From:	Dominika Phillips
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Subject:	Hornsea Project Three (UK) Ltd response to Deadline 4 (Part 7)
Date:	15 January 2019 23:06:22
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Dear Kay, K-J

Please find attached the 7th instalment of documents.

Best regards,

Dr Dominika Chalder PIEMA
Environment and Consent Manager

[redacted]

Environmental Management UK | Wind Power
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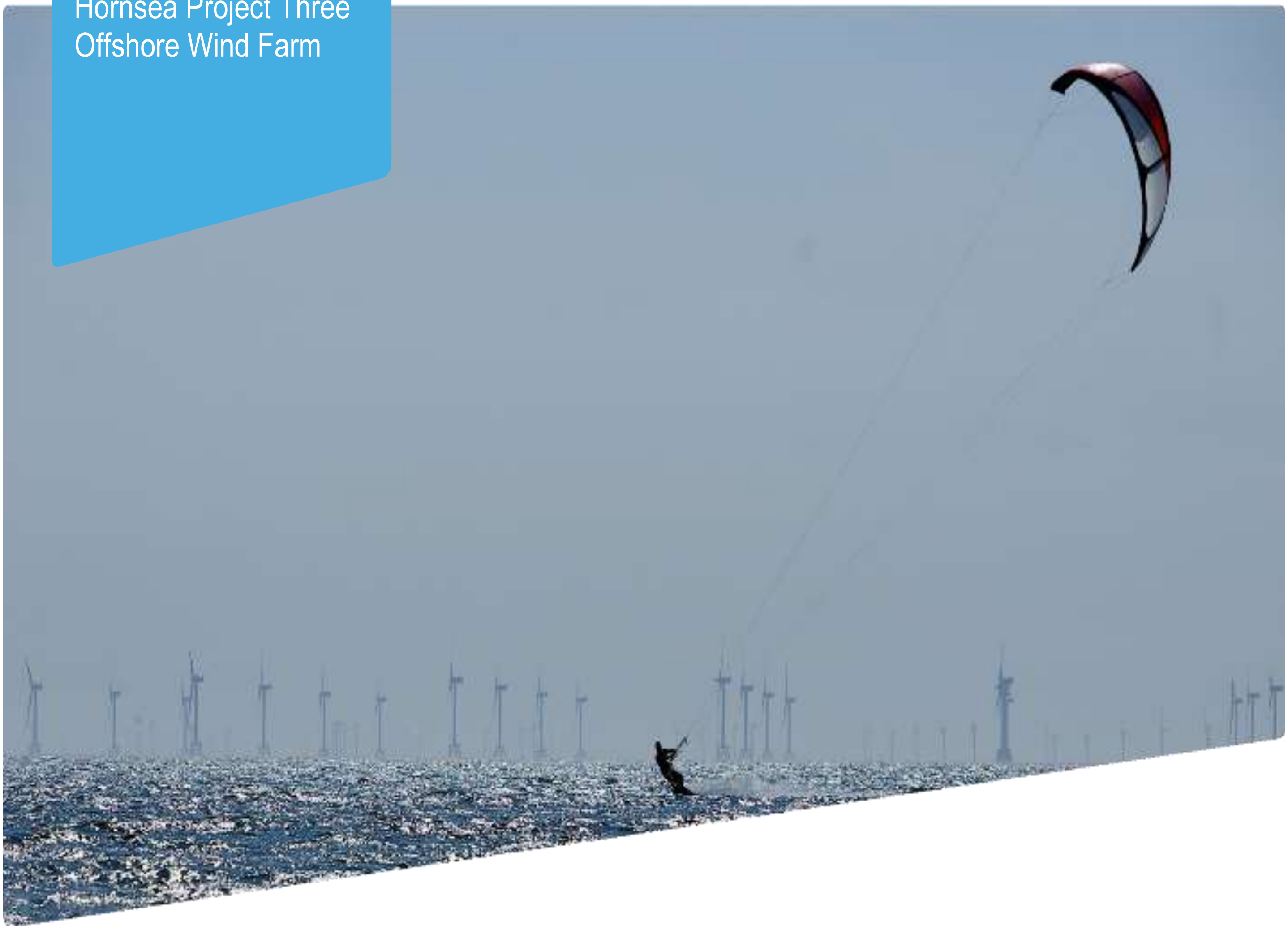
Orsted

Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three

Offshore Wind Farm

Appendix 26 to Deadline 4 Submission – Sotheran et al., 2017

Date: 15th January 2019

Hornsea 3
Offshore Wind Farm

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Marine Conservation Zone Benthic Community Analysis

Sotheran, I., Benson, A. & Johnston, C.M.

September 2017

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JNCC EQA Statement:

Summary

Defra commissioned a range of research (contract MB120) to collect information on the marine environment within offshore Marine Conservation Zones (MCZs). These data were gathered to provide evidence to underpin the MCZ designation or site recommendation. Surveys were undertaken to characterise the seabed habitats and their associated communities and enable broad-scale mapping to inform decisions for marine nature conservation.

Seven of the MCZ sites surveyed were prioritised for biotope classification using benthic community statistical analysis. Envision Mapping Ltd. undertook this analysis in 2016 (Sotheran *et al* 2016)

Three additional sites have subsequently been identified for biotope classification using benthic community statistical analysis. This has been undertaken as an additional phase to the work and the findings are presented in this report.

Regional MCZ project 'Recommended MCZs' (rMCZs) analysed:

- Compass Rose rMCZ
- Markham's Triangle rMCZ
- South Rigg rMCZ

The data analysed were collected using a combination of benthic grab (typically a 0.1m^2 mini Hamon grab) and towed/dropped down video to obtain infaunal data and epibenthic data. Infaunal data were enumerated by counts and biomass, epibenthic data were analysed to SACFOR[1]/counts/%cover. Particle Size Analysis (PSA) data were available to accompany the data, along with partial coverage multibeam echosounder and backscatter data.

The overarching approach to analysis was as follows: the data were processed consistently and the information standardised for statistical analysis. Significant biological groupings were identified within the datasets using the results of infaunal and PSA analysis. Any correspondence between biota groups and sediment PSA data was explored and then matched to biotopes from the Marine Habitat Classification for Britain and Ireland Version 15.03, using published biological comparative tables and biotope descriptions, following the most current guidance. Where there was insufficient species data, the allocation of habitat type was derived from the physical habitat data available. Epibenthic data was statistically analysed for one of the rMCZ sites (Compass Rose rMCZ) where epibenthic communities were considered important or a mixture of hard/consolidated substrata and softer sediment were present.

Multivariate analysis of data from each area was undertaken and the communities present within each rMCZ identified. The following biotopes were assigned using the Marine Habitat Classification for Britain and Ireland (JNCC 2015) after multivariate analysis of the survey data. Table 1 shows the biotopes found within each rMCZ site.

[1] 'Marine Nature Conservation Review (MNCR) SACFOR abundance scale http://jncc.defra.gov.uk/page-2684

Table 1. The habitats and biotopes found to occur within each rMCZ site.

Site	Biotopes*
Compass Rose rMCZ	SS.SSa.OSa SS.SSa.OSa.OfusAfil SS.SCS.OCS
Markham's Triangle rMCZ	SS.SMu.CSaMu SS.SSa.CFiSa.EpusOborApri SS.SCS.CCS SS.SMx.CMx SS.SSa.CMuSa
South Rigg rMCZ	SS.SCS.OCS SS.SSa.OSa.OfusAfil SS.SMu.Omu.[MonPfal] SS.SSa.OSa

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

The results and analyses from the projects have a range of limitations, issues and assumptions associated with each stage of data processing, analysis and production of results. These range from data acquisition limitations such as finite resources and survey strategies which may result in generalisations or extrapolations being required, through to data handling and processing which summarises large data sets and in doing so may lose some finer details within the data. Additionally, the use of multivariate statistical routines to identify significant groupings within the data is advantageous but the final allocation of habitat or biotope is often investigator led and some level of subjectivity may be introduced at this stage. To minimise this effect all results underwent quality control procedures which are documented.

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1 Introduction

The Marine and Coastal Access Act 2009 allows for the creation of Marine Protected Areas (MPAs) called Marine Conservation Zones (MCZs). Under this Act, MCZs protect a range of nationally important marine wildlife, habitats, geology and geomorphology and can be designated anywhere in English and Welsh inshore and UK offshore waters. Recommended MCZs in English inshore and English, Welsh and Northern Irish offshore waters have been identified through the Marine Conservation Zone Project. To date 50 MCZs have been designated following this project. Site Information Centres[2] have been developed by JNCC for MCZs designated in offshore waters or which cross the territorial/offshore boundary. Defra has announced that there will be a third tranche of MCZs for designation to assist in completing an ecologically coherent network of MPAs in UK waters.

Government policy dictates that MCZs should be designated based on “best available evidence”. To this end, Defra commissioned a range of research (contract MB120) to collect information on the marine environment within offshore MCZs Conservation Zones and these data were gathered to provide evidence to underpin the MCZ designation or site recommendation. Surveys have been undertaken to characterise the seabed habitats and their associated communities, and enable broad-scale mapping to inform decisions for marine nature conservation. Summary details of the surveys are provided with full survey methodologies and results found in a series of reports (Cefas reports by Ware and Meadows (2012) and Whomersley and Ware (2012) and Defra reports 13 (2014), 38 (2016a) and 39 (2016b)).

Three of the rMCZ sites surveyed have been selected for biotope classification using benthic community statistical analysis. These are shown in Figure 1 and presented in Table 2. The data available for the analysis were collected using a combination of benthic grab (typically a $0.1m^2$ mini Hamon grab) and towed/dropped down video to obtain infaunal data and epibenthic data. Infaunal data were enumerated by counts and biomass, epibenthic data were analysed to SACFOR[3]/counts/%cover. PSA data were available to accompany the data.

For each site an updated habitat map has been derived by analysing and interpreting the available acoustic and ground truth data collected by the dedicated surveys. Areas with distinct acoustic properties and characteristics were identified visually or automatically and boundaries generated. Information from the PSA was used to assign substrata descriptions and sediment types. The broad-scale habiatat map for each rMCZ has been created through expert visual interpretation of the processed bathymetry, alongside backscatter and groundtruthing data.

[2] JNCC Site Information Centres for offshore MPAs. Available at http://jncc.defra.gov.uk/page-6895
[3] 'Marine Nature Conservation Review (MNCR) SACFOR abundance scale, http://jncc.defra.gov.uk/page-2684

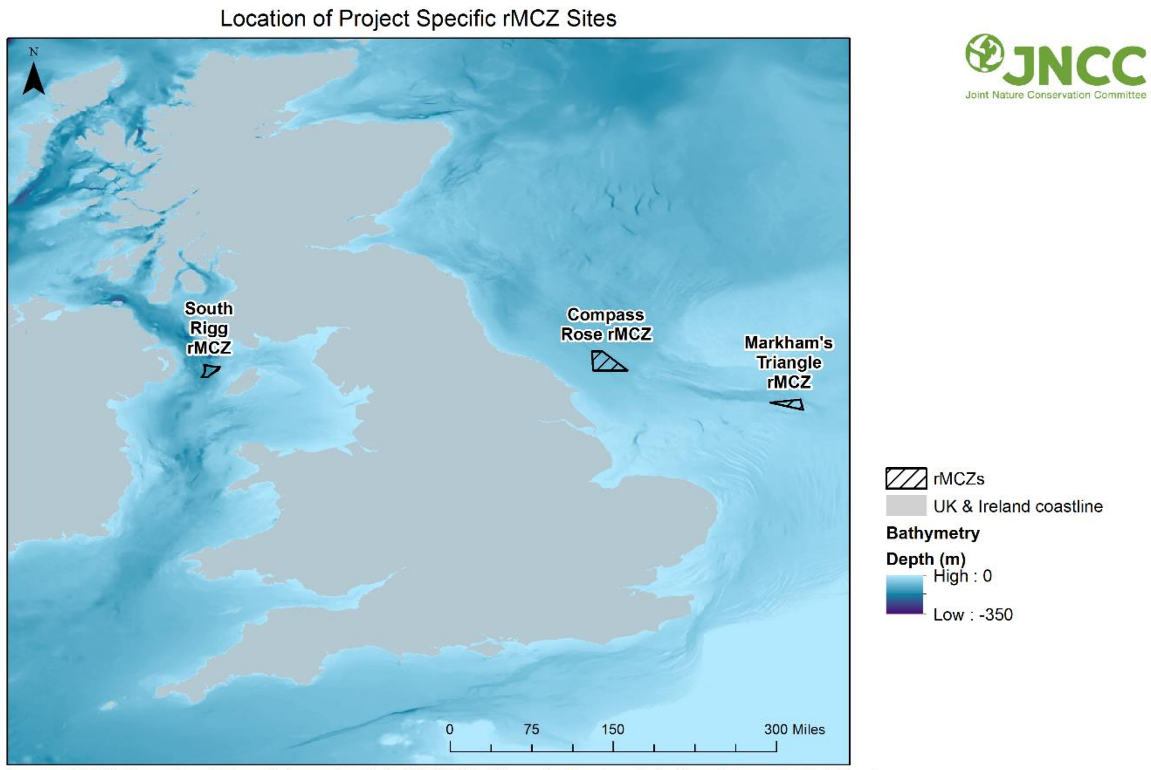

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Figure 1. Location of project rMCZ sites.

Table 2. rMCZ sites with number of benthic sample stations.

Site	Benthic Sample Stations
Compass Rose rMCZ	54
Markham's Triangle rMCZ	50
South Rigg rMCZ	33

This report provides details of the common methodology and approach which was adopted for the community analysis. This includes methods for the data handling and analysis of infaunal and epifaunal datasets, how the epifaunal data was used to support the infaunal analysis and how any associated geophysical acoustic data were used to provide contextual information.

In addition to a brief introduction of each rMCZ site location and features, any site-specific data processing stages are detailed and followed by a summary of the physical habitats identified within each site. Details of the outputs of multivariate and univariate statistical routines are illustrated and the characterising features identified from the analysis are provided along with how these are associated with the habitats and biotopes allocated to the data.

A summary of the results obtained in the context of each site's conservation features is provided and the limitations of the process and outputs described.

Data (Appendix 1) are included within the report to provide the outputs of the analyses for each sample station. The quality assurance and quality checks of analyses for this report are detailed as an annex to this report.

Throughout this report the term ‘biotope’ is used to describe seabed communities identified to level 5 or 6 of the Marine Habitat Classification for Britain and Ireland (JNCC 2015) where the biological information structures the classification and discriminates between community types. Where the biological information does not allow this level of discrimination or where only the physical attributes of the seabed are used for community identification the term ‘habitat’ is used.

Maps are presented as figures throughout the report and where possible standard colour schemes and a map template have been used. For certain maps, which show sample station by sediment or habitat type, alternate colours have been used as these better illustrate and discriminate the difference between classes. The relationship between the colours utilised and the standard EUNIS colour scheme is detailed in Appendix 2.

2 General Methods and Approach

The overarching approach to analysis was as follows: the data were processed consistently and the information standardised for statistical analysis. Cluster analysis was employed using PRIMER-E software to identify significant biological groupings within the datasets using the results of infaunal and PSA analysis. Any correspondence between biota cluster groups and sediment PSA data was explored and then matched to biotopes from the Marine Habitat Classification for Britain and Ireland Version 15.03 (JNCC 2015) using published biological comparative tables and biotope descriptions and following the most recent guidance (Parry 2015).

Where there was insufficient species data, the allocation of habitat type was derived from the PSA data available. Several primary and derived biological parameters values (i.e. total numbers; abundances; species richness and diversity indices) could also be calculated from the species matrices and were used where appropriate to further inform analysis of the site data. Epibenthic data were available from the three sites in the form of video and still imagery, however analysis outputs were only available for Compass Rose rMCZ and Markham's Triangle rMCZ. Where relevant these data were reviewed and cross referenced to sample stations from which infaunal data were available to assist in benthic community classification and identification.

The data provided from each survey was treated independently. Each rMCZ site survey was conducted by different staff at different times and data sets were analysed by different contractors. Due to the differences in sampling and surveying methods results between sites are not comparable. Benthic grab data and drop-down camera data from the same sites were also analysed separately due to differences in sampling equipment.

The generic methods for processing and analysing data are outlined below with specific adaptations or modifications used for each site detailed in the relevant sections.

2.1 Infaunal Analysis and Processing

Infaunal sample data were processed to produce a consistent dataset which was suitable for analysis within statistical packages, PRIMER-E. This process is illustrated in Figure 2 which shows the key stages in the process to account for any inconsistency between sample types, volumes and methods employed during data collection.

Benthic infaunal data were collated into a master Excel spreadsheet for each site for the data analysis. The following rationalisations were used in preparing the data for statistical analysis:

- taxon names were checked and some amended to make compatible with the current accepted species names on the WoRMS species list;
- removal of lifeforms such as eggs or larva: early or transitional life stages of most marine species are often ephemeral and only a temporary phase of the life cycle and therefore may not represent the taxa which typically structure the community;
- removal of juveniles: can also be ephemeral in nature and when present in high numbers can have an overriding influence on the analysis;
- removal of taxa with damage/uncertain identification: ambiguous records which could introduce uncertainty are removed to reduce discrepancies due to misidentification;

- removal of species such as fish: mobile species are removed as they do not form part of the infaunal community and are not permanent members of the community structure;
- removal of taxa with only presence/absence data (majority of which are epifaunal species): the presence/absence records are incompatible with the abundance data such as counts;
- taxa with only presence/absence data, mainly epibenthic species such as hydroids and bryozoans, were excluded in the total number of taxa and in the univariate analysis when calculating diversity indices.

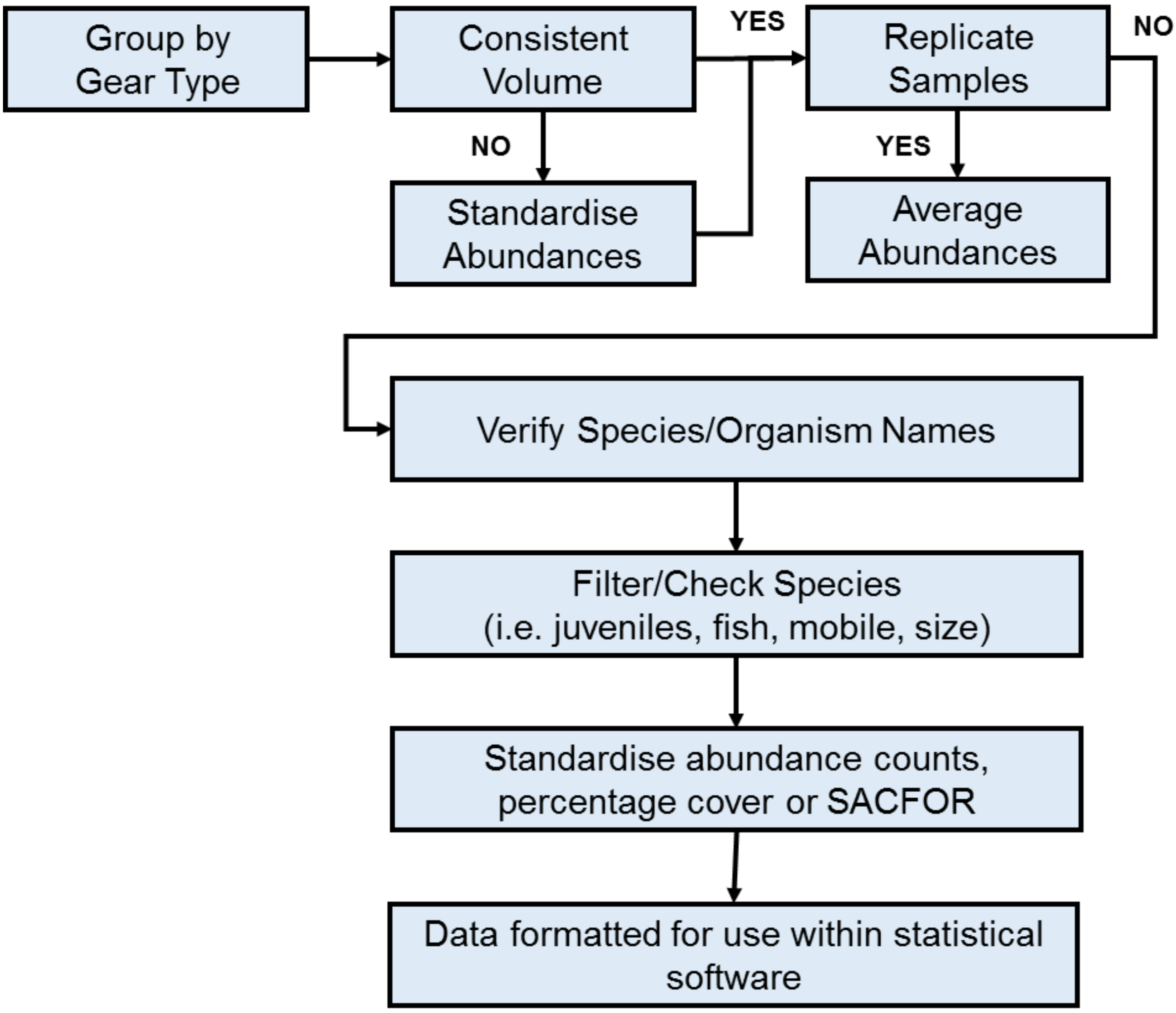

Figure 2. Methodological process for handling data gathered through grab sampling.

2.1.1 Univariate analysis

There are several species diversity indices available and, for the purpose of this report, those most used in literature have been calculated. The indices used are relatively uncomplex calculations and easily understood. The indices were used in the previous study from MCZ community analysis (Sotheran *et al* 2016) and have been used within this project for consistency. PRIMER-E was used to calculate the species diversity indices listed below:

- Number of species (S): the number of species present.
- Number of individuals (N): total number of individuals counted.
- Margalef's index (d): a measure of the number of species present for a given number of individuals. The higher the index, the greater the diversity.
- Pielou's evenness (J'): shows how equally the individuals in a population are distributed. J'=0 – 1. J' is higher, the less variation in the samples.

2.1.2 Multivariate Cluster analysis

Multivariate analysis was used as guidance in biotope assignment and the primary tool for the statistical analysis of the infaunal data was the PRIMER-E software package.
To obtain a measure of the degree of similarity in the faunal composition of each site, cluster analysis was carried out based on a Bray-Curtis similarity index. Prior to analysis, the data from each site required standardisation to reduce discrepancies resulting from observed variability between sample volumes, the sample values were divided by the total or maximum for that sample. Variations in the multivariate cluster analysis are detailed in each site section within this report. In general, as the data consisted of sparse faunal abundance and species richness, with the occasional high abundance of one or two species, square-root transformations were applied. This has the effect of down-weighting the importance of the highly abundant species, so that similarities not only depend on their values but also those of less common taxa. Statistical tests used were Hierarchical Clustering, non-metric Multidimensional Scaling (MDS) Ordination and Species Contributions (SIMPER).

The clustering technique aims to find 'natural groupings' of samples such that samples within a group are more similar to each other, generally, than samples in different groups (Clarke & Warwick 2001). Hierarchical agglomerative methods are the most commonly used clustering techniques. These usually take a similarity matrix, such as Bray-Curtis, and successfully fuse the samples into groups and the groups into larger clusters. The result of the hierarchical clustering is represented by a dendrogram, with samples that are similar linking together towards the higher end of the similarity scale and those that are less similar linking towards the lower end. Various computations were executed to investigate the effect of species removal and/or aggregation on the outcome of the analysis.

The data were examined further to determine the characteristic fauna of the cluster groupings recognised by the clustering technique. The SIMPER (similarity percentages) routine examines and ranks the role of each taxon in contributing to the separation between two groups of samples, or the closeness of the samples within a group. SIMPER was used to determine the main taxa that contributed most to the distinctiveness of the groups identified in the classification process. The species that cumulatively made up 90% of the samples were used and the resulting lists represent the percentage contributions of each species, placed in decreasing order.

Any correspondence between biota groups and sediment PSA data was explored and then matched to biotopes from the Marine Habitat Classification for Britain and Ireland Version 15.03 (JNCC 2015) using the published biological comparative tables and biotope descriptions, and the most recent guidance (Parry 2015). Where there was insufficient species data, the habitat allocation was derived solely from the geological PSA data available for that site.

Data were pooled into higher taxonomic levels and interrogated to explore whether this would improve the cluster groupings. Pooling data by taxonomic hierarchy aggregates abundance counts recorded at species level to genus, family or higher taxonomic orders. Where abundances are low and variable for a species throughout a series of data, aggregating to higher taxonomic order can reduce the number of clusters identified or reduce the scattering (dissimiliarity) of data points within each group when plotted using Multi-Dimensional Scaling (MDS). Where the results of this process enhanced the cluster analysis process the higher level groupings were used, however the lowest taxonomic levels were referred to where applicable during reporting for each site and when recording any characterising species. In some cases, where data contained abundances for both genus and species, analysis was undertaken using these taxa separately as it was assumed the records indicated a difference in taxa, but these records would then be pooled when data were aggregated.

2.2 Epibenthic Analysis and Processing

2.2.1 Review of epibenthic imagery and footage

For two sites, Compass Rose rMCZ and Markham's Triangle rMCZ, epibenthic video data analysis outputs were available. These data consisted of taxa matrices for samples within the rMCZ sites. These sites have epibenthic communities which are considered important within their conservation status, and the results were plotted to compare or verify infaunal data results. Only raw video and stills data were available for South Rigg rMCZ.

For all sites, where of benefit to the community analysis process, video and still images were reviewed and cross referenced to sample stations from which infaunal data were available. This process assisted in identifying possible biotopes present and to determine the nature of the seabed at each sample location and throughout the rMCZ sites. This information assisted the assignment of biotopes to the infaunal samples where they may have been ambiguous or the infaunal statistical analysis did not clearly identify biological groupings.

2.3 Acoustic/geophysical data

For all sites, geophysical data obtained from a multibeam echosounder (MBES) were available, along with backscatter images, but only with partial coverage (Ware and Meadows (2012) and Whomersley and Ware (2012) and Defra reports 13 (2014), 38 (2016a) and 39 (2016b)). The bathymetry and backscatter images or data were imported into GIS which then provided contextual information to assist with the allocation of community types to sample data. The bathymetry was especially helpful in determining which biological depth zone (infralittoral, circalittoral or deep circalittoral) some of the samples should be attributed with. The topography of the seabed can also be visualised which aids understanding in the distribution of habitats/biotopes associated with sample points.

For all sites the bathymetric and backscatter data collected during the surveys had been analysed and broad-scale habitat maps derived from these and grab sample data. The broadscale habitats are from the physical parameters of the geophysical and sample data and have been utilised for contextual data for all the sites.

Defra marine digital elevation model (DEM) data (Defra 2015) were used to infill for the areas lacking data for Compass Rose and Markham's Triangle rMCZs, and to create the best available background and contextual information for the data analysis. For South Rigg rMCZ, survey bathymetry and backscatter covered 100% of the survey area with the DEM data only used for context within the remainder of the rMCZ.

3 Results

Multivariate analysis was undertaken on the infaunal samples to explore significant variation between the samples and to aid with the assignment of biotopes. The classification dendrogram, the ordination plot and the average species composition of the resulting classes were used to justify and describe the characteristics of the groups. The process also draws upon dominant sediment types and the geographic plot of the groups, which show where there are marked spatial clusters in the data.

For each rMCZ a summary is provided detailing a brief overview of the site and its conservation features for context and reference, a description of the statistical analysis undertaken and the results, including:

- a site summary;
- summary of the physical habitats present, including maps of sediment composition and physical habitats;
- details of the site-specific data processing and analysis;
- summary of the characterising species and communities;
- biotope allocation, including relationship to current EUNIS/JNCC habitat classification and maps of location of cluster groupings and biotopes allocated; and
- potential new biotopes for the classification identified through analysis.

For each site data tables are provided in appendices which give details derived from the physical PSA data and details of the biological data derived from statistical analysis and processing.

An initial table includes the sediment proportions from each sample station, the broad scale habitat identified from this along with any descriptions from data processing logs and geographic positions for each station.

A second table shows details of the sediment description, the multivariate group and the biotope or habitat (Marine Habitat Classification for Britain and Ireland (JNCC 2015) and EUNIS classes) assigned to each sample station with any comments noted from the processing such as impoverished samples or physical mismatches between sediment types and biotopes assigned.

3.1 Compass Rose rMCZ

Compass Rose recommended Marine Conservation Zone (rMCZ) is an offshore site located approximately 43km from the North Yorkshire coast (Figure 3). The site covers an area of 552km^2 reaching a depth of around 50 metres.

The site covers a small portion of the Flamborough frontal system. The Flamborough frontal system is defined by the distinct temperature gradient between the waters to the north and south of Flamborough Head, where mixing of the warmer waters of the Southern North Sea and the cooler waters of the northern North Sea occurs. The upwelling in locations such as this allows nutrients to be transported to the surface from deeper, colder waters, which creates a site of increased primary biomass production. The site contains spawning grounds for plaice, herring, lemon sole, sand eel and sprat. It is also a nursery ground for cod, whiting, lemon sole, sand eel and sprat (Defra 2016a).

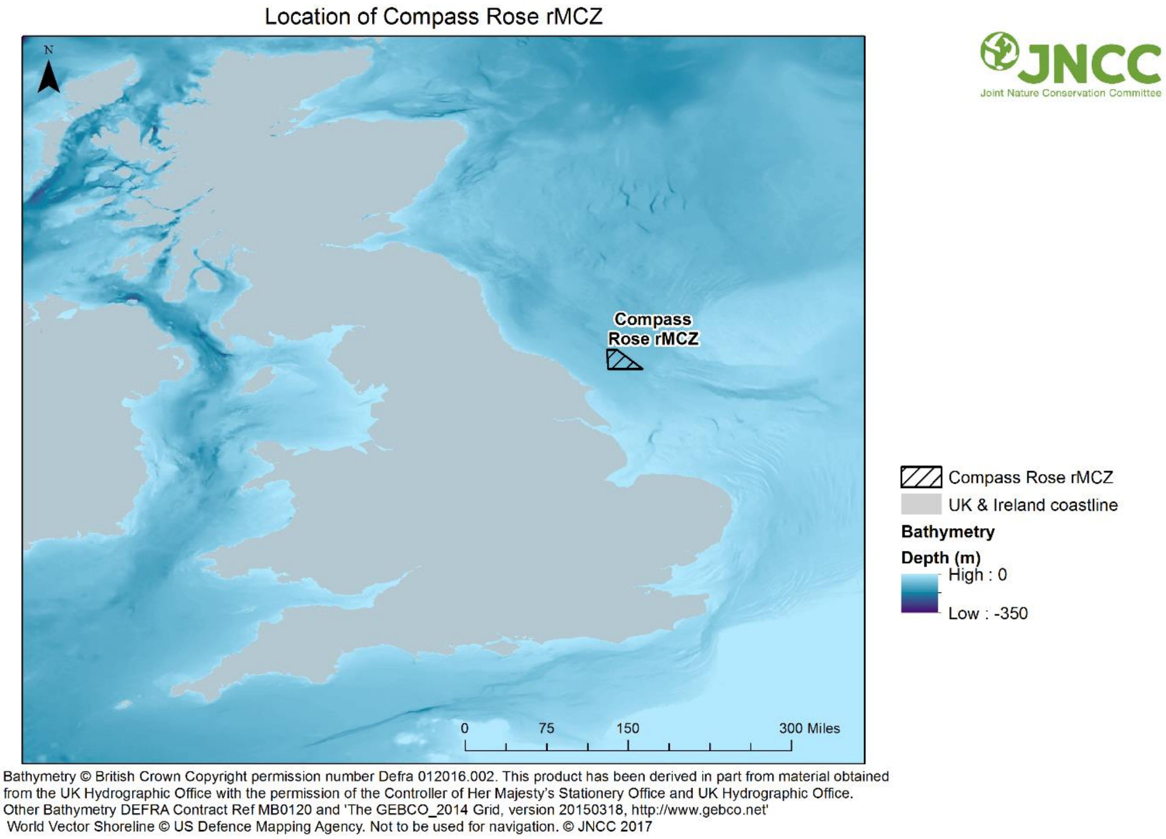

Figure 3. Compass Rose rMCZ location.

The site was recommended for designation by the Net Gain regional MCZ project (Net Gain 2011) due to the presence of the broad-scale habitat type 'Subtidal sand'.

Compass Rose rMCZ was surveyed in March 2012 (Defra 2016) and acquired sediment samples, camera stills and video data with a Day grab and Hamon grab (0.1m$^{2)}$ as well as underwater towed video and stills camera. Multibeam bathymetry and backscatter data were collected opportunistically on transit between the sampling stations. The survey identified the presence of the broadscale habitat 'Subtidal sand' at over two thirds of the site with a mosaic of 'Subtidal coarse or mixed sediments' occupying the remaining third. A full account of the survey methods and results can be found in (Whomersley & Ware 2012; Defra 2016a).

3.1.1 Site specific data processing and analysis

In total, 107 taxa were recorded from the 54 samples collected (Figure 4). Fourteen taxa were removed prior to statistical analysis and are listed in Table 3. These included:

- juveniles: which are often ephemeral in nature and when present in high numbers can have an overriding influence on the analysis;
- taxa with damage/uncertain identification: ambiguous records which could introduce uncertainty are removed to reduce discrepancies due to misidentification;
- a taxon which had been included within the data, yet was not recorded in any samples: in this instance, the taxon (*Astarte borealis*) was removed;
- a taxon, *Alcyonidium gelatinosum* (which is an epifaunal species) with only presence/absence data: the presence/absence records are incompatible with the abundance data such as counts

Table 3. Taxa removed from Compass Rose rMCZ data.

Taxa	Reason Removed
Alcyonidium gelatinosum	Removed as presence only indicated
Amphiura indet. juv.	Removed as indet juv but high numbers to be aware of when assigning habitat/biotopes
Aricidea indet. dam.	Removed as indet and singleton
Astarte borealis	Non-recorded in samples
Asteroidea indet. juv.	Removed as indet and singleton
Bivalvia indet. dam.	Removed as indet & damaged, two single records and represented by numerous other bivalves
Echinocardium indet. dam.	Removed as indet juv but high numbers to be aware of when assigning habitat/biotopes
Echinocardium indet. juv.	Removed as indet juv but high numbers to be aware of when assigning habitat/biotopes
Gammaropsis indet. dam.	Removed as indet & damaged and two single records only
Ophiuroidea indet juv	Removed as indet juv but high numbers to be aware of when assigning habitat/biotopes
Paguridae indet. dam. (juv.)	Removed as indet and singleton
Polynoidae indet. dam.	Removed as indet & damaged and two single records only
Sabellidae indet. dam.	Removed as indet & damaged and three single records
Thracia indet. dam.	Removed as indet and singleton

Compass Rose rMCZ Sample Stations

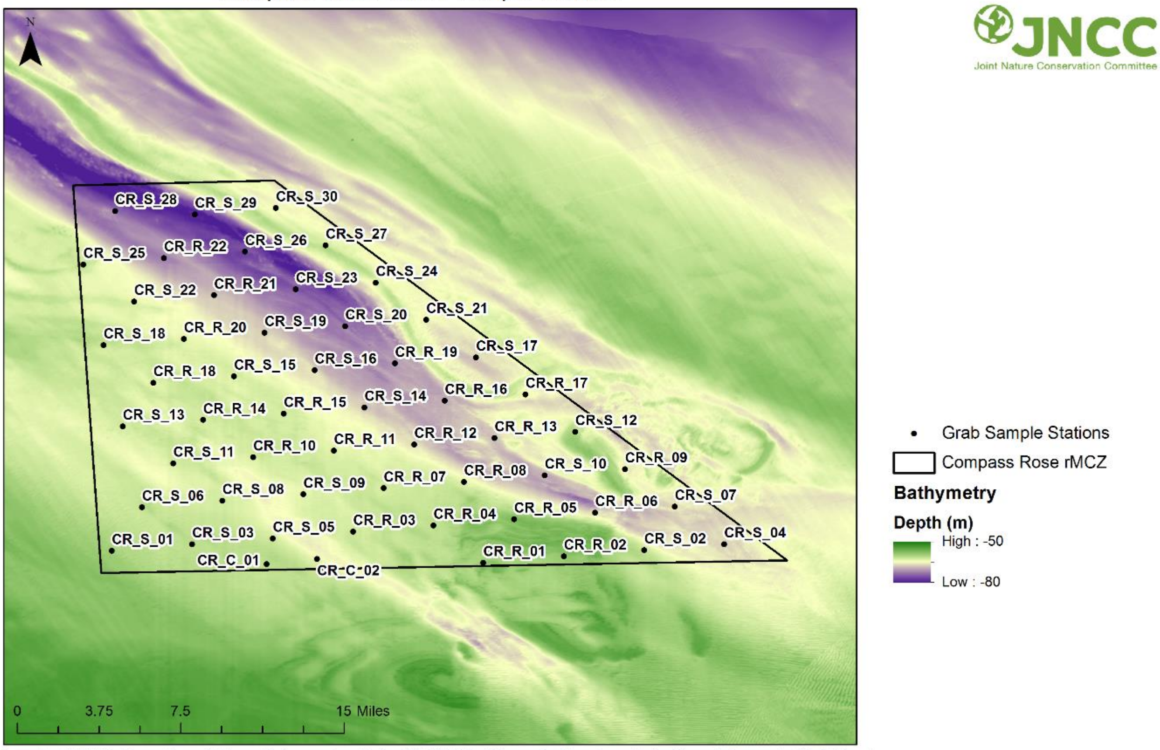

Figure 4. Compass Rose rMCZ sample stations, overlain on multibeam bathymetry data with broadscale bathymetry for context.

3.1.2 Summary of physical habitats

A summary of key parameters of particle size analysis data is provided in Table 22 available in Appendix 1. The site appears relatively homogenous and the particle size data from Compass Rose rMCZ shows the predominant sediments to be sandy in nature, with some elevated levels of gravel in places giving the seabed a coarse substrate. Mixed substrates are found at stations (CR_S_18, CR_R_03 and CR_17) where there are slight increases in the silt/mud content of the gravellier substrates.

The spatial distribution of sediment types is illustrated in Figure 5 and Figure 6 which highlight sediment composition (% sand, gravel and mud) and sediment type respectively, overlain on the broad-scale habitat map (Whomersley & Ware 2012).

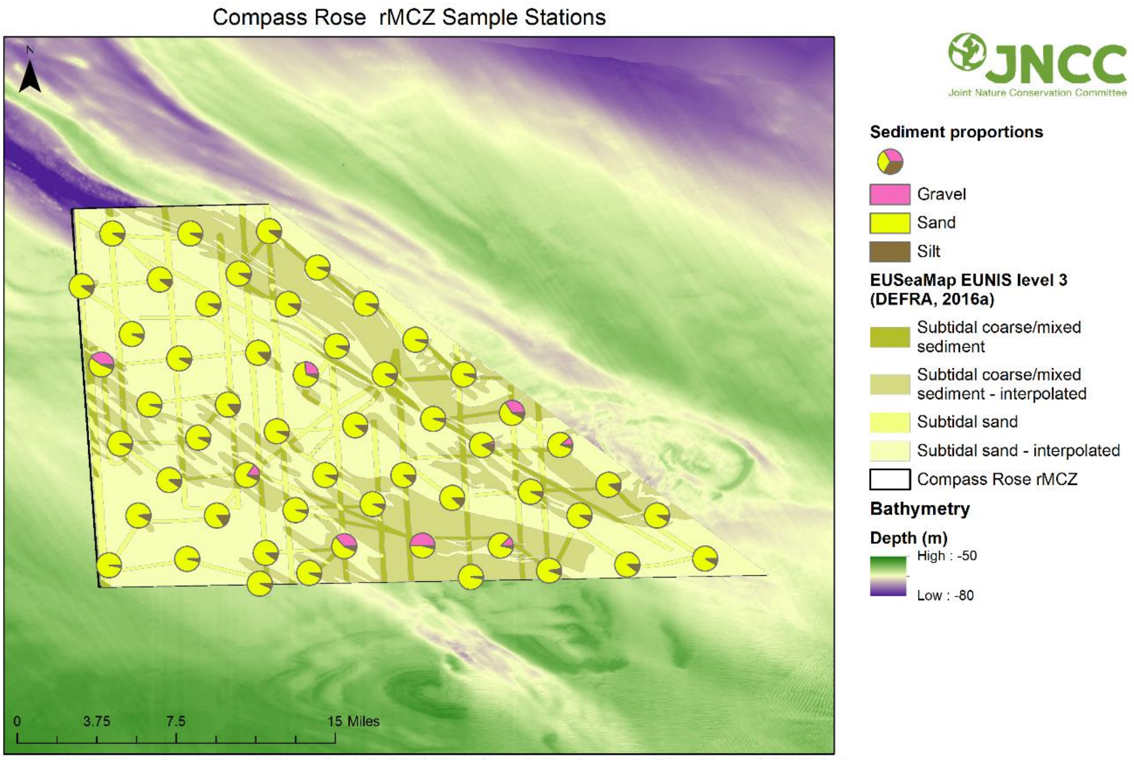

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Figure 5. Compass Rose rMCZ sediment composition of grab samples.

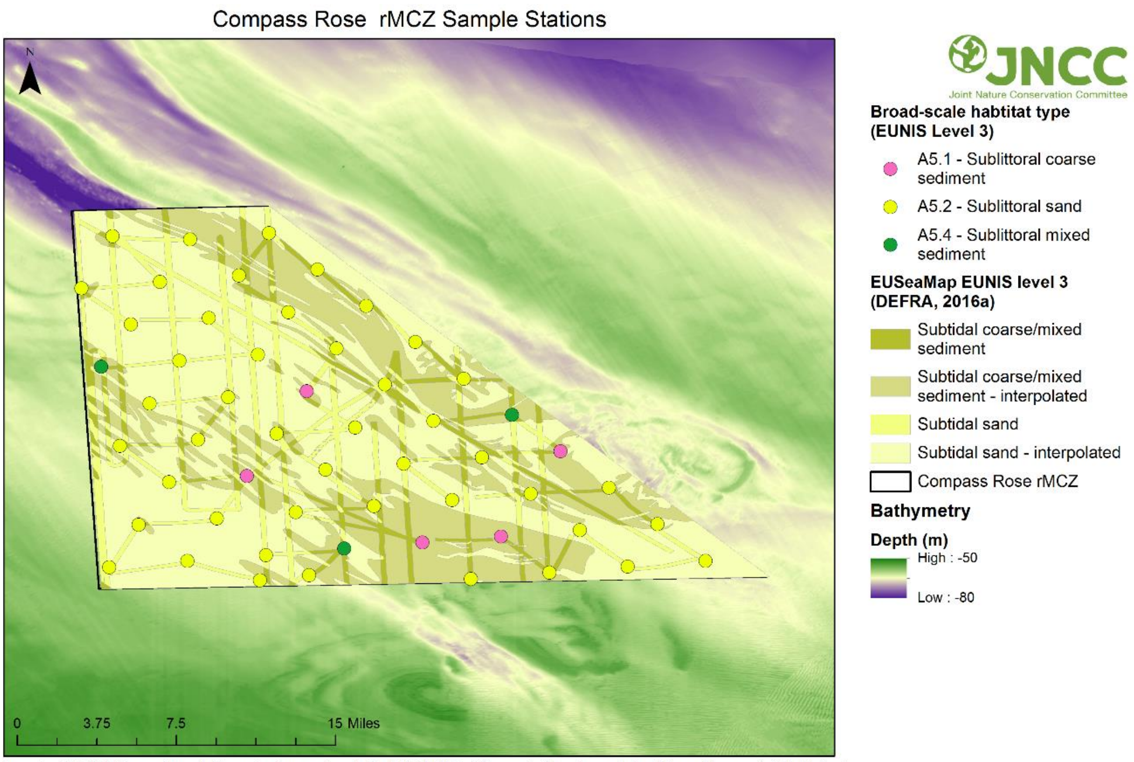

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Figure 6. Compass Rose rMCZ broad-scale habitat from PSA of grab samples.

3.1.3 Statistical results for Compass Rose rMCZ

The SIMPROF routine was used to define sample groups with similar species composition and Figure 7 displays the results of the cluster analysis on the infaunal data. The dendrogram is based on group-averaged Bray-Curtis similarities computed on standardised, square root transformed abundances. Due to the homogeneity of the infaunal community a ‘slice’ at a similarity level of 30% was used to differentiate between the main groupings. This similarity slice was used to group samples which otherwise are separated due to only small variations, which show no practical ecological groupings, within an otherwise homogeneous community.

Figure 8 shows the three dimensional MDS plot of the same similarities. The stress value of 0.13 gives confidence that the three-dimensional plot is an accurate representation of the sample relationships.

The similarities between samples within group c was, on average, 38.2%, with another two groups identified (‘a’ & ‘b’) which contained two outlying samples. The taxa that contributed to the main group are shown in Table 5. The outlying groups ‘a’ and ‘b’ were very impoverished containing less than 5 taxa within each sample. The taxa which contributed to greater than 1% of the similarity for the biological group ‘c’ based on the results of the SIMPER analysis are shown in Table 5. As the outlying clusters have very little taxa, and consist of single samples, comparing similarities between these is inappropriate.

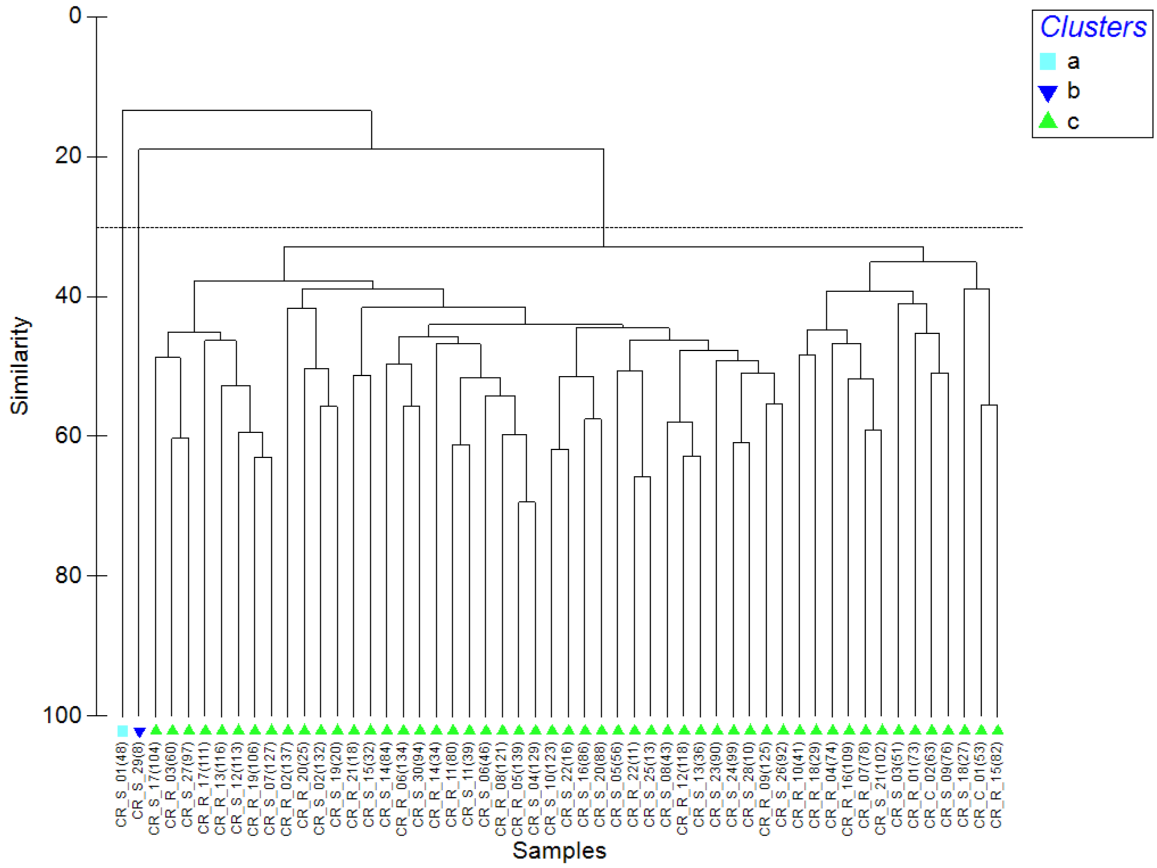

Figure 7. Compass Rose rMCZ dendrogram using similarities from abundance data.

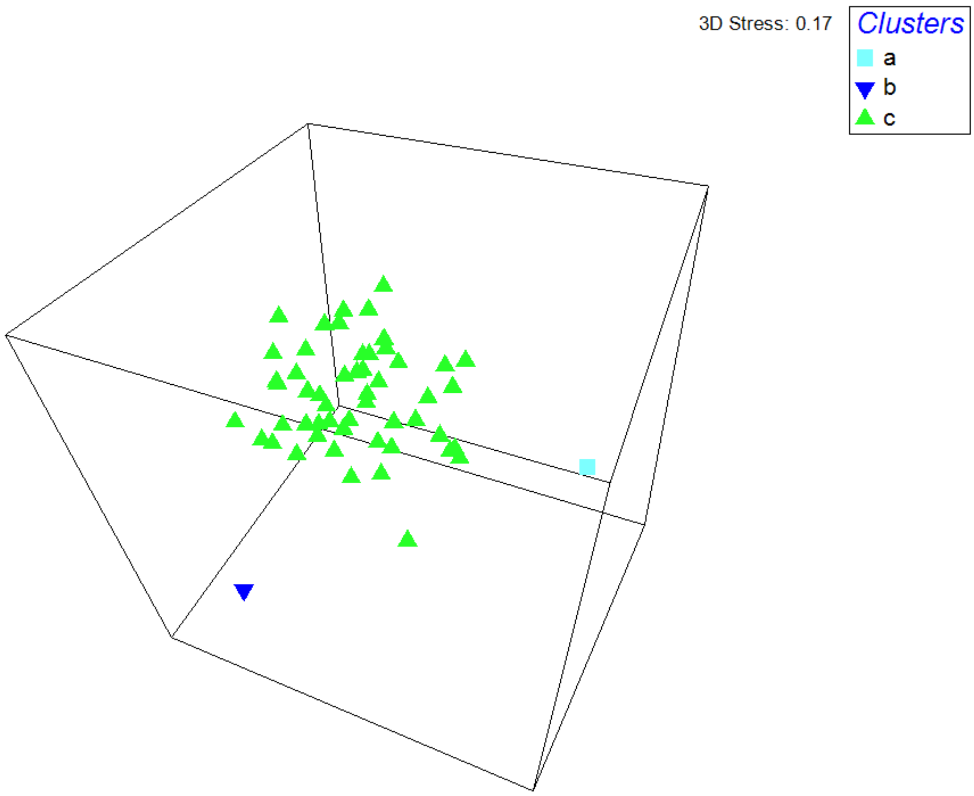

Figure 8. Compass Rose rMCZ MDS plot from abundance data.

3.1.4 Univariate results

The numbers of taxa per sample (S), number of individuals per sample (N), values of Margalef's species richness index (d) and Pielou's evenness index (J') are presented in Table 4.

The samples from Compass Rose rMCZ had sparse faunal abundance and multivariate analysis resulted in three groups, with all but two samples clustering into the larger group 'c'.

The univariate analysis results showed that for the stations which belonged to the large group 'c', the densities of infaunal organisms were low and suggestive of impoverished communities, with the number of taxa recorded (per sample) ranging from 9 to 22 (mean 16) and the number of individuals (per sample) ranging from 16 to 91 (mean 38). The group also appears to exhibit a low level of diversity in terms of Margalef's index (ranging from 1.44 to 2.85, mean 2.41) and a variable but relatively high level of evenness with Pielou's index ranging from 0.62 to 0.99, with a mean of 0.90, indicating little variation within samples.

Conversely, the remaining outlying samples in group 'a' and 'b' showed very low species densities (total taxa per sample was 2 for group 'a' and 4 for group 'b', and the number of individuals per sample 3 and 5 respectively) and therefore reflected very impoverished samples. The diversity indices were also low, with a mean of 0.91 for group 'a' and 1.86 for group 'b' for the Margalef's index. Pielou's index of evenness is again high for both of these groups (mean of 0.92 and 0.96) which supports the very impoverished nature of these samples, and with only single samples meaning comparative statistics are insignificant.

Table 4. Diversity indices and summary univariate statistics for Compass Rose rMCZ infaunal samples.

Station code	Group	Total taxa (S)	Total individuals (N)	Margalef's (d)	Pielou's (J')
CR_C_01(53)	c	9	23	2.55	0.93
CR_C_02(63)	c	22	42	5.62	0.88
CR_R_01(73)	c	20	42	5.08	0.89
CR_R_02(137)	c	18	33	4.86	0.94
CR_R_03(60)	c	16	51	3.82	0.77
CR_R_04(74)	c	14	33	3.72	0.91
CR_R_05(139)	c	13	23	3.83	0.95
CR_R_06(134)	c	22	45	5.52	0.92
CR_R_07(78)	c	16	33	4.29	0.92
CR_R_08(121)	c	21	52	5.06	0.89
CR_R_09(125)	c	22	55	5.24	0.89
CR_R_10(41)	c	13	36	3.35	0.84
CR_R_11(80)	c	19	37	4.99	0.94
CR_R_12(118)	c	17	33	4.58	0.94
CR_R_13(116)	c	21	76	4.62	0.66
CR_R_14(34)	c	15	25	4.35	0.96
CR_R_15(82)	c	11	16	3.61	0.94
CR_R_16(109)	c	9	19	2.72	0.93
CR_R_17(111)	c	18	91	3.77	0.66
CR_R_18(29)	c	15	31	4.08	0.88
CR_R_19(106)	c	20	73	4.43	0.71
CR_R_20(25)	c	15	23	4.47	0.89
CR_R_21(18)	c	17	28	4.80	0.94
CR_R_22(11)	c	14	25	4.04	0.94
CR_S_01(48)	a	2	3	0.91	0.92
CR_S_02(132)	c	13	21	3.94	0.95
CR_S_03(51)	c	11	38	2.75	0.71
CR_S_04(129)	c	16	28	4.50	0.95
CR_S_05(56)	c	16	18	5.19	0.99
CR_S_06(46)	c	17	32	4.62	0.91
CR_S_07(127)	c	17	75	3.71	0.68
CR_S_08(43)	c	15	29	4.16	0.94
CR_S_09(76)	c	19	38	4.95	0.94
CR_S_10(123)	c	17	37	4.43	0.86
CR_S_11(39)	c	17	28	4.80	0.91
CR_S_12(113)	c	14	78	2.98	0.55
CR_S_13(36)	c	21	37	5.54	0.91

Station code	Group	Total taxa (S)	Total individuals (N)	Margalef's (d)	Pielou's (J')
CR_S_14(84)	c	19	37	4.99	0.91
CR_S_15(32)	c	20	44	5.02	0.86
CR_S_16(86)	c	17	26	4.91	0.93
CR_S_17(104)	c	15	43	3.72	0.83
CR_S_18(27)	c	15	30	4.12	0.85
CR_S_19(20)	c	13	24	3.78	0.96
CR_S_20(88)	c	21	55	4.99	0.86
CR_S_21(102)	c	12	25	3.42	0.94
CR_S_22(16)	c	20	36	5.30	0.95
CR_S_23(90)	c	12	34	3.12	0.83
CR_S_24(99)	c	17	47	4.16	0.86
CR_S_25(13)	c	17	35	4.50	0.91
CR_S_26(92)	c	14	40	3.52	0.76
CR_S_27(97)	c	14	40	3.52	0.78
CR_S_28(10)	c	10	26	2.76	0.88
CR_S_29(8)	b	4	5	1.86	0.96
CR_S_30(94)	c	18	30	5.00	0.92

3.1.5 Summary of characterising species and communities

The taxa which form the characterising species for the only significant multivariate grouping (group ‘c’), with a percentage contribution of over 1%, are shown in Table 5, excluding the outlying groups which had less than two samples, for which data cannot be generated.

Table 5. Characterising species for the single multivariate group at Compass Rose rMCZ, showing those with a contribution of over 1%.

Group ‘c’ Species/Taxa	Average Abundance	%age contribution
Scoloplos (Scoloplos) armiger	3.11	17.01
Owenia fusiformis	2.95	14.85
Galathowenia oculata	2.81	11.39
Goniada maculata	1.89	9.03
Bathyporeia elegans	1.61	5.88
Paramphinome jeffreysii	1.38	5.04
Harpinia antennaria	1.44	4.55
Astrorhiza limicola	1.44	4
Amphiura filiformis	1.28	4
Ophelia borealis	1.55	3.96
Nucula nitidosa	1.18	3.36
Nemertea	0.88	2.26
Sthenelais limicola	0.78	1.72
Nephtys longosetosa	0.74	1.69
Spiophanes bombyx	0.6	1.1

3.1.6 Biotope allocation

The groupings produced from the multivariate analysis have been matched to biotopes as defined by the Marine Habitats Classification for Britain and Ireland (JNCC 2015) and using the recent guidance by Parry (2015). Possible candidate biotopes were selected on the basis of species composition, physical parameters, such as sediment and depth, and the results of the multivariate analysis. The taxa which were removed during data processing prior to statistical analysis were reviewed and considered within the biotope allocation process.

A description of habitat types/biotopes allocated to each of the sampling stations is given below and summarised in Table 6 with the spatial distribution of the groups and biotopes illustrated in Figure 9 and Figure 10. Table 23 in Appendix 1 presents details for each sample station with the multivariate group and the biotope or habitat assigned to each sample along with any comments noted from the processing such as impoverished samples or physical mismatches between sediment types and the biotopes assigned.

The two sampling stations within the outlying groups ‘a’ and ‘b’ contained very few taxa for community analysis and were therefore assigned based upon the physical characteristics of the sediment properties and the depths the samples were taken from: **SS.SSa.OSa** (Offshore circalittoral sand) was assigned to both samples.

Stations within group ‘c’ included a range of polychaetes such as *Scoloplos armiger, Owenia fusiformis, Galathowenia oculata* and *Goniada maculata* along with the amphipods, *Bathyporeia elegans* and *Harpinia antennaria*. The brittlestar, *Amphiura filiformis,* was recorded in the majority of samples and juvenile records of Amphiura along with juvenile Ophiuroidea were excluded from the statistical analysis but they are abundant throughout. These species are often recorded in offshore sand habitats and as such the stations which have a sediment type which indicate a sand habitat within this group have been assigned **SS.SSa.OSa.OfusAfil** (*Owenia fusiformis* and *Amphiura filiformis* in offshore circalittoral sand or muddy sand) but due to the low number of taxa within the samples it is suspected this is an impoverished version of this biotope.

In summary Table 7 shows the biotope and habitats found within Compass Rose rMCZ with the characterising species and seabed substrate for each.

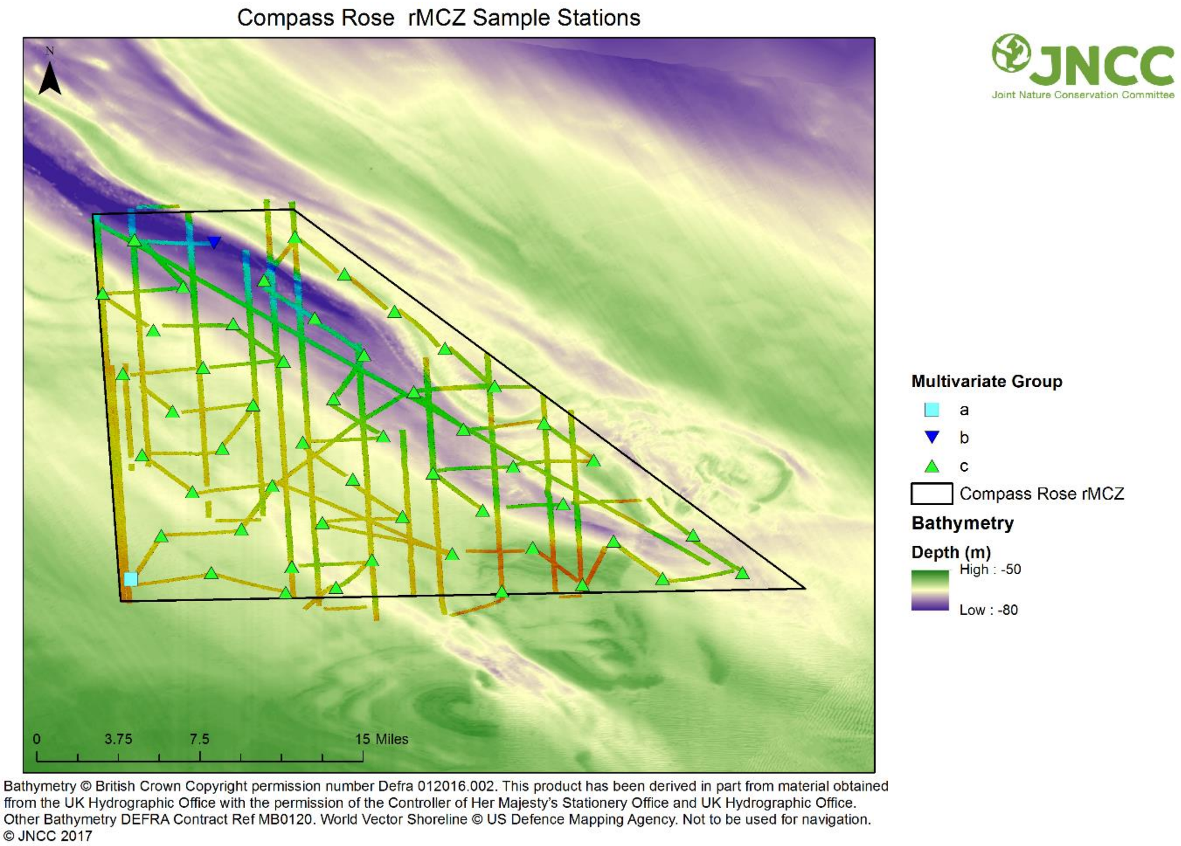

Figure 9. Compass Rose rMCZ sample stations showing multivariate groups.

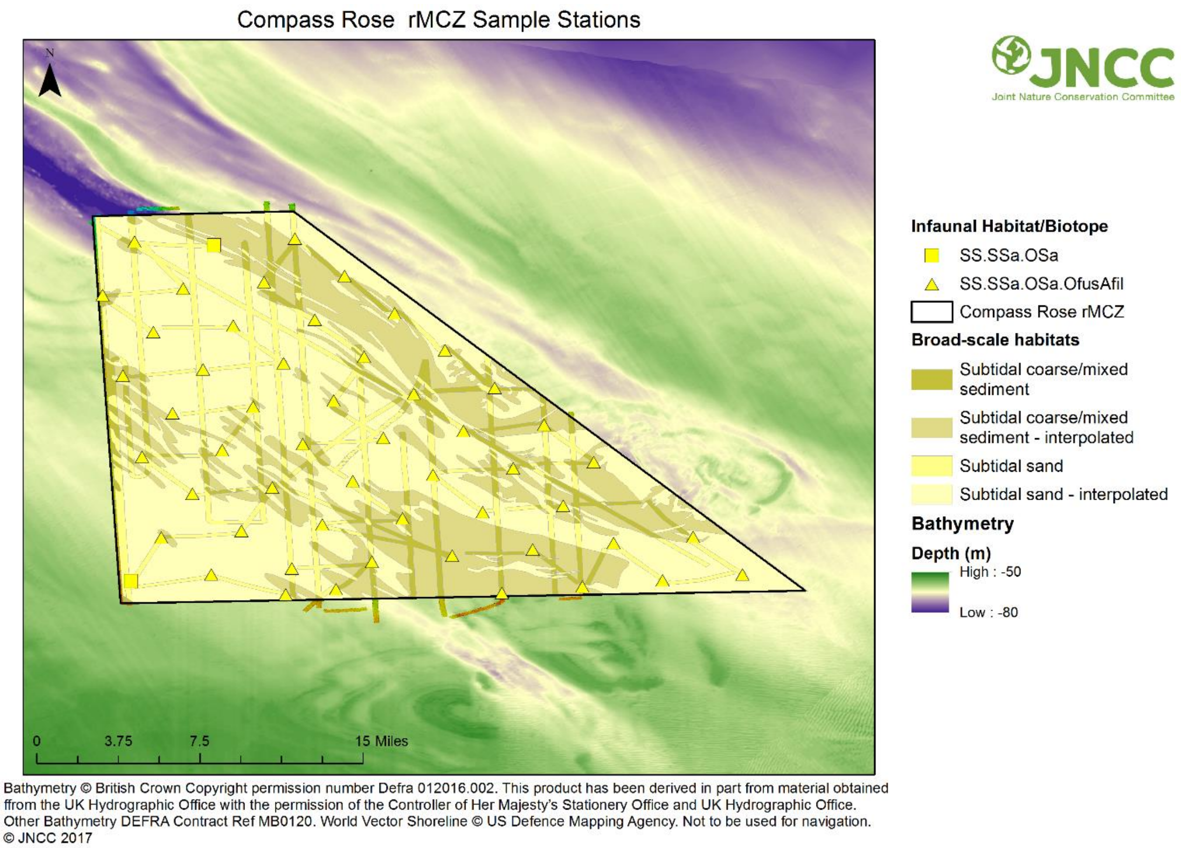

Figure 10. Compass Rose rMCZ sample stations showing biotope/habitats.

Table 6. Summary of multivariate statistical groups and associated habitats and biotopes from the Compass Rose rMCZ.

Multivariate Group	Number of Samples	Biotope Code*	Broad-scale Habitat
a	1	SS.SSa.OSa	Subtidal sand
b	1	SS.SSa.OSa	Subtidal sand
c	52	SS.SSa.OSa.OfusAfil	Subtidal sand, Subtidal mixed sediments, Subtidal coarse sediments

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

Table 7. Summary of habitats/biotopes found within Compass Rose rMCZ.

Habitat/Biotope*	Depth range (m)	Substratum	Infaunal community	Multivariate groups
SS.SSa.OSa	65 – 80	Sand and muddy sand	Impoverished	a, b
SS.SSa.OSa.OfusAfil	60 – 82	Sand and muddy sand Coarse sediments Mixed sediment	*Scoloplos (Scoloplos) armiger* *Owenia fusiformis* *Galathowenia oculata* *Amphiura filiformis* (juv)	c

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

3.1.7 Epibenthic Analysis

Multivariate analysis was undertaken on the 19 epifaunal video samples (Figure 11) available for Compass Rose rMCZ to explore significant variation between the samples and to aid with the assignment of biotopes.

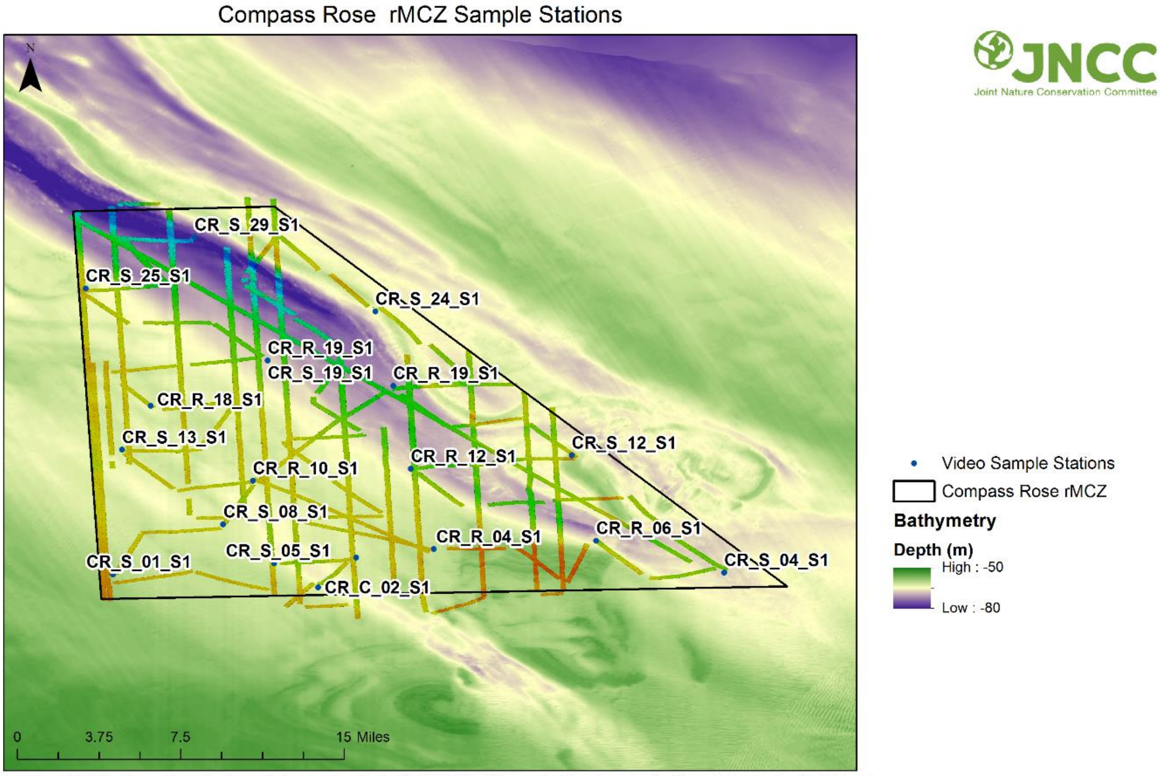

Figure 11. Compass Rose rMCZ video sample stations.

The data for the video samples were provided as SACFOR abundances or presence absence data. As no counts or abundance data were available, all data were transfomed to presence/absence data within PRIMER-E.

The resulting analysis showed all video samples to be very similar (<60%) and only a single cluster grouping was identified with the characterising species shown in Table 8.

Table 8. Characterising species for multivariate groups at Compass Rose rMCZ epibenthic data.

Group 'a' Species/Taxa	Average Abundance	%age contribution
Alcyonium digitatum	0.38	45.07
Paguridae	0.25	17.52
Porifera	0.19	12.18
Flustra foliacea	0.19	7.66
Ophiothrix fragilis	0.19	6.69
Virgularia mirabilis	0.13	5.93

Summary of characterising species and communities

The video has previously been reviewed by Cefas in 2012 and allocated to habitat type based upon visual assessment with 17 of the 19 video samples having been allocated as SS.SSa.OSa and the remaining two assigned to SS.SCS.OCS. The characterising species do not enable the biotope or habitat type to be identified with more confidence and it is recommended that the initial allocated habitat remain with a note of the epifaunal community of *Alcyonium digitatum*, Pagurids, sponges, *Flustra foliacea*, *Ophiothrix fragilis* and *Virgularia* *mirablilis*. The taxa removed from infaunal data during processing were reviewed to assess whether they would form part of the epifaunal community and none were noted.

Figure 12 shows the epibenthic video samples alongside the infaunal grab sample data with their associated communities.

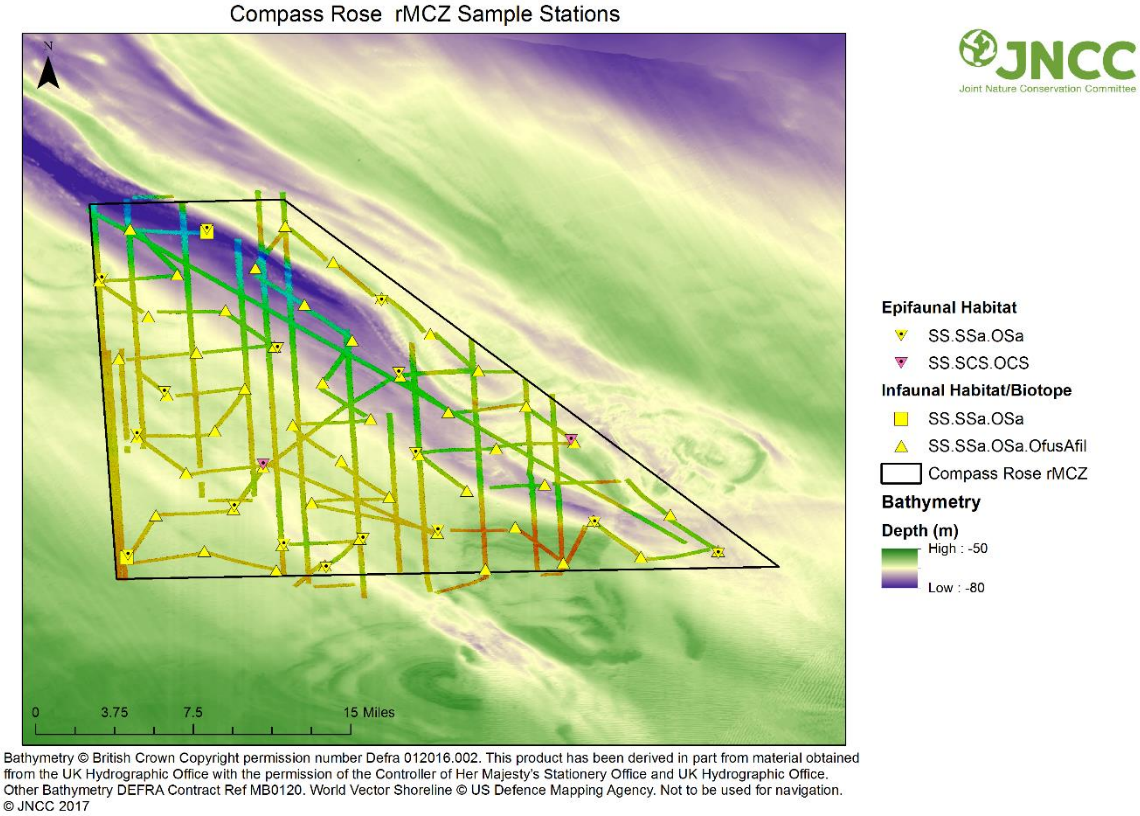

Figure 12. Compass Rose rMCZ video and grab sample stations showing biotopes/habitats on a broad-scale habitat map of the site.

3.1.8 Site Summary

A previous survey (Whomersley & Ware 2012; Defra 2016a) of Compass Rose rMCZ identified the presence of the broad-scale habitat ‘Subtidal sand’ at over two thirds of the site with a mosaic of ‘Subtidal coarse or mixed sediments’ occupying the remaining third.

Within the current analysis, the majority of samples within the Compass Rose rMCZ site have been allocated to the habitat and biotope (SS.SSa.OSa; SS.SSa.OSa.OfusAfil) which are part of the broad-scale habitat ‘Subtidal sand’. Table 9 provides a summary for the habitats and biotopes present within Compass Rose rMCZ with associated broad-scale habitats and other analysis notes.

The physical data for eight of the stations showed subtidal coarse or mixed sediments, but did not cluster together geographically or at higher than 30% similarity. However, they did share characterising species with the rest of group ‘c’ and were attributed to the SS.SSa.OSa.OfulAfil biotope despite the physical mismatches evident in the broad-scale habitats listed (Table 9).

Table 9. Summary table for the habitat/biotopes for Compass Rose rMCZ.

Biotope Code*	Broad-scale Habitat	Group	Depth (m)	Infaunal community	Comments
SS.SSa.OSa.OfusAfil	Subtidal sand, subtidal mixed sediment, subtidal coarse sediments	c	62 - 82	*Scoloplos (Scoloplos) armiger* *Owenia fusiformis* *Galathowenia oculata* *Amphiura filiformis (juv)*	Impoverished community.
SS.SSa.OSa.	Subtidal sand	a,b	65 - 80		Impoverished community.
SS.SCS.OCS	Subtidal coarse	NA	64 - 66	*Alcyonium digitatum* Paguridae Porifera *Flustra foliacea* *Ophiothrix fragilis* *Virgularia mirabilis*	Recorded from video and stills data only therefore is epifaunal.

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

3.2 Markham's Triangle rMCZ

Markham's Triangle rMCZ is 137km from the Humberside coastline in the East of England, with depth ranges between 30-50m deep (Figure 13). The seabed is composed of two broad-scale habitats, subtidal coarse sediment and subtidal sand; other features present include very small areas of rock, mixed sediments and larger areas of subtidal sands and gravels. The site lies adjacent to the Dutch Cleaverbank SAC which is put forward for the protection of harbour porpoise, grey seal and harbour seal and it is very likely that these species will be present within Markham's Triangle rMCZ given the similarities of coarse sediment habitats. To the north of the site lies the Outer Silver Pit which supports communities of crustaceans, marine mammals, fish, algae and other species (Net Gain 2011).

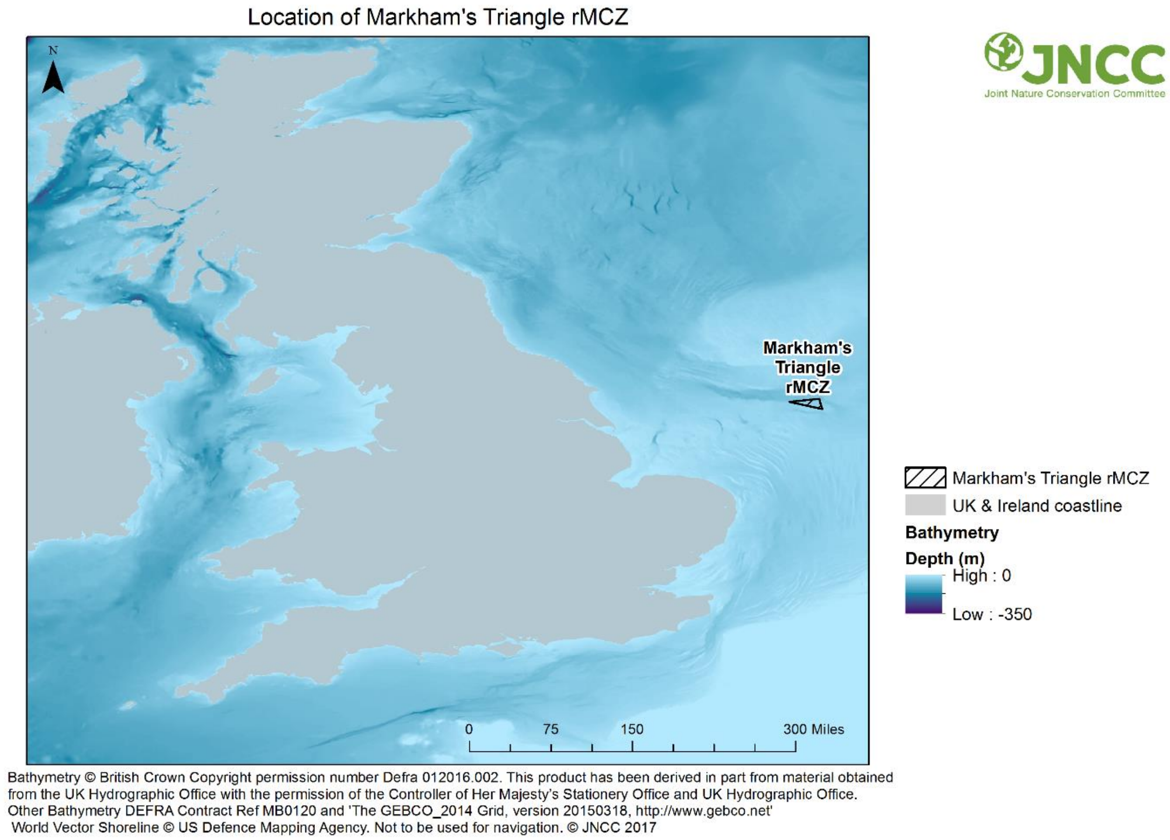

Figure 13. Markham's Triangle rMCZ location.

Markham's Triangle was recommended by the Net Gain regional MCZ project (Net Gain 2011) for MCZ status based upon the presence of two broad scale habitat types; subtidal coarse sediment and subtidal sand.

Markham's Triangle rMCZ was surveyed in April and May 2012 (Ware & Meadows 2012) which acquired multibeam bathymetric data at 75% coverage for the site and the area was sampled using a grab (0.1m^2 mini Hamon grab) and underwater towed video and stills camera. The survey confirmed the presence of the broadscale habitats 'Subtidal coarse sediment' and 'Subtidal sand' within the rMCZ boundary. Additionally, the survey identified the presence of 'Subtidal mud' and 'Subtidal mixed sediments'. A full account of the survey methods and results can be found in Ware and Meadows (2012) and Defra (2014).

3.2.1 Site specific data processing and analysis

In total, 203 taxa were recorded from the 50 samples collected (Figure 14). Twenty-three taxa were removed and a list of the removed taxa is provided in Table 10. These included:

- juveniles: can be ephemeral in nature. These were often the only record of the taxa at this site and present in relatively high numbers which can have an overriding influence on the analysis;
- taxa with damage/uncertain identification: ambiguous records which could introduce uncertainty are removed to reduce discrepancies due to misidentification;
- taxa with only presence/absence data (majority of which are epifaunal species): the presence/absence records are incompatible with the abundance data such as counts;
- raw data which contained row labels for taxonomic order or class and these were discounted unless abundances had been recorded;
- nemertea and capitelids: meiofauna were removed due to their small size and relativly high numbers which can have an overriding influence on the analysis as the high numbers dominate any statistical clustering and similarity analyses.

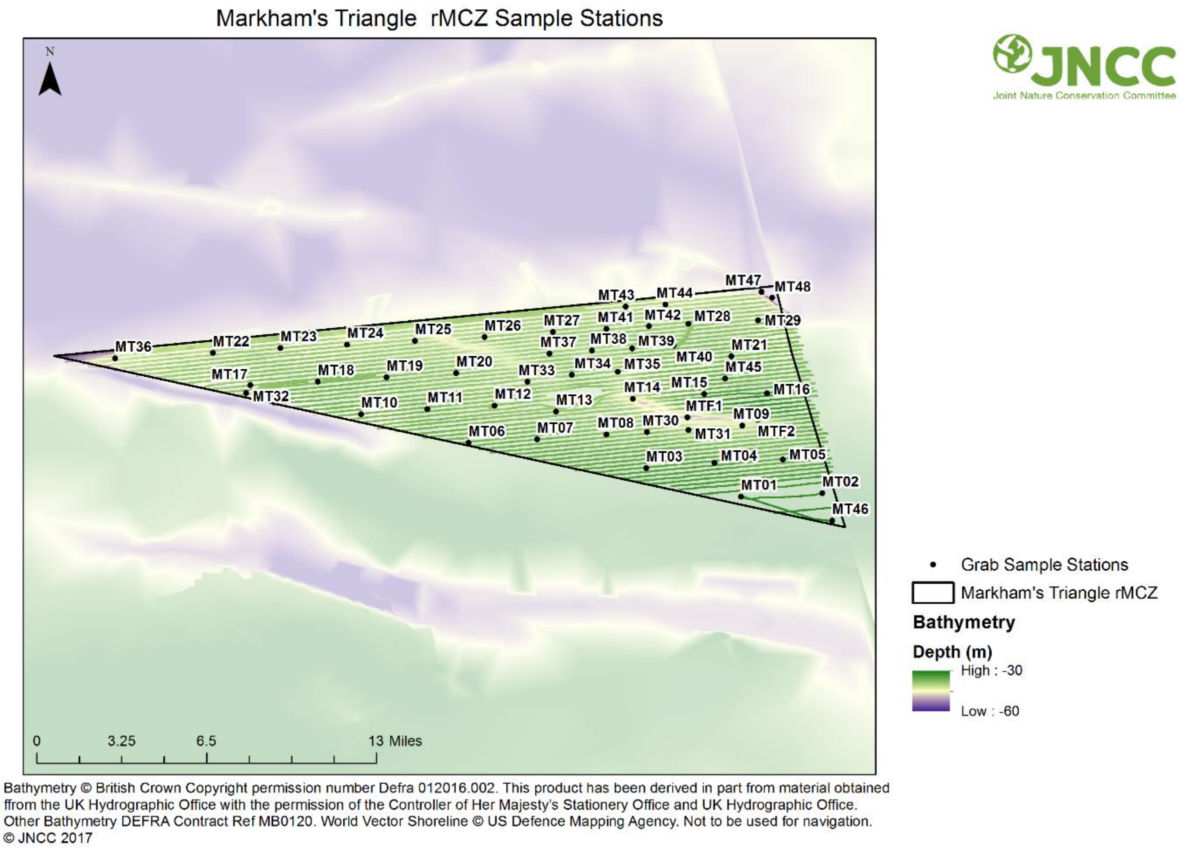

Figure 14. Markham's Triangle rMCZ sample stations, overlain on multibeam bathymetry data with broadscale bathymetry for context.

Table 10. Taxa removed from Markham's Triangle rMCZ data.

Taxa	Reason Removed (taxa number)
Callianassa sp. indet. dam.	Removed as indet and damaged, (5)
Capitellidae indet.	Grouped as Capitellidae, singleton
Cardiidae indet. juv.	Removed as indet juvenille and singleton
Crangon crangon juv.	Removed as junvenile and singleton
Echinocardium indet. juv./dam.	Removed as indet juvenille and damaged (3)
Echinoidea indet. juv.	Removed as indet juvenile (50)
Gammaridea indet. dam.	Removed as indet and damaged (19)
Glycera indet juv.	Removed as indet juvenille and singleton
Glycera lapidum agg.	Renamed *Glycera lapidum*
Hesionidae indet. Dam.	Removed as indet and damaged (3)
Holothurioidea sp. indet. dam.	Removed as indet and damaged (2)
Lumbrineridae indet. Juv.	Removed as indet juvenile (2)
Nephtys indet. Dam./juv.	Removed as indet juvenille and damaged (2)
Nereididae indet dam./juv.	Removed as indet damaged and singleton
Ophiura indet. juv.	Removed as indet juvenile (5)
Ophiuroidea indet. juv.	Removed as indet juvenile (7)
Phyllodocidae sp. indet. Juv./dam.	Removed as indet damaged and singleton
Polynoidae indet. dam./juv.	Removed as indet juvenile (18)
Sipuncula sp. juv./dam.	Removed as indet juvenille and damaged (4)
sp. suffix removed throughout	Taxa taken to genus with no pooling or aggregating
Spionidae Genus A	Spionidae used
Spionidae indet. Dam.	Removed as indet and damaged (6)
TEREBELLIDA sp. indet. Dam.	Removed as indet juvenille and damaged (2)
Upogebia sp. indet. dam.	Removed as indet damaged and singleton
Gobius niger	Removed as epifaunal (1)

3.2.2 Summary of physical habitats

A summary of key parameters of particle size analysis data is provided in Table 24, available in Appendix 1, which shows the area to be dominated by coarse substrate with some mixed substrate where silt levels are elevated. One station (MT48) shows a higher proportion of silt/mud (60%) than the remaining stations. Sandier substrates are found in the 'channel' which runs through the site and where the seabed slopes towards the deeper areas.

The spatial distribution of sediment types is illustrated in Figure 15 and Figure 16 which highlights sediment composition (% sand, gravel and mud) overlain on the broad-scale habitat map (Ware & Meadows 2012).

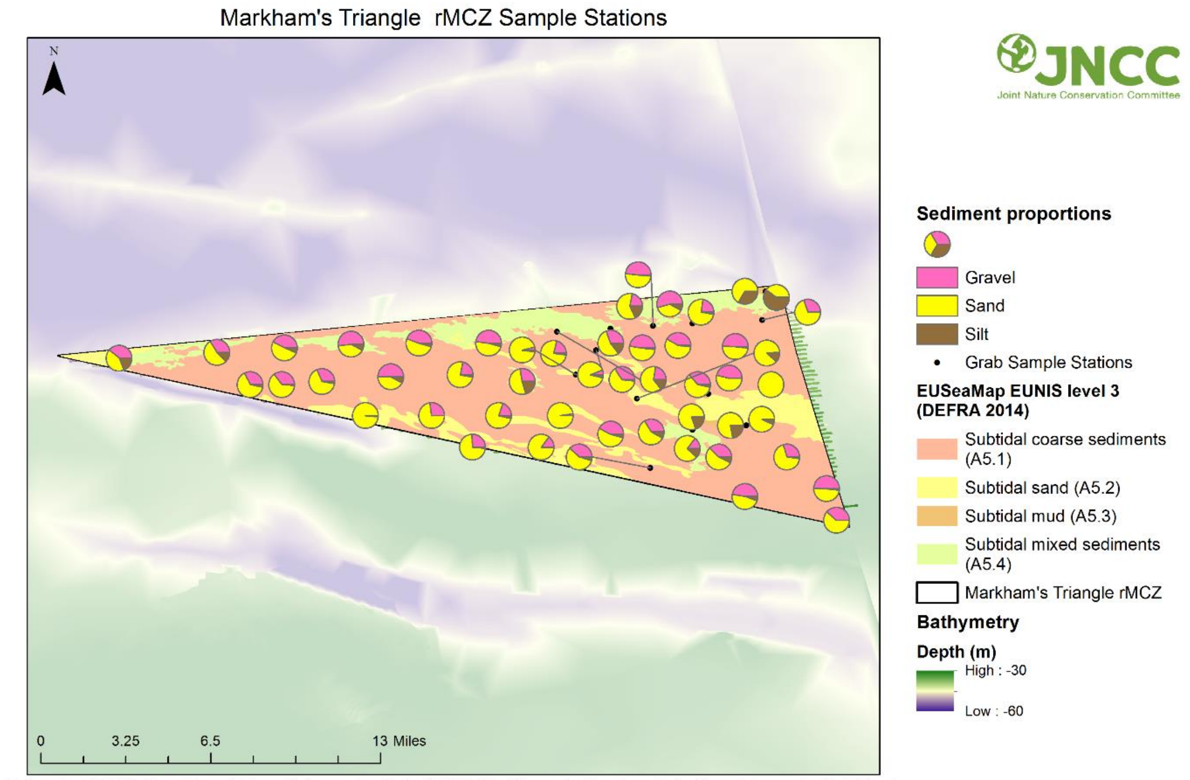

Figure 15. Markham's Triangle rMCZ sediment composition of grab samples with broad-scale habitat map.

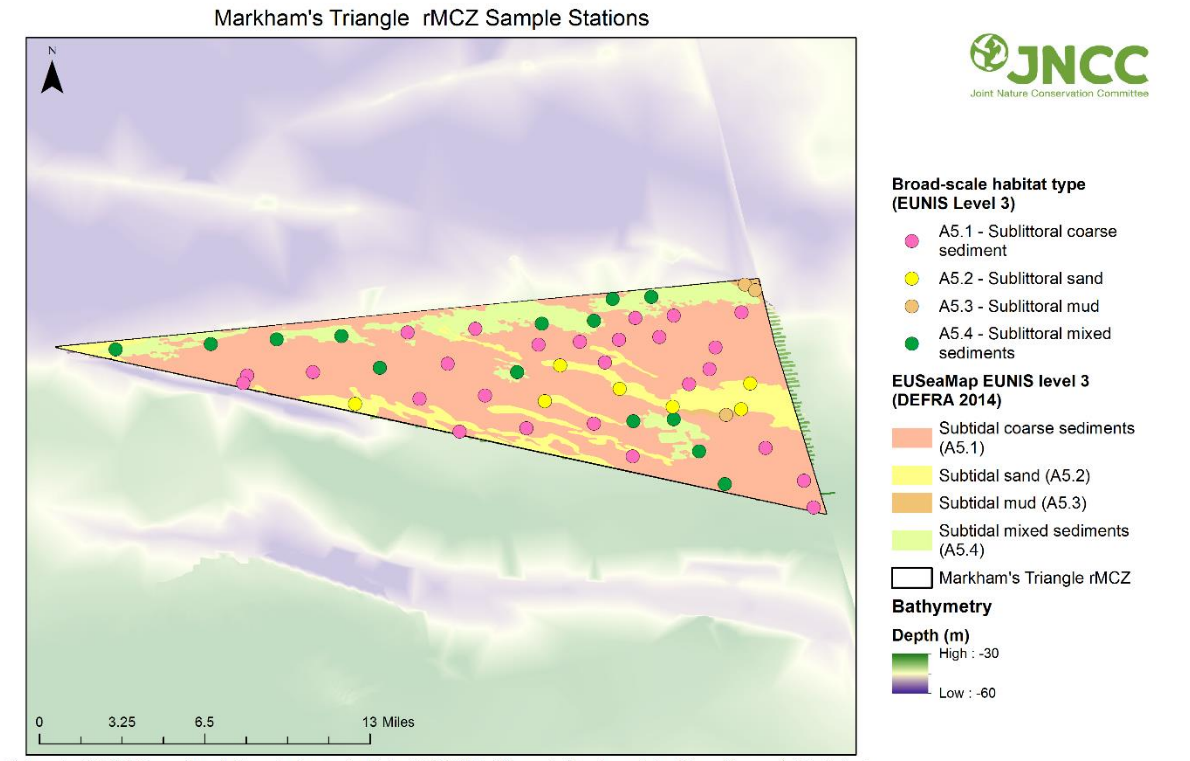

Figure 16. Markham's Triangle rMCZ broad-scale habitat from PSA of grab samples.

3.2.3 Statistical results for Markham's Triangle rMCZ

The SIMPROF routine was used to define sample groups with similar species composition and Figure 17 displays the results of the cluster analysis on the infaunal data which have been aggregated at genus level, with the dendrogram based on group-averaged Bray-Curtis similarities computed on standardised, square root transformed abundances. A 30% similarity cut-off (slice) was used to define most of the groupings which otherwise are separated due to only small variations, which show no practical ecological groupings. Group 'd' used a lower similiarity (26%) which incorporated sample MT22 as this was a single sample and pooled closest to group 'd'.

Genus level aggregation was used as the data contained relatively high number of taxa identified to species level but in low abundances and the species were not common between samples. Aggregation to genus level pooled these taxa and provided common, genus level data for statistical comparison. Non-aggregated data were referred to when identifying the characterising species with a benthic community (Table 14).

Figure 18 shows the three dimensional MDS plot of the same similarities. The stress value of 0.14 gives confidence that the three-dimensional plot is an accurate representation of the sample relationships.

The similarities between samples ranged from about 36% to 52%, with four groups identified ('a', 'b', 'c' & 'd'). The taxa which contributed to greater than 1% of the similarity for each of the biological groups based on the results of the SIMPER analysis are shown in Table 12. The main divisions between samples split group 'a' from the other groups at 10% similarity whilst group 'd' was separated from groups 'b' and 'c' at around 23% similarity.

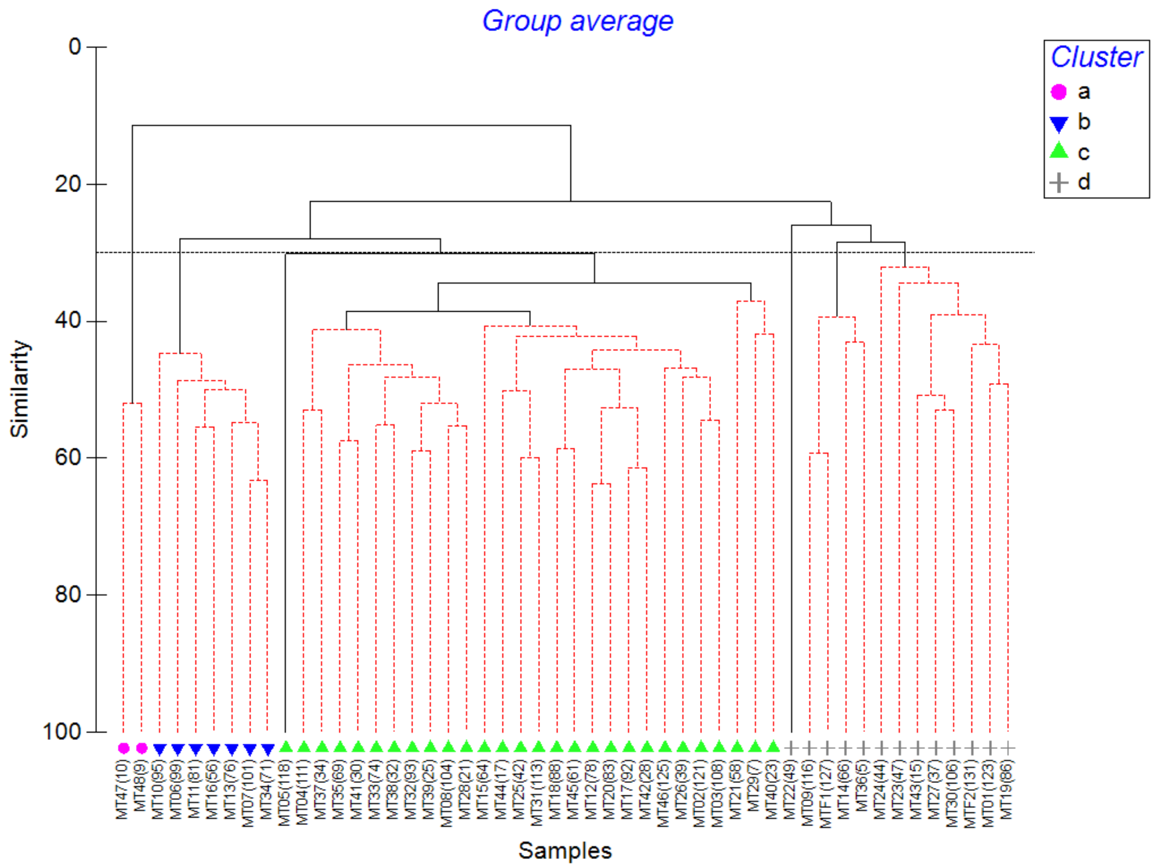

Figure 17. Markham's Triangle rMCZ dendrogram using similarities from abundance data.

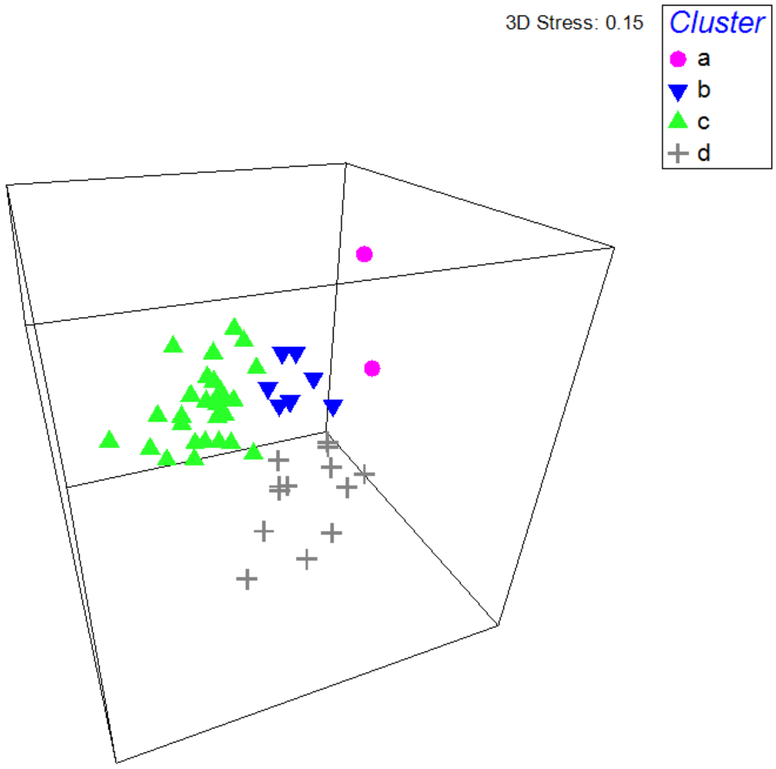

Figure 18. Markham's Triangle rMCZ MDS plot from abundance data.

3.2.4 Univariate results

The numbers of taxa per sample (S), number of individuals per sample (N), values of Margalef's species richness index (d) and Pielou's evenness index (J') are presented in Table 11.

The multivariate analysis for Markham's Triangle rMCZ resulted in four groups, with the majority of samples clustering into groups 'b' and 'c' which share some characterising species and cluster closely with one another. Group 'd' is separate from groups 'b' and 'c' and showed a relatively high degree of similarity (52%), and appears to be less influenced by gravel substrates. The remaining group 'a' contained only two samples but was distinct from the other groups and contains those samples with a high mud/silt content.

The univariate analysis results showed that for group 'c', the densities of infaunal organisms were relatively consistent, with the number of taxa recorded (per sample) ranging from 12 to 36 (mean 22) but the number of individuals (per sample) was more variable ranging from 28 to 116, with a mean of 63. The group appears to exhibit a variable level of richness in terms of Margalef's index (range from 2.68 to ,7.521 mean 5.10) and a relatively consistent high level of evenness with Pielou's index ranging from 0.71 to 0.92 and a mean of 0.83, indicating little variation within samples. Group 'b' exhibits lower numbers of taxa than group 'c' (12 to 19 taxa per sample (mean 15) and 24 to 55 individuals per sample (mean 38)), and with a mean of 3.88 the Margalef's index suggests a lower diversity than Group 'c', but with a similar evenness (Pielou's index mean of 0.86). It is possible the groups are richer or impoverished versions of each other and they do share some common characterising species.

For group 'd', the densities of infaunal organisms were comparable to the other groups, with the number of taxa recorded (per sample) ranging from 11 to 36 (mean 22), but the number of individuals (per sample) varying more from 19 to 156 (mean 83). This group also exhibits a variable level of richness in terms of Margalef's index, ranging from 3.4 to 8.01, with a mean of 5.14, and a variable level of evenness with Pielou's index ranging from 0.59 to 0.93 and a mean of 0.83.

With only two sample stations represented in group 'a', univariate statistics are of little meaning for describing the biological diversities and the values should be considered individually.

Table 11. Diversity indices and summary univariate statistics Markham's Triangle rMCZ infaunal samples.

Station code	Group	Total taxa (S)	Total individuals (N)	Margalef's (d)	Pielou's (J')
MT47(10)	a	21	78	4.59	0.85
MT48(9)	a	7	44	1.59	0.64
MT06(99)	b	13	24	3.78	0.92
MT07(101)	b	12	29	3.27	0.83
MT10(95)	b	17	41	4.31	0.88
MT11(81)	b	17	43	4.25	0.81
MT13(76)	b	15	44	3.70	0.85
MT16(56)	b	12	27	3.34	0.92
MT34(71)	b	19	55	4.49	0.78
MT02(121)	c	25	81	5.46	0.86
MT03(108)	c	25	64	5.77	0.87
MT04(111)	c	16	46	3.92	0.85
MT05(118)	c	19	44	4.76	0.87
MT08(104)	c	20	71	4.46	0.85
MT12(78)	c	21	61	4.87	0.76
MT15(64)	c	25	106	5.15	0.87
MT17(92)	c	22	84	4.74	0.76
MT18(88)	c	16	37	4.15	0.82
MT20(83)	c	26	66	5.97	0.84
MT21(58)	c	25	52	6.07	0.83
MT25(42)	c	33	116	6.73	0.78
MT26(39)	c	23	59	5.40	0.86
MT28(21)	c	27	58	6.40	0.86
MT29(7)	c	16	44	3.96	0.76
MT31(113)	c	36	105	7.52	0.84
MT32(93)	c	18	48	4.39	0.83
MT33(74)	c	23	55	5.49	0.92
MT35(69)	c	14	28	3.90	0.80
MT37(34)	c	20	53	4.79	0.86
MT38(32)	c	16	47	3.90	0.81
MT39(25)	c	19	45	4.73	0.87
MT40(23)	c	19	47	4.68	0.84
MT41(30)	c	12	61	2.68	0.71
MT42(28)	c	25	62	5.82	0.85
MT44(17)	c	28	82	6.13	0.83
MT45(61)	c	21	68	4.74	0.80

Station code	Group	Total taxa (S)	Total individuals (N)	Margalef's (d)	Pielou's (J')
MT46(125)	c	27	65	6.23	0.85
MT01(123)	d	20	50	4.86	0.81
MT09(116)	d	23	96	4.82	0.71
MT14(66)	d	16	31	4.37	0.88
MT19(86)	d	16	61	3.65	0.69
MT22(49)	d	25	57	5.94	0.92
MT23(47)	d	19	45	4.73	0.88
MT24(44)	d	11	19	3.40	0.93
MT27(37)	d	36	79	8.01	0.89
MT30(106)	d	31	66	7.16	0.91
MT36(5)	d	20	75	4.40	0.72
MT43(15)	d	27	74	6.04	0.89
MTF1(127)	d	24	156	4.56	0.59
MTF2(131)	d	20	49	4.88	0.90

3.2.5 Summary of characterising species and communities

Group ‘a’ which comprised just two stations (station MT47 & MT48) was characterised by mud with low numbers of taxa such as *Abra abra* and Nephtys with amphipods Ampelisca and Harpinia. The gastropod Evalea[4] is noted in this group and is abundant (26) in one sample and is found on sandy or gravelly muds.

The largest group, which included thirty-four samples, clustered together at about 40% similarity to form group ‘c’. The taxa which contributed to greater than 5% of the similarity within this group were *Echinocyamus pusillus*, *Urothoe marina*, Laonice and *Ophelia borealis*.

Several characterising species were shared between group ‘b’ and ‘c’, including *Echinocyamus pusillus and Ophelia borealis*. The polychaete *Scoloplos (Scoloplos) armiger* was absent from group ‘c’ but present in ‘b’, which may indicate that group ‘b’ had a sandier substrate than group ‘c’.

Group ‘d’ generally shows less silt/mud content and has characterising species of *Amphiura filiformis*, the razor clam *Phaxas pellucidus,* the amphipod *Urothoe marina* and to a lesser extent *Pholoe baltica* and *Spiophanes* spp. contribute to the grouping.

The taxa which form the characterising species for each of these groups, with a percentage contribution of over 1%, are shown in Table 12.

[4] Taxa have been identified at genus level, Evalea, which has a range of species, some of which have been taxonomically reclassified as Ondina species.

Table 12. Characterising taxa for multivariate groups at Markham's Triangle rMCZ, showing those with a contribution of over 1%.

Group 'a' **Species/Taxa**	**Average Abundance**	**%age contribution**
Abra	4.92	29.29
Nephtys	3.01	19.4
Evalea	5.23	17.96
Ampelisca	2.33	13.81
Harpinia	1.55	9.76

Group 'b' **Species/Taxa**	**Average Abundance**	**%age contribution**
Echinocyamus	4.82	24.39
Ophelia	4.16	20.8
Scoloplos	3.39	17.9
Dosinia	2.43	12.92
Glycinde	1.44	5.35
Pista	1.3	4.7
Phaxas	1.05	1.66
Aonides	0.99	1.58
Spiophanes	0.87	1.56

Group 'c' **Species/Taxa**	**Average Abundance**	**%age contribution**
Echinocyamus	3.9	18.61
Urothoe	2.23	7.6
Laonice	1.9	6.97
Pholoe	1.52	5.47
Abra	1.67	5.41
Syllis	1.55	5.16
Aonides	1.46	5.02
Ophelia	1.56	4.97
Glycera	1.36	4.29
Leptocheirus	1.13	3.3
Pista	1.09	3.14
Protodorvillea	1.2	3.06
Goniadidae	1.01	2.71
Cumacea	0.86	2.38
Nucula	0.97	2.08
Polycirrus	0.81	2.02
Branchiostoma	0.87	1.9
Caulleriella	0.71	1.79
Dosinia	0.67	1.58
Nematoda	0.85	1.47
Eulalia	0.79	1.47

Group 'd' Species/Taxa	Average Abundance	%age contribution
Amphiura	4.21	24.65
Phaxas	2.23	11.51
Urothoe	2.59	9.49
Goniadidae	1.36	6.13
Pholoe	1.33	5.98
Echinocyamus	1.54	5.06
Spiophanes	1.13	4.19
Tellimya	0.98	3.11
Lumbrineris	1.19	2.61
Callianassa	0.93	2.4
Terebellides	0.74	2.31
Amphictene	0.9	2.25
Scoloplos	0.84	2.1
Glycera	0.86	2
Upogebia	0.56	1.55
Ophelia	0.83	1.38
Nephtys	0.52	1.3
Timoclea	0.53	1.16

3.2.6 Biotope allocation

The groupings produced from the multivariate analysis have been matched to biotopes as defined by the Marine Habitats Classification for Britain and Ireland (JNCC 2015) and using the recent guidance by Parry (2015). Possible candidate biotopes were selected based on species composition, physical parameters, such as sediment and depth, and the results of the multivariate analysis. The taxa which were removed during data processing prior to statistical analysis were reviewed and considered within the biotope allocation process.

A description of habitat types/biotopes allocated to each of the sampling stations is given below and summarised in Table 13 with the spatial distribution of the groups and biotopes illustrated in Figure 19 and Figure 20. Table 25 in Appendix 1 presents the multivariate group and the biotope or habitat assigned to each sample with any comments noted from the processing such as impoverished samples or physical mismatches between sediment types and the biotopes assigned.

The two sampling stations within group 'a' have a physical habitat which is muddier than other samples and is categorised as muds and sandy muds. The biota characterising the group are bivalves and polychaetes found in muddy sand or mud based environments, but the community does not match well with any specific biotope within the habitat classification and as such the physical attributes have been used to assign the habitat of **SS.SMu.CSaMu.** This group only consisted of two samples which were characterised by mud with relatively low numbers of taxa, and it was not felt that the biological grouping was strong enough to drive a new biotope based on this information alone.

Group 'b' has biota which is indicative of a sandy habitat and in most cases the sediment analysis supports this, with slightly gravelly or gravelly sands being attributed to the samples. There is very little silt/mud in any of the samples (<2%) and the gravel content is variable with 26% being recorded in two samples. Despite this indicating some of the samples are coarse, the biotope **SS.SSa.CFiSa.EpusOborApri** has been assigned to this group with those samples having mismatched habitat types indicated in Table 25.

Group ‘c’ had an increased gravel content and moderate sand fraction in comparison with other groups and the varying level of silt gives physical habitats of mixed or coarse sediments. The characterising biota has a range of polychaetes, bivalves and amphipods which can be associated with both coarse and mixed substrates. The biotope **SS.SSa.CFiSa.EpusOborApri** has been assigned to this group with all samples having physical mismatches, indicated in Table 25.

Most of the samples within group ‘d’ have a mixed sediment habitat or are muddy sand or sandy mud habitat where gravel fractions are lower. The biota within this group appear to be associated with a sandier substrate than indicated by the physical data, with the bivalve *Phaxas pellucidus* and the brittlestar Amphiura spp. both found in relative abundance. Other less abundant taxa which suggest a coarse habitat (*Urothoe marina* and *Echinocyamus pusillus*) are also present but are found in low abundances. Epibenthic images were also reviewed and confirm heterogeneous physical habitats and biota, rather than one discreet community, therefore the samples within the group have not been allocated to a new biotope, but attributed habitats according to the physical nature of the seabed. Habitats are **SS.SMx.CMx, SS.SSa.CMuSa** and **SS.SMu.CSaMu**.

In summary, Table 14 shows the biotope and habitats found within Markham’s Triangle rMCZ with the characterising species and seabed substrate for each.

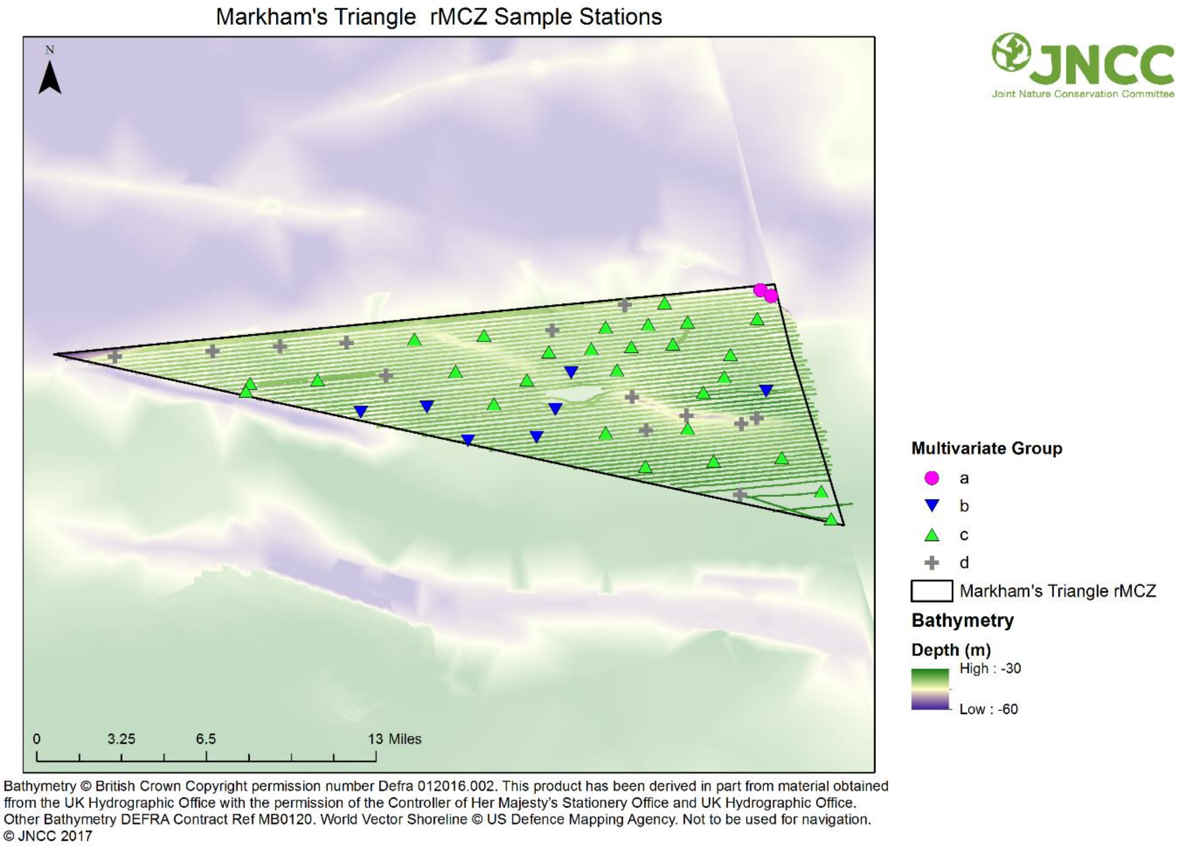

Figure 19. Markham’s Triangle rMCZ sample stations showing multivariate groups.

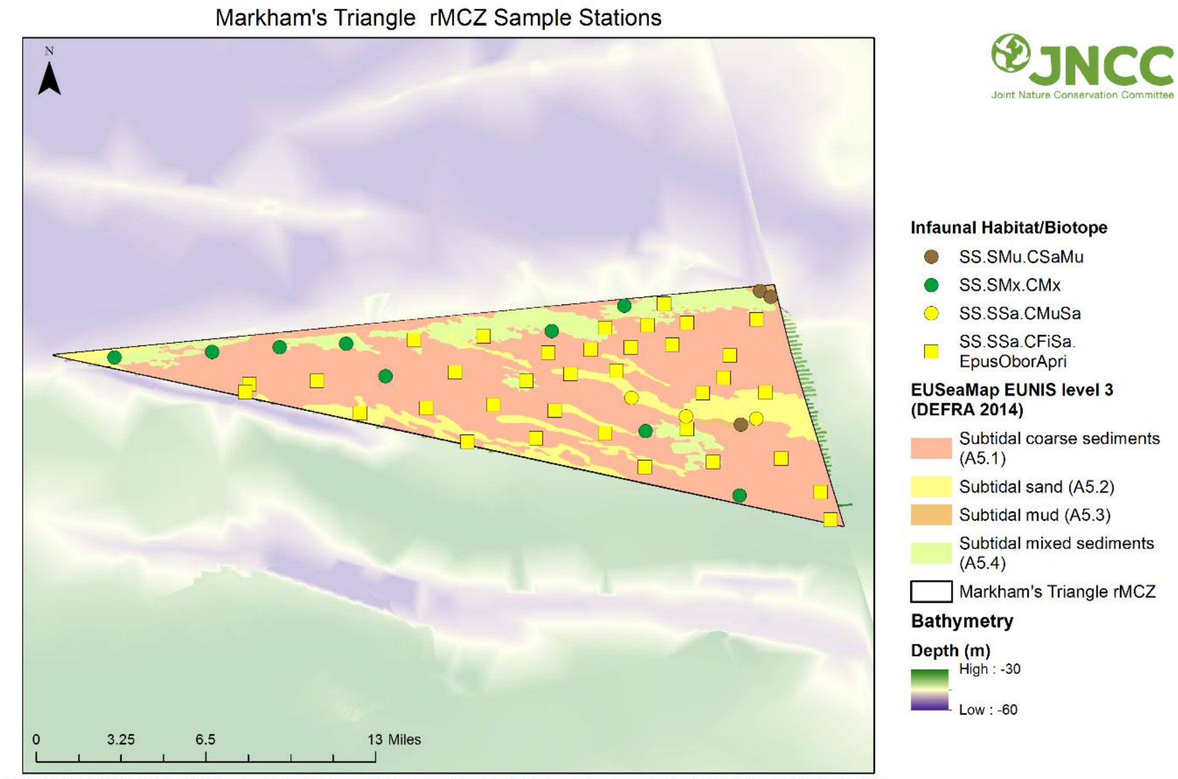

Figure 20. Markham's Triangle rMCZ sample stations showing biotope/habitats.

Table 13. Summary of multivariate statistical groups and associated habitats and biotopes from the Markham's Triangle rMCZ.

Multivariate Group	Number of Samples	Biotope Code*	Broad-scale Habitat
a	2	SS.SMu.CSaMu	Subtidal mud
b	7	SS.SSa.CFiSa.EpusOborApri	Subtidal sand Subtidal coarse sediment
c	28	SS.SSa.CFiSa.EpusOborApri	Subtidal coarse sediment Subtidal mixed sediments
d	1	SS.SMu.CSaMu	Subtidal mud
	3	SS.SSa.CMuSa	Subtidal sand
	9	SS.SMx.CMx	Subtidal mixed sediments

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

Table 14. Summary of habitats/biotopes found within Markham's Triangle rMCZ.

Habitat/Biotope*	Depth range (m)	Substratum	Infaunal community	Multivariate groups
SS.SSa.CMuSa	41 - 45	Sand and muddy sand	*Nephtys* spp, *Abra abra*, *Ampelisca diadema*, *Harpinia antennaria*	d
SS.SSa.CFiSa.EpusOborApri	28 - 39	Fine sand/ coarse and mixed sediments	Echinocyamus *Ophelia borealis*, *Scoloplos armiger*, *Dosinia lupinus*, *Glycinde nordmanni*	b, c
SS.SMx.CMx	30 - 40	Mixed sediment	*Amphiura filiformis,* *Phaxas pellucidus* *Urothoe marina*, Goniadidae, *Pholoe baltica* *Echinocyamus pusillus*	d
SS.SMu.CSaMu	41 - 58	Mud and sandy mud	*Amphiura filiformis,* *Phaxas pellucidus* *Urothoe marina*, Goniadidae, *Pholoe baltica* *Echinocyamus pusillus*	a, d

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

3.2.7 Epibenthic Review

Epibenthic data from 20 video tows (Figure 21) have previously been analysed visually by Cefas in 2012 and allocated to an appropriate habitat or biotope, these were reviewed and it was noted the majority (16) of samples had been allocated to the habitat **SS.SSa.CFiSa** (Circalittoral fine sand) of which 14 samples have a **SS.SSa.CFiSa.EpusOborApri** biotope attributed from infaunal analysis, and the remaining two being allocated to a sandy mud habitat (**SS.SMu.CSaMu**) and a mixed sediment habitat (**SS.SMx.CMx**).

The epibenthic samples not attributed with a sand habitat have been assigned the habitats **SS.SMx.CMx** or **SS.SCS.CCS**, both of which are attributed **SS.SSa.CFiSa.EpusOborApri** from infaunal analysis suggesting a variation in physical habitats between infaunal and epifanunal analysis.

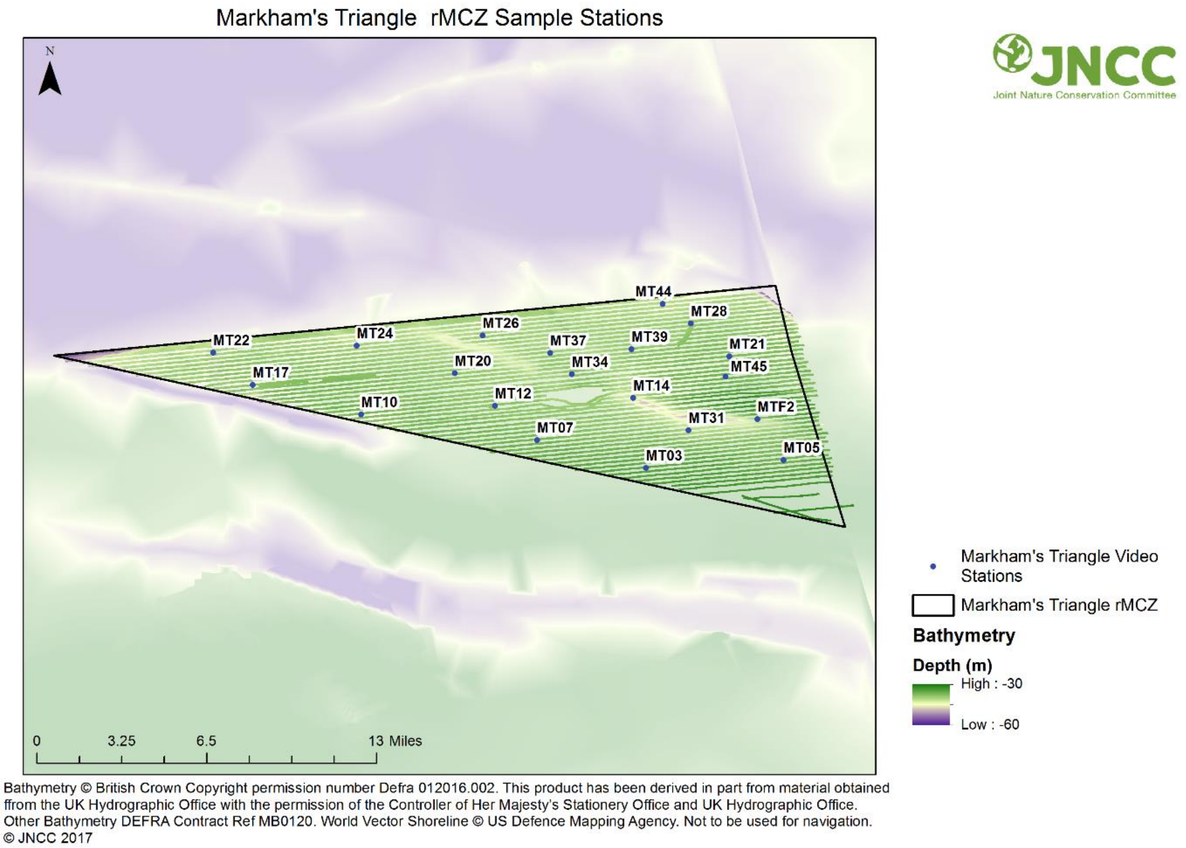

Figure 21. Markham's Triangle rMCZ video sample stations.

The video and still images from each of the stations were reviewed again visually and it would appear the epifauna community does show fine sand with *Asterias rubens* being frequent, Anthozoa (Anemones) and *Alcyonium digitatum* being recorded occasionally along with numberous epibenthic fish species.

The taxa removed from infaunal data during processing were reviewed to assess whether they would form part of the epifaunal community and only the black goby, *Gobius niger*, was noted.

The habitats identified from the original analysis of the video data by Cefas in 2012 have been overlain onto those identified from infaunal analysis (Figure 22). Habitat assessment identified fine sand at 16 stations of which 14 were also identified as a fine sand biotope from infaunal analysis. Epifaunal habitat assessment identified three locations where coarse or mixed habitats were recorded where a fine sand biotope was identified from infaunal analysis.

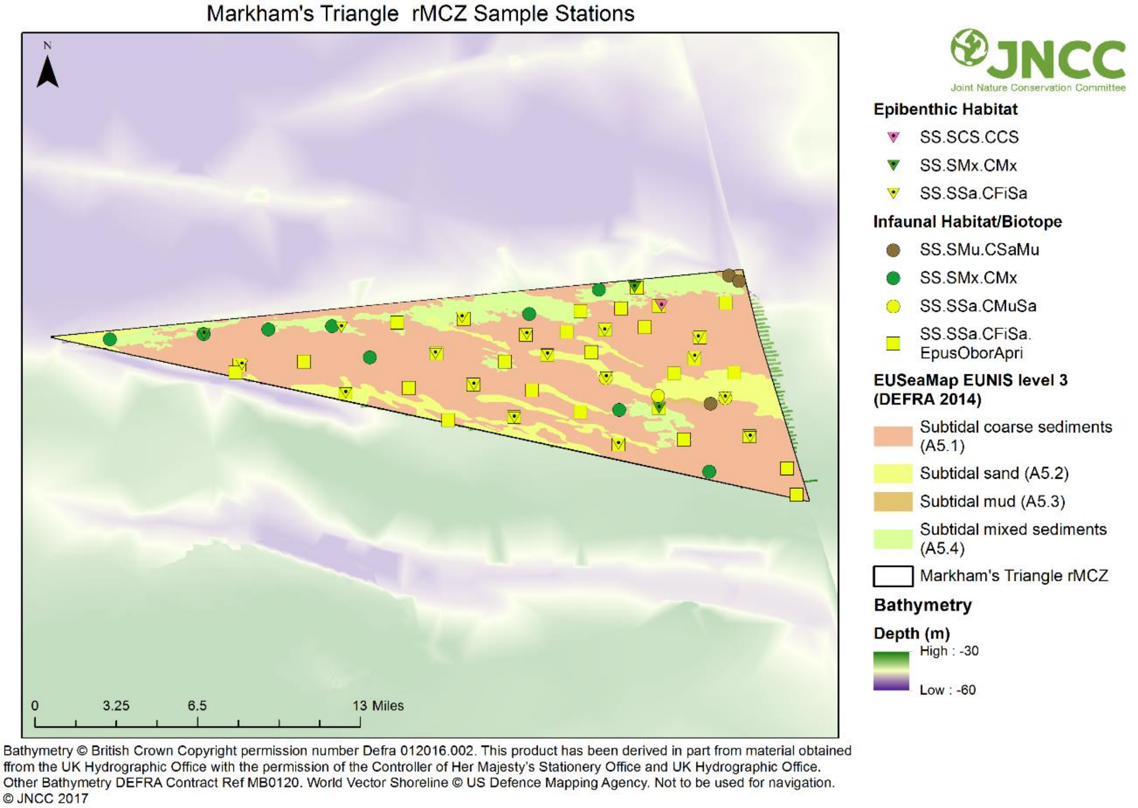

Figure 22. Markham's Triangle rMCZ video and grab sample stations showing biotopes/habitats on a broad-scale habitat map of the site.

3.2.8 Site Summary

A previous survey (Ware & Meadows 2012; Defra 2014) identified the presence of the broadscale habitats 'Subtidal coarse sediment', 'Subtidal sand', 'Subtidal mud' and 'Subtidal mixed sediments' within the rMCZ boundary.

Of the 50 samples analysed within this analysis, 38 (76%) were found to support the presence of 'Subtidal sand' in the area, having been allocated the biotope SS.SSa.CFiSa.EpusOborApri or habitat SS.SSa.CMuSa. The remaining samples confirmed the presence of the broadscale habitats 'Subtidal coarse sediment', 'Subtidal mud' and 'Subtidal mixed sediments'. Table 15 provides a summary for the habitats and biotopes present within Markham's Triangle rMCZ with associated broad-scale habitats and other analysis notes.

Table 15. Summary table for the habitat/biotopes for Markham's Triangle rMCZ.

Biotope Code*	Broad-scale Habitat	Group	Depth (m)	Infaunal community	Comments
SS.SSa.CFiSa.EpusOborApri	Subtidal sand, subtidal coarse sediment subtidal mixed sediments	b, c	34 - 37	*Echinocyamus pusillus* and *Ophelia borealis*	Impoverished with physical mismatches. Also epifaunal.

Biotope Code*	Broad-scale Habitat	Group	Depth (m)	Infaunal community	Comments
SS.SSa.CMuSa	Subtidal sand	d	41 - 45	*Amphiura filiformis*, *Phaxas pellucidus, Urothoe marina*	Reverted to physical data to assign habitat type.
SS.SMx.CMx	Subtidal mixed sediment	d	30 - 40	*Amphiura filiformis, Phaxas pellucidus Urothoe marina*,	Reverted to physical data to assign habitat type. Also epifaunal.
SS.SMu.CSaMu	Subtidal mud	a, d	41 - 58		Reverted to physical data to assign habitat.
SS.SCS.SCS	Subtidal coarse	NA		*Asterias rubens Anthozoa(Anemones) Alcyonium digitatum*	Recorded from video and stills data only, therefore is epifaunal.

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

3.3 South Rigg rMCZ

South Rigg rMCZ is located in the western Irish Sea between three different territorial seas – Northern Irish waters to the west, Scottish waters to the north, and the Isle of Man waters to the east (Figure 23). The site is approximately 28km south of the Mull of Galloway, 90km west of Whitehaven, and 26km north-west of Peel, Isle of Man with seabed depths ranging from 50 to 150 metres. It is one of a number of rMCZs in the Irish Sea, with Mud Hole rMCZ to the east of the Isle of Man and Slieve Na Griddle rMCZ and North St George's Channel rMCZ to the south of South Rigg rMCZ (Defra 2015).

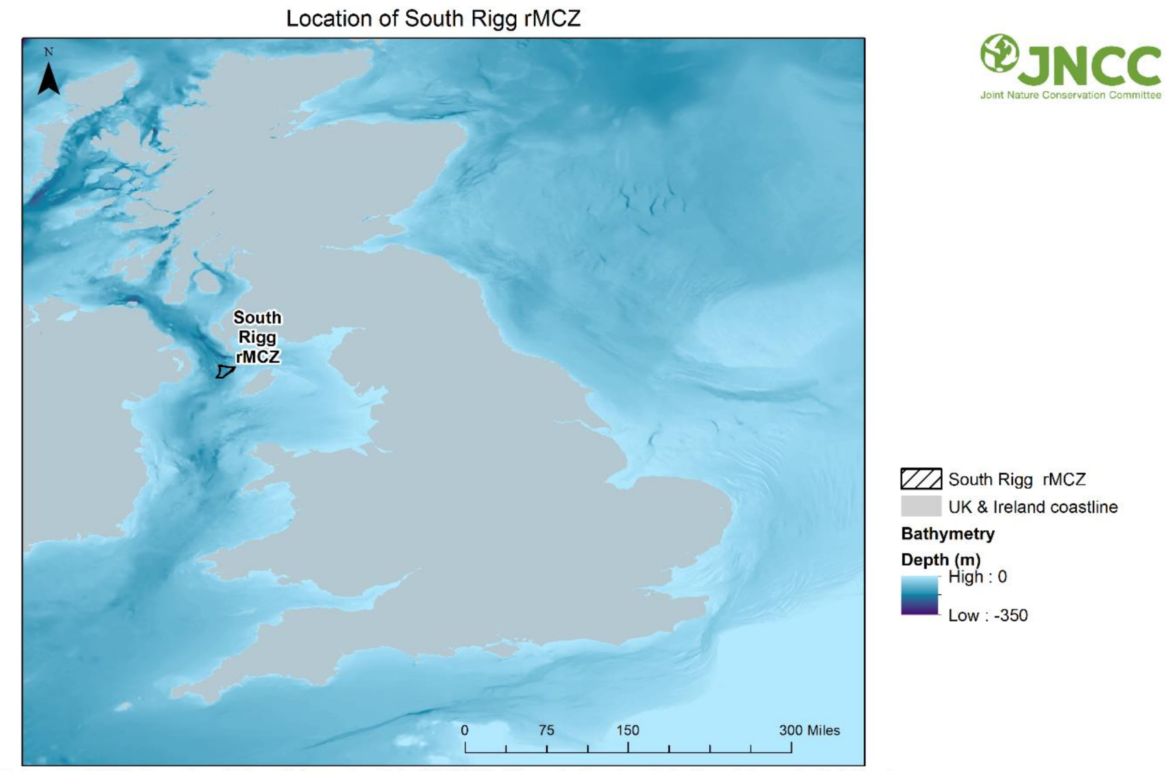

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Figure 23. South Rigg rMCZ location.

The site was recommended by the Irish Sea Conservation Zone regional project (Irish Sea Conservation Zones 2011) for MCZ status to fill gaps in the network for subtidal sand, subtidal mud, and sea-pen and burrowing megafauna communities. This site also contains bedrock outcrops and reef habitats which support a range of species including sea anemones, brittlestars and bryozoans, moss-like animals which in large numbers form a seabed turf. The long-lived bivalve Ocean Quahog (*Arctica islandica*) is also found within the site (Defra 2015).

A previous survey in 2008 collected bathymetry and backscatter data along with grab sample and video imagery which covered the south and west of South Rigg rMCZ site and was reported in Mellor *et al* (2008). The information and outputs from this survey have been referred to during analysis and there is expected to be a commonality between the surveys and where possible biotopes identified or proposed new biotopes can be matched or referred to. The 2008 survey did not cover the north-east of the rMCZ. This area of the site was surveyed in February 2012 by AFBI (Cefas 2016b). Sediment samples were acquired using a Day grab (0.1m^2), and multibeam bathymetry and backscatter data were also acquired which were gridded at 1m resolution for analysis. Raw epibenthic data (video and stills) was provided for context from the 2012 AFBI survey, however due to low quality the video footage has not been further analysed for this report.

The 2012 survey identified the presence of the broadscale habitat ‘Subtidal sand’ in over two thirds of the site, with ‘Subtidal mud’ occupying a quarter of the surveyed area and ‘Subtidal coarse sediment’ present in a small patch. A full account of the survey methods and results can be found in Strong (2012) and Defra (2016b).

3.3.1 Site specific data processing and analysis

In total, 234 taxa were recorded from the 33 samples collected (Figure 24). Twenty-eight taxa were removed prior to statistical analysis and are listed in Table 16 along with notes of where taxa where pooled. These included:

- juveniles: can be ephemeral in nature. These were often the only record of the taxa at this site and present in relatively high numbers which can have an overriding influence on the analysis;
- taxa with damage/uncertain identification: ambiguous records which could introduce uncertainty are removed to reduce discrepancies due to misidentification;
- species such as fish: mobile species are removed as they do not form part of the infaunal community and are not permanent members of the community structure;
- taxa with only presence/absence data (majority of which are epifaunal species): the presence/absence records are incompatible with the abundance data (such as counts); and
- one taxa (*Araphura brevimana*) could not be matched to a WoRMs record, and is possibly a typographical error but as only a single record was noted this was removed due to uncertainty.

Table 16. Taxa removed from South Rigg rMCZ data.

Taxa	Reason Removed (taxa number)
Abra spp juv	Juveniles removed (9)
Alcyonium sp	Presence data only and epifaunal
Ampelisca sp juv	Juveniles removed (2)
Aphelochaeta sp	Pooled to Aphelochaeta (2)
Aphelochaeta sp A	Pooled to Aphelochaeta (7)
Araphura brevimana	No match in WoRMS possibly *Araphura brevimanus* but uncertain and is a singleton
ASCIDIIDAE spp juv	Juveniles removed (1)
Balanus sp	Presence data only and epifaunal
Cardiidae sp juv	Juveniles removed (4)
Cucumariidae spp juv	Juveniles removed (2)
Dosinia sp juv	Juveniles removed (1)
Ebalia spp juv	Juveniles removed (2)
Echinocardium spp juv	Juveniles removed but note high abundances to be aware of when biotoping (21)
ECHINOIDEA spp juv	Juveniles removed but note high abundances to be aware of when biotoping (2)
Gnathia sp juv	Juveniles removed (1)
Haleciidae sp	Presence data only and epifaunal
Majidae sp juv	Juveniles removed (4)
Maldanidae spp juv	Juveniles removed (7)
Mya sp Juv	Juveniles removed (13)
Mytilidae sp juv	Juveniles removed (4)
Nephtys spp juv	Juveniles removed (6)
Nuculidae spp juv	Juveniles removed (2)
Ophiuroidea fragments	removed as damaged and presence only indicated
OPHIUROIDEA spp juv	Juveniles removed but note high abundances to be aware of when biotoping (107)

Taxa	Reason Removed (taxa number)
Pectinariidae spp juv	Juveniles removed (1)
Polychaeta fragments	removed as damaged and presence only indicated
PORIFERA	Presence data only and epifaunal
Serpulidae spp indet	Left as Serpulidae only, difficult to id, suspect used a catchall rather than an uncertain id
Sertulariidae sp	Presence data only and epifaunal
SIPUNCULA spp juv	Juveniles removed (3)
Thyasira sp juv	Juveniles removed (7)

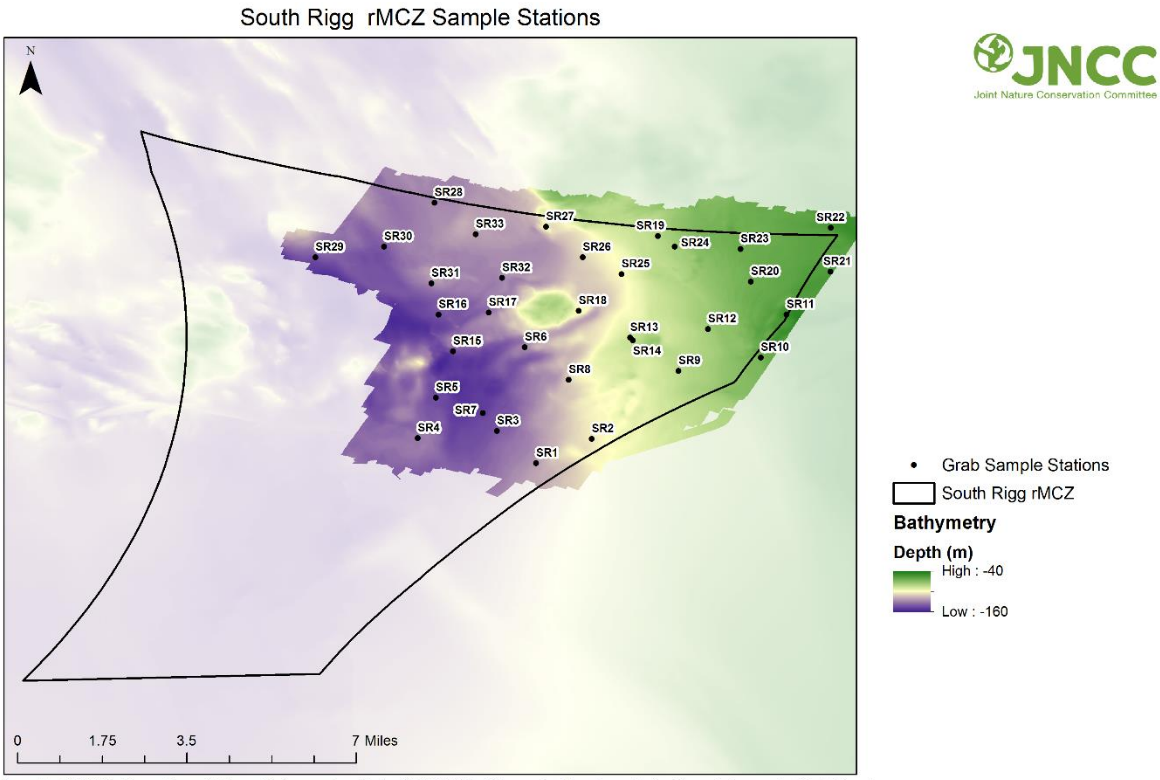

Figure 24. South Rigg rMCZ (north-east section) sample stations, overlain on multibeam bathymetry data with broadscale bathymetry for context.

3.3.2 Summary of physical habitats

The spatial distribution of sediment types is illustrated in Figure 25 which highlights sediment composition (% sand, gravel and mud) overlaid on the broad-scale habitat map generated from the 2012 survey (Defra 2016b). A summary of key parameters of particle size analysis data are provided in Table 26 in Appendix 1.

The north-east section of the site appears to consist of sediments which are predominantly sandy in nature, with the majority of samples (19) being classified as 'Subtidal sand'. Elevated levels of silt in some places give the seabed a muddier substrate, with 'Subtidal mud' allocated at nine stations. Mixed substrates are found at three stations where there are elevated levels of silt/mud content within some of the samples which also contain higher levels of gravel, and only two samples (SR21 & SR22) being classified as 'Subtidal coarse sediment' from PSA data.

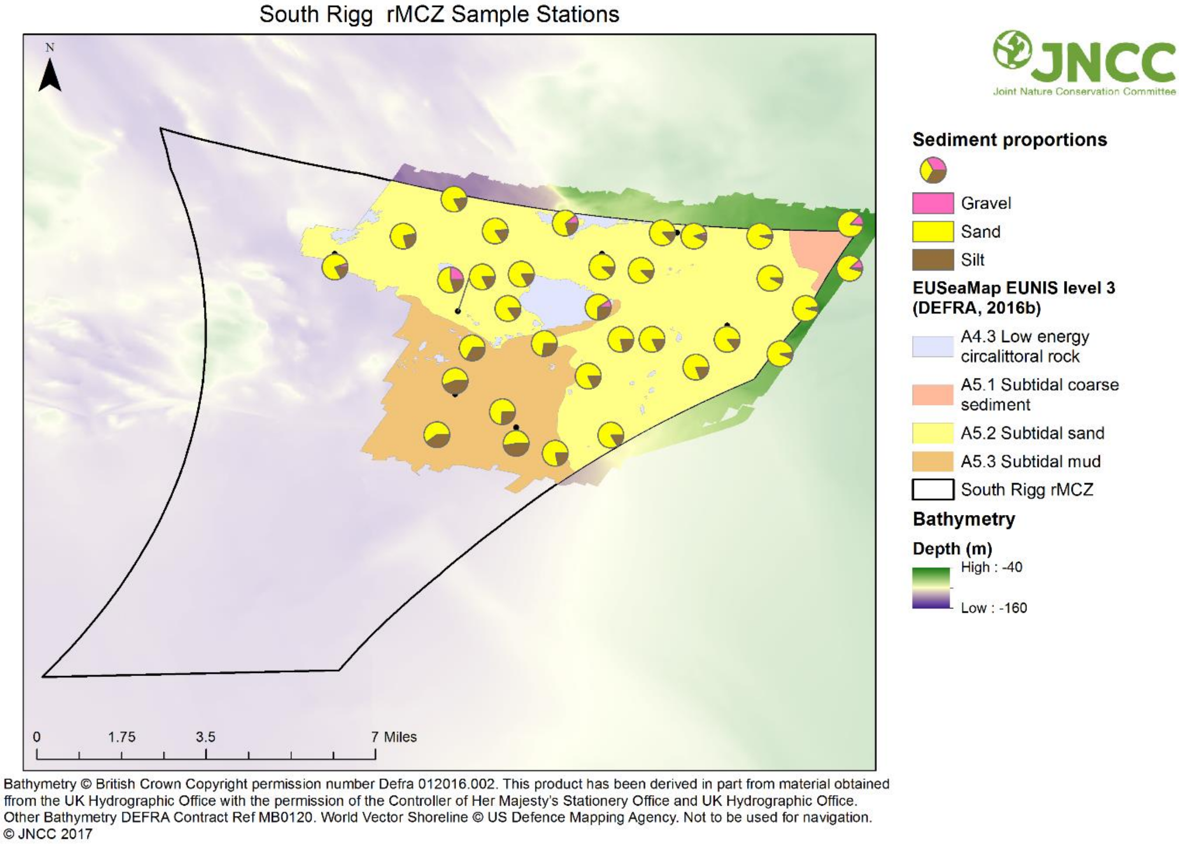

Figure 25. South Rigg rMCZ (north-east section) sediment composition of grab samples with broad-scale habitat map.

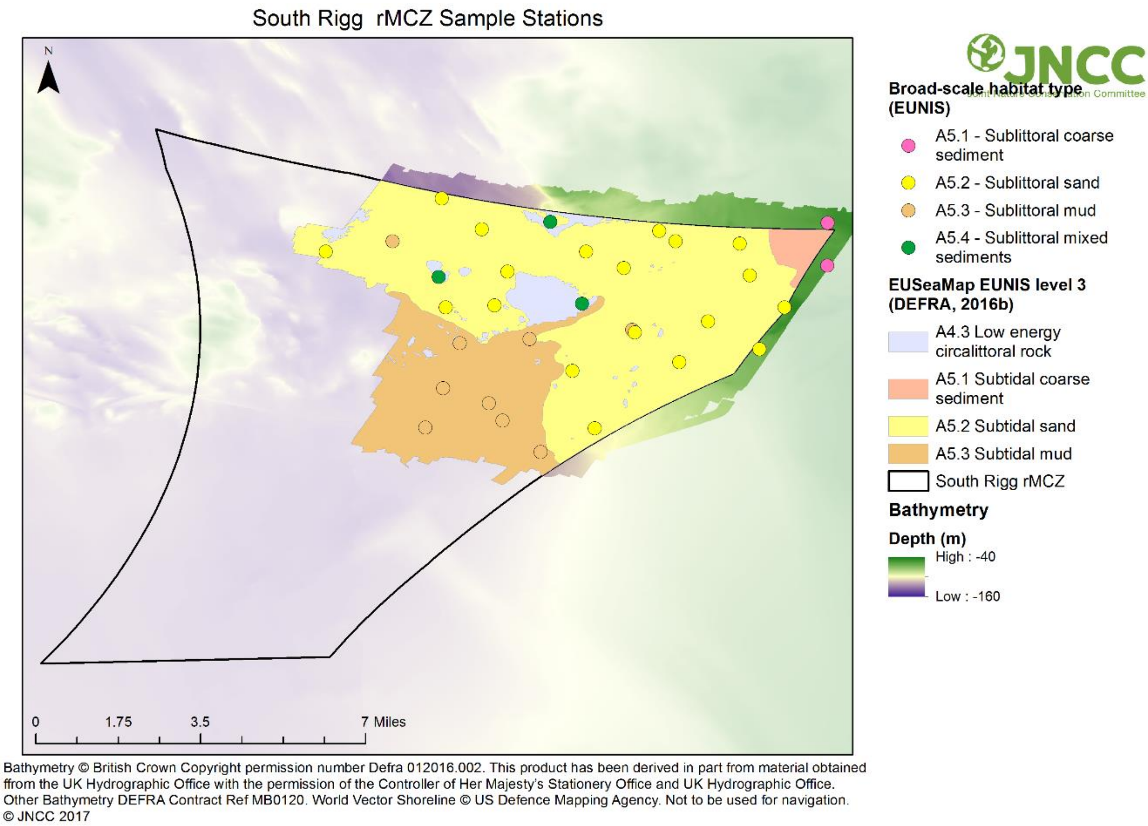

Figure 26. South Rigg rMCZ (north east section) broad-scale habitat from PSA of grab samples.

3.3.3 Statistical results for South Rigg rMCZ

The SIMPROF routine was used to define sample groups with similar species composition and Figure 27 displays the results of the cluster analysis on the infaunal data. The dendrogram is based on group-averaged Bray-Curtis similarities computed on standardised, square root transformed abundances. Due to the homogeneity of the infaunal community a 'slice' at a similarity level of 30% was used to differentiate between the main groupings. This similarity slice was used to group samples which otherwise are separated due to only small variations, which show no practical ecological groupings.

Figure 28 shows the three dimensional MDS plot of the same similarities. The stress value of 0.1 gives confidence that the three-dimensional plot is an accurate representation of the sample relationships.

The similarities between samples ranged from about 36% to 45%, with three groups identified ('a', 'b' & 'c'). The taxa that contributed to the two main groups are shown in Table 18. Sample SR24 was included within group 'b' using a lower similiarity (~22%) as this was single sample and pooled closest to group 'b'.

The taxa which contributed to greater than 1% of the similarity for each of the biological groups based on the results of the SIMPER analysis are shown. The main divisions between samples split group 'a' from the other groups at about 10% similarity whilst group 'b' was separated from the rest of the groups at around 22% similarity. Group 'c' was separated from other groups at under 27% similarity.

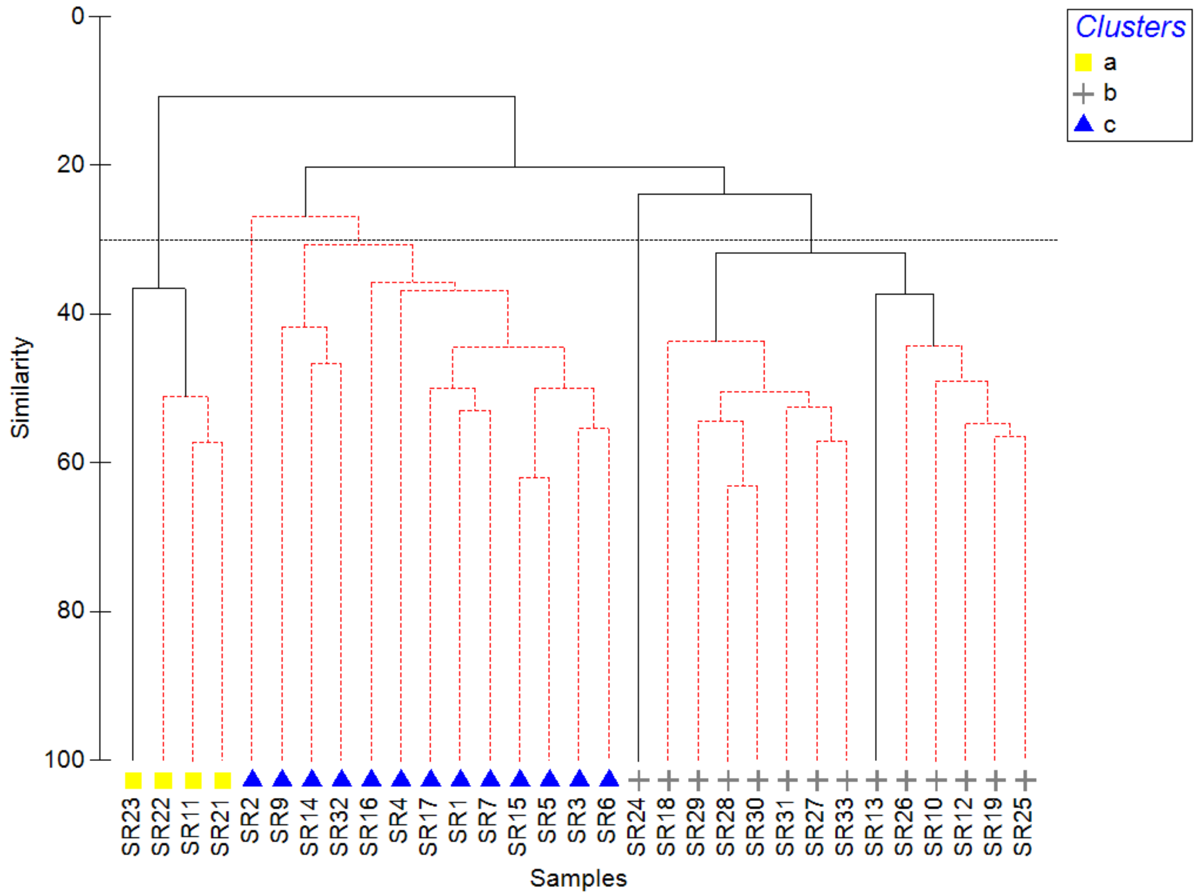

Figure 27. South Rigg rMCZ dendrogram using similarities from abundance data.

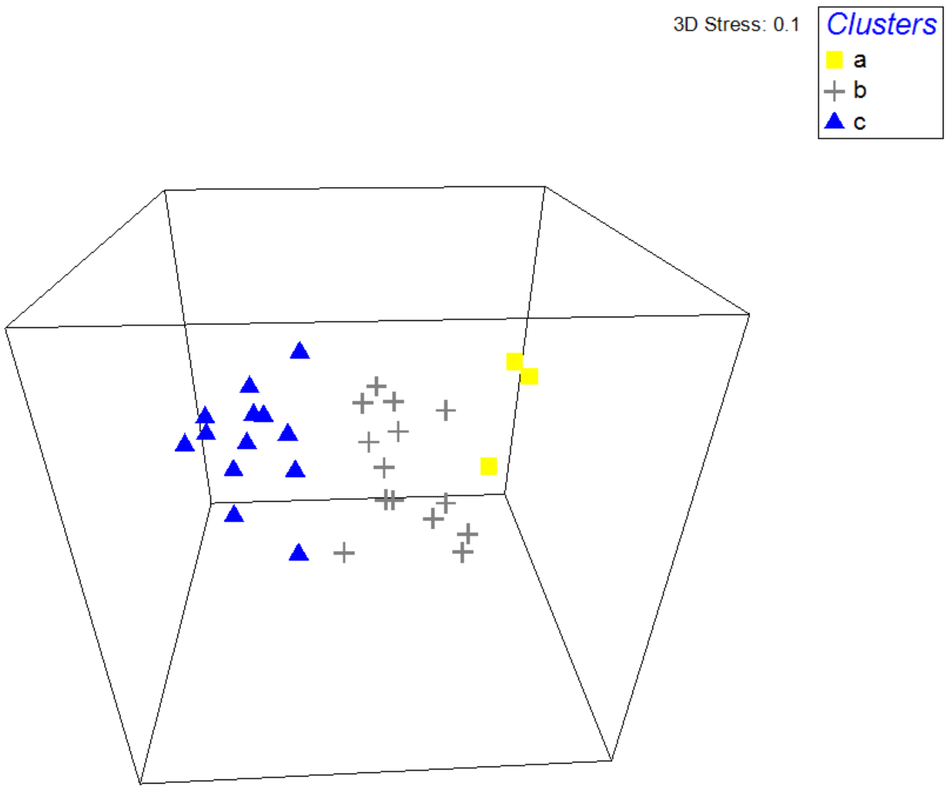

Figure 28. South Rigg rMCZ MDS plot from abundance data.

3.3.4 Univariate results

The numbers of taxa per sample (S), number of individuals per sample (N), values of Margalef's species richness index (d) and Pielou's evenness index (J') are presented in Table 17.

The multivariate analysis for South Rigg rMCZ resulted in three groups, with the majority of samples clustering into the larger groups 'b' and 'c', and the remaining group 'a' containing four samples.

The univariate analysis results showed that for group 'b', the densities of infaunal organisms were moderate, with the number of taxa recorded (per sample) ranging from 24 to 37 (mean 32) and the number of individuals (per sample) ranging from 55 to 415, with a mean of 188. The group appears to exhibit a variable but moderate level of diversity in terms of Margalef's index (ranging from 4.75 to 7.16, mean 6.13) and a moderate level of evenness with Pielou's index ranging from 0.43 to 0.91 and a mean of 0.64.

For group 'c', the densities of infaunal organisms were comparably low, suggestive of impoverished communities, with the number of taxa recorded (per sample) ranging from 6 to 28 (mean 15) and the number of individuals (per sample) ranging from 11 to 53 (mean 27). This group also exhibits a variable but moderate level of diversity in terms of Margalef's index, ranging from 2.085 to 6.80, with a mean of 4.22, and a variable but high level of evenness with Pielou's index ranging from 0.8324 to 0.99 and a mean of 0.93, indicating little variation between samples.

The four sample stations represented in group 'a', also show relatively high species densities, with a mean number of taxa per sample of 50 and a mean number of individuals per sample of 349. The ross worm, *Sabellaria spinulosa,* accounts for the greatest number of individuals within this group. This group also shows a high level of diversity, with

Margalef's indices of between 8.1 and 8.9, and a variable level of evenness with a Pielou's index between 0.40 and 0.81.

Table 17. Diversity indices and summary univariate statistics for South Rigg rMCZ infaunal samples.

Station code	Group	Total taxa (S)	Total individuals (N)	Margalef's (d)	Pielou's (J')
SR11	a	56	485	8.89	0.48
SR21	a	56	511	8.82	0.40
SR22	a	49	275	8.55	0.54
SR23	a	40	123	8.10	0.81
SR24	b	27	55	6.49	0.91
SR10	b	36	133	7.16	0.68
SR12	b	30	219	5.38	0.62
SR13	b	29	62	6.78	0.89
SR18	b	31	146	6.02	0.71
SR19	b	36	173	6.79	0.72
SR25	b	34	242	6.01	0.60
SR26	b	32	171	6.03	0.67
SR27	b	39	415	6.30	0.52
SR28	b	24	124	4.77	0.66
SR29	b	38	204	6.96	0.54
SR30	b	36	162	6.88	0.68
SR31	b	31	231	5.51	0.43
SR33	b	28	293	4.75	0.47
SR1	c	13	27	3.64	0.93
SR14	c	14	29	3.86	0.92
SR15	c	14	15	4.80	0.99
SR16	c	13	20	4.01	0.96
SR17	c	22	41	5.66	0.93
SR2	c	13	26	3.68	0.83
SR3	c	9	13	3.12	0.94
SR32	c	19	51	4.58	0.90
SR4	c	6	11	2.09	0.96
SR5	c	15	24	4.41	0.95
SR6	c	13	22	3.88	0.96
SR7	c	14	20	4.34	0.91
SR9	c	28	53	6.80	0.89
SR8 (no infauna)					
SR20 (no data)					

3.3.5 Summary of characterising species and communities

Four stations clustered together at about 36% similarity to form group ‘a’. The community was dominated by the tube worm, *Sabellaria spinulosa* which contributed to over 29% of the group’s similarity. Other species characteristic of this group included the bivalves *Lyonsia norwegica* and *Musculus subpictus* along with a range of polychaete worms.

Group ‘b’ included fourteen stations clustered together at about 24% similarity. The sandy mud characteristic of these stations had an infaunal community dominated by capitellids of the genus *Dasybranchus* along with species such as *Thyasira biplicata, Terebellides stroemii, Abra nitida* and *Nephtys hystericis*.

The polychaetes *Monticellina* (possibly renamed to *Kirkegaardia*, see Blake 2016) and *Diplocirrus glaucus* dominate group ‘c’ along with the burrowing crustacean *Calocaris macandreae* and the bivalue *Nucula sulcate.* The characterising taxa are all associated with mud habitats which is supported by the PSA data.

The species which form the characterising species for each of these groups, with a percentage contribution of over 1%, are shown in Table 18.

Table 18. Characterising species for multivariate groups at South Rigg rMCZ infaunal, showing those with a contribution of over 1%.

Group ‘a’ Species/Taxa	**Average Abundance**	**%age contribution**
Sabellaria spinulosa	7.31	29.73
Lyonsia norwegica	1.78	6.59
Musculus subpictus	1.25	4.78
Eumida bahusiensis	1.4	4.66
Syllis variegata	1.16	4.38
Galathowenia oculata	1.3	3.63
Nereimyra punctata	0.83	3.03
Owenia fusiformis	1.4	3
Othomaera othonis	0.78	2.98
Polycarpa fibrosa	0.92	2.82
Polynoidae	0.71	2.65
Aphelochaeta	0.65	2.42
Lumbrineris	0.68	1.94
Corbula gibba	0.65	1.75
Syllis cornuta	0.74	1.66
Pholoe baltica	0.76	1.59
Amphipholis squamata	1.19	1.58
Pholoe assimilis	0.71	1.5
Eusyllis blomstrandi	0.63	1.37
Laonice bahusiensis	0.48	1.22
Echinocardium cordatum	0.61	1.21

Group 'b' Species/Taxa	**Average Abundance**	**%age contribution**
Galathowenia oculata	5.96	29.87
Amphipholis squamata	2.63	8.15
Amphiura filiformis	2.19	7.43
Diplocirrus glaucus	1.29	4.93
Owenia fusiformis	1.77	3.97
Pholoe baltica	0.87	3.58
Falcidens crossotus	0.93	3.3
Hiatella arctica	0.87	2.8
Monticellina	0.84	2.21
Cerebratulus	0.58	2.07
Abyssoninoe hibernica	0.67	1.77
Kurtiella bidentata	0.93	1.72
Terebellides stroemii	0.59	1.67
Chaetozone setosa	0.71	1.65
Spiophanes kroyeri	0.65	1.6
Nucula sulcata	0.64	1.51
Glycera unicornis	0.47	1.18
Nemertea	0.45	1

Group 'c' Species/Taxa	**Average Abundance**	**%age contribution**
Monticellina	2.22	12.21
Diplocirrus glaucus	2.7	12.04
Calocaris macandreae	2.44	12.03
Nucula sulcata	2.59	10.69
Nephtys incisa	1.71	7.4
Harpinia antennaria	1.55	6.31
Galathowenia oculata	1.74	5.92
Notomastus	1.57	5.86
Abyssoninoe hibernica	1.19	3.46
Falcidens crossotus	1.17	2.9
Glycera unicornis	1.06	2.71
Mediomastus fragilis	0.88	2.12
Amphiura filiformis	1.11	2.06
Prionospio fallax	0.97	2.03
Cerebratulus	0.85	1.87
Pseudothyone raphanus	0.65	1.29

3.3.6 Biotope allocation

The groupings produced from the multivariate analysis have been matched to biotopes as defined by the Marine Habitats Classification for Britain and Ireland (JNCC 2015) and using the recent guidance by Parry (2015). Possible candidate biotopes were selected on the basis of species composition, physical parameters, such as sediment and depth, and the results of the multivariate analysis. The taxa which were removed during data processing prior to statistical analysis were reviewed and considered within the biotope allocation process.

A description of habitat types/biotopes allocated to each of the sampling stations is given below and summarised in Table 19 with the spatial distribution of the groups and biotopes illustrated in Figure 29 and Figure 30. Table 27 in Appendix 1 presents the multivariate group and the biotope or habitat assigned to each sample with any comments noted from the processing such as impoverished samples or physical mismatches between sediment types and the biotopes assigned.

The sampling stations within group ‘a’ were characterised by the abundance of *Sabellaria spinulosa* and bivalves with either a coarse or sandy substrate and a depth range of 49 – 63m. The community is relatively diverse but in comparison to the other biotopes/habitats identified the characterising species do not match with any described within the current marine habitats classification. The abundance of Sabellaria is not as high as expected in a biogenic reef biotope and a review of epibenthic video, whist of very low quality does not suggest a reef habitat is present. The samples are attributed to **SS.SCS.OCS,** despite a physical mismatch, as the biological community structure supports grouping at this level in the classification hierarchy. With a distinct biological grouping this could be suffixed with a suitable biotope code/name (such as ‘Offshore circalittoral coarse sediment with *Sabellaria spinulosa* and bivalves’) and is referred to as **SS.OCS.OCS.Biotope** for the purposes of reporting and a new biotope suggestion will be proposed.

Group ‘b’ has biota which is indicative of a sandy habitat and in most cases the sediment analysis supports this, with some mixed sediments being attributed to the samples. There are moderate silt/mud fractions in the samples (mean 15.8%) and the gravel content is variable with only 4 samples having greater than 5%, despite this indicating some of the samples are mixed. The characterising species of *Amphiura filiformis* and *Owenia fusiformis* are present and could support the biotope **SS.SSa.OSa.OfusAfil** which has been assigned to this group with those samples having mismatched habitat types indicated in Table 25. This biotope is likely to be an impoverished version or a variation of **SS.SSa.OSa.OfusAfil** and the assignment to this biotope is uncertain but is used to differentiate from samples attributed to SS.SSa.OSa based on physical parameters only.

The previous survey (Mellor *et al* 2008), which surveyed the south and west of South Rigg rMCZ, reports a biotope **SS.SMu.OMu.MonPfal** which is characterised by Monticellina sp, *Prionospio fallax*, *Tharyx killariensis.* With the survey area being adjacent to the current data set, the biotope has similarities to the communities identified within group ‘c’. Therefore this biotope has been assigned to the samples within group ‘c’ due to the similarity of the characterising species and for consistency between the outputs of the 2008 survey and the samples analysed within this study. However, **SS.SMu.OMu.MonPfal** is currenly not contained within the current habitat classification system and **SS.SMu.OMu** should be used if these samples are to be encompassed by the current system.

Two samples did not contain any infaunal information (SR8 show no taxa present, SR20 had no data provided) and as such these were attributed to habitats according to the physical nature of the substrate, **SS.SSa.OSa**.

In summary Table 20 shows the biotope and habitats found within the north-east section of South Rigg rMCZ with the characterising species and seabed substrate for each.

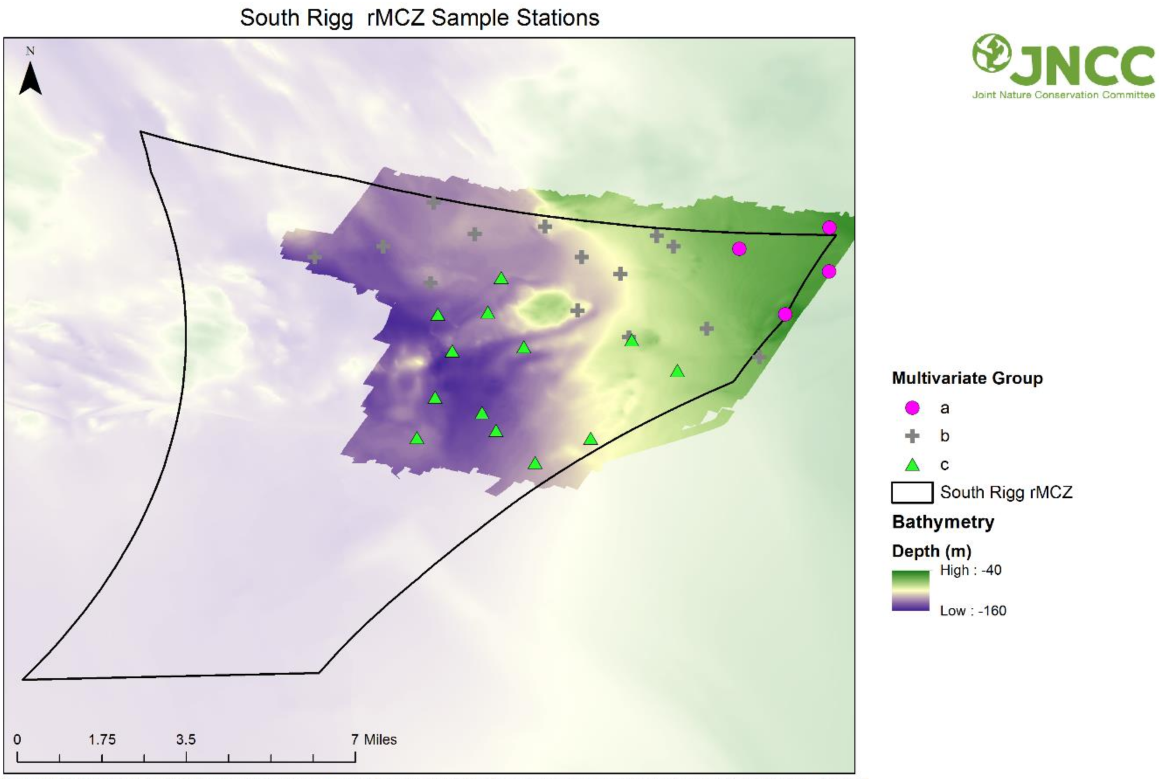

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Figure 29. South Rigg rMCZ (north-east section) sample stations showing multivariate groups.

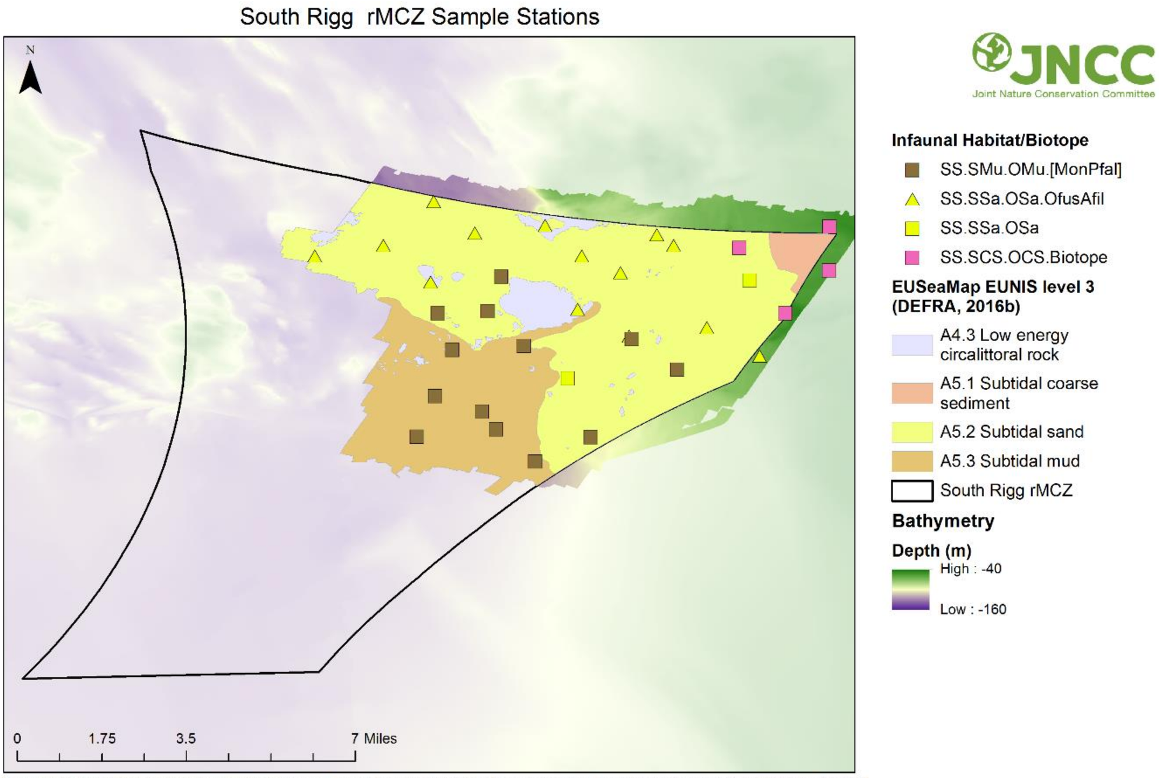

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Figure 30. South Rigg rMCZ (north-east section) samples showing biotope/habitats.

Table 19. Summary of multivariate statistical groups and associated habitats and biotopes for South Rigg rMCZ.

Multivariate Group	Number of Samples	Biotope Code*	Broad-scale Habitat
a	4	SS.SCS.OCS.Biotope	Subtidal coarse sediment Subtidal sand
b	14	SS.SSa.OSa.OfusAfil	Subtidal sand Subtidal mud Subtidal mixed sediments
c	13	SS.SMu.OMu.[MonPfal]	Subtidal mud Subtidal sand
No data	2	SS.SSa.OSa	Subtidal sand

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

Table 20. Summary of habitats/biotopes found within South Rigg rMCZ.

Habitat/Biotope*	Depth range (m)	Substratum	Infaunal community	Multivariate groups
SS.SCS.OCS.Biotope	49 - 63	Coarse sediment and sand	*Sabellaria spinulosa,* *Lyonsia norwegica,* *Musculus subpictus*	a
SS.SSa.OSa.OfusAfil	65 - 136	Sand and muddy sand Mixed sediments	*Galathowenia oculata* *Amphipholis squamata* *Amphiura filiformis* *Owenia fusiformis*	b
SS.SMu.OMu.[MonPfal]	80 - 140	Mud and sandy mud, Sand and muddy sand	Monticellina *Diplocirrus glaucus,* *Calocaris macandreae,* *Nucula sulcata,* *Nephtys incisa,* *Harpinia antennaria* *Galathowenia oculata* Notomastus	c
SS.SSa.OSa	63 - 107	Sand and muddy sand	*None*	NA

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

3.3.7 Site Summary

The 2012 survey identified the presence of the broadscale habitat 'Subtidal sand' in over two thirds of the site, with 'Subtidal mud' occupying a quarter of the surveyed area and 'Subtidal coarse sediment' present in a small patch. A full account of the survey methods and results can be found in Strong (2012) and Defra (2016b).

The samples analysed were attributed to habitats (SS.SMu.OMu, SS.SCS.OCS**.**Biotope, SS.SSa.OSa) or the biotopes (SS.SMu.OMu.[MonPfal] and SS.SSa.OSa.OfusAfil), all of which are part of the broad-scale habitats listed above (approximately half were subtidal sand) and therefore support the presence of these features. The SS.SCS.OCS**.**Biotope is a potential new biotope which will proposed for inclusion in the classification.

The epifaunal community associated with the biotope SS.SMu.OMu.[MonPfal] included the burrowing megafauna such as the thalassinid shrimp *Calocaris macandrea.* Despite only one sea pen being recorded (*Virgularia mirabilis*, Station SR10), the area still may be considered for the MCZ habitat FOCI Sea-pen and burrowing megafauna communities as sea pens can be removed by human activity.

Table 21 provides a summary for the habitats and biotopes present within South Rigg rMCZ with associated broad-scale habitats and other analysis notes.

Table 21. Summary table for the habitat/biotopes for South Rigg rMCZ.

Biotope Code*	Broad-scale Habitat	Group	Depth (m)	Infaunal community	Comments
SS.SSa.OSa	Subtidal sand,		63 - 107	NA	No infaunal data, reverted to physical data to assign habitat type.
SS.SSa.OSa.OfusAfil	Subtidal sand, subtidal mud, subtidal mixed sediment	b	65 - 136	*Galathowenia oculata* *Amphipholis squamata* *Amphiura filiformis* *Owenia fusiformis*	Impoverished community.
SS.SCS.OCS.Biotope	Subtidal coarse sediment, subtidal sand	a	49 - 63	*Sabellaria spinulosa,* *Lyonsia norwegica,* *Musculus subpictus*	Infaunal assemblage supports physical mismatch.
SS.SMu.OMu.[MonPfal]	Subtidal mud, subtidal sand	c	80 - 140	Monticellina *Diplocirrus glaucus,* *Calocaris macandreae,* *Nucula sulcata,* *Nephtys incisa,* *Harpinia antennaria* *Galathowenia oculata* Notomastus	Biotope assigned based on 2008 survey, could revert to SS.SMu.OMu

* Marine Habitat Classification for Britain and Ireland (JNCC 2015)

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4 Limitations

The results and analyses from the projects have a range of limitations, issues and assumptions associated with each stage of data processing, analysis and production of results.

All data sources are assumed to be accurate and of suitable quality to be processed and undergo analyses and it is noted all data have been produced to national guidelines where applicable. It was noted with more historic records taxonomic names may have altered or the taxonomic hierarchy amended post analysis. Where possible the new taxonomic name is used: where taxa were recorded at a taxonomic level which makes attribution to a new name ambiguous, these were left as the orginal name (i.e. *Evalea*, a gastropod which was recorded at a genus level but may be included with the *Ondina* genus since data were analysed).

When processing data, certain steps are taken to attempt to standardise the dataset and ensure data are suitable for analysis. This includes the removal of taxa records which are assumed to be either irrelevant to community structure or which provide overriding influences on analysis. Data provided solely in presence/absence information are also generally excluded as they can not be used in combination with abundance (count) data for multivariate analysis. The effect of this process is moderated by reviewing the removed taxa at a later stage to determine if their presence may have influenced the final results and where they should be considered as characterising species for biotope allocation.

Aggregation of data to higher taxonomic levels may remove some of the detail in the species which characterise sample groupings (see recommendation below).

The underlying statistical analysis routine, Bray Curtis similarity, assumes that the data are from equivalent samples (size or volume) and whilst data do undergo standardisation routines there still may be an effect of small sample sizes in the analysis and outputs. The total number of taxa which are found in each sample could be due to natural variation such as impoverishment or alternatively due to small sample size which is difficult to standardise. To mitigate this limitation, the field reports were reviewed for each site and this information has been noted and accounted for where relevant.

The multivariate groups derived as part of the analysis undertaken within this project are used to identify the habitat and biotopes present within each site. Matching results to the habitat classification is not a precise science and the opinion of the analyst in the choice of a suitable biotope introduces some subjectivity (see recommendation below). A thorough quality control process ensured all results from this report were verified by a second analyst who was not involved with the data processing; mitigating this limitation.

As highlighted in the QC section, the guidance to revert to physical habitat type when no clear biotope is available imposes significant restrictions on the benthic community analysis, given that the sediment component of the Marine Habitat Classification for Britain and Ireland Version 15.03 has not yet been updated to incorporate the large quantities of offshore data collected in recent years, which presents difficulties in matching biotopes for sublittoral sediments (see recommendation below).

Whilst undertaking the analysis, epibenthic data (video and still images) were reviewed to confirm or provide guidance on biotopes which may be present within sites. Video or still imagery were not available for all infaunal samples and the quality of the video was varaible. Coincident video/still data and grab sample data for all sample stations could have been of assistance and may be considered a limitation within the data available (see recommendation below).

Each individual rMCZ site has been surveyed separately, with each site survey being conducted by a range of staff or contractors, over varying timescales, and the resulting data processed and analysed by various sources. As these factors vary between sites, each rMCZ site has been considered independently and analysed as such. This introduces the limitation that the results for each site cannot be compared and it is recommended that comparisons between rMCZ sites are not made.

Sample data for the rMCZs is limited in terms of number of sample stations and the distribution of sample stations throughout each site. Each survey has restricted resources and scientifically justified sampling strategies have been used to optimise sampling for specific features or geographic areas. These sampling strategies and locations provide an evidence base which is extrapolated across the whole site and this may generalise the site or overlook the presence of habitat mosaics or other small scale variations.

When using the marine habitat comparative tables (JNCC 2004), the biological comparative tables are version 04.05 [Online]. [Accessed March 2017] [Available from http://jncc.defra.gov.uk/default.aspx?page=3249]. These understandably have some out of date information with regards to taxa and biotopes and are therefore not ideal to base biotope decisions upon.

4.1 Recommendations

Where data aggregation to higher taxonomic levels removes detail in the species which characterise sample groupings, non-aggregated data should be referred to when identifying characterising species to ensure this level of data is not omitted during community analysis.

Biotope allocation can be subjective and dependent on the opinion of the analyst. This should be considered if the data is utilised within further studies, and a thorough quality control process should verify results and mitigate for this limitation.

It would be very useful to look at clusters identified from similar analysis of other offshore data for similarities to those identified here, for the identification of new potential biotopes, as the sediment component of the Marine Habitat Classification for Britain and Ireland Version 15.03 has not yet been updated to incorporate the large quantities of offshore data collected in recent years.

It is recommended that where resources allow, coincident epibenthic and infaunal data are collected or made available, as epibenthic data (video and still images) can be reviewed to confirm or provide guidance on biotopes which may be present within sites.

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6 Appendix 1: Data tables

6.1 Compass Rose rMCZ Data Tables

6.1.1 Compass Rose rMCZ Samples with physical sediment description and summary with broad-scale habitat type

Table 22. Compass Rose rMCZ: Sediment description, broad-scale habitat and composition details for each sample station.

Station No.	Station code	Latitude	Longitude	Sediment description	Broad-scale habitat	Gravel (%)	Sand (%)	Silt (%)
53	CR_C_01	54.38927	0.21185	sand and muddy sand	Subtidal sand	0.24	93.28	6.48
63	CR_C_02	54.39270	0.24550	sand and muddy sand	Subtidal sand	0.02	93.56	6.42
73	CR_R_01	54.39007	0.35595	sand and muddy sand	Subtidal sand	1.01	96.47	2.52
137	CR_R_02	54.39439	0.40952	sand and muddy sand	Subtidal sand	2.54	91.23	6.23
60	CR_R_03	54.41096	0.26944	mixed sediment	Subtidal mixed sediments	36.53	56.51	6.96
74	CR_R_04	54.41508	0.32283	coarse sediment	Subtidal coarse sediments	49.94	46.16	3.91
139	CR_R_05	54.41899	0.37643	coarse sediment	Subtidal coarse sediments	12.75	83.72	3.53
134	CR_R_06	54.42347	0.43028	sand and muddy sand	Subtidal sand	0.97	90.70	8.33
78	CR_R_07	54.43975	0.28980	sand and muddy sand	Subtidal sand	0.13	93.31	6.57
121	CR_R_08	54.44402	0.34319	sand and muddy sand	Subtidal sand	0.00	88.13	11.87
125	CR_R_09	54.40661	0.21603	sand and muddy sand	Subtidal sand	2.23	88.59	9.17
41	CR_R_10	54.46052	0.20305	coarse sediment	Subtidal coarse sediments	15.10	77.85	7.05
80	CR_R_11	54.46467	0.25657	sand and muddy sand	Subtidal sand	0.07	93.20	6.72
118	CR_R_12	54.46879	0.30992	sand and muddy sand	Subtidal sand	0.07	89.38	10.55
116	CR_R_13	54.47310	0.36349	sand and muddy sand	Subtidal sand	4.24	86.62	9.13
34	CR_R_14	54.48519	0.16969	sand and muddy sand	Subtidal sand	0.79	91.86	7.35
82	CR_R_15	54.48942	0.22336	sand and muddy sand	Subtidal sand	0.05	93.38	6.56
109	CR_R_16	54.49800	0.33033	sand and muddy sand	Subtidal sand	0.28	95.32	4.40
111	CR_R_17	54.50211	0.38402	mixed sediment	Subtidal mixed sediments	33.81	58.72	7.47
29	CR_R_18	54.50989	0.13646	sand and muddy sand	Subtidal sand	0.00	95.66	4.34
106	CR_R_19	54.52285	0.29719	sand and muddy sand	Subtidal sand	1.14	90.88	7.98
25	CR_R_20	54.53918	0.15681	sand and muddy sand	Subtidal sand	0.00	91.95	8.05
18	CR_R_21	54.56829	0.17685	sand and muddy sand	Subtidal sand	0.00	92.32	7.68
11	CR_R_22	54.59305	0.14356	sand and muddy sand	Subtidal sand	0.00	89.89	10.11

Station No.	Station code	Latitude	Longitude	Sediment description	Broad-scale habitat	Gravel (%)	Sand (%)	Silt (%)
48	CR_S_01	54.39806	0.10883	sand and muddy sand	Subtidal sand	0.28	96.87	2.84
132	CR_S_02	54.39850	0.46293	sand and muddy sand	Subtidal sand	0.02	89.64	10.34
51	CR_S_03	54.40239	0.16224	sand and muddy sand	Subtidal sand	0.14	95.88	3.97
129	CR_S_04	54.40244	0.51616	sand and muddy sand	Subtidal sand	0.06	91.74	8.20
56	CR_S_05	54.40641	0.21591	sand and muddy sand	Subtidal sand	0.00	90.35	9.65
46	CR_S_06	54.42714	0.12894	sand and muddy sand	Subtidal sand	1.76	90.80	7.44
127	CR_S_07	54.42754	0.48322	sand and muddy sand	Subtidal sand	0.42	91.82	7.76
43	CR_S_08	54.43132	0.18246	sand and muddy sand	Subtidal sand	0.03	85.03	14.94
76	CR_S_09	54.43565	0.23628	sand and muddy sand	Subtidal sand	0.05	95.22	4.73
123	CR_S_10	54.44822	0.39688	sand and muddy sand	Subtidal sand	0.46	92.70	6.85
39	CR_S_11	54.45621	0.14977	sand and muddy sand	Subtidal sand	0.55	90.24	9.21
113	CR_S_12	54.47729	0.41706	coarse sediment	Subtidal coarse sediments	10.89	84.49	4.63
36	CR_S_13	54.48104	0.11621	sand and muddy sand	Subtidal sand	0.00	92.68	7.32
84	CR_S_14	54.49356	0.27702	sand and muddy sand	Subtidal sand	0.00	90.06	9.94
32	CR_S_15	54.51420	0.19015	sand and muddy sand	Subtidal sand	0.08	86.16	13.77
86	CR_S_16	54.51844	0.24381	coarse sediment	Subtidal coarse sediments	26.77	67.78	5.45
104	CR_S_17	54.52694	0.35108	sand and muddy sand	Subtidal sand	0.09	94.92	5.00
27	CR_S_18	54.53512	0.10343	mixed sediment	Subtidal mixed sediments	40.79	52.82	6.39
20	CR_S_19	54.54322	0.21053	sand and muddy sand	Subtidal sand	0.00	88.38	11.62
88	CR_S_20	54.54768	0.26423	sand and muddy sand	Subtidal sand	0.08	93.22	6.69
102	CR_S_21	54.55196	0.31802	sand and muddy sand	Subtidal sand	0.19	95.06	4.74
16	CR_S_22	54.56414	0.12383	sand and muddy sand	Subtidal sand	0.00	93.95	6.05
90	CR_S_23	54.57236	0.23120	sand and muddy sand	Subtidal sand	0.00	91.23	8.77
99	CR_S_24	54.57664	0.28438	sand and muddy sand	Subtidal sand	0.10	92.85	7.06
13	CR_S_25	54.58862	0.09000	sand and muddy sand	Subtidal sand	1.43	88.56	10.01
92	CR_S_26	54.59729	0.19741	sand and muddy sand	Subtidal sand	0.09	92.06	7.85
97	CR_S_27	54.60141	0.25114	sand and muddy sand	Subtidal sand	0.60	93.56	5.83
10	CR_S_28	54.62435	0.11108	sand and muddy sand	Subtidal sand	0.00	91.93	8.07
8	CR_S_29	54.62213	0.16421	sand and muddy sand	Subtidal sand	0.00	93.20	6.80
94	CR_S_30	54.62633	0.21805	sand and muddy sand	Subtidal sand	0.03	90.13	9.84

6.1.2 Compass Rose rMCZ Samples with associated habitats and biotopes

Table 23. Compass Rose rMCZ: Summary of habitat types and biotopes for sample stations.

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
53	CR_C_01	66	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
63	CR_C_02	68	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
73	CR_R_01	62	Slightly gravelly sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
137	CR_R_02	62	Slightly gravelly sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
60	CR_R_03	66	Muddy sandy gravel	c	Subtidal mixed sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
74	CR_R_04	63	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
139	CR_R_05	60	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
134	CR_R_06	70	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
78	CR_R_07	64	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
121	CR_R_08	67	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
125	CR_R_09	67	Slightly gravelly sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
41	CR_R_10	66	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
80	CR_R_11	65	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
118	CR_R_12	70	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
116	CR_R_13	72	Slightly gravelly sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
34	CR_R_14	67	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
82	CR_R_15	65	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
109	CR_R_16	72	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
111	CR_R_17	67	Muddy sandy gravel	c	Subtidal mixed sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
29	CR_R_18	68	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
106	CR_R_19	74	Slightly gravelly sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
25	CR_R_20	68	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
18	CR_R_21	72	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
11	CR_R_22	75	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
48	CR_S_01	65	Sand	a	Subtidal sand	SS.SSa.OSa	A5.27	
132	CR_S_02	67	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
51	CR_S_03	66	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
129	CR_S_04	70	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
56	CR_S_05	67	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
46	CR_S_06	67	Slightly gravelly sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
127	CR_S_07	69	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
43	CR_S_08	67	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
76	CR_S_09	64	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
123	CR_S_10	74	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
39	CR_S_11	67	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
113	CR_S_12	64	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
36	CR_S_13	66	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
84	CR_S_14	70	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
32	CR_S_15	67	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
86	CR_S_16	71	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
104	CR_S_17	69	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
27	CR_S_18	66	Muddy sandy gravel	c	Subtidal mixed sediments	SS.SSa.OSa.OfusAfil	A5.287	Physical mismatch
20	CR_S_19	72	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
88	CR_S_20	78	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
102	CR_S_21	69	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
16	CR_S_22	66	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
90	CR_S_23	81	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
99	CR_S_24	68	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
13	CR_S_25	64	Slightly gravelly muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
92	CR_S_26	81	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
97	CR_S_27	70	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
10	CR_S_28	82	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	
8	CR_S_29	80	Sand	b	Subtidal sand	SS.SSa.OSa	A5.27	
94	CR_S_30	71	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.287	

6.2 Markham's Triangle rMCZ Data Tables

6.2.1 Markham's Triangle rMCZ Samples with physical sediment description and summary with broad-scale habitat type

Table 24. Markham's Triangle rMCZ: Sediment description, broad-scale habitat and composition details for each sample station.

Station No.	Station code	Latitude	Longitude	Sediment description	Broad-scale habitat	Gravel (%)	Sand (%)	Silt (%)
123	MT01	53.88315	2.83706	Mixed sediments	Subtidal mixed sediments	47.28	47.33	5.39
121	MT02	53.88513	2.88231	Coarse sediments	Subtidal coarse sediments	49.33	48.71	1.96
108	MT03	53.89900	2.78458	Coarse sediments	Subtidal coarse sediments	38.34	57.16	4.50
111	MT04	53.90174	2.82250	Mixed sediments	Subtidal mixed sediments	37.41	55.23	7.36
118	MT05	53.90374	2.86032	Coarse sediments	Subtidal coarse sediments	29.75	68.23	2.02
99	MT06	53.91303	2.68606	Coarse sediments	Subtidal coarse sediments	26.42	72.13	1.45
101	MT07	53.91496	2.72411	Coarse sediments	Subtidal coarse sediments	14.73	84.23	1.05
104	MT08	53.91766	2.76261	Coarse sediments	Subtidal coarse sediments	42.76	52.68	4.56
116	MT09	53.92248	2.83783	Mud and sandy mud	Subtidal mud	0.06	77.71	22.23
95	MT10	53.92878	2.62663	Sand and muddy sand	Subtidal sand	0.94	97.92	1.14
81	MT11	53.93169	2.66329	Coarse sediments	Subtidal coarse sediments	26.81	72.42	0.77
78	MT12	53.93350	2.70052	Coarse sediments	Subtidal coarse sediments	19.89	76.49	3.62
76	MT13	53.93043	2.73462	Sand and muddy sand	Subtidal sand	2.44	96.64	0.92
66	MT14	53.93732	2.77729	Sand and muddy sand	Subtidal sand	1.17	87.15	11.68
64	MT15	53.94001	2.81683	Coarse sediments	Subtidal coarse sediments	36.77	59.83	3.39
56	MT16	53.94048	2.85155	Sand and muddy sand	Subtidal sand	0.57	98.72	0.71
92	MT17	53.94497	2.56506	Coarse sediments	Subtidal coarse sediments	35.13	63.84	1.03
88	MT18	53.94685	2.60250	Coarse sediments	Subtidal coarse sediments	31.39	65.93	2.69
86	MT19	53.94946	2.64066	Mixed sediments	Subtidal mixed sediments	49.73	42.46	7.82
83	MT20	53.95161	2.67918	Coarse sediments	Subtidal coarse sediments	22.04	74.61	3.35
58	MT21	53.96099	2.83177	Coarse sediments	Subtidal coarse sediments	49.24	49.11	1.64
49	MT22	53.96294	2.54432	Mixed sediments	Subtidal mixed sediments	33.78	53.32	12.90
47	MT23	53.96552	2.58173	Mixed sediments	Subtidal mixed sediments	42.26	51.20	6.53
44	MT24	53.96750	2.61869	Mixed sediments	Subtidal mixed sediments	51.66	40.39	7.95
42	MT25	53.96947	2.65634	Coarse sediments	Subtidal coarse sediments	44.34	51.36	4.30
39	MT26	53.97169	2.69502	Coarse sediments	Subtidal coarse sediments	48.02	47.76	4.21

Station No.	Station code	Latitude	Longitude	Sediment description	Broad-scale habitat	Gravel (%)	Sand (%)	Silt (%)
37	MT27	53.97444	2.73281	Mixed sediments	Subtidal mixed sediments	22.40	63.41	14.19
21	MT28	53.97909	2.80802	Coarse sediments	Subtidal coarse sediments	22.96	74.02	3.02
7	MT29	53.98095	2.84662	Coarse sediments	Subtidal coarse sediments	30.24	69.76	0.00
106	MT30	53.91891	2.78501	Mixed sediments	Subtidal mixed sediments	33.32	58.79	7.89
113	MT31	53.92014	2.80803	Mixed sediments	Subtidal mixed sediments	14.44	73.88	11.68
93	MT32	53.94060	2.56278	Coarse sediments	Subtidal coarse sediments	32.30	64.24	3.46
74	MT33	53.94680	2.71880	Mixed sediments	Subtidal mixed sediments	27.37	52.40	20.23
71	MT34	53.95077	2.74341	Sand and muddy sand	Subtidal sand	3.90	94.09	2.02
69	MT35	53.95250	2.76885	Coarse sediments	Subtidal coarse sediments	34.38	63.76	1.87
5	MT36	53.95983	2.49006	Mixed sediments	Subtidal mixed sediments	39.01	42.06	18.94
34	MT37	53.96247	2.73093	Coarse sediments	Subtidal coarse sediments	20.81	76.99	2.21
32	MT38	53.96413	2.75455	Coarse sediments	Subtidal coarse sediments	5.77	90.13	4.11
25	MT39	53.96537	2.77681	Coarse sediments	Subtidal coarse sediments	47.28	51.15	1.57
23	MT40	53.96684	2.79986	Coarse sediments	Subtidal coarse sediments	41.42	56.78	1.80
30	MT41	53.97626	2.76265	Mixed sediments	Subtidal mixed sediments	30.91	54.30	14.79
28	MT42	53.97762	2.78624	Coarse sediments	Subtidal coarse sediments	48.66	49.81	1.53
15	MT43	53.98851	2.77321	Mixed sediments	Subtidal mixed sediments	21.93	60.18	17.89
17	MT44	53.98975	2.79533	Mixed sediments	Subtidal mixed sediments	54.41	37.34	8.25
61	MT45	53.94870	2.82830	Coarse sediments	Subtidal coarse sediments	46.33	53.62	0.05
125	MT46	53.86993	2.88778	Coarse sediments	Subtidal coarse sediments	38.42	60.59	0.99
10	MT47	53.99677	2.84858	Mud and sandy mud	Subtidal mud	0.02	66.38	33.60
9	MT48	53.99348	2.85449	Mud and sandy mud	Subtidal mud	0.02	39.99	59.99
127	MTF1	53.92711	2.80740	Sand and muddy sand	Subtidal sand	0.14	80.30	19.57
131	MTF2	53.92583	2.84646	Sand and muddy sand	Subtidal sand	0.02	93.40	6.58

6.2.2 Markham's Triangle rMCZ Samples with associated habitats and biotopes

Table 25. Markham's Triangle rMCZ: Summary of habitat types and biotopes for sample stations.

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
123	MT01	30	Muddy sandy gravel	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
121	MT02	30	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
108	MT03		Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
111	MT04	33	Muddy sandy gravel	c	Subtidal mixed sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
118	MT05	35	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
99	MT06	35	Gravelly sand	b	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
101	MT07	36	Gravelly sand	b	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
104	MT08		Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
116	MT09	41	Slightly gravelly muddy sand	d	Subtidal mud	SS.SMu.CSaMu	A5.35	
95	MT10		Slightly gravelly sand	b	Subtidal sand	SS.SSa.CFiSa.EpusOborApri	A5.251	
81	MT11	35	Gravelly sand	b	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
78	MT12	36	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
76	MT13	35	Slightly gravelly sand	b	Subtidal sand	SS.SSa.CFiSa.EpusOborApri	A5.251	
66	MT14	41	Slightly gravelly muddy sand	d	Subtidal sand	SS.SSa.CMuSa	A5.26	
64	MT15	33	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
56	MT16	34	Slightly gravelly sand	b	Subtidal sand	SS.SSa.CFiSa.EpusOborApri	A5.251	
92	MT17		Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
88	MT18		Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
86	MT19		Muddy sandy gravel	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
83	MT20	37	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
58	MT21	36	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
49	MT22	38	Muddy sandy gravel	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
47	MT23	38	Muddy sandy gravel	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
44	MT24	38	Muddy sandy gravel	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
42	MT25	39	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
39	MT26	37	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
37	MT27		Gravelly muddy sand	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
21	MT28	37	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
7	MT29	37	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
106	MT30		Muddy sandy gravel	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
113	MT31	39	Gravelly muddy sand	c	Subtidal mixed sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
93	MT32		Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
74	MT33	37	Gravelly muddy sand	c	Subtidal mixed sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
71	MT34	37	Slightly gravelly sand	b	Subtidal sand	SS.SSa.CFiSa.EpusOborApri	A5.251	
69	MT35	37	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
5	MT36		Muddy sandy gravel	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
34	MT37	36	Gravelly sand	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
32	MT38		Gravelly sand	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
25	MT39		Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
23	MT40	36	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
30	MT41	37	Muddy sandy gravel	c	Subtidal mixed sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
28	MT42		Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
15	MT43	40	Gravelly muddy sand	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
17	MT44	40	Muddy sandy gravel	c	Subtidal mixed sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
61	MT45	34	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
125	MT46	28	Sandy gravel	c	Subtidal coarse sediments	SS.SSa.CFiSa.EpusOborApri	A5.251	Physical mismatch
10	MT47	56	Slightly gravelly muddy sand	a	Subtidal mud	SS.SMu.CSaMu	A5.35	
9	MT48	58	Slightly gravelly sandy mud	a	Subtidal mud	SS.SMu.CSaMu	A5.35	
127	MTF1	45	Slightly gravelly muddy sand	d	Subtidal sand	SS.SSa.CMuSa	A5.26	
131	MTF2		Slightly gravelly sand	d	Subtidal sand	SS.SSa.CMuSa	A5.26	

6.3 South Rigg rMCZ Data Tables

6.3.1 South Rigg rMCZ Samples with physical sediment description and summary with broad-scale habitat type

Table 26. South Rigg rMCZ: Sediment description, broad-scale habitat and composition details for each sample station.

Station No.	Station code	Latitude	Longitude	Sediment description	Broad-scale habitat	Gravel (%)	Sand (%)	Silt (%)
1	SR1	54.365	-4.958983	mud and sandy mud	Subtidal mud	0.21	78.22	21.57
2	SR2	54.3723	-4.942333	sand and muddy sand	Subtidal sand	0.15	83.70	16.15
3	SR3	54.3747	-4.970667	mud and sandy mud	Subtidal mud	0.29	52.66	47.05
4	SR4	54.3725	-4.994417	mud and sandy mud	Subtidal mud	0.21	59.59	40.19
5	SR5	54.3847	-4.989	mud and sandy mud	Subtidal mud	0.82	55.23	43.95
6	SR6	54.3998	-4.962333	mud and sandy mud	Subtidal mud	0.12	72.17	27.72
7	SR7	54.38	-4.974833	mud and sandy mud	Subtidal mud	0.01	73.63	26.35
8	SR8	54.39	-4.949167	sand and muddy sand	Subtidal sand	0.01	81.76	18.23
9	SR9	54.3927	-4.916333	sand and muddy sand	Subtidal sand	0.00	81.02	18.98
10	SR10	54.3967	-4.891667	sand and muddy sand	Subtidal sand	1.78	92.07	6.14
11	SR11	54.4095	-4.884	sand and muddy sand	Subtidal sand	2.17	94.03	3.79
12	SR12	54.4052	-4.9075	sand and muddy sand	Subtidal sand	0.16	85.98	13.86
13	SR13	54.4027	-4.930833	mud and sandy mud	Subtidal mud	0.03	78.34	21.63
14	SR14	54.4018	-4.93	sand and muddy sand	Subtidal sand	0.11	81.81	18.08
15	SR15	54.3985	-4.983833	mud and sandy mud	Subtidal mud	0.40	66.85	32.74
16	SR16	54.4095	-4.988167	sand and muddy sand	Subtidal sand	0.93	81.75	17.33
17	SR17	54.4102	-4.973167	sand and muddy sand	Subtidal sand	0.27	84.67	15.06
18	SR18	54.4107	-4.946167	mixed sediments	Subtidal mixed sediments	9.48	64.93	25.59
19	SR19	54.433	-4.92245	sand and muddy sand	Subtidal sand	0.19	87.38	12.43
20	SR20	54.4193	-4.894667	sand and muddy sand	Subtidal sand	0.62	92.18	7.20
21	SR21	54.4223	-4.870833	coarse sediments	Subtidal coarse sediments	11.43	84.26	4.31
22	SR22	54.4355	-4.8707	coarse sediments	Subtidal coarse sediments	13.00	85.39	1.61
23	SR23	54.4292	-4.897733	sand and muddy sand	Subtidal sand	1.71	93.89	4.40
24	SR24	54.4298	-4.9175	sand and muddy sand	Subtidal sand	4.43	88.60	6.96
25	SR25	54.4216	-4.933333	sand and muddy sand	Subtidal sand	0.08	88.05	11.87
26	SR26	54.4267	-4.945	sand and muddy sand	Subtidal sand	0.03	88.30	11.67

Station No.	Station code	Latitude	Longitude	Sediment description	Broad-scale habitat	Gravel (%)	Sand (%)	Silt (%)
27	SR27	54.4358	-4.956	mixed sediments	Subtidal mixed sediments	10.62	68.80	20.58
28	SR28	54.443	-4.989333	sand and muddy sand	Subtidal sand	1.82	81.16	17.02
29	SR29	54.4267	-5.025	sand and muddy sand	Subtidal sand	5.00	77.80	17.21
30	SR30	54.4298	-5.0045	mud and sandy mud	Subtidal mud	3.21	76.05	20.74
31	SR31	54.4188	-4.990333	mixed sediments	Subtidal mixed sediments	24.60	55.34	20.06
32	SR32	54.4205	-4.969167	sand and muddy sand	Subtidal sand	0.21	82.94	16.85
33	SR33	54.4335	-4.977	sand and muddy sand	Subtidal sand	1.99	82.77	15.24

6.3.2 South Rigg rMCZ Samples with associated habitats and biotopes

Table 27. South Rigg rMCZ: Summary of habitat types and biotopes for sample stations.

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
1	SR1	116	Muddy sand	c	Subtidal mud	SS.SMu.OMu.[MonPfal]	A5.37	
2	SR2	99	Muddy sand	c	Subtidal sand	SS.SMu.OMu.[MonPfal]	A5.37	Physical mismatch
3	SR3	132	Muddy sand	c	Subtidal mud	SS.SMu.OMu.[MonPfal]	A5.37	
4	SR4	124	Muddy sand	c	Subtidal mud	SS.SMu.OMu.[MonPfal]	A5.37	
5	SR5	135	Muddy sand	c	Subtidal mud	SS.SMu.OMu.[MonPfal]	A5.37	
6	SR6	119	Muddy sand	c	Subtidal mud	SS.SMu.OMu.[MonPfal]	A5.37	
7	SR7	140	Muddy sand	c	Subtidal mud	SS.SMu.OMu.[MonPfal]	A5.37	
8	SR8	107	Muddy sand	No taxa	Subtidal sand	SS.SSa.OSa	A5.27	Reverted to physical habitat
9	SR9	80	Muddy sand	c	Subtidal sand	SS.SMu.OMu.[MonPfal]	A5.37	Physical mismatch
10	SR10	65	Slightly gravelly sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
11	SR11	49	Slightly gravelly sand	a	Subtidal sand	SS.SCS.OCS.Biotope	A5.15x	Physical mismatch
12	SR12	75	Muddy sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
13	SR13	85	Muddy sand	b	Subtidal mud	SS.SSa.OSa.OfusAfil	A5.272	Physical mismatch
14	SR14	82	Muddy sand	c	Subtidal sand	SS.SMu.OMu.[MonPfal]	A5.37	Physical mismatch
15	SR15	129	Muddy sand	c	Subtidal mud	SS.SMu.OMu.[MonPfal]	A5.37	
16	SR16	134	Muddy sand	c	Subtidal sand	SS.SMu.OMu.[MonPfal]	A5.37	Physical mismatch
17	SR17	127	Muddy sand	c	Subtidal sand	SS.SMu.OMu.[MonPfal]	A5.37	Physical mismatch
18	SR18	95	Muddy sand	b	Subtidal mixed sediments	SS.SSa.OSa.OfusAfil	A5.272	Physical mismatch
19	SR19	80	Muddy sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
20	SR20	63	Sand	No data	Subtidal sand	SS.SSa.OSa	A5.27	Reverted to physical habitat
21	SR21	54	Gravelly sand	a	Subtidal coarse sediments	SS.SCS.OCS.Biotope	A5.15x	
22	SR22	57	Gravelly sand	a	Subtidal coarse sediments	SS.SCS.OCS.Biotope	A5.15x	
23	SR23	63	Slightly gravelly sand	a	Subtidal sand	SS.SCS.OCS.Biotope	A5.15x	Physical mismatch

Station No.	Station code	Depth	Sediment Description	Group	Broad-scale habitat	MHCBI Biotope code	EUNIS code	Comment
24	SR24	74	Slightly gravelly sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
25	SR25	95	Muddy sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
26	SR26	104	Muddy sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
27	SR27	95	gMuddy sand	b	Subtidal mixed sediments	SS.SSa.OSa.OfusAfil	A5.272	Physical mismatch
28	SR28	120	Slightly gravelly muddy sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
29	SR29	136	Slightly gravelly muddy sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	
30	SR30	131	Slightly gravelly muddy sand	b	Subtidal mud	SS.SSa.OSa.OfusAfil	A5.272	Physical mismatch
31	SR31	120	gMuddy sand	b	Subtidal mixed sediments	SS.SSa.OSa.OfusAfil	A5.272	Physical mismatch
32	SR32	120	Muddy sand	c	Subtidal sand	SS.SMu.OMu.[MonPfal]	A5.37	Physical mismatch
33	SR33	115	Slightly gravelly muddy sand	b	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.272	

7 Appendix 2: Colour Schemes

Maps are presented as figures throughout the report and where possible standard colour schemes have been used. For certain maps, which show sample station by sediment or habitat type, alternate have been used as these better illustrate and discriminate the difference between classes. The standard EUNIS colour for each habitat is provided below with the alternate colour used within this report, and red, green and blue values are given for reference.

A5.1; Subtidal coarse sediment; Gravels/Coarse Sediments, SS.SCS

	colour	RED	GREEN	BLUE
EUNIS		255	187	153
ALTERNATE		255	105	190

A5.2; Sublittoral Sand; Sands & Muddy Sands, SS.SSa

	colour	RED	GREEN	BLUE
EUNIS		255	255	128
ALTERNATE		255	255	0

A5.3; Sublittoral Mud; Muds &Sandy Muds; SS.SMu

	colour	RED	GREEN	BLUE
EUNIS		229	197	115
ALTERNATE		145	110	060

A5.4; Subtidal mixed sediments; Subtidal Mixed Sediments; SS.SMx

	colour	RED	GREEN	BLUE
EUNIS		221	255	153
ALTERNATE		000	160	060

8 Annex: QC Comments and feedback

At several stations, physical habitat type has been reverted to for classification as there is no clear match with existing biotopes. This raises several potential issues:

- the biological interest of the sites is reduced;
- information from the biological samples is not fully and easily available without delving into the detail of the statistical analysis; and
- biological detail may be lost when information is summarised.

Recommendations for the three sites follow:

8.1 Compass Rose rMCZ

Eight sample stations from this site whose infauna clustered into group ‘c’ were not attributed to the biotope SS.SSa.OSa.OfulAfil because the habitat type was either mixed or coarse sediment, which did not fit the biotope habitat of sand. Following guidance from JNCC, the habitat type was reverted to for classification of those stations.

However, the stations in question (27, 60, 111, 41, 74, 86, 113 and 139) were not clustered together geographically (see Fig 10), nor did they cluster together on the dendrogram at higher similarity than the 30% cut off used, and they did share characterising species with the rest of group ‘c’. Therefore, it is recommended that these stations are also attributed to the same biotope type (albeit possibly somewhat impoverished) as the rest of group ‘c’: OSa.OfulAfil, with a note that the habitat types don’t match.

REMEDIAL ACTION: Suggestion taken and amendments made to the eight stations in group ‘c’ in the data and report.

8.2 Markham’s Triangle rMCZ

In order to use the biological data to the full, it is recommended that the habitat descriptions are relied upon less and the biotopes for groups ‘a’-‘d’ are described as they cluster from the infaunal analysis. As there are no matching biotopes in the classification it is suggested that:

- a potential new biotope description is suggested for group ‘a’;
- Group ‘c’ should be allocated to the biotope CFiSa.EpusOborApri, with notes that there are habitat mismatches for all stations;
- a potential new biotope description is suggested for group ‘d’;

REMEDIAL ACTION:

- **Group ‘a’ – suggestion not taken.** This group only consisted of two samples which were characterised by mud with low numbers of taxa, and it was not felt that the biological grouping was strong enough to drive a new biotope based on this information alone.
- **Group ‘c’ – suggestion taken.** Group ‘c’ allocated to the biotope CFiSa.EpusOborApri, with notes of the habitat mismatches made.
- **Group ‘d’ – suggestion not taken.** Group ‘d’ is a strong cluster, however it is apparent that stations within group ‘d’ were distinguished by taxa such as *Amphiura filiformis*, the razor clam *Phaxas pellucidus*, the amphipod *Urothoe marina* and to a lesser extent *Pholoe baltica* and Spiophanes spp. These species are representative

of both sandy and coarse habitats, with the majority of stations having a physical substrate recorded as mixed. The biota within this group appear to be associated with a sandier substrate than indicated by the physical data, or a coarse habitat. Epibenthic images were also reviewed and confirm heterogeneous physical habitats and biota, therefore the samples within the group have been attributed habitats according to the physical nature of the seabed

8.3 South Rigg rMCZ

Three infaunal clusters identified from the stats. The clusters are also clustered geographically (Figure 29) and this seems to reflect their sediment composition and to some extent, depth.

The biotopes OSa.OfusAfil and Omu.MonPfal have been allocated to groups ‘b’ and ‘c’ respectively, which seem to be a reasonable match.

There is no biotope match for group ‘a’, so following guidance, it was allocated to the habitat type OCS. However, it appears to be a distinct biotope for which there is reasonable information from four stations, so it is recommended this should be described as a potential new biotope rather than reverting to the habitat type, with a note where habitat type does not match.

REMEDIAL ACTION: Suggestion taken and amendments made to group ‘a’ in the data and report.

8.4 Quality Assurance and Audit Trail

To ensure there is agreement on the biotopes assigned, it is required that a minimum of 10% of data (biotope samples) were checked by a third party/analyst who did not undertake the original data processing, statistical analysis or biotope allocation. Once the third party is satisfied that data have been analysed correctly this is verified in the table below. For this project 100% of data and sample biotope allocation were checked and verified.

Site	Action	Analyst	Reviewer	Checked
Compass Rose rMCZ	Data handling checked, prior to import to primer for analysis	ISS	AB	YES
	Statistical analysis outputs verified	ISS	CJ	YES
	Biotope allocation for each sample agreed	ISS	CJ	YES
Markham’s Triangle rMCZ	Data handling checked, prior to import to primer for analysis	ISS	AB	YES
	Statistical analysis outputs verified	ISS	CJ	YES
	Biotope allocation for each sample agreed	ISS	CJ	YES
South Rigg rMCZ	Data handling checked, prior to import to primer for analysis	ISS	AB	YES
	Statistical analysis outputs verified	ISS	CJ	YES

Site	Action	Analyst	Reviewer	Checked
	Biotope allocation for each sample agreed	ISS	CJ	YES

Data checks were undertaken from 10% of samples randomly selected from each site:

COMPASS ROSE								
Station No.	**Station code**	**Depth**	**Sediment Description**	**Group**	**Broad-scale habitat**	**MHCBI Biotope code**	**EUNIS code**	**Comment**
11	CR_R_22	75	Muddy sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.273	
29	CR_R_18	68	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.279	
88	CR_S_20	78	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.296	
102	CR_S_21	69	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.302	
109	CR_R_16	72	Sand	c	Subtidal sand	SS.SSa.OSa.OfusAfil	A5.305	

Broad-scale habitat classes were incorrect and EUNIS codes were incorrect, all other data were correct. Remedial action was taken to amend tables and correct errors in report. These errors and amends did not affect raw data, processed data or analyses.

MARKHAMS TRIANGLE								
Station No.	**Station code**	**Depth**	**Sediment Description**	**Group**	**Broad-scale habitat**	**MHCBI Biotope code**	**EUNIS code**	**Comment**
10	MT47	56	Slightly gravelly muddy sand	a	Subtidal mud	SS.SMu.CSaMu	A5.35	
15	MT43	40	Gravelly muddy sand	d	Subtidal mixed sediments	SS.SMx.CMx	A5.44	
23	MT40	36	Sandy gravel	c	Subtidal coarse sediments	SS.SCS.CCS	A5.14	
25	MT39		Sandy gravel	c	Subtidal coarse sediments	SS.SCS.CCS	A5.14	
71	MT34	37	Slightly gravelly sand	b	Subtidal sand	SS.SSa.CFiSa.EpusOborApri	A5.251	

All data cross-checked and verified. Biotope assignment agreed.

SOUTH RIGG								
Station No.	**Station code**	**Depth**	**Sediment Description**	**Group**	**Broad-scale habitat**	**MHCBI Biotope code**	**EUNIS code**	**Comment**

1	SR1	136	Muddy sand	c	Subtidal mud	SS.SMu.Omu.[MonPfal]	A5.37	
4	SR4	105	Muddy sand	c	Subtidal mud	SS.SMu.Omu.[MonPfal]	A5.37	
27	SR27	104	gMuddy sand	b	Subtidal mixed sediments	SS.SSa.OSa.OfusAfi	A5.272	Physical mismatch

All data-cross checked and verified. Biotope assignment agreed.

Final documents undergo review and checks, according to the following processes.