





**Cambois Connection – Marine Scheme  
Environmental Statement – Volume 3  
Appendix 8.2: Intertidal Survey Report**

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# Ocean Ecology

Marine Surveys, Analysis & Consultancy

## Cambois Connection Intertidal Survey Report

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## Abbreviations

<b>BSH</b>	Broadscale Habitat
<b>CAA</b>	Civil Aviation Authority
<b>CEEI</b>	Conservation, Ecological and Economic Importance
<b>DEM</b>	Digital Elevation Model
<b>EIA</b>	Environmental Impact Assessment
<b>EMODnet</b>	European Marine Observation and Data Network
<b>EUNIS</b>	European Nature Information System
<b>FOCI</b>	Features of Conservation Interest
<b>GPS</b>	Global Positioning System
<b>GSD</b>	Ground-Sampling Distance
<b>HOCI</b>	Habitat of Conservation Interest
<b>INNS</b>	Invasive Non-Native Species
<b>JNCC</b>	Joint Nature Conservation Committee
<b>MCZ</b>	Marine Conservation Zone
<b>MHWS</b>	Mean High Water Springs
<b>MLWS</b>	Mean Low Water Springs
<b>MNCR</b>	Marine Habitat Classification for Britain and Ireland
<b>MMO</b>	Marine Management Organisation
<b>NERC</b>	Natural Environment and Rural Communities
<b>OEL</b>	Ocean Ecology Ltd
<b>PfCO</b>	Permission for Commercial Operations
<b>RMSE</b>	Root-Mean-Square Error
<b>RPQs</b>	Qualified UAV Pilots
<b>SAC</b>	Special Areas of Conservation
<b>SPA</b>	Special Protection Area
<b>SOCI</b>	Species of Conservation Interest
<b>SSSI</b>	Site of Special Scientific Interest
<b>UAV</b>	Unmanned Aerial Vehicle



## Non-Technical Summary

This report presents the findings of an intertidal survey conducted at Cambois Beach, at the proposed Landfall location for the Cambois Connection associated with the Berwick Bank Offshore Wind Farm (OWF). The key aim was to characterise and map the benthic habitats present across the intertidal zone associated with the cable landfall area.

The survey took place at two sites along Cambois Beach, Northumberland and involved the collection of aerial imagery accompanied by walkover surveys to gather detailed information on the benthic communities present for subsequent habitat / biotope mapping purposes. A comprehensive suite of images and target notes were collected across the full extent of the intertidal survey areas at each site between Mean Low Water Springs (MLWS) and Mean High Water Springs (MHWS). A wide range of broadscale littoral rock and sediment habitats were identified, typical of the Northumberland coastline. Following detailed review, the information collected during the survey was used to produce full coverage habitat / biotope mapping for both survey areas, as well as mapping for each habitat of conservation interest observed.

Both north and south survey areas were found to be dominated by littoral sediment habitats (A2.1 and A2.2) with areas of moderate energy rocky habitats (A1.2), supporting a very sparse community of barnacles and furoids. A greater diversity of habitats was observed within the south survey area, with a large area of shifting coastal sand dune (B1.3), under-bordered by moderate energy cobbles and boulders, identified along the upper shore.

Rocky habitats (mainly composed of cobble and small boulders) were observed at both sites; however, these did not extend into the subtidal zone and as such were not deemed to qualify as Annex I reefs under the EU Habitats Directive.

The shifting coastal dunes (B1.3) habitat identified in the south survey area is protected under Section 41 of the NERC Act as a 'Coastal sand dune'.

No biogenic reef habitat or invasive non-native species (INNS) were observed across the two survey areas.

## 1. Introduction

### 1.1. Project Overview

The survey area was split into two intertidal sites: Site 1 (South) and Site 2 (North) of the cable landfall site on Cambois Beach, Northumberland.

Onshore transmission works comprise the landfall, onshore cable route, substation, and any temporary infrastructure/works.

### 1.2. Background Information

To progress this development, an Environmental Impact Assessment (EIA) is needed for the Cambois Connection Marine Scheme marine licence application submissions to Marine Scotland, and the Marine Management Organisation (MMO). Ocean Ecology Limited (OEL) was commissioned by XODUS to undertake an intertidal habitat survey of the landfall area at Cambois Beach, Northumberland. An intertidal habitat survey was required to characterise and map the intertidal area in Figure 1. The survey area was firstly mapped using an Unmanned Area Vehicle (UAV) to cover the intertidal extent of the landfall location and immediate surrounds. Secondly, an intertidal walkover survey was conducted to ground truth the UAV data along with characterising habitats and species.

This report provides a summary of the survey methodologies employed and detailed mapping of the habitats encountered during the survey. Habitats were determined through detailed interpretation of the UAV imagery, analysis of walkover site images and review of target notes collected in the field allowing for the determination of EUNIS habitats and biotopes (where possible) and subsequent creation of full coverage mapping across the survey areas.

### 1.3. Aims and Objectives

The preliminary aim was to support environmental consenting to permit construction activities. The key objective of the survey was to map the distribution and extent of individual or groups of sediment type and broadscale habitats. A key focus was to also confirm the presence/absence of any habitats and/or features of conservation interest known to occur across the landfalls (e.g., reef and/or mudflats).

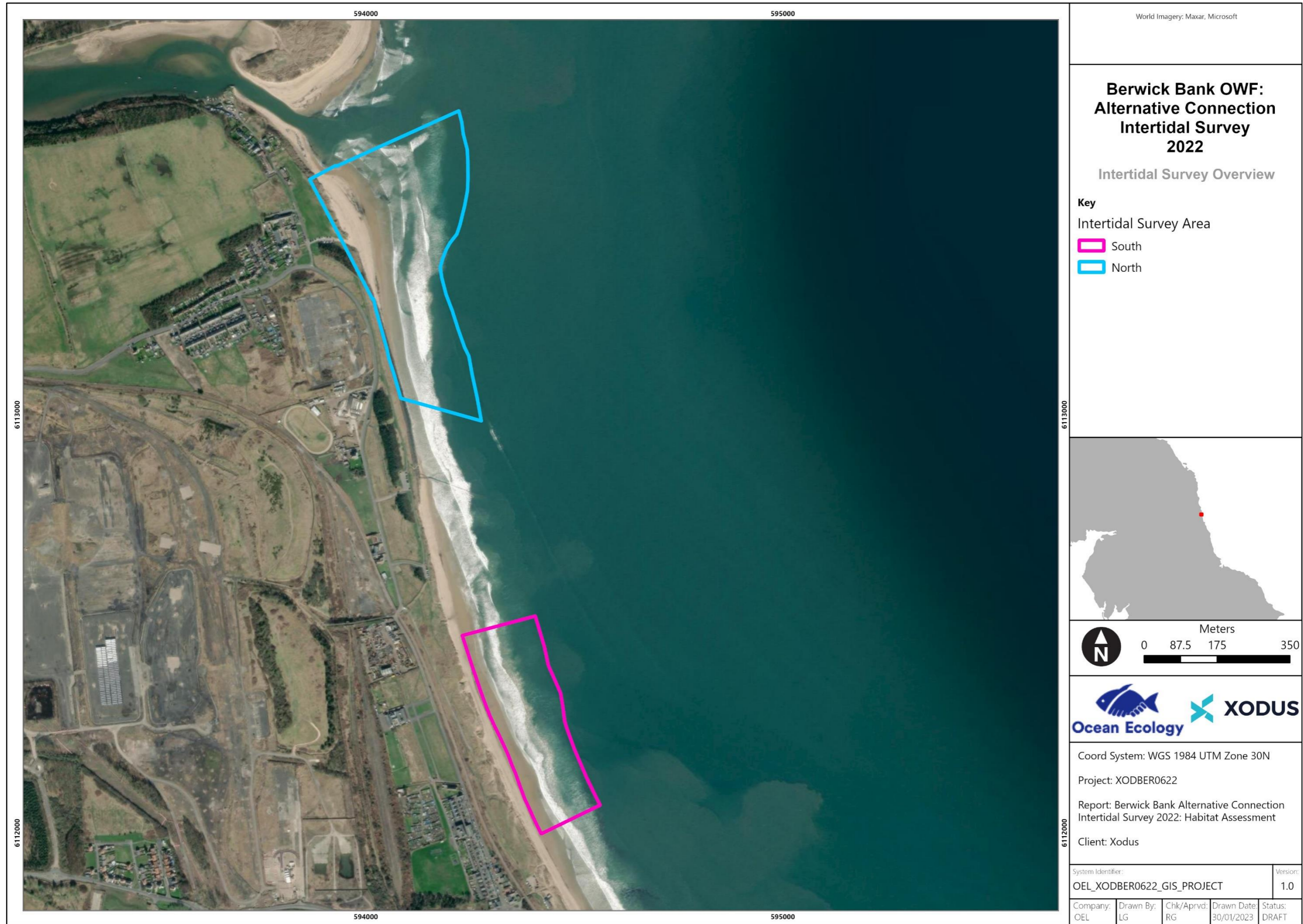


Figure 1 North and South inshore intertidal survey area at Cambois Beach, Northumberland.

## 2. Existing Data

### 2.1. Existing Habitat Mapping

The 2021 EUSeaMap broad-scale predictive model classifies and maps intertidal and subtidal habitats according to the European Nature Information Systems (EUNIS) classification criteria. The system is able to identify keystone species that have been evidenced to inhabit areas with certain environmental conditions and can therefore act as an indicator, allowing inferences of overall community composition. The EUSeaMap data indicated that the habitats present in proximity of the intertidal survey area primarily consisted of Atlantic and Mediterranean high energy infralittoral rock (A3.1) and Atlantic and Mediterranean low energy infralittoral rock (A3.3) as mapped in Figure 2.

### 2.2. Designations

#### 2.2.1 Northumberland Marine Special Protection Area (SPA)

European Commission Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora, commonly known as the 'Habitats Directive' ensured the conservation of a wide range of rare, threatened endemic animal and plant species as well as habitats. The EU Habitats Directive (1992) was transposed into UK law by The Conservation of Habitats and Species Regulations 2017 within 12 nautical miles (nm), and The Conservation of Offshore Marine Habitats and Species Regulations 2017 between 12 nm out to 200 nm or the UK Continental Shelf. Under these regulations, the Northumberland Marine SPA was established in Berwickshire and Northumberland, with its extent encompassing both survey sites (Figure 3). The SPA was designated to protect internationally important breeding seabirds which occur on the Northumberland coast and the offshore areas which these birds use for feeding.

#### 2.2.2 Northumberland Shore Site of Special Scientific Interest (SSSI)

Section 28(1) of the Wildlife and Countryside Act 1981 granted designation to sites of special scientific interest (SSSI) due to the flora or fauna present or the area's geological or physiography. The Northumberland Shore SSSI occupies the stretch of coast that includes both survey sites (Figure 3). This area was designated for the protection of 6 species of non-breeding birds and two main habitats: littoral rock and littoral sediments.

#### 2.2.3 Berwick to St Mary's Marine Conservation Zone (MCZ)

The Marine and Coastal Access Act (2009) provides the legal mechanism to assist in the conservation and enable the recovery of protected wildlife and habitats within Marine Conservation Zones (MCZ). Both survey sites are encompassed by the Berwick to St Mary's MCZ which was established in 2019 for the conservation of common eider during both breeding and non-breeding seasons (Figure 3).

#### 2.2.4 Features of Conservation Interest (FOCI)

Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 defined a list of habitats (HOCl) and species (SOCl) of principal importance for the conservation of biodiversity in England. Several records of SOCl have previously been identified within proximity to the intertidal survey areas, including European eel (*Anguilla anguilla*) and ocean quahog (*Arctica islandica*) (Figure 3).

#### 2.2.5 Coastal Sand Dune

Coastal sand dunes are sand-formed ridge or hill structures, beyond the reach of tides. The HOCl Coastal Sand Dunes is present at the rear of the south survey area and to the north of the north survey area (Figure 3). This habitat also contains Annex I embryonic shifting dunes; shifting dunes along the shoreline with *Ammophila arenaria* and fixed coastal dunes with herbaceous vegetation, which are supporting features for the North Northumberland Dunes Special Area of Conservation (SAC).

#### 2.2.6 Reef

Reefs are rocky marine habitats or biological concretions (e.g., *Sabellaria* reefs or mussel beds) that rise from the seabed. They are generally subtidal but may extend as an unbroken transition into the intertidal zone where they are exposed to the air at low tide. Intertidal areas qualify as Annex I reefs under the EU Habitats Directive only where they are connected to subtidal reefs. Data obtained from the Joint Nature Conservation Committee (JNCC, 2022) and the European Marine Observation and Data Network (European Marine Observation and Data Network, 2018) indicated that Annex I reefs have also been previously mapped in the vicinity of the survey areas in correspondence of EUNIS classifications A3.1, A4.1, A4.2 and A3.3 (Figure 2).

*Sabellaria* reefs and intertidal boulder communities also qualify as HOCl under Section 41 of the NERC Act regardless of whether they are connected to subtidal features.

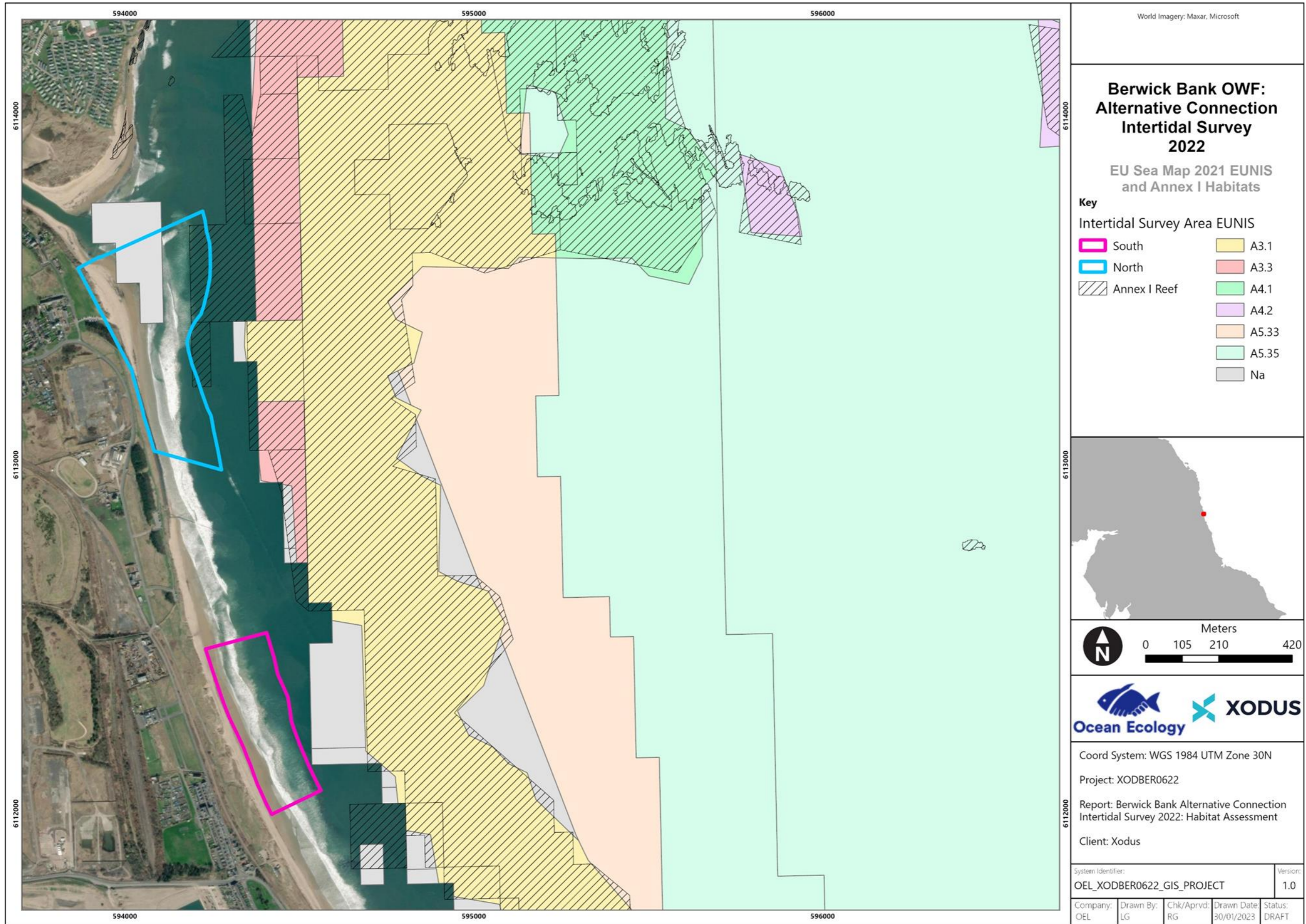


Figure 2 Predicted EUNIS habitats from EU Sea Map 2021 at Cambois Beach, Northumberland (Vasquez et al., 2021).

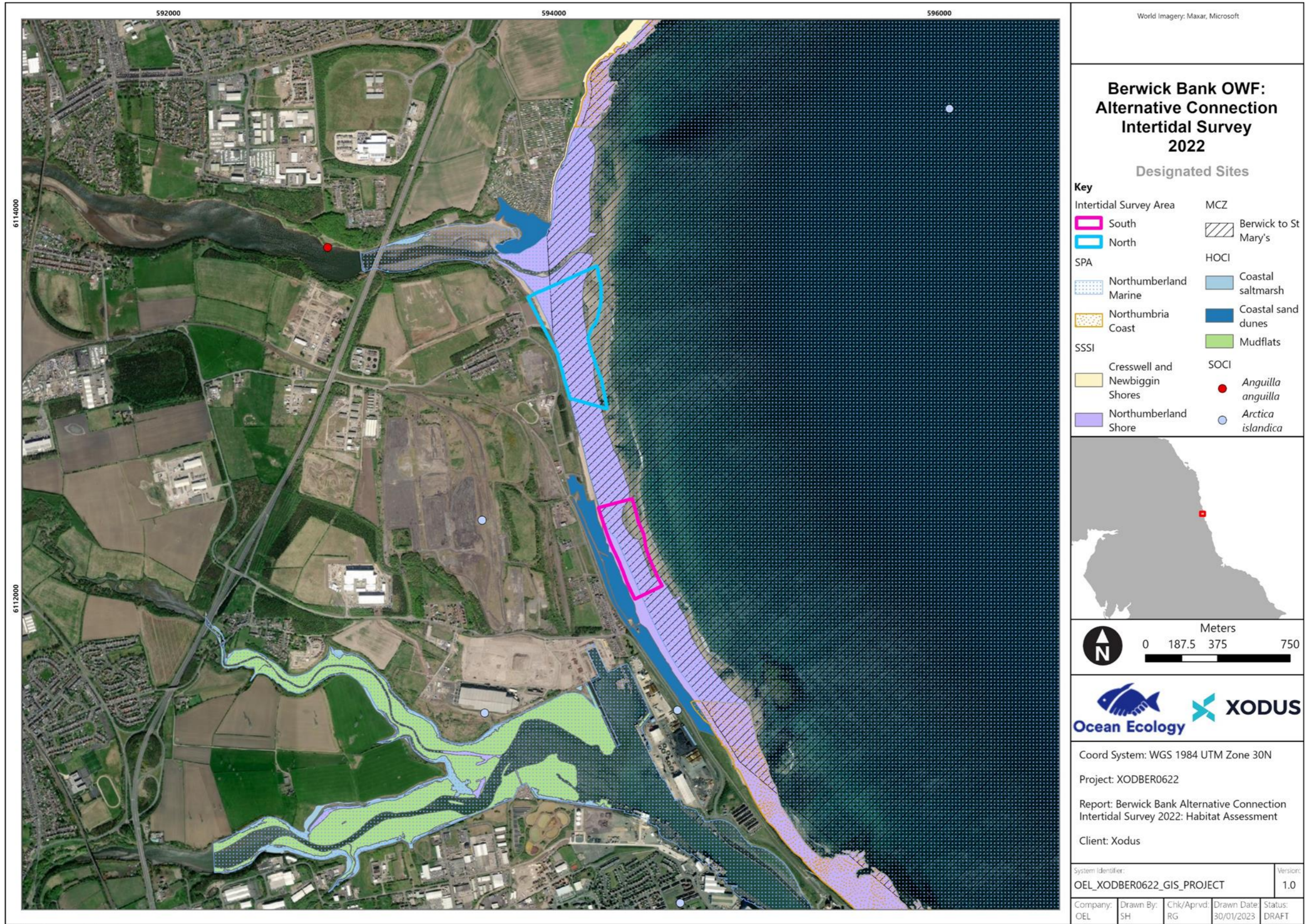


Figure 3 Designated sites in proximity of the intertidal survey area at Cambois Beach, Northumberland.

## 3. Methods

### 3.1 Survey Methods

The intertidal survey covered the two proposed cable landing locations near Blyth, extending from Mean Low Water Springs (MLWS) to Mean High Water Springs (MHWS). An UAV survey was undertaken to collect high-resolution imagery across the survey areas at low water (Figure 4). The survey area included a large, discharged outfall pipeline in the middle of the survey area, which was supported by wooden beams in the lower shore, the pipeline was crossed at breaks in the structure.

#### 3.1.1. Walkover Survey

The walkover survey was undertaken using ESRI Field Maps app on a Bad Elf GPS and GLONASS (2.5 m accuracy) enabled tablet device in line guidance in the Marine Monitoring Handbook (Davies et al., 2001), the CCW Handbook for Marine Intertidal Phase I Survey and Mapping (Wyn et al., 2006) and the latest guidance for characterising intertidal rocky shore and sediment habitats (NRW, 2019). During the walkover survey EUNIS classifications were assigned in consideration of the latest JNCC guidance (Parry, 2019). These were correlated to the Marine Habitat Classification for Britain and Ireland (MNCR) and, where possible, boundaries of habitats / biotopes tracked as polygons in ESRI Field Maps.

Representative examples of each habitat / biotope encountered were photographed. Additionally, the distribution of any features of conservation interest was recorded using photographs and GPS fixes where encountered. The presence of Invasive Non-Native Species (INNS) was also to be noted and their location recorded if encountered. Other information recorded included general site conditions, sediment surface features (e.g., *Lanice conchilega* tube aggregations), sediment type and characteristics, topography, and evidence of any anthropogenic pressures.

Target notes were taken at any notable change in habitat / substrate and identified the presence of any notable features (e.g., intertidal rockpools). These were accompanied by GPS fixes and close-up photographs of each feature, along with general site photographs. Aspect images to the North, East, South and West from each target location were also taken.

#### 3.1.2. UAV Mapping

UAV surveys were undertaken to collect high-resolution imagery across the survey areas at low water. UAV mapping was carried out in consideration of JNCC guidance for use of UAVs in marine benthic monitoring (Crabb et al., 2019). All flights were conducted by OELs Qualified UAV Pilots (Remote Pilot Qualification (RPQs)) under its Permission for Commercial Operations (PfCO) granted by the Civil Aviation Authority (CAA). The UAV used was a DJI Phantom 4 multi-rotor quadcopter. The flight(s) were pre-planned using in Drone Deploy software with line orientation to maximise survey efficiency.



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Full details of the methodologies employed are provided in Annex I.

## 3.2. Analysis

### 3.2.1. UAV Imagery Analysis

Following initial screening to remove any erroneous images, all images collected during the UAV mapping flights underwent Terrain (2D) processing in the Drone Deploy software and were 'stitched' together to generate orthomosaic and Digital Elevation Model (DEM) outputs<sup>1</sup> for the intertidal survey area. Achieved image resolution was ~12 mega pixels with an average orthomosaic image density of 8 images per pixel for both survey areas. A detailed processing and output quality report for each intertidal survey area is provided in Annex I.

The outputs were then used as base maps in GIS to facilitate subsequent habitat / biotope mapping by visual interrogation and delineation of boundaries.

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<sup>1</sup> Note that Ground Control Points (GCPs) were not used to georeference the DEM outputs using real-time kinematic (RTK) GPS coordinates. As such the real-world position of the DEM output are presented subject to error associated with the drone's GPS accuracy whilst the elevation data is presented relative to the take off position of the drone rather than absolute elevation (i.e., Mean Sea Level - MSL). As such the DEM outputs were only used to broadly inform the habitat mapping and should not be used for construction planning and/or navigation purposes.

### 3.3. EUNIS Classification Mapping

EUNIS habitats and biotopes were identified in consideration of JNCC guidance on assigning benthic biotopes (Parry, 2019) to allow the communities to be mapped and allow comparison with existing data. All habitat / biotope determination was undertaken through consideration of the following:

- Existing habitat mapping (derived from EMODnet)
- UAV imagery interpretation
- Review and interpretation of target field notes and imagery
- General site imagery

All mapping processes were conducted in ESRI ArcPro Version 3.0.3. UAV imagery alongside target points notes and photos were used to manually delineate the boundaries (polygons) of the various habitats and biotopes encountered across the survey area. Confidence scores were assigned to each polygon to give an indication of their accuracy. Highest scores were given to polygons where all data sources identified the same habitat/biotope, with distinct boundaries. Lower scores were assigned to polygons where data was limited, and boundaries not obvious. In these cases, polygons were drawn based upon expert judgement, given the information available.

## 4. Results

### 4.1. Survey Progress

The walk over surveys were undertaken across the two sites at Cambois beach near Blyth between 11<sup>th</sup> and 14<sup>th</sup> of December. Table 1 provides a summary of the sampling undertaken and information collected during the surveys.

**Table 1** Summary of sampling undertaken, and information collected during the intertidal survey.

Sampling	South	North
Target Notes	58	63
UAV Imagery	254 Images	387 Images

### 4.2. UAV Survey

UAV imagery was collected at Cambois beach around low water periods on the 12<sup>th</sup> December 2022 (Figure 4). Weather conditions (e.g., wind / precipitation) remained favourable for data collection throughout the survey.

The UAV flight across the south survey area successfully captured 254 high-resolution nadir images across a coverage area of 0.241 km<sup>2</sup> to produce a high resolution orthomosaic model (GSD = 1.94 cm/px) and DEM (GSD = 7.74 cm/px) with an average RSME accuracy level of 1.31 m.

The UAV survey of the north survey area successfully captured 387 high-resolution nadir images across a coverage area of 0.414 km<sup>2</sup> to produce a high resolution orthomosaic model (GSD = 2.18 cm/px) and DEM (GSD = 8.72 cm/px) with an average RSME accuracy level of 1.50 m.

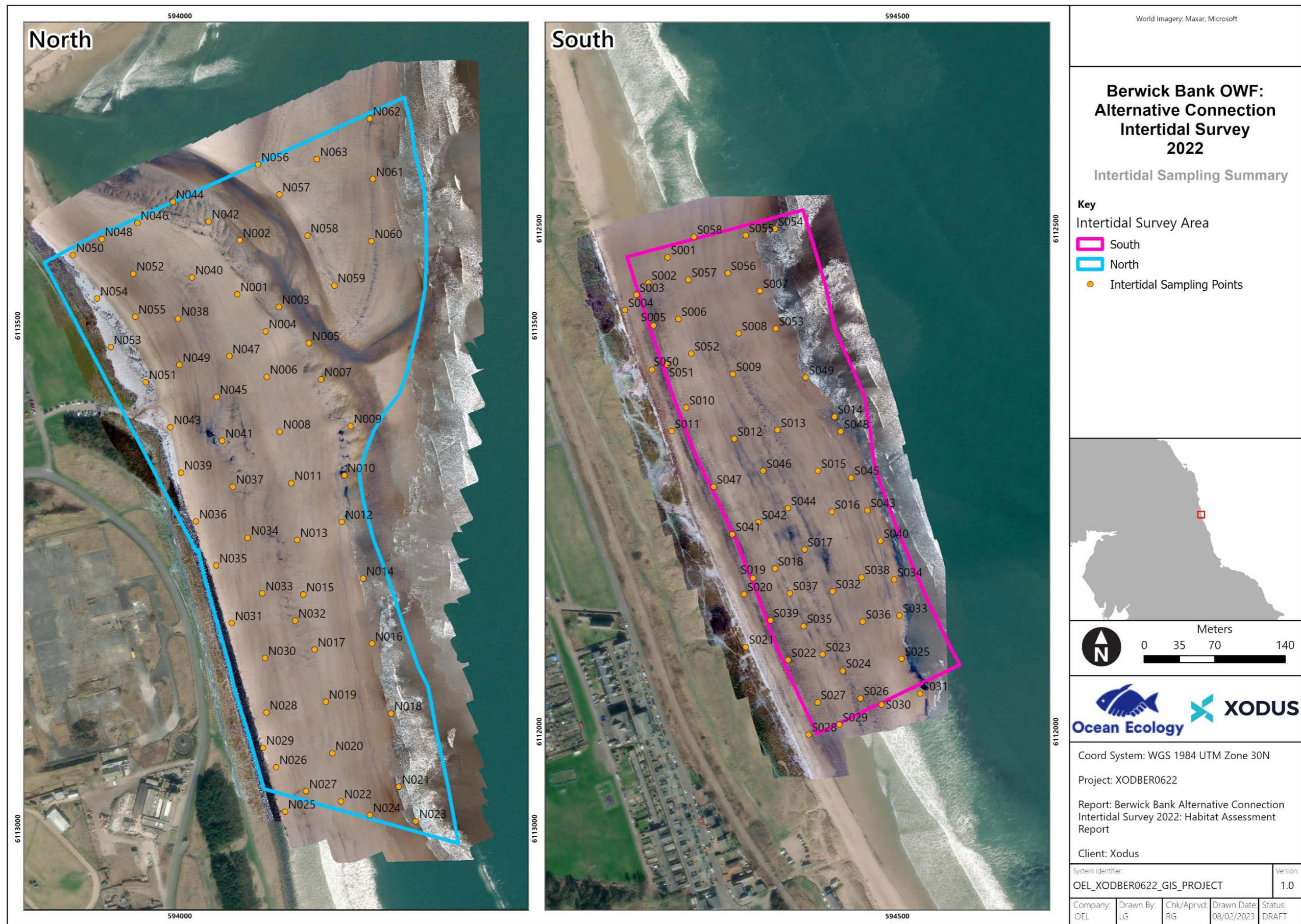
Example aerial images are provided in Plate 1. The full orthomosaic, DEM and 3D model outputs are provided as Annex I along with processing reports.

### 4.3. Target Notes

In total, target notes were taken at 121 locations (58 at the south and 63 at the north survey areas) to provide localised information on habitats and features of interest present across the intertidal areas, to assist in ground truthing of UAV aerial imagery (Figure 4). Full intertidal survey logs for survey areas are provided in Annex II and III, respectively.



**Plate 1** Example UAV imagery at the north survey area (top) showing littoral sand graduating into moderate energy rocky habitat (right) and the south survey area (bottom) showing sand dune habitat under-bordered by moderate energy littoral rock (left) and a mosaic of sediment habitats (right).



**Figure 4** Location of target notes, collected across the north (left) and south (right) survey areas, overlain on orthomosaics generated from UAV imagery at Cambois Beach, Northumberland.

## 4.4. Habitat / Biotope Mapping

### 4.4.1. South Survey Area

There was a total of four BSHs (Table 2) observed across the south survey area as mapped in Figure 5. No unique biotopes (EUNIS level 5 or above) were identified.

The majority of the intertidal survey area was characterised by littoral sand (A2.2). A clear zonation characterised this survey area, where habitats graded from littoral sand (A2.2) on the lower and mid-shore, to littoral coarse sediment (A2.1) and fringing sand dunes (B1.3) on the upper shore.

Along the north and central upper shore of the intertidal survey area, moderate energy littoral rock (A1.2), comprising cobbles and small boulders, was identified between sand dune (B1.3) and sandy shore (A2.2) habitats.

No notable taxa (INNS or species of commercial value) were observed during the walkover survey.

The habitat mapping presented in Figure 5 is provided in shapefile (.shp) format as Annex IV.

**Table 2** Key EUNIS classifications recorded across the south survey area.

EUNIS BSH	EUNIS Biotope	EUNIS Description	Designation
A1.2 – Moderate energy littoral rock	-	Moderate energy littoral rock	-
A2.1 – Littoral coarse sediment	-	Littoral coarse sediment	-
A2.2 – Littoral sand and muddy sand	-	Littoral sand and muddy sand	-
B1.3 – Coastal dunes and sandy shores	-	Coastal dunes and sandy shores	Coastal Sand Dunes (Section 41 of NERC Act) Potential Annex I Dunes

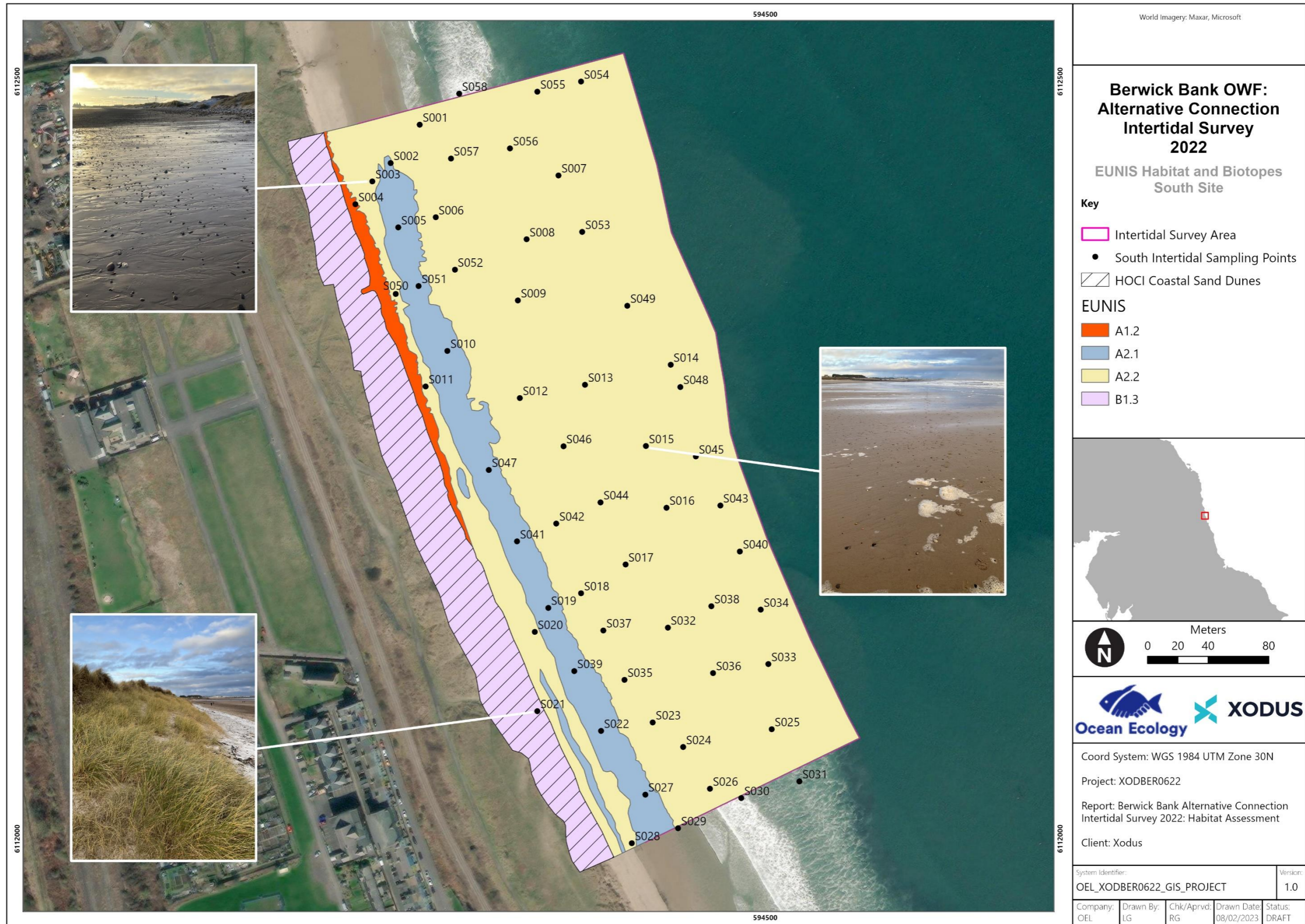


Figure 5 EUNIS habitat and biotope mapping with sampling locations visited during the walkover survey of the south survey area at Cambois Beach, Northumberland.

#### 4.4.2. North Survey Area

There was a total of three BSHs (Table 3) observed across the south survey area as mapped in Figure 6. No unique biotopes (EUNIS level 5 or above) were identified.

The majority of the intertidal survey area was characterised by littoral sand (A2.2). To the north of the survey area, across the lower shore, littoral sand was interspersed with small areas of littoral coarse sediment (A2.1). Along the north upper shore, littoral sand was interspersed with strandline (A2.21).

Along the extreme upper shore of the central and south of the intertidal survey area, moderate energy rocky habitat (A1.2), installed for sea defence purposes, was observed, supporting a sparse community of barnacles and furoids. This habitat was backed by a steep grassland bank to the rear of the survey area.

No notable taxa (INNS, species of commercial value etc.) were observed during the walkover survey.

The habitat mapping presented in Figure 6 is provided in shapefile (.shp) format as Annex IV.

**Table 3** Key EUNIS classifications recorded across the north survey area.

EUNIS BSH	EUNIS Code	EUNIS Description	Designation
A1.2 – Moderate energy littoral rock	-	Moderate energy littoral rock	-
A2.1 – Littoral coarse sediment	-	Littoral coarse sediment	-
A2.2 - Littoral sand and muddy sand	A2.21	Strandline	-



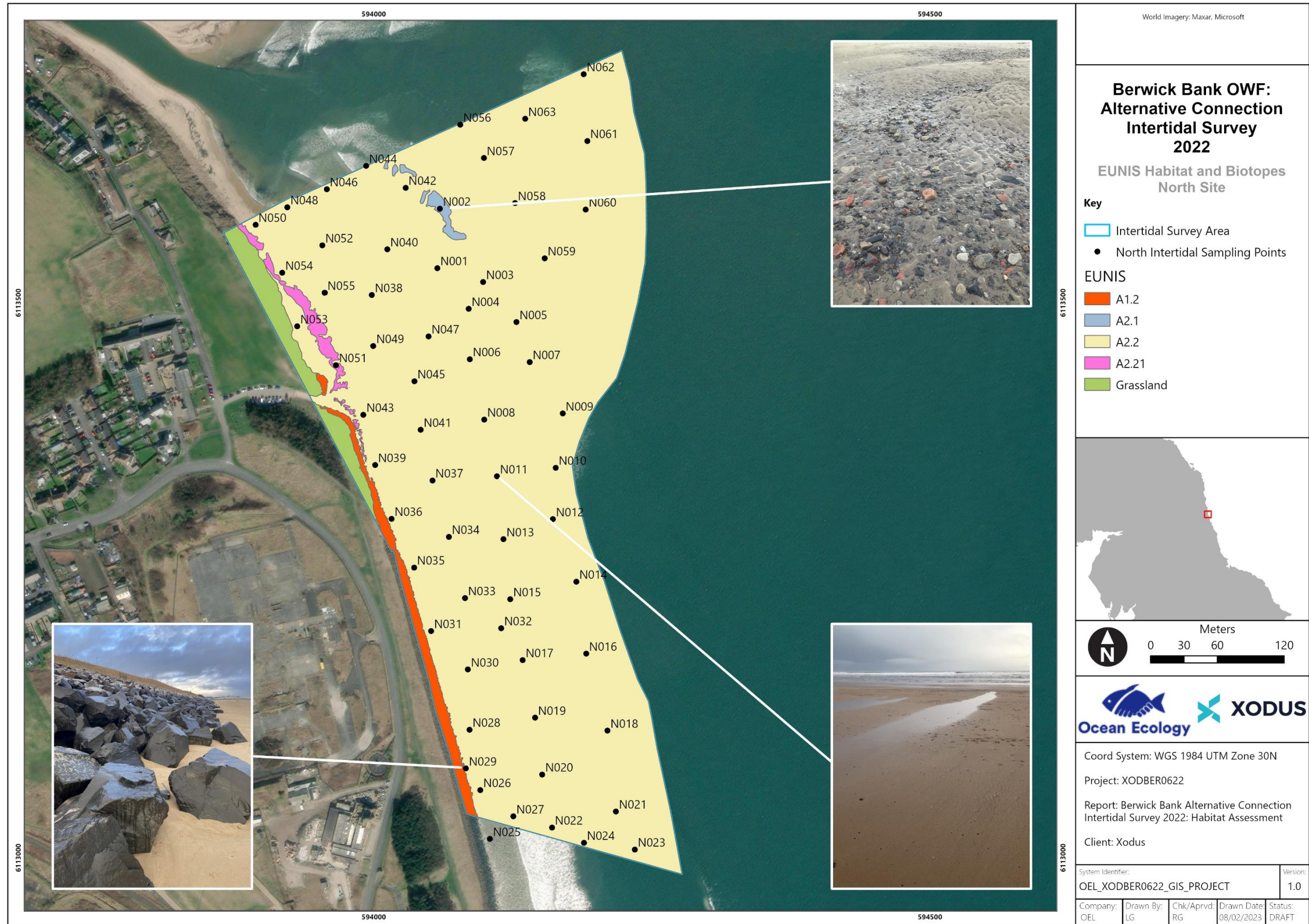


Figure 6 EUNIS habitat and biotope mapping with sampling locations visited during the walkover survey of the north survey area at Cambois Beach, Northumberland.

## 4.5. Features of Conservation Interest

No INNS, biogenic reefs or intertidal under boulder communities were recorded across the two survey areas.

### 4.5.1. Reefs

Both intertidal survey areas were characterised by occasional large areas of rocky habitats comprising moderately exposed boulders and cobbles. Within the north intertidal survey area, rocky habitats supported a sparse community of barnacles and fucoids.

To qualify as an Annex I reef, intertidal rocky features must continue into the subtidal zone. Habitat mapping for the area did not indicate that the rocky habitats mapped in the intertidal zone continued into the subtidal zone, as such no Annex I reef was identified across the two survey areas.

### 4.5.2. Coastal Sand Dunes

Shifting coastal sand dunes (B1.3) were observed and noted at sampling stations S003, S004, S011, S020, S021 and S047 during the south site intertidal walkover survey, along the upper shore (Figure 5, Plate 2). Coastal sand dunes are a HOCl under Section 41 of the NERC and a supporting feature of the North Northumberland Dunes SAC.

Shifting coastal dune habitat (B1.3) also has the potential to qualify as Annex I Embryonic shifting dunes or Shifting dunes along the shoreline with *A. arenaria*, however this area was outside of the scope of this intertidal habitat assessment, beyond the MHWS mark.



**Plate 2** Example imagery of EUNIS classification B1.3 coastal dunes and sandy shores.

## 5. Discussion

This report presents the findings and habitat mapping outputs of the intertidal surveys conducted across locations south and north of the cable landing site, to support environmental consenting to permit decommissioning activities. The surveys involved the collection of UAV aerial imagery accompanied by walkover surveys. The key objective was to map the distribution and extent of individual or groups of broadscale habitats, biotopes, biotope complexes and life forms present as well as confirming the presence/absence of any habitats and/or features of conservation interest (e.g., reef habitats).

A limited range of habitats characterised both survey areas, which were dominated by a variety of littoral sediment habitats (A2.1, A2.2). A clear habitat zonation was observed across the south survey area from littoral sand and muddy sand (A2.2) to littoral coarse sediments (A2.1) and shifting coastal sand dunes (B1.3) on the upper shore. A greater diversity of habitats was observed to the north of this survey area, with a large area of moderate energy rock habitat (A1.2) under-bordering the sand dune fringe. Habitat zonation was less apparent across the north survey area, which was characterised by littoral sand (A2.2) interspersed with small areas of littoral coarse sediment (A2.1) and strandline (A2.21). Moderate energy rocky habitat (A1.2), supporting a sparse community of barnacles and fucoids, was present along the upper shore.

Areas of littoral rock habitats were mapped across both the south and north survey areas. To qualify as Annex I reefs, intertidal habitats must be connected continuously to subtidal Annex I reefs. Habitat mapping for the area did not indicate that the rocky habitats mapped in the intertidal zone continued into the subtidal zone, suggesting that these were not continuous features and therefore did not meet the Annex I reef qualifying criteria.

Shifting coastal sand dune (B1.3) was identified along the upper extent of the south survey area covering an extent of 15240.14 m<sup>2</sup>. Coastal sand dunes are a HOCl under Section 41 of the NERC Act and a supporting feature of the North Northumberland Dunes SAC. This habitat also has the potential to qualify as Annex I Embryonic shifting dunes or Shifting dunes along the shoreline with *A. arenaria*, however this area was outside of the scope of this intertidal habitat assessment.

No biogenic reef habitats, INNS or intertidal boulder communities were observed across the two survey areas.

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# Berwick OWF Alternative Connection Intertidal Survey 2022 - Map #1

Captured: Dec 12, 2022, Processed: Dec 12, 2022



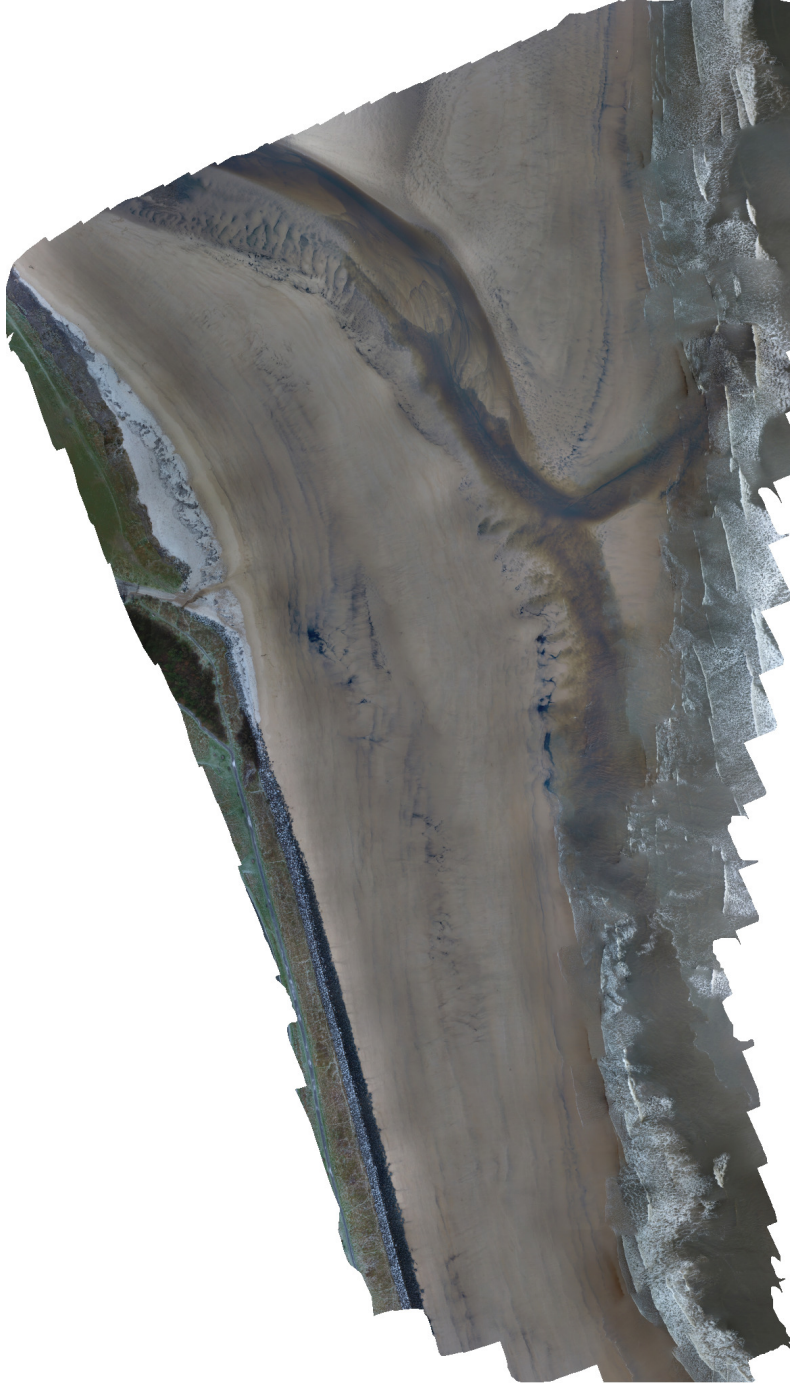
## Map Details Summary (i)

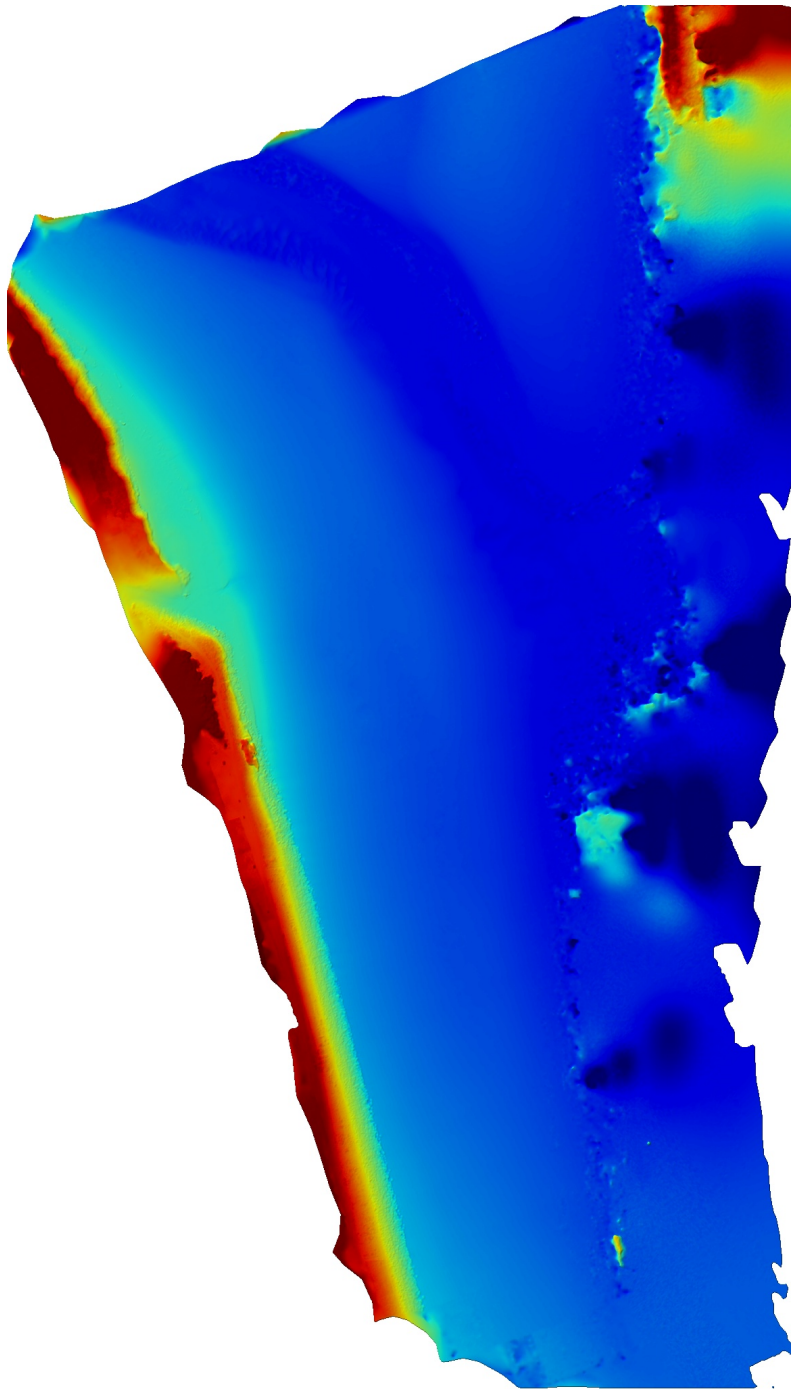
Project Name	Berwick OWF Alternative Connection Intertidal Survey 2022 - Map #1
Photogrammetry Engine	DroneDeploy Proprietary
Date Of Capture	Dec 12, 2022
Date Processed	Dec 12, 2022
GSD Orthomosaic (GSD DEM)	2.18cm/px (DEM 8.72cm/px)
Area Bounds (Coverage)	413971.21m <sup>2</sup> (59%)
Image Sensors	DJI - FC330
Average GPS Trust	10.00m

## Quality & Accuracy Summary (i)

Image Quality	High texture images
Median Shutter Speed	1/143
Images Uploaded (Aligned %)	387 (80%)
Camera Optimization	0.03% variation from reference intrinsics

Preview ⓘ

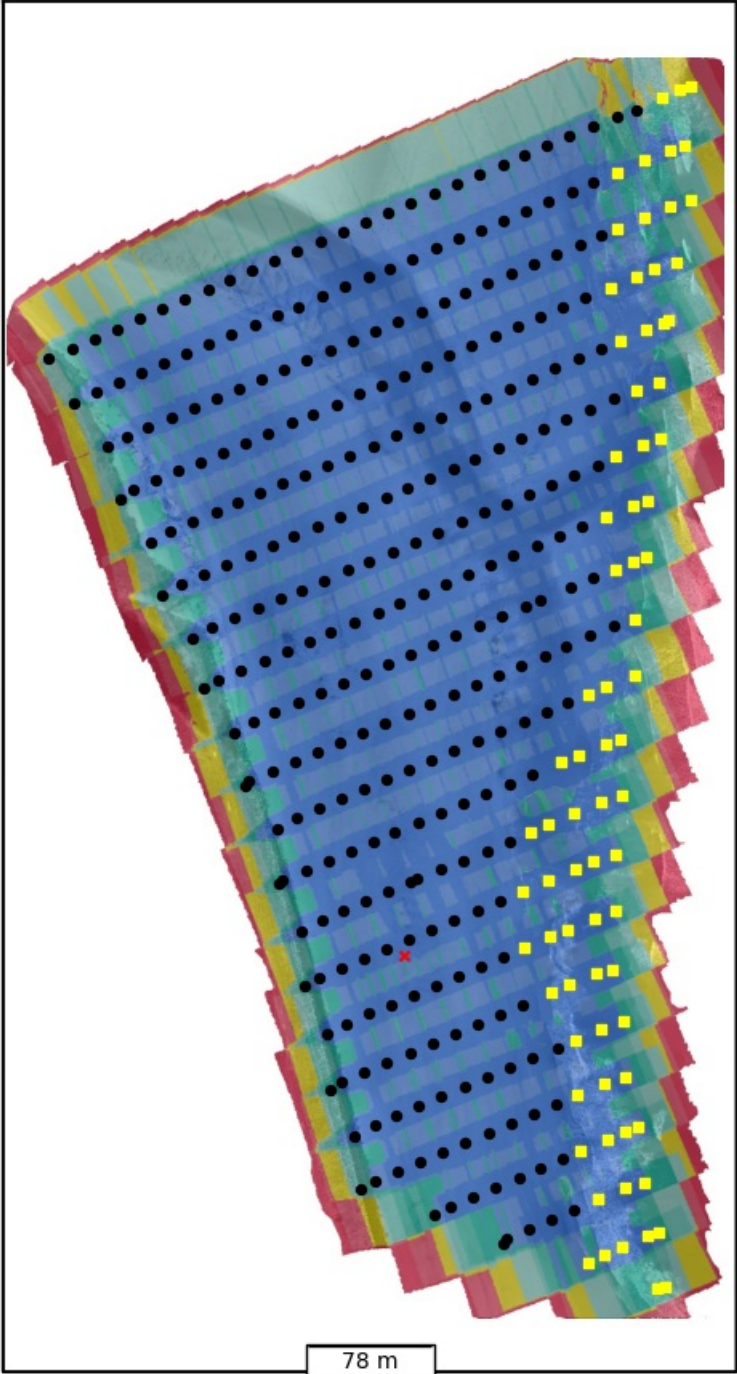






# Dataset Quality Review

Orthomosaic Coverage <sup>(i)</sup>



- ROI
- Aligned
- GPS Aligned
- ✘ Unaligned



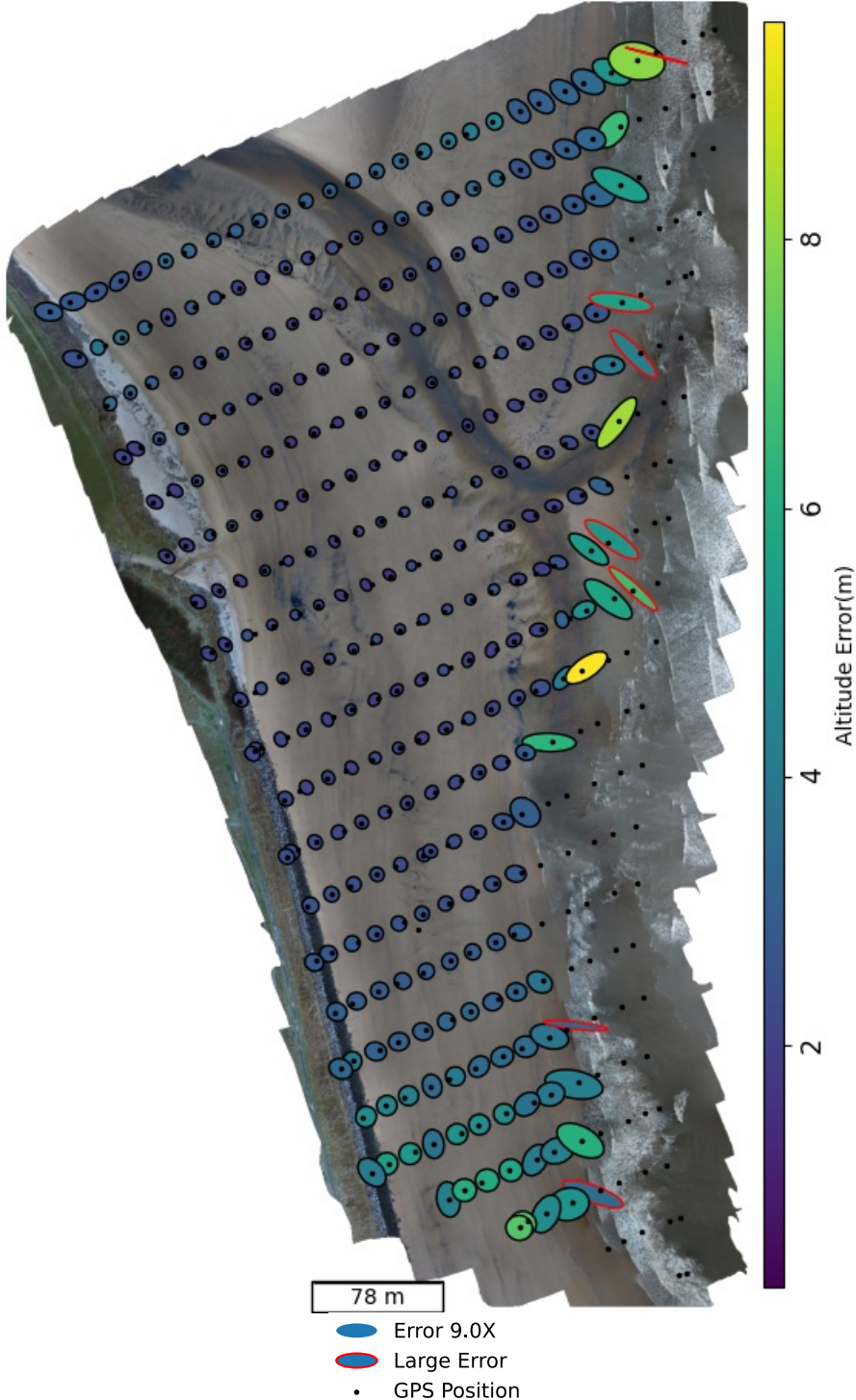
Insufficient coverage, expect large holes in the map, and low accuracy.

Marginal coverage, expect distortion or holes on buildings or sharp edges, and lower accuracy measurements.

Good coverage, expect a high quality reconstruction

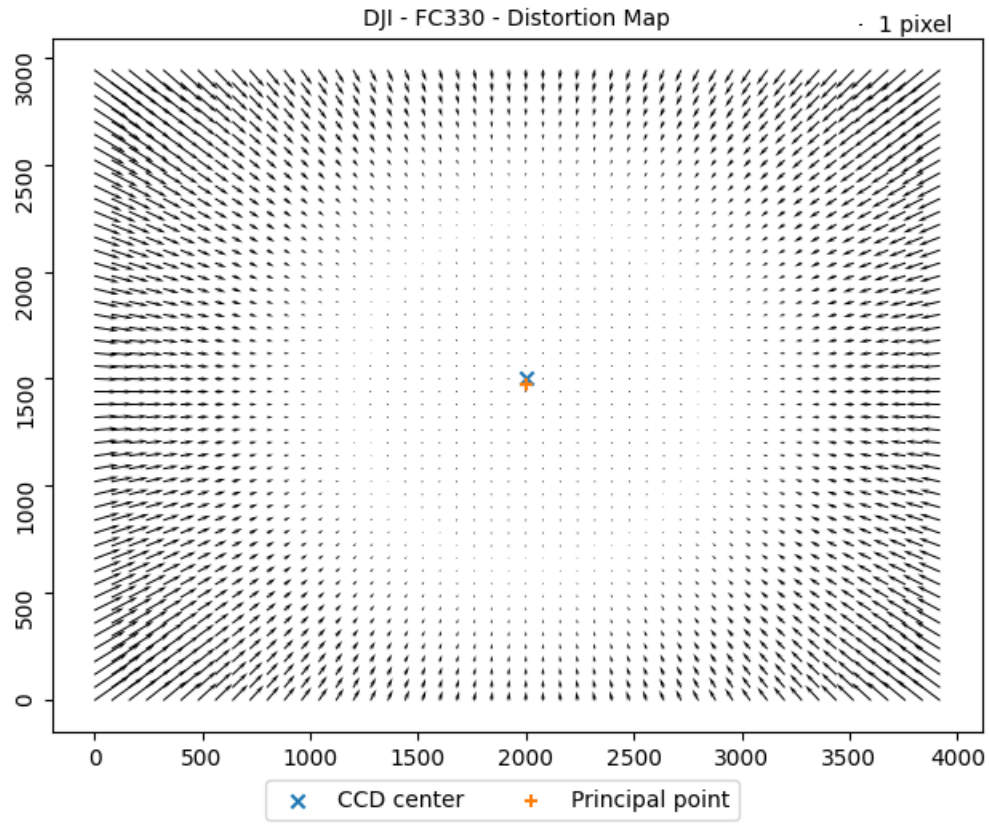
Sensor(s) Used	DJI - FC330
Image Count (by sensor)	387
Image Resolution	4000x3000 (~12MP)
Orthomosaic coverage (% of area of interest)	59.09
Average Orthomosaic Image Density within Structured Area	8 images/pixel
Median Shutter Speed	1/143

Structure from Motion <sup>(i)</sup>

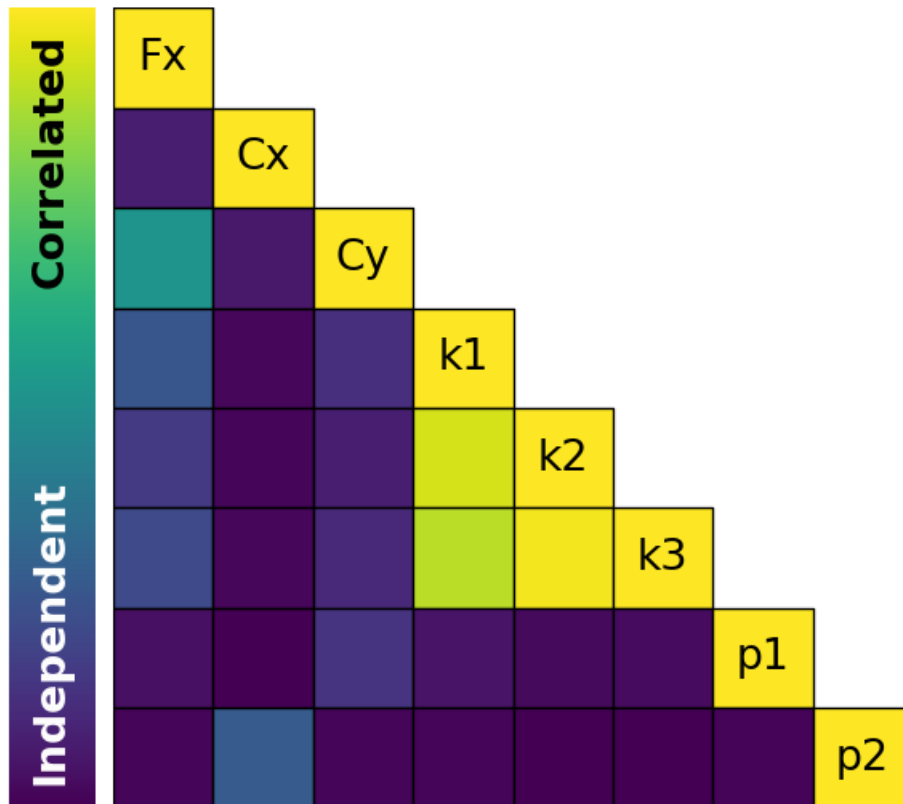


Aligned Cameras	80% 311/387
RMSE of Camera GPS Location	X 2.29m Y 0.95m Z 0.77m RMSE 1.50m

Camera Calibration <sup>(i)</sup>



	Fx	Cx	Cy	k1	k2	k3	p1	p2
<b>Value</b>	2358.79	1998.89	1470.73	-0.00927824	0.00557695	-0.00306039	-0.000113021	0.000101581
<b>Error</b>	2.91736	0.162665	0.163982	0.329242	0.633404	0.391152	0.0232401	0.02747

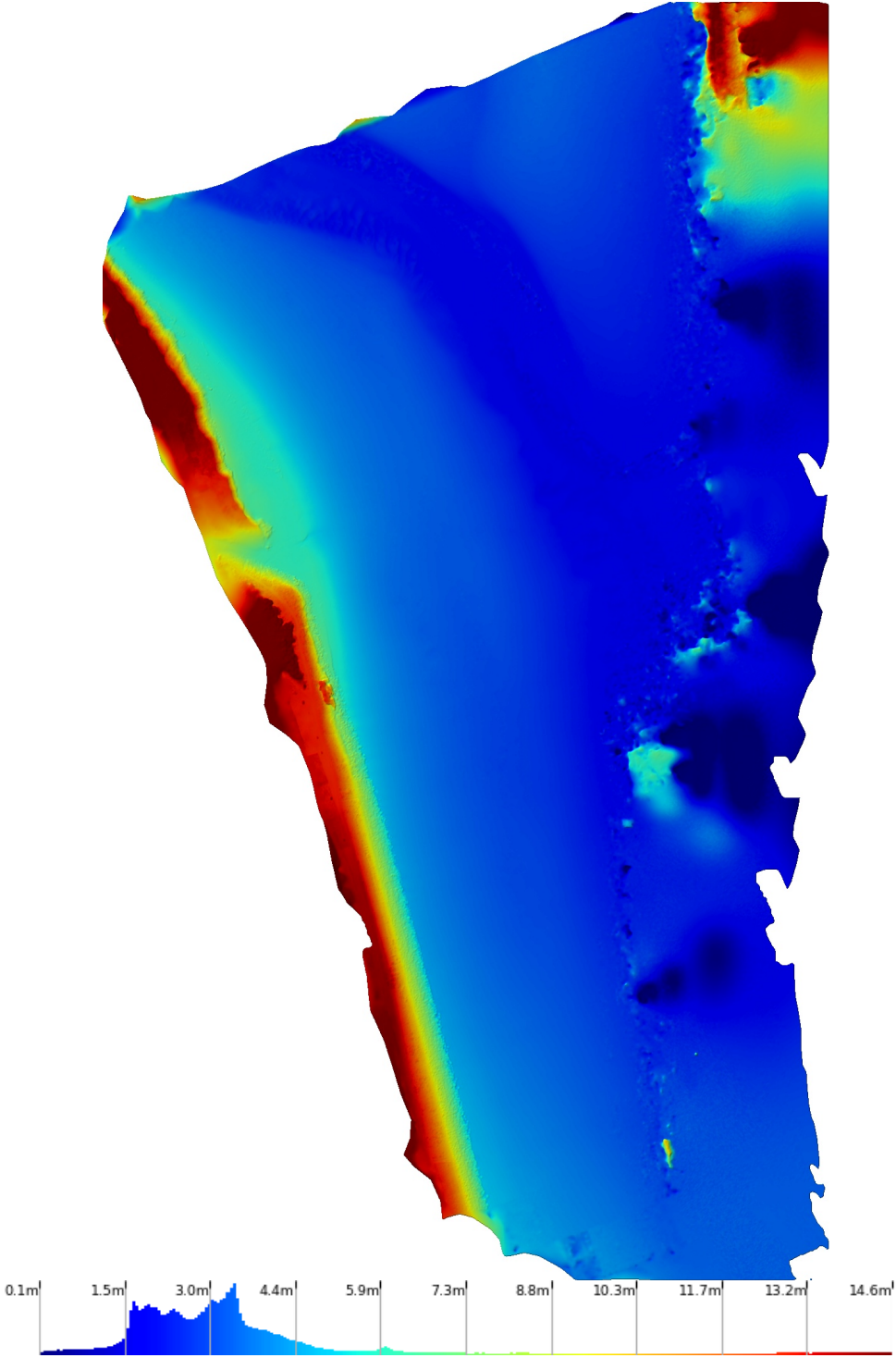


### Densification and Meshing <sup>(i)</sup>

Nadir Images	100%	Include oblique or horizontal images to improve reconstructions of man-made structures.
Oblique images	0%	
Horizontal images	0%	
Total Points	6.2 million	
Point Cloud Density	25.48 points/m <sup>2</sup>	
Mesh Triangles	1.8 million	

# Digital Elevation Model

Mode	Generated from Mesh
DEM GSD	DEM 8.72cm/px
Relative/Absolute	Relative Altitude vs Drone takeoff



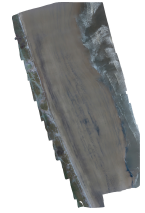


**DroneDeploy**

This map and report was produced with proprietary cloud photogrammetry software from DroneDeploy. [Provide feedback to improve this report](#)

# Berwick OWF Alternative Connection Intertidal Survey 2022 - Map #1

Captured: Dec 12, 2022, Processed: Dec 12, 2022



## Map Details Summary (i)

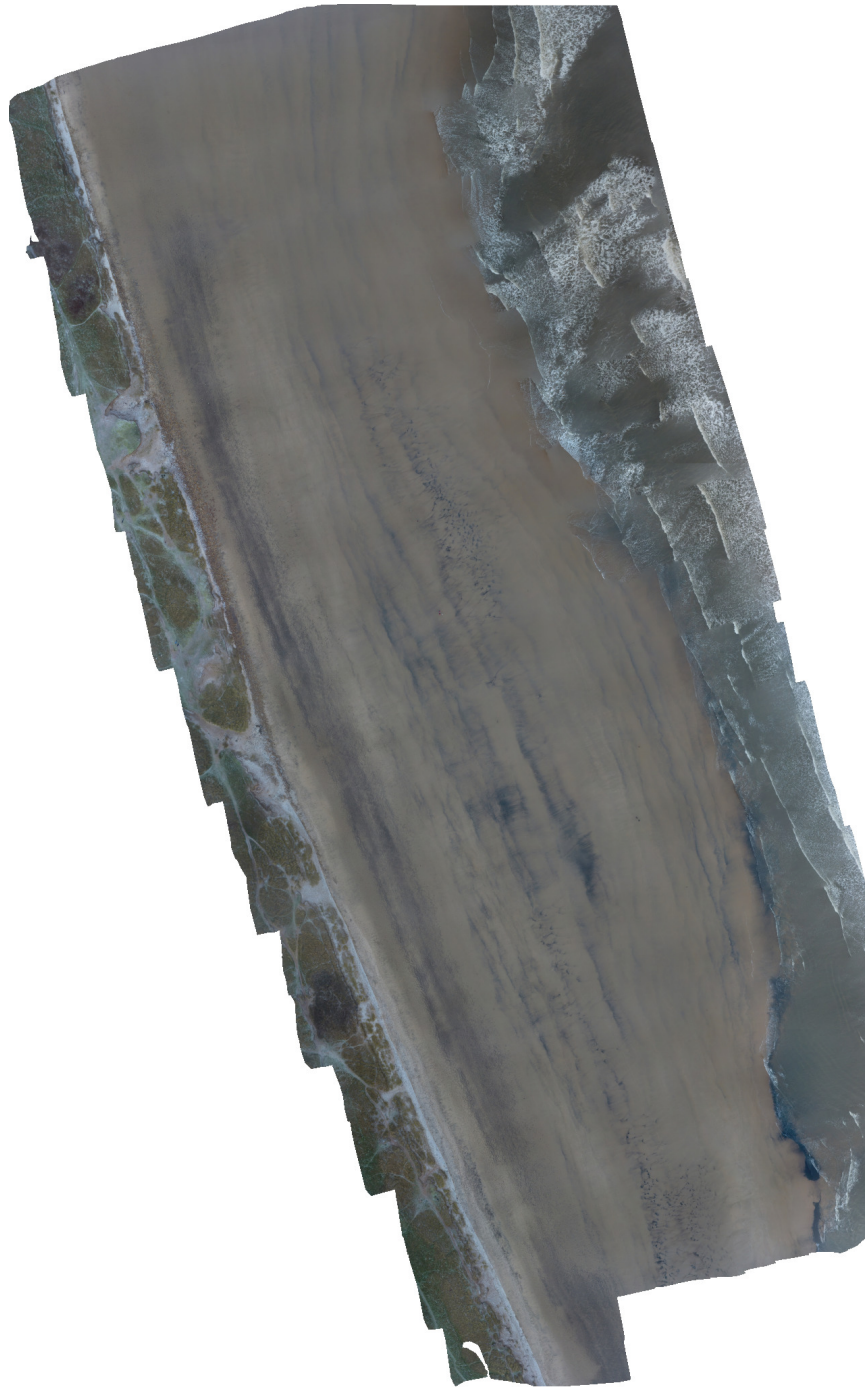
Project Name	Berwick OWF Alternative Connection Intertidal Survey 2022 - Map #1
Photogrammetry Engine	DroneDeploy Proprietary
Date Of Capture	Dec 12, 2022
Date Processed	Dec 12, 2022
GSD Orthomosaic (GSD DEM)	1.94cm/px (DEM 7.74cm/px)
Area Bounds (Coverage)	241596.65m <sup>2</sup> (56%)
Image Sensors	DJI - FC330
Average GPS Trust	10.00m

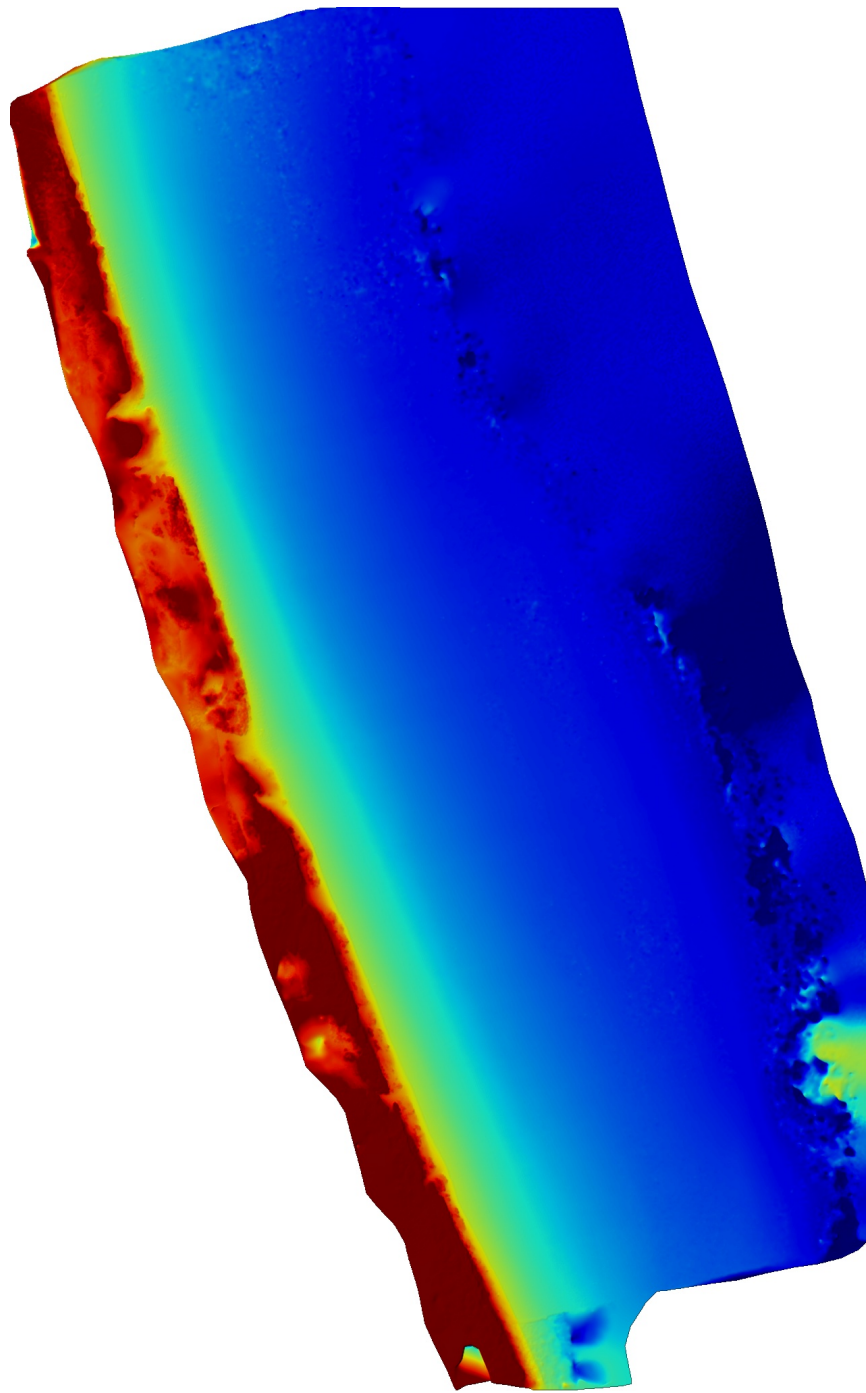
## Quality & Accuracy Summary (i)

Image Quality	High texture images
Median Shutter Speed	1/142
Images Uploaded (Aligned %)	254 (80%)
Camera Optimization	0.03% variation from reference intrinsics



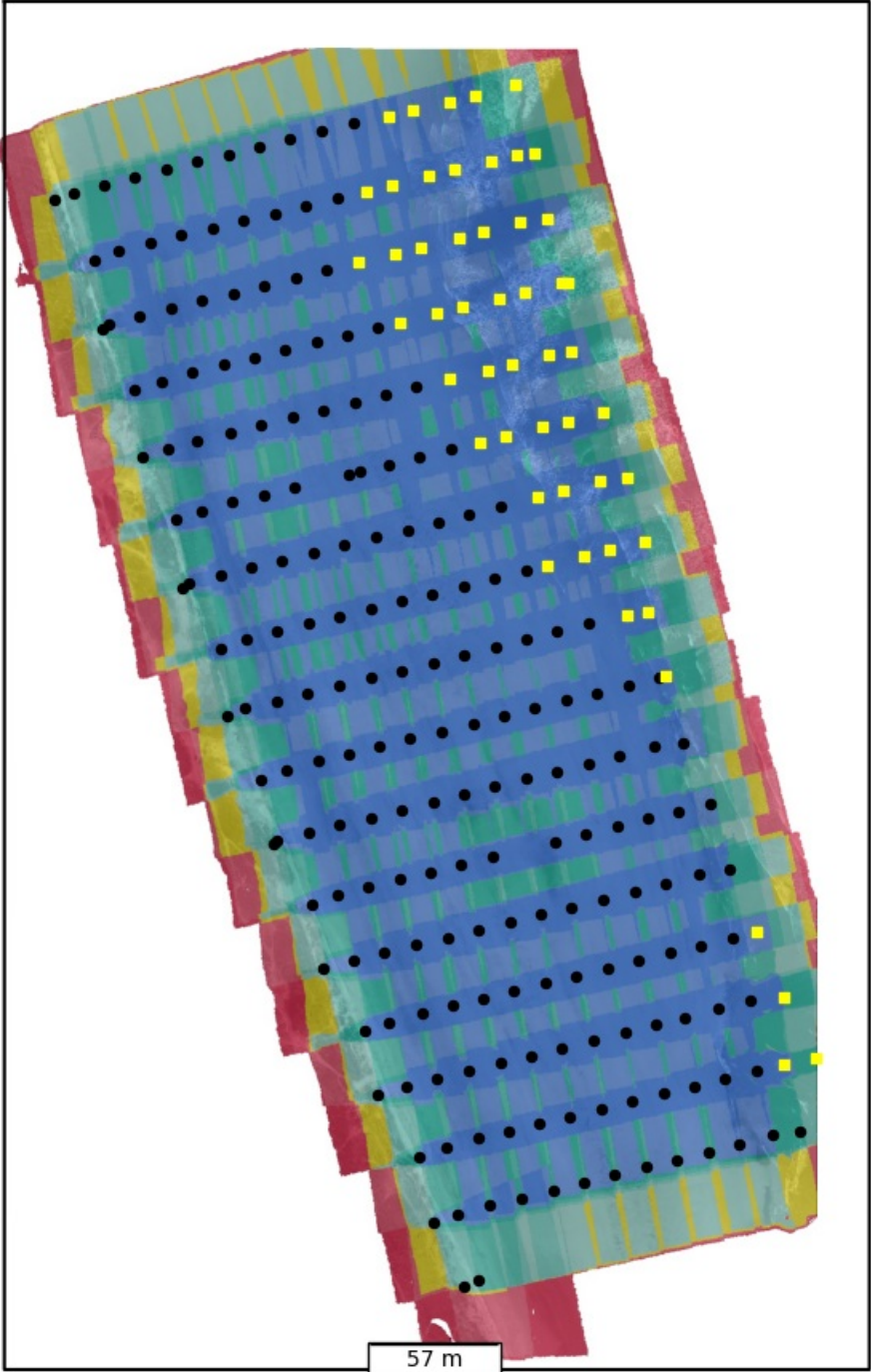
Preview ⓘ



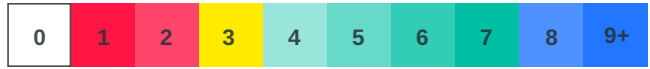


# Dataset Quality Review

Orthomosaic Coverage <sup>(i)</sup>



- ROI
- Aligned
- GPS Aligned



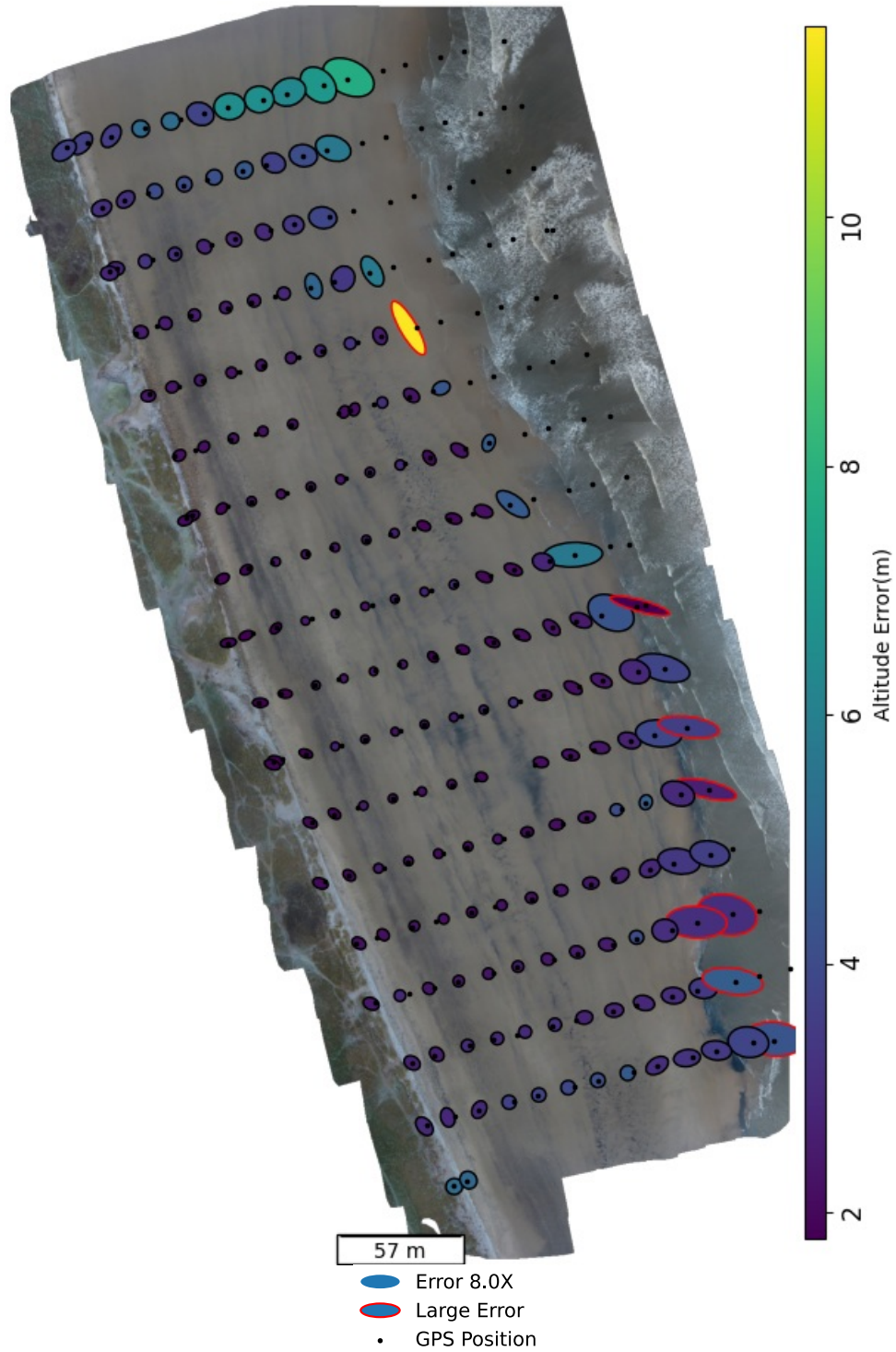
Insufficient coverage, expect large holes in the map, and low accuracy.

Marginal coverage, expect distortion or holes on buildings or sharp edges, and lower accuracy measurements.

Good coverage, expect a high quality reconstruction

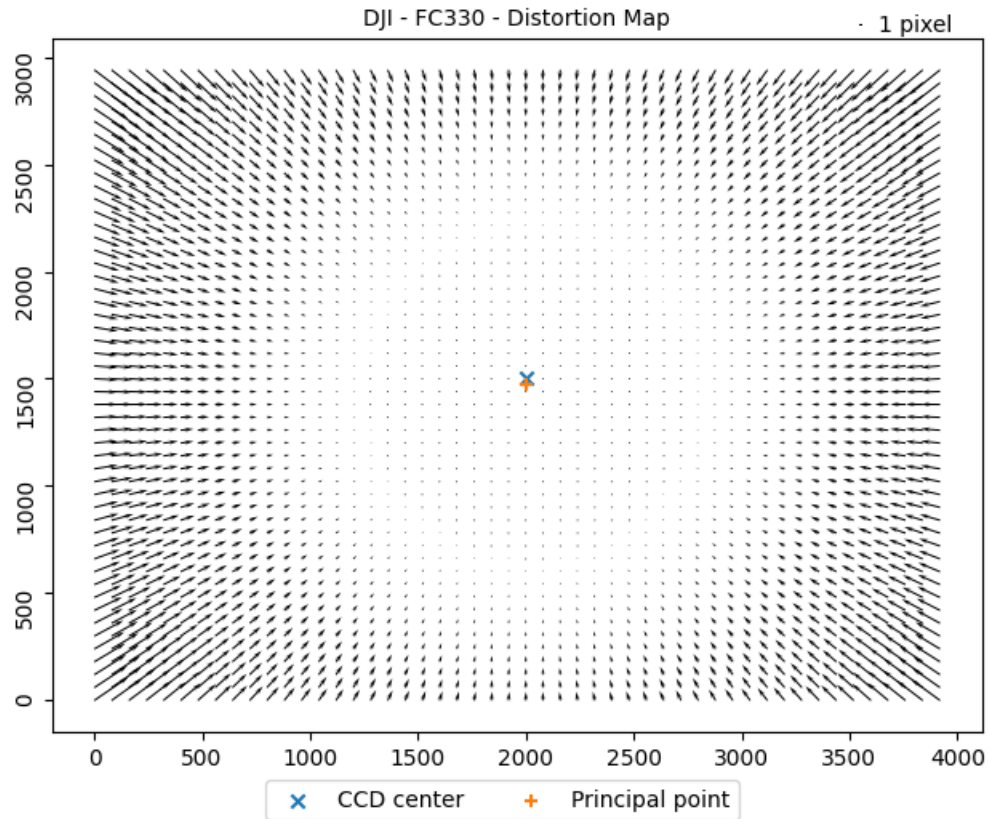
Sensor(s) Used	DJI - FC330
Image Count (by sensor)	254
Image Resolution	4000x3000 (~12MP)
Orthomosaic coverage (% of area of interest)	56.02
Average Orthomosaic Image Density within Structured Area	8 images/pixel
Median Shutter Speed	1/142

# Structure from Motion <sup>(i)</sup>

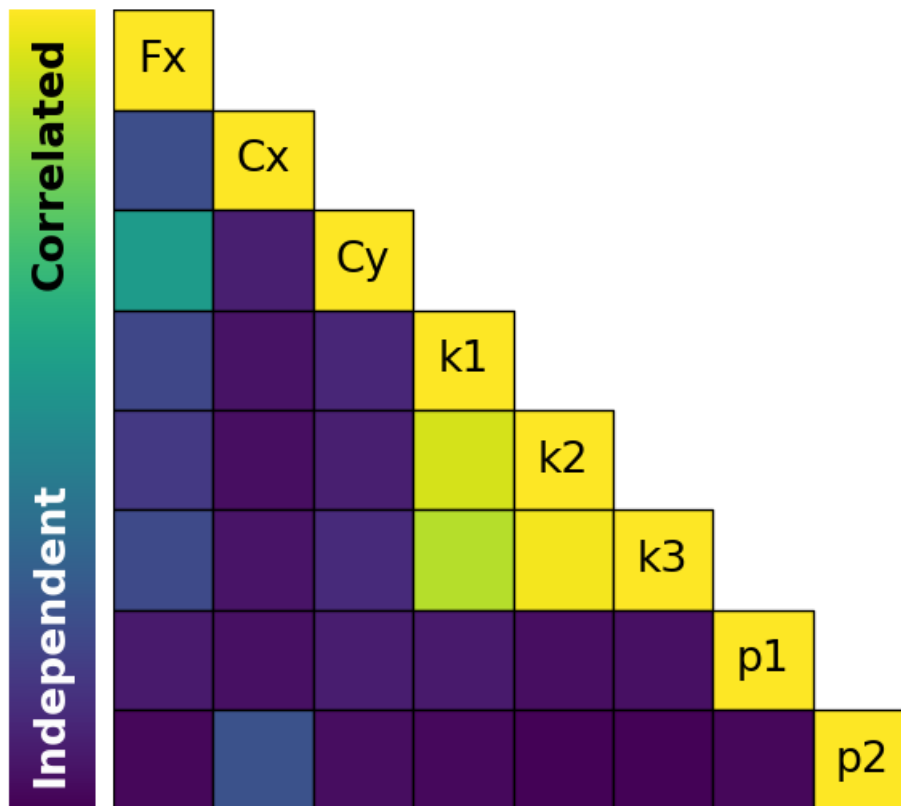


Aligned Cameras	80% 203/254
RMSE of Camera GPS Location	X 2.15m Y 0.60m Z 0.42m RMSE 1.31m

# Camera Calibration <sup>(i)</sup>



	Fx	Cx	Cy	k1	k2	k3	p1	p2
Value	2214.56	2001.78	1477.32	-0.00886451	0.00558941	-0.00271905	-0.000215504	6.39131e-05
Error	2.38432	0.202583	0.211069	0.345977	0.579396	0.310709	0.027157	0.0312314

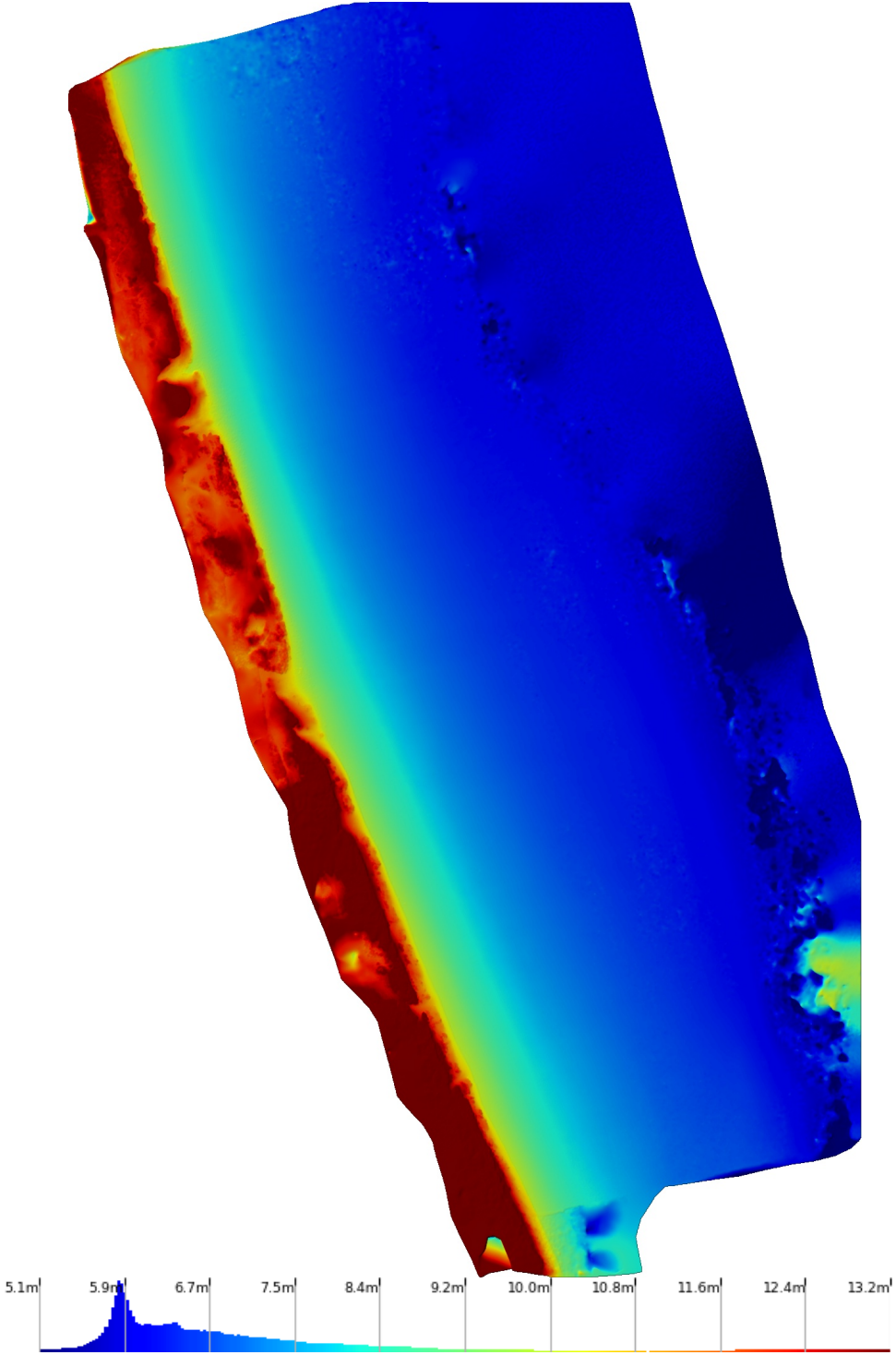


### Densification and Meshing <sup>(i)</sup>

Nadir Images	100%	Include oblique or horizontal images to improve reconstructions of man-made structures.
Oblique images	0%	
Horizontal images	0%	
Total Points	4.3 million	
Point Cloud Density	31.57 points/m <sup>2</sup>	
Mesh Triangles	1.3 million	

# Digital Elevation Model

Mode	Generated from Mesh
DEM GSD	DEM 7.74cm/px
Relative/Absolute	Relative Altitude vs Drone takeoff







**DroneDeploy**

This map and report was produced with proprietary cloud photogrammetry software from DroneDeploy. [Provide feedback to improve this report](#)

Annex II - Target notes for Berwick south site

Station_ID	Sediment Type	Notes	EUNIS_BSH	EUNIS Biotope	HOCI	Latitude	Longitude	Shape
S001	Gravelly Sand	Medium sand with surgical pebbles scattered. Predominantly clean sand.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149903	-1.520702	Point
S002	Sandy Gravel	Higher gravel / pebble content with sand. Runs along the upper shore going south from here.	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.14968	-1.521012	Point
S003	Gravelly Sand	Strip of sand with less pebbles above coarse sediment patch and below strip of rock at sand dune interface.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149573	-1.521203	Point
S004	Cobbles	Cobbles and small boulders and interface between sand dune and sandy shore.	A1.2 : Moderate energy littoral rock	<Null>	<Null>	55.14944	-1.521385	Point
S005	Sandy Gravel	<Null>	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.149297	-1.520947	Point
S006	Gravelly Sand	Sand with pebbles scattered.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149352	-1.520557	Point
S007	Sand	Medium to fine sand. Clean at water line.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149585	-1.519275	Point
S008	Sand	Upper extent of clean fine sand section below Gravelly sand habitat higher up shore.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14921	-1.51962	Point
S009	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.148848	-1.519723	Point
S010	Sandy Gravel	<Null>	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.148558	-1.520463	Point
S011	Cobbles	Cobbles and boulder below sand dune. Sand dune is low lying with underlying conglomerate of sand, clay and cobble / pebble.	A1.2 : Moderate energy littoral rock	<Null>	<Null>	55.14835	-1.520698	Point
S012	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14827	-1.519725	Point
S013	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14834	-1.519045	Point
S014	Sand	Clean medium to fine sand.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.148448	-1.518155	Point
S015	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.147968	-1.518428	Point
S016	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.1476	-1.51823	Point
S017	Sand	Mid shore sand with some gravel / pebble.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.147268	-1.518667	Point
S018	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.147103	-1.519133	Point
S019	Sandy Gravel	Coarse sediment below thin strip of gravelly sand habitat between coarse and sand dune.	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.147022	-1.519477	Point
S020	Gravelly Sand	Area between coarse sediment and sand dunes with less coarse material. Medium sand.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14688	-1.519622	Point
S021	Sand	Sand dune fringe for mapping. Check biotope but essentially the embryo dunes at the sandy beach interface.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14641	-1.519612	Point
S022	Sandy Gravel	<Null>	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.146285	-1.518957	Point
S023	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.146328	-1.518418	Point
S024	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.146178	-1.51811	Point
S025	Sand	Clean medium to fine sand at waterline.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.146273	-1.517188	Point
S026	Gravelly Sand	<Null>	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.145928	-1.517842	Point
S027	Gravelly Sand	Sand with pebbles and small boulders	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.145902	-1.518512	Point
S028	Gravelly Sand	Sand with pebbles and small boulders	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.145615	-1.518662	Point
S029	Gravelly Sand	Sand with pebbles	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.145698	-1.518178	Point
S030	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.145868	-1.517518	Point
S031	Sand	Clean sand at low water line	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14596	-1.516913	Point
S032	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.146889	-1.518242	Point
S033	Sand	Clean sand at low water line	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14666	-1.517208	Point
S034	Sand	Clean sand	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.146983	-1.517277	Point
S035	Gravelly Sand	Sand with pebble and coarse gravel. Same or entire stretch of survey area at this tidal range.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.146585	-1.518702	Point
S036	Sand	Clean sand	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.146613	-1.517783	Point
S037	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14688	-1.51891	Point
S038	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14701	-1.517787	Point
S039	Sandy Gravel	<Null>	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.146643	-1.519221	Point
S040	Sand	Clean sand at low water line	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.147332	-1.517478	Point
S041	Sandy Gravel	<Null>	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.147419	-1.519785	Point
S042	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14752	-1.519374	Point
S043	Sand	Clean sand at low water line	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.147607	-1.517672	Point
S044	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.14764	-1.518911	Point
S045	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.1479	-1.517913	Point
S046	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.147978	-1.519283	Point
S047	Sandy Gravel	Sandy gravel coarse sediment with strip of sand above before cobble / rock and sand dune.	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.147846	-1.520061	Point
S048	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.148315	-1.51806	Point
S049	Sand	Clean sand at low water line	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.148803	-1.51859	Point
S050	Gravelly Sand	Strip of finer material dominated by sand with scattered cobbles, runs along beach at upper shore.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.148903	-1.520987	Point
S051	Sandy Gravel	<Null>	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.148946	-1.520748	Point
S052	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149039	-1.520369	Point
S053	Sand	Clean san at low water line	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149247	-1.519042	Point
S054	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.150139	-1.519021	Point
S055	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.150085	-1.519477	Point
S056	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149751	-1.519772	Point
S057	Gravelly Sandy Mud	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.149699	-1.520386	Point
S058	Sandy Gravel	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.150082	-1.520287	Point

Annex III - Target notes for Berwick north site

Station_ID	Sediment Type	Notes	EUNIS_BSH	EUNIS Biotope	HOCI	Latitude	Longitude	Shape
N001	Sandy Gravel	Sand with pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159463	-1.523718	Point
N002	Gravelly Sand	Sand with pebbles and small boulders	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.159945	-1.523662	Point
N003	Sand	Rippled sand on margin on margin of river input	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159343	-1.523074	Point
N004	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159128	-1.523288	Point
N005	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159013	-1.522617	Point
N006	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158722	-1.523287	Point
N007	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158688	-1.522441	Point
N008	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.15823	-1.5231	Point
N009	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158266	-1.521993	Point
N010	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157829	-1.522108	Point
N011	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157768	-1.522938	Point
N012	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157412	-1.522161	Point
N013	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157258	-1.522867	Point
N014	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.156902	-1.52185	Point
N015	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.156772	-1.522788	Point
N016	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.156318	-1.521734	Point
N017	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.156277	-1.52263	Point
N018	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.155691	-1.521457	Point
N019	Sand	Sand with some small pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.155808	-1.522473	Point
N020	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.155348	-1.522388	Point
N021	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.155036	-1.52136	Point
N022	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.154917	-1.522268	Point
N023	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.154725	-1.521107	Point
N024	Sand	Clean medium to fine sand with occasional scattered pebble. Consistent habitat across the shore with no change.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.154789	-1.521821	Point
N025	Sand	Sand with some small pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.154835	-1.523145	Point
N026	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.155233	-1.523268	Point
N027	Sand	Sand with scattered pebbles. Some standing water forming pools in depressions.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.155013	-1.522808	Point
N028	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.155723	-1.5234	Point
N029	Rock	Gabbion sea defence at extreme upper shore. Clean with only very sparse barnacle and red algae.	A1.3 : Low energy littoral rock	<Null>	<Null>	55.15541	-1.523464	Point
N030	Sand	Sand with small scattered pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.15621	-1.523405	Point
N031	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.156528	-1.523913	Point
N032	Gravelly Sand	Very small isolated patch of coarser sediment with fine coal deposits.	A2.1 : Littoral coarse sediment	<Null>	<Null>	55.156539	-1.522923	Point
N033	Sand	Sand with small scattered pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.156788	-1.523425	Point
N034	Gravelly Sand	Higher pebble / grave content but still BSH sand.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157287	-1.523635	Point
N035	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157045	-1.524135	Point
N036	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157443	-1.524437	Point
N037	Sand	Sand with pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157747	-1.52385	Point
N038	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159257	-1.524649	Point
N039	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.157882	-1.524653	Point
N040	Sand	Soft dry sand with scattered pebbles.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159624	-1.524417	Point
N041	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158158	-1.524002	Point
N042	Gravelly Sand	Sand with mega ripples at margin of river input. Fine coal fragments	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.16012	-1.524141	Point
N043	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.15829	-1.524803	Point
N044	Gravelly Sand	Rippled sand with coal fragments as gravel. Large mega ripple depressions with standing water and gravel / organic debris bottom. No attached algae.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.160303	-1.524691	Point
N045	Sand	Sand with pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158552	-1.524073	Point
N046	Sand	Clean dry medium sand.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.160121	-1.52525	Point
N047	Sand	Sand with small scattered pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158913	-1.523862	Point
N048	Sand	Sand with scattered pebbles.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159982	-1.525813	Point
N049	Sand	Sand with small scattered pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158845	-1.524643	Point
N050	Sand	Upper shore mark with Strandline backed by steep conglomerate of soils / clays with vegetation.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159845	-1.526268	Point
N051	Sand	Medium fine sand	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.158697	-1.525175	Point
N052	Gravelly Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159668	-1.525332	Point
N053	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159017	-1.52571	Point
N054	Sand	Sand underlying frost with scattered debris (trees, bricks and concrete block). Backed by steep soil / clay cliff with vegetation.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159453	-1.525906	Point
N055	Sand	Sand with small scattered pebbles	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159283	-1.525317	Point
N056	Sand	Clean Menciis sand on northern side of river input. Some rippled sands in areas.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.16062	-1.52335	Point
N057	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.160347	-1.523028	Point
N058	Sand	Rippled sand some very coal fragments in places. Forms a spit of sand along river input to tide mark.	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159977	-1.522603	Point
N059	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159525	-1.522198	Point
N060	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.159913	-1.521608	Point
N061	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.160467	-1.521565	Point
N062	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.161008	-1.521593	Point
N063	Sand	<Null>	A2.2 : Littoral sand and muddy sand	<Null>	<Null>	55.160657	-1.522432	Point