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Analysis of biological data from the JC060 survey of areas of conservation interest in deep waters off north and west Scotland

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Contents

1 Introduction

1.1 Survey Objectives

The JC060 cruise was the first, dedicated, deep-water habitat-mapping cruise of the MAREMAP initiative (UK Marine Environmental Mapping Programme). MAREMAP is an initiative aiming to promote integrated surveys by the following NERC organisations and partners: the National Oceanography Centre (NOC); the British Geological Survey (BGS); and the Scottish Association of Marine Science (SAMS), the University of Southampton, Channel Coastal Observatory, Plymouth University (PU), the Maritime and Coastguard Agency (MCA) and the Centre for Environment, Fisheries & Aquaculture Science (CEFAS). The MAREMAP cruise aimed to target four areas of study: the Darwin Mounds in the North Rockall Trough, East Rockall Bank Cliff habitats, the Hatton Basin polygonal faults and fisheries impacts on North-West Rockall Bank. Due to the common interest in the Darwin Mounds and Rockall Bank, JNCC agreed to financially contribute to the survey in order to enhance the pre-existing scientific research plan in order to obtain data and results suitable for management and policy needs. The survey took place from 9 May - 12 June 2011.

The overall objectives of the survey are outlined below:

1. To investigate the response of deep-sea benthic ecosystems to spatial and temporal variability in environmental parameters.
2. To increase the scientific knowledge towards the sustainable management of the deep ocean.
3. To investigate the formation of polygonal fault systems, and the potential association with fluid flow processes.

JNCC specific aims are outlined below:

1. To support NOC and PU objectives that lead to the collation of data and could be used to contribute to, or inform, the JNCC Marine Protected Sites (MPS) monitoring project.
2. To use data from the survey to provide advice to government on the favourable condition status of the Darwin Mounds Site of Community Importance (SCI)l, North-West Rockall Bank SCI and East Rockall Bank candidate Special Area of Conservation (cSAC).
3. To use data from the survey to underpin any site recommendation of East Rockall Bank Area of Search as a Special Area of Conservation.
4. To use data from the survey to provide advice to government on the long term monitoring plans for the Darwin Mounds SCI, North-West Rockall Bank SCI and East Rockall Bank cSAC.

1.2 Site Descriptions

Although six survey areas were visited on the JC060 survey, the Haddock Box and the East Shiant Bank survey areas are excluded from this report as they occur in Irish and territorial Scottish waters respectively.

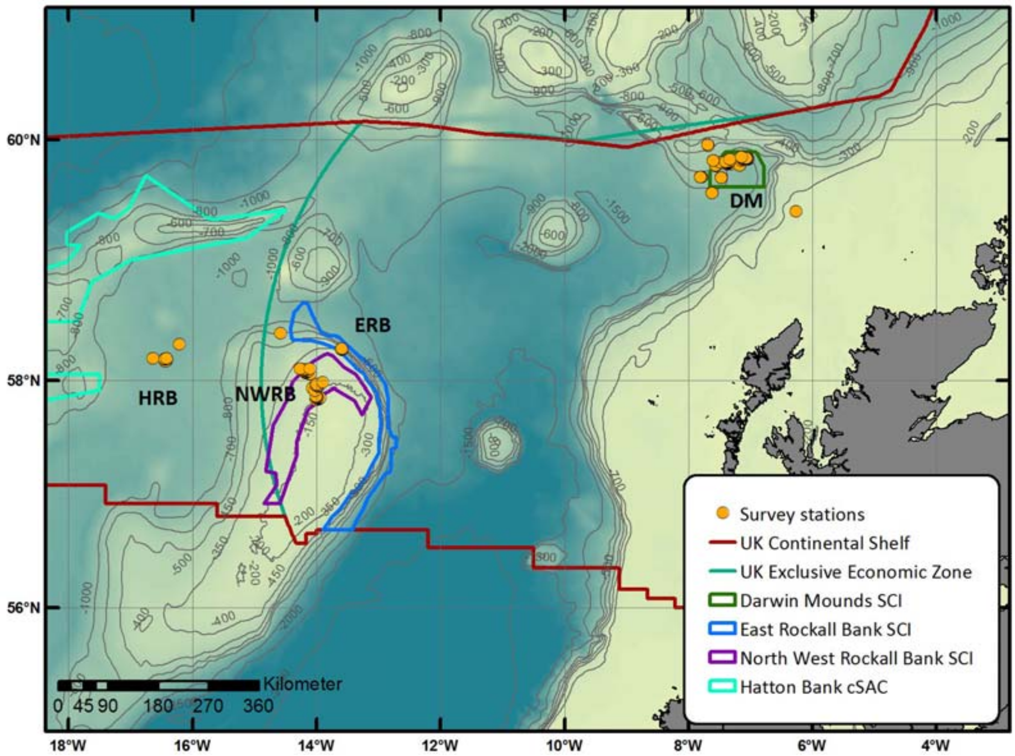


Fig. 1

Figure 1. Overview map of the study areas/sampling locations of cruise JC060. HRB: Hatton-Rockall Basin, NWRB: North-West Rockall Bank, ERB: East Rockall Bank and the DM: Darwin Mounds.

1.2.1 Darwin Mounds Site Description

The Darwin Mounds lie at the north end of the Rockall Trough at a depth of approximately 1000m (Figure 1). They are located beyond the shelf break, approximately 160km northwest of Cape Wrath, Scotland. They represent an extensive area of sandy mounds, each of which is capped with multiple thickets of *Lophelia pertusa*, a cold-water coral. These thickets qualify as Annex I Reef according to the European Commission interpretation (CEC, 2007). The number of thickets varies per mound and they may be between one and several metres wide and up to one metre high. Hundreds of mounds lie within the site, but two particularly dense fields of mounds are present to the northeast and northwest limit of the area (Bett *et al*, 2001). The mounds are up to 100m in diameter and 5m high, and distinguished by a 'tail' feature visible on sidescan sonar. The sandy tails of the mounds support significant dense populations of the xenophyophore *Syringammina fragilissima* (a 5-10cm diameter single-celled organism) (Bett *et al*, 2001). The occurrence of *Lophelia pertusa* reef as thickets capping sandy mounds is believed to be unique in UK waters, and may be related to particular geological processes that may have formed the mounds, offering the cold-water corals a settling ground (Masson *et al*, 2003). Alternative hypotheses have suggested that the sandy mounds formed through baffling of bedload transport by the coral framework (e.g. Wheeler *et al*, 2008; Huvenne *et al*, 2009). Long cores taken throughout some of the Darwin Mounds during JC060 will allow determination of the origin of the mounds with more certainty. The individual reefs on each mound provide a habitat for various species of larger invertebrates such as sponges and Brisingid starfish.

Emergency measures under the EU Common Fisheries Policy prohibiting ‘bottom trawl or similar towed nets operating in contact with the bottom of the sea’ were introduced in August 2003 and extended in February 2004, with a permanent prohibition introduced in March 2004 (De Santo & Jones, 2007). The boundary of the fishing restriction area is the same as that of the SCI.

1.2.2 Hatton-Rockall Basin Polygonal Faults Site Description

The Hatton-Rockall Polygonal Faults Structure (PFS) (Figure 1) was targeted primarily for investigation into the potential for fluid seepage at the site.

Sub-seafloor polygonal faulting is a widespread phenomenon affecting sedimentary basins worldwide (Cartwright *et al*, 2003). It is commonly believed that polygonal faulting is the result of sediment contraction and fluid expulsion. If, as suspected, active fluid expulsion is responsible for these features, then the composition and flux of this fluid will have a substantial impact on our understanding of the global ocean geochemical budget and carbon cycle. Recent investigations of the Hatton Basin have revealed an unprecedented region of polygonal structures that are, uniquely, exposed at the sea floor. Subsequent analysis of pre-existing seismic data reveals that these polygons occur within most of the Hatton Basin. They affect the top 500 to 700m of sediments and are the first seabed polygons of this size and clarity to be observed (Berndt *et al*, 2012). The fact that polygonal deformation in the Hatton Basin reaches the seabed suggests that the formation of the polygons is on-going.

1.2.3 East Rockall Bank Site Description

Rockall Bank is an offshore bank situated in the North East Atlantic, approximately 400 kilometres west of the Outer Hebrides (Figure 1). It is oriented northeast to southwest. Owing to sediment deposition on its flanks, the actual dimensions are difficult to determine, but at ~1000m water depth it is approximately 500 kilometres in length and 200 kilometres wide. Depth ranges from around 700m at the base of the cliffs along the eastern flank of Rockall Bank, to <200m across much of the top of the Bank. A rocky island outcrop around 25m wide and 20m high occurs at 57°35.8’N 13°41.3’W. On account of their sheer size, oceanic banks such as Rockall Bank cause the deviation of ocean currents along their flanks. This facilitates the colonization of habitat-forming corals that depend on a consistent supply of current-transported organic matter and zooplankton (Freiwald *et al*, 2004). Rockall Bank is potentially one of the most extensive sites for biogenic reef formed by cold-water coral species in UK waters.

The East Rockall Bank was identified as a cSAC in light of the presence of bedrock and stony reef within the Rockall Trough and Bank Regional Sea[1]. Previous survey has provided evidence of a rocky escarpment along the eastern side of Rockall Bank, however the data were not sufficient to delimitate the boundaries of this feature and further survey is required.

1.2.4 North-West Rockall Bank Site Description

The northwest area of the Rockall Bank (Figure 1) is covered in a layer of fine sediment, gravel, cobbles and boulders of glacial origin, some of which is shaped into characteristic ‘ploughmark’ formations gouged out by icebergs grounding on the seafloor during the last ice age (Sacchetti *et al*, 2012). These iceberg ploughmarks created a variant of Annex I stony

[1] East Rockall Bank is now a Site of Community Importance (SCI)

reef and consist of lines of cobbles and boulders with a sediment-filled furrow between (Howell *et al*, 2009). The associated biological communities are dependent on this mixed sediment and stony substratum, rather than on the underlying bedrock. Notable species include sessile fauna such as the erect bryozoan *Reteporella* sp., the solitary coral *Caryophyllia* sp, serpulid worms and many types of sponge including globose, tubular, cup and encrusting varieties. Squat lobsters (*Munida rugosa*), sea cucumbers (*Stichopus tremulus*) and the bluemouth red fish (*Helicolenus dactylopterus*) are also present (Howell *et al*, 2009).

Inter-dispersed with the stony reef are sizeable patches of Annex I *Lophelia pertusa* reef and associated species, including erect sponges and the pencil urchin *Cidaris cidaris*. Stands of *Madrepora oculata*, another cold-water coral species, are also present (Howell *et al*, 2009). Evidence from the 1970s suggests that areas of *Lophelia pertusa* reef up to 30m in diameter existed on the North-West Rockall Bank (Wilson, 1979; Davies & Roberts, 2006), though more recent surveys (albeit at different locations in this region) have recorded reefs smaller in size (Howell *et al*, 2009). Cobble rubble surrounds the living reefs in many places, and supports fauna such as the squat lobster *Munida rugosa*, the holothurian *Stichopus tremulus*, brittle stars and encrusting yellow sponges.

For the most part, the SAC follows the boundary of the EU Common Fisheries Policy and North East Atlantic Fisheries Commission demersal fishing closures (EC Regulation No 40/2008, NEAFC Recommendation IX-2008). This closure boundary was recommended by the International Council for the Exploration of the Sea (ICES) in 2005 (ICES, 2005), with further modifications proposed in 2007 (ICES, 2007). The demersal fishing closure was due to be in force until 31 December 2009 but has subsequently been extended.

2 Survey Design and Methods

2.1 Acoustic Acquisition Methods

Eight types of sonar data were collected during the cruise:

1. Autosub EM2000 Multibeam Bathymetry (111 beams, acquired @100m above seabed);
2. Autosub EM2000 Multibeam Backscatter (200kHz, @100m above seabed);
3. Autosub Edgetech Low frequency Sidescan (120kHz, @100m above seabed);
4. Autosub Edgetech High frequency Sidescan (410kHz, @15m above seabed);
5. RRS James Cook EM120 Multibeam bathymetry (101 beams) ;
6. RRS James Cook EM120 Multibeam backscatter (12kHz);
7. RRS James Cook EM710 Multibeam bathymetry (400 beams); and
8. RRS James Cook EM710 Multibeam backscatter (70-100kHz).

2.2 Acoustic Data Processing

Processing of the acoustic data was carried out in a variety of software packages. For the bathymetry data the commercial package CARIS HIPS v7.0 was used, but the backscatter information, together with the low-res and high-res sidescan sonar data were processed with the NOC in-house software Processing of Remotely Sensed Imagery for Seafloor Mapping (PRISM) v4.0 (Le Bas & Huvenne, 2009). Table 1 gives an overview of the different resolutions and data qualities obtained throughout the cruise.

The maps of different resolution were used to understand the spatial structure of the different terrains, and in some cases (specifically the high-resolution sidescan sonar maps) to create local physical habitat maps. In most cases the shipboard bathymetry data was of too coarse a resolution to provide much information with regard to actual biotope mapping.

Table 1. Overview of shipboard and Autosub (AS)-based bathymetry (Bathy), backscatter (Backs) and sidescan sonar (SSS) processing results. See Section 2.1 for the details of the eight types of sonar data collected during the cruise. M = Autosub Mission. ✓ = data was succeessfully collected. ✗ = an unsuccessful attempt was made to collect the data.

Area	Autosub Mission	Autosub EM2000 Bathy	Autosub EM2000 Backs	Autosub Edgetech Low frequency SSS	Autosub Edgetech High frequency SSS	RRS James Cook EM120 Bathy	RRS James Cook EM120 Backs	RRS James Cook EM710 Bathy	RRS James Cook EM710 Backs
Darwin Mounds						✓ (50m)	✗ poor		
	M37	✓ (1m)	✓ (1m)	✗					
	M38	✓ (2m)	✓ (1m)	✗					
East Shiant Bank								✓ (2m)	✓ (2m)
Darwin Mounds	M39	✓ (2m)	✓ (50cm)	✓ (50cm)					
	M40				✓ (20cm)				
Hatton Basin Polygonal Faults						✓ (50m)	✗ poor		
	M41	✓ (2m)	✓ (50cm)		✓ (50cm) (2cm)				
Haddock Box								✓ (20m)	✗ (2m)
East Rockall Bank	M42				✓ (20cm)				
North-West Rockall Bank								✓ (10m)	✓ (2m)
	M43				✓ (50cm)				
	M44				✓ (50cm)				
	M45				✓ (50cm)				
North- West Rockall Bank	M46 (repeatability survey)			✓	✓				
Darwin Mounds	M48				✓ (50cm)				

2.2.1 Autosub EM2000 Multibeam Bathymetry (111 beams)

A project was created for each area and data imported in CARIS HIPS. Initially zero tidal correction was used. A sound velocity profile was inputted, but the software was unable to cope with Autonomous Underwater Vehicle (AUV) depth and was therefore not used. The data was gridded using a BASE (Bathymetry Associated with Statistical Error) grid of 1 or 2m. Editing of the data for attitude, navigation and swath errors was done on the raw data, with 3D editing on geographical surface subset. The data was generally of good
quality, with little noise. However, cross-cutting tracks showed an offset of a couple of metres. This was assumed to be tidal variation and a graph was constructed of differences in height over time, which gave a reasonable tidal curve and this was applied.

2.2.2 Autosub EM2000 Multibeam Backscatter (200kHz)

Processing of the Multibeam backscatter was done in the PRISM software. Transfer of data to PRISM was done via the Neptune replay system which converts the Raw.all files to Proc format which can be read by PRISM. Unfortunately, the internal names in the Raw.all files were set to a single value
and thus conversion to Proc produced the same filenames for every file, i.e. overwriting them. Therefore each file had to be converted individually to Proc and then to CDF (PRISM format).

Navigation was extracted from the CDF files, and the map areas chosen with overlapping edges. Sonar processing and geometrical correction used a 45º course deviation factor for segments and either 1m or 50cm resolution. Overlap of coverage was eliminated by direction priority and range location parameters.

Results were collated in ERDAS Imagine and mosaiced into a single image. Overlapping map edges were feathered and thus removed minor radiometric differences that are otherwise visible to the human eye. Overall position of the resulting grid could be biased according to Autosub positioning offsets.

2.2.3 Autosub Edgetech Low frequency Sidescan (120kHz)

This was a new source of data. Data was slowly downloaded from the Autosub disks, typically taking about 6 hours per dive to download (about 2 minutes for 100Mb). The data files contain the low- and high-frequency sidescan data as well as the chirp sub-bottom profiler. The Edgetech Discover 4200-FS software was used to convert the .jsf format data into XTF format. This has the advantage of viewing the data whilst being converted. Occasionally the data conversion would pause for several minutes for no apparent reason and either then continue processing or jump to another file. Jumps in data were later found to be present and it is assumed that there is a data corruption in the original datafile, possibly missing bytes in the data structure.

Conversion of the sidescan is tempered by the gains set on the video display and thus were set to:

Low Freq: Gain 11dB TVG 1dB/100m

Low Freq: Gain 8dB TVG 5dB/100m (M46 onwards)

The XTF data were then converted into PRISM format (CDF). The original data have a sample rate of 3.456cm but as the ping rate was 2Hz (75cm) the data were averaged and subsampled by a factor of 5 to 17.28cm. Initially data files were given 4000 samples per side but later reduced to 2250 to reduce unnecessarily large filesizes.

Navigation was obtained separately from Autosub data files. It was found that there was a drift and offset of the Edgetech clock relative to the Autosub clock which had to be corrected. It could be calculated from start and end times or from matching features on the seafloor as seen by the sidescan imagery. Vehicle heading was not recorded in the data and thus track heading was used and swath direction was calculated to be perpendicular to this value. Vehicle altitude was also not available and was therefore measured from the first return.

Sonar processing and geometrical correction used a 45º course deviation factor for segments and a 50cm resolution. Overlap of coverage was eliminated by direction priority and range location parameters.

Results were collated in ERDAS Imagine and mosaiced into a single image. Overlapping map edges were feathered and thus removed minor radiometric differences which are otherwise visible to the human eye. The final mosaic was of very good quality for the resolution. Some interference, probably caused by the ADCP is visible at ranges beyond 100m but does not affect much of the data, and may be able to be removed with further investigation as it is symmetrical on both sides of the imagery.

2.2.4 Autosub Edgetech High frequency Sidescan (410kHz)

As mentioned previously in the Low frequency section these data were converted via the Discover 4200-FS software, though the gains used were:

High Freq: Gain 30dB TVG 7dB/100m

High Freq: Gain 25dB TVG 15dB/100m (M44 onwards)

The XTF data were then converted into PRISM format (CDF), and the rest of the processing sequence was very similar to that of the Low frequency EdgeTech data. The final mosaic was of excellent quality for the resolution. Many shadows were seen and thus vertical height of features can be calculated. Much of the imagery was processed at 50cm resolution for speed of processing but the data could be processed at a much higher resolution.

2.2.5 RRS James Cook EM120 Multibeam bathymetry (111 beams)

Processing was carried out in CARIS HIPS v7.0. A zero tidal correction was used. A sound velocity profile was inputted, and the data were gridded using a BASE (Bathymetry Associated with Statistical Error) grid of 50m. Editing of the data for attitude, navigation and swath errors was done on the raw data, followed by 3D editing on the surface subset. The data were generally of only moderate quality, with much noise and attitude induced variation.

2.2.6 RRS James Cook EM120 Multibeam backscatter (12kHz)

Processing of the Multibeam backscatter was carried out in PRISM in much the same way as the processing of the EM2000 backscatter. Only poor results were seen of virtually no value due to too much movement and noise in the watercolumn or under the ship.

2.2.7 RRS James Cook EM710 Multibeam bathymetry (400 beams)

Processing was carried out in CARIS HIPS v7.0, following the same method as the EM120 data. The data was of variable quality, which was very dependent on seastate and steered track. Tracks with headings about 45º from the seastate proved the best. In really poor weather the data was unusable.

2.2.8 RRS James Cook EM710 Multibeam backscatter (70-100kHz)

Processing of the Multibeam backscatter was done in PRISM, following the same method as described for the EM120 data. Results were generally of good quality.

2.3 ROV Stills and Video Acquisition Methods

Video and stills data were acquired using a SeaEye Lynx Remotely Operated Vehicle (ROV) equipped with manipulator tool skid, Kongsberg OE14-208 digital stills camera (plus spare) with 4GB storage, Kongsberg OE14-366 colour zoom camera, bathymetric unit and altimeter (Tritech SK700). The Kongsberg OE14-366 colour zoom camera was equipped with two
5Mw red scaling lasers. A supersub mini transponder was attached to both the ROV and Tether Management System (TMS) for each dive. The Kongsberg colour zoom and digital stills cameras were mounted on the ROV pan and tilt unit with a light strobe fixed to one side, angled for optimum seabed illumination. Fixed by a 10cm spacing bracket the red lasers
were piggy-backed onto the stills camera. The altimeter was attached at the vehicle front end 300mm up from the base of the ROV. For each dive, a single, standard definition video
source was recorded on DVCAM tapes and data from the ROV mounted bathymetric unit captured to text file. Post-dive, images were downloaded from the digital stills camera and together with digitised tapes, all data were backed up to hard disk.

2.4 ROV Stills and Video Analysis Methods

2.4.1 Image Analysis

i Image Cropping

Images were obtained with a Kongsberg OE14-208 camera at an oblique angle, and therefore have an underexposed area at the top of the image. This underexposed area, if quantified, represents the largest part of the image in terms of the seabed area it would display. This can represent a problem in quantitative image analysis, where the worst quality portion of the photograph represents the largest area of seafloor. To avoid this still frames are divided (with a horizontal division) and cropped (to a consistent image size) to remove the dark area of the image (Figure 2.) Example of image before cropping (left) and after (right) taken from 'problem' transect Dive 21 (IMG_9826). 2). This ensures that only the best quality portion of the image is analysed. This process is done automatically with a batch process.

Figure 2. Example of image before cropping (left) and after (right) taken from 'problem' transect Dive 21 (IMG_9826).

The exact area for cropping was calculated to allow all transects to be cropped to the same size. Problem transects were identified as those undertaken on the northeast Rockall Slope, due to the steep terrain, ROV camera angles were adjusted periodically for safety, while lighting angles stayed fixed. Different areas of cropping were trialed to allow the maximum number of images to be retained, whilst cropping the minimum area possible. This was then checked against all remaining transects under the same criteria.

The final crop removed the top 500pixels of every image, reducing image dimensions from 2592 x 1944 pixels to 2592 x 1444 pixels, constituting the top 25.7% of each image. Within problem transects 75% of images could be retained at this level of cropping, with a maximum gap of 2 minutes between acceptable images.

ii Image Scaling

As images do not always capture the same size area of seabed, images must be standardized to control for this variation in analysis. Two red lasers mounted above the camera at a set distance apart allow the width of the field of view (FOV) to be measured fairly accurately. However as camera angle, pitch and roll data were not available, the FOV area can only be estimated, and accurate scaling of animals was not possible.

Lasers were mounted at 10cm apart throughout the cruise so images could be scaled by measuring the distance between laser dots in pixels. The width of a pixel on the seabed can then be calculated (pixels between laser dots/ actual distance between lasers) allowing an accurate measurement of the width of the image on the seabed at the level of the pixels.

The width between lasers was measured in every clear image and an acceptable range of laser pixel widths agreed based on the ability to identify animals of 1cm size or greater, whilst still retaining as many images as possible. Altimeter readings were used to identify 'problem transects' (Polygonal faults Dive 14 was found to have the highest mean altimeter readings, Darwin mounds Dive 25 the lowest mean altimeter readings, while northeast Rockall dive 21 was on a vertical slope so altimeter readings were unreliable) which were used to generate recommended close and distant laser widths which could then be trialed with other transects.

Final agreed measurements were as follows:

Close up/ maximum width of lasers

- 259.2 pixels (equivalent to an image width on the seabed of 100cm)

Distant/ minimum width of lasers

- 115.2 pixels (equivalent to an image width on the seabed of 225cm) All

images found to have a laser width outside of these limits were discarded.

This scaling was used to standardise abundances at the point of cluster analysis to approximate abundance per metre squared.

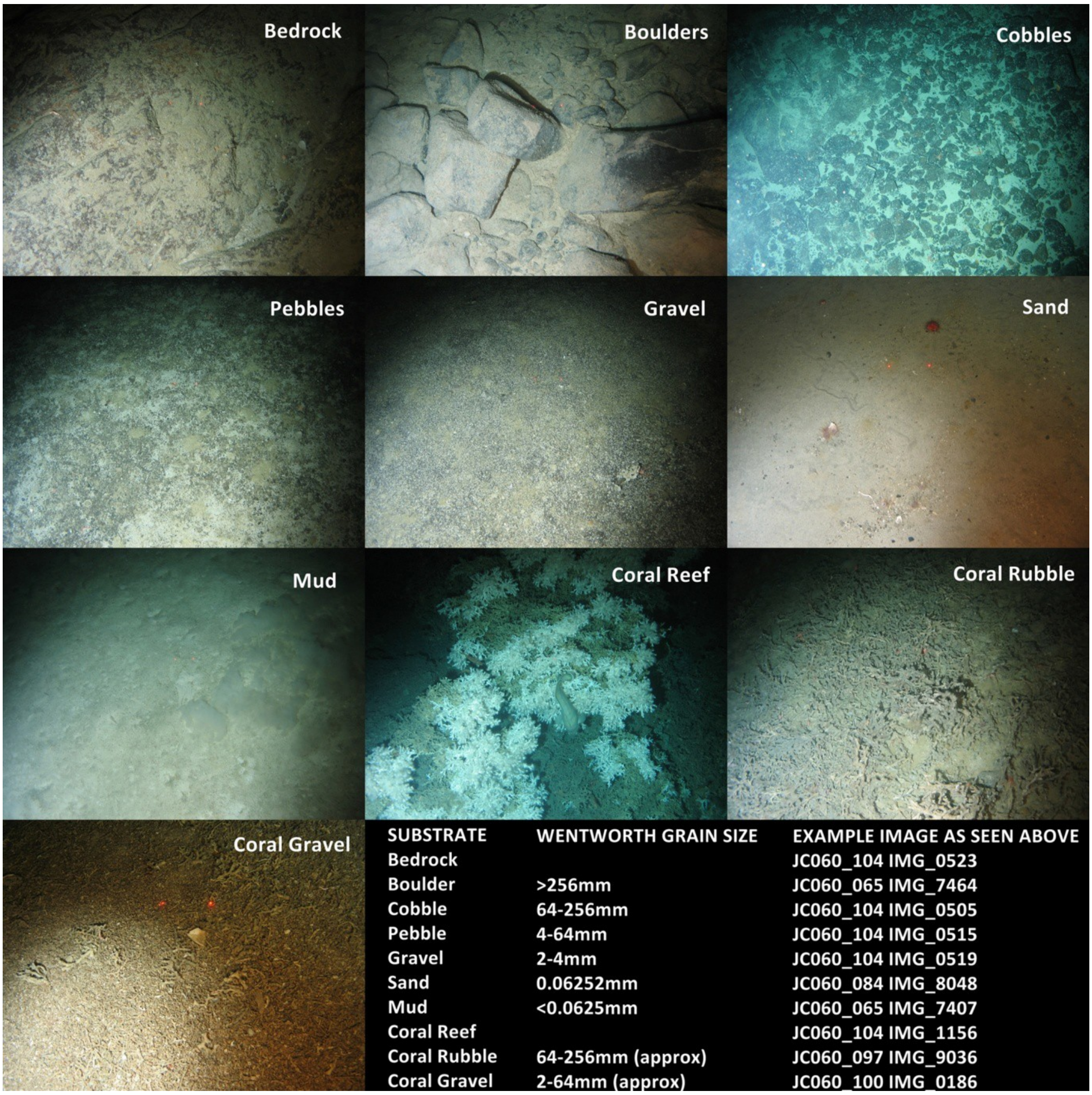
iii Quantitative Analysis of Images

Cropped images within the agreed laser width range were further assessed for distance separation, retaining only images which were one minute apart (or more) in order to reduce the instance of autocorrelation within each transect and to maintain as constant a distance apart as possible. (Dives 21 and 22 on the northeast Rockall escarpment were further spaced to two minutes apart as the ROV moved more slowly here due to the dangers of ascending underwater cliffs.) The resulting retained images were considered the sample dataset.

Each sample 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 (Figure 3).

Please note these substrates should be interpreted individually and not combined, e.g. in the event of Primary Substrate = Mud, Secondary substrate = Sand, this should not be interpreted as sandy mud. Image analysis is not capable of providing that level of detail and the recorded substrates were used in analysis to say ‘this community was found on mud’ but allows a tolerance for species associated with sand/muddy-sand/sandy-mud if there was doubt in the grain size. More often primary and secondary substrates will be recorded as, for example, ‘mud and boulders’, which helps determine why, for instance, the hard substrate associated holothurian *Psolus squamatus* is being found in a predominantly muddy area and in a mud associated community cluster.

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 Kerry Howell and Jaime 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.



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 3. 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.

Morphospecies are named according to the finest taxonomic resolution that can reliably be identified followed by species (sp) 1/sp.2 etc (e.g. Sabellidae sp.1 and Sabellidae sp.2). For especially difficult identifications it is sometimes only possible to consolidate individuals by morphotype (e.g. encrusting sponges are characterised by colour only). The species list compiled by analysis performed at NOC has also been assimilated into the Howell and Davies OTU catalogue for this project, and all species lists provided here show both the OTU number and the final species name agreed by both institutions.

2.5 Mapping

2.5.1 Defining biotopes

All data were standardised to abundance per square metre. Highly mobile species (fish) and unknown taxa were removed from the dataset prior to analysis. All zero samples were also removed. Cluster analysis was performed in PRIMER v.6. Data was transformed using a square root transformation, data clustering was then performed using group average linking, based on a Bray Curtis similarity matrix of transformed image sample data.

In the special case of the East Rockall Bank site where there was an extensive existing dataset the cluster analysis of the combined datasets required a more severe 4th root transformation to allow the combination of: (1) datasets obtained by different methods (Natura 2009 data was acquired using a towed camera system rather than an ROV) and (2) image analysis performed by different people (Natura 2009 data was analysed by Jaime Davies of Plymouth University). In addition and to compensate for (2) a quality assurance (QA) assessment of identified species in each dataset recommended that occasionally taxonomic resolution be coarsened in order to standardise for species not consistently resolved by the two image analysers (analysers: Jaime Davies and Rebecca Ross, e.g. two species of serpulid worm were sometimes confused, therefore the analysis grouped them into 'serpulidae' considering further resolution artificial). The JC060 dataset from this area was first analysed individually, then added to the Natura 2009 dataset (original analysis found in Long *et al* (2013)) for combined cluster analysis to ensure that previously defined biotopes remained relevant when assessed in the context of the full East Rockall Bank dataset

2.5.2 Video Analysis

The video is reviewed at x4 or x8 speed and mapped using biotopes defined by cluster analysis of image data. The video footage also provides the PRIMER defined biotopes with ground-truthing, confirming or altering the definitions as characterised by the image samples. Any additional biotopes encountered are assessed by eye and mapped to each transect accordingly. Habitat sections of insufficient length (<2mins in duration) are not recorded as separate habitats.

2.5.3 Mapping

i Darwin Mounds

The biotope information obtained from the photo/video analysis was overlain onto the AUV-based acoustic maps, and a very good correlation with the high-resolution sidescan sonar data was found. As those maps provide more detail than can accurately be presented in a manually drawn (i.e. 'by eye') geometrical polygon-based interpretation map, it was decided to keep the original sidescan sonar data as a background to the biotope-mapped transects. Further research into automated habitat mapping techniques is currently underway, in an attempt to preserve the sidescan sonar-based detail into the interpretation maps, while in the meantime providing an automated and objective method for this task. However, this is on-going research, and until sufficient confidence in those methods has been achieved, it was preferred not to present those maps for management purposes.

ii Polygonal Faults

An existing substrate interpretation map of this area developed by a masters student at Plymouth University was found to be inadequate for the task of producing a habitat map for the area. For the purposes of this study the biotope mapped video was overlain on existing bathymetry, data collected as part of the DTI SEA7 2005 surveys on the Kommander Jack (Jacobs, 2005), in order to visualise biotope distribution within the area of sampling. No predictive modelling was undertaken as the data were not sufficient to do so.

iii East Rockall Bank

Biotope mapped transects were overlaid on the existing biotope/substrate map for East Rockall developed by Heather Stewart and Jaime Davies as part of the JNCC/BGS/UoP 2009 survey of East Rockall (see Long *et al*, 2013), and compared for congruence. On-going work (Piechaud *et al*, in press) using random forest predictive modelling will shortly provide much improved maps for the area.

iv North-West Rockall Bank

The biotopes observed were overlain onto sediment interpretation maps based on the AUV sidescan sonar backscatter maps. The sediment interpretation was the result of an unsupervised classification which used mean backscatter, average grey level difference, and variance within a 9x9 pixel moving window. Each pixel was assigned to one of six classes: soft, mixed or hard substratum, coral stand or rubble, and exposed bedrock. The classification was based on the approach developed by Huvenne *et al* (2002). Sediment patches of less than 12 pixels were filtered out and assigned to the sediment class represented by the majority of neighbouring pixels.

2.6 Data Quality Assurance/Quality Control (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. In this study two organisations (NOC and Plymouth University) and three individuals were involved in the analysis of data. In order to avoid problems of observer bias, all images from a single site (e.g. Darwin Mounds, Hatton-Rockall Basin, East Rockall Bank or North-West Rockall Bank) were analysed by the same observer. Multivariate analysis was then undertaken on a site-by-site basis and not on the combined dataset. 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 quality assurance/quality control (QA/QC) of the interpreted datasets. In this study, QA of the image data was undertaken according to the following methods. Five percent of images analysed by each individual were chosen at random, by transect and formed the QA/QC dataset. The QA/QC dataset was reanalysed by Dr Kerry Howell at Plymouth University and analysis results compared on an image-by-image basis for misidentification and inconsistency in identification of taxa.

In addition, JNCC required the dataset delivered to be a combined dataset suitable for a combined analysis. Therefore in order to overcome problems of observer bias, each observer re-analysed the part of the QA/QC dataset that constituted others work, and analysis results were compared by Dr Howell on an image-by-image basis for inconsistency in identification of taxa. Where taxa had been inconsistently identified between observers, the taxa were merged into a new grouping that in some cases represented a higher taxonomic level, in other cases represented a morphologically or functionally similar grouping. No formal analysis of QA analysis results was undertaken as there are no established methods for making such comparisons that would be useful in this case.

3 Results

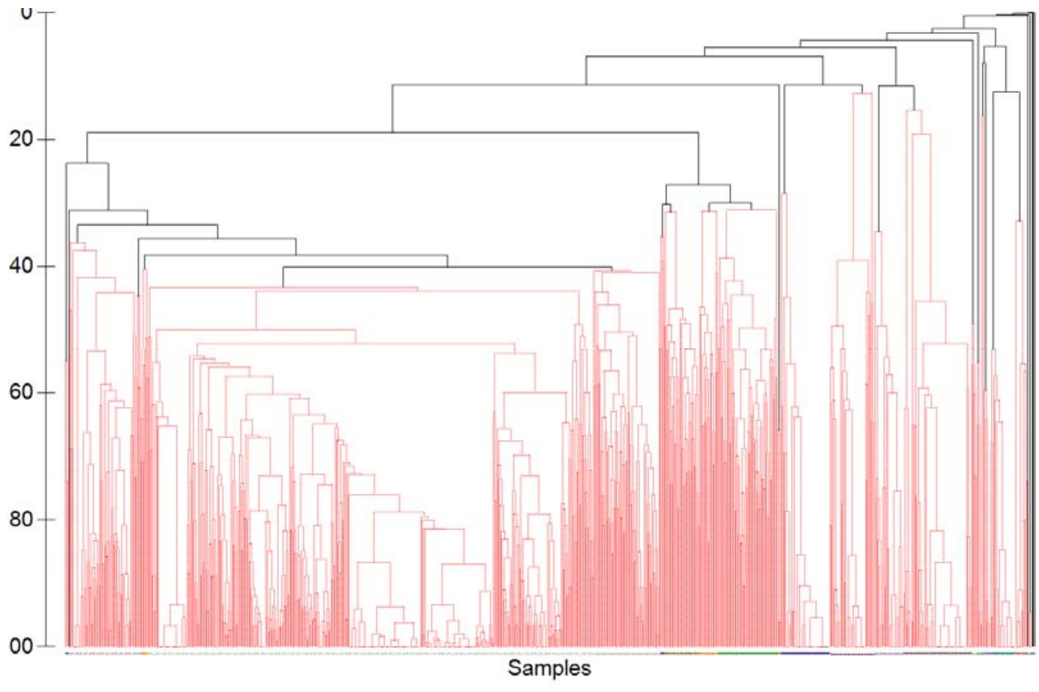
3.1 Darwin Mounds Results

Eight transects were achieved during the JC060 cruise in the Darwin Mounds area with seven providing usable still images. After image cropping, laser scaling, selection for clarity and presence of living fauna, and one minute spacing, 931 images were used in cluster analysis. Seventy-six images lacked temperature measures.

3.1.1 Defining biotopes

SIMPROF tests for evidence of structure in an a priori unstructured set of samples (Clarke & Warwick, 2001). SIMPROF was used to identify 27 statistically significant faunal groupings within the data set (Figure 4) (labelled (A) – (V) and t, e, c, b and a). Five faunal groupings (t, e, c , b and a) were outliers (single images that had a very low similarity to all other groups) and were excluded, five faunal groupings (A, C, K, R and V) were excluded because they contained three or less images, and three more faunal groupings (Q, P, and S) were excluded because they shared a low level of similarity with any other clusters but could not be considered as a different biotope for biological reasons. One group containing four images (G) was kept because it formed a relevant cluster with another significant faunal grouping (H), thus, the two (sharing a high similarity level) were considered as a single cluster (GH).

(A)



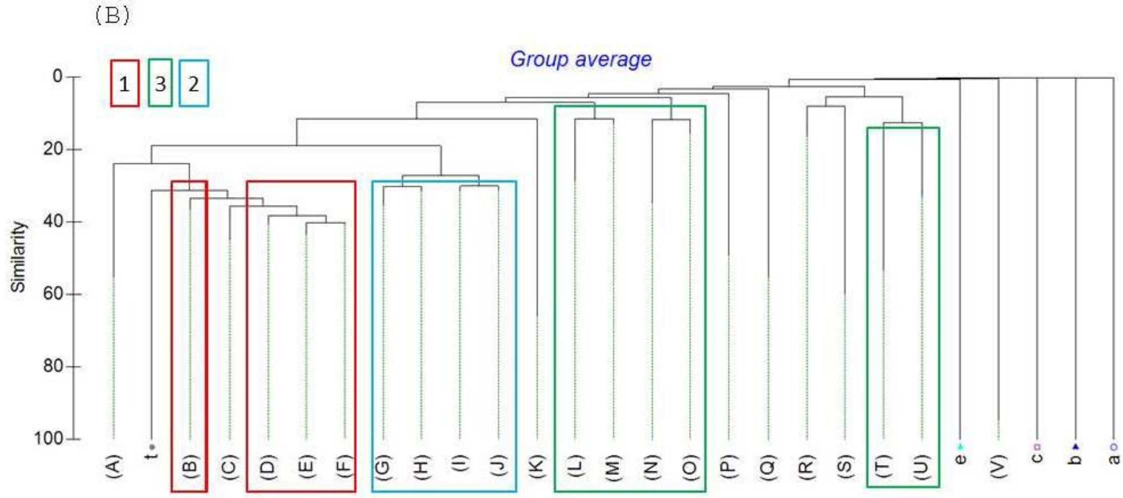


Figure 4. Darwin Mounds cluster dendrograms. The raw dendrogram (A) shows the red SIMPROF groups considered statistically significant clusters (p <0.05). Outliers were then excluded and SIMPROF groups collapsed to give the cluster groupings shown in (B) the final dendrogram.

Thirteen clusters (B, D, E, F, GH, I, J, L, M, N, O, T, U) were considered as relevant biotopes and described as such (see Appendix 1). However, attempts to map these clusters by eye to video data, suggested these faunal groupings were a result of small variations in qualitative and quantitative community composition that were difficult or even impossible to be correctly determined by eye. Since the purpose of the cluster analysis is to guide the definition of biotopes to an appropriate level of resolution so as to identify units for mapping at an appropriate scale, clusters identified by SIMPROF were grouped at a lower level of similarity (approximately 35%). By doing this, it was possible to provide mapping units that were representative of broader scale variation in benthic biological assemblages. As such the final biotopes consisted of clusters BDEF, GHIJ, and LMNOTU. LMNOTU is a grouping of distantly related clusters composed of images on soft sediment with very few species present. It does not form a coherent biotope but the separate entities could not be distinguished by eye in video interpretation. Thus LMNOTU is best considered as a substrate class rather than a biotope and has not been described below.

i Biotope Descriptions

a Cluster BDEF

Biotope Name: Xenophyophore fields

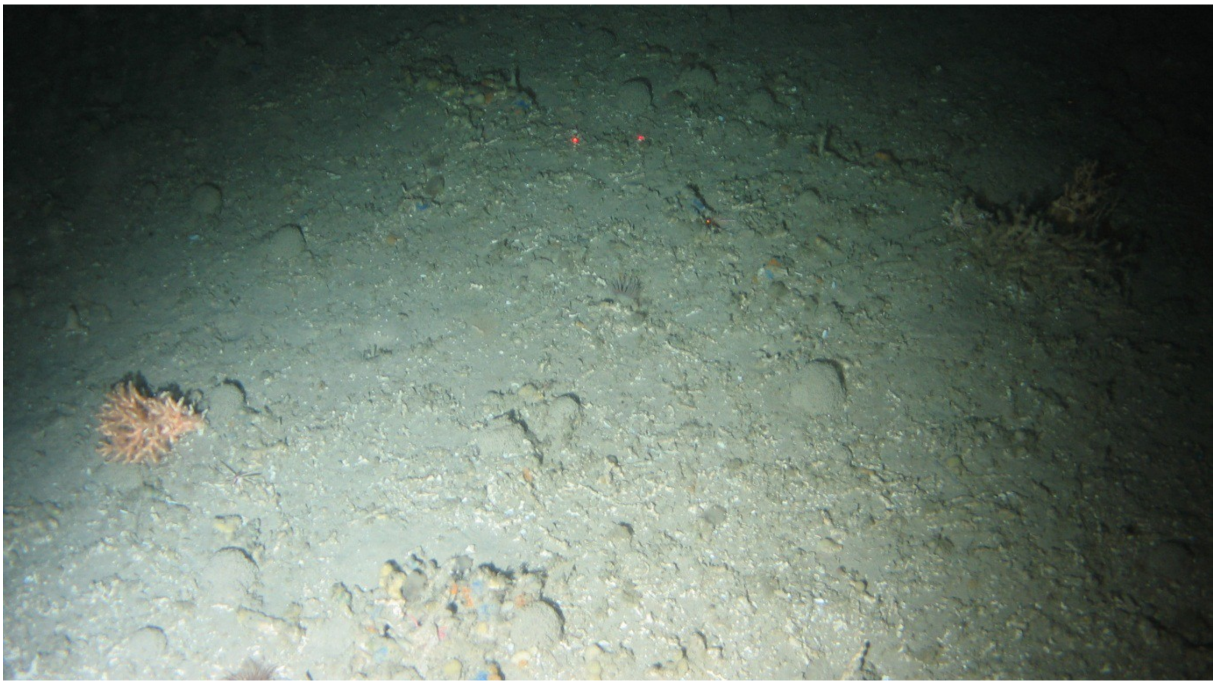
JC060 SIMPER descriptive name:
Xenophyophores on soft sediment
SIMPER within cluster similarity: 49.5%

Characterised (based on 564 images) by Xenophyophores (*Syringammina fragilissima*) on sand 937-1070m water depth, at an average temperature of 7.62 °C. Many other species are present in this group, but none contributing to total variation at more than 2.2%. The substrate can be sand or coral rubble among sand.

b Cluster GHIJ

Biotope Name: *Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand

JC060 SIMPER descriptive name:
Xenophyophores and epifauna on coral rubbles and sand
SIMPER within cluster similarity: 35.08%



Characterised (based on 113 images) by a xenophyophore (*Syringammina fragilissima*) and a complex and diverse fauna associated to coral rubbles, dead coral frames and living corals (no reef was observed though), including white encrusting sponges, halcampid anemones (*Halcampoididae sp.1*), sheltering ophiuroids (*Ophiactis balli*), squat lobster (*Munida tenuimana*), yellow encrusting sponges, blue encrusting sponges, burrowing anemone (*Cerianthidae sp.1*), orange encrusting sponges, small crabs (*Majidae sp. 1*), small colonial octocorals (*Octocorallia sp. 2*) on coral rubbles and sand between 942–1052m water depth at an average temperature of 7.96 °C. The major substrate is coral rubble of various sizes and in rare cases living corals on sand. This biotope is similar in composition to the 'Highly sediment draped scattered coral framework' described in Howell *et al* (2010) from the South West Canyons and Hatton Bank from a depth of 519–942 and average temperature of 8.65 (0.89 SD). Given the current status of the Darwin Mounds, it is recommended that this is considered a separate biotope until a comparative analysis can be undertaken.

3.1.2 Maps

The biotopes identified from the video and photo analysis were mapped on the AUV-based bathymetry, backscatter and sidescan sonar maps. There is a clear correlation between the biotope '*Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand' and the mound features in the acoustic maps (Figures 5–7). However, some scattered coral fragments are also found in the eastern Darwin Mounds, which can only be identified on the highest resolution sidescan sonar maps (Figures 8–11). The Biotope 'Xenophyophore fields' seems ubiquitous in the eastern Darwin Mounds, but very limited in the western area, where it mainly occurs on the outer edges of the mounds. The association between this biotope and the mound 'tails' identified in sidescan sonar maps of the western Darwin Mounds, as reported by Masson *et al* (2003) or Bett *et al* (2001) only seems to hold in a limited number of cases. Apart from this, the western Darwin Mound area is mainly characterised by the biotope (or rather substratum class) 'Scarce fauna on sand' (corresponding to cluster LMNOTU (Figures. 5–7).

The difference between the two areas is probably related to the difference in water-current regime and resulting sediment grain size. The sands in the western Darwin Mounds are finer-grained, and well sorted, and probably more mobile, while the eastern Darwin Mounds area is characterised by coarser sands and a higher amount of pebbles and boulders (Wheeler *et al*, 2008, Huvenne *et al*, 2009). In addition, the eastern Darwin Mounds have experienced a much higher intensity of bottom trawling (Huvenne *et al*, 2012), resulting in a higher amount of scattered coral fragments spread over the sandy seabed.

The maps presented in Figures 7 and 10 clearly demonstrate that, although the mounds can be identified from old TOBI sidescan sonar records (Masson *et al*, 2003) and AUV EM2000 bathymetry and backscatter data, the fine details (e.g. scattered coral) can only be identified from the highest resolution AUV sidescan sonar maps. Given the detail in these maps, and the clear correlation between mounds and high-backscatter targets and the '*Lophelia pertusa'* biotope, it was decided not to convert the sidescan sonar data into a polygon biotope map, as this would reduce the information content.

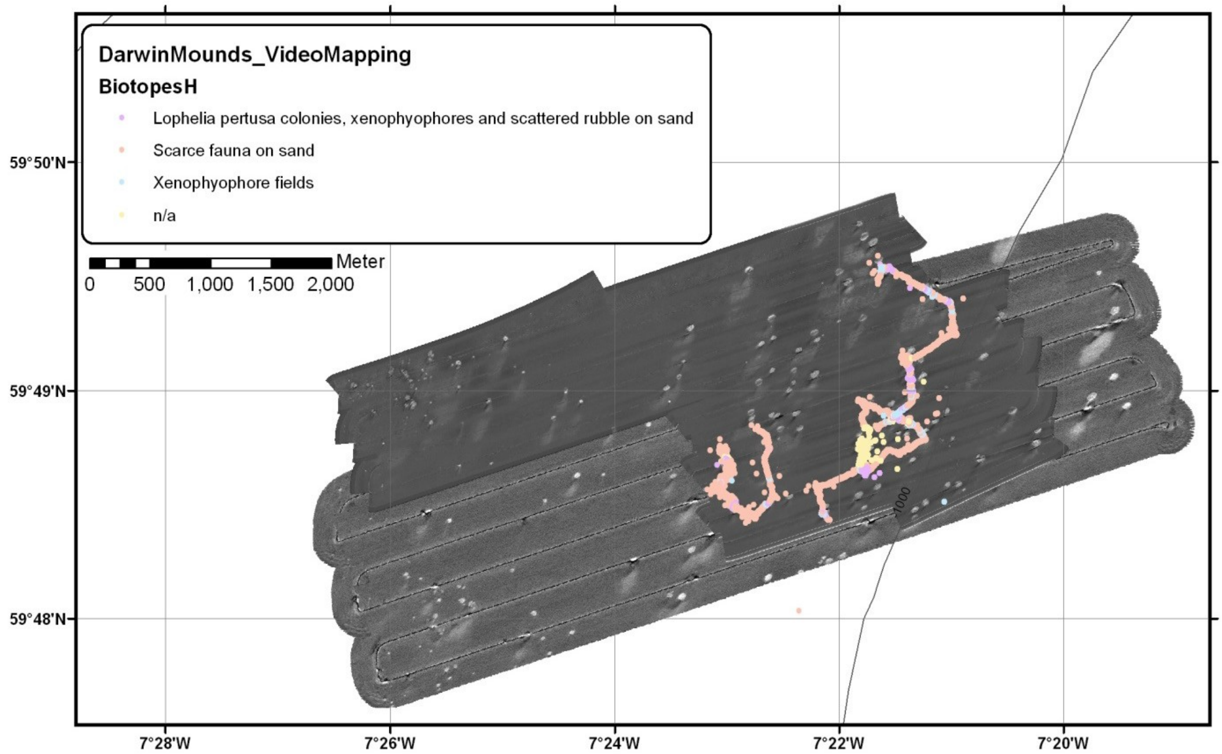


Figure 5. Darwin Mound Biotopes mapped out over the AUV-based backscatter data (background) and high-resolution sidescan sonar data (foreground) of the western Darwin Mound field.

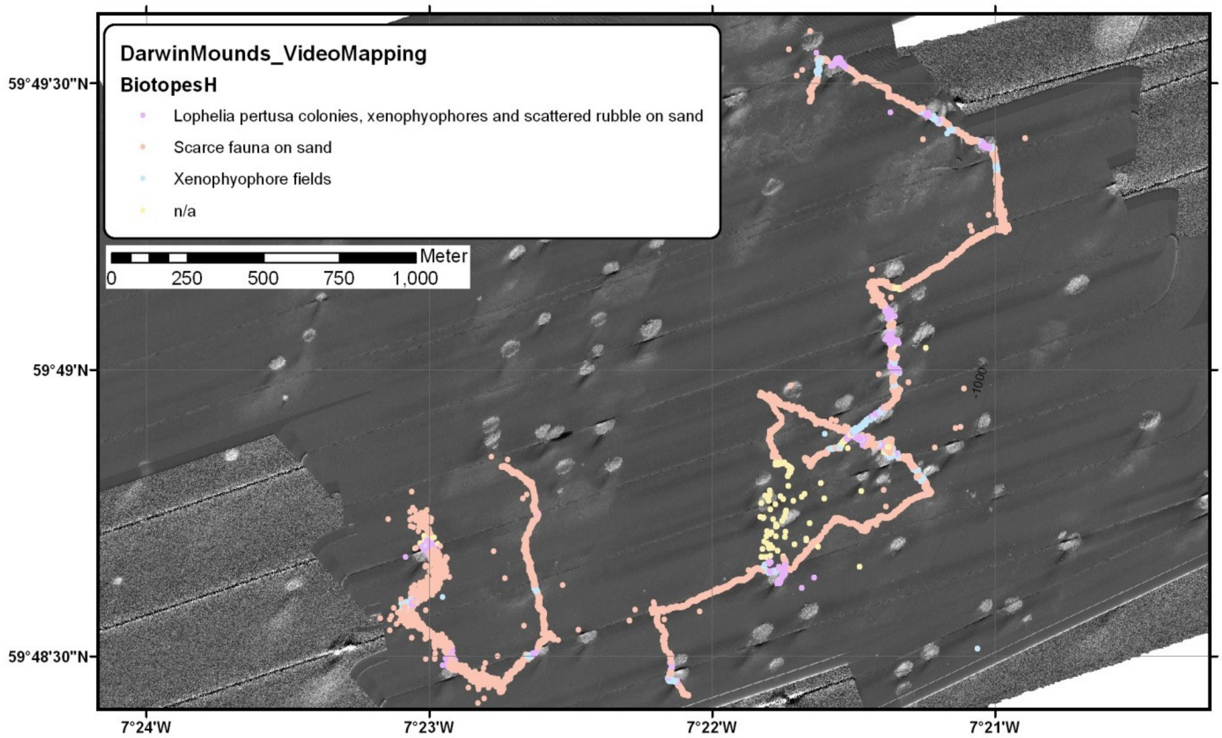


Figure 6. Detail of the video-mapped Biotopes in the western Darwin Mounds. Note the majority of the area is characterised by the 'scarce fauna on sand' biotope, while the '*Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand' biotope is associated with the high-backscatter mound features.

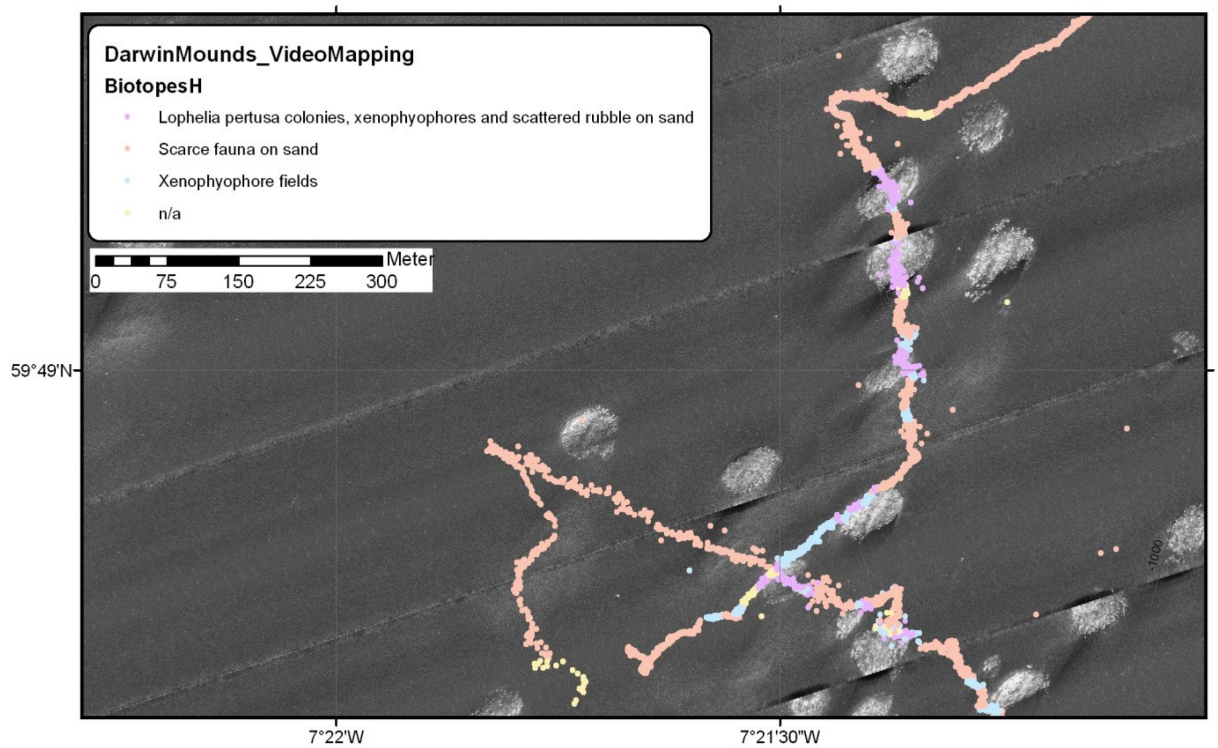


Figure 7. Zoom on part of the western Darwin Mounds, illustrating the association of the '*Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand' biotope with the high-backscatter coral mounds. The 'Xenophyophore fields' biotope is mainly limited to the mound edges, and occasionally to one of the scoured mound tails.

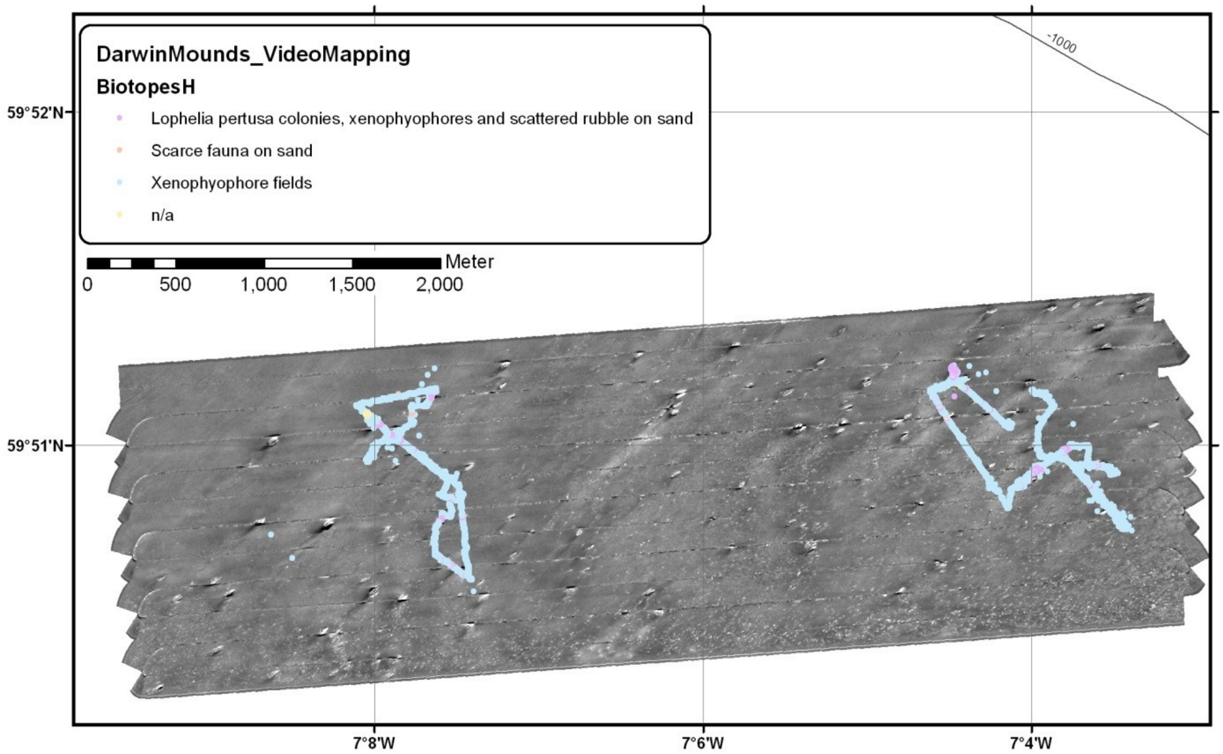


Figure 8. Darwin Mound biotopes mapped out over the AUV-based high-resolution sidescan sonar data of the eastern Darwin Mound field (note that the AUV-based multibeam survey covers the same area as the high-resolution sidescan sonar survey, and therefore is not shown).

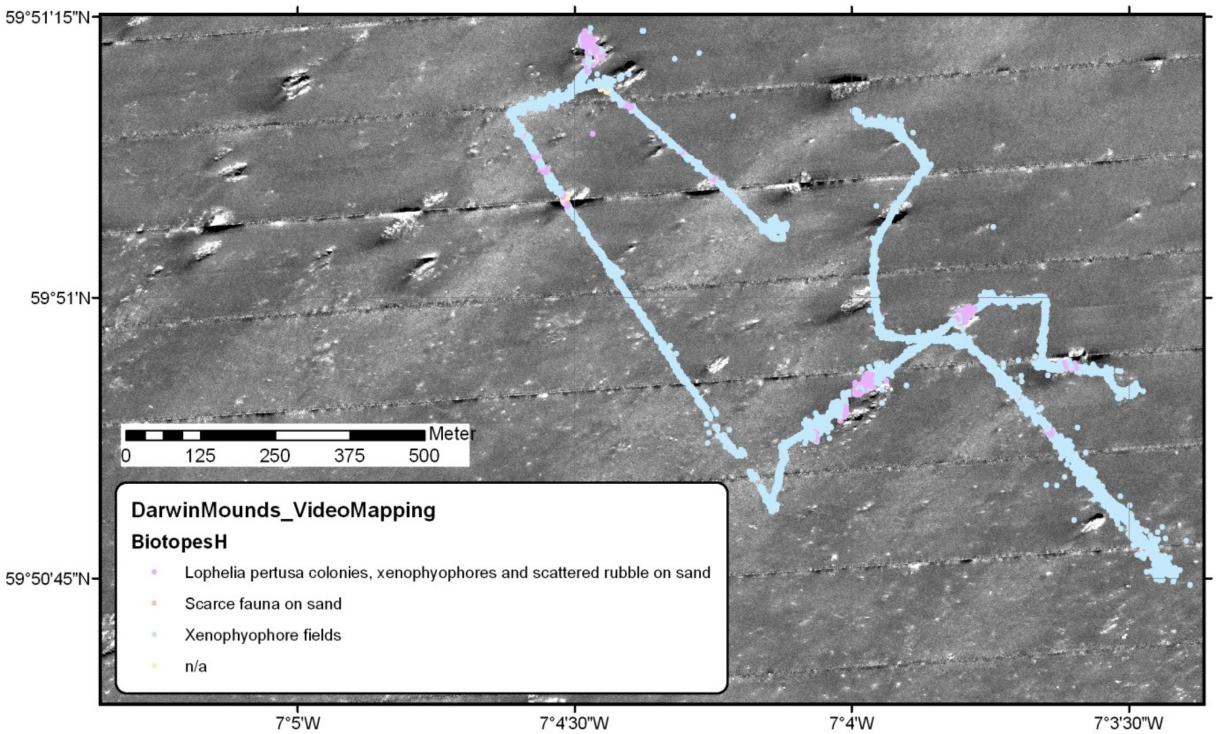


Figure 9. Detail of the video-mapped biotopes in the eastern Darwin Mounds. Note in this case the majority of the area is characterised by the 'Xenophyophore fields' biotope, while the '*Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand' biotope is again associated with the high-backscatter mound features.

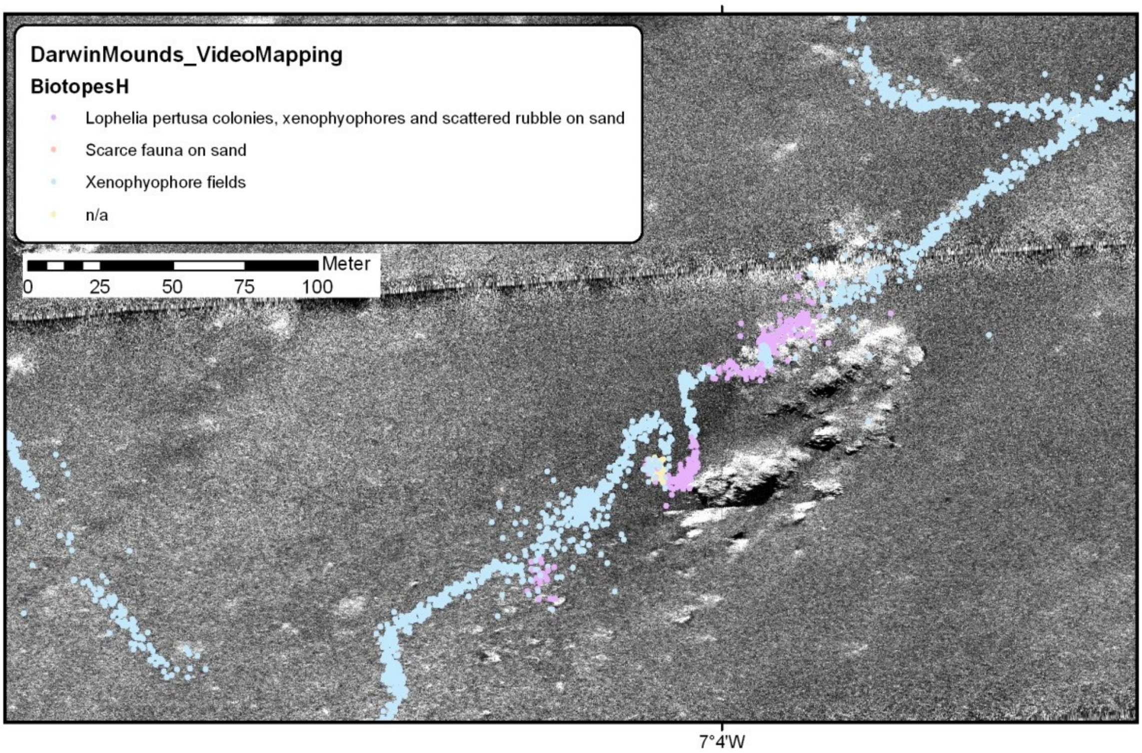


Figure 10. Zoom on part of the eastern Darwin Mounds, illustrating the association of the '*Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand' biotope with the high-backscatter coral mounds. In addition, this biotope is also found on more scattered high-backscatter patches, which may be partly caused by historical trawling impacts.

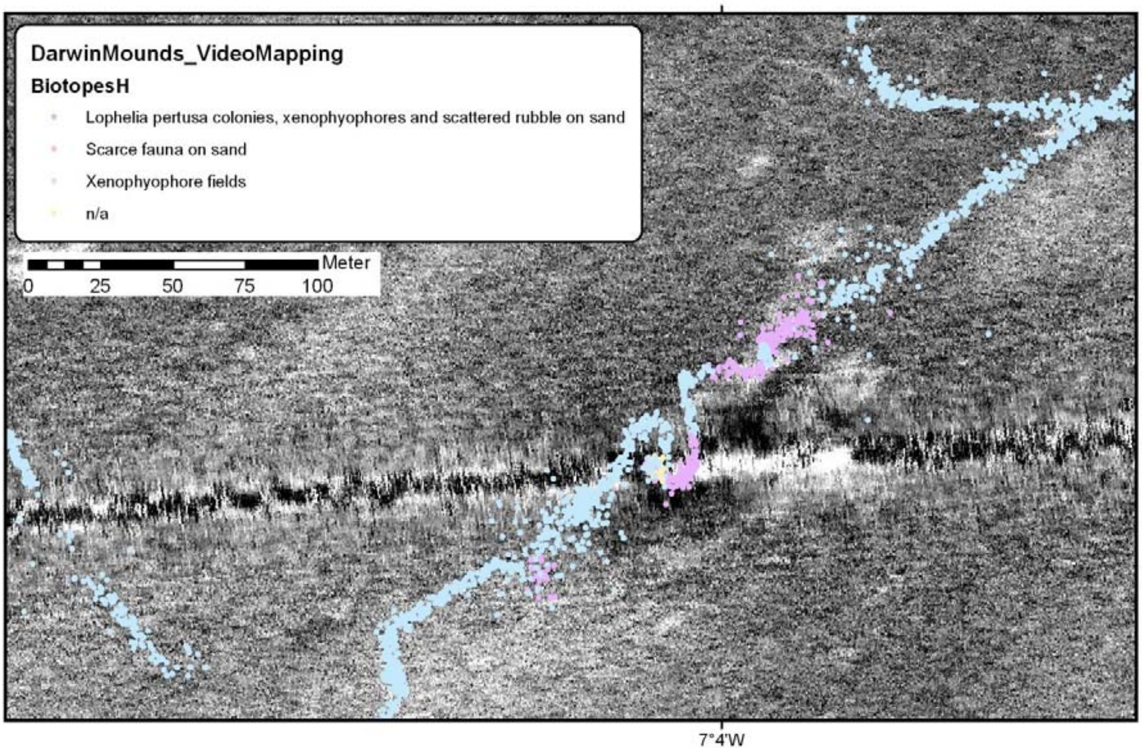


Figure 11. Same zoom as the map above, this time with the AUV-based multibeam backscatter as background, illustrating the advantage of the high-resolution sidescan sonar data over the multibeam backscatter. The mound is just about identifiable, while the scattered coral to the SW of it cannot be recognised in this dataset.

3.2 Hatton-Rockall Basin Polygonal Faults Results

Two ROV transects were undertaken at the polygonal faults site. After image cropping, laser scaling, selection for clarity, and 1 minute spacing, 238 out of the total 539 images were analysed from transect JC060_065 (Dive13). Due to the aim of transect JC060_066 (Dive14), the ROV spent some time circling an interesting rock feature in a pockmark making 1 minute spacing an inappropriate method of separating images equally along a transect whilst remaining comparable to other transects being analysed. Therefore this transect was plotted in GIS and images selected to be a similar distance apart to the one minute method, resulting in only 48 out of the total 146 images being analysed from transect JC060_066 (Dive14) (Figure 12).

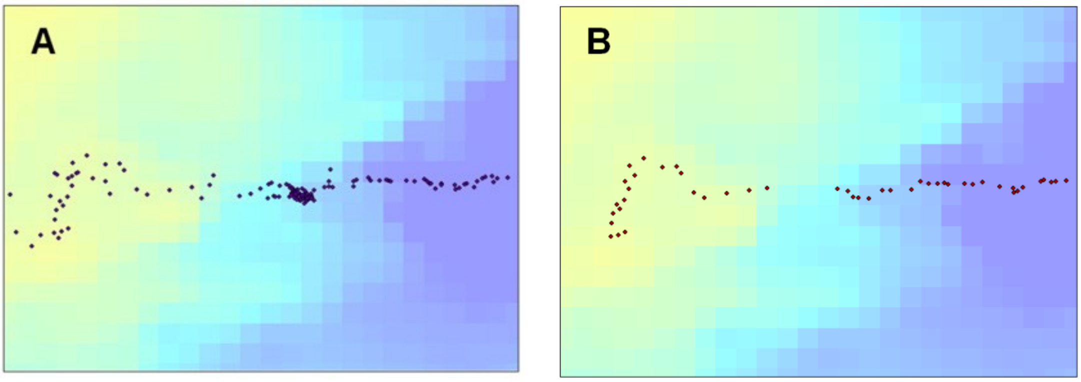
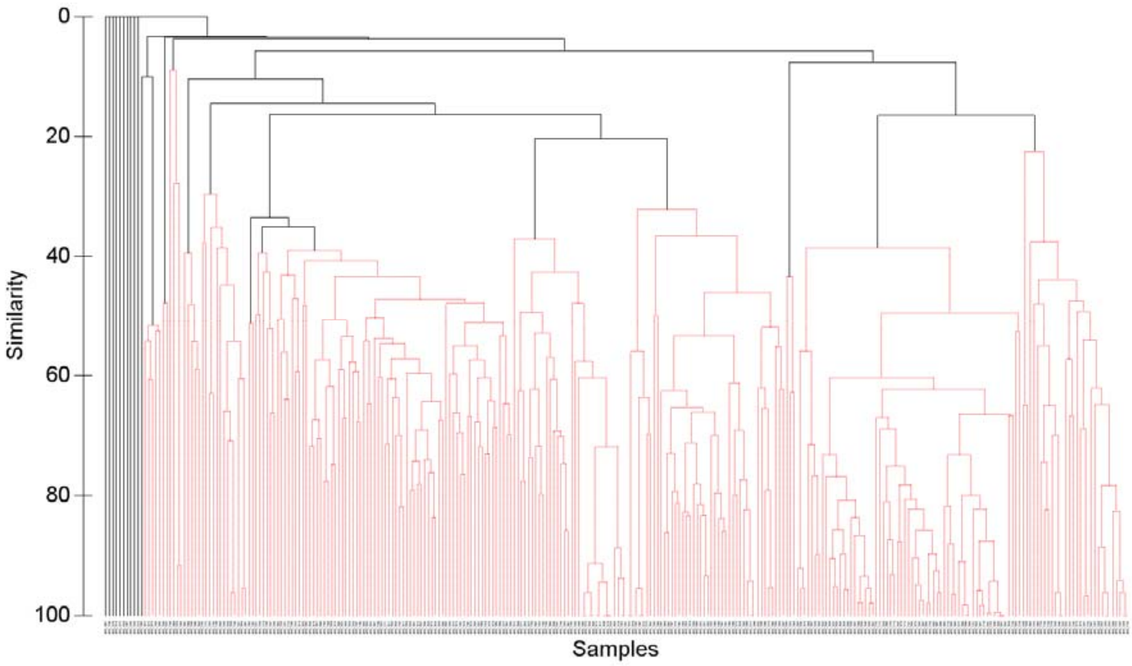


Figure 12. Sample image selection in transect JC060_066 (Dive14). (A) Shows the locations of all 146 original images, the dense cluster of points marking the location of the rock feature in the pockmark, (B) shows the final selection of the 48 analysed images after filtering for laser scaling and image selection at minute spacing and geographic spacing. The blank section is a result of omitting images taken from too high off the bottom.

3.2.1 Defining biotopes

Thirteen significant clusters at the maximum level of subdivision ($p<0.05$) were identified following cluster analysis using the SIMPROF routine (Figure 13). Four of these clusters (B, C, D, K; each with fewer than five images) were considered outliers, representing images of limited epifauna with only one dominant species present.

(A)



(B)

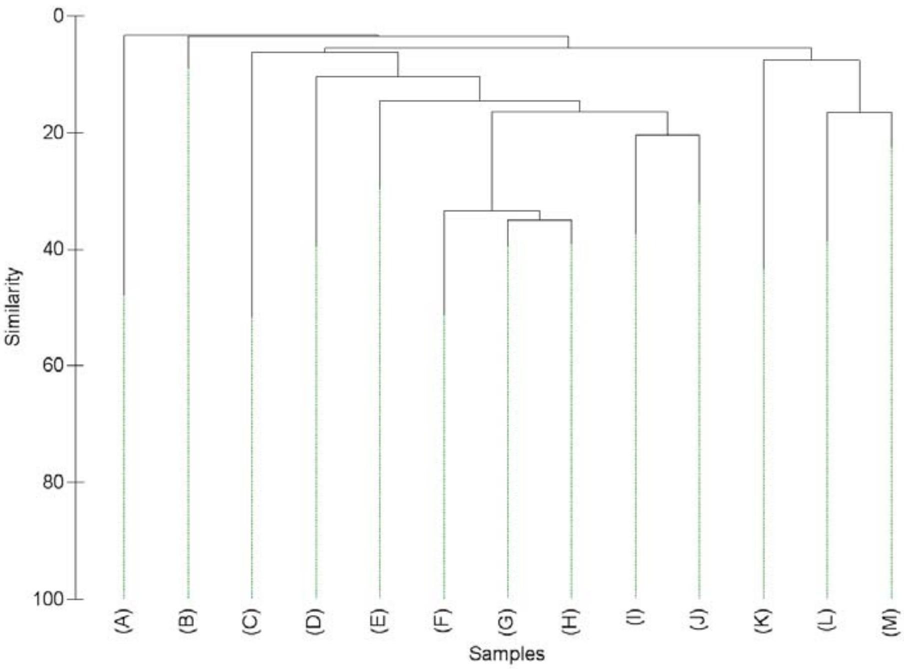


Figure 13. Polygonal Faults cluster dendrograms. The raw dendrogram (A) shows the red SIMPROF groups considered statistically significant clusters ($p < 0.05$). Outliers were then excluded and SIMPROF groups collapsed to give the cluster groupings shown in (B) the final dendrogram.

An assessment by eye of the remaining clusters recommended the consolidation of some groups at lower levels of similarity in order to provide practically useful mapping units. As a result, final cluster combinations were as follows: A, FGH, IJE, LM, effectively clustering SIMPROF clusters at the 20% similarity level with the exception of cluster E. SIMPER analysis of these clusters confirmed their similarity and identified the morphospecies that characterised each cluster. A full description and example image of each biotope are listed in the next section.

i Biotope Descriptions

a Cluster A

Biotope name: Halcampid anemones and white encrusting sponges on mixed substrate

JC060 SIMPER descriptive name:
Halcampid anemones, *Ophiactis abyssicola* & encrusting sponges on hard substrate
SIMPER within cluster similarity: 53.13%

Characterised (based on five images) by halcampid anemones (Halcampoididae sp.1), ophiuroids (*Ophiactis abyssicola*), pale and green encrusting sponges, spider crabs (Majidae sp.1), terebellid polychaetes (Terebellidae sp.2), cup corals (Caryophyllia sp.2), and lamellate sponges. This assemblage is associated with boulders on mud at a depth of 1171–1178m and an average temperature of 5.07°C (standard deviation 0.01°C). This biotope resembles Cluster RE (Halcampid anemones and white encrusting sponges on mixed substrate) of Howell *et al* (2010) although this record extends the depth and temperature ranges and here the assemblage is found on boulders rather than cobbles or pebbles. Although the sample size is small, this biotope is the only one associated with hard substrates in this area. Further qualitative analysis of other image and video data from this area support this description. Please note: the rock depicted, found on JC060_066 (Dive 14), may be a methane derived authigenic carbonate (MDAC) structure, although samples could not be obtained to verify this on this cruise.

b Cluster FGH

Biotope name: A6.621 Facies with *Pheronema grayi*

JC060 SIMPER descriptive name:
Pheronema carpenteri aggregations on soft sediment
SIMPER within cluster similarity: 44.05%

Characterised (based on 74 images) by unidentified tube worms (Sabellidae sp.3), *Pheronema carpenteri*, massive lobose sponges (sp.29), burrowing anemones (Cerianthidae sp.1), ophuroids (*Ophiactis abyssicola*), small unidentified (likely) stalked sponges (Unknown sp.22; possibly juvenile *Hyalonema* sp.1), yellow and pale encrusting sponges and bushy hydrozoans. This biotope is associated with bioturbated mud at depths of 1139-1197m at an average temperature of 5.07°C (standard deviation 0.02°C) and in the context of the area was found only on top of polygons. This biotope has a presence in the literature and is equivalent to EUNIS 2007-11 biotope 'A6.621 Facies with *Pheronema grayi*' (*Pheronema grayi* is cited on the WoRMS website (http://www.marinespecies.org/) as being a synonym of *Pheronema carpenteri* based on Champagne (1995)).

c *Cluster IJE*

Biotope Name: Cerianthid anemones & burrowing megafauna in bioturbated soft sediment

JC060 SIMPER descriptive name:
Cerianthid anemones & burrowing megafauna in bioturbated soft sediment
SIMPER within cluster similarity: 29.98%

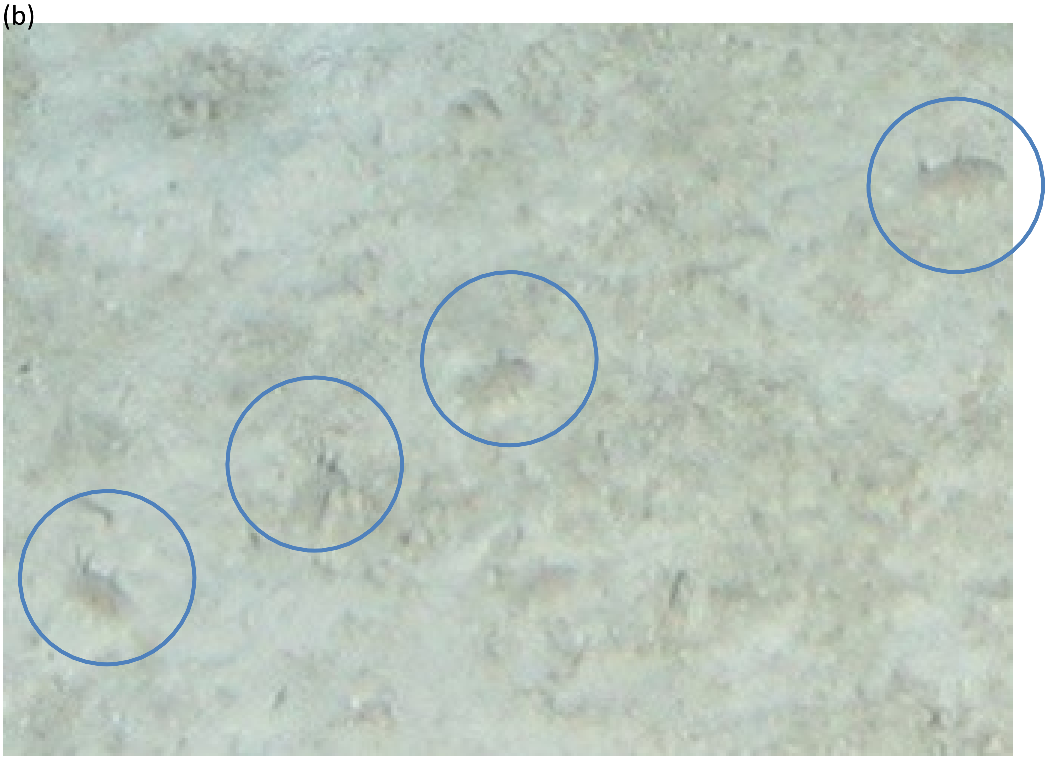
Characterised (based 89 images) by burrowing anemones (Cerianthidae sp.1), unidentified hydroids (Hydrozoa sp.5) and unidentified tube worms (Sabellidae sp.3) on bioturbated mud with phytodetritus. Many large burrows were visible in this area but associated megafauna were not encountered likely due to fauna being mobile enough to escape the view of the ROV. This assemblage is found at water depths of 1143-1184m at an average temperature of 5.07°C (standard deviation 0.01°C) and in the context of the area was found only on the upper slopes of the faults below the polygons. Video observations also reveal the rare occurrence of sea pens (*Virgularia mirabilis*) and stalked sponges (*Hyalonema* sp.1) to be associated with this biotope. This biotope is similar to cluster LM which is characterised by a different burrowing anemone species. As these are hard to tell apart on video, both of these could be considered sub-biotopes and are both most easily captured as EUNIS biotope 'A5.361: Sea pens and burrowing megafauna in circalittoral fine mud', originally described by The Marine Habitat Classification for Britain and Ireland (Connor *et al*, 2004). However, both are found in the bathyal region and thus should be considered deep-water variants of A5.361. This biotope is also similar to 'biotope 12: Mud with abundant cerianthids, and little other fauna' as defined by Davies *et al* (2008) from the South West Approaches, however the biotope in Davies *et al* (2008) was defined from video observation only and so it is difficult to compare directly.

d Cluster LM

Biotope name: Unidentified (possibly Halcampoid) anemones in soft sediment

JC060 SIMPER descriptive name:
Unidentified (possibly Halcampoid) anemones in soft sediment
SIMPER within cluster similarity: 39.74%
(a)

(b)



Characterised (based on 93 images) by burrowing anemones (c.f. halcampoidiae/haloclavidae/ edwardsiidae) on mud between 1171-1184m water depth, at an average temperature of 5.08°C (standard deviation 0.01°C). Video observations also reveal the rare occurrence of sea pens (*Kophobelemnon* sp.2). Also associated with this biotope was the presence of a swarm of juvenile holothurians, likely *Kolga* sp. (Cluster LM (b)). Billett (1981) attributes swarms like this to a massive synchronised spawning event and speculates that aggregations may be in response to food (phytodetritus/other organic matter) availability. However aggregations are infrequent, so the dominance of this species should not be considered representative of this biotope. Although similar to cluster IJE, the mud here featured fewer large burrows than cluster IJE, a different species of burrowing anemone dominated, and the biotope was associated only with the bottom of fault troughs. However visually this biotope is hard to separate from IJE and should therefore be considered a sub-biotope, as it would also equate to a deep water variant of the EUNIS biotope 'A5.361: Sea pens and burrowing megafauna in circalittoral fine mud', originally described by The Marine Habitat Classification for Britain and Ireland (Connor *et al*, 2004). Note this cluster was also identified in the Natura 2009 analysis (Long *et al*, 2013) of East Rockall Bank as 'Biotope LB. Halcampoid anemones on coarse sand' where it was defined as being characterised by halcampid anemones associated with coarse sand, at a temperature of 6.2-7.5°C and a depth of 835-1134m. It is also similar to 'Biotope 12: Mud with abundant cerianthids, and little other fauna' as defined by Davies *et al* (2008) from the South West Approaches.

3.2.2 Maps

When overlying the biotope mapped video data on the bathymetry there is a clear suggestion of a link between the underlying geology and the biology (Figure 14). The EUNIS assemblage 'A6.621 Facies with *Pheronema grayi*' is distributed on the polygon features while the assemblage 'Cerianthid anemones & burrowing megafauna in bioturbated soft sediments' is distributed in the troughs between polygons. While it would be possible to assume this relationship holds across the entire area of the polygonal faults visible in the multibeam within the Hatton-Rockall Basin, it would be unwise to make predictions beyond the scope of the data, and thus modelling of biotope distribution has not been undertaken in the absence of data from beyond the immediate sampling area.

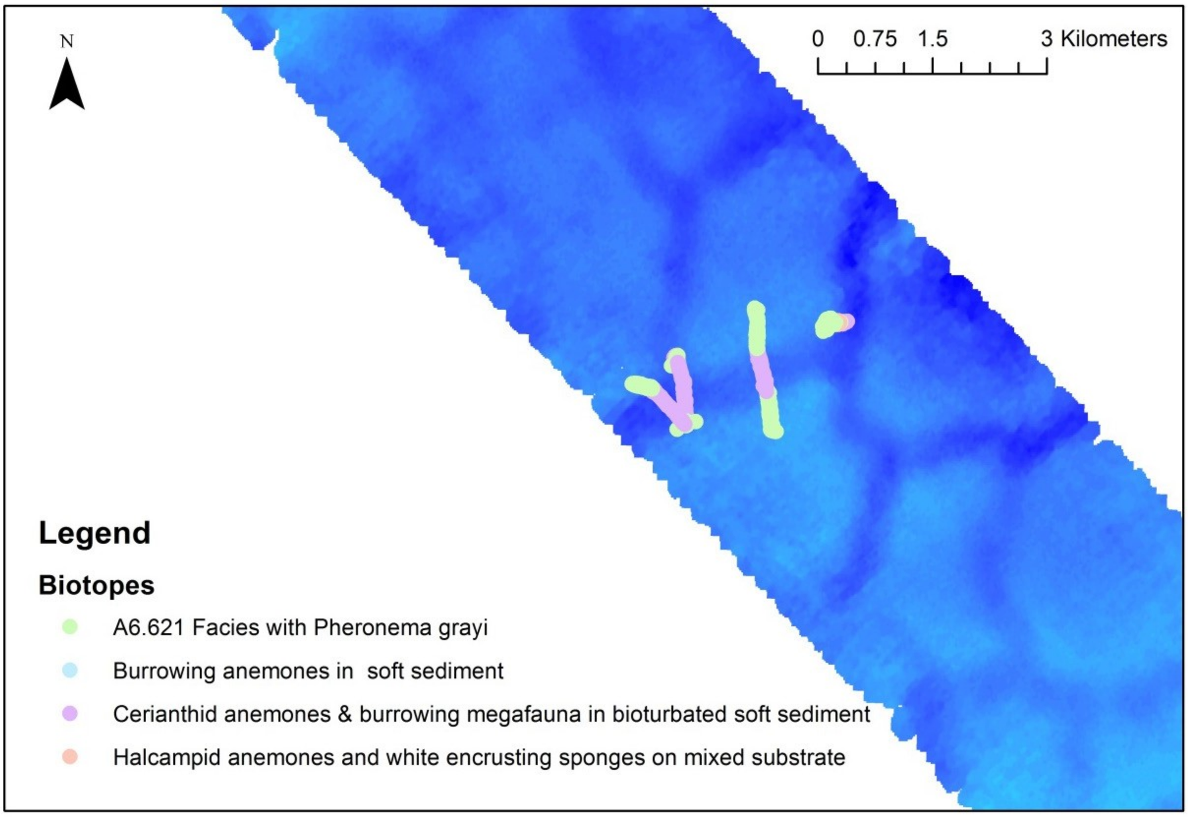


Figure 14. Multibeam bathymetry map (collected as part of the DTI SEA7 2005 Kommander Jack survey (Jacobs, 2005)) overlaid with biotope mapped video transects of the polygonal faults region in the Hatton-Rockall Basin.

The assemblage 'Halcampid anemones and white encrusting sponges on mixed substrate' in this area is found associated with a rock outcrop feature that was identified as potential carbonate crust, however this has not been confirmed. This feature was heavily draped in sediment with areas of soft substrate between outcrops resulting in a mixed assemblage with components of both soft and hard substrates. It is worth noting that an area of boulders was encountered in Dive 13. Very few associated fauna were observed and thus no biotope was described.

3.3 East Rockall Bank (JC060 & Natura 2009) Results

East Rockall Bank - JC060 data only

Two transects were completed at this site. After image cropping, laser scaling, selection for clarity and 2 minute spacing, 134 images out of a total 408 images in transect JC060_100 (Dive 21) were analysed, along with 54 out of 253 in transect JC060_101 (Dive 22).

East Rockall Bank - JC060 & Natura 2009 Combined

The combined analysis of the JC060 data and Natura 2009 data required that the JC060 sample images be reduced to the frequency of those analysed in the Natura 2009 analysis – one image approximately every 50m (Long *et al* 2013). ArcGIS was used to plot the JC060 analysed images and select the samples at 50m spacing for use in the combined analysis. After 50m spacing 283 images were analysed comprising 253 images from the Natura 2009 analysis and 30 images spanning the two JC060 transects.

3.3.1 Defining biotopes

i East Rockall Bank - JC060 data only

SIMPROF analysis identified 18 statistically significant clusters (Figure 15). Due to the more frequent image sampling and the narrow geographic range represented in this site analysis, the majority of clusters represented transitional biotopes. As a result statistically significant clusters were grouped at a lower level of similarity in order to provide useful mapping units.

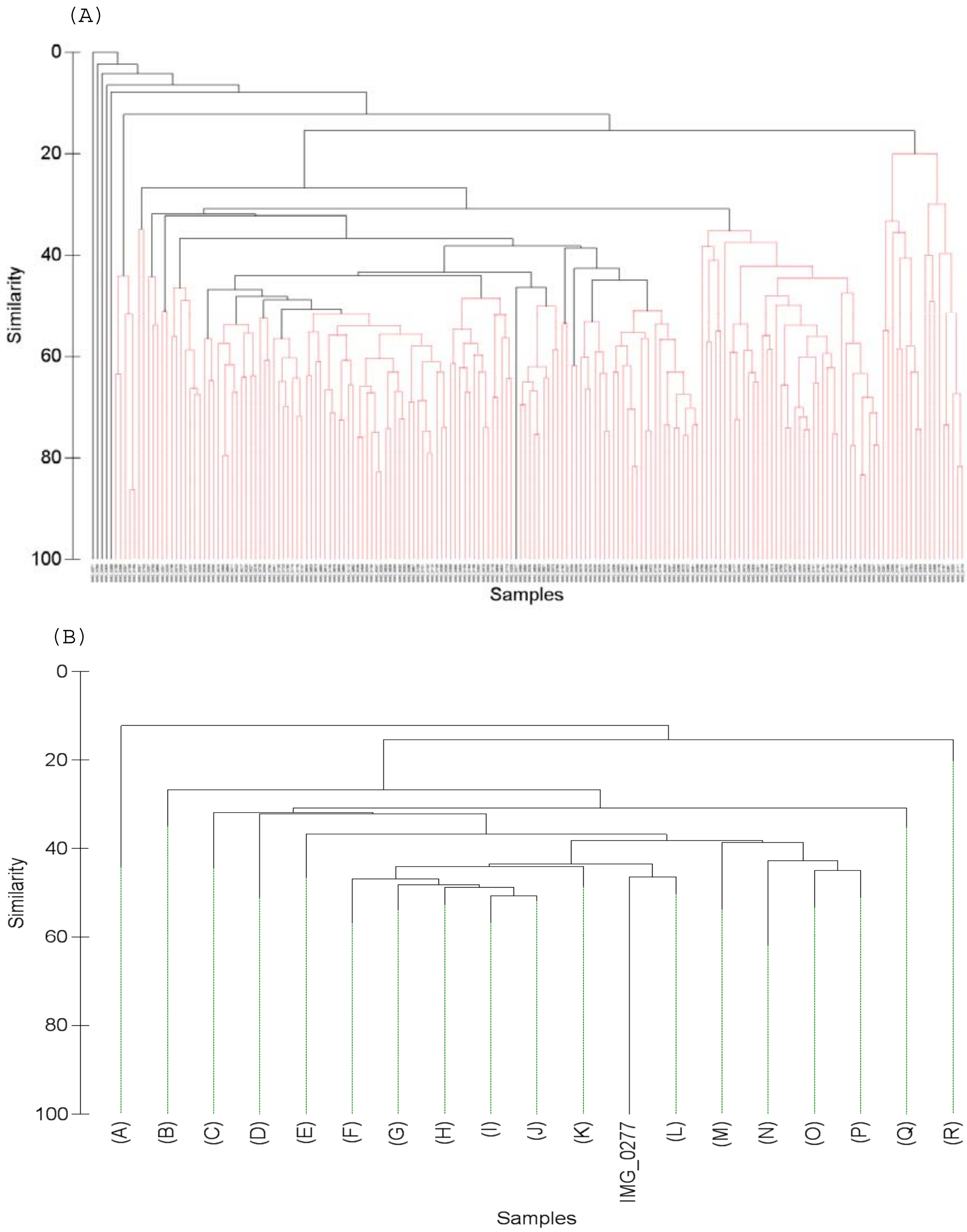


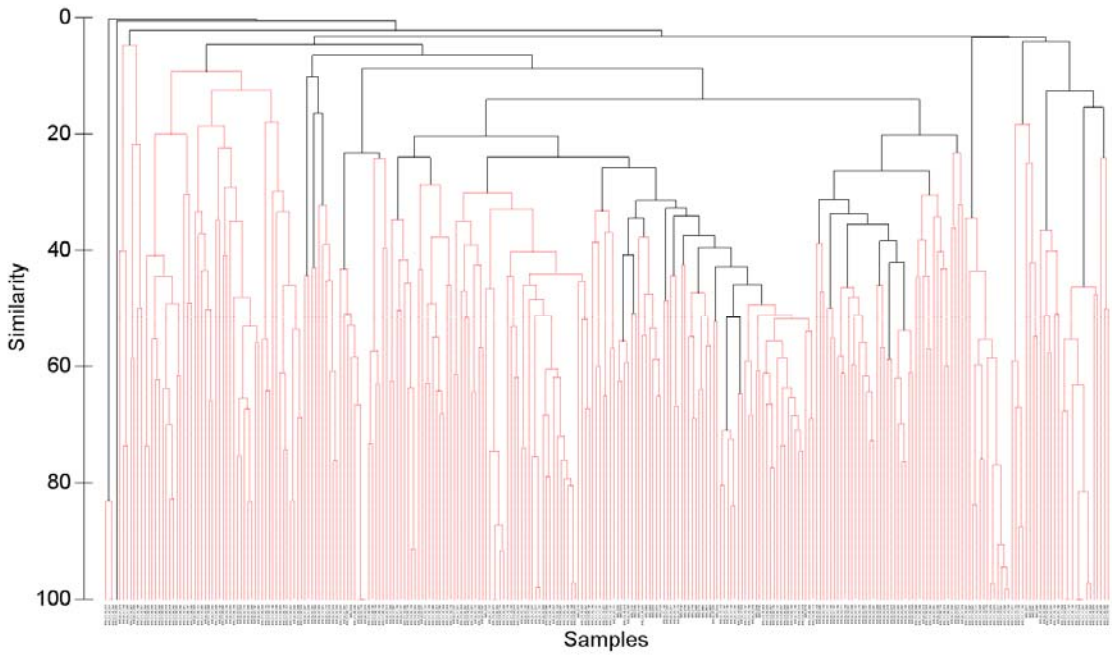
Figure 15. NE Rockall JC060 data cluster dendrograms. The raw dendrogram (A) shows the red SIMPROF groups considered statistically significant clusters (p <0.05). Outliers were then excluded and SIMPROF groups collapsed to give the cluster groupings shown in (B) the final dendrogram.

The final four biotopes were represented by clusters E, FGHIJKL, MNOP, and R, effectively resulting in SIMPROF clusters combined at the 40% similarity level. SIMPER analysis of these clusters confirmed their similarity and identified the morphospecies that characterised each cluster. A full description and example image of each biotope are listed in the next section.

ii East Rockall Bank - JC060 & Natura 2009 Combined

SIMPROF analysis identified 36 statistically significant clusters (Figure 16). Again, in order to provide practically useful mapping units statistically significant clusters were grouped at a lower level of similarity. Final biotope clusters comprised groups C, E, F, J, K, L, MN, O, S, TUW, YZAaAbAc, Ad, and Af , effectively resulting in SIMPROF clusters combined at the 40% similarity level. All other clusters were rejected on the basis of poor taxonomic resolution, being representative of transitional biotopes or as symptomatic of having too small a field of view in a biotope of dispersed fauna and usually dominated by only one species. SIMPER analysis of these clusters confirmed their similarity and identified the morphospecies that characterised each cluster. A full description and example image of each biotope are listed in the next section.

(A)



(B)

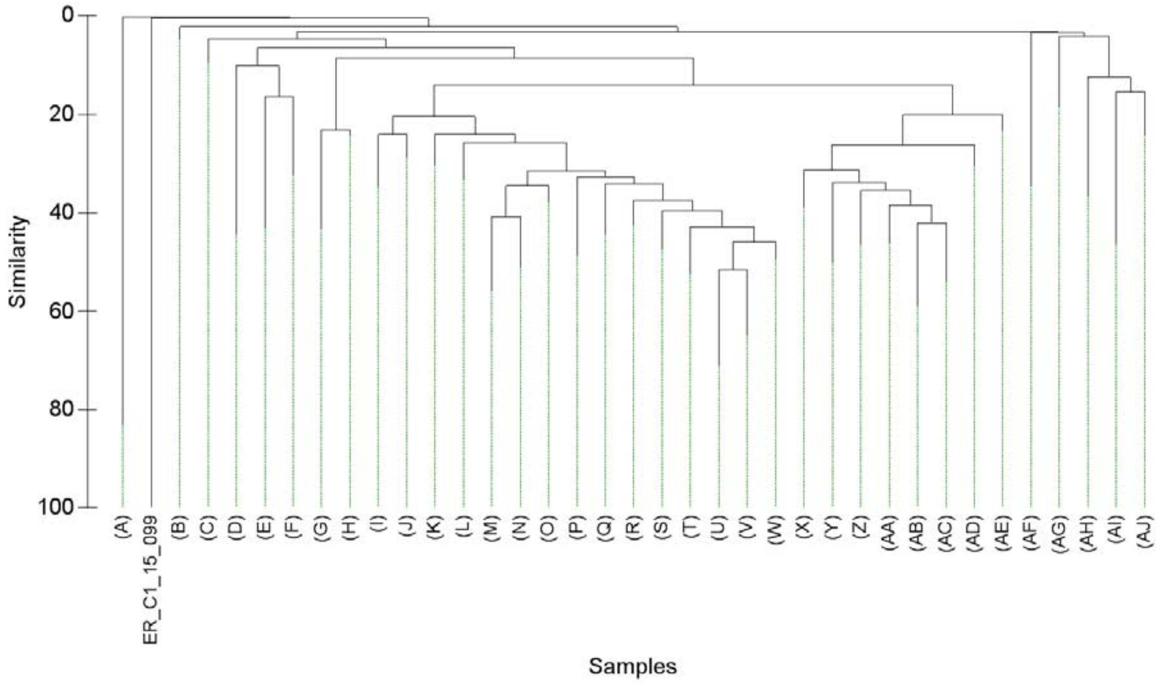


Figure 16. East Rockall Bank combined JC060 and Natura 2009 datasets cluster dendrograms. The raw dendrogram (A) shows the red SIMPROF groups considered statistically significant clusters ($p < 0.05$). Outliers were then excluded and SIMPROF groups collapsed to give the cluster groupings shown in (B) the final dendrogram.

The resulting biotopes are close to those identified in the individual analyses however there are some minor differences. The hydroid ledges from the JC060 dataset are not represented in this analysis, likely due to the reduction of the dataset to one image every 50m resulting in some loss of resolution and highlighting the fact that this patch was of limited size and therefore should be considered as a biotope of more local resolution until further data can test its validity on a wider scale. Additionally the two xenophyophore biotopes identified in Long *et al* (2013) are here represented as only one biotope most likely due to the Anton Dohrn dataset containing further xenophyophore biotopes which causes the CLUSTER routine to consider them as more different relative to the data it is exposed to.

A comparison to the Long *et al* (2013) biotope list is available in Appendix 4.

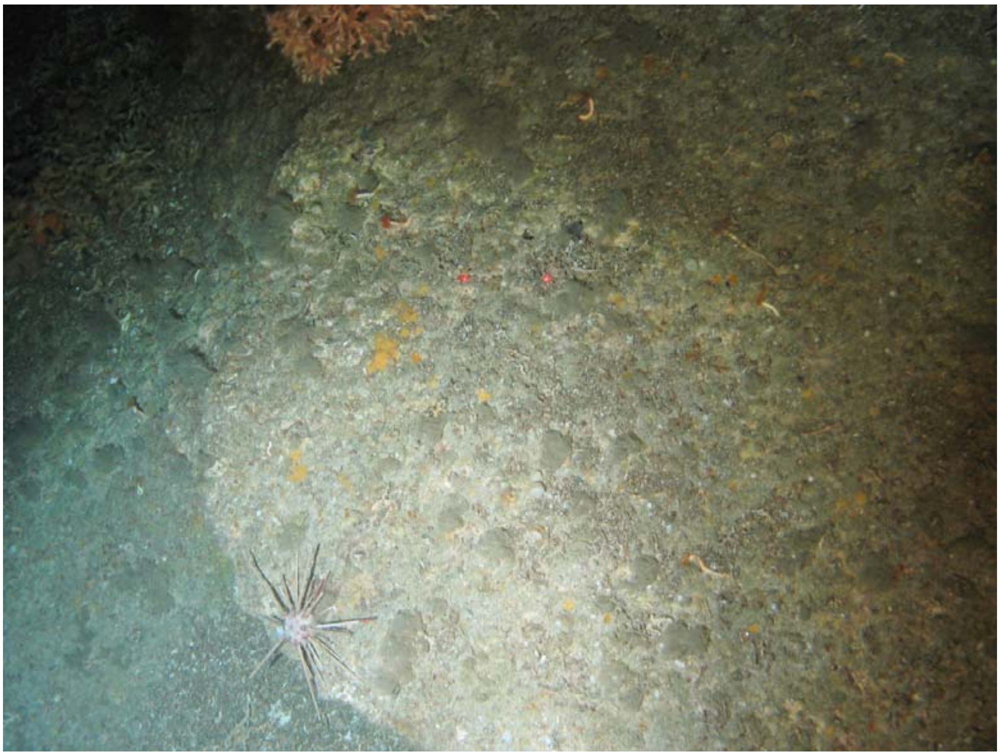
3.3.2 Biotope descriptions

i East Rockall Bank - JC060 data only

a Cluster E (A Sub-Biotope)

Biotope Name: *Lophelia pertusa* reef rubble apron

JC060 SIMPER descriptive name:
Bushy hydroids on rock ledges
SIMPER within cluster similarity: 52.05%



Characterised (based on seven images) by ophiuroids (*Ophiactis balli*), serpulid polychaete worms, bushy hydrozoans, orange and yellow encrusting sponges, halcampid anemones (Halcampoididae sp.1), brachiopods (Brachiopoda sp.1), and pencil urchins (*Cidaris cidaris*). This assemblage is associated with bedrock ledges with a layer of coral gravel/sand, at water depths of 504-559m, and at an average temperature of 9.23°C (standard deviation <0.01°C). Upon review of the video, this cluster is probably best considered a sub-biotope of the *Lophelia pertusa* reef rubble apron. Although visually distinguishable, and with more diverse epifauna, it may be difficult to predict separately from the more general rubble apron biotope, and has not been described at other locations.

b *Cluster FGHIJKL*

Biotope Name: *Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum (Interspersed with discrete coral (*Lophelia pertusa*) colonies on hard substratum)

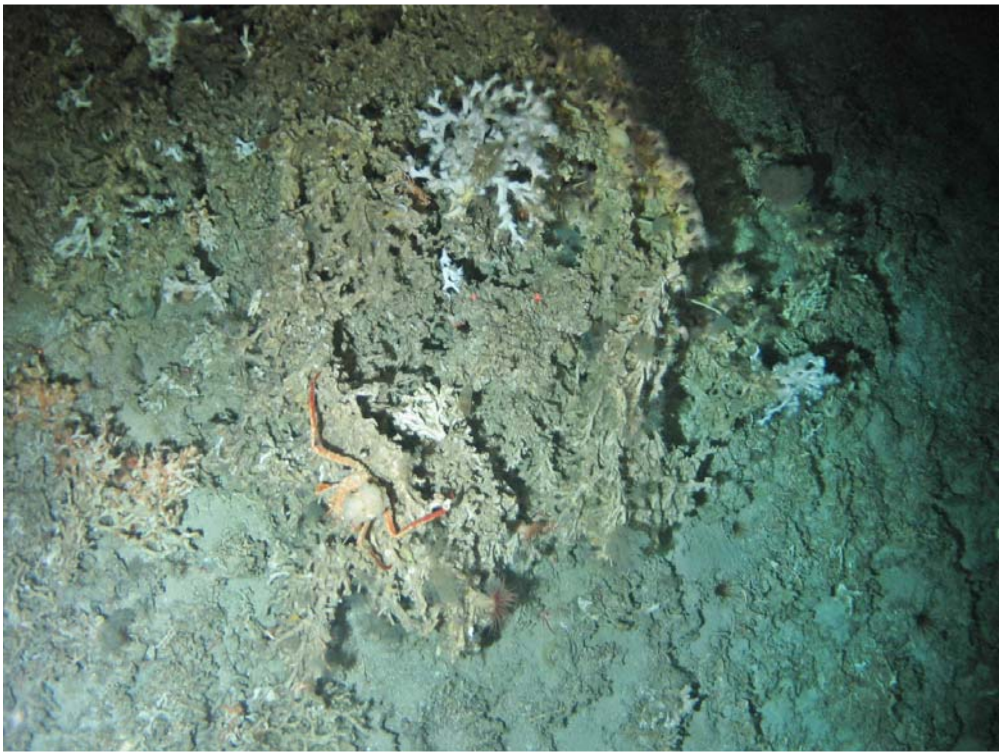
JC060 SIMPER descriptive name:
Encrusting fauna, *Cidaris cidaris* and orange anemones on steep bedrock
SIMPER within cluster similarity: 48.16%

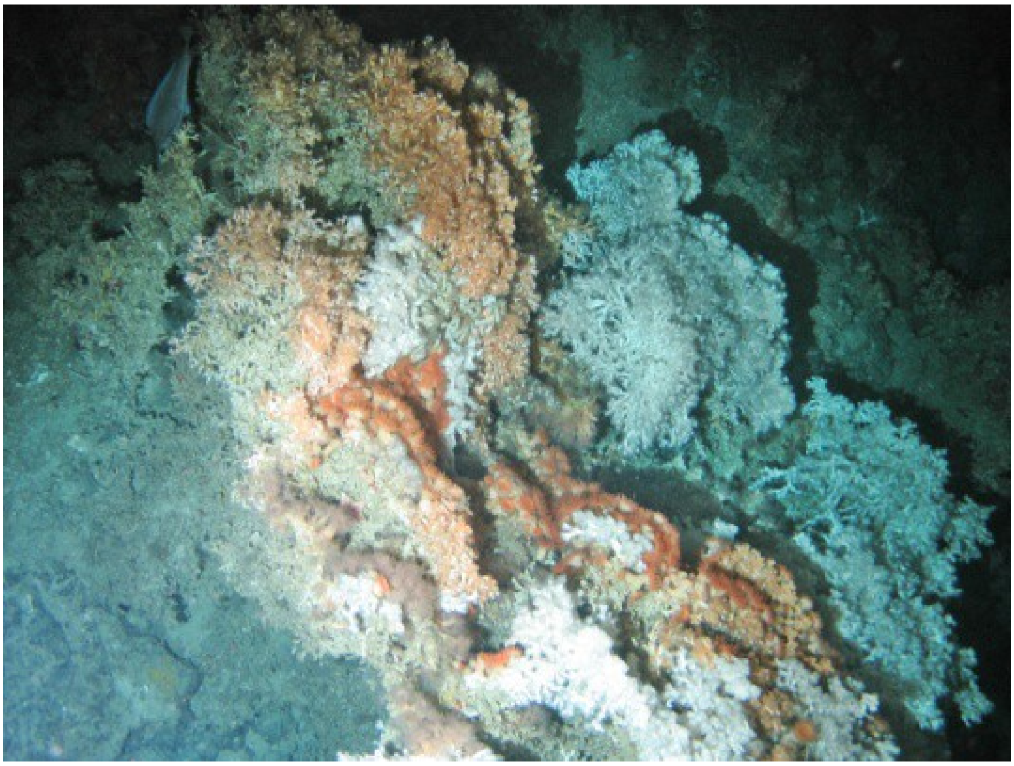
Characterised (based on 76 images) by saddle oysters (Anomiidae sp.1), serpulid polychaetes, ophiuroids (*Ophiactis balli*), pencil urchins (*Cidaris cidaris*), orange anemones (suspected juvenile *Phelliactis* sp.1), phoronid worms, squat lobster (*Munida sarsi*), sessile holothurians (P*solus squamatus*), cup corals (*Caryophyllia* sp.3), bushy hydrozoans, halcampid anemones (Halcampoidea sp.1), stylasterid hydrozoans (*Pliobothrus* sp.), sabellid polychaetes (Sabellidae sp.1), lobose sponges and yellow, pale and blue encrusting sponges. This assemblage is associated with exposed steep bedrock with patches of coral gravel/sand at depths of 395-804m and an average temperature of 9.19°C (standard deviation 0.22°C). Video observations reveal large, yellow lobose sponges, branching sponges, flytrap anemones (*Phelliactis* sp.1), basket stars (*Brisingella* sp.1), the sponge-carrying spider crab (*Paromola cuvieri*), and discrete *Lophelia pertusa* colonies to be among the larger, more disparate, or more mobile species associated with this biotope. An unidentified white encrusting fauna forming numerous tiny (≤1cm) circular patches on bedrock is also present in this biotope. These were removed from analysis due to their over-abundance resulting in skewed clustering. The patches (visible in the image above) are likely to be of hydrozoan or bryozoan origin. This biotope most closely resembles cluster RHD '*Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum interspersed with cluster PBC 'Discrete coral (*Lophelia pertusa*) colonies on hard substratum' identified by Howell *et al* (2010).

c *Cluster MNOP*

Biotope Name: *Lophelia pertusa* reef framework

JC060 SIMPER descriptive name:
Predominantly low-lying dead framework slopes of *Lophelia pertusa* coral reef on steep bedrock
SIMPER within cluster similarity: 48.70%





Characterised (based on 30 images) by coral framework and coral rubble with serpulid polychaetes, ophiuroids (*Ophiactis balli*), pencil urchins (*Cidaris cidaris*), bushy hyrdrozoans, sabellid polychaetes, gregarious pink anemones associated with coral framework (Actiniaria sp.22), living *Lophelia pertusa*, squat lobsters (*Munida sarsi*), pandalid shrimp (*Pandalus borealis*), orange anemones (suspected juvenile *Phelliactis* sp.1), yellow encrusting sponges and ascidians (Ascidiacea sp.2). This assemblage was associated with (predominantly low-lying) coral framework/rubble on steep bedrock slopes at 508-641m at an average temperature of 9.24°C (standard deviation 0.01°C). This biotope resembles the dead framework slopes described by Howell *et al* (2010) with some site specific modification due to the steep terrain. It is also worth noting that two images within this cluster may be more closely associated with the 'live summit of *Lophelia pertusa* reef' (left inset).

d Cluster R

Biotope Name: *Lophelia pertusa* reef rubble apron
(also epifaunally similar to 'Trawl damaged *Lophelia pertusa* rubble')

JC060 SIMPER descriptive name:
Serpulids, bivalves & *Munida sarsi* on coral gravel
SIMPER within cluster similarity: 29.96%

Characterised (based on 15 images) by serpulid polychaetes, bivalves (*Margarites* sp.1), and squat lobsters (*Munida sarsi*) on coral gravel. This biotope was encountered between 544-743m water depths and at an average temperature of 9.25°C (standard deviation 0.02°C). Video observations also reveal the echiuran worm *Bonella viridis* to be associated with this biotope. This biotope is also described by Howell *et al* (2010); however this epifaunal expression of the *Lophelia pertusa* reef apron is closer to Howell's cluster RHE 'Trawl damaged *Lophelia pertusa* rubble'. This is likely a reflection of the steep terrain resulting in the frequent disturbance of the rubble apron due to mass movements ('landslides') from above, resulting in a biotope visually similar to bottoms disturbed by trawling, however it is worth noting that infaunal differences have not been examined and may be different.

ii East Rockall Bank – Combination of (reduced) JC060 data and Natura 2009 data

a Cluster C

Biotope Name: Xenophyophore fields

JC060 SIMPER descriptive name:
Xenophyophore aggregations
SIMPER within cluster similarity: 17.7%

Characterised (based on 45 images) by burrowing anemones (Cerianthidae sp.1), Xenophyophores (*Syringammina fragilissima*), an unidentified white encrusting organism (Unknown sp.29; visible in the example image above, likely of foramaniferan, bryozoan or sponge origin), halcampid anemones (Halcampoididae sp.1), an unidentified cnidarian (Cnidaria sp.1; possibly a medusa or caryophyllid), spider crabs (Majidae sp.1) and shrimp (*Pandalus borealis*). This assemblage is associated with sand, gravel and mixed substrates, between depths of 861-1443m at an average temperature of 5.88°C (standard deviation 0.41°C). Video observations also revealed sea pens (*Pennatula phosphorea*) to be associated with this biotope. In the original Natura 2009 analysis this biotope was spilt into two separate xenophyophore communities (‘Xenophyophores and sea pens on gravelly sand and mixed substrate’ and ‘Xenophyophores and pandalid shrimp on corase sand and gravel’). The consolidation is likely attributed to the combined analysis with the JC060 data resulting in the previously separated xenophyophore communities being considered more similar to each other relative to the new data, while the previous analysis combined with Anton Dohrn seamount data contained further xenophyophore aggregation communities promoting more-detailed resolution. Additionally the Natura 2009 analysis was performed in an earlier version of PRIMER that did not include the SIMPROF routine now used to identify the statistical maximum separation of clusters (Long *et al*, 2013). 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 Vulnerable Marine Ecosystem (VME) by the UN General Assembly resolution 61/105, and is similar to ‘Group 1’ from the Darwin Mounds analysis (Section 3.1.1.1).

b Cluster E

Biotope Name: Brachiopods on bedrock

JC060 SIMPER descriptive name:
Brachiopods on sand veneered bedrock
SIMPER within cluster similarity: 43.02%

Characterised (based on only two images) by brachiopods, terebellid polychaetes (Terebellidae sp.2), and halcampid anemones (Halcampoididae sp.1) on sand veneered bedrock between 1127-1134m and at an average temperature of 6.18°C (0.03°C). Although there were only two images of this biotope analysed, review of the video confirms this as a visually distinguishable biotope. This biotope was not reported in Long *et al* (2013) but a variation does appear in Howell *et al* (2010) as ‘Brachiopods on mixed substrate’, although at much shallower depths. In addition Howell (2010) described this assemblage as ‘*Bathylasma hirsutum – Dallina septigera – Macandrevia cranium* assemblage’ from her review of community data from multiple sites in the Rockall Trough region including the Wyville-Thomson Ridge, summit of the Anton-Dohrn Seamount, Ymir ridge, Explorer and Dangaard Canyons, however again from depths above 1000m.

c Cluster F

Biotope Name: Unidentified (possibly Halcampoid) anemones in soft sediment

JC060 SIMPER descriptive name:
Unidentified (possibly Halcampoid) anemones in soft sediment
SIMPER within cluster similarity: 43.41%

Characterised (based on six images) by unidentified (possibly Halcampoid) anemones (c.f. Halcampoididae/Haloclavidae/Edwardsidae) in soft sediment between 1075-1114m water depth and at an average temperature of 6.27°C (0.05°C). Although this biotope only existed within one transect on East Rockall Bank, it is very similar to cluster LM in the Polygonal Faults encountered during this survey. It was also identified by Long *et al* (2013) as biotope LB.

d Cluster J

Biotope Name: *Reteporella* & Axinellid sponges on mixed substrate

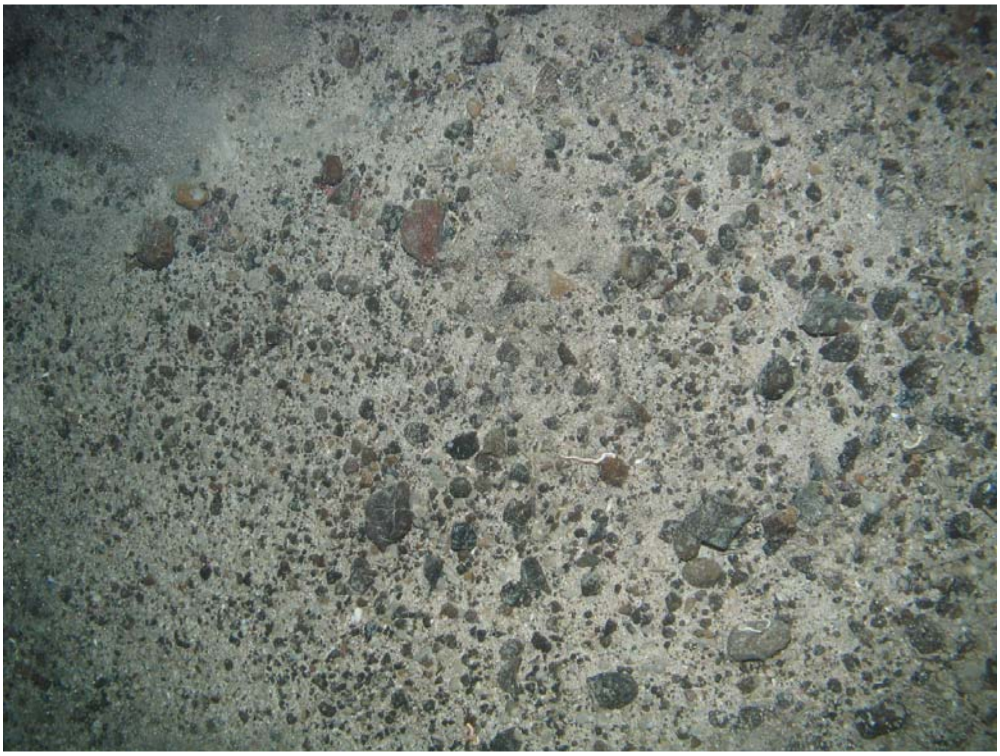
JC060 SIMPER descriptive name:
Reteporella bryozoan & Axinelld sponges on mixed substrate
SIMPER within cluster similarity: 40.42%

Characterised (based on ten images) by squat lobsters (*Munida sarsi*), yellow and pale encrusting sponges, bryozoans (*Reteporella* sp.1), axinellid cup sponges (*Axinella infundibuliformis*) and lobose sponges on mixed substrates between 196-219m water depth and at an average temperature of 9.39°C (standard deviation 0.03°C). This biotope was also described in the original Natura 2009 analysis as biotope MKF (Long *et al*, 2013) and is similar to a deeper expression of ’deep sponge communities (circalittoral)’ described under The Marine Habitat Classification for Britain and Ireland (Connor *et al*, 2004). This biotope was also described in JNCC report 422 (Howell *et al*, 2009).

e Cluster K

Serpulid polychaetes and *Munida* on mixed substrate

JC060 SIMPER descriptive name:
Serpulid polychaetes & *Munida sarsi* on mixed susbtrates and biogenic gravel
SIMPER within cluster similarity: 38.96



Characterised (based on 39 images) by serpulid polychaetes, squat lobsters (*Munida sarsi*) and pale encrusting sponges on mixed substrates and biogenic gravel between 358-823m water depth at an average temperature of 9.33°C (standard deviation 0.19°C). This biotope was also described in the original Natura 2009 analysis (Long *et al*, 2013) , although here likely also includes parts of the Natura 2009 biotopes '*Munida*, saddle oysters and caryophyllids on mixed substrate' (which was closely related in the original analysis, being clusters MKGi and MKGii) and the video defined 'serpulids, encrusting sponges and *Cidaris* on mixed substrate'. This biotope is also described in Howell *et al* (2010) as cluster RG 'Serpulid plychaetes and *Munida* on mixed substrate'.

f *Cluster L*

Biotope Name: *Caryophyllia smithii* & *Actinauge richardi* on sand/gravelly sand

JC060 SIMPER descriptive name:
Caryophyllia smithii & *Actinauge richardi* on sand/gravelly sand
SIMPER within cluster similarity: 38.36%

Characterised (based on seven images) by squat lobsters (*Munida* sarsi), cup corals (*Caryophyllia smithii*, Caryophyllia sp.3), ophiuroids (*Ophiactis balli*), saddle oysters (Anomiidae sp.1), pale encrusting sponges, and hormanthid anemones (*Actinauge richardi*) associated with sand/gravelly sand or mixed substrate between water depths of 218-286m at an average temperature of 9.40°C (standard deviation 0.09°C). This biotope also emerged in the original Natura 2009 analysis as biotope I (Long *et al* 2013) but does not appear in Howell *et al* (2010). The Natura 2009 name retained here reflects the visual identifiers of this disparate biotope.

g Cluster MN

Biotope Name: *Lophelia pertusa* reef rubble apron
(also epifaunally similar to 'Trawl damaged *Lophelia pertusa* rubble' (Howell *et al*, 2010)

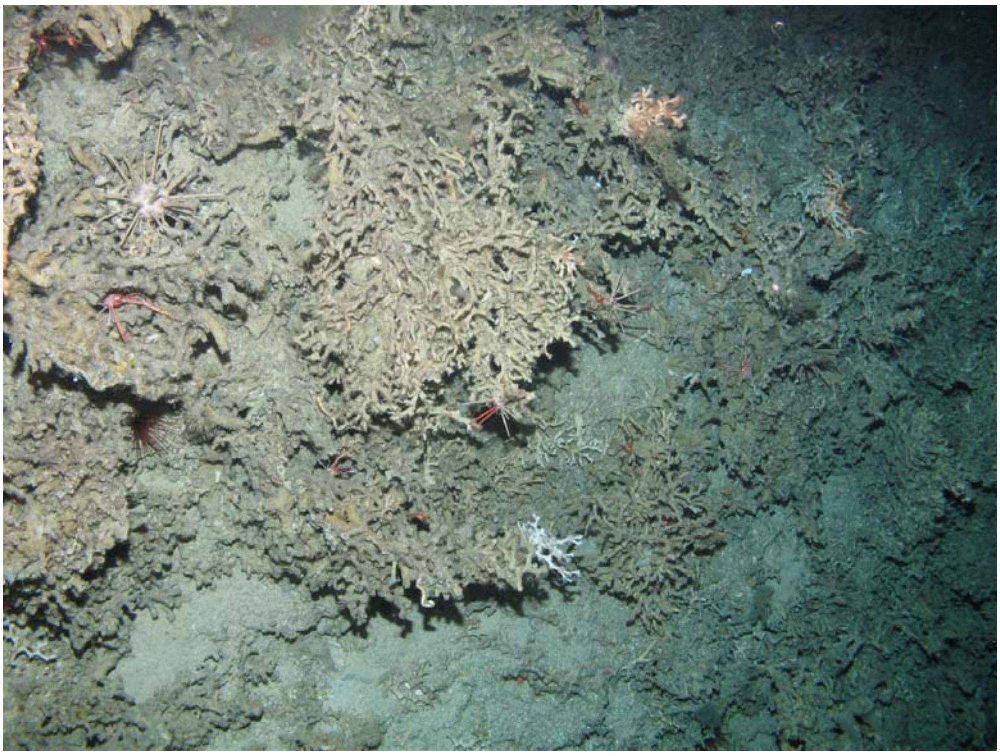
JC060 SIMPER descriptive name:
Serpulids, *Munida sarsi* & ophiuroids on coral gravel
SIMPER within cluster similarity: 48.12%

Characterised (based on six images) by ophiuroids (*Ophiactis balli*), serpulid polychaetes, squat lobsters (*Munida sarsi*), pencil urchins (*Cidaris cidaris*), and bivalves (Margarites sp.1) on coral gravel/low-lying coral rubble at water depths of 493-739m and at an average temperature of 9.24°C (standard deviation 0.02°C). Video observations also reveal the echiuran worm *Bonella viridis* to be associated with this biotope. This biotope is representative of cluster QR from the JC060 only East Rockall Bank analysis. This biotope (as *Lophelia pertusa* reef rubble apron) is also described by Howell *et al* (2010) as cluster RBB; however this expression of the *Lophelia pertusa* reef apron is closer to Howell *et al*'s (2010) cluster RHE 'Trawl damaged *Lophelia pertusa* rubble'. This is likely a reflection of the steep terrain resulting in the frequent disturbance of the rubble apron due to downslope mass movements ('landslides') from above, resulting in a biotope visually similar to bottoms disturbed by trawling, however it is worth noting that infaunal differences have not been examined.

h Cluster O

Biotope Name: *Lophelia pertusa* reef framework

JC060 SIMPER descriptive name:
Dead framework slopes of *Lophelia pertusa* reef (Shallow)
SIMPER within cluster similarity: 47.83%



Characterised (based on seven images) by coral framework and rubble with serpulid polychaetes, pencil urchins (*Cidaris cidaris*), framework forming coral (*Lophelia pertusa*), ophiuroids (*Ophiactis balli*), bushy hydrozoans, pandalid shrimp (*Pandalus borealis*), orange anemones (suspected juvenile *Phelliactis* sp.1), an unidentified red anemone (Actiniaria sp.24), squat lobsters (*Munida sarsi*), lobose sponges and brachiopods (Brachiopod asp.1). This assemblage is associated with water depths of 537-680m and an average temperature of 9.23°C (standard deviation 0.02°C). This biotope is representative of cluster MNOP from JC060 only East Rockall Bank analysis. This biotope resembles the dead framework slopes described by Howell *et al* (2010) with some site-specific modification due to the steep terrain.

i Cluster S

Biotope Name: *Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum

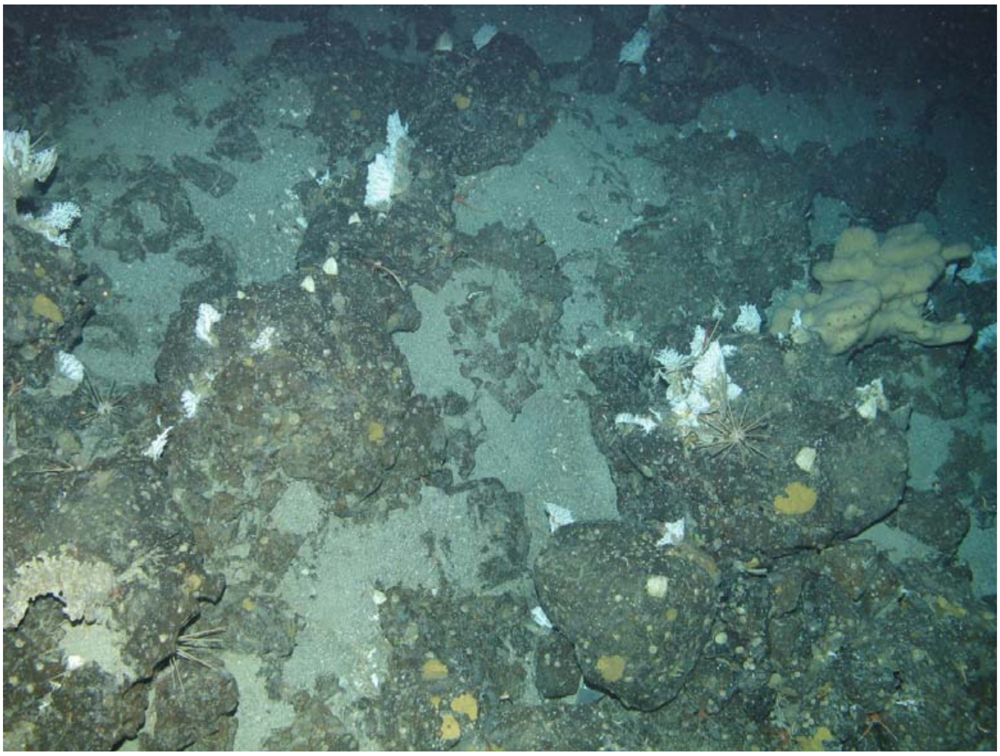
JC060 SIMPER descriptive name:
Encrusting fauna, *Cidaris cidaris* and orange anemones on steep bedrock
SIMPER within cluster similarity: 51.10%

Characterised (based on seven images) by saddle oysters (Anomidae sp.1), serpulid polychaetes, phoronid worms (Phoronida sp.1), ophiuroids (*Ophiactis balli*), pencil urchins (*Cidaris cidaris*), yellow encrusting sponges, orange anemones (suspected juvenile *Phelliactis* sp.1), sessile holothurians (*Psolus squamatus*), halcampid anemones (Halcampoididae sp.1), orange encrusting sponges, and squat lobsters (*Munida sarsi*). This assemblage is found on steep bedrock at water depths of 555-720m at an average temperature of 9.23°C (standard deviation 0.01°C). Video observations reveal large yellow lobose sponges, branching sponges, flytrap anemones (*Phelliactis* sp.1), basket stars (*Brisingella* sp.1), the sponge-carrying spider crab (*Paromola cuvieri*), and discrete *Lophelia pertusa* colonies to be among the larger, more disparate, or more-mobile species associated with this biotope. An unidentified, white encrusting fauna, forming numerous tiny (1cm) circular patches on bedrock is also present in this biotope. These were removed from analysis due to their over-abundance resulting in skewed clustering. The patches (visible in the image above) are likely to be of hydrozoan or bryozoan origin. This biotope predominantly represents the images obtained during JC060 and is equivalent to cluster FGHIJKL.

j Cluster TUW

Biotope Name: Stylasterids and lobose sponges on bedrock and mixed substrate

JC060 SIMPER descriptive name:
Stylasterids and lobose sponges on bedrock and mixed substrate
SIMPER within cluster similarity: 51.20%



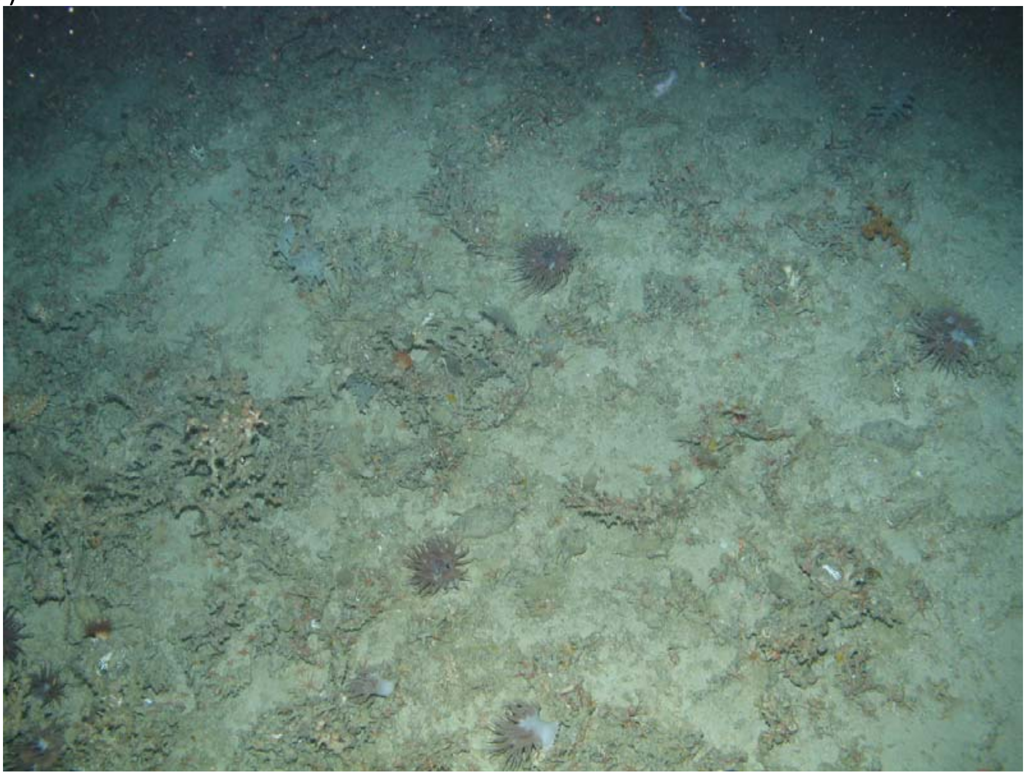
Characterised (based on 26 images) by saddle oysters (Anomidae sp.1), serpulid polychaetes, squat lobsters (*Munida sarsi*), pale, yellow and orange encrusting sponges, ophiuroids (*Ophiactis balli*), brachiopods (Brachiopod a sp.1), pencil urchins (*Cidaris cidaris*), cup corals (Caryophyllia sp.3), pandalid shrimp (*Pandalus borealis*) and stylasterid hydrocorals (Stylaster sp.1). This assemblage was found on bedrock, boulders and mixed substrates between 387-685m water depth and at an average temperature of 9.40°C (standard deviation 0.19°C). Video observations also revealed large, yellow, lobose sponges to be associated with this biotope. This biotope was also identified in the original Natura 2009 analysis as biotope MKE (Long *et al* 2013) but does not feature in Howell *et al* (2010). It appears fairly unique to Rockall Bank most likely due to the shallow depth range over which it occurs.

k Cluster YZAaAbAc

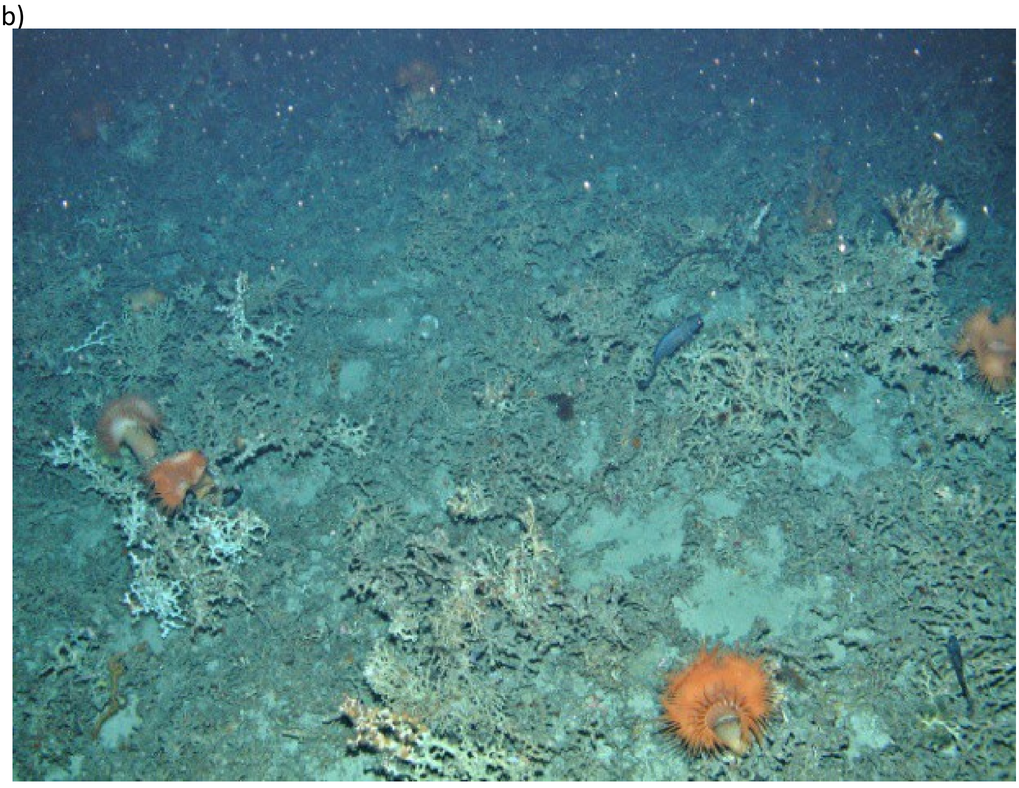
Biotope Name: Highly sediment draped scattered coral framework (deep)

JC060 SIMPER descriptive name:
Halcampid anemones on deep sediment draped low-lying coral framework and rubble
SIMPER within cluster similarity: 40.05%

(a)



(b)



Characterised (based on 25 images) by sediment clogged dead coral structure with halcampid anemones (Halcampoididae sp.1), cup corals (Caryophyllia sp.2), serpulid polychaetes, ophiuroids (*Ophiactis abyssicola*, *Ophiactis balli*), *Lophelia pertusa*, spider crabs (Majidae sp.1), lobose sponges, unidentified, large, purple anemones (Actiniaria sp.16), pencil urchins (*Cidaris cidaris*), squat lobsters (*Munida tenuimana*), blue, pale[2] and yellow encrusting porifera, and Xenophyophores (*Syringammina fragilissima*). This biotope was found between 820-1058m at an average temperature of 6.50°C (standard deviation 0.42°C). Video observations also found corkscrew antipatharians (*Stichopathes* sp.1), glass sponges (*Aphrocallistes* sp.), and flytrap anemones (*Phelliactis* sp.1) to be associated with this biotope. Howell *et al* (2010) describe this biotope as Cluster PBA 'Highly sediment draped scattered coral framework', although here the expression is at a greater depth resulting in some different species, so the name is modified to reflect this. Note: this cluster also includes areas of more classic '*Lophelia pertusa* reef framework' (Cluster YZAaAbAc image(b)).

l Cluster AD

Biotope Name: Sponges, corals and ascidians on mixed substrates, boulders and ledges

JC060 SIMPER descriptive name:
Sponges, corals and ascidians on mixed substrates, boulders and ledges
SIMPER within cluster similarity: 35.27%

Characterised (based on 10 images) by pale, green, yellow, and orange encrusting sponges, cup corals (Caryophyllia sp.2), halcampid anemones (Halcampoididae sp.1), spider crabs (Majidae sp.1), unidentified ascidians (Ascidiacea sp.1, Ascidiacea sp.2), lobose sponges, ophiuroids (Ophiuroidea sp.2, *Ophiactis abyssicola, Ophiactis balli*), burrowing anemones (Cerianthidae sp.1), and urchins (*Echinus* spp.). This assemblage is associated with mixed

[2] Pale refers to white, grey, cream or yellow encrusting sponges (see Section 3.6.2).

substrates, boulders and ledges between 1083-1435m water depths at an average temperature of 5.89°C (standard deviation 0.33°C). This biotope was also identified in the Natura 2009 analysis as biotope MJHii (Long *et al* 2013) but does not appear in Howell *et al* (2010).

m Cluster AF

Biotope Name: Edwardsiid anemones on coarse/gravelly sand

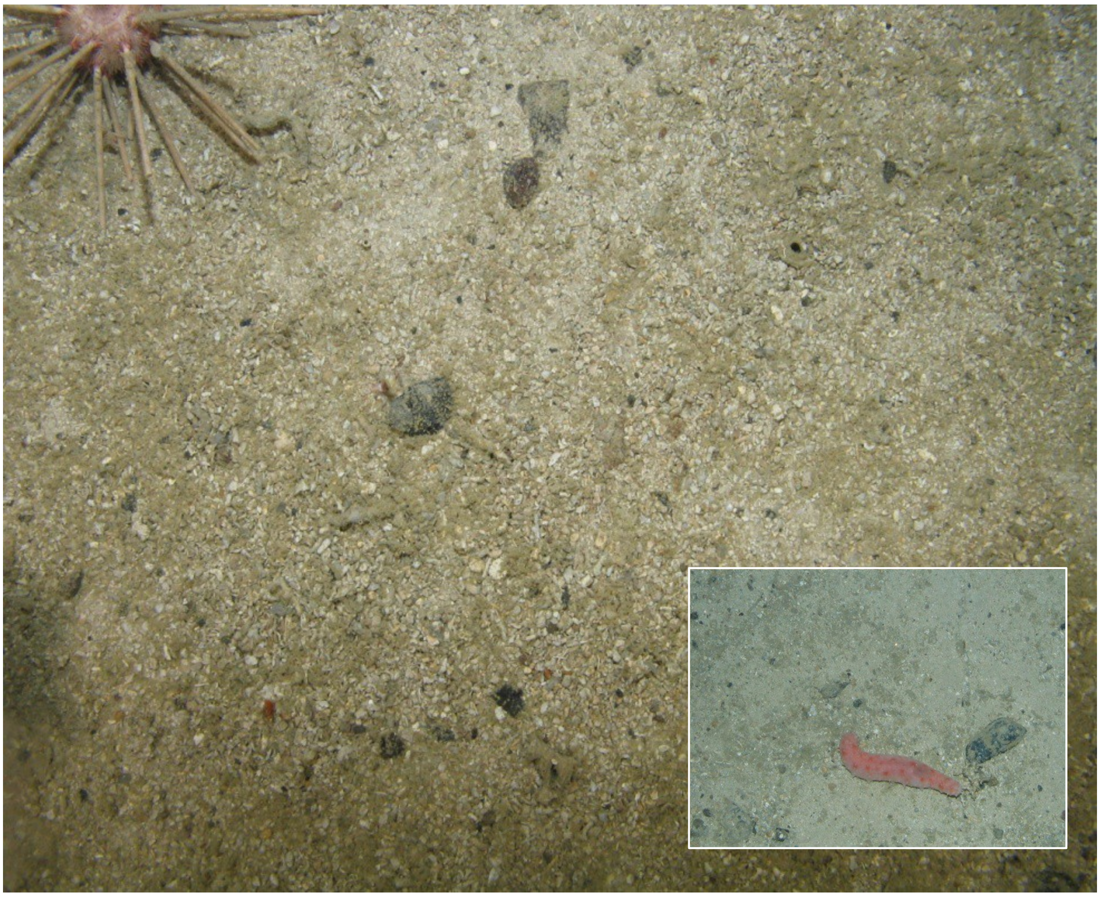
JC060 SIMPER descriptive name:
Edwardsiid anemones on coarse/gravelly sand
SIMPER within cluster similarity: 57.26%

Characterised (based on 13 images) edwardsid anemones (Edwardsiidae sp. 1) on coarse/ gravelly sand between 197-287m water depth at an average temperature of 9.44°C (standard deviation 0.09°C). Inset shows a close up of this image detailing the dense aggregations present. This biotope was also identified in the Natura 2009 analysis (Long *et al*, 2013) as biotope H , and is described in Howell *et al* (2010) as cluster L ‘Edwardsiid anemones and Chaetopterid polychaetes’ where it is noted as difficult to distinguish in more-elevated images.

iii Further biotopes identified from video which did not emerge in cluster analysis

[Video ID]

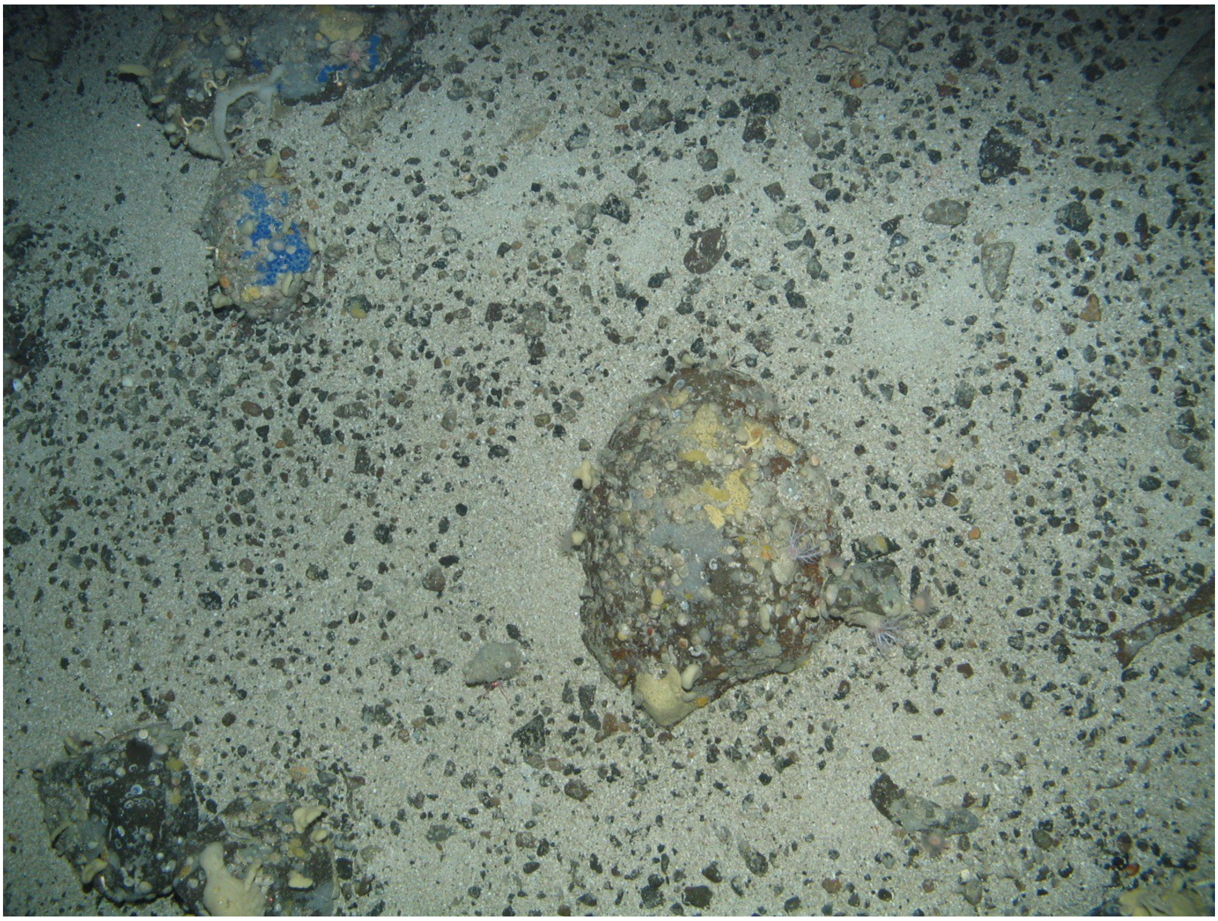
Cidaris cidaris – Parastichopus tremulus community on coarse sand



This community comprises the pencil urching *Cidaris cidaris* and the holothurian *Parastichopus tremulus* (formerly *Stichopus tremulus*) and is found on coarse sand and mixed sediments. It was not identified during cluster analysis, but is apparent when reviewing the video and was also identified during the review of video data in the Natura 2009 analysis. This is likely due to the characterising species being both mobile and disperate, so photo analysis is unlikely to capture it. This community was also identified in Howell *et al* (2010) and Howell (2010) as '*Cidaris cidaris – Stichopus tremulus* community' at an average depth of 510m and an average temperature of 9.20°C.

[Video ID]

<u>*Psolus*, caryophyllids and lamellate sponges on mixed, boulder and bedrock substrate</u>



This community comprises holothurians (*Psolus squamatus*), saddle oysters (*Anomiidae*), ophiuroids, encrusting sponges, caryophyllids, and lamellate sponges on mixed substrates. This community did not emerge from cluster analysis probably due to the similarity to the most abundant species composition of the 'Discrete coral (*Lophelia pertusa*) colonies on hard substratum'. The wide separation of analysed images in the Natura 2009 analysis also results in a lack of re-inforcement as a separate biotope. However, it should be noted that this did appear as a separate biotope from the Natura 2009 cluster analysis due to the lack of JC060 data and inclusion of Anton Dohrn data where this biotope also appears. Howell *et al* (2010) found this biotope at an average depth of 555m and an average temperature of 8.97°C.

3.3.3 Maps

Broadly speaking the JC060 transects agreed with the substrate interpretation undertaken by Heather Stewart (BGS) in (Long *et al*, 2013) (Figure 17). However the biotope interpreted map appears to show little agreement with the new data (Figure 18). Both transects pass through geometrical polygons interpreted as the following biotopes: 'Serpulids, encrusting sponges and *Cidaris* on mixed substrate' and 'Stylasterids and lobose sponges on bedrock and mixed substrate', neither of which appear in either transect. However, the JC060 transects were undertaken to specifically target an area suspected of supporting *Lophelia pertusa* reef habitat, predicted by maximum entropy modelling (Ross & Howell, 2013). *Lophelia pertusa* reef habitat did not feature on East Rockall Bank in the original 2009 survey (Long *et al*, 2013), and thus using 'by-eye' interpretation (as was the method used) it would have been very difficult to predict the presence of a biotope not observed at this site. It is worth noting however, that the areas of both transects that overlie the ‘Serpulids, encrusting sponges and *Cidaris* on mixed substrate’ polygon have been interpreted as *Lophelia pertusa* reef rubble apron (Cluster MN or Cluster R in JC060 only analysis). The ‘*Lophelia pertusa* reef rubble apron’ biotope is characterised by ophiuroids (*Ophiactis balli*), serpulid polychaetes, squat lobsters (*Munida sarsi*), pencil urchins (*Cidaris cidaris)* and bivalves (Margarites sp.1) on coral gravel/low-lying coral rubble. The presence of *Lophelia pertusa* reef framework up slope has resulted in the presence of coral gravel down slope. This has modified the dominant biotope in this region from the predicted ‘Serpulids, encrusting sponges and *Cidaris* on mixed substrate’ to a rubble apron that shares species in common with the ‘Serpulids, encrusting sponges and *Cidaris* on mixed substrate’ biotope and those found associated with coral rubble.

Both transects also overlie a geometrical polygon interpreted as ‘Stylasterids and lobose sponges on bedrock and mixed substrate’. The sections of both transects that overlie this polygon support *Lophelia pertusa* reef framework, *Lophelia pertusa* reef rubble apron, and *Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum. The area of terrain targeted by the JC060 transects is an area of steep ledge features uncharacteristic of the rest of the East Rockall margin. Although we have no doubt that at a very broad scale the ‘Stylasterids and lobose sponges on bedrock and mixed substrate’ is the dominant biotope in the region, at this fine scale the interpretation is incorrect. It is important to note that predictive modelling methods were used to identify this region as potentially supporting *Lophelia pertusa* reef habitat, and it is our opinion that predictive modelling approaches will ultimately produce a more-reliable biotope map for this area. Modification by eye of the existing map would seem entirely inappropriate given the error associated with this method, and thus has not been undertaken.

The existing interpretation of the location of Annex I reef habitat undertaken by Stewart and Davies in Long *et al* (2013) remains valid however there are now confirmed areas of biogenic reef associated with the ledge features in this specific area. The coarse-scale predictive model of Ross and Howell (2013) indicates there may be many other areas of biogenic reef habitat along the East Rockall Margin that have not been sampled. The Ross and Howell (2013) model could be used to better inform the location of Annex I biogenic reef habitat in this region in parallel with the existing biotope map until a full predicted model of biotope distribution on East Rockall Bank can be produced.

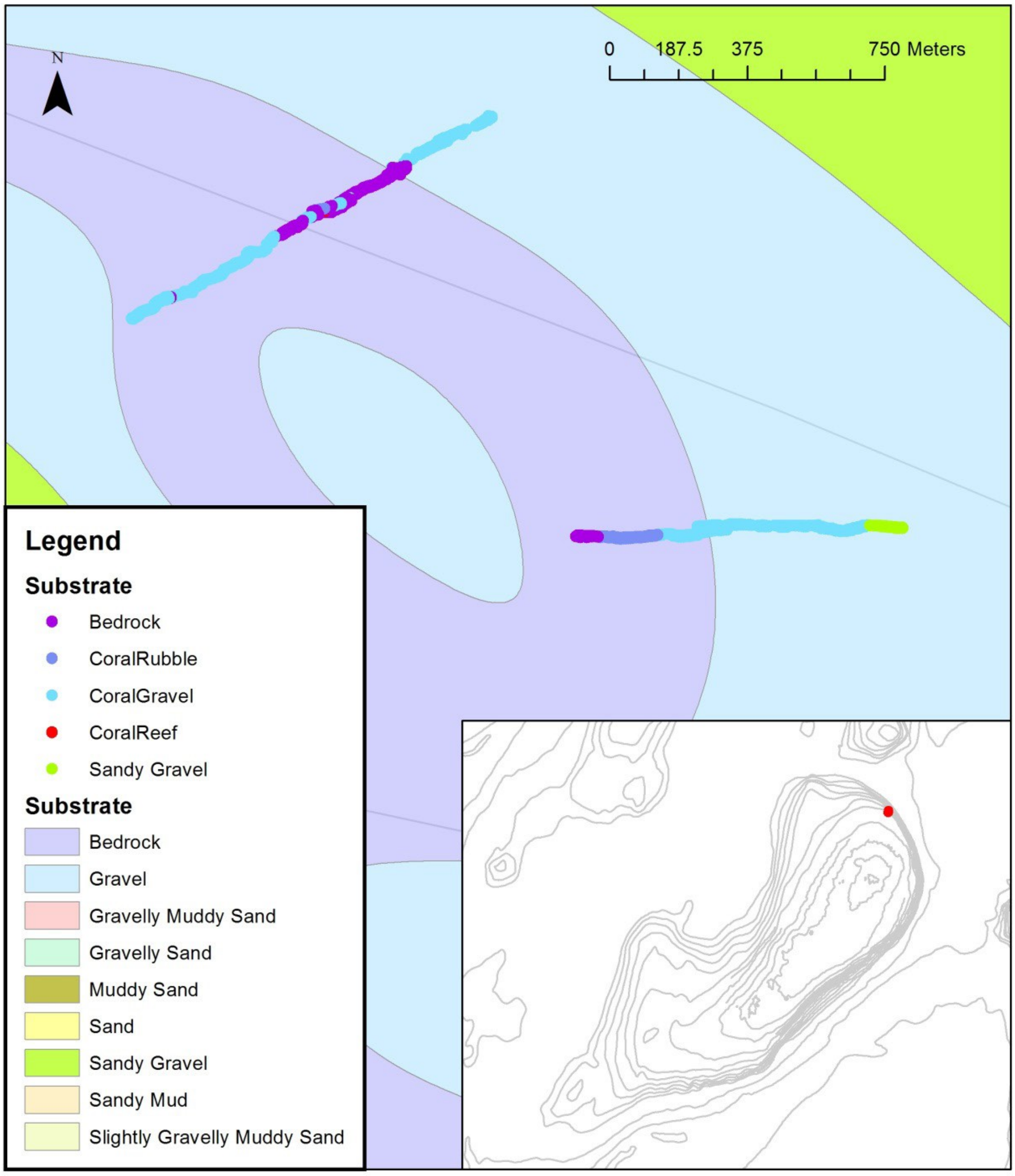


Figure 17. Map of the JC060 transects on the north-eastern flank of Rockall Bank overlaid on the Substrate interpretation produced by Heather Stewart through the 2009 East Rockall Bank-Anton Dohrn survey (Long *et al*, 2013).

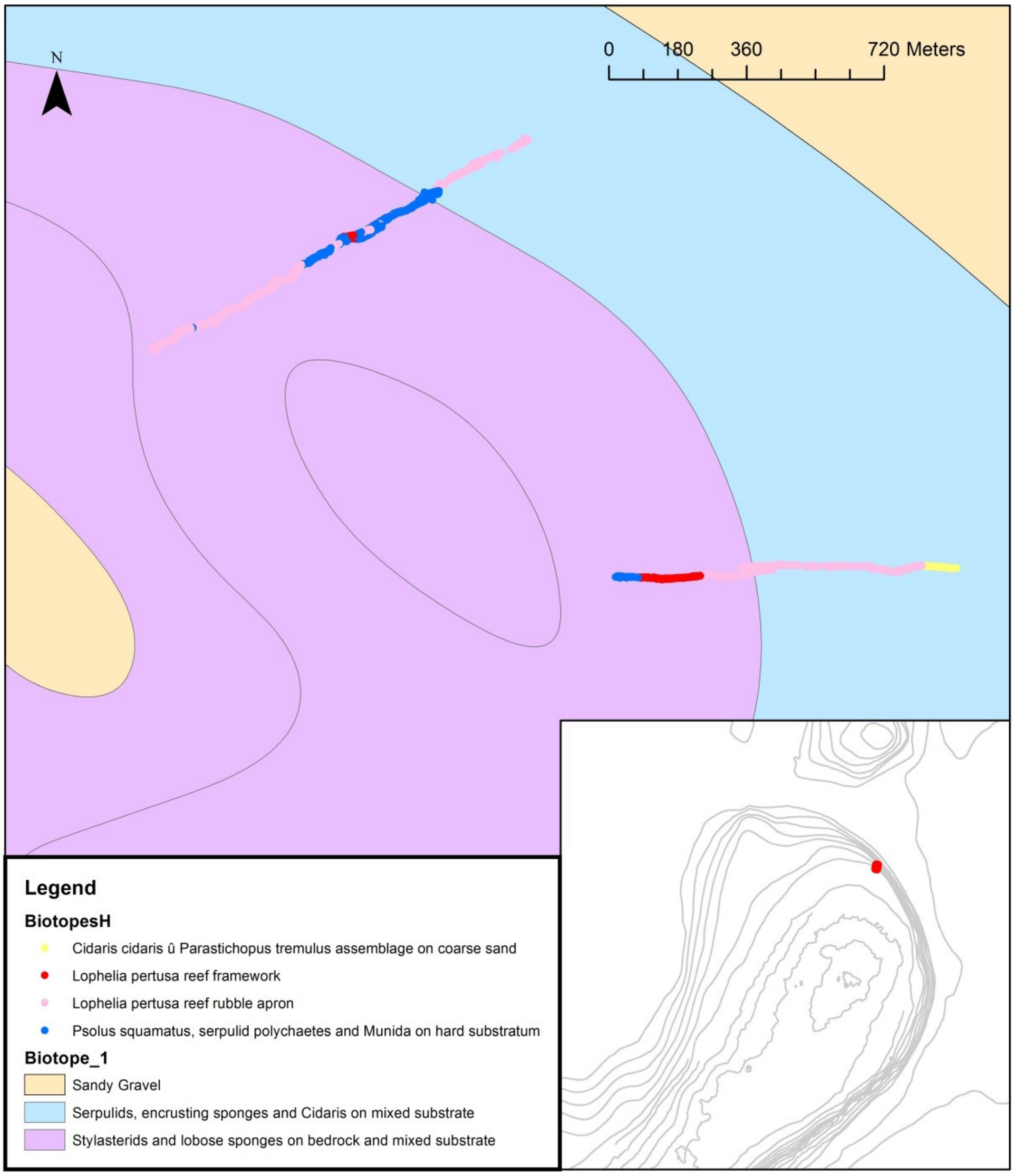


Figure 18. Map of the JC060 transects on the northeastern flank of Rockall Bank overlaid on the biotope interpretation produced by Jaime Davies through the 2009 East Rockall Bank-Anton Dohrn survey (Long *et al*, 2013).

3.4 North-West Rockall Bank Results

Five transects were carried on the western flank of Rockall Bank, for a total length of ~8 km. Out of the 1,943 images collected, a total of 333 images were used for the analysis and 46 OTUs were observed. In transects 97 and 104, a problem occurred with the camera that resulted in respectively 226 and 156 of the captured images to be unreadable.

3.4.1 Defining biotopes

The SIMPROF routine identified 15 clusters to be statistically significant ($p<0.05$) (Figure 19). Of those, seven were composed of single images while clusters A, B, C and E consisted of less than five images. These images usually contained only one or two individuals of rarer OTUs and were not considered further in the analysis. Cluster E was typically dominated by

Parastichopus tremulus and *Munida sarsi*, and likely represents a transition assemblage between soft and mixed sediments. Although cluster D contained seven images, no clear species assemblages could be detected except for the presence of *Henricia* spp.

To provide useful biotopes for mapping, some of the remaining clusters were combined to lower degrees of similarity. Two biotopes were found associated with soft-sediment dominated images, clusters FGH and MN. Images containing varying proportions of mixed sediments were combined to form the cluster IJK. Cluster L represents images containing live *Lophelia pertusa* colonies. This consolidation resulted in SIMPROF clusters combined at the ~ 40% similarity level. SIMPER analysis of these clusters confirmed their similarity and identified the morphospecies that characterised each cluster. Further descriptions and an example image of each biotope are provided in the next section.

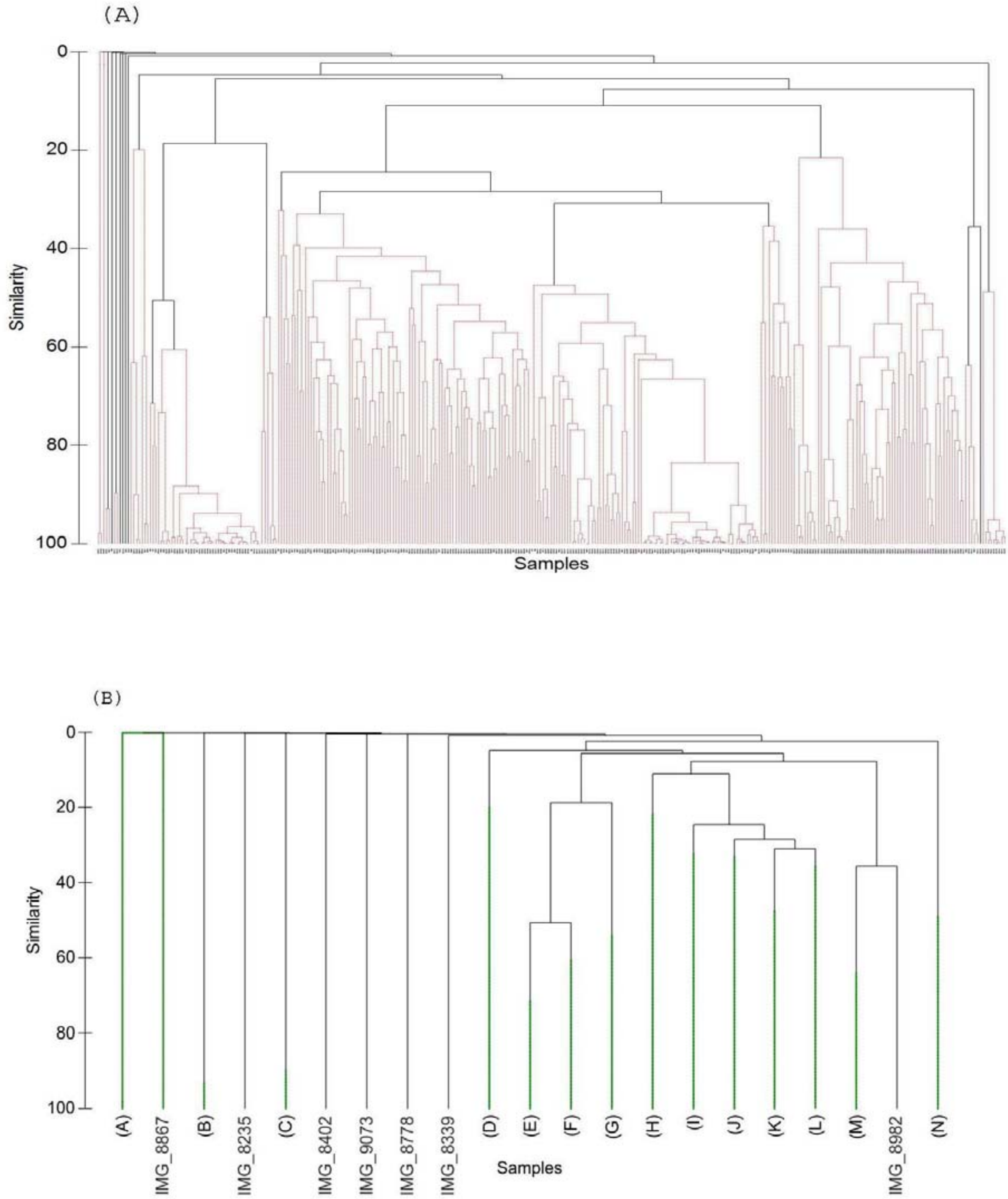


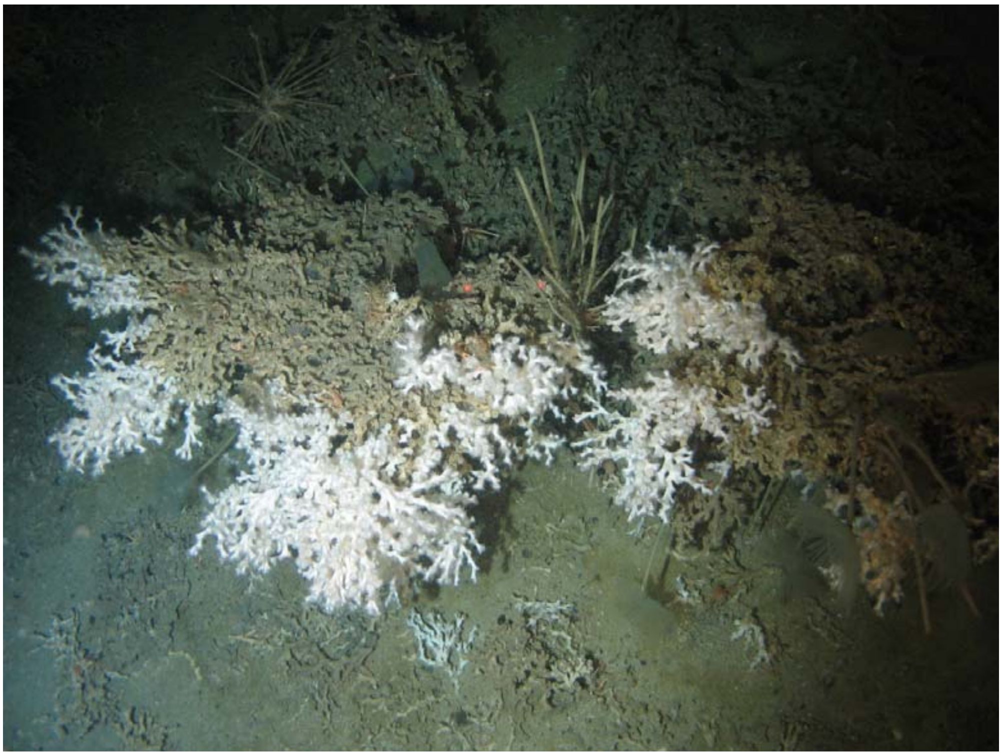
Figure 19. North-West Rockall Bank cluster dendrograms. The raw dendrogram (A) shows the red SIMPROF groups considered statistically significant clusters ($p < 0.05$). Outliers were then excluded and SIMPROF groups collapsed to give the cluster groupings shown in (B) the final dendrogram.

3.4.2 Biotope descriptions

a Cluster L

Biotope Name: *Lophelia pertusa* reef framework

JC060 SIMPER descriptive name:
Lophelia pertusa coral reef
SIMPER within cluster similarity: 46.4%

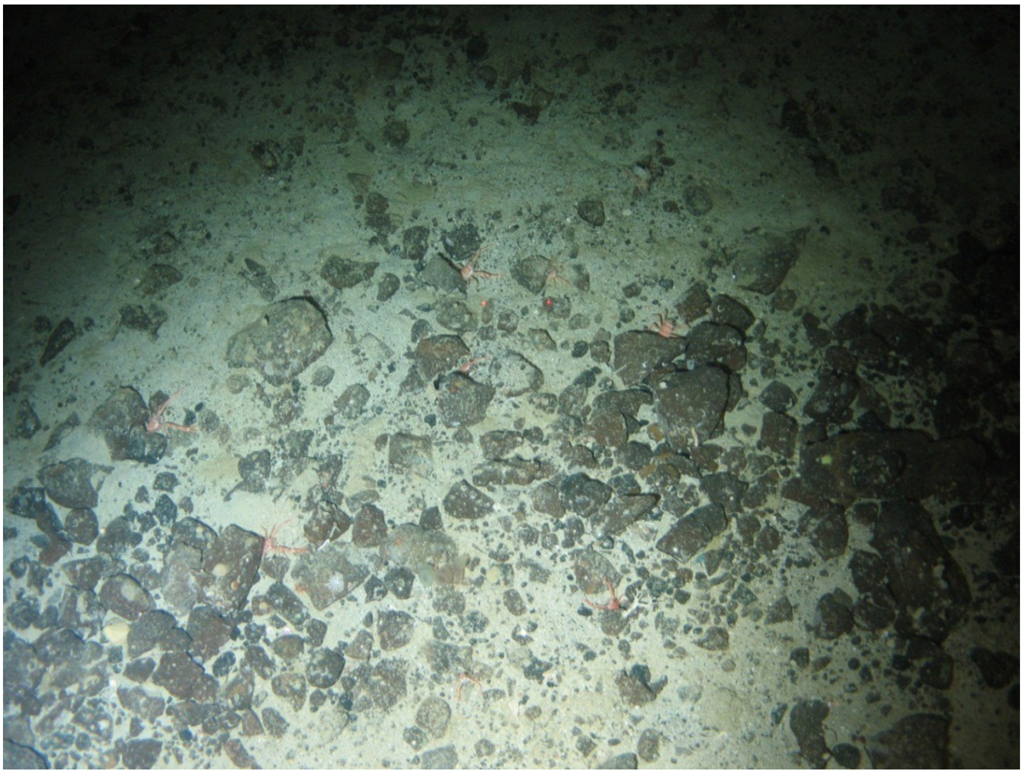


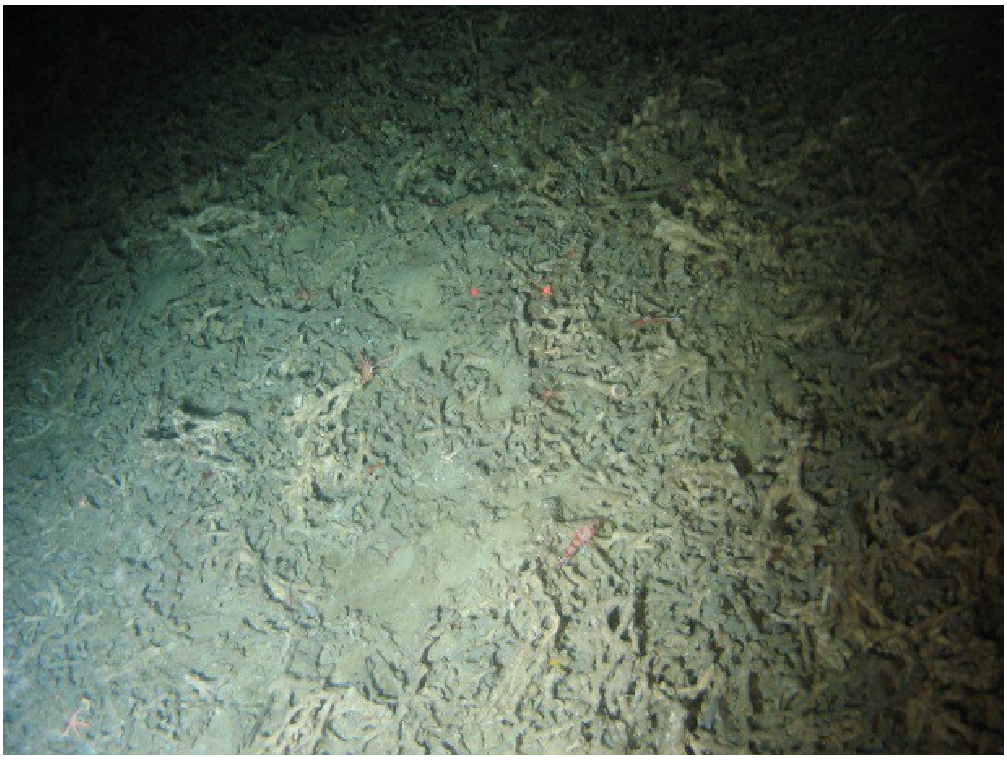
This cluster composed of 12 images is similar to '*Lophelia pertusa* reef framework' biotope described for East Rockall Bank. This cluster was generally observed between 191.4-228.6m in depth and at an average temperature of 9.26°C (standard deviation <0.01°C), and was not found on steep slopes. The coral framework was characterized by both living and dead *Lophelia pertusa* and colonized by Sabellid worms, an unidentified pink anemone species, yellow encrusting sponges and ascidians. Numerous individuals of the squat lobtser *Munida sarsi* were usually present and the echinoid *Echinus* sp. (likely *E. acutus*) was also regularly observed.

b *Cluster IJK*

Biotope Name: *Munida sarsi* and *Reteporella* spp. on mixed or hard sediments

JC060 SIMPER descriptive name:
Munida sarsi and *Reteporella* spp.
SIMPER within cluster similarity: 41.4%





Observed in 177 images, this biotope was by far the most varied and likely represent a mixture or close association with the 'Serpulid polychaetes and *Munida* on mixed substrate' and '*Reteporella* & Axinelld sponges on mixed substrate' biotopes described from East Rockall Bank. It was dominated by *Munida sarsi*, the bryzoan *Reteporella* spp. and various OTUs of encrusting sponges. This cluster also included the few images where exposed bedrock was observed. In these images, encrusting sponge species and bryzoans occurred in greater densities. This biotope occurred in temperatures averaging 9.25°C (standard deviation <0.01°C) and depths of 178.1-311.6m. This biotope has been described previously by Howell *et al* (2009) who described the area as characterised by encrusting sponges and bryozoans, *Reteporella* sp, cyclostome bryozoans, cup sponges (*Axinella* sp and *Phakelia* sp) and an unidentified coral/anemone species.

Cluster J was composed of images containing coral rubble (including large coral rubble fields) and might resemble more closely the '*Lophelia pertusa* reef rubble apron' or 'Trawl damaged *Lophelia pertusa* rubble' biotopes. It likely clustered with H and I because of the dominance of the squat lobster *Munida sarsi* and yellow encrusting sponges.

c *Cluster FGH*

Biotope Name: *Cidaris cidaris – Parastichopus tremulus* community on coarse sand

JC060 SIMPER descriptive name:
Parastichopus tremulus on sand
SIMPER within cluster similarity: 27.8%

Dominated by *Parastichopus tremulus*, this biotope was characterised based on 107 images and similar to the '*Cidaris cidaris – Stichopus tremulus* community' biotope described in Howell *et al* (2010) and Howell (2010). Individuals of *Cidaris cidaris* were observed, but not has frequently as described for these other areas. Substratum for this biotope was characterized by sediments grain sizes ranging from sand to gravel. When gravel was recorded (63 images), an unidentified species of orange worm was frequently observed extending slightly above the sediment. This biotope occurred between 184.5-323.4m in depth at an average temperature of 9.25°C (standard deviation <0.01°C).

d Cluster N and Cluster M

Biotope Name: *Caryophyllia* spp. and shrimps on scattered cobbles

JC060 SIMPER descriptive name:
Caryophyllia spp. on scattered cobbles
SIMPER within cluster similarity: 40.6%

Although not forming a distinct cluster, these images presented similar environmental characteristics (dominated by sand with scattered cobbles), and as they represent only a few images (Cluster M; five images, Cluster N; eight images), are described together. This cluster was observed in 218.8-309.4m depths with temperatures averaging 9.25°C (standard deviation <0.01°C). When cobbles were present, the cup coral *Caryophyllia* spp. was frequently observed while shrimps (likely *Pandalus borealis*) were often present in the surrounding soft sediments.

3.4.3 Maps

The biotopes were overlain over the sediment interpretation map and a close association between the two could be observed. The high sediment heterogeneity observed is associated with quaternary iceberg activity (Sacchetti *et al*, 2012). The landscape is dominated by ploughmark features where cobbles and boulders were left on the edge of furrows which were over time infilled by soft sediments. As found in other areas of the northwest European continental margin, the hard substratum allowed cold-water coral colonies to develop (Freiwald *et al* 1999, Wheeler *et al* 2007).

As with any categorical classification map, the boundaries were difficult to define as a complete gradient from soft sediments to cobble dominated images could be observed. Hence, gravel- and pebble-dominated areas are shown on the following maps even though a specific biotope was not found to be associated with this particular substrate. Similarly, although rubble field tended to be dominated by *Munida sarsi* and resembled the fauna associated with mixed sediments, they were included in the maps below. *Caryophyllia* spp. and shrimps on scattered cobbles biotope was only observed in images captured during mission 44 while exposed bedrock and coral framework were not observed (Figure 21).

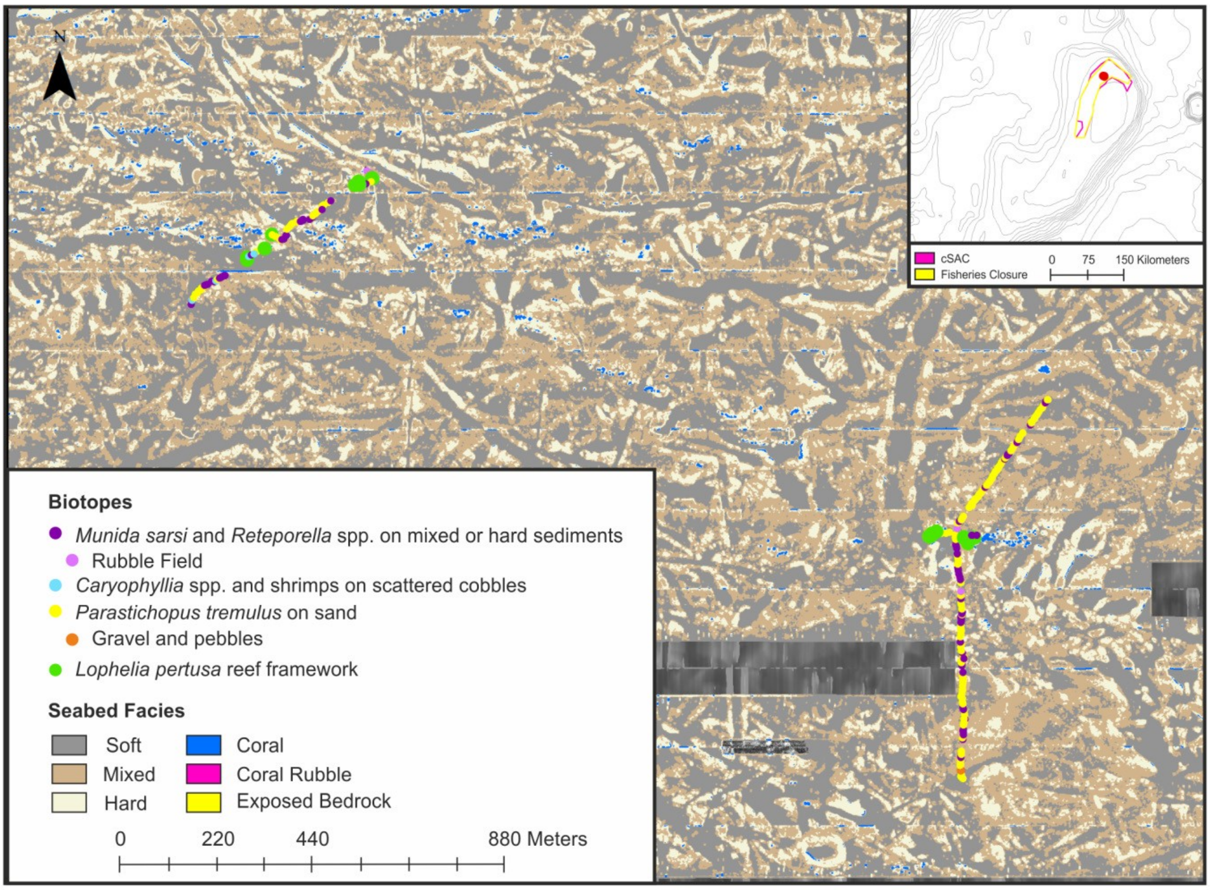


Figure 20. Sediment interpretation map based on the sidescan sonar backscatter survey acquired during AUV mission 43 with ROV dives 16 and 18 overlaid with the biotopes described previously.

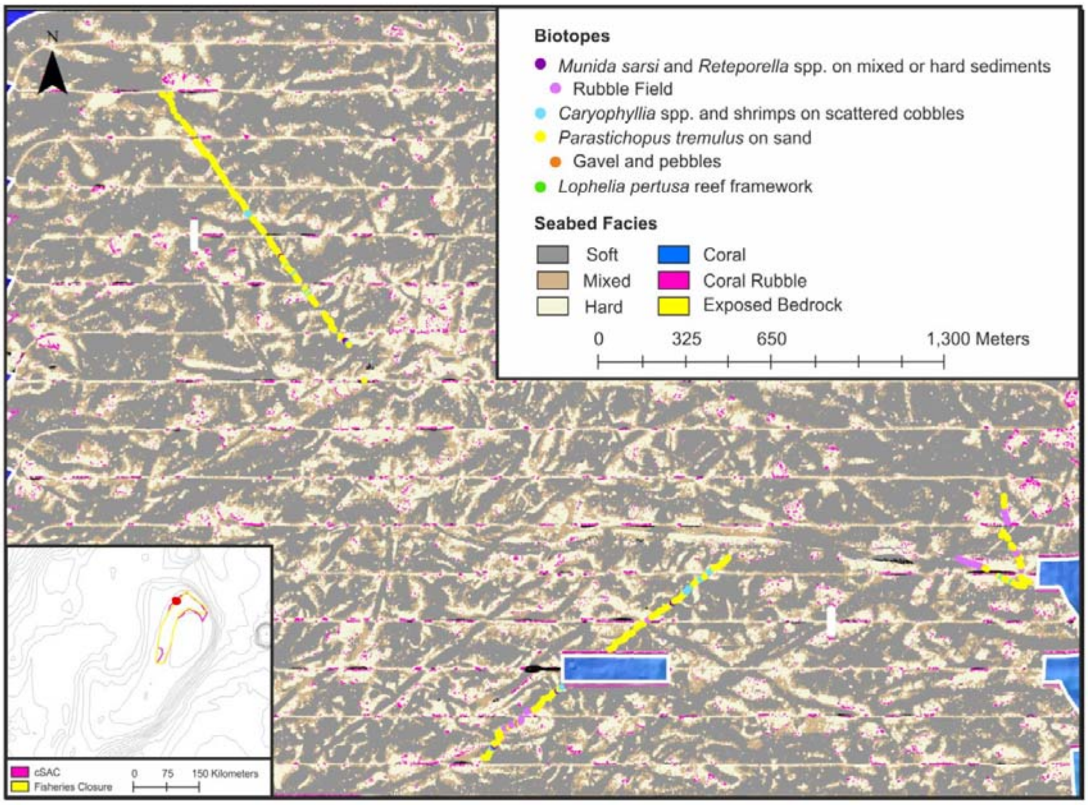


Figure 21. Sediment interpretation map based on the sidescan sonar backscatter survey acquired during AUV mission 44 with ROV dives 19 and 20 overlaid with the biotopes described previously.

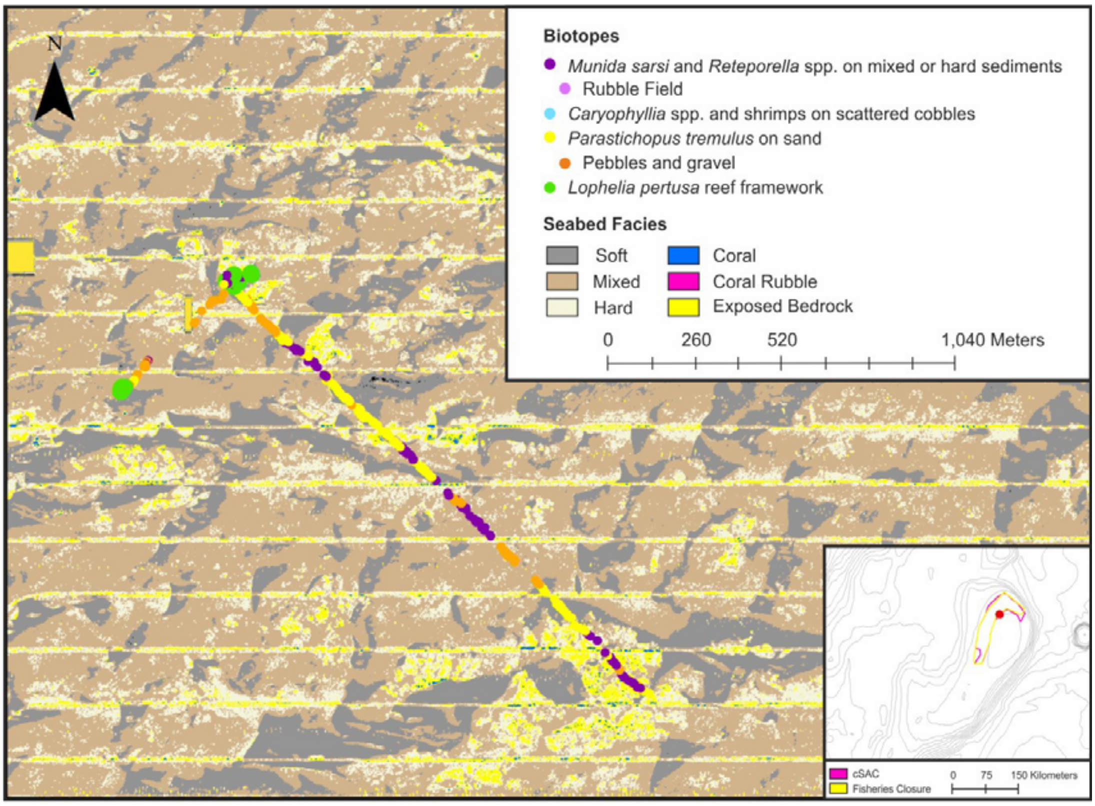


Figure 22. Sediment interpretation map based on the sidescan sonar backscatter survey acquired during AUV mission 44 with ROV dive 23 overlaid with the biotopes described previously.

3.5 Full list of Biotopes

Cluster	Final biotope Name	SIMPER descriptive name	Substrate	Depth Range	Average Temp (standard deviation)	Characterising species/morphospecies	Supporting Reference
Darwin Mounds							
BDEF	Xenophyophore fields	Xenophyophores on soft sediment	Sand, coral rubbles	937 - 1070 m	7.62 °C	*Syringammina fragilissima*	Howell (2010)
GHIJ	*Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand	Xenophyophores and epifauna on coral rubble and sand	Coral gravels , rubbles	942 – 1052 m	7.96 °C	*Syringammina fragilissim,* white encrusting sponges, *Halcampoididae sp.1, Ophiactis Balli, Munida tenuiman,* yellow encrusting sponges, blue encrusting sponges, *Cerianthidae sp.1,* orange encrusting sponges, *Majidae sp. 1, Octocorallia sp. 2*	
Hatton Basin (Polygonal Faults)							
A	Halcampid anemones and white encrusting sponges on mixed substrate	Halcampids *Ophiactis abyssicola* & encrusting sponges on hard substrate	Boulders	1171-1178m	5.07 (0.01)	Halcampoididae sp. 1, O*phiactis abyssicola,* Pale Encrusting Porifera, Green Encrusting Porifera, Majidae sp. 1, Polychaeta sp. 4, Caryophyllia sp. 2, Lamellate Porifera.	Howell *et al* (2010)
FGH	A6.621 Facies with *Pheronema grayi*	*Pheronema carpenteri* aggregations on soft sediment	Mud, sand	1139-1197m	5.07 (0.02)	Sabellidae sp.3, *Pheronema carpenteri,* Porifera massive lobose sp.29, Cerianthidae sp. 1, *Ophiactis abyssicola*, Unknown sp. 22 (stalked possibly porifera), Yellow Encrusting Porifera, Pale Encrusting Porifera, Hydrozoa (bushy).	EUNIS habitat
IJE	Cerianthid anemones & burrowing megafauna in bioturbated soft sediment	Cerianthid anemones & burrowing megafauna in bioturbated soft sediment	Mud, sand, burrows	1143-1184m	5.07 (0.01)	Cerianthidae sp. 1, Hydrozoa sp.5, Sabellidae sp.3.	Potential EUNIS habitat (A5.361) and SS.SMu.CFiMu.SpnMe.g. Connor *et al* (2004) but deeper. Davies *et al* (2007)
LM	Burrowing anemones in soft sediment	Burrowing anemones in soft sediment	Mud, sand	1171-1184m	5.08 (0.01)	Holothuria sp.5 (likely juvenile *Kolga* sp.), Cerianthidae sp.3.	Potential EUNIS habitat (A5.361) and SS.SMu.CFiMu.SpnMe.g. Connor *et al* (2004) but deeper. Davies *et al* (2007)

Cluster	Final biotope Name	SIMPER descriptive name	Substrate	Depth Range	Average Temp (standard deviation)	Characterising species/morphospecies	Supporting Reference
NE Rockall (JC060 only)							
E (Sub-biotope)	*Lophelia pertusa* reef rubble apron	Bushy hydroids on rock ledges	Bedrock ledges	504-559m	9.23 (0.003)	*Ophiactis balli*, Serpulidae, Hydrozoa (bushy), Orange Encrusting Porifera, Halcampoididae sp.1, Yellow Encrusting Porifera, Brachiopoda sp. 1, *Cidaris cidaris*, *Munida sarsi*.	n/a (Howell *et al*, 2010)
FGHIJKL	*Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum	*Encrusting fauna, Cidaris cidaris and orange anemones on steep bedrock*	Steep bedrock	395-804m	9.19 (0.22)	Anomiidae sp. 1, Serpulidae, *Ophiactis balli, Cidaris cidaris,* Yellow Encrusting Porifera, *Phelliactis* sp.1 (juvenile), Phoronida sp. 1, *Munida sarsi,* Pale Encrusting Porifera, *Psolus squamatus,* Caryophyllia sp. 3, Hydrozoa (bushy), Blue Encrusting Porifera, Halcampoididae sp. 1, Pliobothrus sp.1, Sabellidae sp. 1, Lobose Porifera.	Howell *et al* (2010)
MNOP	*Lophelia pertusa* reef framework	Predominantly low-lying dead framework slopes of *Lophelia pertusa* coral reef on steep bedrock	Coral rubble/ coral framework on hard substrate	508-641m	9.24 (0.01)	Serpulidae, *Ophiactis balli, Cidaris cidaris,* Hydrozoa (bushy), Sabellidae sp. 1, Actiniaria sp.22, *Lophelia pertusa, Munida sarsi, Pandalus borealis, Phelliactis* sp.1 (juvenile), Yellow Encrusting Porifera, Ascidiacea sp. 2.	Equivalent to Dead framework slopes of *Lophelia pertusa* reef in Howell *et al* (2010)
R	*Lophelia pertusa* reef rubble apron	Serpulids, bivalves & *Munida sarsi* on coral gravel	Coral gravel	544-743m	9.25 (0.02)	Serpulidae, *Margarites* sp. 1, *Munida sarsi.*	Howell *et al* (2010)
East Rockall Bank (JC060 & Natura 2009)							
C	Xenophyophore fields	Xenophyophore aggregations	Sand, Mud	861-1443m	5.88 (0.41)	Cerianthidae sp.1, *Syringammina fragilissima*, Unknown sp. 29 (bryo/porif), Halcampoididae sp.1, Cnidaria sp.1, Majidae sp.1, *Pandalus borealis*.	Howell,(2010; Long *et al*,(2013
E	Brachiopods on bedrock	Brachiopods on sand veneered bedrock	Bedrock with sand veneer	1127-1134m	6.18 (0.03)	Brachiopoda sp.1, Terebellidae sp.2, Halcampoididae sp.1	Possible modification to Howell *et al* (2010) Brachiopods on coarse sediment

Cluster	Final biotope Name	SIMPER descriptive name	Substrate	Depth Range	Average Temp (standard deviation)	Characterising species/morphospecies	Supporting Reference
F	Unidentified (possibly Halcampoid) anemones in soft sediment	Unidentified (possibly Halcampoid) anemones in soft sediment	Sand, Mud	1075-1114m	6.27 (0.05)	Unidentified anemones (Cf Halcampoididae/Haloclavidae/Edwardsiidae)	Long *et al* (2013) - equivalent to Halcampoid anemones in soft sediment
J	*Reteporella* & Axinellid sponges on mixed substrate	*Reteporella* bryozoan & Axinelld sponges on mixed substrate	Mixed	196-219m	9.39 (0.03)	*Munida sarsi*, Yellow Encrusting Porifera, Pale Encrusting Porifera, *Reteporella* sp.1, *Axinella infundibuliformis*, Lobose Porifera.	Possible EUNIS habitat (A4.12) and (CR.HCR.DpSp in Connor *et al*, 2004) Also identified in Long *et al*, 2013; Howell *et al,* 2009.
K	Serpulid polychaetes and *Munida* on mixed substrate	Serpulid polychaetes & *Munida sarsi* on mixed substrates and biogenic gravel	Mixed substrates, biogenic gravel	358-823m	9.33 (0.19)	Serpulidae, *Munida sarsi*, Pale Encrusting Porifera.	Howell *et al* (2010); Long *et al* (2013)
L	*Caryophyllia smithii* & *Actinauge richardi* on sand/gravelly sand	*Caryophyllia smithii* & *Actinauge richardi* on sand/gravelly sand	sand/ gravelly sand, mixed substrates	218-286m	9.4 (0.09)	*Munida sarsi*, *Caryophyllia smithii*, *Ophiactis balli*, Anomiidae sp. 1, Caryophyllia sp. 3, Pale Encrusting Porifera, *Actinauge richardi*.	Long *et al* (2013)
MN	*Lophelia pertusa* reef rubble apron	Serpulids, *Munida sarsi* & ophiuroids on coral gravel	Coral gravel/ low-lying coral rubble	493-739m	9.24 (0.02)	*Ophiactis balli*, Serpulidae, *Munida sarsi*, *Cidaris cidaris*, *Margarites* sp. 1.	Howell *et al* (2010); Long *et al* (2013)
O	*Lophelia pertusa* reef framework	Dead framework slopes of *Lophelia pertusa* reef (Shallow)	Coral framework, coral rubble	537-680m	9.23 (0.02)	Serpulidae, *Cidaris cidaris*, *Lophelia pertusa*, *Ophiactis balli*, Hydrozoa (bushy), *Pandalus borealis*, *Phelliactis* sp.1 (juvenile), Actiniaria sp.24, *Munida sarsi*, Lobose Porifera, Brachiopoda sp.1.	Howell *et al* (2010) Long *et al* (2013) – equivalent to Dead framework slopes of *Lophelia pertusa* reef in Howell *et al* (2010)

Cluster	Final biotope Name	SIMPER descriptive name	Substrate	Depth Range	Average Temp (standard deviation)	Characterising species/morphospecies	Supporting Reference
S	*Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum	Steep bedrock reef	Steep bedrock	555-720m	9.23 (0.01)	Anomidae sp.1, Serpulidae, Phoronida sp.1, *Ophiactis balli*, *Cidaris cidaris*, Yellow Encrusting Porifera, *Phelliactis* sp.1 (juvenile), *Psolus squamatus*, Halcampoididae sp. 1, Orange encrusting porifera, *Munida sarsi*.	Howell *et al* (2010)
TUW	Stylasterids and lobose sponges on bedrock and mixed substrate	Stylasterids and lobose sponges on bedrock and mixed substrate	Bedrock, boulders, mixed substrates	387-685m	9.40 (0.19)	Anomidae sp.1, Serpulidae, *Munida sarsi*, Pale encrusting porifera, *Ophiactis balli*, Brachiopoda sp.1, *Cidaris cidaris*, Caryophyllia sp.3, *Pandalus borealis*, Yellow encrusting porifera, Orange encrusting porifera, *Stylaster* sp.1.	Long *et al* (2013)
YZAaAbAc	Highly sediment draped scattered coral framework	Halcampid anemones on deep sediment draped low-lying coral framework and rubble	Sediment clogged coral framework, sediment clogged coral rubble	820-1058m	6.5 (0.42)	Halcampoididae sp.1, Caryophyllia sp.2, Serpulidae, *Ophiactis abyssicola*, Ascidiacea sp.2, *Lophelia pertusa*, Majidae sp.1, *Ophiactis balli*, Lobose Porifera, Actiniaria sp. 16(large purple), *Cidaris cidaris*, *Munida tenuimana*, Blue encrusting porifera, Pale encrusting porifera, Yellow encrusting porifera, *Syringammina fragilissima*.	Howell *et al* (2010); Long *et al* (2013)
Ad	Sponges, corals and ascidians on mixed substrates, boulders and ledges	Sponges, corals and ascidians on mixed substrates, boulders and ledges	Mixed, boulders, bedrock ledges	1083-1435m	5.89 (0.33)	Pale Encrusting Porifera, Caryophyllia sp.2, Halcampoididae sp.1, Majidae sp.1, Green Ecnrusting Porifera, Ascidiacea sp.1, Lobose Porifera, Ophiuroidea sp.2, Yellow Encrusting Porifera, *Ophiactis abyssicola, Ophiactis balli*, Orange Encrusting Porifera, Ascidiacea sp. 2, Cerianthidae sp. 1, *Echinus* spp.	Long *et al* (2013)
Af	Edwardsiid anemones on coarse/gravelly sand	Edwardsiid anemones on coarse/gravelly sand	Coarse sand, gravelly sand	197-287m	9.44 (0.09)	Edwardsiidae sp. 1.	Howell *et al* (2010); Long *et al* (2013) Equivalent to Edwardsiid anemones and Chaetopterid polychaetes in Howell *et al* (2010)

Cluster	Final biotope Name	SIMPER descriptive name	Substrate	Depth Range	Average Temp (standard deviation)	Characterising species/morphospecies	Supporting Reference
* (Video ID only)	*Cidaris cidaris – Parastichopus tremulus* assemblage on coarse sand	n/a	Coarse sand	c.510m	c.9.2	*Cidaris cidaris*, *Parastichopus tremulus*	Howell *et al* (2010)
* (Video ID only)	*Psolus*, caryophyllids and lamellate sponges on mixed, boulder and bedrock substrate	n/a	Mixed, Boulders, Bedrock	c.555m	c.8.97	*Psolus squamatus*, Anomidae, ophiuroids, encrusting sponges, Caryophyllidae, lamellate sponges	Long *et al* (2013)
NW Rockall							
L	*Lophelia pertusa* reef framework	*Lophelia pertusa* coral reef	Coral rubble/ coral framework on hard substrate	191.4-228.6m	9.26 (0.003)	*Lophelia pertusa*, Sabellid worms, an unidentified pink anemone species, yellow encrusting sponges, Ascidians, *Munida sarsi* and *Echinus* sp. (likely *E. acutus*)	Howell *et al* .(2010); Long *et al* (2013)
IJK	*Munida sarsi* ad *Reteporella* spp. on mixed or hard sediments	*Munida sarsi* and *Reteporella* spp.	Mixed, boulders, bedrock, coral rubble	178.1-311.6m	9.25 (0.01)	*Munida sarsi* and *Reteporella* spp., encrusting sponges	Likely a mix of two assemblages described in Howell *et al* (2010); Howell *et al* (2009)
FGH	*Cidaris cidaris – Parastichopus tremulus* community on coarse sand	Parastichopus tremulus on sand	soft sediments	184.5-323.4m	9.25 (0.01)	*Parastichopus tremulus*	Howell *et al* (2010)
NM	*Caryophyllia* spp. and shrimps on scattered cobbles	*Caryophyllia* spp. on scattered cobbles	Scattered cobbles in soft sediments	218.8-309.4m	9.25 (0.01)	*Caryophyllia* spp. and shrimps (likely *Pandalus borealis*)	Similar to *Munida* and Caryophillids on coarse sediments Howell *et al* (2010)

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

3.6.1 QA of dataset prior to multivariate analysis

There were instances of constant misidentification of species by individual observers (e.g. mistaking *Zoroaster fulgens* for *Stichastrella rosea*), and these were amended prior to data analyses. Observers were internally consistent in their identification of taxa (a single taxa was always identified as a single taxa and not ever identified as two different taxa) and thus no further changes to the site-based datasets were made prior to multivariate analysis.

3.6.2 Overcoming inter-observer bias in order to produce a combined dataset for delivery to JNCC.

Comparison between analysers revealed a reasonable level of agreement between observers for most groups. However there were clear problems of inconsistent identification of anemones, sponges and ophiuroids. For example distinction between ‘white encrusting’, ‘grey encrusting’ ‘cream encrusting’ and ‘yellow encrusting’ sponges was not reliable and thus these groups were merged into a single taxa and classed as pale encrusting sponges. Similarly with anemones, there were problems of inconsistent identification between observers. Species such as *Phelliactis* were easily identified; however many other morphospecies were not consistently identified between observers, thus were also merged at a higher taxonomic level and/or functional group level. The ophiuroids, which can be highly variable in colour within a species, also had a low level of agreement between observers and again were merged at a higher taxonomic level. Table 3 identifies those taxa that were inconsistently identified between observers and thus were merged either at a higher taxonomic level or into a morphologically or functionally similar grouping in order to produce a combined dataset for delivery to JNCC. There were also inconsistencies in abundance estimates for taxa between observers.

The inconsistent identification of taxa and abundance estimates between observers is not unexpected. There have been few empirical studies that have tested the accuracy of data obtained from visual survey and/or the variation in data extracted by different observers. A full review of this aspect of the analysis process is beyond the scope of this report, however in relevant studies inter-observer agreement on analysis of standard samples of physical and/or image-based specimens (species identification and abundance) is around only 50% (Culverhouse *et al*, 2003; Schoening *et al*, 2012), suggesting problems with misidentification of specimens, or at least differing interpretations of species identities and abundance estimates, is a widespread problem in ecology.

3.6.3 Advice on future use of the combined dataset

In this study problems of observer bias were avoided while retaining as much taxonomic resolution in the dataset as possible by limiting observers to analysing images from one site, and analysing the resulting data on a site-by-site basis. This was a conscious choice as we did not expect any of the assemblages at the study sites to overlap given the difference in depth and environmental setting. However, if it had been preferable to undertake a combined analysis of all site data, the combined dataset, corrected for observer bias in identification of taxa, would undoubtedly provide some different assemblage groupings to those presented in this report, as a result of loss of taxonomic resolution in the data and the need to implement a severe transformation (4^{th} root or presence absence) in order to overcome differences in abundance estimates between observers. It is impossible to know how different the resulting assemblages would be, however it is likely that the major patterns would still emerge.

Table 2. Operational Taxonomic Units merged together as a result of inconsistent identification by between observers with the new taxon name given.

New taxon name	Operational Taxonomic Units comprising the new taxon name					
Ophiuroidea indet.	60	100	246	534	551	
Actiniaria (sediment dwelling)	2	23	984			
Porifera lamellate	181	202	422			
Moridae	249	427				
Porifera massive lobose	5	22	171	232	931	947
Porifera pale encrusting (yellow, white, grey, cream)	803	808	809	801	960	
Porifera green encrusting	7	802				
Porifera massive globose	80	103	407			
Munida indet.	200	339				
Actiniaria indet.	38	901	902	976	900	
Majidae indet.	11	285				
Bivalvia indet.	244	366				
Ascidiacea indet.	20	8				

4 Discussion

4.1 Darwin Mounds

The Darwin Mounds SAC supports three broad-scale biotopes, the main one of conservation concern being '*Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand'. This biotope is closely associated with carbonate mound structures as identified previously.

In terms of condition, observations from acoustic and video analysis suggest the fisheries closure seems to be fairly well respected, but that ecosystem recovery is still a long way away. So far there are no signs of coral recolonisation, and regrowth is very limited.

Some violation of the closure may still occur, as illustrated by two pairs of trawl marks observed in the western Darwin Mounds. Unfortunately, no VMS data were available for this study, so it is difficult to determine how old the marks may be, and how often a potential violation would occur.

The video and photographic data also provided plenty of evidence for seabed litter in the Darwin Mounds, (Figure 23). This mainly consisted of plastics, although metal, fabrics and various types of fishing gear were also found, both in the eastern and western Darwin Mounds. The coral stands form effective obstacles, catching litter items that are transported by the currents sweeping around the head of the North Rockall Trough.

Figure 23. Examples of litter found in the Darwin Mounds, including (clockwise from upper left) plastic bubble wrap, metal, a net (probably rather a cargo net than a type of fishing gear), and plastic packaging.

By now, eight years after the fisheries closure was put in place and the main trawling activity has ceased, it has also become more difficult to distinguish between natural coral rubble and the physical damage caused by trawling, as the broken coral fragments are no longer fresh and may have been scattered by strong currents to a certain extent. The presence of extensive amounts of coral rubble is a natural phenomenon on most cold-water coral reefs and mounds and results from natural cycles of growth and decay. A lot of coral rubble was also found on the western Darwin Mounds, but the presence of sizeable live coral colonies indicates that some of those mounds have never been trawled. Information about long-term recovery of cold-water coral populations is scarce, and continued protection of the Darwin Mound area, combined with regular monitoring is also necessary to obtain further insights in these processes.

4.2 Hatton-Rockall Basin

The distributions 'A6.621 Facies with *Pheronema grayi'* and 'Cerianthid anemones & burrowing megafauna in bioturbated soft sediments' appear related to subtle changes in topography (crest versus trough), and the associated effect on current speed and sediment deposition, rather than any relationship to 'polygonal faults' as a geological entity. 'A6.621 Facies with *Pheronema grayi'* communities have been described by Rice *et al* (1990) from 1250m the Porcupine Seabight, by Barthel *et al* (1996) off Morocco at depths of 740-1300m, by Le Danois (1948) from Ireland to Spain in 1000-2000m water depth, and from 1450m on Goban Spur (Duineveld *et al*, 1997; Flach *et al*, 1998; Lavaleye *et al*, 2002). There are also indications that this species at least may also be common to the west of the Faroe Islands and south of Iceland at depths of between 800 and 1160m (Burton 1928; Copley *et al*, 1996) (see Howell, 2010, for a review). Interestingly Hughes & Gage (2004) have previously recorded *Pheronema carpenteri* aggregations from the Rockall-Hatton Basin at 1100m. These authors also recorded cerianthids and *Munida teuimana* as common within this assemblage.

Pheronema carpenteri is a hexactinellid sponge that forms dense aggregations. These aggregations are associated with an increase in abundance and richness of macrofauna within spicule mats and sponge bodies providing habitat complexity and a hard substrate for epifauna colonization (Rice *et al*, 1990; Bett & Rice, 1992). The 'habitat' role provided by these aggregations is why they are listed under OSPAR as a 'threatened and declining habitat' and also recognised as VME under UNGA 61/105.

Aggregations have been found predominantly between 1000 and 1300 m depth (Rice *et al*, 1990) in areas of high productivity, and possibly proximate to regions of enhanced bottom tidal currents which aid in resuspension of organic matter (Rice *et al*, 1990; White, 2003). It is this requirement for enhanced bottom currents for feeding that may explain the distribution of this species and associated assemblage on the summit of the polygons rather than in the troughs at the edge of the features. Observation of changes in substrate between the two areas suggested sediment was finer in the troughs and thus current speeds lower.

The assemblage 'Cerianthid anemones & burrowing megafauna in bioturbated soft sediments' could be considered as equivalent to the OSPAR listed habitat 'Seapen and burrowing megafauna communities' since the assemblage was characterised by rare occurrences of sea pens (*Virgularia mirabilis*). OSPAR defines this community as *"Plains of fine mud, at water depths ranging from 15–200 m or more, which are heavily bioturbated by burrowing megafauna; burrows and mounds may form a prominent feature of the sediment surface with conspicuous populations of sea-pens, typically* Virgularia mirabilis *and* Pennatula phosphorea*."* This assemblage could also be classified as a Vulnerable Marine Ecosystem (VME) under United Nations General Assembly (UNGA) 61/105.

The Hatton-Rockall basin is clearly an area of 'deep-sea sponge aggregations' and possibly an area for 'Sea pens and burrowing megafauna' depending on the definition used. It should thus be considered for possible management measures. New predictive modelling studies have suggested that this whole area has a high probability of supporting *Pheronema carpenteri* aggregations (Ross & Howell, 2013). No trawl marks or litter were observed from this area and no bottom trawl fishing is currently known to be undertaken here. There is a large pelagic fishery for blue whiting in the Hatton-Rockall Basin, the potential impact of which on the benthos through the food web is unknown.

4.3 East Rockall Bank

A detailed discussion of the condition of this feature is given in Long *et al* (2010) and will not be repeated here. The additional transects undertaken on JC060 have provided further evidence of the presence of cold water coral reefs on the northern flanks of Rockall Bank and associated rubble areas. This finding supports the findings of a recent predictive model (Ross & Howell, 2012) that suggested presence of reef in this area. Rockall Bank is unique within UK waters as it represents an offshore bank with a summit above sea level. This means it has areas on its flanks that are shallower than on any other offshore bank in UK waters. Given the well-documented relationship between species composition and depth in the deep-sea (Howell *et al*, 2002), Rockall Bank is likely to support assemblages not found on any other UK offshore bank, seamount or ridge (but are likely to occur on the continental slope).

4.4 North-West Rockall Bank

The main biotope of conservation interest identified on the western flank of Rockall bank is '*Lophelia pertusa* reef framework'. This biotope was found in three of the five ROV dives carried out, and live coral colonies tended to harbour numerous suspension feeders of various species. The largest coral colonies observed for this area occurred in dive 23. They attracted large schools of fish, suggesting their importance as habitat engineers, and also for fisheries (note that fish were not included in the biotope analysis, which was limited to invertebrates). This dive was located inside the SIC boundary but outside the fisheries closure, based on the data from this survey the area was subsequently recommended for inclusion in the fisheries closure.

Large rubble fields, which could be the result of trawling activities, were observed frequently in both dives 19 and 20. Some trawl marks were visible in the video imagery and in the high-resolution sidescan sonar maps, but it was not possible to determine when the damage might have occurred. No visible signs of recovery from this trawling damage were apparent (e.g. recolonisation of coral rubble or boulders, signs of coral recruitment). One of the unique aspects of this terrain, besides its cold-water corals, is its patchiness, which increases the overall (beta-)diversity. Trawling, by smoothing the terrain into one homogeneous habitat type of coral rubble, seems to have a negative effect on both, which may have severe consequences for the diversity of the area.

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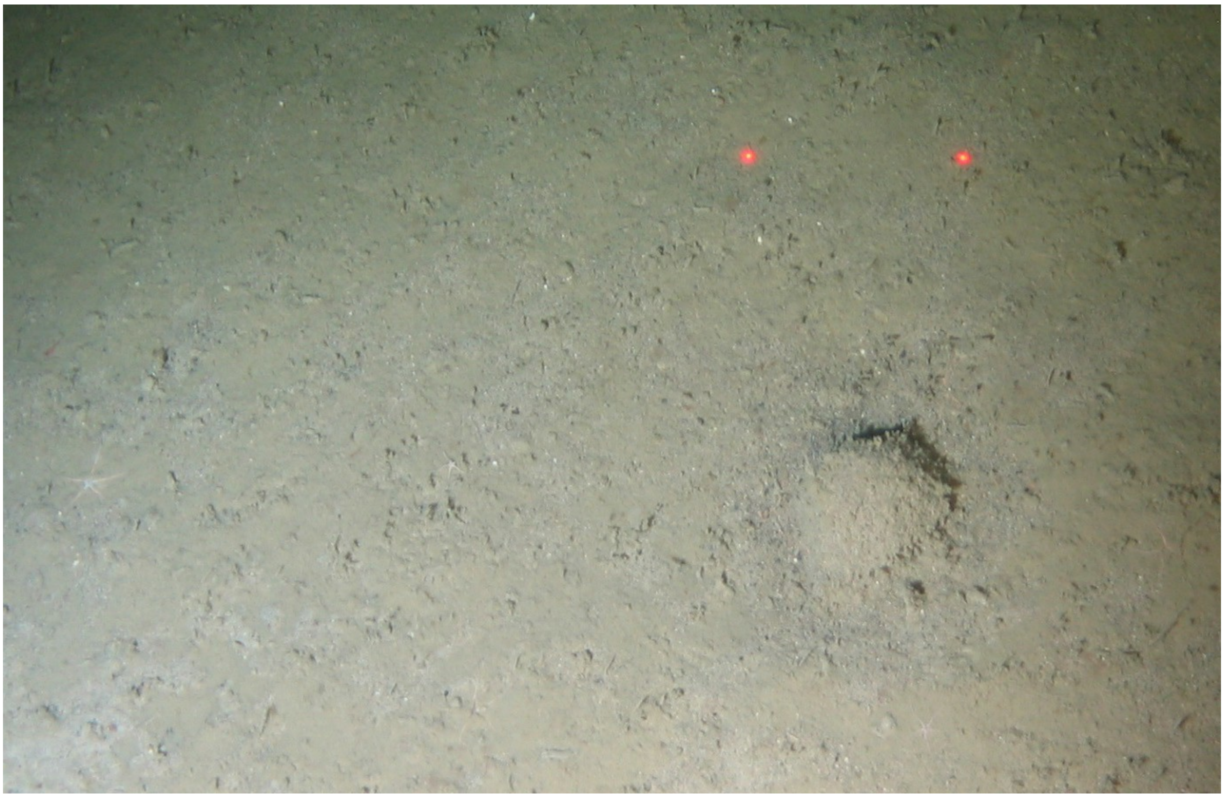
Appendix 1 Darwin Mounds ungrouped biotope descriptions

Group 1 (BDEF)

Contains SIMPROF clusters where Xenophyophores are either first or second contributors in SIMPER analysis.

Cluster B

Biotope name: Xenophyophores with burrowing ophiuroids on soft sediments
JC060 SIMPER descriptive name:
Xenophyophores with burrowing ophiuroids on soft sediments
SIMPER within cluster similarity: 53.4%



Characterised (based on 65 images) by buried ophiuroids (*Amphiuridae sp. 1*) associated to a xenophyophore (*Syringammina fragilissima*) on sandy ground, sometimes with a thin layer of muddy deposit between 937-1070 m water depth, at an average temperature of 7.44 °C. 52 images of this cluster (from a total of 65) are in Dive 25, the most western dive in the eastern area.

Cluster D

Biotope name: Xenophyophores among corals rubble with epifauna
JC060 SIMPER descriptive name:
Xenophyophores among corals rubbles with epifauna
SIMPER within cluster similarity: 47.84%

Characterised (based on eight images) by Xenophyophores (*Syringamina fragilissima*) associated to yellow encrusting sponges, squat lobsters (*Munida tenuimana)* and blue encrusting sponges on scarce coral rubbles and sand between 958-966.7m water depth, at an average temperature of 8.30 °C. This cluster could be considered as Group 2 member (epifauna on coral rubbles) as its classification in Group 1 seems to be due the large number of Xenophyophores more than a real difference in species composition. Moreover, a visual assessment of these images would probably lead to a Group 2 classification given the important part of the surface occupied by coral rubbles.

Cluster E

Biotope name: Xenophyophores field (Howell 2010)
JC060 SIMPER descriptive name:
Xenophyophores field
SIMPER within cluster similarity: 58.37%

Characterised (based on 427 images) by high number of Xenophyophores (*Syringamina fragilissima*) on sand, sometimes with a thin layer of mud, between 950.5 - 1072m water depth, at an average temperature of 7.64 °C. Their density varies from 0.5 individuals per square meters to 14.5 and 4.2 in average. This cluster is by far the largest (45% of the total). In most images, Xenophyophores are not alone, but they are undoubtedly the structuring species in this habitat.

Cluster F

Biotope name: Xenophyophores and ophiuroids on sand and a substrate
JC060 SIMPER descriptive name:
Xenophyophores and ophiuroids on sand and a substrate
SIMPER within cluster similarity: 54.15%

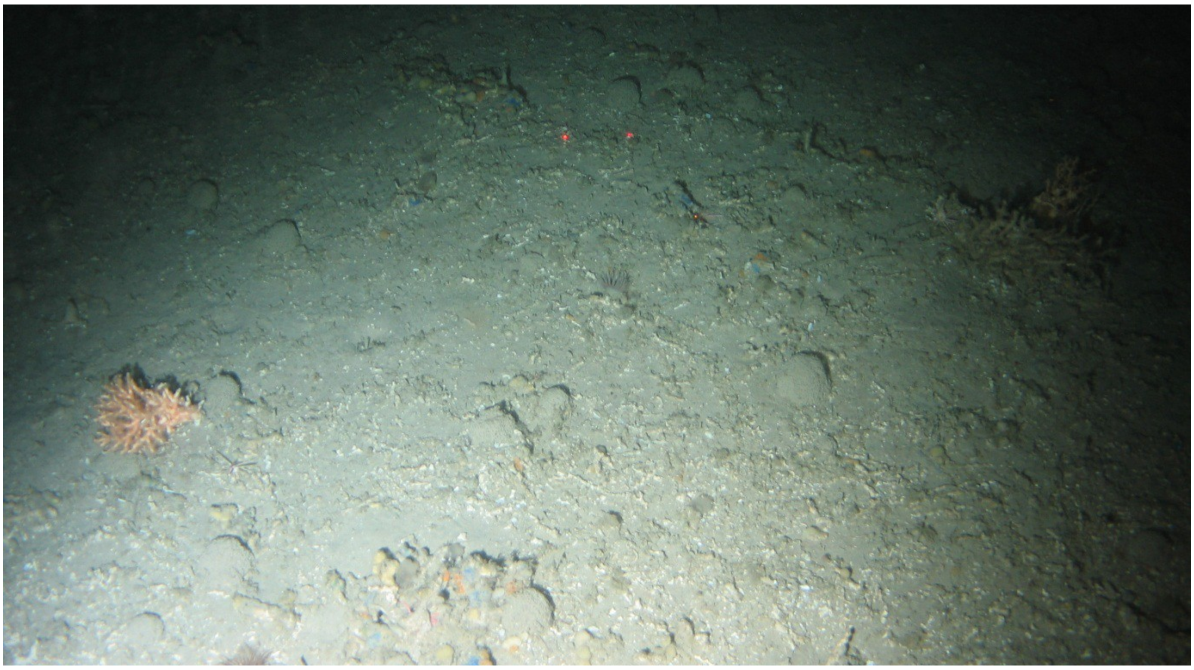
Characterised (based on 64 images) by Xenophyophores (*Syringamina fragilissima*) and ophiuroid (*Ophiactis sp.*) sheltering beneath something (e.g. coral rubbles, rock, urchin test, xenophyophore body) on sand, sometimes with a thin layer of mud, between 959-1057m water depth, at an average temperature of 7.66 °C. This cluster might not be biologically meaningful as it is defined by behaviour of a species, rather than a proper species presence. Most images are coral rubbles without epifauna, thus, this cluster could be considered a transitional state between sand and coral rubbles fauna.

Group 2 (GHIJ)

Contains clusters associated to coral rubbles. These communities are mostly epifauna using the coral rubbles as substrate, living corals, sometimes in large frame forming colonies. Though, the Xenophyophores are present among the rubbles.

Cluster GH

Biotope name: Coral rubble
JC060 SIMPER descriptive name:
Epifauna on coral rubbles
SIMPER within cluster similarity: 44.90%



Characterised (based on 38 images) by encrusting sponges, Xenophyophores (*Syringammina fragilissima*), sheltering ophiuroids (*Ophiactis balli*), echiurians worms (*Bonellia viridis*), and burrowing anemones (*Cerianthidae sp.1*) on Coral rubbles and sand, between 942-966m water depth, at an average temperature of 8.3 °C. Only present on the western part of the study area (Dive 5 and 6). The major difference with other coral rubbles groups is the presence of echiurian worms and a large number of encrusting sponges.

Cluster I

Biotope name: Halcampids, xenophyophores and sand fauna on soft sediment among coral rubble
JC060 SIMPER descriptive name:
Halcampids, xenophyophores and sand fauna on soft sediment among coral rubble
SIMPER within cluster similarity: 53.45%

Characterised (based on 57 images) by halcampids anemones (*Halcampoididae sp. 1*), Xenophyophores (*Syringammina fragilissima*), white encrusting sponges, small crabs (*Majidae sp. 1*), sheltering ophiuroids (*Ophiactis balli*), squat lobster (*Munida tenuimana*) and burrowing anemones (*Cerianthidae sp.1*) on coral rubbles of various size and boulders on sand between 958-1053 m water depth, at an average temperature of 7.61 °C. These taxas tend to be less substrate-dependent (with fewer sponges and fewer attached anemones)

Cluster J

Biotope name: Coral rubble framework with cerianthids
JC060 SIMPER descriptive name:
Epifauna and anemones among large coral rubbles
SIMPER within cluster similarity: 53.45%

Characterised (based on 16 images) by high number of small octocoralian colonial polyps (*Octocorallia sp.2*) Xenophyophores (*Syringammina fragilissima*), halcampids (*Halcampoididae sp. 1*), squat lobster (*Munida tenuimana*), burrowing anemones (*Cerianthidae sp.1*), encrusting sponges (white, yellow and blue), tube worms (serpulidae or phoronidae) and living *Madreopra occulata* on large coral rubbles, or coral frame and sand between 952 -1051m water depth, at an average temperature of 8.05°C. Compared to other Group 2 clusters, the coral rubbles are larger and may form a three-dimensional structure, although they are distributed in individuals colonies of various size. The space between these colonies is sometimes made of bare sand without coral rubbles where burrowing anemones and Xenophyophores can settle, and sometimes by smaller coral rubbles. Contrary to clusters EF and H, this biotope occupies restricted areas and unique images. Though present on both sides of the study area, it occurs mostly on western side.

Group 3 (LMNOTU)

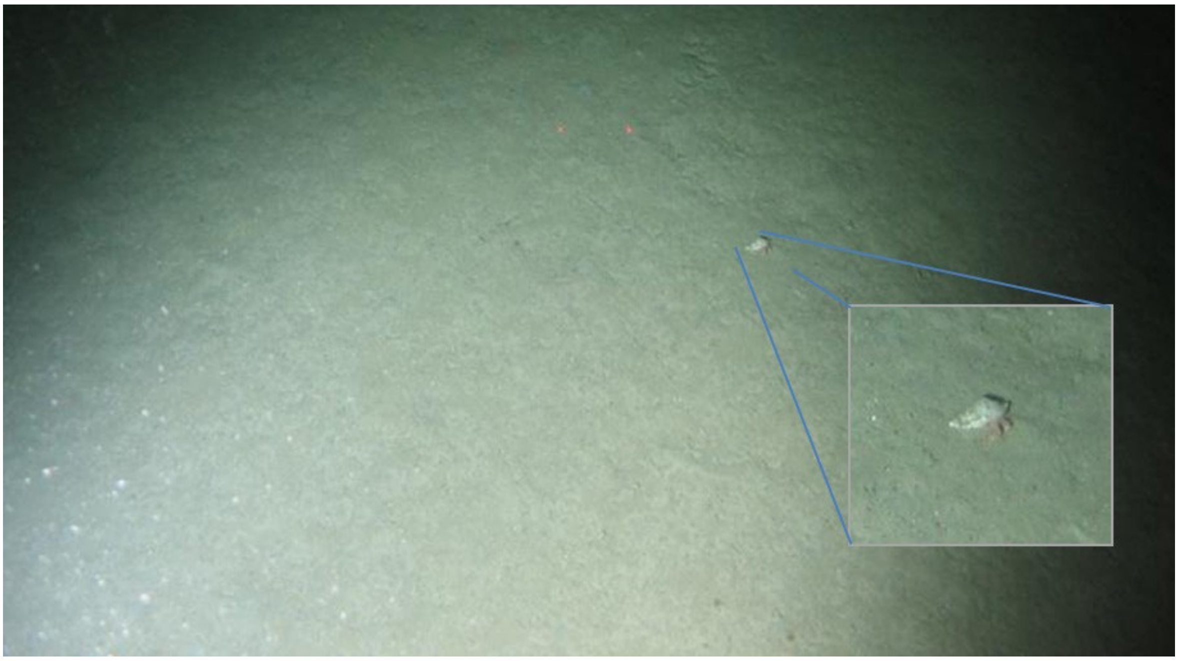
These groups were all characterised by one species in SIMPER analysis. They were therefore regrouped to form clusters L, M, N, O, T and U.

Based on the data available, it is not possible to resolve whether this group is a biotope, several biotopes or a sampling/grouping artefact. The majority of images were taken in the western area and present a scarce fauna on sandy ground without Xenophyophores, (this is not true for all images). But, if the substrate shows a certain constancy, the fauna share a very low similarity (branching occurs between 5 and 10% Bray-Curtis similarity, as shown in the dendrogram Figure 4) and does not form a genuine cluster, but rather includes everything that is not either in Group 1 or Group 2.

The deep-sea sand habitat is known for its need to be defined by large-scale sampling. The scheme of sampling used here doesn't encompass the range of faunal community variation characterising this environment and thus describing biotopes using image data is inappropriate for this type of substrate. However, some of the clusters formed do correspond to biotopes described from previous analysis and analysis within this report, thus we have included the original separate descriptions here for completeness.

Cluster L

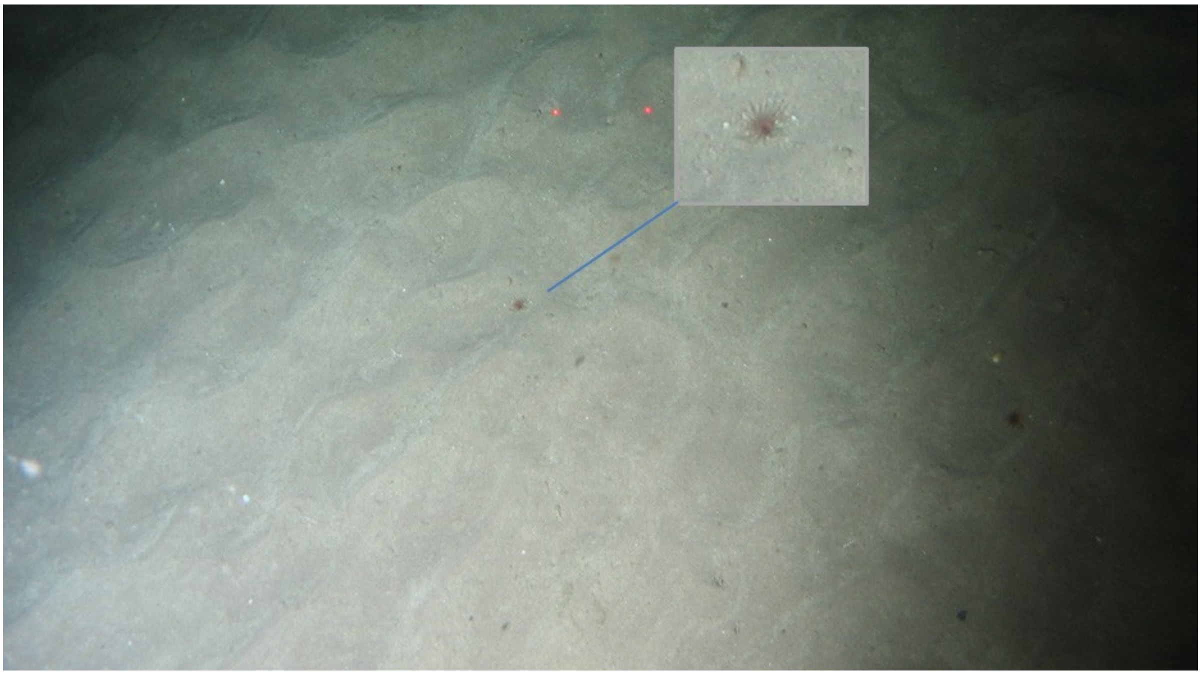
Biotope name: Scarce Pagurids on sand
JC060 SIMPER descriptive name:
Scarce Pagurids on sand
SIMPER within cluster similarity 72.5%



Characterised (based on 47 images) by hermit crabs (*Paguridae spp*) on sand (with or without ripplemarks) between 953-1052m water depth, at an average temperature of 8.12 °C.

Cluster M

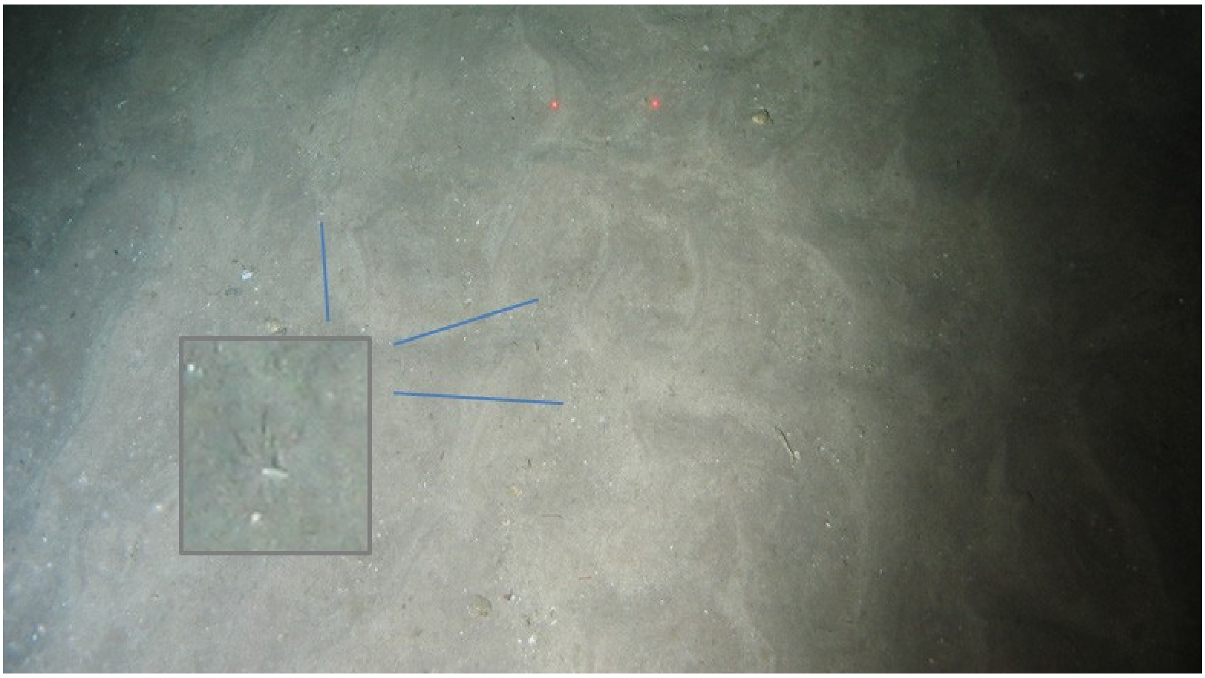
Biotope name: Unidentified (possibly Halcampoid) anemones in soft sediment (Howell *et al* 2010; and this report)
JC060 SIMPER descriptive name:
Burrowing anemones on sand
SIMPER within cluster similarity 50.6%



Characterised (based on 43 images) by burrowing anemone (*Cerianthidae sp. 1*) on sand between 953-1050m water depth, at an average temperature of 8.08°C.

Cluster N

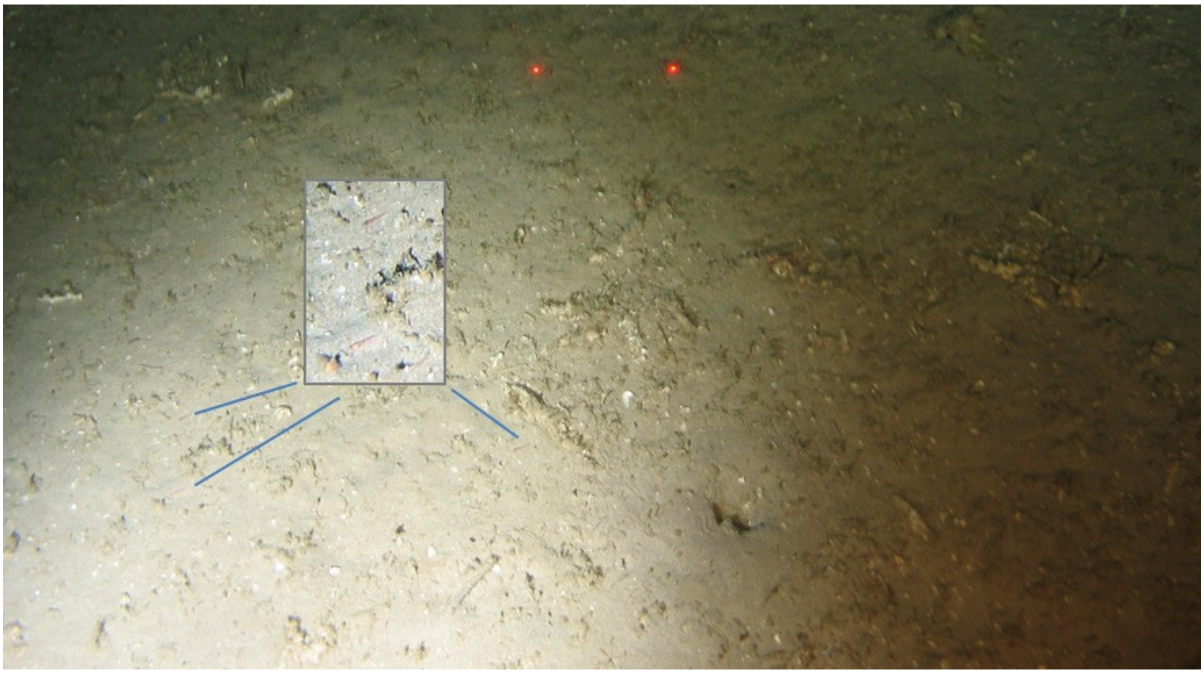
Biotope name: Edwardsiid anemones on sand (Howell *et al*, 2010; and this report)
JC060 SIMPER descriptive name:
Edwardsiids on sand
SIMPER within cluster similarity 60.6%



Characterised (based on 28 images) by unidentified edwardsiids on sand between 962-1038m water depth, at an average temperature of 8.16 °C. This cluster can only be found on western side and might form a coherent community as the edwardsiids defining it only rarely appears in other clusters.

Cluster O

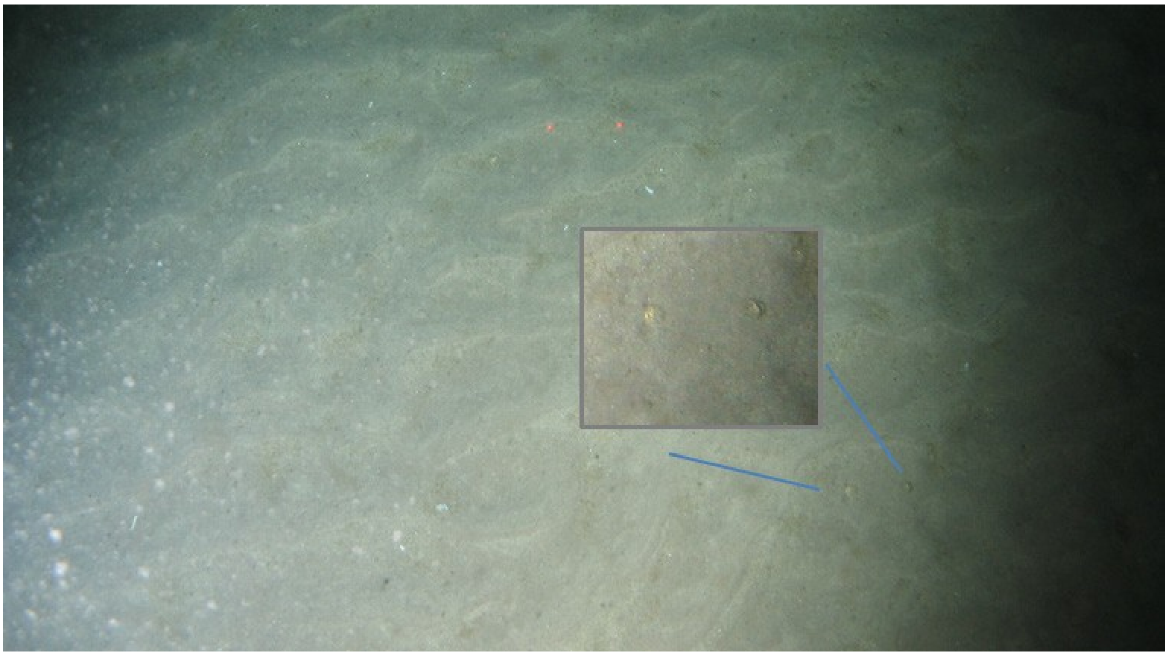
Biotope name: Mysids on sand
JC060 SIMPER descriptive name:
Mysids on sand
SIMPER within cluster similarity 57%



Characterised (based on 65 images) by mysids (*Mysida sp. 1*) on sand between 954-1052m water depth, at an average temperature of 8.01 °C.

Cluster T

Biotope name: Bivalves on sand
JC060 SIMPER descriptive name:
Bivalves on sand
SIMPER within cluster similarity 74.5%



Characterised (based on 24 images) by a bivalve (*Bivalvia sp. 2*) on sand between 958-968m water depth, at an average temperature of 8.17 °C.

Cluster U

Biotope name: Ophiuroids on rippled sediment (Howell *et al* 2010)
JC060 SIMPER descriptive name:
Ophiuroids on sand
SIMPER within cluster similarity 64.78%

Characterised (based on 12 images) by a large ophiuroid (*ophiuroidea sp.2*) on sand between 953-1016m water depth, at an average temperature of 8.21 °C.

Appendix 2 Standard Operating Protocols

Image Preparation

The timestamp from image EXIF information is matched to USBL and CTD data allowing the positioning of each image along the video transect to be recorded.

A frequency of image samples for analysis is agreed. This depends on the frequency of image acquisition, the speed of the camera along the transect, maintaining a frequency which aims to capture the majority of biotopes encountered, and time available for analysis. Images taken either every 30 seconds or 1 minute and obtained at a constant speed of approximately 0.4 knots are usually adequate.

Images are also ‘cleaned’ for clarity and field of view. Field of view can be estimated from a pair of lasers mounted at a known width, allowing the distance between laser dots on the seafloor to be measured, and therefore the width of the image. Additional camera angle, pitch and roll data can be used to make this calculation more accurate, and/or orthorectify the image to account for distortion.

Images obtained at an oblique angle can be cropped to remove the underexposed area of least clarity at the top of the image, in order to maintain the highest quality of quantitative analysis.

Biological Enumeration

All benthic fauna greater than 10mm in size are identified and counted. Sponge colonies and cover species are also counted as individual patches for ease of statistical analysis (percentage cover requires transforming count and percentage cover datasets separately in order to combine them for analysis). SACFOR can be recorded alongside for approximate percentage cover estimates if need be, although this is not used during the statistical analysis.

Taxa are identified to highest taxonomic resolution. If not possible to identify to species, taxa are classified morphologically into Operational Taxonomic Units (OTU). A database of all species/OTUs names and representative images is populated throughout analysis.

Cluster analysis

The species and abundance data for each image, where fauna are present, are entered into PRIMER v.6 or R for cluster analysis. Additional environmental metadata such as depth, temperature and salinity (if available) are also entered as factors of this data when using PRIMER, this can aid in the process of approving cluster definition, and can be used for describing biotopes using the SIMPER routine once clusters are defined.

Data is transformed preferably using a square root transformation although a 4^{th} root transformation might be required where abundance scales are expansive. The square root transformation is considered appropriate given that biotope definition requires that the dominant species maintain the greatest value, while rare species should still be allowed to make a contribution.

The transformed data is then subject to the CLUSTER routine and the biological data allowed to guide biotope definition more objectively. Clusters are then examined and confirmed by eye and compared with existing biotopes as described by Howell (2010). Any biotopes that do not fit into the classification proposed by Howell (2010) are recorded as potentially new biotopes.

Video Analysis

The video is reviewed at x4 or x8 speed and mapped using biotopes defined by cluster analysis of image data. The video footage also provides the PRIMER defined biotopes with ground-truthing, confirming or altering the definitions as characterised by the image samples. Any additional biotopes encountered are assessed by eye and mapped to each transect accordingly. Habitat sections of insufficient length (<2mins in duration) are not recorded as separate habitats.

Quality Assurance (QA)

Five percent of each transect is randomly selected for quality assessment and are analysed according to the image analysis procedure. All of these images are analysed by all parties concerned with image analysis of the dataset, along with an internal quality assessor from each institution. The results of the QA image analysis can compared and used to adjust taxonomic resolution before cluster analysis (e.g. a taxonomic family may be agreed between analysers but genus may not, therefore only family is used during statistical analysis, increasing the degree of agreement between analysers and reducing the incidence of false taxonomic resolution). QA image results are then subject to similarity assessment and scored using a similarity index such as Bray Curtis. A score of >90% similarity is considered good.

Appendix 3 Records of Scottish MPA Features / Habitats in JC060 data

NOTE: These tables do not include biotopes identified in transects undertaken for the Natura 2009 analysis on the basis that these have likely already been identified from the previous report (JNCC report 437; Long *et al* 2013).

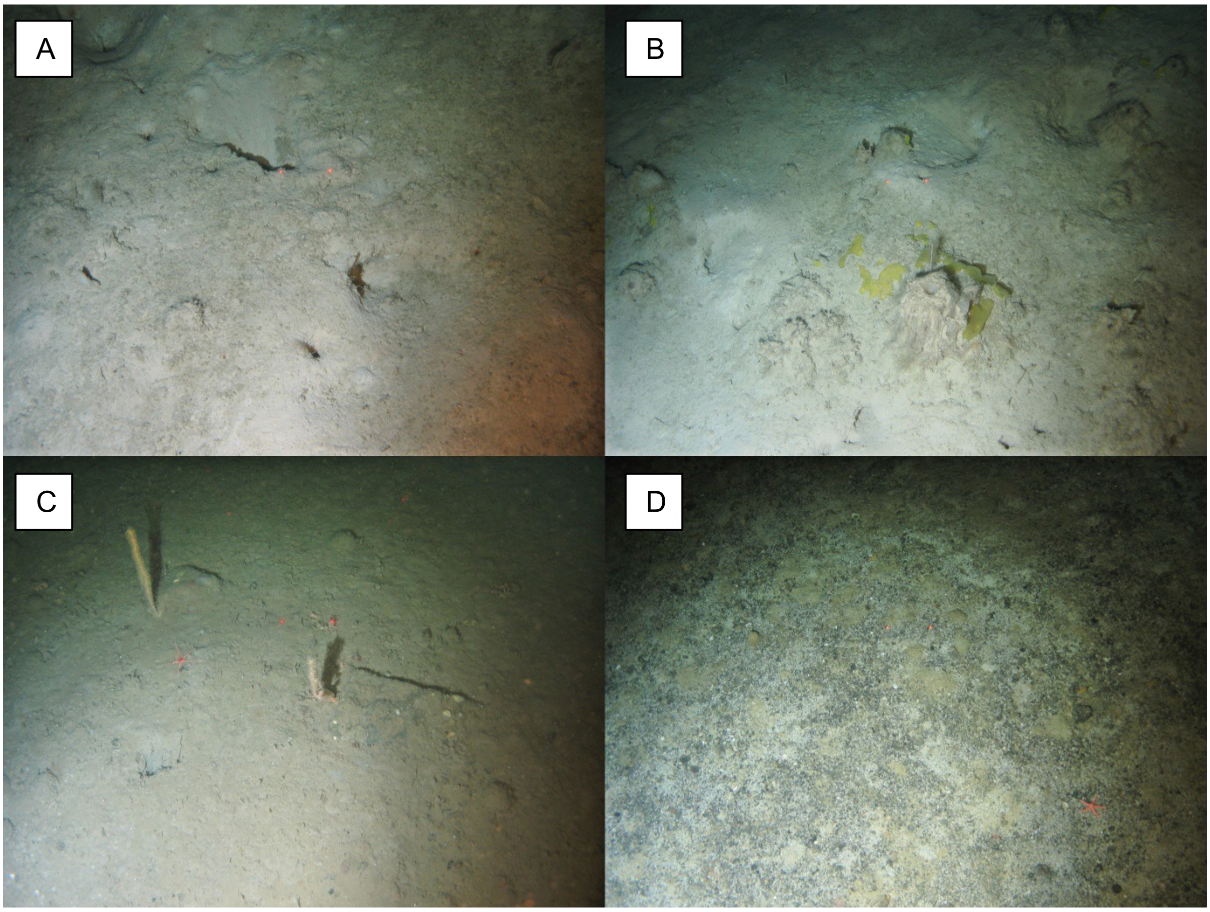
Each of the tables below has been filled out with the location of the features seen. Letters in brackets in the first column correspond with example images after each table.

Seabed habitat Priority Marine Features (PMFs) (of a reasonable size, e.g. minimum size of 5m x 5m).

Scottish MPA Search Features (SF)	Areas/Transects Found	JC060 Analysis Biotope Names
Burrowed Mud **(A)**	Hatton Basin Polygonal Faults JC060_065 (Dive 13) JC060_066 (Dive 14)	Cluster FGH *Pheronema carpenteri* aggregations on soft sediment (A6.621 Facies with *Pheronema grayi*) Cluster IJE Cerianthid anemones & burrowing megafauna in bioturbated mud (SS.SMu.CFiMu.SpnMeg: Sea pens and burrowing megafauna in circalittoral fine mud (A5.361)) Cluster LM Burrowing anemones in soft sediments (SS.SMu.CFiMu.SpnMeg: Sea pens and burrowing megafauna in circalittoral fine mud (A5.361))
Deep sea sponge aggregations **(B)**	Hatton Basin Polygonal Faults JC060_065 (Dive 13) JC060_066 (Dive 14)	Cluster FGH *Pheronema carpenteri* aggregations on soft sediment (A6.621 Facies with *Pheronema grayi*)
Northern sea fan and sponge communities **(C)**	(*Swiftia palladia* found in Darwin mounds, but not dominant in communities)	
Offshore deep sea muds[3] **(C)**		
Offshore subtidal sands and gravels[4] **(D)**	Darwin Mounds (rippled sand) JC060_012 (Dive 2) JC060_020 (Dive 4) JC060_026 (Dive 5) JC060_033 (Dive 6) JC060_110 (Dive 25) JC060_117 (Dive 26) NW Rockall Bank JC060_104 (Dive 23)	

[3] In addition to the continental shelf biotopes listed, the PMF also includes Atlantic and Arctic influenced offshore deep sea muds occurring on and off the continental slope.

[4] In addition to the continental shelf biotopes listed, the PMF also includes Atlantic and Arctic influenced offshore subtidal sands and gravels occurring on and off the continental slope.



Example Images: Seabed habitat Priority Marine Features (PMFs) (of a reasonable size, e.g. minimum size of 5m x 5m).

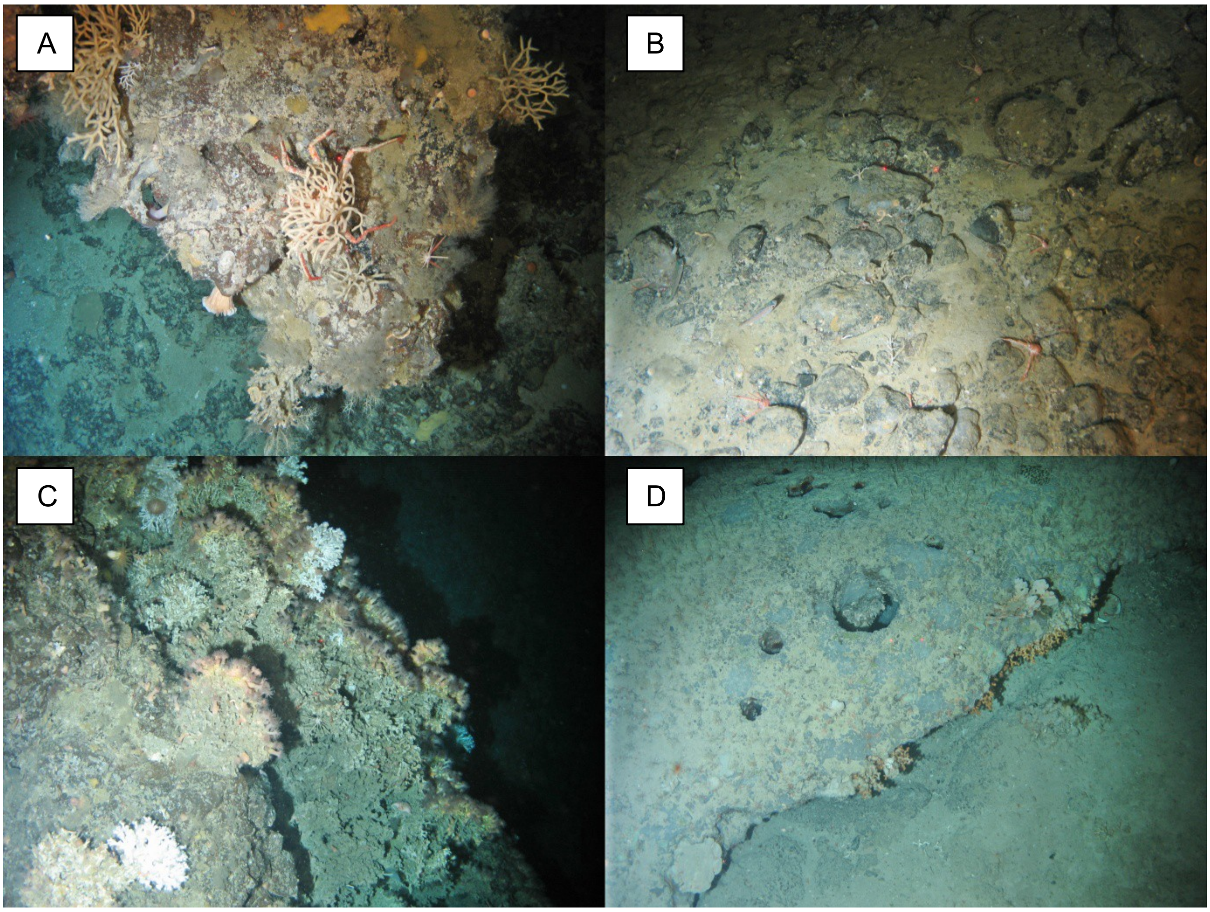
Appendix 4 Habitats

(of a reasonable size, minimum size of 5m x 5m)

Annex 1 habitat	Areas/Transects Found	JC060 Analysis Biotope Names
Bedrock **(A)**	NE Rockall Bank JC060_100 (Dive 21) NW Rockall Bank JC060_101 (Dive 22) JC060_091 (Dive 16) JC060_104 (Dive 23)	Cluster FGHIJKL Encrusting fauna, *Cidaris cidaris* and orange anemones on steep bedrock (Howell *et al* 2010) Discrete coral (*Lophelia pertusa*) colonies on hard substratum)
Stony reef **(B)**	NE Rockall Bank JC060_091 (Dive 16) JC060_093 (Dive 18) JC060_104 (Dive 23)	Cluster IJK *Munida sarsi* and *Reteporella* spp. on mixed or hard sediments
Biogenic reef **(C)**	NE Rockall Bank JC060_100 (Dive 21) NW Rockall Bank JC060_091 (Dive 16) JC060_093 (Dive 18) JC060_104 (Dive 23) Darwin Mounds[5] JC060_012 (dive 2) JC060_020 (dive 4) JC060_026 (dive 5) JC060_033 (dive 6) JC060_110 (dive 25)	Cluster MNOP Predominantly low-lying dead framework slopes of *Lophelia pertusa* coral reef on steep bedrock (Howell *et al* 2010) Dead framework slopes of *Lophelia pertusa* reef) Cluster GHIJ- *Lophelia pertusa* colonies, Xenophyophores and scattered rubble on sand
Mixed reef		
Submarine structures made by leaking gases **(D)**	(Hatton Basin Polygonal Faults[6])	(Cluster A Halcampid anemones, *Ophiactis abyssicola* & Encrusting sponges on hard substrate (Howell *et al* 2010) Halcampid anemones and white encrusting sponges on mixed substrate)

[5] The biotope GHIJ observed at the Darwin Mounds consists of small thickets of *Lophelia pertusa*. This biotope does not fit either the current definition of *Lophelia pertusa* reef or any of the current definitions of Coral Gardens. Although the assemblage is clearly a coral based assemblage, refinement of these defiitions is required in order to unambiguously place the Darwin Mounds assemblage in one community or the other.

[6] Please note there is some question as to the validity of this designation. There is some suggestion that the large rock encountered on JC060_066 (Dive14) could be a methane-derived authigenic carbonate (MDAC) structure, however no samples were obtained to verify this. There is no evidence of existing seepage.



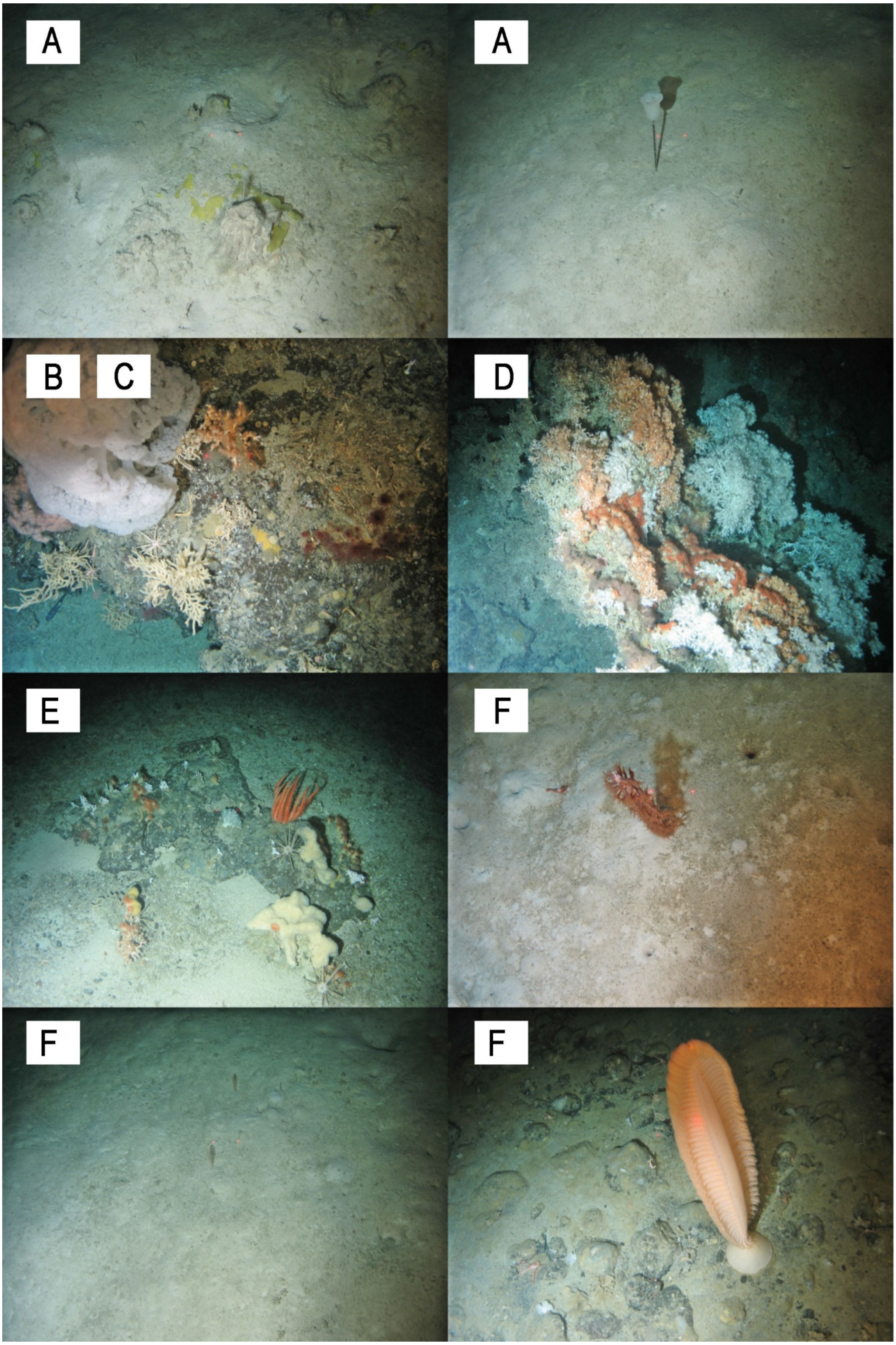
Example Images: Annex 1 habitats (of a reasonable size, e.g. minimum size of 5m x 5m).

Appendix 5 Scottish MPA project low or limited mobility species

Scottish MPA Search Features	Search Features/Priority species			Areas/Transects Found	JC060 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	Hatton Basin Polygonal Faults JC060_065 (Dive 13) JC060_066 (Dive 14)	Cluster FGH ***Pheronema carpenteri*** aggregations on soft sediment (A6.621 Facies with *Pheronema grayi*) -Dense Pheronema carpenteri Cluster IJE. Cerianthid anemones & burrowing megafauna in bioturbated soft sediment (SS.SMu.CFiMu.SpnMeg: Sea pens and burrowing megafauna in circalittoral fine mud (A5.361)) -Occasional *Hyalonema* sp.
Deep sponge aggregations **(B)**	Giant sponge	Class	Desmospongia	NE Rockall JC060_100 (Dive 21)	Cluster FGHIJKL Encrusting fauna, *Cidaris cidaris* and orange anemones on steep bedrock (Howell *et al* 2010) Discrete coral (*Lophelia pertusa*) colonies on hard substratum) -Branching sponges, and one *Geodia* sp.
Coral gardens **(C)**	Leather corals	Order	Alcyonacea	NE Rockall JC060_100 (Dive 21) JC060_101 (Dive 22)	Cluster FGHIJKL Encrusting fauna, *Cidaris cidaris* and orange anemones on steep bedrock (Howell *et al* 2010) Discrete coral (*Lophelia pertusa*) colonies on hard substratum) -Some large pink and white alcyonaceans (cf *Drifa* sp.)
Coral gardens	Gorgonians	Order	Gorgonacea		

Scottish MPA Search Features	Search Features/Priority species			Areas/Transects Found	JC060 Analysis Biotope Names
Coral gardens	Black corals	Order	Antipatharia		n/a
Coral gardens **(D)**	Hard corals	Order	Scleractinia	Hatton Basin Polygonal Faults JC060_066 (Dive 13) JC060_066 (Dive 14)	Cluster A. Halcampid anemones, *Ophiactis abyssicola* & Encrusting sponges on hard substrate (Howell *et al* 2010) Halcampid anemones and white encrusting sponges on mixed substrate) -Caryophyllids and *Madrepora occulata* present.
				NE Rockall Bank JC060_100 (Dive 21) JC060_101 (Dive 22)	Cluster FGHIJKL Encrusting fauna, *Cidaris cidaris* and orange anemones on steep bedrock (Howell *et al* 2010) Discrete coral (*Lophelia pertusa*) colonies on hard substratum) -Caryophyllids and *Lophelia pertusa* Cluster MNOP. Predominantly low-lying dead framework slopes of *Lophelia pertusa* coral reef on steep bedrock (Howell *et al* 2010) Dead framework slopes of *Lophelia pertusa* reef)
				NW Rockall Bank JC060_101 (Dive 22) JC060_091 (Dive 16) JC060_104 (Dive 23)	Cluster L *Lophelia pertusa* reef framework

Scottish MPA Search Features	**Search Features/Priority species**			**Areas/Transects Found**	**JC060 Analysis Biotope Names**
Coral gardens **(E)**	Stony hydroids (lace or hydrocorals	Family	Stylasteridae	NE Rockall Bank JC060_100 (Dive 21) JC060_101 (Dive 22)	Cluster FGHIJKL Encrusting fauna, *Cidaris cidaris* and orange anemones on steep bedrock (Howell *et al* 2010) Discrete coral (*Lophelia pertusa*) colonies on hard substratum) -Occurance of both a *Stylaster* sp. and (possibly more than one) *Pliobothrus* sp. sometimes many.
Coral gardens or Burrowed Mud **(F)**	Sea pens	Order	Pennatulacea	Hatton Basin Polygonal Faults JC060_065 (Dive 13)	Cluster IJE. Cerianthid anemones & burrowing megafauna in bioturbated soft sediment (SS.SMu.CFiMu.SpnMeg: Sea pens and burrowing megafauna in circalittoral fine mud (A5.361)) -Occasional Virgularia mirabilis Cluster LM. Burrowing anemones in soft sediment (SS.SMu.CFiMu.SpnMeg: Sea pens and burrowing megafauna in circalittoral fine mud (A5.361)) -Occasional Kophobelemnon sp.



Example Images: Low or limited mobility species.

Appendix 6 Scottish MPA project Mobile species

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

No Images as they were not found.

Appendix 7 Table of Natura 2009 Analysis East Rockall Bank Biotopes

(from Long *et al* 2013, JNCC report 437)

This is a copy of table 3 from the JNCC report 437 showing the East Rockall Bank Biotopes identified during that analysis. An additional column has been added to show the comparison with the new analysis presented in this report. Subsequently there is a table of the biotope that did not emerge from the Natura 2009 analysis but which now appears in the combined analysis.

Notes:

- The SIMPROF routine was not available during the Natura 2009 analysis.
- The Natura 2009 cluster analysis was performed on the East Rockall Bank and Anton Dohrn datasets combined. This affects which clusters emerge, as clustering is based on similarity within the analysed dataset. Individual area analysis will always reveal more biotopes than when combined with different areas.
- The current analysis combined the Natura 2009 East Rockall Bank data with two new transects from JC060. In order to make sample units more comparable the JC060 dataset was reduced to match the one image every 50m analysed in the Natura 2009 analysis.

Cluster	Biotope names	Characterising species	Substrate	AoS	Supporting reference	Comparison with new 2012 Clusters
H	Edwardsid anemones on coarse/gravelly sand	Edwardsid anemones	Coarse sand/gravelly sand	ER	Howell *et al* (2010)	Agree – cluster Af
I	*Caryophyllia smithii* & *Actinauge richardi* on sand/gravelly sand	*Caryophyllia smithii* and *Actinauge richardi* anemones	Sand/gravelly sand	ER	none	Agree – cluster L
LB	Halcampoid anemones on coarse sand	Halcampid anemones	Coarse sand	ER	Howell *et al* (2010)	Agree – cluster F
MB	Xenophyophores and sea pens on gravelly sand and mixed substrate	Xenophyophores, halcampids, anemones, cerianthids, ophiuroids and sea pens	Gravelly sand and mixed substrate	ER & AD	none	**Combined** with MDB into single xenophyophre cluster – cluster C
MDB	Xenophyophores and pandalid shrimp on coarse sand and gravel	Xenophyophores, halcampids, anemones and hydroid turf	Coarse sand and gravel	ER	none	**Combined** with MB into single xenophyophre cluster – cluster C
MJA	Predominantly dead, low-lying coral rubble	Dead *Lophelia pertusa*, halcampids, caryophyllids and ophiuroids and ascidians	Mixed	ER & AD	Howell *et al* (2010) and Literature	Agree – Cluster YZAaAbAc

Cluster	Biotope names	Characterising species	Substrate	AoS	Supporting reference	Comparison with new 2012 Clusters
MJC	Live biogenic coral reef	Dead and live L. pertusa, *Madrepora oculata*, *Cidaris cidaris*, anemones, *Munida* sp., Gorgonians and Leiopathes sp.	Bioherm	ER & AD	Howell *et al* (2010)	**Combined** within JC060 biotope in cluster O
MJHii	Various sponge forms, corals and ascidians on mixed, boulder and ledges	Encrusting, globose and lamellate sponges, caryophyllids, *Stichopathes*, ascidians	Mixed, boulders and ledges	ER	none	Agree – cluster Ad
MKE	Stylasterids and lobose sponges on bedrock and mixed substrate	Saddle oysters, brachiopods, *Munida*, serpulids, Stylasterids, *Cidaris* and Lobose sponges	Bedrock and mixed	ER	none	Agree – cluster TUW
MKF	*Reteporella* bryozoan and axinellid sponges on mixed substrate	Reteporellid bryozoans, *Munida*, axinellid sponges and encrusting sponges and zoanthids	Mixed	ER	Connor *et al* (2004)	Agree – cluster J
MKGi	*Munida*, saddle oysters and caryophyllids on mixed substrate	*Munida*, encrusting sponges, saddle oysters, serpulids and caryophyllids	Mixed	ER	Howell *et al* (2010)	**Combined** with MKGii in cluster K or in new Psolus, caryophyllids and lamellate sponges on mixed
MKGii	*Munida* and serpulids on mixed and biogenic gravel	*Munida* and serpulids	POS, mixed and BIOG	ER	Howell *et al* (2010)	**Combined** with MKGi in cluster K
* (ID'd from video only)	*Cidaris cidaris* and Stichopus on sand	*Cidaris cidaris* and *Stichopus tremulus*	Coarse sand	ER	Howell *et al* (2010)	Agree – also from video ID
* (ID'd from video only)	Serpulids, encrusting sponges and *Cidaris* on mixed substrate	Serpulids, encrusting sponges and *Cidaris cidaris*	Mixed	ER & AD	Howell *et al* (2010)	**Combined** within cluster K or cluster MN

New to the analysis of Natura 2009 and JC060

Cluster	Biotope names	Characterising species	Substrate	AoS	Supporting reference	Comparison with new 2012 Clusters
NEW	Brachiopods on sand veneered bedrock	Brachiopoda sp.1, Terebellidae sp.2, Halcampoididae sp.1	Bedrock with sand veneer	Natura 2009	Modification of (Howell *et al* 2010)	*NEW* cluster E
NEW	Serpulids, *Munida sarsi* & ophiuroids on coral gravel	Ophiactis balli, Serpulidae, *Munida sarsi, Cidaris cidaris*, *Margarites* sp. 1.	Coral gravel/ low-lying coral rubble	JC060	Howell *et al* (2010) (Long *et al* 2013)	*NEW* cluster MN
NEW	Dead framework slopes of *Lophelia pertusa* reef (Shallow)	Serpulidae, *Cidaris cidaris*, *Lophelia pertusa*, *Ophiactis balli*, Hydrozoa (bushy), *Pandalus borealis*, *Phelliactis* sp.1 (juvenile), Actiniaria sp.24, *Munida sarsi*, Lobose Porifera, Brachiopoda sp.1.	Coral framework, coral rubble	JC060 and Natura 2009	Howell *et al* (2010) (Long *et al* 2013)	*NEW* cluster O Although includes Natura 2009 MJC
NEW	Discrete coral (*Lophelia pertusa*) colonies on hard substratum	Anomidae sp.1, Serpulidae, Phoronida sp.1, *Ophiactis balli*, *Cidaris cidaris*, Yellow Encrusting Porifera, *Phelliactis* sp.1 (juvenile), *Psolus squamatus*, Halcampoididae sp. 1, Orange encrusting porifera, *Munida sarsi*.	Bedrock	JC060 and Natura 2009	Howell *et al* (2010)	*NEW* cluster S
Cluster	Biotope names	Characterising species	Substrate	AoS	Supporting reference	Comparison with new 2012 Clusters
NEW * (ID'd from video only)	*Psolus*, caryophyllids and lamellate sponges on mixed, boulder and bedrock substrate	*Psolus squamatus*, Anomidae, ophiuroids, encrusting sponges, Caryophyllidae, lamellate sponges	Mixed, Boulders, Bedrock	Natura 2009	Howell *et al* (2010)	*NEW* [Video ID] (indicated in Natura 2009 raw data but omitted from report)