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Analysis of seabed imagery from the Hebrides Terrace Seamount (2013)

Cross, T., Howell, K.L., Hughes, E. & Seeley, R.

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For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY
www.jncc.defra.gov.uk

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Acknowledgement

This report was prepared from analysis conducted in 2013 on photographic imagery collected during the JC073 cruise, on the RRS James Cook in May/June 2012, through a Memorandum of Agreement between the JNCC and Heriot-Watt University (HWU) with contribution from the Natural Environment Research Council (NERC). As such the source imagery is jointly owned by the JNCC and HWU acknowledging the contribution of NERC.

The data gathered during this survey shall be used by JNCC as part of its advice to UK Government and the Devolved Administrations. The time spent at the Hebrides Terrace Seamount was appended onto the existing cruise, JC073, which was funded by the UK Ocean Acidification (UKOA) programme as part of the Benthic Consortium research project. The UKOA programme is a collaborative venture between NERC, the Department for Environment, Fisheries & Rural Affairs (Defra) and the Department of Energy & Climate Change (DECC).

THE MARINE BIOLOGICAL ASSOCIATION

Marine Institute
PLYMOUTH UNIVERSITY

Contents

1 Introduction

1.1 Survey objectives

In 2012, seabed imagery from the Hebrides Terrace Seamount was captured on behalf of JNCC by researchers from Heriot-Watt University on the JC073 survey. Three transects were undertaken over two days, one on the summit and two on the eastern slopes. This report outlines the results of the taxonomic analysis of fauna and characterisation of the habitat sampled by these three transects. The data presented here also provide information on the presence and potential extent of Scottish Marine Protected Area search features and Priority Marine Features.

1.2 Site description

The Hebrides Terrace Seamount lies adjacent to the continental slope in the eastern part of the Rockall Trough. It is the smallest of all the seamounts in the UK deep-sea area rising from 2,200m deep to approximatley 1,000m at its summit. It therefore has the deepest summit depth of any of the UK seamounts. It is likely that the structure of this seamount is similar to that of the Anton Dohrn Seamount and Rosemary Bank Seamount, with exposed flanks and bedrock (Graham *et al* 2001).

2 Survey Design and Methods

2.1 ROV Stills and Video Acquisition Methods

Three ROV transects were undertaken using the Irish Marine Institute's *Holland I* ROV. The ROV was equipped with an HD camera mounted at an oblique angle to the seabed, and sensors monitoring position, depth and altitude. The HD camera was equipped with two parallel lasers mounted at a distance of 10cm apart. The specifications of the stills camera, video camera, lighting and laser scaling system fitted to *Holland I* can be seen in Table 1. Speed was not constant throughout transects as the ROV paused when something of interest was observed. Transect lengths were not equal, details of transects lengths are given in Figure 1.

Table 1. *Holland I* ROV imaging specifications

Cameras	
High definition video camera	Insite Mini Zeus camera with direct HDSDI fibre output
Digital stills camera	Kongsberg 14-208
Pilot pan and tilt	Kongsberg 14-366
Fixed zoom camera	Insite Pegasus plus
Lighting	
2x 400Watt Deep-sea Power & Light SeaArc2 HMI lights	
2x 25,000 lument Cathx Ocean APHOS LED lights	
Lasers	
2x Deep-sea Power & Light lasers 100mm spacing	

2.2 ROV Stills and Video Analysis Methods

2.2.1 Still image subsampling

A subsample of the total number of images (990) across all three transects was selected for analysis due to time constraints. For each transect, the spatial position of all images was plotted using GIS, and an image was selected at intervals of as close to 50m as possible. If images at the 50m intervals were of insufficient quality (e.g. sediment stirred up, not focused on seabed), the next nearest image of adequate quality was selected instead. By selecting images based on distance in this manner, a representative sample was achieved across the three transects of differing length. This sub sampling ultimately resulted in a dataset of 140 images. Figure 1 displays the spatial orientation of images selected for analysis on each of the transects and Table 2 provides a breakdown of the number of images selected for analysis on each transect.

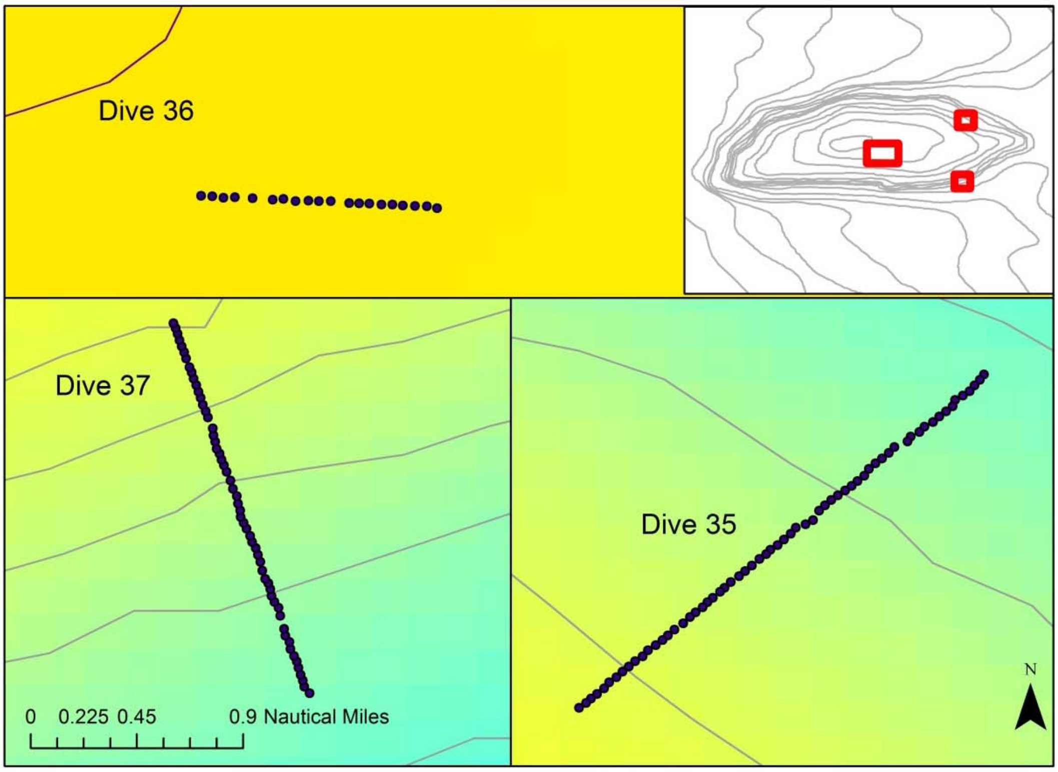


Figure 1. Selection of still images for analysis from all three transects at approximately 50m spacing.

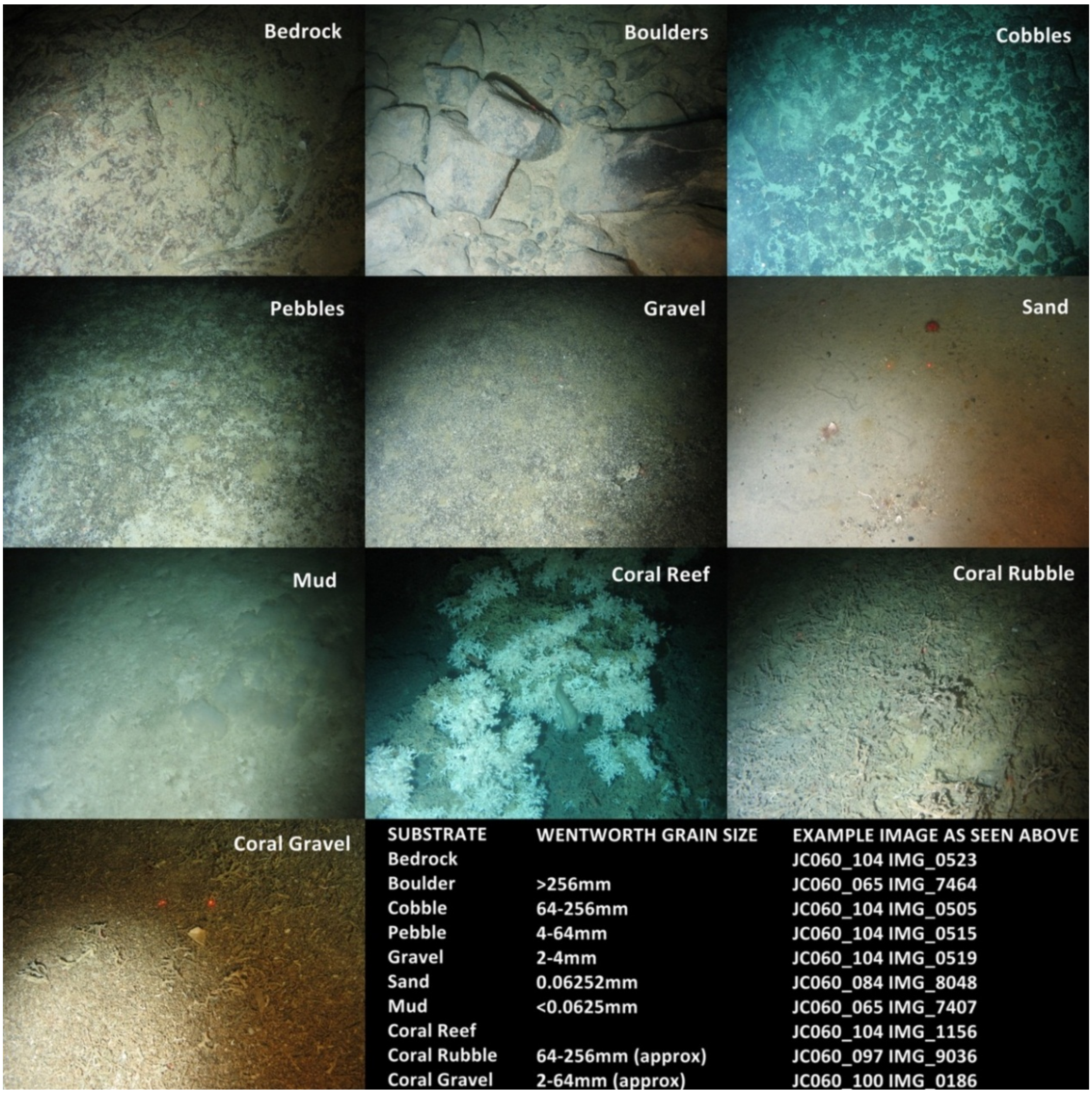
Table 2. Details of number of still images selected for analysis from all three transects at approximately 50m spacing.

Transect	Total Images	Distance(m)	Final images
Dive 35	524	3179.63	64
Dive 36	98	1131.22	20
Dive 37	367	2976.00	56

2.2.2 Still image analysis

For each sample image, the physical and biological habitat was briefly described using a single sentence. The composition of the sub-stratum was then assessed visually using percent cover of the field of view for each sediment type, in accordance with the MNCR categories (see Figure 2). Where rock features (bedrock, boulders, cobbles) were present the physical characteristics of the rock were also recorded using a 1-5 scale, and this was based on the variables identified in the Sub-Littoral Habitat Recording form. Other features of interest such as ripple marks, indicating strong currents, or visible anthropogenic disturbance such as trawl marks or discarded fishing gear was also recorded. Each image was then quantitatively assessed.

All species greater than 1cm in size were identified and counted, with primary and secondary substrates recorded according to a modified Wentworth (1922) scale. The abundance of colonial species such as encrusting sponges was recorded using a SACFOR scale. Where colonial species formed relatively discrete, quantifiable colonies, such as Solenosmilia variabilis, both the abundance of colonies and a SACFOR abundance were recorded. Species identification from images is difficult and sometimes impossible without physical samples. Plymouth University image analysis employed the use of operational taxonomic unit (OTU) numbers in line with the species catalogue developed by Howell & Davies (2010). The OTU method allows different fauna to be identified as distinct morphospecies – discernible as definitely a different species from another animal – allowing the final named identification of the species to be updated when more definitive ground truthing data is made available/experts have been consulted. Morphospecies are named according to the finest taxonomic resolution which can reliably be identified followed by species 1/sp. 2 etc. For especially difficult identifications it is sometimes only possible to consolidate individuals by morphotype (e.g. encrusting sponges are characterised by colour only).



SUBSTRATE	WENTWORTH GRAIN SIZE	EXAMPLE IMAGE AS SEEN ABOVE
Bedrock		JC060_104 IMG_0523
Boulder	>256mm	JC060_065 IMG_7464
Cobble	64-256mm	JC060_104 IMG_0505
Pebble	4-64mm	JC060_104 IMG_0515
Gravel	2-4mm	JC060_104 IMG_0519
Sand	0.06252mm	JC060_084 IMG_8048
Mud	<0.0625mm	JC060_065 IMG_7407
Coral Reef		JC060_104 IMG_1156
Coral Rubble	64-256mm (approx)	JC060_097 IMG_9036
Coral Gravel	2-64mm (approx)	JC060_100 IMG_0186

Figure 2. Modified Wentworth Scale. Example images displaying the different substrate categories and associated grain sized agreed for use in this study. Laser scaling calculations allow for fairly accurate grain sizing.

2.2.3 Video subsampling

In order to partition the video data into discrete units suitable for multivariate analysis, each transect was split into a number of sections. These sections were established by calculating an average speed for the ROV over each transect based on the total distance and time, and then using this average speed in conjunction with the elapsed time to calculate intervals of approximately 10m.

Ten metre video sections containing no species data were excluded from the analysis, since it is not possible to calculate a similarity based on no species. A random quarter sub-sample of the remaining 10m video sections was then taken in order to alleviate the problems associated with sampling along changing habitat gradients (e.g. taking in transition zones) and spatial auto-correlation[1]. As transects were of unequal length, and thus had differing

[1] Spatial autocorrelation is based on Toblers first law 'everything is related to everything else, but near things are more related than distant things' (Tobler 1970). Spatial autocorrelation is a pattern in which observations are related to one another by the geographical distance between them (Fortin and Dale 2005; Legendre and Legendre 1998). When spatial autocorrelation is found to be positive, observations close together have more similar values than those further apart. The presence of spatial autocorrelation poses a serious

numbers of video samples, the random selection was performed within each transect rather than across the whole dataset so as to reflect the proportion of the total number of video samples that each transect represented. The 10m video sections used in the final anaysis are here-in-after refered to as ‘video samples’. Table 3 lists the numbers of video samples that were selected.

Table 3. Number of video samples analysed from each transect

Transect	Total Samples	Distance(m)	Samples selected for analysis
Dive 35	266	3179.63	65
Dive 36	75	1131.22	23
Dive 37	260	2976.00	61

2.2.4 Video analysis

The video sample footage was played back in its entiriety , and the primary and secondary substrate for each discrete video sample was recorded according to a modified Wentworth (1922) scale, following the same guidelines as for the image data above. This allowed for the mapping of biotopes identified by both the still and video analysis along the whole of each transect. In addition, the presence or absence of Annex I habitat (biogenic reef, stony reef or bedrock reef), coral rubble, cobbles or boulders and any human disturbance was recorded separately.

Each video sample was then quantatively assessed, using the same methodology as with the still image data. Due to the lower resolution of the video data in comparison with the stills data, only organisms of >10cm in size were identified and counted. Estimation of those organisms >10cm in size was facilitated by the laser scaling dots.

2.2.5 Data QA/QC

Video and image data are extremely difficult to analyse without the presence of physical samples or an extensive knowledge of the species pool for the region. There is great potential for errors in species identification from video and image analysis and thus it is important to have an established method for QA/QC of the interpreted datasets.

In this study, QA of the photographic imagery data was undertaken according to the following methods. Five percent of images analysed were selected at random, by transect and formed the QA/QC dataset. The QA/QC dataset was reanalysed by Dr Kerry Howell for error in identification and quantification of species. The analysis results were compared for errors image by image. Any species identification problems highlighted by the QA/QC process were addressed in an appropriate fashion (e.g. corrections made). This species QA/QC was undertaken prior to the multivariate analysis.

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weakness in hypothesis testing and prediction (Dorman, 2007; Lennon, 2000) as it violates the assumption of independency and identically distributed errors in model residuals. Whether spatial autocorrelation is a problem in multivariate community analysis is a point for debate. These authors do not feel it is, however, in the absence of a consensus of opinion on this point we have opted for a conservative approach and used a random subsample of the transect data. This would not solve the issue of potential spatial autocorrelation within the data since the data are transect data, but may ease the problem.

There is currently no ring test or agreed scheme for quantifying error in the analysis of epibenthic megafaunal species from video and stills data. Plymouth University is a member of the National Marine Biological Anaytical Quality Control (NMBAQC) scheme for video analysis, however the scheme's current ring tests concern benthic infaunal sample analysis which are not suitable for epibenthic megafaunal data.

2.3 Mapping

2.3.1 Defining biotopes

Highly mobile taxa, such as fish, were then removed from the dataset, and species data from the images and video was analysed separately. The species data was converted into an abundance matrix using R (R Core Team, 2012). Zero data samples were removed, and the data was then imported into PRIMER-E v.6 (Clarke & Gorley 2006). Data was transformed using a square root transformation, and clustering performed using group average linking based on a Bray Curtis similarity matrix of transformed image sample data. Clustering was performed using the SIMPROF routine, with 1,000 mean permutations and 999 simulation permutations, and using a significance level of 1%. The resultant clusters were then examined visually, and divided into those considered to be representative of the data and those not. A SIMPER analysis was then used to confirm this, and to indicate which were the dominant species in each cluster. These clusters were then matched to substrate data to produce the biotopes.

Where there was a match in the video analysis for a biotope identified from the stills analysis or vice versa, the two were merged together and coded with a new cluster name reflecting this. The original cluster names were appended with either a '_S' or '_V' (for still or video respectively) to indicate their origin, and cluster merging was indicated with a '+' sign. This process resulted in a total of eight final biotopes, which can be seen in the full table of biotopes (Section 3.3, Table 4). Where necessary, the final biotopes were renamed to reflect the merging of clusters.

3 Results

3.1 Biotope definition

3.1.1 Biotope definition from image data

Ten significant clusters at the greatest level of subdivision (p<0.01) were identified following cluster analysis in PRIMER v.6 (Clarke & Gorely 2006) (Figures 3 & 4). Of these, two clusters (B and F) were defined by just two samples, and so were not considered to be valid. The remaining eight clusters were assessed visually, and in several instances no ecologically meaningful splits were found. Therefore, clusters C, D & E were consolidated into a new cluster, resulting in a total of six final clusters, A, CDE,G, H, I and J, used to define biotopes. SIMPER analysis confirmed the similarity of these clusters. A description and example image of each of these biotopes is provided in the following section.

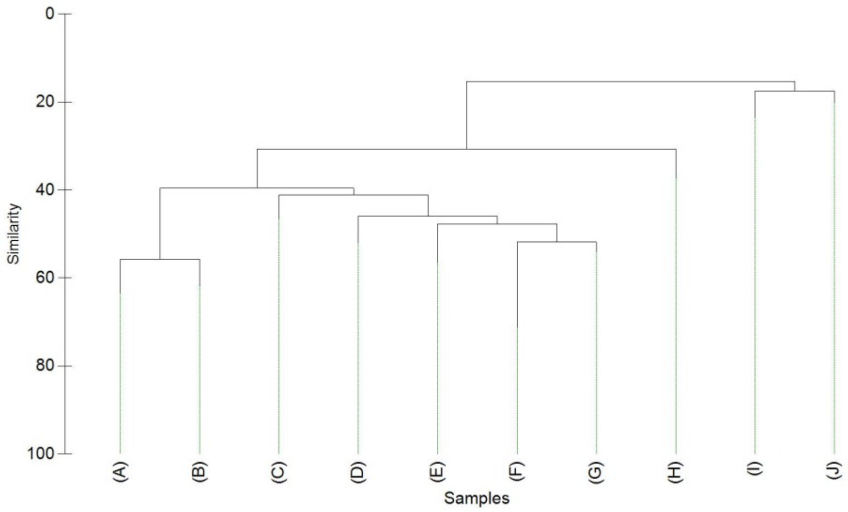


Figure 3. Collapsed dendrogram of statistically significant Hebrides Terrace clusters identified by SIMPROF routine.

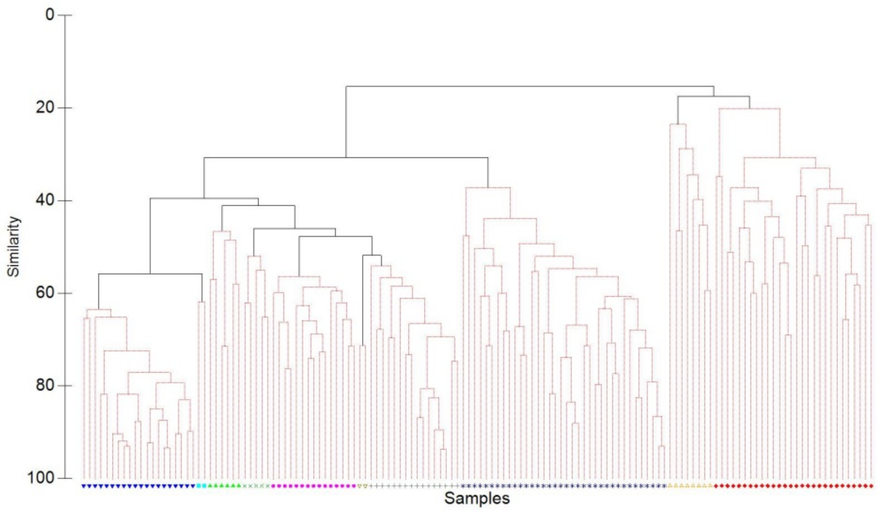
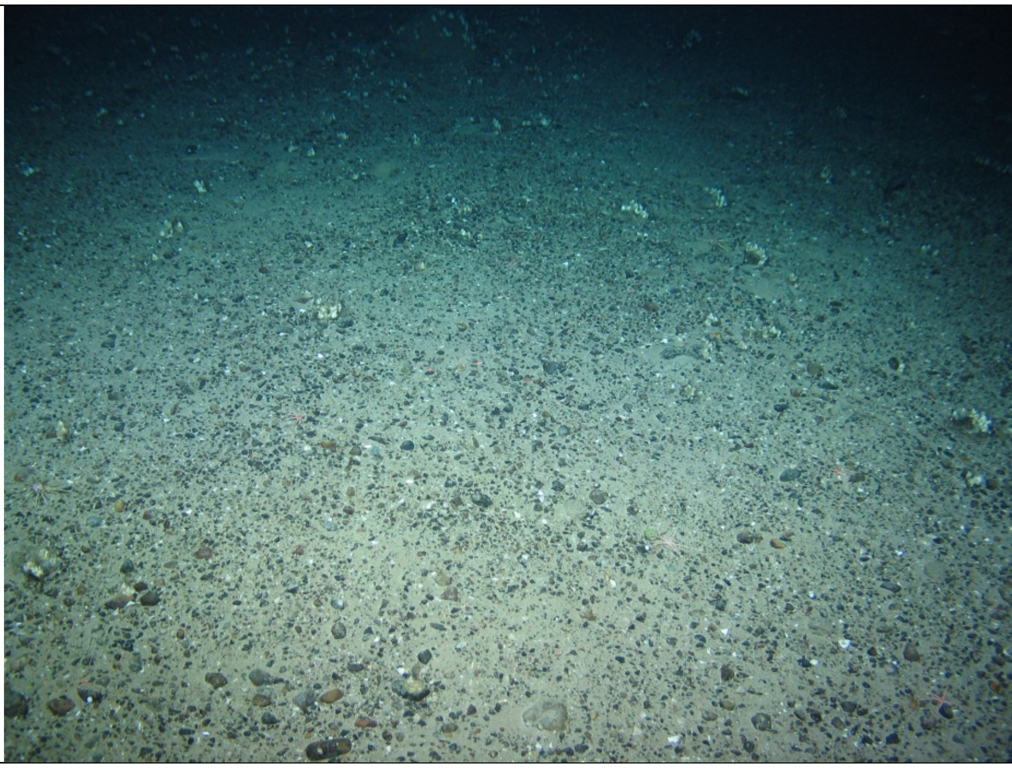


Figure 4. Expanded dendrogram of Hebrides Terrace clusters from image data.

3.1.2 Biotope descriptions

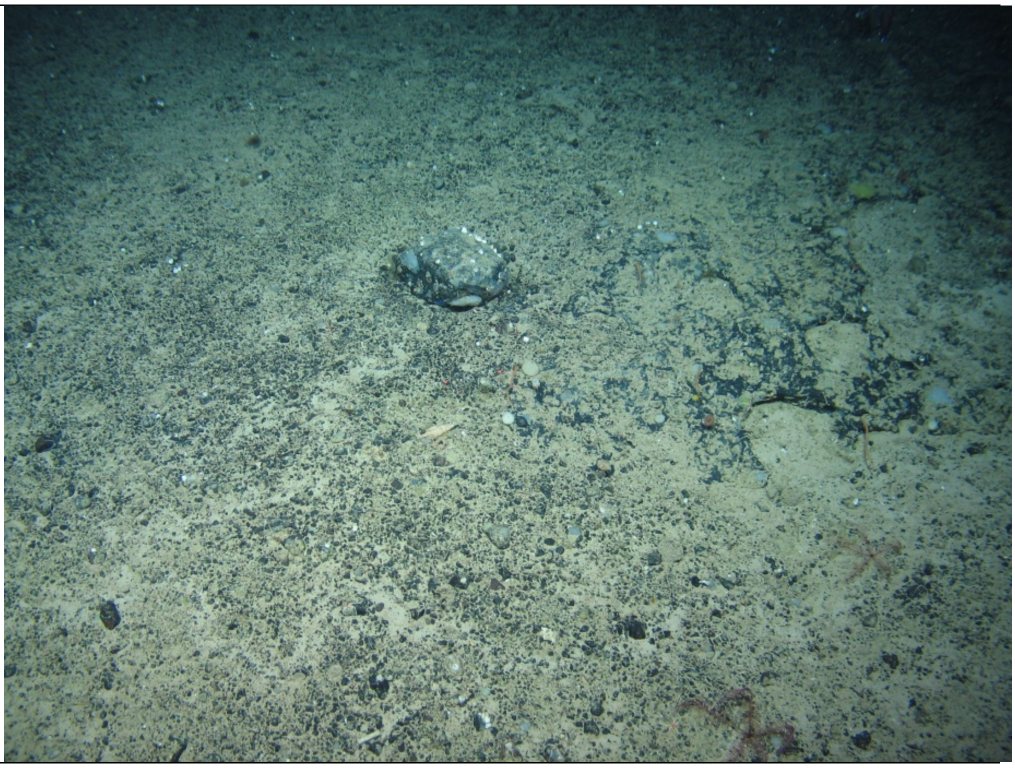
Cluster A: Barnacles, ophiuroids & *Cidaris cidaris* on pebbles with sand
SIMPER within cluster average similarity: 74.34%

Sample image	

This cluster is characterised by Cirripedia sp., Ophiuroidea sp.7 and *Cidaris cidaris.* Cluster A was recorded between depths of 984 to 998.1m, and at a mean depth of 991.41m (SD 4.06). This cluster is found on pebbles mixed with sand, typically with many small boulders. It was recorded on twenty images; exclusively from the summit of the seamount. There was no equivalent matching cluster identified from the video data. This assemblage is similar to the assemblage observed on the summit of the Anton Dohrn Seamount (Narayanaswamy *et al* 2006) but does not resemble any previous described biotope.

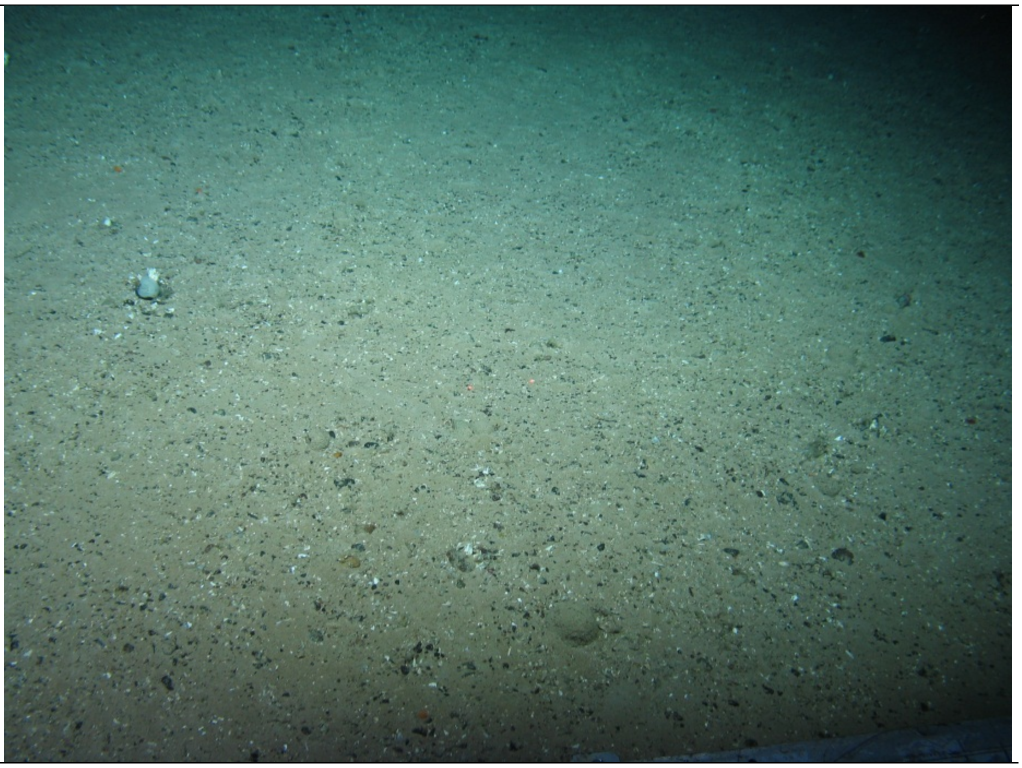
Cluster CDE: Barnacles, antipatharians, and encrusting sponges on sediment draped exposed bedrock and mixed substrate.
SIMPER within cluster average similarity: 57.00%

Sample image



This cluster is characterised by the antipatharian *Stichopathes c.f. gravieri,* Cirripedia sp., various ophiuroids including *Ophiomusium lymani,* the crinoid *Pentametrocrinus* atlanticus, Actinaria sp.20, Caryophyllidae sp., yellow encrusting sponges (Porifera encrusting yellow msp. 2) and white encrusting sponges (Porifera encrusting grey/cream/white msp. 4). Cluster CDE was recorded on 26 samples at depths ranging from 1,213.3m to 1,622.2m, with a mean of 1,480.89m (SD 109.39). Cluster CDE is primarily found on hard substrate such as pebbles or cobbles, possibly with some exposed bedrock, and often with patches of sand. The majority (81%) of instances of this biotope were recorded from transects along the flanks of the seamount. There was no matching cluster from the video data, and no biotope has been described previously that is similar to this although many of the characterising species have been observed on the other banks and seamounts in UK waters.

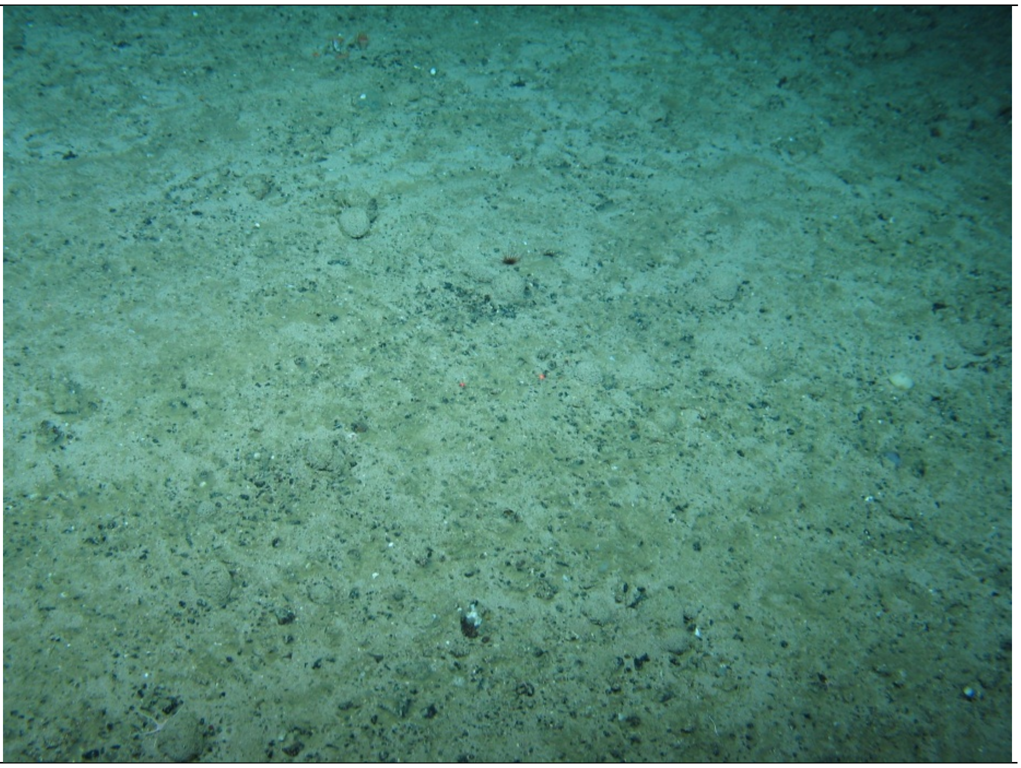
Cluster G: Xenophyophore fields (Xenophyophores and barnacles on gravelly sand)
SIMPER name: Xenophyophores and barnacles on gravelly sand
SIMPER within cluster average similarity: 63.40%

Sample image	

This cluster is characterised by the xenophyophore *Syringammina fragillissima* and *Cirripedia* sp. barnacles. Cluster G was recorded from depths between 1,211.5m to 1,595.5m, with a mean depth of 1,386.83m (SD 173.73). Cluster G is primarily found on sand mixed with gravel with occasional boulders, but in several instances was also recorded on sand mixed with mud. This cluster was recorded in 16 samples, and was approximately evenly split between transects 'Dive 35' and 'Dive 37'. The best matching cluster identified from the video data was Cluster BC. Several xenophyophore dominated biotopes have been described previously from Rockall Bank, Anton Dohrn Seamount and the Darwin Mounds (Long *et al* 2010; JC60 data analysis) and the closest match to this biotope would be cluster MA 'Xenophyophores and ophiuroids on mixed substrate' recorded from Anton Dohrn Seamount (Long *et al* 2010) but the two do differ in the secondary characterising species. This assemblage is not recognised in Howell *et al* (2010), MNCR or EUNIS, but was described in Howell (2010) as "Xenophyophore fields". It is also recognised as a habitat and a VME by the UN General Assembly resolution 61/105.

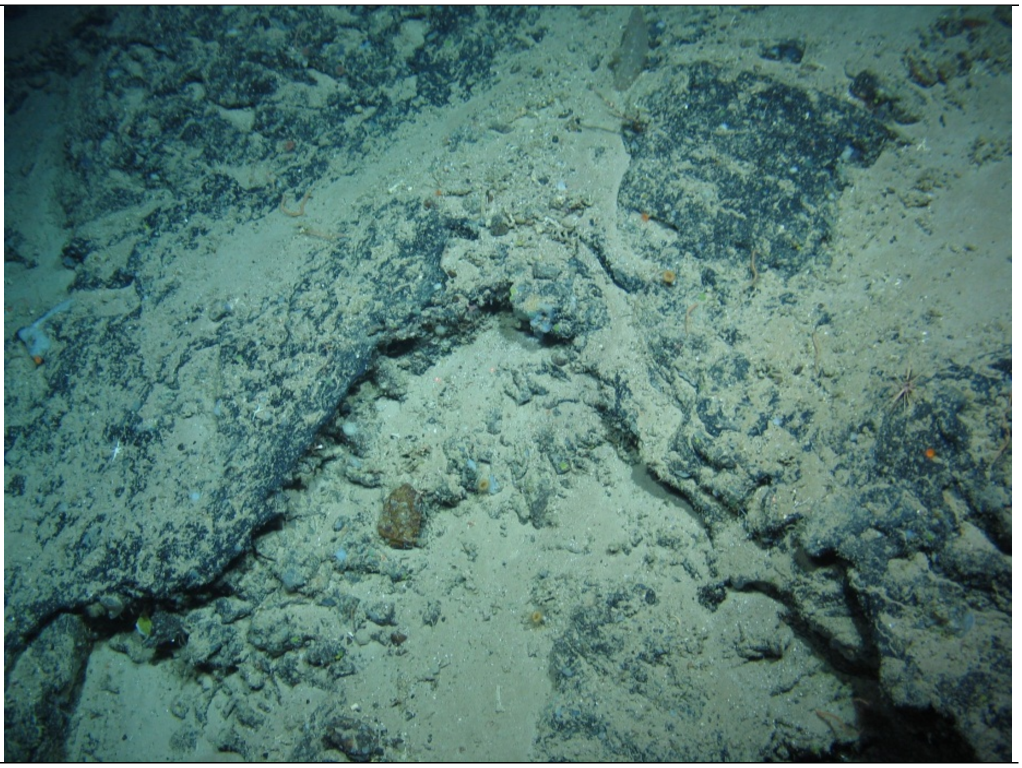
Cluster H: Xenophyophore fields (Xenophyophores and sea pens on gravelly sand and mixed substrate)
SIMPER name: Xenophyophores and cerianthid anemones on sand
SIMPER within cluster average similarity: 50.82%

Sample image



This cluster is characterised by the xenophyophore *Syringammina fragillissima* and Cerianthid anemones. Cluster H was recorded from depths of between 1,208.9m to 1,627.6m, with a mean depth of 1,347.88m (SD 160.65). Cluster H is primarily found on sand mixed with gravel, mud or occasionally pebbles. This cluster was recorded in 36 samples, and these were approximately evenly split between transects 'Dive 35' and 'Dive 37'. The best matching cluster identified from the video data was Cluster A. As with the previous biotope several xenophyophore dominated biotopes have been described previously from Rockall Bank, Anton Dohrn Seamount and the Darwin Mounds (Long *et al* 2010; JC60 data analysis). This biotope may be synonymous with cluster MB 'Xenophyophores and sea pens on gravelly sand and mixed substrate' recorded from Anton Dohrn Seamount (Long *et al* 2010). 'Xenophyophores and sea pens on gravelly sand and mixed substrate' was characterised by xenophyophores, halcampid anemones, cerianthid anemones and ophiuroids, video observation revealed the sea pen species including *Pennatula phosphorea* to be associated with this assemblage. It occurred on gravelly sand to mixed substrate, at a temperature of 3.8-9.2°C and a depth of 1,009-1,770m. Although some of the associated species of 'Xenophyophores and sea pens on gravelly sand and mixed substrate' (Long *et al* 2010) are not present in this assemblage, they may be similar enough to be considered one and the same. This assemblage is not recognised in Howell *et al* (2010), MNCR or EUNIS, but was described in Howell (2010) as "Xenophyophore fields". It is also recognised as a habitat and a VME by the UN General Assembly resolution 61/105.

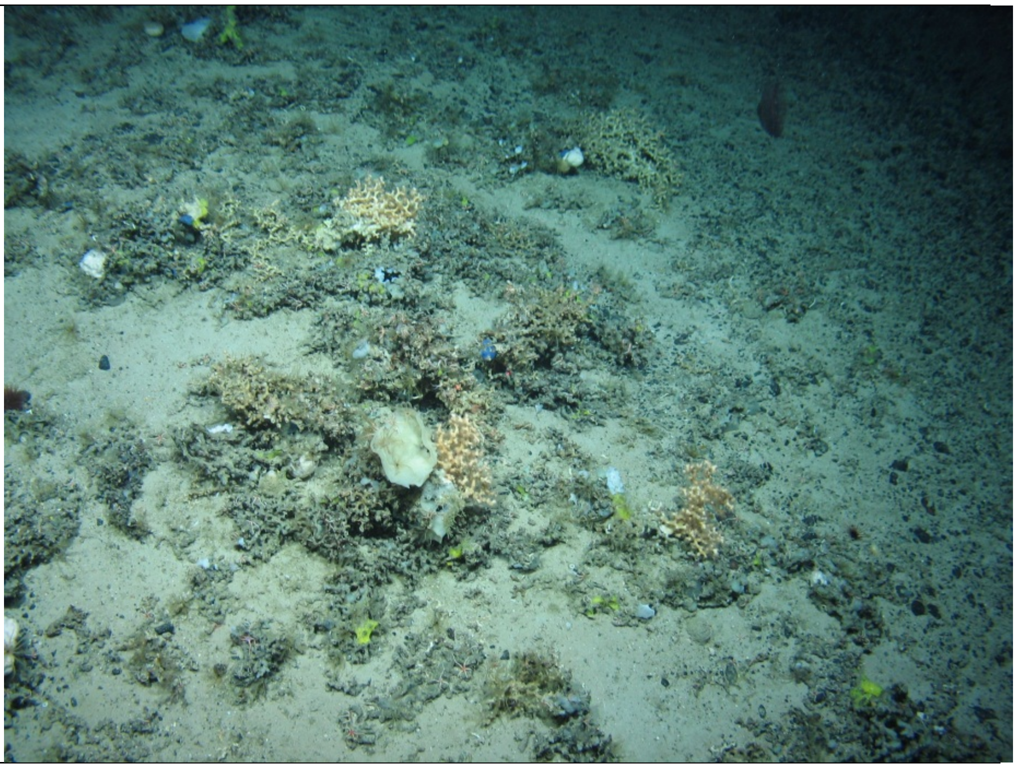
Cluster I: *Stichopathes cf. gravieri,* encrusting sponges, anemones, ascidians and cup corals on bedrock with sand veneer
SIMPER within cluster average similarity: 32.30%

Sample image	

This cluster is characterised by the antipatharian *Stichopathes cf. gravieri,* white encrusting sponges (Porifera encrusting grey/cream/white msp. 4), yellow encrusting sponges (Porifera encrusting yellow msp. 2), *Aphrocallistes* genus massive lobose sponges, Actinaria sp. 20 anemones, Ascididacea sp. 2 ascidians, Caryophylliids & Ophiuroidea. Cluster I was recorded from depths of 1,247.7m to 1,379m, at a mean depth of 1,311.36m (SD 42.7). This cluster was found on bedrock, occasionally with a veneer of sand. Cluster I was recorded on eight samples from both transects ‘Dive 35’ & ‘Dive 37’, with the majority of these from ‘Dive 37’ (62.5%). There was no equivalent matching cluster from the video data, and no previously described biotope that could be considered an equivalent although the species present have been observed on other banks and seamounts within UK waters.

Cluster J: *Solenosmilia variabilis* reef framework with crinoids, encrusting sponges, antipatharians on coral rubble framework and bedrock with patches of sand
SIMPER within cluster average similarity: 33.20%

Sample image



This cluster is characterised by *Solenosmilia variabilis* reef framework, Ophiuroid spp., the crinoids *Pentametrocrinus atlanticus* and Crinoidea sp. 8, Caryophyllidae spp., white encrusting sponges (Porifera encrusting grey/cream/white msp. 4), yellow encrusting sponges (Porifera encrusting yellow msp. 1), the antipatharian *Stichopathes cf. gravieri,* and the ascidian Ascidiacea sp. 2. Cluster J was recorded at depths of between 1,268.3m to 1,659.6m, with a mean of 1,509.30m (SD 88.40). This cluster is typically found on a coral rubble framework, which in turn is found upon hard substrate such as bedrock or cobbles, often with patches of sand. Cluster J was recorded from 28 samples, the vast majority of which were from transect 'Dive 35' (92%), with the remainder from transect 'Dive 37'. The best matching cluster identified from the video data was Cluster E. Cold water coral reef frameworks have been described from the region previously (Davies *et al* 2008; Howell *et al* 2010; Howell 2010; Long *et al* 2010) however the associated species and degree of framework structure present varies with depth and site. The assemblage described here may be equivalent to cluster D11 '*Lophelia pertusa*, soft corals and sponges on hard substratum and coral rubble' in Bullimore *et al* (2013), subsequently reanalysed as D7 '*Solenosmilia variabilis* reef' in Howell, (accepted) observed at an average depth of 1,229.1m and 1,327m respectively.

3.1.3 Biotope definition from video data

Seven significant clusters were identified at the greatest level of subdivision (p<0.01) on the randomly selected quarter sample of video sections following cluster analysis in PRIMER v6 (Figures 5 & 6). Visual assessment of this clusters suggested that there was no ecologically meaningful distinction between clusters B & C, so these were merged into a single cluster, BC. Cluster F was characterised on the basis of a relatively small unknown species, which it was not possible to identify due to insufficient resolution of the video data. The depth and substrate that Cluster F was found on overlapped considerably with other clusters. For these reasons it was not considered to be an ecologically meaningful cluster and was discarded. This resulted in a total of five clusters with which to define biotopes. SIMPER analysis confirmed the similarity of these clusters. A description and example image of each of these biotopes is provided in the following section.

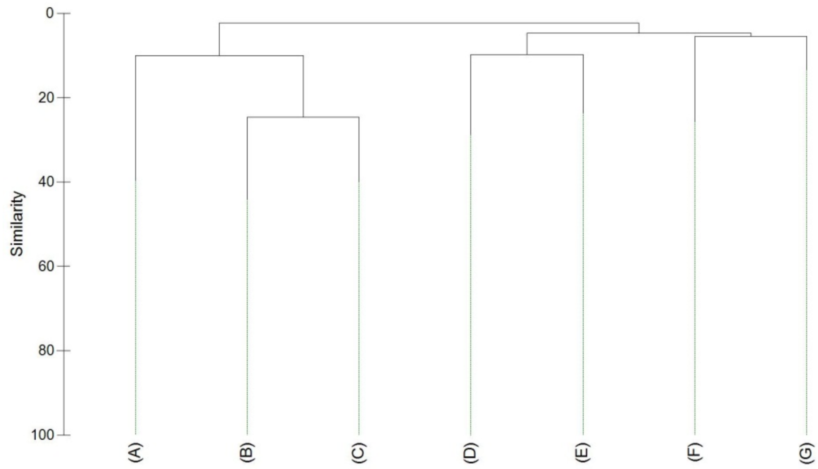


Figure 5. Collapsed dendrogram of statistically significant clusters identified by SIMPROF routine on video data.

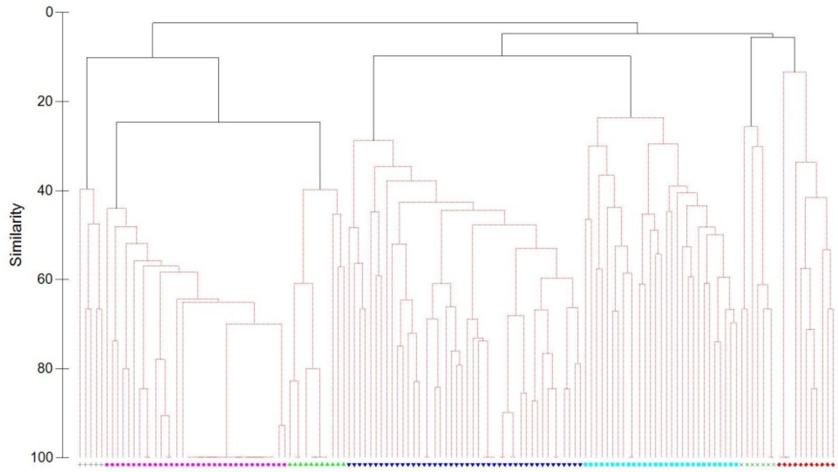
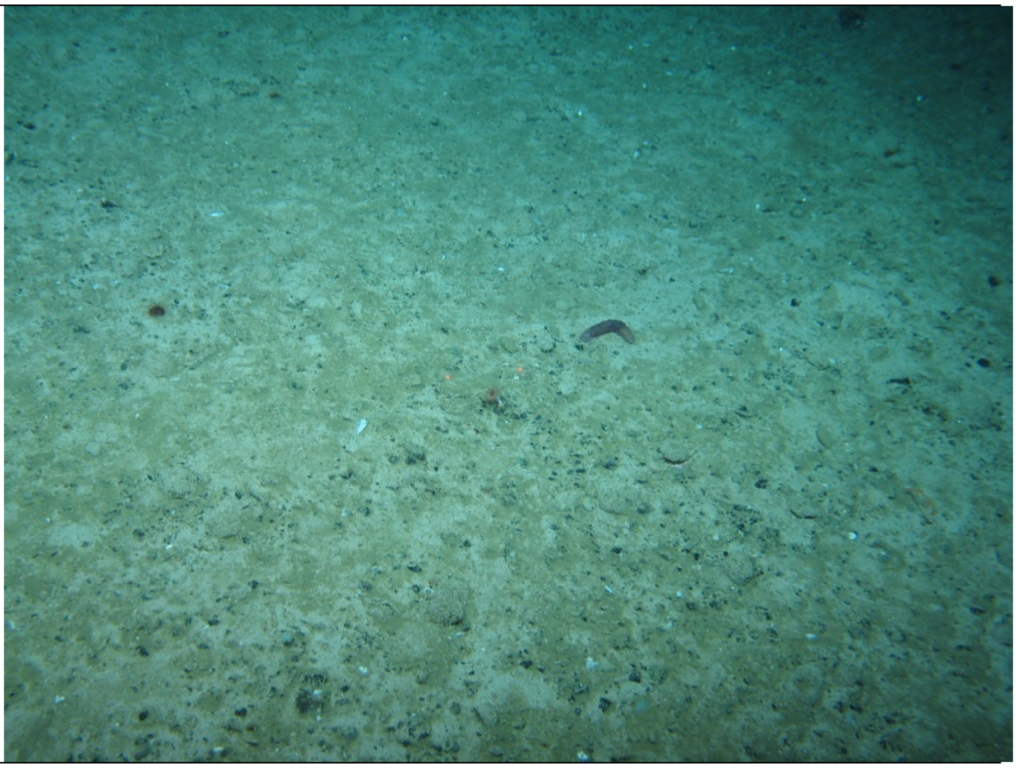


Figure 6. Expanded dendrogram of Hebrides Terrace clusters from SIMPROF.

Cluster A: *Laetmogone* sp. and asteroids on muddy sand
SIMPER within cluster average similarity: 48.19%

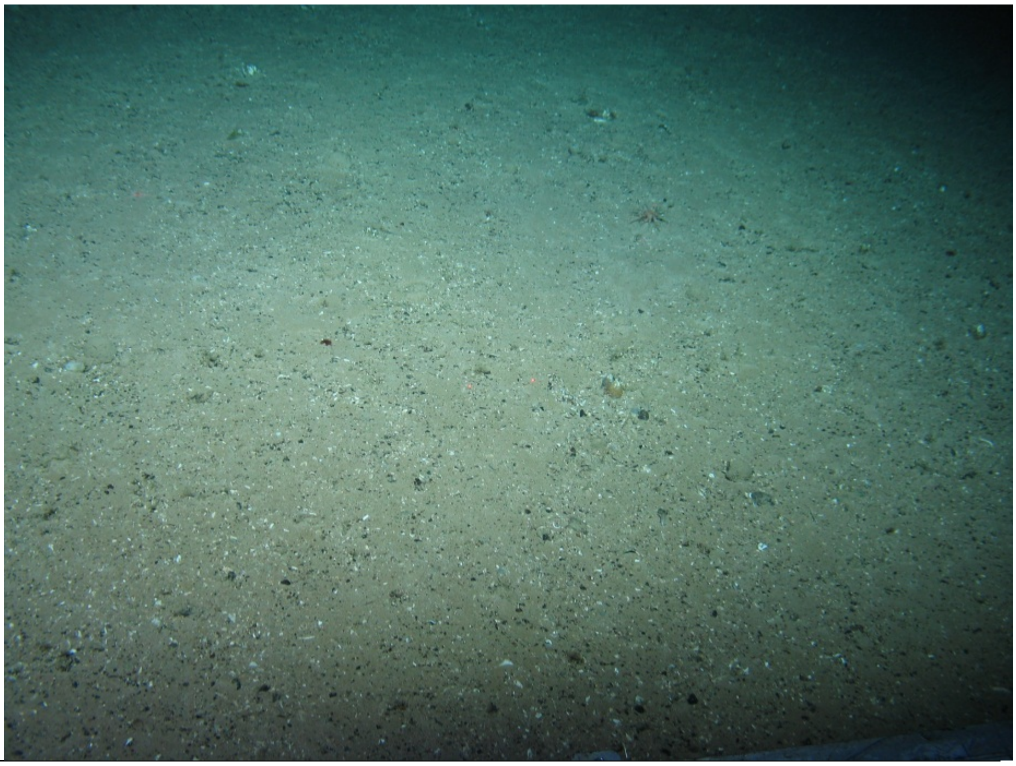
Sample image



This cluster is characterised by *Laetmogone* sp. holothurians and the asteroid *Henricia sanguinolenta*. The principal substrate is sand mixed with mud and occasionally pebbles. This cluster was recorded at depths of 1,259.7m to 1,627.8m, with a mean depth of 1,503.07m (SD 172.28). Cluster A was recorded on five samples; all from the 'Dive 37' transect. The best matching stills cluster is Cluster H. There is no equivalent biotope that has been described previously.

Cluster BC: Echinoids, anemones and crinoids on sand mixed with pebbles/gravel.
SIMPER within cluster average similarity: 67.23%

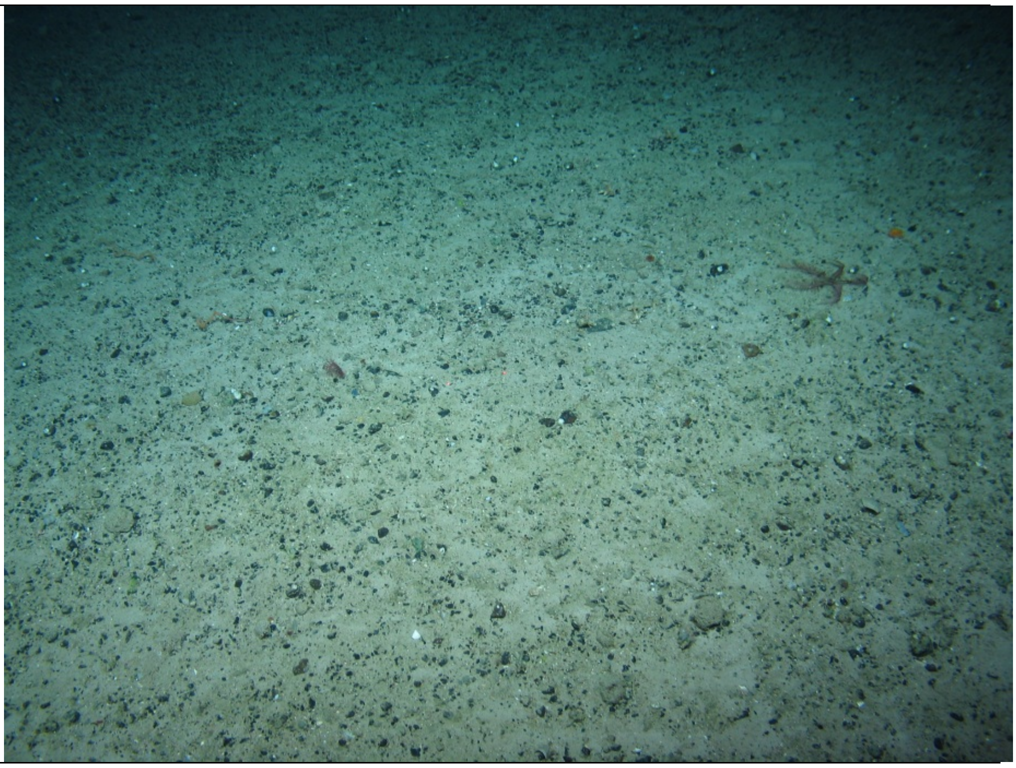
Sample image



This cluster is characterised by *Cidaris cidaris,* the actinarian anemones identified as Actinaria msp. 1, the crinoid *Pentametrocrinus atlanticus* and the echinoid Echinoidea sp. 1. This cluster was recorded between depths of 981m and 1,555.8m, at a mean depth of 1,154.96 m (SD 187.18). Cluster BC occurs principally on substrates of sand mixed with either pebbles or gravel. There were 45 video samples matching this biotope. This cluster was recorded on all three transects; with the majority of samples (47%) from transect 'Dive 36'. The best match for this cluster from the stills data is Cluster A. This assemblage does not resemble any previously described biotope but the characterising species have been observed at other banks and seamounts in the region.

Cluster D: Antipatharians, Crinoids and seapens on coarse sand mixed with pebbles and cobbles.
SIMPER within cluster average similarity 44.03%

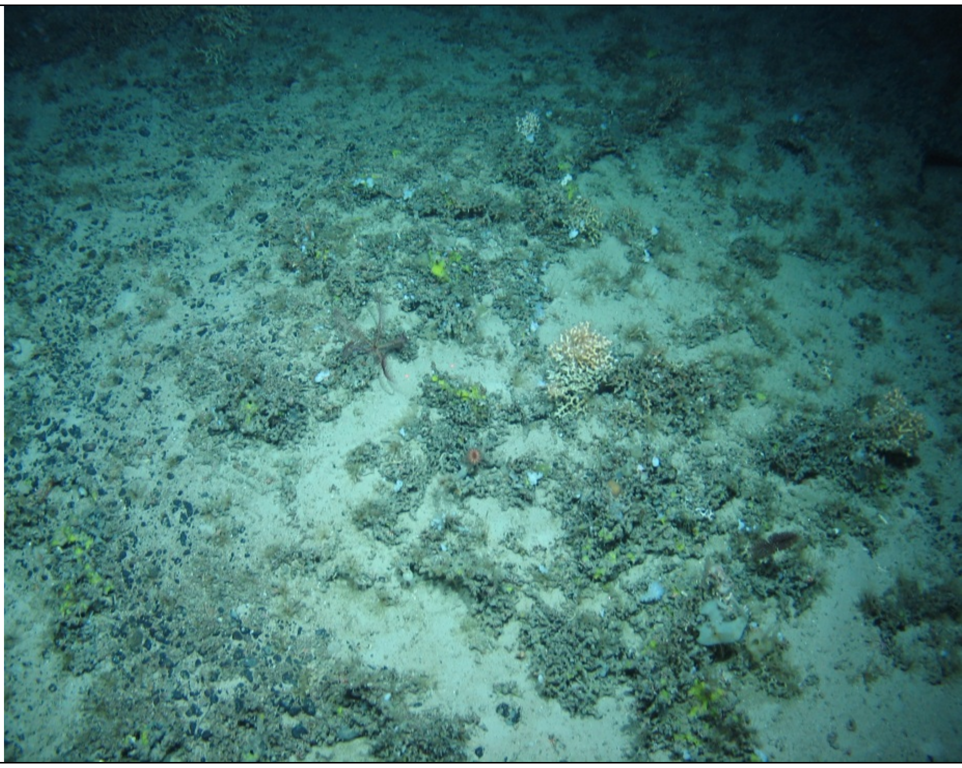
Sample image



This cluster is characterised by the antipatharian *Stichopathes* cf. *gravieri,* the crinoid *Pentametrocrinus atlanticus*, seapens of the genus *Halipteris*, the Holothurians of *Laetmogone* genus, the ophiuroid *Ophiomusium lymani* and the lamellate sponges identified as Porifera lamellate msp. 4. The cluster was recorded on samples ranging between 1,233.9m and 1,655.1m, at a mean depth of 1,529.89m (SD 108.76). The principal substrate for Cluster D is coarse sand, which is typically mixed with pebbles or cobbles, but in several instances was also mixed with mud. This cluster was recorded on 44 samples, all of which originated from the transect 'Dive 37'. The best match from the stills clusters is Cluster CDE. There is no previously defined biotope that is a close match for this one although the characterising species have been observed at other banks and seamounts in the UK deep-sea area.

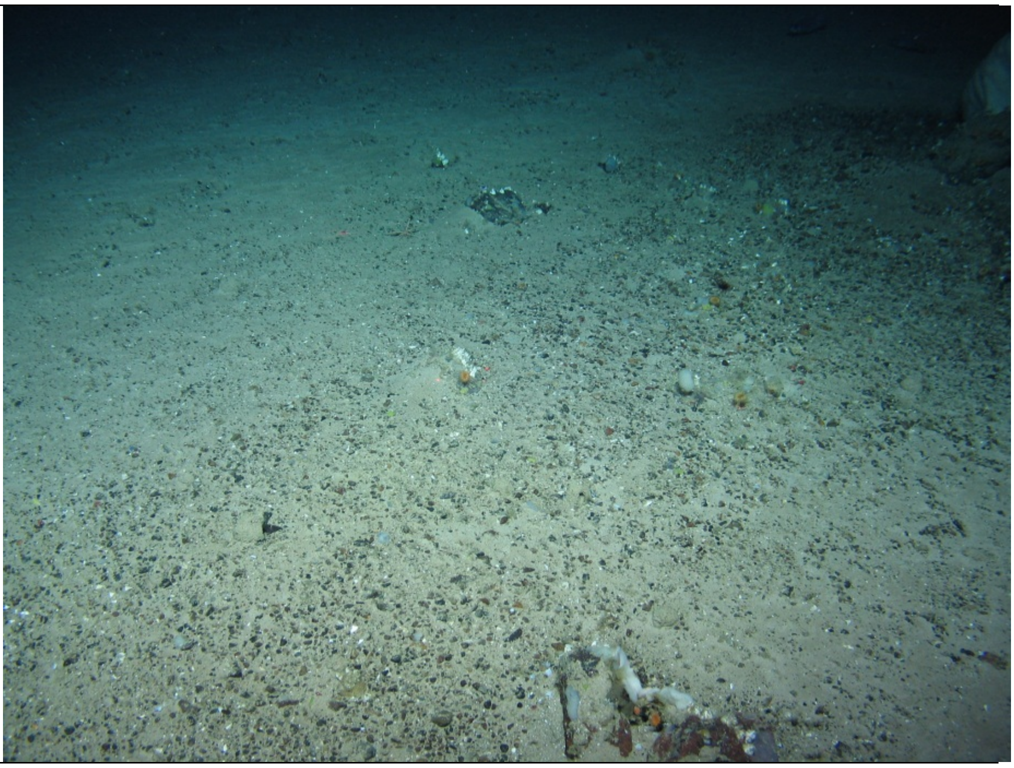
Cluster E: *Solenosmilia variabilis* reef framework with ascidians, lamellate sponges, echinoderms and octocorallia on coral rubble framework with underlying bedrock or cobbles
SIMPER within cluster average similarity 32.10%

Sample image:



This cluster is characterised by the scleractinian coral *Solenosmilia variabilis,* the ascidians identified as Ascidiacea sp. 2, the crinoid *Pentametrocrinus atlanticus*, various lamellate sponges (especially Porifera lamellate msp. 4), the brisingid starfish *Brisinga endecanemos, Halipteris* genus seapens, *Keratoisis* genus bamboo corals, and the antipatharian *Stichopathes* c.f. *gravieri*. This cluster was recorded at depths ranging from 1,238.2m to 1,643.3m, with a mean depth of 1,426.74m (SD 125.41). The principal substrate for Cluster E is either bedrock or cobbles, upon which is typically a framework of coral rubble. Patches of sand were also fairly common in this cluster. Cluster E was recorded on 29 samples originating from both transect 'Dive 35' and 'Dive 37', but was absent from transect 'Dive 36'. The best matching cluster from the stills clusters is Cluster J. As with Cluster J cold water coral reef frameworks have been described from the region previously (Davies *et al* 2008; Howell *et al* 2010; Howell 2010; Long *et al* 2010) however the associated species and degree of framework structure present varies with depth and site. The assemblage described here may be equivalent to Cluster D11 '*Lophelia pertusa*, soft corals and sponges on hard substratum and coral rubble' in Bullimore *et al* (2013), subsequently reanalysed as D7 '*Solenosmilia variabilis* reef' in Howell (accepted) observed at an average depth of 1,229.1m and 1,327m respectively.

Cluster G: Lamellate sponges & caryophyllids on sand mixed with gravel/pebbles and occasional boulders
SIMPER within cluster average similarity: 35.03%

Sample image	

This cluster is characterised by the lamellate sponge identified as Porifera lamellate msp. 4, the caryophyllid identified as Caryophyllia sp. 5 and urchins of the genus *Echinus*. The principal substrate consists of sand mixed with pebbles or gravel, and with occasional boulders. This cluster was recorded at depths ranging from 1,219.9m to 1,268.6m, with a mean depth of 1,245.28m (SD 20.42). Cluster G was recorded on 11 samples; predominantly from the 'Dive 35' transect, but also occurring on the 'Dive 37' transect. There was no equivalent cluster identified from the stills analysis. There is no equivalent biotope that has been described previously.

3.2 Mapping

Dive 35 began toward the base of the seamount at ~1,600m on the northern flank. Here an area of cold water coral reef was observed "*Solenosmilia variabilis* reef framework with crinoids, encrusting sponges, antipatharians on coral rubble framework and bedrock with patches of sand" interspersed with "Barnacles, antipatharians, and encrusting sponges on sediment draped exposed bedrock and mixed substrate". As the transect progressed up-slope further coral dominated communities were encountered "Antipatharians, crinoids and seapens on coarse sand mixed with pebbles and cobbles" before "Xenophyophore fields, echinoids, anemones, barnacles and crinoids on sand mixed with pebbles/gravel" were encountered. Further up slope the community composition reverted to coral dominated with a second area of cold water coral reef associated with an assemblage dominated by "Stichopathes cf. gravieri, encrusting sponges, anemones, ascidians and cup corals on bedrock with sand veneer" and ", "Lamellate sponges & caryophyllids on sand mixed with gravel/pebbles and occasional boulders". Toward the end of the transect at ~1,200m the community again changed to "Xenophyophore fields, echinoids, anemones, barnacles and crinoids on sand mixed with pebbles/gravel". Six biotopes were recorded from this transect, indicating substantial habitat heterogeneity. This should be qualified however, by noting that this transect covered the greatest distance (approx. 3,180m).

Dive 36 at the summit of the seamount consisted of a single biotope type "Barnacles, ophiuroids & *Cidaris cidaris* on pebbles with sand" (Figure 7).

Dive 37 began toward the base of the seamount's southern flank at ~1,620m where the dominant community was "Xenophyophore fields, cerianthid anemones, *Laetomogone* sp. and asteroids on muddy sand". As the transect progressed up the seamount flank coral communities were encountered including "Antipatharians, crinoids and seapens on coarse sand mixed with pebbles and cobbles", "Barnacles, antipatharians, and encrusting sponges on sediment draped exposed bedrock and mixed substrate", "Lamellate sponges and caryophyllids on sand mixed with gravel/pebbles and occasional boulders". A small area of cold water coral reef was encountered "*Solenosmilia variabilis* reef framework with crinoids, encrusting sponges, antipatharians on coral rubble framework and bedrock with patches of sand" before the dominant community again became "Antipatharians, crinoids and seapens on coarse sand mixed with pebbles and cobbles" interspersed with "Xenophyophore fields, echinoids, anemones, barnacles and crinoids on sand mixed with pebbles/gravel". Further up slope a second area of cold water coral reef was encountered and a community dominated by "Stichopathes cf. gravieri, encrusting sponges, anemones, ascidians and cup corals on bedrock with sand veneer". Toward the end of the transect at ~1,200m the dominate community was "Xenophyophore fields, echinoids, anemones, barnacles and crinoids on sand mixed with pebbles/gravel" (Figure 7). Of the eight biotopes defined for the entire seamount, seven were recorded from this transect, indicating substantial habitat heterogeneity. This transect was almost the same length as 'Dive 35', at 2,980m.

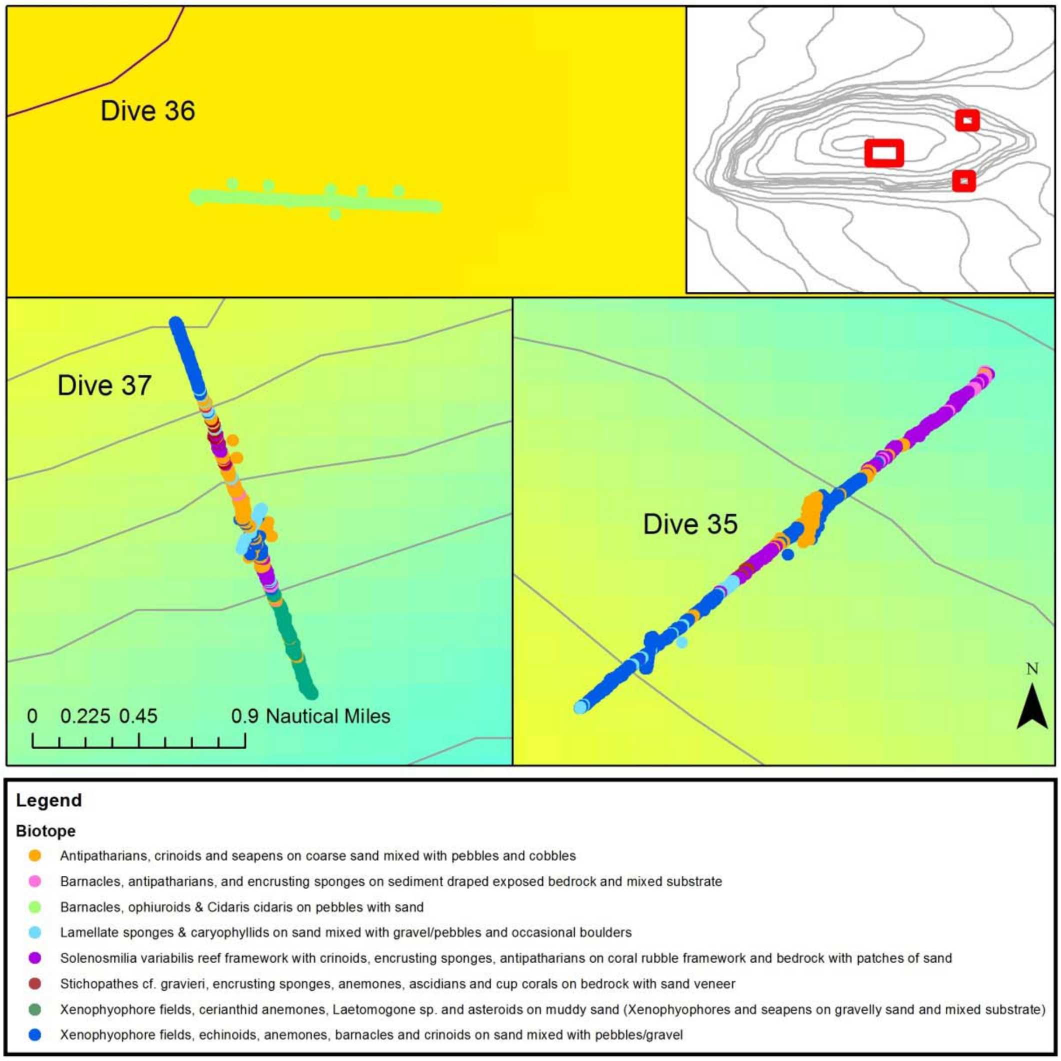


Figure 7. Biotope mapped video transects.

3.3 Final list of biotopes

Table 4. Final list of combined biotopes from still and video data.

Cluster	S/V	Final biotope name	SIMPER descriptive name	Substrate	Depth Range	Average depth (SD)	Characterising species/morphospecies
A_S	Still	Barnacles, ophiuroids & *Cidaris cidaris* on pebbles with sand	Cirripedia sp., Ophiuroids & Echinoids on pebbles with sand	Sand, pebbles, gravel	980.20 - 999	991.12 (4.03)	Cirripedia sp., Ophiuroidea sp.7, *Cidaris cidaris*
CDE_S	Still	Barnacles, antipatharians, and encrusting sponges on sediment draped exposed bedrock and mixed substrate	Cirripedia sp., Antipatharians, encrusting Porifera, Actinaria & Ophiuroidea on pebbles or cobbles with patches of sand	Exposed bedrock, mixed substrate	1441.40 -1661.6	1574.37 (74.15)	Cirripedia sp., Antipatharians, encrusting Porifera, Actinaria & Ophiuroidea
D_V	Video	Antipatharians, crinoids and seapens on coarse sand mixed with pebbles and cobbles.	Antipatharians, Crinoids and seapens on coarse sand mixed with pebbles and cobbles.	Sand, pebbles, cobbles	1216.60-1655.40	1444.36 (106.12)	*Stichopathes cf. gravieri*, *Pentametrocrinus atlanticus*, *Halipteris* sp., *Laetmogone* sp., the ophiuroid *Ophiomusium lymani*, Porifera lamellate msp. 4
G_S+BC_V	Still + Video	Xenophyophore fields, echinoids, anemones, barnacles and crinoids on sand mixed with pebbles/gravel.	Xenophyophores, Cirripedia sp., Echinoids, Actinaria and Crinoidea on sand mixed with pebbles/gravel.	Sand, pebbles, gravel	1208.50-1561.10	1328.99 (138.48)	Xenophyophores, Cirripedia sp., *Cidaris cidaris*, Actinaria msp. 1, *Pentametrocrinus atlanticus*, Echinoidea sp. 1
G_V	Video	Lamellate sponges & caryophyllids on sand mixed with	Lamellate sponges & caryophyllids on sand mixed with	Sand, gravel, pebbles,	1212.40-1506.20	1275.24 (82.89)	Porifera lamellate msp. 4, Caryophyllia sp. 5, *Echinus sp*.

		gravel/pebbles and occasional boulders	gravel/pebbles and occasional boulders	boulders			
H_S+A_V	Still+Video	Xenophyophore fields, cerianthid anemones, *Laetomogone* sp. and asteroids on muddy sand (Xenophyophores and seapens on gravelly sand and mixed substrate)	Xenophyophores, Holothurians and cerianthid anemones on sand, mud and gravel	Sand, mud and gravel	1522.20-1628.00	1597.19 (27.21)	Xenophyophores, cerianthid anemones, *Henricia cylindrella*
I_S	Still	*Stichopathes cf. gravieri*, encrusting sponges, anemones, ascidians and cup corals on bedrock with sand veneer	Antipatharians, Porifera, Actinaria, Ascidaceans & Caryophyllidae on bedrock with sand veneer	Bedrock, sand	1234.00-1390.80	1281.48 (41.19).	*Stichopathes cf. gravieri*, white encrusting sponges (Porifera encrusting grey/cream/white msp. 4), yellow encrusting sponges (Porifera encrusting yellow msp. 2), *Aphrocallistes sp.,* Actinaria sp. 20 anemones, Ascididacea sp. 2 ascidians, Caryophylliids & Ophiuroidea
J_S+E_V	Still+Video	*Solenosmilia variabilis* reef framework with crinoids, encrusting sponges, antipatharians on coral rubble framework and bedrock with patches of sand	*Solenosmilia variabilis* reef with Ophiuroidea, Crinoidea, encrusting sponges, Antipatharians, Ascidians and Caryophyllidae on coral rubble framework and bedrock with patches of sand	Coral rubble, bedrock, sand	1221.80-1660.70	1451.08 (115.56).	*Solenosmilia variabilis* reef, Ophiuroid spp., *Pentametrocrinus atlanticus*, Crinoidea sp. 8, Caryophyllidae spp., Porifera encrusting grey/cream/white msp. 4, Porifera encrusting yellow msp. 1, *Stichopathes cf. gravieri*, Ascidiacea sp. 2., Porifera lamellate msp. 4, *Brissinga endecanemos*, *Halipteris* sp., *Keratoisis* sp.

4 Discussion

4.1 Assessment of feature condition

JNCC has an obligation to report on the condition of Annex 1 habitats. As the next Article 17 reporting for the Habitats Directive is to take place in 2013, JNCC are particularly interested in data which can be used to assess the condition of Annex 1 habitats for the next reporting round.

With this in mind, the presence or absence of deep-sea trawling and marine litter was recorded from the Hebrides Terrace still and video data. Trawl marks were recorded on 15 of the 10m video sample sections, all of which were from the summit of the seamount. No trawl marks were recorded from the still image data. Figure 8 shows an example screen grab of trawl marks recorded on a video segment. No marine litter was recorded from the data.

Figure 8. Example of trawl marks recorded from seamount summit

4.2 Presence of Annex 1 habitat

Three of the final biotopes identified qualify as Annex 1 habitats (Bedrock reef, biogenic reef or stony reef). These are listed in Table 5.

Table 5. Final biotopes meeting Annex 1 criteria.

Cluster	Final biotope name	Annex I reef type
CDE_S	Barnacles, antipatharians, and encrusting sponges on sediment draped exposed bedrock and mixed substrate	Bedrock
I_S	*Stichopathes cf. gravieri*, encrusting sponges, anemones, ascidians and cup corals on bedrock with sand veneer	Bedrock
J_S+E_V	*Solenosmilia variabilis* reef framework with crinoids, encrusting sponges, antipatharians on coral rubble framework and bedrock with patches of sand	Biogenic

4.3 Distribution of habitats of conservation concern

At a very coarse scale all the habitats observed could be described as the MPA search feature 'Seamount Communities', since they occur on a seamount. In addition biotopes A_S, G_S+BC_V and H_S+A_V could also be classed as 'offshore subtidal sands and gravels' since they occur offshore and on subtidal sands and gravels.

At a community scale however, no assemblage of conservation concern was recorded at the seamount summit. While this could be a natural phenomenon, it should be noted there was evidence of trawling on the summit.

Habitats of conservation concern were identified on both the northern and southern flanks of the seamount. Cold water coral reef, here described as "*Solenosmilia variabilis* reef framework with crinoids, encrusting sponges, antipatharians on coral rubble framework and bedrock with patches of sand" was observed associated with two depth bands, at 1,350m and 1,500m. The reef areas observed in Dive 35 appeared to be of better quality than that observed in Dive 37 they were also the most extensive. It is likely that these depth bands are associated with fast currents either as a result of a slight increase in the slope of the terrain at these depths or as a result of geomorphological features that encircle the seamount feature. The rate of change of depth was greatest in these areas, inferring the steepest bottom topography. Without high resolution (>200m) multibeam it is impossible to conclude whether this is the case.

Fields of Xenophyophores were also observed on the seamount flanks. While not an SMPA search feature they are considered a Vulnerable Marine Ecosystem under United Nations General Assembly Resolution 61/105 and thus are noteworthy.

The presence of both Scleractinian coral reef and Xenophyophore aggregations broadly support the findings of predictive modelling studies for this region which found both habitats likely to be present on the flanks of the Hebrides Terrace Seamount (Ross and Howell 2012).

Areas of potential coral gardens "*Stichopathes cf. gravieri,* encrusting sponges, anemones, ascidians and cup corals on bedrock with sand veneer" were also observed on the flanks associated with the cold water coral reef area at 1,300m; and also in the depth band between the two coral reef regions "Antipatharians, crinoids and seapens on coarse sand mixed with pebbles and cobbles". It is at present unclear whether the densities of corals are sufficient to consitiute a coral garden.

No areas of sponge aggregations were observed.

4.4 Placing the Hebrides Terrace in the wider UK context

The assemblages observed on the Hebrides Terrace Seamount were similar to those observed on the neighbouring Anton Dohrn Seamount (Long *et al* 2010). However, many were newly described. This is most likely a result of the deeper depths sampled at this site compared to all other previous comparable studies of UK banks and seamounts, that have largely been restricted to depths <1,000m. The deep-sea fauna are well known to change continuously with depth. The only sites of comparable depth that have been similarly sampled are on Anton Dohrn Seamount, hence the similarity. However, sampling at this site is limited and thus it would be inappropriate to suggest there are no ecological differences between seamount/bank sites. The Hebrides Terrace Seamount has the deepest summit depth of all UK banks and seamounts and as a result may potentially have supported a quite different faunal assemblage to other banks and seamounts. However, the seamount also sits adjacent to the continental slope which supports a large deep-water trawl fishery. Fishing is known to occur on the seamount summit and thus the communities present are unlikely to be in an undisturbed state.

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6 Appendices

Presence of seabed habitats being used to underpin the selection of Nature Conservation MPAs

MPA Search Features	Component habitats / species	Scottish marine area	Areas/Transects Found
Coral gardens	Coral gardens	Offshore waters	Potentially observed in Dive 35 and Dive 37 Seamount flanks
Offshore subtidal sands and gravels	Barnacles, ophiuroids & *Cidaris cidaris* on pebbles with sand; Xenophyophore fields, echinoids, anemones, barnacles and crinoids on sand mixed with pebbles/gravel; Xenophyophore fields, cerianthid anemones, *Laetomogone* sp. and asteroids on muddy sand (Xenophyophores and seapens on gravelly sand and mixed substrate)	Offshore waters	Dive 36, Dive 35 (summit and Northern flank; Dive 35 and Dive 37 Seamount flanks; Dive 37 Southern Flank.
Seamount communities	Seamount communities	Offshore waters	Potentially all observations.

Scottish MPA project Mobile species

Search Features	Species name	Taxon group	Areas/Transects Found
Blue ling (A)	*Molva dypterygia*	Bony fish	n/a
Orange roughy (T%D)	*Hoplostethus atlanticus*	Bony fish	n/a
Sandeels	*Ammodytes marinus*	Bony fish	n/a

Annex 1 habitat	**Areas/Transects Found**	**JC073 Analysis Biotope Names**
Bedrock (A)	Dive 35 Dive 37	Barnacles, antipatharians, and encrusting sponges on sediment draped exposed bedrock and mixed substrate *Stichopathes cf. gravieri*, encrusting sponges, anemones, ascidians and cup corals on bedrock with sand veneer
Stony reef (B)	n/a	n/a
Biogenic reef (C)	Dive 35 Dive 37	*Solenosmilia variabilis* reef framework with crinoids, encrusting sponges, antipatharians on coral rubble framework and bedrock with patches of sand

Scottish MPA project low or limited mobility species

Scottish MPA Search Features	**Search Features/Priority species**			**Areas/Transects Found**	**JC073 Analysis Biotope Names**
Northern feather star aggregations on **mixed substrata**	Northern feather star	Species	*Leptometra celtica*	n/a	n/a
Deep sponge aggregations (A)	Glass sponge	Class	Hexactinellida	n/a	n/a
Deep sponge aggregations (B)	Giant sponge	Class	Desmospongia	n/a	n/a
Coral gardens (C)	Leather corals	Order	Alcyonacea	n/a	n/a
Coral gardens	Gorgonians	Order	Gorgonacea	n/a	n/a
Coral gardens	Black corals	Order	Antipatharia	n/a	n/a
Coral gardens (D)	Hard corals	Order	Scleractinia	n/a	n/a
Coral gardens (E)	Stony hydroids (lace or hydrocorals	Family	Stylasteridae	n/a	n/a
Coral gardens or Burrowed Mud (F)	Sea pens	Order	Pennatulacea	n/a	n/a