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Summary

This report presents the findings from analyses of the acoustic data and groundtruth samples gathered during the seabed survey of the Turbot Bank possible Marine Protected Area (pMPA).

Turbot Bank lies within a coarse sandy sediment plain to the east of Scotland, approximately 65km east of Peterhead on the Aberdeenshire coast, south of the Fladen Ground, and comprises a shelf bank and mound feature. The report describes the presence, location and extent of broadscale habitats, biotopes and Scottish Marine Protected Area (SMPA) Priority Marine Features within the Turbot Bank pMPA.

Full coverage multibeam echosounder data (bathymetry and backscatter) collected under the Civil Hydrography Programme were available for the western half of Turbot Bank pMPA. During a dedicated survey in December 2012, new acoustic data were collected in the eastern part of the bank. Additionally, 102 grab samples, 27 videos and 742 still images were collected. Broadscale habitats were mapped employing the Object-Based Image Analysis software eCognition. Standard univariate and multivariate analyses on the taxon abundance data have been performed to identify distinct faunal assemblages. Multivariate analyses of the infauna and epifauna data was used to identify distinct clusters. EUNIS biotopes were then assigned to the clusters based on the presence of characterising species.

The Turbot Bank pMPA is dominated by two broadscale habitats. These are A5.1 Subtidal Coarse Sediment, which occupies the shallowest parts of the bank and, to a lesser extent, A5.2 Subtidal Sand, which is typically associated with greater water depths on the flanks of the bank. Both broadscale habitats conform to the definition of the SMPA Priority Marine Feature Offshore Subtidal Sands and Gravels, which was present across the entire survey area.

Distinct spatial patterns using infaunal univariate metrics were not observed; however multivariate analysis revealed that infaunal assemblages are dominated by species characteristic of several biotopes found within the Offshore Subtidal Sands and Gravels Priority Marine Feature. Six infaunal stations, located on the flanks of Turbot Bank, have been assigned tentatively to the EUNIS Level 5 biotope A5.251: *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand. However, the majority of infaunal stations could not be asigned any higher than EUNIS Level 3. Epifaunal assemblages across the shallowest part of Turbot Bank are typical of the EUNIS Level 5 circalittoral coarse sediment habitat A5.141: *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. The mobile species of particular importance to the designation of this site, the sand eel *Ammodytes* sp., was identified at 14 of the 70 stations sampled by Hamon grab. No Annex I habitats were found at Turbot Bank pMPA.

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1 Background

The Turbot Bank possible Marine Protected Area (pMPA) has been recommended primarily for the protection of sandeels. This area has also been selected as a ‘science based alternative’ for the features ‘shelf banks and mounds’ and ‘offshore subtidal sands and gravels habitat’ present in the ‘Firth of Forth Banks Complex Nature Conservation MPA proposal’ (SNH & JNCC 2012).

In November 2012, the Centre for Environment Fisheries and Aquaculture Science (Cefas) in partnership with the Joint Nature Conservation Committee (JNCC) conducted an acoustic and groundtruth survey of the Turbot Bank pMPA to gather high quality evidence to confirm the presence of Priority Marine Features and Annex I habitats within the site and to contribute to an evaluation of site condition (further information on Priority Marine Features and Annex I habitats relevant to offshore Scottish waters can be found in Appendices 1-4). The survey was completed successfully in December 2012 and full details can be found in the survey report (Ware 2013).

This report delivers the findings from the analyses of the evidence gathered during the survey.

2 Introduction

2.1. Location of the Turbot Bank pMPA

The Turbot Bank pMPA lies within a coarse sandy sediment plain to the east of Scotland, approximately 65km east of Peterhead on the Aberdeenshire coast (Figure 1), south of the Fladen Ground and comprises a shelf bank and mound feature known as Turbot Bank (SNH & JNCC 2012).

In terms of structural geology, the Turbot Bank is a Permian high[1], characterised by basin margin sequences dominated by carbonate and anhydrite, such as the Turbot Bank Formations (Stewart *et al* 1997). According to British Geological Survey (BGS) sheet 57N 00 ‘Forties’ (BGS 1989), the formations outcropping within the bank are characterised by mudstones, sandstones and lignite of the Palaeocene (Palaeocene Rocks) over almost the entire survey area. Along the eastern boundary, there are interbedded siliciclastic argillaceous rocks and sandstones of Eocene to Pliocene age. The water depth at the site ranges between 55 and 91m (Figure 1).

[1] A structural high is any of various structural features such as a crest, culmination, anticline, or dome (McGraw-Hill Dictionary of Scientific & Technical Terms, 6th Edition, 2003).

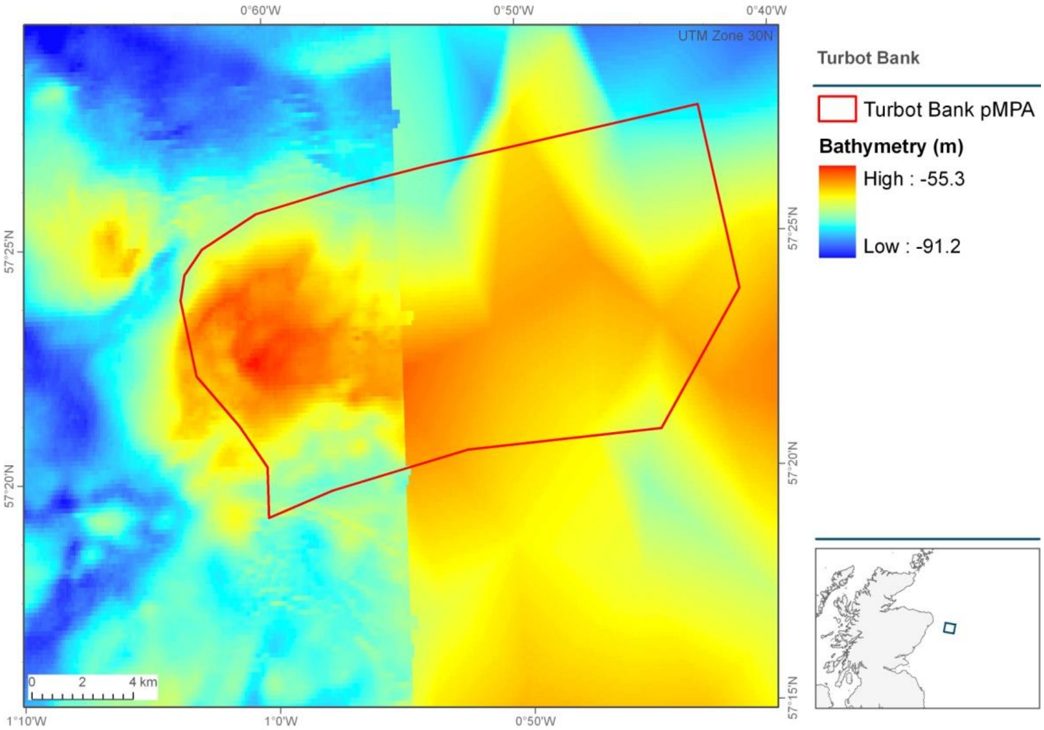

Figure 1: Location and extent of the Turbot Bank pMPA. Bathymetry is from a high resolution Digital Elevation Model (Astrium 2011).

3. Survey Design and Methods

3.1. Planning: including station selection

Multibeam bathymetry data for the western side of the Turbot Bank pMPA had been previously collected (2009-2010) in support of the Civil Hydrography Programme (CHP). Therefore, acoustic data was only collected from the eastern part of the site. Groundtruthing stations across the whole site were selected using the Astrium Digital Elevation Model (DEM) bathymetry layer (Astrium 2011), in the absence of processed multibeam data. Groundtruth methods consisted of grab sampling using a $0.1m^2$ Hamon grab, and seabed imagery using a drop camera system.

Sampling station selection was based on a triangular lattice pattern, with stations placed approximately 2km apart. Additional sampling stations were placed specifically on features of interest and also in an area to the west of the site where the Astrium data indicated that the bank feature extended beyond the current proposed site boundary.

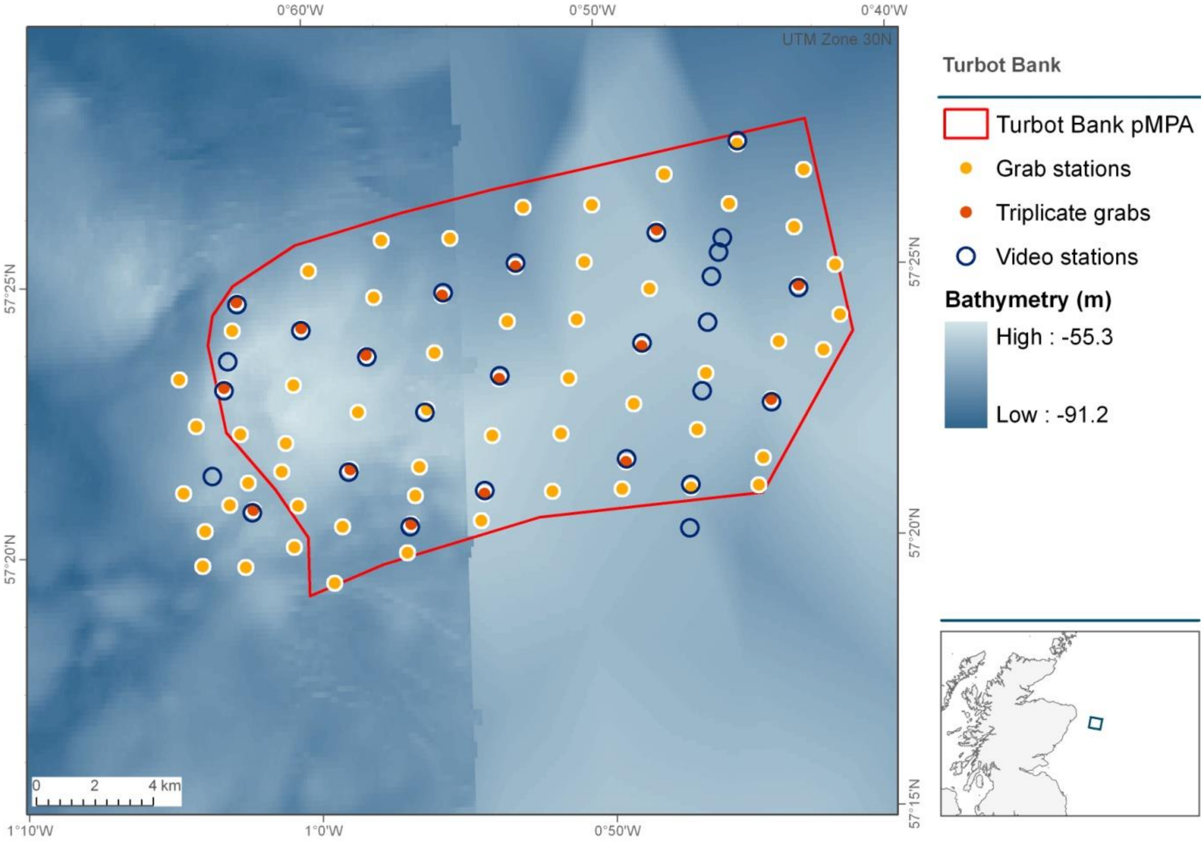

Figure 2: Location of grab and video sampling stations at Turbot Bank pMPA. Bathymetry is from a high resolution Digital Elevation Model (Astrium 2011).

3.2. Acoustic methods

Acoustic data were collected onboard *RV Cefas Endeavour* using a Kongsberg EM2040 multibeam echosounder (MBES) (see Appendix 5 for metadata). This advanced high resolution multibeam system was operated at the 200kHz frequency, considering the water depths present in the area. A Kongsberg Seapath 330+ with Seatex MRU5 system was used to provide positional and motion compensation data.

The raw MBES files (.ALL files) were acquired using the Kongsberg SIS operating system. Bathymetry data were processed using the CARIS HIPS 7.1 SP2 hydrographic data processing system. Tidal data were modelled using Cefas' tidal model software *TStide* and the offsets from Mean Sea Level to Chart Datum (CD) were subsequently applied. Backscatter mosaics were produced using QPS Fledermaus Geocoder Toolkit (FMGT) software.

Full details on the collection and processing of acoustic data can be found in Ware (2013). Full coverage multibeam bathymetry and backscatter data from the Civil Hydrography Programme (CHP) were available for the western part of Turbot Bank. These data were collected as part of the larger Todhead Point to Bosies Bank survey between 12 September 2009 and 4 February 2010. Two survey vessels, *MV Vigilant* and *MV L'Espoir*, both equipped with a Kongsberg EM710 (70-100kHz) were used for data collection. Processed bathymetry data were made available to Cefas post-2013 survey and were further processed using QPS Fledermaus to produce digital elevation surfaces. Raw multibeam echosounder data were provided to Cefas to allow backscatter mosaics to be produced using the QPS FMGT software.

Due to the different operating frequencies (see above), some differences could be observed in the backscatter mosaics derived from both systems.

3.3. Groundtruth sampling methods

Sampling of the seabed, using underwater cameras and sediment sampling devices, was undertaken to groundtruth the acoustic data, and to enable the characterisation of habitats and resident faunal communities within the area (see Appendices 6 and 7 for metadata). Replicate grab samples (three samples separated by a distance of approximately 5m) were collected at a sub-set of stations to explore the effects of survey design and sampling density on the species accumulation curve within the site.

3.3.1. Grab sampling

Sediment samples were collected with a grab system consisting of a $0.1m^2$ mini Hamon grab fitted with a video camera, the combined gear being known as a HamCam. This allowed an image of the undisturbed seabed surface to be obtained for each grab sample. On recovery, the grab was emptied into a large plastic bin and a representative subsample of sediment (approx. 0.5 litres) taken for particle size analysis (PSA). The remaining sample was photographed, then sieved over a 1mm mesh to collect the benthic macrofauna. These were preserved in 4% buffered formaldehyde for later processing ashore. Any cobbles (>64mm) found in the samples were analysed on board using Cefas Standard Operating Procedure (SOP) for cobble analysis (see Appendix 8).

3.3.2. Seabed imagery

The underwater camera system comprised a video camera with capability to also capture still images. Illumination was provided by two Cefas high intensity LED striplights and a flash unit. The camera was fitted with a four-spot laser scaling device to provide a reference scale in the video image. Setup and operation followed the MESH 'Recommended Operating Guidelines (ROG) for underwater video and photographic imaging techniques' (Coggan *et al* 2007). Video was recorded simultaneously to a Sony GV-HD700 DV tape recorder and a computer hard drive. A video overlay was used to provide station metadata, time and Global Positioning System (GPS) location (of the vessel) in the recorded video image.

Camera deployments lasted a minimum of 10 minutes, with the vessel using its dynamic positioning capability to move along the planned transect at c. 0.5 knots (c. $0.25ms^{-1}$) across a 100m 'bullring' centred on the sampling station. Still photographic images were captured at one-minute intervals and opportunistically if features of interest were observed.

3.4. Seabed sample and data processing

3.4.1. Particle size analysis

Particle size analysis (PSA) was carried out by Cefas following standard laboratory practice, and results were checked by Cefas specialist staff following the recommendations of the National Marine Biological Analytical Quality Control (NMBAQC) scheme (Mason 2011). In total, 102 samples were analysed at half phi intervals using a combination of laser diffraction (<1mm fraction)and dry sieving techniques (>1mm). Gradistat software (Blott & Pye 2001) was used to produce all sediment statistics (e.g. mean, mode, skewness). Each sample was also assigned to one of the four EUNIS sediment classes defined by Long (2006), namely coarse sediment, sand, mud and mixed sediment (see Appendix 9).

3.4.2. Grab samples

Infaunal samples were processed by Seastar Survey Ltd following standard laboratory practices, and results were checked following the recommendations of the NMBAQC scheme (Worsfold *et al* 2010). Fauna were identified to lowest taxonomic resolution and weighed. In total, 102 infaunal samples from 70 stations were analysed. Sixteen of the stations were sampled in triplicate in order to determine the rate of species accumulation with increased sampling effort.

3.4.3. Seabed imagery

Video and photographic still images were processed by Envision Mapping Ltd in accordance with the guidance documents developed by Cefas and the JNCC for the acquisition and processing of video and still data (Coggan & Howell 2005). In total, 27 videos and 742 still images were analysed for fauna (using the SACFOR abundance scale[2]) and sediment composition. Three video stations (TRBT75, TRBT76 and TRBT78) were composed of more than one habitat type. These different habitats (or segments) of the main video station have been labelled in the results figures as TRBT75_S1, TRBT75_S2, TRBT76_S1, TRBT76_S2, TRBT78_S1, TRBT78_S2 and TRBT78_S3). The remaining stations have been labelled as [station code] _S1. A EUNIS (2012) Level 3 broadscale habitat and a Marine Nature Conservation Review (MNCR): Marine Habitat Classification v 04.05 (Connor *et al* 2004) biotope codewas assigned to all video segments and still images (see Appendix 10). Videos and still images were additionally checked for evidence of stony reef according to the definition in Irving (2009).

3.5. Data analysis methodologies

A detailed habitat map was produced by analysing and interpreting all available acoustic data available from Cefas and the CHP, and the ground-truth data collected during the survey described in this report (see Section 3.5.3).

3.5.1. Acoustic data interpretation

Bathymetry and backscatter data sets from CHP and Cefas surveys were merged to produce integrated bathymetry and backscatter data layers. The bathymetry data from the two surveys were easily integrated, as both were processed to agreed standards and both surveys provided comparable depth observations. Backscatter data layers from the two surveys could not be integrated as easily. Different multibeam systems, operating at different frequencies were used by the CHP and Cefas surveys (see Section 3.2). The interaction with the seabed at these frequencies differs and can result in differences in backscatter intensities. To account for the differences in backscatter intensity between both systems, ten thousand random 'samples' were taken where the two backscatter data sets overlapped. A statistically significant linear relationship existed between the two backscatter data sets (R^2 = 0.50) and this was used to level the two data sets.

EUNIS class assignments from the particle size data were used in conjunction with the interpreted still images to inform the semi-automated process of map production using object-based image analysis (OBIA; Blaschke 2010) implemented in the software package eCognition v8.8.1. The OBIA was used to map both broadscale habitats and subsequently Scottish Marine Protected Area (SMPA) seabed habitat search features.

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[2] Reference URL: http://jncc.defra.gov.uk/page-2684.

OBIA is a two-step approach consisting of segmentation and classification (Figure 3). The segmentation divides the image into meaningful objects, based on their spectral and spatial characteristics. The resulting objects can be characterised by their various features, such as layer values (mean, standard deviation, skewness, *etc*.), geometry (extent, shape, *etc*.), texture and many others. The subsequent classification of the objects is based on combinations of these features.

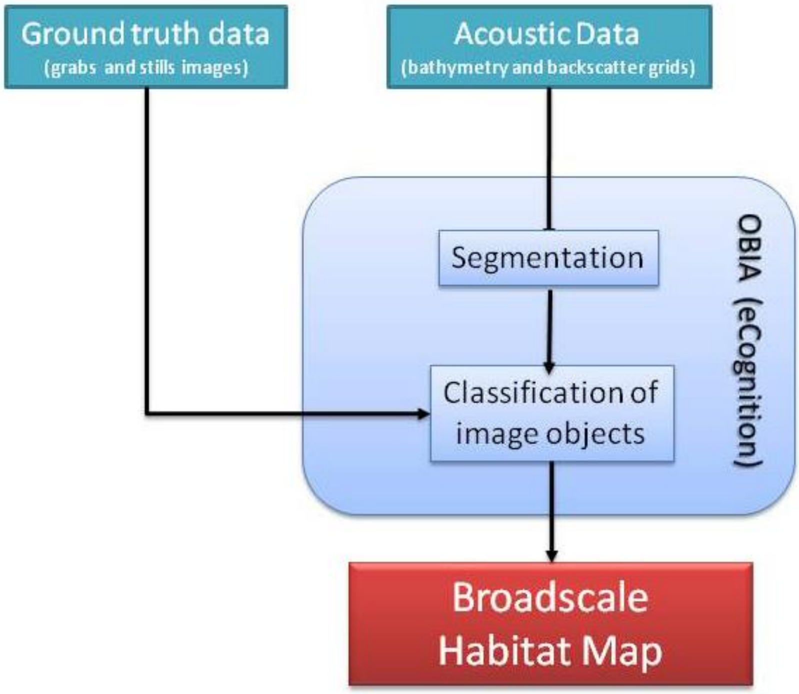

Figure 3: Flow chart outlining the process of producing the broadscale habitat map.

The input layers used for the OBIA were the multibeam backscatter strength and the multibeam bathymetry at a resolution of 5m. Segmentation was carried out employing the 'multiresolution segmentation' algorithm in eCognition. This is an optimisation procedure that starts with an individual pixel and consecutively merges it with neighbouring pixels to form an object. The process continues until a threshold value for a 'scale' parameter is reached, the threshold being determined experimentally by the operator.

The goal of the segmentation is to create meaningful objects in the map image. The size of the objects is influenced by the 'scale' parameter mentioned above and the heterogeneity of the image. For a fixed value of the scale parameter, a homogenous area of seabed will have larger objects than a heterogeneous area. Likewise for a fixed seabed heterogeneity, larger values of the scale parameter produce larger objects than smaller values. The multiresolution segmentation was carried out at pixel level on backscatter strength and bathymetry with a scale parameter of 5.

The classification of the resulting objects was carried out in several steps and used the 'assign class' algorithm in eCognition, with the choices made by the analyst being informed by sediment classes determined for the ground-truth samples (as detailed above). Threshold conditions for defining and discriminating broadscale habitat classes were chosen experimentally. The resulting objects labelled with their respective class name (broadscale habitat type) were exported from eCognition as an ArcGIS shapefile for use in the map figures presented in the results section of this report. SMPA search features were derived from the same data layer.

3.5.2. Faunal data analysis

Grab samples

Statistical analyses were undertaken using PRIMER 6 (Clarke & Gorley 2006). Standard univariate and multivariate analyses were performed on the taxon abundance-by-sample matrix produced by Seastar Survey Ltd. Multivariate analyses were performed on the taxon (SACFOR) abundance by still image matrix created from data produced by Envision Mapping Ltd.

Univariate metrics calculated for each sample include total macrofaunal abundance (N), total number of taxa (S), Hill's (1973) taxon diversity index (N1) and total wet weight biomass (B). Further calculations were performed on data from the 16 stations where triplicate sampling occurred using the Species-Accumulation Plot routine in PRIMER. Calculations were performed separately on replicate A data, then on data from replicates A and B combined, then on all data from the 16 stations. Microsoft Excel was used to graphically display the data.

Multivariate analyses, to determine community composition, were performed on replicate A only from each sampling station in order to avoid the effect of unequal sampling effort. The data were square root transformed prior to calculation of a Bray-Curtis similarity matrix. Hierarchical cluster analysis using the SIMPROF routine was used to identify significantly ($p= 0.05$) different groups of samples. The SIMPER routine was used to identify the taxa contributing to the similarity within and between the statistically defined groups.

Seabed imagery

Composition of epifaunal communities at each of the video stations was determined by multivariate analysis of the taxon (SACFOR) abundance matrix produced from still images only. The SACFOR scale was converted to a numerical scale, where superabundant=6, abundant=5, common=4, frequent=3, occasional=2, rare=1 and present=1. The still image data was averaged within each video segment due to the high and varying number of stills taken for each video station. This method standardized the data and enabled significantly different station groups to be identified. No transformation of the data was undertaken prior to calculation of a Bray-Curtis similarity matrix as the scale used was equivalent to a strong data transformation. Hierarchical cluster analysis using the SIMPROF routine was used to identify significantly ($p= 0.05$) different groups of samples. SIMPER was used to identify the taxa contributing to the within and between group similarity.

Variability in epifaunal communities (and potentially biotopes) along the tows was investigated using the pre-averaged data matrix. The data was subjected to hierarchical cluster analysis and a cut-off at 45% similarity was applied to identify cluster groups. SIMPER was used to identify the taxa contributing to the within and between group similarity. As every still image was assigned to a cluster, each video segment could be checked for consistency along the tow. This ensured the final biotope assignments were accurate for each video segment

3.6. Data Quality Assurance and Quality Control (QA/QC)

All field sampling activities were performed according to the recommendations in the following documents:

- Biological Monitoring: General Guidelines for Quality Assurance document[3]
- Quality Assurance in Marine Biological Monitoring[4]
- Recommended operating guidelines for underwater video and photographic imaging techniques[5]

4. Results

4.1. Multibeam bathymetry and backscatter

Within the mapped area, water depth varies between 55 and 91m below CD (Figure 4). Turbot Bank rises to 55m below CD in the western part of the site boundary. East-west trending subaqueous dunes are situated north and south of the Turbot Bank.

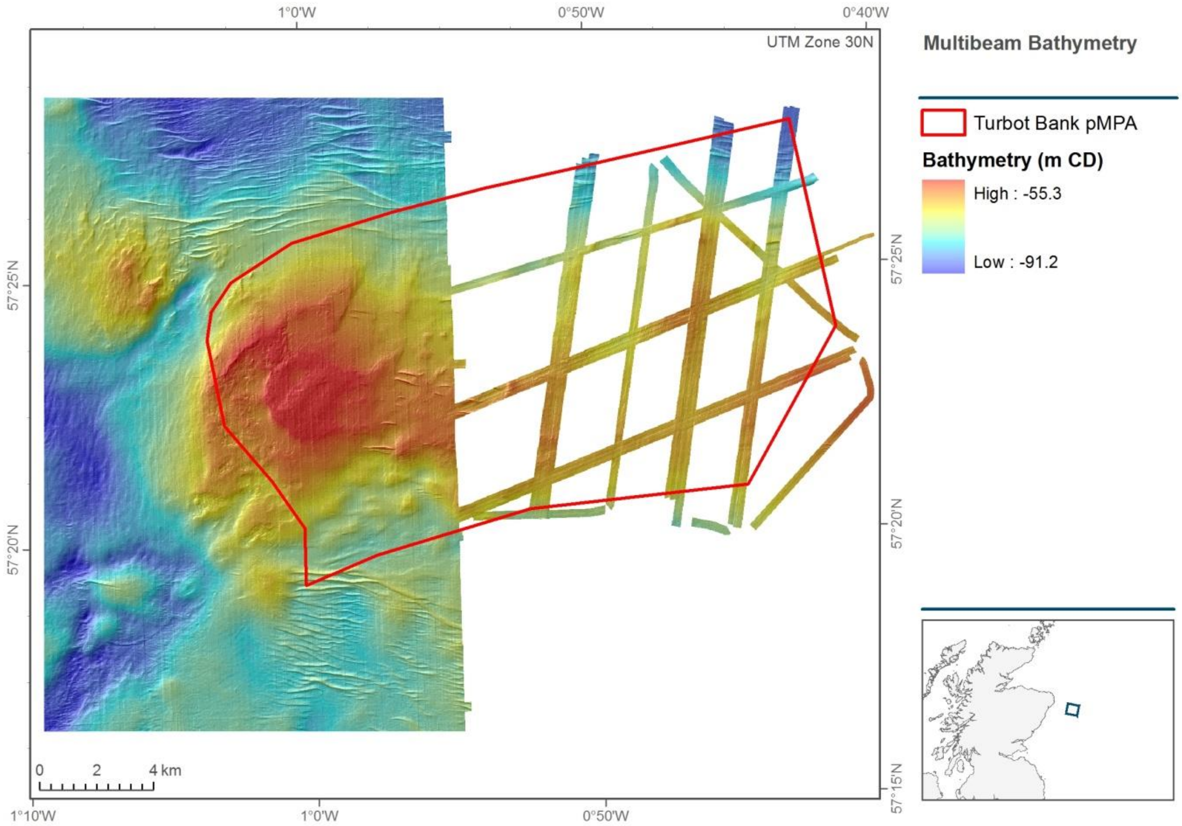

Figure 4: Multibeam bathymetry of Turbot the Bank pMPA. Bathymetry on the left is from CHP survey and on the right from the Cefas 2013 survey.

[3] Reference URL: http://www.marbef.org/qa/documents/PKG85.pdf
[4] Reference URL: http://www.nmbaqcs.org/qa-standards/qa-in-marine-biological-monitoring.aspx
[5] Reference URL: http://www.searchmesh.net/PDF/GMHM3_Video_ROG.pdf

Backscatter is generally high on Turbot Bank, indicating coarse substrates. Backscatter tends to decrease with increasing water depths, hinting at a general fining of sediments towards deeper water (Figure 5).

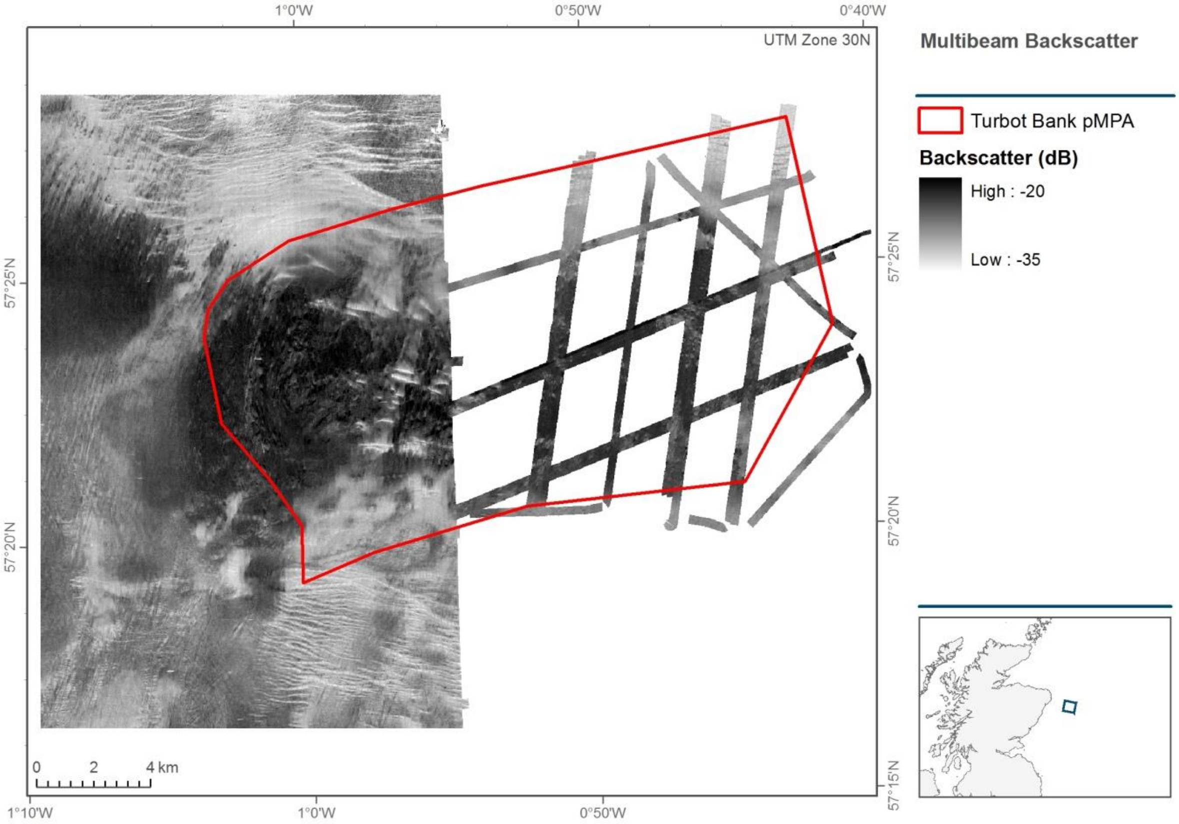

Figure 5: Multibeam Backscatter of the Turbot Bank pMPA. Backscatter on the left is from the CHP survey and on the right from the Cefas 2013 survey.

4.2. Surficial sediments

Of the 102 grab samples analysed for particle size, 94 were classed as coarse sediment, four as mixed sediment and four as sand and muddy sand according to the modified Folk classification (Long 2006). The relative proportions of the major sediment fractions (gravel, sand and silt/clay) for each station are presented in Figure 6. Of the 27 video stations, 26 stations were classed as A5.1 Subtidal Coarse Sediment and one as A5.2 Subtidal Sand according to the EUNIS-based BSH classification (results are presented in Figure 7).

4.3. Habitat map

Turbot Bank is dominated by ‘Subtidal Coarse Sediment’ which occupies the shallowest parts and, to a lesser extent, ‘Subtidal Sand’ which is typically associated with greater water depths on the flanks of Turbot Bank (Figure 8).

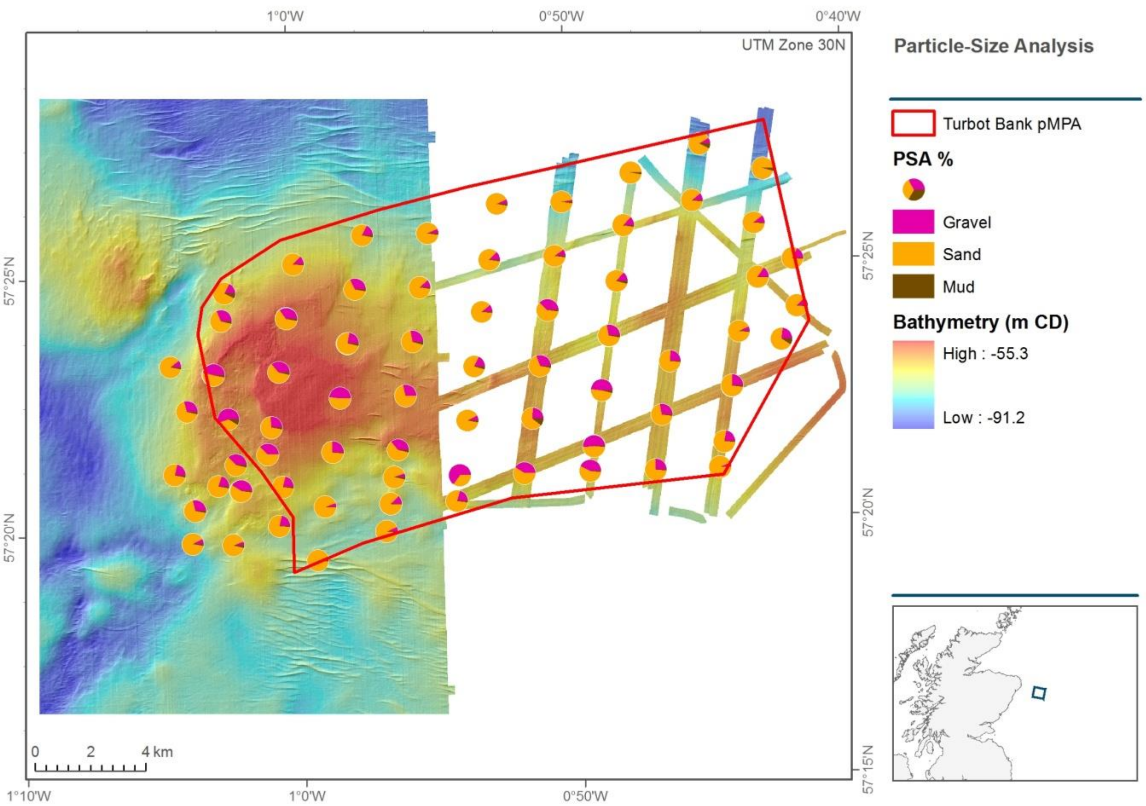

Figure 6: Results from Turbot Bank PSA, displayed as pie charts of % gravel, sand and mud. Bathymetry on the left is from the CHP survey and on the right from the Cefas 2013 survey.

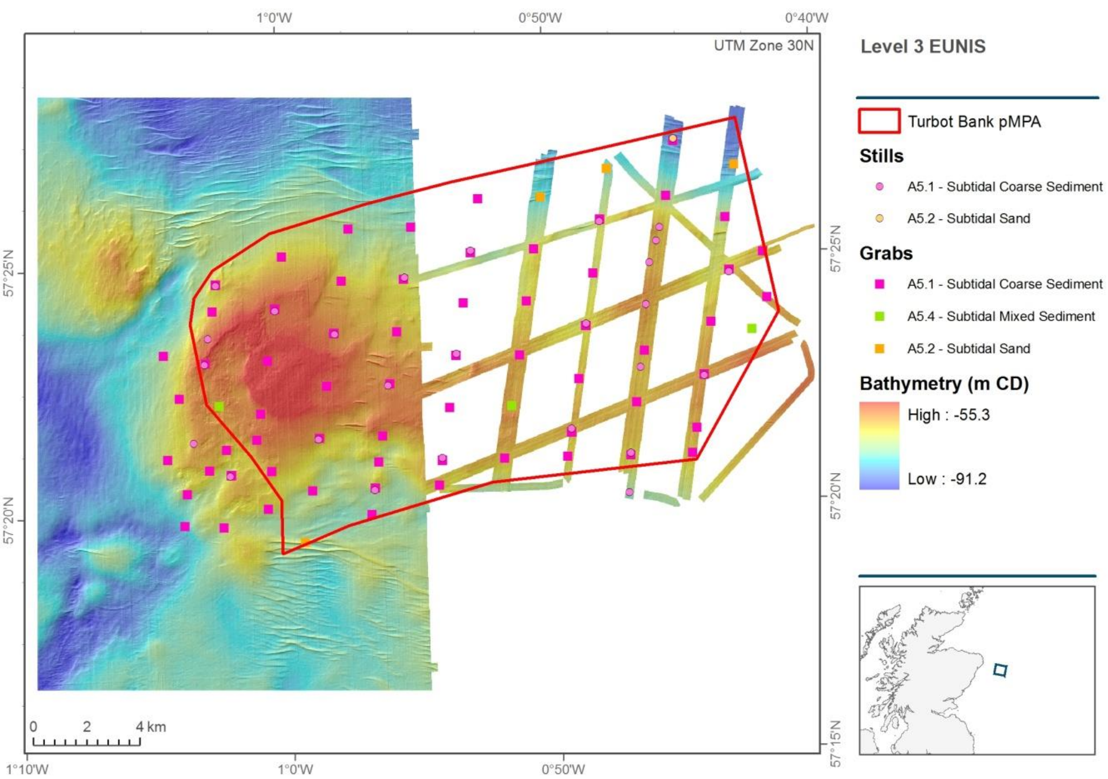

Figure 7: Results from PSA from grabs and sediment classification from still images displayed according to EUNIS Level 3. Bathymetry on the left is from the CHP survey and on the right from the Cefas 2013 survey.

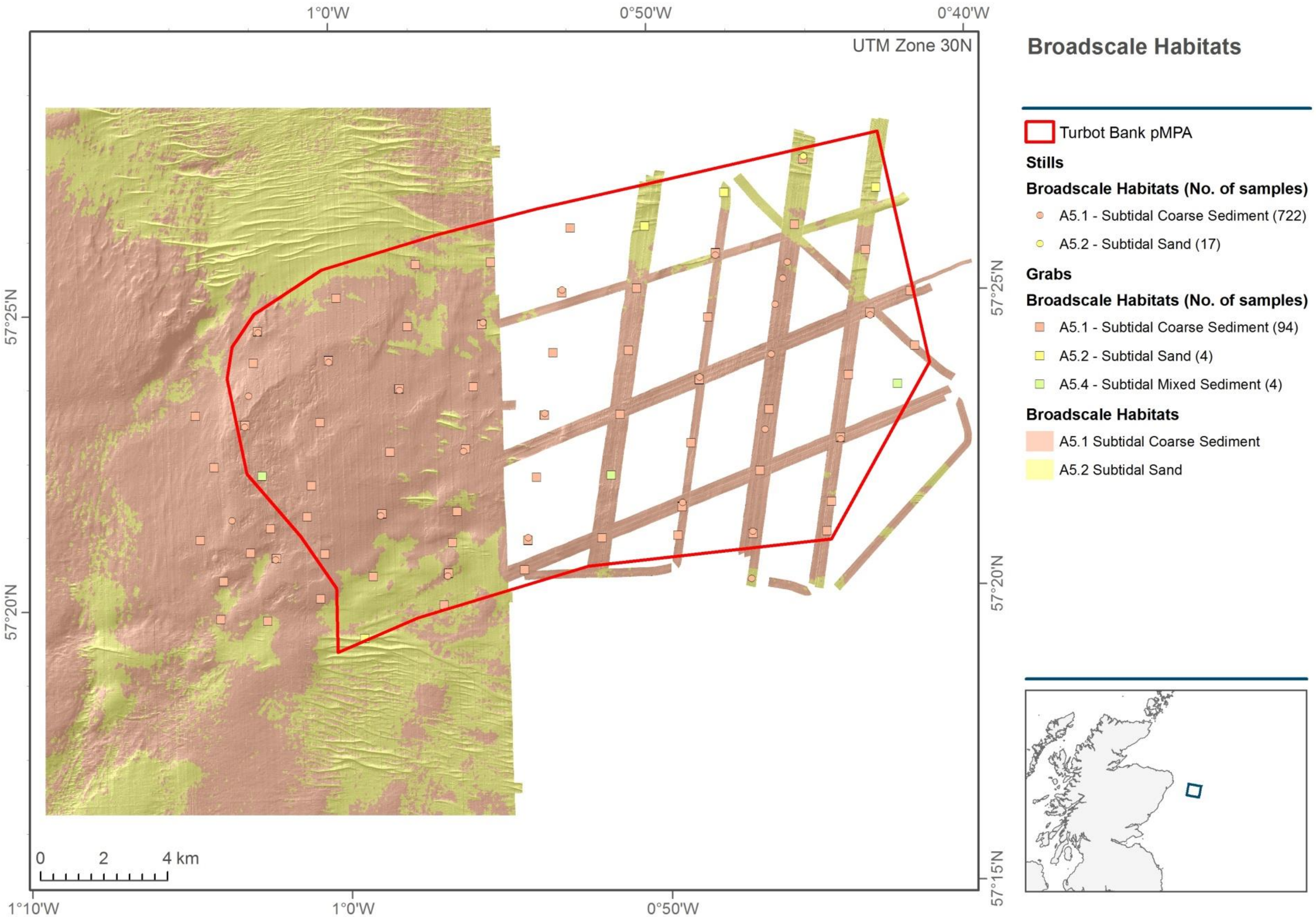

Figure 8: Broadscale habitat types of the Turbot Bank pMPA.

4.4. Patterns in infaunal communities

4.4.1. Univariate analyses

Macrofaunal abundance values per sample ranged between 10 and 483 individuals and numbers of taxa ranged between 7 and 50. Taxon diversity (Hills N1) ranged from 3.52 to 36.74 and biomass ranged between 0.13g and 47.45g per sample. All calculated metrics are presented in Appendix 11.

The distributions of selected calculated metrics across the Turbot Bank pMPA are displayed in (Figure 9, Figure 10 and Figure 11). All metrics displayed high variability across the site; stations within the coarse and sand habitats comprise both high and low values.

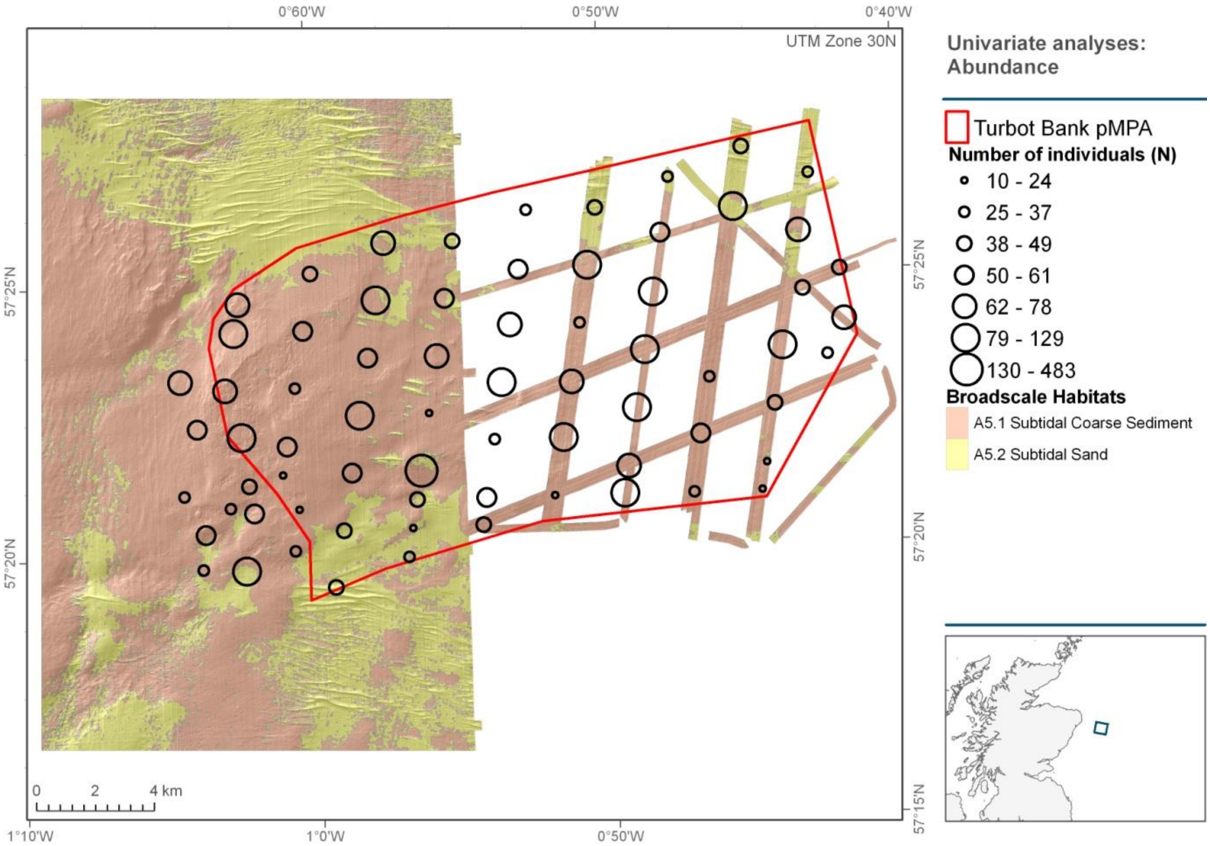

Figure 9: Spatial distribution of the mean number of individuals recorded at the Turbot Bank pMPA.

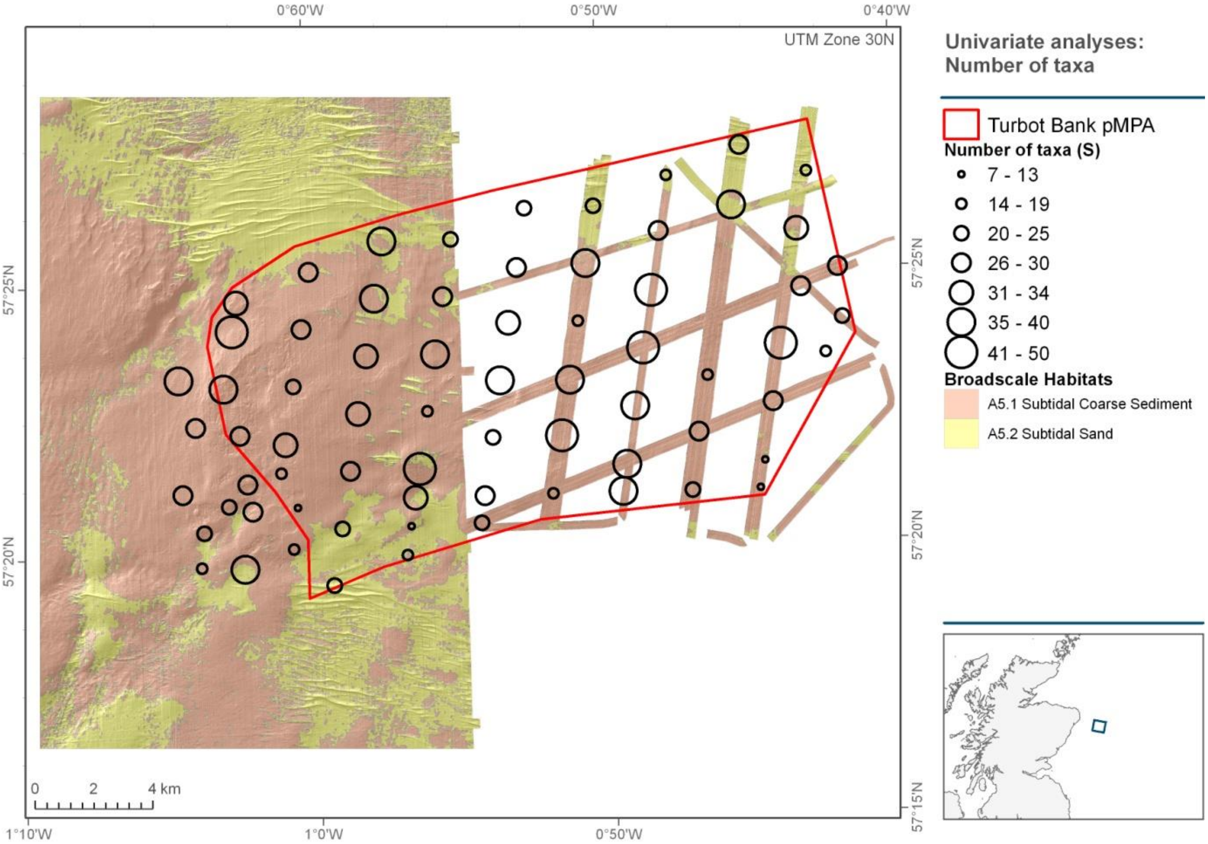

Figure 10: Spatial distribution of the mean number of taxa recorded per station at the Turbot Bank pMPA.

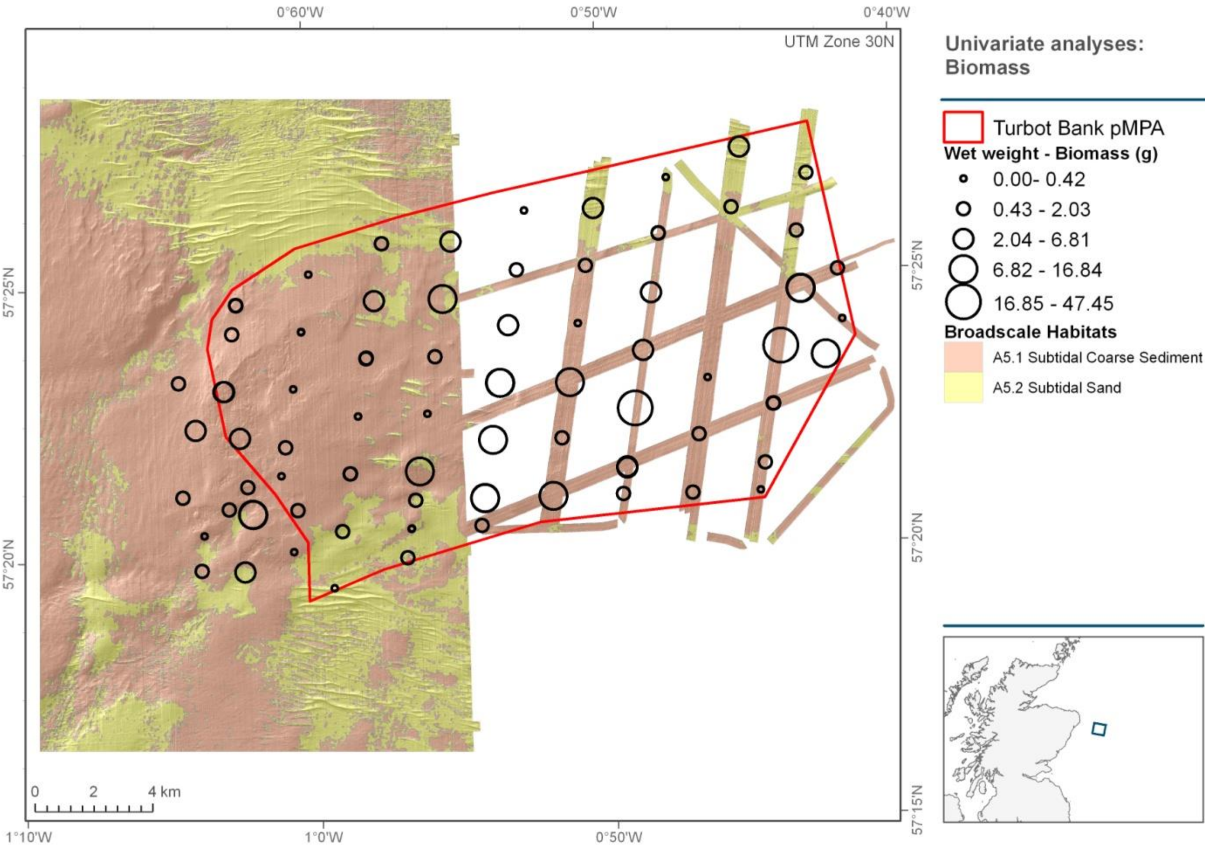

Figure 11: Spatial distribution of the mean biomass recorded per station at the Turbot Bank pMPA.

4.4.2. Cobble analysis

Cobbles (>64mm) were found in 17 grab samples located within the subtidal coarse sediment habitat across the site. The volume calculated for each cobble ranged from 30-690cm^3. Fauna associated with the cobbles included; *Spirobranchus (Pomatoceros)* sp. tubes, hydroids (e.g. *Abietinaria* sp.), bryozoa, barnacles and *Sabellaria* sp. tubes (see Appendix 12).

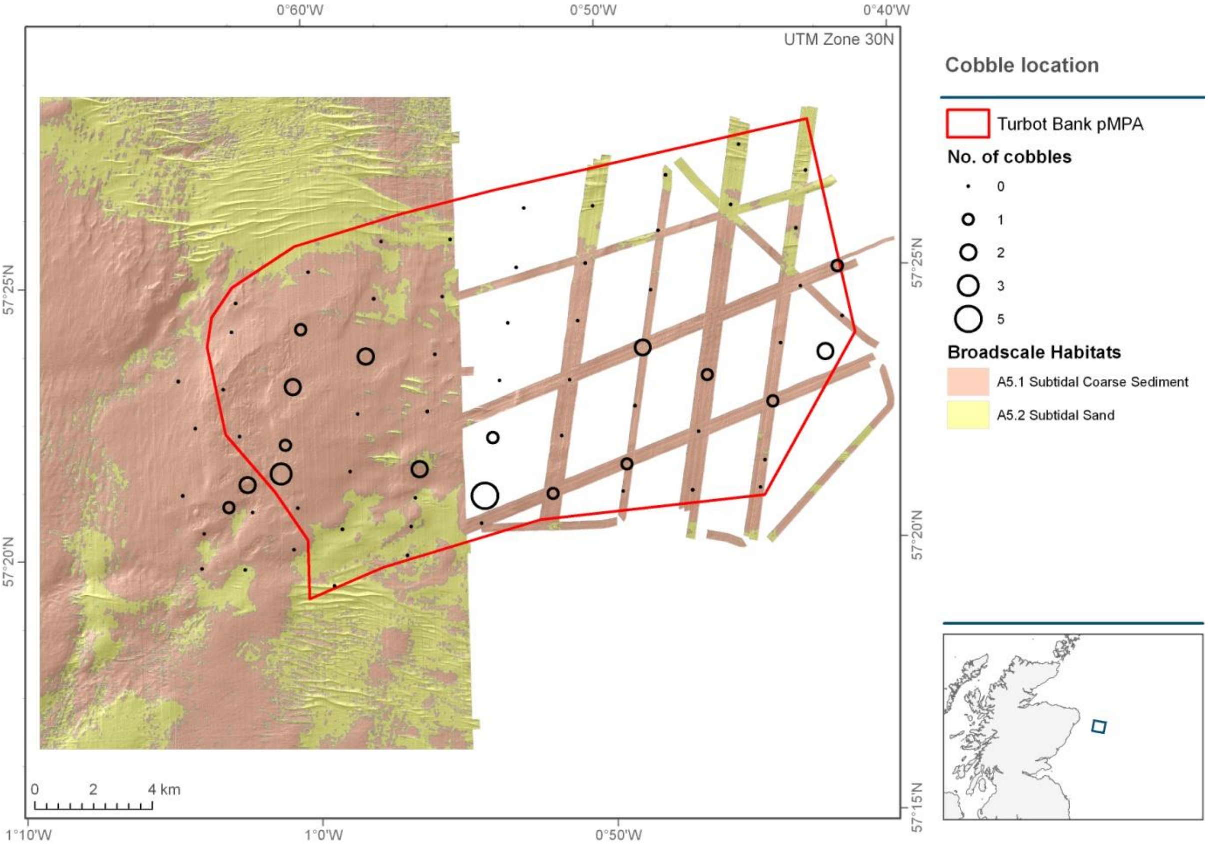

Figure 12: Location and number of cobbles found in grab samples taken on the Cefas 2013 survey of Turbot bank pMPA.

4.4.3. Species accumulation curves

Analysis of the data from the sixteen replicate A samples only, resulted in a total of 141 taxa. A further 16 samples (replicates A and B combined) sampled an extra 39 taxa and by including all replicates (an additional 16 samples) a further 21 taxa were found. The total number of taxa recorded from all three replicates from the 16 stations (48 samples) was 201 (Figure 13). The curves suggest that even with triplicate sampling the species list is not representative of the full complement of species present at the site (the asymptote is not reached).

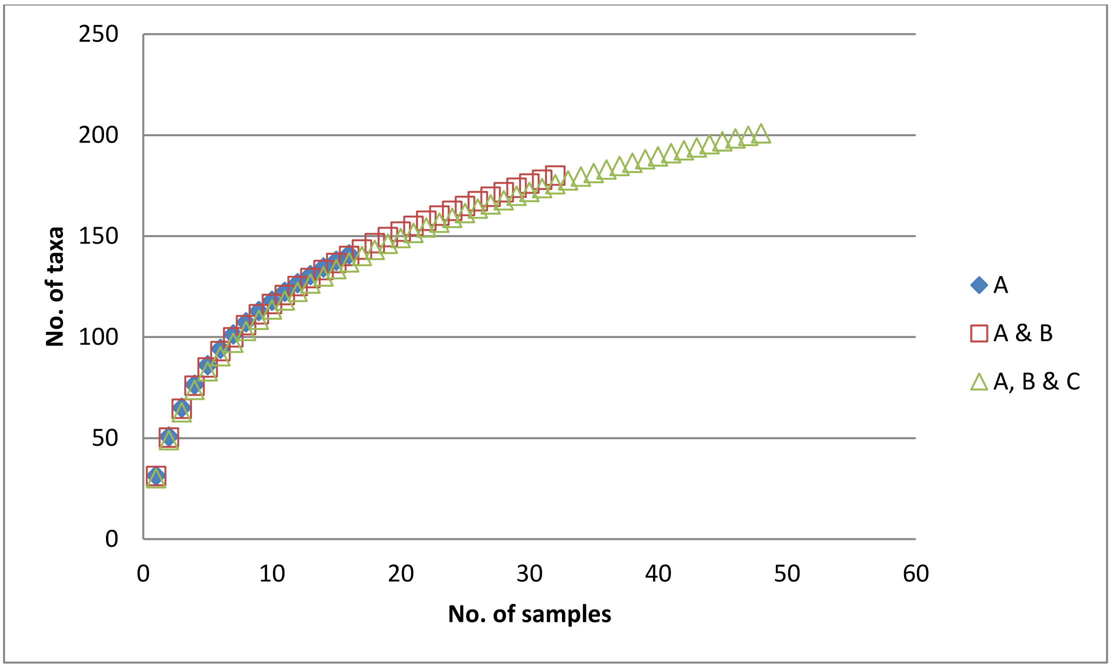

Figure 13: Species accumulation curves for stations sampled in triplicate.

4.4.4. Multivariate analyses

Hierarchical cluster analysis revealed 14 significantly different (p=0.05) assemblages (four of which were each represented by a single station) (Figure 14).

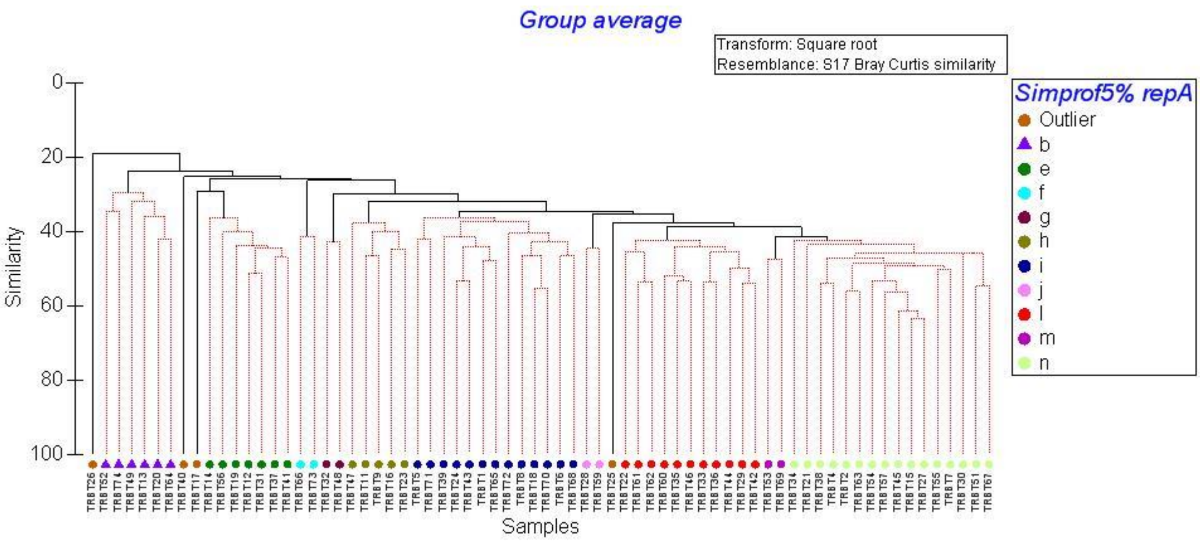

Figure 14: Hierarchical cluster analysis of square root transformed abundance data (rep A) from grab samples taken at the Turbot Bank pMPA (red connecting lines indicate significant groups at p=0.05).

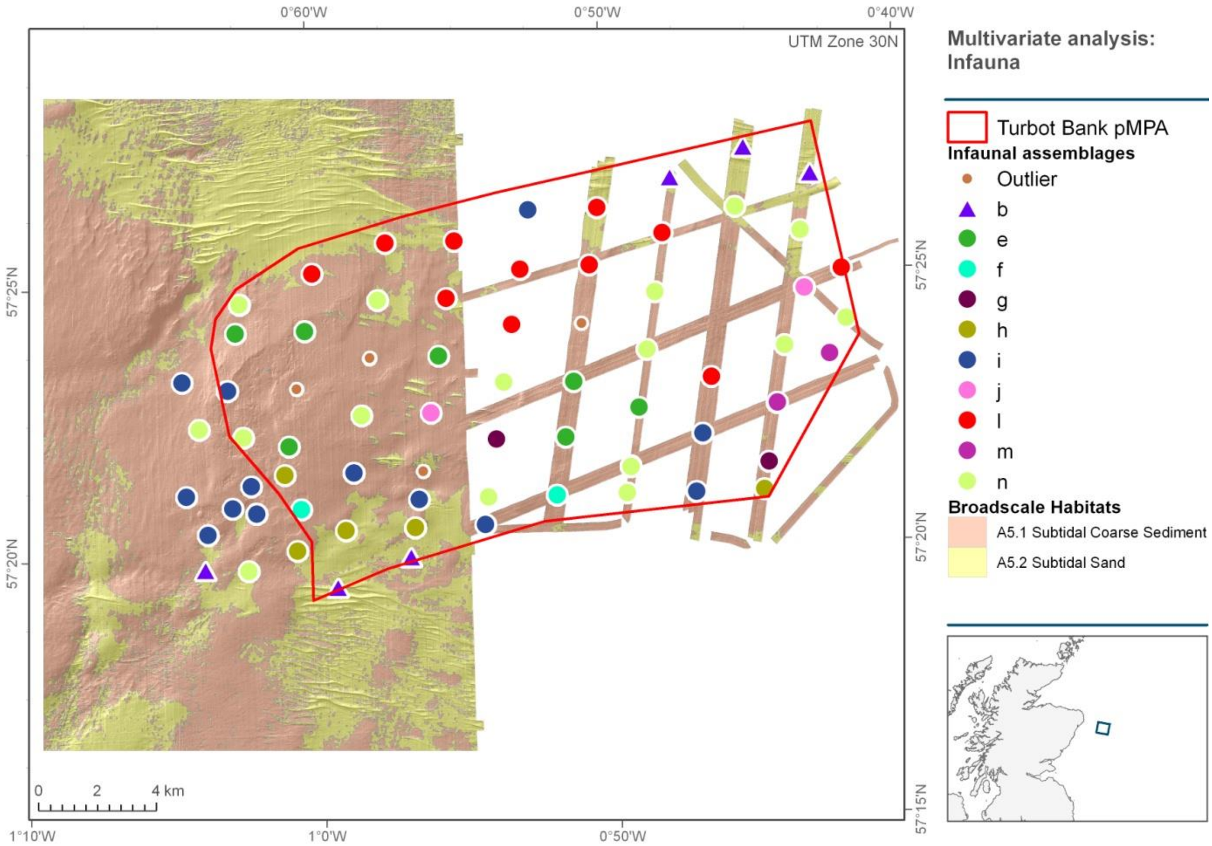

Figure 15: Spatial distribution of the distinct macrofaunal assemblages identified at the Turbot Bank pMPA.

SIMPER analysis revealed that although the assemblage groups were significantly different, the average similarity within each group was low (highest within group similarity was found for groups m and n (47%)). This suggests some overlap between assemblage types. Indeed, the top characterising species of all assemblages were similar (e.g. *Echinocyamus pusillus*, *Glycera lapidum and Notomastus latericeus)* (see Appendix 13). Significant differences between the clusters were largely due to differences in abundance of the characterising species and presence/absence of the less abundant species. For instance, differences between groups i and h (located in the west of the site and beyond the boundary) were due to the presence/absence and abundance differences of 79 taxa, and differences between groups e and n (located across the centre of the site) were due to presence/ absence and abundance differences of 102 taxa. Group m and n were the most similar (41%) in terms of species composition, although group n was located across the site and group m restricted to two stations in the east. Group b was the most distinctly different group due to the higher abundances of *Ophelia borealis*, a polychaete characteristic of sand. Group e was also characterised by the encrusting serpulid polychaete, *Spirobranchus (Pomatoceros) lamarcki,* the crevice dwelling brittle star, *Ophiactis balli,* and the squat lobster, *Galathea intermedia*, all of which prefer habitats containing pebbles and cobbles. The group containing outliers also contained species characteristic of the other groups.

4.5. Patterns in epifaunal communities

Multivariate cluster analysis of the averaged still image data revealed five significantly different assemblage groups, one of which was represented by only one video station segment (outlier) (Figure 16 and Figure 17).

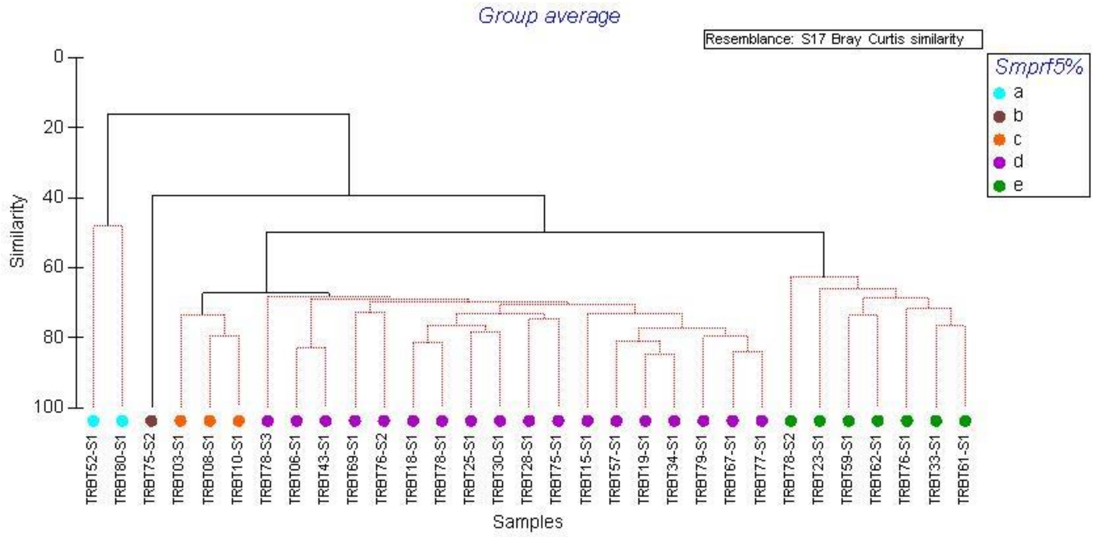

Figure 16: Hierarchical cluster analysis of averaged data from still images, showing significantly different assemblages at p=0.05.

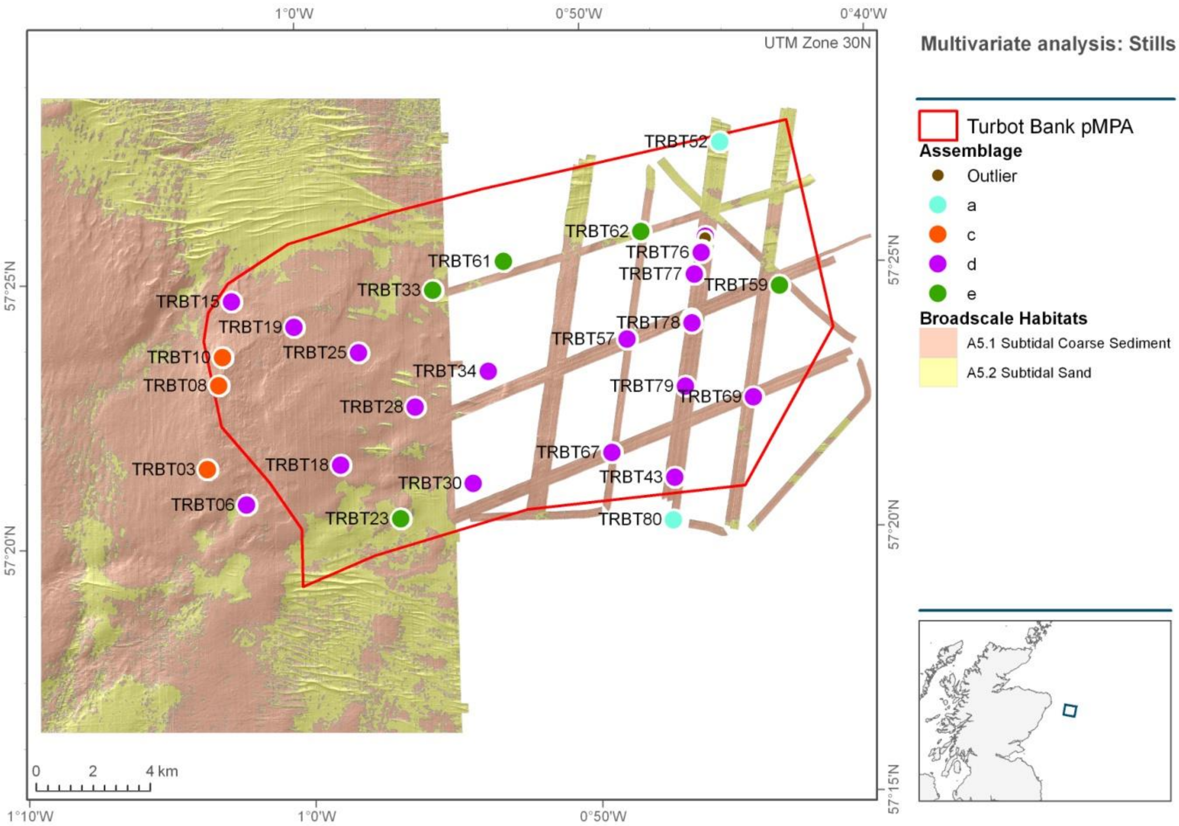

Figure 17: Significantly different assemblage groups from multivariate analysis of still image data.

SIMPER analysis revealed that the top characterising species (species contributing to 50% of the similarity within the group) in groups c and d were the keel worm, *Spirobranchus (Pomatoceros)* sp., and barnacle, *Balanus* sp. Group c was additionally characterised by the bryozoan, *Flustra foliacea*. Translation of the average abundance values back to SACFOR scale showed observations of *Spirobranchus (Pomatoceros)* sp, as common to abundant, *Balanus* sp as frequent and *Flustra foliacea* as occasional. Group a was characterised by rare occurrences of the hermit crab, *Pagurus prideaux* (with the commensal anemone *Adamsia carcinopados*). Group e was characterised by rare to occasional occurrences of *Spirobranchus (Pomatoceros) sp.and F. foliacea*. Differences between group c and d were attributable to higher average abundances of *Balanus* and *Spirobranchus (Pomatoceros) sp.*

and presence of less abundant fauna such as representatives from the squat lobster family Galatheidae and *Munida rugosa* in group c. Group e contained significantly lower abundances of the main characterising species from group c and d (see Appendix 14). Multivariate analysis using unaveraged data from the 742 still images and applying a cut-off at 45% similarity identified 15 cluster groups, six of which contained the majority of images (the remaining clusters consisted only one to three images) (see Appendix 15.1). The majority of images (469) were assigned to group k, which was characterised by common to abundant occurrences of *Spirobranchus (Pomatoceros),* occasional to frequent occurences of *Balanus* and occasional occurences of *Flustra foliacea*. Group i (87 images) was also characterised by the aforementioned taxa, and additionally *Pagurus prideaux* (with the commensal anemone *Adamsia carcinopados*), although average abundances were lower (see Appendix 15.2). Group l (37 images) and m (98 images) were characterised by rare to occasional occurances of *Spirobranchus (Pomatoceros) sp* and *F. folicacea* but neither group contained *Balanus sp.* Group g (20 images) was only characterised by *Spirobranchus (Pomatoceros) sp.* and group o (17 images) contained no identifiable fauna. The variability along each video tow was caculated by determining the number of still images assigned to each cluster per video segment. The percentage of stills assigned to group k (dominant cluster) was also calculated per video segment (see Appendix 15.3).

4.6. Biotopes

The infaunal assemblages (except group b) were dominated by species characteristic of several biotopes detailed under the Offshore Subtidal Sands and Gravels priority marine feature. For example, the EUNIS level 5 biotope: A5.142: *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel, details several species also present at Turbot Bank: *Lumbrineris* spp., *Glycera lapidum, Echinocyamus pusillus*, Nemertea, *Owenia fusiformis* and epifauna such as *Pomatoceros* sp., although the polychaete *M. fragilis* was only found at five stations (maximum of two individuals). The species characterising the deep circalittoral coarse sediment biotope A5.151: *Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand were also dominant species found in the Turbot Bank pMPA (e.g. *Glycera lapidum*, *Notomastus latericeus* and *Lumbrineris gracilis*). Species more commonly associated with sandy biotopes were also characteristic within the coarse sediment stations in the Turbot Bank pMPA, e.g. *Ampelisca brevicornis*, *Aonides paucibranchiata*, *Urothoe marina,* highlighting the heterogeneity of the site. This uncertainty resulted in the EUNIS Level 3 broadscale habitat classification remaining, pending revision of the classification system (with the incorporation of data from offshore stations). Stations within group b have been assigned to A5.251: *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand, although this is tentative due to the absence of the bivalve *Abra prismatica* from the Turbot Bank species list and the fact that in three out of six cases the broadscale habitat was A5.1 Subtidal Coarse Sediment based on PSA results (Figure 18).

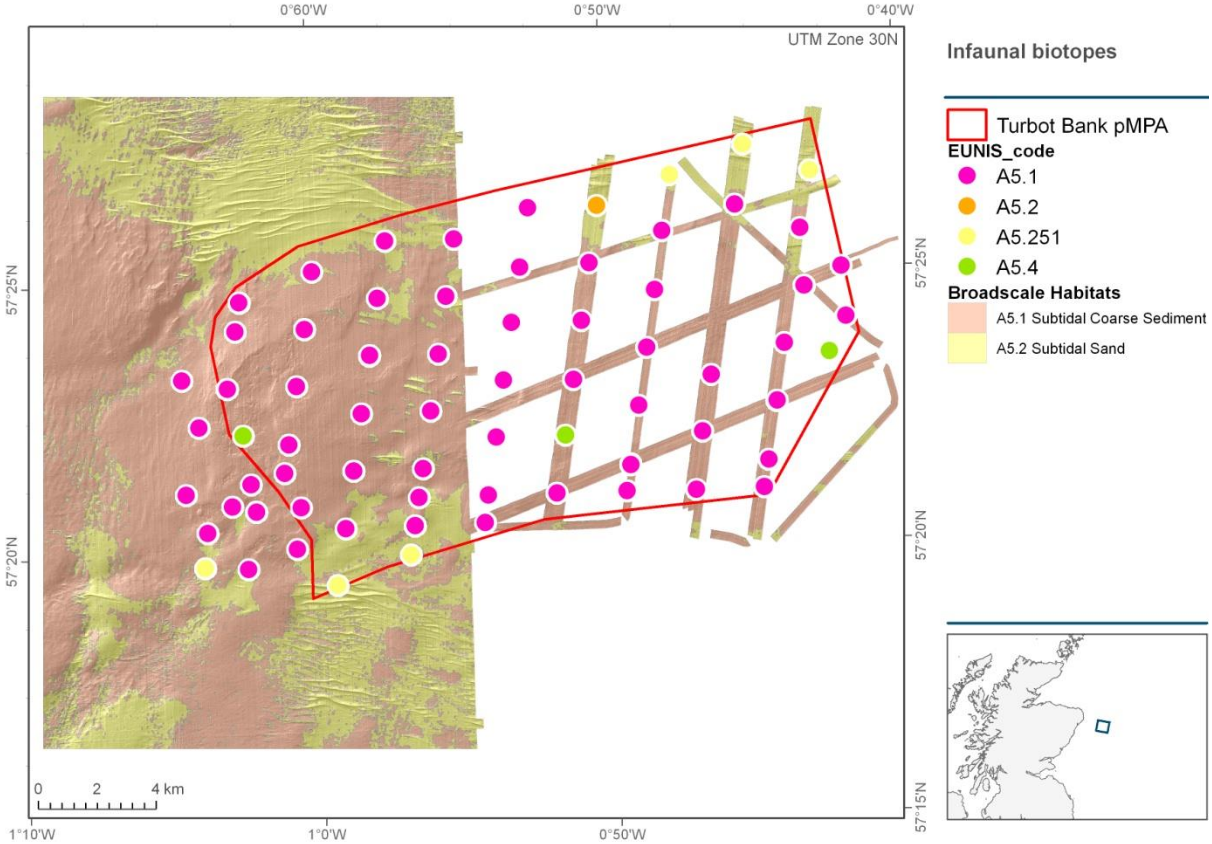

Figure 18: Infaunal biotopes in the Turbot Bank pMPA.

The epifaunal analyses translated into three tentative biotopes. Cluster groups c and d, determined using the averaged still image data, were found to correspond well with the EUNIS Level 5 biotope: A5.141: *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbes and pebbles; with the addition of *F. foliacea*. Group e could not be assigned lower than EUNIS level 3: A5.1: Subtidal coarse sediment. Group a consisted of two stations, of which, one was assigned to A5.2: Subtidal sand (TRBT52). The other station in group a, was assigned A5.1: Subtidal coarse sediment (TRBT80) due to a higher percentage of shell fragments. Both stations were only assigned to EUNIS level 3 due to the absence of biotope characterising species (Figure 19). Investigation into the variability in habitats/species within the tows using all the still image data (unaveraged) showed that, although there was some variability in cluster groups along the tows, the overall biotope assignments correspond well with Figure 19 below.

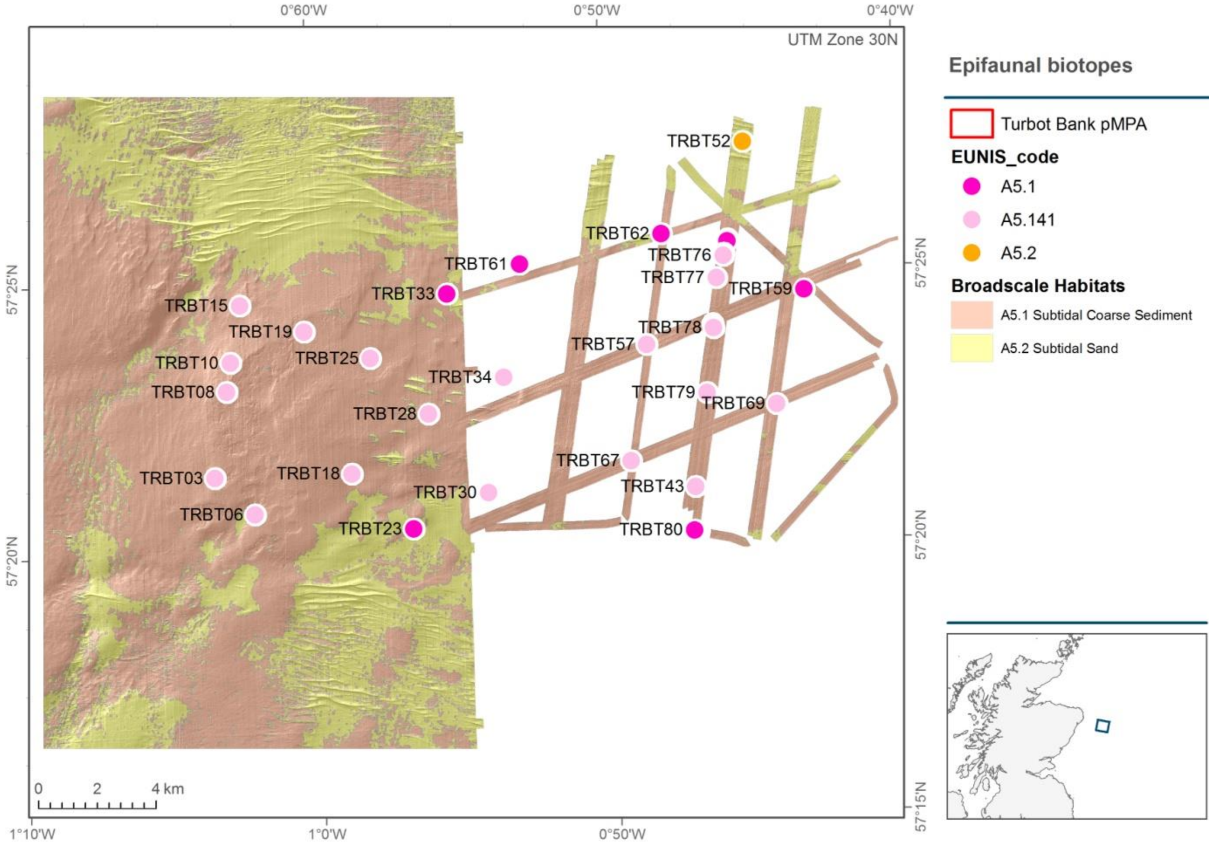

Figure 19: Epifaunal biotopes at Turbot bank pMPA.

4.7. SMPA Priority Marine Features

The MPA Search Feature ‘Offshore Subtidal Sands and Gravels’ was present across the entire survey area. The mobile species of particular importance to the designation of this site, the sand eel *Ammodytes* sp., was identified at 14 of the 70 stations sampled by Hamon grab. However, this sampling equipment is not designed to accurately sample fish; therefore, the number represents a small proportion of *Ammodytes* presumed present at the site at the time of sampling. The species was not observed in any of the video tows.

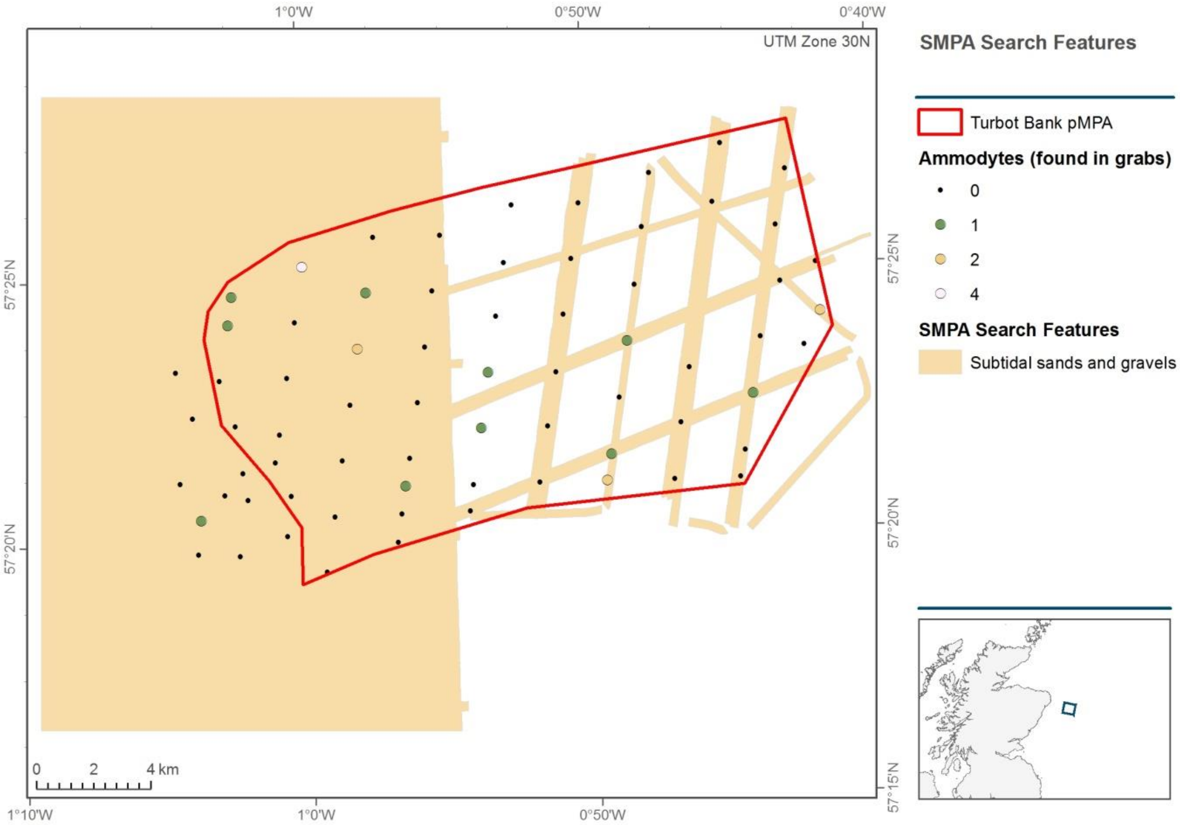

Figure 20: SMPA search features on Turbot Bank.

4.8. Annex I habitats

No Annex I habitats were found at Turbot Bank pMPA.

5. Discussion and Conclusions

5.1. Summary of habitats and features recorded

The Turbot Bank pMPA is dominated by 'Subtidal Coarse Sediment' which occupies the shallowest parts and, to a lesser extent, 'Subtidal Sand' which is typically associated with greater water depths on the flanks. There was no evidence of stony reef as defined by Irving (2009), although the occasional cobble was observed at several stations across the site. No spatial patterns were observed in any of the infaunal univariate metrics calculated; i.e. high and low values were found within both the coarse and sand habitats. Species accumulation curves suggested that a large number of samples would be needed to account for the entire species complement in the pMPA, which may have important implications for future assessments.

Infaunal assemblages are dominated by species characteristic of several biotopes found within the 'Offshore Subtidal Sands and Gravels' priority marine feature, which was present across the entire survey area. Epifaunal assemblages across the shallowest part of Turbot Bank are typical of the circalittoral coarse sediment habitat A5.141: *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. A transitory habitat is found on the flanks of the bank where *Spirobranchus* (*Pomatoceros*) sp. and *Balanus* are less abundant, which may be due to a change in sediment characteristics (decrease in the proportion of gravels). The northern and southern boundaries are characterised by subtidal sands.

The sandeel, *Ammodytes* spp., was present in low numbers at 14 of the stations sampled by grab and was not seen on any of the video tows. The sampling gear used during the survey is not designed to sample mobile species, therefore the presence and extent of *Ammodytes* spp. is predicted to be greater than our results suggest.

An assignment of EUNIS Level 5 biotopes was only possible for A5.141: *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles and A5.251: *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand. These biotopes fall within the circalittoral depth zone. A comparison with modelled biological zones from EUSeaMap (Cameron & Askew 2011) indicates the presence of the deep circalittoral zone within the Turbot Bank area (Figure 21). Based on this comparison, there is a certain mismatch between predicted biological zones and mapped biotope occurrences. This might be due to current inadequacies in the EUNIS/MNCR classification which is still underdeveloped for the deep circalittoral zone. It might therefore simply be the case that similar assemblages exist in the circalittoral and deep circalittoral, but this might currently not be reflected in the classification.

It is, however, important to understand how the predicted biological zones were derived. The boundary between the circalittoral and deep circalittoral is approximated by the wave base, which equals half the wave length of surface waves. It is generally assumed that waves interact with the seabed in water depths shallower than half the wave length. This is, however, only a rule of thumb and other values, e.g. a quarter of the wave length (Komar 1998) have been advocated. As part of the EUSeaMap project, the boundary of the circalittoral/deep circalittoral was tested with biological data, and a wave length/depth ratio of 2.2 rather than 2 was found, but it was felt that the evidence was not sufficiently strong to justify the change. Additionally, wave properties including the wave length vary over time. Therefore, it needs to be defined which statistic, e.g. the mean or the maximum wave length over a certain period of time, should be used. Finally, the length of the period over which wave statistics are available will have an effect as well.

The problem is further confounded by the fact that the quality of the bathymetric data is also having an effect on the delineation of the deep circalittoral. An inspection of the predicted boundaries reveals a suspicious north-south trending boundary in the centre of Figure 21. This might be related to poorer data quality in the eastern half of the site. Unfortunately, Cameron and Askew (2011) only give a source confidence score for the bathymetry data of the North Sea as a whole. It is therefore not possible to assess potential differences in relation to the quality of the bathymetry data. Finally, the resolution of the predicted data layer is relatively coarse (10.8 arcsec). Therefore, in summary the predicted biological zones are more appropriate for broadscale applications and should be viewed as indicative only.

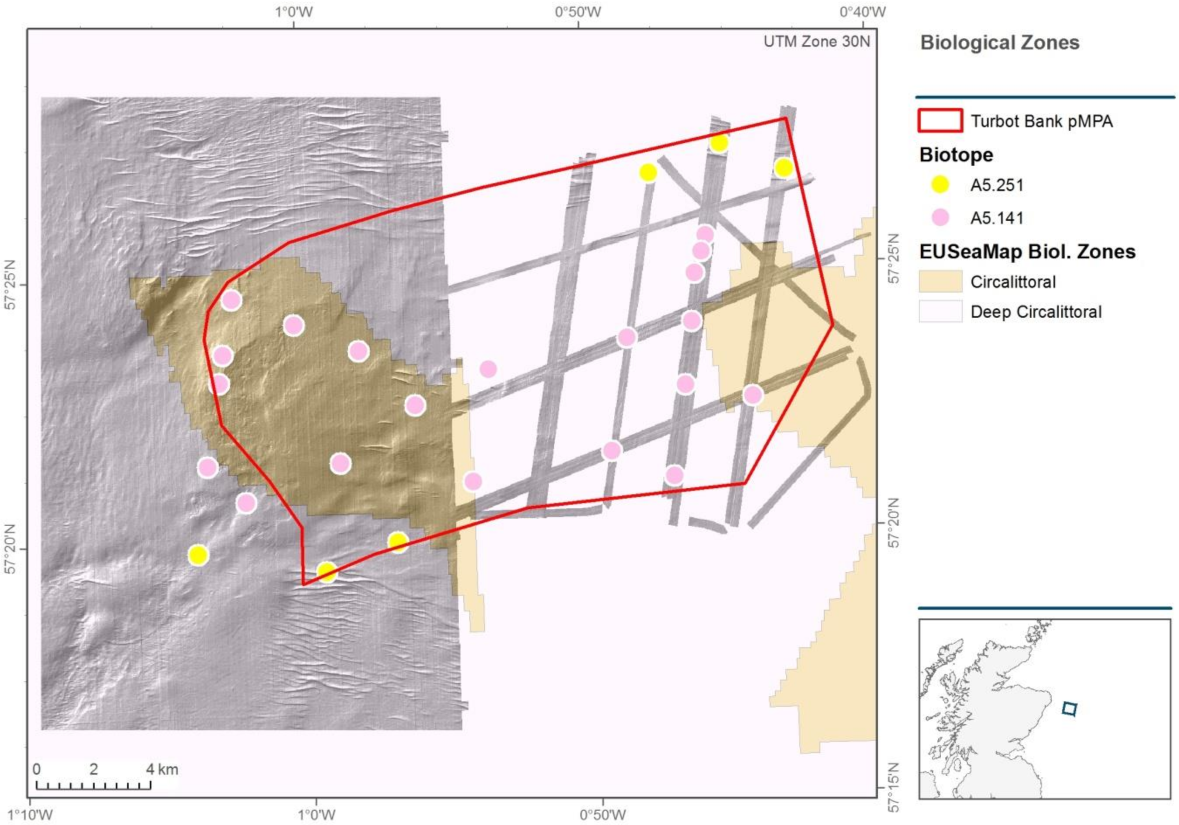

Figure 21: Comparison of mapped biotopes (EUNIS Level 5) and predicted biological zones according to EUSeaMap.

5.2. Data limitations

The sampling data (grabs and still images) were biased towards Subtidal Coarse Sediment, with only a few stations attributed to other broadscale habitats. Therefore, it was not feasible to split the data into training and test sets. Consequently, no formal external accuracy assessment with independent ground-truth data of the produced habitat map could be carried out. However, an assessment of the internal accuracy, i.e. how well the predicted habitats matched the training data, indicated an agreement of 85.4% based on grab samples. Based on still images the agreement was 92.8%.

This analysis of existing and new survey data has provided substantial, robust evidence for the presence and extent of the mapped sedimentary broadscale habitats and biotopes. However, because it is impractical (and undesirable) to sample the entire area of the site with grabs and video, there is a chance that a feature may exist within the site but has not been recorded, especially if it is limited in extent.

The precise location of the boundaries between the broadscale habitats depicted on the map (Figure 8) should be regarded as indicative, not definitive. In nature, such boundaries are rarely abrupt. Instead, it is typical for one broadscale habitat to grade into another across a transitional boundary. In contrast, the mapped boundaries are abrupt and have been placed using best professional judgement.

Faunal assemblages could not be assigned with any confidence to EUNIS level 5 other than A5.141 (*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles) and A5.251 (*Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand) due to the current limitations of the EUNIS classification system regarding offshore habitats. This is particularly relevant for the infaunal assemblages found in the coarse sediment areas, which contained species characteristic of several biotopes both within Subtidal Sand and Subtidal Coarse sediment biotopes.

The sampling gear used during the survey did not efficiently sample mobile fish species, therefore abundance and extent of *Ammodytes* spp. is presumed to be an underestimate.

6. Acknowledgements

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Appendices

Appendix 1. List of SMPA seabed habitat Search Features/Priority Marine Features in Scottish offshore waters

MPA search feature/Priority Marine Feature	**Component habitats/species**
Burrowed mud	Seapens and burrowing megafauna in circalittoral fine mud
	Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud
	Tall seapen *Funiculina quadrangularis*
	Fireworks anemone *Pachycerianthus multiplicatus*
	Mud burrowing amphipod *Maera loveni*
Carbonate mound communities	Carbonate mound communities
Cold-water coral reefs	Coral reefs
Coral gardens	Coral gardens
Deep sea sponge aggregations	Deep sea sponge aggregations
Northern sea fan and sponge communities	Northern sea fan *Swiftia pallida*
	Deep sponge communities (circalittoral)
Offshore deep-sea muds	*Ampharete falcata* turf with *Parvicardium ovale* on cohesive muddy sediment near margins of deep stratified seas
	Formaniferans and *Thyasira* sp. in deep circalittoral fine mud
	Levinsenia gracilis and *Heteromastus filiformis* in offshore circalittoral mud and sandy mud
	Paramphinome jeffreysii, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud
	Myrtea spinifera and polychaetes in offshore circalittoral sandy mud
Offshore subtidal sands and gravels	*Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand
	Hesionura elongata and *Protodorvillea kefersteini* in offshore coarse sand
	Echinocyamus pusillus, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand
	Abra prismatica, Bathyproeia elegans and polychaetes in circalittoral fine sand
	Maldanid polychaetes and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand
	Owenia fusiformis and *Amphiura filiformis* in offshore circalittoral sand or muddy sand
Seamount communities	Seamount communities
Submarine structures made by leaking gases	Submarine structures made by leaking gases

Appendix 2. List of low or limited mobility species in Scottish offshore waters

MPA search feature	**Species name**	**Taxon group**
Northern feather star aggregations on mixed substrata	*Leptometra celtica*	Starfish and feather stars
Fan mussel aggregations	*Atrina pectinata*	Snails, clams, mussels and oysters
Ocean quahog aggregations	*Arctica islandica*	Snails, clams, mussels and oysters

Appendix 3. List of mobile species relevant to Turbot Bank pMPA

MPA search feature	Species name	Taxon group
Sandeels	*Ammodytes marinus and A. tobianus*	Bony fish

Appendix 4. Annex I Habitats

Annex I Habitats
Atlantic salt meadows
Estuaries
Lagoons
Large shallow inlets and bays
Mediterranean and thermo-Atlantic halophilious scrubs
Mudflats and sandflats not covered by seawater at low tide
Reefs
Salicornia and other annuals colonising mud and sand
Sandbanks which are slightly covered by seawater all the time
Spartina swards
Submerged or partially submerged caves
Submarine structures made by leaking gases

Appendix 5. Survey Metadata: Acoustic

Date	Time	SOL/EOL	Station code	Stn No.	Replicate	Latitude (D.D)	Longitude (D.D)
27/11/2012	00:39	SOL	TURBOT MB	170	TRBTB5200	57.45100	0.83200
27/11/2012	01:46	EOL	TURBOT MB	170	TRBTB5200	57.33800	0.86700
27/11/2012	03:23	SOL	TURBOT MB	170	TRBTB5400	57.45200	0.82800
27/11/2012	04:45	EOL	TURBOT MB	170	TRBTB5400	57.38300	0.86400
27/11/2012	06:16	SOL	TURBOT MB	170	TRBTBASE7	57.46300	0.75400
27/11/2012	07:39	EOL	TURBOT MB	170	TRBTBASE7	57.34300	0.79100
27/11/2012	08:54	EOL	TURBOT MB	170	TRBTB7200	57.34300	0.78800
27/11/2012	10:07	SOL	TURBOT MB	170	TRBTB7200	57.46000	0.75100
27/11/2012	11:38	EOL	TURBOT MB	170	TRBTB7400	57.33506	0.78748
27/11/2012	12:54	SOL	TURBOT MB	170	TRBTB7400	57.46140	0.74960
27/11/2012	21:48	EOL	TURBOT MB	170	TRBTBASE5	57.34100	0.87000

Date	Time	SOL/EOL	Station code	Stn No.	Replicate	Latitude (D.D)	Longitude (D.D)
27/11/2012	22:55	SOL	TURBOT MB	170	TRBTBASE5	57.45000	0.83600
29/11/2012	00:35	EOL	TRBT_MM	217	TRANSIT LINE WEST	57.33957	0.90617
29/11/2012	01:01	SOL	TRBT_MM	217	TRANSIT LINE WEST	57.34065	0.82878
29/11/2012	15:24	SOL	TRBT_MM	217	TRANSIT TO TRBT8100	57.33519	0.77251
29/11/2012	15:31	EOL	TRBT_MM	217	TRANSIT TO TRBT8100	57.33294	0.75674
29/11/2012	15:33	SOL	TRBT_MM	217	TRBT8100	57.33470	0.75499
29/11/2012	17:04	EOL	TRBT_MM	217	TRBT8100	57.46547	0.71357
29/11/2012	17:13	SOL	TRBT_MM	217	TRBT8300	57.46555	0.70999
29/11/2012	18:59	EOL	TRBT_MM	217	TRBT8300	57.33365	0.75185
29/11/2012	18:59	EOL	TRBT_MM	217	TRNSIT TO TRBT100 FROM TRBT300	57.38499	0.67647
29/11/2012	19:21	SOL	TRBT_MM	217	TRNSIT TO TRBT100 FROM TRBT300	57.33322	0.71000
29/11/2012	19:28	SOL	TRBT_MM	217	TRBT100	57.38629	0.68223
29/11/2012	20:56	EOL	TRBT_MM	217	TRBT100	57.33862	0.91762
29/11/2012	21:06	SOL	TRBT_MM	217	TRBT300	57.34028	0.91982
29/11/2012	22:33	EOL	TRBT_MM	217	TRBT300	57.38849	0.68049
29/11/2012	22:38	SOL	TRBT_MM	217	TRANSIT TRBT300-TRBTB6-300	57.39158	0.67794
29/11/2012	23:22	EOL	TRBT_MM	217	TRANSIT TRBT300-TRBTB6-300	57.45072	0.78834
29/11/2012	23:27	SOL	TRBT_MM	217	TRBTB6-300	57.44863	0.79283
29/11/2012	00:33	EOL	TRBT_MM	217	TRBTB6-300	57.34134	0.82669

SOL = Start of line, EOL = End of line

Appendix 6. Survey Metadata: Grabs

Date sampled	Stn No.	Station code	Rep	Time sampled	Latitude (D.D)	Longitude (D.D)
26/11/2012	112	TRBT33	A	06:02	57.41101	-0.92374
26/11/2012	112	TRBT33	B	06:09	57.41101	-0.92384
26/11/2012	112	TRBT33	C	06:15	57.41097	-0.92381
26/11/2012	113	TRBT35	A	06:44	57.42850	-0.91824
26/11/2012	114	TRBT29	A	07:13	57.42850	-0.95757
26/11/2012	115	TRBT22	A	08:02	57.41965	-0.99955
26/11/2012	116	TRBT15	A	08:29	57.41082	-1.04126
26/11/2012	116	TRBT15	B	08:41	57.41087	-1.04124
26/11/2012	116	TRBT15	C	08:46	57.41088	-1.04136
26/11/2012	118	TRBT12	A	09:57	57.40197	-1.04393
26/11/2012	119	TRBT19	A	10:30	57.40219	-1.00470
26/11/2012	119	TRBT19	B	10:47	57.40215	-1.00457
26/11/2012	119	TRBT19	C	10:53	57.40211	-1.00458
26/11/2012	121	TRBT27	A	12:40	57.41101	-0.96278
26/11/2012	122	TRBT31	A	13:07	57.39346	-0.92917
26/11/2012	123	TRBT25	A	13:28	57.39345	-0.96835
26/11/2012	123	TRBT25	B	13:40	57.39352	-0.96819
26/11/2012	123	TRBT25	C	13:49	57.39358	-0.96804
26/11/2012	124	TRBT17	A	14:20	57.38476	-1.01004
26/11/2012	126	TRBT5	A	15:21	57.38741	-1.07497
26/11/2012	127	TRBT8	A	15:40	57.38451	-1.04955
26/11/2012	127	TRBT8	B	15:58	57.38450	-1.04918
26/11/2012	127	TRBT8	C	16:05	57.38450	-1.04912
26/11/2012	128	TRBT4	A	16:29	57.37285	-1.06593
26/11/2012	129	TRBT7	A	16:49	57.37003	-1.04105
26/11/2012	131	TRBT11	A	18:13	57.35821	-1.01812
26/11/2012	132	TRBT14	A	18:36	57.36694	-1.01534
26/11/2012	133	TRBT21	A	19:00	57.37583	-0.97371
26/11/2012	134	TRBT28	A	19:41	57.37601	-0.93433
26/11/2012	135	TRBT26	A	20:16	57.35844	-0.93972
26/11/2012	136	TRBT24	A	20:37	57.34968	-0.94254
26/11/2012	137	TRBT18	A	21:01	57.35835	-0.97903

Date sampled	Stn No.	Station code	Rep	Time sampled	Latitude (D.D)	Longitude (D.D)
26/11/2012	137	TRBT18	B	21:06	57.35839	-0.97908
26/11/2012	137	TRBT18	C	21:12	57.35839	-0.97901
26/11/2012	138	TRBT73	A	21:52	57.34752	-1.00941
26/11/2012	139	TRBT6	A	22:21	57.34666	-1.03490
26/11/2012	139	TRBT6	B	22:27	57.34660	-1.03478
26/11/2012	139	TRBT6	C	22:42	57.34663	-1.03460
26/11/2012	140	TRBT71	A	23:11	57.34836	-1.04825
26/11/2012	141	TRBT70	A	23:40	57.35511	-1.03739
26/11/2012	142	TRBT72	A	00:18	57.35239	-1.07424
27/11/2012	143	TRBT1	A	00:43	57.34055	-1.06258
27/11/2012	144	TRBT74	A	01:04	57.32985	-1.06453
27/11/2012	145	TRBT2	A	01:24	57.32912	-1.04014
27/11/2012	146	TRBT9	A	01:47	57.33490	-1.01224
27/11/2012	147	TRBT16	A	02:00	57.34074	-0.98442
27/11/2012	148	TRBT23	A	02:23	57.34099	-0.94520
27/11/2012	148	TRBT23	B	02:29	57.34104	-0.94511
27/11/2012	148	TRBT23	C	02:34	57.34108	-0.94508
27/11/2012	149	TRBT20	A	02:53	57.33220	-0.94793
27/11/2012	150	TRBT13	A	03:19	57.32343	-0.98980
28/11/2012	171	TRBT47	A	13:21	57.34971	-0.74686
28/11/2012	172	TRBT48	A	13:34	57.35800	-0.74383
27/11/2012	173	TRBT69	A	14:15	57.37590	-0.73813
27/11/2012	173	TRBT69	B	14:22	57.37590	-0.73807
27/11/2012	173	TRBT69	C	14:36	57.37605	-0.73805
28/11/2012	174	TRBT53	A	15:40	57.39065	-0.70739
28/11/2012	175	TRBT51	A	15:58	57.39360	-0.73279
28/11/2012	176	TRBT55	A	16:21	57.40129	-0.69756
28/11/2012	177	TRBT59	A	16:39	57.41087	-0.72049
28/11/2012	177	TRBT59	B	16:46	57.41093	-0.72053
28/11/2012	177	TRBT59	C	16:55	57.41100	-0.72055
28/11/2012	178	TRBT60	A	18:02	57.41670	-0.69918
28/11/2012	179	TRBT54	A	18:26	57.42868	-0.72181
28/11/2012	180	TRBT64	A	18:46	57.44619	-0.71540

Date sampled	Stn No.	Station code	Rep	Time sampled	Latitude (D.D)	Longitude (D.D)
28/11/2012	181	TRBT52	A	19:13	57.45482	-0.75292
28/11/2012	182	TRBT49	A	19:40	57.44615	-0.79489
28/11/2012	183	TRBT63	A	20:03	57.43651	-0.75850
28/11/2012	184	TRBT62	C	18:58	57.42915	-0.80030
28/11/2012	184	TRBT62	A	20:33	57.42921	-0.80036
28/11/2012	184	TRBT62	B	20:38	57.42918	-0.80035
28/11/2012	186	TRBT45	A	21:57	57.41113	-0.80544
28/11/2012	188	TRBT57	A	22:58	57.39347	-0.81090
28/11/2012	188	TRBT57	B	23:04	57.39351	-0.81102
28/11/2012	188	TRBT57	C	23:10	57.39354	-0.81096
28/11/2012	189	TRBT46	A	23:45	57.38462	-0.77490
29/11/2012	190	TRBT41	A	00:11	57.37580	-0.81643
29/11/2012	191	TRBT68	A	00:40	57.36730	-0.78074
29/11/2012	192	TRBT43	A	01:12	57.34950	-0.78547
29/11/2012	193	TRBT38	A	01:34	57.34980	-0.82475
29/11/2012	194	TRBT67	A	01:46	57.35800	-0.82202
29/11/2012	194	TRBT67	B	01:56	57.35790	-0.82200
29/11/2012	194	TRBT67	C	02:11	57.35774	-0.82203
29/11/2012	195	TRBT66	A	02:33	57.34970	-0.86434
29/11/2012	196	TRBT65	A	02:55	57.34138	-0.90536
29/11/2012	197	TRBT30	A	03:10	57.34961	-0.90307
29/11/2012	197	TRBT30	B	03:15	57.34966	-0.90307
29/11/2012	197	TRBT30	C	03:19	57.34970	-0.90306
29/11/2012	198	TRBT37	A	03:45	57.36735	-0.85857
29/11/2012	199	TRBT32	A	04:04	57.36739	-0.89756
29/11/2012	200	TRBT56	A	04:27	57.38437	-0.85296
29/11/2012	201	TRBT34	A	04:46	57.38482	-0.89265
29/11/2012	201	TRBT34	B	04:51	57.38483	-0.89264
29/11/2012	201	TRBT34	C	04:55	57.38486	-0.89250
29/11/2012	202	TRBT40	A	05:19	57.40237	-0.84750
29/11/2012	203	TRBT36	A	05:38	57.40241	-0.88704
29/11/2012	204	TRBT42	A	06:01	57.41990	-0.84216
29/11/2012	205	TRBT61	A	06:20	57.41928	-0.88144

Date sampled	Stn No.	Station code	Rep	Time sampled	Latitude (D.D)	Longitude (D.D)
29/11/2012	205	TRBT61	B	06:25	57.41924	-0.88145
29/11/2012	205	TRBT61	C	06:30	57.41922	-0.88152
29/11/2012	206	TRBT44	A	07:00	57.43737	-0.83692
29/11/2012	207	TRBT39	A	07:26	57.43740	-0.87598

Appendix 7. Survey metadata: Video and still imagery

			START OF VIDEO				END OF VIDEO						
Date	**Stn Code**	**Stn No.**	GPS Time (hh:mm)	DecLat WGS84	DecLong WGS84	Tape counter (mm.ss)	GPS Time (hh:mm)	DecLat WGS84	DecLong WGS84	Tape counter (mm.ss)	Length of video	Broadscale Habitat	No. of stills
26/11/2012	TRBT19	120	11:28	57.40143	-1.00495	00:36:05	11:40	57.40194	-1.00374	00:48:13	0:12	Coarse	30
27/11/2012	TRBT23	151	03:53	57.34014	-0.94584	00:26:26	04:12	57.34174	-0.94455	00:45:31	0:19	Coarse	37
27/11/2012	TRBT28	152	04:42	57.37519	-0.93558	00:00:00	05:06	57.37659	-0.93340	00:24:30	0:24	Coarse	44
27/11/2012	TRBT18	153	05:40	57.35757	-0.97999	00:24:30	05:59	57.35889	-0.97834	00:43:49	0:19	Coarse	35
27/11/2012	TRBT06	154	06:31	57.34588	-1.03559	00:00:00	06:51	57.34739	-1.03420	00:20:17	0:20	Coarse	28
27/11/2012	TRBT03	155	07:12	57.35741	-1.05776	00:20:17	07:33	57.35889	-1.05680		0:21	Coarse	31
27/11/2012	TRBT08	156	08:12	57.38370	-1.04970	00:00:00	08:28	57.38500	-1.04912	00:16:16	0:16	Coarse	32
27/11/2012	TRBT10	157	08:48	57.39254	-1.04701	00:16:16	09:08	57.39415	-1.04634	00:36:23	0:20	Coarse	34
27/11/2012	TRBT15	158	09:33	57.41002	-1.04092	00:36:23	09:53	57.41159	-1.04184	00:57:58	0:21	Coarse	23
27/11/2012	TRBT25	159	10:58	57.39281	-0.96762	00:00:00	11:18	57.39413	-0.96930	00:19:22	0:19	Coarse	30
27/11/2012	TRBT33	160	11:50	57.41180	-0.92327	00:19:22	12:06	57.41050	-0.92373	00:36:00	0:16	Coarse	23
27/11/2012	TRBT61	161	12:44	57.42025	-0.88138	00:36:00	13:07	57.41859	-0.88166	00:57:54	0:21	Coarse	26
27/11/2012	TRBT34	162	13:42	57.38577	-0.89227	00:00:00	14:02	57.38408	-0.89264	00:20:53	0:20	Coarse	27
27/11/2012	TRBT30	163	14:37	57.35058	-0.90293	00:20:57	15:02	57.34884	-0.90328	00:41:24	0:20	Coarse	29
27/11/2012	TRBT67	164	15:44	57.35899	-0.82153	00:00:00	16:08	57.35731	-0.82218	00:24:39	0:24	Coarse	35
27/11/2012	TRBT57	165	16:46	57.39447	-0.81073	00:24:29	17:04	57.39305	-0.81078	00:43:03	0:18	Coarse	24
27/11/2012	TRBT62	166	17:49	57.42825	-0.80056	00:00:00	18:11	57.43007	-0.80029	00:22:21	0:22	Coarse	34
27/11/2012	TRBT59	167	18:46	57.40989	-0.72061	00:22:23	19:09	57.41156	-0.72049	00:44:58	0:22	Coarse	27
27/11/2012	TRBT69	168	19:46	57.37507	-0.73806	00:00:00	20:06	57.37678	-0.73838	00:21:20	0:21	Coarse	32
29/11/2012	TRBT52	208	08:27	57.45571	-0.75263	00:07:17	08:47	57.45477	-0.75303	00:21:19	0:14	Sand	22
29/11/2012	TRBT75	209	09:19	57.42603	-0.76295	00:21:19	09:32	57.42501	-0.76355	00:34:31	0:13	Coarse	28
29/11/2012	TRBT76	210	09:57	57.42167	-0.76544	00:34:31	10:09	57.42074	-0.76573	00:46:29	0:11	Coarse	17

			START OF VIDEO				END OF VIDEO						
Date	**Stn Code**	**Stn No.**	GPS Time (hh:mm)	DecLat WGS84	DecLong WGS84	Tape counter (mm.ss)	GPS Time (hh:mm)	DecLat WGS84	DecLong WGS84	Tape counter (mm.ss)	Length of video	Broadscale Habitat	No. of stills
29/11/2012	TRBT77	211	10:32	57.41431	-0.77005	00:46:29	10:42	57.41346	-0.77028	00:57:26	0:10	Coarse	15
29/11/2012	TRBT78	212	11:08	57.40020	-0.77301	00:00:00	11:29	57.39859	-0.77230	00:20:32	0:20	Coarse	42
29/11/2012	TRBT79	213	13:30	57.37911	-0.77746	00:20:32	13:45	57.37823	-0.77778	00:32:39	0:12	Coarse	19
29/11/2012	TRBT43	214	14:14	57.35049	-0.78543	00:32:04	14:27	57.34958	-0.78577	00:45:04	0:13	Coarse	18
29/11/2012	TRBT80	215	14:53	57.33717	-0.78690	00:00:00	15:02	57.33686	-0.78698	00:08:03	0:08	Coarse	6

Appendix 8. Standard Operating Procedure for the analysis of the cobble fraction from a grab sample onboard a research vessel

After the grab is retrieved and the bucket is emptied in the crate, the following procedure should be followed for the analysis of the cobble fraction. The standard SOP's for grab analysis should be used in conjunction with this SOP.

1. Empty the contents of the grab into a large container (e.g. fish box). Add a suitable label (Cruise ID, Station No., Station Code) and photograph the entire sample, using a digital camera.

2. Empty the sample into a graduated bucket and record the sample volume to the nearest 0.5 litre.

3. Take a 500ml (if only a smaller volume could be collected this should be recorded on the log sheet) sub-sample for PSA analysis and store in a labelled, plastic container. The sub-sample should be representative for the <64mm fraction and should NOT include cobbles (>64mm).

4. Set up the benthos sorting table with two grids inside the table, a 5mm mesh first and a 64mm mesh on top. Place a 1mm sieve at the outlet.

5. Empty the sample from the graduated bucket into the benthos sorting table as usual, and wash with seawater hoses. The cobbles will be retained on the 64mm mesh.

6. Remove the 64mm mesh (complete with cobble fraction) from the benthos sorting table, place it on the deck, add a suitably large label (Cruise ID, Station No., Station Code) and take a photograph of the entire cobble sample using a digital camera.

7. Prepare and label a suitable sized bucket. The cobbles are to be preserved in formalin for later biological analysis. Use appropriate internal and external labels.

8. Collect a Cobble log sheet and fill in the header data: Cruise Name, Station Number, Station Code, Date, Gear Type and Number of cobbles. Tick the photo box to show you have photographed the entire sample.

9. For each individual cobble, do the following
    a. Place the cobble on a suitable background (not shiny), next to a scale object (e.g. ruler) and a label showing Cruise Code, Station Number, Station Code and COBBLE NUMBER. Photograph the arrangement with a digital camera.
    b. Using vernier callipers, measure the thre perpendicular dimensions of the cobble (length, width and height = x, y and z) to the nearest millimetre and note these on the record sheet.
    c. Record the weight of the cobble (grams).
    d. Record the volume of the cobble (cm^3). Determine this by displacement of water in a graduated measuring vessel.
    e. Record the hardness of the rock on a 3-point scale, judging the hardness from a fingernail scratch test. See the attached sheet on rock types and hardness for guidance.

Hard	No scratch left by fingernail scratch test (e.g. granite, flint)
Medium	Feint scratch is left (e.g. sandstone)
Soft	Deep scratch is left (e.g. chalk or mud-stone). Soft rocks can often be broken by hand.

f. Record the texture of the rock on a 3-point scale from smooth to rough.

1	Smooth rock surfaces
2	Intermediate roughness
3	Rough or pitted rock surfaces

g. Record the type of rock using the attached sheet on rock types and hardness as guidance. Do not guess. If you don’t know (or can’t tell), record ‘unknown’.

h. Record the shape of the rock on a 4-point scale. Angular, Sub-angular, Sub-rounded, Rounded. See attached sheet on particle shapes for guidance.

A	Angular
SA	Sub-angular
SR	Sub-rounded
R	Rounded

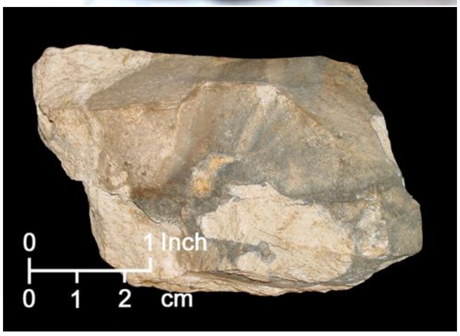
i. Record the extent of faunal coverage on the cobble using the categories given in the table below.

0	No attached fauna/flora
1	Individuals on ONE surface only
2	Individuals on more than one surface
3	Individuals on all surfaces but coverage incomplete
4	100% coverage on all rock surfaces

j. Record the main type of faunal coverage, in a brief statement. E.g. barnacles, hydroid turf.

k. Place the cobble in bucket of preservative.

<table>
<tr><td colspan="2">HARD</td></tr>
<tr><td rowspan="2">Flint



- highly variable in colour but easily recognized by its high hardness, very fine grain size and conchoidal fracture
- Grain size: microscopic</td><td>Quartzite

- composed predominantly of quartz
- coarser grained than sandstone</td></tr>
<tr><td>Coal

Characteristics: black colour, low density</td></tr>
<tr><td colspan="2"></td></tr>
</table>

MEDIUM	
Sandstone  Grainy texture	**Limestone**  Fossil fragments visible, porous
Slate  is similar in appearance to mudstone and shale due to the low grade of metamorphism but can be distinguished by its slaty cleavage and more dense, compact nature	

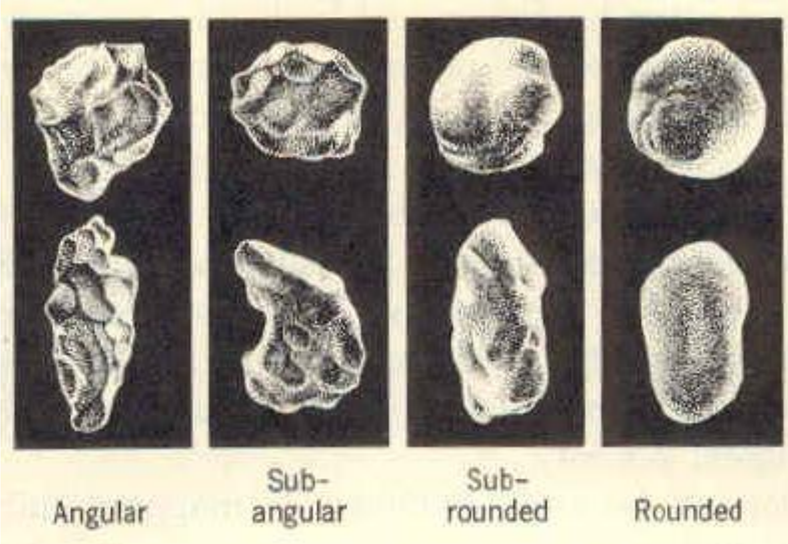
<table>
<tr><td colspan="2">SOFT</td></tr>
<tr><td>Chalk

fine-grained nature and white colour</td><td>Mudstone

Grain size: silt and clay (mud)</td></tr>
<tr><td>Shale

fine-grained mudstone which breaks into thin parallel sheets and is softer and less dense than slate</td><td></td></tr>
</table>

Guide to particle shapes



Appendix 9. Analysis of sediment samples: classification and composition

Station number	Station code	Replicate	% Gravel	% Sand	% Silt/Clay	Folk symbol	EUNIS groups
112	TRBT33	A	14.39	83.67	1.94	gS	coarse sediment
112	TRBT33	B	16.51	83.31	0.18	gS	coarse sediment
112	TRBT33	C	11.70	86.16	2.14	gS	coarse sediment
113	TRBT35	A	6.69	91.39	1.92	gS	coarse sediment
114	TRBT29	A	17.32	79.93	2.76	gS	coarse sediment
115	TRBT22	A	13.30	85.56	1.14	gS	coarse sediment
116	TRBT15	A	29.17	66.89	3.94	gS	coarse sediment
116	TRBT15	B	20.37	77.00	2.63	gS	coarse sediment
116	TRBT15	C	16.97	76.21	6.82	gS	coarse sediment
118	TRBT12	A	31.04	65.26	3.70	sG	coarse sediment
119	TRBT19	A	41.44	53.65	4.91	sG	coarse sediment
119	TRBT19	B	56.61	39.99	3.41	sG	coarse sediment
119	TRBT19	C	35.33	62.03	2.64	sG	coarse sediment
121	TRBT27	A	31.80	65.61	2.59	sG	coarse sediment
122	TRBT31	A	27.25	68.47	4.28	gS	coarse sediment
123	TRBT25	A	33.32	65.15	1.53	sG	coarse sediment
123	TRBT25	B	29.70	67.67	2.63	gS	coarse sediment
123	TRBT25	C	22.58	73.74	3.67	gS	coarse sediment
124	TRBT17	A	36.27	60.16	3.56	sG	coarse sediment
126	TRBT5	A	10.71	86.77	2.52	gS	coarse sediment
127	TRBT8	A	27.80	69.57	2.64	gS	coarse sediment
127	TRBT8	B	24.13	67.23	8.64	gmS	mixed sediments
127	TRBT8	C	45.99	50.96	3.04	sG	coarse sediment
128	TRBT4	A	29.22	67.16	3.63	gS	coarse sediment
129	TRBT7	A	54.95	36.68	8.38	msG	mixed sediments
131	TRBT11	A	36.87	62.38	0.75	sG	coarse sediment
132	TRBT14	A	26.60	70.94	2.47	gS	coarse sediment
133	TRBT21	A	47.52	51.71	0.77	sG	coarse sediment
134	TRBT28	A	28.38	71.01	0.61	gS	coarse sediment
135	TRBT26	A	36.23	60.37	3.39	sG	coarse sediment
136	TRBT24	A	5.11	91.64	3.25	gS	coarse sediment
137	TRBT18	A	26.00	72.17	1.83	gS	coarse sediment
137	TRBT18	B	14.29	83.47	2.24	gS	coarse sediment
137	TRBT18	C	25.52	72.84	1.63	gS	coarse sediment
138	TRBT73	A	21.53	76.89	1.59	gS	coarse sediment
139	TRBT6	A	11.02	85.10	3.88	gS	coarse sediment
139	TRBT6	B	51.67	46.75	1.58	sG	coarse sediment
139	TRBT6	C	40.41	57.97	1.61	sG	coarse sediment
140	TRBT71	A	19.74	77.49	2.77	gS	coarse sediment
141	TRBT70	A	37.03	59.30	3.67	sG	coarse sediment
142	TRBT72	A	21.00	76.15	2.85	gS	coarse sediment

Station number	Station code	Replicate	% Gravel	% Sand	% Silt/Clay	Folk symbol	EUNIS groups
143	TRBT1	A	28.56	68.55	2.89	gS	coarse sediment
144	TRBT74	A	8.18	89.61	2.21	gS	coarse sediment
145	TRBT2	A	5.91	89.83	4.26	gS	coarse sediment
146	TRBT9	A	21.14	77.60	1.27	gS	coarse sediment
147	TRBT16	A	5.51	93.34	1.15	gS	coarse sediment
148	TRBT23	A	8.51	89.75	1.74	gS	coarse sediment
148	TRBT23	B	18.03	80.95	1.02	gS	coarse sediment
148	TRBT23	C	11.95	86.94	1.11	gS	coarse sediment
149	TRBT20	A	6.19	91.80	2.01	gS	coarse sediment
150	TRBT13	A	1.59	96.74	1.67	(g)S	sand and muddy sand
171	TRBT47	A	6.20	92.99	0.81	gS	coarse sediment
172	TRBT48	A	21.81	77.08	1.11	gS	coarse sediment
173	TRBT69	A	16.22	81.95	1.84	gS	coarse sediment
173	TRBT69	B	12.59	85.06	2.35	gS	coarse sediment
173	TRBT69	C	24.47	73.03	2.51	gS	coarse sediment
174	TRBT53	A	23.29	67.54	9.17	gmS	mixed sediments
175	TRBT51	A	6.66	91.93	1.41	gS	coarse sediment
176	TRBT55	A	12.17	86.16	1.67	gS	coarse sediment
177	TRBT59	A	28.48	70.25	1.27	gS	coarse sediment
177	TRBT59	B	8.48	89.02	2.50	gS	coarse sediment
177	TRBT59	C	15.58	83.25	1.17	gS	coarse sediment
178	TRBT60	A	17.56	80.95	1.50	gS	coarse sediment
179	TRBT54	A	10.28	88.08	1.64	gS	coarse sediment
180	TRBT64	A	0.52	95.17	4.31	S	sand and muddy sand
181	TRBT52	A	8.57	84.67	6.76	gS	coarse sediment
182	TRBT49	A	1.23	96.35	2.42	(g)S	sand and muddy sand
183	TRBT63	A	11.00	87.07	1.93	gS	coarse sediment
184	TRBT62	A	10.32	87.48	2.21	gS	coarse sediment
184	TRBT62	B	15.25	83.61	1.14	gS	coarse sediment
184	TRBT62	C	13.07	84.50	2.43	gS	coarse sediment
186	TRBT45	A	13.74	81.64	4.62	gS	coarse sediment
188	TRBT57	A	38.71	57.34	3.95	sG	coarse sediment
188	TRBT57	B	34.41	62.79	2.80	sG	coarse sediment
188	TRBT57	C	27.90	69.11	2.99	gS	coarse sediment
189	TRBT46	A	23.75	74.50	1.76	gS	coarse sediment
190	TRBT41	A	48.30	47.99	3.72	sG	coarse sediment
191	TRBT68	A	28.23	69.53	2.25	gS	coarse sediment
192	TRBT43	A	25.60	73.00	1.40	gS	coarse sediment
193	TRBT38	A	42.64	55.75	1.60	sG	coarse sediment
194	TRBT67	A	24.70	72.47	2.82	gS	coarse sediment
194	TRBT67	B	42.41	56.00	1.59	sG	coarse sediment

Station number	Station code	Replicate	% Gravel	% Sand	% Silt/Clay	Folk symbol	EUNIS groups
194	TRBT67	C	51.01	47.67	1.32	sG	coarse sediment
195	TRBT66	A	40.03	59.06	0.91	sG	coarse sediment
196	TRBT65	A	20.01	77.34	2.66	gS	coarse sediment
197	TRBT30	A	66.08	33.08	0.84	sG	coarse sediment
197	TRBT30	B	29.64	69.48	0.88	gS	coarse sediment
197	TRBT30	C	64.44	34.80	0.77	sG	coarse sediment
198	TRBT37	A	24.00	65.58	10.43	gmS	mixed sediments
199	TRBT32	A	7.43	89.66	2.91	gS	coarse sediment
200	TRBT56	A	30.44	66.84	2.72	sG	coarse sediment
201	TRBT34	A	15.42	82.36	2.22	gS	coarse sediment
201	TRBT34	B	17.44	77.45	5.11	gS	coarse sediment
201	TRBT34	C	17.31	78.09	4.61	gS	coarse sediment
202	TRBT40	A	37.38	60.71	1.91	sG	coarse sediment
203	TRBT36	A	10.85	87.81	1.34	gS	coarse sediment
204	TRBT42	A	9.70	88.25	2.05	gS	coarse sediment
205	TRBT61	A	18.51	79.58	1.92	gS	coarse sediment
205	TRBT61	B	10.87	87.54	1.59	gS	coarse sediment
205	TRBT61	C	12.70	85.05	2.25	gS	coarse sediment
206	TRBT44	A	2.53	94.90	2.57	(g)S	sand and muddy sand
207	TRBT39	A	6.21	91.02	2.77	gS	coarse sediment

Appendix 10. Biotopes description derived from video and still images

Video Sample Ref	Brief Habitat Description (Physical and biotic)	Broadscale Habitat	Habitat FOCI	EUNIS code	MNCR code
TRBT03_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT06_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT08_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT10_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT15_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT18_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT19_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT23_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS
TRBT25_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT28_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT30_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT33_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS
TRBT34_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT43_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT52_S1	Sparse fauna on fine sand	A5.2 - Subtidal Sand	Subtidal Sands and Gravels	A5.2	SS.SSa
TRBT57_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT59_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS

Video Sample Ref	Brief Habitat Description (Physical and biotic)	Broadscale Habitat	Habitat FOCI	EUNIS code	MNCR code
TRBT61_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS
TRBT62_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS
TRBT67_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT69_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT75_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT75_S2	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS
TRBT76_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS
TRBT76_S2	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT77_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT78_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT78_S2	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS
TRBT78_S3	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT79_S1	Coarse sediment with Pomatoceros	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.141	SS.SCS.CCS.PomB
TRBT80_S1	Sparse fauna on coarse sediment	A5.1 - Subtidal Coarse Sediment	Subtidal Sands and Gravels	A5.1	SS.SCS

Appendix 11. Faunal assemblage metrics calculated for each grab sample

Station code	Replicate	Species no. (S)	Abundance (N)	Hill's diversity (N1)	Biomass (g)
TRBT1	A	23	57	16.82	0.4196
TRBT11	A	17	24	14.79	0.1498
TRBT12	A	42	90	32.18	0.5795
TRBT13	A	21	44	14.54	0.2759
TRBT14	A	32	61	24.15	0.60902
TRBT15	A	37	89	25.45	0.4873
TRBT15	B	32	74	20.46	0.6352
TRBT15	C	28	65	14.01	1.3389
TRBT16	A	21	43	16.25	0.8415
TRBT17	A	25	27	24.37	0.3034
TRBT18	A	30	53	23.43	0.9352
TRBT18	B	29	61	23.24	0.4439
TRBT18	C	29	58	20.17	0.4627
TRBT19	A	33	65	25.06	0.5884
TRBT19	B	38	75	28.77	0.3453
TRBT19	C	19	29	16.53	0.1688
TRBT2	A	36	87	23.62	2.3353
TRBT20	A	19	30	17.13	1.3171
TRBT21	A	34	94	23.61	0.3637
TRBT22	A	28	48	20.73	0.295
TRBT23	A	13	25	8.25	0.1517
TRBT23	B	15	18	13.23	0.201
TRBT23	C	12	22	8.35	0.3821
TRBT24	A	33	49	28.18	0.7195
TRBT25	A	22	43	16.78	1.6823
TRBT25	B	26	53	17.24	0.3284
TRBT25	C	45	82	35.91	0.651
TRBT26	A	42	483	3.52	14.6876
TRBT27	A	36	95	26.57	2.8539
TRBT28	A	15	21	12.90	0.1395
TRBT29	A	37	69	27.17	1.5453
TRBT30	A	32	67	24.98	0.5582
TRBT30	B	23	41	19.28	36.1691
TRBT30	C	30	54	24.32	0.5578
TRBT31	A	35	73	26.45	0.5487
TRBT32	A	25	37	21.90	16.8382
TRBT33	A	30	56	23.71	1.0446
TRBT33	B	31	64	22.94	26.0179
TRBT33	C	24	59	16.85	0.34771
TRBT34	A	28	88	16.39	43.7181
TRBT34	B	40	121	22.65	0.6377
TRBT34	C	41	118	23.25	2.828

Station code	Replicate	Species no. (S)	Abundance (N)	Hill's diversity (N1)	Biomass (g)
TRBT35	A	24	39	18.65	2.2998
TRBT36	A	33	69	23.40	5.2602
TRBT37	A	42	94	30.91	1.4681
TRBT38	A	37	95	22.32	2.0273
TRBT39	A	21	37	16.85	0.3324
TRBT4	A	28	57	20.23	2.8133
TRBT40	A	17	28	14.04	0.2461
TRBT41	A	40	106	28.02	47.45099
TRBT42	A	35	90	23.52	0.6063
TRBT43	A	22	36	18.31	0.4226
TRBT44	A	24	47	15.59	3.0065
TRBT45	A	43	112	28.23	3.8207
TRBT46	A	18	35	14.00	0.3162
TRBT47	A	9	19	7.60	0.1722
TRBT48	A	10	15	8.62	0.6858
TRBT49	A	18	27	14.73	0.203
TRBT5	A	35	71	27.60	0.7091
TRBT51	A	50	104	36.74	47.3577
TRBT52	A	28	45	22.99	3.0275
TRBT53	A	18	35	14.90	13.2199
TRBT54	A	33	78	23.26	0.6671
TRBT55	A	25	73	17.79	0.3999
TRBT56	A	38	72	31.42	9.9029
TRBT57	A	44	138	26.69	4.0214
TRBT57	B	45	115	27.05	6.7935
TRBT57	C	48	134	28.04	1.4473
TRBT59	A	29	42	25.60	1.086
TRBT59	B	29	65	21.39	4.2369
TRBT59	C	21	37	18.07	32.2747
TRBT6	A	33	62	22.75	18.5602
TRBT6	B	25	49	18.32	0.5731
TRBT6	C	25	47	20.65	1.2997
TRBT60	A	27	45	20.62	0.643
TRBT61	A	27	57	19.52	2.5001
TRBT61	B	31	62	21.74	0.4028
TRBT61	C	29	58	20.15	1.0725
TRBT62	A	31	64	22.74	0.71
TRBT62	B	26	51	22.03	0.4208
TRBT62	C	26	43	20.91	0.8737
TRBT63	A	35	97	20.81	1.13304
TRBT64	A	18	28	16.75	0.4482
TRBT65	A	21	40	16.27	0.6934
TRBT66	A	18	23	16.63	16.1226
TRBT67	A	42	77	34.26	0.7231

Station code	Replicate	Species no. (S)	Abundance (N)	Hill's diversity (N1)	Biomass (g)
TRBT67	B	33	60	27.63	5.074
TRBT67	C	37	65	30.85	1.1157
TRBT68	A	28	57	22.11	0.5997
TRBT69	A	32	56	22.95	1.0862
TRBT69	B	29	44	24.27	0.47301
TRBT69	C	21	39	14.33	1.4674
TRBT7	A	30	105	14.08	3.8866
TRBT70	A	26	46	20.80	1.4821
TRBT71	A	22	32	19.23	0.6629
TRBT72	A	26	36	23.45	0.8945
TRBT73	A	7	10	6.26	0.7678
TRBT74	A	18	30	15.44	0.68
TRBT8	A	35	61	26.18	0.7218
TRBT8	B	40	82	26.68	7.1514
TRBT8	C	31	74	20.61	0.5432
TRBT9	A	18	28	14.58	0.36311

Appendix 12. Cobble analysis results

Station Code	No. Cobbles	Cobble no.	Photo	length (x)	Width (y)	Height (z)	Volume (cm3)	Hardness (H/M/S)	Texture	Type	Shape	Coverage (0/1/2/3/4)	Faunal Coverage notes
TRBT19	1	1	Y	109	75	31	60	H	1	UNKNOWN	SA	3	SERPULIDS, BRYOZOANS
TRBT25	1	1	Y	105	65	30	75	H	1	UNKNOWN	SA	2	SERPULIDS
TRBT25	1	1	Y	65	54	40	30	H	2	UNKNOWN	SA	2	SERPULIDS, HYDROID
TRBT17	2	1	Y	80	50	30	40	H	2	UNKNOWN	SR	2	SERPULIDS
		2	y	90	70	60	200	H	2	UNKNOWN	SR	2	SERPULIDS
TRBT11	3	1	Y	110	77	64	130	H	1	UNKNOWN	A	3	SABELLARIA, ENCRUSTED TUBE WORMS, HYDROIDS, BRYOZOAN, SPONGE POLYMASTIA
		2	Y	92	78	53	75	H	1	ASAULT GRANITE	SR	3	SABELLARIA, ENCRUSTED TUBE WORMS
		3	Y	75	74	22	55	H	1	ASAULT GRANITE	R	3	ENCRUSTED TUBE WORMS
TRBT14	1	1	Y	114	64	58	190	H	1	GRANITE	SR	3	HYDROID, BRYOZOAN, ENCRUSTED TUBE WORM
TRBT26	2	1	Y	105	64	64	80	H	1	GRANITE	SR	3	SABELLARIA, HYDROID, BARNACLE, BRYOZOA
		2	Y	142	100	128	690	H	1	GRANITE	SR	3	SABELLARIA, HYDROID, ENCRUSTED TUBE WORM, BRYOZOA AND DEAD CORAL
TRBT71	1	1	Y	95	60	55	190	H	3	UNKNOWN	SA	3	SERPULIDS, BARNACLE, BRITTLESTAR, SEDIMENT GRAIN WORM TUBE
TRBT70	2	1	Y	80	65	45	110	H	3	UNKNOWN	SA	3	HYDROID AND SERPULID
		2	Y	110	84	55	320	H	2	UNKNOWN	SR	2	SERPULIDS
TRBT69	1	1	y	80	70	60	220	H	1	UNKNOWN	SR	1	SERPULIDS
TRBT53	2	1	Y	70	60	50	50	H	1	UNKNOWN	R	1	SERPULIDS, 1 TUBE
		2	Y	100	95	50	150	H	1	UNKNOWN	SR	0	
TRBT60	1	1	Y	95	65	53	160	H	2	UNKNOWN	SA	1	SERPULID
TRBT57	1			95	93	32	70	H	3	UNKNOWN	SA	4	SERPULID
TRBT57	1	1	Y	85	83	23	100	H	2	GRANITE	A	3	ENCRUSTED TUBE WORMS, BRYOZOAN, HYDROIDS
TRBT46	1	1	Y	156	114	88	460	H	2	GRANITE	A	2	ENCRUSTED TUBE WORMS, BRYOZOAN
TRBT67	1	1	Y	70	45	63	30	H	1	FLINT	SR	2	WORM TUBES
TRBT66	1	1	Y	110	80	40	180	H	2	GRANITE	SA	2	WORM TUBES
TRBT30	2	1	Y	81	54	50	70	H	2	GRANITE	SA	2	WORM TUBES
		1	Y	79	49	56	210	H	1	GRANITE	SA	1	SPONGE

TRBT30	1	1	Y	135	120	55	550	H	2	UNKNOWN	A	2	WORM TUBES
TRBT30	2	1	Y	140	89	36	130	H	1	UNKNOWN	SA	0	
		2	y	114	90	55	550	H	1	BLACK	SA	2	WORM TUBES, BRYOZOAN
TRBT32	1	1	Y	92	75	40	70	H	1	UNKNOWN	SR	3	WORM TUBES

Key: See Appendix 8 for detailed information for each category.

Appendix 13. Taxa characteristic of each faunal assemblage identified from grabs (replicate A) at Turbot Bank pMPA (taxa contributing to 50% of group similarity)

	SIMPROF Groups (assemblages)									
Taxa	**b**	**e**	**f**	**g**	**h**	**i**	**j**	**l**	**m**	**n**
Echinocyamus pusillus	1.57	1.67	1.41	1.71	2.49	2.24	2	2.81	2.78	2.61
Glycera lapidum	0.87	1.8		1.71		1.4		1.35	1.5	2.22
Notomastus latericeus					1.46	1.38		1.83	1.71	2.22
NEMERTEA	1.04			1.5		1.08	1.57	1.35	1.71	
Goniadella gracilis					1.78	1.51	1.21	1.45		1.51
Aonides paucibranchiata			1				1	1.41		
Sabellidae (juv)										3.24
Galathea intermedia		2.25								
Chone infundibuliformis										2.16
Spirobranchus lamarcki		2.16								
Atylus vedlomensis										1.72
Ophelia borealis	1.66									
Scalibregma inflatum		1.59								
Urothoe marina			1.57							
Lumbrineris gracilis		1.53								
Leptochiton asellus		1.47								
Ophiactis balli		1.34								
Eulalia mustela									1.21	
Polycirrus medusa								1.17		
SPATANGOIDA (juv)	1.07									
Owenia fusiformis						1.04				
Phyllodocidae				1						
Pisione remota									1	
Trypanosyllis coeliaca							1			

Values represent average abundances of square root transformed data. Colours indicate relative abundances (where red = high, yellow = medium and green = low). Taxa shown represent the top 50% characterising each group.

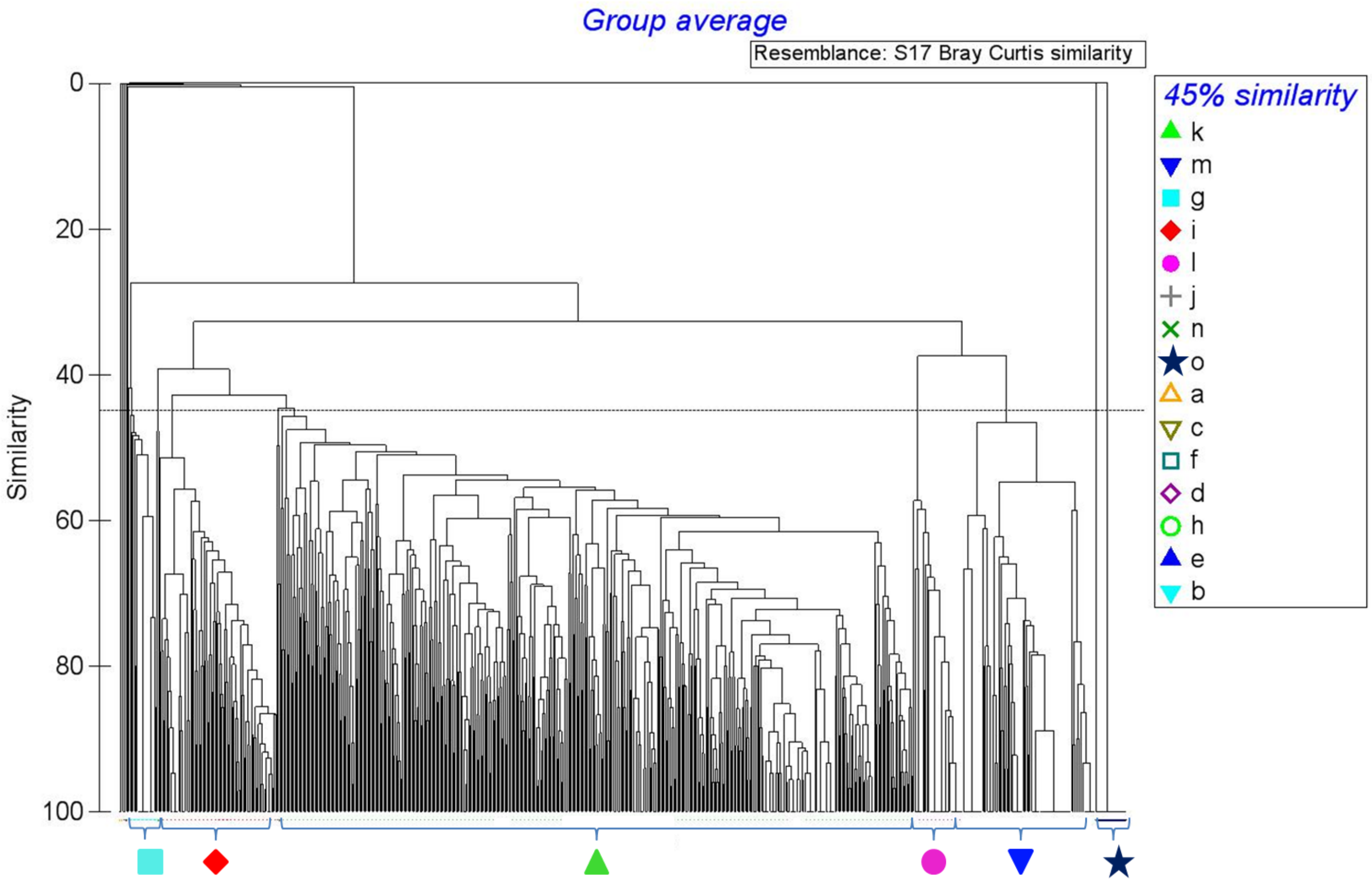
Appendix 14. Taxa characteristic of each faunal assemblage identified from averaged stills at Turbot Bank pMPA (taxa contributing to 50% of group similarity)

	SIMPROF Groups (assemblages)			
Taxa	**a**	**c**	**d**	**e**
Pomatoceros		4.54	4.42	1.71
Balanus		3.2	2.53	
Flustra foliacea		2.38		1.59
Pagurus prideaux	0.51			
Adamsia carciniopados	0.34			

Values represent average abundances of non- transformed SACFOR data. Colours indicate relative abundances (where red = high, yellow = medium and green = low). Taxa shown represent the top 50% characterising each group.

Appendix 15. Results of analyses using non-averaged stills SACFOR data

Appendix 15.1 Cluster analysis using all still images: major clusters have been highlighted below the cluster dendrogram using the corresponding colours and symbols in the key.



Appendix 15.2 Taxa characteristic of each faunal assemblage identified from all still images at Turbot Bank pMPA (taxa contributing to 90% of group similarity).

	Cluster group					
Taxa	g	i	k	l	m	o
Pomatoceros	2	3.71	4.45	1.27	1.76	
Flustra foliacea		1.87	1.95	1.49	1.94	
Balanus		2.02	2.77			
Unidentifiable burrowing megafauna				3.03		
Pagurus prideaux		3				
Adamsia carciniopados		2				
No identifiable fauna						1

Values represent average abundances of non-transformed SACFOR data. Colours indicate relative abundances (where red = high, yellow = medium and green = low). Taxa shown represent the top 90% characterising each group.

Appendix 15.3 Table of video station variability according to cluster group at 45% similarity (all still images).

	Number of stills assigned to cluster group																
Station	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	Total no. stills	Percentage in group k
TRBT03							1		2		27		1			31	87
TRBT06							1		3		23	1				28	82
TRBT08									9		23					32	72
TRBT10									4		30					34	88
TRBT15									3	1	19					23	83
TRBT18									8		22		5			35	63
TRBT19							1		3		26					30	87
TRBT23							1		6		10	3	13	1	3	37	27
TRBT25							2		1	1	24		2			30	80
TRBT28							1		6		36		1			44	82
TRBT30							1		3		21		4			29	72
TRBT33							1		1			5	16			23	0
TRBT34									1		26					27	96
TRBT43									2	1	15					18	83
TRBT52	2		2						3			4	2		4	17	0
TRBT57									1		23					24	96
TRBT59							2		1		5	3	14		2	27	19
TRBT61						1			2			8	13		2	26	0
TRBT62				1			4	1	3		3	11	10		1	34	9
TRBT67								1	3		31					35	89
TRBT69									6		26					32	81
TRBT75_S1									3		19					22	86
TRBT75_S2					1						1		3		1	6	17
TRBT76_S1							1		2		1	1	5		1	17	6
TRBT76_S2									1		5					6	83

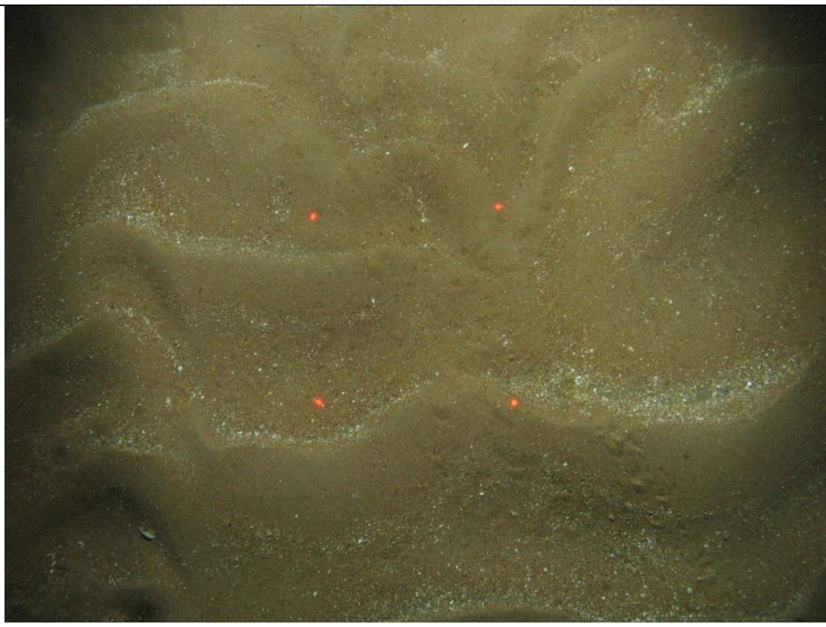
Number of stills assigned to cluster group

Station	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	Total no. stills	Percentage in group k
TRBT77									1		14					15	93
TRBT78_S1									5		13		5			23	57
TRBT78_S2							4		1		3	1	3			12	25
TRBT78_S3											7					7	100
TRBT79									2		16					18	89
TRBT80		1							1				1		3	6	0
													Grand total			**742**	

Major clusters are highlighted by colours that correspond with cluster in Appendix 14.1. Cells indicating number of still images within each cluster are highlighted according to abundances, where red = high, yellow = medium and green = low. Final column indicates percentage of stills assigned to group k (dominant cluster) – cells highlighted in pink indicate >70% occurance in group k. Group k corresponds with A5.141: *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles.

Appendix 16. Example images of EUNIS habitats identified at Turbot Bank pMPA

A5.1: Sublittoral Coarse Sediment e.g. Video stations: TRBT23, TRBT33, TRBT59, TRBT61 and TRBT62	
A5.141: *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles e.g. Video stations: TRBT15, TRBT19, TRBT25, TRBT28, TRBT34, TRBT57, TRBT78	

A5.2: Sublittoral Sand e.g. Video stations: TRBT52, TRBT80	
A5.251: *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand e.g. Grab stations: Cluster b TRBT52, TRBT13, TRBT20, TRBT49, TRBT64, TRBT74	

A5.4: Sublittoral mixed sediments e.g. Grab samples: TRBT7, TRBT37, TRBT53	

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