Improvement Programme for England's Natura 2000 Sites (IPENS) – Planning for the Future IPENS031

Berwickshire Intertidal Rocky Reefs

Berwickshire and North Northumberland Coast Special Area of Conservation (SAC)

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This project is part of the IPENS programme (LIFE11NAT/UK/000384IPENS) which is financially supported by LIFE, a financial instrument of the European Community'.

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Foreword

The **Improvement Programme for England's Natura 2000 sites (IPENS)**, supported by European Union LIFE+ funding, is a new strategic approach to managing England's Natura 2000 sites. It is enabling Natural England, the Environment Agency, and other key partners to plan what, how, where and when they will target their efforts on Natura 2000 sites and areas surrounding them.

As part of the IPENS programme, we are identifying gaps in our knowledge and, where possible, addressing these through a range of evidence projects. The project findings are being used to help develop our Theme Plans and Site Improvement Plans. This report is one of the evidence project studies we commissioned.

Surveys of the intertidal rocky reef were commissioned for the Berwickshire and North Northumberland Coast Special Area of Conservation (SAC). The site was surveyed during August 2013 with the aim to survey and quantify the extent of the rooky reef intertidal feature in order to provide evidence for assessing changes within the site and to be able to monitor future changes. An assessment of anthropogenic influences, impacting on identified features, such as coastal defences, and damaging or potentially damaging activities, was undertaken and mapped where possible.

A total of 39 biotopes and 3 biotope complexes were recorded across the survey area. There were no significant differences from the baseline of biotope distribution for the area carried out in 1999.

A range of anthropogenic activities were recorded within or adjacent the SAC that posed a potential risk to the biodiversity and the health of the rocky shores, including coastal residential developments, sewage and freshwater discharge, agricultural runoff, recreational and commercial small craft mooring, anchoring, sailing and cleaning, commercial ship traffic and tourism. The presence of, and observed impacts of coastal engineering and anthropogenic activities were very few.

Issues identified within the report have been incorporated into the Northumberland Coastal Site Improvement Plan.

The key audience for this work is the staff within Natural England and land managers and it will be used to inform management requirements within the site.

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Berwickshire Intertidal Rocky Reefs

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The Marine Biological Association of the United Kingdom has prepared this report and associated products for Natural England in fulfilment of its contractual obligations under the referenced contract.

This report has been prepared with due care and diligence and with the skill reasonably expected of a reputable consultant experienced in the types of work carried out under the contract and as such the findings in this report are based on an interpretation of data which is a matter of opinion on which professionals may differ and unless clearly stated is not a recommendation of any course of action.

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Executive Summary

- This survey was carried out between 16th – 27th August 2013 to update the condition assessment of the littoral reefs in the English section of the Berwickshire and North Northumberland Coast Special Area of Conservation.
- Data was collected from existing fixed vertical transects, and to complete the Phase I survey carried out in 2009 to include Inner Farne and Brownsman.
- A wider shore area covering approximately 500m belt transect centred around the transect locations was re-surveyed to Phase I level and examined against data collected in 2009.
- There was little change in the biotopes recorded in the wider shore (Phase I) surrounding the fixed transects of the intertidal rocky reefs in comparison with previous surveys and established baselines.
- Shore height profiles for each of the eight transects were re-measured and showed little difference to the baseline established in 2002.
- There was little change in the biotopes recorded along the fixed transects (Phase II) of the intertidal rocky reefs in comparison with previous surveys and established baselines.
- Those changes observed were due to sediment influence or to different biotope classifications selected for similar assemblages by the respective surveyors.
- The difficulties associated with statistical analysis of past data as outlined by Foster-Smith *et al.* (2010) have been taken into account and quantitative sampling has been conducted in two habitats, rocky platforms and underboulder communities, in both mid and low eulittoral areas. These data have been collected in defined areas along each of the fixed transects to ensure repeatability and provide a scientifically robust baseline against which future change can be measured.
- Rocky platform random quadrat surveys were carried out at Howick, Inner Farne, Brownsman, Castlehead Rocks and Brotherston's Hole.
- Underboulder surveys were carried out at Boulmer, Newton Point and Ladies Skerrs.
- There were some differences in communities found on rocky platform reefs in both the mid and low eulittoral, as well as between-shore differences. The communities observed were typical of moderately exposed shores in the northeast of England and the highest species diversity was recorded in the low eulittoral at Howick.
- Underboulder communities differed between the mid and low eulittoral but were typical of those found across the UK.
- No nationally rare / scarce or Invasive Non-Native Species were recorded during any of the surveys carried out.
- There was a notable increase in ephemeral algae at Boulmer and Brotherston's Hole in 2013 compared to the 2002 and 2009 surveys.
- A range of anthropogenic activities were recorded throughout the BNNC SAC but unlike many other areas of England there were no artificial defences present in the survey area.
- There were no significant differences between the baseline transect of 2002 and the current survey in 2013, or from the baseline of biotope distribution for the area in 1999 (Brazier *et al.*, 1996).

1.0 Introduction

The Berwickshire and North Northumberland Coast European Marine Site (BNNC EMS) encompasses 115km of coastline from Alnmouth in Northumberland to Fast Castle Head in Berwickshire. The site extends out to 4 nautical miles and encompasses Holy Island, the Farne Islands and the St Abbs and Eyemouth Voluntary Marine Reserve in Scotland. The BNNC EMS has two European designations including the Berwickshire and North Northumberland Coast Special Area of Conservation (BNNC SAC) and the intertidal habitats of the Lindisfarne Special Protection Area.

The Berwickshire and North Northumberland Coast is one of the most varied stretches of coastline in the UK containing a diverse variety of marine habitats and associated species and communities. It is an unusually diverse area of the North Sea, in both a UK and European context. The area boasts examples of the cleanest east coast sand and seagrass beds as part of the intertidal mudflat and sandflat feature, along with moderately exposed reefs. Intertidal and subtidal sea caves contribute to the habitat diversity whilst 97% of the UK grey seal population can be found in the area (English Nature & Scottish Natural Heritage 2000).

The rocky reefs of the BNNC SAC form one of several interest features of the site and the intertidal rocky reefs and kelp forest communities are sub-features of this reef feature. In accordance with their statutory monitoring duties Natural England and Scottish Natural Heritage have a duty to monitor the condition of the reefs in order to report on the conservation status of the habitats once every six years. The conservation objective for the reef feature as outlined in the current Regulation 35 (previously Regulation 33 but updated in accordance with the amendments to the Habitats and Species Regulations in 2010) advice is '*subject to natural change, maintain in favourable condition the reefs, in particular: the extent, distribution, diversity and species richness of reef communities'*.

The conservation advice provided under Regulation 35 is currently undergoing a review and will be updated to provide improved conservation advice and clarity on all marine protected areas. At the time of writing this review was still taking place and therefore the updated conservation advice has not been referred to within this report.

The baseline of biotope distribution across the BNNC SAC was first described by Brazier *et al.*, (1996) and permanent vertical transects were established at 12 locations across the SAC in 2002. A repeat survey of the fixed transects was carried out in 2009 but was unable to be completed at all sites with inclement weather preventing access to the Farne Islands. The data collected as part of the 2002 survey were described as a useful baseline for the area but caution was advised on the applicability of the data to inform subtle changes suggesting that only gross changes in the biotopes recorded in subsequent surveys would be possible (Moore 2003). The data collected as part of the survey in 2009 did not show a change in biotope distribution from the baseline collected in 1999 or the survey carried out in 2002, nor did it show a change in species composition or abundance between 2002 and 2009. A number of recommendations were put forward in the 2009 survey to improve the methodology previously used and therefore make the data collected applicable to informing and reporting on the condition of the BNNC SAC and to inform how the site should be managed into the future (Foster-Smith *et al.*, 2010).

Additional data that have also been collected on the rocky shores within the BNNC SAC. The national MarClim project run by the Marine Biological Association of the UK (MBA) and co-funded by Natural England has been carrying out annual intertidal surveys at four sites within the BNNC SAC since 2009. These shores are close to or at the sites of the fixed transects for Boulmer, Howick, Castlehead Rocks and Inner Farne (due to access issues in 2013 this site was switched for Newton Point). MarClim uses a broadscale approach to collect data on intertidal indicator species for climate change. MarClim includes a suite of Invasive Non-Native Species (Mieszkowska 2012) and provides robust long-term data to monitor the effects of climate change across the UK. MarClim surveys are also conducted at a further 54 sites around England and 40 sites in Wales, providing data by which to place the shores of the north east into a national context.

1.1 Aims and Objectives

The aim of the work carried out as part of this survey was to determine the condition of the rocky shore features and sub-features of the English section of the Berwickshire and North Northumberland Special Area of Conservation and to determine if these features were in favourable condition.

The specific aims of the littoral rock survey were:

1. To complete the 2009 survey (Foster-Smith *et al*., 2010) where only ten of twelve transects were surveyed. Missing transects included those on Brownsman and Inner Farne, which were to be completed along with Phase I biotope maps of the surrounding areas. Additionally, a Phase I biotope map of Brotherston's Hole should also be produced.
2. To complement the 2009 survey (Foster-Smith *et al*., 2010) by updating the assessment of the littoral reef interest feature by carrying out surveys within all the existing transects. Specifically, the aim is to a set number of readily identifiable stations in the vicinity of the transects that shall be subsequently sampled quantitatively. This intertidal work will be combined with a structured search of selected more cryptic habitats (e.g., under boulder communities) to provide more robust data to enable statistical consideration now and in the future.
3. To quantify the extent of the rocky reef intertidal, and compare against baseline data.
4. To provide added value recording any rare species/assemblages and highlighting any potential changes which may be linked to climate change or other impacts, including Invasive Non-Native Species (INNS).

More specifically the following objectives were:

1. Update the assessment of the reef interest feature by finishing the previous transect surveys at Brownsman and Inner Farne and three Phase 1 biotope maps (as indicated as omissions in the report by Foster-Smith *et al*., 2010), and report the data against the background of existing information.
2. To carry out quantitative surveys at a number of agreed locations to provide information on species composition of different biotopes and how this differs across the study area (in four of the eight transects on the shores in the English region of the

BNNC SAC). Stratified sampling should be conducted according to methods outlined in CSM Guidance and the Marine Monitoring Handbook, but see section 4.3.

3. To quantify the extent of the rocky reef intertidal in the BNNC EMS and compare against baseline data (Foster-smith, 1998).
    a. A secondary objective of the work is to identify sub-feature and representative notable biotopes within the SAC.
    b. Additionally, an assessment of anthropogenic influences, impacting on identified features would be useful. These should be mapped where possible and should include: Coastal defences along the study area, and damaging or potentially damaging activities.

Surveys to meet these objectives will be designed and conducted in order to:

1. Provide an assessment of the direction of ecological change by the integration of previously obtained relevant data.
2. Provide an ecological baseline for attribute condition (from which to assess future change) where this baseline is not identified in the supplementary information (data sheets) and reports provided by Natural England.
3. Develop a survey design giving statistically robust enough results to enable the collection of compatible future data permitting quantitative long term trend analysis.
4. Allow anthropogenic influences, impacting on the ability of the sub-feature to achieve Favourable Condition, to be identified and where possible quantified.
5. Where possible, ensure that newly collected data is compatible (analytically) with historical survey data, but at the very least will make reference to and utilise such historical data.

2.0 Methods

2.1 Extent of Rocky Habitat

The extent and spatial distribution of littoral rock habitats, including boulders and cobbles, was quantitatively determined using scaled aerial photographic images as recommended in the CSMG and Marine Monitoring Handbook (MMH). This included quantitative mapping of any artificial habitat in the area. The spatial extent of littoral rock habitat, along with the co-ordinates of the horizontal start and endpoints of the section of habitat and a general description of habitat type (e.g. vertical cliff, boulder field etc.) was measured and recorded. Ground-truthing was carried out at each site during the field surveys.

An assessment of anthropogenic influences impacting on identified features was carried out. Areas of potential impact were documented and mapped where possible and included coastal defences along the study area and damaging or potentially damaging activities.

The data from this desk-based exercise has been digitally archived and made available to in both digital map and database formats (see Section 3.1 and Electronic Appendix).

2.2 Transect Survey and Distance/Height Profile

Transect surveys were carried out at each of eight shores (Table 1). The surveys were conducted during low water spring tides between 15-26th August 2013.

Table 1: Survey sites within the English section of the Berwickshire and North Northumberland Coast Special Area of Conservation

	Name of Site	Transect Survey		Phase 1 Survey	Rocky Platform Survey	Boulder Turning Survey
		Top of Transect	Bottom of Transect			
1	North of Boulmer	55.424810 -1.580318	55.424309 -1.575726			
2	South of Rumbling Kern, Howick	55.446783 -1.586582	55.447022 -1.585615			
3	Newton Point, Newton-by-the-Sea	55.522435 -1.609421	55.521931 -1.609062			
4	North of St. Cuthbert's Chapel, Inner Farne	55.618178 -1.655674	55.618230 -1.655150			
5	NW point, Brownsman, Farne Islands	55.635025 -1.627745	55.635268 -1.627965			
6	Castle Head Rocks, Holy Island	55.688794 -1.792402	55.688405 -1.790480			
7	Ladies Skerrs, Berwick-upon-Tweed	55.774148 -1.991574	55.773680 -1.990219			
8	South of Brotherston's Hole, Berwick-upon-Tweed (using Foster-Smith Transect)	55.785056 -1.999767	55.785316 -1.998316			

The position of the upper permanent markerbolt for each transect was re-located and replaced to ensure easy re-location in future years. The methods followed that of Foster-Smith *et al.* 2010 enabling direct data comparisons between the two surveys, as well as historical data. Access to, and locations of each of the transects can be found in Appendix A.

Specifically;

1. A transect tape was laid in a straight line between the upper and lower fixed transect marker points located in the supralittoral and lower eulittoral respectively.
2. A distance/height profile of biotopes encountered along the transect was surveyed by measuring the distance along the transect tape for the upper and lower vertical

boundaries of each successive biotope encountered along the vertical transect, starting at the upper eulittoral endpoint markerbolt and working down the shore. The height of each boundary was recorded using a theodolite and survey pole. The profile was measured from the position of low water at the time of the survey and converted to chart datum using local tide tables.

3. Based on visual inspection along a belt spanning 1.5m either side of the transect tape the horizontal boundaries of the biotopes was recorded and mapped.
4. The species composition of each biotope was recorded, including those occurring in pools, crevices and the underside of boulders.
5. The abundance of all algae and sessile animals was recorded using an estimate of percentage cover within the 3m band of the biotope. A total of more than 100 % cover was recorded in the event of overlapping species. Mobile species were recorded using the SACFOR scale and the percentage cover of bare rock within each biotope was also recorded. The SACFOR scale was used to record the abundance of sessile species on the underside of boulders within each biotope.

2.3 Phase 1 Biotope Surveys

The range and distribution of biotopes was determined by Phase I biotope surveys at eight sites within the English section of the Berwickshire and North Northumberland SAC for the purpose of this survey (Table 1).

Within each shore the entire accessible rocky intertidal habitat from the Mean High Water Springs height to Mean Low Water Springs height was mapped to Phase I standard in a 500m corridor. This corridor was centred around the fixed transect and mapped according to standard CSM guidance in the Marine Monitoring Handbook, following standard methodology detailed in Bunker et al. 2002 and Wyn et al. 2000. Biotopes were classified using the standard JNCC Marine Habitat Classification for Britain and Ireland, Version 04.05 Littoral Rock Section (Connor 2004).

All biotopes were digitally photographed using a camera with GPS image tagging enabled and labelled according to biotope classification and will be supplied in the Electronic Appendix. Images of the transect including detailed shots of the markerbolts and the wider shore were also taken to provide contextual data. Photographs of rare, notable and invasive species were taken. Photographs of any visible human impacts were also taken and the location and biotope(s) in which they occurred recorded.

Digital GIS maps following the MESH ROGs were produced from the polygon maps created during the field surveys and the biotope classification data and will be supplied in the Electronic Appendix. The location of the horizontal and vertical boundaries of each section in the low, mid and high shore, along with the locations of each biotope mapped, were recorded using GPS set to WGS84 standard (as OSGB36 cannot be mapped using the standard MESH GIS biotope software).

2.4 Rocky Platform Quantitative Survey

Rocky platform quadrat surveys were carried out on five shores within the vicinity of the permanent transect locations (Table 1). The shores were chosen based on the exposure of the shore and the presence of suitable rocky platform habitat.

At each survey location, rocky platform surveys were carried out at two shore heights; low shore and mid shore (biologically defined from keystone species present). At each shore height one belt transect 5m in width (vertical) by 10m in length (horizontal) was marked along the fixed transect in order that the area where the quantitative quadrats were carried out could be re-located. The mid and low shore belt transects were separated by approximately 20m.

Within each belt transect, thirty 50 x 50 cm quadrats (totalling 60 quadrats per shore and facilitating between-shore height comparisons) were randomly selected and surveyed. The percentage cover of sessile animals and all seaweeds was recorded to species level or the highest taxonomic level possible in the field. Large (>5 mm length) mobile macroinvertebrates within the quadrats were identified and counted.

Any invasive species present including those flagged as high impact species under the Water Framework Directive were quantitatively recorded using this methodology.

2.5 Boulder Turning Quantitative Survey

Boulder surveys were carried based on standard methods detailed in Chapman (2002) at three shores based on the exposure of the shore and the presence of suitable boulder fields (Table 1). Boulder surveys were conducted on shores with exposed conditions in both the mid and lower eulittoral.

At each survey location, boulder surveys were carried out at two shore heights; low shore and mid shore (biologically defined from keystone species present). At each shore height one belt transect 5m in width (vertical) by 10m in length (horizontal), separated by approximately 20m was selected and marked at vertical heights along the fixed transects.

Within each belt transect, twenty-five (as per Chapman 2002) boulders were randomly selected and surveyed, totalling 50 boulders per shore and facilitating between shore height comparisons. Each boulder was lifted or overturned depending on size and the following parameters recorded:

1. Abundance of mobile fauna on the underside of the boulder and underlying substratum was recorded to species level or the highest taxonomic level possible in the field.
2. The percentage cover of sessile fauna on the underside of the boulder was recorded to species level or the highest taxonomic level possible in the field using 25 point intersections within a 10cm by 10cm quadrat.

3. Large (>5 mm length) mobile macroinvertebrates on the underside of the boulder and substratum below the boulder were identified and counted. Infauna buried in sediment under the boulders was not included.
4. The length and width of the underside surface of each boulder was measured to calculate the area as an ellipse (Figure 1).

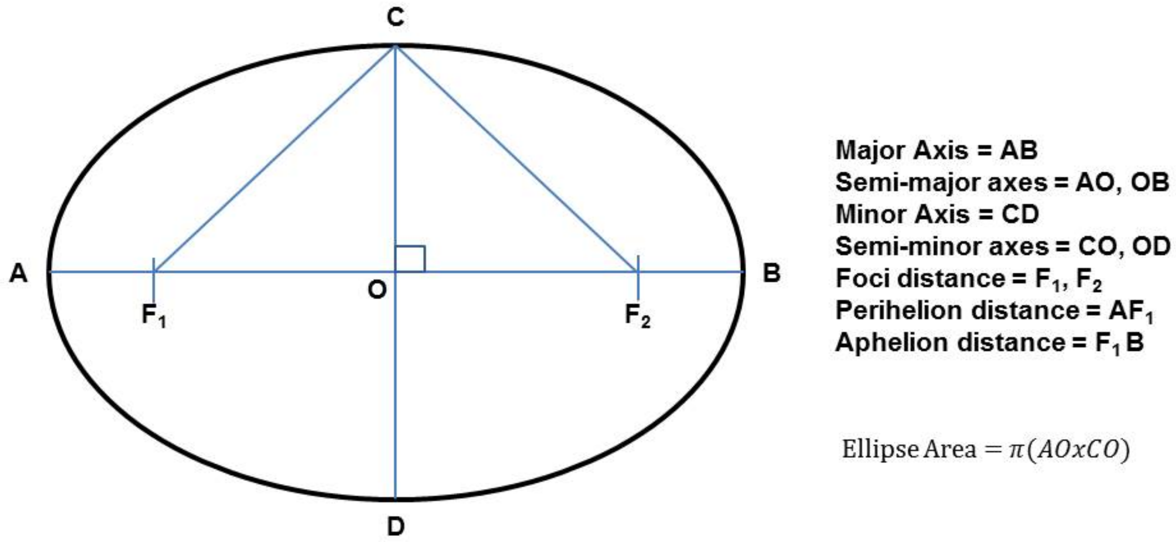


Figure 1: Properties and equation for calculating the area of an ellipse

2.6 Data Analysis

The methodology employed for the rocky platform and boulder transects allows repeat surveys to be carried out in the same area. The survey design facilitates the statistical analysis of complex temporal and spatial patterns at different spatial scales and allows interactions to be quantified. Species-area curves were carried out to provide an assessment of the power of the sampling design.

Data were analysed using univariate Analysis of Variance (ANOVA) examining patterns of species richness at different shore heights and across different shore for both the rocky platform quadrats and the under boulder communities using SPSS. The compositions of communities in both of these habitats was analysed using the multivariate techniques Analysis of Similarity (ANOSIM) and Similarity of Percentages (SIMPER) to discover if there were any dissimilarities between the communities and if so which species were contributing to these dissimilarities. Multi-Dimensional Scaling Ordination (MDS) was used to visually display any dissimilarities between the communities. All multivariate analyses were completed using PRIMER (V5) software.

Temporal patterns of abundance of keystone species will also be able to be analysed once a time-series is established using ANOVA with Height as a fixed factor, Sites nested with Height as a random factor, replicate periods as a random factor and times as a random factor.

3.0 Results

3.1 Extent of Littoral Rock Habitat & Anthropogenic Impacts

Classification of littoral rock and artificial structures present in the intertidal was undertaken using ERDAS Imagine 9.3 and ArcGIS 10.0 software. These area calculations report (Table 2), for the first time, the extent of littoral rock throughout the English section of the BNNC EMS along with the extent of artificial rock (Figure 2). These calculations cannot be compared to the work of Foster-Smith (1998) due to extent calculations broken down by biotope type (for the entire SAC) and life form type specifically for the area between Seahouses and Dunstaburgh Castle. Biotopes were not recorded across 100% coverage within the SAC as part of this contract but for specific sites (Figure 2).

Table 2: Extent of littoral rock and artificial substrate in the English section of the Berwickshire and North Northumberland Special Area of Conservation

	Area (m^2)	Area (km^2)
Total littoral rock	7152467.0100	7.1525
Total artificial rock	27246.2855	0.0272
Artificial rock on littoral rock	5596.9518	0.0056
Artificial rock adjacent to littoral rock	15896.4970	0.0159

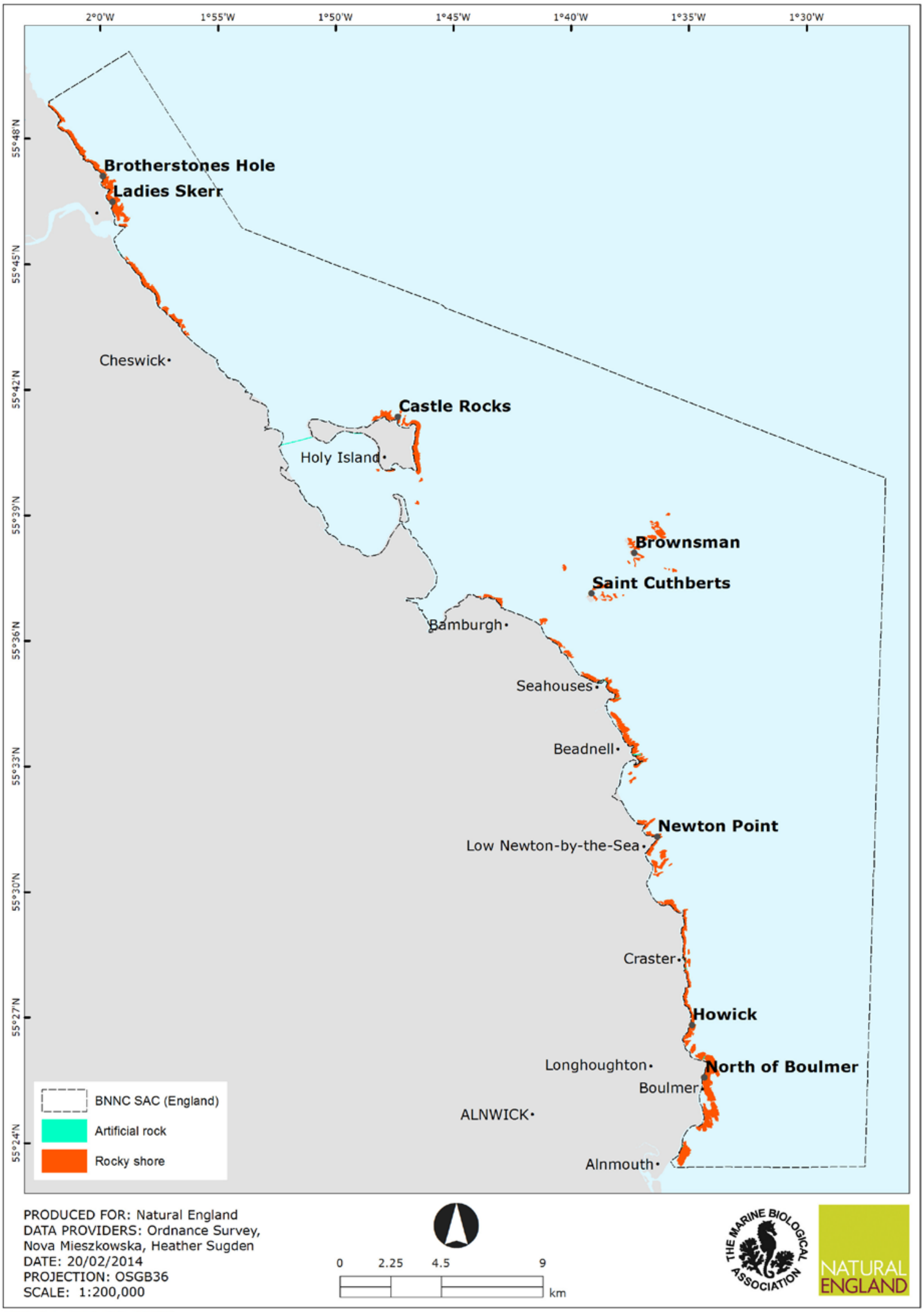


Figure 2: Extent of littoral rock and artificial rock in the English section of the Berwickshire and North Northumberland Special Area of Conservation

A number of anthropogenic activities were recorded throughout the English section of the Berwickshire and North Northumberland SAC (Table 3). Tourism and recreational use of the shores was apparent in many areas with family's rockpooling and boulder turning, people walking on the shore and SCUBA divers around the Farne Islands. Coastal residential developments are common along this part of the coastline along with sewage and freshwater discharge and agricultural runoff from surrounding farmland. Recreational and commercial small craft mooring, anchoring, sailing and cleaning and commercial ship traffic are all facilitated by the harbours at Berwick and Seahouses and the mooring areas at Craster and Boulmer.

Table 3: Summary of observed anthropogenic activity (highlighted in red) in the Berwickshire and North Northumberland Special Area of Conservation

	Anthropogenic Activities					
Site	Angling	Pleasure Boats	Fishing Boats	SCUBA Diving	Ferry / Diving Boat	Tourists
Boulmer		■	■			■
Howick	■		■			
Newton Point		■	■			■
Inner Farne			■	■	■	■
Brownsman						
Castlehead Rocks		■				■
Ladies Skerrs						■
Brotherston's Hole						■

3.2 Boulmer

3.2.1 Site Description

Figure 3: Boulmer in the Berwickshire and North Northumberland Coast Special Area of Conservation

The shore at Boulmer (Figure 3) was accessed by an unmarked path down the low bedrock cliff approximately 20m north of the start of the transect (Figure 4a), with parking directly opposite the farm house (Appendix A). The shore at Boulmer was moderately sheltered and faced southeast. The intertidal habitat was formed from a succession of sandstones, shale, thin coal and limestones from the Upper Carboniferous period with prominent dykes of quartz dolerite (Whin Sill) protruding from the shore (Barne et al 1995). The survey site comprised a large expanse of algal dominated rock ridges across the mid and lower eulittoral area, backed in the upper eulittoral by partially vegetated low bedrock cliffs (Figure 3). A small area of muddy sand separated the upper eulittoral zone from the mid eulittoral ridges.

The marker bolt at the top of the transect was replaced and sited on the top of the bedrock for ease of relocation (Figure 4b).

Figure 4: a) Access onto the shore down the low vegetated cliffs and b) New marker bolt on the top of the bedrock alongside the old screw marker at Boulmer in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.2.2 Fixed Transect Survey

The transect line at Boulmer stretched for 300m beginning in the bedrock cliffs at the top of the shore (Figure 5 & 6), a summary of the transect is shown in Table 4.

The supralittoral rocks hosted lichen communities including **A**bundant[1] *Verrucaria maura*, **R**are *Caloplaca marina* and *Xanthoria parietina* with **C**ommon *Ulva intestinalis* (B1)[2] for the first 20m down the transect from the upper endpoint. *V. maura* became **S**uperabundant in the upper eulittoral along with **S**uperabundant *Fucus spiralis* (B2) between 20-25.3m.

The mid eulittoral was colonised by **A**bundant *Fucus vesiculosus* and **A**bundant *Ascophyllum nodosum* across 9.8m of bedrock ridges (B3) and species diversity in this area was low, probably due to smothering by the surrounding mud and sand. This area of mid eulittoral rock was separated from the main body of the shore by a large area (14.7m in length along the transect) of mud with boulders (B4), supporting **A**bundant *F. vesiculosus* and *A. nodosum*. A 2.5m length biotope classified the same as B3 was then followed by 23m of mud and shale with **S**uperabundant *U. intestinalis* and **F**requent *F. vesiculosus* (B5).

The midshore bedrock ridges were dominated by **S**uperabundant *F. vesiculosus* and **A**bundant *Fucus serratus* with **A**bundant *Ceramium spp* (B6) for 23.3m. As the height of the ridges alternated (Figure 4) the proportions of species characterising the biotopes began to

[1] Abundance categories are deliberately capitalized with the first letter in bold to highlight these as SACFOR abundance categories and not a descriptor of species abundance
[2] Biotope numbers as encountered vertically along the transect from high to lowshore are annotated with the letter B and the number of the biotope.

change. Whilst *F. vesiculosus* remained **S**uperabundant, *A. nodosum* and *F. serratus* were recorded as **C**ommon (B7). A further 15.75m down the transect line a stretch of **S**uperabundant *F. vesiculosus* ledges with underlying **A**bundant *Rhodothamniella floridula* was recorded for a distance of 26.13m (B8). At the base of the mid eulittoral ridges large rockpools began to appear and were dominated by **C**ommon *Halidrys siliquosa* and **A**bundant *Ceramium spp* (B9). This biotope extended for 26.13m downshore.

As ledges stepped up in vertical height from these pools, **S**uperabundant *A. nodosum* dominated the ridges within a biotope containing **C**ommon *F. vesiculosus* and *F. serratus* for 41.02m (B7a). This ledge led straight into a large pool with **A**bundant *Ectocarpus spp* (B10).

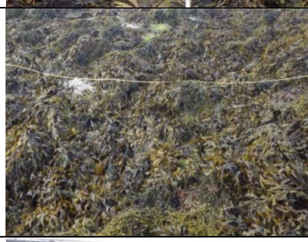
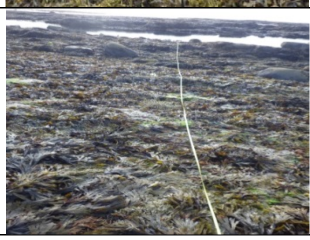
A sandy gully dominated by **S**uperabundant *F. serratus* (B11) separated the mid eulittoral ledges from the low eulittoral ledges across a distance of 12.5m along the transect. In the lower eulittoral area a second band of B8 (26m), followed by B7a (36.2m), were present before a large rockpool containing **C**ommon *Laminaria digitata*, **A**bundant *H. siliquosa* and **S**uperabundant *F. serratus* abutted the base of the next ridge (B12).

The final set of ledges in the low eulittoral began with a third band of 7a (1.9m), followed by a slope with an 11.2m biotope containing **S**uperabundant *F. serratus* (B13) before leading into biotope 7b (25.8m in length down the tranect) which was dominated by *F. serratus* but with **C**ommon *A. nodosum* and *F. vesiculosus*. The transect line finished 300m from the upper endpoint of the transect in biotope B13. The kelps then dominated the lower eulittoral / infralittoral fringe with **S**uperabundant *L. digitata* and **C**ommon *Laminaria hyperborea*. Species diversity increased with distance down the shore.

Table 4: Biotope descriptions along the fixed transect survey at Boulmer in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1	LR.FLR.Lic.YG Bedrock, sand, cobbles and slabs	0 - 20.0	
B2	LR.FLR.Lic.Ver.B *Fucus spiralis* bedrock	20.0 - 25.3	
B3	LR.LLR.FVS.AscVS *Fucus vesiculosus* and *Ascophyllum nodosum* bedrock	25.3 - 35.1	

B4	LR.LLR.F.Asc.FS Large boulders on mud	35.1 - 49.8	
B3	LR.LLR.FVS.AscVS *Fucus vesiculosus* and *Ascophyllum nodosum* bedrock	49.8 - 52.3	
B5	LR.LLR.FVS.AscVS Mud - Shale underneath	52.3 - 75.3	
B6	LR.LLR.FVS.AscVS *Fucus vesiculosus* & patchy *Fucus serratus* on bedrock	75.3 - 98.6	
B7	LR.LLR.FVS.AscVS *Fucus vesicuosus, Ascophyllum nodosum* and *Fucus serratus* on bedrock	98.6 - 114.35	
B8, B9 (complex)	LR.LLR.F.Fves.FS *Fucus vesiculosus* bedrock LR.FLR.Rkp.Cor *Halidrys siliquosa* pools	114.35 - 140.8	
B7a, B9 (complex)	LR.LLR.F.Asc.FS *Ascophyllum nodosum, Fucus vesicuosus* and *Fucus serratus* on bedrock LR.FLR.Rkp.Cor *Halidrys siliquosa* pools	140.8 - 181.5	
B10	LR.FLR.Rkp.Cor Pools	181.5 - 181.5	

B11	LR.FLR.Rkp.Cor Sandy Gully	181.5 - 193.0	
B8	LR.LLR.F.Fves.FS *Fucus vesiculosus* bedrock	193.0 - 219.0	
B7a	LR.LLR.F.Fves.FS *Ascophyllum nodosum, Fucus vesicuosus* and *Fucus serratus* on bedrock	219.0 - 255.2	
B12	LR.LLR.F.Fves.FS *Laminaria digitata, Fucus serratus* and *Halidrys siliquosa* pool	255.2 - 255.2	
B7a	LR.LLR.F.Fves.FS *Ascophyllum nodosum, Fucus vesicuosus* and *Fucus serratus* on bedrock	255.2 - 257.1	
B13	LR.LLR.F.Fserr.FS *Fucus serratus* slopes	257.1 - 268.3	
B7b	LR.LLR.F.Fserr.FS *Fucus serratus, Ascophyllum nodosum* and *Fucus vesicuosus* on bedrock	268.3 - 294.1	

B13	LR.LLR.F.Fserr.FS *Fucus serratus* slopes	294.1 - 300.0	

The biotopes recorded along the fixed transect at Boulmer had changed in terms of classification and vertical extent for some component biotopes between the initial survey in 2002 and subsequent surveys in 2009 and 2013.

In the Foster-Smith 2009 report an analysis of change in species abundance was conducted to examine the changes in the abundance of cover species between the 2002 survey and the 2009 survey. This analysis has not been repeated using the data from this survey for several reasons.

Firstly, the analysis carried out in 2009 was based on "*dividing the fixed transects into upper, mid and low shore sections based on shore height, distance along transect and biotope, and marking these divisions with a feature common to both profiles*". The division of the shore zones in this way did not match the actual division of upper, mid and low shore areas as defined by the species living there. For example at Boulmer the mid shore area began at 25.3m along the length of the transect but has been placed at 111m for the purpose of the analysis.

Secondly, the analysis amalgamated cover species across different biotopes and calculated an average for each species losing the variation inherent in species abundances. Each percentage cover of a given species was multiplied by the linear extent of the biotope it was found within but the area that the record was taken from is not defined. For example, the percentage cover of a species within a 5m long biotope was recorded across the extent of this biotope and then multiplied by this linear extent. This also does not take into account the width of the area that the biotope was recorded in.

Upon closer examination for the data from 2009, it is stated that the abundance of all cover species were recorded using percentage cover, but in fact some of them have been recorded using the SACFOR scale for abundance with no underlying percentage cover detailed. It is therefore impossible to replicate the method using two inherently different types of data.

The method is not statistically valid and does not produce an accurate assessment of the mean abundance of each species surveyed within each shore height. The derivation of a final arbitrary score of abundance does not compare with the standard SACFOR scale used, is meaningless given the series or errors and incorrect assumptions and applications of the data and therefore should not be used as an accurate assessment of SACFOR abundance for species within a shore height, nor repeated in future analyses.

Lichens were present in the supralittoral section of the transect in all three survey years, although the vertical extent differed from 10m (2002) to 4m (2009) to 20m (2013) (Figure 5). The second biotope encountered down the transect was LR.FLR.Lic.Ver.B in 2013. This biotope contained yellow and black lichens and had not been recorded in either the 2009 survey (which instead found bare rock), nor the 2002 survey, where *Fucus spiralis* was the dominant species between 11.6-21.2m. *F. spiralis* was recorded as a 4m vertical band in 2009 but only between 21-25m. The area between 25.3-35.1m was classified as LR.LLR.FVS.AscVS due to the dominance of *Ascophyllum nodosum* in 2013. Between approximately 51m-115m the biotope composition was different in all three survey years, however, all biotopes recorded were indicative of disturbed and sediment influenced habitat dominated by ephemeral algae (2013), mud and sand (2009) or polychaete/bivalve-dominated mid estuarine mud (2002). In 2013 the mid section of this area from 75.3-98.6m contained *F. vesiculosus* and from 98.6m to 114.35m *A. nodosum*, indicating that at least in this region the flora were representative of species from rock, not sediment dominated habitat. This record is very different from the disturbed sediment influenced biotopes reported in the previous two surveys. The remainder of the transect showed less variation between survey years, with vertical bands of *F. vesiculosus* and *A. nodosum* interspersed with gulleys containing muddy sand in 2002 and 2009 that had changed to coralline algae biotopes in 2013. Again this is likely due to the suspended and deposited sediment on this shore. Comparisons between surveys highlight that despite the same or similar dominant species being present, different biotope classifications were given, highlighting the importance of phase II species lists and abundances to ascertain that in reality, little had changed between the survey years.

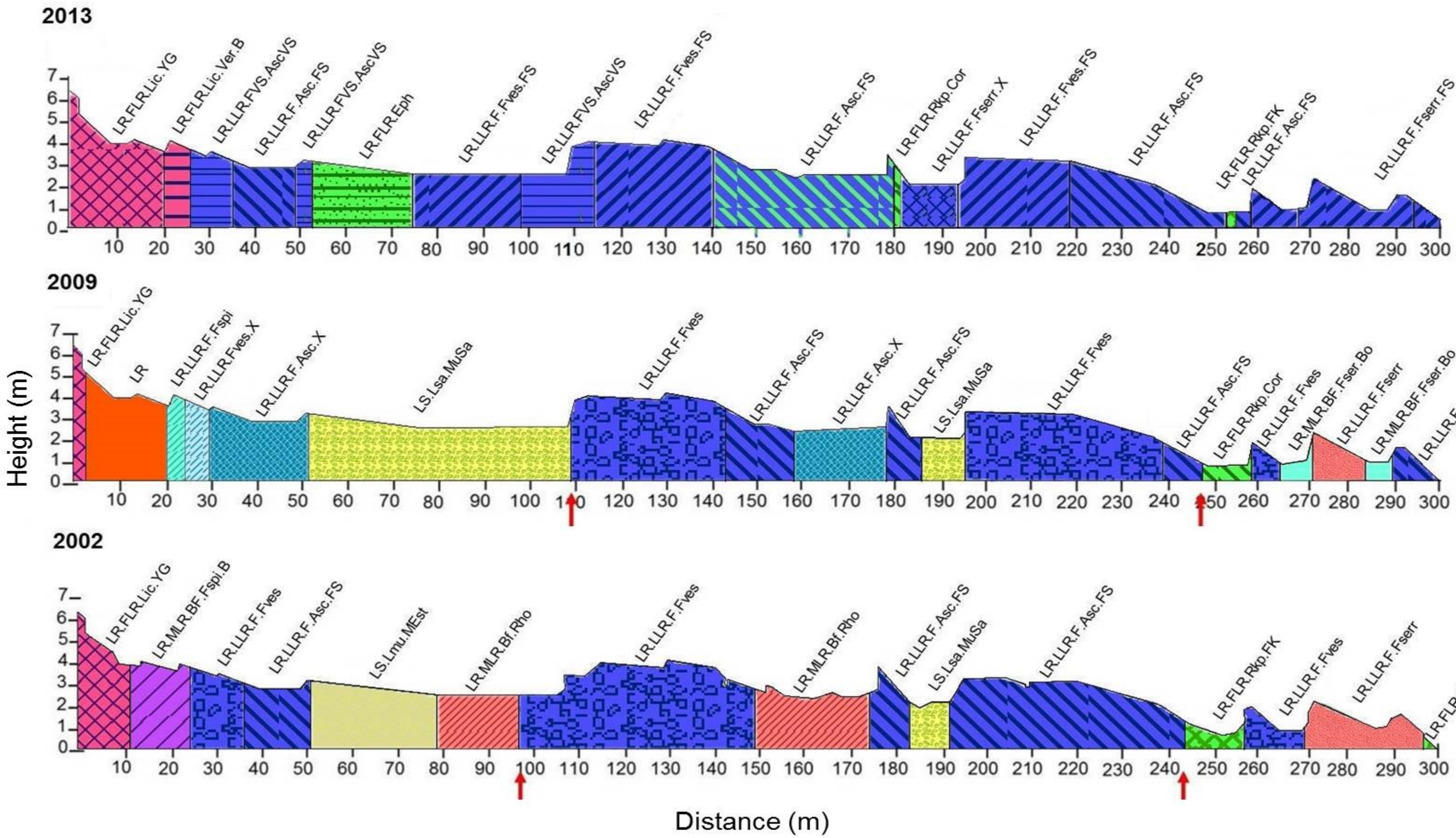


Figure 5: a) Shore height profile for the fixed transect survey at Boulmer with biotope boundaries marked, b) 2009 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation, for 2009 and 2002 the transects have been divided into an upper, mid and lower shore at boundaries between biotopes at approximately the same position on the shore (marked by the red arrows).

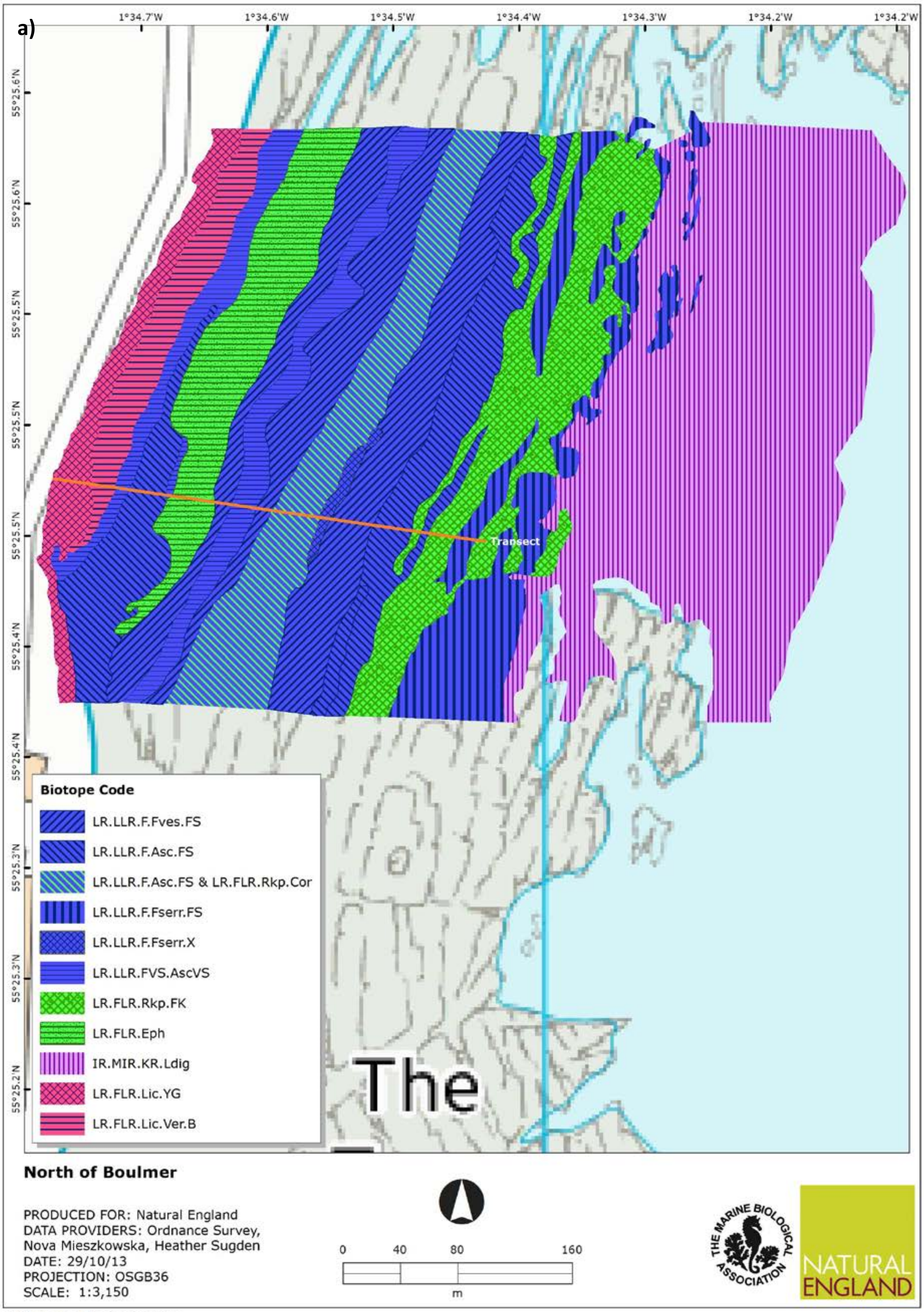
3.2.3 Phase I Survey

The Phase I surveys of Boulmer in 2009 and 2013 show a very different suite of biotopes and associated vertical zonation from the supralittoral to shallow infralittoral zones, with only three biotopes occurring in the same location in both years. A total of 14 biotopes were reported in 2009 whereas only 11 biotopes were recorded (Table 5) but despite this very few of the dominant species describing the biotopes were different. In 2009 no lichens were recorded and the upper to mid eulittoral contained a succession of fucoid biotopes dominated by *F. spiralis*, *F. vesiculosus* and *A. nodosum* in vertical succession before a 50m band of mud and then *F. serratus*, typical of low eulittoral habitats in a gully. Downshore of this, *S. balanoides*, *F. vesiculosus* and reds were followed by *R. floridula*, then a coralline pool, before an unknown biotope (that has no listing on the map key in the 2009 report), before a low eulittoral zone of *F. serratus*.

In 2013 supralittoral yellow and grey lichens gave way to black lichens before *A. nodosum* dominated the upper to mid eulittoral zone. The muddy patch had converted to *A. nodosum* and ephemeral algae. The gully contained *A. nodosum* and coralline pool species. The lower eulittoral did not contain the *S. balanoides/F.vesiculosus* or *R. floridula* biotopes, instead being colonized by *F. serratus, F. vesiculosus* and *A. nodosum,* leading into coralline pools and then *F. serratus* (Figure 6).

Table 5: Phase I biotopes recorded in 2009 and 2013 at Boulmer in the Berwickshire and North Northumberland Special Area of Conservation with the dominant species in each biotope

Biotope Code	2009	2013	Dominant Species
LR.MLR.BF.Rho	■		*Rhodothamniella floridula*
LR.LLR.F.Asc	■		*Ascophyllum nodosum*
LR.LLR.F.Asc/ LR.LLR.F.Fves/LR.LLR.F.Fserr	■		*Ascophyllum nodosum / Fucus vesiculosus / Fucus serratus*
LR.LLR.F.Fserr	■		*Fucus serratus*
LR.LLR.F.Fserr.FS	■	■	*Fucus serratus*
LR.LLR.F.Serr/ LR.LLR.F.Fves	■		*Fucus serratus / Fucus vesiculosus*
LR.LLR.F.Fspi	■		*Fucus spiralis*
LR.LLR.F.Fves	■		*Fucus vesiculosus*
LR.FLR.Lic.Ver.B	■	■	*Verrucaria maura*
LR	■		
LS.LSa.MuSa	■		
LR.HLR.MusB.Sem.FvesR	■		*Semibalanus balanoides & Fucus vesiculosus*
LR.HLR.MusB.Sem.Sem	■		*Semibalanus balanoides & Patella vulgata*
LR.FLR.Rkp.Cor	■	■	*Coralline algae*
LR.LLR.F.Fves.FS		■	*Fucus vesiculosus*
LR.LLR.F.Asc.FS		■	*Ascophyllum nodosum*
LR.LLR.F.Asc.FS & LR.FLR.Rkp.Cor		■	*Ascophyllum nodosum & Coralline algae*
LR.LLR.F.Fserr.X		■	*Fucus serratus*
LR.LLR.FVS.AscVS		■	*Ascophyllum nodosum*
LR.FLR.Rkp.FK		■	*Fucus serratus & Laminaria digitata*
LR.FLR.Eph		■	*Ulva intestinalis*
LR.FLR.Lic.YG		■	*Xanthoria parietina & Caloplaca marina*
IR.MIR.KR.Ldig		■	*Laminaria digitata*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55°25.2'N
Transect
The
Biotope Code
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LR.LLR.F.Asc.FS
LR.LLR.F.Asc.FS & LR.FLR.Rkp.Cor
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LR.LLR.F.Fserr.X
LR.LLR.FVS.AscVS
LR.FLR.Rkp.FK
LR.FLR.Eph
IR.MIR.KR.Ldig
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THE MARINE BIOLOGICAL ASSOCIATION
NATURAL ENGLAND

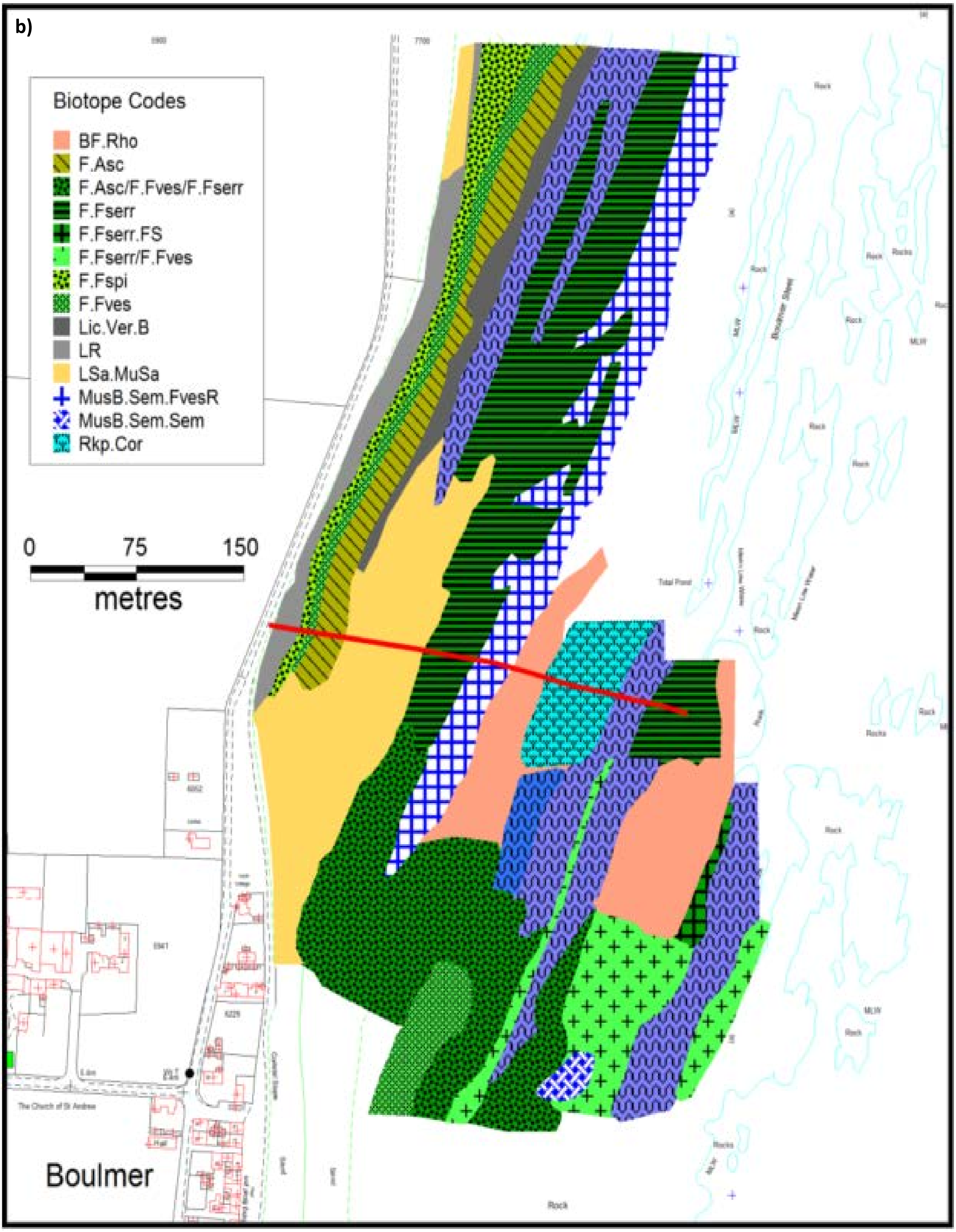


Figure 6: Phase 1 biotope map at Boulmer in a) 2013 and b) 2009 with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.3 Howick

3.3.1 Site Description

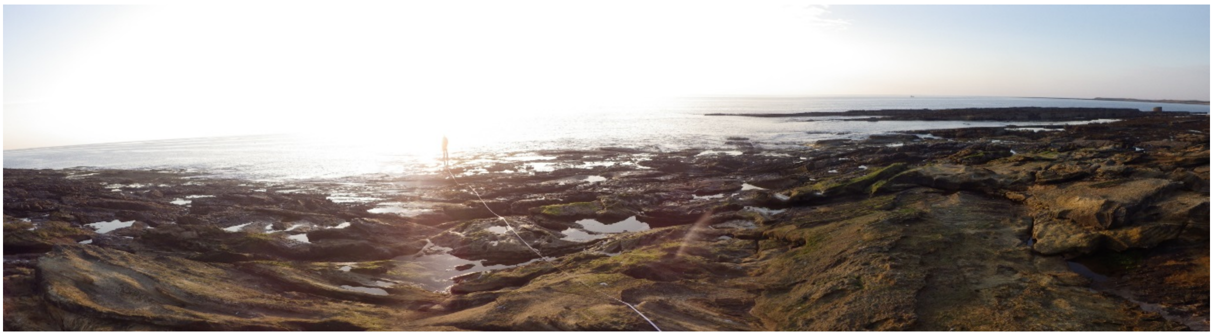


Figure 7: Howick in the Berwickshire and North Northumberland Coast Special Area of Conservation

The shore at Howick was located approximately 500m south of Rumbling Kern facing a southeasterly direction (Figure 7). It was accessed along the coastal path to the south of the beach car park (Appendix A). The rock type was predominately sandstone from the Upper Carboniferous with predominantly flat, moderately exposed, gradually sloping reef dominated by limpets and barnacles with a variety of microhabitats including cracks, crevices, pools, overhangs and ledges (Figure 8a). The shore was backed by low bedrock cliffs immediately behind with an area of sandy beach to the south. The transect marker bolt was replaced and located on the top side of the highest vertical section of open rock for ease of relocation (Figure 8b).

Figure 8: a) Location placer shot behind the transect marker and b) New marker bolt on the top of the bedrock at Howick in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.3.2 Fixed Transect Survey

The transect line at Howick stretched for 66m with the upper endpoint located at the highest elevation point of supralittoral rock. The endpoint was not located at the most landward extent of the shore, as there was an area of lower elevation rock habitat approximately 20m in length stretching from the cliff to the start of the raised rock reef area that was at infralittoral height (Figure 9 & 10) and a summary of the transect is shown in Table 6.

The supralittoral hosted yellow and grey lichens with *V. maura* **A**bundant, **C**ommon *Xanthoria parietina*, **F**requent *Prasiola stipitata* and **O**ccasional *Caloplaca marina* between the upper transect endpoint at 0m and 4.6m (B1). Immediately below this lichen biotope along the seaward trajectory of the transect was a 6.9m length biotope dominated by **S**uperabundant *P. stipitata*, **A**bundant *V. maura* and **C**ommon *Ulva intestinalis* (B2).

Below this biotope in the upper eulittoral was an 0.45m band with an assemblage containing **S**uperabundant *V. maura*, **C**ommon *Fucus spiralis* and **F**requent *Pelvetia canaliculata* (B3). **A**bundant *Semibalanus balanoides* and **C**ommon *Patella vulgata* were recorded the mid eulittoral bedrock, although the **S**uperabundant *V. Maura* meant that this 0.9m biotope was not classified as barnacle dominated. The turfing algae *Mastocarpus stellatus* also occurred **F**requently across this biotope (B4). Shallow coralline rockpools were regularly recorded across the mid eulittoral interspersing the *V. maura* and barnacle-covered bedrock. These pools contained **S**uperabundant *Lithothamnion spp* and **A**bundant *Corallina officinalis* and *Ceramium spp* (B5) and formed a complex with B4.

Shallow coralline algae pools were present on the fringe of the lower eulittoral containing **S**uperabundant *Lithothamnion spp*, **A**bundant *C. officinalis*, *Blidingia spp*. and *Ceramium spp.* (B6). The lower eulittoral rocky platforms were characterised by a mosaic of kelps and red algae with **S**uperabundant *Laminaria digitata* and over 30 additional species of algae recorded. Several invertebrate species were also found in this biotope (B7) (Appendix B). Kelps fringed the infralittoral zone at Howick with **A**bundant *L. digitata*, *Laminaria hyperborea* and *F. serratus* (B8).

Table 6: Biotope descriptions along the fixed transect survey at Howick in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1	LR.FLR.Lic.YG Yellow and grey lichens	0-4.6.0	
B2	LR.FLR.Lic Pra *Prasiola stipitata* on bedrock	4.6-11.5	
B3	LR.MLR.BF.FspiB *Fucus spiralis* and *Pelvetia canaliculata*	11.5-17.1	
B4	LR.FLR.Lic.Ver.B (in a complex with B5) Barnacles and limpets on bedrock with *Verrucaria maura*	17.1-45.0	
B5	LR.FLR.Rkp.Cor.Cor Coralline algal pools	17.1-45.0	
B6	LR.FLR.Rkp.Cor *Halidrys siliquosa* pools	45.0-52.3	
B7	LR.FLR.Rkp.Cor Shallow coralline algal pool	52.3-62.0	

B8	IR.MIR.KR Kelps and red algae	62.0-66.0	

The transect at Howick showed a high degree of similarity in vertical distribution and composition of biotopes between 2013 and the 2002 and 2009 surveys. Yellow lichens typified the first biotope recorded from the upper marker at the top of the transect in all three survey years. The second biotope encountered in the upper eulittoral was dominated by *Prasiola stipitata* in all three years, occurring in slightly different distances along the transect between 2.8-9.4m in 2002, 6.0-9.5m in 2009 and 1.45-2.70m in 2013, followed downshore by a biotope classified by *Pelvetia canaliculata* (9.5 – 12 m in 2002, 9.5-12.5m in 2009). *P. canaliculata* was not recorded within transect line in 2013 but was found in the surrounding areas during the Phase I survey.

The mid-eulittoral region along the transect had changed in terms of biotope classification, although upon inspection of data and photographs from all three surveys it appeared that the lichen *V.maura* and barnacle *Semibalanus balanoides* are the two most abundant species in all survey years within biotopes B5, 6 and 7, with small fluctuations in the abundance of these species dictating the change in biotope classification between the years.

Himanthalia elongata dominated the lower eulittoral habitat in 2002 and 2009, but was present in lower abundances in 2013. The habitat was classified in 2013 by the high densities of coralline algae in shallow pools, with kelp and red seaweeds marking the lower eulittoral/upper infralittoral fringe at the bottom end of the transect (Figure 9 & 10).

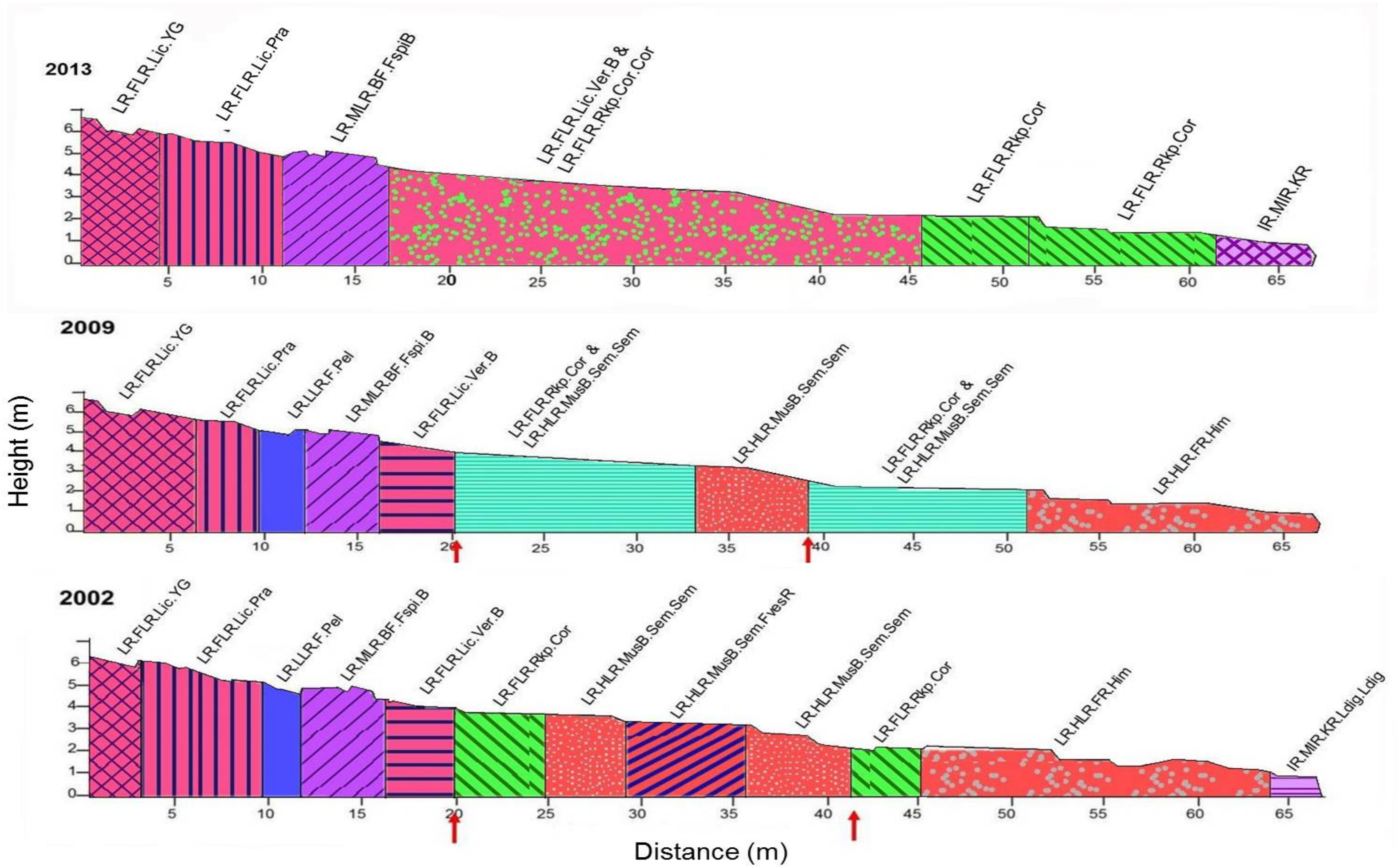


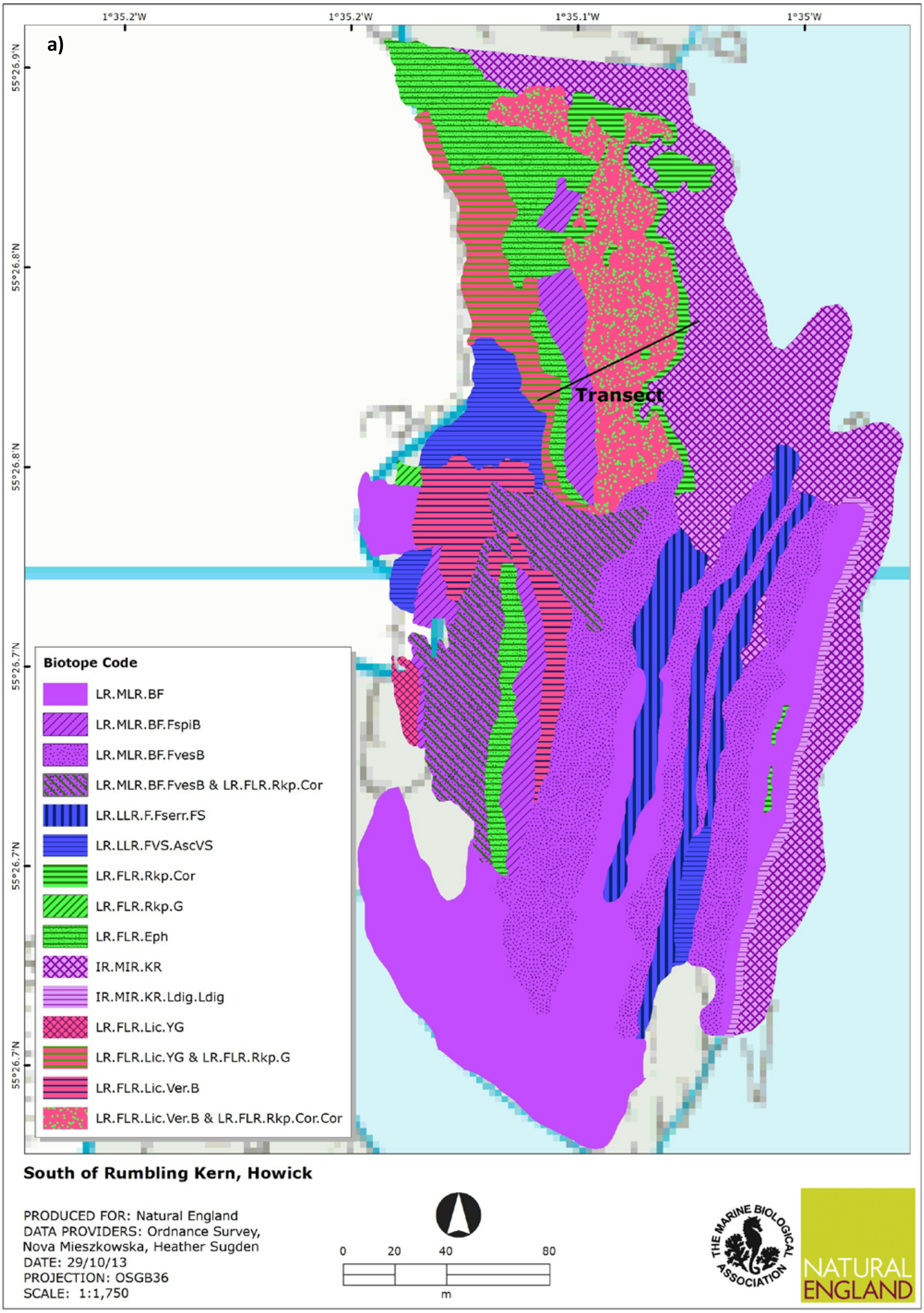
Figure 9: a) Shore height profile for the fixed transect survey at Howick with biotope boundaries marked, b) 2010 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation, for 2009 and 2002 the transects have been divided into an upper, mid and lower shore at boundaries between biotopes at approximately the same position on the shore (marked by the red arrows).

3.3.3 Phase I Survey

The Phase I survey in 2009 recorded a total of 16 biotopes whereas in 2013 15 biotopes were recorded (Table 7) with 3 biotopes recorded in both surveys. Vertical zonation of biotopes at Howick in the region of the fixed transect were similar between 2009 and 2013 (Figure 10), although the same assemblage of *S. balanoides* and *V. maura* was classified as different biotopes despite *V. maura* being the most abundant species in both years. No *Mytilus* spp. were recorded in 2013. The southern sector of the reef has a different sequence of biotopes in the two years, however, when the component species are compared between surveys these do not differ much, suggesting that operator choice of biotope code was different rather than a huge change in the actual species present and dominant at this site.

Table 7: Phase I biotopes recorded in 2009 and 2013 at Howick in the Berwickshire and North Northumberland Special Area of Conservation with the dominant species in each biotope

Biotope Code	2009	2013	Dominant Species
LR.MLR.BF.FvesB	■	■	*Fucus vesiculosus*
LR.MLR.BF.Rho	■		*Rhodothamniella floridula*
LR.LLR.F.Fserr / LR.LLR.F.Fves	■		*Fucus serratus / Fucus vesiculosus*
LR.LLR.F.Fspi	■		*Fucus spiralis*
LR.LLR.F.Pel	■		*Pelvetia canaliculata*
LR.HLR.FR.Him	■		*Himonthalia elongate*
LR.FLR.Lic.Pra	■		*Prasiola stipitata*
LR.FLR.Lic.Ver.B	■	■	*Verrucaria maura*
LR.FLR.Lic.YG	■	■	*Xanthoria parietina & Caloplaca marina*
LR	■		
LSa.MuSa	■		
LR.HLRMusB.MytB	■		*Mytilus spp & Semibalanus balanoides*
LR.HLR.MusB.Sem.FvesR	■		*Semibalanus balanoides & Fucus vesiculosus*
LR.HLR.MusB.Sem.Sem	■		*Semibalanus balanoides & Patella vulgata*
LR.FLR.Rkp.Cor / MusB.Sem.Sem	■		*Coralline algae/ Semibalanus balanoides & Patella vulgata*
LR.FLR.Rkp.FK	■		*Fucus serratus & Laminaria digitata*
LR.MLR.BF		■	*Semibalanus balanoides*
LR.MLR.BF.FspiB		■	*Fucus spiralis*
LR.MLR.BF.FvesB / LR.FLR.Rkp.Cor		■	*Fucus vesiculosus / Coralline algae*
LR.LLR.F.Fserr.FS		■	*Fucus serratus*
LR.LLR.FVS.AscVS		■	*Ascophyllum nodosum*
LR.FLR.Rkp.Cor		■	*Coralline algae*
LR.FLR.Rkp.G		■	*Prasiola stipitata & Verrucaria maura*
LR.FLR.Eph		■	*Ulva intestinalis*
IR.MIR.KR		■	*Laminaria digitata & Lithothamnion spp*
IR.MIR.KR.Ldig.Ldig		■	*Laminaria digitata*
LR.FLR.Lic.YG / LR.FLR.Rkp.G		■	*Xanthoria parietina & Caloplaca marina / Prasiola stipitata*
LR.FLR.Lic.Ver.B / LR.FLR.Rkp.Cor.Cor		■	*Verrucaria maura / Lithothamnion spp*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Transect
Biotope Code
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LR.MLR.BF.FvesB
LR.MLR.BF.FvesB & LR.FLR.Rkp.Cor
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LR.LLR.FVS.AscVS
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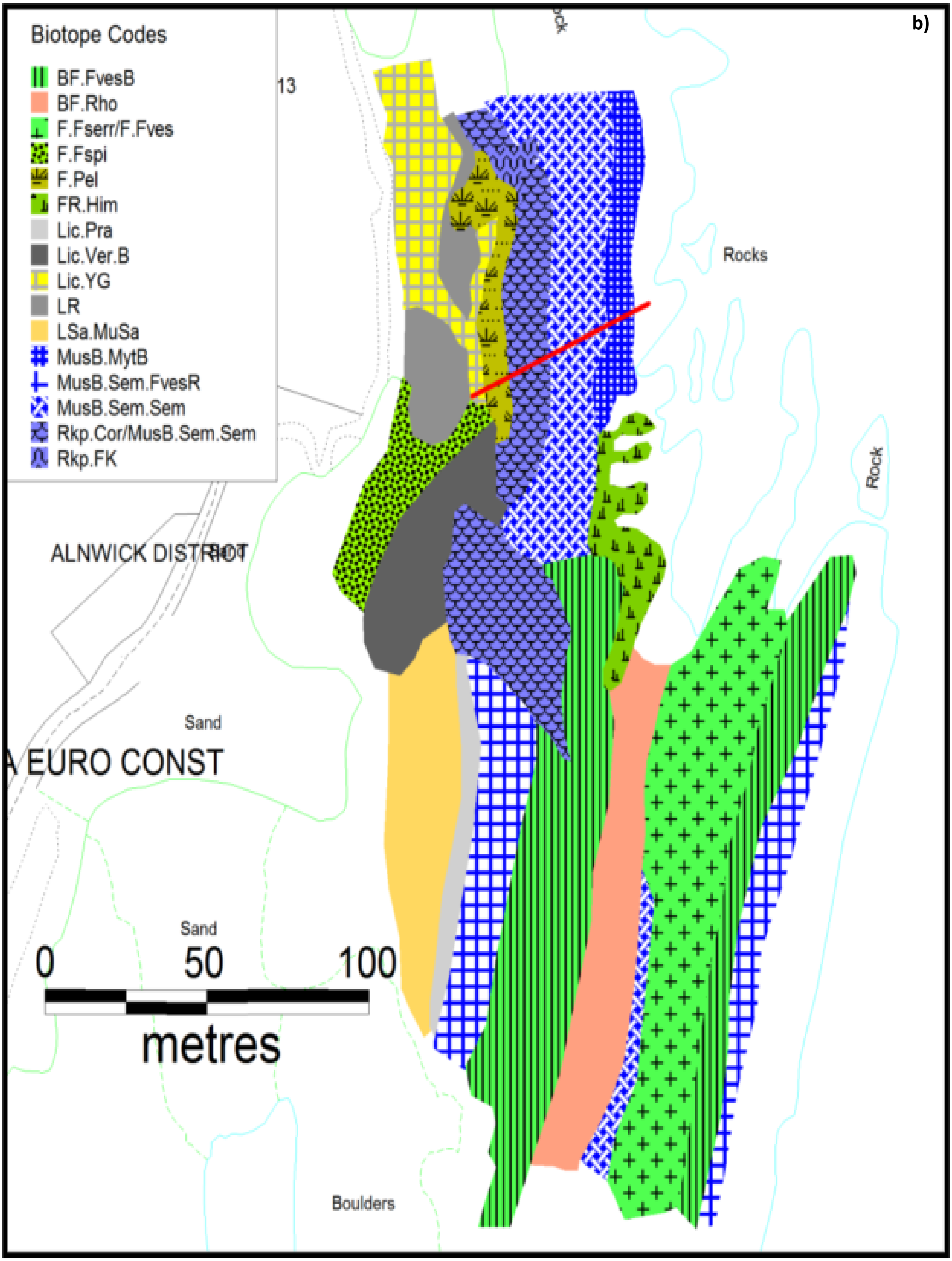


Figure 10: Phase 1 biotope map at Howick in a) 2013 and b) 2009 with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.4 Newton Point

3.4.1 Site Description

Figure 11: Newton Point in the Berwickshire and North Northumberland Coast Special Area of Conservation

Access was via the coastal path from the National Trust car park (Appendix A). The survey site at Newton Point (Figure 11) faced a southeasterly direction and was moderately exposed. The bedrock type was Whin Sill basalt, characterised by columnar outcrops with deep vertical fissures (Barne et al 1995). The survey site was a complex shore made up of a gradually sloping flat reef with a series of ledges, cracks, crevices and rock pools ending in a kelp dominated gully with a boulder field separating Pern Carr Rock from Lobster Carr Rock. The shore was backed by gently sloping supralittoral boulders. The transect was placed out on the point backed by a vertical barnacle dominated drop down into the lower eulittoral kelp (Figure 12a). The transect marker bolt was replaced in the same area of the supralittoral lichen zone (Figure 12b).

Figure 12: a) Location and orientation of the transect on Pern Carr Rock and b) the upper transect marker bolt at Newton Point in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.4.2 Fixed Transect Survey

The transect line at Newton Point stretched for 65 m from the top of Pern Carr Rock into the kelp dominated gully separating Pern Carr Rock from Lobster Rock (Figure 13 & 14). The transect began in the supralittoral black lichen zone with a 3.9m length biotope containing **S**uperabundant *V. maura* and **F**requent *P. stipitata* (B1). A summary of the transect is shown in Table 8. *V. maura* remained the dominant species in the upper eulittoral with a small 2.2m band of **C**ommon *P.canaliculata*, however, in constrast to previous surveys no *F. spiralis* was recorded in the upper eulittoral zone (B2).

The mid eulittoral region was characterised along a 15.6m stretch of the transect by **S**uperabundant *S. balanoides* and **C**ommon *P. vulgata*, with patches of **C**ommon *F. vesiculosus* (B3). Small coralline pools with **S**uperabundant *Lithothamnion spp* and **A**bundant *C. officinalis* were present across the barnacle bedrock (B7).

Two large pools were interspersed the barnacle bedrock at the base of two ledges. These pools contained **A**bundant *H. siliquosa* as well as coralline algae, **S**uperabundant *Lithothamnion spp* and *C. officinalis*. The pools supported several invertebrate species including starfish, winkles and crabs (B4).

Rocky ledges stepped up in vertical height onto flat bedrock slopes supporting **S**uperabundant *F. vesiculosus* in the mid eulittoral between 37.7 and 40.6m distance down the transect (B5). This bedrock slope ran from the lower mid eulittoral to the infralittoral fringe at 60m. In the lower eulittoral dominant *F. vesiculosus* was replaced by dominant **S**uperabundant *F. serratus* and **A**bundant *H. elongata* (B6).

The infralittoral fringe was dominated by kelps with **S**uperabundant *Laminaria digitata*, **A**bundant coralline algae and several invertebrate species (B8) extending to the end of the transect line at 65m. The gully in the infralittoral fringe contained a boulder field in the lower eulittoral area between the two spits of rock.

Table 8: Biotope descriptions along the fixed transect survey at Newton Point in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1	LR.FLR.Lic.Ver Verrucaria maura and green on bedrock	0-3.9	
B2	LR.LLR.FVS.PelVS Pelvetia canaliculata bedrock	3.9-6.1	

B3	LR.HLR.MusB.Sem.Sem Barnacle bedrock	6.1-21.7	
B7	LR.FLR.Rkp.Cor.Cor Small coralline pools	6.1-21.7	
B4	LR.FLR.Rkp.Cor *Halidrys siliquosa* pools	21.7-27.62	
B3	LR.HLR.MusB.Sem.Sem Barnacle bedrock	27.62-35.0	
B4	LR.FLR.Rkp.Cor *Halidrys siliquosa* pools	35.0-37.7	
B5	LR.MLR.BF.FvesB *Fucus vesiculosus* slopes (in a complex with B6)	37.7-40.6	
B6	LR.LLR.F.Fserr.FS *Fucus serratus* slope	40.6-60.0	
B8	IR.MIR.KR.Ldig.Ldig Kelps	60.0-65.0	

A *V. maura* biotope was present at the highest shore level from the start of the transect to between 0 and 3.5m (2002), 4 m (2009) and 3.9m (2013) followed by a narrow band of up to 2 m in vertical extent of *P. canaliculata*. In 2002 and 2009 subsequent biotopes characterised by *F. spiralis* and *F. vesiculosus* respectively in the upper to mid eulittoral region had been replaced in 2013 by a barnacle biotope due to the most abundant species being *S. balanoides* (Figures 13 & 14). Coralline pools were recorded in all years interspersing the bedrock biotopes in all years. In both 2013 and 2009 a *F. vesiculosus* biotope occurred around the 37.5 m distance along the transect. This was not present in 2002. The type and extent of biotopes along the fixed transect remained unchanged in the lower eulittoral region between survey years.

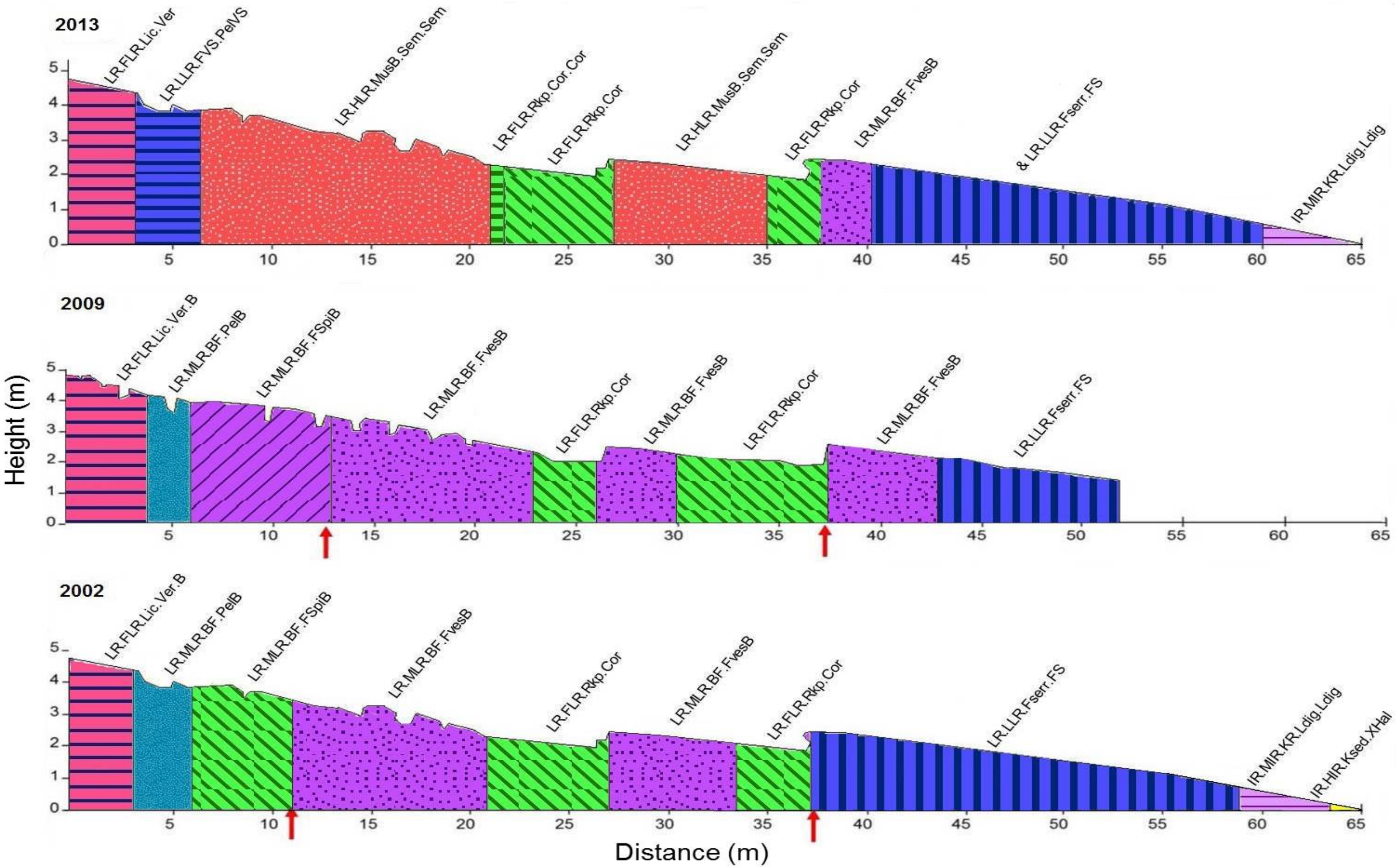


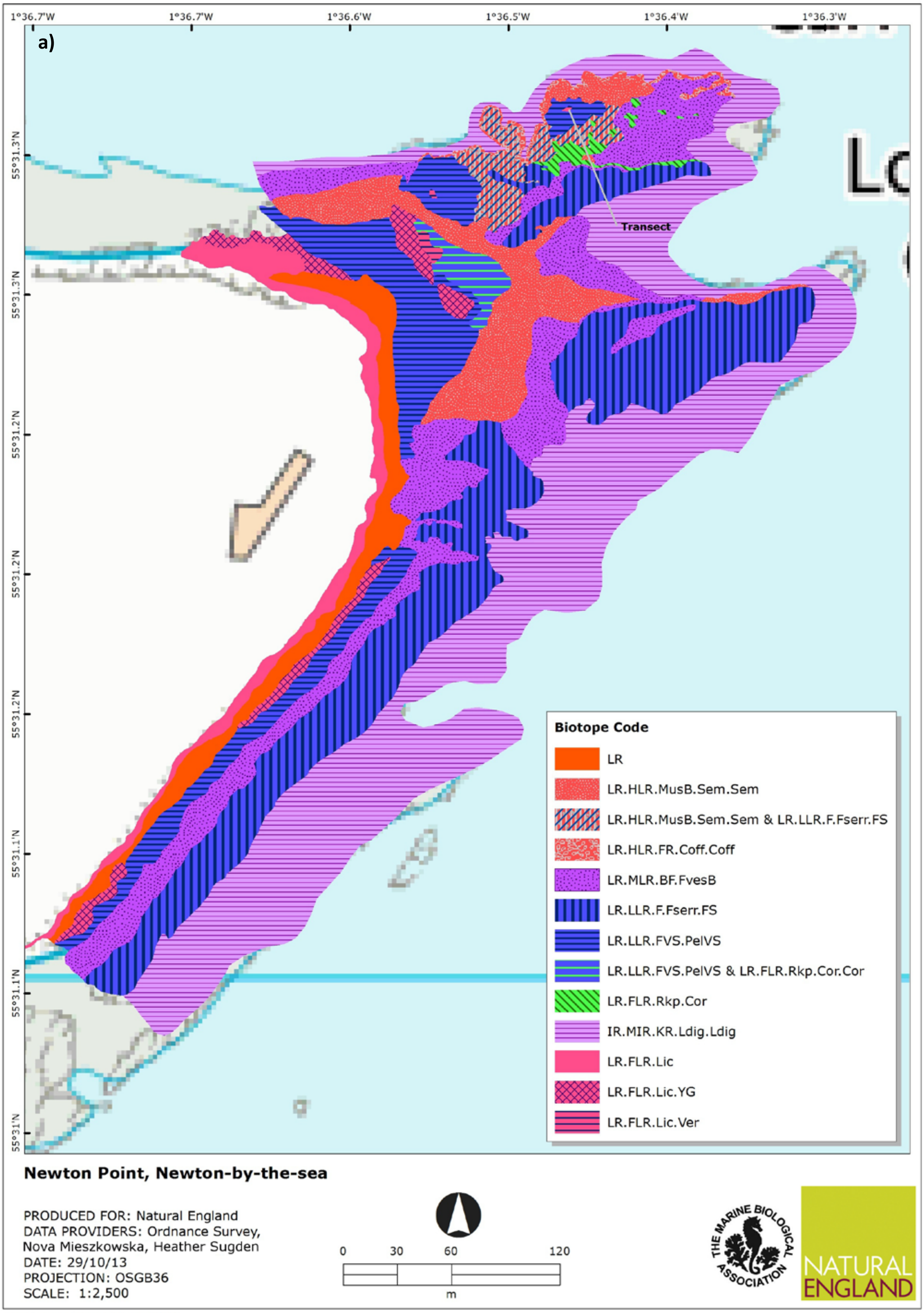
Figure 13: a) Shore height profile for the fixed transect survey at Newton Point with biotope boundaries marked, b) 2010 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation, for 2009 and 2002 the transects have been divided into an upper, mid and lower shore at boundaries between biotopes at approximately the same position on the shore (marked by the red arrows).

3.4.3 Phase I Survey

The Phase I survey conducted at Newton Point in 2013 covered a much larger area than that conducted in 2009 (Figure 14). A total of 11 biotopes were recorded during the 2009 survey whereas 13 biotopes were recorded during the 2013 survey with 5 biotopes present during both surveys (Table 9). At Newton Point the overall composition of the shore comprised of similar biotopes between years, and differences appear again to be due to operator selection of biotope code and the spatial detail at which the maps were drawn (see last paragraph in this section).

Table 9: Phase I biotopes recorded in 2009 and 2013 at Newton Point in the Berwickshire and North Northumberland Special Area of Conservation with the dominant species in each biotope

Biotope Code	2009	2013	Dominant Species
FR	■		
LR.MLR.BF.FvesB	■	■	*Fucus vesiculosus*
LR.FLR.Rkp.FK	■		*Fucus serratus & Laminaria digitata*
LR.LLR.F.Serr/ LR.LLR.F.Fves	■		*Fucus serratus / Fucus vesiculosus*
LR.LLR.F.Fserr.FS	■	■	*Fucus serratus*
LR.LLR.F.Fspi	■		*Fucus spiralis*
LR.LLR.FR.Him	■		*Himonthalia elongata*
LR.FLR.Lic.Ver.B	■		*Verrucaria maura*
LR.FLR.Lic.Ver	■	■	*Verrucaria maura*
LR.FLR.Lic.YG	■	■	*Xanthoria parietina & Caloplaca marina*
LR		■	
LR.HLR.MusB.Sem.Sem	■	■	*Semibalanus balanoides & Patella vulgata*
LR.HLR.MusB.Sem.Sem / LR.LLR.F.Fserr.FS		■	*Semibalanus balanoides & Patella vulgata / Fucus serratus*
LR.HLR.FR.Coff.Coff		■	*Corallina officinalis*
LR.LLR.FVS.PelVS		■	*Pelvetia canaliculata*
LR.LLR.FVS.PelVS / LR.FLR.Rkp.Cor.Cor		■	*Pelvetia canaliculata / Coralline algae*
LR.FLR.Rkp.Cor	■	■	*Coralline algae*
IR.MIR.KR.Ldig.Ldig		■	*Laminaria digitata*
LR.FLR.Lic		■	*Lichens*


a)
1°36.7'W
1°36.7'W
1°36.6'W
1°36.5'W
1°36.4'W
1°36.3'W
55°31.3'N
55°31.3'N
55°31.2'N
55°31.2'N
55°31.2'N
55°31.1'N
55°31.1'N
55°31'N
Transect
Biotope Code
LR
LR.HLR.MusB.Sem.Sem
LR.HLR.MusB.Sem.Sem & LR.LLR.F.Fserr.FS
LR.HLR.FR.Coff.Coff
LR.MLR.BF.FvesB
LR.LLR.F.Fserr.FS
LR.LLR.FVS.PelVS
LR.LLR.FVS.PelVS & LR.FLR.Rkp.Cor.Cor
LR.FLR.Rkp.Cor
IR.MIR.KR.Ldig.Ldig
LR.FLR.Lic
LR.FLR.Lic.YG
LR.FLR.Lic.Ver
Newton Point, Newton-by-the-sea
PRODUCED FOR: Natural England
DATA PROVIDERS: Ordnance Survey,
Nova Mieszkowska, Heather Sugden
DATE: 29/10/13
PROJECTION: OSGB36
SCALE: 1:2,500
0
30
60
120
m
THE MARINE BIOLOGICAL ASSOCIATION
NATURAL ENGLAND

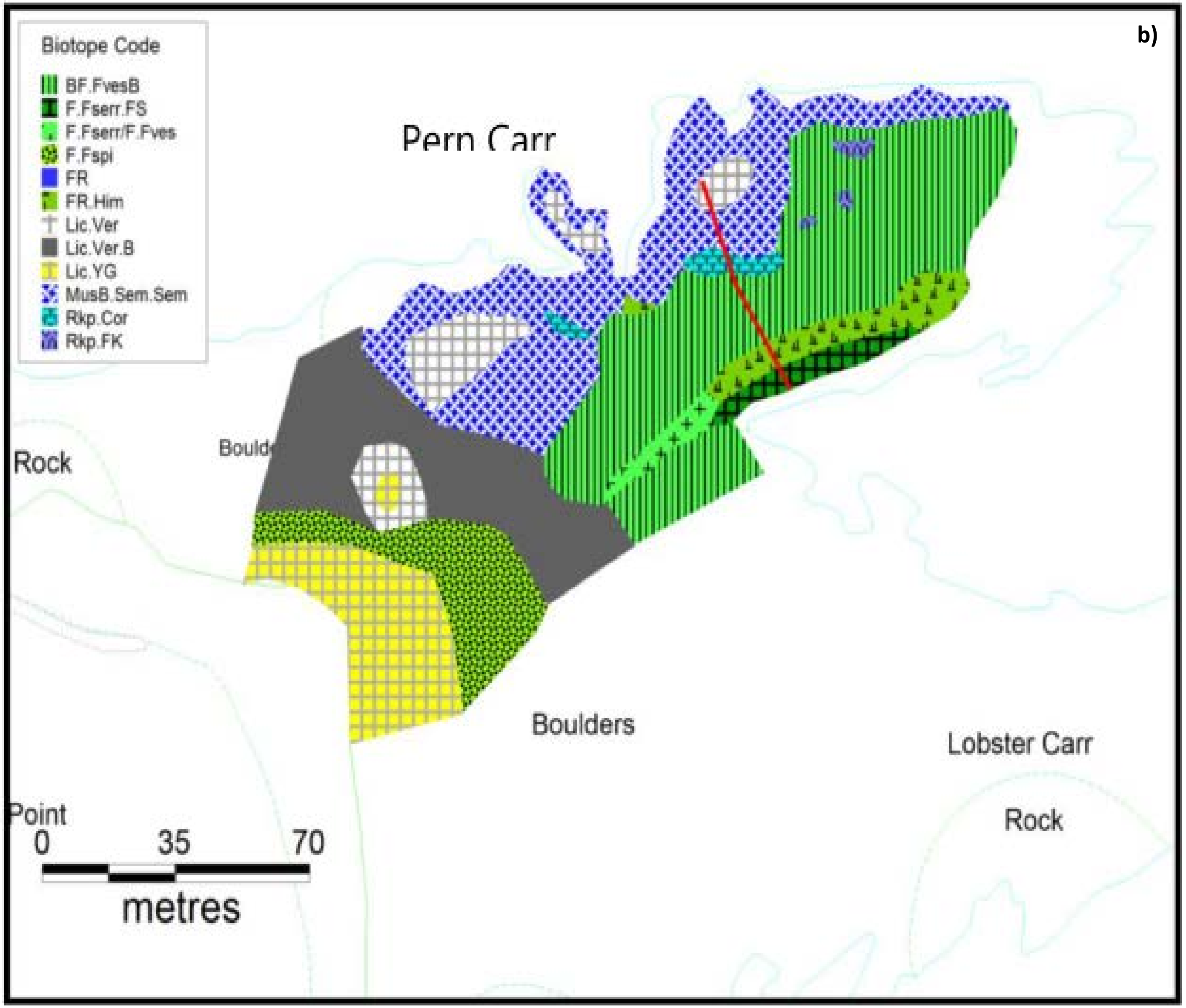


Figure 14: Phase 1 biotope map at Newton Point in a) 2013 and b) 2009 with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.5 Inner Farne

3.5.1 Site Description

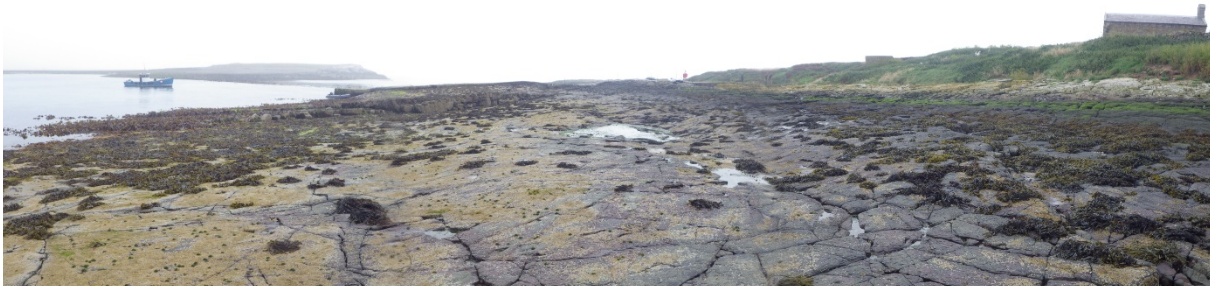


Figure 15: Inner Farne in the Berwickshire and North Northumberland *Coast* Special Area of Conservation

Inner Farne was accessed via boat from Seahouses harbour on the mainland through contact with the National Trust wardens based on the island. Once on the island the transect was a short walk across approximately 200m along the intertidal bedrock (Figure 15) in a northeasterly direction from the landing strip to the point of the island directly in front of the wardens cottage (Figure 16a). The hard igneous rock, 'Whin Sill', was characterised by many cracks, deep fissures and small depressions forming rockpools and offering microniches for a diversity of species. The transect was located along a sloping bedrock shore facing a northwesterly direction. This site was moderately exposed. The marker bolt was replaced in the supralittoral yellow lichen biotope (Figure 16b).

Figure 16: a) Location placer shot in front of the wardens cottage and b) New marker bolt on the top of the bedrock on Inner Farne in the Berwickshire and North Northumberland Coast Special Area of Conservation

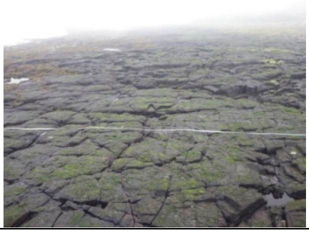
3.5.2 Fixed Transect Survey

The transect on Inner Farne extended 34m down the steeply sloping bedrock shore (Figure 17 & 18) from supralittoral rock covered by yellow and grey lichens (B1) with **A**bundant *T. atra*, **A**bundant *V. maura*, **C**ommon *C. marina* and **C**ommon *X. parietina,* followed by **A**bundant *P. stipitata* on bedrock (B2) and **A**bundant *V. maura* and *P. stipitata* on bedrock (B3) that extended to the upper infralittoral fringe. A summary of the transect is shown in Table 10.

The upper eulittoral was divided into two biotopes with **S**uperabundant *P. canaliculata* and *V. maura* on a bedrock slope (B4) followed vertically below this biotope by **S**uperabundant *F. spiralis* and *V. maura* on bedrock (B5). The mid eulittoral was characteristically dominated by **A**bundant *F. vesiculosus* and **A**bundant *S. balanoides* on bedrock (B6). There was a steep ledge at the end of this biotope leading into a flat coralline and green algal pool with **S**uperabundant *Lithothamnion spp*, **A**bundant *C. officinalis*, **C**ommon *Blidingia spp.* and **C**ommon *S. balanoides* (B7). The mid eulittoral then continued with **S**uperabundant *S. balanoides* and **C**ommon *F. vesiculosus* (B6a).

The low eulittoral slope supported **C**ommon *H. elongata* and **C**ommon *F. serratus*, with **A**bundant *Lithothamnion spp* and **A**bundant *S. balanoides* (B8). The transect ended in the lower eulittoral/infralittoral fringe with **S**uperabundant *L. digitata* kelps with **O**ccasional *A. esculenta*, **A**bundant *M. stellatus*, **A**bundant *Palmaria palmata* and **S**uperabundant *Lithothamnion spp* (B9). The infralittoral zone beyond the end of the transect supported a kelp fringe dominated by **S**uperabundant *Laminaria hyperborea*, **A**bundant *L. digitata*, **C**ommon *Saccharina latissima*, **C**ommon *Sacchoriza polyschides* and **C**ommon *A. esculenta*. The edible urchin *Echinus esculentus* was **C**ommon in these kelps.

Table 10: Biotope descriptions along the fixed transect survey on Inner Farne in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1 & B1a	LR.FLR.Lic.YG & LR.FLR.Rkp.G Yellow and Grey lichens & Ephemeral pools	0.0-1.05	
B2	LR.FLR.Lic.Pra *Prasiola stipitata* on bedrock	1.05-4.0	

B3	LR.FLR.Lic.Ver *Verrucaria maura* & *Prasiola stipitata* on bedrock	4.0-7.0	
B4	LR.LLR.F.Pel *Pelvetia canaliculata* on bedrock	7.0-11.95	
B5	LR.MLR.BF.FspiB *Fucus spiralis* on bedrock	11.95-15.45	
B6	LR.MLR.BF.FvesB *Fucus vesiculosus* and barnacle bedrock	15.45-17.7	
B7	LR.FLR.Rkp.Cor.Cor Coralline and green algal pool	17.70-19.6	
B6a	LR.MLR.BF.FvesB Barnacles and *Fucus vesiculosus* on bedrock	19.6-28.0	
B8	LR.HLR.FR.Him *Himonthalia elongata* and barnacles on bedrock	28.0-31.2	
B9	IR.MIR.KR.Ldig.Ldig *Laminaria digitata* dominated kelps	31.2-33.4	

The fixed transect on Inner Farne remained largely unchanged between the initial survey in 2002 and the 2013 resurvey. A small area of *F. spiralis* was recorded in the current survey between 11.95-15.45 m along the transect but was not present in 2002, whereas a narrow biotope between 12.5 – 15 m characterized by the barnacle *S. balanoides* was present in 2002 but not in 2013 (Figures 17 & 18).

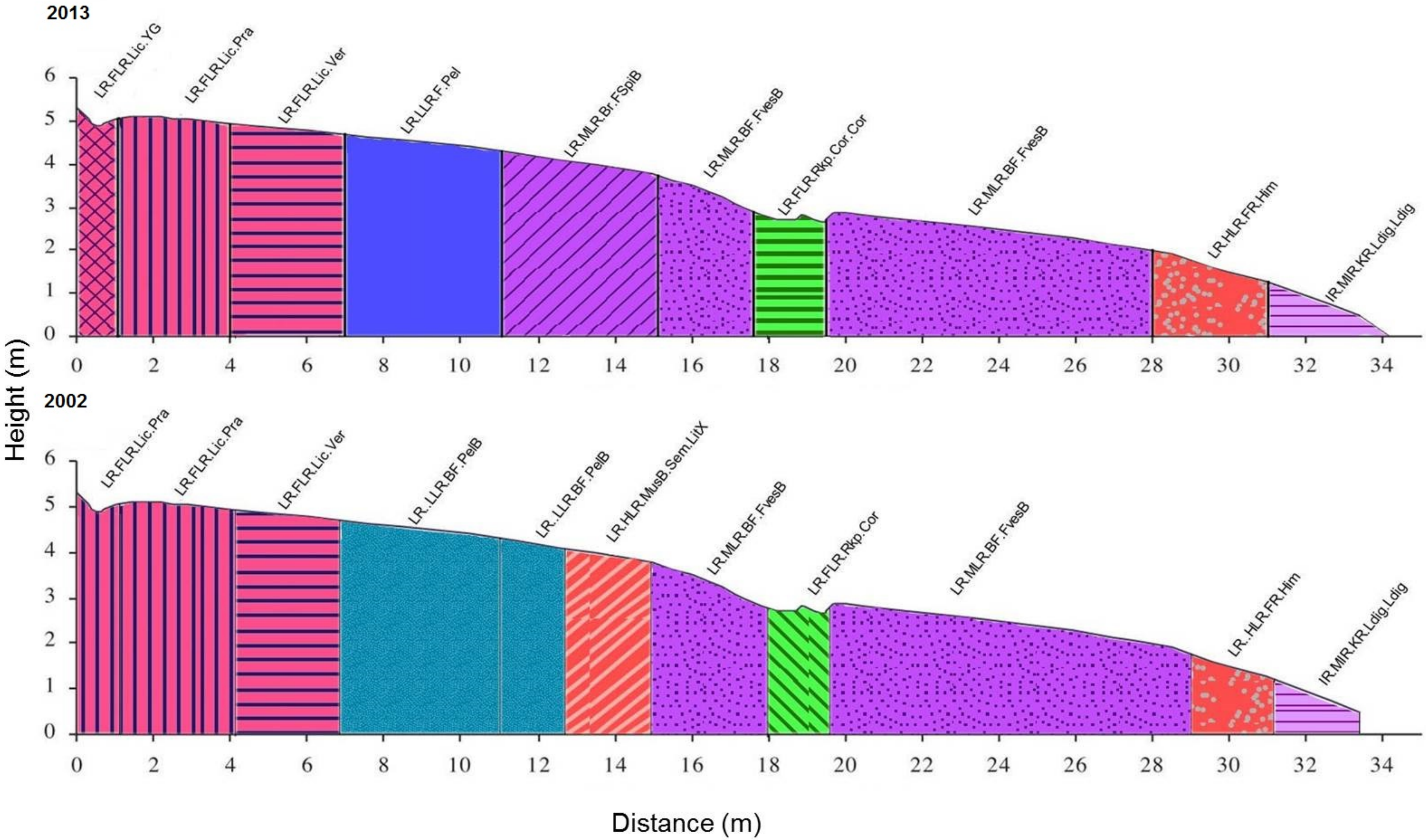


Figure 17: a) Shore height profile for the fixed transect survey on Inner Farne with biotope boundaries marked, b) 2010 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.5.3 Phase I Survey

The Phase I survey on Inner Farne in 2013 provides a baseline of Phase I information as no Phase I survey was carried out in 2009. A total of 17 biotopes were recorded on the shore at Inner Farne (Figure 18). The composition of biotopes on the shore was similar to that reflected in the fixed transect survey. In the supralittoral rock pools containing the green algae *Prasiola stipitata* were present within a predominant yellow and grey lichen zone. This was followed by a wide band of *P. stipitata* on bedrock and then *Verrucaria maura* in the lower supralittoral. A thin band of *Pelvetia canaliculata* gave way to a thin band of *Fucus spiralis* in the upper eulittoral before a wide band of *Fucus vesiculosus* in the mid eulittoral. *Himonthalia elongata* was present across the extent of the low eulittoral before entering an extensive kelp forest in the shallow sublittoral. The kelps in Inner Farne formed distinct zones between *Laminaria digitata* and *Laminaria hyperborea*. Towards the southeast of the shore was a large band of *Saccharina latissima* whilst *Saccorhiza polyschides* was found under the pier.

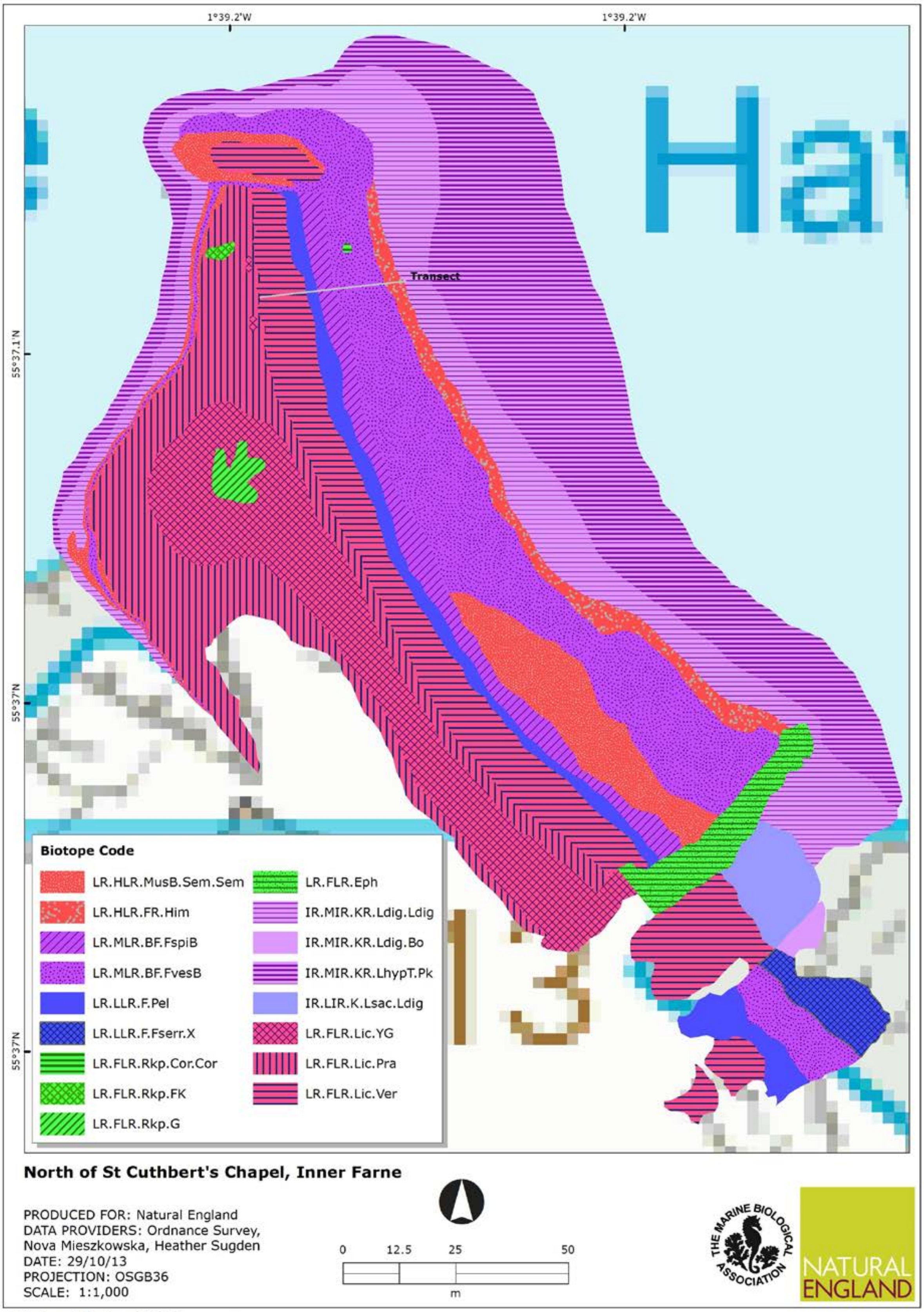


Figure 18: Phase 1 biotope map on Inner Farne with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.6 Browsman

3.6.1 Site Description

Figure 19: Brownsman in the Berwickshire and North Northumberland Coast Special Area of Conservation

Brownsman was accessed by RIB from Inner Farne through contact with the National Trust wardens based on the island (Figure 19). The transect was located a short walk around to the north-northeasterly tip of the island in front of the wardens cottage (Figure 20a). Brownsman offered a similar habitat to that found on Inner Farne with a steeper sloping moderately exposed bedrock shore. The hard igneous rock, 'Whin Sill', was characterised by many cracks, deep fissures and small depressions forming rockpools and offered microhabitats for a diversity of species. The marker bolt for the upper transect was replaced in the supralittoral yellow lichen area, on top of the bedrock for ease of relocation (Figure 20b).

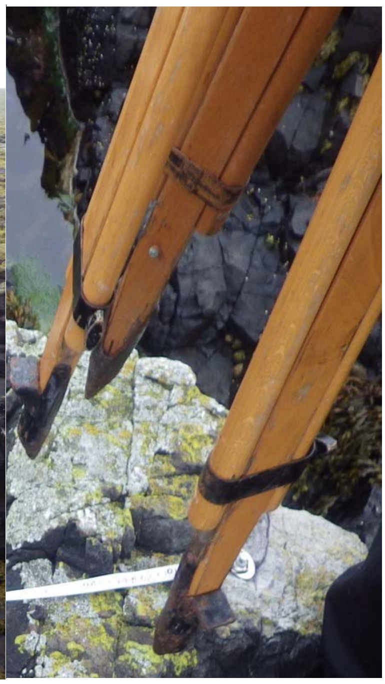


Figure 20: a) Location placer shot in front of the warden's cottage and b) New marker bolt on the top of the bedrock on Brownsman in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.6.2 Fixed Transect Survey

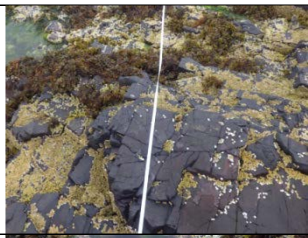
The transect on Brownsman extended for 32m down the steeply sloping bedrock shore (Figure 21 & 22). A summary of the transect is shown in Table 11. The transect began in the supralittoral where the yellow and grey lichens present included **S**uperabundant *X. parietina*, **A**bundant *C. marina* and **C**ommon *T. atra* (B1). Immediately behind the start of the transect was a deep vertical crevice approximately 1.5m in width that was mapped for the phase I element but did not form part of the fixed transect (Figure 22).

The upper eulittoral on Brownsman did not support any *P. canaliculata* or *F. spiralis* unlike on Inner Farne. Black and green lichens dominated with **A**bundant *V. maura* and **A**bundant *P. stipitata* (B2). This biotope was followed by **S**uperabundant *V. maura* and **C**ommon *Porphyra spp.* on bedrock (B3). The mid eulittoral was similar in terms of biotope composition to Inner Farne, with barnacles and fucoids dominating the bedrock slope (B4), **A**bundant *F. vesiculosus* and **A**bundant *S. balanoides*, followed by a large coralline algal pool with **A**bundant *Lithothamnion spp*, **A**bundant *C. officinalis* and **A**bundant *Ceramium spp* (B5).

The low eulittoral began with barnacle dominated bedrock where *S. balanoides* and *Patella ulysipponensis* were both **A**bundant (B6). This led straight into the low eulittoral / infralittoral tide swept bedrock with a kelp fringe where **S**uperabundant *L. digitata* dominated and **A**bundant *L. hyperborea* and **C**ommon *A. esculenta* were present (B7).

Table 11: Biotope descriptions along the fixed transect survey on Brownsman in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1	LR.FLR.Lic.YG Yellow and grey lichens	0.0-3.0	
B2	LR.FLR.Lic.Pra *Verrucaria maura* and lichens	3.0-12.0	
B3	LR.FLR.Lic.Ver *Verrucaria maura* and *Porphyra* spp. on bedrock	12.0-14.77	

B4	LR.MLR.BF.FvesB Barnacles and *Fucus vesiculosus*	14.77-22.4	
B5	LR.FLR.Rkp.Cor.Cor Coralline algal pool	22.4-23.7	
B4	LR.MLR.BF.FvesB Barnacles and *Fucus vesiculosus*	23.7-25.5	
B6	LR.HLR.MusB.Sem Barnacles and *Patella ulysipponensis*	25.5-29.8	
B7	IR.MIR.KT.XKT Kelps	29.8-32.1	

The fixed transect on Brownsman remained largely unchanged from that recorded in 2002. In the mid eulittoral there was a greater dominance by *F. vesiculosus* in 2013 resulting in a change in the biotope classification from the barnacle dominated biotopes in 2002. In the low eulittoral the small band of coralline dominated shore had disappeared, replaced by *S. balanoides* as the dominant species on the bedrock down to the kelp zone (Figures 21 & 22).

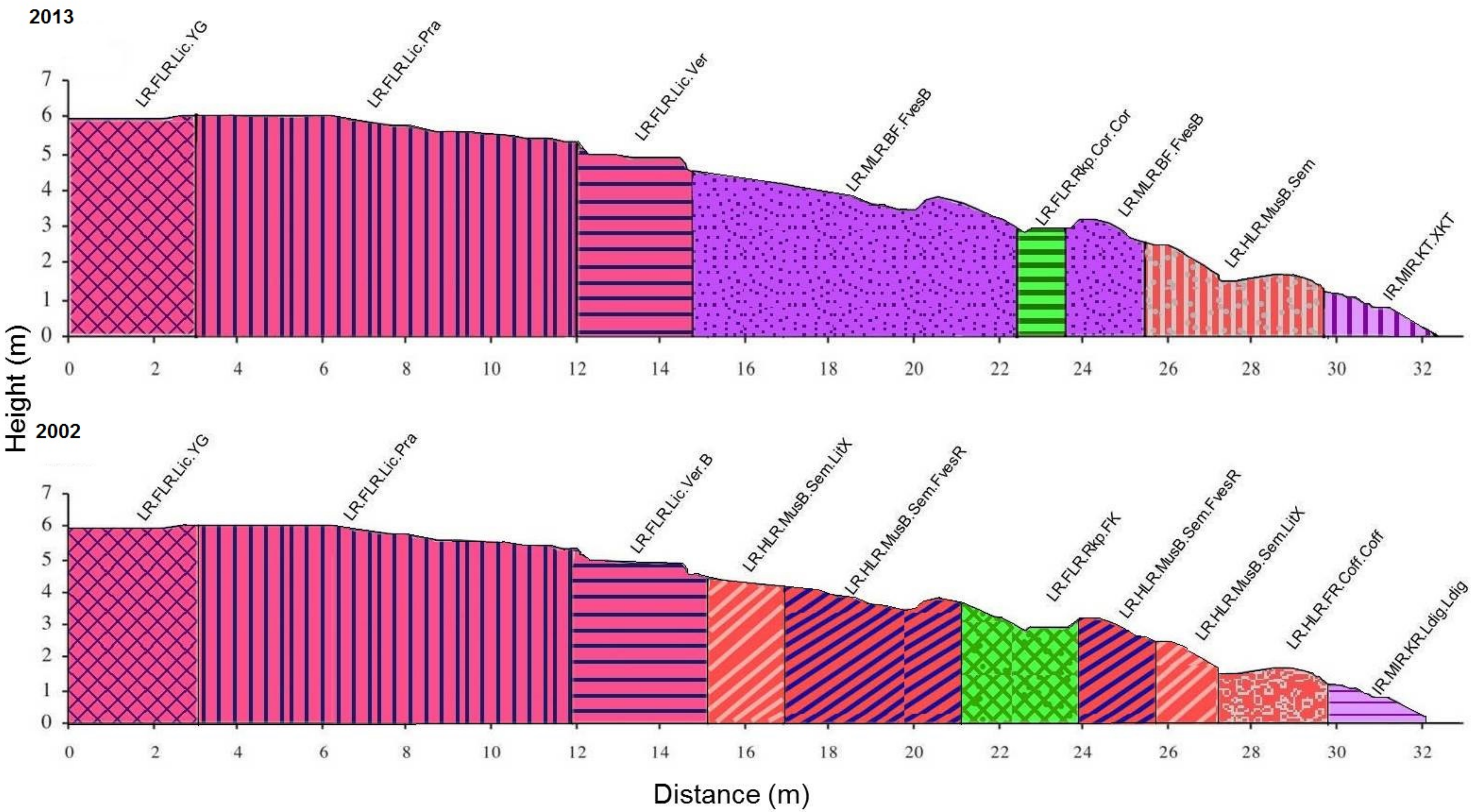


Figure 21: a) Shore height profile for the fixed transect survey on Brownsman with biotope boundaries marked, b) 2010 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.6.3 Phase I Survey

The Phase I survey on Brownsman in 2013 provides a baseline of Phase I information as no Phase I survey was carried out in 2009. A total of 9 biotopes were recorded on the shore at Brownsman (Figure 22). The composition of biotopes on the shore at Brownsman was identical to the fixed transect. In addition a wide band of *Semibalanus balanoides* and *Patella vulgata* were recorded around the low eulittoral which led into a mixed kelp forest in the shallow sublittoral. A gully containing ephemeral green and red seaweeds separated the northwest side of the shore from the north east although no differences in biotope composition was seen to either side of this gully.

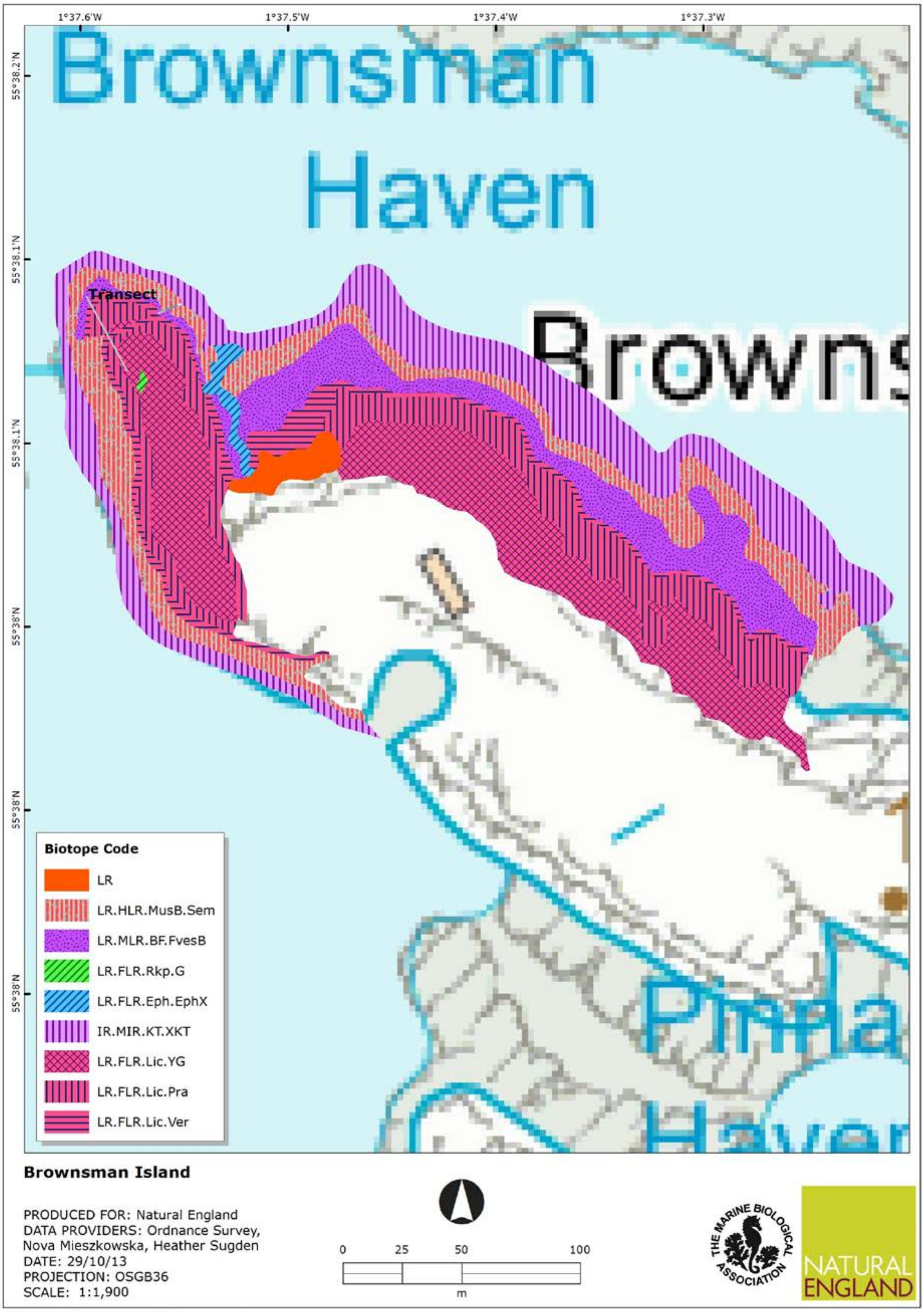


Figure 22: Phase 1 biotope map on Brownsman with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.7 Castlehead Head Rocks, Holy Island

3.7.1 Site Description

Figure 23: Castlehead Rocks, Holy Island in the Berwickshire and North Northumberland Coast Special Area of Conservation

The shore at Castlehead Rocks on Holy Island was accessed via a long walk through the sand dunes from the main road on the Island. Parking was in a large lay-by located before the main visitor car park, providing access straight across the dunes (Appendix A). Castlehead Rocks headland was a gradually sloping, moderately exposed bedrock shore, facing northeast, with stepped platforms on the northern side of the reef (Figure 23). The igneous rock provided a variety of habitats including cracks, crevices, ledges and rockpools. The transect was laid in an east-southeasterly direction in line with the navigation buoy on the eastern shore and was backed by a series of ledges leading down into the infralittoral zone behind the transect to the northwest (Figure 24a). An additional marker was placed alongside the existing marker bolt at the start of the transect to aid relocation (Figure 24b).

Figure 24: a) Location placer shot opposite the navigation buoy and b) Marker bolts on the top of the bedrock at Castlehead Rocks in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.7.2 Fixed Transect Survey

The transect at Castlehead Rocks on Holy Island extended 130m down the gently sloping bedrock shore (Figure 25 & 26). A summary of the transect is shown in Table 12. The upper transect boundary was located in the supralittoral bedrock within a 6m band of yellow and grey lichens where *C. marina* and *X. parietina* were **C**ommon and *V. maura* was **A**bundant (B1).

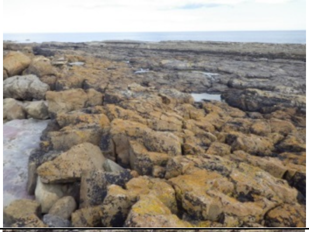
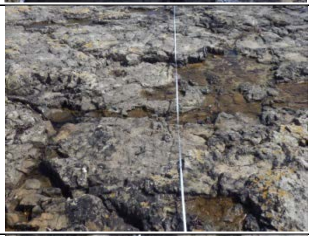
The upper eulittoral bedrock slope within the transect began with a biotope 6m in length containing **C**ommon *V. maura* and **F**requent *U. intestinalis* (B2) before an 8m stretch of mostly bare rock with patchy **F**requent *V. maura* (B3). A thin strip 3m in length of **A**bundant *P. canaliculata* followed this biotope (B4) and a 3m boundary strip of **A**bundant *P. canaliculata* and **C**ommon *F. spiralis* (B5) (both biotopes were given the same classification code due to the dominance of *P. canaliculata*) separated B4 from a 5m stretch of **S**uperabundant *F. spiralis* (B6).

The mid eulittoral began with a 3m wide coralline encrusting algal pool characterised by **C**ommon *M. stellatus* and **C**ommon *Lithothamnion spp* (B7). This formed a complex with another large pool containing the same species but with **C**ommon *Laurencia spp* in addition (B7a). Both of these coralline algal pools were part of a complex with **F**requent *F. spiralis* and **C**ommon *P. vulgata* on bedrock (B8). A second coralline encrusting pool (B7b) with **C**ommon *Lithothamnion spp*, **F**requent *C. officinalis* and **A**bundant *Osmundia pinnatifida* followed B8.

A 6m biotope with **A**bundant *F. vesiculosus* and **A**bundant *S. balanoides* on bedrock (B9) also contained a large coralline encrusting pool (B7b) and followed B8. **S**uperabundant *F. vesiculosus* and **A**bundant *F. serratus* on bedrock (B10) stretched for 20m before the mid eulittoral ended with a large pool containing **A**bundant *H. siliquosa*, **A**bundant *C. officinalis* and **C**ommon *Dumontia contorta* (B11).

The low eulittoral began with **S**uperabundant *S. balanoides* and **C**ommon *F. serratus* on bedrock (B12). This biotope was interrupted by a second pool containing *H. siliquosa* (B11) but continued towards the end of the transect which was characterised by dominant **S**uperabundant *F. serratus* and red algae on bedrock (B13). The infralittoral zone beyond the lowshore end of the transect was fringed by kelps with **S**uperabundant *L. digitata*, **C**ommon *L. hyperborea* and **C**ommon *A. esculenta*.

Table 12: Biotope descriptions along the fixed transect survey at Castlehead Rocks in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1	LR.FLR.Lic.YG Yellow grey lichens	0.0-6.4	
B2	LR.FLR.Lic.Ver *Verrucaria maura* – black lichens	6.4-12.5	
B3	LR.FLR.Lic.Ver Bare rock with patchy *Verrucaria maura*	12.5-20.67	
B4	LR.LLR.F.Pel *Pelvetia canaliculata* bedrock	20.67-23.85	
B5	LR.LLR.F.Fspi.FS *Pelvetia canaliculata* and *Fucus spiralis* bedrock	23.85-26.7	
B6	LR.LLR.F.Fspi.FS *Fucus spiralis* bedrock	26.7-31.32	
B7	LR.FLR.Rkp.Cor.Cor Coralline encrusting pool	31.32-34.75	

B7a	LR.FLR.Rkp.Cor.Cor (Complex with B7 and B8) Coralline encrusting pool with additional species	31.32-34.75	
B8	LR.LLR.F.Fspi.FS *Fucus spiralis* and *Patella vulgata* bedrock	34.75-50.64	
B7b	LR.FLR.Rkp.Cor.Cor Coralline encrusting pool – second occurance	50.64-59.0	
B9	LR.MLR.BF.FvesB *Fucus vesiculosus* on bedrock	59.0-65.14	
B7b	LR.FLR.Rkp.Cor.Cor (Complex with B9) Coralline encrusting pool – second occurance	59.0-65.14	
B10	LR.LLR.F.Fves *Fucus vesiculosus* and *Fucus serratus* on bedrock	65.14-85.73	
B11	LR.FLR.Rkp.Cor *Halidrys siliquosa* pool	85.73-90.09	
B12	LR.MLR.BF Barnacles and *Fucus serratus* bedrock	90.09-91.25	

B11	LR.FLR.Rkp.Cor *Halidrys siliquosa* pool	91.25-93.42	
B12	LR.MLR.BF Barnacles and *Fucus serratus* bedrock	93.42-97.57	
B13	LR.MLR.BF.Fser.R *Fucus serratus* and red algae bedrock	97.57-129.0	

The fixed transect at Castlehead Rocks had undergone some shifts in biotope composition across the survey years. The extent of the yellow lichen biotope had decreased in subsequent surveys from a maximum vertical length of 16m in 2002 to a minimum of 6m in 2013. *P. stipitata* replaced a large extent of this biotope in terms of vertical coverage in 2009, whereas in 2013 *V. maura* occupied the area along the transect from 6.4-20.67m. The *P. canaliculata* biotope had decreased in vertical extent in the upper eulittoral area. The extent of the *F. spiralis* biotope had increased since 2002 and in 2013 occupied a large area of the upper eulittoral approximately 16m in vertical extent. Despite the biotope classification of this biotope being slightly different across all years the component species and abundances were similar. Coralline algal pools were a feature along the length of the transect in all three survey years (Figures 25 & 26).

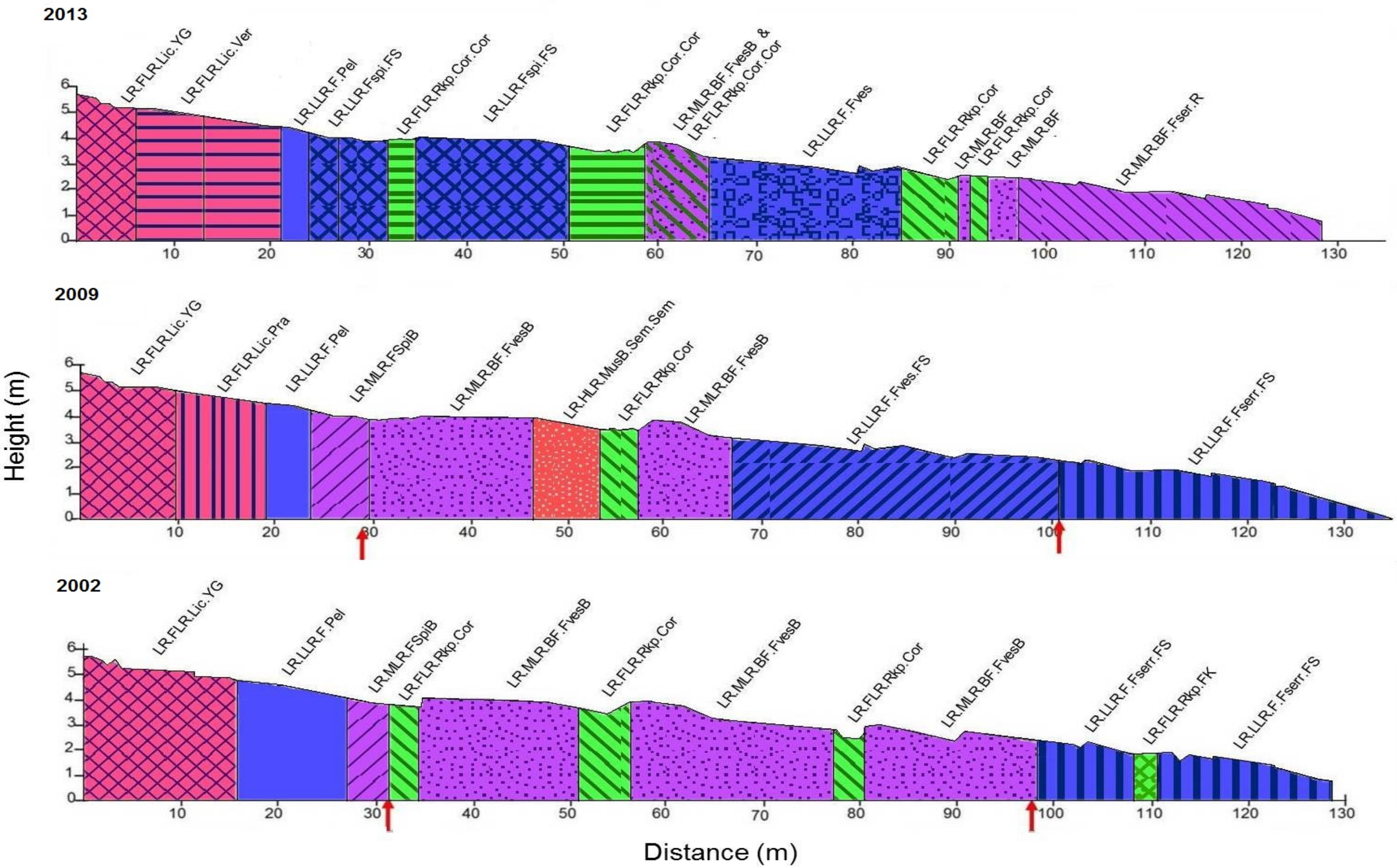


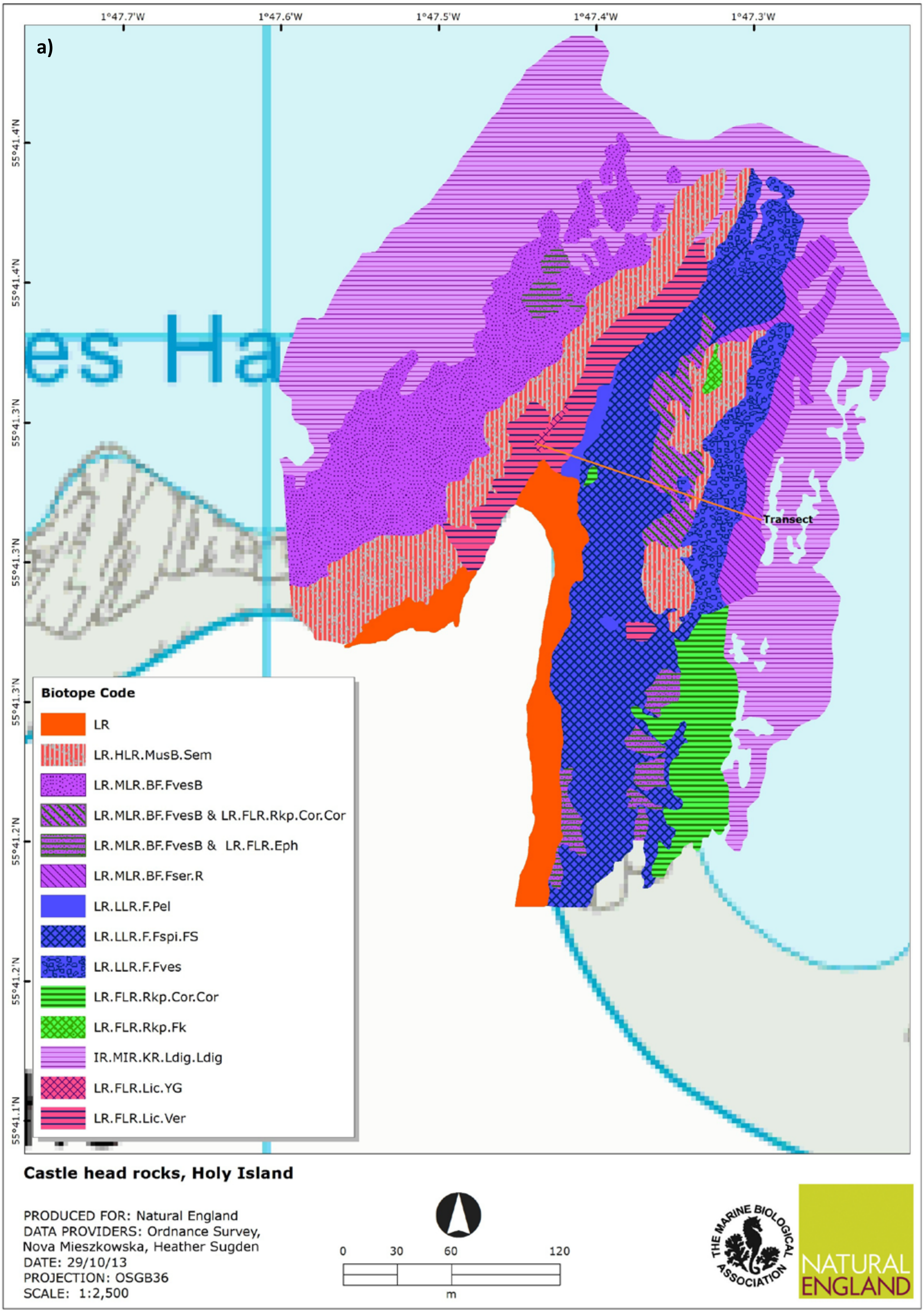
Figure 25: a) Shore height profile for the fixed transect survey at Castlehead Rocks with biotope boundaries marked, b) 2010 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation, for 2009 and 2002 the transects have been divided into an upper, mid and lower shore at boundaries between biotopes at approximately the same position on the shore (marked by the red arrows).

3.7.3 Phase I Survey

A total of 14 biotopes were recorded during the Phase I survey in both 2009 and 2013 with 4 biotopes recorded during both surveys (Table 13). Castlehead Rocks had similar biotopes present on the eastern side of the reef in the vicinity of the transect in 2009 and 2013 (Figure 26). However, between the transect and the sandy beach to the south the rock was dominated by *S. balanoides* and *R. floridula* in 2009 but by F*. spiralis, F. vesiculosus*, patches of ephemeral green algae and shallow coralline pools in 2013. On the western reef the succession of platforms was recorded to have bare rock in the upper eulittoral and patches of barnacles and mussels in the mid eulittoral, with *F. serratus* dominating the lower eulittoral in 2009. This was not the case in 2013, where yellow and green lichens in the supralittoral were succeeded by barnacle and *F. vesiculosus* mosaics in the upper and mid eulittoral, followed by *F. serratus*. There is no evidence to suggest that this has been caused by anthropogenic influences, with no reported disturbances to the rocky reefs in this area, and would therefore be considered to be a result of natural change. The 2013 assemblage and vertical zonation patterns recorded are what would be typically expected of a semi- to exposed sloping bedrock shore in the region under 'natural' conditions. The presence of *R. floridula* on the reef section close to the beach in 2009 is likely the result of sediment deposition in the vicinity of the beach. Again this is likely to be the result of shifting local hydrodynamics and weather driven sea conditions, with a change to fucoid domination once the sediment had been removed from the area by wave action.

Table 13: Phase I biotopes recorded in 2009 and 2013 at Castlehead Rocks in the Berwickshire and North Northumberland Special Area of Conservation with the dominant species in each biotope

Biotope Code	2009	2013	Dominant Species
LR.MLR.BF.Fser	■		*Fucus serratus*
LR.MLR.BF.FvesB	■	■	*Fucus vesiculosus*
LR.MLR.BF.Rho	■		*Rhodothamniella floridula*
LR.LLR.F.Fserr	■		*Fucus serratus*
LR.LLR.F.Fserr.FS	■		*Fucus serratus*
LR.LLR.F.Fspi	■		*Fucus spiralis*
LR.LLR.F.Pel	■	■	*Pelvetia canaliculata*
LR.LLR.FR.Him	■		*Himonthalia elongata*
LR.FLR.Lic.Ver.B	■		*Verrucaria maura*
LR.FLR.Lic.Ver.Ver	■		*Verrucaria maura*
LR.FLR.LicYG	■	■	*Xanthoria parietina & Caloplaca marina*
LR	■	■	*Fucus serratus & Laminaria digitata*
LR.HLR.MusB.MytB	■		*Mytilus spp & Semibalanus balanoides*
LR.HLR.MusB.Sem.Sem	■		*Semibalanus balanoides & Patella vulgata*
LR.HLR.MusB.Sem		■	*Semibalanus balanoides & Patella vulgata*
LR.MLR.BF.FvesB / LR.FLR.Rkp.Cor.Cor		■	*Fucus vesiculosus / Coralline algae*
LR.MLR.BF.FvesB / LR.FLR.Eph		■	*Fucus vesiculosus / Ulva intestinalis*
LR.MLR.BF.Fser.R		■	*Fucus serratus*
LR.LLR.F.Fspi.FS		■	*Fucus spiralis*
LR.LLR.F.Fves		■	*Fucus vesiculosus*
LR.FLR.Rkp.Cor.Cor		■	*Coralline algae*
LR.FLR.Rkp.FK		■	
IR.MIR.KR.Ldig.Ldig		■	*Laminaria digitata*
LR.FLR.Lic.Ver		■	*Verrucaria maura*



1°47.7'W
1°47.6'W
1°47.5'W
1°47.4'W
1°47.3'W
55°41.4'N
55°41.4'N
55°41.3'N
55°41.3'N
55°41.3'N
55°41.2'N
55°41.2'N
55°41.1'N
a)
Transect
Biotope Code
LR
LR.HLR.MusB.Sem
LR.MLR.BF.FvesB
LR.MLR.BF.FvesB & LR.FLR.Rkp.Cor.Cor
LR.MLR.BF.FvesB & LR.FLR.Eph
LR.MLR.BF.Fser.R
LR.LLR.F.Pel
LR.LLR.F.Fspi.FS
LR.LLR.F.Fves
LR.FLR.Rkp.Cor.Cor
LR.FLR.Rkp.Fk
IR.MIR.KR.Ldig.Ldig
LR.FLR.Lic.YG
LR.FLR.Lic.Ver
Castle head rocks, Holy Island
PRODUCED FOR: Natural England
DATA PROVIDERS: Ordnance Survey, Nova Mieszkowska, Heather Sugden
DATE: 29/10/13
PROJECTION: OSGB36
SCALE: 1:2,500
0 30 60 120
m
THE MARINE BIOLOGICAL ASSOCIATION
NATURAL ENGLAND

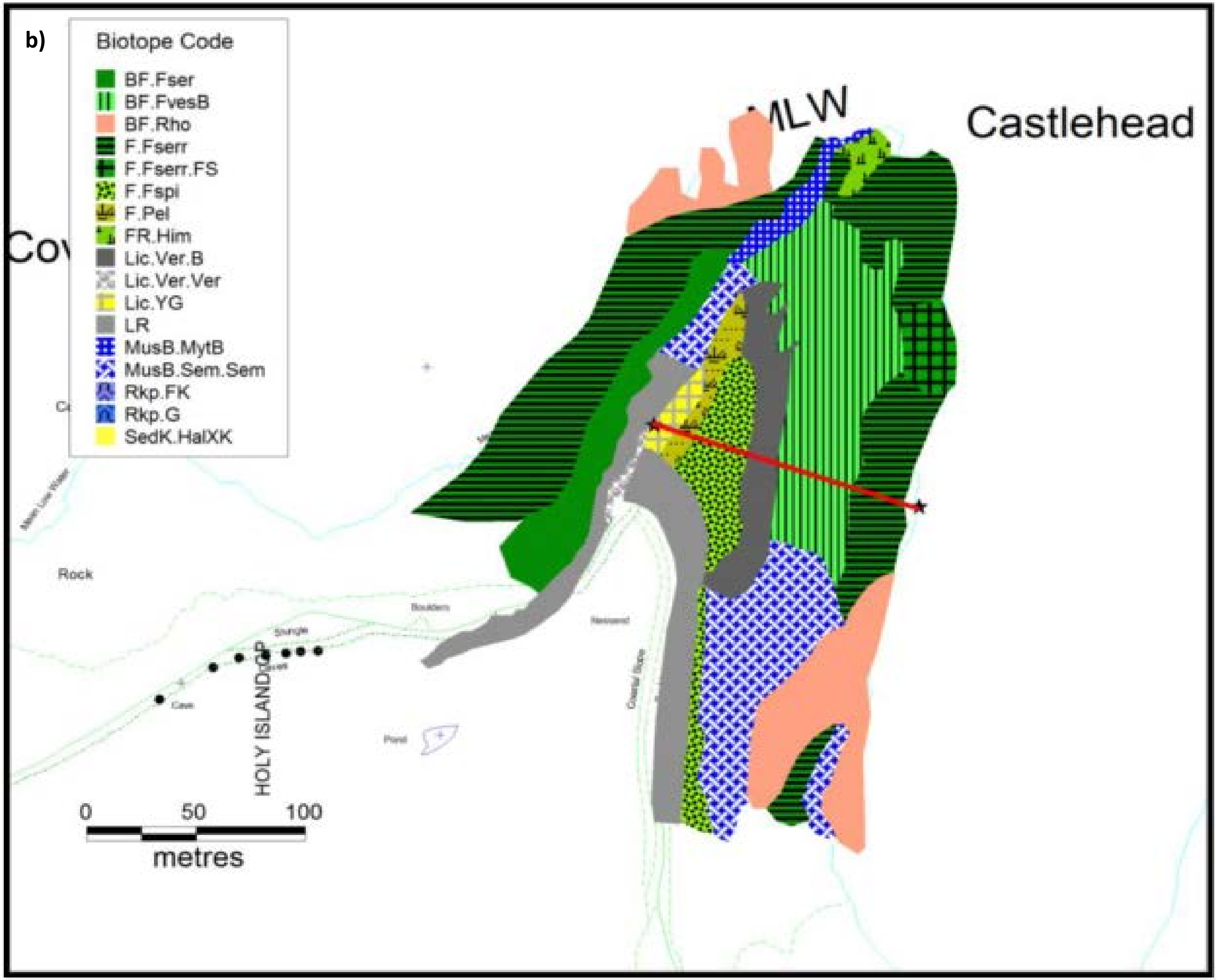


Figure 26: Phase 1 biotope map at Castlehead Rocks in a) 2013 and b) 2009 with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.8 Ladies Skerrs

3.8.1 Site Description

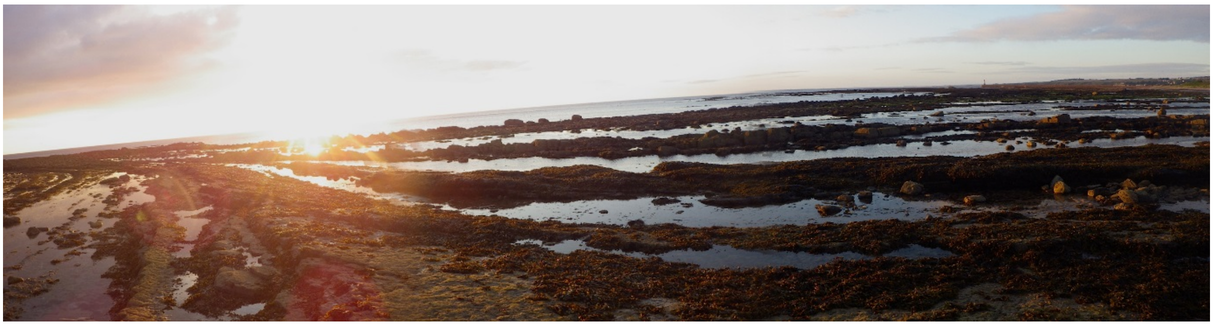


Figure 27: Ladies Skerrs in the Berwickshire and North Northumberland Coast Special Area of Conservation

Ladies Skerrs was a moderately exposed sloping bedrock shore facing an easterly direction (Figure 27). The shore was accessed via public parking at the Magdelene Fields golf club followed by a short walk along the cliff top and down the beach steps (Appendix A). The transect was located in the mid eulittoral area and began on a small section of upper eulittoral bedrock (Figure 28a). The finely bedded sandstone bedrock provided a series of low ridges and extensive shallow pools with large areas of water retention. The rock was weathered and had many pitted and vertical surfaces providing a variety of habitats. There were no large rock features here such as large boulder or overhangs, and the smaller boulder habitat was limited. The upper marker bolt of the transect was been replaced on the top of the bedrock for ease of relocation (Figure 28b).

Figure 28: a) Location placer shot in front of cliffs backing the shore and b) New marker bolt alongside the 2002 marker on the top of the bedrock at Ladies Skerrs in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.8.2 Fixed Transect Survey

The transect at Ladies Skerrs extended 107m down a gradually sloping shore with low ridges and bedrock platforms (Figure 29 & 30). A summary of the transect is shown in Table 14.

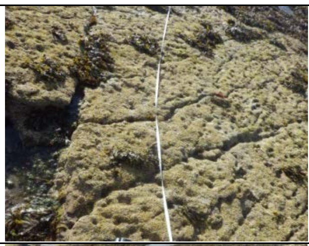
The transect began in the upper eulittoral within barnacle and limpet bedrock habitat containing **S**uperabundant *S. balanoides* and **A**bundant *P. vulgata* (B1). The vertical extent of the upper eulittoral along the transect was 4.6m and only contained this one biotope. This led immediately into the mid eulittoral with a 4m length biotope containing **S**uperabundant *F. vesiculosus* and **A**bundant *S. balanoides* on a bedrock slope (B2). This slope led to the base of a ridge with a shallow coralline rockpool where *Lithothamnion spp.* was **S**uperabundant, *C. officinalis* **A**bundant, *H. siliquosa* **C**ommon, *Ceramium spp.* **C**ommon and *Osmundia pinnatifida* **C**ommon (B3). The ridge stepped up onto a second bedrock slope with **S**uperabundant *F. vesiculosus* (B4) and this slope (and biotope) ended 5.8m further down the transect in a shallow coralline rockpool (B5) with the same species as those recorded in B3.

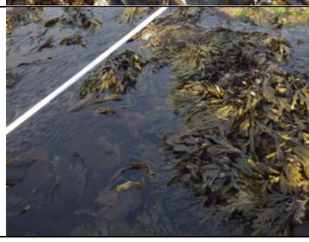
The ridge became more complex here with a series of short ridges and ledges where *F. vesiculosus* and *S. balanoides* dominated (B6) with the same abundances as recorded in B2. A very large shallow pool (17m in width) separated the mid eulittoral from the low eulittoral. The pool was characterised by **C**ommon *F. vesiculosus*, **C**ommon *Fucus serratus* and **C**ommon *H. siliquosa*, along with **A**bundant *O. pinnatifida*, *C.officinalis* and *S. balanoides* (B7).

The low eulittoral was dominated by *F. serratus* but was separated into four distinct biotopes. Firstly low rock ridges with **S**uperabundant *F. serratus*, **C**ommon *Cladphora rupestris* and **C**ommon *S. balanoides* (B8) were recorded in an 11.19m length biotope. As the barnacles declined in abundance with distance down the transect, **S**uperabundant *R. floridula* and **A**bundant *Ulva intestinalis* were recorded for the next 14.57m (B9). Fingers of bedrock with **C**ommon *L.digitata* and **O**ccasional *S. latissima* stretched for 19.24m (B10) before the transect ended with **S**uperabundant *F. serratus* and **A**bundant *L. digitata* on bedrock and boulders extending over the final 20m (B11).

The infralittoral fringe beyond the end of the transect supported kelps with **A**bundant *L. digitata* and *L. hyperborea* and **F**requent *S. latissima, A. esculenta* and *H.elongata*.

Table 14: Biotope descriptions along the fixed transect survey at Ladies Skerrs in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1	LR.HLR.MusB.Sem Barnacle and limpet bedrock	0.0-4.6	
B2	LR.MLR.BF.FvesB *Fucus vesiculosus* and *Semibalanus balanoides* on bedrock	4.6-8.6	
B3	LR.FLR.Rkp.Cor Shallow coralline pools	8.6-10..3	
B4	LR.LLR.F.Fves.FS *Fucus vesiculosus* on bedrock	10.3-16.1	
B5	LR.FLR.Rkp.Cor Shallow coralline pools	16.1-19.99	
B6	LR.MLR.BF.FvesB *Fucus vesiculosus* and *Semibalanus balanoides* on bedrock – Second occurrance	19.99-26.5	
B7	LR.FLR.Rkp.Cor (Complex with B6) Large shallow pool	26.5-42.0	

B8	LR.MLR.BF.Fser.R *Fucus serratus* low rock ridges	42.0-53.19	
B9	LR.MLR.BF.Fser.R & LR.FLR.Eph *Fucus serrauts* and *Ulva intestinalis* ledges	53.19-67.76	
B10	LR.MLR.BF.Fser.R *Fucus serratus* fingers	67.76-87.0	
B11	IR.MIR.KR.Ldig *Fucus serratus* and *Laminaria digitata* on bedrock and boulders	87.0-107.0	

The biotope classifications, vertical order and extent within the fixed transect at Ladies Skerrs were very similar to both transects surveys in 2002 and 2009. The only notable difference was recorded in the mid eulittoral where a previous biotope of *Rhodothamniella floridula* had been replaced by one dominated by ephemeral algae and *Fucus serratus* (Figures 29 & 30).

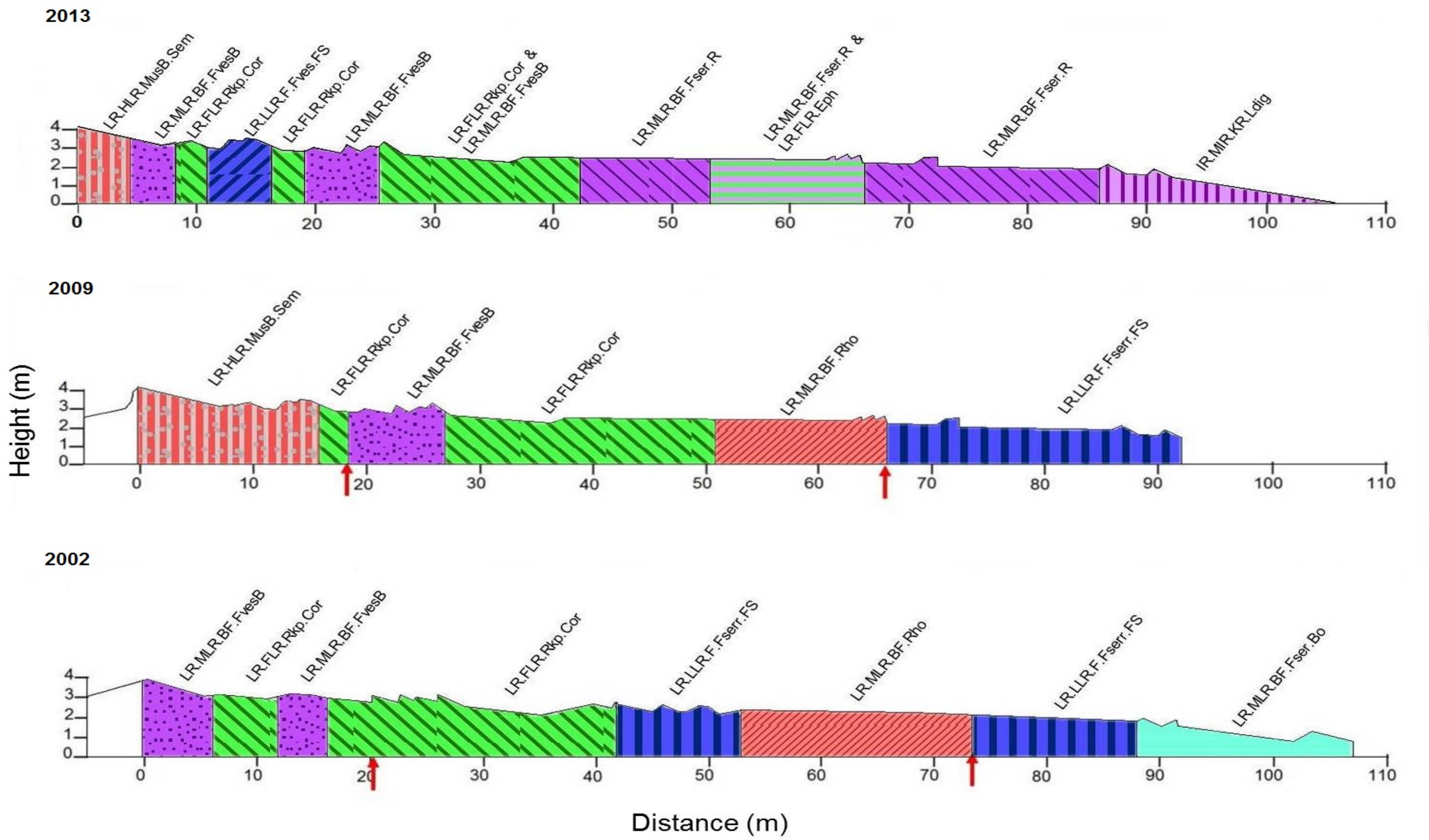


Figure 29: a) Shore height profile for the fixed transect survey at Ladies Skerrs with biotope boundaries marked, b) 2010 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation, for 2009 and 2002 the transects have been divided into an upper, mid and lower shore at boundaries between biotopes at approximately the same position on the shore (marked by the red arrows).

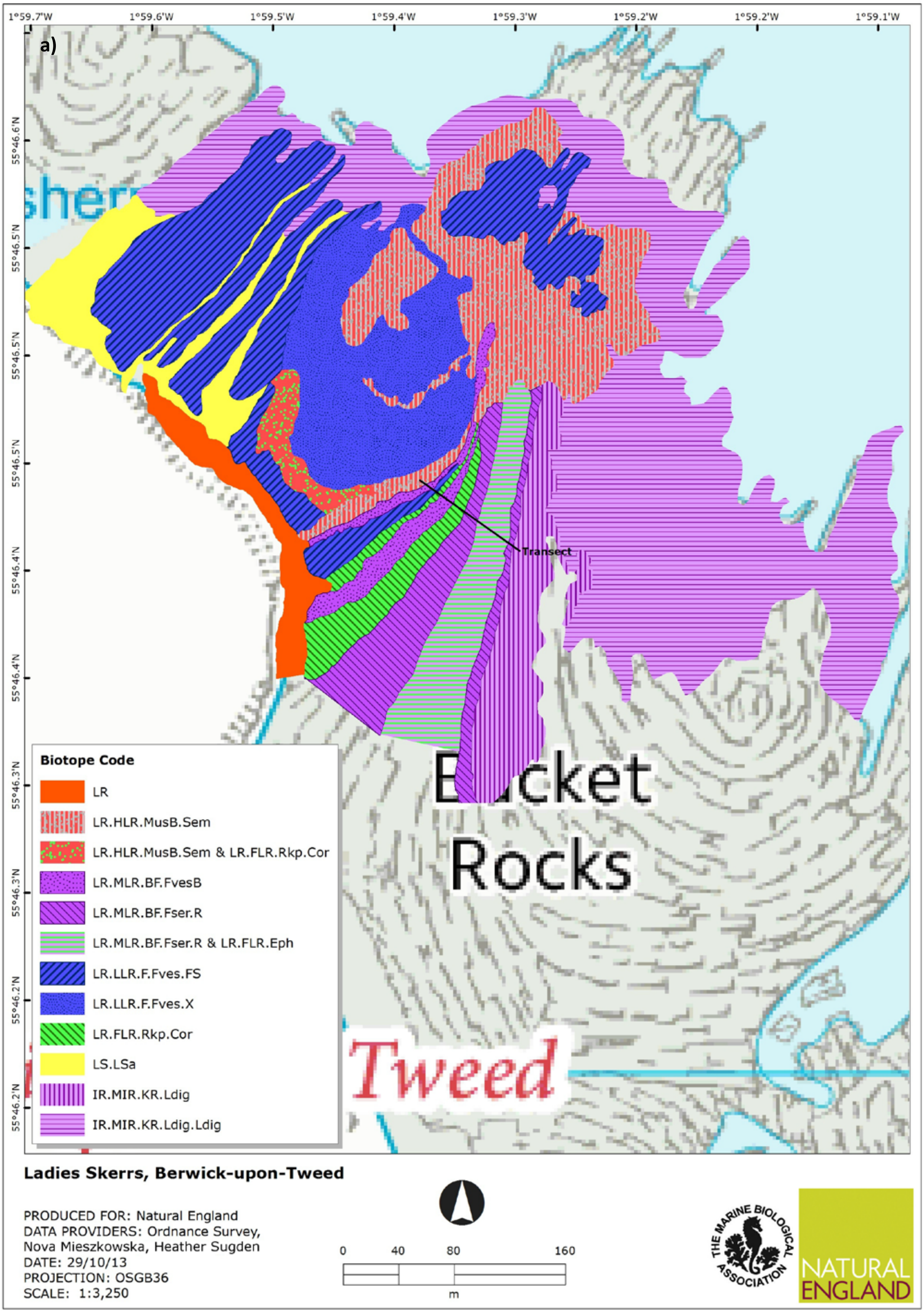
3.8.3 Phase I Survey

The Phase I survey report 14 biotopes present in the 2009 survey (not all biotopes shown in the map are present in the key and are therefore unknown in the context of this map) compared to 12 biotopes present in the 2013 survey with 4 biotopes in common (Table 15). The Phase I biotope maps at Ladies Skerrs for 2009 and 2013 have similar biotopes present in the region where the fixed transect was located, although there is less detail in the 2009 map compared to the transect (Figure 30). Out on the point the 2009 survey recorded all intertidal rock covered in fucoids, whereas in the 2010 MarClim survey and 2013 Phase I survey the upper and mid-eulittoral habitat was dominated by barnacles, with *F. vesiculosus* and *F. serratus* in the mid to low eulittoral. There is no evidence to suggest that this has been caused by anthropogenic influences, with no reported disturbances to the rocky reefs in this area, and would therefore be considered to be a result of natural change possibly as the result of shifting sediments. Alternatively this could be recorder error since natural change resulting in the loss of large fucoid plants on this scale would be unusual in the space of a one year cycle. The large bowl that formed the centre of Ladies Skerrs was classified as a coralline algal pool in 2009, whereas in 2013 it was a *F.vesiculosus* biotope.

The presence of patches of *Mytilus* spp. at several shores in 2009 but not in 2013 demonstrated how mussel beds can be temporally variable and a single spatfall can colonize for a few years but then disappear if no new propagules settle in that habitat.

Table 15: Phase I biotopes recorded in 2009 and 2013 at Boulmer in the Berwickshire and North Northumberland SAC with the dominant species in each biotope

Biotope Code	2009	2013	Dominant Species
LR.MLR.BF.Fser	■		*Fucus serratus*
LR.MLR.BF.FvesB	■	■	*Fucus vesiculosus*
LR.LLR.F.Fserr	■		*Fucus serratus*
LR.LLR.Fves.FS	■	■	*Fucus vesiculosus*
FR.Him	■		*Fucus vesiculosus*
IR.MIR.KR.Ldig.Ldig	■	■	*Himonthalia elongata*
LR.FLR.Lic.Ver.B	■		*Laminaria digitata*
LR	■	■	*Verrucaria maura*
LR.HLR.MusB.MytB	■		*Mytilus spp & Semibalanus balanoides*
LR.HLR.MusB.Sem.FvesR	■		*Semibalanus balanoides & Fucus vesiculosus*
LR.HLR.MusB.Sem.Sem	■		*Semibalanus balanoides*
LR.FLR.Rkp.Cor	■	■	*Coralline algae*
LR.HLR.MusB.Sem		■	*Semibalanus balanoides*
LR.HLR.MusB.Sem / LR.FLR.Rkp.Cor		■	*Semibalanus balanoides / Coralline algae*
LR.MLR.BF.Fser.R		■	*Fucus serratus*
LR.MLR.BF.Fser / LR.FLR.Eph		■	*Fucus serratus / Ulva intestinalis*
LR.LLR.Fves.X		■	*Fucus vesiculosus*
LS.LSa		■	
IR.MIR.KR.Ldig		■	*Laminaria digitata*


1°59.7'W
1°59.6'W
1°59.5'W
1°59.4'W
1°59.3'W
1°59.2'W
1°59.2'W
1°59.1'W
55°46.6'N
55°46.5'N
55°46.5'N
55°46.5'N
55°46.4'N
55°46.4'N
55°46.3'N
55°46.3'N
55°46.3'N
55°46.2'N
55°46.2'N
a)
Transect
Bucket
Rocks
Tweed
Biotope Code
LR
LR.HLR.MusB.Sem
LR.HLR.MusB.Sem & LR.FLR.Rkp.Cor
LR.MLR.BF.FvesB
LR.MLR.BF.Fser.R
LR.MLR.BF.Fser.R & LR.FLR.Eph
LR.LLR.F.Fves.FS
LR.LLR.F.Fves.X
LR.FLR.Rkp.Cor
LS.LSa
IR.MIR.KR.Ldig
IR.MIR.KR.Ldig.Ldig
Ladies Skerrs, Berwick-upon-Tweed
PRODUCED FOR: Natural England
DATA PROVIDERS: Ordnance Survey,
Nova Mieszkowska, Heather Sugden
DATE: 29/10/13
PROJECTION: OSGB36
SCALE: 1:3,250
0
40
80
160
m
THE MARINE BIOLOGICAL ASSOCIATION
NATURAL ENGLAND

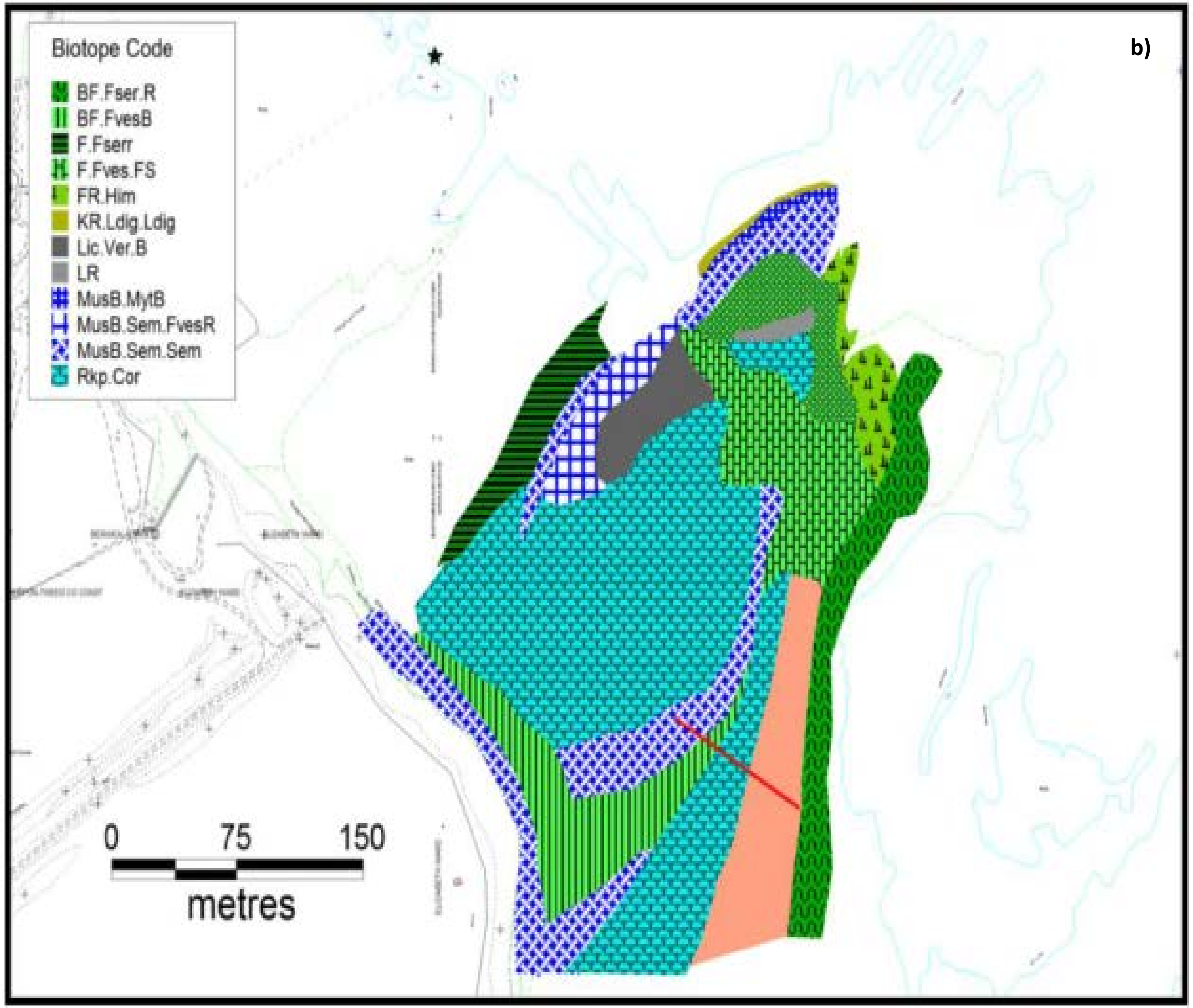


Figure 30: Phase 1 biotope map at Ladies Skerrs in a) 2013 and b) 2009 with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.9 Brotherston's Hole

3.9.1 Site Description

Figure 31: Brotherston's Hole in the Berwickshire and North Northumberland Coast Special Area of Conservation

The transect at Brotherston's Hole was located beneath the golf club, to the south of a sewage outflow pipe and backed by high sandstone cliffs. Access was through the caravan park (Appendix A). Access to the transect site is recommended down the beach steps with a walk to the north across the beach and the rocks. The cliff area above the transect site was a vertical drop to either side and topped with thick bracken and was not recommended as an access route.

Brotherston's Hole was a moderately exposed gently sloping bedrock platform shore facing an east-northeasterly direction (Figure 31). Weathered sandstone bedrock created smooth and pitted surfaces. A variety of habitats were present on the shore including rockpools, vertical rock faces and overhangs with damp sheltered areas. There were some limited underboulder habitats present. The upper transect marker was located on the left entrance wall of a small cave at the base of the cliff (Figure 32a). The upper marker bolt was replaced on the side of this cave to aid relocation (Figure 32b).

Figure 32: a) Top of transect in small cave and b) New marker bolt on the side of the cave at Brotherston's Hole in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.9.2 Fixed Transect Survey

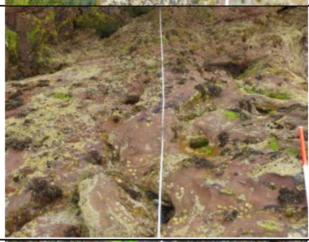
The transect at Brotherston's Hole extended 100m down the gradually sloping broken bedrock shore from the upper marker on the cave wall into the infralittoral kelp bed (Figure 33 & 34). A summary of the transect is shown in Table 16.

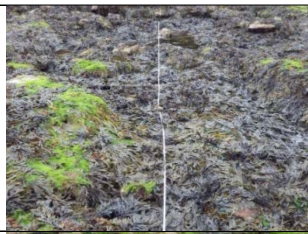
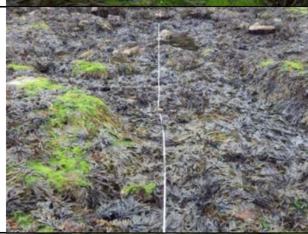
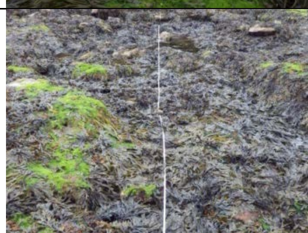
The transect began in the supralittoral zone on the vertical cliff face backing the shore. **A**bundant *Melarhaphe neritoides* characterised the top 2m section of the vertical cliff (B1) whilst **S**uperabundant *V. maura*, **A**bundant *P. vulgata* and **A**bundant *M. neritoides* characterised the lower 3m (B2).

The upper eulittoral around the base of the cliff was very damp and shaded even at midday. This section of the transect was recorded as the 0m mark along the transect to distinguish the vertidal cliff from the rest of the shore, and supported **A**bundant *C. officinalis*, **A**bundant *P. vulgata* and **C**ommon *F. vesiculosus* to a distance of 6.4m (B3). Near-horizontal bedrock extended 3.8m down the shore with **S**uperabundant *S. balanoides* and **A**bundant *P. vulgata* (B4). As the bedrock habitat stepped down into the mid eulittoral along the transect it became more complex with crevices and cobbles present. **A**bundant *F. vesiculosus* dominated this 4.3m length biotope (B5). Large boulders became a feature on the mid eulittoral and fucoids dominated the area with **S**uperabundant *F. serratus*, **C**ommon *F. vesiculosus* and **A**bundant *Rhodothamniella floridula* extending for 10.8m (B6). Large coralline and green algal pools (1.32m in length) were present and characterized by **S**uperabundant *C. officinalis* and **A**bundant *Blidingia spp.* (B7) before fucoids on bedrock and boulders continued (B8) with the same species as B6.

Moving into the low eulittoral the same four biotopes appeared in several bands down the transect line. **A**bundant *U. intestinalis* and **C**ommon *F. serratus* (B9) was a common feature of the low eulittoral. This appeared on a further three occasions and was always interspersed with **S**uperabundant *F. serratus* and **C**ommon *H. elongata* on bedrock and occasional boulder (B8a & B10). Towards the end of the transect this changed slightly with B9 occurring in the middle of two stretches of kelp on bedrock and boulder with **S**uperabundant *L. digitata*, **F**requent *A. esculenta* and **A**bundant *F. serratus* (B11). This biotope extended beyond the end of the transect into the infralittoral.

Table 16: Biotope descriptions along the fixed transect survey at Brotherston's Hole in the Berwickshire and North Northumberland Coast Special Area of Conservation

Biotope Number	Biotope Code and Description	Distance along transect (m)	Photo reference
B1	LR Vertical bedrock with *Melarhaphe neritoides*	5.0-3.0	
B2	LR.FLR.Lic.Ver Vertical bedrock with *Verrucaria maura*	3.0-0.0	
B3	LR.HLR.FR.Coff.Coff *Corallina officinalis* on bedrock	0.0-6.4	
B4	LR.HLR.MusB.Sem.Sem Bedrock and large boulders with *Semibalanus balanoides*	6.4-10.2	
B5	LR.MLR.BF.FvesB *Fucus vesiculosus* on bedrock	10.2-14.5	
B6	LR.LLR.F.Fserr.X Fucoid bedrock and boulders	14.5-24.58	
B7	LR.FLR.Rkp.Cor.Cor Coralline and green algal pools	24.58-25.9	

B8	LR.LLR.F.Fserr.X Fucoid bedrock and boulders	25.9-38.88	
B9	LR.HLR.FR.Him & LR.FLR.Eph *Ulva intestinalis* on bedrock and *Himanthalia elongata*	38.88-42.64	
B8a	LR.LLR.F.Fserr.FS *Fucus serratus* on bedrock and occasional boulders	42.64-45.78	
B9	LR.HLR.FR.Him & LR.FLR.Eph Ulva intestinalis on bedrock	45.78-54.28	
B10	LR.LLR.F.Fserr.FS *Fucus serratus* on bedrock and occasional boulders	54.28-61.9	
B9	LR.HLR.FR.Him & LR.FLR.Eph *Ulva intestinalis* on bedrock	61.9-66.0	
B10	LR.LLR.F.Fserr.FS *Fucus serratus* on bedrock and occasional boulders	66.0-71.74	
B9	LR.HLR.FR.Him & LR.FLR.Eph *Ulva intestinalis* on bedrock	71.74-82.38	

B11	IR.MIR.KR.Ldig.Ldig Kelps on bedrock and boulders	82.38-91.10	
B9	LR.HLR.FR.Him & LR.FLR.Eph *Ulva intestinalis* on bedrock	91.10-94.0	
B11	IR.MIR.KR.Ldig.Ldig Kelps on bedrock and boulders	94.0-99.5	

The biotopes recorded in the upper eulittoral of fixed transect at Brotherston's Hole had changed since the previous surveys in 2002 and 2009. *F. spiralis* was no longer recorded in this area of the transect and had been replaced by coralline algae, *S. balanoides* and *F. vesiculosus. F. serratus* dominated biotopes at the upper boundary of mid eulittoral areas due to very low lying substratum and high water retention. The lower half of the transect was comprised a series of raised ridges and low lying gullies. The gullies here were dominated by *F. serratus* which was consistent with previous years, but the ridges despite having the brown algae *H. elongata* present were also heavily dominated with ephemeral algae in 2013 (Figures 33 & 34).

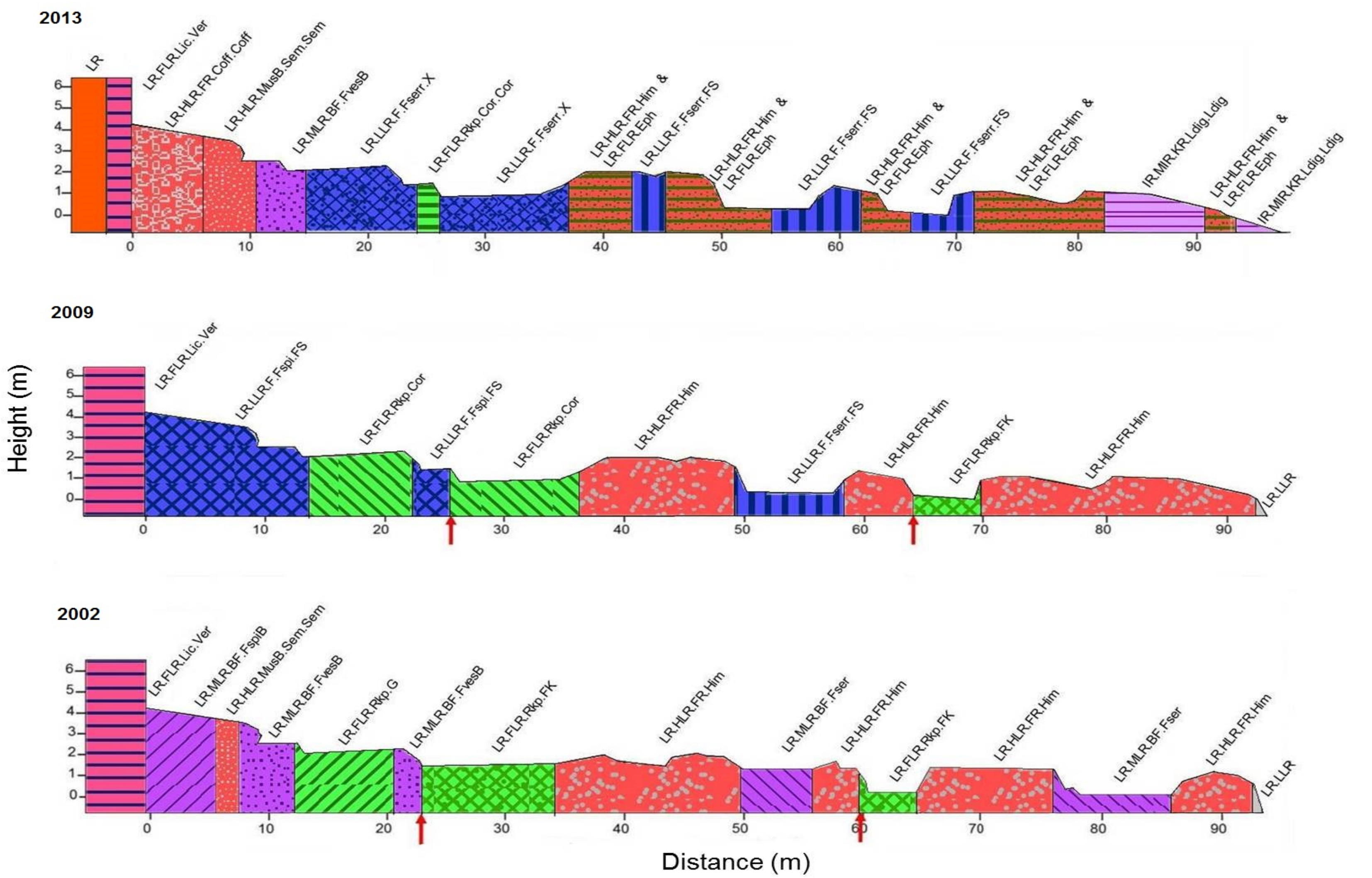


Figure 33: a) Shore height profile for the fixed transect survey at Brotherston's Hole with biotope boundaries marked, b) 2010 survey and c) 2002 survey in the Berwickshire and North Northumberland Coast Special Area of Conservation, for 2009 and 2002 the transects have been divided into an upper, mid and lower shore at boundaries between biotopes at approximately the same position on the shore (marked by the red arrows).

3.9.3 Phase I Survey

The Phase I survey Brotherston's Hole in 2013 provides a baseline of Phase I information as no Phase I survey was carried out in 2009. A total of 16 biotopes were recorded on the shore at Brotherston's Hole (Figure 34). The composition of biotopes on the shore was very complex with raised platforms and gullies supporting different biotopes. In the supralittoral were vertical cliffs with the black lichen *Verrucaria maura* and *Melarhaphe neritoides*. The upper eulittoral was characterised by large areas of ephemeral algae interspersed with barnacle bedrock. The mid eulittoral was made up of biotopes dominated by *Himonthalia elongata* with *Ulva intestinalis* and *Fucus serratus* whilst in the low eulittoral kelps penetrated into the shore through the low lying gullies. To the south of the shore rockpool containing coralline algae were present whilst the extent of *F. serratus* increased to cover the majority of the littoral area.

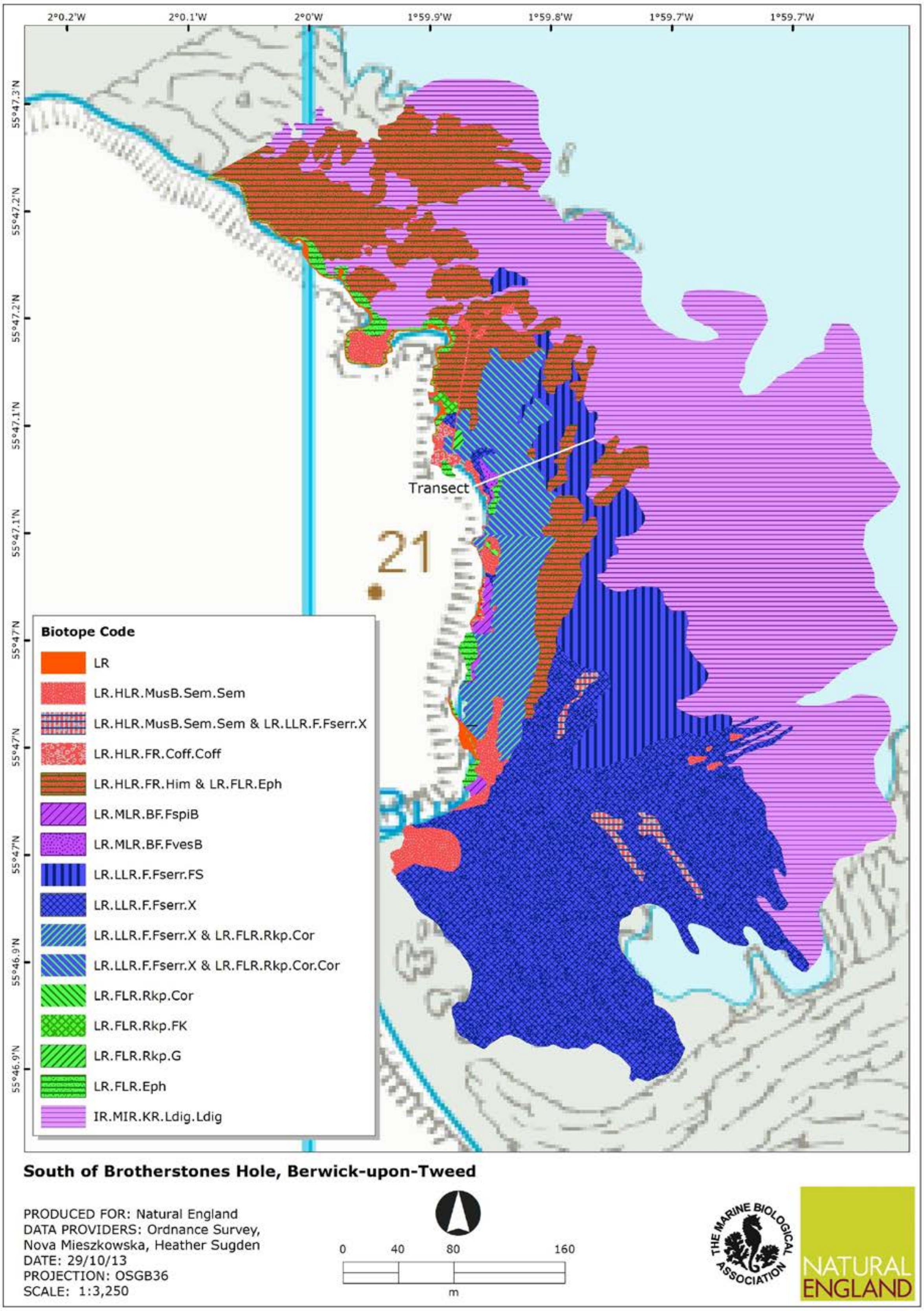


Figure 34: Phase 1 biotope map at Brotherston's Hole with location of fixed transect marked in the Berwickshire and North Northumberland Coast Special Area of Conservation

3.10 Rocky Platforms

Data collected for the replicated quadrat abundance survey were used in the following analyses (Appendix B). Species richness as calculated using Margalef's species richness test that produces a score from 0 (low species richness) to 12 (high species richness) showed significantly differences ($p < 0.001$) between the low eulittoral habitats of the five shores surveyed, varying between 1.44 and 7.46 (Figure 35). Tukey's post-hoc analysis showed that Howick and Inner Farne were not significantly different from each other and had greater species richness than all other sites. Howick, Inner Farne and Brownsman had significantly higher species richness than Castlehead Rocks and Brotherston's Hole ($P < 0.001$) and there were no significant differences between the latter two sites (Figure 34).

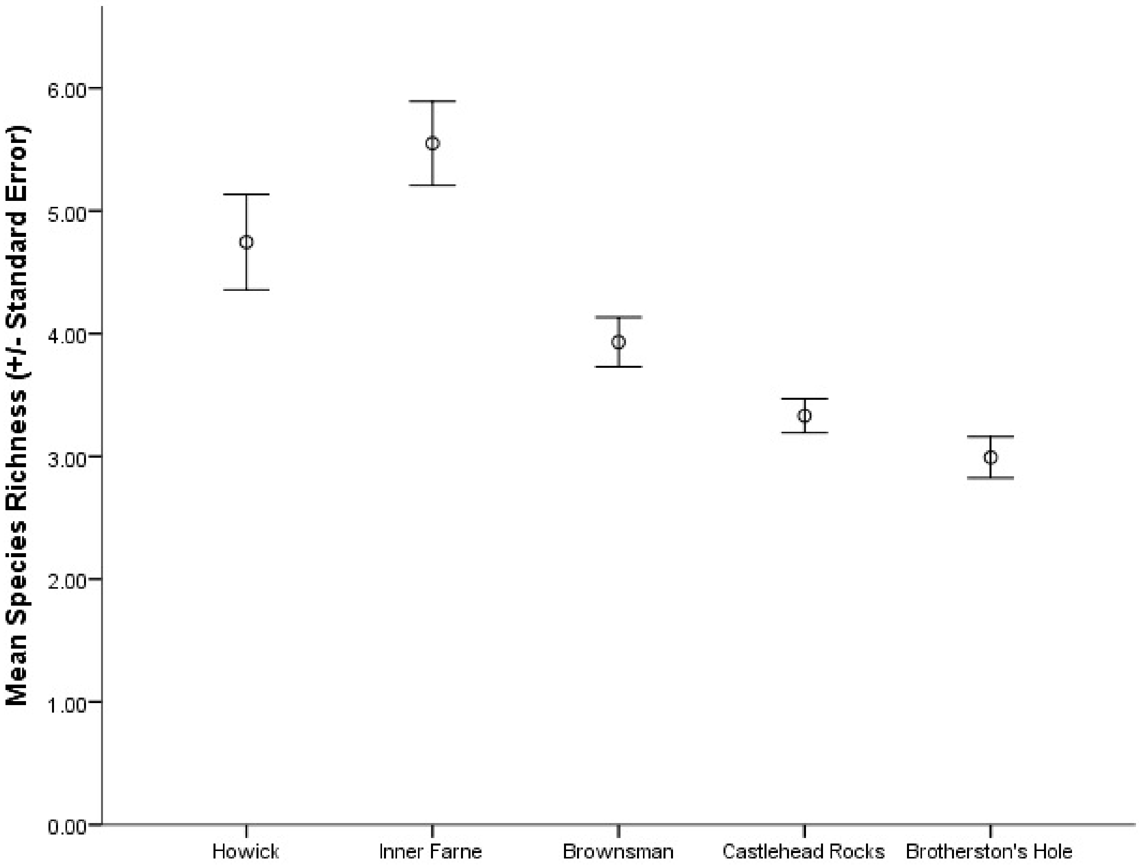


Figure 35: Mean species richness in the low eulittoral rocky platform habitats of the Berwickshire and North Northumberland Coast Special Area of Conservation

Primer software uses a three point scale to assign the degree of dissimilarity between communities based on the derived R statistic: 0-0.25 - few dissimilarities between the communities, 0.25-0.75 - moderate dissimilarities between the communities, 0.75 - 1.0 - High dissimilarities between the communities (Clarke & Gorley 2006). ANOSIM showed significant dissimilarities between the composition of the communities found in the low eulittoral ($R = 0.348$, $p = 0.01$) with the largest differences in community occurring between

Brownsman and Castlehead Rocks (Table 17). Similarity of Percentages (SIMPER) attributed the majority of these differences to the contributions of *Cladophora rupestris*, that was not found at Brownsman but was recorded with coverage between 5-70% at Castlehead Rocks, *Fucus serratus*, absent from Brownsman but recorded as 100% cover in every quadrat at Castlehead Rocks and *Patella ulysipponensis*, not recorded at Castlehead Rocks but was present in abundances up to 31 individuals per 0.5m x 0.5m quadrat.

Table 17: Species contributions to dissimilarities in community composition in the low eulittoral rocky platform habitat of the Berwickshire and North Northumberland Coast Special Area of Conservation

Pairwise Comparison	R Statistic	Sig. Level (%)	Species Contributions
Brownsman & Castlehead Rocks	0.712	0.1	*Cladophora rupestris* (7.65%) *Fucus serratus* (7.65 %) *Patella ulysipponensis* (7.4%)
Brownsman & Howick	0.365	0.1	*Patella ulysipponensis* (5.86%) *Verrucaria mucosa* (4.64%) *Fucus serratus* (3.90%)
Brownsman & Inner Farne	0.419	0.1	*Patella ulysipponensis* (5.71%) *Palmaria palmata* (5.44%) *Himanthalia elongata* (5.08%)
Brownsman & Bortherston's Hole	0.64	0.1	*Patella ulysipponensis* (4.02%) *Verrucaria mucosa* (1.73%) *Fucus serratus* (1.58%)
Castlehead Rocks & Howick	0.28	0.1	*Corallina officinalis* (1.41%) *Semibalanus balanoides* (1.12%) *Cladophora rupestris* (1.03%)
Castlehead Rocks & Inner Farne	0.385	0.1	*Palmaria palmata* (2.61%) *Ulva intestinalis* (2.36%) *Himanthalia elongata* (2.06%)
Castlehead Rocks & Brotherston's Hole	0.523	0.1	*Ulva intestinalis* (6.75%) *Cladophora rupestris* (6.10%) *Lithothamnion spp.* (5.58%)
Howick & Inner Farne	0.173	0.1	*Palmaria palmata* (4.54%) *Himanthalia elongata* (3.66%) *Ulva intestinalis* (3.41%)
Howick & Brotherston's Hole	0.31	0.1	*Corallina officinalis* (1.86%) *Lithothamnion spp.* (1.30%) *Ulva intestinalis* (1.21%)
Inner Farne & Brotherston's Hole	0.339	0.1	*Lithothamnion spp.* (3.84%) *Palmaria palmata* (3.8%) *Corallina officinalis* (3.30%)

Multi-Dimensional Scaling Ordination (MDS) of the species composition from replicate quadrat data in the lowshore area for each shore showed how each datapoint, representing a species assemblage within an individual replicate quadrat spread away from the central similarity point. The MDS plot revealed that Howick and Inner Farne had a higher spread of datapoints than Brownsman, Brotherston's Hole and Castlehead Rocks due to higher variation in the species present within the 30 replicate quadrats. This reflected the higher species diversity at these two sites, with 49 and 51 species respectively as opposed to 24 species recorded at Brownsman and Brotherston's Hole and 21 species at Castlehead Rocks. These high diversity sites contained similar species to the lower diversity sites but with far more macroalgal species also present. Note that the stress value of the ordination was 0.13 and should be interpreted with caution (Figure 36).

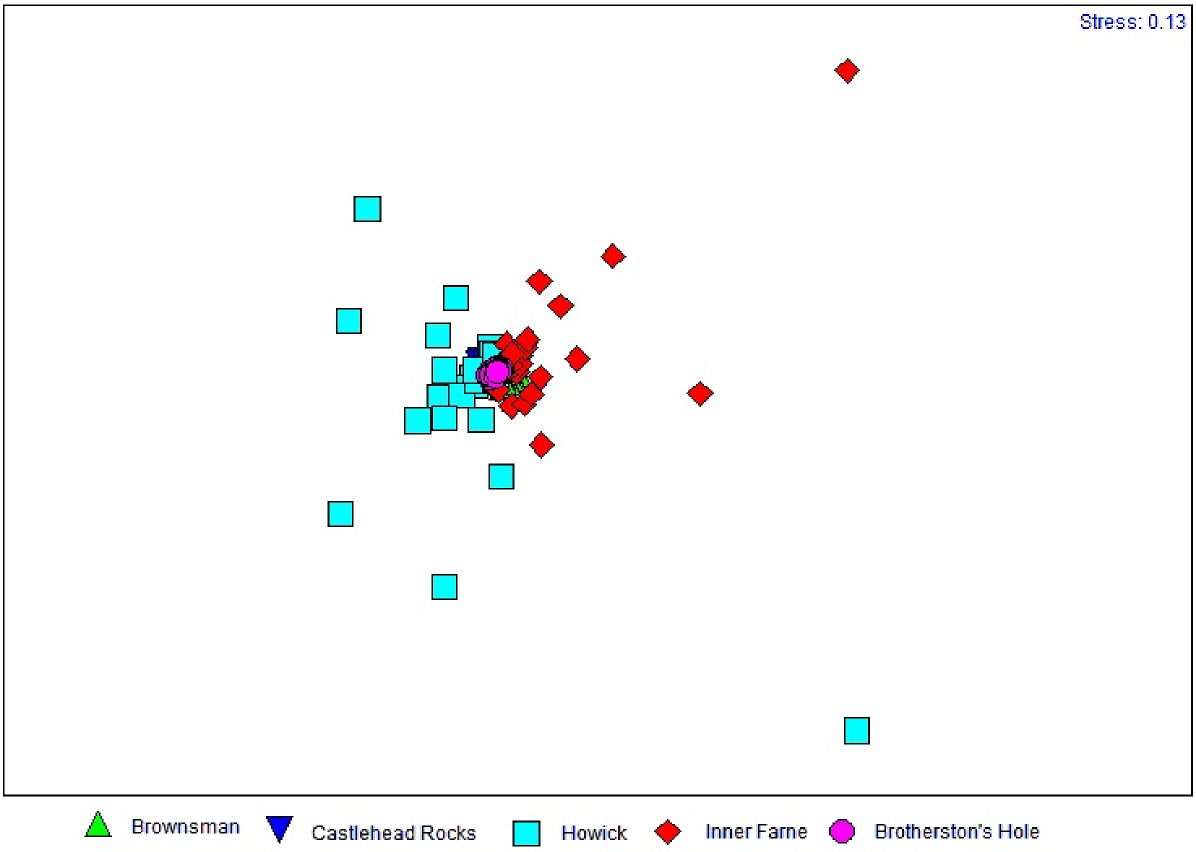


Figure 36: Multi-Dimensional Scaling Ordination of species composition within quadrats in the low eulittoral rocky platform habitat of the Berwickshire and North Northumberland Coast Special Area of Conservation. Based on Bray Curtis Similarity coefficient, non-standardised data and presence / absence transformations.

Species richness was significantly different (p <0.001) between the mid eulittoral habitats of the five shores surveyed varying between 1.82 (low species richness) and 5.41 (moderate species richness). Tukey's post-hoc analysis showed that Inner Farne was significantly different from all other sites with the highest species richness in the mid eulittoral habitat (p <0.05). Brownsman and Brotherston's Hole were not significantly different from each other but were significantly different from both Howick and Castlehead Rocks (P <0.001). There were no significant differences between Howick and Castlehead Rocks which supported the lowest species richness of the mid eulittoral habitats surveyed (Figure 37).

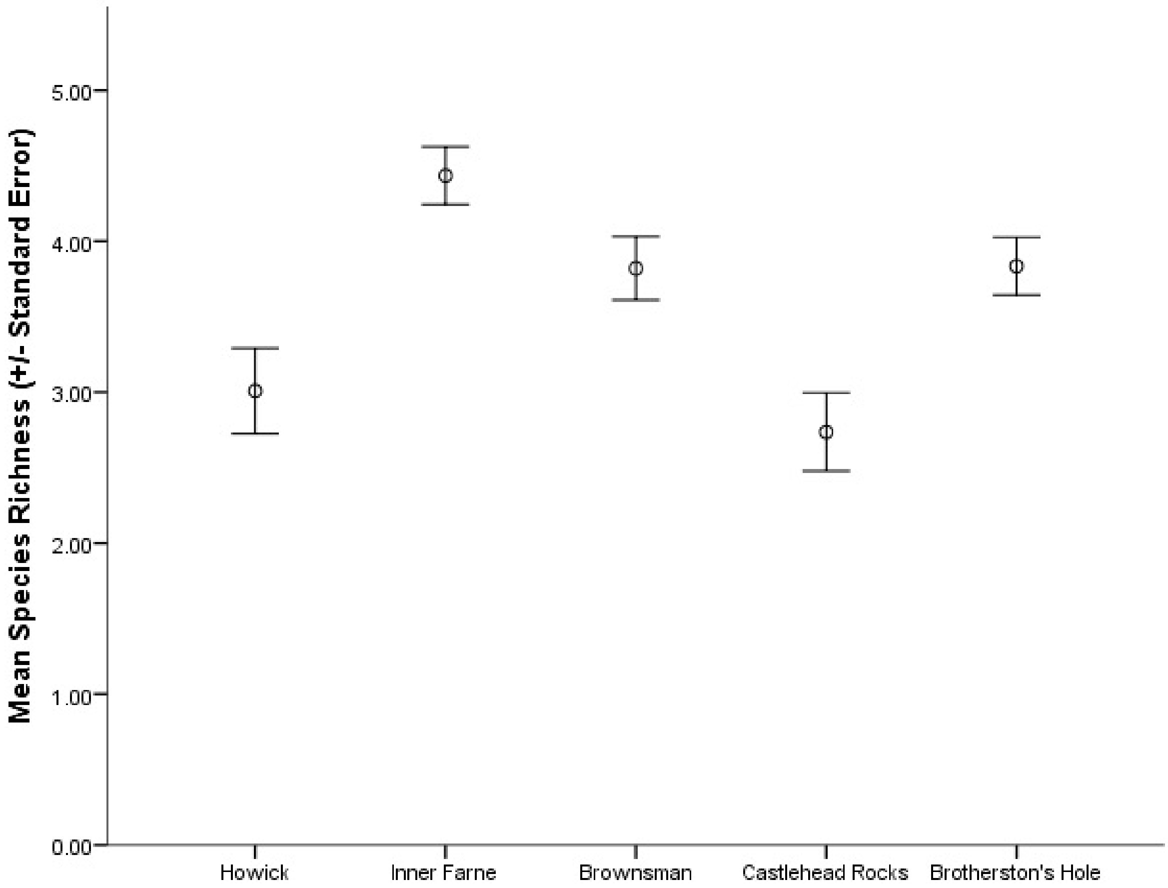


Figure 37: Mean species richness in the mid eulittoral rocky platform habitats of the Berwickshire and North Northumberland Coast Special Area of Conservation

ANOSIM showed some significant dissimilarities between the composition of the communities found in the mid eulittoral (R = 0.327, p = 0.01) with the largest differences in community occurring between Brownsman and Brotherston's Hole (Table 18). SIMPER analysis attributed the majority of these differences to the contributions of *F. serratus,* **S**uperabundant (80-90% coverage per quadrat) at Brotherston's Hole but not found at Brownsman, *Mytilus spp*. not found at Brotherston's Hole but occurring between 0-5% coverage per quadrat at Brownsman and *V. Maura,* not recorded at Brotherston's Hole but present between 20-70% in most quadrats at Brownsman.

Table 18: Species contributions to dissimilarities in community composition in the mid eulittoral rocky platform habitat of the Berwickshire and North Northumberland Coast Special Area of Conservation

Pairwise Comparison	R Statistic	Sig. Level (%)	Species Contributions
Brownsman & Castlehead Rocks	0.363	0.1	*Littorina littorea* (8.97%) *Fucus vesiculosus* (8.39%) *Mytilus spp.* (7.82%)
Brownsman & Howick	0.344	0.1	*Fucus vesiculosus* (9.99%) *Mytilus spp.* (9.31%) *Porphyra spp*. (6.75%)
Brownsman & Inner Farne	0.291	0.1	*Verrucaria maura* (6.29%) *Verrucaria mucosa* (5.75%) *Palmaria palmata* (5.53%)
Brownsman & Brotherston's Hole	0.511	0.1	*Fucus serratus* (6.62%) *Mytilus spp.* (6.45%) *Verrucaria maura* (5.96%)
Castlehead Rocks & Howick	0.195	0.1	*Littorina littorea* (13.04%) *Verrucaria maura* (10.84%) *Lithothamnion spp*. (7.30%)
Castlehead Rocks & Inner Farne	0.307	0.1	*Littorina littorea* (7.70%) *Fucus vesiculosus* (7.45%) *Verrucaria mucosa* (6.39%)
Castlehead Rocks & Brotherston's Hole	0.338	0.1	*Littorina littorea* (8.25%) *Fucus serratus* (7.84%) *Mastocarpus stellatus* (7.76%)
Howick & Inner Farne	0.345	0.1	*Fucus vesiculosus* (7.96%) *Verrucaria mucosa* (6.79%) *Verrucaria maura* (6.66%)
Howick & Brotherston's Hole	0.439	0.1	*Verrucaria maura* (7.91%) *Mastocarpus stellatus* (7.41%) *Fucus serratus* (6.95%)
Inner Farne & Brotherston's Hole	0.395	0.1	*Fucus serratus* (5.66%) *Mastocarpus stellatus* (5.35%) *Verrucaria mucosa* (5.26%)

MDS showed how each data point, representing a species assemblage within an individual replicate quadrat spread away from the central similarity point. Quadrats showed some clustering by site and different species assemblages for each site, represented by the data points being in a different two dimensional location on the MDS plot. Inner Farne and Brownsman were the only two sites where data points occupied a similar space within the MDS, albeit with a wider spread between the data points at Inner Farne. This was due in part to the higher species diversity of 40 species compared to 25 species at Brownsman resulting in a higher number of unique assemblage combinations. The stress value of the ordination was 0.18 and should be interpreted with caution (Figure 38).

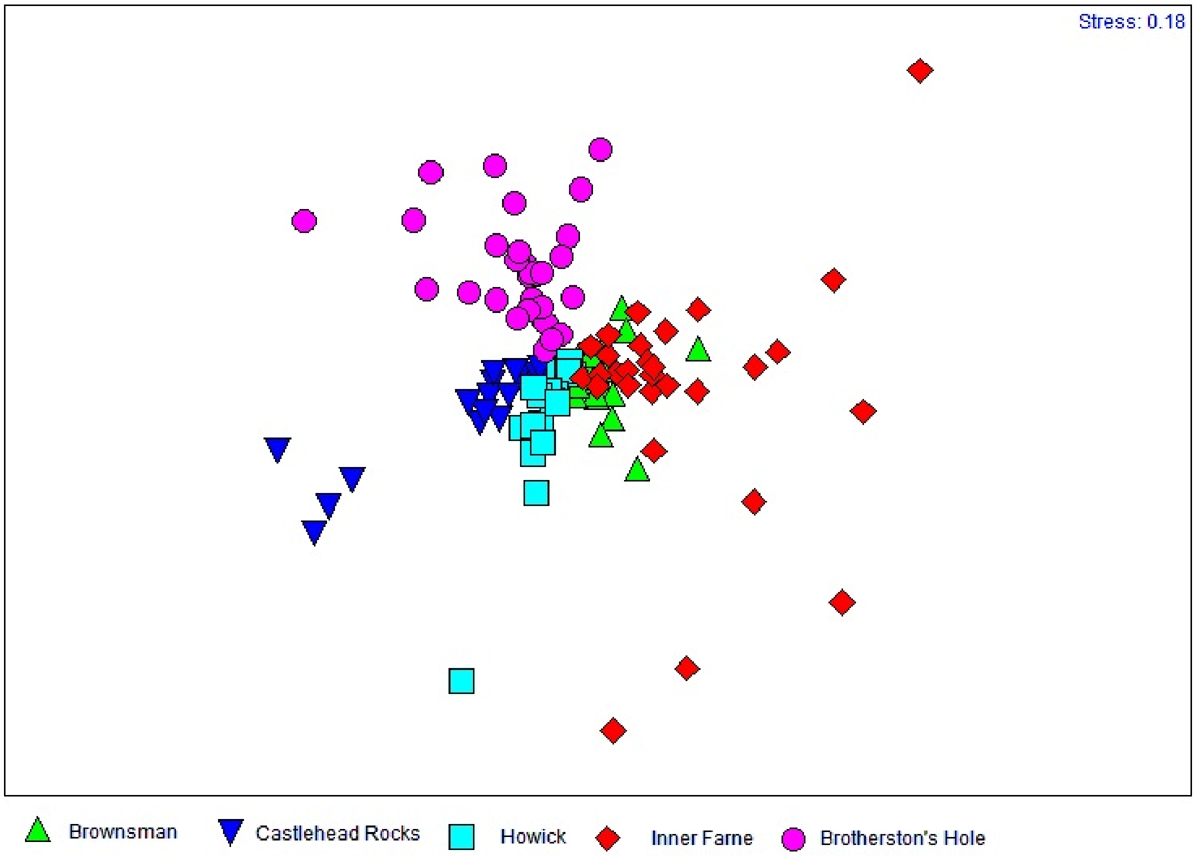


Figure 38: Multi-Dimensional Scaling Ordination of species recorded within replicate quadrats in the mid eulittoral rocky platform habitat of the Berwickshire and North Northumberland Coast Special Area of Conservation. Based on Bray Curtis Similarity coefficient, non-standardised data and presence / absence transformations.

Species-area curves were carried out on the rocky platform quadrat data to examine the relationship between the area of the habitat surveyed and the number of species found within that area (Figure 39). These curves indicated that the quantitative sampling which has been conducted in support of the Phase I and II surveys was of an appropriate level of effort to record the number of species present on each of the shores and that increasing the effort (i.e. number of quadrats conducted on the shore) would not increase the number of species recorded.

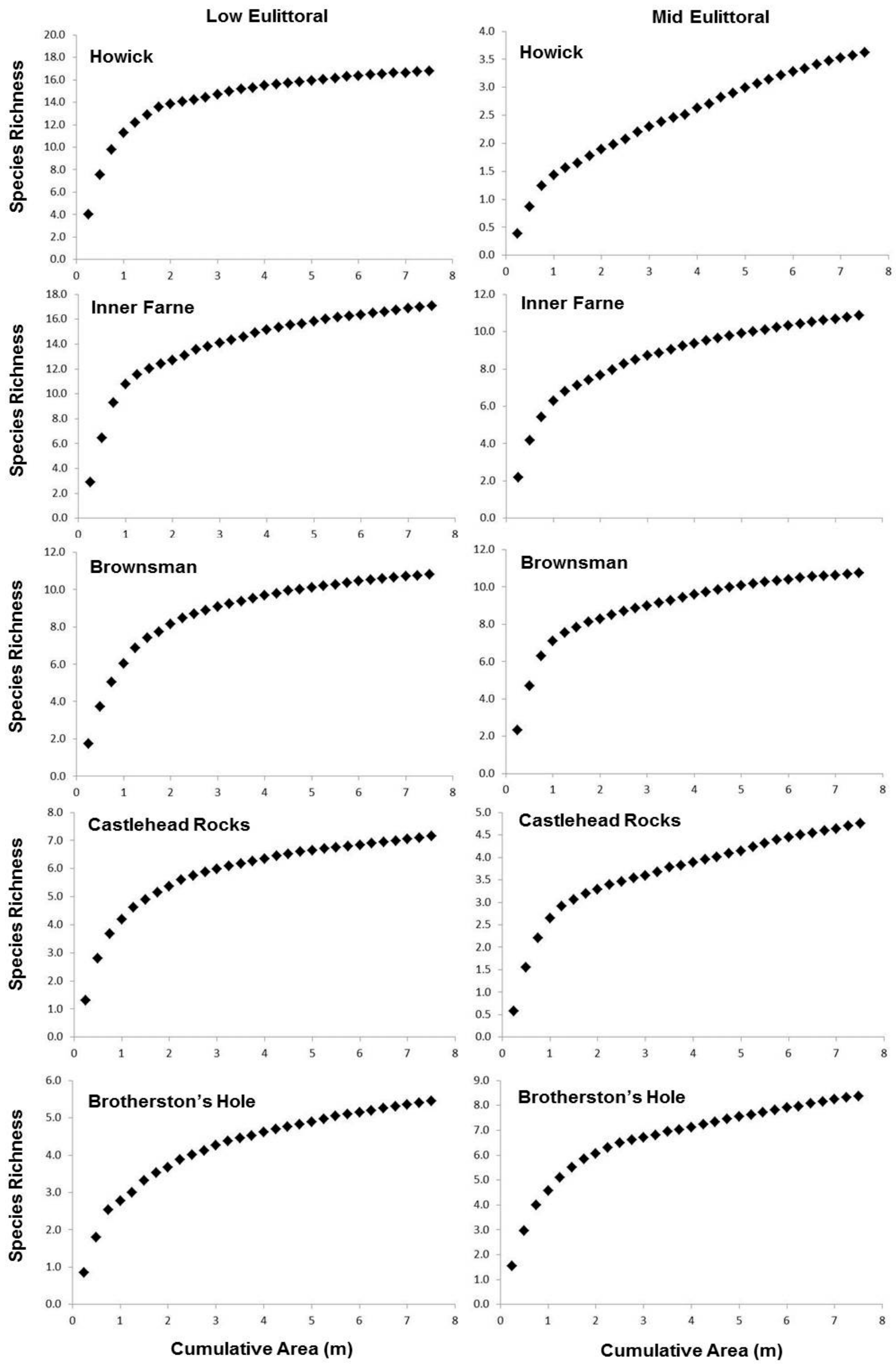


Figure 39: Species-area curve at both the low and mid eulittoral rocky platforms at Howick, Inner Farne, Brownsman, Castlehead Rocks and Brotherston's Hole in the Berwickshire and North Northumberland Special Area of Conservation.

3.11 Boulder Fields

Species richness was significantly different within the midshore at each location ($p = 0.005$) and also in the lowshore at each location ($p = 0.002$). Tukey's post-hoc analysis detected significant differences between Ladies Skerrs (highest species richness) and both Boulmer ($p = 0.020$) and Newton Point ($p = 0.009$) within the mid eulittoral boulderfields, and significant differences between the higher species richness at Newton Point and both Boulmer ($p = 0.003$) and Ladies Skerrs ($p = 0.017$) in the low eulittoral boulderfields (Figure 40).

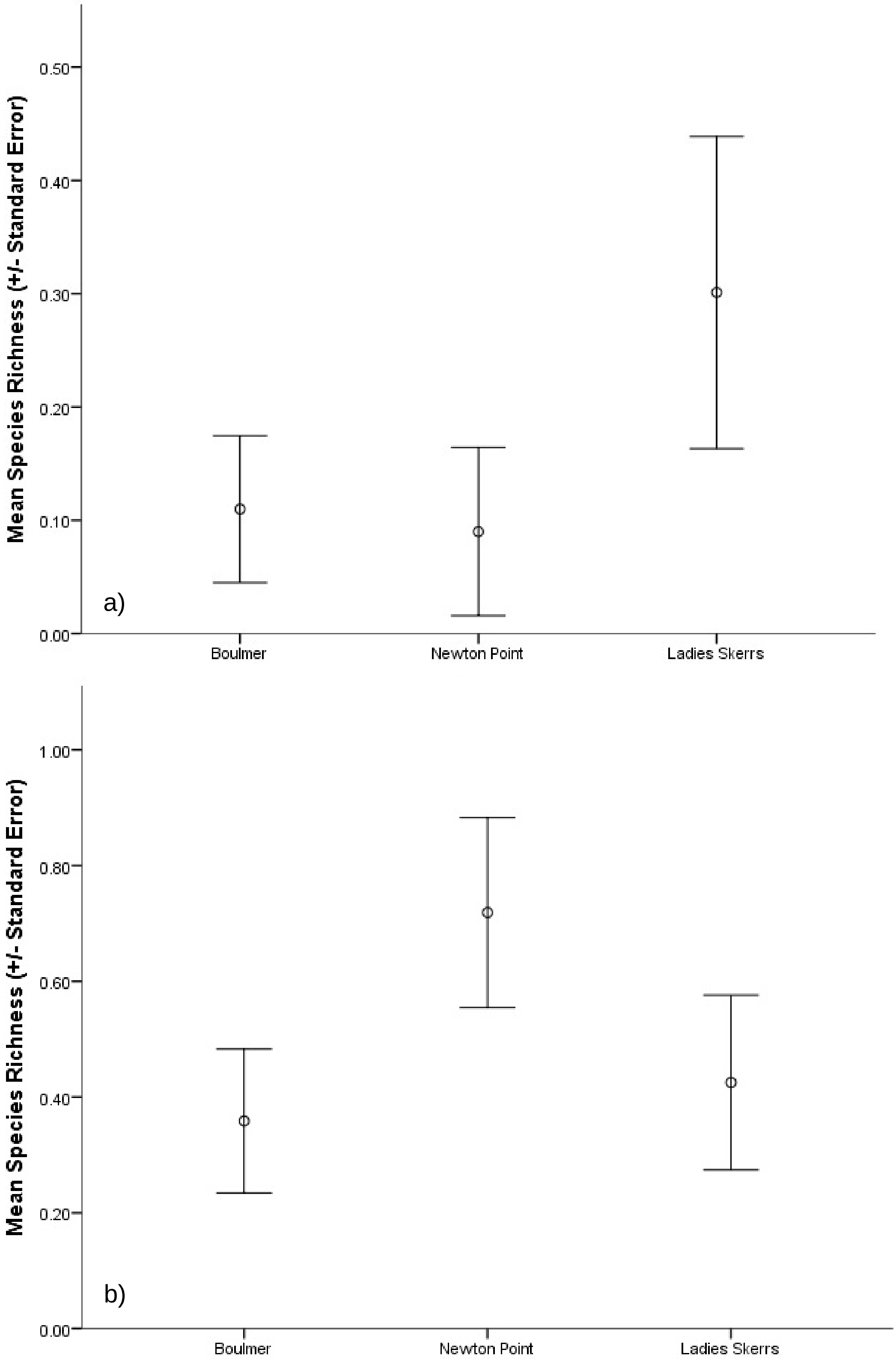


Figure 40: Species richness of under boulder communities in a) mid and b) low eulittoral habitats of the Berwickshire and North Northumberland Coast Special Area of Conservation

ANOSIM showed few significant dissimilarities between the composition of the communities found under boulders in the mid eulittoral (R = 0.262, p = 0.01) with the largest differences in under boulder communities occurring between Boulmer and Newton Point (R = 0.439, p =

0.01). SIMPER attributed the majority of these differences to the contributions of *Spirorbis spirorbis* (57.86%) and *S. balanoides* (28.63%). *S. spirorbis* occurred under 291 of the 625 quadrat intersect points with a mean occurrence of 11.64 times per quadrat at Boulmer, whereas this species was only recorded under 3 out of 625 intersect points with a mean occurrence of 0.12 times per quadrat at Newton Point (Appendix B). *S. balanoides* occurred under 75 intersect points with a mean occurrence of 3 times per quadrat at Boulmer, and 108 times with a mean occurrence per quadrat of 4.32 at Newton Point.

MDS shows a good ordination of these data and supports the results of the ANOSIM with some (R being in the mid-range Primer ANOSIM category, see above) dissimilarities between the underboulder communities in the mid eulittoral (Figure 41).

Figure 41: Multi-Dimensional Scaling Ordination of under boulder communities in the mid eulittoral of the Berwickshire and North Northumberland Coast Special Area of Conservation. Based on Bray Curtis Similarity coefficient, standardised data and square-root transformations.

ANOSIM showed very few significant dissimilarities between the composition of the communities found under boulders in the low eulittoral (R = 0.194, p = 0.01) with the largest differences in under boulder communities occurring between Ladies Skerrs and Newton Point (R = 0.316, p = 0.01). SIMPER attributed the majority of these differences to the contributions of *Oshurkovia littoralis* (20.0%), *Spirorbis spirorbis* (16.35%) and *Lithothamnion spp* (11.51%). *O. littoralis* occurred under 11 out of 625 intercept points with a mean occurrence of 0.44 per quadrat at Ladies Skerrs, and 112 out of 625 points, mean occurrence 4.48 times per quadrat at Newton Point. *S. spirorbis* at Ladies Skerrs was recorded 70 times with a mean occurrence of 2.8 times per quadrat, whereas at Newton it was recorded under 139 intercect points with a mean of 5.6 per quadrat. *Lithothamnion* spp. occurred under 63/625 points (mean 2.52) at Ladies Skerrs, but only 11/625 points (mean 0.44) at Newton Point.

MDS showed tight clustering of species assemblages within and between all three shores, with the exception of one outlier quadrat at Newton Point, indicating very similar species assemblages under the low eulittoral boulders both within and between sites (Figure 42). This outlier quadrat contained very few species when compared to the other 19 quadrats for lowshore boulders at Newton Point, with only one *Actinia equina*, one *Cancer pagurus* and eight *Gibbula cineraria* present. There was no obvious disturbance to this boulder prior to the survey.

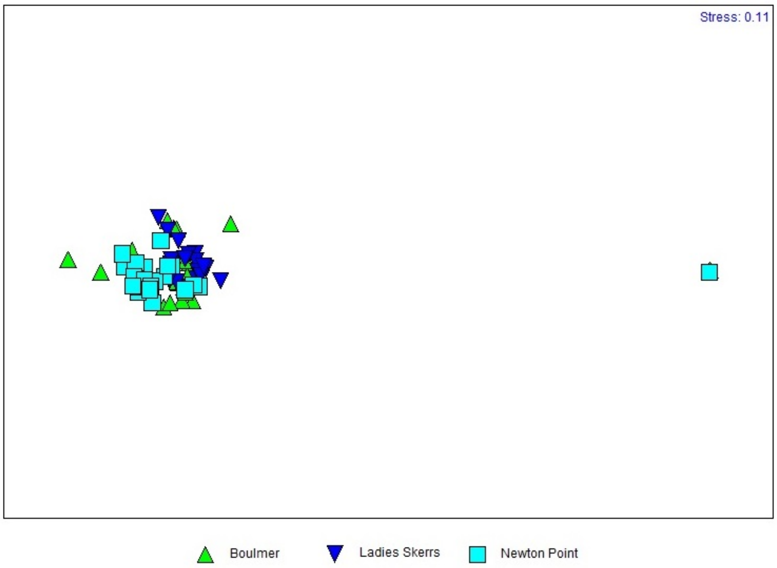


Figure 42: Multi-Dimensional Scaling Ordination of under boulder communities in the low eulittoral of the Berwickshire and North Northumberland Coast Special Area of Conservation. Based on Bray Curtis Similarity coefficient, standardised data and square-root transformations.

Species-area curves were carried out on the under boulder quadrat data to examine the relationship between the area of the habitat surveyed and the number of species found within that area (Figure 43). These curves indicated that the quantitative sampling which has been conducted in support of the Phase I and II surveys was of an appropriate level of effort to record the number of species present on each of the shores and that increasing the effort (i.e. number of quadrats conducted on the shore) would not increase the number of species recorded.

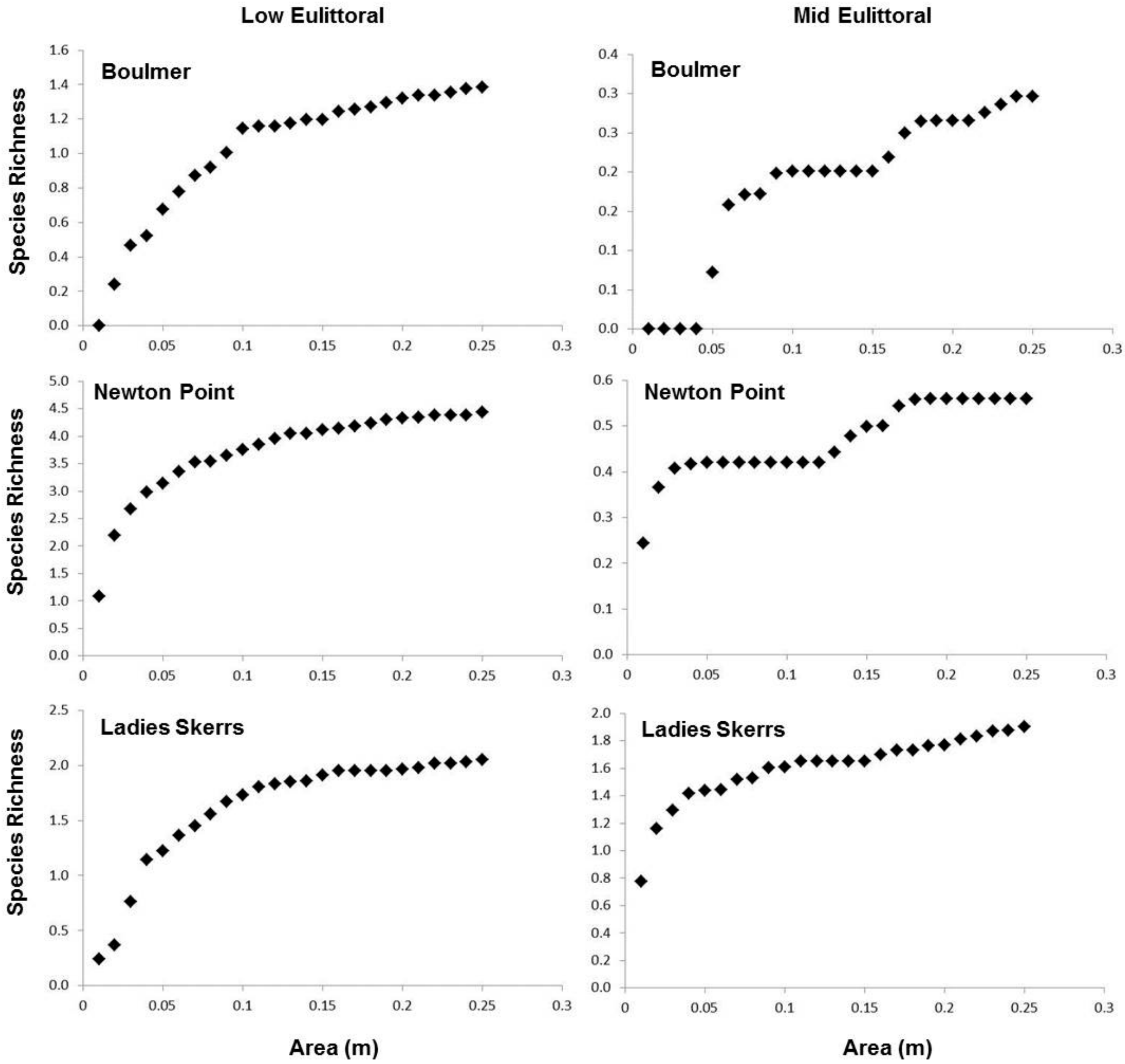


Figure 43: Species-area curve at both the low and mid eulittoral boulder fields at Boulmer, Newton Point and Ladies Skerrs in the Berwickshire and North Northumberland Special Area of Conservation.

4.0 Discussion

4.1 Overall Discussion

The intertidal reefs of the Berwickshire and North Northumberland Coast SAC (BNNC SAC) surveyed for this contract (2013) were macroalgal dominated flat reef and boulder habitats. The geology of the area from Berwick upon Tweed to Boulmer was formed of a repetitive sequence of limestones and sandstones of the Lower Carboniferous period. A significant intrusion of quartz dolerite or 'Whin Sill' formed a series of Dykes from the Tweed to Holy Island and further south at Boulmer, lying in an East North Easterly direction. The Farne Islands formed part of this intrusion and due to the rock resistance to weathering the rock formed a complex series of crags and cracks in littoral habitats. This variety of habitats hosted a moderate diversity of intertidal species in comparison to shores on the mainland such as Castlehead Rocks and Brotherston's Hole. A total of 39 biotopes and 3 biotope complexes were recorded across the BNNC SAC survey area. Statistical comparisons of biotope composition between the eight shores surveyed showed that shores with similar habitat types and exposures (i.e. flat rocky platforms, complex gullies and overhangs or boulder fields) supported similar biotope types and therefore clustered together in multidimensional scaling analyses presented above. In contrast, discrete grouping of shores arising from the statistical analysis of biotope composition showed that different habitat types supported significantly different combinations and numbers of biotopes. This general pattern of biotope distribution matched the species expected if sites were in 'favourable condition' as detailed in Brazier *et al.,* (1996). Sheltered to exposed shores (Boulmer and Brotherston's Hole) were fucoid dominated, whereas moderately exposed shores (Howick, Newton Point, Holy Island, Inner Farne and Brownsman) were populated by barnacle and fucoid mosaics.

4.2 Condition Assessment

The results discussed from this survey have been collected to inform the condition of the BNNC SAC and more specifically the sub-feature 'intertidal rocky reefs' of the reef feature. Table 19 summarises the favourable condition measures and targets for each attribute of the sub-feature of the feature investigated herein. In this table a summary of the results has been provided against the measure of each attribute but in short suggest that there has been little change in the biotopes found along the fixed transects and wider shores of the intertidal rocky reefs in comparison with previous surveys and against the established baselines (Brazier *et al.,* 1996, Foster-Smith 1998).

4.3 Phase I

The Boreal kelp *Alaria esculenta* and the Lusitanian kelp *Sacchoriza polyschides* were both only recorded on the Farne Islands (Inner Farne and Brownsman Island) and not at any mainland sites. The biogeographic range of *A. esculenta* is retreating to higher latitudes with warming of the marine climate and the southern limit in the North Sea has retreated from Robin Hoods Bay (1980s) to Filey Brigg (Bowman, pers. comm, MarClim database). The northern distributional limits of *S. polyschides* are found in the North Sea, and this species has not yet been recorded at abundances greater than isolated individuals within the intertidal zone anywhere north of southwest England (MarClim database). This species has been able to extend north in shallow subtidal habitats due to the less severe cold temperatures compared to the intertidal, and has been occasionally recorded off the coast of northeast England (Howson *et al.* 2006). It is likely that both species were found in the shallow infralittoral during the 2013 survey on the Farne Islands due to the rapid drop off to deeper water from the littoral zone and a lower range of environmental temperatures than in shallower coastal waters on the mainland.

The Phase I surveys of Boulmer in 2009 and 2013 show a very different suite of biotopes and associated vertical zonation from the supralittoral to shallow infralittoral zones, with only three biotopes occurring in the same location in both years. In 2009 no lichens were recorded and the upper to mid eulittoral contained a succession of fucoid biotopes dominated by *F. spiralis*, *F. vesiculosus* and *A. nodosum* in vertical succession before a 50m band of mud and then *F. serratus*, typical of low eulittoral habitats in a gully. Downshore of this, *S. balanoides*, *F. vesiculosus* and reds were followed by *R. floridula*, then a coralline pool, before an unknown biotope (that has no listing on the map key in the 2009 report), before a low eulittoral zone of *F. serratus*. As no information or data was recorded for this unknown biotope we cannot comment on what it may have been, or whether it is the same as recorded in 2013.

In 2013 supralittoral yellow and grey lichens gave way to black lichens before *A. nodosum* dominated the upper to mid eulittoral zone. The muddy patch had converted to *A. nodosum* and ephemeral algae. The gully contained *A. nodosum* and coralline pool species. The lower eulittoral did not contain the *S. balanoides/F.vesiculosus* or *R. floridula* biotopes, instead being colonized by *F. serratus, F. vesiculosus* and *A. nodosum,* leading into coralline pools and then *F. serratus.*

Upon comparison of the 2009 transect biotopes with the 2009 Phase I maps, less than half of the biotopes recorded on the transect are represented on the map despite many being metres in vertical length. In contrast, 15 of the 17 biotopes recorded on the 2013 transect are represented in the Phase I map (two being vertical biotopes and thus having zero horizontal distance). After comparing the transect biotopes in 2009 with the 2013 transect and phase I data we conclude that the differences between biotopes in the Phase I maps are unlikely to reflect a real difference in the intertidal community.

Vertical zonation of biotopes at Howick in the region of the fixed transect were similar between 2009 and 2013, although the same assemblage of *S. balanoides* and *V. maur*a was classified as different biotopes despite *V. maura* being the most abundant species in both years. No *Mytilus* spp. were recorded in 2013. The southern sector of the reef has a different sequence of biotopes in the two years, however, when the component species are compared between surveys these do not differ much, suggesting that operator choice of biotope code was different rather than a huge change in the actual species present and dominant at this site.

At Newton Point the overall composition of the shore comprised of similar biotopes between years, and differences appear again to be due to operator selection of biotope code and the spatial detail at which the maps were drawn (see last paragraph in this section).

Castlehead Rocks had similar biotopes present on the eastern side of the reef in the vicinity of the transect in 2009 and 2013. However, between the transect and the sandy beach to the south the rock was dominated by *S. balanoides* and *R. floridula* in 2009 but by F*. spiralis, F. vesiculosus*, patches of ephemeral green algae and shallow coralline pools in 2013. On the western reef the succession of platforms was recorded to have bare rock in the upper eulittoral and patches of barnacles and mussels in the mid eulittoral, with *F. serratus* dominating the lower eulittoral in 2009. This was not the case in 2013, where yellow and green lichens in the supralittoral were succeeded by barnacle and *F. vesiculosus* mosaics in the upper and mid eulittoral, followed by *F. serratus*. There is no evidence to suggest that this has been caused by anthropogenic influences, with no reported disturbances to the rocky reefs in this area. The pattern of vertical zonation in 2013 is typical of undisturbed semi- to exposed shores, whereas the species present in 2009 would be expected given sediment deposition as can occur in the vicinity of soft sediment habitat. The change in biotopes observed is therefore most likely to be a result of natural change driven by local weather and hydrodynamic conditions.

The Phase I biotope maps at Ladies Skerrs for 2009 and 2013 have similar biotopes present in the region where the fixed transect was located, although there is less detail in the 2009 map compared to the transect. Out on the point the 2009 survey recorded all intertidal rock covered in fucoids, whereas in the 2010 MarClim survey and 2013 Phase I survey the upper and mid-eulittoral habitat was dominated by barnacles, with *F. vesiculosus* and *F. serratus* in the mid to low eulittoral. There is no evidence to suggest that this has been caused by anthropogenic influences, with no reported disturbances to the rocky reefs in this area, and would be unlikely to be the result of shifting sediments as neither *S. balanoides* or fucoids are tolerant of sediment deposition. Alternatively this could be a difference in recorder classification of biotopes since natural change resulting in the loss of large fucoid plants on this scale would be unusual in the space of a one year cycle and the barnacles present were not dominated by juveniles. The large bowl that formed the centre of Ladies Skerrs was classified as a coralline algal pool in 2009, whereas in 2013 it was a *F.vesiculosus* biotope. Our conclusion is that the 2009 surveyors found the same or similar species present but selected different biotope classifications. This is possible given the numerous biotope classifications containing generic or species specific fucoid and barnacle combinations, however, we are confident that our assignment of biotopes is correct as they are based on assessments of quantitative abundance of the dominant species present.

The presence of patches of *Mytilus* spp. at several shores in 2009 but not in 2013 demonstrated how mussel beds can be temporally variable and a single spatfall can colonize for a few years but then disappear if no new propagules settle in that habitat.

Visual comparisons of 2009 vs 2013 maps show a higher degree of spatial detail in the 2013 maps and as a result, more biotopes being recorded. This highlights the degree of operator error / judgement inherent in the Phase I process and thus apparent differences in the size, classification and number of biotopes must be subject to more intense interrogation including comparisons with Phase II data and photographs of the survey sites. In this instance much of the observed differences were not due to significant changes in the species and biotopes present on the shore but to differences in the detail of the maps and to the biotope classifications used for similar species assemblages.

Table 19: Favourable Condition Table for the interest feature Reefs and Sub-Feature Rocky Reefs as detailed in the current Regulation 33 (2)(a) advice for the Berwickshire and North Northumberland Coast Special Area of Conservation

Interest feature	Sub-feature	Attribute	Measure	Target	Comments
Reefs	Rocky shore communities	Distribution of rocky shore communities	Distribution of intertidal rocky shore biotopes (listed in Appendix C) measured using littoral extent during the summer, once during a reporting cycle.	Distribution of intertidal rocky shore biotopes should not deviate significantly from an established baseline (Brazier *et al.*, 1996), subject to natural change.	Small changes in some upper eulittoral biotopes due to sediment scouring between the 2009 and 2013 surveys. The overall distribution of biotopes does not deviate from the established baseline (Brazier *et al.,* 1996), however there were no extensive *Mytilus spp* beds recorded at any of the sites in the BNNC SAC. *Mytilus spp* beds within this region frequently undergo oscillations in habitat occupancy as a result of natural cycles.
	Kelp forest communities (intertidal only within this report)	Distribution of characteristic communities	Distribution of kelp dominated biotopes (in particular the biotopes listed in Appendix C), measured once during the reporting cycle.	Distribution of kelp dominated biotopes should not deviate significantly from an established baseline (Foster-Smith, 1998), subject to natural change.	The previous baseline does not discriminate between the long-term, stable infralittoral fringe dominated by *Laminaria digitata* and the slightly deeper zone dominated by *Laminaria hyperborea*. This zonation within the kelp ark was evident at all sites surveyed. The data collected as part of the current survey could not be compared to the 2002 or 2009 survey as these surveys were unable to access the infralittoral zone. The Boreal kelp *Alaria esculenta* and the Lusitanian kelp *Sacchoriza polyschides* were both only recorded on the Farne Islands (Inner Farne and Brownsman Island) and not at any mainland sites.
		Species composition of characteristic communities	Presence and abundance of composite species (in particular, red algal species, for example LhypR.Ft biotope), measured during summer, once during the reporting cycle.	Presence and abundance of composite species should not deviate significantly from an established baseline (Brazier *et al.,* 1996), subject to natural change.	Presence and abundance of composite species does not deviate from the established baseline but the above point on kelp species also applies here as different epibiota species associated with different kelp species. The data collected as part of the current survey could not be compared to the 2002 or 2009 survey as these surveys were unable to access the infralittoral zone.

4.4 Human activities and impacts

There were a range of human activities occurring within or adjacent to the BNNC SAC that posed a potential risk to biodiversity and the health of the rocky shores; coastal residential developments, sewage and freshwater discharge, agricultural runoff, recreational and commercial small craft mooring, anchoring, sailing and cleaning, commercial ship traffic and tourism (see Section 3.1). These activities could result in the following pressures; domestic waste, accelerated cliff erosion, sewage discharge, agricultural runoff (synthetic chemicals, nitrogenous waste, terrestrial sediment), nutrient and freshwater discharge, sedimentation, marine litter, marine noise, wake wash from powerboats and jetskis, trampling of the foreshore. The presence of, and observed impacts of coastal engineering and anthropogenic activities were very few. Overall, very little litter, either marine or terrestrial, was recorded across the survey area, there were no Invasive Non-Native Species recorded. Artificial coastal defences were not present on any of the shores surveyed within the SAC.

There was an increase in the abundance of ephemeral algae recorded at Boulmer and Brotherston's Hole and this had altered the biotopes recorded at some points along a fixed transect. This occurred at Boulmer in the area of sediment between 55-75m along the transect and at Brotherston's Hole from 38m down to the end of the transect on the top of the rock ridges. Green algae within the Ulvaceae family are ephemeral and founder species, often occurring on intertidal habitats that have been subjected to a disturbance event such as freshwater runoff, scouring, sediment smothering or other removal of existing climax communities. They can occur as part of the natural succession of rocky shore communities but this is only seen during early spring months where bare habitat exists prior to the colonization by marcoalgal sporelings.

Large patches of *Ulva lactuca* and *U. intestinalis* were recorded in the upper and mideulittoral regions at Brotherston's Hole, Newton (on the reef between the Point and the sandy beach at St Mary's Haven), Boulmer and Howick. The occurrence of such large patches was most likely to be due to large movements of sediment throughout the area (*pers. obs.*), as no evidence of freshwater or sewage/terrestrial runoff was found in the vicinity of these areas. No additional data on the presence of ephemeral algae was available for the BNCC intertidal habitats to allow temporal comparison.

4.5 Quantitative Work

Quantitative sampling was introduced in 2013 for both rocky platform habitats and under boulder communities. The methodology was designed to be both repeatable and scientifically robust, allowing both univariate and multivariate analysis of replicated, quantitative data. The 2013 quadrat dataset should therefore be considered as the quantitative baseline against which all future surveys can be compared, and will allow change in these communities to be statistically determined. Species-area curves showed that the level of sampling effort employed in these methodologies was of sufficient effort and that by increasing the number of quadrats conducted it would be unlikely to find an increase in the number of species recorded.

The rocky platform reefs of the Berwickshire and North Nothumberland Special Area of Conservation show some variation in the species richness that they support. Species composition varied between the mid and lowshore locations, and between sites with highest species richess recorded on Inner Farne in both the mid and low eulittoral habitat. The lowest species richness was recorded at Brotherston's Hole in the low eulittoral and Castlehead Rocks in the mid eulittoral. This variation in species richness could be due to a number of reasons included the isolated nature of the shore at Inner Farne (although the shore on Brownsman had much lower species diversity) to small scale local hydrodynamics and warm water eddies influencing the shores and therefore the species which live there. The diversity of the communities on rocky reefs reflects the diversity of the habitats found there.

No nationally rare and scarce species and no INNS were found in the rocky platform surveys, and the assemblages at each site were typical of those found on the north east of England. The pacific oyster *Crassostrea gigas* is farmed on the mussel beds of Fenham Flats near Holy Island and although no individuals were recorded on the reefs in the area, the surrounding reefs should be monitored for escapes as sea temperatures rise. The value of repeat surveys using quantitative, replicated methodologies with respect to INNS will be to identify initial site(s) of introduction and track vectors and dynamics of spread in real time, allowing rapid and effective adaptive management strategies and actions to be implemented before INNS become established across the wider northeast region. Biotopes alone will not detect INNS as there are few INNS biotope classifications (with the exception of *Sargassum muticum*) and the methodology for assigning biotopes based on dominance of species means that INNS may become established and spread well before they are able to outcompete natives to the extent that they are the most dominant species in an assemblage.

The boulder fields of the BNNC SAC supported very low numbers of species and whilst there were obvious differences in species composition between the mid and low eulittoral locations at each site, there were little differences between sites in mid eulittoral fields and only few differences between low eulittoral fields, although *S. spirorbis* and *S. balanoides* were recorded at every boulder survey location.

No nationally rare and scarce species and no INNS were found in the underboulder surveys, and the assemblages at each site were typical of those found on the underside of boulders around the UK. Despite this the orange tipped sea squirt, *Coralla eumyota* has been recorded and verified in boulder habitats to the south of the BNNC SAC at Lynemouth in recent surveys conducted by the Big Sea Survey and the abundance and distribution of this species is currently being assessed.

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