National Network Of Regional Coastal Monitoring Programmes
Northeast Coastal Monitoring Programme

SEABED MAPPING

Sunderland to Redcar

TR109

North East Coastal Observatory

Channel Coastal Observatory
National Oceanography Centre
European Way
Southampton
SO14 3ZH

Tel: +44 (0)23 8059 8472
e-mail: cco@channelcoast.org
Website: www.channelcoast.org

Document Title: **Seabed Mapping: HI1543 Sunderland to Redcar**

Reference: **TR109**

Status: **FINAL**

Date: **16/12/2020**

Project Name: **Scarborough Borough Council Seabed Mapping Project**

Authors: **W. Amos & M. Lusty**

Approved By: **R. Siddle**

Date	Status
16/12/2020	First Draft
19/01/2021	Final

Contents

Introduction

Technological improvements in bathymetric survey equipment and the widespread introduction of multibeam echosounder systems (MBES) within the offshore survey industry have meant that it is now increasingly cost-effective to achieve 100% sea floor coverage. Although the primary purpose is generally to survey the bathymetry of the seabed, interpretation of acoustic backscatter information and groundtruthing data collected during the survey, in combination with the bathymetry, can be used to produce indicative maps of other features, such as marine habitats, substrate type and anthropogenic features.

A swath bathymetry survey of the seabed between Sunderland and Redcar (HI1543, Figure 1) was commissioned by Scarborough Borough Council, as part of the Regional Coastal Monitoring Programme (RCMP). The survey area covered approximately 166 km^2 extending up to 7km offshore and was completed by Clinton Marine Survey on 18th January 2018. The survey delivered 100% seafloor coverage to IHO Order 1a, along with backscatter and 38 groundtruthing sediment samples. The survey is part of the North East Regional Coastal Monitoring Programme and follows the specifications of the programme. Its purpose was to acquire Multibeam data of the coastal and nearshore area in accordance with the requirements of IHO ORDER 1A. Inshore limit for HI1543 is defined as MLWS which is 1.0 m above CD at Whitby and 0.9 m above CD at River Tees. This limit has been reached when possible with regards to navigational safety. An adjoining survey (HI1491 Whitby to Redcar, Figure 1) was also completed in 2017 and habitat mapped by the Channel Coastal Observatory (CCO). Data from this survey will be included in the maps, for completeness.

All data collected through the National Network of Regional Coastal Monitoring Programmes and the Maritime and Coastguard Agency's CHP are collected to meet the CHP Specification, fully validated, supported with metadata, and freely available under the Open Government Licence. Collecting high quality seabed data can still be prohibitively expensive and time consuming for many stakeholders. It is vital that stakeholders take advantage of the increasing wealth of high resolution seabed data being collected and made freely available.

Scarborough Borough Council (SBC) commissioned the CCO to interpret the available bathymetry, backscatter and groundtruthing data to inform a range of coastal management, marine conservation, and planning policy objectives.

This report describes the methodology and interpretation of the bathymetry, backscatter and groundtruthing data through a series of detailed thematic maps, including surficial substrate, EUNIS level 3 marine habitats and anthropogenic features.

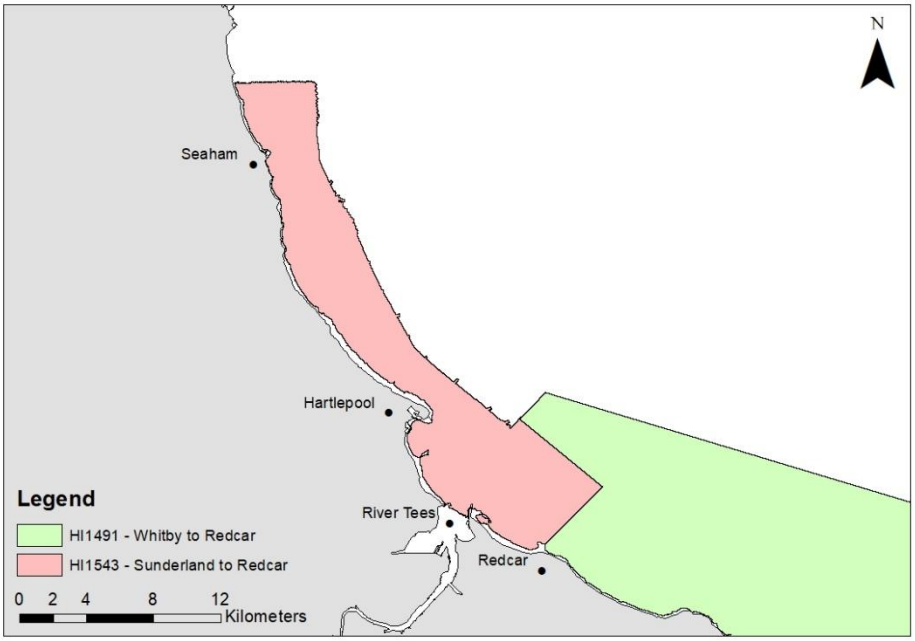


Figure 1: Survey coverage. HI1543 'Sunderland to Redcar' (SBC survey, 2018) and previous adjoining survey HI1491 'Whitby to Redcar' (SBC Survey, 2017)

Marine Habitat Classification Scheme

Marine habitats were mapped using the European Nature Information System (EUNIS) habitat classification. There have been some small changes to the naming conventions on the maps to make labelling easier, specifically *Atlantic and Mediterranean* has been removed as a prefix for all Infralittoral and Circalittoral rock. Furthermore, *Sublittoral Sand* includes *Muddy Sand* as a suffix, to better describe the habitat. A classification table, with EUNIS 2007 codes, correct nomenclature and scientific descriptions, can be found in Annex 2. The EUNIS system is the parent of the JNCC Marine Habitat Classification for Britain and Ireland system, and can be translated if needed.

In the 2019 EUNIS update, energy regimes were removed from habitat names for certain regions and grouped by rock type (e.g. *Atlantic and Mediterranean High Energy Circalittoral rock* and *Atlantic and Mediterranean Low Energy Circalittoral rock* are now grouped together as just *Atlantic and Mediterranean Circalittoral rock*) for certain locations. Whilst many of these don't apply to the UK, be aware that this publication uses the 2007 EUNIS structure.

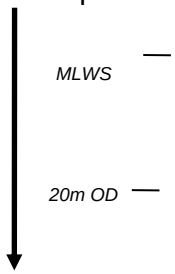
The EUNIS systems has a hierarchical classification, ranging from basic descriptions (low level classifications) such as littoral rock, to very detailed descriptions (high level classifications). Up to 6 levels are defined but Levels 4-6 involve the biology and accordingly the MBES survey can be used to map to Level 3 only; nevertheless, the results of Level 3 and substrate mapping can be used by other agencies who might wish to map to a more detailed level.

Level 1 Environment (marine)

A single category is defined within EUNIS to distinguish the marine environment from terrestrial and freshwater habitats.

Level 2 Broad habitats

These are extremely broad divisions of national and international application for which EC Habitats Directive Annex I habitats (*e.g.* reefs, mudflats and sandflats not covered by seawater at low tide) are the approximate equivalent. At Level 2, there are eight broad marine habitats classifications (Table 1).



Rock	Rock and thin Sediment	Sediment
Littoral Rock	*Littoral Rock and thin Sediment*	*Littoral Sediment*
Infralittoral Rock	*Infralittoral Rock and thin Sediment*	*Sublittoral Sediment*
Circalittoral Rock	*Circalittoral Rock and thin Sediment*	

Table 1: EUNIS Level 2 marine habitat classifications

Level 3 Main habitats

These serve to provide very broad divisions of national and international application which reflect major differences in biological character. They are equivalent to the intertidal Sites of Special Scientific Interest (SSSI) selection units (for designation of shores in the UK) (JNCC, 1996) and can be used as national mapping units. At Level 3 (Table 2), the broad habitat types from Level 2 are sub-divided further based on sediment type, wave exposure and tidal current strength.

<table>
<tr><th colspan="3">Rock</th><th colspan="3">Rock and thin Sediment</th><th colspan="4">Sediment</th></tr>
<tr><td>High energy littoral rock</td><td>Moderate energy littoral rock</td><td>Low energy littoral rock</td><td>High energy littoral rock and thin Sediment</td><td>Moderate energy littoral rock and thin Sediment</td><td>Low energy littoral rock and thin Sediment</td><td>Littoral mud</td><td>Littoral sand</td><td>Littoral mixed sediment</td><td>Littoral coarse sediment</td></tr>
<tr><td>High energy infralittoral rock</td><td>Moderate energy infralittoral rock</td><td>Low energy infralittoral rock</td><td>High energy infralittoral rock and thin Sediment</td><td>Moderate energy infralittoral rock and thin Sediment</td><td>Low energy infralittoral rock and thin Sediment</td><td rowspan="2">Sublittoral mud</td><td rowspan="2">Sublittoral sand</td><td rowspan="2">Sublittoral mixed sediment</td><td rowspan="2">Sublittoral coarse sediment</td></tr>
<tr><td>High energy circalittoral rock</td><td>Moderate energy circalittoral rock</td><td>Low energy circalittoral rock</td><td>High energy circalittoral rock and thin Sediment</td><td>Moderate energy circalittoral rock and thin Sediment</td><td>Low energy circalittoral rock and thin Sediment</td></tr>
</table>

Table 2: Level 3 marine habitat classifications

In the classifications, ‘Rock’ refers collectively to bedrock, stable and artificial substrata (concrete, wood, metal). ’Rock and thin Sediment’ collectively refers to areas where Rock is only covered by a thin veneer of sediment and at times the geology beneath the sediment can be defined or becomes visible. Seismic and acoustic surveys of such areas often suggest that they should be classified as Rock habitats. However, grab samples or video trawls if available suggest the area should be classified as sediment. These type of habitats can show characteristics of both hard and soft substrate with both epifauna and infauna present. Rock and thin Sediment acts as an interim between the pure Rock and Sediment areas. Cobbles and pebbles with gravel and coarse sand are collectively referred to as ‘Coarse Sediment’. ‘Mixed Sediment’ consists of mixtures of gravel, sand and mud which may contain stones and shells.

The littoral zone lies landward of Mean Low Water Springs (MLWS) with the sublittoral zone seaward of MLWS. For areas of ‘Rock” or ‘Rock and thin Sediment’, the sublittoral zone is split into the infralittoral zone and the circalittoral zone based upon site-specific biological parameters (see Marine Habitat Boundaries section).

Habitat Mapping Methodology

Bathymetry, backscatter and groundtruthing data were used to provide information for the production of maps displaying anthropogenic features (*e.g.* cables and pipelines, wrecks, trawl marks and sea defence structures), substrate type and Level 3 seabed habitat maps (Figure 2).

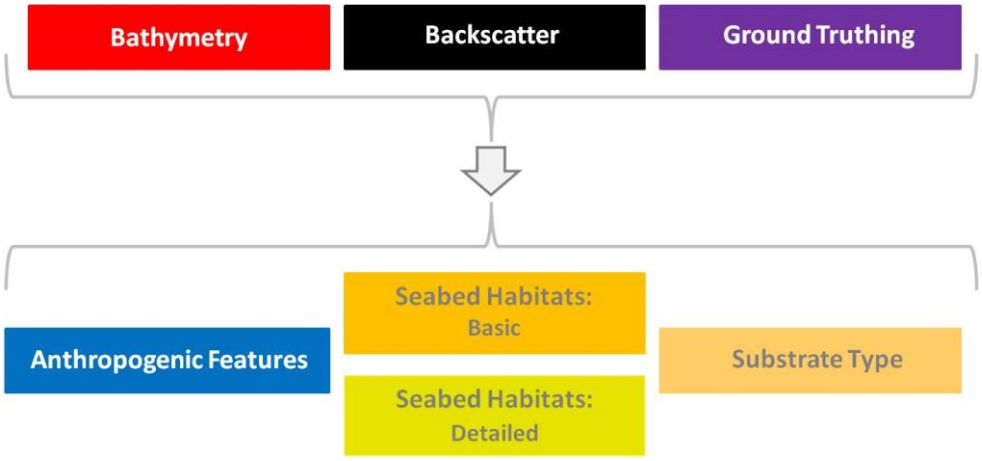


Figure 2: Seabed mapping stages

Bathymetry

The IHO Order 1a standard swath bathymetry surveys commissioned by the Northeast Regional Coastal Monitoring Programme and the Maritime & Coastguard Agency (MCA), were collected in accordance with the MCA Civil Hydrography Programme Survey Specification A (March 2016). The survey commenced on 30th November 2017 and was completed on 18th January 2018. Bathymetry data were acquired using a hull-mounted Kongsberg EM2040 Multibeam Echo-Sounder (MBES). The UKHO undertook quality-control of the data and produced a quality-controlled data set in WGS84/Chart Datum, at 1m resolution.

The bathymetry data was loaded into CARIS HIPS and SIPS 10.4 in order to export the files as one single layer for subsequent use in ArcGIS v10.6. Figure 3a illustrates the high resolution of the bathymetry and superimposed on aerial photography. Figure 3a also demonstrates the required overlap with land-based survey data thus avoiding the well-known "white ribbon" strip of seabed close to the shore where data seldom is captured. Depths in a number of the figures are colour-coded with orange colours indicating shallow depths and dark blue the deepest areas.

Hillshade

Within ArcGIS v10.6, a hillshade layer was derived which is a form of artificial sun-illumination which helps to enhance depth changes and features in the bathymetry dataset. This layer is particularly useful for displaying and enhancing areas of bedforms and seabed of variable texture where there are numerous depth changes across relatively short distances. Figure 3b illustrates how the hillshade layer can enhance the bathymetry.

Seabed Slope

The seabed slope map distinguishes those areas of the seabed that have a steep gradient or sharp changes in slope from those areas which are relatively flat; this aids the identification of bedrock and geological features, sedimentary bedforms and anthropogenic features (e.g. pipelines and channels). The seabed slope is derived within ArcGIS by calculating the slope angle of the seabed using a central cell and comparing its value to those around it. An extensive rock platform extending from Redcar and other geological features clearly illustrate the change in slope angle (Figure 3c). The colour scheme used is a classified symbology dividing the slope angles into 9 categories. Green indicates relatively flat or low angle topography, with increasing slope represented by gradation from yellow to orange, and red indicating steepest slope angles.

Backscatter

The intensity of the return acoustic signal, termed “backscatter” indicates the nature and relative composition of the seabed. This can provide information on the roughness and texture of the seabed substrate, and variability and changes in sediment type. Backscatter files were delivered by the survey contractor in a post-processed file format as a mosaiced GeoTIFF image.

Many factors can influence backscatter intensity, for example, changes in seabed slope or adjustments to survey vessel equipment configurations. It is not simply the case that a given backscatter intensity represents a defined sediment type. The backscatter data layer does not provide information as to what types of sediment the boundaries are showing – for example gravel to sand or sand to mud. To define this substrate type or marine habitat, combined analysis of bathymetry, backscatter and groundtruthing information is required. Backscatter, therefore, requires expert analysis and must be viewed in combination with bathymetry and groundtruthing information to give confidence in the resulting substrate and marine habitat maps.

The importance of backscatter for substrate classification and habitat mapping can be seen by the changes in the intensity (grey scale) of the backscatter that are not visible in the bathymetry, as exemplified in Figure 3d. Since the backscatter boundaries are observed across numerous survey track lines, it can be concluded that these denote a real change in seabed texture; for example, either constrained pockets of sediment within an area of exposed or outcropping bedrock, or of a different grain-size to the surrounding substrate.

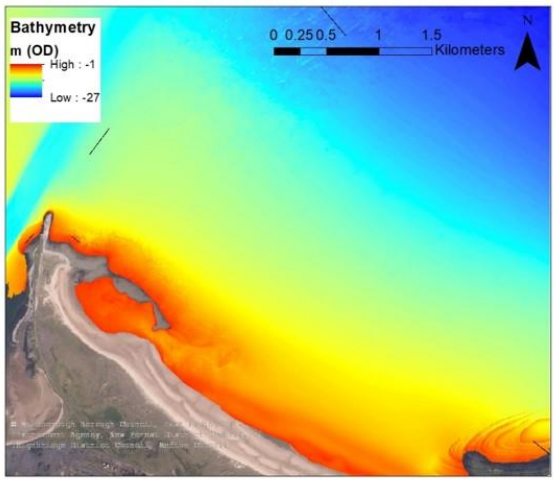


Figure 3a: Bathymetry, Redcar

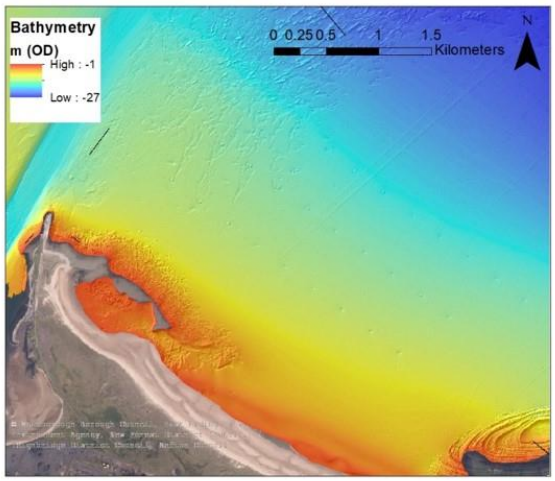


Figure 3b: Hillshade, Redcar

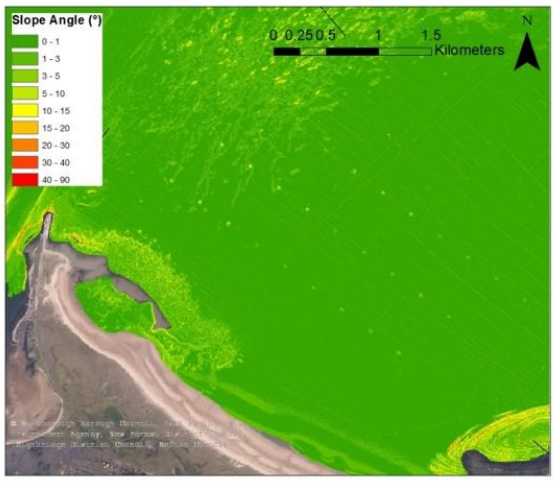


Figure 3c: Slope, Redcar

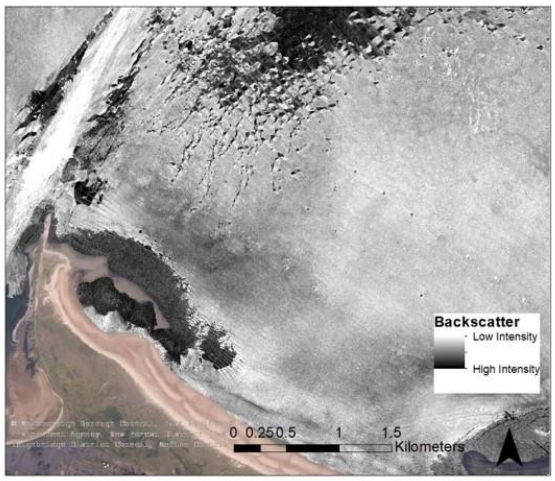


Figure 3d: Backscatter (Intensity), Redcar

Ground Truthing

Ground truthing data is a key requirement to enable the production of detailed substrate, marine habitat and biotope-type maps. A wide range of information can be useful, such as sediment samples, photographs and videos of seabed and features, topographic beach survey data for inter-tidal areas, nearshore marine geology maps (solid and drift) and visual dive records and observations.

38 sediment samples were collected via van Veen grab during the survey, as per the MCA Civil Hydrography Programme Specification. Figure 4 shows some examples of the sediment types identified in the survey area. The full map of sediment grab locations can be found at the end of Annex 3.

Figure 4a - Rock/ Sediment Absent

Figure 4b - Mud

Figure 4c - Sand

Figure 4d - Coarse Sediment

Figure 4: Sediment variation in the nearshore zone: Rock/ Sediment Absent, Mud, Sand, and Coarse Sediment

An assessment of sediment volume recovered from each sample also provided an indication of the thickness of sediment. This aided interpretation in areas of seabed where the surface expression of the underlying geology was spatially variable. Further substrate information was sourced from JNCC MarineRecorder, Seasearch, BGS and Scarborough Borough Council.

Hydrodynamic Data

To inform the interpretation of the marine habitats within the area of interest information from the Northeast Regional Coastal Monitoring Programme's network of waverider buoys was used. In particular, a Datawell Waverider MKIII buoy located approximately 4.5km offshore of Whitby, in 17 m of water, was used to assess the hydrodynamic conditions. Tidal currents were estimated from UKHO Admiralty Chart tidal diamonds. These data were collectively assessed against national indicative criteria to determine the typical hydrodynamic energy conditions within the study area, in order to map the energy regime at the seabed for the whole survey area to aid with determination of marine habitat boundaries (see Marine Habitat Boundaries section below).

Marine Habitat Boundaries

A number of boundaries are needed to comply with the EUNIS and JNCC habitat classification systems.

A littoral to sublittoral boundary was created by producing a Mean Low Water Springs (MLWS) contour using the MLWS level for Whitby of 1m above CD and 0.9m above CD for the River Tees. This gives a littoral to sublittoral boundary of -1.95m OD, although the majority of the survey area is deeper than this boundary. A boundary for the infralittoral to circalittoral boundary is required, which is known as the depth at which only 1% of light will penetrate to the seabed. UKSeaMap have created a broad scale resolution habitat map that follows EUNIS habitat classification which was created in 2010 (McBreen *et al.,* 2011) and updated in 2016. The UKSeaMap 2010 Technical Report modelled the depth that light penetrates to the seabed. Combining this with real measurements of Secchi disk depths gathered during the survey, the infralittoral - circalittoral depth has been set at -7m CD, giving a value of -10m OD for the entire area. Both boundaries were created by producing a contour in ArcGIS v10.6 using the bathymetry data.

Energy boundaries are also required for Level 3 classification. The UKSeaMap 2010 Technical Report (McBreen *et al.*, 2011) categorised the entirety of the survey area seabed as being exposed to high energy.

Evidence for using these definitions is found in the CCO Annual Wave Report 2018 for the nearest waverider at Whitby, which reports the average 12 monthly significant wave height (H_s) as 0.94m and recorded 5 storms that created conditions that exceeded local 4.35m significant wave height storm alert threshold. The largest recorded significant wave height (over a half hour period) was 6.60m and the highest monthly average Hs was 1.97m in the month of March, which also saw the 2 largest storms. Using average wave characteristics, a depth can be calculated where wave energy will regularly interact with the seabed.

Admiralty tidal stream currents at the surface indicate that during peak spring flows the tidal stream can be between 1.4 and 2.2 knots throughout the area.

JNCC MarineRecorder database snapshots and Seasearch observations were also kindly provided by JNCC to aid with habitat classifications. They provide evidence of faunal turf communities, macro-algae mats and seaweeds that favour exposed rock towards the shore, and mobile species further offshore. Sediment samples collected for ground truthing also support an energy regime that is higher nearshore, and decreases gradually into deeper water, by giving evidence of cleaner coarse sediment nearshore and examples of silt towards deeper water.

Using all of the above data allowed the seabed to be classified into useful indicative habitat and substrate maps, with an energy boundary between high and moderate energy estimated at -20m OD. Some boundaries are definitive, such as the edge of a rock platform or a protruding rocky outcrop. Other boundaries, especially those between sediment types and the infralittoral – circalittoral boundary, cannot always be treated as definitive because the change is gradual and can vary seasonally. The boundary is placed in the best position using the data available but often these boundaries transition imperceptibly into one another. Such boundaries cannot be treated as exact boundaries but as a representation of what is present in the survey area.

Substrate Map

A substrate map was derived by removing the depth boundaries and the 'Rock and thin Sediment' category. Where the seabed was categorised as 'Rock and thin Sediment' it was re-classified to reflect the surficial sediment type of the thin veneer of sediment overlying the rock. The example shown in Figure 5 indicates areas of bedrock and variations in broad sediment types, from Sand and Muddy Sand to Coarse Sediment.

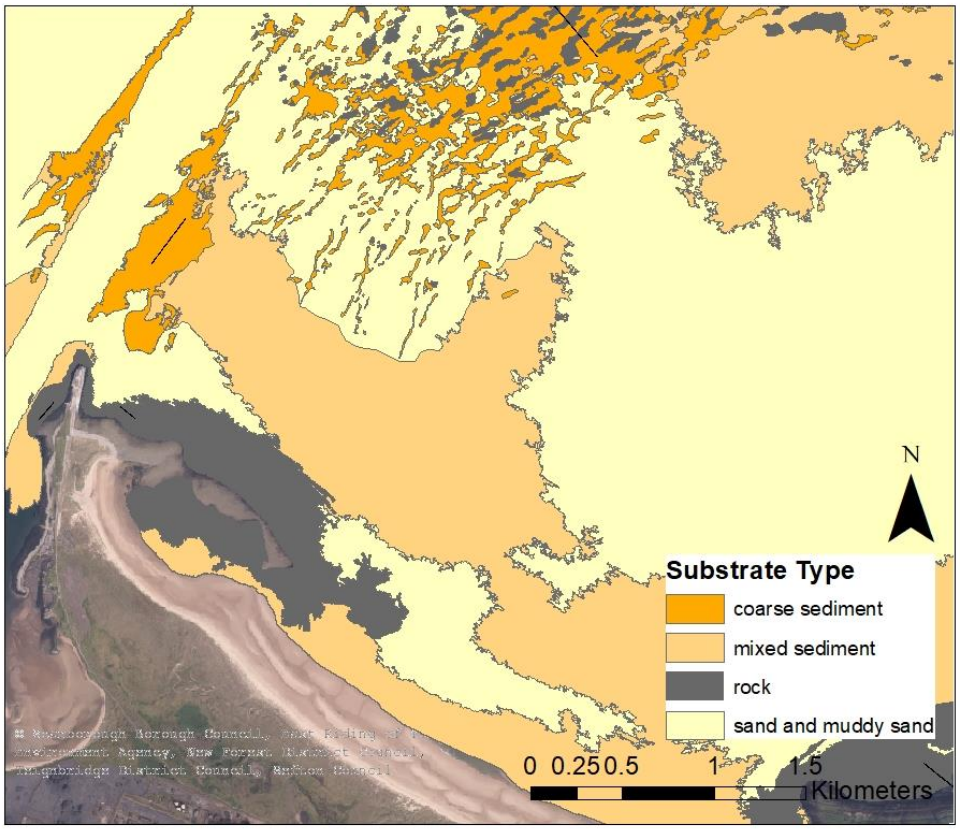


Figure 5: Substrate mapping, Redcar

Anthropogenic Features

Anthropogenic features were identified in the bathymetry, including approximately 726 meters of exposed pipeline, on the south-eastern edge of the survey area, illustrated below in Figure 6. Such features are easily discernible using the hillshade layer.

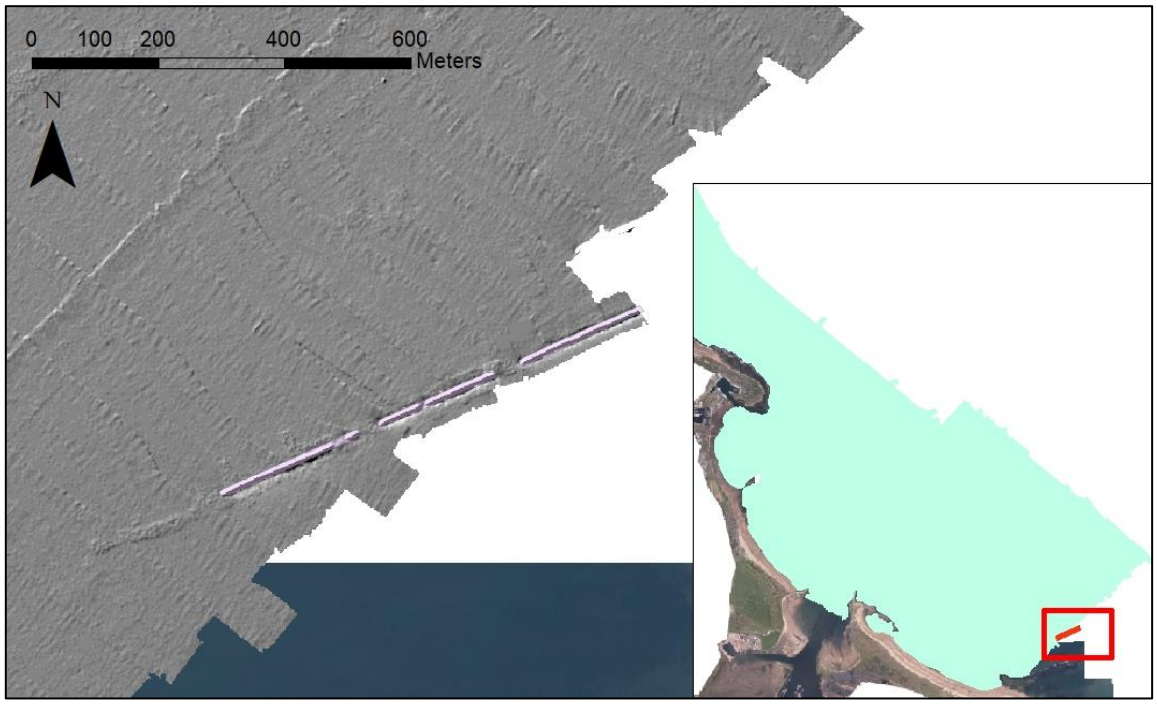


Figure 6: Anthropogenic features; exposed pipeline at Redcar

65 total wrecks are listed by the UKHO in the area between Sunderland and Redcar. The contractor surveyed 25 of these (6 were at depths too shallow for the survey vessel, and 34 could not be identified). The contractor found a further 44 unidentified objects, of which 1 was later identified as an unlisted wreck, 11 were unidentified objects on the seabed and the rest were geological formations. 17 of the wrecks can be seen in the processed data.

Confidence

The MESH confidence assessment tool was used to determine confidence levels in the acquired remote sensing data, groundtruthing data and the interpreted mapping and data products, so that end-users can determine their adequacy for decision-making (see https://webarchive.nationalarchives.gov.uk/20101014084131/http://www.searchmesh.net/Default.aspx?page=1780#MESHConfidenceScoresheet).

Bathymetric data collected in accordance with and achieving compliance with the MCA Civil Hydrography Programme Specification generally produces a high confidence level due to the 100% seafloor coverage and vertical and horizontal positional accuracies. The Confidence Assessment for this marine habitat mapping report is 82 (Appendix 1), indicating a high level of confidence in the remote sensing data acquisition, groundtruthing available and interpretation of the various datasets to generate the series of maps and datasets. To improve the score, the survey would require in-situ observations of sediment, substrate, flora and fauna, by an expert, using video/ still imagery transects or a scientific diver, which is beyond the scope of the project as Level 3 provides sufficient detail when mapping for the Regional Coastal Monitoring Program (RCMP).

Seabed Mapping Results

The swath bathymetry data are freely available, under Open Government Licence, from www.coastalmonitoring.org either as text, asci or SD (Fledermaus) files. The EUNIS Level 3 marine habitat map and substrate type maps are also available for viewing and download as shapefiles. Summary maps of:

- Bathymetry
- Backscatter
- Seabed slope
- Anthropogenic features
- EUNIS (JNCC) level 3 marine habitat
- Substrate

Have been prepared for the following inshore sections of coastline:

- Seaham
- Dawdon to Horden
- Horden to Crimdon
- Crimdon to Hartlepool
- Hartlepool to Redcar

Seaham

The northern-most section of the survey area is characterised by a predominantly gravel and mixed sediment beach, bordered by small cliffs, with a shallow gradient which persists offshore. The Level 3 habitat map shows the nearshore littoral sediments to be either mixed (*Littoral Mixed Sediment*) or fine (*Littoral Sands and Muddy Sands).* The mixed sediment patches become finer with depth into the sublittoral zone, changing from *Sublittoral Mixed Sediments* to *Sublittoral Sands and Muddy Sands*.

The backscatter map shows patches of high intensity along the shoreline, indicating exposed rock. Some of these patches are present above the MLWS depth as *High Energy Littoral Rock*, and can be identified on the beach as rock pools on the superimposed aerial photography. JNCC MarineRecorder entries confirm these patches of rock below the MLWS depth as boulders with Faunal Turf communities, and confirm their classification as *High Energy Infralittoral Rock* by including observations of kelp on exposed rock and *Flustra Foliacea* on boulder reefs.

There is a large exposed *High Energy Infralittoral Rock* platform around Seaham harbour, shown on the habitat map and as bedrock on the substrate map. The platform is noticeable on the hillshade and slope maps through its uneven texture, and the stark contrast in intensity on the backscatter map, compared to the surrounding sediments. The platform continues into the circalittoral zone becoming *High Energy Circalittoral Rock*. The slope map shows the platform to drop off to be buried beneath sediment. The exposed rock and rock platform at Seaham are only buried by a thin veneer of sediment in some places, however, and are present under the sediment in most of the survey area. The bathymetry map coupled with the hillshade shows where the sediment rises to cover the rock geology. As a result, much of the circalittoral zone has been classified as *High Energy Circalittoral Rock with thin Sediment* and *Moderate Energy Circalittoral Rock with thin Sediment*, as the energy regime decreases with depth past 20m. The rest of the area, including where the sediment is thick enough to mask the geology, has been classified as *Sublittoral Sands and Muddy Sand*, with some patches of *Sublittoral Coarse Sediments*. Groundtruthing and further MarineRecorder entries support the classification of Sublittoral Sands and Muddy Sands by providing evidence of “Fine, well sorted sand, ripples, fragments of shell and coal”.

There are some small bedforms in the circalittoral zone, as shown on the substrate map, including 4 patches of Sandwaves. The largest of these is formed in coarse sediment near the northern edge of the survey area. Figure 7 shows a cross section of these Sandwaves, and Figure 8 shows the bathymetry of the Sandwaves. Although the wave pattern is not particularly defined, there are two clear shoaling ridges compared to the negative gradient of the surrounding bed, shown on the bathymetry coupled with hillshade, that are too defined to be geology masked with sediment. The feature has a height of 1.8m and a wavelength of 130m. There is also a small amount of scour, creating a 0.25m drop where the finer *Sublittoral Sands and Muddy Sands* stops and the underlying layer of *Sublittoral Coarse Sediment is revealed*.

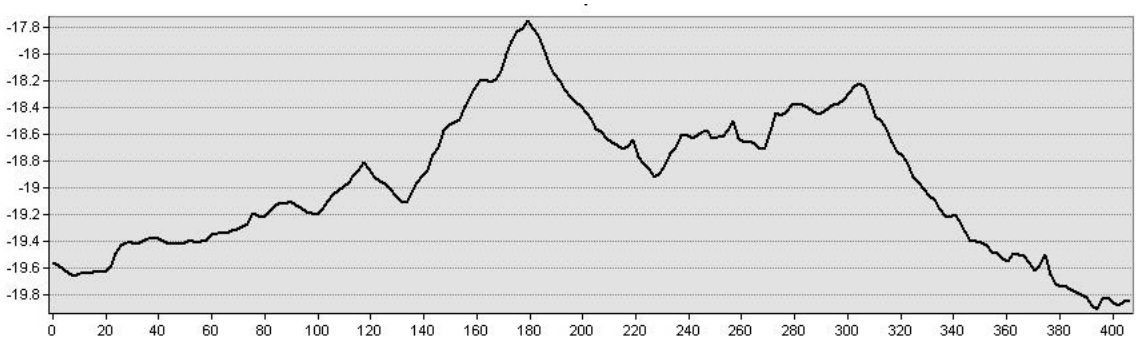


Figure 7: Sandwave Cross section

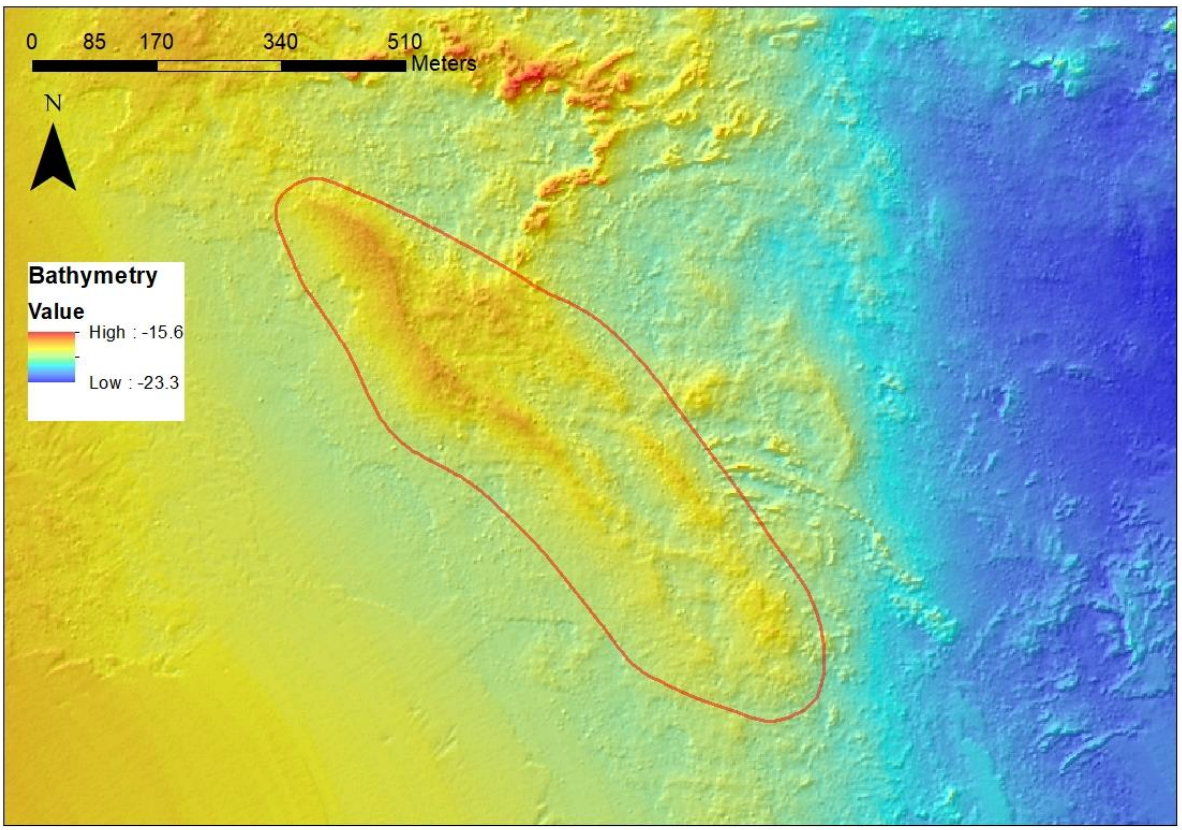
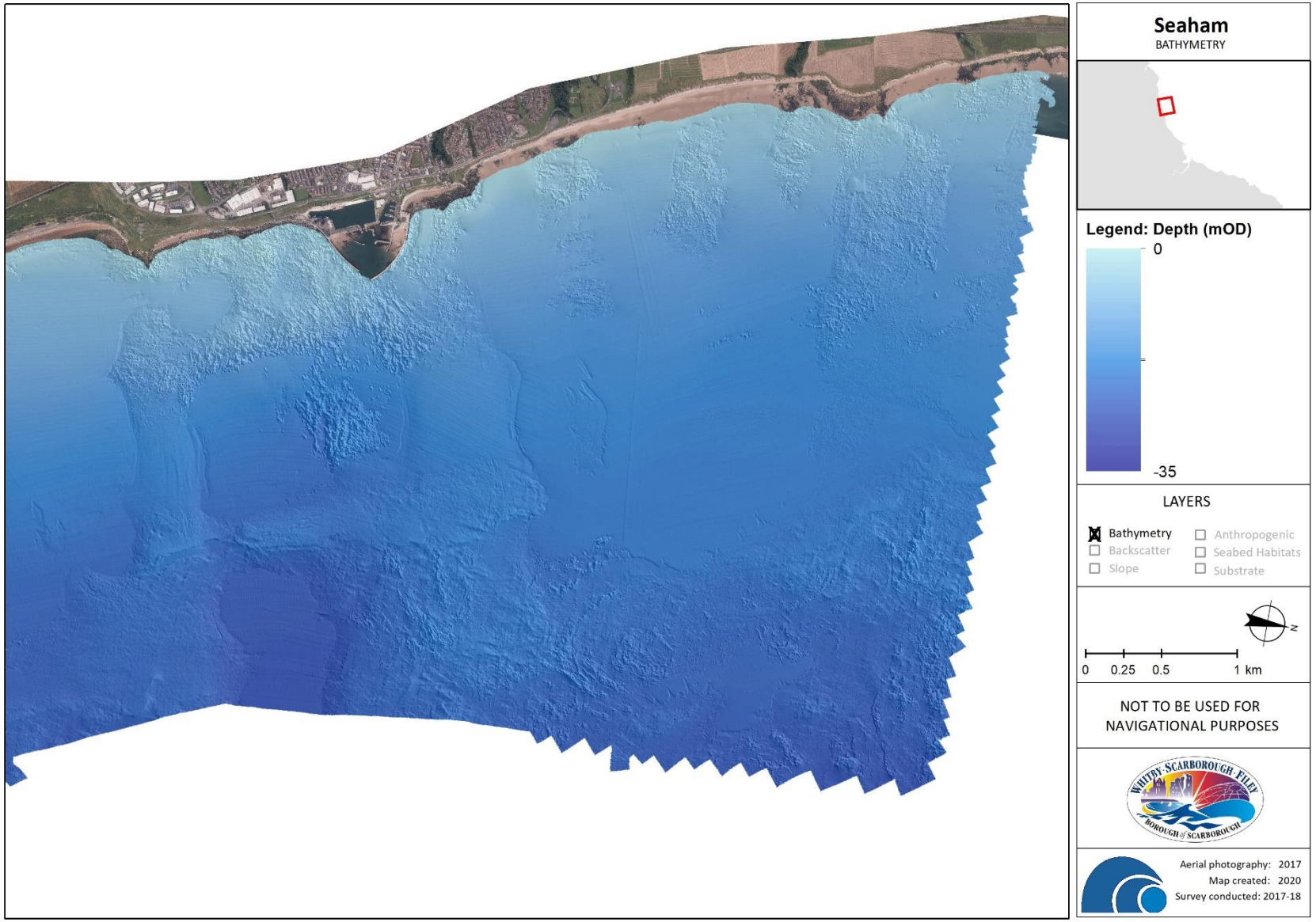
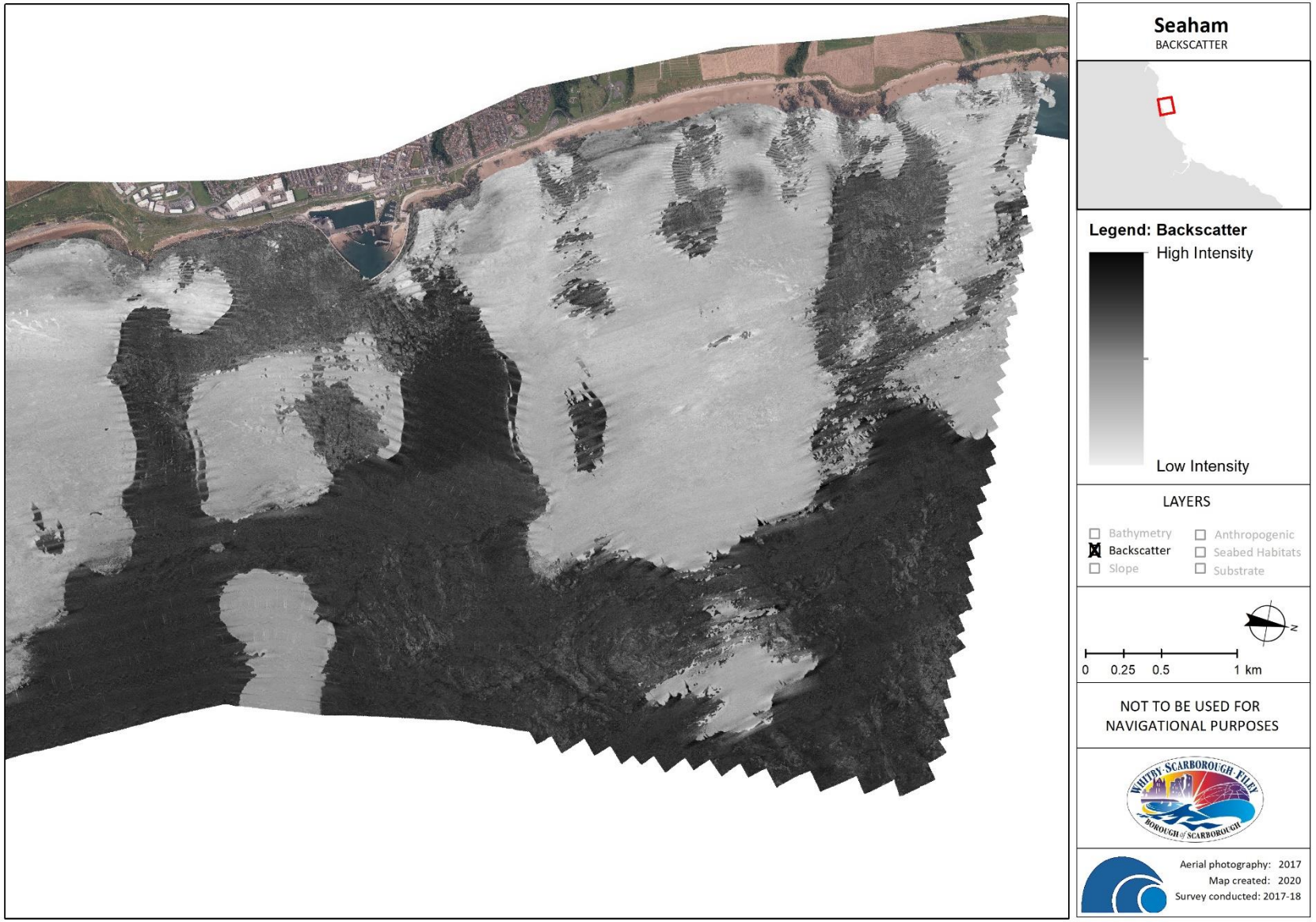
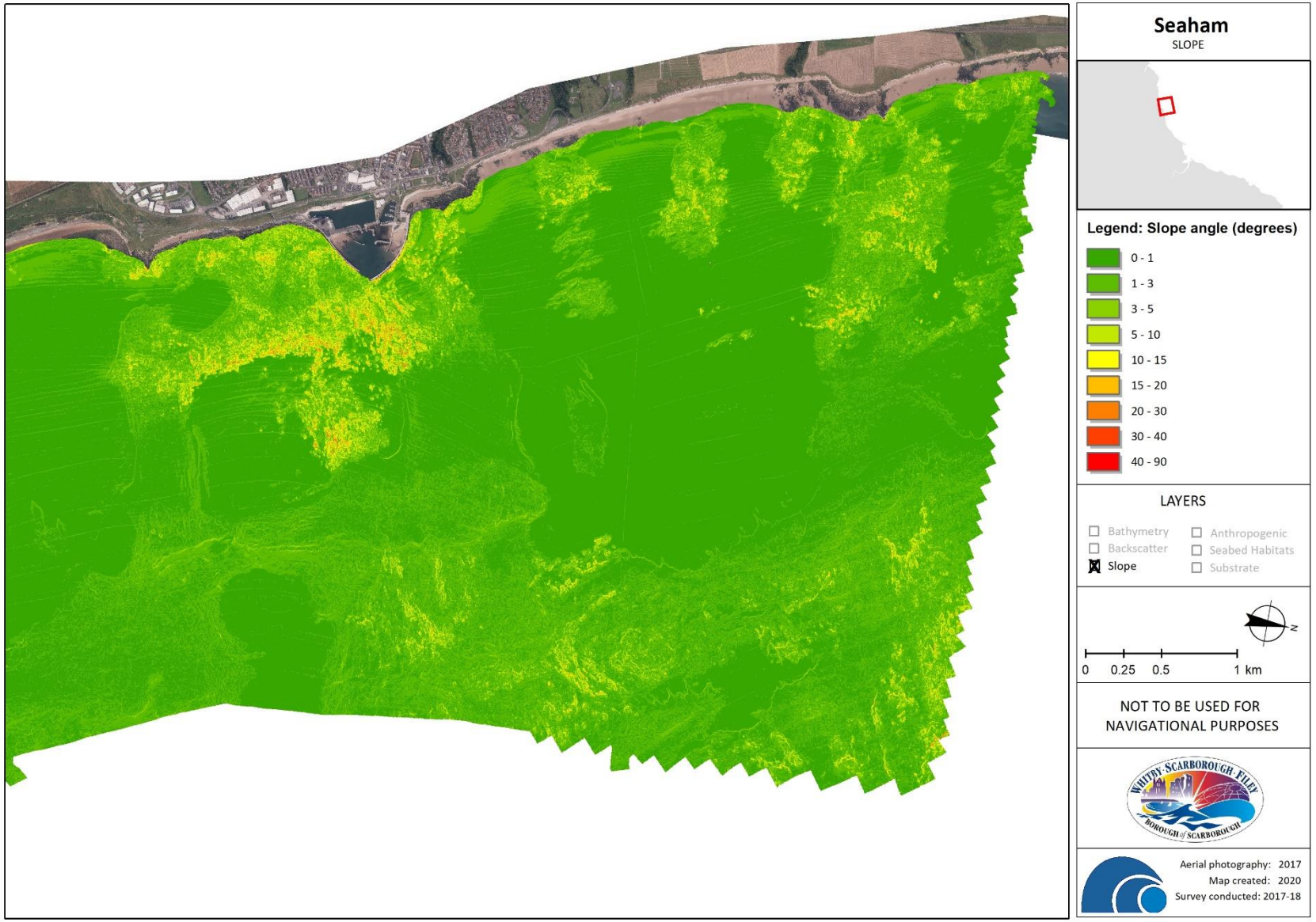


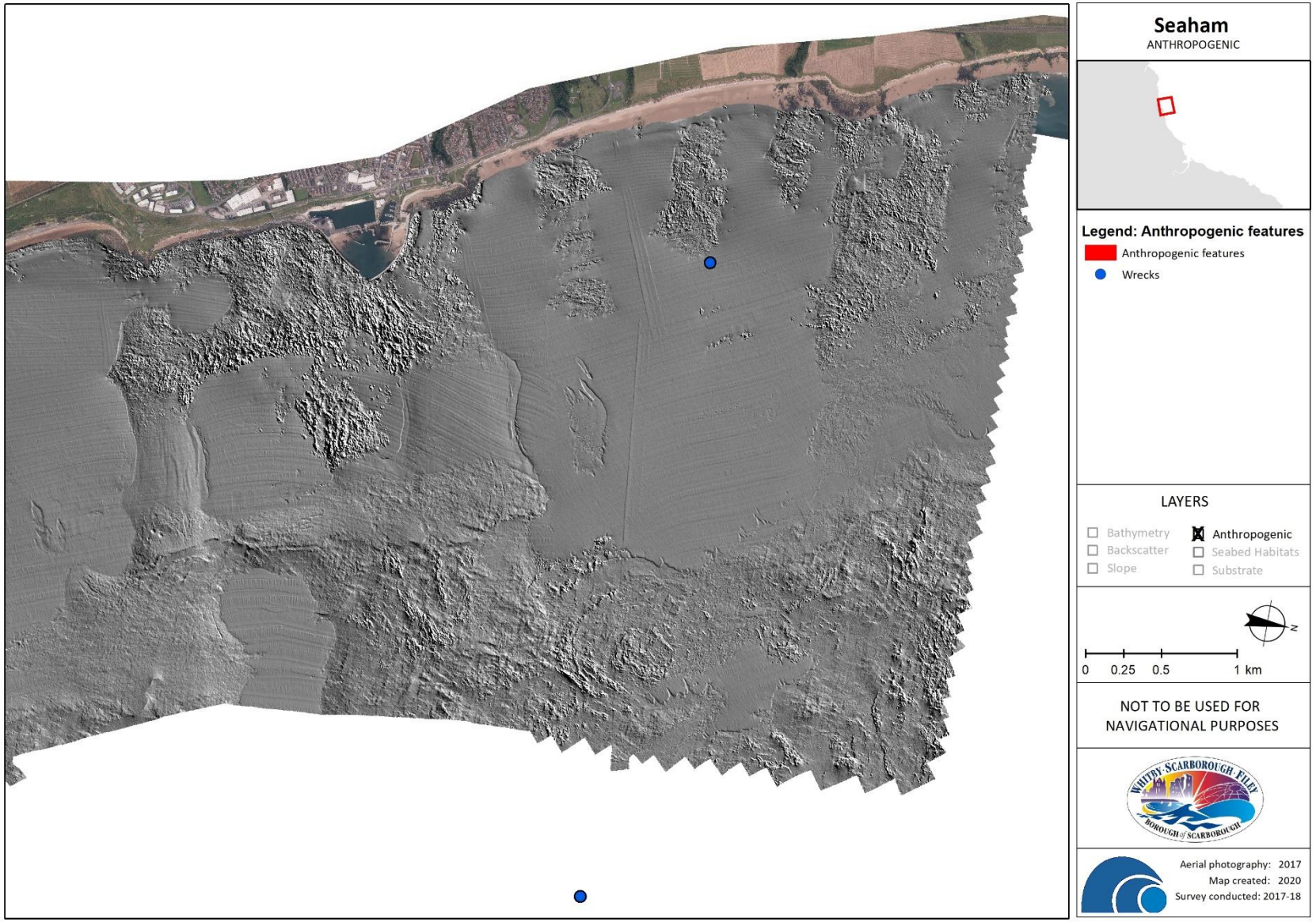
Figure 8: The most defined example of Sandwave Bathymetry

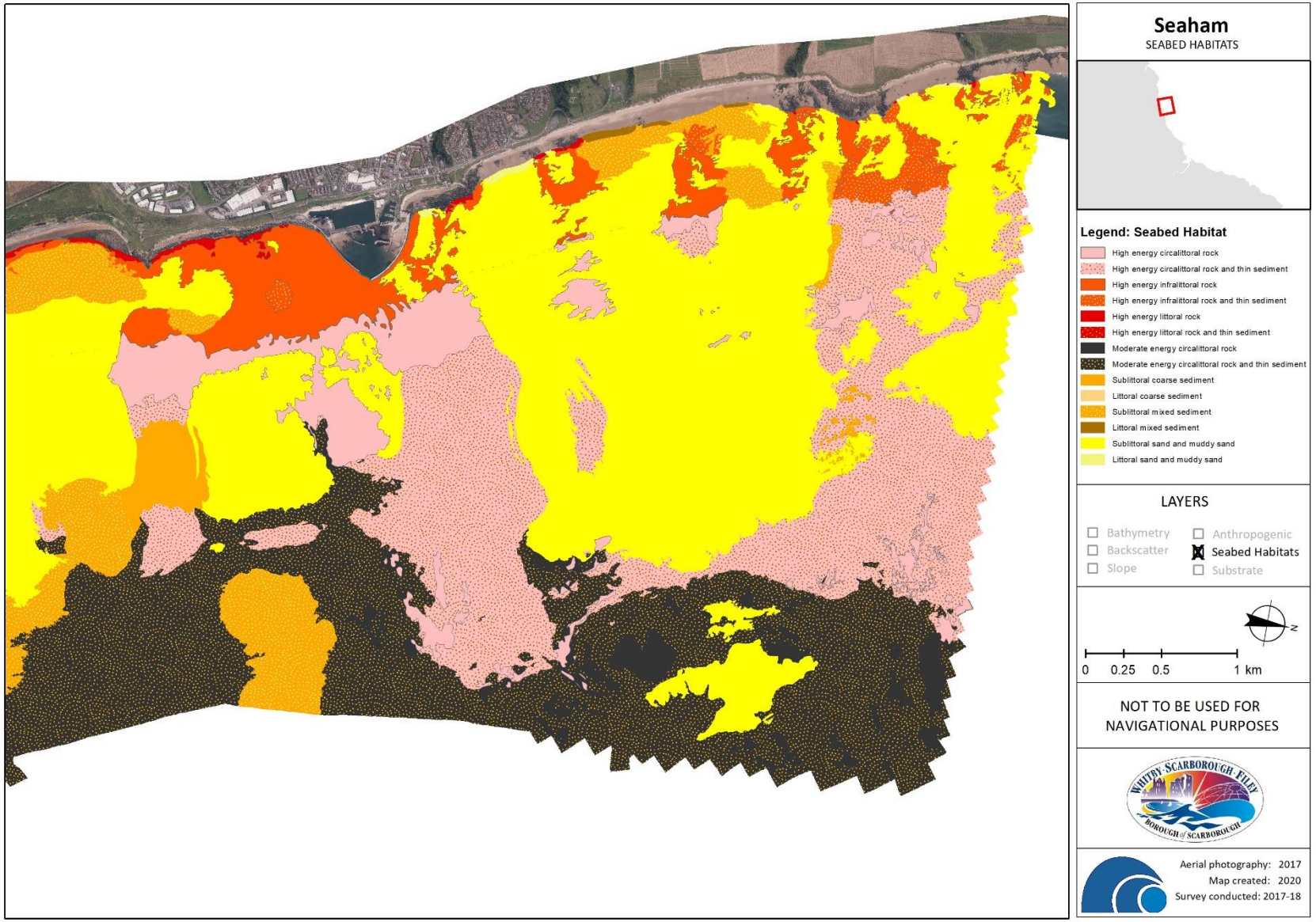
There is 1 wreck in the section with no scour marks.

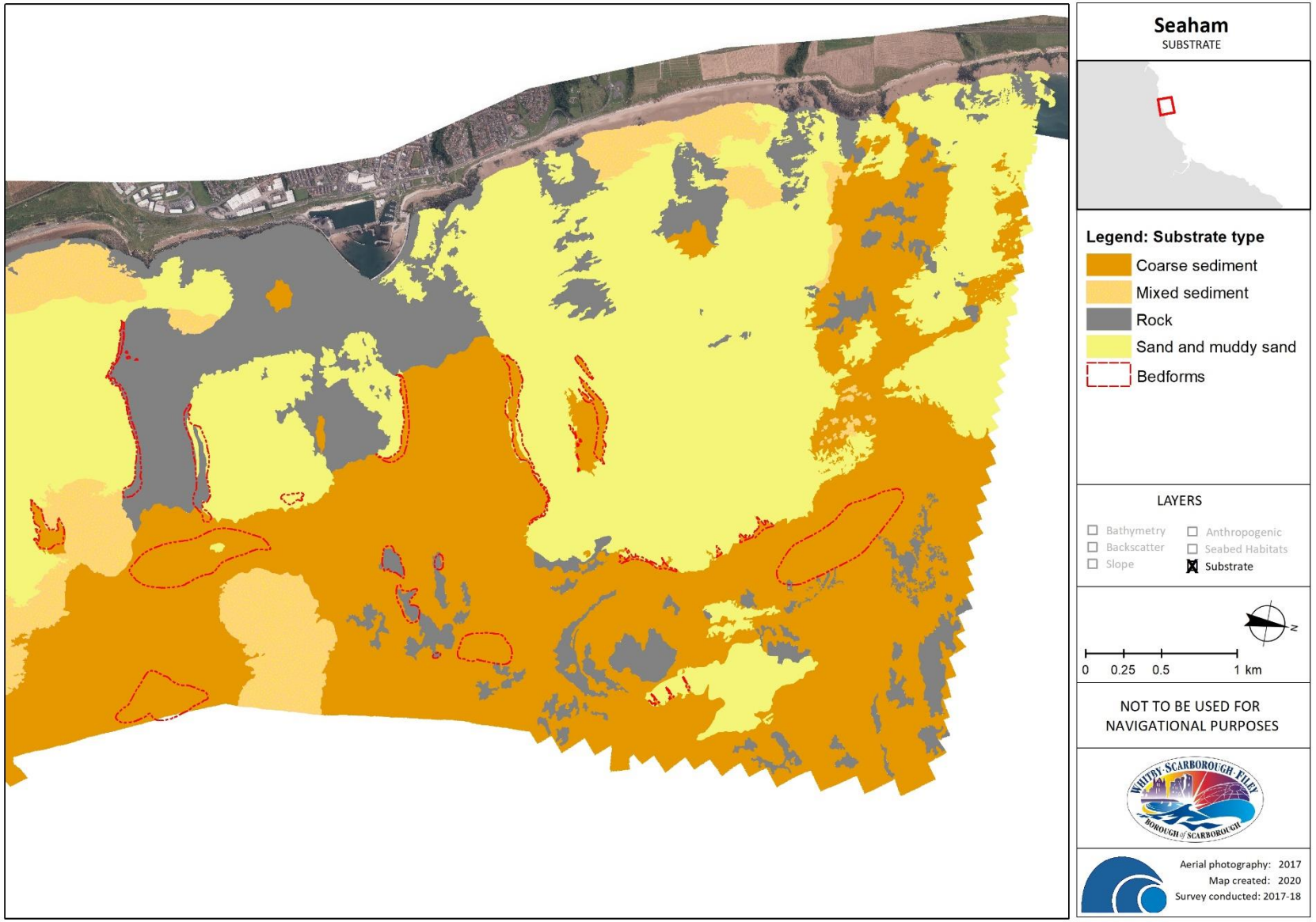

Seaham
BATHYMETRY
Legend: Depth (mOD)
0
-35
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Seaham
BACKSCATTER
Legend: Backscatter
High Intensity
Low Intensity
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Seaham
SLOPE
Legend: Slope angle (degrees)
0 - 1
1 - 3
3 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 40
40 - 90
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Seaham
ANTHROPOGENIC
Legend: Anthropogenic features
Anthropogenic features
Wrecks
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Seaham
SEABED HABITATS
Legend: Seabed Habitat
High energy circalittoral rock
High energy circalittoral rock and thin sediment
High energy infralittoral rock
High energy infralittoral rock and thin sediment
High energy littoral rock
High energy littoral rock and thin sediment
Moderate energy circalittoral rock
Moderate energy circalittoral rock and thin sediment
Sublittoral coarse sediment
Littoral coarse sediment
Sublittoral mixed sediment
Littoral mixed sediment
Sublittoral sand and muddy sand
Littoral sand and muddy sand
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Seaham
SUBSTRATE
Legend: Substrate type
Coarse sediment
Mixed sediment
Rock
Sand and muddy sand
Bedforms
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18

Dawdon to Horden

The coast between Dawdon and Horden is rocky, with multiple small bays of narrow gravel beaches sheltered by headlands, vegetated cliffs and boulders along the foreshore. The gradient here is steep in the littoral zone, near the shore, but levels out with depth. Almost of the shore here is classified as *High Energy Littoral Rock* above the MLWS depth of -1.95m OD, and *High Energy Infralittoral Rock* below this depth. The backscatter shows the nearshore to have patchy sections of high intensity, and the hillshade and slope maps support this by illustrating an uneven bed texture. This is confirmed by the MarineRecorder entries along this stretch detailing boulders, rock pools and overhangs with observations of Faunal Turf and other macro-algae. The rocky coastline is bordered by a band of *Sublittoral Mixed Sediment*, and some smaller patches of coarse sediment. This is again supported by groundtruthing from grab samples and MarineRecorder entries detailing a mixture of sand and gravel dominated material.

Sublittoral Sands and Muddy Sand dominates the Infralittoral zone, with a few large patches of *Sublittoral Mixed Sediments*. The Circalittoral zone is mostly bedrock masked by sediment, classified as *Moderate Energy Circalittoral Rock*, with a few shoaling fingers that can be classified with a higher energy regime as areas of *High energy Circalittoral Rock*.

There two more patches of poorly defined Sandwaves, and some small patches identified by the contractor during initial processing as ripples. The sediments are confirmed as fine sand by grab samples taken a few meters away. Figure 9 shows the cross section of one of these patches, illustrating an average wave height of approximately 5cm and a wavelength of 10 to 20m. The larger wavelength indicates these feature were originally misidentified as ripples, and should have been classified as megaripples. To be classified as a ripple, the feature must have a height of less than 6cm and a wavelength of less than 60cm, whereas megaripples are classified as having a wave height of 6 to 150cm and a wavelength of 60 to 200cm. There are also some small patches of scour around the base of the cliffs and boulder reefs, as is to be expected in a mesotidal wave exposed environment.

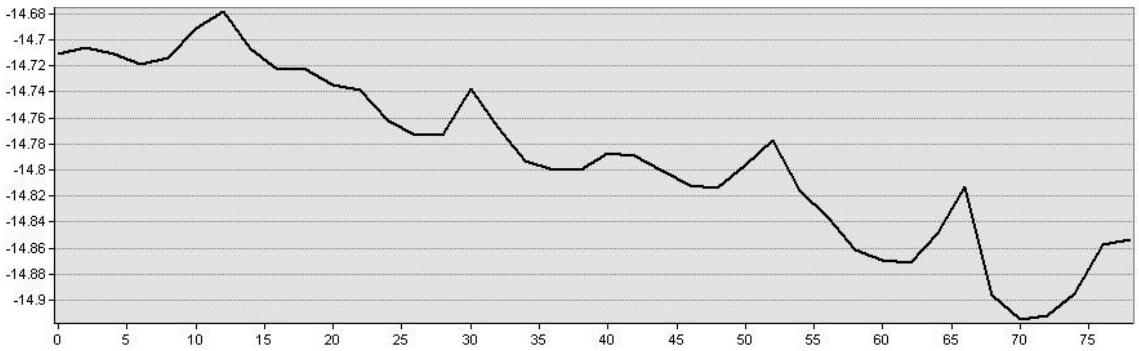
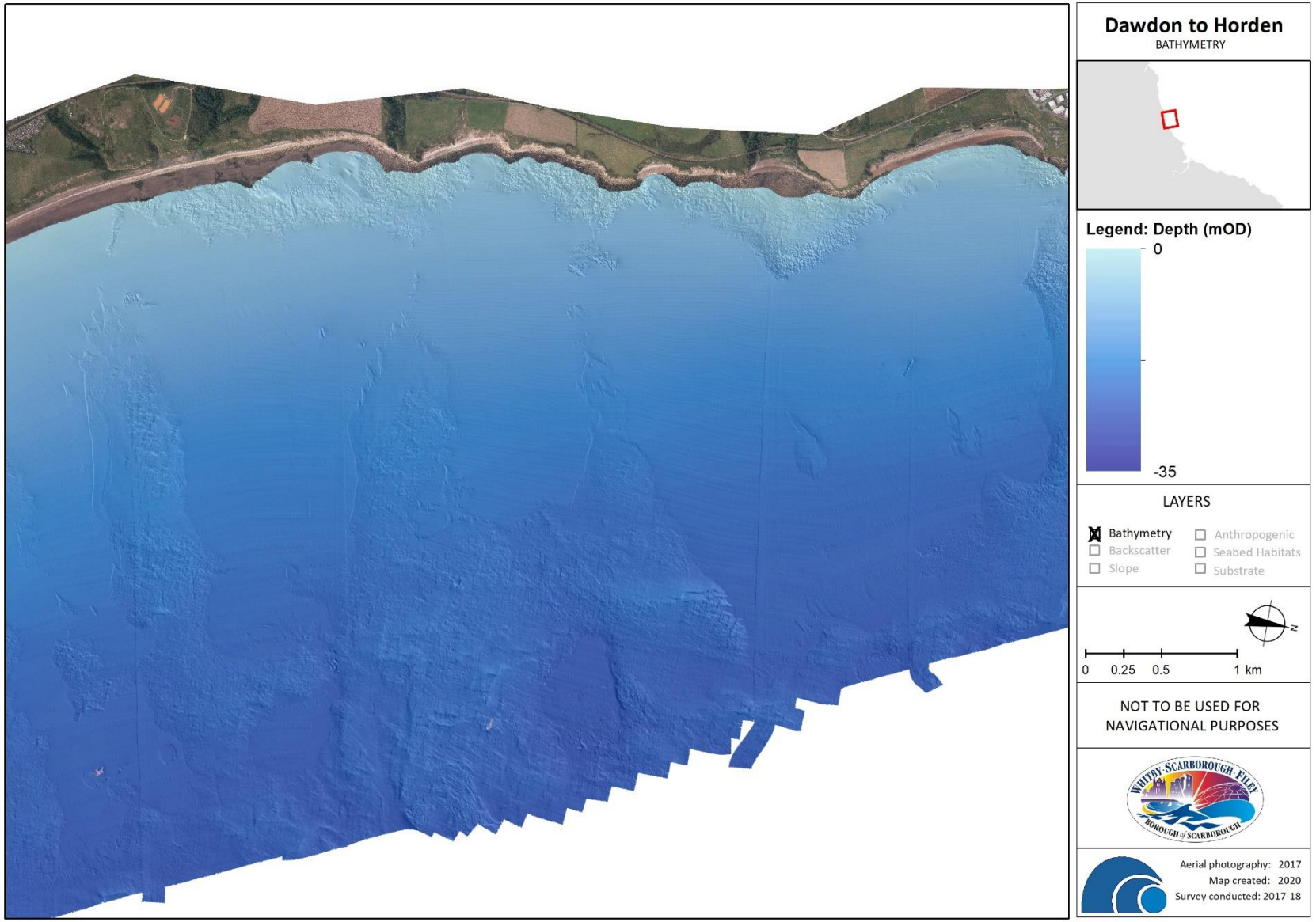
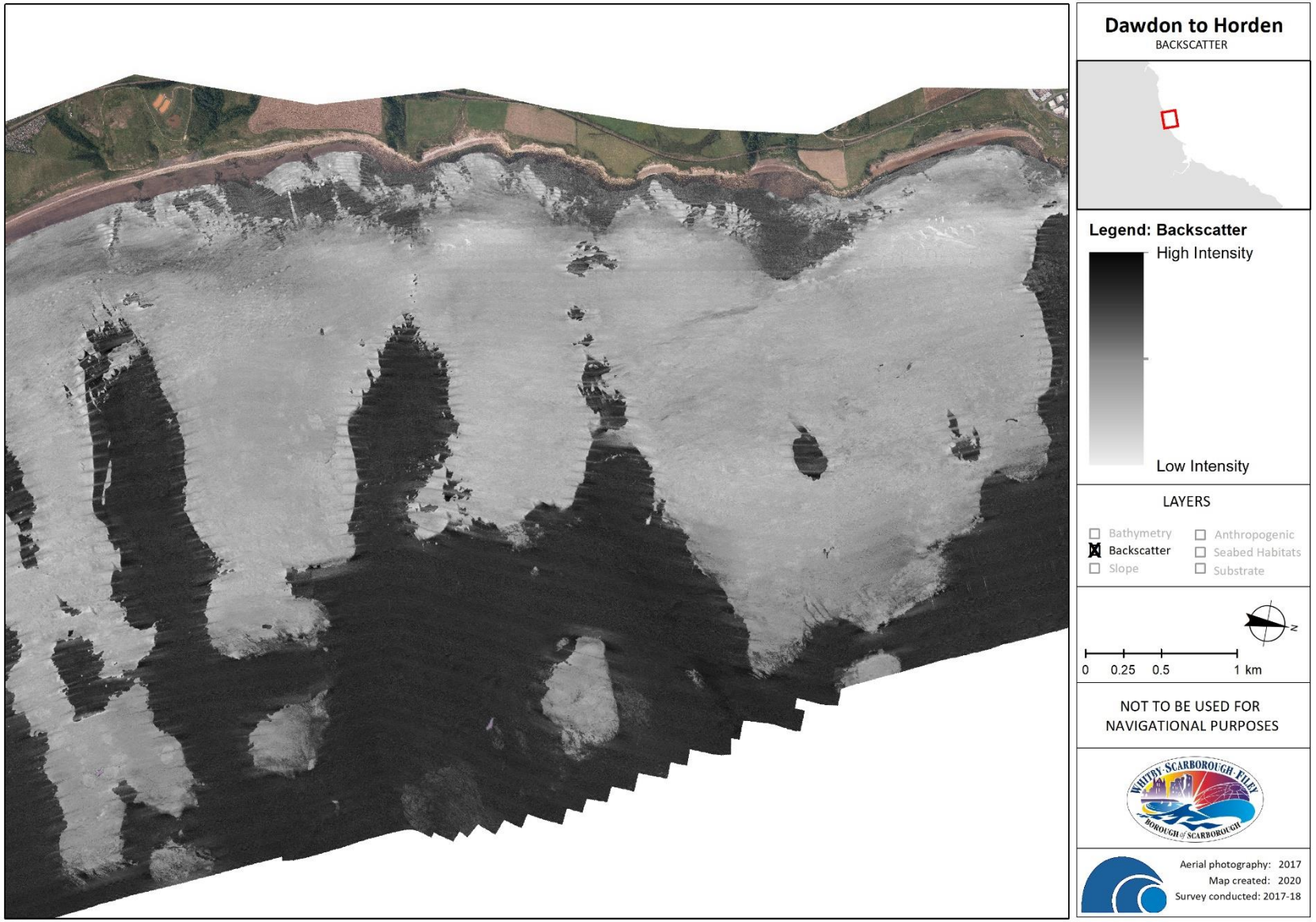
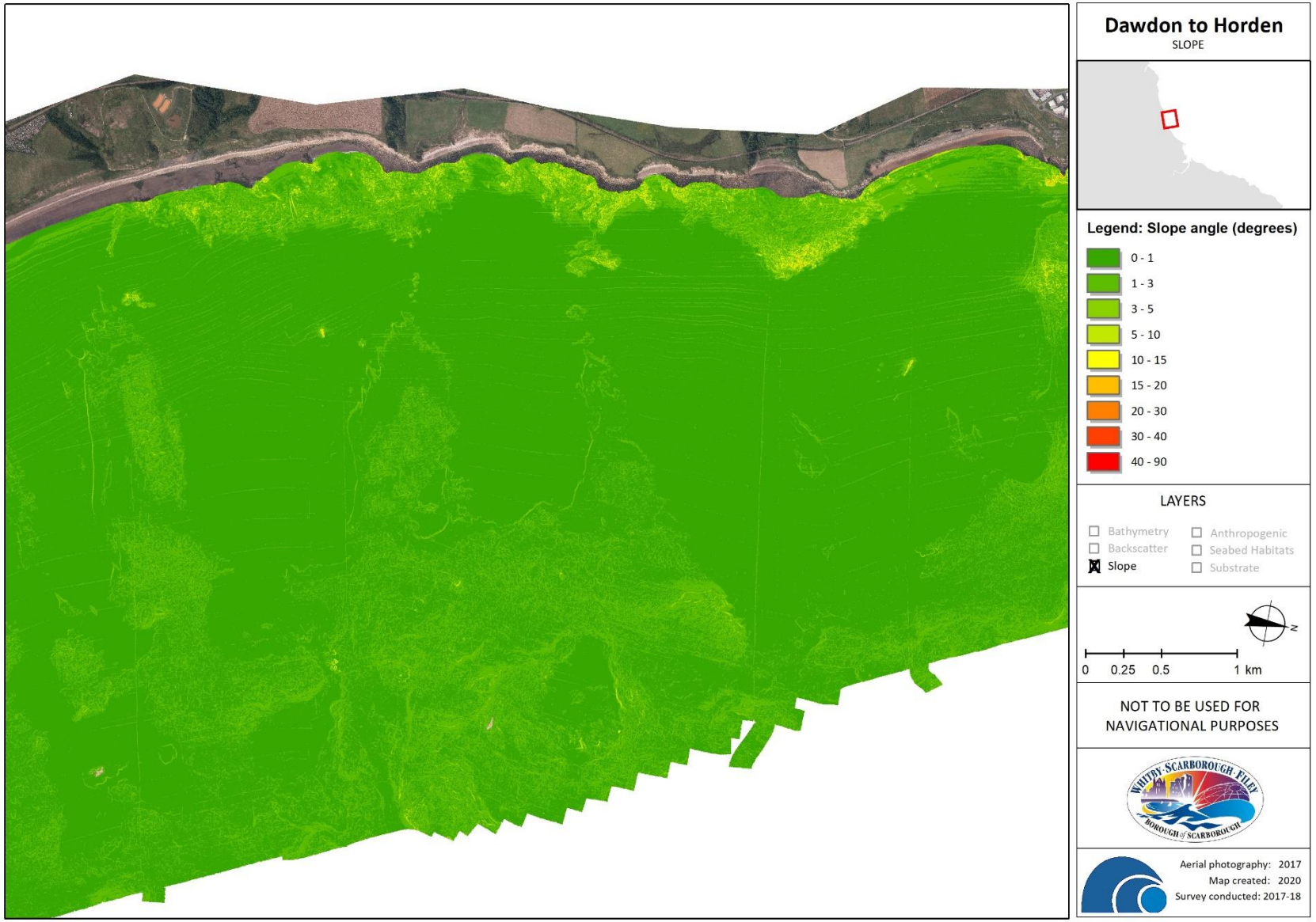


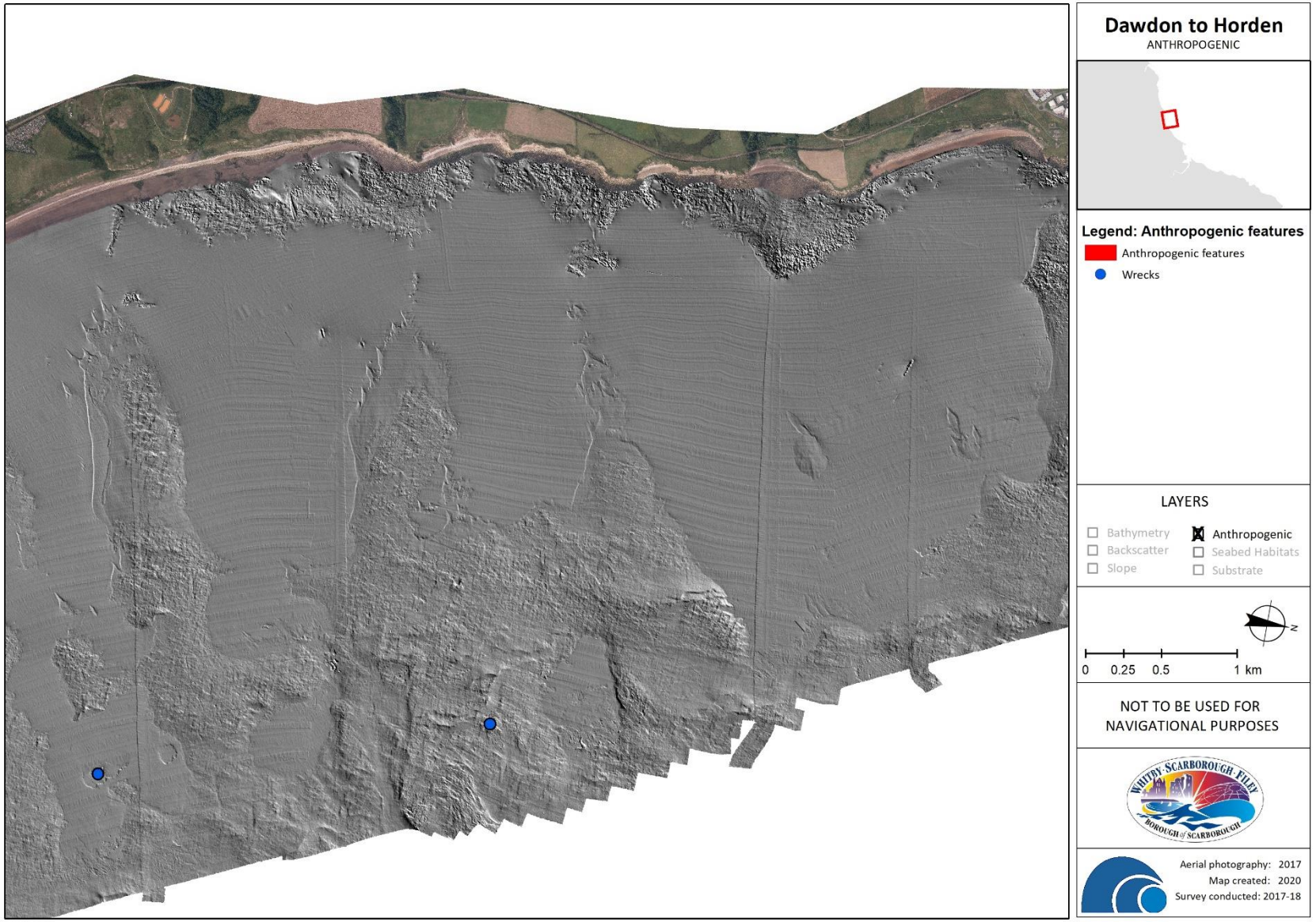
Figure 9: Megaripple Cross Section

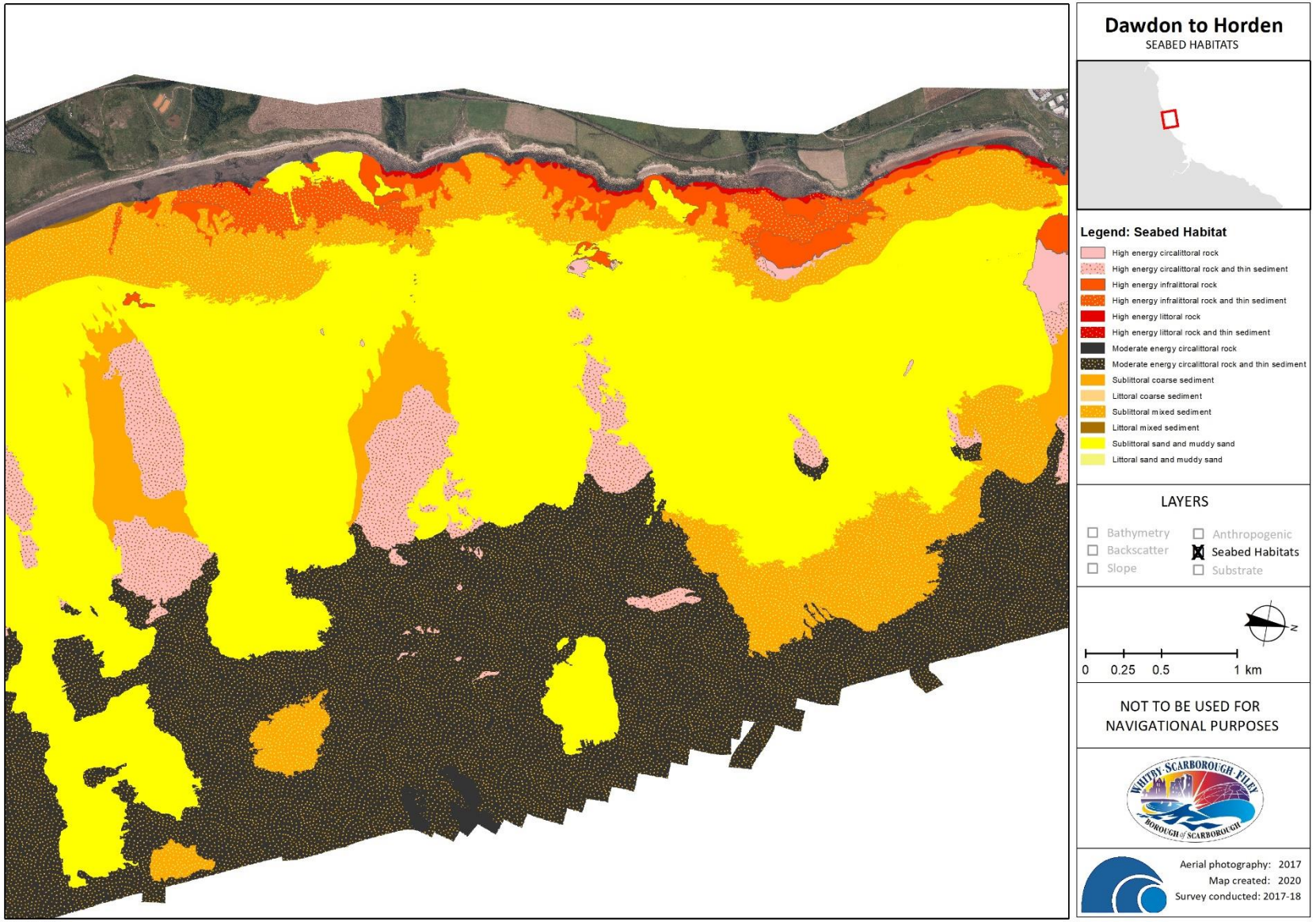
Two wrecks can be seen on the Anthropogenic Features map; the wreck to the north has no scour, whereas the wreck to the south has minor scour south of the object, indicating northerly currents strong enough to reach the bed at 24m below OD.

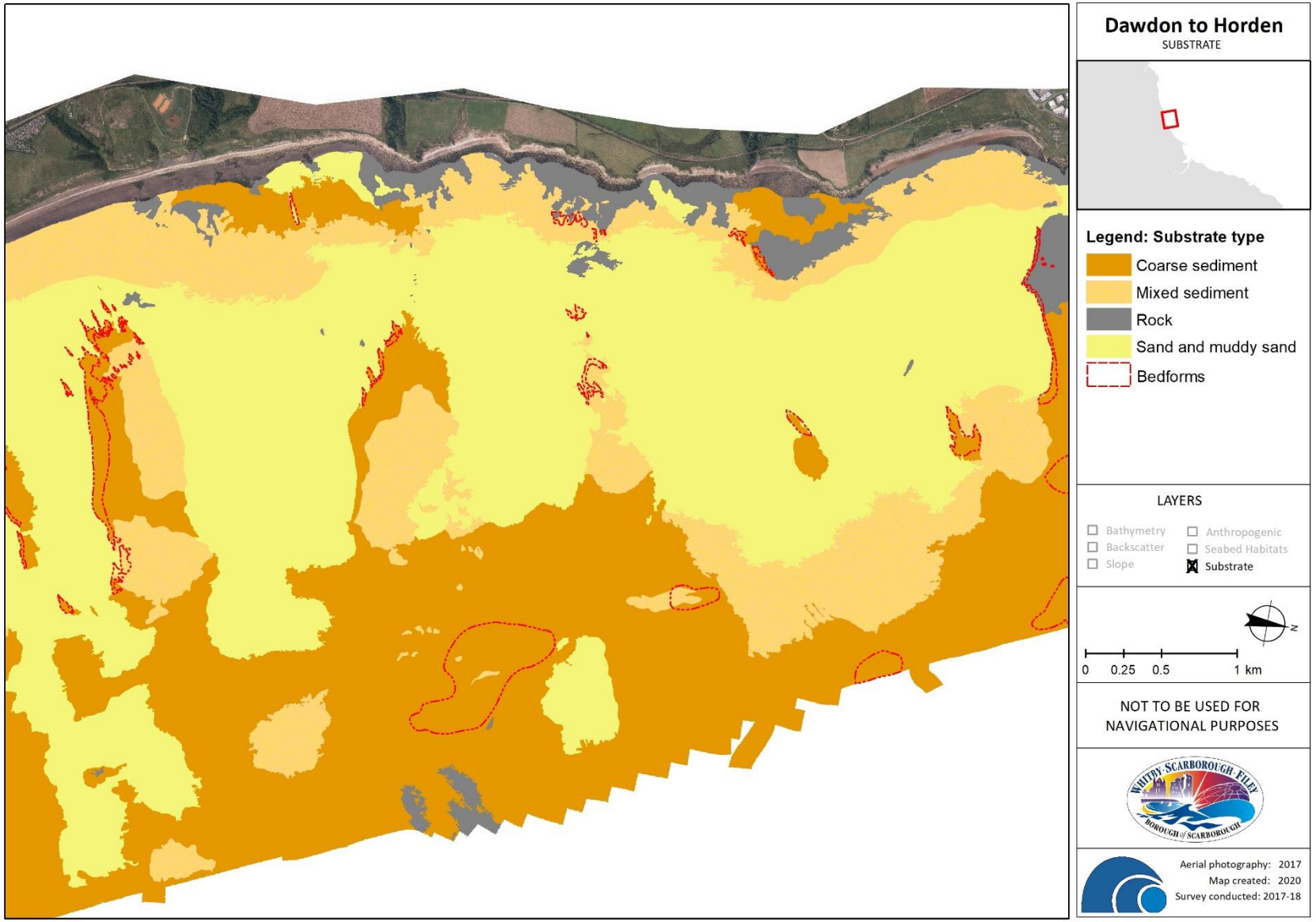

Dawdon to Horden
BATHYMETRY
Legend: Depth (mOD)
0
-35
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Dawdon to Horden
BACKSCATTER
Legend: Backscatter
High Intensity
Low Intensity
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Dawdon to Horden
SLOPE
Legend: Slope angle (degrees)
0 - 1
1 - 3
3 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 40
40 - 90
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Dawdon to Horden
ANTHROPOGENIC
Legend: Anthropogenic features
Anthropogenic features
Wrecks
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Dawdon to Horden
SEABED HABITATS
Legend: Seabed Habitat
High energy circalittoral rock
High energy circalittoral rock and thin sediment
High energy infralittoral rock
High energy infralittoral rock and thin sediment
High energy littoral rock
High energy littoral rock and thin sediment
Moderate energy circalittoral rock
Moderate energy circalittoral rock and thin sediment
Sublittoral coarse sediment
Littoral coarse sediment
Sublittoral mixed sediment
Littoral mixed sediment
Sublittoral sand and muddy sand
Littoral sand and muddy sand
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Dawdon to Horden
SUBSTRATE
Legend: Substrate type
Coarse sediment
Mixed sediment
Rock
Sand and muddy sand
Bedforms
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18

Horden to Crimdon

The back beach between Horden and Crimdon consists of gravel with a larger intertidal zone than the beaches to its north. The intertidal zone contains mixed sediments (classified as *Littoral Mixed Sediments*) and boulders (classified as patches of *High Energy Littoral Rock*). Below MLWS, the whole section of coast is bordered by a roughly 360m wide band of *Sublittoral Mixed Sediments* (121m at its narrowest and 606m at its widest).

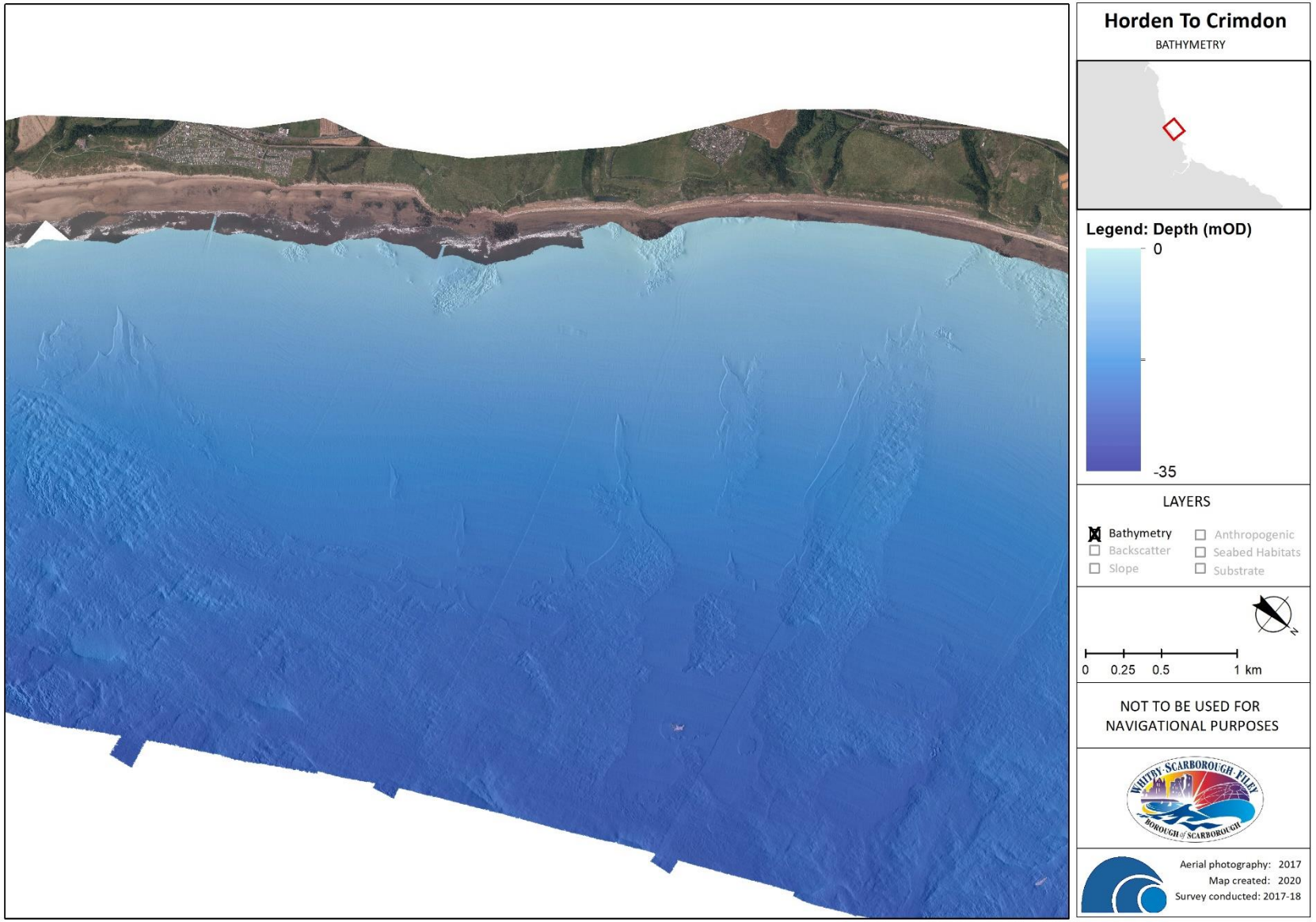
Beyond this band, the Infralittoral zone and the Circalittoral zone are predominantly *Sublittoral Sands and Muddy Sands*. Moving towards the lower end of the energy regime, the backscatter shows the sediment is masking bedrock, and therefore the eastern edge of the survey area is classified as *Moderate Energy Circalittoral Rock and thin Sediment* or *High Energy Circalittoral Rock and this Sediment* where the geology is above -20m OD. The sediment covering the bedrock is coarse, however, unlike the finer sands and muds that dominate the area above -20m OD. There are some small patches of exposed bedrock (*High energy Circalittoral rock*) that break the sediment veneer towards Crimdon, that confirm the masked geology interpreted from the backscatter.

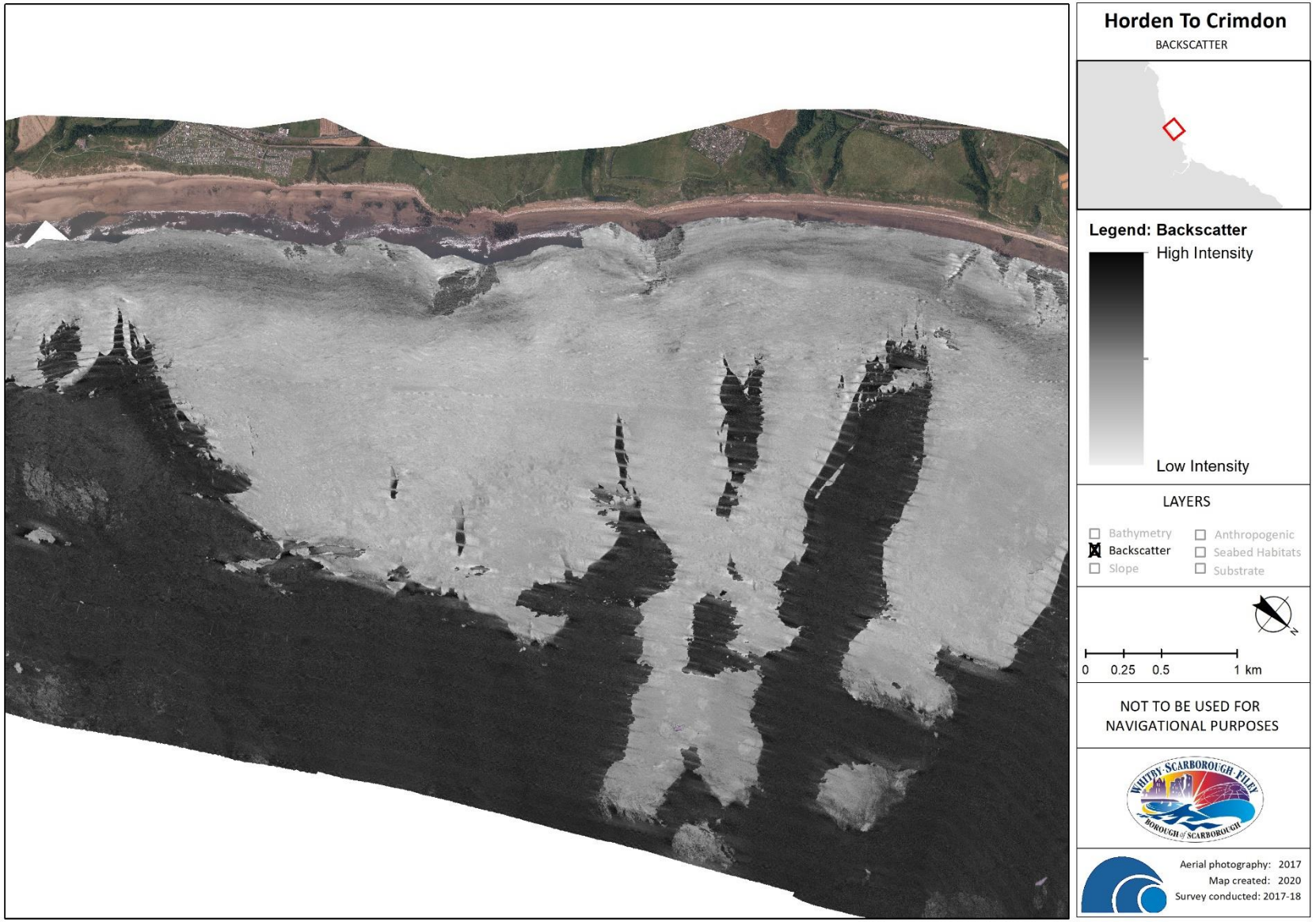
MarineRecorder and Seasearch entries located seaweeds in the intertidal zone, and edible Mussel beds (*Mytilus edulis*) on cobble reefs near the shore. It also confirms the deeper sections of High energy Circalittoral Rock with observations of *Alcyonium digitatum* (Commonly referred to as Dead Man's Fingers), *Hydrobia sp.* (sea snails) and *Hiatella arctica* (sea snails with cone shaped shells), who's presence indicates an exposed environment [1]. Groundtruthing also confirms the deeper extension of *Sublittoral Sands and Muddy Sands* seen on the substrate map with a sample recorded as *Muddy Sand* at -21m OD.

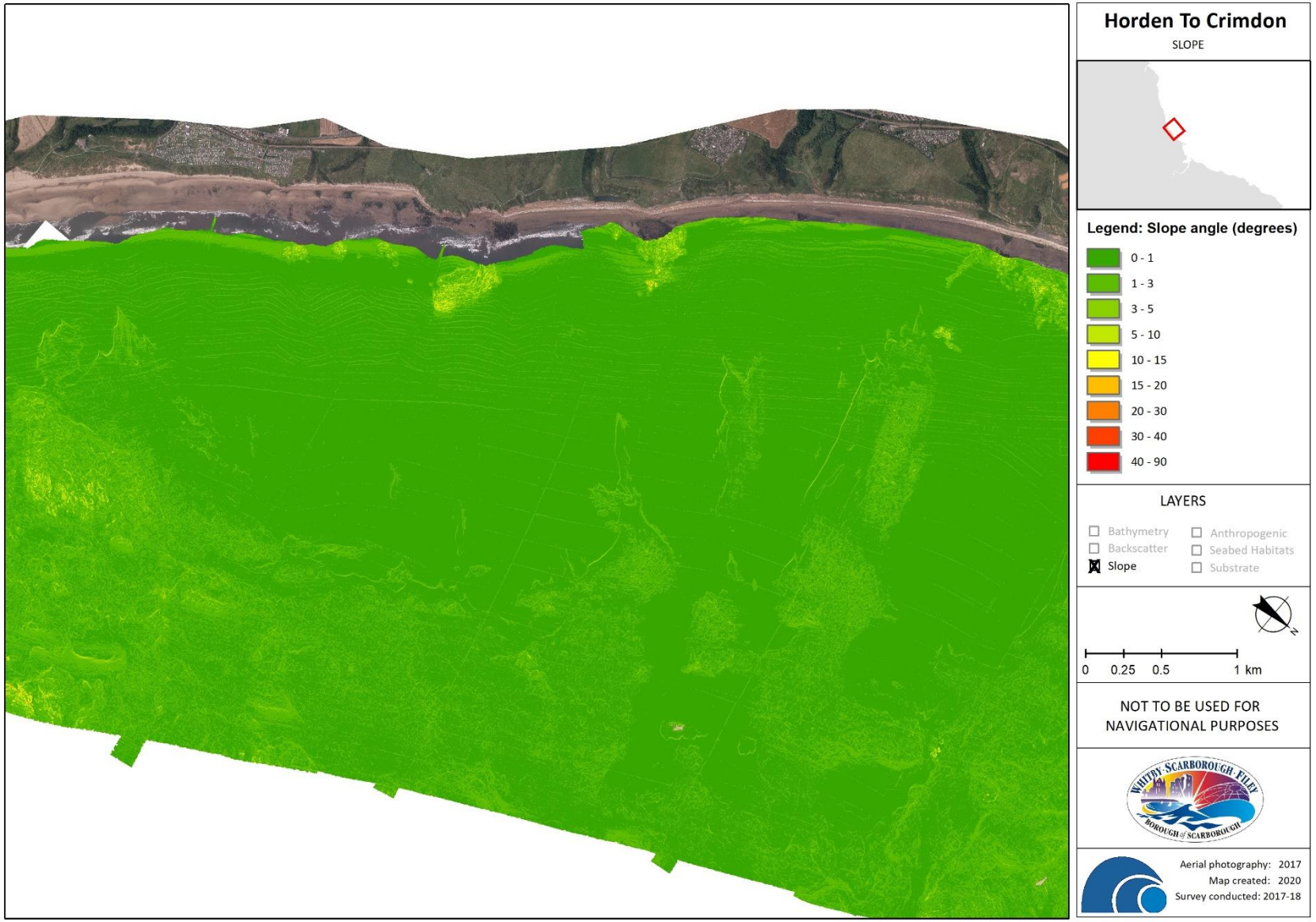
There are more patches of poorly defined megaripples (misidentified as ripples) throughout the area. A resolution of 1m is too coarse to reliably identify ripples, as the wavelength required to classify a ripple is 60cm or less. Therefore, ripples can only be reliably identified in this project from MarineRecorder entries by dive or video surveys.

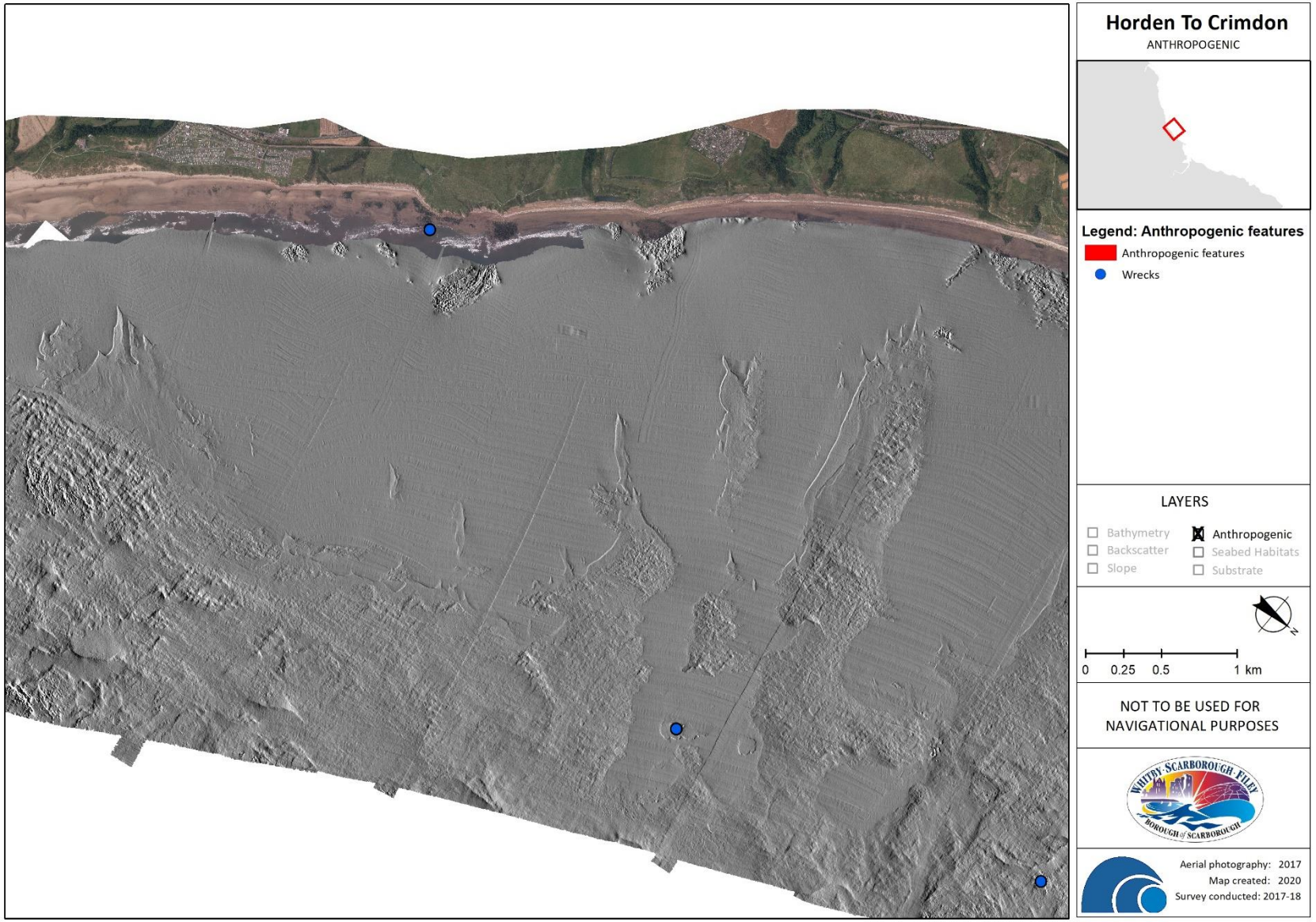
There are two wrecks between Horden and Crimdon (the northern wreck on the Anthropogenic Features map is included in the previous section). One of these is above MLWS and was not covered by the survey extent. The remaining wreck has no evidence of scour.

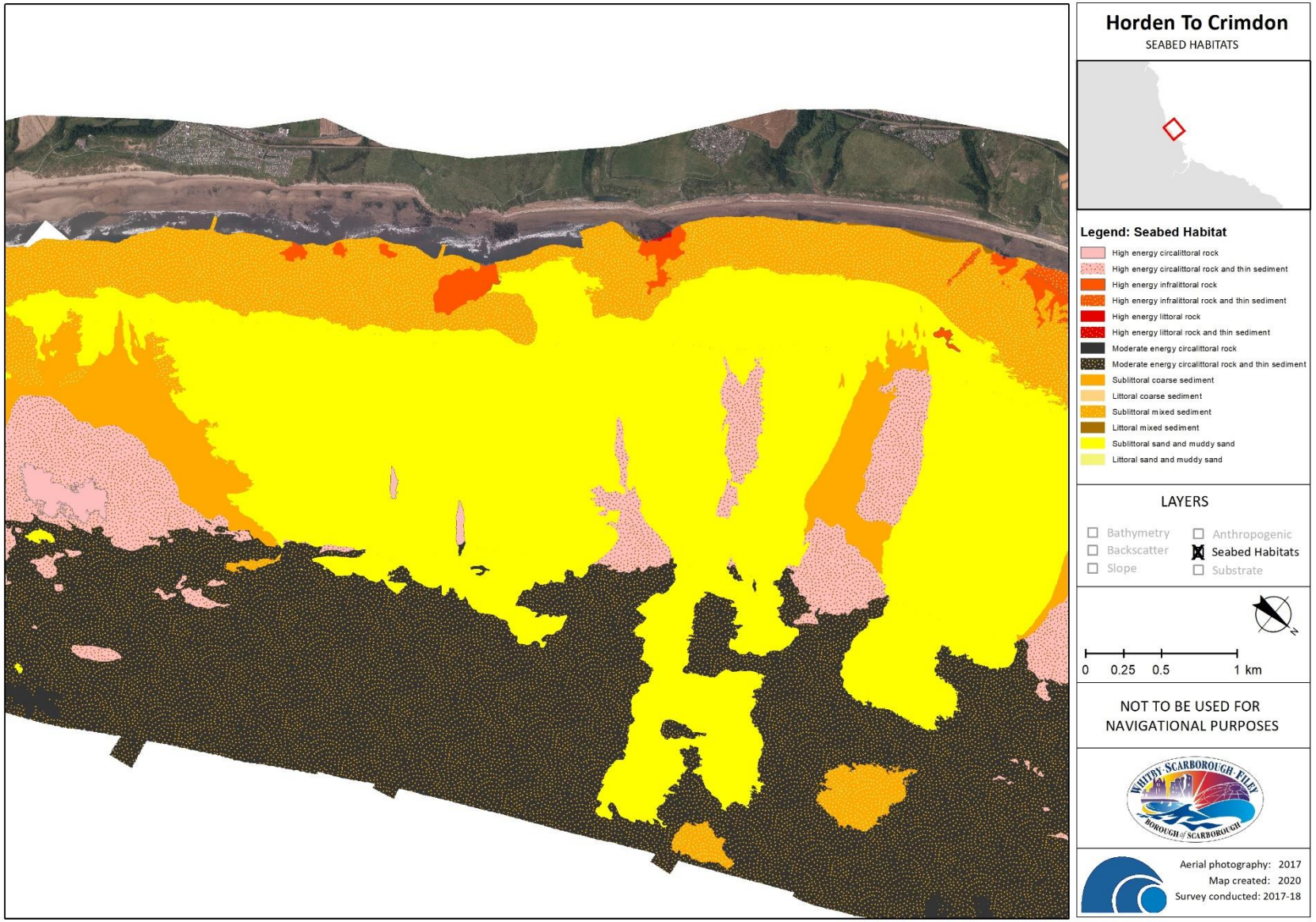
[1] Marlin Biotic Species Register - http://www.marlin.ac.uk/biotic/browse.php?sp=4133.

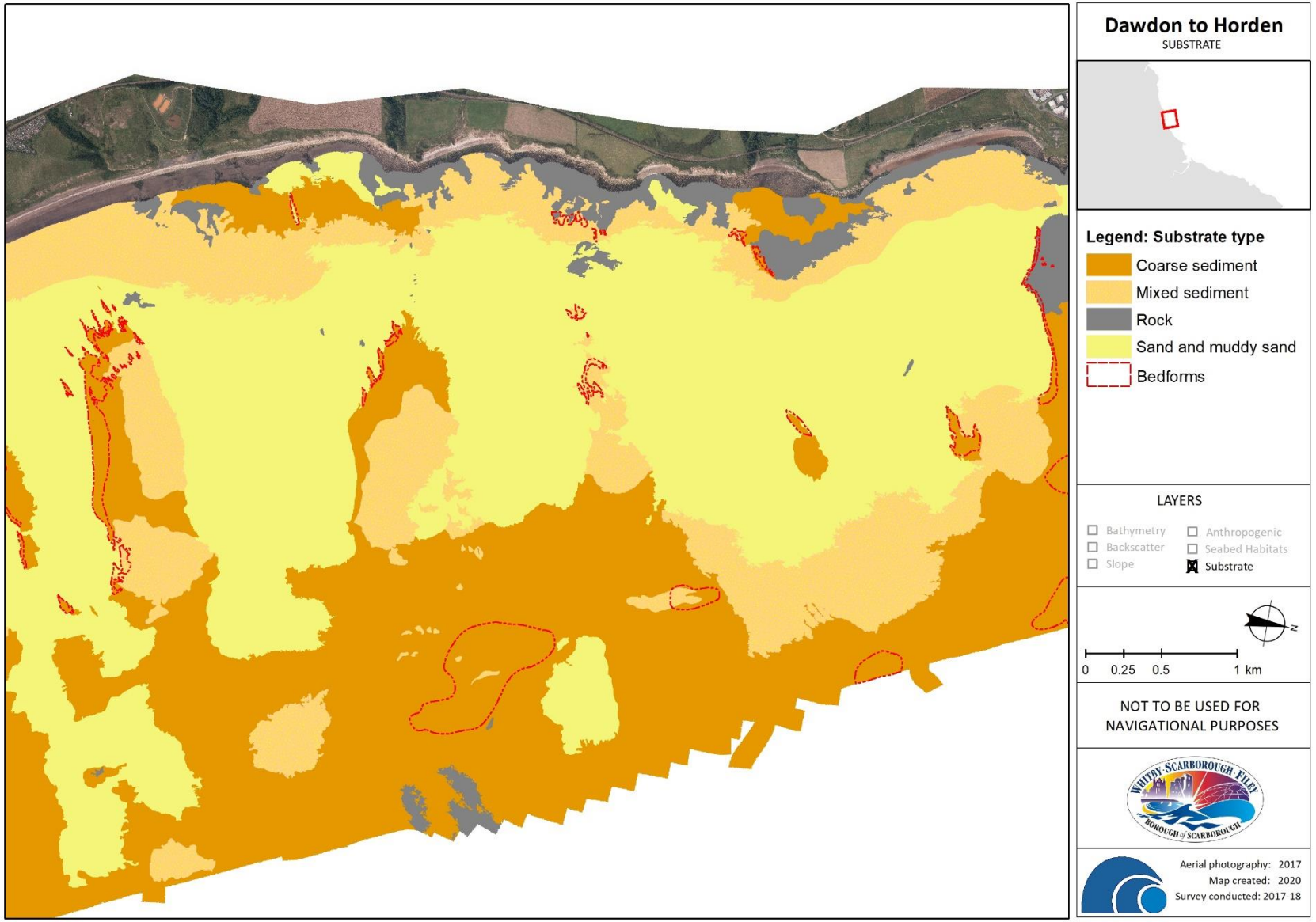

Horden To Crimdon
BATHYMETRY
Legend: Depth (mOD)
0
-35
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Horden To Crimdon
BACKSCATTER
Legend: Backscatter
High Intensity
Low Intensity
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Horden To Crimdon
SLOPE
Legend: Slope angle (degrees)
0 - 1
1 - 3
3 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 40
40 - 90
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Horden To Crimdon
ANTHROPOGENIC
Legend: Anthropogenic features
Anthropogenic features
Wrecks
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Horden To Crimdon
SEABED HABITATS
Legend: Seabed Habitat
High energy circalittoral rock
High energy circalittoral rock and thin sediment
High energy infralittoral rock
High energy infralittoral rock and thin sediment
High energy littoral rock
High energy littoral rock and thin sediment
Moderate energy circalittoral rock
Moderate energy circalittoral rock and thin sediment
Sublittoral coarse sediment
Littoral coarse sediment
Sublittoral mixed sediment
Littoral mixed sediment
Sublittoral sand and muddy sand
Littoral sand and muddy sand
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Dawdon to Horden
SUBSTRATE
Legend: Substrate type
Coarse sediment
Mixed sediment
Rock
Sand and muddy sand
Bedforms
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18

Crimdon to Hartlepool

Between Crimdon and Hartlepool, the beach changes from mixed and coarse sediments with cliffs at the back of the beach to fine sand backed by vegetated dunes. The dunes are present until the beach meets Hartlepool headland. The intertidal zone is flat *Littoral Sands and Muddy Sands* exclusively, with no patches of exposed rock. *Sublittoral Sands and Muddy Sands* cover the majority of the area, including offshore.

Towards Crimdon, the Infralittoral zone contains a band, from Steetley pier northwards, of *Sublittoral Mixed Sediments* that extends out into the Circalittoral zone, before becoming thin and exposing some patches of bedrock (and only thinly covering the rest of the geology). These are classified as *High Energy Circalittoral Rock* or *Moderate Energy Circalittoral Rock* where exposed, or *High Energy Circalittoral Rock with thin Sediment* and *Moderate Energy Circalittoral Rock with thin Sediment* where veiled with coarse sediment. The backscatter map shows where this layer of bedrock, that has been present on the eastern edge of the survey area throughout the northern sections of the extent, ends to give way to a deeper layer of finer sediment.

South of the dunes, The Headland is situated on an outcrop of Dolostone sedimentary bedrock[2]. The shore has exposed *High Energy Littoral Rock*, which extends into the Circalittoral zone, remaining exposed throughout, and changes classification to *High Energy Infralittoral Rock* (in the Infralittoral zone), *High Energy Circalittoral Rock* (in the Circalittoral zone) and *Moderate Energy Circalittoral Rock* (in the Circalittoral zone where the energy regime decreases). The hillshade and slope maps illustrate the geology well. MarineRecorder entries and groundtruthing confirm the beaches to be fine sand, and also include observations of *Mytilus edulis* on the rock platform. It further supports the high energy classification near the shore by recording *Laminaria digitata* in a series of rock pools, also on the rock platform, which thrive on wave exposed hard substrata, commonly found throughout the UK [1].

The coast south of Hartlepool remains dominated by *Sublittoral Sands and Muddy Sands*, with a small band of *Sublittoral Mixed Sediments* around MLWS and some negligible patches of *High Energy Infralittoral Rock with thin Sediment*. East of Hartlepool, there is a patch exposed *Moderate Energy Circalittoral Rock* with infilled coarse sediment. The sediment has evidence of ripples between the exposed rock.

Hartlepool harbour has a dredged channel at its mouth, about 150m wide and 3m deep. A cross section of the channel can be seen in Figure 10. The sediment at the bottom of the channel is thin enough to detect bedrock beneath, and has been classified as *High Energy Infralittoral Rock with thin Sediment*. The backscatter shows this thin layer to give a lower intensity return, suggesting they are softer and made of finer material deposited in the channel, which explains the need for dredging.

There are 2 wrecks east of Hartlepool Harbour, both sat in small scour pits, and 1 to the north with no evidence of scour.

[1] Marlin Biotic Species Register - http://www.marlin.ac.uk/biotic/browse.php?sp=41.

[2] British Geological Survey - http://mapapps.bgs.ac.uk/geologyofbritain/home.html.

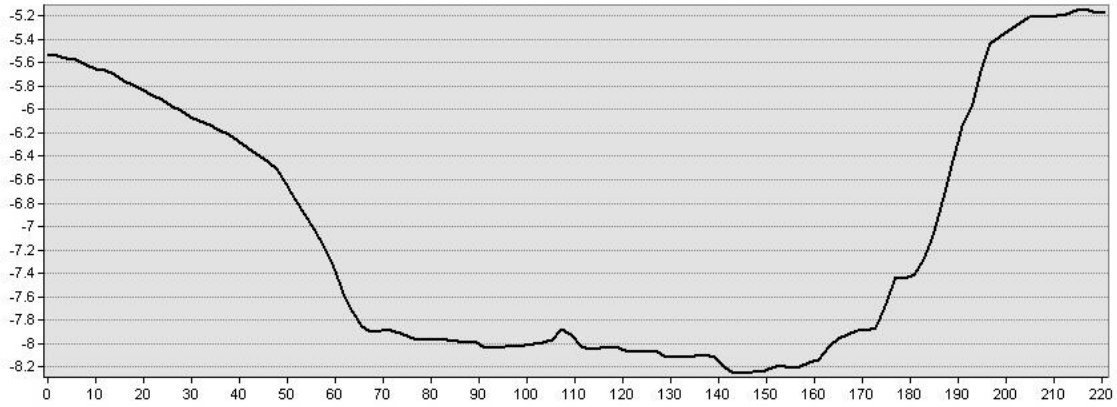
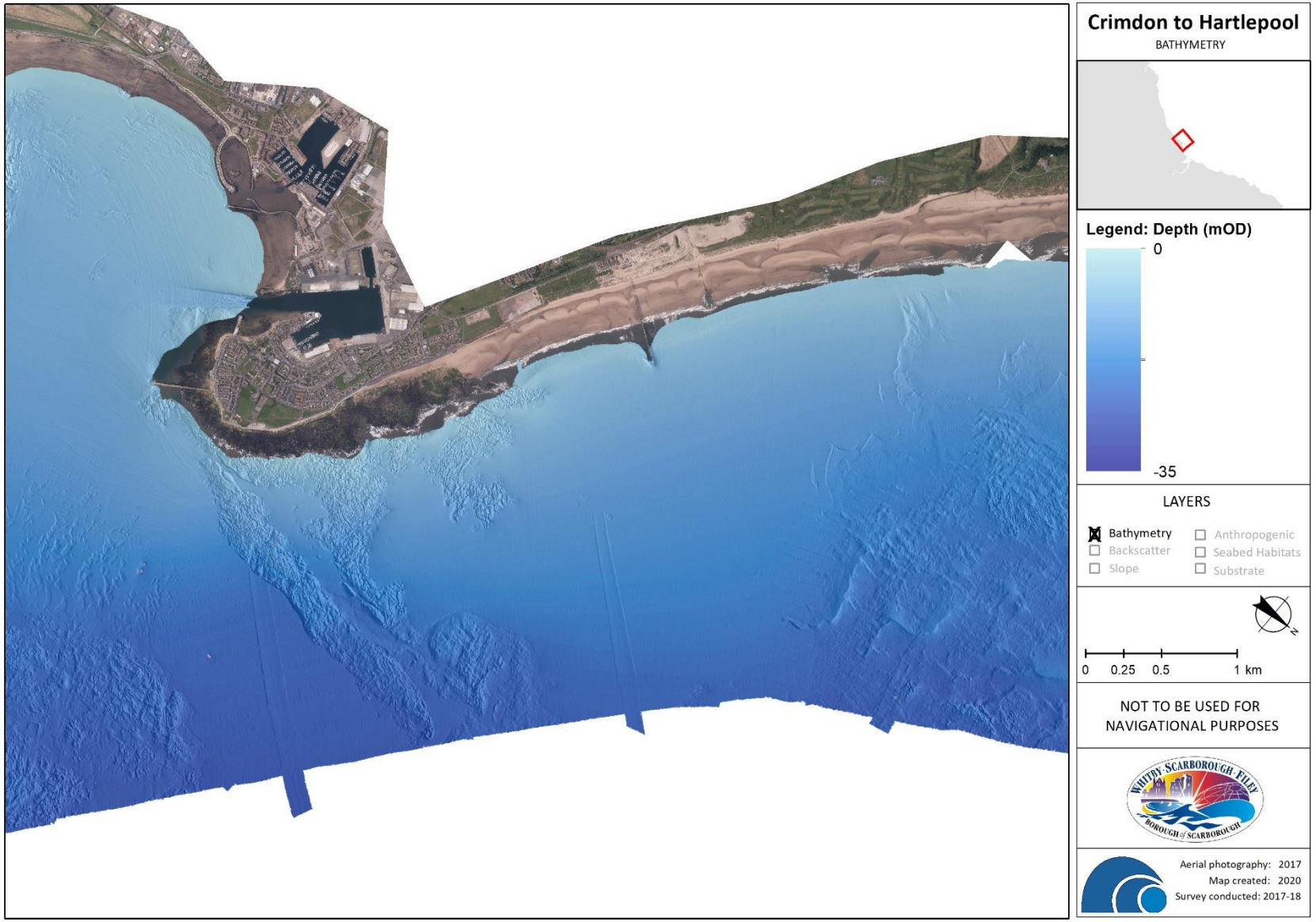
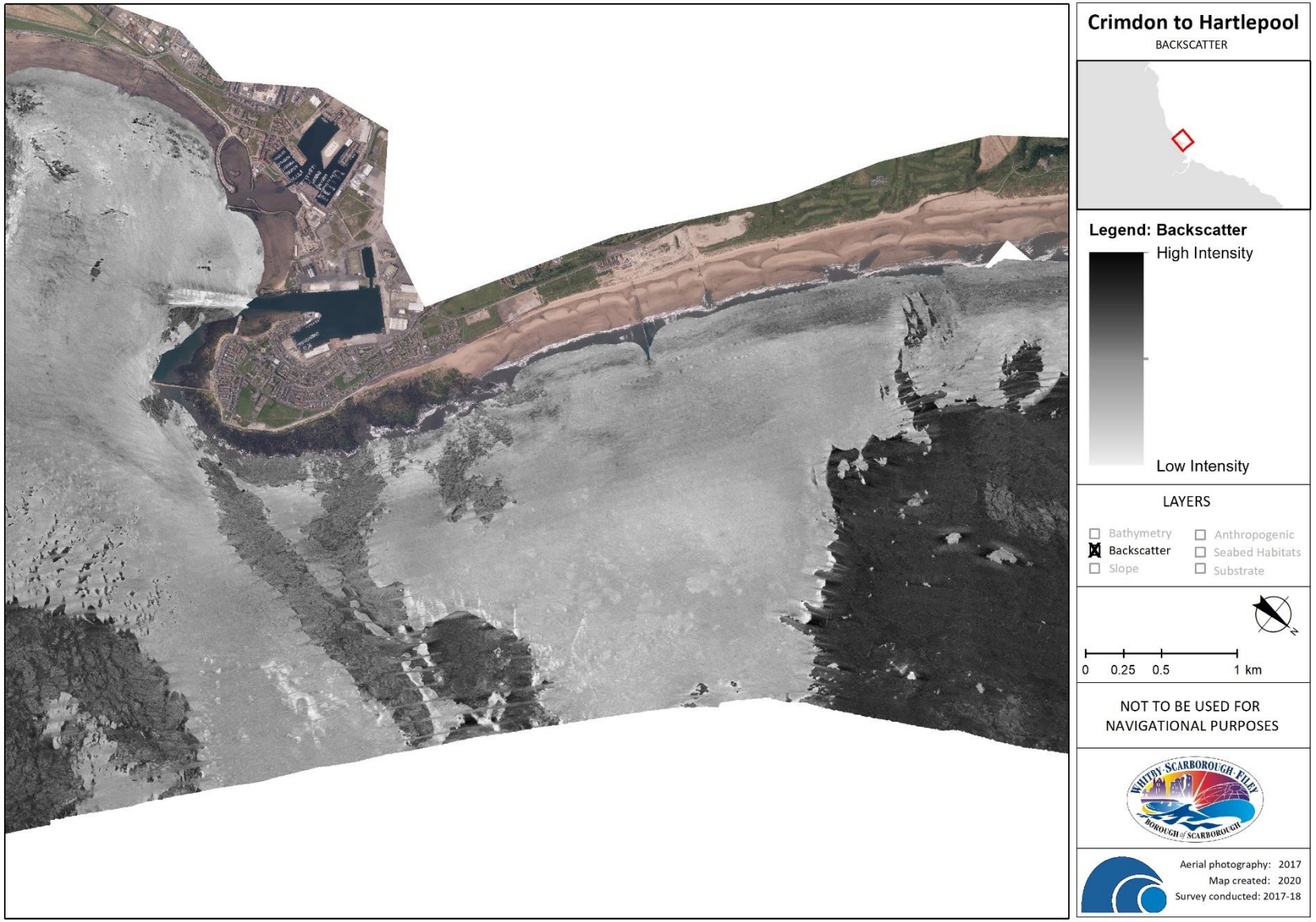
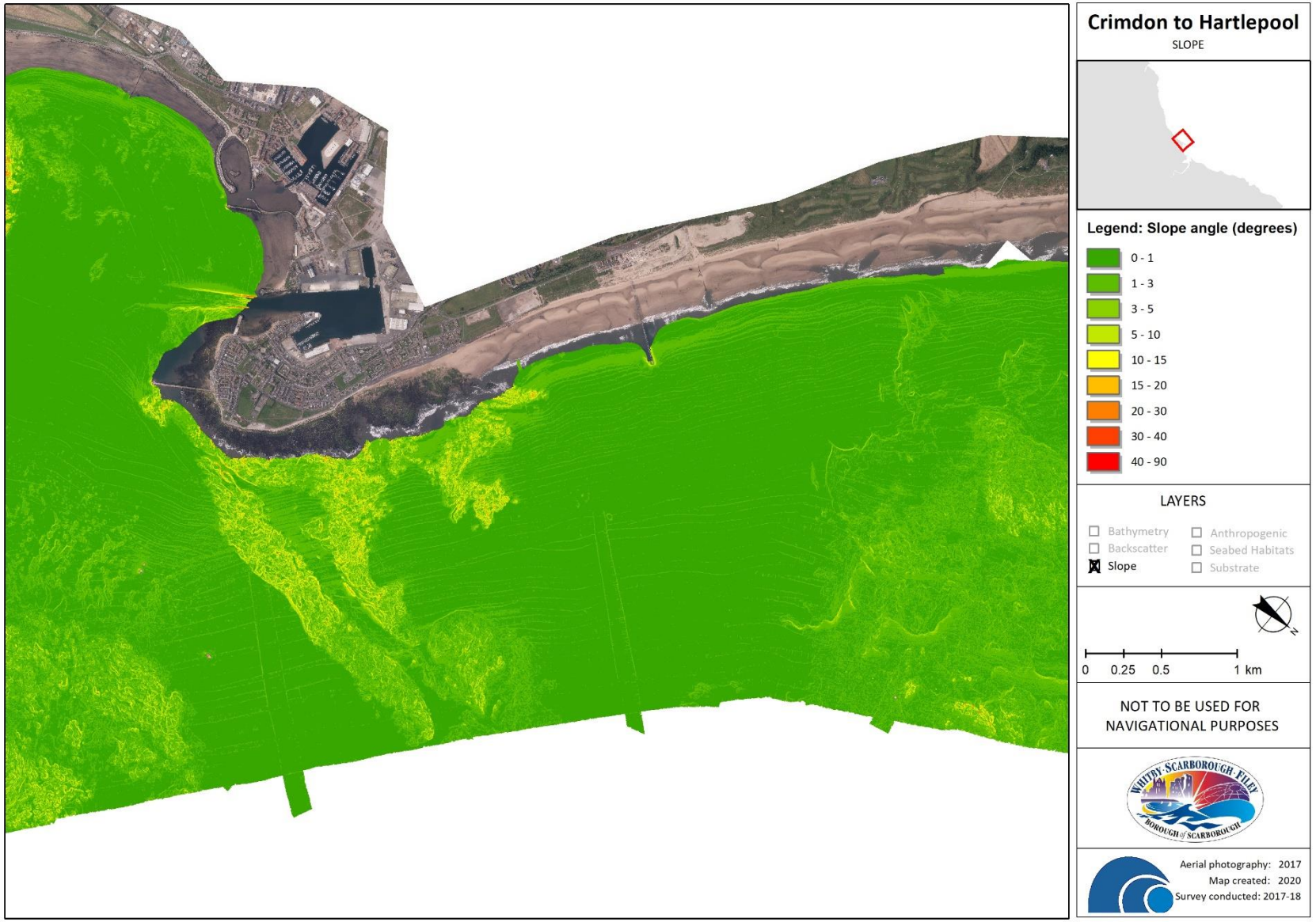
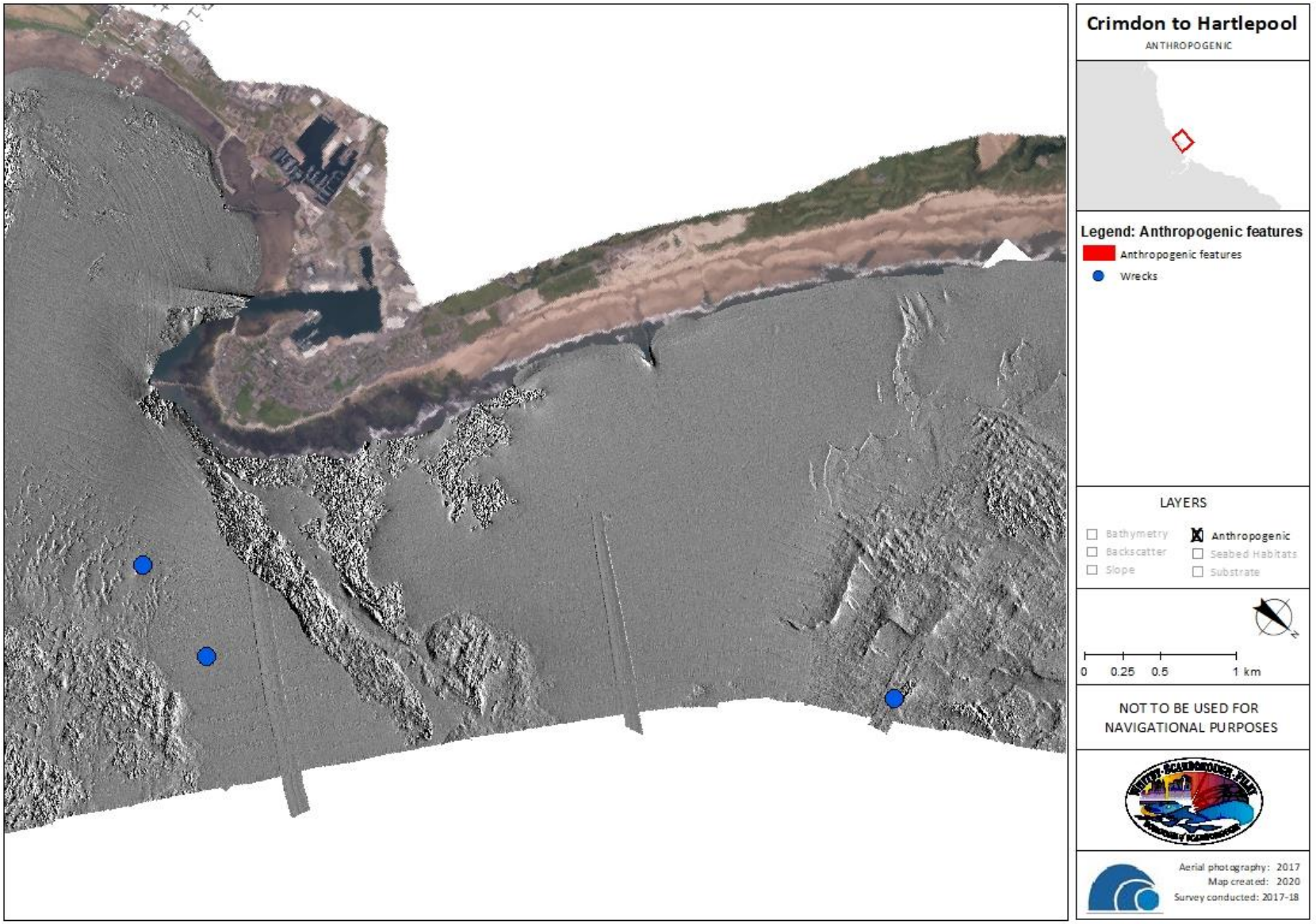


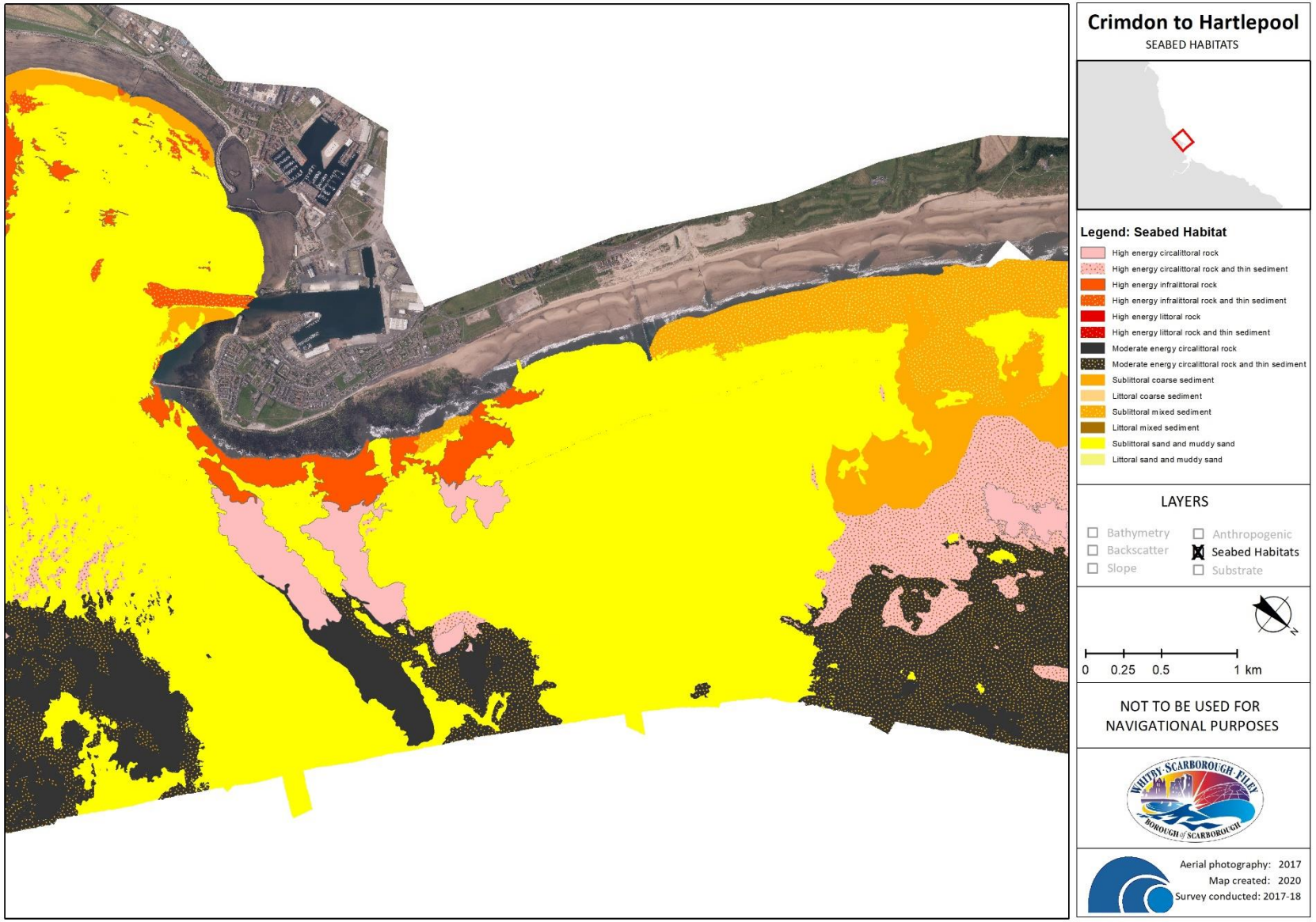
Figure 10: Cross Section of dredged channel at Hartlepool Harbour

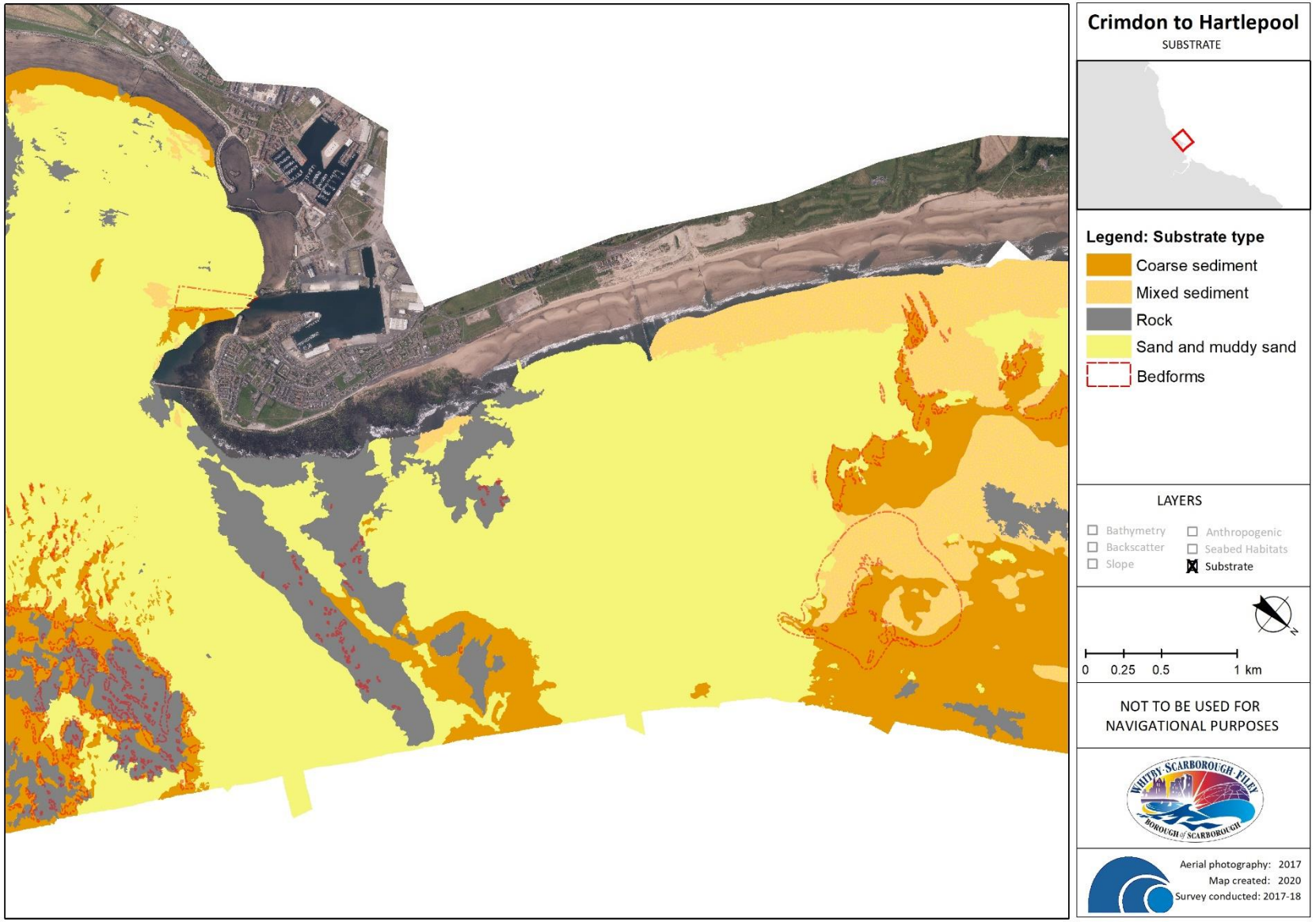

Crimdon to Hartlepool
BATHYMETRY
Legend: Depth (mOD)
0
-35
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Crimdon to Hartlepool
BACKSCATTER
Legend: Backscatter
High Intensity
Low Intensity
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Crimdon to Hartlepool
SLOPE
Legend: Slope angle (degrees)
0 - 1
1 - 3
3 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 40
40 - 90
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Crimdon to Hartlepool
ANTHROPOGENIC
Legend: Anthropogenic features
Anthropogenic features
Wrecks
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Crimdon to Hartlepool
SEABED HABITATS
Legend: Seabed Habitat
High energy circalittoral rock
High energy circalittoral rock and thin sediment
High energy infralittoral rock
High energy infralittoral rock and thin sediment
High energy littoral rock
High energy littoral rock and thin sediment
Moderate energy circalittoral rock
Moderate energy circalittoral rock and thin sediment
Sublittoral coarse sediment
Littoral coarse sediment
Sublittoral mixed sediment
Littoral mixed sediment
Sublittoral sand and muddy sand
Littoral sand and muddy sand
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Crimdon to Hartlepool
SUBSTRATE
Legend: Substrate type
Coarse sediment
Mixed sediment
Rock
Sand and muddy sand
Bedforms
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.25 0.5 1 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18

Hartlepool to Redcar

The southernmost section of the survey area contains the mouth of the River Tees and Teesmouth Nature reserve. The surrounding beaches of Tees Bay hold fine sands and are again backed by vegetated dunes. North of the river mouth, the shore is classified as *Littoral Sands and Muddy Sands* above MLWS and *Sublittoral Sands and Muddy Sands* below MLWS. The latter classification covers the majority of this section of the survey. MarineRecorder entries confirm the sediment in the nearshore to be fine, and mobile. South of the river mouth the shore is classified as *Littoral Mixed Sediments* and *Sublittoral Mixed sediments* above and below MLWS respectively. The backscatter map shows most of the seabed to be homogeneous, with smaller areas of contrasting high intensity rock than the bed north of Hartlepool.

Patches of exposed *Moderate Energy Circalittoral Rock* and *Moderate Energy Circalittoral Rock with thin Sediment* are present on the seaward edge of the survey extent, with the same infilled patches of coarse sediment and small ripples as Hartlepool. MarineRecorder observations also detail these patches of small ripples. Each side of the river mouth is sheltered by outcrops of High Energy Infralittoral Rock (and *High Energy Littoral Rock* where they break the surface), that do not extend into deeper water.

There are two large, noticeable geological formation at either end of Tees Bay. The formation to the north is a large outcrop that breaks the surface, classified as *High Energy Littoral Rock* with a base of High Energy Infralittoral Rock, is a sandstone formation [2], and can be seen in Figure 11a. The larger southern formation is comprised of layers of Redcar Mudstone and Staithes Sandstone [2], has the same classification as the northern formation, and can be seen in Figure 11b. This formation is also noticeable through water from aerial photography, and only just breaks the surface on spring lows.

[2] British Geological Survey - http://mapapps.bgs.ac.uk/geologyofbritain/home.html.

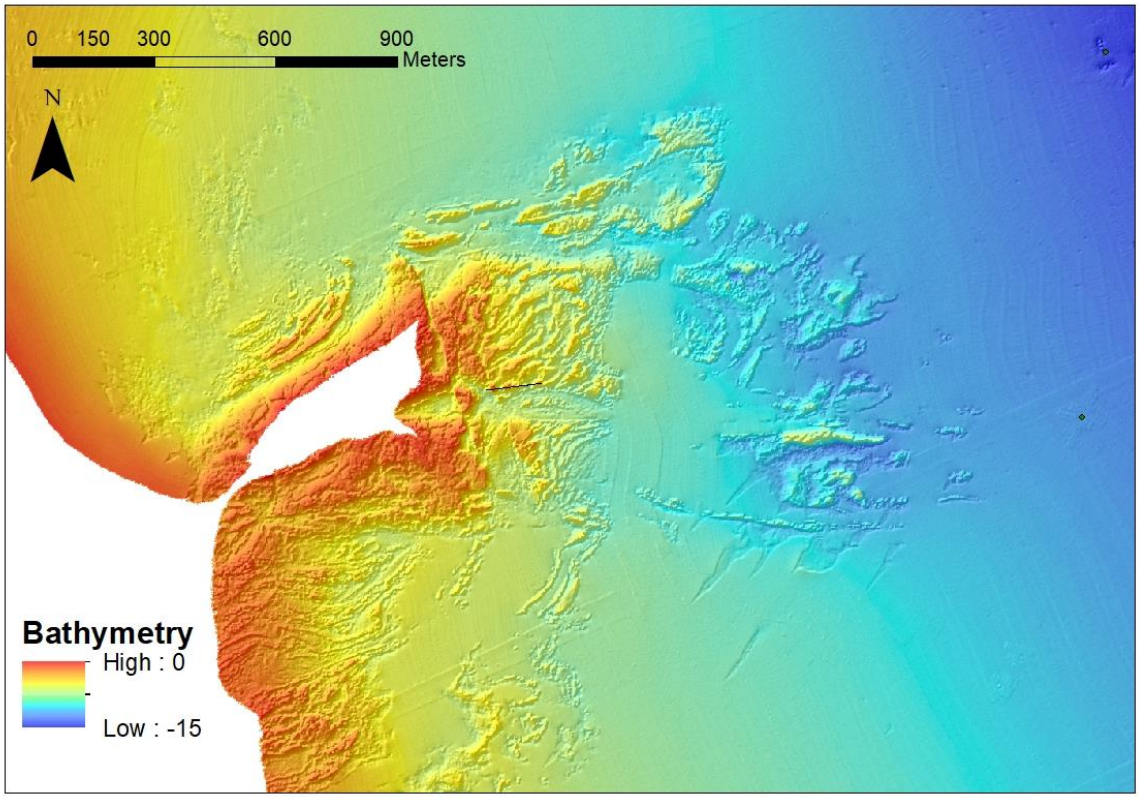


Figure 11a: Northern Sandstone geological formation

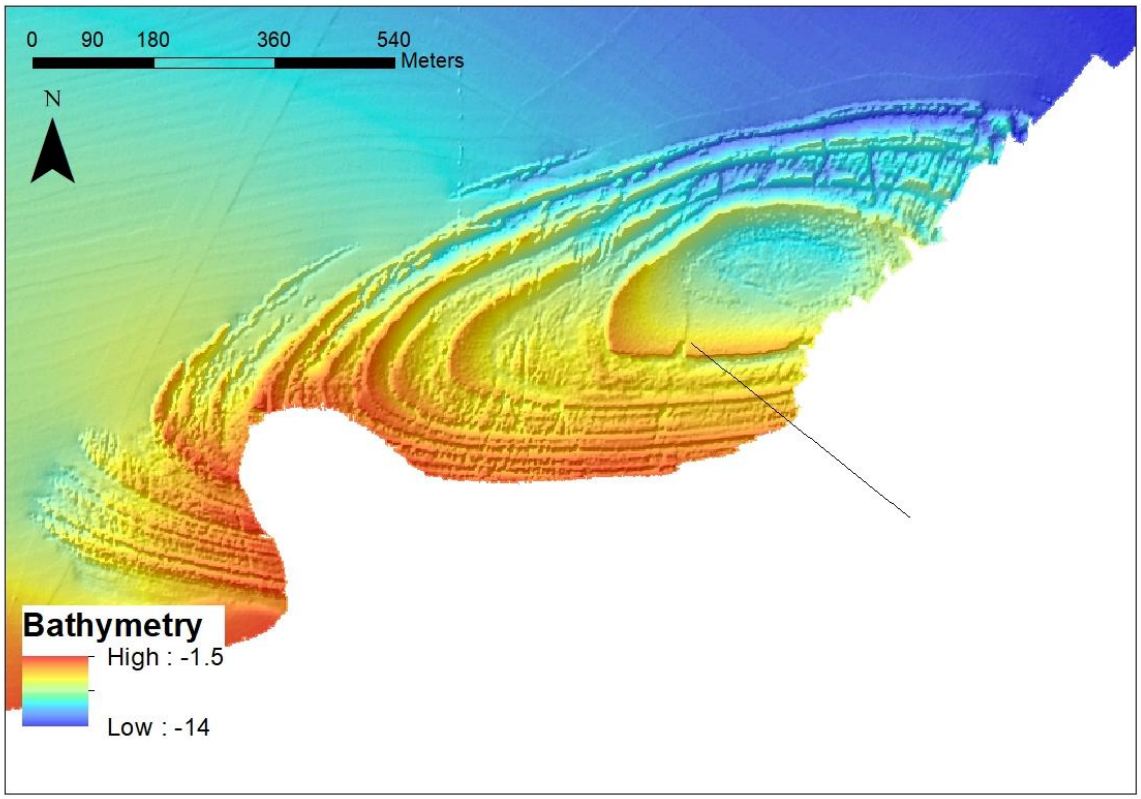


Figure 11b: Southern Sandstone and Mudstone geological formation

The mouth of the River Tees is dredged periodically, and therefore the channel on the bed is clearly visible on the hillshade, slope and backscatter maps. Scour has extended the channel 3km beyond the landward edge of the survey extent, between two thin bands of exposed *High Energy Circalittoral Rock*. The softer fluvial sediments have deposited a layer of silt on the bottom of the scoured channel, which is highlighted as the area of lowest intensity for the whole survey on the backscatter map. Figure 12 shows a cross section of the channel, which widens to over 500m as it moves offshore. The northern bank of the channel is shallower and steeper.

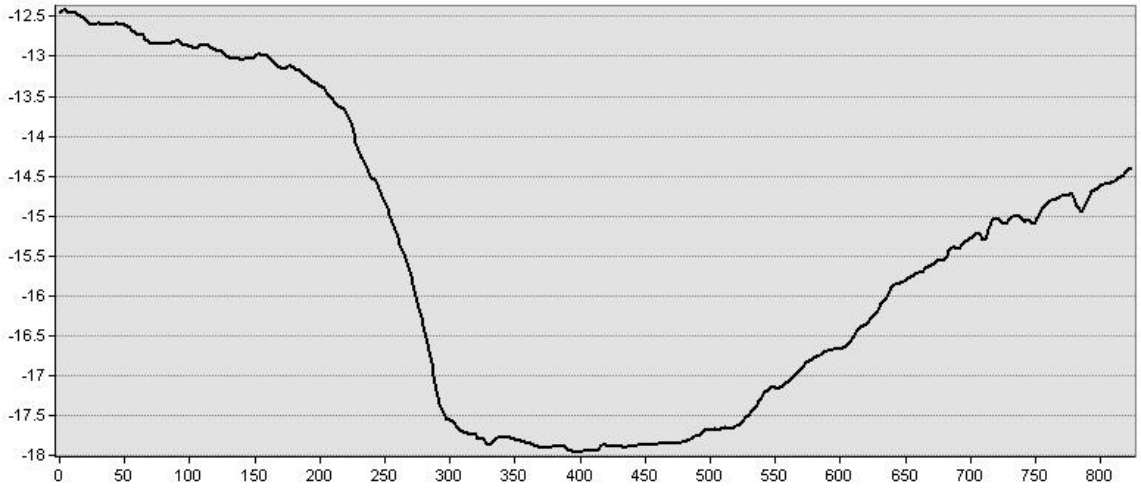
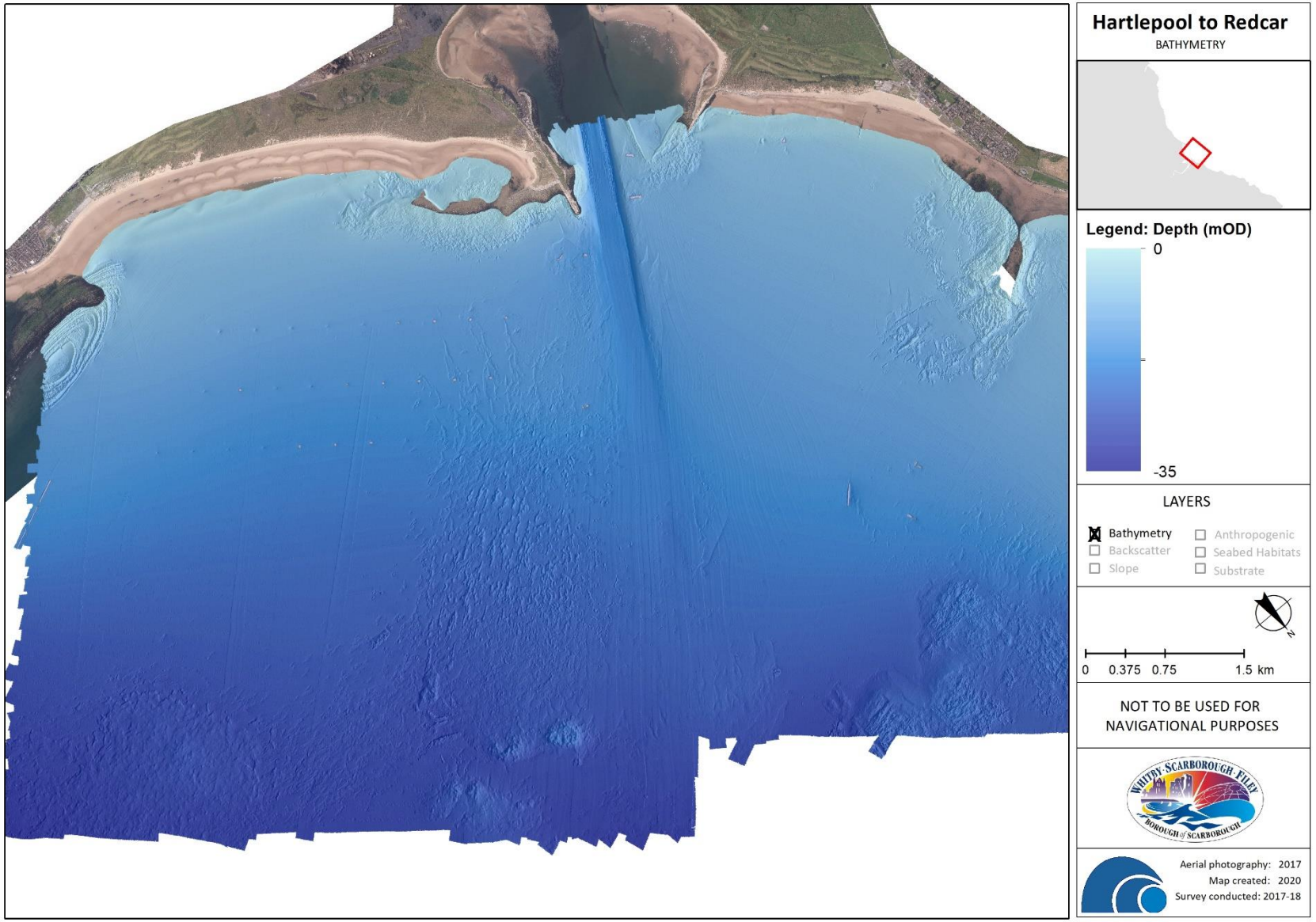
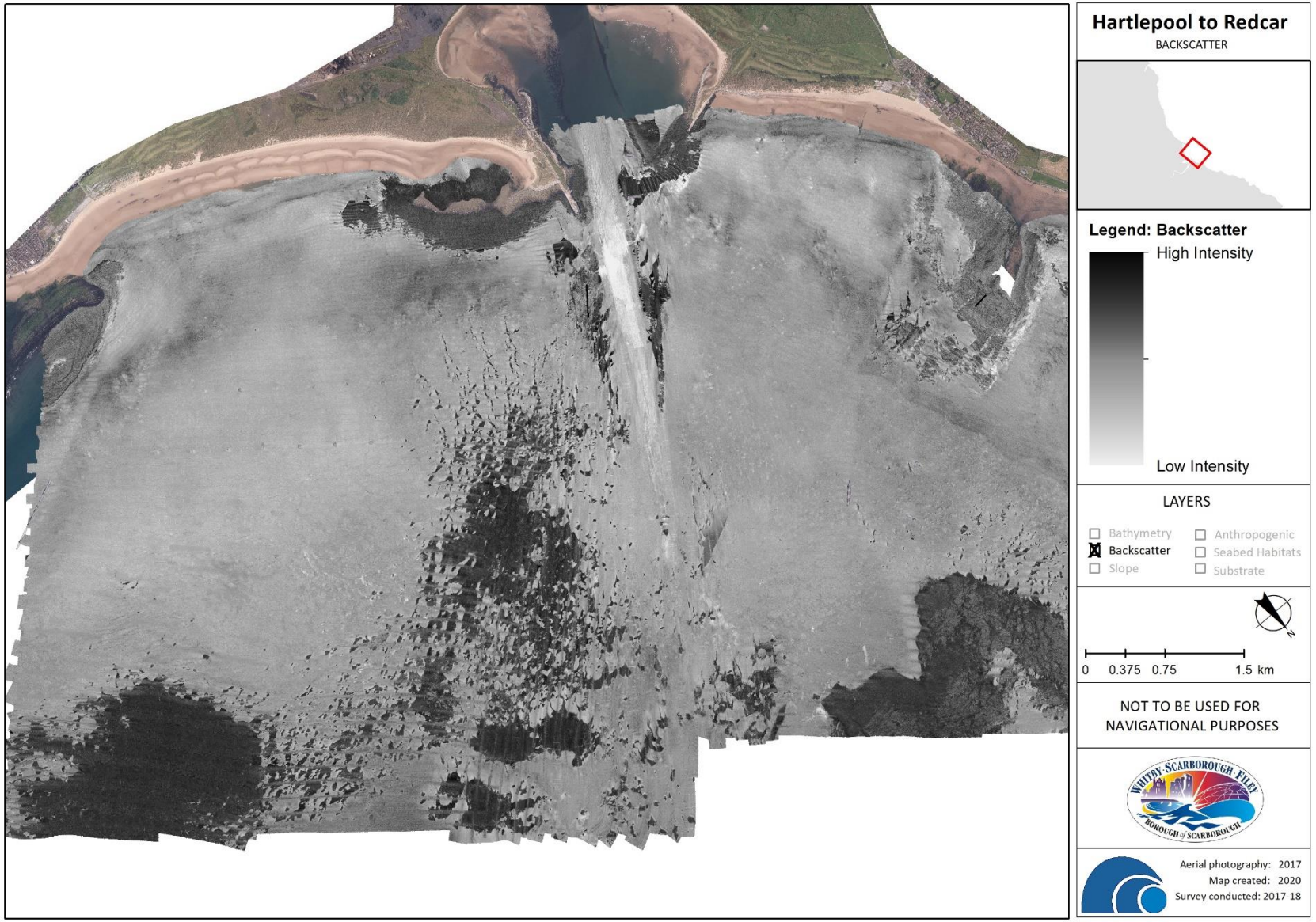
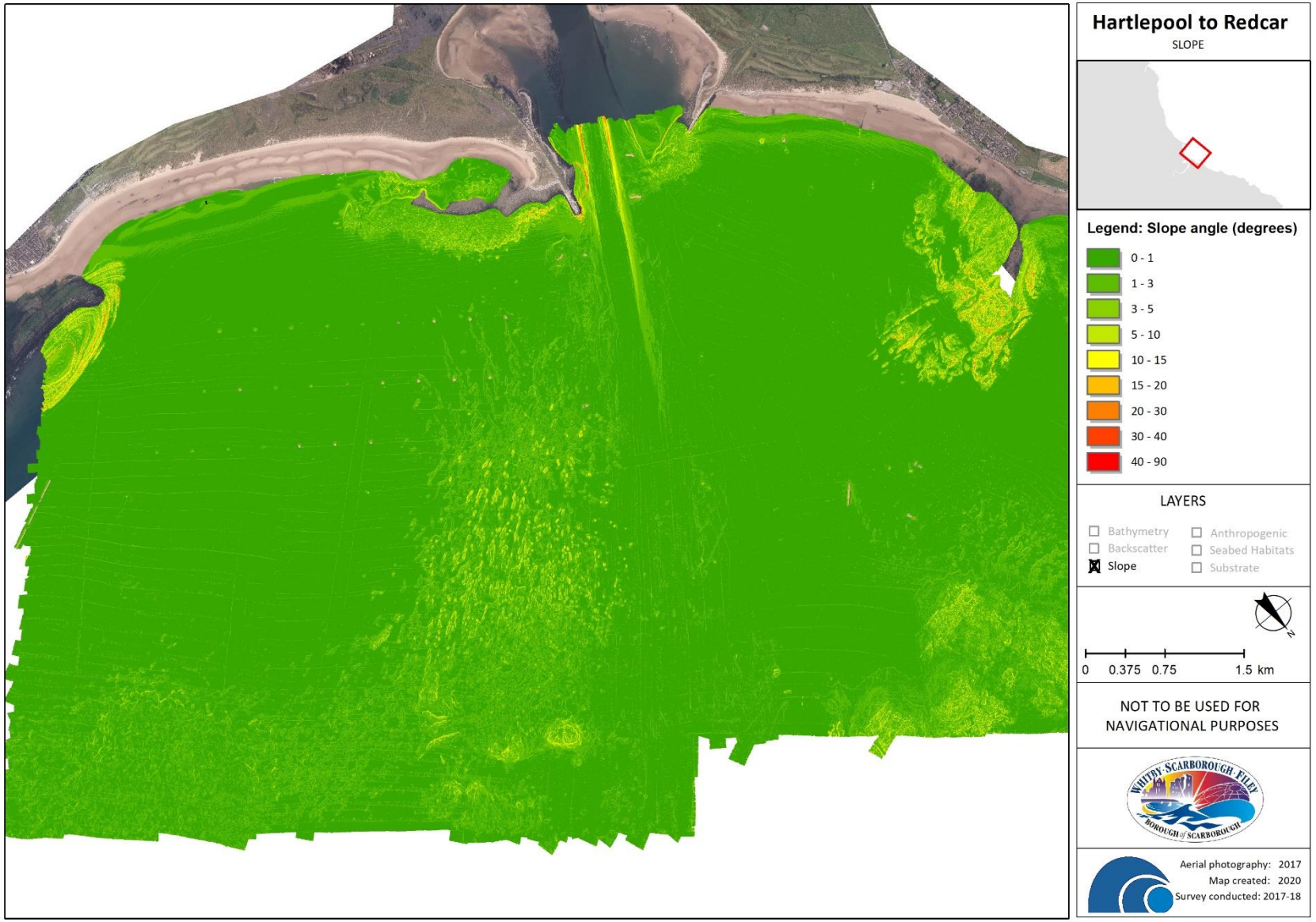


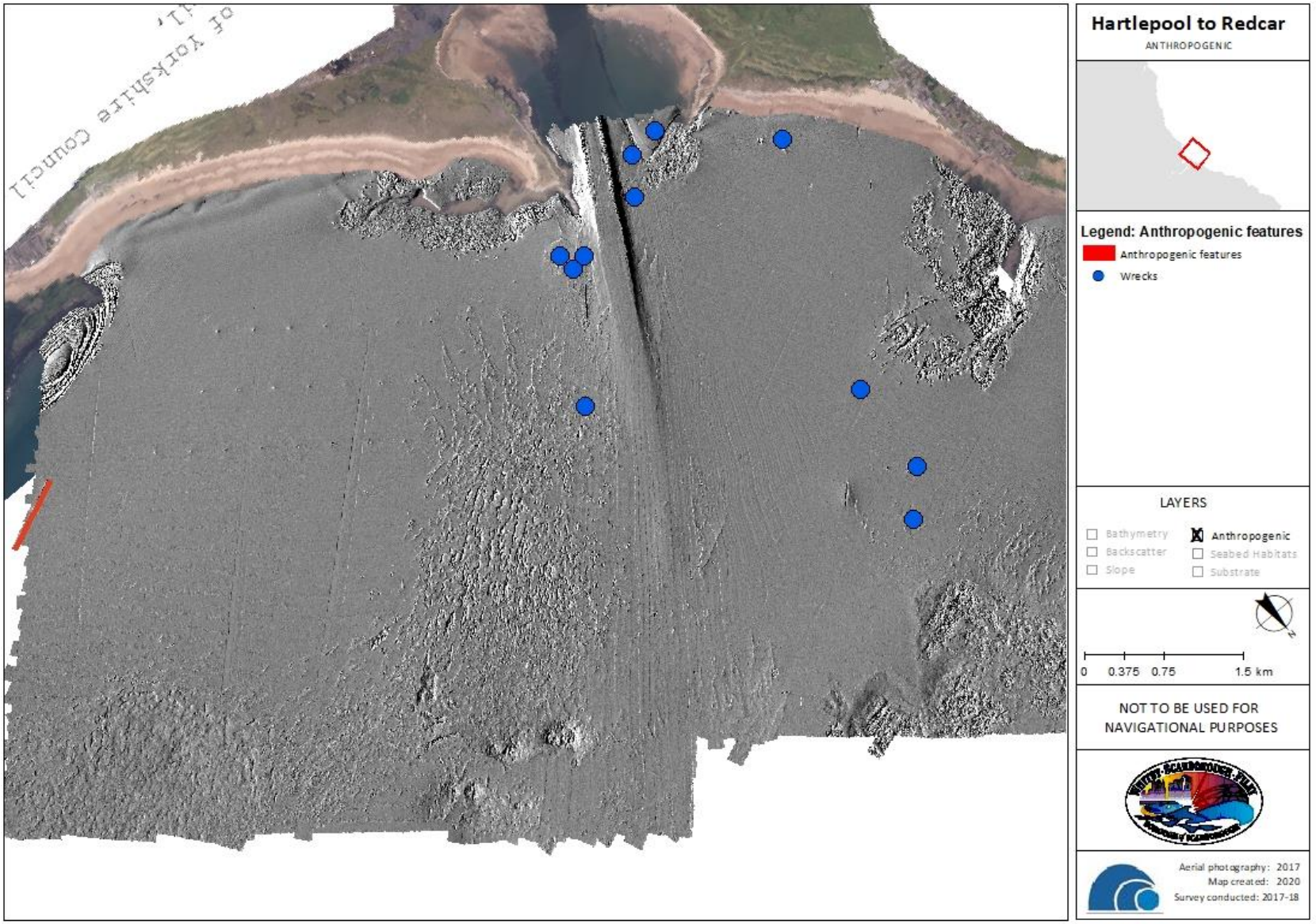
Figure 12: River Tees dredged channel cross section

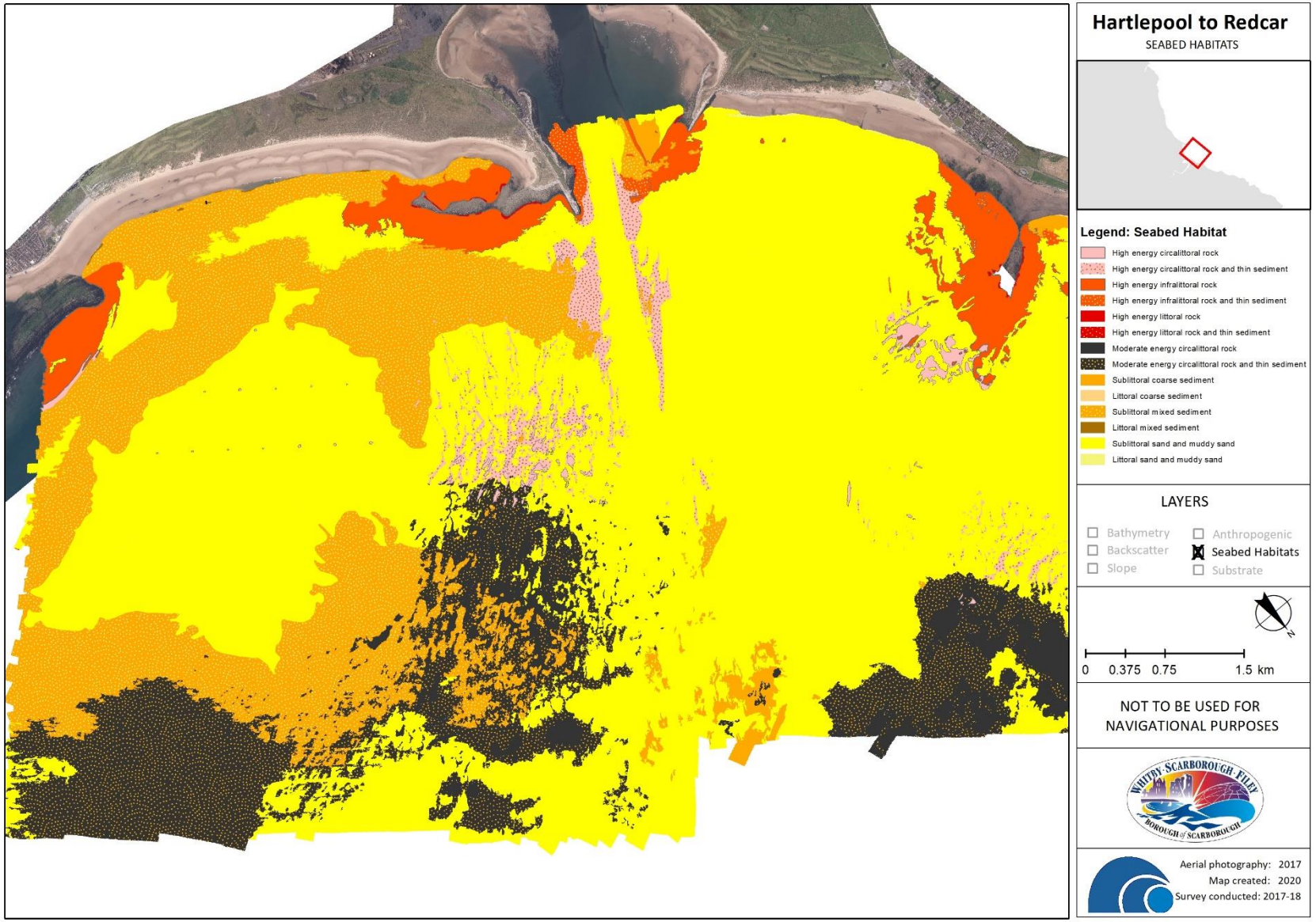
There is an exposed pipeline on the southern edge of the survey area, with a small amount of scour around the target, leaving 726m without cover (shown previously in Figure 6). There are 11 wrecks in this southern section; none have any evidence of scour.

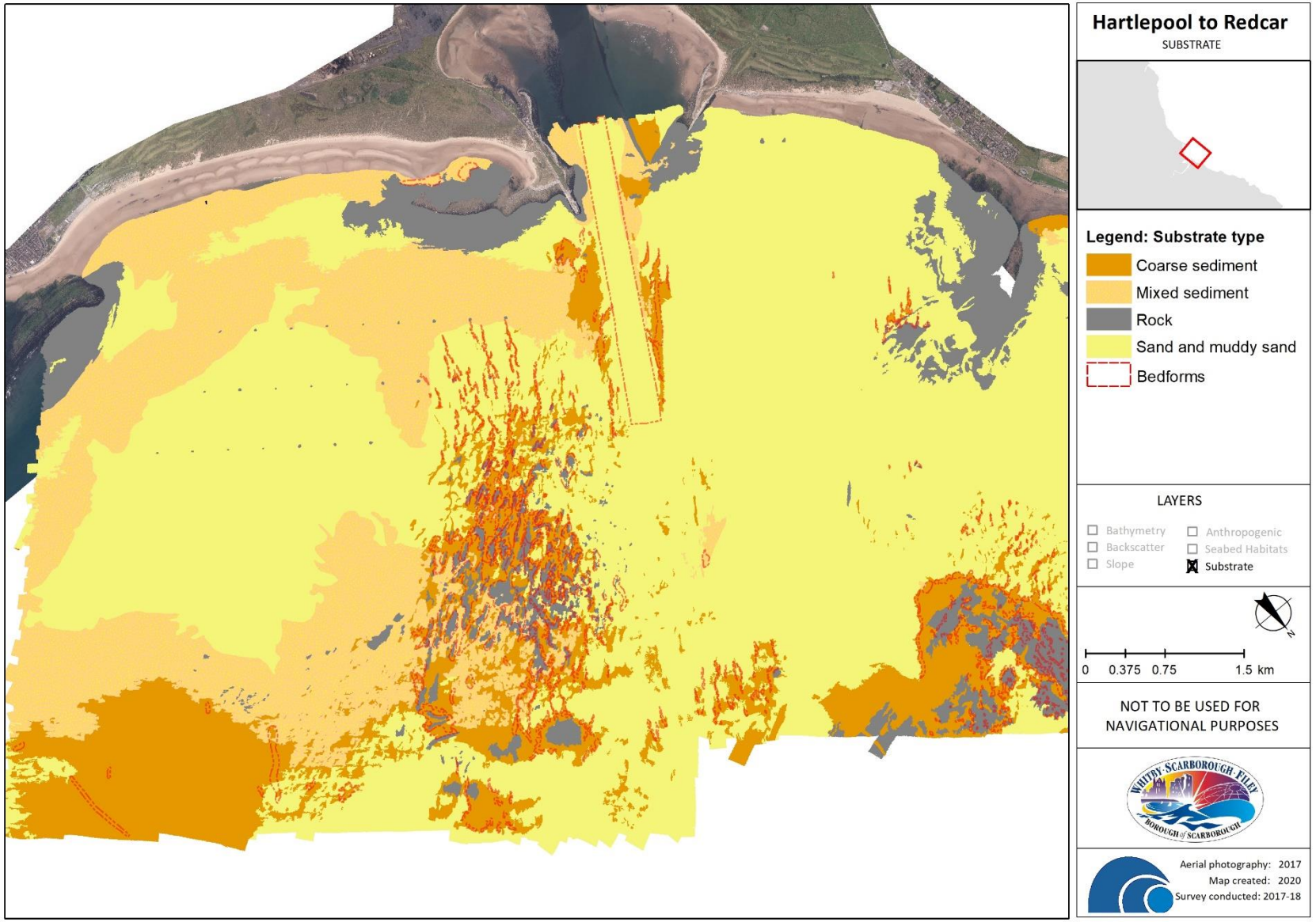

Hartlepool to Redcar
BATHYMETRY
Legend: Depth (mOD)
0
-35
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.375 0.75 1.5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Hartlepool to Redcar
BACKSCATTER
Legend: Backscatter
High Intensity
Low Intensity
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.375 0.75 1.5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Hartlepool to Redcar
SLOPE
Legend: Slope angle (degrees)
0 - 1
1 - 3
3 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 40
40 - 90
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.375 0.75 1.5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Hartlepool to Redcar
ANTHROPOGENIC
Legend: Anthropogenic features
Anthropogenic features
Wrecks
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
0 0.375 0.75 1.5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Hartlepool to Redcar
SEABED HABITATS
Legend: Seabed Habitat
High energy circalittoral rock
High energy circalittoral rock and thin sediment
High energy infralittoral rock
High energy infralittoral rock and thin sediment
High energy littoral rock
High energy littoral rock and thin sediment
Moderate energy circalittoral rock
Moderate energy circalittoral rock and thin sediment
Sublittoral coarse sediment
Littoral coarse sediment
Sublittoral mixed sediment
Littoral mixed sediment
Sublittoral sand and muddy sand
Littoral sand and muddy sand
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.375 0.75 1.5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
WHITBY · SCARBOROUGH · FILEY
BOROUGH of SCARBOROUGH
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Hartlepool to Redcar
SUBSTRATE
Legend: Substrate type
Coarse sediment
Mixed sediment
Rock
Sand and muddy sand
Bedforms
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 0.375 0.75 1.5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18

References

Coggan, C., James, C., Pearce, B. & Plim, J. (2011). Using the EUNIS habitat classification system in broadscale regional mapping: some problems and potential solutions from case studies in the English Channel. ICES CM 2011/G:03

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L., Leiberknecht, L.M., Northen, K.O., and Reker, J.B. (2004). The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough.

McBreen, F., Askew, N., Cameron, A., Connor, D., Ellwood, H., Carter, A., (2011), UK SeaMap 2010 Predictive mapping of seabed habitats in UK waters, JNCC Report 446, ISBN 0963 8091

Acknowledgements

Valuable groundtruthing and substrate information was kindly provided by JNCC marine recorder, British Geological Survey Geoindex's and the Northeast Regional Coastal Monitoring Programme. The MCA's Civil Hydrography Programme bathymetry data kindly provided by colleagues from the MCA hydrographic team under Open Government Licence.

Annex 1 Confidence Assessment

	HI1543 Sunderland to Redcar – 2017/18
Remote Technique	3
Remote Coverage	3
Remote Positioning	3
Remote Standards Applied	3
Remote Vintage	3
Biological Groundtruth Technique	1
Physical Groundtruth Technique	2
Groundtruth Positioning	3
Groundtruth Density	2
Groundtruth Standards Applied	3
Groundtruth Vintage	3
Groundtruth Interpretation	2
Remote Interpretation	3
Detail Level	1
Map Accuracy	3
Remote score	100
Groundtruth score	71.67
Interpretation score	75
Overall score	82

https://webarchive.nationalarchives.gov.uk/20101014084131/http://www.searchmesh.net/Default.aspx?page=1780#MESHConfidenceScoresheet

Remote Techniques
An assessment of whether the remote technique(s) used to produce this map were appropriate to the environment they were used to survey. If necessary, adjust your assessment to account for technique(s) which, although appropriate, were used in deep water and consequently have a significantly reduced resolution (i.e. size of footprint):
3 = technique(s) highly appropriate
2 = technique(s) moderately appropriate
1 = technique(s) inappropriate

Remote Coverage
An assessment of the coverage of the remote sensing data including consideration of heterogeneity of the seabed. This can be simply achieved in a coverage x heterogeneity matrix, as illustrated below:

		Heterogeneity		
		Low	Moderate	High
Coverage	Poor (large gaps between swaths; Track spacing >100m)	2	1	1
	Moderate (50%; track spacing <100m)	3	2	1
	Good (100%; track spacing <50m)	3	3	3

Remote Positioning & Ground Truthing Position
An indication of the positioning method used for the remote / ground-truth data:
3 = differential GPS
2 = GPS (not differential) or other non-satellite 'electronic' navigation system
1 = chart based navigation, or dead-reckoning

Remote & Ground Truthing Standards Applied
An assessment of whether standards have been applied to the collection of the remote / ground-truth data. This field gives an indication of whether some data quality control has been carried out:
3 = remote / ground-truth data collected to approved standards
2 = remote / ground-truth data collected to 'internal' standards
1 = no standards applied to the collection of the remote / ground-truth data

Remote Vintage & Ground Truthing Vintage
An indication of the age of the remote / ground-truth data:
3 = < 5yrs old.
2 = 5 to 10yrs old.
1 = > 10yrs old.

Biological Ground Truthing Technique
An assessment of whether the groundtruthing techniques used to produce this map were appropriate to the environment they were used to survey. Use scores for soft or hard substrata as appropriate to the area surveyed.

Soft substrata predominate (i.e. those having infauna and epifauna)	Hard substrata predominate (i.e. those with no infauna)
3 = infauna AND epifauna sampled AND observed (video/stills, direct human observation) 2= infauna AND epifauna sampled, but NOT observed (video/stills, direct human observation) 1 = infauna OR epifauna sampled, but not both. No observation.	3 = sampling included direct human observation (shore survey or diver survey) 2 = sampling included video or stills but NO direct human observation 1 = benthic sampling only (e.g. grabs, trawls)

Physical Ground Truthing Technique
An assessment of whether the combination of geophysical sampling techniques were appropriate to the environment they were used to survey. Use scores for soft or hard substrata as appropriate to the area surveyed.

Soft substrata predominate (i.e. gravel, sand, mud)	Hard substrata predominate (i.e. rock outcrops, boulders, cobbles)
3 = full geophysical analysis 2 = sediments described following visual inspection of grab or core samples (e.g. slightly shelly, muddy sand) 1 = sediments described on the basis of remote observation (by camera).	3 = sampling included in-situ, direct human observation (shore survey or diver survey) 2 = sampling included video or photographic observation, but NO in-situ, direct human observation 1 = samples obtained only by rock dredge

Ground Truthing Sample Density
An assessment of what proportion of the polygons or classes (groups of polygons with the same 'habitat' attribute) actually contain ground-truth data:
3 = Every class in the map classification was sampled at least 3 times
2 = Every class in the map classification was sampled
1 = Not all classes in the map classification were sampled (some classes have no ground-truth data)

Ground Truthing Interpretation
An indication of the confidence in the interpretation of the groundtruthing data. Score a maximum of 1 if physical ground-truth data but no biological ground-truth data were collected:
3 = Evidence of expert interpretation; full descriptions and taxon list provided for each habitat class
2 = Evidence of expert interpretation, but no detailed description or taxon list supplied for each habitat class
1 = No evidence of expert interpretation; limited descriptions available

Remote Interpretation
An indication of the confidence in the interpretation of the remotely sensed data. (Interpretation techniques can range from 'by eye' digitising by experts to statistical classification techniques):
3 = Appropriate technique used and documentation provided
2 = Appropriate technique used but no documentation provided
1 = Inappropriate technique used

Detail Level
The level of detail to which the 'habitat' classes in the map have been classified:
3 = Classes defined on the basis of detailed biological analysis
2 = Classes defined on the basis of major characterising species or lifeforms
1 = Classes defined on the basis of physical information, or broad biological zones

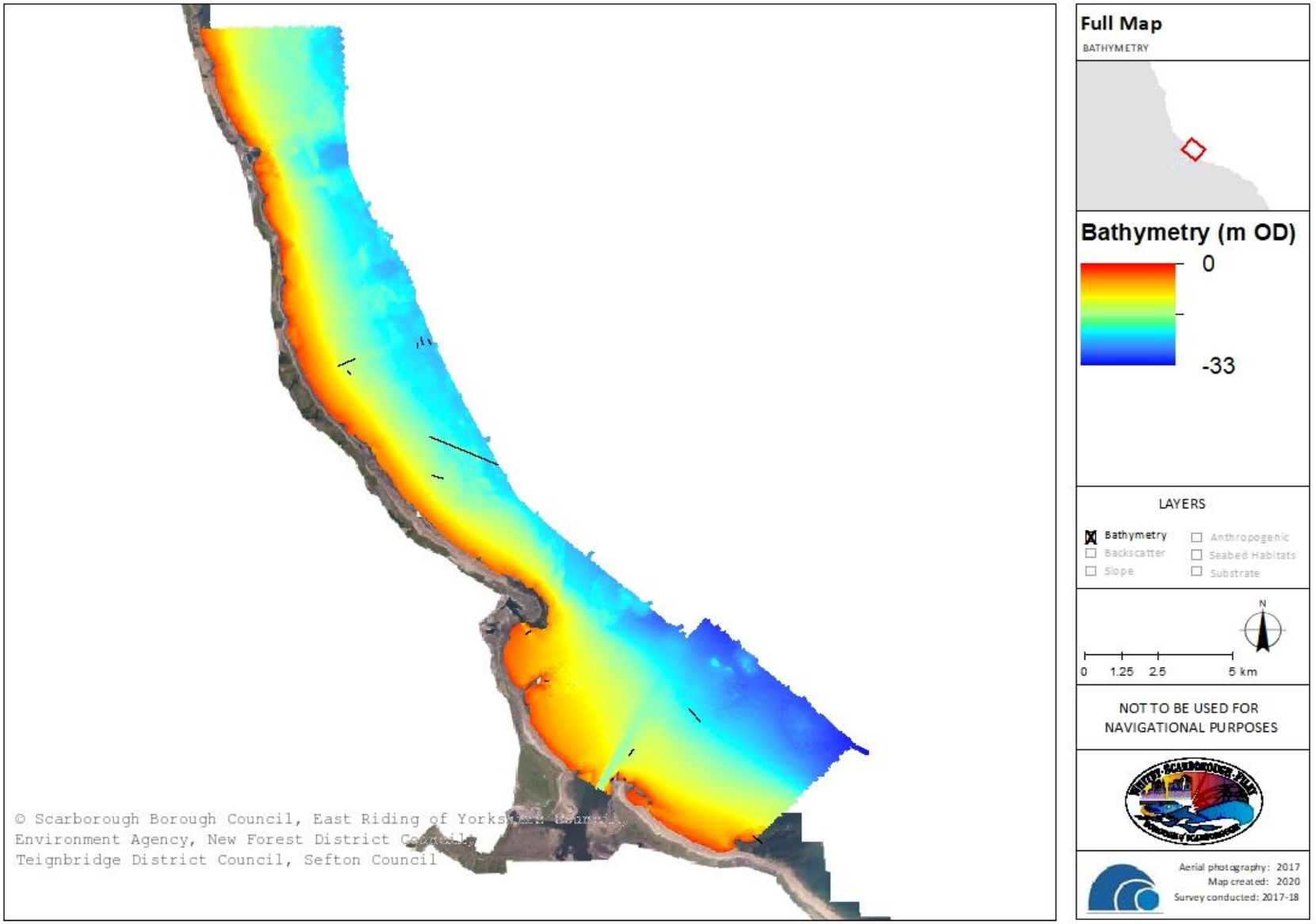
Map Accuracy
A test of the accuracy of the map:
3 = high accuracy, proven by external accuracy assessment
2 = high accuracy, proven by internal accuracy assessment
1 = low accuracy, proved by either external or internal assessment OR no accuracy assessment made

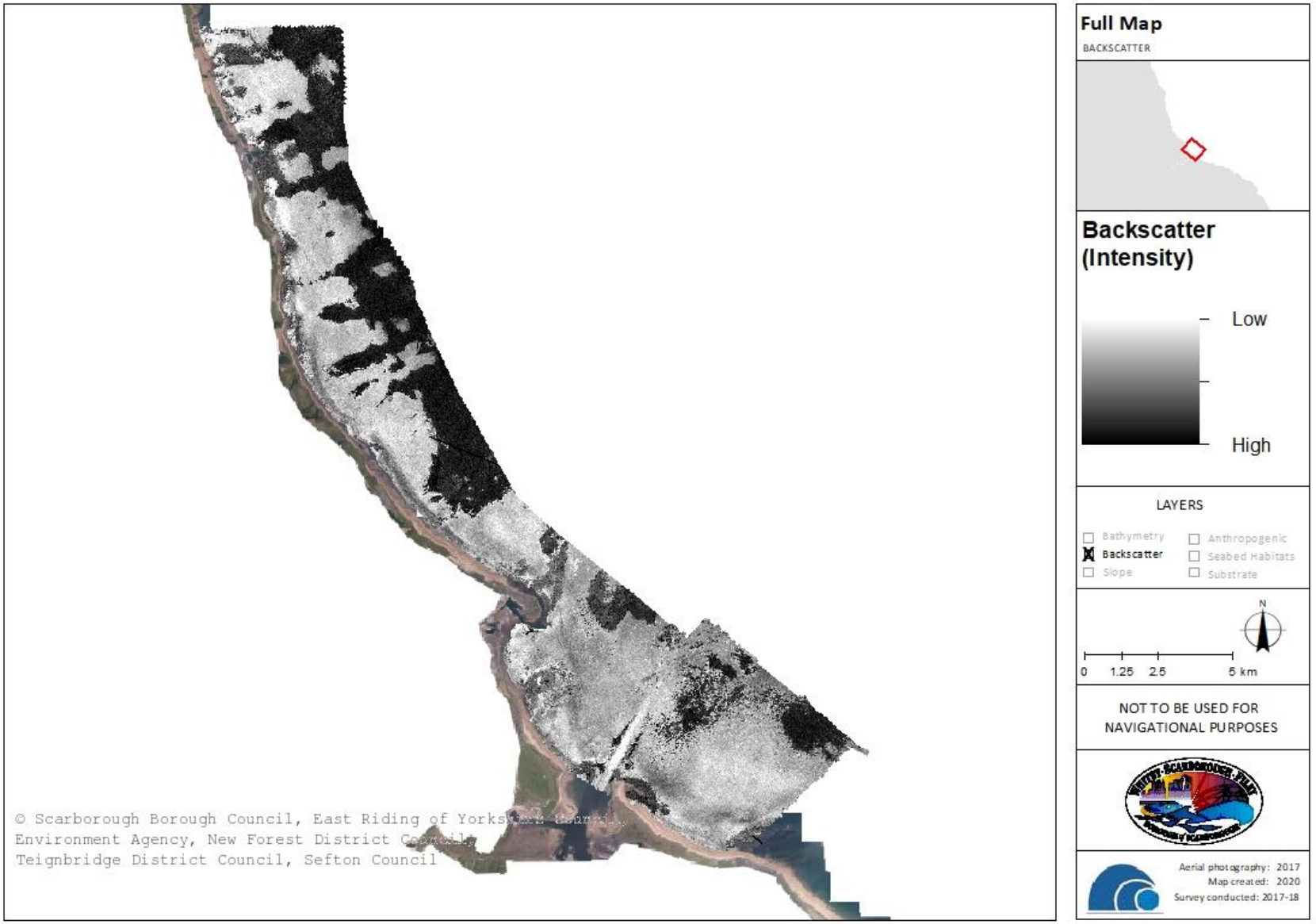
Annex 2 EUNIS Habitat Classification

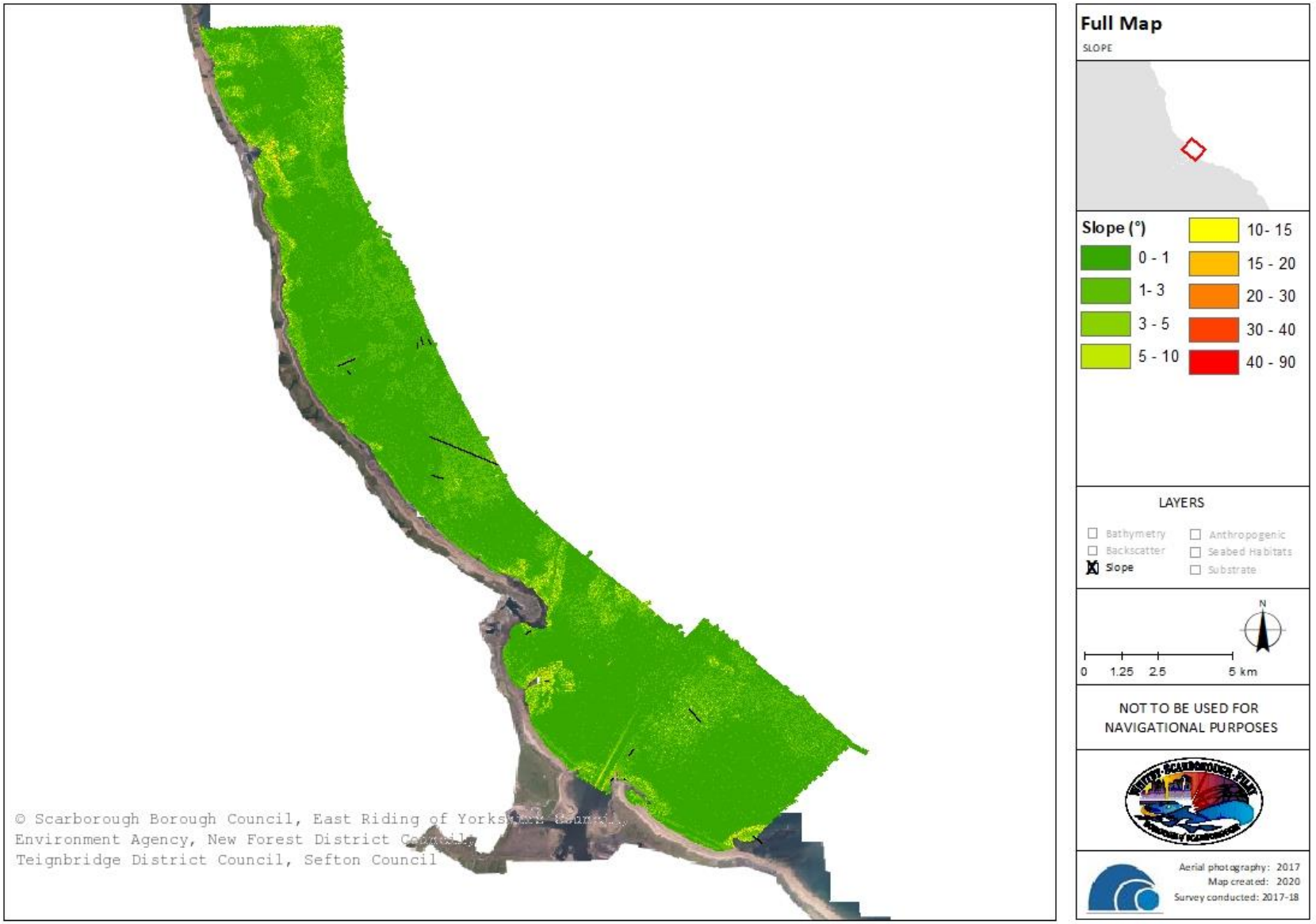
Name	Code	Description
High Energy Littoral Rock	A1.1	Extremely exposed to moderately exposed or tide-swept bedrock and boulder shores.
Littoral Coarse sediment	A2.1	Littoral coarse sediments include shores of mobile pebbles, cobbles and gravel, sometimes with varying amounts of coarse sand. The sediment is highly mobile and subject to high degrees of drying between tides.
Littoral Sand and muddy sand	A2.2	Shores comprising clean sands (coarse, medium or fine-grained) and muddy sands with up to 25% silt and clay fraction. Shells and stones may occasionally be present on the surface. The sand may be duned or rippled as a result of wave action or tidal currents. Littoral sands exhibit varying degrees of drying at low tide depending on the steepness of the shore, the sediment grade and the height on the shore.
Littoral Mixed sediment	A2.4	Shores of mixed sediments ranging from muds with gravel and sand components to mixed sediments with pebbles, gravels, sands and mud in more even proportions. By definition, mixed sediments are poorly sorted.
(Atlantic and Mediterranean) High Energy Infralittoral Rock	A3.1	Rocky habitats in the infralittoral zone subject to exposed to extremely exposed wave action or strong tidal streams.
(Atlantic and Mediterranean) Moderate Energy Infralittoral Rock	A3.2	Predominantly moderately wave-exposed bedrock and boulders, subject to moderately strong to weak tidal streams.
(Atlantic and Mediterranean) High Energy Circalittoral Rock	A4.1	Occurs on extremely wave-exposed to exposed circalittoral bedrock and boulders subject to tidal streams ranging from strong to very strong. Typically found in tidal straits and narrows.
(Atlantic and Mediterranean) Moderate Energy Circalittoral Rock	A4.2	Mainly occurs on exposed to moderately wave-exposed circalittoral bedrock and boulders, subject to moderately strong and weak tidal streams.
Sublittoral Coarse sediment	A5.1	Coarse sediments including coarse sand, gravel, pebbles, shingle and cobbles which are often unstable due to tidal currents and/or wave action. These habitats are generally found on the open coast or in tide-swept channels of marine

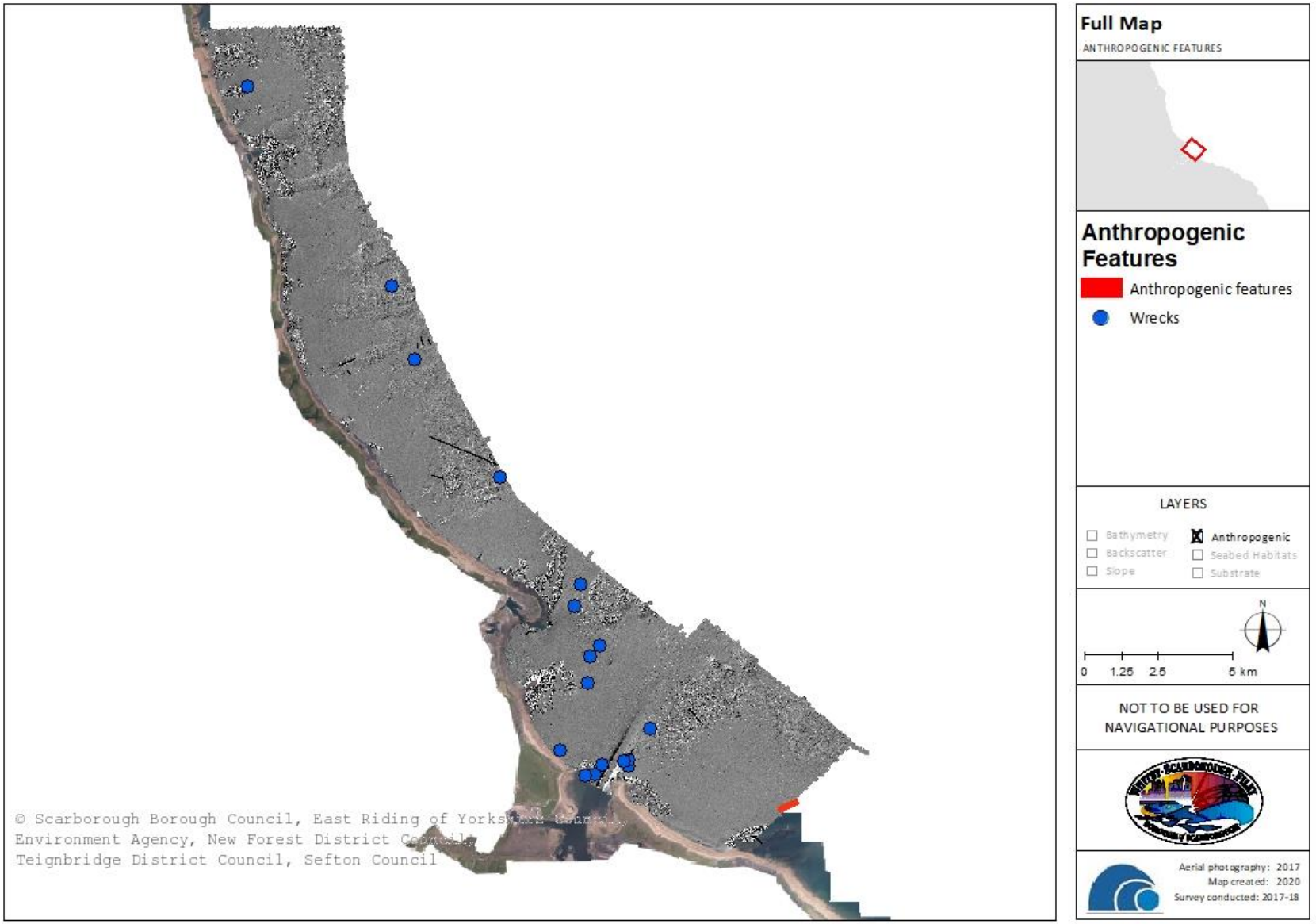
		inlets. They typically have a low silt content and a lack of a significant seaweed component.
Sublittoral Sand	A5.2	Clean medium to fine sands or non-cohesive slightly muddy sands on open coasts, offshore or in estuaries and marine inlets. Such habitats are often subject to a degree of wave action or tidal currents which restrict the silt and clay content to less than 15%.
Sublittoral Mixed sediment	A5.4	Sublittoral mixed (heterogeneous) sediments found from the extreme low water mark to deep offshore circalittoral habitats. These habitats incorporate a range of sediments including heterogeneous muddy gravelly sands and also mosaics of cobbles and pebbles embedded in or lying upon sand, gravel or mud.

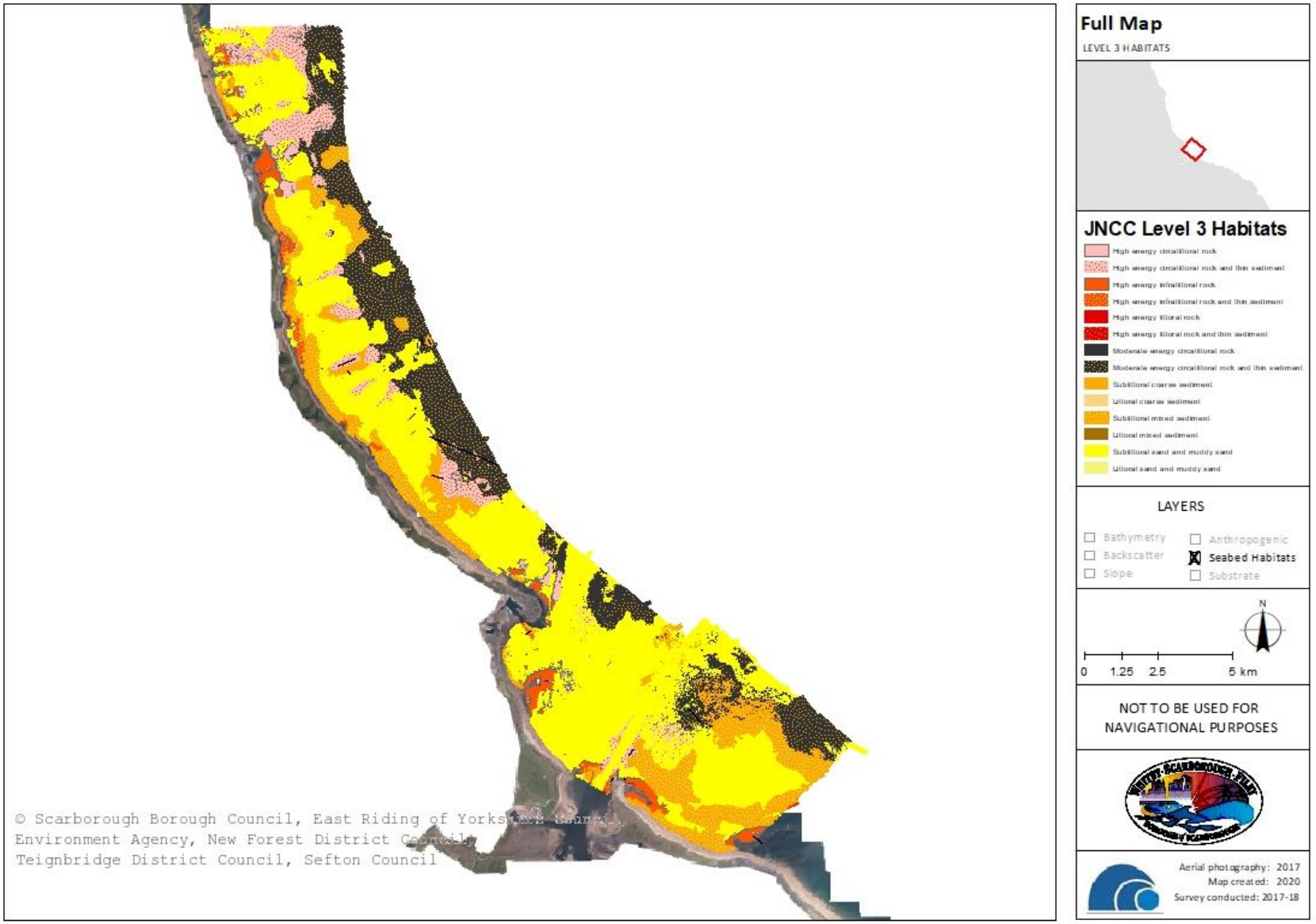
Annex 3 Full Maps

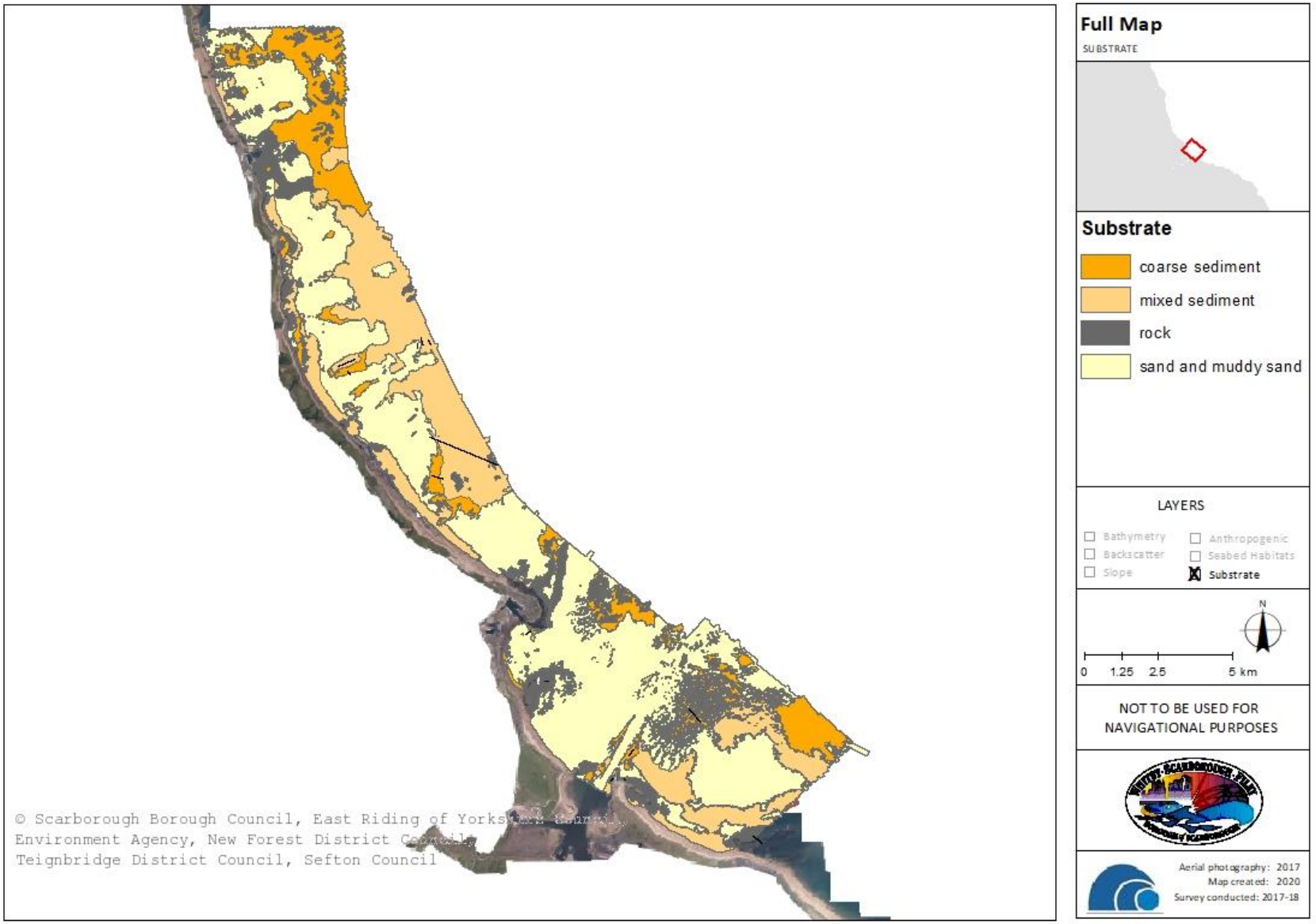

Full Map
BATHYMETRY
Bathymetry (m OD)
0
-33
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 1.25 2.5 5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18
© Scarborough Borough Council, East Riding of Yorkshire Council,
Environment Agency, New Forest District Council,
Teignbridge District Council, Sefton Council


© Scarborough Borough Council, East Riding of Yorkshire Council,
Environment Agency, New Forest District Council,
Teignbridge District Council, Sefton Council
Full Map
BACKSCATTER
Backscatter (Intensity)
Low
High
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 1.25 2.5 5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Full Map
SLOPE
Slope (°)
0 - 1
1- 3
3 - 5
5 - 10
10- 15
15 - 20
20 - 30
30 - 40
40 - 90
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 1.25 2.5 5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18
© Scarborough Borough Council, East Riding of Yorkshire Council,
Environment Agency, New Forest District Council,
Teignbridge District Council, Sefton Council


© Scarborough Borough Council, East Riding of Yorkshire Council,
Environment Agency, New Forest District Council,
Teignbridge District Council, Sefton Council
Full Map
ANTHROPOGENIC FEATURES
Anthropogenic Features
Anthropogenic features
Wrecks
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 1.25 2.5 5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18


Full Map
LEVEL 3 HABITATS
JNCC Level 3 Habitats
High energy circalittoral rock
High energy circalittoral rock and thin sediment
High energy infralittoral rock
High energy infralittoral rock and thin sediment
High energy littoral rock
High energy littoral rock and thin sediment
Moderate energy circalittoral rock
Moderate energy circalittoral rock and thin sediment
Sublittoral coarse sediment
Littoral coarse sediment
Sublittoral mixed sediment
Littoral mixed sediment
Sublittoral sand and muddy sand
Littoral sand and muddy sand
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 1.25 2.5 5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18
© Scarborough Borough Council, East Riding of Yorkshire Council,
Environment Agency, New Forest District Council,
Teignbridge District Council, Sefton Council


Full Map
SUBSTRATE
Substrate
coarse sediment
mixed sediment
rock
sand and muddy sand
LAYERS
Bathymetry
Backscatter
Slope
Anthropogenic
Seabed Habitats
Substrate
N
0 1.25 2.5 5 km
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18
© Scarborough Borough Council, East Riding of Yorkshire Council,
Environment Agency, New Forest District Council,
Teignbridge District Council, Sefton Council

Full Map

GRAB SAMPLE LOCATIONS

Sediment sample locations

N

0 1.25 2.5 5 km

NOT TO BE USED FOR NAVIGATIONAL PURPOSES

Aerial photography: 2017
Map created: 2020
Survey conducted: 2017-18