JNCC Report
No: 612

Identification of Littoral and Sublittoral Rock biotopes from community analysis results

Johnston, C.M.[1], Northen, K.[2], Holt, R.[3] & Parry, M.

February 2019

ISSN 0963-8091

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:

Johnston, C.M., Northen, K., Holt, R. & Parry, M. 2019 Identification of Littoral and Sublittoral Rock biotopes from community analysis results. *JNCC Report No. 612*. JNCC, Peterborough, ISSN 0963-8091.

This report is compliant with the JNCC Evidence Quality Assurance Policy http://jncc.defra.gov.uk/default.aspx?page=6675.

1. Crangon Ltd, 15 Cross Bank, Great Easton, Market Harborough, Leicestershire LE16 8SR

2. Blue-C Ecology, Combe Lodge, Bampton, Devon EX16 9LB
https://www.blue-c-ecology.co.uk/

3. CloudBase Productions Ltd, Tan Hwfa, Llanllechid, Bangor, Gwynedd LL57 3LA
http://www.cloudbasepro.co.uk/

Summary

The existing Marine Habitat Classification for Britain and Ireland was developed in the late 1990s with the last wholesale update in 2004. Since then, a large amount of data has been collected by survey throughout Britain. The classification is being updated in stages, with the most recent update, adding a deep-sea section, in 2015. Updates to the Littoral and Sublittoral Sediment parts of the classification are underway with analysis of sublittoral sediment data performed in 2016 and subject to expert review in 2017. The project reported here was commissioned to review outputs of cluster analysis of community data from the Littoral and Sublittoral Rock sections of the classification, with a view to identifying new biotopes from the data obtained since 2004 and reviewing and updating biotopes from those sections of the classification.

Although the initial remit of the work was to review littoral rock, infralittoral rock and circalittoral rock biotopes, after initial examination of preliminary analysis results the scope was modified to focus entirely on data for circalittoral rock, recognising that this section of the classification was where most difficulties in assigning data to biotope types had been encountered. This report details the process followed, problems encountered, lessons learned and future recommendations from the interpretation of community data analysis.

When the Marine Habitat Classification (Connor *et al* 2004) was last revised, in 2004, most survey data representing Sublittoral Rock was collected by standard Marine Nature Conservation Review (MNCR) Phase 2 detailed survey methodology. The classification was therefore based on those data, which were collected using standardised methodology. The MNCR was undertaken by the JNCC on behalf of the conservation agencies to establish the range of marine communities around the UK coastline. In 1998 the MNCR ceased, since this time, there has been a considerable amount of new data collected for sublittoral rock by various methods: monitoring data (transects, quadrats), volunteer diver Seasearch data, video (towed, drop-down, ROV), stills photography, and acoustic multibeam and side-scan data.

The main findings of the contract:

The initial data analysis run for this work included large volumes of data derived from various survey methodologies (Phase 1, Phase 2, Monitoring, Seasearch, Video, stills). Initial assessment of the resulting clusters revealed that clusters were separated out by survey and more detailed sampling method, rather than by biological differences. Several additional analyses were then performed, progressively reducing the datasets to try to distinguish valid biological community groupings. Effort was focussed on two survey methodologies to reduce the variability in the data:

1) diver collected semi-quantitative Phase 2 MNCR-type data; and
2) video data (drop-down, towed).

Cluster analysis of the Phase 2 data, combined with review of nine proposals for new circalittoral rock biotopes, resulted in recommended addition of two new biotopes.

Cluster analyses of the video data were less conclusive due to variability in both data collection and analysis methods. However, combined with review of survey reports, they did assist with developing recommended changes to Levels 4 (biotope complex) and 5 (biotope) of the hierarchical structure of the moderate and high energy circalittoral rock part of the classification. Video data were found to be insufficiently detailed taxonomically for any new biotopes to be described.

Recommended changes to the hierarchy are:

i) amalgamate high energy and moderate energy circalittoral rock sections of the classification at level 3 (habitat complex);
ii) re-arrange the faunal turf (XFa), faunal crust (EcCr) and deep sponge (DpSp) biotope complexes at Level 4 into three new biotope complexes: Hydrozoan dominated faunal turf communities; Sponge dominated faunal turf communities; and Scour/sediment influenced faunal turf communities. Re-distribute their Level 5 and 6 biotopes and sub-biotopes between them.

Further work will be required to provide descriptions of the three new Level 4 biotope complexes and to update biotope descriptions to reflect occurrence of these biotopes in deeper waters, wider environmental conditions and regional variations, based on data obtained since 2004.

Some potential additional analyses are suggested which could be performed to improve the classification in more minor ways.

Contents

1 Introduction

The Marine Habitat Classification for Britain and Ireland (JNCC 2015) was originally developed in 1996, using data collected for the Marine Nature Conservation Review (MNCR). These data were predominantly from coastal waters down to 50m depth. The classification was substantially updated in 2004, at which time a number of additional sublittoral sediment biotopes were added, based on literature review rather than analysis of survey data. Since 2004 JNCC, Natural England, Natural Resources Wales, Dept. of Environment for Northern Ireland and Scottish Natural Heritage and others have undertaken or commissioned numerous surveys in offshore and nearshore circalittoral waters, driven by the need to characterise seabed habitats in order to identify Marine Protected Areas. When analysing data from such surveys, it has often not been possible to match data to existing biotopes. In 2015 a new section of the classification was developed (Parry *et al* 2015) to cover deep offshore seabed habitats (generally deeper than 200m), and there remains poor coverage of circalittoral rock and sediment habitats occurring in waters between 50 and 200m depth.

JNCC is undertaking a project, in collaboration with the statutory nature conservation bodies (SNCBs), the Environment Agency, Agri Food and Biosciences Institute (AFBINI) and Cefas to improve coverage of the classification by analysing new and old survey data together with the aim of identifying new biotopes and to revise existing ones. JNCC are revising existing sections of the classification in turn. In 2016/17 an update to the Sublittoral Sediment section was drafted. The current phase of development is to conduct analysis of new data for Sublittoral Rock, Littoral Sediment and Littoral Rock habitats and to update the classification in these areas.

Crangon Ltd were commissioned by JNCC to assess the results of JNCC's cluster analysis of marine benthic community data for Littoral Rock and Sublittoral Rock habitats.

This report documents the process of attempting to analyse the UK dataset to test the validity of the current biotopes, incorporating new data collated since the classification was published in 2004 and identifying any new biotopes. It outlines the methods employed to analyse the data, the results, describes the problems encountered during the analysis process and makes recommendations on new biotope proposals and on structural changes to parts of the classification to improve attribution of biotopes to circalittoral rock sample data and to improve presentation of biotopes in map format.

1.1 Project objectives

The aim of the project was to ensure that new or revised Sublittoral Rock, Littoral Sediment and Littoral Rock biotopes have been correctly identified from data and represent real communities that occur in the field. The initial remit of work awarded to Crangon Ltd was to investigate Littoral and Sublittoral (infralittoral and circalittoral) Rock biotopes.

In addition, over the years since the last classification revision, new biotope proposals have been submitted to JNCC by users who have recorded a community they don't think is represented in the classification. Crangon Ltd would compare these biotope proposals for sublittoral rock biotopes with the community clusters from analysis and decide whether they represent true communities that should be included in the classification.

It was noted that any newly identified biotopes should meet set criteria outlined in the 'Distinguishing and defining types' section of Connor *et al* (2004)[1].
The initially outlined objectives for the work were to:

a) for each community cluster, to review characterising species and full cluster species lists along with associated environmental variables;
b) assess the validity of each community cluster against the criteria for distinguishing and defining biotopes, using expert knowledge of species' habitat preferences, field experience and scientific literature to guide decisions;
c) match clusters to existing biotopes in the classification, or flag as a new biotope;
d) group community clusters by matched biotope and compare species composition from different methods. Highlight differences between communities sampled by different methods and suggest reasons behind this;
e) for sublittoral rock, match new biotope proposals to biotopes found in the analysis, and comment on whether the biotope proposals with no match are likely to be real communities that occur in the field and meet the criteria to be a new biotope.

Following review of the results of the first and second cluster analyses, additional objectives were added to the work:

f) review available reports of surveys conducted since 2004 to determine if cluster analyses had been performed on a survey by survey basis on circalittoral rock habitat data, and whether comments on the 'fit' of sample data to the classification had been made within survey reports;
g) provide a report outlining methods and consolidating conclusions from all the above work.

2 Review of clusters from analysis

2.1 JNCC data selection and community analysis

Marine benthic sample data such as survey and sample information, species lists, physical attributes and biotopes recorded is held by JNCC on the Access database known as Marine Recorder. Data is extracted from the Marine Recorder database in the form of a Marine Recorder Snapshot. In preparation for the analysis to review the Littoral and Sublittoral Rock biotopes, JNCC extracted data from the July 2016 version of the Marine Recorder snapshot, as well as 28 additional private sector and Cefas surveys collated by Cefas.

JNCC collated data for analysis splitting the data into subsets by zone and broad substrate type. This contract used only the Littoral and Sublittoral Rock data sets. Due to the very large number of samples included in the analysis (121,921 in total) and variability in how data had been collected (which would affect the cluster analysis), these datasets were split further based on method of data collection. Cluster analysis was carried out separately by JNCC on each subset of the data using R analytical software, as outlined in Appendix 1 and detailed in Parry and Lillis (in press).

The results of cluster analysis for littoral and sublittoral rock community data were supplied to Crangon Ltd for expert review, to identify clusters that were likely to represent true communities in the field.

[1] http://jncc.defra.gov.uk/page-3091. "Distinguishing and defining types" in Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. & Reker, J.B. (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. In: JNCC (2015) The Marine Habitat Classification for Britain and Ireland Version 15.03 [Online].

JNCC supplied a summary for each community cluster (example given in Appendix 2) and additional information, including:

- metadata on the samples it was described from;
- associated environmental variables;
- full species list and characterising species;
- map images showing the distribution of each community cluster;
- outputs from analysis (e.g. dendrograms from cluster analysis, MDS ordination plots) to provide context.

Following initial review of the results of the cluster analysis, where true communities could not be identified due to 'noise' in the data, refinements to the subsets of data were made. Community analysis was undertaken by JNCC four times using different selections of data.

2.1.1 Review of new biotope proposals

Since the last classification revision, new biotope proposals have been submitted to JNCC by users who have recorded a community they don't think is represented in the classification. As part of this project, Crangon Ltd were tasked with comparing these biotope proposals with the community clusters from analysis and to advise whether they represent true communities that should be included in the classification. There were 9 proposed Circalittoral Rock biotopes to review (see Table 1).

Table 1: List of proposed new biotopes for circalittoral rock.

Biotope no.	Proposed biotope name	Proposed code
Biotope 1	*Axinella infundibuliformis* and other massive and encrusting sponges on circalittoral bedrock or boulders subject to strong tidal streams	None given
Biotope 2	*Polyplumaria flabellata* and *Diphasia alata* hydroid community on circalittoral bedrock or boulders subject to waves and tidal streams.	None given
Biotope 3	*Porella compressa* with cup corals, sponges, *Cellapora pumicosa* and crustose communities on wave-exposed circalittoral rock	CR.MCR.EcCr.CarSp.PenPcom.1
Biotope 4	*Porella compressa* with cup corals and sparse crustose communities on wave-exposed circalittoral rock	CR.MCR.EcCr.CarSp.PenPcom.2
Biotope 5	Brittlestars overlying coralline crusts, *Parasmittina trispinosa* and *Caryophyllia smithii* on wave-exposed circalittoral rock, northern version	CR.MCR.EcCr.CarSp.Bri.1
Biotope 6	No name given	CR.MCR.EcCr.UrtSed
Biotope 7	No name given	CR.MCR.EcCr.FaAlCr.Bri (no algae)
Biotope 8	Communities on high relief MDAC/soft circalittoral rock	CR.MCR.SfR.MDAC.1
Biotope 9	Communities on low relief MDAC/soft circalittoral rock	CR.MCR.SfR.MDAC.2

2.2 First cluster analysis

The first community cluster analysis was carried out on the full UK dataset from MR snapshot, divided into five subsets of data as described below.

Dataset 1
Methods: Recording (Phase I), Recording (Phase II), Seasearch
Spatial type: Line
Substrate: Rock 100%
Zone: Littoral

Dataset 2
Methods: Recording (Phase I), Recording (Phase II), Seasearch
Spatial type: Line
Substrate: Rock 100%
Zone: Sublittoral

Dataset 3
Methods: Photography – underwater, Video - underwater (drop-down), Video - underwater (towed)
Spatial type: Line
Substrate: Rock 100%
Zone: Sublittoral

Dataset 4
Methods: Recording (Phase I), Recording (Phase II), Seasearch
Spatial type: Line
Substrate: Rock 100%
Zone: Littoral and sublittoral (estuary and lagoon data)

Dataset 5
Methods: Photography – underwater, Video - underwater (drop-down), Video - underwater (towed)
Spatial type: Point, line, area
Substrate: Rock 100%
Zone: Littoral and sublittoral (estuary and lagoon data)

The sample data included species data with either quantitative counts or semi-quantitative SACFOR scale units assigned. Prior to analysis certain samples were excluded and taxonomic records were edited as described below, and a species matrix was generated using presence data. The analyses were undertaken on presence/absence of species, but the species data were presented in the cluster summaries (example at Appendix 2) with SACFOR abundances for reference (see http://jncc.defra.gov.uk/page-2684).

When survey data is entered into Marine Recorder the data can be 'tagged' to indicate any deviation from a complete dataset. If the recording of species has been hindered, e.g. through adverse weather conditions or insufficient recording time, to the extent that surveyors were not able to record an exhaustive list/representative of all the species present then the species associated with that particular sample will be flagged 'I' denoting an incomplete record of species. Such samples were excluded from analysis.

Communities may occur across habitats in transitional zones or as a mosaic depending on the habitat. Where the species listed for a sample are considered to span more than one

biotope then the biotope can be assigned to a sample record as a 'P' part biotopes. Several part biotopes may be assigned to one sample in this instance. These samples were also excluded from analysis.

Samples excluded:

- surveys with clearly incomplete species lists
- impacted surveys [e.g. where known sewage discharge]
- 'part' biotopes

Edits to species data:

- records as juveniles, pelagic, uncertain species and non-living records were excluded
- species list checked against the World Register of Marine Species (WoRMS)

It was immediately apparent from the initial review of the first set of community analysis results that virtually all the clusters produced were artefactual. Where discernible, clusters appeared to group by survey type, survey event or geographically, and by presence of suites of ubiquitous and common species, rather than basing clustering on the finer differences in biological composition of the records required to describe biotopes.

The presentations of the dendrograms representing these large datasets were almost unreadable, given the concentration of splits on such a large scale, and could not be used effectively to aid assessing the results. The number of samples processed in the analysis were simply too great to enable any interpretation of the dendrograms.

It was apparent from reviewing five initial clusters from each of the Littoral Rock and Sublittoral rock datasets that there was too much 'noise' generated in the data by combining methodologies, and the clusters were not representative of naturally occurring communities. For example, one cluster (cluster D1_06_2) contained data representing Phase 1, Phase 2 and transect surveys and had 23 different biotopes already assigned to the field records associated with this cluster. Detailed monitoring data were also forming discrete clusters but the clusters did not include data beyond one survey area and one survey type.

All the clusters for the sublittoral video had very limited species lists associated with them, with in many cases few taxa identified to species or genus and many only identified to higher levels such as Porifera or Bryozoa. Such records would be tagged as 'incomplete' if recorded during Phase 2 surveys and would have been excluded from biotope-defining data analysis.

The initial analysis was undertaken selecting only records with 100% bedrock in the habitat description. Crangon advised JNCC that this would exclude far too much valid data from the analysis (i.e. samples consisting predominantly of bedrock, but with some cobbles, boulders or finer sediments present, would have been excluded). For the second and third analyses, records with greater than 50% bedrock were included. The different proportions of bedrock, boulders and sediment are key to defining many of the biotopes, where substratum type, sand-scour and siltation *etc*, all influence species composition.

2.3 Second cluster analysis

Following initial review of the first cluster analysis it was clear the preliminary community cluster results were not sensible. Consequently, the dataset on which the analysis was carried out was reduced. Greater refinement of the data was necessary to reduce the amount of variability in the data and reduce the sample sizes being analysed so that analysis results such as dendrograms could be interpreted. Different categories of data from Marine Recorder were therefore excluded from the cluster analysis as described below.

Littoral Rock and Infralittoral Rock data were excluded in order to focus on the Circalittoral Rock section of the classification where most problems had been encountered, and where the majority of the new data had been collected that might lead to new or revised biotopes needing to be described.

Monitoring sample data were excluded as monitoring records from multiple survey events at different times from only one habitat at one site clustered together closely and therefore skewed the overall results. They were also much more detailed taxonomically than many other records, and in some cases recording was focussed on a defined subset of taxa rather than on complete recording from the habitat.

Variability in records within the category of data collected by volunteer Seasearch divers was too inconsistent to allow for robust community analysis. Some samples collected by expert recorders were highly detailed with many taxa identified to species level, including rarer or cryptic examples; other samples had low numbers of taxa recorded only to family or higher level (e.g. Porifera, Bryozoa), and there was no straightforward way to separate out such records in Marine Recorder. This dataset was therefore excluded from the analysis process. It should be noted that many Seasearch records are of a high standard, but it is the variability in the recording that negated the use of the dataset.

Data from samples collected prior to 1999 (the cut-off date for samples used to develop the 04.05 version of the classification) were excluded, with the exception of those tagged in Marine Recorder as ‘core biotope’ records. The rationale being that all such data not tagged as a core biotope record will have been thoroughly examined during the 2004 development of the biotope classification and therefore would not contribute to further development at this stage.

Differences between similar biotopes depend often on differences in abundance of particular species or taxa. Analysing semi-quantitative samples by presence/absence does not enable such differences to be detected, so the second and subsequent analyses used a scale from 1-7 based on the SACFOR scale. Records where ‘presence’ rather than an abundance was recorded were allocated a score of 1, with 2-7 being allocated to rare, occasional, frequent, common, abundant and superabundant respectively.

Differences from previous analysis highlighted in blue.

Samples excluded:

- surveys with clearly incomplete species lists
- impacted surveys
- lagoon/estuary/variable salinity
- ‘part’ biotopes
- records tagged with ‘incomplete’ rep quality
- monitoring surveys
- non-core biotope samples (pre-1999 only)

Edits to species data:

- juveniles, pelagic, uncertain species and non-living records excluded
- species list checked against the World Register of Marine Species (WoRMS)
- taxa removed or merged where taxa were recorded at more than one taxonomic level and could potentially be duplicates of the same species

Two subsets of the data created:

Dataset 1
Methods: Recording (Phase II)
Spatial type: Point, line, area
Substrate: Rock >50%
Zone: Circalittoral

Dataset 2
Methods: Photography – underwater, Video - underwater (drop-down), Video - underwater (towed)
Spatial type: Point, line, area
Substrate: Rock >50%
Zone: Circalittoral

Data analysis
Species matrix created using SACFORP 1-7 scale data.

Progress was made in the second analyses by refining and targeting data-sets to cut out methodological bias and 'noise' in the data caused by inconsistent recording of taxa at various levels of detail.

The refined second run of community analysis, using only Phase 2 data and where bedrock comprised ≥50% of the substratum, produced several community clusters that represented more cohesive groups, concurring with the biotopes already tagged to these records, as seen in Table 2. Most clusters generally grouped records from sites into similar geographic areas. However, many were still too broad, for example, the species in cluster NA11 indicated a commonality of grazing influence; NA26 represented a geographically diverse range of sites which appeared to be characterised by scour-tolerant species. Only one cluster, NA45, warranted further analysis to potentially identify new deeper circalittoral biotopes.

Table 2: Examples of clusters from the second analysis of Phase II circalittoral rock data.

Cluster code	No. of samples	Location	Description	Biotope codes
NA2	30	Sheltered Scottish sealochs	Mix of low energy bryozoans & ascidians	Eight: mix of CR.LCR, CR.MCR, SS.SBR, SS.SMu
NA10	13	Sheltered Scottish sealochs	*Modiolus*	SS.SMx.CMx.CIloModHo
NA11	10	Irish sea area	Mix of grazed communities	CR.MCR.EcCr and CR.HCR.XFa
NA12	5	W Scotland	*Swiftia*	CR.HCR.XFa.SwiLgAs
NA26	34	Widespread	Scoured communities	Nine: CR.HCR.XFa, CR.MCR.EcCr, SS.SCS and SS.SMx
NA31	44	NE coast	Grazed community	CR.MCR.EcCr.FaAlCr
NA45	48	Western Wales, Ireland, England & Firth of Lorn	High-mod energy deeper circalittoral biotopes	Eight: CR.HCR.DpSp, CR.HCR.XFa, CR.MCR.EcCr

Two other areas warranted further analysis, *Modiolus* communities and deep, tide-swept circalittoral rock communities. Samples with the horse mussel *Modiolus modiolus* split into

several clusters but there remained too much 'noise' within the dataset in this particular analysis.

2.4 Third cluster analysis

Following examination of the results of the first and second data analyses, analysis was focussed on more refined subsets of data: i) two selected areas of Phase II Circalittoral Rock data, and ii) a refined dataset of video/photographic records.

The reasons for further analysis of the Phase II Circalittoral Rock data were that:

- the second analysis produced several community clusters that warranted further investigation into *Modiolus* communities. It was therefore decided to select all Phase II records of *Modiolus modiolus* for analysis;
- similarly, one of the clusters produced in the second run of analysis represented a large group of west-coast, exposed, relatively deep communities. This dataset was selected for further analysis to try and tease apart the data into more coherent groups, as data from such environmental conditions was very sparse at the time of developing the 04.05 version of the classification.

The reasons for further analysis of the video/photographic data were that:

- the video /photographic analysis was run as analysis 2 for the same reasons, but where taxa had been recorded to a reasonable level of detail, arbitrarily selected to be where at least 50 % of taxa records were to either species, genus or family level. The purpose was to eliminate records with the majority of taxa identified to higher taxonomic levels to avoid very general community clusters characterised only by insufficiently detailed taxa such as Echinodermata, Crustacea, Bryozoa, which could represent many different species. This reduced the dataset from 12,428 samples representing 101 surveys to 5,971 samples representing 91 surveys.

Duplicate taxa were removed from the analysis. Where taxonomic records were merged the SACFOR score was also merged. The greatest SACFOR score was selected to represent the taxon, as the one most likely to separate out in the cluster analysis.

2.4.1 Modiolus data

Five community clusters, shown in Table 3, represented all four current *Modiolus* biotopes:

i) SS.SMx.CMx.ClloModHo
Sparse *M. modiolus*, dense *Cerianthus lloydii* and burrowing holothurians on sheltered circalittoral stones and mixed sediment.

ii) SS.SBR.SMus.ModT
M. modiolus beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata.

iii) SS.SBR.SMus.ModHAs
M. modiolus beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata.

iv) SS.SBR.SMus.ModCvar
M. modiolus beds with *Chlamys varia*, sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata.

Table 3: Biotopes assigned to community clusters from analysis of samples where *Modiolus* was recorded.

Cluster code	No. of samples	Location	Description	Biotope codes
08	5	Firth of Clyde sea lochs	*Modiolus* recorded as Occasional	All tagged SS.SMx.CMx.ClloModHo
15	7	North East coast of England	*Modiolus* recorded as Rare	All tagged CR.MCR.EcCr.FaAlCr
22	6	Open coast from Shetland and Orkney to the Ards Peninsula, Northern Ireland	*Modiolus* recorded as Abundant	All tagged SS.SBR.SMus.ModT
32	6	Strangford Lough	*Modiolus* recorded as Occasional	4 assigned to SS.SBR.SMus.ModHAs, 2 to SS.SMx.CMx
33	7	Strangford Lough	*Modiolus* recorded as Common	6 assigned to SS.SBR.SMus.ModCvar, 1 to SS.SBR.SMus.ModHAs

The results of the analysis supported the current split of *Modiolus* biotopes, and did not identify any potential new *Modiolus* biotopes.

2.4.2 Deep circalittoral rock data

The analysis of the Phase 2 Circalittoral Rock data revealed an interesting community cluster in P2_NA_ 45. There were 48 samples within this cluster, all from western UK, wave-exposed, tide-swept and relatively deep (22-41m below chart datum) locations. Samples were tagged with a variety of biotopes, eight in total from the biotope complexes CR.HCR.DpSp (deep sponge communities), CR.HCR.FaT (very tide-swept faunal communities), CR.MCR.EcCr (Echinoderms and crustose communities) and SS.SMx.CMx (Circalittoral mixed sediment communities), but the majority of records (37 of 48 samples) were tagged with CR.HCR.XFa complex or its associated biotopes. This group warranted further investigation to tease apart the data.

JNCC re-analysed the community data from the original cluster P2_NA_ 45. Three main sub-clusters came from the analysis. The smaller cluster of five samples, located in Lundy and the Isles of Scilly, are influenced by fauna associated in these instances with vertical rock (*Actinothoe*, *Alcyonidium* spp., *Caryophyllia*, *Corynactis*, *crisiid* turf and encrusting sponges). Cluster 5, with 12 samples from exposed sites spanning Northern Ireland to southern Ireland, was species-rich, characterised by a range of sponges, particularly *Axinella infundibuliformis*, hydroids *Nemertesia* spp. and *Sertularella* spp., *Corynactis*, *Caryophyllia*, *Porella*, and with *Eunicella* present in some of the cluster records. There was a broad range of biotopes already associated with this cluster, mostly CR.MCR.EcCr.CarSp, with CR.HCR.XFa.ByErSp and CR.HCR.DpSp.PhaAxi, so still quite a mixed group. The survey team collecting these records has considerable local expertise in identification, and so the records are almost certainly influenced by surveyor bias – the records being consistently more species-rich than many others.

The most coherent group is cluster 7. The samples are predominantly from The Maidens and Rathlin Island in Northern Ireland, extending to one sample site in the Firth of Lorn,

West Scotland. This cluster represents relatively deep (20-30m BSL), wave-exposed sites. Although there is no associated tidal information attached to these data, these areas are known to experience strong tidal streams. 14 of the 18 sample records are tagged with CR.HCR.XFa. Significantly 16 of the records are tagged as an 'uncertain' biotope match suggesting they may not fit with any of the current biotopes in the classification. The report of the Maidens survey (Goodwin *et al* 2011) suggests that two communities of this nature encountered on the survey do not match any existing biotope descriptions in the current classification (Conner *et al* 2004). Both these communities were proposed to JNCC as potential new biotopes. Interestingly, these communities are within cluster 7.

The proposed new biotope communities were described as follows:

Goodwin *et al* (2011) Habitat 4: Deep water sponge community
This biotope occurs in deeper areas, typically >25m. It is out of the strongest tidal streams, and the bedrock is often covered in a fine layer of silt. *Caryophyllia smithii* is abundant or common. It is characterised by the presence of common or frequent *Axinella infundibuliformis* sponges and other massive sponges such as *Raspailia hisipida, Raspailia ramosa*, *Stelligera stuposa*, *Polymastia boletiformis* and *Haliclona viscosa*. Encrusting sponges are also common. The hydroid *Nemertesia antennina* is often frequent. The closest biotope to this is CR.HCR.DpSp.PhaAxi (characterised by both *Phakellia* and *Axinella*), although this biotope is normally associated with areas subject to strong tidal streams (although less than the more exposed *Tubularia*-dominated sites). *Phakellia ventilabrum* is absent in these new records, with this deep-water species typically found on the westernmost coasts of Scotland and Ireland. We therefore propose that a new sub biotope should be designated.

Goodwin *et al* (2011) Habitat 5: *Polyplumaria flabellata* and *Diphasia alata* hydroid community
This biotope is characterised by the presence of the hydroids *Polyplumaria flabellata*, *Diphasia alata* and *Aglaophenia tubulifera,* with *Diphasia fallax* often present growing on other hydroids. These species may vary in proportions but are usually all common or frequent. The hydroid *Lytocarpium myriophyllum* may be present, often only patchily. The soft coral *Alcyonium digitatum* and the cup coral *Caryophyllia smithii* are often common. In shallower areas red algae such as *Delesseria sanguinea* may be frequent. The hydroids *Nemertesia antennina* and *N. ramosa* are often frequent. A crisiid turf may be present together with other bryozoans such as *Cellaria* sp.

The survey report states that the hydrographic conditions present and the proximity of deep water to the Maidens plateau result in conditions not found in many other UK areas and consequently these habitats are extremely rare. In addition, the hydroid communities are extremely rare and unlikely to have been encountered widely in other areas of the UK. Habitat 5: *Polyplumaria* and *Diphasia* community does not fit with any of the XFa.ByErSp sub-biotopes.

There are a diverse range of hydroids present in several of the samples within the cluster, representing the *Polyplumaria* and *Diphasia* community described by Goodwin *et al* 2011; those found in greater abundance include *Aglaophenia tubulifera*, *Nemertesia* spp., *Polyplumaria flabellate*, *Diphasia* spp. and *Sertularella gayi*. Data from the Deep Water Sponge community is also within cluster 7, particularly prominent in this group are *Axinella infundibuliformis*, *Stelligera stuposa*, *Myxilla* sp. and *Raspailia* sp. It should be noted that a diverse range of sponges are found in samples across this cluster.

Conclusions:
There is unlikely to be much additional supportive data for these two biotopes proposed from Goodwin *et al* 2011 due to their rarity and scarcity of data from such depths. However, the

detailed species assemblage data and habitat descriptions do support the description of a new biotope. It may be that additional information from deep circalittoral rock video data may fit this biotope in the future, although it is likely to remain a rare habitat.

A high level of surveyor expertise, particularly with respect to sponge and hydroid identification, has almost certainly resulted in these data forming their own separate, but nonetheless, valid cluster.

Proposed *Porella* biotopes from Solan Bank – There are no Phase 2 data for this area as it is derived from offshore and video surveys. Interestingly, a search for *Porella* in the Phase 2 data species spreadsheet (DiveVideo_CR_P2_hclust_h0.7_Species_ClusterResults) reveals that most of the records are also in the cluster **P2_NA_ 45**. Insufficient detailed taxonomic data were available to either recommend or reject these two new biotope proposals, and the cluster analysis did not identify them as distinct from other samples.

2.4.3 Video data

The third re-run of analysis of the video data still proved problematic. Two problems were evident. Firstly, the lists of 'characterising' species for each cluster are really lists of the few taxa that are common between samples, many of which are ubiquitous and recorded only to family or higher level, rather than groups of species which characterise a biotope or biotope complex.

For example, V1_02_1 the characterising species list comprised:

Bryozoa
Porifera
Rhodophyta
Spirobranchus
Marthasterias glacialis

It is not possible to discern from such results whether several species within the same family are present, but not able to be distinguished from each other on video, or whether only one species is present, but it is not possible to identify it to species level from video records. At level 5 and 6 in the classification (v04.05), different biotopes are distinguished from each other by differences in species abundances within higher taxonomic groups (e.g. within the larger groupings of Porifera, Bryozoa, Anthozoa), combined with differences in energy level and substratum type. In deep waters (approximately >50m) not subject to strong tidal streams, energy level is less of an influence on biotopes than in shallower waters.

The second problem was that many clusters were including samples assigned to a mixture of three Level 4 biotope complexes – HCR.XFa (mixed faunal turf communities), MCR.EcCr (echinoderms and crustose communities) and to some extent HCR.DpSp (deep sponge communities). There was still no clear pattern in clustering of these complexes or their biotopes. We strongly suspect, but without going back to individual sample records cannot confirm, that this could be partly due to variability in assigning of sample records to biotopes because of a poor fit of sample data to the existing classification. Reasons for this could also be due to low diversity of taxa on video records, difficulties in identifying down to species level from video for some taxa, lack of environmental information at sample resolution, and variability in both video analysis methods and biotope selection by different analysts.

In conclusion, assessment of the cluster analyses and of the new biotope proposals confirmed that video samples generally cannot provide sufficiently resolved data to define any new biotopes, even when stills photographs have been taken simultaneously with video and used to improve identification of taxa.

The third cluster analysis to some extent separated out groups of samples assigned the same detailed biotope during video analysis, but the two biotope complexes HCR.XFa and MCR.EcCr in particular, and to some extent HCR.DpSp were still not separated out by the analysis.

In order to try to further resolve the above problems, a review of survey reports (see Section 2.5) was carried out, to identify if cluster analyses had already been performed on datasets from individual surveys.

2.5 Report review for existing statistical analyses of circalittoral rock data

When it became clear that the third cluster analyses of circalittoral rock data collected by video were still not showing clear clustering by biotopes, an alternative parallel approach was agreed.

Since the 2004 version of the classification was published, numerous marine surveys have been undertaken, many of which collected data by video and photographic methods, focussed mainly on potential Marine Protected Areas (Special Areas of Conservation and Marine Conservation Zones). Reports of marine surveys, where these included areas of circalittoral hard substrata, were reviewed to help refine where revision of the biotope classification might be needed. The approach was intended as a brief initial review of a small selection of reports likely to yield information quickly (i.e. those reports where cluster analysis was known to have been performed already).

The reviews aimed to identify:

i) if multivariate statistical analysis had been performed on data for hard substrata post-survey;
ii) where such analysis had resulted in clusters or groups that could not be well-matched to existing biotopes within the classification; and
iii) if useful comment had been made in the report on difficulties in matching data to biotopes for circalittoral hard substrata.

Initially only reports identified by JNCC for MCZ surveys where it was known that community analysis had been performed were reviewed, to locate where recognisable clusters could not be matched to an existing biotope. However, most of the areas considered for MCZ designation were identified for their sand, mud, mixed or coarse sediment broad scale habitats, with only a few including areas of circalittoral hard substrata, so there was little pertinent information in these reports.

Because offshore Special Areas of Conservation (SACs) had been identified for their 'reef' and 'sublittoral structures made by leaking gases' habitats and most of these habitats were located in circalittoral waters, JNCC reports of surveys of offshore SACs were added to the review. Reports of seabed habitats in waters deeper than 200m were not included, as this section of the biotope classification has already been revised (http://jncc.defra.gov.uk/page-6998).

Reports from MPA surveys included in the initial review are listed in the Table 4 below (full references, notes and conclusions are tabulated in Appendix 4).

Table 4: Reports included in initial review of reports for cluster analysis.

Marine Protected Area	Source
Fulmar rMCZ; Offshore Brighton rMCZ; Western Channel rMCZ	JNCC Report 593 http://jncc.defra.gov.uk/page-7278
Holderness Offshore rMCZ; Inner Bank rMCZ; North-west of Jones' Bank rMCZ; South Isles of Scilly rMCZ; Farnes East rMCZ; Greater Haig Fras rMCZ; Offshore Overfalls rMCZ	JNCC Report 595 http://jncc.defra.gov.uk/page-7289
North East Farnes Deep rMCZ; East Haig Fras rMCZ; South-west Deeps rMCZ; Swallow Sand rMCZ	JNCC Report 588 http://jncc.defra.gov.uk/page-7235
Compass Rose rMCZ; Markham's Triangle rMCZ; South Rigg rMCZ	JNCC Report 608 http://jncc.defra.gov.uk/page-7471
Haig Fras SAC	JNCC-Cefas Report 004 http://jncc.defra.gov.uk/page-7090
Pobie Bank SAC	JNCC Report 433 http://jncc.defra.gov.uk/page-5025
Croker Carbonate slabs SAC	JNCC Report 430 http://jncc.defra.gov.uk/page-5347
Solan Bank SAC	JNCC Report 430 and 582 http://jncc.defra.gov.uk/page-7234
Stanton Banks SAC	JNCC Report 425 http://jncc.defra.gov.uk/page-4654

The initial review did not identify any significant information that could assist in resolving biotopes or identifying new ones, beyond what had already been provided in terms of new biotope proposals to JNCC (see Section 4.1).

The review scope was then extended to:

iv) identifying specific smaller data sets that would be most fruitful to re-analyse on a survey-by-survey or area-by-area basis, to try to reduce 'noise' in the data that had been complicating the previous statistical analyses.

Sourcing such widely and variously distributed data is not without its challenges. This range of surveys had been commissioned by several different organisations (JNCC, Defra, Scottish Natural Heritage, Natural England, Natural Resources Wales), and the field surveys and analyses were carried out by a larger range of institutions or contractors, who each have a different mechanism for publishing their reports. In most cases reports are made available online, and individual pdf files can be located through search-engines if the title or part of the title of the report is known. These survey reports vary widely in content, and are not listed as a series of 'marine survey reports', and none of the publication sources facilitates finding such reports by using keywords. The majority of the reports are made available by JNCC, Defra (for Natural England and Cefas) and Scottish Natural Heritage:

JNCC survey reports are published in two report series (JNCC and JNCC-Cefas report series) available online and listed in chronological order through the JNCC publications catalogue (http://jncc.defra.gov.uk/page-1482). Relevant reports vary in content from

individual survey cruise reports (listing practical details of what data were collected, when and how) to reports of data analyses and habitat mapping using data from one or multiple individual surveys. The detail of the content of the report, or the area or MPA(s) to which it relates, is not always obvious from the title.

Defra surveys are commissioned through Defra's Science Research and Development programme and may be conducted by various institutions and commercial consultancies. Most of the surveys of English MPAs were carried out by Cefas, often jointly with one of the Statutory Nature Conservation Bodies. Reports are made available via Defra's Science and Research Projects database under the relevant research project (MB0129 in the case of MCZ reports). Research projects can be searched-for only using general themes (e.g. Marine conservation; Monitoring; nature conservation).

Scottish Natural Heritage reports are published as commissioned research reports on their website.

In order to narrow down the search for reports to be reviewed, the data from Marine Recorder held in the Excel file for the restricted dataset for Analysis 3 (DiveVideo_CR_VI_G50_PhysCluster.xls) was used (where >50% taxa recorded to species/family level). A pivot table was extracted, identifying for each of the 91 surveys included, its Marine Recorder reference number, geographical location (Regional Sea), and the number of samples and the range of biotopes representing circalittoral rock recorded for that survey. From this list, all surveys (35) where the number of samples was low (generally <6) and/or the biotopes recorded were mainly from sedimentary, coarse or mixed substratum types were excluded from review. For six of the remaining surveys, reports had already been reviewed as they related to offshore rMCZs or SACs. This exercise left a more manageable list of 46 surveys (with reasonably detailed taxonomic records from samples of circalittoral hard substrata) to be added to the report review, for the reasons outlined in i)-iii) above.

Internet searches identified reports relating to most of the 46 remaining surveys. Some reports related to analysis of data from several surveys in one or several areas. For some MPAs, there were several separate reports containing analyses of data relating to that area or MPA. Many were reports collecting evidence for MCZ identification; these reports contained lists of species and % abundance within the site recorded from videos and still photography, but samples were matched only to broadscale habitat types (L2 or 3 of the classification). Biotopes identified from video analysis at Level 4, 5 or 6 of the classification were not included in the reports. In several cases references for reports of video/photographic analyses were included in these reports, but the analysis reports themselves could not be located online.

The spreadsheet at Appendix 4 lists the reports reviewed, the area (usually an MPA) to which it relates, Regional Sea in which the area lies, the Marine Recorder (MR) survey reference, the number of circalittoral rock samples from that survey in MR. Rough notes on the range of relevant L4 biotope complexes noted, and notes on the content of the report and whether comment on biotope matching was made. Columns also note which surveys had relevant data that could be used for further community analysis for circalittoral rock (many related to sediments or mixed substrata), whether cluster analysis had been carried out on the circalittoral rock data to allocate biotopes, and whether new biotopes were proposed or discussed in the report. The reviewer and date are also noted. This table is not precise, it was intended as a rough guide to which reports might hold useful information for biotope definition and further cluster analysis. Filtering the table by columns L (data for biotope id?), M (Cluster analysis of CR samples?) and N (new biotope/biotope split proposed?) enables sorting and closer examination of the information.

Of all the reports reviewed, in only eight had there been any cluster analysis of circalittoral rock or hard substratum data (see Table 5).

Table 5: List of reports where cluster analysis of circalittoral rock had been performed (refer to Appendix 4 for further detail).

Report	Short description
JNCC-Cefas Report 017	Croker Carbonate Slabs initial monitoring report
JNCC-Cefas Report 012	Solan Bank Reef environmental data analysis
JNCC Report 582	Solan Bank SAC video analysis
JNCC Report 433	Biological data interpretation of the Reef East of Shetland Isles Area of Search [now Pobie Bank SAC]
JNCC Report 595	Offshore Overfalls rMCZ community analysis
Natural England Report 160	Isle of Scilly Complex SAC reef feature condition assessment
JNCC Report 593	Western Channel rMCZ community analysis
JNCC Report 588	E. Haig Fras rMCZ community analysis of grab and video data

In three of these cases (at Croker Carbonate Slabs SAC, at Pobie Bank SAC and at E. Haig Fras rMCZ) a new biotope was proposed. The circalittoral rock biotopes recorded at all of these survey areas tended to be faunal turf, faunal crust and deep sponges (CR.HCR.XFa, CR.MCR.EcCr or CR.HCR.DpSp). For three of the reports (JNCC report 433 surveys of Reef E. of Shetland 2003 & 2006; NE report 160 Isles of Scilly survey 2013 and JNCC-Cefas report 017 Croker Carbonate Slabs survey 2015), the data were either not in the subset of MR data created for the third cluster analysis (where >50% of taxa were recorded to species or family level), or were not in Marine Recorder at all.

2.6 Fourth cluster analysis

The report review identified that cluster analysis of circalittoral rock records from individual surveys since 2004 had rarely been carried out (cluster analysis that was carried out focussed on communities of sediment or mixed habitats). It was decided that it may be worthwhile performing cluster analysis separately on data from individual surveys or small groups of surveys carried out by the same organisation in the same geographical area. Reducing the datasets still further would remove some variability in how data were collected and analysed, reduce regional variation, and may enable patterns to be discerned, particularly between the faunal turf/crust biotope complexes. Following the review of reports, a fourth set of cluster analyses was performed to assist in determining how the structure of the classification at Levels 3, 4 and 5 for circalittoral rock could be adjusted to accommodate lower taxonomic resolution data from video samples, and at the same time to facilitate mapping of biological communities at biotope complex level.

The fourth cluster analysis focussed entirely on video data, using only samples where at least 50% of taxa records were to either species or family level. The results of the report review (see Section 2.5) were used to identify surveys in each region with sufficient samples to be worth attempting cluster analysis on a survey by survey basis. Separate analyses were performed on individual or small groups of surveys in the same region by the same organisation, focussed on deep circalittoral habitats where significant new (post-2004) data were available.

Cluster analyses were performed separately on samples from the groups of surveys shown in Table 6.

Table 6: List of surveys included in fourth cluster analysis.

Group	Regional Sea	Sub-group	SAC/MCZ area survey	Marine Recorder survey reference
1	Western Channel & Celtic Sea	A	Haig Fras 2012 Greater Haig Fras 2012 Haig Fras SAC 2012	MRCON 041 00000002 MRCON 042 00000005 MRCON 040 0000000A MRCON 041 00000009
		B	Isles of Scilly SAC 2014 + 2011 Bristow to the Stones 2013	MRNE 01660 0000009 MRNE 01300 0000003 MRNE 01080 0000030
		C	Cape Bank 2007 Cape Bank 2014 Lizard 2007 Manacles 2012	MRNE 01020 0000006 MRNE 01020 0000048 MRNE 01020 0000005 MRNE 01450 0000008
		D	Whitsand & Looe Bay 2013 Padstow Bay 2013 Kingmere 2012	MRNE 01080 000002C MRNE 01080 0000028 MRNE 01450 0000007
		E	Hartland to Tintagel 2013	MRNE 01080 0000020
2	Eastern Channel	A	South of Portland 2014 South Dorset 2013 Chesil Beach & Stennis Ledges 2013	MRNE 01710 0000002 MRNE 01080 000002B MRNE 01080 0000027
		B	Central Channel 2006 Wight-Barfleur 2012 Eastern English Channel 2005	MRMIT 6000 000001C MRCON 040 0000000C MRMIT 6000 000000D
		C	Bembridge 2012 Needles 2014	MRNE 01080 000001E MRNE 01760 0000002
		D	Offshore Brighton 2012 Folkestone-Pomerania 2012+2014 Dover-Folkestone 2012	MRCON 042 00000008 MRNE 01450 0000009 MRNE 01410 0000003 MRNE 01080 000002F

Following initial examination of clusters, data from the South of Portland 2014 survey were excluded as they clustered all together. On examination of the species records, it appeared an identical list of 39 taxa had been listed as ‘present’ in all samples from the video analysis, the only difference between samples being slight variances in abundance of a very small number of taxa.

Notes on each of the clusters resulting from the analysis are tabulated in the standard Community Analysis Review Form spreadsheet at Appendix 5.

The results of the fourth analysis of regionally isolated samples suffered from the same challenges as the previous analyses, in that clusters were separated out on the basis of short lists of taxa in common, many of which were identified only to family or higher level (e.g. Porifera, Bryozoa), and again, the coarser level faunal turf/crust biotope complexes of HCR.XFa, MCR.EcCr and HCR.DpSp were not separated out by the analysis.

The conclusion that even cluster analysis from individual surveys cannot separate out samples assigned to these three biotope complexes supports the expert view that the classification hierarchy needs to be modified in that area. Assessment of the clusters did

help to consolidate our recommendations on how the hierarchy can be modified, without modifying individual biotope descriptions, to enable assigning biotopes and biotope complexes to video samples using all the biological information available.

A subjective expert view of the analysis indicated that faunal turf/crust samples where Level 5 biotopes had been assigned tended to be clustered into three broad groups: those with greater diversity of sponges, those with a mix of scour/sediment tolerant taxa (e.g. *Flustra foliacea*, *Cliona* sp, *Urticina* sp), and a large, diverse group with a mix of anthozoans (*Alcyonium digitatum*, cup corals, anemones). This expert conclusion supports the need to adapt the structure of the classification for faunal turf/crust biotope complexes to facilitate assigning biotopes from video samples, and which would also facilitate mapping of biotope complexes using such data.

3 Summary of issues and problems encountered

3.1 Issues with the 04.05 circalittoral rock classification identified by users

Table 7 outlines issues identified with the classification during the project from users in the Statutory Nature Conservation Bodies and their contractors, and from our combined reviews of information.

Table 7: Issues with circalittoral rock classification v04.05 identified by users.

Issue	Current biotope code	Proposed biotope code or comment
***Modiolus modiolus* biotopes** NRW: We really need to have a level 4 code for *Modiolus* biotopes, at the moment you have to use either SS.SBR.Mus which includes *Mytilus* beds, or the very specific level 5 *Modiolus* codes, which aren't a good fit for the N. Anglesey *Modiolus.* Lack of biotope for *Modiolus* on circalittoral rock	SS.SBR.Mus or CR.MCR.CMus	Third cluster analysis supports current L5 *Modiolus* biotope grouping with biotopes on mixed substrata. Separating mussel beds by species at L4 would unbalance the classification (too detailed) – no change recommended.
CR.HCR.XFa and CR.MCR.EcCr biotope complexes, L5 and L6 biotopes and sub-biotopes There are mismatches in the XFa and MCR.EcCr biotope complexs, and to a slightly lesser extent the HCR.DpSp complex, between field records and biotope descriptions. The L4 descriptions currently describe northern and western (largely Scottish) variants of these communities (as do the L5 biotopes underneath them). Now that more data have been collected from elsewhere in UK, including many samples by video (where identification of species is often less detailed), there is no comparable general faunal turf/crusts biotope complex which fits these records. This has resulted in samples with a wide range of species and abundances being tagged with these biotope complex codes, which need re-analysis with the new data. Also: Biotopes in CR.HCR.XFa occurring in moderate energy conditions. For example, around Anglesey, particularly in turbid conditions, species assemblages of hydroids, bryozoans (*Bugula*, *Crisia*), sponges (*Amphilectus*, *Dysidea*, *Cliona*, *Pachymatisma*) and ascidians (*Clavellina*, *Aplidium*) occur; but with no or very little *Alcyonium* or *Flustra*. Regional variation in the mixed faunal 'turf' biotopes vary hugely – often spanning a much wider range of energy levels and depth ranges than intimated in the current descriptions. The descriptive text for the L4 complex notes it occurs in a range of energy levels, and a number of reports from surveys recorded this biotope noting that energy levels were moderate rather than high. Allocation of video sample data to these biotope complexes or their subtypes is problematic where diversity may be low and identification to species or family level is not possible for some taxa – data do not match descriptions well. Mapping broadscale habitats (at L3) using biotope codes from samples (at L4 or higher) is possibly misleading if very similar communities are either split artificially into high and moderate energy circalittoral rock categories or are combined into one very broad category.	CR.HCR.XFa (all biotopes) CR.MCR.EcCr (all biotopes) CR.HCR.DpSp	Cluster analysis of post-2004 sample data, including obtained by video, confirms lack of separation between XFa and EcCr at biotope complex level, supported by comments made in numerous survey reports. See Recommendations section for options for structural changes to classification.

Issue	Current biotope code	Proposed biotope code or comment
There is high variability in how faunal turf (XFa) and faunal crust (EcCr) biotopes or complexes have been assigned to samples due to poor match with descriptions.		
***Eunicella verrucosa* biotope(s)** Biotopes characterised by species with well-defined biogeographic limits would benefit from refinement of level 6 biotopes. When close to a species' centre of biogeographic range it will tend to occupy a much wider range of energy levels, depth ranges and substrata than a species at the edge of its biogeographic range. The sea fan *Eunicella verrucosa*, for example, has a south and western distribution and occupies a wide range of habitats/energy levels in the south-west of England compared to a much narrower range nearing its northern limits in Pembrokeshire and the west coast of Ireland. Many samples with *Eunicella* present are currently assigned to this 'bucket' biotope because of the presence of *Eunicella*, rather than fitting the full biotope description more fully. This is particularly the case when analysing video - sea fans being a very noticeable, large, characteristic 'identifier' (although the deep sponge biotope HCR.DpSp.PhaAxi also has *Eunicella*, but this tends to be used only for deeper video survey records). The other fauna and flora in this broad *Eunicella* biotope, however, vary considerably, ranging from very sparse associated fauna (as highlighted in recent Seasearch records of *Eunicella* forests with very few other species) to very rich assemblages of species that are characteristic of circalittoral rock in the regions they are found. Beyond the northern range of *Eunicella,* circalittoral rock in similar energy regimes still supports similar suites of species and the biotopes are placed elsewhere in the XFa complex. There are also field records from circalittoral rock in SW England which have a very similar range and abundance of species as in the *Eunicella* biotope even if they don't contain *Eunicella*. These are then occasionally tagged with the *Eunicella* biotope as a 'best match' in the absence of a more appropriate 'fit' resulting in confusion when looking the biogeographical range of the biotope compared to its characterising species. Conversely any seabed habitat that happens to include *Eunicella* gets tagged as CR.HCR.XFa.ByErSp.Eun even if it is missing the bryozoan and large sponge turfs as recorded during Seasearch surveys in Dorset.	CR.HCR.XFa.ByErSp.Eun	Sub-divisions of the CR.HCR.XFa.ByErSp.Eun and CR.HCR.XFa.ByErSp biotopes. See Recommendations section for potential detailed analyses.
***Swiftia pallida* biotope(s)** The range of abundance of *Swiftia* in each biotope requires careful examination. It is, however, likely that assessing *Swiftia* abundance to tag field data with the appropriate biotope code is diverting users from carefully analysing the other fauna in this group of biotopes. It is also worth noting that the current level of splits within this group of *Swiftia* biotopes is not mirrored in the CR.HCR.XFa.ByErSp.Eun biotope (see above).	CR.MCR.EcCr.CarSwi CR.MCR.EcCr.CarSwi.Aglo MCR.EcCr.CarSwi.LgAs CR.HCR.XFa.SwiLgAs	Consider editing guidance on use of SACFOR scale. See Recommendations section for potential detailed analyses.
Level 6 biotopes – regional variations in biotopes Mismatches, where abundances of characterising species vary from those in the current version of the classification, are regularly encountered. Some are from records taken in areas		

Issue	Current biotope code	Proposed biotope code or comment
of transition – e.g. part way between a tide-swept and tide-sheltered location, but others are often regional variants of biotopes where, for example, a particular species is present in very different proportions. If that species has a marked influence on the community structure if found in large numbers, e.g. grazing pressure from *Echinus esculentus*, which is far less common in many Irish Sea locations compared to Scottish waters, relative abundance of turf forming plants and animals can vary hugely. This is reflected in the large range of biotopes under the CR.HCR.XFa (mixed faunal turfs) code. For example, in Welsh waters the assemblage of species in CR.HCR.XFa.ByErSp.DysAct deviates from those found in the field; the foliose bryozoan *Chartella papyracea*, which is often common in this habitat, is not mentioned in the biotope description. The result is questionable matches to biotopes in areas outside those where 'older' core data have been used to describe the biotopes in the 2004 classification.		Consider developing Regional Variants of biotopes, and/or updating text on regional variations to biotope descriptions.
Sand-scoured biotopes. Mobile sand veneer over bedrock with scour-tolerant sponges and bryozoa Circalittoral rock partially and periodically inundated with sand is only represented in the circalittoral part of the classification in the CR.MCR.EcCr.UrtScr biotope and there are also lower/moderate diversity sand-scour influenced biotopes in the HCR.XFa.FluCoAs group. The biotope description provided by Baldock and Sharrock (Seasearch data) is of a far more species-diverse biotope with a range of long-lived and sometimes rare sponges that are present because of the mild scouring action of the partially mobile, clean sand veneer over bedrock that is present at these sites.	CR.MCR.EcCr.UrtScr (in part), HCR.XFa.FluCoAs (in part)	CR.HCR.XFa.ByErSp.SScr See Recommendations section for potential detailed analyses.
Variable salinity variants of circalittoral rocky biotopes The variable salinity component of the level 4 Biotope Complex code description 'CFa**VS**' is misleading, as the description states it may be found in full salinity.	CR.MCR.CFaVS.CuSpH	See Recommendations section for potential detailed analyses.

3.2 Data issues

- What problems have there been in analysing the data for this purpose?
- What are the limitations of this type of data?

There is now a vast amount of data on a wide range of habitats throughout the UK collated in Marine Recorder. Large quantities of new data on circalittoral hard substrata have been acquired since the 2004 version of the classification. The available data have been collected over a period of approximately 15 years by a large number of people and organisations, for different purposes, by a variety of methods, to varying degrees of taxonomic specificity, and as such there is considerable variability or 'noise' in the quality of those data when analysing large, mixed datasets. These differences between data samples are greater than the subtle differences in community composition we are trying to detect.

It was immediately evident from the 13 subsets of data identified by JNCC for further analysis that the sediment and the rock datasets were split very differently. Whereas littoral sediment was subdivided into nine categories according to sampling type, both littoral rock and sublittoral rock were each initially divided into only two based on sampling method, respectively, diver recording and video recording. Sediments are generally sampled quantitatively; the samples are collected and analysed, usually according to standardised methods, resulting in counts of species per unit area. Most taxa are identified to species level unless damaged or juvenile. Hence the initial analyses of large datasets separated out clusters of data by survey, by sampling method, by analysis method, and by precision in taxonomic identification, rather than by biological differences in community composition. By comparison, *in situ* survey of rocky communities is undertaken on the shore or by divers, using a variety of survey methodologies: phase 1, phase 2, detailed, phase 3 monitoring, Seasearch, line, point and quadrat. Survey of deeper circalittoral rock areas beyond diving depths is undertaken by remote methods, most often by drop-down or towed video, with or without accompanying stills images to aid identification, and occasionally by ROV (remote operated vehicle). Resulting images are highly variable in quality and resolution, from very high to very poor, which fundamentally affects the quality of biological or physical data that can be obtained from them. Inter-surveyor (and image-analyser) bias and adverse environmental conditions can affect both the efficiency of species recording *in situ* as well as the data obtainable from photographic images.

Data used to develop the 04.05 version of the classification for circalittoral rock were collected by mainly standardised MNCR methods, and were generally restricted to areas in less than 30-50m water depth, with uneven distribution across UK waters. Assigning biotopes to samples from circalittoral rock areas in deeper waters and from areas that were not sampled previously has proved challenging, as in many cases the data do not 'fit' the biotope descriptions well. There is a tendency for analysts to pragmatically assign 'best fit' biotopes, even when the match is poor, unless they have sufficient taxonomic and environmental information to be able to describe a new biotope – which is rarely the case for video records. This has resulted in a large, but unknown, number of biotope records held in Marine Recorder which do not match the biotope descriptions well, particularly variants of circalittoral faunal turfs and crusts on rock, which are widespread across UK waters. Re-analysis of taxonomic (rather than biotope) data from video/image samples during this project has helped to some extent to resolve biotopes for these areas, but higher resolution taxonomic data is needed to better describe variation between such biotopes. This is only achievable by obtaining more high-resolution images, preferably with accompanying physical samples, for analysis from specific habitats (such as can be obtained using ROVs). This would enable better description of differences between these faunal crust and turf biotopes in areas beyond diving depths.

3.2.1 Video data analysis

Much of the new data was collected to characterise hard substrata in potential Marine Protected Areas in deeper waters beyond the 30-50m maximum depth range of scuba diving, where the only practical survey method is video or stills photography. Camera technology and survey methods have developed rapidly over the period of data collection. However, distinguishing between certain taxa and species from video and stills records is still not possible, and does not vary consistently between taxonomic groups – accuracy of identification of species, even from high quality images, depends on size, distinctiveness and consistency of form and number of similar taxa. This presents challenges in assigning samples to biotope or biotope complex types, and means that video data are usually of insufficient resolution to use in describing detailed new biotopes with sufficient confidence. The data are therefore skewed by readily identifiable species, rather than a true representation of the species assemblage and relative abundances. This was apparent from the characterising species in the cluster summaries that listed many higher taxa. Under-represented groups are hydroids, bryozoans and sponges where it was not possible, from the species lists alone to know if these were encrusting, turf form or solitary erect individuals, and whether a record at family level was of one species or represented several hard-to-distinguish related species.

As well as the challenges of obtaining good clear images, and identifying taxa to sufficient levels of detail to enable distinction between communities, sampling techniques and methods of video and photographic analysis have developed considerably over the period during which these data were collected. Standardisation of methods for collection and analysis of images from video and stills (e.g. through the National Marine Biological Analytical Quality Control scheme) is far less developed than for either sediment sampling or *in situ* recording on shore or by divers. This means that there is much greater variability between samples due to method of collection and analysis – variability that may be greater than those biological differences in communities which we are trying to detect through statistical analysis. However, there are now large volumes of video sample data available, and for hard substrata in waters deeper than 30-50m video is the only practical method of data collection.

Variability in method of image collection is reasonably well identified from records in Marine Recorder, and standardised methods are now reasonably well developed. Detail of method of analysis used, however, is not readily identified from reports of surveys, and is therefore not identifiable from records stored in Marine Recorder. The result is that records cannot be readily separated into those collected and analysed by comparable methods for statistical analysis. More rapid standardisation of recording and analysis of new image data, and re-categorisation followed by statistical analysis of earlier data collected and analysed by similar methods would provide better data to facilitate distinguishing different communities of circalittoral rock habitats from recent samples.

4 Conclusions and recommended changes to biotope classification for Circalittoral Rock

This section outlines our expert conclusions and recommended changes to the classification, bearing in mind that it is currently used for multiple purposes and any changes will have implications – both positive and negative - for many work areas. Our conclusions are based on our combined assessment of the results of the various analyses, on comments received by JNCC, from the SNCBs, from the nine new biotope proposals included above, the review of reports of video analysis from surveys, and our combined knowledge of the many types of marine biological survey and analysis and their application, including issues associated with mapping of habitats and biotopes.

Defining biotopes is not a precise quantitative exercise. It requires marine biological knowledge and experience from a wide range of geographical locations, detailed knowledge of sampling methods and sources of data, combined with targeted analysis of sets of data which have been collected, identified and analysed by comparable methods.

In order to remain useful, the classification needs to be adapted to enable attribution of biotopes or biotope complexes from video and photographic data. The current circalittoral rock section of the classification (v04.05) and its hierarchical structure was developed using data from more taxonomically rich samples from shallower waters, with most taxa identified to species or at least family level, and knowledge of the energy level in a sample location. Without that level of detailed sample information from video data it is not possible to distinguish between biotope complexes (Level 4) and more detailed biotopes (Levels 5 and 6) in many cases, and the classification simply does not work well. This is a particular problem for assigning biotopes from samples which have faunal crusts and turfs and some sponges, but without detailed species or environmental information. It is often not possible to determine reliably which habitat or biotope complex that sample belongs in, from high energy mixed faunal turf CR.HCR.XFa, moderate energy echinoderm and crustose CR.MCR.EcCr, and deep sponge communities HCR.DpSp.

Combining the outcomes from the community analysis, the review of proposed new biotopes, review of reports from analysis of survey data, and focussing on where specific difficulties with allocating biotopes have been encountered, Crangon have the following recommendations. These fall into three types:

i) recommended changes to individual biotopes that can be made without further analysis;
ii) recommended modifications to the structure of the classification to facilitate allocation of biotopes particularly for video or less detailed records and to assist in mapping of biotopes; and
iii) suggestions where further analysis of specific subsets of data may resolve new and existing biotopes in particular ‘problem’ areas.

4.1 New biotope proposals

Of the nine proposed circalittoral rock biotopes that had been submitted to JNCC we recommend two for addition to the classification system:

1. *Axinella infundibuliformis* and other massive and encrusting sponges on circalittoral bedrock or boulders subject to strong tidal streams.
2. *Polyplumaria flabellata* and *Diphasia alata* hydroid community on circalittoral bedrock or boulders subject to waves and tidal streams.

For the other seven proposed new biotopes for circalittoral rock, insufficient detailed taxonomic data were available to either recommend or reject the proposals, and the cluster analysis did not identify those samples as distinct from samples assigned other faunal crust biotopes. Full details of the review, including reasoning and confidence assessment, can be found in Appendix 6.

4.2 Structural changes to the classification

Structural changes to the circalittoral rock section of the classification are recommended, based on a combination of results of the cluster analyses, expert knowledge of the classification, experience of analysing biological communities throughout UK, and of the

benefits and limitations of different methods for sampling and analysing results from circalittoral hard substrata. Two suggested options for changes are outlined below.

The first option (duplication of biotopes across energy levels) is simple to effect, but is a very coarse solution and does not resolve some of the difficulties encountered or make best use of the biological information available from samples. It is an option that might be applied across other areas of the classification as well as for circalittoral rock.

The second option is specific to circalittoral rock and assimilates the results of the analyses performed, review of reports and comments made by users of the classification. It enables better biotope attribution from less detailed sample data obtained by video, and facilitates mapping of biological communities using the classification.

4.2.1 Option 1: Duplicate biotope complexes and/or biotopes across different energy levels

Faunal turf (XFa) and faunal crust (EcCr) biotope complexes could be duplicated across different energy levels within the classification where those biotopes have been recorded across a range of energy levels (this information is included in the current classification in the Habitat (physical) description), e.g. XFa - mixed faunal turf communities occur in MCR and HCR. This will solve the problem of biotopes being ‘forced’ or mis-allocated into one area or another of the classification, and will facilitate mapping biotope complexes and overlaying L4 biotope complexes onto L3 habitat complex maps. However, it does not solve the problem of mis-attribution of biotope types due to lower taxonomic resolution obtainable from video samples.

Consideration as to whether duplication of certain biotopes or biotope complexes across the circalittoral rock and sediment parts of the classification is justified was not considered as part of this contract, but should also be considered.

4.2.2 Option 2: Re-arrange biotopes under Levels 3, 4 and 5 of the classification (moderate and high energy circalittoral rock)

Apart from consideration of the potential new biotopes discussed elsewhere in this report, the analyses and assessments performed have not indicated any justified changes to descriptions or scope of sub-biotopes or biotopes at Levels 5 and 6 of the classification. However, they have confirmed the problems noted with allocation of sample data to biotopes at Levels 3 and 4 particularly within the XFa and EcCr, and to some extent DpSp biotope complexes.

To address some of the difficulties encountered, the following changes to the structure of the classification are recommended:

i) amalgamate high energy and moderate energy circalittoral rock sections of the classification at level 3 (habitat complex);
ii) re-arrange the faunal turf (XFa), faunal crust (EcCr) and deep sponge (DpSp) biotope complexes at Level 4 and their biotopes and sub-biotopes at Levels 5 and 6 as shown in Table 8 below.

Table 8: Suggested changes to biotope hierarchy for high and moderate energy circalittoral rock section of classification.

High and Moderate energy circalittoral rock MCR							
Very tide-swept faunal communities FaT	**Hydrozoan dominated faunal turf communities FaTH**	**Sponge dominated faunal turf communities FaTSp**	**Scour/sediment influenced faunal turf communities FaTS**	**Circalittoral *Sabellaria* reefs (on rock) CSab**	**Soft rock communities SfR**	**Circalittoral mussel beds (on rock) Cmus**	**Circalittoral faunal communities in variable salinity CFaVS**
BalTub	**EcCr**	**DpSp**	**FluCoAs**	**Sspi**	**Pid**	**CMyt**	**CuSpH**
CTub	**CvirCri**	NEW Maidens sponge	FluCoAs.Paur	Sspi.ByB	**Pol**	**Mdis**	CuSpH.As
CTub.CuSp	NEW Maidens hydroids	PhaAxi	FluCoAs.SmAs	Sspi.As	**Hia**		CuSpH.VS
CTub.Adig	**SwiLgAs**	**ByErSp**	FluCoAs.X				**HbowEud**
	CarSwi	ByErSp.Eun	**SpNemAdia**				
	CarSwi.Aglo	ByErSp.DysAct	**UrtScr**				
	CarSwi.LgAs	ByErSp.Sag	**FluHocu**				
	AdigVt	**SpAnVt**	**Mol**				
		CarSp					
	FaAlCrG	CarSp.Bri	**FaAlCrS**				
	FaAlCr.Adig	CarSp.PenPcom	FaAlCr.Flu				
	FaAlCr.Car	**SubCriTf**	FaAlCr.Sec				
	FaAlCr.Bri		FaAlCr.Pom				
Proposed new biotopes	NEW Maidens sponge	***Axinella infundibuliformis*** **and other massive and encrusting sponges on circalittoral bedrock or boulders subject to strong tidal strea**					
	NEW Maidens hydroids	***Polyplumaria flabellata*** **and** ***Diphasia alata*** **hydroid community**					
No change	New L4, L5 and L6 split	New L4, L5 and L6 split	New L4, L5 and L6 split	No change	No change	No change	No change
NB XFa and EcCr L4 complexes have disappeared, biotopes split between FaTH, FaTSp and FATS. FaAlCr L5 biotope split between FaTH and FaTS based mainly on g							

Descriptions of the three new Level 4 faunal turf biotope complexes would need to be prepared, and descriptions of those Level 5 biotopes which have been split between the new L4 complexes (e.g. FaAlCr) would need to be revised. Some of the biotope description text often reflects the data behind the 04.05 version of the classification, which was heavily biased towards western Scottish biotopes, and may need to be modified for the reasons below:

- to reflect new data collected from other areas and to describe regional variations in biotope complexes;
- to better accommodate biological data which have of necessity been recorded to less taxonomic detail (i.e. video data).

4.3 Potential changes requiring focussed re-analysis

The following are our recommendations for areas where problems have been identified, either with recording at Phase II, or where large amounts of new data have been collected (mostly by video or a combination of video and stills photography) since the 2004 version of the classification and potential new biotopes are needed.

Level 6 biotopes – regional variations in biotopes	
Current biotope code	-
Proposed biotope code	-
Issue	Mismatches, where abundances of characterising species vary from those in the current version of the classification, are regularly encountered. Some are from records taken in areas of transition – e.g. part way between a tide-swept and tide-sheltered location, but others are often regional variants of biotopes where, for example, a particular species is present in very different proportions. If that species has a marked influence on the community structure if found in large numbers, e.g. grazing pressure from *Echinus esculentus*, which is far less common in many Irish Sea locations compared to Scottish waters, relative abundance of turf forming plants and animals can vary hugely. This is reflected in the large range of biotopes under the CR.HCR.XFa (mixed faunal turfs) code. For example, in Welsh waters the assemblage of species in CR.HCR.XFa.ByErSp.DysAct deviates from those found in the field; the foliose bryozoan *Chartella papyracea*, which is often common in this habitat, is not mentioned in the biotope description. The result is questionable matches to biotopes in areas outside those where 'older' core data have been used to describe the biotopes in the 2004 classification.
Recommended immediate action	Review the 'old' regional classifications and determine what regions of GB are represented or not. Compare regional descriptions against 'global' descriptions to gauge where the greatest mismatches occur.
Recommended further action	Biotopes characterised by species with well-defined biogeographic limits would benefit from refinement of level 6 biotopes (see also *Eunicella* biotopes). This situation described above could be alleviated by tightening and refining the descriptions at a finer level of resolution. Developing level 6 biotope coding to reflect the locality and describing biotopes using geographically grouped data from more restricted areas of the UK coastline would effectively give more confidence to matching field records to biotope descriptions.
Analysis required	Certain biotopes would require re-analysis to tease out regional variants and the coding structure would have to be re-ordered in some cases to reflect local characteristics compared to more widespread common features that would be used to label higher level biotopes. There will also inevitably be areas of coast where there is no high-resolution data to form such regional codes at present. JNCC developed regional editions of the biotope classification in the 1990s, as a pre-cursor to the UK classification, where the biotope descriptions were created from local/regional field data.

The following are suggested new biotopes raised by the SNCBs, which appear to be justified proposals, but which also require some further data analysis:

***Eunicella verrucosa* biotope(s)**	
Current biotope code	CR.HCR.XFa.ByErSp.Eun
Proposed biotope code	Sub-divisions of the CR.HCR.XFa.ByErSp.Eun and CR.HCR.XFa.ByErSp biotopes
Issue	Biotopes characterised by species with well-defined biogeographic limits would benefit from refinement of level 6 biotopes. When close to a species' centre of biogeographic range it will tend to occupy a much wider range of energy levels, depth ranges and substrata than a species at the edge of its biogeographic range. The seafan *Eunicella verrucosa*, for example, has a south and western distribution and occupies a wide range of habitats/energy levels in the south-west of England compared to a much narrower range nearing its northern limits in Pembrokeshire and the west coast of Ireland. Most *Eunicella* records are currently put in a 'bucket' biotope description that encourages users to include all records of *Eunicella* in this biotope. This is particularly tempting when analysing video - seafans being a very noticeable, large, characteristic 'identifier' (although the deep sponge biotope HCR.DpSp.PhaAxi also has *Eunicella*, but this tends to be used only for deeper video survey records). The other fauna and flora in this broad *Eunicella* biotope, however, vary considerably, ranging from very sparse associated fauna (as highlighted in recent Seasearch records of *Eunicella* forests with very few other species) to very rich assemblages of species that are characteristic of circalittoral rock in the regions they are found. Beyond the northern range of *Eunicella,* circalittoral rock in similar energy regimes still supports similar suites of species and the biotopes are placed elsewhere in the XFa complex. There are also field records from circalittoral rock in SW England which have a very similar range and abundance of species as in the *Eunicella* biotope even if they don't contain *Eunicella*. These are then occasionally tagged with the *Eunicella* biotope as a 'best match' in the absence of a more appropriate 'fit' resulting in confusion when looking the biogeographical range of the biotope compared to its characterising species. Conversely any seabed habitat that happens to include *Eunicella* gets tagged as CR.HCR.XFa.ByErSp.Eun even if it is missing the bryozoan and large sponge turfs as recorded during Seasearch surveys in Dorset (as mentioned above).
Recommended immediate action	Create a new *Eunicella* biotope based on the Dorset Seasearch data.
Recommended further action	It should be possible to insert information on general regional differences into the biotope description at level 4 in the XFa complex that will then lead the reader to detailed and/or regional XFa biotopes at level 5 and 6 in the classification. The current CR.HCR.XFa.ByErSp and CR.HCR.XFa.ByErSp.Eun biotopes should be sub-divided to show regional variation (or at least have regional variation included in the descriptions).
Analysis required	Yes – although will also require qualitative analysis of data.

***Swiftia pallida* biotope(s)**	
Current biotope code	CR.MCR.EcCr.CarSwi CR.MCR.EcCr.CarSwi.Aglo MCR.EcCr.CarSwi.LgAs CR.HCR.XFa.SwiLgAs
Proposed biotope code	-
Issue	The range of abundance of *Swiftia* in each biotope requires careful examination. It is, however, likely that assessing *Swiftia* abundance to tag field data with the appropriate biotope code is diverting users from carefully analysing the other fauna in this group of biotopes. It is also worth noting that the current level of splits within this group of Swifita biotopes is not mirrored in the CR.HCR.XFa.ByErSp.Eun biotope (see above).

Recommended immediate action	Check, if possible, which size classes have been used to assign SACFOR abundance scales to the records of *Swiftia*. There is some evidence to suggest that a suite of *Swiftia* records have been assigned an abundance score based on a size range of *Swiftia* being 3-15cm whereas others are based on a size range of >15cm. This would result in the latter being falsely assigned an order of magnitude higher abundance.
Recommended further action	Consider the validity of splitting other biotopes at this level of resolution.
Analysis required	Re-analyse the current data tagged with *Swiftia* biotope codes to test validity of the current splits.

4.4 Possible additional changes to the classification

The following are areas of the classification where issues have been identified by the SNCBs, which need further consideration before recommending any additional analyses. They are areas where duplication of biotopes across different sections of the classification, or closer examination of specific datasets may be helpful.

***Modiolus modiolus* biotopes**	
Current biotope code	CR.MCR.CMus, SS.SBR.SMus (and sub-biotopes)
Proposed biotope code	-
Issue	*Modiolus* is a characterising species in 4 biotopes which are all sub-coded under SS.SBR.SMus, which also has a sub-code for *Mytilus edulis* beds (CMyt). Lack of biotope for *Modiolus* on circalittoral rock.
Recommended immediate action	
Recommended further action	Consider (re-)scoring good quality video/stills images with the aim of reinforcing the biotope descriptions and any regional variants.
Analysis required	Re-analyse *Modiolus* data to re-define the main differences between geographic and main habitat differences in *Modiolus* beds, some of which are probably based on artefactual differences arising from inconsistent survey technique and natural differences in patchiness and species composition in the bedform. This should include re-analysis of the records tagged with SS.SMx.CMx.ClloModHo. We anticipate data will resolve into a suite of biotopes: one or more characterised by *Modiolus* that live semi-buried in sediment to form a distinct biogenic reef (perhaps with splits between the Welsh/Irish and Scottish variants of *Modiolus* bed); one or more biotopes where *Modiolus* form aggregations on rocky substrata (mainly in sealochs / N and W Scotland) and other records where *Modiolus* is only a component, at low density, of a suite of species that are part of other biotopes (Scottish sealoch records and Northumberland/SE Scotland N Sea Coast). Note: Recent re-analysis of the *Modiolus* records seems to show the above assumptions to be true with there being detectable differences between the north Scottish *Modiolus* beds and beds in Strangford Lough – although the Welsh video data, which should be of reasonable resolution, should be tested in the re-analysis. Other records of *Modiolus* as a component of other biotopes occur in SE Scotland and Northumberland, and the Scottish sealoch records fit the ModHo biotope well.

Sand-scoured biotopes. Mobile sand veneer over bedrock with scour-tolerant sponges and bryozoa	
Current biotope code	CR.MCR.EcCr.UrtScr (in part), HCR.XFa.FluCoAs (in part)
Proposed biotope code	CR.HCR.XFa.ByErSp.SScr
Issue	Circalittoral rock partially and periodically inundated with sand is only represented in the circalittoral part of the classification in the CR.MCR.EcCr.UrtScr biotope and there are also lower/moderate diversity sand-scour influenced biotopes in the HCR.XFa.FluCoAs group. The biotope description provided by Baldock and Sharrock (Seasearch data) is of a far more species-diverse biotope with a range of long-lived and sometimes rare sponges that are present because of the mild

	scouring action of the partially mobile, clean sand veneer over bedrock that is present at these sites.
Recommended immediate action	Recommend community data from Dorset and Devon (see both Lin Baldock's and Sally Sharrock's reports) be used to create a new proposed biotope description. This might fit in the CR.HCR.XFa biotope complex – suggest CR.HCR.XFa.ByErSp.SScr
Recommended further action	Would be worth searching all circalittoral rock data for the occurrence of some of the key species of sponge. This might locate more records of the same biotope.
Analysis required	Check clusters from a combination of the Seasearch data combined with data from a search of all data based on characterising species

Variable salinity variants of circalittoral rocky biotopes

Current biotope code	CR.MCR.CFaVS.CuSpH
Proposed biotope code	-
Issue	The variable salinity component of the level 4 Biotope Complex code description 'CFa**VS**' is misleading, as the description states it may be found in full salinity.
Recommended immediate action	The physical factors driving the species composition of the biotopes in the CR.MCR.CFaVS group is not clear and unlikely to be fluctuating salinity alone. Most of the examples are probably in sheltered areas and embayments where turbidity is high and the circalittoral zone relatively shallow (and thermally less stable?) compared to open coast where water is deeper and better mixed and clarity is higher. The biotopes, for example CR.MCR.CFaVS.CuSpH.As, are similar to others that are not associated with reduced salinity and could be regarded as level 6 sub-types of open-coast biotopes rather than in a sub category of CR.MCR.CFaVS. Having type or typical localities and more information on the biogeography of the examples given would clarify where to expect these biotopes.
Recommended further action	Review all variable salinity biotopes and consider what the main environmental 'driver' is. Consider regional variants.
Analysis required	Qualitative re-working of biotopes in this biotope.

5 References

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen, K.O. & Reker, J.B. (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. In: JNCC (2015) The Marine Habitat Classification for Britain and Ireland Version 15.03 [Online].

Goodwin, C., Picton, B., Breen, J. & Edwards, H. (2011) The Maidens — Report from the Sublittoral Survey Northern Ireland project. Northern Ireland Environment Agency Research and Development Series No. 11/02.

JNCC. (2015) The Marine Habitat Classification for Britain and Ireland Version 15.03 [Online]. [Date accessed 28 Dec 2017]. Available from: http://jncc.defra.gov.uk/MarineHabitatClassification

Parry, M.E.V. & Lillis, H. (in press) Identification of biotopes for the Marine Habitat Classification for Britain and Ireland: detailed methods report. JNCC Report, JNCC, Peterborough. ISSN 0963-8091.

Appendix 1: Outline of analysis

JNCC undertook analysis of each of the 13 subsets of data using R analytical software, as reported in Parry and Lillis (in press) and outlined below:

1. Species matrix created.
2. Bray-Curtis distance matrix created.
3. Hierarchical agglomerative clustering performed and a dendrogram produced.
4. Dendrogram used to select a suitable height cut off for creating clusters.
5. Dendrogram cut and resulting clusters stored in a new column in the physical data.
6. Clusterboot function used to assess the stability of clusters by bootstrapping and adding noise points.
7. Indval function used to find the relative frequency of each species compared with other clusters.
8. Summary table created to show the physical variables associated with each cluster.
9. Summary table created to give the full species list associated with each cluster.

If the dataset was so large it needed to be broken down to look at patterns further, the following steps were undertaken:

10. Dendrogram reviewed to identify cluster groups containing clusters with similar substrate types. All clusters were aggregated into these cluster groups for further analysis.
11. The dataset was filtered to select one cluster group for further review.
12. Steps 1-9 were repeated for each cluster group.

Clusters with fewer than five samples were disregarded. The results of the clusterboot were reviewed and clusters with low scores for either bootstrap or noise were rejected as unstable. A score of 0.6 was used as a cut-off. Clusters for which only one or two species had a relative frequency of over 0.5, but had a large number of species overall, were rejected. These were considered not to represent identifiable communities, as the samples in the cluster were not very similar in their species composition. R markdown was used to create summaries for those clusters that were not rejected.

Appendix 2: Community cluster analysis summary report example

See pdf supplied as supplemental information with this report:
Appendix2_CommunityClusterAnalysisSummaryReportExample

Appendix 3: Community analysis review form: third analysis – Phase II

See spreadsheet supplied as supplemental information with this report:
Appendix3_CommunityAnalysisReviewForm_ThirdAnalysis_Phase_II

Appendix 4: Review of reports

See spreadsheet supplied as supplemental information with this report:
Appendix4_ReviewOfReports

Appendix 5: Community analysis review form: fourth analysis - video

See spreadsheet supplied as supplemental information with this report:
Appendix5_CommunityAnalysisReviewForm_FourthAnalysis_Video

Appendix 6: Community analysis review form: new biotope proposals

See spreadsheet supplied as supplemental information with this report:
Appendix6_CommunityAnalysisReviewForm_NewBiotopeProposals