Cumbria Coast MCZ Littoral Rock Baseline Surveys: Final Report

Natural England

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Cover Image: View of Cumbria Coast MCZ during field survey© APEM Ltd

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1. Executive Summary

The Cumbria Coast MCZ extends over 27 km of Cumbria's coastline, from St. Bees Head in the north to the Esk River in the Ravenglass estuary in the south. The site is almost wholly intertidal except around St. Bees Head, where the site extends ~1 km seaward of the mean high water mark. St Bees Head supports the best, most extensive and important examples of intertidal rocky shore habitats and communities on the predominantly sedimentary coast of north-west England. The site overlaps with the Drigg coast SAC and the St Bees Head SSSI, designated for its large colony of seabirds. Part of Natural England statutory obligations under the EU Habitats Directive is the monitoring of notable communities included in the European Conservation Objectives for SACs also included in the European-wide Natura 2000 network of internationally important sites.

The main aim of this current study was to acquire 100% intertidal biotope coverage for the rocky shore habitats to provide comparison against previous data acquired and enable a preliminary condition assessment. The objectives of the project were:

- To map the extent, distribution and composition of biotopes within the features to High Energy Intertidal Rock BSH and Intertidal Underboulder Communities HOCI
- To map the presence, extent and species composition of representative biotopes:
    - LR.MLR.BF.Fser.Bo - *Fucus serratus* and underboulder fauna on exposed to moderately exposed lower eulittoral boulders
    - IR.MIR.KR.Ldig.Bo - *Laminaria digitata* and underboulder fauna on sublittoral fringe boulders
- To report any anthropogenic influences impacting on identified features

A particular focus for these surveys were the High Energy Intertidal Rock BSH areas, primarily around St Bees Head and Intertidal Underboulder Communities HOCI around the mean low water (MLW) mark on Barn Scar and Kokoarrah rocks. The distribution of survey effort was adjusted to ensure these habitats and communities were well represented in the samples.

The survey approach focused on developing a cost effective sampling strategy using Phase I walkover and 0.25 m^2 quantitative quadrats (Phase II) intertidal sampling techniques and additional assessment of underboulder communities. Locations for transects were targeted based on previous survey data, aerial imagery, site access, biological and environmental conditions and the need for new data. All sampling positions were decided in consultation with the Natural England project lead. To gather robust quantitative data, representative sites were selected to characterise the biotopes present along the length of each transect. Sample locations were selected at three shore heights along the transect with a focus on collecting data from the upper shore, mid shore and lower shore where possible and in accordance with how far the hard substrate biotopes extended in accordance with the Phase I methodology. The survey was conducted from 27th September 2015 to 1st October 2015 and nine transect locations that were successfully surveyed using Phase I, Phase II and underboulder community survey techniques. Due to access and tidal window constraints, another three transects were surveyed using Phase I survey techniques only.

The most common macroalgae taxa encountered during the quadrat survey was *Ulva* sp.. *Patella vulgata* was the most common invertebrate. The effort for the underboulder community survey was directed to representative areas of boulder habitat within the MCZ:

primarily at St Bee's Head and Barn Scar. A total of 83 boulders were sampled from nine transects with a total of 77 taxa recorded. The most commonly observed species in the underboulder communities was *Spirobranchus* sp.

Of the six biotopes/biotope complexes that were the focus of this survey, four were identified within the MCZ: LR.HLR.MusB, LS.LBR.Sab, LR.MLR.BF.Fser.Bo and IR.MIR.KR.Ldig.Bo. Within the LS.LBR.Sab complex is LS.LBR.Sab.Salv *Sabellaria alveolata* reefs on sand-abraded eulittoral rock which is an internationally important community. Aggregations of this habitat were only recorded as the predominant biotope at three mid-shore sites at Barn Scar near Drigg. Individuals were found at 34 sites composing up to 70% of the 0.25 m^2 quadrat samples indicating a patchy distribution throughout the MCZ.

There appears to be limited anthropogenic influences on the MCZ. Whilst recreational activity was observed within the MCZ this was primarily a small number of dog walkers and recreational anglers. However, it should be noted that this survey was conducted outside of the main tourist season when higher numbers of visitors may be expected to visit the area. Sellafield Power Station was noted as well as drainage from freshwater and sewage outputs.

A comparison of survey data between a similar survey conducted in 2013 to the 2015 survey has shown a difference in the abundance of key species between years. The data suggest an increase in *Fucus* sp. and *Ulva* sp. coverage and a decrease in *Laminaria* sp. The invasive *Austrominius modestus* forms a significant component of the new community but does not appear to have been present during the previous survey in 2013. No other non-native species were observed during the current survey. There also appears to be a significant decrease in the presence and extent of *Sabellaria alveolata* reef within the MCZ. The 2013 survey reported extensive *Sabellaria* reef across the MCZ whereas the 2015 survey only recorded at one mid-shore site at Barn Scar near Drigg.

The preliminary assessment considers that the CO to maintain the total extent and spatial distribution of intertidal rock has been met. The preliminary assessment considers that the CO to restrict the introduction of INNS has been partially achieved. As some of the key biotope complexes for the MCZ have declined, the preliminary assessment has found that the CO target to maintain the presence and spatial distribution of intertidal rock communities has not been met.

Due to the difference in survey approaches between 2013 and 2015, and the potential for some changes to have been caused by natural variation, it is not possible to make a specific recommendation for the following MCZ attributes:

- Structure: presence and abundance of typical species of both intertidal rock and underboulder communities;
- Extent and distribution of intertidal underboulder communities; and
- Distribution: presence and spatial distribution of intertidal underboulder communities.

This survey has provided a good baseline for underboulder communities within the MCZ which can be used to make comparisons against with future surveys.

2. Introduction

2.1 Background

APEM was commissioned by Natural England to conduct an intertidal survey of the rocky shore habitats and their notable communities within the Cumbria Coast Marine Conservation Zone (MCZ) (Figure 1). The purpose of this survey was to assess the selected features and associated attributes associated within the Cumbria Coast as part of the MCZ monitoring requirements. This will allow condition assessment judgements to be made on the components of the MCZ.

This document outlines the methodology and results of the rocky shore intertidal surveys. It highlights the notable communities encountered on site and provides a general account of anthropogenic pressures identified at the time of survey that may impact the MCZ integrity.

2.2 Cumbria Coast MCZ

The Cumbria Coast MCZ extends over 27 km of Cumbria's coastline, from St. Bees Head in the north to the Esk River in the Ravenglass estuary in the south. The site is almost wholly intertidal except around St. Bees Head, where the site extends ~1 km seaward of the mean low water springs mark. St Bees Head supports the best, most extensive and important examples of intertidal rocky shore habitats and communities on the predominantly sedimentary coast of north-west England (DEFRA, 2013). The extensive intertidal boulder and cobble reefs, or 'scars', within the site support good examples of nationally important honeycomb worm reefs. Where these scars extend to the low water mark, particularly at Barn Scar and Kokoarrah Rocks, they support rich marine wildlife including some of the best examples of underboulder communities on the coast of north-west England.

The site overlaps with the Drigg coast SAC and the St Bees Head SSSI, designated for its large colony of seabirds. The Cumbria Coast MCZ has been designated for four rock Broad Scale Habitats (BSH) and three Habitat Features of Conservation Importance (HOCI) (Table 1).

The focus of the current survey is to acquire high quality biological information of suitable resolution to produce a sufficient baseline according to Common Standards Monitoring guidance for the High Energy Intertidal Rock BSH and Intertidal Underboulder Communities HOCI.

Figure 1 Extent of the Cumbria Coast MCZ.

Table 1 Features of Cumbria Coast MCZ. The BSA and HOCI focus of this work are highlighted.

Feature name	Feature type
High energy intertidal rock	**Broad scale habitat**
Intertidal biogenic reefs	Broad scale habitat
Intertidal sand and muddy sand	Broad scale habitat
Moderate energy infralittoral rock	Broad scale habitat
Honeycomb worm (*Sabellaria alveolata*) reefs	HOCI
Intertidal underboulder communities	**HOCI**
Peat and clay exposures	HOCI

2.3 Objectives

The main aim of this current study was to acquire 100% intertidal biotope coverage for the rocky shore habitats to provide comparison against previous data acquired and enable a preliminary condition assessment.

The objectives of the project were:

- To map the extent, distribution and composition of biotopes within the features to High Energy Intertidal Rock BSH and Intertidal Underboulder Communities HOCI
- To map the presence, extent and species composition of representative biotopes:
    - LR.MLR.BF.Fser.Bo - *Fucus serratus* and underboulder fauna on exposed to moderately exposed lower eulittoral boulders
    - IR.MIR.KR.Ldig.Bo - *Laminaria digitata* and underboulder fauna on sublittoral fringe boulders
- To report any anthropogenic influences impacting on identified features

A particular focus for these surveys were the High Energy Intertidal Rock BSH areas, primarily around St Bees Head and Intertidal Underboulder Communities HOCI around the mean low water (MLW) mark on Barn Scar and Kokoarrah rocks. The distribution of survey effort was adjusted to ensure these habitats and communities were well represented in the samples.

3. Methods

3.1 Survey design and sampling strategy

The proposed survey approach focused on developing a cost effective sampling strategy using Phase I walkover and quantitative quadrats (Phase II) intertidal sampling techniques and additional assessment of underboulder communities. The survey design aimed to obtain standardised information on the presence and extent of the target BSH and HOCI within the Cumbria Coast MCZ including the production of biotope maps for intertidal rocky shore habitats. The Phase I biotope allocation approach enabled a broad characterisation of the communities present within the MCZ. The Phase II methods provided species composition and abundance data for specific transects suitable for the application of statistical analyses.

3.1.1 Transect locations

Locations for transects were targeted based on previous survey data, aerial imagery, site access, biological and environmental conditions and the need for new data. All sampling positions were decided in consultation with the Natural England project lead. The consultation resulted in eighteen potential transects being identified across the site (Figure 2 and Figure 3).

From the eighteen original target transect locations provided to Natural England in the initial proposal, ten were preselected following discussions with Natural England. The final sites for the transects were refined during the planning stage using previous data and aerial images to give full coverage of the specific features of interest identified for this survey. However, due to access constraints there were variations to the locations of these transects. Transect 1 and 2 could not be accessed for health and safety reasons and instead were assessed using Phase I techniques from the top of the cliffs. Transects 6 & 7 were moved as the when the surveyors went to these locations there were no rocky shore habitats present. The senior survey decided to move these transects approximately 500 m further along the shore to the next available area of rocky habitat. For further details on the planning process see the field report (Taylor & Antill, 2015).

To gather robust quantitative data, representative sites were selected to characterise the biotopes present along the length of each transect. Sample locations were selected at three shore heights along the transect with a focus on collecting data from the upper shore, mid shore and lower shore where possible and in accordance with how far the hard substrate biotopes extended. The low shore and high shore were determined by the state of the tide by restricting the survey to the water's edge for the period two hours before and after the predicted low tide time for the day, and to the area immediately below the high water reach for the pervious tide (i.e. below the strand line), respectively. Mid shore elevations were assigned using a combination of state of the tide, beach slope, and the relative position of the main species on the shore profile (banding) in accordance with the Phase I methodology.

A total of nine quadrat sites were sampled on each transect with three replicates each at low, mid and upper shore where possible. At transect 17 it was only possible to survey the upper shore due to daylight and tide constraints.

To gather semi-quantitative data on underboulder communities, representative sites were selected to characterise the two described underboulder communities:

- LR.MLR.BF.Fser.Bo - *Fucus serratus* and underboulder fauna on exposed to moderately exposed lower eulittoral boulders
- IR.MIR.KR.Ldig.Bo - *Laminaria digitata* and underboulder fauna on sublittoral fringe boulders

Sample (boulder) locations were selected randomly whilst in the field at low to mid-shore and to provide good coverage of the potential areas featuring the two biotopes listed above.

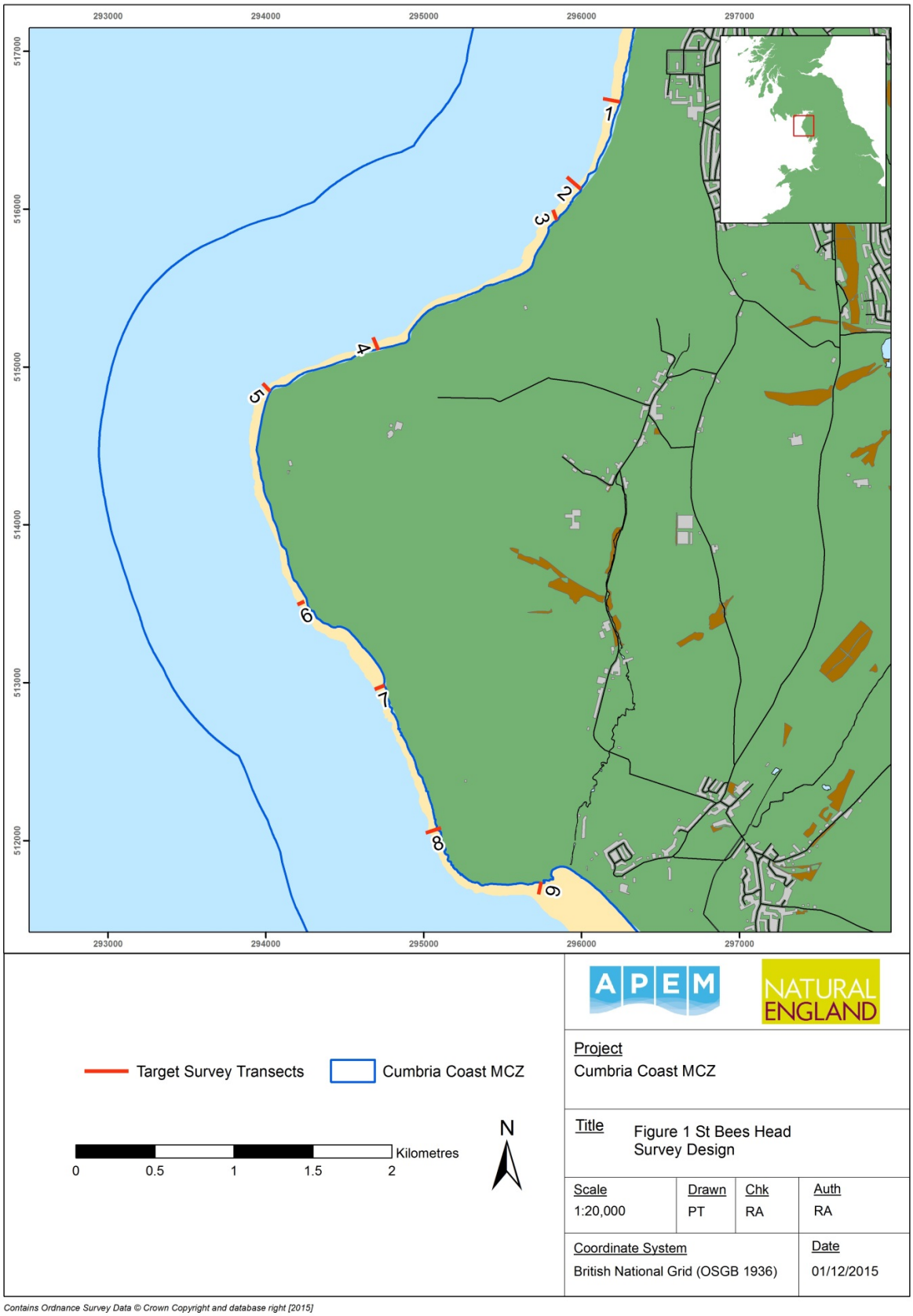

Figure 2 Target transect locations and details of sampling conducted within the northern sector (Whitehaven to St Bees Head) of the Cumbria Coast MCZ.

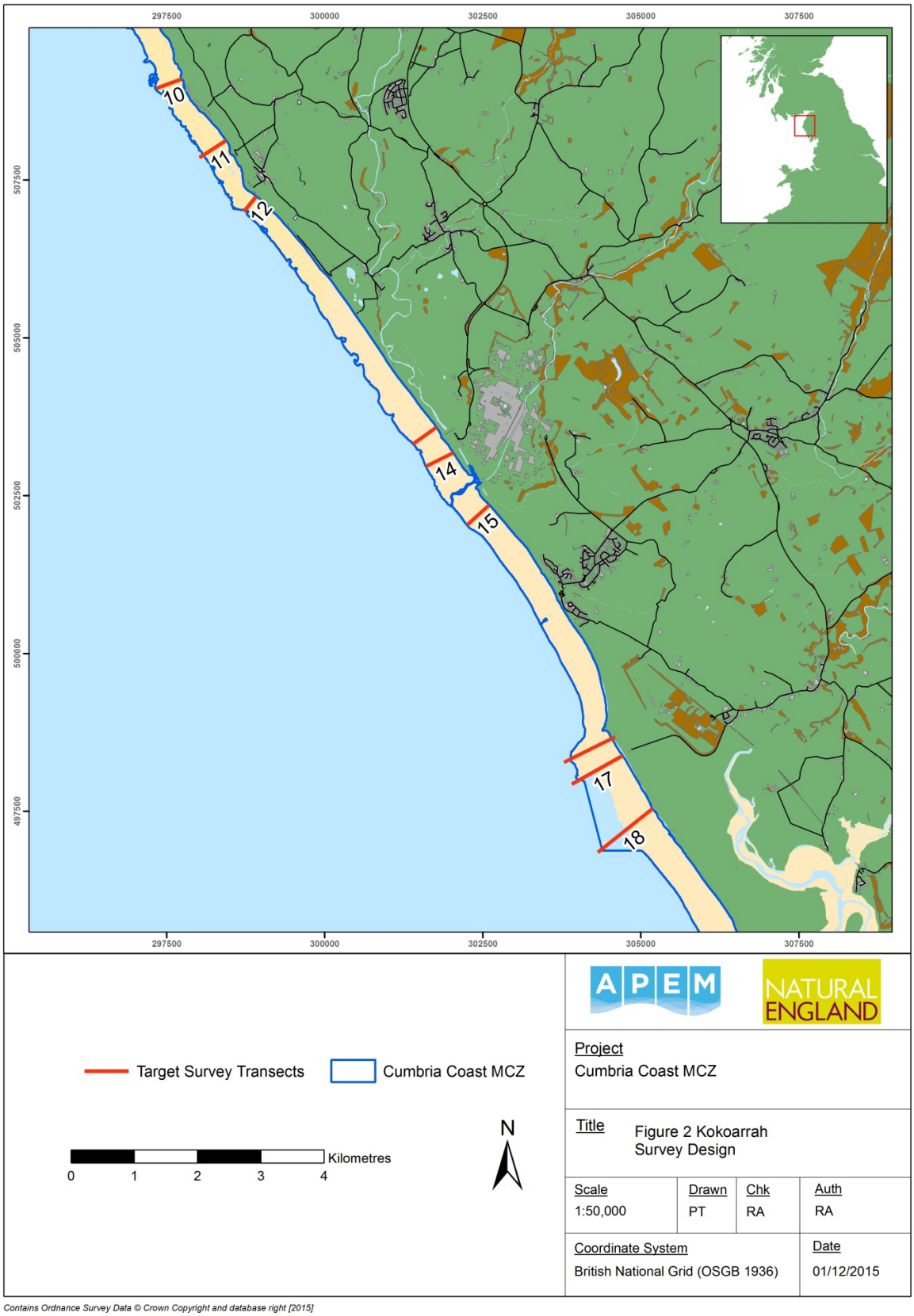

Figure 3 Target transect locations and details of sampling conducted within the southern sector (St Bees Head to Ravenglass) of the Cumbria Coast MCZ.

3.1.2 Survey design

The Phase I survey aimed to record the range and extent of biotopes present in intertidal areas by assigning biotopes *in situ* following best practice guidance including the Countryside Council for Wales (CCW) Handbook for Marine Intertidal Phase I mapping surveys, Marine Monitoring Handbook, CSM guidance and JNCC biotope allocation guidance (Wyn & Brazier, 2001; Connor *et al.,* 2004; Davies *et al.,* JNCC, 2004, JNCC, 2010). This stage served to confirm the extent and type of biotopes present, and validate the selection of sampling locations for detailed investigation as part of the Phase II survey. The quantitative quadrat (Phase II) survey was conducted at the same time as the Phase I survey using 0.25 m^2 quadrats. For algae and encrusting organisms (including barnacles) percentage cover of the quadrat was estimated, for other species the numbers of individuals within the quadrat was counted (e.g. limpets *Patella* sp., beadlet anemones *Actinia equina*) in accordance with methods outlined in CSM Guidance and the Marine Monitoring Handbook. See Section 3.6.1 for information on consistency of percentage cover estimates between surveyors.

The underboulder community assessment was conducted concurrently to Phase I and Phase II using a method modified from Chapman (2002). A total of ten boulders were sampled at each transect by either turning them, if small enough, or using an endoscope camera for larger boulders. Additionally, locations of the boulders were recorded using a hand held GPS (accuracy 5 m or better). All boulders were returned to their original position following assessment to minimise any potential risk to cause damage to the community present.

3.2 Data recording

For the quadrat surveys, a range of information was recorded onto modified MNCR field recording sheets including:

- Substrate type (bedrock, cobbles, boulders, etc.)
- Presence of macroalgae (% coverage recorded if present)
- Anthropogenic pressures (e.g. pipe lines, bait diggers, point source pollution)
- Notes on features of interest

Each underboulder community was recorded using modified MNCR habitat forms with all conspicuous biota recorded to the lowest taxonomic level possible in the field (usually to species). The photographs taken of each sampling location were reviewed by a second taxonomist when back in the laboratory to confirm the field identifications and provide quality assurance to the process.

3.3 Sampling site access and survey periods

The field work was conducted between 27th September 2015 and 1st October 2015 during spring tides in order to optimise the length of time available for each survey and to ensure the lower reaches of the shores could be sampled. The lower shore was visited two hours either side of the predicted low water. For further details, see the field report (Taylor & Antill, 2015).

All land access permissions were sourced by Natural England. Where possible, sites were accessed by foot from the closest available path. Transects 1 and 2 could not be accessed on foot for health and safety reasons were assessed from the top of the cliffs. The Phase I survey at these sites was therefore less detailed and no Phase II sampling was possible. An initial assessment was made from the cliff and then photos of the sites and information obtained from Transect 3 (the next one along) were used to infer likely biotopes at the site.

3.4 Photographic evidence

Digital photographs were taken of each quadrat and underboulder community sample to allow quality assurance of the data recorded. Additional photographs were taken of representative or unidentifiable fauna where possible to document or allow confirmation of species identity respectively. General photographs of the areas surveyed were also taken, which included views from each site towards the land and sea, where possible, along the transects.

3.5 Post-survey analysis

On completion of the surveys, raw data were transferred to electronic spreadsheets and checked for errors using automated data filters and data consistency checks. Potential errors such as transcription errors were cross-referenced with field notes and corrected. This included a GPS waypoints log and GPS tracks log (Appendix 1). The GPS waypoints were subsequently used to create maps showing the locations (to within 5 m) of the quadrats taken during the survey (Appendix 4). Biotopes were assigned according to JNCC's National Marine Habitat Classification for Britain and Ireland: Version 04.05 (Connor et al., 2004). The classification used species information, relative abundances, exposure of the shore and substrate type. These data allocated at each quadrat location could then be compared to the habitats identified in the 2013 survey.

All GIS outputs were generated in ArcGIS v9.2 and metadata were produced in accordance with MEDIN standards in the MESH data exchange format (DEF).

3.6 Statistical analysis

Microsoft Excel 2013 was used for general data formatting and exploration. PRIMER v6 (Clarke and Gorley, 2006) was used for the multivariate statistical analysis carried out.

3.6.1 Truncation and data consolidation

Data were transferred by the surveying taxonomists from field notes to electronic files in a standard format (see Appendix 2 and 3) to create sample factors for use in the cluster and ordination analyses e.g. shore height, physical data, biotope allocated, and enable the data to be easily manipulated into the correct format for the calculations of univariate statistics (e.g. diversity indices) and ordination analysis.

Once data had been transferred to the standard format, each taxonomist's data were reviewed by senior taxonomists to ensure all species identifications and names, and

recording of percentage composition for biological and physical data were consistent across team members.

Final Analytical Quality Control (AQC) of the quadrat and underboulder community data was carried out by the project manager to ensure there were no spelling or transcription mistakes, all relevant fields had been completed and the species were in order of their species directory code. Any inconsistency was corrected at this stage and the final datasets made available for final analysis.

3.6.2 Species richness

Species richness (number of taxa) was calculated using the 'Count' function in Excel. This allowed the number of taxa per quadrat to be determined. No other useful diversity indices could be calculated as the data were a combination of percentage coverage of encrusting, colonial or canopy-forming species (e.g. macroalgae, barnacles, bryozoans, etc.), and actual abundances of free-living species (e.g. *Littorina* sp., *Nucella lapillus,* etc.) which cannot be directly compared due to the different units of measurement used.

3.6.3 Community analysis

The data were considered separately as percentage coverage data and simple counts for the purposes of description but were combined as presence/absence data for the purposes of performing community ordination analysis. As both the quadrat and underboulder community data was recorded as percentage coverage for encrusting/colonial and canopy-forming organisms and as actual abundances for free-living species, as per standard guidance, the different units of measurement cannot be directly compared and so a presence/absence transformation was applied. This type of transformation gives less abundant species in the matrix equal weight to more abundant species. Whilst this approach allows the use of all species data it precludes the use of quantitative information in the analysis of biological assemblages.

To enable multivariate analysis to be carried out, an appropriate definition of resemblance between samples must be provided to signify the similarity between samples. The Jaccard index was used in the current analysis. This similarity measure eliminates matching attributes that share a zero (0) value as evidence of similarity and is recommended for presence/absence data. A perfect similarity score would be 100. The index syntax is given by the formula:

$$J = \frac{(100 \times a)}{(a + b + c)}$$

Where:

- a is the total number of species present in both samples;
- b is the total number of species present in sample 1 but absent from sample 2; and
- c is the total number of species absent in sample 1 but present in sample 2.

Cluster analysis was used to visualise the groupings of samples based on their faunal composition. Agglomerative, hierarchical clustering was carried out on the Jaccard's resemblance (similarity) matrix. The method groups the samples into small groups first (i.e. those with the highest levels of similarity based on faunal composition). These first groups

are subsequently grouped together into larger groups, based on group averages, lowering the level of similarity until all of the samples are in a single cluster at the lowest level of similarity between samples. A dendrogram was used to show the results of this clustering and indicates the level of similarity between each group of samples.

The similarity profile test (SIMPROF) was also implemented as part of the hierarchical clustering to identify how many distinct groups existed based on the null hypothesis (H_0) that the resultant sample clusters did not share a significant group structure. This test does not consider samples to be divided into groups prior to analysis and considers each sample independently. This test was carried out during the hierarchical cluster analysis using group average and the default SIMPROF setting in PRIMER for permutations (Mean: 1000, Simulations: 999) and significance level (5%).

Finally, Similarity Percentage analysis (SIMPER) was used to summarise discriminating features of the more abundant biotopes identified in the analysis. The analysis was conducted on frequency of species sightings by biotope type. Frequencies were calculated by averaging the presence/absence-transformed data from the three replicates collected at each station. The SIMPER analysis provides the average percentage contribution from each species to the overall biotope assemblage and a measure of the variation expected within the replicate sites assigned to each biotope.

4. Results

4.1 Quantitative quadrat survey

4.1.1 Species distribution

A total of 84 quadrats (each 0.25 m^2) were assessed during the Phase II survey with a total of 51 macrophyte taxa, 13 Crustacea taxa, 13 Mollusca taxa, 10 Annelida taxa, six Cnidaria taxa, five Bryozoa taxa, two Tunicata taxa, and one Porifera, Echinodermata and Fungi taxon each. The full dataset is presented in Appendix 3.

There were 103 taxa recorded in total across all the quadrats. It was not possible to identify some organisms to species level, primarily due to small size e.g. *Dexamine* sp. or the complexity of the genus, e.g. *Idotea* sp. These were recorded at either genus or family level, whichever was most appropriate.

The macroalgal taxa *Ulva* sp. (including *U. intestinalis*), *Fucus* sp. (juveniles) and *Fucus serratus* were the three most common taxa found at 55, 30 and 26 quadrats respectively out of a total of 84 quadrats.

The macroalgae with the greatest percentage cover within the quadrats was by *Ulva* sp. (including *U. intestinalis*), *Fucus serratus* and *Chondrus crispus* with *Ulva* sp. with 12%, 11% and almost 7%% of the macroalgal cover, respectively (Figure 4). *Ulva intestinalis* is found all around the UK and at all levels of the shore. *Fucus serratus* is found on the low shore of sheltered areas around the UK. *Chondrus crispus* is found on low to mid sections of rocky shores and is also widely distributed around the UK.

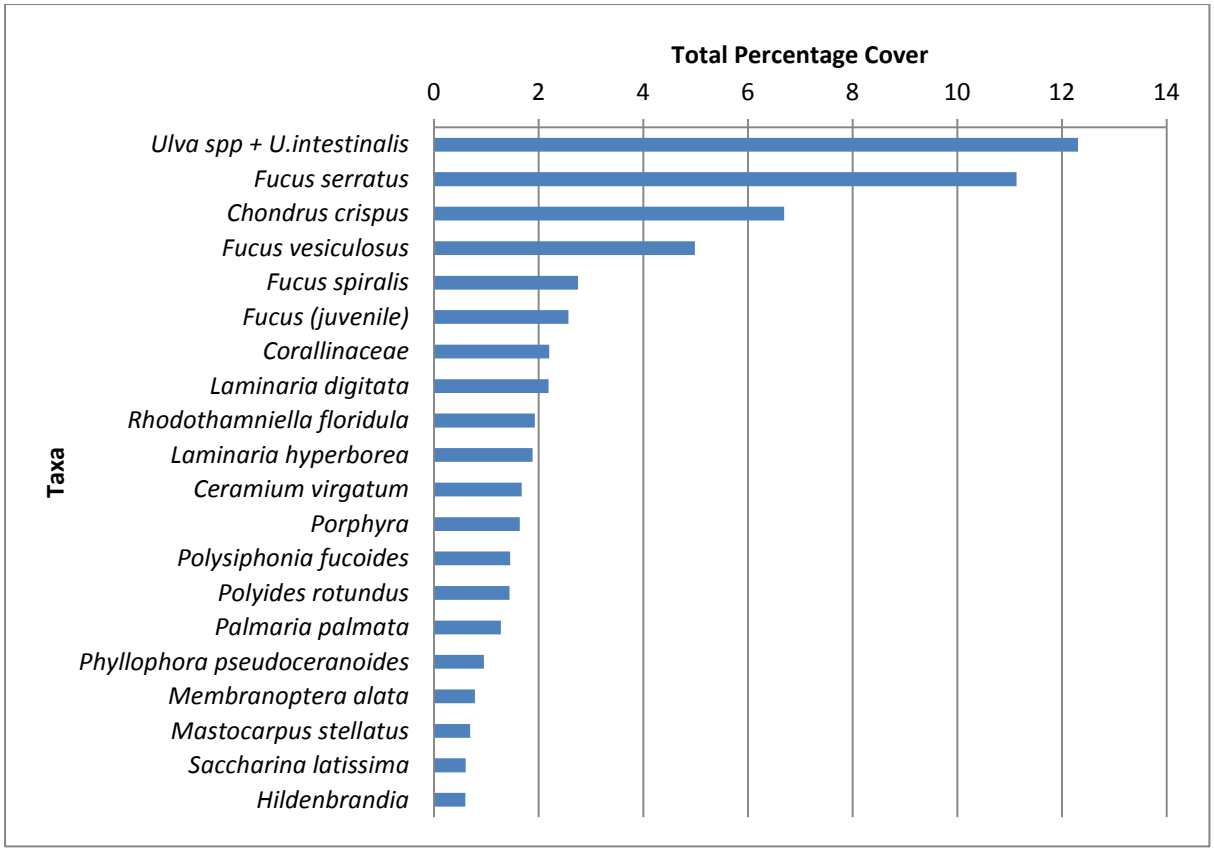

Figure 4 Ranked percentage cover of macroalgal species across the total quadrats assessed. Only species contributing over 0.5% of the total abundance are included (based on percentage coverage data). For the full species list see Appendix 3.

A total of 51 invertebrate taxa were recorded in the quadrats. Some taxa were recorded as percentage cover as it was not possible to ascertain the number of individuals within the time allocated to undertake the survey work, and in some cases they were colonial.

The most common, and also the most abundant invertebrate taxa were *Patella vulgata, Littorina littorea* and *Littorina saxatilis* which were recorded in 28, 12 and 11 quadrats respectively out of a total of 84 quadrats. The greatest percentage contribution to invertebrate abundance within the quadrats was also by *P. vulgata* with a contribution of over 41% (Figure 5). *P. vulgata* is a limpet found throughout the UK at all shore heights where there is suitable rocky habitat on which to attach itself. *L littorea* and *L. saxatilis* are periwinkles that are found at all shore heights around the UK. *L. littorea* is found on rocky shores and occasionally in sandy or muddy habitats on sheltered shores whereas *L. saxatilis* is primarily found in crevices of rock and under stones. *Gammarus* sp., an amphipod, were found in only four quadrats with 70 individuals in two quadrats on the upper shore of Transect 9 and contributed over 10% of the total invertebrate abundance.

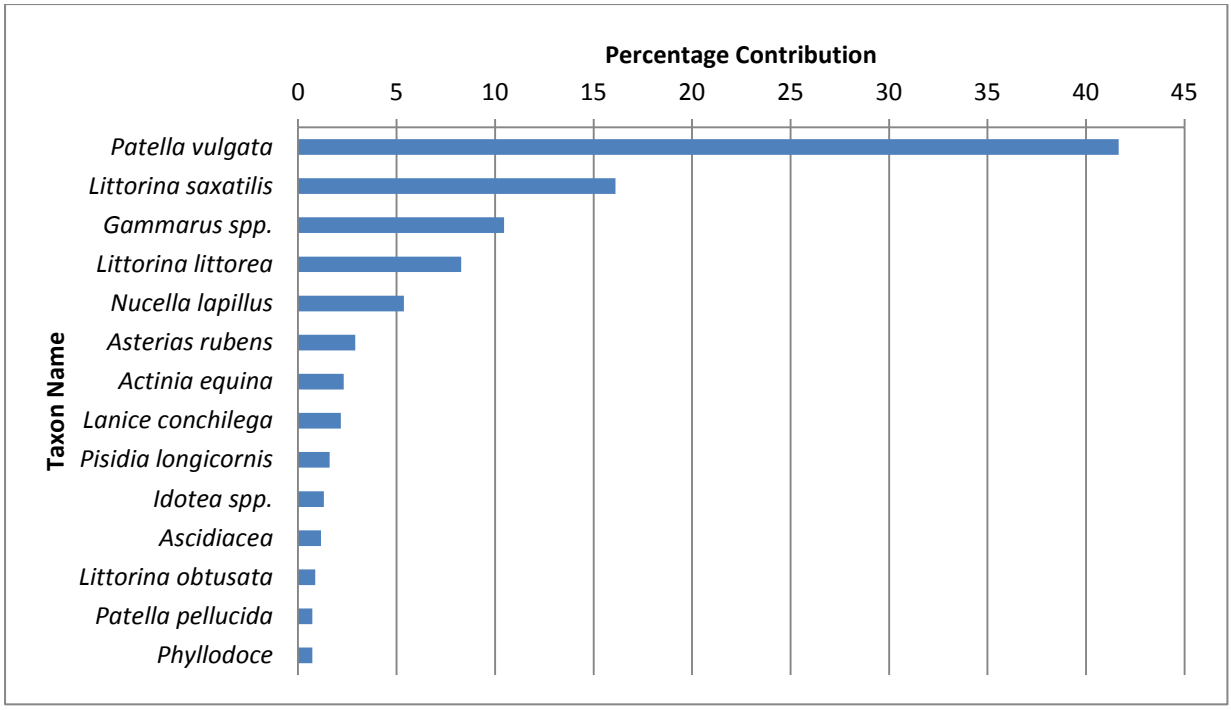

Figure 5 Ranked, percentage contribution of the invertebrate species cumulatively comprising 95% of the total abundance (based on actual count data). For the full species list see Appendix 3.

4.1.2 Species diversity

The mean number of taxa was lower at upper shore sites and was generally highest at lower shore sites (Table 2). The highest mean number of taxa was found on the lower shore at the most northerly and most southerly sites (Transects 3, 6, 7, 16 and 18) with transects between these areas having a lower mean number of taxa (Transects 9, 10, 11 and 13). Transects 10, 11 and 13 are located in areas that are primarily sand habitats with patchy areas of intertidal rock habitat.

Table 2 Mean number of taxa identified in each station (average % coverage and actual abundance data combined) with standard deviation and coefficient of variation (CV) indicated.

Transect no.	Shore height	Mean no. of taxa	Standard deviation	CV (%)
3	Upper	5.00	1.00	20%
3	Middle	9.00	3.61	40%
3	Lower	19.33	2.08	11%
6	Upper	5.67	1.53	27%
6	Middle	15.33	2.52	16%
6	Lower	21.67	3.06	14%
7	Upper	6.33	1.53	24%
7	Middle	12.67	2.52	20%
7	Lower	18.67	2.52	13%

Transect no.	Shore height	Mean no. of taxa	Standard deviation	CV (%)
9	Upper	7.67	2.08	27%
9	Middle	8.67	0.58	7%
9	Lower	10.67	4.51	42%
10	Upper	5.33	2.08	39%
10	Middle	8.00	1.00	13%
10	Lower	9.67	2.31	24%
11	Upper	3.67	2.08	57%
11	Middle	8.33	2.08	25%
11	Lower	8.00	3.61	45%
13	Upper	3.33	0.58	17%
13	Middle	8.00	1.00	13%
13	Lower	4.00	1.73	43%
16	Upper	4.33	1.15	27%
16	Middle	10.67	2.31	22%
16	Lower	23.00	5.29	23%
17	Upper	2.00	0.00	0%
18	Upper	6.33	3.79	60%
18	Middle	8.00	5.29	66%
18	Lower	20.33	0.58	3%

4.1.3 Habitat diversity

The most common biotopes found in the quadrats were LR.FLR.Eph.Ent, LR.HLR.MusB.Sem.LitX, LR.MLR.BF.Fser.R and LR.MLR.BF.FspiB (Table 3). These biotopes are all found on moderately exposed shores. LR.FLR.Eph.Ent is found where there is considerable freshwater runoff although freshwater runoff was only observed close to one of the transects (three replicate quadrats) at Transect 7 (see Section 4.6.2). Maps of all the biotopes recorded throughout the MCZ are provided in Appendix 4.

Table 3 Biotopes encountered during the quantitative survey by shore elevation. The values indicate the number of quadrats where the biotope was recorded.

Biotope Code	Lower Shore	Mid Shore	Upper Shore	Count
IR.MIR.Kr.Ldig.Bo	3			3
IR.FIR.IFou variant	3			3
IR.HIR.KFaR.LhypR	3			3
LR.MLR.BF.Rho	3			3
IE.HIR.K.Sed	1			1
LR.MLR.BF.Fser.R	6	3		9
LR.MLR.BF.Fser	3	3		6
LR.MLR.BF	2	3		5

LR.HLR.MusB.Sem.LitX	3	3	3	9
LR.HLR.MusB.Sem.Fves		3		3
LR.MLR.BF.FvesB		3		3
LS.LBR.Sab.Salv		3		3
LR.LLR.F.Fves		3	2	5
LR.MLR.BF.FspiB		2	6	8
LR.HLR.MusB.Sem.Sem		1	3	4
LR.FLR.Eph.EntPor			3	3
LR.FLR.Eph.BLitX			2	2
LR.FLR.Eph.Ent			11	11
Total frequency	**27**	**27**	**30**	**84**

4.1.4 Community analysis

Hierarchical clustering was conducted on pooled replicates. This approach was used to ensure a more robust dataset for the identification of community trends across the area. Similarity profile permutation tests were conducted on a Jaccard similarity matrix calculated from presence-absence data. The similarity profile (SIMPROF) (Clarke and Gorley, 2006) test suggested the presence of an underlying community structure in the dataset (Figure 6). Five distinct clusters were detected (5% significance level), shore elevation appears to explain some of the grouping with middle and upper shore location sharing similar communities and generally separated form lower shore samples (Figure 7).

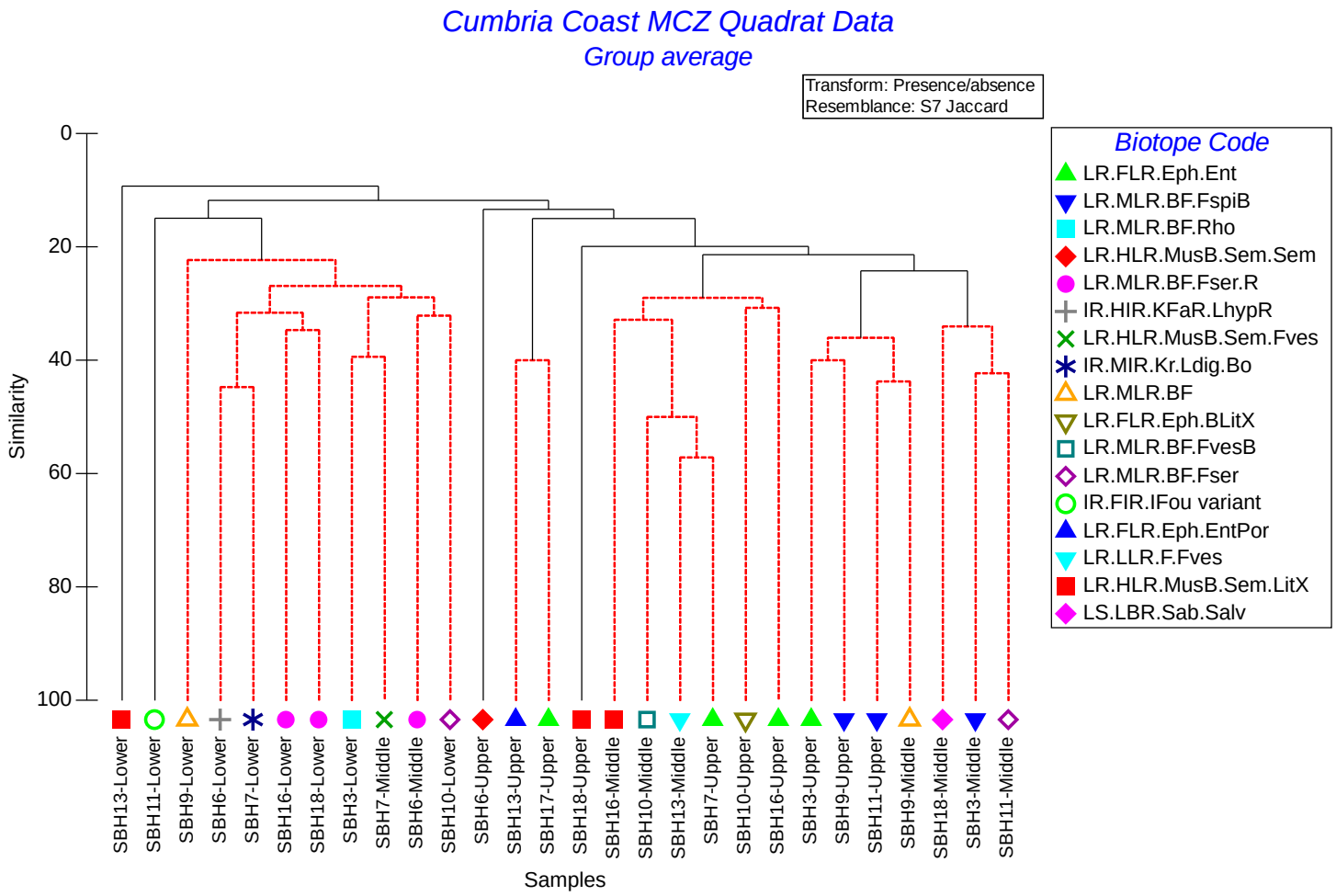

Figure 6 Cumbria Coast MCZ Rocky Shore 2015 group average sorting dendrogram based on presence/absence transformed abundance and percentage coverage data. Samples presented by survey location with replicates combined for each transect and shore height. Jaccard similarity and the SIMPROF test were used. Symbols are coded according to biotope.

Multi-dimensional scaling (MDS) (Figure 7) suggest a grouping of stations in relation to the shore elevation to which they have been allocated.

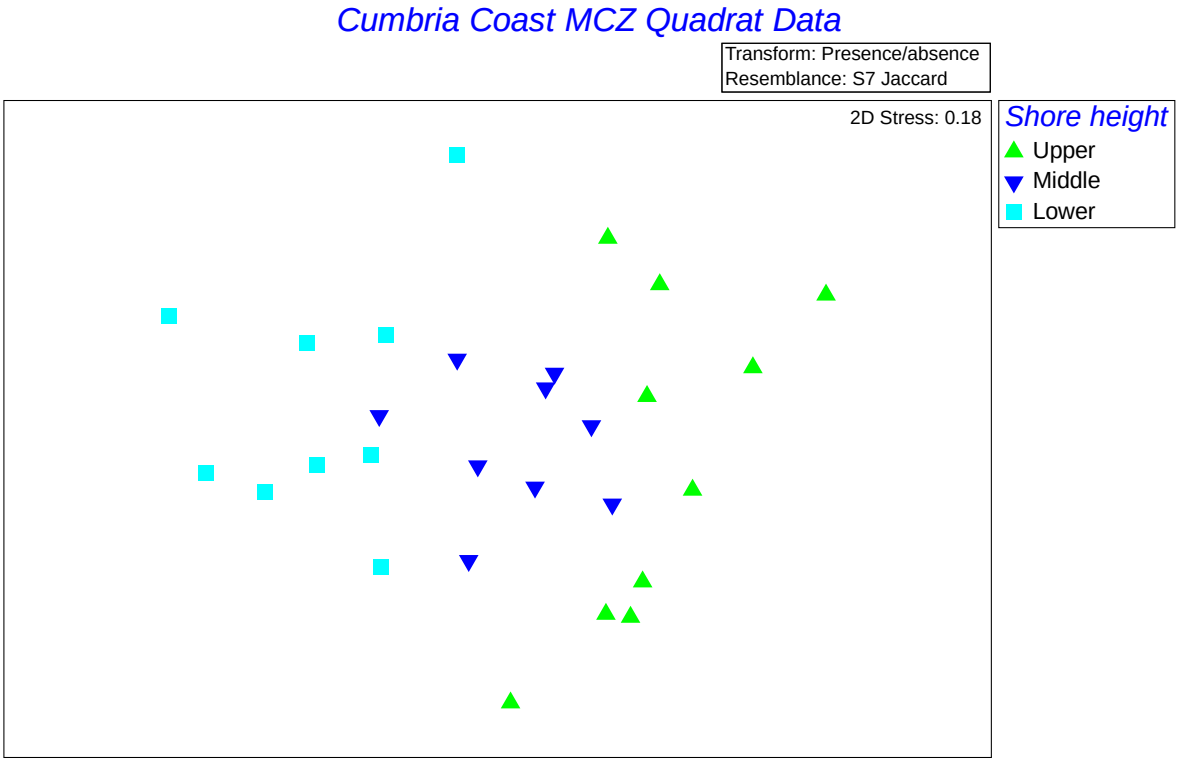

Figure 7 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) configuration plot of taxa presence/absence data using Jaccard similarity. Sample symbols are shown according to shore elevation.

4.2 Biotope composition

Biotope codes were assigned to each quadrat sample by the senior taxonomist in the field. These assignations were confirmed by a second taxonomist post survey and added as sample factors to the faunal data for the multivariate analysis. The community composition of biotopes was determined by applying SIMPER (Clarke and Gorley, 2006) on the abundance and percentage coverage data (no summing of replicates) using Bray-Curtis similarity. The method was only applied to those biotopes found at four or more stations to prevent bias due to low replication. Results are presented in Section 4.2.1 to 4.2.8 together with MDS ordination plots showing the samples assigned to the biotope.

4.2.1 LR.FLR.Eph.Ent

Enteromorpha sp. on freshwater-influenced and/or unstable upper eulittoral rock

This is a hard substratum biotope found on the upper shore. It is relatively unstable or may be subject to considerable freshwater runoff. This biotope is typically very species poor and

characterised by dense mats of *Enteromorpha* sp., though *Ulva lactuca* can occur as well. It occurs at a wide range of shore heights from the supralittoral down to the upper eulittoral and a wide range of wave exposure ranges. It is generally devoid of fauna, except for occasional limpets *Patella vulgata*, winkles *Littorina littorea* or *Littorina saxatilis* and barnacles *Semibalanus balanoides*. Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Semibalanus balanoides*, *Patella vulgata* and *Littorina saxatilis*.

Table 4 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. The table shows higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.FLR.Eph.Ent	**Average similarity: 29.93**			**N=11**	
Species	**Frequency**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Ulva	0.82	17.32	1.16	57.86	57.86
Fucus vesiculosus	0.45	3.18	0.46	10.63	68.48
Porphyra	0.27	1.95	0.23	6.51	74.99
Austrominius modestus	0.36	1.84	0.34	6.16	81.15
Fucus (juvenile)	0.36	1.84	0.34	6.16	87.31
Encrusting bryozoa	0.27	1.27	0.24	4.25	91.56

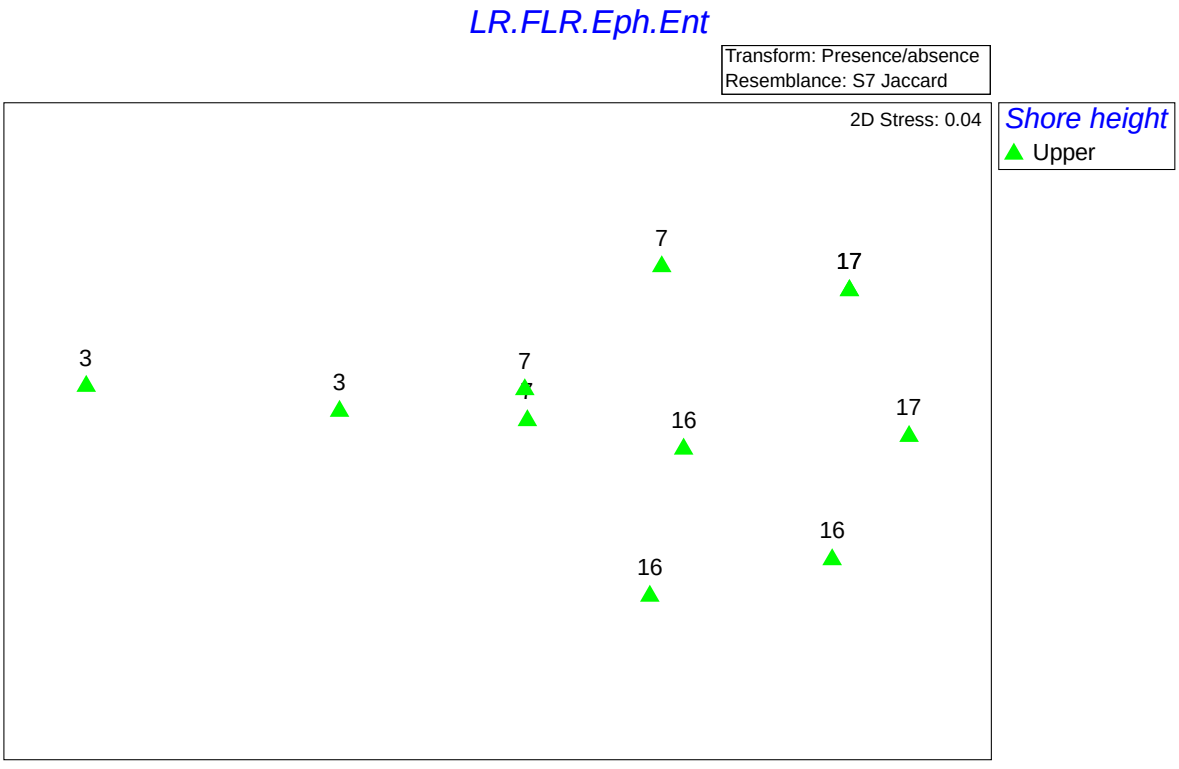

Figure 8 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. The sample number gives the transect number for the individual replicate (three for each transect and shore height) and symbols indicate shore elevation. Transects are numbered in a continue sequence starting from the north (Transect 3 at St Bees Head) to the south (Transect 17 at Barn Scar near Drigg).

4.2.2 LR.MLR.BF

Barnacles and fucoids on moderately exposed shores

This biotope complex includes moderately exposed rocky shores. The complex is characterised by fucoids and barnacles on bedrock and boulder where the extent of fucoid cover is less than the blanket coverage associated with more sheltered shores. Other species may include *Littorina littorea*, *Nucella lapillus* and *Mastocarpus stellatus*. LR.MLR.BF was only found at Transect 9 which is south of St Bee's Head. Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Semibalanus balanoides, Littorina littorea*, *Nucella lapillus, Mastocarpus stellatus, Pelvetia canaliculata* and *Verrucaria maura*.

Table 5 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. the table show higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.MLR.BF	**Average similarity: 57.63**			**N=5**	
Species	**Frequency**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Fucus (juvenile)	1	11.79	8.02	20.46	20.46
Ulva intestinalis	1	11.79	8.02	20.46	40.91
Patella vulgata	1	11.79	8.02	20.46	61.37
Porphyra	0.8	7.17	1.14	12.44	73.81
Hildenbrandia	0.8	6.52	1.16	11.31	85.11
Mytilus edulis	0.6	3.94	0.62	6.83	91.95

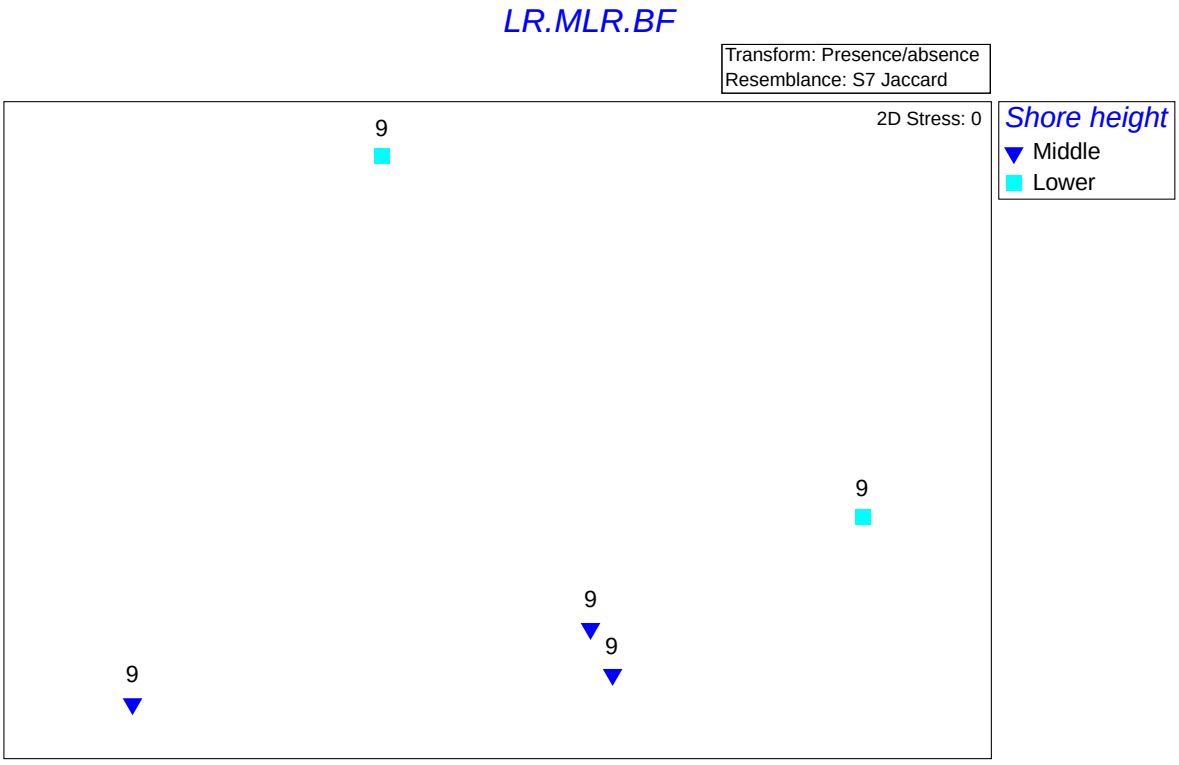

Figure 9 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. Labels are identical to Figure 8.

4.2.3 LR.MLR.BF.FspiB

Fucus spiralis on exposed to moderately exposed upper eulittoral rock

This is an upper eulittoral bedrock biotope found on exposed to moderately exposed shores. It is characterised by a band of *Fucus spiralis* overlying *Verrucaria maura* and *V. mucosa*. It supports a community of *Patella vulgate*, *Littorina saxatilis* and *L. littorea*, *Mytilus edulis* and *Semibalanus balanoides*. *Nucella lapillus* and *Anurida maritima* can be found in cracks and crevices. Ephemeral green seaweeds such as *Enteromorpha intestinalis* can be common in the summer. Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Anurida maritima*, *Littorina littorea*, *Littorina saxatilis*, *Nucella lapillus*, *Mytilus edulis,* and *Verrucaria maura.*

Table 6 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. the table show higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.MLR.BF.FspiB	**Average similarity: 22.06**			**N=8**	
Species	**Frequency**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Ulva intestinalis	0.63	4.75	0.7	21.55	21.55
Semibalanus balanoides	0.5	3.21	0.5	14.54	36.09
Patella vulgata	0.5	2.69	0.49	12.21	48.29

Fucus vesiculosus	0.38	1.67	0.33	7.57	55.87
Fucus (juvenile)	0.38	1.51	0.32	6.85	62.71
Hildenbrandia	0.38	1.35	0.34	6.14	68.85
Cladophora rupestris	0.38	1.24	0.33	5.63	74.48
Rhodothamniella floridula	0.38	1.13	0.34	5.14	79.61
Fucus spiralis	0.25	0.55	0.19	2.49	82.1
Ralfsia verrucosa	0.25	0.55	0.19	2.49	84.59
Verrucaria mucosa	0.25	0.55	0.19	2.49	87.08
Gammarus	0.25	0.55	0.19	2.49	89.58
Ulva	0.25	0.51	0.19	2.31	91.89

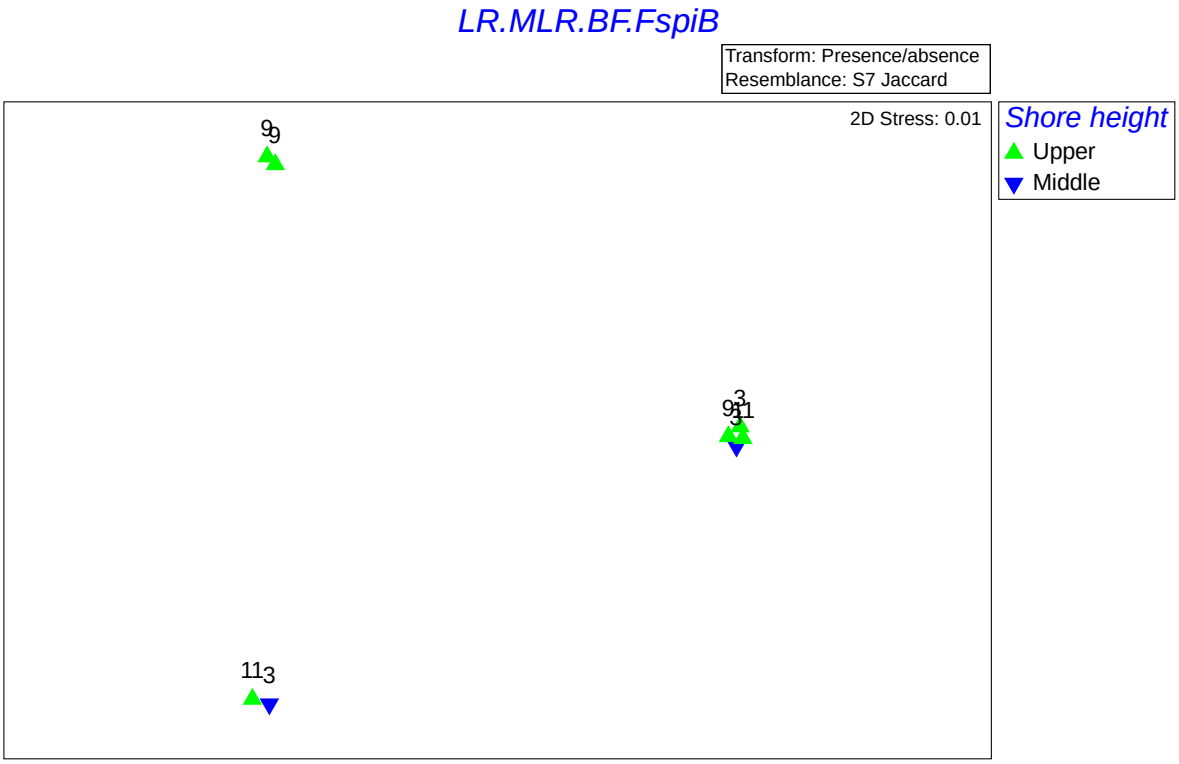

Figure 10 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. Labels are identical to Figure 8.

4.2.4 LR.MLR.BF.Fser

Fucus serratus on moderately exposed lower eulittoral rock

Lower eulittoral bedrock and stable boulders on moderately exposed to sheltered shores with a canopy of the wrack *Fucus serratus* and an associated fauna consisting of the limpet *Patella vulgata*, the barnacle *Semibalanus balanoides*, the whelk *Nucella lapillus*, the anemone *Actinia equina* and the sponge *Halichondria panicea*. Green seaweeds such as *Enteromorpha intestinalis* and *Ulva lactuca* are usually present among/beneath the *F.*

serratus canopy. This biotope was recorded at Transects 10 and 11 which are both close to Nethertown. Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Halichondria panicea*, *Spirorbidae, Semibalanus balanoides, Carcinus maenas, Gibbula cineraria, Patella vulgata, Littorina littorea, Nucella lapillus, Corallinaceae, Chondrus crispus, Lomentaria articulata, Osmundea pinnatifida* and *Mastocarpus stellatus (petrocelis).*

Table 7 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. The table show higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.MLR.BF.Fser	**Average similarity: 35.14**			**N=6**	
Species	**Frequency**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Fucus serratus	1	11.33	6.74	32.24	32.24
Balanus crenatus	0.67	4.14	0.78	11.79	44.02
Sabellaria alveolata	0.67	4.14	0.78	11.79	55.81
Dynamena pumila	0.5	2.09	0.48	5.94	61.75
Electra pilosa	0.5	2.09	0.48	5.94	67.69
Flustrellidra hispida	0.5	2.09	0.48	5.94	73.63
Hildenbrandia	0.5	1.88	0.48	5.34	78.97
Ulva	0.33	0.89	0.26	2.53	81.5
Membranipora membranacea	0.33	0.83	0.26	2.37	83.87
Mytilus edulis	0.33	0.83	0.26	2.37	86.25
Actinia equina	0.33	0.83	0.26	2.37	88.62
Porphyra	0.33	0.78	0.26	2.23	90.85

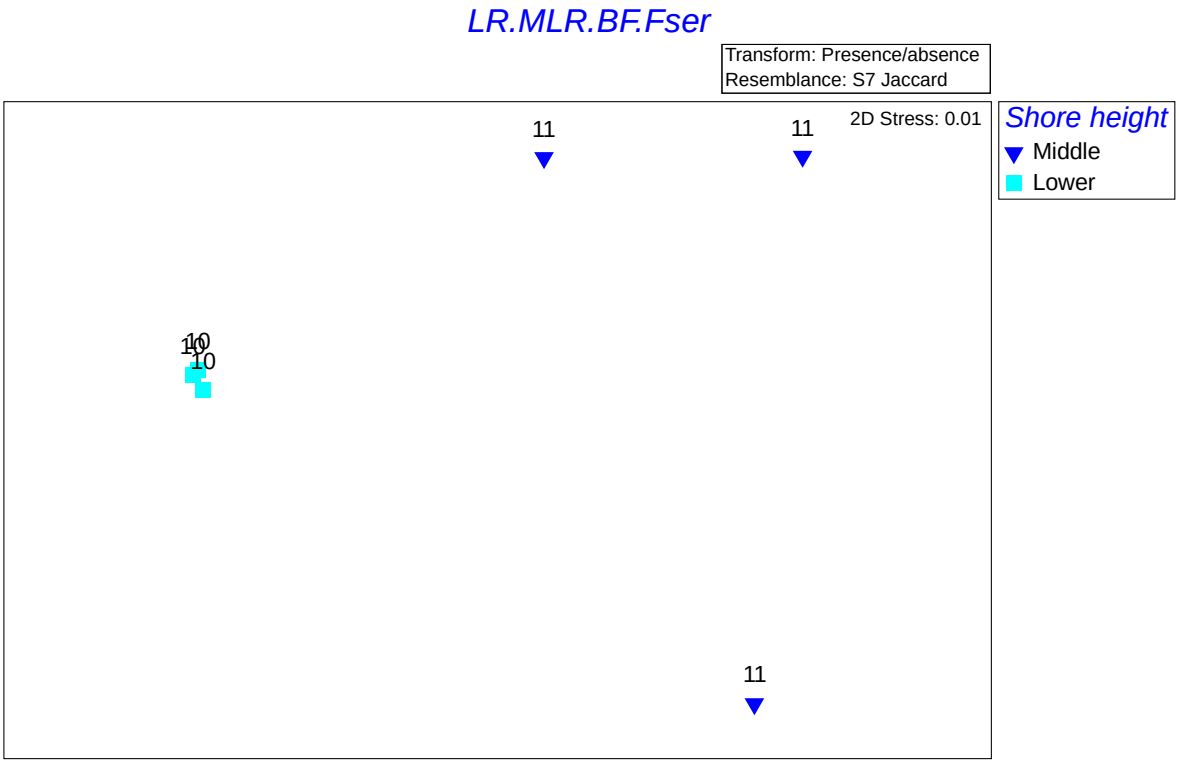

Figure 11 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. Labels are identical to Figure 8.

4.2.5 LR.MLR.BF.Fser.R

Fucus serratus and red seaweeds on moderately exposed lower eulittoral rock

This is a variant of the lower eulittorial bedrock biotope found on moderately exposed shores. It is characterised by mosaics of *Fucus serratus* and turf-forming red seaweeds including *Osmundea pinnatifida*, *Mastocarpus stellatus* or *Corallina officinalis*. *Dynamena pumila* and *Halichondria panacea* can be present in dense populations. Other red seaweeds may be present including *Palmaria palmata*, *Lomentaria articulata*, *Membranoptera alata* and *Chondrus crispus*. Green seaweeds such as *Cladophora rupestris, Enteromorpha intestinalis* and *Ulva lactuca* are present though usually in small numbers. Micro-habitats of permanently damp refuges between the stones and underneath the seaweed canopy can support *Patella vulgata*, *Semibalanus balanoides* or *Nucella lapillus,* and *Littorina littorea* and *Carcinus maenas* may be present under any boulders in the habitat. LR.MLR.BF.Fser.R was recorded at Transects 6 (St Bees Head), 16 and 18 (Barn Scar near Drigg). Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Halichondria panicea, Dynamena pumila, Semibalanus balanoides, Carcinus maenas, Littorina littorea, Nucella lapillus, Lomentaria articulata, Osmundea pinnatifida, Ulva intestinalis, Ulva lactuca* and *Cladophora rupestris.*

Table 8 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. the table show higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.MLR.BF.Fser.R	**Average similarity: 46.82**			**N=9**	
Species	**Frequency**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Corallinaceae	1	5.22	6.97	11.14	11.14
Electra pilosa	1	5.22	6.97	11.14	22.29
Spirobranchus	0.89	4.05	1.76	8.65	30.94
Chondrus crispus	0.89	3.87	1.79	8.27	39.21
Palmaria palmata	0.78	3.03	1.13	6.48	45.69
Fucus serratus	0.78	2.91	1.14	6.22	51.9
Ceramium virgatum	0.78	2.79	1.15	5.95	57.85
Membranipora membranacea	0.78	2.79	1.15	5.95	63.8
Mytilus edulis	0.67	2.38	0.83	5.09	68.9
Balanus crenatus	0.67	2.24	0.81	4.78	73.67
Flustrellidra hispida	0.56	1.29	0.61	2.75	76.42
Plocamium cartilagineum	0.56	1.27	0.61	2.72	79.14
Membranoptera alata	0.56	1.26	0.61	2.7	81.84
Patella vulgata	0.44	1.01	0.44	2.15	83.99
Idotea	0.44	0.84	0.44	1.8	85.79
Gelidium	0.44	0.74	0.44	1.58	87.37
Saccharina latissima	0.44	0.74	0.44	1.58	88.94
Mastocarpus stellatus	0.33	0.55	0.3	1.17	90.11

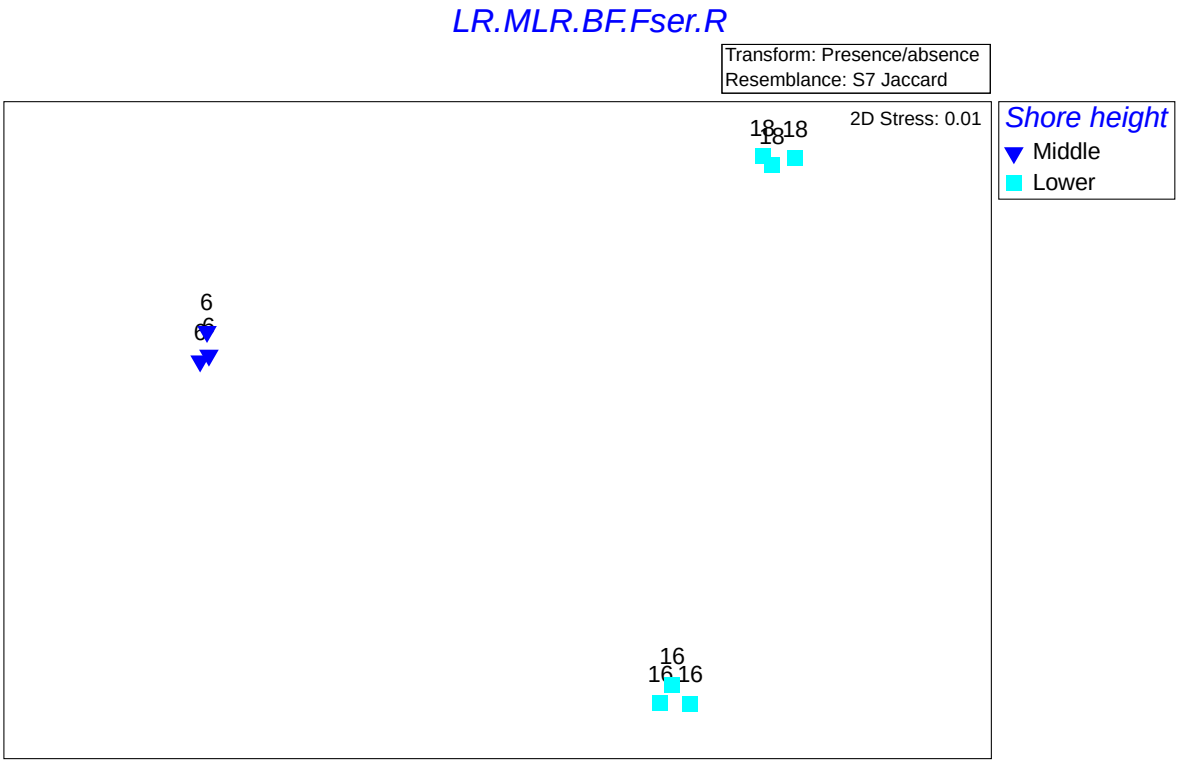

Figure 12 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. Labels are identical to Figure 8.

4.2.6 LR.LLR.F.Fves

Fucus vesiculosus on moderately exposed to sheltered mid eulittoral rock

This habitat is found on moderately exposed to very sheltered mid eulittoral bedrock and large boulders. It is characterised by dense canopies of *Fucus vesiculosus* with sparse coverings of *Semibalanus balanoides* and *Patella vulgata*. *Mytilus edulis* may be present in cracks and crevices. Other species may include a variety of winkles including *Littorina littorea* and *Littorina saxatilis, Nucella lapillus* and *Carcinus maenas*. *Ascophyllum nodosum* may be present in areas of localised shelter. This biotope was recorded at Transects 10, 11 (near Nethertown) and 13 (near Sellafield). Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Semibalanus balanoides, Carcinus maenas, Patella vulgata, Littorina littorea, Littorina saxatilis, Nucella lapillus, Mytilus edulis* and *Ascophyllum nodosum.*

Table 9 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. the table show higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.LLR.F.Fves	**Average similarity: 34.60**	**N=5**	

Species	Frequency	Av.Sim	Sim/SD	Contrib%	Cum.%
Sabellaria alveolata	0.8	9.24	1.11	26.72	26.72
Ulva	0.8	9.24	1.11	26.72	53.43
Fucus vesiculosus	0.6	4.92	0.61	14.21	67.64
Austrominius modestus	0.6	3.76	0.62	10.87	78.51
Fucus (juvenile)	0.6	3.76	0.62	10.87	89.37
Fucus serratus	0.4	1.25	0.32	3.61	92.99

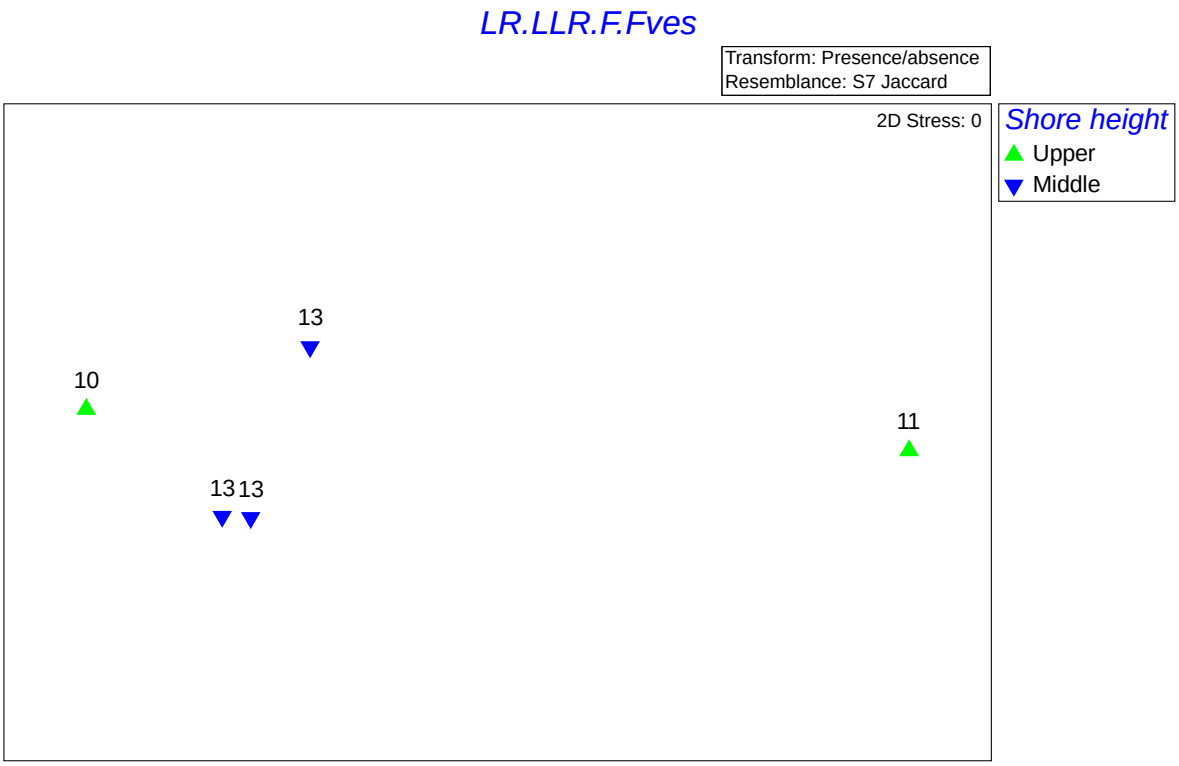

Figure 13 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. Labels are identical to Figure 8.

4.2.7 LR.HLR.MusB.Sem.Sem

Semibalanus balanoides, *Patella vulgata* and *Littorina* sp. on exposed to moderately exposed or vertical sheltered eulittoral rock

This is a mid to upper eulittoral bedrock and large boulders biotope found on very exposed to sheltered shores. It is characterised by dense aggregations of *Semibalanus balanoides* and *Patella vulgata*. Species diversity is relatively low although though occasional cracks and crevices in the rock can provide a refuge for small individuals of *Mytilus edulis*, *Littorina* sp. and *Nucella lapillus*. Macroalgae is not usually found in high numbers although cracks and crevices in the bedrock may hold a sparse macroalgae community and patches of *Osmundea pinnatifida* can be present throughout the habitat. *Verrucaria mucosa* may be relatively abundant. This biotope was recorded at Transects 3 and 6 which are both at St

Bees Head. Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Nucella lapillus, Ulva intestinalis* and *Verrucaria mucosa.*

Table 10 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. the table show higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.HLR.MusB.Sem.Sem	**Average similarity: 40.84**			**N=4**	
Species	**Frequence**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Mytilus edulis	0.75	8.93	0.9	21.86	21.86
Semibalanus balanoides	0.75	8.93	0.9	21.86	43.72
Littorina saxatilis	0.75	8.93	0.9	21.86	65.58
Patella vulgata	0.75	8.93	0.9	21.86	87.44
Osmundea pinnatifida	0.5	2.56	0.41	6.28	93.72

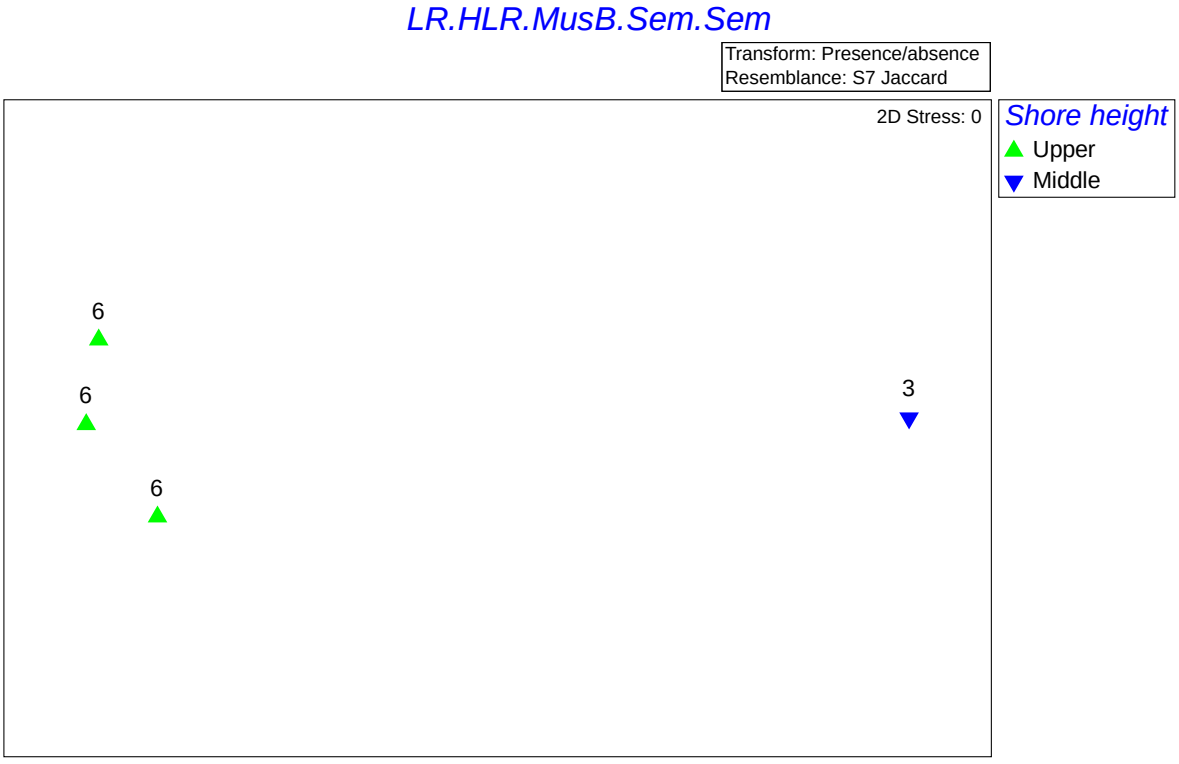

Figure 14 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. Labels are identical to Figure 8.

4.2.8 LR.HLR.MusB.Sem.LitX

Semibalanus balanoides and *Littorina* sp. on exposed to moderately exposed eulittoral boulders and cobbles

This is a eulittoral habitat with large patches of boulders, cobbles and pebbles found on exposed to moderately exposed shores. It is characterised by *Semibalanus balanoides* and, on larger rocks, *Patella vulgata*. Other fauna include *Littorina littorea*, *L. saxatilis*, *Nucella lapillus*, *Actinia equina* and with lower abundance *Mytilus edulis*, *Carcinus maenas*, gammarid amphipods and *Austrominius modestus*. Ephemeral green seaweeds such as *Enteromorpha intestinalis* may cover cobbles and boulders. The foliose red seaweeds *Chondrus crispus*, *Mastocarpus stellatus* and *Osmundea pinnatifida* as well as *Fucus vesiculosus* may also occur in low abundance on cobbles and boulders. On more sheltered shores, *Gibbula cineraria* and *G. umbilicalis* can be found. This biotope was recorded at Transects 13 (near Sellafield), 16 and 18 (Barn Scar near Drigg). Characterising species for this biotope that were either not present or had a lower than expected contribution to the recorded communities assigned to this biotope include *Actinia equina, Carcinus maenas*, *Patella vulgata*, *Mytilus edulis*, *Corallinaceae, Mastocarpus stellatus* and *Fucus vesiculosus.*

Table 11 Cumbria Coast MCZ Rocky Shore 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity. the table show higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used). N indicates the number of quadrats in which the biotope was found.

Group LR.HLR.MusB.Sem.LitX	**Average similarity: 28.62**			**N=9**	
Species	**Frequency**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Austrominius modestus	0.78	7.24	1.1	25.29	25.29
Spirobranchus	0.44	3.19	0.41	11.16	36.44
Semibalanus balanoides	0.56	2.87	0.61	10.04	46.48
Littorina littorea	0.56	2.87	0.61	10.04	56.52
Sabellaria alveolata	0.44	2.34	0.43	8.18	64.7
Balanus crenatus	0.33	2.14	0.29	7.49	72.18
Nucella lapillus	0.44	1.69	0.44	5.9	78.09
Porphyra	0.33	1.39	0.29	4.85	82.93
Ulva intestinalis	0.33	1.23	0.29	4.3	87.23
Littorina saxatilis	0.33	0.87	0.3	3.04	90.27

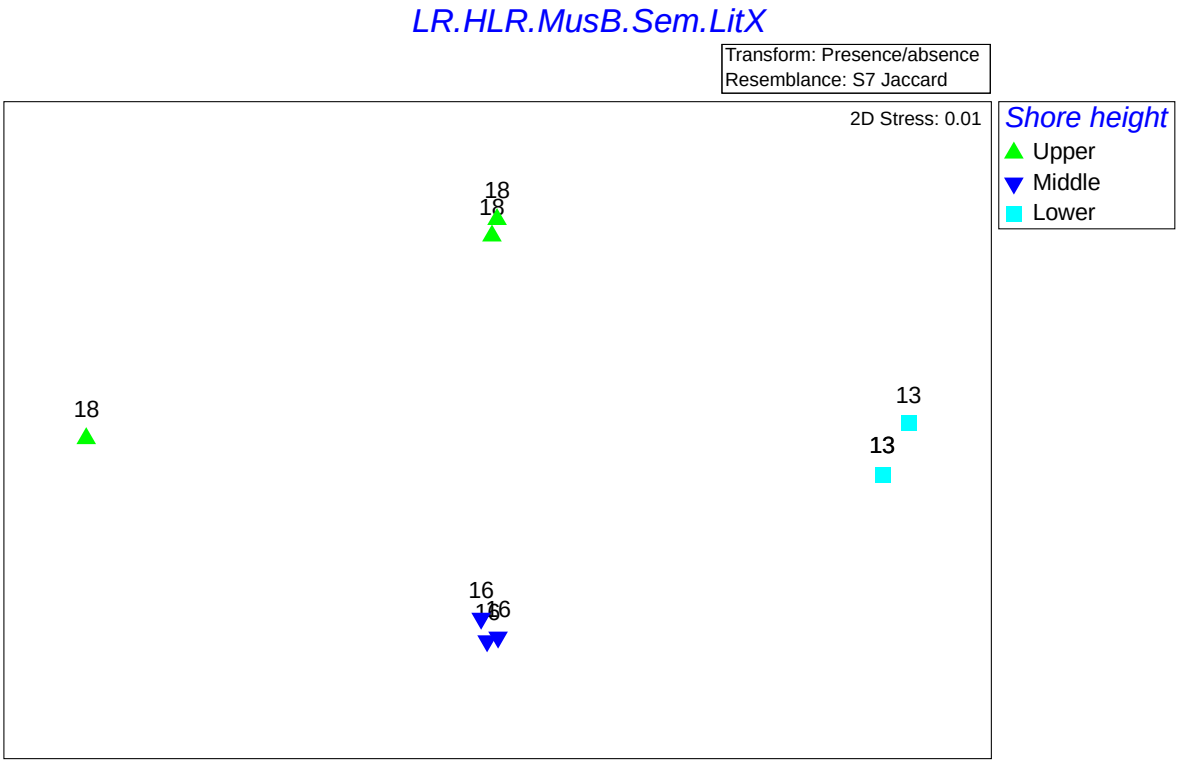

Figure 15 Cumbria Coast MCZ Rocky Shore 2015 Non-metric Multidimensional Scaling (MDS) ordination plot for the samples assigned to the biotope. Labels are identical to Figure 8.

4.3 Nationally and more than nationally important communities

The main feature of conservation interest encountered in the Cumbria Coast MCZ was *Sabellaria alveolata* reef which is defined as the biotope LS.LBR.Sab.Salv *Sabellaria alveolata* reefs on sand-abraded eulittoral rock. Aggregations of this nationally and internationally important Annex I habitat were only recorded as the predominant biotope at three mid-shore sites at Barn Scar near Drigg (Transect 18). Individuals were found at 34 sites composing up to 70% of the 0.25 m^2 quadrat samples indicating a patchy distribution throughout the MCZ.

Figure 16 LS.LBR.Sab.Salv observed at Transect 18 at Barn Scar near Drigg (left) at Station SBH18-5 (right).

4.4 Non-native intertidal species

The barnacle *Austrominius modestus* was recorded in 30 of the 84 quadrats taken. None were observed at transects 6 or 17. These invasive barnacles were found in all the remaining transects and at all heights on the shore, often in the same location as *Balanus crenatus* and *Semibalanus balanoides* (Figure 17).

No other non-native species were observed during the survey.

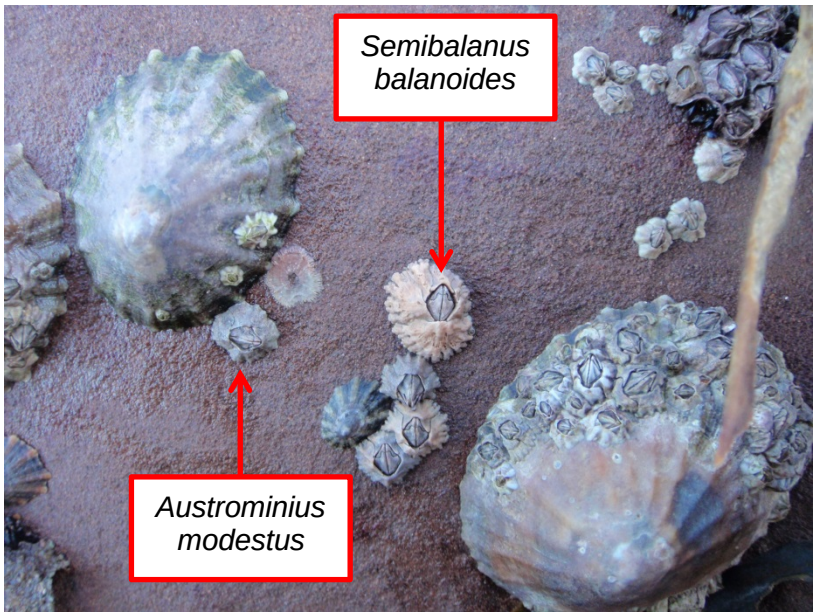

Figure 17 *Austrominius modestus* and *Semibalanus balanoides* amongst limpets on the mid-shore at Transect 7.

4.5 Underboulder communities

4.5.1 Underboulder species distribution

A total of 83 boulders were sampled from nine transects with a total of 77 taxa recorded. A breakdown of the number of taxa recorded within the major taxonomic groups is provided in Table 12. The full data set is provided in Appendix 3.

Table 12 Major groups recorded during the Cumbria 2015 underboulder community survey.

Group	Number of Taxa within Group
Porifera	2
Cnidaria	8
Platyhelminthes	1
Nemertea	2
Sipuncula	1
Annelida	10
Chelicerata	1
Crustacea	12
Mollusca	11
Bryozoa	9
Echinodermata	4
Tunicata	4
Osteichthyes	1
Rhodophyta	8
Chromophycota	1
Chlorophycota	2
Total	**77**

It was not possible to identify some organisms to species level, primarily due to small size or the complexity of the genus. These were recorded at either genus or family level, whichever was most appropriate.

For boulders that were too large to be turned, taxa were recorded as presence/absence rather than actual counts. As such it was not possible to conduct statistical analysis of abundance and the data was transformed to presence/absence for multivariate analysis.

The most commonly observed species in the underboulder communities was *Spirobranchus* sp. which was observed on 71 of the 83 boulders surveyed followed by encrusting Bryozoa and Sessilia which were observed on 60 and 51 boulders respectively (Figure 18).

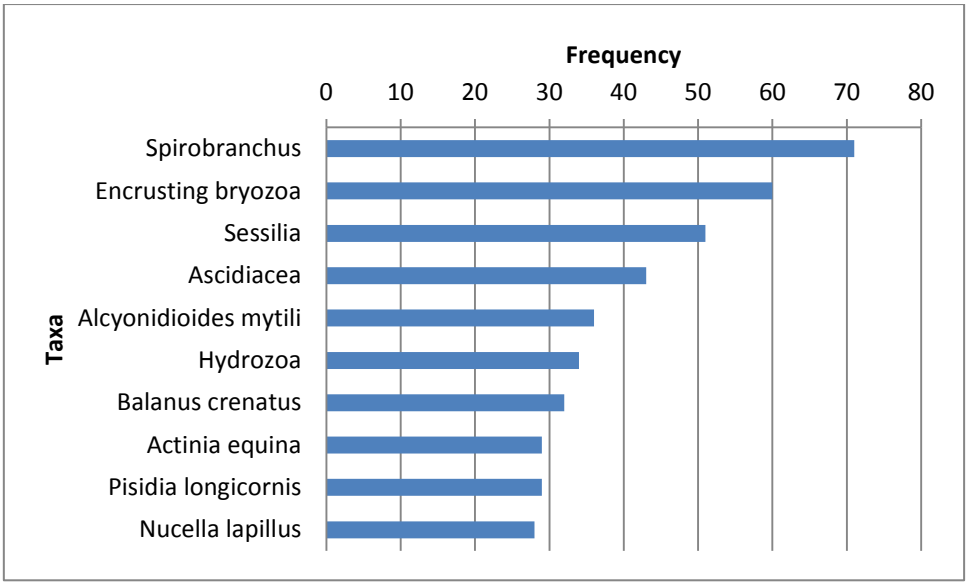

Figure 18 Cumbria Coast MCZ Underboulder Community Survey 2015 ranked frequency of the 10 most common underboulder taxa (based on presence only).

4.5.2 Underboulder habitat diversity

A total of 10 biotope codes were assigned to the 83 boulders sampled (Table 13). Only one true underboulder biotope was recorded A3.2112 (IR.MIR.KR.Ldig.Bo). The rest are variants of the most appropriate rocky habitat biotopes as the communities recorded did not fit into the only two underboulder community codes (A1.2142 and A3.2112) as these sites were not dominated by green macroalgae such as *Fucus* or *Laminaria* sp. The other underboulder biotope that was the focus of this survey, A1.2142 (LR.MLR.BF.Fser.Bo), was not recorded on any of the boulders sampled.

Table 13 Cumbria Coast MCZ Underboulder Community Survey 2015 biotopes encountered during the underboulder community survey. The values indicate the number of boulders where the biotope was recorded.

Biotope Code	Count
LR.HLR.MusB.Sem.Sem variant	8
LR.MLR.BF.FspiB variant	3
LR.MLR.BF.Fser.R variant	18
IR.MIR.KR.Ldig.Bo	9
LR.MLR.BF variant	8
LR.MLR.BF.FvesB variant	7
IR.FIR.IFou variant	10
LR.LLR.F.Fves variant	11
LR.FLR.Eph.BLitX variant	4
LS.LBR.Sab.Salv variant	5
Total	**83**

4.5.3 Underboulder community analysis

Hierarchical clustering with SIMPROF analysis suggested an eight-cluster community structure in the dataset for underboulder communities within the Cumbria Coast MCZ (Figure 19).

Multi-dimensional scaling (MDS) (Figure 20) showed some evidence of grouping of boulder stations in relation to the boulder size to which they have been allocated. However, the stress level indicates the plot is not as close a fit to the actual dissimilarities as would be ideal. The tighter cluster of larger boulders could be an indication of a more stable community on this habitat in relation to small boulders which are more likely to be moved as a result of storm conditions. Shore elevation was not a defining factor for underboulder communities and so has not been shown here.

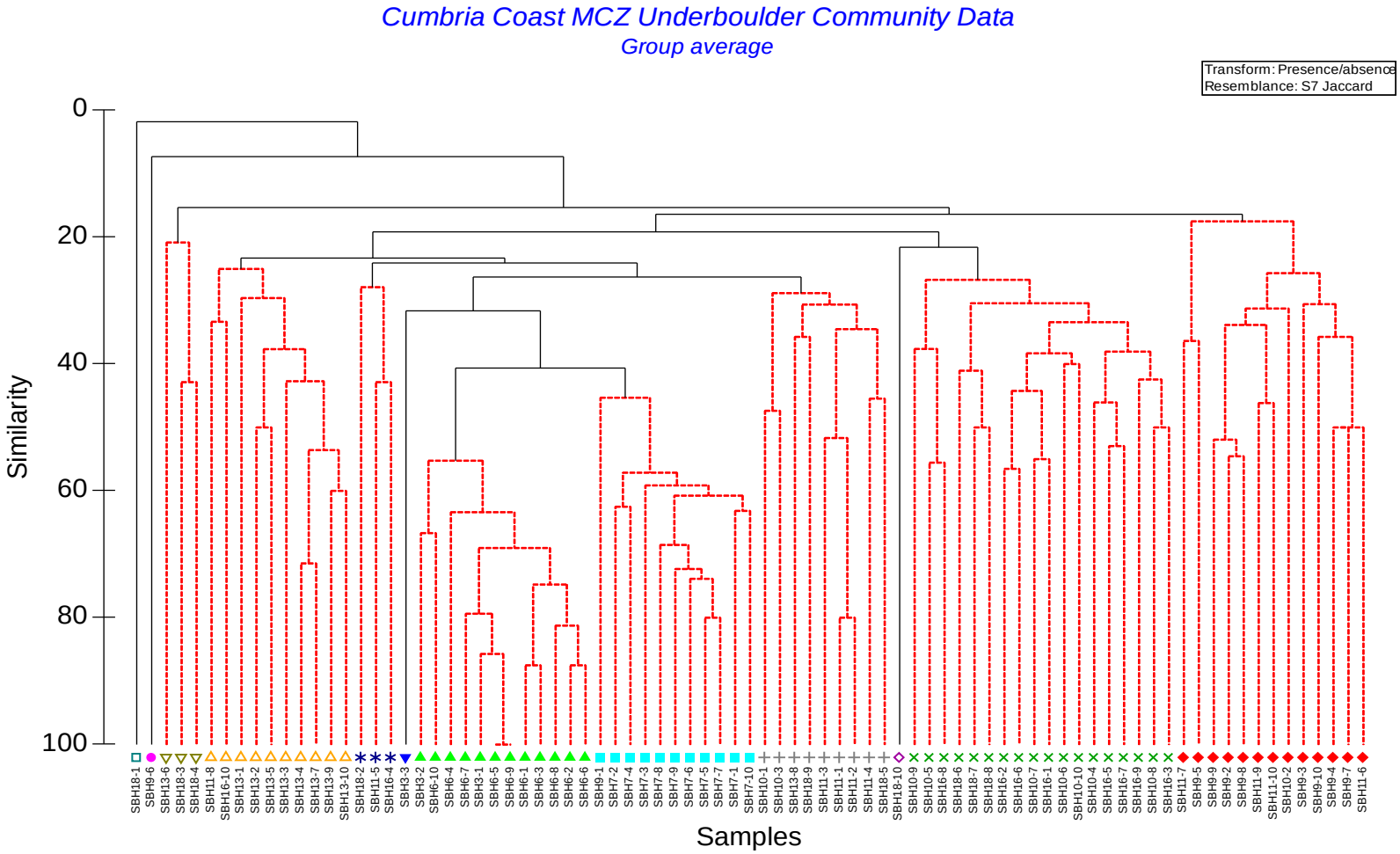

Figure 19 A group average sorting dendrogram based on presence/absence transformed abundance and percentage coverage data for each quadrat sample for the Cumbria Coast MCZ Underboulder Community Survey 2015. Jaccard similarity and the SIMPROF test were used. Symbols are coded according to clustered community structures.

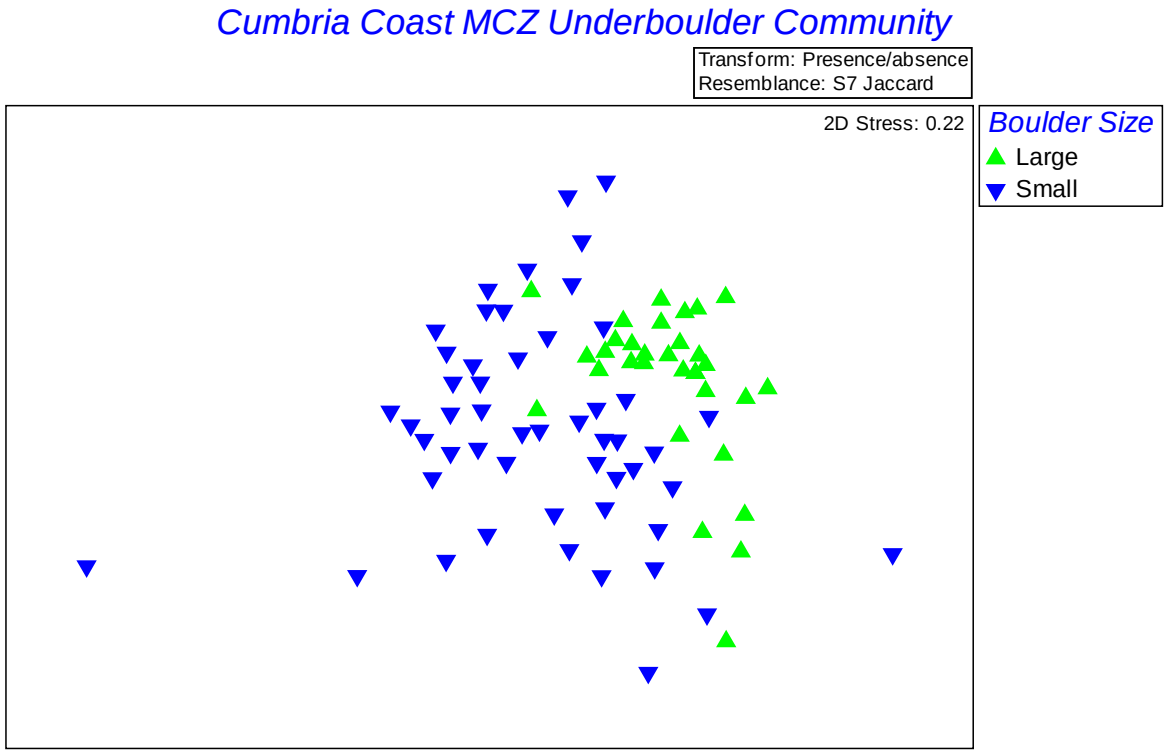

Figure 20 Cumbria Coast MCZ Underboulder Community Survey 2015 Non-Parametric Dimensional Scaling (MDS) configuration plot of taxa presence/absence boulder data using Jaccard similarity. Symbols are shown according to approximate boulder size. Large boulders are those too large to turn during sampling. Small boulders could be rolled over to assess the community semi-quantitatively before the boulder was returned to its original position.

4.5.4 Non-native intertidal species

The barnacle *Austrominius modestus* was recorded at Transect 10 north of Nethertown, and Transect 16 and 18 at Barn Scar near Drigg. These boulders were all located on the low shore.

No other invasive species were observed.

4.6 Anthropogenic pressures

4.6.1 Recreational activity

There were a number of dog walkers of other users of the beach throughout the MCZ. There was some evidence of leisure use of the foreshore (e.g. graffiti on the rocks and cliff) near Transect 9 which is north of the main recreational beach from the village of St Bees.

4.6.2 Drainage

There are sewage outflows from the coastal path near Transect 1 at the northern end of St Bee's Head, Transect 10 north of Nethertown and Transect 13 near the Sellafield Power Station. There was freshwater runoff at Transect 7 in Fleswick Bay, mid-way along St Bee's Head which affected the communities present along this transect (LR.FLR.Eph.Ent, *Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock).

4.6.3 Fishing and harvesting activity

Evidence of recreational fishing activity was noted throughout the MCZ. Angling was observed at Transects 1-3 in the north of St Bee's Head although access to this shore is difficult which is likely to limit the number of visitors. Angling was also observed at Transects 9 (south St Bee's Head), 11 (near Nethertown) and 18 (Kokoarrah, southernmost extreme of the MCZ).

Netting was observed at Transects 10 (north of Nethertown), 13 (near Sellafield Power Station), 16 and 17 (both at Kokoarrah).

There was also evidence of bait collecting including digging for bait at Transects 10, 13, 16 and 17, turning boulders for small crabs ('peelers') at Transects 16 & 17.

At Transect 11 there was evidence of algae collection for use as fertilizer.

4.6.4 Power station

Transect 13 is located shoreward of the Sellafield Nuclear Power Station.

4.6.5 Sea wall

There is a sea wall landward of Transect 11 that acts as the upper limit of the 'rocky' artificial substrate.

4.6.6 Military use

Eskmeals Firing Range is approximately 5 km south of Transect 18 at Kokoarrah.

5. Preliminary condition assessment

5.1 Comparison with historic data

In February to March 2013 a verification survey of intertidal habitats within the Cumbria Coast recommended MCZ was conducted by MESL and APEM. APEM conducted a survey of the rocky shore (MESL & APEM, 2013). Some of the field team that conducted the 2013 rocky shore survey were involved in the current 2015 intertidal rock survey. The 2013 rocky shore survey used Phase I and Phase II (quadrat) survey techniques so the data collected during the previous survey are a useful comparison to the current survey. The following

section provides a summary of the main features of the intertidal rock habitat in 2013 (Section 5.1.1). This is followed by a comparison between the findings of the 2013 survey and the data collected in the 2015 survey (Section 5.1.2). The location of transects undertaken during the 2013 and 2015 surveys is provided in Figure 21 and Figure 22.

Transects 16 and 17 from the 2015 survey re-sampled areas that were sampled during 2013 (Figure 22). Other transects in the northern area had intended to be re-sampled but needed to be relocated as the rocky shore habitats were no longer present in the target areas. It is likely that these rocky shore areas have come inundated with sand. However, Transect 6 and Transect 9 form the 2015 survey are within 500 m of areas where transects were undertaken in 2013 (Figure 21).

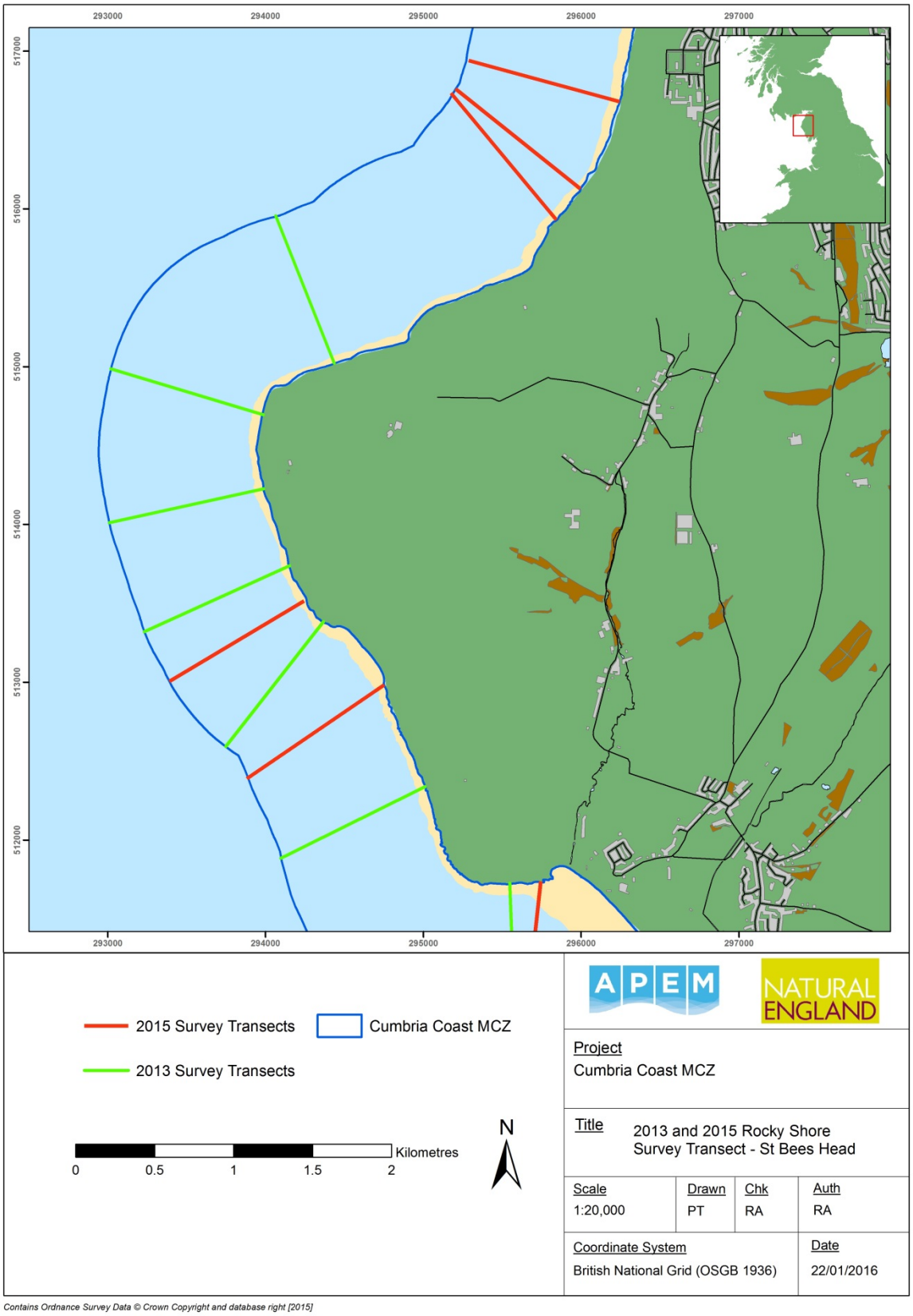

Figure 21 Transect locations of sampling conducted within the northern sector (Whitehaven to St Bees Head) during the 2013 and 2015 rocky shore surveys of the Cumbria Coast MCZ.

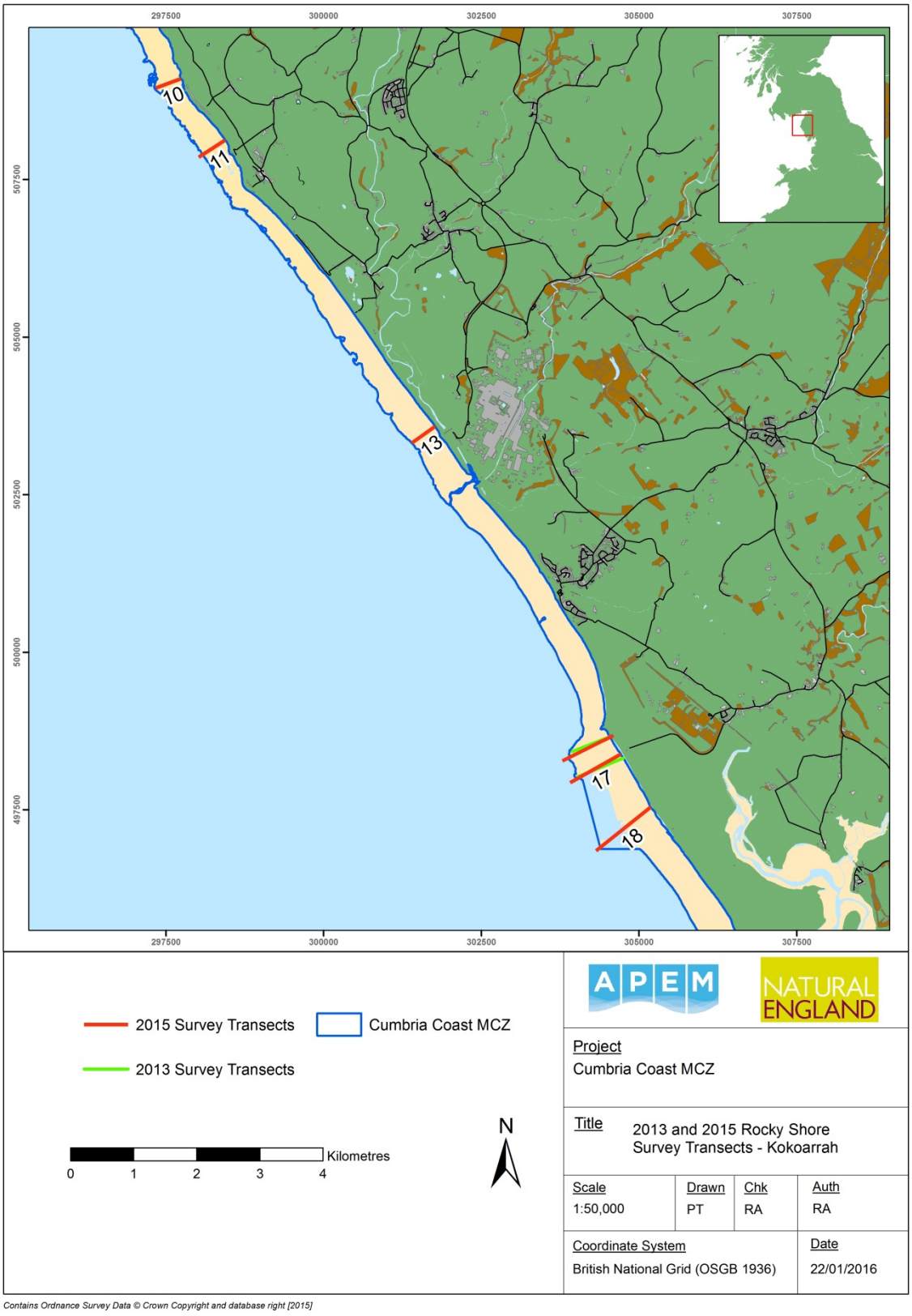

Figure 22 Transect locations of sampling conducted within the southern sector (St Bees Head to Ravenglass) during the 2013 and 2015 rocky shore surveys of the Cumbria Coast MCZ.

5.1.1 Cumbria Coast Rocky Shore Survey 2013

The most common encrusting organisms recorded in quadrats during the intertidal Cumbria coast MCZ verification survey of 2013 were barnacles (MESL & APEM, 2013). An algal canopy was recorded at most sites and the most common macrophyte species was *Fucus serratus* followed by *Mastocarpus stellatus* 40 and 27 from a total of 79 quadrats, respectively. The next most common encrusting organisms were *Mytilus edulis* juveniles and *Sabellaria alveolata* which were recorded in 33 and 32 of 79 quadrats respectively.

The most common free-living species recorded in quadrats was *Patella* sp. with a total abundance of 173 individuals. The most abundant species were Littorinids: *Littorina saxatilis* with 404 individuals, *L. littorea* with 305 individuals and *Littorina* sp. (not determined) with 104 individuals.

The 2013 rocky shore survey recorded the following biotope complexes within the High Energy Intertidal Rock BSH:

- A1.11 (LR.HLR.MusB) – Mussel and/or barnacle communities;
- A1.12 (LR.HLR.FR) – Robust fucoid and/or red seaweed communities;
- A1.15 (LR.HLR.FT) – Fucoids in tide-swept conditions; and
- A2.71 (LS.LBR.Sab) – Littoral (*Sabellaria*) reefs.

A1.11 (LR.HLR.MusB) was common around St Bees Head particularly at mid-shore.

Two biotopes within the A1.12 (LR.HLR.FR) complex were recorded: LR.HLR.FR.Pal *Palmaria palmata* on very exposed to moderately exposed lower eulittoral rock was only found at two sites and LR.HLR.FR.Mas was only found at one site. These biotopes were never recorded as the dominant biotope at the site.

The biotopes within the A1.15 (LR.HLR.FT) complex were generally restricted to two sites at Barn Scar near Drigg, at the southern extent of the site, although LR.HLR.FT.FserTX (A1.153) was found amongst the *Palmaria palmata* and *Laminaria digitata* at St Bees Head. However, these biotopes were not recorded as the dominant biotopes at these sites.

Aggregations of *Sabellaria* reef (A2.71, LS.LBR.Sab) were concentrated around the southern part of St Bees Head down to Nethertown and at Barn Scar near Drigg. *Sabellaria* reef was observed at all sites with the exception of those assessed by vessel at low tide.

The following biotopes for Underboulder Communities were recorded within the 2013 rocky shore survey:

- A1.2142 (LR.MLR.BF.Fser.Bo) – *Fucus serratus* and underboulder fauna on exposed to moderately exposed lower eulittoral boulders; and
- A3.2112 (IR.MIR.KR.Ldig.Bo) – *Laminaria digitata* and underboulder fauna on sublittoral fringe boulders.

The moderate energy littoral rock complex (A1.2, LR.MLR) that A1.2142 is part of was recorded at five sites at St Bees Head and Drigg but the only confirmed observation of this biotope was at one site at St Bees Head where it formed the main biotope in the lower-mid shore region.

A3.2112 was recorded at three sites at St Bees Head in the mean low water *Laminaria digitata* region.

The intertidal survey undertaken in 2013 recorded a total of 39 biotopes or biotope complexes within the survey area. The most frequently recorded were:

- A1.1131 (LR.HLR.MusB.Sem.Sem) – *Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock;
- A1.2141 (LR.MLR.BF.Fser.R) – *Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock;
- A2.711 (LS.LBR.Sab.Salv) – *Sabellaria alveolata* reefs on sand-abraded eulittoral rock; and
- A1.451 (LR.FLR.Eph.Ent) – *Enteromorpha* spp. on freshwater-influenced and/or unstable upper eulittoral rock.

The non-native intertidal species *Sargassum muticum* Japanese wireweed, and the red algae *Polysiphonia harveyi* (which is now called *Neosiphonia harveyi*), were recorded during the 2013 intertidal survey. These species were not recorded during the 2015 survey but the invasive barnacle *Austrominius modestus* was recorded in 30 of the 84 quadrats taken.

5.1.2 Comparison of findings from 2013 to the present

The most common macrophyte species in 2013 was *Fucus serratus* followed by *Mastocarpus stellatus* whereas in the 2015 surveys, the most common macrophyte were *Ulva* sp. (including *U. intestinalis*), *Fucus* sp. (juvenile) and *Fucus serratus*. The 2013 survey was conducted in February and March whereas the 2015 survey was conducted in September and October so it is possible that the difference in seasons may be the cause of some of this apparent shift rather than a permanent change in the communities. Rocky shore communities are known to exhibit seasonal change but the degree of change is not well understood (Davies *et al.*, 2001).

In 2013 the most common invertebrate was *Patella* sp. and the most abundant were Littorinids. In 2015, the most common, and also the most abundant invertebrate taxa were *Patella vulgata, Littorina littorea* and *Littorina saxatilis* and so there was no change in the most common invertebrate species.

A total of 18 biotopes were recorded within the 0.25 m^2 quadrats during the 2013 rocky shore survey. The 2015 surveys also observed a total of 18 biotopes from within the quadrats; eight of these were the same as those recorded in 2013. Of the biotopes and biotope complexes that are the focus of these surveys, two biotope complexes were not recorded within the quadrats of either survey: A1.12 (LR.HLR.FR) and A1.15 (LR.HLR.FT) (Table 14). The mussel and barnacle complex, A1.11 (LR.HLR.MusB) showed a similar frequency between the 2013 and 2015 surveys. However, three biotope/biotope complexes have reduced in frequency between the 2013 and 2015 surveys: A2.71 (LS.LBR.Sab), A1.2142 (LR.MLR.BF.Fser.Bo) and A3.2112 (IR.MIR.KR.Ldig.Bo).

Aggregations of *Sabellaria alveolata* were only recorded within quadrats at three mid-shore sites at Barn Scar near Drigg (Transect 18). Individuals were found at 34 sites composing up to 70% of the 0.25 m^2 quadrat samples indicating a patchy distribution throughout the MCZ but there were no areas of reef observed during the Phase I or Phase II surveys in 2015 (see Section 4.3). The recorded decline in *Sabellaria alveolata* reef (A2.71) within the MCZ

from 2013 to 2015 may be the result of natural variation between years, however this cannot be determined with data from the current survey.

Table 14 Biotopes and biotope complexes recorded within quadrats in the 2013 and 2015 intertidal rock surveys that are listed within the Cumbria Coast MCZ Conservation Objectives. The percentage values indicate the relative contribution of the biotope.

EUNIS Code	JNCC Biotope Code 15.03	Quadrats in 2013 Survey (%)	Quadrats in 2015 Survey (%)
A1.11	LR.HLR.MusB	19%	11%
A1.12	LR.HLR.FR	absent	absent
A1.15	LR.HLR.FT	absent	absent
A2.71	LS.LBR.Sab	absent*	1%
A1.2142	LR.MLR.BF.Fser.Bo	absent	6%
A3.2112	IR.MIR.KR.Ldig.Bo	10%	4%
-	Other biotopes	71%	79%

* Although this biotope was not in quadrats at part of the Phase II survey it was observed during the Phase I survey at most sites.

The five most common biotopes recorded during the Phase II surveys has changed between 2013 and 2015 (Table 15). None of the same Level 4/5 biotopes are present in the top five for each survey.

Table 15 Top five dominant biotopes recorded in the quadrat surveys undertaken in 2013 and 2015. Biotopes of focus for this assessment are highlighted in bold. The values indicate the absolute occurrence of the biotope.

2013 Quadrat Survey		2015 Quadrat Survey	
Dominant Biotopes	Frequency	Dominant Biotopes	Frequency
LS.LBR.Sab.Salv	11	LR.FLR.Eph.Ent	11
LR.FLR.Eph.BLitX	10	**LR.HLR.MusB.Sem.LitX**	9
LR.MLR.BF.FvesB	9	LR.MLR.BF.Fser.R	9
IR.MIR.KR.Ldig.Bo	8	LR.MLR.BF.FspiB	8
LR.MLR.MusF.MytFR	7	LR.MLR.BF.Fser	6

A comparison was carried out between the quantitative quadrat data collected in 2013 with quantitative quadrat data from the current survey using PRIMER (Clarke and Gorley, 2006). For both datasets the replicates were summed to provide a single record for each transect/shore height combination. In addition, some taxa were grouped to ensure a robust dataset for comparison. This approach means that greater taxonomic resolution was disregarded in one dataset (2015) and alternative ways to report recorded taxa to lower the risk of having artefacts were considered. However, by truncating the taxa, when comparing grouped items, some of the variability that makes the two initial datasets so different will be 'smoothed out'. Grouping the taxa too much will make both datasets the same. This grouping was conducted by senior taxonomist who used their knowledge and experience to determine the correct level to group data. Data were also amended to remove non-numerical

values before importing into PRIMER software. For details on how data were truncated and taxa grouped for this analysis see Appendix 5. The data were a mixture of percentage coverage and actual counts of taxa and so was transformed to presence/absence data. Similarity profile permutation tests were conducted on a Jaccard similarity matrix calculated from presence-absence data. The similarity profile (SIMPROF) (Clarke and Gorley, 2006) test suggested some separation of communities between survey years (Figure 23). This was further supported by multi-dimensional scaling (MDS) which showed that there was grouping of stations by survey year (Figure 24).

ANOSIM was run within PRIMER (Clarke and Gorley, 2006) to test whether there was a significant difference in the assemblage of taxa recorded between years. The ANOSIM routine returned a sample statistic (Global R) of 0.234 indicating a minimal degree of separation in the species assemblage between years (with a significance level of 0.1%).

Analysis of the two different surveys using SIMPER (Clarke and Gorley, 2006) indicates the greatest contribution to the community is by barnacles in both survey years. There is a decrease in the contribution by limpets *Patella vulgata* with an average frequency in 2013 of 0.7 and in 2015 of 0.56. The contribution by *Ulva* sp. has increased from an average frequency of 0.33 in 2013 to 0.8 in 2015 (Table 16). Communities dominated by barnacles, fucoids and limpets are often subject to large natural variation due to seasonal and non-seasonal factors and inter-annual changes such as variations in climate can cause changes in the communities (Hartnoll & Hawkins, 1985) This variation in the contribution of species observed here appears to be within this natural variability.

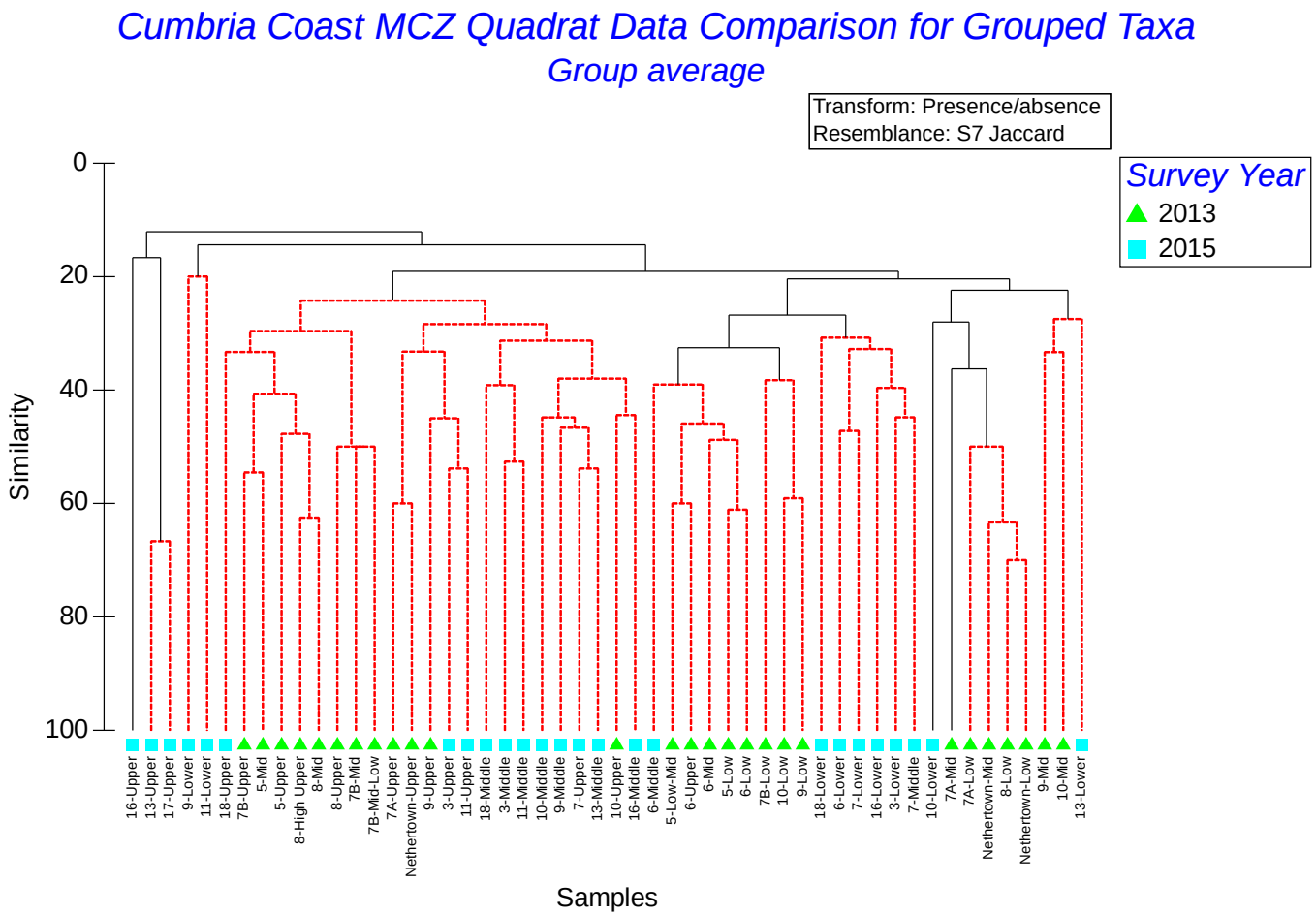

Figure 23 A group average sorting dendrogram based on presence/absence transformed abundance and percentage coverage data for each quadrat sample for the Cumbria Coast Rocky Shore Survey 2013 and the Intertidal Rock Survey 2015. The dataset was grouped to enable comparison of data from the two surveys. Jaccard similarity and the SIMPROF test were used. Symbols represent the survey year in which data were collected.

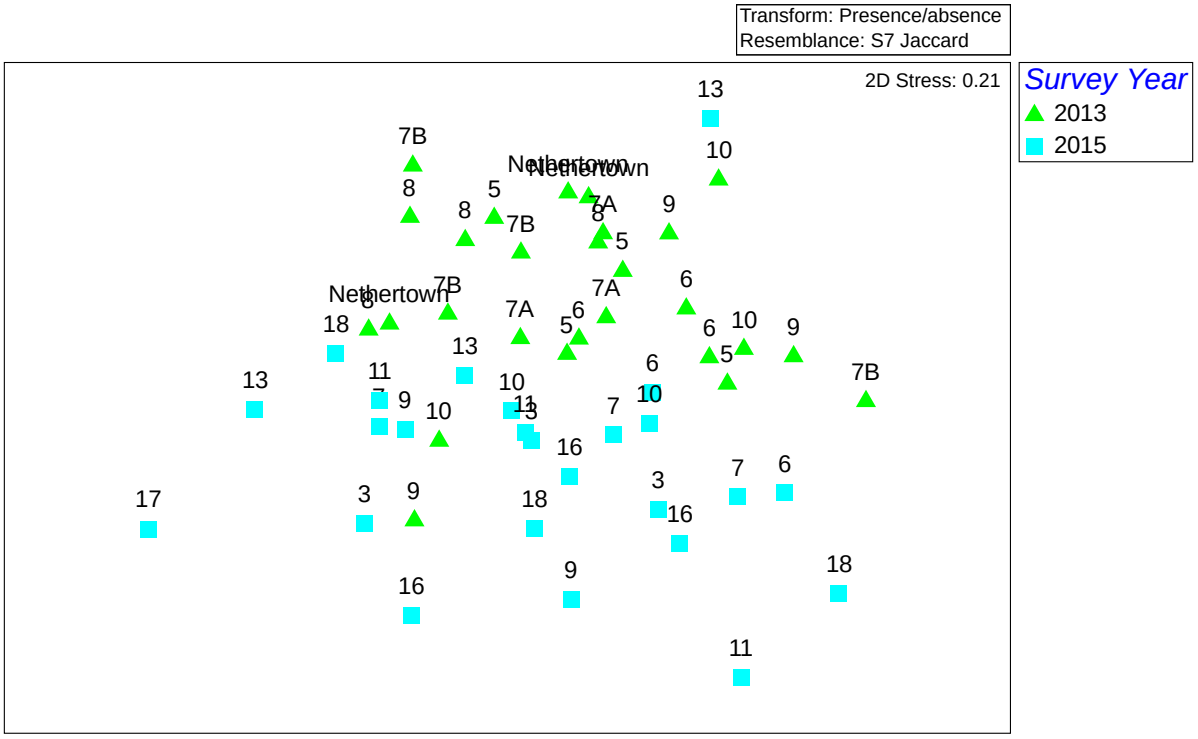

Figure 24 Cumbria Coast Rocky Shore 2013 and 2015 Non-metric Multidimensional Scaling (MDS) configuration plot of taxa presence/absence data using Jaccard similarity. Sample labels are given by transect and symbols are shown according to survey year.

Table 16 Cumbria Coast MCZ Rocky Shore 2013 and 2015 SIMPER analysis table providing frequency of diagnostic species, variability and contribution to the group similarity for 2015 and 2013 followed by the diagnostic species, variability and contribution to the group dissimilarity between survey years. The table shows higher-contributing species to the cumulative similarity percentage (a cut-off value of 90% was used).

Group 2015	Average similarity: 34.21				N=84
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib %**	**Cum. %**
Sessilia	0.88	5.8	1.37	16.97	16.97
Ulva sp.	0.8	5.18	1.03	15.14	32.1
Porphyra sp.	0.52	2.42	0.51	7.08	39.18
Patella vulgata	0.56	2.02	0.63	5.89	45.07
Mytilus edulis	0.6	1.93	0.69	5.63	50.7
Spirobranchus	0.56	1.8	0.6	5.25	55.95
Fucus sp. juvenile	0.52	1.79	0.56	5.24	61.19
Sabellaria alveolata	0.52	1.7	0.56	4.98	66.17
Fucus serratus	0.48	1.27	0.5	3.72	69.89
Chondrus crispus	0.48	1.12	0.51	3.28	73.18

Group 2015	Average similarity: 34.21				N=84
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib %**	**Cum. %**
Fucus vesiculosus	0.32	0.86	0.32	2.52	75.7
Hildenbrandia sp.	0.36	0.8	0.36	2.34	78.04
Nucella lapillus	0.36	0.78	0.36	2.27	80.31
Electra pilosa	0.4	0.66	0.41	1.92	82.23
Ceramium sp.	0.36	0.62	0.36	1.82	84.05
Bryozoa	0.36	0.57	0.35	1.67	85.72
Corallinaceae	0.36	0.57	0.36	1.66	87.38
Rhodothamniella floridula	0.32	0.5	0.3	1.47	88.84
Littorina saxatilis	0.24	0.38	0.23	1.1	89.94
Cladophora sp.	0.24	0.3	0.22	0.87	90.81

Group 2013	Average similarity: 39.70				N=79
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib %**	**Cum. %**
Sessilia	0.96	9.31	2.34	23.45	23.45
Patella vulgata	0.7	4.8	0.92	12.09	35.53
Fucus serratus	0.67	4.25	0.8	10.71	46.24
Sabellaria alveolata	0.67	3.8	0.84	9.57	55.81
Mytilus edulis	0.56	3.22	0.6	8.11	63.93
Mastocarpus stellatus	0.52	2.13	0.57	5.37	69.29
Nucella lapillus	0.44	1.78	0.47	4.48	73.77
Corallinaceae	0.44	1.44	0.47	3.62	77.39
Littorina saxatilis	0.33	1.17	0.33	2.96	80.34
Ulva sp.	0.33	0.94	0.32	2.36	82.71
Rhodothamniella floridula	0.33	0.85	0.33	2.14	84.85
Littorina sp.	0.3	0.75	0.29	1.9	86.75
Littorina littorea	0.3	0.75	0.28	1.88	88.63
Spirobranchus	0.3	0.62	0.29	1.56	90.18

Groups 2013 & 2015	Average dissimilarity = 69.38					
	Group 2013	Group 2015				
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib %**	**Cum. %**
Ulva sp.	0.33	0.8	2.71	1	3.91	3.91
Porphyra sp.	0.19	0.52	2.42	0.86	3.48	7.39
Fucus serratus	0.67	0.48	2.35	0.83	3.38	10.77

Groups 2013 & 2015	Average dissimilarity = 69.38					
	Group 2013	Group 2015				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib %	Cum. %
Mytilus edulis	0.56	0.6	2.24	0.8	3.23	14
Sabellaria alveolata	0.67	0.52	2.2	0.85	3.18	17.18
Patella vulgata	0.7	0.56	2.18	0.8	3.14	20.31
Spirobranchus	0.3	0.56	2.14	0.91	3.09	23.4
Fucus sp. juvenile	0.07	0.52	2.13	0.94	3.07	26.47
Nucella lapillus	0.44	0.36	2.09	0.85	3.01	29.48
Mastocarpus stellatus	0.52	0.16	2.08	0.91	3	32.48
Corallinaceae	0.44	0.36	1.93	0.88	2.78	35.26
Littorina saxatilis	0.33	0.24	1.87	0.74	2.69	37.95
Rhodothamniella floridula	0.33	0.32	1.77	0.79	2.55	40.51
Ceramium sp.	0.3	0.36	1.69	0.81	2.44	42.94
Littorina littorea	0.3	0.2	1.65	0.7	2.38	45.32
Chondrus crispus	0	0.48	1.63	0.9	2.35	47.67
Fucus vesiculosus	0.07	0.32	1.61	0.69	2.33	49.99
Electra pilosa	0.26	0.4	1.6	0.85	2.31	52.3
Hildenbrandia sp.	0.04	0.36	1.48	0.72	2.13	54.43
Palmaria palmata	0.22	0.28	1.35	0.72	1.95	56.38
Littorina sp.	0.3	0	1.27	0.59	1.84	58.22
Bryozoa	0.04	0.36	1.25	0.7	1.8	60.02
Amphipoda	0.26	0.12	1.19	0.61	1.72	61.74
Corallina officinalis	0.26	0.08	1.16	0.59	1.67	63.41
Actinia equina	0.19	0.2	1.08	0.63	1.56	64.97
Cladophora sp.	0.07	0.24	1.07	0.57	1.55	66.52
Laminaria digitata	0.22	0.16	1.02	0.64	1.46	67.98
Asterias rubens	0.07	0.24	0.92	0.58	1.33	69.31
Urticina felina	0.22	0.04	0.9	0.53	1.3	70.61
Idotea	0.11	0.2	0.9	0.56	1.3	71.91
Flustrellidra hispida	0.07	0.24	0.89	0.59	1.28	73.19
Dynamena pumila	0.11	0.16	0.8	0.53	1.15	74.34
Lanice conchilega	0.07	0.12	0.73	0.44	1.05	75.39
Rhodophyta	0	0.16	0.71	0.41	1.03	76.42
Polysiphonia sp.	0.11	0.12	0.7	0.49	1.01	77.42
Sessilia	0.96	0.88	0.69	0.34	1	78.42
Littorina obtusata	0.04	0.16	0.63	0.45	0.91	79.33
Membranoptera alata	0	0.24	0.62	0.55	0.9	80.23
Molgula manhattensis	0	0.2	0.57	0.49	0.83	81.06
Polyides rotundus	0	0.2	0.57	0.49	0.83	81.88

Groups 2013 & 2015	Average dissimilarity = 69.38					
	Group 2013	Group 2015				
Species	**Av.Abund**	**Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib %**	**Cum. %**
Delessaria sanguinea	0	0.2	0.57	0.48	0.83	82.71
Ralfsia verrucosa	0.04	0.16	0.55	0.46	0.8	83.51
Ascophyllum nodosum	0.15	0	0.55	0.39	0.79	84.3
Osmundea pinnatifida	0.11	0.04	0.53	0.38	0.77	85.06
Lepidochitona cinerea	0.11	0.04	0.51	0.38	0.73	85.79
Fucus spiralis	0.04	0.08	0.49	0.34	0.71	86.5
Gibbula sp.	0.04	0.08	0.48	0.34	0.69	87.19
Gelidium sp.	0	0.16	0.45	0.42	0.65	87.84
Phyllophora pseudoceranoides	0	0.16	0.41	0.43	0.6	88.43
Plocamium cartilagineum	0	0.16	0.4	0.43	0.58	89.01
Chaetomorpha melagonium	0	0.12	0.39	0.34	0.57	89.58
Rissoa parva	0.07	0.04	0.35	0.33	0.5	90.08

5.2 Preliminary assessment

Table 17 Preliminary condition assessment for each attribute of the High Energy Intertidal Rock sub-feature of the Cumbria Coast MCZ as defined in the conservation objectives.

MCZ Attribute	Target	Condition Recommendation: Is Target Met? Justification & Notable Comments (incl. comparisons with previous data)
Structure: presence and abundance of typical species	Maintain the abundance of listed typical species, to enable each of them to be a viable component of the habitat.	The comparative exercise conducted between surveys suggests that barnacles have continued to dominate the community. There were differences in the macrophytes observed. In 2013 the highest abundance of macroalgae was *Fucus serratus* and *Mastocarpus stellatus* and in 2015 the highest abundance of macroalgae was *Ulva* sp., *Fucus* sp. and *Fucus serratus.* Analysis of the taxa contributing the most to the dissimilarity between years (using SIMPER) indicated an increase in *Ulva* sp. between years and a decrease in the contribution by limpets *Patella vulgata* and *Fucus serratus*. Although the all typical species have been recorded, there appears to be a shift in the abundance of typical species in the habitat. These differences may be the result of natural variation, or an artefact due to comparing data collected at different seasons, however, a definitive conclusion cannot be stablished with the current study. It is not possible to determine if the CO target for this attribute has been met.
Distribution: presence and spatial distribution of intertidal rock communities	Maintain the species composition of the presence and spatial distribution of intertidal rock communities.	The most common biotopes within the intertidal rock habitat have changed since the last survey although the biotope complexes A1.45 (LR.FLR.Eph) and A1.21 (LR.MLR.BF) are still common. A comparison between the communities recorded during both surveys shows a clear difference between years. In particular, there is a noticeable decline in the presence of *Sabellaria alveolata* reef (A2.71). The reason for this decline is not

MCZ Attribute	Target	Condition Recommendation: Is Target Met? Justification & Notable Comments (incl. comparisons with previous data)
		clear. It could be the result of seasonal differences or natural variability such as the movement of sand smothering rocky shore communities. The mussel and barnacle complex, A1.11 (LR.HLR.MusB) showed a similar frequency between the 2013 and 2015 surveys. However, three biotope/biotope complexes have reduced in frequency between the 2013 and 2015 surveys: A2.71 (LS.LBR.Sab), A1.2142 (LR.MLR.BF.Fser.Bo) and A3.2112 (IR.MIR.KR.Ldig.Bo). As some of the key biotope complexes for the MCZ, and the internationally important biotope A2.71 have declined, the CO target for this attribute is not met.
Extent and distribution	Maintain the total extent and spatial distribution of intertidal rock	Whilst some areas were observed to be covered in a fine layer of sand, the majority of the intertidal rock habitat has not changed since the last survey. As such the CO target for this attribute has been met.
Structure: Non-native species and pathogens	Restrict the introduction of non-native species and pathogens and their impacts.	None of the invasive species previously recorded within the MCZ were observed during the current survey, however, as they were previously recorded infrequently and the current survey did not cover 100% of the site, it is possible that these species may be present but not observed on the targeted transects. However, a different invasive species, *Austrominius modestus,* was recorded at several stations throughout the MCZ in 2015. *A. modestus* was prevalent at some locations and it is likely that since 2013 the population of this INNS species has colonised areas where it was not previously present. It is unknown whether the presence of this species is having a detrimental effect on native species. *Sargassum muticum* was not observed during the recent survey so does not appear to have significantly increased its range within the MCZ, however, a new invasive species has been recorded therefore the CO are partially achieved.

MCZ Attribute	Target	Condition Recommendation: Is Target Met? Justification & Notable Comments (incl. comparisons with previous data)

Table 18 Preliminary condition assessment for each attribute of the Intertidal Underboulder Communities sub-feature of the Cumbria Coast MCZ as defined in the conservation objectives.

MCZ Attribute	Target	Condition Recommendation: Is Target Met? Justification & Notable Comments (incl. comparisons with previous data)
Structure: Non-native species and pathogens	Restrict the introduction of non-native species and pathogens and their impacts.	None of the invasive species previously recorded as present within the Cumbria Coast MCZ were observed during the recent survey. However, the invasive barnacle *Austrominius modestus* was recorded in several underboulder communities in the central and southern areas of the MCZ. This species is easily identified and so if previously present is likely to have been recorded. Therefore the CO target for this attribute is not met.
Structure: presence and abundance of typical species	Maintain the abundance of listed typical species, to enable each of them to be a viable component of the habitat.	Whilst the previous intertidal rock survey noted the presence of underboulder communities, it did not record their presence or community composition quantitatively. As such it was not possible to conduct a statistically meaningful comparison of underboulder communities between the 2013 and 2015 surveys. However, the two underboulder community biotopes present in the 2013 survey suggest that at least some of the underboulder communities are dominated by: *Fucus serratus*, red algae, *Patella vulgata*, *Nucella lapillus*, *Actinia equina* and *Semibalanus balanoides*; and *Laminaria digitata,* other green algae, red algae, bryozoans and a variety of fauna including decapods, barnacles, polychaetes, amphipods and gastropods.

MCZ Attribute	Target	Condition Recommendation: Is Target Met? Justification & Notable Comments (incl. comparisons with previous data)
		The 2015 survey recorded *Fucus* on only three boulders, and did not record any *Laminaria*. However, there were frequent observations of red algae, *N. lapillus*, *A. equina*, Bryozoa, decapods, barnacles and polychaetes. Due to the difference in survey approaches between 2013 and 2015, and the inability to make a statistically meaningful comparison between the two surveys, it is not possible to make a specific recommendation of the condition of this attribute. The preliminary assessment for this attribute is, therefore, unknown.
Extent and distribution	Maintain the total extent of intertidal boulder habitat, and spatial distribution as defined on the map, subject to natural variation in sediment veneer.	Whilst the previous intertidal rock survey noted the presence of underboulder communities, it did not record their presence or community composition quantitatively. Biotopes were noted for the two boulder communities that have been classified within the EUNIS biotope system but their exact location and extent is unknown. Biodiversity-rich underboulder communities were observed on many of the boulders sampled during the 2015 survey. The current survey has recorded the presence of A3.2112 (IR.MIR.KR.Ldig.Bo) on lower-mid shore boulders at St Bees Head. A1.2142 (LR.MLR.BF.Fser.Bo) was not observed on any of the boulders. Whilst it is not possible to conduct a statistically significant comparison of underboulder communities between the 2013 and 2015 surveys the extent of the habitat is unlikely to change except as a result of boulders being covered in sediment. Or alternatively, resulting from anthropogenic influence such as boulder turning while collecting crab bait. This activity was noted by the survey team at transects 16 & 17. The community analysis suggested an underlying community structure that separates large (potential target of bait collectors) and small (not affected by bait collectors) boulders. Whether this is a natural effect driven by the size of the boulder or affected by human intervention is beyond any logical
Distribution: presence and spatial distribution of intertidal underboulder communities	Maintain the presence and spatial distribution of intertidal underboulder communities.	

MCZ Attribute	Target	Condition Recommendation: Is Target Met? Justification & Notable Comments (incl. comparisons with previous data)
		inference from the survey data alone. Furthermore, due to the difference in survey approaches between 2013 and 2015, the inability to make a statistically meaningful comparison between the two surveys or confirm any cause-effect relationship, it is not possible to make a specific recommendation of the condition of this attribute. The preliminary assessment for this attribute is, therefore, unknown. However, the current survey will form a good baseline for future comparisons to be made.

6. Summary and conclusions

1. The effort for the quantitative quadrat survey was directed to representative areas of rocky shore biotopes geographically spread throughout the MCZ. A total of 84 quadrats (0.25 m^2) were assessed across 10 transects. A total of 103 taxa were recorded within this data set.

2. The most common macroalgae taxa encountered during the quadrat survey was *Ulva* sp. found in 55 quadrats. *Patella vulgata* was the most common invertebrate found in 28 quadrats.

3. The effort for the underboulder community survey was directed to representative areas of boulder habitat within the MCZ: primarily at St Bee's Head and Barn Scar. A total of 83 boulders were sampled from nine transects with a total of 77 taxa recorded.

4. The most commonly observed species in the underboulder communities was *Spirobranchus* sp. which was observed on 71 of the 83 boulders surveyed.

5. Of the six biotopes/biotope complexes that were the focus of this survey, four were identified within the MCZ: LR.HLR.MusB, LS.LBR.Sab, LR.MLR.BF.Fser.Bo and IR.MIR.KR.Ldig.Bo.

    - Within the LS.LBR.Sab complex is LS.LBR.Sab.Salv *Sabellaria alveolata* reefs on sand-abraded eulittoral rock which is an internationally important community. Aggregations of this habitat were only recorded as the predominant biotope at three mid-shore sites at Barn Scar near Drigg (Transect 18). Individuals were found at 34 sites composing up to 70% of the 0.25 m^2 quadrat samples indicating a patchy distribution throughout the MCZ.

6. The Australian barnacle *Austrominius modestus* was recorded in 30 of the 84 quadrats taken and on boulders on three of the transects surveyed. No other non-native species were observed during the survey.

7. There appears to be limited anthropogenic influences on the MCZ. Whilst recreational activity was observed within the MCZ this was primarily a small number of dog walkers and recreational anglers. However, it should be noted that this survey was conducted outside of the main tourist season when higher numbers of visitors may be expected to visit the area. Sellafield Power Station was noted as well as drainage from freshwater and sewage outputs.

8. A comparison of survey data between a similar survey conducted in 2013 to the 2015 survey has shown a difference in the abundance of key species between years. The data suggest an increase in *Fucus* sp. and *Ulva* sp. coverage and a decrease in *Laminaria* sp. The invasive *Austrominius modestus* forms a significant component of the new community but does not appear to have been present during the previous survey in 2013. There also appears to be a significant decrease in the presence and extent of *Sabellaria alveolata* reef within the MCZ. The 2013 survey reported extensive *Sabellaria* reef across the MCZ whereas the 2015 survey only recorded this biotope at one mid-shore site at Barn Scar near Drigg.

9. The preliminary assessment considers that the CO to maintain the total extent and spatial distribution of intertidal rock has been met.

10. The preliminary assessment considers that the CO to restrict the introduction of INNS has been partially achieved.

11. As some of the key biotope complexes for the MCZ have declined, the preliminary assessment has found that the CO target to maintain the presence and spatial distribution of intertidal rock communities has not been met.

12. Due to the difference in survey approaches between 2013 and 2015, and the potential for some changes to have been caused by natural variation, it is not possible to make a specific recommendation for the following MCZ attributes:

    - Structure: presence and abundance of typical species of both intertidal rock and underboulder communities;
    - Extent and distribution of intertidal underboulder communities; and
    - Distribution: presence and spatial distribution of intertidal underboulder communities.

13. This survey has provided a good baseline for underboulder communities within the MCZ which can be used to make comparisons against with future surveys.

7. References

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APPENDIX 1

Master GPS waypoints tracks log - see the project page on the Access to Evidence Catalogue.

APPENDIX 2

Quadrat data set - see the project page on the Access to Evidence Catalogue

APPENDIX 3

Underboulder Community data - see the project page on the Access to Evidence Catalogue

APPENDIX 4

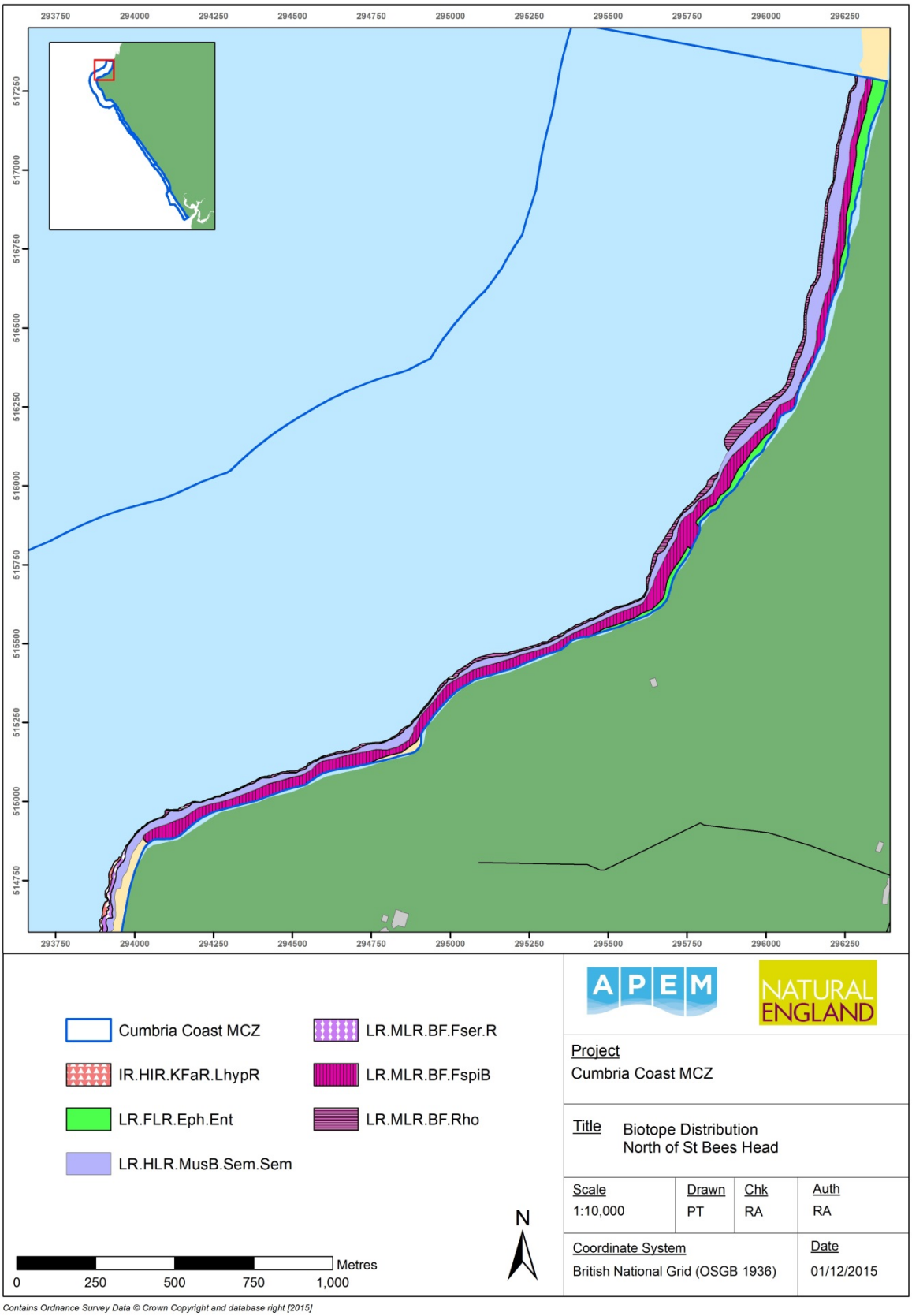

Figure 25 Cumbria Coast MCZ 2015 Intertidal rock biotope map of St Bees Head - North.

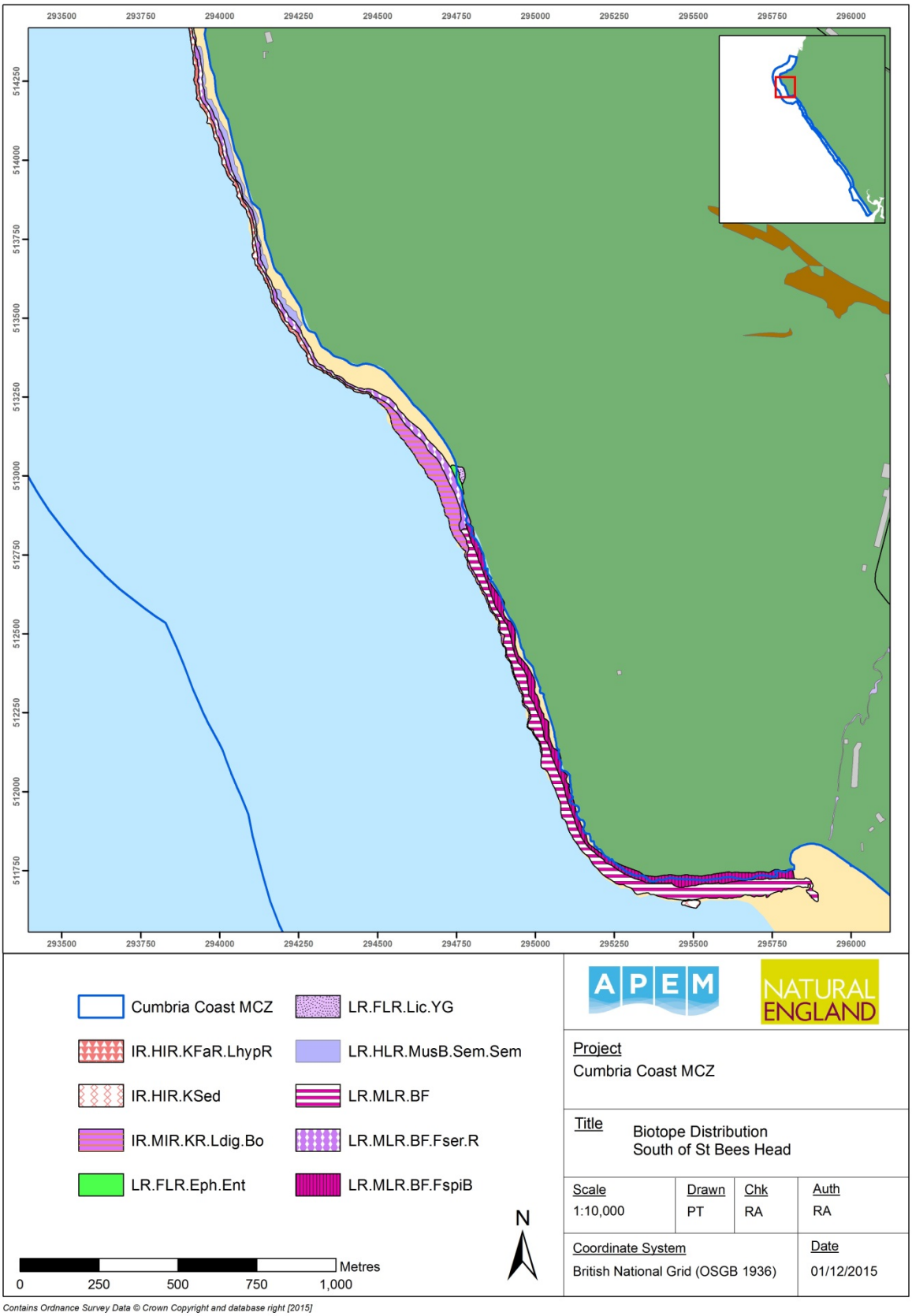

Figure 26 Cumbria Coast MCZ 2015 Intertidal rock biotope map of St Bees Head - South.

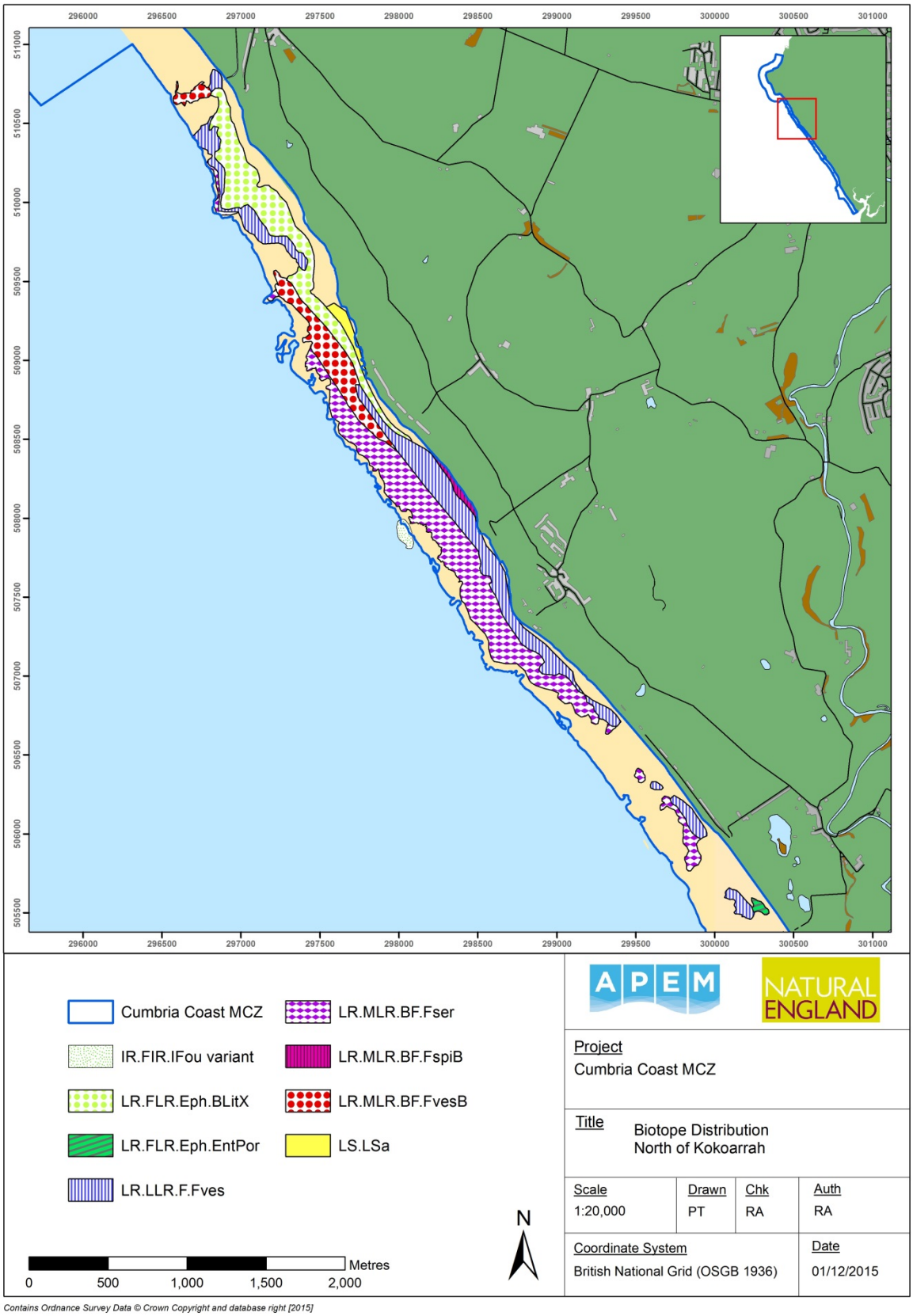

Figure 27 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Kokoarrah - North.

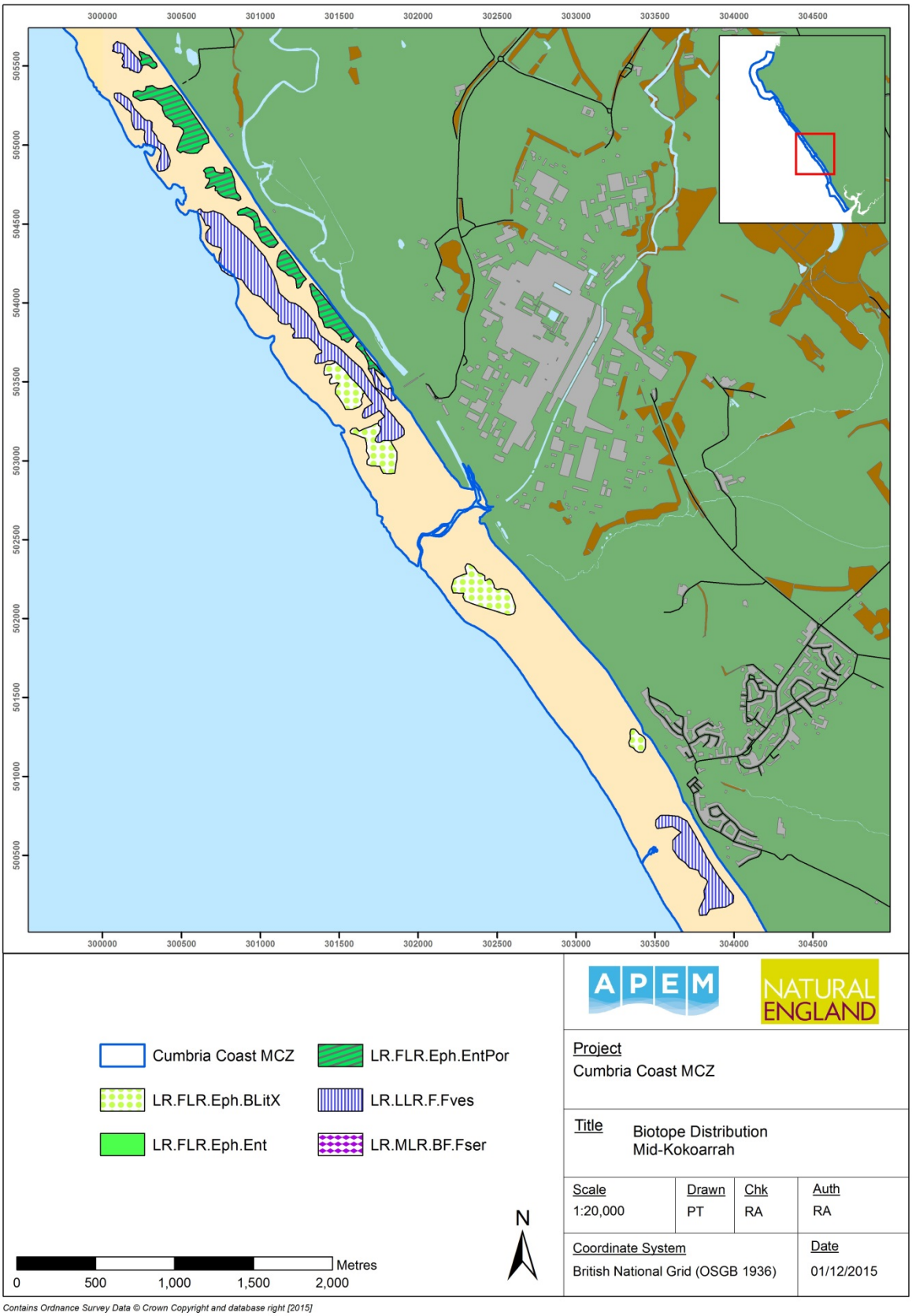

Figure 28 Cumbria Coast MCZ 2015 Intertidal rock biotope map of mid-Kokoarrah.

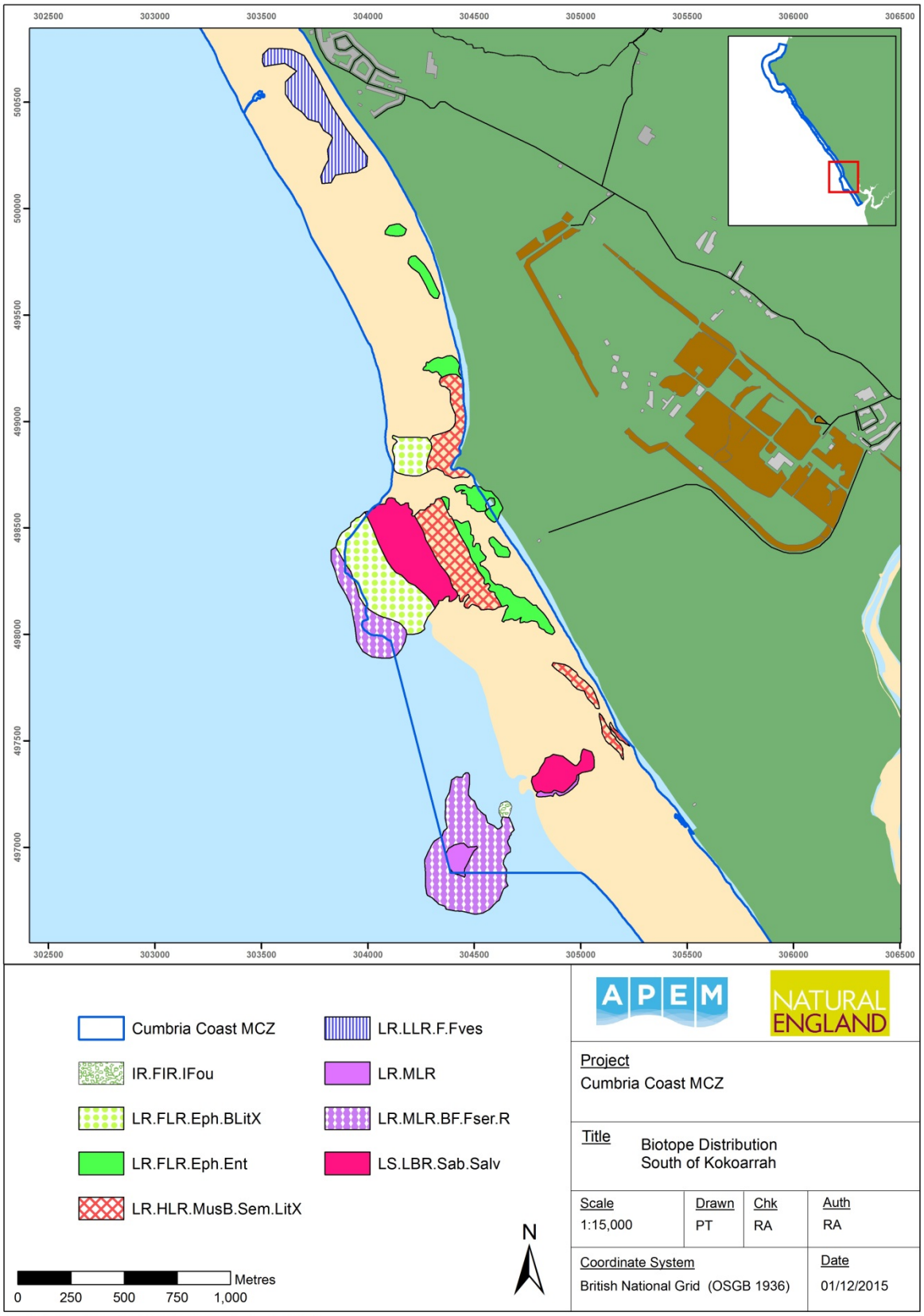

Figure 29 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Kokoarrah - South.

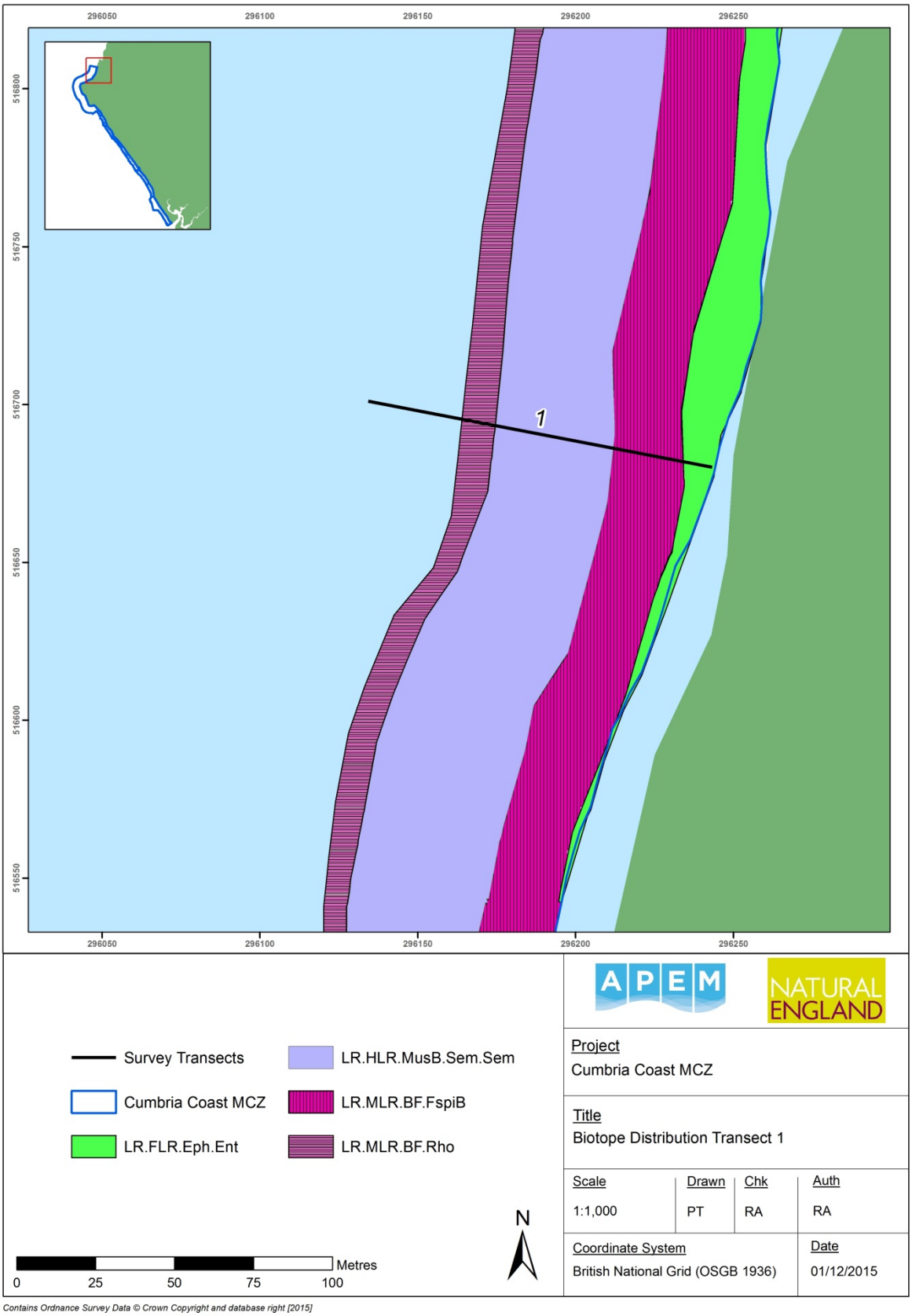

Figure 30 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 1.

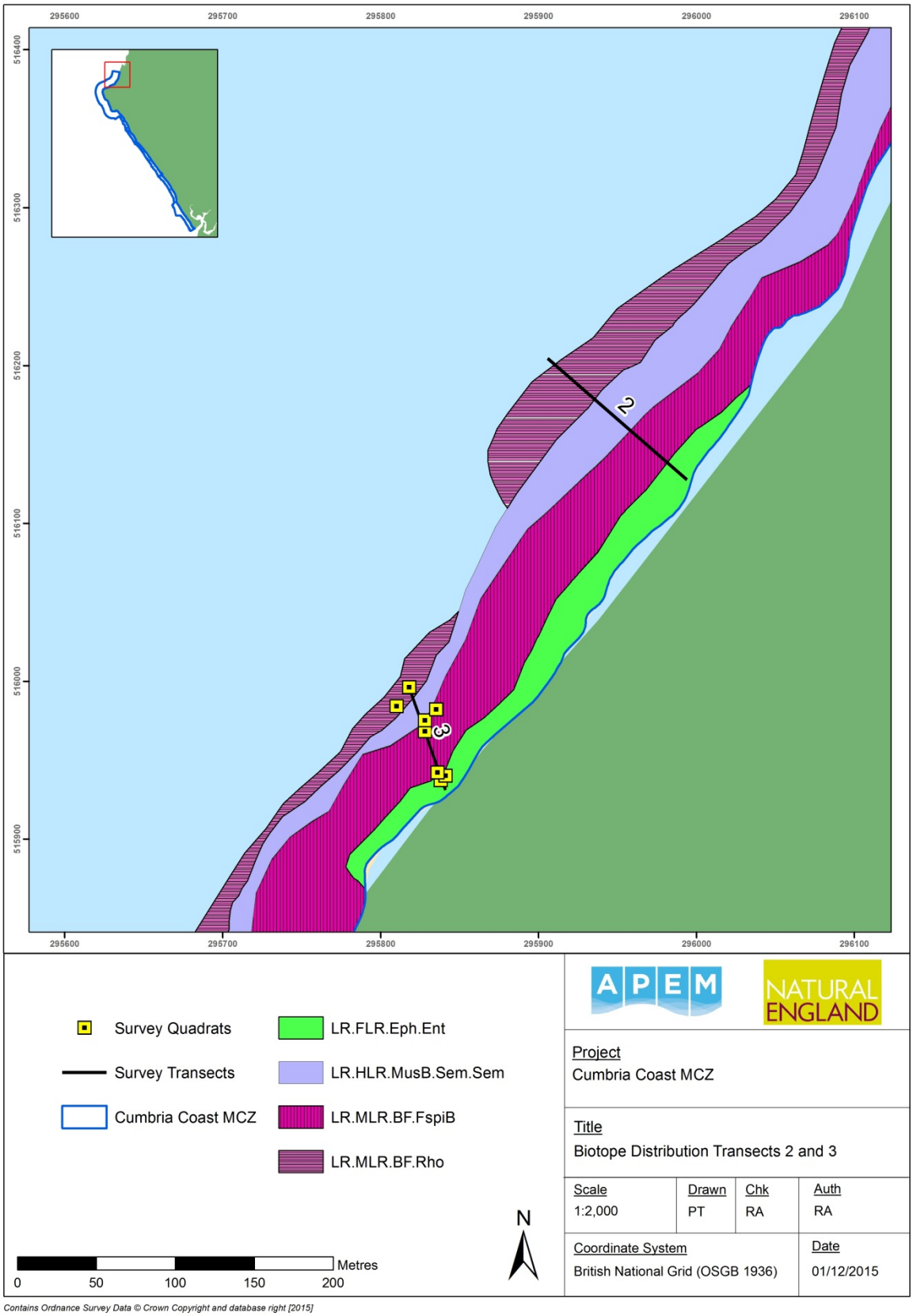

Figure 31 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 2 and 3.

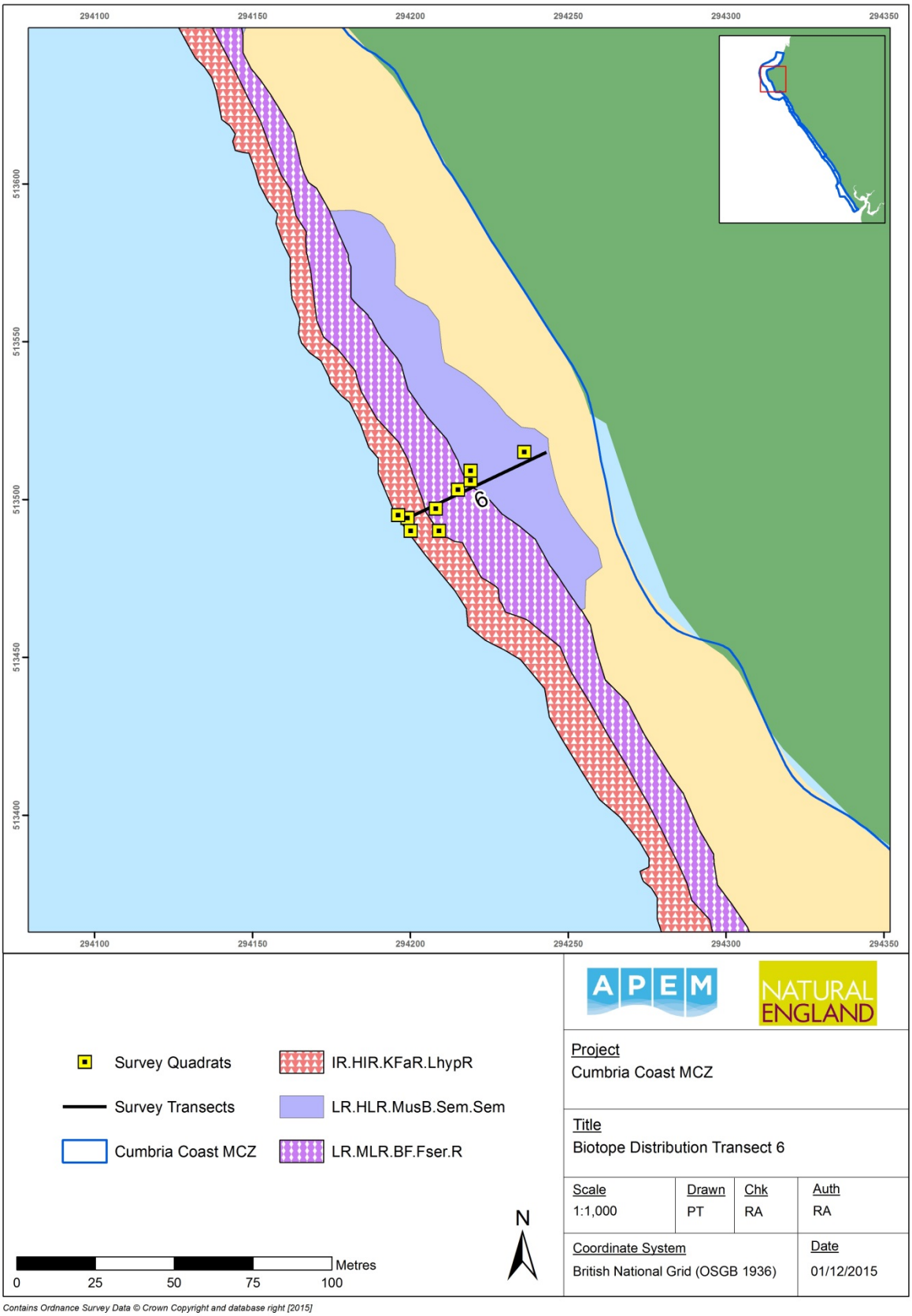

Figure 32 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 6.

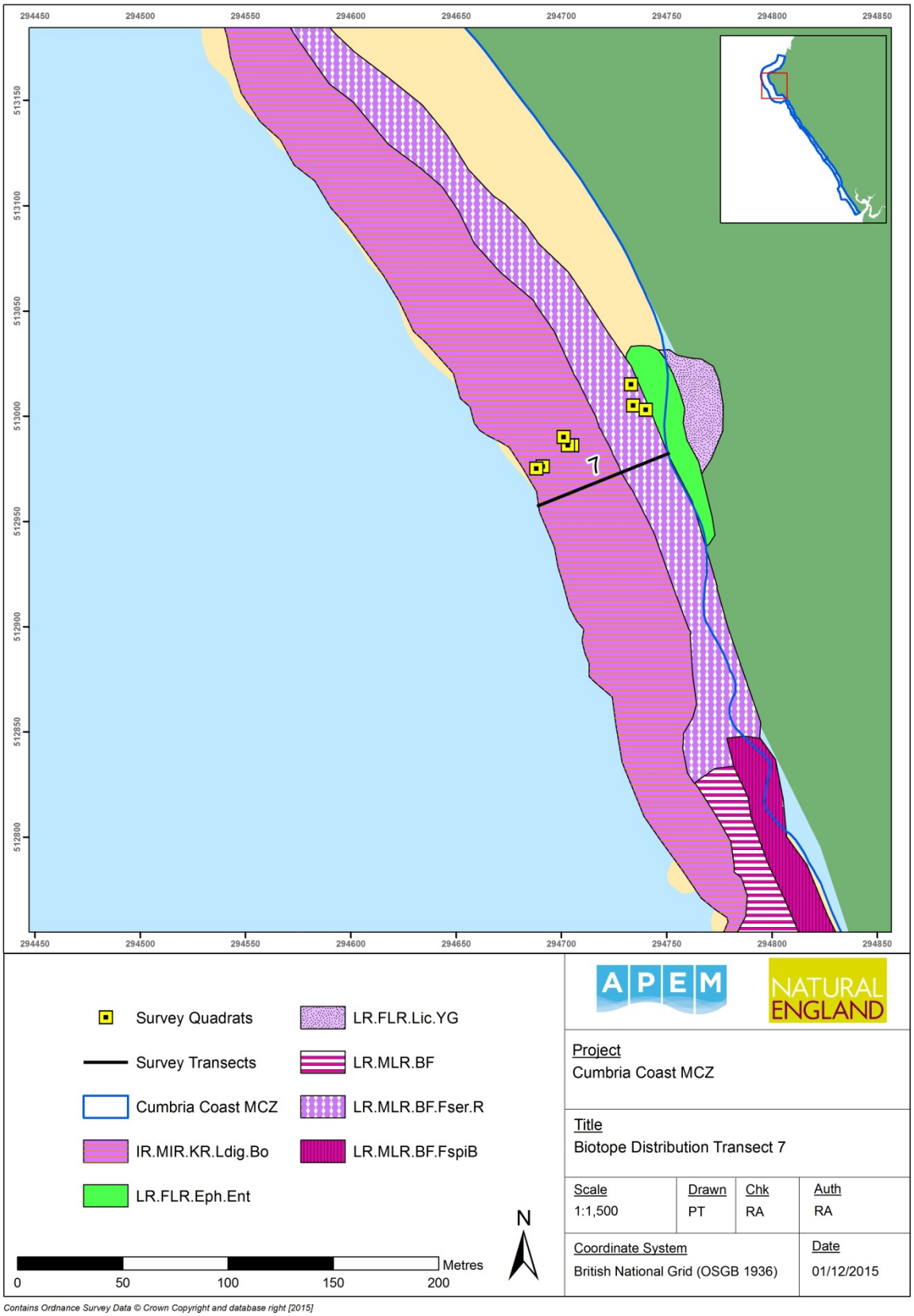

Figure 33 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 7.

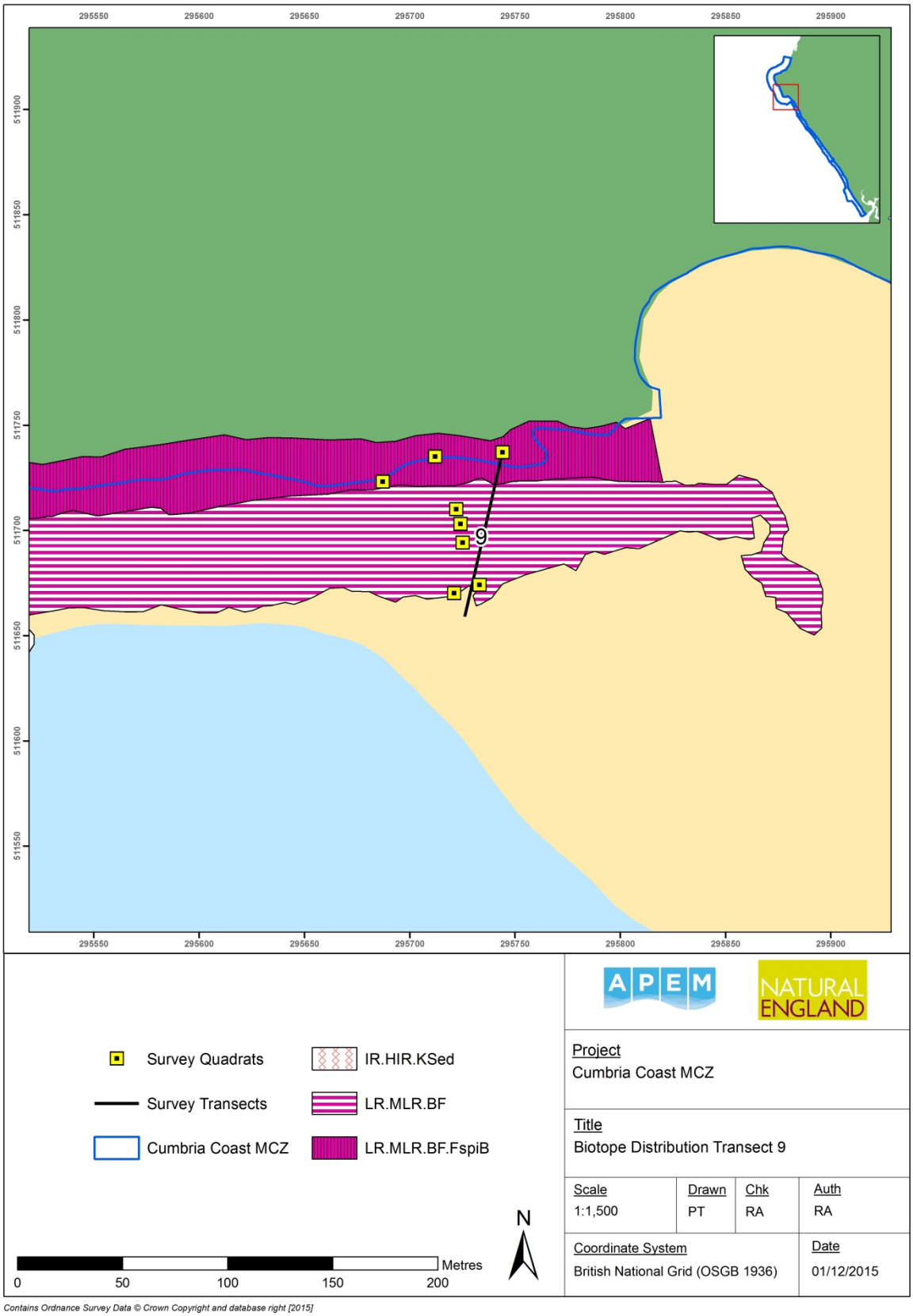

Figure 34 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 9.

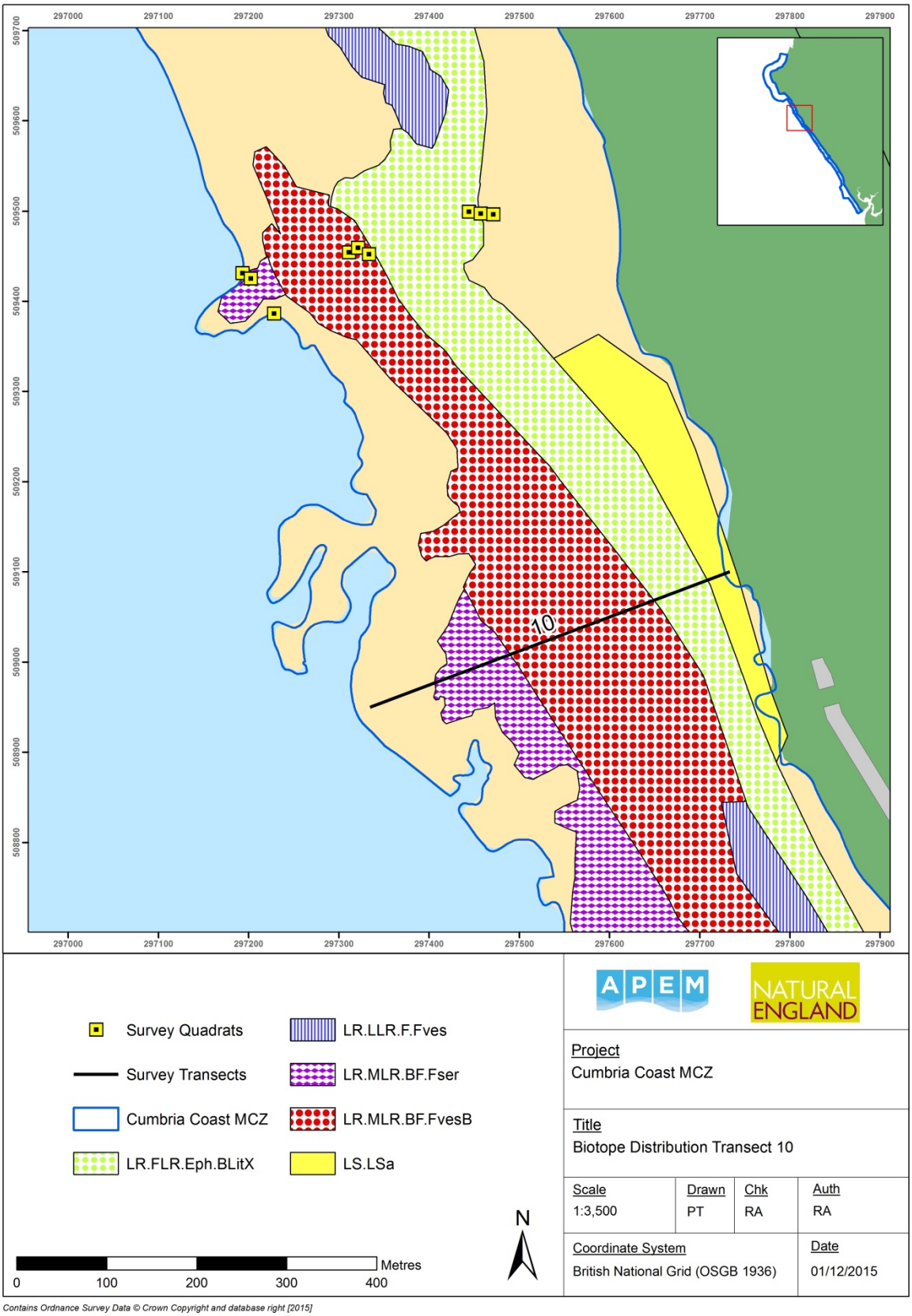

Figure 35 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 10.

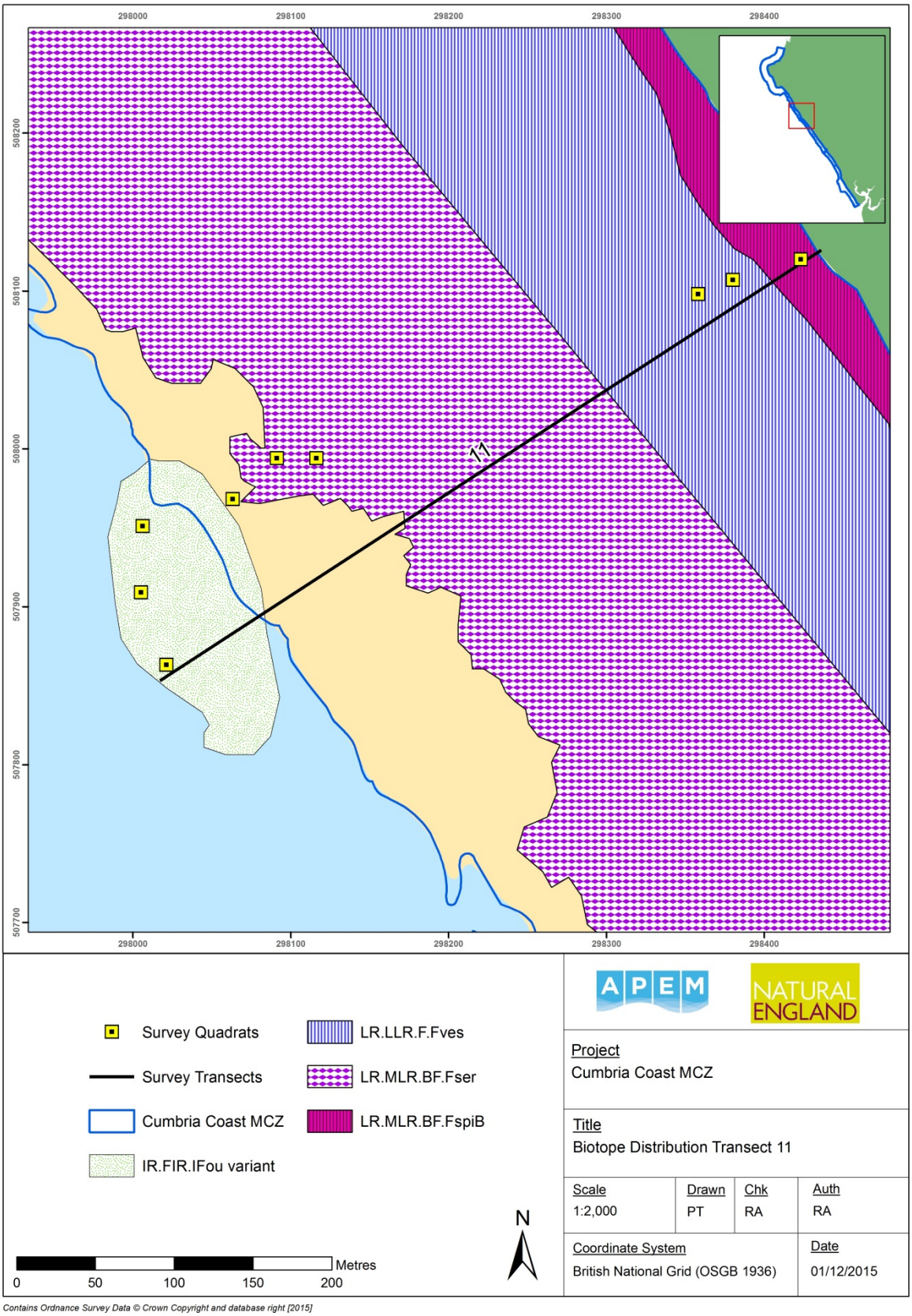

Figure 36 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 11.

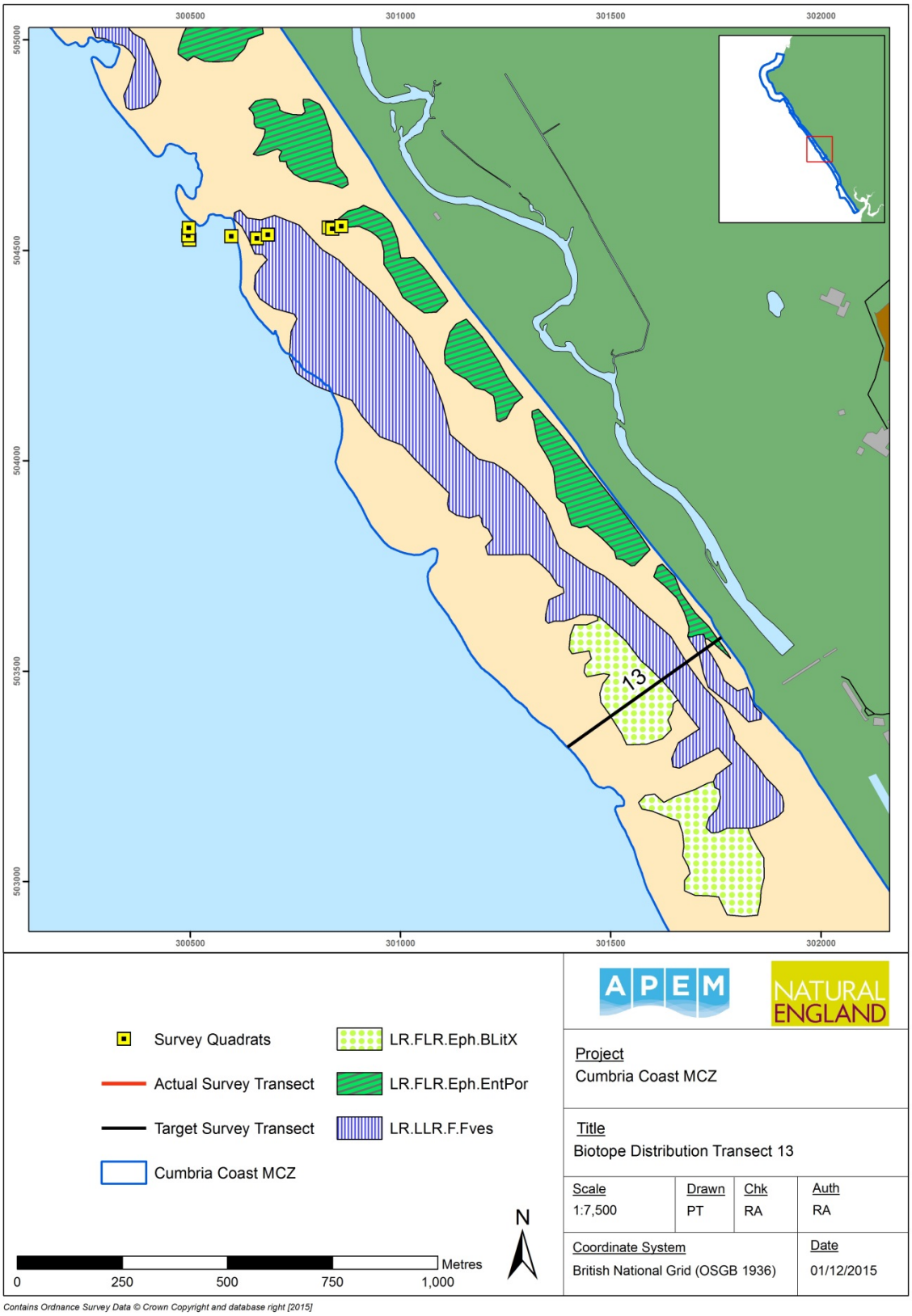

Figure 37 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 13. The target location for Transect 13 was a sandy sediment habitat and so the transect was moved approximately 1 km north to the nearest rocky habitat to the target location.

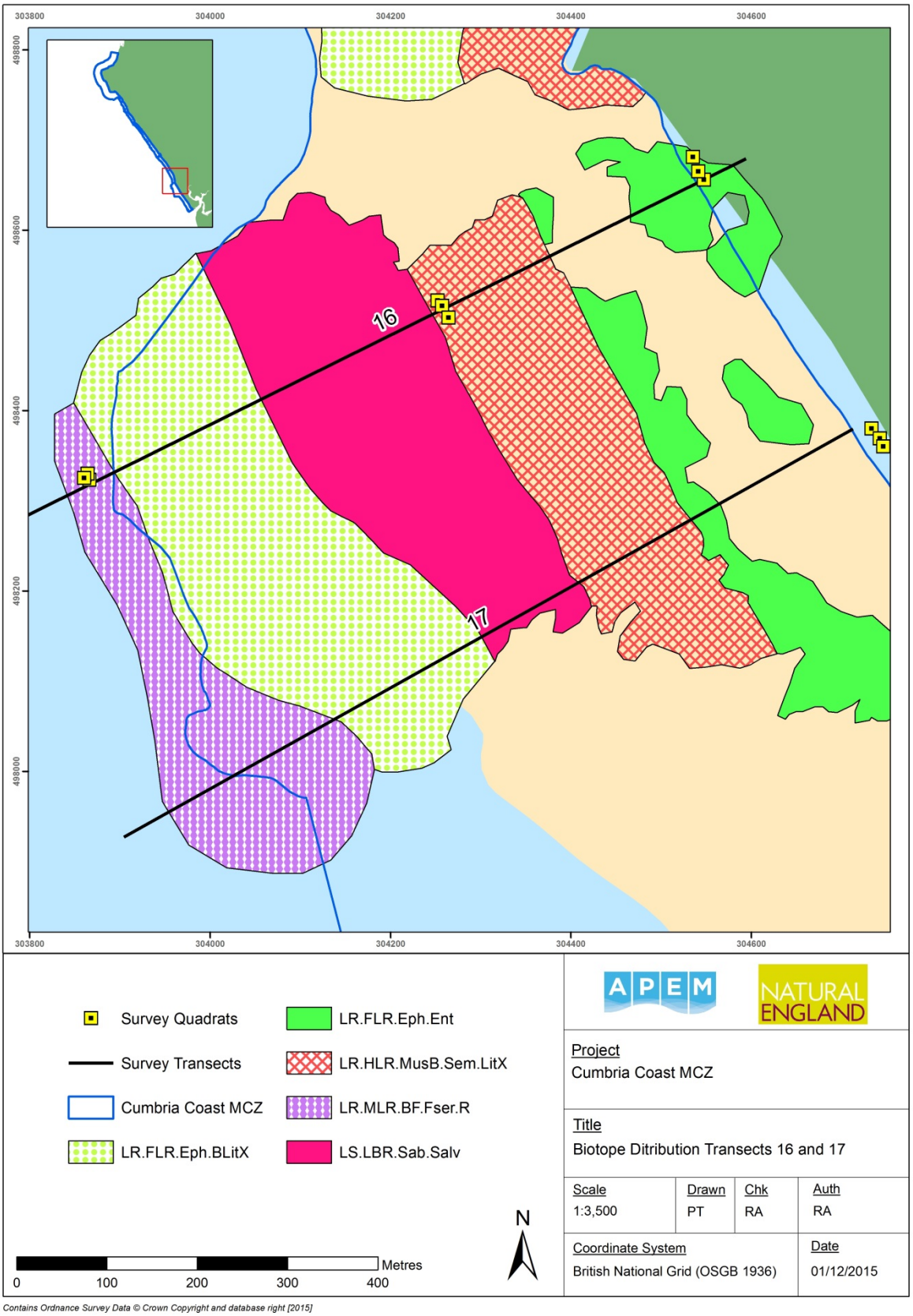

Figure 38 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 16 and 17.

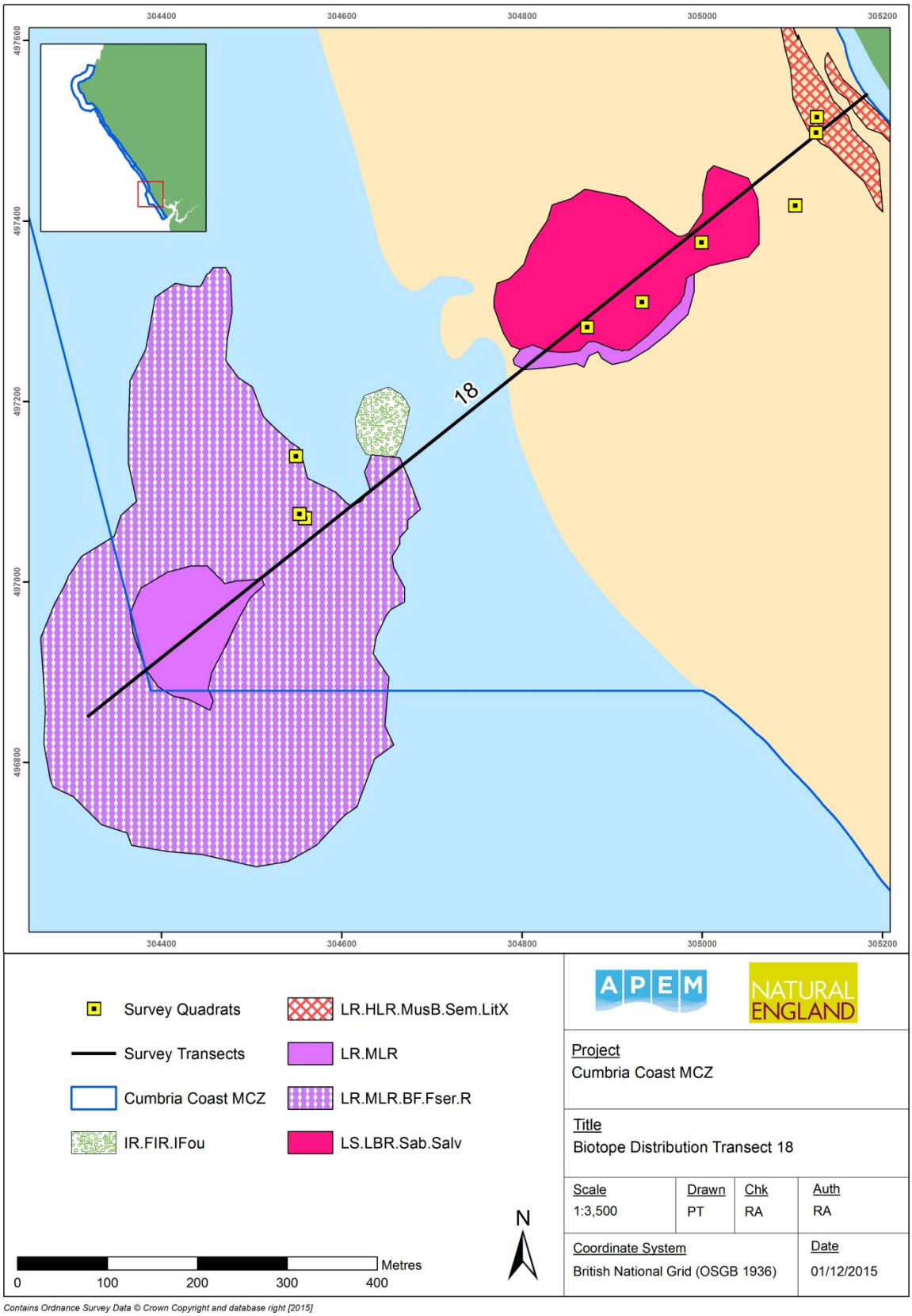

Figure 39 Cumbria Coast MCZ 2015 Intertidal rock biotope map of Transect 18.

APPENDIX 5

Data truncation for comparison of 2013 and 2015 surveys

As percentage cover data is often recorded with non-numerical terms such as <1% or <5% coverage, the data needs to be amended before it can be imported to PRIMER. These terms were amended as set out below.

From	To
<1	0.5
<5	2.5
>5	6
<10	9

All formatting needed to be removed and data had to be changed to absolute numbers so 9% became 0.09 etc.

In order to make a meaningful comparison between survey years, taxa were grouped to provide a similar level of taxonomic resolution between years. For example, recordings of *Cladophora* sp. and *Cladophora rupestris* were merged to *Cladophora* sp. Eggs and casts were also removed. Once the data were truncated the new combined dataset was imported to PRIMER for analysis.

Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk** .

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