Defining biological assemblages (biotopes) of conservation interest in the submarine canyons of the South West Approaches (offshore United Kingdom) for use in marine habitat mapping.

Jaime S. Davies[a,*], Kerry L. Howell[a], Heather A. Stewart[b], Janine Guinan[c,d] and Neil Golding[e]

[a]Marine Biology and Ecology Research Centre, University of Plymouth, Plymouth, PL4 8AA, UK
[b] British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA, UK
[c] Marine Institute, Riuville Oranmore, Galway, Ireland
[d] Present address : INFOMAR Programme, Geological Survey of Ireland, Beggars Bush, Haddington Road, Dublin 4, Ireland
[e]Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough, PE1 1JY, UK
* jaime.davies@plymouth.ac.uk

Abstract

In 2007, the upper part of a submarine canyon system located in water depths between 138 and 1165 m in the South West (SW) Approaches (North East Atlantic Ocean) was surveyed over a 2 week period. High-resolution multibeam echosounder data covering 1106 km^2, and 44 ground-truthing video and image transects were acquired to characterise the biological assemblages of the canyons. The SW Approaches is an area of complex terrain, and intensive ground-truthing revealed the canyons to be dominated by soft sediment assemblages. A combination of multivariate analysis of seabed photographs (184-1059 m) and visual assessment of video ground-truthing identified 12 megabenthic assemblages (biotopes) at an appropriate scale to act as mapping units. Of these biotopes, 5 adhered to current definitions of habitats of conservation concern, 4 of which were classed as Vulnerable Marine Ecosystems. Some of the biotopes correspond to descriptions of communities from other megahabitat features (for example the continental shelf and seamounts), although it appears that the canyons host modified versions, possibly due to the inferred high rates of sedimentation in the canyons. Other biotopes described appear to be unique to canyon features, particularly the sea pen biotope consisting of *Kophobelemnon stelliferum* and cerianthids.

Keywords (Submarine canyons, Conservation, Deep-sea, Benthos, Habitat mapping, Biotopes, Cold-water corals, *Lophelia pertusa*)

1. Introduction

Submarine canyons are topographically complex features (Harris and Whiteway 2011) that are incised into many of the world's continental shelves and margins (e.g. Hickey, 1995; Brodeur, 2001). Canyons have been reported as containing diverse bottom types (Kottke et al. 2003), described as areas of high habitat heterogeneity (Schlacher et al. 2007), and are suggested to enhance biodiversity on landscape scales (Vetter et al. 2010). The presence of submarine canyons on the continental slope can significantly alter the hydrodynamic regime of the region, thus canyons may be highly unstable environments subject to periodically intense currents, debris transport, sediment slumps and turbidity flows (Shepard and Marshall, 1973; Inman et al. 1976; Gardner, 1989).

Canyons may act as conduits, transporting sediment and organic matter from the continental shelf to the deep sea (Shepard, 1951; Heezen et al. 1955; Monaco et al. 1990), and can be areas of enhanced production and species diversity as a result of the accumulation of organic matter and/or upwelling of nutrient rich waters (Hickey 1995).

Submarine canyons have been suggested to play a role in generating areas of high megabenthic biodiversity due to their complex topographies (Schlacher et al. 2007). Canyon fauna flourish as a result of suspension feeding organisms benefiting from accelerated currents within canyons (Rowe, 1971) as well as increased secondary production (Vetter et al. 2010) due to the exploitation of local increases in zooplankton during vertical migration (Greene et al. 1988). In addition, detritivores benefit from enhanced sedimentation rates and accumulated macrophytic detritus (Vetter, 1994; Harrold et al. 1998). However, a high incidence of disturbance through sediment transport by intense tidal currents, turbidity currents and detrital flows may be unfavourable to sessile invertebrate megafauna while favouring highly motile species (Rowe, 1971; Vetter and Dayton, 1999; Vetter et al. 2010). Topographic features such as canyons, which provide enhanced food supply, diverse habitats, and alter hydrodynamic activity have been described as 'Keystone structures' (Vetter et al. 2010). Keystone structures are defined as "distinct spatial structures providing resources, shelter or 'goods and services' crucial for other species" (Tews et al. 2004). Those canyons which act as keystone structures, and may be described as biodiversity hotspots, merit special attention in management (Smith et al. 2008). The inclusion of canyons as examples of topographical features that may potentially support Vulnerable Marine Ecosystems (VMEs) (FAO 2009) reflects this.

Establishing a representative network of deep-sea Marine Protected Areas offers one tool with which to address the conservation needs of the deep sea. The need to establish such networks is driven by a number of international and national policies. The United Nations Convention of the Law of the Sea (UNCLOS) is an international agreement that provides the legal basis for high seas Marine Protected Areas (UNCLOS 1982). The Convention on Biological Diversity (CBD) is an international legally binding treaty which includes within it a requirement for nations to establish a 'comprehensive, effectively managed and ecologically representative network of Marine Protected Areas by 2020' [(COP 10 Decision X/2) CBD 2010]. The Oslo-Paris Convention (OSPAR) is the current legal mechanism guiding international cooperation on the protection of the marine environments of the North-East Atlantic; the agreement is between 15 European countries and the European Commission. Annex V of the OSPAR convention (The convention for the protection of the Marine Environment of the North East Atlantic) lists a number of deep-sea habitats as 'threatened or declining', including: seamounts, *Lophelia pertusa* reefs, coral gardens, carbonate mounds, and sea pen and burrowing megafauna communities. It calls for nations to establish, “an ecologically coherent network of well managed Marine Protected Areas by 2020” for the protection of these listed habitats.

Within Europe, the main legislative power for managing fisheries and marine nature conservation is based on the Common Fisheries Policy and Habitats Directive (92/43/EEC). The Habitats Directive (conservation of the natural habitats of wild fauna and flora) is the first international tool to address the protection of selected habitats and species, listed under the Directive’s Annex I (habitats) and II (species). The Habitats Directive requires member states to designate and protect sites as Special Areas of Conservation (SACs). These protected areas together create the *Natura 2000* sites, a network of protected areas throughout the EC. Cold-water coral reefs, coral gardens and sponge dominated communities all come under the definition of Annex I listed ‘reef’ habitat.

The challenge now is how to practically implement such networks given our limited understanding of the deep sea ecosystem. While a number of deep-sea habitats have been identified as vulnerable to anthropogenic activities (e.g. cold-water coral reefs and sponge aggregations) (FAO 2008), poor knowledge of the distribution of these habitats hinders conservation efforts and network planning. Additionally, it is difficult to use criteria (such as those set out by the FAO) that have been developed for assessing habitat vulnerability (FAO 2008) as many deep-sea habitats have yet to be described, particularly in terms of their rarity, resistance, resilience and vulnerability. For example, although some habitats, such as cold-water coral reefs, are easily damaged from activities such as bottom trawling, it is not cold-water coral reefs that are subject to repeated trawling action in the way that some soft bottom deep-sea habitats are (Thrush et al. 2001). Additionally, to create the synergy needed for an MPA network design, a better understanding is urgently needed of which species are present, their distribution, and some detail about their connectivity; this may be achieved through the use of physical oceanography proxies and/or knowledge about species reproduction/larval dispersal.

For nations to fulfil their legal requirements in terms of conservation they require maps that inform them of the spatial distribution of species and habitats. In light of the vast area covered by the deep sea, numerous approaches have been adopted to mapping, with a view to preserving deep-sea habitats (Harris and Whiteway, 2009; Howell, 2010). Mapping at a landscape scale (megahabitat scale of kilometres to tens of kilometres; *sensu* Greene et al. 1999), using large topographic features such as submarine canyons, allows large areas to be covered using lower resolution data, and is thus both cost and time effective. Whilst mapping at this scale may be appropriate for generalised, global conservation efforts, these mapping units have less ecological or biological meaning due to their lack of detail. Most ecological and biological processes occur at a finer scale. Therefore, the production of meaningful fine-scale habitat maps (< 1 km) which adequately take into account lateral and vertical variation within these megahabitat features is necessary. In recent years significant research effort has been focused on seamount features, adding much to our understanding of these systems (Clark et al. 2010; Howell et al. 2010a; Rowden et al. 2010; Shank, 2010). However, contrastingly, submarine canyons are more poorly sampled, and thus less well understood (De Leo et al. 2010).

To implement ecologically representative networks, biologically meaningful maps are required to inform managers on the distribution and diversity of habitats. To adequately protect species and habitats, particularly those that are listed as being of conservation interest, the approach taken needs to be at a scale that is relevant to the biology. Taking a bottom-up approach, through first defining benthic assemblages that can then act as fine-scale mapping units, cannot only be used to inform the distribution of assemblages, but may also allow the inference of associations between biology and larger scale features (geomorphology), which may then enable these large scale features to be used for mapping across broad areas. To achieve an ecologically coherent network across regions, and globally, we need to be able to combine habitat maps originating from national and international programmes. To date deep-sea maps produced by different projects / countries are not able to be combined because of a lack of an agreed deep-sea classification system and recognised and agreed definitions of mapping units. To overcome this, standardisation of mapping practices is necessary, with consistent terms used.

To adequately protect vulnerable habitats, there is a need for clarity in the working definitions used. Habitats such as *Lophelia pertusa* reefs have been widely documented (Wilson, 1979; Mortensen et al. 1995; De Mol et al. 2002) and the definition of these habitats are more widely recognised. There are few descriptions of benthic assemblages from canyon systems (Schlacher et al. 2010), and none in the context of statistically defining units for use in habitat mapping, or assessing the potential conservation value of canyons. Consequently, the objective of this study is to: support international habitat mapping efforts through developing standardised descriptions of deep-sea biological assemblages, with a focus on assemblages that fit descriptions of 'listed' habitats, for use as functional and consistent mapping units (biotopes).

2. Material and methods

2.1 Study area

The SW Approaches study area is located on the Celtic Margin and is an area characterised by a number of submarine canyons (Figure. 1; Huthnance et al. 2001; Mulder et al. 2012). The upper reaches of three canyons were the target of this investigation. Two of those are located in UK waters: Dangeard Canyon (also known as Dangaard Canyon), and Explorer

Canyon (first in this special issue, see Stewart et al. (2014, this issue)). The head of Dangeard Canyon is around 12 km in width and ~1500 m at its deepest point, including its network of tributary gullies that feed into the main canyon which is itself around 7 km in width. The head of Explorer Canyons is around 11 km wide, compared to the main Explorer Canyon which is around 8 km in width and ~1500 m deep. We are constrained by the dataset as the canyons continue before merging downslope, feeding into the Whittard Canyon. The shelf break, which marks the boundary between the near horizontal sea floor of the continental shelf and the steeper continental slope, occurs between 180 and 250 m water depth. Mean slope angles along the Celtic Margin are 11° although locally very steep gradients to the vertical occur along canyon walls (Cunningham et al. 2005; Stewart et al. 2014). Two canyons are located in UK waters, the Dangeard (also known as Dangaard) and Explorer (first named here) canyons, and were the target of this study.

The Dangeard and Explorer canyons are separated by smooth interfluves, which are areas of un-dissected relict continental shelf and slope (Figure 2). These interfluves host two mini-mound provinces with individual mounds up to 3 m in height above the surrounding sea floor and 50-150 m in diameter (Stewart et al. 2014). In the canyon heads, the dendritic pattern of tributary gullies is clearly imaged in the study area forming drainage basins. Well developed "cauliflower" shaped amphitheatre rim features were identified in the canyon heads and flanks indicative of shelf-ward erosion. Stewart et al. (2014) present a geological interpretation of the study area.

2.2 Data acquisition

From 4th-18th June 2007 Dangeard and Explorer canyons and the flank of a third canyon (located in Irish waters) in the SW Approaches were surveyed onboard the *RV Celtic Explorer* (The Marine Institute, Ireland). High-resolution ground-truthing and multibeam echosounder (MBES) data were acquired (Figures 2 and 3) over an area of 1106 km^2; MBES was acquired using a hull mounted Kongsberg Simrad EM1002 system capable of collecting swath bathymetry to ~1000 m water depth (see Stewart and Davies (2007) and Stewart et al. (2014) for more details). A Seatronics drop-frame camera system was used to acquire video and image data. The camera system comprised a DTS 6000 digital video telemetry system with a live feed to the vessel, and a five megapixel Kongsberg Simrad digital stills camera (containing a Canon Powershot G5). The cameras were mounted opposite each other (with lights either side) at oblique angles to the seabed for optimal seabed coverage and to aid species identification. The frame was also fitted with a CDT sensor to record depth, altitude and temperature, and an ultra-short baseline (USBL) beacon to collect accurate positional data for the frame, allowing accurate environmental and positional data for still images to be extracted from data files. To enable quantitative analysis of data, the fields of view for both the stills and video cameras were calibrated (an image taken) at varying altitudes of the camera frame above the seabed (on seabed, 1 m, 2 m and 3 m) to enable area to be calculated. Calibration was achieved by attaching a gridded quadrat of known dimensions (grid cell size of 4.9 cm by 5.5 cm) to the base of the camera frame and the area of each still image was calculated using the appropriate calibration grid image for its altitude.

Transect locations were chosen using the processed multibeam bathymetry and backscatter data. ‘Sampling’ was stratified by depth, topographic feature, and seabed substratum (inferred from backscatter data); and where possible, replicate sampling was undertaken within and between canyons. Transect position and orientation was chosen dependent on the terrain, on the steep areas of the canyon flank it was decided that it was safer for the towed camera to travel down- rather than along-slope. The vessel’s DP was used to keep the camera on chosen transects.

Transects were *approx*. 500 m in length, and sampling occurred over a depth range of 184-1094 m. The drop-frame was deployed from the starboard side of the vessel and towed 1-3 m above the seabed at a vessel speed of *approx*. 0.5 knots (min 0.3 and max 0.7) with tows lasting between 0.5-1.5 hrs. Forty four transects were undertaken (see Table A1 for full details). Following the MESH [1] guidelines for data collection, a 2-5 minute camera stabilisation period was undertaken at the beginning of each transect to ensure the camera was moving at a constant speed. Video footage was recorded along the entire transect, and at approximately one minute intervals the drop-frame was landed and a stills image taken (sampling unit) which will be referred to here as a 'sample' image. Additional images were also taken to capture abrupt changes in substratum (i.e. from sand to bedrock) and to aid in species identification.

2.3 Biological data analysis

2.3.1Quantitative analysis of image data

'Sample' images and those taken at abrupt changes in substratum were reviewed and poor quality images removed, predominantly due to silt clouds obscuring the image or the image being out of focus. The remaining images were quantitatively analysed using image area (derived from the calibration grids). An inherent problem with working in the deep sea is the lack of specimens to aid in identification, and without physical samples it is difficult, and in many cases impossible to identify organisms to species level from image data; however, observed organisms can be identified as distinct morphospecies (morphotypes).

All visible organisms >1 cm (at their widest point), as determined using the calibration grid for scale, were identified as distinct morphospecies and assigned an Operational Taxonomic

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[1] The principal purpose of the Mapping European Seabed Habitats (MESH) project is to harmonise the way in which habitat mapping initiatives are undertaken in the northwest Europe (www.searchmesh.net).

Unit (OTU) number. OTUs were identified to the lowest possible taxonomic level, which can correspond to species, genus, family or higher taxonomic levels depending on the group. All individuals were enumerated except in the case of encrusting, colonial and lobose forms where area cover was used.

2.3.2 Community analysis

Count and cover data were treated independently prior to multivariate analysis, each were standardised to 1 m^2 (percent/1 m^2 for cover). To allow combined analysis of count and percent cover data, a standardisation function was employed to place each matrix on the same scale (Stevens and Connolly, 2004; Howell et al. 2010b). First the data were transformed to standardise the distribution of the data then each entre in the matrix was divided by the sum of the matrix total and multiplied by an appropriate factor to put the count and cover on relative scales (Prof. R. Clarke *pers. comm*). Count data were square root transformed, each entre divided by the sum of the matrix and multiplied by 200; cover data were 4th root transformed, divided by the sum of the matrix and multiplied by 100, to place both matrices on a scale of 0.01-1.019. Once each matrix was standardised, they were merged in PRIMER (v.6) and multivariate community analysis was undertaken as described below. Seabed substratum composition was assigned to each 'sample' image using the modified Folk diagram (Folk 1954; Long 2006).

Standard multivariate community analysis techniques were used to identify faunally distinct benthic assemblages within the study area. Highly mobile species such as fish, which use multiple habitats and can thus confound the result of the cluster analysis, were removed prior to data analysis. Cluster analysis with group-averaged linkage was performed using a Bray-Curtis similarity matrix derived from transformed (standardised), combined species count and percent cover data. The SIMPROF routine of the PRIMER software [similarity profile

(Clarke et al. 2008)] was used to identify significant clusters ($p < 0.01$) and the SIMPER [similarity percentages (Clarke, 1993)] routine used to identify those species that characterise those clusters. Characterising species were defined as those species with a high similarity/standard deviation ratio (Clarke, 1993), and contributed > 5% to that cluster similarity.

2.3.3 Characterising mapping units (biotopes)

There is a discrepancy between the faunal assemblages identified using community analysis methods and what is required from a practically applicable mapping unit used in producing necessarily generalised maps of variation in the biological composition of the seabed. Clusters identified by SIMPROF ($p < 0.01$) were assessed against the following criteria and rejected or accepted as faunally distinct clusters on that basis: 1) Outlier clusters were taken at a 1% Bray-Curtis similarity level on the dendrogram and discarded. 2) Clusters that contained small numbers of images (in this study less than 7 images) were deemed not sufficient to allow an adequate description of a coherent assemblage and were also discarded. 3) Those clusters that had an average similarity (SIMPER) of less than 15% were defined as not being coherent. 4) In line with existing habitat classification systems (e.g. EUNIS, (Davies and Moss, 1999-2002), SIMPROF clusters were split on the basis of substratum type. 5) SIMPROF clusters were combined at a lower similarity node on the dendrogram if it produce a more practical mapping unit (appropriate scale).

Following standard multivariate analysis, faunally distinct clusters were assessed against a second set of criteria to determine their use as mapping units. Only those clusters that subsequently met these criteria were further analysed in terms of their faunal composition. To function as a mapping unit assemblages must 1) occur at a scale relevant to the resolution of the acoustic data and the scale of existing widely accepted benthic communities such as cold water coral reefs (e.g. 10 m scale), and 2) be easily identified from video data.

Mapping units, hereinafter referred to as 'biotopes', were defined in terms of their characterising species, as determined by SIMPER analysis, together with the range of environmental conditions over which they occurred in this study, and named according to the dominant species, in accordance with the EUNIS classification system. As a result of the small size of the sampling unit (field of view of the image 'samples') the larger conspicuous fauna were not always adequately sampled, thus additional descriptive elements were added from video observations. A 1-way Analysis of Similarity (ANOSIM) was performed on a normalised depth and temperature, Euclidean distance matrix to test if biotopes (factor) were different in terms of measured environmental variables.

To identify those biotopes which could be considered of conservation concern, biotopes were compared with current definitions of 'listed' habitats under the OSPAR Convention and the EC Habitats Directive. Specifically, to identify those which are VMEs, the guidelines of the FAO (FAO 2009) and current OSPAR definitions were used (OSPAR (Agreement 2008-6).

2.3.4 Distribution of biotopes

Video transects were reviewed and visually classified (guided by the sample image classification) using the newly defined biotopes, and changes of biotope type within a transect were mapped using ArcGIS 9.3 Abiotic data were extracted from the mapped data to define the environmental range of the distribution of each biotope.

3. Results

3.1 Biological data analysis

Twenty three hours of video footage and 5000 still images were collected over the survey area. Of these images, 1073 were 'sample' images [those taken at *approx*. 1 minute intervals (equating to ~30 m)]; upon inspection 199 were discarded due to poor quality.

3.1.1 Quantitative analysis of image data

Eight hundred and seventy four 'samples' were quantitatively analysed with 161 morphospecies identified and catalogued. Those samples where no fauna were recorded were removed prior to the multivariate analysis. Cluster analysis was performed on the remaining 746 samples. Three broad categories of substratum were revealed from the image analysis: hard substratum (16 %), reef habitats (4%) and soft substratum (80%).

3.1.2 Community analysis

The SIMPROF routine identified 43 clusters ($p < 0.01$) (see Table A2 for statistical results of clusters). Using the criteria described in Sect. 2.3.3, outlier clusters were removed (cluster a-q) and those that did not act as coherent units for mapping discarded. The remaining 11 clusters were accepted as practically applicable mapping units. Results from the cluster analysis of still image "samples", including SIMPER analysis (characterising species) and a description of the environmental characteristics associated with each cluster are shown in Table A2 (see appendix A1 for SIMPER results).

3.1.3 Characterising mapping units (biotopes)

In total 11 biotopes were identified from the cluster analysis (Figure. 4) and related to available environmental data to describe distinct biotopes (see Table 1 for details). A 1-way ANOSIM test of environmental data (depth and temperature) for the 11 biotopes defined from image data revealed a significant difference in environmental conditions between biotopes (Global R = 0.265, p < 0.01). Thirty one pairwise tests were significant and Fig. 5 illustrates an nMDS plot showing a variation of biotopes relating to environmental conditions. Two groups are apparent and appear to be related to depth zones, one on the left comprising of 5 biotopes (x, y, al, ac and aj) a deeper zone (654-894 m average depth of biotopes) and the other having 4 biotopes (am, aq, ap and ao) at shallower depths (326-477 m average depth of biotopes). Biotope r and ah are most dissimilar, although appear not to be strongly related to either of the main groups observed in Figure. 5.

Visual classification of video data according to the newly defined biotopes revealed an assemblage that did not fit with any of those defined (Lop.Cri: *L. pertusa* and crinoids on bedrock). Upon reviewing the data, it was apparent that image sample data had failed to capture this assemblage (due to limited areas of bedrock captured by the still images). Based on visual assessment of the assemblage it appears similar to assemblages described by Wienberg et al. (2008) and Howell et al. (2010b) and was therefore classified as such. In the interests of fully characterising the Canyons region, and given that this previously described biotope is of particular conservation importance due to the occurrence of listed species (*L. pertusa*), as well as being the only bedrock community observed in the canyons that may be classed as Annex I bedrock reef (under the EC Habitats Directive), its distribution within the canyon system is also considered here. Thus a total of 12 biotopes were described from the SW Approaches (Figure 6).

3.1.4 Distribution of biotopes

Qualitative assessment of biotope distribution, determined from visually classified video transect data, (Table 1, see also Fig A1-A2 for mapped distribution of biotopes) revealed that six of the 12 biotopes were observed in all 3 canyons, 4 soft sediment biotopes (Kop.Cer, Cer, Amp.Cer and Oph), a mixed substratum (shell hash) biotope (Mun.Lep) and Lop.Cri on bedrock. Five biotopes fit with the 'listed habitats' definition. The sea pen biotope Kop.Cer was observed in all three canyons on the flank and incised channels over a depth of 463-1059 m. The bedrock associated biotope, Lop.Cri, was also observed in all canyons, occurring on incised channels, tributary gullies, flank and amphitheatre rims features over a depth of 253-1022 m. The *L .pertusa* reef biotope Lop.Mad was only observed once in Explorer canyon on flute features 795-940 m, while the dead framework biotope Lop.Hal was observed in both Explorer and Dangeard canyons on the flanks and flute features (697-927 m). The coral rubble biotope Oph.Mun was observed in Explorer and Dangeard canyons on incised channel and mini-mound features over a depth of 303-1017 m.

4. Discussion

Submarine canyons are considered to be potential biodiversity hotspots; however, to date there is very little data on canyon community composition of these features, particularly potential importance as features of conservation interest. Soft sediment habitats dominate the canyons of the SW Approaches, with 80% of analysed images and 60% of the described biotopes. Five of the biotopes could be considered of conservation interest. Of these five, only four come under the definition of VMEs, three could be classified as cold-water coral reefs under the EC Habitats Directive and OSPAR Convention, whist the fourth could be classed as 'Sea pen and burrowing megafauna communities' or coral garden under the current OSPAR definition. The fifth could be considered bedrock reef under the EC Habitats Directive. Seven biotopes were soft sediment communities or faunally-sparse and thus, have little or no perceived conservation interest; of these, three have been previously described by a number of authors while four are new descriptions (see Appendix A2 for descriptions). Those habitats that are listed under policy (OSPAR and EC Habitats Directive) will be discussed in terms of a description of the new biotopes defined and related to other research, those which are not 'listed' habitats will not be discussed; however full descriptions for each are given in Appendix A2.

4.1 Descriptions of 'listed' habitats for use as mapping units (biotopes)

4.1.1 Cold-water coral reef

Three biotopes were defined that could be considered as cold-water coral reef, these communities represent distinct reef zones (*sensu* Mortensen et al. 1995) or macrohabitats (*sensu* Greene et al. 1999) each with different associated fauna forming distinct communities.

<u>*Lophelia pertusa* reef</u>

This biotope (Lop.Mad, cluster ah) was characterised by dead *L. pertusa* framework and live patches of *L. pertusa* and *Madrepora oculata* which provide a structural habitat for associated species. Other characterising species (as identified by SIMPER) were small anemones (Actiniaria sp.13) and an unidentified species (Unknown sp.26) which were associated with *L. pertusa*. Additional species identified from qualitative video observations were *Pandalus borealis* and the echinoid *Cidaris cidaris*; halcampoid anemones (Halcampoididae sp.1) inhabited the interspersed sediment patches in the reef. Other conspicuous fauna observed from the image and video data were large cerianthid anemones, the decapod *Bathynectes* sp. and the fish *Lepidion eques*. This assemblage was observed on steep flute features on the flank of Explorer canyon over a depth of 795-940 m and temperature of 9.41-9.92°C.

This assemblage corresponds to the 'live *Lophelia* zone' as described by Mortensen et al. (1995) which is the main reef habitat found on the summit of the reef and consists of predominantly live *L. pertusa* interspersed with areas of dead broken skeleton.

Lophelia pertusa is widely distributed in the North Atlantic, in oceanic waters at temperatures of 4-12°C (Roberts et al. 2006) and is predominantly found at depths of 200-1000 m but has been recorded shallower and deeper (Zibrowius, 1980). *L. pertusa* has been identified as occurring in areas subjected to fast currents such as carbonate mounds (De Mol et al. 2002), ridges and pinnacles (Howell et al. 2007). Pfannkuche et al. (2004) observed *L. pertusa* reef on the slopes of the Castor mound in the Belgica mound province (Porcupine Seabight) from 950-1036 m depth, and describe complete cover of live and dead coral colonies of *L. pertusa* and *Madrepora oculata* with antipatharians, actinians and hexactinellid sponges present. Howell et al. (2010b) described a similar *L. pertusa* reef from various locations within UK waters as being characterised by the reef-forming corals *L. pertusa* and *M. oculata*, hydroids, anemones, decapods, cerianthids and echinoderms (ophiuroids and echinoids); whilst a similar assemblage was observed from Anton Dohrn Seamount (Davies et al. subm.) consisting of *L. pertusa* (dead and live), *M. oculata*, *Cidaris cidaris* and anemones.

Whilst the assemblage defined from the SW Approaches canyons has some of the same associated species as described previously from reef habitat, the canyon assemblage appears to be subject to increased sedimentation which is clearly visible from the image and video data; although an analysis of sedimentation rates has not been carried out. Canyons are likely to experience increased rates of sediment transport as a result of hydrodynamic regime (Vetter and Dayton, 1998). The interpreted higher level of sedimentation in the study area may result in a lower proportion of live *L. pertusa* colonies and fewer suspension feeders (Brooke and Ross, 2014); however, a full comparative analysis would be required to test this.

Predominantly dead low-lying coral framework

The assemblage identified as Lop.Hal (cluster aj) was characterised by small live colonies of *L. pertusa* and dead *L. pertusa* framework with sediment infill, the sediment areas provided microhabitats for soft sediment dwelling organisms such as cerianthid (Cerianthidae sp. 1) and halcampoid (Halcampoididae sp.1) anemones. Fauna associated with the dead framework were small growths of live *Madrepora oculata*, the bamboo coral *Acanella*, ascidians and crinoids. This assemblage was observed from the Explorer and Dangeard canyons on the flanks, and on a flute feature over a depth of 697-927 m and temperature of 8.97-9.77°C.

Mortensen et al. (1995) and Roberts et al. (2009) describe a 'Dead coral framework' zone that is characterised by suspension feeders including sponges, actinians, and other coral species (gorgonians) with smaller epifauna such as bryozoans, hydroids and barnacles. Similar assemblages have also been described from Rockall Bank (Wilson 1979; Howell et al. 2010b), Hatton Bank (Howell et al. 2010b) and Anton Dohrn Seamount (Davies et al. subm.). The 'Dead coral framework' zone (*sensu* Mortensen et al. 1995) is known to be the most diverse area of a reef (Jensen and Frederiksen, 1992; Mortensen et al. 1995). Whilst the assemblage described by the present study may be functionally similar to the dead framework assemblages of Wilson (1979), Mortensen et al. (1995) Roberts et al. (2009) and Howell et al. (2010b), based on their descriptions it would appear this assemblage is more sediment in-filled, as there are more sediment dwelling organisms associated with this biotope. A similar assemblage has been reported on the upper slope and summit of Erik mound in the Belgica province from 818-855 m depth (Pfannkuche et al. 2004). Coral rubble with isolated live patches of *L. pertusa* and *M. oculata* and a low abundance of associated fauna (antipatharians and *Aphrocallistes* sp.) was described with muddy sand areas between the rubble inhabited by *Cerianthus* sp. (Pfannkuche et al. 2004).

Ophiuroids and *Munida sarsi* associated with coral rubble

Biotope Oph.Mun (cluster ap) was identified as a typical reef rubble habitat which was characterised by coral fragments in the form of rubble/biogenic gravel. The rubble was acting as a habitat for the squat lobster *Munida sarsi* and the ophiuroid Ophiuroidea sp.5. The assemblage was found associated with incised channels and mini-mound features on the interfluves in Explorer and Dangeard canyons over a depth range of 303-1017 m and a temperature of 7.98-11.5°C.

Oph.Mun biotope corresponds to 'the *Lophelia* rubble zone' described by Mortensen et al. (1995) which is the outer 'apron' of the reef where the framework has been (bio)eroded and accumulates at the base of the reef, the squat lobster *Munida sarsi* dominates this zone.

4.1.2 'Sea pen and burrowing megafauna' communities/coral gardens

Kophobelemnon stelliferum and cerianthids on mud/sand

The assemblage Kop.Cer (cluster y) was associated with mud and muddy sand substratum and was characterised by the sea pen *Kophobelemnon stelliferum* and cerianthid anemone. Other conspicuous fauna associated with this assemblage were the large *Bolocera*-like anemones (Sagartiidae sp. 3), sea pens *Halipteris* sp., a number of echinoderm species including the asteroid *Pseudarchaster* sp., the crinoid *Pentametrocrinus atlanticus* (sediment dwelling) and the holothurian *Benthogone* sp. Video observations revealed the bamboo coral *Acanella arbuscula* to be more abundant than suggested from the image analysis. Kop.Cer biotope was observed most frequently and was widespread throughout the canyons. The assemblage was observed from all three canyon flanks, and from an incised channel in Explorer Canyon, over a depth range of 463-1059 m and a temperature of 8.87-10.85°C.

Kophobelemnon stelliferum is an upper bathyal species (Rice et al. 1992) and is known to be a deeper sea pen species (López-González and Williams, 2010) widely distributed at depth from 400-2500 m in the north Atlantic and Pacific oceans (Rice et al. 1992). Rowe (1971) reported the occurrence of a *K. stelliferum* from Hatteras canyon between 1440-2060 m and considered this species to be a 'canyon indicator' as it was not found away from the canyon. Whether this assemblage is unique to the canyon system here is unknown as no comparable data are available from the neighbouring continental slope.

The sea pen assemblage has not been described from the deep sea but is similar to the shallower EUNIS 'Sea pen and burrowing megafauna in circalittoral mud' biotope and that described by Kenchington et al. (2014). Kenchington et al. (2014) describe a biotope from the Gully Canyon characterised by 3 corals, the sea pens *Pennatula* spp. and *Halipteris* spp. and the small soft coral *Acanella arbuscula*. A xenophyophore biotope with an abundance of sea pens has also been described from Anton Dohrn Seamount (Davies et al. subm.), although this community is distinct from that observed on Anton Dohrn Seamount.

Sea pens are known to increase local biodiversity through increased habitat heterogeneity (Birkeland, 1974; Buhl-Mortensen et al. 2010). Sea pens are protected under the UK Biodiversity Action Plan (UKBAP) as 'Mud habitats in deep water' which corresponds to the OSPAR 'Threatened and/or Declining Habitat' 'Sea pen and burrowing megafauna communities' (OSPAR Agreement 2008-6). The newly described assemblage could also be considered both a VME (FAO 2009) and a 'coral garden' habitat (OSPAR 2010). The OSPAR definition is very broad and incorporates both hard and soft substratum assemblages;

this may lead to misinterpretation, and thus misrepresentation of this habitat within a network of MPAs. Soft-bottom coral gardens can be dominated by solitary scleractinians (caryophyllids), sea pens or certain types of bamboo corals (e.g. *Acanella* sp.), whilst hard-bottom coral gardens are often found to be dominated by gorgonians, stylasterids, and/or black corals (ICES, 2007). The '*Kophobelemnon stelliferum* and cerianthid' biotope described from the submarine canyons of the SW Approaches may also satisfy the criteria for being classed as a VME. This assemblage is 'unique or rare' in the sense that it may be unique to canyons, and sea pens are known to be vulnerable to fishing activities (Troffe et al. 2006) and provide structural complexity for associated species (Buhl-Mortensen et al. 2010). They may also be important nursery grounds for fish, for example, Redfish larvae have been associated with 5 species of sea pen in the northwest Atlantic (Baillon et al. 2012).

4.1.3 Other reef habitat under EC Habitats Directive

L. pertusa and crinoids on bedrock

As this biotope was described from the video, characterising species were assessed visually. Small growths of *Lophelia pertusa* (live & dead), the holothurian *Psolus squamatus* and Holothuroidea sp.4; the corkscrew antipatharian *Stichopathes* sp. and crinoids were identified as characterising species from video. The assemblage was associated with bedrock and was observed from the Dangeard, Explorer and Irish canyons associated with incised channels, amphitheatre rims, tributary gullies (canyons heads) and the flanks over a depth of 253-1022 m and temperature range of 7.93-11.42°C.

The assemblage appears to be a highly sedimented version of the 'Discrete coral' biotope described by Wienberg et al. (2008) and Howell et al. (2010b). The assemblage described by Wienberg et al. (2008) was associated with ridge features on the flanks of Rockall Bank between 650-675 m and dominated by a diverse range of corals (gorgonians, antipatharians, soft corals and stylasterids); whilst Howell et al. (2010b) describe a modified version of this assemblage from Hatton Bank with a lower proportion of gorgonians and antipatharians but with the addition of *L. pertusa*.

4.2 Potential modelling use of biotope data

It is generally recognised that organisms show a particular affinity for certain types of topographical features or terrain (Džeroski and Drumm 2003) and multibeam bathymetry and derived terrain variables can potentially provide important information that can aid in the delineation and characterisation of biological communities (Wilson et al. 2007). Typically, surrogates used in habitat mapping are parameters that can be derived directly from the acoustic multibeam data, such as slope, aspect, rugosity, Bathymetric Position Index (BPI) and backscatter strength.

Once biotopes have been characterised, it is possible to use predictive modelling technique to map their distribution using such surrogates. This has been achieved for single species mapping (e.g. Davies & Guinotte, 2011) and has recently been applied to habitat mapping (Dolan et al. 2008; Guinan et al. 2009; Howell et al. 2011; Ross and Howell, 2012). However, to date, there are few examples of this approach being applied in the deep sea. Where this approach has been applied in the deep sea, it has generally been either on a basin-wide scale (Davies & Guinotte, 2011), or over small areas focused on specific habitats (using ROV acquired resolution acoustic data), such as cold water coral reefs (Dolan et al. 2008; Anderson et al. 2011), seeps (Sager et al. 1999; Baco et al. 2010) or vents (Desbruyères et al. 2001; Kelley et al. 2001), using project specific mapping units (or facies / biotopes).

Multibeam bathymetry data and its derived layers have proved significant in mapping and predicting the distribution of benthic assemblages in the deep sea (e.g. Ross and Howell, 2012; Knudby et al. 2013). However submarine canyons are complex topographic features that are often associated with increased sedimentation rates and sediment transport, and are often hydrodynamically complex (Shepard 1951; Heezen et al. 1955) . The degree to which topographic variables are able to act as surrogates for the environmental parameters important in determining species and assemblage distributions within these complex environments is unknown. Studies which undertake predictive modelling mapping approaches validated using independent data are required to further elucidate the effectiveness of predictive modelling the distribution of habitats and species in submarine canyons.

5. Conclusion

With easily recognised, defined biological assemblage units, the identification of assemblages that could be considered VMEs becomes much simpler and more comprehensive, i.e. not restricted to those communities that have received the most research attention. Efforts to map the distribution of VMEs are more easily combined across studies and / or regions. In addition, the classification of all benthic assemblages into named 'habitats' allows a more effective assessment of representativeness of a network, and consideration of anthropogenic impacts on habitats other than those that are highly 'charismatic', such as cold water coral assemblages.

The SW Approaches submarine canyons harbour a range of biological assemblages, some of which correspond to those described from other megahabitat features, such as seamounts or the continental shelf. Other assemblages may be unique to canyons, but this is merely speculative as there is little comparable data. The SW Approaches canyons harbour assemblages of conservation concern, including three *L. pertusa* biotopes, one sea pen and burrowing megafauna biotope, and one bedrock reef and thus could be considered a keystone structure. The findings of this work have extended our knowledge of submarine canyons by providing much needed, comprehensive descriptions of biological assemblages, and suggest that canyons may harbour modified versions of assemblages observed on other megahabitat features.

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Figure legends

Figure 1: The study area on the Celtic Margin encompassing Dangaard and Explorer canyons and the eastern flank of a third canyon in Irish waters. Bathymetric contours are provided by GEBCO, the 200 m depth contour (dashed line) marks the approximate position of the continental shelf break. The UK median line corresponds to the UK continental shelf limit.

Figure 2: Plan (a) and 3D view (b) of multibeam bathymetry acquired over the survey area, meso-scale geomorphology (*sensu* Greene et al. 1999) is labelled. Fig. 2b is visualised in Fledermaus^{TM} software, for scale of features see Fig. 2a.

Figure 3: Multibeam bathymetry data and video transects acquired over the SW Approaches survey area. Black dots represent video transects and are labelled with transect names.

Figure 4: Dendrogram of hierarchical cluster analysis of species data, clusters identified using the SIMPROF routine ($p < 0.01$). Dendrogram (a) shows those clusters identified as outliers at a 1% Bray Curtis similarity level and (b) remaining clusters for rejection/acceptance process. SIMPROF clusters have been collapsed for illustrative purposes.

Figure 5: Example images of biotopes showing fauna characteristic of each assemblage. Codes given to biotopes correspond to SIMPROF clusters in brackets: Bat.Hyd (r), Amp.Cer (al), Kop.Cer (y), Unk.Cer (ac), Lop.Cri (not defined from cluster analysis), Lop.Hal (aj), Lop.Mad (ah), Cer (x), Oph (am), Ser.Bra (ao), Mun.Lep (aq), Oph.Mun (ap). Lop.Cri was not identified from the cluster analysis, but described from the video.

Figure 6: nMDS ordination plot of pairwise ANOSIM test for depicting difference in environmental variables between biotopes. Cluster letters correspond to biotope codes: r (Bat.Hyd), al (Amp.Cer), y (Kop.Cer), ac (Unk.Cer), aj (Lop.Hal), ah (Lop.Mad), x (Cer), am (Oph), ao (Ser.Bra), aq (Mun.Lep), ap (Oph.Mun).

Figure A1: Mapped distribution of defined biotopes in the SW Approaches. Figures a-f represent the biotope mapped along the transects: (a) Amp.Cer, (b) Bat.Hyd, (c) Cer, (d) Kop.Cer, (e) Lop.Cri, (f) Lop.Hal.

Figure A2: Mapped distribution of defined biotopes in the SW Approaches. Figures a-f represent the biotope mapped along the transects: : (a) Lop.Mad, (b) Mun.Lep, (c) Oph, (d) Oph.Mun, (e) Ser.Bra, (f) Unk.Cer.

Greyscale legends

Figure 3: Multibeam bathymetry data and video transects acquired over the SW Approaches survey area. White dots represent video transects and are labelled with transect names.

Table legends

Table 1: Summary of mapped biotope data, abiotic data extracted from video metadata, geomorphology and substratum extracted from ArcGIS 9.3 layers.* refers to the biotope described from the video footage.

Table A1: Transects undertaken in the SW Approaches canyons: transect code, site (canyon), start and end of transect, length, number of statistical images analysed per transect, average depth and temperature (standard deviation) per transect, topographical feature sampled by transect and generalised seabed substrate within transects.

Table A2: Clusters identified from multivariate hierarchical analysis with associated environmental parameters, and SIMPER results identifying the taxa that characterise the clusters.

Appendix A1: SIMPER results for the SW Approaches

Full lists of species present in each assemblage described in Sect. 4. Characterising species, as identified by the SIMPER routine, are indicated in bold. #### denotes where the number is infinitive or cannot calculated, as in the case of Sim/SD, where the SD is zero and cannot be divided.

Group a
All the similarities are zero

Group b
Less than 2 samples in group

Group c
Average similarity: 42.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sabellidae sp. 1	**0.46**	**42.26**	**#######**	**100.00**	**100.00**

Group d
Less than 2 samples in group

Group e
Less than 2 samples in group

Group f
Average similarity: 100.00

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
***Benthogone* sp.**	**0.16**	**100.00**	**#######**	**100.00**	**100.00**

Group g
Less than 2 samples in group

Group h
Less than 2 samples in group

Group i
Less than 2 samples in group

Group j
Less than 2 samples in group

Group k

Average similarity: 25.93

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
***Protoptilum* sp.**	**0.22**	**16.67**	**0.58**	**64.27**	**64.27**
***Pseudarchaster* sp.**	**0.17**	**9.27**	**0.58**	**35.73**	**100.00**

Group l

Average similarity: 68.45

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Edwardsiidae sp. 1	**0.27**	**68.45**	**4.76**	**100.00**	**100.00**

Group m

Average similarity: 44.15

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Halcampoididae sp. 3	**0.32**	**24.63**	**0.58**	**55.78**	**55.78**
Unknown sp. 13	**0.22**	**19.53**	**0.58**	**44.22**	**100.00**

Group n

Average similarity: 49.42

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Unknown sp. 15	**0.19**	**49.42**	**#######**	**100.00**	**100.00**

Group o

Average similarity: 50.48

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sagartiidae sp. 3	**0.29**	**48.48**	**1.78**	**96.05**	**96.05**
Kophobelemnon stelliferum	0.06	1.70	0.22	3.38	99.42
Calveriosoma fenestratum	0.02	0.29	0.09	0.58	100.00

Group p

Average similarity: 18.04

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Actiniaria sp. 14	**0.05**	**10.48**	**0.39**	**58.07**	**58.07**
Cerianthidae sp. 3	**0.10**	**6.14**	**0.44**	**34.04**	**92.11**
Crinoidea sp. 1	0.07	1.42	0.26	7.89	100.00

Group q

Average similarity: 10.73

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
***Caryophyllia* sp. 2**	**0.11**	**4.00**	**0.32**	**37.27**	**37.27**
Porifera encrusting sp. 1	**0.09**	**3.60**	**0.31**	**33.50**	**70.77**
Hydrozoa (flat branched)	**0.15**	**2.15**	**0.24**	**19.99**	**90.75**
Bathynectes sp.	0.04	0.40	0.13	3.71	94.47
Bolocera tuediae	0.05	0.30	0.13	2.77	97.23

Cerithioidea sp.	0.05	0.30	0.13	2.77	100.00

Group r

Average similarity: 25.07

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
cf. *Bathylasma* sp.	**0.42**	**16.33**	**0.58**	**65.13**	**65.13**
Hydrozoa (bushy)	**0.14**	**8.74**	**0.57**	**34.87**	**100.00**

Group s

Average similarity: 14.78

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Terebellidae sp. 1	**0.26**	**14.94**	**0.79**	**60.27**	**60.27**
Actiniaria sp. 17	**0.15**	**8.96**	**0.39**	**36.16**	**96.43**
Serpulidae sp. 1	0.04	0.47	0.17	1.91	98.34
Bonellia viridis	0.06	0.41	0.17	1.66	100.00

Group t

Average similarity: 38.99

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Amphipoda sp. 1	**0.25**	**38.99**	**#######**	**100.00**	**100.00**

Group u

Average similarity: 20.08

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
***Colus* sp. 2**	**0.35**	**20.08**	**1.28**	**100.00**	**100.00**

Group v

Average similarity: 49.37

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Pachycerianthus multiplicatus	**0.38**	**42.08**	**3.23**	**85.22**	**85.22**
Cerianthidae sp. 1	**0.11**	**7.30**	**0.58**	**14.78**	**100.00**

Group w

Less than 2 samples in group

Group x

Average similarity: 54.39

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Cerianthidae sp. 1	**0.31**	**54.10**	**2.63**	**99.47**	**99.47**
Sagartiidae sp. 3	0.01	0.06	0.05	0.10	99.57
Echinus spp.	0.01	0.05	0.05	0.10	99.67
Munida sarsi	0.01	0.05	0.05	0.09	99.76
Cerianthidae sp. 3	0.01	0.03	0.03	0.05	99.81
Unknown sp. 26	0.01	0.02	0.03	0.04	99.85

Ophiothrix fragilis	0.01	0.02	0.03	0.04	99.89
Pseudarchaster sp.	0.01	0.02	0.03	0.03	99.92
Caryophyllia sp. 2	0.01	0.02	0.03	0.03	99.95
Kophobelemnon stelliferum	0.00	0.02	0.03	0.03	99.98
Halcampoididae sp. 1	0.01	0.01	0.03	0.02	100.00

Group y

Average similarity: 49.80

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Kophobelemnon stelliferum	**0.34**	**42.07**	**2.54**	**84.46**	**84.46**
Cerianthidae sp. 1	**0.14**	**7.03**	**0.55**	**14.12**	**98.59**
Ophiuroidea sp.1	0.04	0.41	0.11	0.82	99.41
Halcampoididae sp.3	0.02	0.13	0.06	0.27	99.68
Pentametrocrinus atlanticus	0.02	0.06	0.06	0.13	99.81
Crinoidea sp. 2	0.03	0.04	0.04	0.08	99.89
Ophiactis balli	0.01	0.04	0.04	0.07	99.96
Acanella sp.	0.01	0.02	0.04	0.04	100.00

Group z

Average similarity: 41.11

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Ophiactis balli	**0.71**	**38.06**	**2.29**	**92.59**	**92.59**
Cerianthidae sp. 1	0.07	1.82	0.27	4.42	97.01
Munida sarsi	0.08	0.60	0.20	1.46	98.47
Serpulidae sp. 1	0.05	0.20	0.11	0.49	98.96
Actinauge richardi	0.02	0.13	0.06	0.32	99.28
Halcampoididae sp. 1	0.05	0.12	0.11	0.29	99.57
Zoanthidea sp. 1	0.03	0.06	0.06	0.16	99.72
Unknown sp. 26	0.02	0.06	0.06	0.15	99.87
Echinus spp.	0.01	0.03	0.06	0.07	99.94
Hydrozoa (bushy)	0.02	0.02	0.06	0.06	100.00

Group aa

Less than 2 samples in group

Group ab

Average similarity: 31.57

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Sabellidae sp. 2	**0.76**	**31.57**	**9.59**	**100.00**	**100.00**

Group ac

Average similarity: 47.47

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Unknown sp. 26	**1.03**	**36.24**	**2.41**	**76.36**	**76.36**
Cerianthidae sp. 1	**0.26**	**6.79**	**0.93**	**14.31**	**90.67**
Ophiactis balli	0.32	2.32	0.36	4.88	95.55
Lophelia pertusa (dead structure)	0.10	0.74	0.20	1.57	97.11
Halcampoididae sp. 1	0.09	0.58	0.23	1.21	98.33
Amphiuridae sp. 1	0.05	0.26	0.14	0.55	98.88
Ophiuroidea sp. 1	0.06	0.19	0.13	0.41	99.29
Munida sarsi	0.03	0.12	0.11	0.26	99.55
Lophelia pertusa	0.04	0.07	0.09	0.15	99.69
Terebellidae sp. 1	0.01	0.04	0.08	0.09	99.78
Psolus squamatus	0.02	0.03	0.08	0.06	99.84
Echinus spp.	0.02	0.02	0.07	0.05	99.89
Sagartiidae sp. 3	0.01	0.01	0.03	0.02	99.91
Brachiopoda sp. 1	0.01	0.01	0.03	0.02	99.92
Bathynectes sp.	0.01	0.01	0.03	0.01	99.94
Ascidiacea sp. 2	0.01	0.01	0.03	0.01	99.95
Bolocera tuediae	0.01	0.01	0.03	0.01	99.96
Crinoidea sp. 1	0.00	0.01	0.03	0.01	99.97
Galatheidae sp. 1	0.01	0.01	0.03	0.01	99.98
Pandalus borealis	0.02	0.00	0.03	0.01	99.99
Actiniaria sp. 9	0.01	0.00	0.03	0.01	100.00

Group ad

Average similarity: 59.02

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
***Lophelia pertusa* (dead structure)**	**0.41**	**58.36**	**3.76**	**98.89**	**98.89**
Munida sarsi	0.04	0.66	0.26	1.11	100.00

Group ae

Less than 2 samples in group

Group af

Less than 2 samples in group

Group ag

Less than 2 samples in group

Group ah

Average similarity: 66.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
***Lophelia pertusa* (dead structure)**	**0.78**	**21.36**	**5.39**	**32.24**	**32.24**
Lophelia pertusa	**0.55**	**14.17**	**3.49**	**21.39**	**53.63**
Madrepora oculata	**0.46**	**11.60**	**2.99**	**17.51**	**71.14**
Unknown sp. 26	**0.46**	**5.49**	**0.70**	**8.28**	**79.42**

Actiniaria sp. 13	**0.28**	**4.06**	**0.99**	**6.12**	**85.54**
Pandalus borealis	0.15	2.79	1.20	4.21	89.75
Cerianthidae sp. 1	0.14	2.51	1.09	3.79	93.54
Halcampoididae sp. 1	0.18	2.16	0.70	3.25	96.79
Cidaris cidaris	0.10	1.47	0.68	2.22	99.01
Bathynectes sp.	0.04	0.32	0.33	0.49	99.50
Hydrozoa (bushy)	0.05	0.21	0.21	0.31	99.81
Koehlermetra porrecta	0.04	0.04	0.07	0.06	99.87
Hydrozoa (flat branched)	0.02	0.03	0.08	0.05	99.92
Porania pulvillus	0.01	0.03	0.08	0.04	99.96
Gastropoda sp. 1	0.01	0.01	0.05	0.01	99.97
Munida sarsi	0.01	0.01	0.05	0.01	99.98
Brisingella coronata / *Brisinga endecacnemos*	0.03	0.01	0.05	0.01	99.99
Henricia sanguinolenta	0.01	0.01	0.05	0.01	100.00

Group ai

Average similarity: 61.28

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Unknown sp. 26	**2.70**	**34.64**	**3.31**	**56.53**	**56.53**
***Lophelia pertusa* (dead structure)**	**0.81**	**11.70**	**8.18**	**19.09**	**75.61**
Madrepora oculata	**0.45**	**6.09**	**3.62**	**9.93**	**85.55**
Lophelia pertusa	0.42	2.49	0.58	4.07	89.61
Actiniaria sp. 13	0.46	2.40	0.58	3.92	93.53
Edwardsiidae sp. 1	0.28	1.98	0.58	3.23	96.77
Halcampoididae sp. 1	0.32	1.98	0.58	3.23	100.00

Group aj

Average similarity: 54.00

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
***Lophelia pertusa* (dead structure)**	**0.55**	**30.59**	**3.35**	**56.65**	**56.65**
Halcampoididae sp. 1	**0.20**	**8.73**	**1.27**	**16.16**	**72.80**
Lophelia pertusa	**0.21**	**6.92**	**0.76**	**12.82**	**85.63**
Cerianthidae sp. 1	**0.24**	**6.16**	**0.77**	**11.40**	**97.03**
Madrepora oculata	0.17	1.60	0.26	2.97	100.00

Group ak

Average similarity: 66.33

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%

Halcampoididae sp. 5	**0.30**	**66.33**	**4.38**	**100.00**	**100.00**

Group al

Average similarity: 53.22

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Amphiuridae sp. 1	**0.62**	**40.91**	**2.56**	**57.53**	**57.53**
Cerianthidae sp. 1	**0.46**	**20.85**	**1.18**	**41.59**	**99.12**
Munida sarsi	0.05	0.34	0.13	0.64	99.76
Ophiuroidea sp. 5	0.02	0.05	0.05	0.08	99.84
Terebellidae sp. 1	0.01	0.03	0.03	0.05	99.89
Kophobelemnon stelliferum	0.01	0.02	0.02	0.03	99.93
Brachiopoda sp. 1	0.01	0.01	0.02	0.02	99.95
Pachycerianthus multiplicatus	0.01	0.01	0.02	0.02	99.97
Edwardsiidae sp. 1	0.01	0.01	0.03	0.02	99.99
Caryophyllia sp. 3	0.01	0.00	0.02	0.01	100.00

Group am

Average similarity: 47.39

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Ophiuroidea sp. 1	**1.12**	**46.57**	**2.13**	**98.27**	**98.27**
Amphiuridae sp. 1	0.07	0.48	0.14	1.01	99.28
Munida sarsi	0.02	0.07	0.05	0.15	99.43
Ophiactis balli	0.03	0.07	0.06	0.14	99.56
Cerianthidae sp. 1	0.02	0.05	0.06	0.10	99.67
Caryophyllia sp. 1	0.03	0.03	0.04	0.07	99.74
Serpulidae sp. 1	0.02	0.03	0.04	0.06	99.80
Porifera encrusting sp. 1	0.01	0.01	0.02	0.02	99.82
Ophiuroidea sp. 5	0.02	0.01	0.03	0.02	99.84
Kophobelemnon stelliferum	0.01	0.01	0.03	0.02	99.86
Actinauge richardi	0.01	0.01	0.02	0.02	99.88
Caryophyllia smithii	0.01	0.01	0.02	0.02	99.90
Leptometra celtica	0.01	0.01	0.02	0.01	99.91
Crinoidea sp. 5	0.01	0.01	0.02	0.01	99.92
Polychaeta sp. 7	0.00	0.00	0.01	0.01	99.93
Actiniaria sp. 17	0.01	0.00	0.01	0.01	99.94
Terebellidae sp. 1	0.01	0.00	0.01	0.01	99.94
Majidae sp. 1	0.00	0.00	0.01	0.01	99.95
Ophiothrix fragilis	0.01	0.00	0.01	0.01	99.96
Sagartiidae sp. 3	0.00	0.00	0.01	0.01	99.96
Cerianthidae sp. 3	0.01	0.00	0.01	0.01	99.97

Ophiactis abyssicola	0.01	0.00	0.01	0.01	99.97
Polychaeta sp. 5	0.01	0.00	0.01	0.00	99.98
Astropecten irregularis	0.00	0.00	0.01	0.00	99.98
Virgularia mirabilis	0.00	0.00	0.01	0.00	99.98
Paguridae spp.	0.00	0.00	0.01	0.00	99.99
Unknown sp. 15	0.00	0.00	0.01	0.00	99.99
Brachiopoda sp. 1	0.00	0.00	0.01	0.00	99.99
Caryophyllia sp. 2	0.00	0.00	0.01	0.00	99.99
Pandalus borealis	0.00	0.00	0.01	0.00	99.99
Polychaeta sp. 1	0.01	0.00	0.01	0.00	99.99
Pentametrocrinus atlanticus	0.00	0.00	0.01	0.00	99.99
Unknown sp. 13	0.00	0.00	0.01	0.00	99.99
Tubularia sp. 2	0.00	0.00	0.01	0.00	100.00

Group an

Average similarity: 49.67

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Crinoidea sp. 5	**0.39**	**45.53**	**2.16**	**91.66**	**91.66**
Stichopathes* cf. *gravieri	**0.12**	**4.14**	**0.44**	**8.34**	**100.00**

Group ao

Average similarity: 27.51

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Serpulidae sp. 1	**0.39**	**20.63**	**0.99**	**74.99**	**74.99**
Brachiopoda sp. 1	**0.11**	**4.52**	**0.26**	**16.42**	**91.40**
Munida sarsi	**0.12**	**1.57**	**0.23**	**5.69**	**97.10**
Caryophyllia smithii	0.05	0.63	0.14	2.28	99.38
Ophiuroidea sp. 1	0.03	0.10	0.06	0.36	99.73
Actinauge richardi	0.01	0.07	0.06	0.27	100.00

Group ap

Average similarity: 41.38

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Ophiuroidea sp. 5	**1.13**	**37.87**	**2.36**	**61.53**	**61.53**
Munida sarsi	**0.75**	**12.22**	**1.33**	**35.36**	**96.89**
Leptometra celtica	0.06	0.35	0.17	0.86	97.74
Amphiuridae sp. 1	0.07	0.25	0.12	0.62	98.36
Hydrozoa (bushy)	0.05	0.25	0.12	0.61	98.97
Serpulidae sp. 2	0.05	0.14	0.07	0.34	99.31
Paguridae spp.	0.04	0.10	0.13	0.25	99.55
Brachiopoda sp. 1	0.03	0.07	0.07	0.16	99.72

Echinus spp.	0.03	0.06	0.07	0.15	99.87
Cerianthidae sp. 1	0.03	0.05	0.07	0.13	100.00

Group aq

Average similarity: 33.11

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Munida sarsi	**0.31**	**28.05**	**1.21**	**84.74**	**84.74**
Leptometra celtica	**0.16**	**3.18**	**0.30**	**9.60**	**94.33**
Crinoidea sp. 5	0.07	0.89	0.18	2.70	97.03
Cerianthidae sp. 1	0.03	0.42	0.14	1.25	98.29
Caryophyllia smithii	0.03	0.20	0.08	0.61	98.90
Ophiuroidea sp. 1	0.03	0.13	0.08	0.38	99.28
Ophiactis balli	0.03	0.11	0.07	0.33	99.61
Caryophyllia sp. 2	0.02	0.05	0.04	0.15	99.76
Echinus spp.	0.01	0.03	0.03	0.08	99.84
Porifera encrusting sp. 31	0.01	0.02	0.03	0.07	99.90
Porifera encrusting sp. 3	0.01	0.01	0.03	0.04	99.94
Actinauge richardi	0.01	0.01	0.03	0.03	99.98
Ophiuroidea sp. 5	0.01	0.01	0.03	0.02	100.00

Appendix A2: Biotope descriptions for non-listed habitats defined from the SW Approaches

<u>cf. *Bathylasma* sp. and hydroid assemblage on bedrock</u>

The biotope Bat.Hyd, identified as cluster r, was characterised by barnacles (cf. *Bathylasma* sp.) and Hydrozoa (bushy) associated with steep bedrock outcrop towards the base of Explorer canyon at a depth of 902-912 m and a temperature of 8.99-9°C. Bat.Hyd assemblage was only observed for a short period during a single camera-transect.

Bathylasma is a widespread bathyal species in the NE Atlantic (Gage 1986). A number of assemblages have been described from the region; Pfannkuche et al. (2004) describe a *Bathylasma* cf. *hirsutum* assemblage associated with drop stones between 636-650 m water depth on a prominent escarpment feature in the Belgica mound province; however, Gage

(1986) describes a *Bathylasma hirsutum* assemblage with the brachiopod *Dallina septigera* and *Macandrevia cranium* from rocky, high current areas on the Wyville-Thomson Ridge and the summit of the Anton Dohrn Seamount in a water depth band ranging from 200-700 m. He also noted the remains of plates of *Bathylasma hirsutum* covering the substratum of the floor of a gorge between the Wyville-Thomson Ridge and Ymir ridge and suggested this species may cover the walls of this gorge. Howell et al. (2010b) describe an assemblage characterised by large barnacles (noted as possibly *Bathylasma hirsutum*) and brachiopods (noted as possibly *Dallina septigera*) on the summit of the Anton Dohrn Seamount at *approx*. 600 m water depth.

Amphiuridae ophiuroids and cerianthid anemones on bioturbated mud/sand

The biotope Amp.Cer, identified as cluster al, was characterised by occasional cerianthid anemones and amphiuridae sp.1 ophiuroids on bioturbated mud and sand and was observed throughout the canyons over a wide depth range of 184-943 m and temperature of 9.59-11.69°C associated with the canyon head, flanks and was also observed on from one transect on the continental shelf. Note, this assemblage has not been previously described from the deep sea.

Annelids, hydroids and cerianthids on bedrock ledges

The biotope Unk.Cer, identified as cluster ac, was characterised by cerianthid anemones, annelid worms and hydroid species associated with bedrock ledges. Ophiuroid species and the squat lobster *Munida sarsi* were also commonly observed. The biotope was observed from both Dangaard and Explorer canyons from the canyon head and incised channels (canyon floor) associated with bedrock ledges over a depth range of 238-1070 m and a temperature of 8.36-11.51°C. This kind of biotope has not been previously described in the deep sea.

Cerianthids on sediment draped bedrock

The biotope Cer, identified as cluster x, was characterised by cerianthid anemones associated with areas of bedrock covered with a sand veneer – thus preventing the attachment of fauna and acting as a soft sediment habitat. The assemblage was observed on wide range of geomorphological features including canyon head, flank, amphitheatre rims and incised channels. It was observed from the three canyons over a water depth and temperature range of 360-1064 m and 8.98-11.3°C, respectively. This assemblage has not been previously described from the deep sea. This assemblage has a similar distribution to the 'Cerianthid anemones on bioturbated mud/sand' biotope.

Burrowing (*Amphiura* sp.) and surface dwelling ophiuroids on mud/sand

The biotope Oph, identified as cluster am, was characterised by surface dwelling ophiuroids associated with soft sediment (mud-sand). Burrowing ophiuroids (*Amphiura* sp.) were also identified as being characteristic of this biotope from video observations. The assemblage was found on the flanks, incised channels and amphitheatre rims; and occurred in the three canyons at water depths of 184-1094 m and temperatures of 7.67-11.69°C. This assemblage has not been previously described from the deep sea.

Serpulids and brachiopods on mixed substratum

The biotope Ser.Bra, identified as cluster ao, was associated with cobble and pebble substratum with serpulid polychaetes (Serpulidae sp. 1) and brachiopods (Brachiopoda sp. 1) attached to the hard substratum and squat lobsters (*Munida sarsi*) associated with the surrounding soft sediment. The assemblage was observed only on the smooth flank of Dangaard canyon between 691-764 m and over a temperature range of 10.1-10.5°C.

The Ser.Bra assemblage is similar to that described by Howell et al. (2010b) as ‘brachiopods on mixed substrate’ which was widely observed between 266-803 m water depth on a number of features in UK waters. Narayanaswamy et al. (2006) also reported a similar assemblage from Anton Dohrn Seamount, where abundant brachiopods were associated with coarse sediment on the seamount summit.

Munida sarsi and *Leptometra celtica* on mixed substratum

The biotope Mun.Lep, identified as cluster aq, was associated with mixed and biogenic gravel (shell hash) substratum on the canyon head and interfluves features from all three canyons. It occurred over a wide depth and temperature range (183-792 m; 9.79-11.79°C) and was characterised by the crinoid *Leptometra celtica*, the squat lobster *Munida sarsi*. This assemblage occurred on the interfluves between the mini-mounds features and was also associated with tributary gullies.

Leptometra celtica were more abundant at the canyon heads and on the edge of the flanks, which suggests they are positioning themselves within optimal conditions for feeding. The occurrence of *Leptometra celtica* has been reported by a number of authors; Lavaleye et al. (2002) reported abundant crinoids at 190 m from the NW Iberian Margin and 200 m from the Goban Spur, and Flach et al. (1998) found the crinoid to be the dominant fauna at a station at 208 m water depth from the continental Shelf (Goban Spur).

Assemblage code	**Cluster**	**Assemblage name**	**Depth (m)**	**Temperature (°C)**	**Topographical Feature**	**Substratum**	**Canyon**
Bat.Hyd	r	cf. *Bathylasma* sp. and hydroid	902-912 m	8.99-9°C	Incised channel	Bedrock	Explorer
Kop.Cer	y	*Kophobelemnon stelliferum* and	463-1059	8.87-10.85°C	Flank and incised channel	Mud and muddy sand	Explorer, Irish
Cer	x	Cerianthids on sediment draped	360-1064	8.98-11.3°C	Canyon head, amphitheatre rims,	Bedrock with sand veneer	Explorer, Irish
Unk.Cer	ac	Annelids, hydroids and cerianthids on	238-1070	8.36-11.51°C	Canyon head and incised	Bedrock and bedrock with	Explorer and
Lop.Mad	ah	*Lophelia pertusa* reef	795-940 m	9.41-9.92°C	Flute feature	Coral framework	Explorer
Lop.Hal	aj	Predominantly dead low-lying	697-927 m	8.97-9.77°C	Flank and flute feature (end of	Coral rubble, bedrock and	Explorer and
Amp.Cer	al	Amphiuridae ophiuroids and	184-943 m	9.59-11.69°C	Flank, canyon head and	Mud and sand	Explorer, Irish
Oph	am	Burrowing (*Amphiura* sp.) and	184-1094	7.67-11.69°C	Flank, tributary gullies,	Mud and sand	Explorer, Irish
Ser.Bra	ao	Serpulids and brachiopods on	691-764 m	10.1-10.5°C	Flank	Mixed	Dangaard
Oph.Mun	ap	Ophiuroids and *Munida sarsi*	303-1017	7.98-11.5°C	Incised channels and	Biogenic gravel (coral	Explorer and
Mun.Lep	aq	*Munida sarsi* and *Leptometra celtica*	183-792 m	9.79-11.79°C	Interfluves and canyon head	Mixed, biogenic	Explorer, Irish
Lop.Cri	*	*L. pertusa* and crinoids on	253-1022	7.93-11.42°C	Incised channels, tributary gullies,	Bedrock	Explorer, Irish

Table 1: Summary of mapped biotope data, abiotic data extracted from video metadata, geomorphology and substratum extracted from ArcGIS 9.3 layers.* refers to the biotope described from the video footage.

Transect	Canyon	Start position	End position	Transect length (m)	# of images analysed	Average depth (m) (SD)	Average temperature (°C) (SD)	Topographical unit	Generalised seabed substrate
C_1_1	Irish	48.496292 -9.872838	48.48386 -9.872061	1382.6	62	847.3 (77.4)	9.47 (0.23)	Flank	Mud-rich sediments
C_1_2	Irish	48.560068 -9.834236	48.562948 -9.830817	407.6	13	294.2 (4.9)	11.36 (0.002)	Flank	Sandy gravel
C_1_3	Irish	48.569407 -9.841935	48.569343 -9.846046	300	12	379.5 (26.35)	11.29 (0.008)	Flank	Sand-rich sediments with bedrock cropping out where

									slope angle greatest (amphitheatre rim)
C_1_4	Irish	48.560629 -9.857881	48.562805 -9.861409	341.7	19	520.2 (103.6)	10.54 (0.07)	Flank	Bedrock cropping out where slope steepest. Gravel-rich sediments immediately down slope of the outcrop becoming mud dominated as water depths increase
C_2_1	Dangeard	48.42006 -9.57345	48.41612 -9.57048	488.8	25	298.3 (26.4)	11.46 (0.12)	Flank	Sand dominated sediments with increasing proportion of gravel in vicinity of slump headwall
C_2_2	Dangeard	48.40366 -9.54235	48.40192 -9.54559	308.1	18	652.7 (0.69)	10.34 (0.008)	Canyon head	Sand
C_2_3	Dangeard	48.39257 -9.57007	48.38936 -9.5751	513.6	31	776.1 (13.3)	9.85 (0.09)	Canyon head	Sand-rich sediments and gravelly sand. Bedrock cropping out where slope steepest
C_2_4	Dangeard	48.38358 -9.67091	48.38097 -9.66819	344.5	16	402.1 (3.63)	11.02 (0.03)	Flank	Gravelly sand
C_2_5	Dangeard	48.37245 -9.68566	48.36802 -9.68436	498.7	20	591.06 (26.42)	10.46 (0.2)	Flank	Mud-rich sediments
C_2_6	Dangeard	48.358798 -9.723825	48.35458 -9.721601	476.6	7	803.1 (21.12)	9.28 (1.89)	Flank	Mud-rich sediments
C_2_7	Explorer	48.3782 -9.77602	48.37945 -	468.7	17	756.3 (22.2)	9.79 (0.09)	Flank	Sand

			9.78212						
C_2_8	Explorer	48.44012 -9.68199	48.4446 -9.68242	496.7	18	917.6 (6.6)	9.26 (0.13)	Flank	Sandy gravel becoming sand dominated as water depths increase. Bedrock cropping out where slope steepest
C_2_9	Explorer	48.471652 -9.621832	48.473303 -9.625192	288.4	9	644.8 (129.29)	10.36 (0.43)	Flank	Sand
C_2_10	Explorer	48.482903 -9.574269	48.483972 -9.578344	317.5	14	463.1 (149.8)	10.78 (0.45)	Flank	Sand
C_2_11	Explorer	48.498926 -9.613132	48.494222 -9.608227	633.5	27	895.8 (4.6)	9.05 (0.03)	Flank	Bedrock cropping out where slope steepest. Sand and gravelly sand observed on the gully bottom
C_2_12	Explorer	48.513442 -9.504434	48.515962 -9.499202	472.5	24	274.7 (21.2)	11.26 (0.02)	Canyon head	Sand-rich sediments with increasing proportion of gravel upslope of gully wall where bedrock observed cropping out where slope steepest
C_2_13	Explorer	48.522986 -9.590885	48.519347 -9.591295	405.3	19	463.4 (76.5)	10.95 (0.18)	Canyon head	Sand-rich sediments. Bedrock cropping out where slope steepest
C_2_14	Explorer	48.477797 -	48.472027 -	669.1	39	839.2 (27.69)	9.83 (0.04)	Flank	Majority of substrate obscured

		9.656658	9.65408						by encrusting fauna. Bedrock occasionally observed
C_2_15	Explorer	48.468016 -9.736981	48.467249 -9.730129	512.9	15	533.7 (46.5)	10.61 (0.16)	Flank	Sand-rich sediments becoming mud-rich as water depths increase
C_2_16	Explorer	48.424931 -9.870741	48.422278 -9.875607	462.6	14	827.9 (42.57)	9.4 (0.21)	Flank	Mud-rich sediments
C_2_17	Explorer	48.452397 -9.80016	48.449009 -9.800205	373.1	15	463.2 (203.4)	10.81 (0.82)	Flank	Mud-rich sediments
C_2_18	Explorer	48.46419 -9.714515	48.460047 -9.716963	491.7	18	751.3 (32.02)	9.75 (0.002)	Flank	Mud-rich sediments. Bedrock cropping out in slump headwall
C_2_19	Explorer	48.496112 -9.643017	48.491418 -9.643671	519.6	16	684.2 (16.7)	10.16 (0.01)	Flank	Mud-rich sediments
C_2_20	Explorer	48.463347 -9.647097	48.466764 -9.650272	439.2	12	884.8 (38.4)	9.56 (0.04)	Canyon floor	Bedrock cropping out at sea bed.
C_2_21	Dangeard	48.425403 -9.609103	48.423773 -9.612227	286.6	14	257.9 (54.3)	11.52 (0.14)	Interfluve	Sand
C_2_22	Dangeard	48.397624 -9.649594	48.395215 -9.647836	297.9	16	334.8 (4.27)	11.17 (0.03)	Interfluve	Gravelly sand
C_2_23	Dangeard	48.346638 -9.779156	48.341737 -9.783882	599.7	26	769.8 (16.9)	9.71 (0.07)	Flank	Mud-rich sediments. Bedrock cropping out and increasing gravel content where slope steepest

C_2_24	Dangeard	48.376516 -9.639434	48.373696 -9.640584	321.9	11	746.2 (33.1)	9.61 (0.13)	Flank	Mud-rich sediments
C_2_25	Dangeard	48.377362 -9.60101	48.374678 -9.598054	353.7	10	750.4 (16.9)	9.8 (0.03)	Flank	Mud-rich sediments
C_2_26	Dangeard	48.438655 -9.483831	48.434266 -9.485687	471.4	24	318.8 (8.1)	11.5 (0.07)	Canyon head	Sand-rich sediments with bedrock cropping out where slope angle greatest in slump headwall
C_2_27	Explorer	48.575601 -9.483186	48.573985 -9.486711	313.1	15	187.8 (3.1)	11.68 (0.001)	Continental shelf	Sand
C_2_28	Explorer	48.554515 -9.537413	48.552849 -9.530352	551.1	27	260.7 (17.9)	11.4 (0.002)	Canyon head	Gravelly sand.Bedrock cropping out where slope steepest in gully wall
C_3_1	Dangeard	48.308271 -9.552125	48.310245 -9.554577	492.9	20	208.9 (2.3)	11.48 (1.91)	Interfluve	Gravelly sand with smaller sections of sandy gravel
C_3_2b	Dangeard	48.307334 -9.604809	48.311251 -9.601967	485.2	27	306.7 (0.75)	11.49 (0.001)	Interfluve	Gravelly sand. Sandy gravel over mini-mounds
C_3_3	Dangeard	48.401267 -9.455041	48.397704 -9.45152	474.3	18	240.2 (26.1)	11.5 (0.02)	Canyon head	Gravelly sand with bedrock cropping out where slope angle greatest in slump headwall
C_3_4	Dangeard	48.360553 -9.480041	48.361247 -9.483062	236.9	9	240 (1.14)	11.37 (0.01)	Canyon head	Sandy gravel and gravelly sand with bedrock cropping out where

									slope angle greatest (amphitheatre rim)
C_3_5	Dangeard	48.362028 -9.497481	48.359728 -9.498505	251.4	13	389.8 (13.9)	11.01 (0.29)	Canyon head	Sand with bedrock cropping out where slope angle greatest.
C_3_6	Dangeard	48.36122 -9.555971	48.36202 -9.558434	178.7	23	976.3 (10.6)	7.917 (0.14)	Canyon floor	Bedrock cropping out at sea bed with veneer of sand- and gravel-rich sediments in places
C_3_7	Dangeard	48.29185 -9.64142	48.29685 -9.64276	564.1	27	352.8 (0.82)	11.19 (0.02)	Interfluve	Gravelly sand. Sandy gravel over mini-mounds
C_3_8	Dangeard	48.33173 -9.63122	48.33523 -9.6355	498.4	23	536.1 (55.6)	10.91 (0.12)	Flank	Sand
C_3_9	Dangeard	48.31193 -9.70631	48.3163 -9.70437	506.1	17	722.6 (38.1)	10.16 (0.11)	Flank	Sand
C_3_10	Dangeard	48.30147 -9.73274	48.30583 -9.73504	511.7	26	799.4 (52.4)	10.11 (0.15)	Flank	Sand
C_3_11	Dangeard	48.28054 -9.74772	48.2812 -9.75445	501.6	25	724 (22.12)	10.27 (0.17)	Flank	Gravelly sand
C_3_12	Dangeard	48.347194 -9.534032	48.352059 -9.534006	537	23	774.5 (57.9)	9.71 (0.13)	Canyon head	Bedrock cropping out at sea bed with veneer of mud-rich sediments in places

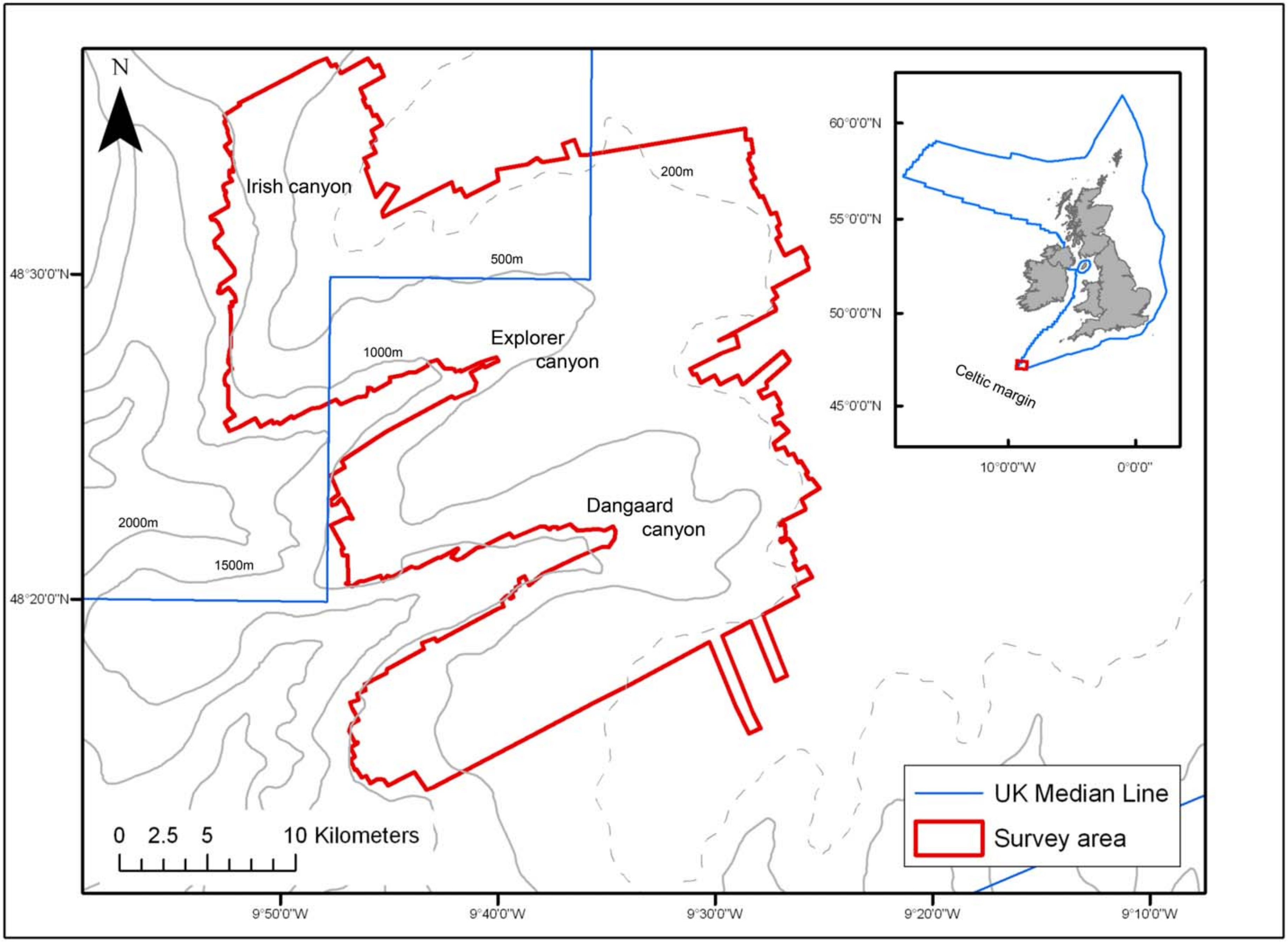
Table A1: Transects undertaken in the SW Approaches canyons: transect code, site (canyon), start and end of transect, length, number of statistical images analysed per transect, average depth and temperature (standard deviation) per transect, topographical feature sampled by transect and generalised seabed substrate within transects.

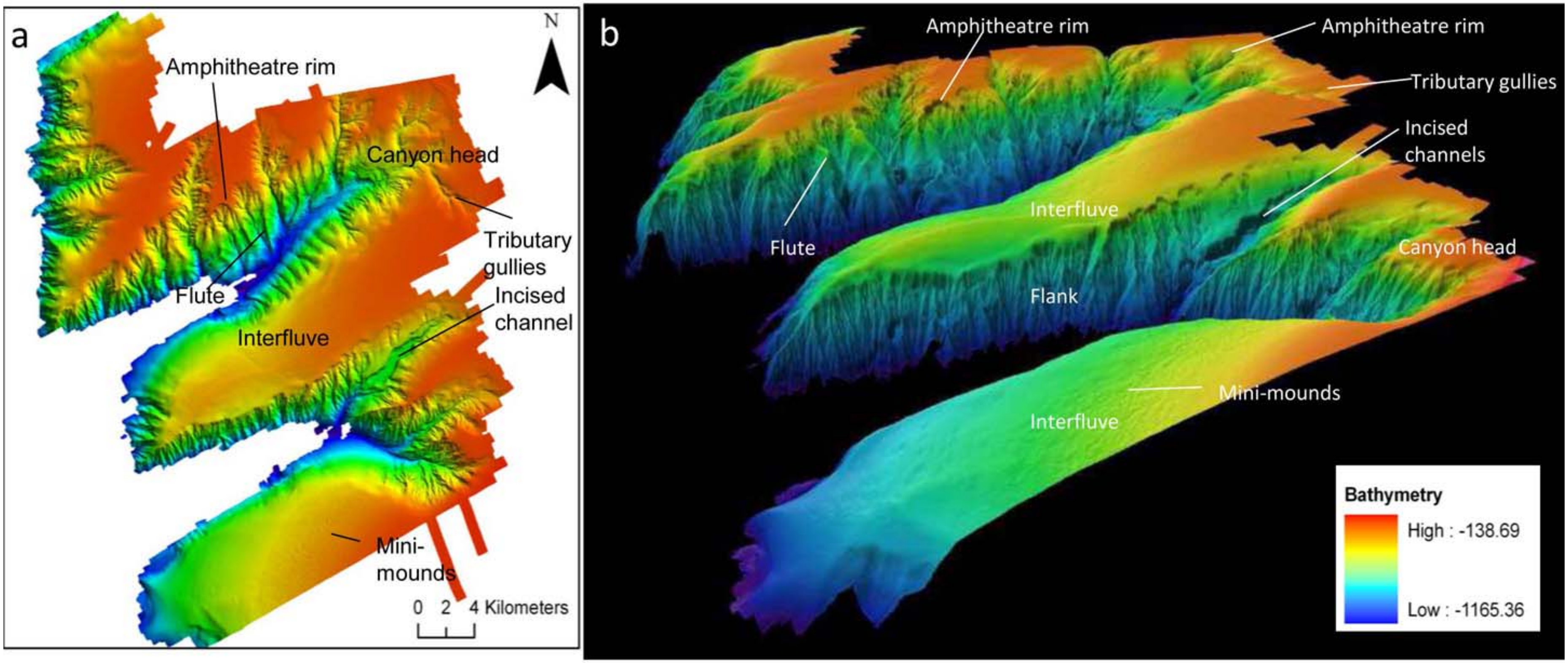
Cluster	No. images	Useful mapping unit	SIMPER similarit	Temp range (°C)	Average Temp (SD)	Depth range	Average Depth (SD)	Characterising species
a	2	N	0	9.6-11.3	10.487 (1.21)	316-840	578 (370.5)	
b	1	N		11.54	11.546	256	256	
c	2	N	42.26	10.4-11.7	11.118 (0.90)	210-695	452.5 (342.9)	Sabellidae sp. 1
d	1	N		9.252	9.252	850	850	
e	1	N		11.49	11.496	309	309	
f	3	N	100	9.0-10.4	9.951 (0.80)	508-866	694.3 (151.3)	*Benthogone* sp.
g	1	N		11.49	11.497	311	311	
h	1	N		11.54	11.542	256	256	
i	1	N		10.00	10.007	788	788	
j	1	N		9.91	9.91	762	762	
k	3	N	25.93	9.7-10.4	9.970 (0.38)	602-755	695.6 (82.1)	*Protoptilum* sp., *Pseudarchaster*
l	4	N	68.45	11.22-	11.388 (0.23)	212-401	342.5 (88.6)	Edwardsiidae sp. 1
m	3	N	44.15	8.8-9.1	9.02 (0.12)	885-1006	947.3 (60.5)	Halcampoididae sp. 3, Unknown
n	2	N	49.42	11.549	11.549	321-323	322 (1.4)	Unknown sp. 15

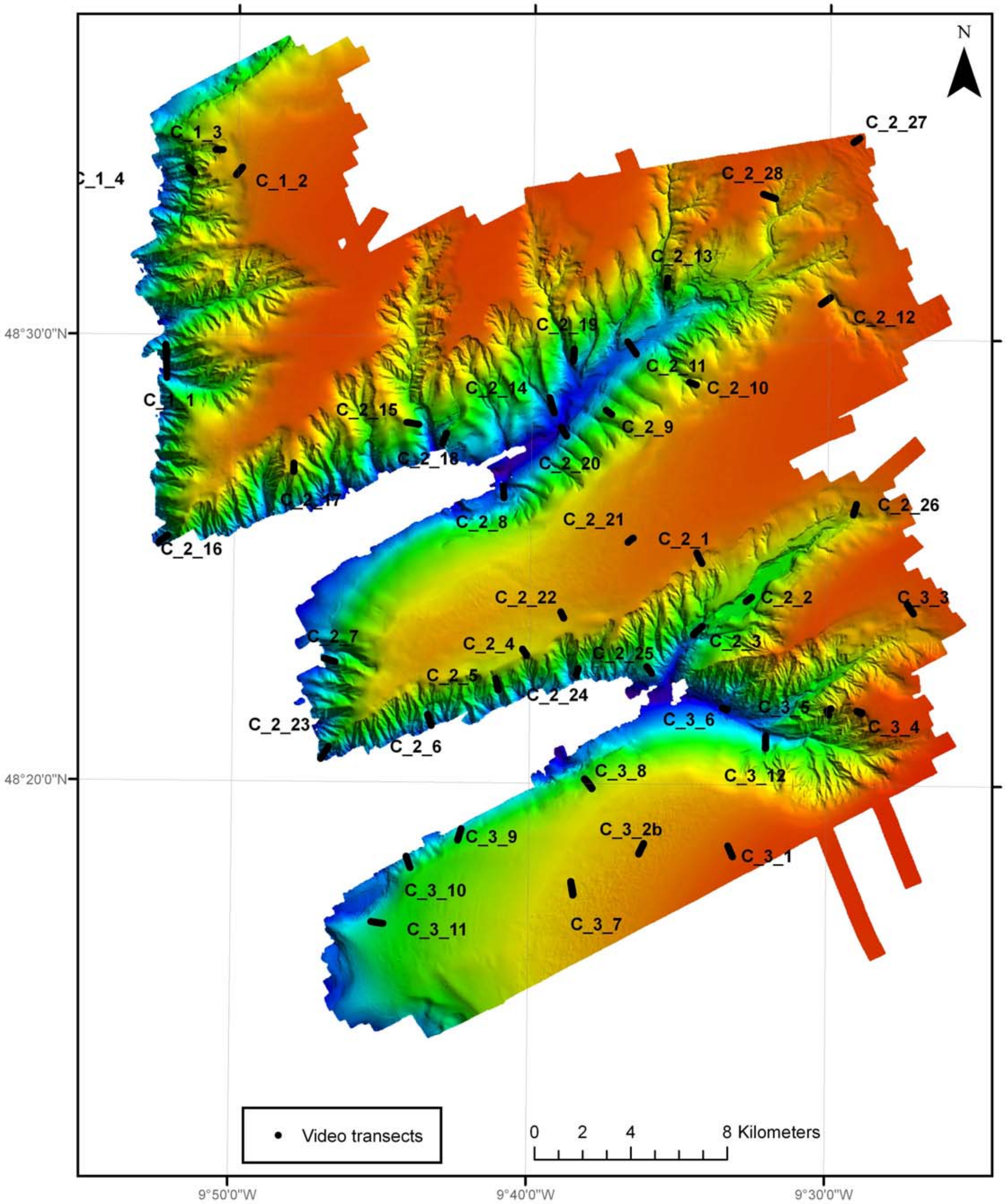
o	16	N	50.48	9.3-10.2	9.732 (0.24)	714-928	800.6 (51.7)	Sagartiidae sp. 3
p	6	N	18.04	8.9-11.1	10.499 (0.83)	331-1059	596.5 (249.7)	Actiniaria sp. 14, Cerianthidae sp. 3
q	11	N	10.73	7.7-11.6	10.465 (1.24)	185-1009	543 (305.4)	*Caryophyllia* sp. 2, Porifera encrusting sp. 1, Hydrozoa (flat branched)
r	7	Y	25.07	8.9-11.6	10.062 (1.32)	190-909	625.7 (341.4)	cf. *Bathylasma* sp., Hydrozoa (bushy)
s	9	N	14.78	10.3-11.4	11.11 (0.47)	238-800	407 (222.8)	Terebellidae sp. 1, Actiniaria sp. 17
t	2	N	38.99	9.2-9.7	9.745 (0.03)	729-782	755.5 (37.4)	Amphipoda sp. 1
u	4	N	20.08	8.1-10.1	9.379 (0.94)	741-1015	852.5 (122.6)	*Colus* sp. 2
v	3	N	49.37	10.5-11.3	11.026 (0.43)	378-601	452.6 (128.4)	*Pachycerianthus multiplicatus*, Cerianthidae sp. 1
w	1	N		11.174	11.174	333	333	
x	49	Y	54.39	9.0-11.5	9.922 (0.59)	308-954	738.6 (164.7)	Cerianthidae sp. 1
y	39	Y	49.80	9.1-10.3	9.544 (0.29)	609-953	836.7 (89.3)	*Kophobelemnon stelliferum*, Cerianthidae sp. 1
z	23	N	41.11	8.0-11.5	10.31 (1.20)	295-1054	615.6 (288.2)	*Ophiactis balli*
aa	1	N		9.599	9.599	938	938	
ab	3	N	31.57	8.0-9.8	9.207 (1.01)	781-1012	869 (124.9)	Sabellidae sp. 2
ac	46	Y	47.47	7.7-10.7	9.294 (0.82)	316-1048	829.7 (166.7)	Unknown sp. 26, Cerianthidae sp. 1

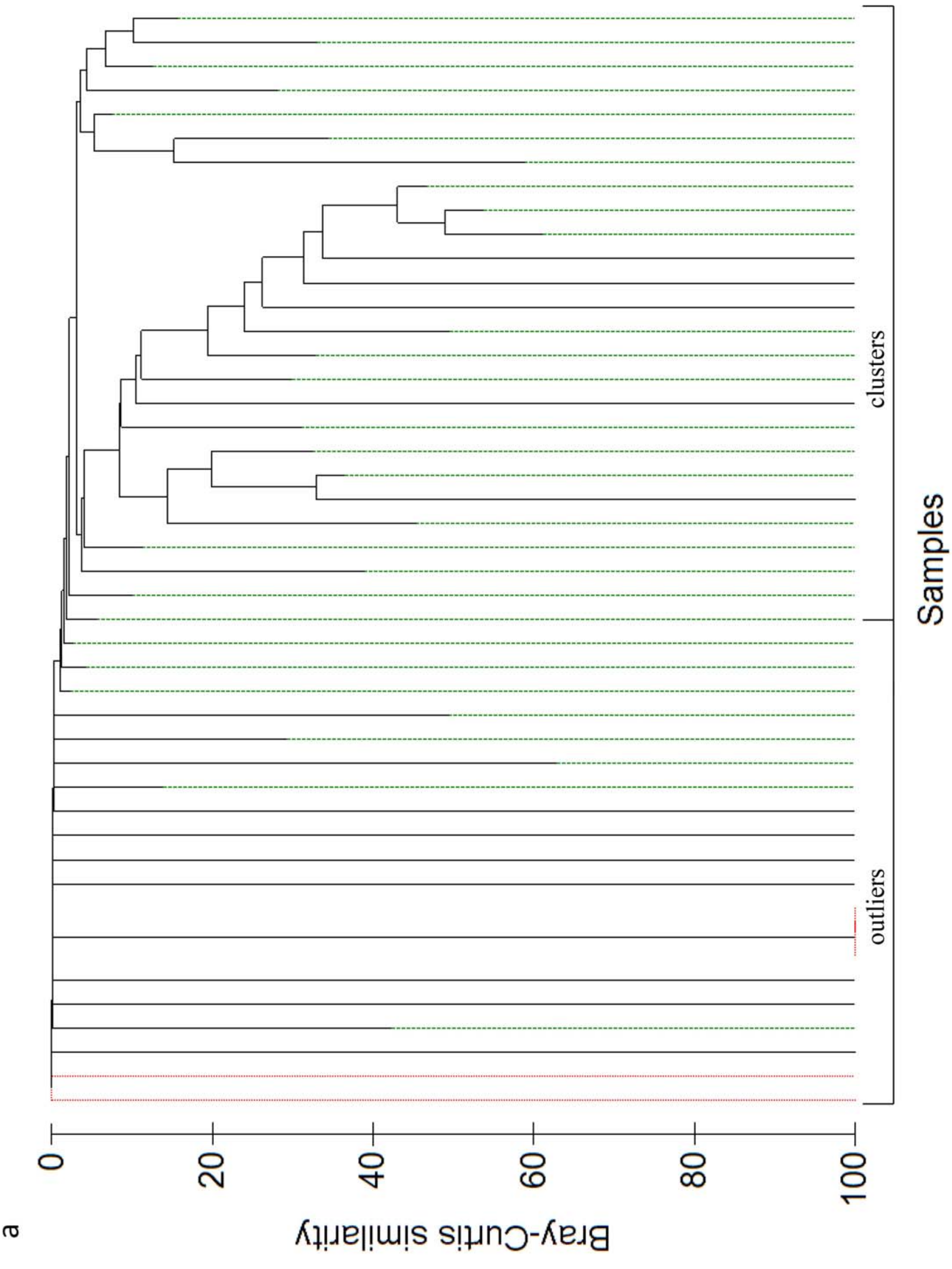
ad	6	N	59.02	9.0-11.7	9.517 (1.06)	184-942	778.8 (294.2)	*Lophelia pertusa* (dead structure)
ae	1	N		9.763	9.763	699	699	
af	1	N		9.878	9.878	798	798	
ag	1	N		9.011	9.011	874	874	
ah	30	Y	66.25	9.5-9.9	9.780 (0.09)	797-938	860.9 (43.7)	*Lophelia pertusa* (dead structure), *Lophelia pertusa*, *Madrepora oculata*, Unknown
ai	3	N	61.28	9.5-9.7	9.646 (0.08)	914-936	922.3 (11.9)	Unknown sp. 26, *Lophelia pertusa* (dead structure), *Madrepora oculata*
aj	7	Y	54.00	9.0-9.8	9.377 (0.39)	816-942	894.6 (55.6)	*Lophelia pertusa* (dead structure), Halcampoididae sp. 1, *Lophelia pertusa* Cerianthidae
ak	3	N	66.33	9.7-11.3	10.523 (1.09)	417-782	640.3 (195.7)	Halcampoididae sp. 5
al	71	Y	53.22	7.6-11.5	10.163 (0.98)	254-1008	654.3 (218.9)	Amphiuridae sp. 1, Cerianthidae sp. 1
am	276	Y	47.39	8.9-11.8	10.803 (0.64)	205-1021	477.3 (195.37)	Ophiuroidea sp. 1
an	6	N	49.67	10.5-11.4	10.988 (0.38)	257-600	433.1 (159.6)	Crinoidea sp. 5, *Stichopathes* cf. *gravieri*
ao	24	Y	27.51	9.4-11.8	10.943 (0.68)	189-803	464.1 (214.9)	Serpulidae sp. 1, Brachiopoda sp. 1, *Munida sarsi*
ap	20	Y	41.38	9.6-11.6	10.926 (0.73)	252-791	423.9 (212.9)	Ophiuroidea sp. 5, *Munida sarsi*
aq	51	Y	31.11	9.0-11.7	11.303 (0.40)	192-825	326.4 (124.0)	*Munida sarsi*, *Leptometra celtica*

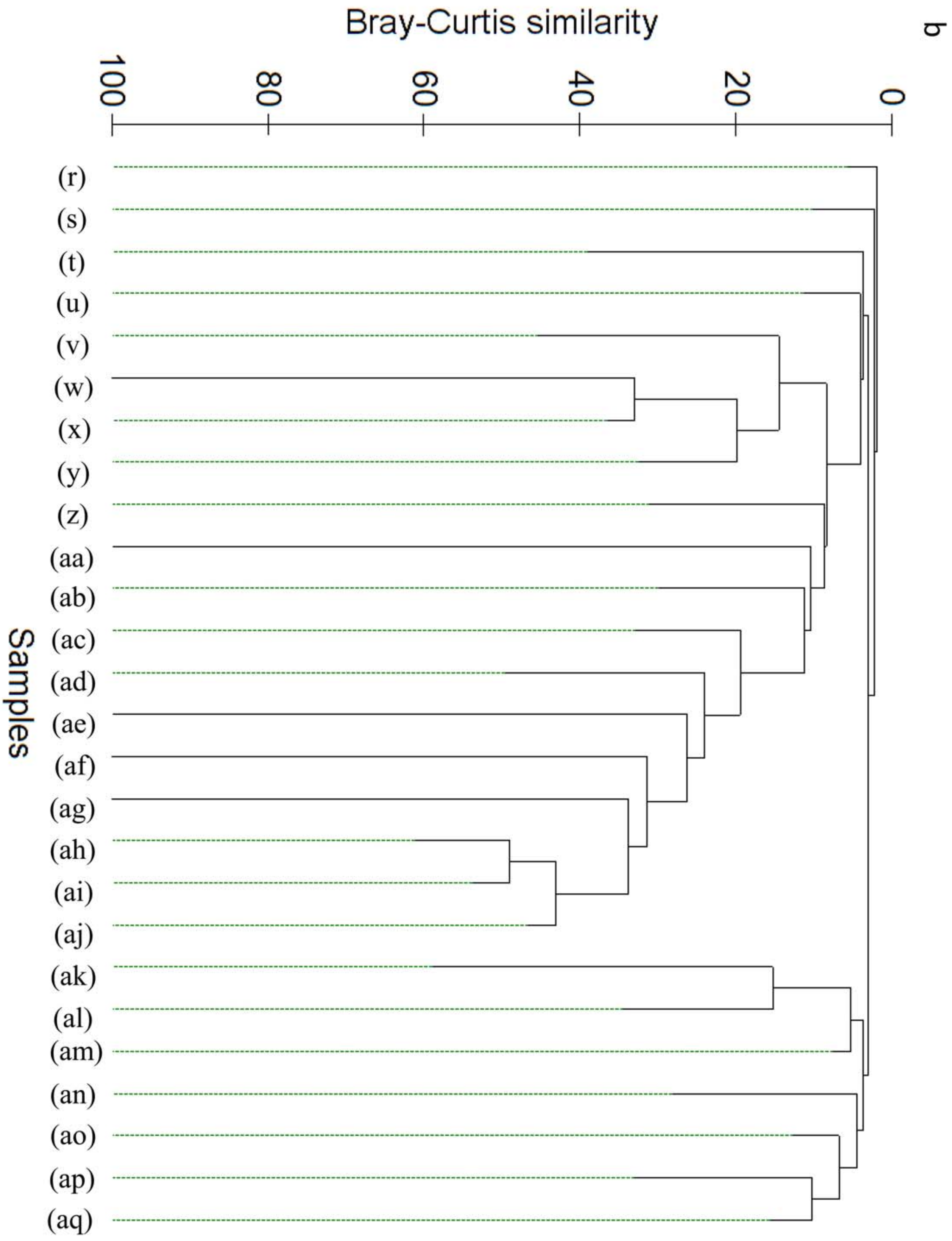
Table A2: Clusters identified from multivariate hierarchical analysis with associated environmental parameters, and SIMPER results identifying the taxa that characterise the clusters.

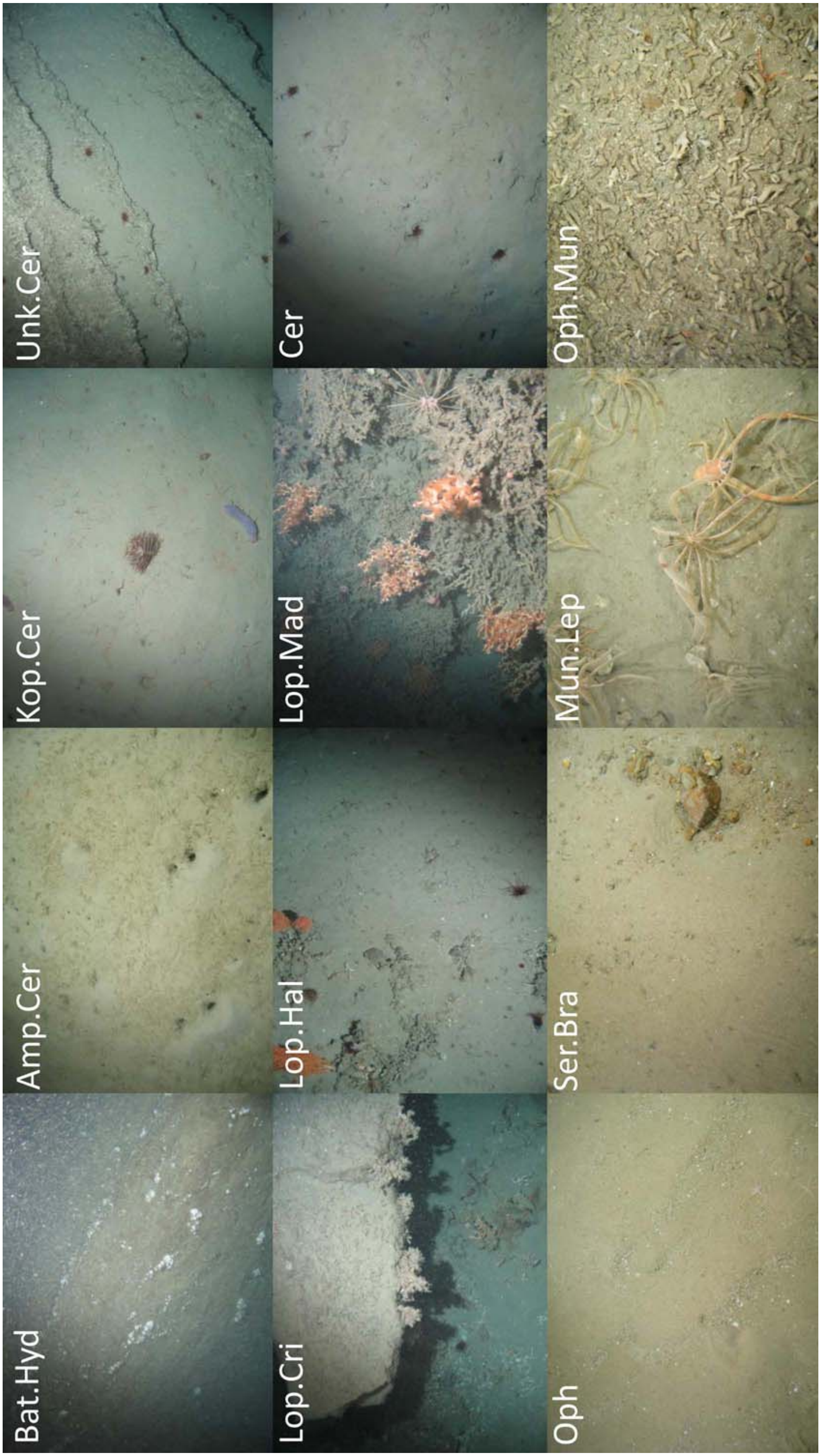

N
Irish canyon
Explorer canyon
Dangaard canyon
200m
500m
1000m
1500m
2000m
48°30'0"N
48°20'0"N
9°50'0"W
9°40'0"W
9°30'0"W
9°20'0"W
9°10'0"W
0 2.5 5 10 Kilometers
60°0'0"N
55°0'0"N
50°0'0"N
45°0'0"N
10°0'0"W
0°0'0"
Celtic margin
UK Median Line
Survey area

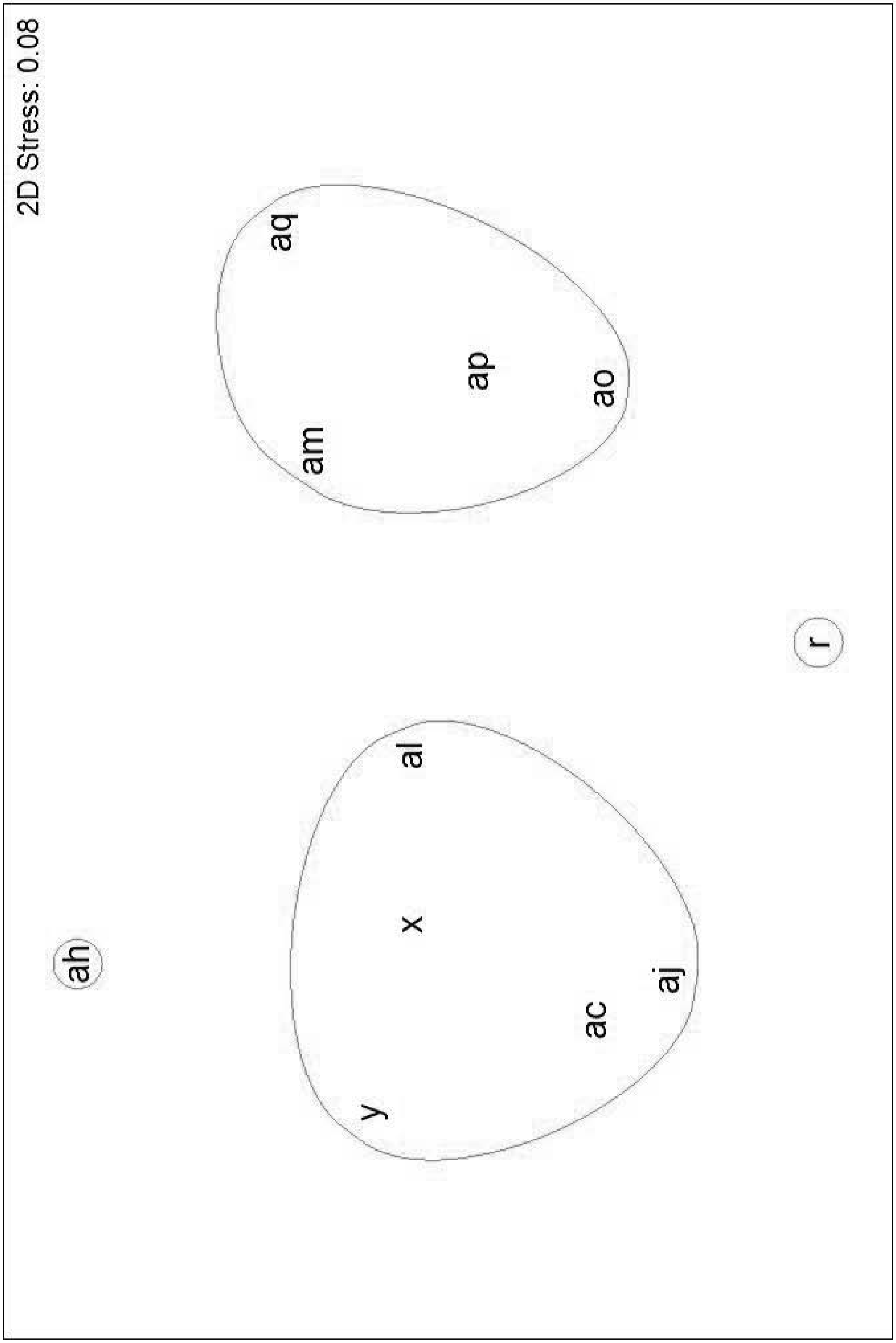

a
N
Amphitheatre rim
Canyon head
Tributary gullies
Flute
Incised channel
Interfluve
Mini-mounds
0 2 4 Kilometers
b
Amphitheatre rim
Amphitheatre rim
Tributary gullies
Incised channels
Interfluve
Flute
Canyon head
Flank
Mini-mounds
Interfluve
Bathymetry
High : -138.69
Low : -1165.36

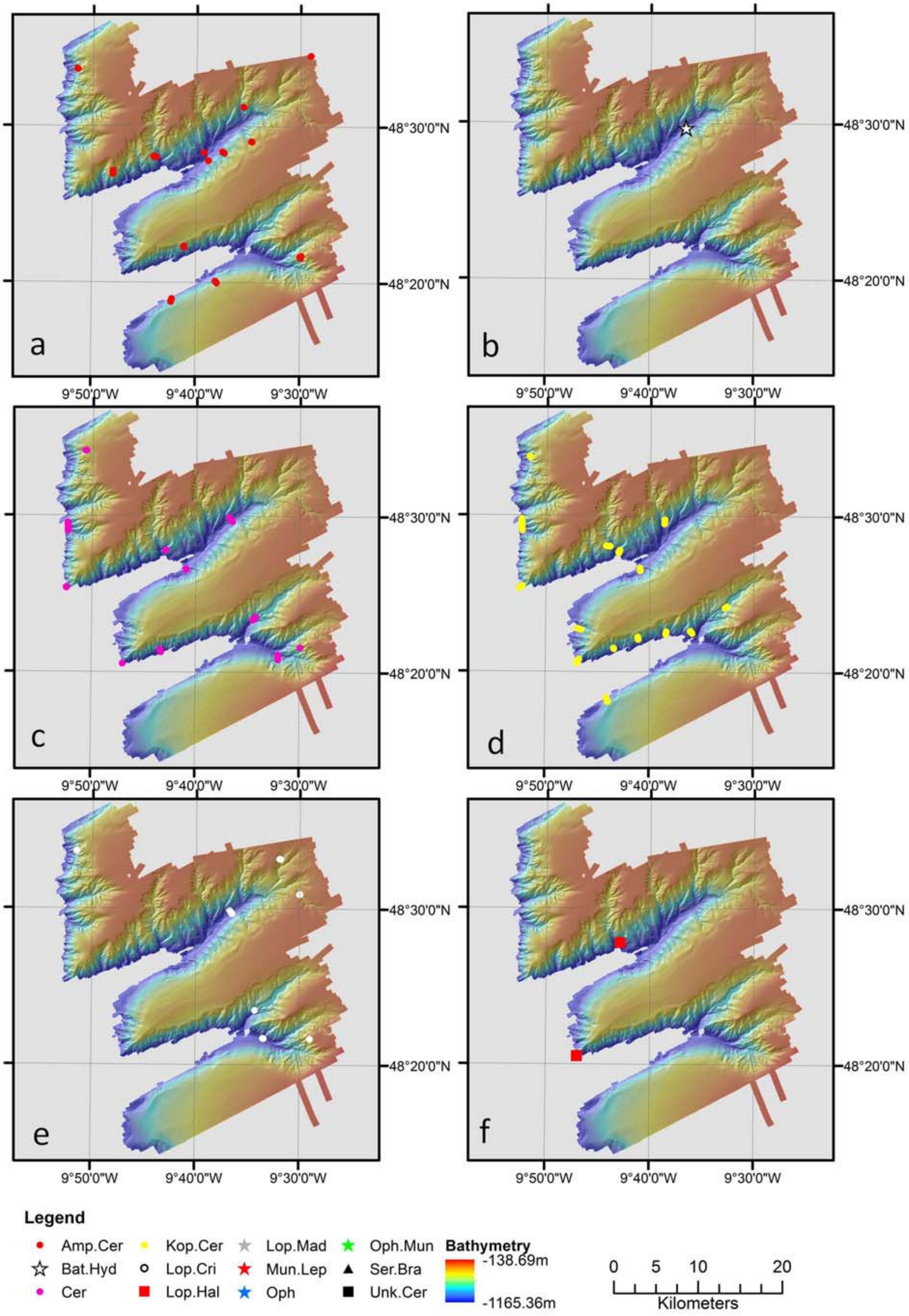

N
C_1_3
C_1_4
C_1_2
C_2_27
C_2_28
C_2_13
C_2_12
C_2_19
C_2_11
C_2_10
C_2_14
C_1_1
C_2_15
C_2_9
C_2_18
C_2_20
C_2_17
C_2_8
C_2_21
C_2_26
C_2_1
C_2_16
C_2_22
C_2_2
C_3_3
C_2_7
C_2_4
C_2_3
C_2_25
C_2_5
C_2_24
C_3_5
C_3_6
C_3_4
C_2_23
C_2_6
C_3_8
C_3_12
C_3_9
C_3_2b
C_3_1
C_3_10
C_3_7
C_3_11
48°30'0"N
48°20'0"N
9°50'0"W
9°40'0"W
9°30'0"W
● Video transects
0 2 4 8 Kilometers

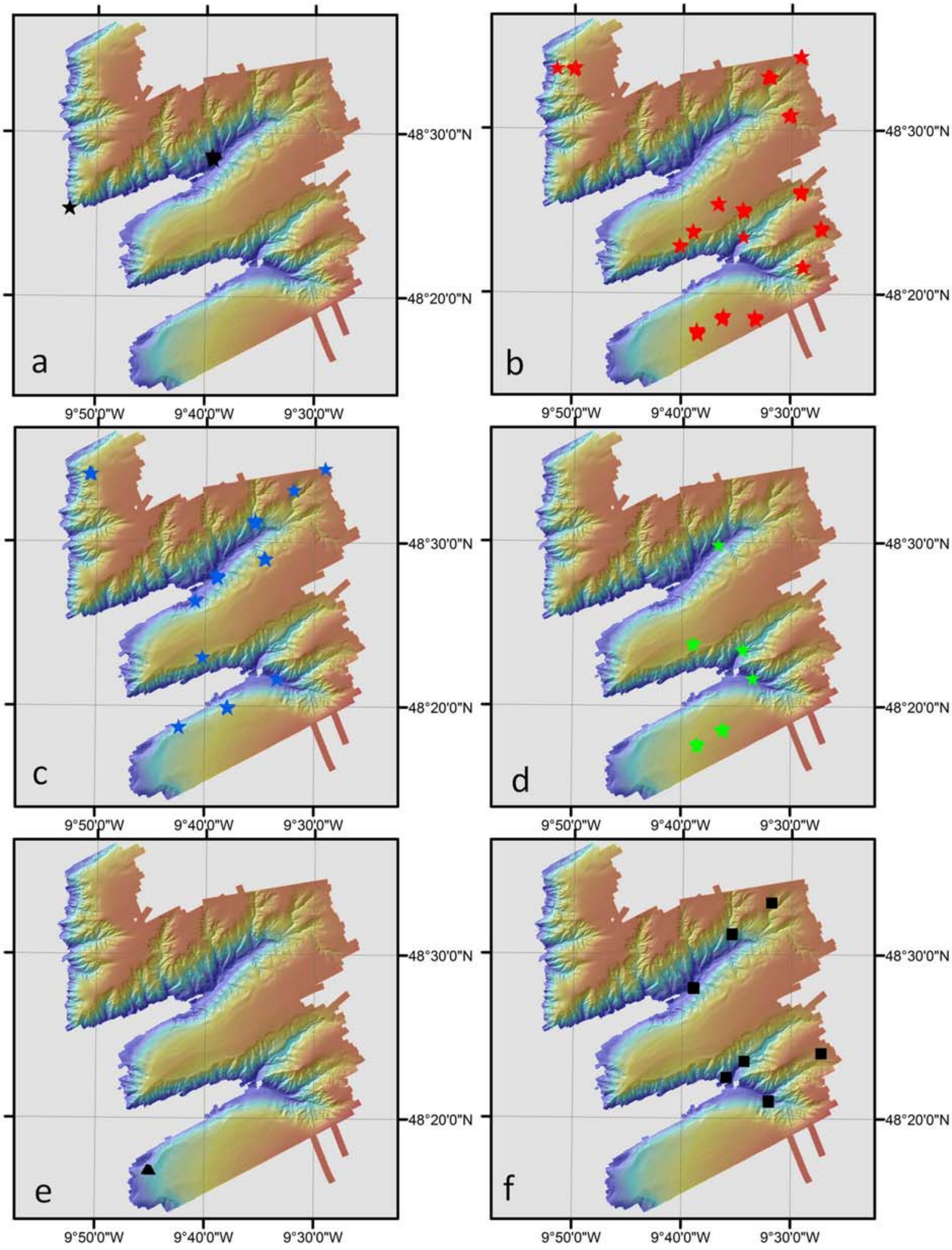

a
Bray-Curtis similarity
0
20
40
60
80
100
outliers
clusters
Samples


b
Bray-Curtis similarity
100
80
60
40
20
0
Samples
(r)
(s)
(t)
(u)
(v)
(w)
(x)
(y)
(z)
(aa)
(ab)
(ac)
(ad)
(ae)
(af)
(ag)
(ah)
(ai)
(aj)
(ak)
(al)
(am)
(an)
(ao)
(ap)
(aq)


Oph.Mun
Mun.Lep
Ser.Bra
Oph
Cer
Lop.Mad
Lop.Hal
Lop.Cri
Unk.Cer
Kop.Cer
Amp.Cer
Bat.Hyd


2D Stress: 0.08
aq
ap
ao
am
r
al
x
ah
aj
ac
y


a
b
c
d
e
f
48°30'0"N
48°20'0"N
9°50'0"W
9°40'0"W
9°30'0"W
Legend
● Amp.Cer
☆ Bat.Hyd
● Cer
● Kop.Cer
○ Lop.Cri
■ Lop.Hal
★ Lop.Mad
★ Mun.Lep
★ Oph
★ Oph.Mun
▲ Ser.Bra
■ Unk.Cer
Bathymetry
-138.69m
-1165.36m
0
5
10
20
Kilometers


a
b
c
d
e
f
48°30'0"N
48°20'0"N
9°50'0"W
9°40'0"W
9°30'0"W