Scalby Ness to Filey Brigg Rocky Shore Survey

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Final Report

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Executive Summary

The intertidal rocky shore between Scalby Ness and Filey Brigg in North Yorkshire exhibits some of the most important geology across the UK and has several Sites of Special Scientific Interest (SSSI) designated in the area for this geology. There is also a SSSI designated for the overwintering bird population at Filey Brigg. The Purple Sandpiper which over winter here do so for the habitat and food offered by the rocky intertidal area. Despite this the area is not currently designated for its biological interest and the marine ecology which can be found here.

The recent recommendation for Marine Conservation Zones under the Marine and Coastal Access Act has, however, recognised the rocky shore habitat which can be found here and the site has been put forward as a candidate Marine Conservation Zone (cMCZ).

The aims of the current contract were therefore to provide ecological information to support the designation of biological SSSI's in the Scalby Mills to Filey Brigg area and inform possible designation of a cMCZ here. The data gathered as part of the survey will act as a baseline of information for the area. Phase I and Phase II surveys were conducted at nine sites in the survey area.

The intertidal rocky reefs of the survey area have been classified as exposed shores typical of North Sea communities. Flat reef and boulder habitats throughout the survey area were dominated by fucoids and exhibited relatively low species diversity compared to other intertidal shores in the north east of England. This is however thought to be due to the time of year at which the survey was conducted and it is expected that the undisturbed and pristine nature of the shores in this area will support much greater diversity during the spring and summer months.

A total of 48 biotopes and 9 biotope complexes were recorded across the survey area. The results clearly show that the area surveyed can be split into four distinct regions based on the biotopes present. Two previously unrecorded species of red algae and one Invasive Non-Native Species (INNS) of barnacle (*Austrominius modestus*) were found.

The shores of the survey area offer a good example of natural rocky shore habitats characteristic of the North Sea. The Nab to The Wyke area at the centre of the survey site are expected to be little impacted by anthropogenic activities due to backing by vertical cliffs and the difficulty associated with accessing these areas. Although the other sites of the area have significant influence from artificial habitats there is no evidence to suggest that these artificial habitats are negatively affecting the natural species compositions of the shores. Recommendations regarding access to the shores and future surveys have been made.

1.0 Introduction

The intertidal rocky shore between Filey Brigg and Scalby Ness in North Yorkshire exhibits some of the most important geology throughout the country with rock formations dating back to the Jurassic period. The rocks here are predominantly Lower Calcareous Grit, Hambleton Oolite and Middle Calcareous Grit. They contain significant fossil records providing vital evidence about the state of marine fauna dating back through several key geological periods and providing a paleoecological timeline of previous marine ecosystems. Consequently, much of this area has designations for Sites of Special Scientific Interest (SSSI) with respect to the geology. To the south of the survey area Filey Brigg is also designated as a SSSI due to the nationally significant overwintering population of Purple Sandpiper, currently designated by the RSPB as a species with unfavourable conservation status in Europe (SPEC = Species of European Conservation Concern).

To the south of Filey Brigg the Flamborough Head European Marine Site extends from Bridlington in the south to Bempton Cliffs in the north. This area is designated as a Special Protection Area (SPA) for its seabird colonies, as well as a Special Area of Conservation (SAC) for its intertidal and subtidal chalk reefs, the intertidal and shallow subtidal sea caves and the biodiversity these habitats support.

The Filey Brigg to Scalby Ness area currently has no biological designation for the marine ecology of the intertidal zone. Despite this it has been recognised for the habitat it offers under the Marine Conservation Zone project and consequently has been put forward as a candidate Marine Conservation Zone (cMCZ). Natural England are also undertaking a review of the possible extension to the SPA at Flamborough Head and Bempton Cliffs into the Filey Brigg area. This has led to a need for data about the species diversity inhabiting the intertidal zone of the area which will inform any future designations.

1.1 Aims and Objectives

The current contract was conducted to provide ecological information to support the possible designation of biological SSSI's in the region north of the Flamborough Head European Marine Site and provide supporting evidence for the proposed Marine Conservation Zone in the area. The data gathered will be used to provide a baseline of information to support all future condition monitoring should the area be designated. The aims of the current contract were:

- To obtain standardised information for the intertidal rocky shore and to produce biotope maps of the rocky communities
- To identify any qualifying SSSI features as defined in JNCCs guidelines on the selections of biological SSSI's within the survey area
- To provide an ecological baseline for the current condition of features within the site

Specific Objectives of the contract were:

- To carry out Phase 1 biotope surveys of the intertidal zone of the rock habitats of the survey area at a number of individual survey locations across the site according to the methods outlined in the CSMG, Marine Monitoring Handbook and the CCW Handbook for Marine Intertidal Phase 1 Survey and Mapping
    - Identify and map the extent and distribution of littoral rock habitats (including boulders & cobbles) within the agreed sample areas.
    - Identify and map the extent and distribution of biotopes and biotope complexes according to The JNCC Marine Habitat Classification for Britain and Ireland Version 04.05 (Connor et al., 2004), within the littoral rock habitats
    - Provide semi-quantitative information on species composition across the range of rocky habitat biotopes and biotope complexes identified

- To carry out Phase II surveys at a number of agreed locations to provide quantitative information on species composition of different biotopes and how this differs across the study area

- To identify any qualifying SSSI features as outlined in JNCC's Guidelines for the selection of biological SSSIs for rocky shore sites

- Assess anthropogenic influences, impacting on identified features. These should be mapped where possible and should include;

    - Coastal defences along the study area
    - Damaging or potentially damaging activities

2.0 Methods

The Scalby Ness to Filey Brigg rocky intertidal habitat was divided into six sectors encompassing eight survey sites for the proposed survey, based on the intertidal area boundaries of the existing SSSIs (designated for their geological interest), the proposed boundary of the recommended Marine Conservation Zone and gaps in existing survey coverage. Locations of potential impacts from human activities were also taken into account.

Rocky Intertidal Phase I Surveys were carried out at nine shores between 14th October 2012 and 19th October 2012 (Fig. 1). The timetable for surveying the sites was amended in the field in order to assess and secure safe access to the rocky shore areas at Chimney Hole and The Wyke. As a result of this amendment an additional shore at Castle Rocks was also surveyed to complete biotope coverage in the area between Gristhorpe and Red Cliff SSSI and Filey Brigg SSSI, thereby providing coverage of an extra 1.8km of intertidal reef to link The Nab and Chimney Hole sites. Phase I surveys were carried out according to the methods outlined in the CSM Guidance, Marine Monitoring Handbook and the CCW Handbook for Marine Intertidal Phase I Survey and Mapping (Wyn et al., 2000; Davies et al. 2001) and standard international MarClim methodologies (Approved by Natural England for National rocky habitat monitoring) for quantitative quadrat sampling of key structural invertebrate taxa (MarClim protocols 2012). Biotope classifications were determined using the National Marine Habitat Classification for Britain and Ireland: Version 04.05 (Connor et al. 2004).

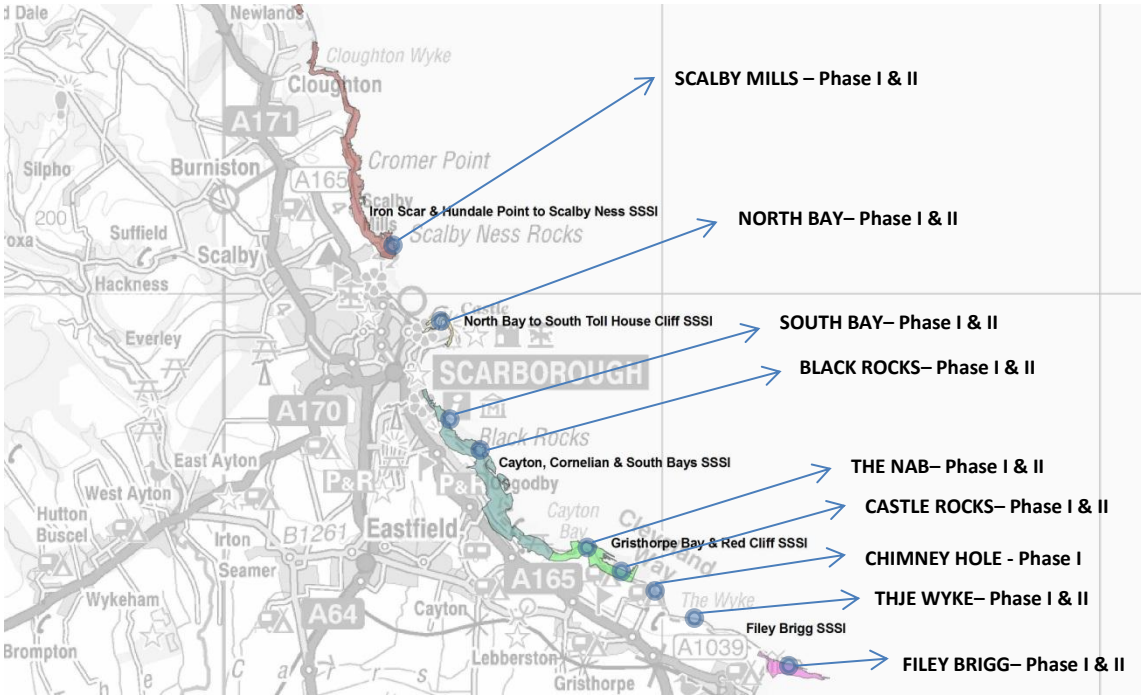

Figure 1: Survey Locations and existing geological Sites of Special Scientific Interest (SSSI)

Rocky Intertidal Phase 2 Surveys were carried out at all eight shores between 14th October 2012 and 19th October 2012. An additional shore at Castle Rocks was also surveyed to complete biotope coverage in the area between Gristhorpe and Red Cliff SSSI and Filey Brigg SSSI. Phase 2 surveys were carried out according to the methods outlined in the CSM Guidance, Marine Monitoring Handbook (Davies et al. 2001). Species present within the biotopes were identified and their abundance assessed using the standard SACFOR categorical abundance scoring system. Stratified random quadrat surveys for keystone barnacle and limpet species were conducted at all nine survey sites. There were no random quantitative quadrat surveys for notable species/biotopes conducted in the area due to no notable biotopes or species being found.

2.1 Phase I and II Rocky Intertidal Biotope Surveys

The range and distribution of biotopes was spatially mapped and classified using the standard Phase I methodology within each biotope. The Scalby Ness to Filey Brigg survey area has been divided into six sectors for the proposed survey, as previously detailed.

Within each sector, a corridor transect covering a horizontal distance along the shore of approximately 500m with a vertical extent from the High Water Spring Tide height to Low Water Spring Tide height was mapped using CSM Phase 1 biotope protocols (as detailed in Wyn et al. 2000, authors having being cross-calibrated with the MBA survey team in the field), including characteristic and notable biotopes for the area. The location of the horizontal and vertical boundaries of each corridor, along with the locations of each biotope mapped was recorded using GPS set to WGS84 standard.

Digital photographs of each survey location and each biotope recorded were taken and will be provided as part of the contract deliverables.

Phase 2 surveys were also carried out within the transect corridors at all nine locations as the survey team felt that is was more accurate to assign biotope classifications to biotopes where all macrofauna and flora had been recorded rather than the dominant few species, and the additional information allows quantitative statistical comparisons far beyond that achievable by biotope comparisons alone. The surveys spatially mapped the location and extent of characteristic and notable rocky intertidal biotopes. The species present within each biotope were recorded and assigned a SACFOR abundance score in accordance with the MarClim national protocols (Mieszkowska et al. 2006). Stratified random sampling of keystone structural and functional species of limpets and barnacles were carried out using ten replicate quadrats (5 x 2cm quadrats at high, mid and lowshore for barnacles, 50 x 50 cm quadrats at midshore for limpets) where suitable habitat was available.

Digital GIS maps following the MESH ROG's have been produced from the polygon maps created during the Phase I & II field surveys and the biotope classification data. Biotope polygons were digitised from 'neat' field maps and attributed to field data cleaned and transferred to excel spreadsheet using ArcGIS 10.0. Following specific methodology from the CCW Handbook for Marine Intertidal Phase 1 Biotope Mapping Survey, biotope polygons were assigned appropriate colours and symbols. All maps were produced at very high resolution for ease of use.

2.2 Statistical Analysis

Multi-Dimensional Scaling Ordination (MDS) plots have been undertaken using data collected in the current survey to determine any spatial dissimilarities between the rocky intertidal areas surveyed. Cluster analysis shows which shores are most similar to one another using the biotopes that are found there. Both analyses were carried out in the PRIMER software package, V5.

3.0 Results

The intertidal rocky reefs in the Scalby Ness to Filey Brigg rocky shore area are comprised predominantly of exposed reefs (Ballantine 1961) facing in a north easterly direction (Table 1).

Table 1: Exposure Classification (after Ballantine 1961)

Category	Physical description	Charactieristic biota	Notes
Extremely Exposed	Heavy surf more or less continuously.	*A. esculenta F. vesiculosus (e vesiculosus)* *P. ulysipponensis* Abundant from kelp zone to midshore *M. neritoides* & *L. saxatilis* Common or Abundant	*Laminarians* rare or absent
Very Exposed	The most exposed type of shore to be found on the mainland	*L. digitata* Common to Abundant *F. vesiculosus* Rare to Common *P. canaliculata* & *F. serratus* possible Barnacles Abundant *P. ulysipponensis* Abundant from kelp zone to midshore	No other fucoids
Exposed	Shores like this common on west coast, receive full force of Atlantic storm waves	*L. digitata* Common to Abundant P. *canaliculata, F. vesiculosus, F. serratus* Occasional, other fucoids absent *L. pygmaea* Common to Abundant *N. lapillus* common on open rock *Mytilus* spp. confined to cracks	
Semiexposed	Reduction from full wave exposure immediately apparent to the critical observer	*L. digitata* Common to Abundant *P. canaliculata* Occasional to Common but forming a distinct zone *F. serratus* Occasional to Common, *F. vesiculosus* Rare *F. spiralis* & *A. nodosum* Absent Barnacles Abundant *P. lineatus* & *G. umbilicalis* Common	
Fairly Sheltered	Large stones present are rarely moved by waves & develop semi-permanent assemblages	*L. digitata* Abundant & dominant *P. canaliculata* Frequent to Common *L. pygmaea* Rare to Frequent Barnacles Common to Abundant *M. neritoides* Occasional to Common in upper eulittoral fringe only *P. lineatus* & *G. umbilicalis* Abundant	
Sheltered	Considerable permanent fauna underneath cobbles and boulders but not sheltered enough that mud & silt deposited in quantity.	*L. digitata* & *S. latissima* may be Common *P. canaliculata* Abundant forming a dense zone *A. nodosum* Occasional to Common *S. balanoides* Common but fucoids dominate mid-lowshore *P. lineatus* & *G. umbilicalis* Abundant	
Very Sheltered	Rocky shores of this unit not common as where wave action substantially reduced, sand & mud deposited in high quantities	All fucoids Common to Abundant & form continuous cover over most of shore. *A. nodosum* covers most eulittoral bedrock. Barnacles Rare to Frequent only on steep slopes. P. *ulysipponensis* & *P. despressa* Absent	

The accepted scale for defining the exposure of a shore is Ballantine's (1961) scale. Whilst this is calculated based on wave fetch, defined as the distance a wave has travelled before it

meets land, the scale is scored based on the biota present as a result of the prevailing wave fetch conditions. This scale was derived from observations made on coastlines around south Wales. Therefore it must be applied to the east coastline of the north sea with caution; typically algal dominated shores are semi-exposed to very sheltered, whereas in the north sea, even exposed shores can be algal dominated. This is not due to low exposure per se, but the result of a lack of many species of grazers, or those present being so in low abundances due to the location being close to or beyond the northern distributional limits for many grazing species native to the UK. On these coastlines one of the best guides is the absence, or abundance of *Ascophyllum nodosum*, a brown alga that is very sensitive to wave exposure and only occurs in significant densities on shores that are fairly sheltered to very sheltered. In addition, barnacle densities in the mid and lower eulittoral tend to be higher in more exposed locations where fucoids are less abundant, although again this is complicated by the release of algae from grazing pressure on North Sea shores and so barnacles tend to dominate steeper sloping shores and the upper eulittoral.

Table 2: Exposure classification of shores in the Scalby Ness to Filey Brigg rocky intertidal area

Site	GPS Location	Access	Direction / Aspect	Exposure
Scalby Mills	54.3024° N -0.4077° W	Across bridge from road	South southeast Southeast – Northeast main section of reef	Fairly sheltered Semiexposed
North Bay	54.2885° N - 0.3935° W	Steps onto shore at beach end	North northwest	Gradient from Fairly Sheltered at sandy beach end to Semiexposed at the headland
South Bay & Black Rocks	54.2709° N - 0.3910° W	Steps onto shore near pavilion	Northeast	Exposed
The Nab	54.2431° N -0.3397° W	Steps onto beach at Cayton Bay	North northeast	Exposed
Castle Rocks	54.2378° N -0.3261° W	Steps onto beach at Cayton Bay	North northeast	Exposed
Chimney Hole	54.2311° N - 0.3131° W	Steps onto beach at Cayton Bay	East	Exposed
The Wyke	54.2277° N -0.3056° W	Steps onto beach at Cayton Bay	North northeast	Exposed
Filey Brigg	54.2159° N -0.2630° W	Path onto beach by Filey Sailing Club	North South	Exposed Sheltered

Flat reef and boulder habitats throughout the survey region were dominated by fucoids and exhibited low species diversity with a few species of sponges and anemones present (Table 3). Intertidal communities had a low density of grazers and low grazer species diversity. In addition, the lower environmental temperatures typical of this region of the North Sea

compared to much of the coastal seas of the UK means that native Boreal macroalgae are able to survive and reproduce, whilst many species of Lusitanian grazers found elsewhere in the UK are unable to reproduce and survive in this area. The combination of environmental and biotic factors results in algal dominated shores despite the exposed nature of the coastline.

Table 3: Range of species diversity (H' - Shannon Wiener) on each of the shores in the Scalby Ness to Filey Brigg survey area

Shore	Species Diversity (H')	
	Min	Max
Scalby Mills	0	2.72806
North Bay	0	2.65862
South Bay & Black Rocks	0	3.03643
The Nab	0	1.90853
Castle Rocks	0	3.13122
Chimney Hole	0	1.70947
The Wyke	0	2.41033
Filey Brigg	0	1.80583

The North Yorkshire coast is located in an area of the North Sea where few intertidal species reach either their northern or southern range limits. Most lusitanian species of warm water origins have not reached this area either via expansion along the English Channel and north into the North Sea along the temperature gradient from the west to east Channel, nor, as is the case with the chthamalid barnacles and topshell *Gibbula umbilicalis*, by northern range limits which have extended around the northeast tip of Scotland and are following the inverted latitudinal temperature gradient caused by the North Atlantic Drift south into the Northern North Sea. The only intertidal species which does have a range limit in this area is the cold water native kelp *Alaria esculenta*.

Within such an area the loss or gain of species is only likely to occur by one of three means; appearance of an invasive non-native species (and potential displacement of one or more native species), pressures relating to human activities such as artificial coastal engineering, pollution, loss of habitat by construction or sedimentation or freshwater runoff or natural environmental stocasticity which will be visible at multiple shores over a wide area. All of these are acute, small scale pressures and would be picked up in the data from surveys spanning the extent of coastline such as was surveyed for this contract, as shores either side of the impacted zone would still retain the same communities at similar abundances over multiple years.

Alaria esculenta was only found at Filey Brigg in low abundance. MarClim and Big Sea Surveys carried out by Mieszkowska and Sugden dating back to the start of the 2000s have shown that his cold water native macroalgae is declining in abundance and the southern range limits in the North Sea have retracted northwards from Robin Hoods Bay to Seaton Sluice between the onset of climate change in the mid-1980s and the 2010s.

The coldwater sugar kelp *Saccharina latissima* was patchy throughout the survey area. This species is declining throughout mainland Europe from France to Norway but no declines in

abundance at MarClim long-term survey sites have been recorded within UK rocky reef communities.

Two species of red algae previously unrecorded in the northeast (*Chondra capillaris* and *Spyridia filamentosa*) were recorded as part of this survey in the area between The Nab and The Wyke (Fig. 2).

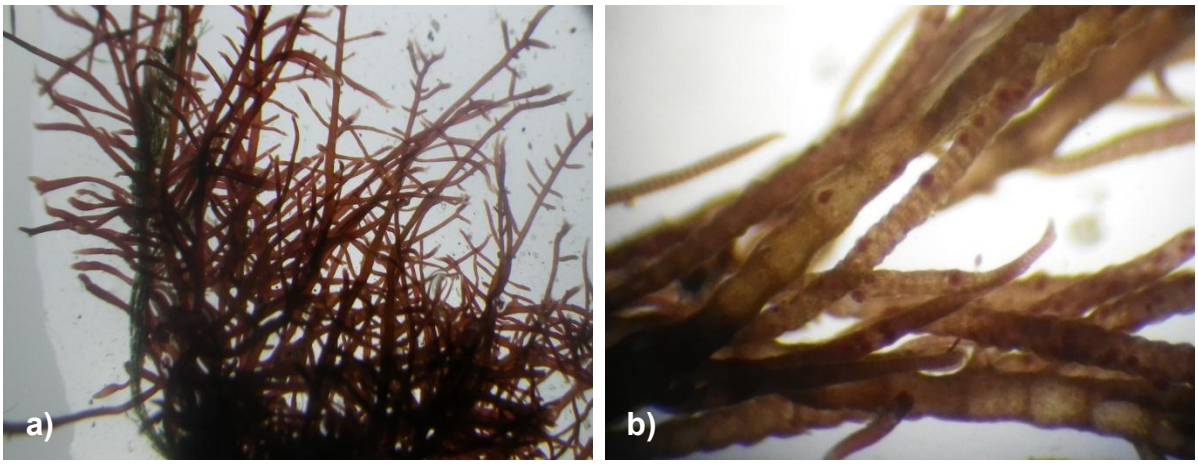

Figure 2: Microscopic images of a) *Chondria capillaris* and b) *Spyridia filamentosa*

The Invasive Non-Native Species (INNS) *Austrominius modestus* was found on the rocky reef survey at North Bay and Filey Brigg on the natural habitat. This is a species which has been documented in the UK since the 1940s and has no known impact on the native community. In recent annual MarClim surveys in the area carried out for National Natural England contracts it has been recorded in low numbers at nearby sites. There is no evidence that this INNS is outcompeting or excluding native species at the rocky intertidal reefs surveyed for this contract and it does not change the structure or functioning of these communities. No other INNS were found in any of the survey transects.

There are extensive areas of artificial habitat in the area from Black Rocks to Scalby Mills with more artificial sea defences planned over the coming year. Sections of artificial sea defences surveyed during the biotope mapping fieldwork did not find species or novel assemblages that could not be found on nearby natural habitat.

The intertidal area between Scalby Ness and Filey Brigg can be distinctly split into four separate regions based on the biotopes recorded in the intertidal area. A total of 48 biotopes classifications were recorded (Table 4) along with 9 biotope complexes (Table 5). Filey Brigg, to the south of the survey area, exhibited the most biotopes of all the shores surveyed, with 12 biotopes completely different from all other shores surveyed. Scalby Mills, to the north of the survey area only exhibited 13 biotopes but despite this nearly half of these biotopes were unique to this shore in the area surveyed. These two shores at the northern and southern end of the survey area show a different biotope composition from all of the shores in between (Figure 3) but they are most similar to one another (Figure 4). The area between Scalby Mills and Filey Brigg can be further split into two groups. The shores at North Bay, South Bay and Black rocks have 5 biotopes in common (Table 4) and are similar to one another (Figures 3 & 4), whilst the area of The Nab, Castle Rocks, Chimney Hole and The

Wyke have 8 biotopes in common (Table 4) and form a distinct group from the other shores (Figure 3 & 4).

Table 4: Biotope summary of the Scalby Ness to Filey Brigg rocky intertidal area

Biotope Code	Scalby Mills	North Bay	South Bay & Black Rocks	The Nab	Castle Rocks	Chimney Hole	The Wyke	Filey Brigg
LR	■	■						■
LR.HLR	■							
LR.HLR.FR								■
LR.LLR.F.Fves	■							
LR.LLR.F.Fves.X	■							
LR.LLR.F.Fspi.FS	■							
LR.MLR.BF.FspiB	■		■	■	■	■	■	■
LR.MLR.BF	■							■
LR.FLR.Rkp.SwSed	■	■						
LR.HLR.MusB.Sem	■							■
LR.MLR.BF.Fser.Bo	■				■	■		■
LR.HLR.FR.Mas	■							■
IR.HIR.Ksed.XKScrR	■	■		■	■	■	■	
LR.LLR.F.Pel	■	■		■				■
LR.HLR.MusB.Sem.Sem		■	■	■				■
LR.FLR.Eph.EntPor		■						
LR.HLR.MusB.MytB		■						
LR.MLR.BF.FvesB		■	■					■
LR.FLR.Eph		■	■	■				■
IR.MIR.KR		■	■					
IR.MIR.KR.Ldig								■
IR.MIR.KR.Ldig.Bo		■						
LR.MLR.BF.Fser.R		■					■	■
LR.MLR.BF.PelB		■			■			
LR.HLR.MusB.Sem.FvesR		■	■					■
LR.LLR.F.Fves.FS			■					■
LR.FLR.Lic.Bli			■	■	■		■	
LR.FLR.Eph.EphX				■		■		■
LR.FLR.Lic								■
LR.FLR.Lic.Ver								■
LR.FLR.Lic.Ver.Ver				■	■	■	■	
LR.LLR.F.Fspi				■				
LR.LLR.FVS.AscVs				■	■	■	■	■
LR.MLR.BF.Fser				■	■	■		
LR.HLR.MusB.Sem				■	■			
LR.LLR.F.Fserr.X				■				
LR.LLR.F.Fserr.FS								■
LR.FLR.Eph.EphX				■				
LR.FLR.Rkp.G				■				■
LR.FLR.Rkp								■
LR.FLR.Rkp.FK								■
LR.FLR.Lic.Ver.B						■		■
LR.MLR.BF.Rho						■	■	■
LR.HLR.FR.Him							■	
LR.FLR.Rkp.Cor								■

LR.FLR.Rkp.Cor.Cor								
LR.FLR.Eph.Ent								
LR.MLR.MusF.MytFves								
Total	**13**	**14**	**8**	**15**	**9**	**9**	**8**	**29**

Table 5: Biotope Complexes recorded over the Scalby Ness to Filey Brigg rocky intertidal area

Biotope Complex	**Scalby Mills**	**North Bay**	**South Bay & Black Rocks**	**The Nab**	**Castle Rocks**	**Chimney Hole**	**The Wyke**	**Filey Brigg**
LR.HLR.FR.Mas & LR.FLR.Rkp.Cor								
LR.MLR.BF.Fser.Bo & LR.HLR.Mus.Sem.Sem								
LR.FLR.Rkp.FK & LR.MLR.BF.Fser.Bo								
LR.MLR.BF.FspiB & LR.FLR.Rkp.Cor.Cor								
LR.HLR.FR & LR.FLR.Rkp.Cor								
LR.MLR.BF.Fser.R & LR.FLR.Rkp.Cor.Cor								
LR.HLR.MusB.Sem.Sem & LR.FLR.Rkp.Cor.Cor								
LR.HLR.FR & LR.FLR.Rkp.Cor.Cor								
LR.FLR.Lic.Bli & LR.MLR.BF.FspiB								
Total	**2**	**0**	**3**	**3**	**1**	**1**	**0**	**1**

Figure 3: Multi-Dimensional Scaling Ordination of biotopes found throughout the Scalby Ness to Filey Brigg rocky intertidal area. Based on Bray Curtis Similarity coefficient, non-standardised data, and presence / absence transformations.

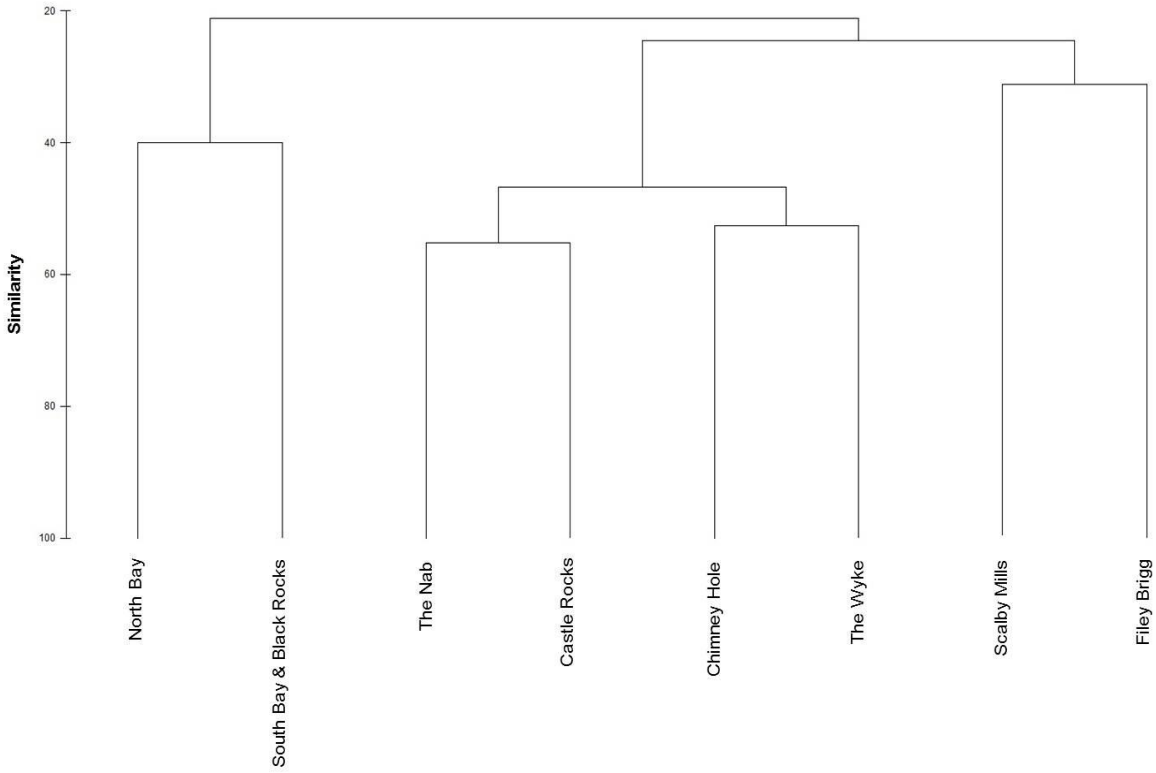

Figure 4: Cluster Analysis of percentage similarity of biotope compositions between the survey sites, all sites show significant differences

3.0.1 Quantitative limpet surveys

Patella vulgata was the only species of limpet recorded in any of the quantitative quadrat counts done in this region. The warm water *P. depressa* does not occur this far north and the cosmopolitan *P. ulysipponensis* tends to be restricted to the lower eulittoral open rock and mid-eulittoral pools, although it can occur on open mid-eulittoral rock where the exposure is significantly high enough to keep the mid-eulittoral wet through most of the period of tidal emersion and consequently for coralline algae to proliferate, providing habitat and food for *P. ulysipponensis*. Table 5 shows that the highest densities of P. vulgata, at Filey Brigg, The Wyke and Castle Rocks were all recorded in LR.HLR.MusB.Sem.Sem biotopes typified by abundant barnacle densities and low algal coverage. These quadrats had to be done in the upper mid-eulittoral on elevated boulders of platforms where highest densities of limpets were found to occur.

At Chimney Hole, The Nab, South Bay and Black rocks the densities of limpets are only one third of those at the other sites, due to proliferation of macroalgae across the entire intertidal zone. The North Bay artificial rock armour habitat was not covered in erect, canopy forming algae like the natural shores but the smooth substrate is likely to have resulted in lower densities of limpets due to both unsuitable habitat for homescars and the lack of suitable algal diet.

Table 6: Mean limpet densities per 50x50cm quadrat (0.25m2)

	Patella vulgata mean densities per 0.25m^2
Filey Brigg	127.6
The Wyke	108.7
Chimney Hole	37.5
Castle Rocks	N/A no suitable habitat
The Nab	36.9
South Bay & Black Rocks	39.9
North Bay	32.5
Scalby Mills	98.2

3.0.2 Quantitative barnacle surveys

Replicated quadrat counts for adult and juvenile barnacles were carried out in the midshore at every site except Castle Rocks where there was no suitable habitat. High and lowshore counts were also done at those sites where barnacles were found. The cold water *Semibalanus balanoides* and the invasive *Austrominius modestus* were found, but no warm water chthamalid barnacles as this survey region is beyond the biogeographic range limits.

A. modestus was only found at North Shore and Scalby Mills, and at both sites in very low densities (Table 6). North Shore and The Nab both had very high densities of *S. balanoides* up to 11.5 per cm^2. The remaining sites all had densities approximately 50% lower with the exception of Chimney Hole, where low densities of 0.8 per cm^2 resulted from the lack of

suitable midshore habitat not colonized by sediment-binding red algae or canopy-forming fucoids. These densities are typical of undisturbed shores of the habitat type, exposure and community composition found in the UK.

Table 7: Mean barnacle densities per 10cm^2

	Shore height	*Semibalanus balanoides* adult	*Semibalanus balanoides* juvenile	*Austrominius modestus* adult	*Austrominius modestus* juvenile
Filey Brigg	high	2.5	6.2	0	0
Filey Brigg	mid	7.2	0	0	0
Filey Brigg	low	10	0	0	0
The Wkye	mid	5.7	0	0	0
Chimney Hole	mid	0.8	2.1	0	0
The Nab	high	4.9	0.5	0	0
The Nab	mid	9.5	0	0	0
The Nab	low	8.5	3.6	0	0
South Bay & Black Rocks	mid	5.2	0	0	0
North Shore	mid	11.5	0	0.03	0
Scalby Mills	high	2.2	5.5	0	0
Scalby Mills	mid	5.1	13	0.01	0
Scalby Mills	low	3.8	9.3	0.25	0

3.0.3 Extent of littoral Reefs and Artificial Habitats

Classification of littoral rock and artificial structures present in the intertidal was undertaken using ERDAS Imagine 9.3 and ArcGIS 10.0 software. Aerial imagery supplied from the Channel Coastal Observatory and Natural England were clipped in ArcGIS to intertidal zone of the Isle of Wight SAC (shapefile provided by Natural England).

Once clipped, images were classified into habitats: "littoral rock", "artificial structures" or "other substrate" in ERDAS Image 9.3. The software classifies image pixels with similar spectral properties which are then collated into meaningful groups and assigned a habitat. Initial unsupervised classifications of the images were carried out to objectively classify pixels into categories containing similar values (combined data from the red, blue and green bands). Classes were identified using the ISODATA algorithm using a maximum of six iterations to reveal spectral distance patterns in the data. Once pixels had been characterised by a similar spectral signature, the unsupervised classification was compared to the ground situation, via ground truthing as well as using known persistent bedrock, boulders, cobbles, sea walls, gryones, piers, rip rap and other structures from previous studies, aerial imagery, Ordnance Survey 1:10,000 tiles and UKHO admiralty charts to identify littoral rock pixels for the supervised classification. These pixels were selected on the images and their spectral information used to specify ‘signatures’ (numerical descriptors for

processing algorithms) of the littoral rock and artificial structures present across the image scene.

Once all images were characterised, the resulting raster files were converted to shapefiles in ArcGIS. Using the original aerial images, polygons were edited by eye to ensure best representation of the habitat. Total areas of the habitats were then calculated (Table 8).

Table 8: Littoral Rock and Artificial Substrate Extent

Habitat	Area (m^2)	Area (Km^2)
Littoral rock	1357591.48	1.36
Artificial substrate	84428.7	0.08
Artificial substrate on littoral rock	879.93	0.00088
Artificial substrate adjacent to littoral rock	1966 (length in metres)	

3.1 – Filey Brigg

3.1.1 Site Description

Figure 5: Filey Brigg Survey Site a) looking to the Brigg b) access path onto the Brigg

Filey Brigg is designated as a SSSI for its geological interest. It is a key Corallian site showing extensive exposures of Lower Calcareous Grit, the Hambleton Oolite and Middle Calcareous Grit. The 'Ball Beds' which are well exposed here are lost further west in Yorkshire. Filey Brigg is also recognised as an important site for overwintering purple sandpiper which occurs here in nationally significant number on the intertidal rocky shore.

Filey Brigg is the most southerly site in the survey area (Fig. 1) and extends out from the headland in an easterly direction into The North Sea (Fig. 5a). Half of the Brigg is very exposed to the north and half much more sheltered to the south. This difference in exposure is reflected in the species found in the two areas and therefore the biotopes found here. The intertidal area is composed of flat sloping bedrock in the centre of the Brigg. To the North side this sloping bedrock becomes a series of vertical ledges and flat extensions down into the sublittoral (Fig. 6a). Towards the cliff on the north side large boulders dominate. To the south side the bedrock gently slopes down into the sublittoral and is covered by large boulders (>1m: Fig. 6b).

The intertidal area at Filey Brigg covers a large area and hosts a variety of different habitats resulting in a diverse intertidal community. There is a well-worn concrete path all the way to end of the Brigg making the shore accessible and it is a popular site for visitors (Fig. 6c). The access path is devoid of any species until the last few metres where ephemeral green algae encroach. The path is surrounded by ephemeral green algae for the majority of its length (LR). The path sits just below the ridge of the exposed north face and the algae *Pelvetia cannaliculata* (LR.LLR.F.Pel) and *Fucus spiralis* (LR.MLR.BF.FspiB) are consequently present here (Fig. 6d). Vast meadows of ephemeral *Ulva intestinalis, U. linza* and *U. lactuca* (LR.FLR.Eph) cover the sloping bedrock down to the boulders (Fig. 6e), along with *Semibalanus balanoides* dominated slopes (LR.FLR.Lic.Ver) and they are interspersed with large rock pools (LRFLR.Rkp.G) with high abundances of the brown filamentous algae *Ectocarpus spp* (Fig. 6f). The sheltered boulders (LR.MLR.BF.Fser.Bo) hosted a high abundance of *Fucus serratus* (**S**uperabundant) and *Ascophyllum nodosum* (**A**bundant) along with *Patella vulgata* and *Semibalanus balanoides* (both **C**ommon).


a)


b)


c)


d)

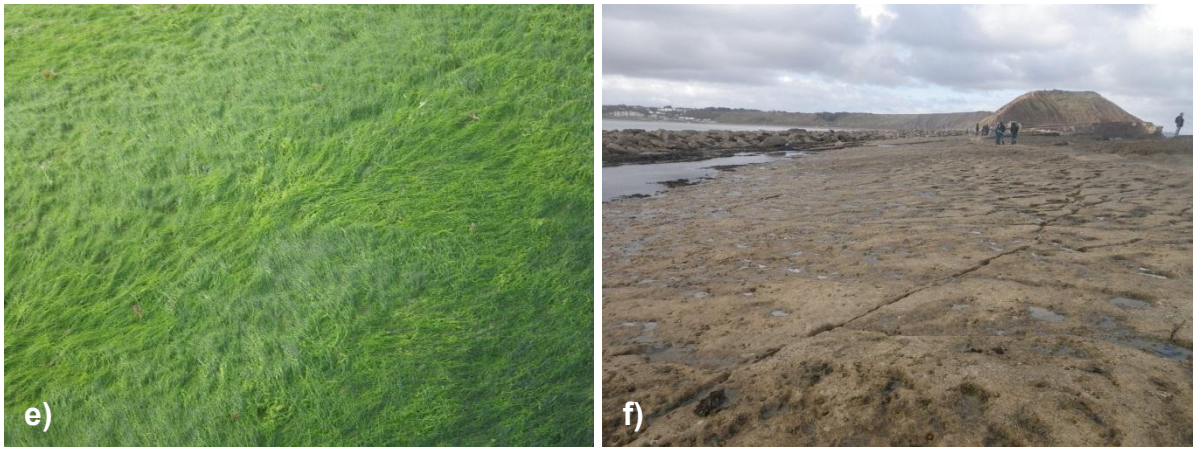

Figure 6: a) North face ledges, b) South face slopes and boulders, c) Visitors to the Brigg, d) *Pelvetia cannaliculata* and *Fucus spiralis* on the south face, e) *Ulva spp* meadows and f) *Semibalanus balanoides* dominated slopes with *Ectocarpus spp* pools

On the north face of the Brigg the greater exposure here has resulted in a very different composition of species and biotopes. The vertical ledges (LR.HLR.MusB.Sem.FvesR) and flats were dominated by *P. vulgata* and *S. balanoides* (both **A**bundant) and these ledges stepped down onto red algae dominated platforms (Fig. 7a). The ledges on the north face ended in the kelp zone (IR.MIR.KR.Ldig, Fig. 7b) dominated by *Laminaria digitata* (**S**uperabundant). The cold water kelp *Alaria esculenta* was also found on the north face of Filey Brigg (Fig. 7c) and comparisons with historical data suggest a retreat of its range limit with Filey Brigg as the southern limit of a few isolated stands of this species. To the tip of the Brigg the sloped area was dominated by red algae (LR.MLR.BF.FserR) and is subjected to extreme exposure (Fig. 7d). There were no notable or characteristic biotopes recorded at Filey Brigg.

Figure 7: a) Vertical and flat *Semibalanus balanoides* ledges stepping down into red algae, b) kelp zone, c) *Alaria esculenta* and d) red algae platforms at the tip of the Brigg

3.1.2 Filey Brigg Biotope Map

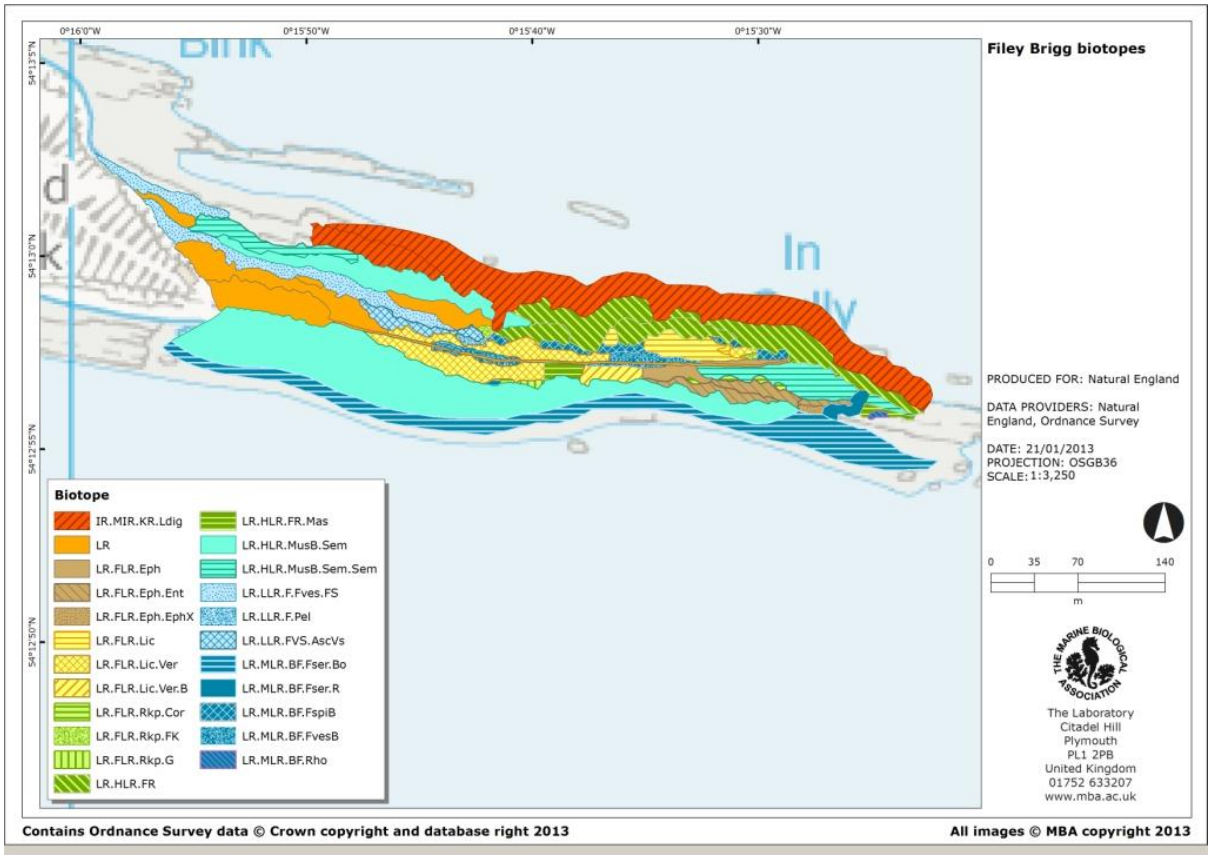

Figure 8: Filey Brigg Biotope Map

3.2 – The Wyke

3.2.1 Site Description

Figure 9: The Wyke Survey Site

The Wyke is located just north of Filey Brigg (Fig. 1) and is an extensive area of narrow intertidal rocky reef (50m) at the base of vertical cliffs (Fig. 9). It is an as yet undesignated part of the survey area. The cliffs of the Wyke are an extension from the Gristhorpe Bay area and are probably comprised of the same geology. The area faces a north / northeasterly aspect and is an exposed part of the coastline (Tables 1 & 2). It is an extremely inaccessible area and requires a long walk from Cayton Bay along the shore or access by boat.

The intertidal area of the Wyke is composed of large boulders and cliff debris and extends for approximately 50m from the base of the cliff to MLWS (Fig.10a). Below the cliff face a 2m wide highshore area was dominated by the lichen *Verrucaria maura* (**S**uperabundant: LR.FLR.Lic.Ver.Ver) and below this a 1m wide band of both *Blidingia spp* (**S**uperabundant) covered boulders (LR.FLR.Lic.Bli) and *Fucus spiralis* (**S**uperabundant) covered boulders (LR.MLR.BF.FspiB) occurred (Fig. 10b).

A wide band (8m) of *Fucus vesiculosus* (**A**bundant) and *Ascophyllum nodosum* (**S**uperabundant) boulders (LR.LLR.FVS.AscVS) followed the highshore biotopes down into the mid shore area, very few species of animals were present in these biotopes. Distinct zonation continued down the shore with *Fucus serratus* (**A**bundant) and *Himanthalia elongata* (**C**ommon: LR.MLR.BF.Fser.R) dominated boulders (15m wide), followed by *Mastocarpus stelaltus* (**S**uperabundant) and *H. elongata* (**A**bundant: LR.HLR.FR.Him) dominated boulders (Fig. 10c, 20m wide) and finally sediment binding red algae (*Rhodothamniella floridula*: **S**uperabundant) dominated boulders (Fig. 10d, LR,MLR.BF.Rho) before extending into the kelp zone (IR.HIR.KSed.XKScrR). Although the three biotopes making up the mid to lower shore all appear to be very similar there was a significant difference in the species dominating the biotope as well as the species living within the biotope to justify the classification used. There were no notable or characteristic biotopes recorded in the Wyke.

Figure 10: a) Boulder habitat of the Wyke, b) Vertical zonation of *Verrucaria maura, Blidingia spp* and *Fucus spiralis*, c) *Mastocarpus stellatus* dominated boulders (LR.HLR.FR.Him), d) Biotopes LR.HLR.FR.Him and LR,MLR.BF.Rho

3.2.2 The Wyke Biotope Map

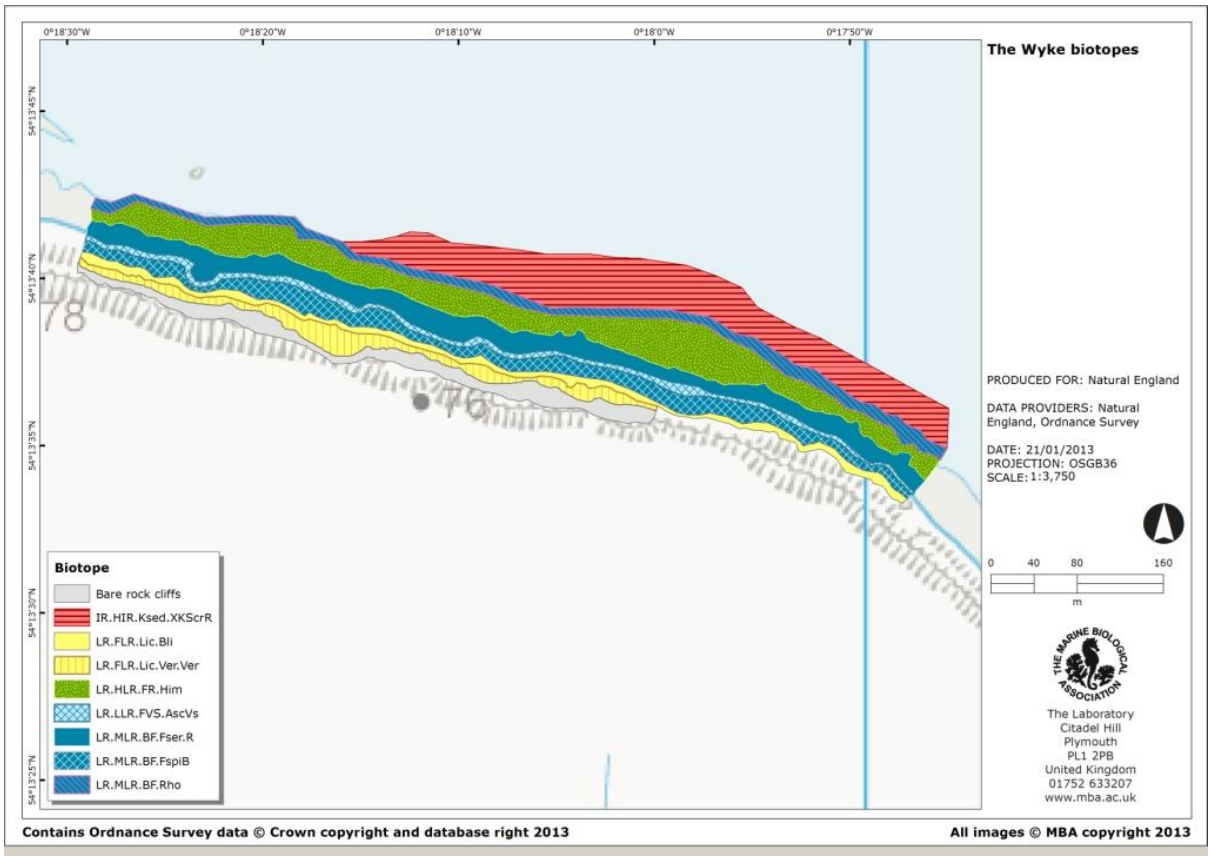

Figure 11: The Wyke Biotope Map

3.3 – Chimney Hole

3.3.1 Site Description

Figure 12: Chimney Hole survey site

Chimney Hole (Fig. 12) is located to the north of the Wyke and south of Castle Rocks (Fig. 1). Again it is an undesignated part of the survey area with extremely difficult access. Access to the shore here requires a long walk across the shore from Cayton Bay or access by boat. Access through the 'Chimney' is not recommended without appropriate safety gear (Fig. 13a & 13b). The shore at Chimney Hole predominately faces in an easterly direction and is an exposed shore (Tables 1 & 2).

Figure 13: a) Access down onto the shore at Chimney Hole, b) Chimney Hole in the cliff face

The intertidal area here is predominately boulders but there are patches of exposed bedrock. The intertidal area at Chimney Hole exhibits clear vertical zonation of species and therefore biotopes with a total of 11 biotopes present. The high shore area (Fig.14a) is again made up of boulders dominated in *Verrucaria maura* (**S**uperabundant: LR.FLR.Lic.Ver.Ver), followed by *Blidingia spp* and *Fucus spiralis* boulders (LR.MLR.BF.FspiB), *Fucus vesiculosus* and *Ascophyllum nodosum* boulders (LR.LLR.FVS.AscVs) and ending in a midshore biotope complex of *Ascophyllum nodosum*, *Fucus vesiculosus* and *Fucus serratus* on boulders and bedrock (LR.MLR.BF.Fser.Bo & LR.MLR.BF.Fser).

Large boulders covered in red algae (LR.MLR.BF.Rho & LR.HLR.FR.Mas) and green ephemerals (LR.FLR.Eph.EphX) dominated the lowshore area of this shore (Fig. 14b & 14c).The small patches of bedrock (LR.HLR.FR & LR.FLR.Rkp.Cor.Cor) was dominated in red algae, *Mastocarpus stellatus* (**C**ommon) and contained small rockpools (Fig. 14d) with *Ceramium spp* (**S**uperabundant).

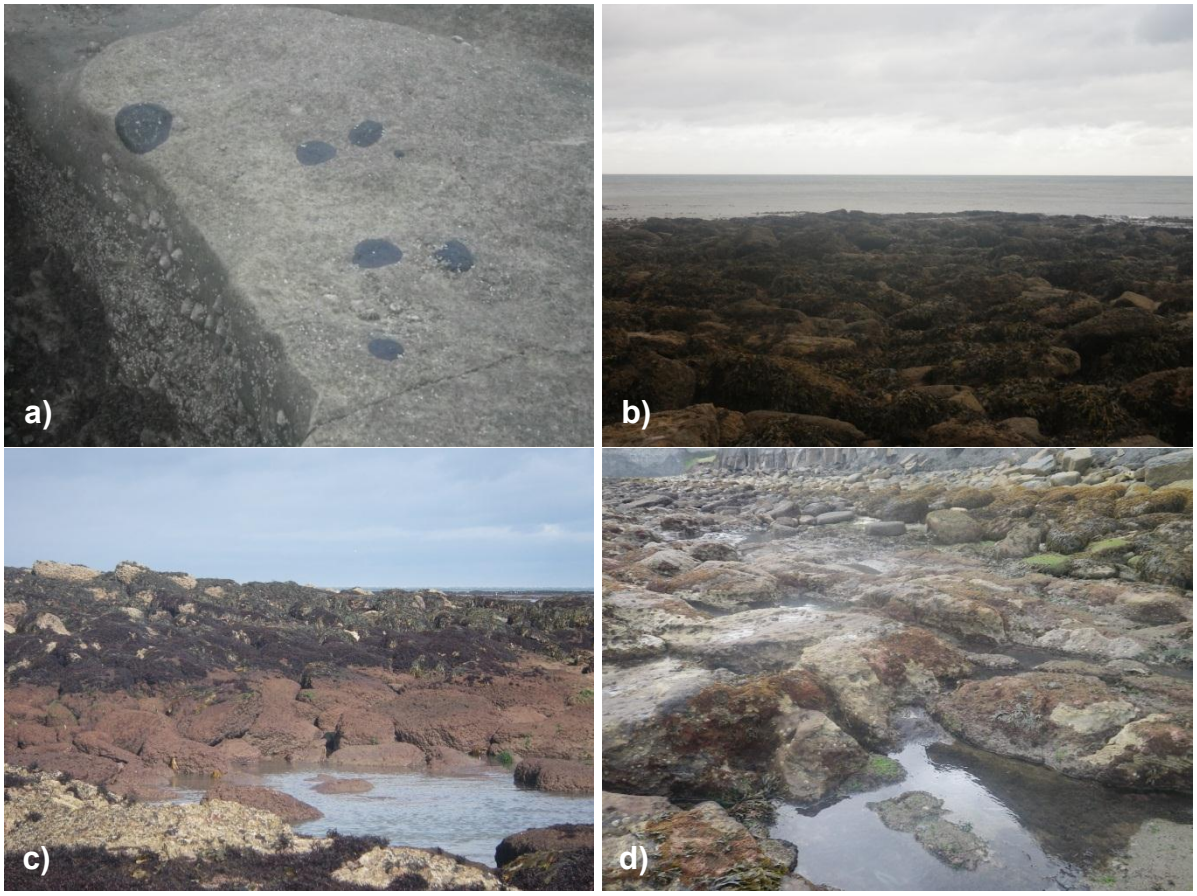

Figure 14: a) High shore boulders with *Verrucaria maura*, b) Midshore biotope complex boulders and bedrock, c) Lowshore boulders d) bedrock patches with pools

3.3.2 Chimney Hole Biotope Map

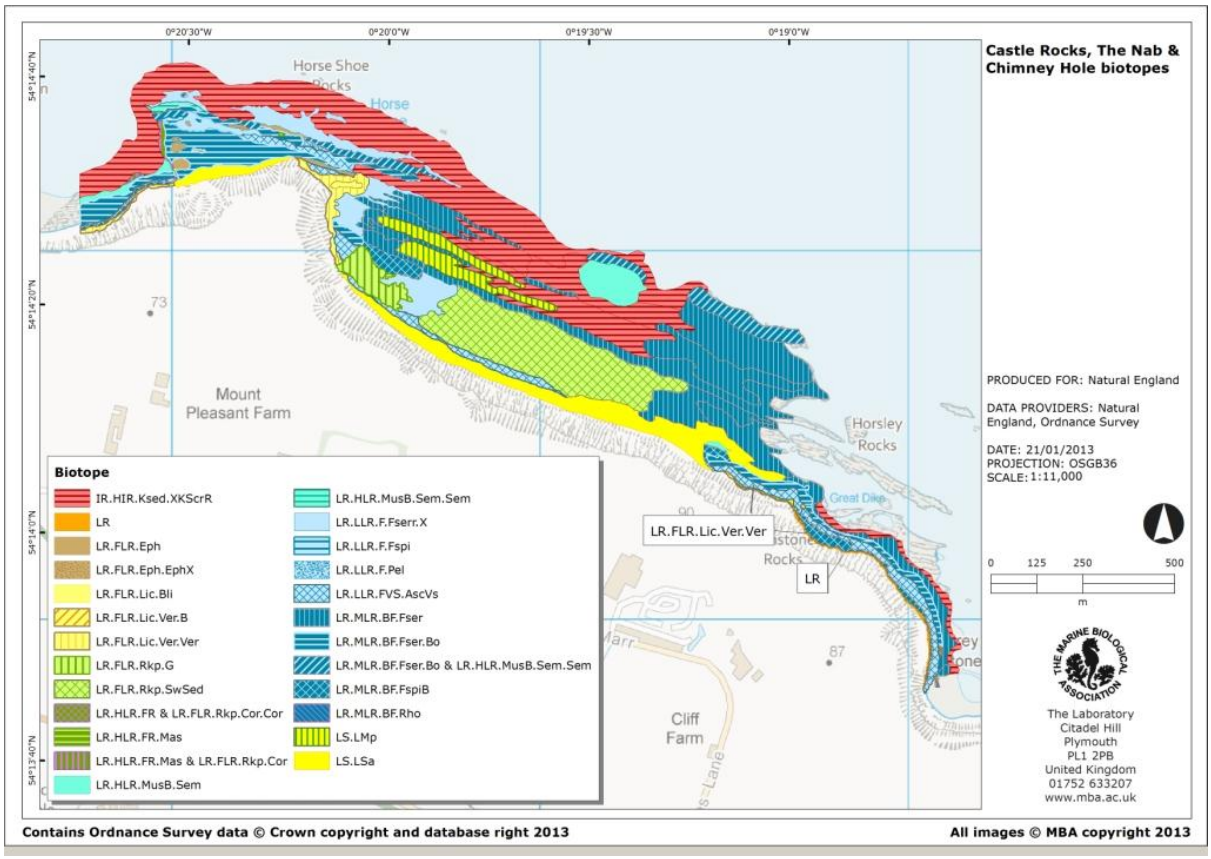

Figure 15: Chimney Hole, Castle Rocks and The Nab Biotope Map

3.4 – Castle Rocks

3.4.1 Site Description

Figure 16: Castle Rocks survey site

Castle Rocks is located to the south of the Nab and Cayton Bay (Fig. 1) and is part of the Gristhorpe Bay and Red Cliff SSSI, designated for its geological interest. The site is nationally important for the Middle Jurassic in Yorkshire with great historical significance. The overlying Scalby formation is also of considerable interest and the area at Gristhorpe is probably the most famous of its kind with several species of flora described by early geologists.

Castle Rocks faces in a north / northeasterly direction and is an exposed site (Tables 1 & 2). The rocky intertidal shore is extensive in this part of the survey area and is made up of bedrock ledges with gullies running in a north westerly to south easterly direction (Fig. 16). Across the bedrock outcrop there are extensive boulder fields lying over the bedrock (Fig 17a). As the shore meets the steep cliff faces a Sandy cobble / shingle beach separates them and there is a lagoon (LR.FLR.Rkp.SwSed) with *Chorda filum* (**A**bundant), *Fucus serratus* (**A**bundant) and *Halidrys siliquosa* (**C**ommon: Fig 17b) running in between the headlands (Fig 17c).

Castle Rocks is an algal dominated shore with complicated zonation across the intertidal area due to the constant changes in shore height from the horizontal ledges. At the base of the cliffs there are classic highshore boulders with a zone of *Verrucaria maura* (**S**uperabundant: LR.FLR.Lic.Ver.Ver), a zone of *Blidingia spp* (**S**uperabundant) and *Fucus spiralis* (**S**uperabundant:Lr.MLR.BF.FspirB) and a zone of *Fucus vesiculosus* (**A**bundant) and *Ascophyllum nodosum* (**S**uperabundant: LR.LLR.FVS.AscVs). This pattern of zonation is one which is repeated throughout the middle of the survey area (Fig 17d). Highshore areas are not limited to the base of the cliff and are also found in patches across the bedrock (on both bedrock and boulders), these areas of highshore contain *Pelvetia cannaliculata* (**A**bundant: Fig. 17e), this species was sporadically distributed across the survey area (LR.MLR.BF.PelB).

The majority of the intertidal area was composed of a biotope complex (LR.MLR.BF.Fser.Bo & LR.MLR.BF.Fser) made up of dominant algae species alternating between bedrock and boulders (Fig. 17f). In this area *F. vesiculosus* (**S**uperabundant), *A. nodosum* (**A**bundant) and *Fucus serratus* (**S**uperabundant) dominated with various species of algae and invertebrate associated with them. Most notable two previously unrecorded species of red algae were recorded in this part of the survey area (Fig. 2).

Figure 17: a) Bedrock ledges with overlying boulders, b) *Chorda filum* and *Fucus serratus* in the lagoon, c) lagoon and sandy bay below the steep cliff, d) Highshore zonation, e) *Pelvetia canaliculata*, f) LR.MLR.BF.Fser.Bo & LR.MLR.BF.Fser

3.5 – The Nab

3.5.1 Site Description

Figure 18: The Nab survey site

The Nab is located to the south end of Cayton Bay (Fig. 1) and is part of the Gristhorpe Bay and Red Cliff SSSI, designated for its geological interest. The site is nationally important for the Middle Jurassic in Yorkshire with great historical significance. The overlying Scalby formation is also of considerable interest and the area at Gristhorpe is probably the most famous of its kind with several species of flora described by early geologists.

The intertidal rocky shore area at The Nab is very similar to that found at Castle Rocks with extensive bedrock ledges with gullies running in a north westerly to south easterly direction (Fig. 18). The aspect of the shore is north / northeasterly and the shore is exposed (Tables 1 & 2). At the Cayton Bay end of the site large boulders dominate the area (Fig. 19a). Towards the lowshore these boulders (Fig. 19b: LR.HLR.FR.Mas & LR.FLR.Rkp.Cor) are host to under boulders communities such as *Actinia equina* (**O**ccasional), *Halichondria panicea* (**F**requent) and the hydroid *Dynamena pumila* (**C**ommon). Moving into the lowshore the boulders host ascidians such as *Botrylloides leachi* (Fig. 19c: **A**bundant).

The large boulders give way to bedrock ledges at the headland of the Nab (Fig. 19d) which are composed of a number of biotopes alternating with the different heights of the ledges and gullies. Large intertidal pools (LR.FLR.Rkp.FK & LR.MLR.BF.Fser.Bo) are situated in the middle of this extensive area of bedrock (Fig. 19e) with several species of algae supported in this area. Although not many invertebrate species were recorded in the rock pools there is no reason why these areas should not be biologically diverse during the summer months. High shore bedrock with *Pelvetia canaliculata* (**S**uperabundant: LR.LLR.F.Pel) was also found in this area (Fig. 19f). The entire survey site at The Nab was surrounded by kelp forests dominated by *Laminaria digitata* (**S**uperabundant).

Figure 19: a) Boulders marking the edge of The Nab, looking north to Cayton Bay, b) LR.HLR.FR.Mas & LR.FLR.Rkp.Cor, c) Under boulder community with *Botrylloides leachi*, d) bedrock biotope complexes, e) Large midshore pools, f) *Pelvetia canaliculata*

3.6 – Black Rocks & South Bay

3.6.1 Site Description

Figure 20: a) South Bay & Black Rocks survey site and b) Artificial sea walls at South Bay

Black Rocks and South Bay are designated as part of the Cayton, Cornelian and South Bays SSSI for both the geological and biological interest. Geologically the area is a composite section of Middle to early Upper Jurassic deposits and biologically the area is important for the species-rich vegetation and invertebrates of the cliffs. Black Rocks and South Bay face in a northeasterly direction and are both exposed shores (Tables 1 & 2).

The area of Black Rocks and South Bay is located just to the south of Scarborough (Fig.1). The intertidal area here is mostly flat bedrock with some gullies (Fig 20a) but not the gully / ledge formations seen further to the south. The bedrock of South Bay is interspersed with sandy beach (Fig. 21a) whilst that of Black rocks is not. The area is also characterised by the extensive areas of artificial coastal defences (Fig. 20b) which extend across both part of the rocky shore and the sand bay, with more coastal defences planned. Despite the extensive coastal defences there was no evidence to suggest that they are supporting different species assemblages than those found in natural habitats. In fact *Blidingia spp* (**S**uperabundant), *Ulva intestinalis* (**A**bundant) and *Fucus spiralis* (**A**bundant) along with

Patella vulgata (**C**ommon) and *Semibalanus balanoides* (**A**bundant) were all present in these areas (Fig. 21c) as are often seen on natural highshore rocks.

The midshore area of Black Rocks and South Bay was relatively biotope poor with 2 biotopes present in the area. The majority of the area was flat bedrock characterised by the red sand binding algae *Rhodothamniella floridula* (**S**uperabundant) with small pools (LR.HLR.FR.Mas & LR.FLR.Rkp.Cor: Fig. 21b) which supported coralline encrusting algae (**A**bundant), *Polyides rotundus* (**C**ommon: Fig. 21d) and *Chaetomorpha lineum* (**F**requent: Fig. 21e)

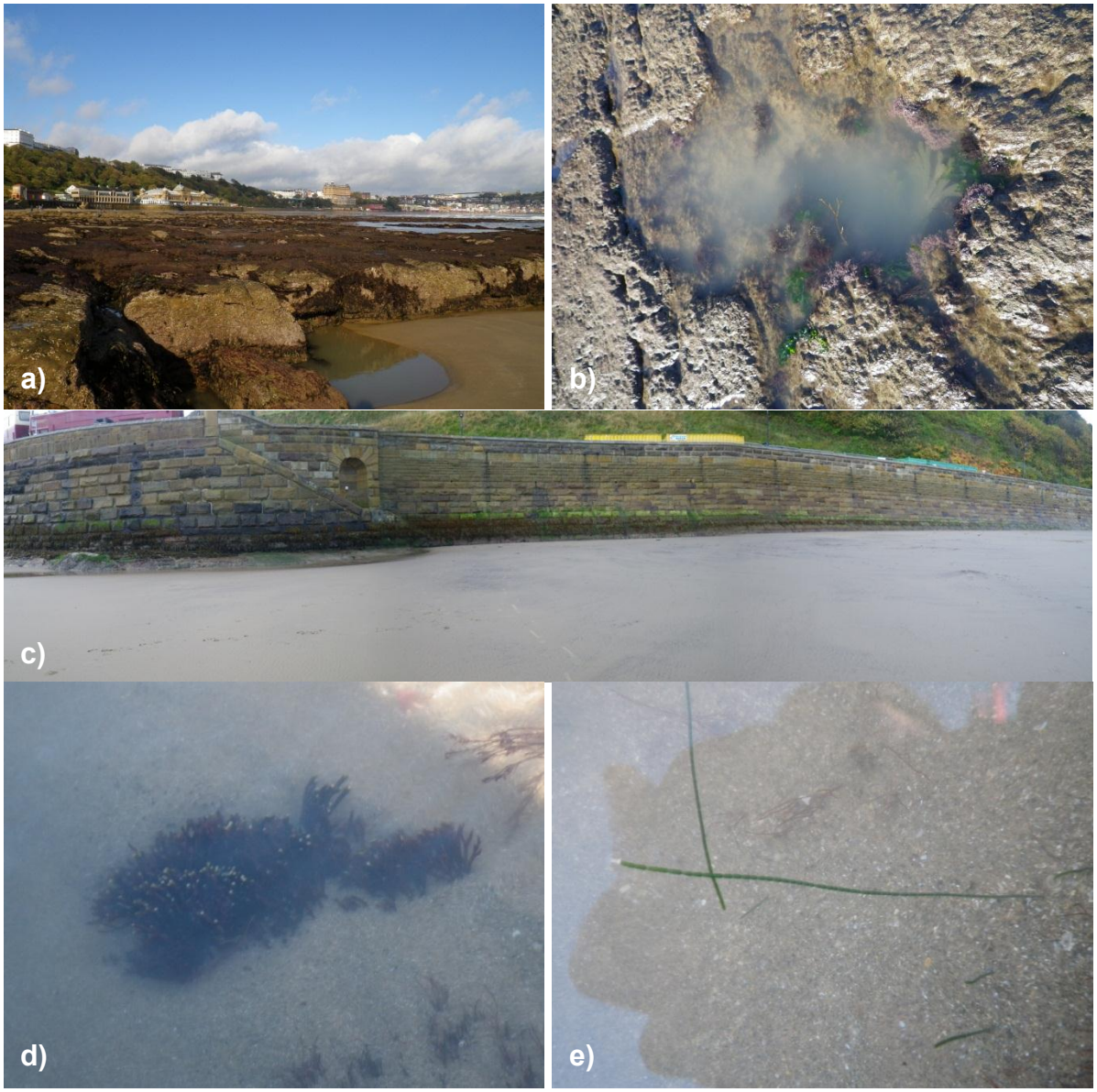

Figure 21: a) South Bay rocks interspersed with sand, b) Flat *Rhodothamniella floridula* bedrock with small pools, c) Highshore zonation on artificial walls, d) *Polyides rotundus* and e) *Chaetomorpha lineum*

The red algae bedrock is interspersed with open areas of flat bedrock dominated by *Semibalanus balanoides* (**S**uperabundant: LR.HLR.MusB.Sem.Sem & LR.FLR.Rkp.Cor.Cor)

in the midshore (Fig. 22a). The lowshore area is typically characterised by *Fucus serratus* (**S**uperabundant: LR.MLR.BF.Fser.R & LR.FLR.Rkp.Cor.Cor) before meeting the kelp forest. The kelp forest (IR.MIR.KR) at Black Rocks was similar to other kelp forests of the area with *Laminaria digitata* recorded as **S**uperabundant and *Saccharina latissima* as **C**ommon (Fig. 22b). A number of invertebrate species were also recorded here including the nudibranch *Acanthodoris pilosa* (**F**requent: Fig. 22c), the honeycomb worm *Sabellaria aveolata* (**O**ccasional: Fig 22d), as well as several species of bryozoan, barnacles and tube worms.

Figure 22: a) *Semibalanus balanoides* bedrock, b) Kelps, c) *Acanthodoris pilosa* and d) *Sabellaria aveolata*

3.6.2 Black Rocks and South Bay Biotope Map

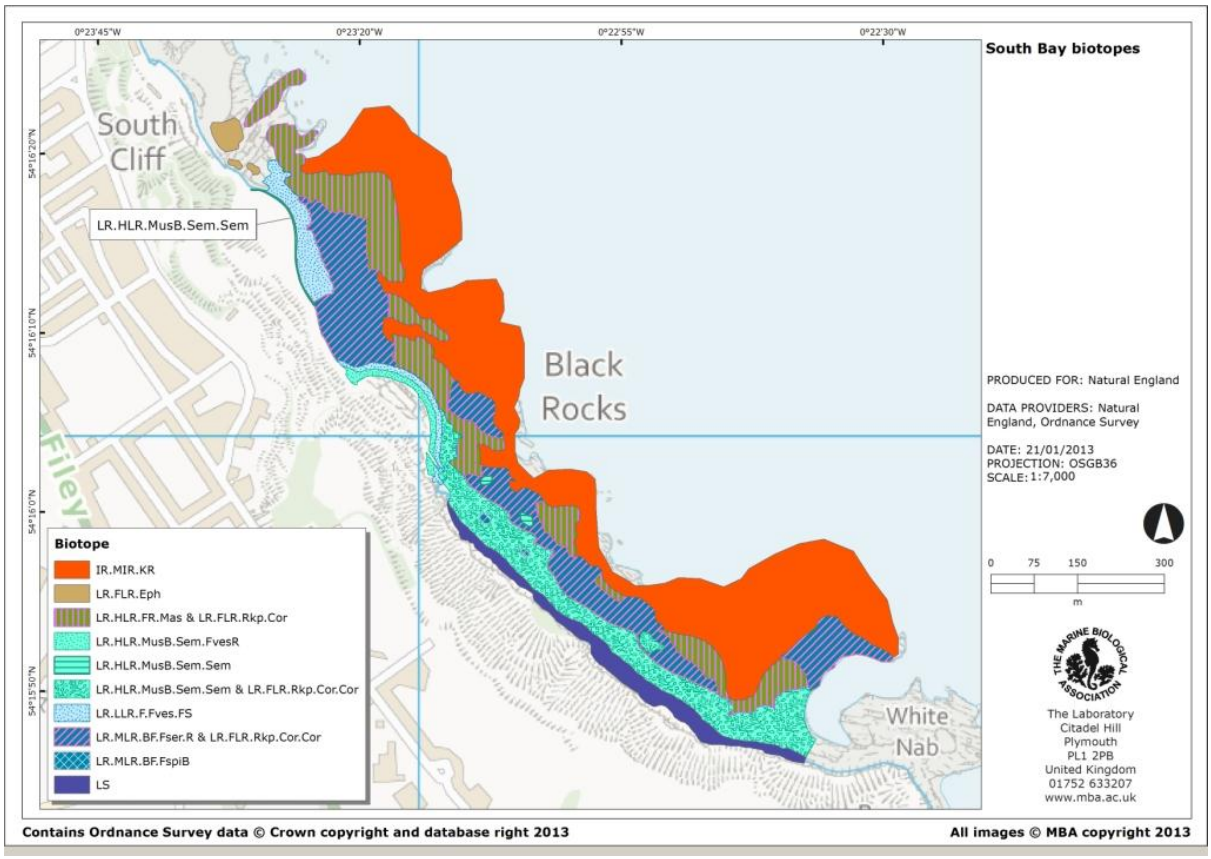

Figure 23: Black Rocks and South Bay Biotope Map

3.7 – North Bay

3.7.1 Site Description

Figure 24: North Bay survey site with artificial wall

North Bay is located to the north of Scarborough (Fig. 1) and forms part of the North Bay to South Toll House Cliff SSSI. The area is designated for its geological interest showing complete succession through the Callovian Stage and the Lower Oxfordian Substage. North Bay faces in a north / northwesterly direction and follows a gradient of exposure from sheltered (at the sandy end) to semi-exposed at the headland (Tables 1 & 2).

The intertidal rocky shore area here is relatively small and is predominantly boulder fields (Fig. 24) with some bedrock outcrops towards the headland (Fig. 25a). The area is heavily influenced by artificial habitats backed by a steeply sloping rock armour sea wall comprised of large >1m boulders, not only across the entire rocky shore area but across much of the sandy habitat as well. The artificial habitat in this area shows no evidence of supporting different species than that supported by natural rocky shore habitats. The small periwinkle *Melarhaphe neritoides* (**A**bundant) and rough periwinkle *Littorina saxatalis* (**C**ommon) are characteristic fauna of highshore areas (LR.HLR.MusB.Sem.Sem) and appear to have taken advantage of the habitat created (Fig 25b).

The natural rocky shore area begins in the midshore with a boulder field (LR.MLR.BF.FvesB) which has some artificial aggregate. The area is typical of intertidal boulder habitats (Fig. 25c) with a high species diversity found here. *Fucus serratus* (**A**bundant) and *Fucus vesiculosus* (**A**bundant) are the dominant canopy forming algae in this location and it provides habitat for a number of other species of algae, including the sand binding red algae *Rhodothamniella floridula* (**A**bundant).

The only invasive non-native species (INNS) was recorded at North Bay. The barnacle *Austrominius modestus* (**F**requent) was recorded in the natural boulders (Fig. 25d) consistently across the whole survey site. This is the only site within the survey area that this species was found.

The lowshore habitat of North Bay is characterised by small macroalgae boulders (IR.MIR.KR) which are fringed by a kelp forest (IR.MIR.KR.Ldig.Bo). Concrete cylinders (Fig. 25e: LR) and tetrapods (Fig. 25f: LR) are common along the length of North Bay.

Figure 25: Bedrock outcrops towards the headland, b) *Melarhaphe neritoides* and *Littorina saxatalis* on artificial habitats, c) natural boulder habitat, d) *Austrominius modestus*, e) Concrete cylinder defences and f) Tetrapod defences

3.7.2 North Bay Biotope Map

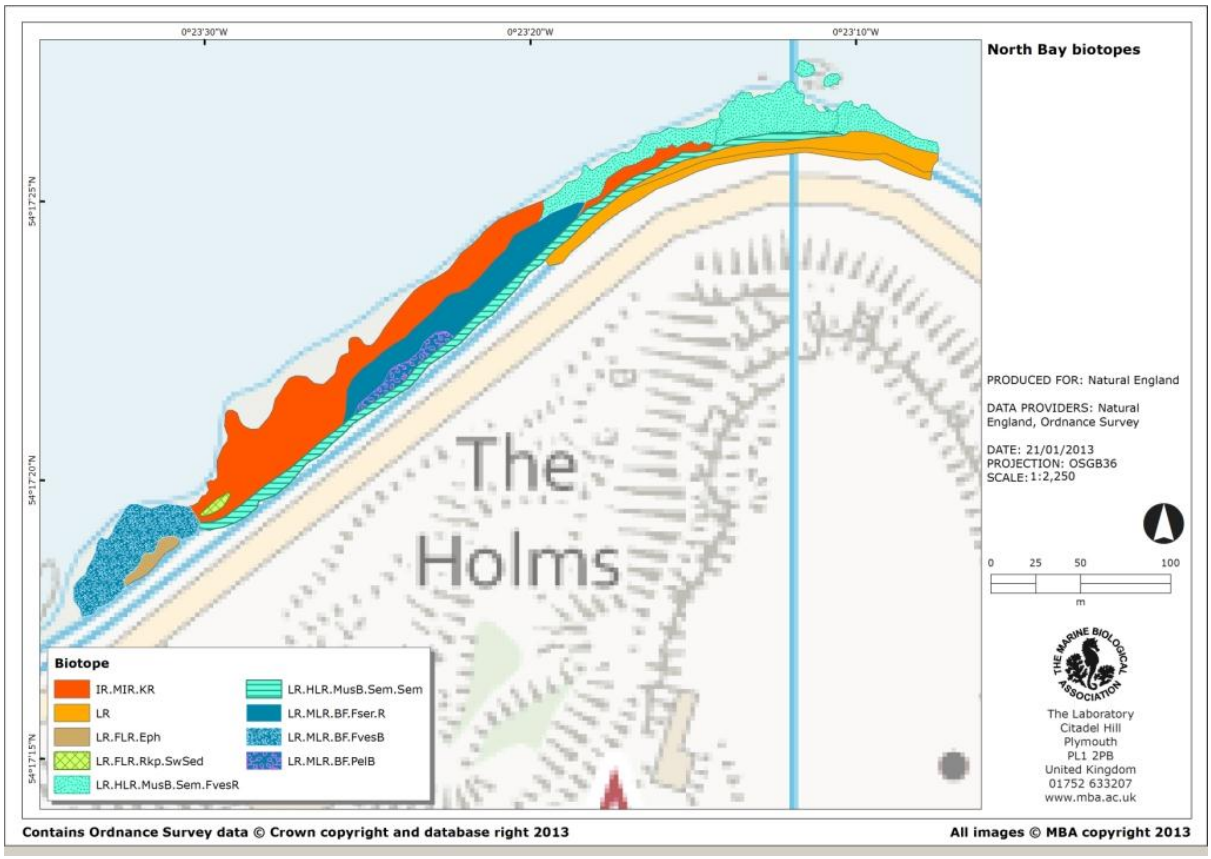

Figure 26: North Bay Biotope Map

3.8 – Scalby Mills

3.8.1 Site Description

Figure 27: Scalby Mills survey site

Scalby Mills is located to the north of Scarborough (Fig. 1) and marks the northern limit of the survey area. It is part of the Iron Scar and Hundale Point to Scalby Ness SSSI designated for its geological interest. The shore at Scalby Mills faces in a south / southeasterly direction moving around the headland to a southeasterly / northeasterly aspect. It has a gradient of exposure following the aspect of the shore from fairly sheltered to semi exposed (Tables 1 & 2).

The shore at Scalby Mills is backed by sloping and vertical cliff and the rocky intertidal area is composed of boulders interspersed over bedrock (Fig. 27). There is a large freshwater influence on the shore from riverine input (Fig. 28a: LR.HLR) and the influence of the freshwater can clearly be seen extending across the shore as a seemingly empty corridor covered in *Semibalanus balanoides* (Fig. 28b: LR.HLR.MusB.Sem). A concrete aggregate pipe runs across the shore (LR.LLR.F.Fspi.FS) making access relatively easy (Fig. 28b).

The highshore area of Scalby Mills was made up of bedrock at the base of the cliffs with large boulders (Fig. 28c: LR.MLR.BF.FspiB). Typical highshore species were found here such as *Fucus spiralis* (**S**uperabundant), *Blidingia spp* (**A**bundant), *Porphyra umbilicalis* (**C**ommon), *Melarhaphe neritoides* (**C**ommon) and *Littroina saxatalis* (**A**bundant). At the base of the highshore boulders and bedrock were several pools (Fig. 28c: LR.MLR.BF.FspiB & LR.FLR.Rkp.Cor.Cor).

The midshore intertidal area at Scalby Mills is exceptionally extensive and is dominated by macroalgae on large boulders and bedrock. Several different biotopes make up this area including *Semibalanus balanoides* (**S**uperabundant) boulders and bedrock (LR.HLR.MusB.Sem), *Fucus vesiculosus* (**A**bundant) and *Fucus serratus* (**A**bundant) boulders and bedrock (LR.MLR.BF.Fser.Bo), and a giant midshore rockpool (LR.FLR.Rkp.SwSed) which was species poor (Fig. 28d). A rare hydroid was found in the

midshore, *Sertularella gayi* (**R**are), and although common around the British Isles this was the only site in the survey area where it was found (Fig. 28e).

The lowshore area at Scalby Mills comprised flat lowshore ledges (LR.HLR.FR & LR.FLR.Rkp.Cor) with the sediment binding *Rhodothamniella floridula* (**A**bundant) and pools with the coralline algae *Corallina officinalis* (**S**uperabundant) and *Halidrys siliquosa* (**A**bundant) amongst the most abundant species (Fig 28f). The lowshore ledges extended into large boulders and bedrock (LR.HLR.FR.Mas) with *Mastocarpus stellatus* (**S**uperabundant) and *Cladophora rupestris* (**S**uperabundant). The area was fringed with a kelp forest.

Figure 28: a) Riverine input to Scalby Mills rocky shore, b) Riverine influence along *Semibalanus balanoides* corridor, c) Highshore bedrock, boulders and pools, d) Midshore rockpool, e) *Sertularella gayi* and f) Lowshore ledges

3.8.2 Scalby Mills Biotope Map

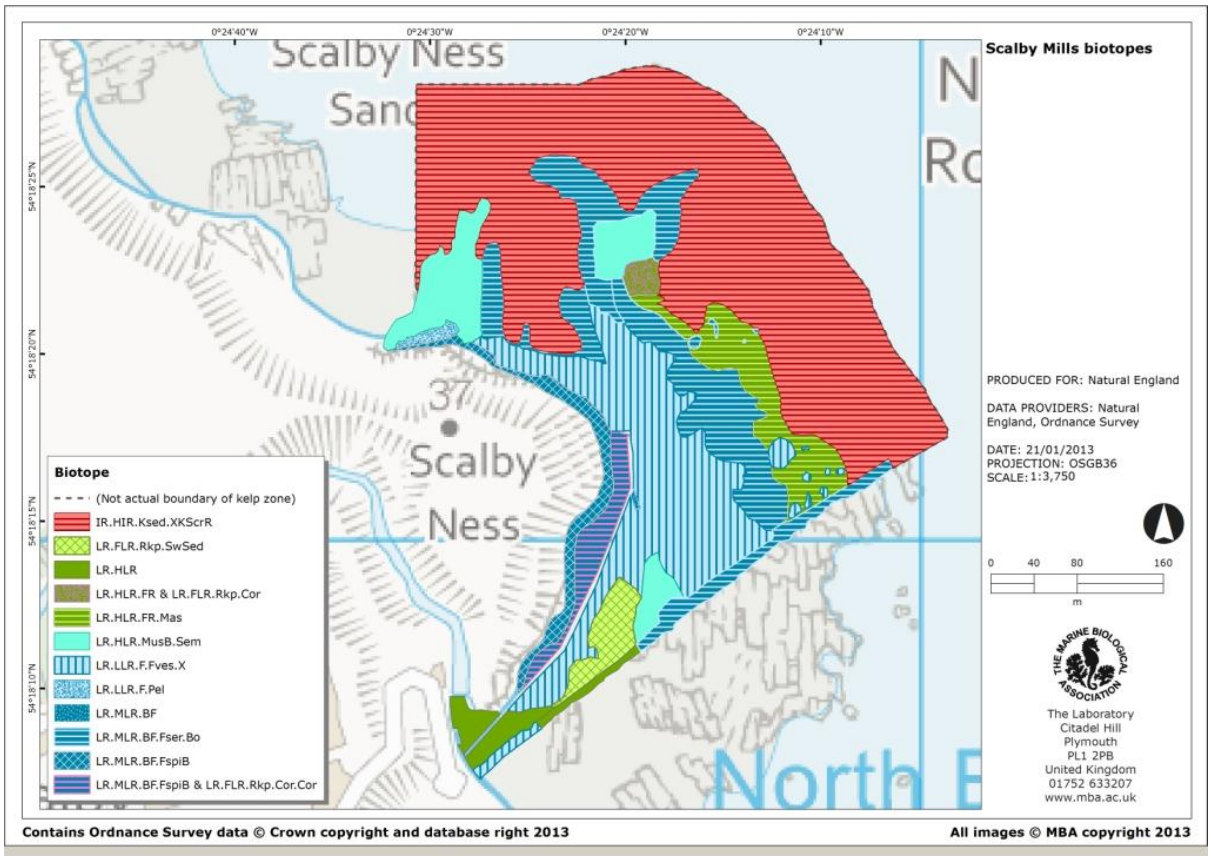

Figure 29: Scalby Mills Biotope Map

4.0 Discussion

The intertidal rocky reefs between Scalby Ness and Filey Brigg in North Yorkshire are classified in this survey as predominantly exposed (with small areas of moderately exposed and sheltered) shores typical of the North Sea coastline such as those found in the wider Northumberland region. Flat reef and boulder habitats were the most dominant substrate. These intertidal habitats were dominated by fucoids and exhibited relatively low species diversity and abundances compared to other intertidal areas in the north east of England and the wider English rocky intertidal coastline. This is, however, thought to be due to a combination the time of year at which the survey was conducted and the lack of high densities of grazers found around most of the English coastline outside of the north east. The shores surveyed in the area were found to be generally undisturbed and pristine and it is expected that as a result of this the area should support a much greater diversity during the spring and summer months.

Many intertidal invertebrates, such as crustaceans become cryptic in winter months and retreat into deep crevices or deeper waters. Many species of algae are also annual and die back or reduce in abundance during the winter months.

The boulder habitats surveyed offered a range of sizes and a variety of potential habitats for colonization. Although large areas of the habitats were influenced by sediment the sand binding algae, *Rhodothamniella floridula*, was highly abundant in the area preventing large areas of scour and the removal of benthic invertebrates. Under boulder habitats, including gullies and crevices were prevalent in the area, offering dark, damp and shady conditions, especially in some of the larger boulder fields (>1m). This diversity of habitats would be ideal to support a higher abundance and diversity of invertebrates such as sponges (*Halichondria panicea, Hymeniacidon perlevis* and *Grantia compressa*), colonial and solitary tunicates (*Botrylloides leachi, Botryllus schlosseri* and *Dendrodoa grossularia*), nudibranchs (*Doris pseudoargus, Onchidoris billamelata* and *Ancanthodoris pilosa*), hydroids (*Dynamena pumila* and *Obelia geniculata*) and bryozoans (*Electra pilosa, Membranipora mebranacea*, *Cryptosula pallasiana* and *Oshurkovia littoralis*) all of which are common in the surrounding areas of the north east of England. The occurrence of some of these species in the survey area, however, cannot be supported by the results of this survey. The previous MarClim survey does highlight how the abundance of, for example*, Halichondria panicea* has changed at Filey Brigg. In the 2012 survey conducted at Filey Brigg it was recorded as **A**bundant whereas it was **C**ommon (20%) in the current survey. This example indicates how difficult it would be to extrapolate the results of the current survey to give an indication of what the communities would look like at other times of the year.

The rock pools found throughout the survey area offered examples of the potential to be highly diverse in both algal species and invertebrate species, despite being species poor at the time of the surveys. Rock pools surveyed to both the north and south of the area show high diversity of both red and green algae as well as supporting species of brittle stars (*Amphipholis squamata* and *Ophiothrix fragilis*), starfish (*Asterias rubens* and *Henricia oculata*), juvenile sea urchins (*Psammechinus miliaris* and *Echinus esculentus*), nudibranchs (*Berthella plumula* and *Doris pseudoargus*), the sea hare *Aplysia punctata*, along with several species of crab, especially the hermit crab *Pagarus bernhardus* and the periwinkle

Littorina littorea. The brown algae *Halidrys siliquosa* has also been increasing in abundance through the north east of England and in some instances populations of the stalked jellyfish *Craterolophus convolvulus* are highly abundant in rock pool habitats (pers obs – The Big Sea Survey project, Newcastle University). If the rock pools of the survey area are similar to the rock pools of the surrounding area then they are expected to be highly diverse during the spring and summer months, but once again this cannot be supported by the data collected herein. A comparison with selected species surveyed during the 2012 MarClim survey reveal that the broad clawed porcelain crab, *Porcellana platycheles*, was **A**bundant at Scalby Mills in August 2012 whereas it was recorded as **N**ot **S**een during the current survey. The species present on each shore and within each biotope can be found in Electronic Appendix 1 – The survey data sheets and Electronic Appendix 3.

A total of 48 biotopes classifications and 9 biotope complexes were recorded across the survey area. Biotopes were classified according to the species which were recorded within each biotope and following the National Marine Habitat Classification for Britain and Ireland (Conner et al 2004). The limitations of assigning biotopes following this classification means that not all of the biotopes were accurately classified: for example less abundant species were not represented; the full range of exposure was not available; and the substrate upon which the biotope was recorded was not offered for inclusion. This has resulted in the same biotope been assigned to several compositions but with an additional note for exposure and habitat.

Formal statistical comparisons of species diversity between shores cannot be carried out due to the confounding effect of the methods used in determining biotopes. To determine the species diversity of a shore the entire area must be randomly sampled and every species on the shore have an equal chance of being recorded, or by application of quantitative survey methods such as vertical transects (not the belt transects required for this contract, but structured, scientifically robust transect methodologies). Stratifying the sampling by biotope prevents this from happening due to the difference in extent of a biotope patch, even if the arbitrary biotope classification is the same. However, informal comparisons of the range of species diversity found on the shores and the diversity of biotopes can be examined. South Bay and Black Rocks shows the highest range in species diversity of the shores surveyed (Table 3) and Filey Brigg shows the highest diversity of biotopes recorded throughout the survey area (Table 4).

The results clearly show that the survey area can be split into four distinct regions based on the biotopes present. Scalby Mills and Filey Brigg are clearly dissimilar from the other areas surveyed. Filey Brigg is different from the other sites due to the large number of biotopes recorded here which are linked to the high diversity of habitats found and the exposed nature of the shore. Filey Brigg has several biotopes in common with all of the other sites surveyed in the area. Scalby Mills has fewer biotopes than Filey Brigg but 8 biotopes in common with Filey Brigg hence the similarity to this site. The majority of biotopes recorded at Scalby Mills are different from the other areas surveyed.

The habitats at Filey Brigg and Scalby Mills are made up of a combination of flat bedrock, large rock pools and boulder fields consisting of cracks, crevices and gullies. It is this range of habitats which is thought to support a larger number of biotopes when compared with the other shores in the survey area. South Bay and Black Rocks were predominately flat

bedrock habitats with some gullies and crevices and a few boulders. All other shores in the survey area were dominated by large boulder fields. Although these boulders look suitable to support high levels of diversity (i.e. they are various sizes, they probably experience varying degrees of disturbance and there will be varying degrees of exposure associated with their habitats) there is little overall diversity in the habitats. The middle area of Castle Rocks and The Nab did consist of gully formations and some flat bedrock which offers alternative habitat for colonization but which at the time of the survey were species poor. If similar to other areas in the region during the spring and summer these areas would be expected to be higher in diversity, but this is something that cannot be supported by the data collected herein.

Two previously unrecorded species of red algae, *Chondra capillaris* and *Spyridia filamentosa,* were found in the middle section of the survey area between The Nab and The Wyke. *Chondra capillaris* is suggested to be present around the whole of the UK (algaebase) but very few records have been recorded. Where it has been recorded it is present on the south and east coasts of England and throughout Wales. Most records for this species are from the Marine Conservation Society Seasearch Project (subtidal records) and the British Phycological Society (NBN Gateway). *Spyridia filamentosa* is also suggested to occur throughout the UK but once again records are heavily weighted to the south west coast of England. These records were recorded by the British Phycological Society and JNCC on specific targeted surveys of these areas (NBN Gateway). Both species are small red algae and it is suggested that they are not new species in the survey area (i.e. they have not migrated here with warming climates or been moved through anthropogenic means) but rather that they have been overlooked in previous surveys in surrounding areas or that they have not been specifically searched for in the area.

The shores of the survey area offer a good example of natural rocky shore habitats, characteristic of the North Sea. They appear to be in a natural state with flora and fauna typical of their exposure and location. The exposure of the shores in the survey area vary from exposed to fairly sheltered and this can be seen in the species assemblages seen on the shores, for example patches of *Ascophyllum nodosum* are seen in more sheltered areas. An exception to this is the influence of freshwater at Scalby Mills. This freshwater influence would be here anyway due to the riverine outflow but it does appear to have been artificially channelled to enter the bay along a thin strip and it therefore does not have a large footprint on the communities living on the shore here.

The shores of the survey area are all algal dominated due to a lack of grazers. This type of community is typical of other intertidal rocky shores outside of the survey area in the north east of England which are influenced by similar levels of exposure. Coastal habitats located in The North Sea are much colder environments than similar habitats on the Atlantic coast. This difference in temperature is reflected in the types and diversity of species found on the shores. For example, where you would typically find 4-5 species of top shells on west coasts of the UK only 1-2 species will be found on north east coasts. *Alaria esculenta* is a native coldwater kelp that has been negatively affected by warming temperatures over the last three decades. Comparisons with historical data from the 1950s in southwest England and the 1970s and 1980s from the Robin Hoods Bay marine laboratory (closed in the mid 1980s) show that the southern range limit of *A. esculenta* has retracted north in this area and is currently located at Filey Brigg. This species was recorded at Filey Brigg but not at any other

survey site within the proposed SSSI. Surveys carried out between 2010 and 2012 by Mieszkowska and Sugden for MarClim and the Big Sea Survey have found *A. esculenta* to be present in the region at Seaton Sluice, Castelhead Rocks Holy Island and the Farne Islands. The wider area is therefore an important region for this coldwater kelp.

The shores located in the survey area do not appear to have been impacted by anthropogenic pressures and little evidence of marine litter was found. Of note is the narrow concrete path at Filey Brigg and the sewage outflow pipe at Scalby Mills, However, both the path and the sewage pipe have created their own biotopes and do not appear to have any residual influence on the surrounding communities. The Nab to The Wyke area at the centre of the survey site are expected to be little impacted by anthropogenic activities due to backing by vertical cliffs and the difficulty associated with accessing these areas. Recommendations regarding access to the shores and future surveys have been made. Although the other sites of the area have significant influence from artificial habitats there is no evidence to suggest that these artificial habitats are negatively affecting the natural species compositions of the shores. In fact if anything the artificial habitats created by these defences have provided additional mid to high shore rocky habitats in the area and the species found associated with them do not differ from those found in natural mid to high shore habitats.

In response to rising and stormier seas caused by climate change, coastal defence structures are proliferating and are becoming dominant features of coastal landscapes, particularly in urbanized areas of the UK. Whilst the primary function of these structures is to protect coastal infrastructure, they inevitably have a significant impact on the local environment, by alteration of habitat, local hydrography, sediment flow and exposure. Currently, 46% of the English coastline is protected by artificial structures (Masselink & Russell 2010).

Several factors can affect the species and assemblages which colonize artificial coastal structures. Vertical position in the intertidal zone, slope, surface roughness and habitat heterogeneity (including water-retaining features) are important factors determining the diversity of colonizing epibiota on artificial structures (Coombes et al. 2011; Firth & Crowe 2010). There are several types of structure and construction units deployed around the UK including concrete and aggregate walls, gabions, wooden pilings, rock armour and informal rubble. Each has its own specific properties with respect to the material, surface rugosity, microhabitat provision and the orientation and slope which will dictate which species can successfully colonize. Some artificial defences have enhanced the proliferation of invasive species such as *Codium fragile* (Bulleri & Arioldi 2009), although there is little evidence in the UK of this happening outside of enclosed areas such as harbours, ports and marinas.

The artificial structures encountered in the survey area were rock armour at North Bay, concrete sea walls and rock armour at South Bay and a concrete aggregate pipeline at Scalby Mills. None of these structures hosted invasive non-native species. The rock armour had lower species diversity than natural boulders located in the vicinity which probably resulted from the smoother surface of the armour rocks than the natural habitat. The concrete sea walls were smooth, vertical structures hosting small littorinids in the upper eulittoral and macroalgae. The concrete pipeline is frequently used as a path by people accessing the shore and therefore the upper surface had patchy *F. vesiculosus, S.*

balanoides and ephemeral *Porphyra umbilicalis, Ulva linza* and the red alga *Mastocarpus stellatus*, predominantly on the sides of the structure.

The rock armour walls at North Bay, and South Bay and the Stone and concrete walls at South Bay do not support any species not found elsewhere in the area on natural habitat. Species diversity is lower than on surrounding natural habitat but in the most part there would be no suitable natural high shore habitat at these locations so there are no current adverse effects evidenced in the local community assemblage. An extension of the sea wall northwards at South Bay towards the seafront at Scarborough is planned within the next 18 months and should be monitored upon completion to determine how this affects local intertidal biodiversity. No artificial structures were present along the length of coastline from The Nab to Filey Brigg.

The only INNS recorded in the survey is the Australasian barnacle *Austrominius modestus,* which has been established in the UK since the 1940s and has become a naturalised member of rocky intertidal communities with no adverse effects on native species. It was only present in two shores in the region, reflective of the wider trend seen in annual MarClim surveys extending up the Northumberland coastline. The northeast of England is unique in the low number of established INNS and we recommend that any future records of INNS within ports, harbours, marinas and aquaculture facilities be quickly dealt with and subsequently monitored on nearby natural reefs to ensure that any escapes are managed and eradicated prior to successful colonisation and spread.

The survey area sits within the England and Wales Area 1 (E & W 1) as defined in the JNCC areas of search for the designation of biological SSSI's and based on major coastal cell boundaries (Motyka & Brampton 1993). The supporting evidence for the selection of biological SSSI's is summarized in Table 9.

Table 9: Supporting evidence against biological SSSI features as defined in the guidance for the selection of biological SSSI's, JNCC

	Biological SSSI	Supporting Evidence
Criteria	Size (extent)	Natural rock – 136 ha Artificial substrate - 8 ha All habitat features extend throughout the survey area
	Diversity	Good habitat diversity with overhangs, underboulder habitats, rockpools and open rock surfaces Good winter species diversity, expected to increase in summer months
	Naturalness	The Wyke, Chimney Hole, Castle Rock and The Nab are all excellent examples of rocky shores with little or no anthropogenic modifications.
	Rarity	None – but see below
	Fragility	The shores in the survey area are examples of exposed, robust communities
	Area of Search (AOS)	E & W 1 – with Filey Brigg marking the southern boundary point of the AOS
Selection Units	Exposure of Shores	Range of shores from exposed to fairly sheltered – offering good examples of each
	Special Habitat Features	• Massive boulder fields – Filey Brigg, The Nab, The Wyke, Castle Rocks, Chimney Hole, North Bay • Moderate boulder fields - Filey Brigg, The Nab, The Wyke, Castle Rocks, Chimney Hole, North Bay, Scalby Mills • Small boulder fields – South Bay & Black Rocks • Surge gullies – The Nab & Castle Rocks • Overhangs – Filey Brigg, The Nab, Castle Rocks • Crevices - Filey Brigg, The Nab, Castle Rocks, South Bay & Black Rocks, Scalby Mills • Rockpools – All shores
	Annex 1 – Nationally important communities	None
	Annex 2 – nationally rare and scarce species	None
	Annex 3 – Wildlife & Countryside Act	None
Features	Best example of a particular habitat in AOS	• The Wyke, Chimney Hole, Castle Rocks and The Nab offer the best example of unmodified shores in the AOS • The shores of the survey area also offer good examples of habitat diversity, including artificial defences in the AOS
	Variety of high quality shore types	• All shores offer a range of habitats and a range of exposure. • Typical of the area

		• Little anthropogenic pressure even where artificial coastal defences are found
	Good quality examples of specialised habitats	• Flat bedrock – Filey Brigg, South Bay & Black Rocks, Scalby Mills, The Nab, Castle Rocks • Boulder fields of varying sizes (both extent and size of boulder) – All shores • Rockpools – All shores • Surge gullies – The Nab & Castle Rocks • Vertical cliff – Filey Brigg • Overhangs – Filey Brigg, The Nab, Castle Rocks Crevices – Filey Brigg, The Nab, Castle Rocks, South Bay & Black Rocks, Scalby Mills
	Habitat or community features of a restricted nature on national / international nature	LR.HLR.FR.Mas – Scalby Mills & Filey Brigg LR.MLR.BF.PelB (although listed as Common, this biotope is Scarce on the east coast of England) – North Bay & Castle Rocks LR.FLR.Lic.Bli – North Bay, South Bay & Black Rocks, The Nab & The Wyke LR.LLR.F.Fserr.X – The Nab LR.MLR.MusF.MytFves – Filey Brigg
	Complete zonation down the shore with mature community types, where relevant	The Wyke Chimney Hole Castle Rocks The Nab
	One or more marine species currently considered nationally rare / scarce	Under the definitions of the guidelines for designation of biological SSSI Annex 1-3 there are no species considered nationally rare. But care should be taken in this interpretation as the majority of species require the warmer waters of the south and west UK and have never been recorded on north east coast. • *Alaria esculenta* – considered declining in abundance around UK is present at Filey Brigg • Only one INNS found at Filey Brigg and North Shore • It is expected that further cold water species would be found in this area where they are declining in warmer areas of the UK
	Site covers a large area or has extensive lateral extent in continuous or discrete units depending on the degree of natural and man-made interpretations	Natural rock – 136 ha Artificial substrate - 8 ha

Within the AOS the only other area designated as a biological SSSI for its intertidal rocky reef features is within the Robin Hood's Bay SSSI which lies to the north of the Scalby Ness

to Filey Brigg survey area. Robin's Hoods Bay was designated for its important low intertidal habitats encompassing moderately exposed flat bedrock and moderately exposed large and massive boulder fields. It also supports nationally scarce red algal turf biotopes and the nationally uncommon *Rhodothamniella floridula* biotope. The habitats designated in the Robin Hood's Bay SSSI are also present in the current survey area, along with a number of other important features (Table 9).

The survey area between Scalby Ness and Filey Brigg has also been selected as a candidate Marine Conservation Zone (cMCZ) under the regional Net Gain project. The area classified as NG10 Castle Ground is thought to provide the broadscale habitats A1.1-A1.3 (high-low energy intertidal rock) as defined in the Ecological Network Guidance (ENG) as well as the habitat features of conservation interest (FOCI) 'Intertidal Under Boulder Communities'. The area has, as part of this survey, been identified as having the broadscale habitats A3.1 – A3.3 (high-low energy infralittoral rock). The supporting evidence for the features of the cMCZ, as outlined in the ENG, are summarized in Table 10.

The rMCZ of NG10 Castle Ground covers an area of 3.7km^2 with nearly half of this area (1.36km^2) covered by rocky intertidal shores which have been surveyed as part of the current contract. NG10 sits in the middle of the Net Gain MCZ area and the habitats located here offer a replication of just one other site within the Net Gain region, NG13 Coquet to St. Mary's, which shows examples of the same broadscale habitats and FOCI.

Table 10: Candidate Marine Conservation Zone features as outlined in the Ecological Network Guidance with supporting evidence

	MCZ Feature	Supporting Evidence
Ecological Considerations	Threatened, declining or rare species / habitats	**Broadscale Habitats** A1.1 High energy intertidal rock – Filey Brigg A1.2 Moderate energy intertidal rock – Scalby Mills A1.3 Low energy intertidal rock - None A3.1 High energy infralittoral rock – Filey Brigg A3.2 Moderate energy infralittoral rock – Scalby Mills A3.3 Low energy infralittoral rock – Filey Brigg **Habitat Features of Conservation Interest (FOCI)** Intertidal under boulder communities – Boulder fields are located throughout the survey area at the following shores: Filey Brigg, The Wyke, Chimney Hole, Castle Rocks, The Nab, North Shore and Scalby Mills **Species of Conservation Interest (SOCI)** None found
	Important species / habitats	See above for broadscale habitats / FOCI *Alaria esculenta* – **Filey Brigg**. This species has a rapidly changing range edge in response to climate change and is found is isolated patches within the survey area.
	Ecological significance	Offers a cold water habitat representative of North Sea coastlines at the same level of exposure. Some cold water species are supported in the area where they have disappeared from other parts of the UK.
	High natural diversity	Good habitat diversity with overhangs, underboulder habitats, rockpools and open rock surfaces, along with a range of shore exposures Good winter species diversity, expected to increase in summer months
	Sensitivity	The shores in the survey area are examples of exposed, robust communities
	Naturalness	The Wyke, Chimney Hole, Castle Rock and The Nab are all excellent examples of rocky shores with little or no anthropogenic modifications.
	Size and position of site	The survey area lies in the middles of the Net Gain area, NG10 Castle Ground, and is proposed to cover an area of 3.7km^2.
Practical	Size	Natural rock - 1.36km2 Artificial substrate - 0.08km2
	Potential for recovery	The shores in the survey area are examples of regularly disturbed and robust intertidal communities
	Scientific Value	The rMCZ at NG10 replicates the habitats identified within NG13 (Coquet to St. Mary's). The two rMCZ's are the only examples of these habitats with the regional MCZ project (Net Gain).

5.0 Recommendations

The shores of the survey area are backed by vertical cliffs. The unstable, near-vertical, high cliff faces extending from The Nab past The Wyke to Filey Brigg prevents safe access to and from the shore. The roped access down the vertical, 300m high cliff face at Chimney Hole is not recommended as the rope is old and the single tie point into the cliff cannot be ascertained to be safe to withstand use. Similar roped access points down unstable, muddy cliff faces between Chimney Hole and The Nab are not recommended. Therefore to survey the Wyke and Chimney Hole requires a walk of approximately 4km each way from the Cayton Bay access point, mostly across rocky reef covered in slippery macro algae. An hour and a half walk each way should be factored into these sites, or access by RIB, landing on the sandy beach between Chimney Hole and The Wyke recommended.

It is recommended that future surveys should be carried out at the same time of year in order that the results are comparable to the baseline data recorded herein. However, it is also recommended that caution should be used when interpreting this data as a basis for the overall species diversity of the site. Due to the difficulty in access the sites do appear to be in good condition in comparison to one another and to other areas of the north east of England. This conclusion can only be drawn from knowledge of the area during the winter months, it is not based on the data gathered, and cannot be extrapolated to the condition of the sites at other times of the year. The only exception to this is North Bay which is heavily influenced by artificial structures and is much smaller in extent than the other shores surveyed.

A ground truthing survey should be completed during spring or summer months in order to establish whether the species diversity drops off significantly during the winter as suspected. It is also recommended that the condition of shores outside of the survey area be assessed following the same methodology outlined herein in order to put the condition of the survey area into a regional context.

Future surveys should be carried out using the same methodology as for this survey. We recommend as far as is practical, Phase II species lists and abundances be recorded for each biotope as changes in response to human pressures, climate change and changes in natural environmental conditions will be manifested initially in less abundant species not those from which biotope classifications are derived.

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