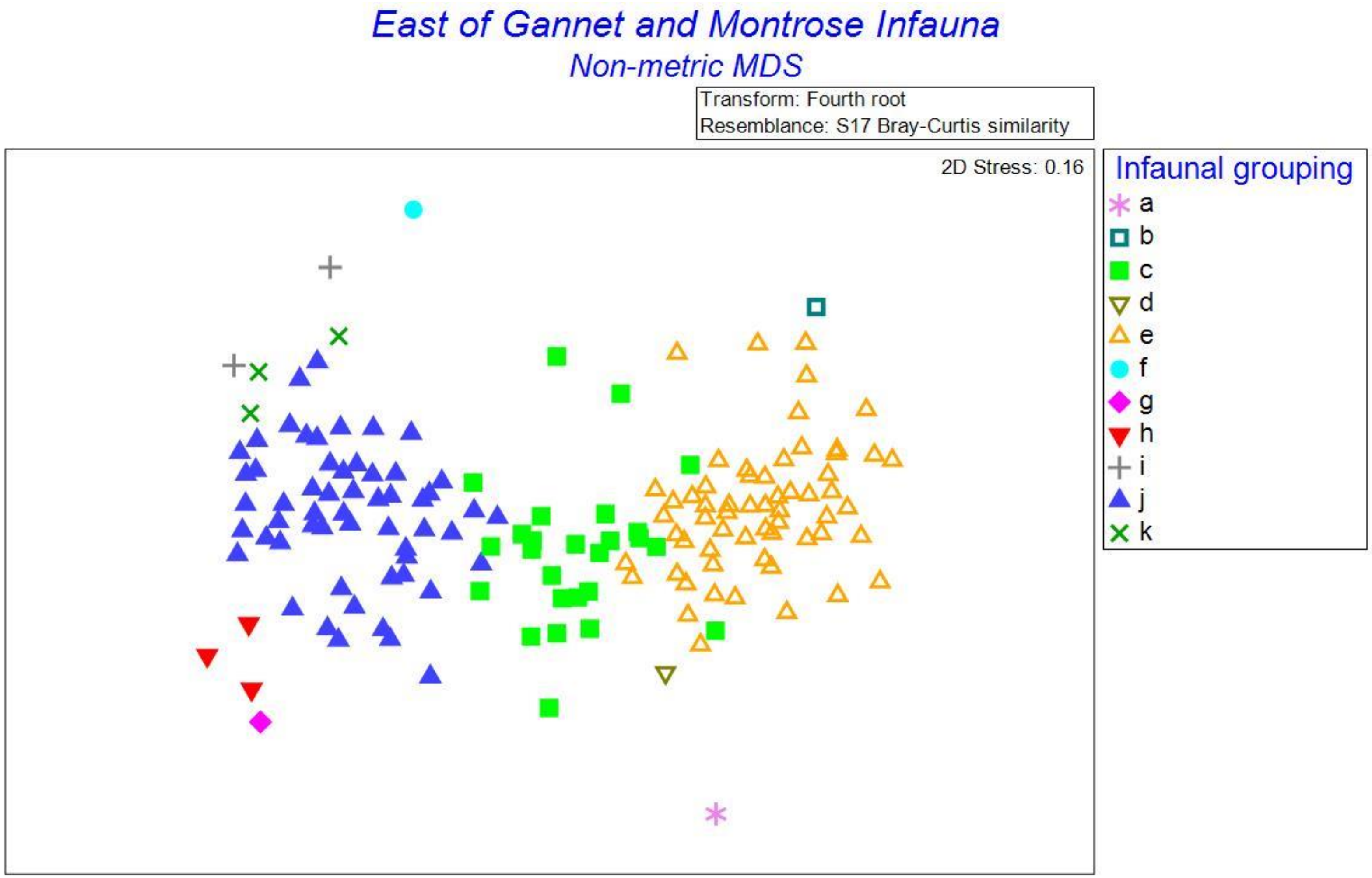

Figure 8: Non-metric multidimensional scaling (nMDS) of fourth-root transformed infaunal data from 155 grab samples taken during survey 1515S to East of Gannet and Montrose Fields MPA (2015). Groups a to k were derived from a SIMPROF analysis with a cut-off level of 47% infaunal cluster similarity.

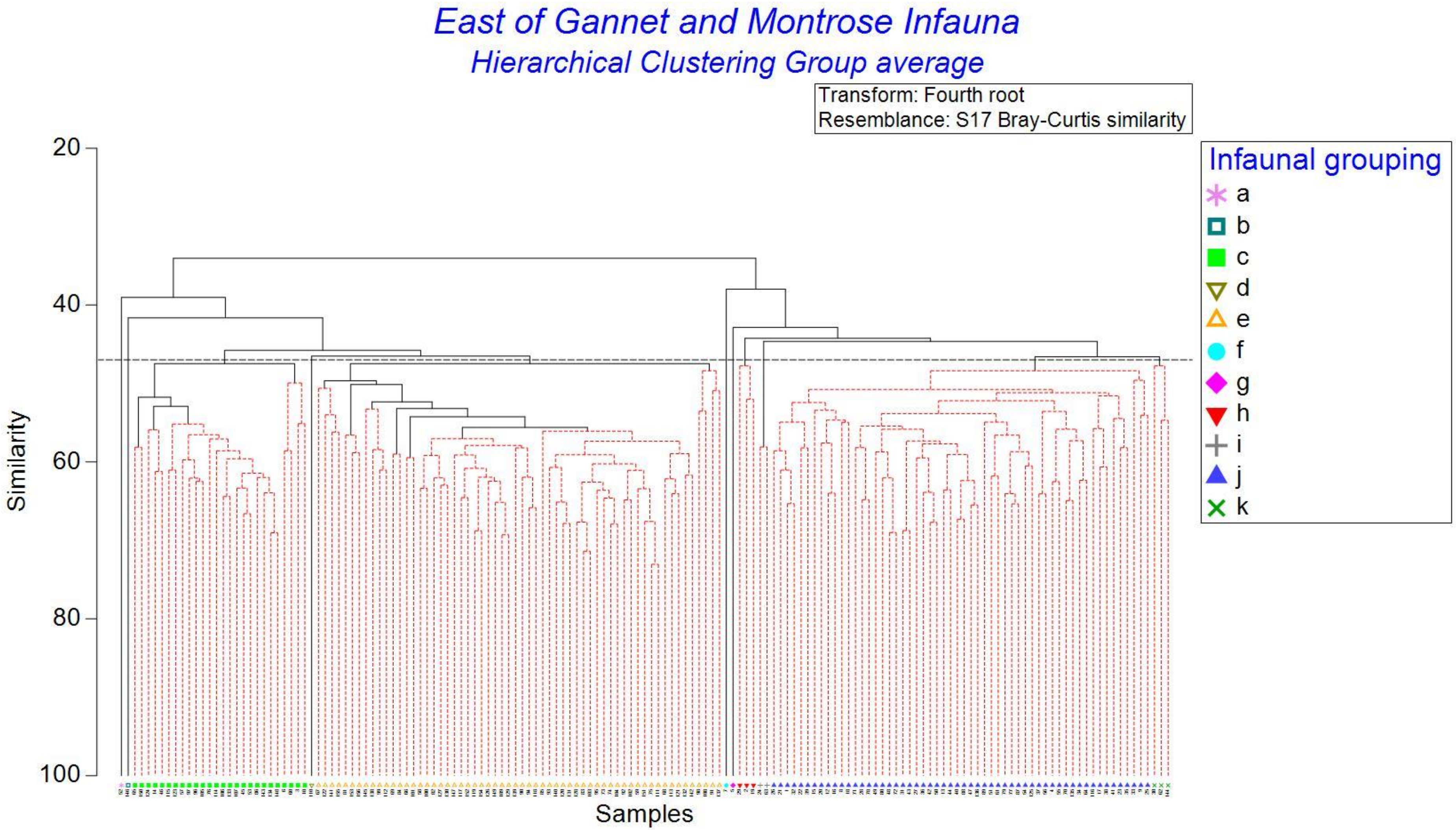

Figure 9: Dendrogram of fourth-root transformed infaunal data from 155 grab samples from survey 1515S to East of Gannet and Montrose Fields MPA (2015). The horizontal dashed line indicates the 47% cut-off in infaunal cluster similarity used to define groups for further SIMPER analysis, producing the 11 distinct infaunal groups shown in the key (a-k). The solid black lines of the hierarchical cluster define significant relationships, whereas the red dashed lines denote unsupported relationships (*p>0.05)*. The correlation of the dendrogram = 0.76869.

Table 6: Results of the SIMPER test at 47% infaunal cluster similarity. The clustering identifies a total of 11 community assemblages, detailing the five species contributing most to average community 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: 53.45					
Taxa	Av. Abun.	Av. Sim.	Sim/SD	Contrib%	Cum%
Paramphinome jeffreysii	2.45	3.31	6.96	6.19	6.19
Spiophanes bombyx	1.98	2.58	5.20	4.83	11.02
Amphiura filiformis	1.80	2.43	8.06	4.54	15.56
Ampharete falcata	1.64	2.10	4.90	3.93	19.49
Ampelisca tenuicornis	1.41	1.91	6.81	3.58	23.07
Group e					
Average similarity: 53.68					
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%	Cum%
Paramphinome jeffreysii	2.29	3.80	7.27	7.07	7.07
***Notomastus* sp.**	1.92	3.17	5.94	5.91	12.98
Spiophanes kroyeri	1.73	2.92	4.36	5.43	18.41
Spiophanes bombyx	1.76	2.85	4.05	5.31	23.72
***Thyasira* sp.**	1.72	2.73	2.32	5.09	28.80
Group h					
Average similarity: 49.17					
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%	Cum%
Amphiura filiformis	1.87	5.26	68.70	10.70	10.70
Spiophanes bombyx	1.54	4.33	19.88	8.81	19.51
Scoloplos armiger	1.66	4.04	19.71	8.22	27.73
Labidoplax buskii	1.39	3.67	7.11	7.46	35.19
Goniada maculata	1.31	3.57	10.07	7.27	42.46
Group i					
Average similarity: 58.10					
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%	Cum.%
Amphiura filiformis	2.11	4.72	n/a	8.13	8.13
Scoloplos armiger	1.78	4.40	n/a	7.57	15.69
Kurtiella bidentata	1.78	4.40	n/a	7.57	23.26
Spiophanes bombyx	1.63	4.13	n/a	7.10	30.36
Paramphinome jeffreysii	1.60	3.97	n/a	6.84	37.20

Table 6 (continued):

Group j					
Average similarity: 52.19					
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%	Cum.%
Amphiura filiformis	2.18	3.99	6.62	7.64	7.64
Spiophanes bombyx	1.98	3.52	6.62	6.74	14.39
Paramphinome jeffreysii	1.97	3.30	4.17	6.32	20.71
Scoloplos armiger	1.76	3.24	7.44	6.20	26.91
Owenia borealis	1.31	2.06	2.11	3.95	30.86
Group k					
Average similarity: 50.06					
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%	Cum.%
Amphiura filiformis	2.30	4.33	10.80	8.65	8.65
Owenia borealis	1.80	3.38	12.36	6.74	15.39
Scoloplos armiger	1.80	3.19	9.02	6.36	21.76
Pectinaria auricoma	1.51	2.63	14.02	5.26	27.01
***Galathowenia* sp.**	1.38	2.58	13.20	5.16	32.18

Table 7: The dissimilarity between infaunal community groups c, e, and j, from the SIMPER cluster analysis, at a 47% 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 compared	Average dissimilarity (%)	Primary contributing species	Diss./SD	% Contribution to average dissimilarity
c, e	54.23	*Scoloplos armiger*	2.81	2.01
		Amphiura chiajei	1.69	1.79
		Owenia borealis	1.69	1.68
		Amphiura filiformis	1.36	1.58
		Ampharete falcata	1.35	1.47
c, j	56.95	*Notomastus* sp.	1.73	1.74
		Lumbrineris sp.	2.06	1.64
		Praxillella affinis	1.65	1.59
		Gnathia spp. (incl. *G. oxyuraea*)	1.79	1.54
		Urothoe elegans	1.67	1.53
e, j	68.15	*Notomastus* sp.	3.01	2.38
		Scoloplos armiger	3.88	2.28
		Amphiura chiajei	2.88	2.17
		Lumbrineris sp.	3.03	2.09
		Amphiura filiformis	1.68	1.94

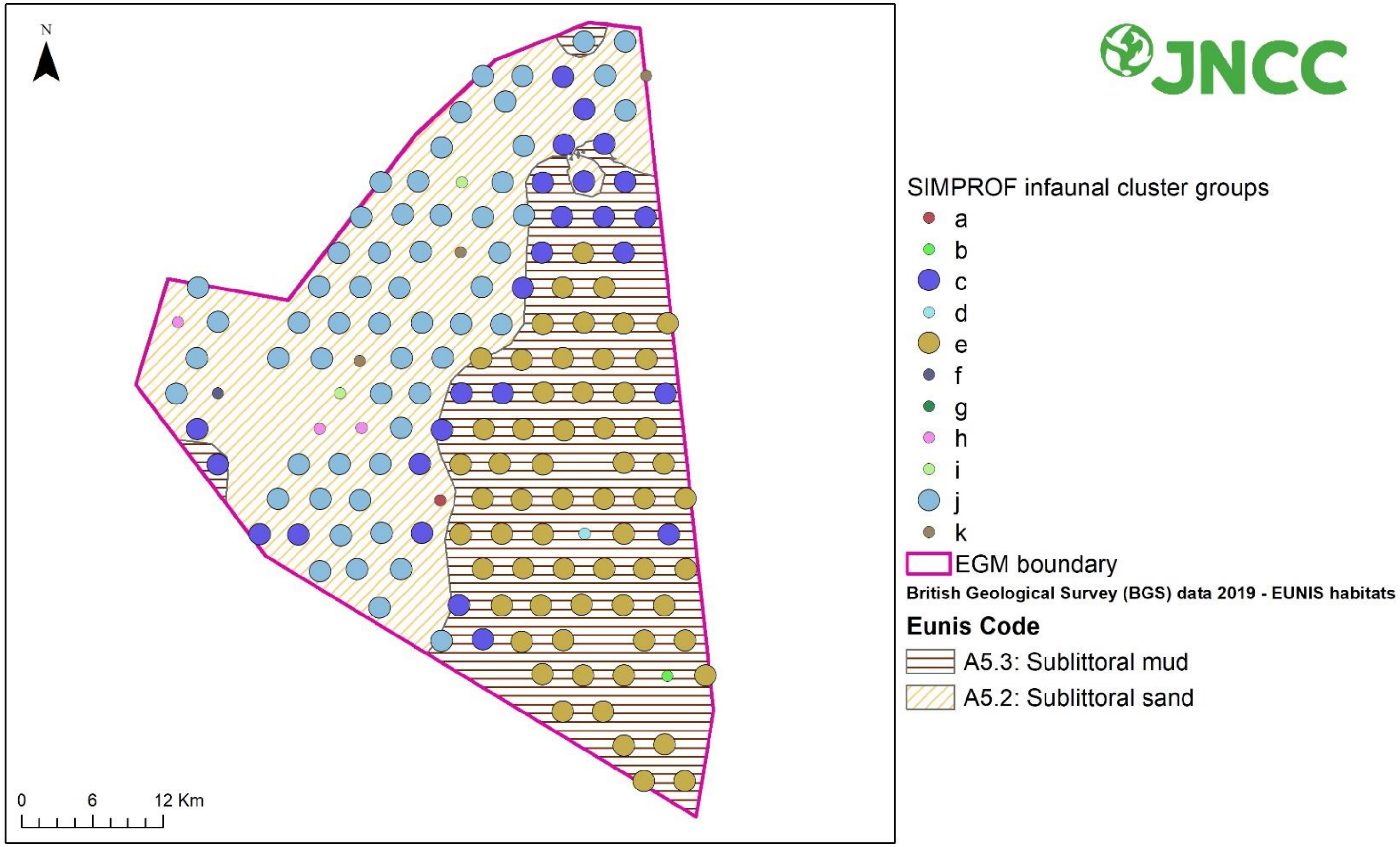

Figure 10: SIMPROF groups (cut off level at 47% similarity) superimposed on distribution of broadscale habitats identified for East of Gannet and Montrose Fields MPA. Infaunal data were fourth-root transformed and derived from 155 grab samples taken during survey 1515S of EGM (2015). The symbols for groups c, e and j have been projected larger, as they represent 92% all samples.

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 13. The combination of environmental variables best explaining the observed infaunal patterns was percentage of fines (Fi) and water depth (Wa), with a correlation (Rho) value of 0.606. This was the highest correlation for any combination of the four variables. The strongest correlation with a single variable was with percentage of fine sediment, with a value of 0.555 (Table 8).

Table 8: 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. Data derived from 155 grab samples taken during survey 1515S to East of Gannet and Montrose Fields MPA (2015).

BEST results: Infaunal Resemblance (samples unclustered)		
Number of variables	**Corr. (Rho)**	**Selections**
1	0.555	Fi
2	**0.606**	Fi, Wa
3	0.594	Sa, Fi, Wa
4	0.545	Gr, Sa, Fi, Wa

The variables percentage of fines and water depth were further interpreted and added to the nMDS of the infaunal community clusters for visual investigation (Figure 11, Figure 12). Infaunal cluster group e tends to associate with finer and deeper sediment (indicated by larger bubble plots for ‘percentage of fine sediment’ and ‘water depth’) when compared to groups j and c, and the majority of other infaunal cluster groups. For dissimilarities between groups e and j specifically, see Table 7, Table 8, and Appendix 14. A correlation between these species and the percentage of fine sediment and water depth revealed that they are positively or negatively correlated with the environmental variables (Table 9). Additionally, when the R value for water depth is positive for the species, it is also positive for percentage of fines, which supports the high correlation between the two variables (78.29%) (Appendix 13).

Table 9: Pearson’s R correlation coefficient values for each species contributing most to the dissimilarity of infaunal groups e and j, and the environmental variables which best explain the observed patterns in infaunal community composition, i.e. water depth and percentage of fine sediment.

Variable	*Notomastus* sp. (R value)	*Amphiura chiajei* (R value)	*Amphiura filiformis* (R value)	*Scoloplos armiger* (R value)	*Lumbrineris* (R value)
Water Depth (m)	0.515	0.674	-0.615	-0.527	0.582
Percentage of Fines (%)	0.508	0.719	-0.655	-0.604	0.589

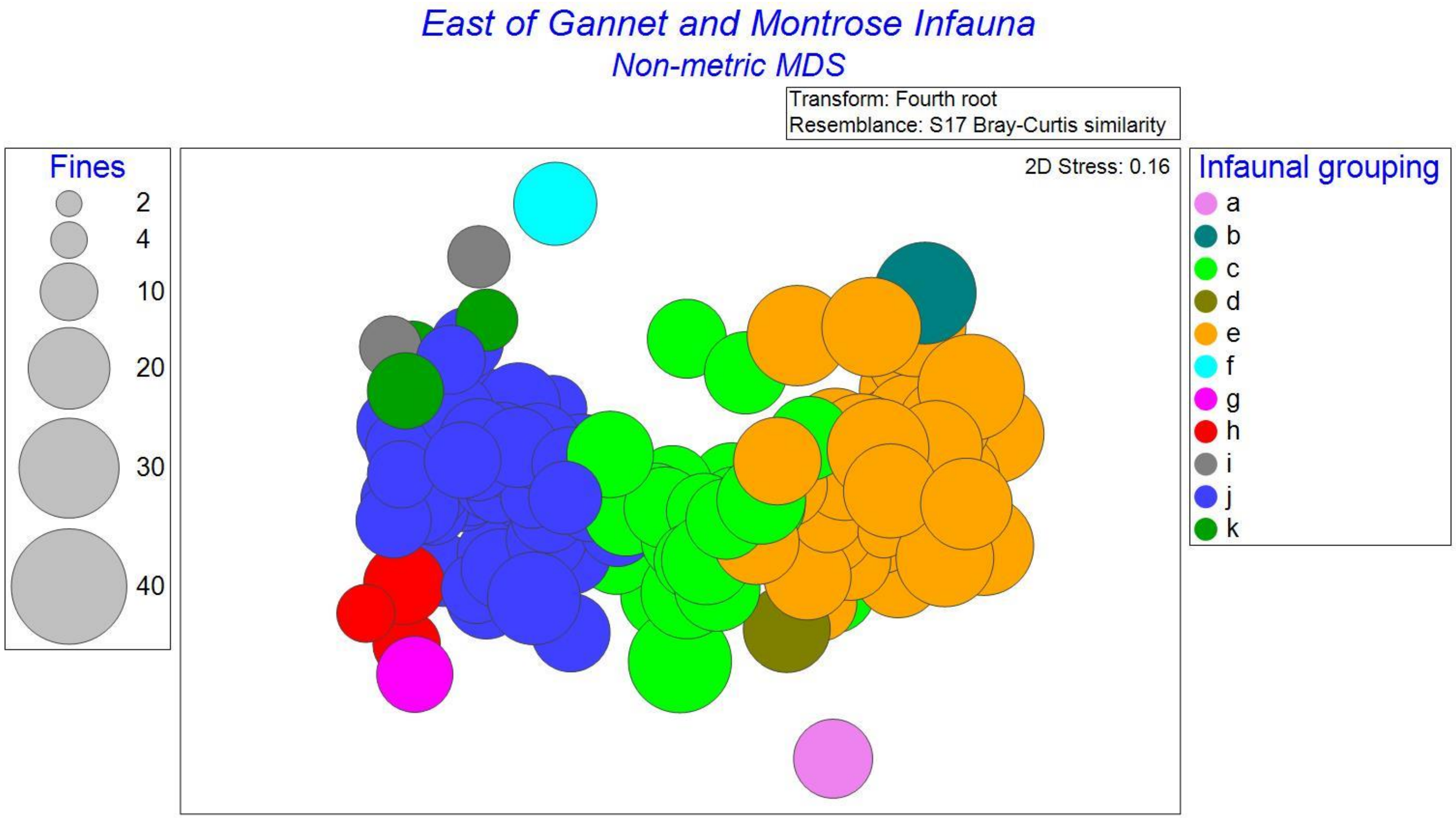

Figure 11: Non-metric multidimensional scaling (nMDS) of fourth-root transformed infaunal data from 155 grab samples taken during survey 1515S to East of Gannet and Montrose Fields MPA (2015). Groups a to k were derived from a SIMPROF analyses at a cut-off level of 47% infaunal cluster similarity. The overlain bubble plot shows the distribution of percentage of fine sediment (maximum of 40%) in the samples.

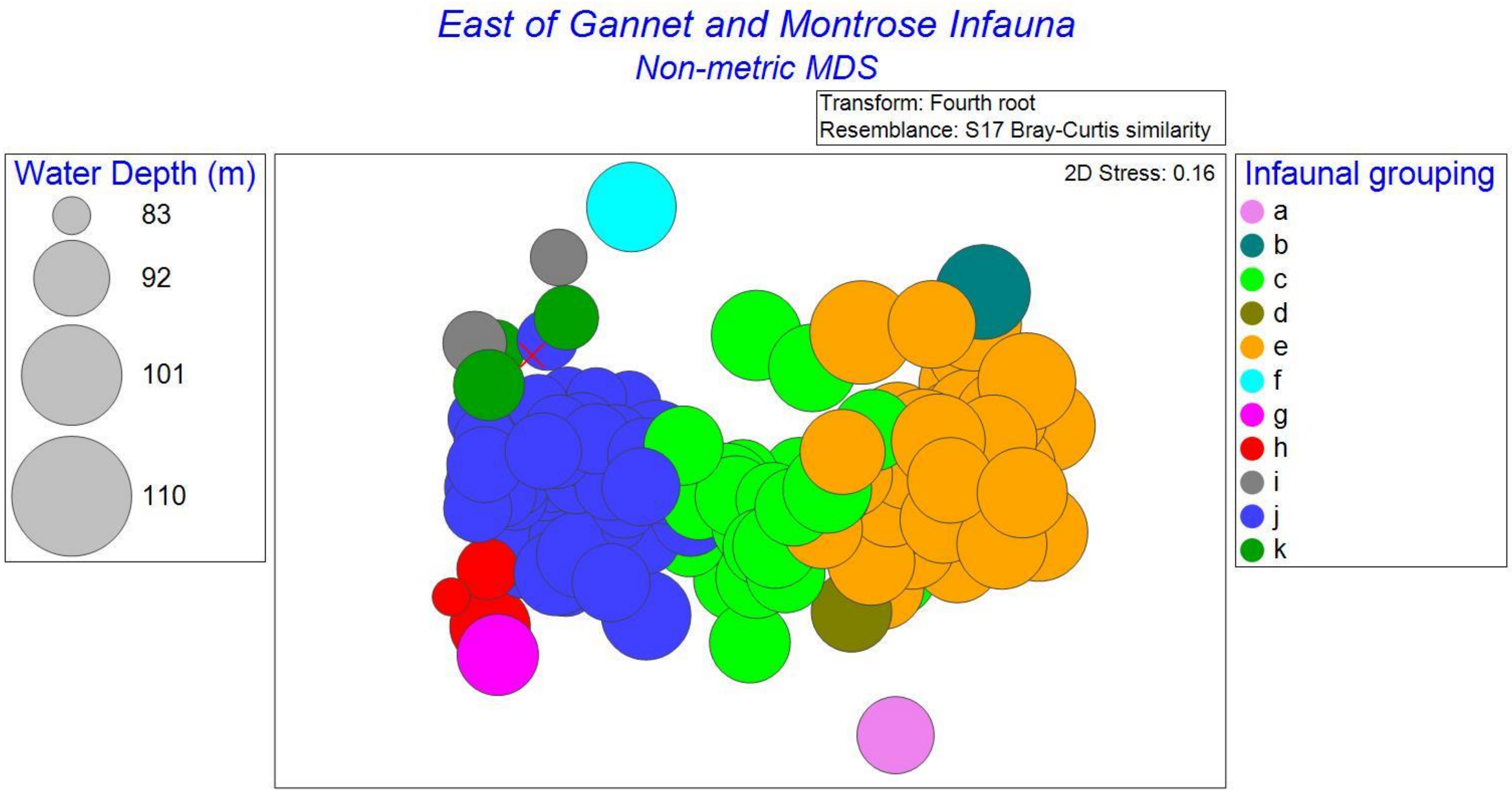

Figure 12: Non-metric multidimensional scaling (nMDS) of fourth-root transformed infaunal data from 155 grab samples taken during survey 1515S to East of Gannet and Montrose Fields MPA (2015). Groups a to k were derived from a SIMPROF analyses at a cut off level of 47% infaunal cluster similarity. The overlaid bubble plot shows the distribution of water depth, maximum 110m depth.

Relationship of the infaunal community within sedimentary habitats

The results of the infaunal analysis from 155 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.

The nMDS ordination of infaunal assemblages from hierarchical clustering and SIMPROF testing, overlaid with the corresponding EUNIS level 3 habitat for each sample, shows some overlap in the 2D nMDS (Figure 13). 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 and A5.3 Sublittoral mud are the most representative for the samples, reflective of their distribution throughout the site and frequency of samples, as indicated above (Table 3, Figure 6, Figure 7).

Further analysis of the 47% SIMPROF groups shows that these infaunal assemblages are aligned with the sediment classifications identified in EGM (Figure 14) which are not highly distinctive. On the nMDS (Figure 13), groups a, h, i, j and k correspond with the EUNIS habitat classification of Sublittoral sand (A5.2). The habitat 'Sublittoral mixed sediments' (A5.4) shows only some limited alignment with group c and is more strongly associated with groups g and h, being distributed across the whole nMDS plot. Groups b, d, e, and f mainly occur in Sublittoral mud (A5.3). The PCA enforces that % sand and % fines are driving the patterns in the infaunal community composition observed (Figure 13). The distribution of groups with EUNIS level 3 habitat types is further illustrated in Figure 14, in which it can be seen that some sample groups occur entirely within one sedimentary habitat (e.g. groups a, b, d, f, g, i and k) although it should be noted sample numbers in these groups are consistently low ($n \leq 3$).

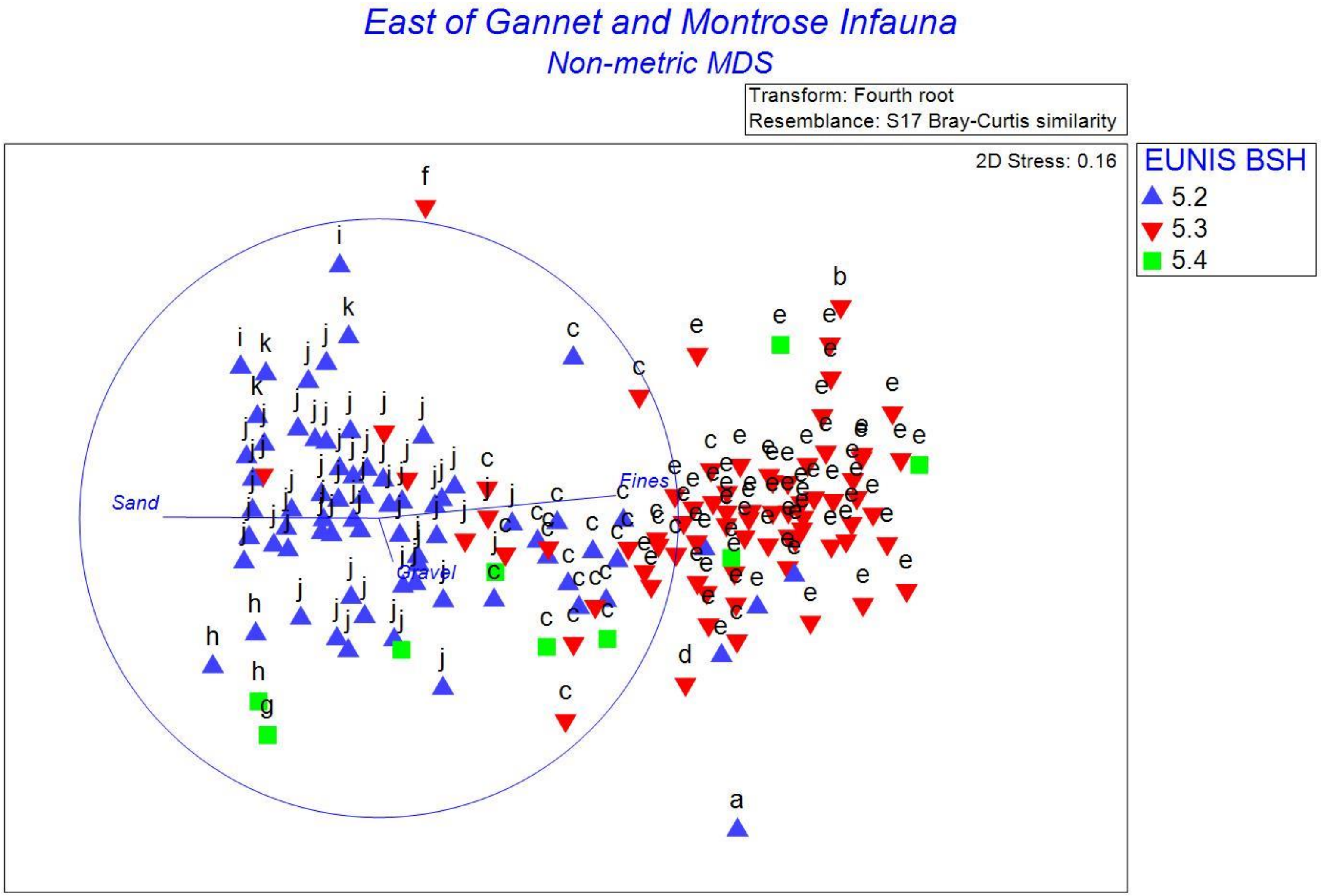

Figure 13: Non-metric multidimensional scaling (nMDS) of infaunal fourth-root transformed abundance data with the EUNIS habitats indicated (see key). The principal component analysis (PCA) of percentage composition of fines, sand and gravel is also overlaid. The infaunal cluster groups, as identified through SIMPROF analysis, are labelled above each symbol. All data are derived from 155 grab samples taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

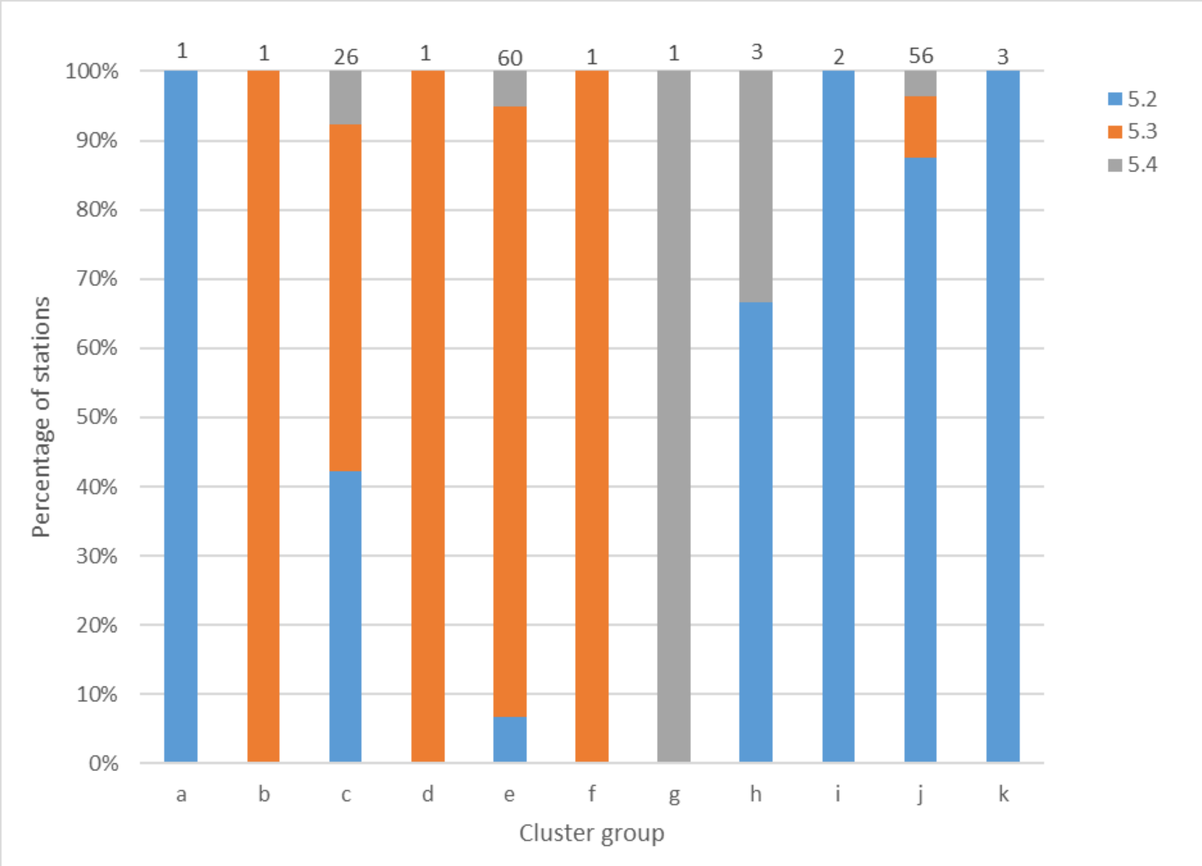

Figure 14: The percentage of stations of each SIMPROF group in the three EUNIS level 3 habitats identified. The number of stations per group is indicated above each bar. Data based on 155 grab samples taken during survey 1515S (2015) to East of Gannet and Montrose Fields MPA.

There is some variation across the three EUNIS sedimentary habitats regarding infaunal univariate biodiversity indices, such as diversity and richness (Table 10). Total abundance (N) was higher in samples from Sublittoral mud (A5.3) than in those from Sublittoral sand (A5.2) and Sublittoral mixed sediments (A5.4). However, total number of species (S), species richness (d), and diversity (in both Shannon's and Simpson's indices) were highest in samples from A5.2, followed very closely by samples from A5.3. Samples from habitat A5.4 were the most depauperate overall, with the lowest abundances, species richness and diversity. However, these results might be biased due to the fact that the group A5.4 contains fewer samples than the other two groups (A5.2, n=72; A5.3, n=74; A5.4, n=9) Figure 6 and Figure 7).

Table 10: Summary statistics of infaunal univariate diversity indices per EUNIS level 3 habitat. All data derived from 155 grab samples taken during survey 1515S of EGM (2015).

	Total species (S)	Total individuals (N)	Species richness (d)	Pielous evenness (J)	Shannons diversity (H(loge))	Simpsons diversity (1-Lambda)
Sublittoral sand (A5.2)	243	11799	25.81	0.69	3.78	0.95
Sublittoral mud (A5.3)	236	13795	24.65	0.68	3.74	0.95
Sublittoral mixed sediments (A5.4)	141	1685	18.84	0.74	3.68	0.93

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 11). 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, Paramphinome jeffreysii,* and *Spiophanes bombyx.* For the EUNIS level 3 habitats the highest typifying and discriminatory species is *A. filiformis*, with a 7.91% contribution to overall similarity taxa and consistently contributing (with highest Sim/SD of 4.72). The Sublittoral mud (A5.3) was typified by *P. jeffreysii* (with highest 7.41% contribution and highest discriminating species (Sim/SD 6.45). Sublittoral mixed sediments were typified by *Spiophanes bombyx* (with highest % contribution of 7.22) which also represented the most discriminating species (with highest Sim/SD of 5.73).

Table 11: The ten infaunal taxa contributing most % (Contrib.%) to the average similarity of three groups of samples (based on fourth-root transformed infaunal abundances) by EUNIS Level 3 sedimentary habitats. Samples are grouped for broadscale habitat types 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.

Group (A5.2)					
Average similarity: 46.84					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Amphiura filiformis	2.09	3.71	4.72	7.91	7.91
Paramphinome jeffreysii	2.01	3.25	3.54	6.94	14.85
Spiophanes bombyx	1.87	3.15	3.23	6.73	21.58
Scoloplos armiger	1.57	2.65	2.23	5.66	27.24
Owenia borealis	1.26	1.84	1.70	3.92	31.16
Antalis entalis	1.14	1.75	1.66	3.74	34.90
Spiophanes kroyeri	1.16	1.61	1.49	3.44	38.33
Labidoplax buskii	1.15	1.60	1.43	3.41	41.75
Goniada maculata	1.06	1.48	1.27	3.15	44.90
***Galathowenia* sp.**	1.15	1.47	1.22	3.14	48.03
Group (A5.3)					
Average similarity: 48.87					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Paramphinome jeffreysii	2.27	3.62	6.45	7.41	7.41
Spiophanes bombyx	1.84	2.89	5.68	5.92	13.33
Spiophanes kroyeri	1.65	2.69	4.74	5.49	18.82
***Notomastus* sp.**	1.68	2.42	1.91	4.95	23.77

***Thyasira* sp.**	1.61	2.36	1.99	4.84	28.60
***Galathowenia* sp.**	1.58	2.21	2.10	4.53	33.14
***Lumbrineris* sp,**	1.43	2.14	2.06	4.38	37.52
Abyssoninoe hibernica	1.18	1.65	1.48	3.37	40.89
Praxillella affinis	1.18	1.63	1.58	3.34	44.23
Amphiura chiajei	1.22	1.55	1.06	3.17	47.40
Group (A5.4)					
Average similarity: 38.74					
Species	**Av. Abund.**	**Av. Sim.**	**Sim/SD**	**Contrib.%**	**Cum.%**
Spiophanes bombyx	1.78	2.80	5.73	7.22	7.22
Paramphinome jeffreysii	2.14	2.67	1.70	6.89	14.11
***Nemertea* sp.**	1.30	2.21	4.64	5.69	19.81
Amphiura filiformis	1.52	2.00	1.55	5.15	24.96
Ampelisca tenuicornis	1.14	1.60	1.68	4.13	29.09
Scoloplos armiger	1.30	1.39	0.81	3.59	32.68
***Notomastus* sp.**	1.26	1.37	1.04	3.53	36.21
Goniada maculata	1.06	1.27	1.08	3.28	39.49
Phyllodoce groenlandica	1.02	1.18	1.12	3.04	42.53
Antalis entalis	0.89	1.11	1.11	2.87	45.40

3.2.1 Assignment of Infaunal Biotopes

Biotopes were assigned using the species contributing most to each of the 11 identified groups, by percentage contribution, up to a cumulative contribution of 70% (Clarke *et al.* 2008). The biotope assignment is shown in Table 12. 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 EGM was dominated by “*Paramphinome jeffreysii*, *Thyasira* spp*.* and *Amphiura filiformis* in offshore circalittoral sandy mud (SS.SMu.OMu.PjefThyAfil)”, describing the fauna in Groups c, e, i and j. The fauna in these groups was defined by the presence of *P. jeffreysii* and an *Amphiura* species, most commonly *A. filiformis,* and less commonly *A. chiajei.* These biotopes were suggestive of offshore circalittoral sandy mud habitat types, which were closely supported by the dominance of A5.2 Sublittoral sand and A 5.3 Sublittoral mud EUNIS habitats, identified by the infaunal groups throughout the site (Figure 6 and Figure 7).

The only other biotope identified for EGM was “*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (SS.SSa.OSa.OfusAfil)”, which described the h and k clusters within EGM (Table 12). The biotope corresponds to offshore circalittoral sand or muddy sand, which fits the designation of A5.2 Sublittoral sands and A5.3 Sublittoral muds well. Assignment of the higher-level habitats of “Offshore circalittoral sand” (SS.Ssa.Osa)” and “Offshore circalittoral mud” (SS.Smu.Omu)” were considered for group ‘h’ and partially for group ‘k’. These may still be broadly applicable, however the definition of SS.SSa.OSa.OfusAfil is preferable for our understanding of the ecology at EGM.

Table 12: Infaunal species contributing most (up to 70% cumulative contribution) to each of the 11 identified SIMPROF groups, with details for biotope assignment and summary description.

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	EUNIS level 3 habitats (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description and details for assignment
Group c	*Paramphinome jeffreysii*	6.19	**A5.3 Sublittoral mud,** A5.2 Sublittoral sand, A5.4 Sublittoral mixed sediments	89.7 to 98.9	*Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud (**SS.SMu.OMu.PjefThyAfil**)	Characteristic fauna included *P. jeffreysii* as the primary contributor, *Thyasira* spp., *Amphiura filiformis* and other taxa included in the description, such as *Goniada maculata* and *Spiophanes kroyeri*. Deep, offshore cohesive sandy mud fits the description well, as this site is dominated by A5.3 Sublittoral mud and A5.2 Sublittoral sand from PSA.
	Spiophanes bombyx	4.83				
	Amphiura filiformis	4.54				
	Ampharete falcata	3.93				
	Ampelisca tenuicornis	3.58				
	Scoloplos armiger	3.51				
	Owenia borealis	3.45				
	Galathowenia sp.	3.38				
	Spiophanes kroyeri	3.21				
	Praxillella affinis	3.05				
	Labidoplax buskii	2.82				
	Nemertea sp.	2.80				
	Notomastus sp.	2.76				
	Thyasira sp.	2.74				
	Urothoe elegans	2.71				
	Lumbrineris sp.	2.66				
	Gnathia (incl. *G. oxyuraea*)	2.66				
	Eclysippe vanelli	2.60				
	Antalis entails	2.28				
	Pseudonotomastus southerni	2.27				
	Goniada maculata	2.16				
	Pectinaria auricoma	1.71				
	Terebellides shetlandica	1.66				
Group e	*Paramphinome jeffreysii*	7.07	**A5.3 Sublittoral mud,** A5.2 Sublittoral sand,	97.0 to 102.3	*Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in	Characteristic fauna included *P. jeffreysii* as the primary
	Notomastus sp.	5.91				

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	EUNIS level 3 habitats (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description and details for assignment
	Spiophanes kroyeri *Spiophanes bombyx* *Thyasira* sp. *Lumbrineris* sp. *Amphiura chiajei* *Galathowenia* sp. *Abyssoninoe hibernica* *Praxillella affinis* *Phylo grubei* *Axinulus croulinensis* *Eclysippe vanelli* *Pseudonotomastus southerni* *Nemertea* sp. *Pholoe pallida* *Astacilla dilatata* *Glycera unicornis* *Chone* sp.	5.43 5.31 5.09 4.98 4.57 4.50 4.25 3.88 3.54 2.93 2.79 2.17 1.78 1.63 1.54 1.54 1.51	A5.4 Sublittoral mixed sediments		offshore circalittoral sandy mud (**SS.SMu.OMu.PjefThyAfil**)	contributor, a *Thyasira sp*., and other taxa included in the description, such as *Amphiura chiajei* and *Spiophanes kroyeri*. Deep, offshore cohesive sandy mud fits the description well, as this site is dominated by A5.3 Sublittoral mud from PSA.
Group h	*Amphiura filiformis* *Spiophanes bombyx* *Scoloplos armiger* *Labidoplax buskii* *Goniada maculata* *Sthenelais limicola* *Antalis entalis* *Spiophanes kroyeri* *Trichobranchus roseus*	10.7 8.81 8.22 7.46 7.27 6.27 6.27 5.89 5.89	**A5.2 Sublittoral sand**, A5.4 Sublittoral mixed sediments	83.0 to 93.5	*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (**SS.SSa.OSa.OfusAfil**)	Absence of *Owenia* spp., however, presence of *Amphiura filiformis* as the highest contributing taxa. Description includes taxa such as *Gonida maculata*, *Spiophanes kroyeri*, and *Labidoplax buskii* as contributory

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	EUNIS level 3 habitats (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description and details for assignment
	Chaetoderma nitidulum	5.89				taxa. The sand dominated sedimentary habitat adds to the confidence of this biotope assignment.
Group i	*Amphiura filiformis* *Scoloplos armiger* *Kurtiella bidentata* *Spiophanes bombyx* *Paramphinome jeffreysii* *Goniada maculata* *Pectinaria auricoma* *Pennatula phosphorea* *Polynoe scolopendrina* *Glycera unicornis* *Chaetozone* sp. *Cirratulus* sp. *Bathyporeia elegans*	8.13 7.57 7.57 7.10 6.84 5.19 5.19 4.37 4.37 4.37 4.37 4.37 4.37	**A5.2 Sublittoral sand**	86.7 to 88.5	*Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud (**SS.SMu.OMu.PjefThyAfil**)	Characteristic fauna included *P. jeffreysii*, although not as the primary contributing species, *A. filiformis* and *G. maculata.* It is worth noting the presence of *Pennatula phosphorea* among the contributory taxa. The EUNIS BSH most commonly associated with group *i* supports this designation, closely aligned with the offshore circalittoral sandy mud, specified in the biotope description.
Group j	*Amphiura filiformis* *Spiophanes bombyx* *Paramphinome jeffreysii* *Scoloplos armiger* *Owenia borealis* *Antalis entalis*	7.64 6.74 6.32 6.20 3.95 3.56	**A5.2 Sublittoral sand**, A5.3 Sublittoral mud, A5.4 Sublittoral mixed sediment	82.7 to 96.7	*Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud (**SS.SMu.OMu.PjefThyAfil**)	Characteristic fauna includes *P. jeffreysii,* a *Thyasira* spp., *A. filiformis* and other taxa included in the description, such as *L. buskii, G. maculate* and *S.*

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	EUNIS level 3 habitats (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description and details for assignment
	Goniada maculata *Spiophanes kroyeri* *Pectinaria auricoma* *Thyasira flexuosa* *Chaetoderma nitidulum* *Galathowenia* sp. *Labidoplax buskii* *Ampharete falcata* *Nemertea* sp. *Diplocirrus glaucus* *Phyllodoce groenlandica* *Cirratulus* sp. *Chaetozone setosa*	3.45 3.30 3.27 3.08 2.98 2.94 2.83 2.47 2.47 2.43 2.41 2.29 2.22				*kroyeri*. Deep, offshore cohesive sandy mud fits the description fairly well, although it is noted that the site is dominated by A5.2 Sublittoral sand, rather than A5.3 Sublittoral mud. However, throughout group 'j' there is evidence of all three identified sedimentary habitats from the PSA.
Group k	*Amphiura filiformis* *Owenia borealis* *Scoloplos armiger* *Pectinaria auricoma* *Galathowenia* sp. *Spiophanes bombyx* *Antalis entalis* *Goniada maculata* *Nemertea* sp. *Diplocirrus glaucus* *Pennatula phosphorea* *Sthenelais limicola* *Nephtys longosetosa*	8.65 6.74 6.36 5.26 5.16 4.54 4.54 4.21 4.1 4.07 3.83 3.83 3.83	**A5.2 Sublittoral sand**	87.0 to 90.5	*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand (**SS.SSa.OSa.OfusAfil**)	Presence of an *Owenia* sp. and *A. filiformis* as highly contributory species. Also, in description of biotope are *G. maculata, Diplocirrus glaucus,* and a *Spiophanes sp*. The BSH of the group fits the description well, with A5.2 Sublittoral sand being the dominant habitat type.

Infaunal Cluster Group	Characterising taxa of cluster	Contribution (%)	EUNIS level 3 habitats (bold denotes primary)	Depth range (m)	Marine Habitat Classification for Britain and Ireland: Habitat\Biotope	Description and details for assignment
	Cirratulus sp.	3.83				
	Ampelisca macrocephala	3.83				

3.3 Epifaunal biotopes

Due to the sparse nature of the stills data, and low taxonomic resolution, it was determined that the data were unsuited for epifaunal univariate or multivariate statistical analyses. Epifaunal community analysis focused on broad characterisation using the relative abundance of sea pen and burrowing megafaunal communities (Sections 3.4 and 3.5) and the identification of biotopes from the imagery.

All video and stills data were identified to be either EUNIS BSH 'A5.3 – Subtidal mud' or 'A5.4 – Subtidal mixed sediment', loosely matching the PSA results (see Section 3.1.1). All video (58 tows) and most stills (511 stills of 622 were identified as the 'Burrowed mud' PMF; 111 stills were not assigned a PMF feature), where evidence of either sea pens or burrows and burrowing megafaunal was observed (Benson & Sotheran 2016). Data for biotope assignment were further investigated by visual assessment and community data acquisition - the following Marine Nature Conservation Review (MNCR) codes were identified: 'SS.SMu.CFiMu.SpnMeg - Sea pens and burrowing megafauna in circalittoral fine mud'; 'SS.SMu.CSaMu - Circalittoral sandy mud'; and 'SS.SMx.CMx - Circalittoral mixed sediment', which were all present in the video and stills data, and 'SS.SMu.CSaMu.VirOphPmax - *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud, which were identified from stills. These results are summarised in Table 13. It should be noted, that the biotopes, particularly 'SS.SMu.CFiMu.SpnMeg' are not exact matches, and this biotope was accepted due to the high number of sea pens, rather than burrowing megafauna, at the site.

Table 13: The MNCR Biotope codes identified from the 58 video tows and 622 stills. The number and percentage of each tow or still within the corresponding MNCR code is given. Data from survey 1515S (2015) to East of Gannet and Montrose Fields MPA.

MNCR Code	Video	Stills
(SS.SMu.CFiMu.SpnMeg) - Sea pens and burrowing megafauna in circalittoral fine mud	15 (25.9%)	11 (1.7%)
SS.SMu.CSaMu - Circalittoral sandy mud	40 (69.0%)	595 (95.8%)*
SS.SMx.CMx - Circalittoral mixed sediment'	3 (5.2%)	3 (0.5%)
SS.SMu.CSaMu.VirOphPmax - *Virgularia mirabilis* and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud	0 (0.0%)	12 (1.9%)
Undefined		1 (0.2%)**
Totals	**58**	**622**

* The total of 595 includes samples from station "1515S_EGM011_S209", which did not have associated PSA grab sampled data – it has been included here as it does have video and stills habitat data.
** One still "1515S_EGM129_S329_S1_012" had no associated metadata available.

3.4 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 (155) was 69 individuals from 44 of the stations (Figure 15).

The spatial distribution of ocean quahog recorded from grab samples is shown in Figure 15. 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 15).

Of the ocean quahog specimens, 17 were identified as ‘mature’ and 39 as ‘juvenile’ in infaunal analysis by the contractor (Thomson Unicomarine 2016 and Appendix 22). For 13 specimens no assessment of maturity was made, as these were acquired during grab operations on the vessel, recorded, and returned to the sea (Appendix 15). Sexual maturity and life history of ocean quahog are poorly known, and the determination of maturity is difficult (Thompson *et al*. 1980), so results must be interpreted with a degree of caution.

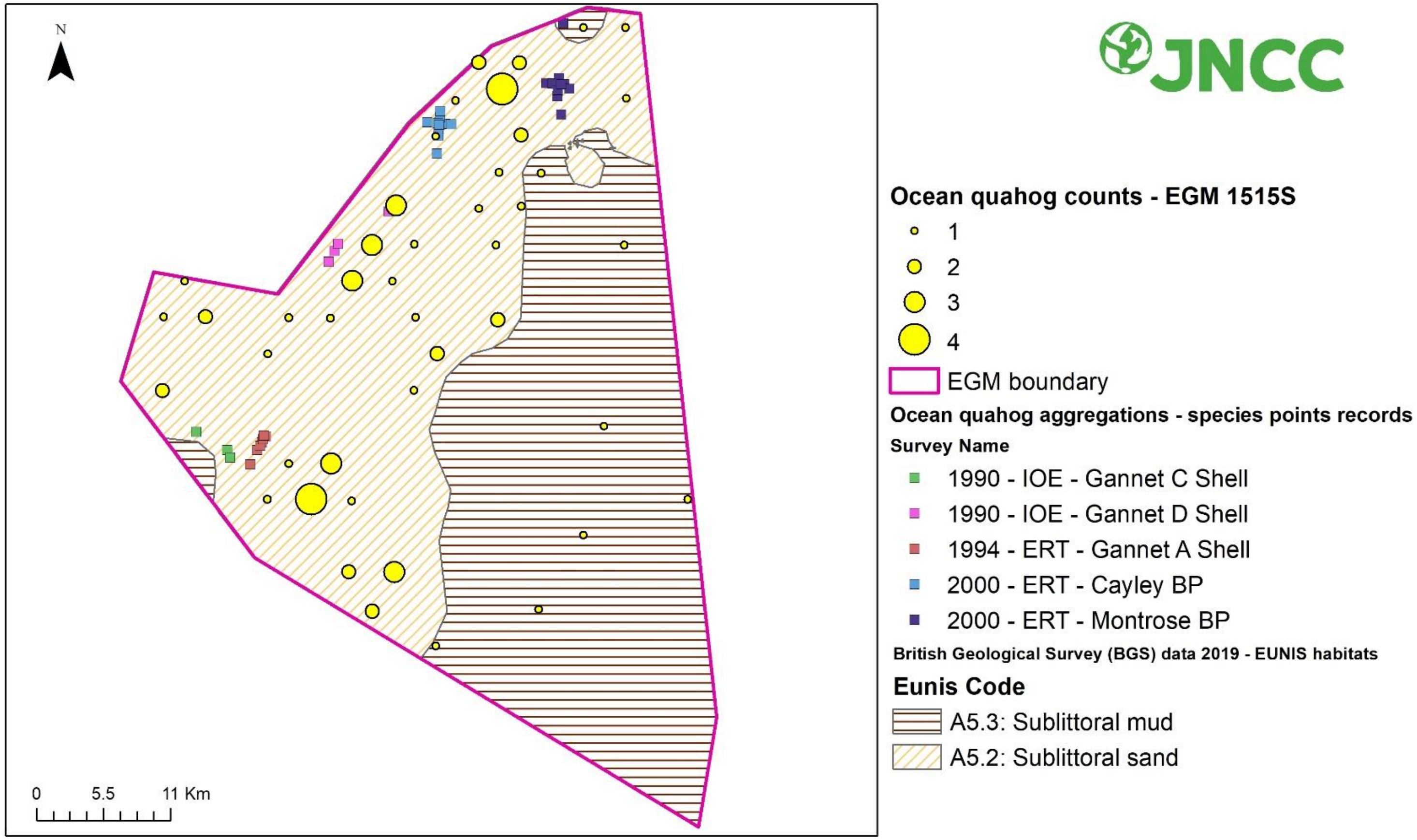

Figure 15: Distribution of sampled ocean quahog (*Arctica islandica*) obtained from grab samples taken during survey 1515S at East of Gannet and Montrose Fields MPA (2015). The figure shows the number of individuals sampled at each station. Abundance data for ocean quahog from previous survey data is also displayed.

3.4.1 Supporting habitat of ocean quahog

The total number of sampled *Arctica islandica* from the 155 grabs, collected in 44 grabs, confirmed that the highest proportion of the species occurs in the EUNIS level A5.2 Sublittoral sands. Of the 72 grab samples in this habitat, 33 sampled a total of 57 ocean quahog specimens (79.2% occurrence in grabs) (Figure 16), approximately 83% of all ocean quahog sampled. The PMF species also occurred in the other sedimentary habitats identified at the site, in lower numbers, particularly low in A5.3 Sublittoral mud. In 74 grabs in Sublittoral mud 7 individuals were collected (9.5% occurrence in grabs, 10.1% of total ocean quahog sampled), and five individuals from 9 grabs (55.6% grab sampling occurrence, 7.2% of total ocean quahog sampled) in Sublittoral mixed sediment (Figure 16).

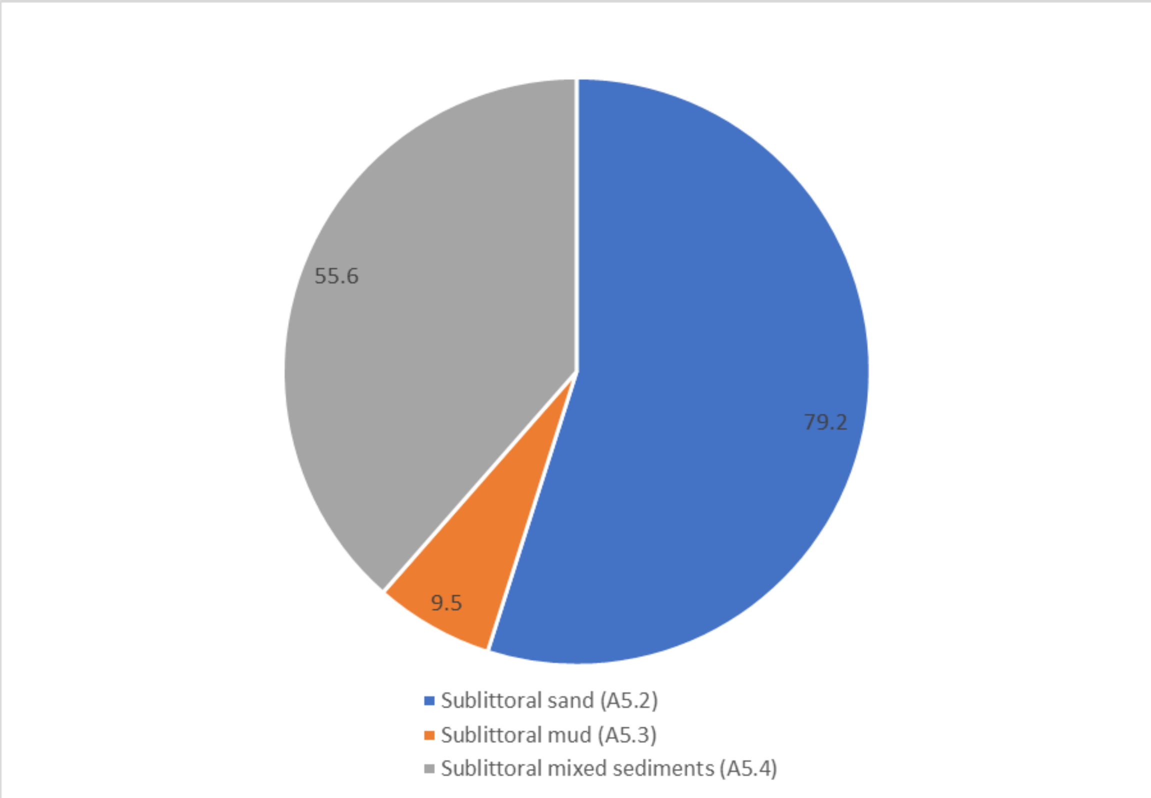

Figure 16: Percentage of ocean quahog from grabs within each of the benthic sedimentary habitats of EGM. Data are based on 155 grab samples, 72 grabs in A5.2, 74 in A5.3 and 9 in A5.4, taken during survey 1515S of East of Gannet and Montrose Fields MPA and the sampling success of grabs (2015). A total of 69 ocean quahog individuals were obtained, from 44 of the 155 total grabs, and include both mature and juvenile specimens.

3.5 Additional Priority Marine Features (PMF)

The analysis of the video tow data resulted in the sediment observed in all 58 tows being identified as “Burrowed Mud”, in addition to the other habitat classifications specified above (Section 3.3 and Table 13). Species indicative of the Priority Marine Feature (PMF) “Burrowed Mud” broad habitat and component PMFs “Sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu.SpnMeg)” and “Tall sea pen *Funiculina quadrangularis*” were identified from observed from the video and stills data (Table 14, Table 15 and Appendix 16).

The sea pen species identified from video analysis included *Funiculina quadrangularis, Pennatula phosphorea* and *Virgularia mirabilis.* For each species, the number of individuals across all 58 tows was: 159 (*F. quadrangularis);* 36,203 (*P. phosphorea*); and 986 (*V.*

mirabilis) (Table 14 and Appendix 16). *P. phosphorea* dominated across the site, being present in all video tows, with a maximum count of 3003 individuals observed in one station tow, averaging ca. 624 individuals per tow within the site, and 2.0 individuals observed per metre of tow, on average (Table 14). *V*. *mirabilis* was the second most commonly observed, with a maximum of 170 individuals observed in one tow, and average density across all tows of 0.1 individuals per metre. The sea pen *F*. *quadrangularis* was the least common species of sea pen, with the maximum number of individuals seen in one tow being 44, and overall average relative abundance of 0.009 individuals per metre of tow (Table 14). The results of the density calculations, including the species totals per BSH are shown below (Table 14, Table 15, and Figure 17, Figure 18, Figure 19). Figure 20 shows the sea pen species composition and distribution observed indicating the predominance of *P*. *phosphorea* throughout the site.

Prior to fourth-root transformation, a correlation between abundances of different sea pen species was undertaken (Table 16). There was a negative correlation between *P. phosphorea* and both *V. mirabilis* and *F. quadrangularis*, and a positive correlation between *F. quadrangularis* and *V. mirabilis*. *P. phosphorea* is more abundant than the other two species throughout EGM (Table 14, Table 15).

The results of hierarchical clustering and SIMPROF testing of the sea pen abundance data, fourth-root transformed, indicate that the structure of the sea pen community does not follow a strong statistical structure (Appendix 17). The SIMPROF test indicated that the presence of no structure in the sea pens species cannot be rejected, with a real π of 0.76, as a measure of the departure of the sampled profile structure, from 999 randomly permuted profiles which is within the distribution of randomly permuted, unstructured profiles at significance p<0.006. Therefore, we can accept that there may not be an interpretable structure to the sea pen abundance assemblages and further interpretation must be taken with caution, supported in the dendrogram of results (Appendix 18) and associated nMDS plot of results (Appendix 19).

The result of a SIMPER analysis showed that average similarity within groups was high (Table 17), ranging from 79.41 (assemblage 'd') to 89.21 (assemblage 'b'). This high within-group similarity is expected, due to the comparisons of only three species. *P. phosphorea* being the most common and abundant of the three species, was the highest contributing species to overall similarity in all three assemblages. The presence and consistency of contribution of *F. quadrangularis*, is an important driver of assemblages, with the highest value of 'Sim/SD' at 13.75 in assemblage 'b' and the absence of the species in assemblage 'c' is noteworthy.

A SIMPER analysis was undertaken on the EUNIS level 3 habitats as a factor to the infaunal dataset in PRIMER, to allow a further investigation of the sea pen species contributing to each EUNIS level 3 habitats (Table 18). The results of the SIMPER analysis similarly indicate *P. phosphorea* as the highest species contributing to overall similarity of the assemblages and consistently the highest discriminatory species for all identified EUNIS level 3 habitats. This is likely due the relatively much higher abundance of *P. phosphorea*, in comparison with the two other sea pen species. Of note is the differences in the highest contributing and discriminatory species, after *P. phosphorea*, in the other EUNIS level 3 habitats. *F. quadrangularis* is the second highest contributing and discriminatory species in A5.2 subtidal sand, whereas *V. mirabilis* is the second highest contributing species in A5.3 Sublittoral mud. *F. quadrangularis* makes very minor (0.6%) or no contribution to the structure of A5.3 Sublittoral mud and A5.4 Sublittoral mixed sediment, respectively, due to its much lower abundance in this habitat, relative to *P. phosphorea* and *V. mirabilis*. The abundance and percentage of sea pens within each of the EUNIS sedimentary habitats identified at the site are illustrated in Figure 21. However, as stated above these results, based on a SIMPROF analysis in which the 'real' results were not sufficiently distant from random permutations, should be interpreted with caution – likely due to the comparison of low variables (three species) within 58 samples and the presence of a highly abundant species in comparison with the other two.

A table of the observations of sea pens, ocean quahog, and number of megafaunal burrows, including the calculated ratios per metre of video tow data is provided in Appendix 16.

Table 14: Summary statistics from the analysis of sea pen and megafauna burrow relative abundances based on counts from 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

	***Virgularia mirabilis* counts**	***Pennatula phosphorea* counts**	***Funiculina quadrangularis* counts**	**Number of sea pen lying flat**	**Number of broken sea pen**	***Burrowing megafauna* - Number of burrows**	**Total tow length (m)**	**Sea pen (per m) - *Virgularia mirabilis***	**Sea pen (per m) - *Pennatula phosphorea***	**Sea pen (per m) - *Funiculina quadrangularis***	***Burrowing megafauna*- burrows (per m)**
Maximum	170	3003	44	11	9	33	434.00	0.50	8.10	0.13	0.13
Mean	17	624	3	1	1	4	318.80	0.10	2.00	0.01	0.01
Minimum	0	9	0	0	0	0	235.00	0.00	0.00	0.00	0.00
Total	986	36203	159	62	36	206	18493.00	n/a	n/a	n/a	n/a

Table 15: Total number of sea pen individuals and burrowing megafauna, as identified from all video tows, presented per benthic sedimentary habitat at the site (derived from grab PSA data). All data derived from samples taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

BSH	*V. mirabilis* – Total	*P. phosphorea* – Total	*F. quadrangularis* – Total	Sea pen – Number lying flat	Sea pen – Number broken	*Burrowing megafauna* – Number of burrows	*V. mirabilis* – average relative abundance (per m)	*P. phosphorea* – average relative abundance density (per m)	*F. quadrangularis* – average relative abundance (per m)	Sea pen- Number lying flat – average relative abundance (per m)	Sea pen - Number broken – average relative abundance (per m)	*Burrowing megafauna* – average relative abundance (per m)
Sublittoral sand (A5.2)	300	26525	81	43	18	4	0.03	2.74	0.01	0.01	0.00	0.00
Sublittoral mud (A5.3)	457	6670	7	8	1	180	0.07	0.98	0.00	0.00	0.00	0.03
Sublittoral mixed sediment (A5.4)	196	2399	71	10	17	22	0.12	1.43	0.04	0.01	0.01	0.01
Undefined	33	609	0	1	0	0	0.11	2.09	0.00	0.00	0.00	0.00

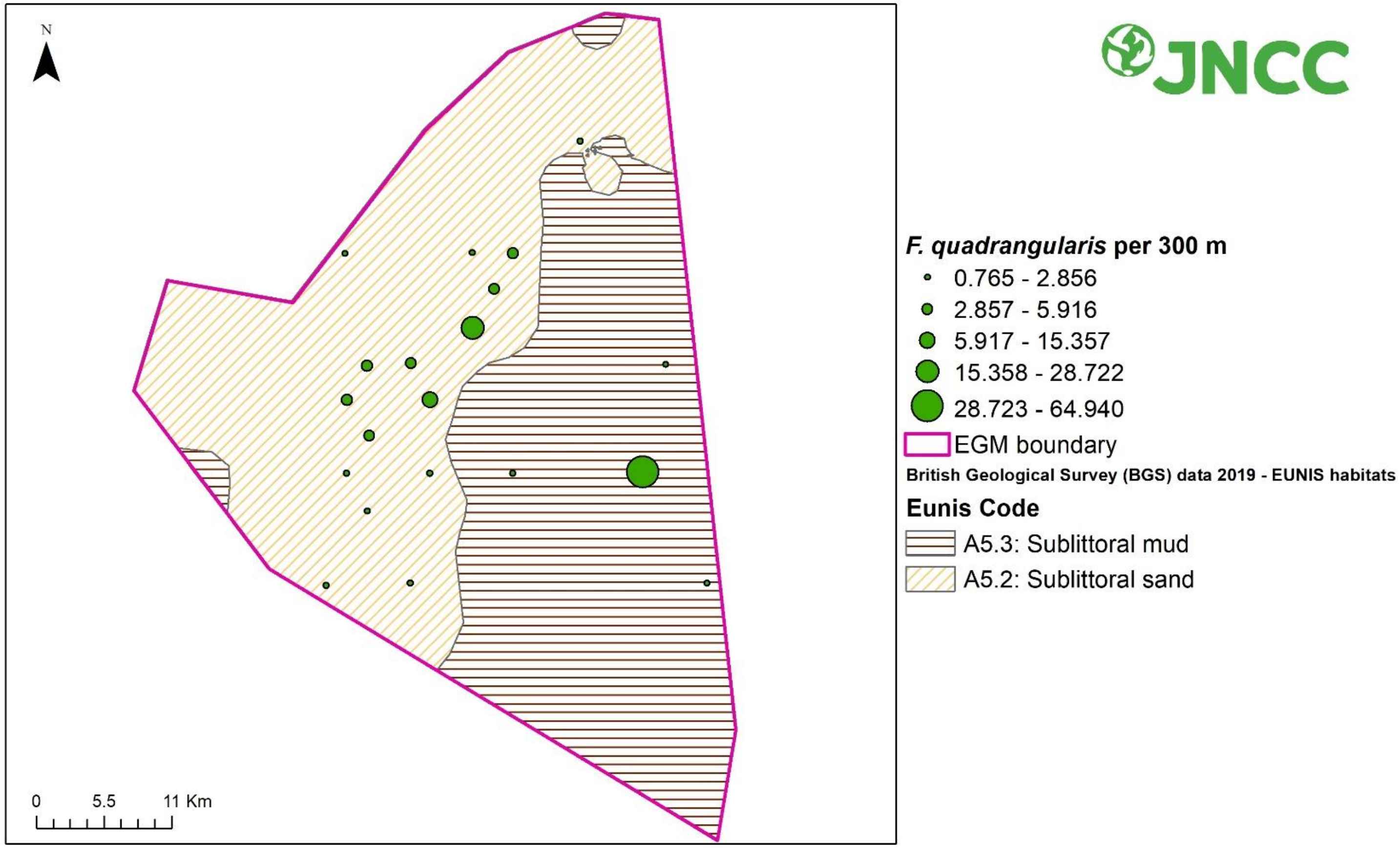

Figure 17: Density of *Funiculina quadrangularis* per 300m tow within EGM. Bubble size denotes the relative density of observed sea pen species, all data derived from 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

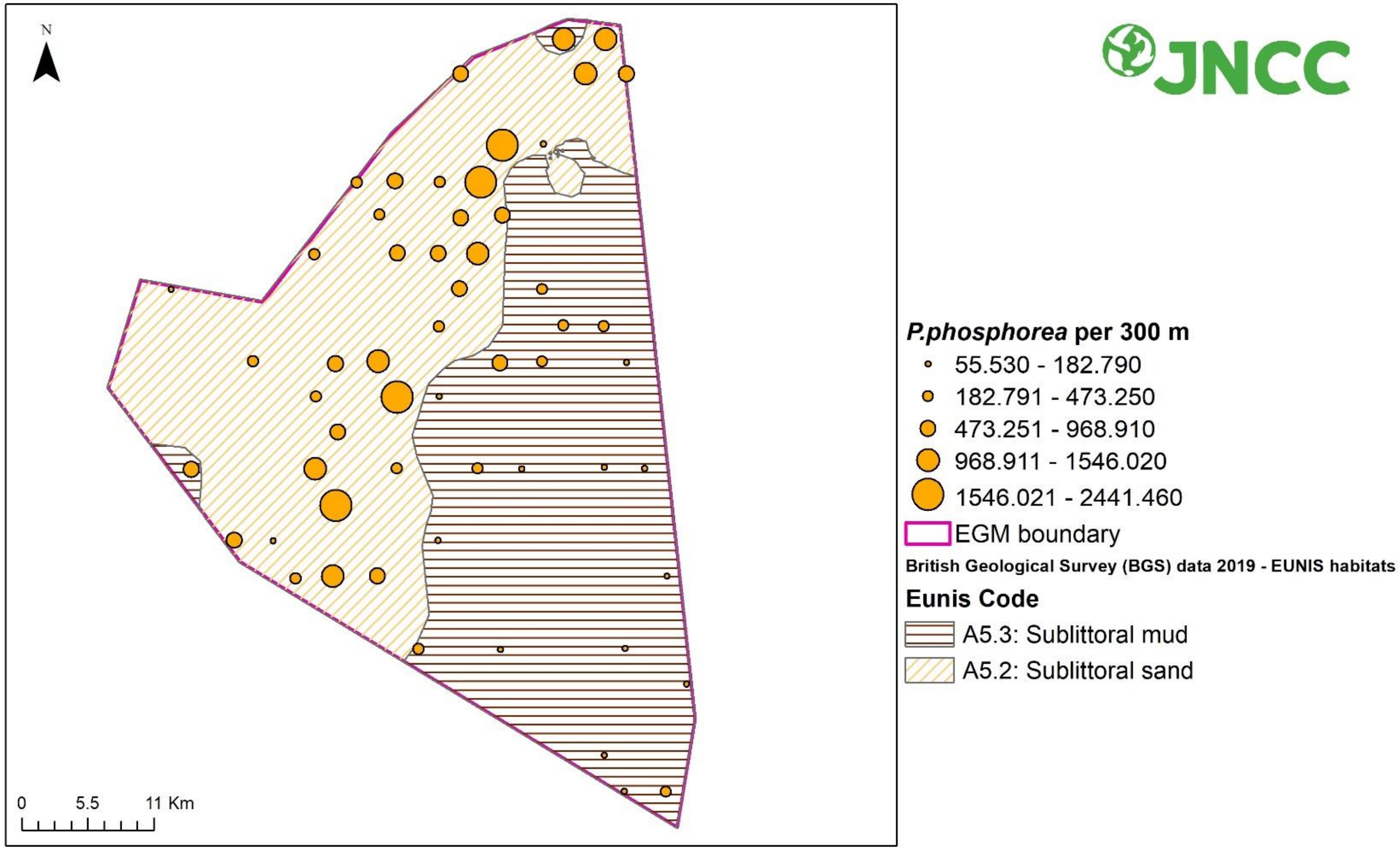

Figure 18: Calculated density of *Pennatula phosphorea* per 300m tow within EGM. The size of the points denotes the relative density of observed sea pen species. All data derived from 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

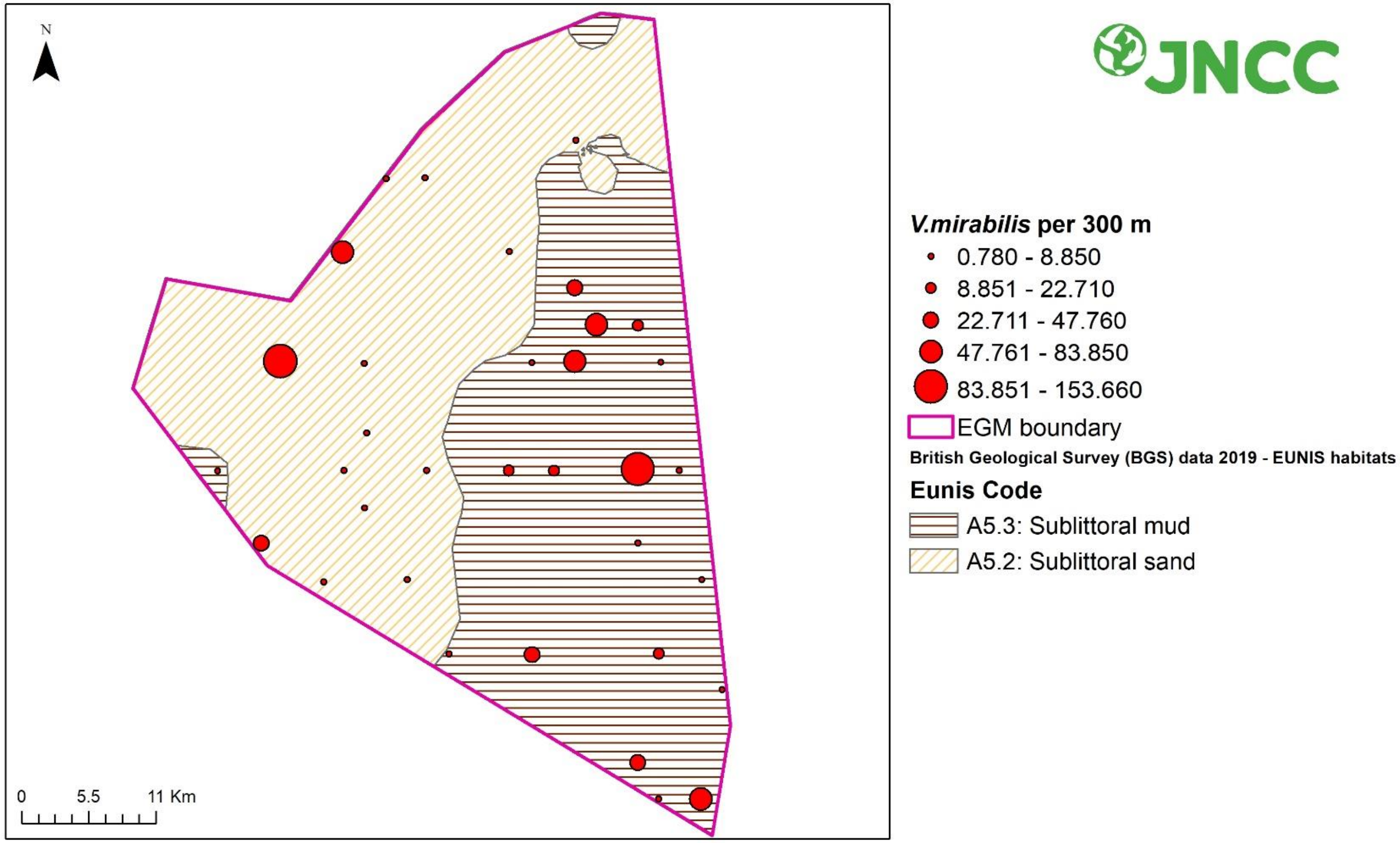

Figure 19: Calculated density of *Virgularia mirabilis* per 300m tow within EGM. The size of the points denotes the relative density of observed sea pen species. All data derived from 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

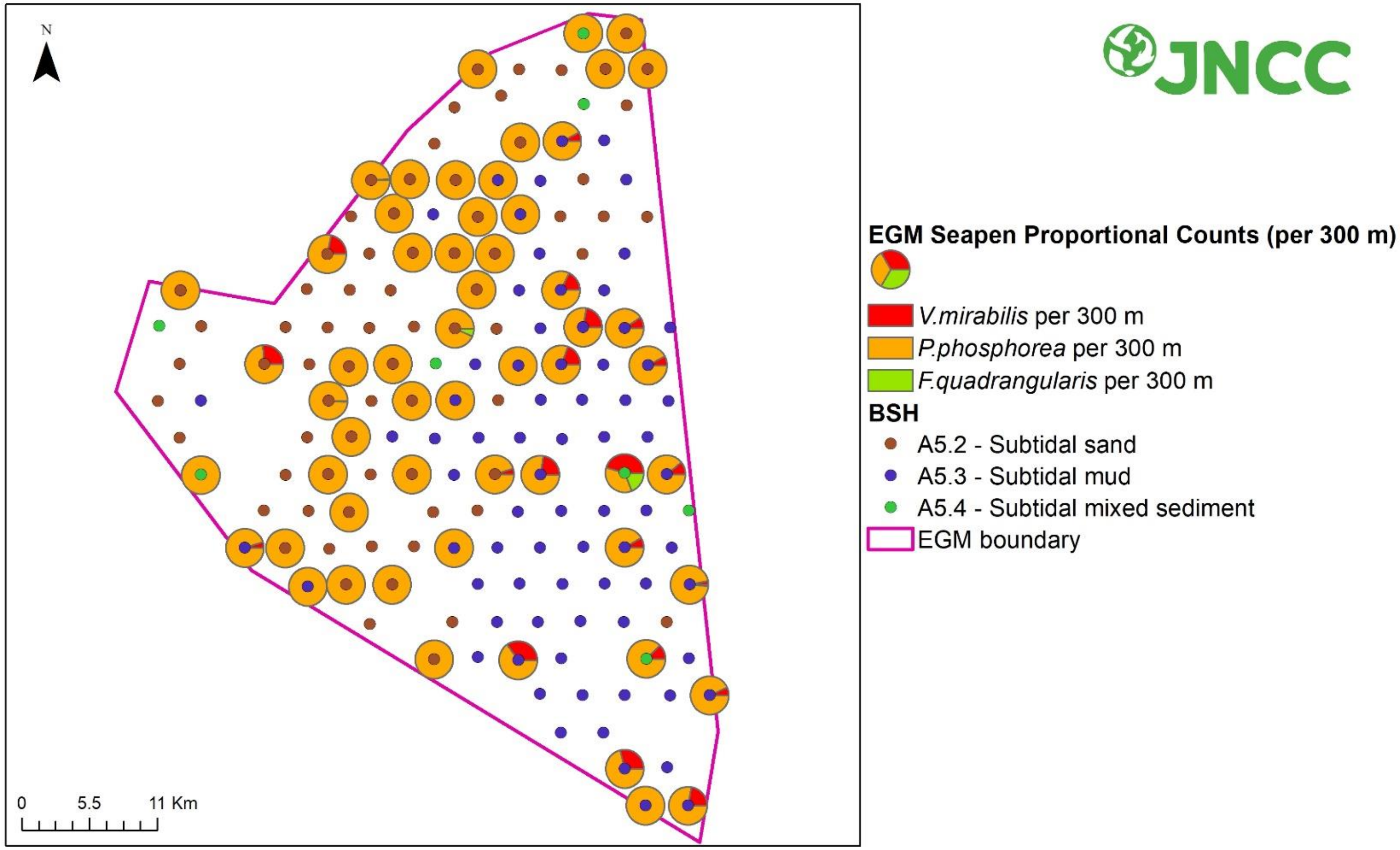

Figure 20: Proportional counts of the three observed sea pen species, *Funiculina quadrangularis, Pennatula phosphorea* and *Virgularia mirabilis* per 300m tow within EGM. All data derived from 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

Table 16: Pearson's correlation of untransformed abundance data for the three sea pen species observed on the 1515S survey of East of Gannet and Montrose Fields MPA (2015).

	V. mirabilis	*P. phosphorea*	*F. quadrangularis*
V. mirabilis			
P. phosphorea	-0.27		
F. quadrangularis	0.45	-0.06	

Table 17: Group-average similarity and contribution of each of the three sea pen species to the average similarity for three assemblages of sea pen species. Av. Abund. = contribution of this species to average abundance, Av. Sim. = contribution of this species to average similarity, Sim/SD = Standard deviation of similarity and Contrib% = percentage contribution to the community group. Note, one assemblage containing only one sample has been removed. All data derived from samples taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

Group b				
Average similarity: 89.21				
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%
P. phosphorea	4.14	54.62	11.08	61.23
V. mirabilis	1.42	18.46	4.96	20.69
F. quadrangularis	1.19	16.13	13.75	18.08
Group c				
Average similarity: 85.50				
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%
P. phosphorea	3.6	54.65	8.86	63.91
V. mirabilis	2.31	30.85	4.15	36.09
Group d				
Average similarity: 79.41				
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%
P. phosphorea	5.28	77.18	7.15	97.19
F. quadrangularis	0.44	1.3	0.28	1.64
V. mirabilis	0.35	0.93	0.25	1.17

Table 18: Group-average similarity and contribution of each of the three sea pen species to the average similarity for the three identified EUNIS sedimentary habitats at the EGM, A5.2 Sublittoral sand, A5.3 Sublittoral mud and A5.4 Sublittoral mixed sediments. AvAbund = contribution of this species to average abundance, Av. Sim. = contribution of this species to average similarity, Sim/SD = Standard deviation of similarity and Contrib% = percentage contribution to the community group. All data derived from samples taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

Group 5.2				
Average similarity: 77.01				
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%
P. phosphorea	5.12	70.77	6.04	91.9
F. quadrangularis	0.67	3.59	0.53	4.66
V. mirabilis	0.65	2.65	0.43	3.44
Group 5.3				
Average similarity: 77.32				
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%
P. phosphorea	3.81	58.74	6.73	75.97
V. mirabilis	1.63	18.12	1.24	23.43
F. quadrangularis	0.21	0.47	0.17	0.6
Group 5.4				
Average similarity: 65.93				
Species	Av. Abund.	Av. Sim.	Sim/SD	Contrib%
P. phosphorea	4.58	55.05	3.25	83.49
V. mirabilis	1.79	10.88	0.87	16.51

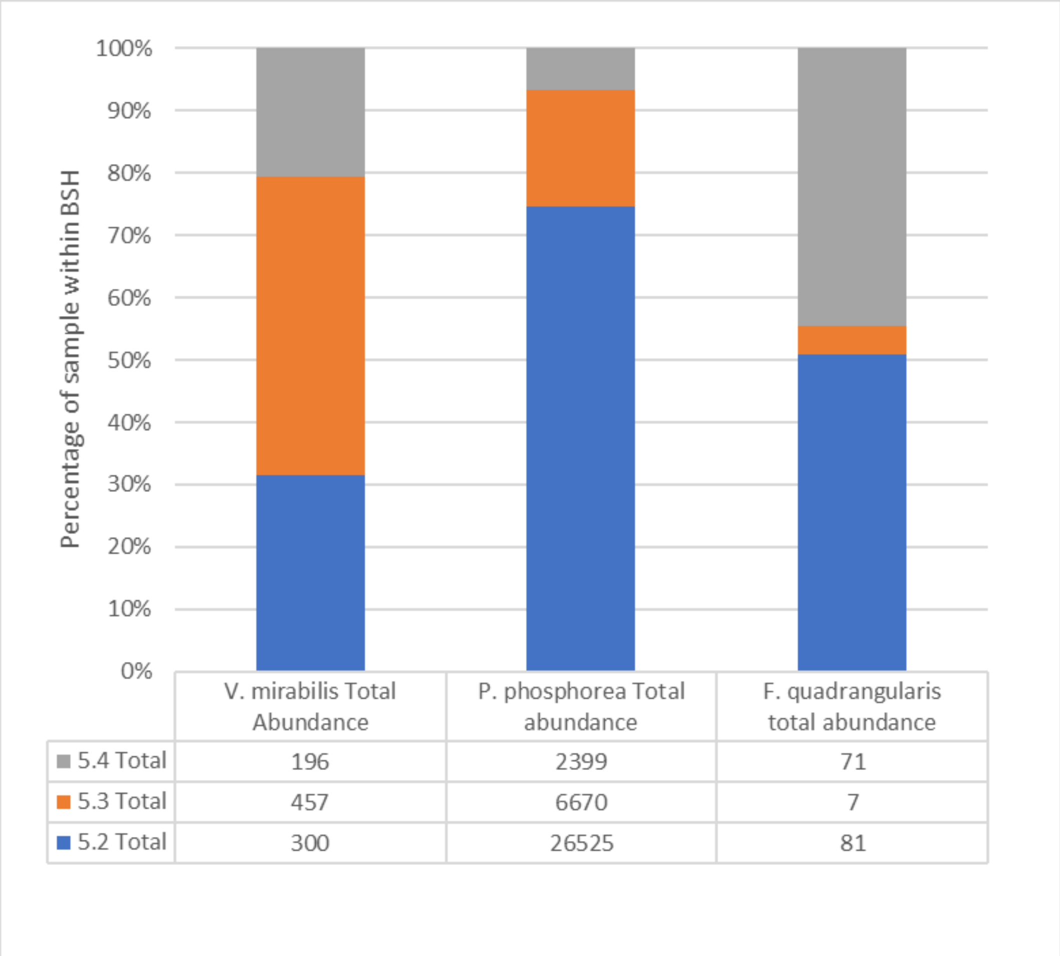

Figure 21: The percentage of total sea pens per Broadscale Habitat (A5.2, A5.3 and A5.4). Data are based on 58 video tows and 622 still images taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

Megafaunal burrows were counted employing the same method as for the sea pens, and burrow densities were also calculated for each of the three BSH in which they were observed (Figure 22). The relative abundance of megafaunal burrows across EGM is depicted in Figure 23. For most tows, relative abundances for megafaunal burrows do not meet, nor exceed, the threshold levels given by the OSPAR guidance (OSPAR 2010) for the OSPAR Threatened and/or Declining Habitat 'Sea-pens and burrowing megafauna'. Only one tow (1515S_EGM152_S219_S1) met the OSPAR criterion of densities of large burrows per metre of tow being >0.1/m^2. Maximum densities of this tow were 0.125/m^2 megafaunal burrows (Table 19).

Table 19: Burrow density thresholds for characterising 'Burrowed mud' and, consequently, 'Sea pen and burrowing megafauna communities'.

Burrow category	Density threshold
small burrow (<3cm diameter)	≥1/m^2
large burrow (>3cm diameter)	≥0.1/m^2
small burrow + large burrow	≥1/m^2

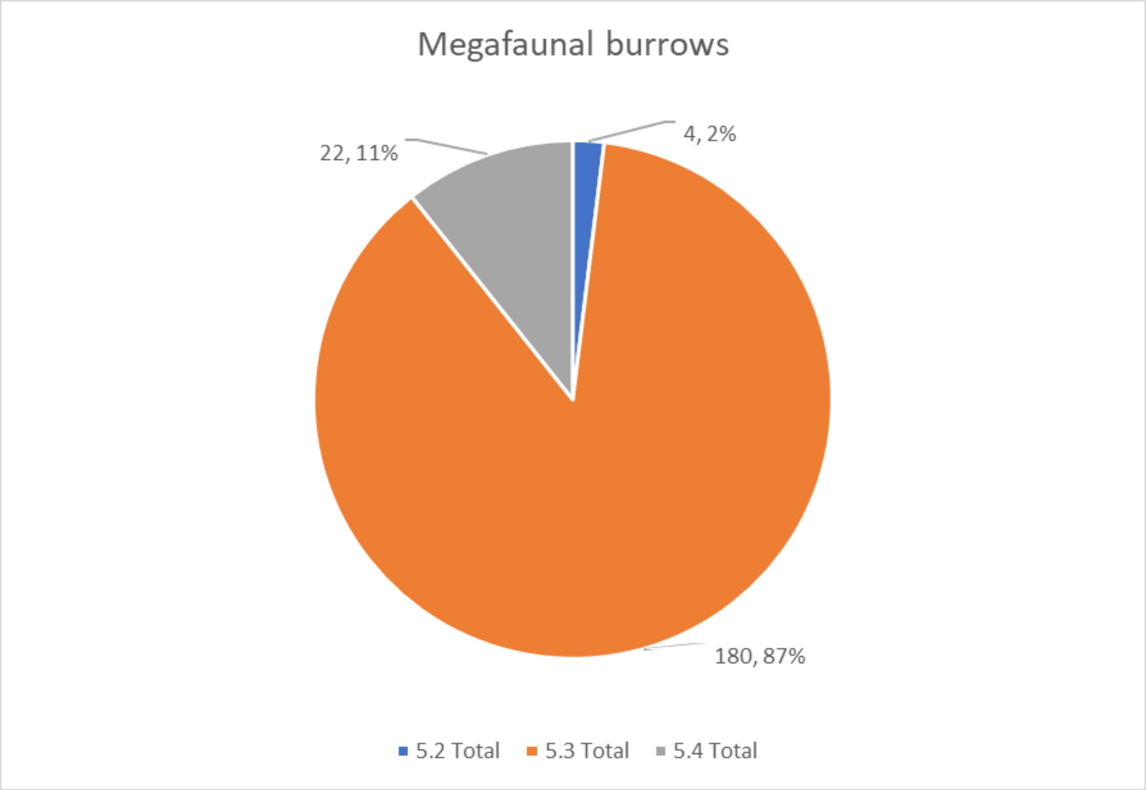

Figure 22: Total number of observed large (>3cm) megafaunal burrows for three EUNIS sedimentary habitats identified. Data are based on 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

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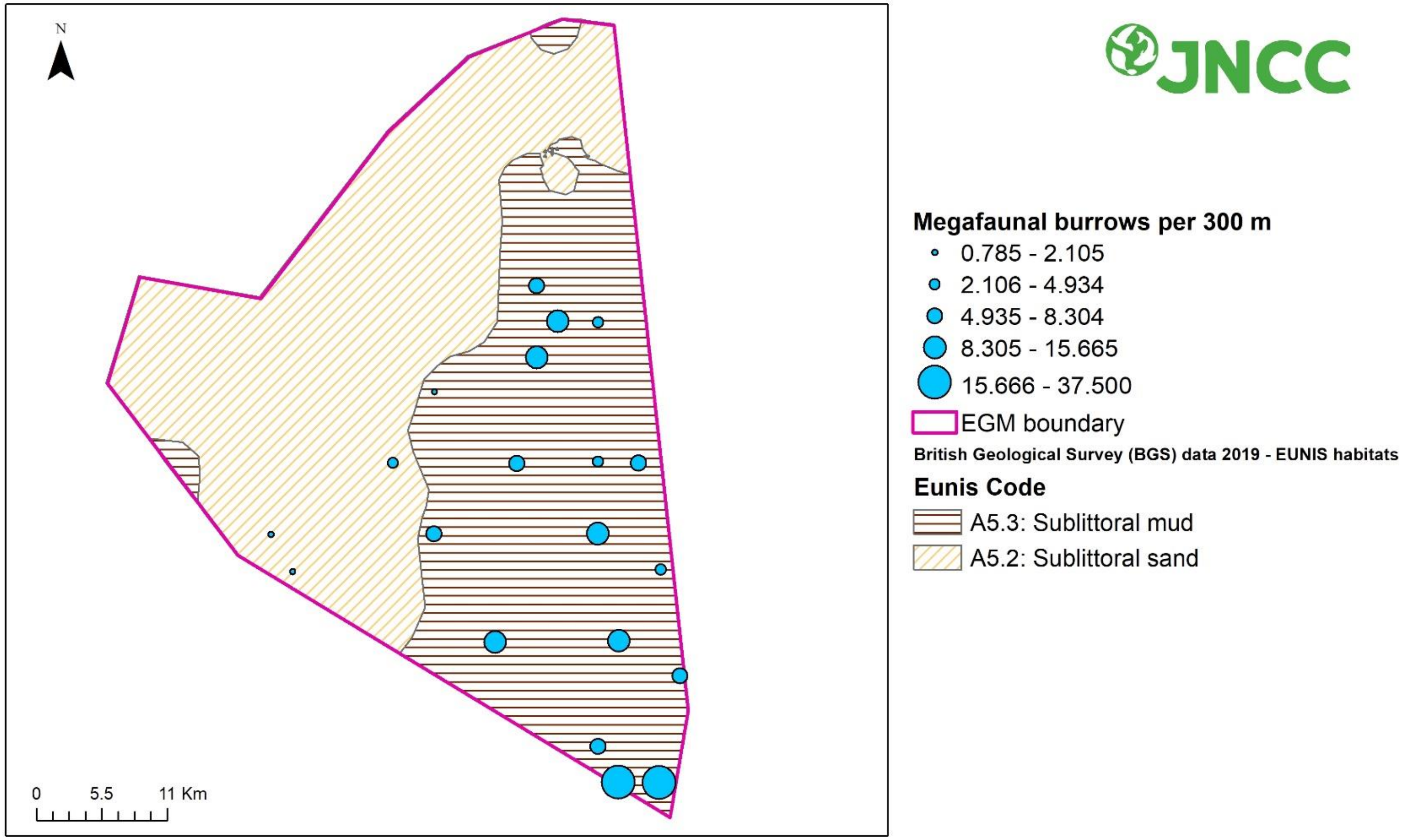

Figure 23: Calculated density of megafaunal burrows per 300m tow within EGM. The size of the points denotes the relative density of the feature. Data are based on 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

3.6 Non-indigenous species (NIS)

The infaunal and epifaunal taxon lists generated from the infaunal samples and seabed imagery data 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 and identified as significant by the UK Non-Native Species Secretariat. These taxa are listed in Appendix 5.

No instances of the presence of NIS were detected in the infaunal or epifaunal data.

3.7 Marine litter

Potential anthropogenic impacts were observed in seven camera tow transects at EGM (Table 20). Further detail on the MSFD litter categories (EU Commission 2013) can be found in Appendix 20.

Table 20: Potential anthropogenic impacts observed in camera tows.

Station Name	Date	Time	Marine Litter Category
1515S_EGM008_S240	27/10/2015	19:10	Litter/debris (uncategorised)
1515S_EGM017_S332	01/11/2015	03:49	B1/B2: can
1515S_EGM024_S210	26/10/2015	06:44	A5/A6: fishing line
1515S_EGM087_S243	27/10/2015	00:10	A1: bottle and B7: cable
1515S_EGM116_S237	25/10/2015	20:07	A14: blue plastic
1515S_EGM129_S329	31/10/2015	23:53	B8: metal pipes
1515S_EGM142_S328	31/10/2015	22:17	B7: cable

4 Discussion

4.1 Benthic and environmental overview

It is evident from the results of the grab sampling of EGM that the extent and distribution of the sedimentary habitats identified within EGM during the 2015 survey are different from previously reported results (2012) (see Section 1.3 and Figure 1), hence the habitat map was updated to reflect this change (Figure 4 and Appendix 23). This difference may be due to differences in sampling design, with different station locations, extent, and the use of a different type of grab with a larger surface area (i.e. a Hamon grab with $0.25m^2$ in 2015, whereas a Van Veen grab ($0.1m^2$) was used in 2012) (O'Connor 2016).

The results from the biological community SIMPROF analysis defined 11 infaunal cluster groups. Approximately 92% of all samples belonged to three main infaunal groups identified as c, e and j. These groups were shown to be statistically distinct, but within-group similarity was variable (see Section 3.2.).

EGM is similar to other MPAs, of its vicinity in the North Sea. The Norwegian Boundary Sediment Plain Nature Conservation MPA, Turbot Bank MPA and Fulmar Marine

Conservation Zone all consist of sandy or muddy sediment (JNCC 2019). Norwegian Boundary Sediment Plain Nature Conservation MPA is similarly designated for ocean quahog aggregations and offshore subtidal sands and gravels as sediment types suitable for ocean quahog colonisation. The Fulmar MCZ infauna shares the biotope classification of 'A5.376 *Paramphinome jeffreysii*, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud', under which as EGM is mainly described (see below). The Fulmar MCZ epifauna is classed under the biotope 'A5.354 Virgularia mirabilis and *Ophiura* spp. with *Pecten maximus* on circalittoral sandy or shelly mud' and habitat 'A5.44x Circalittoral mixed sediments', reflecting the presence of sea pen species and mixed sediments, similar to EGM.

4.2 Offshore deep-sea muds

4.2.1 Extent and distribution

The 2015 survey grab sampling and subsequent PSA data indicate an increase in the known extent of Offshore deep-sea mud (A5.3 Sublittoral muds, as equivalent) from previously available data in 2012. This increase in extent is especially evident in the south eastern half of the site (Figure 1 and Figure 4), and required an update of the habitat map (Appendix 23). With the results of the 2015 survey we have attained an improved understanding of the offshore deep-sea mud habitats throughout the site, which will allow for more robust monitoring of the site in the future.

4.2.2 Physical and biological structure

The PMF Offshore deep-sea muds was associated with deeper regions of the site (e.g. 88 to 102m). Of the main infaunal cluster groups, e was the most closely associated with Offshore deep-sea muds. Infaunal cluster groups b, d and f occurred in mud, exclusively, however the small numbers of samples in these groups makes it difficult to determine any trends in community composition (Figure 11, Figure 12). Infaunal group e was typified by the polychaete *Paramphinome jeffreysii*. Other important species contributions include the polychaetes *Notomastus* sp., *Spiophanes kroyeri* and *Spiophanes bombyx,* and the bivalve *Thyasira* sp. These species are all typical of a muddy or sandy-mud benthic habitat (JNCC 2015; George & Hatman-Schroder 1985).

The infauna which contribute most to the dissimilarity between group e and group j were found to correlate to depth and percentage of fine sediment (Table 9). Those which respond positively to both depth and fine sediment e.g. *Notomastus* sp. and *Amphiura chiajei* are present in the higher contributing species of group 'e', but absent in the contributory species of group 'j', and the opposite applicable – indicating the two assemblages are distinguished, at least in part, by depth and percentage of fines. Depth is often a proxy for other environmental variables such as temperature, salinity, nutrients, chlorophyll a, chlorophyll b and others. In future, collection of more extensive environmental parameters may provide further clarity into the community composition at EGM

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

4.3.1 Extent and distribution

The 2015 survey grab sampling and subsequent PSA results indicate a decrease in the known extent in Offshore subtidal sands and gravels (A5.2 Sublittoral sand and A5.4 Sublittoral mixed sediment, as equivalent) from predictive mapping in 2012. The A5.2 Sublittoral sand sediment is distributed in the north and north-west areas of the site (Figure 4 and Figure 1) (Appendix 23). The extent and distribution of the sublittoral mixed sediment is limited, being interspersed throughout the site so sparsely that it is not represented in the updated habitat map due to low confidence levels (Appendix 23) (Figure 4). The 'A5.15 deep-circalittoral coarse sediment' habitat, indicated in the predictive map prior to the 2015 survey (Figure 1), was absent from the 2015 survey results (Figure 4). However, the 1515S sampling design, although giving a good coverage of the site, may not have sufficiently sampled this particular area.

4.3.2 Physical and biological structure

The areas identified as A5.2 Sublittoral sand and A5.4 Sublittoral mixed sediments were generally associated with shallower regions of the site, relative to the areas defined as A5.3 Sublittoral mud (82 to 99 m for A5.2, and 92 to 97 m for A5.4). Infaunal cluster groups j, as well as f, g, h, i and k were most closely associated with A5.2 Sublittoral sand (Figure 10, Figure 13, Figure 15). Infaunal cluster group j was typified by *Amphiura filiformis* and *Spiophanes bombyx*. The infaunal communities of these groups are indicative of biota of muddy sand, or coarser sediments, such as the brittlestar, *A. filiformis* and polychaete, *S. armiger,* both shown to have a negative correlation with depth and fine sediment at the site (Table 9).

The Sublittoral mixed sediments showed the closest associations with infaunal cluster groups g, h and c, however, these were not strong associations. The infaunal clusters are typified by *A. filiformis* and *P. jeffreysii*, and similarly occurring species to the infaunal cluster groups of e and j. This may represent a transition, or simply that the species associated are versatile, and the gradient of change is not strong. Information on further environmental parameters, as noted above, may allow further interpretation, or conclude there is not a strong gradient of change. The relatively broad classification scale for sedimentary habitat employed may distort the separation of the three major infaunal assemblages, c, e and j, and they may be more accurately described as components of an infaunal community continuum.

4.4 Ocean quahog distribution

Ocean quahog were mainly found within the A5.2 Sublittoral sand habitats, although were also recorded in mud and mixed sediment (Figure 15, Figure 16). It may be postulated that ocean quahog exhibits some suitability to A5.2 Sublittoral sands at EGM, although conclusions cannot be made due to the low number of samples for the species. The presence of ocean quahog on Offshore subtidal sands and gravel habitats supports the designation of this habitat at EGM. The updated understanding of the extent and distribution of this habitat will aid any future monitoring efforts at EGM.

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 sampled in EGM, in comparison to mature specimens, this skew may be evident. 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 species 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 acknowledges that the large Hamon grab may not be the 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 favour box coring, dredging, or otherwise (Appendix 21). Dredging is likely to be too destructive for future monitoring of the protected features. Future monitoring efforts would more feasibly and valuably assess the habitats supporting the colonisation of ocean quahog, rather than targeting the species themselves. Visual survey proved ineffective in collecting information on ocean quahog*,* as no siphons of the species were observed.

4.5 Biotope classification

Although distinctions and differences between the main infaunal groups (c, e and j) exist, they can be broadly defined under the same biotope. This definition under the same biotope supports that the infaunal groups c, e and j may be part of a community continuum throughout EGM. “SS.SMu.OMu.PjefThyAfil” describes the community structure and habitat composition for groups c, e, and j, and also group i. Groups h and k were assigned the biotope of “SS.SSa.OSa.OfusAfil”, due to the absence of *P. jeffreysii* differentiating these groups. The assignment of biotopes is subjective and exact matches to biotope classifications are highly unlikely, reflected in none of the observed groups producing a perfect match to any of the biotope definitions

The biotopes identified during visual assessment of the video and stills data were adopted, described with “SS.SMu.CFiMu.SpnMeg”, “SS.SMu.CSaMu”, “SS.SMx.CMx”, and “SS.SMu.CSaMu.VirOphPmax”. These biotopes are not perfect matches, particularly with the adoption of ‘SS.SMu.CFiMu.SpnMeg’, accepted due to the high number of sea pens, rather than burrowing megafauna, at the site (Table 13). High densities of sea pen species, particularly *Pennatula phosphorea*, in the absence or low densities of burrowing megafauna were recorded at EGM. A biotope is proposed to describe the occurrence of sea pen species in the absence or low density of burrowing megafauna in offshore sand and mud habitats to capture the epifaunal composition evident at EGM.

4.6 Additional Priority Marine Features (PMF)

Taxa indicative of the ‘Burrowed mud’ broad habitat PMF, with the component biotope ‘sea pens and burrowing megafauna in circalittoral fine mud (SS.SMu.CFiMu,SpnMeg)’, and component species ‘Tall sea pen – *Funiculina quadrangularis*’ were observed in video and stills data attained from the 2015 survey of EGM.

Three sea pen species occurred throughout the site. *Pennatula phosphorea* is dominant throughout the site. In the western areas of the site, covered by sublittoral sands, *F. quadrangularis* were more abundant than *V. mirabilis*, whereas in sublittoral mud, *V. mirabilis* were more abundant than *F. quadrangularis* (Figure 20). In general, densities of *V. mirabilis* were higher than of *F. quadrangularis* throughout the site (Figure 20). Abundance of three species are correlated, in which increased abundance of *P. phosphorea*, negatively correlates to *F. quadrangularis* and *V. mirabilis*, whereas occurrence of *F. quadrangularis* and *V. mirabilis* are positively correlated – emphasising the dominance of *P. phosphorea.* The three sea pen assemblages were found to be similar, evident in the nMDS plot produced, all within 60% similarity: sedimentary broadscale habitat is not a strongly distinguishing driver of community composition (Appendix 19). The spatial distribution of the three species of sea pen is likely to be due to quite subtle differences in habitat preferences of each species. It is concluded that community structure cannot be reliably interpreted from relative sea pen abundances (Appendix 17, Appendix 18), so results and interpretations must be treated with caution.

The surrounding habitat of each of the 58 video tows was identified as 'burrowed mud' where seapens or burrows were present, however burrows were not identified in high densities across the video tows. More megafaunal burrows appeared in habitats identified as Sublittoral mud (A5.3) (Table 15, Figure 23). In the habitat identified as 'offshore deep-sea muds', sea pens (especially *V. mirabilis* and *P. phosphorea)* are commonly present in the same video tow and in immediate vicinity to burrows. *F. quadrangularis* was most commonly identified in Sublittoral sand habitat (A5.2), followed closely by Sublittoral mixed sediments (A5.4) (Table 15 and Figure 17). A lack of specificity in the assignment of the burrowed mud PMF makes the interpretation of results and the identification of the habitat difficult in MPAs. Further assessment of the number, size and density of burrows which is required to meet the assignment of burrowed mud would be useful for future monitoring and assessment of this feature, if it indeed exists in EGM.

5 Recommendations for future monitoring

5.1.1 Operational and sampling design

East of Gannet and Montrose Fields MPA is a site with spatial variability in habitat type across the site, and consequently, a variable community structure across these habitat types. The comprehensive grab sampling regime of the 1515S survey allowed for a comprehensive view of the sedimentary habitat and community structure and provided some observations of the epifauna at the site in video tow operations. Although these operations were largely successful, the following recommendations for future monitoring surveys are:

- a stratified monitoring design should be adopted to allow for a clearer distinction across the three habitat types. The 1515S survey has provided an updated understanding of the sedimentary habitat extent and distribution of EGM which can aid a stratified design;
- 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;
- further monitoring should aim to measure the environmental parameters at EGM, such as seabed temperature, salinity, chlorophyll a, chlorophyll b, organic carbon, oxygen and nutrients. Future monitoring surveys should be conducted at the same time of year to limit the influence of seasonal changes;
- From the low sampling success of ocean quahog, a $0.25m^2$ Hamon grab may not be the ideal sampling gear for assessment of the species population 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;
- the large Hamon grab proved effective in sampling the habitat supporting ocean quahog, as sediment samples were obtained from 155 of 156 visited stations. However, the report recommends that for future monitoring of EGM, 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 directly compared to previous results obtained with gears of the same sampling area. A gear comparison study could be used to improve understanding of sampling differences of infauna between a $0.25m^2$ and $0.1m^2$ Hamon grab.
- the scaling lasers on the camera systems used were unable to be seen in imagery, either due to the intensity of the lasers, or a malfunction of the components. Video footage provides valuable information in regard to the epifaunal communities at the site, and the ability to calculate field of view accurately and subsequently density of

epifaunal taxa and features, such as sea pens or megafaunal burrows. Camera footage should be tested before and reviewed during survey operations to ensure the data collected is suitable for analysis

5.1.2 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 collection 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 could be feasibly achieved. The collection of environmental parameters, such as temperature, salinity, organic carbon, water currents and turbidity may reveal further trends in the infaunal communities and any changes in sedimentary habitats. The rate of temporal change is poorly understood at the site, in regard to both the biological and physical structure at the site, so further monitoring at the site, or similarly designated habitats or features at other sites may indicate the temporal variability and rate of change to allow conservation objectives to be updated accordingly.
- Clarification is needed on the criteria and assignment of priority marine features: the designated features ‘Ocean quahog aggregations’ and ‘Offshore deep-sea muds’ do not have specific scientific criteria in order to assign the PMF. 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 habitats. It is advised that a depth, consistent with habitat classification is adopted, such as the over 200m depth being conserved ‘deep-sea’ as in the Marine Habitat Classification of Britain and Ireland (Parry *et al.* 2015). The ‘criteria for assignment of ‘burrowed mud’ is unclear, as the number, size and density of burrows is not stated in order to confidently classify the PMF. 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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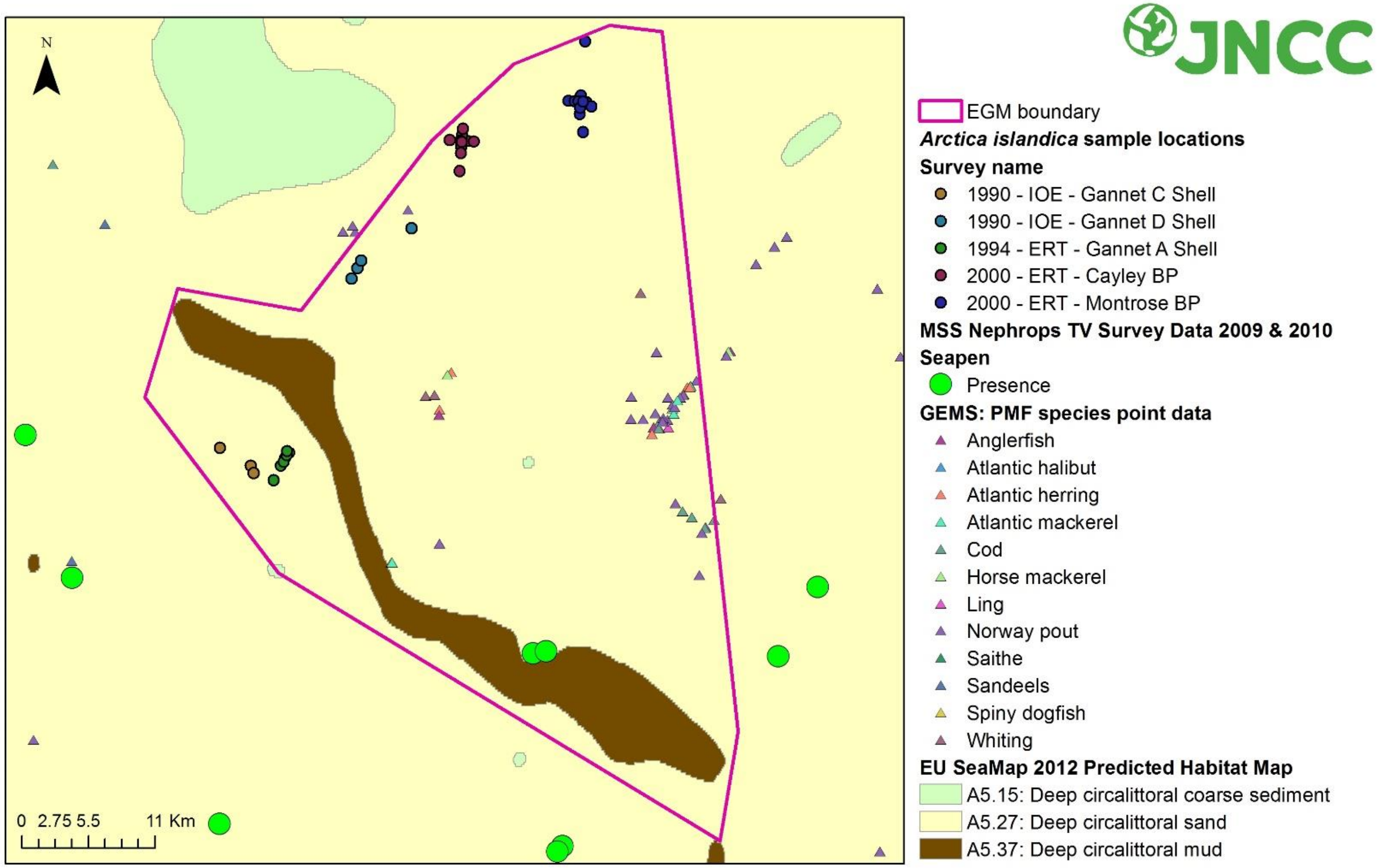
Appendices

Appendix 1: Habitat conversion table, allowing the conversion and comparison of the designation and identified habitats within East of Gannet and Montrose Fields MPA (Robson 2014).

Priority Marine Features (Scotland)	EUNIS Type 3	EUNIS Corresponding biotopes	EUNIS description
Offshore deep-sea muds	A5.3	A5.35	Circalittoral sandy mud
		A5.36	Circalittoral fine mud
		A5.37	Deep circalittoral mud
	A6.5	n/a	Deep-sea mud
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: Previous biological and physical data available for the EGM site.

Appendix 3: 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. Employing 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 (i.e. from species to genus level). In such cases, 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 EGM prior to 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 infaunal data collected at EGM 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' and algae were removed;
- fragmented fauna (recorded as 'present' only) were removed;
- unidentifiable fauna (e.g. Species B, unidentified faunal turf) were removed;
- colonial taxa (recorded as 'present' only) were also removed; in this instance the retention of colonial taxa in grab samples was very low, therefore these taxa were excluded from further analysis as part of the infaunal dataset.

Raw taxon-by-sample datasets often misrepresent the actual list of species present in a set of samples. This is typically due to identification issues, such as the presence of damaged fauna, under-developed juveniles, or species which are difficult to identify. Expert judgement was used to rationalise the remaining taxa, and to reduce the taxon list to reflect the actual species list as far as practicable, given the identification limitations. Total abundances of individual taxa were calculated to aid in assessing the impacts of retention or removal from the dataset. This information was used to inform a series of decisions on whether to merge lower resolution taxa (e.g. species) to a higher level in the taxonomic hierarchy (e.g. to genus or family), or to discard a higher resolution taxon from the dataset to avoid losing species-level information.

Appendix 4: Epifaunal data truncation protocol

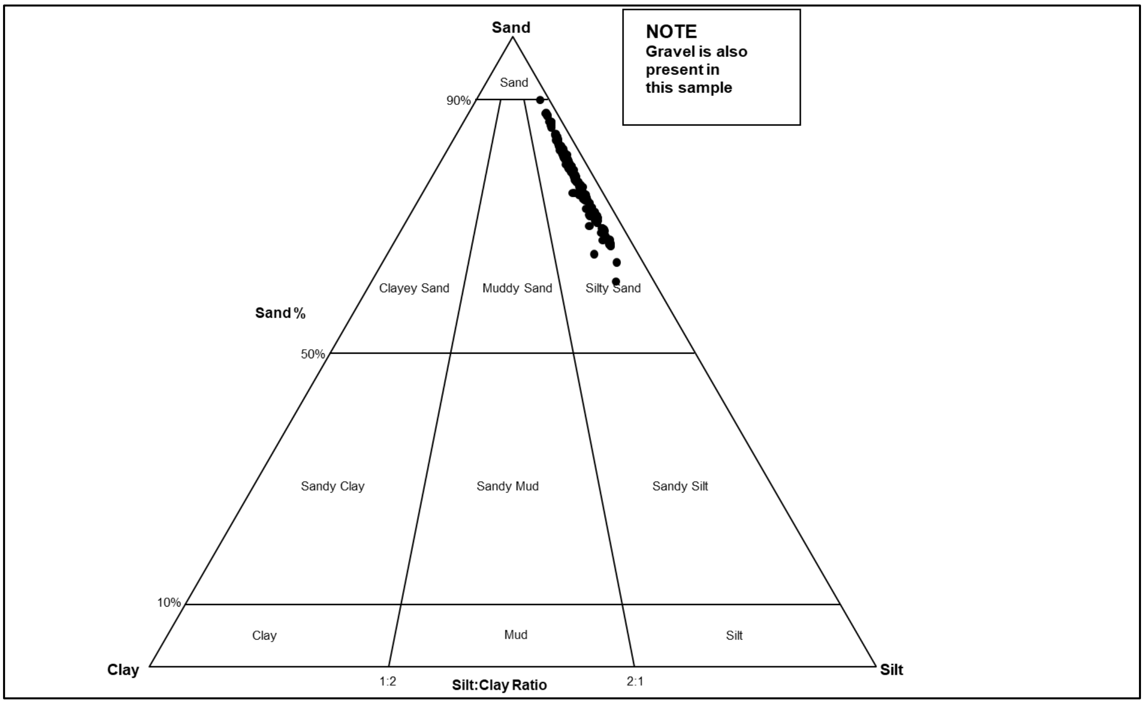
As described in Appendix 3, truncation serves to remove spurious entries and ensure the dataset being analysed is as robust as possible and an accurate representation of the faunal communities observed. Due to the nature of the imagery identification at EGM, a large number of identifications were made at a high taxonomic level. As such, the truncation carried out on epifaunal datasets was minimal.

Details of the data preparation and truncation protocols applied to the EGM epifaunal datasets pre-analysis are provided below:

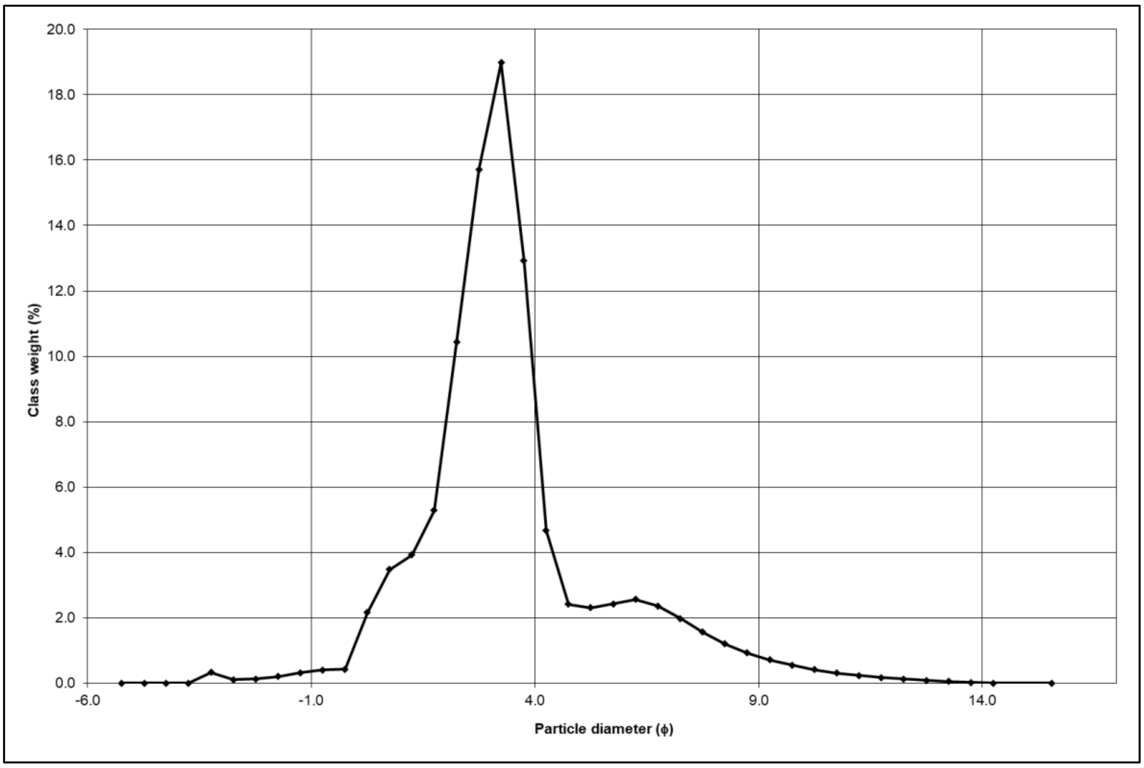
- records of fish and mobile species were removed;
- records of ‘eggs’ were removed;
- where recorded, meiofauna (i.e. nematodes) and fauna that cannot be accurately resolved from imagery at resolution were removed;
- unidentifiable fauna (e.g. Species B, unidentified faunal turf) were removed.

Appendix 5: 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).

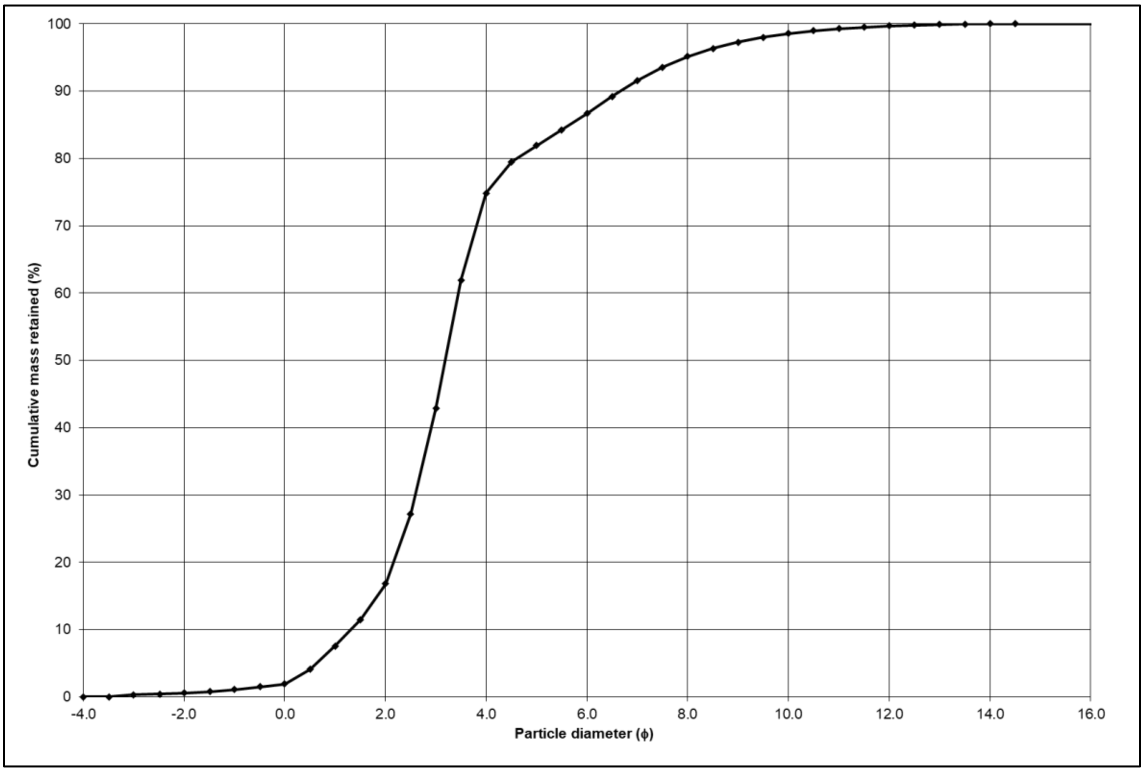
Species name	List	Species name	List
Acartia (Acanthacartia) tonsa	Present	*Alexandrium catenella*	Horizon
Amphibalanus amphitrite	Present	*Amphibalanus reticulatus*	Horizon
Asterocarpa humilis	Present	*Asterias amurensis*	Horizon
Bonnemaisonia hamifera	Present	*Caulerpa racemosa*	Horizon
Caprella mutica	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		



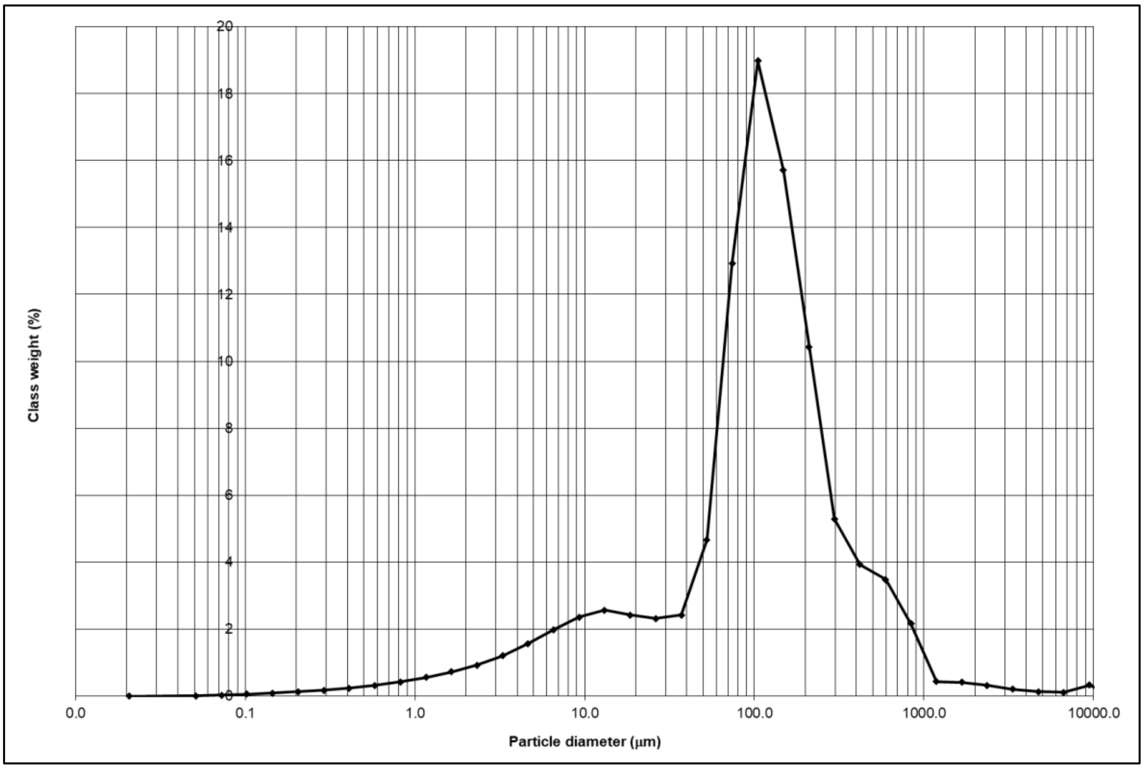
Appendix 6: Sand silt and clay diagram for EGM. Diagram generated through GRADISTAT.



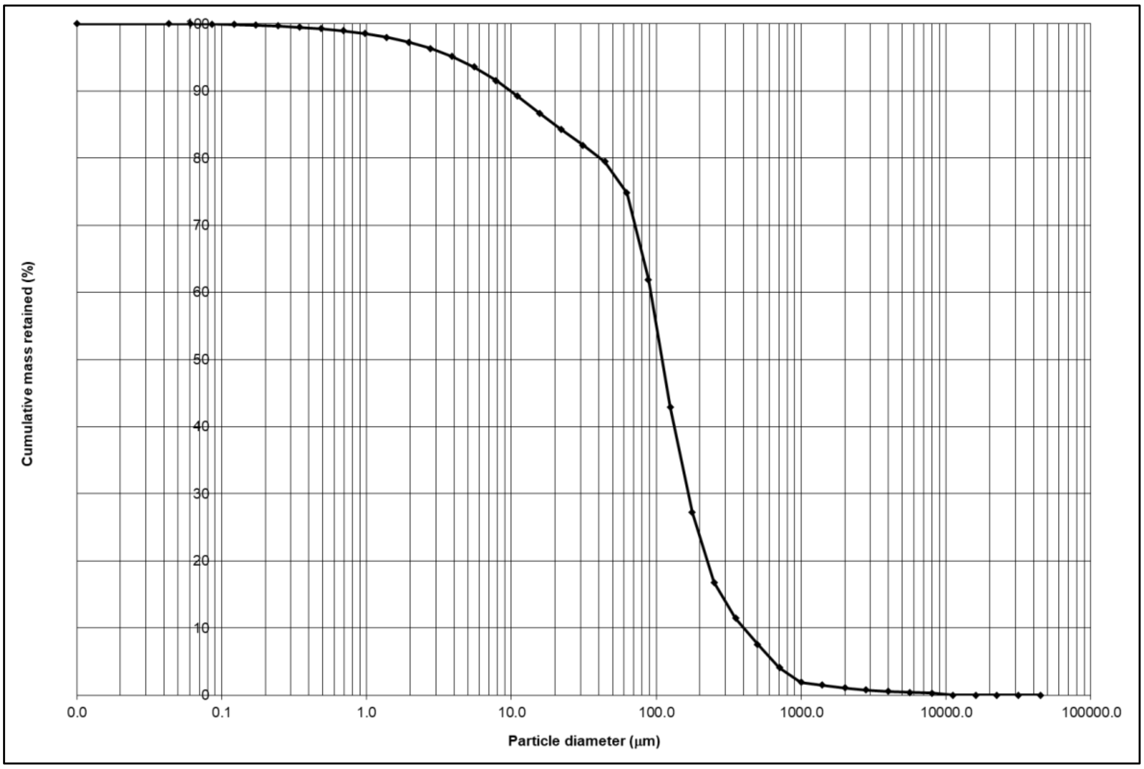
Appendix 7: Sediment particle size distribution (phi) for sampled grab stations of EGM. Graph generated through GRADISTAT.



Appendix 8: Cumulative distribution (phi) for the EGM grab samples. Graph generated through GRADISTAT.



Appendix 9: Sediment particle size distribution (microns) for sampled grab stations of EGM. Graph generated through GRADISTAT.



Appendix 10: Cumulative distribution (microns) for the EGM grab samples. Graph generated through GRADISTAT.

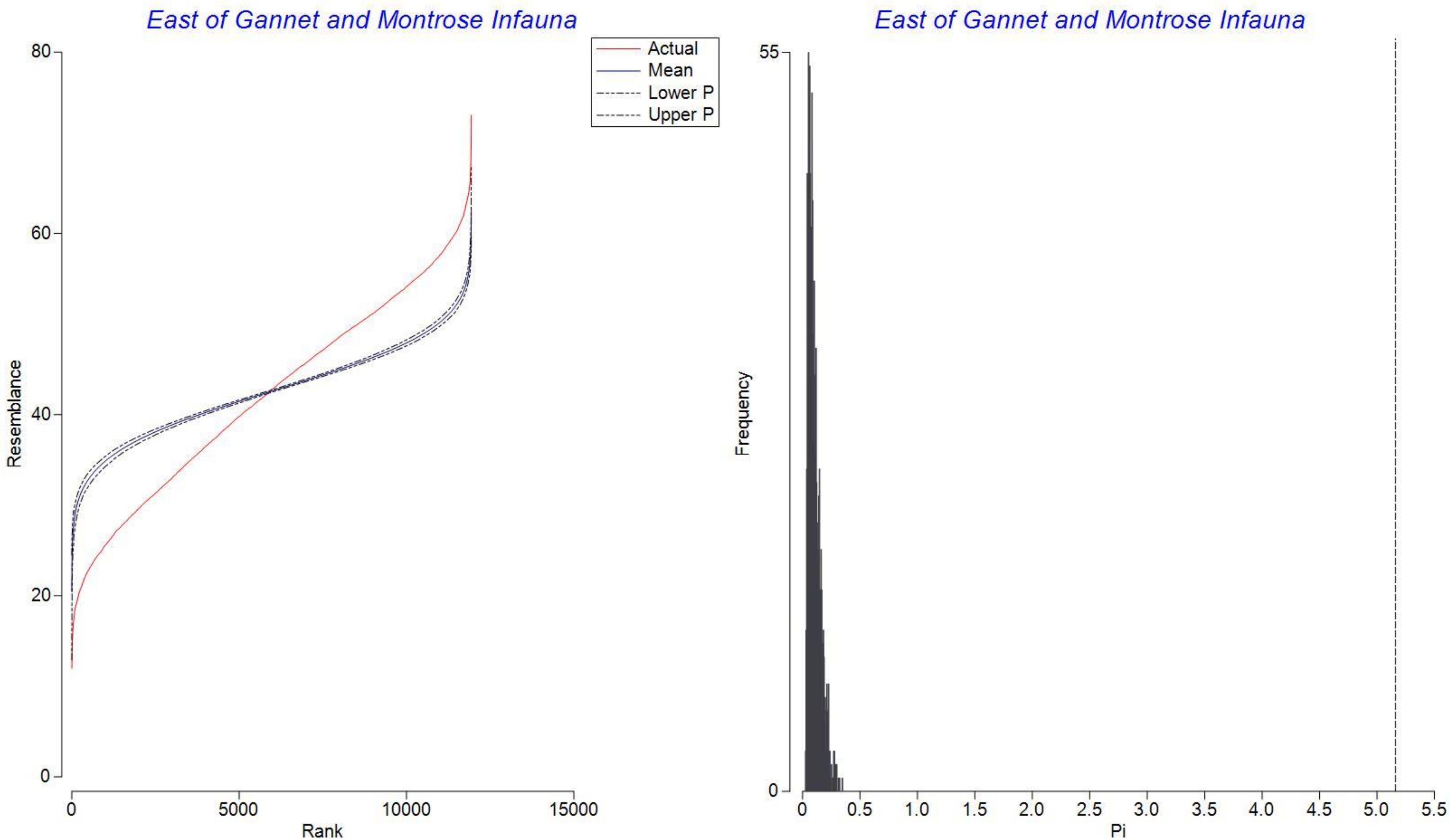
Appendix 11: Summary statistics of the infaunal analysis of EGM from grab sampling.

Station Number	*S*	*N*	*d*	*J'*	*H'(loge)*	*1-Lambda'*
1	44	134	8.779	0.871	3.296	0.951
2	31	83	6.789	0.834	2.863	0.914
3	38	91	8.202	0.904	3.289	0.960
4	44	197	8.139	0.802	3.033	0.915
5	30	77	6.676	0.892	3.034	0.945
6	53	201	9.805	0.870	3.452	0.951
7	34	81	7.509	0.913	3.221	0.960
8	37	133	7.361	0.827	2.986	0.927
9	43	127	8.670	0.845	3.180	0.945
10	42	98	8.942	0.928	3.468	0.968
12	45	142	8.878	0.854	3.252	0.943
13	43	119	8.788	0.884	3.323	0.956
14	44	165	8.422	0.856	3.241	0.948
15	44	121	8.966	0.861	3.258	0.946
16	41	158	7.901	0.803	2.981	0.912
17	48	183	9.022	0.813	3.147	0.930
18	36	90	7.778	0.900	3.226	0.951
19	26	62	6.057	0.898	2.926	0.942
20	37	121	7.507	0.824	2.977	0.922
21	49	217	8.922	0.809	3.147	0.915
22	45	168	8.587	0.831	3.162	0.936
23	40	133	7.975	0.859	3.169	0.941
24	33	89	7.129	0.862	3.015	0.939
25	33	97	6.995	0.890	3.113	0.950
26	38	167	7.229	0.796	2.895	0.901
27	43	115	8.852	0.868	3.266	0.948
28	42	132	8.397	0.811	3.030	0.912
29	32	75	7.180	0.885	3.068	0.942
30	37	117	7.560	0.834	3.012	0.919
31	44	138	8.727	0.891	3.373	0.958
32	39	129	7.819	0.878	3.215	0.948
33	32	102	6.703	0.843	2.921	0.922
34	30	112	6.146	0.829	2.818	0.915
35	32	92	6.856	0.885	3.067	0.939
36	41	134	8.167	0.841	3.125	0.933
37	41	142	8.071	0.832	3.090	0.933
38	42	226	7.564	0.790	2.951	0.912
39	58	225	10.524	0.833	3.382	0.947
40	37	159	7.102	0.863	3.118	0.940
41	47	211	8.595	0.847	3.261	0.942
42	34	162	6.486	0.813	2.868	0.915
43	41	146	8.026	0.796	2.957	0.909

44	48	176	9.090	0.805	3.115	0.910
45	47	264	8.250	0.835	3.216	0.944
46	50	159	9.667	0.861	3.367	0.952
47	44	149	8.593	0.854	3.231	0.943
48	44	169	8.382	0.827	3.129	0.924
49	38	128	7.626	0.798	2.901	0.900
50	38	157	7.318	0.821	2.988	0.919
51	50	203	9.222	0.742	2.901	0.876
52	34	188	6.302	0.797	2.809	0.899
53	60	279	10.477	0.846	3.466	0.949
54	59	328	10.012	0.750	3.057	0.906
55	35	120	7.102	0.850	3.022	0.930
56	35	111	7.219	0.817	2.906	0.918
57	55	271	9.639	0.832	3.336	0.942
58	45	157	8.702	0.878	3.341	0.956
59	46	209	8.423	0.820	3.139	0.925
60	42	99	8.923	0.871	3.255	0.944
61	51	174	9.692	0.810	3.183	0.928
62	52	201	9.617	0.792	3.129	0.926
63	33	115	6.744	0.797	2.786	0.898
64	35	119	7.114	0.825	2.935	0.914
65	51	172	9.713	0.859	3.379	0.952
66	37	173	6.986	0.873	3.151	0.947
67	55	143	10.881	0.881	3.530	0.963
68	49	216	8.930	0.811	3.158	0.925
69	50	237	8.961	0.767	3.000	0.898
70	30	100	6.297	0.852	2.897	0.927
71	43	156	8.317	0.817	3.072	0.927
72	33	109	6.821	0.822	2.873	0.915
73	54	265	9.499	0.810	3.231	0.934
74	48	238	8.589	0.782	3.027	0.922
75	50	335	8.428	0.673	2.633	0.807
76	54	263	9.512	0.834	3.326	0.943
77	42	165	8.030	0.802	2.996	0.913
78	48	184	9.013	0.824	3.190	0.935
79	49	228	8.841	0.808	3.144	0.932
80	32	164	6.079	0.833	2.888	0.925
81	43	182	8.071	0.823	3.096	0.934
82	45	232	8.078	0.776	2.954	0.915
83	43	189	8.013	0.850	3.197	0.944
84	51	154	9.927	0.841	3.308	0.937
85	58	347	9.745	0.746	3.028	0.896
86	51	308	8.726	0.771	3.033	0.892
87	52	198	9.644	0.794	3.139	0.925

88	40	211	7.287	0.780	2.877	0.910
89	46	172	8.742	0.777	2.976	0.905
90	33	170	6.231	0.753	2.631	0.874
91	39	122	7.910	0.830	3.040	0.926
92	30	118	6.079	0.825	2.807	0.914
93	59	273	10.340	0.786	3.203	0.930
94	31	148	6.003	0.804	2.761	0.910
95	42	178	7.912	0.827	3.093	0.930
96	71	329	12.077	0.780	3.324	0.927
97	64	383	10.592	0.749	3.117	0.921
98	35	136	6.921	0.816	2.902	0.921
99	29	111	5.945	0.821	2.765	0.918
100	45	174	8.529	0.864	3.291	0.950
101	40	234	7.149	0.770	2.841	0.902
102	45	154	8.735	0.861	3.277	0.949
103	45	183	8.446	0.836	3.182	0.938
104	48	210	8.790	0.828	3.204	0.940
105	58	289	10.059	0.786	3.192	0.927
106	57	219	10.391	0.833	3.366	0.939
107	55	266	9.671	0.785	3.146	0.906
108	33	119	6.696	0.849	2.968	0.935
109	32	147	6.212	0.864	2.994	0.931
110	44	180	8.280	0.721	2.727	0.853
111	44	220	7.972	0.798	3.022	0.905
112	39	134	7.759	0.843	3.089	0.936
113	46	220	8.343	0.822	3.148	0.934
114	66	321	11.262	0.819	3.433	0.947
115	45	248	7.981	0.717	2.729	0.839
116	55	278	9.596	0.727	2.913	0.866
117	41	123	8.312	0.847	3.145	0.943
118	42	194	7.783	0.802	2.999	0.924
119	51	198	9.455	0.814	3.200	0.939
120	47	228	8.472	0.796	3.064	0.926
121	57	247	10.164	0.796	3.216	0.922
122	47	185	8.812	0.818	3.151	0.929
123	47	216	8.558	0.808	3.112	0.922
124	48	109	10.018	0.910	3.522	0.969
125	54	213	9.886	0.799	3.189	0.931
126	43	123	8.728	0.918	3.452	0.966
127	43	178	8.105	0.858	3.228	0.949
128	42	194	7.783	0.819	3.062	0.925
129	37	149	7.194	0.861	3.109	0.945
130	55	185	10.344	0.851	3.411	0.950
131	43	224	7.761	0.794	2.985	0.920

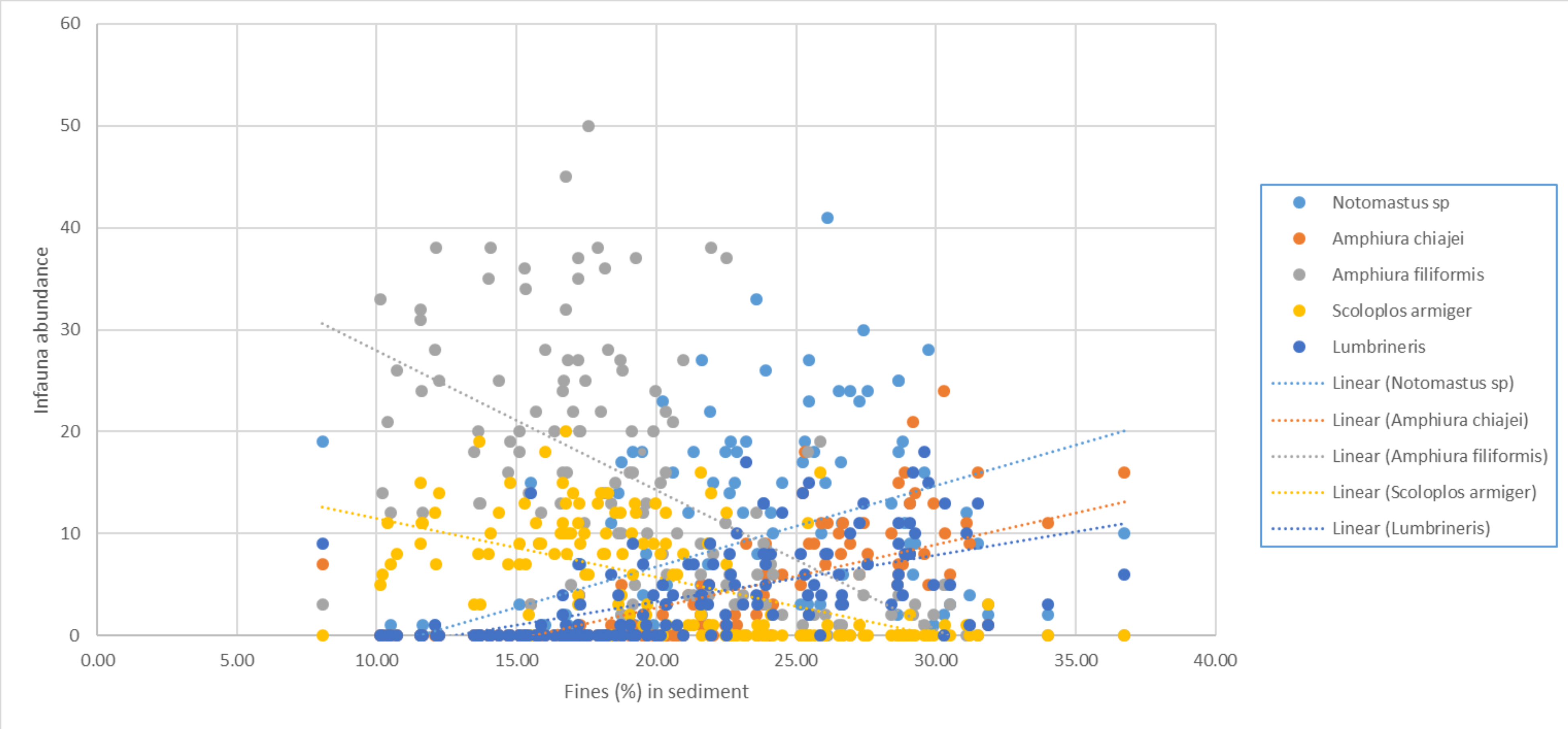
132	52	203	9.599	0.859	3.395	0.953
133	55	258	9.725	0.801	3.211	0.921
134	54	264	9.505	0.787	3.141	0.912
135	24	68	5.451	0.845	2.685	0.909
136	49	193	9.121	0.775	3.016	0.901
137	32	89	6.906	0.904	3.134	0.953
138	31	119	6.277	0.863	2.962	0.933
139	46	215	8.379	0.839	3.210	0.949
140	53	263	9.332	0.760	3.019	0.895
141	38	202	6.970	0.825	3.000	0.934
142	53	257	9.371	0.807	3.205	0.937
143	58	315	9.909	0.814	3.305	0.933
144	39	157	7.515	0.819	2.999	0.923
145	30	81	6.599	0.875	2.976	0.939
146	29	65	6.708	0.930	3.130	0.960
147	45	218	8.172	0.801	3.051	0.913
148	46	166	8.803	0.845	3.234	0.937
149	40	153	7.753	0.848	3.127	0.930
150	47	194	8.732	0.715	2.751	0.835
151	52	173	9.897	0.842	3.325	0.946
152	41	163	7.853	0.864	3.207	0.948
153	35	102	7.351	0.907	3.225	0.958
154	45	162	8.648	0.805	3.065	0.912
155	39	166	7.434	0.823	3.014	0.932
156	37	115	7.587	0.896	3.237	0.953



Appendix 12: Results of the SIMPROF analysis to determine the structure of the infaunal resemblance data from the 1515S survey of EGM (2015). Global test statistics (π 5.16, p<0.001) at 999 permutations.

Appendix 13: Correlation table for the available measured environmental variables recorded in the 2015 survey of EGM. Highlighted fields with red have a correlation >90%, those highlighted in orange have a statistical correlation between 80-89.99%. For the purposes of this report, and the testing of variables it was determined that those sharing a >90% in which one would be selected on the basis of ecological sensibility to the site, as a representation of those variables.

EGM Enviromental Factors	Lat	Long	BSH	Gravel	Sand	Fines	Water Depth (m)	SurfaceSAR AVG	Subsurface AVG	KWfishingH AVG	% 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:	MEAN	SORTING	SKEWNES	KURTOSIS	Mode 1
Lat																															
Long	47.10																														
BSH	77.42	47.74																													
Gravel	56.77	40.00	53.55																												
Sand	25.16	53.55	9.03	38.71																											
Fines	74.84	50.32	92.26	54.84	6.45																										
Water Depth (m)	74.34	47.37	80.26	51.32	23.03	78.29																									
SurfaceSAR AVG	67.10	50.32	69.03	65.16	23.23	76.77	68.42																								
Subsurface AVG	63.87	50.97	67.10	67.10	25.16	74.84	67.76	96.77																							
KWfishingH AVG	65.81	50.32	67.74	65.16	24.52	75.48	67.11	98.71	98.06																						
% V COARSE GRAVEL:	48.39	45.81	46.45	81.29	45.81	54.19	45.39	74.84	78.06	76.13																					
% COARSE GRAVEL:	50.32	42.58	49.68	85.81	43.87	53.55	46.05	70.32	73.55	71.61	92.90																				
% MEDIUM GRAVEL:	54.84	38.06	51.61	89.03	41.94	51.61	51.97	63.23	65.16	63.23	75.48	77.42																			
% FINE GRAVEL:	58.06	40.00	57.42	88.39	38.71	54.84	53.95	61.29	61.94	61.29	74.84	76.77	78.71																		
% V FINE GRAVEL:	58.71	41.94	55.48	94.19	38.06	55.48	53.29	64.52	66.45	64.52	79.35	81.29	85.81	91.61																	
% V COARSE SAND:	60.65	38.71	58.71	89.68	36.13	58.71	57.24	66.45	68.39	66.45	80.00	81.94	86.45	85.81	92.90																
% COARSE SAND:	67.10	51.61	60.00	62.58	41.29	61.29	55.26	58.71	59.35	58.71	60.65	62.58	61.94	62.58	65.81	70.32															
% MEDIUM SAND:	50.97	47.10	41.29	55.48	57.42	46.45	41.45	52.90	54.84	54.19	62.58	61.94	56.13	52.90	54.84	59.35	78.71														
% FINE SAND:	26.45	50.97	14.19	43.87	88.39	9.03	19.08	24.52	25.16	25.81	45.81	45.16	45.81	45.16	43.23	40.00	33.55	49.68													
% V FINE SAND:	68.39	52.90	83.23	49.68	15.48	88.39	80.92	76.77	77.42	76.77	58.06	53.55	47.74	49.68	50.32	53.55	57.42	45.16	10.32												
% V COARSE SILT:	74.84	50.32	85.81	56.13	11.61	92.26	80.92	83.23	81.29	81.94	60.65	57.42	54.19	54.84	56.77	60.00	58.71	46.45	9.03	90.97											
% COARSE SILT:	73.55	50.32	84.52	57.42	12.90	88.39	72.37	80.65	77.42	79.35	58.06	56.13	58.06	58.71	59.35	62.58	61.29	45.16	16.77	80.65	88.39										
% MEDIUM SILT:	76.13	52.90	93.55	50.97	10.32	94.84	76.32	71.61	69.68	70.32	49.03	48.39	47.74	54.84	52.90	54.84	60.00	45.16	12.90	83.23	87.10	85.81									
% FINE SILT:	71.61	50.97	86.45	49.03	17.42	87.74	74.34	69.68	69.03	68.39	49.68	49.03	48.39	51.61	50.97	55.48	58.06	41.94	17.42	82.58	80.00	77.42	91.61								
% V FINE SILT:	71.61	49.68	83.87	50.32	17.42	87.74	73.68	70.97	70.32	69.68	52.26	50.32	49.68	50.32	50.97	55.48	58.06	44.52	17.42	82.58	80.00	76.13	89.03	97.42							
% CLAY:	70.97	52.90	87.10	52.26	12.90	88.39	75.00	71.61	70.97	70.32	51.61	49.68	49.03	54.84	54.19	57.42	56.13	38.71	18.06	83.23	81.94	79.35	89.68	91.61	89.03						
MEAN	67.10	51.61	84.52	47.10	15.48	88.39	78.29	74.19	72.26	72.90	52.90	48.39	46.45	49.68	47.74	50.97	50.97	36.13	18.06	89.68	87.10	80.65	84.52	86.45	86.45	89.68					
SORTING	69.68	42.58	71.61	71.61	32.26	67.74	61.84	57.42	58.06	57.42	59.35	63.87	70.97	71.61	73.55	76.77	76.77	64.52	33.55	58.71	61.29	62.58	71.61	67.10	65.81	65.16	57.42				
SKEWNESS	25.16	53.55	23.23	30.97	78.06	23.23	31.58	32.26	34.19	33.55	48.39	42.58	30.32	32.26	29.03	29.68	30.97	47.10	75.48	32.26	28.39	24.52	25.81	31.61	32.90	30.97	34.84	21.94			
KURTOSIS	20.00	50.97	11.61	52.90	84.52	15.48	25.00	37.42	40.65	38.71	61.29	58.06	52.26	46.45	50.97	47.74	36.13	53.55	80.65	23.23	23.23	21.94	10.32	13.55	16.13	18.06	21.94	24.52	76.77		
Mode 1	67.10	49.03	70.32	67.74	21.94	78.06	69.74	90.97	92.90	92.26	76.13	71.61	65.81	62.58	67.10	70.32	60.00	51.61	21.94	81.94	84.52	80.65	72.90	70.97	72.26	75.48	76.77	60.00	29.68	37.42	



Appendix 14: Correlation of the abundance of taxa contributing the most to the dissimilarity between infaunal cluster groups e and j against percentage of fine sediment in the sampling from the 1515S survey of Est of Gannet and Montrose Fields MPA (2015). The Pearson's Correlation lines are shown in the corresponding colour of the taxa abundance markers and indicate a positive or negative correlation dependant on orientation.

Appendix 15: Table shows the number of ocean quahog obtained from 155 grab sample stations.

Station ID	Ocean quahog – *adults*	Ocean quahog - juveniles	*Arctica islandica* Returned to sea	Total Count
EGM001 009 64068	-	2		2
EGM002 001 64069	-	-	1	1
EGM003 010 64070	-	-		0
EGM004 004 64071	-	2		2
EGM005 002 64072	-	-		0
EGM006 011 64073	-	-		0
EGM007 008 64074	-	-		0
EGM008 003 64075	-	1		1
EGM009 005 64076	-	-		0
EGM010 012 64077	-	-		0
EGM011 007 64078	-	-		0
EGM012 056 64079	1	-		1
EGM013 006 64080	-	1		1
EGM014 055 64081	-	-		0
EGM015 074 64082	-	1		1
EGM016 111 64083	1	-		1
EGM017 013 64084	-	-		0
EGM018 057 64085	-	3	1	4
EGM019 075 64086	-	-		0
EGM020 093 64087	-	-		0
EGM021 112 64088	-	-		0
EGM022 054 64089	-	-		0
EGM023 073 64090	-	-	3	3
EGM024 092 64091	-	-		0
EGM025 110 64092	-	1		1
EGM026 126 64093	-	-		0
EGM027 038 64094	1	1		2
EGM028 058 64095	-	-	1	1
EGM029 076 64096	-	-		0

EGM030 094 64097	-	-		0
EGM031 113 64098	1	2		3
EGM032 127 64099	-	-		0
EGM033 014 64100	1	1		2
EGM034 053 64101	-	-		0
EGM035 072 64102	-	-		0
EGM036 091 64103	-	-		0
EGM037 109 64104	-	-		0
EGM038 125 64105	-	3		3
EGM039 141 64106	-	-		0
EGM040 039 64107	3	-		3
EGM041 077 64108	-	-		0
EGM042 095 64109	-	-		0
EGM043 114 64110	-	1		1
EGM044 128 64111	-	3		3
EGM045 052 64112	-	-		0
EGM046 071 64113	-	-		0
EGM047 090 64114	-	1		1
EGM048 108 64115	1	-		1
EGM049 124 64116	-	1		1
EGM050 140 64117	-	-		0
EGM051 015 64118	-	1		1
EGM052 059 64119	-	-		0
EGM053 078 64120	-	-		0
EGM054 096 64121	1	1		2
EGM055 129 64122	-	-		0
EGM056 142 64123	-	1		1
EGM057 037 64124	-	-		0
EGM058 051 64125	-	-		0
EGM059 070 64126	-	-		0
EGM060 089 64127	-	-		0
EGM061 107 64128	-	-		0

EGM062 123 64129	-	-		0
EGM063 139 64130	-	-		0
EGM064 149 64131	1	-		1
EGM065 016 64132	-	-		0
EGM066 040 64133	-	-		0
EGM067 060 64134	-	-		0
EGM068 079 64135	-	-		0
EGM069 097 64136	-	-		0
EGM070 115 64137	-	-		0
EGM071 130 64138	-	-	1	1
EGM072 150 64139	-	-	2	2
EGM073 036 64140	-	-		0
EGM074 050 64141	-	-		0
EGM075 069 64142	-	-		0
EGM076 088 64143	-	-		0
EGM077 106 64144	-	2		2
EGM078 122 64145	1	-		1
EGM079 138 64146	-	1		1
EGM080 148 64147	1	3		4
EGM081 017 64148	-	-		0
EGM082 041 64149	-	-		0
EGM083 061 64150	-	-		0
EGM084 080 64151	-	-		0
EGM085 098 64152	-	-		0
EGM086 116 64153	-	-		0
EGM087 131 64154	-	1		1
EGM088 143 64155	1	-	1	2
EGM089 151 64156	1	1		2
EGM090 018 64157	-	-		0
EGM091 035 64158	-	-	1	1
EGM092 049 64159	-	-		0
EGM093 068 64160	-	-		0

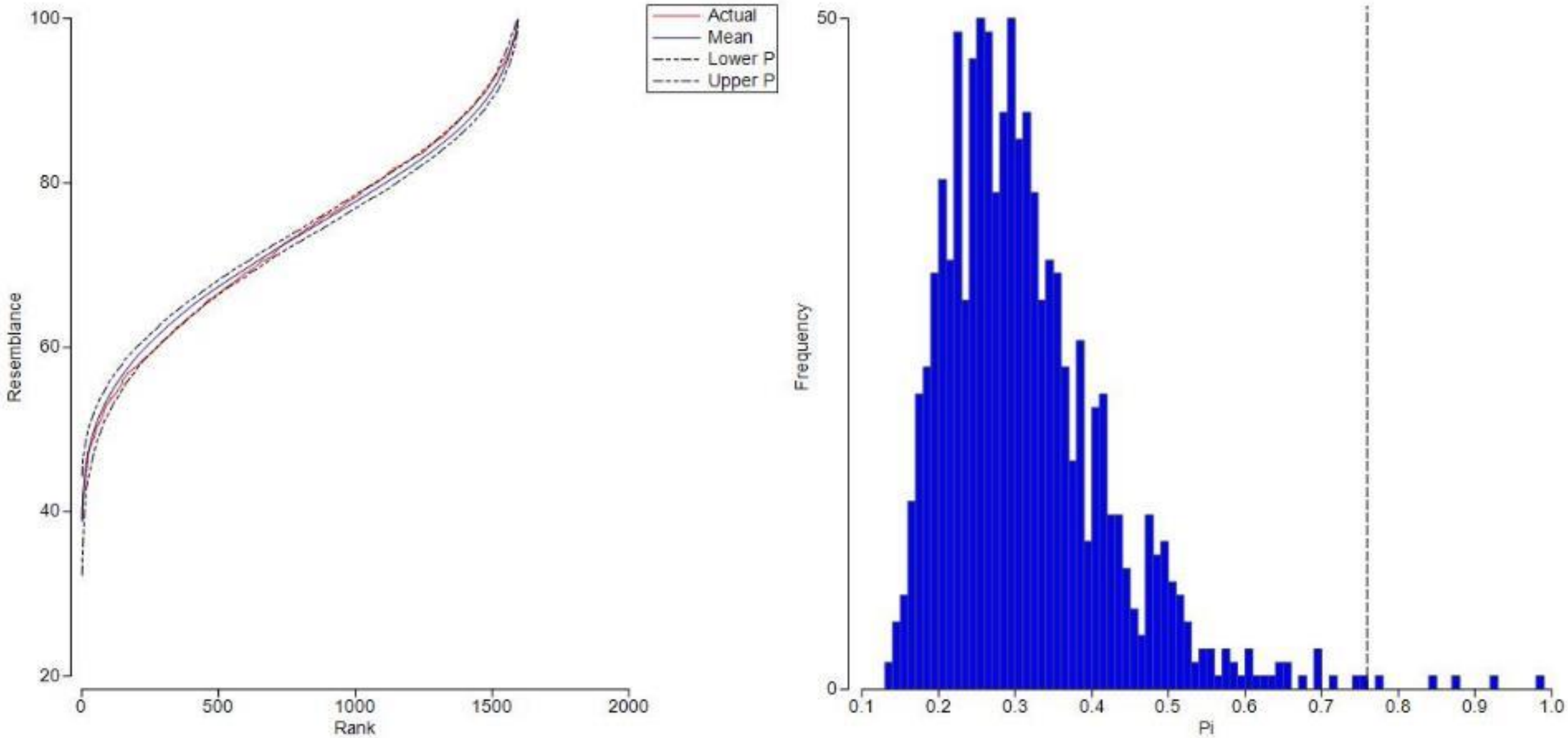
EGM094 087 64161	-	-		0
EGM095 105 64162	-	-		0
EGM096 121 64163	-	-		0
EGM097 137 64164	-	1		1
EGM098 019 64165	-	-		0
EGM099 031 64166	-	-		0
EGM100 042 64167	-	-		0
EGM101 062 64168	-	-		0
EGM102 081 64169	-	-		0
EGM103 099 64170	-	-		0
EGM104 117 64171	-	-		0
EGM105 132 64172	-	-		0
EGM106 144 64173	-	-		0
EGM107 152 64174	-	-		0
EGM108 028 64175	-	-		0
EGM109 034 64176	-	-		0
EGM110 048 64177	-	1		1
EGM111 086 64178	-	-		0
EGM112 104 64179	-	-		0
EGM113 120 64180	-	-		0
EGM114 136 64181	-	-		0
EGM115 147 64182	-	-		0
EGM116 156 64183	1	-		1
EGM117 020 64184	-	-		0
EGM118 043 64185	-	-		0
EGM119 063 64186	-	-		0
EGM120 082 64187	-	1		1
EGM121 100 64188	-	-		0
EGM122 118 64189	-	-		0
EGM123 133 64190	-	-		0
EGM124 145 64191	-	-		0
EGM125 153 64192	-	-		0

EGM126 021 64193	-	-		0
EGM127 027 64194	-	-		0
EGM128 033 64195	-	-		0
EGM129 047 64196	-	-		0
EGM130 067 64197	-	-		0
EGM131 085 64198	-	-		0
EGM132 103 64199	-	-		0
EGM133 119 64200	-	1		1
EGM134 135 64201	-	-		0
EGM135 146 64202	1	-		1
EGM136 155 64203	-	-	1	1
EGM137 022 64204	-	-		0
EGM138 030 64205	-	-		0
EGM139 044 64206	-	-		0
EGM140 064 64207	-	-		0
EGM141 083 64208	-	-		0
EGM142 101 64209	-	-		0
EGM143 134 64210	-	-		0
EGM144 154 64211	-	-		0
EGM145 024 64212	-	-		0
EGM146 026 64213	-	-		0
EGM147 032 64214	-	-		0
EGM148 046 64215	-	-		0
EGM149 066 64216	-	-		0
EGM150 084 64217	-	-		0
EGM151 102 64218	-	-		0
EGM152 023 64219	-	-		0
EGM153 029 64220	-	-		0
EGM154 045 64221	-	-		0
EGM155 065 64222	-	-	1	1
EGM156 025 64223	-	-		0
Totals	**17**	**39**	**13**	**69**

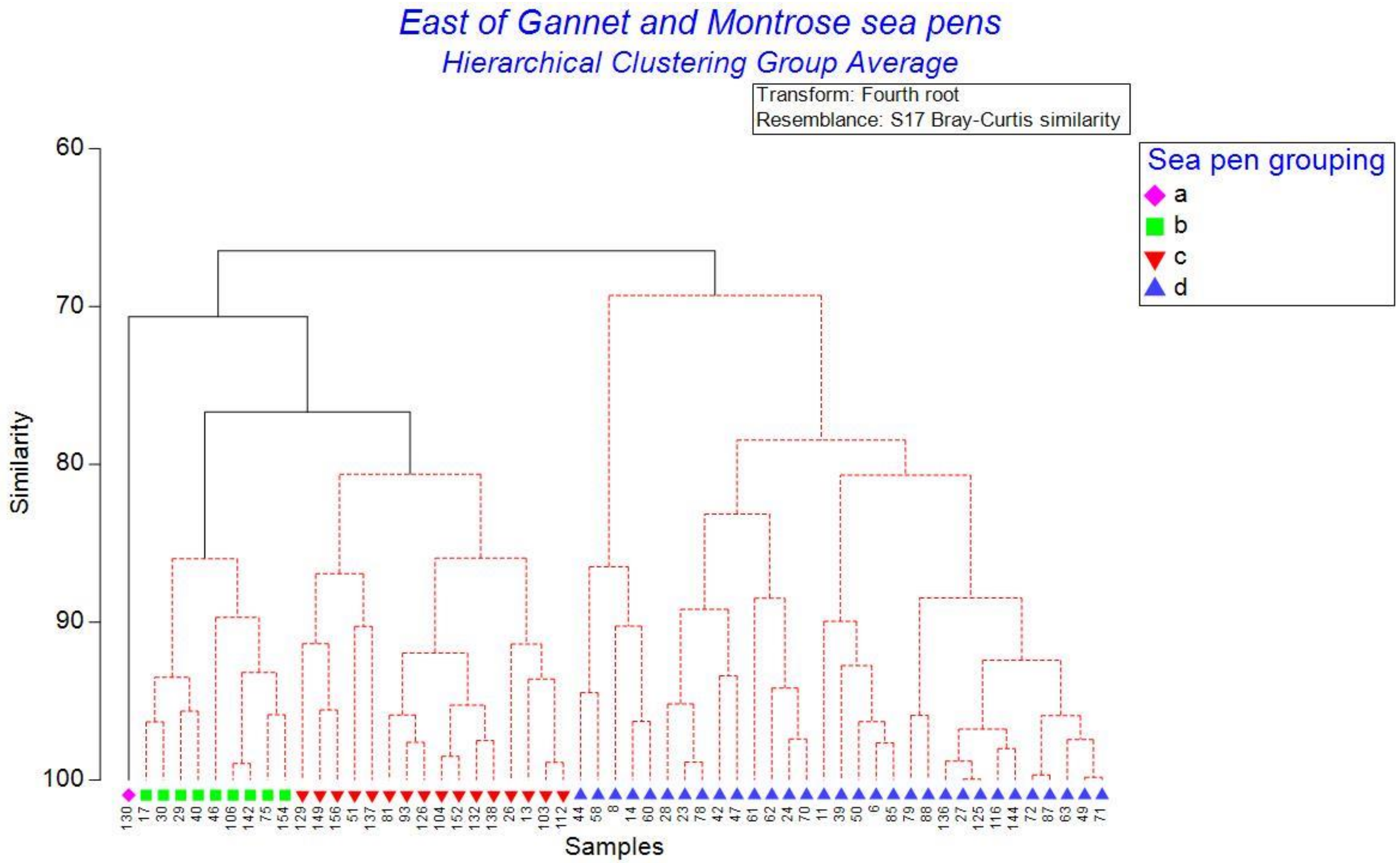
Appendix 16: Sea pen and burrowing megafauna counts, and relative abundance based on counts from 58 video tows taken during survey of East of Gannet and Montrose Fields MPA (2015).

Station Number	*Virgularia mirabilis* counts	*Pennatula phosphorea* counts	*Funiculina quadrangularis* Counts	Number of sea pen lying flat	Number of broken sea pen	Sea pen - Condition (Fouling - none, lightly, heavily) 1-3	Number of burrows	*Arctica islandica* siphons	Length (derived from stills locations)	*Virgularia mirabilis* per metre of tow	*Pennatula phosphorea* per metre of tow	*Funiculina quadrangularis* per metre of tow	Number of sea pen lying flat per metre of tow	Number of broken sea pen per metre of tow	Condition (Fouling - none, lightly, heavily) 1-3	Number of burrows per metre of tow
6	3	831	0	9	0	1	0	0	361	0.00831	2.301939	0	0.024931	0	0.00277	0
8	0	52	0	0	0	1	0	0	281	0	0.185053	0	0	0	0.003559	0
11	33	609	0	1	0	1	0	0	291	0.113402	2.092784	0	0.003436	0	0.003436	0
13	170	479	0	1	0	1	0	0	393	0.43257	1.21883	0	0.002545	0	0.002545	0
14	0	98	0	0	0	1	1	0	269	0	0.364312	0	0	0	0.003717	0.003717
17	2	335	2	1	0	1	1	0	382	0.005236	0.876963	0.005236	0.002618	0	0.002618	0.002618
23	1	1495	3	0	0	1	0	0	378	0.002646	3.955026	0.007937	0	0	0.002646	0
24	0	560	7	0	2	1	0	0	355	0	1.577465	0.019718	0	0.005634	0.002817	0
26	99	351	1	0	0	1	0	0	392	0.252551	0.895408	0.002551	0	0	0.002551	0
27	0	1462	0	0	0	1	0	0	350	0	4.177143	0	0	0	0.002857	0
28	2	1720	1	0	0	1	0	0	261	0.007663	6.590038	0.003831	0	0	0.003831	0
29	3	668	5	11	2	1	0	0	254	0.011811	2.629921	0.019685	0.043307	0.007874	0.003937	0
30	2	472	3	2	1	1	0	0	247	0.008097	1.910931	0.012146	0.008097	0.004049	0.004049	0
39	5	433	0	1	0	1	0	0	314	0.015924	1.378981	0	0.003185	0	0.003185	0
40	2	809	2	1	0	1	0	0	296	0.006757	2.733108	0.006757	0.003378	0	0.003378	0
42	0	1319	4	1	0	1	0	0	263	0	5.015209	0.015209	0.003802	0	0.003802	0
44	0	326	0	0	0	1	0	0	353	0	0.923513	0	0	0	0.002833	0
46	1	235	1	2	1	1	3	0	282	0.003546	0.833333	0.003546	0.007092	0.003546	0.003546	0.010638
47	0	1813	15	4	1	1	0	0	293	0	6.187713	0.051195	0.013652	0.003413	0.003413	0
49	0	692	0	4	0	1	0	0	258	0	2.682171	0	0.015504	0	0.003876	0
50	1	681	0	0	0	1	0	0	324	0.003086	2.101852	0	0	0	0.003086	0
51	2	238	0	4	0	1	0	0	299	0.006689	0.795987	0	0.013378	0	0.003344	0
58	0	209	0	3	0	1	9	0	343	0	0.609329	0	0.008746	0	0.002915	0.026239
60	0	132	0	0	0	1	2	0	285	0	0.463158	0	0	0	0.003509	0.007018
61	0	376	27	0	5	1	0	0	282	0	1.333333	0.095745	0	0.01773	0.003546	0
62	0	659	1	1	0	1	0	0	276	0	2.387681	0.003623	0.003623	0	0.003623	0
63	0	568	0	4	0	1	0	0	364	0	1.56044	0	0.010989	0	0.002747	0
70	0	702	6	1	4	1	0	0	326	0	2.153374	0.018405	0.003067	0.01227	0.003067	0
71	0	702	0	1	0	1	0	0	388	0	1.809278	0	0.002577	0	0.002577	0
72	0	914	0	1	0	1	0	0	283	0	3.229682	0	0.003534	0	0.003534	0
75	11	216	2	1	1	1	0	0	256	0.042969	0.84375	0.007813	0.003906	0.003906	0.003906	0
78	1	1319	3	0	1	1	0	0	269	0.003717	4.903346	0.011152	0	0.003717	0.003717	0
79	0	2163	0	0	0	1	0	0	337	0	6.418398	0	0	0	0.002967	0
81	51	95	0	0	0	1	20	0	383	0.133159	0.248042	0	0	0	0.002611	0.052219
85	3	656	0	0	0	1	0	0	341	0.008798	1.923754	0	0	0	0.002933	0

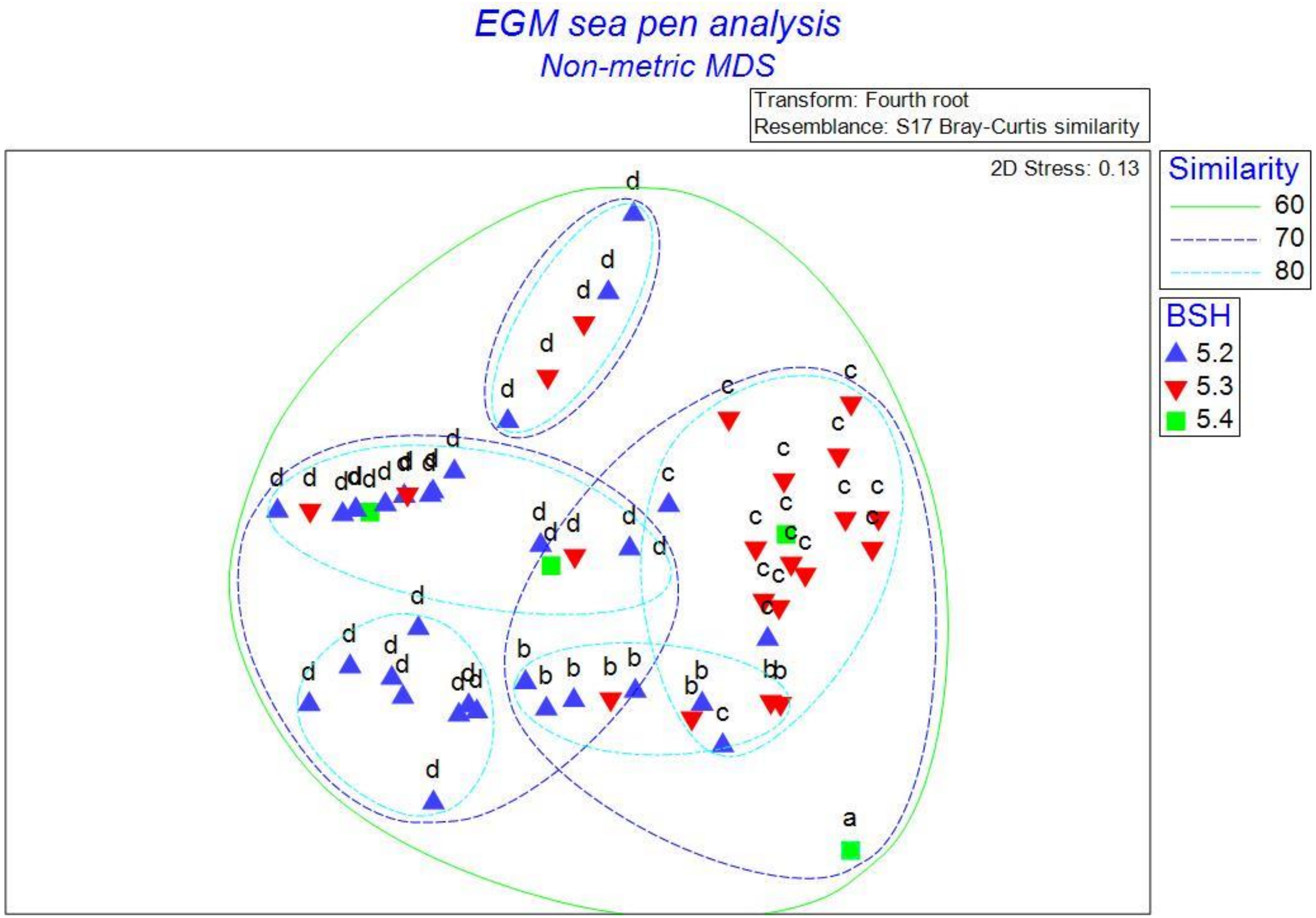
87	0	891	0	1	0	1	0	0	304	0	2.930921	0	0.003289	0	0.003289	0
88	0	3003	0	0	0	1	0	0	369	0	8.138211	0	0	0	0.00271	0
93	28	97	0	0	0	1	9	0	379	0.073879	0.255937	0	0	0	0.002639	0.023747
103	81	340	0	1	0	1	17	0	326	0.248466	1.042945	0	0.003067	0	0.003067	0.052147
104	46	209	0	0	0	1	8	0	289	0.15917	0.723183	0	0	0	0.00346	0.027682
106	10	119	1	1	0	1	0	0	375	0.026667	0.317333	0.002667	0.002667	0	0.002667	0
112	90	314	0	0	0	1	13	0	322	0.279503	0.975155	0	0	0	0.003106	0.040373
116	0	1266	0	1	0	1	0	0	314	0	4.031847	0	0.003185	0	0.003185	0
125	0	1470	0	2	0	1	0	0	351	0	4.188034	0	0.005698	0	0.002849	0
126	30	73	0	0	0	1	7	0	303	0.09901	0.240924	0	0	0	0.0033	0.023102
129	4	43	0	0	0	1	16	0	350	0.011429	0.122857	0	0	0	0.002857	0.045714
130	3	9	27	0	9	1	0	0	328	0.009146	0.027439	0.082317	0	0.027439	0.003049	0
130	165	122	44	0	8	1	5	0	328	0.503049	0.371951	0.134146	0	0.02439	0.003049	0.015244
132	23	224	0	1	0	1	5	0	304	0.075658	0.736842	0	0.003289	0	0.003289	0.016447
136	0	1613	0	1	0	1	0	0	313	0	5.153355	0	0.003195	0	0.003195	0
137	1	106	0	0	0	1	21	0	235	0.004255	0.451064	0	0	0	0.004255	0.089362
138	25	171	0	0	0	1	17	0	434	0.057604	0.394009	0	0	0	0.002304	0.039171
142	9	108	1	0	0	1	0	0	315	0.028571	0.342857	0.003175	0	0	0.003175	0
144	0	1080	0	0	0	1	0	0	336	0	3.214286	0	0	0	0.002976	0
149	8	65	0	0	0	1	9	0	339	0.023599	0.19174	0	0	0	0.00295	0.026549
152	57	198	0	0	0	1	33	0	264	0.215909	0.75	0	0	0	0.003788	0.125
154	6	180	3	0	1	1	4	0	315	0.019048	0.571429	0.009524	0	0.003175	0.003175	0.012698
156	8	113	0	0	0	1	6	0	271	0.02952	0.416974	0	0	0	0.00369	0.02214
Total	986	36203	159	62	36	n/a	206	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a



Appendix 17: Results of the SIMPROF analysis to determine the structure of the sea pen resemblance data from the 1515S survey of EGM (2015). Global test statistics (π = 0.76, p<0.006) at 999 permutations.



Appendix 18: Dendrogram of fourth-root transformed sea pen abundance data from 58 video tows from survey 1515S to East of Gannet and Montrose Fields MPA (2015). The hierarchical cluster analysis produced 4 distinct sea pen species assemblages or groups, shown in the key (‘a’- ‘d’). The black, unbroken lines of the hierarchical cluster define structured relationships, whereas the red dashed likes denote relationships with no structure (not statistically distinct at *p*<0.05). Assemblage ‘d’ has no structure beyond approximately, 70% similarity, whereas ‘a’ splits from ‘b’ and ‘c’ at approximately 72% similarity, with ‘c’ and ‘d’ splitting at approximately 76%. The correlation of the dendrogram = 0.69027.



Appendix 19: nMDS plot of sea pen abundance data, fourth-root transformed, with the broadscale habitats factor overlain. Dashed lines indicate similarity percentage levels. Letters a-d indicate assemblages established through SIMPROF analysis. Percentages of similarity, derived from hierarchical clustering and SIMPROF are shown in dashed, coloured lines at 60%, 70% and 80% similarity. Data are based on 58 video tows taken during survey 1515S of East of Gannet and Montrose Fields MPA (2015).

Appendix 20: 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.

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 = 25cm^2
B: ≤ 10*10cm = 100cm^2
C: ≤ 20*20cm = 400cm^2
D: ≤ 50*50cm = 2500cm^2
E: ≤ 100*100cm = 10000cm^2
F: ≥ 100*100cm = 10000cm^2

Appendix 21: Responses from external partners on the most suitable gear type to sample *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)[6], 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 22: 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: https://hub.jncc.gov.uk/assets/78cb6096-16a3-4904-9014-f17fc56d402a#JNCC-MSS-Report-1-Appendix22.pdf

Appendix 23: Geostatistical Modelling Work for East of Gannet and Montrose Fields NCMPA - GeoAnalytics and Modelling Programme
Commissioned Report CR/19/062 provided by British Geological Survey.

This document has been provided as supplemental information and can be downloaded from the report webpage: https://hub.jncc.gov.uk/assets/78cb6096-16a3-4904-9014-f17fc56d402a#JNCC-MSS-Report-1-Appendix23.pdf

[6] SPI was discounted before the 1515S EGM (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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