Flamborough Head Intertidal Survey 2022

Phase 1 and 2 survey of intertidal rocky shore habitats within the Flamborough Head SSSI

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Foreword

A Phase I and Phase II intertidal survey of specific sites around Flamborough Head was undertaken by Seastar Survey Ltd in 2022 to investigate the potential for their inclusion within a Site of Special Scientific Interest (SSSI). This report does not itself make a case for designation, rather it provides an objective record of the survey findings which will be used to support Natural England's independent assessment of special interest.

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Executive summary

Background

Flamborough Head, located on the north Yorkshire coast, is a chalk headland which projects eastward into the North Sea, close to the biogeographic boundary between two North Sea waterbodies. The site is the most northerly chalk outcrop in the UK and represents the most southerly aera of extensive bedrock in the North Sea. The site covers approximately 14 % of coastal chalk exposure in the UK and is located at the southern limit of distribution of several northern species. The site is characterised by high chalk cliffs and the littoral reefs at Flamborough Head are considered to be the most diverse in the UK.

In 2022, Natural England wished to collect evidence to support the potential redesignation and expansion of several SSSI's along the Yorkshire coastline which had been previously notified for their biological and/or geological interest. As part of this evidence collection, Seastar Survey Ltd. ('Seastar') were contracted by Natural England to undertake a Phase I and Phase II intertidal survey within a specific units of the Flamborough Head SSSI. The aim of the Phase I survey was to determine the type, distribution and extent of the habitats present by assigning biotopes *in situ* on vertical (i.e. running from high to low shore) 60 m wide belt transects. The aim of the Phase II survey was to provide data on the species composition (i.e. community structure) of component communities within the main/dominant biotopes at high, mid and low shore at each transect.

Main Findings

- Three belt transects were successfully surveyed in accordance with best practice guidance within the specified survey area over a single spring tide in October 2022;
- At each transect, all habitat types present within a 60 m wide 'belt' were recorded and assigned a biotope as per the latest iteration of the MNCR Marine Habitat Classification for Britain and Ireland;
- Maps detailing the type, range and distribution of each identified biotope were created for each transect;
- No biotopes considered nationally or internationally important (as listed in Annex I of Brazier *et al*., 2019) were recorded during the survey;
- The rockpool biotope **LR.FLR.Rkp.SwSed**, which is listed as a biotope of special interest, was recorded at transects FH02 and FH03;
- Twelve biotopes that are considered typical of the whole shore types that should be represented in the SSSI series (as listed in Annex II of Brazier *et al*. (2019)) were identified during the survey;
- Generally, the biotopes identified were representative of sheltered shores, with six of the nine rock biotopes identified listed as being typical of wave sheltered rock;
- No biotopes typical of wave exposed rock were identified, however five of the biotopes identified are listed as typical of the moderately wave exposed rock whole shore type;

- In addition to the SSSI biotopes identified, two habitats of interest in Great Britain (as listed in Annex II of Brazier *et al*. (2019)) were identified during the survey: intertidal chalk and maritime cliff and slopes;
- The habitat and species data collected as part of the survey are considered of sufficient quality and resolution to be suitable in supporting future assessments of feature condition based on CSM guidance.

Contents

Introduction

One of the core duties of Natural England is to ensure protection and management of Sites of Special Scientific Interest (SSSIs), which are England's very best wildlife and geological sites and which are legally protected under the Wildlife and Countryside Act 1981 as amended by the Countryside and Rights of Way (CROW) Act 2000 and the Natural Environment and Rural Communities (NERC) Act 2006.

Natural England wished to collect evidence to support the potential redesignation and expansion of several SSSI's along the Yorkshire coastline which had been previously notified for their biological and/or geological interest. As part of this evidence collection, Seastar Survey Ltd. ('Seastar') were contracted by Natural England to undertake a Phase I and Phase II intertidal survey within a specific units of the Flamborough Head SSSI. The location of the survey area is shown in Figure 1.1.

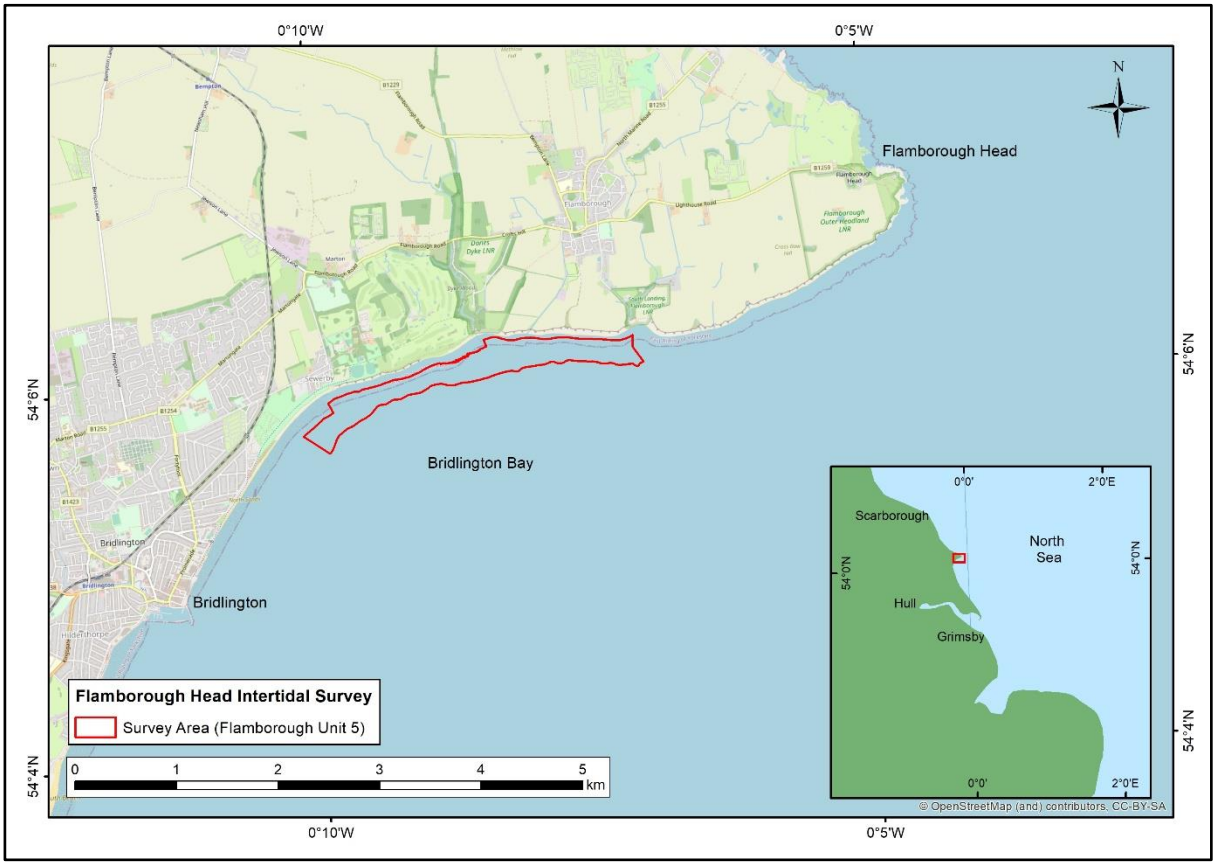

Figure 0.1: Location of the 2022 Flamborough Head intertidal survey area. © OpenStreetMap (and) contributors. CC-BY-SA.

Site description

Flamborough Head, located on the north Yorkshire coast, is a chalk headland which projects eastward into the North Sea, close to the biogeographic boundary between two North Sea waterbodies. The site is the most northerly chalk outcrop in the UK and represents the most southerly aera of extensive bedrock in the North Sea. The site covers

approximately 14 % of coastal chalk exposure in the UK (9 % of all European chalk exposure) and is located at the southern limit of distribution of several northern species (English Nature, 2000). The site is characterised by high chalk cliffs and the littoral reefs at Flamborough Head are considered to be the most diverse in the UK (JNCC, 2022a).

Flamborough Head was notified as a SSSI in 1986. The site comprises the coastal chalk cliffs of Flamborough Head between Reighton and Sewerby. The cliff line exposes a variety of geological features and the chalk has been eroded to form stacks and caves, particularly between North Cliff and Castlemere Hole. The rock exposures are also of interest in supporting important breeding bird colonies, whilst the clifftops support interesting plant communities (English Nature, 2000). On the south coast of Flamborough Head the cliffs are less actively eroded than those to the north, however shore platforms are well developed, with beaches composed primarily of sand and chalk pebbles, with few flints fed from the cliffs (English Nature, 2000).

The southern coast of Flamborough Head is generally characterised by wide wave-cut rock platforms, although the rock is interrupted by beaches composed of sand or chalk pebbles at South Landing and Danes Dyke. Where rock is present, the upper shore is generally characterised by boulders with bedrock present in the mid and low shore zones. The area is dominated by fucoid wracks, with *Fucus vesiculosus* present in the mid shore and a wide band of *F. serratus* in the lower shore. At the sublittoral fringe, an extensive zone of the sand-binding red algae *Rhodothamniella floridula* is present, indicating the influence of sand in this area (Musk *et al*., 2010; Howson, 2001). The pitted nature of the rock platforms present have resulted in the presence of small rockpools throughout the area (English Nature, 2000).

The survey area set by Natural England for the 2022 intertidal survey encompassed, either in full or in part, four SSSI units. A summary of these units is given in Table 1.1. These units were last assessed in 2010; three of the units are currently considered to be in favourable condition, while one (unit 25, Sewerby 1) is considered to be in unfavourable condition but recovering.

Table 0.1: Summary of the Flamborough Head SSSI units encompassed within the 2022 survey area.

SSSI unit no.	SSSI unit name	Area (ha)	Habitat	Condition
23	Danes Dyke 1	5.89	Supralittoral rock	Favourable
24	Danes Dyke 2	15.44	Supralittoral rock	Favourable
25	Sewerby 1	12.47	Supralittoral rock	Unfavourable - recovering
26	Sewerby 2	26.97	Supralittoral rock	Favourable

The Flamborough Head SSSI falls within several other designations. These include the Flamborough Head Special Area of Conservation (SAC), qualifying under the Habitats Directive (92/43/EEC) and the Conservation of Habitats and Species Regulations 2017 (as amended) due the presence of the Annex I habitats reefs, vegetated sea cliffs of the Atlantic and Baltic Coasts, and submerged or partially submerged sea caves. In addition, the site falls within the Flamborough and Filey Coast Special Protection Area (SPA). The unique chalk cliff habitats support the largest mainland seabird colony in England, including the only mainland gannetry in England, the largest kittiwake colony in the UK and the largest guillemot and razorbill colonies in England (Natural England, 2022).

Previous relevant survey work

The first comprehensive intertidal biotope mapping survey of Flamborough Head SAC was carried out in 2000 (Howson, 2001). The monitoring transects established as part of this survey were resurveyed in 2010 (Musk *et al*., 2010). Of the nine monitoring transects previously surveyed, two were located within the area to be surveyed in 2022; MT8 (South Cliff) and MT9 (Sewerby Rocks). The locations of these transects are shown in Figure 1.2.

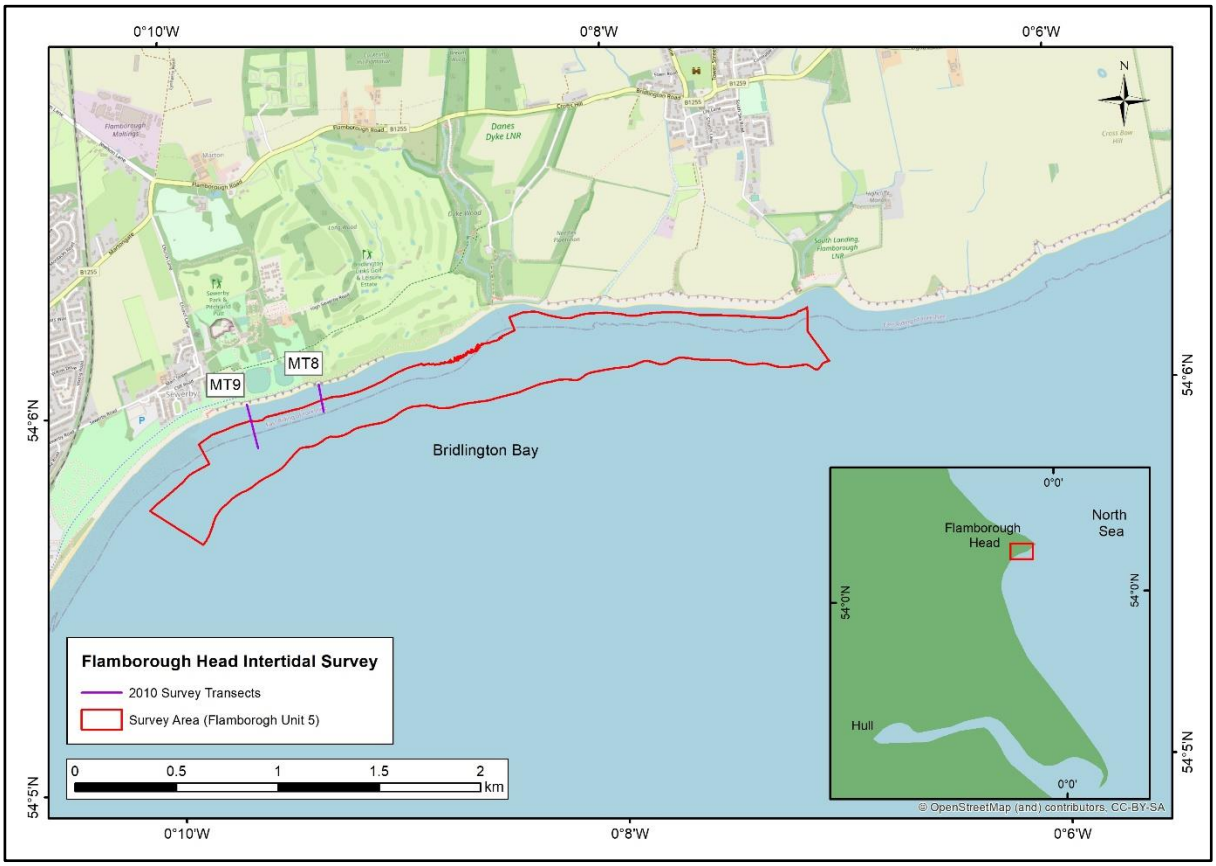

Figure 0.2: Location of transects MT8 and MT9 surveyed as part of the intertidal biotope mapping survey of Flamborough Head SAC in 2000 (Howson, 2001) and 2010 (Musk *et al*., 2010) © OpenStreetMap (and) contributors. CC-BY-SA.

Transect MT8 was described by Musk *et al*. (2010) as a moderately exposed bedrock platform shore, while MT9 was described as a mixed sand and sand-scoured rock shore. The biotopes identified in both 2001 and 2010 at each transect are listed in Table 1.2.

Table 0.2: MNCR biotope codes recorded at monitoring transects MT8 and MT9 at Flamborough Head in 2000 and 2010 (*after* Musk *et al*., 2010). NB. All biotope codes have been updated as per the latest version of the Marine Habitat Classification for Britain and Ireland (JNCC, 2022b). Some cells have been left blank intentionally.

Transect	Biotope no.	2010	2001
MT8	1	LS.LCS.Sh.BarSh*	LS.LCS.Sh.BarSh
	2	LR.FLR.Eph.Ulv	LR.FLR.Eph.Ulv
	3	LR.MLR.BF.FvesB	LR.MLR.BF.FvesB
	4	LR.HLR.MusB.Sem.Sem	
	5	LR.HLR.MusB.Sem.FvesR	LR.HLR.MusB.Sem.Sem
	6	LR.LLR.F.Fves.FS	LR.MLR.BF.FvesB
	7	LR.FLR.Rkp.G	LR.FLR.Rkp.Cor
	8	LR.LLR.F.Fserr.FS	LR.LLR.F.Fserr.FS
	9	*Ceramium* biotope	LR.HLR.FR?
	10	LR.MLR.BF.Rho	LR.MLR.BF.Rho
MT9	1	LS.LCS.Sh.BarSh	LS.LCS.Sh.BarSh
	2	LS.LSa.MoSa.BarSa	
	3	LR.MLR.BF.FvesB	LR.MLR.BF.FvesB
	4	LR.MLR.MusF.MytFves	LR.HLR.MusB.Sem.Sem
	5	LR.MLR.MusF.MytFves	LR.MLR.BF.FvesB
	6	LR.HLR.MusB.MytB	LR.HLR.MusB.Sem.Sem
	7	LR.MLR.MusF.MytFR	LR.MLR.BF.FvesB LR.MLR.MusF.MytFR
	8	LR.HLR.MusB.Sem.LitX	LR.MLR.MusF.MytFR
	9	*Ceramium* biotope	
	10	LS.LSa.FiSa.Po	-

* see Appendix V for biotope glossary.

In 2010, the upper shore at both transects was composed of barren chalk cobbles at the base of the cliffs (**LS.LCS.Sh.BarSh**), followed by a narrow band of either sand-covered bedrock (MT8) or barren sand (MT9). This was followed by a zone of *F. vesiculosus* on bedrock outcrops (**LR.MLR.BF.FvesB**). However, the zonation patterns and biotopes of the mid and lower shore differed between the transects.

The mid shore of MT8 was characterised by the barnacle *Semibalanus balanoides* on bedrock (**LR.HLR.MusB.Sem.Sem**), at times present alongside rare *F. vesiculosus* and red seaweeds (**LR.HLR.MusB.Sem.FvesR**). Below this zone, abundant *F. vesiculosus* was present on flat bedrock (**LR.LLR.F.Fves.FS**). The low shore was characterised by superabundant *F. serratus* on bedrock (**LR.LLR.F.Fserr.FS**), and, below this, a mosaic of bedrock and mixed sediment with *Ceramium virgatum*, not fitting any specific biotope. At the sublittoral fringe, the sand-binder *R. floridula* became the dominant algal species (**LR.MLR.BF.Rho**).

In contrast to MT8, the mid shore of MT9 was found to be characterised by the blue mussel, *Mytilus edulis*, as well as the barnacle *S. balanoides*, both abundant, with sparse *F. vesiculosus* also present (**LR.MLR.MusF.MytFves**). As the *F. vesiculosus* disappeared, *M. edulis* became more abundant (**LR.HLR.MusB.MytB**), though further down the shore red algal species including *Osmundea pinnatifida* and *Chondrus crispus* became more prevalent (**LR.MLR.MusF.MytFR**). As at MT8, a band of bedrock and mixed sediment (cobbles) was present in the low shore, again characterised by *C. virgatum*, however below this zone, at the sublittoral fringe, an area of rippled sand (**LS.LSa.FiSa.Po**) was present.

The biotopes recorded in Howson (2001) varied slightly from those recorded by Musk *et al*. (2010), however the taxa present were broadly very similar and the differences in biotope, particularly at MT8, are likely due to shifts in the abundance of characterising taxa between years. However, the *M. edulis* beds present on MT9, which were found throughout the mid shore in 2010, were only recorded in 2001 from further down the shore, indicating some degree of natural change at this location.

Survey aims and objectives

The main aim of the survey was to determine and/or verify the extent and distribution of two ‘whole shore’ selection units (wave-exposed rock and moderately wave-exposed rock) and the presence and distribution of SSSI Annex I biotopes, as listed in Brazier *et al*. (2019).

The survey objectives were:

- To conduct a Phase I survey of the intertidal rock zone habitats at three belt transects within the survey area;
- To identify and map the extent and distribution of intertidal rock habitats within the transects;
- To identify and map the extent and distribution of littoral rock biotopes present;
- To identify any marine intertidal features that qualify for selection as part of a SSSI;
- To characterise the habitats observed by providing semi-quantitative data on species composition of representative intertidal rock habitat biotopes;
- To carry out a Phase II survey to provide descriptions of the taxa within the main littoral habitats identified during the Phase I survey;

- To provide sufficient data to inform a condition assessment of the feature;
- To record the presence and abundance of any non-indigenous species (NIS);
- To identify anthropogenic influences impacting on the ability of the features of interest to achieve favourable condition, and;
- To carry out timed searches for a specific list of taxa at each transect.

Methodology

Project plan

The survey approach focused on developing a cost-effective sampling strategy using Phase I and Phase II intertidal sampling techniques. In order to ensure analytical consistency within and between datasets, and to allow any spatial and temporal change in habitat condition to be detected, the collection and analysis of the data was completed in accordance with Common Standards Monitoring (CSM) guidance (JNCC, 2004) and procedural guidelines outlined in the Marine Monitoring Handbook (Davies *et al*., 2001), and the CCW Handbook for Marine Intertidal Phase I Survey and Mapping (Wyn, *et al*., 2006).

Prior to selecting the three belt transect locations, aerial photography data were obtained from Channel Coast Observatory (CCO) via coastalmonitoring.org/ and were imported into ArcGIS. In addition, open-source Ordinance Survey (OS) data were obtained from osdatahub.os.uk/downloads/open to aid planning.

The locations of the three belt transects were selected in order to ensure good geographical spread, with the aim of capturing data additional to that captured by the 2010 survey, i.e. geographically separated from the 2000/2010 monitoring transects. Transect locations were determined following examination of available aerial photography to ensure sampling of intertidal rock habitat, with additional reference to known access points to ensure collection of data at repeatable locations. The positions of the planned transects are given in Table 2.1 and Figure 2.1.

Table 0.1: Start of line (SOL) and end of line (EOL) positions of the centre line of each of the three planned belt transects to be surveyed during the 2022 Flamborough Head intertidal survey.

Transect no.	Transect Name	SOL Position WGS84		EOL Position WGS84		Bearing (deg) to EOL
		Latitude	Longitude	Latitude	Longitude	
FH01	Sewerby Steps	54.100694	-0.158733	54.099653	-0.158518	170
FH02	Danes Dyke	54.104208	-0.138666	54.102883	-0.138727	180
FH03	South Landing	54.103737	-0.121512	54.102744	-0.121265	170

Figure 0.1: Locations of the intertidal belt transects surveyed during the 2022 Flamborough Head intertidal survey © OpenStreetMap (and) contributors. CC-BY-SA.

Tide times

The survey was conducted on 10th – 12th October 2022 over a spring tide in order that the maximum intertidal area could be surveyed.

The tide times for Flamborough Head for the period of survey are given in Table 2.2. It was found that survey could be conducted reliably approximately two hours before and after low water.

Table 0.2: Tide times for the period in which the Flamborough Head intertidal surveys were conducted. All times are for Flamborough Head in local time (BST).

Date	High Water time (am)	HW1 Height (m)	Low Water time	LW Height (m)	High Water time (pm)	HW2 Height (m)
Mon 10th Oct 2022	05:09	6.2	11:47	0.6	17:47	6.0
Tue 11th Oct 2022	05:46	6.2	12:22	0.7	18:20	5.9
Wed 12th Oct 2022	06:23	6.2	12:55	0.9	18:51	5.8

Access

The three belt transects were selected with reference to access points, and as such access to the beach for each of the transects was relatively simple. FH01 was accessed via Sewerby Steps, FH02 was accessed by the path leading from the Danes Dyke carpark to the beach, and FH03 was accessed via the slipway at the lifeboat station at South Landing.

Phase I survey methods

The aim of the Phase I survey was to determine the range, distribution and extent of the habitats present by assigning biotopes *in situ* on vertical (i.e. running from high to low shore) 60 m wide belt transects, in accordance with best practice guidance.

Start of line (SOL) and end of line (EOL) positions for each transect were input into a Garmin GPSMAP 276Cx portable chartplotter prior to the survey. These included a central transect line, and two parallel 'boundary' lines, one 30 m either side of the central transect line.

At each transect, all habitat types present within the 60 m wide belt were recorded and assigned a biotope as per the latest iteration of the MNCR Marine Habitat Classification for Britain and Ireland (JNCC, 2022b), incorporating information regarding species composition and abundance, shore height, exposure of the shore and substrate type. The vertical width of each habitat was recorded, and GPS positions were taken using the GPSMAP portable chartplotter (which used both GPS and GLONASS sensors for improved positional accuracy) at each habitat boundary on the central transect line. The distribution of biotopes 30 m either side of the central line were recorded using wireframe map annotations. In addition, the track function in the GPS was used to map each biotope boundary.

For each identified biotope, a detailed habitat description was recorded using modified MNCR field forms, including information regarding shore position, substrate type and percentage cover, rock type, surface relief, texture and stability, modifiers such as scour, silt and macroalgal mats, and any anthropogenic influences present. In addition, for each identified habitat a list of the dominant/conspicuous biota present was produced with taxa enumerated using the semi-quantitative SACFOR scale. Any additional relevant metadata, including time, state of tide, weather etc., were also recorded.

Photographs documenting the zonation patterns present were taken at three locations (high, mid and low shore) along each central transect line. At each location, the GPS position was recorded and photographs were taken up-shore, down-shore, and along-shore in both directions.

Phase II survey methods

The aim of the Phase II survey was to provide data on the species composition (i.e. community structure) of component communities within the main/dominant biotopes at high, mid and low shore at each transect.

Phase II transects were run ‘horizontally’ (i.e. along-shore), centred on the Phase I transects. In order to avoid transition zones, transects were placed in the middle of the habitat being targeted wherever possible. Along each 30 m transect, 3 x 0.25 m^2 quadrats were placed using a random approach. A random number generator was used to generate three numbers between -15 and 15 and the quadrats placed this number of metres from the centre point, with negative numbers indicating west of the transect and positive numbers the east. For ease, the distance was generally paced out rather than measured.

Each quadrat was assigned a unique sample number and photographed prior to further assessment. The GPS position of each quadrat was recorded together with the time and any other relevant metadata (distance from centre line, state of tide, weather etc.).

For each quadrat, a detailed habitat description was recorded using modified MNCR field forms, including information regarding shore position, substrate characteristics and modifiers. In addition, for each quadrat, a list of all biota present was produced with taxa

enumerated using percentage cover (for encrusting or turf taxa) or counts (for individual free-living taxa). Where potential underboulder communities were identified (i.e. where cobbles and boulders were present within the quadrat), additional assessment was undertaken. Cobbles and boulders were lifted and/or turned and the undersides photographed. A modified MNCR field form was used to record boulder characteristics (e.g. boulder shape, presence of pitting or crevices) and a list of all taxa present on the underside was produced, with taxa enumerated using the semi-quantitative SACFOR scale. Following identification of biota the boulders were replaced in their original position and orientation in order to minimise any potential damage to the community present.

Where species could not be identified in the field, photographs were taken and identification carried out at a later date.

Timed searches

Following completion of the Phase I and Phase II surveys at each transect, timed searches were conducted in order to record the presence of particular NIS, climate change indicator species, and rare/notable taxa. The list of taxa searched for was provided by Natural England (see Appendix VII).

Three 10 minute searches were conducted consecutively by a single field scientist at each belt transect. Each search encompassed the whole vertical extent of the shore and was not restricted to the transect width. Particular attention was paid to searching under boulders and overhangs, and in rockpools, crevices/fissures and gullies. Listed taxa identified during each search were recorded as present. Those taxa searched for but not found were recorded as absent.

Opportunistic survey methods

When transiting on foot to, from and between transects, any NIS and anthropogenic influences, such as freshwater outflows and litter or other anthropogenic materials, were documented. In each instance, the position was recorded from the GPS and a photograph was taken. Where anthropogenic influences were clearly impacting the surrounding environment, details of this were recorded. Where NIS were encountered, abundance was recorded using the semi-quantitative SACFOR scale.

Analysis

All field notes, including field sketches, were digitised post-survey and photographic records were reviewed by a senior marine ecologist to confirm the assigned biotopes and taxon identifications. Species lists were created for each Phase I habitat and Phase II quadrat ensuring that all taxa were recorded in accordance with the World Register of Marine Species (WoRMS Editorial Board, 2022) and assigned an MCS alphanumeric bio-

code according to Howson and Picton (1997), where applicable, to avoid problems in species nomenclature.

Statistical analysis

The quantitative data acquired during the Phase II surveys included a combination of count data (for individual free-living taxa) and percentage cover data (for turf, encrusting and meadow taxa). As the two types of data cannot be directly compared, species diversity indices could not be calculated, with the exception of number of species (S) and, for count taxa, number of individuals (N).

Multivariate analysis of the data was carried out using PRIMER (Plymouth Routines in Multivariate Ecological Research) v6 (Clarke and Warwick, 2001). Prior to analysis, quadrats in which no taxa were identified were removed from the analysis. All taxa, including under-boulder taxa, were included in the analysis, although where appropriate taxa were merged.

As count data and percentage cover data cannot be directly compared, in order to perform community analysis the Phase II quadrat data were transformed. This was achieved by first assigning each taxon occurrence an appropriate SACFOR score, dependent on the growth form or individual size and taking into account the area of the quadrat used. Following this, the SACFOR scores were transformed using the method described in Strong and Johnson (2020), which transforms SACFOR codes into numerical values using a specific set of corresponding numerical conversion values for each growth form / individual size followed by log transformations (base 2 for percentage cover data, base 10 for count data). This method unifies the count and cover information within a single range of values, enabling count and percentage cover data to be merged for analytical purposes, although the aligned values remain ordinal in nature.

The transformed data were analysed using the Bray-Curtis similarity coefficient. This was followed by cluster analysis in which the sites were group averaged and a resultant dendrogram plotted to illustrate the level of similarity between quadrats. A similarity profile test (SIMPROF) was also conducted as part of the cluster analysis in order to identify the presence of distinct groups, using the default SIMPROF setting in PRIMER for permutations (Mean: 1000, Simulations: 999) and significance level (5 %). Non-metric multi-dimensional scaling (MDS) was then carried out to further assess the presence of any similarities between samples. The SIMPER routine in PRIMER was subsequently used to assess the difference in characteristic taxa between sample clusters.

GIS

Data obtained during the Phase I and Phase II surveys were imported into ArcGIS. These included all GPS trackplots and relevant point data from both Phase I (e.g. positions of boundary changes) and Phase II (quadrat data). The data were overlaid on available aerial photography obtained from CCO. Utilising these data together with the wireframe

map field sketches created during the Phase I surveys, polygons were created within the GIS in order to map the location of the different biotopes identified within each of the three belt transects.

During post-survey data analysis, it was observed that significant discrepancies were present between the position of features mapped during the survey using the GPS (accurate ±3 m) and the position of the features as seen on the CCO aerial photography used during the survey planning phase. On average, the positional difference observed was approximately 12 m, with the GPS data consistently plotting a feature to the north of the position of the same feature on the aerial photography. The error was investigated by comparison with other sources of aerial photography and with Ordnance Survey charts, however no obvious explanation for the discrepancy was discovered. Following discussions with Natural England, it was decided that, for the purpose of presentation, habitat maps should be produced with reference to the aerial photography. Therefore, whilst habitat polygons that were mapped and measured in the field are accurate in terms of their shape and size, there is a potential positional error of ~12 m between the centre point of the mapped polygon and its actual location. This error has not in any way impacted the validity of the data and the maps presented in this report are correct in respect of size and distribution of the habitats.

All GIS outputs were generated using ArcGIS v10.2 and were produced in accordance with MEDIN standards using the MESH data exchange format (DEF).

Results

The logs detailing the results of the Phase I surveys are provided in Appendix I and II and the results of the Phase II surveys are provided in Appendix III and IV. A glossary of the MNCR biotope codes mentioned in this report is provided in Appendix V.

FH01 (Sewerby Steps)

The Sewerby Steps transect (FH01) was situated between two transects (MT8 and MT9) surveyed in 2010. The shore is south-facing, moderately exposed, and is composed of a mixture of bedrock, cobbles and boulders, and sand. The distribution of biotopes at this transect is shown in Figure 3.1.

The upper 6.5 m of the beach, under the cliffs, was composed of barren, well-rounded chalk cobbles and boulders (H01: **LS.LCS.Sh.BarSh**). This was followed by a 5 m wide band of *Fucus spiralis* (common) and ephemeral green seaweeds, particularly *Cladophora* sp., on mixed substrate including cobbles, pebbles and sand-affected bedrock surrounded by barren sand (H02: **LR.LLR.F.Fspi.X**). This zone gave way to a zone of cobbles and boulders overlying firm sand which were dominated by *F. vesiculosus* (superabundant) together with *Semibalanus balanoides* (occasional) and common *Patella vulgata* (H03: **LR.LLR.F.Fves.X**). Below this the substrate changed from cobbles and boulders to bedrock, with abundant *F. vesiculosus* and *Ulva intestinalis* (also abundant) present together with common *P. vulgata* and frequent *S. balanoides* (H04: **LR.LLR.F.Fves.FS**). This band of bedrock extended down the shore for 5 m, but gave way to a second zone of *F. vesiculosus* on a mixture of cobbles, boulders and bedrock (H05: **LR.LLR.F.Fves.X**), though barnacles were less frequent here (rare) than in previous zones. In addition, areas of firm sand (**LS.LSa.MoSa.BarSa**) were present within this zone.

The low shore was primarily characterised by dense (superabundant) *F. serratus* on relatively flat bedrock (H06: **LR.LLR.F.Fserr.FS**), although patches of *F. vesiculosus* (occasional) were also observed. The number of taxa recorded was higher in this zone than in the mid-shore, with a number of red algal species identified, including *Osmundea pinnatifida*, *Rhodothamniella floridula*, and *Chondrus crispus*. Below the *F. serratus* zone, at extreme low shore, was a zone of sand-affected bedrock with a veneer of patchy mixed sediment (H07). The red seaweeds *Ceramium* sp. and *C. crispus* were recorded as common in this zone, while other algal taxa such as *R. floridula*, *O. pinnatifida*, *U. intestinalis*, *U. lactuca* and *Cladophora* sp. were all present in low abundance. Faunal species including the periwinkle *Littorina littorea* and the barnacles *S. balanoides* and *Balanus balanus* were also recorded in very low abundances. The community observed does not fit a specific biotope description, and was recorded simply as '*Ceramium* zone.' Small (<1 cm) *Mytilus edulis* were observed in this zone, though only as sparse individuals; no evidence of Annex I blue mussel bed biotopes (considered nationally or internationally important or of special interest) was observed.

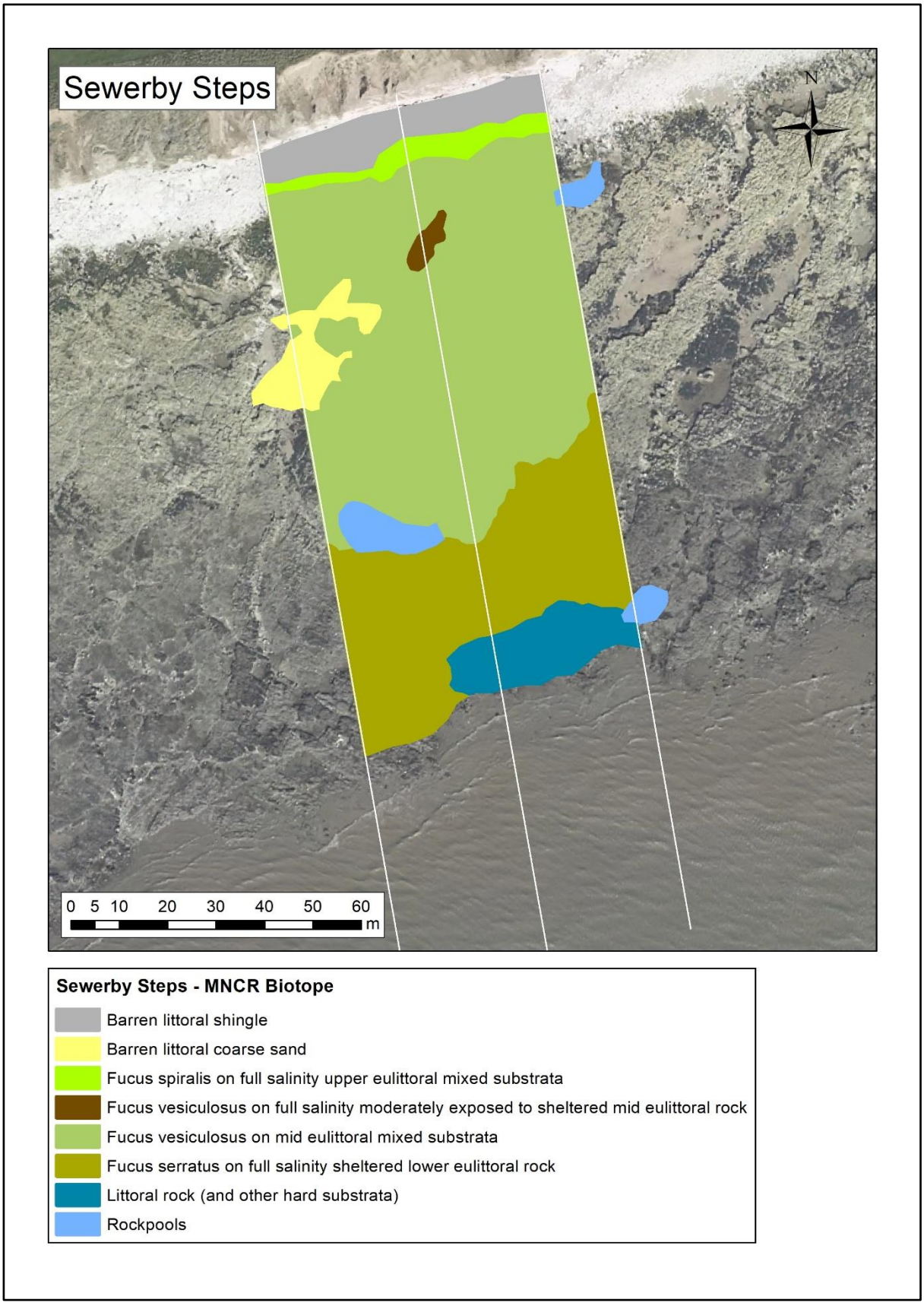

Figure 0.1: distribution of MNCR biotopes (JNCC, 2022b) at transect FH01 (Sewerby Steps) surveyed as part of the Flamborough Head intertidal survey 2022. Ortho-rectified aerial photography obtained from Channel Coastal Observatory)

FH02 (Danes Dyke)

The shore at the Danes Dyke transect (FH02) was south-facing, moderately exposed, and consisted of a sand and cobble upper shore and a bedrock platform mid-shore. In the low shore, the bedrock platform became a series of ridges running in a northwest/southeast direction, separated by long, narrow and shallow pools/channels with sediment floors. The distribution of biotopes at this transect is shown in Figure 3.2.

The upper 21 m of the shore was composed, as at Sewerby Steps, of barren chalk cobbles and boulders (H01: **LS.LCS.Sh.BarSh**). Following this, a 5 m band of chalk cobbles and boulders on firm sand was present, the cobbles colonised by a mixture of *F. spiralis*, *U. intestinalis* (both frequent) and *Cladophora* sp. (H02: **LR.LLR.F.Fspi.X**). Below this was a narrow (2 m) band of firm, well-sorted medium sand (H03: **LS.LSa.MoSa.BarSa**), followed by a 6 m wide zone consisting of sand-inundated occasionally exposed bedrock characterised by patchy *F. vesiculosus* (common) with small quantities of other algal taxa including *F. spiralis*, *U. intestinalis*, *U. lactuca*, and *Cladophora* spp. (H04: **LR.LLR.F.Fves**). A second narrow (4 m) band of sand was present below this zone, composed of rippled fine to medium sand with common worm casts visible (H05: **LS.LSa.FiSa.Po**).

Below the sediment-dominated upper shore, the beach was primarily composed of bedrock with small pockets of soft sediment present in crevices and fissures between the rock. In the upper 13 m of this bedrock zone, the biota consisted of a mosaic of different algal species, particularly *U. intestinalis* (superabundant) and *F. vesiculosus* (common), with abundant underlying *R. floridula*, abundant *P. vulgata* and sparse *S. balanoides* (H06: **LR.LLR.F.Fves.FS**). Below this zone, the bedrock was found to be very flat, with a wide expanse (~60 m) of the shore covered with very dense (>90 %) *F. serratus* (H07: **LR.LLR.F.Fserr.FS**). While at first glance the area appeared to be completely dominated by *F. serratus*, several other algal species were present in this zone, including patches of dense *F. vesiculosus* and *R. floridula* (both common). Where small pools were present, algal diversity was higher and included the green seaweeds *Ulva* spp. and *Cladophora* spp., red seaweeds such as *C. crispus*, *Plocamium cartilagineum*, and *Heterosiphonia plumosa*, and the brown seaweed *Cladostephus spongiosus*. The kelp *Saccharina latissima* was also recorded in low abundance (<1 %) within the larger rockpools present in this zone.

The lower boundary of habitat 07 was marked by a long, 2 m wide, fairly shallow (~15 cm) rockpool situated between bedrock ridges. The floor of the rockpool consisted of a sand veneer over rock and the biota was dominated by finely branching red seaweeds and *Cladophora rupestris*, with several other algal species (including *C. crispus*, *P. cartilagineum*, *H. plumosa*, *C. spongiosus, Ulva* spp., *S. latissima*) present in low abundance (H08: **LR.FLR.Rkp.SwSed**).

Below this rockpool, on a bedrock ridge, the biota was much the same as in habitat 07, with a mat of *R. floridula* beneath a canopy of superabundant *F. serratus* together with *Ceramium* sp., *C. crispus* and *C. spongiosus* in low abundances. However, due to the

higher abundance of the sand-binder *R. floridula* (abundant), this zone (H09) was assigned the biotope **LR.MLR.BF.Rho**. Another rockpool, approx. 10 m in width, marked the lower boundary of H09. As with H08, the rockpool was fairly shallow and sediment-floored, with a thin sand veneer over rock, although some areas of deeper, rippled sand were also present. This zone was characterised by mixed seaweeds, particularly finely branching reds and *Cladophora rupestris*, although the kelps *Laminaria digitata* and S. *latissima* were also present in low abundance (H10: **LR.FLR.Rkp.SwSed**). A third zone characterised by *F. serratus* and *R. floridula* on sand-affected bedrock (H11: **LR.MLR.BF.Rho**) was present below this rockpool, and extended almost to the waterline.

Below H11, an area of dense *Ceramium* sp. on sand-affected bedrock with patches of mixed sediment was observed close to the low water mark. However, as this area remained mostly underwater even at low water this zone was not surveyed and species abundance could not be accurately estimated. As at FH01, no biotope was found to adequately fit the community observed. Below this zone, at extreme low water, dense *L. digitata* and *S. latissima* could be seen on rippled sand (presumably overlying bedrock). While this area could not be reached and the biota could not be enumerated, the biotope **IR.LIR.K.Slat.Ldig** was tentatively assigned to this zone. In the sublittoral fringe, *L. digitata* stipes could be seen above the sea surface, likely attached to bedrock and/or boulders (**IR.MIR.KR.Ldig**).

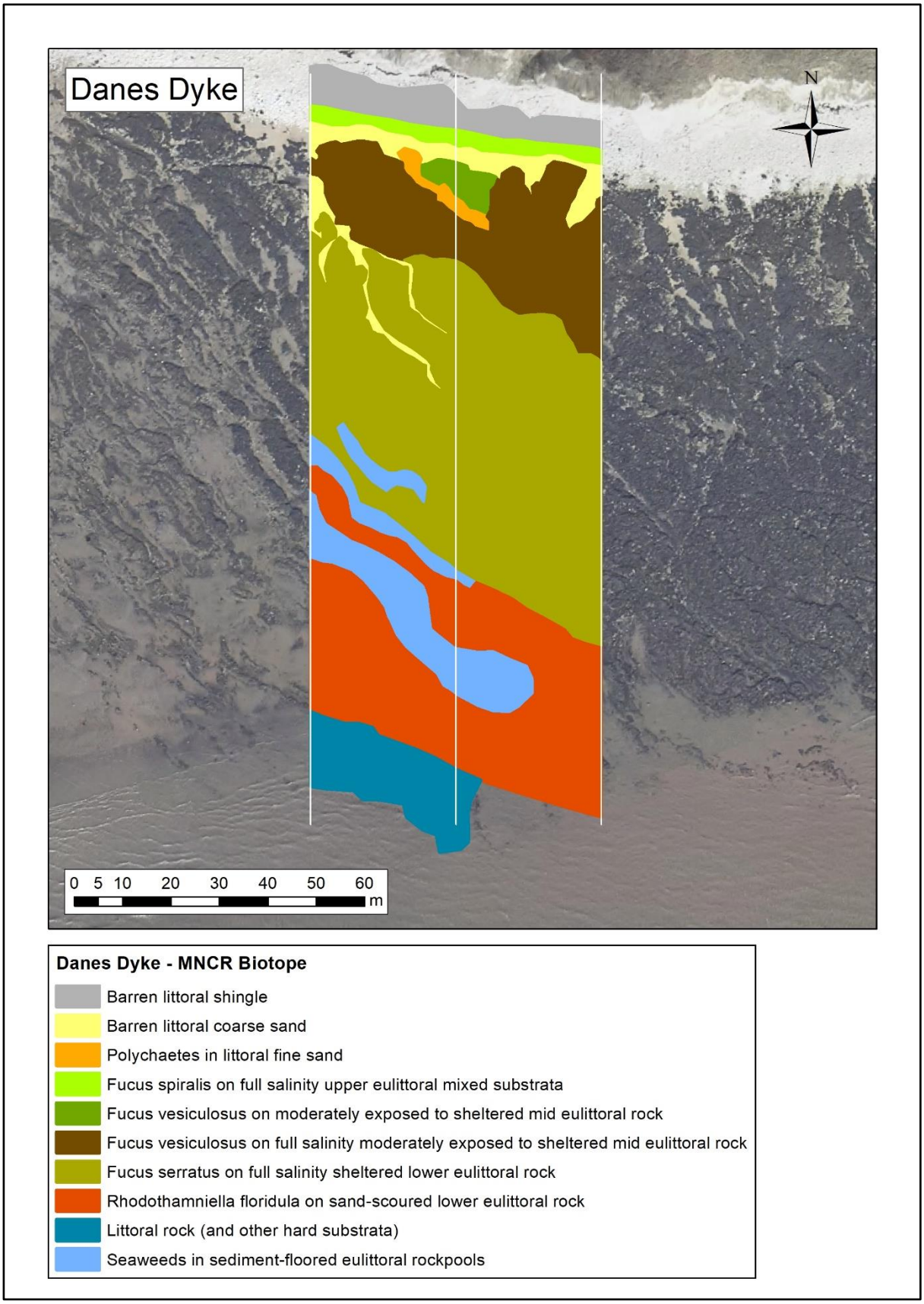

Figure 0.2: distribution of MNCR biotopes (JNCC, 2022b) at transect FH02 (Danes Dyke) surveyed as part of the Flamborough Head intertidal survey 2022. (Ortho-rectified aerial photography obtained from Channel Coastal Observatory)

FH03 (South Landing)

The shore at the South Landing transect (FH03), as at the previous transects, is south-facing, moderately exposed and backed by high chalk cliffs, with a narrow band of sand in the upper shore separating the cliffs from the rest of the bedrock platform shore. The distribution of biotopes at this transect is shown in Figure 3.3.

The upper 8 - 11 m of the beach, under the cliffs, was composed of barren, well-rounded chalk cobbles and boulders (H01: **LS.LCS.Sh.BarSh**). This was followed by a 4.5 m wide band of slightly gravelly shelly sand (H02: **LS.LSa.MoSa.BarSa**). Within this zone, occasional cobbles and small boulders were present and small (<5 m^2) patches of exposed bedrock were visible. Below this was a 6 m band of sand-affected bedrock with a mixture of *F. vesiculosus* (abundant) and *U. intestinalis* (common), with occasional *F. spiralis* also present (H03: **LR.LLR.F.Fves**). Down the shore, toward the first major bedrock 'step,' the degree of scour decreased, creating a narrow (2 m) but distinct zone of superabundant *F. vesiculosus* on rock, (H04: **LR.LLR.F.Fves.FS**).

The upper boundary of H05 was marked by a sharp increase in the height of the bedrock, with a 0.5 m 'step' separating it from H04. The upper faces of the rock were generally flat, although there were numerous crevices and fissures present in the surface of the rock. In addition, the rock surface was generally very heavily pitted with abundant sediment-grain worm tubes, likely *Boccardiella* sp., present, particularly in eroded fissures. The biota present in this zone consisted of a mosaic of *F. vesiculosus* (abundant) and the barnacle *S. balanoides* (frequent) with abundant *P. vulgata* (H05: **LR.MLR.BF.FvesB**). Below this zone, as the shore slopes gently seaward, the *F. vesiculosus* gradually gives way to dense (superabundant) *F. serratus* on otherwise very bare rock (H06: **LR.LLR.F.Fserr.FS**). Other algal taxa, including *C. crispus*, *Ceramium* sp., *O. pinnatifida* and *Ulva* spp., were present only in very low abundances, although small patches of *R. floridula* (occasional) were visible throughout the lower parts of the zone.

Within H06, several long, narrow rockpools were present. All displayed similar characteristics, being sediment-floored, approx. 20-25 cm depth, with mixed seaweeds, particularly the green seaweeds *U. lactuca* and *C. rupestris*, dominating the biota. While the biota present strongly resembled the description for the biotope **LR.FLR.Rkp.G** ('Green seaweeds (*Ulva* spp. and *Cladophora* spp.) in shallow upper shore rockpools'), the presence of rippled sand and the shore position of the observed rockpools meant that the biotope **LR.FLR.Rkp.SwSed** was deemed more appropriate.

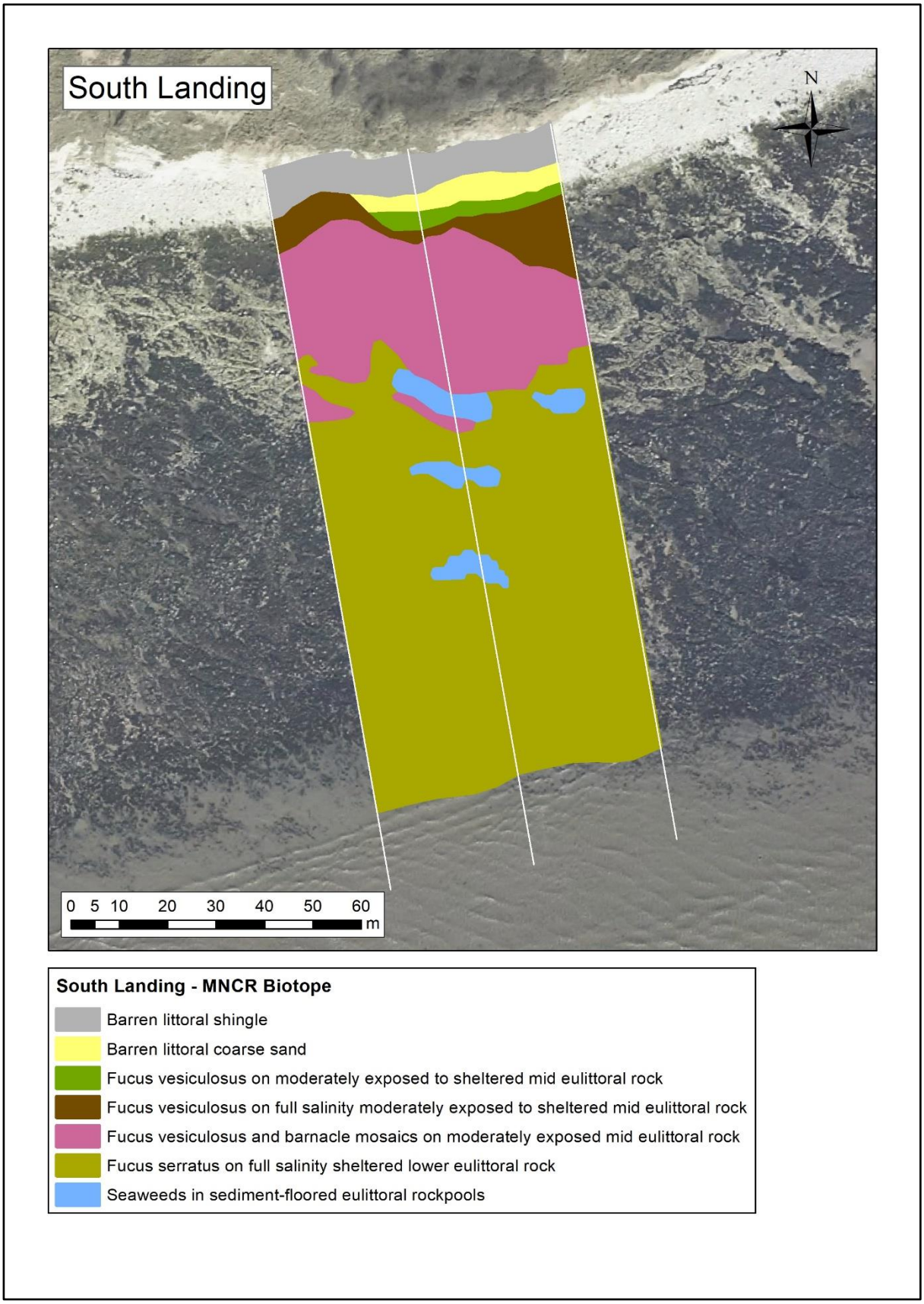

Figure 0.3: distribution of MNCR biotopes (JNCC, 2022b) at transect FH03 (South Landing) surveyed as part of the Flamborough Head intertidal survey 2022. Ortho-rectified aerial photography obtained from Channel Coastal Observatory)

Phase II results

Species abundance

A total of 40 taxa were identified during the Phase II quadrat surveys, with 103 individuals present across all transects (excluding percentage cover taxa). The breakdown of numbers of taxa (*S*) and total individuals (*N*) identified in the quadrats is shown in Table 3.1.

Table 0.1: Total numbers of taxa (S) and individuals (N) identified in quadrats during the Flamborough Head Phase II intertidal survey 2022.

	FH01		FH02		FH03		Total	
	S	**N***	**S**	**N**	**S**	**N**	**S**	**N**
Upper shore	6	2	8	2	2	0	**12**	**4**
Mid shore	20	27	10	3	12	65	**27**	**95**
Low shore	15	3	17	0	16	1	**30**	**4**
Total	**25**	**32**	**26**	**5**	**25**	**66**	**40**	**130**

*Only countable taxa were included in total *N*, i.e. percentage cover taxa are excluded from counts.

The numbers of taxa identified at each transect were very similar, with a total of 25-26 taxa recorded at each transect. The number of taxa identified was highly dependent on shore height, with a general trend of increasing *S* with decreasing shore height (i.e. toward low water). There was an exception to this, however, with a greater number of taxa being present in the mid shore at FH01 compared to the low shore. This was primarily due to a large number of taxa being present in a single mid-shore quadrat (564_02#01). The substrate in this quadrat consisted of cobbles overlying bedrock, rather than the flat bedrock present in the other two quadrats on this horizontal transect. This highly localised increase in substrate complexity likely provided additional habitat for animal species such as *Littorina* spp., which were comparatively abundant within this quadrat.

While the number of taxa was generally highest in the low shore, the numbers of countable taxa (*N*) were highest in the mid-shore at all transects, with this trend largely due to the variation in the numbers of limpets *(P. vulgata*) and periwinkles (*Littorina* spp.) on each transect.

Species composition

The results of the cluster and ordination analysis of the Phase II quadrat data are shown in Figures 3.4 and Figure 3.5. The SIMPROF analysis indicated the presence of three clusters (B, C and D), together with a single outlier (564_04#01).

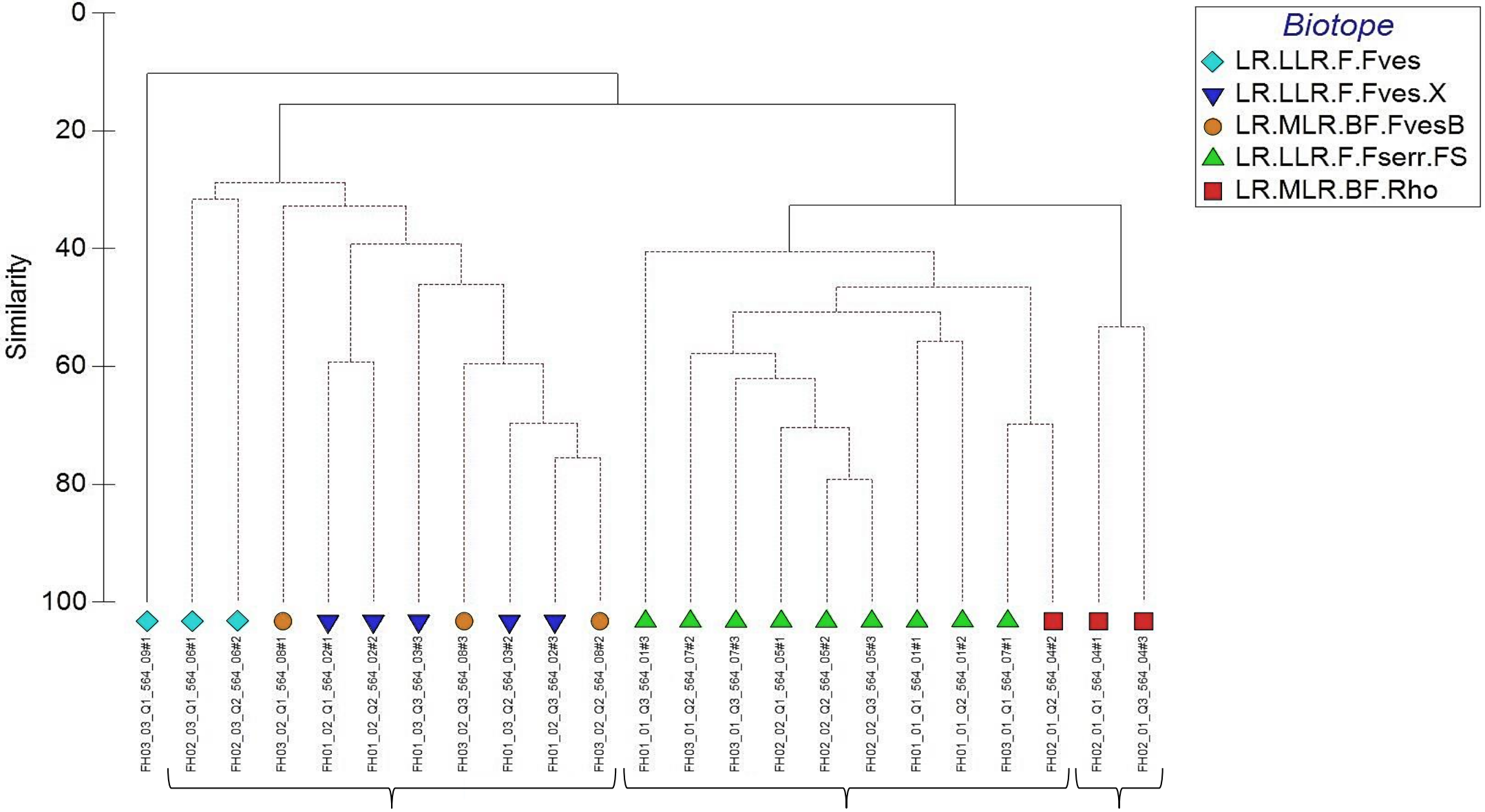

Figure 0.4: Cluster analysis of the Phase II quadrat data collected as part of the Flamborough Head intertidal survey 2022. Red dotted lines indicate significant results of SIMPROF analysis at 5 %. Assigned cluster names are indicated. Biotopes are those assigned to the relevant habitat during the Phase I surveys.

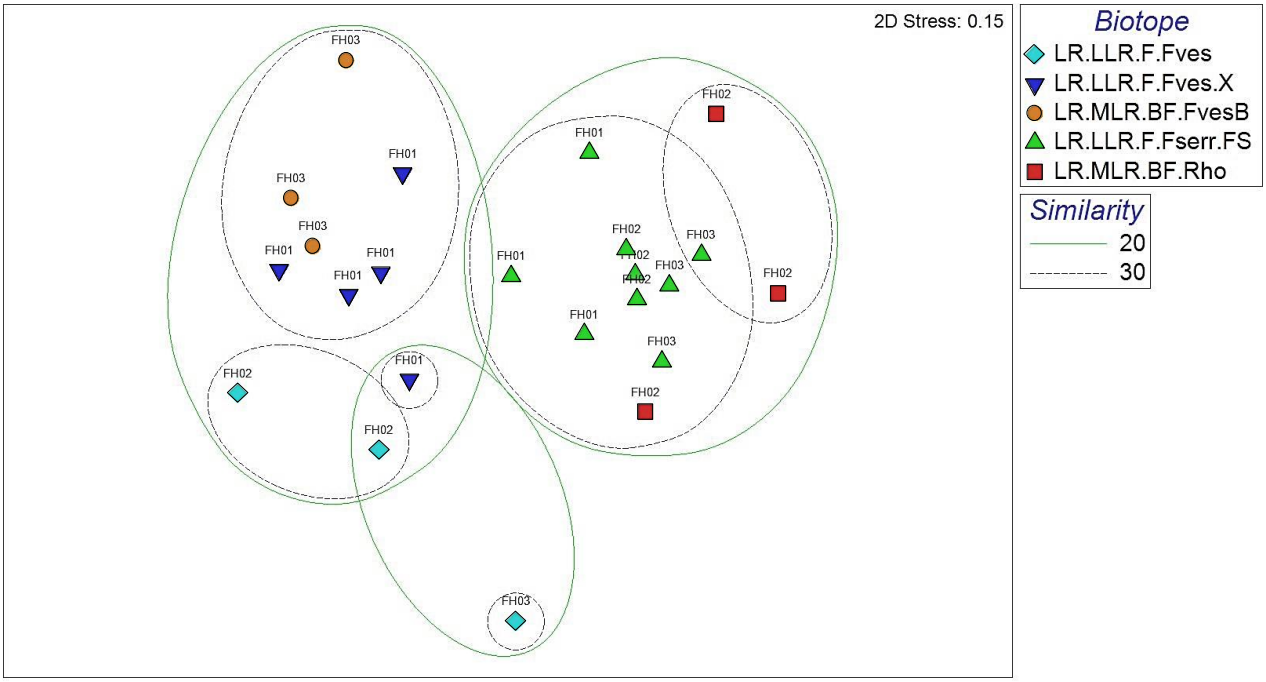

Figure 0.5: Ordination analysis of the Phase II quadrat data collected as part of the Flamborough Head intertidal survey 2022. Biotopes are those assigned to the relevant habitat during the Phase I surveys.

Generally the clusters identified correlated with the biotopes assigned in the field during the Phase I surveys. Cluster B consisted of two quadrats from low-shore FH02 (**LR.MLR.BF.Rho**), while cluster C was composed of nine quadrats (three from each transect) from habitats dominated by *F. serratus* (**LR.LLR.F.Fserr.FS**), together with the final quadrat from low-shore FH02 (564_04#02). Cluster D was more variable, including quadrats from the mid and upper shore of FH01 (**LR.LLR.F.Fves.X**) and the mid shore of FH03 (**LR.MLR.BF.FvesB**). In addition, this cluster included two quadrats from high shore FH02 (**LR.LLR.F.Fves**), although these were separated from the rest of the quadrats in this cluster at approximately 30 % similarity.

SIMPER analysis was carried out on the three groups identified by the SIMPROF component of the cluster analysis. A summary of the results of the analysis are presented in Table 3.2. The full results of the SIMPER analysis are presented in Appendix VI.

Table 0.2: SIMPER analysis of the Phase II quadrat data collected as part of the Flamborough Head intertidal survey 2022. Some cells have been left blank intentionally.

Cluster	Species	Average Similarity	% Contribution
B	*Ceramium* sp.	23.33	43.75
	Fucus serratus	16.67	31.25
	Dynamena pumila	6.67	12.5
	Vertebrata lanosa	6.67	12.5
C	*Fucus serratus*	25.10	49.39
	Corallinaceae	6.62	13.02
	Cladophora sp.	5.77	11.36
D	*Fucus vesiculosus*	14.87	38.21
	Ulva intestinalis	6.43	16.51
	Patella vulgata	6.27	16.10
	Fucales (sporelings)	5.05	12.98

The primary taxon uniting the quadrats in cluster C was found to be *F. serratus*, contributing ~50 % of average similarity within this group, supporting the biotope assignment of **LR.LLR.F.Fserr.FS** to the areas in which these quadrats were sampled. Despite being present in a habitat generally dominated by dense *R. floridula*, the two quadrats in cluster B were primarily characterised by dense *Ceramium* sp. together with *F. serratus*. The main sources of dissimilarity between clusters B and C included *Ceramium* sp. (17.68 % contribution to dissimilarity), which was absent from cluster C, and the relative abundance of *F. serratus* (6.8 %), which was less abundant in cluster B. While the characterising species (*R. floridula*) of the biotope assigned to FH02 H11 (**LR.MLR.BF.Rho**) was absent from two of the three quadrats, it is assumed that this is due to localised patchiness of taxa combined with the randomised method of selection of quadrat locations. Given that *R. floridula* was superabundant in the third of the quadrats from this location, and taking into consideration the results of the Phase I survey, the assignment of the biotope **LR.MLR.BF.Rho** to this area was deemed to be appropriate.

The quadrats in cluster D were found to be characterised primarily by *F. vesiculosus*, which contributed ~38 % of average similarity within this group. While this supports the assignment of the various *F. vesiculosus* dominated biotopes to the habitats in which these quadrats were placed, no significant difference was detected between those quadrats within the **LR.MLR.BF.FvesB** biotope region at FH03, which in addition to abundant *F. vesiculosus* was characterised by barnacle mosaics on bedrock, and those from areas of mixed substrate with more contiguous expanses of *F. vesiculosus* (**LR.LLR.F.Fves.X**).

Presence of SSSI habitats

No biotopes considered nationally or internationally important (as listed in Annex I of Brazier *et al*., 2019) were recorded during the survey. The rockpool biotope **LR.FLR.Rkp.SwSed**, which is listed as a biotope of special interest, was however recorded at both FH02 and FH03.

A summary of the biotopes identified that are typical of each of the whole shore types that should be represented in the SSSI series as listed in Annex III of Brazier *et al*. (2019) is shown in Table 3.3. Generally, the biotopes identified were representative of relatively sheltered shores, with six of the nine rock biotopes identified listed as being typical of wave sheltered rock. No biotopes typical of wave exposed rock were identified, however five of the biotopes identified are listed as typical of moderately wave exposed rock. Of these, one of these biotopes (**IR.MIR.KR.Ldig**) was only tentatively identified due it being in the subtidal, while two were only present at one of the three transects; the mid shore biotope **LR.MLR.BF.FvesB** was only present at FH03, while the biotope **LR.MLR.BF.Rho** was only present in the low shore at FH02. Only the biotope **LR.LLR.F.Fves** and the associated sub-biotope **LR.LLR.F.Fves.FS** were present in some form in the mid shore at all three transects.

Table 0.3: Biotopes identified during the Flamborough Head intertidal survey 2022 that are typical of each of the whole shore types that should be represented in the SSSI series. Adapted from Brazier *et al*. (2019). (Cells with the character "Y" indicate, that the biotope is classified as part of the corresponding whole shore types, blank cells are left intentionally).

Biotope	Wave exposed rock	Moderately wave exposed rock	Wave sheltered rock	Mixed substrate	Sand and coarse sediment	Sand and muddy sand
LR.MLR.BF.FvesB		Y				
LR.MLR.BF.Rho		Y	Y			
LR.LLR.F.Fspi.X				Y		
LR.LLR.F.Fves		Y	Y			
LR.LLR.F.Fves.FS		Y	Y			
LR.LLR.F.Fves.X				Y		
LR.LLR.F.Fserr.FS			Y			
LS.LCS.Sh.BarSh					Y	
LS.LSa.MoSa.BarSa					Y	
LS.LSa.FiSa.Po					Y	Y
IR.MIR.KR.Ldig		Y	Y			
IR.LIR.K.Slat.Ldig			Y			

In addition to the SSSI biotopes identified, two habitats of interest in Great Britain (as listed in Annex II of Brazier *et al*. (2019)) were identified: intertidal chalk and maritime cliff and slopes. The former was limited to the very upper shore at each transect, consisting of barren chalk cobbles and boulders at the foot of the chalk cliffs which are characteristic of the coast around Flamborough Head.

Timed searches

Three 10-minute searches were carried out at each transect following completion of the Phase I and Phase II surveys. The full results of the timed searches are provided in Appendix VII.

Only one species from the list provided by Natural England was identified in any of the searches. The blue mussel *M. edulis* was identified in two of the timed searches at Sewerby Steps (FH01) and two searches at South Landing (FH03). Very few individuals were observed, and those that were identified were fairly small (<2 cm), but these were present in both the mid and low shore, generally in rock crevices.

While not present on the list of species to be searched for, the barnacle *Austrominius modestus*, a non-indigenous species, was identified during one of the timed searches at Danes Dyke (FH02), although only in very low abundance. A total of five individuals were observed on a single small patch of rock in the low shore within H09. No other NIS were observed during any part of the survey.

Discussion

Comparisons with previous data

The locations of the three belt transects surveyed in 2022 were selected in order to ensure good geographical spread, with the aim of capturing data additional to that captured by the 2010 survey and were hence geographically separated from the 2000/2010 monitoring transects, making direct comparisons between years problematic. However, broad descriptive comparisons can be made and may indicate the possibility of temporal change in the dominant habitats present throughout the survey area.

While the upper shore biotopes show good consistency between years, the mid shore biotopes identified in 2022 are markedly different to those identified in previous surveys. The mid shore biotopes at transects MT08 and MT09, surveyed in 2001 and 2010, were primarily characterised by faunal-dominated biotopes such as the barnacle-dominated **LR.HLR.MusB.Sem.Sem** and the blue mussel bed biotopes **LR.MLR.MusF.MytFves** and **LR.MLR.MusF.MytFR** (Musk *et al*., 2010). By contrast, the mid-shore biotopes in the 2022 survey are algal-dominated, with generally very little fauna present. The exception to this was at FH03, where barnacle mosaics were present alongside dense patches of *F. vesiculosus* and the biotope **LR.MLR.BF.FvesB** was recorded. This biotope was present in the mid shore of both MT08 and MT09 in both 2001 and 2012, but was absent from FH01 and FH02. It is possible that these differences represent a natural temporal variation in biological communities, due to e.g. a decrease in scour or a reduction in storm activity, however without resurveying the monitoring transects established by Howson (2001) this cannot be confirmed.

The low shore regions of MT08 and MT09 were assigned biotopes relatively similar to those assigned in 2022, with the *F. serratus* dominated **LR.LLR.F.Fserr.FS**, which was present at all three transects in 2022, and the *R. floridula* dominated **LR.MLR.BF.Rho**, which was present at FH02, both present at MT08 in both 2001 and 2010. In addition, the 2010 survey identified a ‘Ceramium biotope’ at both MT08 and MT09 very similar in description to the *Ceramium* sp. dominated low shore habitats observed at both FH01 and FH02. Given the apparent stability of this habitat, it is possible that the observed community represented an as yet undescribed biotope, however additional work would be required before this could be suggested as an addition to the marine habitat classification.

Summary and recommendations

All objectives of the survey, including the mapping of the extent and distribution of littoral rock habitats and biotopes via Phase I survey techniques, the characterisation of the observed habitats via collection of species composition data as part of the Phase II surveys, and the timed searches to record notable taxa and NIS, were successfully completed in accordance with best practice procedural guidelines.

The primary aim of the survey was to determine and/or verify the extent and distribution of two 'whole shore' selection units (wave-exposed rock and moderately wave-exposed rock) within the specified survey area. However, the littoral biotopes identified within the survey area were generally representative of wave-sheltered rock, with six of the nine rock biotopes identified listed as being typical of wave sheltered rock. While four of these six biotopes (and one additional identified biotope) are also listed as representative of moderately wave exposed rock, these biotopes were found to be somewhat patchy in distribution, being either tentatively assigned or present at only one of the three transects. The exception to this was the biotope **LR.LLR.F.Fves** and the associated sub-biotope **LR.LLR.F.Fves.FS**, which were present in some form in the mid shore at all three transects. No biotopes representative of the whole shore selection unit 'wave-exposed rock' were identified at any of the three transects.

Despite the lack of wave-exposed rock and moderately wave-exposed rock biotopes, the survey confirmed the presence of marine intertidal features which qualify for selection of part of a SSSI. In addition to the biotopes identified which are representative of wave-sheltered rock, two habitats of interest in Great Britain (as listed in Annex II of Brazier *et al*. (2019)) were identified: intertidal chalk and maritime cliff and slopes. The rockpool biotope **LR.FLR.Rkp.SwSed**, which is listed as a biotope of special interest, was also recorded at two of the three transects.

The results of the intertidal survey described in this report, together with the results of the survey carried out in 2010, should be considered as an ecological baseline for the intertidal features of the survey area, against which potential future change can be measured. As per the objectives of the survey, the data collected are of sufficient quality and resolution to be suitable in supporting future assessments of feature condition based on CSM guidance.

It is recommended that the transects established in this survey be considered as monitoring transects for future surveys, in order to identify and measure any potential spatial and temporal changes in the composition, distribution and extent of representative and/or notable biotopes and habitat condition. Future surveys may also wish to include the monitoring transects established by Howson (2001) and resurveyed by Musk *et al*. (2010) to increase spatial coverage of surveys and to investigate potential features of interest such as blue mussel beds, which were present in previous surveys but which were not observed during the 2022 survey.

References

Brazier, D.P., Hiorns, N., Kirkham, E., Singfield, C., Street, M., Steel, L. and Kent, F. (2019). Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 1b Marine Intertidal and Shallow Subtidal Habitats. Joint Nature Conservation Committee, Peterborough.

Clarke, K.R. and Warwick, R.M. (2001). Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER –E, Plymouth.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. and Vincent, M. (2001). Marine Monitoring Handbook, 405 pp, ISBN 1-85716-550-0.

English Nature (2000). English Nature's advice for the Flamborough Head European marine site given under Regulation 33(2) of the Conservation (Natural Habitats &c.) Regulations 1994.

Howson, C.M. (2001). Flamborough Head cSAC intertidal survey. English Nature contract No. T3/2000. Peterborough, English Nature.

Howson, C.M. and Picton, B.E. (1997). The species directory of the marine fauna and flora of the British Isles and surrounding seas. Ulster Museum Publication, 276. The Ulster Museum: Belfast, UK.

JNCC (2022a). Flamborough Head designated Special Area of Conservation (SAC). https://sac.jncc.gov.uk/site/UK0013036 (Accessed: October 2022).

JNCC (2022b). The Marine Habitat Classification for Britain and Ireland Version 22.04. Available from: https://mhc.jncc.gov.uk/. (Accessed: October 2022).

JNCC (2004). Common Standards Monitoring Guidance for Marine, Version August 2004, ISSN 1743-8160.

Musk, W.A., Smith, T. and Thomson, S. (2010). Biotope Mapping of the Intertidal Reef Feature at Flamborough Head Special Area of Conservation. Report to Natural England.

Natural England (2022). Flamborough and Filey Coast SPA. Available from: https://designatedsites.naturalengland.org.uk/SiteGeneralDetail.aspx?SiteCode=UK9006101&SiteName=flamborough%20head&countyCode=&responsiblePerson=&unitId=&SeaArea=&IFCAArea=. (Accessed October 2022).

Strong, J.A. & Johnson, M. (2020). Converting SACFOR data for statistical analysis: validation, demonstration and further possibilities. Marine Biodiversity Records **13**:2. 18 pages.

WoRMS Editorial Board. (2022). World Register of Marine Species. Available from: http://www.marinespecies.org at VLIZ (Accessed: October 2022).

Wyn, G., Brazier, P., Birch, A.B., Cooke, A., Jones, M., Lough, N., McMath, A. and Roberts, S. (2006). Handbook for Marine Intertidal Phase 1 Biotope Mapping Survey. Countryside Council for Wales, 114pp.

Appendices

Appendix I: Phase I survey logs (summary)

All positions are WGS84 latitude and longitude, decimal degrees (D.DDDDDD). Times are recorded in local time (BST).

Site Name	Transect Number	Planned SOL Position		Survey Date	Actual SOL Position			Actual EOL Position			Transect Bearing (degrees)	Number of Habitat Zones
		Latitude	Longitude		Latitude	Longitude	GPS Accuracy (± m)	Latitude	Longitude	GPS Accuracy (± m)		
Sewerby Steps	FH01	54.100580	-0.158770	10/10/2022	54.100694	-0.158733	3.0	54.099653	-0.158518	3.0	170	7
Danes Dyke	FH02	54.104150	-0.138590	11/10/2022	54.104208	-0.138666	3.0	54.102883	-0.138727	3.0	180	11
South Landing	FH03	54.103690	-0.121470	12/10/2022	54.103737	-0.121512	3.0	54.102744	-0.121265	3.0	170	6

Site Name	Transect Number	Habitat Number	Shore Position	Habitat width (m)	Habitat Description	MNCR Biotope Code
Sewerby Steps	FH01	1	Strandline	6.5	Barren chalk cobbles and boulders at strandline.	LS.LCS.Sh.BarSh
Sewerby Steps	FH01	2	Upper	5	*Fucus spiralis* and ephemeral green seaweeds on upper-shore mixed substrate.	LR.LLR.F.Fspi.X
Sewerby Steps	FH01	3	Upper	14	*Fucus vesiculosus* on cobbles and boulders on sand with *Semibalanus balanoides* and *Patella vulgata*.	LR.LLR.F.Fves.X
Sewerby Steps	FH01	4	Mid	5	*Fucus vesiculosus* on bedrock with *Ulva intestinalis*, *Semibalanus balanoides* and *Patella vulgata*.	LR.LLR.F.Fves.FS
Sewerby Steps	FH01	5	Mid	60	*Fucus vesiculosus* on cobbles, boulders and bedrock with small sand-floored rockpools present.	LR.LLR.F.Fves.X
Sewerby Steps	FH01	6	Low	20	Dense *Fucus serratus* on low-shore bedrock with *Osmundea pinnatifida*, *Rhodothamniella floridula*.	LR.LLR.F.Fserr.FS
Sewerby Steps	FH01	7	Low	11	Sand-affected low-shore bedrock and mixed substrate with *Ceramium* sp.	[no good fit]
Danes Dyke	FH02	1	Strandline	21	Barren chalk cobbles and boulders at strandline.	LS.LCS.Sh.BarSh
Danes Dyke	FH02	2	Upper	5	*Fucus spiralis* and ephemeral green seaweeds on upper-shore mixed substrata.	LR.LLR.F.Fspi.X
Danes Dyke	FH02	3	Upper	2	Barren, firm, well-sorted medium sand.	LS.LSa.MoSa.BarSa
Danes Dyke	FH02	4	Upper	6	Sand-covered/affected bedrock with patchy *Fucus vesiculosus* and green seaweeds.	LR.LLR.F.Fves

Site Name	Transect Number	Habitat Number	Shore Position	Habitat width (m)	Habitat Description	MNCR Biotope Code
Danes Dyke	FH02	5	Upper	4	Rippled sand veneer over bedrock.	LS.LSa.FiSa.Po
Danes Dyke	FH02	6	Mid	13	*Fucus vesiculosus*, *Ulva intestinalis* and *Rhodothamniella floridula* on bedrock with *Patella vulgata*.	LR.LLR.F.Fves.FS
Danes Dyke	FH02	7	Mid	60	Dense *Fucus serratus* on bedrock with *Rhodothamniella floridula* and *F. vesiculosus*.	LR.LLR.F.Fserr.FS
Danes Dyke	FH02	Rockpool 1	Mid	2	Mixed seaweeds in sediment-floored rockpools.	LR.FLR.Rkp.SwSed
Danes Dyke	FH02	8 Rockpool 2	Mid	2	Mixed seaweeds in sediment-floored rockpools.	LR.FLR.Rkp.SwSed
Danes Dyke	FH02	9	Low	11	Dense *Fucus serratus* on bedrock with *Rhodothamniella floridula*.	LR.MLR.BF.Rho
Danes Dyke	FH02	10 Rockpool 3	Low	10	Mixed seaweeds in sediment-floored rockpools.	LR.FLR.Rkp.SwSed
Danes Dyke	FH02	11	Low	14	Dense *Fucus serratus* on bedrock with *Rhodothamniella floridula*.	LR.MLR.BF.Rho
South Landing	FH03	1	Strandline	8	Barren chalk cobbles and boulders with sparse encrusting biota.	LS.LCS.Sh.BarSh
South Landing	FH03	2	Upper	4.5	Sparse biota on barren gravelly sand with occasional cobbles/boulders and patches of exposed bedrock.	LS.LSa.MoSa.BarSa
South Landing	FH03	3	Upper	6	*Fucus vesiculosus* on sand-affected bedrock with *Ulva intestinalis*.	LR.LLR.F.Fves
South Landing	FH03	4	Upper	2	Dense *Fucus vesiculosus* on bedrock.	LR.LLR.F.Fves.FS

Site Name	Transect Number	Habitat Number	Shore Position	Habitat width (m)	Habitat Description	MNCR Biotope Code
South Landing	FH03	5	Mid	33	*Fucus vesiculosus* and barnacle mosaics on mid-shore bedrock with *Patella vulgata*.	LR.MLR.BF.FvesB
South Landing	FH03	6	Low	80	Dense *Fucus serratus* on bedrock.	LR.LLR.F.Fserr.FS
South Landing	FH03	Rockpool 1	Low	3	Mixed seaweeds in sediment-floored rockpools.	LR.FLR.Rkp.SwSed
South Landing	FH03	Rockpool 2	Low	2	Mixed seaweeds in sediment-floored rockpools.	LR.FLR.Rkp.SwSed
South Landing	FH03	Rockpool 3	Low	34	Mixed seaweeds in sediment-floored rockpools.	LR.FLR.Rkp.SwSed
South Landing	FH03	Rockpool 4	Low	4	Mixed seaweeds in sediment-floored rockpools.	LR.FLR.Rkp.SwSed

Appendix II: Phase I species matrix

Species recorded during the Phase I habitat surveys at each transect surveyed as part of the Flamborough Head intertidal survey 2022. Species abundances are recorded using the semi-quantitative SACFOR scale. *Note: blank cells indicate absence of taxon in the specified habitat.*

Taxon	Qualifier	SACFOR	Sewerby Steps (FH01) habitat						
			1	2	3	4	5	6	7
Verrucaria maura		Crust/meadow							
Halichondria (Halichondria) panicea	Encrusting	Crust/meadow							
Dynamena pumila		Massive/turf							
Actinia equina		1-3cm							
Laniceconchilega		1-3cm							
Spirobranchus	sp.	Crust/meadow							
Austrominius modestus		Crust/meadow							
Semibalanus balanoides		Crust/meadow			O	F	R	O	R
Balanus balanus		Crust/meadow							R
Lepidochitona cinerea		1-3cm							
Patella vulgata		3-15cm			C	C	C	C	
Littorina littorea		1-3cm							O
Littorina obtusata		1-3cm							
Littorina saxatilis		1-3cm							

Taxon	Qualifier	SACFOR	Sewerby Steps (FH01) habitat						
			1	2	3	4	5	6	7
Nucella lapillus		1-3cm						O	
Mytilus edulis	Juvenile	3-15cm							R
Membranipora membranacea		Crust/meadow							
Rhodophyta	Dark red crusts	Crust/meadow							
Rhodophyta	Finely branching red indet.	Massive/turf							
Rhodophyta	Finely branching red sp. A	Massive/turf							
Rhodothamniella floridula		Massive/turf						O	R
Corallinaceae	Indet. red calcareous crusts	Crust/meadow							R
Corallina officinalis		Massive/turf							
Chrondrus crispus		Massive/turf						R	C
Plocamium cartilagineum		Massive/turf							
Ceramium	sp.	Massive/turf							C
Heterosiphonia plumosa		Massive/turf							
Osmundea pinnatifida		Massive/turf						F	R
Vertebrata lanosa	Epiphytic	Massive/turf							
Cladostephus spongiosus		Massive/turf						R	
Laminaria digitata		Crust/meadow							
Saccharina latissimi		Crust/meadow							

Taxon	Qualifier	SACFOR	Sewerby Steps (FH01) habitat						
			1	2	3	4	5	6	7
Fucales	Sporelings	Crust/meadow	R	O	R	R		R	
Fucus	sp. indet.	Crust/meadow							
Fucus serratus		Crust/meadow					O	S	R
Fucus spiralis		Crust/meadow		C					
Fucus vesiculosus		Crust/meadow		R	S	A	S	O	
Chlorophyta	Filamentous green	Massive/turf							
Ulva intestinalis		Massive/turf			O	A		R	R
Ulva	spp. indet.	Massive/turf							
Ulva lactuca		Massive/turf							R
Cladophora	sp.	Massive/turf	R	A	F		R	R	O
Cladophora rupestris		Massive/turf							

Taxon	Qualifier	SACFOR	Danes Dyke (FH02) habitat											
			1	2	3	4	5	6	7	Rock pool 1	8	9	10	11
Verrucaria maura		Crust/meadow												
Halichondria (Halichondria) panicea	Encrusting	Crust/meadow											R	
Dynamena pumila		Massive/turf										R		R
Actinia equina		1-3cm											P	P
Laniceconchilega		1-3cm									P			
Spirobranchus	sp.	Crust/meadow							R	R	R	R	R	
Austrominius modestus		Crust/meadow										R		
Semibalanus balanoides		Crust/meadow						R	R				R	
Balanus balanus		Crust/meadow							R					R
Lepidochitona cinerea		1-3cm												P
Patella vulgata		3-15cm						A	F				P	
Littorina littorea		1-3cm												
Littorina obtusata		1-3cm							P					
Littorina saxatilis		1-3cm												
Nucella lapillus		1-3cm												
Mytilus edulis	Juvenile	3-15cm												
Membranipora membranacea		Crust/meadow												R

Taxon	Qualifier	SACFOR	Danes Dyke (FH02) habitat											
			1	2	3	4	5	6	7	Rock pool 1	8	9	10	11
Rhodophyta	Dark red crusts	Crust/meadow												
Rhodophyta	Finely branching red indet.	Massive/turf								A	O			
Rhodophyta	Finely branching red sp. A	Massive/turf									S		A	
Rhodothamniella floridula		Massive/turf				R		A	C			A		A
Corallinaceae	Indet. red calcareous crusts	Crust/meadow								R		R		R
Corallina officinalis		Massive/turf												
Chrondrus crispus		Massive/turf							R	R	R	R		R
Plocamium cartilagineum		Massive/turf							R		R			
Ceramium	sp.	Massive/turf										O	F	F
Heterosiphonia plumosa		Massive/turf							R		R			
Osmundea pinnatifida		Massive/turf											R	
Vertebrata lanosa	Epiphytic	Massive/turf				R						R		
Cladostephus spongiosus		Massive/turf							R		O	O	O	O
Laminaria digitata		Crust/meadow											R	
Saccharina latissima		Crust/meadow							R	R	R		R	R
Fucales	Sporelings	Crust/meadow		O				R			R		R	R

Taxon	Qualifier	SACFOR	Danes Dyke (FH02) habitat											
			1	2	3	4	5	6	7	Rock pool 1	8	9	10	11
Fucus	sp. indet.	Crust/meadow					R							
Fucus serratus		Crust/meadow						O	S	O	F	S	O	S
Fucus spiralis		Crust/meadow		F		O								
Fucus vesiculosus		Crust/meadow				C		C	C					
Chlorophyta	Filamentous green	Massive/turf												
Ulva intestinalis		Massive/turf		F		O	R	S	O	O	R	R	R	R
Ulva	spp. indet.	Massive/turf							R	R	R			
Ulva lactuca		Massive/turf				R		R	R	R	R	R	R	R
Cladophora	sp.	Massive/turf		F		O		O	R	F		O		
Cladophora rupestris		Massive/turf									C		C	

Taxon	Qualifier	SACFOR	South Landing (FH03) habitat									
			1	2	3	4	5	6	Rock pool 1	Rock pool 2	Rock pool 3	Rock pool 4
Verrucaria maura		Crust/meadow	R		R							
Halichondria (Halichondria) panicea	Encrusting	Crust/meadow										
Dynamena pumila		Massive/turf						R				
Actinia equina		1-3cm					P		P			
Laniceconchilega		1-3cm										
Spirobranchus	sp.	Crust/meadow			R			R	R		R	R
Austrominius modestus		Crust/meadow										
Semibalanus balanoides		Crust/meadow					F	R	R	O		R
Balanus balanus		Crust/meadow										
Lepidochitona cinerea		1-3cm										
Patella vulgata		3-15cm		P	C	C	A	C	C	A		F
Littorina littorea		1-3cm			P				P			
Littorina obtusata		1-3cm			P							
Littorina saxatilis		1-3cm					P					
Nucella lapillus		1-3cm						P		F		F
Mytilus edulis	Juvenile	3-15cm										
Membranipora membranacea		Crust/meadow						R				

Taxon	Qualifier	SACFOR	South Landing (FH03) habitat									
			1	2	3	4	5	6	Rock pool 1	Rock pool 2	Rock pool 3	Rock pool 4
Rhodophyta	Dark red crusts	Crust/meadow			R							
Rhodophyta	Finely branching red indet.	Massive/turf										
Rhodophyta	Finely branching red sp. A	Massive/turf				R			O	F	O	F
Rhodothamniella floridula		Massive/turf				R	R	O		R		
Corallinaceae	Indet. red calcareous crusts	Crust/meadow				R	R	R	R	R		R
Corallina officinalis		Massive/turf								R		
Chrondrus crispus		Massive/turf				R		R	O		R	R
Plocamium cartilagineum		Massive/turf										
Ceramium	sp.	Massive/turf						R				
Heterosiphonia plumosa		Massive/turf										
Osmundea pinnatifida		Massive/turf						R		R		
Vertebrata lanosa	Epiphytic	Massive/turf					R					
Cladostephus spongiosus		Massive/turf						O	R	R		R
Laminaria digitata		Crust/meadow										
Saccharina latissima		Crust/meadow						R				
Fucales	Sporelings	Crust/meadow	R	R	R		R	R	R		R	

Taxon	Qualifier	SACFOR	South Landing (FH03) habitat									
			1	2	3	4	5	6	Rock pool 1	Rock pool 2	Rock pool 3	Rock pool 4
Fucus	sp. indet.	Crust/meadow										
Fucus serratus		Crust/meadow						S	O	O	O	O
Fucus spiralis		Crust/meadow		R	O							
Fucus vesiculosus		Crust/meadow			A	S	A		O			
Chlorophyta	Filamentous green	Massive/turf	R	R	F							
Ulva intestinalis		Massive/turf		R	C	F	C	R	O		O	R
Ulva	spp. indet.	Massive/turf										
Ulva lactuca		Massive/turf				R	R	R	A	A	S	F
Cladophora	sp.	Massive/turf				O		R				
Cladophora rupestris		Massive/turf							F	O	O	O

Appendix III: Phase II survey logs (summary)

All positions are recorded in WGS84 latitude and longitude in decimal degrees (D.DDDDDD).

Quadrat distances: negative numbers are alongshore west of transect centre, positive numbers are alongshore east of transect centre.

Phase II transect summary:

Site Name	Transect Number	Shore Position	Habitat Zone	Survey Date	Central position		GPS Accuracy (± m)	Quadrat distance from centre (m)		
					Latitude	Longitude		Q1	Q2	Q3
Sewerby Steps	FH01_01	Low	6	10/10/2022	54.099864	-0.158552	3.0	2	6	8
Sewerby Steps	FH01_02	Mid	5	10/10/2022	54.100160	-0.158651	3.0	1	4	8
Sewerby Steps	FH01_03	Upper	3	10/10/2022	54.100610	-0.158686	3.0	4	-4	-9
Danes Dyke	FH02_01	Low	11	11/10/2022	54.102901	-0.138685	3.0	0	4	-5
Danes Dyke	FH02_02	Mid	7	11/10/2022	54.103405	-0.138639	3.0	-4	5	6
Danes Dyke	FH02_03	Upper	4	11/10/2022	54.104086	-0.138599	3.0	2	-3	-8

South Landing	FH03_01	Low	6	12/10/2022	54.102898	-0.121257	3.0	3	-3	-8
South Landing	FH03_02	Mid	5	12/10/2022	54.103598	-0.121393	3.0	10	-6	-15
South Landing	FH03_03	Upper	3	12/10/2022	54.103633	-0.121378	3.0	9	11	-5

Phase II quadrat summary:

Transect Number	Shore Position	Date	Time (BST)	Quadrat Number	Sample Number	Latitude	Longitude	Habitat Description
FH01_01	Low	10/10/2022	11:43	Q1	564_01#1	54.099824	-0.158468	*Fucus serratus* and *F. vesiculosus* on bedrock.
FH01_01	Low	10/10/2022	11:50	Q2	564_01#2	54.099847	-0.158521	*Fucus serratus* and *F. vesiculosus* on bedrock.
FH01_01	Low	10/10/2022	11:58	Q3	564_01#3	54.099904	-0.158465	*Fucus serratus* on bedrock.
FH01_02	Mid	10/10/2022	12:18	Q1	564_02#1	54.100168	-0.158620	*Fucus vesiculosus* on bedrock.
FH01_02	Mid	10/10/2022	12:35	Q2	564_02#2	54.100168	-0.158522	*Fucus vesiculosus* on bedrock.
FH01_02	Mid	10/10/2022	12:41	Q3	564_02#3	54.100200	-0.158387	*Fucus vesiculosus* on bedrock with *Ulva intestinalis* and *Patella vulgata*.
FH01_03	Upper	10/10/2022	13:20	Q1	564_03#1	54.100639	-0.158642	Firm well-sorted medium sand.

FH01_03	Upper	10/10/2022	13:26	Q2	564_03#2	54.100630	-0.158810	*Fucus vesiculosus* and *Ulva intestinalis* on bedrock.
FH01_03	Upper	10/10/2022	13:31	Q3	564_03#3	54.100515	-0.158808	Sparse algae on cobbles overlying firm well-sorted medium sand.
FH02_01	Low	11/10/2022	12:26	Q1	564_04#1	54.102901	-0.138685	*Ceramium* sp. and *Fucus serratus* on sand-affected bedrock with pebbles and cobbles.
FH02_01	Low	11/10/2022	12:33	Q2	564_04#2	54.102798	-0.138551	*Rhodothamniella floridula* on sand-affected bedrock with *Fucus serratus* and *Cladostephus spongiosus*.
FH02_01	Low	11/10/2022	12:39	Q3	564_04#3	54.102767	-0.138655	*Ceramium* sp. and *Fucus serratus* on sand-affected bedrock.
FH02_02	Mid	11/10/2022	12:50	Q1	564_05#1	54.103509	-0.138709	Dense *Fucus serratus* on bedrock.
FH02_02	Mid	11/10/2022	12:56	Q2	564_05#2	54.103475	-0.138599	Dense *Fucus serratus* on bedrock.
FH02_02	Mid	11/10/2022	13:02	Q3	564_05#3	54.103480	-0.138557	Dense *Fucus serratus* on bedrock.
FH02_03	Upper	11/10/2022	13:14	Q1	564_06#1	54.104074	-0.138622	*Fucus vesiculosus* and *Rhodothamniella floridula* on bedrock covered with sand veneer.
FH02_03	Upper	11/10/2022	13:21	Q2	564_06#2	54.104088	-0.138726	*Fucus vesiculosus* on bedrock covered with sand veneer.
FH02_03	Upper	11/10/2022	13:27	Q3	564_06#3	54.104057	-0.138765	Rippled shelly sand.
FH03_01	Low	12/10/2022	12:41	Q1	564_07#1	54.102915	-0.121252	Dense *Fucus serratus* on bedrock.

FH03_01	Low	12/10/2022	12:48	Q2	564_07#2	54.102876	-0.121319	Dense *Fucus serratus* on bedrock.
FH03_01	Low	12/10/2022	12:56	Q3	564_07#3	54.102899	-0.121388	Dense *Fucus serratus* on bedrock.
FH03_02	Mid	12/10/2022	13:16	Q1	564_08#1	54.103578	-0.121264	*Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on mid-shore bedrock.
FH03_02	Mid	12/10/2022	13:24	Q2	564_08#2	54.103573	-0.121493	*Ulva intestinalis* on bedrock with *Fucus vesiculosus*, *Semibalanus balanoides* and *Patella vulgata*.
FH03_02	Mid	12/10/2022	13:29	Q3	564_08#3	54.103595	-0.121579	*Fucus vesiculosus* and *Ulva intestinalis* on bedrock with *Rhodothamniella floridula*.
FH03_03	Upper	12/10/2022	13:53	Q1	564_09#1	54.103702	-0.121269	*Fucus spiralis* and green algae on sand-covered bedrock.
FH03_03	Upper	12/10/2022	13:58	Q2	564_09#2	54.103707	-0.121296	Firm, well-sorted shelly sand.
FH03_03	Upper	12/10/2022	14:00	Q3	564_09#3	54.103689	-0.121504	Slightly gravelly sand with sparse pebbles.

Appendix III: Phase II survey logs (summary)

All positions are recorded in WGS84 latitude and longitude in decimal degrees (D.DDDDDD).

Quadrat distances: negative numbers are alongshore west of transect centre, positive numbers are alongshore east of transect centre.

Phase II transect summary:

Site Name	Transect Number	Shore Position	Habitat Zone	Survey Date	Central position		GPS Accuracy (± m)	Quadrat distance from centre (m)		
					Latitude	Longitude		Q1	Q2	Q3
Sewerby Steps	FH01_01	Low	6	10/10/2022	54.099864	-0.158552	3.0	2	6	8
Sewerby Steps	FH01_02	Mid	5	10/10/2022	54.100160	-0.158651	3.0	1	4	8
Sewerby Steps	FH01_03	Upper	3	10/10/2022	54.100610	-0.158686	3.0	4	-4	-9
Danes Dyke	FH02_01	Low	11	11/10/2022	54.102901	-0.138685	3.0	0	4	-5
Danes Dyke	FH02_02	Mid	7	11/10/2022	54.103405	-0.138639	3.0	-4	5	6
Danes Dyke	FH02_03	Upper	4	11/10/2022	54.104086	-0.138599	3.0	2	-3	-8

South Landing	FH03_01	Low	6	12/10/2022	54.102898	-0.121257	3.0	3	-3	-8
South Landing	FH03_02	Mid	5	12/10/2022	54.103598	-0.121393	3.0	10	-6	-15
South Landing	FH03_03	Upper	3	12/10/2022	54.103633	-0.121378	3.0	9	11	-5

Phase II quadrat summary:

Transect Number	Shore Position	Date	Time (BST)	Quadrat Number	Sample Number	Latitude	Longitude	Habitat Description
FH01_01	Low	10/10/2022	11:43	Q1	564_01#1	54.099824	-0.158468	*Fucus serratus* and *F. vesiculosus* on bedrock.
FH01_01	Low	10/10/2022	11:50	Q2	564_01#2	54.099847	-0.158521	*Fucus serratus* and *F. vesiculosus* on bedrock.
FH01_01	Low	10/10/2022	11:58	Q3	564_01#3	54.099904	-0.158465	*Fucus serratus* on bedrock.
FH01_02	Mid	10/10/2022	12:18	Q1	564_02#1	54.100168	-0.158620	*Fucus vesiculosus* on bedrock.
FH01_02	Mid	10/10/2022	12:35	Q2	564_02#2	54.100168	-0.158522	*Fucus vesiculosus* on bedrock.
FH01_02	Mid	10/10/2022	12:41	Q3	564_02#3	54.100200	-0.158387	*Fucus vesiculosus* on bedrock with *Ulva intestinalis* and *Patella vulgata*.
FH01_03	Upper	10/10/2022	13:20	Q1	564_03#1	54.100639	-0.158642	Firm well-sorted medium sand.

FH01_03	Upper	10/10/2022	13:26	Q2	564_03#2	54.100630	-0.158810	*Fucus vesiculosus* and *Ulva intestinalis* on bedrock.
FH01_03	Upper	10/10/2022	13:31	Q3	564_03#3	54.100515	-0.158808	Sparse algae on cobbles overlying firm well-sorted medium sand.
FH02_01	Low	11/10/2022	12:26	Q1	564_04#1	54.102901	-0.138685	*Ceramium* sp. and *Fucus serratus* on sand-affected bedrock with pebbles and cobbles.
FH02_01	Low	11/10/2022	12:33	Q2	564_04#2	54.102798	-0.138551	*Rhodothamniella floridula* on sand-affected bedrock with *Fucus serratus* and *Cladostephus spongiosus*.
FH02_01	Low	11/10/2022	12:39	Q3	564_04#3	54.102767	-0.138655	*Ceramium* sp. and *Fucus serratus* on sand-affected bedrock.
FH02_02	Mid	11/10/2022	12:50	Q1	564_05#1	54.103509	-0.138709	Dense *Fucus serratus* on bedrock.
FH02_02	Mid	11/10/2022	12:56	Q2	564_05#2	54.103475	-0.138599	Dense *Fucus serratus* on bedrock.
FH02_02	Mid	11/10/2022	13:02	Q3	564_05#3	54.103480	-0.138557	Dense *Fucus serratus* on bedrock.
FH02_03	Upper	11/10/2022	13:14	Q1	564_06#1	54.104074	-0.138622	*Fucus vesiculosus* and *Rhodothamniella floridula* on bedrock covered with sand veneer.
FH02_03	Upper	11/10/2022	13:21	Q2	564_06#2	54.104088	-0.138726	*Fucus vesiculosus* on bedrock covered with sand veneer.
FH02_03	Upper	11/10/2022	13:27	Q3	564_06#3	54.104057	-0.138765	Rippled shelly sand.
FH03_01	Low	12/10/2022	12:41	Q1	564_07#1	54.102915	-0.121252	Dense *Fucus serratus* on bedrock.

FH03_01	Low	12/10/2022	12:48	Q2	564_07#2	54.102876	-0.121319	Dense *Fucus serratus* on bedrock.
FH03_01	Low	12/10/2022	12:56	Q3	564_07#3	54.102899	-0.121388	Dense *Fucus serratus* on bedrock.
FH03_02	Mid	12/10/2022	13:16	Q1	564_08#1	54.103578	-0.121264	*Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on mid-shore bedrock.
FH03_02	Mid	12/10/2022	13:24	Q2	564_08#2	54.103573	-0.121493	*Ulva intestinalis* on bedrock with *Fucus vesiculosus*, *Semibalanus balanoides* and *Patella vulgata*.
FH03_02	Mid	12/10/2022	13:29	Q3	564_08#3	54.103595	-0.121579	*Fucus vesiculosus* and *Ulva intestinalis* on bedrock with *Rhodothamniella floridula*.
FH03_03	Upper	12/10/2022	13:53	Q1	564_09#1	54.103702	-0.121269	*Fucus spiralis* and green algae on sand-covered bedrock.
FH03_03	Upper	12/10/2022	13:58	Q2	564_09#2	54.103707	-0.121296	Firm, well-sorted shelly sand.
FH03_03	Upper	12/10/2022	14:00	Q3	564_09#3	54.103689	-0.121504	Slightly gravelly sand with sparse pebbles.

Appendix IV: Phase II species matrix

Species recorded during the Phase II quadrat surveys at each transect surveyed as part of the Flamborough Head intertidal survey 2022. Species abundances are recorded using either percentage cover (for crust/meadow and massive/turf taxa) or counts (for individual taxa). *Note: blank cells indicate absence of taxon in the specified sample.*

Taxon	Qualifier	SACFOR	Sewerby Steps sample								
			564_01#1	564_01#2	564_01#3	564_02#1	564_02#2	564_02#3	564_03#1	564_03#2	564_03#3
Dynamena pumila		Massive/turf			<1						
Spirobranchus	sp.	Crust/meadow									
Semibalanus balanoides		Crust/meadow	<1		<1	2					
Balanus balanus		Crust/meadow									
Amphipoda		1-3cm									
Patella vulgate		3-15cm				1	1	5		2	
Littorina littorea		1-3cm			1	2	1				
Littorina fabalis		1-3cm			1	2	2				
Littorina obtusata		1-3cm			1	3	5				
Littorina saxatilis		1-3cm				3					

Taxon	Qualifier	SACFOR	Sewerby Steps sample								
			564_01#1	564_01#2	564_01#3	564_02#1	564_02#2	564_02#3	564_03#1	564_03#2	564_03#3
Mytilidae		Crust/meadow									
Mytilus edulis	Juvenille	3-15cm									
Mytilus edulis		3-15cm									
Alcyonidium diaphanum		Massive/turf									
Membranipora membranacea		Crust/meadow		<1							
Electra Pilosa		Crust/meadow									
Didemnidae		Crust/meadow				<1					
Rhodophyta	Dark red crusts	Crust/meadow		2							
Rhodophyta	Fan-shaped red	Massive/turf									
Rhodophyta	Filamentous indet.	Massive/turf									
Rhodophyta	Membranous red	Massive/turf		5	1		3				
Rhodothamniella floridula		Massive/turf									
Corallinaceae	Indet. red calcareous crusts	Crust/meadow	1	1	20	5				<1	
Chondrus crispus		Massive/turf									
Ceramium	sp.	Massive/turf									

Taxon	Qualifier	SACFOR	Sewerby Steps sample								
			564_01#1	564_01#2	564_01#3	564_02#1	564_02#2	564_02#3	564_03#1	564_03#2	564_03#3
Osmundea	sp.	Massive/turf	<1	<1							
Vertebrata lamosa	Epiphytic	Massive/turf									
Cladostephus spongiosus		Massive/turf									
Fucales	Sporelings	Crust/meadow	<1			<1	1	<1			<1
Fucus serratus		Crust/meadow	30	95	100						
Fucus spiralis		Crust/meadow									
Fucus vesiculosus		Crust/meadow	25	5		80	85	45		20	1
Chlorophyta	Filamentous indet.	Massive/turf									
Ulva intestinalis		Massive/turf				3		35		20	1
Ulva lactuca		Massive/turf	<1			<1	<1				
Cladophora	Epiphytic	Massive/turf					<1				
Cladophora	sp.	Massive/turf	<1	100		>1	1	1			3

Taxon	Qualifier	SACFOR	Danes Dyke sample								
			564_04#1	564_04#2	564_04#3	564_05#1	564_05#2	564_05#3	564_06#1	564_06#2	564_06#3
Dynamena pumila		Massive/turf	<1		<1		<1	<1			
Spirobranchus	sp.	Crust/meadow	2								
Semibalanus balanoides		Crust/meadow									
Balanus balanus		Crust/meadow									
Amphipoda		1-3cm									
Patella vulgate		3-15cm									
Littorina littorea		1-3cm									
Littorina fabalis		1-3cm					1		1		
Littorina obtusata		1-3cm						2		1	
Littorina saxatilis		1-3cm									
Mytilidae		Crust/meadow									
Mytilus edulis	Juvenille	3-15cm									
Mytilus edulis		3-15cm									
Alcyonidium diaphanum		Massive/turf			<1						
Membranipora membranacea		Crust/meadow			<1		<1	<1			

Taxon	Qualifier	SACFOR	Danes Dyke sample								
			564_04#1	564_04#2	564_04#3	564_05#1	564_05#2	564_05#3	564_06#1	564_06#2	564_06#3
Electra Pilosa		Crust/meadow				<1					
Didemnidae		Crust/meadow									
Rhodophyta	Dark red crusts	Crust/meadow					<1				
Rhodophyta	Fan-shaped red	Massive/turf									
Rhodophyta	Filamentous indet.	Massive/turf	1								
Rhodophyta	Membranous red	Massive/turf									
Rhodothamniella floridula		Massive/turf		85					15		
Corallinaceae	Indet. red calcareous crusts	Crust/meadow				<1	1	<1			
Chondrus crispus		Massive/turf		20							
Ceramium	sp.	Massive/turf	40		70						
Osmundea	sp.	Massive/turf	<1								
Vertebrata lamosa	Epiphytic	Massive/turf	<1		<1						
Cladostephus spongiosus		Massive/turf		20							
Fucales	Sporelings	Crust/meadow	2	<1		<1	<1	<1	<1		
Fucus serratus		Crust/meadow	10	25	15	100	100	85			

Taxon	Qualifier	SACFOR	Danes Dyke sample								
			564_04#1	564_04#2	564_04#3	564_05#1	564_05#2	564_05#3	564_06#1	564_06#2	564_06#3
Fucus spiralis		Crust/meadow							10		
Fucus vesiculosus		Crust/meadow							35	35	
Chlorophyta	Filamentous indet.	Massive/turf							<1		
Ulva intestinalis		Massive/turf									
Ulva lactuca		Massive/turf									
Cladophora	Epiphytic	Massive/turf								1	
Cladophora	sp.	Massive/turf		<1	1	<1	<1	<1			

Taxon	Qualifier	SACFOR	South Landing sample								
			564_07#1	564_07#2	564_07#3	564_08#1	564_08#2	564_08#3	564_09#1	564_09#2	564_09#3
Dynamena pumila		Massive/turf	<1	<1							
Spirobranchus	sp.	Crust/meadow		<1							
Semibalanus balanoides		Crust/meadow				25	2	<1			
Balanus balanus		Crust/meadow			<1						
Amphipoda		1-3cm		P							
Patella vulgate		3-15cm				39	11	2			
Littorina littorea		1-3cm									
Littorina fabalis		1-3cm									
Littorina obtusata		1-3cm						2			
Littorina saxatilis		1-3cm				10					
Mytilidae		Crust/meadow				1					
Mytilus edulis	Juvenille	3-15cm			1						
Mytilus edulis		3-15cm				1					
Alcyonidium diaphanum		Massive/turf									
Membranipora membranacea		Crust/meadow	<1	<1	<1						

Taxon	Qualifier	SACFOR	South Landing sample								
			564_07#1	564_07#2	564_07#3	564_08#1	564_08#2	564_08#3	564_09#1	564_09#2	564_09#3
Electra Pilosa		Crust/meadow		<1							
Didemnidae		Crust/meadow									
Rhodophyta	Dark red crusts	Crust/meadow									
Rhodophyta	Fan-shaped red	Massive/turf			1						
Rhodophyta	Filamentous indet.	Massive/turf									
Rhodophyta	Membranous red	Massive/turf									
Rhodothamniella floridula		Massive/turf	8					50			
Corallinaceae	Indet. red calcareous crusts	Crust/meadow		25	1			2			
Chondrus crispus		Massive/turf	<1								
Ceramium	sp.	Massive/turf									
Osmundea	sp.	Massive/turf									
Vertebrata lamosa	Epiphytic	Massive/turf									
Cladostephus spongiosus		Massive/turf	5	2	3						
Fucales	Sporelings	Crust/meadow	3		10	<1	2				
Fucus serratus		Crust/meadow	100	98	100						

Taxon	Qualifier	SACFOR	South Landing sample								
			564_07#1	564_07#2	564_07#3	564_08#1	564_08#2	564_08#3	564_09#1	564_09#2	564_09#3
Fucus spiralis		Crust/meadow							12		
Fucus vesiculosus		Crust/meadow					3	60			
Chlorophyta	Filamentous indet.	Massive/turf	<1								
Ulva intestinalis		Massive/turf				<1	50	20			
Ulva lactuca		Massive/turf						1			
Cladophora	Epiphytic	Massive/turf									
Cladophora	sp.	Massive/turf	5	1	<1				20		

Appendix V: MNCR biotope code glossary

Definitions of all MNCR biotope codes used in this report, including a summary of the biotopes recorded in the 2022 survey area in different years (NB. 2001 and 2010 surveys indicate MT08 and MT09 only). (Cells with the character “Y” indicate presence, blank cells indicate absence).

MNCR Biotope code (JNCC, 2022)	MNCR biotope name	EUNIS (2007) code	2022	2010	2001
LR.HLR.MusB.MytB	*Mytilus edulis* and barnacles on very exposed eulittoral rock.	A1.111			Y
LR.HLR.MusB.Sem.Sem	*Semibalanus balanoides*, *Patella vulgata* and *Littorina* spp. on exposed to moderately exposed or vertical sheltered eulittoral rock.	A1.1131		Y	Y
LR.HLR.MusB.Sem.FvesR	*Semibalanus balanoides*, *Fucus vesiculosus* and red seaweeds on exposed to moderately exposed eulittoral rock.	A1.1132		Y	
LR.HLR.MusB.Sem.LitX	*Semibalanus balanoides* and *Littorina* spp. on exposed to moderately exposed eulittoral boulders and cobbles.	A1.1133		Y	
LR.HLR.FR	Robust fucoid and/or red seaweed communities.	A1.12			Y
LR.MLR.MusF.MytFves	*Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock.	A1.221		Y	
LR.MLR.MusF.MytFR	*Mytilus edulis*, *Fucus serratus* and red seaweeds on moderately exposed lower eulittoral rock.	A1.222		Y	Y
LR.MLR.BF.FvesB	*Fucus vesiculosus* and barnacle mosaics on moderately exposed mid eulittoral rock.	A1.213	Y	Y	Y

LR.MLR.BF.Rho	*Rhodothamniella floridula* on sand-scoured lower eulittoral rock.	A1.215	Y	Y	Y
LR.LLR.F.Fspi.X	*Fucus spiralis* on full salinity upper eulittoral mixed substrata.	A1.3122	Y		
LR.LLR.F.Fves	*Fucus vesiculosus* on moderately exposed to sheltered mid eulittoral rock.	A1.313	Y		
LR.LLR.F.Fves.FS	*Fucus vesiculosus* on full salinity moderately exposed to sheltered mid eulittoral rock.	A1.3131	Y	Y	
LR.LLR.F.Fves.X	*Fucus vesiculosus* on mid eulittoral mixed substrata.	A1.3132	Y		
LR.LLR.F.Fserr.FS	*Fucus serratus* on full salinity sheltered lower eulittoral rock.	A1.3151	Y	Y	Y
LR.FLR.Rkp.G	Green seaweeds (*Ulva* spp. and *Cladophora* spp.) in shallow upper shore rockpools.	A1.421		Y	
LR.FLR.Rkp.Cor	Coralline crust-dominated shallow eulittoral rockpools.	A1.411			Y
LR.FLR.Rkp.SwSed	Seaweeds in sediment-floored eulittoral rockpools.	A1.413	Y		
LR.FLR.Eph.Ulv	*Ulva* spp. on freshwater-influenced and/or unstable upper eulittoral rock.	A1.451		Y	Y
LS.LCS.Sh.BarSh	Barren littoral shingle.	A2.111	Y	Y	Y
LS.LSa.MoSa.BarSa	Barren littoral coarse sand.	A2.221	Y	Y	
LS.LSa.FiSa.Po	Polychaetes in littoral fine sand.	A2.231	Y	Y	
IR.MIR.KR.Ldig	*Laminaria digitata* on moderately exposed sublittoral fringe rock.	A3.211	Y		
IR.LIR.K.Slat.Ldig	*Saccharina latissima* and *Laminaria digitata* on sheltered sublittoral fringe rock.	A3.3131	Y		

Appendix VI: Results of SIMPER analysis on Phase II quadrat species data

Similarity Percentages – one-way analysis of species contributions between clusters identified using SIMPROF test at 5 %.

Resemblance: S17 Bray Curtis similarity.

Cut off for low contributions: 90.00 %.

Factor Groups	
FH03_03_Q1_564_09#1	a
FH02_01_Q1_564_04#1	b
FH02_01_Q3_564_04#3	b
FH01_01_Q1_564_01#1	c
FH01_01_Q2_564_01#2	c
FH01_01_Q3_564_01#3	c
FH02_01_Q2_564_04#2	c
FH02_02_Q1_564_05#1	c
FH02_02_Q2_564_05#2	c
FH02_02_Q3_564_05#3	c
FH03_01_Q1_564_07#1	c
FH03_01_Q2_564_07#2	c
FH03_01_Q3_564_07#3	c
FH01_02_Q1_564_02#1	d
FH01_02_Q2_564_02#2	d
FH01_02_Q3_564_02#3	d
FH01_03_Q2_564_03#2	d
FH01_03_Q3_564_03#3	d
FH02_03_Q1_564_06#1	d
FH02_03_Q2_564_06#2	d
FH03_02_Q1_564_08#1	d
FH03_02_Q2_564_08#2	d
FH03_02_Q3_564_08#3	d

Group a

[Less than 2 samples in group]

Group b

Average similarity: 53.33

Species	Av. abund*	Av. sim	Sim/SD	Contrib%	Cum.%
Ceramium sp.	7.0	23.33	-	43.75	43.75
Fucus serratus	5.0	16.67	-	31.25	75.00
Dynamena pumila	2.0	6.67	-	12.50	87.50
Vertebrata lanosa	2.0	6.67	-	12.50	100.00

Group c

Average similarity: 50.82

Species	Av. abund	Av. sim	Sim/SD	Contrib%	Cum.%
Fucus serratus	7.7	25.10	6.43	49.39	49.39
Corallinaceae	3.0	6.62	1.22	13.02	62.42
Cladophora sp.	2.6	5.77	1.85	11.36	73.77
Fucales	2.3	5.06	0.91	9.96	83.73
Membranipora membranacea	1.8	3.21	0.70	6.31	90.04

Group d

Average similarity: 38.92

Species	Av. abund	Av. sim	Sim/SD	Contrib%	Cum.%
Fucus vesiculosus	5.4	14.87	1.51	38.21	38.21
Ulva intestinalis	3.3	6.43	0.72	16.51	54.73
Patella vulgate	3.2	6.27	0.84	16.10	70.83
Fucales	2.1	5.05	0.84	12.98	83.81

Species	Av. abund	Av. sim	Sim/SD	Contrib%	Cum.%
Littorina obtusata	1.8	1.53	0.37	3.92	87.73
Cladophora sp.	1.1	1.14	0.33	2.92	90.66

Groups a & b

Average dissimilarity: 91.43

Species	Av. abund (group a)	Av. abund (group b)	Av. diss	Diss/SD	Contrib.%	Cum.%
Ceramium sp.	0.0	7.0	17.45	4.83	19.08	19.08
Fucus serratus	0.0	5.0	12.46	4.83	13.63	32.71
Fucus spiralis	5.0	0.0	12.46	4.83	13.63	46.34
Cladophora sp.	6.0	1.5	10.67	3.60	11.67	58.01
Dynamena pumila	0.0	2.0	4.98	4.83	5.45	63.46
Vertebrata lanosa	0.0	2.0	4.98	4.83	5.45	68.92
Membranipora membranacea	0.0	1.5	4.29	0.71	4.69	73.60
Amphipoda	0.0	2.0	4.26	0.71	4.65	78.26
Spirobranchus sp.	0.0	1.5	3.19	0.71	3.49	81.75
Rhodophyta filamentous	0.0	1.5	3.19	0.71	3.49	85.24
Fucales	0.0	1.5	3.19	0.71	3.49	88.73
Cladophora rupestris	0.0	1.5	3.19	0.71	3.49	92.22

Groups a & c

Average dissimilarity: 87.80

Species	Av. abund (group a)	Av. abund (group c)	Av. diss	Diss/SD	Contrib.%	Cum.%
Fucus serratus	0.0	7.7	19.12	5.91	21.77	21.77
Fucus spiralis	5.0	0.0	12.43	6.88	14.15	35.93

Species	Av. abund (group a)	Av. abund (group c)	Av. diss	Diss/SD	Contrib.%	Cum.%
Cladophora sp.	6.0	2.6	9.04	2.50	10.29	46.22
Corallinaceae	0.0	3.0	7.36	1.62	8.39	54.60
Fucales	0.0	2.3	5.92	1.38	6.74	61.34
Membranipora membranacea	0.0	1.8	4.29	1.15	4.88	66.22
Cladostephus spongiosus	0.0	1.6	3.68	0.71	4.19	70.41
Rhodothamniella floridula	0.0	1.1	2.60	0.45	2.96	73.37
Fucus vesiculosus	0.0	1.0	2.47	0.45	2.81	76.18
Dynamena pumila	0.0	1.0	2.41	0.94	2.75	78.93
Littorina obtusata	0.0	0.8	2.00	0.47	2.28	81.20
Littorina fabalis	0.0	0.8	1.91	0.47	2.18	83.39
Chrondrus crispus	0.0	0.8	1.89	0.41	2.16	85.54
Electra pilosa	0.0	0.6	1.65	0.46	1.88	87.42
Rhodophyta membranous red	0.0	0.7	1.56	0.47	1.77	89.20
Semibalanus balanoides	0.0	0.6	1.46	0.47	1.66	90.85

Groups a & d

Average dissimilarity: 91.18

Species	Av. abund (group a)	Av. abund (group d)	Av. diss	Diss/SD	Contrib.%	Cum.%
Fucus vesiculosus	0.0	5.4	14.49	2.07	15.89	15.89
Cladophora sp.	6.0	1.1	14.06	2.21	15.42	31.31
Fucus spiralis	5.0	0.5	12.84	1.95	14.09	45.39
Ulva intestinalis	0.0	3.3	9.33	1.08	10.23	55.62
Patella vulgate	0.0	3.2	7.97	1.23	8.74	64.36
Fucales	0.0	2.1	5.66	1.24	6.21	70.57

Species	Av. abund (group a)	Av. abund (group d)	Av. diss	Diss/SD	Contrib.%	Cum.%
Littorina obtusata	0.0	1.8	4.14	0.70	4.54	75.11
Semibalanus balanoides	0.0	1.5	3.43	0.65	3.76	78.88
Rhodothamniella floridula	0.0	1.2	2.85	0.47	3.12	82.00
Littorina fabalis	0.0	1.2	2.42	0.58	2.66	84.65
Corallinaceae	0.0	1.0	2.12	0.58	2.32	86.98
Littorina saxatilis	0.0	1.0	1.87	0.44	2.05	89.03
Cladophora epiphytic	0.0	0.5	1.66	0.41	1.82	90.85

Groups b & c

Average dissimilarity: 67.28

Species	Av. abund (group b)	Av. abund (group c)	Av. diss	Diss/SD	Contrib.%	Cum.%
Ceramium sp.	7.0	0.0	11.90	7.06	17.68	17.68
Corallinaceae	0.0	3.0	5.05	1.61	7.51	25.19
Fucus serratus	5.0	7.7	4.58	3.53	6.80	31.99
Vertebrata lanosa	2.0	0.0	3.40	7.06	5.05	37.04
Cladophora sp.	1.5	2.6	3.24	1.38	4.82	41.86
Amphipoda	2.0	0.4	3.11	0.97	4.62	46.48
Fucales	1.5	2.3	2.99	1.00	4.45	50.93
Cladostephus spongiosus	0.0	1.6	2.58	0.73	3.84	54.77
Membranipora membranacea	1.5	1.8	2.52	0.95	3.74	58.51
Spirobranchus sp.	1.5	0.3	2.33	0.97	3.47	61.98
Rhodophyta filamentous	1.5	0.0	2.29	0.97	3.40	65.38
Cladophora rupestris	1.5	0.0	2.29	0.97	3.40	68.78

Species	Av. abund (group b)	Av. abund (group c)	Av. diss	Diss/SD	Contrib.%	Cum.%
Alcyonidium diaphanum	1.0	0.0	1.87	0.97	2.78	71.57
Rhodothamniella floridula	0.0	1.1	1.81	0.46	2.69	74.26
Dynamena pumila	2.0	1.0	1.73	0.95	2.57	76.83
Fucus vesiculosus	0.0	1.0	1.69	0.47	2.52	79.35
Osmundea sp.	1.0	0.4	1.59	0.96	2.37	81.72
Ulva lactuca	1.0	0.2	1.56	0.96	2.32	84.04
Littorina obtusata	0.0	0.8	1.37	0.48	2.03	86.07
Littorina fabalis	0.0	0.8	1.33	0.48	1.97	88.05
Chrondrus crispus	0.0	0.8	1.32	0.42	1.96	90.01

Groups b & d

Average dissimilarity: 93.44

Species	Av. abund (group b)	Av. abund (group d)	Av. diss	Diss/SD	Contrib.%	Cum.%
Ceramium sp.	7.0	0.0	12.80	3.83	13.69	13.69
Fucus vesiculosus	0.0	5.4	9.45	2.19	10.11	23.81
Fucus serratus	5.0	0.0	9.14	3.83	9.78	33.59
Ulva intestinalis	0.0	3.3	6.04	1.12	6.46	40.05
Patella vulgate	0.0	3.2	5.38	1.30	5.76	45.81
Dynamena pumila	2.0	0.0	3.66	3.83	3.91	49.72
Vertebrate lanosa	2.0	0.0	3.66	3.83	3.91	53.64
Amphipoda	2.0	0.4	3.27	0.94	3.49	57.13
Membranipora membranacea	1.5	0.0	3.05	0.92	3.27	60.40
Fucales	1.5	2.1	2.84	0.92	3.04	63.43

Species	Av. abund (group b)	Av. abund (group d)	Av. diss	Diss/SD	Contrib.%	Cum.%
Cladophora sp.	1.5	1.1	2.84	0.93	3.03	66.47
Littorina obtusata	0.0	1.8	2.79	0.75	2.99	69.46
Spirobranchus sp.	1.5	0.0	2.43	0.94	2.60	72.06
Rhodophyta filamentous	1.5	0.0	2.43	0.94	2.60	74.66
Cladophora rupestris	1.5	0.0	2.43	0.94	2.60	77.26
Semibalanus balanoides	0.0	1.5	2.38	0.68	2.54	79.81
Alcyonidium diaphanum	1.0	0.0	2.04	0.92	2.18	81.99
Rhodothamniella floridula	0.0	1.2	1.97	0.48	2.11	84.10
Ulva lactuca	1.0	0.7	1.84	1.00	1.97	86.06
Littorina fabalis	0.0	1.2	1.73	0.61	1.85	87.91
Osmundea sp.	1.0	0.0	1.62	0.94	1.73	89.65
Corallinaceae	0.0	1.0	1.47	0.62	1.58	91.23

Groups c & d

Average dissimilarity: 82.73

Species	Av. abund (group b)	Av. abund (group d)	Av. diss	Diss/SD	Contrib.%	Cum.%
Fucus serratus	7.7	0.0	14.04	3.79	16.97	16.97
Fucus vesiculosus	1.0	5.4	8.32	1.81	10.05	27.03
Ulva intestinalis	0.0	3.3	6.03	1.15	7.28	34.31
Patella vulgate	0.0	3.2	5.38	1.33	6.50	40.81
Corallinaceae	3.0	1.0	4.64	1.25	5.61	46.42
Cladophora sp.	2.6	1.1	3.82	1.26	4.61	51.03

Species	Av. abund (group b)	Av. abund (group d)	Av. diss	Diss/SD	Contrib.%	Cum.%
Rhodothamniella floridula	1.1	1.2	3.26	0.67	3.95	54.98
Littorina obtusata	0.8	1.8	3.24	0.86	3.91	58.89
Membranipora membranacea	1.8	0.0	3.18	1.15	3.85	62.74
Cladostephus spongiosus	1.6	0.0	2.75	0.72	3.33	66.07
Semibalanus balanoides	0.6	1.5	2.72	0.80	3.28	69.35
Fucales	2.3	2.1	2.65	0.88	3.20	72.55
Littorina fabalis	0.8	1.2	2.47	0.74	2.99	75.54
Dynamena pumila	1.0	0.0	1.79	0.95	2.16	77.70
Mytilus edulis	0.4	0.8	1.55	0.56	1.88	79.58
Littorina littorea	0.4	0.8	1.48	0.57	1.78	81.36
Rhodophyta membranous red	0.7	0.3	1.45	0.57	1.75	83.12
Chondrus crispus	0.8	0.0	1.41	0.42	1.70	84.82
Littorina saxatilis	0.0	1.0	1.36	0.48	1.64	86.46
Electra pilosa	0.6	0.0	1.18	0.47	1.43	87.89
Ulva lactuca	0.2	0.7	1.17	0.68	1.41	89.29
Rhodophyta dark red crusts	0.6	0.0	1.07	0.48	1.29	90.58

*Please note that, due to data transformation, abundance figures are not representative of real-world species abundances.

Appendix VII: Timed searches results

List of taxa provided to Seastar Survey Ltd. by Natural England to be searched for during timed searches conducted as part of the Flamborough Head intertidal survey 2022.

Abbreviations: CCI = Climate Change Indicator Species; PRNS = Potentially Rare and Notable Species with qualifier given in brackets (FOCI = Feature of Conservation Interest; BAP = Biodiversity Action Plan species); NIS = Non-Indigenous Species.

Species name (as provided)	Species name (WoRMS, 2022)	Common name	Species Descriptor	Species distribution notes
Gibbula umbillicalis	*Steromphala umbilicalis*	Purple topshell	CCI	
Phorcus lineatus	*Phorcus lineatus*	Toothed topshell	CCI	Species has a southwesterly distribution.
Melarphe neritoides	*Melarhaphe neritoides*	Small periwinkle	CCI	
Chthamalus montagui/ stellatus	*Chthamalus montagui/ stellatus*	Montagu's/Poli's stellate barnacle	CCI	
Balanus perforatus	*Perforatus perforatus*	An acorn barnacle	CCI	
Patella depressa	*Patella depressa*	Black-footed limpet	CCI	Species has a generally southwesterly distribution, though there are some records from Scotland.
Patella ulyssiponensis	*Patella ulyssiponensis*	China limpet	CCI	
Tectura testudinalis	*Testudinalia testudinalis*	Common tortoiseshell limpet	CCI	
Actinia fragacea	*Actinia fragacea*	Strawberry anemone	CCI	
Anemonia viridis	*Anemonia viridis*	Snakelock anemone	CCI	Species is present on south and western coasts of the UK.

Alaria esculenta	*Alaria esculenta*	Dabberlocks/badderlocks/ winged kelp	CCI	
Bifurcaria bifurcata	*Bifurcaria bifurcata*	Brown tuning fork weed/ brown forking weed	CCI	Species has a southwesterly distribution, though there are some records from Scotland.
Laminaria ochroleuca	*Laminaria ochroleuca*	Golden kelp	CCI	Species has a southwesterly distribution.
Fucus distichus	*Fucus distichus*	A brown algae	CCI, PRNS (BAP)	Species only recorded from Scotland.
Padina pavonica	*Padina pavonica*	Peacock's tail	PRNS (FOCI, BAP)	Species is present on southern coasts of the UK.
Ascophyllum nodossum	*Ascophyllum nodosum*	Wig wrack/knotted wrack/egg wrack	PRNS (BAP)	
Ostrea edulis	*Ostrea edulis*	Native oyster	PRNS (FOCI, BAP)	
Mytilus edulis	*Mytilus edulis*	Blue mussel	PRNS (FOCI)	
Sabellaria alveolata	*Sabellaria alveolata*	Honeycomb worm	PRNS (FOCI)	
Lucernariopsis campanulata	*Calvadosia campanulata*	Stalked jellyfish	PRNS (FOCI)	Species not known from North Sea coasts.
Haliclystus spp.	*Haliclystus*	Stalked jellyfish	PRNS (FOCI)	
Pollicipes pollicipes	*Pollicipes pollicipes*	Gooseneck barnacle	PRNS (FOCI, BAP)	Records are sparse.
Amphibalanus amphitrite	*Amphibalanus amphitrite*	Striped barnacle	NIS	Species is present on southern coasts of the UK.

Asterocarpa humilis	*Asterocarpa humilis*	Compass sea squirt	NIS	Species is present on southern coasts of the UK.
Bonnemaisonia hamifera	*Bonnemaisonia hamifera*	Red seaweed	NIS	Rarely recorded from North Sea coasts.
Caprella mutica	*Caprella mutica*	Japanese skeleton shrimp	NIS	Species not known from North Sea coasts.
Crassostrea angulata	*Magallana angulata*	Portuguese oyster	NIS	Records are sparse.
Crepidula fornicata	*Crepidula fornicata*	Slipper limpet	NIS	Species has not yet reached as far north as Flamborough Head.
Diadumene lineata	*Diadumene lineata*	Orange-striped sea anemone	NIS	Species has a southwesterly distribution, though there are some records from Scotland.
Didemnum vexillium	*Didemnum vexillum*	Carpet sea squirt	NIS	Species not known from North Sea coasts.
Ficopomatus enigmaticus	*Ficopomatus enigmaticus*	Marine tubeworm	NIS	Species primarily known from ports; biofouling species.
Grateloupia doryphora	*Grateloupia doryphora*	Red seaweeds	NIS	Species has a southerly distribution.
Grateloupia turuturu	*Grateloupia turuturu*	Devil's Tongue Weed (macroalgae)	NIS	Species has a southerly distribution.
Magallana gigas	*Magallana gigas*	Pacific oyster	NIS	Species widespread in the UK, only one record from near Flamborough Head.
Rapana venosa	*Rapana venosa*	Asian rapa whelk	NIS	Records are sparse.

Sargassum muticum	*Sargassum muticum*	Japanese weed, wireweed	NIS	Rarely recorded from North Sea coasts.
Undaria pinnatifida	*Undaria pinnatifida*	Japanese kelp	NIS	Rarely recorded from North Sea coasts.
Styela clava	*Styela clava*	Leathery sea squirt	NIS	Rarely recorded from North Sea coasts.
Urosalpinx cinerea	*Urosalpinx cinerea*	American oyster drill	NIS	Primarily present in the Thames and on southern coasts.
Watersipora subatra	*Watersipora subatra*	Red ripple Bryozoan	NIS	Species has a southerly distribution.
Schizoporella japonica	*Schizoporella japonica*	Orange ripple Bryozoan	NIS	Records are sparse; primarily recorded from Shetland and Orkney Islands.

Timed search results for each of the three transects surveyed as part of the Flamborough Head intertidal survey 2022. (Some cells are left blank intentionally).

Species name (WoRMS, 2022)	Searched for?	FH01			FH02			FH03		
Steromphala umbilicalis	Y	A	A	A	A	A	A	A	A	A
Phorcus lineatus	Y	A	A	A	A	A	A	A	A	A
Melarhaphe neritoides	Y	A	A	A	A	A	A	A	A	A
Chthamalus montagui/stellatus	Y	A	A	A	A	A	A	A	A	A
Perforatus perforatus	Y	A	A	A	A	A	A	A	A	A
Patella depressa	Y	A	A	A	A	A	A	A	A	A
Patella ulyssiponensis	Y	A	A	A	A	A	A	A	A	A
Testudinalia testudinalis	Y	A	A	A	A	A	A	A	A	A
Actinia fragacea	Y	A	A	A	A	A	A	A	A	A
Anemonia viridis	Y	A	A	A	A	A	A	A	A	A
Alaria esculenta	Y	A	A	A	A	A	A	A	A	A
Bifurcaria bifurcata	N	A	A	A	A	A	A	A	A	A
Laminaria ochroleuca	N	A	A	A	A	A	A	A	A	A
Fucus distichus	N	A	A	A	A	A	A	A	A	A
Padina pavonica	N	A	A	A	A	A	A	A	A	A
Ascophyllum nodosum	Y	A	A	A	A	A	A	A	A	A

Ostrea edulis	Y	A	A	A	A	A	A	A	A	A
Mytilus edulis	Y	**P**	A	**P**	A	A	A	**P**	**P**	A
Sabellaria alveolata	Y	A	A	A	A	A	A	A	A	A
Calvadosia campanulata	Y	A	A	A	A	A	A	A	A	A
Haliclystus	Y	A	A	A	A	A	A	A	A	A
Pollicipes pollicipes	Y	A	A	A	A	A	A	A	A	A
Amphibalanus amphitrite	Y	A	A	A	A	A	A	A	A	A
Asterocarpa humilis	N	.	.	.	.	.	.	.	.	.
Bonnemaisonia hamifera	Y	A	A	A	A	A	A	A	A	A
Caprella mutica	N	.	.	.	.	.	.	.	.	.
Magallana angulata	Y	A	A	A	A	A	A	A	A	A
Crepidula fornicata	Y	A	A	A	A	A	A	A	A	A
Diadumene lineata	Y	A	A	A	A	A	A	A	A	A
Didemnum vexillum	Y	A	A	A	A	A	A	A	A	A
Ficopomatus enigmaticus	Y	A	A	A	A	A	A	A	A	A
Grateloupia doryphora	N	.	.	.	.	.	.	.	.	.
Grateloupia turuturu	N	.	.	.	.	.	.	.	.	.
Magallana gigas	Y	A	A	A	A	A	A	A	A	A
Rapana venosa	N	.	.	.	.	.	.	.	.	.
Sargassum muticum	Y	A	A	A	A	A	A	A	A	A
Undaria pinnatifida	Y	A	A	A	A	A	A	A	A	A

Styela clava	Y	A	A	A	A	A	A	A	A	A
Urosalpinx cinerea	N	.	.	.	.	.	.	.	.	.
Watersipora subatra	N	.	.	.	.	.	.	.	.	.
Schizoporella japonica	N	.	.	.	.	.	.	.	.	.

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