JNCC Report

No: 530

A Deep-sea Section for the Marine Habitat Classification of Britain and Ireland v15.03

M.E.V. Parry[1], K.L. Howell[2], B.E. Narayanaswamy[3], B.J. Bett[4], D.O.B. Jones[4], D.J. Hughes[3], N. Piechaud[2], T.D. Nickell[3], H. Ellwood[1], N. Askew[1], C. Jenkins[1] and E. Manca[1]

[1]JNCC; [2]University of Plymouth; [3]Scottish Association for Marine Science; [4]Biogeochemistry & Ecosystems, National Oceanography Centre.

March 2015

ISSN 0963 8901

For further information please contact:

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

This report should be cited as:

Parry, M.E.V., Howell, K.L., Narayanaswamy, B.E., Bett, B.J., Jones, D.O.B., Hughes, D.J., Piechaud, N., Nickell, T.D., Ellwood, H., Askew, N., Jenkins, C. & Manca, E. 2015. A Deep-sea Section for the Marine Habitat Classification of Britain and Ireland. *JNCC report* No. 530 Joint Nature Conservation Committee, Peterborough

Contents

Summary

This report has been produced to accompany the release of the JNCC Marine Habitat Classification for Britain and Ireland Version 15.03 which has been published on the JNCC website[1]. Version 15.03 of the JNCC Classification replicates the previous Version 04.05 (Connor *et al* 2004), which covers the littoral zone to the deep-circalittoral zone (<200m as a rule of thumb), but adds a new deep-sea section. This report describes the process by which the deep-sea section was developed, defines categories for each characterising variable used and discusses why they were selected, and outlines the final full structure of the deep-sea section. The deep-sea section has been added to the classification hierarchy[2] and full deep-sea habitat descriptions are available by selecting the habitat name from this page. As well as reviewing this report, users of Version 15.03 should refer to Connor *et al* (2004) which provides more general information about the background behind the classification, how the shallower section was developed, and how to use the classification.

The deep-sea section comprises the following levels:

Level 1	**Environment**: Marine
Level 2	**Biological zone** (biogeographic region and vertical zone): Atlantic upper bathyal, mid bathyal, lower bathyal, upper abyssal, mid abyssal, lower abyssal Arctic mid bathyal, lower bathyal, upper abyssal Atlanto-Arctic upper bathyal
Level 3	**Substratum**: Rock and other hard substrata, mud, sand, coarse sediment, mixed sediment, biogenic substrate
Level 4	**Broad community**
Level 5	**Biological assemblage**

IMPORTANT

Version 15.03 of the classification which includes the deep-sea section supersedes versions 04.05, 97.06 and 03.02.
Users of the classification must ensure they state which version has been used in any reports, data interpretation or field survey.
Version 15.03 should be referenced as both Connor *et al* (2004) and Parry *et al* (2015) (this report).

[1] jncc.defra.gov.uk/MarineHabitatClassification
[2] jncc.defra.gov.uk/marine/biotopes/hierarchy.aspx

1 Introduction

The current Marine Habitat Classification for Britain and Ireland v04.05 (Connor *et al* 2004) (hereafter referred to as the JNCC classification) describes seabed habitats from the intertidal zone down to depths of c.200m. It has become a priority to develop a deep-sea section to allow deep-sea survey data acquired by JNCC and Statutory Nature Conservation Bodies (SNCBs) to be assigned a biotope. This should help prevent numerous new biotopes being proposed independently for similar data and, as such, losing cohesion within the classification community. The deep-sea section is available for all users of the JNCC classification including the private sector. This report has been produced to accompany the release of the JNCC Marine Habitat Classification for Britain and Ireland Version 15.03 which has been published on the JNCC website[3]. Version 15.03 of the JNCC Classification replicates the previous Version 04.05 (Connor *et al* 2004) which covers the littoral zone to the deep-circalittoral zone (<200m as a rule of thumb), but adds a new deep-sea section.

This paper will outline categories for environmental factors, broad community types and specific biological assemblages to be used in the classification of deep-sea habitats. The deep-sea classification outlined in this paper builds on previous work undertaken at a EUNIS deep-sea workshop held at Plymouth University in April 2010, work undertaken at the National Oceanography Centre (NOC), Southampton to assign biotopes to deep-sea grab data from the Faroe-Shetland Channel region (Bett 2012), and two unpublished JNCC papers (Jenkins 2012; Parry 2013), which considered options for the overall structure of a deep-sea classification. The proposed broad communities and biotopes have been developed as a result of two contracts run by JNCC to look at patterns in infaunal and epifaunal deep-sea communities (Nickell *et al* 2013; Piechaud & Howell 2013). Broad trends identified in these contracts have also guided proposed categories for environmental factors. The final deep-sea section was agreed following a further expert workshop at JNCC in April 2014, and this paper has been reviewed by a wider group of deep-sea specialists[4].

It is hoped that the new deep-sea biotopes will be considered for inclusion in the upcoming revision of EUNIS to ensure classification within the UK is consistent with the approach taken at the European scale.

This report describes the process by which the deep-sea section was developed, defines categories for each characterising variable used in the classification and discusses why they were selected, and outlines the final full structure of the deep-sea section. In addition to this report, the full deep-sea biotope descriptions will be made available on the JNCC website[5].

2 Approach and methods used

JNCC has been building on lessons learnt from existing classification systems to develop a new deep-sea section for the Marine Habitat Classification for Britain and Ireland. The process undertaken for this work is discussed here.

2.1 Review of the existing EUNIS deep-sea section

The EUNIS habitat classification system[6] is frequently used by JNCC to report on habitats for European commitments. The Marine Strategy Framework Directive and its requirement

---

[3] jncc.defra.gov.uk/MarineHabitatClassification
[4] Deep-sea specialists from the following institutions undertook the review: University of Plymouth; Scottish Association for Marine Science (SAMS); National Oceanography Centre, Southampton (NOCS).
[5] http://jncc.defra.gov.uk/marine/biotopes/hierarchy.aspx
[6] European Nature Information System habitat classification: http://eunis.eea.europa.eu/habitats.jsp

for consistent broad-scale seabed maps for European waters mean that EUNIS is now receiving increased attention. The current deep-sea section of EUNIS (Box 1) has received some criticism from the scientific community for a number of reasons; the vast expanse of deep sea is not sub-divided into biological zones as is the case for shallower waters, level 3 includes categories for large geomorphological features (e.g. deep-sea trenches) at the same level as substrate types, and there are only six biotopes defined in the whole section (Galparsoro *et al* 2012; Howell 2010). Considering this feedback, the deep-sea section from EUNIS has not been replicated in the JNCC Classification and, instead, a new section has been developed taking into account these lessons learnt.

A revision of the structure of the whole marine part of EUNIS, including the deep-sea section, is planned over the next 1-2 years. A preliminary revised structure for the upper 3 levels of marine EUNIS was developed at a workshop held by the European Environment Agency (EEA) in November 2013. This latest version of EUNIS marine may be altered further during a review process undertaken in 2014 and is therefore not yet publicly available; however, the structure of the deep-sea section of the JNCC classification has been developed to be compatible with the likely new structure of EUNIS based on discussions at the workshop.

Box 1: Existing EUNIS deep-sea section

A deep-sea section was developed for the EUNIS classification (Davies & Moss 2004) following a workshop with the Scottish Association for Marine Science (SAMS) and the National Oceanographic Centre (NOC) in 2000. The overall structure of the current EUNIS deep-sea section is summarised in Table 2.1. All areas deeper than 200m are grouped under a single zone 'deep sea bed'. User feedback on the current EUNIS deep-sea section was considered when developing the new deep-sea section for the JNCC classification.

Table 2.1: Summary of the existing deep-sea section of the EUNIS classification.

Level 1 Environ-ment	Level 2 Broad biological zone	Level 3 Substratum/feature	Level 4 More specific substratum/biology/ feature	Level 5 Biological community/details on feature
Marine	Deep sea bed	Rock and artificial hard substrata	e.g. Deep-sea bedrock, communities of deep-sea corals, oceanic ridges	e.g. Deep-sea *Lophelia pertusa* reefs, active vent fields
		Mixed substrata		
		Sand		
		Muddy sand		
		Mud		
		Bioherms		
		Raised features of the deep-sea bed		
		Deep-sea trenches and canyons, channels, slope failures and slumps on the continental slope		
		Vents, seeps, hypoxic and anoxic habitats of the deep sea		

2.2 Development of an overall structure

An options paper was produced by JNCC (Jenkins 2012 - unpublished report) to outline various proposals for the structure of the upper levels of a deep-sea section using work undertaken by Howell (2010) (Box 2) as a basis. Following on from this options paper, a preliminary structure for the upper levels of the deep-sea section was proposed (Parry 2013

– unpublished report). The draft proposal outlined which variables should be used to define each level of the deep-sea classification and suggested categories for defining environmental variables. The specific categories used at each level were refined taking into consideration results from data analysis (see Section 2.3) and feedback from deep-sea experts. The structure was reviewed a final time and revised slightly to make it more compatible with the existing shallower part of the JNCC classification.

Box 2: Past deep-sea biotope work: proposed deep-sea classification structure for the NE Atlantic

Howell (2010) proposed a structure for a deep-sea classification covering the NE Atlantic based on evaluation of the suitability of various environmental factors (Table 2.2). The proposed structure incorporated biogeography (level 1), biological zones (level 2), substratum (level 3) and biology (level 4), with bioherms separated from other types at level 1. Vents and seeps were not included in this classification as a separate category. The reasoning behind the inclusion of certain factors and not others is discussed further in the referenced literature. Biological communities included at level 4 (Howell *et al* 2010) were identified using mostly SEA7 part 2 data and some JNCC deep-sea survey data collected in the Faroe-Shetland Channel, Hatton Bank, Rosemary Bank Seamount, Wyville Thomson Ridge and the South-west Canyons. Biotopes described only the epifaunal component of the community as they were based on video data. In 2012 a deep-sea EUNIS workshop was held at Plymouth University to identify where the defined biotopes have been recorded elsewhere in Europe, and highlight any additional biotopes. Attendees from across Europe brought relevant datasets for discussion. Howell has since expanded the biotope list defined in the 2010 paper based on this workshop.

Table 2.2: Summary of proposed deep-sea classification structure for the NE Atlantic from Howell (2010).

Level 1 Biogeography	Level 2 Biological zone	Level 3 Substratum	Level 4 Biology
Arctic	Upper slope	Mud	e.g. Ophiuroids and white encrusting sponges on coarse sediments
		Sand	
		Mixed	
		Coarse	
		Hard	
	Upper bathyal	As above	
	Mid bathyal	As above	
Atlantic	Upper slope	As above	
	Upper bathyal	As above	
	Mid bathyal	As above	
	Lower bathyal	As above	
	Abyssal	As above	
Bioherms	Upper slope	Lophelia pertusa reef	
		Sponge communities	
	Upper bathyal	Sponge communities	
	Mid bathyal	Sponge communities	

2.3 Data analysis - identification of deep-sea assemblages

Two contracts were let by JNCC to define deep-sea species assemblages that would form the most detailed biological categories in the classification. One contract (Nickell *et al* 2013) focused on the infauna, and was undertaken by the Scottish Association for Marine Science (SAMS), building on work undertaken by Bett (e.g. 2001, 2012) (Box 3). The other (Piechaud & Howell 2013; Box 2) focused on epifauna and was undertaken by Plymouth University, building on Howell's previous work (Howell 2010; Howell *et al* 2010). Both contracts adopted a similar method using cluster analysis to identify assemblages. Results informed the definitions of biogeographic regions and vertical biological zones used in the classification, as well as descriptions of deep-sea assemblages and their parent broad community categories. More detail on the datasets used, methods and results can be found in the methods papers (Piechaud & Howell 2013; Nickell *et al* 2013) and supporting material produced. The results of these contracts will be discussed further in the section below, as justification for the final structure.

Box 3: Past deep-sea biotope work: proposed deep-sea infaunal biotopes for the Faroe-Shetland Channel Region

In 2012 JNCC commissioned work to propose biotopes based on patterns identified from infaunal data collected within the Strategic Environmental Assessment area 4 (SEA4) in Scotland's northern deep seas (Bett 2012). Biotopes were defined using data aggregated to family level due to taxonomic inconsistencies between datasets. Biotopes were separated based (a) water mass (Atlantic, Arctic or Atlanto-Arctic), (b) depth/biological zone and substratum, and (c) on their geographic location (north or west of Shetland) [a proxy for hydrodynamic regime], (Table 2.3). These variables were used to describe biotopes but were not placed in a hierarchical classification as part of the work. Biotopes were described in this format: [community] in [region][substrate][depth zone], for example 'Spionidae-Syllidae-Syllidae in Atlantic Sand and Muddy Sand (100-300m)'. It was suggested that, if the current EUNIS structure was expanded to include proposed biotopes, 'Atlantic bathyal sand', 'Atlanto-Arctic bathyal sand', 'Arctic bathyal muddy sand' and 'Arctic bathyal mud' would be added at level 4 and specific biotopes added at level 5. The biotopes specified at level 5 would reflect further variation with depth.

Table 2.3: Proposed biotopes for Scotland's northern deep seas, Strategic Environmental Assessment area 4 (SEA4), adapted from Bett (2012).

West of Shetland				North of Shetland			
Faroe-Shetland/Faroe Bank Channels				Norwegian Basin			
100-300m	300-600m	600-200m	>1200m	100-300m	300-600m	600-1200m	>1200m
Atlantic	Atlanto-Arctic	Arctic	Arctic	Atlantic	Atlanto-Arctic	Arctic	Arctic
Sand & muddy sand	Sand & muddy sand	Sand & muddy sand	Mud & sandy mud	Sand & muddy sand	Sand & muddy sand	Mud & sandy mud	Mud & sandy mud
Spionidae-Syllidae-Syllidae in Atlantic sand and muddy sand (100-300m)	Spionidae-Capitellidae-Syllidae in Atlanto-Arctic sand and muddy sand (300-600m)	Cirratulidae-Maldanidae-Maldanidae in Arctic sand and muddy sand (600-1200m)	Oweniidae-Capitellidae-Maldanidae in Arctic mud and sandy mud (>1200m)	Spionidae-Paraonidae-Spatangoida in Atlantic sand and muddy sand (100-300m)	Spionidae-Terebellidae-Syllidae in Atlanto-Arctic sand and muddy sand (300-600m)	Cirratulidae-Oweniidae-Thyasiridae in Arctic mud and sandy mud (600-200m)	Capitellidae-Oweniidae-Myriotrochidae in Arctic mud and sandy mud (>1200m)

2.4 Consultation

A range of deep-sea experts have been consulted at all stages of development. Feedback on the draft proposal for overall structure was collated from deep-sea experts at various institutions[7], and this was taken into account when finalising the structure. The epifaunal assemblages defined by Piechaud and Howell (2013) took into account results of a workshop at Plymouth University, at which deep-sea researchers from across Europe compared recorded communities and agreed which constituted the same biotope. Data analysis work undertaken to define infaunal and epifaunal assemblages for inclusion (see Section 2.3) was subject to internal QA and review by staff at JNCC. Interpretation of results and definition of biogeographic regions and biological zones was undertaken at a final JNCC

[7]Responses were received from Plymouth University, Scottish Association for Marine Science (SAMS), Heriot-Watt University, National Oceanography Centre (NOC), Marine Scotland Science (MSS), Ifremer, Centre for Environment, Fisheries & Aquaculture Science (Cefas) and Scottish Natural Heritage (SNH).

workshop in April 2014 with experts who had previously been involved in deep-sea biotope work from Plymouth University, the National Oceanography Centre (NOC) and SAMS. The final deep-sea classification and this report were subject to a final review by workshop participants, other deep-sea experts who had not been able to attend final workshop, and senior staff at JNCC. This work has been officially signed off by members of the Benthic sub-group of the Healthy and Biologically Diverse Seas Evidence Group.

3 The overall structure of the deep-sea section

Preliminary work was undertaken by JNCC to produce an options paper (Jenkins 2012 - unpublished report) to outline various proposals for the structure of the upper levels of a deep-sea section using work undertaken by Howell (2010) (Box 2) as a basis. Five options were given for various ways of incorporating biogeography, biological zone and substratum into the top levels of a hierarchical classification system and outlined the relative benefits and disadvantages of each option. This paper was discussed with EUNIS users at a 2012 MESH Atlantic workshop, but no firm decision was made on the favoured approach.

Following on from the options paper, a draft structure for the upper levels of the deep-sea section was proposed (Parry 2013 – unpublished report). This structure was developed based on analysis of the advantages of each option considered in the preceding JNCC paper and also existing deep-sea classifications used in Europe. This draft proposed structure incorporated biogeographic region (level 2), biological zone (level 3), substratum (level 4), broad community (level 5) and species composition (level 6). This proposed structure differed from the existing system in a number of ways. The existing JNCC classification defines categories at each level that are considered to represent true divergences in biological community. This results in different environmental variables being introduced at different levels in various parts of the classification. For example, the sublittoral zone is divided into infralittoral and circalittoral at level 2 for rock, but level 4 for sediment, because infralittoral and circalittoral sediment communities do not differ so much as on rock. Feedback from users has indicated that the existing approach is not intuitive and means that broad scale maps will have to incorporate different levels if only based on environmental variables (Parry 2014; Galparsoro 2013). Consequently, it was decided that adopting a more user-friendly format was preferable, with the same environmental factors describing the habitats at each level. The draft proposal suggested categories for defining environmental variables but acknowledged that further work was needed to decide whether these were appropriate. Feedback on the draft proposal was collated from deep-sea experts[8], and is summarised below:

- There was broad support for changing the structure to introduce the same environmental variables at each level, and including infauna and epifauna assemblages separately.
- The majority of respondents agreed with the environmental variables included, and their position in the hierarchy.
- There was broad agreement that the zones needed further work, but not what they should be.
- Several respondents thought that biogenic reef should be included as a substratum type, and some thought that chemosynthetic habitats should be separated out in some way.

The variables recommended in this report were included in the final deep-sea section. The structure of the classification was revised a final time, taking into account feedback. Final

[8] Responses were received from Plymouth University, Scottish Association for Marine Science (SAMS), Heriot-Watt University, National Oceanography Centre (NOC), Marine Scotland Science (MSS), Ifremer, Centre for Environment, Fisheries & Aquaculture Science (Cefas) and Scottish Natural Heritage (SNH).

changes involved combining levels 2 and 3 in the draft structure to a single level 2 for biogeographic region and biological zone to keep the total number of levels the same as the existing system so habitats at the same level were more comparable. Acting on feedback on the draft proposed structure, and to improve compatibility with a proposed new EUNIS system, biogenic reef was added as a separate substratum category. The specific categories used at each level were considered further based on results of data analysis contracts (see Section 2.3). The final structure for the deep-sea section is outlined in Table 3.1.

Table 3.1: Summary of the final structure for the deep-sea section.

Level no	Level name	Defining variable(s)
1	Environment	Depth/height above/below high water mark, categorised into marine, coastal or terrestrial (the whole section is marine in this case)
2	Biological zone	Combination of biogeographic region and vertical biological zone – based on water mass properties (many variables including temperature, salinity, depth and geolocation)
3	Substratum	Substratum type taken from EUNIS level 3 plus biogenic substratum
4	Broad community	Broad community type based on taxa present
5	Biological assemblage	Specific species composition of assemblages

4 Definition of environmental variable categories

This section describes how the results of data analysis were used to define standardised categories for the component variables which together make up levels 1 to 3 of the deep-sea classification and provides justification for the choices made. Definitions for levels and associated categories have been based on evidence from survey data analysis and current understanding from published literature.

4.1 Level 1 Environment

This variable has one possible category; ‘marine’, which is inherited from EUNIS. Within EUNIS, ‘marine’ is divided from other terrestrial environments at level 1. All of the JNCC classification deep-sea biotopes will be classified as ‘marine’ in order to be consistent with existing classification systems.

4.2 Level 2 Biological zone

Based on feedback on the draft structure for the deep-sea section it was initially decided that biogeographic region (e.g. Arctic, Atlantic) should be the highest level in the classification (under ‘marine’) as it represents the largest spatial unit, followed by vertical zone (e.g. upper bathyal, lower bathyal). However, in order for the total number of levels in the deep-sea section to match the existing classification, biogeographic region and vertical zone have been combined into a single level 2, named ‘biological zone’ that represents ‘3D biogeography’. Biogeographic region is likely to be incorporated into the next revision of EUNIS, so including this as a variable in the JNCC Classification deep-sea section would improve compatibility. Within biogeographic regions, biological communities show further zonation, generally in relation to depth and factors associated with depth (e.g. water temperature, salinity, substratum type). Characterising habitats by vertical zone allows consistent comparison of habitats across different regions. Vertical zone is included as a factor in the current shallower section of the JNCC Classification and in EUNIS so needs to be included for the deep-sea section to ensure compatibility. A common criticism of the current EUNIS classification is that the deep sea is not subdivided into smaller biological zones (Galparsoro *et al* 2012) so this will be addressed in the JNCC deep-sea section.

4.2.1 Analysing broad-scale biological zonation patterns

Broad-scale patterns in biological community structure were assessed by interpreting results from analysis undertaken for the JNCC contracts to identify deep-sea infaunal and epifaunal assemblages. Areas of the greatest biological change were identified in order to establish where appropriate boundaries for biological zones may be. Biological patterns between biogeographic region and with depth were reviewed.

It has been long known (Thomson 1874) and is widely accepted that UK waters cross two biogeographic regions that have very distinct fauna: the North-East Atlantic and the cooler waters of the Arctic (Bett 2001; Dinter 2001; Howell 2010; UNESCO 2009). Atlantic and Arctic waters meet north of the Wyville Thomson Ridge in the Faroe-Shetland Channel. Biogeographic regions should be defined primarily by their characterising fauna but this is not yet well understood and an environmental proxy, generally depth, is often used to define regions and for broad-scale habitat mapping. The 2010 predictive seabed habitat map for UK waters, UKSeaMap (McBreen *et al* 2010) mapped the boundary between the Arctic and Atlantic biogeographic regions along the 500m contour within the Faroe-Shetland Channel based on the position of warm and cold water masses and associated communities in the area (Bett 2001). Bett (2012) identified a transition zone between Atlantic and Arctic waters at depths of 300–600m in the Faroe-Shetland Channel, based on analysis of infaunal SEA4 data (Table 2.3). This transition zone (hereafter referred to as the Atlanto-Arctic region) experiences unusual rapid and dramatic fluctuations in water temperature as a result of vertical movements in water mass boundaries.

The 2013 JNCC contract to define deep-sea infaunal assemblages (Nickell *et al* 2013) involved the analysis of additional data from the Atlantic, along with the Faroe-Shetland Channel SEA4 data used in Bett’s (2012) analysis. Cluster analysis undertaken for this contract also identified two Atlanto-Arctic biotopes which occurred between 200-500m and 200/300-600m in the Faroe-Shetland Channel (biotope H and I - see dendrogram presented in Appendix 4). These Atlanto-Arctic biotopes clustered separately from both deeper Arctic biotopes (C-G) and an Atlantic biotope (B) found at similar depths, indicating that distinguishable infaunal communities occur in the transition zone. The Atlanto-Arctic epifauna is characterised by *Geodia* and other massive sponge epifaunal assemblages (Boreal Ostur) which are unique to that region within UK waters (Bett 2001, 2012; Piechaud & Howell 2013). It was decided that Atlanto-Arctic should be classed as a separate region in the classification rather than being classified under ‘Arctic’ or ‘Atlantic’ as it has such unusual environmental conditions and distinct communities.

In addition to differences between broad biogeographic regions, continuous change in biological distributions with depth is to be expected (see e.g. Gage & Tyler 1991). Howell (2010) defined five biological zones (upper slope, upper bathyal, mid bathyal, lower bathyal and abyssal) within the deep sea based on epifaunal data predominantly from the Atlantic and extensive review of the scientific literature (see paper for details). Depth boundaries were established as a proxy for various other environmental factors. Feedback on the draft structure for the deep-sea section indicated further work was needed to refine these zones. This work focused on epifaunal communities, so infaunal data also needed to be considered when defining final biological zones.

The JNCC contract to identify deep-sea epifaunal assemblages (Piechaud & Howell 2013) found assemblages with overlapping ranges (Appendix 5), but some broad patterns in change could be identified. In the Atlantic a small number of assemblages were only recorded at depths of <300m: '*Caryophyllia smithii* & *Actinauge richardi*' assemblage and '*Reteporella & Axinellid sponges*'. These assemblages are similar to those described in deep circalittoral biotopes CR.HCR.DpSp.PhaAxi and CR.HCR.XFa.SwiLgAs in the existing shallower section of the classification. A further area of change was evident in the Atlantic somewhere between 1000m and 1200m, where numerous assemblages had their lower boundary. For example, 'Cidarid urchin assemblage' and '*Kophobelemnon* field' occurred down to 1000m while '*Dallina septigera* and *Macandrevia cranium* assemblage' and 'Cerianthid anemones and burrowing megafauna' occur down to 1200m. The reef-forming species of coral also switches from *Lophelia pertusa* to *Solenosmilia variabilis* between these depths; this is supported by a further study by Henry and Roberts (2014). Little epifaunal data were available to predict biological zonation in deeper waters. One area of change could occur between 1800m and 2000m where the lower limits of '*Pheronema carpenteri* field' '*Syringammina fragilissima* field' and *Solenosmilia variabilis* assemblages were recorded. Few epifaunal data were available to assess biological zonation in the Arctic. Both the assemblages 'Corymorpha, Gersemia, Zoantharia and *Heliometra glacialis*' and '*Heliometra glacialis*, Actinostolid anemones and tube worm assemblage' had an upper limit of approximately 900m indicating this may be an area of change.

The JNCC contract to identify deep-sea infaunal assemblages (Nickell *et al* 2013) found two shallower Atlantic biotopes (H and K) in the upper Faroe-Shetland Channel at approximately 100-250m (Appendix 4). Two deeper Atlantic biotopes were recorded from the Rockall area with slightly overlapping depth ranges: biotope B (400-1000m) and biotope A (900-2050m). Biotopes I and J were recorded in the Atlanto-Arctic from 200-600m. In Arctic waters, four shallower biotopes (D, E, F and G) with overlapping ranges between 600 and 1400m were identified, and one deeper biotope (D) which occurred from 1300-2300m. These results were similar to those found by Bett (2012) based on infaunal data from the Faroe-Shetland Channel only; in this work an Arctic zone was recorded from 600-1200m and a deeper Arctic zone at >1200m.

It should be noted that the depth ranges given for assemblages refer only to where they have been recorded to date, so it is possible that this will change as more information becomes available.

4.2.2 Modelling environmental variables to identify potential biogeographic zones

Limited biological data for the deep sea means it can be difficult to infer patterns in faunal zonation if boundaries are not associated with known environmental changes that are likely to drive biological differences. Biogeographic classification may be based on distinct water mass types (see e.g. Bett 2012 for deep-sea application). Piechaud and Howell (2013) found that water mass had a significant contribution to variation in epifaunal community type, and had a stronger effect than water temperature, salinity or depth alone. Consequently, it was decided that biological zones should be linked to water mass (i.e. variation in water mass properties), if supported by biological data. This allows boundaries for biological zones to be defined in terms of environmental variables where biological data are sparse or absent. These biological zones are here termed 'proxy biogeographic zones' (PBZ), being based on environmental variables rather then ecological data.

The spatial distribution of water masses (i.e. their properties) and other environmental variables at the seabed can be modelled based on oceanographic data. Ten 'nominal PBZs' present in UK deep waters were identified at the final JNCC deep-sea workshop using a method implemented by Bett and Jones (unpublished) in an attempt to identify practical biogeographic regions (Box 4; Figure 4.1).

Box 4: Modelling water masses at the seabed

PBZs at the seabed were identified by K-means clustering using the variables depth, salinity, temperature, dissolved oxygen and particulate organic carbon flux. The data layers used were taken from the World Ocean Atlas[1], with the exception of particulate organic carbon flux which was derived from Lutz *et al* (2007), and all were standardised to a resolution of 0.25 degrees. The analysis was carried out for the north-east Atlantic Ocean, Mediterranean and Black Sea.

K-means clustering divides data points into groups based on common variations in the input variables. Each resultant cluster represents a relatively homogeneous region. Data were classified using k-means clustering (MacQueen 1967) with 200 iterations each for 2 to 16 defined clusters. The optimal number of clusters was selected using the 'simple structure index' (Dimitriadou *et al* 2002). The k-means analysis was run three times: 1) using all the data (temperature, salinity, dissolved oxygen, POC flux and GEBCO depth); 2) using all the data with the simplified depths levels from the WOA, and 3) with all the data except depth (temperature, salinity, dissolved oxygen, POC flux). The optimal cluster numbers were 1) 11 (all data), 2) 15 (all data with WOA depth) and 3) 8 (all except depth) respectively. The model using WOA depth was selected for further assessment, representing a good compromise between known variations in deep-sea ecology and the 'real' resolution of the data. Of the 15 'PBZs' identified in the optimal k-means analysis, ten occurred within UK waters.

The distributions of the 'PBZs' were assigned a biological zone name according to their approximate positions in relation to biogeographic regions and vertical depth zones identified in previous work. First they were divided by biogeographic province:

- PBZs 1 to 6 correspond with areas identified by Bett (2001), Dinter (2001) *et al* as being in the Atlantic biogeographic region.
- PBZs 8 to 10 correspond with areas identified by Bett (2001), Dinter (2001) *et al* as being in the Arctic biogeographic region.
- PBZ 7 corresponds with the area identified by Bett (2012) as the Atlanto-Arctic region – previously identified as occurring between depths of 300m and 600m in the Faroe-Shetland Channel.

Within each biogeographic province, the water masses were then assigned names using standard terminology for vertical zones:

- The six Atlantic water masses were named Atlantic upper bathyal (1), mid bathyal (2), lower bathyal (3), "upper abyssal"[9] (4), "mid abyssal"[9] (5) and lower abyssal (6).
- The Atlanto-Arctic water mass takes the place of the deeper part of the Atlantic upper bathyal where this meets the cold Arctic waters, so this was named the Atlanto-Arctic upper bathyal (7).
- There are three Arctic zones, the shallowest of which subducts below the Atlanto-Arctic upper bathyal in UK waters. These Arctic waters masses were named Arctic mid bathyal (8), lower bathyal (9) and upper abyssal (10) accordingly.

[9] Note AtMA and AtUA are not strictly different bathymetric zones, but represent a combination of bathymetric and spatial variation related to NW-SE water mass spreading.

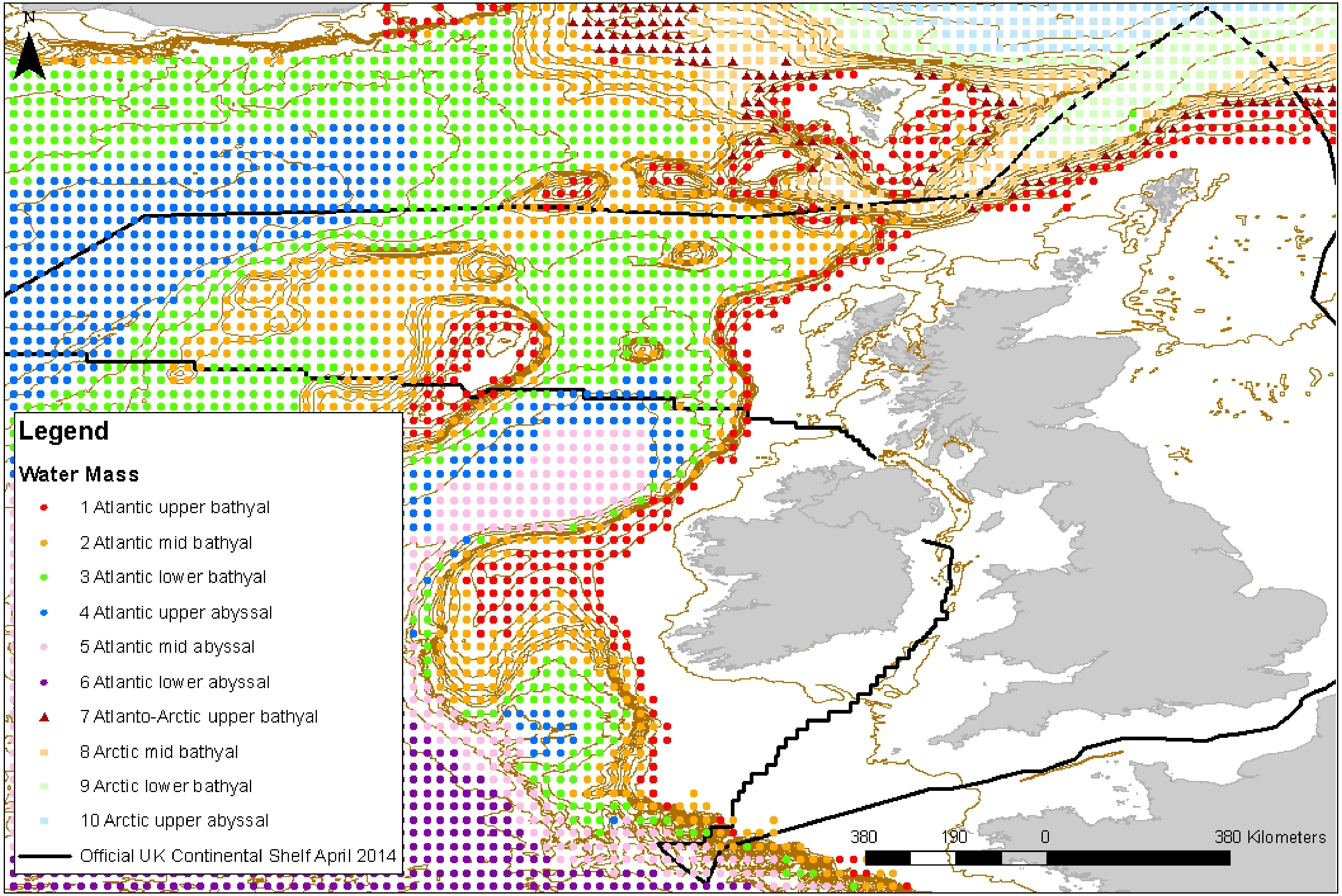

Figure 4.1: Map showing modelled 'Proxy Biogeographic Zones' at the seabed assigned to deep-sea zones.

4.2.3 Identifying PBZs by depth alone

Users will be provided with a raster PBZ layer to show the modelled location of zones; however, the resolution of this is low and will not be useful in areas of rapid depth change such as the South-west Approaches. As depth is the variable in the model that is most easily established and also has the highest resolution data associated with it, approximate depths associated with the PBZ boundaries at the seabed have been determined to assist users in deciding which zone their sample falls in, particularly in areas of rapid depth change. The depth boundaries of the 'nominal PBZs' vary spatially across UK waters and depend on factors other than depth; for example the Atlantic lower bathyal water mass extends deeper in the area around Anton Dohrn seamount than to the southeast of Rockall bank (Figure 4.1). This means any depth boundaries set for the PBZs will not completely match the water mass boundaries everywhere so they should be used only as a guide. Further work will be undertaken in the future to improve modelled maps of zones, and depth proxies may change accordingly.

It is important to note that the k-means clustering output selected for use here is based on WOA depth bands, i.e. not full resolution GEBCO depth. Standard WOA depth bands give 100m resolution 200-1500m, 250m resolution 1500-2000m, and 500m resolution 2000-6000m, such that deriving full depth resolution proxies for these cluster groups will be subject to some 'error'. Note also that some clusters will be primarily defined or differentiated by other environmental variables (e.g. temperature, salinity, oxygen concentration, POC flux), such that depth proxies should only be used as a first-order approximation. To define depth proxies for biological zones, first a subset of points included in the water mass model was taken from within a bounding box of UK waters. This ensured that results were not skewed by data in other parts of Europe which may have different PBZ depth variations. Box plots were then created to show the distribution of full GEBCO resolution depths associated with each PBZ (Figure 4.2).

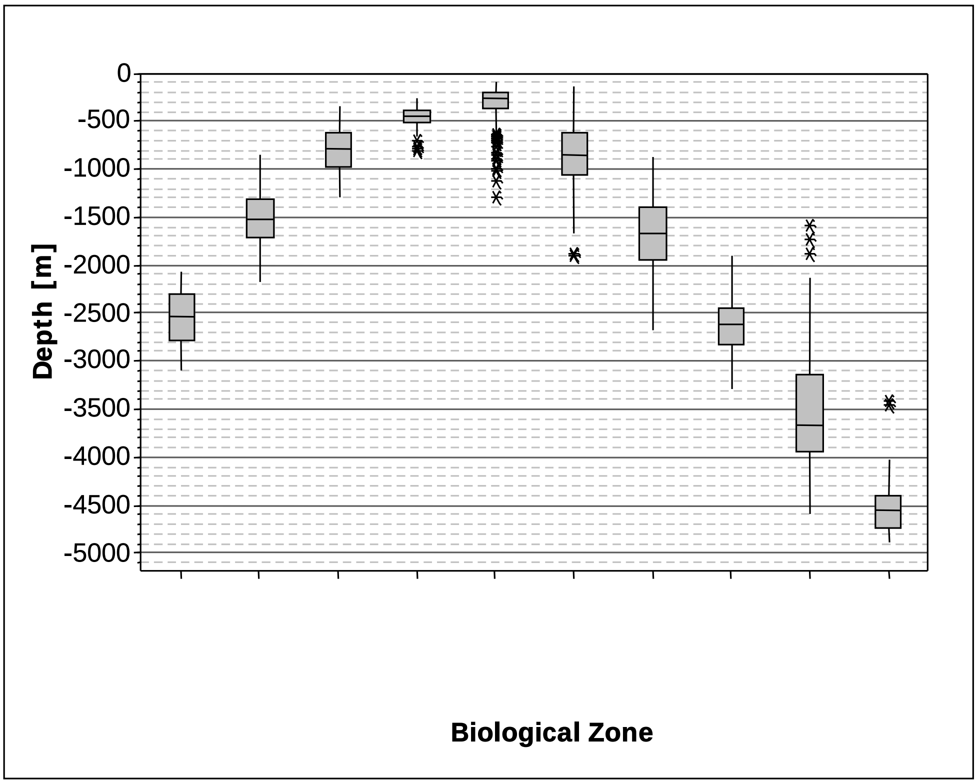

Figure 4.2: Box plots showing the depth distributions of deep-sea proxy biogeographic zones in the UK area.

The depths recorded within the inter-quartile range for each PBZ did not overlap and followed the expected pattern with relation to biological zone. However, there was substantial overlap in the full depth range associated with zones confirming that in some places the depth boundary can deviate a great deal from the depths typical of that zone. Depth proxies for boundaries were defined as the midpoint of median depths for adjacent zones. This was undertaken separately for the transition from the shallowest to deepest Atlantic zones, and the transition from shallow Atlantic waters, through the Atlanto-Arctic zone, to deeper Arctic waters north-east of Scotland. This method could obviously not be applied for the upper boundary of shallowest zone (Atlantic upper bathyal) or the lower boundary of the deepest zones (Atlantic lower abyssal and Arctic upper abyssal), where boundaries are the spatial limits of the data. The Atlantic upper bathyal water mass extends shallower than 200m, which supports epifaunal and infaunal evidence that some deep-sea communities can also occur in the deep circalittoral zone (infaunal biotopes H & K [Appendix 4] and epifaunal assemblages '*Caryophyllia smithii* & *Actinauge richardi* assemblage' and '*Reteporella & Axinellid sponges*'). Further work would be needed to investigate whether the deep-circalittoral and upper bathyal, as defined here, actually have the same communities and could be merged. For practical reasons, it was considered best to keep the upper boundary of the upper bathyal at 200m, as this is the existing limit defined for the shallower section of the classification, corresponding roughly to the edge of the continental slope in UK waters. The lower boundary of deepest Atlantic and Arctic zones was taken as the deepest recorded point for the zone. All depth proxy values were rounded to the nearest 100m to reflect associated uncertainty. Depth proxies are summarised in Table 4.1.

Table 4.1: Depth proxies for deep-sea biological zones in the JNCC classification.

	Depth Proxy [m]	**Approximate bottom water temperature [^{o}C]**
Atlantic region zone transitions		
Atlantic upper bathyal	200–600	7–10
Atlantic mid bathyal	600–1300	6–9
Atlantic lower bathyal	1300–2100	3–4
Atlantic upper abyssal	2100–3100	3
Atlantic mid abyssal	3100–4100	3
Atlantic lower abyssal	>4100	3
Arctic region zone transitions		
Atlantic upper bathyal	200–300	7–10
Atlanto-Arctic upper bathyal	300–600	1–4
Arctic mid bathyal	600–1100	-1–0
Arctic lower bathyal	1100–2000	-1
Arctic upper abyssal	2000–3100	-1

The proxy depth ranges of the PBZs were compared with the depth ranges of deep-sea biological assemblages recorded (Section 4.2.1) to assess how well the PBZs reflect change in biological community composition. The depth proxies identified broadly reflect patterns in biological communities discussed at the beginning of this section.

4.2.4 Summary

In conclusion, level 2 of the JNCC classification will incorporate proxy biogeographic zones objectively derived from multivariate environmental data that attempt to represent the three-dimensional nature of deep-sea biogeography. These zones are named based on the appropriate broad biogeographic province (Arctic, Atlantic or Atlanto-Arctic) and vertical depth zone (upper/mid/lower bathyal or upper/mid/lower abyssal). Level 2 habitat descriptions are available in Appendix 3. Depth proxies for vertical depth zones are provided (Table 4.1), although these may not exactly match zone boundaries in all places as the depth of different water masses varies spatially. It should be noted that biological descriptions for each zone are based on limited survey data, and are likely to be developed in the future when new data become available.

For reporting purposes, JNCC may have to assign habitats to either the Arctic or Atlantic region. The contract to define deep-sea epifaunal assemblages (Piechaud & Howell 2013) found that many of the biotopes that occurred in the shallower bathyal Atlanto-Arctic waters of the Faroe-Shetland Channel also occurred in Atlantic waters of similar depths. Based on this evidence, the Atlanto-Arctic habitats should be classed as Atlantic, rather than Arctic, if a strict dichotomy is necessary for reporting or mapping purposes.

4.3 Level 3 Substratum

It is long (e.g. Peterson's and Thorson's classical works) widely accepted (Gray & Elliott 2009) that substratum has a substantial influence on biological community type. Substratum is always included as a factor in seabed classification systems but the categories used to define the substrata may differ.

The current JNCC classification (Connor *et al* 2004), as well as EUNIS (Davies & Moss 2004), divides substratum initially into two categories (rock and other hard substrata and sediment) and then further divides sediment into four categories (sand & muddy sand, mud & sandy mud, coarse sediment and mixed sediment). These categories were selected for the original Classification following expert workshops for the BIOMAR project and were backed by scientific evidence (Long 2006). It was suggested at the EUNIS deep-sea workshop that substratum could simply be divided into rock and sediment, as it is difficult to determine sediment type using video footage, and also because sediment type correlates with depth in the deep sea, with sediments in deeper zones generally (but not always) only comprising mud. However, JNCC and SNCB research surveys sometimes involve the collection of grab samples in addition to video footage, so it would be possible to identify the sediment type in these cases. It would be helpful for the classification to further define sediment type to some degree and, where sediment type is unclear, a best guess could be made by looking at other factors such as depth and biology. From a nature conservation perspective it would be simplest to retain the four broad sediment categories in level 3 of the current classification to retain compatibility. Various listed habitats, including MCZ broad-scale habitats (NE/JNCC 2010) and MSFD predominant habitats (OSPAR 2012), are taken from the current EUNIS level 3. Rock has been introduced at the same level as the four sediment types following the new structure whereby environmental variables are introduced consistently at each level. The four broad sediment categories can be described in terms of Folk (1954) classification sediment categories (e.g. sandy gravel – sG, muddy sand – mS). A common correspondence between these systems is shown in Figure 4.3.

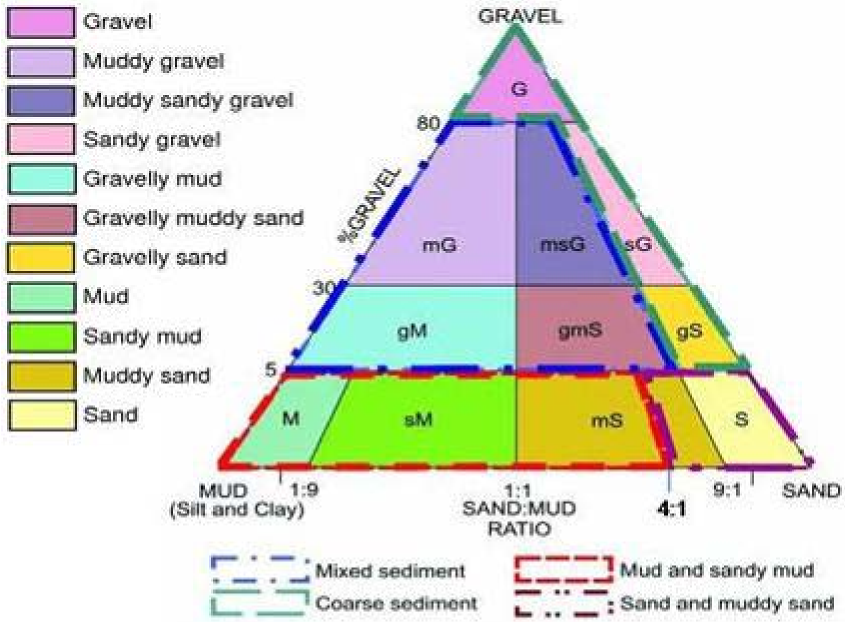

Figure 4.3: Folk (1954) ternary diagram overlain with a common interpretation of their equivalence to JNCC/EUNIS broad sediment categories (Long 2006).

The current classification separates biogenic reef from other substratum types if on sediment, but not if on rock; users can find this counter-intuitive. As discussed in Section 3, some experts who commented on the draft deep-sea structure suggested that biogenic reef should be a substratum category as it can cover the underlying substrate and form a new surface. Consequently, a separate 'biogenic structure' category has been included in the deep-sea section. This should be selected regardless of whether the biogenic structure is on rock or sediment. 'Biogenic structure' includes only continuous structures (living or dead) which cover the underlying substratum, not aggregations of structure forming species (e.g. discrete corals or sponges), or biogenic material which has been broken down to form the substratum (e.g. coral rubble, shell fragments). It can be important for work such as sensitivity assessments to understand which substratum a biogenic reef occurs on. Although this will not be clear from the biogenic structure biotope name itself, it will be evident from the biotope assigned to surrounding areas and the physical data associated with the sample. Often biogenic reef is patchy; where this is the case areas would be described as a mosaic of a biogenic biotope and another biotope on a specified substratum (e.g. 'Atlantic lower bathyal live *Solenosmilia variabilis* reef'/'Discrete colonies of *Solenosmilia variabilis* on Atlantic lower bathyal coarse sediment').

As discussed in Section 3, some experts who commented on the draft deep-sea structure suggested that chemosynthetic habitats such as whale falls, vents and seeps should be separated from other broad types as the chemistry is driving changes in community rather than the substratum. However, this is not a significant issue for the UK as there is only one known potential cold seep in the UK deep-sea waters (ICES 2013). No chemosynthetic systems with obvious megafaunal expressions have yet been defined for the UK. For this reason, chemosynthetic will not be included as a characterising variable in the JNCC classification deep-sea section. In the future, chemosynthetic biotopes may be added. For such biotopes, it would be mentioned in the description page that the chemistry is an important factor influencing that community.

In summary, level 3 of the deep-sea classification will classify habitats into the four broad sediment categories used in EUNIS level 3, plus 'rock and other hard substrata' from EUNIS level 2. Biogenic substratum will also be included as a substrate category at level 3.

5 Definition of biological components

The biological components of the deep-sea section have been developed through contracts run by JNCC with SAMS and Plymouth University (see Section 2.2). The biological community will be classified first by broad community (level 4) and then by specific biological assemblages (level 5), which are nested within the broad communities.

A widely recognised problem with the current Marine Habitat Classification for Britain and Ireland is that most biotopes describe either the epifaunal OR the infaunal component of the biological community BUT not both (Parry 2014). Past attempts to link epifaunal and infaunal communities in order to define all encompassing biotopes have not been successful (Verling & Blythe-Skyrme 2007) so epifaunal and infaunal broad communities and their ‘child’ assemblages have been kept separate.

There have been a limited number of surveys undertaken in the deep sea so some level 3 habitat types have not yet been sampled. This means that some level 4 habitat types do not yet have any ‘child’ level 4 or level 5 biotopes because the biological assemblages associated with them are not known. Additional biotopes will be added as new survey data become available.

5.1 Level 4 Broad community

Broad communities are introduced at level 4; these are described in detail in Appendix 3. The environment in which broad communities have been recorded to date is described in their online description pages using the variables and categories outlined in Section 2.2. The broad communities are roughly equivalent to the community descriptions for rock habitats in level 4 of the current shallower section of the JNCC classification (e.g. ‘Mussel and/or barnacle communities’, ‘mixed faunal turf communities’). Level 4 habitats should be easier to identify from video than level 5 communities, and possible to select without being a taxonomic expert. Broad communities are thought to occupy a certain niche and fulfil a certain functional role. Their niche could span several zones or substratum types. The same broad community could occupy a similar niche in different regions or zones, although the species composition may differ (i.e. parallel communities). For example, ‘cold water coral reef’ is associated with hard substratum and provides a structural framework; it is found in both the upper bathyal and lower bathyal but the reef forming species shifts from *Lophelia pertusa* to *Solenosmilia variabilis*.

Unlike the current shallow section of the classification, in the new deep-sea section the same broad community can be associated with more than one region, zone or substratum type. Allowing the same broad community type to be associated with different regions, zones and substratum types, instead of linking it to the zone and substratum where it is most common in a rigid hierarchy means the system is less open to misinterpretation. Users of the current system can assume that a community found, for example, only in the circalittoral rock section cannot be associated with any other zone or substratum when this may not be the case. The broad community description is based on current knowledge of where it has been found to date. In the future, if a broad community is regularly found associated with a new region, zone or substratum, then a new level 4 habitat will be added.

Broad communities listed are mostly epifaunal. The infaunal biotopes identified through the JNCC 2013 contract (Nickell *et al* 2013), and preceding work by Bett (2001, 2013), were useful in showing broad patterns to inform biogeographic region and biological zone definitions but, unfortunately, it was not possible to produce clear community descriptions based on the results. Due to taxonomic discrepancies between different datasets used, the infaunal data had to be aggregated to family level. Taxonomy is a particular problem for the deep sea as many species are new to science and hard to identify to species level. Many individuals are described in a format such as [genus name] A, which makes it difficult to combine datasets that used different coding systems. The family level data did reveal meaningful trends but, as the same common families occur across the whole deep sea, the biotopes identified had only small shifts in the relative abundances of the same families. This made it impossible to describe different communities sufficiently so a user could match data to a certain description. For this reason, only a single broad community was included for deep-sea infauna: 'mixed infauna dominated by polychaetes'. It is hoped that in the future species level data can be used to identify more specific infaunal broad communities and biological assemblages. It is, also, often impossible to identify epifaunal taxa to species level, but this did not pose the same problem for defining biotopes. The composition of epifaunal communities was more distinct, with each having few, but different, characterising taxa, rather than differing abundances of the same taxa, as was the case for infauna.

5.2 Level 5 Biological assemblage

At level 5, more specific biological assemblages are introduced nested under the appropriate broad community type. These biological assemblages specify characterising species where possible.

Biological assemblages are linked to one 'parent' broad community. They are equivalent to the biology descriptions for biotopes in level 5 of the current shallower section of the JNCC classification (e.g. '*Mytilus edulis* and barnacles', '*Flustra foliacea* and colonial ascidians'). Biological assemblages described are all epifaunal as infaunal analysis used family level data (see Section 2.2). The methodology undertaken to identify epifaunal assemblages can be found in Piechaud and Howell (2013). These deep-sea biological assemblages have been defined based primarily on analysis of SEA7 part 2 data and some JNCC survey data, with additional recognised biotopes included from the academic literature. Assemblages are similar to those originally defined by Howell (2010), but have been refined following further analysis. The list described in Piechaud and Howell (2013) has been slightly revised after further work and these changes are described in Appendix 6. Biological assemblages are generally specific to biogeographic region, but may occur across zones or substratum types if the characterising taxa are generalist and/or have a broad range.

The associated environment that biological assemblages have been recorded in has been classified using the variables and categories outlined in Section 4. This combination of the biological assemblage and its associated environmental parameters is classed as a 'biotope'. There is a key difference between a 'biotope' and a 'biological assemblage'. The analysis undertaken to develop deep-sea biotopes looked at patterns in biological community and identified biological assemblages. A biological assemblage is just the biological component of a biotope (e.g. *Kophobelemnon* field). The biotopes defined at level 5 in the deep-sea classification consist of a recognised biological assemblage AND its associated environment (e.g. *Kophobelemnon* field on Atlantic upper bathyal mud). In some cases a biological assemblage can occur across more than one zone or substratum type. A separate biotope is described where environmental variables differ, even if the biological assemblage identified from the analysis is the same (e.g. *Kophobelemnon* field on Atlantic **mid** bathyal mud). Biotopes with the same epifaunal assemblage in the name will obviously be similar biologically, but it was considered valid to include them separately as the associated infauna is likely to differ. Also, assemblages were defined from video data which was often not sufficient to identify taxa to a low level. It is likely that there will be some differences between assemblages found in different zones and substrata which were not evident from the data available. Allowing this replication of biological assemblage also assists users as it means the correct environmental variables are evident in the biotope name. In the current classification, assemblages are only associated with environmental variables with which they are most commonly associated so users often have to assign a biotope where the environmental variables described in the biotope name do not match their sample. It is important to be able to pinpoint the correct region, zone, substratum type from a classified habitat name to help with sensitivity assessments and allow habitats to be translated into different classifications such as EUNIS. This new system employed for the deep-sea section allows users to identify where biotopes may be similar biologically (they have the same assemblage in the name) but also know where environmental conditions differ. This can help with conservation planning; for example, practitioners may want to ensure both *Kophobelemnon* fields on **sand** and *Kophobelemnon* fields on **mud** are protected adequately.

6 The final deep-sea section for the JNCC Classification

The overall structure of the deep-sea section is summarised in Figure 6.1. The full deep-sea section is outlined in Appendices 2 and 3 as follows:

- Appendix 2: Deep-sea classification summary spreadsheet;
- Appendix 3: Deep-sea habitat descriptions.

A detailed description page has been developed for each biotope that gives a text overview, lists the characterising taxa, and states the depth range, water temperature range *etc*. where it has been recorded to date (Appendix 3).

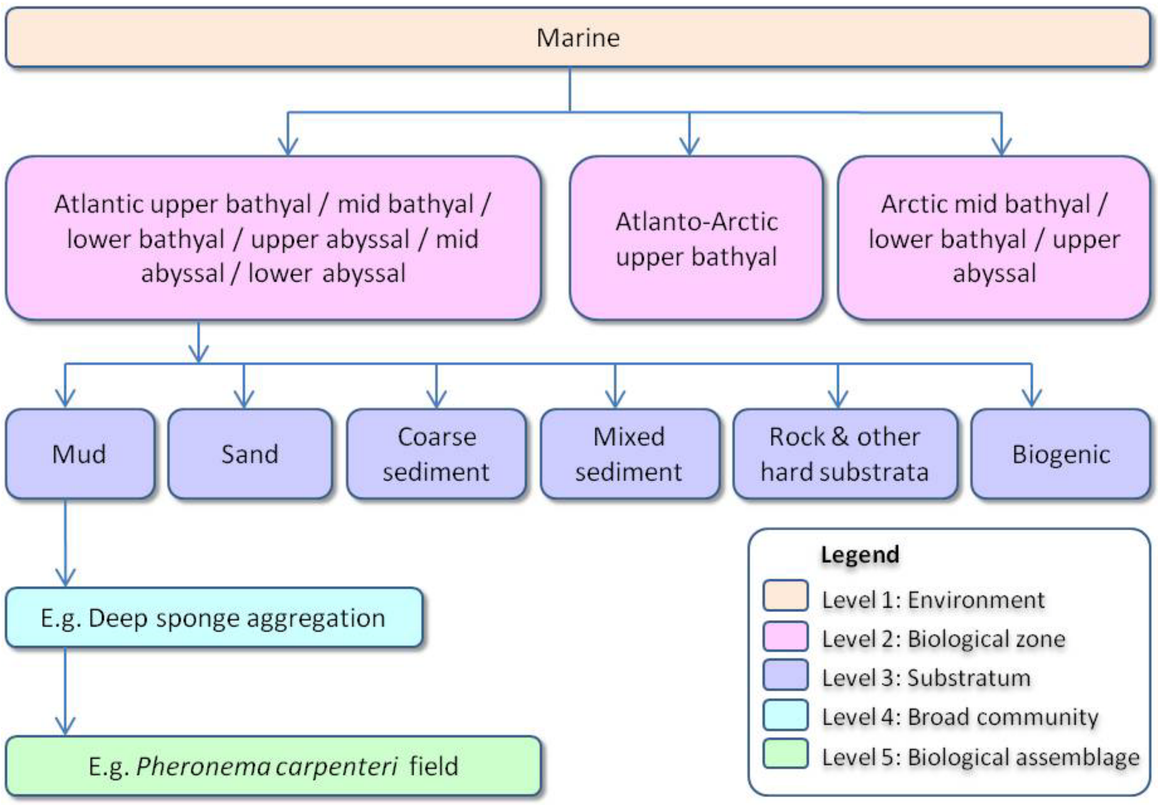

Figure 6.1: Structure of the deep-sea section for the Marine Habitat Classification of Britain and Ireland.

6.1 Summary of key features of the new deep-sea section

The new deep-sea section to the JNCC classification enables users to assign a biotope to data collected from waters deeper than 200m. It differs from the current EUNIS classification as the deep sea is divided by biogeographic region and vertical zones and topographic features are not used to characterise habitats. For the deep-sea section, a number of changes have been made to the structure of the classification to address some user issues identified with the current shallower section of the classification (Parry 2014):

- Environmental variables are introduced consistently at each level in the deep-sea section to make the system more intuitive;
- habitat types are characterised by biogeographic region as well as vertical zone (i.e. jointly the proxy biogeographic zone) at level 2 to adequately capture broad spatial patterns in biological diversity;
- all level 4 habitat types are defined by broad community rather than further differences in substratum type;
- epifaunal and infaunal broad communities and assemblages are included separately as, in practice, a sample will only capture part of the community;
- broad communities and biological assemblages are replicated as separate habitat types where they can be associated with more than one environmental variable category used in the classification.

6.2 Using the deep-sea section

General guidance and information on using the JNCC habitat classification is found in Connor *et al* (2004) which is also published in the habitat classification section of the JNCC website[10]. Much of this general guidance also applies when classifying deep-sea habitats. An internal JNCC report detailing further guidance on assigning a biotope is available on request from MarineHabitatClassification@jncc.gov.uk.

The user should work through the classification hierarchy from level 1 to 5 selecting a 'child' habitat type of the habitat selected at the level above. The deep-sea section has been added to the overall JNCC classification hierarchy online[11] but it should be noted that the variables incorporated at each level differ from the rest of the classification at this point. The habitat descriptions provided in Appendix 3 of this document are also available online when the user clicks on the habitat name in the hierarchy. In the future, all deep-sea samples currently held by JNCC will be assigned a biotope using the new deep-sea section and records added to a distribution map on the biotope page. Indicative broad-scale GIS layers showing the modelled position of proxy biogeographic zones will be available for download from the JNCC classification download page[12], but it should be noted that these layers are derived from low resolution (0.25 degree) physical data and will not be accurate at a fine scale. In areas of steep topography it may be more appropriate to use depth proxies to estimate the relevant zone than the modelled biological zone layer.

The following list contains some specific recommendations on the use of the deep-sea classification:

- If a mosaic is present, for example, a rock biotope interspersed with a coarse sediment biotope, JNCC recommends that all present habitats/biotopes are recorded. This flexibility allows the user to more accurately describe a site. A single biotope needs to be at least 5x5m (Connor *et al* 2004) so a mosaic is made up of patches smaller than this. It may not be possible to identify exactly the area of a biotope patch using the data available, but this rule of thumb can be used to estimate where the patch is large enough to be considered a separate biotope.
- If a biological assemblage is recorded outside the range of physical conditions given in the relevant biotope description then it can still be used to classify the habitat; however, JNCC request that the user informs JNCC at

[10] http://jncc.defra.gov.uk/MarineHabitatClassification
[11] http://jncc.defra.gov.uk/marine/biotopes/hierarchy.aspx
[12] http://jncc.defra.gov.uk/page-1645

MarineHabitatClassification@jncc.gov.uk so the biotope description can be revised accordingly.

- JNCC should also be contacted at the email address above if a new biological assemblage or broad community is discovered.
- Individual sample points will describe either epifauna or infauna, depending on the method used. Physical sample data would be assigned an infaunal broad community and assemblage, while visual data would be assigned an epifaunal broad community and assemblage. Infauna may overlap spatially with epifauna, but may have different boundaries.

6.3 Compatibility with other systems

EUNIS habitats are listed under various pieces of legislation. It is, therefore, important to be able to translate between the JNCC classification and EUNIS. The categories used for the deep-sea section have been selected to be compatible with the proposed new revision of EUNIS, which is still under development. A correlation table[13] has been developed by JNCC to allow EUNIS habitats to be translated into the JNCC classification and habitats listed under various pieces of conservation legislation. This table will be updated to incorporate the deep-sea section.

The JNCC deep-sea section has also be developed to be as compatible as possible with Marine Strategy Framework Directive (MSFD) predominant habitats. The newly defined deep-sea zones relate roughly to Howell's (2010) categories that were used to define terminology for the predominant habitats (OSPAR 2012). However, it should be noted that zone names differ as some users were not comfortable with the term 'upper slope' being used in the deep sea. This change in terminology means zones shift so 'upper slope' is now 'upper bathyal', 'upper bathyal' is now 'mid bathyal' *etc*. The depth boundaries of the zones in the JNCC deep-sea section differ slightly from those proposed by Howell (2010) as they are based on modelled proxy biogeographic zones rather than epifaunal data; however, they can be roughly correlated (Table 6.1).

Table 6.1: Correlation between MSFD predominant habitats and new JNCC deep-sea habitats.

MSFD deep-sea predominant habitat	JNCC deep-sea habitats (level 3)
Upper bathyal sediment	Upper bathyal sand/mud/coarse sediment/ mixed sediment
Upper bathyal rock and biogenic reef	Upper bathyal rock/biogenic substrate
Lower bathyal sediment	Mid/lower bathyal sand/mud/coarse sediment/mixed sediment
Lower bathyal rock and biogenic reef	Mid/lower bathyal rock/biogenic substrate
Abyssal sediment	Upper/mid/lower abyssal sand/mud/coarse sediment/mixed sediment
Abyssal bathyal rock and biogenic reef	Upper/mid/lower abyssal rock/biogenic substrate

[13] http://jncc.defra.gov.uk/page-6767

7 References

Bett, B.J. 2012. Seafloor biotope analysis of the deep waters of the SEA4 region of Scotland's seas. JNCC Report No. 472.

Bett, B.J. 2001. UK Atlantic Margin Environmental Study: Introduction and overview of bathyal benthic ecology. Continental Shelf Research. 21, 917-956.

Connor, D., Allen J.H., Golding, N., Howell, K.L., Lieberknecht L.M., Northen, K.O. & Reker, J. 2004. The Marine Habitat Classification for Britain and Ireland. Version 04.05. Introduction.

Connor, D.W., Gilliland, P.M., Golding, N., Robinson, P., Todd, D. & Verling, E. 2006. UKSeaMap: the mapping of seabed and water column features of UK seas. Joint Nature Conservation Committee, Peterborough.

Dauvin, J.C., Bellan, G., Bellan-Santini, D., Castric, A., Comolet-Tirman, J., Francour, F., Gentil, F., Girard, A., Gofas, S., Mahé, C., Noël, P. & de Reviers, B. 1994. Typologie des Znieff-Mer. Liste des paramètres et des biocénoses de côtes françaises metropolitaines. 2ème édition. Museum National d'Histoire Naturelle, Paris : 64p.

Davies, C.E. & Moss, D. 2004. EUNIS Habitat Classification Marine Habitat Types: Revised Classification and Criteria. C02492NEW. Centre for Ecology & Hydrology (CEH) Dorset.

Dinter, W.P. 2001. Biogeography of the OSPAR Maritime Area. Federal Agency for Nature Conservation. [1st], 1-167. Bonn, Germany, Bundesamt fur Naturschutz.

Federal Geographic Data Committee (FGDC). 2012. FGDC-STD-18-2012. Coastal and Marine Ecological Classification Standard. Reston, VA Federal Geographic Data Committee.

Galparsoro, I., Connor, D.W., Borja, A., Aish, A., Amorim, P., Bajjouk, T., Chambers, C., Coggan, R., Dirberg, G., Ellwood, H., Evans, D., Goodin, K.L., Grehan, A., Haldin, J., Howell, K., Jenkins, C., Giulia Mo, M., Buhl-Mortensen, P., Pearce, B., *et al* 2012. Using EUNIS habitat classification for benthic mapping in European seas: Present concerns and future needs. Marine Pollution Bulletin. 64, 2630-2638.

HELCOM. 2013. HELCOM HUB – Technical Report on the HELCOM Underwater Biotope and habitat classification. Balt. Sea Environ. Proc. No. 139.

Henry, L. & Murray Roberts, J. 2014. Recommendations for best practice in deep-sea habitat classification: Bullimore *et al* as a case study. ICES Journal of Marine Science. 71(4), 895-898.

Howell, K.L. 2010. A benthic classification system to aid in the implementation of marine protected area networks in the deep/high seas of the NE Atlantic. Biological Conservation. 143, 1041-1056.

Howell, K.L., Davies J.S. & Narayanaswamy, B.E. 2010. Identifying deep-sea megafaunal epibenthic assemblages for use in habitat mapping and marine protected area network design. Journal of the Marine Biological Association of the United Kingdom. 90, pp 33-68.

ICES. 2013. Vulnerable deep-water habitats in the NEAFC Regulatory Area. Special request, Advice June 2013.

Irving, R. 2009. The identification of the main characteristics of stony reef habitats under the Habitats Directive. Summary report of an inter-agency workshop 26-27 March 2008. JNCC Report No. 432.

Jenkins, C. 2012. Options for a structural change to the deep sea classification of the 'National Marine Habitat Classification for Britain and Ireland' and its possible application to EUNIS. JNCC Draft report (unpublished).

Long, D. 2006. BGS detailed explanation of seabed sediment modified folk classification. Available at
http://www.searchmesh.net/PDF/GMHM3_Detailed_explanation_of_seabed_sediment_classification.pdf

NE/JNCC. 2010. Marine Conservation Zone Project: Ecological Network Guidance.

Nickell, T.D., Narayanaswamy, B.E. & Hughes, D.J. 2013. Definition of deep-sea infaunal assemblages for inclusion in a deep-sea section of the Marine Habitat Classification for Britain and Ireland: Methods and summary of results.

OSPAR. 2012. MSFD Advice Manual and Background Document on Biodiversity. Version 3.2. Prepared by the OSPAR Intersessional Correspondence Group on the Coordination of Biodiversity Assessment and Monitoring (ICG COBAM) under the responsibility of the OSPAR Biodiversity Committee (BDC).

Parry, M. 2013. A Proposed Structure for the Deep-sea Section of the Marine Habitat Classification of Britain and Ireland (draft). Unpublished.

Parry, M. 2014. JNCC Marine Habitat Classification: Overview of User Issues. JNCC report 529

Peres, J.M. & Picard, J. 1964. Nouveau manuel de bionomie benthique de la mer M,diterran,e. Edition revue et augment,e. Recueil des Travaux de la Station Marine d'Endoume. 31, 1-137.

Piechaud, N. & Howell, K.L. 2013. Definition of epifaunal assemblages for inclusion in a deep sea section of the Marine Habitat Classification of Britain and Ireland: Methods report.

UNEP. 2006. Classification of Benthic Marine Habitat Types for the Mediterranean Region. UNEP (OCA)/MED WG 149/5 Rev.

UNESCO. 2009. Global Open Oceans and Deep Seabed (GOODS) – Biogeographic Classification. Paris, UNESCO-IOC. IOC Technical Series, 84.

Verling, E. & Blyth-Skyme, V. 2007. Integration of infaunal and epifaunal data in habitat map Production. MESH report.

Appendix 1: Version Control

BUILD STATUS:

Version	Date	Author	Reason/Comments
1.0	22.01.2014	Megan Parry	First draft
1.1	25.04.2014	Megan Parry	Incorporate NA comments, revise assemblage list, incorporate feedback from final workshop
1.2	16.07.2014	Megan Parry	Incorporate HE comments
1.3	30.07.2014	Megan Parry	Update zones section
1.4	06.08.2014	Megan Parry	Final for external review
2.0	12.11.2014	Megan Parry	Incorporate final comments.
2.1	16.12.2014	Megan Parry	Final proof check

DISTRIBUTION:

Copy	Version	Issue Date	Issued To
Electronic	1.0	18.03.2014	NA (JNCC), NG (JNCC)
Link	1.1	18.06.2014	HE (JNCC)
Link	1.3	05.08.2014	HE (JNCC)
Electronic	1.4	07.08.2014	KH (PU); BN, DH, TN (SAMS); BB (NOC); FN (MSS); MR (HWU); BL (JNCC); HBDSEG benthic sub-group
Electronic	2.0	14.11.2014	BL (JNCC), HBDSEG benthic sub-group
Electronic	2.1	16.12.2014	JNCC communications team

Appendix 2: Deep-sea classification summary table

Appendix 2 is supplied as a separate Excel document with this report. This spreadsheet lists all the deep-sea habitats from level 1 to 5 within a hierarchical structure.

Appendix 3: Deep-sea habitat descriptions

Appendix 3 is supplied as a separate Excel document with this report. Habitat descriptions for each level are provided in different tabs. The biotope tab can be filtered by physical variables.

Appendix 4: Dendrogram from infauna cluster analysis

Supporting information supplied with Nickell *et al* (2013). This is provided as a separate PDF with this report as the figure is very detailed and needs to be viewed larger than the space available here.

Appendix 5: Recorded depth range of epifaunal biological assemblages

Biological assemblage		Water depth [m]																														
		200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	4000	5000
Ar	Corymorpha, Gersemia, Zoantharia and *Heliometra glacialis*						■	■	■																							
Ar	*Heliometra glacialis*, Actinostolid anemone and tube worm							■	■																							
Ar	Pale encrusting sponge and serpulid assemblage					■	■	■	■	■	■	■	■	■	■	■	■	■														
AA	*Geodia* and other massive sponge assemblage			■	■																											
AA	Pale encrusting sponge and serpulid assemblage		■	■	■																											
At	*Acanella arbuscula* assemblage								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
At	*Bathylasma hirsutum* assemblage	■	■	■	■	■	■	■	■																							
At	*Caryophyllia smithii* and *Actinauge richardi* assemblage	■																														
At	Cidarid urchin assemblage	■	■	■	■	■	■	■	■	■																						
At	Cerianthid anemone and burrowing megafauna assemblage	■	■	■	■	■	■	■	■	■	■	■																				
At	*Dallina septigera* and *Macandrevia cranium* assemblage	■	■	■	■	■	■	■	■	■	■	■																				
At	*Gracilechinus acutus norvegicus* assemblage						■	■	■	■	■	■	■	■																		
At	*Gracilechinus alexandri*, *Psilaster* and *Plinthaster*													■	■	■	■	■	■	■	■	■	■	■	■							
At	*Hygrosoma petersii*, *Benthothuria funebris* and *Oneiroph.*																												■			
At	*Kophobelemnon* fields	■	■	■	■	■	■	■	■	■																						
At	*Leptometra celtica* assemblage	■	■	■	■	■	■																									
At	Lobose sponge and stylasterid assemblage		■	■	■	■																										
At	Discrete *Lophelia pertusa* colonies			■	■	■	■	■	■																							
At	Live *Lophelia pertusa* reef	■																														
At	Mixed coral assemblage on dead *Lophelia pertusa* reef			■	■	■	■	■	■	■	■																					
At	Mixed coral assemblage on dead *Solenosmilia* reef												■	■	■																	
At	*Ophiomusium lymani* and cerianthid anemone assemblage																■	■														
At	Pale encrusting sponge and serpulid assemblage		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■														
At	*Pheronema carpenteri* field				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■												
At	*Psolus squamatus* and encrusting sponge assemblage				■	■	■	■	■	■	■	■	■	■	■	■	■	■														
At	*Psolus squamatus*, Anomiidae, serpulid polychaete		■	■	■	■	■	■																								
At	*Psycropotes longicauda* and *Oneirophanta mutabilis*																													■	■	■
At	*Reteporella* and Axinellid sponge assemblage	■	■																											■	■	■
At	Discrete *Solenosmilia variabilis* colonies											■	■	■	■	■	■															
At	Live *Solenosmilia variabilis* reef										■	■	■	■	■	■	■															
At	Squat lobster assemblage	■	■	■	■	■	■	■	■	■	■	■																				
At	*Syringammina fragilissima* field							■	■	■	■	■	■	■	■	■	■	■	■													
At	Thaumatocrinus jungerseni assemblage																													■		

Summary based on biological assemblages described by Piechaud and Howell (2013).

Appendix 6: Final revisions made to broad community/biological assemblage names

The changes below were made to the broad community and biological assemblage names outlined in Piechaud and Howell (2013) before inclusion in the final list of deep-sea habitats.

Broad communities

1. ‘Coral gardens’ was renamed ‘Mixed cold water coral community’ to avoid confusion with the OSPAR habitat which has a slightly different definition.
2. Seapen field changes to seapens and burrowing megafauna.
3. ‘Encrusting organism dominated assemblages’ changed to ‘sparse encrusting community’.
4. ‘Ophiuroid dominated assemblages’ separated into ‘burrowing ophiuroid community and ‘surface dwelling ophiuroid community’ to distinguish between these two types as distinct biotopes cannot be described at level 5.

Biological assemblages

1. Some assemblages were excluded as they were believed to constitute a mosaic of other biotopes: ‘Highly sediment draped scattered (*Lophelia pertusa*) coral framework’; ‘Halcampid anemones and white encrusting sponges’; ‘Squat lobsters and pale encrusting sponges’; ‘*Lophelia pertusa* colonies, xenophyophores and scattered rubble’; ‘Annelids, hydroids and cerianthids on sediment draped bedrock ledges’.
2. *Lophelia* reef sub-biotopes listed at level 6 were included as biotopes at level 5 instead as they belonged in different parts of the classification if *Lophelia* framework was considered ‘biogenic substrate’ and *Lophelia* rubble was considered ‘coarse sediment’. They were renamed to describe the biological assemblage and placed in the appropriate placed under the appropriate broad community. Only live *Lophelia* reef summit and dead *Lophelia* framework was considered to comprise the broad community ‘cold water coral reef’. *Lophelia* rubble was included under ‘sparse encrusting community’. This was thought to better represent the actual species composition of the communities, while the biotope names make it evident that rubble *Lophelia* is also present.
3. For consistency ‘Boreal ostur’ was renamed ‘*Geodia* and other massive sponges’ to include species specific information.
4. ‘Mixed corals and zoanthid coral garden on *Solenosmilia variabilis* framework and coral rubble’ was renamed ‘Mixed coral assemblage on dead *Solenosmilia* reef framework’ to avoid confusion with OSPAR coral gardens and make a distinction from live reef.
5. Any reference to substrate removed from assemblage as information on substrate in the biotope name will come from the parent habitat.