East Riding of Yorkshire Coastal Habitat Monitoring Project 2015

Report prepared by North & East Yorkshire Ecological Data Centre
for East Riding of Yorkshire Council
March 2016

Table of Contents

1 Context and Background

At the inception of the National Network of Regional Coastal Monitoring Programmes of England, habitat baselines were established for a number of the Coastal Cells. These used remote sensing methodologies combined with Aerial Photograph Interpretation (API), supported by detailed terrestrial survey to provide ground-truthing. The Integrated Habitat System (IHS), developed by the Somerset Environmental Record Centre (SERC) was used in the aerial photograph interpretation and a tool developed by Natural England was used to standardise the attribution of habitat data within GIS.

Although no Coastal Habitat Baseline was established for the coast of the East Riding of Yorkshire from Speeton to Spurn Head, an extensive broad habitat survey of the whole East Riding was undertaken between 2007 – 2009 to inform the process of identification, evaluation and adoption of Local Wildlife Sites (LWS). Though this survey did not resolve habitats to Priority Habitat level (this was not the purpose of the survey), it used the same methodology of IHS, the Natural England Habitat Attribution Tool and selective ground-truthing. In addition, the Local Wildlife Site Survey subsequently generated Phase 1 habitat mapping of a range of sites within the coastal strip. Consequently data already exists, which is consistent with the approaches taken in the first iteration of the coastal monitoring programme, even though it is of lower habitat resolution.

The Crick Framework provides a model for the hierarchical integration of remote sensed data, including satellite data, with terrestrial surveys to facilitate the efficient monitoring of habitat change and the iterative improvement of detailed habitat mapping. This framework has been adopted by Defra. Crick Framework compliant habitat mapping has been piloted through the three phase Making Earth Observation Work for Environmental Monitoring (MEOW) project, funded by Defra through Joint Committee for Nature Conservation (JNCC). Earth Observation (EO) based approaches are set to replace the traditional Aerial Photography Interpretation (API) approaches over the next five to ten years. This change will be driven by a combinations of Government policy and economics. The INSPIRE Directive and the European funded Sentinel 2 satellites will make source data more accessible and the processing technology will become less expensive and consequently more available. As the technology matures, it is expedient to take a hybrid approach in which computers are used to identify habitat polygons; an activity which is both time consuming and difficult to undertake manually. Human experts can then be used to attribute polygons using a range of API and field based techniques. Datasets generated in this way will be vital in training automated habitat recognition software as EO techniques become more widely used. It is hoped that this technology could significantly reduce the cost of wide-scale habitat monitoring.

Natural England have also developed new methodologies for identification and condition assessment of Broad, Priority and Annex 1 habitats since 2008, which supersede the IHS methodology for a range of purposes. Phase 4 of the MEOW project, recently funded by Defra through JNCC, is formalising the integration of priority habitat assignment and habitat condition assessment on the ground with Crick Framework compliant remote sensing methodologies.

North and East Yorkshire Ecological Data Centre (NEYEDC) has built on the survey work already undertaken within the East Riding of Yorkshire to produce a habitat evidence base that is not only accurate and consistent with the Defra Biodiversity Monitoring and Surveillance Strategy (2015 – 2018) but also amenable to efficient future iteration and the detection of change.

2 Purpose of the Mapping

Habitat mapping was undertaken to provide freely available coastal and terrestrial habitat data for use by Local Authorities and statutory agencies. Local Authorities and other public bodies have a statutory responsibility to consider impacts upon Special Areas of Conservation (SAC) and Special Protection Areas (SPA) as well Sites of Special Scientific Interest (SSSI) when preparing plans and projects. They also have a wider duty to have regard to biodiversity under the Natural Environment and Rural Communities (NERC) Act 2006. Section 41 of the NERC Act contains lists of habitats and species which are of principal importance for the conservation of biodiversity and also referred to as biodiversity priority habitats and species. Additionally, Local Authorities report to Defra on biodiversity through the Single Data List 160-00 Local Sites in positive conservation management.

The mapping focuses on priority habitats and other habitats which help to support the coherence of the coastal habitat networks. The habitat data will be stored and managed by NEYEDC, the Local Ecological Records Centre (LERC), so that it can be integrated with other relevant data sets such as Phase 1 and Local Wildlife Sites. The principal objectives of the mapping are:

- Identification and quantification of regional coastal change;
- Identification and strategic consideration of coastal and erosion risks;
- Assisting development of Biodiversity Action Plans (BAPs);
- Providing contextual information to support HRAs of coastal strategies, plans and programmes.

2.1 Location and Extent of the Mapping

Broad, Priority and Annex 1 habitats were mapped from the supplied remote sensing data (aerial photography of the East Riding coast provided by East Riding of Yorkshire Council (ERYC)) and supplemented by existing survey data, already held and managed by the NEYEDC.

The extent of the area to be mapped was the East Riding coast from Speeton in the north to Spurn Point in the south. However, south of the narrow neck at Spurn (approximately TA421140), habitats will only be determined by API, subject to the limit of aerial photography coverage. There will be no ground-truthing surveys south of the narrow neck.

The landward extend of the survey area will normally be defined by the 100 year erosion line, as identified in the Shoreline Management Plan 2 (subject to subsequent revisions). This is subject to the extent of the aerial photography data. In any locations where this is less than the predicted 100 year erosion line then the limit of landward mapping will be the extent of the aerial photography.

In most cases the 100 year erosion line, or aerial photography limit, will divide an existing Mastermap polygon. In these cases only the habitats within the erosion line or other limit will be mapped. The erosion line based mapping limit will enable the survey to be integrated with other coastal management work and will provide data on habitats at risk of loss to coastal erosion. The seaward extent of the survey for conventional API mapping and ground-truthing will be mean low water. The area to be mapped includes parts of three National Character Areas (NCAs): the Yorkshire Wolds, Holderness and the Humber.

3 Overarching Methodology

The projects set out to provide an evidence base covering two aspects of the coastal habitats of the East Riding of Yorkshire; habitat extent and habitat condition.

3.1 Aerial Photography Interpretation

In order to establish habitat extent, polygons were segmented using Crick Framework compliant methodologies from a combination of remote sensed data, which included satellite images, visible spectrum aerial photographs, colour infra-red aerial photographs and LiDAR data. Polygons were assigned Broad Habitat, Priority Habitat and Annex 1attributes according to the Field Survey Key and Allocation Rules to Broad, Priority and Annex 1 Habitats (Natural England, 2014), using Aerial Photography Interpretation (API) techniques, which draw on existing survey data where available and on expert local knowledge. In addition, where possible, tentative National Vegetation Classification (NVC) and Phase 1 attributions were made. These will be subsequently improved in the course of future ground-truthing, monitoring surveys and other work carried out by the East Riding of Yorkshire Council and partner organisations.

3.2 Ground Surveys

Two types of ground-thruthing were undertaken in connection with the project. These surveys were necessary to support the API process. During the 2015 field season, detailed surveys of a limited number of sites, already known to have significant biodiversity interest, were undertaken to baseline the condition of priority habitats. This will form the basis of on-going habitat condition monitoring.

During the 2016 field season, rapid assessment of a stratified sample of points, representative of all habitat classes identified through API, will be used for ground-truthing and the improvement of the data.

3.3 Unmanned Aerial Vehicle Surveys

Unmanned Aerial Vehicle (UAV) surveys of six priority sites were undertaken to allow more detailed monitoring of aspects of priority sites that are not covered by the ground surveys. The use of UAV captured imagery allows greater resolution analysis than is possible from the less detailed remote sensed data used for the mapping of the entire coast, where the minimum mappable units (MMU), are expected to be between 0.01ha and 0.25ha depending on habitat type.

4 Detailed Methodology

4.1 Habitat Segmentation

A habitat segmentation of the study area was undertaken with the support of Environmental Systems, the consultancy that undertook phases 1 – 4 of the Making Earth Observation Work for Environmental Management (MEOW) project on behalf of JNCC. Environmental Systems are acknowledged to be leaders in the field of

habitat mapping using Earth Observation techniques. The segmentation was based on all the available data, as detailed in Table 1 below, using the Trimble eCognition software product.

Table 1: Data sources for polygon segmentation

Data	Custodian
Ordanance Survey (OS) MasterMap	ERYC through Pan Government Agreement
Aerial photography from the Regional Monitoring Programme	ERYC
LiDAR data for coastal strip	EA
Contextual data including erosion models and mean low water line	ERYC
Natural England SSSI condition monitoring and assessment data	NEYEDC
Natural England condition assessment (outside SSSI) pilot data	NEYEDC
ERY Broad Habitat API data	NEYEDC
ERY LWS data	NEYEDC

Computerised habitat segmentation is highly cost effective when compared to manual polygon creation. It is replicable and is free of the significant subjectivity that is inherent in manual polygon detection and the between operator variability that is associated with undertaking such large API projects.

4.2 Use of Mastermap

The use of OS MasterMap as a segmentation for the identification of the un-enclosed coastal habitats of the East Riding of Yorkshire by API is problematic for a number of reasons. The MasterMap objects often do not correspond well with the features visible in recent remote sensed imagery due to the rapidly eroding nature of the East Riding of Yorkshire coastline and the frequency of landslips on the areas which are intermediate between soft and hard cliffs. In addition, the MasterMap polygons boundaries do not correspond well with the vegetation features observed in the aerial imagery, necessitating significant manual segmentation of polygons to adhere to previous API methodologies. This is very time consuming and would be beyond the scope of the current project in terms of human resources.

OS MasterMap was used to identify rivers, streams, buildings, gardens and elements of infrastructure and in the production of some of the segmentation masks. It was also used as a fall back where the remote sensed data was of poor quality or poorly geo-referenced.

4.3 Seaward and Landward Habitat Extents

The seaward and landward extent of habitats were established using a combination of aerial photography and LiDAR data, not the OS Mastermap product.

4.4 Segmentation Boundaries

By definition, the boundaries of the segmentation were limited to the extent of the available remote sensing products and in particular the aerial photography. In order to reduce the size of the data files, the habitat segmentation was cropped to Mean Low Water.

4.5 Habitat Classifications

There are a number of habitat classifications in use in the UK and Europe. These classifications were developed for different purposes and are not mutually consistent. This project has focused on using the classification systems most often associated with statutory and administrative instruments; the UK Priority Habitats and the European Annex 1 habitats.

Primary habitat classifications were attributed following a key abstracted from Field Survey Key and Allocation Rules to Broad, Priority and Annex 1 Habitats (Natural England, 2014). This key is included as Appendix 1 of this report.

Where the information is available from existing surveys, or where expert opinion has allowed informed interpretation of the available aerial imagery, tentative Phase 1 and National Vegetation Classification (NVC) codes have been suggested for habitat polygons. Though the attribution of NVC types to intermediate cliff types like those found at the northern end of the East Riding of Yorkshire coast is not normally recognised, largely because few cliffs of this type were represented in the original NVC survey, habitats with close affinity to MC8 – MC11 have been recorded in surveys by reputable sources, and these have been incorporated in the data collation.

4.6 Ground Truthing

Ground-truthing related to the training of the API assessor took place during the 2015 field season and is discussed later in this report.

A programme of rapid assessment ground-truthing will be used to verify the automatic segmentation of polygons and the API of habitats in order to improve the knowledge base. Ground-truthing will concentrate on:

- Areas where the limit of marine influence is unclear, especially cliff top areas of grassland;
- Areas where Priority Habitats cannot be confidently distinguished from broad habitats through remote sensing techniques. This will often be mosaics made up of habitat stands that are smaller than the MMU;
- Areas that provide a good representation of Priority Habitat types;
- Areas which are by definition Priority Habitats, but which have poor ecological condition e.g. rapidly eroding cliffs and coastal slopes with short lived vegetation derived from abandoned arable or amenity grassland;

4.7 Detailed Surveillance and Condition Assessment of Priority Sites

The following sites were selected for detailed surveillance and / or condition assessment activities. The sites are detailed in Table 2 below:

Table 2: Surveillance and / or condition monitoring sites

Site Code	Site Name	Habitats	UAV Survey 2015
ERYCM-01EAS	Easington	Fen, Marsh & Swamp / Saltmarsh / Sand	
ERYCM-02COW	Cowden	Vegetation on the top of soft cliffs.	Yes
ERYCM-03BARM	Barmston	Neutral Grassland / Fen, Marsh & Swamp / Sand Dunes / Wetland Tall Herbs or Sedges	
ERYCM-04BRID	Bridlington	Sand Dunes	Yes
ERYCM-05FLAM	Flamborough	Hard, Soft and Intermediate Cliffs	Yes
ERYCM-06BEMP	Bempton	Intermediate Cliffs	
ERYCM-07THOR	Thornwick Bay	Fen, Marsh & Swamp, Soft Cliffs and Intermediate Cliffs.	
ERYCM -08NTZ	Flamborough No Take Zone	Intermediate Cliffs and Rocky Shore	Yes

At each of these sites, surveillance polygons were identified within habitats stands that were considered to be representative of the sites primary features of biodiversity interest. Measures were then taken to record the extent, structure and composition of these surveillance polygons.

In order to record the species composition of each polygon, a number of random quadrats were undertaken in accordance with Mapping the Extent and Assessing Annex 1 Habitats and Priority Habitats in England (Natural England, 2014). For each quadrat, a full species list and % cover was recorded. The data was digitised in the Recorder 6 database and subsequently used to assign an affinity with NVC types and mean Ellenburgh and CSR indices using the Mavis software developed by the Centre for Ecology and Hydrology (CEH).

In order to record the detailed extent of the habitat, and of structural features within it, for example the vegetation height, scrub development, trampling and distribution of individual species across the polygon, high resolution visible spectrum, ”red edge” infra-red aerial images and digital elevation data were captured using a UAV.

4.8 Data Attribution Model

For each of the polygons, some or all of the attributes detailed in Table 3 were captured.

Table 3: Data Attribution Model

Class Name	CLASS_NAME
Shape Length	SHAPE_LENG
Shape Area	SHAPE_AREA
Vegetation Note	VEG_NOTE
Broad Habitat Code	BH_CODE
Habitat Key Code	BH_KEY
Annex 1 Code	AN_1_CODE
Condition Score	CON_SCORE
Phase 1 Code	PH1_CODE
NVC Code	NVC_CODE
Land Cover	LAND_COV
Land Use	LAND_USE

4.9 Data Management

The data will be manged by the North and East Yorkshire Ecological Data Centre in line with the Centre's policies and practice. All species data will be held on the Centre's Recorder 6 database, from which it will be available to support all environmental decision processes within the East Riding of Yorkshire and passed on to the National Biodiversity Network Gateway (NBNG) for wider dissemination.

5 Summary of Products and Deliverables

5.1 Pre-Processing of Remote Sensing Data

Before the segmentation of objects as polygons and the subsequent attribution of the polygons could take place, an amount of pre-processing and calibration of the remote sensed data was necessary. At this stage, it became clear that the quality of the data would limit the ability to undertake Aerial Photography Interpretation of habitats. The following issues are worthy of noting.

The peak time to assess the extent and composition of coastal vegetative communities is between May and September. Since the aerial photography is generated for the purpose of monitoring physical rather than biological change, it is undertaken in April and November. Some habitats are very difficult to assess from aerial imagery during the winter and early spring. To some extent, this was addressed through the ground-truthing and interpreter training that was undertaken during the project period, however, some ground-truthing of the data will be necessary at optimum times during the 2016 field season to allow improvement of the data. This will not be an additional cost to the project.

There are some distortions and discrepancies in the aerial imagery which effect the geo-referencing of the aerial images. This phenomenon is illustrated in Figures 1 and 2 below. Both images are registered within the same GIS environment and are seen at the same resolution. The green line common to both images is the Natural England national cliff and coastal slope inventory polygon.

These are quite localised, but where they occur make both segmentation and attribution unreliable. It is hoped that these can be resolved when the next iteration of aerial imagery becomes available.

Figure 1: Section of Cliff North of Flamborough Head April 2015 Survey

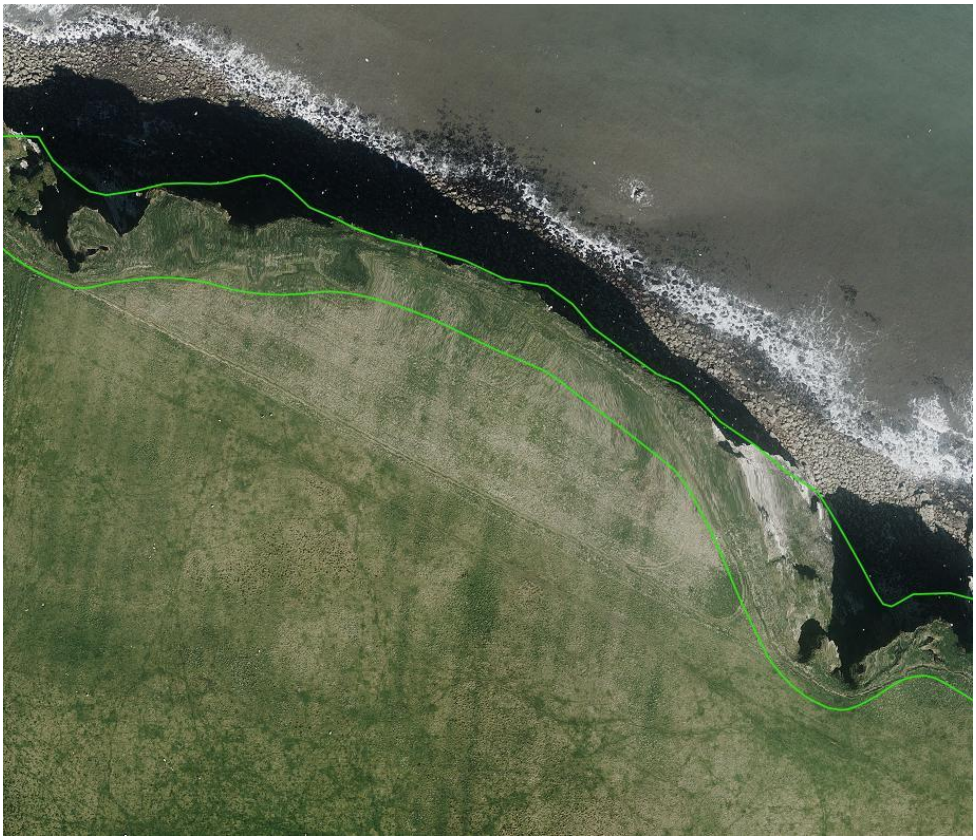
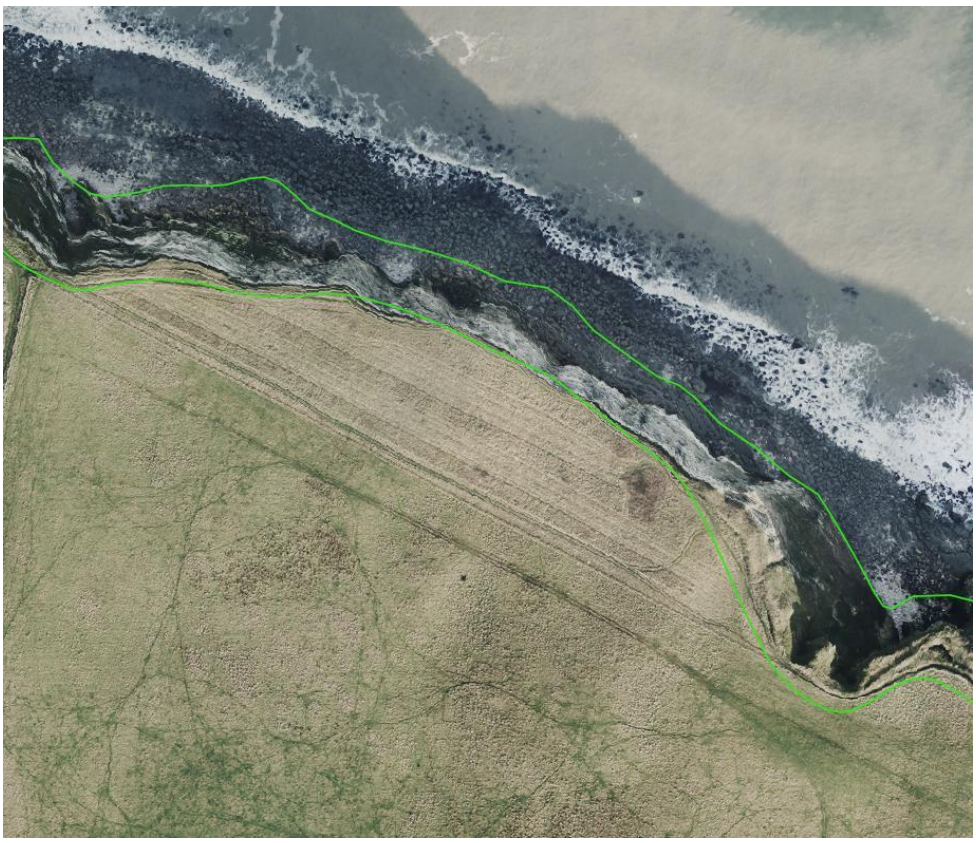


Figure 2: Section of Cliff North of Flamborough Head, November 2015 Survey



In some areas, the degree of cliff shading reduces the confidence with which habitats can be segmented and attributed to a very low level, as illustrated in Figure 3. Though a tentative segmentation has been attempted, the polygons in these areas have not been attributed at this time.

Figure 3: High Levels of Shading East of North Landing Flamborough Head.

5.2 Segmentation of GIS Polygons

The habitat segmentation was undertaken at two resolutions, with smaller objects being allowed within the areas of known biodiversity interest than over the rest of the coastline. In total, over half a million polygons were identified in the initial segmentation. This level of segmentation will facilitate the consistent incorporation of additional information at a wide range of scales, including the most detailed ecological field survey, to the coastal habitat evidence base going forward.

In addition, three segmentation masks were developed, with a view to pre-identification of some features. These were intended to identify agricultural land and campsites, man-made objects and dense scrub vegetation, an example of which is given in figure 4. Within these areas, the segmentation of the polygons was greatly simplified. It is thought that with the use of ground-truth data, these masks could be made significantly more effective and in particular, the scrub mask (Figure 5).

In hind sight, the level of segmentation outside the monitoring sites may be greater than necessary for practical purposes, however, this technology is relatively new and some errors of judgement are inevitable. In the future, a number of "unnecessary" polygons, for example within urban areas, will be removed whilst others may be merged in consultation with officers of ERYC. At this time, the data may be retiled to optimise end user experience.

Figure 4: Shows three levels of segmentation, red within the Cowden Ranges Monitoring Site (marked by the orange line), green outside the monitoring area and blue hatched in the area covered by the agricultural mask.

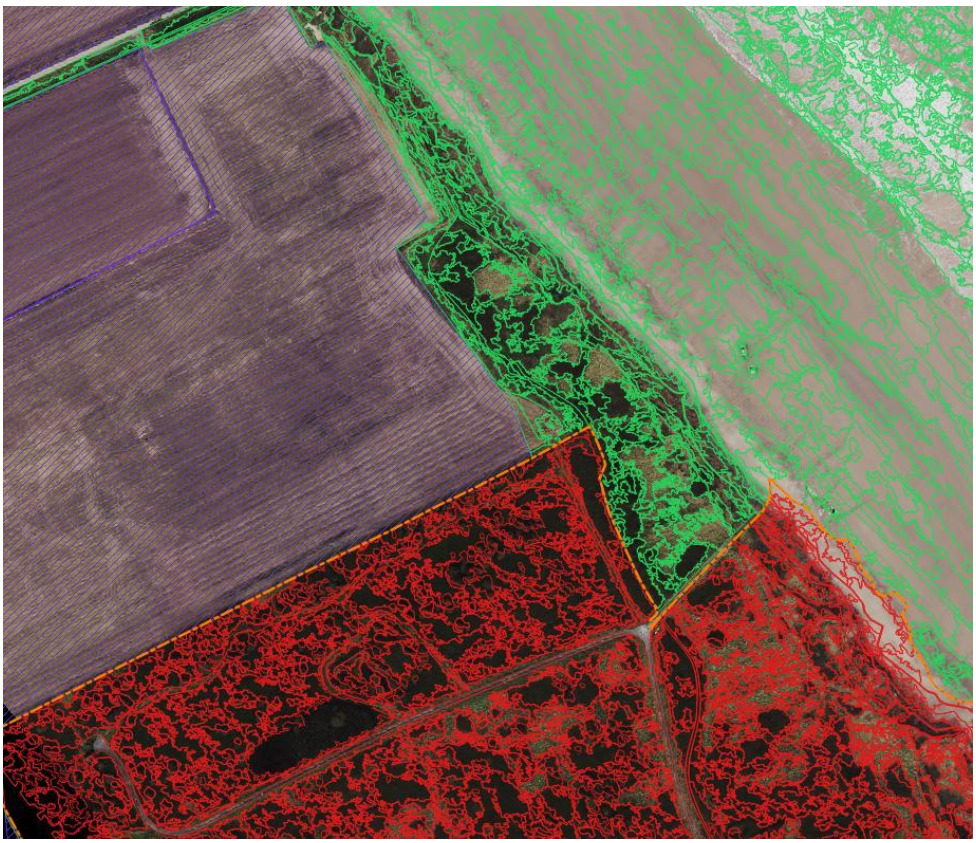
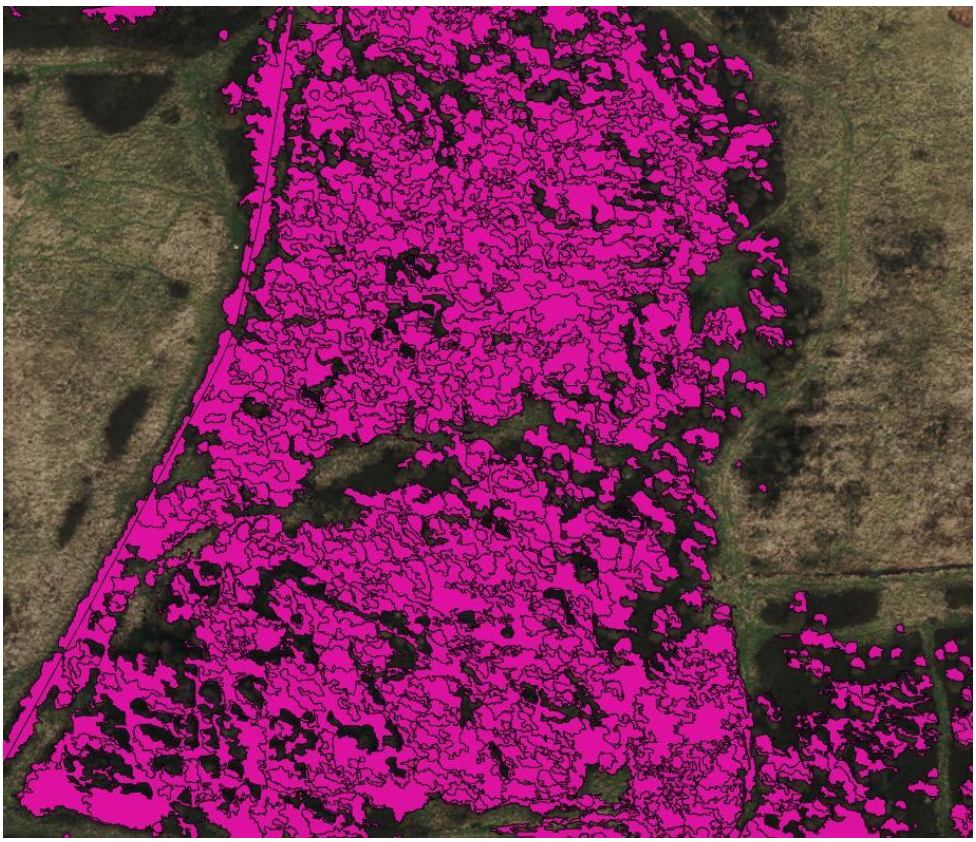


Figure 5: Scrub mask applied to a section of the Cowden Ranges surveillance site

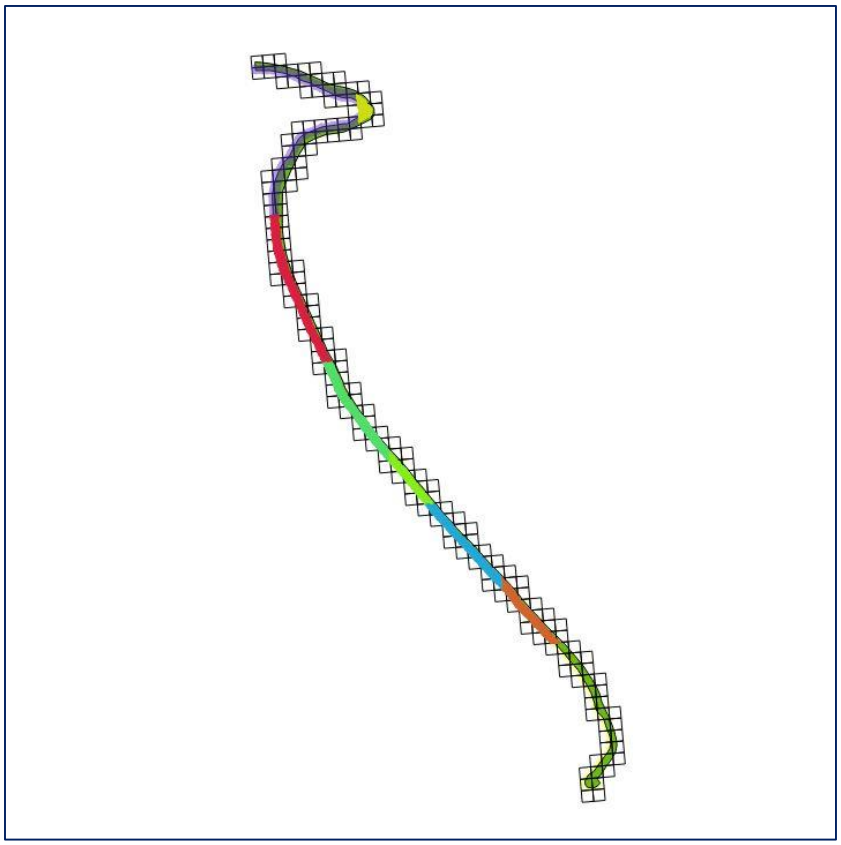


5.2.1 Tiling of the Segmentation

The segmentation was carried out as a single coverage, which created a very large Shape File. In order to reduce processing time during attribution, the segmentation was tiled. Originally it was intended to use the same tiling as the original aerial imagery supplied by ERYC, however, in practice, this proved to be quite inefficient, with significant moving between a very large number of tiles. The coverage was subsequently tiled into seven areas, as illustrated in Figure 6. These included five stretches of coastline South of Bridlington and two unequal tiles covering Flamborough Head and Bridlington. This reflected the intensity of work and density of habitat features that was anticipated in these areas.

The segmentation was undertaken for the whole coastline, however the attribution of polygons was limited to the area defined in the contract brief; Speeton to the Neck of Spurn.

Figure 6: Tiling of the segmentation, showing original aerial photography tiling and the seven tile used in the project



5.3 Ground-Truthing

The project requires two types / phases of ground-truthing:

5.3.1 Pre-attribution Ground-Truthing (Aerial Photograph Interpretation (API) training)

Before undertaking API it is valuable for the habitat assessors to visit a range of sites across the whole assessment area with copies of the aerial photographs to get a feel for the general appearance of the main habitat types in the imagery that is to be used. In an ideal world, the API assessor would see examples of all the habitat types that will be considered during attribution. In reality however, there were insufficient resources within the project to allow this, and the late commencement date of the project made the completion of the field surveys within the required survey window a higher priority. In the preparation for the habitat attribution in this project, one visit was made to each of the map tiles described above.

5.3.2 Post-attribution Ground-Truthing (verifying the data products derived from the attribution)

During the field season following the project, it will be necessary to undertake an extensive ground-truthing and quality assurance process to verify the data layers produced during the attribution process.

5.4 Attribution of Habitat Polygons

There are two hierarchies of classification commonly used in the UK. The first is primarily used in the context of national biodiversity conservation strategy and administrative / legislative instruments. It includes the UK Priority Habitats and the European Annex 1 Habitats. The second derives from ecological research and mapping and comprises the Phase 1 and National Vegetation Classification (NVC) typologies. Overarching both of these is the Broad Habitat Classification, used in previous versions of the Countryside Survey. This is the periodic remotely sensed land cover survey that covers the whole of the UK. The Broad Habitat Classification is a coarse set of habitat types used to describe all land-cover in the UK. The minimum unit of mapping in the Countryside Survey is from 25m to 5m (depending on the version of the survey and the satellite data available to inform mapping).

The project specification requires attribution of the segmented polygons to Broad, Priority and Annex 1 level, however, these classifications mask a great deal of ecological detail in terms of both habitat extent and habitat quality. For example, all marine cliff and coastal slope is regarded as a UK Priority Habitat, regardless of the biodiversity that it supports. This view has been informed by the study of exceptional examples of both hard and soft cliffs from around the county, but is not true of the soft cliffs of much of the East Riding of Yorkshire. For this reason, where the data is available, polygons have also been attributed using the Phase 1 and NVC classifications. It is felt that going forward, polygons can be retrospectively attributed with detailed ecological classifications as data becomes available through other sources and initiatives, for example the Local Wildlife Site (LWS) process.

5.4.1 Broad Habitat Classification

The original Broad Habitat Classification was developed during the 1990s and published in 'Biodiversity, The UK Steering Group Report; Meeting the Challenge of Rio' (1995). It was later modified to provide a context for how Priority Habitats sat in the context of the whole UK.

5.4.2 Annex 1 Habitat Classification

Annex 1 classification is a trans-Europe habitat classification that directly devolves from Council Directive 92/43/EEC Conservation of Natural Habitats of Wild Fauna and Flora. Member states have a requirement to protect and restore these habitats. It is necessarily a broad-brush classification with the classes being derived from relatively large expanses of habitat right across Europe. The correspondence of UK manifestations of some habitats to the classification may be ecologically quite loose and their geographical extent inconsistent. The whole of Flamborough Head would be classified as 1230.4 (Vegetation on Intermediate Soft Cliffs), whilst three sand dune habitat types (2110 – Embryonic Shifting Dunes, 2120 – Shifting Dunes along the shoreline with *Ammophia arenaria* and 2130 – Fixed Dues with Herbaceous Vegetation) occur in a 100m length of foreshore at Hildethorpe, South of Bridlington (Figure 7). No doubt these habitats run for tens of miles on some European shorelines.

Figure 7: Three Annex 1 habitats occurring in a 100m length of Sand Dune habitat at Hilderthorpe.

5.4.3 UK Priority Habitat Classification

The UK Priority Habitat Classification derives from the work carried out under the UK Biodiversity Action Plan (UK BAP), which was replaced by the UK Post-2010 Biodiversity Framework in 2012. The Framework devolves the role previously undertaken by the UK BAP to country level. The UK Priority Habitat Classification forms the basis of the statutory lists of priority species, which constitute Section 41 of the Natural Environment and Rural Communities Act (NERC) 2006.

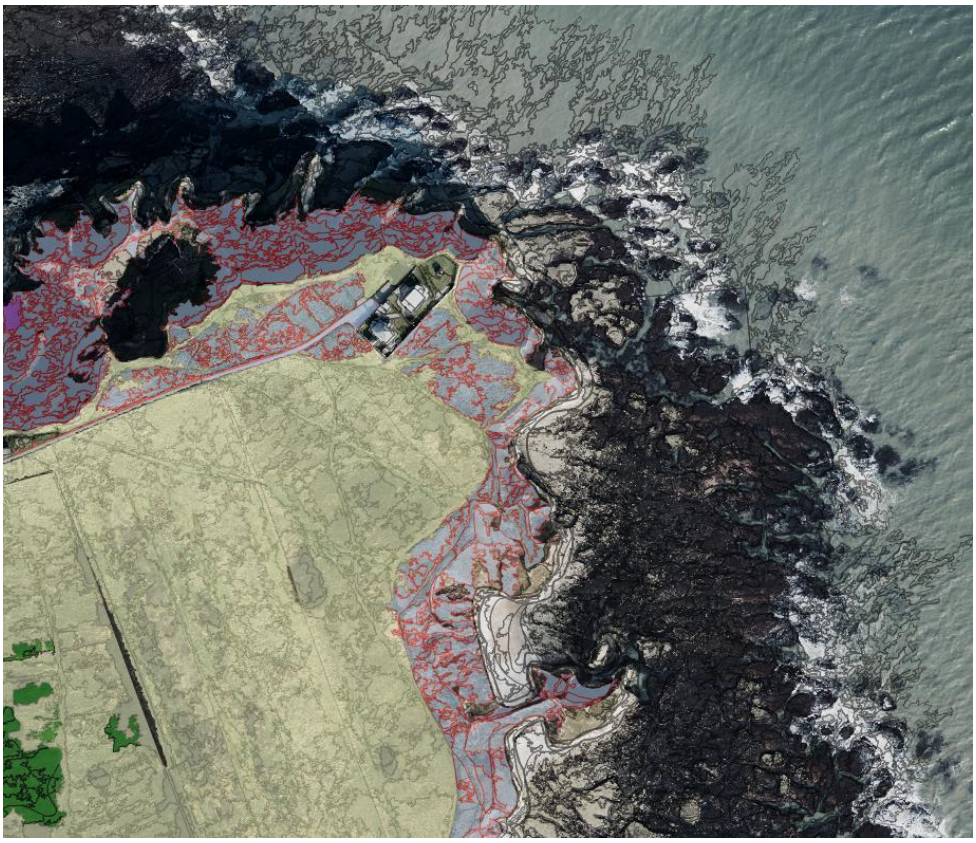
Though the UK BAP was, in part, the UK response to its obligations under Council Directive 92/43/ECC, there are some notable discrepancies with respect to the Annex 1 classification, especially in terms of coastal habitats. The most notable of these is that whilst the Annex 1 classification recognises vegetated intermediate cliffs, like those found at Flamborough, the Priority Habitat Classification only recognises Hard and Soft Cliffs.

Whilst the Annex 1 classification refers to “vegetated sea cliffs”, the Priority Habitat encompasses the whole of the cliff and coastal slope, whether vegetated or not. The definition of where the landward extent of the cliff and coastal slope habitat is vague, but the habitat is described as including cliff top grasslands. It is often taken to be defined in terms of the limit of maritime influence on the vegetation and the point of enclosure of land for agricultural purposes, though these are not made explicit in the habitat description.

Such issues pose a number of problems in attributing habitat polygons within these classifications, not least the fact that the cliff-top vegetation on the coast of the East Riding of Yorkshire often shows very little maritime influence and agriculture is often practiced right up to the edge of rapidly eroding cliffs. For pragmatic purposes, we have endeavoured to map the vegetation on cliffs, coastal slopes and cliff tops on the understanding that

physical topography of the cliffs are already monitored and mapped for other purposes (Figure 8). It should, therefore, be possible to derive the un-vegetated area of cliff and coastal slopes.

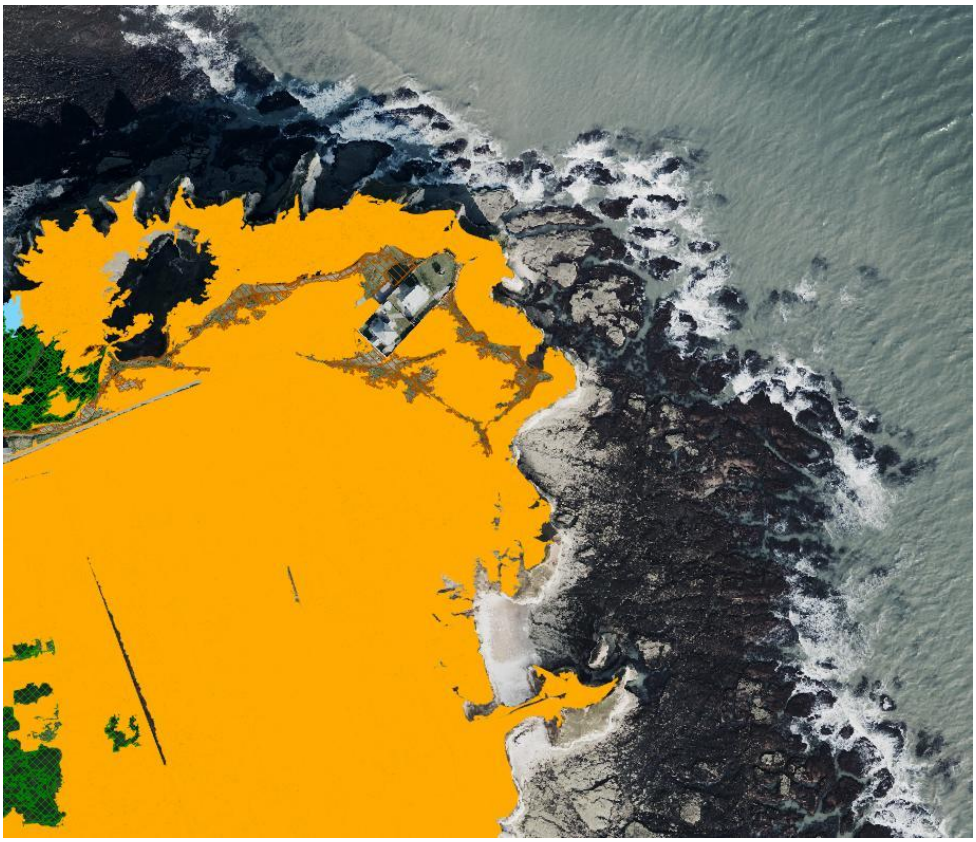
Figure 8: Area of Flamborough Head, mapped using Broad and Priority Habitat type attributions (Priority Habitats are outlined in red). Note that whilst the scrub on the cliff top grassland shows up in the Broad Habitat classification, it cannot be seen in the Priority Habitat classification.



5.4.4 Phase 1 Habitat Classification

The Phase 1 habitat classification was developed during the 1980s as a way of recording habitats over large areas manually onto paper maps. It pre-dates the wide availability of Geographic Information Systems (GIS) and the capacity to easily overlay data in layers offered by this technology. It is intended for medium resolution mapping and emphasises land use, and structural aspects of vegetation, as illustrated in Figure 9.

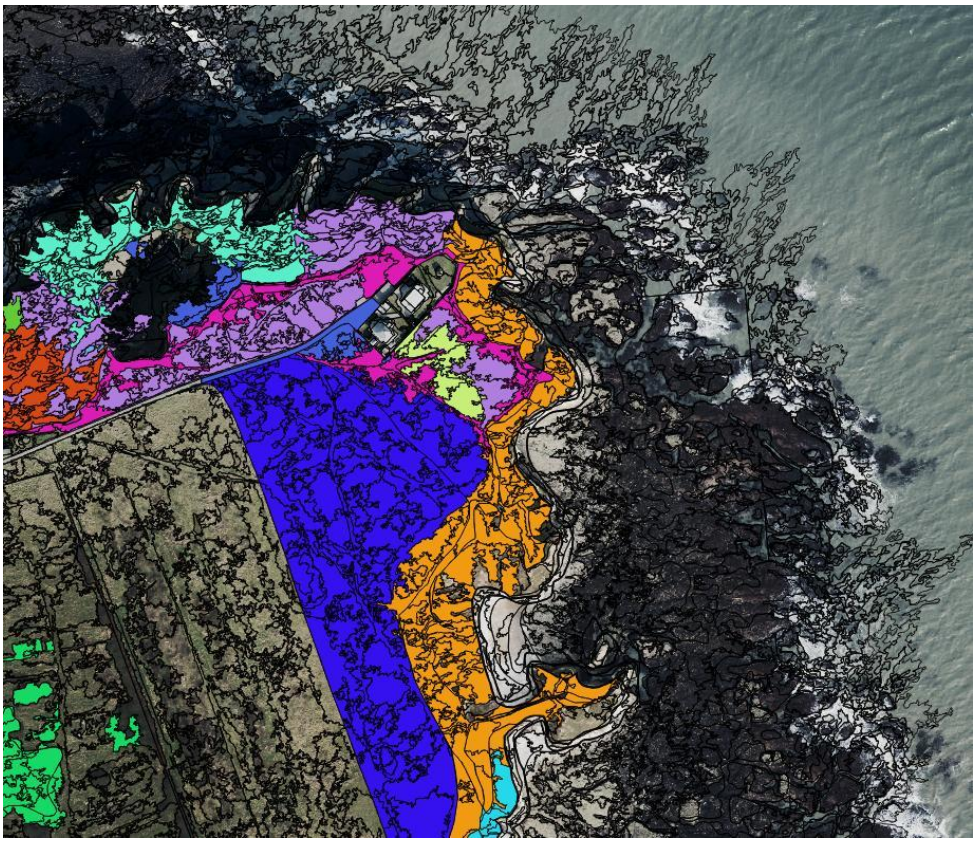
Figure 9: Area of Flamborough Head mapped using Phase 1 habitat classification attributions. Note that the grassland, scrub, wetland and tall ruderal vegetation types stand out clearly in this interpretation.



5.4.5 National Vegetation Classification

The National Vegetation Classification (NVC) is the most detailed mainland UK-wide classification system, based on a meta-analysis of a very large number of samples from across England, Scotland and Wales. It offers far more detailed ecological mapping of plant communities, but is time consuming to undertake, requiring detailed fieldwork. The NVC has a weakness with respect to its use along the East Riding of Yorkshire coastline. This coastline was under-represented in the work that led up to the development of the NVC system and in some respects, whilst the vegetation found here may have affinities with NVC classes, these may not always be a good fit with a given habitat having similar affinities to several NVC habitat types. In particular, the NVC offers no specific classification for intermediate cliffs or of rapidly eroding soft cliffs. Figure 10 illustrates the same area of Flamborough Head as described in Figures 8 and 9 mapped according to the NVC system.

Figure 10: Area of Flamborough Head Mapped using NVC attributes. Notice the increased resolution of the vegetation communities.



5.4.6 Issues relating to habitat attribution

An important element in the ascription of habitats following the attribution key (Appendix 1), is the definition of the cliff, coastal slope and adjacent areas. In the early part of the key (4e), this is defined in terms of the limit of marine influence on the vegetation, with the presence of halophytic species and the use of Ellenburgh indicators being seen as the defining factor invoking the use of coastal classifications. In 18a, the line of enclosure is introduced in order to help clarify the limit of marine influence.

Initial indications from the detailed field-surveys suggest that whilst vegetation on the cliffs, coastal slopes and slumps is consistent with the cliff and coastal slope classification, being different in character from adjacent terrestrial habitats, the vegetation of the cliff tops and adjacent to cliff top paths shows little marine influence, being more influenced by the degree of agricultural improvement and nutrient enrichment that they may have experienced. Much of the cliff top vegetation then is consistent with semi-improved and rank neutral grassland despite its Priority Habitat and Annex 1 status. For this reason, the grassland habitats of the cliff tops outside clear enclosure lines have been attributed as neutral grasslands in terms of Broad and Priority habitat except where evidence or local knowledge has suggested that this should be otherwise. Enclosed grassland habitats have been assumed to be terrestrial in nature, unless evidence exists of marine influence. All areas adjacent to cliffs outside enclosure have been attributed as Annex 1 habitat, in accordance with the key.

In addition to issues surrounding the attribution of coastal grasslands, the attribution of scrub habitats also posed something of an issue. Scrub habitat is considered of significant biodiversity value in a coastal context. Whilst scrub composed of gorse *Ulex europaeus* can be attributed as broadleaved woodland within the above schema, all other scrub would be subsumed within either grassland or maritime cliff and coastal slope habitat

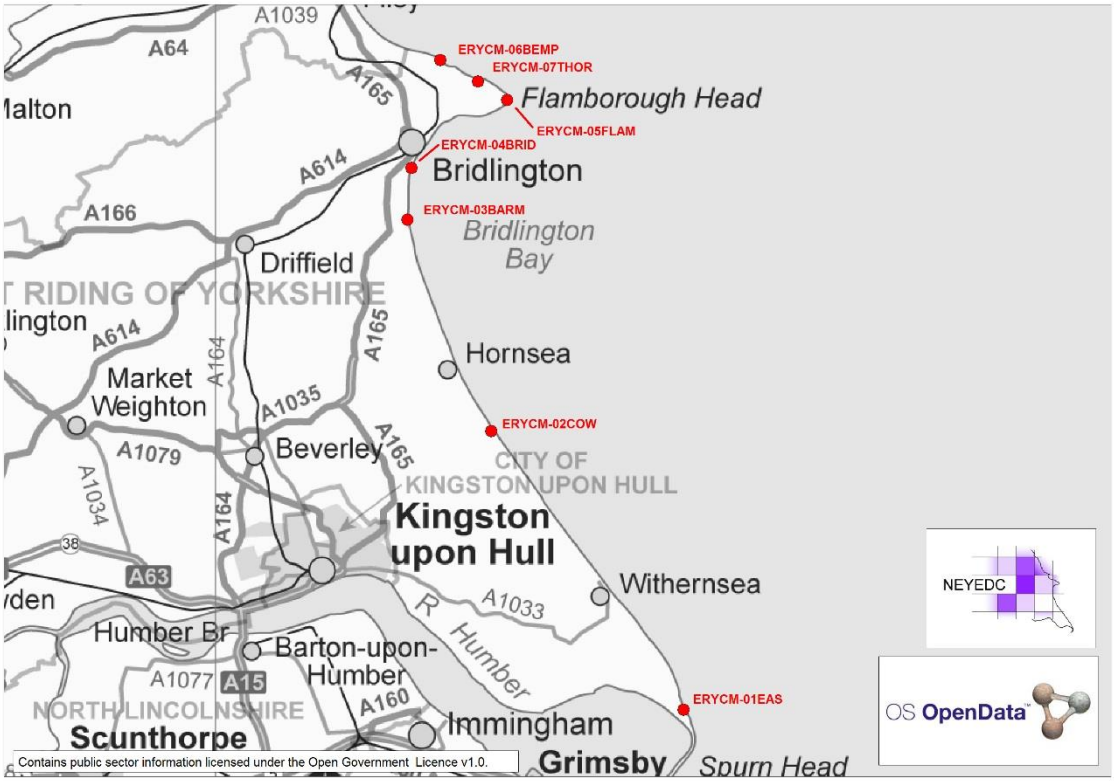
types. A decision was made therefore, that where dense scrub exists, it has been attributed as BH1 (broadleaved woodland), rather than as one of the habitat types which occur later in the key.

5.5 Condition Assessment

In assessing and monitoring the biodiversity value of habitats it is necessary to consider both the extent and condition of the habitats. Whilst API and in the near future Earth Observation offer rapid and efficient ways to map habitat extent, habitat condition currently requires significant resources and expertise on the ground.

As outlined above, the biodiversity interest of the East Riding of Yorkshire Coast is not evenly distributed along its length, but is concentrated in small pockets, many of which are well recognised, discrete sites. It was decided to identify a number of monitoring polygons within these sites, at which to monitor habitat condition, both in order to detect change at these sites over time and to provide a condition reference against which to compare habitats at other points on the coast as the need arises. Figure 11 and Table 2 outlines the sites selected for more detailed survey and the establishment of monitoring polygons.

Figure 11: Sites at which detailed monitoring polygons were established.



There are three key components to monitoring habitat condition; the composition of the vegetation communities, the structure / spatial distribution of their components and the populations of other organisms that they support. The collation of data on species distributions and populations is part of the function of a Local Environmental Record Centre like NEYEDC, however, collating data on this aspect of habitat condition is beyond the scope of the current project.

5.5.1 Vegetation Composition

There are well established techniques for establishing the composition of vegetation, which involve identifying the presence and cover of all the species that occur within a random sample of quadrats from a representative stand of vegetation.

Surveillance polygons were established at each of the sites outlined in Figure 11 / Table 2. A series of quadrats were carried out within each polygon and the species recorded. In addition ecological notes were made for each polygon and illustrative photographs taken.

Figure 12: Date and time stamped photograph at TA41401690 (Easington) over sea buckthorn (Polygon III) across to sea couch 'meadow' (Polygon IV) down to distant saline lagoon. Note narrow strip of common reed in immediate foreground constituting part of Polygon V running along the base of an old embankment.

Maps of each surveillance site, with surveillance polygons and the distribution of sample quadrats can be seen in Appendix 2. Specimen vegetation composition data for each polygon is presented in Appendix 3, with the full dataset being available as a separate document (8.3Mb)

5.5.2 Analysis of Vegetation Composition Data

In developing the baseline data, the vegetation composition data was used to ascribe NVC vegetation types to each of the surveillance polygons and is summarised in Table 3.

Table 3: Summary of vegetation types found within the surveillance polygons at each site.

Site Code	Site Name	Number of Polygons	Broad Habitats Present	NVC types Present
ERYCM-01EAS	Easington	7	BH11, BH17a, BH17d, BH19a, BH19b, BH19f	S24, SD4, SD6, SD18, SM8, SM10, SM12
ERYCM-02COW	Cowden	1	BH18b	MG5, MG9, MC9
ERYCM-03BARM	Barmston	4	BH6, BH11, BH19a, BH21	MG1, S4, S26, SD4, SD5, SD6, SD24
ERYCM-04BRID	Bridlington	1	BH19	SD4, SD5, SD6, SD7, SD8, SD9
ERYCM-05FLAM	Flamborough	4	BH18a, BH18b, BH18d	MG9, MC10, OV24, OV25, OV26
ERYCM-06BEMP	Bempton	2	BH18d	MC10, OV24, OV25
ERYCM-07THOR	Thornwick Bay	3	BH11, BH18b, BH18d	MC10, S4a

For future monitoring purposes, this baseline data can be compared with respect to any future data sets in the following ways:

- The data can be re-analysed against the NVC for changes in "goodness of fit", that might indicate an overall change in the plant community;
- The data can be analysed between monitoring instances for newly recorded species and species which have been lost from the site. These can not only be used as a general indicator of change, but in combination with Ellenburgh and CSR indicators give an indication of the drivers of change, for example salinity, disturbance or increased nutrient status.

5.5.3 Structure / Distribution of Community Components

Whilst quadrats detect the detailed composition of plant communities, they do not give any information about the spatial distribution of the components of the community across the polygon. For many species, the affinity with a given habitat is not based on the presence of the whole habitat, but rather one component of that habitat, for example, an insect species may be very intimately associated with a single plant species on which it feeds. Other species may have no requirement for specific species, but rather need vegetation with specific structural characteristics, for example tall hollow stems in which to hibernate.

Recording structure and distribution at this level of detail is very difficult in the field and to do so meticulously requires the time intensive use of GPS or similar surveying equipment, which is beyond the resources of this and most other surveillance programmes. Conventional aerial photography with a ground resolution of between 20cm and 50cm is not sufficiently clear to allow these factors to be assessed using API. An added issue in this case is that the key diagnostic features of habitat component structure and distribution are far less evident in April and November than at the height of the growing season between May and July.

To overcome the issues of resolution and timing, this project has introduced the use of an Unmanned Aerial Vehicle (UAV), which is capable of rapid deployment at the appropriate point in the field season and produces imagery at 4cm resolution on the ground. An example of the UAV imagery is illustrated in Figure 13, compared to conventional aerial photography in Figure 14.

Figure 13: Detail from an aerial image of vegetation in the Flamborough Head surveillance polygon taken using a UAV – resolution is approximately 4cm pixel on the ground. Notice individual flowers can be discerned at this resolution.

Figure 14: Detail of the same area of the Flamborough Head surveillance polygon taken by conventional aerial

photography, shown at the same scale – resolution is approximately 20cm on the ground.

5.5.4 Analysis of UAV data

There is no widely accepted standard approach to recording or mapping vegetation community structure or component distribution at this scale, though Defra have elements of vegetation structure as condition indicators within their approach to monitoring the condition of Sites of Special Scientific Interest (SSSIs), these are either confined to quadrats or made by subjective consideration of the site by the surveyor. These broad indicators of structure where gathered as part of the condition assessment field work.

The UAV data will become particularly useful when vegetation change is detected between iterations of monitoring. A particular advantage of the UAV data is that it not only includes visible spectrum aerial photography but also red edge infra-red imagery and a local Digital Elevation Model (DEM). In combination, this makes it possible to identify areas of actively growing vegetation from areas of dead vegetation, bare ground and rock. It also enables the construction of 3D renderings of the aerial images, allowing the cliff face vegetation to be assessed more easily than is possible with standard aerial photographs and traditional API techniques. By synchronising UAV flights with the flowering period of key plant components of the plant communities, it would be possible, using image analysis techniques, to colour individual inflorescences within an image; Figures 15, 16 and 17 show these different techniques.

Figure 15: Red Edge Infra-red image captured by UAV

Figure 16: Local DEM generated from UAV data

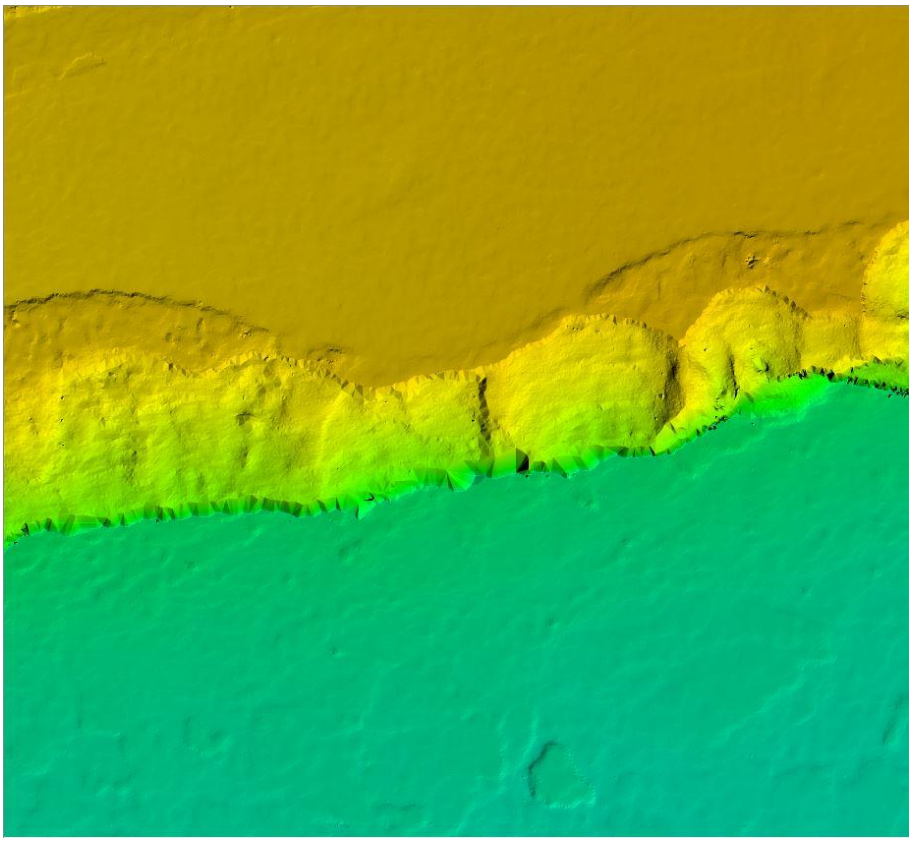
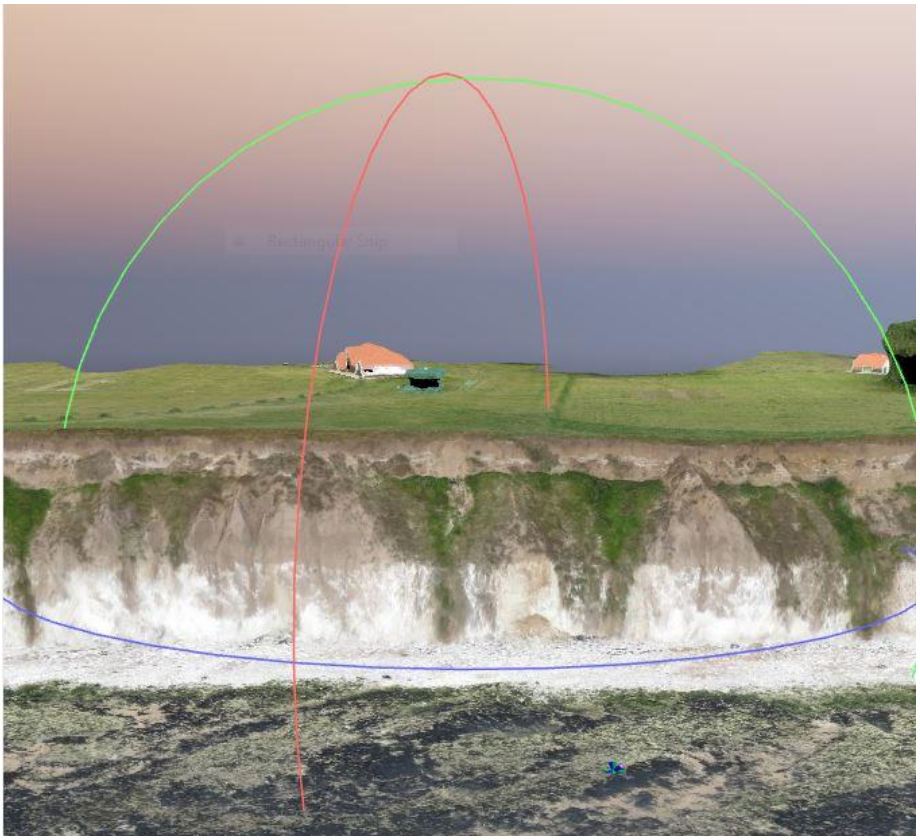


Figure 17: 3D rendering of visible UAV image from cliff area adjacent to the Flamborough Head no take zone.



6 End-User Data Products Derived From Project Data

NEYEDC will work with officers of East Riding of Yorkshire Council to produce a suite of user defined products from the project data that meet the end-user requirements. These will include, but will not be limited to:

- Broad and Priority Habitat Layer (Esri Shapefile format)
- Annex Habitat Layer (Esri Shapefile format)
- Phase 1 Habitat Layer (Esri Shapefile format)
- NVC Habitat Layer (Esri Shapefile format)
- Detailed Aerial Images of monitoring sites (Geo-TIFF format)
- Detailed field data (Excel spreadsheet)

In addition, the data will be entered into the Centre's GIS and spatial database systems and will be disseminated to stakeholders in environmental decision-making processes in accordance with the existing Memorandum of Agreement between ERY Council and NEYEDC.

7 Future Monitoring

NEYEDC would like to work with ERYC to develop a cost effective monitoring programme building on the base-line established through this project.

8 Appendix 1 – Key for attribution of Broad, Priority and Annex 1 Habitats (from Field Survey Key and Allocation Rules to Broad, Priority and Annex 1 Habitats (Natural England, 2014)

Key Code	Descriptor	Key Code links	Broad / Priority Code	Annex 1 Code	Indicative NVC Code
1e	Sparsely vegetated rock, mud, sand or shingle	15			
4e	Scrub on sand dunes & shingle	19, 15			
4d	Broadleaf woodland	5			
5d	>= 75% cover native oak or birch	9			
5f	Not a above		BH1		
9a	Stands of oak, with Hornbeam and Bluebells		LMD		W10
10a	Ulex europaeus >25%		BH1		W23
13b	Bracken >= 95% cover or with or without a sparse understorey		BH9		U20, W25
13c	Vegetation consisting of crops including grass leys in arable rotation		BH4		
14a	Coastal areas where the sea regularly disturbs vegetation or vegetation contains halophytic species or where species in quadrats have an Ellenberg salt indicator >0	15			
15a	Hard sea cliffs mostly devoid of vegetation		BH18/MC	1230	
15b	Soft cliffs devoid of vegetation		BH18 / MC	1230	
15c	Sand dunes devoid of vegetation	19			
15d	Vegetation consisting of frequent to dominant halophytes, usually on mud often with base ground	16			
15e	Sea cliff vegetation with halophytes more or less prominent	18			
15f	Vegetation growing on sand dunes	19			

15g	Generally linear, ephemeral, seasonal and often patchy vegetation just above the high-tide mark		BH19	1210	
15h	Sparsely vegetated shingle, often reflecting patterns of former shingle ridge development with halophytes, species tolerant of maritime exposure and other more wide ranging species		VS	1220	
15i	Reed is dominant, but with halophytic species such as Sea-purselane in a sparse under layer		BH11 / RB		S4, S24, S25, S26
15j	Grassland with only few halophytes on enclosed land, grazed by livestock. Ditches and drains obvious		CFGM		
17a	Pioneer vegetation on lower saltmarsh		BH21/ SM	1310	SM7 – 9, SM27
17b					
18a	Vegetation on and / or at the top of hard cliffs outside the line of enclosure of if there is no enclosure line, where vegetation ceases to have an obvious maritime influence		BH18 / MC	1230.1	MC1 – MC12
18b	Vegetation on and / or at the top of soft cliffs with no sign of hard engineering, outside the line of enclosure of if there is no enclosure line, where vegetation ceases to have an obvious maritime influence. Includes vegetation on slumped deposits		BH18 / MC	1230.2	
18c	Vegetation on or at the top of soft cliffs where the cliff is stabilised by hard engineering		BH18 / MC	1230.3	
18d	Vegetation on and / or at the top of intermediate cliffs with no sign of hard engineering, outside the line of enclosure of if there is no enclosure line, where vegetation ceases to have an obvious maritime influence. Includes vegetation on slumped deposits		BH18 / MC	1230.4	MC8 - 11
18e	Vegetation on or at the top of intermediate cliffs where the cliff is stabilised by hard engineering		BH18 / MC	1230.5	

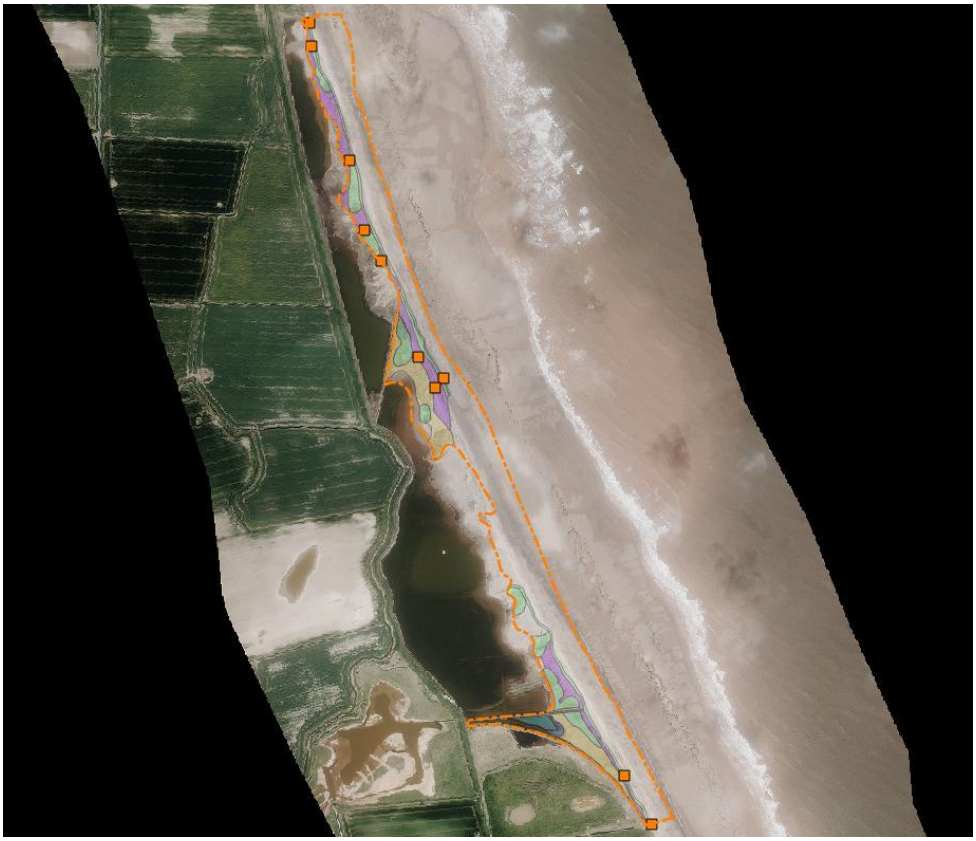
19a	Low sand dunes at the top of a beach with very sparse vegetation made up predominantly of strandline species such as Sea-rocket and the two salt tolerant sand binding grasses; lyme-grass and sea couch		BH19 / SD	2110	SD4
19b	Unstable dunes with Marram a prominent feature of vegetation or dominant		BH19 / SD	2110	SD6
19i	Dunes with scub other than Sea Buckthorn (within its natural distribution), Juniper or Creeping Willow		BH19		
20a	Pulse disturbance vegetation	21			
20b	Press-disturbance vegetation	26			
21a	Wetland tall herbs or sedges frequent to dominant	22			
21b	Wetland tall herbs occasional to absent	23			
22b	Aquatic vegetation where macrophytes persist as emergent within standing water		BH13		
22c	Stands dominated by Reed in standing saline or fresh water		BH11 / RB		S4, S24, S25, S26
22d	Vegetation fringing open water developed as a narrow band as part of the hydrosere between standing water and up-slope vegetation		BH11		
22e	Fertile wetland tall-herb vegetation with less than 50% grass cover		BH11/ LF		OV26
23a	Mid-to late pulse disturbance vegetation consisting entirely of long-lived perennials with little or no open ground		BH6		OV23, OV25, OV27, MG1
23b	Early successional pulse-disturbance vegetation dominated by annual weeds as well as perennial species, usually with conspicuous open ground		BH4/ BH17		OV21 - 23
23c	Vegetation containing some annual weeds but consisting mainly of long lived perennials including grasses		BH6		OV24

	but <50% cover. Some shrubby species may be present as infrequent juveniles				
23d	Soft coastal cliffs with no halophytes present	18	BH6/ MC		
27a	Productive grasses and white clover usually predominate	28	NG		
27b	Cover of grass species, white clover and red clover <50%. Typically rich in forb species		BH6/ LM	6510	MG4, MG5, MG8
27c	Neutral flushes typically marking enriched spring lines and water seepage zones		BH11		
28a	Palatable grasses dominate. Grass cover over 50%. Improved grassland		BH5		
28b	Palatable grasses dominate, usually rye grasses and timothy <25% or below and other grasses more prominent	29			
29a					
29b					
29c	Not as above		NG		MG6, MG9 - 13

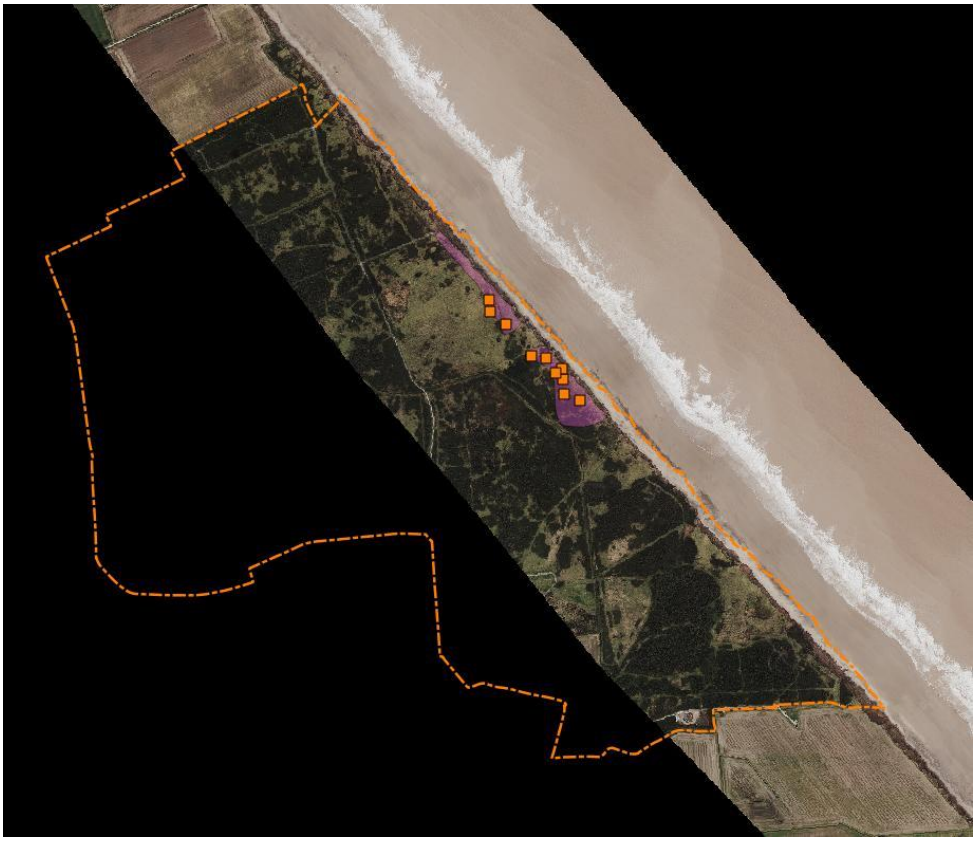
9 Appendix 2 – Monitoring Sites

The following images show the habitat monitoring sites; the orange dashed line signifies the site boundary, shaded areas highlight the surveillance polygons and orange squares quadrat locations

ERYCM-01EAS - Easington



ERYCM-02COW - Cowden

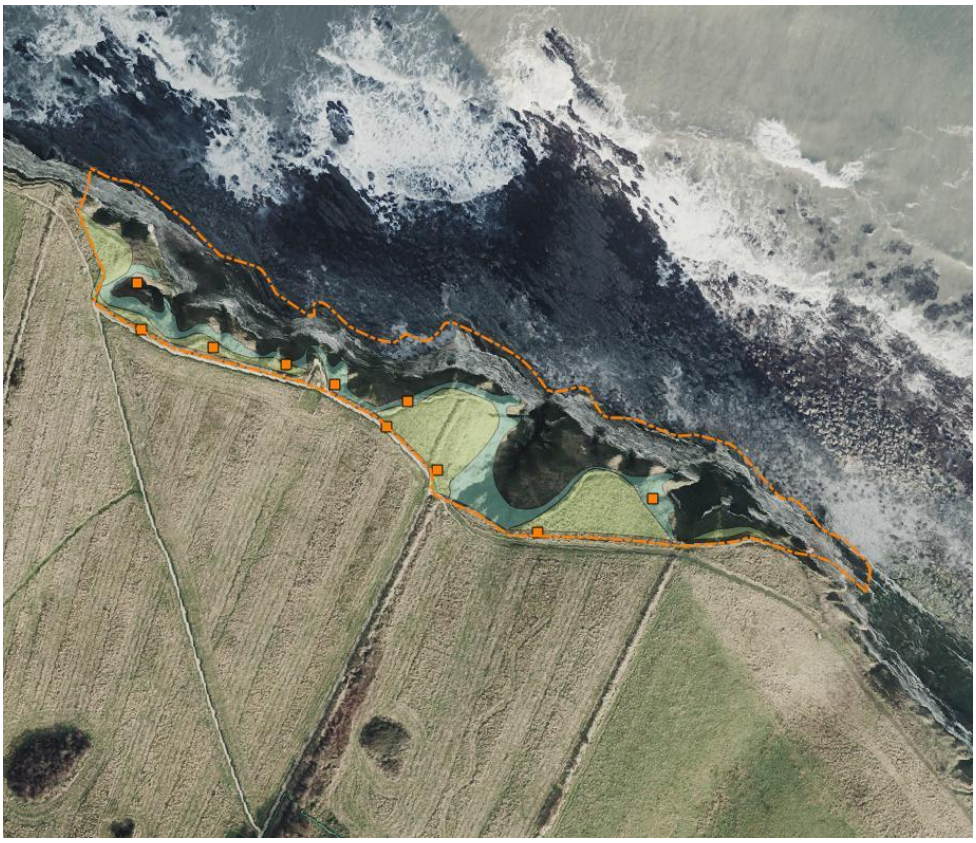


ERYCM-03BARM - Barmston

ERYCM-04BRID - Bridlington

ERYCM-05FLAM - Flamborough

ERYCM-06BEMP - Bempton



ERYCM-07THOR – Thornwick Bay

10 Appendix 3 – Sample Field Data From Condition Assessment Field Surveys

Completed Habitat Surveillance Survey Sheets for: ERYCM-03BARM, Barmston Polygon I

Habitat Condition Assessment Form

NEYEDC

Recording form for supra-littoral rock v1.0

Barmston	**Polygon:** *(roman numeral)*	I	**Surveyor(s): PJC/KR**			**Ref: ERYCM-03BARM-I**
Grid Reference of Polygon Centroid:	**TA1660**					
Keyed Out Habitat:	**BH11**	**Subjective NVC Type:**			S4	S26
Change in Area of Polygon (Ha) *Office use*		**Direction of Change** +ve / 0 / -ve		**Type:** natural / anthropogenic		

Surveyor Notes: The key elements of condition to be noted are presence of appropriate zonation, presence of transitional communities and presence of appropriate mosaics. In scoring these elements, the surveyor should consider the "goodness-of-fit" of the sampled quadrat as part of these wider condition indicators. Low fit should be scored at 80%, medium fit at 90% and good fit 100%. As these criteria are considered to be quite vague, additional surveyors notes would be valuable.

This site, lying in a bowl, is possibly the remains of a mere. It is drained by two ditches runnining West to East with outfalls onto the beach in continual excavation. A walkiing stick was pushed to a depth of ca 80 cm into peat in the bed of a dried-out shallow pond containing sea aster and sea club-rush indicating brackish content. Seasonal inundation by both fresh and salt water, the former from higher ground to the west (Hamiltion Hill, 26 m) and the latter coming in by over-topping the narrow low mobile dunes on seasonal high tides, lends to this polygon being extensive over the central region of this bowl.

Eutrophication is evident with red goosefoot Chenopodium rubrum and nettle Urtica dioica under the reeds.

	Quadrat Locations (NGR)				
	1	2	3	4	5
	TA16886004	TA16826024	TA16806029	TA16866034	TA16916014
	Condition Indicators for each quadrat				
Presence of appropriate zonation					
Presence of transitional communities					
Presence of appropriate mosaics.					
% Bare ground					

	6	7	8	9	10
	TA16916014	TA16926001	TA16895993	TA16865995	TA16775996
	Condition Indicators for each quadrat				
Presence of appropriate zonation					
Presence of transitional communities					
Presence of appropriate mosaics.					
% Bare ground					

Property of NEYEDC, if found please return to: NEYEDC, 5 College Street, York, YO1 7JF

Page 1 of 1

v1.0 August 2015

Habitat Condition Assessment Recording Form

NEYEDC

Recording form for supra littoral rock BH 18 v1.0

Ref: ERYCM-03BARM-I

Species present within each quadrat	% cover within each quadrat						
	1	2	3	4	5	6	7
NGR	TA16886004	TA16826024	TA16806029	TA16866034	TA16916014	TA16916014	TA16926001
Subjective NVC	S4	S4, S26	S4, S21		S4	S4	S4
Bare ground							
Phragmites australis	100	95	80		100	100	95
Cirsium arvense		5					
Atriplex prostrata		1	10				
Bolboschoenus maritimus			5				
Chenopodium rubrum			5				
Cirsium vulgare							
Dipsacus fullonum							5
Conium maculatum							
Urtica dioica							
	8	9	10				
NGR	TA16895993	TA16865995	TA16775996				
Subjective NVC	S4, S26	S4, S26	S4				
Bare ground							
Phragmites australis	95	70	100				
Cirsium arvense							
Atriplex prostrata	5	5					
Bolboschoenus maritimus							
Chenopodium rubrum							
Cirsium vulgare							
Dipsacus fullonum							
Conium maculatum		5					
Urtica dioica		20					