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Identifying deep-sea megafaunal epibenthic assemblages for use in habitat mapping and marine protected area network design

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International efforts are currently being made to establish networks of marine protected areas (MPAs) for the purposes of conservation of marine biodiversity. One of the primary objectives of MPA networks is to achieve representation of all marine biological diversity. Since we do not know the extent of biological diversity nor its distribution and function, we use surrogates to represent biological diversity. At a broad scale, measures of the physical environment are used, however at a fine scale biological assemblages have been shown to provide better representation of known biological diversity. While there are well known descriptions of assemblages for shallow water environments, few such descriptions of deep-sea benthic assemblages have been attempted. This paper provides descriptions of deep-sea epibenthic megafaunal assemblages based on a broad-scale video and stills image survey of the upper bathyal (200–1000 m) regions of the Rockall Trough and eastern Faroe–Shetland Channel. One thousand nine hundred and eighty-seven images were analysed from 139 video transects sampled from Dangaard and Explorer Canyons, Rosemary Bank Seamount, Hatton Bank, Wyville-Thomson Ridge, and the continental slope west and north-west of Shetland. Quantitative data obtained were analysed using cluster analysis and SIMPER analysis in Primer V.6 to identify benthic assemblages and their characterizing species. Thirty-one epibenthic megafaunal assemblages are defined by their characterizing species, and their distribution in terms of site, depth, temperature and substratum type. These 31 'biotopes' provide consistent units for use in biological mapping efforts and assessments of representativeness in MPA network design. To facilitate the incorporation of these biotopes into existing deep-sea classification systems the biotopes have been assigned to broad substratum types. This is consistent with the use of substratum as a surrogate in many existing systems.

Keywords: video, habitat mapping, habitat classification, marine protected areas, deep sea, megafauna, seamounts, epibenthic, biotopes

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INTRODUCTION

The call for better spatial management of our marine environment is growing globally. Specifically, there is momentum for the establishment of networks of marine protected areas (MPAs) driven by International, European and (within the UK) national initiatives, as well as a need to identify the distribution of vulnerable marine ecosystems (VMEs). At an international level the Convention on Biological Diversity (CBD) highlights the establishment of marine and coastal protected areas as one of its key themes. Signatories to the CBD are committed to the goal adopted at the 2002 World Summit on Sustainable Development to establish representative networks of protected areas in the maritime environment by 2012. At a regional level Annex V (on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area) of the 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) gives the OSPAR Commission a duty to develop means, consistent with international law, for instituting protective, conservation, restorative or precautionary measures related to specific areas or sites or related to particular species of habitats. A target date of 2010 has been set by OSPAR contracting parties to achieve 'an ecologically coherent network of well managed Marine Protected Areas'. At a European level the EC Habitats and Species Directive (92/43/EEC) requires the establishment of protected areas (Special Areas of Conservation (SACs)) for habitats and species, listed under Annex I and Annex II respectively of the directive, in areas of sea under the jurisdiction of member states. In addition the Marine Strategy Framework Directive requires member states to achieve good environmental status in Europe's seas by 2020.

Criteria by which MPAs can be selected have been set out by the world conservation union (IUCN, 1994). These criteria include naturalness, biogeographical importance, ecological importance, economic importance, scientific importance, international or national significance and practicality/feasibility. An emerging central theme of the objectives of MPA selection is the concept of representativeness, or representative systems of MPAs (and similar terms, e.g. representation and representivity; Kelleher *et al.*, 1995; Boersma & Parrish, 1999). IUCN guidelines for highly protected areas (categories Ia, II, and III), including marine areas, now include representativeness as a major criterion (IUCN, 1994).

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The current call for representativeness as a major criterion for MPA design has as a prerequisite, an understanding of the distribution (e.g. maps) of that which we wish to represent. From an ecological and ideological perspective the aim is to represent examples of all biological and functional diversity within a reserve network. From a practical perspective this is completely impossible, since biological diversity operates at a range of scales and we do not know the extent of biological diversity, nor its distribution and function. Representation goals therefore generally aim to represent patterns of biodiversity at nominated spatial and/or organizational scales. In this respect then, we use the term 'representativeness' in its strictest sense as defined by Stevens (2002), to mean representation of every type of 'habitat' occurring in an area under consideration, where 'habitat' is defined, following Stevens (2002), the scale at which management of marine protected areas occurs, i.e. the local (10s km) or finer scales. Mapping of biological diversity at these spatial scales requires the use of surrogates, for which known distribution is achievable, to represent biological, and to a degree, functional diversity. Surrogates that have been used for biological diversity include biogeographical region (Allee *et al.*, 2001; Roff & Taylor, 2000; Butler *et al.*, 2001), depth (Allee *et al.*, 2001; Roff &Taylor, 2000; Butler *et al.*, 2001), seabed features/geomorphology (Greene *et al.*, 1999; Allee *et al.*, 2001; Butler *et al.*, 2001; Harris, 2007), substratum (Allee *et al.*, 2001; Roff & Taylor, 2000; Connor *et al.*, 2004; Davies *et al.*, 2004) and biological assemblages (Connor *et al.*, 2004; Davies *et al.*, 2004; Harris, 2007). These surrogates also operate, and are as a result mappable, at a variety of spatial scales, and are often arranged into hierarchical classification systems. Where only data of coarse resolution are available, higher level surrogates, usually a measure of the physical environment, are used to represent variation in biological diversity. These coarse scale surrogates inevitably do not effectively represent the biological variation present. Consequently selection of MPAs based on coarse level surrogates alone may well fail to represent even known biological diversity (Ward *et al.*, 1999; Stevens & Connolly, 2004; Williams *et al.*, 2009). As a result, and where data are available, finer level surrogates, such as biological assemblages, are used.

While biological assemblages could be defined on a site to site base, as surrogates for the biological diversity of the area, it is more useful, in terms of marine environmental management and MPA network design, to use consistent terms across broad regions. More specifically, in order that the maps, on which measures of representativeness are derived, are comparable between areas/regions, the units on which they are based need to be consistently defined, and ideally as part of a classification system. While there are well known descriptions of assemblages for shallow water environments following the works of Peterson (1913), Jones (1950), Glémarec (1973) and others, few such descriptions of deep-sea benthic assemblages have been attempted (Le Danois,1948; Laubier & Monniot, 1985). It should be noted however, that a number of deep-sea benthic assemblages and communities are widely recognized, e.g. cold-water coral reefs and *ostur* (sponge communities), while more are being described through the political process (e.g. coral gardens (OSPAR MASH07/4—Agenda item 4)).

The increasing encroachment of anthropogenic activities on the deep-sea marine environment (Glover & Smith, 2003; Davies *et al.*, 2007) has brought into sharp focus the need to conserve and manage this environment appropriately. Internationally, establishing networks of MPAs to conserve deep-sea and high seas biodiversity (Cripps & Christiansen, 2001; Gjerde & Breide, 2003; Scovazzi, 2004; Williams *et al.*, 2009) are receiving high priority. In order that the objective of representativeness can be applied to MPA network design within the deep-sea and high seas it is vital that a hierarchical classification system is developed that is applicable to the deep-sea. While a number of classification systems exist that are applicable to the deep-sea (Greene *et al.*, 1999; Allee *et al.*, 2001; Roff & Taylor, 2000; Butler *et al.*, 2001; Davies *et al.*, 2004; Madden *et al.*, 2008), few incorporate units at the biological assemblage level. This is at least in part a result of the lack of described biological assemblages.

The aim of the present study is to provide descriptions of deep-sea epibenthic megafaunal assemblages, which are scientifically based, exist on a scale relevant to mapping efforts and the cost-effective methods commonly used in habitat mapping (e.g. broad scale acoustic survey coupled with video groundtruthing) (10s of metres), and can be easily slotted into existing hierarchical classification systems. The European Continental Margin to the west of the British Isles is one of the best known regions of the deep-sea in the world, and has been described as 'the cradle of deep-sea biology' (Gage, 2001) (Figure 1). Our in-depth understanding of the ecology of this region of the deep-sea makes this area an ideal place from which to describe deep-sea benthic biological

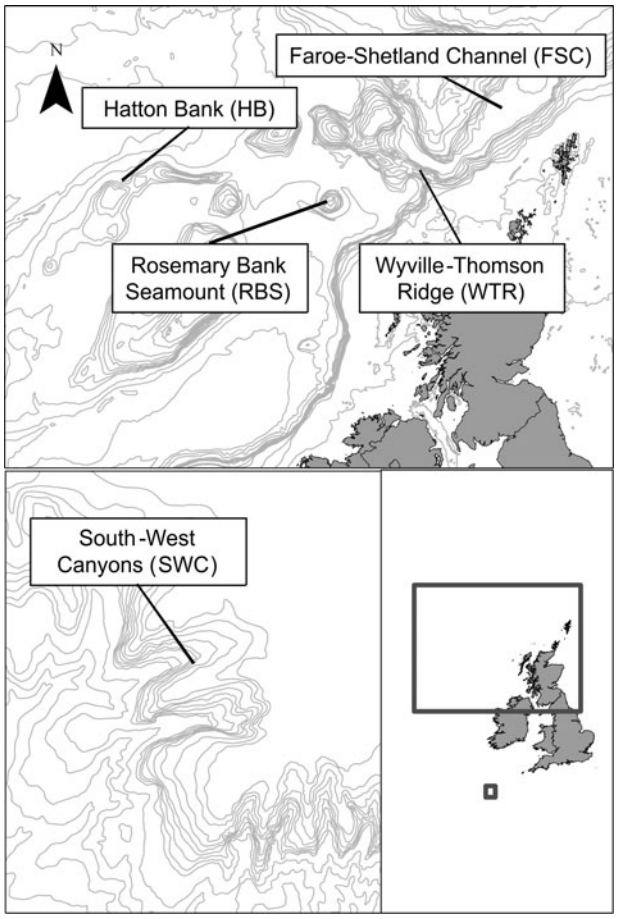

Fig. 1. The European continental margin west of the British Isles, with sample locations identified. Bathymetry lines are at 100 m intervals to 1000 m, then at 500 m intervals. Projected using the British National Grid.

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assemblages. The study is limited to 1000 m; since most anthropogenic activities occur above this depth, therefore the need for assemblage descriptions is arguably most pressing for this region.

MATERIALS AND METHODS

Site description

The European Continental Margin to the west of the British Isles is topographically complex (Figure 1). Within this region lie three seamounts (*sensu stricto*), numerous banks and hills, canyons, and the Wyville-Thomson Ridge (WTR), which separates the Faroe–Shetland Channel (FSC) basin from the Rockall Trough basin. The Rockall Trough is bounded to the west by the Rockall–Hatton Plateaux, to the north by the WTR and a chain of banks and seamounts, and to the east by the European Continental Shelf. It opens to the south onto the Porcupine Abyssal Plain. The trough shallows progressively from 4000 m in the south-west to 1000 m in the north-east where it meets the base of the WTR. The FSC is a deep basin separating the Faroe Plateau from the Scottish continental shelf. The FSC broadens and deepens north-eastward from 90 km wide, 1000 m deep at the base of the WTR to 190 km wide, 1500 m in the north, where it opens into the Norwegian Sea (Figure 1). The hydrographic regime is complex with warm waters of Atlantic origin flowing north-eastward, overlying cold waters of Arctic origin flowing south-westward (Turrell *et al.*, 1999). The boundary between these water masses is dynamic occurring between 400 and 600 m on the eastern flank of the channel.

Data collection

Collection of biological data from the Faroe–Shetland Channel Continental Slope (FSC), WTR, Rosemary Bank Seamount (RBS) and Hatton Bank (HB) was undertaken over a two month period (August–October 2006) using the commercial research vessel MV 'Franklin'. Collection of biological data from the SW Canyons (SWC) was undertaken over a thirteen day period in June, 2007 on the RV 'Celtic Explorer' (Figure 1). One hundred and thirty-nine video transects were undertaken in total (Table 1). Transects were selected to cover a range of substrates, depths and geomorphological features using existing multibeam bathymetry and backscatter data.

For both vessels the Seatronics drop frame system was deployed from the starboard side of the vessel. The system comprised an integrated DTS 6000 digital video telemetry system, which provided a real time video link to the surface, a digital stills camera (5 mega pixel, Kongsberg OE14-208) and a colour video camera (Kongsberg OE14-366). Both video and stills cameras were mounted opposite each other at an oblique angle (video: 24°; stills: 22°) to the seabed to aid in species identification. Sensors monitored depth, altitude and temperature, and an Ultra Short Base Line (USBL) beacon provided accurate position data.

Each transect was nominally 500 m in length, however deviations from planned transect lengths did occur (i.e. if the terrain or currents became too difficult to control the camera). For the majority of tows, vessel speed was approximately 0.5 knots (minimum 0.3 and maximum 0.7 knots), with most tows lasting between 0.5 and 1.5 hours. The drop frame was towed in the water column between one and three metres (dependant on substrate type and currents) above the seabed. At the beginning of each tow, starting from when the sea floor became visible, a 2–3 minute period was allowed before sampling, to enable the camera to stabilize before commencing the transect. At approximately 1 minute intervals the camera was landed on the seabed and a still image obtained, exceptions were when the substratum was extremely (1) soft (silt clouds); (2) rocky, uneven, delicate (coral); or (3) descending a cliff face; here the camera was not landed and images were between 1 and 3 m above the seabed. Images taken at 1 minute intervals are hereafter referred to as 'sample' images.

To maximize the number of biological assemblages recognized, images were obtained where habitat boundaries occurred. In addition opportunistic images were obtained to aid in species identification. The fields of view of both the stills and video cameras were calibrated using a gridded quadrat of known dimensions. Calibrations were made for 'on bottom' (drop frame fully landed on the seabed) and at

Table 1. Distribution of sample effort on each feature within the study area.

	SW Canyons (SWC)	Hatton Bank (HB)	Rosemary Bank Seamount (RBS)	Wyville-Thomson Ridge (WTR)	Faroe–Shetland Channel Continental Slope (FSC)
Number of stations	45	37	14	15	28
Average length of tow (sd)	529 m (153 m)	644 m (158 m)	582 m (267 m)	666 m (305 m)	914 m (499 m)
Total images analysed	873	539	107	208	260
Number of images with fauna	782	477	104	196	255
% of images with benthic fauna	89.58	88.50	97.20	94.23	98.08
Depth-range sampled (m)	184–1059	495–951	330–980	459–911	422–979
Temperature-range sampled (°C)	7.7–11.8	7.2–9.3	7.8–9.5	−0.7–10.1	−0.7–9.5
Total no. morphospecies	164	158	99	158	162
Mean no. morphospecies/image	2.61	3.86	6.14	8.82	6.26
% images where primary substrate was mud–sand	90.03	56.59	37.38	15.38	33.08
% images where substrate was mixed	2.29	32.65	48.60	71.63	58.08
% images where primary substrate was bedrock, boulder, cobble	7.67	10.76	14.02	12.98	8.85

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1 m, 2 m and 3 m above the seabed to aid in quantitative analysis. Field of view size was as follows: on bottom = 2247 cm^2, 1 m = 6423 cm^2, 2 m = 24953 cm^2, 3 m = 56144 cm^2.

Data extraction and analysis

Identification of species from images is difficult and in many cases impossible without obtaining physical samples. However, securing such samples is particularly problematic when working in the deep-sea. Consequently here 312 distinct morphospecies were defined, catalogued and used in subsequent image analysis. In general morphospecies correspond to species, however for some groups (e.g. sponges) it may correspond to genus, family or higher taxonomic level. The morphospecies catalogue is available from the authors upon request.

All 'sample' images and images obtained at habitat boundaries were reviewed and poor quality images removed. The remaining images were quantitatively analysed in the following manner. All organisms >1 cm were identified and counted. For encrusting forms percentage cover was calculated using a calibrated grid superimposed over the image. For the most part the images analysed were of the same size field of view, although in some cases images taken 'off bottom' were required for analysis, particularly where landing the camera was inappropriate (i.e. on coral reef habitats). For this reason abundance data obtained from each image were standardized as density (indiv. m^{-2}) prior to statistical analysis. Raw and standardized image data were stored in an access database. For each image analysed substratum type was assessed by eye and assigned a primary and secondary sediment class-size (Wentworth, 1922) following the methods of Stein *et al.* (1992) and Yoklavich *et al.* (2000).

Data derived from each of the 1753 useable images were considered a 'sample' and used in the analysis. No pooling of images was undertaken as it would have been inappropriate and unhelpful to make any prior assumptions as to what might or might not be part of the same assemblage. Prior to analysis highly mobile species (i.e. fish) were removed from the dataset. In order to allow a more comprehensive analysis of biological data abundance and percentage cover data were analysed together. Inspection of abundance data revealed these data ranged over a 0–1000 point scale, where percentage cover data ranged over a 0–100 point scale. Standardized abundance data were therefore divided by 10 to bring the two datasets onto the same scale allowing them to be combined. Combined per cent cover and abundance data were analysed using PRIMER v.6 (Clarke & Warwick, 2001). Cluster analysis with group averaged linking was performed on Bray–Curtis similarity matrix produced using square-root transformed data, to guide the identification of biological assemblages at a scale relevant to mapping efforts (10s of m). The square-root transformation was selected in order to allow those species of intermediate abundance to contribute to the similarity calculations while not providing too much weight to rarer species introducing 'noise' into an already 'noisy' dataset. The more extreme 4th root transformation gave too much weight to rare species, which is unhelpful in achieving the aim of identifying broad-scale assemblages. The SIMPER routine in PRIMER v. 6 was used to identify the characteristic species of each assemblage. Temperature, depth and substrate data for images within a cluster were used to provide general descriptions of the environmental conditions under which each assemblage occurred. Water mass was interpreted from temperature, depth and location data using the published hydrology of the region (Ellett *et al.*, 1986; Turrell *et al.*, 1999). Water masses present in the region are defined as Arctic (present in FSC, <1°C), Atlantic (present in Rockall Trough or upper 400 m of FSC, 5–12°C), or Intermediate (present in FSC, 1–5°C).

Video data associated with the analysed images was reviewed to test the ease of recognition and scale/extent of described communities from visual data.

RESULTS

Of the 1987 images analysed from 139 video transects sampled, 1753 images contained visible benthic fauna (Table 1). Sampling effort was greatest, in terms of number of video transects sampled and number of images analysed, in the SW Canyons and lowest on Rosemary Bank Seamount (Table 1). The depth-ranges sampled were broadly comparable across all features; however, the temperature range recorded was substantially wider in the Faroe–Shetland Channel and on the Wyville-Thomson Ridge than at the other sample sites (Table 1). Sampling effort was not even across substratum types reflecting genuine differences in substratum availability at each site (Table 1).

Hierarchical cluster analysis using PRIMER v.6 showed images clustering by substratum type (Figure 2a) and within a substratum category, by temperature/water mass (Figure 2b,c). Eighteen major clusters were identified at the 1% similarity level breaking the dataset into a more manageable size. Each of these major clusters were further analysed for the presence of sub-clusters reflective of coherent benthic assemblages at higher levels of similarity. A further 27 sub-clusters were identified through this analysis (Table 2). Those clusters containing less than 10 images (clusters A–E, G–H, J, M and sub-clusters OC, RA, RC, and RHB) were considered outliers and/or not representative of coherent benthic assemblages, and were not considered further. Clusters OA and OD contained exactly 10 images each but were characterized by poorly taxonomically resolved species. Following analysis of the video associated with the images belonging to these clusters neither were thought to represent distinct biological assemblages and were therefore not considered further. Cluster N was characterized by Mysids, which are a benthopelagic, mobile species. This cluster was not considered a coherent benthic assemblage and was therefore also not considered further.

In total 26 benthic assemblages were identified from cluster analysis that could be distinguished in the associated video and existed on a scale appropriate to broadscale mapping efforts (Table 2; Figure 3). Five of these assemblages were unique to the canyon feature and one was unique to the ridge feature (Table 2). No assemblages were unique to the seamount, bank or continental slope features. Three assemblages were restricted to the cold waters of the Faroe–Shetland Channel, occurring on the continental slope and/or on the north side of the Wyville-Thomson Ridge. Sixteen were restricted to the warm waters of the Rockall Trough and upper warm water masses of the Faroe–Shetland Channel. One assemblage was restricted to the warm waters

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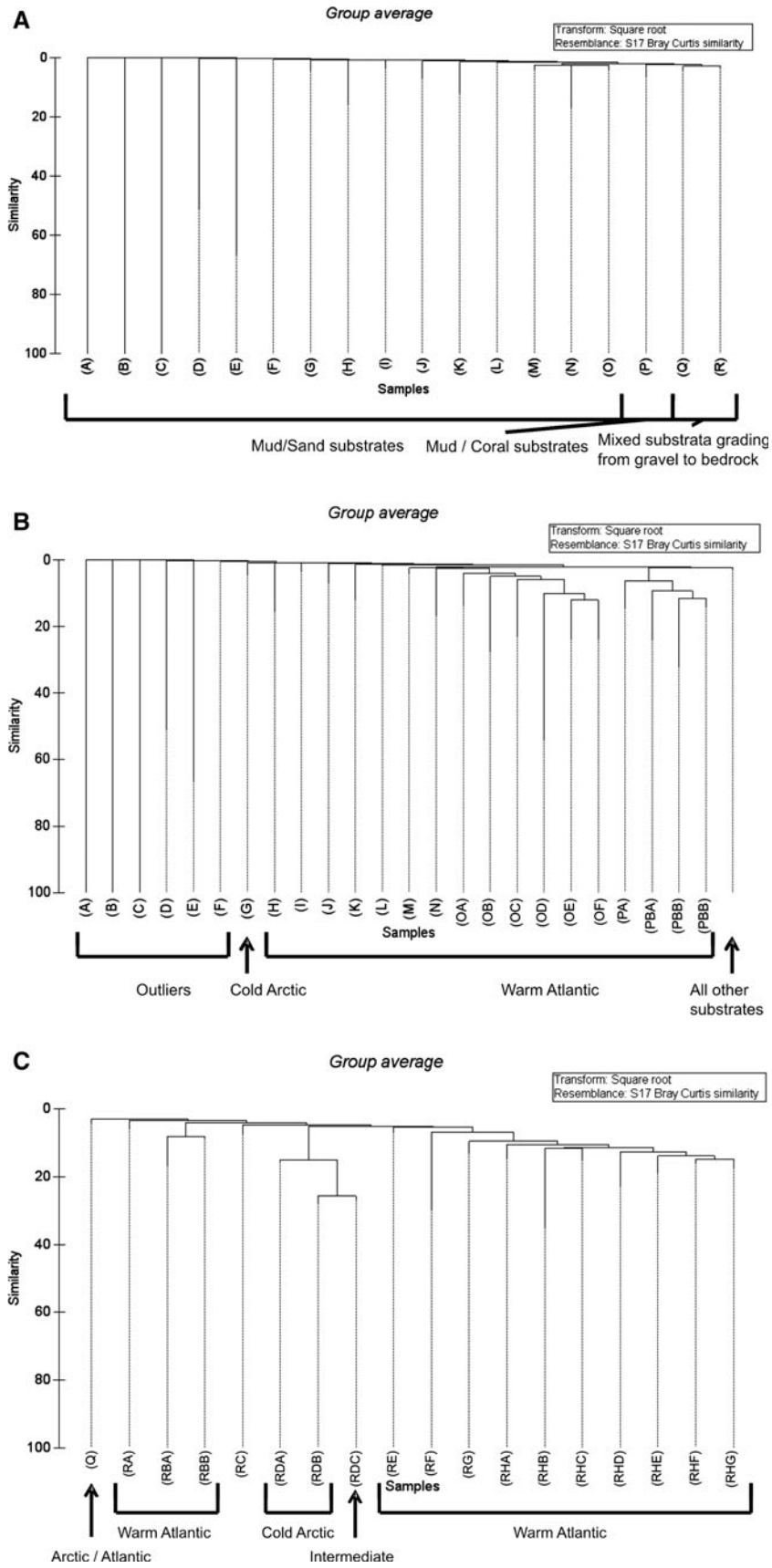

Fig. 2. Hierarchical cluster analysis of species sample data: (A) all data; (B) sand–mud and coral substrates; (C) mixed to bedrock substrates. Major clusters have been collapsed for display purposes.

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Table 2. Clusters identified from quantitative analysis of image data, distribution, characterizing species and associated environmental parameters are indicated for each cluster.

Major cluster (no. of images)	Sub-cluster (no. of images)	Further sub-cluster (no. of images)	Retained (SIMPER similarity level %)	Substrate	Temp range °C	Average temp °C (SD)	Depth-range m	Average depth m (sd)	Feature (outliers)	Characterizing species
A–E (<10)			N	–					–	
F (27)			Y (33)	Sand; gravely sand	1–7.7	0.33 (1.89)	518–809	732 (107)	WTR, FSC (SWC, HB)	Halcampoididae msp. 5
G&H (>10)			N	–	–		–		–	
I (25)			Y (24)	Mud; muddy sand	8–11	9.76 (0.43)	465–928	778 (102)	SWC	Sagartiidae, unidentified juvenile pennatulid
J (>10)			N	–	–		–		–	
K (23)			Y (27)	Sand; mixed cobble, pebble, gravel sand	8–11	9.2 (0.35)	419–852	510 (99)	RBS, HB, WTR	*Cidaris cidaris*, *Caryophyllia* msp. 3, Ophiuroidea msp. 5
L (36)			Y (29)	Sand; mixed sand, pebble, cobble	1–12	8.7 (1.62)	212–899	598 (151)	All	Edwardsiidae msp. 1, Chaetopteridae msp. 1
M (>10)			N	–	–		–		–	
N (20)			N	Sand; mixed sand, pebbles	−1–12	9.37 (2.85)	238–937	593 (165)	SWC, HB, FSC	*Mysida* spp.
O (547)	OA (10)		N	Sand; mixed sand, pebbles	8–12	9.94 (1.01)	301–709	522 (149)	SWC, HB, WTR	Paguridae, Cerianthidae msp. 2
	OB (58)		Y (39)	Coarse sand; mixed sand, gravel (including biogenic gravel), pebble	7–12	7.94 (1.42)	290–951	787 (175)	HB, FSC, SWC	*Lanice* cf.
	OC (<10)		N	–	–		–		–	
	OD (10)		N	Mixed coarse sand, gravel, pebbles	9–11	10 (0.66)	584–913	752 (115)	SWC	Unidentified polychaete
	OE (87)		Y (44)	Mud; sand	7–12	10.33 (0.88)	252–1008	624 (224)	SWC	Amphiuridae sp.
	OF (378)		Y (48)	Sand; mud	−1–12	9.82 (1.83)	205–1021	578 (238)	HB, RB, SWC, FSC	Ophiuroidea msp. 1
P (238)	PA (97)		Y (37)	Mud; muddy sand	7–12	9.78 (0.76)	242–1059	734 (201)	SWC	Cerianthidae msp. 1, *Kophobelemnon* sp
	PB (141)	PBA (12)	Y (31)	Sand, biogenic gravel (coral)	7–10	8.65 (0.89)	519–942	812 (141)	SWC, HB	Ophiuroidea msp. 1, Cerianthidae msp. 1
		PBB (49)	Y (49)	Bedrock with sand/mud veneer	7–11	9.36 (0.78)	316–1048	827 (160)	SWC	hydroids, Cerianthidae msp. 1
		PBC (80)	Y (27)	Bedrock; boulders, cobbles, biogenic reef	7–10	9 (0.79)	505–942	771 (124)	HB, SWC, WTR	*Lophelia pertusa*, *Madrepora occulata*, hydroids, *Actiniaria* msp. 14, *Pandalus borealis*, Cerianthidae msp. 1, Ophiuroidea msp. 1, *Cidaris cidaris*
Q (105)			Y (17)	Muddy sand; mixed pebbles, cobbles, sand	−1–12	3.11 (4.80)	111–1027	737 (109)	FSC, SWC, HB	Sabellidae msp. 1 and msp. 2, Polychaete msp. 6, Ophiuroidea msp. 4, Porifera (white) encrusting msp. 1
R (692)	RA (<10)		N	–	–	–	–	–	–	
	RB (70)	RBA (18)	Y (28)	Mixed sand, pebble, shell	9–12	11.19 (0.48)	190–699	328 (148)	SWC	*Leptometra celtica*, Crinoidea msp. 5
		RBB (52)	Y (27)	Biogenic gravel (coral rubble); mixed sand, pebbles, cobbles, boulders, bedrock	6–12	10.99 (1.34)	185–825	435 (200)	SWC, HB, RBS, WTR	*Munida* spp., *Caryophyllia* msp. 2
	RC (<10)		N	–	–	–	–	–	–	
	RD (126)	RDA (15)	Y (26)	Mixed sand, gravel, pebbles, cobbles, boulders	−1–8	1.1 (2.75)	549–820	651 (91)	FSC	*Ophiactis abyssicola*, cyclostome bryozoans, Porifera (white) encrusting msp. 1
		RDB (94)	Y (45)	Pebbles, cobbles, boulders	−0.65–0.45	(0.17)	626–903	819 (76)	WTR	*Ophiactis abyssicola*, Sabellidae msp. 2, Cyclostomatida msp. 2, Porifera (white) encrusting msp. 1, Zoanthidea msp. 1, Hydroidomedusa (bushy msp), Anthozoa msp. 1, Halcampoididae msp. 3

	RDC (17)	Y (37)	Pebbles, cobbles, boulders, biogenic gravel	−1–8	4.39 (3.15)	588–901	710 (136)	FSC, HB	*Ophiactis abyssicola*, Porifera (white) encrusting msp. 1
RE (43)		Y (22)	Mud; sand; mixed sand, gravel, pebble, cobble	7–12	8.69 (0.91)	321–1006	736 (179)	HB, RBS, WTR, SWC	Halcampoididae msp. 3, Polychaeta msp. 4, Porifera (white) encrusting msp. 1
RF (32)		Y (51)	Mixed sand, gravel, pebble cobble	7–12	9.39 (0.72)	266–803	560 (121)	All	Brachiopoda
RG (56)		Y (27)	Mixed sand, gravel (including biogenic gravel), pebble cobble, boulder	6–12	9.5 (2.20)	189–961	475 (208)	HB, RB, SWC, WTR	Serpulidae msp. 1, *Munida* spp., Porifera (white) encrusting msp. 1
RH (354)	RHA (20)	Y (28)	Mixed sand, gravel (including biogenic gravel), pebble, cobble	7–9	8.21 (0.33)	615–1015	828 (93)	HB, RB, SWC	Ophiuroidea msp. 6, Porifera (white) encrusting msp. 1, Majidae msp. 1, Porifera (blue) encrusting msp. 16, Bryozoa (encrusting) msp. 1, Brachiopoda
	RHB (<10)	N	–	–	–	–	–	–	
	RHC (45)	Y (27)	Mixed pebble, sand, gravel (including biogenic gravel), cobble	−1–12	6.33 (3.61)	272–980	628 (169)	HB, RB, SWC, FSC	Porifera (white) encrusting msp. 1, Serpulidae msp. 3
	RHD (87)	Y (31)	Cobble, boulder, bedrock	7–10	8.97 (0.40)	332–963	555 (120)	HB, RB, SWC, FSC	Anomiidae msp. 1, *Psolus squamatus*, Porifera (white) encrusting msp. 1, Serpulidae msp. 3, *Munida* spp., Brachiopoda
	RHE (72)	Y (27)	Mixed, sand, gravel (including biogenic), pebble, cobble, boulder, bedrock	−1–12	8.27 (3.65)	180–1054	539 (213)	All	*Ophiactis balli*, Porifera (white) encrusting msp. 1, *Munida* spp.
	RHF (14)	Y (25)	Coral rubble, mixed gravel (biogenic), pebble, cobble and boulder	7–9	8.58 (0.57)	772–883	760 (71)	HB, RBS, WTR	Halcampoididae msp. 1, Bryozoa (encrusting) msp. 1, Porifera (white) encrusting msp. 1, *Munida* spp., Serpulidae msp. 1, Serpulidae msp. 2, Porifera (yellow) encrusting msp. 12, *Ophiactis abyssicola*, *Caryophyllia* msp. 2, *Caryophyllia* msp. 3, *Henricia sanguinolenta*, Majidae msp. 1, Ascidiacea msp. 2.
	RHG (113)	Y (25)	Mixed pebble, cobble, gravel (including biogenic)	0–10	7.91 (1.55)	343–867	486 (62)	FSC, WTR, RBS, HB	Porifera (white) encrusting msp. 1, *Munida* spp., Brachiopoda, Ophiactis balli, Ophiuroidea msp. 6, Porifera (yellow) encrusting msp. 12, Porifera massive lobose msp. 12, Serpulidae msp. 1, Porifera (green) encrusting msp. 25, Porifera (orange) encrusting msp. 3, Porifera (cream) encrusting msp. 27

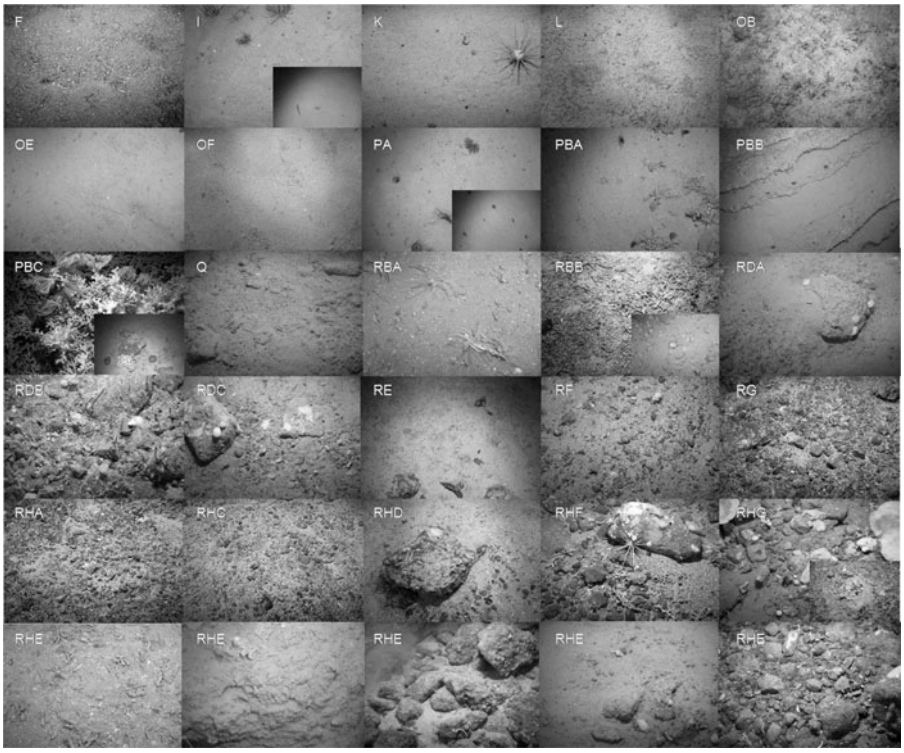

Fig. 3. Example representative images of the 26 assemblages identified from hierarchical cluster analysis.

of the Faroe–Shetland Channel, occurring on both the continental slope and Wyville-Thomson Ridge. Six assemblages were found over the full range of temperatures sampled. For these six assemblages it is likely that poor taxonomic resolution of the characterizing species masks differences in assemblage composition between cold and warm water masses.

In order for the 26 biological assemblages identified here to be easily slotted into existing classification schemes it is essential that they can be attributed to a single broad substratum category of the type used in existing classification schemes. RHE occurred on multiple substratum 'types' and was therefore further subdivided to aid its application to mapping efforts. In addition some assemblages identified here (PBC, RBB, RHE and RHF) mix well described biological communities (e.g. cold water coral reefs) with other assemblages containing similar key species (e.g. other assemblages containing isolated or small *Lophelia pertusa* colonies). The resolution of such assemblages is not sufficient for management efforts, and further division is required to identify these distinct communities as separate to the rest of the assemblage. In the case of the *Lophelia pertusa* reef this is necessary given the legal status and perceived conservation value of cold water coral reef communities.

DISCUSSION

After further subdivision of those clusters identified above, 31 assemblages and their associated environmental parameters or 'biotopes' (*sensu* Connor *et al.*, 2004) were described (Table 3) from quantitative analysis of 1987 images from 139 video transects sampled from the upper bathyal zone (200–1000 m) of the north-east Atlantic. Full descriptions and morphospecies lists are provided in an Appendix to this paper. The described 'biotopes' (*sensu* Connor *et al.*, 2004) provide easily recognizable consistent 'units' on which mapping efforts can be based. However, in order for these biotope units to be useful, in terms of marine environmental management and MPA network design, the biological mapping 'units' need to be incorporated into a hierarchical classification system.

Nearly all existing habitat classification systems categorize the habitat according to substratum at their lowest levels (Allee *et al.*, 2001; Roff & Taylor, 2000, Connor *et al.*, 2004; Davies *et al.*, 2004). As this project was undertaken in European waters the European Habitat Classification System EUNIS (Davies *et al.*, 2004) has been used as a template for the broad substratum categories, into which assemblages could be slotted. However, it should be noted that refinement of existing systems based on emerging 'bottom-up' information about patterns of biodiversity should be undertaken in preference to forcing new information into existing hierarchical structures. Within EUNIS the following substratum categories are recognized: deep-sea mud, deep-sea muddy sand, deep-sea sand, deep-sea mixed substrata, deep-sea rock and deep-sea bioherms. The 31 assemblages described here have been assigned to the most appropriate of the existing EUNIS substratum categories (Table 3). The category deep-sea muddy sand has not been used as it was not possible to consistently distinguish this category using video/image data. The following discussion has been structured around these broad substratum categories. Each of the assemblages described above is, where possible, compared with assemblages described in the literature. The comparison is based on the presence of the characterizing species and, where available, descriptions of the broad environmental parameters (e.g. depth and substratum type).

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Table 3. Final assemblages defined from analysis and further subjective division of clusters to aid in practical use and incorporation to existing classification schemes.

Cluster	SIMPER similarity %	Further divided	EUNIS substratum category	Proposed name of assemblage/ community	Average depth of assemblage observations	Average temp °C (SD)	Principal water mass assemblages observed in	Features assemblage observed on	Supporting references
F	33	N	Sand	Halcampid anemones in rippled sand	732	0.33	Arctic	WTR, FSC	None
I*	24	N	Mud	Sagartiid anemones and juvenile pennatulids	778	9.76	Atlantic	SWC	None
K	27	N	Sand	*Cidaris cidaris–Stichopus tremulus* community	510	9.20	Atlantic	RBS, HB, WTR	Gage, 1986; Axlesson, 2003; Wienberg *et al.*, 2008
L*	29	N	Sand	Edwardsiid anemones and Chaetopterid polychates	598	8.70	Atlantic	All	None
OB	39	N	Sand	*Lanice* beds	787	7.94	Atlantic	HB, FSC, SWC	Van Hoey *et al.*, 2008
OE	44	N	Mud	Communities of amphiurid ophiuroids	624	10.33	Atlantic	SWC	Petersen, 1918; Jones, 1950, 1951; Glémarec, 1973; Mackie, 1990
OF	48	N	Sand	Ophiuroids on rippled sediment	578	9.82	Atlantic	HB, RB, SWC, FSC	Wienberg *et al.*, 2008
PA	37	N	Mud	*Kophobelemnon stelliferum* and cerianthid anemones	734	9.78	Atlantic	SWC	Rowe, 1971; Rice *et al.*, 1992
PBA	31	N	Bioherm	Highly sediment draped scattered coral framework	812	8.65	Atlantic	SWC, HB	None
PBB	49	N	Rock	Hydroid turf and cerianthid anemones on sediment draped rock ledges	827	9.36	Atlantic	SWC	None
PBC	23	Y	Rock	Discrete coral (*Lophelia pertusa*) colonies on hard substratum	637	8.89	Atlantic	HB, SWC, WTR	Wienberg *et al.*, 2008
	36		Bioherm	Live summit of *Lophelia pertusa* reef	844	9.06	Atlantic	HB, SWC	Mortensen *et al.*, 1995; Freiwald *et al.*, 2004; Foubert *et al.*, 2005; Huvenne *et al.*, 2005; Wheeler *et al.*, 2005a,b; Wienberg *et al.*, 2008.
Q	17	N	Mixed	Sabellids, white encrusting sponges and ophiuroids on mixed substrate.	737	3.11	Arctic/Atlantic	FSC, SWC, HB	None
RBA	28	N	Mixed	Crinoid (*Leptometra celtica*) communities at the shelf edge	328	11.19	Atlantic	SWC	Lavaleye *et al.*, 2002
RBB	26	Y	Mixed	*Munida* and Caryophillids on mixed substrates	382	10.99	Atlantic	SWC, HB, RBS	None
	30		Bioherm	*Lophelia pertusa* reef rubble apron	524	9.50	Atlantic	SWC, HB, WTR	Mortensen *et al.*, 1995; Freiwald *et al.*, 2004; Foubert *et al.*, 2005; Huvenne *et al.*, 2005; Wheeler *et al.*, 2005a,b; Wienberg *et al.*, 2008.
RDA	26	N	Mixed	Cyclostomes, ophiuroids and white encrusting sponges on mixed substrates	651	1.10	Arctic	FSC	None
RDB	45	N	Rock	Zoanthids, *Ophiactis abyssicola* and sabellids on hard substratum	819	−0.5	Arctic	WTR	Jones *et al.*, 2007; BIOFAR Proceeding, 2005

Continued

Table 3. Continued

Cluster	SIMPER similarity %	Further divided	EUNIS substratum category	Proposed name of assemblage/ community	Average depth of assemblage observations	Average temp °C (SD)	Principal water mass assemblages observed in	Features assemblage observed on	Supporting references
RDC	37	N	Mixed	*Ophiactis abyssicola* and white encrusting sponges on mixed substrates	710	4.39	Intermediate/Atlantic	FSC, HB	None
RE*	22	N	Mixed	Halcamid anemones and white encrusting sponges on mixed substrate	736	8.69	Atlantic	HB, RBS, WTR, SWC	None
RF*	51	N	Mixed	Brachiopods on mixed substrate	560	9.39	Atlantic	All	None
RG*	27	N	Mixed	Serpulid polychaetes and *Munida* on mixed substrate	475	9.50	Atlantic	HB, RB, SWC, WTR	None
RHA*	28	N	Mixed	White and blue encrusting sponges, ophiuroids and majids on mixed substrate	828	8.21	Atlantic	HB, RB, SWC	None
RHC*	27	N	Mixed	White encrusting sponges and serpulids on mixed substrate.	628	6.33	All	HB, RB, SWC, FSC	None
RHD	31	N	Rock	*Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum.	555	8.97	Atlantic	HB, RB, SWC, FSC	Wienberg *et al.*, 2008
RHE	27	Y	Mixed	*Ophiactis balli* and *Munida rugosa* on mixed substrate	569	7.85	Atlantic	SWC, RBS, FSC, WTR	None
	51		Rock	*Ophiactis balli* and *Munida rugosa* in vesicular rock	447	9.28	Atlantic	HB, RBS	None
	37		Bioherm	Trawl damaged *Lophelia pertusa* rubble.	351	11.27	Atlantic	SWC	None
RHF	30	Y	Mixed*	Caryophyllids, *Munida* and encrusting sponges on mixed substrate	745	8.84	Atlantic	HB, RBS, WTR	None
	35		Bioherm	Dead framework slopes of *Lophelia pertusa* reef	798	7.90	Atlantic	HB	Mortensen *et al.*, 1995; Freiwald *et al.*, 2004; Foubert *et al.*, 2005; Huvenne *et al.*, 2005; Wheeler *et al.*, 2005a,b; Wienberg *et al.*, 2008.
RHG	25	N	Bioherm	Boreal *Ostur*	486	7.91	Intermediate	FSC, WTR, RBS, HB	Klitgaard *et al.*, 1997; Bett, 2001; Klitgaard & Tendal, 2004.

*Some uncertainty as to the validity of these biotopes, see text for details.

Deep-sea mud and sand assemblages

Eight of the described assemblages could be designated sand or mud assemblages (Table 3). Five could be supported by reference to the peer reviewed literature.

The assemblage described by cluster F was essentially limited to the cold waters of the FSC and was associated with a specific geomorphological feature (unpublished data). Although this assemblage has not been described previously, video observations suggest it is a distinct assemblage that merits recognition.

Cluster I was restricted to the Canyon feature and it is assessed below together with other canyon-restricted assemblages.

The assemblage described by cluster K is broadly comparable to an assemblage described by Gage (1986) from this region. Gage (1986) identified two assemblages in the bathymetric zone ranging from 200–700 m in the Rockall Trough from trawl samples. One of these assemblages is situated on sandy deposits. Within this assemblage megafauna is sparse but the echinoderm species *Cidaris cidaris*, *Spatangus raschi* and *Stichopus tremulus* are relatively abundant within trawl samples (Gage, 1986). Gage also notes the occurrence of these species from the continental shelf in the North Sea, around the Shetlands, in the Norwegian Trench, on Porcupine Bank and the summit of Anton Dohrn Seamount, Rockall Plateaux and other banks to the north (Sussbach & Breckner, 1911; Pawsey & Davis, 1924; Dyer *et al.*, 1982; Cranmer, 1985). More recently Axlesson (2003) found that the sandy sediments of the UK continental slope were dominated by irregular echinoids (possibly *Spatangus purpureus*) and the holothurian *Stichopus tremulus*. Wienberg *et al.* (2008), in their description of the faunal assemblage on the soft sediments near the Franken Mound at 650 m on Rockall Bank, noted *Cidaris cidaris* as the most common species, as well as asteroids, holothurians, cerianthids and *Bolocera tuediae*. Observations from the video associated with those images belonging to cluster K, together with video observations from the seamounts and banks of the Rockall Trough in general, suggest that cluster K represents a distinct assemblage occurring on sandy substrata throughout the Rockall Trough.

The assemblage termed cluster L has not been described previously from the deep-sea. This assemblage is characterized by Edwardsiid anemones (Edwardsiidae msp. 1) and polychaetes (Chaetopteridae msp. 1). Observation of the video associated with the images belonging to this cluster, reveals that Chaetopterids are not useful as a distinguishing species. The assemblage is difficult to distinguish visually from that of cluster K as the Edwardsiid anemones are difficult to see when the camera is elevated. It is however distinguishable by the greatly reduced abundance of, and in some areas absence of, *Stichopus tremulus*. Quantitative analysis of video data would provide a more detailed description of this assemblage.

The assemblage described by cluster OB has not been described previously from the deep-sea, but is well known to occur in both littoral and subtidal shelf regions (Van Hoey *et al.*, 2008). The assemblage is characterized by dense aggregations of a species that has been *provisionally* identified as the sand mason worm, *Lanice conchilega*. Although we cannot be certain the species observed in this study is *L. conchilega* as no physical samples were taken, this species is known to occur to depths of 1900 m (Hartmann-Schröder, 1996) making it at least possible. Assemblages of sand mason worms can reach densities of several thousand individuals per square metre (Van Hoey *et al.*, 2008), in sediments ranging from mud to coarse sand (Van-Hoey *et al.*, 2008). Their distribution is primarily determined by sedimentology (Willems *et al.*, 2008), however hydrology and food supply have also been correlated with the occurrence of the densest aggregations (Van Hoey *et al.*, 2008). *Lanice conchilega* is regarded as a habitat structuring species as its presence in high densities affects the surrounding benthic assemblage. Both density and species richness of benthos increase with increasing density of *L. conchilega* up to a critical density (500–1000 ind/m^2) (Van Hoey *et al.*, 2008). The habitat structuring properties of these aggregations and their wide recognition in the literature suggest this can be regarded as a distinct assemblage within the deep-sea.

Wienberg *et al.* (2008) note in areas of rippled seabed, high abundances of ophiuroids. In the present study cluster OF is characterized by ophiuroids and is present over a similar temperature and depth range to cluster K. Observations from the video associated with those images belonging to cluster OF also identify this assemblage as being associated with rippled seabed. Video observations from the banks and seamounts of the Rockall Trough suggest that this is a distinct assemblage that occurs on rippled sand seabed throughout the Rockall Trough.

The assemblages described by clusters I, OE and PA were all limited to the SW Canyons (if outliers are omitted). Descriptions of the megafaunal assemblages of canyons are lacking despite numerous publications dealing with the subject (Rowe, 1971; Headrich *et al.*, 1975; Hecker *et al.*, 1988; Cartes *et al.*, 1994; Sarda *et al.*, 1994; Vetter & Dayton, 1999; Duineveld *et al.*, 2001; Schlacher *et al.*, 2007) making comparison impossible.

Cluster I was characterized by anemones (tentatively identified as belonging to the family Sagartiidae) and unidentified juvenile pennatulids. This assemblage has not been described previously in the literature. Analysis of the video associated with images belonging to this cluster suggests this assemblage is found in close proximity, and in some cases is difficult to distinguish from that assemblage described by cluster PA. It is possible that this cluster may not represent a distinct assemblage at all, rather an artefact of the sampling method used. However, quantitative analysis of video data would be required to test this.

Cluster OE was characterized by amphiurid ophiuroids. Existing assemblages within EUNIS characterized by members of this group include: (1) *Amphiura filiformis*, *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud (A5.351); (2) *Amphiura filiformis* and *Nuculoma tenuis* in circalittoral and offshore muddy sand (A5.353); and (3) *Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud (A5.363). (1) and (2) are considered part of the *Amphiura filiformis* dominated circalittoral etage described by Glémarec (1973) and the 'off-shore muddy sand association' described by other workers (Jones, 1951; Mackie, 1990). Whereas (3) is considered part of the 'Boreal Offshore Mud Association' and '[Brissopsis–Chiajei]' assemblages described by other workers (Petersen, 1918; Jones, 1950). Cluster OE could be considered a deep-water extension of one (or more) of these existing assemblages. However, lack of infaunal data does not allow an assessment of whether the assemblage described by cluster OE is one of these assemblages listed or a new deep-sea variant.

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The assemblage described by cluster PA is similar to an existing assemblage within EUNIS, Sea pens and burrowing megafauna in circalittoral fine mud (A5.36). A5.36 is characterized by the sea pens *Virgularia mirabilis* and *Pennatula phosphorea* together with the burrowing anemone *Cerianthus lloydii* and the ophiuroid *Amphiura* spp. Cluster PA is also characterized by sea pens and cerianthid anemones although not those listed in A5.36. '*Lifetraces*' indicative of burrowing megafauna were also observed from images belonging to this cluster, however these were not quantified or included in the analysis. PA could be considered a deep-water version of A5.36. The characterizing species, the sea pen *Kophobelemnon stelliferum*, is widely distributed along the continental slopes of the northern Atlantic and Pacific Oceans at depths from 400 m to 2500 m although it has been reported from 40 m in Norwegian waters (Rice *et al.*, 1992). Photographic observations of this species from the Hatteras Canyon in the north-western Atlantic suggest it can be locally abundant reaching densities of up to 12 m^2 (Rowe, 1971). Photographic studies in the Porcupine Seabight suggest rather lower densities of 2.6 m^2 (Rice *et al.*, 1992). Visual inspection of the images published in Rice *et al.* (1992) suggests that the assemblage described by cluster PA is not limited to canyon systems. Its absence from other areas surveyed within this study is most likely a reflection of the lack of comparable substratum sampled, with this assemblage being found on fine mud or sandy mud substrate.

Deep-sea mixed substratum assemblages

Twelve of the described assemblages could be considered as occurring on mixed substrates (gravel–cobble) (Table 3). One assemblage could be supported by reference to the peer reviewed literature (RBA). Of the remaining assemblages 3 (RHE, RHF and RBB), were further subdivided on the basis of broad substrate type and/or separation of cold-water coral reef communities from similar non-reef associated communities, for use in a classification system (Table 3). Clusters RBB and RHF contained examples of an assemblage associated with cold water coral reefs communities. These sub-assemblages are supported in the literature and are discussed under 'Bioherms'. The non-coral reef examples of RHF were few, however video observations suggest it may be an identifiable community of use in classification and mapping. The non-coral reef examples of RBB were more numerous and justification of this assemblage as a distinct entity is clearer than for RHF. The assemblage defined by cluster RHE occurred on three broad substratum types, one of which was associated with a region of trawl damaged cold water coral reef (now rubble) (see below). However, this assemblage was primarily observed on mixed substrate. Video observations suggest this is a distinct community that is easily identified although no supporting descriptions of such a community could be found in the literature.

The assemblage described by cluster RBA is similar to an assemblage described by Lavaleye *et al.* (2002) from this region. These authors describe a shelf edge station on Goban Spur at 200 m as dominated by *Leptometra celtica* and a comparable station at 190 m on the Iberian margin as dominated by crinoids. These authors attribute the high densities of these organisms at the shelf-break to the occurrence of rich concentrations of suspended organic particles. This assemblage was only observed from the SW Canyons and was present at the heads of the canyons (Davies, unpublished data). Observations from the video associated with the images from cluster RBA suggest this assemblage occurs in areas of strong current flow.

Clusters Q and RDA were essentially limited to the cold waters of the FSC. No descriptions of epibenthic mixed sediment assemblages could be found in the literature, for comparison. Similarly the assemblages described by clusters RDC, RE, RF, RG, RHA and RHC could not be compared to the assemblages described. Visually it is difficult to distinguish between those images belonging to clusters RE, RF, RG, RHA and RHC. Further analysis of the spatial distributions and geomorphological associations of these clusters may reveal important differences between these assemblages, supporting their identification and description. However, in practical terms it may be impossible to tell these assemblages apart through visual survey.

Deep-sea rock assemblages

Five of the described assemblages could be considered as occurring on hard substrates (Table 3). Three assemblages could be supported by reference to the literature (PBC, RDB and RHD). One (RHE) was primarily observed on mixed substrates and is discussed under that heading. While the final (PBB) was restricted to canyon features.

The assemblage described by cluster PBB is interesting in that it could also be considered a sand–mud substratum assemblage. This assemblage was associated with bedrock ledges or outcrop, in-filled or covered with a veneer of fine sediment. It is therefore characterized by a hydroid turf (attached to the rock outcrop) and cerianthid anemones (Cerianthidae msp. 1) burrowed into the soft sediment areas. Although this assemblage has not been described previously, observation from the video associated with the images within cluster PBB reveals an easily identified distinct assemblage.

The assemblage described by cluster PBC included all images with live *Lophelia pertusa*. *Lophelia pertusa* has a cosmopolitan distribution but has been found most frequently in the north-esatern Atlantic. It is known to tolerate temperatures between 4 and 13°C (Freiwald, 2002), and is found from 39–3383 m. It can be found growing as isolated colonies, as well as forming bush-like clumps and reef like framework structures. Cluster PBC included examples of images from live sections of biogenic reef as well as growths of small colonies on rock outcrop, and boulders and cobble dropstones. The division of this assemblage into communities of cold water coral reefs and 'other assemblages characterized by *Lophelia pertusa*' is discussed more fully under Bioherms. However, clearly it is useful and ecologically meaningful to distinguish between areas of cold water coral reef framework (bioherms) and discrete colonies of *L. pertusa*. Wienberg *et al.* (2008) made this distinction in their descriptive paper defining coral assemblages associated with hard ground ridges separately to coral reef assemblages. They describe discrete colonies of octocorals, antipatherian and few *Lophelia*; up to 1–2 m diameter, accompanied by sponges, hydroids, actinians, crustaceans, echinoderms and fish.

The assemblage described by cluster RDB was limited to the cold waters of the FSC and specifically the base of the Wyville-Thomson Ridge. Although no description is available

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observations of images taken as part of the BIOFAR project (BIOFAR Proceeding, 2005) and other photographic studies of the base of the FSC (Jones *et al.*, 2007) suggest this assemblage is present in other parts of the FSC and is easily recognizable. Further subdivision of this cluster may be possible and desirable as more data become available, particularly with regard to the spatial distribution of this assemblage and associations with geomorphological features. Video observations suggest there may be three distinct assemblages within this cluster that are associated with slope and water current strength. However, quantitative analysis of video data is required.

The assemblage described by cluster RHD is similar to hard ground assemblages described previously from the Rockall Trough. Wienberg *et al.* (2008) describe gravel to boulder sized debris colonized by serpulids, bryozoans, *Psolus* sp., *Pliobothrus symmetricus* and Stylaster, *Phelliactis* sp., octocorals, sponges, *Munida* sp., *Paramola* sp., *Pagarus* sp. and fish. Although the description of this cluster is somewhat more limited in the list of species that characterize this assemblage, video observations associated with the images belonging to this cluster, suggest these are the same assemblages.

Bioherms

COLD-WATER CORAL ASSEMBLAGES

In this study five assemblages were identified that were associated with cold-water coral reefs and/or reef-building corals (PBA, PBC, RBB, RHF and RHE). Cold water coral mounds (frameworks and bioherms) are widely recognized as a distinct biological community. These structures are generally divided in three 'zones' based largely on the condition of the coral (mostly living summit regions, mostly dead slope regions, and coral rubble apron) (Mortensen *et al.*, 1995; Foubert *et al.*, 2005; Huvenne *et al.*, 2005; Wheeler *et al.*, 2005a,b; Wienberg *et al.*, 2008). The biological assemblages (clusters) identified here corresponded well to these zones and are discussed in that context.

MOSTLY LIVING SUMMIT REGIONS

Cluster PBC included examples of the live summit regions of cold-water coral reef, as well as dense *L. pertusa* clumps growing on exposed basalt, right down to small colonies growing on isolated dropstones. The biological assemblage of the live sections of a cold-water coral reef framework is ecologically distinct from the biological assemblages associated with small colonies of *L. pertusa* on hard substrate. The coral framework, on which the live coral assemblage sits, provides a habitat for hundreds if not thousands of species (Freiwald *et al.*, 2004). The summit region itself however, supports few permanently attached organisms as living corals are very successful in preventing fouling. Among those species that are permanently attached are the polychaete *Eunice norvegica*, the parasitic foraminiferan *Hyrrokkin sarcophagi*, and clusters of bivalves including *Delectopecten vitreus* and *Acesta excavata* (Freiwald *et al.*, 2004).

MOSTLY DEAD SLOPE REGIONS

Cluster RHF describes the assemblages of the mostly dead slope regions of cold water coral mound assemblages as well as other regions of accumulated dead *L. pertusa*, for example around the base of a basalt rock outcrop, or the base of a large boulder with *L. pertusa* colonies growing it. Freiwald *et al.* (2004) list those species occurring within this zone. Amongst the megafauna, gorgonians, actinians and sponges are conspicuous and abundant, while on smaller scale hydrozoans, bivalves, brachiopods, bryozoans and barnacles are prevalent (Freiwald *et al.*, 2004). Observations of the video associated with the images from cluster RHF confirm the actinians (*Phelliactis* sp.) and sponges as conspicuous and abundant megafauna, however these large bodied species are infrequently captured by the image samples and thus do not appear as characterizing species of this assemblage. Further description of this assemblage from quantitative analysis of video data is required.

CORAL RUBBLE APRON

Cluster RBB includes examples from the rubble apron 'zone' of cold water coral mounds as well as other mixed sediment substrates which provide a similar 'habitat' to the rubble apron 'zone'. Mortensen *et al.* (1995) identified high abundances of the squat lobster, *Munida sarsi* from this 'zone', which is consistent with the characterizing species of this cluster. Freiwald *et al.* (2004) also list encrusting sponges and echiurid worms as common to this zone. Observations from the video associated with the images from cluster RBB confirm the presence of the echiuran *Bonellia viridis* in this assemblage.

MODIFIED COLD-WATER CORAL COMMUNITIES

Clusters PBA and RHE appear to represent modified versions of described communities associated with cold water coral reefs. In regions where the broken reef framework (dead slope zone and to an extent the rubble apron zone) has become heavily draped in sediment the community composition understandably changes. Species such as cerianthid anemones become dominant. Cluster PBA appears to represent such an assemblage and is comparable to an assemblage described by Wheeler *et al.* (2007): 'Sediment-clogged coral framework facies'. This cluster was primarily observed in the canyons where heavy sedimentation of coral frameworks was observed (J. Davies, University of Plymouth, unpublished data). Similarly cluster RHE contained examples of images from coral mounds that had been damaged by trawling activity (J. Guinan, Marine Institute Galway, unpublished data). Although the species composition of these regions was similar to that of other mixed sediments, and as the characterizing species go, similar to the rubble apron zone of intact cold-water coral mounds, it may be desirable to identify this assemblage as distinct from non-coral assemblages for the purposes of environmental management.

DEEP-SEA SPONGE AGGREGATIONS

Cluster RHG primarily describes sponge-rich assemblages in the Faroe–Shetland Channel with outlying observations from the Wyville-Thomson Ridge, Rosemary Bank and Hatton Bank, most likely a result of the use of morphospecies for sponge identification. Observation of video data associated with the images from this cluster reveals a rich sponge fauna, including large raised sponge-covered structures and massive sponge forms. This assemblage was centred on the 500 m contour in a region where temperature was observed to fluctuate from below 0 to more than 7°C. Sponge assemblages

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are well known to occur in the Faroe–Shetland Channel (Klitgaard *et al.*, 1997; Bett, 2001) as well as further north in the Norwegian Sea, Greenland Sea, western Barents Sea, Reykjanes Ridge and Denmark Strait (for a full review see Klitgaard & Tendal, 2004). The assemblages or *ostur* have been classified by Klitgaard & Tendal (2004) into two types: a boreal *ostur* dominated by *Geodia barretti*, *Geodia macandrewi*, *Geodia atlantica*, *Isops phlegraei*, *Stryphnus ponderosus* and *Stelletta normani* and a cold water *ostur* characterized by the same genera but represented by different species. Boreal *ostur* occur around the Faroe Islands, Norway, Sweden, parts of the Western Barents Sea and south of Iceland; while cold water *ostur* occur north of Iceland, in the Denmark Strait, off east Greenland and north of Spitzbergen. It is likely that the *ostur* observed here are of the boreal type.

CONCLUSIONS

This study represents one of the first attempts to systematically define assemblages of deep-sea organisms and their associated environmental parameters (biotopes) for the purposes of biological (habitat) mapping and providing fine-scale surrogates for representing biological diversity in marine environmental management and MPA network design. Thirty-one benthic assemblages and their associated environmental parameters, 'biotopes', have been identified from the broad geographical region of the Rockall Trough and Faroe–Shetland Channel (Table 3). Supporting descriptions of 14 of these assemblages were uncovered in the existing literature.

The 31 assemblages defined here provide consistent units for use in biological (habitat) mapping efforts and assessments of representativeness in MPA network design. It should be noted that these are preliminary descriptions based on analysis of image data. It is anticipated that these descriptions will evolve as more data from a wider area and from different sampling tools become available over time. Ideally the biological assemblages defined here should be incorporated into a hierarchical classification system. However, few existing classification systems, which are applicable to the deep-sea (Greene *et al.*, 1999; Allee *et al.*, 2001; Roff & Taylor, 2000; Butler *et al.*, 2001; Davies *et al.*, 2004; Madden *et al.*, 2008), incorporate units at the biological assemblage level. One important exception, which is most relevant to the region that is the focus of this study, is the European Habitat Classification System (EUNIS) (Davies & Moss, 1999; Davies *et al.*, 2004). This system already includes units at the biotope level some of which are consistent with the assemblages identified by this study (e.g. EUNIS A6.611: Deep-sea [*Lophelia pertusa*] reefs). The assemblages described here could be easily incorporated into that system dramatically improving its usefulness at fine-scale resolution.

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APPENDIX. DESCRIPTIONS OF FINAL BIOTOPES WITH FULL MORPHOSPECIES LISTS FOR EACH

Deep-sea mud and sand assemblages

Halcampid anemones in rippled sand—Cluster F

This cluster contained 27 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 33.07%. SIMPER analysis identified this assemblage as characterized by anemones belonging to the family Halcampoididae (Halcampoididae msp. 5). Analysis of the environmental parameters associated with this assemblage suggests it is found on sand and gravely sand substrate, at temperatures between −1 and 7.7°C (mean 0.33°C SD 1.89°C) and at depths of 518–809 m (mean 732 m SD 107 m). This assemblage was primarily observed in the Fare–Shetland Channel, with single outlying observations from the South-West Canyons and Hatton Bank.

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Halcampid anemones in rippled sand—Cluster F	
SIMPER-characterizing species	**Morphospecies**
*	Halcampoididae msp. 5
	Ophiuroidea msp. 3
	Actinostolidae msp. 1
	Porifera encrusting msp. 1
	Polynoidae/Aphroditidae msp. 1
	Porifera encrusting msp. 10
	Branchiocerianthus msp.
	Porifera massive globose msp. 7
	Porifera massive lobose msp. 13
	Bonellia viridis
	Unknown msp.
	Munnopsurus giganteus
	Reteporella msp. 1
	Bryozoa msp. 1
	Porifera encrusting msp. 28
	Porifera encrusting msp. 32
	Porifera encrusting msp. 12
	Phelliactis msp. 1
	Stichopathes cf. *gravieri*
	Porifera encrusting msp. 6
	Gorgonacea msp. 2

Sagartiid anemones and juvenile pennatulids—Cluster I

This cluster contained 25 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 23.91%. SIMPER analysis identified this assemblage as characterized by anemones belonging to the family Sagartiidae and unidentified juvenile pennatulids. Analysis of the environmental parameters associated with this assemblage suggests it is found on mud and muddy sand substrate, at temperatures between 8 and 11°C (mean 9.76°C SD 0.43°C), and at depths of 465–928 m (mean 778 m SD 102 m). This assemblage was restricted to the South-West Canyons.

Sagartiid anemones and juvenile pennatulids—Cluster I	
SIMPER-characterizing species	**Morphospecies**
*	Unidentified juvenile pennatulid
	Amphiuridae msp. 1
*	Sagartiidae msp. 3
	Kophobelemnon stelliferum
	Pennatulacea msp. 2
	Majidae msp. 1
	Pseudarchaster msp. 1
	Cerianthidae msp. 1
	Crinoidea msp. 1
	Bathynectes msp.
	Acanella msp. 1
	Polychaeta msp. 7
	Unknown msp.

Cidaris cidaris–Stichopus tremulus community—Cluster K

This cluster contained 23 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 26.53%. SIMPER analysis identified this assemblage as characterized by urchins (*Cidaris cidaris*), cup corals (*Caryophyllia* msp. 3) and unidentified ophuroids (Ophiuroidea msp. 5). Analysis of the environmental parameters associated with this assemblage suggests it is found on sand and mixed cobble, pebble, gravel–sand substrates, at temperatures between 8 and 11°C (mean 9.20°C SD 0.35°C), and at depths of 419–852 m (mean 510 m SD 99 m). This assemblage was observed on Rosemary Bank Seamount, Hatton Bank and the shallow summit of the Wyville-Thomson Ridge.

Cidaris cidaris–Stichopus tremulus community—Cluster K	
SIMPER-characterizing species	**Morphospecies**
*	Ophiuroidea msp. 5
*	*Caryophyllia* msp. 3
*	*Cidaris cidaris*
	Echinoidea msp. 2
	Ophiactis abyssicola
	Serpulidae msp. 1
	Brachiopoda msp. 1
	Psolus squamatus
	Porifera encrusting msp. 16
	Majidae msp. 1
	Halcampoididae msp. 3
	Halcampoididae msp. 4
	Porifera lamellate msp. 3
	Munida msp.
	Heliometra glacialis
	Ophiuroidea msp. 8
	Porifera encrusting msp. 1
	Porifera encrusting msp. 3
	Porifera encrusting msp. 35
	Porifera encrusting msp. 27
	Porifera massive globose msp. 2

Edwardsiid anemones and Chaetopterid polychaetes—Cluster L

This cluster contained 36 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 28.80%. SIMPER analysis identified this assemblage as characterized by edwardsiid anemones (Edwardsiidae msp. 1) and polychaetes (Chaetopteridae msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is found on sand and mixed substrates of sand–pebble and cobble, at temperatures between 1 and 12°C (mean 8.70°C SD 1.62°C), and at depths of 212–899 m (mean 598 m SD 151 m). This assemblage was observed in the South-West Canyons, on Hatton Bank, Rosemary Bank Seamount, and the warm shallow regions of the Wyville-Thomson Ridge and Faroe–Shetland Channel.

Edwardsiid anemones and Chaetopterid polychaetes—Cluster L	
SIMPER-characterizing species	**Morphospecies**
*	Edwardsiidae msp. 1
*	Chaetopteridae msp. 1
	Stylasteridae msp. 1
	Cerianthidae msp. 1
	Porifera encrusting msp. 1
	Halcampoididae msp. 3

Continued

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Edwardsiid anemones and Chaetopterid polychaetes—Cluster L	
SIMPER-characterizing species	**Morphospecies**
	Anomiidae msp. 2
	Velatida msp. 1
	Bryozoa msp. 1
	Ophiactis balli
	Serpulidae msp. 3
	Lophelia pertusa
	Mysida msp. 1
	Bivalvia msp. 1
	Porifera massive lobose msp. 8
	Caryophyllia msp. 3
	Psolus squamatus
	Majidae msp. 1
	Porifera massive globose msp. 4
	Colus msp. 2
	Unknown msp.
	Henricia sanguinolenta
	Astropecten irregularis
	Stichopus tremulus
	Spirorbidae msp. 1
	Porifera massive lobose msp. 12
	Porifera massive fig msp. 1
	Porifera encrusting msp. 10
	Zoanthidea msp. 1
	Porifera encrusting msp. 12
	Hydroidomedusa (bushy)
	Porifera encrusting msp. 30

Lanice beds—Cluster OB

This cluster contained 58 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 39.36%. SIMPER analysis identified this assemblage as characterized by tube worms (*Lanice* cf.) at an average density of 12 tubes per m^2. Analysis of the environmental parameters associated with this assemblage suggests it is associated with coarse sand and mixed sand, gravel (including biogenic gravel), and pebble substrates, primarily at temperatures of 7–12°C (single observation at −1°C) (mean 7.94°C SD 1.42°C), and depths of 290–951 m (mean 787 m SD 175 m). This assemblage was primarily observed on Hatton Bank, with a single observation from the South-West Canyons and one from the Faroe–Shetland Channel.

Lanice beds—Cluster OB	
SIMPER-characterizing species	**Morphospecies**
*	*Lanice* cf. msp. 1
	Ophiuroidea msp. 1
	Majidae msp. 1
	Porifera encrusting msp. 1
	Cerianthidae msp. 1
	Serpulidae msp. 1
	Ophiactis abyssicola
	Porifera massive globose msp. 4
	Brachiopoda msp. 1
	Edwardsiidae msp. 1

Continued

Lanice beds—Cluster OB	
SIMPER-characterizing species	**Morphospecies**
	Stylasteridae msp. 1
	Bryozoa msp. 1
	Anomiidae msp. 2
	Caryophyllia msp. 3
	Porifera spherical msp. 1
	Ascidiacea msp. 2
	Ophiuroidea msp. 6
	Galatheidae msp. 1
	Psolus squamatus
	Phelliactis msp. 1
	Caryophyllia msp. 2
	Mysida msp. 2
	Munida msp.
	Ophiuroidea msp. 8
	Anthozoa msp. 1
	Paguridae mspp
	Syringammina fragillissima
	Porifera massive globose msp. 1
	Porifera encrusting msp. 25
	Porifera encrusting msp. 10
	Serpulidae msp. 3
	Mysida msp. 1
	Henricia sanguinolenta
	Stichopus tremulus
	Echinoidea msp. 2
	Crinoidea msp. 1
	Bonellia viridis
	Halcampoididae msp. 1
	Anomiidae msp. 1
	Actiniaria msp. 4
	Gersemia msp. 2
	Unidentified worm tubes
	Aphrocallistes msp.
	Margarites msp. 1
	Unknown msp.
	Crinoidea msp. 5
	Porifera massive lobose msp. 8

Communities of amphiurid ophiuroids—Cluster OE

This cluster contained 87 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 44.30%. SIMPER analysis identified this assemblage as characterized by burrowing ophiuroids (Amphiuridae). Analysis of the environmental parameters associated with this assemblage suggests it is associated with fine mud and sand substrates that occasionally may also have with a small percentage of gravel and pebbles, at temperatures of 7–12°C (mean 10.33°C SD 0.88°C), and depths of 252–1008 m (mean 624 m SD 224 m). This assemblage was only observed in the South-West Canyons.

Communities of amphiurid ophiuroids—Cluster OE	
SIMPER-characterizing species	**Morphospecies**
*	Amphiuridae msp. 1
	Ophiuroidea msp. 1
	Cerianthidae msp. 1
	Cnidaria msp. 2

Continued

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Communities of amphiurid ophiuroids—Cluster OE	
SIMPER-characterizing species	**Morphospecies**
	Terebellidae msp. 1
	Sabellidae msp. 1
	Ophiothrix fragilis
	Munida msp.
	Mysida msp. 1
	Serpulidae msp. 1
	Ophiactis abyssicola
	Ophiuroidea msp. 3
	Actiniaria msp. 2
	Halcampoididae msp. 3
	Tubularia msp. 2
	Cerianthidae msp. 2
	Ophiactis balli
	Kophobelemnon stelliferum
	Leptometra celtica
	Edwardsiidae msp. 1
	Crinoidea msp. 1
	Unidentified juvenile pennatulid
	Sagartiidae msp. 3
	Unknown msp.
	Ophiuroidea msp. 4
	Actiniaria msp. 5
	Polychaeta msp. 6
	Cerianthidae msp. 3
	Unidentified worm tubes
	Actiniaria msp. 15
	Porifera encrusting msp. 31
	Brachiopoda msp. 1
	Caryophyllia msp. 2
	Paguridae mspp.
	Echinoidea msp. 2
	Colus msp. 2
	Pseudarchaster msp. 1
	Hydroidomedusa (flat branched)
	Pandalus borealis
	Actiniaria msp. 9
	Ophiuroidea msp. 7
	Actiniaria msp. 13
	Unknown msp.
	Actinauge richardi
	Crinoidea msp. 6
	Unknown msp.
	Porifera encrusting msp. 1
	Porifera encrusting msp. 38

Ophiuroids on rippled sediment—Cluster OF

This cluster contained 378 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 47.99%. SIMPER analysis identified this assemblage as characterized by ophiuroids (Ophiuroidea msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is associated with sand and mud substrates that may also have with a small percentage of gravel and pebbles, at temperatures of −1 to 12°C (mean 9.82°C SD 1.83°C), and depths of 205–1021 m (mean 578 m SD 238 m). This assemblage was primarily observed in the South-West Canyons, on Hatton Bank and Rosemary Bank Seamount, with only 5 observations from the Faroe–Shetland Channel.

Ophiuroids on rippled sediment—Cluster OF	
SIMPER-characterizing species	**Morphospecies**
*	Ophiuroidea msp. 1
	Mysida msp. 1
	Lanice msp. 1
	Ophiactis balli
	Cerianthidae msp. 1
	Amphiuridae msp. 1
	Caryophyllia msp. 3
	Munida msp.
	Edwardsiidae msp. 1
	Sabellidae msp. 1
	Ophiuroidea msp. 6
	Porifera encrusting msp. 1
	Unidentified juvenile pennatulid
	Kophobelemnon stelliferum
	Halcampoididae msp. 3
	cf. *Antipathella* msp. 1
	Serpulidae msp. 1
	Syringammina fragillissima
	Chaetopteridae msp. 1
	Halcampoididae msp. 1
	Crinoidea msp. 5
	Ophiuroidea msp. 3
	Leptometra celtica
	Polychaeta msp. 6
	Polychaeta msp. 4
	Ophiothrix fragilis
	Caryophyllia msp. 2
	Unknown msp.
	Hydroidomedusa (bushy)
	Ophiactis abyssicola
	Brachiopoda msp. 1
	Actiniaria msp. 18
	Sagartiidae msp. 3
	Paguridae mspp.
	Phoronida msp. 1
	Caryophyllia smithii
	Cerianthidae msp. 3
	Echinoidea msp. 2
	Pandalus borealis
	Actinauge richardi
	Serpulidae msp. 2
	Polychaeta msp. 5
	Porifera encrusting msp. 2
	Serpulidae msp. 3
	Anomiidae msp. 2
	Spirorbidae msp. 1
	Polynoidae/Aphroditidae msp. 1
	Sabellidae msp. 2
	Ascidiacea msp. 2
	Majidae msp. 1
	Psolus squamatus
	Cnidaria msp. 1
	Virgularia mirabilis
	Benthogone msp.
	Porifera encrusting msp. 4
	Polychaeta msp. 1
	Terebellidae msp. 1
	Unknown msp.
	Ophiuroidea msp. 2
	Unknown msp.
	Unknown msp.

Continued

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Ophiuroids on rippled sediment—Cluster OF	
SIMPER-characterizing species	**Morphospecies**
	Octocorallia msp. 4
	Lophelia pertusa
	Porifera encrusting msp. 38
	Bryozoa msp. 1
	Cerianthidae msp. 2
	Crinoidea msp. 1
	Actiniaria msp. 15
	Colus msp. 2
	Crinoidea msp. 6
	Stichopus tremulus
	Bonellia viridis
	Bathynectes msp.
	Reteporella msp. 1
	Actiniaria msp. 3
	Porifera cup msp. 3
	Scyphozoa msp. 1
	Pycnogonida msp. 2
	Pterasteridae msp. 1
	Epizoanthus msp. 1
	Unknown msp.
	Crinoidea msp. 3
	Epimeria loricata
	Unknown msp.
	Pennatula phosphorea
	Alcyonacea msp. 5
	Unknown msp.
	Hydroidea msp.
	Porifera encrusting msp. 28
	Porifera encrusting msp. 10
	Zoanthidea msp. 1
	Porifera encrusting msp. 30
	Porifera encrusting msp. 15
	Porifera encrusting msp. 24
	Porifera encrusting msp. 6
	Porifera massive lobose msp. 14
	Ophiuroidea msp. 7
	Ophiuroidea msp. 5
	Porifera encrusting msp. 3

Kophobelemnon stelliferum and cerianthid anemones—Cluster PA

This cluster contained 97 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 37.05%. SIMPER analysis identified this assemblage as characterised by cerianthid anemones (Cerianthidae msp. 1) and the sea pen *Kophobelemnon* msp. Analysis of the environmental parameters associated with this assemblage suggests it is associated with fine mud and muddy-sand substrates that occasionally may also have a small percentage of gravel and pebbles, at temperatures of 7–12°C (mean 9.78°C SD 0.76°C), and depths of 242–1059 m (mean 734 m SD 201 m). This assemblage was primarily observed in the South-West Canyons, with limited observations from Hatton Bank, Rosemary Bank Seamount and the Wyville-Thomson Ridges (8 in total). Reanalysis of the images in this cluster suggests that poor taxonomic resolution of the cerianthid anemones is likely to have lead to the clustering of these 8 images with this assemblage type.

Kophobelemnon stelliferum and cerianthid anemones—Cluster PA	
SIMPER-characterizing species	**Morphospecies**
*	Cerianthidae msp. 1
*	*Kophobelemnon stelliferum*
	Cerianthidae msp. 2
	Munida msp.
	Halcampoididae msp. 3
	Actinauge richardi
	Caryophyllia msp. 2
	Sagartiidae msp. 3
	Pseudarchaster msp. 1
	Crinoidea msp. 2
	Crinoidea msp. 4
	Caryophyllia smithii
	Cerianthidae msp. 3
	Echinoidea msp. 2
	Funiculina quadrangularis
	Mysida msp. 1
	Ophiactis balli
	Crinoidea msp. 5
	Majidae msp. 1
	Crinoidea msp. 1
	Hydroidea msp.
	Tubularia msp. 2
	Acanella msp. 1
	Calveriosoma fenestratum
	Cyclostomatida msp. 4
	Asteronyx loveni
	Lophelia pertusa
	Ophiuroidea msp. 1
	Amphiuridae msp. 1
	Unidentified juvenile pennatulid
	Serpulidae msp. 1
	Halcampoididae msp. 1
	Ophiothrix fragilis
	Brachiopoda msp. 1
	Actiniaria msp. 18
	Benthogone msp.
	Unknown msp.
	Colus msp. 2
	Stichopus tremulus
	Mysida msp. 2
	Cidaris cidaris
	Pennatulacea msp. 2
	Polychaeta msp. 7
	Porania pulvillus
	Unknown msp.
	Luidia ciliaris
	Porifera encrusting msp. 1
	Zoanthidea msp. 1
	Porifera encrusting msp. 3
	Porifera massive lobose msp. 12
	Porifera encrusting msp. 31
	Porifera encrusting msp. 38

Deep-sea mixed substratum assemblages

Sabellids, white encrusting sponges and ophiuroids on mixed substrate—Cluster Q

This cluster contained 105 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 16.67%. SIMPER analysis identified this assemblage as

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characterized by polychaetes of the family Sabellidae (msp. 1 and msp. 2), unidentified polychaetes (Polychaete msp. 6), unidentified ophiuroids (Ophiuroidea msp. 4) and white encrusting sponges (Porifera encrusting msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is found on muddy-sand and mixed pebbles, cobbles and sand, over the range of temperatures sampled (sub-zero to 12°C; mean 3.11°C SD 4.80°C), and over the range of depths sampled (111–1027 m) (mean 737 m SD 190 m). This assemblage was primarily observed in the cold waters of the Faroe–Shetland Channel, however it was also observed in the South-West Canyons and on Hatton Bank. The poor taxonomic resolution of some of the characterizing species likely masks genuine differences in benthic assemblages, particularly from cold and warmer waters. However, physical sampling would be required to confirm this.

Sabellids, white encrusting sponges and ophiuroids on mixed substrate—Cluster Q

SIMPER-characterizing species	Morphospecies
*	Sabellidae msp. 1
*	Sabellidae msp. 2
*	Polychaeta msp. 6
	Porifera encrusting msp. 30
*	Ophiuroidea msp. 4
	Unidentified worm tubes
	Ophiactis balli
	Gersemia msp. 2
	Porifera massive globose msp. 4
*	Porifera encrusting msp. 1
	Porifera massive globose msp. 9
	Ophiactis abyssicola
	Corallimorphidae msp. 2
	Serpulidae msp. 2
	Porifera encrusting msp. 12
	Porifera massive lobose msp. 12
	Anthozoa msp. 1
	Porifera massive fig msp. 1
	Halcampoididae msp. 5
	Porifera massive globose msp. 10
	Munida msp.
	Brachiopoda msp. 1
	Porifera encrusting msp. 28
	Porifera massive lobose msp. 4
	Cerianthidae msp. 1
	Lanice msp. 1
	Branchiocerianthus msp.
	Heliometra glacialis
	Anomiidae msp. 2
	Porifera massive lobose msp. 13
	Alcyonacea msp. 2
	Ophiuroidea msp. 1
	Mysida msp. 1
	Alcyonacea msp. 1
	Caridea msp. 1
	Porifera encrusting msp. 15
	Lophelia pertusa
	Chaetopteridae msp. 1
	Reteporella msp. 1
	Ophiuroidea msp. 6
	Actiniaria msp. 4

Continued

Sabellids, white encrusting sponges and ophiuroids on mixed substrate—Cluster Q

SIMPER-characterizing species	Morphospecies
	Crinoidea msp. 1
	Ophiuroidea msp. 8
	Sagartiidae msp. 3
	Epimeria loricata
	Unknown msp.
	Porifera encrusting msp. 2
	Porifera boring msp. 1
	Actiniaria msp. 7
	Psolus squamatus
	Amphipoda msp. 1
	Stylasteridae msp. 1
	Halcampoididae msp. 3
	Echinoidea msp. 2
	Actinostolidae msp. 1
	Crinoidea msp. 2
	Colus msp. 2
	Unknown msp.
	Unknown msp.
	Aphrocallistes msp.
	Unknown msp.
	Cyclostomatida msp. 2
	Pycnogonida msp. 3
	Porifera lamellate msp. 6
	Actiniaria msp. 5
	Porifera cup msp. 1
	Pandalus borealis
	Edwardsiidae msp. 1
	Serpulidae msp. 3
	Gastropoda msp. 1
	Cyclostomatida msp. 4
	Stichastrella rosea
	Halcampoididae msp. 1
	Majidae msp. 1
	Crinoidea msp. 3
	Porifera lamellate msp. 7
	Syringammina fragillissima
	Tubularia msp. 2
	Phoronida msp. 1
	Polychaeta msp. 5
	Virgularia mirabilis
	Pycnogonida msp. 2
	Pycnogonida msp. 1
	Benthoctopus/*Bathypolypus*
	Bivalvia msp. 2
	Unknown msp.
	Anthozoa msp. 3
	Zoanthidea msp. 1
	Drifa msp. 1
	Actiniaria msp. 6
	Porifera encrusting msp. 6
	Hydroidomedusa (bushy)
	Stichopathes cf. *gravieri*
	Phakellia ventilabrum
	Gorgonocephalus msp. 1
	Porifera encrusting msp. 23
	Porifera encrusting msp. 10
	Porifera massive lobose msp. 8
	Porifera massive globose msp. 1
	Porifera encrusting msp. 8
	Ascidiacea msp. 2

Continued

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Sabellids, white encrusting sponges and ophiuroids on mixed substrate—Cluster Q	
SIMPER-characterizing species	**Morphospecies**
	Caryophyllia msp. 2
	Paromola cuvieri
	Unknown msp.
	Pectinidae mspp
	Porifera encrusting msp. 16
	Porifera encrusting msp. 25
	Porifera encrusting msp. 20

Crinoid (*Leptometra celtica*) communities at the shelf edge—Cluster RBA

This cluster contained 18 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 26.78%. SIMPER analysis identified this assemblage as characterized by Crinoids (*Leptometra celtica* and Crinoidea msp. 5). Analysis of the environmental parameters associated with this assemblage suggest it is found on mixed sediments of sand and pebbles–shells, at temperatures between 9 and 12°C (mean 11.19°C SD 0.48°C), and at depths of 190–699 m (mean 328 m SD 148 m). This assemblage was observed in the South-West Canyons only.

Crinoid (*Leptometra celtica*) communities at the shelf edge—Cluster RBA	
SIMPER-characterizing species	**Morphospecies**
*	Crinoidea msp. 5
*	*Leptometra celtica*
	Ophiuroidea msp. 1
	Stichopathes cf. *gravieri*
	Ophiuroidea msp. 4
	Cerianthidae msp. 1
	Munida msp.
	Caryophyllia msp. 4
	Halcampoididae msp. 3
	Caryophyllia msp. 2
	Ophiuroidea msp. 5
	Cidaris cidaris
	Ophiactis abyssicola
	Caryophyllia smithii
	Hydroidomedusa (bushy)
	Madrepora oculata
	Actiniaria msp. 4
	Echinoidea msp. 2
	Actiniaria msp. 1
	Polychaeta msp. 7
	Actiniaria msp. 15
	Echinus msp. 1
	Unknown msp.

Cluster RBB contained 52 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 26.60%. In order to recognize the biological distinctness of cold water coral reef rubble communities and other mixed substrate communities of similar megafaunal composition this assemblage was divided, post analysis, into two distinct biotopes. The mixed substrate biotope is described below and the coral reef associated biotope is described under 'Bioherms'.

Munida and Caryophyllids on mixed substrates—RBB mixed

This grouping contained 33 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 26.32%. SIMPER analysis identified this assemblage as characterized by squat lobsters (*Munida* mspp.) and crinoids (*Leptometra celtica*). Analysis of the environmental parameters associated with this assemblage suggest it is found on mixed sediments of sand, pebbles and cobbles, at temperatures between 8 and 12°C (mean 11°C SD 0.83°C), and at depths of 185–825 m (mean 382 m SD 198 m). This assemblage was observed in the South-West Canyons, Hatton Bank, and Rosemary Bank Seamount.

Munida and Caryophyllids on mixed substrates—RBB mixed	
SIMPER-characterizing species	**Morphospecies**
*	*Munida* msp.
*	*Leptometra celtica*
	Hydroidomedusa (flat branched)
	Caryophyllia msp. 2
	Serpulidae msp. 2
	Ophiactis balli
	Echinoidea msp. 2
	Stichopathes cf. *gravieri*
	Actinauge richardi
	Ascidiacea msp. 2
	Sabellidae msp. 1
	Cerianthidae msp. 1
	Ophiuroidea msp. 1
	Halcampoididae msp. 1
	Bonellia viridis
	Porifera encrusting msp. 18
	Porifera massive lobose msp. 13
	Ophiuroidea msp. 5
	Caryophyllia smithii
	Echinus msp. 1
	Brachiopoda msp. 1
	Actinostolidae msp. 1
	Polychaeta msp. 5
	Cerianthidae msp. 2
	Alcyonacea msp. 5
	Astropecten irregularis
	Corallimorphidae msp. 1
	Facelinidae msp. 1
	Porifera encrusting msp. 31
	Porifera encrusting msp. 38
	Hydroidomedusa (bushy)
	Porifera encrusting msp. 1
	Unknown msp.
	Zoanthidea msp. 1

Cyclostomes, ophiuroids and white encrusting sponges on mixed substrates—Cluster RDA

This cluster contained 15 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 26.33%. SIMPER analysis identified this assemblage as characterized by ophiuroids (*Ophiactis abyssicola*), cyclostome bryozoans and white encrusting sponges

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(Porifera encrusting msp. 1). Analysis of the environmental parameters associated with this assemblage suggest it is found on mixed sediments of sand, gravel, pebbles, cobbles and boulders, at temperatures between −1 and 8°C (mean 1.1°C SD 2.75°C), and at depths of 549–820 m (mean 651 m SD 91 m). This assemblage primarily occurred in the cold waters of the Faroe–Shetland Channel; however two images within the cluster were from Hatton Bank. The images from Hatton Bank were outliers to the main body of the cluster and are most likely drawn into the cluster by the poor taxonomic resolution of one the characterizing species (white encrusting sponges).

Cyclostomes, ophiuroids and white encrusting sponges on mixed substrates—Cluster RDA

SIMPER-characterizing species	Morphospecies
*	Cyclostomatida msp. 2
*	*Ophiactis abyssicola*
*	Porifera encrusting msp. 1
	Reteporella msp. 1
	Unidentified worm tubes
	Porifera massive lobose msp. 12
	Ophiactis balli
	Caryophyllia msp. 2
	Ophiuroidea msp. 1
	Porifera encrusting msp. 28
	Gersemia msp. 2
	Branchiocerianthus msp.
	Phelliactis msp. 1
	Spirorbidae msp. 1
	Lophelia pertusa
	Porifera encrusting msp. 22
	Ascidiacea msp. 2
	Sabellidae msp. 1
	Brachiopoda msp. 1
	Sabellidae msp. 2
	Corallimorphidae msp. 2
	Anthozoa msp. 1
	Colus msp. 2
	Aphrocallistes msp.
	Cyclostomatida msp. 4
	Benthoctopus/*Bathypolypus*
	Gorgonacea msp. 7
	Unknown msp.
	Porifera massive lobose msp. 7
	Caryophyllidae msp. 3
	Porifera encrusting msp. 14
	Porifera encrusting msp. 26
	Porifera encrusting msp. 34
	Porifera encrusting msp. 10
	Porifera encrusting msp. 25
	Porifera encrusting msp. 2
	Porifera boring msp. 1
	Porifera encrusting msp. 6
	Polychaeta msp. 1
	Porifera encrusting msp. 17
	Astropecten irregularis

Ophiactis abyssicola and white encrusting sponges on mixed substrates—Cluster RDC

This cluster contained 17 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 37.38%. SIMPER analysis identified this assemblage as characterized by ophiuroids (*Ophiactis abyssicola*) and white encrusting sponges (Porifera encrusting msp. 1). Analysis of the environmental parameters associated with this assemblage suggest it is found on coarse sediments of pebbles, cobbles and boulders and coral, at temperatures between −1 and 8°C (mean 4.39°C SD 3.15°C), and at depths of 588–901 m (mean 710 m SD 136 m). This assemblage primarily occurred in the intermediate waters of the Faroe–Shetland Channel and on Hatton Bank. It is likely that poor taxonomic resolution of one of the characterizing species (white encrusting sponge) has lead to the formation of this cluster.

***Ophiactis abyssicola* and white encrusting sponges on mixed substrates—Cluster RDC**

SIMPER-characterizing species	Morphospecies
*	*Ophiactis abyssicola*
*	Porifera encrusting msp. 1
	Porifera encrusting msp. 24
	Unidentified worm tubes
	Hydroid turf
	Porifera encrusting msp. 28
	Porifera encrusting msp. 30
	Porifera encrusting msp. 32
	Gorgonacea msp. 4
	Ophiuroidea msp. 1
	Porifera encrusting msp. 19
	Porifera massive lobose msp. 13
	Actiniaria msp. 8
	Reteporella msp. 1
	Caryophyllia msp. 2
	Porifera massive lobose msp. 8
	Branchiocerianthus msp.
	Ascidiacea msp. 2
	Hydroidomedusa (bushy)
	Porifera massive lobose msp. 12
	Porifera encrusting msp. 2
	Porifera encrusting msp. 12
	Porifera massive lobose msp. 14
	Porifera encrusting msp. 34
	Porifera massive globose msp. 4
	Sabellidae msp. 2
	Serpulidae msp. 1
	Henricia sanguinolenta
	Cyclostomatida msp. 2
	Halcampoididae msp. 5
	Brachiopoda msp. 1
	Bryozoa msp. 1
	Porifera encrusting msp. 6
	Porifera encrusting msp. 16
	Actiniaria msp. 6
	Zoanthidea msp. 1
	Porifera encrusting msp. 10
	Halcampoididae msp. 3
	Caryophyllia msp. 4
	Sabellidae msp. 1
	Ascidiacea msp. 3
	Caridea msp. 1
	Porifera massive globose msp. 3
	Ophiactis balli
	Halcampoididae msp. 1
	Ophiuroidea msp. 8

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Ophiactis abyssicola and white encrusting sponges on mixed substrates—Cluster RDC	
SIMPER-characterizing species	**Morphospecies**
	Pandalus borealis
	Porifera lamellate msp. 7
	Phakellia ventilabrum
	Majidae msp. 2
	Porifera massive globose msp. 8
	Porifera encrusting msp. 3
	Lophelia pertusa
	Madrepora oculata
	Polychaeta msp. 1
	Porifera encrusting msp. 15
	Porifera massive lobose msp. 9
	Phelliactis msp. 1
	Heliometra glacialis
	Porifera encrusting msp. 20
	Gersemia msp. 2
	Anthozoa msp. 2
	Anomiidae msp. 1

Halcampid anemones and white encrusting sponges on mixed substrate—Cluster RE

This cluster contained 43 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 22.33%. SIMPER analysis identified this assemblage as characterized by anemones belonging to the family Halcampoididae (Halcampoididae msp. 3), an unidentified tube worm (Polychaeta msp. 4), and white encrusting sponges (Porifera encrusting msp. 1). Analysis of the environmental parameters associated with this assemblage suggest it is associated with mud, sand and mixed sediments of sand with gravel, pebbles and rarely cobbles, primarily at temperatures between 7 and 12°C (8.69°C SD 0.91°C), and at depths of 321–1006 m (mean 736 m SD 179 m). This assemblage was observed on Hatton Bank, Rosemary Bank, South-West Canyons and a single observation from the shallow summit of the Wyville-Thomson Ridge.

Halcampid anemones and white encrusting sponges on mixed substrate—Cluster RE	
SIMPER-characterizing species	**Morphospecies**
*	Polychaeta msp. 4
*	Halcampoididae msp. 3
	Ophiuroidea msp. 1
	Madrepora oculata
	Lanice msp. 1
*	Porifera encrusting msp. 1
	Serpulidae msp. 1
	Brachiopoda msp. 1
	Ophiactis balli
	Sabellidae msp. 1
	Cerianthidae msp. 1
	Ophiuroidea msp. 6
	Anomiidae msp. 2
	Halcampoididae msp. 1

Continued

Halcampid anemones and white encrusting sponges on mixed substrate—Cluster RE	
SIMPER-characterizing species	**Morphospecies**
	Ophiactis abyssicola
	Majidae msp. 1
	Kophobelemnon stelliferum
	Munida msp.
	Caryophyllia msp. 2
	Psolus squamatus
	Bryozoa msp. 1
	Serpulidae msp. 2
	Unknown msp.
	Porifera encrusting msp. 10
	Spirorbidae msp. 1
	Halcampoididae msp. 6
	Ophiuroidea msp. 8
	Edwardsiidae msp. 1
	Bonellia viridis
	Ophiuroidea msp. 7
	Ascidiacea msp. 2
	Serpulidae msp. 3
	Pterasteridae msp. 1
	Actinauge richardi
	Chaetopteridae msp. 1
	Stylasteridae msp. 1
	Syringammina fragillissima
	Caryophyllia msp. 3
	Velatida msp. 1
	Mysida msp. 2
	Unknown msp.
	Caryophyllidae msp. 2
	Porifera massive lobose msp. 8
	Lophelia pertusa
	Porifera encrusting msp. 26
	Porifera encrusting msp. 25
	Majidae msp. 2
	Porifera encrusting msp. 6
	Porifera massive lobose msp. 12
	Octocorallia msp. 2
	Paguridae mspp
	Porifera encrusting msp. 29
	Stichopathes cf. *gravieri*
	Actiniaria msp. 1
	Ascidiacea msp. 1
	Pheronema carpenteri
	Phelliactis msp. 1

Brachiopods on mixed substrate—Cluster RF

This cluster contained 32 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 51.02%. SIMPER analysis identified this assemblage as characterized by brachiopods (Brachiopoda). Analysis of the environmental parameters associated with this assemblage suggest it is associated with sand sediments with some degree of coarser material of gravel, pebbles and rarely cobbles size, primarily at temperatures between 7 and 12°C (9.39°C SD 0.72°C), and at depths of 266–803 m (mean 560 m SD 121 m). This assemblage was observed on Hatton Bank, Rosemary Bank, South-West Canyons and the warm shallow regions of the Wyville-Thomson Ridge and Faroe–Shetland Channel.

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Brachiopods on mixed substrate—Cluster RF	
SIMPER-characterizing species	**Morphospecies**
*	Brachiopoda msp. 1
	Munida msp.
	Serpulidae msp. 1
	Psolus squamatus
	Hydroidomedusa (bushy)
	Cidaris cidaris
	Halcampoididae msp. 1
	Edwardsiidae msp. 1
	Halcampoididae msp. 3
	Ophiuroidea msp. 1
	Serpulidae msp. 2
	Spirorbidae msp. 1
	Serpulidae msp. 3
	Chaetopteridae msp. 1
	Porifera lamellate msp. 7
	Echinoidea msp. 2
	Amphiuridae msp. 1
	Porifera massive lobose msp. 8
	Porifera massive lobose msp. 12
	Porifera encrusting msp. 30
	Porifera encrusting msp. 6
	Porifera encrusting msp. 3
	Porifera massive globose msp. 2

Serpulid polychaetes and *Munida* on mixed substrate—Cluster RG

This cluster contained 56 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 26.64%. SIMPER analysis identified this assemblage as characterized by serpulid polychaetes (Serpulidae msp. 1), squat lobsters (*Munida* mspp.) and white encrusting sponge (Porifera encrusting msp. 1). Analysis of the environmental parameters associated with this assemblage suggest it is associated with sand sediments with some degree of coarser material of gravel (including biogenic gravel), pebbles and rarely cobble and boulder size, primarily at temperatures between 6 and 12°C (9.50°C SD 2.20°C), and at depths of 189–961 m (mean 475 m SD 208 m). This assemblage was observed on Hatton Bank, Rosemary Bank, South-West Canyons and the warm shallow regions of the Wyville-Thomson Ridge. A single image in this cluster was from the cold (−1°C) waters of the Faroe–Shetland Channel and was most likely drawn into this cluster as a result of the poor taxonomic resolution of one of the characterizing species (white encrusting sponges).

Serpulid polychaetes and *Munida* on mixed substrate—Cluster RG	
SIMPER-characterizing species	**Morphospecies**
*	Serpulidae msp. 1
*	Porifera encrusting msp. 1
	Ophiactis balli
	Stylasteridae msp. 1
*	*Munida* msp.

Continued

Serpulid polychaetes and *Munida* on mixed substrate—Cluster RG	
SIMPER-characterizing species	**Morphospecies**
	Anomiidae msp. 1
	Halcampoididae msp. 3
	Psolus squamatus
	Terebellidae msp. 1
	Caryophyllia smithii
	Porifera encrusting msp. 30
	Anomiidae msp. 2
	Amphiuridae msp. 1
	Caryophyllia msp. 2
	Phakellia ventilabrum
	Ophiuroidea msp. 1
	Bryozoa msp. 1
	Paguridae mspp
	Mysida msp. 1
	Actiniaria msp. 17
	Halcampoididae msp. 6
	Galatheidae msp. 1
	Bivalvia msp. 1
	Porifera encrusting msp. 12
	Hydroidomedusa (bushy)
	Brachiopoda msp. 1
	Bonellia viridis
	Edwardsiidae msp. 1
	Serpulidae msp. 2
	Cerianthidae msp. 1
	Actinauge richardi
	Actiniaria msp. 9
	Ophiothrix fragilis
	Porifera massive lobose msp. 8
	Porifera encrusting msp. 27
	Cidaris cidaris
	Porifera encrusting msp. 25
	Porifera encrusting msp. 16
	Porifera boring msp. 1
	Porifera encrusting msp. 3
	Chaetopteridae msp. 1
	Sabellidae msp. 1
	Stichopathes cf. *gravieri*
	Anthozoa msp. 2
	Hydroidomedusa (flat branched)
	Echinus msp. 1
	Actiniaria msp. 15
	Crinoidea msp. 3
	Virgularia mirabilis
	Paromola cuvieri
	Unknown msp.
	Cerianthidae msp. 3
	Gorgonacea msp. 6
	Ophiuroidea msp. 3
	Porifera encrusting msp. 28
	Porifera encrusting msp. 31
	Porifera encrusting msp. 8
	Porifera encrusting msp. 10
	Porifera massive globose msp. 1
	Spirorbidae msp. 1
	Phelliactis msp. 1
	Gorgonacea msp. 5
	Porifera encrusting msp. 6
	Porifera massive globose msp. 2
	Porifera encrusting msp. 29
	Porifera encrusting msp. 38

Continued

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Serpulid polychaetes and *Munida* on mixed substrate—Cluster RG	
SIMPER-characterizing species	**Morphospecies**
	Gersemia msp. 2
	Porifera lamellate msp. 3
	Caryophyllia msp. 3
	Cyclostomatida msp. 4
	Corallimorphidae msp. 1
	Calveriosoma fenestratum

White and blue encrusting sponges, ophiuroids and majids on mixed substrate—Cluster RHA

This cluster contained 20 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 27.80%. SIMPER analysis identified this assemblage as characterized by ophiuroids (Ophiuroidea msp. 6), white encrusting sponge (Porifera encrusting msp. 1), majid crabs (Majidae msp. 1), blue encrusting sponge (Porifera encrusting msp. 16), encrusting bryozoan (Bryozoa msp. 1), and brachiopods (Brachiopoda). Analysis of the environmental parameters associated with this assemblage suggest it is associated with mixed sediments of sand, gravel (including biogenic gravel), pebbles and cobbles, primarily at temperatures between 7 and 9°C (8.21°C SD 0.33°C), and at depths of 615–1015 m (mean 828 m sd 93 m). This assemblage was primarily observed on Hatton Bank and Rosemary Bank with a single observation from the deepest part of the South-West Canyons sampled (1015 m).

White and blue encrusting sponges, ophiuroids and majids on mixed substrate—Cluster RHA	
SIMPER-characterizing species	**Morphospecies**
*	Ophiuroidea msp. 6
*	Porifera encrusting msp. 1
	Psolus squamatus
	Porifera encrusting msp. 4
	Stylasteridae msp. 1
*	Majidae msp. 1
	Ophiuroidea msp. 5
	Halcampoididae msp. 1
*	Brachiopoda msp. 1
	Anomiidae msp. 2
	Polychaeta msp. 4
*	Bryozoa msp. 1
	Cerianthidae msp. 1
	Lophelia pertusa
*	Porifera encrusting msp. 16
	Serpulidae msp. 1
	Caryophyllia msp. 2
	Cyclostomatida msp. 2
	Porifera cup msp. 3
	Actiniaria msp. 2
	Crinoidea msp. 1
	Ascidiacea msp. 2
	Munida msp.
	Serpulidae msp. 3
	Porifera encrusting msp. 3
	Chaetopteridae msp. 1

Continued

White and blue encrusting sponges, ophiuroids and majids on mixed substrate—Cluster RHA	
SIMPER-characterizing species	**Morphospecies**
	Edwardsiidae msp. 1
	Serpulidae msp. 2
	Actiniaria msp. 9
	Cyclostomatida msp. 4
	Ophiuroidea msp. 7
	Syringammina fragillissima
	Anthozoa msp. 1
	Colus msp. 2
	Porifera massive lobose msp. 11
	Porifera encrusting msp. 25
	Hydroidomedusa (bushy)
	Cidaris cidaris
	Sabellidae msp. 2
	Porifera encrusting msp. 8
	Porifera massive globose msp. 1
	Porifera encrusting msp. 38
	Halcampoididae msp. 3
	Galatheidae msp. 1
	Bonellia viridis
	Sabellidae msp. 1
	Porifera lamellate msp. 7
	Echinoidea msp. 2
	Lanice msp. 1
	Ophiactis abyssicola
	Pterasteridae msp. 1
	Reteporella msp. 1
	Porifera massive globose msp. 4
	Bryozoa msp. 2
	Porifera spherical msp. 1
	Acanella msp. 1
	Polychaeta msp. 8
	Porifera massive lobose msp. 8
	Porifera encrusting msp. 10
	Stichopathes cf. *gravieri*
	Porifera encrusting msp. 32
	Porifera encrusting msp. 31
	Hydroidomedusa (flat branched)
	Porifera boring msp. 1
	Porifera encrusting msp. 15
	Caryophyllia msp. 3
	Caridea msp. 1
	Ceramaster/*Peltaster*/*Plinthaster*
	Porifera encrusting msp. 20
	Porifera encrusting msp. 35
	Porifera encrusting msp. 13

White encrusting sponges and serpulids on mixed substrate—Cluster RHC

This cluster contained 45 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 27.03%. SIMPER analysis identified this assemblage as characterized by white encrusting sponge (Porifera encrusting msp. 1) and serpulid polychaetes (Serpulidae msp. 3). Analysis of the environmental parameters associated with this assemblage suggest it is associated with coarse mixed sediments of pebbles sand, gravel (including biogenic gravel), and cobbles, and occurs at the full range of temperatures encountered (−1 and 12°C, mean 6.33°C SD 3.61°C), and at depths of 272–980 m (mean 628 m SD 169 m). This

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assemblage was primarily observed on Hatton Bank, Rosemary Bank, the South-West Canyons and the Faroe–Shetland Channel.

White encrusting sponges and serpulids on mixed substrate—Cluster RHC

SIMPER-characterizing species	Morphospecies
*	Porifera encrusting msp. 1
*	Serpulidae msp. 3
	Ophiactis balli
	Porifera encrusting msp. 30
	Lanice msp. 1
	Halcampoididae msp. 3
	Ophiuroidea msp. 4
	Psolus squamatus
	Chaetopteridae msp. 1
	Echinoidea msp. 2
	Porifera massive globose msp. 4
	Brachiopoda msp. 1
	Stylasteridae msp. 1
	Anomiidae msp. 2
	Porifera lamellate msp. 7
	Porifera massive lobose msp. 13
	Serpulidae msp. 2
	Ophiuroidea msp. 3
	Polynoidae/Aphroditidae msp. 1
	Actiniaria msp. 13
	Porifera encrusting msp. 25
	Hydroidomedusa (bushy)
	Porifera encrusting msp. 3
	Porifera encrusting msp. 12
	Ophiuroidea msp. 5
	Halcampoididae msp. 1
	Cerianthidae msp. 1
	Actiniaria msp. 2
	Munida msp.
	Sabellidae msp. 1
	Ophiuroidea msp. 1
	Ophiuroidea msp. 2
	Porifera encrusting msp. 38
	Edwardsiidae msp. 1
	Crinoidea msp. 1
	Syringammina fragillissima
	Colus msp. 2
	Paguridae mspp.
	Mysida msp. 1
	Gersemia msp. 2
	Unidentified worm tubes
	Henricia sanguinolenta
	Amphipoda msp. 1
	Aphrocallistes msp.
	Porifera encrusting msp. 33
	Holothuroidea msp. 1
	Bryozoa msp. 1
	Porifera encrusting msp. 16
	Porifera massive lobose msp. 12
	Porifera encrusting msp. 10
	Porifera encrusting msp. 6
	Porifera encrusting msp. 23
	Lophelia pertusa
	Porifera massive globose msp. 1
	Porifera encrusting msp. 35
	Porifera cup msp. 1
	Porifera massive lobose msp. 3

Continued

White encrusting sponges and serpulids on mixed substrate—Cluster RHC

SIMPER-characterizing species	Morphospecies
	Porifera encrusting msp. 26
	Porifera encrusting msp. 34
	Actiniaria msp. 1

Cluster RHE contained 72 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 27.05%. In order to allow the allocation of biotope to a single broad substratum category to facilitate their incorporation into existing classification schemes and to reflect likely differences in assemblages not reflected in analysis of megafaunal communities, this assemblages was divided, post analysis, into three distinct biotopes. The mixed substrate biotope is described below, the hard substrate biotope is described under 'deep-sea rock' and the cold water coral associated biotope is described under 'bioherms'.

Ophiactis balli and *Munida rugosa* on mixed substrate—Cluster RHE mixed

This grouping contained 58 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 26.62%. SIMPER analysis identified this assemblage as characterized by ophiuroids (*Ophiactis balli*), white encrusting sponge (Porifera encrusting msp. 1), squat lobsters (*Munida* mspp.) and hydrocorals (Stylasteridae msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is associated with mixed substrates of sand, gravel, pebble, cobble and boulders, and occurs over the full range of temperatures (−1 and 12°C, mean 7.85°C SD 3.94°C), and depths encountered 180–1054 m (mean 569 m SD 226 m). This assemblage was observed from all submarine features except Hatton Bank.

***Ophiactis balli* and *Munida rugosa* on mixed substrate—Cluster RHE mixed**

SIMPER-characterizing species	Morphospecies
*	*Ophiactis balli*
*	Stylasteridae msp. 1
	Bryozoa msp. 1
	Anomiidae msp. 2
*	*Munida* msp.
	Anomiidae msp. 1
	Serpulidae msp. 2
*	Porifera encrusting msp. 1
	Hydroidomedusa (bushy)
	Porifera encrusting msp. 27
	Serpulidae msp. 1
	Halcampoididae msp. 1
	Porifera encrusting msp. 26
	Porifera encrusting msp. 3
	Porifera encrusting msp. 16
	Caryophyllia msp. 3
	Hydroidea msp.

Continued

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Ophiactis balli and _Munida rugosa_ on mixed substrate—Cluster RHE mixed

SIMPER-characterizing species	Morphospecies
	Cerianthidae msp. 1
	Serpulidae msp. 3
	Sabellidae msp. 1
	Bryozoa msp. 2
	Ophiactis abyssicola
	Amphiuridae msp. 1
	Porifera encrusting msp. 12
	Caryophyllia msp. 4
	Unidentified worm tubes
	Chaetopteridae msp. 1
	Porifera massive lobose msp. 13
	Cidaris cidaris
	Henricia sanguinolenta
	Porifera encrusting msp. 38
	Porifera encrusting msp. 25
	Echinoidea msp. 2
	Porifera encrusting msp. 28
	Cyclostomatida msp. 2
	Colus msp. 2
	Kophobelemnon stelliferum
	Porifera massive lobose msp. 3
	Porifera encrusting msp. 31
	Porifera encrusting msp. 6
	Ophiuroidea msp. 1
	Edwardsiidae msp. 1
	Porifera massive globose msp. 4
	Bivalvia msp. 1
	Actinauge richardi
	Pycnogonida msp. 3
	Leptometra celtica
	Porifera encrusting msp. 2
	Spirorbidae msp. 1
	Ascidiacea msp. 2
	Ceramaster/Peltaster/Plinthaster
	Reteporella msp. 1
	Ophiuroidea msp. 3
	Terebellidae msp. 1
	Pterasteridae msp. 2
	Polychaeta msp. 6
	Porifera encrusting msp. 14
	Porifera encrusting msp. 15
	Unknown msp.
	Porifera massive globose msp. 1
	Porifera massive lobose msp. 8
	Psolus squamatus
	Brachiopoda msp. 1
	Halcampoididae msp. 3
	Polynoidae/Aphroditidae msp. 1
	Paguridae mspp.
	Caryophyllidae msp. 2
	Stylaster msp. 1
	Porifera lamellate msp. 3
	Porifera lamellate msp. 7
	Gersemia msp. 2
	Holothuroidea msp. 1
	Bonellia viridis
	Polychaeta msp. 8
	Caryophyllia smithii
	Phakellia ventilabrum
	Branchiocerianthus msp.
	Porifera massive globose msp. 7
	Sagartiidae msp. 2
	Cyclostomatida msp. 3
	Asterias rubens
	Porifera lamellate msp. 2
	Sagartiidae msp. 3
	Munnopsurus giganteus
	Unknown msp.
	Unknown msp.
	Porifera encrusting msp. 22
	Porifera massive lobose msp. 12
	Zoanthidea msp. 1
	Porifera encrusting msp. 13
	Porifera massive lobose msp. 9
	Porifera encrusting msp. 20
	Porifera encrusting msp. 29
	Gorgonacea msp. 9

Continued

Cluster RHF contained 14 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 25.02%. In order to recognize the biological distinctness of cold water coral reef rubble communities and other mixed substrate communities of similar megafaunal composition this assemblage was divided, post analysis, into two distinct biotopes. The mixed substrate biotope is described below and the cold water coral reef associated biotope is described under 'bioherms'.

Caryophyllids, *Munida*, and encrusting sponges on mixed substrate—Cluster RHF

This grouping contained 10 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 30.26%. SIMPER analysis identified this assemblage as characterised by halcampid anemones (Halcampoididae msp. 1), encrusting bryozoans (Bryozoa msp. 1), white encrusting sponge (Porifera encrusting msp. 1), squat lobsters (*Munida* mspp.), serpulid polychaetes (Serpulidae msp. 2), encrusting yellow sponge (Porifera encrusting msp. 12), ophiuroids (*Ophiactis abyssicola*), cup corals (*Caryophyllia* msp. 3), seastars (*Henricia sanguinolenta*), majid crabs (Majidae msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is associated with coarse mixed substrates of pebble, cobble and boulders, and occurs at temperatures of 8 to 9°C (mean 8.84°C SD 0.43°C), and depths of 659–883 m (mean 745 m SD 79 m). This assemblage was observed from Hatton Bank, Rosemary Bank Seamount and the Wyville-Thomson Ridge.

Caryophyllids, _Munida_ and encrusting sponges on mixed substrate—Cluster RHF

SIMPER-characterizing species	Morphospecies
*	Bryozoa msp. 1
*	*Ophiactis abyssicola*
*	*Caryophyllia* msp. 3

Continued

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Caryophyllids, *Munida* and encrusting sponges on mixed substrate—Cluster RHF

SIMPER-characterizing species	Morphospecies
	Porifera encrusting msp. 2
*	Porifera encrusting msp. 1
*	Majidae msp. 1
*	Porifera encrusting msp. 12
*	*Munida* msp.
	Lophelia pertusa
*	Serpulidae msp. 2
*	Halcampoididae msp. 1
	Psolus squamatus
	Porifera massive lobose msp. 8
	Chaetopteridae msp. 1
	Ophiuroidea msp. 5
	Stylasteridae msp. 1
	Serpulidae msp. 1
	Brachiopoda msp. 1
	Porifera massive lobose msp. 2
*	*Henricia sanguinolenta*
	Porifera encrusting msp. 22
	Porifera encrusting msp. 19
	Hydroidomedusa (bushy)
	Porifera encrusting msp. 10
	Porifera massive globose msp. 1
	Cidaris cidaris
	Porifera encrusting msp. 6
	Porifera encrusting msp. 3
	Anomiidae msp. 1
	Serpulidae msp. 3
	Majidae msp. 2
	Caryophyllia msp. 2
	Ascidiacea msp. 2
	Hydroidomedusa (flat branched)
	Reteporella msp. 1
	Anomiidae msp. 2
	Colus msp. 2
	Pandalus borealis
	Stichopathes cf. *gravieri*
	Lanice msp. 1
	Isididae msp. 1
	Ascidiacea msp. 1
	Axinella infundibuliformis
	Porifera encrusting msp. 38
	Porifera encrusting msp. 31
	Porifera encrusting msp. 14
	Porifera encrusting msp. 18
	Porifera encrusting msp. 4
	Porifera encrusting msp. 8
	Porifera encrusting msp. 16
	Porifera encrusting msp. 32

Deep-sea rock assemblages

Hydroid turf and cerianthid anemones on sediment draped rock ledges—Cluster PBB

This cluster contained 49 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke &Warwick, 2001) revealed the average similarity within this group to be 49.21%. SIMPER analysis identified this assemblage as characterized by hydroids and cerianthid anemones (Cerianthidae msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is associated with bedrock with a sand–mud veneer, at temperatures of 7–11°C (mean 9.36°C SD 0.78°C), and depths of 316–1048 m (mean 827 m SD 160 m). This assemblage was only observed in the South-West Canyons.

Hydroid turf and cerianthid anemones on sediment draped rock ledges—Cluster PBB

SIMPER-characterizing species	Morphospecies
*	Hydroidea msp.
	Ophiactis balli
*	Cerianthidae msp. 1
	Halcampoididae msp. 1
	Amphiuridae msp. 1
	Ophiuroidea msp. 1
	Unknown msp.
	Munida msp.
	Lophelia pertusa
	Madrepora oculata
	Unknown msp.
	Ascidiacea msp. 2
	Edwardsiidae msp. 1
	Pandalus borealis
	Brachiopoda msp. 1
	Mysida msp. 1
	Psolus squamatus
	Echinoidea msp. 2
	Actiniaria msp. 9
	Kophobelemnon stelliferum
	Terebellidae msp. 1
	Sagartiidae msp. 3
	Bathynectes msp.
	Actiniaria msp. 2
	Crinoidea msp. 1
	Acanella msp. 1
	Unidentified juvenile pennatulid
	Serpulidae msp. 1
	Mysid*a* msp. 2
	Hydroidomedusa (flat branched)
	Galatheidae msp. 1
	Isididae msp. 1
	Unknown msp.
	Octocorallia msp. 1
	Pterasteridae msp. 1
	Majidae msp. 1
	Chaetopteridae msp. 1
	Actinauge richardi
	Crinoidea msp. 2
	Crinoidea msp. 5
	Calveriosoma fenestratum
	Cidaris cidaris
	Paguridae mspp
	Bonellia viridis
	Crinoidea msp. 3
	Actiniaria msp. 5
	Stichopathes cf. *gravieri*
	Koehlermetra porrecta
	Porifera lamellate msp. 7
	Decapoda msp. 2
	Hydroidomedusa (bushy)

Cluster PBC—This cluster contained 80 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 27.34%. In order to recognize the biological

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distinctness of cold water coral reef communities and other hard substrate communities of similar megafaunal composition this assemblage was divided, post analysis, into two distinct biotopes. The hard substrate biotope is described below and the cold water coral reef associated biotope is described under 'bioherms'.

Discrete coral (*Lophelia pertusa*) colonies on hard substratum—Cluster PBC rock

This assemblage contained 28 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 23.25%. SIMPER analysis identified this assemblage as characterized by the cold water corals *Lophelia pertusa* and *Madrepora occulata*, anemones (Phelliactis msp. 1), decapods (*Munida* msp.), sessile holothurians (*Psolus squamatus*) and encrusting yellow sponge (Porifera encrusting msp. 15). Analysis of the environmental parameters associated with this assemblage suggests it is found on bedrock and boulders, cobbles on sand–mud seabed. This assemblage occurs at temperatures of 8–10°C (mean 8.89°C SD 0.30°C), and depths of 505–942 m (mean 637 m SD 111 m). This assemblage was observed in the South-West Canyons, Hatton Bank and on the Rockall Trough side of the Wyville-Thomson Ridge.

Discrete coral (*Lophelia pertusa*) colonies on hard substratum—Cluster PBC rock

SIMPER-characterizing species	Morphospecies
*	*Lophelia pertusa*
*	*Madrepora oculata*
	Porifera encrusting sp. 15
*	*Munida* sp.
*	*Phelliactis* sp. 1
*	*Psolus squamatus*
	Brachiopoda sp. 1
	Ascidiacea sp. 2
	Porifera encrusting sp. 1
	Serpulidae sp. 1
	Zoanthidea sp. 1
	Pandalus borealis
	Ophiactis balli
	Chaetopteridae sp. 1
	Caryophyllia sp. 3
	Octocorallia sp. 1
	Reteporella sp. 1
	Amphiuridae sp. 1
	Ophiuroidea sp. 6
	Bryozoa sp. 1
	Porifera encrusting sp. 12
	Porifera massive lobose sp. 8
	Actiniaria sp. 1
	Sabellidae sp. 1
	Edwardsiidae sp. 1
	Corallimorphidae sp. 2
	Serpulidae sp. 3
	Porifera encrusting sp. 19
	Serpulidae sp. 2
	Velatida sp. 1
	Anomiidae sp. 2
	Gastropoda sp. 1
	Isididae sp. 1

Continued

Discrete coral (*Lophelia pertusa*) colonies on hard substratum—Cluster PBC rock

SIMPER-characterizing species	Morphospecies
	Alcyonacea sp. 4
	Ophiuroidea sp. 5
	Polynoidae/Aphroditidae sp. 1
	Alcyonacea sp. 2
	Amphipoda sp. 1
	Stylaster sp. 1
	Porifera massive globose sp. 2
	Sabellidae sp. 2
	Hydroidomedusa (bushy)
	Porifera encrusting sp. 22
	Actiniaria sp. 4
	Stylasteridae sp. 1
	Caryophyllia sp. 2
	Porifera encrusting sp. 10
	Cerianthidae sp. 1
	Caryophyllia sp. 4
	Halcampoididae sp. 3
	Cidaris cidaris
	Stichopathes cf. *gravieri*
	Anthothela grandiflora
	Porifera encrusting sp. 16
	Porifera encrusting sp. 4
	Porifera encrusting sp. 35
	Ophiactis abyssicola
	Gorgonacea sp. 2
	Porifera branching-erect
	Cyclostomatida sp. 4
	Stichopus tremulus
	Stichastrella rosea
	Porania pulvillus
	Echinoidea sp. 2
	Chaceon affinis
	Anthomastus grandiflora
	Actiniaria sp. 9
	Acanella sp. 1
	Paguridae mspp.
	Bonellia viridis
	Halcampoididae sp. 4
	Sagartiidae sp. 1
	Ascidiacea sp. 3
	Echinoidea sp. 1
	Brisingella coronata/*Brisinga endecacnemos*
	Galatheidae sp. 1

Zoanthids, *Ophiactis abyssicola* and sabellids on hard substratum—Cluster RDB

This cluster contained 94 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 45.32%. SIMPER analysis identified this assemblage as characterized by ophiuroids (*Ophiactis abyssicola*), sabellid polychaetes (Sabellidae msp. 2), cyclostome bryozoans (Cyclostomatida msp. 2), white encrusting sponges (Porifera encrusting msp. 1), zoanthids (Zoanthidea msp. 1), hydroids (Hydroidomedusa (bushy msp)), soft corals (Anthozoa msp. 1) and halcampid anemones (Halcampoididae msp. 3). Analysis of the environmental parameters associated with this assemblage suggests it is found on coarse sediments of pebbles, cobbles and boulders,

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at temperatures between −0.65 and 0.45°C (mean −0.5°C SD 0.17°C), and at depths of 626–903 m (mean 819 m SD 76 m). This assemblage only occurred in the cold waters on the north side of the Wyville-Thomson Ridge.

Zoanthids, *Ophiactis abyssicola* and sabellids on hard substratum—Cluster RDB

SIMPER-characterizing species	Morphospecies
*	*Ophiactis abyssicola*
*	Sabellidae msp. 2
*	Cyclostomatida msp. 2
	Caryophyllia msp. 4
*	Halcampoididae msp. 3
*	Zoanthidea msp. 1
*	Porifera encrusting msp. 1
*	Hydroidomedusa (bushy)
	Unidentified worm tubes
*	Anthozoa msp. 1
	Gorgonacea msp. 4
	Gersemia msp. 2
	Halcampoididae msp. 5
	Actiniaria msp. 5
	Actinostolidae msp. 1
	Serpulidae msp. 1
	Alcyonacea msp. 1
	Branchiocerianthus msp.
	Pycnogonida msp. 3
	Heliometra glacialis
	Tubularia msp. 2
	Porifera encrusting msp. 24
	Porifera encrusting msp. 28
	Ophiuroidea msp. 1
	Polychaeta msp. 1
	Anthozoa msp. 2
	Porifera massive globose msp. 7
	Pycnogonida msp. 1
	Porifera cup msp. 1
	Porifera massive globose msp. 4
	Sagartiidae msp. 4
	Alcyonacea msp. 2
	Actiniaria msp. 6
	Porifera massive lobose msp. 3
	Sabellidae msp. 1
	Edwardsiidae msp. 1
	Serpulidae msp. 3
	Crossaster papposus
	Pycnogonida msp. 2
	Hydroidomedusa (flat branched)
	Porifera lamellate msp. 4
	Crinoidea msp. 1
	Bryozoa msp. 2
	Reteporella msp. 1
	Actiniaria msp. 7
	Porifera encrusting msp. 20
	Porifera encrusting msp. 30
	Porifera massive globose msp. 6
	Porifera massive lobose msp. 11
	Porifera spherical msp. 2
	Henricia sanguinolenta
	Porifera massive lobose msp. 12
	Ascidiacea msp. 3
	Porifera cup msp. 3
	Porifera massive lobose msp. 4

Continued

Zoanthids, *Ophiactis abyssicola* and sabellids on hard substratum—Cluster RDB

SIMPER-characterizing species	Morphospecies
	Porifera massive globose msp. 1
	Ascidiacea msp. 2
	Colus msp. 2
	Porifera encrusting msp. 9
	Porifera encrusting msp. 18
	Porifera boring msp. 1
	Hydroidomedusa msp. 2
	Porifera massive lobose msp. 7
	Polynoidae/Aphroditidae msp. 1
	Hydroidomedusa msp. 1
	Caprellidae msp. 1
	Porifera encrusting msp. 29
	Echinoidea msp. 2
	Serpulidae msp. 2
	Porifera lamellate msp. 3
	Bryozoa msp. 3
	Porifera massive lobose msp. 10
	Porifera encrusting msp. 17
	Gastropoda msp. 2
	Brachiopoda msp. 1
	Gorgonacea msp. 9
	Unknown msp.
	Amphipoda msp. 1
	Porifera massive globose msp. 5
	Aeolidiidae msp. 1
	Porifera encrusting msp. 3
	Sagartiidae msp. 1
	Phelliactis msp. 1
	Benthoctopus/*Bathypolypus*
	Actiniaria msp. 4
	Caridea msp. 1
	Halcampoididae msp. 4
	Terebellidae msp. 1
	Pterasteridae msp. 1
	Porifera spherical msp. 1
	Sagartiidae msp. 2
	Bathypolypus msp.
	Porifera massive globose msp. 3
	Cyclostomatida msp. 3
	Pterasteridae msp. 2
	Geodia msp. 1
	Asterias rubens
	Capulus msp.
	Porifera encrusting msp. 10
	Porifera encrusting msp. 23
	Gorgonocephalus msp. 1
	Porifera massive globose msp. 9
	Porifera massive lobose msp. 13

Psolus squamatus, serpulid polychaetes and *Munida* on hard substratum—Cluster RHD

This cluster contained 87 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 30.78%. SIMPER analysis identified this assemblage as characterized by saddle oysters (Anomiidae msp. 1), sessile holothurians (*Psolus squamatus*), white encrusting sponge (Porifera encrusting msp. 1), serpulid polychaetes (Serpulidae msp. 3), squat lobsters (*Munida* mspp.), and brachiopods (Brachiopoda). Analysis of the environmental

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parameters associated with this assemblage suggests it is associated with mixed substrates of cobble, boulder and bedrock with sand, pebble and gravel, and occurs at temperatures of 7 to 10°C (mean 8.97°C SD 0.40°C), and at depths of 332–963 m (mean 555 m SD 120 m). This assemblage was primarily observed on Hatton Bank, Rosemary Bank, the warm shallow region of the Faroe–Shetland Channel, with a single observation from the South-West Canyons.

***Psolus squamatus*, serpulid polychaetes and *Munida* on hard substratum—Cluster RHD**

SIMPER-characterizing species	Morphospecies
*	Anomiidae msp. 2
*	*Psolus squamatus*
*	Porifera encrusting msp. 1
	Spirorbidae msp. 1
	Ophiactis balli
*	Serpulidae msp. 3
*	*Munida* msp.
*	Brachiopoda msp. 1
	Halcampoididae msp. 3
	Serpulidae msp. 1
	Madrepora oculata
	Stylasteridae msp. 1
	Ascidiacea msp. 2
	Corallimorphidae msp. 2
	Lophelia pertusa
	Porifera encrusting msp. 28
	Serpulidae msp. 2
	Chaetopteridae msp. 1
	Porifera encrusting msp. 30
	Porifera encrusting msp. 12
	Caridea msp. 1
	Hydroidomedusa (bushy)
	Cidaris cidaris
	Porifera encrusting msp. 25
	Bryozoa msp. 1
	Porifera encrusting msp. 32
	Porifera massive lobose msp. 8
	Stichopathes cf. *gravieri*
	Caryophyllia msp. 3
	Porifera encrusting msp. 6
	Porifera encrusting msp. 3
	Paguridae mspp
	Porifera encrusting msp. 9
	Cerianthidae msp. 1
	Pandalus borealis
	Lanice msp. 1
	Sabellidae msp. 1
	Ophiuroidea msp. 1
	Ophiactis abyssicola
	Reteporella msp. 1
	Leiopathes msp. 1
	Sabellidae msp. 2
	Porifera massive globose msp. 1
	Majidae msp. 1
	Phelliactis msp. 1
	Actiniaria msp. 1
	Porifera encrusting msp. 14
	Bathypathes patula
	Porifera massive globose msp. 4
	Ophiuroidea msp. 5
	Ophiuroidea msp. 2
	Edwardsiidae msp. 1
	Halcampoididae msp. 6
	Caryophyllidae msp. 2
	Caryophyllia msp. 2
	Anthomastus grandiflora
	Porifera encrusting msp. 4
	Porifera encrusting msp. 31
	Porifera massive lobose msp. 12
	Porifera encrusting msp. 13
	Crinoidea msp. 1
	Corallimorphidae msp. 1
	Porifera encrusting msp. 10
	Echinoidea msp. 2
	Halcampoididae msp. 1
	Henricia sanguinolenta
	Ophiuroidea msp. 6
	Ophiuroidea msp. 7
	Majidae msp. 2
	Caryophyllia msp. 4
	Tubularia msp. 2
	Phoronida msp. 1
	cf. *Antipathella* msp. 1
	Porifera encrusting msp. 23
	Porifera encrusting msp. 35
	Porifera encrusting msp. 16
	Porifera encrusting msp. 8
	Mysida msp. 1
	Porifera encrusting msp. 22
	Stylaster msp. 1
	Stichopus tremulus
	Porifera encrusting msp. 38
	Porifera branching-erect
	Actiniaria msp. 9
	Porifera massive globose msp. 2
	Porifera encrusting msp. 18
	Porifera encrusting msp. 17
	Octocorallia msp. 1
	Hydroidomedusa (flat branched)
	Porifera lamellate msp. 3
	Margarites msp. 1
	Gersemia msp. 1
	Heliometra glacialis
	Porifera encrusting msp. 20
	Octocorallia msp. 2
	Colus msp. 2
	Galatheidae msp. 1
	Acanella msp. 1
	Ceramaster/Peltaster/Plinthaster
	Gastropoda msp. 1
	Stichastrella rosea
	Isididae msp. 1
	Brisingella coronata/Brisinga endecacnemos

Ophiactis balli and *Munida rugosa* in vesicular rock—Cluster RHE rock

This grouping contained 9 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 50.59%. SIMPER analysis identified this assemblage as characterized by ophiuroids (*Ophiactis balli*), white encrusting sponge (Porifera encrusting msp. 1), cyclostome bryozoans (Cyclostomatida msp. 2), saddle oysters (Anomiidae msp.

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2), coral (*Madrepora oculata*), serpulid polychaetes (Serpulidae msp. 2), sessile holothurians (*Psolus squamatus*) and squat lobsters (*Munida* msp.). Analysis of the environmental parameters associated with this assemblage suggest it is associated with boulders and bedrock, and occurs at approximately 9°C (mean 9.28°C SD 0.14°C), and at depths of 330–501 m (mean 447 m SD 50 m). This assemblage was observed on Hatton Bank and Rosemary Bank Seamount.

***Ophiactis balli* and *Munida rugosa* in vesicular rock—Cluster RHE rock**	
SIMPER-characterizing species	**Morphospecies**
*	*Ophiactis balli*
*	Porifera encrusting msp. 1
	Cyclostomatida msp. 2
*	Anomiidae msp. 2
	Madrepora oculata
*	Serpulidae msp. 2
	Psolus squamatus
*	*Munida* msp.
	Brachiopoda msp. 1
	Chaetopteridae msp. 1
	Serpulidae msp. 1
	Stylasteridae msp. 1
	Actiniaria msp. 2
	Spirorbidae msp. 1
	Bryozoa msp. 1
	Porifera encrusting msp. 32
	Ascidiacea msp. 2
	Cidaris cidaris
	Actiniaria msp. 5
	Porifera encrusting msp. 31
	Porifera encrusting msp. 3
	Halcampoididae msp. 3
	Corallimorphidae msp. 2
	Pandalus borealis
	Majidae msp. 1
	Crinoidea msp. 1
	Halcampoididae msp. 1
	Ceramaster/Peltaster/Plinthaster
	Polynoidae/Aphroditidae msp. 1
	Porifera encrusting msp. 28
	Porifera encrusting msp. 30
	Porifera encrusting msp. 25
	Porifera encrusting msp. 10
	Porifera massive globose msp. 1
	Porifera massive globose msp. 2

Bioherms

Live summit of *Lophelia pertusa* reef—Cluster PBC reef

This assemblage contained 52 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 35.81%. SIMPER analysis identified this assemblage as characterized by the cold water corals *Lophelia pertusa* and *Madrepora occulata*, hydroids, unidentified anemones (Halcampoididae msp. 1, Actiniaria msp. 14), decapods (*Pandalus borealis*) and cerianthid anemones (Cerianthidae msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is a cold water coral reef assemblage (substratum not visible), which occurs at temperatures of 7–10°C (mean 9.06°C SD 0.96°C), and depths of 775–938 m (mean 844 m SD 45 m). This assemblage was observed in the South-West Canyons and on Hatton Bank.

Live summit of *Lophelia pertusa* reef—Cluster PBC reef	
SIMPER-characterizing species	**Morphospecies**
*	Hydroidea sp.
*	*Lophelia pertusa*
*	*Madrepora oculata*
*	Actiniaria sp. 14
*	Halcampoididae sp. 1
	Brisingella coronata/Brisinga endecacnemos
*	*Pandalus borealis*
*	Cerianthidae sp. 1
	Cidaris cidaris
	Sabellidae sp. 2
	Koehlermetra porrecta
	Caryophyllia sp. 2
	Ascidiacea sp. 2
	Bathynectes sp.
	Munida sp.
	Serpulidae sp. 1
	Ophiactis abyssicola
	Hydroidomedusa (flat branched)
	Hydroidomedusa (bushy)
	Octocorallia sp. 1
	Porifera encrusting sp. 1
	Sabellidae sp. 1
	Stichastrella rosea
	Halcampoididae sp. 3
	Stichopathes cf. *gravieri*
	Ophiactis balli
	Gastropoda sp. 1
	Porifera encrusting sp. 2
	Protanthea simplex
	Porania pulvillus
	Isididae sp. 1
	Cyclostomatida sp. 4
	Lanice sp. 1
	Porifera massive lobose sp. 8
	Reteporella sp. 1
	Henricia sanguinolenta
	Corallimorphidae sp. 2
	Hydroidomedusa (irregularly branched)
	Porifera encrusting sp. 15
	cf. *Antipathella* sp. 1
	Gorgonacea sp. 7
	Echinoidea sp. 2
	Crinoidea sp. 1
	Chaceon affinis
	Ophiuroidea sp. 8
	Ophiuroidea sp. 1
	Edwardsiidae sp. 1
	Galatheidae sp. 1
	Chaetopteridae sp. 1
	Margarites sp. 1
	Cerianthidae sp. 3
	Caryophyllia sp. 3
	Actinostolidae sp. 1

Continued

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Live summit of *Lophelia pertusa* reef—Cluster PBC reef	
SIMPER-characterizing species	**Morphospecies**
	Branchiocerianthus sp.
	Anthomastus grandiflora
	Paromola cuvieri
	Porifera encrusting sp. 10
	Anthothela grandiflora
	Actiniaria sp. 1
	Anthozoa sp. 2
	Porifera massive globose sp. 4
	Bathypathes patula
	Porifera encrusting sp. 38
	Gorgonacea sp. 10
	Majidae sp. 1
	Serpulidae sp. 2
	Gersemia sp. 2
	Caryophyllia sp. 4
	Majidae sp. 2
	Gorgonacea sp. 6
	Actiniaria sp. 11
	Alcyonacea sp. 4
	Desmophyllum sp. 1
	Bathypathes sp. 1
	Actiniaria sp. 9

Dead framework slopes of *Lophelia pertusa* reef—Cluster RHF reef

This grouping contained 4 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 35.07%. SIMPER analysis identified this assemblage as characterized by halcampid anemones (Halcampoididae msp. 1), serpulid polychaetes (Serpulidae msp. 1, Serpulidae msp. 2), encrusting white and yellow encrusting sponges (Porifera encrusting msp. 1 and Porifera encrusting msp. 10), cup corals (*Caryophyllia* msp. 2,), and ascidians (Ascidiacea msp. 2). Analysis of the environmental parameters associated with this assemblage suggests it is associated with coral rubble, and occurs at temperatures of 7 to 8°C (mean 7.9°C SD 0.2°C), and depths of 772–822 m (mean 798 m SD 28 m). This assemblage was observed on Hatton Bank.

Dead framework slopes of *Lophelia pertusa* reef—Cluster RHF reef	
SIMPER-characterizing species	**Morphospecies**
*	Halcampoididae msp. 1
*	*Caryophyllia* msp. 2
*	Ascidiacea msp. 2
*	Serpulidae msp. 1
*	Porifera encrusting msp. 1
	Ophiuroidea msp. 8
	Octocorallia msp. 2
*	Serpulidae msp. 2
	Hydroidomedusa (flat branched)
	Brachiopoda msp. 1
	Sabellidae msp. 2
	Madrepora oculata
	Munida msp.
	Sabellidae msp. 1

Continued

Dead framework slopes of *Lophelia pertusa* reef—Cluster RHF reef	
SIMPER-characterizing species	**Morphospecies**
	Ophiactis abyssicola
	Chaetopteridae msp. 1
	Reteporella msp. 1
	Psolus squamatus
*	Porifera encrusting msp. 10
	Henricia sanguinolenta
	Bonellia viridis
	Majidae msp. 1
	Corallimorphidae msp. 1
	Stichastrella rosea
	Polychaeta msp. 4

Lophelia pertusa reef rubble apron—RBB reef

This grouping contained 19 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 30.23%. SIMPER analysis identified this assemblage as characterized by squat lobsters (*Munida* mspp.) and ascidians (Ascidiacea msp. 2). Analysis of the environmental parameters associated with this assemblage suggest it is found on coral rubble, at temperatures between 6 and 12°C (mean 9.5°C SD 1.52°C), and at depths of 307–825 m (mean 524 m SD 175 m). This assemblage was observed in the South-West Canyons, Hatton Bank, and the shallow summit of the Wyville-Thomson Ridge.

Lophelia pertusa reef rubble apron—Cluster RBB reef	
SIMPER-characterizing species	**Morphospecies**
*	*Munida* msp.
*	Ascidiacea msp. 2
	Caryophyllia msp. 2
	Sabellidae msp. 2
	Psolus squamatus
	Actiniaria msp. 4
	Sabellidae msp. 1
	Ophiuroidea msp. 6
	Cerianthidae msp. 1
	Ophiuroidea msp. 5
	Actiniaria msp. 1
	Chaetopteridae msp. 1
	Porifera lamellate msp. 2
	Alcyonacea msp. 3
	Lophelia pertusa
	Ophiuroidea msp. 1
	Ophiactis balli
	Reteporella msp. 1
	Edwardsiidae msp. 1
	Henricia sanguinolenta
	Cyclostomatida msp. 1
	Echiura msp. 1
	Porifera encrusting msp. 27
	Porifera massive globose msp. 1
	Porifera encrusting msp. 34
	Porifera encrusting msp. 26

Trawl damaged *Lophelia pertusa* rubble—Cluster RHE reef

This grouping contained 5 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick,

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2001) revealed the average similarity within this group to be 36.66%. SIMPER analysis identified this assemblage as characterized by ophiuroids (*Ophiactis balli*) and serpulid polychaetes (Serpulidae msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is associated with mixed substrates of sand and coral rubble, at 11°C (mean 11.27°C SD 0.13°C), and 305–365 m depth (mean 351 m SD 26 m). This assemblage was observed from the South-West Canyons.

Trawl damaged *Lophelia pertusa* rubble—Cluster RHE reef	
SIMPER-characterizing species	**Morphospecies**
*	*Ophiactis balli*
	Porifera encrusting msp. 31
	Munida msp.
*	Serpulidae msp. 1
	Zoanthidea msp. 1
	Ophiuroidea msp. 1
	Edwardsiidae msp. 1
	Crinoidea msp. 5
	Unknown msp.
	Porifera encrusting msp. 34

Highly sediment draped scattered coral framework—Cluster PBA

This cluster contained 12 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 30.75%. SIMPER analysis identified this assemblage as characterized by ophiuroids (Ophiuroidea msp. 1) and cerianthid anemones (Cerianthidae msp. 1). Analysis of the environmental parameters associated with this assemblage suggests it is associated with sand substrates with biogenic gravel (coral rubble), at temperatures of 7–10°C (mean 8.65°C SD 0.89°C), and depths of 519–942 m (mean 812 m SD 141 m). This assemblage was primarily observed in the South-West Canyons, and on Hatton Bank.

Highly sediment draped scattered coral framework—Cluster PBA	
SIMPER-characterizing species	**Morphospecies**
*	Halcampoididae msp. 1
*	Cerianthidae msp. 1
	Madrepora oculata
	Brachiopoda msp. 1
	Psolus squamatus
	Syringammina fragillissima
	Ascidiacea msp. 2
	Lophelia pertusa
	Munida msp.
	Pterasteridae msp. 1
	Ophiuroidea msp. 8
	Margarites msp. 1
	Isididae msp. 2
	Cerianthidae msp. 2
	Caryophyllia msp. 2
	Majidae msp. 1
	Crinoidea msp. 1
	Acanella msp. 1

Continued

Highly sediment draped scattered coral framework—Cluster PBA	
SIMPER-characterizing species	**Morphospecies**
	Edwardsiidae msp. 1
	Sabellidae msp. 1
	Chaetopteridae msp. 1
	Ophiuroidea msp. 2
	Ophiuroidea msp. 5
	Unidentified worm tubes
	Porifera encrusting msp. 1
	Porifera encrusting msp. 16

Boreal *ostur*—Cluster RHG

This cluster contained 113 images. Analysis of this cluster using the SIMPER routine in PRIMER 6 (Clarke & Warwick, 2001) revealed the average similarity within this group to be 25.27%. SIMPER analysis identified this assemblage as characterized by white encrusting sponge (Porifera encrusting msp. 1), squat lobsters (*Munida* mspp.), brachiopods (Brachiopoda), ophiuroids (*Ophiactis balli*, Ophiuroidea msp. 6), yellow encrusting sponge (Porifera encrusting msp. 12), massive lobose sponge (Porifera massive lobose msp. 12), serpulid polychaetes (Serpulidae msp. 1), green encrusting sponge (Porifera encrusting msp. 25), orange encrusting sponge (Porifera encrusting msp. 3), cream encrusting sponge (Porifera encrusting msp. 27). Analysis of the environmental parameters associated with this assemblage suggests it is associated with coarse mixed substrates of pebble, cobble and gravel (including biogenic), occurs at temperatures of 0 to 10°C (mean 7.91°C SD 1.55°C), and depths of 343–867 (mean 486 m SD 62 m). This assemblage was primarily observed from the Faroe–Shetland Channel and the Wyville-Thomson Ridge, with 2 observations from Hatton Bank and three from Rosemary Bank Seamount.

Boreal *ostur*—Cluster RHG	
SIMPER-characterizing species	**Morphospecies**
*	Porifera encrusting msp. 1
*	Brachiopoda msp. 1
*	*Ophiactis balli*
*	Ophiuroidea msp. 6
*	Porifera massive lobose msp. 12
*	*Munida* msp.
*	Porifera encrusting msp. 12
*	Serpulidae msp. 1
	Ophiactis abyssicola
*	Porifera encrusting msp. 27
	Porifera lamellate msp. 7
	Porifera encrusting msp. 36
	Porifera massive lobose msp. 14
	Bryozoa msp. 1
	Porifera encrusting msp. 37
	Stylasteridae msp. 1
	Porifera encrusting msp. 2
	Porifera encrusting msp. 26
	Porifera encrusting msp. 28
	Porifera massive lobose msp. 8
	Porifera encrusting msp. 24

Continued

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Boreal *ostur*—Cluster RHG	
SIMPER-characterizing species	**Morphospecies**
*	Porifera encrusting msp. 25
*	Porifera encrusting msp. 3
	Porifera massive lobose msp. 9
	Porifera massive lobose msp. 13
	Anomiidae msp. 2
	Hydroidomedusa (bushy)
	Porifera cup msp. 1
	Cidaris cidaris
	Phakellia ventilabrum
	Porifera massive lobose msp. 3
	Porifera encrusting msp. 8
	Porifera encrusting msp. 30
	Porifera encrusting msp. 38
	Reteporella msp. 1
	Porifera encrusting msp. 16
	Porifera encrusting msp. 6
	Caryophyllia msp. 3
	Porifera encrusting msp. 29
	Porifera encrusting msp. 18
	Henricia sanguinolenta
	Porifera massive globose msp. 1
	Sabellidae msp. 1
	Porifera encrusting msp. 10
	Porifera massive lobose msp. 2
	Chaetopteridae msp. 1
	Axinella infundibuliformis
	Porifera encrusting msp. 35
	Sabellidae msp. 2
	Geodia msp. 1
	Echinoidea msp. 2
	Hydroidomedusa (irregularly branched)
	Porifera lamellate msp. 6
	Porifera encrusting msp. 23
	Lophelia pertusa
	Porifera encrusting msp. 20
	Anomiidae msp. 1
	Porifera massive globose msp. 4
	Bivalvia msp. 1
	Porifera encrusting msp. 17
	Serpulidae msp. 2
	Pterasteridae msp. 1
	Velatida msp. 1
	Serpulidae msp. 3
	Pandalus borealis
	Phoronida msp. 1
	Gastropoda msp. 1
	Bivalvia msp. 2
	Porifera massive lobose msp. 11
	Porifera encrusting msp. 15
	Ophiuroidea msp. 5
	Ascidiacea msp. 2
	Hydroidomedusa (flat branched)
	Colus msp. 2
	Caryophyllia msp. 4
	Cyclostomatida msp. 2

Continued

Boreal *ostur*—Cluster RHG	
SIMPER-characterizing species	**Morphospecies**
	Halcampoididae msp. 3
	Porifera lamellate msp. 3
	Mysida msp. 1
	Cyclostomatida msp. 4
	Porifera spherical msp. 1
	Ascidiacea msp. 3
	Porifera encrusting msp. 14
	Porifera encrusting msp. 13
	Porifera encrusting msp. 9
	Porifera encrusting msp. 31
	Stichopus tremulus
	Porifera massive globose msp. 3
	Majidae msp. 1
	Ascidiacea msp. 1
	Ophiuroidea msp. 8
	Ophiuroidea msp. 1
	Ceramaster/Peltaster/Plinthaster
	Ophiuroidea msp. 3
	Paguridae mspp.
	Gersemia msp. 2
	Holothuroidea msp. 1
	Porifera massive globose msp. 7
	Ophiuroidea msp. 2
	Tubularia msp. 2
	Porifera branching-erect
	Ophiuroidea msp. 4
	Crinoidea msp. 3
	Halcampoididae msp. 5
	Pycnogonida msp. 2
	Porifera massive lobose msp. 7
	Actiniaria msp. 4
	Astropecten irregularis
	Porifera massive fig msp. 1
	Unknown msp.
	Polyplacophora mspp.
	Porifera massive lobose msp. 5
	Polychaeta msp. 1
	Unidentified worm tubes
	Porifera encrusting msp. 22
	Madrepora oculata
	Porifera encrusting msp. 34
	Tritoniidae msp. 1
	Porifera massive globose msp. 2
	Porifera massive globose msp. 10
	Unknown msp.
	Munnopsurus giganteus
	Porifera cup msp. 3
	Porifera spherical msp. 2
	Caryophyllia msp. 2

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